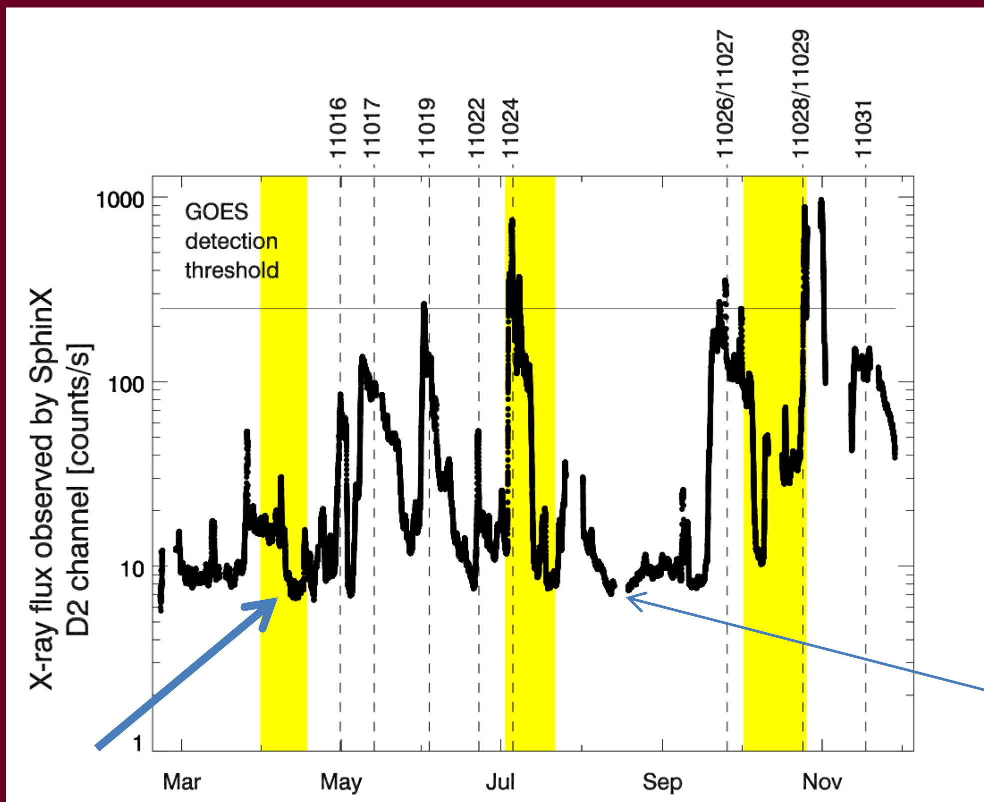
New instruments under development at Wrocław SPD, SRC

RESPECT Rosja, FIAN

SphinX-NG, GSFC

SphinX heritage (PIN diode detectors)



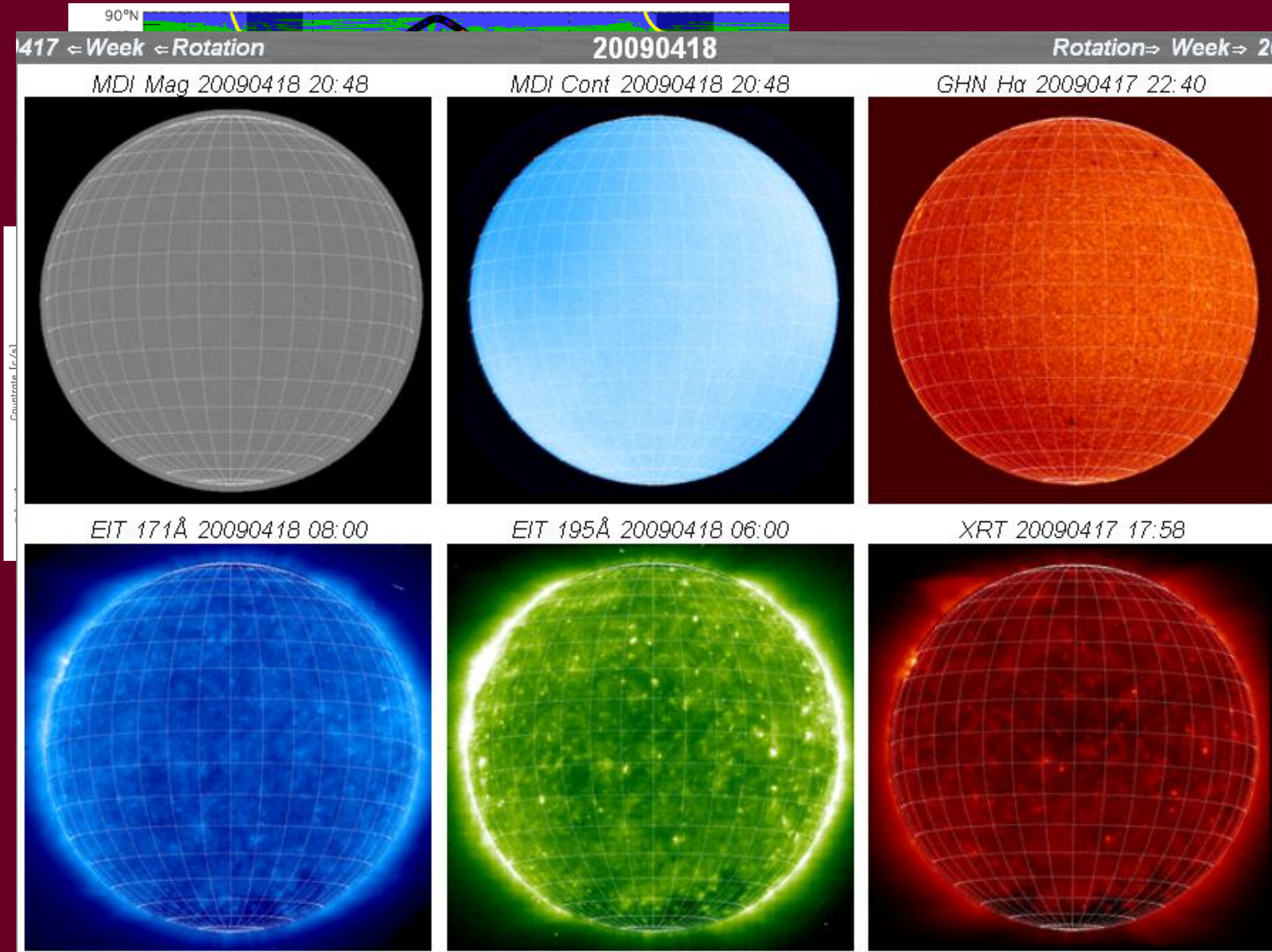
- There is a lower limit for solar X-ray flux of the Sun in the energy range

E > 1 keV

~5 × 10^{-10} W/m^2

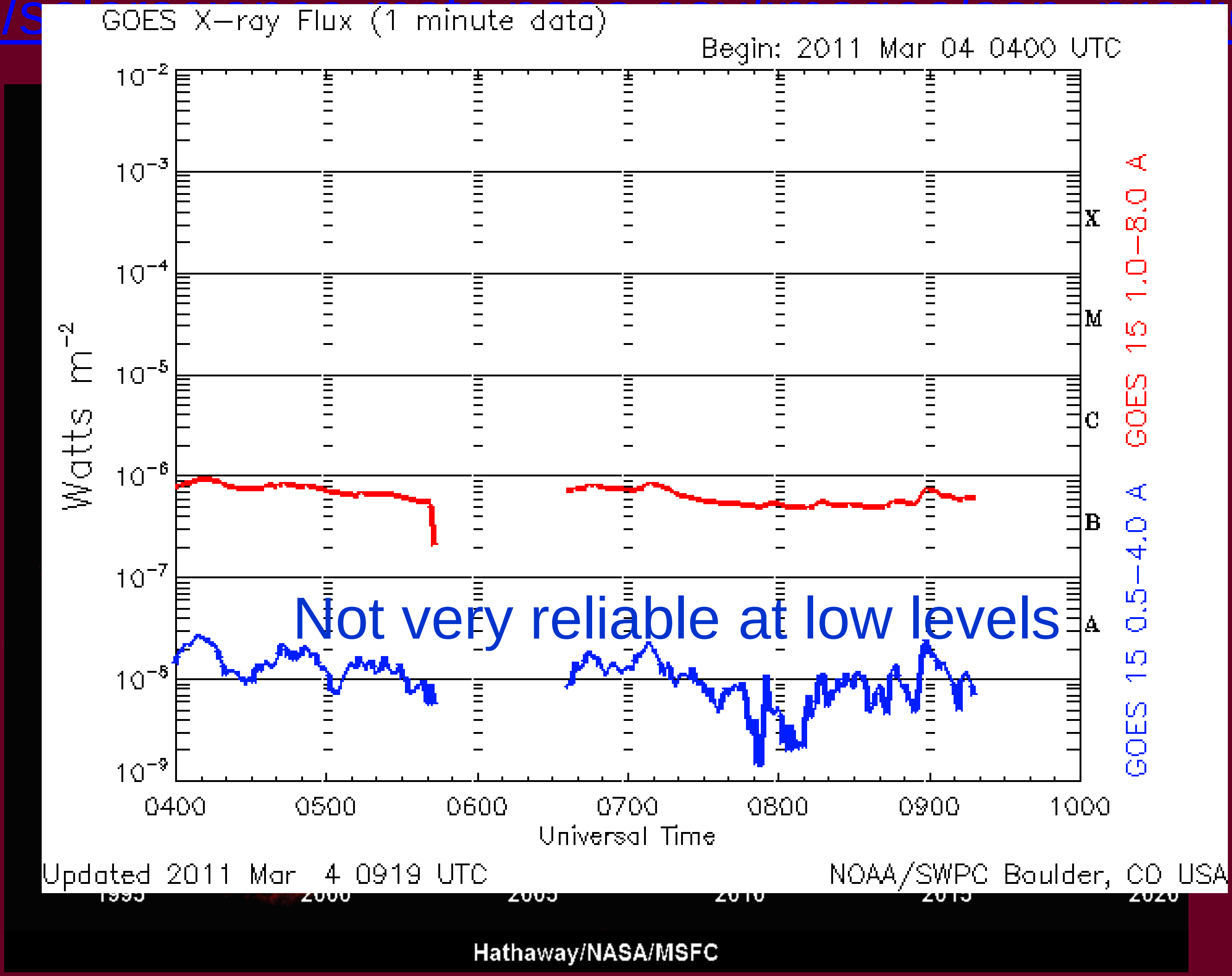
No measurements after November 2009 ☹

Only full-Sun spectra


90°N
417 ⇐Week ⇐Rotation
20090418
Rotation⇒ Week⇒ 20
MDI Mag 20090418 20:48
MDI Cont 20090418 20:48
GHN Hα 20090417 22:40
EIT 171Å 20090418 08:00
EIT 195Å 20090418 06:00
XRT 20090417 17:58

