

SoLEXS – A low-energy X-ray Spectrometer for Solar Coronal Studies

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Plan of the Talk

- Introduction
- Science Goals
- Instrument Specifications
- Status

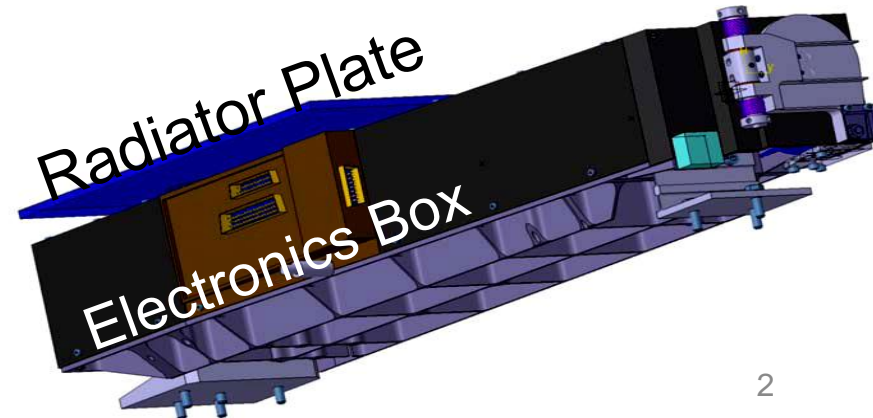
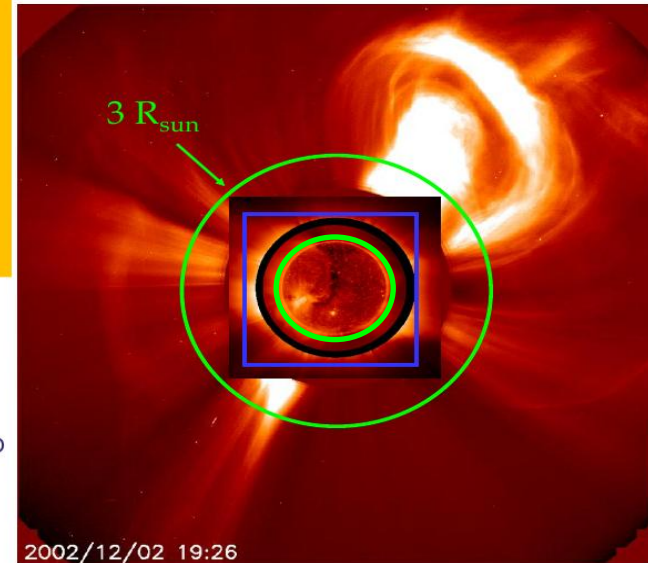
Aditya-1 Main Payload

- Coronal waves
 - Intensity oscillation
- Dynamics & Characteristics of Coronal Loops
 - Simultaneous multi-line observations
- Topology of Magnetic Fields
 - Simultaneous polarimetry at emission line and continuum
- Dynamics of CMEs at Lower Corona
 - As close to disk as possible

Overlay of solar Corona as recorded by different instruments onboard SoHO and their FOV

Green signifies Our FOV

EIT: disk image
UVCS and LASCO



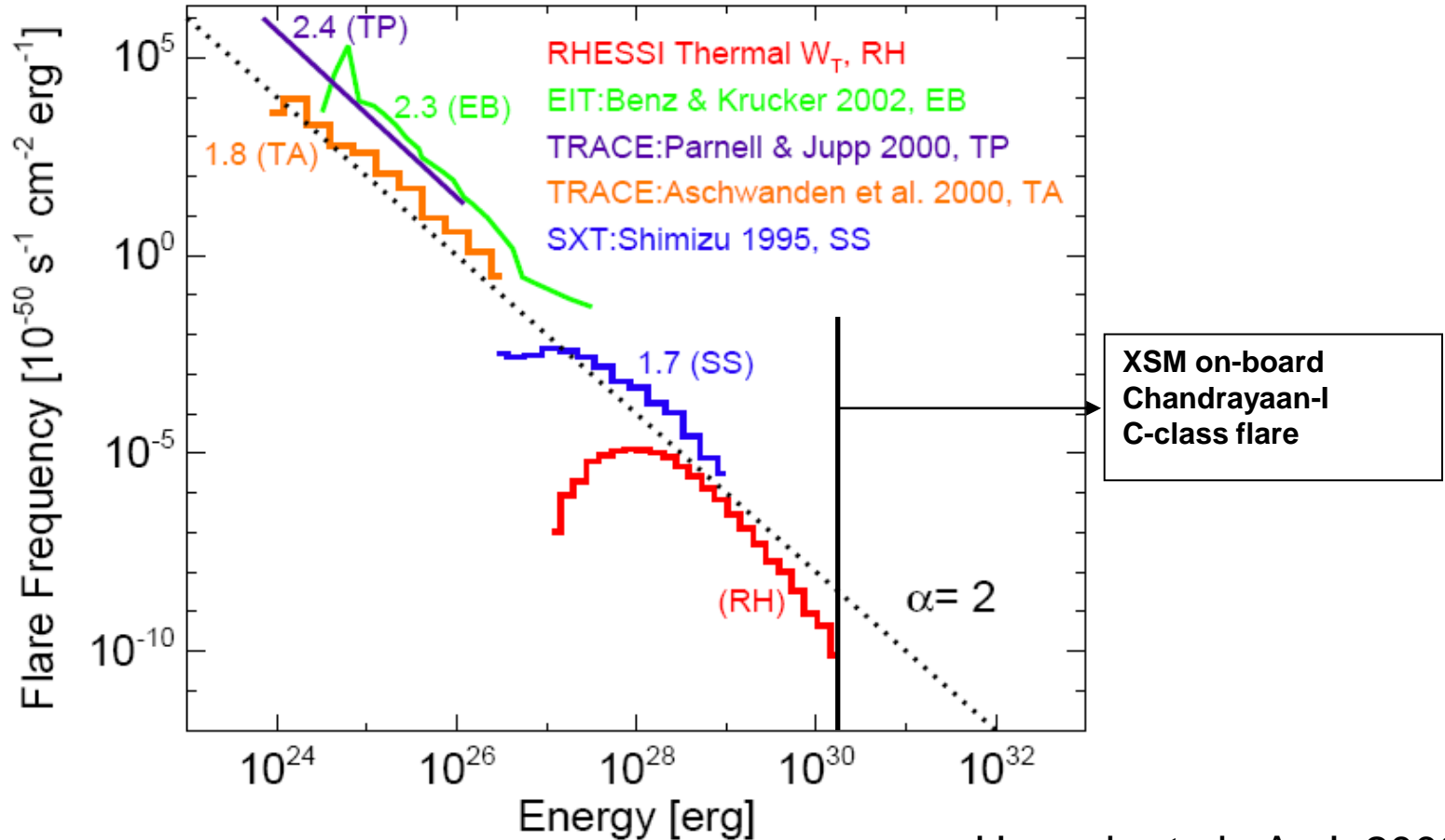
SoLEXS Goals

- Flare Studies – DC Heating & Micro-flare Statistics
- FIP Effect
- Flare-CME Relations
- Possible Flare trigger to Main payload

