SphinX early operations

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SphinX CoI & associated scientists

- FIAN: Dr. Sergey Kuzin, TESIS PI
- **MEPhI: Prof. Yury Kotov, CORONAS-Photon PM**
- AI CzAS: Dr. Franta Farnik
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The Confirmed International Team

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Instrument status

- Flight model at FIAN (this Friday) undergoing final adjustments (Russian Team)
- This Monday (MK+WT) will reload the flight programme at FIAN
- Ground sector software v1 exists (SG)
- A part of the calibration results have been analysed (MS)
- Preparations for real-time activities are in progress (all)

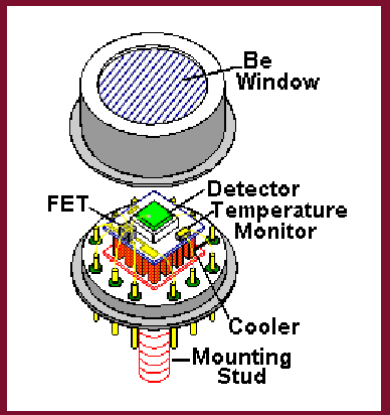
Talk content

- Average properties of four measurement channels
- Telemetry allowances
- Moving parts within the instruments- how to operate them
- Basic operation modes
- Detecting flares and/or RadZone passages

Measurement channels

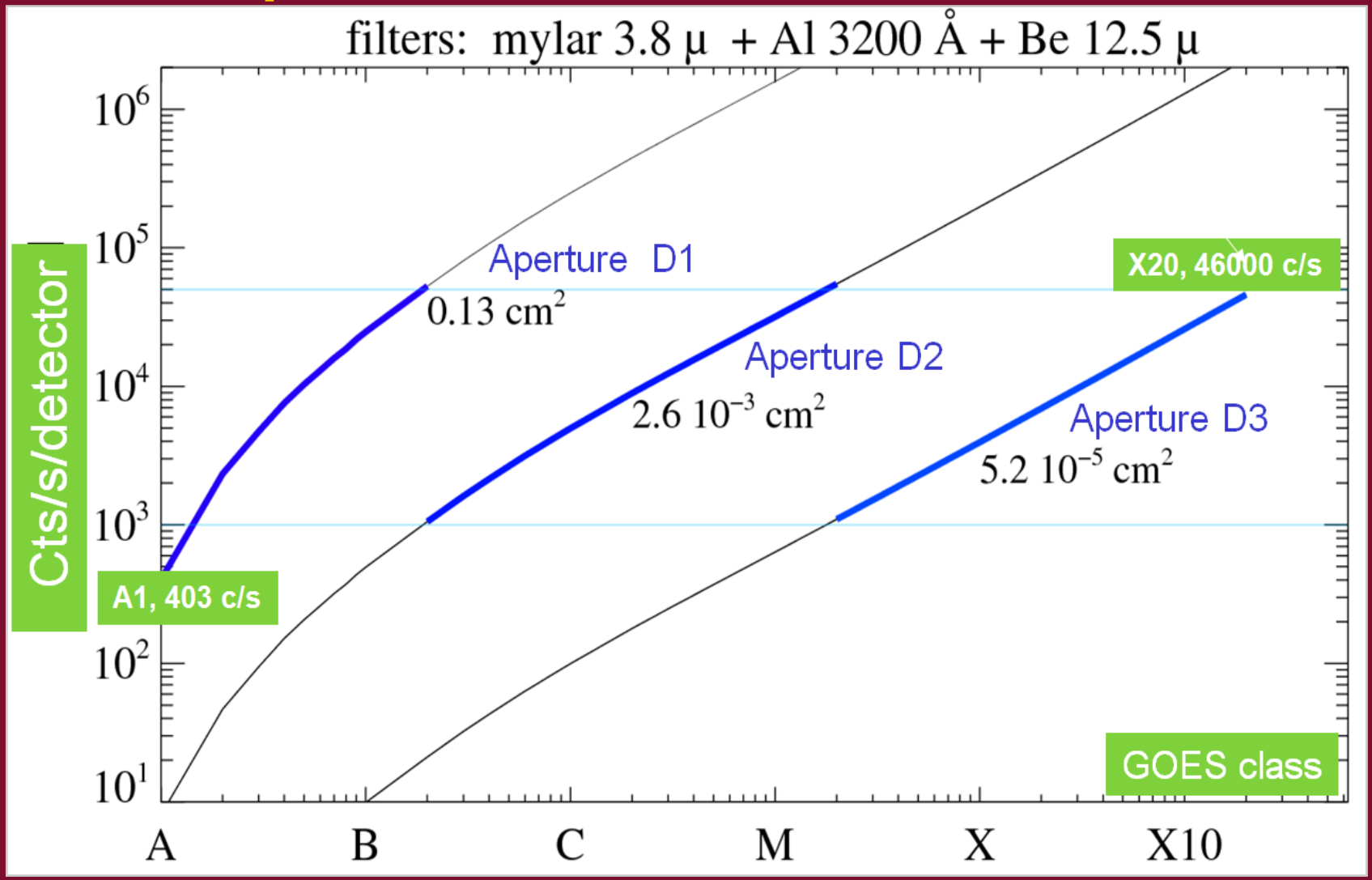
Photometric **FFU**

D1	D2	D3	D4
ϕ: 5 mm	ϕ: 4 mm	ϕ: 4 mm	ϕ: 4 mm
A: 13.0 mm^2	A: 0.26 mm^2	A: 0.0052 mm^2	A: 13.0 mm^2
8 µs	25 µs	25 µs	25 µs
Up to	Up to	Up to	Up to
60 000 cts/s	20 000 cts/s	20 000 cts/s	20 000 cts/s
FWHM: 490 eV	FWHM: 290 eV	FWHM: 290 eV	FWHM: 290 eV



Detectors (four units): 256/1024 **energy bins**
Amptek, Peltier cooled (-50 deg) Si PIN diodes.
Detectors' support plate thermally connected to external heat radiator via heat sink pipe.
Photon arrival time measured to within 1**µs**
(in Time Stamping Mode)

Expected total count rates

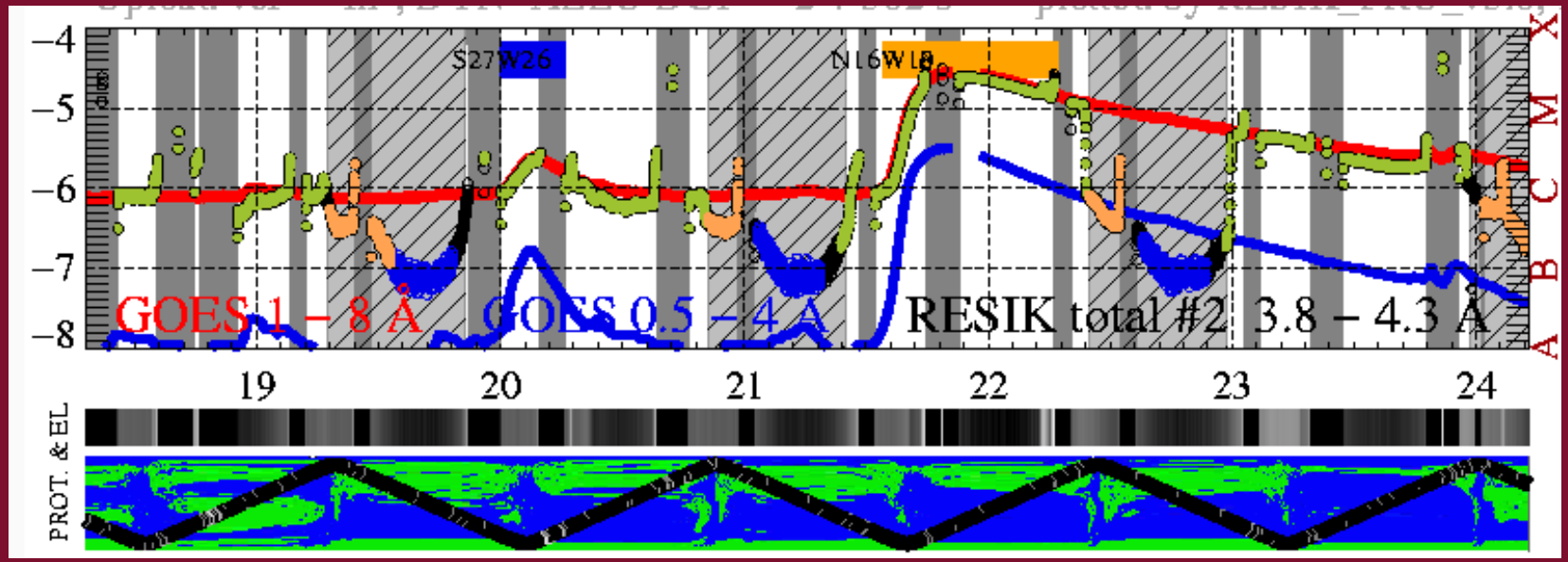


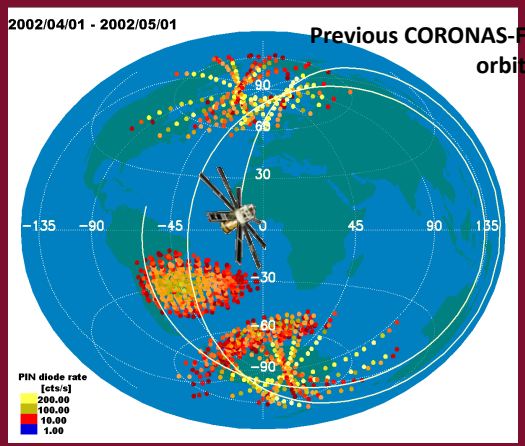
Courtesy; Marek Siarkowski

The measurement environment,

bcgd: ~0.01 cts/s/bin up to 1 cts/s/bin (SAA)

