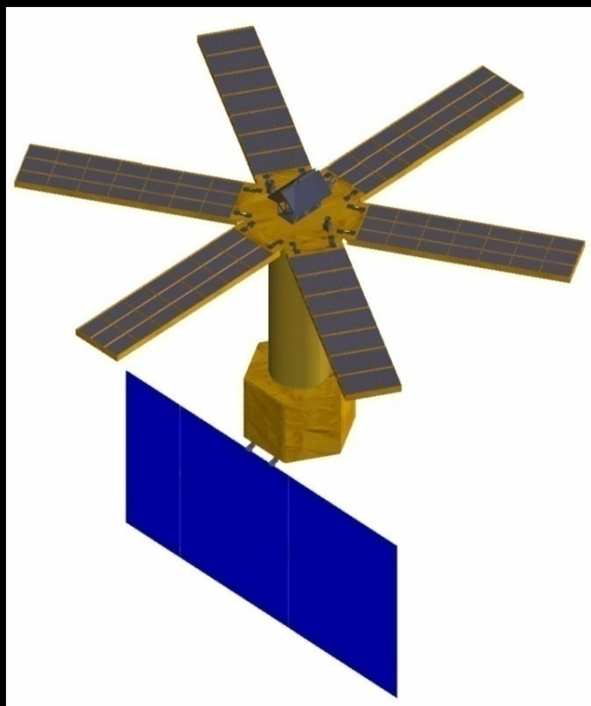
LOFT

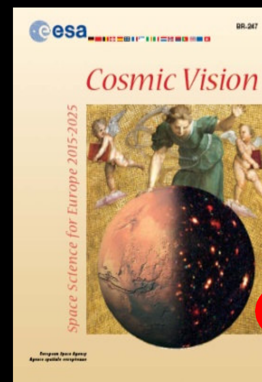
the Large Observatory For x-ray Timing

Marco Feroci (INAF/IAPS, Rome, Italy)

on behalf of the LOFT Consortium

LOFT: the Large Observatory For x-ray Timing





3. What are the fundamental physical laws of the Universe?

3.1 Explore the limits of contemporary physics

Use stable and weightless environment of space to search for tiny deviations from the standard model of fundamental interactions

3.2 The gravitational wave Universe

Make a key step toward detecting the gravitational radiation background generated at the Big Bang

3.3 Matter under extreme conditions

Probe gravity theory in the very strong field environment of black holes and other compact objects, and the state of matter at supra-nuclear energies in neutron stars

LOFT Science Team composed of scientists from:

Australia, Brazil, Canada, Czech Republic, Denmark, Finland, France, Germany, Greece, India, Ireland, Israel, Italy, Japan, the Netherlands, Poland, Spain, Sweden, Switzerland, Turkey, United Kingdom, USA

LOFT Consortium: national representatives:

Jan-Willem den Herder	SRON, the Netherlands
Marco Feroci	INAF/IAPS-Rome, Italy
Luigi Stella	INAF/OAR-Rome, Italy
Michiel van der Klis	Univ. Amsterdam, the Netherlands
Thierry Courvousier	ISDC, Switzerland
Silvia Zane	MSSL, United Kingdom
Margarita Hernanz	IEEC-CSIC, Spain
Søren Brandt	DTU, Copenhagen, Denmark
Andrea Santangelo	Univ. Tuebingen, Germany
Didier Barret	IRAP, Toulouse, France
Renè Hudec	CTU, Czech Republic
Andrzej Zdziarski	N. Copernicus Astron. Center, Poland
Juhani Huovelin	Univ. of Helsinki, Finland
Paul Ray	Naval Research Lab, USA
Joao Braga	INPE, Brazil
Tad Takahashi	ISAS, Japan

The wider LOFT Community …

a large area mission must have a large-area community …

The LOFT Mission

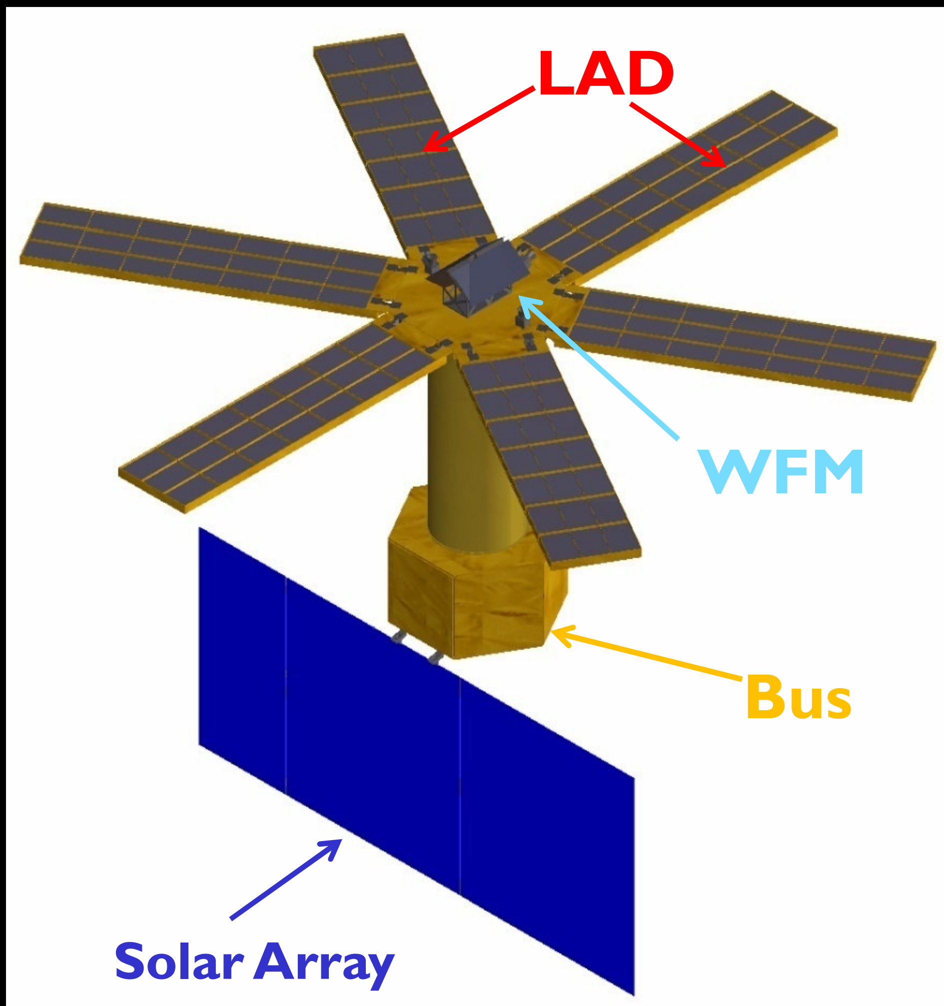
LOFT is specifically designed to exploit the diagnostics of very rapid X-ray flux and spectral variability in compact objects, yielding unprecedented information on strongly curved spacetimes and matter under extreme conditions of density and magnetic field strength.

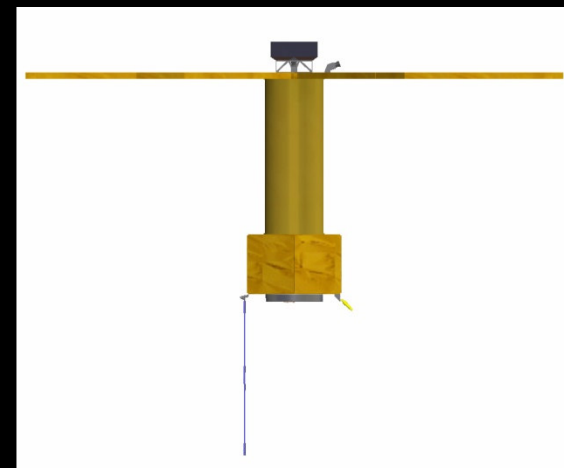
LOFT will investigate variability from submillisecond QPO's to years long transient outbursts.

