14. Appendix 4 : CDS STUDIES

In this Appendix we include CDS studies submitted to us by members of the solar community. Occasionally we may have edited fragments of the text, but the science contents remains the responsibility of its authors. For all studies which have a CDS sequence, we have actually programmed this sequence using CDS software planning tools. Thus, the parameters are reasonably realistic, according to our current understanding of the instrument. This understanding is likely to evolve as real data become progressively available, and some of the parameters may change, in particular, instrument sensitivities. Hence, for example, the 'study duration' should be used as a guidance only.

Each study is given a five-letter acronym which follows the study title, and studies are arranged alphabetically according to this acronym. We found this order useful for a quick location of a given study. A full list of studies is given in Table 6.1 in Chapter 6. For those not yet familiar with this Appendix, for easier identification, we have grouped the studies under several characteristic topics in Table 14.1 below. Sometimes the same study may appear under several diferent topics.

We thank everyone for their contributions and would like to encourage further submissions of proposals to carry out CDS observations.

Table 14.1: CDS studies grouped by science topics

Science topic	Study ID
Elemental Abundances	ABSTR, ABVAR, ATRIC, HELEN, TRACE
Synoptic Observations	AERON, NISAT, SPECT, SYNOP
Coronal Mass Ejections	EDCME, EJECT
Flows	BROAD, CHROM, HIVEL, SPOTV, FFLOW
Spectral Diagnostics	ATOMI, FEINT, IRRAD, NONEQ, O5DEN, OPAC1, OPAC2, S11DE
Coronal Holes	BOUND, CHOLE, CHSTR, TGRAD
Various Coronal Structures	BRPNT, COSAR, DYNAC, FILLF, INHOM, STREM,
Prominences Filaments	POBS1, FFLOW
Coronal Heating	FLARE, MICRO, NANOF, NFCTR
Temperature, Emission Measure	EMSQS, PTCOR, TGRAD
Wave Activity	BROAD, WAVE
Calibration	AERON, ALIGN, GIMCP, ICAL1, ICAL2, ICCAL, NIMCP, NISAT, SPECT, TEST3, TEST4
Test	TEST1, TEST2, TEST3, TEST4, TEST5, TEST6, TEST7

Mg Abundance In Streamers And Open Field Areas [ABSTR]

Contributor(s): G. Poletto (Arcetri), R.A. Harrison (RAL)

Scientific Justification

An issue that can be addressed by SOHO-CDS is that of element abundances in streamers. Depending on the value of the first ionization potential (FIP), elements can be divided into high FIP (ionization potential > 10 eV) and low FIP (ionization potential < 10 eV) elements: it is well known that in between the photosphere and the corona, because of some fractionation mechanism, the relative abundance of low to high FIP elements is enhanced (Meyer, 1991). Although the fractionation mechanism has not yet been unambiguously identified, ion-neutral separation in a magnetic field is usually invoked and different suggestions are made as to the forces (e. g., gravitational, electromagnetic) responsible for this effect (Vauclair and Meyer, 1985, Von Steiger and Geiss, 1989, Henoux and Somov, 1992, Antiochos, 1993).

A determination of element abundances in streamers is especially relevant in view of the claim that the ratio of high to low FIP elements depends on the magnetic field configuration, being highest in closed field structures and steadily decreasing to low values as we move to large scale loops and completely open fields (see Fig. 7 in Meyer, 1993). Evaluating abundances at different heights along, and across, the streamer's axis, should allow us to detect a different abundance ratio as we move from closed to open regions, if the abundance ratio is really a function of the magnetic field configuration. This research may be an ideal case for a collaborative study: CDS and SUMER may determine Ne, Mg and O abundances at lower coronal levels, while UVCS has the capability of determining Mg and O abundances at greater heights. Here we focus on the determination of Mg abundance in open vs. closed field areas.

There are two means to perform such a study: cooperating with other experiments we may point to the central axis of a streamer and make above limb measurements up to the largest accessible height. Other experiments may take data at higher levels (however, the relevance of measurements made at the same height by other experiments has not to be underestimated, as it would allow us to cross-check the values of abundances inferred via different instruments). This kind of measurements leads to the determination of the abundance vs. height profile in a streamer and overlying open field area. Alternately, we may take data *across* the streamer axis, at some height above the limb, covering both the closed field lines of the streamer and the open field area adjacent to the streamer. This approach requires CDS to point to a region partially covered by a streamer and partially covered by a coronal hole. Otherwise, the instrument should be repointed to cover, first, the central part of a streamer and, second, the central part of an adjacent hole. In the following, we choose to follow this latter alternative.

In this case, we don't need to reach high levels in the corona; anyhow, we assume that we have to accumulate over 100 s in each raster location, as we will observe at some height above the limb. Density values can be derived via the density sensitive line ratio 319/367 (Mg VII), temperatures can be derived from the sequence of lines from available ions; hence abundances will not be affected by uncertainties in these parameters. We need no compression, as we have 5 (lines) x 21 pixels x 16 bits x 120 = 202000 bits at 10 kbit/s = 20.2 s (< of the dwell time).

Study Details

Spectrometer: Normal Incidence

Slit:	2 x 240 arcsec
Raster Area:	2 x 2 arcmin
Step (DX, DY)	2 arcsec, 0 arcsec
Raster Locations:	60 x 1
Exposure Time:	100 s
Duration of raster:	111.5 min
Number of rasters:	2 (streamer + adjacent coronal hole)
Total duration:	223 min
Line selection:	Mg VI (349 Å), Mg VII (319 Å), Mg VIII (313 Å), Mg IX (368 Å), Mg X (624 Å)
Bins Across Line:	21
Telemetry/Compression:	truncated to 12 bits. 7.5 s/exposure = 5 lines x21 bins x60 pixels x12 bits /10 kbits/s
Pointing:	streamer region. Repoint to an adjacent coronal hole
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not necessary
Frequency:	

Product:
2 intensity maps of streamer/coronal hole areas, in 5 lines, of size 2 x 2 arcmin, spatial resolution 2 arcsec.

Joint Observations:
SUMER, UVCS

Abundance Variations In Different Solar Regions - [ABVAR]

Contributor(s) - H.E. Mason

Scientific Justification:

There is evidence for abundance variations in different regions of the solar atmosphere - depending on the first ionisation potential. This could be studied by looking at the ratios of selected lines in sequences, e.g. a Ne, Mg selection, for different regions on the solar disc. A suitable Ne, Mg selection would be Ne III 489.50Å, Ne V 482.10/416.20Å, Ne VI 401.14Å, Ne VII 465.22Å, Mg VI 400.68Å, Mg VII 434.93Å, Mg VIII 436.73/430.46Å and Mg IX 444.03Å. Electron density would be given by the Mg VIII ratio. In practice, given the exposure time and the suggested lines, we select the entire GIS wavelength range. The exposure time is such that we may expect 20% or better counting statistics on most of the lines listed above, in quiet Sun conditions; there is no need for fast time resolution.

Study Details

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcseconds
Raster Area:	60 x 60 arcseconds
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	15 x 15 = 225
Exposure Time:	15 seconds
Duration of Raster:	3790 seconds (63.2 minutes) incl. overheads
Number of Rasters:	3
Total Duration:	189.6 minutes
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression required.
Pointing:	To pre-selected target
Flags:	May be run in response to interinstrument flag for particular target. Could run with CDS as flag Master
Solar Feature Tracking:	May be used. Not essential.
Frequency:	To be run on a selection of different solar features during occasional campaigns during mission.

Product

Three 60x60 arcsec images with 4 arcsecond resolution with full spectral information

Aeronomy/Calibration Support Programme - [AERON]

Contributor(s) - R.A. Harrison

Scientific Justification:

The idea of this study is to provide full Sun He II 304Å data for comparison to the on board monitor (SEM), and to provide a full Sun EUV scan for aeronomy studies. The calibration study will enable a projection of the monitor data through CDS to SUMER and UVCS. The exercise, requires 130 repointings of CDS - and should be performed rarely!
**** HEALTH WARNING! It may not be possible to run this Study due to excessive count rates in the GIS system. This will depend on the final senstivity of the CDS instrument. Extreme caution should b exercised before deciding to run this Study.****

Study Details

Spectrometer:	Grazing Incidence
Slit:	90 x 240 arcseconds
Raster Area:	90 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	5 seconds
Duration of Raster:	9 seconds (include. overheads)
Number of Rasters:	130 (see pointing entry)
Total Duration:	19.5 minutes
Line Selection:	GIS Band Two
Bins Across Line:	N/A
Telemetry/Compression:	Straight Copy
Pointing:	Perform 130 rasters at the following locations, given as distances in arcsec from Sun centre (+ve to west and north):

(-8.25,14), (-6.75,14), (-5.25,14), (-3.75,14), (-2.25,14), (-.75,14), (.75,14), (2.25,14), (3.75,14), (5.25,14), (6.75,14), (8.25,14), (-12.75,10), (-11.25,10), (-9.75,10), (-8.25,10), (-6.75,10), (-5.25,10), (-3.75,10), (-2.25,10), (-.75,10), (.75,10), (2.25,10), (3.75,10), (5.25,10), (6.75,10), (8.25,10), (9.75,10), (11.25,10), (12.75,10), (-14.25,6), (-12.75,6), (-11.25,6), (-9.75,6), (-8.25,6), (-6.75,6), (-5.25,6), (-3.75,6), (-2.25,6), (-.75,6), (.75,6), (2.25,6), (3.75,6), (5.25,6), (6.75,6), (8.25,6), (9.75,6), (11.25,6), (12.75,6), (14.25,6), (-14.25,2), (-12.75,2), (-11.25,2), (-9.75,2), (-8.25,2), (-6.75,2), (-5.25,2), (-3.75,2), (-2.25,2), (-.75,2), (.75,2), (2.25,2), (3.75,2), (5.25,2), (6.75,2), (8.25,2), (9.75,2), (11.25,2), (12.75,2), (14.25,2), (-14.25,-2), (-12.75,-2), (-11.25,-2), (-9.75,-2), (-8.25,-2), (-6.75,-2), (-5.25,-2), (-3.75,-2), (-2.25,-2), (-.75,-2), (.75,-2), (2.25,-2), (3.75,-2), (5.25,-2), (6.75,-2), (8.25,-2), (9.75,-2), (11.25,-2), (12.75,-2), (14.25,-2), (-14.25,-6), (-12.75,-6), (-11.25,-6), (-9.75,-6), (-8.25,-6), (-6.75,-6), (-5.25,-6), (-3.75,-6), (-2.25,-6), (-.75, -6), (.75,-6), (2.25,-6), (3.75,-6), (5.25,-6), (6.75,-6), (8.25,-6), (9.75,-6), (11.25,-6), (12.75,-6), (14.25,-6), (-12.75,-10), (-11.25,-10), (-9.75,-10), (-8.25,-10), (-6.75,-10), (-5.25,-10), (-3.75,-10), (-2.25,-10), (-.75,-10), (.75,-10), (2.25,-10), (3.75,-10), (5.25,-10), (6.75,-10), (8.25,-10), (9.75,-10), (11.25,-10), (12.75,-10), (-8.25,-14), (-6.75,-14), (-5.25,-14), (-3.75,-14), (-2.25,-14), (-.75,-14), (.75,-14), (2.25,-14), (3.75,-14), (5.25,-14), (6.75,-14), (8.25,-14).

Flags:	This Study will not make us of flags.

Solar Feature Tracking: Not necessary

Frequency: To be run on a few occasions during mission

Product

Full Sun map with GIS 2nd wavelength band (256-338Å) with 130 locations of 1.5 x 4 arcminute resolution.

Joint Observations

AERON is part of SOHO Intercalibration JOP 3, known as Intercalibration 3. This JOP compares CDS and EIT full Sun maps with the SEM 304Å intensity.

SUMER/CDS Alignment Calibration - [ALIGN]

Contributor(s) - R.A. Harrison (RAL), K. Wilhelm, I. Büttner (Lindau)

Scientific Justification:

Periodically, we must check the relative alignment between the CDS, SUMER and EIT instruments and the NIS and GIS components of CDS. Much of the interdisciplinary science with SOHO demands a good knowledge of the relative alignments between the coronal devices. This should be done as part of the regular calibration programme with the following sequence performed perhaps once per month. The study has two phases, the first is for SUMER/CDS-NIS alignment, the second for EIT/SUMER/CDS-GIS alignment. Common lines in each phase provide the link between the NIS and GIS components for the inter-CDS alignment check.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	30 x 240 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	15 x 1 = 15
Exposure Time:	20 seconds
Duration of Raster:	369 seconds (including overheads)
Number of Rasters:	2
Total Duration:	738 seconds
Line Selection:	Alignment Line Selection (4 lines)
Bins Across Line:	21
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	30 x 30 arcseconds
Step (DX, DY):	2 arcseconds, 2 arcseconds
Raster Locations:	15 x 15 = 225
Exposure Time:	10 seconds
Duration of Raster:	3276 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	54.6 minutes
Line Selection:	Full GIS output (Analysis will use the following: GIS/NIS common: FeXIV 334.17Å, FeXIII

320.80Å,

MgVIII 313.73Å; GIS/EIT common: FeIX 171.07Å,
Fe XII 195.12Å, Fe XV 284.16Å, He II 303.78Å;

	GIS/SUMER: Ne VIII 770.40Å)
Bins Across Lines:	N/A
Telemetry/Compression:	16 to 12 bit compression

Phase 3

Same as Phase 1

Phase 4

Same as Phase 2

Phase 5

Same as Phase 1

Phase 6

Same as Phase 2

Grand Total Duration:	180 minutes (incl. all overheads)
Pointing:	To pre-selected site - probably quiet Sun
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	To be performed regularly - maybe once per month.

Product

Phase 1: Two 0.5x4 arcminute NIS maps in 4 lines. Phase 2: One 0.5x0.5 arcminute GIS map in the entire GIS spectrum. In both cases we have 2 arcsecond resolution.

Joint Observations

This Study is part of the SOHO Intercalibration JOP 4 - SUMER/CDS ALIGNMENT CALIBRATION, which involves CDS, SUMER and EIT.

Check On The Atomic Physics Of Ions Used For Diagnostic Purposes [ATOMI]

Contributors: M. Landini, B. Monsignori Fossi and P. McWhirter/J. Lang

Scientific Justification

Many lines pairs have been suggested in order to make diagnostic measurements of temperature and density in the solar atmosphere. In order to increase confidence in the use of these it is proposed here to take, for example, the Be-like sequence of ions and, using CDS and SUMER at the same time, to measure the intensities of as many lines as can be detected from each of these ions. These may then be compared with the intensities calculated using the most reliable atomic data that are available. The instrument pointing will be at the quiet sun and an observed differential emission measure distribution (derived, for example, from the observing sequence EMSQS) will be used in conjunction with the atomic calculation to predict the spectral intensities.

The object is to show that a self-consistent set of intensities is calculable for each ion in agreement with the observations. Disparities will be a measure of the uncertainty associated with the diagnostic procedures and will help in associating error bars with various determinations. An example of the observations that we envisage is the case of O V presented in the accompanying table.

Table: List of possible spectral lines of O V

	transition	J-J	λ (Å)		
1	$2s^2\ ^1S$ - $2s2p\ ^1P^o$	0-1	629.730	S + C(NIS2)	(l)
2	$2s^2\ ^1S$ - $2s3p\ ^1P^o$	0-1	172.169	C(GIS1)	(l)
	$2s^2\ ^1S$ - $2s4p\ ^1P^o$	0-1	135.523	outside λ range	
3	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	1-2	758.678	S + C(GIS4)	(l)
	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	0-1	759.441	S + C(GIS4)	(l)
	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	1-1	760.228	S + C(GIS4)	(l)
	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	2-2	760.445	S + C(GIS4)	(l)
	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	1-0	761.128	S + C(GIS4)	(l)
	$2s2p\ ^3P^o$ - $2p^2\ ^3P$	2-1	762.003	S + C(GIS4)	(l)
4	$2s2p\ ^1P^o$ - $2p^2\ ^1D$	1-2	1371.292	S	(l)
5	$2s2p\ ^1P^o$ - $2p^2\ ^1S$	1-0	774.518	S + C(GIS4)	(l)

6	$2s2p\ ^3P^o$ - $2s3s\ ^3S$	0-1	215.040	C(GIS4)	
	$2s2p\ ^3P^o$ - $2s3s\ ^3S$	1-1	215.103	C(GIS4)	
	$2s2p\ ^3P^o$ - $2s3s\ ^3S$	2-1	215.5	C(GIS4)	
7	$2s2p\ ^1P^o$ - $2s3s\ ^1S$	1-0	248.459	outside λ range	
8	$2s2p\ ^3P^o$ - $2s3d\ ^3D$	0-1	192.751	C(GIS1)	
	$2s2p\ ^3P^o$ - $2s3d\ ^3D$	1-2	192.799	C(GIS1)	
	$2s2p\ ^3P^o$ - $2s3d\ ^3D$	2-3	192.906	C(GIS1)	
9	$2s2p\ ^1P^o$ - $2s3d\ ^1D$	1-2	220.352	C(GIS1)	
	$2s^2\ ^1S$ - $2s2p\ ^3P$	0-1	1218.406	S	(l)

Lines marked (l) are listed in either the CDS or SUMER books or in both as having been identified in the solar spectrum.

On the other hand we have included in the list lines that can be expected to be quite weak. We feel it is important to attempt to measure such lines if only to put limits on their intensities for comparison with predicted values.

The selection of O V as an example was arbitrary although Be-like ions are important for this study as they offer important diagnostic possibilities. Clearly we would want to extend our studies to C III, N IV, Ne VII, Mg IX etc. although these later ions are less interesting from the point of view of diagnostics they could provide on the atomic physics.

Because of the large number of line ratios that have been suggested for diagnostic purposes there are many possible ways of extending this study to other ion sequences. The choice will depend on the popularity of particular line ratios, problems with their interpretation and availability of a wide range of good quality atomic data. In any case we believe such studies are essential to establish the reliability of any diagnostic method.

In making the observations the istruments should be pointed at a quiet region on the solar surface and probably should ‘sit and stare’. The slit should be chosen to give good spectral resolution and dwell times should be adequate to ensure 1 percent statistical counting errors. Since some of the lines are weak these times may be quite long and may in the end be determined by background scatter or continuum. In order to find plasma at different densities it could be valuable to point in and out of a coronal hole and for low density some measurements off the limb may be needed.

With the very long dwell times envisaged there should be no significant demand on the telemetry and a complete read-out of all the detectors should be possible. Some switching between the NI and the GI components of CDS will be necessary and the proportion between them determined by the count rates. When using GI component it will be best to use the same long slit as for the NI observations ie. 2 arsec x 240 arcsec. It may be an advantage to perform slow rasters over a small section of selected target region.
By doing the observations in this way it will be possible to collect all the data needed for an

data analysis and not the observing sequence. The observing sequence has similarities to the CDS Spectral Atlas study (SPECT) and by comparison with that it would seem that a total duration time for the observations of about 3 hours will be necessary. For SUMER the Spectral Atlas is envisaged to take about twice this time. For the present proposal a reduced raster area would be acceptable. It may be convenient to combine the present proposal with both Spectral Atlases although we would want to use both components of CDS (not included in the present version of SPECT).

