IRIS Technical Note 31
IRIS science planning

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1. Introduction

The main goal of this document is to provide an outline and guide to early operations so that IRIS obtains high quality and novel measurements that address the three science goals from the very start of the scientific mission, when throughput is maximal and the Sun is likely to be the most active. In the following we briefly outline the basic IRIS observing modes that have been designed to address these goals (section 2), the observing tables (section 3), the linelists (section 4), count rates (section 5), and targets (section 6).

2. Basic IRIS observing modes

IRIS contains an imaging spectrograph that allows observations of:
- spectra in two wavelength ranges in the FUV (1331-1358Å, 1390-1407Å)
- spectra in a wavelength range in the NUV (2782-2834Å)
- slit-jaw images in two bandpass in the NUV (Mg II h/k 2796Å and Mg II wing 2832Å) and two bandpasses in the FUV (C II 1330 Å, Si IV 1400Å)

IRIS has a slit that is 1/3” wide. The imaging devices have 1/6” pixels with a spatial resolution of 0.33-0.4” in the FUV and NUV. The slit-jaw images cover a FOV of 175”x175”, while the slit has a length of 175”.

The spectral pixel size is 13mÅ with a spectral resolution of 26mÅ in the FUV, and 26mÅ and 60mÅ respectively in the NUV.

High throughput, and fast readout and mechanism movements allows cadences for the spectra to be as short as 1-2 seconds, with rastering options varying from sit-and-stare, dense (at 1/3” or less step sizes), sparse (>1/3”) and various combinations of sparse and dense possible.

The spacecraft can be pointed anywhere within 4 arcmin off the solar limb. IRIS can be rolled at any angle from -90 to 90 degrees with respect to solar north for extended periods of time.

While IRIS is extremely flexible in its operations, we strive to limit complexity in operations, calibration and data analysis by exploiting a selection of workhorse modes that can address all of the above science goals.

3. Observing Tables

The IRIS science planner can choose from a variety of observing tables. There are calibration OBS tables which have an OBS-ID larger than 4.2 billion.
The pre-defined or default observing tables are used for science observations. They have OBS-IDs that start with 3.8 or 4.0 billion. They are organized so that they ALWAYS take an FUV and NUV spectrum simultaneously, with various SJI images slotted in as desired. The cadence, raster type, exposure times are controlled by the OBS-ID numbers, as outlined in Table 1.

OBS ID parent	Description
0-100	Basic raster type (sit-and-stare, rasters, …)
0-2,000	SJI choices
0-12,000	Exposure times
0-220,000	Summing modes (applied to FUV, NUV, SJI)
0-750,000	FUV summing modes
0-4,000,000	SJI cadence
0-10,000,000	Compression choices
0-180,000,000	Linelists
3.8-4 billion	OBS table generation number

Table 1: OBS ID numbering scheme

Here are some details:
1. OBS-ID 0 to 1999: variations in cadence and wavelength choice of the four SJI filter images (C II 1335Å, Si IV 1400Å, Mg II h/k 2796Å, Mg II h/k wing 2830Å). Nominally cadence is ~10 seconds. If a “s” is following the wavelength, it means the cadence is slower (~60 seconds).

2. OBS-ID 2000 to 13999: variations in exposure time. Deep x 2 means exposure times are doubled, which lowers the cadence by roughly a factor of 2. Etc.

3. OBS-ID 20,000 to 239,999: variations in onboard summing for the whole spectrograph.

4. OBS-ID 250,000 to 999,999: variations in onboard summing but applied only to the FUV spectra.

5. OBS-ID 1 million to 4 million: variations in SJI cadence.

6. OBS-ID 10 million to 20 million: variations in compression.

7. OBS-ID 20 million to 200 million: variations in linelist (and thus cadence, see ITN 1 and below), including full readout.

There are now two versions of the tables:

- Version 4.0 was generated before launch, contains less optimal line lists, and rasters 10-41 are running much slower than we should ever run: v40 OBS-ID 10-41 should never be run. **Version 4.0 is now deprecated.**
- Version 3.8 was generated in September 2013, contains optimized line lists and rasters. **Planners should use version 3.8 unless they have good reason to use 4.0.**

The default table selector running in the timeline software or the table creator shows a drop-down menu that allow the planner to select properties of the observing sequence, as outline in table 2.

For v38 the OBS tables 1-49 are aggressive in terms of timing, i.e., they run as fast as possible, which could lead to skipped frames. For now these are preferred.
Tables 51-99 are somewhat slower but otherwise identical to 1-49, i.e., table 51 is a slightly slower table than table 1, and so on.