SAA Night RB RB Night Flare

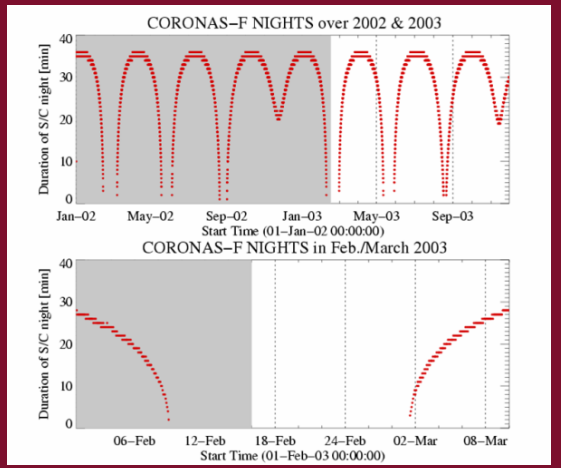


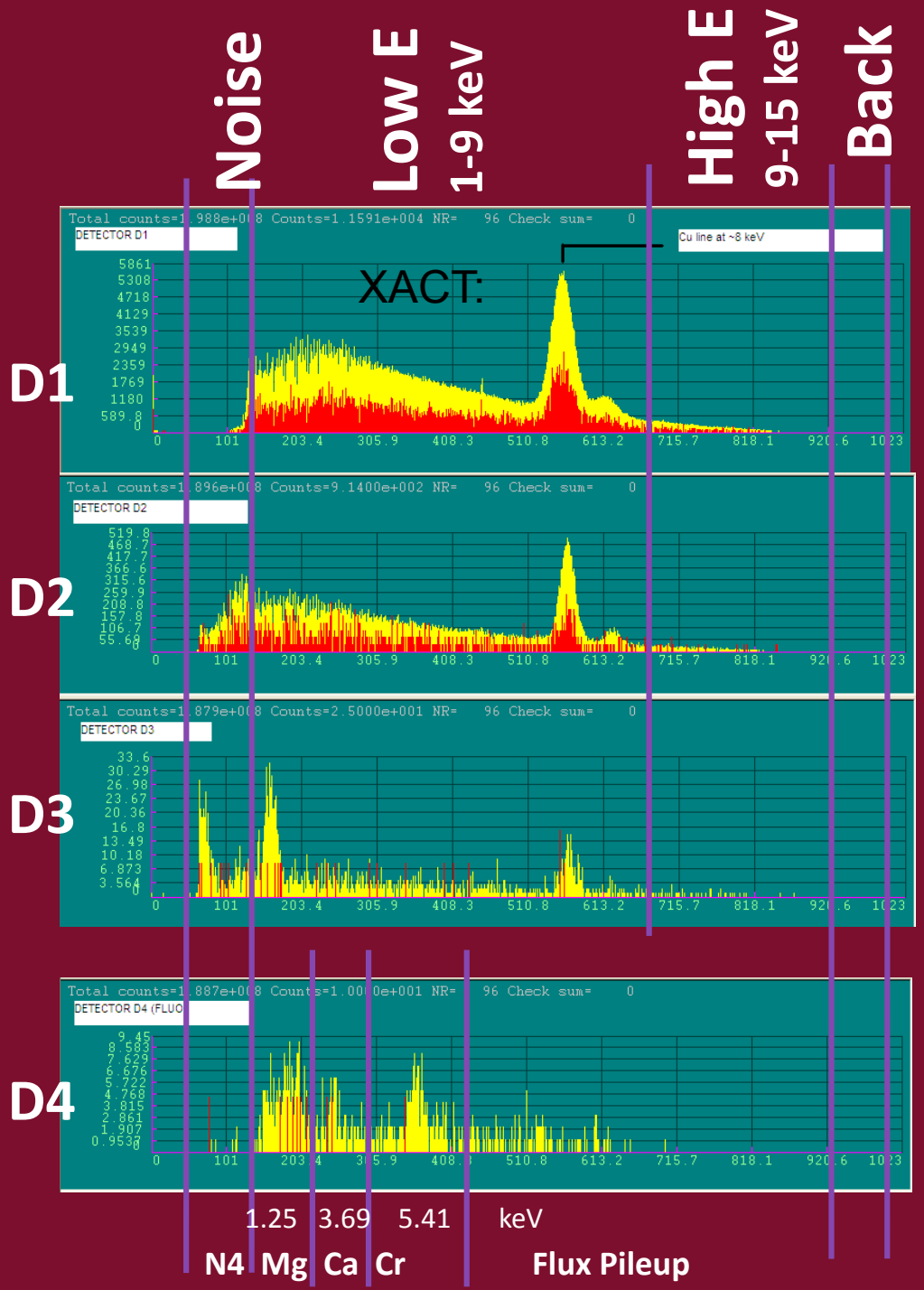


Important pahases

- S/C X-ray day
- S/C optical day
- S/C optical night
- S/C X-ray night

❑Terminator crossing





Basic:
Fluxes each 1s

N1 L1 H1 B1 (4)

N2 L2 H2 B2 (4)

N3 L3 H3 B3 (4)

N4 Mg Ca Cr FP B4 (6)

18x2bytes=36 bytes/s

20 bytes/s compressed

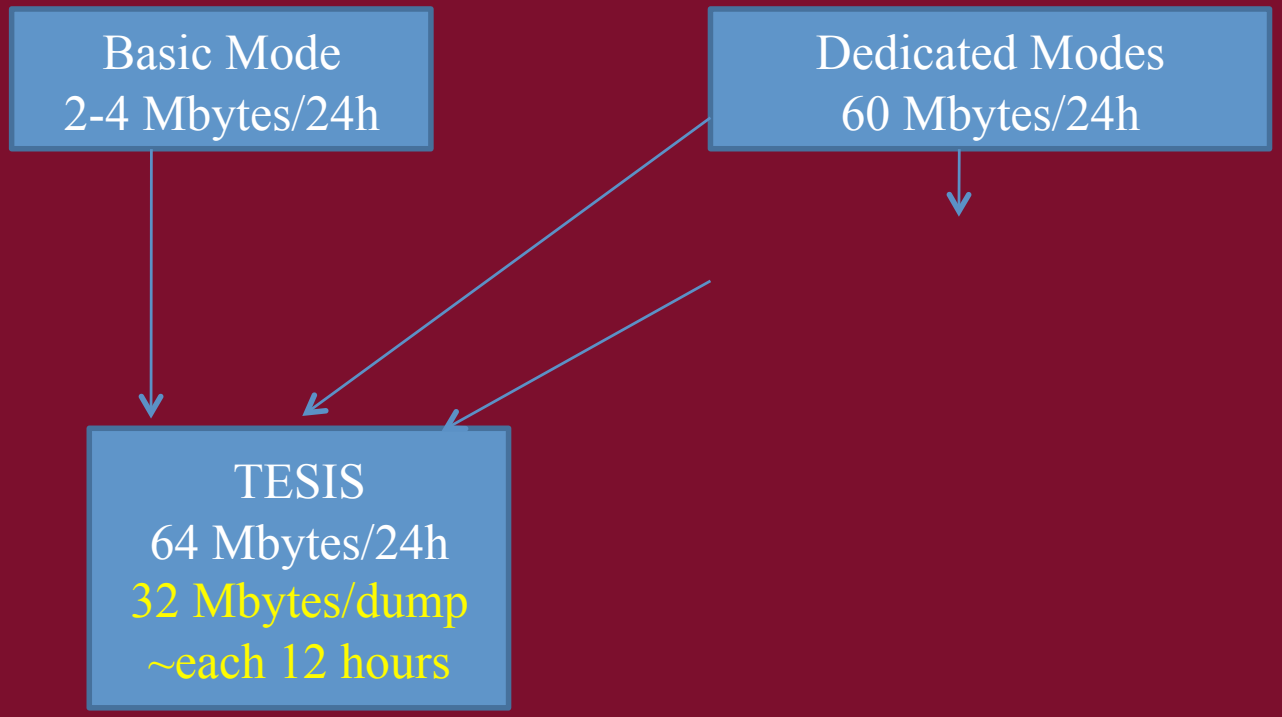
~2 MB/24h

SphinX Telemetry budget

we will be able to provide to SphinX about 50-60 Mbyte per day

- 3-4 Mbytes per each orbit (16orbits x 4 Mbytes = 64 Mbytes)
- 64 Mbytes/day= 64/86400= 740 bytes/s
- Basic mode 20 byte/s data+ 20byte/s housekeeping

- 700 byte/s left to dedicated data stream



Basic mode

- Better than GOES time resolution (1 s) Goes has formally 3s, but longer electronic time constant (range spike ~10s?)
- Possibility to determine T, EM from flux ratios
  - H1/L1, H2/L2,H3/L3 depending on saturation
  - Proper selection of „discriminator energy” in order to best match the GOES
  - Ca/Mg & Cr/Ca channels (D4)
- Particle Background (B1,B2,B3,B4, FP) and thermal detector noise: (N1,N2,N3,N4)

Flare & radiation belts detection algorithm (Zbigniew Kordylewski)

- Radiation belts (calculated from S/C but…)
  - B4 > threshold (10 cts/s)
  - B1,B2,B3: two of them exceed threshold (10 cts/s)
- For flare class and phase NOT the rates are stored but TIMES (DataGatherTimes) in which 512 cts are collected in every of the channels L or H
  - Fluxes should scale as the apertures
  - 10 consecutive DGT are analysed, 3L, 3H
- Shutter position is set accordingly to the flare class in order to prevent detectors

Time stamping mode

D1, D2 or D3 rates < 10^3/s

- Time stamping mode from: D1, D2, D3, D4
  - 3 Bytes for processor time of the detector event start
  - 1 byte for the amplitude
  - Allows to determine the difference between eventarrival to within 2 μs ~2/1000 accuracy
  - Absolute timing to within 0.001s against UT

Expected rates

D1= 10^3 events/s (event: Amplitude 1byte, time 3 bytes)-4 KB/s

D2= 10 events/s, D3= 10 events/s, D4= 10 events/s

Total: 4Kbytes/s – can last for ~10000s (3 h) each dump with factor ~2 compression → 6h. If 100 cts/s → 60 h, so round the clock.

Waiting time analysis – is the process at low count rate Poissonian?

Wheatland, The Astrophysical Journal, Volume 679, Issue 2, pp. 1621-1628, 2008

- Radioactive sources give an ideal example of the statistics
- To what degree the arrival times of photons from the „quiet" corona have „no memory" i.e they have the exponential waiting time distribution? (Models for flare statistics assume or predict that flares are independent events- however this is under question)

$$p_\tau(\tau) = \lambda_0 e^{-\lambda_0 \tau},$$

- The primary task for the initial part of the mission where the activity is expected to be low.

Calibration

- D1,D2,D3 spectra
  - During flares ~> M1
  - Until 10^6 cts collected for each detector
  - Approximately each month
  - If v. quiet condition then on the command from the ground for 10 min

Terminator transit:

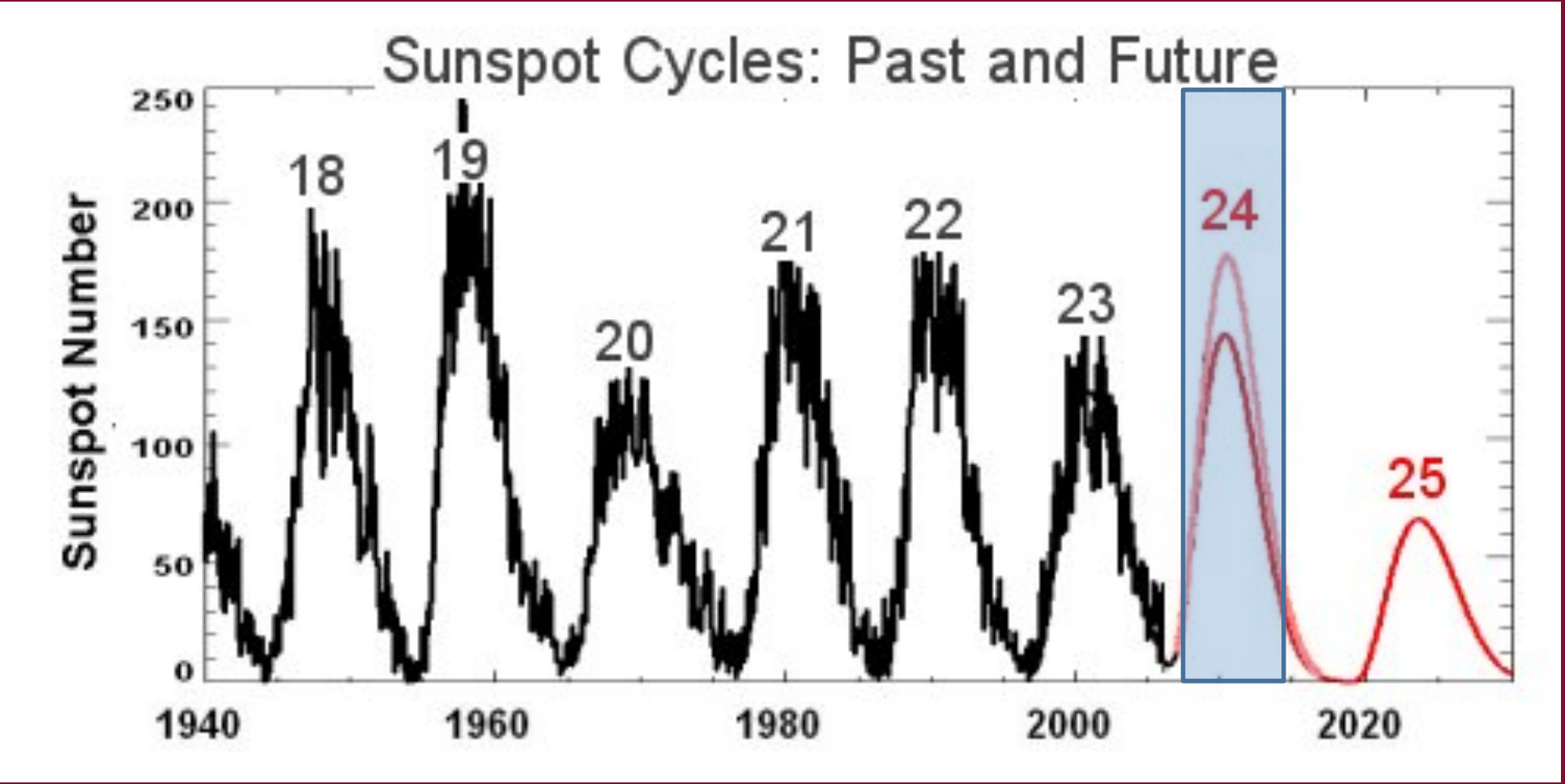
Profile of Earth atmospecric absorption

- X-ray terminator crossing algorithm operational on board
  - Predict the entry/exit to within few seconds
  - Spectra 256 energy bins each 0.1 sec give at least 1 km resolution in the vertical Earth absorption profile
  - Time stamping or spectral mode depending on the flare flag

Early operations

- Launch of Coronas-Photon
  January 29, 2009, Plesetsk
- Swith-on of TESIS 2-3 weeks later?
- SphinX ON: 3 weeks after launch
  - very low activity below A1 level, however some A class flares possible D1 ~100 cts/s
  - Learning the instrument
    - first several days: all apertures open, Basic+time stamping all the time until telemetry is filled ~12 hours cross Calibration with GOES
    - Next few days „black current" all aperture closed: calibration of background particle environment
    - Mid of March 2009: nominal operation starts

Predicted behaviour of activity during active phase of Coronas-Photon



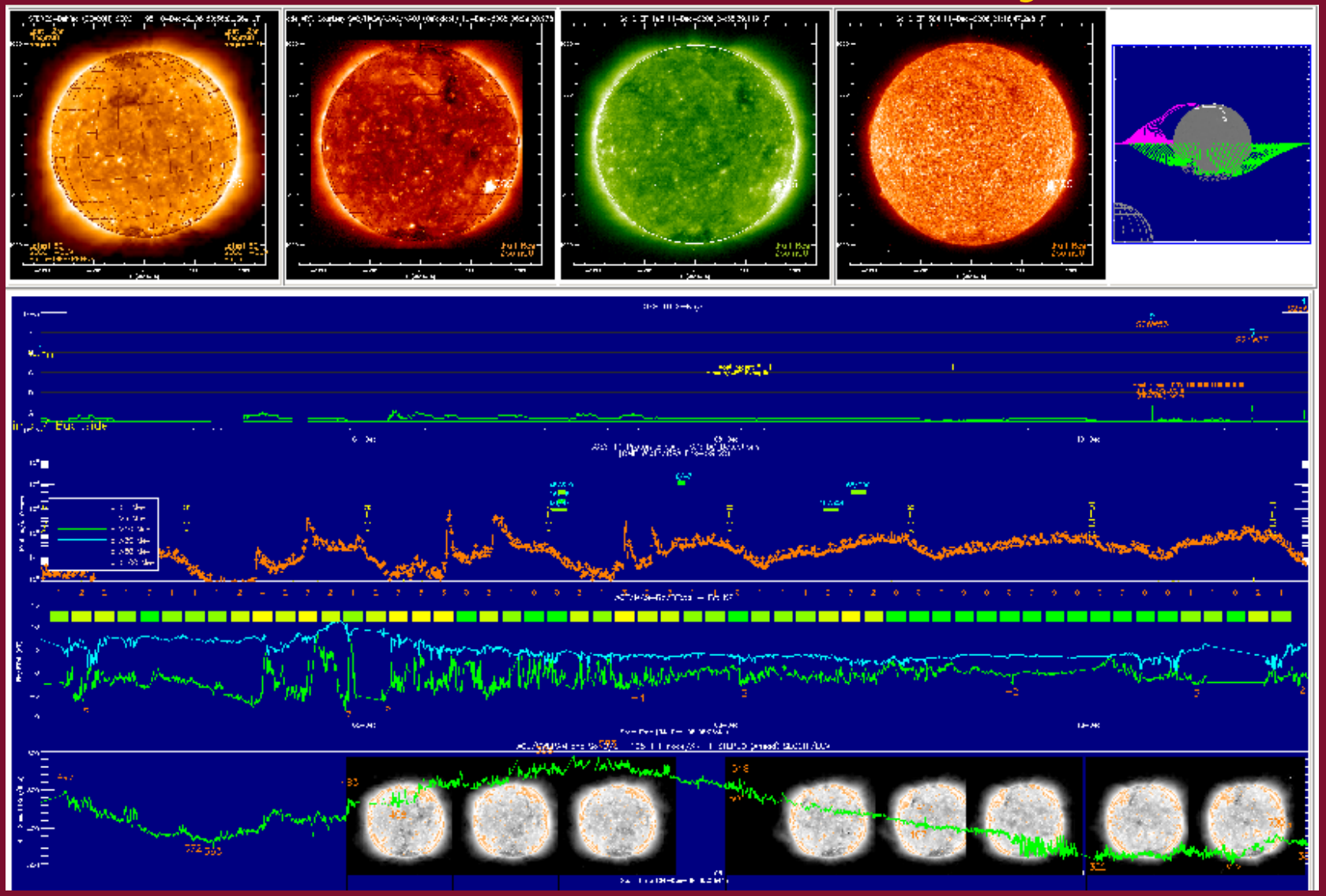
http://science.nasa.gov/headlines/y2006/10may_longrange.htm

Present flaring activity

Event#	EName	Start	Stop	Peak	GOES Class
1	gev_20081104_0148	2008/11/04 01:48:00	02:37:00	02:00:00	A7.1
2	gev_20081104_0317	2008/11/04 03:17:00	03:36:00	03:30:00	C1.0
3	gev_20081104_0537	2008/11/04 05:37:00	05:44:00	05:41:00	B1.0
4	gev_20081105_1252	2008/11/05 12:52:00	13:03:00	12:56:00	B3.4
5	gev_20081105_2344	2008/11/05 23:44:00	23:49:00	23:46:00	A8.4
6	gev_20081106_1116	2008/11/06 11:16:00	12:18:00	11:34:00	A9.3
7	gev_20081110_2018	2008/11/10 20:18:00	20:38:00	20:31:00	B3.0
8	gev_20081110_2215	2008/11/10 22:15:00	22:46:00	22:29:00	A5.1
9	gev_20081111_0838	2008/11/11 08:38:00	09:49:00	08:39:00	A5.4
10	gev_20081112_0002	2008/11/12 00:02:00	00:25:00	00:09:00	B1.4
11	gev_20081112_0852	2008/11/12 08:52:00	09:40:00	09:23:00	A4.3
12	gev_20081112_1256	2008/11/12 12:56:00	13:36:00	13:17:00	A2.9
13	gev_20081113_0623	2008/11/13 06:23:00	06:55:00	06:44:00	A2.1
14	gev_20081129_0930	2008/11/29 09:30:00	14:30:00	13:20:00	A3.8

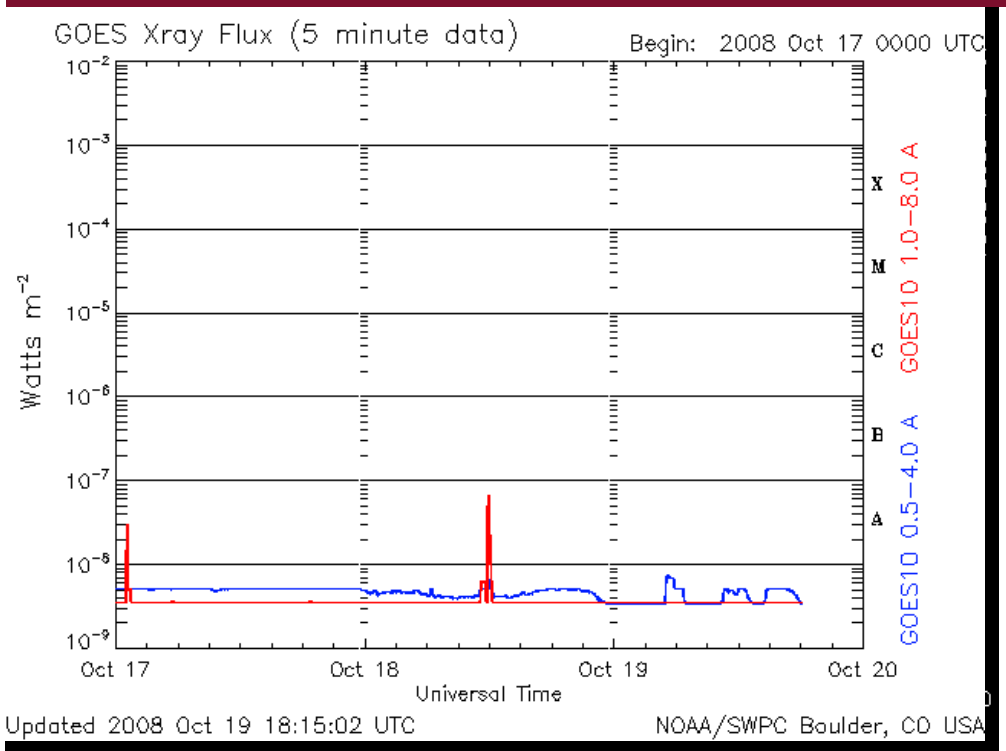
http://www.lmsal.com/solarsoft/latest_events/