CDS Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arc sec.
Step (DX, DY):	2 arcsec, 0 arcsec
Raster locations:	30
Raster Area:	60 x 240 arcsec
Exposure time:	300 seconds
Duration of Raster:	171.5 minutes
Number of rasters:	1
Total duration:	2.86 hours
Line Selection:	Full output
Bins Across Line	N/A
Telemetry/Compression	12 bits

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arc sec.
Step (DX, DY):	2, 2 arcsec
Raster locations:	10 x 10
Raster Area:	20 x 20 arcsec
Exposure time:	180 seconds
Duration of Raster:	330.6 minutes
Number of rasters:	1
Total duration:	5.5 hours
Line Selection:	Full output
Bins Across Line	N/A
Telemetry/Compression	no compression
Grand Total Duration	9 hrs 20 min
Pointing:	Quiet Sun, Coronal hole, off limb, limb.
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	OFF

Product
Full GIS and NIS spectrum from the same area

Joint Observations:
SUMER

Spectroscopic Studies of Elemental Abundances in the Transition Region and Inner Corona – [ATRIC]

Contributors: A. Fludra (RAL)

Scientific Justification

There is ample evidence that the abundances of elements in the solar corona differ systematically from those in the photosphere. The general coronal/photospheric fractionation appears to be related to the first ionization potential (FIP) of the element. Measurements of SW and SEP established that, on average, the ratio of abundances of low FIP elements (FIP < 10 eV) to high FIP elements (FIP > 11 eV) in the corona is a factor of 3 to 4 higher than in the photosphere (Breneman and Stone 1985, Meyer 1985a, 1985b). Similar evidence came from the spectroscopic study of coronal abundances (Veck and Parkinson 1981, Feldman 1992, Fludra and Schmelz 1995).

An important issue is whether the low FIP elements are enhanced or the high FIP elements are depleted in the corona relative to their photospheric abundances. Since the bulk of the plasma is hydrogen, the question hinges on their relative behaviour to hydrogen. Recent SEP observations seem to imply that the low FIP elements are enhanced in the corona by a factor of 3 to 4 and the high FIP elements have photospheric abundances (e.g. Reames 1994). On the contrary, spectroscopic results (Veck and Parkinson 1981; Fludra et al. 1991, 1993; Fludra and Schmelz 1995) suggest that the average coronal enhancement of low-FIP calcium is only a factor 1.5--2, abundances of silicon, magnesium and iron are probably close to their photospheric values, while sulphur (intermediate FIP) is depleted in the corona by a factor of about two and high-FIP elements (oxygen, neon) are depleted by a factor of four. Moreover, the fractionation pattern is not always step-like, but may exhibit a gradual dependence on FIP (Fludra and Schmelz 1995).

Possibly even more surprising than the systematic differences in the coronal and photospheric composition is the growing evidence for abundance variability in the corona itself. Variations in calcium abundances from flare to flare were reported for the first time from the spectra from the Bent Crystal Spectrometer on SMM (Sylwester, Lemen and Mewe 1984, Lemen et al. 1986). Later, variations of abundances of other elements have been found in SMM data for active regions and flares (Strong et al. 1991, Fludra et al. 1991, Schmelz and Fludra 1993) and P78-1 and Skylab data (Feldman 1992 and references therein), with some indication that the abundance may depend on the type of coronal structure, being different for an open magnetic configuration, active regions, and gradual or impulsive flares.

Method

The wavelength range of the Coronal Diagnostic Spectrometer includes many spectral lines of most of the important elements both from the low-FIP group (Na, Ca, Si, Mg, Fe) and the high-FIP group (O, N, Ne, C, Ar, He), and the intermediate sulphur. We envisage performing the abundance studies for different targets both on the solar disk and on the limb to investigate the following features of the elemental abundances: dependence on FIP (step-like pattern or gradual dependence, exceptions from the pattern), variability with time, spatial variability and dependence on the type of observed structures and the magnetic field configuration. A crucial measurement of absolute abundances (i.e. with respect to Hydrogen) would be highly desirable if reliable measurements of the solar continuum proved possible.

The following targets will be chosen: quiet Sun, active region loops (seen on the disk and on the limb), bright points, polar plumes, streamers, coronal hole. 50 lines from 13 elements in the Normal Incidence range have been selected. Full Grazing Incidence spectrum will also be recorded, and about 30 lines of Ne, Mg, Si and Fe ions, plus 22 lines from other elements (S

Na, Cr, C, Ca, P, Ar, N, O) have been suggested for analysis. This choice of lines has been made so as to avoid line blending where possible.

A general approach to this study will involve deriving the differential emission measure distribution based on a set of Mg and Ne lines covering the temperature range log(T)= 4.4 - 6.0. This analysis will use the Mg/Ne abundance determined from Mg VI 399.27, 400.68, 403.32Å lines which have similar G(T) functions to Ne VI 399.83, 401.14, 401.94, 403.26Å lines (Feldman 1992) and can give Mg/Ne abundance independently of the DEM distribution. Iron lines will be used to derive DEM in the range log(T) = 5.6 - 6.5, and the overlapping part of DEM(Fe) and DEM(Mg+Ne) will determine Fe/Mg abundance. Using this combined DEM distribution, relative abundances of all other elements (Si, Ca, Al, S, C, O, N, Ar) will be derived from line fluxes in the Grazing Incidence and Normal Incidence range.

A simpler, more robust approach could involve deriving the emission measures for temperatures corresponding to the peak of G(T) functions, and comparing these emission measures for lines which have similar peak temperatures.

Other selected line pairs, whose emissivity functions have similar dependence on temperature, can be used independently of DEM analysis (as proposed in other abundance studies in the Blue Book) and will serve as a test of the DEM approach.

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Study Details (Example)

Phase 1

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcsec
Raster Area:	10 x 10 arcsec
Step (DX, DY)	2 arcsec, 2 arcsec
Raster Locations:	5 x 5
Exposure Time:	60 s
Duration of raster:	25 min
Number of rasters:	1
Total duration:	25 min
Line selection:	full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	straight copy 13 s/exposure =

Pointing:	quiet sun/AR loop/C. hole/polar plume
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not required
Frequency:	Regular intervals

Phase 2

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsec
Raster Area:	10 x 240 arcsec
Step (DX, DY)	2 arcsec, 0 arcsec
Raster Locations:	5 x 1
Exposure Time:	120 s
Duration of raster:	617 sec
Number of rasters:	1
Total duration:	10.3 min
Line selection:	NIS ‘Abundance’ Line List (50 lines)
Bins Across Line:	15
Telemetry/Compression:	truncate to 12 bits; 108 s/exposure = 50 lines x15 bins x120 pixels x12 bits /10 kbits/s
Grand Total Duration:	35.3 min.
Pointing:	the same target as Phase I
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not required
Frequency:	Regular
Grand Total Duration	35.3 min

Product
Full GIS output: a 10x10 arcsec map. NIS intensities in selected lines suitable for abundance analysis, taken from the same area as GIS lines.

Joint Observations
(1) SUMER, UVCS
(2) UVCS, SUMER, LASCO, CELIAS, ERNE, COSTEP: for targets that can be linked to Solar Wind and Solar Energetic Particle observations.
ATRIC is part of JOP 21 (Solar Abundances from EUV Spectra).

Coronal Hole Boundary Study - [BOUND]

Contributor(s) - J. Insley and V. Moore (Imperial College), R.A. Harrison (RAL)

Scientific Justification:

To understand the evolution of coronal holes one must identify processes at work in the boundaries, especially as the holes grow and decay. This study looks for small scale activity in the coronal hole boundaries as well as allowing an identification of the relationship between the boundary and the supergranular structure. The study has three parts - Phase 1: looks for the structure of the boundary, with temperature and density diagnostics, with a range of Fe and Si ions; Phase 2: sits at the same location and, with a faster cadence, looks for small scale activity; Phase 3: is identical to Phase 1.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	60 x 240 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	30 x 1 = 30
Exposure Time:	15 seconds
Duration of Raster:	554 seconds
Number of Rasters:	3
Total Duration:	27.7 minutes (incl. overheads)
Line Selections:	Coronal Hole Line Selection 2 (9 lines)
Bins Across Line:	11
Telemetry/Compression	16 to 12 bit compression

Phase 2

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	60 x 60 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	30 x 1 = 30
Exposure Time:	2.5 seconds
Duration of Raster:	124 seconds
Number of Rasters:	50
Total Duration:	103.3 minutes (incl. overheads)
Line Selections:	Coronal Hole Line Selection 3 (6 lines)
Bins Across Line:	11
Telemetry/Compression	16 to 12 bit compression select only 60 arcsec along slit

Phase 3

Identical to Phase 1

Grand Total Duration:	159 minutes
Pointing:	Across coronal hole boundary
Flags:	Would not be run in response to interinstrument flag. May operate with CDS as flag Master or Receiver.
Solar Feature Tracking:	May be used, depending on target
Frequency:	To be run on a number of occasions during mission

Product

Three 60x240 arcsecond maps at the beginning and end of the Study period of the coronal hole boundary in a range of lines giving temperature and density diagostics, plus series of 50 smaller maps of cadence 100s for a smaller group of lines, to identify flows, brightenings etc...

Enhanced Line Broadening With Altitude - [BROAD]

Contributor(s) - R.A. Harrison (RAL), D. Hassler (Boulder)

Scientific Justification:

Consider a radially outward propagating Alfvén wave and assume it is not being damped in the region of observation. The wave energy flux will be constant as

$$\rho \ < \delta v^2 > \ V_A \ A \ = \text{Constant.}$$

From left to right the terms are the plasma density, the mean square velocity fluctuation, the Alfvén velocity and the cross section of the flux tube through which the wave travels. Given the Alfvén velocity as

$$V_A = (B / \ (4\pi\rho)^{1/2}),$$

we can see that

$$< \delta v^2 > \ = \ (\text{Constant} \ / \ AB \ \rho^{1/2}).$$

As one views regions of increasing altitude, i.e. decreasing density, in the corona, the line broadening may be expected to increase. Since the function includes the product AB, which may be complex in closed magnetic regions, the best sites for using these calculations for determinng the presence of MHD waves would be coronal holes of the edges of streamers.

Hassler et al. (1990, Ap. J. Lett. 348, L77) showed rocket flight data for Mg X 609Å and 625Å with significant broadening increasing to altitudes of 1.2$R_\odot$. Typical figures showed broadenings from 40km/s at the limb to 60km/s at 1.2$R_\odot$. This is despite the fact that their pointing was not ideal, possibly clipping the closed structures within a streamer, and they used the blended 609Å line. As they point out, there are several reasons for such broadening: (i) systematic flows, (ii) spatial variation of the thermal Doppler width, (iii) variations in the optical depth and (iv) MHD waves. A fall in the value of the magnetic field strength will also cause a broadening, as will a fall in the cross section used.

We suggest a similar, yet more comprehensive programme using some of the brighter spectral lines available with the GIS. We require well separated lines with the best possible spectral resolving powers. The CDS-GIS resolving power will be restricting, but with careful analyis, we should be able to determine flows of several tens of km/s upwards. Also, since no thorough study of this kind has been done, we do not know whether the earlier rocket results were typical or not. We include some cooler lines to correlate with the limb crossing and include a dwell time which will give counting statistics to a few percent for some lines. The best resolving power is found in the longer GIS wavelength bands. Thus, the best lines to use for this Study are: S XIV 417.60Å, Fe XV 481.46Å, Fe XVI 360.76Å (2nd order), Mg IX 705.80Å, O III 702.98Å and He II 303.78Å. However, since we are using the GIS with a long accumulation time, the line selection is academic - the full spectrum can be returned.

Study Details

Spetrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	2 x 200 arcseconds
Step (DX, DY):	0 arcsecond, 2 arcseconds
Raster Locations:	1 x 100 = 100
Exposure Time:	100 seconds
Duration of Raster:	11031 seconds (183.85 minutes)
Number of Rasters:	1

Total Duration:	11031 seconds (183.85 minutes)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression	No compression required (2048 x 4 x 16 / 10000 = 13.1s, i.e. only 13% of standard telemetry used. Therefore only requires 1.3 kbit/s.
Pointing:	This Study uses an E-W scan (future ones may use a N-S scan). Thus, pointing would be to the west or east limb. The 200 arcsecond strip must be such that at least 10 arcseconds is on the disc. The centre of the CDS F.O.V. will be at the centre of the 200 arc -second strip. Thus, pointing should be to 90 arcseconds above limb. The target area should be a coronal hole, streamer/streamer leg, quiet region...
Flags:	This Study would not be run in response to an interinstrument flag but CDS could act as flag Master.
Solar Feature Tracking:	Not necessary
Frequency:	To be run on several features on a number of occasions during mission.

Product

A 2x200 arcsec profile from disc to corona with 2 arcsec resolution, in all the wavelengths available to the GIS.

Joint Observations

This Study should be run in conjunction with SUMER POP 04, Line Broadening as a Signature of Hydromagnetic Waves.

Bright Points – [BRPNT]

Contributors: A. Fludra (RAL)

Scientific Justification

Bright points are small regions of enhanced X-ray and EUV emission in the corona, associated with the emergence or disappearance of magnetic flux on the solar surface. They are observed in the quiet corona and also in coronal holes. Their size is between 10 and 40 arcseconds, with lifetimes ranging between two hours and two days (Harvey et al. 1994). Most of the variability of the EUV emssion of the quiet sun comes from the bright points. They evolve on timescales of several minutes.Recently, 17 GHz radio emission has been detected from some of X-ray bright points, and some of them have also been observed to flare.

It is proposed to perform joint observations of bright points using CDS, SUMER, EIT, MDI, Yohkoh SXT, Nobeyama radio heliograph and ground-based magnetograph data and He I 10830 data.

The following BP properties will be studied: size, lifetime, relation to magnetic field, temperature, emission measure, emission in different wavelength ranges. Observations with high time resolution are preferable.

The study BRPNT described below focuses on individual bright points to observe their origin and evolution, provide density and temperature diagnostics, and trace variability of their EUV emission. We also want to find out whether every magnetic bipole has an associated EUV bright point (this was not the case for coronal BP observed by Yohkoh).

Sequence: phase 1 (NIS), phase 2 (GIS), phase 1 (NIS). This could be repeated several times, throughout the BP's life (up to 10-12 hours). Simultaneously recorded magnetograms are needed.

References:

Harvey et al. 1994, ASP Conference Series Vol. 68: Solar Active Region Evolution, ed. K.S. Balasubramaniam and G.W. Simon, p. 377.

Kundu, M., Shibasaki, K, Enome, S., and Nitta, N., 1994, ApJ, 431, L155

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsec
Raster Area:	60 x 60arcsecond
Step (DX, DY)	2 arcsec, 0 arcsec
Raster Locations:	30 x 1

Exposure Time:	10 s
Duration of raster:	380 sec
Number of rasters:	10
Total duration:	63.4 minutes

Line selection:	Bright Point Selection 1 (16 lines)
Bins Across Line:	15
Telemetry/Compression	truncate to 12 bits. 8.3 s/exposure = 16 lines x 15 bins x 60 pixels x 12 bits /10 kbits/s
Pointing:	to a bright point. Location must be known from EIT or Yohkh images
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking	Yes

Phase 2

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcsec
Raster Area:	40 x 40 arcsec
Step (DX, DY)	4 arcsec, 4arcsec
Raster Locations:	10 x 10
Exposure Time:	15 s
Duration of raster:	1692 sec
Number of rasters:	1
Total duration:	28.2 min
Line selection:	full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	straight copy 13 s/exposure
Pointing:	to a bright point - location must be known from NIS, EIT or Yohkoh image
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Yes
Grand Total Duration	91.6 min

Product:
A GIS 60 x 60 arcmin image in 16 lines. The raster area can be made larger if the number of lines are reduced or longer exposure time is used. The a 40 x 40 arcsec NIS image of a bright point, full GIS output. Practice will show whether 2x2 slit is preferable in order to obtain finer spatial details even at the expense of increasing the duration of raster. For a small BP, if the pointing accuracy is good, the area of the raster can be reduced to 20x20 arcseconds.

Joint Observations:
SUMER, EIT, MDI, Yohkoh SXT, Nobeyama radio heliograph and ground-based

Coronal Hole Study - [CHOLE]

Contributor(s) - V. Moore & J. Insley (Imperial College), R.A. Harrison (RAL)

Scientific Justification:

We know that coronal holes appear as voids in emission characteristic of the hot corona and that they are associated with open field lines and high speed wind streams. Despite the fact that the corona is fundamentally different to the closed equatorial structures, the underlying chromosphere remains essentially the same. Within coronal holes we have identified some coronal structures - e.g. X-ray bright points and macrospicules. There are many questions: How does the wind become accelerated in open structures? Is it accelerated at the boundaries or throughout the hole structure? How does the coronal field relate the chromospheric structure? How do bright points and macrospicules relate to the coronal hole? How does a hole grow or shrink? What are the densities and temperatures of coronal hole plasmas? What is the nature of the coronal hole boundary?

Specifically, in this study we wish to examine coronal holes in a variety of wavelengths to concentrate on structure identification and evolution (for a temperature gradient study see Gabriel and Bely-Dubau later in this section). We wish to include basic temperature, density and flow distribution capabilities as a function of height and across the hole (including the boundary). Since coronal holes are relatively long lived structures which vary slowly with time, no real time or short period planning is required. In general, one could expect to plan observations a week in advance.

Since the 4 x 4 arc minute field of view of CDS will be smaller than most holes, we need to select regions within a selected coronal hole - i.e the boundary, the central region etc...

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	4 x 4 arcminute
Step (DX, DY):	2 arcsecond, 0 arcsecond
Raster Locations:	120 x 1 = 120
Exposure Time:	30 seconds
Duration of Raster:	3800 sec (63 min) incl. overheads
Number of Rasters:	open
Total Duration:	open (must be several hours)
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	15
Telemetry/Compression:	16 to 12 bit truncation compression. 12 (lines) x 15 (bins) x 120 x 12 bits @ 10 kbit/s = 26s. No bottleneck.
Pointing:	To pre-planned coronal hole site no repointing
Flags:	This Study will not be run in response to an interinstrument flag. CDS could be flag Master during this operation.

Solar Feature Tracking:	Not necessary in general (near limb operations), but may be required.
Frequency:	Run during campaigns on many occasions during mission.

Product

CHOLE produces 4x4 arcmin maps of a coronal hole region in 12 lines, repeated every hour. 15 pixels are returned across each line to allow studies of line shifts and shapes.

Joint Observations

May be used in conjunction with SUMER POP 21 (Coronal Hole Study).

Chromospheric Oscillations – [CHROM]

Contributor: J.G. Doyle, Armagh Observatory

Scientific Justification:

The key question which I wish address concerns the heating of quiescent coronae in the Sun and cool stars in general, as the physical mechanism responsible is currently uncertain. One suggestion which has recently found observational support is the suggestion that coronal heating is associated with subsurface turbulent motions, and controlled in some way by magnetic structures. For example, the jostling of the loop footpoints by convection creates low-frequency variations (waves) of various modes on the magnetic field.

During the last year of activities of the Solar Maximum Mission, the ultraviolet spectrograph (UVSP) was 'stuck' at the same wavelength (the UV continuum region close to 1375Å). As a result, several months of excellent data were obtained for many different solar features; flares, active regions, 'quiescent' regions, etc. A preliminary analysis of some of this data has revealed periodicities in the range 3 to 5 minutes (Drake et al. 1988, Doyle et al. 1993). It is unclear what these are due to, with suggestions ranging from radial p-mode oscillations, photo-ionization of the Si I continuum region by transition regions photons, to acoustic waves. Equally, they may be the magneto-acoustic-gravity waves mentioned in the red book contribution 8.1.2.4 by Staude. Here, we plan a joint SUMER-CDS programme to look at selected lines and continuum regions.

Study Details:

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcsecond
Step (DX, DY):	4, 4 arcsec
Raster Locations:	2 x 2
Raster Area:	8 x 8 arcsec
Exposure Time:	7 sec
Duration of Raster:	30 sec (inc. overheads)
Number of Rasters:	about 180
Total Duration:	>90 min
Line Selection:	GIS detectors 3 & 4 only - full output (Analysis will use selected lines: Ne VII 465., Ne I 743.7, C II 687.2, O II 718.5, continuum 750 - 755 Å)
Telemetry/Compression:	Straight copy 6.5 s/exposure = 2 bands x2048 bins x 16 bits/10 kbit/s
Pointing:	Quiet Sun, pre-planned location
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: could be used if pointing less than 60 degree from the centre
(Sun rotates 8.9 arcsec per hour)

Product:
GIS Band 3 and 4 output from a small area to monitor intensity variations of selected lines with time.

