Planning coordinated observations with IRIS

Bart De Pontieu

IRIS-9 tutorials

June 2018

Why coordinate with IRIS?

- IRIS provides high-cadence, high-resolution imaging and spectroscopy of the chromosphere, transition region and select flare/coronal emission
- IRIS observations come with a variety of high-level data products, analysis tools, models, and experts to aid in analysis
- Flexible observing modes and rapid turnaround in targeting and delivering data on desired features

Timeline of your IRIS Coordination

- **<u>As soon as possible (ideally months in advance for coordinated observations; a week before for other types of observations):</u>**

If you are interested in obtaining IRIS observations (either in coordination with other observatories or just from IRIS alone), please contact the IRIS PI (Bart De Pontieu, bdp@lmsal.com) as soon as possible with your request. If you also include Hinode data, then include the information below in your IHOP request

Your request should include:

- science rationale

- target, desired roll angle
- requested day/time and duration
- key constraints and/or a suggested OBS-ID both for low-data rate (< 0.5 Mbit/s) and high-data rate options (to take into account telemetry limitations)

- other participating instruments
- contact info

Once your observation request has been received and approved, it will be entered in the coordination calendar (if it is in coordination with other observatories).

Timeline of your IRIS Coordination

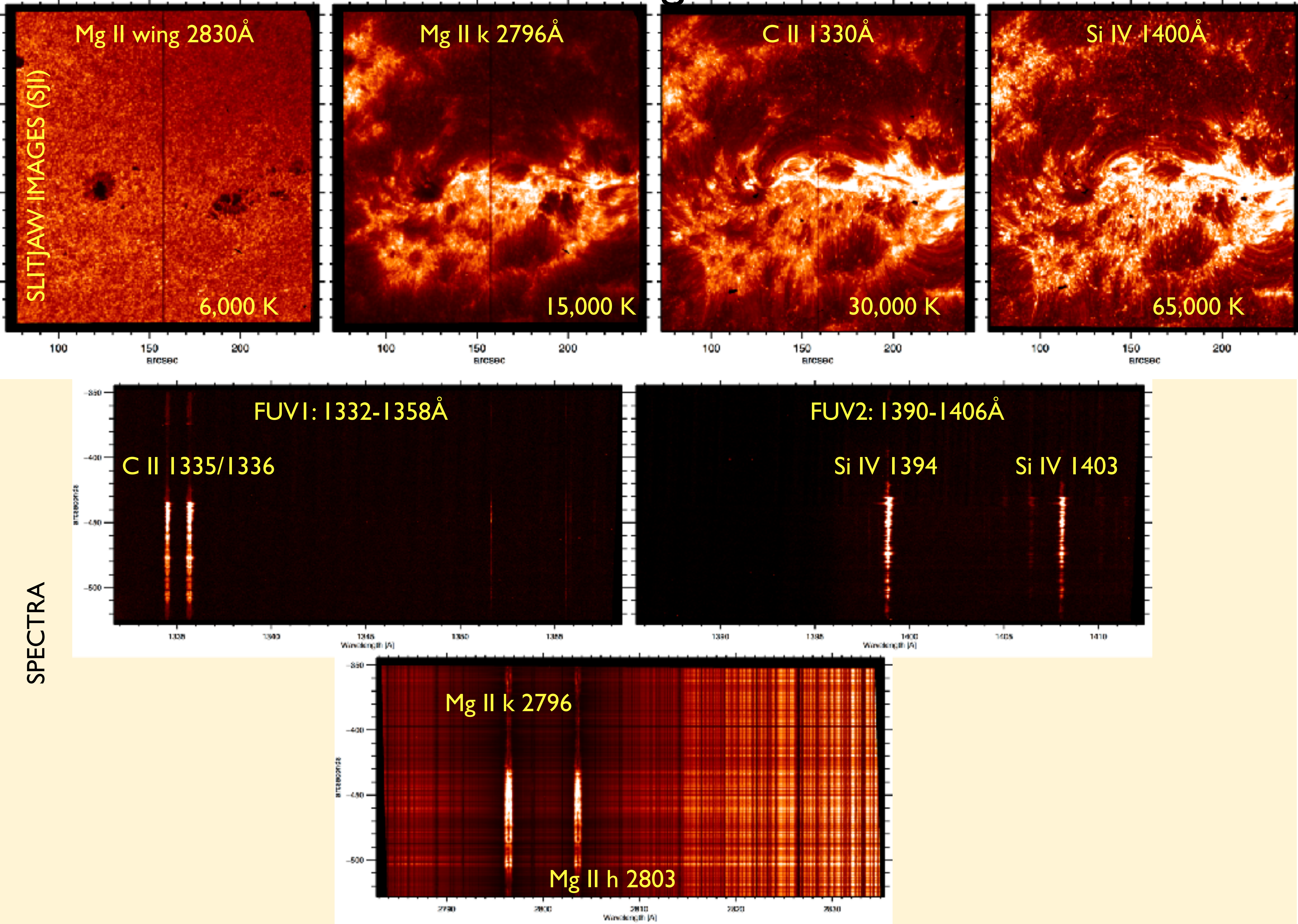
- **<u>Two days before observation:</u>**
  Confirm exact timing and targeting with your planner at iris_planner@lmsal.com

- Final targeting delivered to planner 15-16 UT on the day before (IRIS day starts at 04 UT) unless planner confirms otherwise

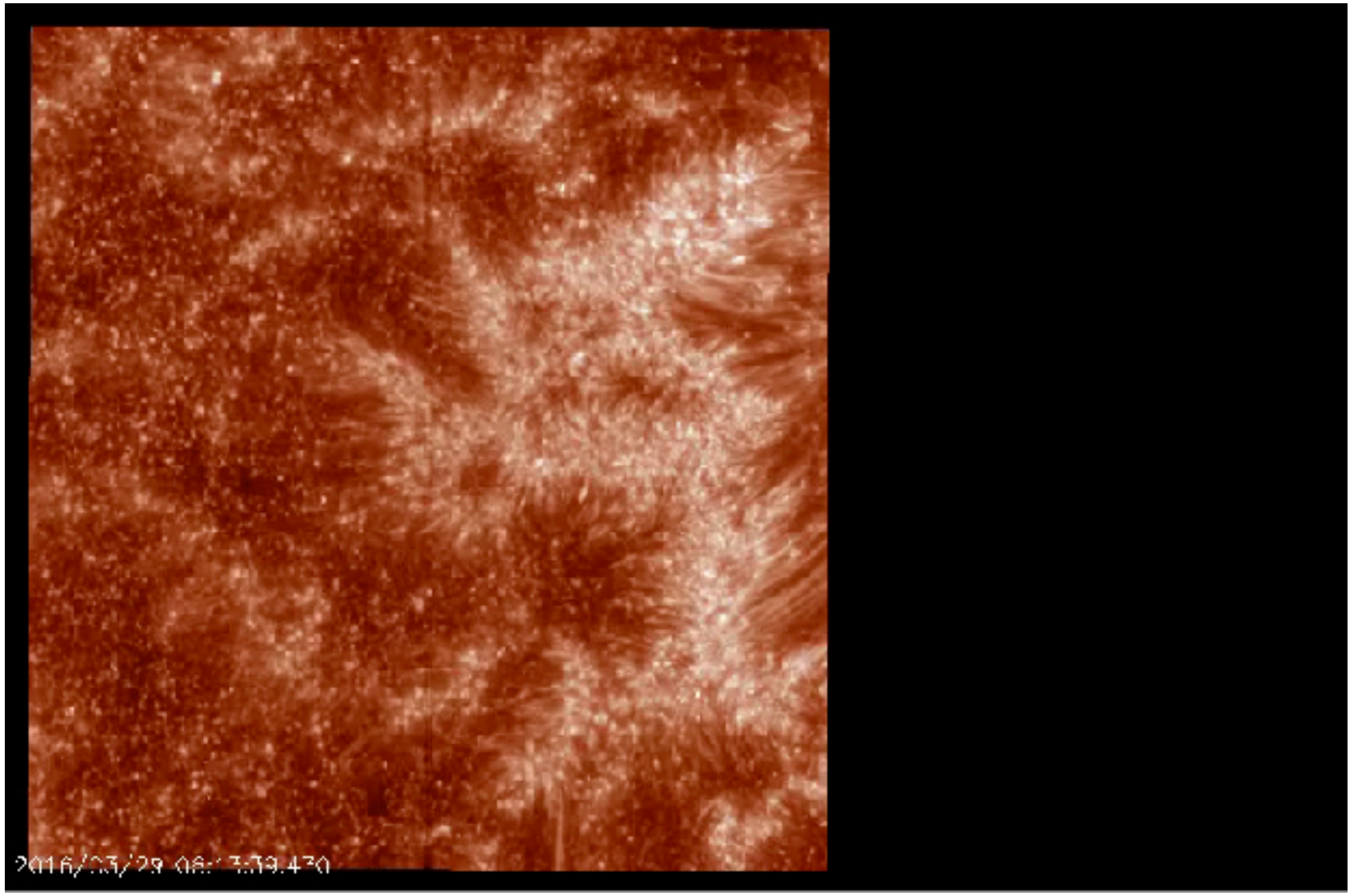
Timeline of your IRIS Coordination

- **If you also coordinate with Hinode, then please submit an IHOP**
  - IHOPs are IRIS-Hinode Operation Plans
  - Contact Hinode team and IRIS PI (bdp@lmsal.com) following instructions on Hinode HOP page (http://hinode.msfc.nasa.gov/hops.html), including science justification, key constraints and requests for Hinode instruments and IRIS. For IRIS, this ideally is an initial guess for the OBS ID, duration, targets. These can be finalized after initial submission.
  - IHOPs are discussed once per month for approval and observing during next month.

IRIS wavelength choices



IRIS resolution and slit



- IRIS has one slit, which is 1/3” wide. The imaging devices have 1/6” pixels with an effective spatial resolution of ~0.33” in the FUV and ~0.4” in the NUV.
- The slit can be moved across the solar disk with step sizes of 0.35”, 1” or 2” up to a spatial range of roughly 120”x175”.
- The slit-jaw images cover a FOV of up to 175”x175”, while the slit has a length of 175”.
- The spectral pixel size is 13mÅ with an effective spectral resolution of ~27mÅ in the FUV, and 26mÅ pixels and effective spectral resolution of ~55mÅ in the NUV.
- To boost signal-to-noise and/or reduce telemetry data can be summed onboard, both spectrally or spatially.

IRIS cadence

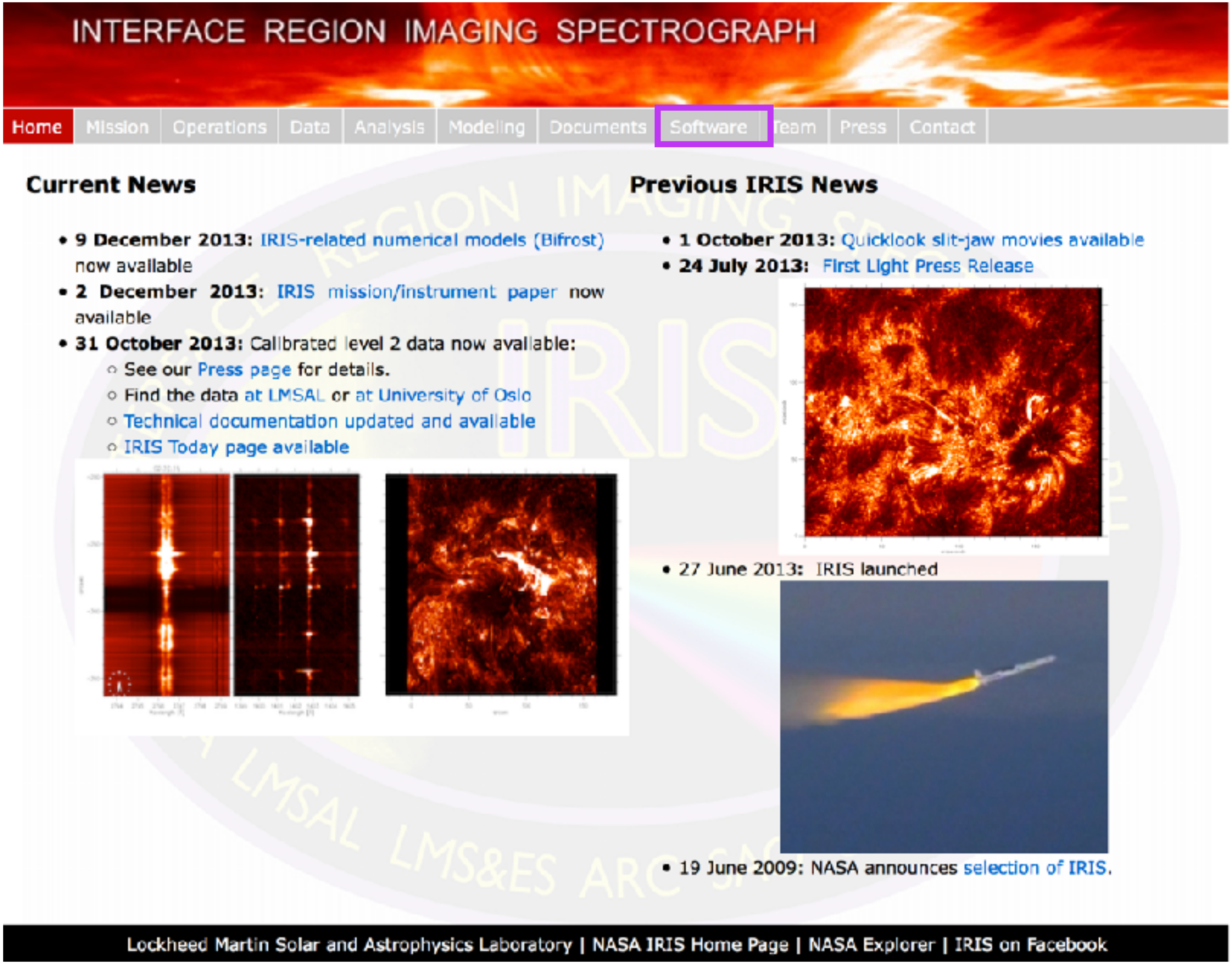
- High throughput, and fast readout and mechanism movements allows cadences for the spectra to be as short as 1.5-2 seconds, with slit-jaw cadences as short as 1.5-2 seconds.
- Typical exposure times for bright lines such as C II 1335Å, Si IV 1402Å and Mg II h/k 2796Å are 2-8s for active regions, 8-15s for quiet Sun and coronal hole, with exposure times of 30 or 60s to detect fainter lines.

IRIS pointing and roll

- 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. The roll angle is restricted for several days twice per month (around first and last quarter of the Moon phase). Non-zero roll angles can cause reduced telemetry (up to a factor of 2-3 lower in the worst case).

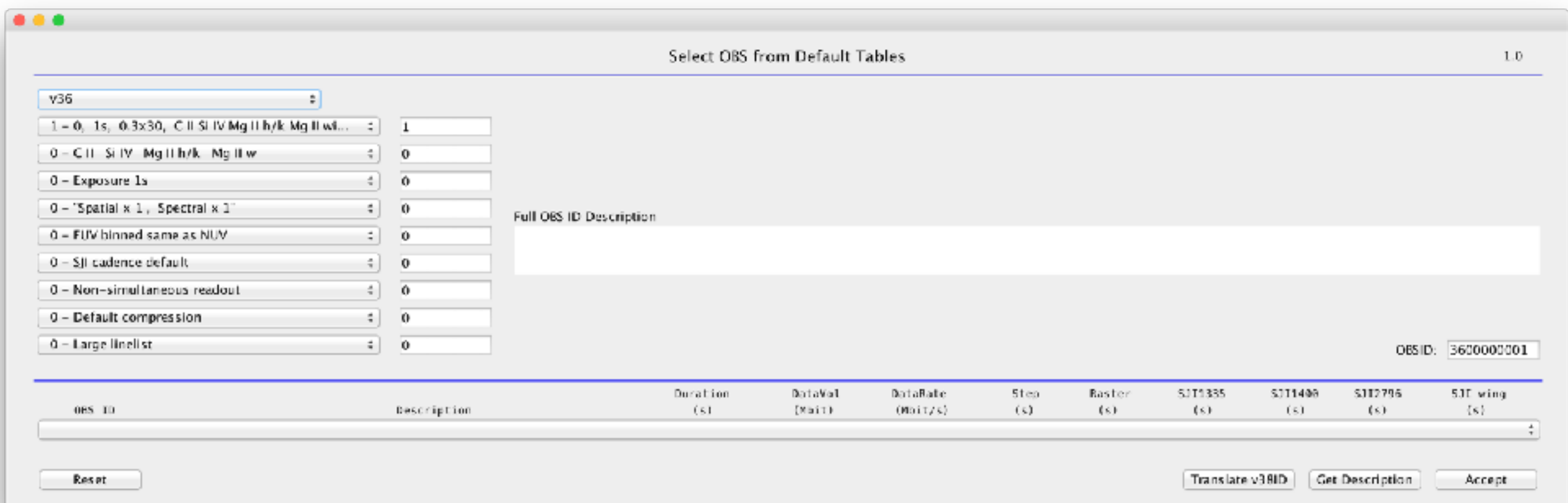
IRIS home page

http://iris.lmsal.com/index.html



Parameters of an IRIS observation

- IRIS has a range of different observing modes
  - Explore observing parameter space with the table selector tool (http://iris.lmsal.com/software.html)
  - Download Table Selector directly from this link: (https://www.lmsal.com/iris_science/doc?cmd=dcur&proj_num=IS0299&file_type=tgz)



Install Table Selector

- Unpack tar file
- cd to unpacked directory
- java -jar PreDefinedTables.jar v36 -standalone

