A proposed Italian contribution to the MIRAX Scientific Payload

Lorenzo Amati

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on behalf of groups at:

INFN Trieste: A. Vacchi, G. Zampa, ..
INAF/IASF-Rome: M. Feroci, E. Costa, …
INAF/IASF-Bologna: L. Amati, C. Labanti,…
Univ. of Ferrara: F. Frontera, ..
INAF HQs: A. Argan
Univ. of Pavia: P. Malcovati, …

SciNeGHE 2010

The Italian MIRAX Collaboration

INAF	IASF Rome	Marco Feroci, Andrea Argan, Riccardo Campana, Imma Donnarumma, Yuri Evangelista, Ettore Del Monte, Sergio Di Cosimo, Giuseppe Di Persio, Francesco Lazzarotto, Marcello Mastropietro, Ennio Morelli, Fabio Muleri, Enrico Costa, Luigi Pacciani, Massimo Rapisarda, Alda Rubini, Paolo Soffitta
	IASF Bologna	Lorenzo Amati, Claudio Labanti, Martino Marisaldi, Fabio Fuschino, Mauro Orlandini, Alessandro Traci
INFN	Sez. Trieste	Andrea Vacchi, Gianluigi Zampa, Nicola Zampa, Alexander Rashevski, Valter Bonvicini
	Sez. Bologna	Giuseppe Baldazzi
	Sez. Roma 2	(Marco Feroci, Ettore Del Monte, Yuri Evangelista, Riccardo Campana, Luigi Pacciani)
University	Ferrara	Filippo Frontera, Cristiano Guidorzi, Ruben Farinelli
	Pavia	Piero Malcovati, Luca Picolli, Marco Grassi

Background

- **Scientific motivation**:
  a) broad band spectroscopy (1 keV – 10 MeV) of the prompt emission of GRBs;
  b) X-ray All Sky Monitoring in 2 – 50 keV

- **2006-2009:** definition of specific science goals and requirements, investigation of instrument concepts and mission of opportunities allowing to achieve these science goals were supported by ASI-INAF contract for AAE, with P.I.s L. Amati (GRB Monitor) and M. Feroci (All-Sky Monitor)

- In parallel, R&D activities on detectors suitable for such instrumentation (innovative Silicon Drift detectors and scintillator detectors) were performed at INAF/IASF institutes in Rome and Bologna (supported by ASI) and (and in colaboration with) INFN (Trieste, Bologna)

- **2009-2010:** following prelimiary contacts, meetings and discussions, the P.I. J. Braga (INPE, Brazil) invited us to propose a possible payload for the Brazilian MIRAX experiment on-board the LATTES satellite (to be launched in 2015-2016)

- **June 2010:** the MIRAX science case and payload concept proposed by the Italian colaboration were succesfully presented and discussed at a meeting at INPE

- **July 2010:** the Brazilian Space Agency (ABE) formally solicited and invited ASI to discuss the possible Italian contribution to MIRAX, based also on existent agreements of cooperation in space programmes

GRB prompt emission down to soft X-rays

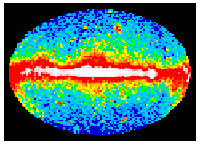
❑ Despite the huge advances occurred in the last years, the GRB phenomenon is still far to be fully understood

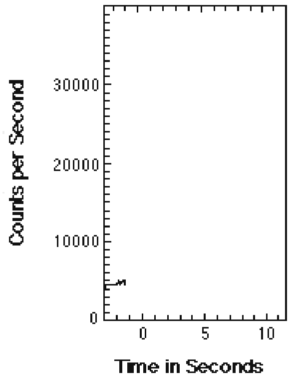
❑ It is recognized that the GRB phenomenon can be understood only going back to the study of the Prompt Emission

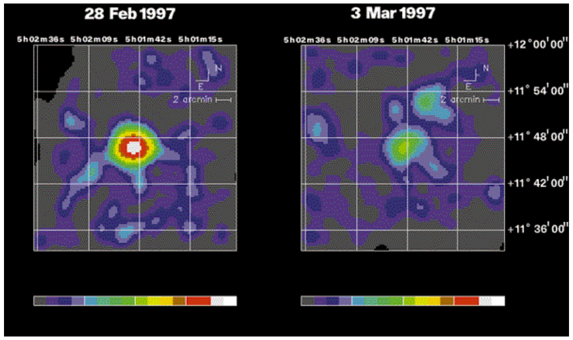
❑ A very broad energy band down to soft X-rays is needed.

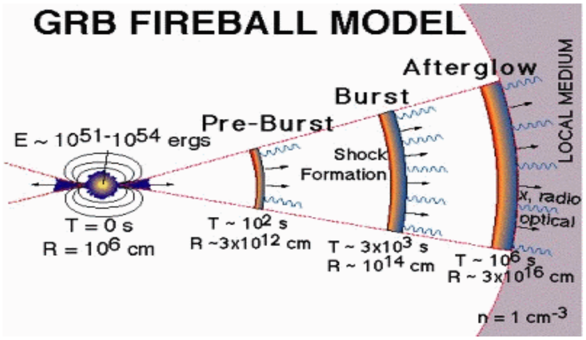
❑ Measurements down to a few keV were provided in the past by BeppoSAX, but a higher sensitivity and energy resolution is urgently needed.

❑ Present GRB experiments are limited to prompt emission > ~10 keV; future (SVOM, EXIST,) > ~ 5 - 8 keV

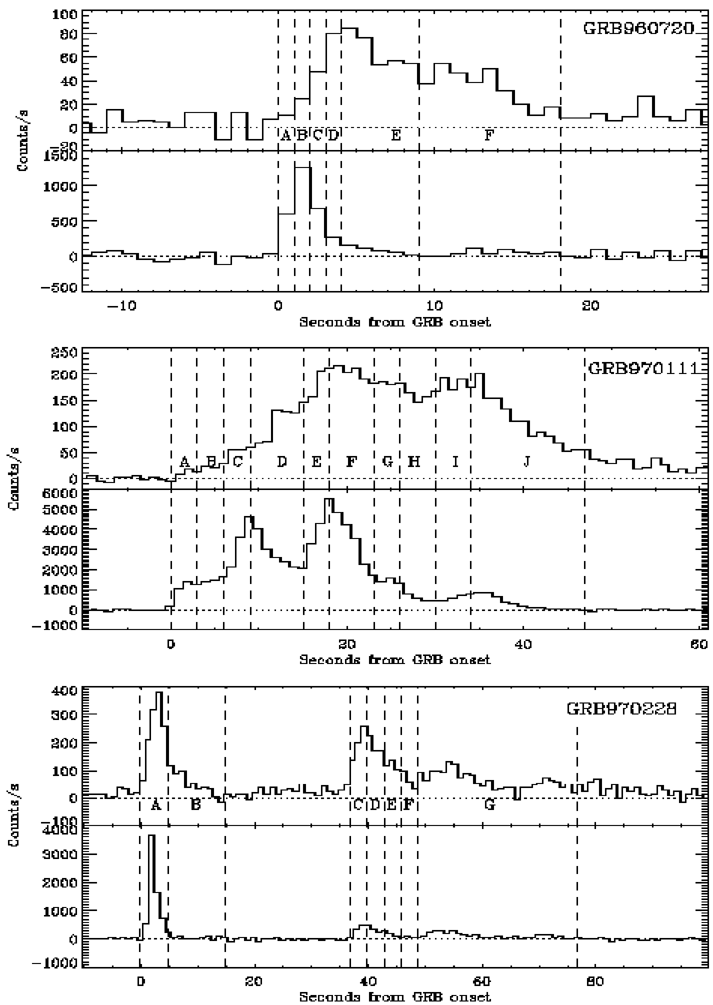


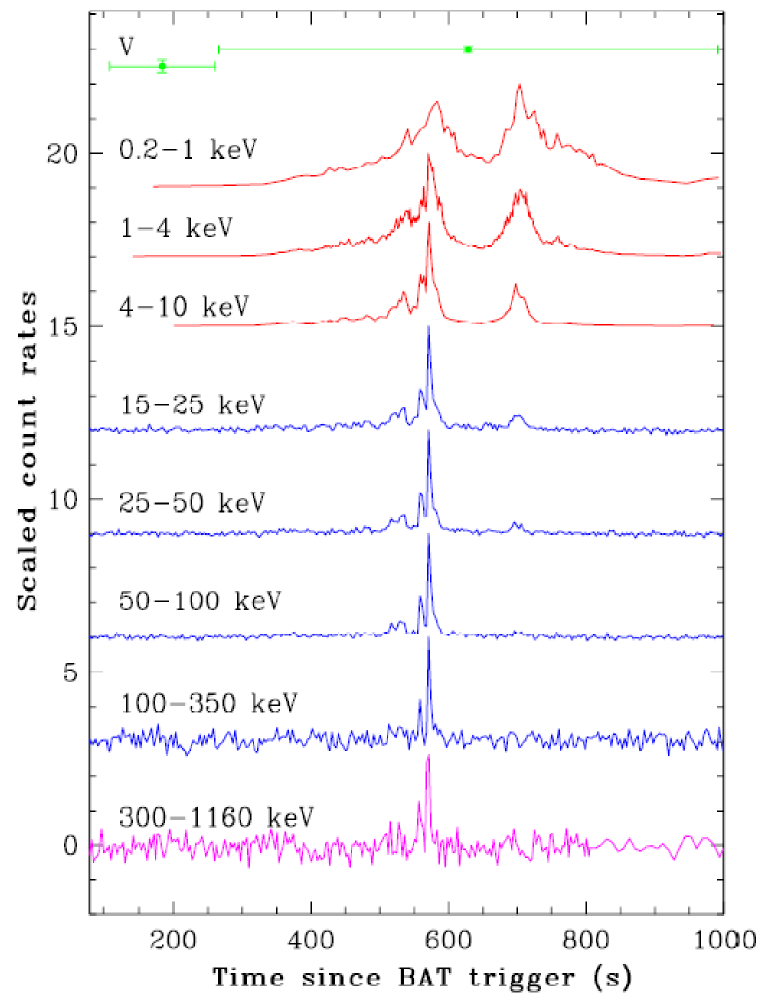






❑ Relevance of GRB prompt low energy (<15 keV) X-ray emission

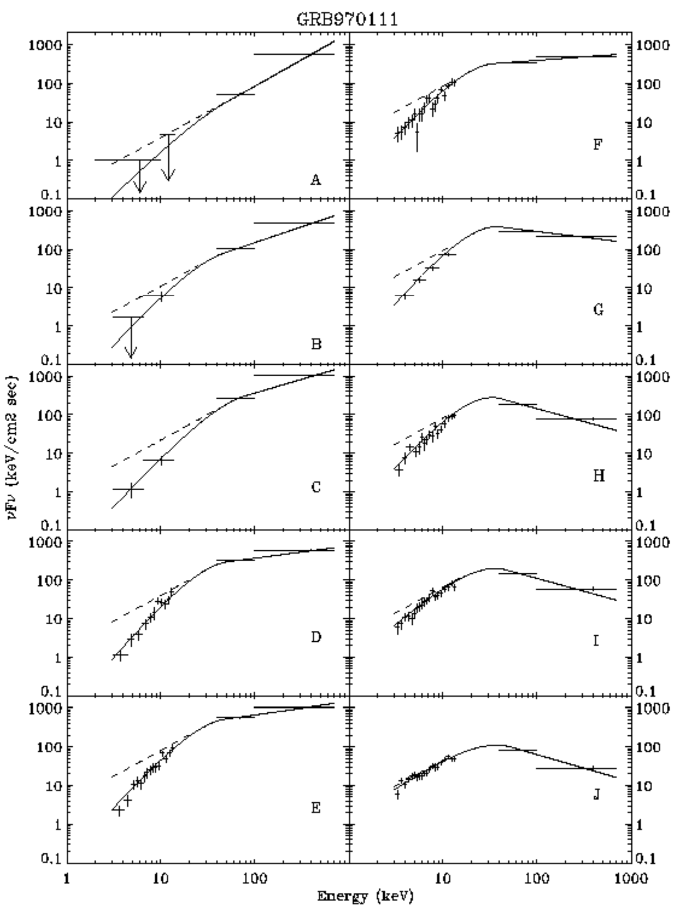


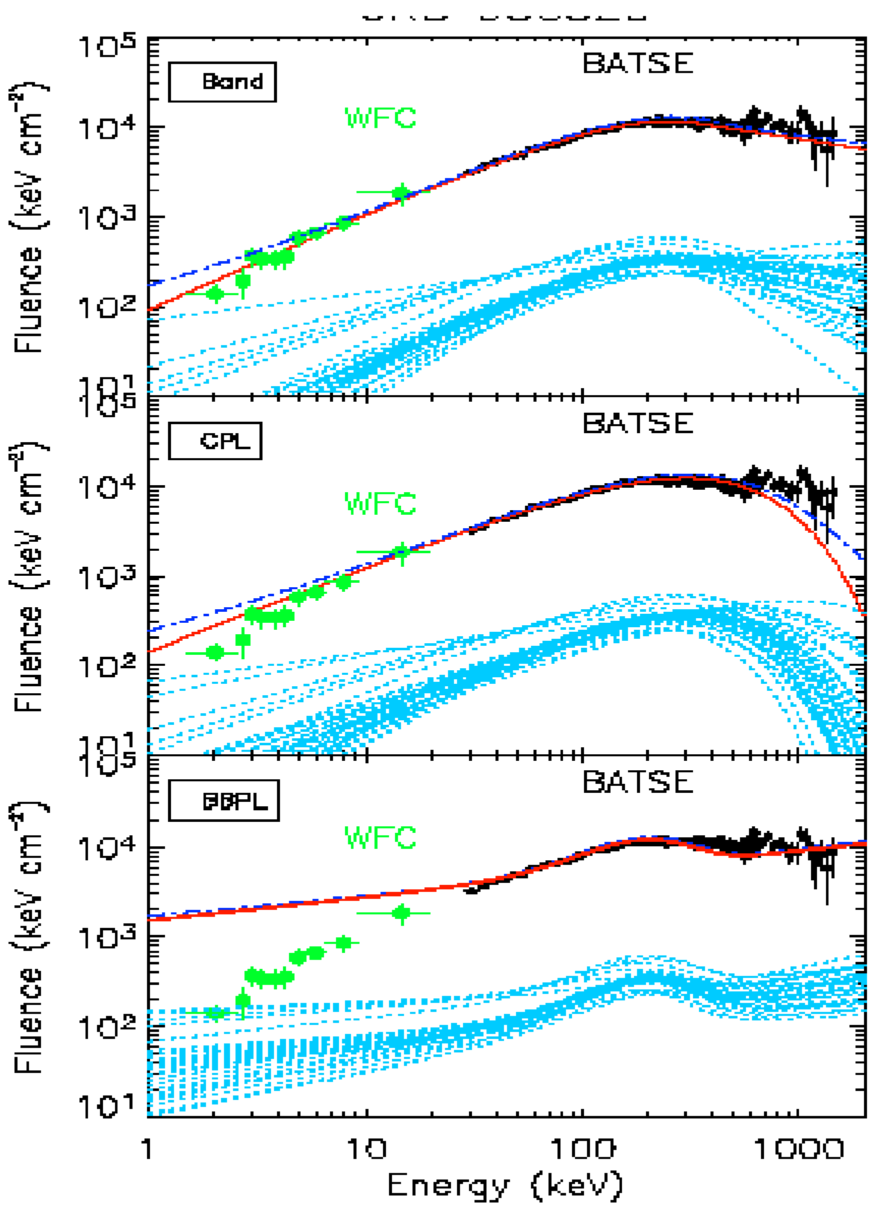


BeppoSAX (top: 2-28 keV, bottom: 40-700 keV)