Joint Observations:
SUMER

Coronal Hole Structure - [CHSTR]

Contributor(s) - J. Insley and V. Moore (Imperial College), R.A. Harrison (RAL)

Scientific Justification:

This Study is designed to examine the temperature/density structure within a coronal hole. Coronal holes contain structure such as macrospicules as well the supergranulation, at low altitudes, and features such as coronal rays. The precise relationship between these features and the predominantly open field of the coronal hole is unknown - e.g. why does the chromosphere below a coronal hole appear to be identical to that below a closed field region?

This Study includes observations over a large field of view using a broad range of bright Fe emission lines, a selection of density sensitive ratios, and the Mg X line as an established identifier of the coronal hole boundary.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	4 x 4 arcmin
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	120 x 1 = 120
Exposure Time:	22 seconds
Duration of Raster:	3000 seconds (50 minutes)
Number of Rasters:	open
Total Duration:	open
Line Selections:	Coronal Hole Line Selection 1 (13 lines)
Bins Across Line:	11
Telemetry/Compression:	16 to 12 bit compression
Pointing:	To a selected portion of a coronal hole on the disc.
Flags:	Not to be run in response to an interinstrument flag but may be run with CDS as flag Master/Receiver
Solar Feature Tracking:	In general not necessary - depends on target
Frequency:	To be run on a number of occasions during mission

Product
4 x 4 arcminute maps of a coronal hole in a selection of lines, including density and temperature information, every 50 minutes.

Coronal Structure Above An Active Region - [COSAR]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

This programme makes use of a technique employed by Neupert and others for OSO-7 images. Several images are produced in various iron ions and in conjunction with a photospheric magnetogram a coronal force-free magnetic field calculation is performed to match to the loop structures with those observed. A different value for α may be used for each image. Since the ions represent different temperature regimes the differences between the coronal models highlights the hierarchy in the magnetic structures, showing structures at differing altitutudes. We take the study a stage further by using a complete range of iron ions with temperatures of formation between log Te = 6.0 and 7.1, including some density sensitive pairs. The use of such a range of ions allows the study to be used simultaneously for differential emission measure work.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	2 x 2 arcminutes
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	15 seconds
Duration of Raster:	920 sec (15.3 min)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Iron Line Selection (11 lines)
Bins Across Line:	21
Telemetry/Compression:	Select only 60 pixels along slit. 16 to 12 bit compression
Pointing:	To pre-planned active area; no repointing
Flags:	Will not be run in response to interinstrument flag but could be run with CDS as flag Master
Solar Feature Tracking:	May be required on certain target locations
Frequency:	Run as part of occasional campaigns

Product

A series of 2x2 arcminute maps of time resolution 15 minutes, of an active region, with resolution 2 arcseconds, in 11 lines representing a wide range of temperatures. Some density senstive pairs are available and full spectral information on each of the lines is retained for flow diagnostics.

Joint Observations/Activities

This study must be supported by a simultaneous magnetogram observation and requires the

Dynamics of Solar Active Structures – [DYNAC]

Contributors: P.Mein and B.Schmieder DASOP, Observaory of Paris, Meudon.

Scientific Justification

The aim of this program is to study the flow (steady and rapid variation) in and around chromospheric structures in the transition region and coronal lines. Mostly lines in SUMER range will be used, however we need to observe low temperatures (2 x10^4 K) with bothCDS and SUMER to coalign the observations with chromospheric ground-based observations. The steady flow in the enviroment of a prominence will allow us to answer questions on formation mechanisms (Injection of chromospheric material or condensation of coronal plasma). A Center to limb investigation may be relevant in this program. Rapid time variations of the velocities may be detected in small scale structures, eruptive filaments, surges, spicules. We need a fast raster scanning over a large area. We plan to observe in 2 phases:

Phase 1 covers 300 x 300 arcsec with SUMER and 240 x 240 arcsec with CDS.Phase 2 covers 120 x 120 arcsec with SUMER and 120 X240 arcsec with CDS (120 x 120 arcsec may be used for CDS for shorter telemetry time). These new areas will be located inside the previous larger rasters. A step of 6 arcsec will be selected and consecutive rasters will be shifted by 2 arcsec in each of the following 3 scans. After 3 successive rasters with 2 arcsec shift we plan to come back to the initial position. We plan to observe the magnetic field using the French-Italian telescope THEMIS in Tenerife and the chromospheric velocity field with the MSDP spectrograph. Observations during the european day time are required.

CDS Study Details

Phase 1*: reference image*

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsec
Raster Area:	4 x 4 arcmin
Step (DX, DY)	2 arcsec, 0 arcsec
Raster Locations:	120 x 1
Exposure Time:	10 s
Duration of raster:	1218 sec
Number of rasters:	1
Total duration:	20.3 min
Line selection	He I 584, OV 629, Mg X 625 Å, Si IX 342, Si IX 345, Mg IX 368 Å
Bins Across Line:	11 (if more, then the exposure needs to be longer)
Telemetry/Compression:	truncate to 12 bits 9 s/exposure = 6 lines x 11 bins x 120 pixels x 12 bits /10 kbits/s
Pointing:	active region
Flags:	N/A
Solar Feature Tracking:	OFF

Product: Reference image, 4 x 4 arcmin

Phase 2

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsec
Raster Area:	2 x 2 arcmin
Step (DX, DY)	6 arcsec, 0 arcsec
Raster Locations:	20 x 1 20 locations, 6 arcsec step (consecutive rasters offset by 2 arcsec)
Exposure Time:	10 s
Duration of raster:	204 s
Number of rasters:	3
Total duration:	10 min
Line selection	He I 584, OV 629, Mg X 625 Å, Si IX 342, Si IX 345, Mg IX 368 Å
Bins Across line	21 (may be 15)
Telemetry/Compression:	truncate to 12 bits 9 s/exposure = 6 lines x21 bins x60 pixels x12 bits /10 kbits/s
Pointing:	selected from the reference image (ph. 1) each consecutive raster offset by 2 arcsec.
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not necessary
Grand Total Duration:	30.3 minutes

Product:
Three ‘sparse’ images, sampling area of 2 x 2 arcmin. When combined together, they form a full 2 x 2 arcmin image

Joint Observations
Other Instruments on SOHO: SUMER, EIT, LASCO and UVCS if there is an eruption
Ground based observations during the european daytime: MSDP(Meudon, Pic, Tenerife), Halpha, magnetic field (THEMIS through 1996/ Gregory in Tenerife, Potsdam), white light in Debrecen, Hungary. Nancay: radio heliograph

Earth-Directed CME Study - [EDCME]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

See case for EJECT, which was for CME observations above the limb. In this case, the pointing is suited to collaboration with particle/field instruments at L1 or Earth-vicinity.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsecond
Raster Area:	4 x 4 arcminute
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	3 seconds
Duration of Raster:	191 sec (incl. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	11
Telemetry/Compression:	Sum across lines.
Pointing:	To selected target such as a prominence or active region near disc centre.
Flags:	Not normally run in response to interinstrument flag but may be used with CDS as flag Master/Receiver.
Solar Feature Tracking:	Not used in general for this Study
Frequency:	To be run in campaigns of duration 5-6 days on numerous occasions during mission.

Product

This Study produces a series of 4 x 4 arcminute intensity maps in 12 emission lines of a wide variety of temperatures, repeated every 3 minutes, for a pre-planned period, with resolution 4 arcseconds.

Joint Observations

This Study forms the core observation of the SOHO Joint Observing Plan #8 - the EARTH-DIRECTED CME STUDY. This involves CDS, SUMER, EIT, LASCO, CELIAS, ERNE plus potential involvement from other instruments.

Mass Ejection Study - [EJECT]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

A coronal mass ejection (CME) represents a major restructuring of the corona, as a huge cloud of matter is expelled into space. It represents a major enhancement to the solar wind and is related to flare and geomagnetic activity. Thus, our ultimate goal has to be to predict CME activity and, therefore, predict flare and geomagnetic activity. A programme to observe CME activity must involve large fields of view, in order to encompass the largest structures, combined with sufficient spatial resolution to view associated small scale features. Furthermore, since we require a good view of the coronal/chromosheric activities in the lead up to a CME or chromospheric ejection, the event itself and the interplanetary response, we must use a combination of several instruments on more than one platform.

First, a target must be chosen. This would most likely be an active region or prominence near to the limb (the coronagraph instruments are most sensitive in the plane of the sky). Ideally, one would select a target at about W40 and track it until it is beyond the limb. Whislt disc and low-coronal devices concentrate on the target, the coronal instruments should concentrate on observations of the corona above the target.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsecond
Raster Area:	4 x 4 arcminute
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	3 seconds
Duration of Raster:	357 sec (incl. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	11
Telemetry/Compression:	Sum across lines. Given 12 (lines) x 1 (pixel) x 120 (pixels) x 16 (bits per word) @ 10 kbit/s = 2.3 s. No bottleneck.
Pointing:	To limb-approaching target no repointing
Flags:	This Study would not normally be run in response to an interinstrument flag but may be used with CDS as flag Master.
Solar Feature Tracking:	Not used in general for this Study (operations near to limb).
Frequency:	To be run in campaigns of duration 5-6 days on numerous occasions during mission.

Product

This Study produces a series of 4 x 4 arcminute intensity maps in 12 emission lines of a wide variety of temperatures, repeated every 3 minutes, for a pre-planned period, with resolution 4 arcseconds.

Joint Observations

This Study forms the core observation of the SOHO Joint Observing Plan #3 - the CME ONSET STUDY. This involves CDS, SUMER, EIT, LASCO, UVCS plus potential involvement from other instruments.

JOP #3 has been adopted by the Inter Agency Consultative Group (IACG) to form the core of a multispacecraft operation, involving Yohkoh, TRACE, Coronas and other platforms as well as SOHO.

SUMER POP 25 is complementary to this Study.

Emission Measure Study Of The Quiet Sun - [EMSQS]

Contributor(s) - R.W.P. McWhirter (Abingdon)

Scientific Justification:

The primary objective of this Study is to derive physical models of the solar atmosphere over the range where its temperature lies between 30,000 K and 3 million K. The method is to measure spectral intensities of series of iso-electronic ions from selected areas of the disc and from these derive contour maps of constant differential emission measure. These will enable structures to be identified whose vertical scale size will be determined by following them round with solar rotation till they can be observed above the limb. Some of the spectral lines observed will be chosen to be sensitive to the electron density so that models will include estimates of temperature, plasma pressure and physical size and enable meaningful comparisons to be made with theoretical models based on energy and pressure balance. This in turn should give some clues as to the nature of the mechanism heating the corona.

This study would be greatly enhanced by combining it with observations of the dynamical aspects of the structures using measurements from SUMER. This instrument would also be able to provide intensity data for iso-electronic lines at wavelengths longer than those available from the NI component of CDS.

Using images from EIT and ground-based data, we should select a region free from activity, filamentary structures and coronal holes, towards the centre of the disc.

The basic operation involves three raster sequences, one in normal incidence, one in grazing incidence followed by another in normal incidence. Each of the NIS raster sequences involves 3 individual rasters.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	2 x 2 arcminutes
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	20 second
Duration of Raster:	1220 sec
Number of Rasters:	3 (different line selections)
Total Duration:	3660 sec
Line Selections:	Raster 1: Lithium-like Line Selection (10 lines) Raster 2: Beryllium-like Line Selection (4 lines) Raster 3: Boron-like Line Selection (11 lines)
Bins Across Line:	21
Telemetry/Compression:	No compression Select 60 pixels along slit (2 arcmin) (21 x 60 x 10 x 16 = 20 sec @ 10 kbit/s.)

Phase 2

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcsecond
Raster Area:	2 x 2 arcminutes
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	30 x 30 = 900
Exposure Time:	13 seconds
Duration of Raster:	2000 seconds
Number of Rasters:	1
Total Duration:	2000 seconds
Line Selections:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Identical to phase 1

Grand Total Duration:	7.6 hours
Pointing:	To pre-planned quiet Sun location no repointing
Flags:	Will not be run in response to an interinstrument flag but may be run with CDS as flag Master.
Solar Feature Tracking:	Generally not necessary.
Frequency:	To be run a few times during the mission

Product

Six NIS intensity maps at 2 arcsecond resolution in three sets of lines - providing a range of temperatures from isoelectronic sequences. One GIS map of same size with 4 arcsec resolution, with full spectra in GIS bands at each location.

The Fe XIV Intercombination Lines – [FEINT]

Contributors: F. P. Keenan, V. J. Foster, A. E. Kingston (QUB); K. J. H. Phillips (RAL)

Scientific Justification

Emission lines arising from allowed transitions between the $3s^2 3p\ ^2P$ levels and $3s3p^2$ or $3s^2 3d$ states in Al-like Fe~XIV have been frequently observed in solar spectra between ~210 and 350 Å. Their usefulness as electron density diagnostics for the emitting plasma is well known (see, for example, Keenan *et al*. 1991a and references therein). Previously (Keenan *et al*. 1991b) we have examined EUV spectra of solar flares obtained with the S082A spectrograph on board *Skylab*, and provisionally identified the 5 components of the Fe XIV $3s^2 3p\ ^2P$ - $3s3p^2\ ^4P$ intercombination multiplet (see Table 1 for transitions and wavelengths). A comparison of the observed Fe XIV line intensities with theoretical predictions revealed good agreement between theory and experiment, confirming our identifications. In addition, we noted that line ratios involving the intercombination lines were quite sensitive to changes in the electron density with, for example, I(447.37Å)/I(444.26Å) varying by a factor of 3.3 between $N_e = 10^8$ and 10^{11} cm^{-3}. Coupled with the wavelength proximity of the transitions, this implied that the ratios are potentially very useful N_e diagnostics for intermediate density solar features, such as the quiet Sun and active regions.
Unfortunately, the S082A data were not of high enough quality to measure the Fe XIV intercombination lines to a sufficient accuracy to investigate their usefulness as N_e diagnostics. We therefore intend to observe the lines in a range of solar features using the CDS. In addition, we will obtain measurements of the Fe XIV 211.32, 219.12 and 220.08Å features, in order to compare densities derived from the intercombination lines with those from I(219.12Å)/I(211.32Å) and I(219.12Å)/I(220.08Å).

References:

Keenan, F.P. *et al.* 1991a, Astrophys. J. **373**, 695.
Keenan, F.P. *et al.* 1991b, Astrophys. J. **379**, 406.

Table 1: Wavelengths of Fe XIV $3s^2 3p\ ^2P$ - $3s3p^2\ ^4P$ intercombination transitions.

Transition	Wavelength (Å)
$^2P_{1/2} - {}^4P_{1/2}$	444.26
$^2P_{1/2} - {}^4P_{3/2}$	429.54
$^2P_{3/2} - {}^4P_{1/2}$	484.86
$^2P_{3/2} - {}^4P_{3/2}$	467.39
$^2P_{3/2} - {}^4P_{5/2}$	447.37

Study Details:

Spectrometer:	Grazing Incidence
Slit:	2x2 arcsecond
Raster Area:	30x30 arcsecond
Step (DX, DY):	2, 2 arcsec
Raster Locations:	15 x 15 = 225
Exposure Time:	15 sec
Duration of Raster:	3418 sec (inc. overheads)
Number of Rasters	2
Total Duration:	114 min

Line Selection: Full GIS output. Lines used (band 1 and 3):
Fe XIV 211.32, 219.12, 220.08, 444.26, 429.54, 484.86, 467.39, 447.37 Å.

Telemetry/Compression: straight copy
13.1 s =
4 bands x 2048 bins x 16 bits /10 kbits/s

Pointing: coronal hole, quiet sun, active region

Frequency:

Flags: Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: Not necessary

Product:
30 x 30 arcsec maps, with 2 arcsec resolution, in 8 spectral lines, with time resolution of 57 minutes.

Filling Factors of Coronal Loops
[FILLF]

Contributor(s): J. Klimchuk (NRL), R.A. Harrison (RAL)

Scientific Justification

This Study aims to derive filling factors of specific targets - mainly coronal loops - through the comparison of density measurements from line ratios and EM calculations. It is suggested that CDS is pointed to well defined loops so that a good estimate of the depth of the loop (along the line of sight) can be determined, and to reduce the influence of surrounding features. At least for the first version of this study a series of iron ions is used, including a good temperature range and several density diagnostics. Time and spatial resolution are not critical to this study, thus the raster is performed over a relatively long period and the 4x240 arcsec slit is used, rather thean the 2x240 arcsec slit, to increase the intensities.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsec
Raster Area:	2 x 4 arcmin
Step (DX, DY)	4 arcsec, 0 arcsec
Raster Locations:	30 x 1
Exposure Time:	50 s
Duration of raster:	25 min
Number of rasters:	2
Total duration:	50 min
Line selection:	Iron Line Selection (NIS) - 11 lines
Bins Across Line:	21
Telemetry/Compression:	No compression required.
Pointing:	Portion of a selected coronal loop.
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	To be decided at time of running.
Frequency:	Occasional throughout mission.

Product:

2 intensity maps of coronal loop in 11 lines, of size 2 x 4 arcmin, spatial resolution 4 arcsec.

Study of Filament Flows
[FFLOW]

Contributor(s): A.I. Poland (GSFC), J. Zirker (NOAO), O. Engvold (Oslo)

Scientific Justification

The source of mass for quiescent filaments is still an open question. According to current thinking, the mass is injected from the chromosphere, possibly along the long appendages (feet or barbs) rather than by condensation of coronal matter. This study is complementary to a SUMER study and together they will test this idea further. Dopler velocities in several lines formed at different temperatures would be observed in a suitable filament with SUMER. Intensity variations of hot lines, in the vicinity of the filament would be observed by CDS to search for the cooling of coronal plasma and collapse into the filament.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsec
Raster Area:	80 x 240 arcsec
Step (DX, DY)	4 arcsec, 0 arcsec
Raster Locations:	20
Exposure Time:	20 s
Duration of raster:	8 min (Include. overheads)
Number of rasters:	Open
Total duration:	Open (8 x n min)
Line selection:	TBD - Including Mg IX 368 Å and O V 629 Å. (5 lines)
Bins Across Line:	21
Telemetry/Compression:	No compression required if only 5 lines.
Pointing:	Selected area of filament.
Flags:	Probably not used in this Study.
Solar Feature Tracking:	To be decided at time of running.
Frequency:	Occasional throughout mission.

Product:

Intensity maps of size 80 x 240 arcsec, spatial resolution 4 arcsec, every 8 minutes in up to 5 NIS lines.

Elementary Coronal Heating Events - [FLARE]

Contributor(s) - R.A. Harrison (RAL) and E.R. Priest (St Andrews)

Scientific Justification:

There has been much discussion in recent years about the heating of the corona through small flare-like events. It may be possible to detect such events using CDS and investigate their relationship to *macroscopic* flare activity, i.e. to study the distribution and nature of flare-like activity from macro- to microscopic levels. Given the limited temperature range and temporal resolution of previous instruments, CDS is in a unique position to locate these events and trace their effect through the solar atmosphere. This Study calls for a small, rapid NIS raster to be performed, on a quiet Sun location many times. The line selection covers a wide temperature range and the narrowest slit is used to obtain the best resolution. Ideally, the operation should be supplemented by SUMER observations at longer wavelengths. The CDS wavelength selection is limited by the need for very high time resolution. We choose a few bright (> 25 c/s in active Sun), well separated lines from a wide T range.

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	10 x 60 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	5 x 1 = 5
Exposure Time:	0.5 seconds
Duration of Raster:	16 seconds (incl. overheads)
Number of Rasters:	100 (minimum)
Total Duration:	27 minutes (minimum)
Line Selection:	Microflare Line Selection
Bins Across Line:	11
Telemetry/Compression:	16 to 12 bit compression Select only 30 pixels along slit
Pointing:	Quiet Sun location
Flags:	No flag operation
Solar Feature Tracking:	Not used
Frequency:	To be run on numerous targets throughout mission

Product
Rapidly produced 10x60 arcsecond images of quiet Sun, in 4 very bright lines.

