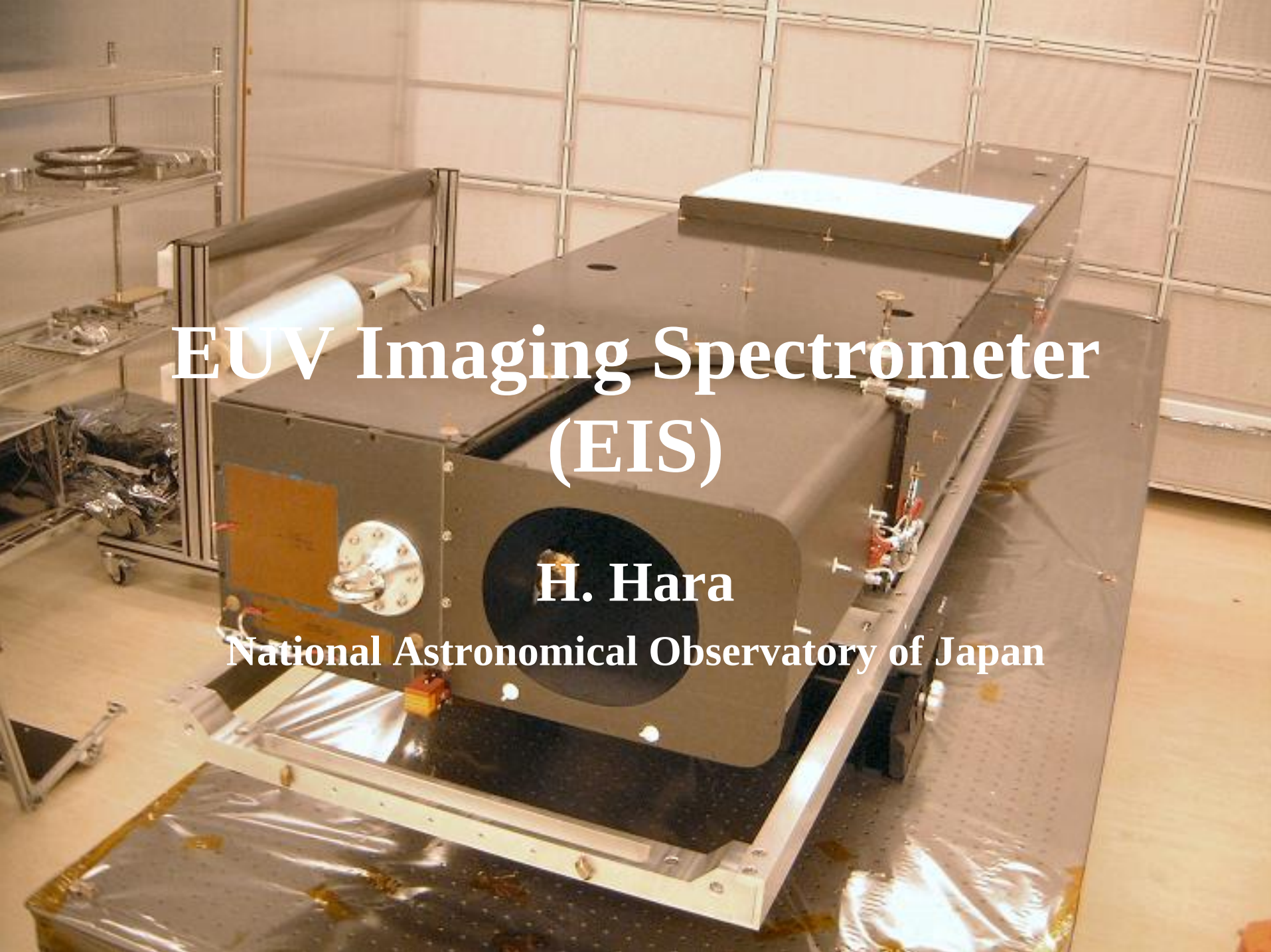


EUV Imaging Spectrometer (EIS)

H. Hara

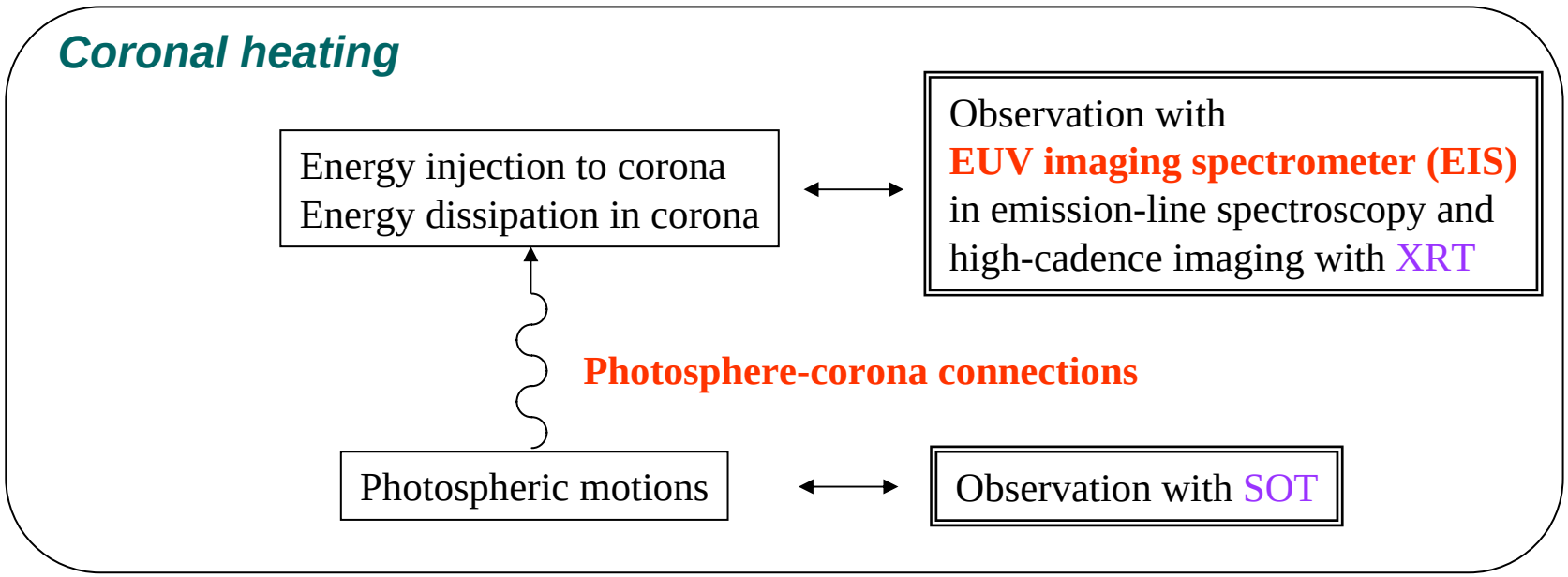
National Astronomical Observatory of Japan