Expected future solar activity

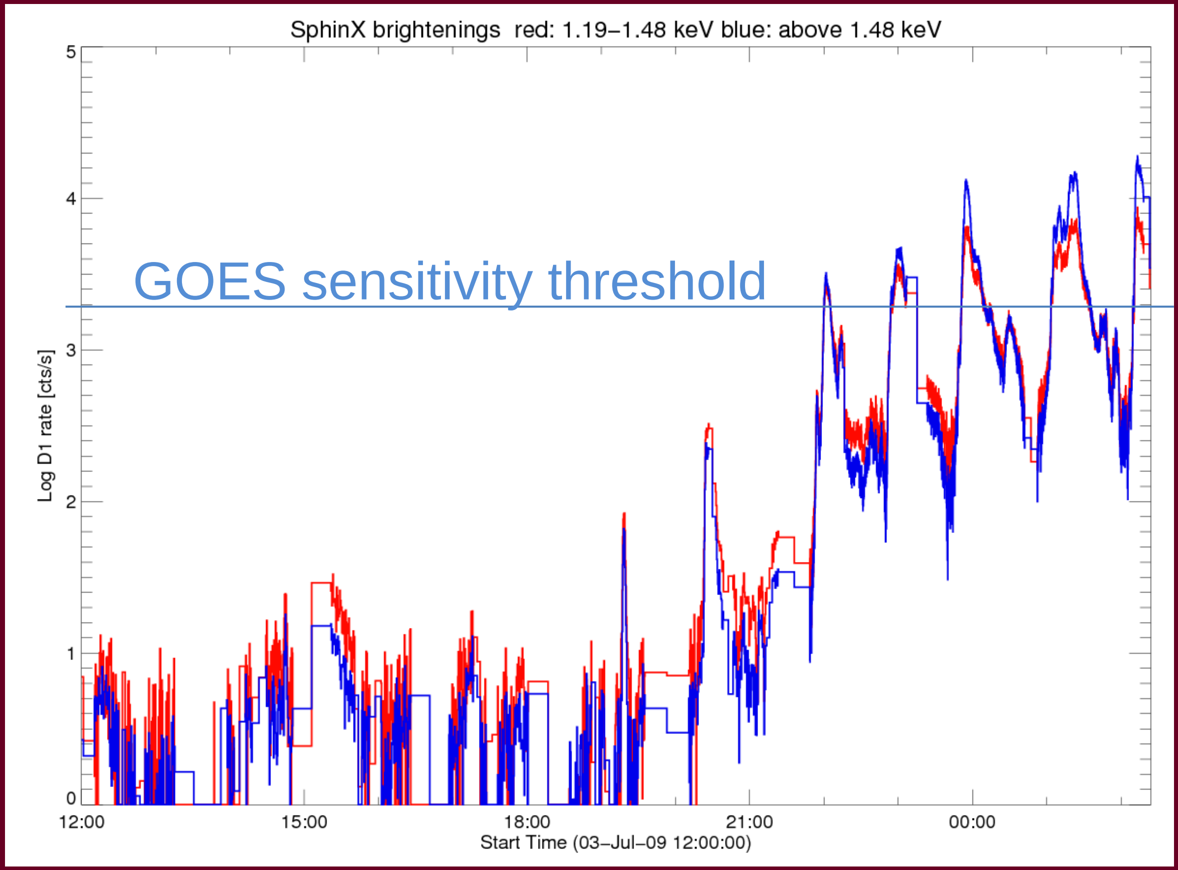
http://s...ct_l.gif



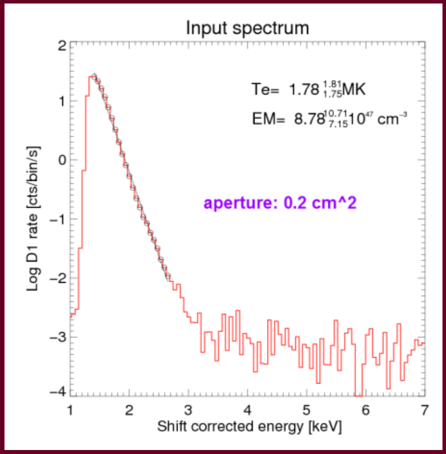
Advance spectral and high-time measurements of solar spectra in the energy range 1- 15 keV

- Study variability of the X-ray Sun with sensitivity 100-1000 x GOES→ T & EM v short (0.1s) & long (hours) timescales
- Allow for medium-angular-resolution imaging in this range – resolve individual AR spectral & time components → study AR energy balance – i.e the thermal component

Lone AR 11024 studies in progress (BS, MS, Harvard)



- Variability in timescales 1 s ÷ days



Typical flux values for non-active Sun

- Be 12 μ thicknes filter,
- 0.5 mm thickness Si crystal (absorber)

~10 cts/s/mm^2

  – 1-few cm^2 in order to collect few thousands cts in 1s necessary → reveal spectra at few keV

- Classical detectors: 300eV resolution, better (~130 eV) desired

For very active Sun (X20 flare)

- 10^8 cts/s/mm2 !!!, so apertures should be of the order of 10 microns in order to operate at 10^4 cts/s or much thicker filters must be applied (three apertures, factor 50 progression of decreasing size used in SphinX)
- RHESSI „adventure” with attenuators (elaborated thicker filters) has not been fully successful however…
- In STIX, no attenuators will most probably be used (this week discussion)

SDD

Si drift detectors (Amptek, Ketek)

http://www.amptek.com/drift.html

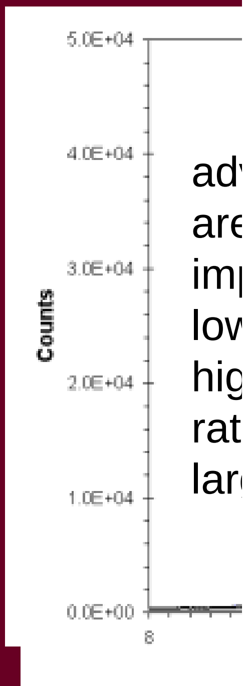
- Filters, Be 12 µ thicknes on sealed apertures up to 1cm^2
- Crystal thickness (Si absorber) <0.5 mm

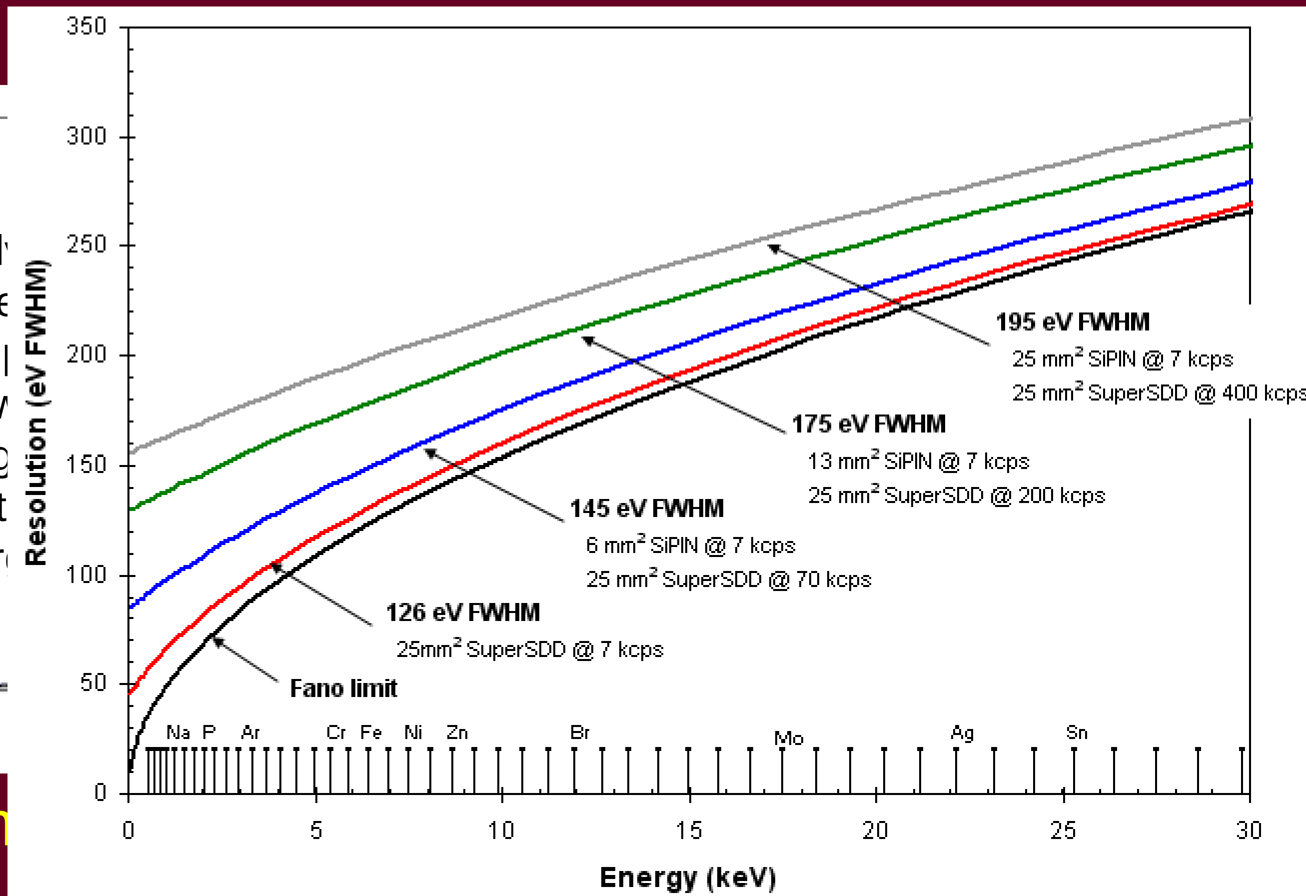
A silicon drift detector (SDD) is a type of photodiode, functionally similar to a PIN photodiode, but with a unique electrode structure to improve performance. Amptek's SDDs are optimized for X-ray spectroscopy.

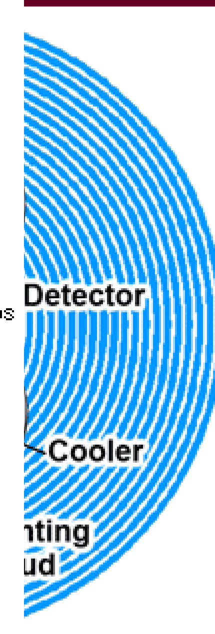
The key advantage of the SDD is that it has much lower capacitance than a conventional diode of the same area, therefore reducing electronic noise at short shaping times. For X-ray spectroscopy, an SDD has better energy resolution while operating at much higher count rates than a conventional diode. The SDD uses a special electrode structure to guide the electrons to a very small, low capacitance anode.