Swift XRT (rare / unique case) + Swift/BAT + konus/WIND

❑ Test of the prompt emission mechanisms with X-ray spectra

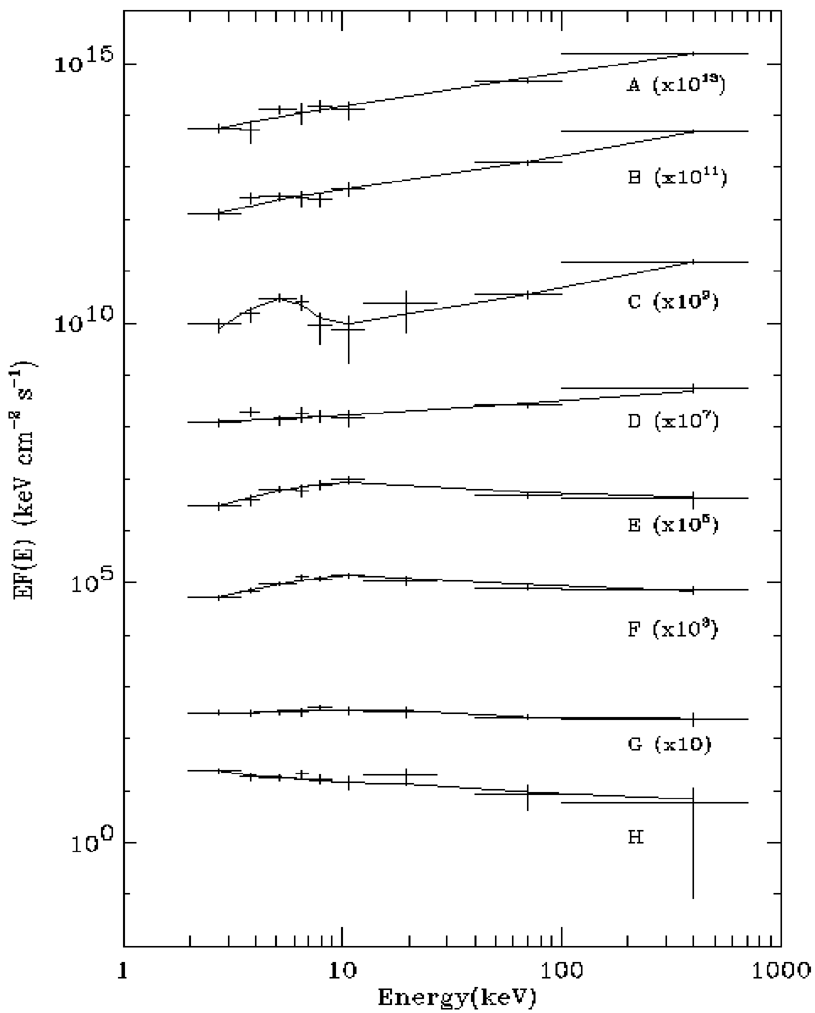




(FF et al. 2000; Ghirlanda et al. 2007)

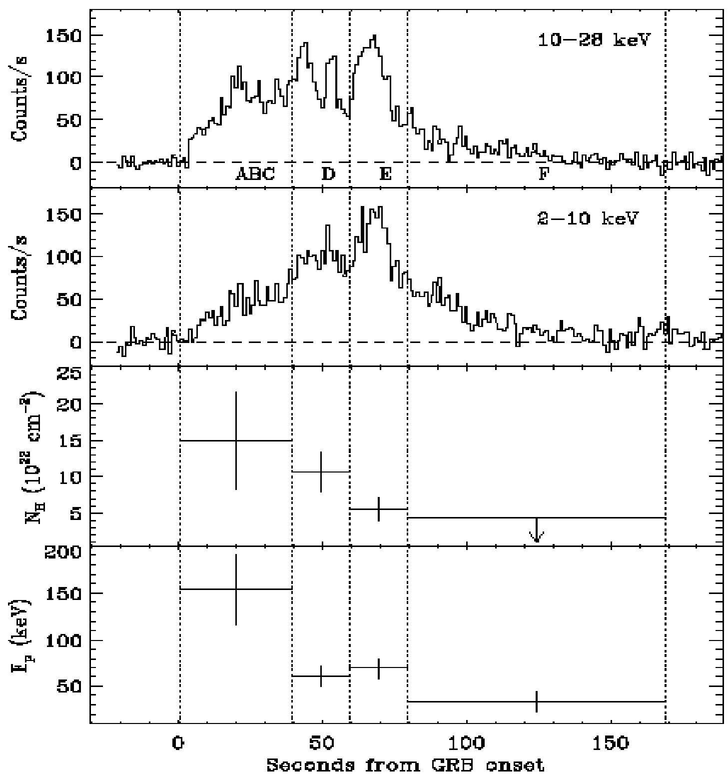
❑ Tansient bump, consistent with a 2 keV blackbody, observed in the low energy band with BeppoSAX WFC

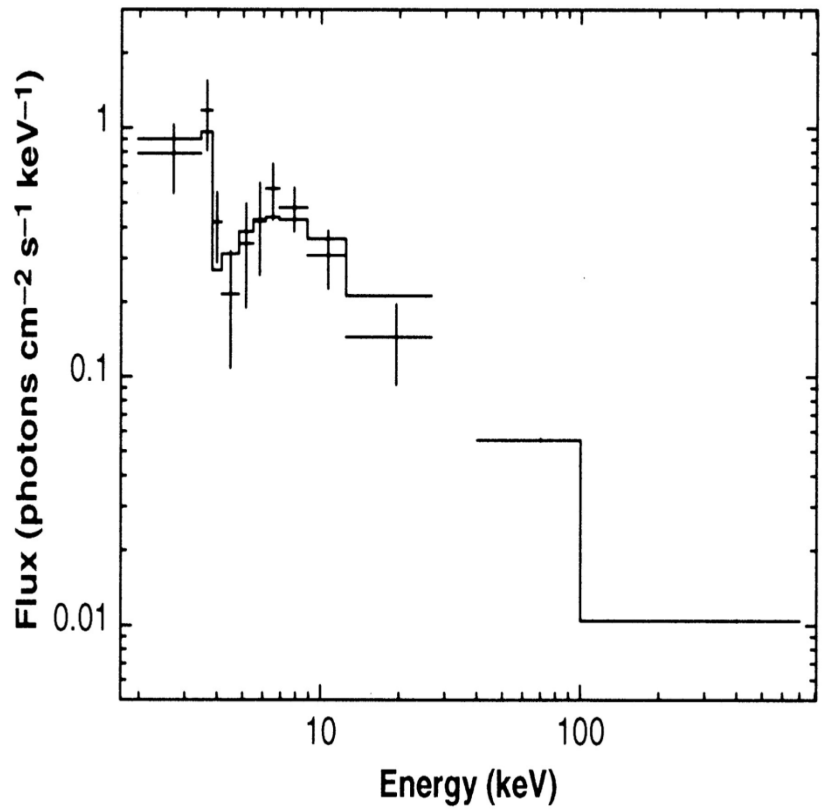
GRB 990712



Frontera et al. 2001

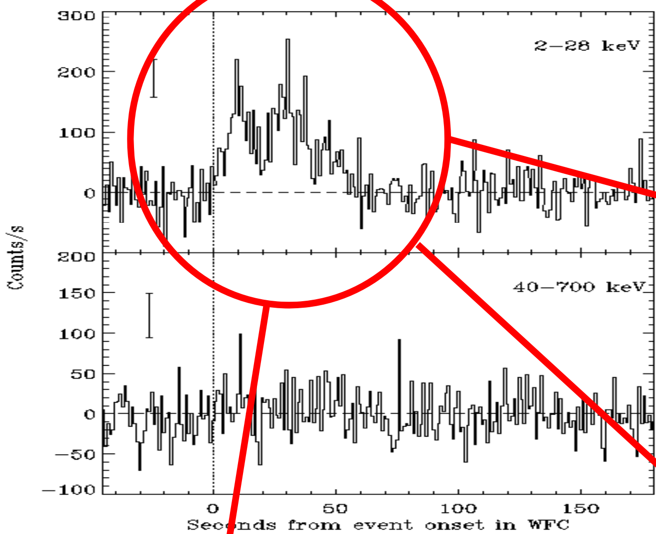
❑ X-ray features: properties (density profile, composition) of circum-burst environment (progenitors, X-ray redshift)

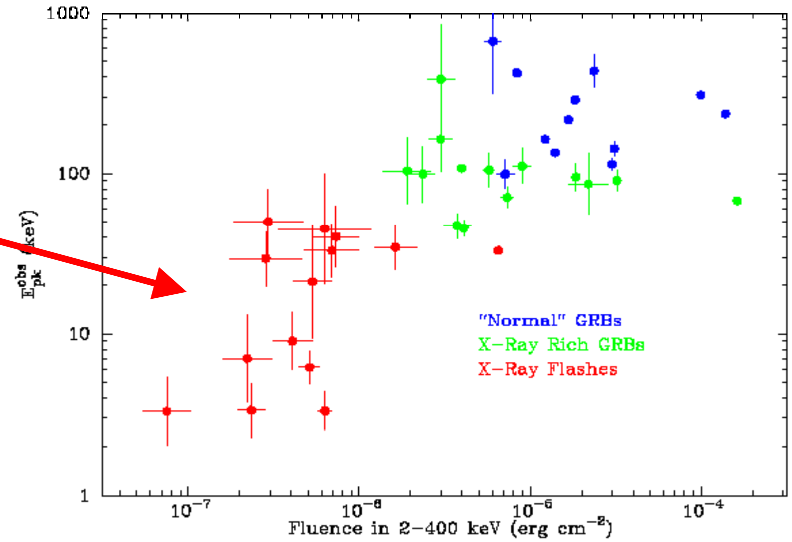




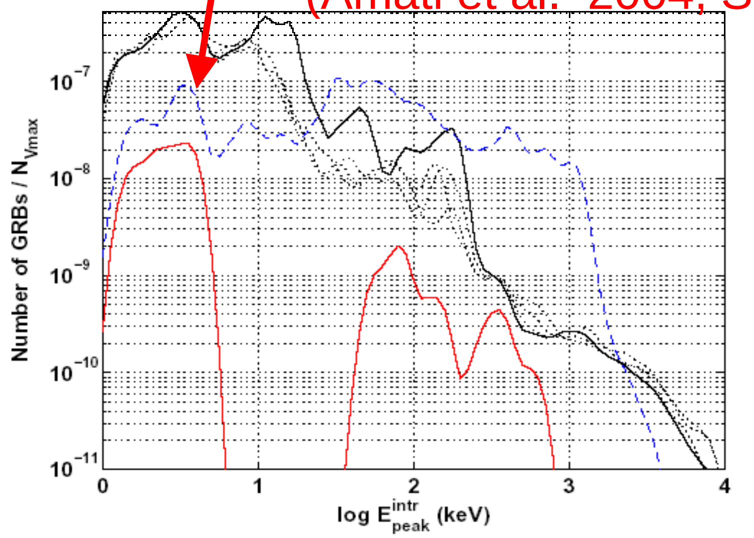
(Frontera et al., ApJ, 2004, Amati et al, Science, 2000)

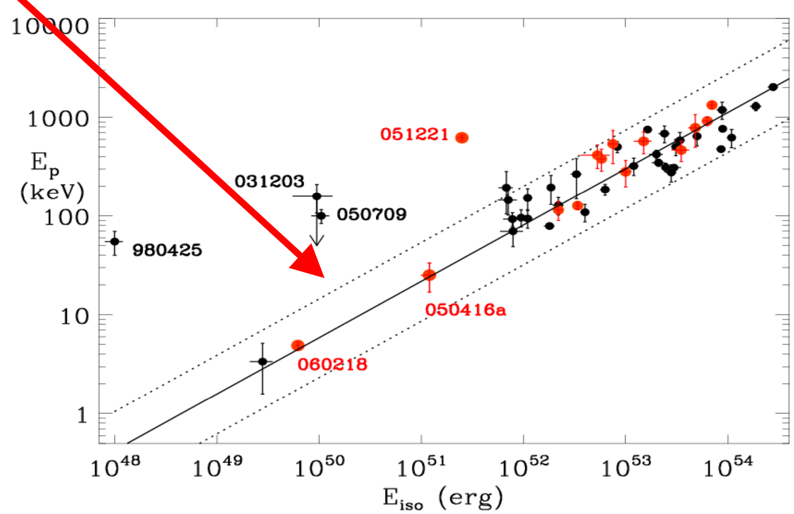
❑ X-Ray Flashes: origin, population size, link with GRB