EIS Science

Yohkoh*, *SOHO, and TRACE :

reveal dynamic solar corona (flare, plasmoid, jet, coronal expansion …)

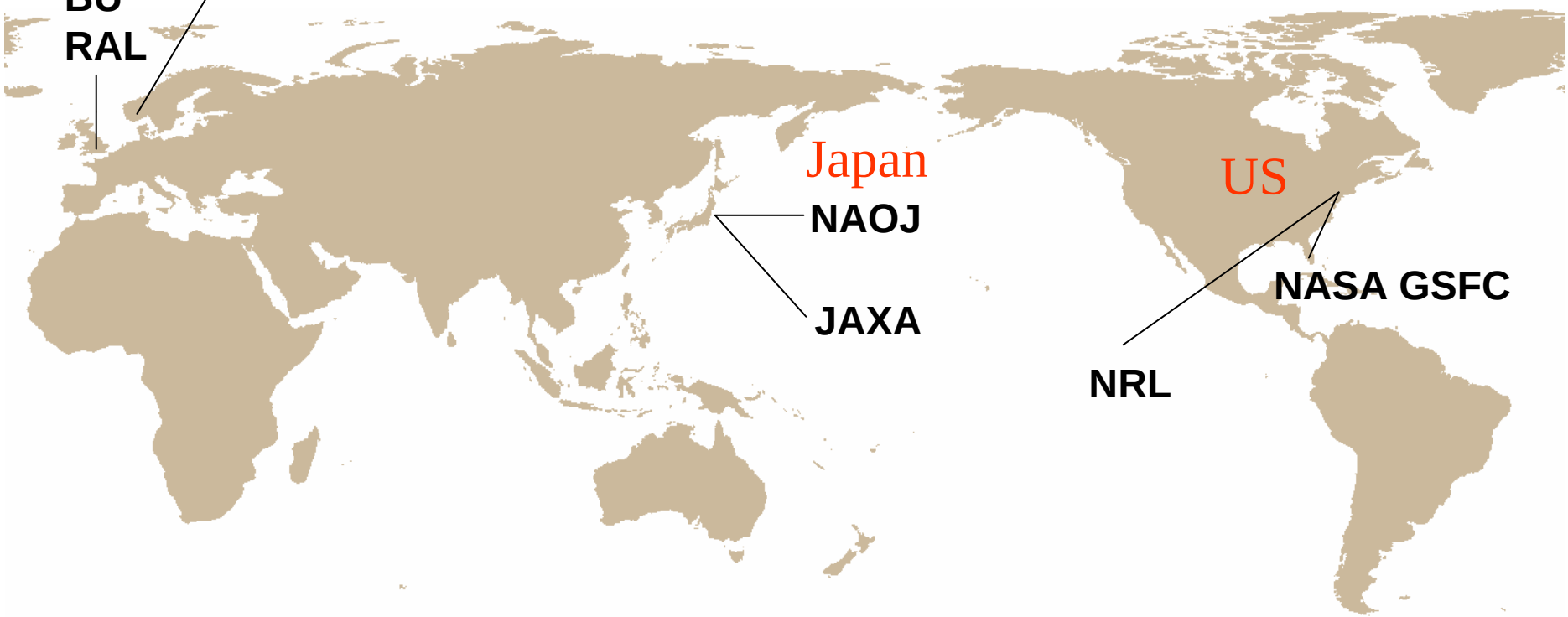
→ Necessity of higher-cadence coronal velocity-field measurements



Flare/CME physics Reconnection physics, Site of large non-thermal line broadening, …

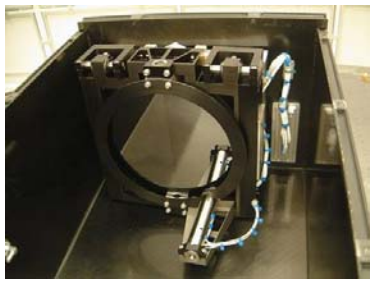
International Collaboration

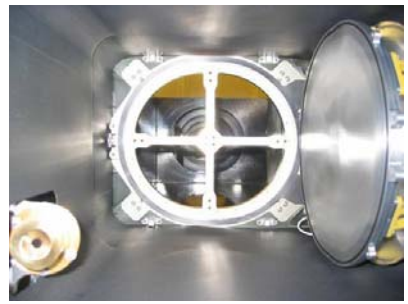
EIS Development team

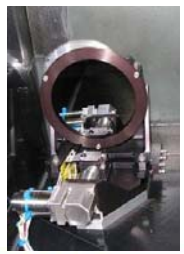


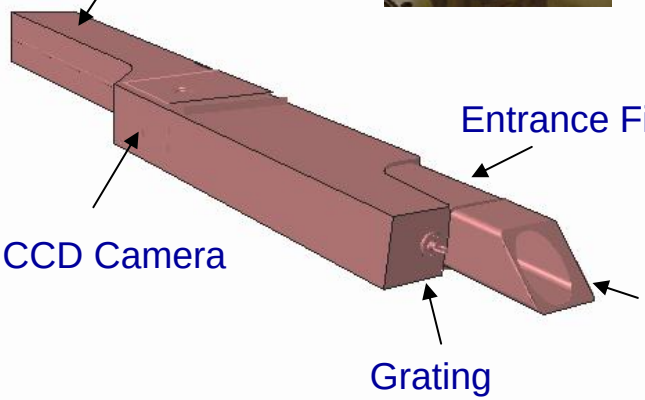
The development started in 1999.
The EIS was delivered to JAXA in summer 2003.