Index of Flare Frequency

Author	Index	Instrument & Wavelength
Shimizu & Tsuneta (1997)	-1.74	YOKOH & Soft X-ray
Berghmans et al. (1998)	-1.35	EIT/SoHO & 195 Å
Krucker & Benz (1998)	-2.3 to -2.6	EIT/SoHO & 195 Å + 171 Å
Parnell & Jupp (2000)	-2.0 to -2.6	TRACE & 195 Å + 171 Å
Aschwanden et al (2000)	-1.83	TRACE & 195 Å + 171 Å
Benz & Krucker (2002)	-2.31	EIT/SoHO & 195 Å + 171 Å
Winebarger et al. (2002)	-2.8 to -3.0	TRACE + SUMER & 195 Å + 171 Å + 1600 Å
Christe et al. (2007)	-1.7	RHESSI X-Ray

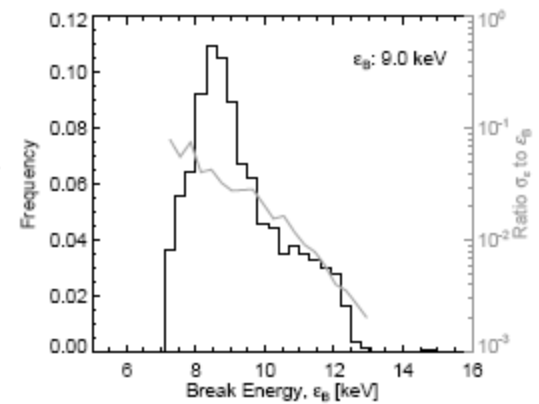
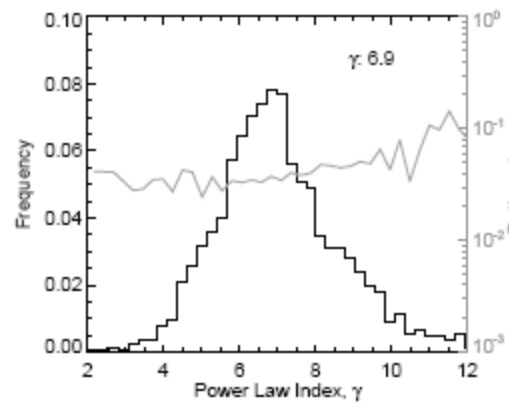
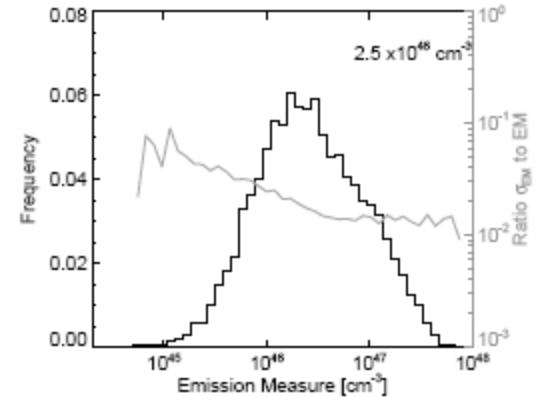
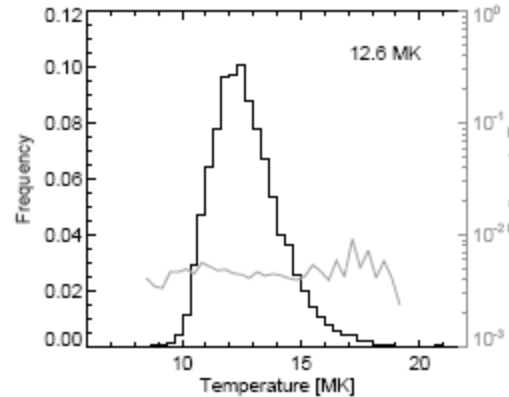
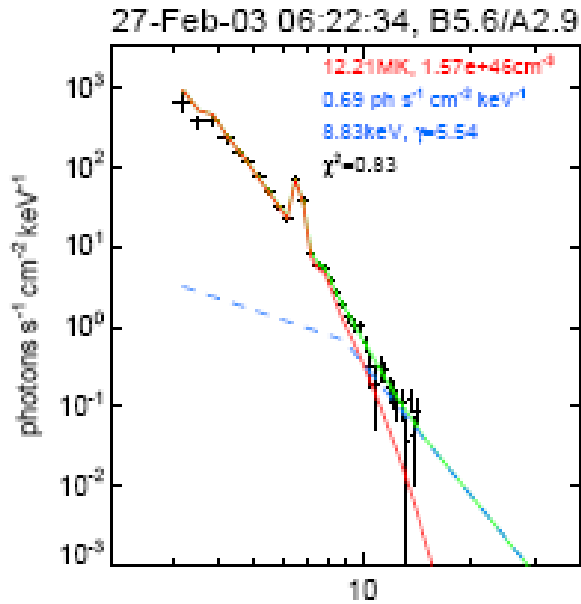
DC-Heating Scenario