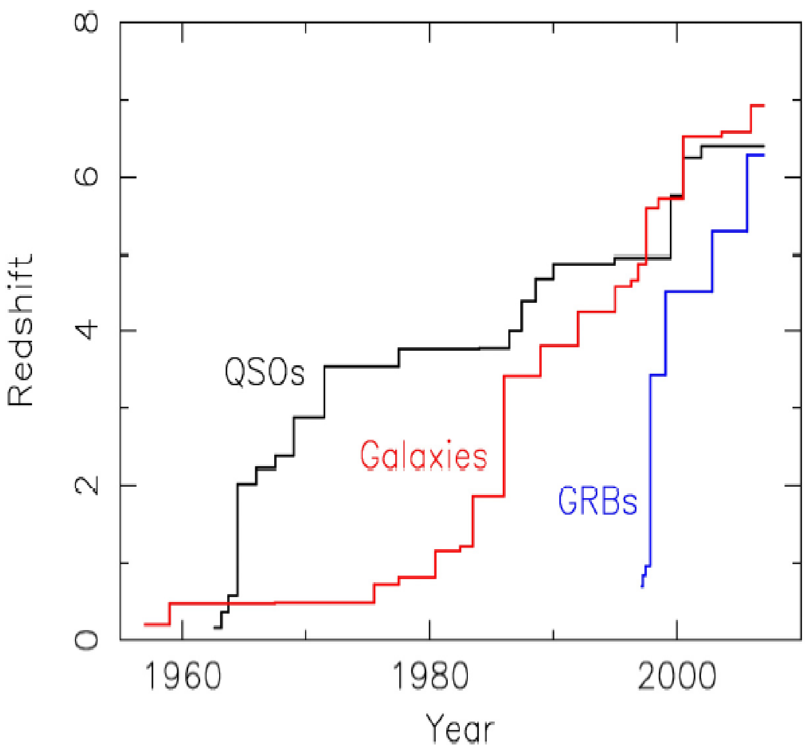
(Amati et al. 2004, Sakamoto et al. 2005

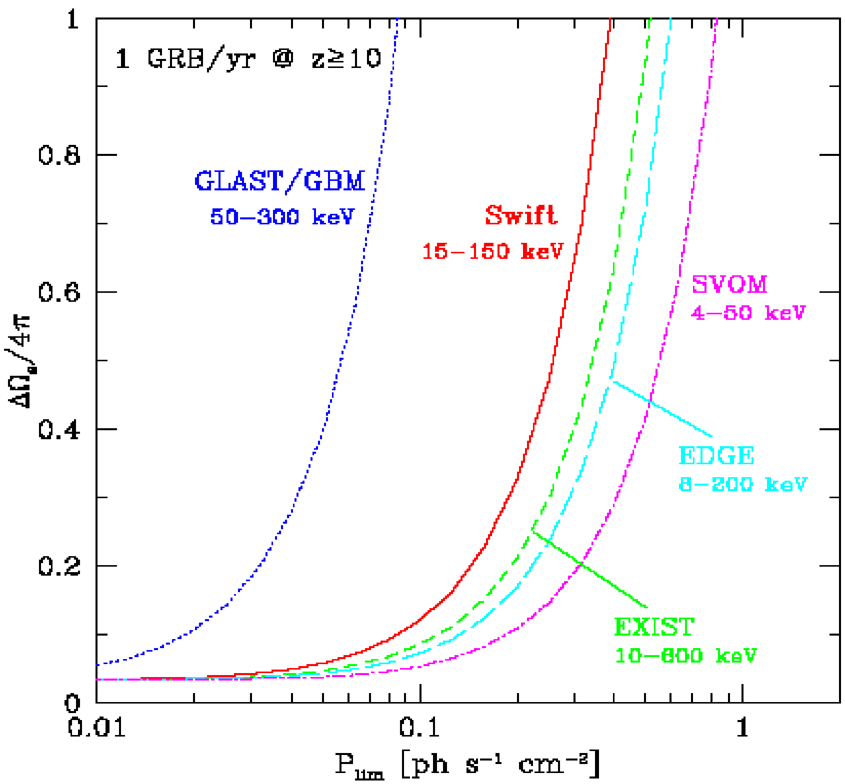




(Amati 2008, Pelangeon et al. 2008

❑ Increasing the detection rate of high-z GRB with low energy threshold: SFR up to dark ages, pop III stars, ...





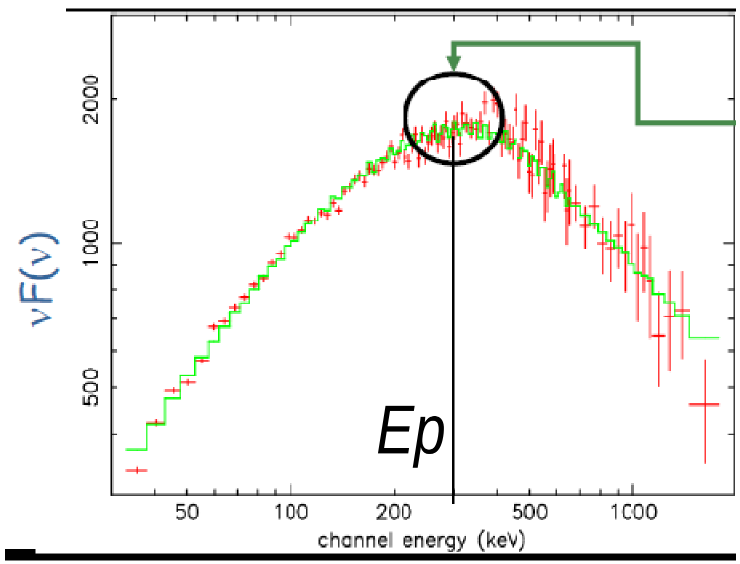
(Salvaterra et al. 2007)

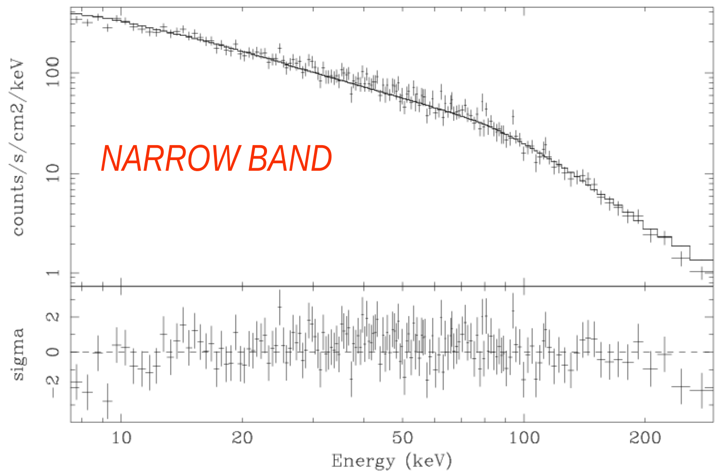
❑ GRB broad band prompt emission: peak energy estimate

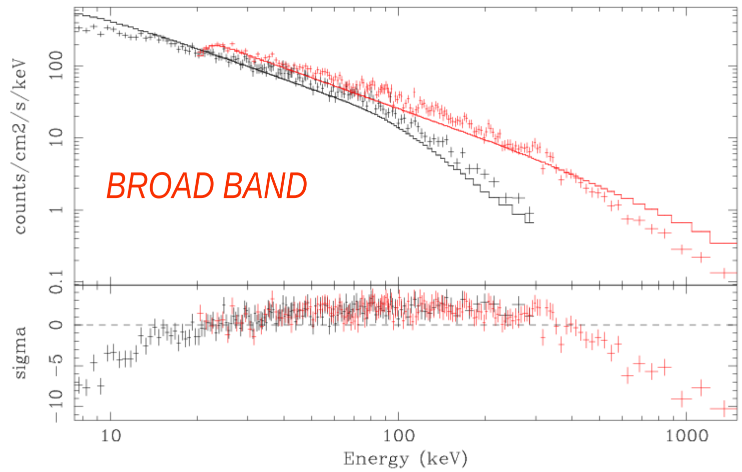
- ❑ the accurate measurement of the spectral parameters of GRB prompt emission is fundamental to test the emission models and, in particular, to test and use Ep-Eiso correlation

- ❑ Swift cannot provide a high number of firm Ep estimates, due to BAT 'narrow' energy band (sensitive spectral analysis only from 15 up to ~200 keV) -> a broad energy band is needed

- ❑ in last years, Ep estimates for some Swift GRBs from Konus/WIND, SUZAKU, Fermi/GBM







❑ investigation of the Ep,i – Eiso (Amati) relation

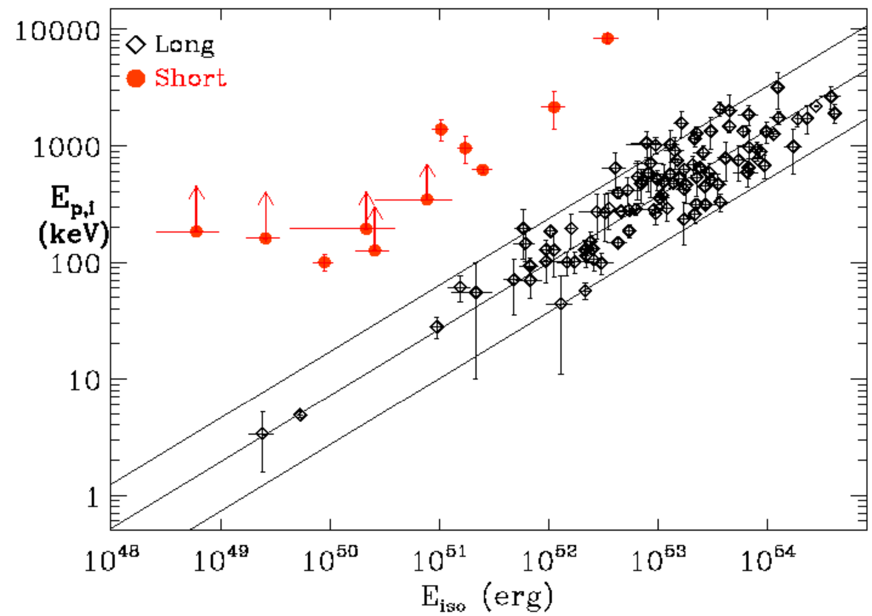
➢ **Ep,i - Eiso relation can give crucial information on the physics of GRBs, like:**

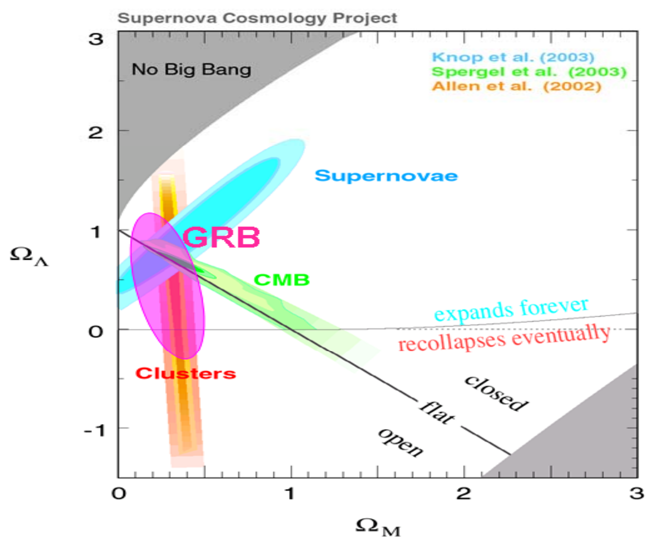
➢ **Study of the GRB explosion origin and process;**

➢ **Radiation production / emission mechanisms.**

➢ **Ep,i - Eiso relation can also be a powerful instrument for cosmology**

➢ **A much larger sample of GRBs with known Ep and z is needed.**





X-ray All-Sky Monitoring and Survey

Science objectives opened by continuous All Sky Monitoring are extremely wide-spectrum, numerous and general. Long-term, continuous monitoring of Galactic sources allows the study of source/class properties not easily or unaccessible to specific, short observations, although more sensitive.

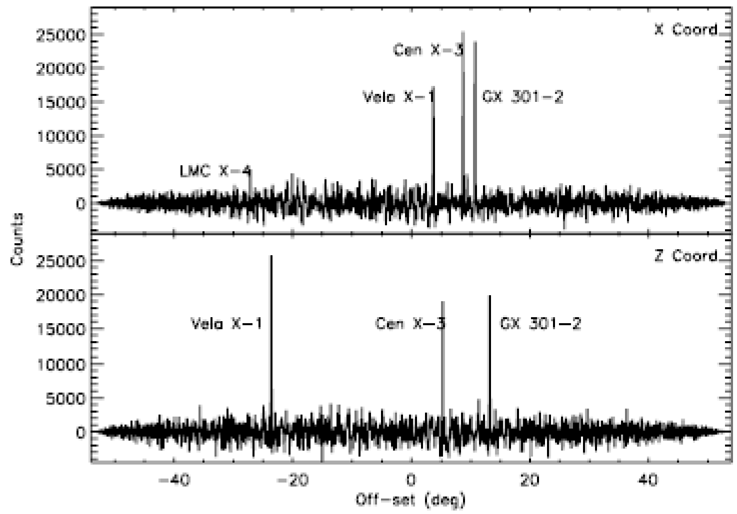
Examples are:

- discovery of new transient sources;
- discovery and long-term evolution of orbital, superorbital and spin periodicities, period derivatives and quasi-periodicities (QPOs);
- intensity and spectral state changes in BHC;
- multi-frequency correlation between timing, spectral and intensity parameters;
- discovery and monitoring of bursting behaviour (bursters, SGRs, AXPs, ...);
- a complete all sky survey.