SDD

Si drift detectors (Amptek, Ketek)







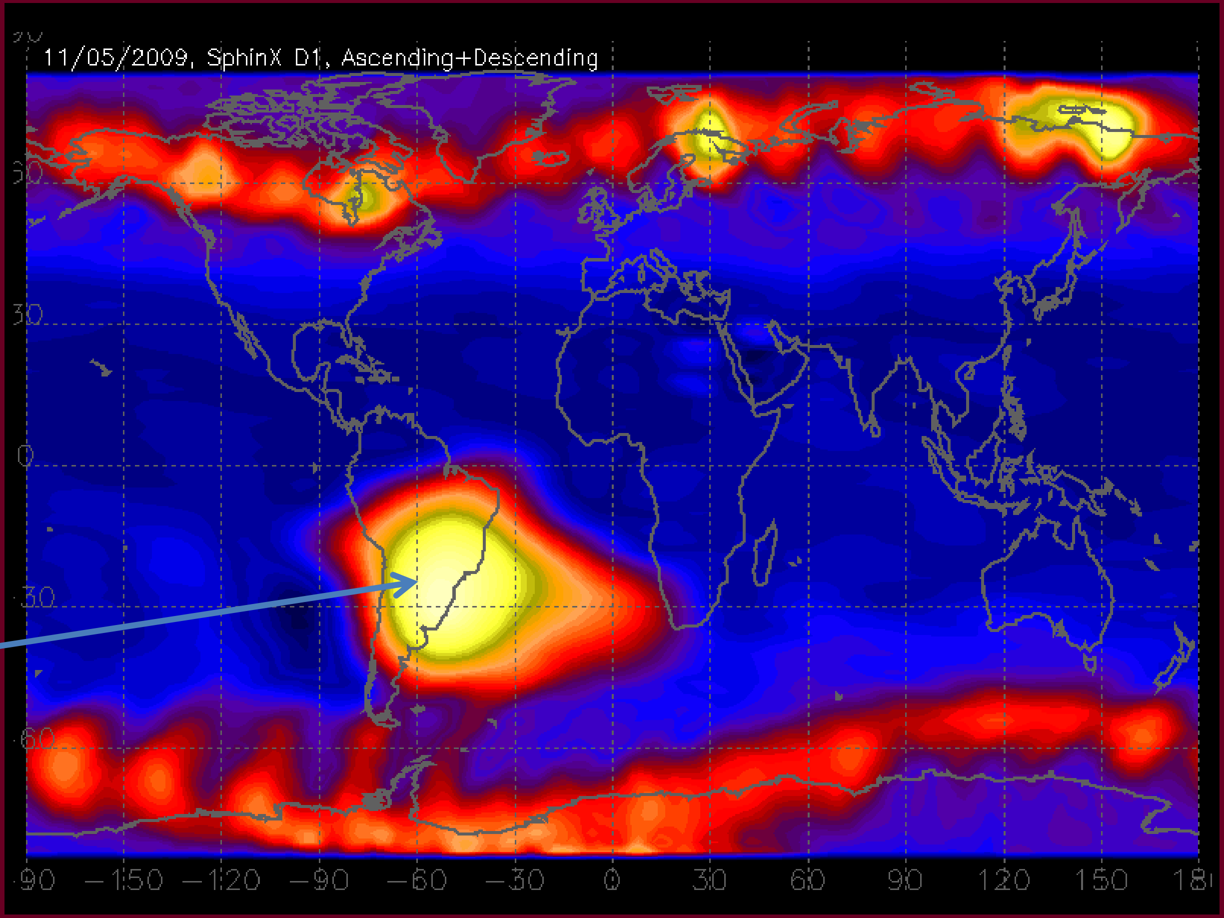
Dynam … ead of

three for SphinX) to cover the dynamic range

Much lower noise, but same sensitivity to particles

How SphinX 25 mm² PIN detector responds to particle environment

SphinX heritage ~at 550km polar orbit



100 cts/s

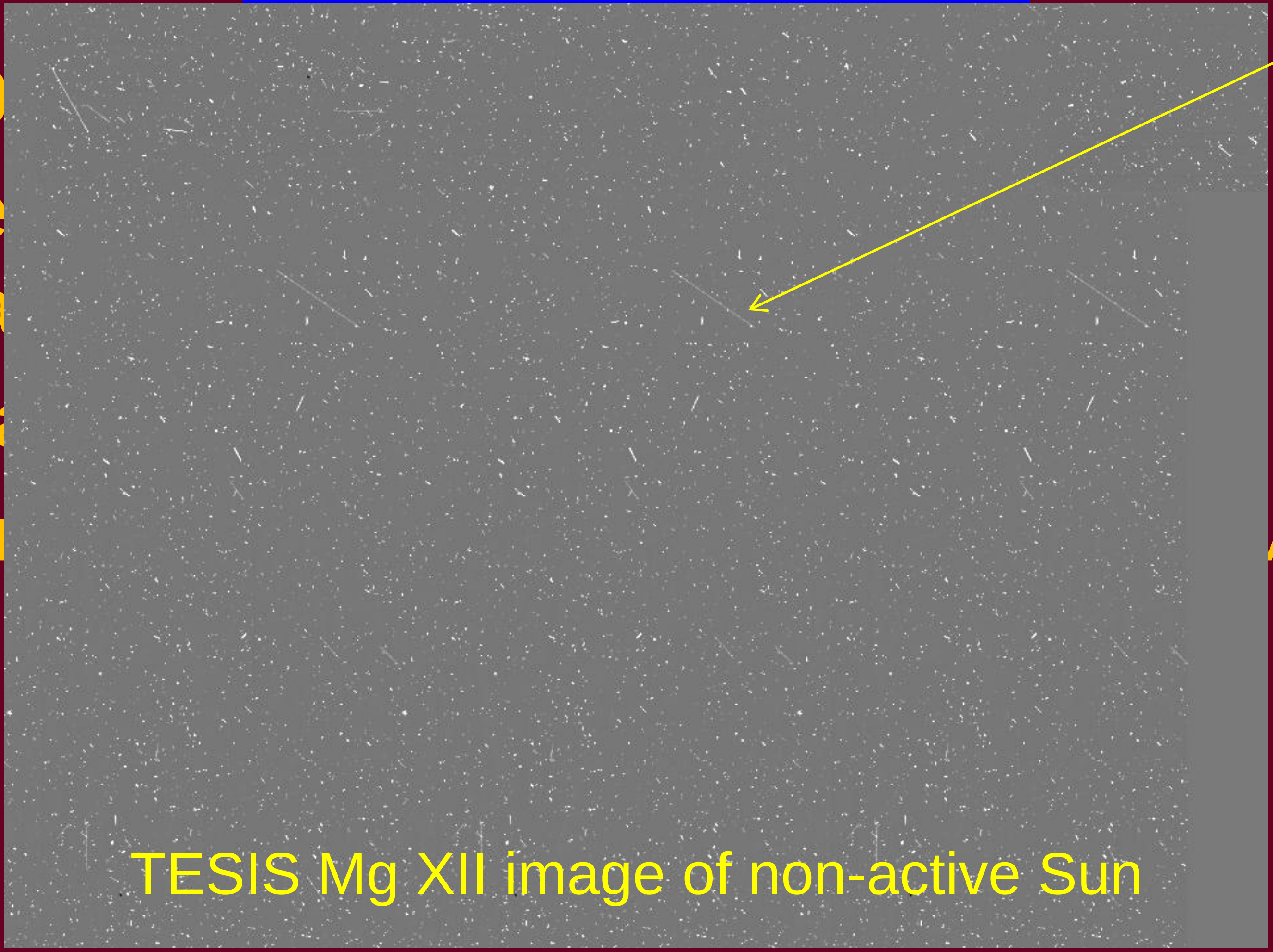
< 1 ct/s

1000 cts/s

CCD- back illuminated

http://www.e2v.com/

- 10
- Le
  tra
- Tr
- Al Mg
  XI

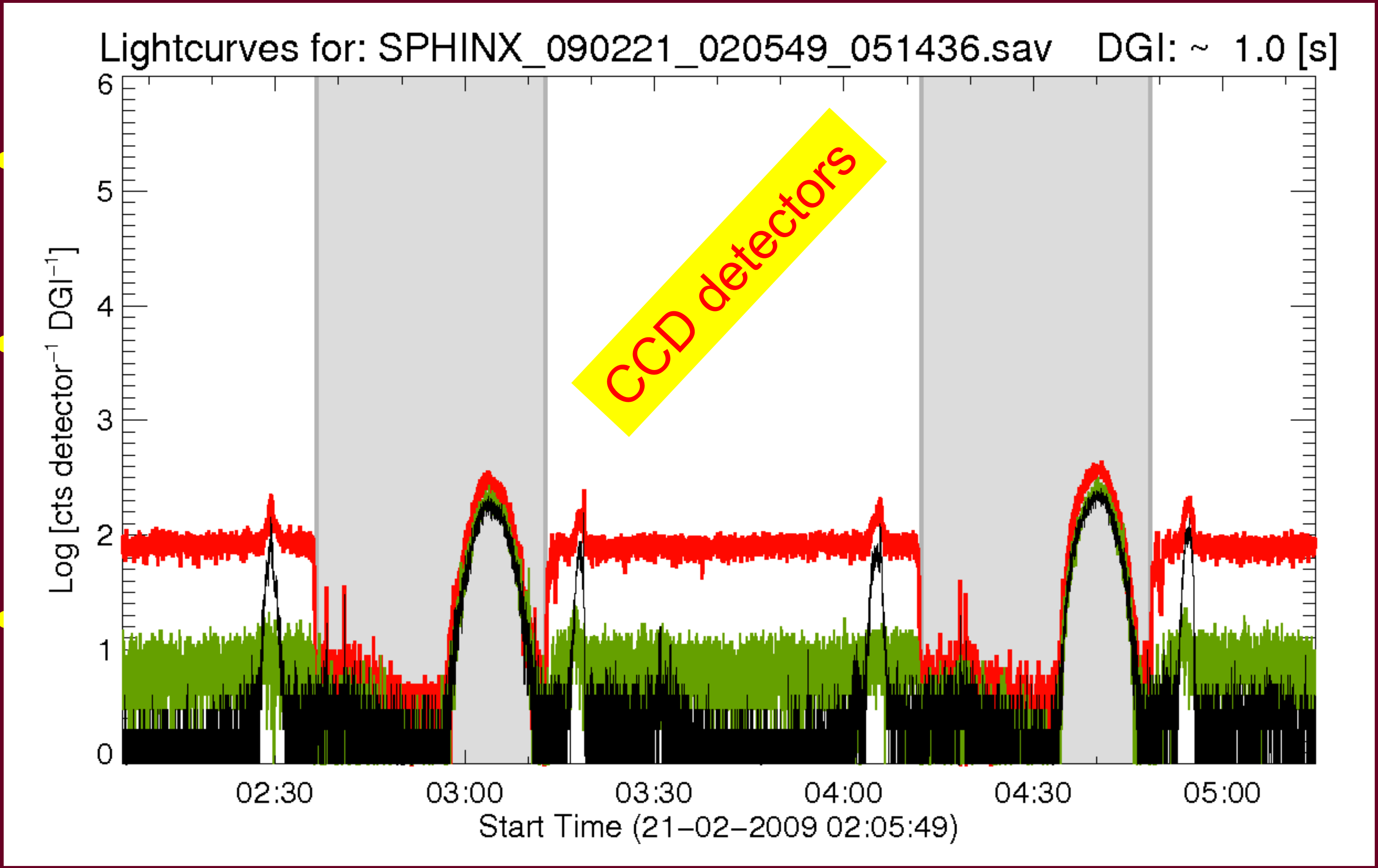


TESIS Mg XII image of non-active Sun

Desired orbits and payload availability

- Orbits
  - LEO equatorial (+), ISS, see the Sun for 60 min each 100 min orbit, SAA, telemetry non-continuous, 400-700 km
  - LEO Polar semi Sun Synchronous (++) Coronas, up to 3 weeks out of shadow, SAA polar ovals, telemetry non-continuous, 400-700 km
  - Geosynchronous (geostationary) (++++), SDO, constant sunshine, continuous telemetry ~36000 km
  - L1 (SOHO) (+++)- far for fast telemetry
  - Interplanetary (Solar Orbiter, Interheliozond) (+++) telemetry problems, but 20x higher fluxes due to proximity
- Availability
  - Russia, FIAN, IZMIRAN, national programs (monitoring, military, ISS-LEO, IHZ interplanetary 0.25-0.7 a.u.)- Kuzin, Kuznetsov
  - US, piggyback nanosatellites ~1-few liters volume, LEO, NASA, GSFC, Brian Dennis

Russian Earth monitoring satellites:



Рентгеновский СПЕКТрофотометр РЕСПЕКТ ReSpect

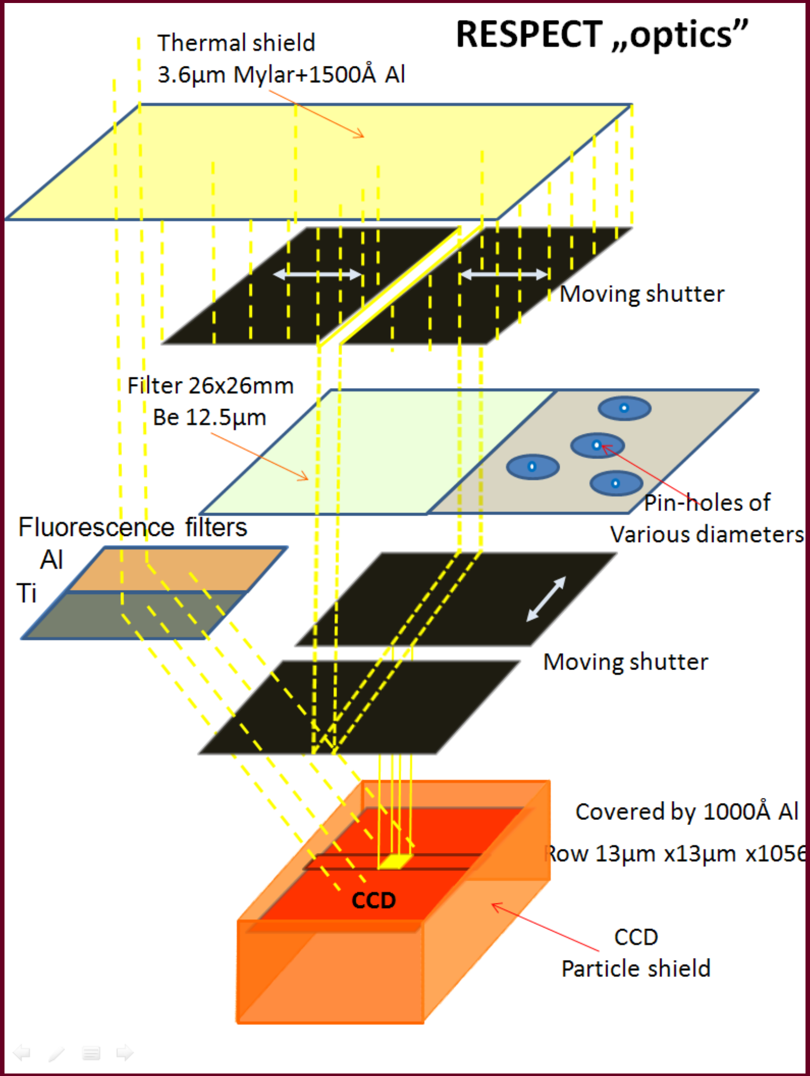
ФИАН - ЦКИ ПАН

Agreement 2009

Launch ~2013

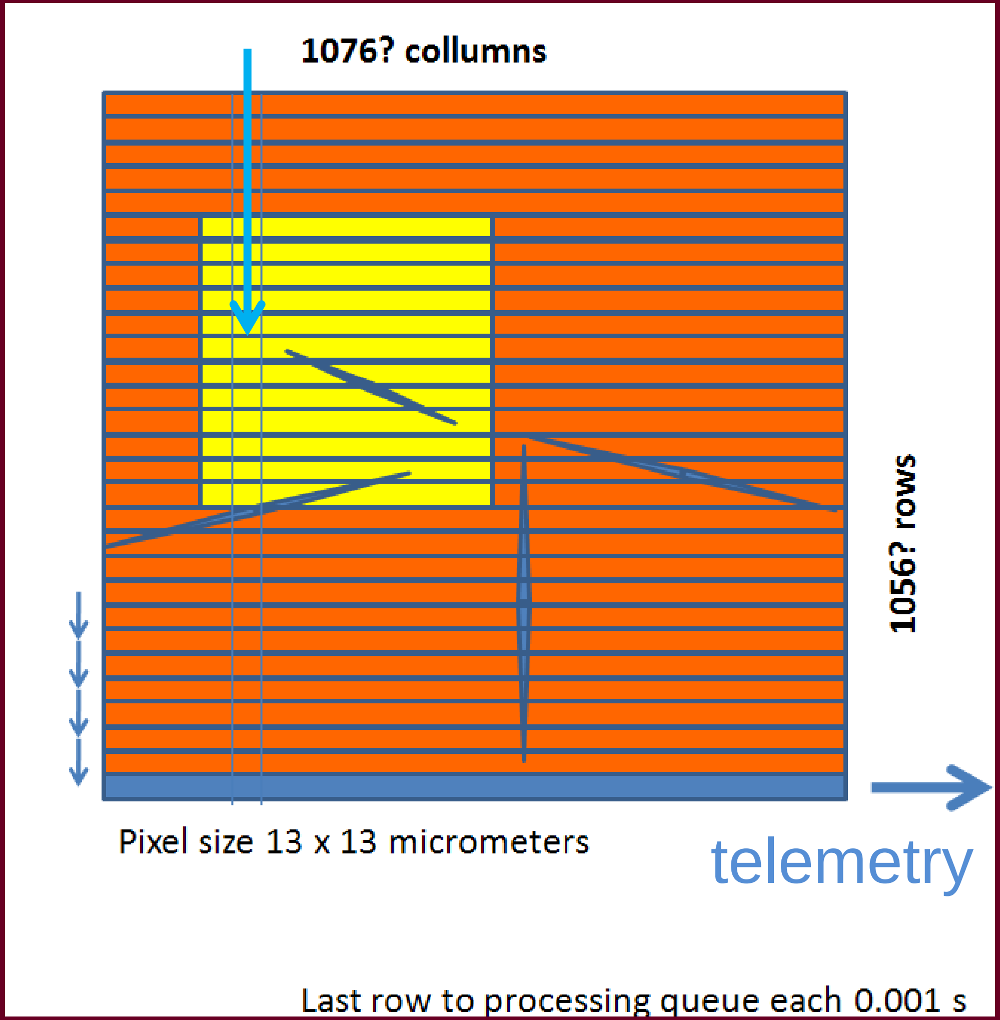
- Spectral range 0.8-15 KeV
- Registration of single photon
- Registration activity from quiet corona to X-class flares
- Good energetic resolution
- Temporal resolution less than 1 second
- Long life-time (8 years)
- Absolute calibration during the lifetime
- Operation in radiation belts, flare and after-flare fluxes of gamma-rays and energetical particles
- FOW 6°

RESPECT measurements ideology



- The front aperture is limited by system of two front-side moving diaphragms with flat sharp edges (1 µ rrms nonuniformity)
- Slit width can be adjusted using respective sensors to within similar accuracy down to a fraction of the CCD pixel (13 x13 µ). The slit can be "moved" to any position within the input FOV (prevents memory effect)
- On the same upper shaft, the ensemble of pin-hole system of various cross-sections is fixed, allowing to select desired size of the active pinhole, depending on the solar activity level. On the underneath of the second upper shaft, the Fe^{55} radioactive source producing Mn characteristic lines at 5.9 keV is placed.

RESPECT ideology < 2 cts/pixel/exposure



Any solar photon absorbed within active CCD area produces electron-hole pairs in the Si, proportional to photon energy. 3.65 eV is required to produce one electron-hole pair. Therefore the signal from such an event, usually expressed in DN can be assed to determine photon energy if less than one photon is recorded over the "active " life of the pixel in question (at most one second if the CCD row read-out time is 0.001s and number of rows is ~1000. This property is exploited in RESPECT design, where we make effords to have always the probability of less than 2 cts/pixel as integrated over exposure time of the pixel. Pixel exposure time to solar illumination is the time any pixel is find within the solar-illuminated area defined by slit positions, angular extend of the source (30 arc min for the non-active corona, 2arcmin for AR 20 acrsec for flare) and diffraction effects on the slits or pin-holes (depending on energy). The signal from a single soft X-ray photon is expected to be in the range between 200 and 2000 DN (0.75-7.5 keV). Larger signals may correspond to particles and therefore can be used to differentiate between photons and particles.

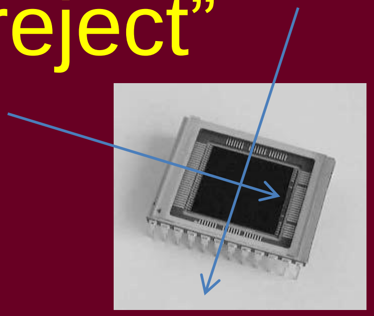
Expected fluxes –source sizes & diffraction to be taken into account

Table 1 . Expected fluxes per CCD pixel at various levels of solar activity

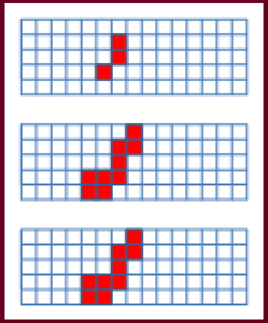
State	SphinX class	rate/full CCD	rate/pixel	rate/line=1ms	rate/optimin pix no
Non-active Sun	Q5	1500	1.5e-3	1.5/1024p	1500/1mln
	A-class	2.5e4	0.025	25/1024p	2.5e4/1mln
	B-class	2.5e5	0.25	100/400p	7.2e3/(400x400)
	C	2.6e6	2.5	100/40p	4e3/(40x40)
	M	2.5e7	25	100/4p	400/(4x4)
	X	2.5e8	250	100/0.4p	40/0.4x0.4
	X10	2.5e9	2500	250/0.1p	25/0.1x0.1

RESPECT particle rejection

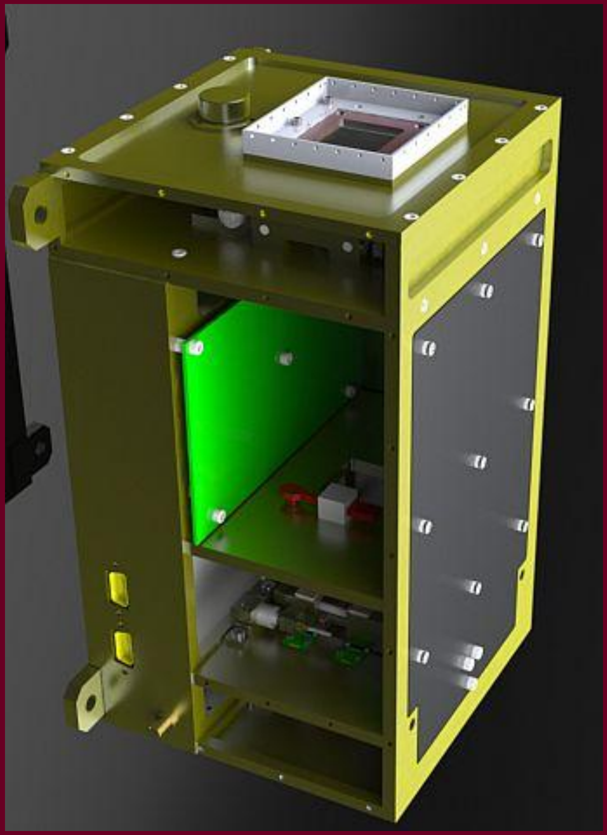
- Amplitude analysis > 2000 DN „reject”
- Track identification (ZK)
- Coodinate (attitude) conditions