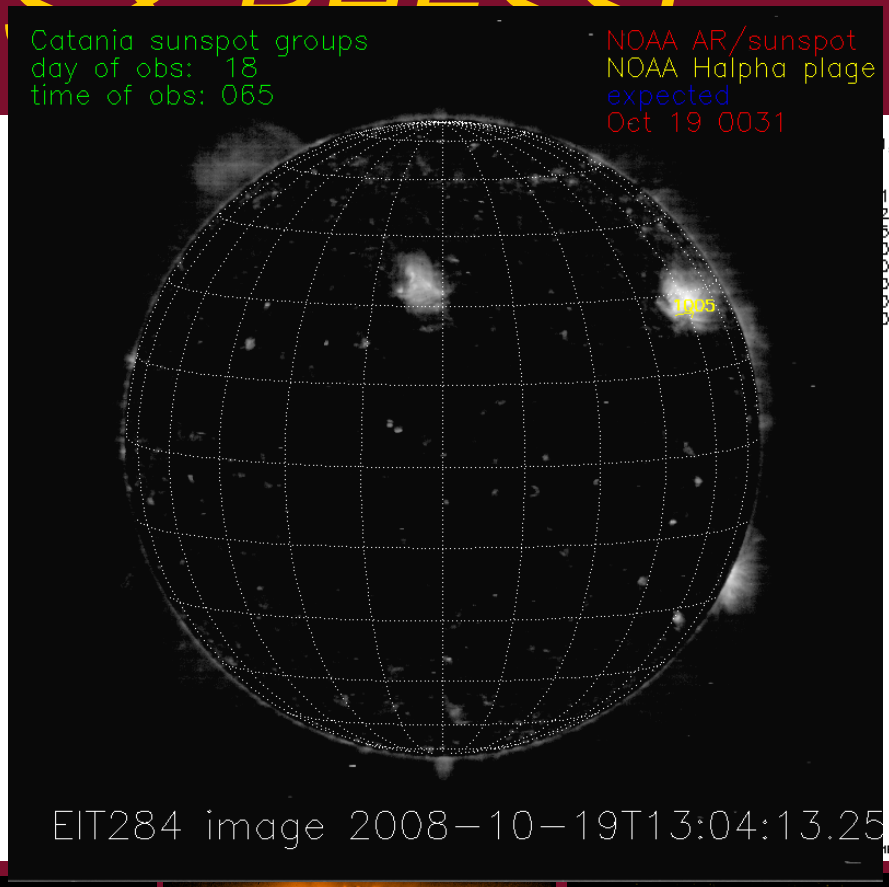
Lockheed summary

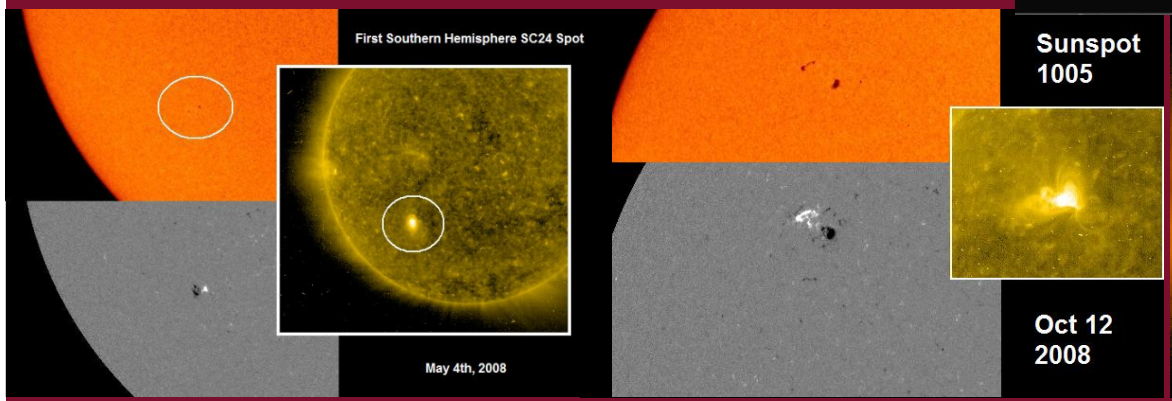


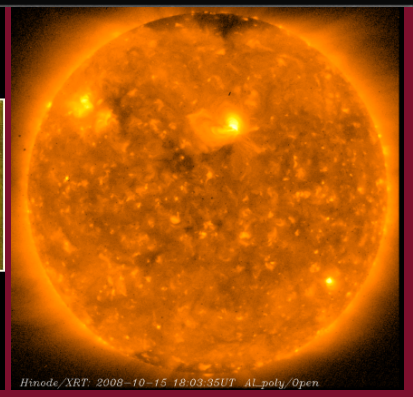
Thank you ☺

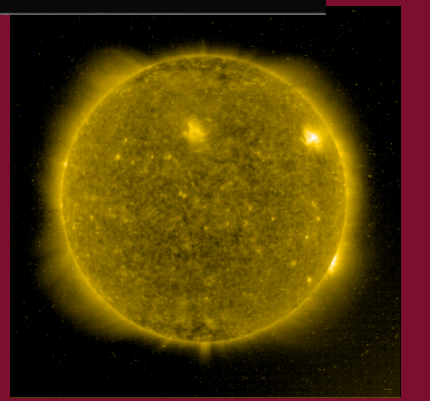
Recent *GOES & RHESSI*







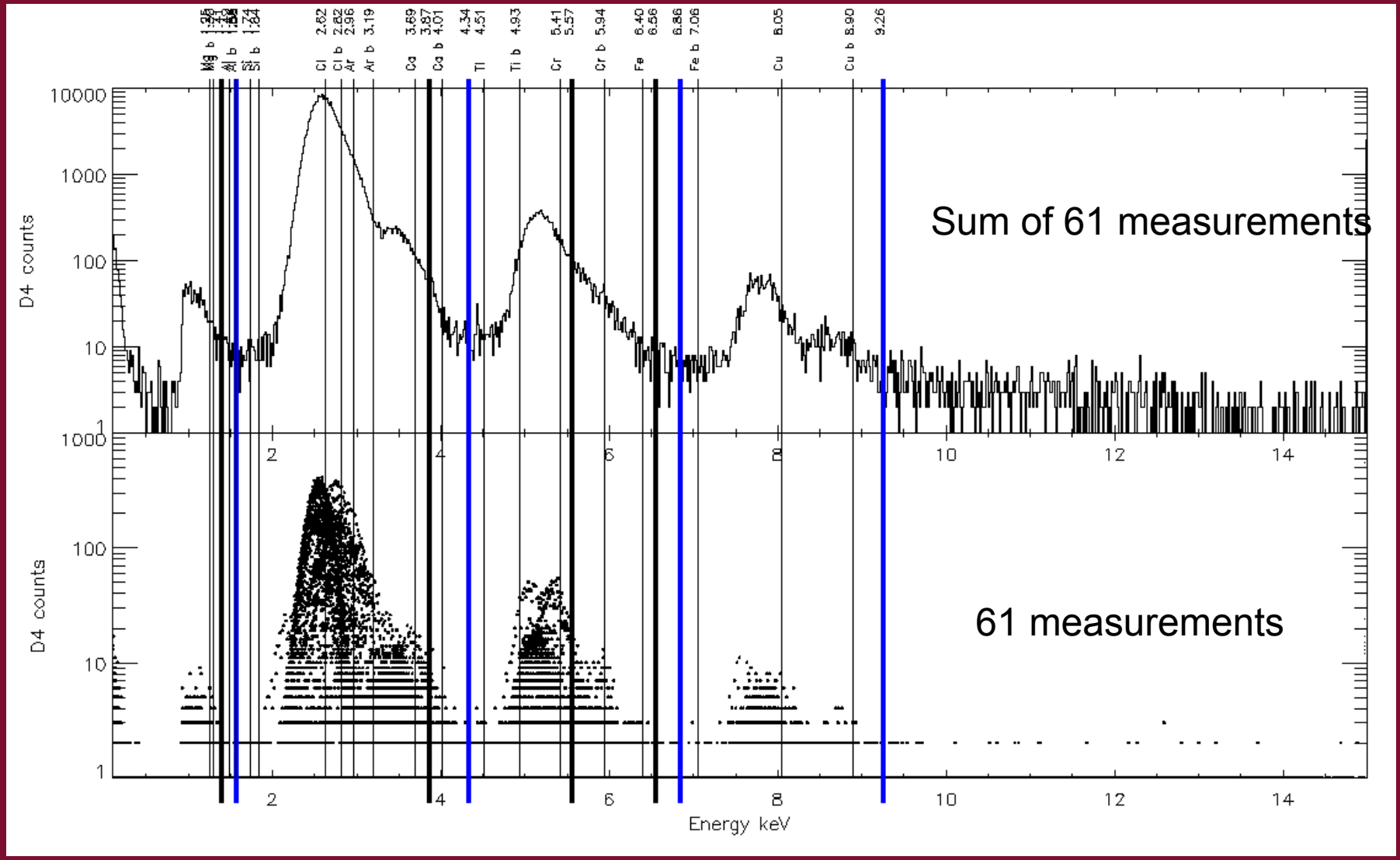




Overwhelming interest to SphinX

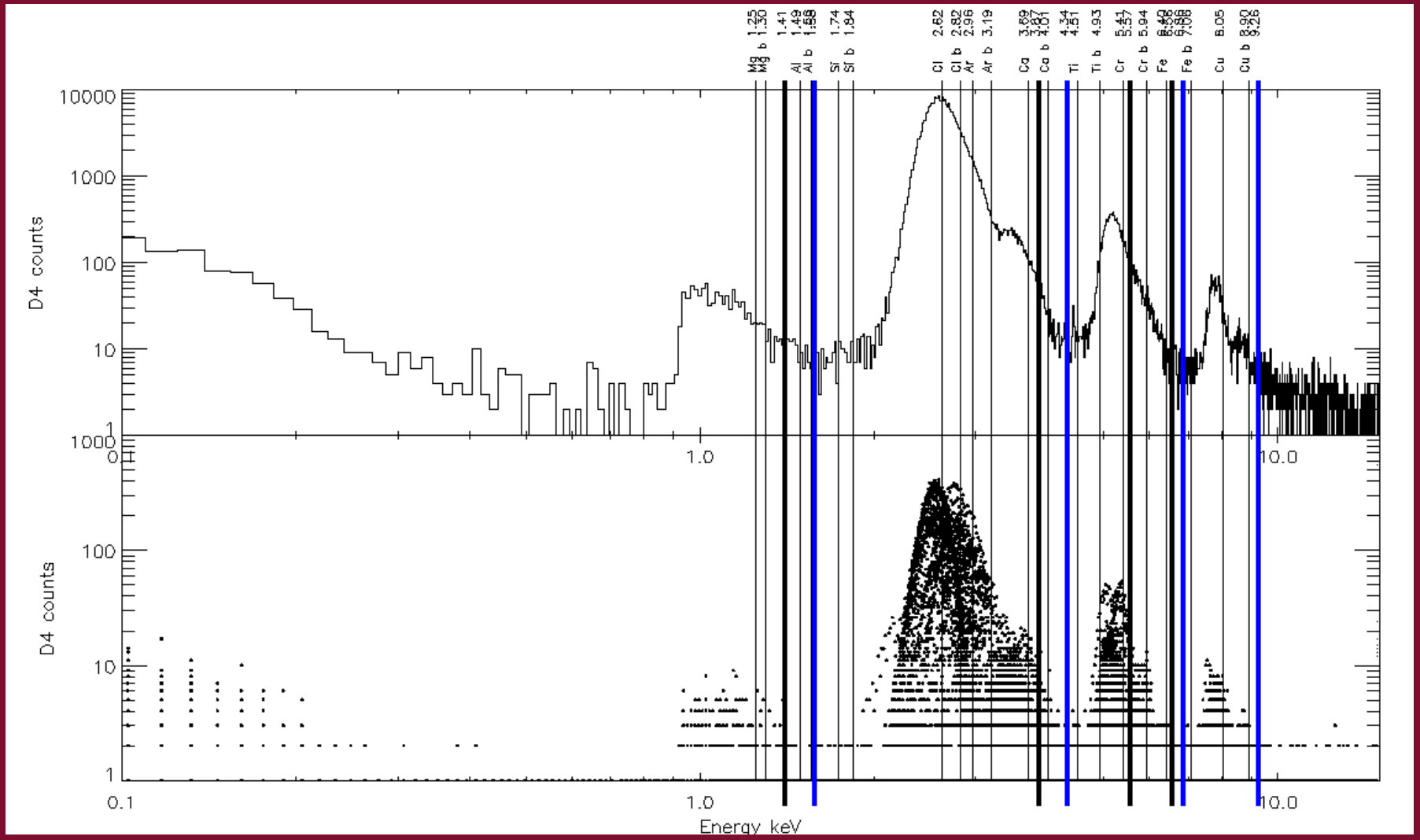
- RHESSI →
- Hinode XRT →
- Quiet Sun modellers ISSI Bern →
- HD Flare modellers →
- Space weather →
- Global oscillation people →