OBS-ID	Raster step	Steps	Raster FOV	SJI FOV	Description
1	0.33	1s	0.3x30	60x60	Small sit-and-stare
2	0.33	1s	0.3x60	60x60	Medium sit-and-stare
3	0.33	1s	0.3x120	120x120	Large sit-and-stare
4	0.33	1s	0.3x175	175x175	Very large sit-and-stare
5	0.33	2s	0.33x30	60x60	Small dense 2-step raster
6	0.33	2s	0.33x60	60x60	Medium dense 2-step raster
7	0.33	2s	0.33x175	175x175	Very large dense 2-step raster
8	1	2s	1x60	60x60	Medium sparse 2-step raster
9	1	2s	1x120	120x120	Large sparse 2-step raster
10	1	2s	1x175	175x175	Very large sparse 2-step raster
11	2	2s	2x60	60x60	Medium coarse 2-step raster
12	2	2s	2x120	120x120	Large coarse 2-step raster
13	2	2s	2x175	175x175	Very large coarse 2-step raster
14	0.33	4s	1x30	60x60	Small dense 4-step raster
15	0.33	4s	1x60	60x60	Medium dense 4-step raster
16	0.33	4s	1x175	175x175	Very large dense 4-step raster
17	1	4s	3x60	60x60	Medium sparse 4-step raster
18	1	4s	3x120	120x120	Large sparse 4-step raster
19	1	4s	3x175	175x175	Very large sparse 4-step raster
20	2	4s	6x60	60x60	Medium coarse 4-step raster
21	2	4s	6x120	120x120	Large coarse 4-step raster
22	2	4s	6x175	175x175	Very large coarse 4-step raster
23	0.33	8s	2.32x30	60x60	Small dense 8-step raster
24	0.33	8s	2.32x60	60x60	Medium dense 8-step raster
25	0.33	8s	2.32x175	175x175	Very large dense 8-step raster
26	1	8s	7x60	60x60	Medium sparse 8-step raster
27	1	8s	7x120	120x120	Large sparse 8-step raster
28	1	8s	7x175	175x175	Very large sparse 8-step raster
29	2	8s	14x60	60x60	Medium coarse 8-step raster
30	2	8s	14x120	120x120	Large coarse 8-step raster
31	2	8s	14x175	175x175	Very large coarse 8-step raster
32	0.33	16s	5x60	60x60	Medium dense 16-step raster
33	0.33	16s	5x120	120x120	Large dense 16-step raster
34	0.33	16s	5x175	175x175	Very large dense 16-step raster
35	1	16s	15x60	60x60	Medium sparse 16-step raster
36	1	16s	15x120	120x120	Large sparse 16-step raster
37	1	16s	15x175	175x175	Very large sparse 16-step raster
38	2	16s	30x120	120x120	Large coarse 16-step raster
39	2	16s	30x175	175x175	Very large coarse 16-step raster
40	0.33	64s	20.8x120	120x120	Large dense 64-step raster
41	0.33	64s	20.8x175	175x175	Very large dense 64-step raster
42	1	64s	63x120	120x120	Large sparse 64-step raster
43	1	64s	63x175	175x175	Very large sparse 64-step raster
44	2	64s	126x120	120x120	Large coarse 64-step raster
45	2	64s	126x175	175x175	Very large coarse 64-step raster
46	0.33	400s	131.7x175	175x175	Very large dense raster
47	0.33	96s	31.35x175	175x175	Dense synoptic raster
48	1	36s	35x175	175x175	Sparse synoptic raster
49	2	18s	34x175	175x175	Coarse synoptic raster

OBS ID	Description
0	C II Si IV Mg II h/k Mg II w
100	C II Si IV Mg II h/k Mg II w s
200	C II Si IV Mg II w s
300	C II Mg II h/k Mg II w s
400	Si IV Mg II h/k Mg II w s
500	C II Mg II w s
600	Si IV Mg II w s
700	Mg II h/k Mg II w s
800	Si IV Mg II h/k Mg II w
900	C II Mg II h/k Mg II w
1000	C II Si IV Mg II w
1100	C II Si IV Mg II h/k
1200	C II Si IV
1300	C II Mg II h/k
1400	Si IV Mg II h/k
1500	C II
1600	Si IV
1700	Mg II h/k
1800	Mg II w
1900	Mg II h/k Mg II w
0	1s exposures
2000	Deep x 0.5
4000	Deep x 2
6000	Deep x 4
8000	Deep x 8
10000	Deep x 15
12000	Deep x 30

OBS ID	Description
0	Spatial x 1, Spectral x 1
20000	Spatial x 1, Spectral x 2
40000	Spatial x 1, Spectral x 4
60000	Spatial x 1, Spectral x 8
80000	Spatial x 2, Spectral x 1
100000	Spatial x 2, Spectral x 2
120000	Spatial x 2, Spectral x 4
140000	Spatial x 2, Spectral x 8
160000	Spatial x 4, Spectral x 1
180000	Spatial x 4, Spectral x 2
200000	Spatial x 4, Spectral x 4
220000	Spatial x 4, Spectral x 8
0	FUV spectrally rebinned x 1
250000	FUV spectrally rebinned x 2
500000	FUV spectrally rebinned x 4
750000	FUV spectrally rebinned x 8
0	SJI cadence ~10s
1000000	SJI cadence 0.25x faster
2000000	SJI cadence 0.5x faster
3000000	SJI cadence 3x faster
4000000	SJI cadence 10x faster
0	Default compression
10000000	Lossless compression
0	Large Linelist
20000000	Medium Linelist
40000000	Small Linelist
60000000	Flare Linelist
80000000	Full Readout