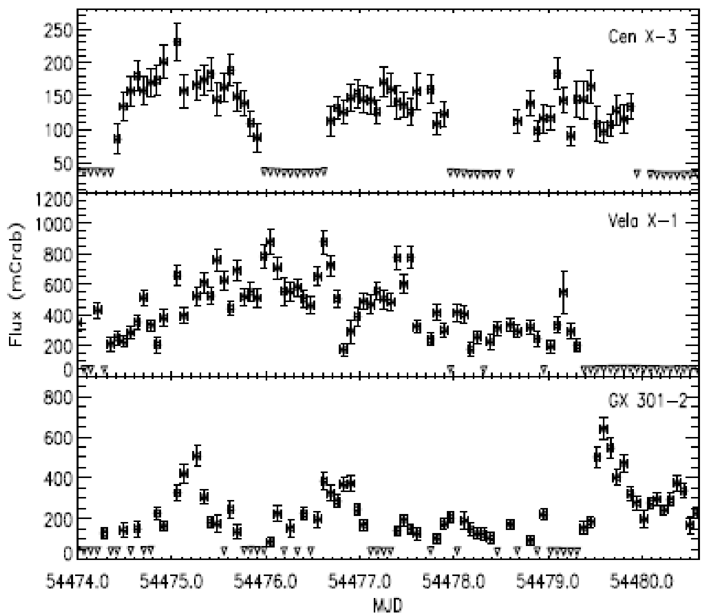
Wide field of View – Simultaneous Monitoring

a SuperAGILE snapshot of the the Vela region

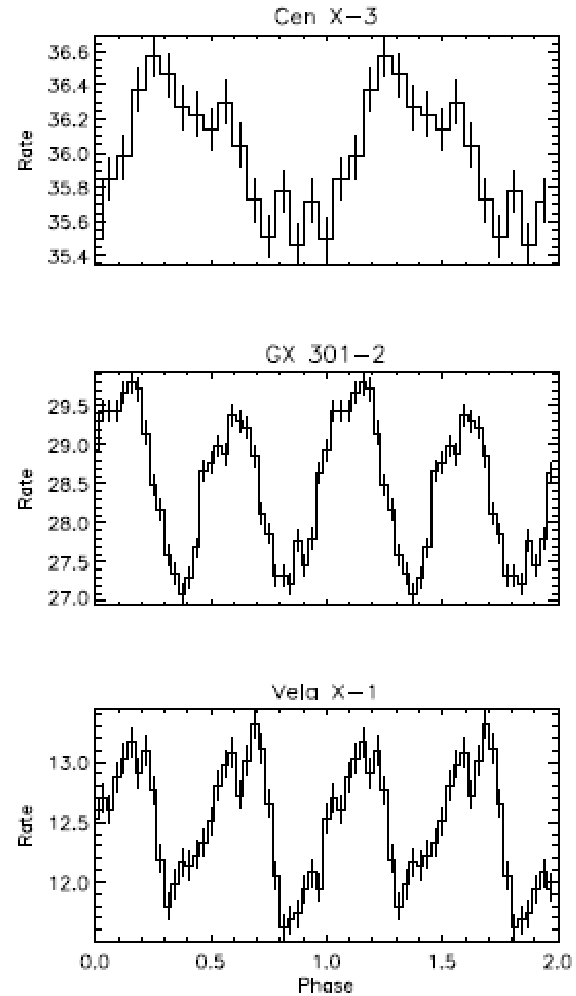
2 x 1D images



lightcurves

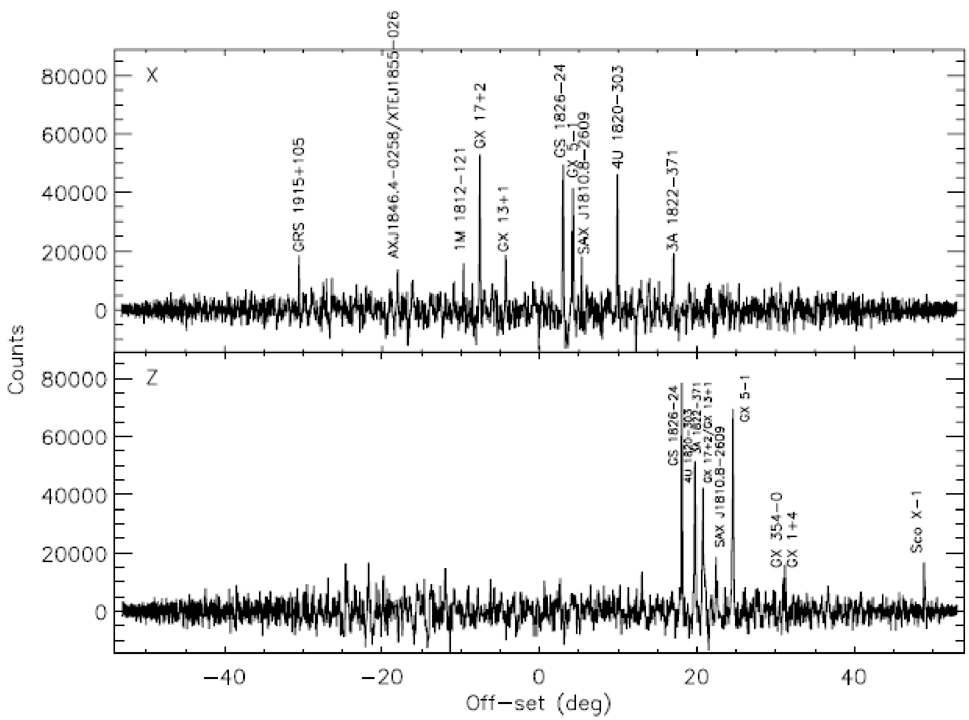


Folded Pulse Shapes



Galactic Center & Gamma Ray Bursts

A&A 510, A9 (2010)



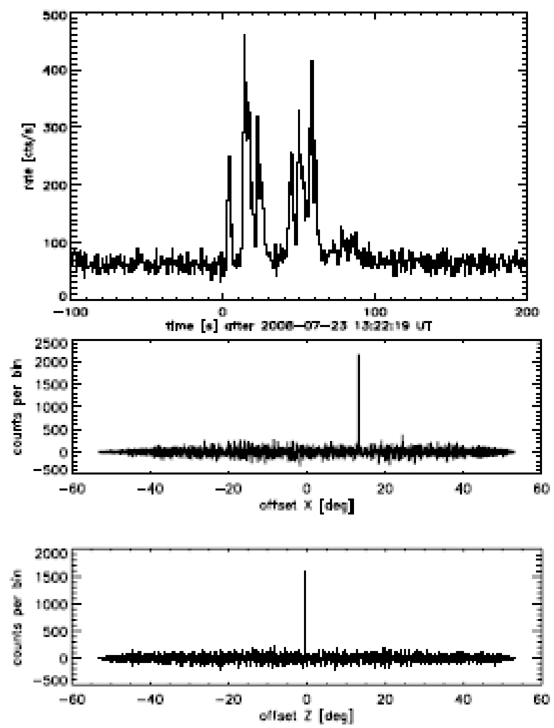


Fig. 8. A 600 ks long exposure to a field near to the Galactic Center, from 13th to 22nd October 2007. The field is centered at RA = 296.265, Dec = −18.840 (l = 21.430, b = −20.031). In these images, the Galactic Center (l = 0, b = 0) is at SuperAGILE coordinates X = 8.7, Z = 28.1.

The ASM Science: “Service”

The most sensitive observatories of any generation carry state-of-the-art detectors and experiments, allowing to perform unprecedented studies of individual sources, over a narrow field of view (~1º or less).

A monitoring experiment is then needed to trigger ToOs, to catch the most interesting states of the sources, often unpredictable. Also, specific observations can be put in the context of the history or evolution of the source (or class of sources) if monitoring is continuously available.

Several X-ray missions have put wide field experiments in their baseline requirements (e.g., RXTE, BSAX, INTEGRAL, Suzaku, ...). Over the last decade, the RXTE/ASM - and now Swift/BAT, ISS/MAXI and INTEGRAL/IBIS - have made All Sky Monitoring a task “taken for granted” by our Community. But these experiments will not be up there forever ...

International Scenario for All-Sky/Wide-Field Monitoring

Mission	Experiment	Energy Range (keV)	Angular Resolution (arcmin)	50 ks Sensitivity (mCrab)	Field of View FWZR (deg)	Area (cm^2)	Nominal Operation/ Launch
INTEGRAL (ESA)	ISGRI	20-200	12	~3-5	29 x 29	2600	2002-2012
SWIFT (USA)	BAT	15-150	17	~5	100 x 60	5240	2005-2008+
RossiXTE (USA)	ASM	2-12	12	~5	12 x 110 (scan)	90	1996-2010
AGILE (Italy)	SuperAGILE	18-60	6	10	107 x 68	1400	Jul 2007-?
ISS (Japan)	MAXI	2-30/0.5-10	90/90	2/4	1.5 x 160 (scan)	5350/200	2009-2011+
ASTROSAT (India)	SSM CZTI	2-10 10-100	10 8	10 0.2	6 x 90 (scan) 17 x 17	180 1000	2011 (?)
SVOM/ECLAIRs (France, China)	CXG/SXC	4-300/1-12	*40/2*	*3/N/A*	105 x 105	1000/100	2012
EXIST (USA)	LET/HET	5-30/10-600	0.9/5	*N/A*	131 x 65	56000	>2015(?)

Basic concept for a GRB and X-ray all-sky monitor

Science Drivers:
1. Wide-band spectroscopy of the prompt emission of GRBs
2. All-sky monitoring of Galactic and Extragalactic X-ray sources

Instrument Requirements:
1. High sensitivity (~few mCrab) over a broad energy band (few keV to few MeV)
2. Arcmin X-ray imaging over full sky

Proposed Implementation:
- All-Sky X-ray Monitor:
  2-50 keV, imaging, based on Silicon Drift Detectors with Coded Mask
- High Energy Spectrometer:
  20 keV – 5 MeV, non-imaging based on crystal scintillators (CsI, NaI, LaBr3, …)

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R&D on Silicon-based Wide Field Cameras

- High Spatial Resolution (~100μm) solid state detectors allows good angular resolution with short mask-detector distance
=> short shielding (low weight)

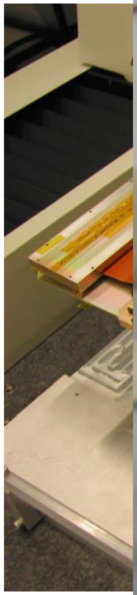
- Low-energy bandpass (below 40-50 keV) requires only thin shielding and mask => low weight

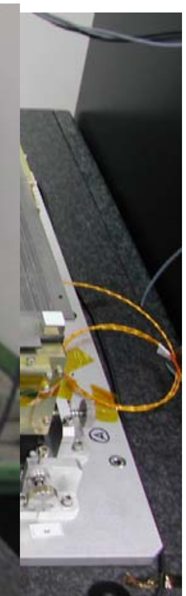
- Strip (1D) read-out => high ratio geometric area *vs* power

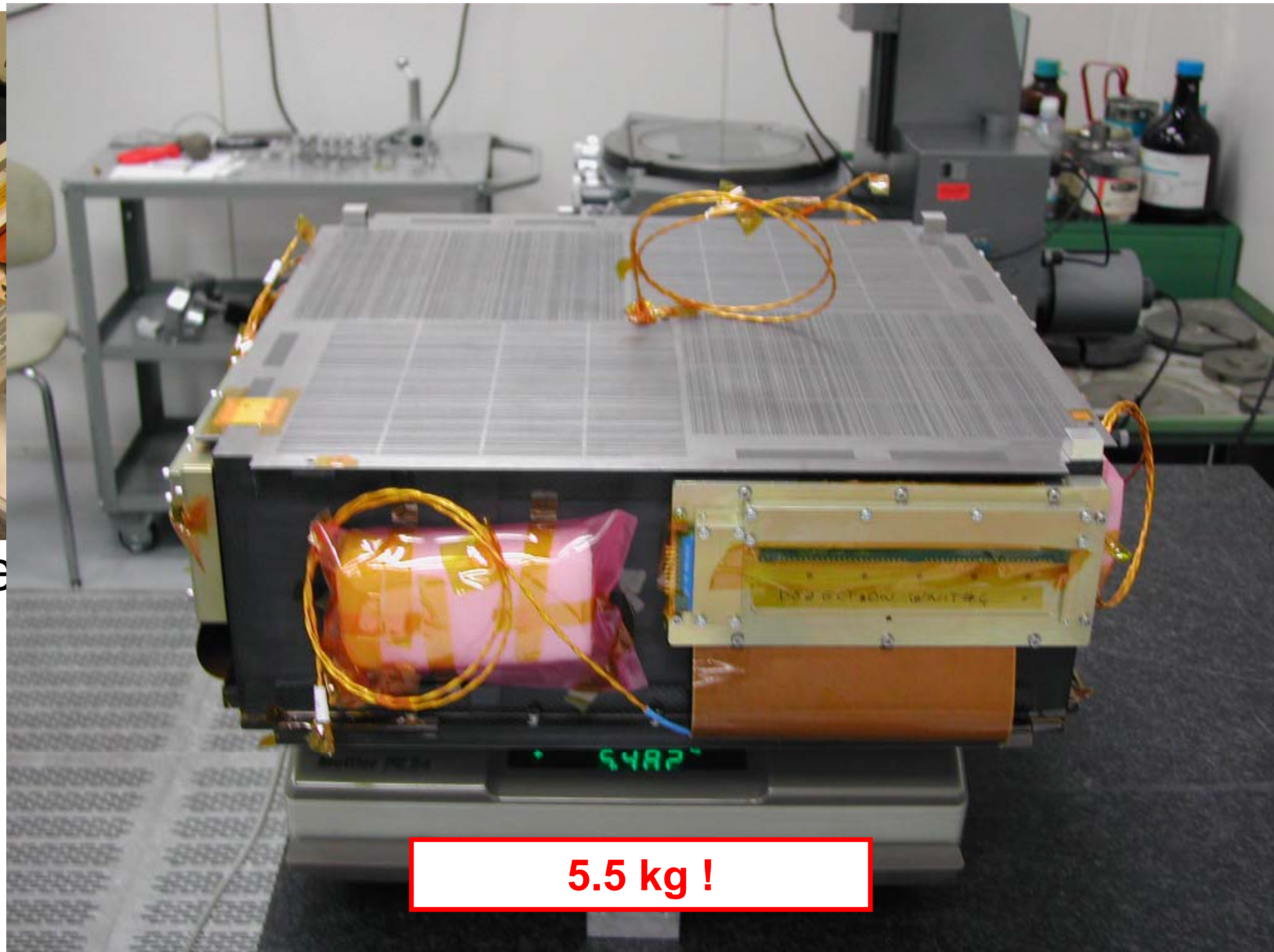
- (and steep spectra of cosmic sources help
=> higher fluxes at lower energies)

Silicon: Established and Improving Technology
High Commercial availability
Fine Pitch
Low Energy

Background: SuperAGILE







Dete

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Where is the difference ?