PALERMO XACT – D4 calibration data set, courtesy Szymon Gburek



Vertical black thick lines – present channel edges for D4 basic mode – [24, 66, 95, 112]

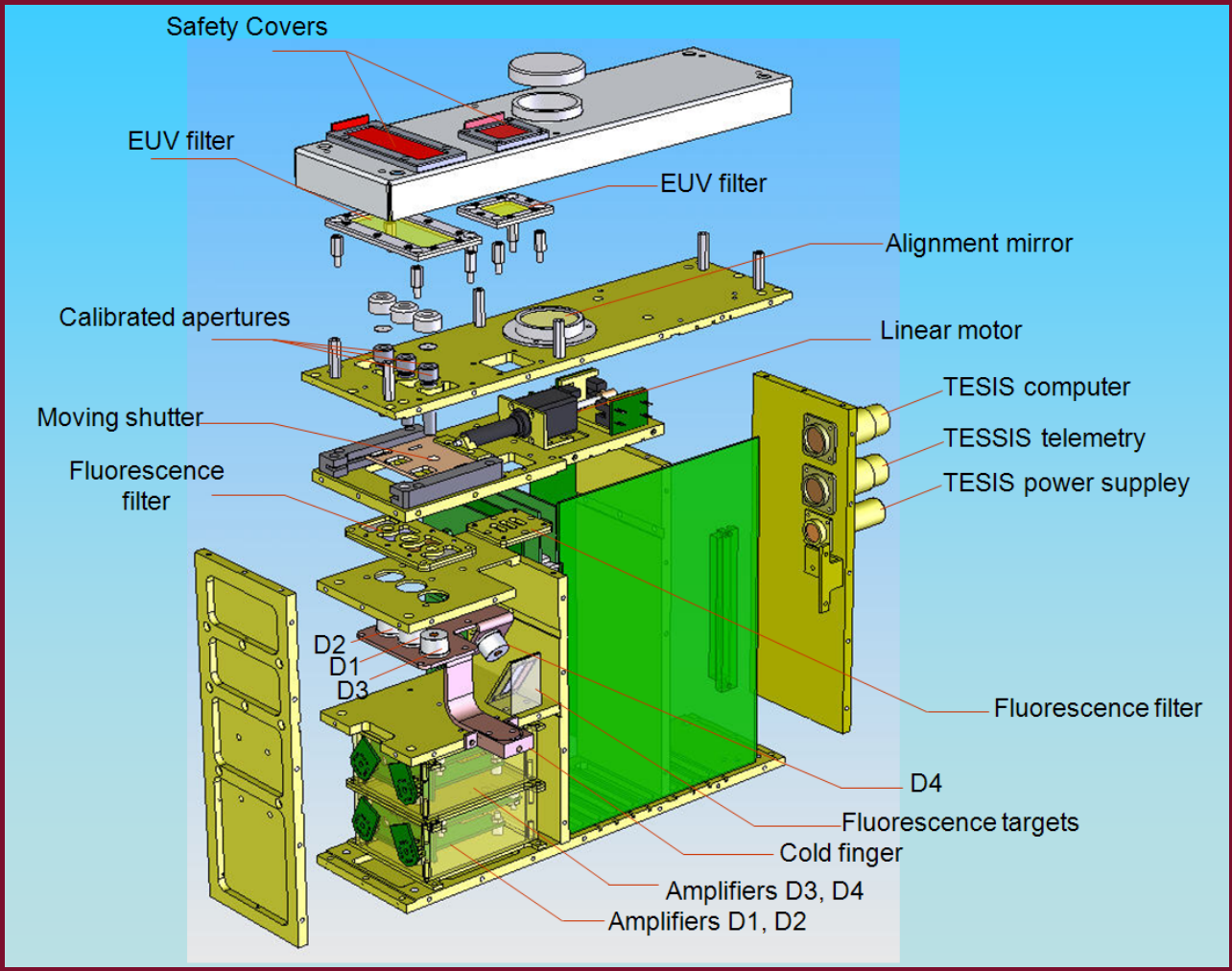
Vertical blue thick lines – NEW channel edges for D4 basic mode – [27, 74, 117,



Same as above – xlog scale

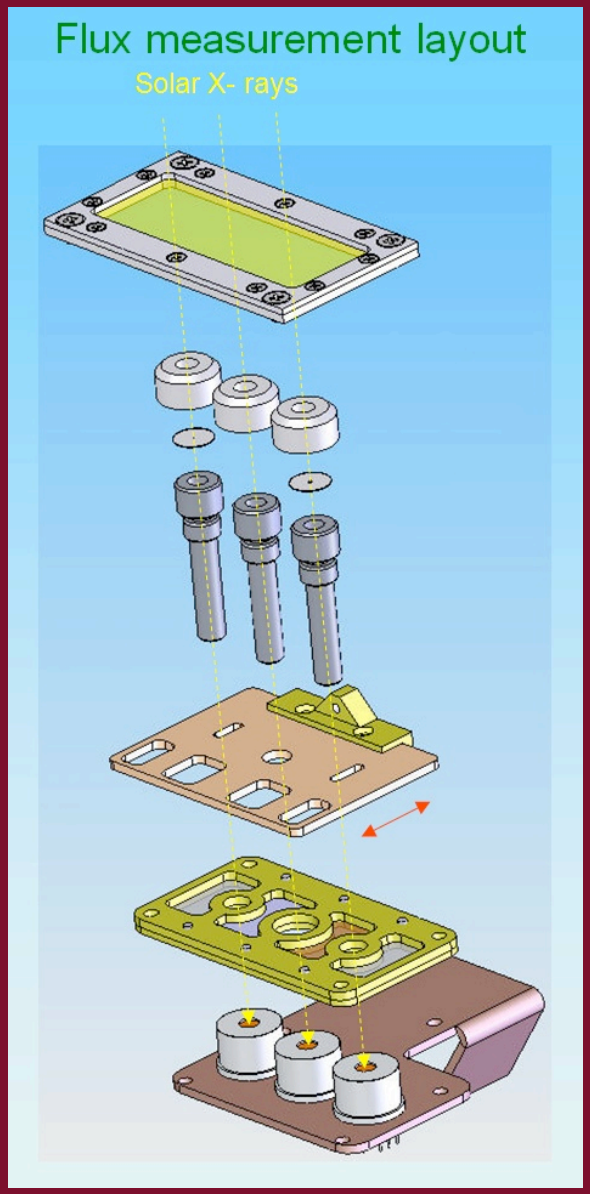
D4_basic.pro

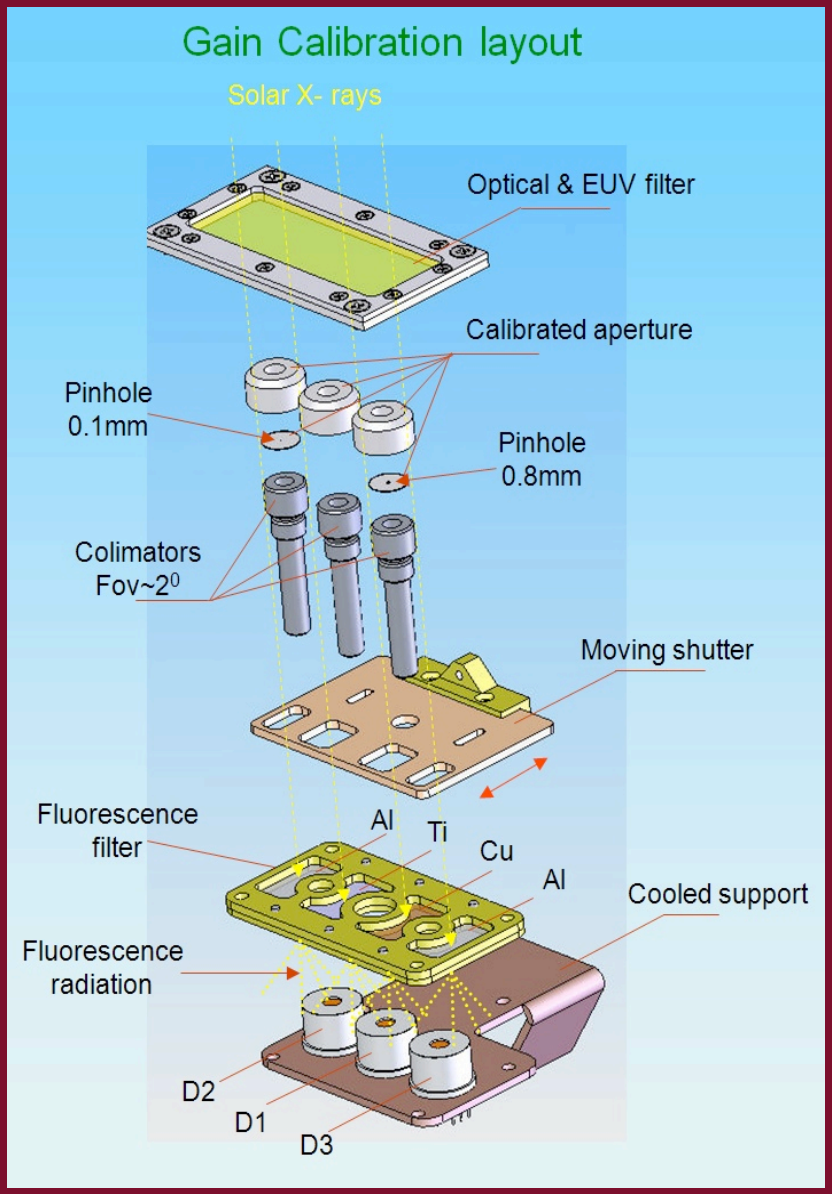
The construction



- EUV filters (doubly aluminized Mylar)
- Photometer
  - Collimators (+-2.5 deg)
  - Three apertures
  - D1, D2, D3
- Shutter
  - Stepper motor
- FFU
  - Filters
  - Targets
  - D4
- Electronics
  - Front end Amptek
  - Digital „our”
- Controller
  - Software
  - reprogramming
- Heat sink
- Alignment mirror