Joint Observations
FLARE is used as a component of JOP1, the Study of emerging magnetic flux, in conjunction with SUMER, EIT and other instruments.

Flow Distribution Study - [FLOWS]

Contributor(s) - R.A. Harrison (RAL), O. Kjeldseth-Moe (Oslo)

Scientific Justification:

We see many examples of flows within the solar atmosphere, including the HRTS jets and turbulent events, and chromospheric sprays/surges and upflows in spicules. Tracing the flow patterns through the atmosphere in an attempt to identify their cause and their impact on the atmosphere requires multiwavelength coverage which has, to date, not been available. Using SUMER and CDS simultaneously, we may provide excellent coverage with a useful capability for detecting shifts from chromosphere to corona. CDS is capable of detecting wavelength shifts due to flows of order a few tens of km/s and upwards, in bright, well separated lines. This Study is complementary to the HIVEL study but does not involve a raster operation, the long CDS slit is used to view just a few lines for fast operation.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	2 x 240 arcsecond
Step (DX, DY):	0 arcsecond, 0 arcsecond
Raster Locations:	1 x 1 = 1
Exposure Time:	3 seconds
Duration of Raster:	4.3 sec (incl. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Fast Dynamic Line Selection (4 lines)
Bins Across Line:	15
Telemetry/Compression:	Truncate to 12 bits Select 120 arcsec along line (60 pixels) Given 4 (lines) x 15 (pixels) x 60 (pixels) x 12 (bits) @ 10 kbit/s = 4.3 sec with truncation.
Pointing:	To pre-planned location no repointing
Flags:	Could be run in response to interinstrument flag if particular target is sought (e.g. bright point) and may be used with CDS as flag Master.
Solar Feature Tracking:	Generally not necessary, unless particular target is to be followed over many hours.
Frequency:	To be run during frequent campaigns during mission on various targets.

Product

2 x 240 arcsec image of Sun in 4 lines with full spectral information, every 4.3 seconds.

SUMER POP 24 (Explosive Event Study) may be used in conjunction with FLOWS. Could be used as part of JOP 15.

GIS MICROCHANNEL PLATE DECAY MONITORING - [GIMCP]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

Since the grating and GIS detectors are fixed with respect to one another, lines appear at the same place on the detector faces at all times. This can result in a decrease in sensitivity over time and regular monitoring is essential.

Ideally, one would produce a flat field image of the detectors once per day/week./month but we are unable to do this. The best we can do is use the CDS wide slit (90x240 arcseconds), but for the GIS, this produces count-rates which cannot be processed by the CDHS. Thus, the best we can do is use the 8 x 50 arcsecond slit. Thus, this Study has two parts. In phase 1 we use the 2 x 2 arcsecond slit to define the locations of the line centres, i.e. the sites of most likely depletion. In phase 2, we open up the slit to 8 x 50 asrceconds. One would expect a depletion in the centre of the wider slit image. We must use this scheme on quiet Sun locations. The entire GIS spectral ranges must be returned with no data compression.

Study Details

Phase 1

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	2 x 2 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	113 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	113 seconds
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	8 x 50 arcseconds
Raster Area:	8 x 50 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	113 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	113 seconds
Line Selection:	Full GIS output

Bins Across Line:	N/A
Telemetry/Compression:	No compression
Grand Total Duration:	4 minutes (incl. all overheads)
Pointing:	Quiet Sun
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	To be run at least once per week. More often in first months.

Product

Full GIS spectrum of quiet Sun, using narrowest then widest GIS slit, to identify sensitivity variations in GIS detectors.

Helium Enhancement In The Quiet Sun - [HELEN]

Contributor(s) - C. Jordan (Oxford)

Scientific Justification:

Jordan (1975, MNRAS, 170, 429; 1980 Phil. Trans. Roy. Soc. London, A297, 541) has shown that Helium lines are enhanced in the "quiet" Sun as compared with other transition region lines formed at similar temperatures. The enhancement is less pronounced in coronal holes and over sunspots. It was proposed that this effect is due to the local temperature gradient and some mechanism "mixing" the Helium ions with hotter electrons. This has been investigated more recently by Shoub.

One method of investigating this effect requires observations of He II 304Å and 256Å, in coronal holes and the quiet Sun. It would be useful to have the He II 1640Å line, since it relates to the opacity of the 256Å line (both from 3p level), again, in the coronal hole and quiet Sun regions. However, this line is above the limit of the SUMER instrument and, whereas CDS can view the 304Å line in first and second orders in the GIS and NIS, the 256Å line is right on the edge of one of the GIS ranges and may not be too useful. We can, however, supplement observations of the 304Å line with the 243Å line in second order in the GIS. Both lines should be observed in the quiet Sun and a coronal hole.

This observation should be accompanied by simultaneous measurements from a group of transition region lines formed between about 70,000 K and 200,000 K. The following can be detected by CDS (GIS): O III 703Å, O V 760Å, N III 686Å, N IV 765Å, Ne III 490Å, and this list could be supplemented by observations of Si IV 1394Å and 1403Å by SUMER. A similar programme for He I could include the 584Å and 537Å lines though such a routine would require the use of the NIS, since this band is not available to the GIS.

This observation does not require fast time resolution or a particularly large image. The anticipated count rate of the 304Å line (for 2x2 arcsec area) is 150 s^{-1} in quiet Sun, yet the 243Å, in second order would have about 0.5 s^{-1}. The latter would drive the exposure time of this Study. At first, an exposure time of 30 seconds is suggested; this can be modified as the instrument perfromance becomes well kown. However, for such an exposure time, the nature of the line selection is academic since all GIS data can be returned with no compression.

It is useful to have an image sufficiently large to identify the structures within which we are looking. Thus, we suggest the use of the 2 x 2 arcsecond slit with a 30 x 30 arcsecond field of view.

Study Details

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	30 x 30 arcsecond
Step (DX, DY):	2 arcsecond, 2 arcsecond
Raster Locations:	15 x 15 = 225
Exposure:	30 seconds
Duration of Raster:	113 minutes (incl. overheads)
Number of Rasters:	3
Total Duration:	5.7 hours
Line Selection:	Full GIS output
Bins Across Line:	N/A

Telemetry/Compression:	No compression
Pointing:	To pre-selected quiet Sun or coronal hole area
Flags:	Would not be run in response to interinstrument flag. Could be run with CDS as flag Master.
Solar Feature Tracking:	Unnecessary.
Frequency:	To be run occasionally on quiet Sun and coronal hole sites

Product

Three maps of a quiet Sun or coronal hole region for the full GIS spectral ranges, with the 2x2 arcsec slit, over a field 30x30 arcsec.

Joint Observations

To be run in conjunction with SUMER POP 22 (Helium Enhancement in the Quiet Sun).

High Velocity Event Study - [HIVEL]

Contributor(s) - O. Kjeldseth-Moe (Oslo), R.A. Harrison (RAL)

Scientific Justification:

We see many examples of flows within the solar atmosphere, including the HRTS jets and turbulent events, and chromospheric sprays and surges and upflows in spicules. Tracing the flow patterns through the atmosphere in an attempt to identify their cause and their impact on the atmosphere requires multiwavelength coverage which has, to date, not been available. Using SUMER and CDS simultaneously, we may provide excellent coverage with a useful capability for detecting shifts from chromosphere to corona.

CDS is capable of detecting wavelength shifts due to flows of order a few tens of km/s and upwards, in bright, well separated lines. In this Study we consider a region of the Sun 0.5 x 0.5 arc minute in size and select a series of bright lines with good temperature coverage (20,000 to 2.5 million K). We require fast rastering and the best spectral resolution. Thus, the NIS with a 2 x 240 arc second slit is the best candidate.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	30 x 30 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	15 x 1 = 15
Exposure Time:	2 seconds
Duration of Raster:	37 sec (incl. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Dynamic Line Selection (9 lines)
Bins Across Line:	15
Telemetry/Compression:	Straight Copy
Pointing:	To pre-planned location no repointing
Flags:	Could be run in response to interinstrument flag if particular target is sought (e.g. bright point) and may be used with CDS as flag Master.
Solar Feature Tracking:	Generally not necessary, unless particular target is to be followed over many hours.
Frequency:	To be run during frequent campaigns during mission on various targets.

Product

30x30 arcsec intensity maps in 9 lines repeated every 71 seconds for a pre-planned period. Spatial resolution 2 arcsec. For each location, full spectral information for the 9 lines is available.

Joint Observations

SUMER POP 24 (Explosive Event Study) may be used in conjunction with HIVEL. Also, this Study is a component of JOP 15.

Intercalibration 1 - [ICAL1]

Contributor(s) - R.A. Harrison

Scientific Justification:

This Study is the CDS component of the SOHO Intercalibration JOP 1 which is designed to cross calibrate the CDS-NIS, CDS-GIS, SUMER, UVCS and EIT instruments, through the observation of complementary wavelength ranges. Full details can be found in the write-up for IJOP#1.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcseconds
Raster Area:	1 x 4 arcminutes
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	15 x 1 = 15
Exposure Time:	80 seconds
Duration of Raster:	1246 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	1246 seconds (incl. overheads)
Line Selection:	Intercalibration Line Selection (13 lines)
Bins Across Line:	15
Telemetry/Compression:	No compression required (13 lines x 15 x 120 pixels x 16 bits can be extracted in 37.5 sec - only uses half telemetry)

Phase 2

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcseconds
Raster Area:	32 x 32 arcseconds
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	8 x 8 = 64
Exposure Time:	20 seconds
Duration of Raster:	1296 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	1296 seconds (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Same as Phase 1

Phase 4

Same as Phase 2

Phase 5

Same as Phase 1

Phase 6

Same as Phase 2

Phase 7

Same as Phase 1

Phase 8

Same as Phase 2

Grand Total Duration:	203.4 minutes (incl. overheads)
Pointing:	All instruments should be directed to the same quiet Sun location centred on a region between 12-15 arcminutes from Sun centre (UVCS restriction).
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	To be used at regular intervals during mission

Product

NIS and GIS spectra in wavelength ranges appropriate for cross calibration in raster areas of 1x4 arcminutes and 32x32 arcseconds, respectively.

Intercalibration 2 - [ICAL2]

Contributor(s) - R.A. Harrison (RAL)

Scientific Case:

Using the SEM output for the total solar 304Å output, and projecting through the EIT image to determine what fraction of this comes from the CDS field of view, we may determine an absolute measure of 304Å output from the features seen by CDS. This can be used to monitor the calibration of CDS at this wavelength and can be used to derive typical EUV emissions from different solar features - which may be used to predict the solar influence on the ionosphere. Projection to other wavelength ranges through the use of intensity ratios which are invariant may be used to calibrate other wavelengths in the CDS, SUMER and UVCS ranges.

Study Details

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcseconds
Raster Area:	2 x 2 arcminutes
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	30 x 30 = 900
Exposure Time:	3 seconds
Duration of Raster:	2900 seconds
Number of Rasters:	1
Total Duration:	2900 seconds (48.3 minutes) incl. overheads
Line Selections:	256-338Å band - i.e. 2nd GI Detector
Bins Across Line:	N/A
Telemetry/Compression:	No compression required
Pointing:	Anywhere on disc viewed by EIT
Flags:	No flag activity
Solar Feature Tracking:	Not necessary
Frequency:	Once per month throughout mission

Product

2x2 arcminute map in full wavelength range of 2nd GIS detector with 4 arcsecond resolution.

Joint Observations

To be used as part of Intercalibration JOP 2, involving CDS, SEM, EIT, SUMER, UVCS.

SUMER/CDS Intensity Cross-Calibration - [ICCAL]

Contributor(s) - R.A. Harrison (RAL), K. Wilhelm (Lindau)

Scientific Justification:

This Study provides an intensity cross-calibration between CDS and SUMER. It should be part of a regular calibration programme. It makes use of common wavelength bands between CDS and SUMER and between the two CDS spectrometers. The Study is part of SOHO Intercalibration JOP 5 - see IJOP #5 documentation for full details.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcseconds
Raster Area:	32 x 240 arcseconds
Step (DX, DY):	4 arcseconds
Raster Locations:	8 x 1 = 8
Exposure Time:	30 seconds
Duration of Raster:	433 seconds (incl. overheads)
Number of Rasters:	2
Total Duration:	866 seconds
Line Selection:	Intercalibration Line Selection (13 lines)
Bins Across Line:	21
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcseconds
Raster Area:	32 x 32 arcseconds
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	8 x 8 = 64
Exposure Time:	20 seconds
Duration of Raster:	1296 seconds
Number of Rasters:	1
Total Duration:	1296 seconds (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Same as Phase 1

Phase 4

Same as Phase 2

Phase 5

Same as Phase 1

Phase 6

Same as Phase 2

Grand Total Duration:	130 minutes (incl. all overheads)
Pointing:	Pre-planned location - probably quiet Sun
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	To be run on regularly - maybe once per month

Product

A series of NIS and GIS images of the Sun, 32x240 and 32x32 arcseconds in size, respectively, in a group of emission lines common to two of the following: GIS/NIS, GIS/SUMER, NIS/SUMER.

Joint Observations

This Study is part of Intercalibration JOP 5 - SUMER/CDS Intensty Cross-Calibration.

Inhomogeneities In Coronal Emission - [INHOM]

Contributor(s) - H.E. Mason (Cambridge)

Scientific Justification:

A comparison of electron densities derived from line ratios and absolute intensity gives a measure of the inhomogeneous structure present. This could be done for several density diagnostic pairs - especially bright, well separated, well calibrated lines. Here we suggest the use of several density senstivie ratios - namely, Si IX 345.13/341.95Å, Si X 347.40/356.04Å, Fe XII 338.26/364.47Å and Fe XIII 320.80/348.18Å. To explore the inhomogeneities over a reasonable area of the solar surface we choose to use the NIS. The exposure time is set to obtain 10% counting statistics using the 4x4 arcsecond slit.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcseconds
Raster Area:	240 x 240 arcseconds
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	25 seconds
Duration of Raster:	1550 seconds (26 minutes) incl. overheads
Number of Rasters:	several
Total Duration:	open
Line Selection:	Density Sensitive Line Selection
Bins Across Line:	21
Telemetry/Compression:	16 to 12 bit compresion
Pointing:	Pre-planned location
Flags:	May be run in response to interinstrument flag for certain targets. May run with CDS as flag Master.
Solar Feature Tracking:	May be used on occasions. In general no needed.
Frequency:	To be run on several target areas during mission

Product

4x4 arcminute maps with 4 arcsecond resolution, every 26 minutes in a range of density sensitive line pairs.

Total Solar Irradiance – [IRRAD]

Contributor(s): W. T. Thompson, GSFC

Scientific Justification:

The idea of this study is to provide full Sun EUV spectra for comparison with simultaneous spectra taken by SUMER. The objectives of this study are similar to those for the aeronomy program AERON. However, it differs in that a detailed solar spectrum is returned. The exercise requires 64 repointings of CDS, and should be performed rarely.

Study Details

Spectrometer:	Normal Incidence
Raster Area:	4 arcmin by 4 arcmin
Slit:	4 x 240 arcsec
Step (DX, DY):	4 arcsec, 0 arcsec
Raster Locations:	60
Exposure:	7 s
Duration of raster:	420 sec
Number of rasters:	64
Total duration:	7 hr 50 min (includes 5% overhead for repointing)
Pointing:	First raster centered 14 arcmin N and 14 arcmin E of Sun center. "Raster" course pointing to cover Sun - cover area 32x32 arcmin square, centered at Sun center 8x8 square - 64 locations.
Line selection:	The entire normal incidence spectra are returned summed along the slit, for a total of 2048 data values of 32 bits each, using the SUMLINE algorithm.
Bins Across Line:	N/A

Telemetry/Compression: Summing along the slit provides a compression factor of 120. No additional compression is required for the standard telemetry rate of 11.3 kbit/s. However, the exposure time could not be reduced further without causing a problem with the telemetry rate. The objectives of this study could be met with a shorter exposure time if there was an additional compression mode that is not currently on board the CDS instrument. I propose that a SUMBOX compression mode be available which would take as its arguments two numbers representing the number of pixels to sum over in both the X and Y dimensions. So that both numbers can be stored in the compression option word, they will be restricted to byte values. For this study, I would increase the amount of compression by a factor of two by summing over 120 pixels in the spatial direction, and 2 pixels in the spectral direction.

Frequency:	Occasional, throughout mission
Flags:	This study would not be run in response to an inter-instrument flag. CDS would not be flag Master or Receiver.
Solar Feature Tracking:	Not required

Product

Full spectra representing the total from slit positions in a 480x8 raster covering the face of the sun. These are then summed together into a single spectra representing the total solar output.

Microflare Study - [MICRO]

Contributor(s): R.A. Harrison (RAL), J. Gurman (GSFC)

Scientific Justification

Several Studies have been directed at the observation of small brightenings. This Study complements those by providing a fast raster over a small area, returning the full GIS spectral information.

Study Details

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcsec
Raster Area:	20 x 20 arcsec
Step (DX, DY)	4 arcsec, 4 arcsec
Raster Locations:	5x5 = 25
Exposure Time:	13 s
Duration of raster:	375 sec (Include. overheads)
Number of rasters:	Open
Total duration:	Open (375 x n sec)
Line selection:	Full GIS output
Bins Across Line:	n/a
Telemetry/Compression:	No compression required.
Pointing:	Selected area of quiet Sun.
Flags:	Could be run in response to interinstrument flag but will not be run with CDS as flag Master
Solar Feature Tracking:	To be decided at time of running.
Frequency:	Occasional throughout mission.

Product:

Intensity maps of size 20 x 20 arcsec, spatial resolution 4 arcsec, in full GIS range, produced every 375 seconds.

Joint Observations

This Study is used in JOP1 scheme, along with the FLARE Study. JOP1 is directed at the study of emerging magnetic flux.

Coronal Heating Via Nanoflares – [NANOF]

Contributors: G. Poletto (Arcetri), R.A. Kopp (LANL), E. Hiei and T. Shimizu (Tokyo), R.A. Harrison (RAL)

Scientific Justification

Yohkoh SXT images have revealed transient flare-like brightnenings (Shimizu et al., 1992) that are suggestive of nanoflares. Whether these transient brightenings represent enough energy to account for coronal heating, is, however, a matter of debate. This proposal is aimed at understanding whether the transient brightenings that may be observed by SOHO CDS experiment can be interpreted in terms of the brightest among the family of mini-events responsible for the heating of the solar corona and, in this case, whether SOHO CDS data enable us to verify the nanoflare coronal heating hypothesis.

In order to answer these questions, I propose to make use of the model developed by Kopp and Poletto (Kopp and Poletto, 1993) which describes the temporal evolution of plasma confined in a rigid magnetic flux tube and subject to a short-lived energy release event. The model assumes that energy is released in a cool, nearly empty loop, and that thermal conduction, radiative losses, and gravitational downfall take the loop back to its initial state. This model has been extended to handle repetitive events and, by this means, it has been shown how the solar corona, comprised of many such loops, may eventually build up as a consequence of the occurrence of myriads of ``nanoflares''. Briefly, multiple energy release events on a single loop, occurring at random times and with random energies -following, however, a power law energy distribution function with a low energy threshold $E_{min} \geq 10^{23}$ erg- if sufficiently frequent, may prevent the loop ever from returning to its initial state and eventually build up a loop with typical coronal temperature and density values.

CDS will measure brightness fluctuations over an area which may include a few loops and with a spatial resolution likely insufficient to resolve individual loops. Hence, CDS data show, at any one time, the outcome from the superposition of fluctuations occurring at random times and with random energies over those loops. Because of this, most likely only the largest events can still be individually recognizable, and they may look too few and too far apart to be responsible for coronal heating. In order to simulate what CDS observes, one should know how many loops are contained within the imaged area (and the size distribution of these loops), as well as how the (nano)flares are distributed in energy (i.e., the power-law index, α). Because both of these, at present, are poorly known, it will be probably difficult to establish whether or not CDS data are consistent with the nanoflare heating hypothesis.