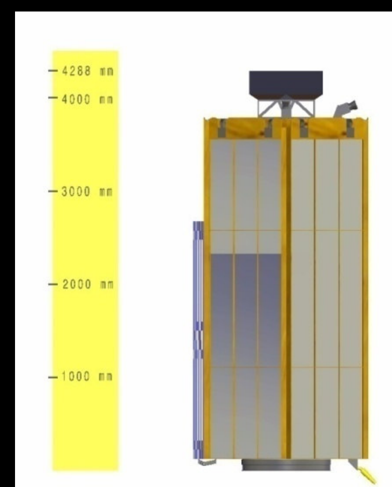
The LOFT LAD has an effective area ~20 times larger than any largest predecessor, uniquely combined with a "CCD-class" energy resolution.

The LOFT WFM has a few steradian field of view at soft X-rays to discover and localise X-ray transients and impulsive events and monitor spectral state changes, triggering follow-up observations and providing a wealth of science in its own.

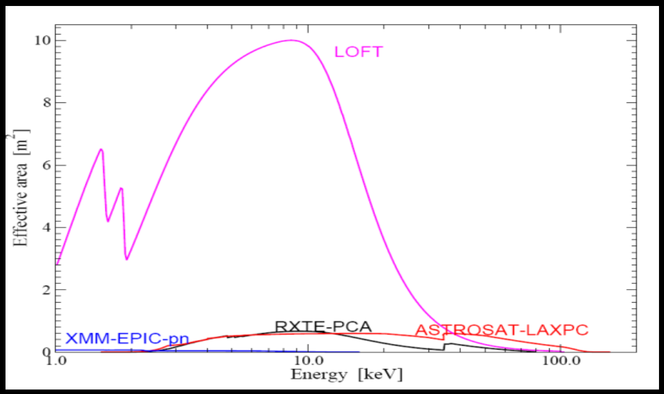
The LOFT satellite (from proposal)

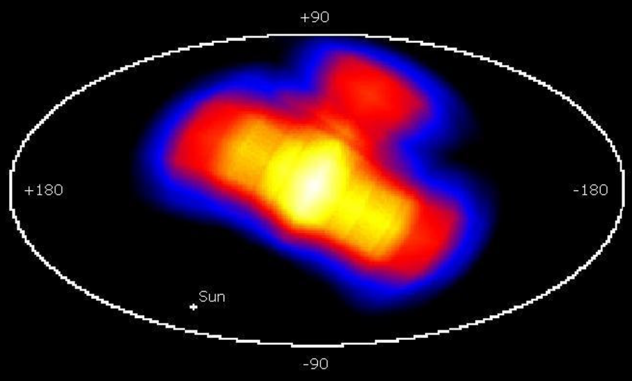






The LOFT Instruments (today)





LAD – Large Area Detector	
Effective Area	4 m^2 @ 2 keV 8 m^2 @ 5 keV 10 m^2 @ 8 keV 1 m^2 @ 30 keV
Energy range	2-30 keV primary 30-80 keV extended
Energy resolution FWHM	260 eV @ 6 keV 200 eV @ 6 keV (45% of area)
Collimated FoV	1 degree FWHM
Time Resolution	10 µs
Absolute time accuracy	1 µs
Dead Time	<1% at 1 Crab
Background	<10 mCrab (<1% syst)
Max Flux	500 mCrab full event info 15 Crab binned mode

WFM- Wide Field Monitor	
Energy range	2-50 keV primary 50-80 keV extended
Active Detector Area	1820 cm^2
Energy resolution	300 eV FWHM @ 6 keV
FOV (Zero Response)	180°x90° + 90°x90°
Angular Resolution	5' x 5'
Point Source Location Accuracy (10-σ)	1' x 1'
Sensitivity (5-σ, on-axis) Galactic Center, 3 s Galactic Center, 1 day	 270 mCrab 2.1 mCrab
Standard Mode	5-min, energy resolved images
Trigger Mode	Event-by-Event (10µs res) Realtime downlink of transient coordinates

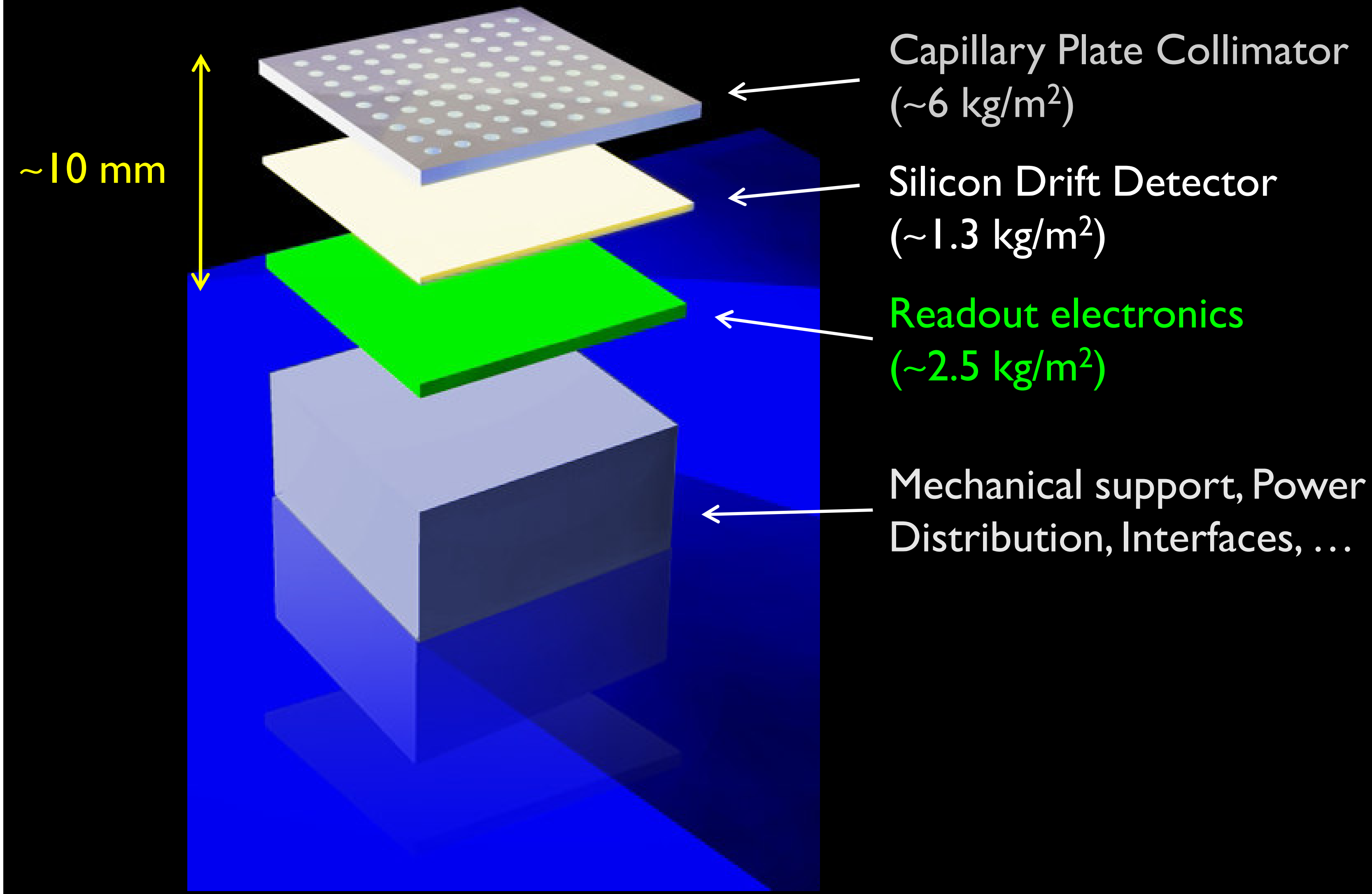
Main Mission update wrt M3 Proposal & Status

- ❑ Launcher switch to Soyuz (Vega marginal: ~10% excess – simpler design)
- ❑ Deployment/Panel structure to Prime (request by ESA)
- ❑ Mission lifetime extended to 4+1 years (science-driven)
- ❑ Optimal orbit: equatorial and low-altitude (science-driven)
- ❑ X-band downlink (request by ESA)
- ❑ Launch window 2022-2024 (request by ESA)