EIS Optical Layout









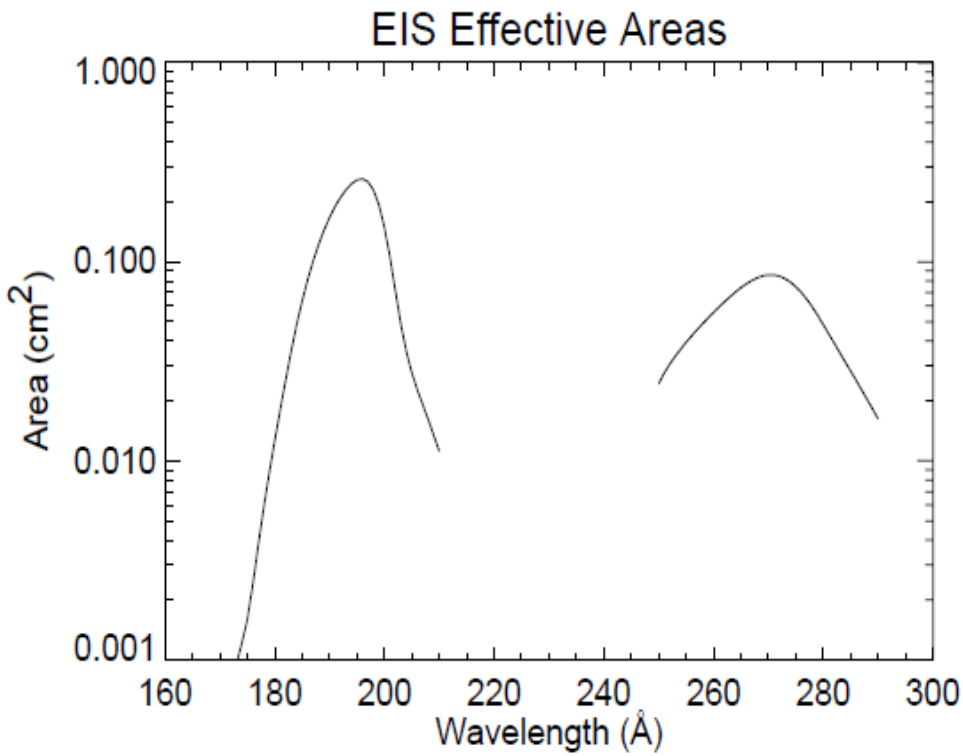
Performance

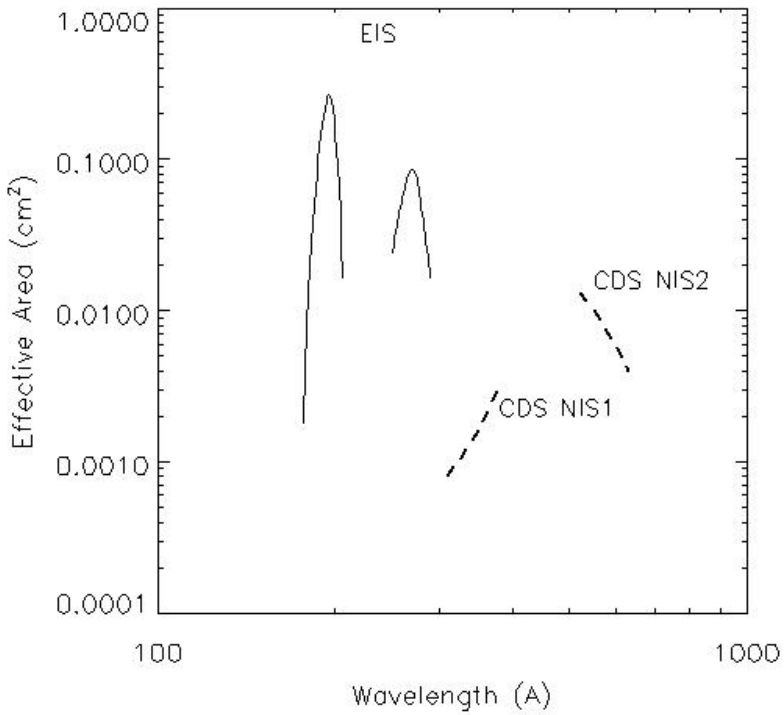
- Large Effective Area in EUV band: **short-λ band** 170-210 A & **long-λ band** 250-290 A
  Mo/Si **multi-layer coated** Mirror and Grating
  High QE CCD: Two 2048×1024 back illuminated CCD
- Spatial resolution: 2 arcsec resolution over raster-scan area
  (1 arcsec pixel sampling)
- Line spectroscopy of 20-30 km/s pixel sampling
- Instrumental width in emission lines for 1 arcsec slit observation:
  short-λ band: 47 mA, long-λ band: 58 mA

- Raster-scan area (EW×NS): 590×512 arcsec^2 max.
  FOV center can move in East-West direction by ±890 arcsec.

- Wide temperature coverage: log T = 4.7, 5.4, 6.0-7.3
- Simultaneous observation of multiple lines up to **25**

EIS Effective Area





EIS Sensitivity

Detected photons per 1″×1″ area of the sun per 1 sec exposure.

AR: active region

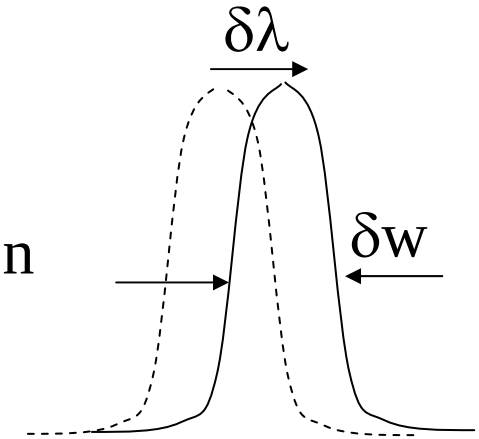
Ion	Wavelength (A)	logT	$N_{photons}$	
			AR	M2-Flare
Fe X	184.54	6.00	15	36
Fe XII	186.85 / 186.88	6.11	13/21	105/130
Fe XXI	187.89	7.00	-	346
Fe XI	188.23 / 188.30	6.11	41 / 15	110/47
Fe XXIV	192.04	7.30	-	4.0×10^4
Fe XII	192.39	6.11	46	120
Ca XVII	192.82	6.70	31	1.8×10^3
Fe XII	193.52	6.11	135	305
Fe XII	195.12 / 195.13	6.11	241/16	538/133
Fe XIII	200.02	6.20	20	113
Fe XIII	202.04	6.20	35	82
Fe XIII	203.80 / 203.83	6.20	7/20	38/114

Ion	Wavelength (A)	logT	$N_{photons}$	
			AR	M2-Flare
Fe XVI	251.07	6.40	-	108
Fe XXII	253.16	7.11	-	71
Fe XVII	254.87	6.60	-	109
Fe XXVI	255.10	7.30	-	3.3×10^3
He II	256.32	4.70	16	3.6×10^3
Si X	258.37	6.11	14	62
Fe XVI	262.98	6.40	15	437
Fe XXIII	263.76	7.20	-	1.2×10^3
Fe XIV	264.78	6.30	20	217
Fe XIV	270.51	6.30	17	104
Fe XIV	274.20	6.30	14	76
Fe XV	284.16	6.35	111	1.5×10^3