The Kopp-Poletto model can be used to build a set of simulations showing the predicted brightness versus time profile, for a number of lines forming at different temperatures, over an area as large as that analyzed by CDS, for a few representative values of loop dimensions (length and diameter) and nanoflare power-law index α. Depending on the loop size and the value of α, we may show how the brightness vs. time profile will appear in different lines, as a consequence of nanoflares occurring all over the loops contained in the imaged area. Comparison between data and model predictions will allow us to constrain the model parameters and/or to get some insight into the loop size distribution and α value.

We require high time resolution and spectral resolution adequate to image individual lines, in order to identify the temperature regime we are dealing with. NIS with a 2×240 arcsec slit appears as the best candidate. We plan to observe brightness fluctuations in 4 lines, (forming at slightly increasing temperatures in the 10^6 to $\approx 3 \times 10^6$ K regime) over a limited area. For instance, the CDHS can read out only 0.5 arc minutes of the 4 arcmin slit; it will be interesting to point both to a quiet and to an active regions, to analyze differences in the heating rate at different locations. Hence we need 1 slit position to the raster (per quiet/active

Study Details:

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Step (Dx, DY):	2, 0 arcsec
Raster Area:	2 x 30 arcsec
Raster Locations:	1
Exposure Time:	1 sec
Duration of Raster:	1 sec
Number of Rasters	at least several hundred
Total Duration:	open
Line Selection:	Mg IX (368 Å); Si X (347 Å); Fe XIV (334 Å); Fe XVI (360 Å)
Bins Across Line:	11
Telemetry/Compression:	truncated to 12 bits 0.8 s/exposure = 4 lines x 11 bins x 15 pixels x 12 bits /10 kbits/s
Pointing:	a quiet region, an active region
Frequency:	regular
Flags:	Will not be run in response to inter-instrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not required

Product:
Many intensity maps of quiet/active area of size 2 x 30 arcsec, in 4 lines, spatial resolution 2 arcsec, taken at a high temporal frequency, over a time interval of about half an hour.

NIS Microchannel Plate Decay Monitoring - [NIMCP]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

Since the gratings and VDS detector are fixed with respect to one another, lines appear at the same place on the detector face at all times. This can result in a decrease in sensitivity over time and regular monitoring is essential.

Ideally, one would produce a flat field image of the detector once per day/week./month but we are unable to do this. The best we can do is use the CDS wide slit (90x240 arcseconds). Thus, this Study has two parts. In phase 1 we use the 2 x 240 arcsecond slit to define the locations of the line centres, i.e. the sites of most likely depletion. In phase 2, we open up the slit. One would expect a depletion in the centre of the wide slit image. We must use this scheme on quiet Sun locations. The entire NIS spectral ranges must be returned although the most obvious measure to use is to sum along the windows.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	2 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	393 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	393 seconds
Line Selection:	Full NIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Normal Incidence
Slit:	90 x 240 arcseconds
Raster Area:	90 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	393 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	393 seconds
Line Selection:	Full NIS output
Bins Across Line:	N/A

Telemetry/Compression:	No compression
Grand Total Duration:	18 minutes (incl. all overheads)
Pointing:	Quiet Sun
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	To be run at least once per week. More often in first months.

Product

Full NIS spectrum of quiet Sun, using narrowest then widest slit, to identify sensitivity variations in VDS detector.

NI Spectral Atlas - [NISAT]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

As with the SPECT GIS Study, the Normal Incidence Spectral Atlas is designed to explore thoroughly the rather poorly known EUV wavelength region, to identify and interpret the spectrum, and to allow a monitoring capability for the instrument. This Study should be performed regularly on quiet Sun and active Sun targets.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	20 x 240 arcsecond
Step (DX, DY):	2 arcsecond, 0 arcsecond
Raster Locations:	10 x 1 = 10
Exposure Time:	20 seconds
Duration of Raster:	220 sec (incl. overheads)
Number of Rasters:	10
Total Duration:	2200 sec (37 min)
Line Selection:	Full NIS output
Bins Across Line:	N/A
Telemery/Compression:	Sum along lines (i.e. remove spatial dimension) The spectrum lies in 2 bands of 1024 x 120 pixels. Summing reduces this to 2 x 1024 x 16 (bits) which can be returned in 3.3 s. No bottleneck.
Pointing:	To pre-planned location no repointing
Flags:	This Study will not be run in response to an interinstrument flag and will not be run with CDS as flag Master.
Solar Feature Tracking:	Not necessary.
Frequency:	Part of synoptic and monitoring programme to be performed regularly on QS and AR conditions.

Product

Full NIS spectral information (with no spatial information) for 10 2x240 arcsecond strips of the solar disc.

Evidence for Nano-Flares in Coronal and Transition Region Lines [NFCTR]

Contributors: V. Hansteen (University of Oslo and HAO), and P. Judge (HAO)

Scientific Justification

We propose to look for evidence of downwardly propagating, nano-flare generated compressive waves in the corona and transition region. As a secondary goal we would consider the fate of the upwardly propagating acoustic waves that presumably heat the chromospheric cell centres.

In the first picture, the sudden deposition of energy in the corona from a nano-flare event will lead to the generation of acoustic waves propagating along the magnetic field lines and towards the transition region. The waves will on reaching the transition region compress the material. Since the intensity of an allowed optically thin emission line scales roughly with the (electron) density squared, emission will be enhanced as the transition region is pushed downward. Hansteen (1993) has shown quantitatively that the net effect of this process is *on average* a redshifted line profile when one integrates the emission over the full wave cycle.

In the second picture, the upwardly propagating wave field that is heating the chromospheric cell centers would be expected to produce components in the lower transition region emission lines that are, on average, blueshifted.

Current line shift observations indicate that the nano-flare picture is more important in the lower transition region, but it is neither adequately tested by observations nor can the acoustic model be ruled out. Therefore we propose two observing sequences with CDS and SUMER to test directly these pictures.

In the first sequence we would monitor a small quiet Sun region in lines spanning a large range of temperatures with CDS looking for brightenings in the high temperature lines. Concurrently we would observe the same region at much higher spectral resolution with SUMER in lines typical of the transition region such as C IV, N V or O V expecting to see enhanced emission and (red-) shifts delayed by some few seconds (for the fast mode) to some tens of seconds (for the slow mode), assuming loop lengths are on the order of 10^4 km.

In the second method we would use CDS in the same manner as above but with SUMER observing density dependent lines from O IV], S IV] as well as Si IV at a high signal to noise ratio without the need for high temporal resolution, but instead attempting to extract densities as a function of projected Doppler velocity from the monochromatic intensities of density sensitive lines. This method was successfully applied to high quality data from the Hubble Space Telescope by Judge (1994) to argue that outward propagating shock waves do not heat the chromosphere of a typical giant star. Applied to the O IV] and S IV] lines, the method (taking into account blended features following Judge's analysis) will provide a direct, unambiguous test of the upward or downward propagation of compressive waves since a correlation between high electron density and redshift is required in order for the proposed mechanism to be active. The CDS portion of this experiment would reveal the level of activity in the field of view during our exposure.

The region of the Sun studied is tailored to minimize the cycle time while ensuring that the SUMER and CDS fields overlap; a 20 x 60 arcsecond field should be sufficient. We have set up a nominal time span for this experiment to cover an hour but it may be of interest to run these sequences over longer timespans in order to isolate lower-frequency information such as the expected 3 minute oscillations.

Since the coronal heating mechanisms apparently differ inside and outside of coronal holes, an important experiment is to run these sequences both inside and outside of a coronal hole.

References

Hansteen V. H.: 1993 ``A New Interpretation of the Red-Shift Observed in Optically Thin Transition Region Lines'', ApJ 402 741.
Judge P. G.: 1994 ``The `Monochromatic Density Diagnositic' Technique: First Density Components in the Chromosphere of αTauri'', ApJ 430, 351.

We select a series of bright lines with good temperature coverage ($2x10^4$ K to $2.5x10^6$ K). We require fast rastering and good spectral resolution; we will therefore use the NIS with a 2x240 arcsecond slit. To cover our 20 x 60 arcsecond field we need 10 slit positions to the raster -- the CDHS will read out only the central 1 arcmin of the slit. We believe that, say, 11 pixels across each of 10 lines will give us adequate coverage of line shifts. This corresponds to velocities on the order of 300km/s.

Study Details

Spectrometer	Normal Incidence
Slit	2x240 arcseconds
Raster Area	20x60 arcseconds
Step (DX, DY):	2 arcsecond, 0 arcsecond
Raster Locations	10
Exposure Time	4s
Duration of Raster	61s
Number of Rasters	100
Total Duration	101.7 minutes
Line Selection	Dynamic Selection supplemented by Mg X line: He I 584.33Å, O IV 554.52Å, O V 629.73Å, Mg VIII 315.02Å, Mg IX 368.06Å, Fe XIV 334.17Å, Fe XVI 360.76Å, O III 599.59Å, Ne VI 562.83Å, Mg X 624.94Å
Bins Across Line	11
Telemetry/Compression	compression by 1.24 required
Pointing	To pre-planned location (Quiet Sun or Coronal Hole) No repointing necessary.
Solar Feature Tracking	may be used if the study is performed over long periods
Frequency	At least once!

Product

20x 60 arcsec intensity maps in 10 lines repeated every 61 seconds for a period of approximately 1.5 hour. Spatial resolution 2 arcsec.

Observational Tests For Non-Equilibrium Ionization In The Solar Corona – [NONEQ]

Contributors: D. Spadaro (Catania)

Scientific Justification:

Non-equilibrium ionization may be produced by a variety of processes in the solar corona, for example, by mass flows through the large temperature gradients of the transition region or by impulsive heating and cooling. Any deviation from equilibrium ionization would have a strong effect on the radiation from the corona and on the interpretation of solar observations; hence, it is important to determine observational signatures of non-equilibrium. Spadaro et al. (1994) examined several temperature-sensitive line ratios which can be used as such signatures: C IV (1548.2 Å)/(312.4 Å), O IV (789.4 Å)/(554.4 Å), O V (629.7 Å)/(172.2 Å), O VI (1031.9 Å)/(173.0 Å), O VI (1031.9 Å)/(150.1 Å). These line ratios were calculated for four coronal loop models which have a steady flow and which are known to have significant departures from equilibrium ionization. In general, non-equilibrium causes a considerable reduction in the line ratios, more than an order of magnitude in the downflowing leg of the loop model with the largest mass flows. In particular, the C IV line ratio is the most sensitive to non-equilibrium. We propose to apply this test to coronal loops observed by CDS and SUMER, selecting appropriate targets on the limb and disk.

References: D. Spadaro, P. Leto, and S.K. Antiochos, 1994, Ap. J., ??

Study Details

<u>Phase 1</u>

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsec
Raster Area:	30 arcsec by 4 arcmin
Step (DX, DY)	2 arcsec, 0 arcsec
Raster Locations:	15 x 1
Exposure Time:	10 s
Duration of raster:	193 sec (incl. overheads)
Number of rasters:	1
Total duration:	3.2 min
Line selection:	C IV (312.4 Å), O IV (554.4 Å), O V (629.7 Å) plus other strong lines to identify the loop?
Bins Across Line:	21
Telemetry/Compression:	truncate to 12 bits 9 s/exposure = 3 lines x 21 bins x 120 pixels x 12 bits /10 kbits/s
Pointing:	to a loop location, if known. If not known, a 4 x 4 arcmin NIS raster may be needed to search
Flags:	Will not be run in response to inter-instrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not necessary

Phase 2

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcsec
Raster Area:	30 x 10 arcsec
Step (DX, DY)	2 arcsec, 2 arcsec
Raster Locations:	15 x 5
Exposure Time:	15 s
Duration of raster:	1139 sec
Number of rasters:	1
Total duration:	19 min
Line selection:	Full GIS output. Lines used: C IV (312.4 Å), O IV (789.4 Å) - likely to be outside of range?, O V (172.2 Å), O VI (173.0 Å), O VI (150.1 Å)
Bins Across Line:	N/A
Telemetry/Compression:	straight copy 13 s/exposure = 4 bands x 2048 bins x 16 bits /10 kbits/s
Pointing:	a 'leg' of a coronal loop. The same location as in Phase 1.
Flags:	N/A
Solar Feature Tracking:	OFF
Comment:	Near Real Time commanding
Grand Total Duration:	22.2 minutes.

Product:

Phase 1: 30 arcsec x 4 arcmin image in three lines. Phase 2: 30 x 10 arcsec image along the leg of the loop.

Joint Observations:
SUMER

Electron Densities From The O V 761.1 Å/760.4 Å Line Ratio [O5DEN]

Contributor(s): F. P. Keenan, V. J. Foster, A. E. Kingston (QUB); K. J. H. Phillips (RAL)

Scientific Justification:

Emission lines from transitions in O V have been frequently observed by a variety of solar instruments, including the S082A/B and S-055 spectrographs on board Skylab (Widing *et al.* 1982; Doyle *et al*. 1983). Ratios involving these lines, such as I(192.9 Å)/I(220.4 Å) in S082A spectra and I(761.1 Å)/I(629.7 Å) in S-055 observations, are very sensitive to changes in the electron density, and hence in principle should provide useful N_e-diagnostics for the emitting plasma (Keenan *et al*. 1991, 1994). However unfortunately they are also very dependent on the adopted electron temperature, implying that they are of limited use in deriving accurate densities, unless the temperature has been independently determined. Very recently we have used new atomic physics calculations for O V to derive the emission line ratio $R = I(2s2s\ ^3P_1 - 2p^2\ ^3P_0)/I(2s2p\ ^3P_2 - 2p^2\ ^3P_2)$ = I(761.1 Å)/I(760.4 Å), and our results are shown in Table 1 as a function of electron density for two temperatures. The ratio is clearly extremely density sensitive, varying by a factor of ~15 between log N_e = 8 and 12. However, unlike other O V diagnostics, it is practically independent of temperature, a change in T_e of a factor of 2 leading to at most a ~10% change in R. Hence it should be an excellent density indicator for a wide range of solar features.Current solar observations (in particular those from S-055) are of too low a spectral resolution to reliably measure R (see Doyle *et al.* 1983). We therefore propose to determine the ratio in CDS observations of a variety of solar features, including the quiet Sun, coronal holes and sunspots, to investigate the usefulness of R as a density diagnostic.

References:
Doyle, J.G. *et al.* 1983, Solar Phys. **89**, 243.
Keenan, F.P. *et al.* 1991, Astrophys. J. **382**, 349.
Keenan, F.P. *et al.* 1994, Solar Phys. (in press).
Widing, K.G. *et al.* 1982, Astrophys. J. **257**, 913.

Table 1: Theoretical values of R = I(761.1 Å)/I(760.4 Å) in O V.

Log N_e	Log T_e = 5.3	Log T_e = 5.6
8.0	0.0172	0.0179
9.0	0.0223	0.0221
10.0	0.0642	0.0588
11.0	0.1930	0.1840
12.0	0.2590	0.2570

Study Details:

Spectrometer:	Grazing Incidence
Slit:	2x2 arcsecond
Raster Area:	30x30 arcsecond
Step (DX, DY):	2, 2 arcsec
Raster Locations:	15 x 15 = 225
Exposure Time:	15 sec
Duration of Raster:	3418 sec = 57 minutes (inc. overheads)

Number of Rasters	2 - 3
Total Duration:	114 - 171 min
Line Selection:	Full GIS output. Lines used: O V 760.4 Å, O V 761.1 Å
Telemetry/Compression:	straight copy 13.1 s = 4 bands x 2048 bins x 16 bits /10 kbits/s
Pointing:	quiet/active regions, coronal hole
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Could be used.

Product:
30 x 30 arcsec maps, with 2 arcsec resolution, full GIS spectrum, with time resolution of 57 minutes. 2 spectral lines used.

Opacity In Spectral Lines Of Ions Of Modest Charge – [OPAC1]

Contributors: M. Landini, B.Monsignori-Fossi and P.McWhirter.

Scientific Justification.

The proposal is to measure the optical thickness of lines of ions of relatively low charge by observing the way their intensity ratios vary in the vicinity of the solar limb. This method depends on observing a line pair having the same upper level so that their intensity ratio in optically thin conditions is simply the ratio of their transition probabilities. Otherwise the ratio is modified by the effect of opacity. It was pioneered by Doyle and McWhirter (Mon.Not.R.ast.Soc. **1993**, 947, 1980) who applied it to C III using Skylab data. They were able to derive by their analysis an approximate estimate of the physical thickness of the C III 'layer'. Such an estimate may be extended to a determination of the temperature gradient in that region of the atmosphere and thus of the conducted thermal flux assuming a shell-like structure of the atmosphere. The present proposal is to extend these measurements and deductions to the ions of O IV, Si III and O III using both CDS and SUMER. The dominant factor which determines the opacity in a spectral line is the product $n_l f_{l,u}$ L where n_l is the population density of the lower level of the transition, $f_{l,u}$ is the absorption oscillator strength and L is the physical depth of the emitting plasma along the line of sight. For an effect to be detectable by this method the ratio between the relevant products $n_l f_{l,u}$ L must be significantly greater than unity - in the case of C III mentioned above it was about 3. In the accompanying table values of $g_l f_{l,u}$ are listed to provide an approximate way of estimating the ratio between the $n_l f_{l,u}$ L products (g_l is the statistical weight of the lower level).

transition	J_l - J_u	λ (Å)	g_l	$f_{l,u}$	g f
O IV					
$2s^2 2p\ ^2P^o$ - $2s2p^2\ ^2P$	1/2 - 3/2	553.330	2	0.13	0.26
$2s^2 2p\ ^2P^o$ - $2s2p^2\ ^2P$	1/2 - 1/2	554.075	2	0.25	0.50
$2s^2 2p\ ^2P^o$ - $2s2p^2\ ^2P$	3/2 - 3/2	554.514	4	0.31	1.24
$2s^2 2p\ ^2P^o$ - $2s2p^2\ ^2P$	3/2 - 1/2	555.261	4	0.064	0.26
Si III					
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	2 - 2	1298.960	5	0.423	2.1
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	1 - 1	1298.891	3	0.141	0.42
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	2 - 1	1303.320	5	0.140	0.70
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	1 - 0	1301.146	3	0.188	0.56
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	1 - 2	1294.543	3	0.235	0.7
$3s3p\ ^3P^o$ - $3p^2\ ^3P$	0 - 1	1296.726	1	0.565	0.57
O III					
$2s^2 2p^2\ ^3P$ - $2s2p^3\ ^3S^o$	2 - 1	508.182	5	0.19	0.95
$2s^2 2p^2\ ^3P$ - $2s2p^3\ ^3S^o$	1 - 1	507.683	3	0.19	0.57
$2s^2 2p^2\ ^3P$ - $2s2p^3\ ^3S^o$	0 - 1	507.391	1	0.19	0.19

For O IV the most sensitive line pair is 3/2-3/2 and 1/2-3/2 where the ratio of the gf's is about 5 (the sensitivity ratio). The other pair could also be used although less sensitive (sensitivity ratio is about 2). The 1/2-1/2 and 3/2-3/2 components are probably sufficiently well separated to be resolved by the spectrometer. For Si III the obvious choice is 2-2 to 1-2 where the sensitivity ratio is 3. Blending of 2-2 and 1-1 may be a problem but the effect of 1-1 can be estimated by measuring either 2-1 or 0-1 and a correction made. This last line pair is relatively insensitive to opacity and a measure of their ratio may be used as a check on the theory and accuracy of measurement (see the C III paper referenced above). For O III the 2-1 component will be taken with either of the other two or maybe both - preferably 0-1 where the sensitivity ratio is 5 but there may be a problem with the blending of these lines. In the paper of Doyle and McWhirter a relatively crude approximation was used to represent the effect of opacity. For this work a slightly more sophisticated approximation will be adopted where the effect of scattering will be treated on a layer by layer basis but without going to the complexity of a radiative transfer calculation. The normal incidence section of the CDS would be used for O IV and O III and SUMER for Si III although all the wavelengths fall within the SUMER range. For the observations the instruments should be pointed at a quiet region and 20 arc sec in from either the east or west limb and then scanned stepwise in say 2 arc sec steps out over the limb to 10 arc sec above it. Narrow slits should be used to give good spectral resolution and dwell times should be adequate to give about 1% statistical accuracy of measured count rate (i.e. about 10,000 counts). For this, dwell times of about 5 min should be adequate giving a total experiment time of say 1.5 hours. The demands on telemetry for the proposal as described are very modest even if it is decided to read out ever minute.We have made a study of other ions and believe the method can readily be extended to cover lines in N IV (S), O V (C), Si IV (S), S IV (C&S), Ne III (C), N III (C), Ne V (C), Na III (C) and S III (S) where C means CDS and S means SUMER. By including a number of these in the observing sequence good use could be made of the slightly unusual pointing requirements of these observations. By extending the experiment in this way the temperature gradient over a range of temperatures may be probed.