Hannah et al., ApJ, 2008

Spectrometer with reasonable energy coverage and Good spectral resolution

Micro-Flare Statistics

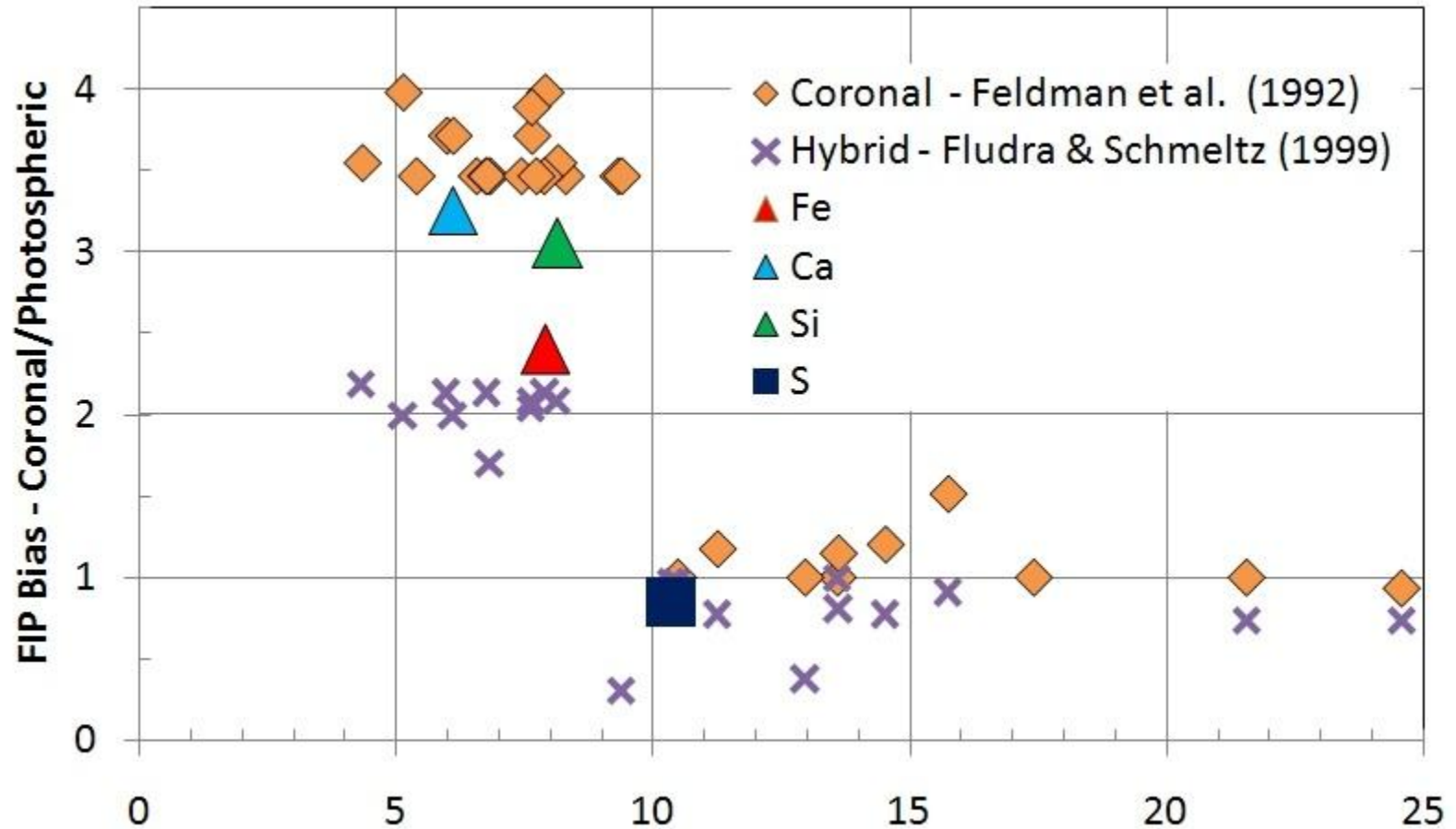


- Non-thermal fittings only above 7 keV
- Lower-end of break energy is observationally biased
- Several micro-flare events with lower energies are missed

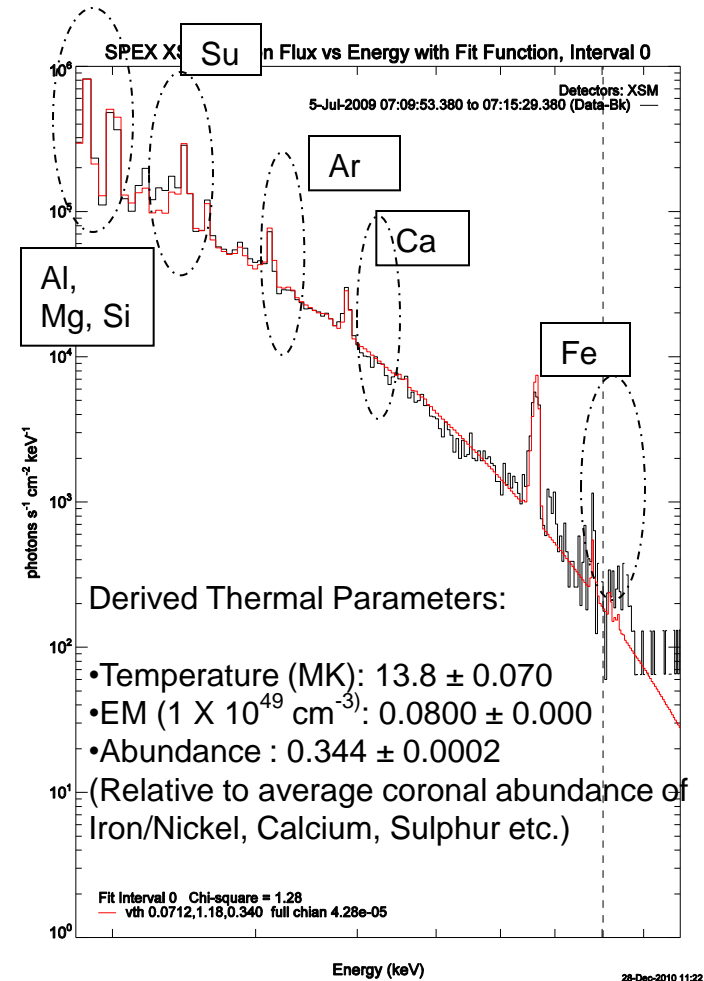
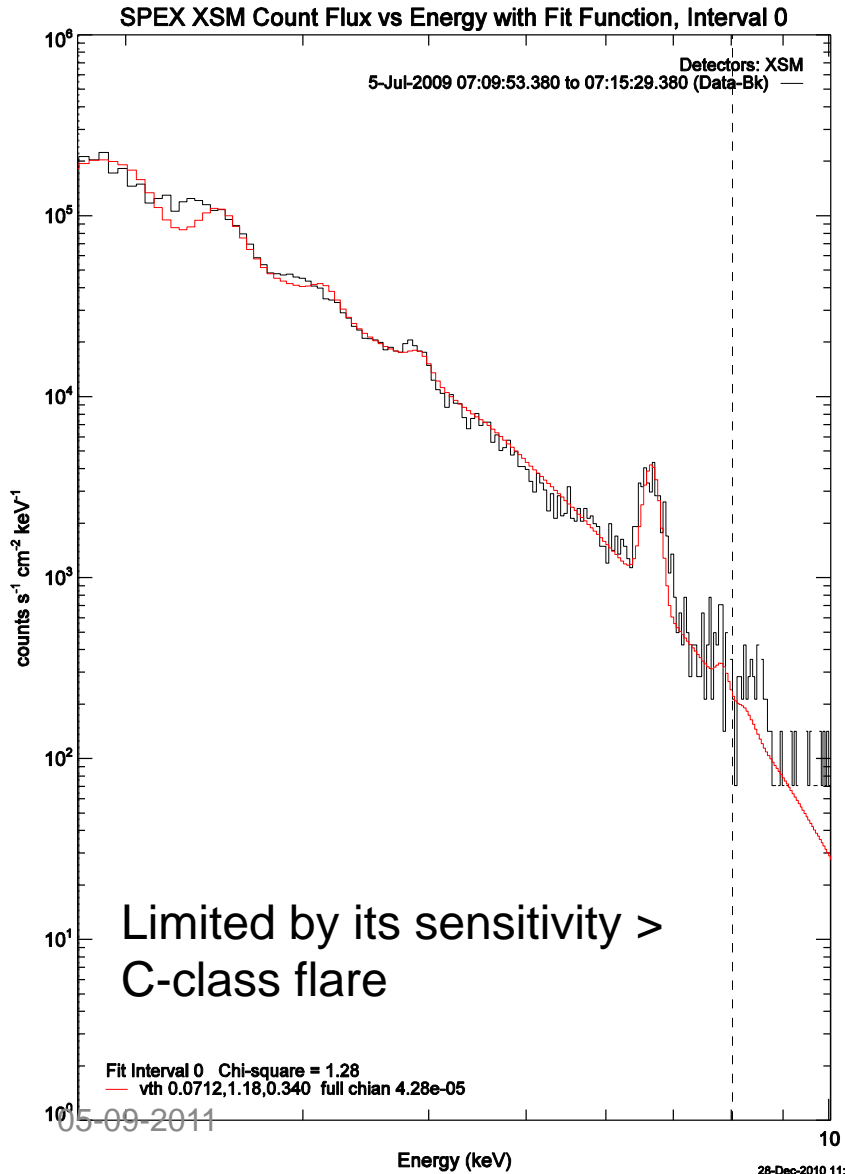
Hannah et al., ApJ, 2008

Spectrometer with lower energy ($\sim 1\text{keV}$) coverage with good resolution will enhance this study