- ❑ Peak effective area 10 m^2 (consolidated design)
- ❑ LAD Sky visibility expanded (now 50% / 75%)
- ❑ WFM expanded (FoV, number of cameras)
- ❑ Onboard GRB trigger and realtime coordinate transmission added (science)

Assessment Phase extended to end-2013 to cover "full Phase A", Payload AO issued

The Key to LOFT:
low weight/power/volume per unit effective area

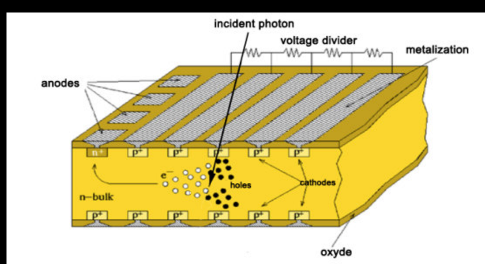


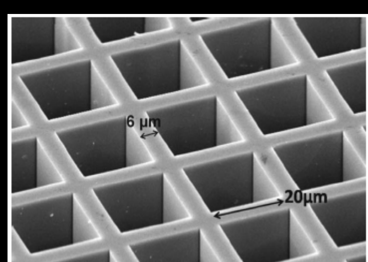
The Large Area Detector (LAD)

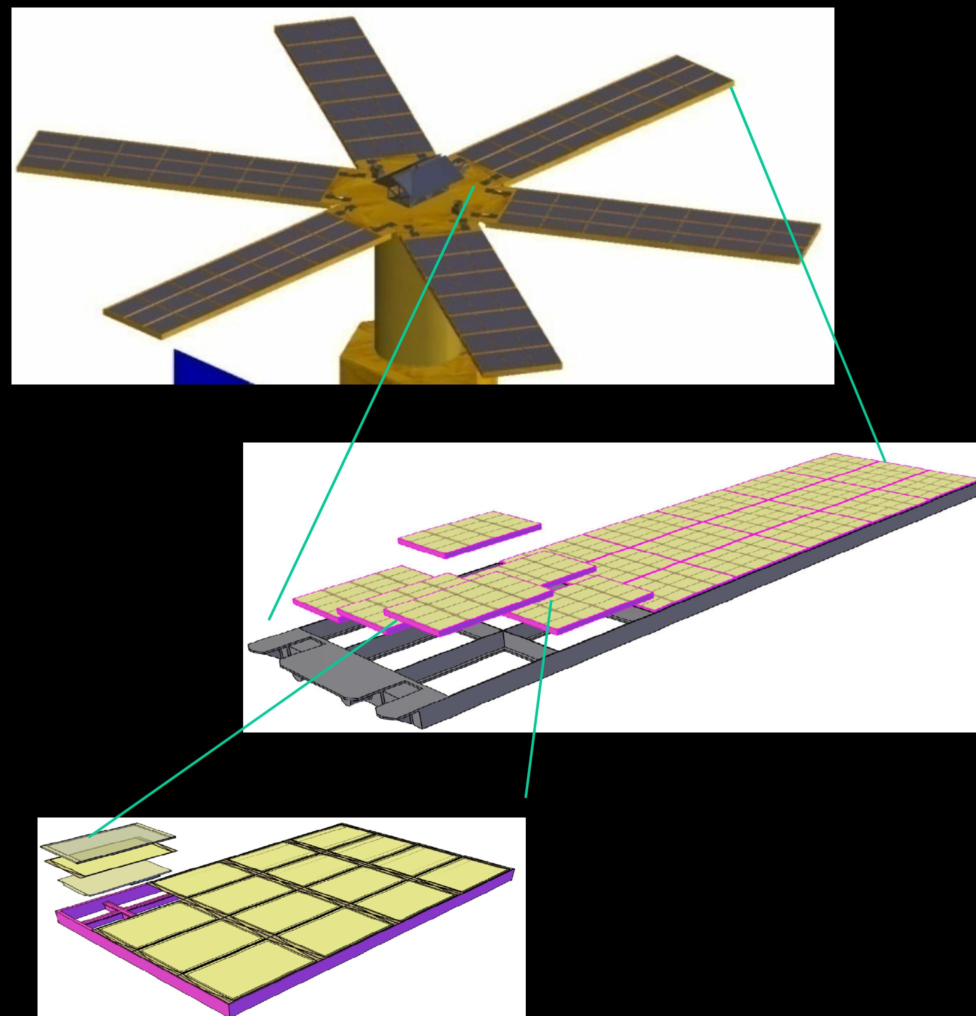
Fully modular/redundant by design (126 independent modules)

Fine detector segmentation ($5x10^5$ read-out channels, 0.3 cm^2 each, deadtime and the pile-up minor issues).

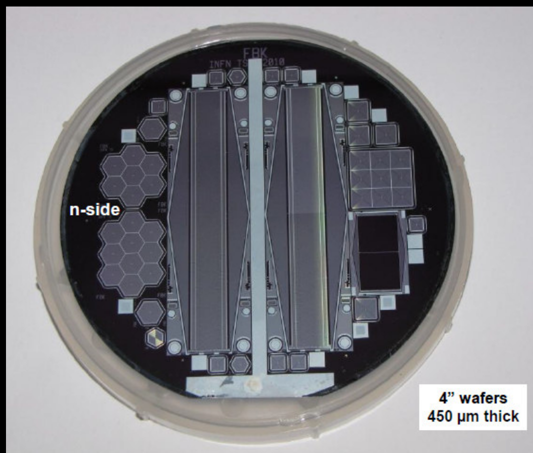
Driving Technology:
large-area Silicon Drift Detectors and capillary plate collimators.