Study Details:

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Step (DX, DY):	2, 0 arcsecond
Raster Area:	30 x 240 arcsecond
Raster Locations	15 x 1
Exposure Time:	300 sec
Duration of Raster:	4502 sec (inc. overheads)
Number of Rasters:	open
Total Duration:	open
Pointing:	Quiet Sun, start 20 arcsec inside E or W limb, move outwards with a step of 2 arcsecond
Line Selection:	O IV 553.330, 554.075, 554.514, 555.261 Å O V (C), S IV, Ne III, N III, Ne V, Na III (Wavelengths to be specified)
Bins Across Line:	21
Telemetry/Compression:	truncate to 12 bits
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: Not required (observations on the limb)

Product:
This study produces 30 x 240 arcsec intensity maps in four O IV lines

Joint Observations:
SUMER

Line Opacity Project – [OPAC2]

Contributor: J.G. Doyle, Armagh Observatory

Doyle & McWhirter (1980, MNRAS 193,947) have shown that near the solar limb, there is a measurable optical thickness. This method uses two lines which arise from the same upper level, and are thus in optically thin conditions proportional to the ratio of their transition probabilities. The lines used in the above study were from the C III 1176 multiplet. Doyle & McWhirter showed that the (2-2) component had an optical thickness which varies from 1.21 at 1 arcsec inside the limb to 0.068 at disc center. They also showed that it is possible to estimate the physical line-of-sight thickness of the emitting layer. Here, we propose a similar method but applied to a range of ions, thus to different temperatures and hence atmospheric layers. This sequence will be combined with a similar sequence on the SUMER.

Study Details:

Phase 1

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcsecond
Step (DX, DY):	2, 0 arcsec
Raster Area:	24 x 2 arcsec
Raster Locations:	12 x 1
Exposure Time:	240 sec
Duration of Raster:	2882 sec (inc. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	full GIS output (O V and N III lines in band 4), (Ne III, Mg VII, Ne VI in band 3)
Bins Across Line:	N/A
Telemetry/Compression:	straight copy 13.1 s/exposure = 4 bands x 2048 bins x 16 bits /10 kbits/s
Pointing:	Quiet Sun, Limb from -12 to +10 arcsec from the limb

Phase 2

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Step (DX, DY):	2, 0 arcsec
Raster Area:	24 x 240 arcsec
Raster Locations:	12 x 1
Exposure Time:	240 sec
Duration of Raster:	2882 sec (inc. overheads)
Number of Rasters:	open
Total Duration:	open
Line Selection:	Ne V 568.42, Ne V 569.76, Ne V 569.83

	Ne V 572.11, O IV 553.33, O IV 554.51 Å
Bins Across Line:	21
Telemetry/Compression:	truncate to 12 bits 18.1 s/exposure = 6 lines x 21 bins x 120 pixels x 12 bits /10 kbits/s
Grand Total Duration:	open
Pointing:	Quiet Sun, Limb from −12 to +10 arcsec from the limb
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not necessary

Product:
Intensities of selected GIS and NIS lines as a function of the distance from the limb

Joint Observations:
SUMER

Coronal Plumes And High Speed Solar Wind Streams [PLUME]

Contributors: G. Poletto (Arcetri), R.A. Harrison (RAL), E. Hiei, Y. Uchida, J. Khan (Tokyo), G. Noci, M. Velli (Univ. of Florence), S. Suess (MSFC)

Scientific Justification:

Coronal plumes are thought to be the major source of the solar wind mass flux originating in polar coronal holes. Plumes have been observed in Mg IX (368 Å) and Mg X Skylab images (Bohlin et al., 1975, Withbroe, 1986; Karovska et al., 1994) and in the 171 to 173 Å band by Walker et al. (1988) with a normal incidence multilayer telescope. The Skylab spatial resolution was 5×5 arcsec; the plumes emission persists, in Skylab data, up to at least 4.5 arcmin above the limb. Knowing more about plumes is relevant to a number of topics: unless we understand plumes, we are bound to know little both of the physics of coronal holes and of the origin of the mass supply to the high speed solar wind streams. Here we propose a two-step project: we can pursue, via CDS alone, a study of plumes (and of bright points which purportedly lie at the base of plumes) and we can do a collaborative research, with UVCS, to relate the number and physical characteristics of plumes to the physical parameters of the solar wind originating from the area over which plumes (and bright points) are observed. The study of the physical properties of plumes requires limb observations. CDS should point to a polar region, covering some area inside the limb as well as the above-limb lower coronal levels. Densities in plumes range between 10^7 cm^{-3}, at $R=1.5R_{sun}$, and 3×10^8 cm^{-3} at $R=R_{sun}$, their lifetime is estimated to be at least several hours. Hence, if we plan to analyze the time evolution of the physical structure of plumes, we need high spatial resolution, long dwell times and continuous observations over a time of approximately one day. However, this can be done over the CDS FOV, with no repointing, just at the time of a campaign. Because of the scarcity of existing data, which allows us only to make a guess of the time needed to get good data, it would be advisable, before starting a campaign, to make a short-duration test observing over a small area, to get guidelines for a better selection of dwell times, both in this phase of the project and in the later collaborative research. In order to cover a good temperature interval, we may choose to make observations in lines from 4 ions: Mg IX and Mg X, forming at $T\approx10^6$K, cover the range over which previous data have been obtained, Fe XIV (temperature of formation $\approx2\times10^6$ K) and O V (temperature of formation $\approx2\times10^5$ K), cover ranges over which data are still missing and may provide information about the temporal evolution of plumes. Lines from these ions fall in NIS range, which should be used with a slit of 2 arcsec $\times$ 240 arcsec, rastering through the whole FOV of CDS. The output from this PHASE 1 study should clarify the relationship between Bright Points and plumes: in the description of PHASE 2, we assume that, in agreement with the present understanding, Bright Points are located at the base of plumes and can thus be considered plumes' proxies. Phase 2 of this project focusses on the association between Bright Points and the mass flux of high speed solar wind streams. That bright points might be the sources of the mass flux in high speed streams, had been already hypothesized by Davis and Golub (1980), from preliminary work, based on Skylab data. These authors suggested that the number of bright points in a given area might be proportional to the mass flux in the high speed stream originating from that area. However, this topic has not been further addressed. We propose to make a joint CDS-UVCS observational campaign: to this end, CDS should take data over an area as large as the coronal hole and observations should be repeated over the hole lifetime, once per month. Continuous observations over an extended time are no longer required, but the need for a complete coverage of the coronal hole area is likely to require a repointing of the instrument. Possibly, we may need observations only in a couple of lines. At the same time, UVCS should obtain data on the solar wind emanating from the hole, leading, through Doppler dimming techniques, to an estimate of the speed of the wind, and, via traditional methods, to a density determination.

Study Details:

Spectrometer: Normal Incidence
Slit: 2 x 240 arcsecond
Raster Area: 4 x 4 arcmin
Step (DX, DY): 2, 0 arcsec
Raster Locations: 120 x 1

Phase 1

Exposure Time: 200 sec
Raster Duration: 24018 sec
Number of Rasters 3 - 4
Total Duration: 18 - 24 hours

Line Selection: Mg IX (368 Å), Mg X (624 Å), Fe XIV (334 Å), O V (592 Å)

Bins Across Line: 21 bins

Telemetry/Compression: truncated to 12 bits
12 s/exposure =
4 lines x 21 bins x 120 pixels x 12 bits /10 kbits/s

Pointing: an area on the limb

Frequency:

Flags: Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: disabled (observations on the limb)

Phase 2

Exposure Time: 10 sec
Duration of Raster: 1218 sec (inc. overheads)
Number of Rasters 3-4 (covering the area of the coronal hole)
Total Duration: 60 - 80 minutes

Line Selection: Mg IX (368 Å), Mg X (624 Å)

Bins across Line: 21 bins

Telemetry/Compression: truncated to 12 bits
6 sec=2 lines x21 bins x 120 pixels x 12 bits /10 kbits

Pointing: coronal hole

Frequency: once per month, over the lifetime of the coronal hole

Flags: Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: Not necessary

3-4 intensity maps of coronal hole/above limb areas, in 4 lines, of size 4 x 4 arcmin, spatial resolution 2 x 2 arcsec.

Joint Observations:
UVCS

Prominence Observing Programme 1
[POBS1]

Contributor(s): A.I. Poland (GSFC), B. Schmeider (Meudon)

Scientific Justification

The purpose of this Study is to observe prominences on the limb with CDS and SUMER, to determine temperature, density and flows as a function of time in the prominence and surrounding corona. An important aspect of this programme, and a unique capability for SOHO, is to observe the prominence material over a wide range of temperatures to determine if observed visibility changes at one temperature are due to density or temperature effects. A part of this question is, does material in small scale structure appear and disappear because of density or temperature effects? Another aspect is the material flow in small scale structures. Poland and Mariska developed a syphon flow model for prominence development. This Study will help determine if the predicted velocity flows occur in real prominences.

Study Details

<u>Phase 1:</u>

Spectrometer:	Normal Incidence
Slit:	90 x 240 arcsec
Raster Area:	3 x 4 arcmin
Step (DX, DY)	90 arcsec, 0 arcsec
Raster Locations:	2 x 1
Exposure Time:	100 s
Duration of raster:	220 s
Number of rasters:	1
Total duration:	220 s
Line selection:	Prominence Line Selection 1 - Fe XIII 320 Å, Fe XIV 334 Å, Si IX 341 and 345 Å Mg IX 368 Å, He I 522 Å, O III 525 Å, He I 537 Å O IV 553 and 554 Å, Ne VI 562 Å, He I 584 Å O III 599 Å, He II 304 Å (2nd), Mg X 624 Å and O V 629 Å. 16 lines.
Bins Across Line:	45
Telemetry/Compression:	45 x 120 x 16 x 16 bits = 1382400 bits. In 100 s rate = 13.824 kbit/s. Therefore, compression of 1.4 required.
Pointing:	Pointing such that limb appears is first exposure with as much of the prominence as possible. The second exposure covers the region above this.

<u>Phase 2:</u>

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsec
Raster Area:	2 x 4 arcmin
Step (DX, DY)	4 arcsec, 0 arcsec

Raster Locations:	30 x 1
Exposure Time:	100 s
Duration of raster:	50 min
Number of rasters:	open
Total duration:	open
Line selection:	Prominence Line Selection 1 - Fe XIII 320 Å, Fe XIV 334 Å, Si IX 341 and 345 Å Mg IX 368 Å, He I 522 Å, O III 525 Å, He I 537 Å O IV 553 and 554 Å, Ne VI 562 Å, He I 584 Å O III 599 Å, He II 304 Å (2nd), Mg X 624 Å and O V 629 Å. 16 lines.
Bins Across Line:	10
Telemetry/Compression:	No data compression required.
Pointing:	Cover the lower portion of the area covered by Phase 1.
Grand Total Duration:	Open
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking:	Not required.
Frequency:	Occasional throughout mission.

Product:

Overlappogram image of prominence and overlying corona in 16 lines followed by 4 arcsecond images of the same region in the same lines.

Joint Observations:

This Study is part of JOP 12 which involves SUMER and CDS and potential contributions from other SOHO and ground based instruments.

Peak Temperature Of The Corona - [PTCOR]

Contributor(s) - R.W.P. McWhirter (Abingdon)

Scientific Justification:

The object is to measure coronal temperature vs height, especially in open-field regions above coronal holes, using line ratios senstive to temperature. For a CDS campaign it may be an advantage to measure more than one pair of lines from the same ion and this measurement should be done simultaneously with a DEM analysis of the same region.

The line selection is subject to several criteria. For example, the ion must have at least one low lying level compared with the others in order that the line intensity ratio be sensitive to temperature. Also, the ion must be relatively simple so that the relevant atomic rate co-efficients can be calculated with confidence. A selection of possible lines of Li-like, Be-like and Na-like ions is given in the table. It seems that the best approach is to build an observing sequence round the CDS-GIS and SUMER instruments so that with good co-alignment and good cross calibration all pairs of lines can be measured simultaneously.

Sequence	Ion	Log Te	Transition	Wavelength (Å)
Li-like	C IV	5.0	2S-2P	1548.202
			2S-3P	312.422
			2P-3D	384.178
	N V	5.3	2S-2P	1238.821
			2S-3P	209.274
			2P-3D	247.706
	O VI	5.5	2S-2P	1031.926
			2P-3D	173.082
			2P-3S	184.117
Be-like	N IV	5.2	$2s^2\ {}^1S$-$2s2p\ {}^1P$	765.148
			$2s^2\ {}^1S$-$2s3p\ {}^1P$	247.205
	O V	5.4	$2s^2\ {}^1S$-$2s2p\ {}^1P$	629.703
			$2s^2\ {}^1S$-$2s3p\ {}^1P$	172.169
Na-like	S VI	5.3	3S-3P	933.38
			3S-4P	248.99
			3S-5P	191.48
			3P-3D	706.48
			3P-4D	290.13
			3D-4F	464.68
	Ar VIII	5.6	3S-3P	700.245
			3S-4P	158.92
			3P-4D	180.25
			3P-3D	526.46
	Ca X	5.8	2S-3P	557.763
			3P-3D	419.754
			3D-4F	167.049
	Fe XVI	6.3	3S-3P	335.407
			3P-3D	262.967

In practice, the Study described below uses sufficiently long exposure times to allow the full GIS spectrum to be output - no line selection is necesary. However the intensities of the above lines drives the exposure required. The most demanding observation will be of an open field region above a polar coronal hole where the density is lower than in neighbouring closed field regions. However, for such large scale regions a spatial resolution of about 1 arcminute is sufficient. Thus, we use the large 8x50 arcsecond slit. For the weakest lines, which may be of intensity 0.1 c/s in quiet Sun per 2x2 arcsecond, we find intensities of 10 per second for the 8x50 slit. For coronal hole regions, this may be 1 per second, or less. To obtain 10% counting statistics, we would need to expose for at least 100 seconds at each location, on the disc. For observations off-limb one should expect a factor of 10 or more longer than this. We choose to expose for 1000 seconds at each location. Since the structures in question are long lived such exposure times are quite reasonable.

Above the limb the spectrum is much less crowded so that it should in general be possible to relax the demands for high spectral resolution. For CDS instrument with the chosen slit it should be possible to identify the required lines.

In the Study, it is assumed that the long axis of the raster is following a solar radius vector.

Study Details

Spectrometer:	Grazing Incidence
Slit:	8 x 50 arcsecond
Raster Area:	56 x 210 arcsecond
Step (DX, DY):	16 arcseconds, 20 arcseconds
Raster Locations:	4 x 9 = 36
Exposure Time:	1000 seconds
Duration of Raster:	36050 seconds
Number of Rasters:	1
Total Duration:	10.01 hours (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression
Pointing:	To pre-selected coronal hole location
Flags:	No flag operation during this Study
Solar Feature Tracking:	Not required
Frequency:	To be run on several occasions during mission.

Product

Four parallel scans of 8x210 arcseconds from disc to 210 arcseconds above the limb, for all GIS spectrum.

Electron Densities From S XI – [S11DE]

Contributor(s): F. P. Keenan, V. J. Foster (QUB); K. J. H. Phillips (RAL); K. M. Aggarwal (Delhi)

Scientific Justification:

Very reliable density diagnostics will be required for the interpretation of CDS observations, and Harrison (1994) has recently produced a summary of prime density sensitive line ratios which may be employed for this purpose. Included in this list are ratios involving the S XI 215.97 and 190.37 Å lines. Recently, (Keenan *et al.* 1993) have produced new calculations for the R_1 = I(215.97 Å)/I(191.29 Å) and R_2 = I(190.37 Å)/I(191.29 Å) line ratios in S XI, confirming the density sensitivity of line pairs containing the 215.97 or 191.29 Å transitions, as R_1 and R_2 vary by factors of ~9 and ~10, respectively, between $\log(N_e)$ = 9 and 11 (see Table 1). This, coupled with the wavelength proximity of the lines, and the fact that the ratios show little temperature sensitivity (Keenan *et al.* 1993), makes them ideal N_e–diagnostics. However a comparison of the theoretical values of R_1 and R_2 with *Skylab* S082A observations leads to electron density estimates much larger than those deduced from line ratios in Fe XIV. As S XI and Fe XIV are formed at similar electron temperatures, and hence presumably arise in adjacent regions of the solar atmosphere, one would expect $N_e(R_1,R_2) \cong N_e$ (Fe XIV). The unrealistically high densities derived from R_1 and R_2 imply that the observed ratios are too large, which is probably due to blending of the 215.97 and 190.37 Å lines with nearby features (Keenan *et al.* 1993). We therefore intend to reobserve R_1 and R_2 in higher resolution CDS spectra, and in addition to obtain data for the Fe~XIV 211.32, 219.12 and 220.08 Å features. A comparison of densities from R_1 and R_2 with those from I(219.12 Å)/I(211.32 Å) and I(219.12 Å)/I(220.08 Å) in Fe XIV will allow us to investigate if the discrepancies found using the S082A dataset may be resolved, and hence if the S XI ratios may be usefully employed in the analysis of CDS observations.

References:
Harrison, R.A. 1994, CDS Density Sensitive Line Pairs, CDS--SOHO Memo.
Keenan, F.P. *et al.* 1993, Astrophys. J. **413**, 826.

Table 1: Theoretical S XI ratios R_1 = I(215.97Å)/I(191.29Å) and R_2 = I(190.37Å)/I(191.29Å) at $\log T_e = 6.2$.

$\log N_e$	R_1	R_2
9.0	0.060	0.022
10.0	0.156	0.059
11.0	0.522	0.220

Study Details:

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcsecond
Raster Area:	30 x 30 arcsecond
Step (DX, DY):	2 arcsec, 2 arcsec
Raster Locations:	15 x 15 = 225
Exposure Time:	15 sec
Duration of Raster:	3418 sec (inc. overheads)
Number of Rasters	1
Total Duration:	57 min

Line Selection:	Full GIS output. (Lines used for analysis will be S XI 190.37,191.29,215.97, Fe XIV 211.32,219.12,220.08 Å)
Telemetry/Compression:	straight copy 13.1 s = 4 bands x2048 bins x16 bits /10 kbits/s
Pointing:	quiet/active regions
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master

Solar Feature Tracking: Could be used

Product:
30 x 30 arcsec maps, with 2 arcsec resolution, with time resolution of 57 minutes. Full GIS output, 6 spectral lines used.