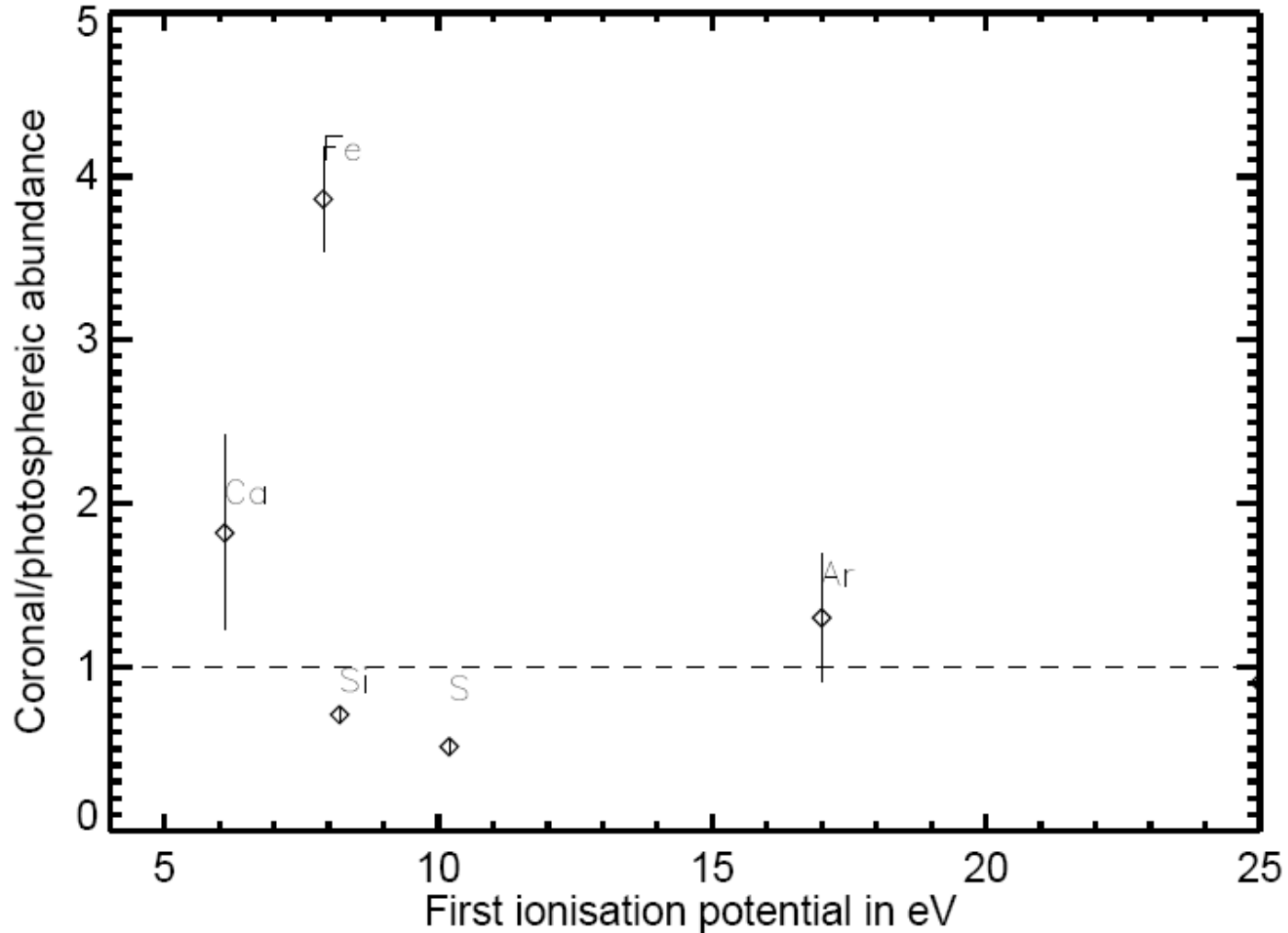
FIP - Effects



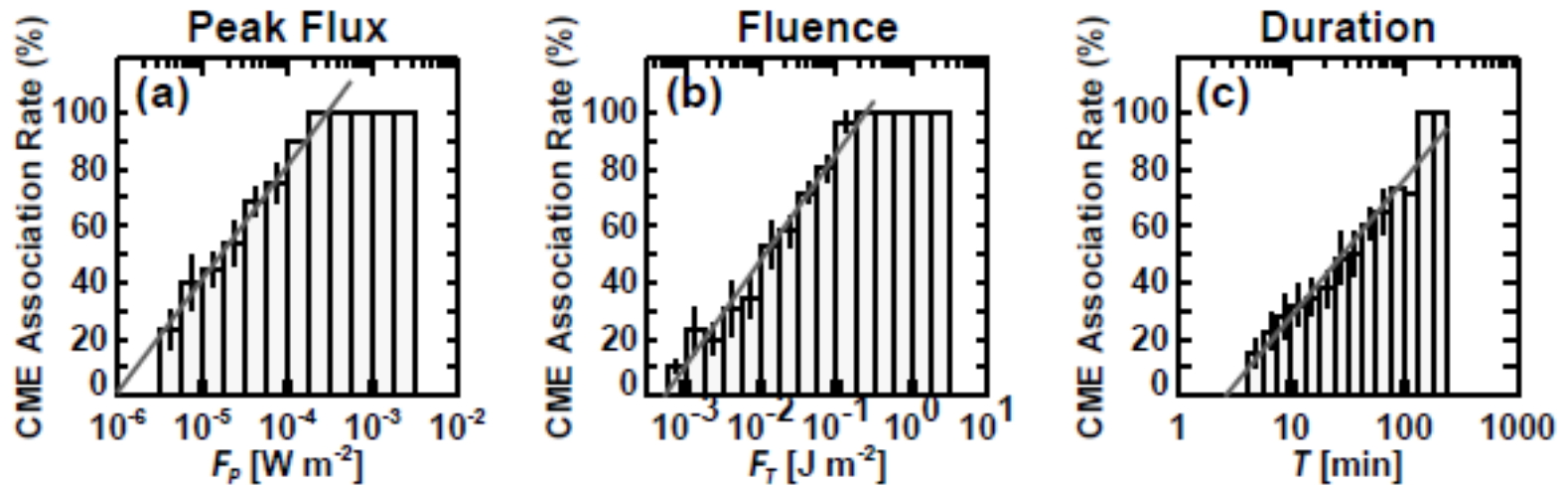
XSM on-board Chandrayaan-1



Abundances Comparison

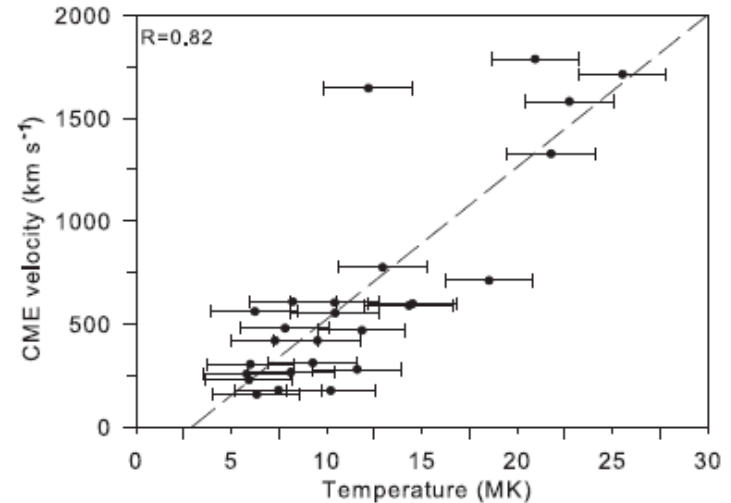
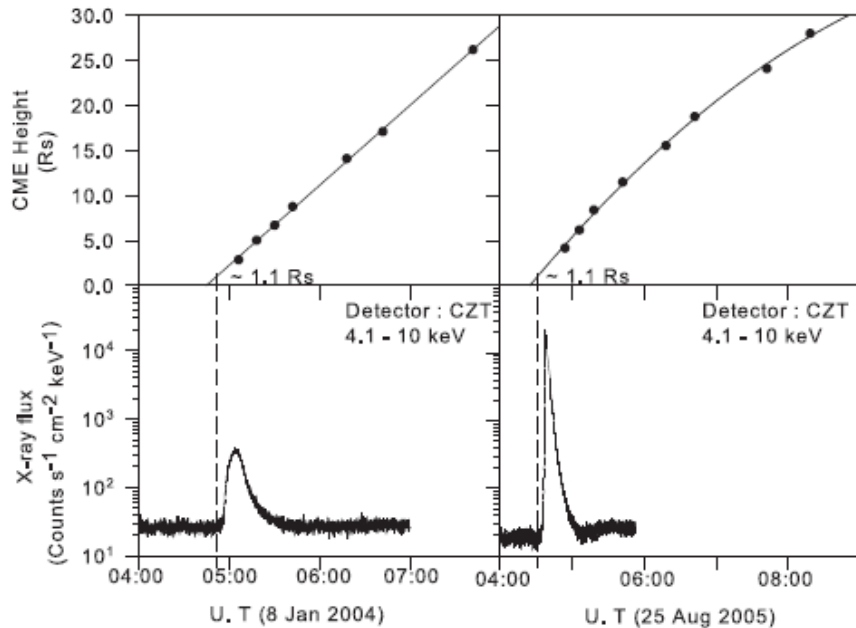


Flare – CME Association



From Yashiro & Gopalswamy (2008)

Flare – CME Association



SOXS Light Curve and SoHO CME

- CME Velocity is strongly correlated with the Flare temperature
- Initiation of the CME happens before the flare peak?

Jain et al., 2010

Flare – CME Associations

Some numbers

Flare class	Total	Dimming in at least one channel	Dimming in three channels	CME beyond 5 Rs
M	11	9	1	2
C	64	23	5	7
B	60	36	11	15
A	22	20	4	7
Non-flare	9	4	1	2

- A majority of large (M- and C-class) flares are non-eruptive.
- Dimming, if observed in multiple channels of EUVI, is a good indicator of CME.
- Dimming observed only in one channel may represent thermal effects and failed eruptions.