The Photometer: 3 detectors

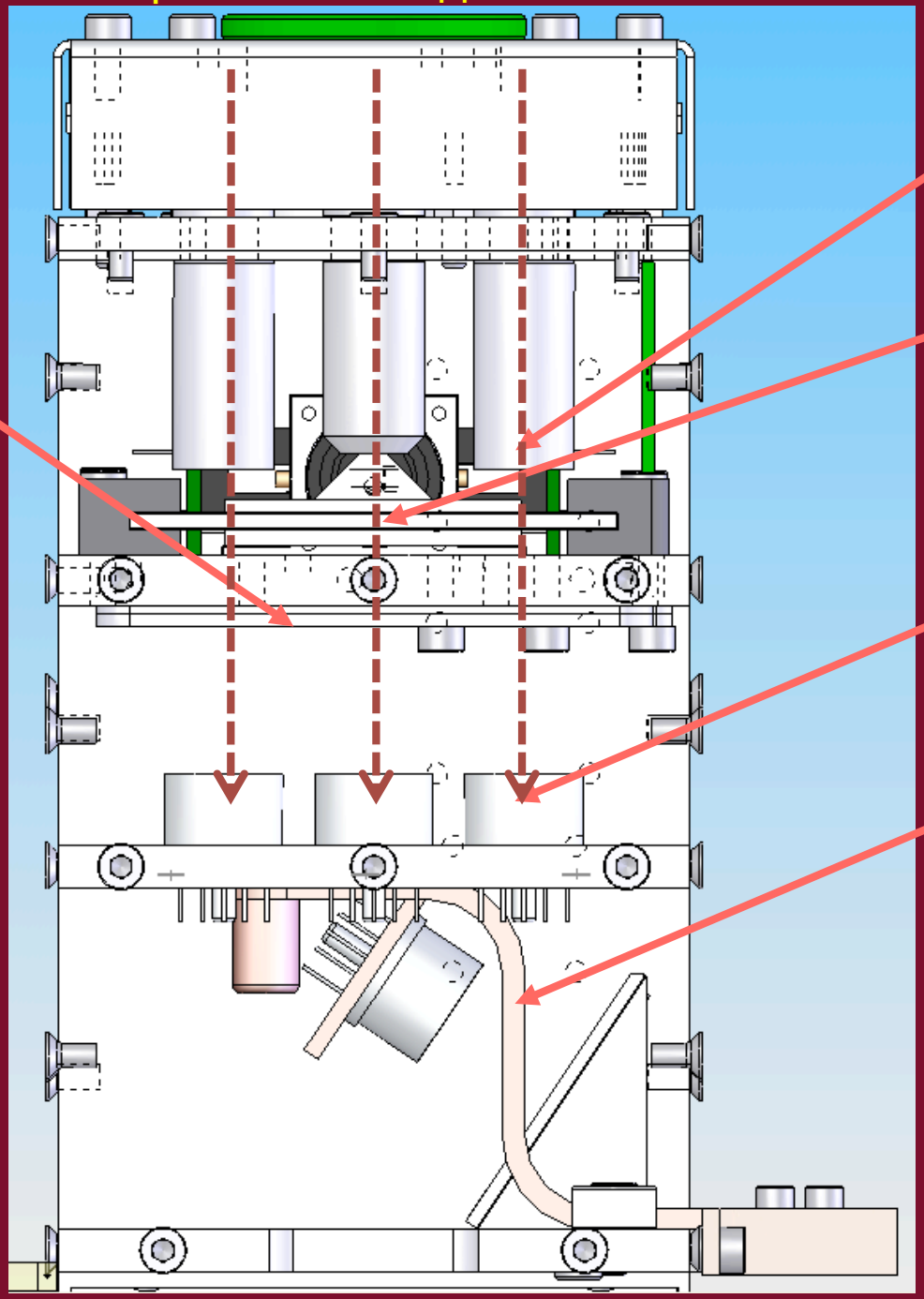




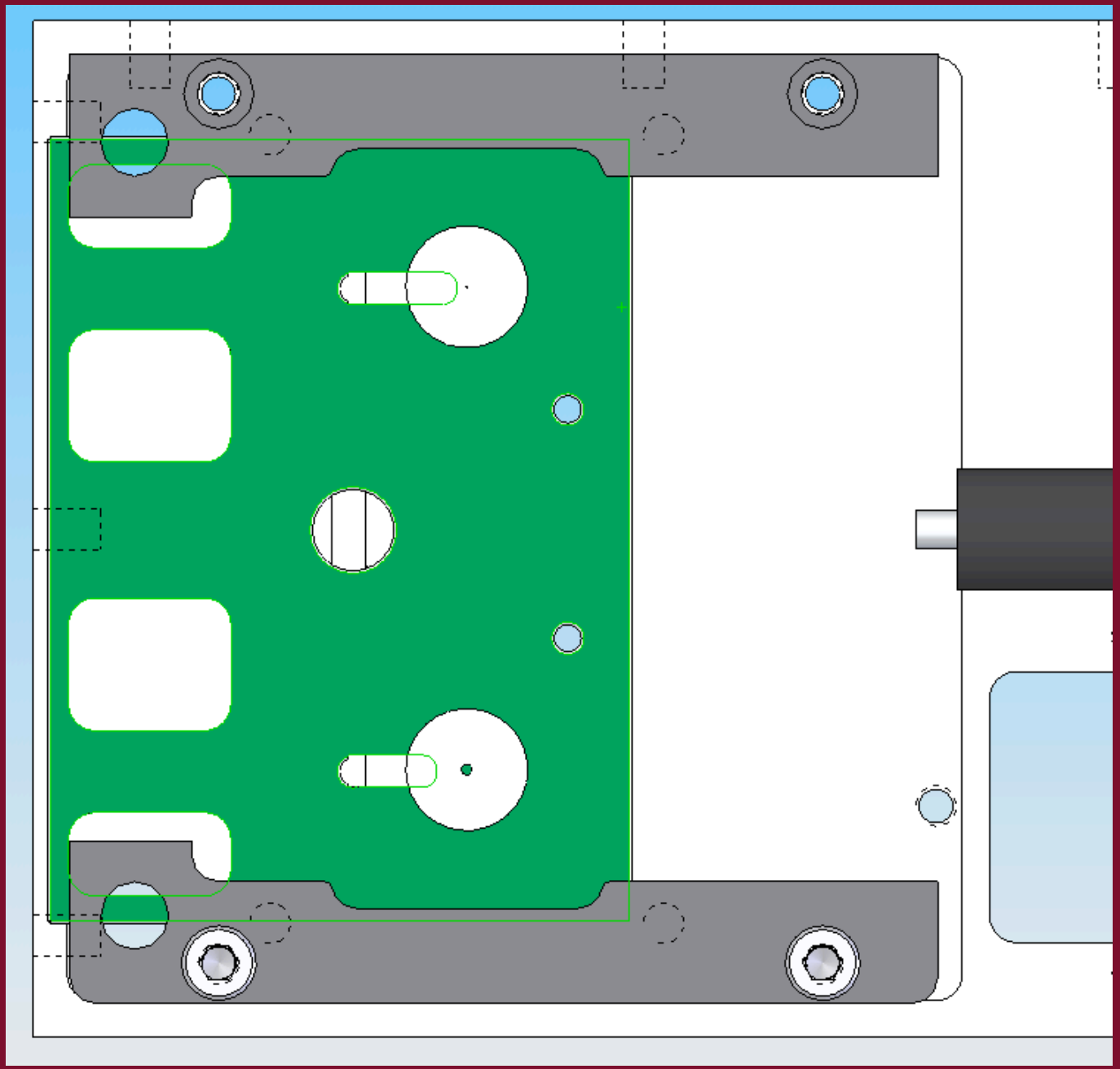
- Several states possible
  - Completely blocked- only the background counts measured
  - Direct solar illumination blocked- back-luorescence from calibration foils „active”
  - D1, amd/or D2, and or D3 channels opened for flares of various intensity

Al.:
Ti:
Cu:

Shutter positions – stepper motor



Dark current



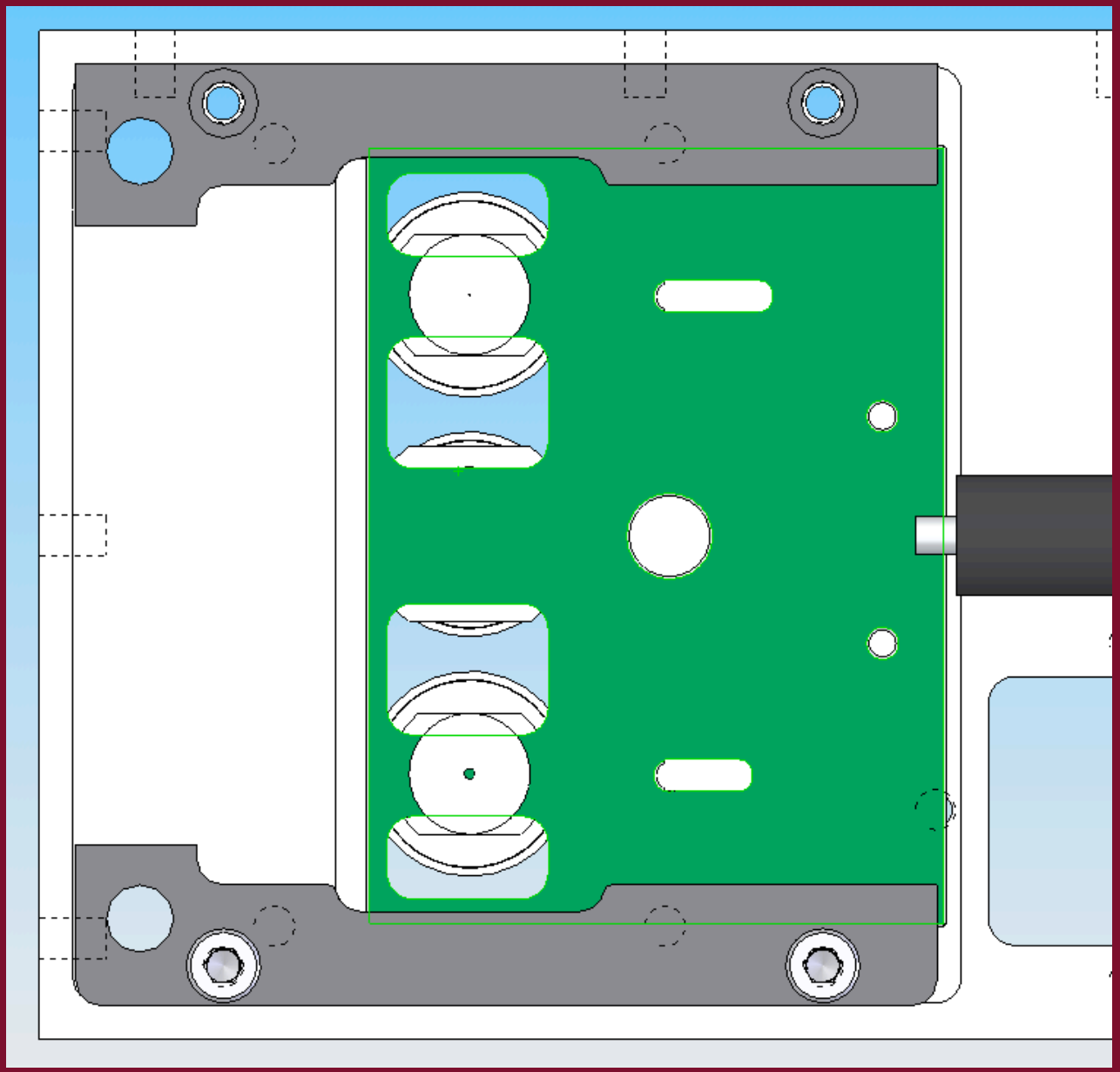
D3= 100µ

D1= 5mm

D2= 800µ

Calibration

Stepper motor 0.04mm/step

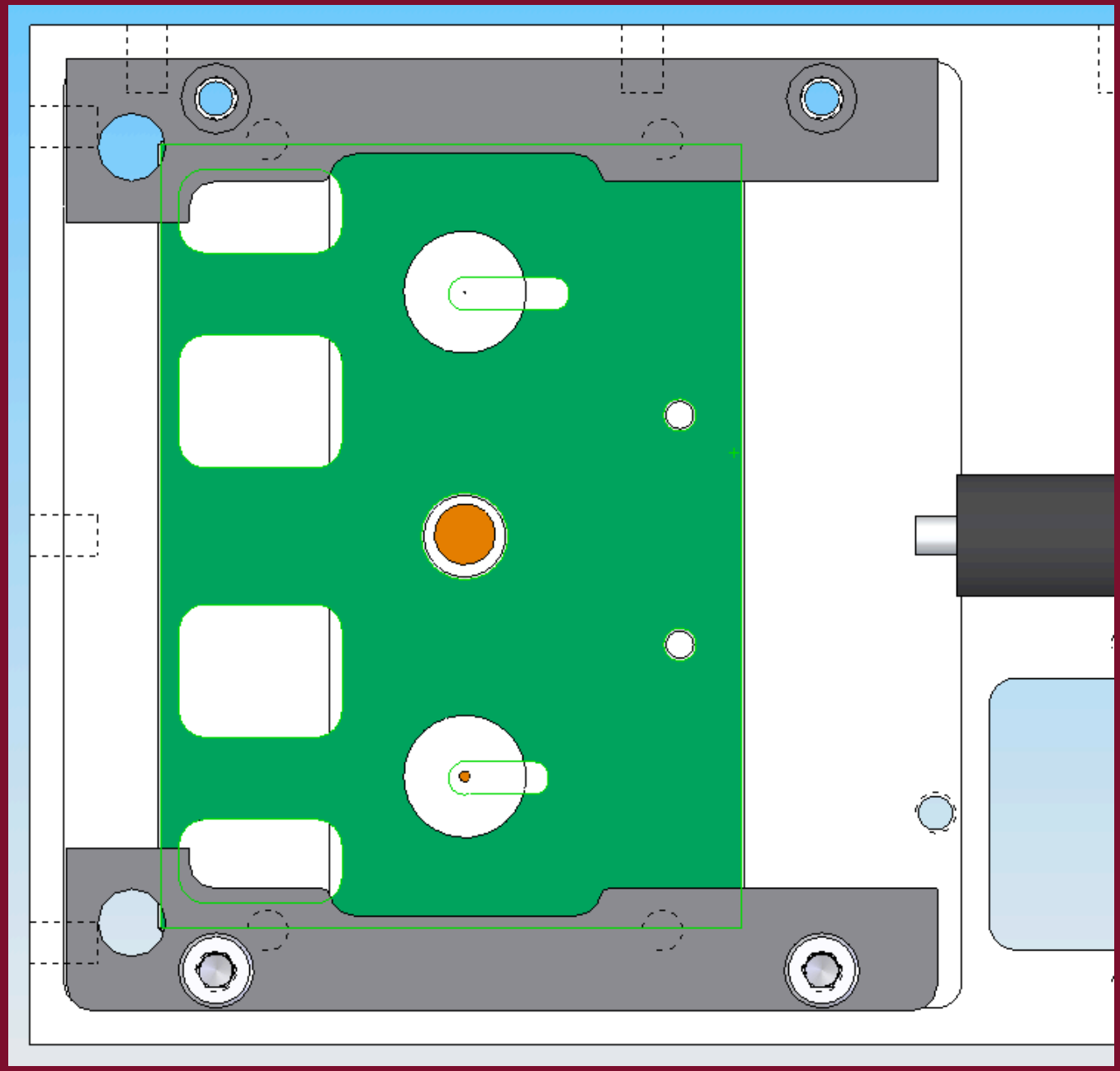


D3= 100µ

D1= 5mm

D2= 800µ

Low activity < B2 GOES

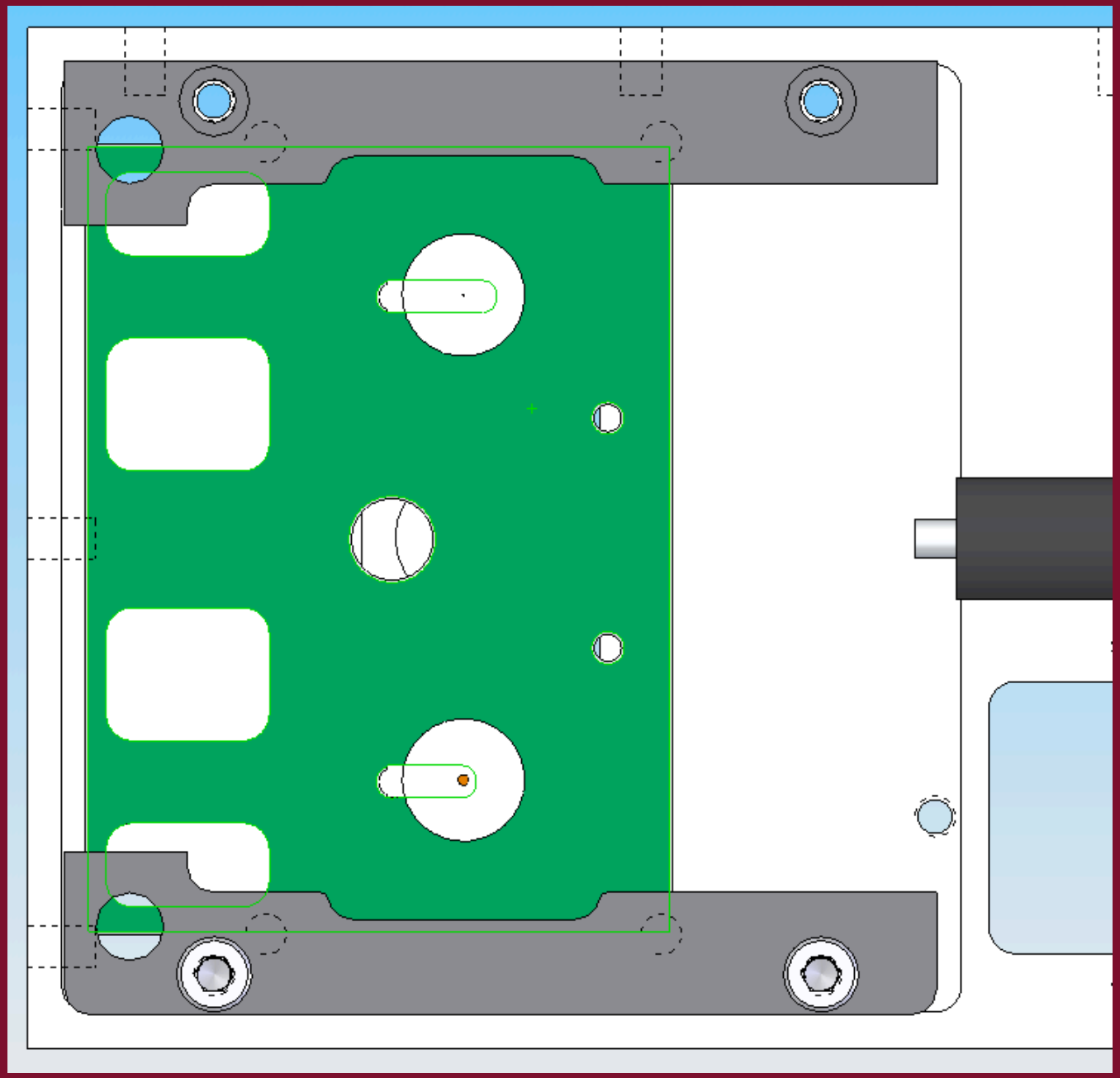


D3= 100µ

D1= 5mm

D2= 800µ

Medium activity >B2 < M2 GOES

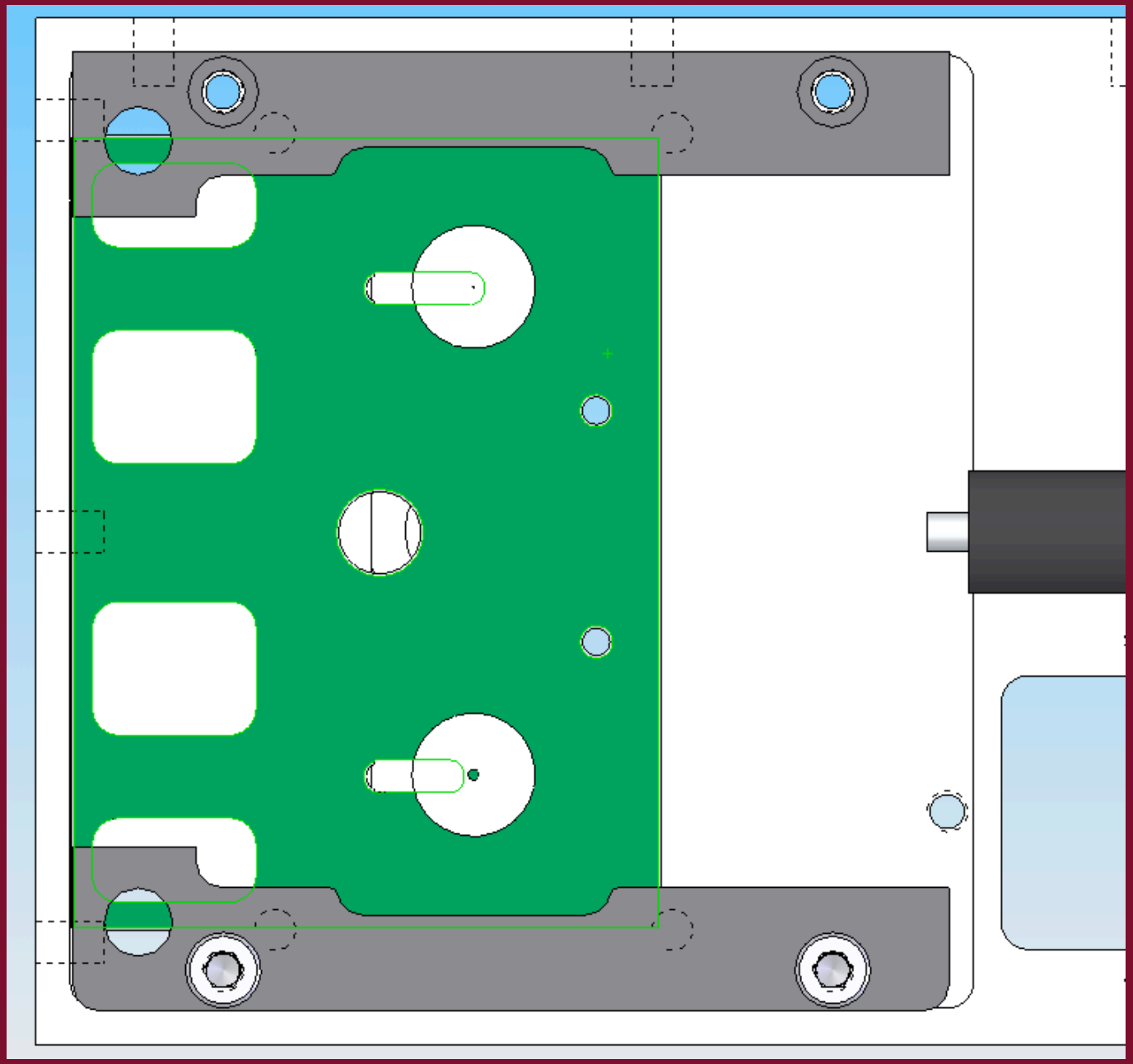


D3= 100µ

D1= 5mm

D2= 800µ

High activity > M2 GOES

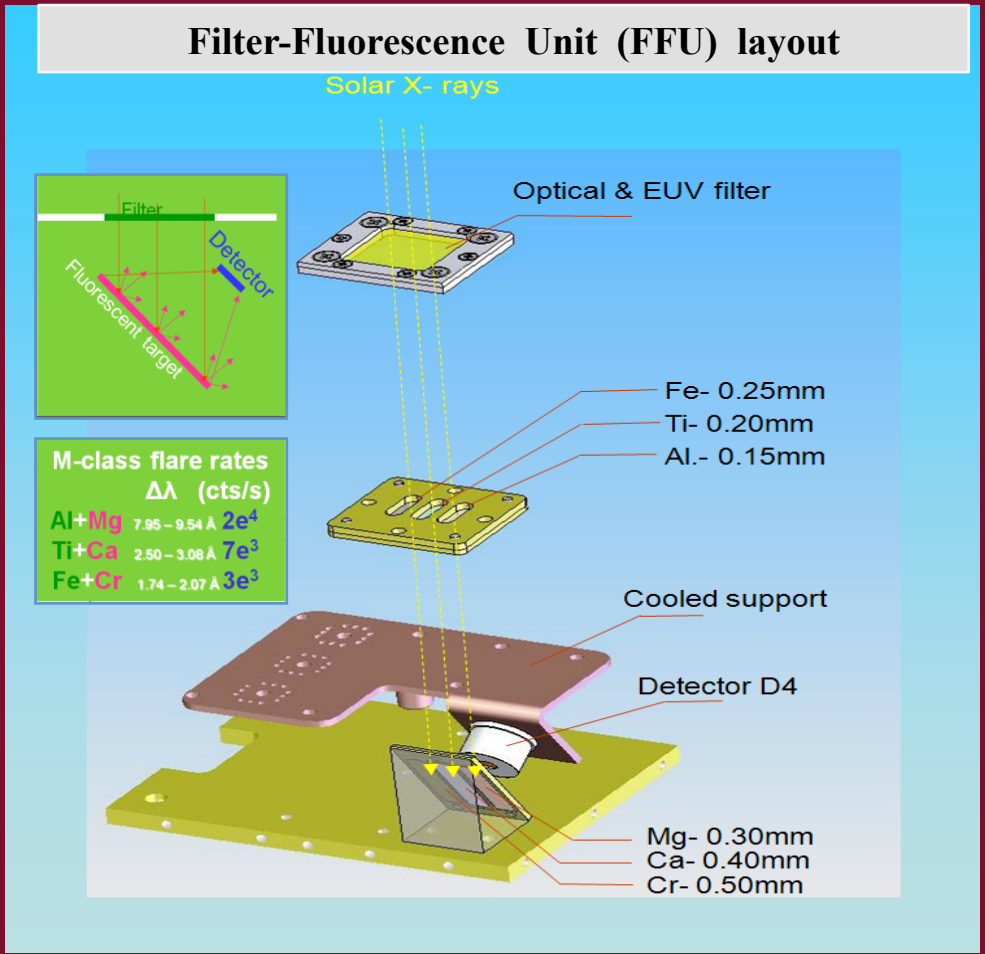


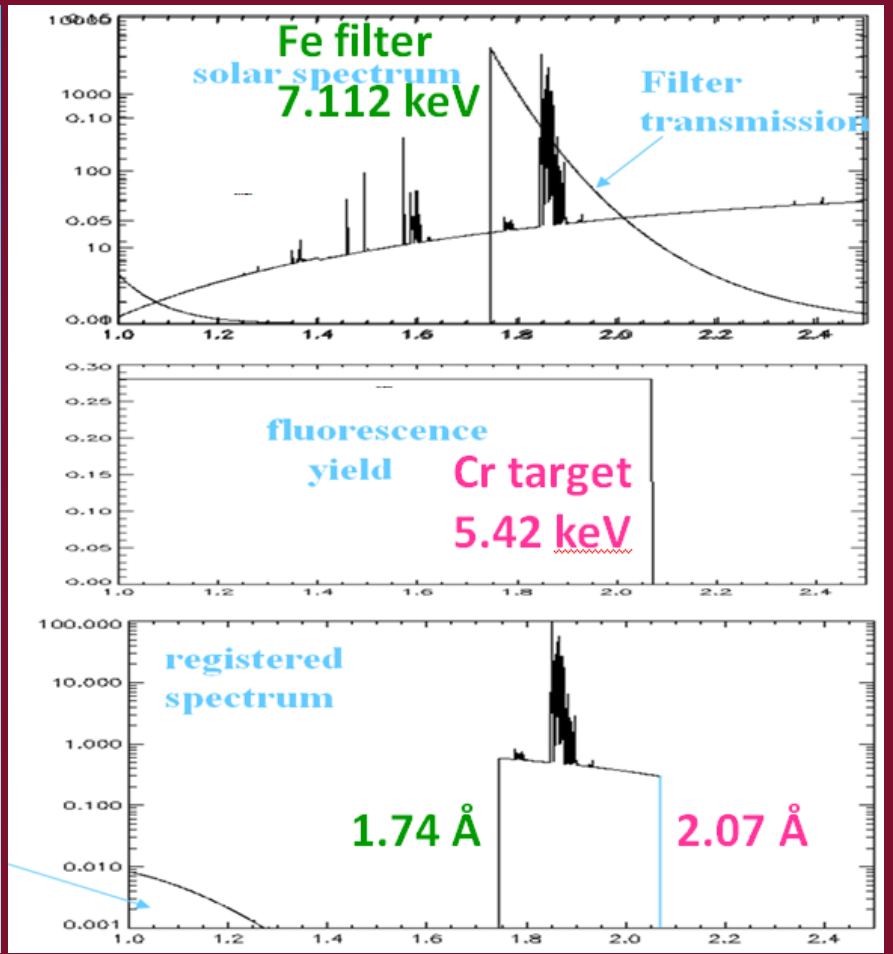
D3= 100µ

D1= 5mm

D2= 800µ

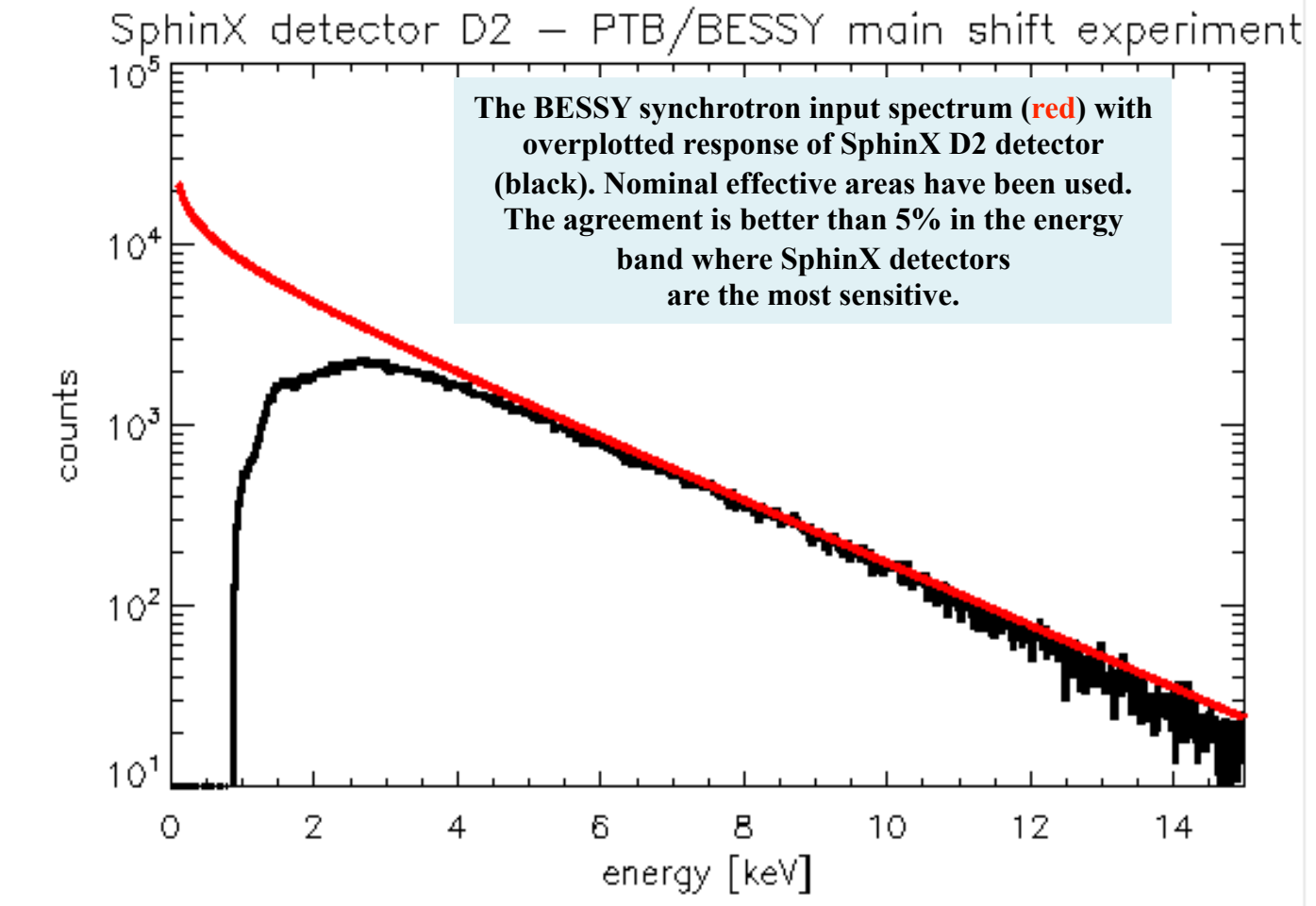
The FFU unit (filter-fluorescence unit)





This unit will be active all the time: time stamping < 1000 cts/s or spectra (256 bins)

How it looks from the tests



BESSY Berlin Synchrotron:

- **All detector linearity: perfect (0.1%) over 0.8-14.5 keV; dynamic range 10^4.**
- **absolute response known to better than 5% against reference synchrotron source.**
- **pile-up matrices known as measured from X-ray 4 crystal monochromator spectra obtained at 8 energies between 1.5 and 8 keV**

SphinX: Solar Photometer in X-rays

FIAN, MEPhI, AI Ondrejov, Palermo University

SphinX a Fast Soft X-ray Spectrophotometer for the CORONAS Solar Mission

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Yury D. Kotov
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J. Astrophys. Astr. (2008) **29,** 1–5

http://www.cbk.pan.wroc.pl/body/publikacje/2008/SphinX.pdf

SphinX: A Fast Solar Photometer in X-rays

J. Sylwester[1,*], S. Kuzin[2], Yu. D. Kotov[3], F. Farnik[4] & F. Reale[5]

Operation modes

- Basic: 2-4 MB/24h runs all the time
- Dedicated
  - Spectra each second
    - 4 detectors *256*1byte =1024bytes/s but mostly one detector provides spectra so

      ~ 300 bytes/s so 30MB/0.3 = 100000s - 30 hours!!!
  - Time stamping

    on every detector when count rate <1000/s

    Spectra are being built on the ground
  - Terminator crossing
    - » Spectra each 0.1 s to get height absorption profiles