Observables

Information from a single emission line

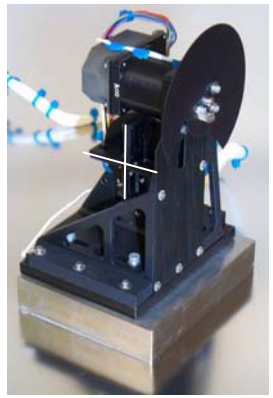
- Line intensity
- Line shift by Doppler motion
- Line width: temperature, non-thermal motion



Information from selected two line ratio

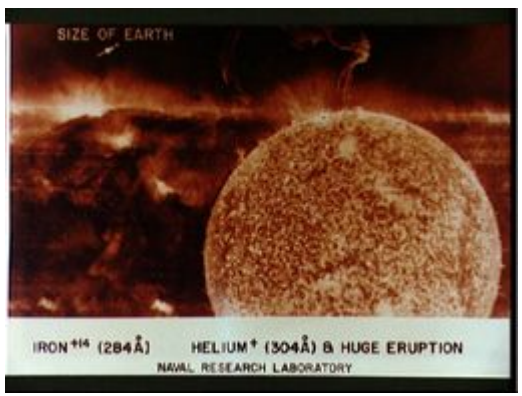
- Temperature
- Density

EIS Slit/Slot



- Four slit selections available
- Direction of slit length: north-south direction
- **EUV line spectroscopy**
  - 1 arcsec × L arcsec slit for the best quality of image/spectrum quality
  - 2 arcsec × L arcsec slit for a higher throughput

- **EUV Imaging** (Velocity information is convolved.)
  - 40 arcsec × L arcsec slot for imaging with little overlap
  - 266 arcsec × L arcsec slot for hunting transient events

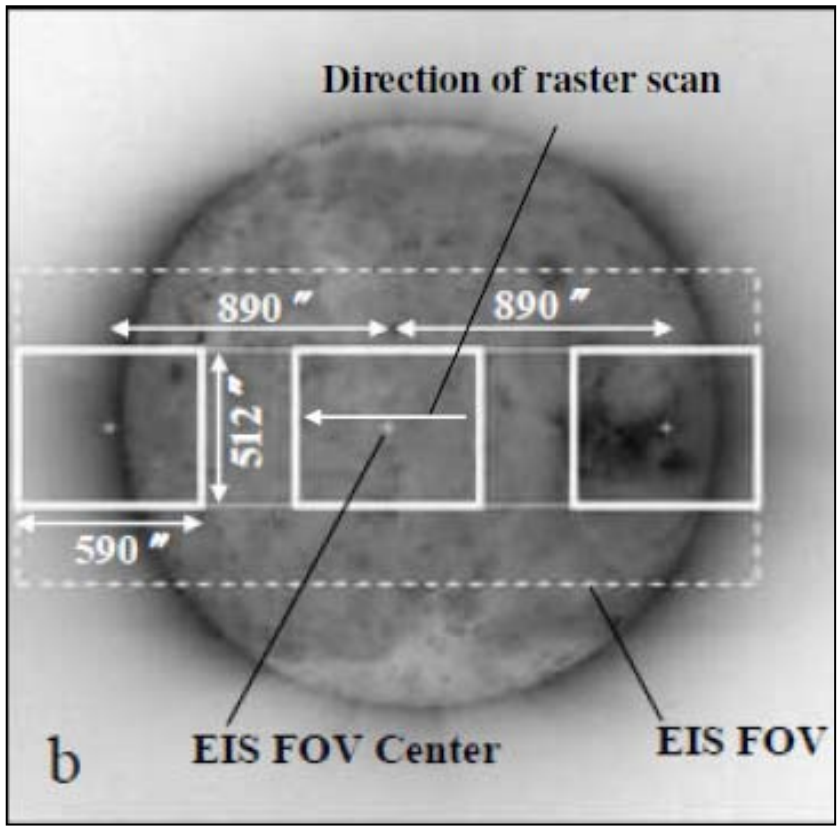


L > 1024 arcsec (=CCD height)

EIS Field-of-View (FOV)