- Statistics for B-class or less intense flares is biased, since these flares are included preferentially for their CME-related signatures.

Other Missions

Lunar Related:

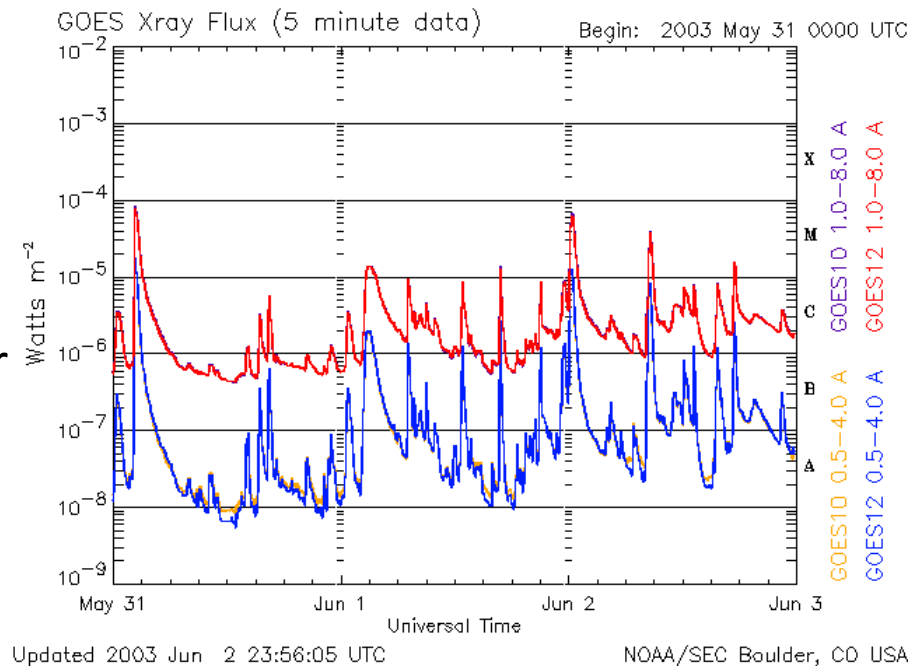
- XSM on Smart-1 ESA mission: a solar X-ray spectrometer to support the D-CIXS
- XSM on Chandrayaan-1 mission: a solar X-ray spectrometer to support C1XS
- XSM on Chandrayaan-2 mission: a solar X-ray spectrometer to support CLASS
- XSM on Messenger

Solar Related:

- GOES – A series of solar X-ray monitor – no spectra
- RHESSI – Both imaging and spectroscopy – limited spectral resolution ($\sim 1\text{keV}$ @ 5.9 keV) and cut-off at 3 keV
- SOXS – High spectral resolution spectrometer ($\sim 700\text{ eV}$ @ 5.9 keV) and cut-off at 4 keV . Mission ended during 2011
- SphinX – Solar Photometer (launched on Jan. 2009) on CORONAS-PHOTON. Expected good spectral resolution ($\sim 290\text{ eV}$ @ 5.9 keV). Will cover the all class of flares. Expected lifetime is 3-years (up to 2012). Energy range 0.5 to 15 keV . Mission ended during 2010