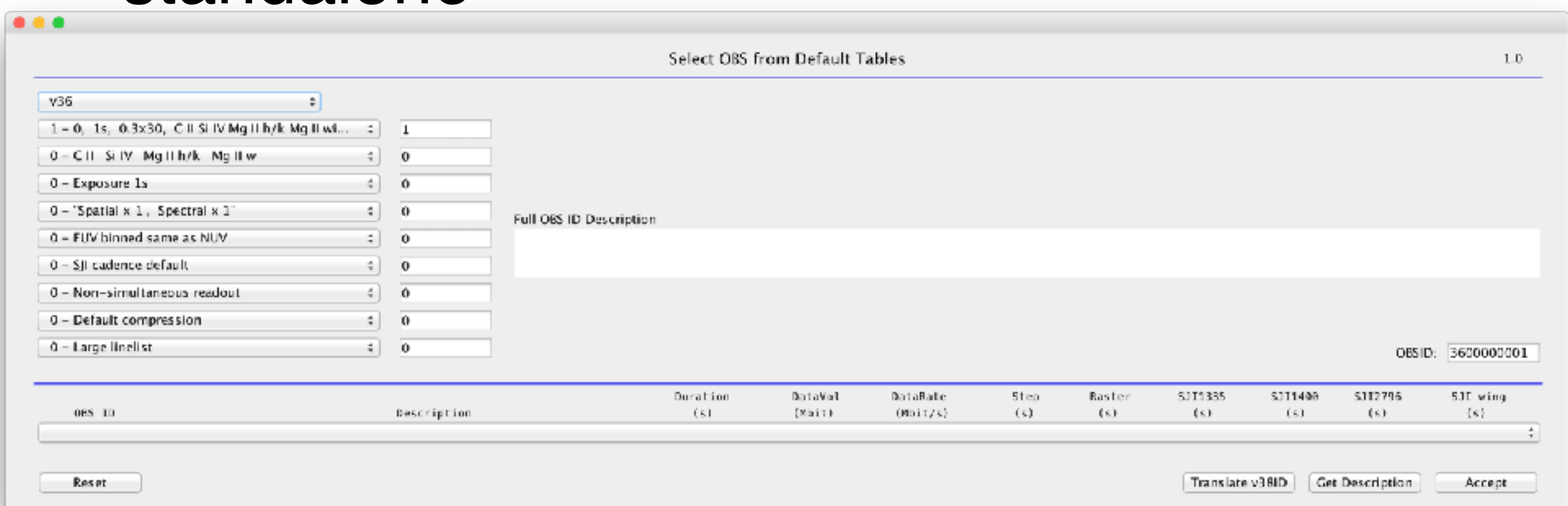


Table Selector Output

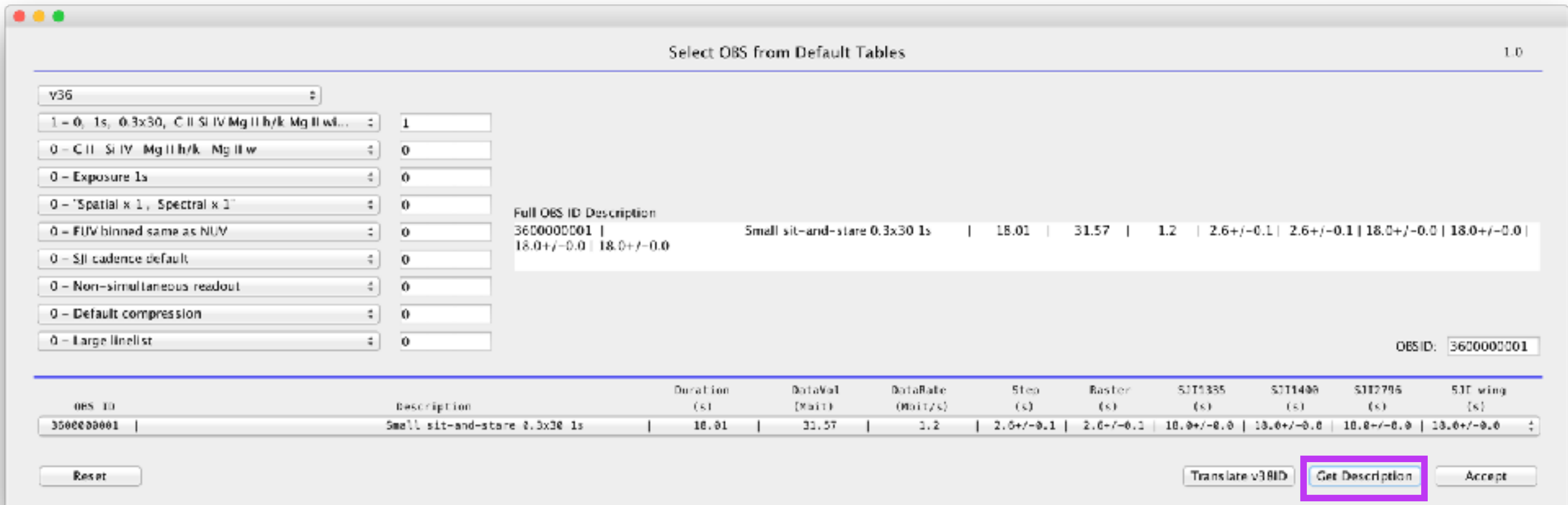


Table Selector Output

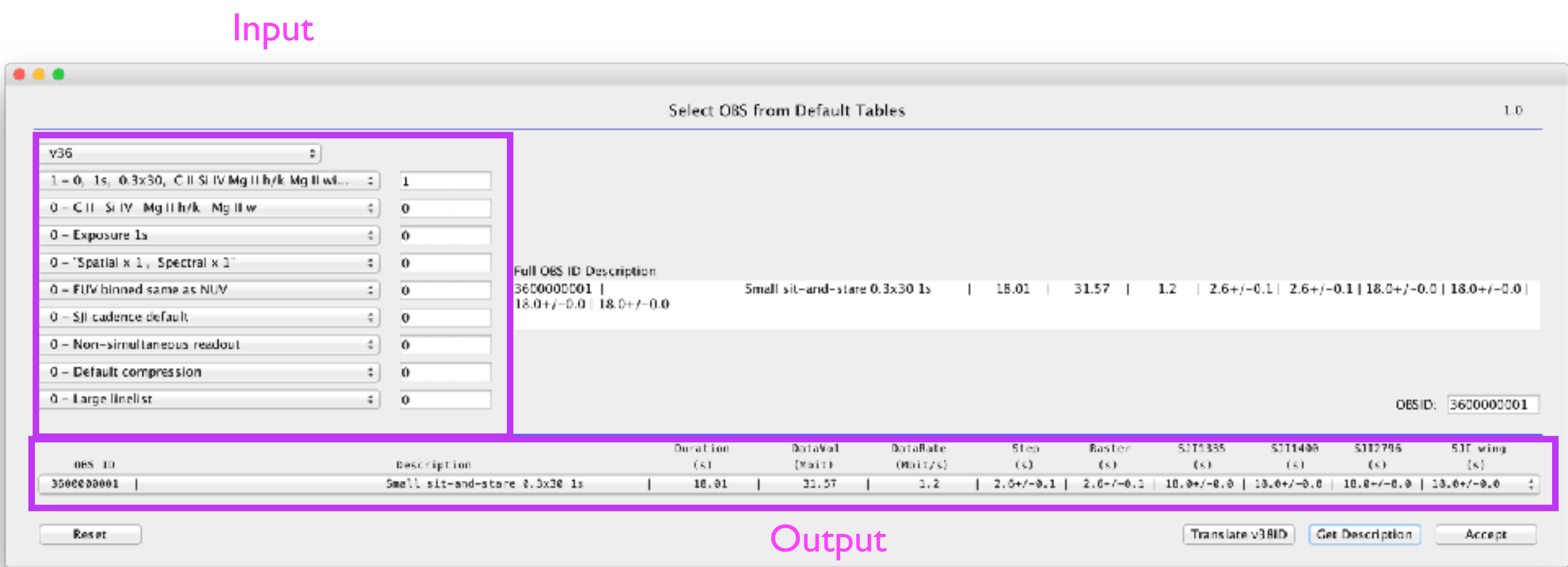
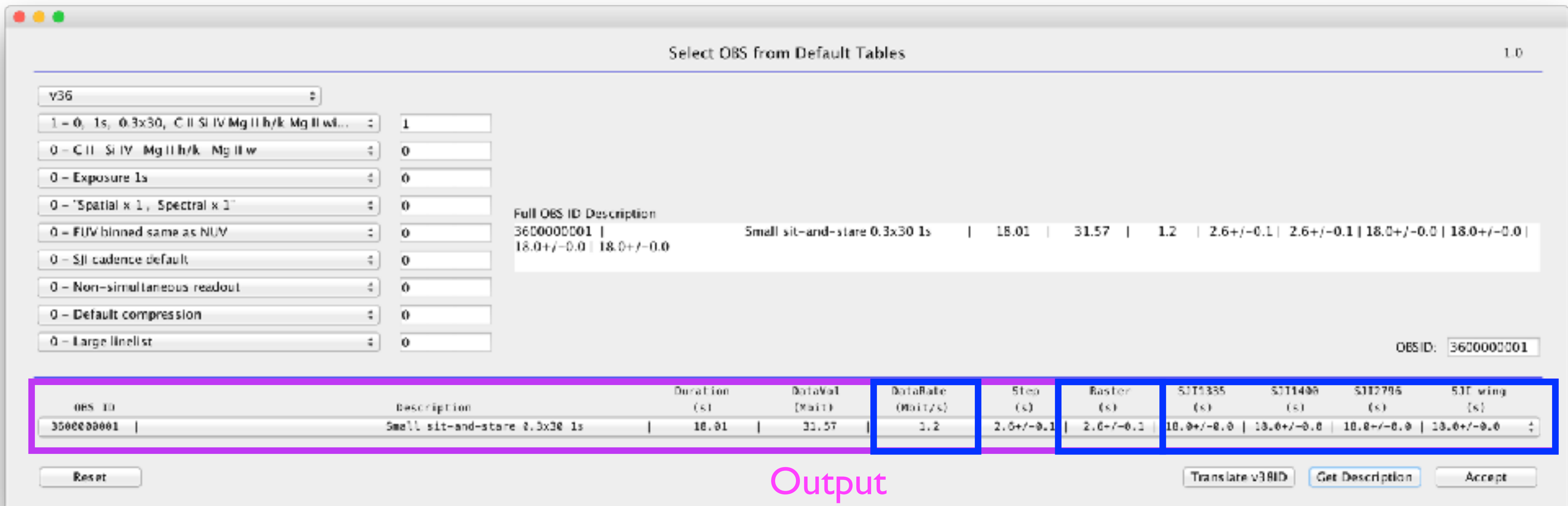


Table Selector Output



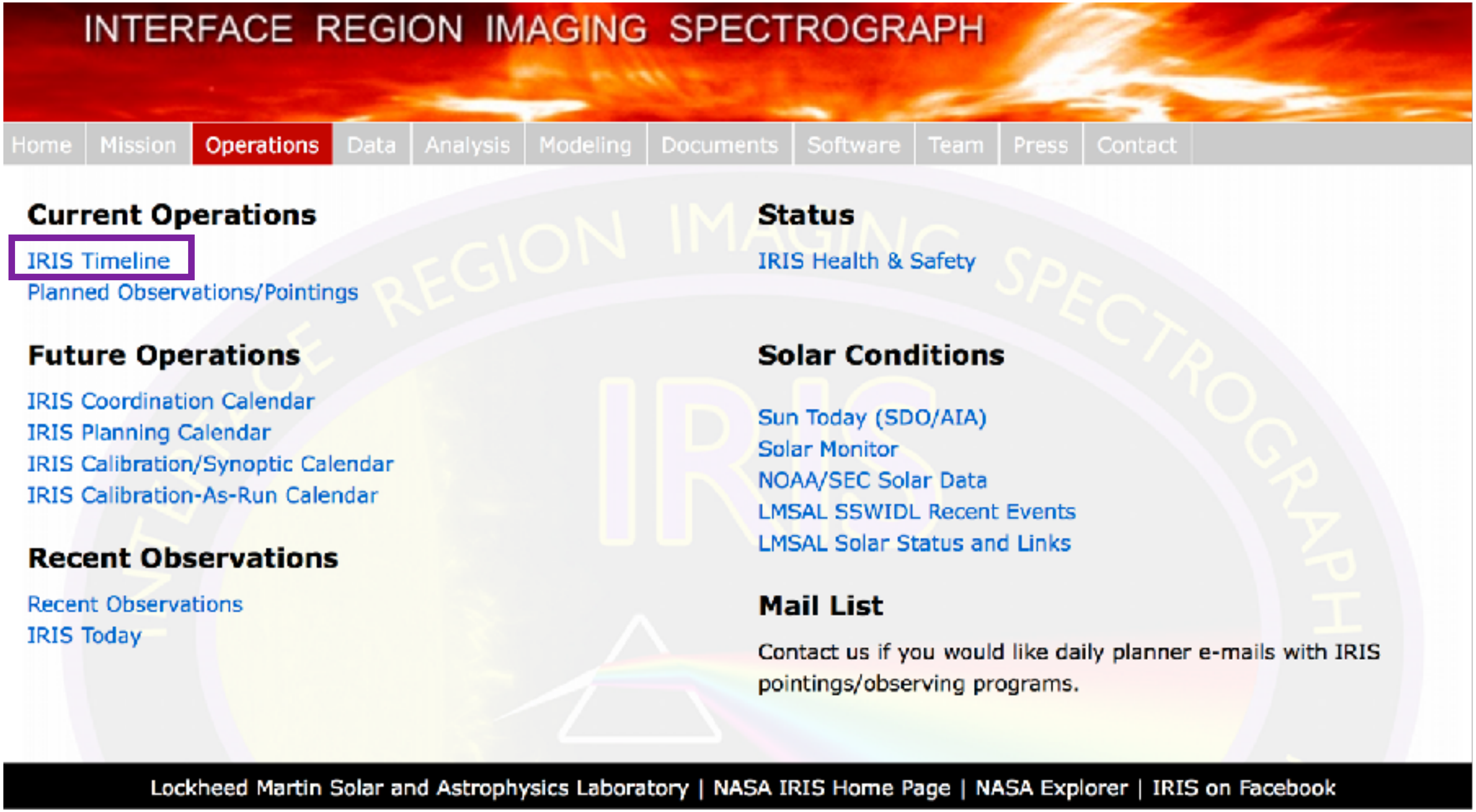
Average IRIS datarate = 0.7 Mbit/s

Cadence of raster in seconds

Cadence of various slit-jaw images

How is IRIS operated?

http://iris.lmsal.com/operations.html



5 timelines per week (Mon-Fri) from 4 UT to 4 UT

How is IRIS operated?

http://iris.lmsal.com/health-safety/timeline/

IRIS Science Planning Files

IRIS Home Page
IRIS Health and Safety Page

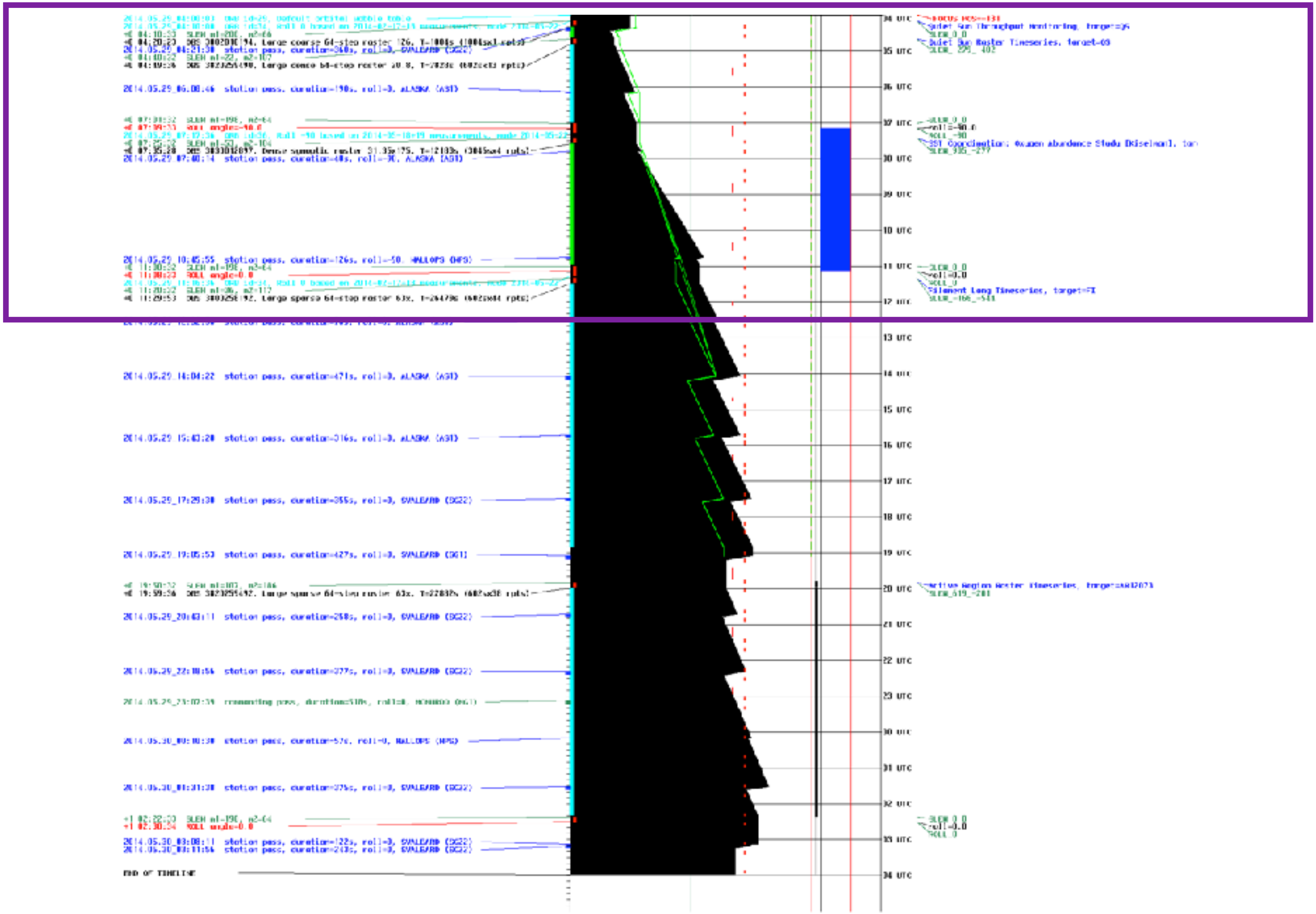
IRIS timeline GIF explained (somewhat)
IRIS Daily Pointings and FOVS Overlaid On AIA Context Images
Planned Observation Summaries
Recent IRIS Observations

Date	TLI	TIM	SCI	GIF	MEM
30-may-2014	TLI	TIM	SCI	GIF	-
29-may-2014	TLI	TIM	SCI	GIF	MEM
28-may-2014	TLI	TIM	SCI	GIF	MEM
24-may-2014	TLI	TIM	SCI	GIF	MEM

jun-2014	sci_monthly
may-2014	sci_monthly
apr-2014	sci_monthly
mar-2014	sci_monthly
feb-2014	sci_monthly

How is IRIS operated?

http://iris.lmsal.com/health-safety/timeline/



How is IRIS operated?