N

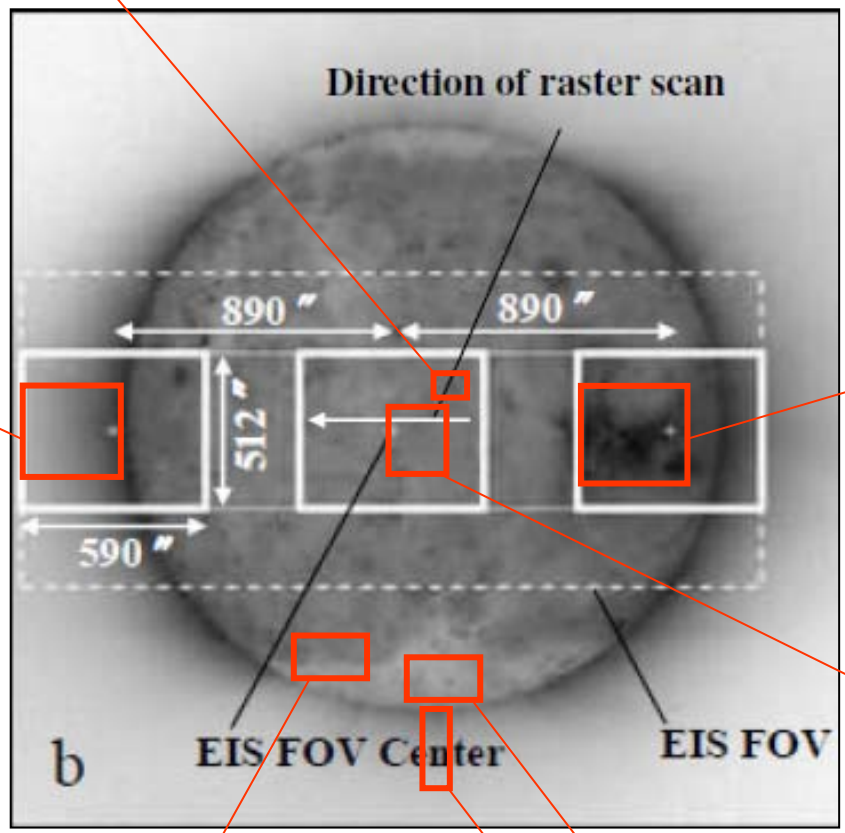
E



W

S

EIS Science Targets



Bright Point

Limb/beyond the limb

Active regions/Flares

Quiet Sun/
Network brightening

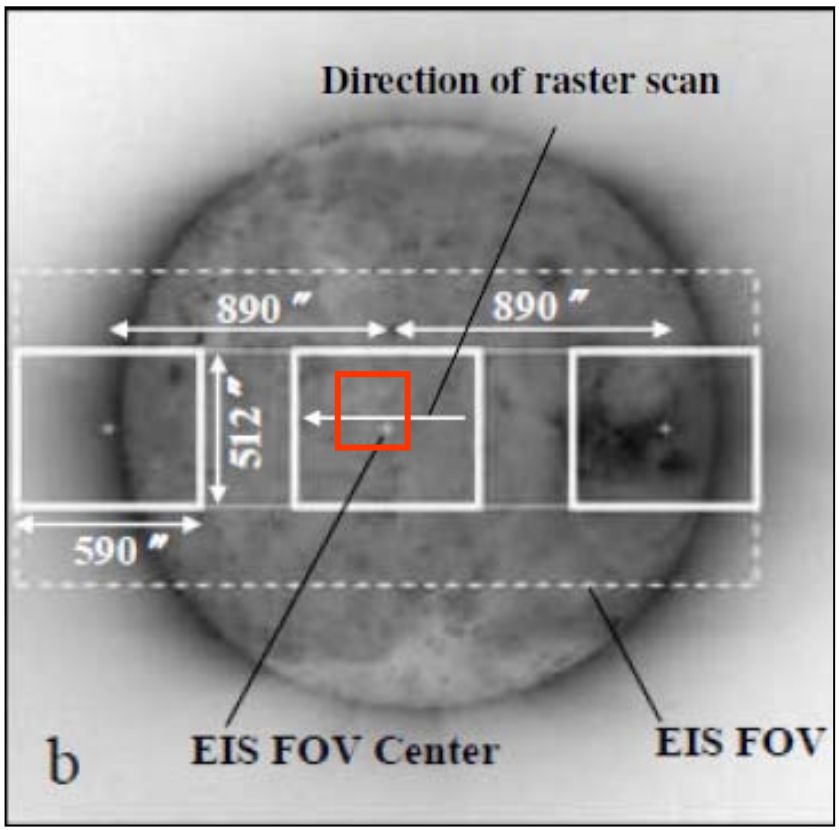
Coronal Hole

Coronal Hole Boundary

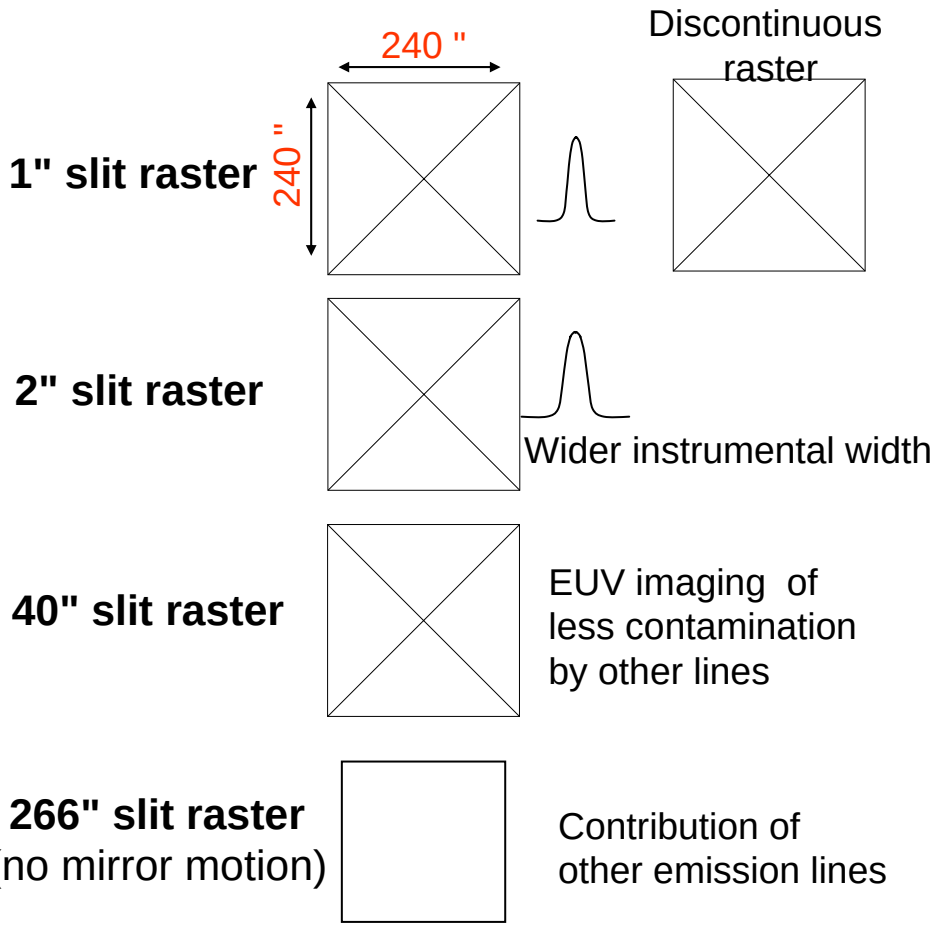
Polar Plume

S/C re-pointing required

EIS Observations



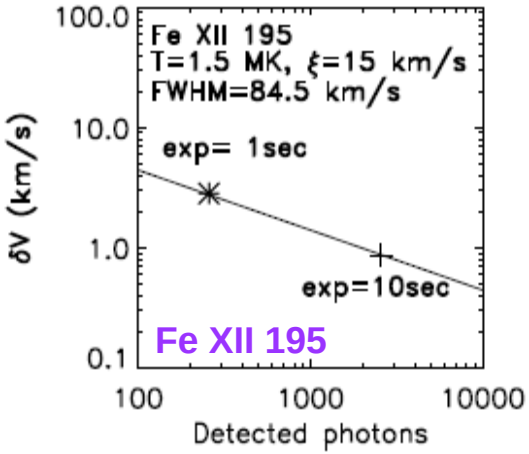
Examples of 240" ×240" Raster Scan

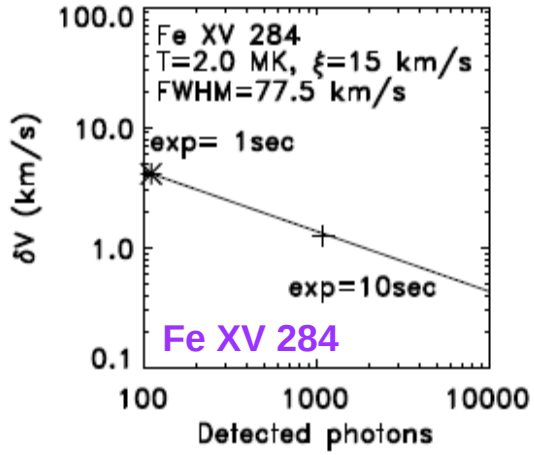


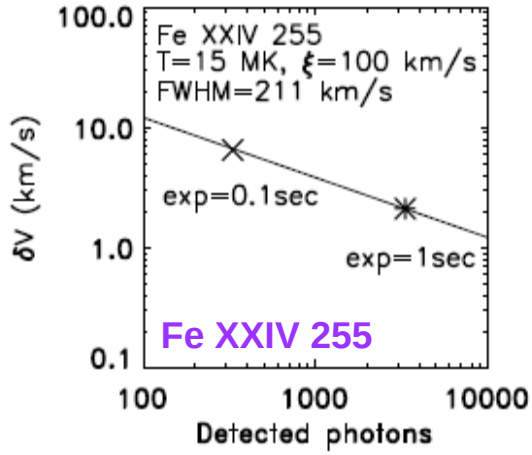
Expected Accuracy of Velocity

AR-line | AR-line | FL-line (GOES-M2)