Requirements

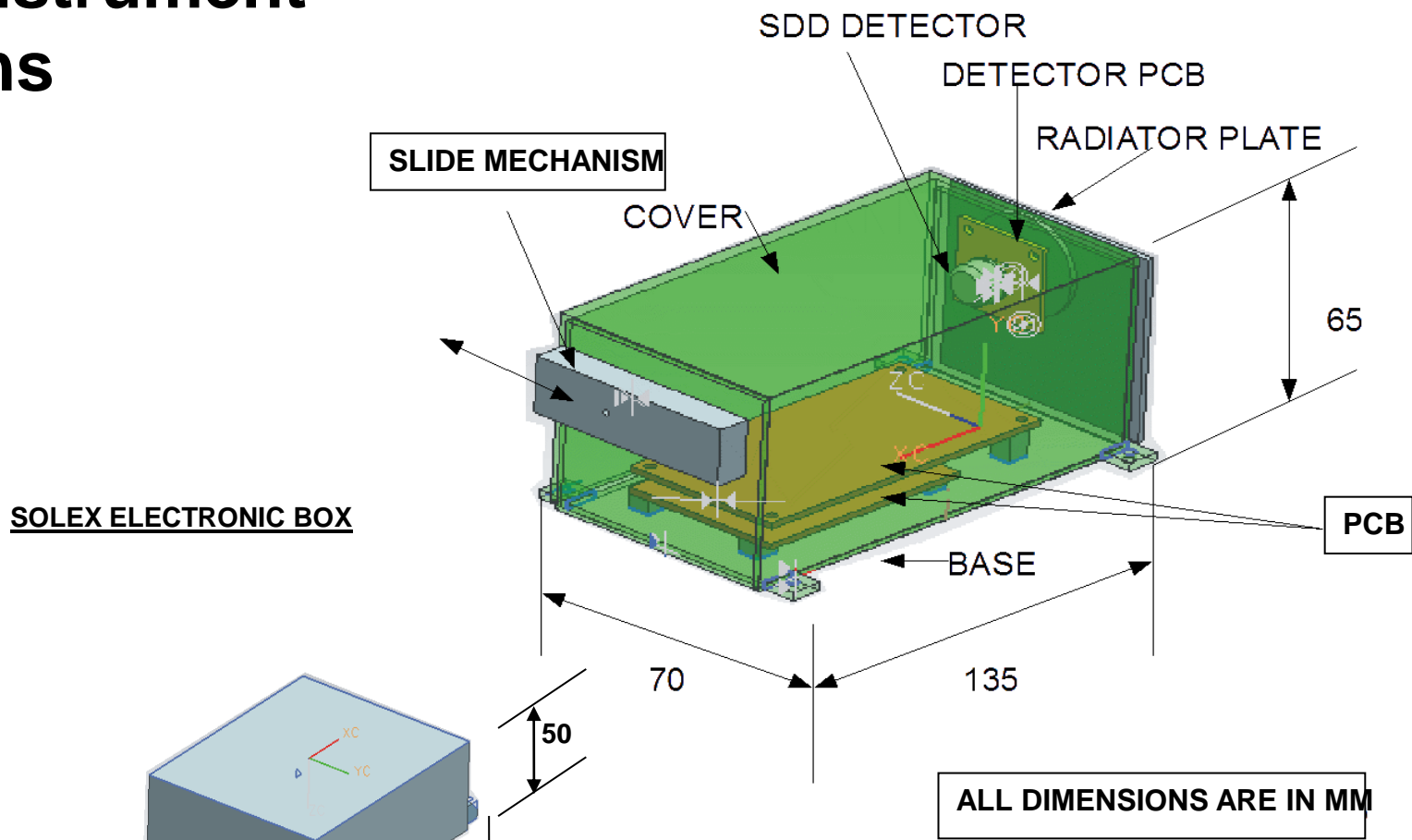
- Cover all class of flares (A to X10-class)
 - 10^{-8} W/m^2 to 10^{-2} W/m^2
 - require two detectors or a mechanism
- Spectral coverage 1 – 30 keV
- Spectral resolution $\sim 250 \text{ eV}$ or better
 - require cooling to about -20°C .
- Temporal cadence – 1sec or better
- FOV - $\pm 1^\circ$ or lesser



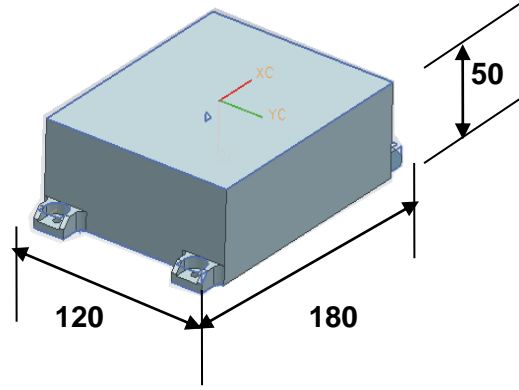
Properties	Desired	SoLEXS Capabilities
Energy Range of Operation (>5% efficiency in keV)	0.5 – 30	1.0 – 30
Spectral resolution at 6keV	< 250eV	250 eV
Dynamic Range Maximum Count Rate	< A to > X-class flares	< A to X-class flares ~ 500,000 cps
Detector/Aperture Area	0.1 mm ² 5 mm ²	~ 0.1mm ² ~ 5 mm ²
Cooling (ΔT)	- 60 degrees to ambient	- 50 degrees to ambient
Radiation Hardness	Sustain 10^9 protons with only 10% degradation in spectral resolution	To Be Estimated
Angular Resolution	arcsecs to < 1 arcminute	Non-imaging

SoLEXS Instrument Dimensions

CONCEPTUAL VIEW OF SOLEX DETECTOR BOX



SOLEXS ELECTRONIC BOX



ALL DIMENSIONS ARE IN MM

Resource Requirements

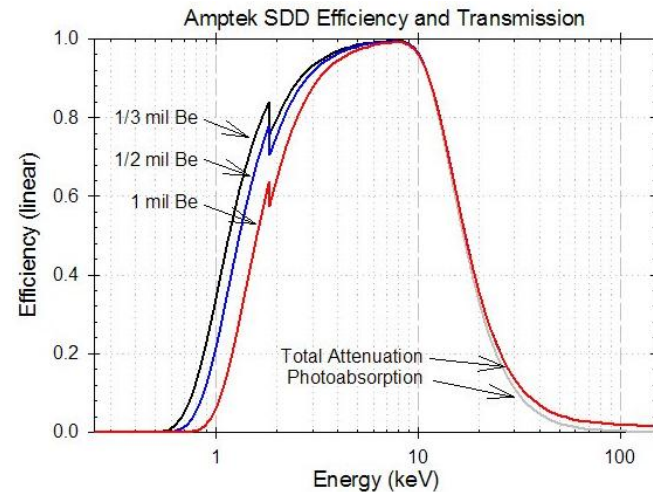
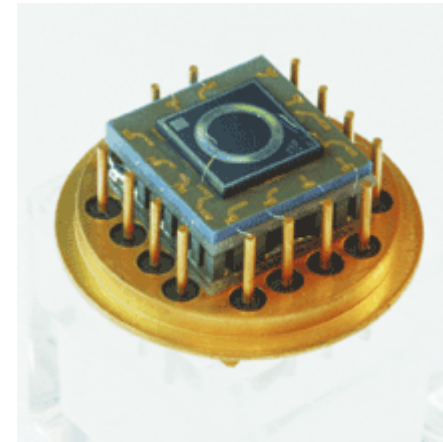
Parameter	Box1	Box2	Total
Mass (Kg)	< 1 + Mechanism	< 1	< 2 + Mechanism
Size (L X W X H; in cm)	15 X 6 X 6	18 X 12 X 7	Separate mounting (<1m)
Regulated Power	NA	NA	~ 12.25 + Mechanism
Storage	--	--	< 50 MB for 12- hour

* About 2 Watts of power can be saved if the 1553 bus is common with the main payload