	Energy Range (keV)	Angular Resolution (arcmin)	1-day Sensitivity (mCrab)	Field of View (deg^2)	Area (cm^2)	Detector Position Res. (mm)	Mask-Detector Dist. (mm)	Weight (kg)
INTEGRAL/IBIS	20-2000	12	~3-5	29 x 29	2600	4.6	3200	700
Swift/BAT	15-150	17	~5 (*)	100 x 60	5240	4	1000	>200 (*)
ISS/MAXI	2-30	6	2	1.5 x 160	5350	1	770	490
BeppoSAX/WFC	2-28	5	~5	40 x 40	140	0.5	700	43
RossiXTE/ASM	2-12	12	10	12 x 110	90	0.5	300	>30 (*)
HETE-2/WXM	2-25	36	N/A	90 x 80	175	1	187	>20 (*)
AGILE/SuperAGILE	18-60	6	~15	106 x 68	1444	0.121	140	5.5

(*) Not available from literature: "reasonable guess" based on the instrument/mask properties

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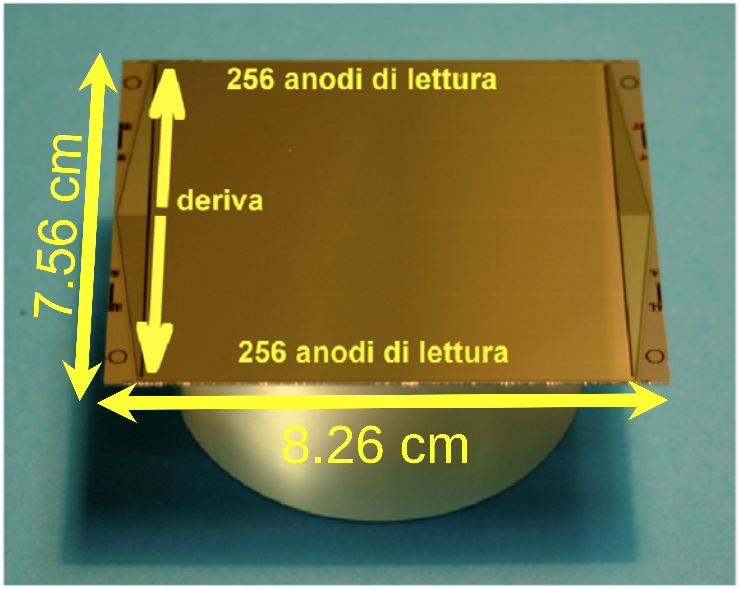
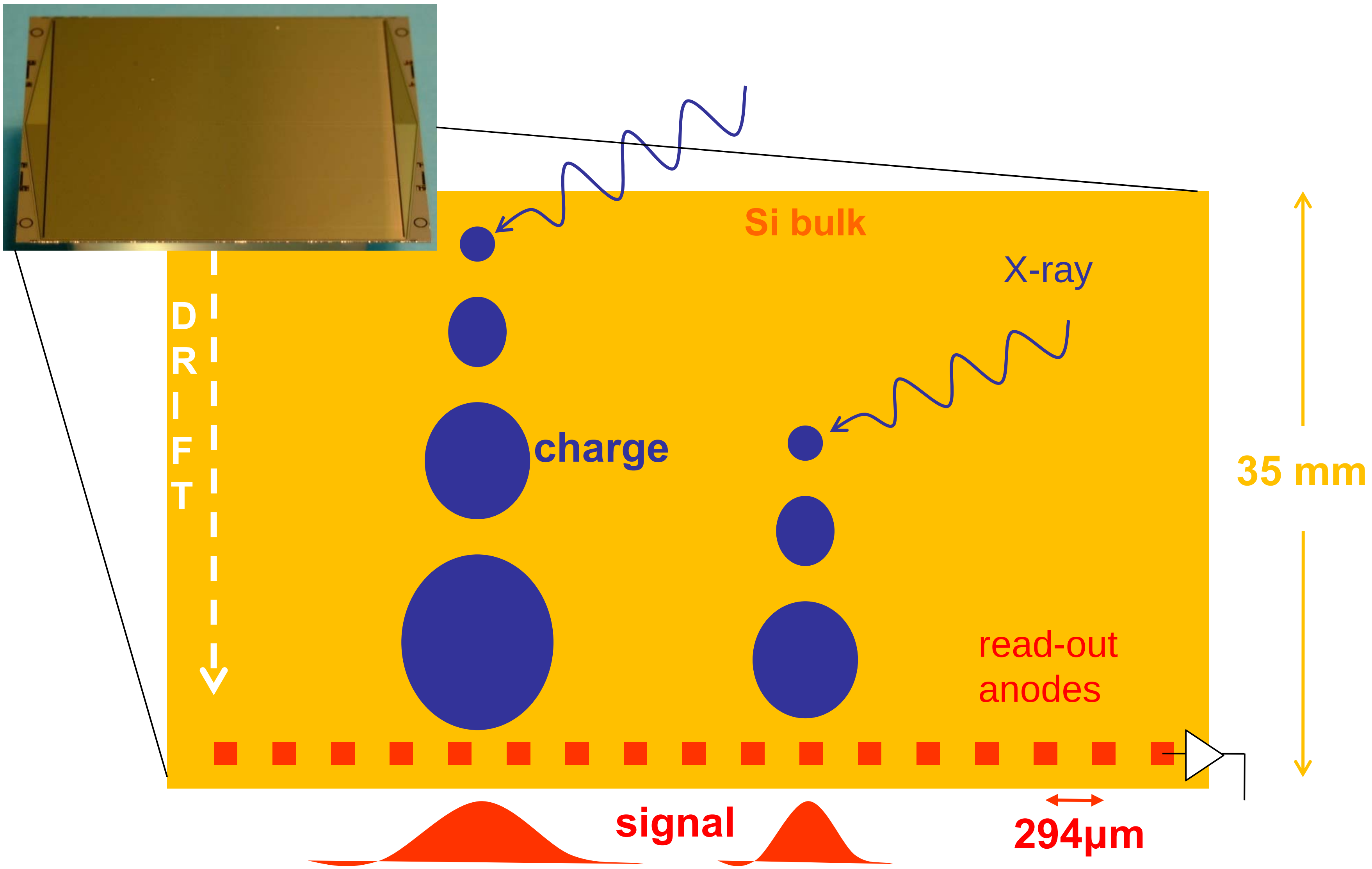
A Step Forward: the ALICE Silicon Drift Detector

- ALICE-D4 detectors, designed by INFN-Trieste (A. Vacchi et al.) and manufactured by Canberra, Inc.
- Designed for particle tracking in the ALICE experiment at LHC



- 256 anodes for each half of the detector tile
- 35 mm max drift length
- 294 μm pitch (distance between anodes)
- 300 μm thickness

The ALICE-SDC Working Principle



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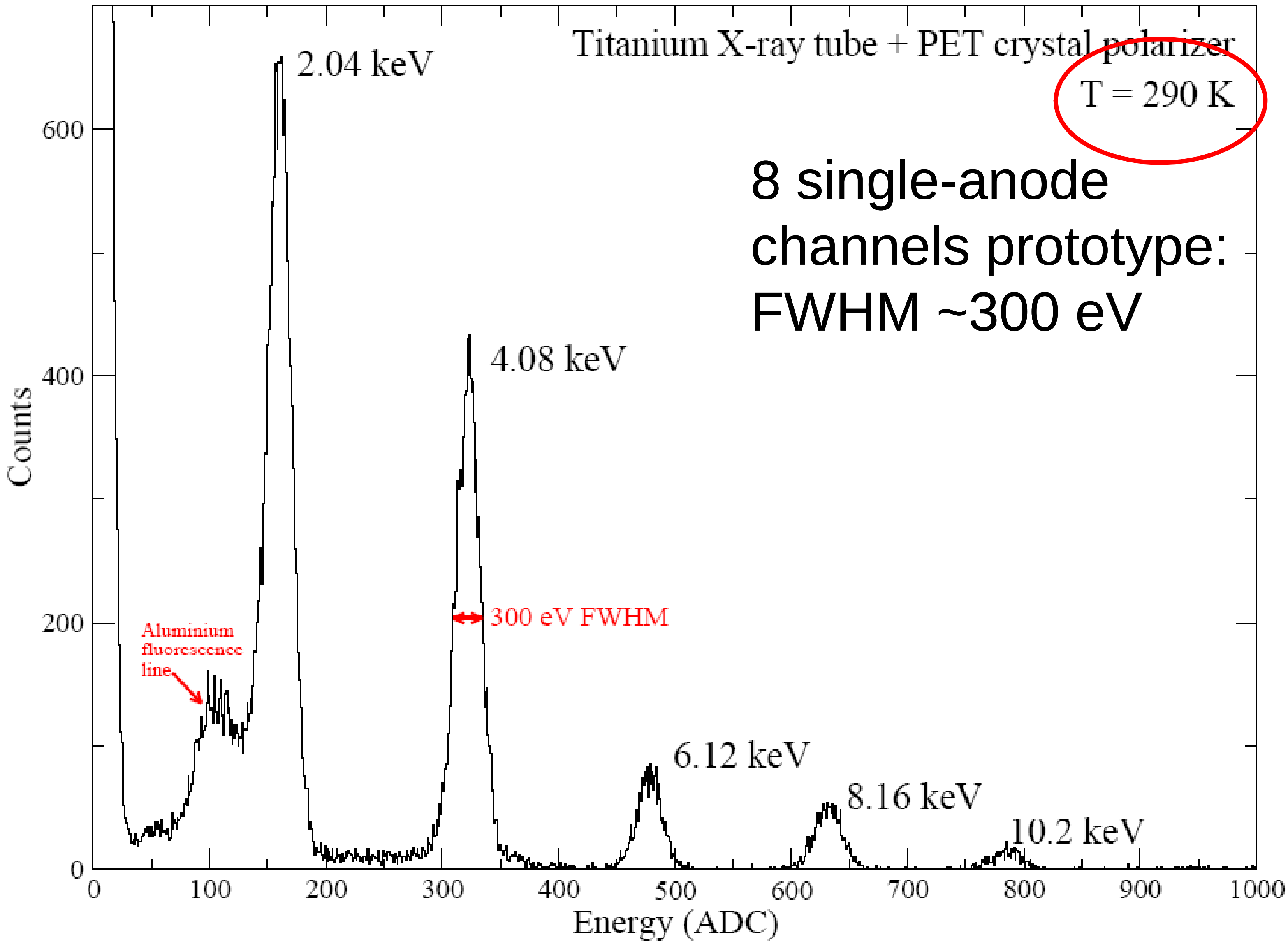
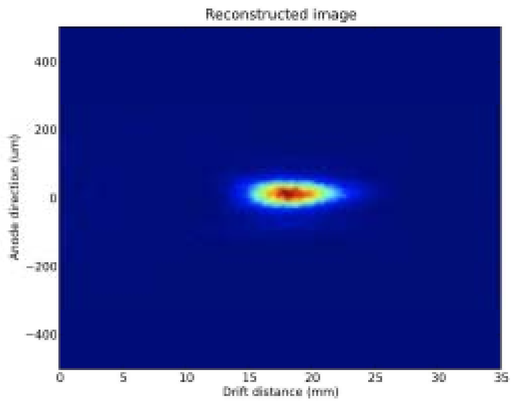
Test Results with a Lab Prototype



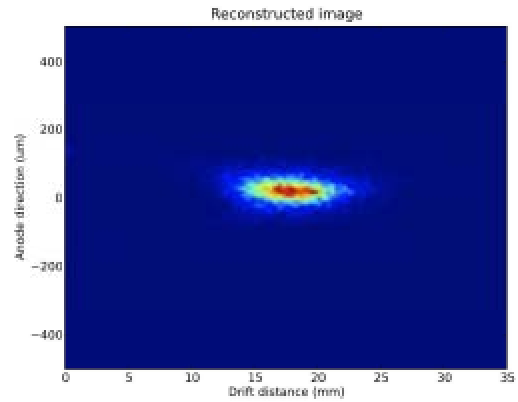
8 single-anode channels prototype: FWHM ~300 eV