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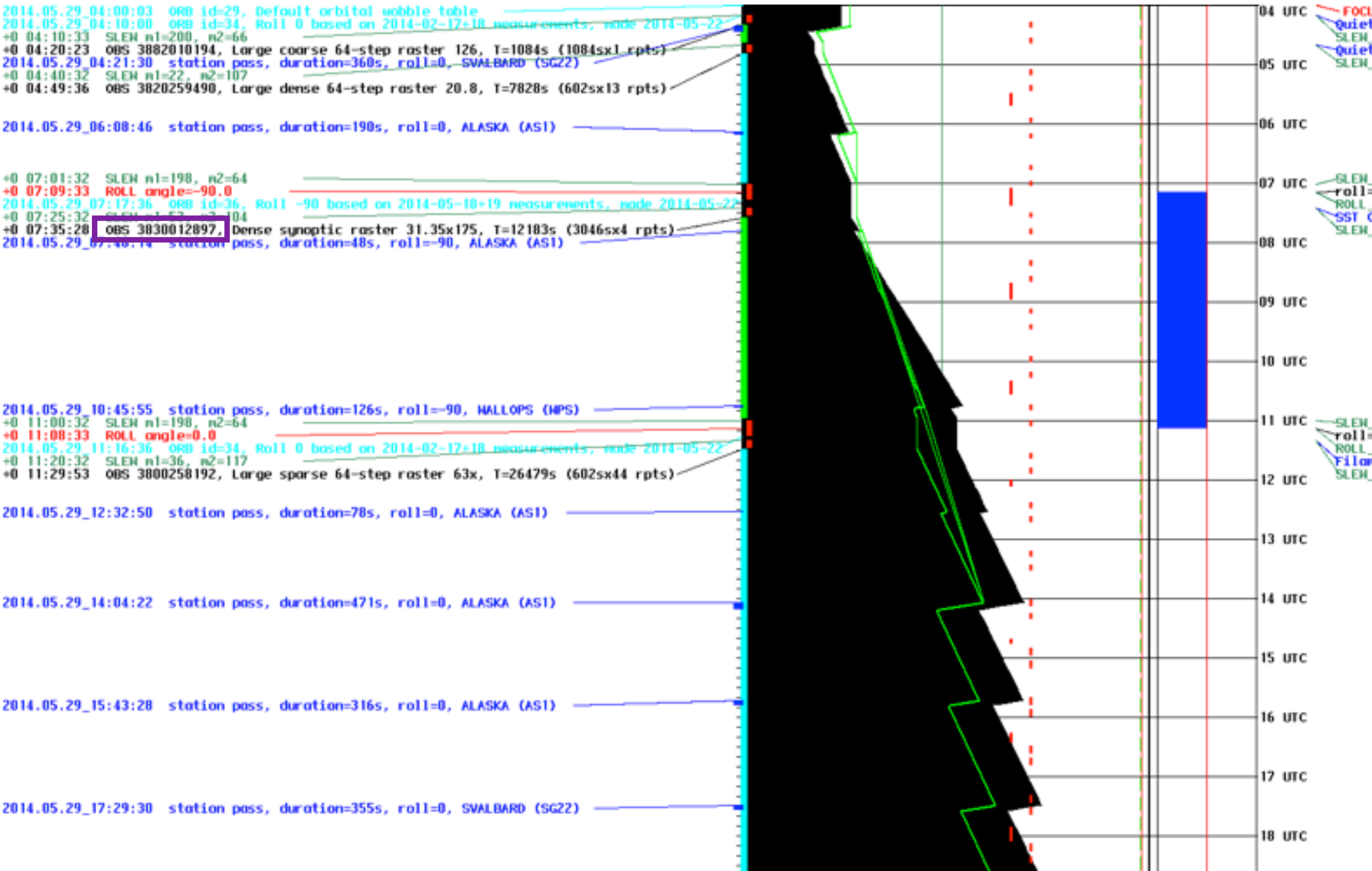


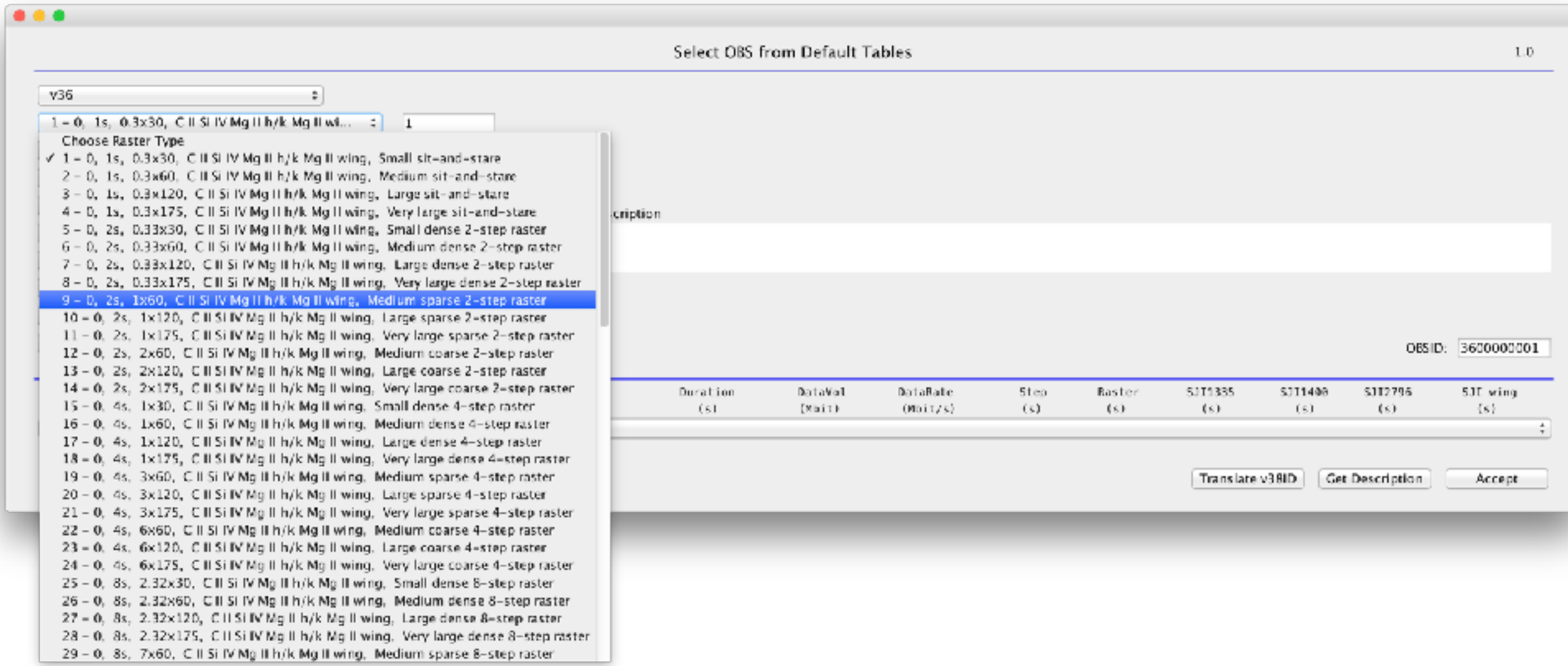
Pre-defined Observing Tables

OBS ID parent	Description
0-100	Basic raster type (sit-and-stare, rasters, …)
0-2,000	SJI choices
0-14,000	Exposure times
0-220,000	Summing modes (applied to FUV, NUV, SJI)
0-500,000	FUV summing modes
0-4,000,000	SJI cadence
0-5,000,000	Readout method (simultaneous, non-simultaneous)
0-10,000,000	Compression choices
0-80,000,000	Linelists
3.6-4 billion	OBS table generation number

Table 1: OBS ID numbering scheme for table generation v3.6

- Millions of predefined observing modes
- OBS-ID defines properties
- Three generations available, currently v3.6 is preferred

Field-of-view and Raster mode

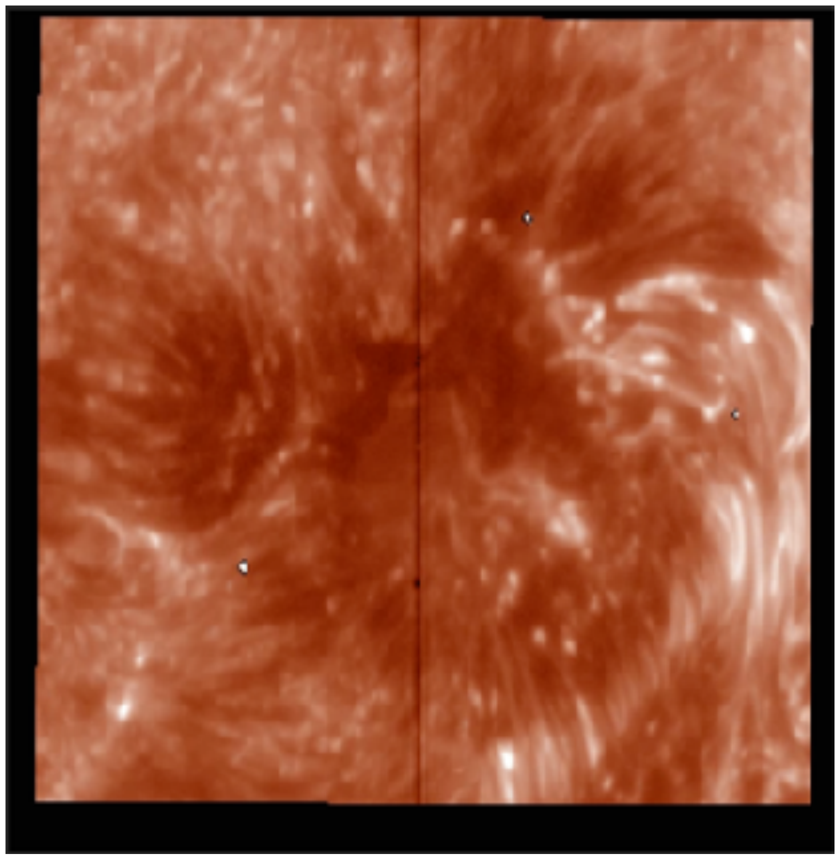


Field-of-view

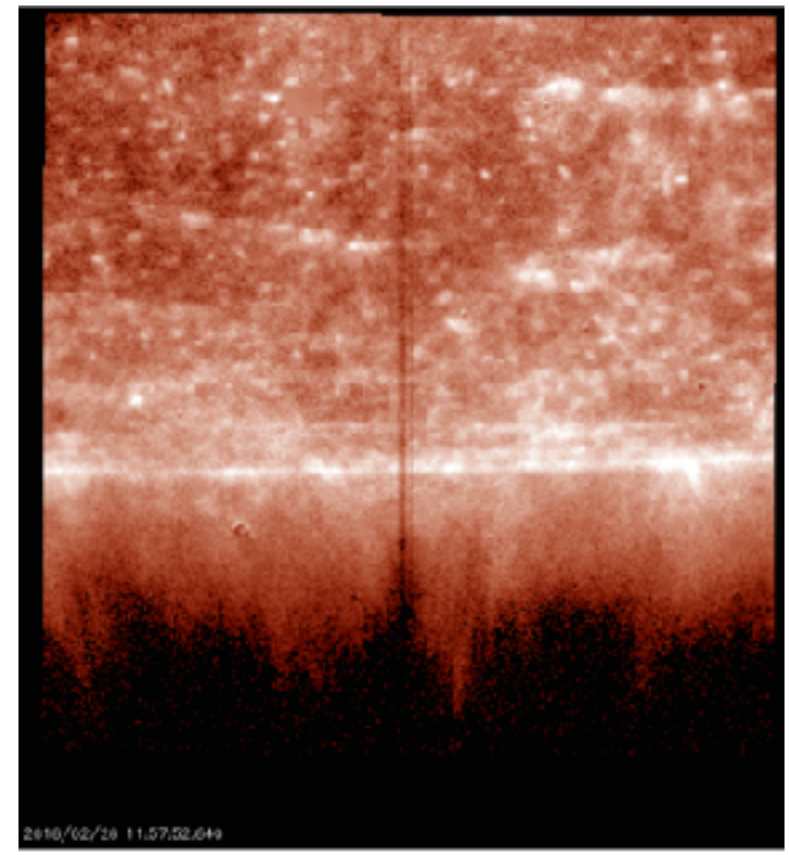
IRIS allows for 4 different choices of field-of-view:

- very large (175”x175” for SJI, 175” along slit for spectra)
- large (120”x120” for SJI, 120” along slit for spectra)
- medium (60”x60” for SJI, 60” along slit for spectra)
- small (60”x60” for SJI, 30” along slit for spectra)

Field-of-view



Small FOV (30”) is very small and only useful if telemetry is major concern

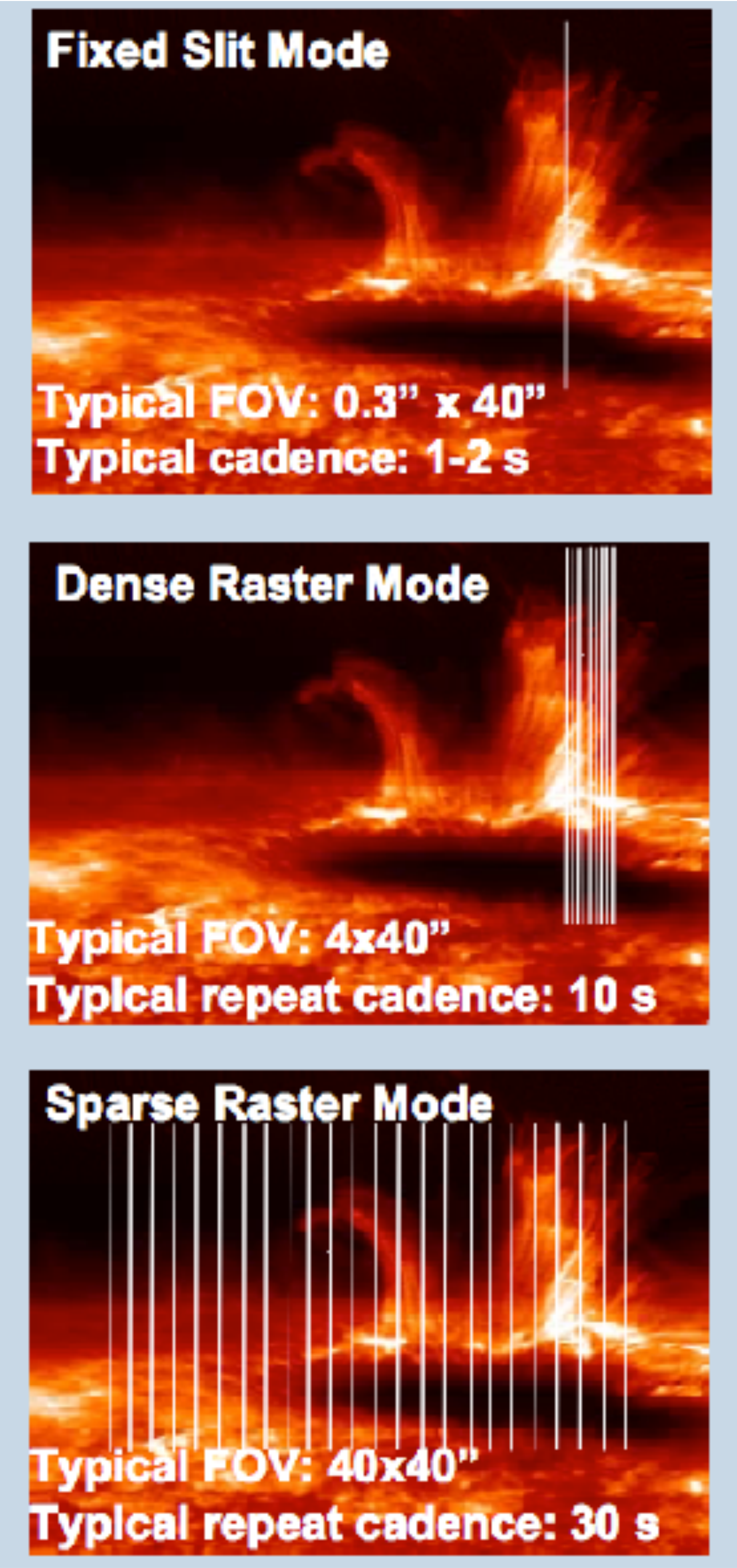


Typical programs use medium (above) or large

For coordinated observations with ground-based telescopes, medium is usually sufficient, unless the science goal aims to capture rare events like flares, CMEs, etc... in which case large or even very large may be preferred.

The required data rate scales with the field-of-view somewhere between linearly and quadratically.

IRIS raster modes



Sit-and-stare
Dense raster (0.33" steps)
Sparse raster (1" steps)
Coarse raster (2" steps)

IRIS can either operate in:
- "sit-and-stare" mode (slit stays at one location on the Sun)
- perform a raster scan.