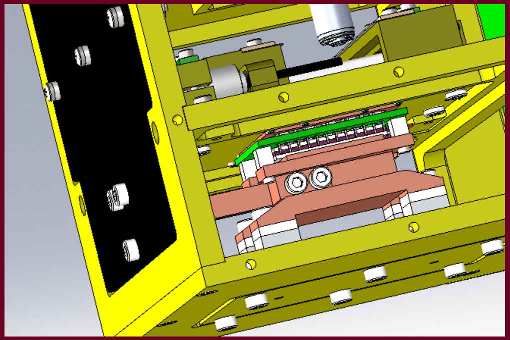


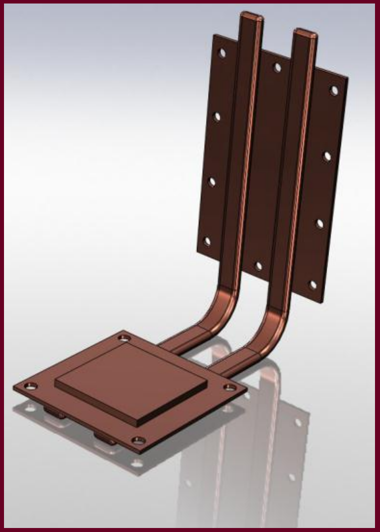
- Linear and/or chess-horse patterns removed



RESPECT- actual construction details (Jarek Bąkała)

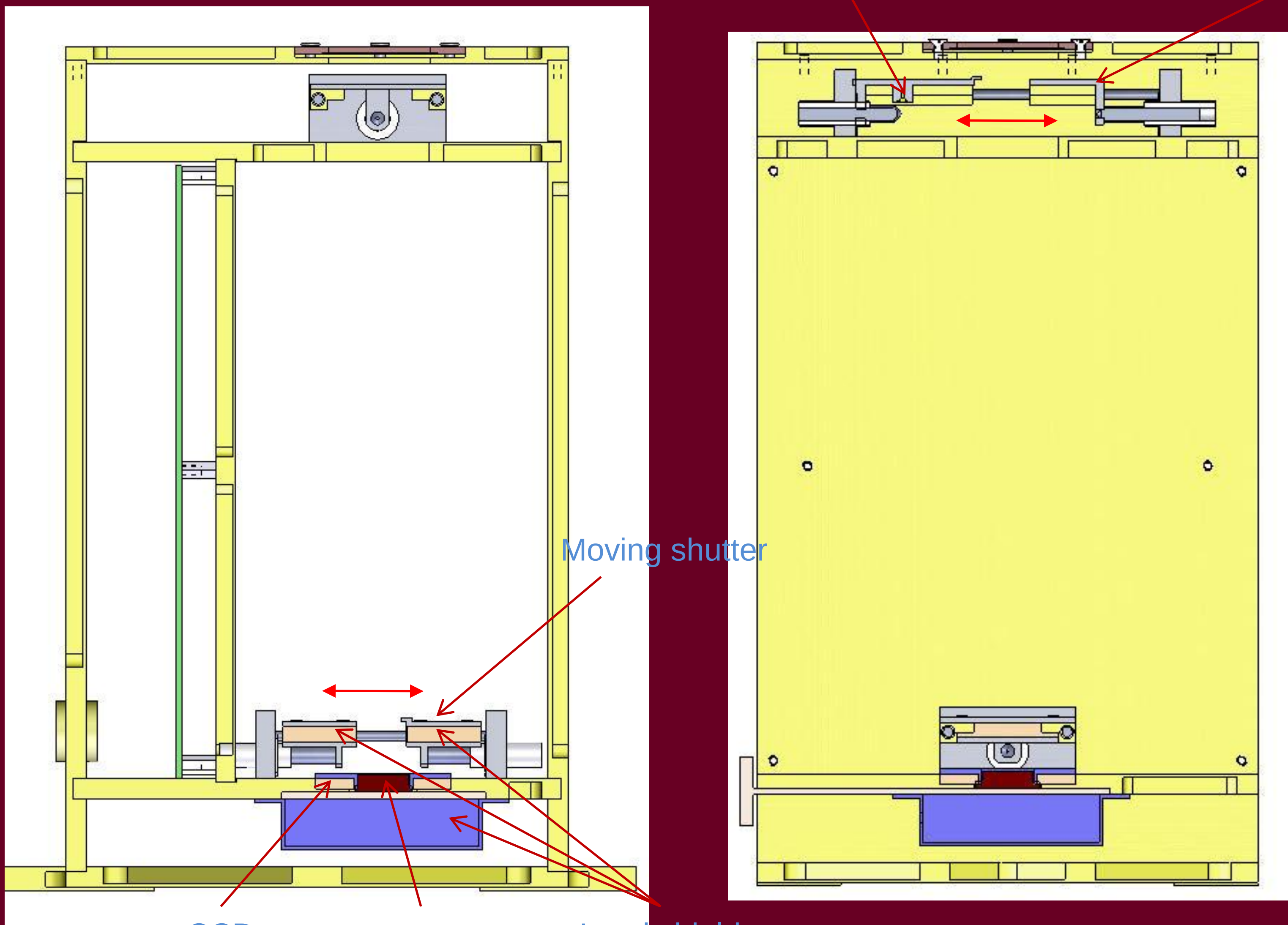






Mass: < 3kg

passive and operate by two-phase heat transport (e.g., evaporation and condensation)

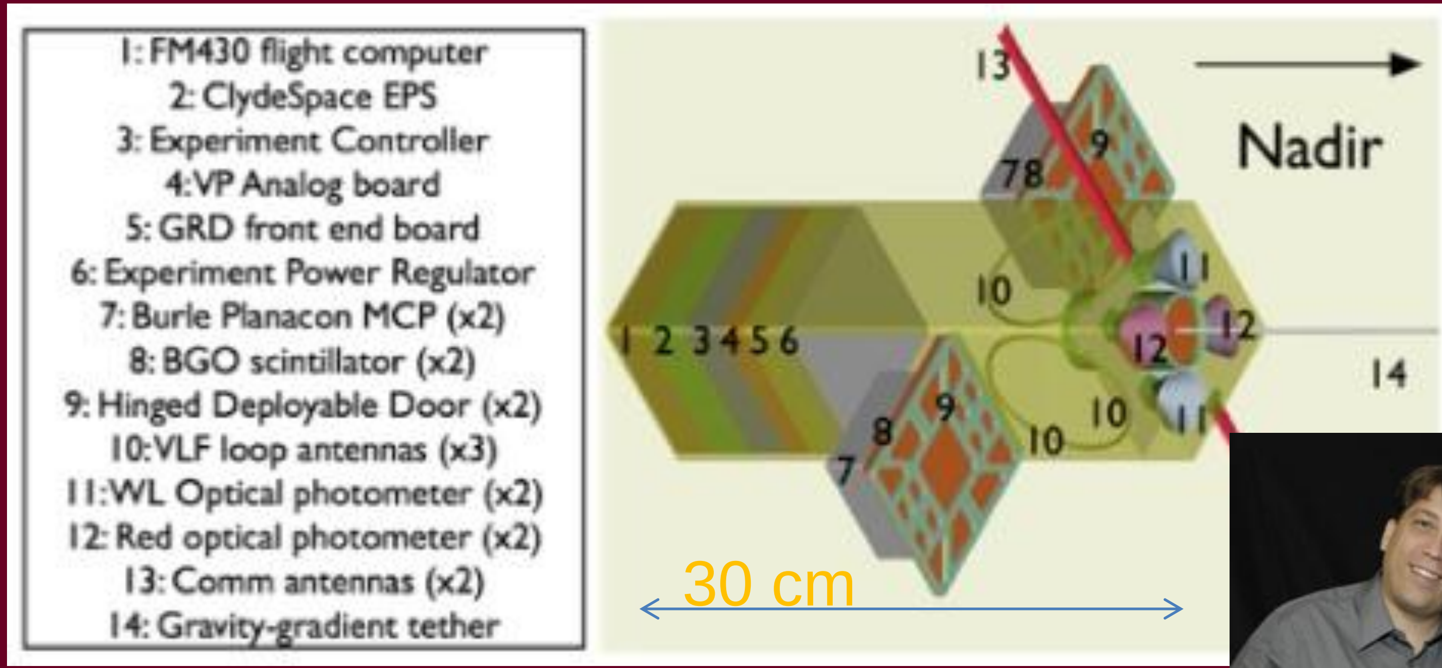

Fe55
Moving shutter
25 cm
Moving shutter
CCD
Lead shield
CCD
Lead shield

RESPECT-present status

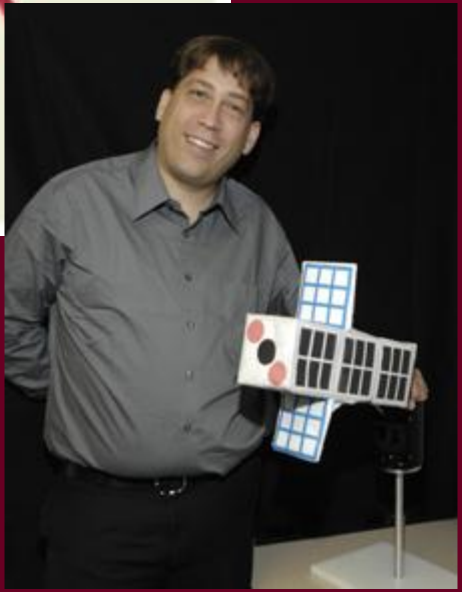
- Details of mechanical construction nearly finished- to be agreed this Wednesday with FIAN- will receive CCD for tests
- technology of straight edge construction available (1μ rms over 30 mm)
- Alignment & precise position calibration procedures known
- Ongoing are Vacuum & Thermal tests of piezzo and (stepper) motors (5)
- Test equipment present including powerfull X-ray source (Amptek), precision vacuul drives & cooling systems present
- Data reformatting & visualisation tasks are to be added as the data are going to the „public domain"

Nanosatellites CubeSat

http://firefly.gsfc.nasa.gov/Spacecraft/satellite.html

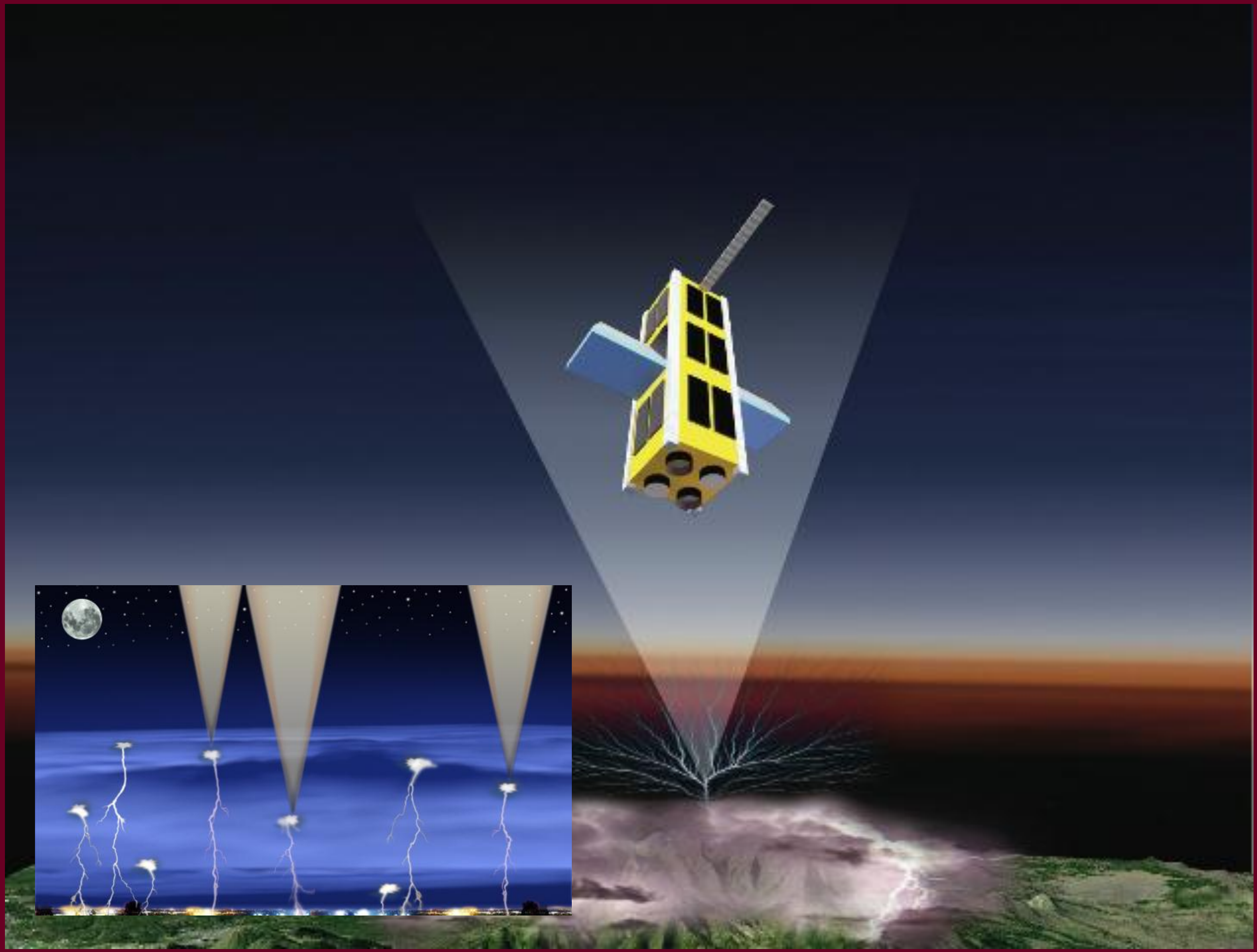


Doug Rowland, principal investigator for 'Firefly' stands next to the real size model of the nano satellite.