Table 2: v38 OBS ID scheme

4. Linelists

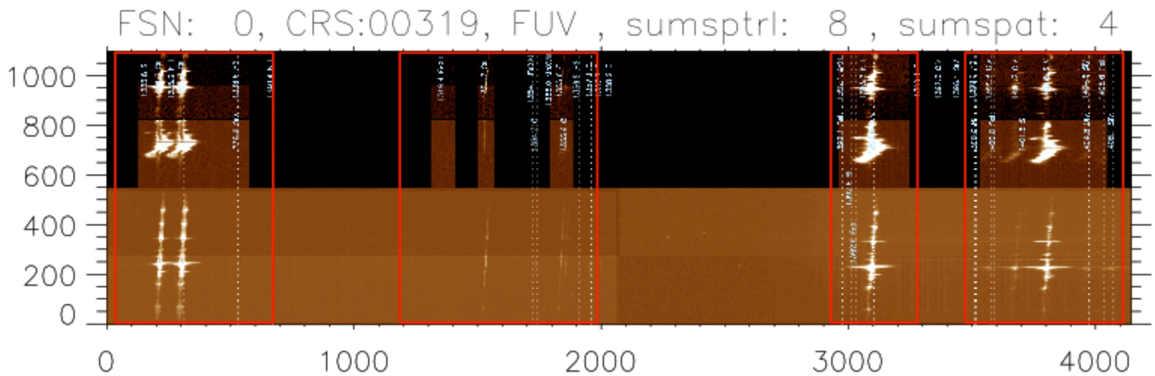
Five different linelists have been predefined. The 80 million series is full readout so contains the full wavelength range in both FUV and NUV.
The other linelists are:

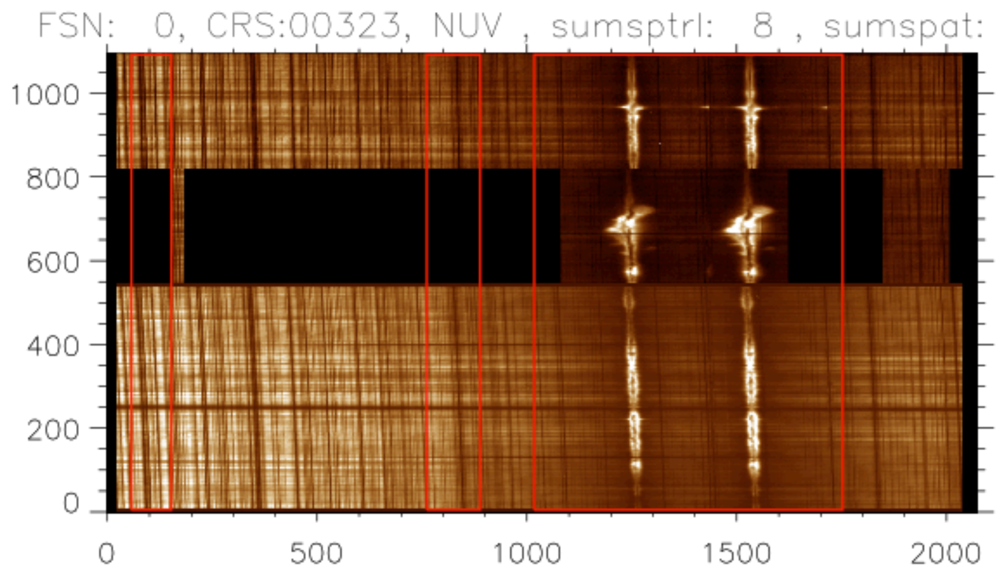
- Large Linelist (0 million)
- Medium Linelist (20 million)
- Small Linelist (40 million)
- Flare Linelist (60 million)

The following figures illustrate the wavelength ranges covered by the linelists. Note that larger wavelength regions take longer to read out and affect the cadence. These also lead to much larger downlink rate. The fastest cadence can be reached with the small linelist.

In what follows below readout times are given for 1x1 summing. Summed images are read out faster. ROI drawn as red boxes on real IRIS spectra showing the most explosive events I could find (no flares yet). NUV: wavelength increasing towards the left, as imaged by the camera (=Level 0).