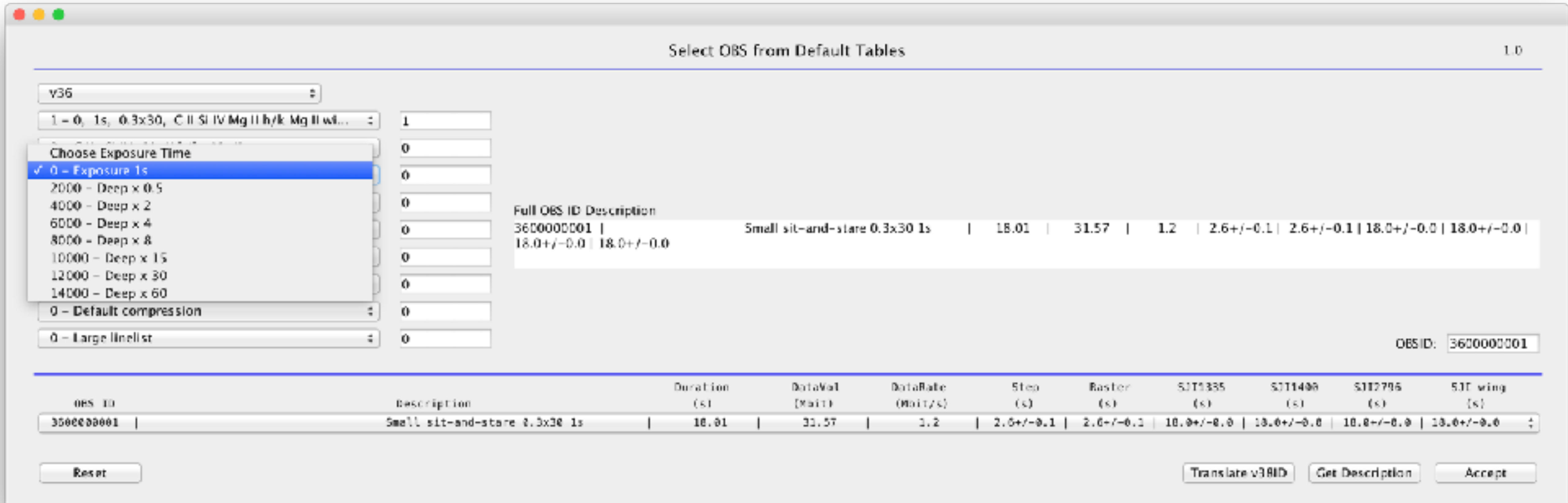
The raster scan requires two choices to be made:
- step size: 0.35" (dense), 1" (sparse), or 2" (coarse)
- number of steps: 2, 4, 8, 16, 32, 48, 64, 96, 128, 192, 256, 320, 400

The field-of-view of the sit-and-stare is 0.33" x length of slit-read-out.

The field-of-view of the raster scan (in the direction perpendicular to the slit) is then given by "step-size x number-of-steps", e.g., a dense 320 step raster scan covers about 105". Note that not all combinations of dense/sparse/coarse with the number of steps are available

OBS-ID	Step size	Number of steps	Raster FOV (arcsec x arcsec)	SJI FOV (arcsec x arcsec)	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	0.33x120	120x120	Large dense 2-step raster
8	0.33	2s	0.33x175	175x175	Very large dense 2-step raster
9	1	2s	1x60	60x60	Medium sparse 2-step raster
10	1	2s	1x120	120x120	Large sparse 2-step raster
11	1	2s	1x175	175x175	Very large sparse 2-step raster
12	2	2s	2x60	60x60	Medium coarse 2-step raster
13	2	2s	2x120	120x120	Large coarse 2-step raster
14	2	2s	2x175	175x175	Very large coarse 2-step raster
15	0.33	4s	1x30	60x60	Small dense 4-step raster
16	0.33	4s	1x60	60x60	Medium dense 4-step raster
17	0.33	4s	1x120	120x120	Large dense 4-step raster
18	0.33	4s	1x175	175x175	Very large dense 4-step raster
19	1	4s	3x60	60x60	Medium sparse 4-step raster
20	1	4s	3x120	120x120	Large sparse 4-step raster
21	1	4s	3x175	175x175	Very large sparse 4-step raster
22	2	4s	6x60	60x60	Medium coarse 4-step raster
23	2	4s	6x120	120x120	Large coarse 4-step raster
24	2	4s	6x175	175x175	Very large coarse 4-step raster
25	0.33	8s	2.32x30	60x60	Small dense 8-step raster
26	0.33	8s	2.32x60	60x60	Medium dense 8-step raster
27	0.33	8s	2.32x120	120x120	Large dense 8-step raster
28	0.33	8s	2.32x175	175x175	Very large dense 8-step raster
29	1	8s	7x60	60x60	Medium sparse 8-step raster
30	1	8s	7x120	120x120	Large sparse 8-step raster
31	1	8s	7x175	175x175	Very large sparse 8-step raster
32	2	8s	14x60	60x60	Medium coarse 8-step raster
33	2	8s	14x120	120x120	Large coarse 8-step raster
34	2	8s	14x175	175x175	Very large coarse 8-step raster
35	0.33	16s	5x60	60x60	Medium dense 16-step raster
36	0.33	16s	5x120	120x120	Large dense 16-step raster
37	0.33	16s	5x175	175x175	Very large dense 16-step raster
38	1	16s	15x60	60x60	Medium sparse 16-step raster
39	1	16s	15x120	120x120	Large sparse 16-step raster
40	1	16s	15x175	175x175	Very large sparse 16-step raster
41	2	16s	30x60	60x60	Medium coarse 16-step raster
42	2	16s	30x120	120x120	Large coarse 16-step raster
43	2	16s	30x175	175x175	Very large coarse 16-step raster
44	0.33	10.24x60	32s	60x60	Medium dense 32-step raster
45	0.33	10.24x120	32s	120x120	Large dense 32-step raster
46	0.33	10.24x175	32s	175x175	Very large dense 32-step raster
47	1	31x60	32s	60x60	Medium sparse 32-step raster
48	1	31x120	32s	120x120	Large sparse 32-step raster
49	1	31x175	32s	175x175	Very large sparse 32-step raster
50	2	62x60	32s	60x60	Medium coarse 32-step raster
51	2	62x120	32s	120x120	Large coarse 32-step raster
52	2	62x175	32s	175x175	Very large coarse 32-step raster
53	2	94x120	48s	120x120	Large coarse 48-step raster
54	2	94x175	48s	175x175	Very large coarse 48-step raster
55	0.33	20.8x60	64s	60x60	Medium dense 64-step raster
56	0.33	20.8x120	64s	120x120	Large dense 64-step raster
57	0.33	20.8x175	64s	175x175	Very large dense 64-step raster
58	1	63x60	64s	60x60	Medium sparse 64-step raster
59	1	63x120	64s	120x120	Large sparse 64-step raster
60	1	63x175	64s	175x175	Very large sparse 64-step raster
61	2	126x120	64s	120x120	Large coarse 64-step raster
62	2	126x175	64s	175x175	Very large coarse 64-step raster
63	0.33	31.35x60	96s	60x60	Medium dense 96-step raster
64	0.33	31.35x120	96s	120x120	Large dense 96-step raster
65	0.33	31.35x175	96s	175x175	Very large dense 96-step raster
66	1	95x120	96s	120x120	Large sparse 96-step raster
67	1	95x175	96s	175x175	Very large sparse 96-step raster
68	0.33	42.2x60	128s	60x60	Medium dense 128-step raster
69	0.33	42.2x120	128s	120x120	Large dense 128-step raster
70	0.33	42.2x175	128s	175x175	Very large dense 128-step raster
71	0.33	63.1x60	192s	60x60	Medium dense 192-step raster
72	0.33	63.1x120	192s	120x120	Large dense 192-step raster
73	0.33	63.1x175	192s	175x175	Very large dense 192-step raster
74	0.33	84.2x120	256s	120x120	Large dense 256-step raster
75	0.33	84.2x175	256s	175x175	Very large dense 256-step raster
76	0.33	105.3x120	320s	120x120	Large dense 320-step raster
77	0.33	105.3x175	320s	175x175	Very large dense 320-step raster
78	0.33	131.7x175	400s	175x175	Very large dense 400-step raster
79	1	35x175	36s	175x175	Sparse synoptic raster
80	2	34x175	18s	175x175	Coarse synoptic raster

Exposure time



The exposure time is the same for FUV/NUV and SJI.

It typically is a compromise value: it sets the signal-to-noise (S/N) of the observations, which depends on the type of target.

The exposure time also drives the raster (and SJI) cadence, as well as the data rate.

Available values are 0.5, 1, 2, 4, 8, 15, 30 and 60 seconds.

Exposure time

The signal-to-noise consideration depends on the type of spectral lines observed. The S/N of the NUV spectra is much higher than for the FUV channel, so the FUV signal requirements usually set the exposure time. For the brightest lines in the FUV (C II 1335Å and 1402Å) reasonable signal can be obtained in:

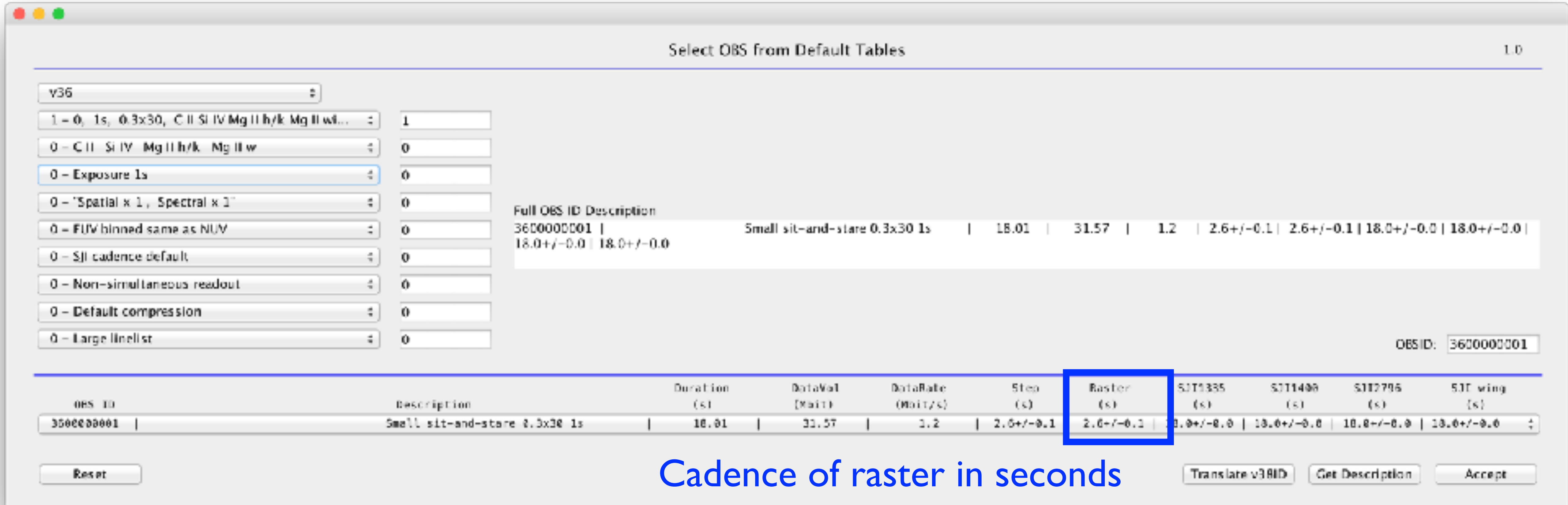
- 2-4s for active regions
- 8-15s for quiet Sun and coronal hole

For fainter lines (e.g., O I 1355Å, Fe XII 1349Å) , longer exposure times and/or summing will be required (as well as non-simultaneous readout and lossless compression).

Note that when pointing at active regions, the Automatic Exposure Control (AEC) algorithm usually operates to limit and reduce exposure times when large flares occur.

Best option is to study previous datasets and determine the optimal exposure time for your science goals

Raster cadence



Once you have decided on which type of raster you require, you should consider the raster cadence that results from your choice. This is given by:

-number-of-steps x (exposure time + overhead)

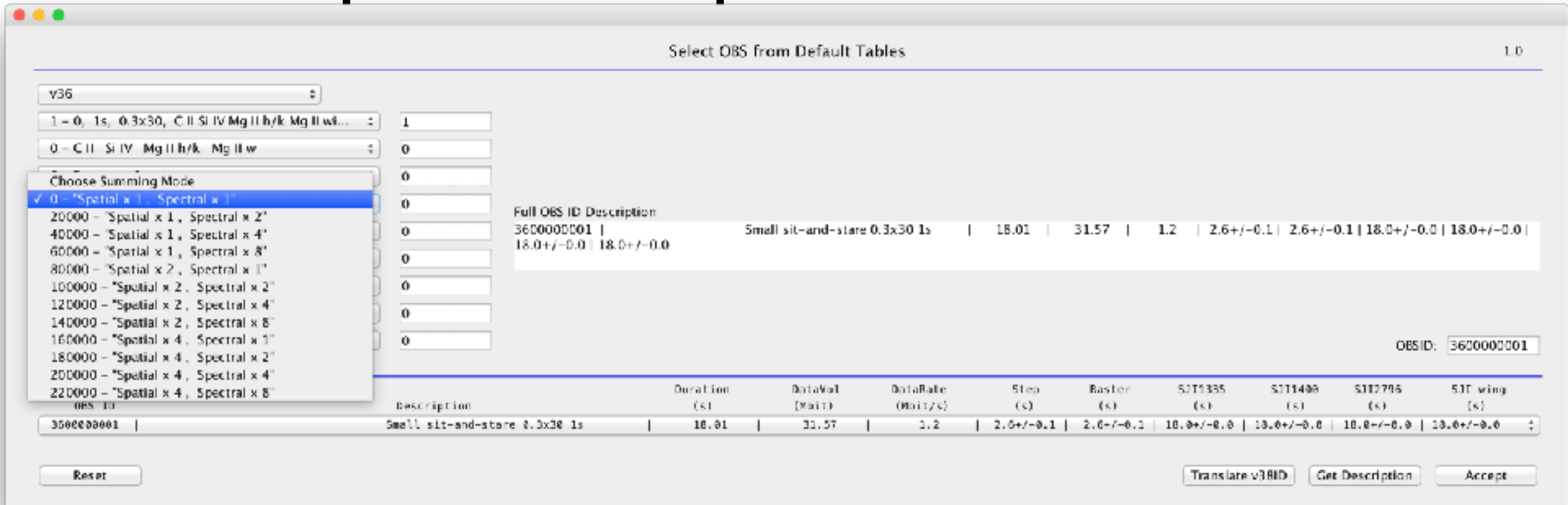
The overhead depends on how much of the detector you read out, but is typically of order 0.5-1.5 s. This means that a 320 step raster with 2s exposures can take up to 320 x (2+1.5) = 1120 seconds, i.e., almost 20 minutes.

Raster cadence

Considerations for raster cadence:

- Obviously, the larger the number of raster steps, the slower the repeat cadence.
  - Your choice will be a compromise between how dynamic your events are, and what kind of spatial coverage you need to cover them adequately.
  - Think of using a sparse or coarse step size to increase spatial coverage while reducing number of steps
  - To have a better raster cadence, think about reducing the exposure time and retaining signal-to-noise by summing onboard
  - Exact numbers of raster timing can be obtained through the OBS Table Tool.

Spatial and Spectral Resolution



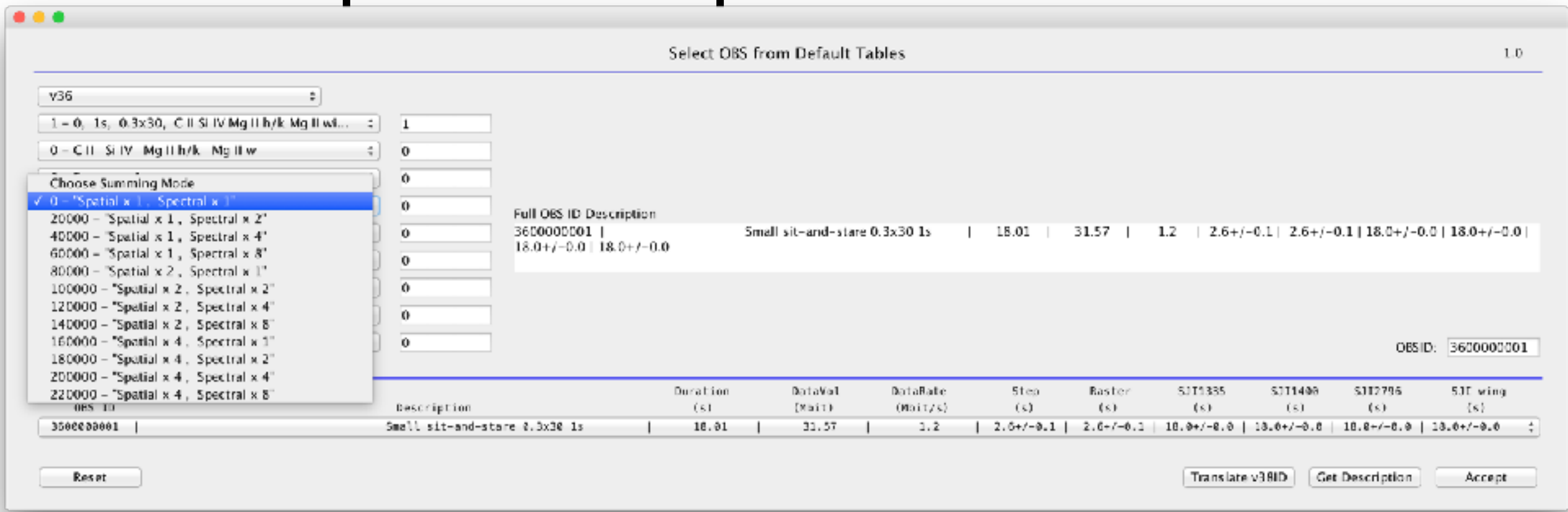
The highest spatial and spectral resolution (no onboard summing) is the default observing mode.