Cubesat (NSF): T_{errestrial}G_{amma-ray}F_{lashes}

http://science.nasa.gov/science-news/science-at-nasa/2010/29jan_firefly/



NASA's Compton Gamma Ray Observatory (CGRO) first discovered TGFs in the 1990s. Designed to look outward at cosmic sources of gamma rays, CGRO also caught rare but tantalizing glimpses of gamma rays coming from Earth.

TGFs are likely produced by beams of very energetic electrons, which are accelerated in the intense electric fields generated by large thunderstorm systems.

Before CGRO, many scientists thought these very energetic types of radiation could be generated only near the Sun, or in black holes, large galaxies, or neutron stars.

FERMI Antimatter: http://www.nasa.gov/mission_pages/GLAST/news/fermi-thunderstorms.html

Aim: to extend and continue investigations of solar hot plasmas

- Focus on soft X-ray range 0.8-15 keV
  - Bulk of thermal emission is formed
  - Substantial radiative cooling of the plasma takes place
- Provide sufficient spectral & time resolution in a wide dynamic range
  - Photon stamping: Energy resolution (200 eV) & arrival time (down to 1 microsec)
  - Two detectors, two apertures: tiny-M+class flares large: non-active corona
- Allow to study & monitor (of importance for space weather)
  - long term solar flux variability, average temperature & emission measure behavior, DEM studies, coronal energy balance
  - coronal plasma abundances
- Provide measurements of orbital background particle fluctuations and auroral X-ray spectra (one detector in anti-solar orientation)
- Measure soft X-ray signatures of Terrestrial Gamma-ray Flashes

Recommended satellite and orbit

- Satellite:

  Cube-sat or Firefly type

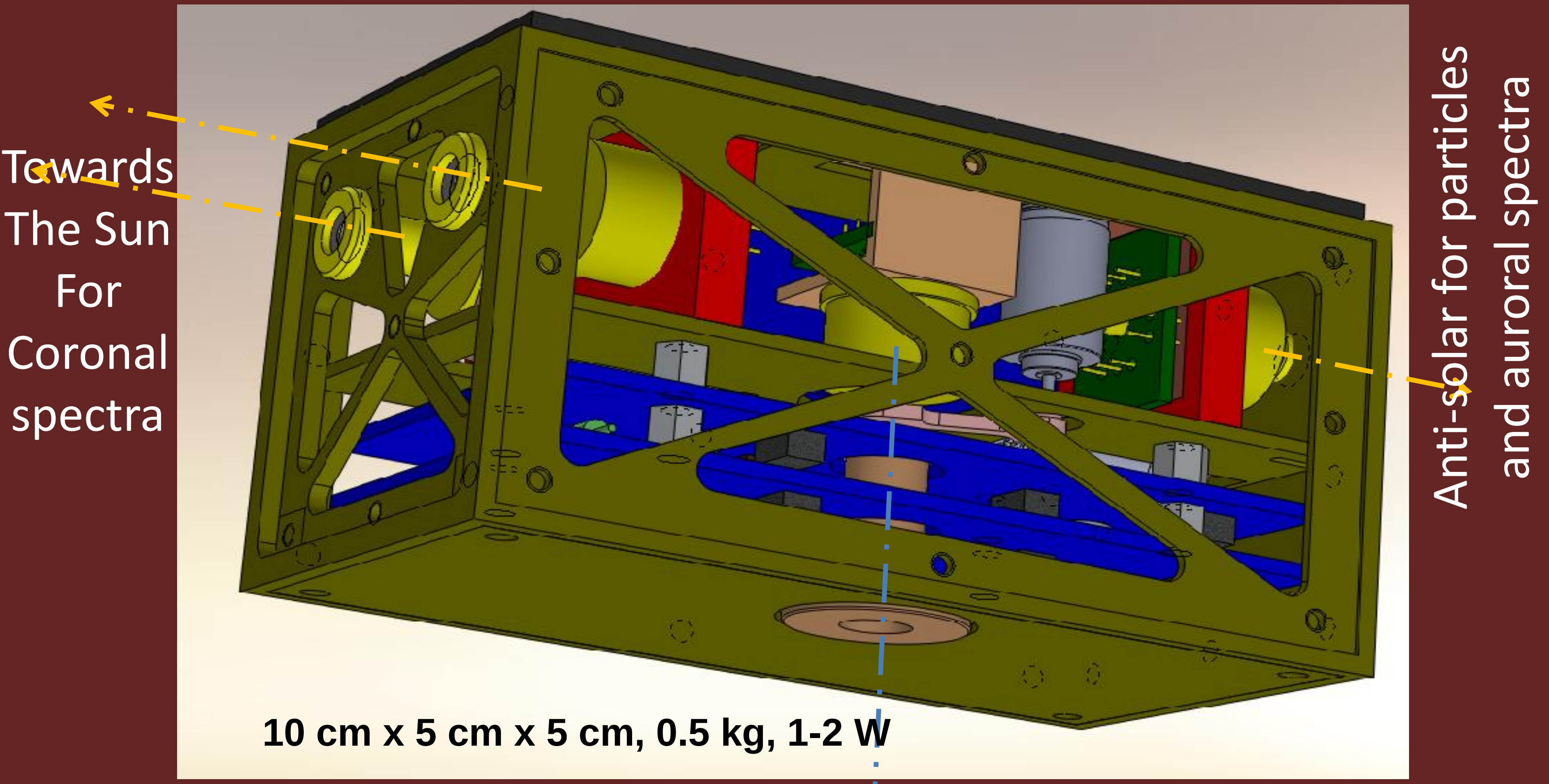
- Orbit:

  polar, sun synchronous, ├ Sun

  one-axis constntly directed towards the solar disc centre within +- 1 degree, other to satellite Nadir

- 1 year+ lifetime, perigee above 300 km

SphinX-NG possible configuration:
detectors: 3 SDD+1CdT, Peltier cooled

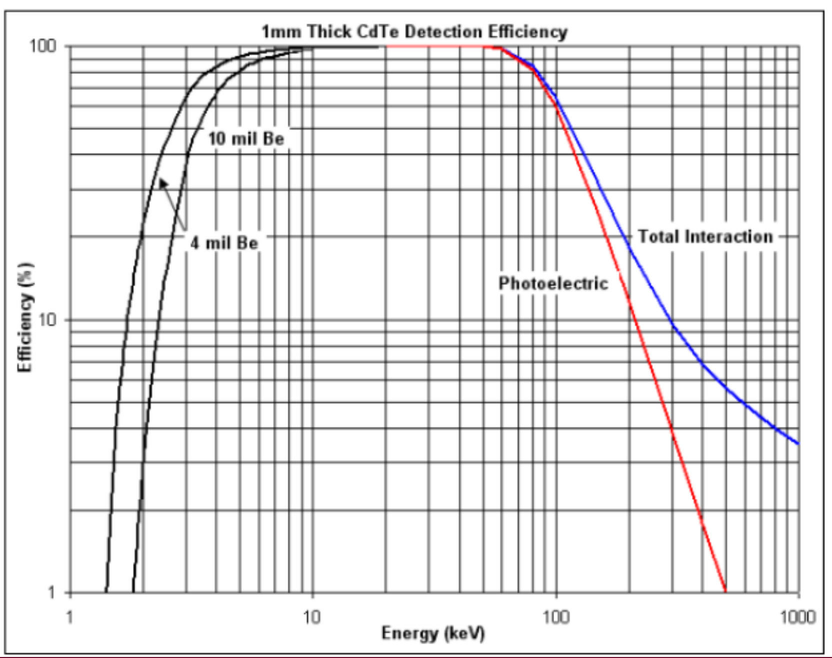


Towards the Earth for GRF detection (Nadir)

SphinX-NG detectors (Ketek)

Si SDD 3
CdT 1

KETEK VITUS Silicon Drift Detectors Status Feb 2010			VITUS Premium Class				
			FWHM [eV]	P/B	Max ΔT [K]	P_{tec} [W] @ ΔT = 55 K	P_{tec} [W] @ max ΔT
NEW* VITUS H30	30mm²	Be** 12.5µm	≤ 127*	> 10000	75	< 1 W	< 2 W
NEW*** VITUS H50	50mm²	Be 12.5µm	≤ 127*	> 10000	75	< 1 W	< 2 W



Quantities to be measured

- Event amplitudes 12 bits → conversion to energy (solar & auroral X-rays, particles, & their secondary effects)
- Arrival time 1 μs → allow to build spectra at any longer time resolution as far as statistics allows
- Housekeeping info
  - Temperatures, voltages, currents
  - FPGA technology for electronics
- Compressed data are send to telemetry buffor

Expected fluxes to be seen (from SphinX heritage)

- Non-active corona (AR absent, often in 2009)
  - 1000 cts/s in large aperture detector, particle background < 0.001 cts/s/bin outside polar ovals and SAA
- X-flare: 10^4 cts/s, through a tiny aperture (1 mm^2)
- Polar ovals: between 100 and 10^4 cts/s/detector for low and high geomagnetic activity
- SAA: ~1000 cts/s