Spectral Atlas - [SPECT]

Contributor(s) - R.W.P. McWhirter (Abingdon) and R.A. Harrison (RAL)

Scientific Justification:

There are two important reasons for producing a spectral atlas from the CDS-GIS - (i) This region of the spectrum has been studied very little and this will be one of the only times that it has been possible to do so with a pointed instrument covering such a wide spectral range, (ii) A standard atlas can be used to determine the characteristics of the instrument in flight. It will for example be important to be able to know how well it will be possible to resolve certain spectral lines when designing observing sequences and to know with certainty that particular lines can be detected. For this reason it will be an advantage to prepare at least a preliminary atlas at an early stage in the mission.

The atlas should be done regularly on quiet Sun and active Sun sites. Once a month should be the minimum frequency - to provide a thorough view of the solar spectrum and to monitor the CDS spectral response against "constant" solar conditions.

Study Details

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcsecond
Raster Area:	30 x 30 arcsecond
Step (CX, DY):	2 arcsecond, 2 arcsecond
Raster Locations:	15 x 15 = 225
Exposure Time:	50 seconds
Duration of Raster:	11293 sec (188.2 min) incl. overheads.
Number of Rasters:	1
Total Duration:	11293 sec (188.2 min)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression required 2048 pixels for each of 4 detectors, with 16 bit words per pixel, = 4 x 2048 x 16 bits to return. This takes 13.1 s, assuming 10 kbit/s of telemetry devoted to science data. This compares to a dwell time of 50 sec - only 26.2% of the telemetry used.
Pointing:	To pre-planned location no repointing
Flags:	This Study will not be run in response to an interinstrument flag and will not be run with CDS as flag Master.
Solar Feature Tracking:	Not used in general. Sun rotates 13º per day (central meridian), i.e. 215 arcsec per day, or 8.9 arcsec per hour or 0.15 arcsec per min, viewed from Earth. With accumulation time of 50 sec, Sun will have rotated 0.12 arcsec. Over raster period, Sun will rotate 30 arcsec, if target is

	near central meridian equator. Thus, may require Solar Feature Tracking to operate during this Study. However, since this is a spectral atlas which will be used frequently on quiet Sun, some degree of image blurring due to rotation can be tolerated.
Frequency:	Part of synoptic and monitoring programme to be performed at minimum of once per month on QS and AR

Product

This Study provides 225 spectra for the four GIS wavelength bands for each of 15 x 15 locations of a raster covering an area of 30 x 30 arcsec with 2 x 2 arcsec resolution.

Joint Observations

This Study is complementary to SUMER POP number 05 - the SUMER Solar Spectral Atlas.

Sunspot Velocity Fields - [SPOTV]

Contributor(s) - P. Maltby (Oslo)

Scientific Justification:

The velocity field in and around sunspots is known to be rather complicated. Whereas the velocity field is mainly restricted to the sunspot at photospheric heights, the flow has a larger horizontal extent in the chromosphere and appears to follow superpenumbral filaments. In the transition region both upflows and downflows may occur within the same sunspot area. Studies of the line profiles strongly suggest a fine structure in the flow field, since more than one distinct line-of-sight velocity may occur within the same spatial resolution element.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	60 x 120 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	30 x 1 = 30
Exposure Time:	15 seconds
Duration of Raster:	454 seconds
Number of Rasters:	open
Total Duration:	open
Line Selection:	Sunspot Line Selection (9 lines)
Bins Across Line:	21
Telemetry/Compression:	16 to 12 bit compression; select only 60 pixels along slit; 9 x 21 x 60 x 12 bits = 14 sec.
Pointing:	Pre-planned Sunspot location
Flags:	Would not be run in response to interinstrument flag but may run with CDS as flag Master
Solar Feature Tracking:	May be used
Frequency:	Occasional

Product
60x120 arcsecond maps of a sunspot area, with full spectral information over 9 lines, once every 454 seconds.

Joint Observations
To be run in conjunction with SUMER POP number 17, Sunspot Velocity Fields. Part of JOP 18.

Streamer Study - [STREM]

Contributor(s) - R.A. Harrison

Scientific Justification:

There are many outstanding questions concerning streamer structure, evolution and stability and some of these can be addressed by CDS, for example:

- What is the temperature, density, flow structure of a streamer?
- Can we detect upflows of "cool" material in the streamer legs, yet outside the closed loop structures?
- Can we determine differences in the nature of the closed, open, cusp and current sheet regions?
- Can we determine parameter gradients across the current sheet/streamer legs etc...?

In the campaign described below CDS is pointed to a region with covers the cusp region, at least part of one, preferably two, legs, and some of the "stem" above the cusp (the current sheet). Given a 4x4 arcmin field of view, this is just about possible but will probably mean that the entire CDS field is above the solar limb - i.e. intensities will be low! Three observations are needed, of the same streamer - as it approaches the western limb (10-20 degrees), as it sits above the western limb and beyond the limb. This is primarily to detect the upflows in the legs which, at the limb would not be detectable. Given a 2-D streamer, at the limb there will be no Doppler shift from the upflowing material in the leg. Prior to the limb-crossing the there will be a blue shift and after the limb crossing, there will be a red shift.

For the lines given, intensities range from 1.0 to 120.0 counts per 4x4 arcsec on the Sun. In the corona, we will see a significant fall-off and much may depend on the precise altitude of the cusp, which could be anywhere from 0.2 to 1.0 solar radii above the limb. Assuming a drop in intensity of a factor of 10, and a desire for 20% statistics on the weakest lines, we must accumulate for 250 Seconds at each location of the raster.

The line selection includes a series of bright iron emission lines from a wide range of temperatures, with some density diagnostic ratios. It includes a cool line for co-registration with, for example, the limb, as well as some flare-like temperature lines.

Study Details

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcsecond
Raster Area:	4 x 4 arcminute
Step (DX, DY):	4 arcsecond, 0 arcsecond
Raster Locations:	60 x 1 = 60
Exposure Time:	250 seconds
Duration of Raster:	255 minutes
Number of Rasters:	1
Total Duration:	4 hours 15 minutes (incl. overheads)
Line Selection:	Iron Line Selection (11 lines)
Bins Across Line:	21
Telemetry/Compression:	No compression required (11 lines x 21 x 120 pixels x 16 bits = 44s)

	leg and current sheet
Flags:	Would not be run in response to interinstrument flag but may be run with CDS as Master/Receiver
Solar Feature Tracking:	Not necessary (limb observations)
Frequency:	To be run on occasional campains during mission, each campaign including observation of same streamer approaching limb, on limb and beyond limb.

Product
One 4x4 arcminute image of a streamer base in a range of iron lines, with full spectral information across each at each 4 arcsecond location.

Joint Observations
Part of JOP 28 - streamers - involving CDS, SUMER, UVCS, LASCO and EIT.

Synoptic Study - [SYNOP]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

The Synoptic Study is designed to monitor the global evolution and structure of the Sun. It will allow a thorough study of the stability and evolution of large-scale features in conjunction with coronagraph (LASCO, UVCS) and full-Sun devices (EIT, the GOES satellites, ground-based observations etc...) and will provide information for correlative studies with observations of interplanetary structures. This Study will also be used to identify potential targets for later CDS studies. By definition, a synoptic sequence must be taken regularly from the same platform and with the same view (i.e. the same line selection etc...). The plan is to perform such a sequence on a daily basis.

The Sun's diameter is 30 arc minutes. A full scan of the Sun would take far too long; the plan is to produce a north-south scan, 4 arc minutes wide, centred on central meridian, once a day. Given the full 4 arc minute field of view of the CDS we require at least 8 images with a repointing of the instrument between each. It is desirable to have some coverage above the poles. We, therefore, propose an 8 image scan using rasters of the full 4 x 4 arcminute CDS field. We note that although there is no particular demand for speed in this operation, the scale of the rastering demands that we use the NIS. The central meridian of the Sun will rotate 3.6 arcmin in one day, so the CDS scans will provide complete coverage.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcsecond
Raster Area:	4 x 4 arcminute
Step (DX, DY):	2 arcsecond, 0 arcsecond
Raster Locations:	120 x 1 = 120
Exposure Time:	15 seconds
Duration of Raster:	2040 sec (34 min) incl. overheads
Number of Rasters:	8
Total Duration:	280 minutes (4.5 hours)
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	11
Telemetry/Compression:	Variable Block Word Length (VBWL default) compression scheme. 12 lines x 11 pixels x 120 pixels x 16 bits @ 10 kbit/s gives 25 s without compression. Factor of 1.67 required.
Pointing:	First raster with F.O.V. centred at solar central meridian and 1 arcmin south of N. pole. Each subsequent raster offset by 4 arcminutes south of the last.
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master.
Solar Feature Tracking:	May be used to offset rasters.

Frequency: To be run once per day preferably at the same time

Product

The SYNOP Study provides eight 4x4 arcmin intensity maps of 12 key emission lines making up a 4x32 arcmin map along the N-S axis of the solar disc. Resolution 2 arcsec.

Joint Observations

Other SOHO instruments will be operating Synoptic schemes and the data-sets will be complementary. The SUMER Synoptic Sequence (POP 31) and the Full Disk Image (POP 06) will be used in conjunction with SYNOP.

GIS Switch On Study - [TEST1]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

This sequence checks the GIS operation without any use of mechanism activity. It should be performed as one of the earliest activities of the commissioning phase.

Study Details

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds or "home" slit
Raster Area:	Same as slit size
Step (DX, DY):	0 arcsecond, 0 arcsecond
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	100 seconds
Number of Rasters:	36
Total Duration:	1 hour
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression
Pointing:	To wherever CDS is directed (no repointing activity)
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	During any commissioning or basic test activity

Product
Full GIS spectrum for 36 exposures, with time resolution 100 seconds.

NIS Switch On Study - [TEST2]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

This sequence checks the NIS operation without any use of mechanism activity. It should be performed as one of the earliest activities of the commissioning phase.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds or "home" slit
Raster Area:	Same as slit size
Step (DX, DY):	0 arcsecond, 0 arcsecond
Raster Locations:	1 x 1 = 1
Exposure Time:	100 seconds
Duration of Raster:	100 seconds
Number of Rasters:	10
Total Duration:	30 min (incl. all overheads)
Line Selection:	Dump Entire CCD Image
Bins Across Line:	N/A
Telemetry/Compression:	No compression (overheads incorporate CCD readout time)
Pointing:	To wherever CDS is directed (no repointing activity)
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	During any commissioning or basic test activity

Product

Full NIS CCD dump, including full spectrum for 10 exposures, with time resolution 30 minutes.

CDS Coarse Pointing Calibration - [TEST3]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

This Study performs a four limb scan in the shape of a large cross, to identify the location of the Sun. It is used to calibrate the pointing mechanism and the Sun Sensor. There is no need for the operation to start at Sun centre.

Study Details

Spectrometer:	GIS Zero Order Detector
Slit:	8 x 50 arcsecond or "home" slit
Raster Area:	same as slit size
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	20 seconds
Duration of Raster:	20 seconds
Number of Rasters:	290
Total Duration:	100 minutes (incl. overheads)
Line Selection:	None (ZOD output only)
Bins Across Line:	N/A
Telemetry/Compresion:	N/A
Pointing:	E-W Scan: 250 rasters, starting from 1000 arcseconds E with 8 arcsecond steps westward. Then, N-S Scan: 40 rasters, starting from 1000 arcseconds N with 50 arcseconds steps southward.
Flags:	N/A
Solar Feature Tracking:	N/A
Frequency:	During commissioning phase and at intervals during mission

Product

Large cross of resolution 8 arcseconds (E-W) and 50 arcseconds (N-S) with Zero Order Detector intensities only

CDS Fine Pointing Calibration - [TEST4]

Contributor(s) - R.A. Harrison

Scientific Justification:

This is similar to TEST3 but uses the GIS detectors and the 2x2 arcseconds slit.

Study Details

Phase 1

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	240 x 2 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	120 x 1 = 120
Exposure Time:	15 seconds
Duration of Raster:	30 minutes
Number of Rasters:	8 (see pointing)
Total Duration:	250 minutes (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	2 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 2 arcseconds
Raster Locations:	1 x 120 = 120
Exposure Time:	15 seconds
Duration of Raster:	30 minutes
Number of Rasters:	8 (see pointing)
Total Duration:	250 minutes (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Grand Total Duration:	8.33 hours
Pointing:	Phase 1: Rasters centred on: 14 arcmin E, 10 arcmin E, 6 arcmin E, 2 arcmin E, 2 arcmin W,

	6 arcmin W, 10 arcmin W, 14 arcmin W. Phase 2: Rasters centred on: 14 arcmin N, 10 arcmin N, 6 arcmin N, 2 arcmin N, 2 arcmin S, 6 arcmin S, 10 arcmin S, 14 arcmin S.
Flags:	N/A
Solar Feature Tracking:	N/A
Frequency:	During commission phase and at intervals during mission

Product
Large cross of resolution 2 arcseconds with full GIS spectrum.

GIS Test Study - [TEST5]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

This Study is a test of the full GIS operation - exercising all of the mechanisms used in normal GIS operation. It includes three sequences with different slits and raster areas.

Study Details

Phase 1

Spectrometer:	Grazing Incidence
Slit:	8 x 50 arcseconds
Raster Area:	240 x 200 arcseconds
Step (DX, DY):	8 arcseconds, 50 arcseconds
Raster Locations:	30 x 4 = 120
Exposure Time:	20 seconds
Duration of Raster:	42 minutes (incl. overhead)
Number of Rasters:	1
Total Duration:	42 minutes
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	2 x 2 arcseconds
Raster Area:	20 x 20 arcseconds
Step (DX, DY):	2 arcseconds, 2 arcseconds
Raster Locations:	10 x 10 = 100
Exposure Time:	30 seconds
Duration of Raster:	53 minutes (incl. overhead)
Number of Rasters:	1
Total Duration:	53 minutes
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Spectrometer:	Grazing Incidence
Slit:	4 x 4 arcseconds
Raster Area:	40 x 40 arcseconds
Step (DX, DY):	4 arcseconds, 4 arcseconds
Raster Locations:	10 x 10 = 100

Exposure Time:	30 seconds
Duration of Raster:	53 minutes (incl. overhead)
Number of Rasters:	1
Total Duration:	53 minutes

Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression
Grand Total Duration:	148 min
Pointing:	To quiet Sun area
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	During commission phase and at intervals during mission

Product

Three rasters of a quiet Sun area using the three GIS slits and the full GIS spectral output.

NIS Test Study 1 - [TEST6]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

There are two Studies for testing the full operation of the NIS system, one provides only limited spectral information but performs complete raster operations, whereas the other consists of single point rasters with the full spectrum returned.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	240 x 240 arcseconds
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	120 x 1 = 120
Exposure Time:	30 seconds
Duration of Raster:	63 minutes (incl. overheads)
Number of Rasters:	1
Total Duration:	63 minutes
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	15
Telemetry/Compression:	No compresion

Phase 2

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcseconds
Raster Area:	240 x 240 arcseconds
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	60 x 1 = 60
Exposure Time:	40 seconds
Duration of Raster:	42 minutes (incl. overheads)
Number of Rasters:	1
Total Duration:	42 minutes
Line Selection:	Synoptic Line Selection (12 lines)
Bins Across Line:	15
Telemetry/Compression:	No compresion

Grand Total Duration:	105 minutes
Pointing:	To quiet Sun area
Flags:	Not used

Solar Feature Tracking:	Not used
Frequency:	During commission phase and at intervals during mission

Product

Two rasters of a quiet Sun are using the two main NIS slits and a 12 line selection.

NIS Test Study 2 - [TEST7]

Contributor(s) - R.A. Harrison (RAL)

Scientific Justification:

See TEST6.

Study Details

Phase 1

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	2 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	50 seconds
Duration of Raster:	445 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	7.4 minutes
Line Selection:	Full NIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Normal Incidence
Slit:	4 x 240 arcseconds
Raster Area:	4 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds
Raster Locations:	1 x 1 = 1
Exposure Time:	50 seconds
Duration of Raster:	445 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	7.4 minutes
Line Selection:	Full NIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Spectrometer:	Normal Incidence
Slit:	90 x 240 arcseconds
Raster Area:	90 x 240 arcseconds
Step (DX, DY):	0 arcseconds, 0 arcseconds

Raster Locations:	1 x 1 = 1
Exposure Time:	50 seconds
Duration of Raster:	445 seconds (incl. overheads)
Number of Rasters:	1
Total Duration:	7.4 minutes
Line Selection:	Full NIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression
Grand Total Duration:	22.2 minutes
Pointing:	To quiet Sun area
Flags:	Not used
Solar Feature Tracking:	Not used
Frequency:	During commission phase and at intervals during mission

Product

Three single point rasters using all NIS slits, providing a full spectral coverage.

Temperature Gradient In A Coronal Hole - [TGRAD]

Contributor(s) - A.H. Gabriel (Orsay) and F. Bely-Dubau (Nice)

Scientific Justification:

Our knowledge of coronal temperatures in open field regions is very limited. The intensity of spectroscopic emission is small - 20-100 times less than closed field regions - due to the low density. Important questions regarding the role of coronal holes in the acceleration of the solar wind demand better information on the variation with height of the coronal temperature.

Thermal models of solar wind acceleration require high temperatures at the base of the wind. Observed wind velocities would require at least 4 million K. Such temperatures are not excluded from present observations if the acceleration occurs at heights not yet observed in emission. However some recent solar wind models propose direct transfer of momentum from Alfvén waves to the medium without dissipation; i.e. without the need for high temperatures. In this case the 1 million K observed in the low corona may be the maximum, and the temperature could fall at greater heights. Thus the determination of the temperature gradient between 1' and 5' above the limb becomes a critical measurement.

In view of the low emission of this part of the corona the best means to measure the temperature is by observations tangientially at the limb. Coronal holes usually exist at the poles and are particularly clear during solar minimum, about the time of the SOHO launch. They can also exist from time to time at lower latitudes. However, such holes will in general be much smaller, and their brightness will usually be contaminated by non-hole regions in the line of sight. For reliable observations we are limited to the poles.

We make use of a temperature sensitive ratio. As the line of sight is perpendicular to the principal temperature gradient we can propose to use a very sensitive line ratio, and interpret the ratio in terms of a local isothermal plasma. We avoid using ionisation ratios or differential emission measure analyses, since these are based on the assumption of ionisation equilibrium, which might not be valid in low density solar wind conditions. However, we would supplement this by analysis of a set of iron ions for a differential emission measure complementary analysis. Since the region scanned could cover a wide range of temperatures we choose a Li-like ion, which is generally present over a wide range. The most sensitive ratio, taking into account solar abundances is that of O VI 2s-2p/2s-3d. Thus, the complete line selection would be (for CDS) O VI 172.93Å and 173.08Å, Fe VIII 168.17Å, Fe IX 171.07Å, Fe X 174.53Å Fe X 177.24Å, Fe XI 180.40Å, Fe XI 188.22Å, Fe XII 193.51Å, Fe XII 186.88Å, Fe XIII 203.79Å, Fe XIII 200.02Å, Fe XIV 211.32Å and Fe XV 284.16Å. However, in practice, the exposure times for this Study are long enough for all of the CDS GIS data to be returned to ground easily.

The O VI ratio consists of lines at 1032 and 1038Å and 173Å and it requires that one of the lines is observed by SUMER and one by CDS. There will be some concern about the relative calibration and alignment, but we do not need absolute information for the ratio. It will be sufficient to see how the temperature increases or decreases above the limb, and to rely on the Sun itself to provide the absolute temperature at the base. Measurements of the SUMER lines present no problem as they are bright. For the 173Å line from CDS there is an intensity problem. We choose the 4 x 240 arcsec slit (provided for the NIS channel) with the GIS, and align this parallel to the solar limb, then it is possible to propose a sequence of stepped positions starting just inside the limb and moving into the corona. We require 5% counting statistics per position and assume that the coronal hole on the disk is 10x weaker than the quiet Sun in estimating exposure times. Note that to get the 4x240 arcsec slit parallel to the limb for a polar coronal hole it is necessary to roll SOHO by 90º.