Binning on the ground (i.e., after data was taken) can always be used during the data analysis stage…

But summing onboard offers significant advantages:

- it lowers the data rate so observations can be run for a longer duration
- it boosts the signal of faint lines above the digitization threshold (which on-the-ground summing cannot accomplish)
- it increases S/N so that exposure times can be lowered thus improving raster cadence

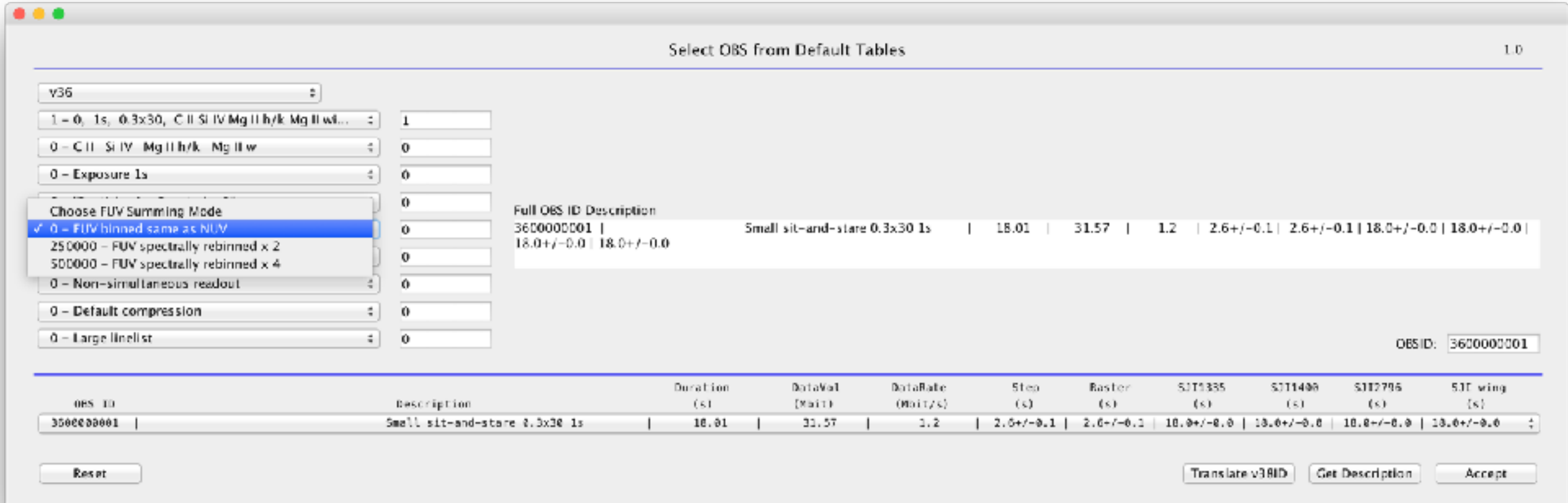
Spatial and Spectral Resolution



Data can be summed onboard in the spatial direction (x2, x4) or in the spectral direction (x2, x4, x8). A summing mode of 1x2 would be no summing spatially, and x2 summing in the spectral direction.

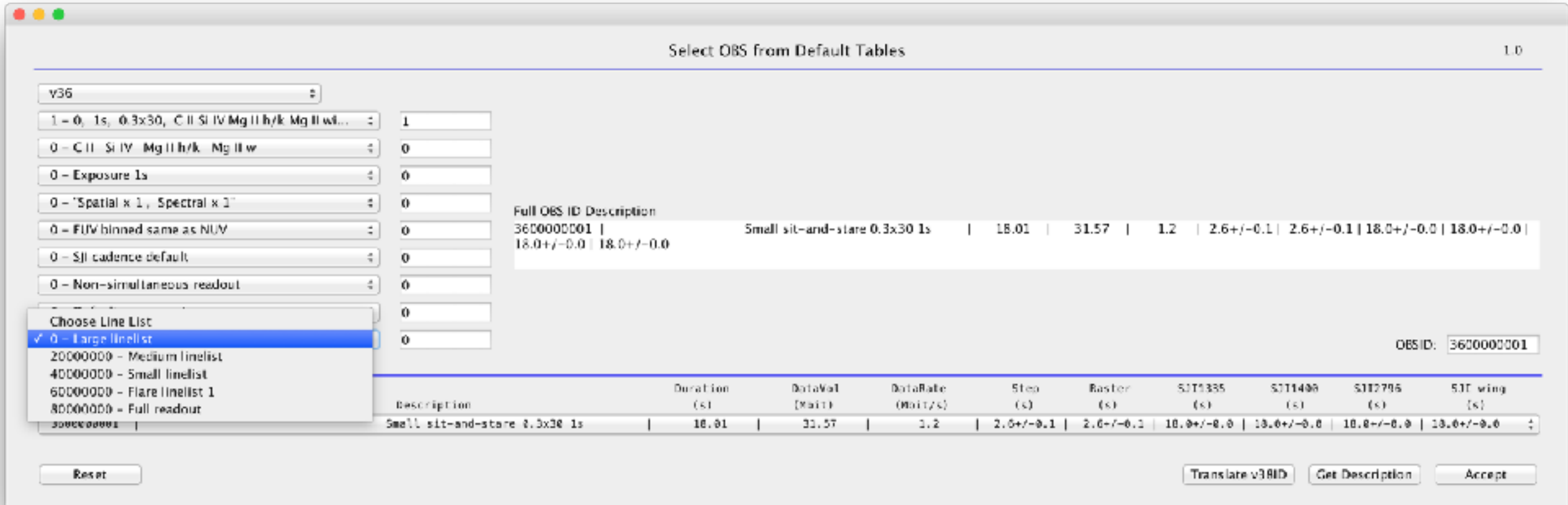
Note that asymmetric summing modes (e.g., 1x4, 2x1) are typically discouraged since they lead to slit-jaw images in which the spatial of both spatial dimension is different, i.e., images with incorrect aspect ratio. If you desire asymmetric summing, please provide a detailed scientific rationale.

FUV only summing



Since the S/N in the NUV spectra is much better than in the FUV, there is also an FUV specific summing mode (FUVx2, FUVx4, FUVx8). Most used summing modes are probably FUVx2 (spectral summing x 2 but only for the FUV spectra) and 2x2 (i.e., spatial x2, spectral x 2, for all channels).

Line Lists



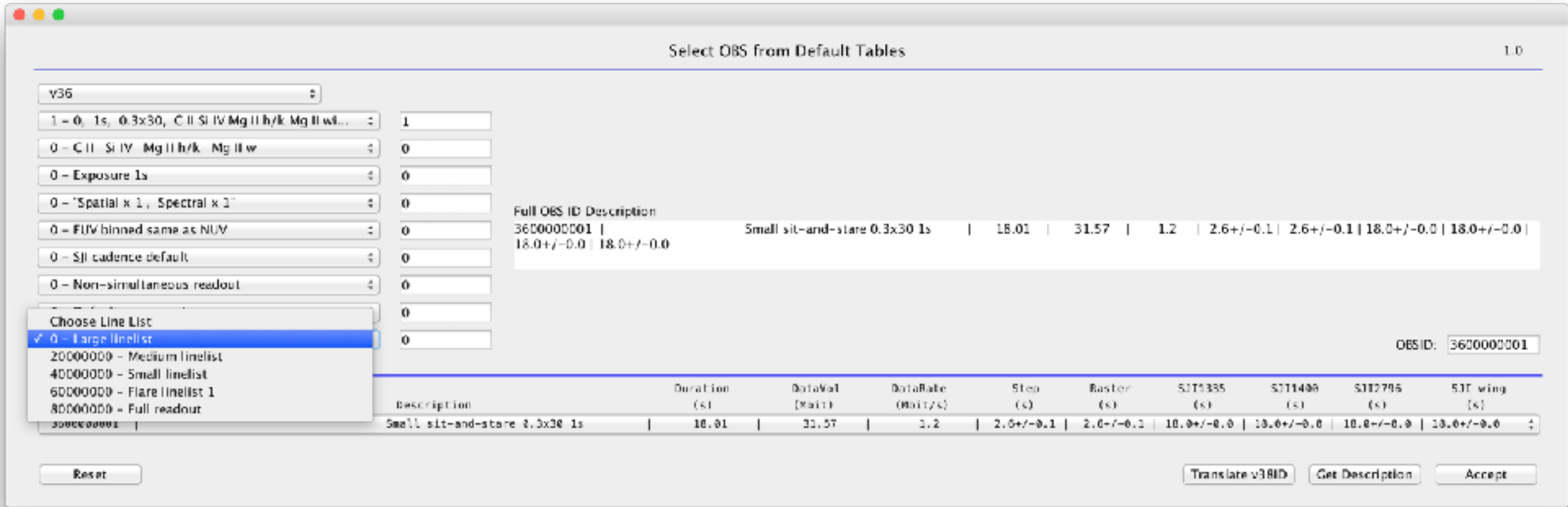
While IRIS observes a spectral range from 1331-1358Å, 1390-1406Å and 2782-2834Å, we rarely read out and downlink the full detector range.

This is to save telemetry and speed up read-out.

We have five pre-defined linelists you can choose from.

By default we use the medium line list. If you desire a different linelist, please let us know.

Line Lists



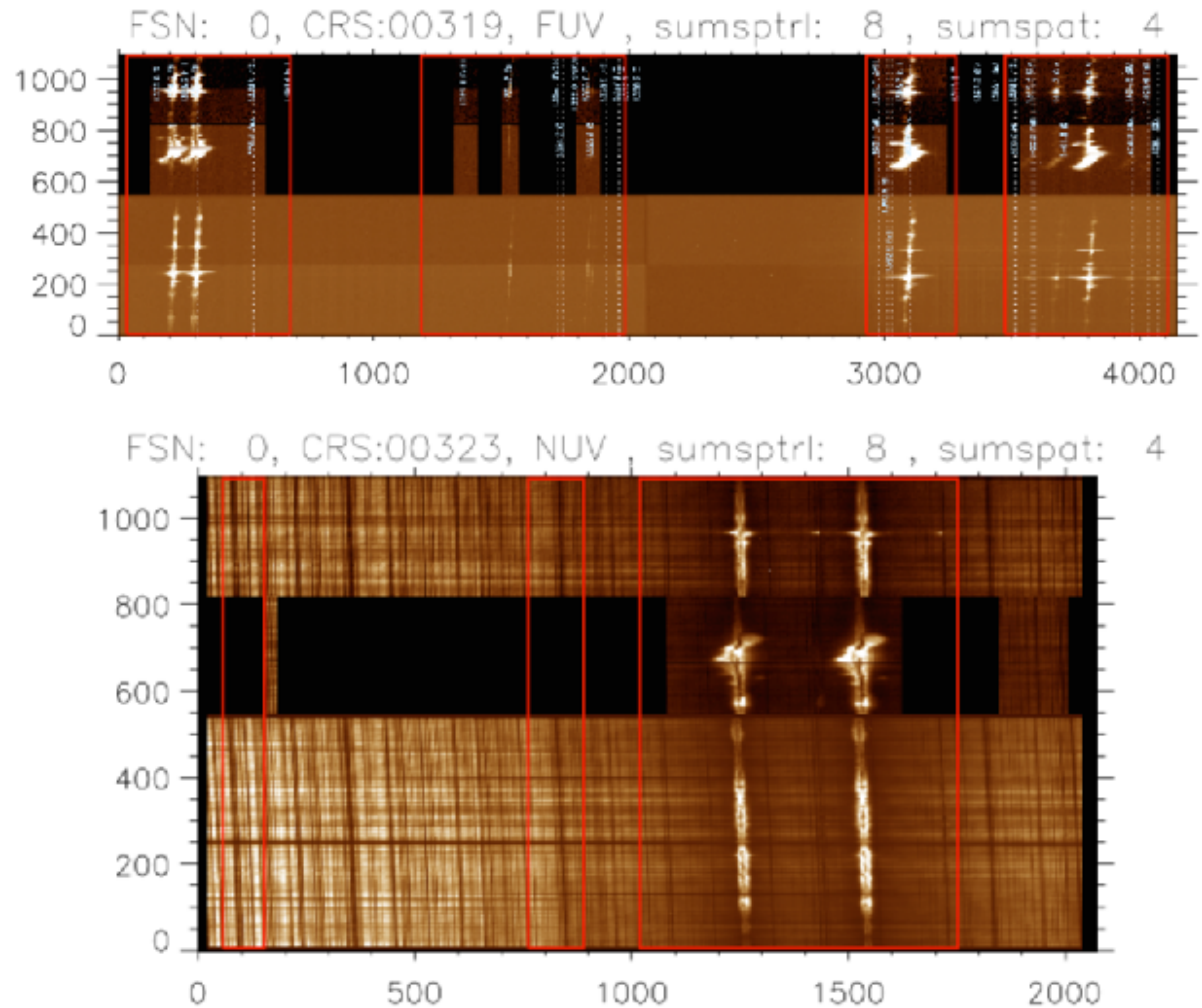
Five different linelists have been predefined. The 80 million series is full readout so contains the full wavelength range in both FUV and NUV.
The other linelists are:

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

Note that larger wavelength regions take longer to read out and affect the cadence. These also lead to larger downlink rate. The fastest cadence can be reached with the small linelist.

Line Lists

7.1 Large Linelist (0 million)

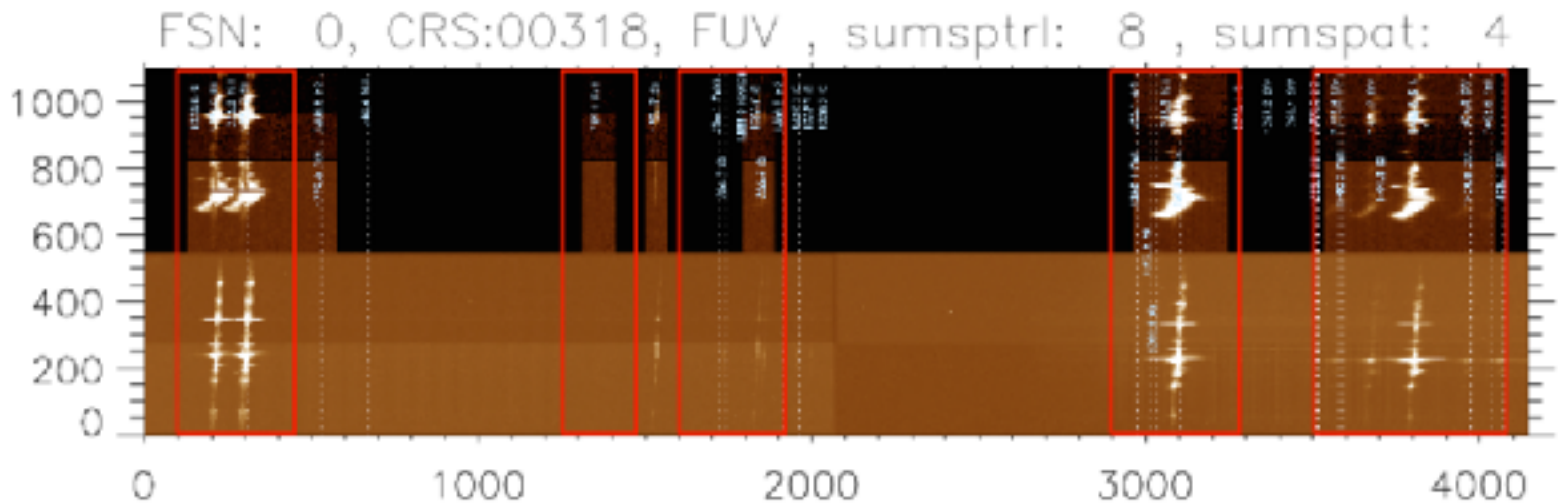


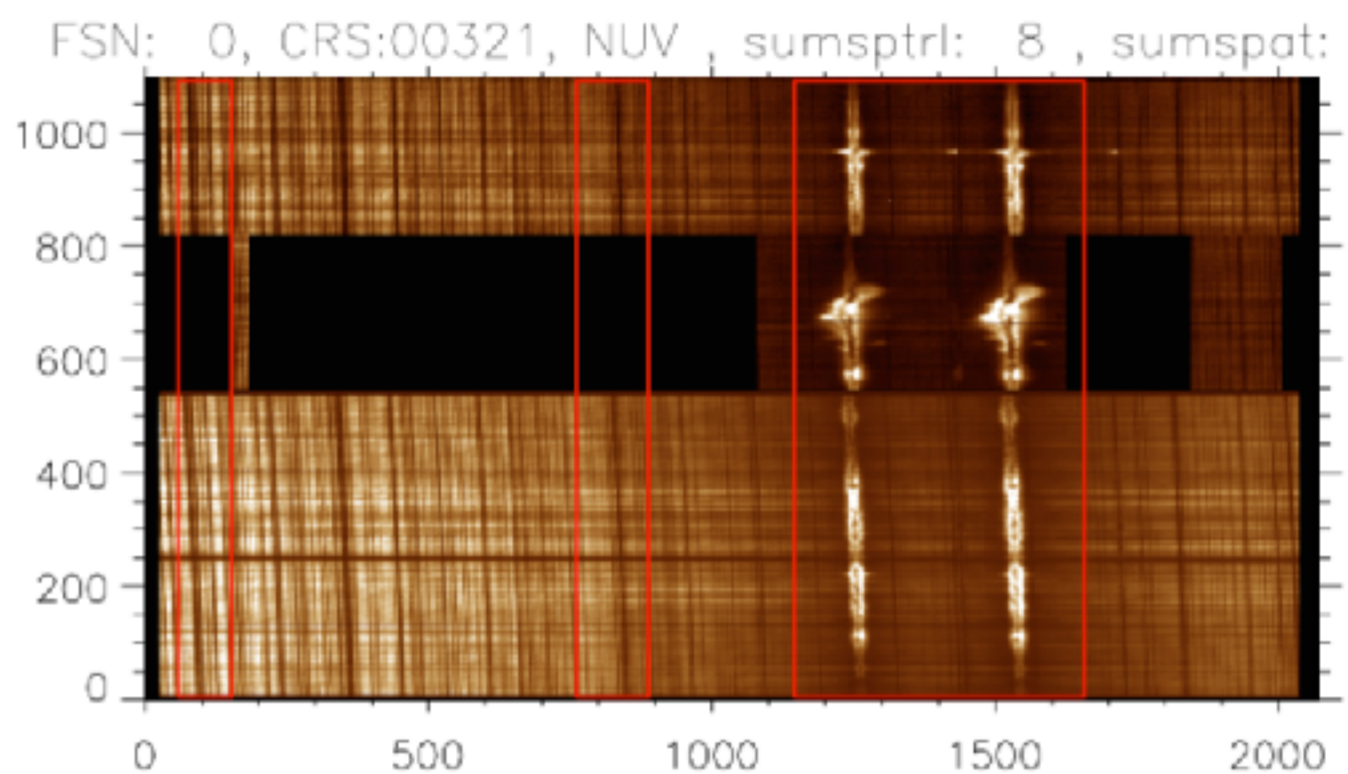
FUV: Regions of interest containing most lines are downlinked.

NUV: A spectral region of about ~600 km/s (Doppler) around Mg II lines is read-out . Only linelist apart from flare and full read-out list that will also capture Mg II 3p-3d transitions for both lines.