Position Resolution

4.5 keV Measured

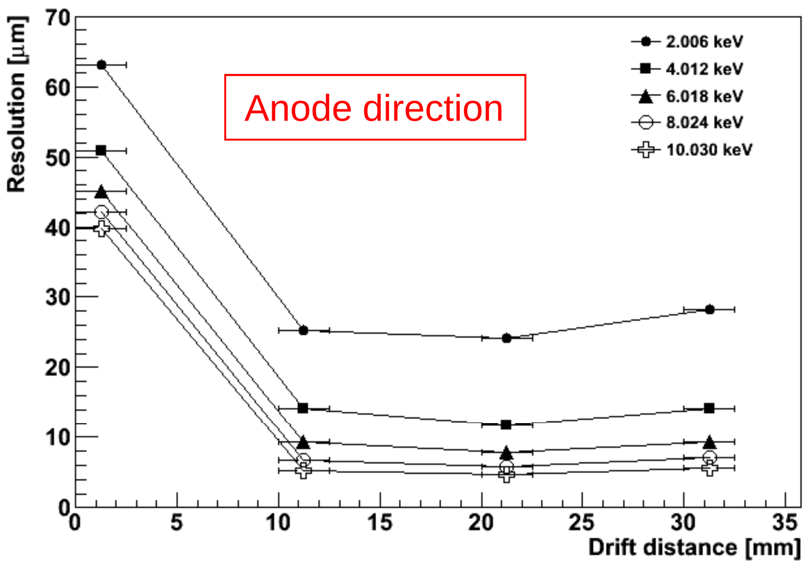


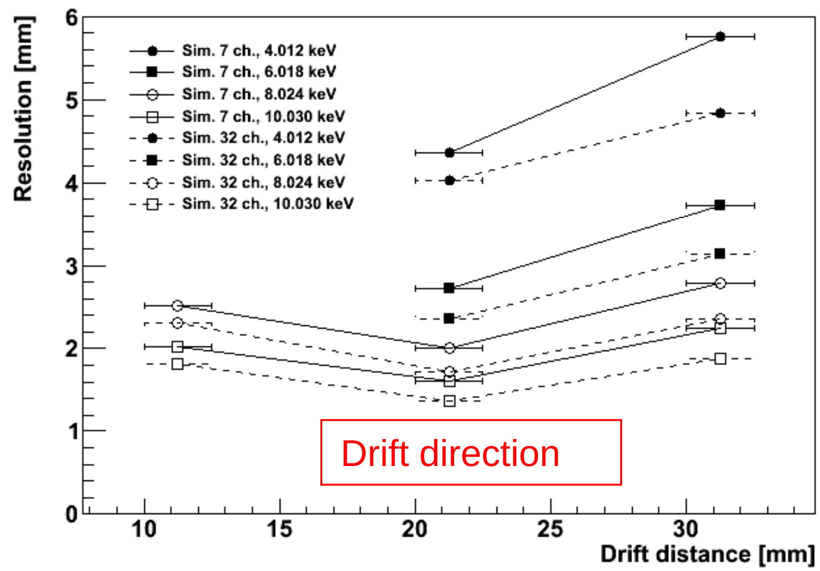
4.5 keV Simulated



100 µm

5 mm





The MIRAX mission

- First Brazilian-led astronomical satellite project
- High-energy astrophysics observational window for the Brazilian community
- International collaboration ⇒ expertise in space missions and cost sharing
- Strong participation of Brazilian institutions and industry
- public data in MIRAX mission centers, NASA HEASARC archive and others

MIRAX brief history

- **May 2000:** Selected by INPE's Astrophysics Division to be part of INPE's scientific satellite program
- **2000:** Collaboration with CASS/UCSD: crossed-strip CdZnTe detectors
- **2001:** Collaboration with IAA/Tübingen: onboard computer and software development
- **2001:** Collaboration with MIT: science and software for data analysis, archiving and distribution
- **2001:** First presentation at Brazilian Astronomical Society (SAB) meeting - open to community participation
- **2002:** - Approved by AEB (Brazilian Space Agency)
  - First workshop held at INPE S.J.Campos
- **2004:** HXI detailed design and simulations start

MIRAX brief history

- **2005:** - Included explicitly at Brazilian National Plan for Space Activities
  - Second workshop held at INPE – AIP proceedings book
- **2007:** Decision to put MIRAX onboard Lattes (alongside EQUARS – atmosphere, aeronomy mission)
- **2008:** protoMIRAX balloon project started; UCSD CZT detectors phased-out due to lack of NASA funding
- **2009**: initial contacts about a possible collaboration with Un. Ferrara - Prof. Filippo Frontera - and INAF – Marco Feroci and Lorenzo Amati: soft X-ray and gamma-ray instruments for GRB science:
- **2010:** meeting in Brazil with Italian researchers and engineers; ICRANet support – Prof. Remo Ruffini

MIRAX baseline parameters

Mission and spacecraft parameters		
Mass	~500 kg (PMM total), ~120 kg (MIRAX payload)	
Power	~240 W (total), ~100 W (MIRAX payload)	
Orbit	Near equatorial (15 º) , circular, ~600 km, 4 years	
Telemetry	Telemetry: X-band, ~2-3 Mbps TBD	
Launch	not earlier than 2015; launcher to be selected	
Instrument parameters	Hard X-ray Imager (HXI) - INPE	GRB/ASM (preliminary) INAF/INFN/Univ.
Energy range	10-200 keV	2 keV – > 1 MeV
Angular Resolution	$< 1^{o}$ TBD	4 arcmin
Detector type	2mm-thick CZT array	Silicon drift chamber/CsI
Spectral resolution	< 5 kev @ 60 keV (FWHM)	~1 keV @ 60 keV
Localization	< ~ 10 arcmin (10 σ) – TBD	< ~ 1 arcmin (10 σ)
Field-of-view	20^{o} x 20^{o} FWHM – TBD	2 sr
Sensitivity	~ 10 mCrab (1 day, 5 σ)	< 5 mCrab (1 day, 5 σ)

The proposed Italian payload for MIRAX

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Proposed Implementation:

- All-Sky X-ray Monitor (XRM):
  2-50 keV, 6 units, Imaging, Silicon Drift Detectors with Coded Mask
- Soft Gamma-ray Spectrometer (SGS):
  20 keV – 5 MeV, non-imaging, NaI(Tl)/CsI(Na) crystals in phoswich configuration

The X-Ray Monitor

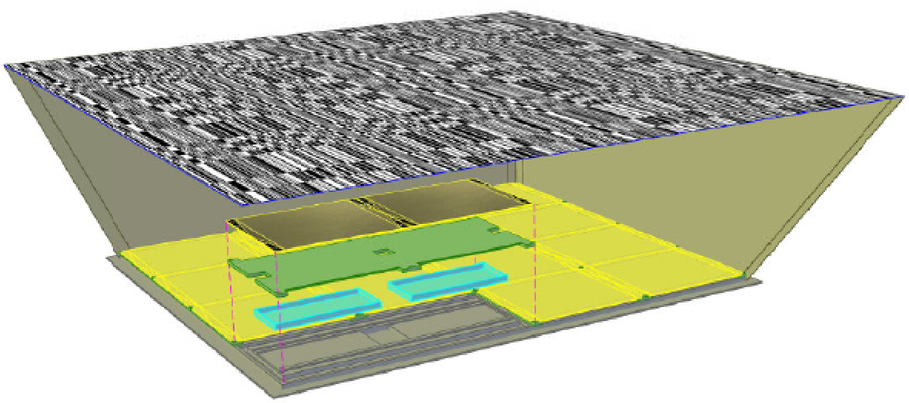
The SDC detector has asymmetric position resolution: ≤100μm in one direction and ~2-3 mm in the orthogonal direction.

⇒ Asymmetric 2D coded mask

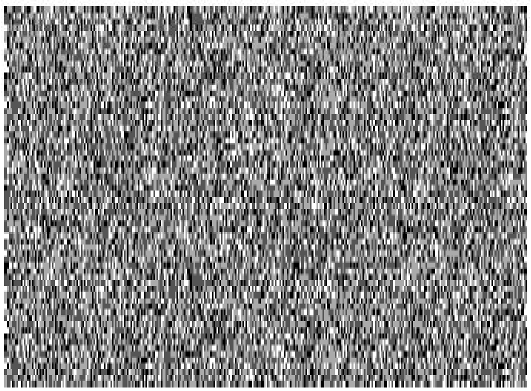
⇒ 2 orthogonal units always looking at the same FoV to guarantee arcmin prompt localization of Gamma Ray Bursts (double area for persistent sources)

Modular approach: the detector size can be adjusted to match the scientific requirements and fit the mass/volume/power/telemetry/budget constraints.

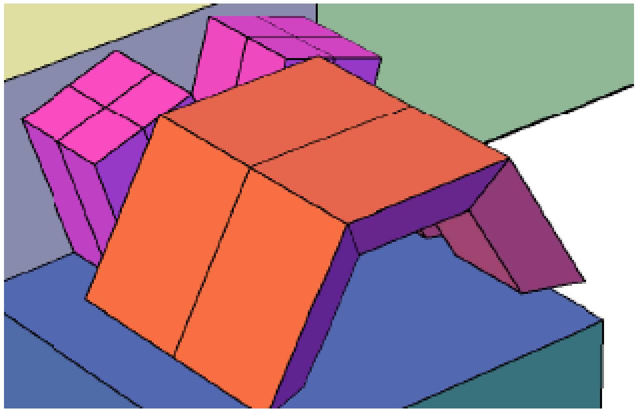
Single Camera Module

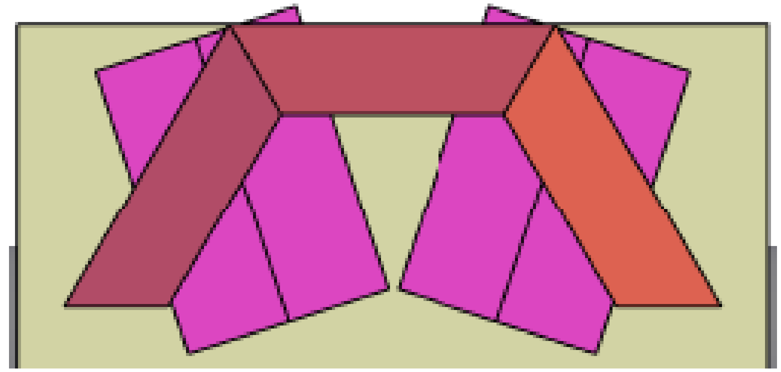


2D Asymmetric Coded Mask



A possible experiment geometry





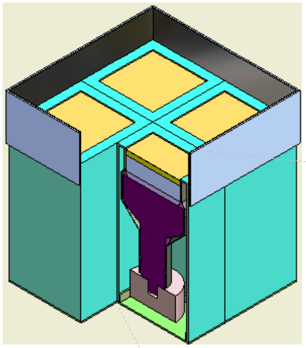
Single Detector unit [cm^2]:	30.00 x 22.0 (640)
Mask [cm^2]:	43.86 x 32.0
Mask-detector distance [cm]:	12.0
Angular Resolution [arcmin]:	6
Fully-coded angle, X direction [deg]	60.0
Fully-coded angle, Y direction [deg]	45.2
Fully-coded FoV [sr]	0.77
Partially-coded FoV [sr]	3.44
FoV zero response, X direction [deg]	144.0
FoV zero response, Y direction [deg]	132.1

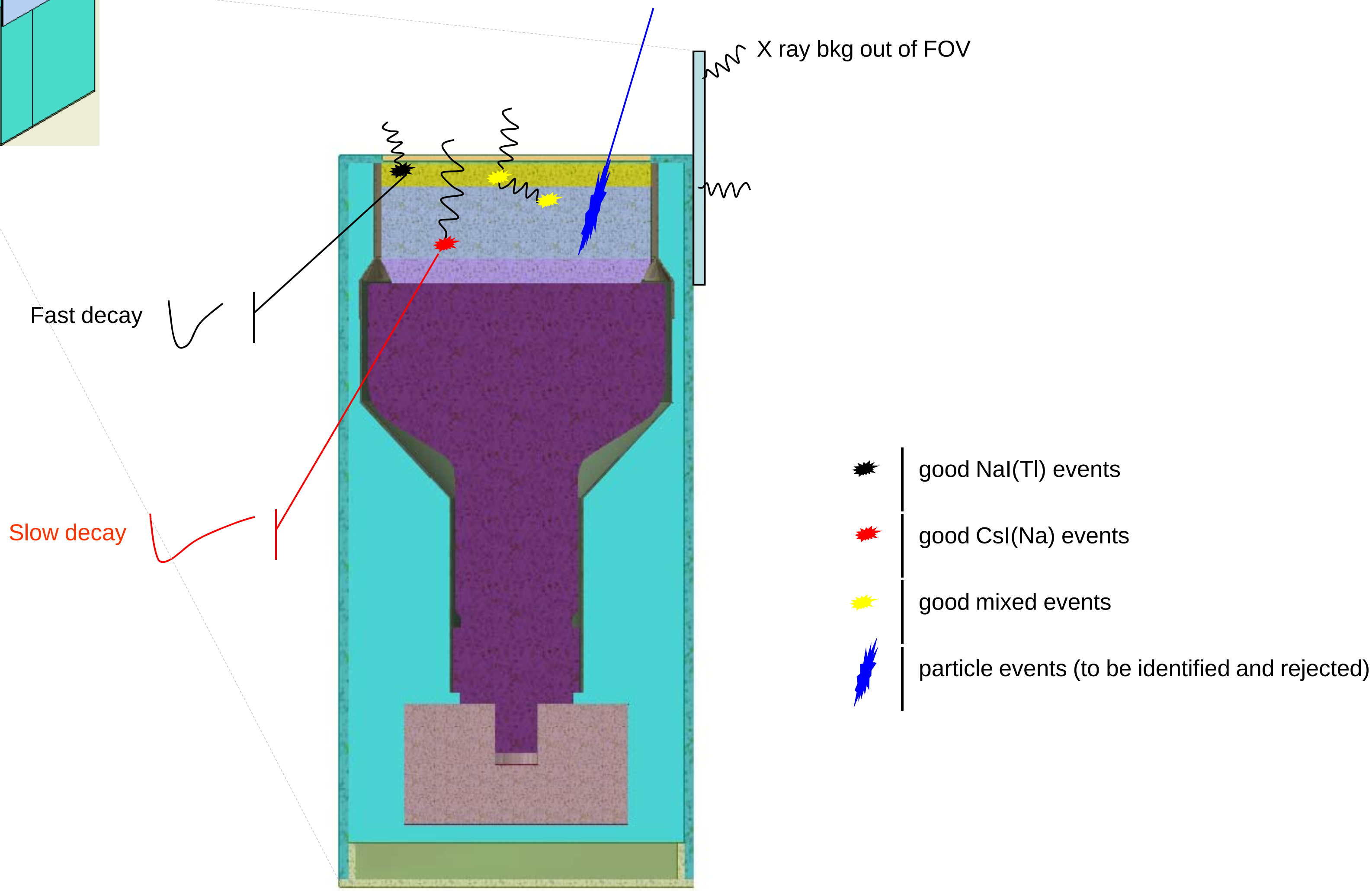
Transit time in fully-coded FoV [s]:	678.6