4.1 Large Linelist (0 million)

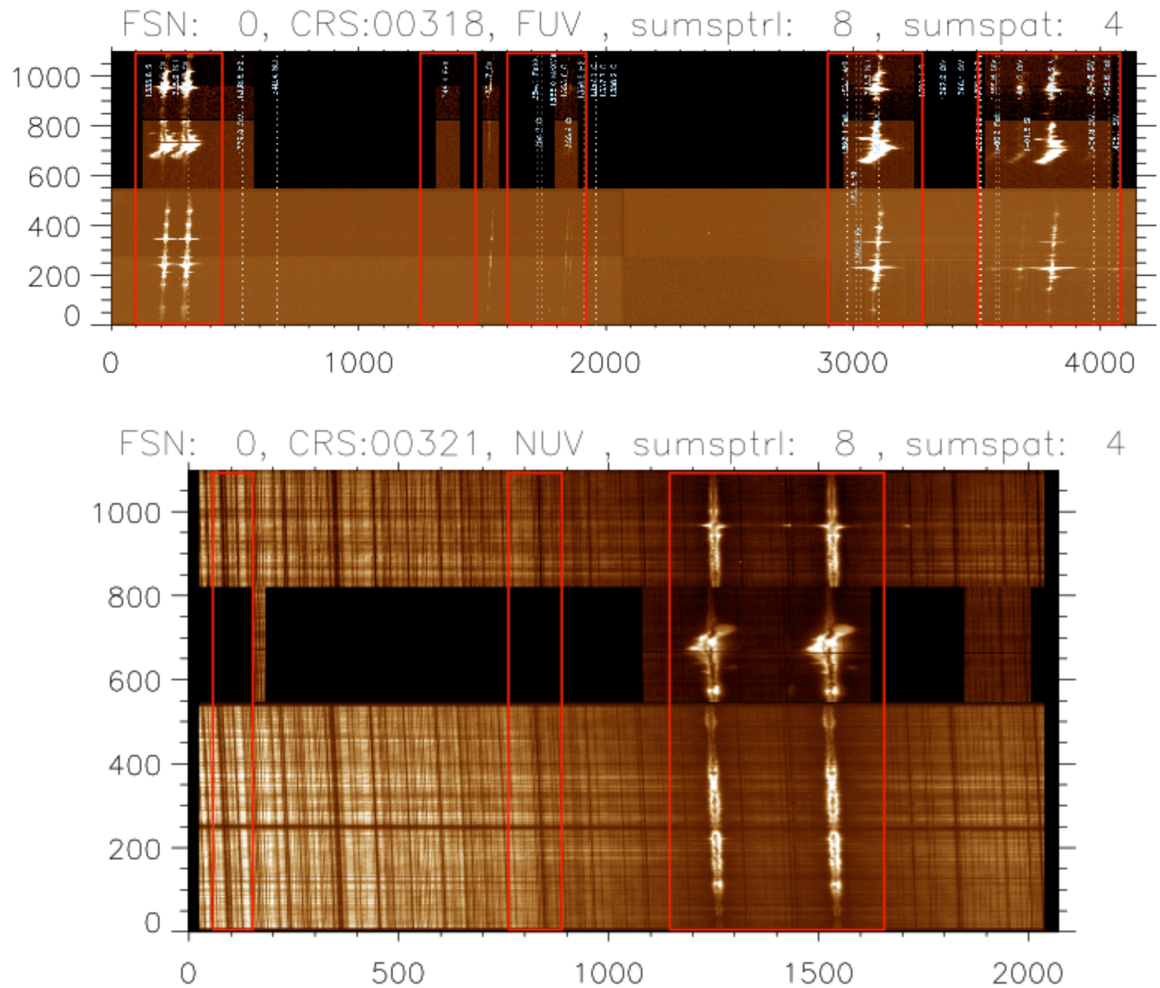




FUV: Nearly the full CCD is read out due to mirroring (not shown), but only ROI containing most lines are downlinked. A full readout would take ~760 ms, but would have a significantly larger data volume for downlink. Readout time: 691 ms.

NUV: ~600 km/s Doppler around Mg II lines. Only linelist apart from flare list that will also capture Mg II 3p-3d transitions for both lines. Readout time: > 470 ms (depending on SJI)

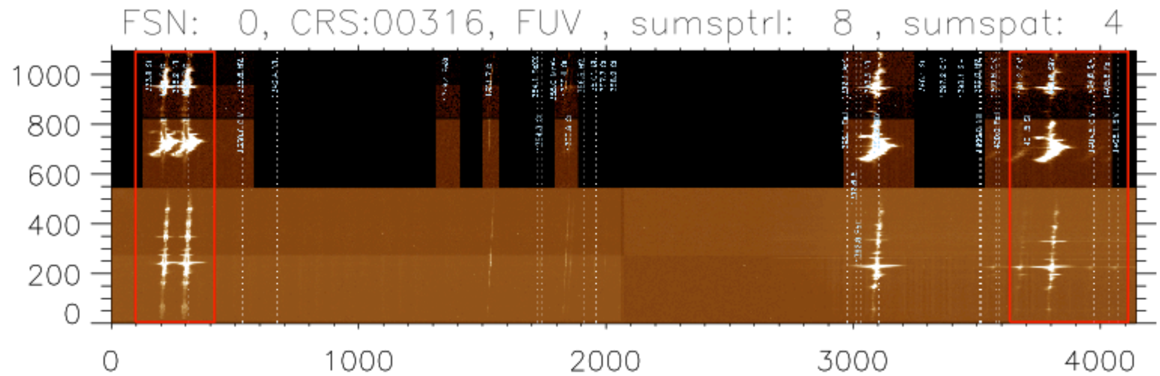
4.2 Medium Linelist (20 million)