Detector

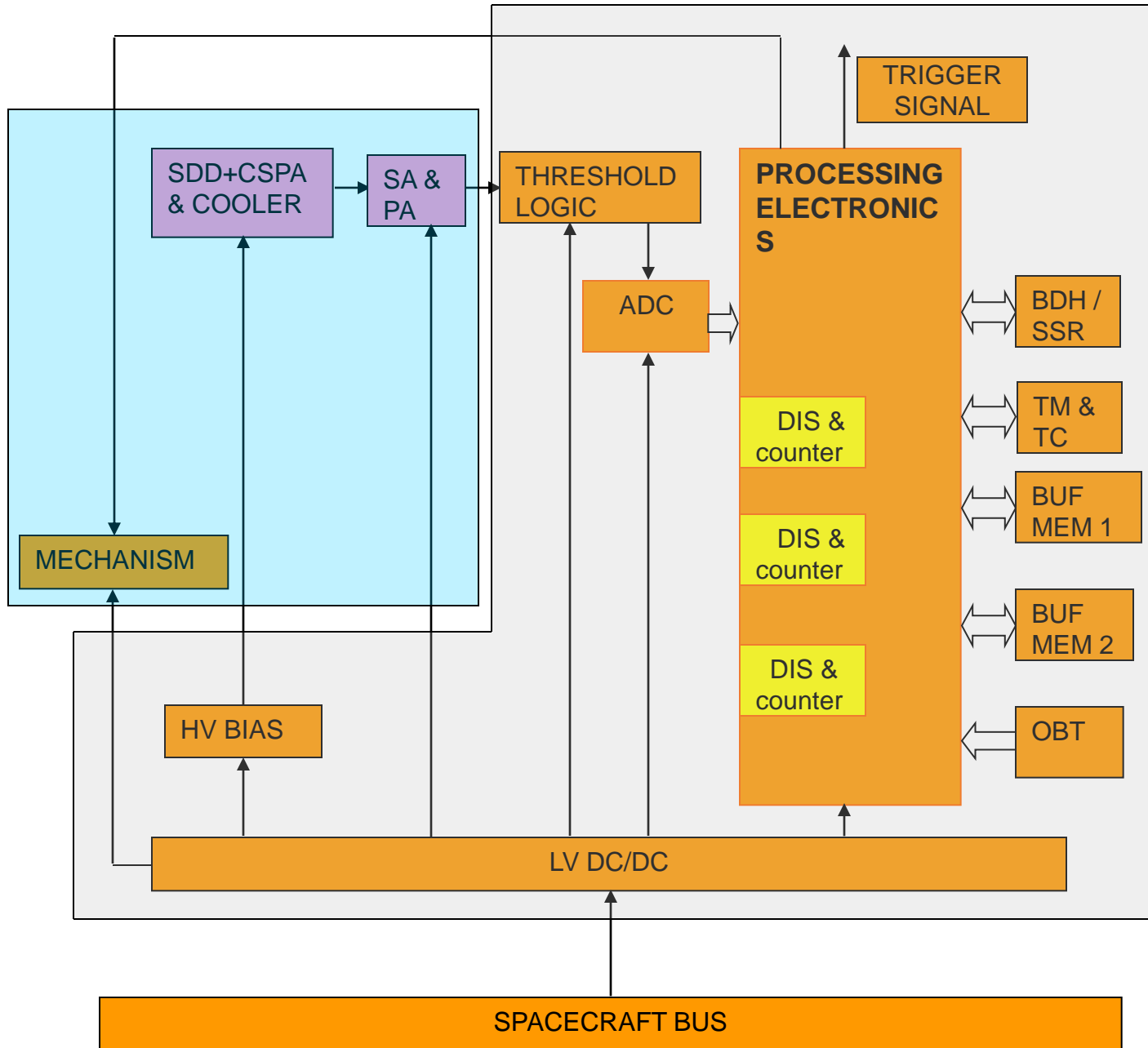
SDD is used as an APXS sensor on Mars Pathfinder

- Silicon Drift Detector (SDD)
 - High count rate (500,000 cps) with good spectral resolution (< 175 eV @ 5.9 keV)
 - Small area (~ 0.1 mm²) for flares C to X10 and large area (~ 5 mm²) for flares from $< A$ to C class



SDD	Silicon Drift Detectors
CSPA	Charge Sensitive Pre-amplifier
SA	Shaping Amplifier
PA	Post Amplifier
PD	Peak Detector
DIS	Discriminator

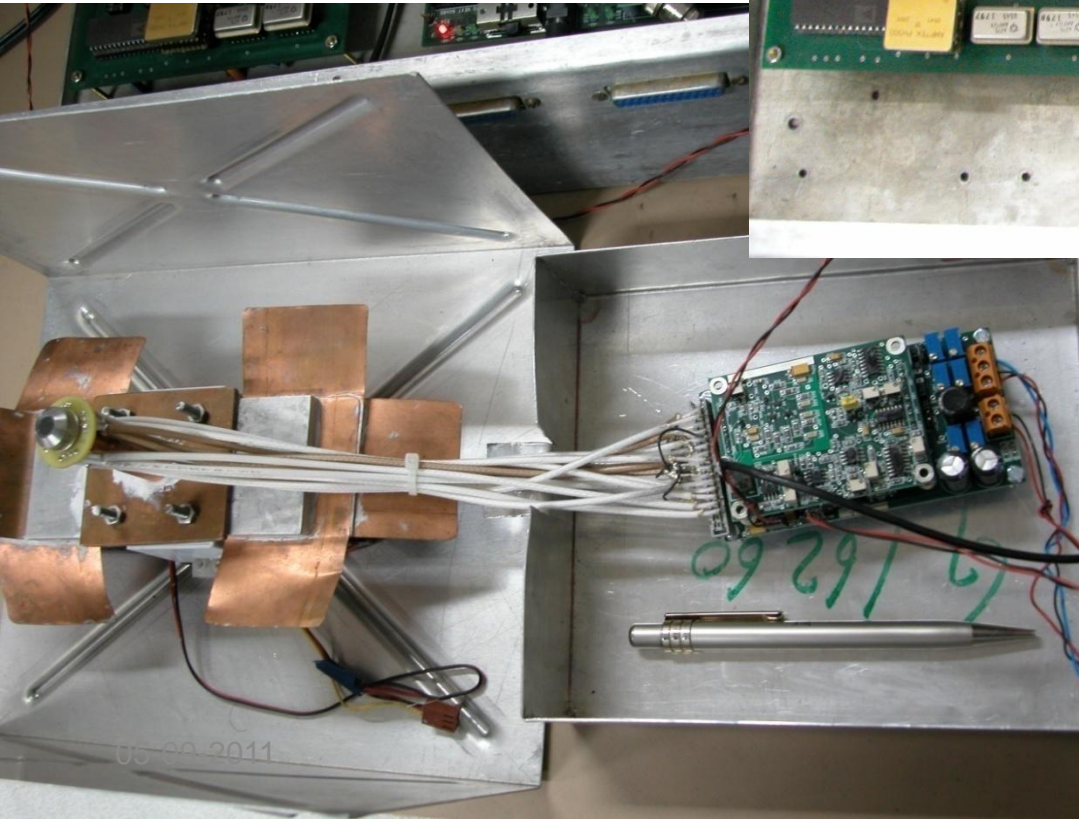
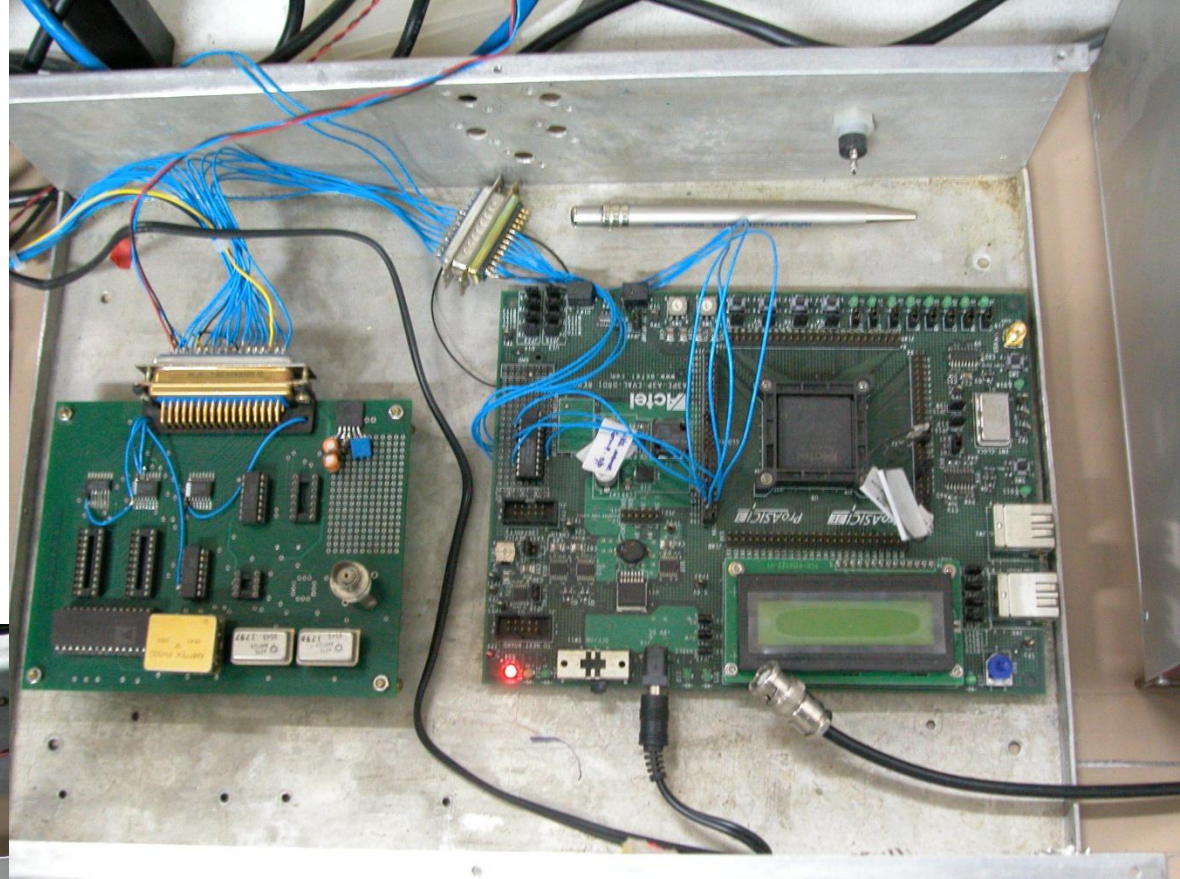
Detector Box
 Electronics Box