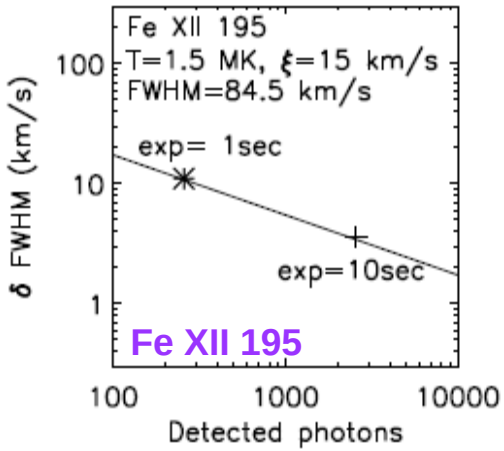
Doppler Velocity

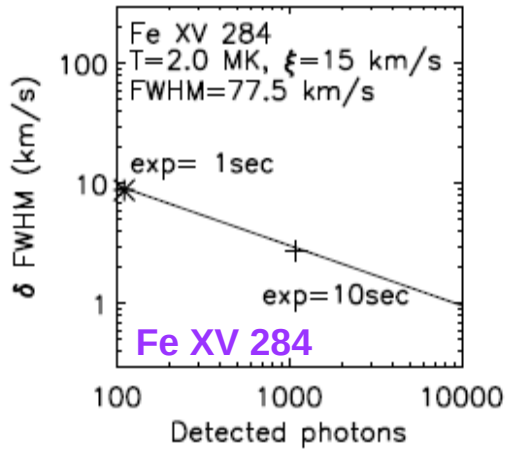


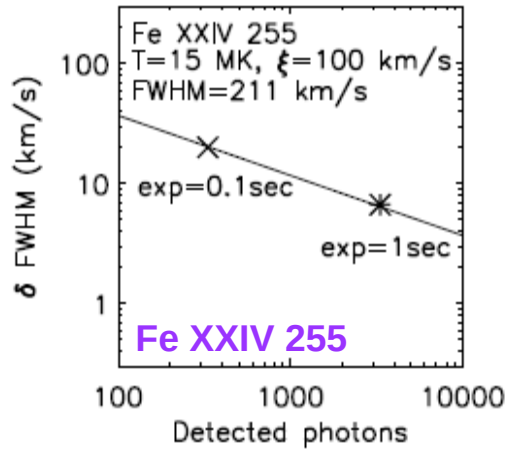




Line Width

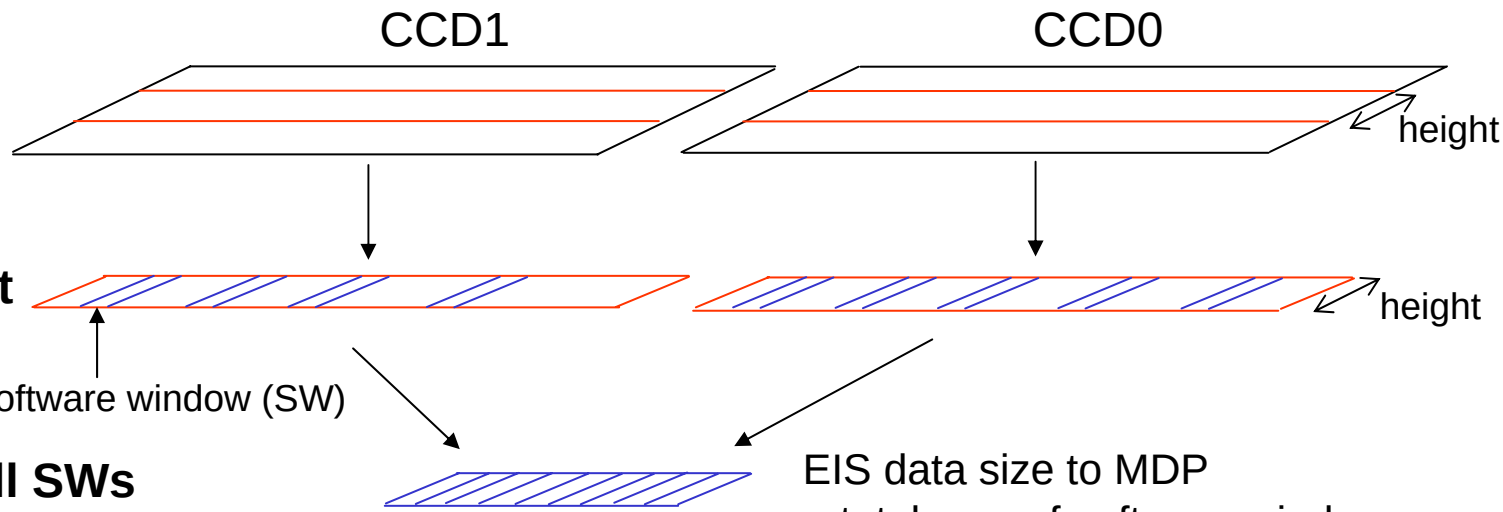






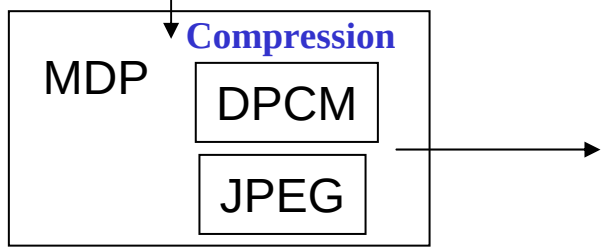
Number of detected photons (1"×1" area)$^{-1}$

EIS Image Data



EIS data size to MDP
= total sum of software windows
= $\sum (\text{window width})_i * (\text{window height})_i$