Line Lists

7.2 Medium Linelist (20 million)



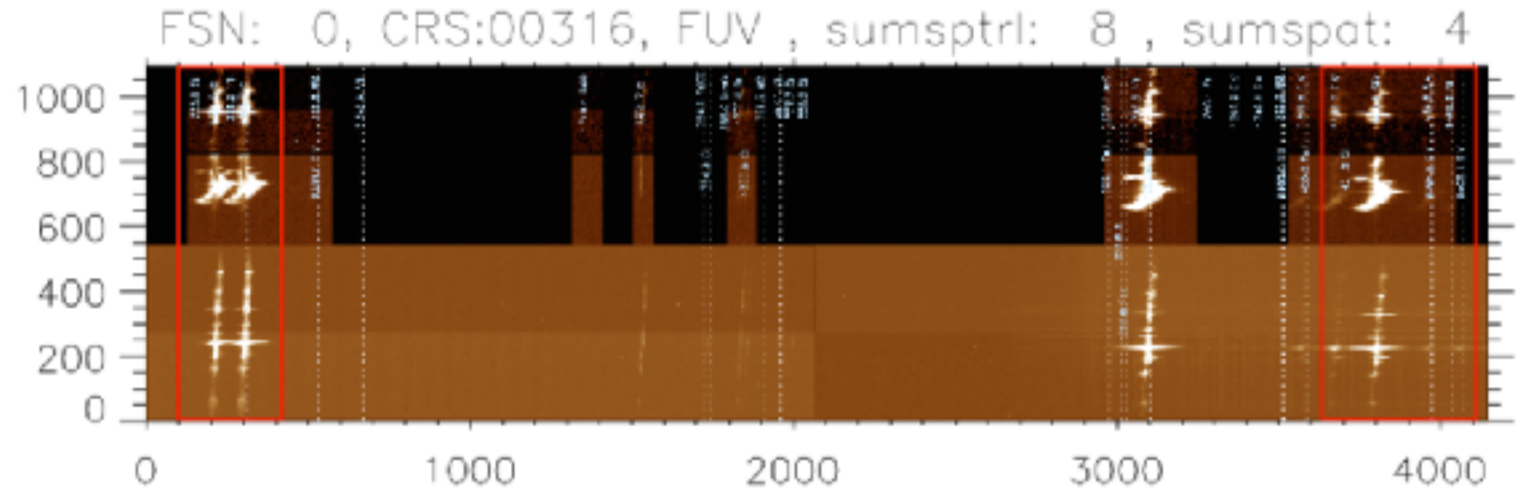


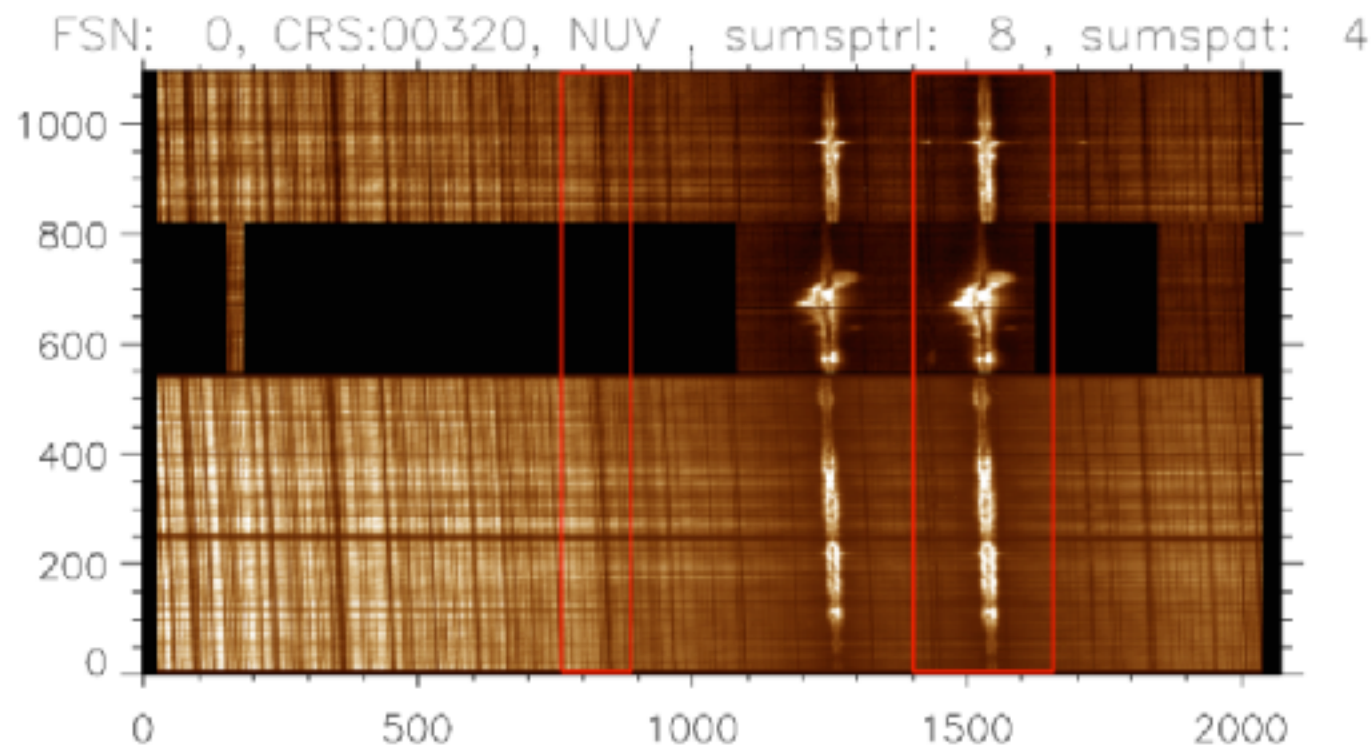
FUV: includes most lines, 300 km/s for most regions.

Medium: Both Mg II lines, photospheric reference line, plus continuum. ~300 km/s Doppler for Mg II.

Line Lists

7.3 Small Linelist (40 million): NO CORONAL LINE



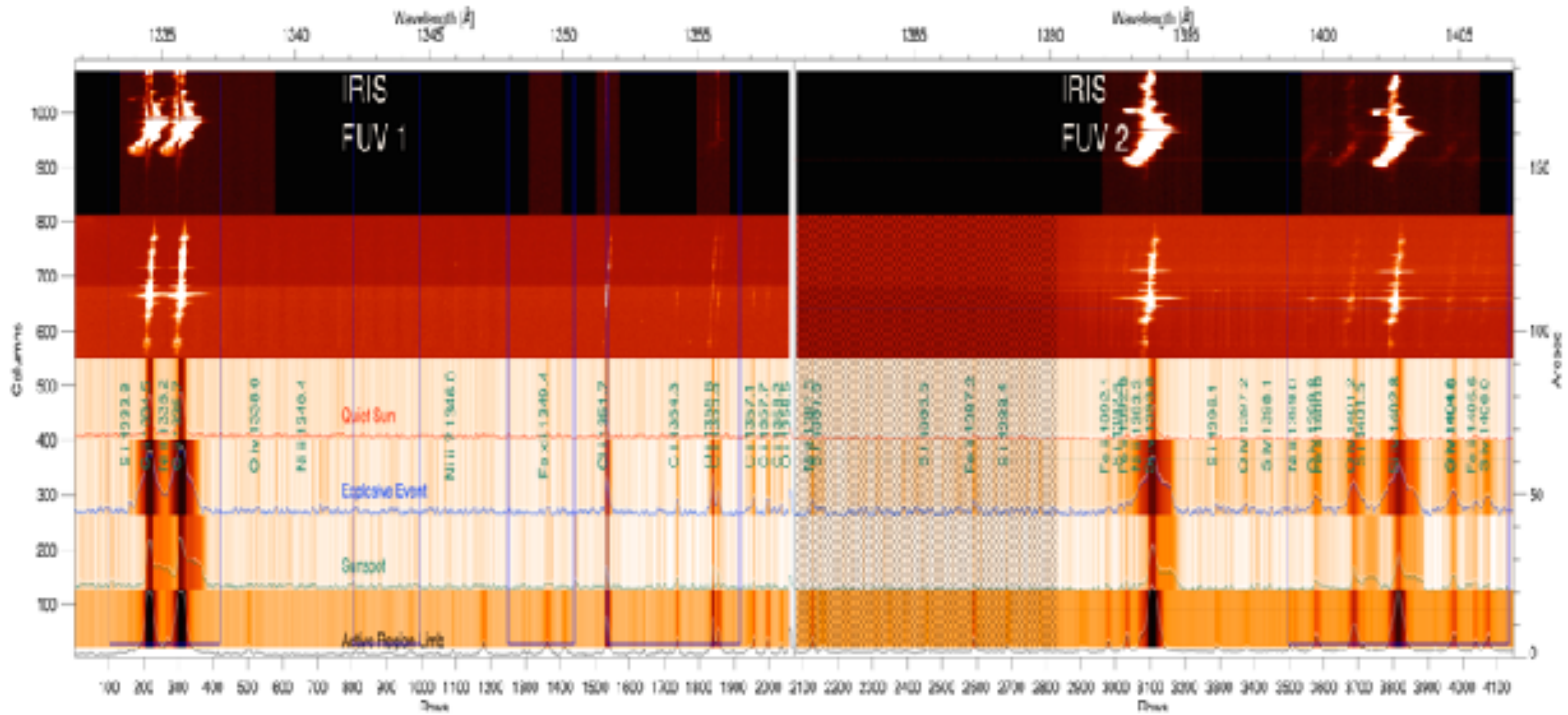


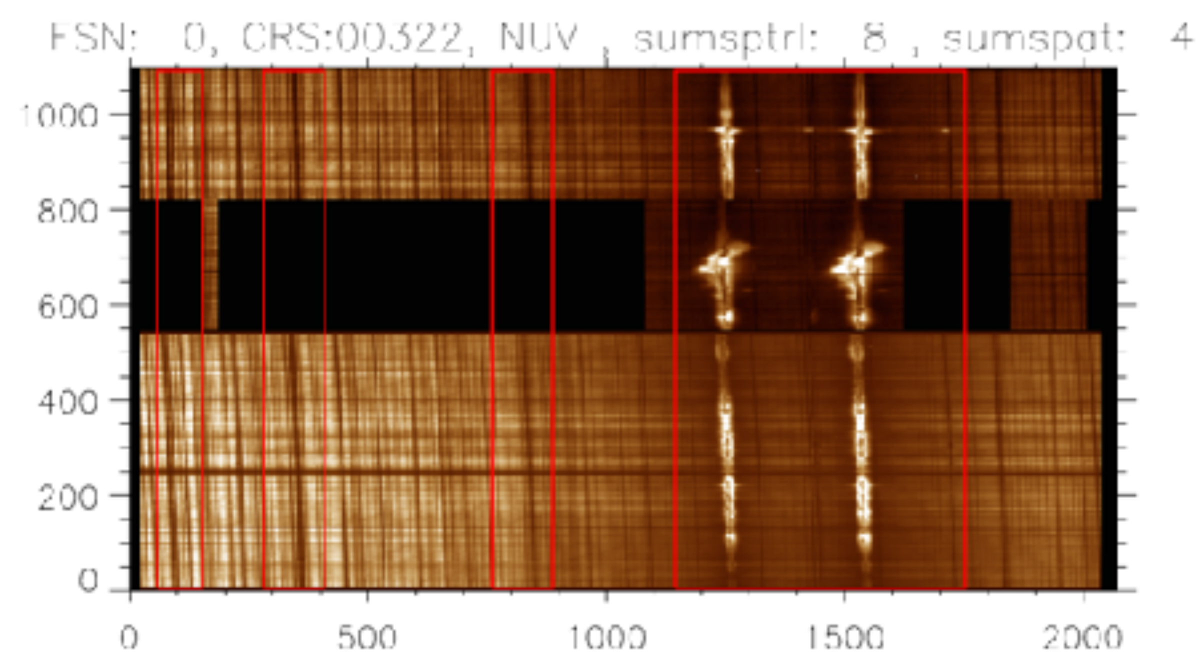
FUV: minimal readout for fast observing programs, ~400 km/s Doppler shifts, focusing on Si IV and C II. No Fe XII or O IV 1399.

NUV: Only Mg II K line, plus photospheric reference. ~300 km/s Doppler.

Line Lists

7.4 Flare Linelist (60 million)

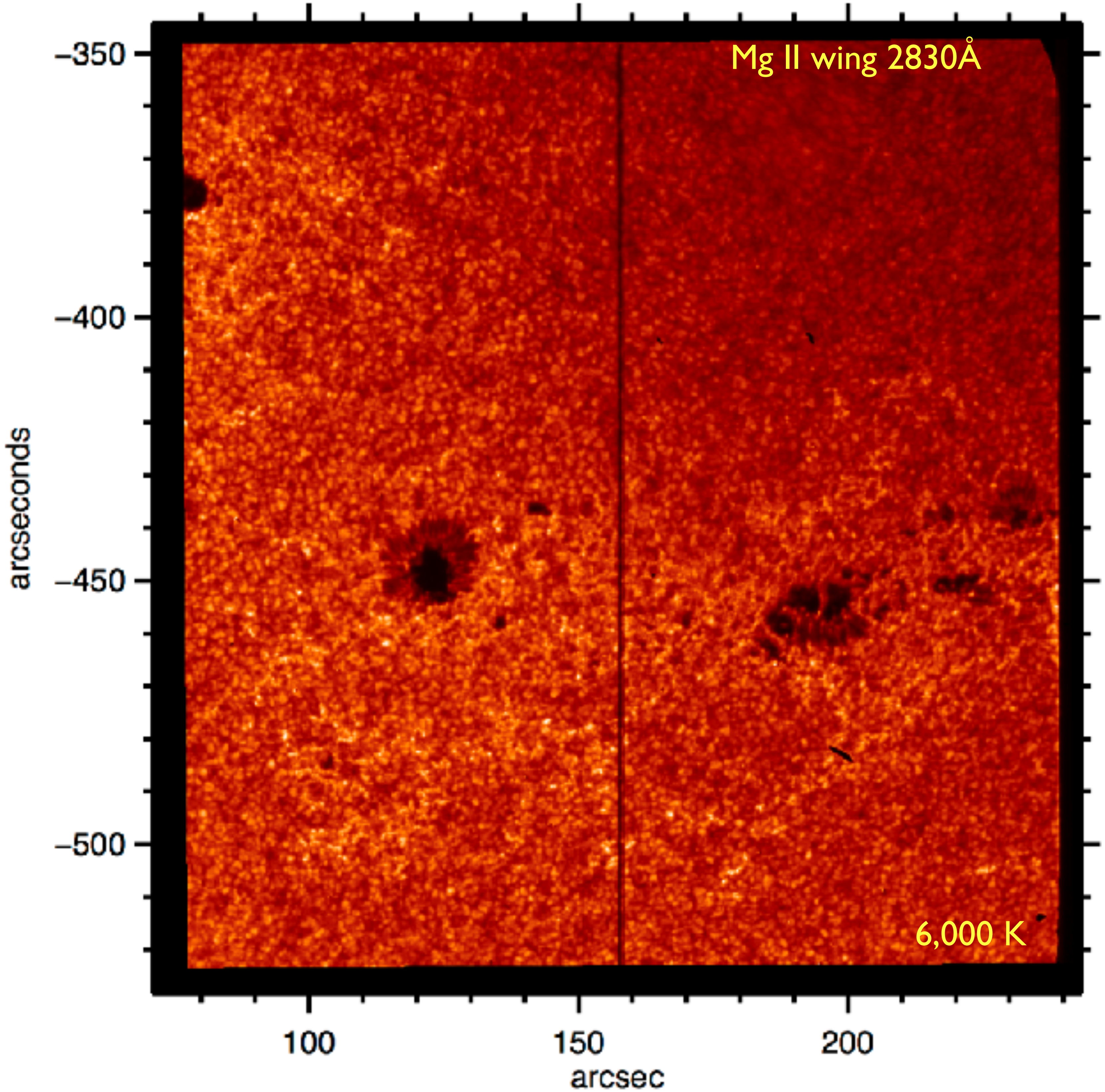




FUV: Si IV and CII. Both Fe lines (XXI and XII) and (allowed) O IV 1343.5 line (flare only). Also includes the S IV 1406 line to assist use of O IV 1399/1401/1404 density sensitive line pairs.

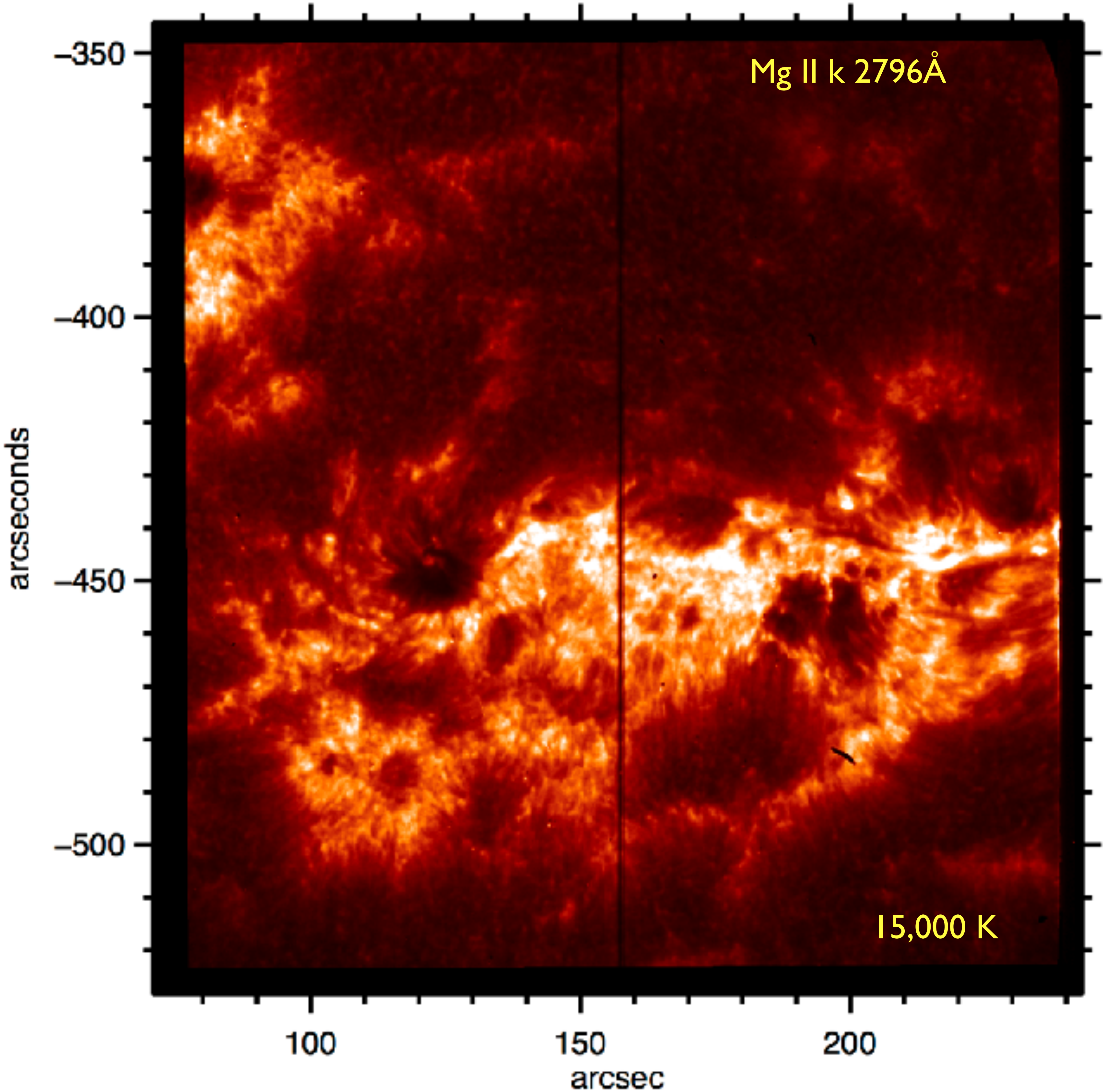
NUV: 600 km/s Doppler for blue wing.