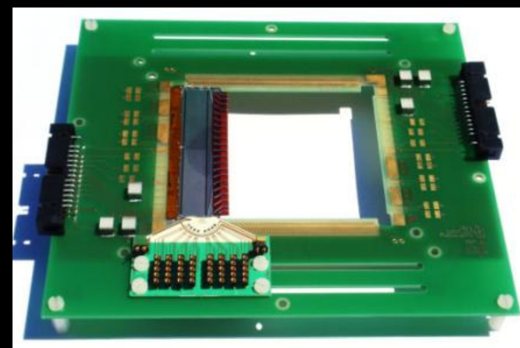


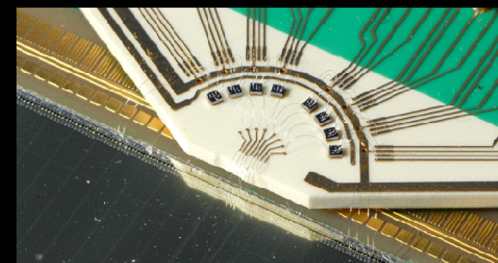


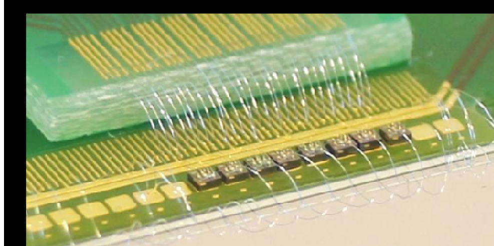


SDD Development @ FBK









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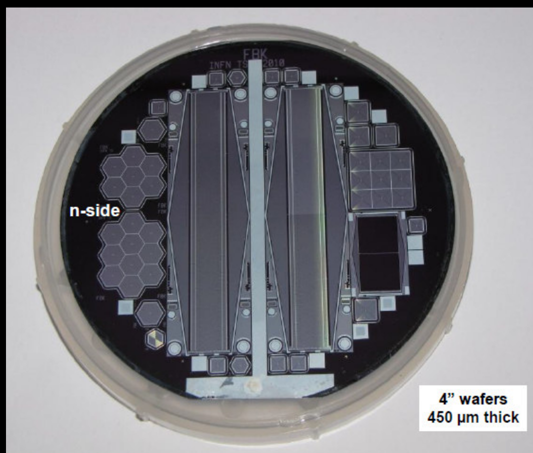
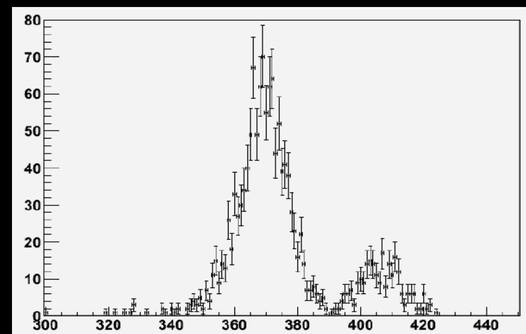
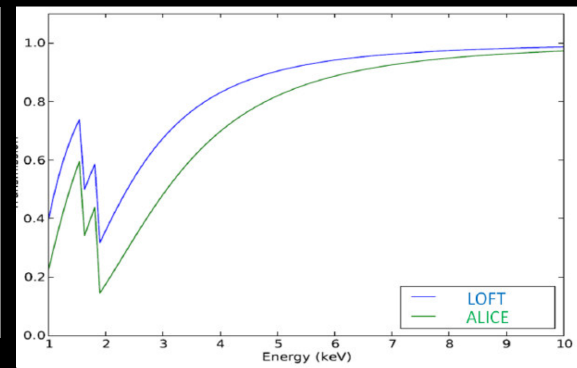
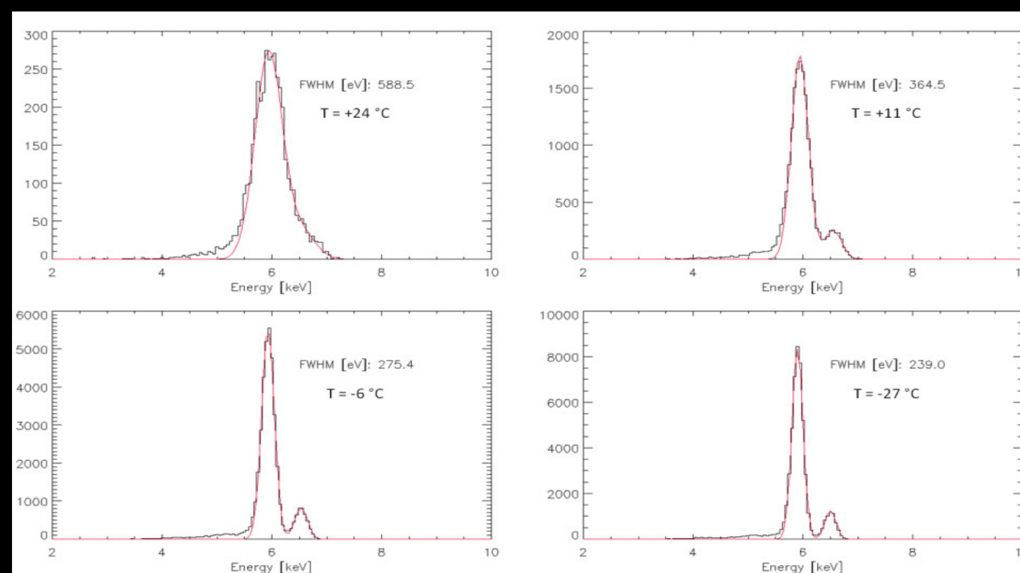
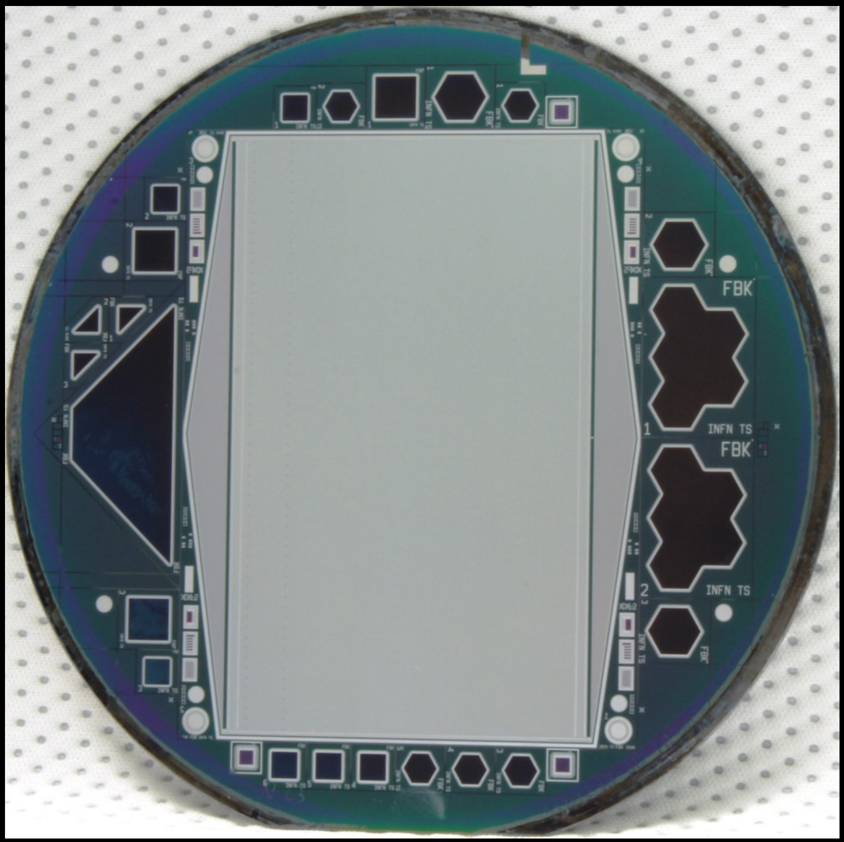


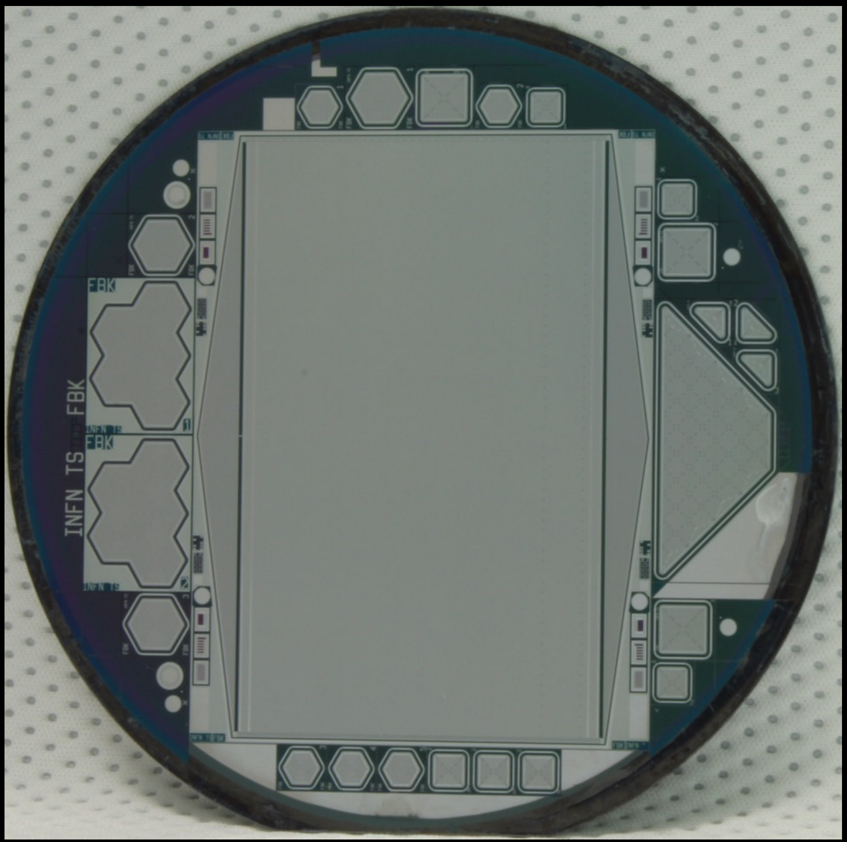






Fresh from the (FBK) oven (delivered Nov 2012)