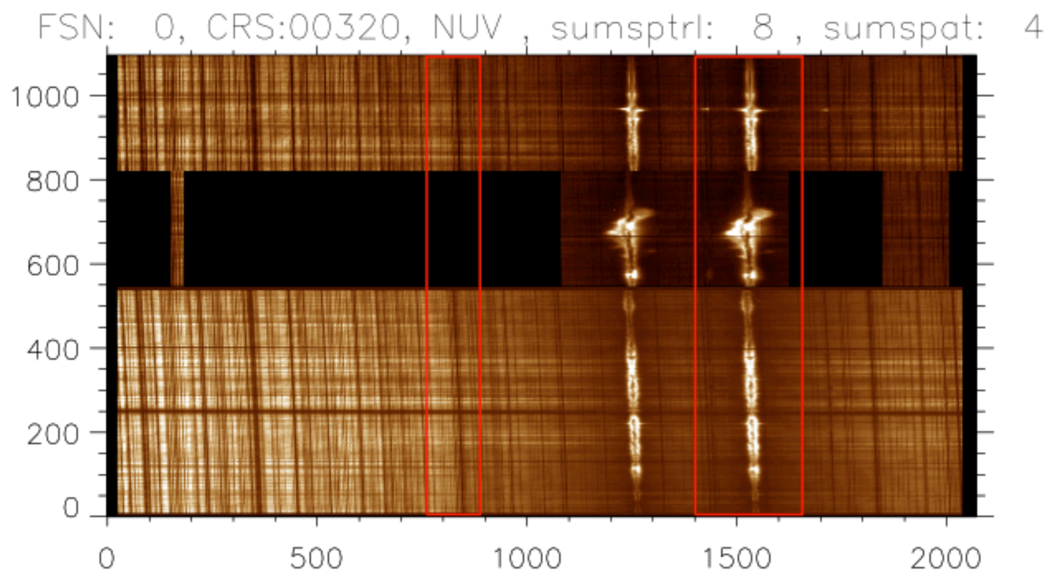


FUV: includes most lines, 300 km/s for most regions. Readout time: 620 ms.

Medium: Both Mg II lines, photospheric reference line, plus continuum. ~300 km/s Doppler for Mg II. Readout time: >409 ms (depending on SJI)