Raw data



Compression ratio
= compressed data size/ input data size to MDP

Data rate ~ [EIS data size to MDP] * [Compression Ratio] / Cadence

EIS Data Flow

Small spectral window (25 max)

Data compression
DPCM(loss less) or 12bit-JPEG

CCD Readout Electronics

control

EIS ICU

2Mbps max
~1.3 Mbps

S/C MDP

Large hardware CCD window

Observation table

	1″ slit obs.	40″ slot obs.	250″ slot obs.
Spec.width	16	40	250
Spatial width	256″	512″	256
No. of lines	8	4	4
Compression*	25%	20 %	20%
Cadence	3 sec	6 sec	20 sec
Rate	42.7 kbps	42.7 kbps	40 kbps

* **for 16 bit/pixel data**

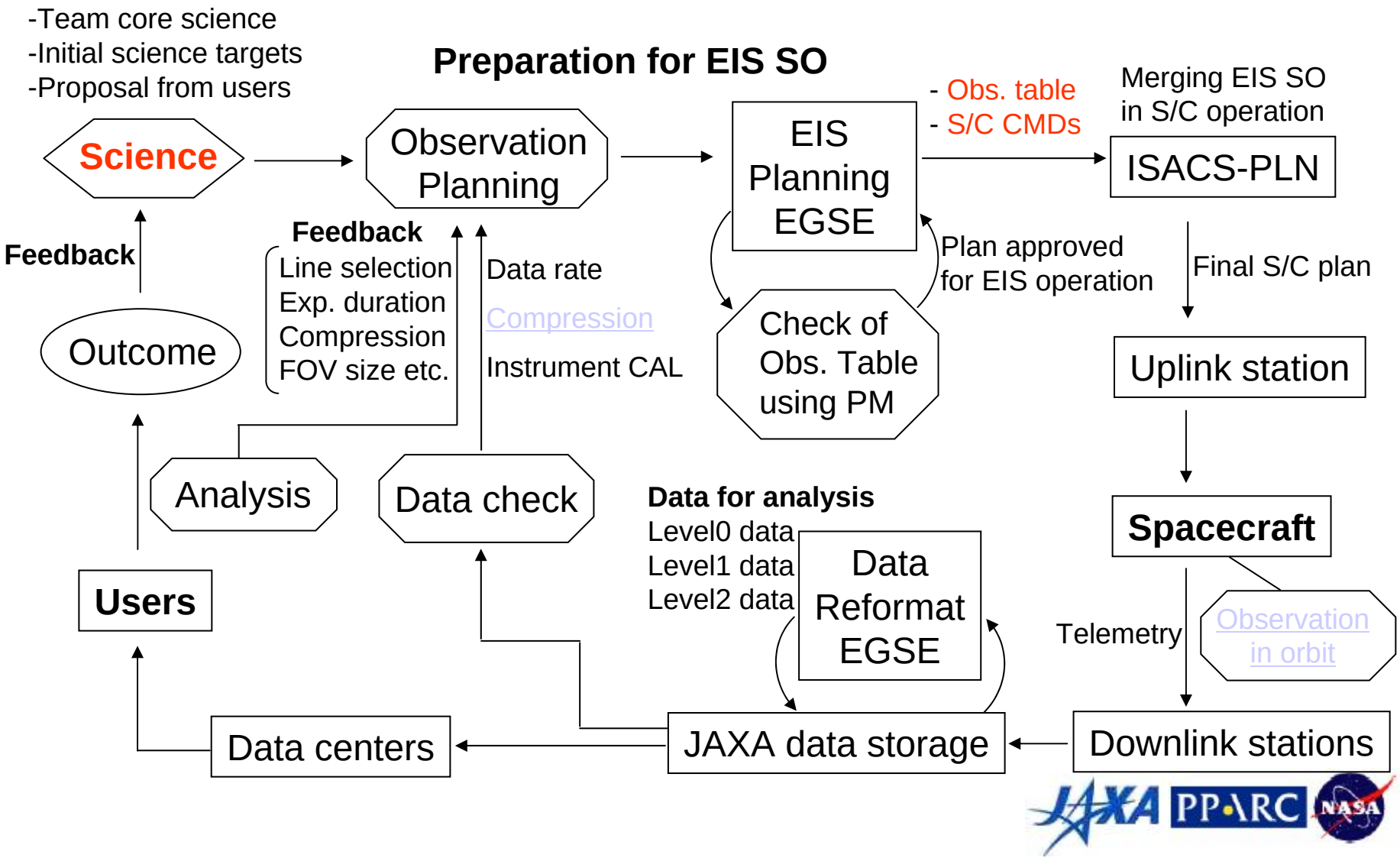
13 min cadence for 4′×4′ rastering

~ 260 kbps max
for short duration,
~ 45 kbps average

Average rate depends on number of downlink stations.

Telemetry data format

EIS Science Operation



Summary

- EIS is an excellent instrument to investigate the dynamical solar upper atmospheres.

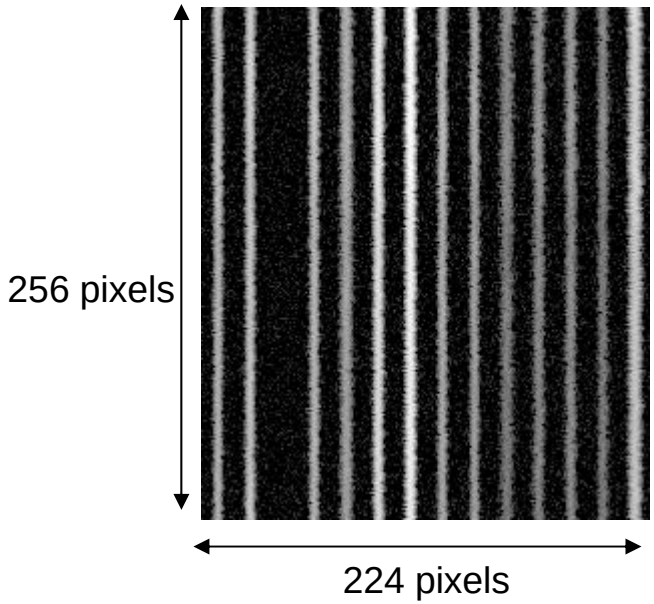
- Scientific output will strongly depend on the EIS observation planning in which ideas of scientists are deeply contained.