X-ray Monitor parameters

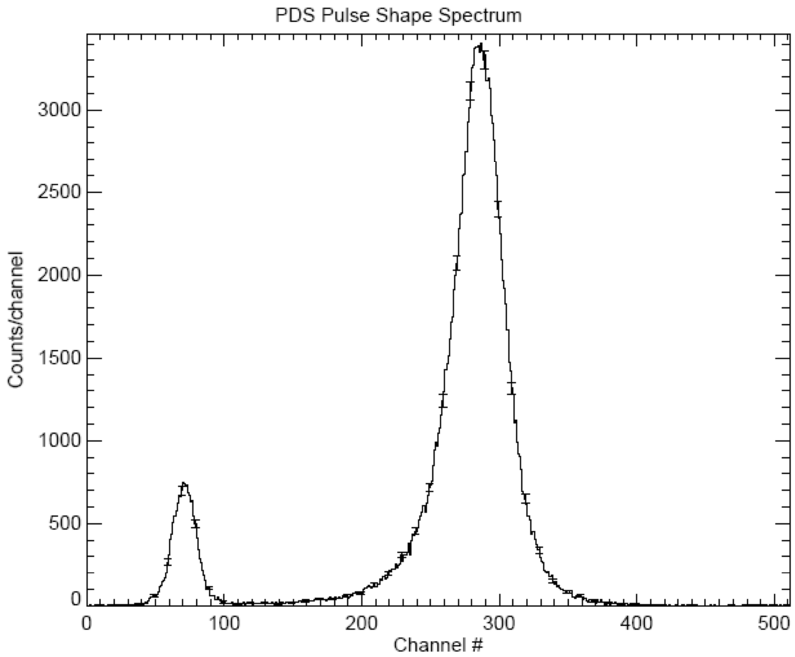
Parameter	**Expected Value**
Energy Range	2-50 keV
Energy Resolution	From 250 to 500 eV FWHM
Time Resolution	~10 μs
Effective Area	~550 cm^2 in FCFoV (spectroscopy)
Angular Resolution	5 arcminutes
Point Source Location Accuracy	<1 arcminute
Field of View	~2.5 steradians FCFoV ~3.5 steradians PCFoV
Sensitivity (5-σ, 1 detector, imaging, for spectroscopy 1.4 better)	700 mCrab or ~2 ph/cm^2/s in 1s, FCFOV 90 mCrab or ~0.3 ph/cm^2/s in 60s, FCFOV <26 mCrab/orbit in >Half Sky <10 mCrab/elapsed day over All Sky ~ 3 mCrab/50 ks
Source Transit Time in FoV	700 s /orbit
Telemetry (orbit average)	3800 kbits/s

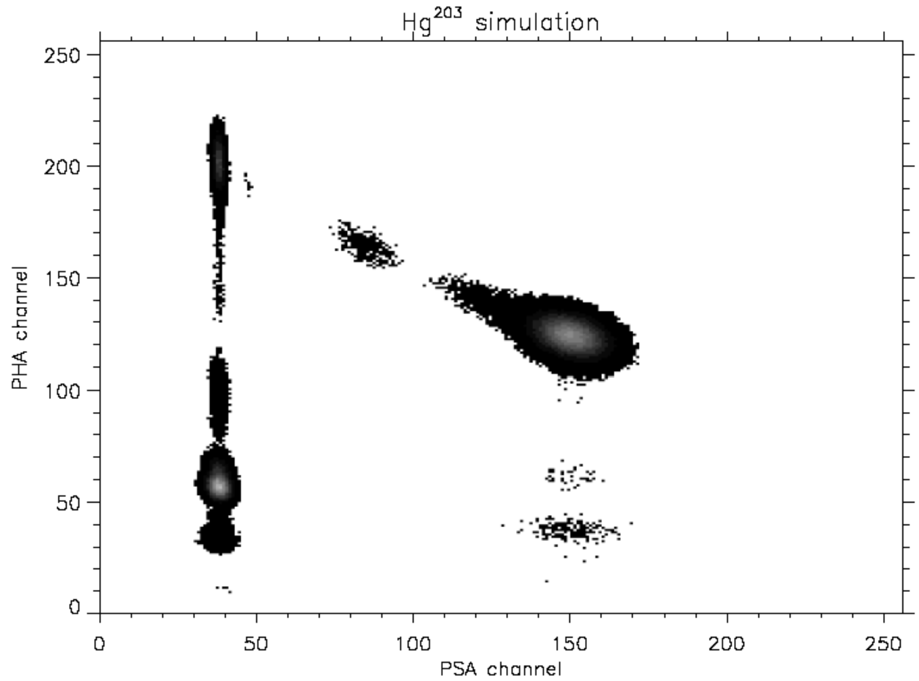
The Soft Gamma-Ray Spectrometer: phoswich configuration





Effectiveness of phoswich technique





Effectiveness of the Pulse Shape Analysis (PSA) for the phoswich detectors of the BeppoSAX/PDS instrument

PSA parameter is a measure of the duration in time of a fraction of the signal (typically from 20% to 90% of the maximum)

PHA is Pulse Hight Amplitude of the signal

Soft Gamma-ray Spectrometer parameters

Parameter	Expected Value
Energy Range	20 - 5000 keV
Energy Resolution	15% @ 60 keV , 8% #662 keV
Time Resolution	~ 1 μs
Effective Area (on axis)	~1000 cm2 up to 300 keV, ~ 700 cm2 up to 1000 keV
Field of View	~2.5 steradians
Sensitivity (5-σ)	~ 1 Crab in 1s
Telemetry (orbit average)	40 kbits/s

MIRAX Mission Profile

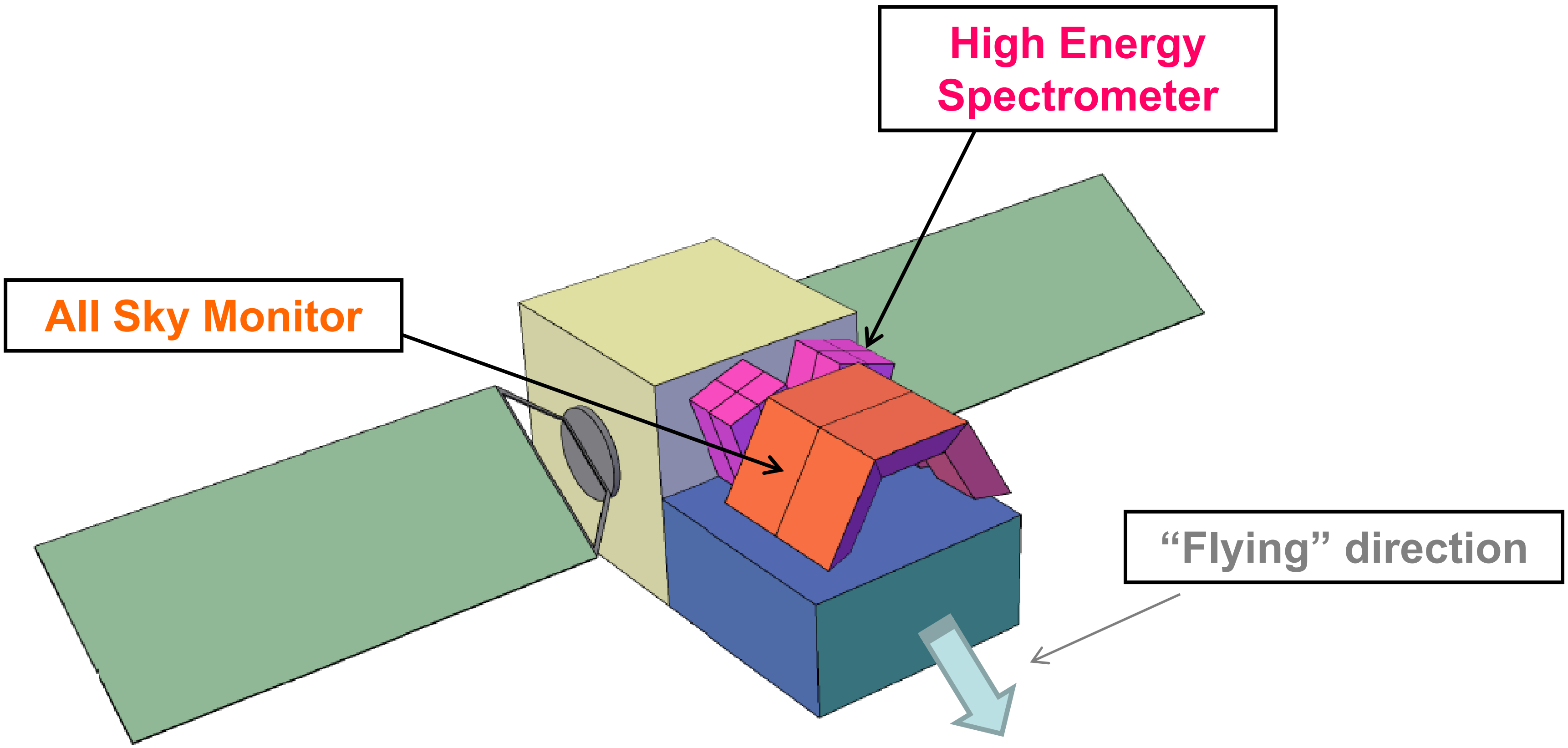
The *Lattes* mission will bring a ~ 1 m x 1 m x 1 m Payload Bay.

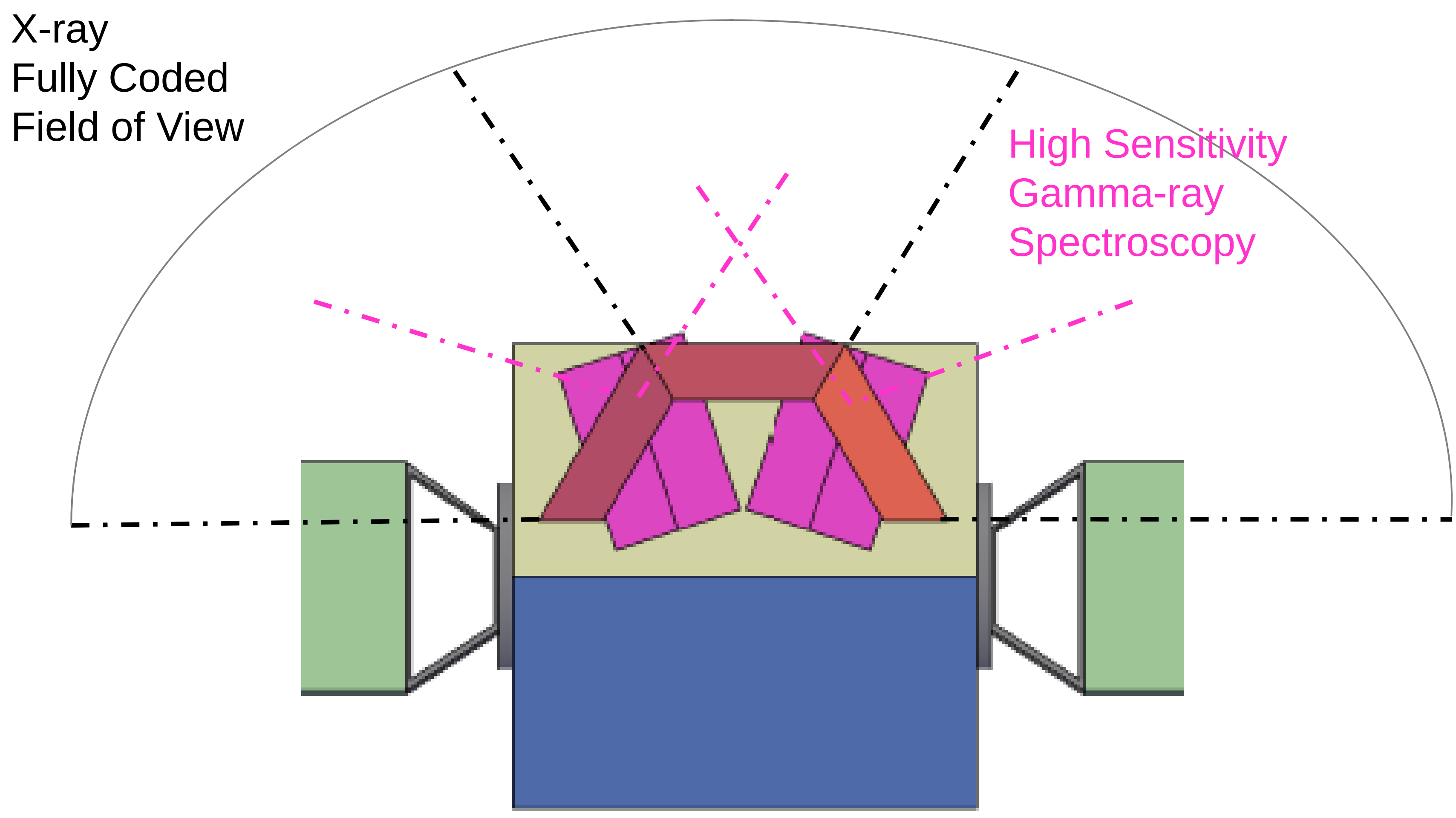
The *Lattes* Payload Bay will host two scientific missions:
• the MIRAX high energy astrophysics mission
• the EQUARS atmospheric science mission

The *Lattes* satellite will “fly” over the Earth, always exposing the same orientation to the Nadir and Zenith directions. This strategy will allow the two missions to operate simultaneously (EQUARS will always look at the atmosphere, MIRAX will always look at the open sky).