4.3 Small Linelist (40 million): NO CORONAL LINE

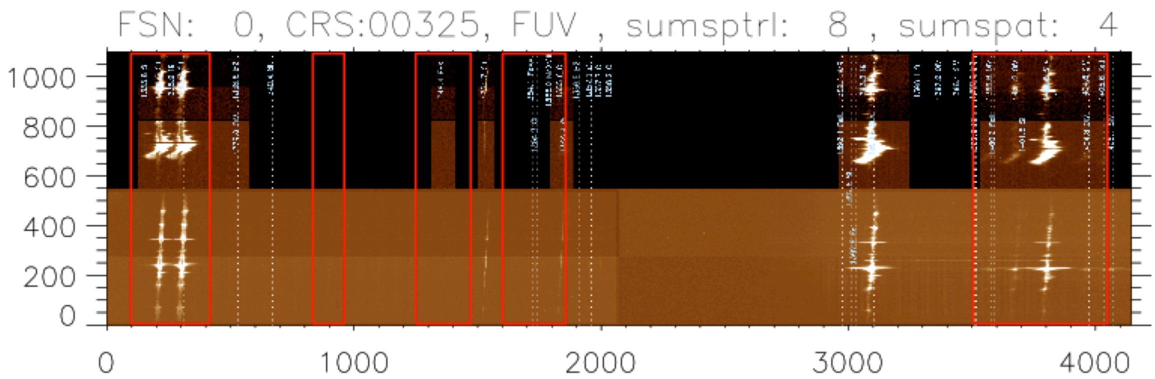


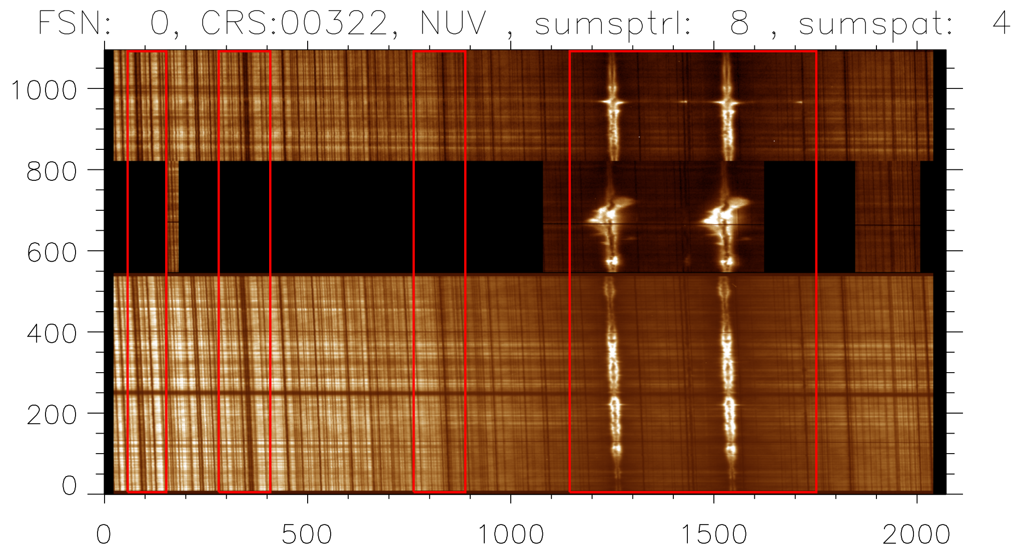


FUV: minimal readout for fast observing programs, ~400 km/s Doppler shifts, focusing on Si IV and C II (and some extra lines that we got due to mirroring and 8x4 readout restrictions). If the width of the box around 1405 A were changed, that would automatically decrease the captured Doppler shifts near the first C II line (because of readout mirroring). That's why there is a rather large range to the right of Si IV. All other lists include O IV 1399, so it is skipped for this list. Readout time: 339 ms

NUV: Only Mg II K line, plus photospheric reference. ~300 km/s Doppler. Readout time: >313 ms (depending on SJI)

4.4 Flare Linelist (60 million)





FUV: Si IV and CII. Both Fe lines (XXI and XII) and (allowed) O IV 1343.5 line (flare only). The Fe XXI line can easily show 2nd component emission at 400km/s blueward in flares. We have already seen such high velocities in HINODE/EIS flare observations. The line pair of O IV 1399/1401 is the best density sensitive line pair in IRIS spectral range. Readout time: 523 ms.

NUV: 600 km/s Doppler for blue wing. Keeping some of the red wing (~250 km/s) because there might be a red asymmetry. It looks like this asymmetry could be observed up to ~100 km/s in previous H-alpha and Ca K observations, with rather low spatial resolution (http://adsabs.harvard.edu/abs/1960BAICz..11..177F). More lines in the wing are added to possibly see line core reversals. These reversals could help diagnosing the height of the flare heating. Readout time: > 470 ms (depending on SJI)

5. Count rates

To ensure that data is obtained with reasonable signal-to-noise the exposure time should be adapted to the target on the Sun. The figures below show the typical count rates for 4s exposure times, both on disk and off limb.

Preliminary analysis suggest the following exposure times are reasonable:

- AR plage, sunspots: 2s exposure times, if coronal lines desired, 30s exp. time
- QS/CH: 4-8s exposure times
- Filament may be OK with 4s exposure times
- Spicules: 4-8s exposure times