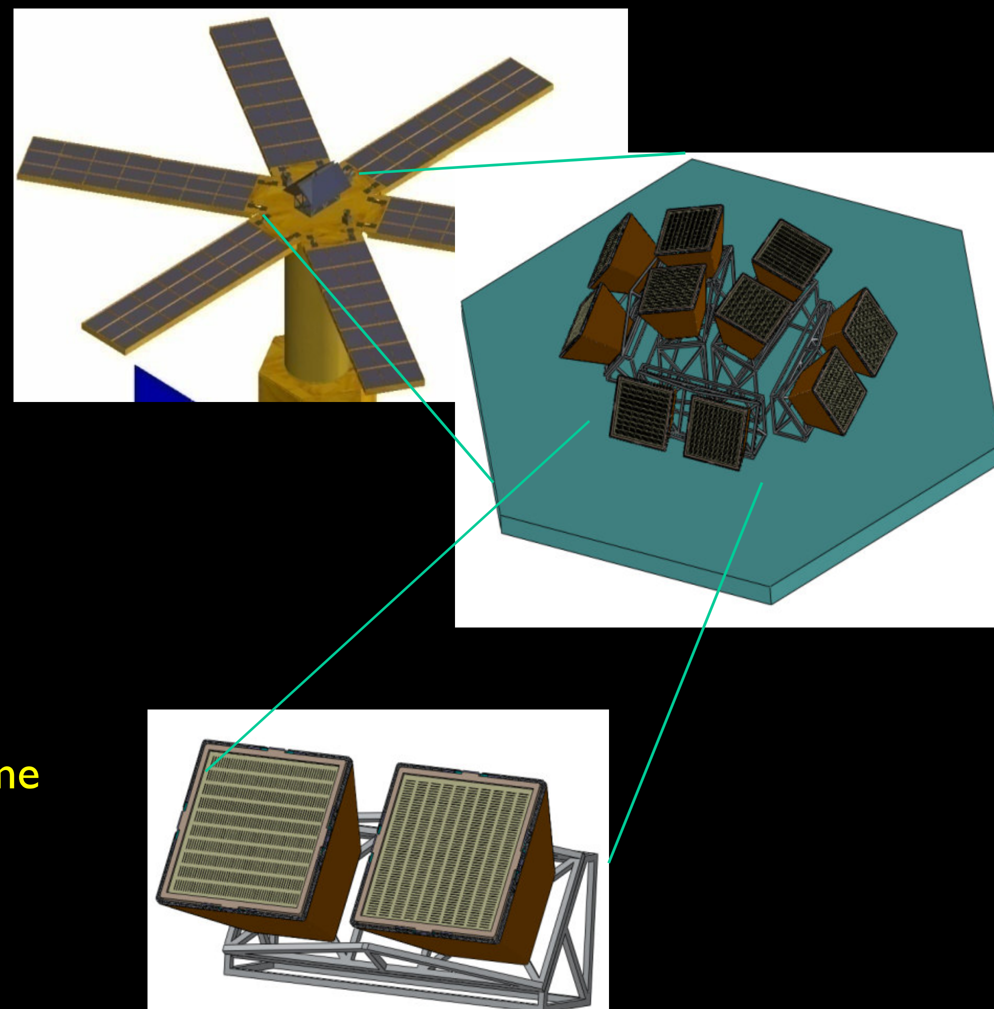


The Wide Field Monitor (WFM)

5 Independent Units, each one composed of 2 cameras.

WFM FoV covers >50% of the LAD-accessible sky at any time, in the 2-50 keV energy range

Onboard triggering, imaging and coordinate distribution of transient events.



Driving Technology:
large-area Silicon Drift Detectors (same as LAD) and coded masks.

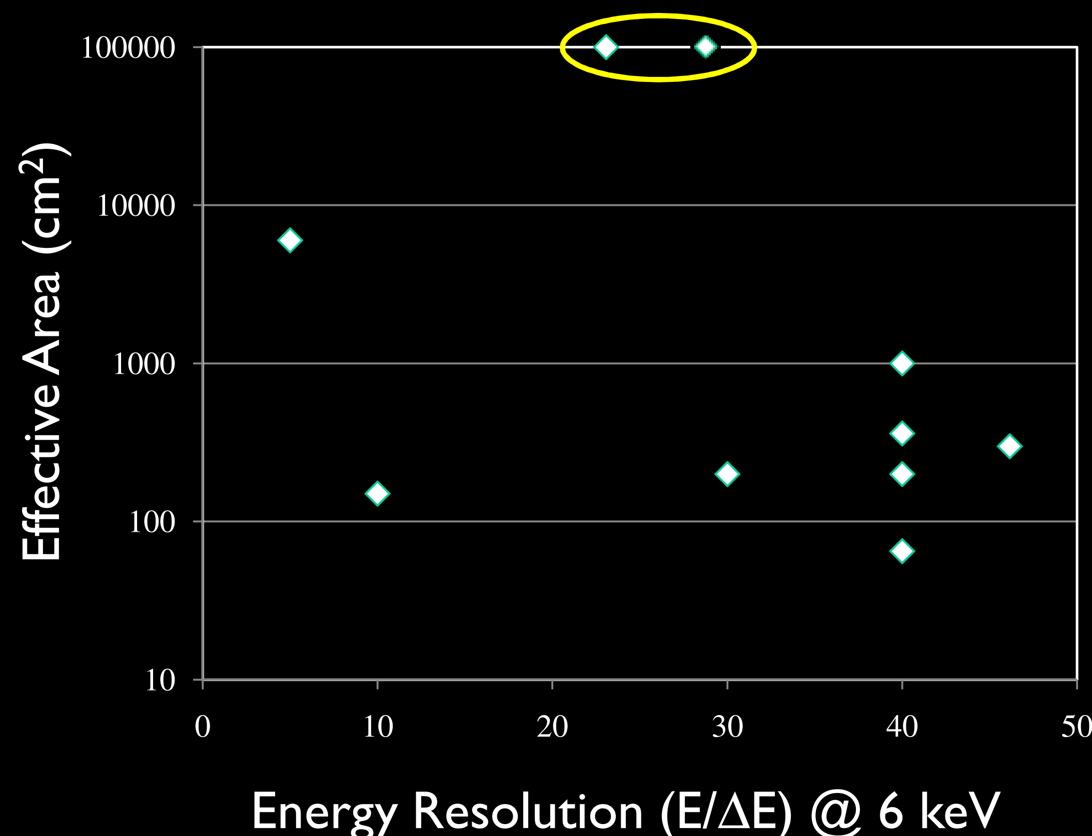
LOFT as an Observatory

Not a "super-RXTE". A (nearly-)"CCD"-class resolution with huge effective area.
(and a wide-field, arcmin, soft X-ray, 300 eV resolution WFM)

Access to spectroscopy on time scales unaccessible to other observatories and/or access to flux variability timescales simply still "unknown" (e.g., seconds in blazars).

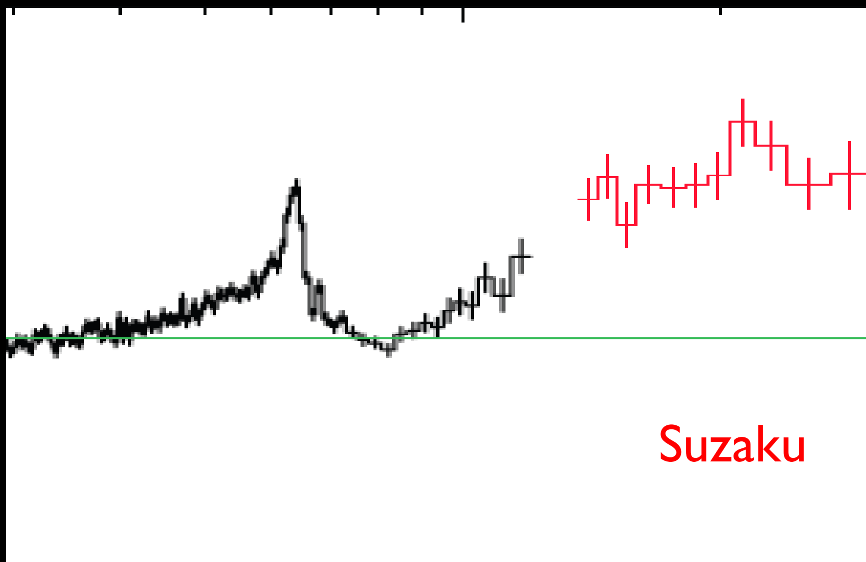
LOFT/LAD in context:

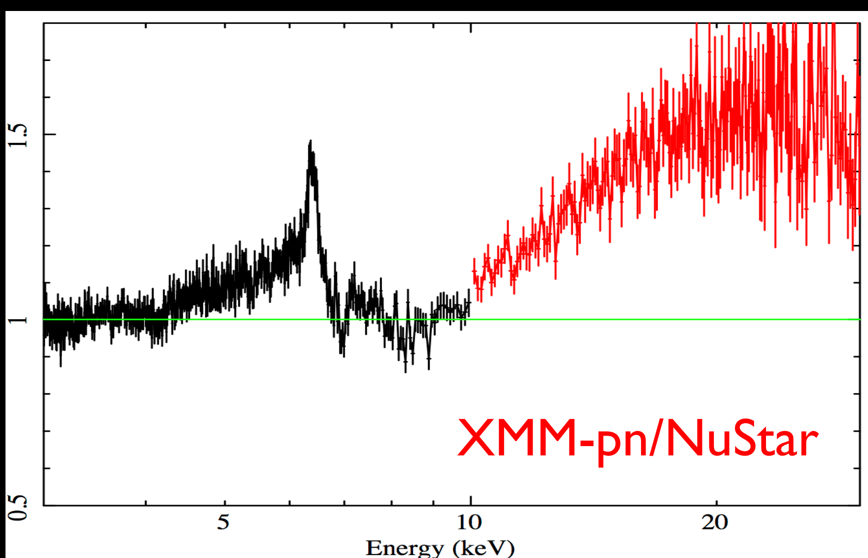
ASCA
BeppoSAX
RXTE
Chandra
XMM
Swift
Suzaku
Astro-H



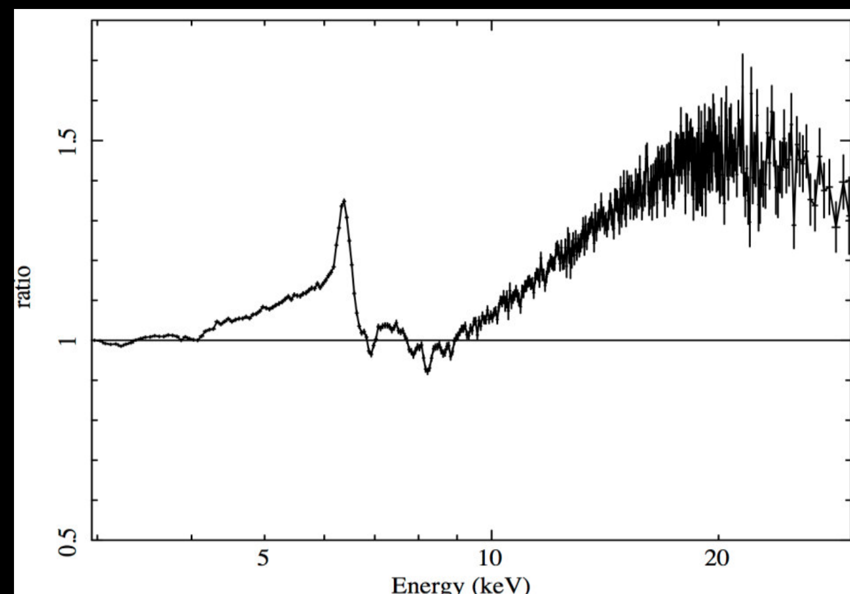
LOFT as a general Observatory: mCrab-class AGNs

Today





With LOFT



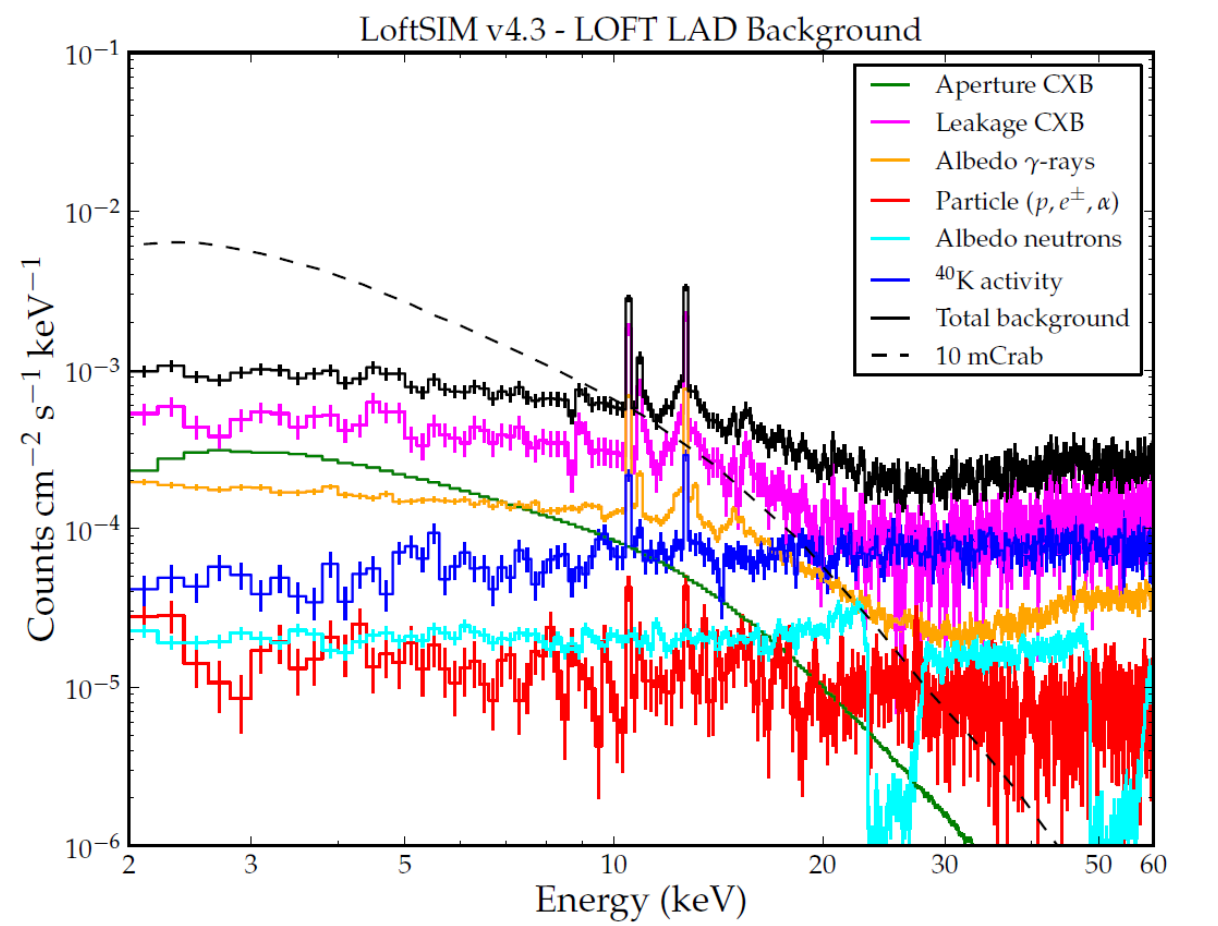
(Here MCG-6-30-15, 2 mCrab.)