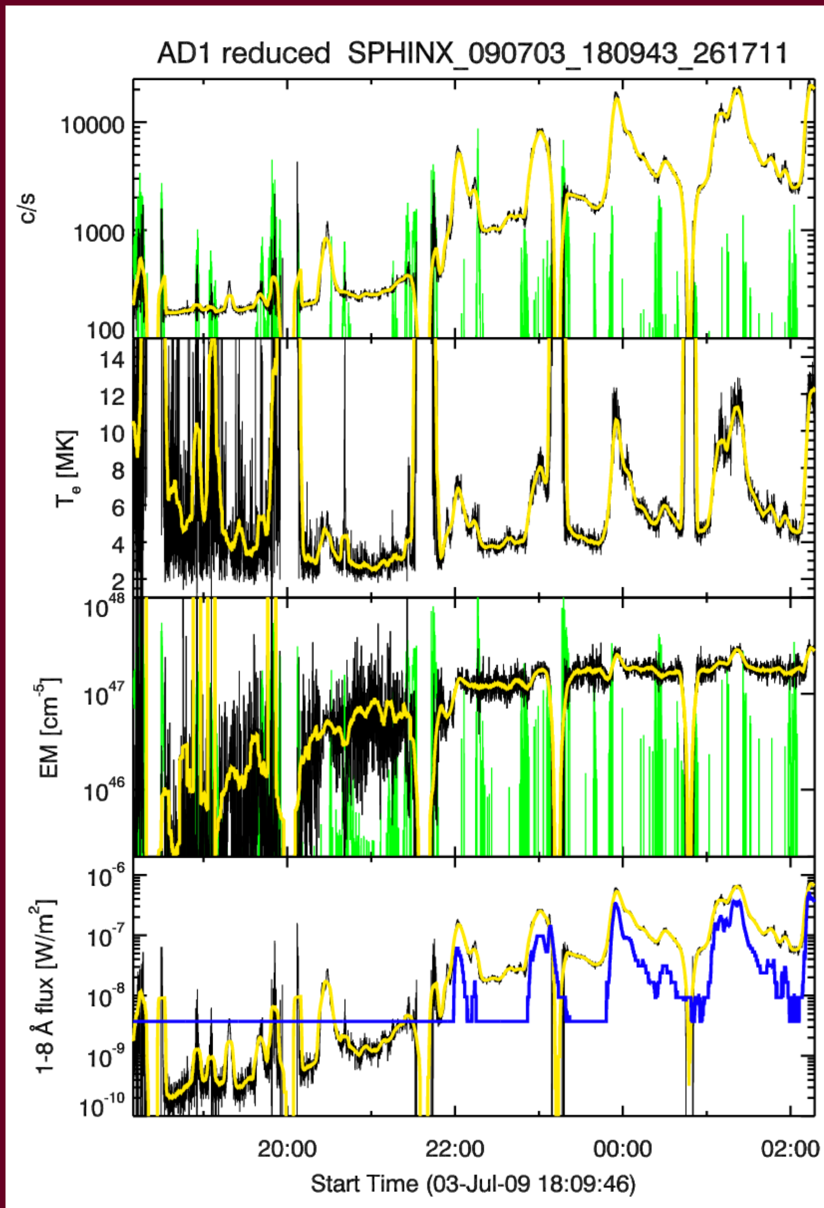
SphinX-NG status

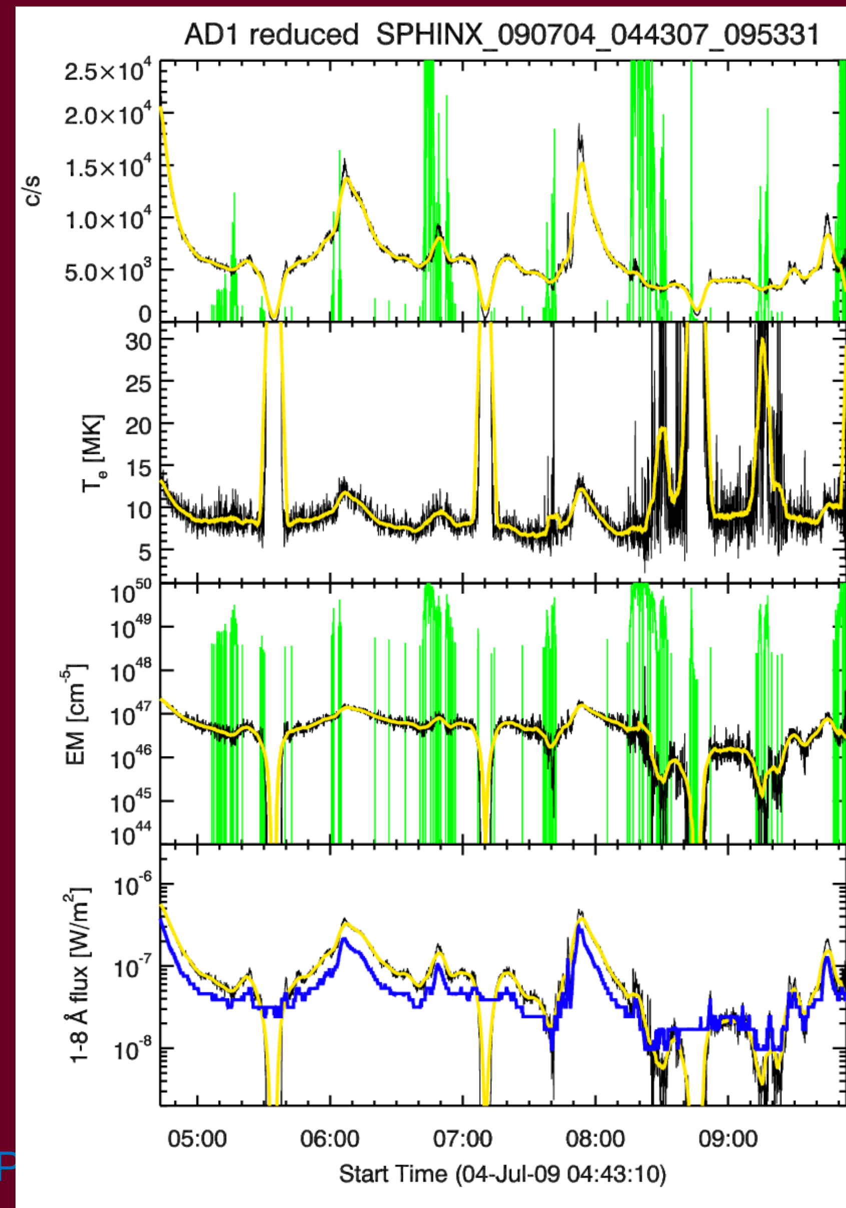
- Direct collaboration between SRC and GSFC (first US visit in November, Jim Slavin & Doug Rowland). http://press.cbk.waw.pl/10/cbk10111701/index.html
- Brian Dennis set up as NASA contact
- Details of „return visit" to GSFC to be fixed today during the telecon with Brian-sign-up of agreement
  – US provides the launch opportunity within their nano-satellite programme
  – Poland- construction of the instrument (funding application through NCN, 1.5-2 mln zł this spring)