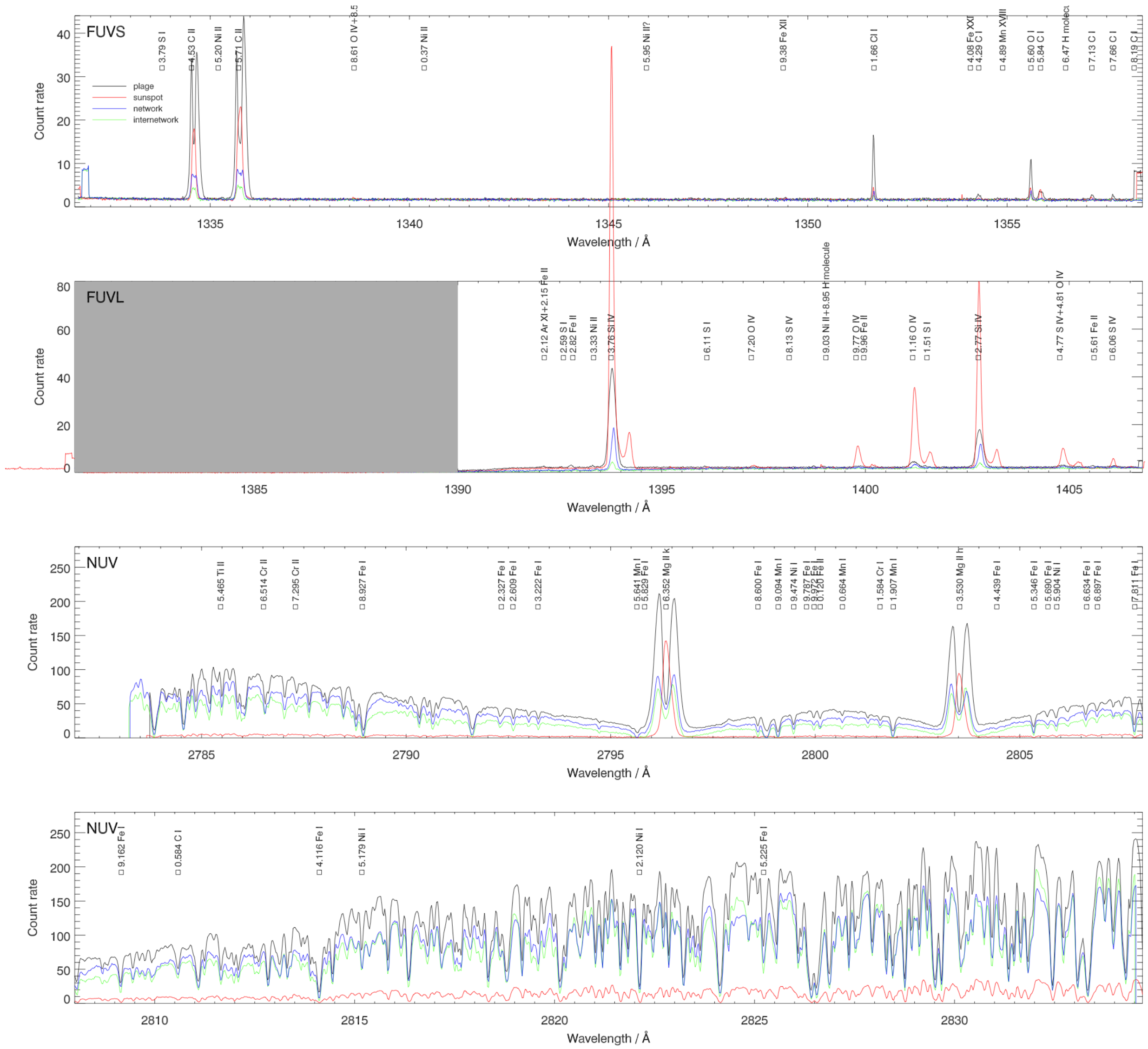


Figure: Typical count rates for on-disk targets in 4s exposure time.

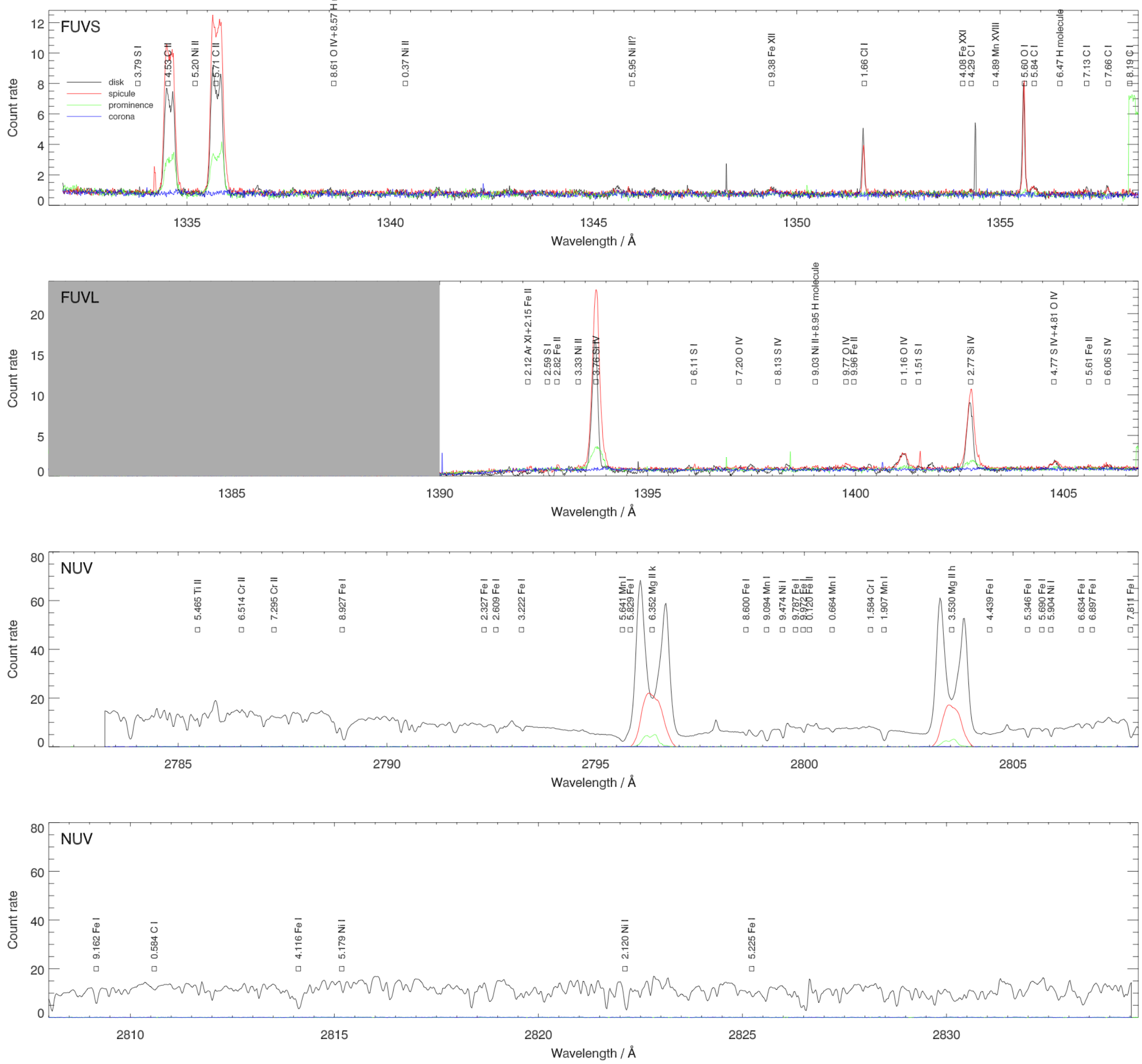


Figure: Typical count rates for limb targets in 4s exposure time.