Status

FEE + PE

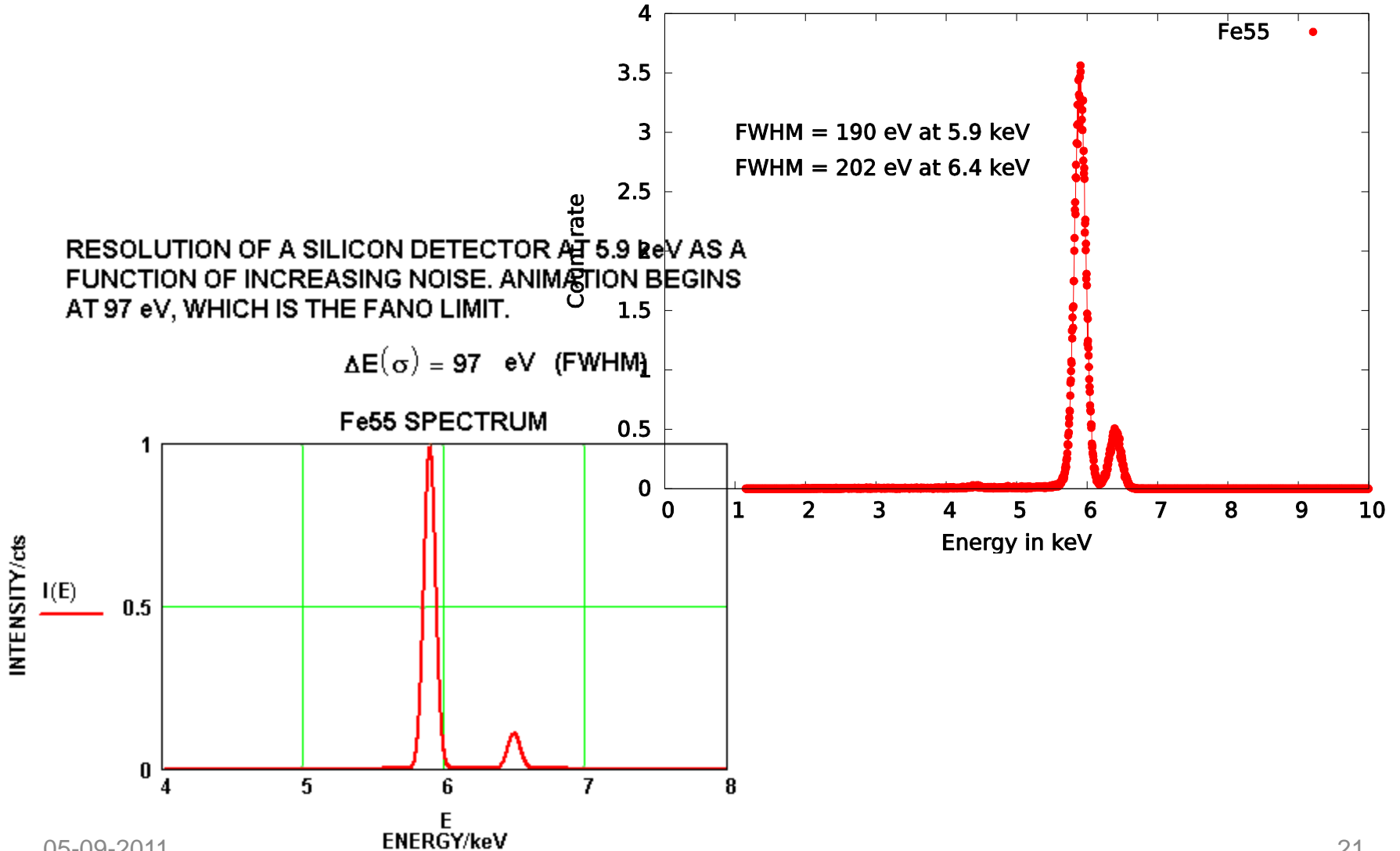
SDD + CSPA



- Laboratory verification of the SDD + CSPA and FEE + PE
- All tests were carried out with laboratory power supplies
- DC-DC converters are being added to the chain for End-to-End testing

Laboratory Results

Fe55 radioactive source spectrum



Summary

- A high spectral resolution and low-energy X-ray coverage of solar corona will enhance the science goals of Aditya-1
- This instrument can also provide a flare trigger to switch the main payload for CME watch
- Laboratory model of this payload is getting ready
- Accommodation study of this instrument with Aditya-1 is underway