Preliminary observing program breakdown

4-years Breakdown: ~50% driving science + 50% for observatory science

Source Type	TOO	Sources	Pointings	Total Time (ks)	Science Goal
BH transient outbursts	Yes	4	800	2400	SFG1,2,4
Persistent BH	No	2	400	1600	SFG 1,2,4
AGN	No	30	50	8000	SFG 5
Msec pulsar outburst	Yes	3	250	1000	EOS1, SFG2,3
NS transient bright outburst	Yes	3	250	1800	EOS 1,2 SFG 3
Persistent bright NS	No	12	350	4800	EOS 1,2 SFG 2,3
NS transient weak outburst	Yes	6	6	120	EOS 2
Persistent weak NS	No	14	14	280	EOS 2
Bursters	Yes	10	40	1000	EOS 2

LAD Background: estimate



LAD Background components:

1. Aperture CXB: 9%
2. CXB leak: 53%
3. Earth albedo leak: 20%
4. Coll. Radioactivity 14%

5. Particles: 6%

95% of the LAD background is due to intrinsically "steady sources"

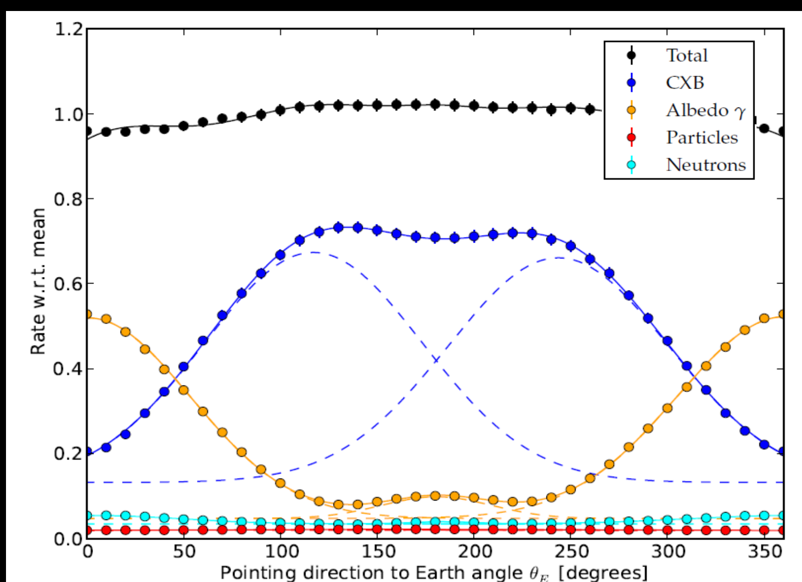
Campana et al. 2012, arXiv1209.1661C

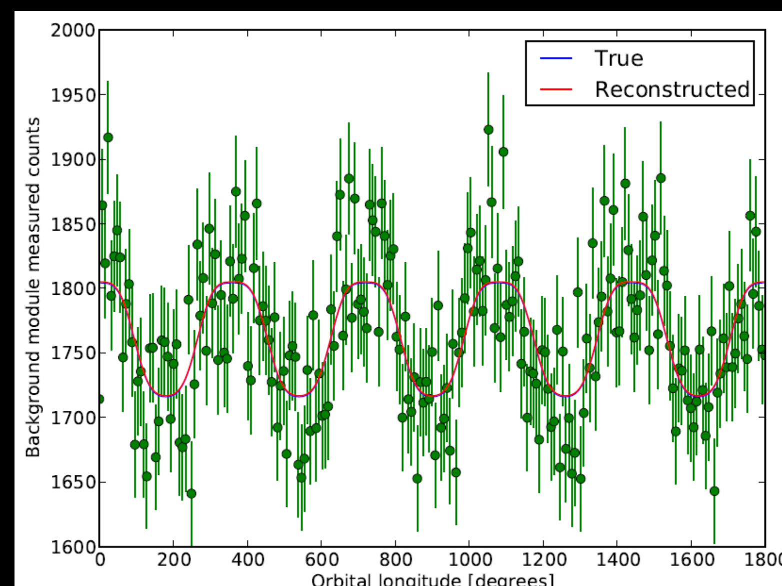
LAD Background: knowledge

Analysis and MC simulations show that the LAD background is dominated (>80%) by a photon component: high energy photons of CXB and Earth albedo "leaking" through the collimator. Both sources are steady and predictable.

The rotation of the spacecraft in the orbit causes a modulation of the background due to the different spectrum of CXB and Albedo. Max modulation is <20% (cf. factor 2-3 of RXTE). This is easily described by a geometrical model.

In addition to that, we introduced a "blocked collimator" for 1 Module (<1% of the area) able to monitor continuously the non-aperture background (95% of total), providing an independent modelling of the background variation with <0.3% accuracy over the orbital timescale.

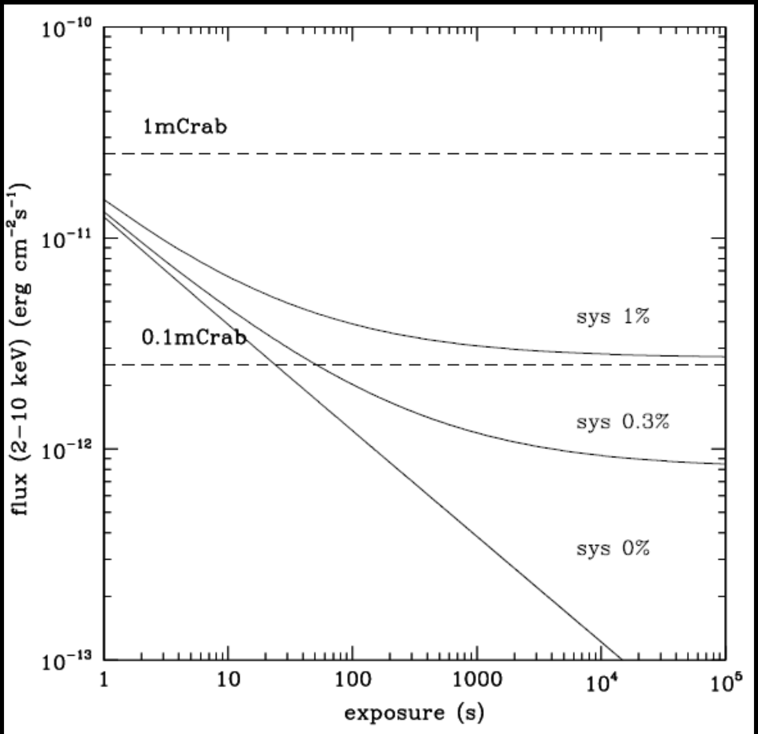




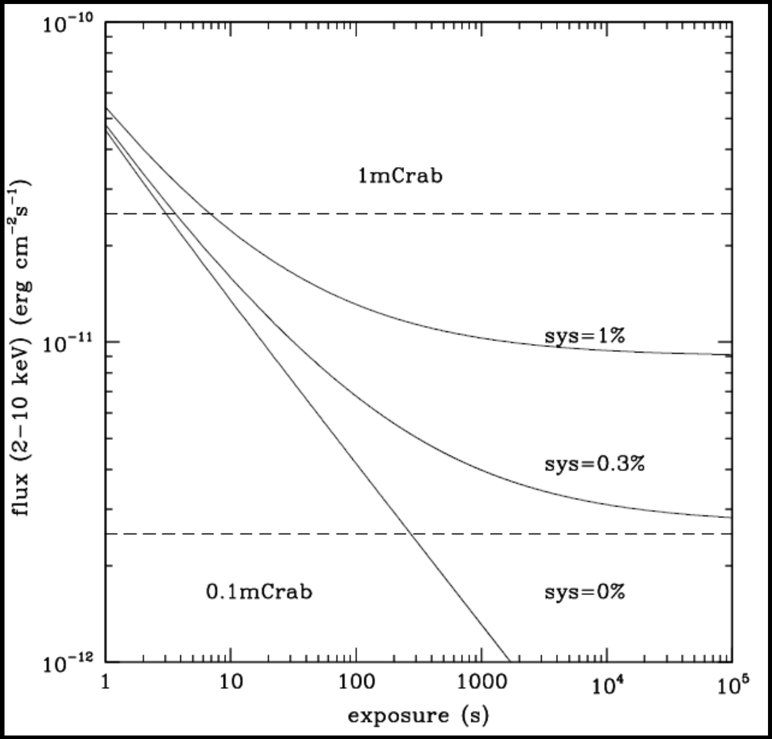
LAD Sensitivity

Thanks to its unprecedented through-put (Crab gives ~240,000 cts/s on the LAD), the 3-sigma sensitivity is ~1 mCrab/s. This gives access to unexplored spectral variability times-scales. At the same time, an accurate control of the background systematics is recognized as very important.