EIS
SOLAR-B

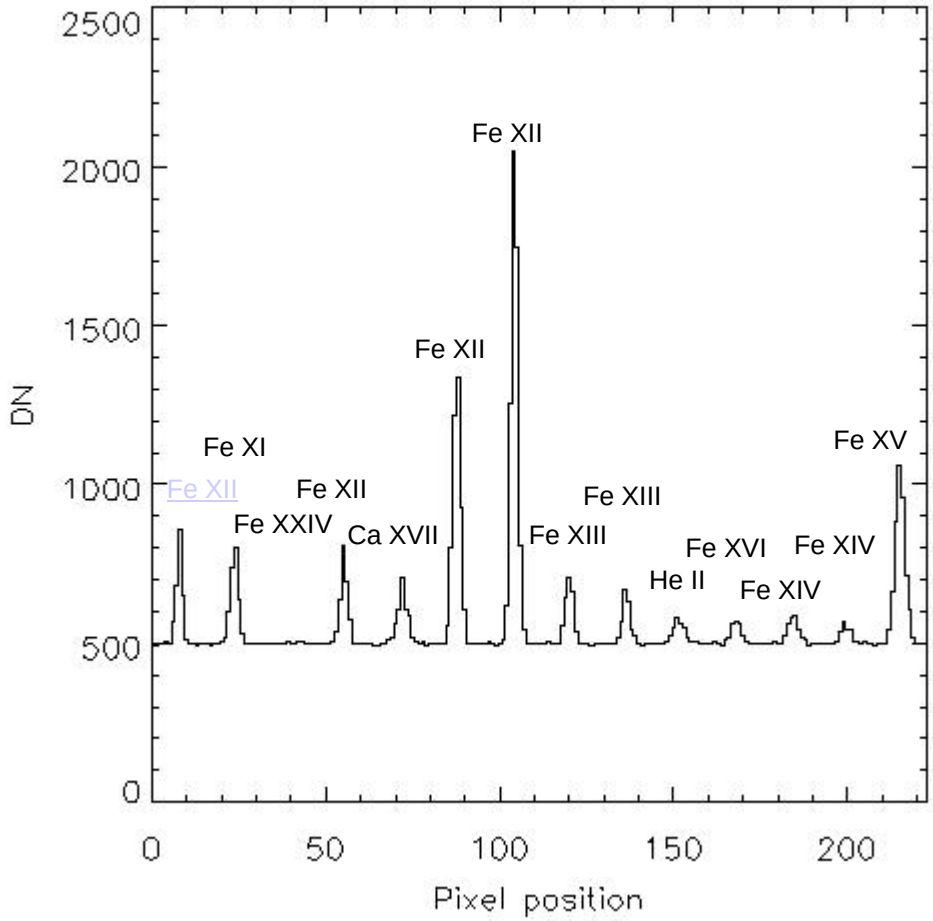
END

JAXA PPARC NASA

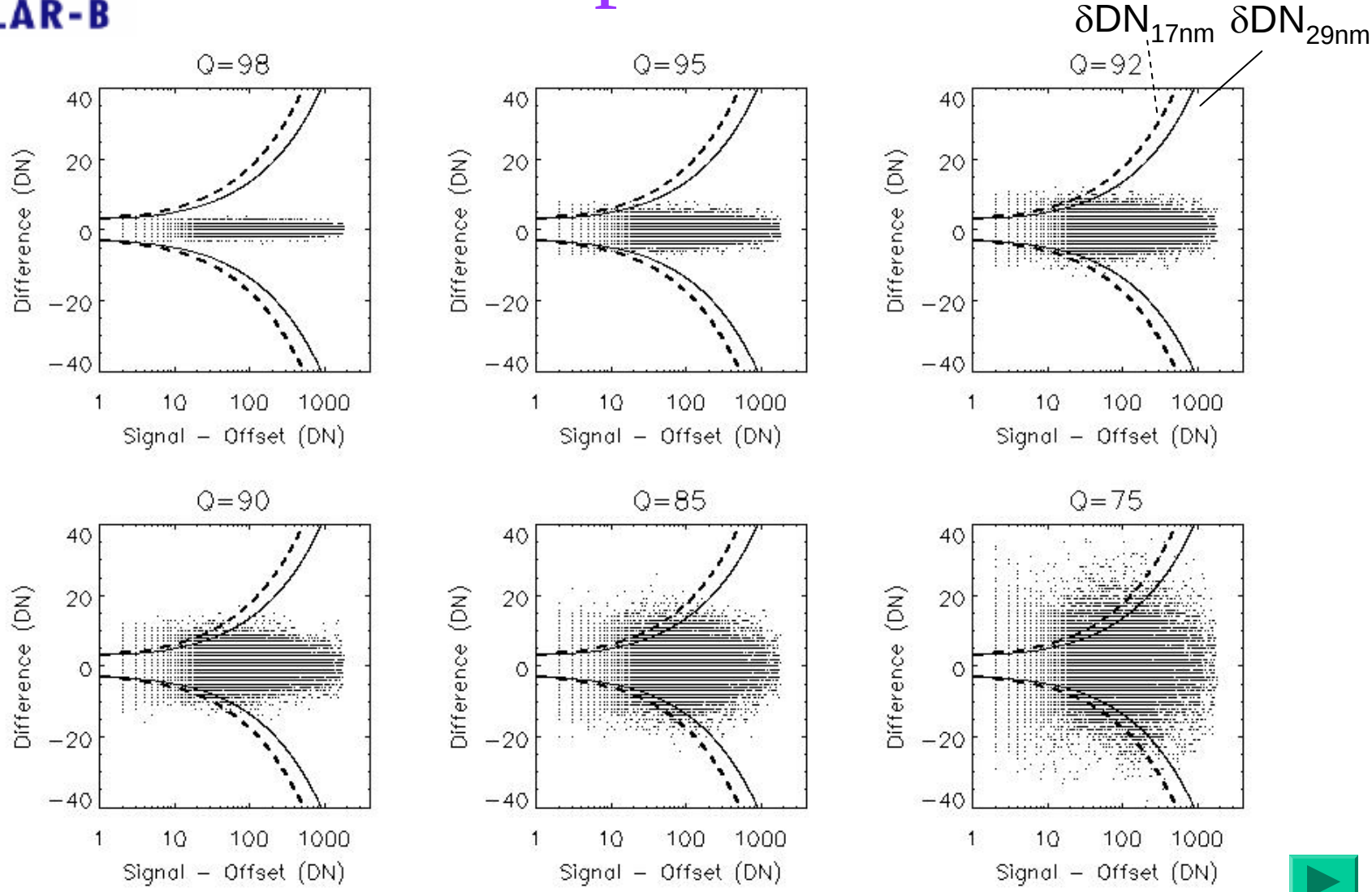
MDP JPEG Compression



AR spectrum for 5 sec integration



JPEG compression error



X: signal – offset [DN] ; offset~ 500

Y: decomp(comp(Original)) – Original [DN]

Compression Error for Q=85

Compression ratio = 0.19