Thank you

SphinX-NG

GOES vs SphinX

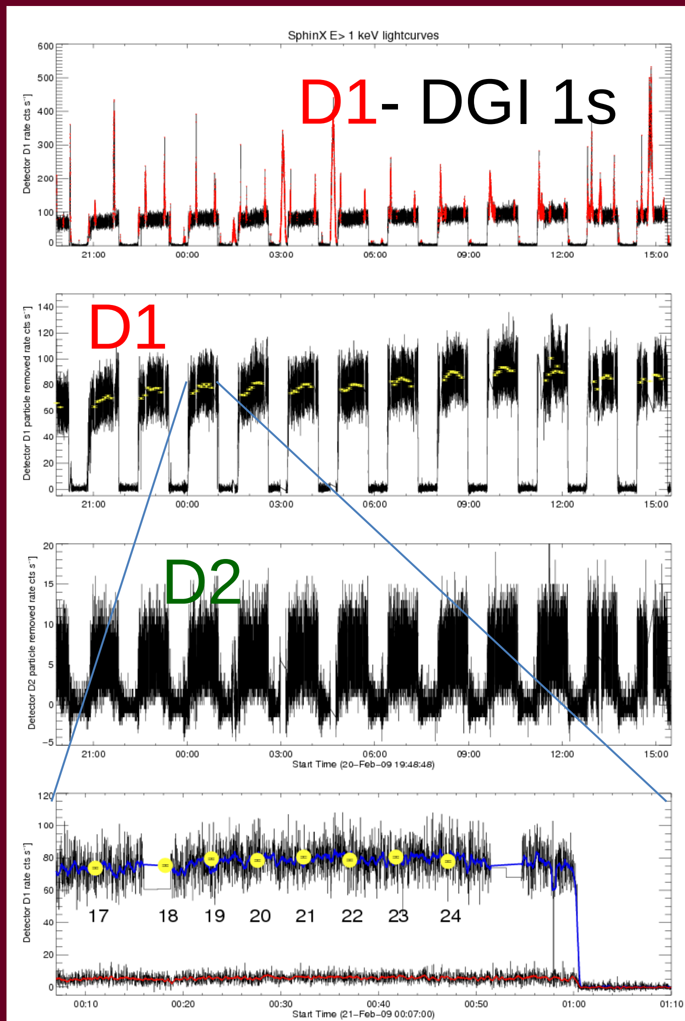


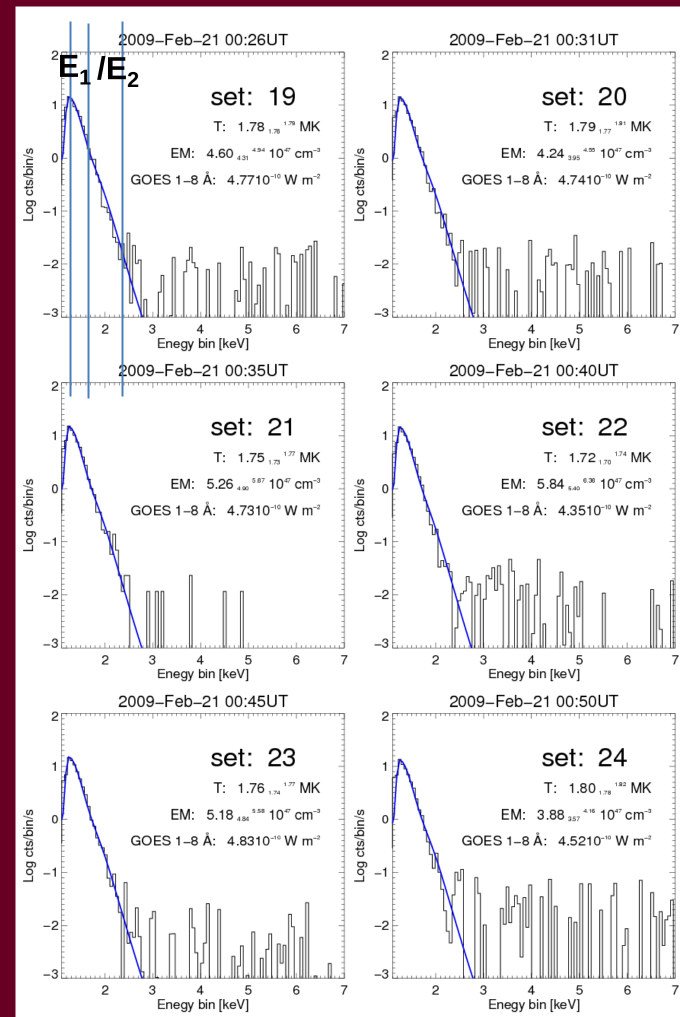


New X-ray classes

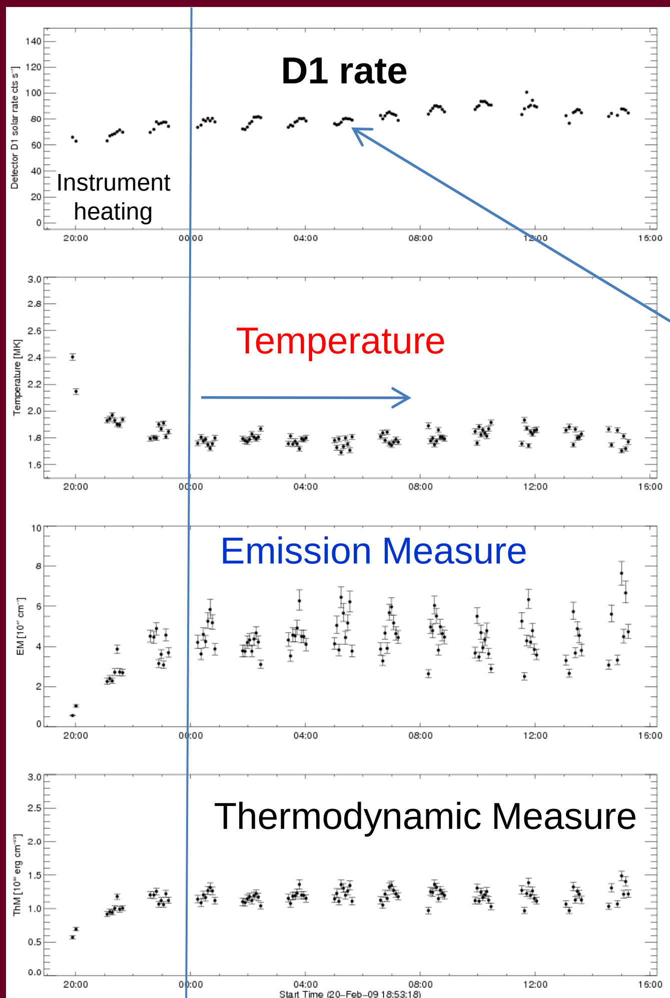
- We are introducing new „classes” of X-ray solar variability, below *GOES* A1.0
  - A = 10^{-8} W/m^2 (present lowest)
  - S = 10^{-9} W/m^2
  - Q = 10^{-10} W/m^2
- SphinX in its D1 channel is capable to observe events 100 x less intense than *GOES*
  - Most of variability since the launch is observed to happen below the *GOES* delectability threshold

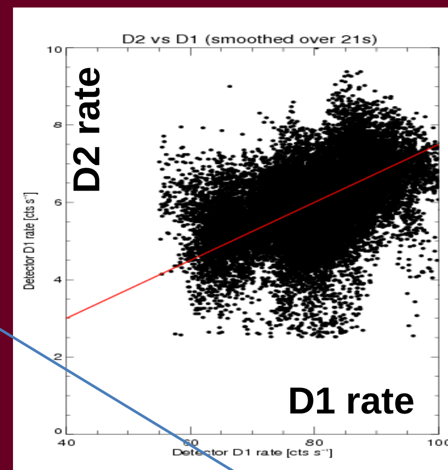
Determination of absolute levels of X-ray solar luminosity E > 1 keV

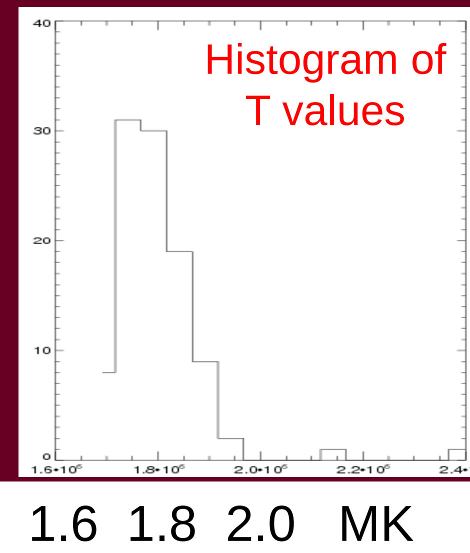




X-ray fluence at E > 1 keV







Example: for data set No. 50

Te 1.71 MK [1.69, 1.72]

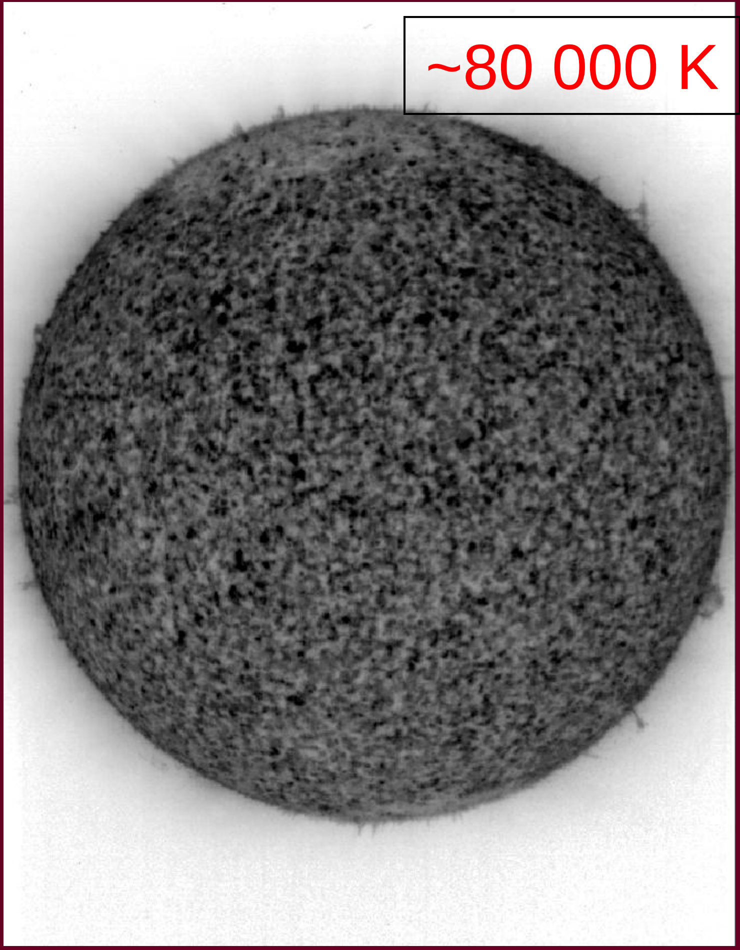
EM 6.2 [5.7 , 6.7] 10^{47} cm^{-3}

Flux [1 - 15 keV] 1.4 10^{-8} W/m2

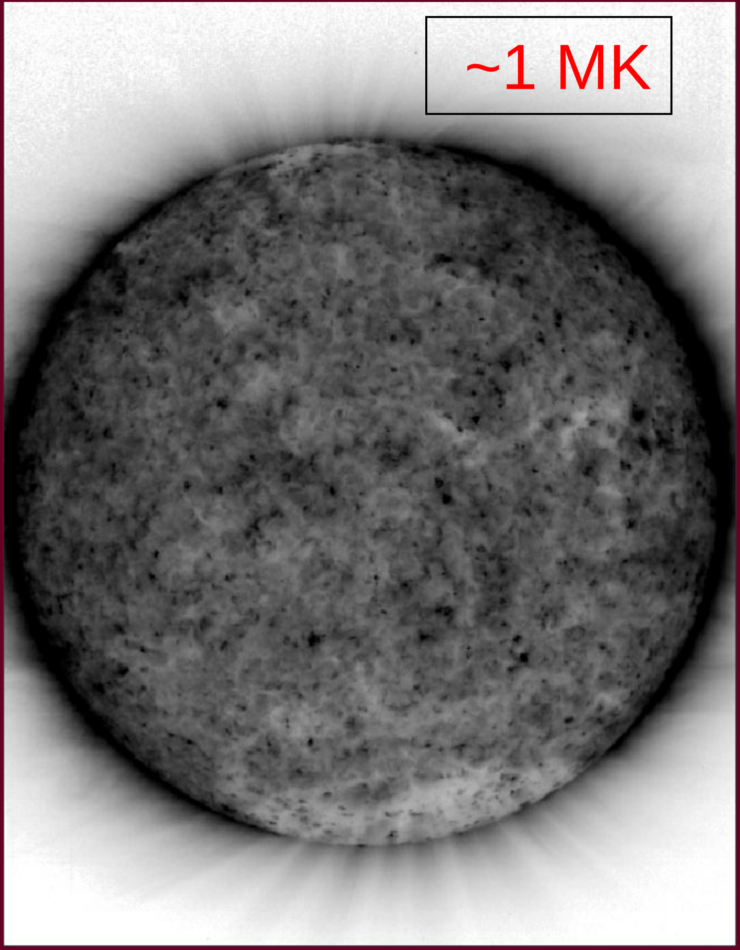
Flux $_{GOES}$ [1 – 8 Å] 4.2 10^{-10} W/m2

TESIS images (courtesy Sergey Bogaczev FIAN)

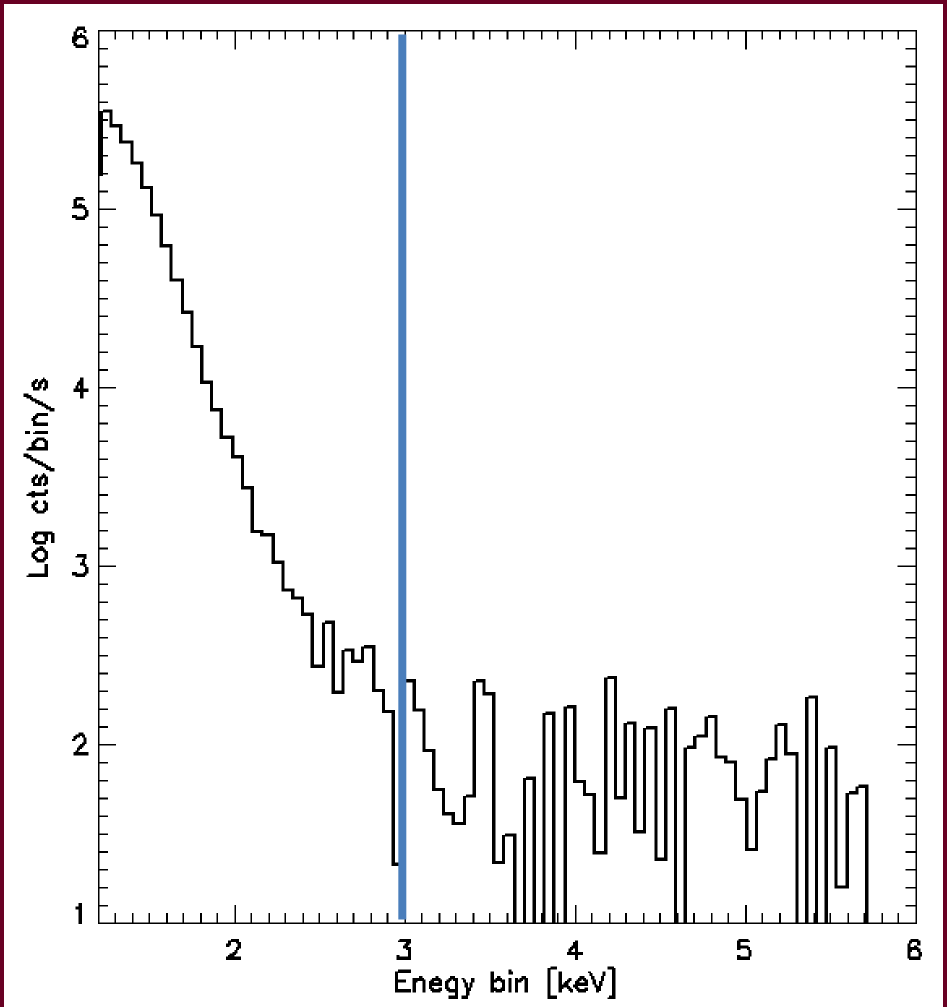
2009 02 20 18:28:42 304 Å



2009 02 20 18:27:42 171 Å



Longer exposure: ~18 hours



Counts below 3 keV
~ 1 mln
Counts above 3 keV
~ 3000

Ratio: 0.003
Any coronal heating model should „obey" this measurement from now on