3-sigma

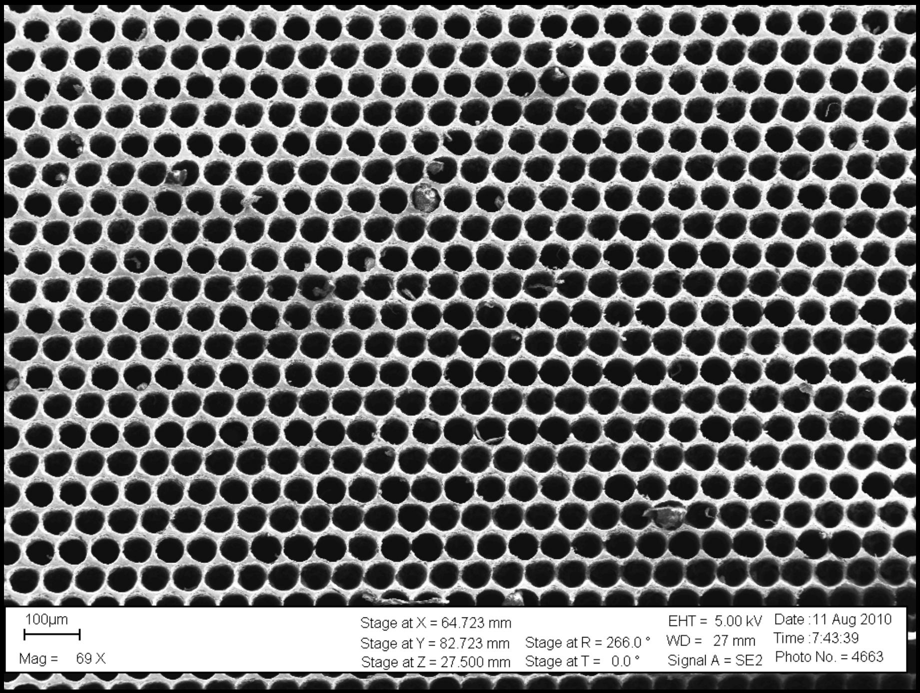


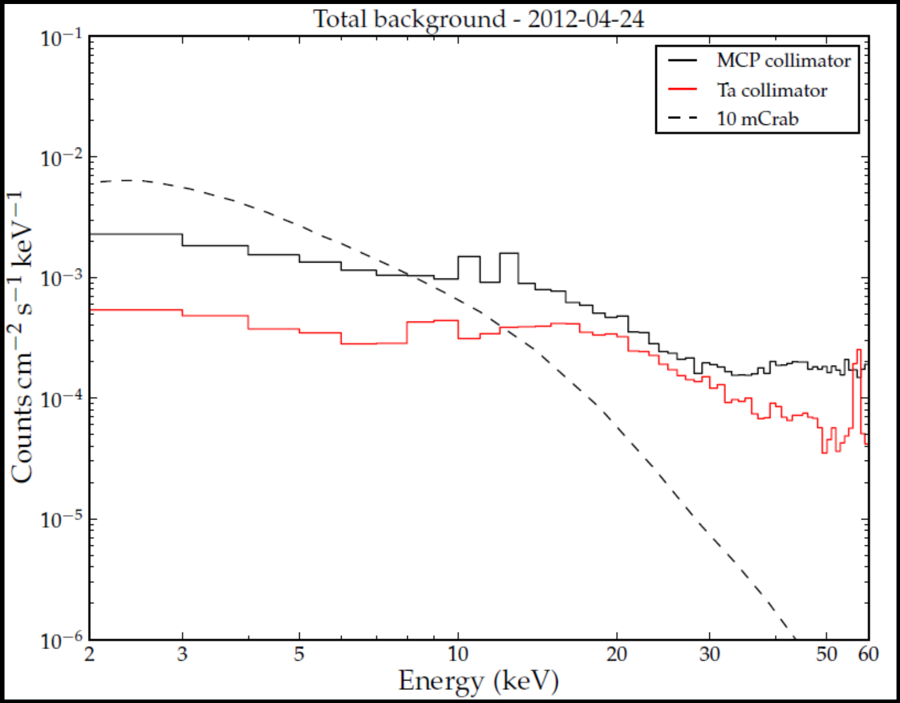
10-sigma



LAD Science Enhancement

On-going technology development activities in the US (but with a German company) aim at reproducing the capillary-plate structure in metal. Tantalum prototypes already produced. The leakage background would be almost entirely removed. NASA MoO being submitted.

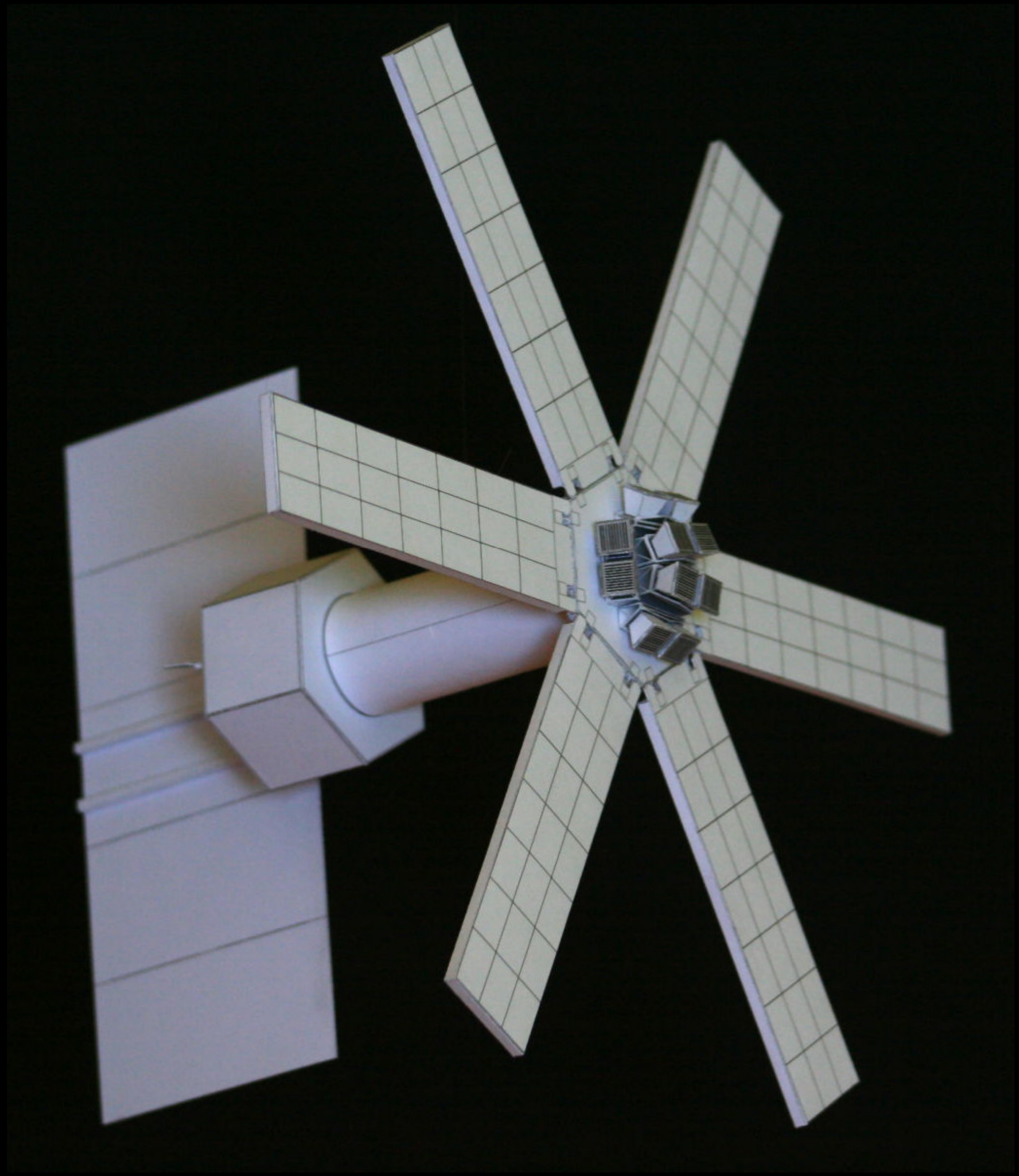




LOFT Web Page and Toy Model

http://www.isdc.unige.ch/loft

- Mission info
- Simulation Tools
- Project status updates
- Public Outreach



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