Slit-jaw Choices



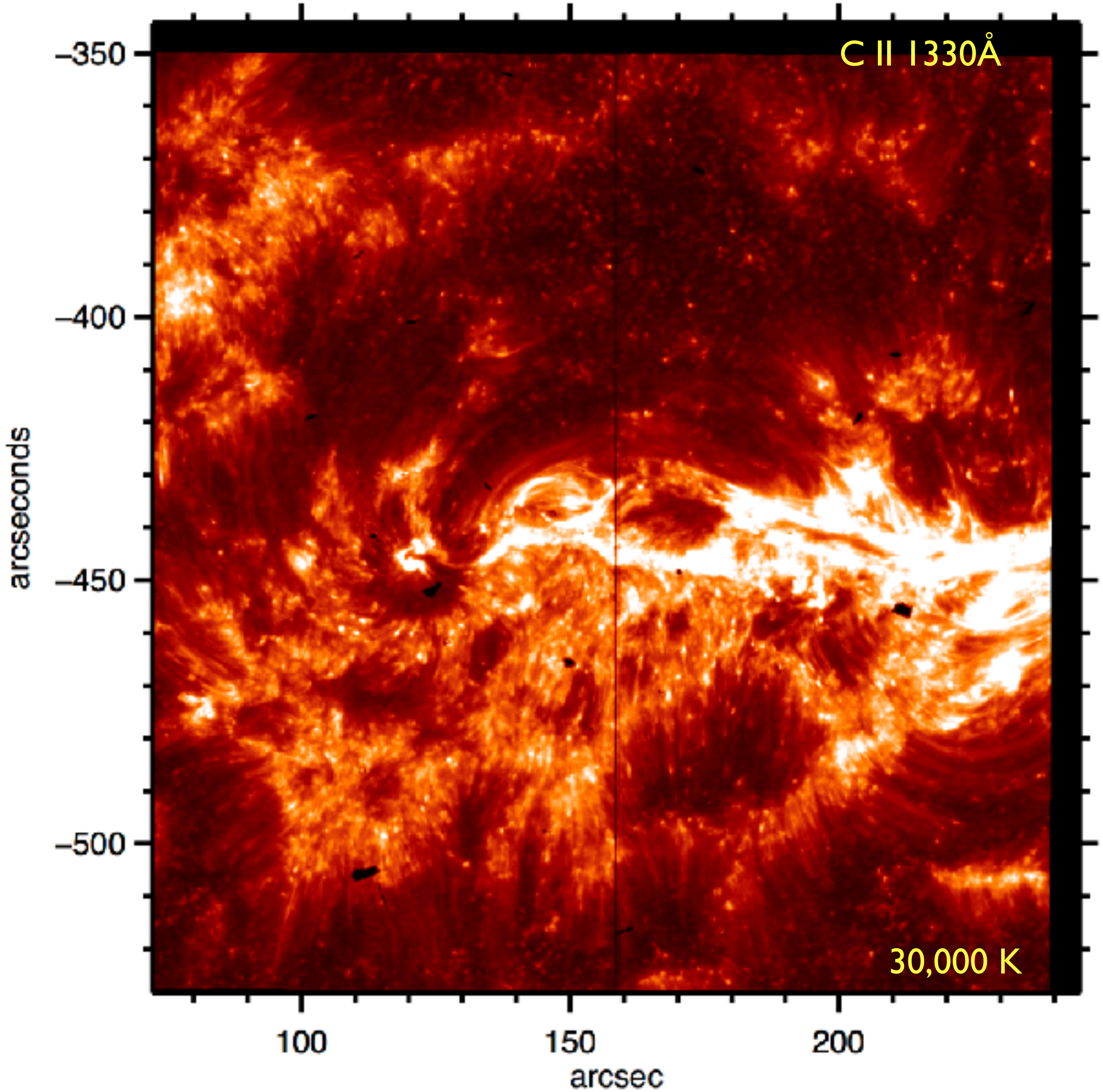
2830, dominated by wing of Mg II h/k lines (photosphere), best for alignment with photospheric images from the ground

Slit-jaw Choices



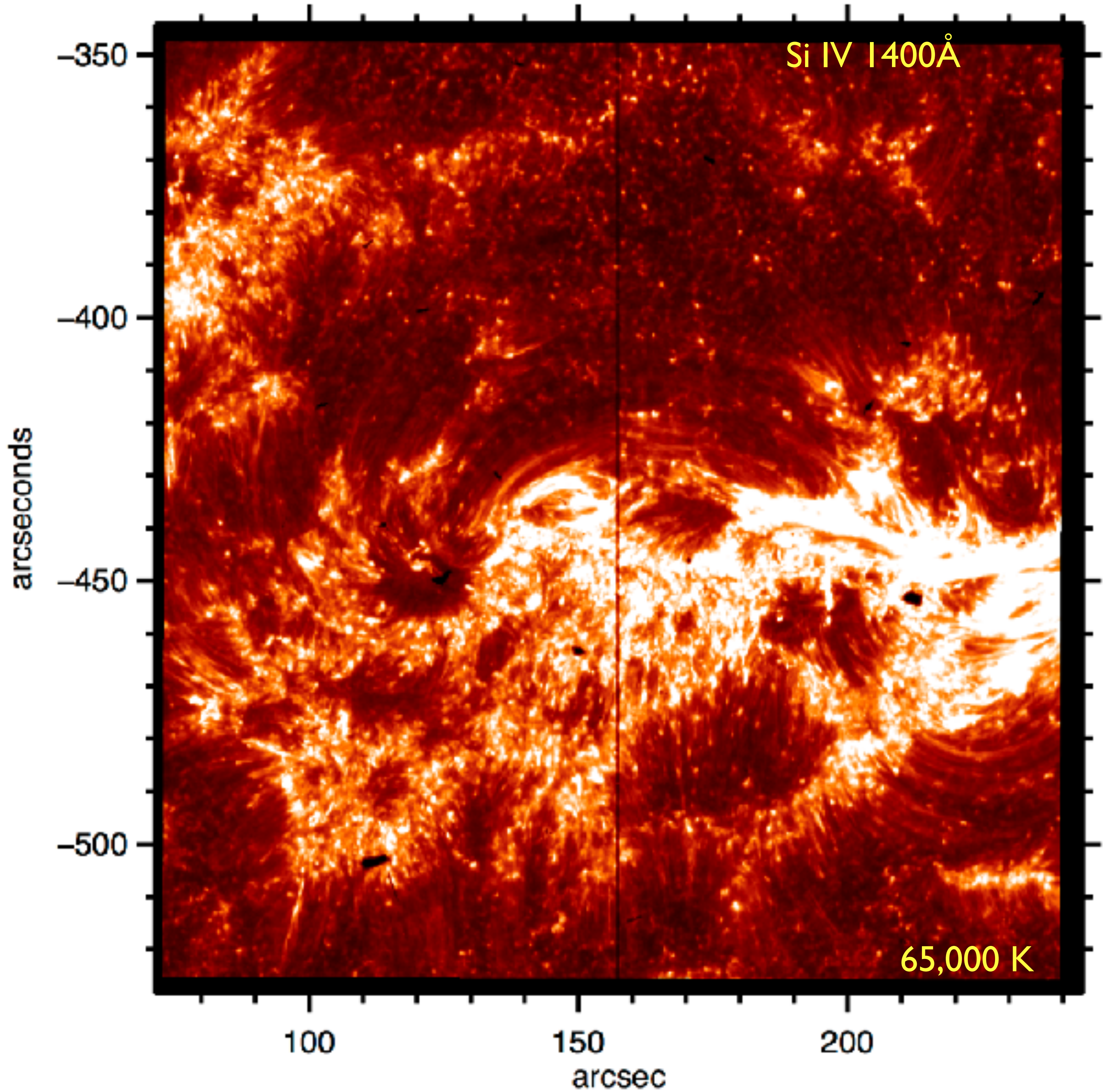
2796, dominated by Mg II k (chromosphere) and inner wings (photosphere), can be aligned with SDO 1600 and photospheric images from the ground

Slit-jaw Choices



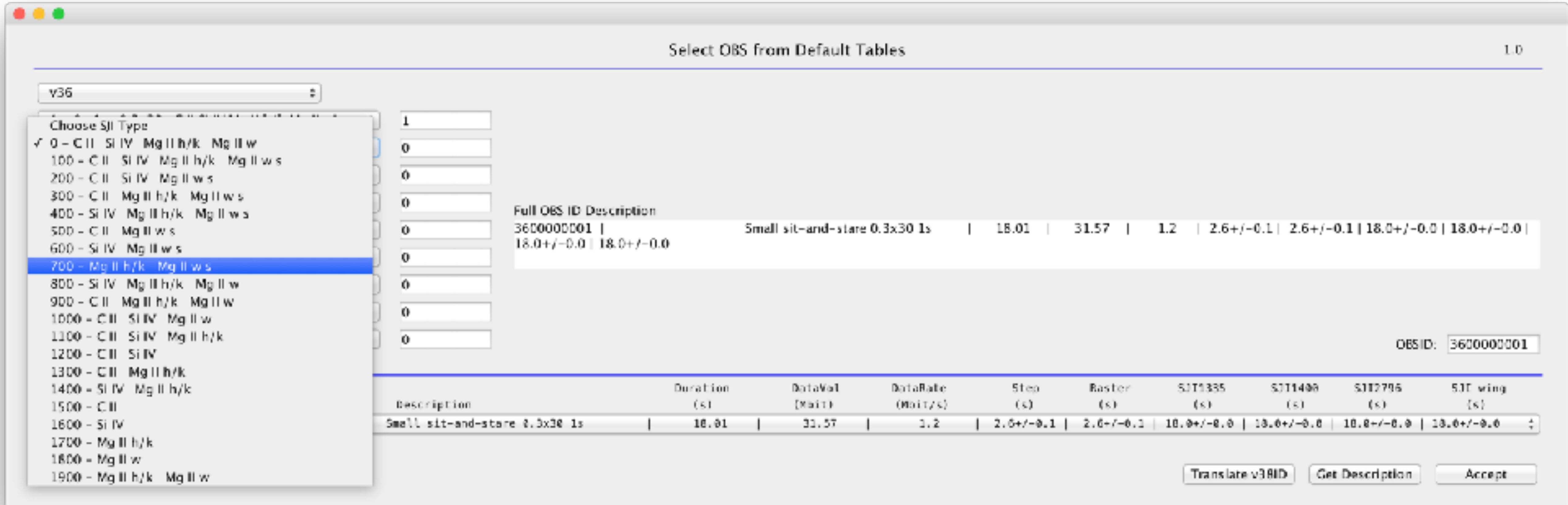
1330, dominated by FUV continuum (upper photosphere, low chromosphere) and C II 1335Å lines (upper chromosphere, lower transition region), can be aligned with SDO 1600 (and some bright points are the same as photospheric/chromospheric images from the ground)

Slit-jaw Choices



1400, dominated by FUV continuum (upper photosphere, low chromosphere) and Si IV 1394/1402Å lines (transition region), can be aligned with SDO 1600 (and some bright points are the same as photospheric/chromospheric images from the ground)

Slit-jaw Choices

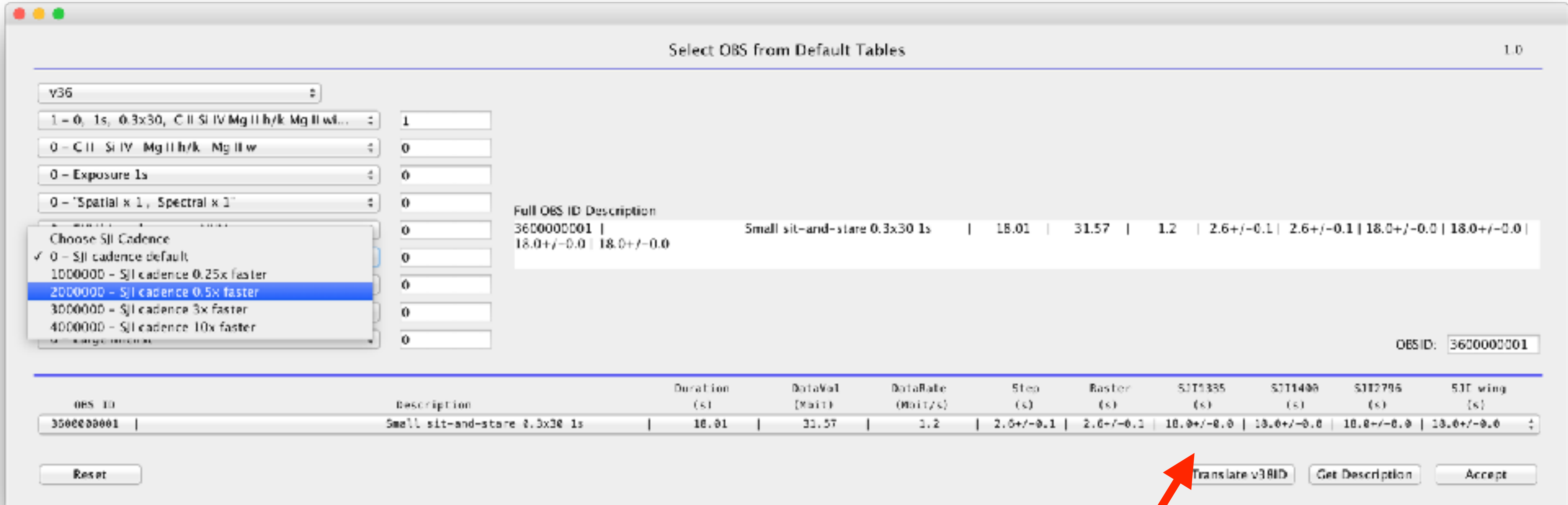


For your desired observations, you should choose which slit-jaw filters you would like images from, with almost any combination of these 4 filters available.

Keep in mind that these slit-jaw images cannot be taken simultaneously — one type of slit-jaw image is available per time-step (during which we always take FUV and NUV spectra). So if you would like all 4 slit-jaw types, the fastest cadence of each individual SJI type is 4x cadence of spectra.

It is possible to get any combination of 2796/1330/1400 at high cadence and combine it with a slower cadence for 2830 (for context).

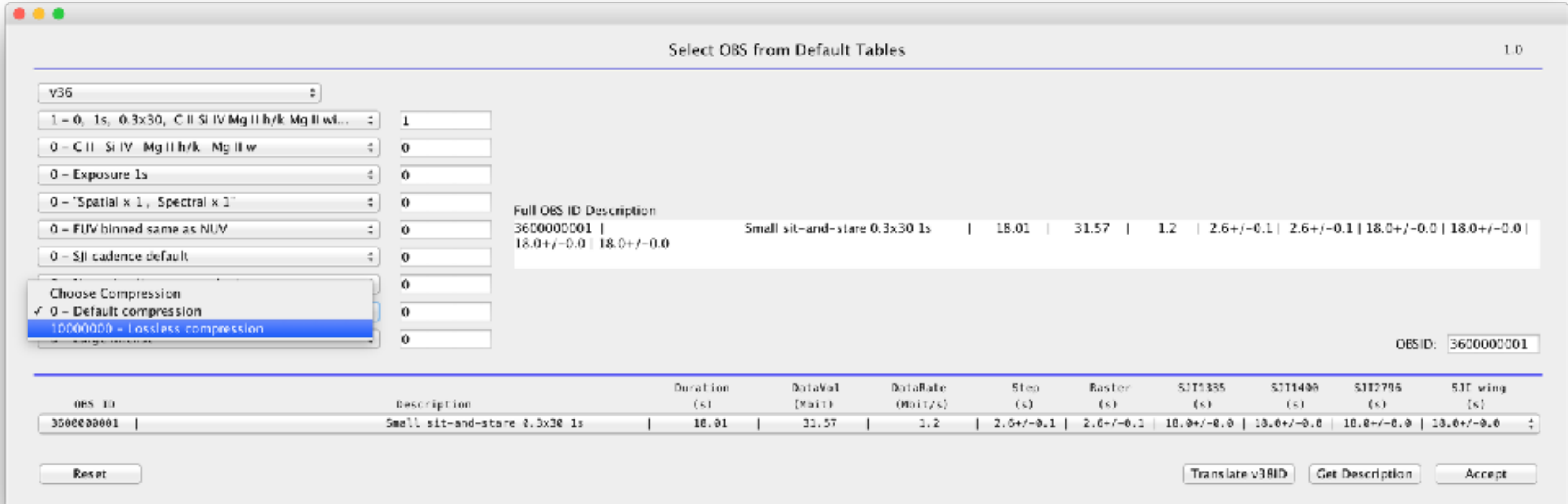
Slit-jaw Cadence



Default observing modes are optimized to take each SJI as fast as possible, but please let us know if you need the absolute highest cadence for each type. The fastest SJI cadence IRIS can provide would be a single channel (e.g., 1400) with short exposures of 2s — the cadence would be order 3s in this case.

Always check the effective SJI cadence!!!