Study Details

Phase 1

Spectrometer:	Grazing Incidence
Slit:	4 x 240 arcseconds
Raster Area:	80 x 240 arcseconds
Step (DX, DY):	4 arcseconds, 0 arcseconds
Raster Locations:	20 x 1 = 20
Exposure Time:	100 seconds
Duration of Raster:	2020 seconds
Number of Rasters:	1
Total Duration:	2020 seconds (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 2

Spectrometer:	Grazing Incidence
Slit:	4 x 240 arcseconds
Raster Area:	144 x 240 arcseconds
Step (DX, DY):	8 arcseconds, 0 arcseconds
Raster Locations:	18 x 1 = 18
Exposure Time:	1000 seconds
Duration of Raster:	18200 seconds
Number of Rasters:	1
Total Duration:	18200 seconds (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Phase 3

Spectrometer:	Grazing Incidence
Slit:	4 x 240 arcseconds
Raster Area:	96 x 240 arcseconds
Step (DX, DY):	12 arcseconds, 0 arcseconds
Raster Locations:	8 x 1 = 8
Exposure Time:	5000 seconds
Duration of Raster:	40400 seconds
Number of Rasters:	1
Total Duration:	40400 seconds (incl. overheads)
Line Selection:	Full GIS output
Bins Across Line:	N/A
Telemetry/Compression:	No compression

Grand Total Duration:	16.8 hours
Pointing:	Phase 1: FOV centre to 24 arcsec above limb Phase 2: FOV centre to 136 arcsec above limb Phase 3: FOV centre to 256 arcsec above limb NOTE SPACECRAFT ROLL
Flags:	Will not be run in response to interinstrument flag and should not be run with CDS as flag Master or Receiver.
Solar Feature Tracking:	Not required
Frequency:	Should be run on a few occasions during mission especially when spacecraft rolled by 90º

Product

Scan of all GIS spectrum from 16 arcsec within limb to 304 arcsec above limb, from a 240 arcsec wide swath.

Joint Observations

This Study should be run with the SUMER POP 34, Temperature Gradient in a Coronal Hole. It is a component of JOP 2.

Abundances Of Trace Elements In The Transition Region [TRACE]

Contributors: F. P. Keenan, V. J. Foster (QUB), K. J. H. Phillips (RAL)

Scientific Justification:

Over the past few years much effort has been invested on deriving the chemical composition of the solar atmosphere, using both ultraviolet and X-ray observational data (see, e.g. Widing and Feldman 1993; Phillips *et al.* 1993). However many elements still have very poorly known abundances, especially 'trace' elements such as P and Cl (Grevesse and Anders 1989). Reliable solar abundances for these elements are needed, not only because they are interesting in their own right, but also because they are used in conjunction with interstellar medium abundances to infer element depletions, and hence interstellar grain compositions (e.g. Dufton *et al.* 1986; Keenan *et al.* 1990). We therefore propose to measure accurate relative abundances for several trace elements using CDS observations. Initially, we will observe the $2s^2\ ^1S - 2s2p\ ^1P$ resonance lines in Be-like ions between Na VIII and Ca XVII (see Table 1 for species/wavelengths). As the trace elements (such as P and Cl) have nearly identical contribution functions to those of adjacent ions with well determined abundances (such as Si and S), we can determine their relative abundances using the relative intensities of relevant lines (Keenan and Phillips 1990). From these abundance ratios we may hence infer the absolute values for the trace elements, using the known results for Mg, Si, S and Ca (Grevesse and Anders 1989). The above measurements will be compared to results obtained from X-ray spectra (e.g. Phillips *et al.* 1993), to investigate if there are significant differences. In particular, we wish to confirm the findings of Doschek *et al.* (1985), who derived a much larger K/Ca ratio in the corona than in the photosphere, implying a strong anticorrelation between the enrichment of elements in the upper solar atmosphere and their first ionization potential (see Feldman 1992).

References:

Doschek, G.A., Feldman, U. and Seely, J.F. 1985, MNRAS **217**, 317.
Dufton, P.L., Keenan, F.P. and Hibbert, A. 1986, Astr. Astrophys. **164**, 179.
Feldman, U. 1992, Phys. Scripta **46**, 202.
Grevesse, N. and Anders, E. 1989, AIP Conf. Proc. **183**, 201.
Keenan, F.P. *et al.* 1990, Astrophys. J. **348**, 322.
Phillips, K.J.H. *et al.* 1993, Astrophys. J. **419**, 426.
Phillips, K.J.H. and Keenan, F.P. 1990, MNRAS **245**, 4P.
Widing, K.G. and Feldman, U. 1993, Astrophys. J. **416**, 392.

Table 1: Wavelengths of $2s^2\ ^1S - 2s2p\ ^1P$ transitions in Be-like ions.

Species	Wavelength (Å)
Na VIII	411.16
Mg IX	368.06
Al X	332.78
Si XI	303.32
P XII	278.30
S XIII	256.68
Cl XIV	237.70
Ar XV	221.10
K XVI	205.50
Ca XVII	192.82

Study Details:

Spectrometer:	Grazing Incidence
Slit:	2x2 arcsecond
Raster Area:	30x30 arcsecond
Step (DX, DY) :	2, 2 arcsec
Raster Locations:	15 x 15 = 225
Exposure Time:	15 sec
Duration of Raster:	3418 sec (inc. overheads)
Number of Rasters	1
Total Duration:	57 min
Line Selection:	Full GIS output. (Lines used for analysis: Na VIII 411.16, Al X 332.78, Si XI 303.32, P XII 278.30, Ar XV 221.10, K XVI 205.50, Ca XVII 192.82 Å ($2s^2\ ^1\mathrm{S} - 2s2p\ ^1\mathrm{P}$ transitions in Be-like ions.)
Telemetry/Compression:	straight copy 13.1 s = 4 bands x 2048 bins x 16 bits /10 kbits/s
Pointing:	quiet/active regions
Flags:	Will not be run in response to interinstrument flag and will not be run with CDS as flag Master
Solar Feature Tracking	Not necessary

Product:
30 x 30 arcsec maps, with 2 arcsec resolution, in 7 spectral lines, with time resolution of 2290 sec. 21 pixels returned across each line.

Observing Wave Activity With SOHO - [WAVE]

Contributor(s) - K. McClements (Culham), D. Alexander (Montana), R.A. Harrison (RAL)

Scientific Justification:

The very high spectral and spatial resolution which will become available with the SUMER instrument on SOHO may enable us to detect low frequency waves in the solar corona, through the measurement of EUV line widths. Such observations, made in conjunction with CDS, could provide a definitive means of testing wave theories of coronal heating. The method behind this Study is discussed in detail in McClements, Harrison and Alexander (1991, Solar Phys. 131, 41).

The work of McClements et al. shows that the contribution of wave broadening to the total line width will be greatest in the case of heavy ions formed at low temperature. Consider, for example, the 1242Å line of FeXII, formed at 1.6 million K. Assuming a field of 10 G and a density of $10^9 cm^{-3}$ we find that $\Delta\lambda = 0.28$Å when the magnetic field is normal to the line of sight, and $\Delta\lambda = 0.06$Å when it lies along the line of sight. At 1242Å, the optimum spectral resolution of SUMER is 0.025Å, and therefore Alfvén wave broadening should be easily detectable.

The analysis may be generalized to any wave mode. We note that Alfvén waves and acoustic waves produce opposite variations of line width with the direction of the magnetic field.

A large (e.g. active region) loop is identified in the centre of the disc, using the CDS instrument. SUMER is then pointed at a loop footpoint, where the magnetic field is expected to be predominantly longitudinal. The loop is tracked (using CDS and SUMER in conjunction) to the western limb, at which point the footpoint magnetic field will be predominantly transverse. During this time, if the Alfvén wave theory is indeed correct, the width of a line formed in the low corona ought to rise steadily in accordance with the McClements et al. study. Alternatively, one could track a loop from the eastern limb to disc centre. Very long integration times can be used, since the relevant timescale is several days. For this reason, even relatively faint lines can be used. The high spatial resolution will reduce to a minimum the effects of macroturbulence or differential plasma motion on the line width, and will also increase the possibility that the magnetic field within a single pixel has a well--defined direction.

The operation listed below gives the basic features of the CDS support programme. The pointing is either to active regions in search of a loop or to a pre-defined loop. The programme may be broken off and returned to on several occasions as the loop crosses the Sun. Alternatively, we may choose to follow the loop continually. The CDS data will determine the SUMER pointing. At least one common CDS/SUMER line will ensure good alignment of images after the operation - we use the He I 584.33Å line for this.

Study Details

Spectrometer:	Normal Incidence
Slit:	2 x 240 arcseconds
Raster Area:	4 x 4 arcminutes
Step (DX, DY):	2 arcseconds, 0 arcseconds
Raster Locations:	120 x 1 = 120
Exposure Time:	20 seconds
Duration of Raster:	2760 seconds (46 minutes) (incl. overheads)
Number of Rasters:	open
Total Duration:	open

Line Selection:	Dynamic Line Selection (9 lines)
Bins Across Line:	15
Telemetry/Compression:	16 to 12 bit compression
Pointing:	To pre-selected active region/loop site
Flags:	Will not be run in response to interinstrument flag but may be run with CDS as Master/Receiver.
Solar Feature Tracking:	May be required, depending on location of target.
Frequency:	To be run in occasional campaigns during mission

Product

4x4 arcmin images with 2 arcsec resolution every 46 minutes in 9 spectral lines - for supporting a SUMER/CDS wave detection programme. 21 pixels are returned across the line profiles.

CDS Study Form

Study Title and ID

Contributor(s) -

Scientific Justification:

Study Details

Spectrometer:
Slit:
Raster Area:
Step (DX, DY):
Raster Locations:

Exposure Time:
Duration of Raster:
Number of Rasters:
Total Duration:

Line Selection:
Bins Across Line:

Telemetry/Compression:

Pointing:

Flags:

Solar Feature Tracking:

Frequency:

Product

Joint Observations

[**Submit to:** CDS Science Planning and Exploitation Committee, c/o Dr R.A. Harrison, Building R25, Rutherford Appleton Laboratory, Chilton, Didcot, Oxfordshire OX11 0QX, UK.]

15. Appendix 5: DATABASES - LINE LISTS

FULL GIS OUTPUT (GIS)

Full 4 x 2048 pixel output covering the ranges 151-221, 256-338, 393-493, 656-785Å.

FULL NIS OUTPUT (NIS)

Full 1024 x 256 pixel output, covering the two NIS wavelength ranges 308-381, 513-633Å

FULL NIS CCD IMAGE (NIS)

Complete dump of entire VDS CCD - 1024 x 1024 pixels.

GIS 2ND DETECTOR (GIS)

Full output of 2nd GIS detector, i.e. 256-338Å.

NIS BAND ONE (NIS)

Full output from NIS 308-381Å band.

SYNOPTIC LINE SELECTION (NIS)

This is a series of NIS well separated lines giving a good range of temperatures with some density diagnostics.

Ion	Wavelength (Å)	Log Te	Comment
He I	584.33	4.3	cool, granulation, depleted in holes
Mg VI	349.13	5.6	
Mg VIII	313.73	5.9	
Mg IX	368.06	6.0	good for hole boundary/structure
Mg X	624.94	6.1	
Fe XI	369.16	6.1	
Fe XII	364.47	6.2	
Fe XII	338.26	6.2	density sensitive with 364.47
Fe XIII	320.80	6.2	
Fe XIII	318.14	6.2	density sensitive with 320.80
Fe XIV	334.17	6.3	
Fe XV	327.02	6.3	

DYNAMIC LINE SELECTION (NIS)

This selection gives a series of bright, NIS lines of widely varying temperatures which are

Ion	Wavelength (Å)	Log Te
He I	584.33	4.3
O III	599.59	4.9
O IV	554.52	5.3
Ne VI	562.83	5.6
Mg VIII	313.73	5.9
Mg IX	368.06	6.0
Fe XIII	320.80	6.2
Fe XIV	334.17	6.3
Fe XVI	335.40	6.4

FAST DYNAMIC LINE SELECTION (NIS)

This selection is a shorter version of the Dynamic Line Selection, for faster operation.

Ion	Wavelength (Å)	Log Te
He I	584.33	4.3
O IV	554.52	5.3
Mg IX	368.06	6.0
Fe XIV	334.17	6.3

LITHIUM-LIKE LINE SELECTION (NIS)

This selection consists of the relatively bright Lithium-like 2s-2p transitions.

Ion	Wavelength (Å)	Log Te
Mg X	624.94	6.0
Mg X	609.79	6.0
Al XI	550.00	6.2
Al XI	567.80	6.2
Si XII	520.67	6.3
Ar XVI	353.92	
K XVII	326.78	
K XVII	365.66	
Ca XVIII	344.77	
C IV	312.44	

BERYLLIUM-LIKE LINE SELECTION (NIS)

This selection consists of the Be-like $2s^2\ ^1S$ - $2s2p\ ^1P$ transitions available in the NIS.

Ion	Wavelength (Å)	Log Te
O V	629.73	5.3
Mg IX	368.06	6.0
Al X	332.77	6.0
Si XI	303.33 (2nd order)	6.2

BORON-LIKE LINE SELECTION (NIS)

This selection consists of the Boron-like $2s^2 2p$ - $2s2p^2$ transitions which are available in the NIS ranges.

Ion	Wavelength (Å)	Log Te
Mg VIII	313.73	5.9

Mg VIII	317.01	5.9
Mg VIII	339.00	5.9
Si X	347.40	6.0
Si X	356.04	6.0
O IV	553.33	5.3
O IV	554.52	5.3
O IV	555.28	5.3
O IV	609.79	5.3
Ne VI	558.59	5.6
Ne VI	562.83	5.6

IRON LINE SELECION (NIS)

This is a series of relatively bright, ground state transition lines for a wide temperature range of iron ions from Fe X to Fe XXII. It includes the He I line to allow co-registration with cooler temperature observations but as this list will often be used on active regions the He I line at 522Å is chosen in preference to the much brighter He I line at 584Å.

Ion	Wavelength (Å)	Log Te	Comment
He I	522.20	4.3	cool line for co-registration with longer wavelength data - not as bright as 584Å in AR
Fe X	345.74	6.1	
Fe XI	369.16	6.1	
Fe XII	338.26	6.2	density diagnostic w. 364Å
Fe XII	364.47	6.2	density diagnostic w. 338Å
Fe XIII	348.18	6.2	density diagnostic w. 359Å
Fe XIII	359.64	6.2	density diagnostic w. 348Å
Fe XIV	334.17	6.3	
Fe XVI	335.40	6.4	
Fe XXI	335.9	7.1	hot, flare-like line
FeXXII	349.3	7.1	hot, flare-like line

SUNSPOT LINE SELECION (NIS)

This is a series of relatively bright line from a range of temperatures, suitable for studying the corona above sunspots.

Ion	Wavelength (Å)	Log Te	Comment
He I	522.20	4.3	Not as excessively bright at He I 584 (i.e. less chance of saturation in active region)
O III	599.59	4.9	
O IV	554.52	5.3	
O V	629.73	5.3	
Ne VI	562.83	5.6	
MgVIII	315.02	5.9	
Mg IX	368.06	6.0	
Fe XIV	334.17	6.3	
Fe XVI	360.76	6.4	

DENSITY SENSITIVE LINE SELECION (NIS)

This selection provides 8 relatively bright lines, i.e. 4 density sensitive pairs found in the NIS.

Ion	Wavelength (Å)	Log Te

Si IX	345.13	6.0
Si IX	341.95	6.0
Si X	347.40	6.0
Si X	356.04	6.0
Fe XII	338.26	6.2
Fe XII	364.47	6.2
Fe XIII	320.80	6.2
Fe XIII	348.18	6.2

CORONAL HOLE LINE SELECION 1 (NIS)

This selection provides a sequence of bright Fe emission lines from a range of temperatures, some density sensitive ratios and the Mg IX line which is excellent for identifying coronal hole boundaries and structure.

Ion	Wavelength (Å)	Log Te	Comment
Fe VIII	370.43	5.6	
Fe X	365.57	6.1	
Fe XI	356.54	6.1	
Fe XII	364.47	6.2	density sensitive with 338.17
Fe XII	338.17	6.2	density senstive with 364.47
Fe XIII	348.18	6.2	
Fe XIV	334.17	6.3	
Fe XVI	335.40	6.4	
Si IX	349.87	6.0	density sensitive with 341.95
Si IX	341.95	6.0	density senstive with 349.87
Si X	347.40	6.0	density sensitive with 356.04
Si X	356.04	6.0	density sensitive with 347.40
Mg IX	368.06	6.0	good identifier of c. hole boundary and structure

CORONAL HOLE LINE SELECION 2 (NIS)

This selection provides a sequence of bright Fe emission lines from a range of temperatures, some density sensitive ratios and the Mg IX line which is excellent for identifying coronal hole boundaries and structure.

Ion	Wavelength (Å)	Log Te	Comment
Fe VIII	370.43	5.6	
Fe X	365.57	6.1	
Fe XII	364.47	6.2	density sensitive with 338.17
Fe XII	338.17	6.2	density senstive with 364.47
Fe XIV	334.17	6.3	
Fe XVI	335.40	6.4	
Si IX	349.87	6.0	density sensitive with 341.95
Si IX	341.95	6.0	density senstive with 349.87
Mg IX	368.06	6.0	good identifier of c. hole boundary and structure

CORONAL HOLE LINE SELECION 3 (NIS)

This selection provides a basic sequence for the identification of coronal hole structure, flows, brightenings etc...

Ion	Wavelength (Å)	Log Te	Comment
He I	584.33	4.3	identifies granulation
Mg IX	368.06	6.0	identifies coronal hole boundary and structure

O III	599.59	4.9	
Ne VI	562.83	5.6	
Fe XIII	320.80	6.2	
Fe XVI	335.40	6.4	

MICROFLARE LINE SELECION (NIS)

This selection provides a basic core of very bright lines for use in fast operations looking for, e.g. microflares.

Ion	Wavelength (Å)	Log Te	Comment
He I	537.03	4.3	
O IV	554.52	5.3	
Mg IX	368.06	6.0	
Fe XIV	334.17	6.3	

INTERCALIBRATION LINE SELECION (NIS)

This selection consist of the NIS lines required for cross calibration with the GIS, with SUMER, EIT and UVCS.

Ion	Wavelength (Å)	Log Te	Seen also in:-
MgVIII	313.73	6.0	GIS
MgVIII	315.02	6.0	GIS
MgVIII	317.01	6.0	GIS
Fe XIII	320.80	6.2	GIS
Fe XV	321.78	6.3	GIS
Fe XV	327.02	6.3	GIS
Fe XIV	334.17	6.3	GIS
Fe XVI	335.40	6.4	GIS
Si IX	345.13	6.0	GIS
Si XII	520.67	6.3	UVCS
He I	584.33	4.3	SUMER
Mg X	609.79	6.0	SUMER,UVCS
Mg X	624.94	6.0	SUMER,UVCS

ALIGNMENT LINE SELECION (NIS)

This selection consist of the NIS lines required for co-alignment activities with SUMER and the GIS.

Ion	Wavelength (Å)	Log Te	Seen also in:-
MgVIII	313.73	6.0	GIS
Fe XIII	320.80	6.2	GIS
Fe XIV	334.17	6.3	GIS
He I	584.33	4.3	SUMER

PROMINENCE LINE SELECION 1 (NIS)

This selection covers a range of cool and hot lines suitable for the study of prominences.

Ion	Wavelength (Å)	Log Te	Comments
Fe XIII	320	6.2	
Fe XIV	334	6.3	

Si IX	341	6.0	
Si IX	345	6.0	
Mg IX	368	6.0	
He I	522	4.3	
O III	525	4.9	
He I	537	4.3	
O IV	553	5.3	
O IV	554	5.3	
Ne VI	562	5.6	
He I	584	4.3	
O III	599	4.9	
He II	304	4.7	2nd order
Mg X	624	6.1	
O V	629	5.3	