6. Typical Observing Programs to be run

6.0 Overall comments

As observations are collected and data is analyzed the typical OBS programs to be run will continue to evolve. Here are some top-level comments [early Oct 2013]:

- The Sun changes on very short timescales, of order 5-20s. When considering observing programs, a compromise between exposure times (counts!) and raster cadence needs to be considered, depending on the science goal. High cadence runs are high priority, but statistical studies of regions at lower cadence are also important.

- High cadence runs are high priority. In practice this means that for high cadence runs we can run 1/2/4/8 step rasters in ARs (short exposure times) and for other targets we will run more 1/2 step rasters (long exposure times). The 2-step rasters are useful for propagation studies. Typical high cadence run is 1 to a few hours (because of data rate limitations).

- Single or low repeat large raster scans before and after high cadence runs are important. These can have many more steps than high cadence runs, either sparse or coarse 64-step rasters or dense 400 step rasters. Beware of the data limitations here.

- Timeseries of medium raster scans (dense/sparse/coarse 64 step rasters) are very useful too -- we have not yet taken many of these and should take more.

- Coronal observations are of high interest and require longer exposure times (~30s). Should be taken often in the next few weeks for all different targets. Take some nice sit-and-stares and deep raster scans of ARs, QS, CH, etc...

- To reduce datarate FUVx2 is useful -- other summing modes should be used sparingly except in one case (“low-daterate program”, see below)

- Lossy compression is fine for now.

- Typical SJI combination to be used is 100-series if it doesn’t lead to issues with cadence. Cadence of SJI’s 1330, 1400 and 2796 should not go much above 20-30 seconds. For many high cadence runs we probably don’t want SJI cadence to go much above 10s. If cadence goes beyond what you want because of long exposure times, drop the 2830 first. If that still leads to issues in terms of cadence, then drop 1330, then 2796, leaving 1400 as the winner.

- The small linelist should ONLY be used if very high cadence is the main focus. It does not have the coronal line so should generally be avoided. Typically the medium linelist should probably be used.

The overall activities consist of observations of:

6.1 Active Regions

The goal is to track an active region on a roughly daily basis as it crosses from one limb to the other to sample a wide variety of viewing angles and activity stages. For each “day” of observing the active region, IRIS should spend a significant fraction of a day pointed at roughly the same target while obtaining a variety of types of rasters:

a. large dense or coarse rasters that cover a large fraction of the active region,
b. small dense (and thus fast) rasters to study dynamics,
c. sit-and-stare “rasters” (to focus on the fastest dynamics),
d. deep rasters (to obtain the weakest lines), etc…
e. propagation studies (two or four step fast rasters)

The smaller rasters should be focused alternately on sunspots, plage or fans (whereas the larger rasters will cover the whole region). We should also perform some of these observations while rolled. Most of these observations should be done with solar rotation tracking.

6.2 Quiet Sun

The goal is to obtain quiet Sun observations for a variety of viewing angles from the limb to disk center. This should be done every few days so as not to interfere with the active region tracking too much (see 6.1). For each day of “observing” the quiet Sun, IRIS should spend about 6 hours pointed at roughly the same target and obtain a variety of types of rasters:

a. small dense (and thus fast) rasters to study dynamics,
b. large dense or coarse rasters that cover a large fraction of the active region,
c. sit-and-stare “rasters” (to focus on the fastest dynamics),
d. deep rasters (i.e, 30s exp time, to obtain the weakest lines), etc…
e. propagation studies (two or four step fast rasters)

Note that the quiet Sun count rates are lower so the cadence of these observations will be reduced compared to active region. We should also perform some of these observations while rolled. Most of these observations should be done with solar rotation tracking.

6.3 Coronal Hole

The goal is to obtain coronal hole observations for a variety of viewing angles from the limb to disk center, starting with the limb. The exposure times are similar to those in quiet Sun, but the overall approach is similar to that described in 6.2: every few days we should focus on a coronal hole for about 6-12 hours.

6.4 Prominences

The goal is to obtain prominence observations for a variety of viewing angles from the limb to disk center, starting with the limb. The exposure times will be longer than in quiet Sun, but the overall approach is similar to that described in 6.2: every few days we should focus on a prominence for about 6-12 hours.

6.5 Flares/CMEs

As flaring regions appear, we should consider some flare/CME watch programs, i.e., after some of our basic science targets have been satisfactorily observed. The flare/CME watch programs should focus on moderate cadence, moderate field of view programs with AEC enabled.

6.6 Synoptic Observations

The synoptic program is still being defined, but a preliminary list of observations includes:

a. full disk coarse rasters in several bright lines,
b. limb-to-limb relatively narrow rasters from pole to pole, along the equator, and a variety of angles from solar north.

These programs will be run every week or so and will take up a significant fraction of the day.

6.7 Calibration

Every week or so we will obtain flat-field, dark current and “orbital wobble” calibration studies. In addition, depending on targets of opportunity, we will do occasional stellar calibrations.