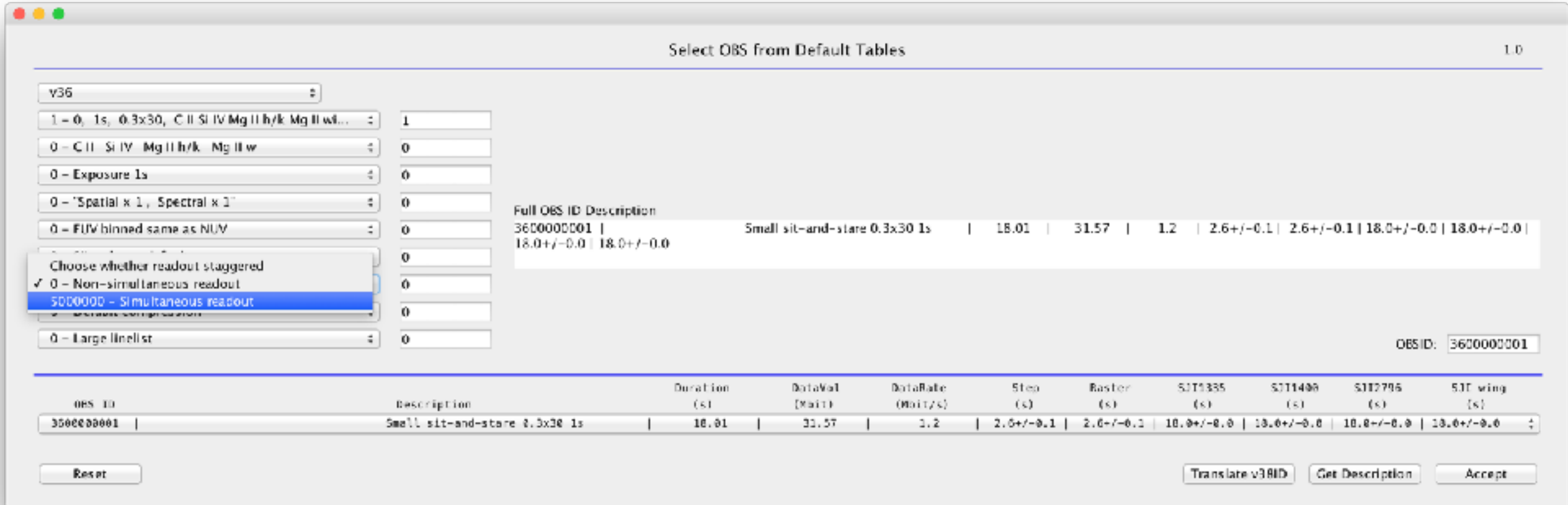
Compression mode



Default is lossy compression which is adequate for bright lines and normal observations

If you’re interested in faint lines, choose “lossless compression”. This leads to higher data rates

Readout mode



Default is non-simultaneous readout which is adequate for most science goals

If very high cadence is critical, select simultaneous readout. Note that this leads to electronic read-out noise which can be very problematic for FUV spectra (given the lower signal-to-noise)

Other considerations

- **Roll**
  - Slit can be rolled up to +/- 90 degrees (e.g. to align with the limb, or cross the AR neutral line)
  - Rolls can be limited on certain days (twice per month), or can impact telemetry rate; work with planner to determine optimal roll
  - Best to choose 0, +-45 or +-90 degree (for pointing stability)

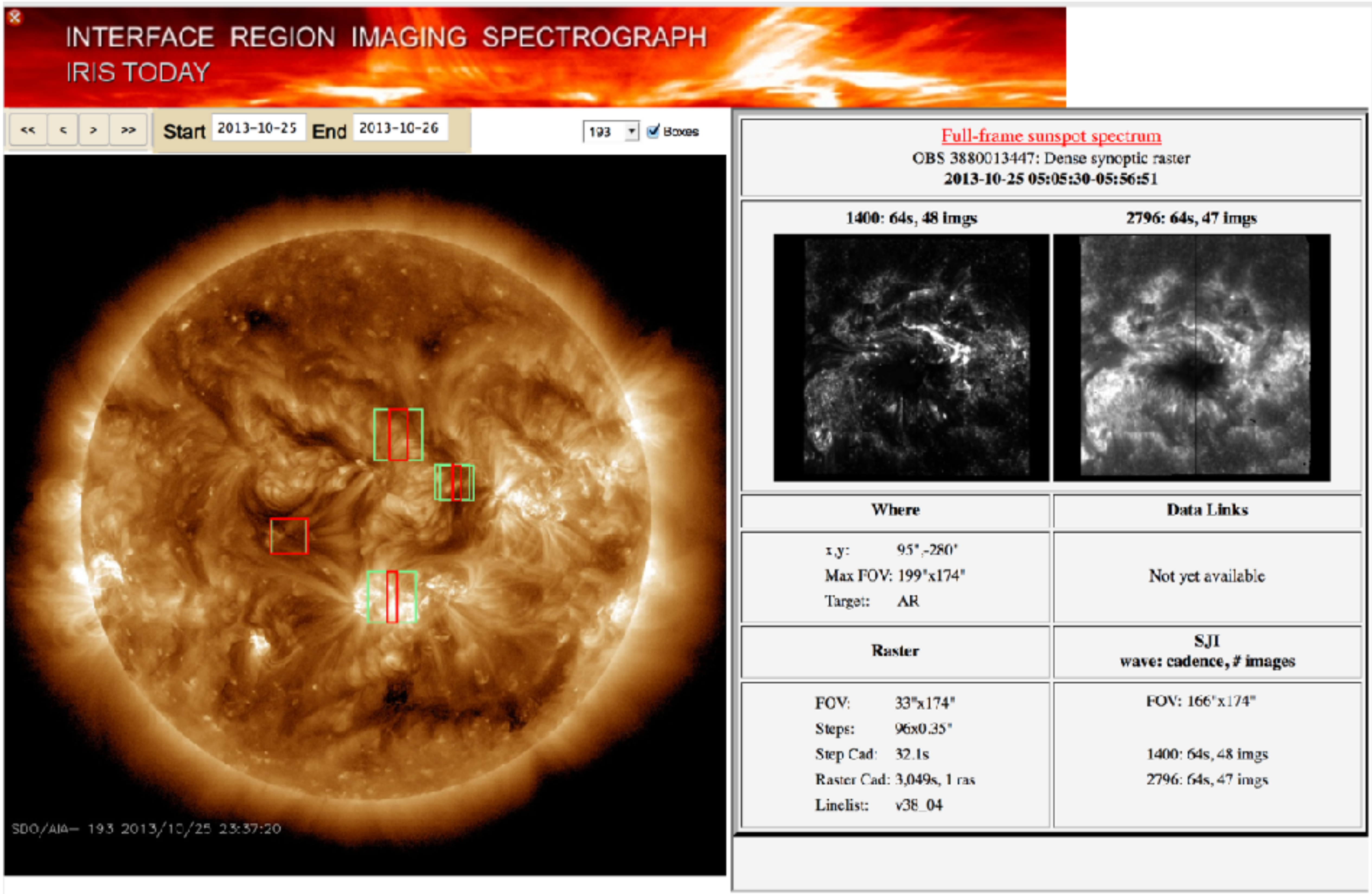
- **Limb Observations**
  - Generally best to have the slit on the disk for at least part of the observation
  - Even better if the slit fiducial is on the disk
  - Consider rolling so the slit is parallel or perpendicular to the limb
  - Easiest co-alignment with GBO is through SJI 2832 (granulation), but also possible with 1400 or 2796

Other considerations

- **Solar rotation tracking**
  - Recommended for most observations, but can be left off for wide rasters, long runs, or limb observations
- **SAA**
  - Certain orbits are affected by particle storms (image spikes); if you're especially sensitive to these, request that the planner choose a time period to minimize SAA during your observation
- **AEC**
  - Automatic exposure control kicks in when there is a flare
  - Generally the planner will worry about this (setting up the AEC if there is any chance of a flare in the field), but let them know if you think it should be disabled (e.g. you are looking for faint features in an active region)

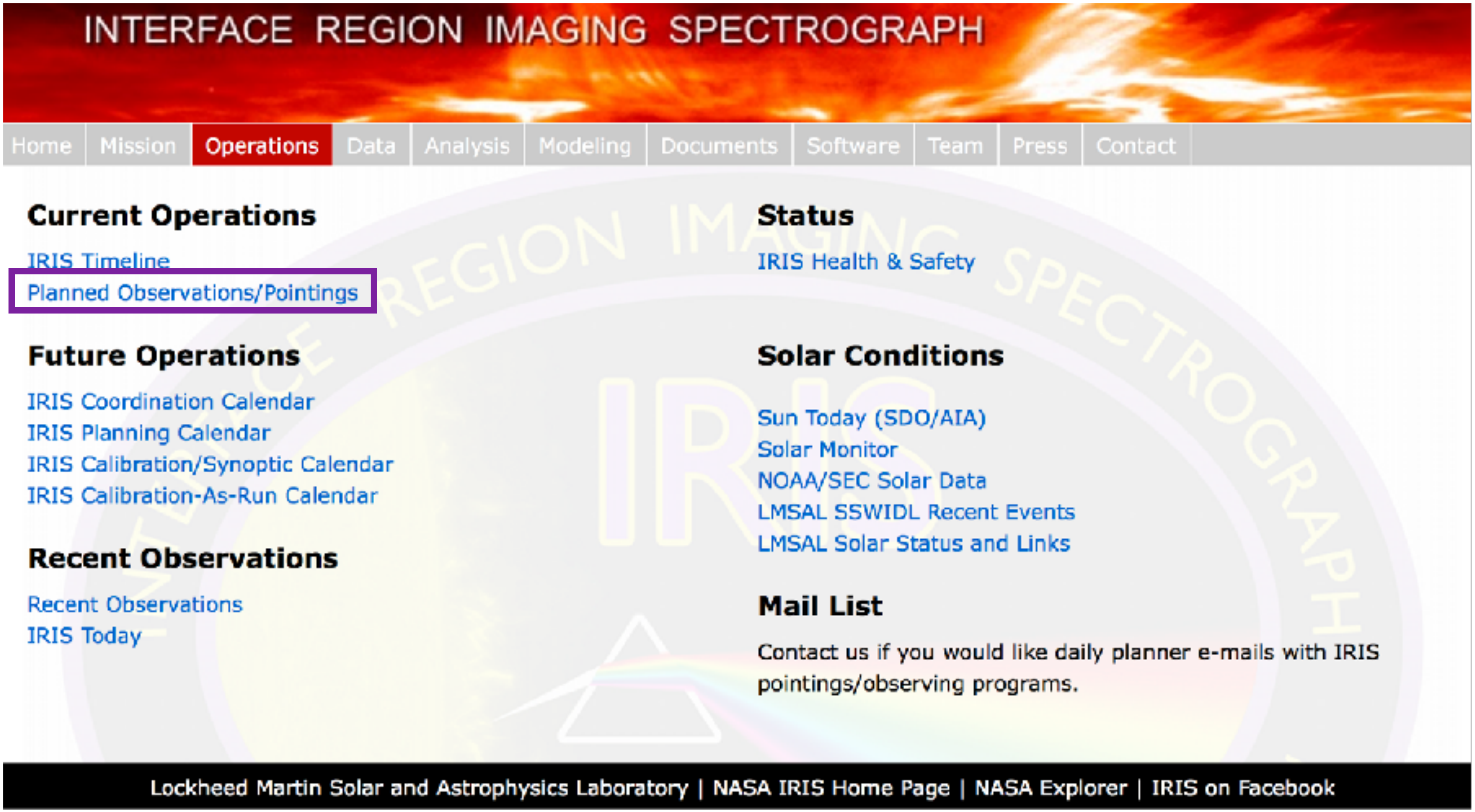
Finding data: IRIS observing plans

http://iris.lmsal.com/iristoday



How is IRIS operated?

http://iris.lmsal.com/operations.html



Heliophysics Events Knowledgebase Coverage Registry (HCR)

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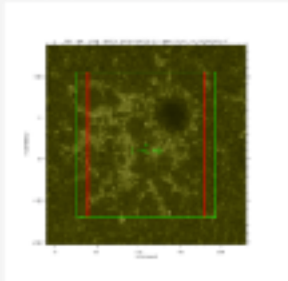
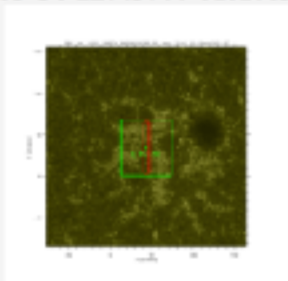
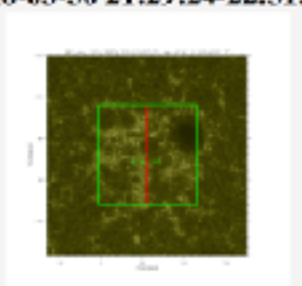
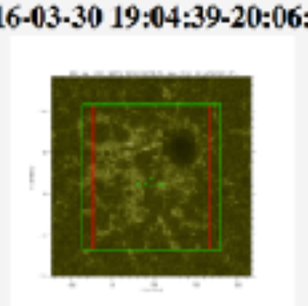
Planned Observations

All IRIS planned observations (most recent first)

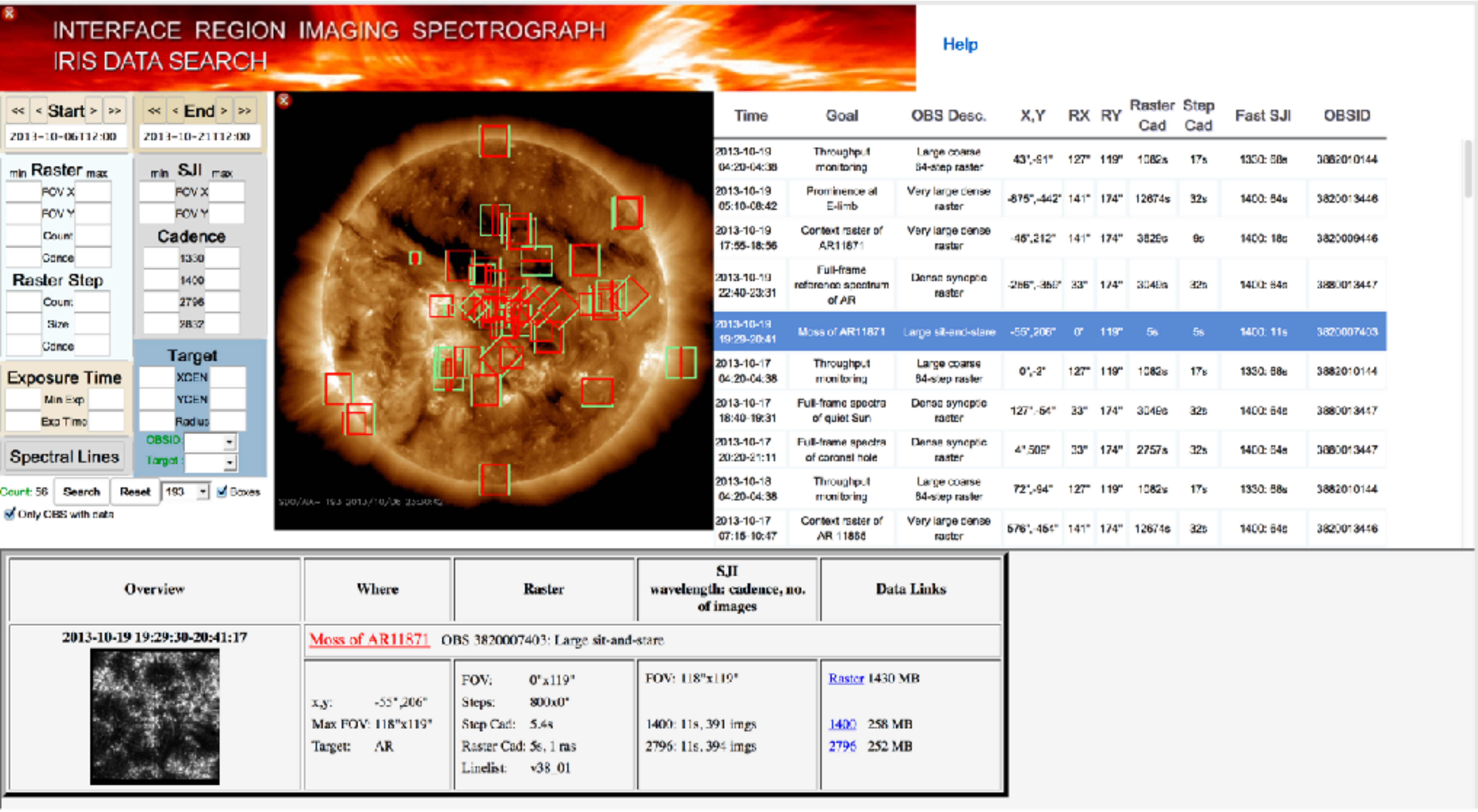
Filter by instrument: IRIS

10278 matches
[1] 2 3 4 5 6 7 8 9 10 ...686 next

Overview	Where	Raster	SJI
2016-03-31 01:29:09-02:30:31	AR monitoring, 400-step raster, AR12526 OBS 3600108078: Very large dense 400-step raster		
	x,y: 110",18' Max FOV: 140"x175" Target: AR Nearby Events		
2016-03-30 22:43:44-01:17:31 +1d	IHOP 243 on plage, AR12526 OBS 3655602035: Medium dense 16-step raster		
	x,y: 44",35' Max FOV: 5"x62" Target: AR Nearby Events		
2016-03-30 21:29:24-22:31:59	explosive events study, AR 12526 OBS 3664101603: Large sit-and-stare		
	x,y: 56",30' Max FOV: 0"x119" Target: AR Nearby Events		
2016-03-30 19:04:39-20:06:01	AR monitoring, 400-step raster, AR12526 OBS 3600108078: Very large dense 400-step raster		
	x,y: 47",20' Max FOV: 140"x175" Target: AR Nearby Events		

Finding data: IRIS data search

http://iris.lmsal.com/search



Conclusions

- IRIS can provide powerful insight on a wide range of science questions

- Maximizing its utility for your observation requires:
  - Thinking about exactly what you want to measure
  - Weighing relative importance of various observable parameters
  - Working with the planner to design the observation and choose the target

- IRIS team looks forward to working with you!
- Check out IRIS Technical Note 50 for more details:
  - https://www.lmsal.com/iris_science/doc?cmd=dcur&proj_num=IS0301&file_type=pdf
- IRIS data available at: http://iris.lmsal.com/search
- Documentation available at: http://iris.lmsal.com/documents.html