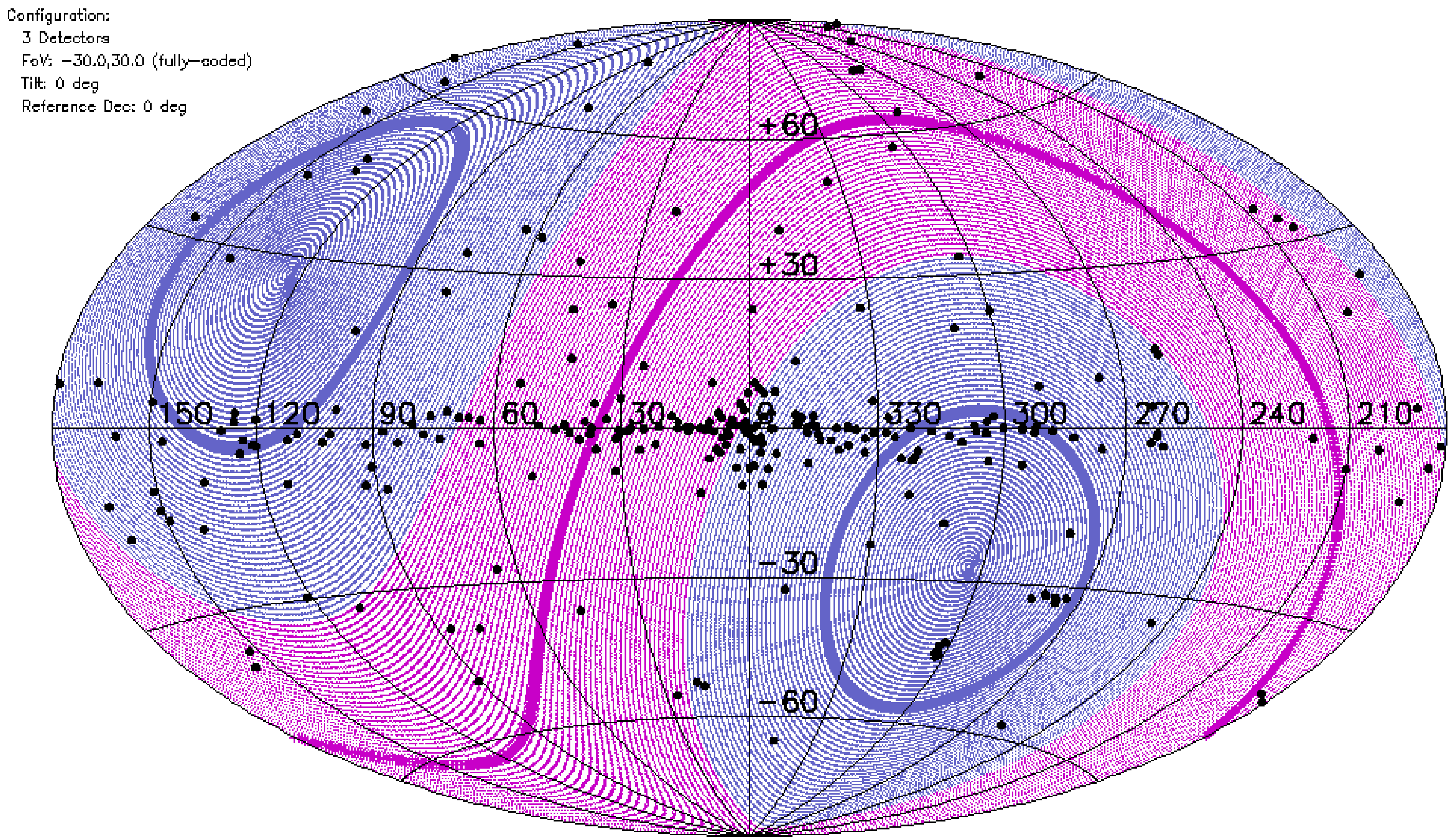
The MIRAX attitude will scan the sky at the speed of 4º/minute. This will enable the MIRAX XRM and SGS experiments to scan almost the full sky, avoiding the Earth blockage .

Possible MIRAX Payload Configuration

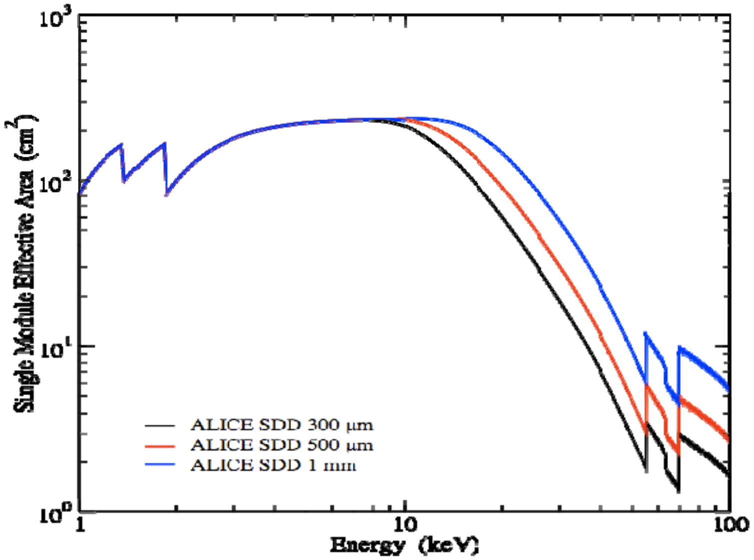



X-ray
Fully Coded
Field of View
High Sensitivity
Gamma-ray
Spectroscopy

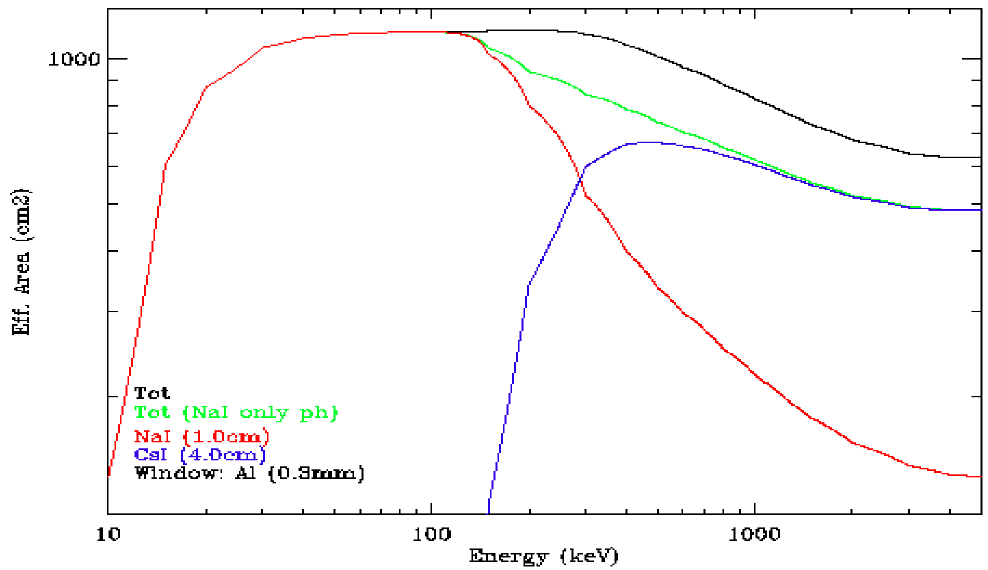
X-ray Sky Coverage every orbit (90 minutes)



Broad Band Spectral Coverage

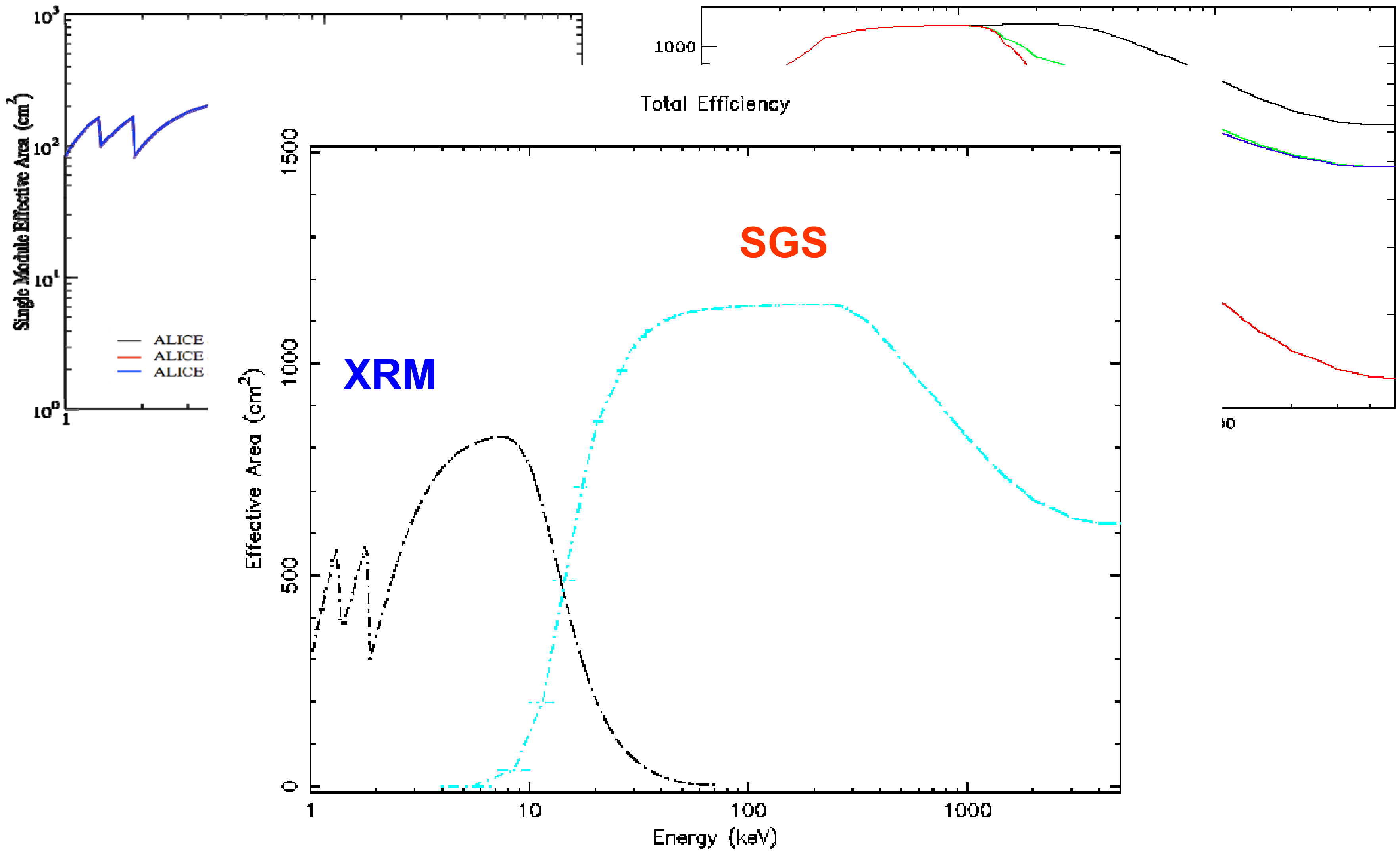


XRM

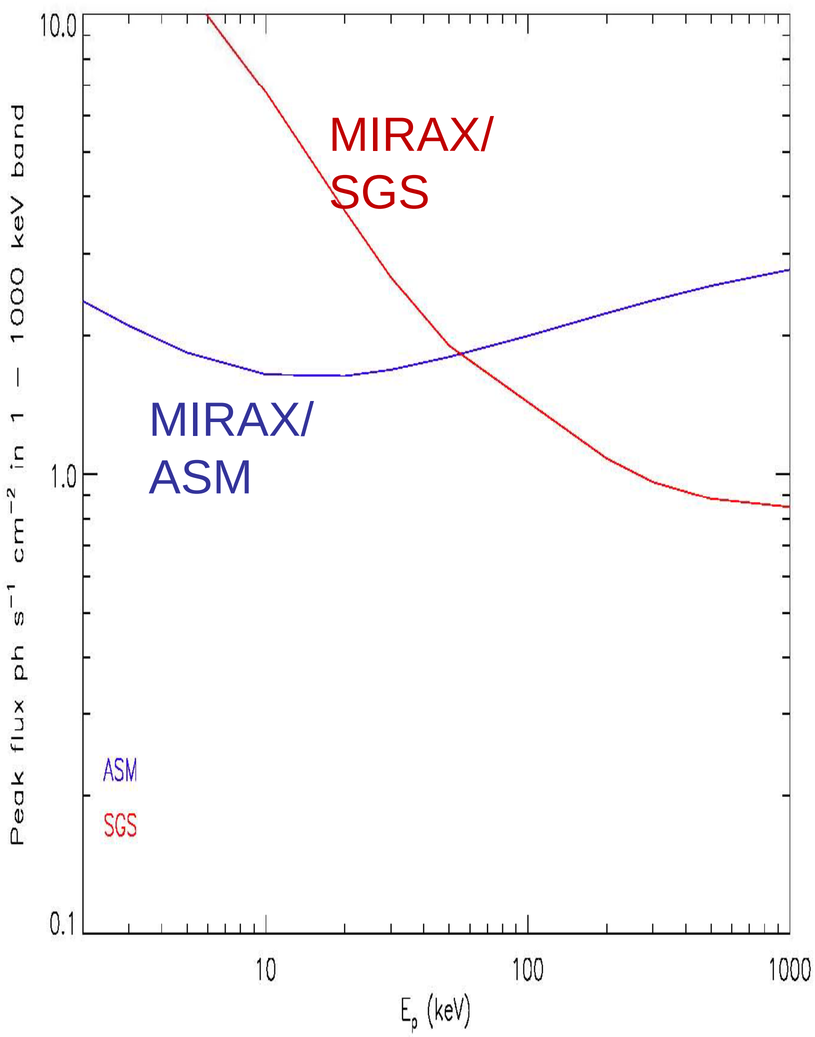


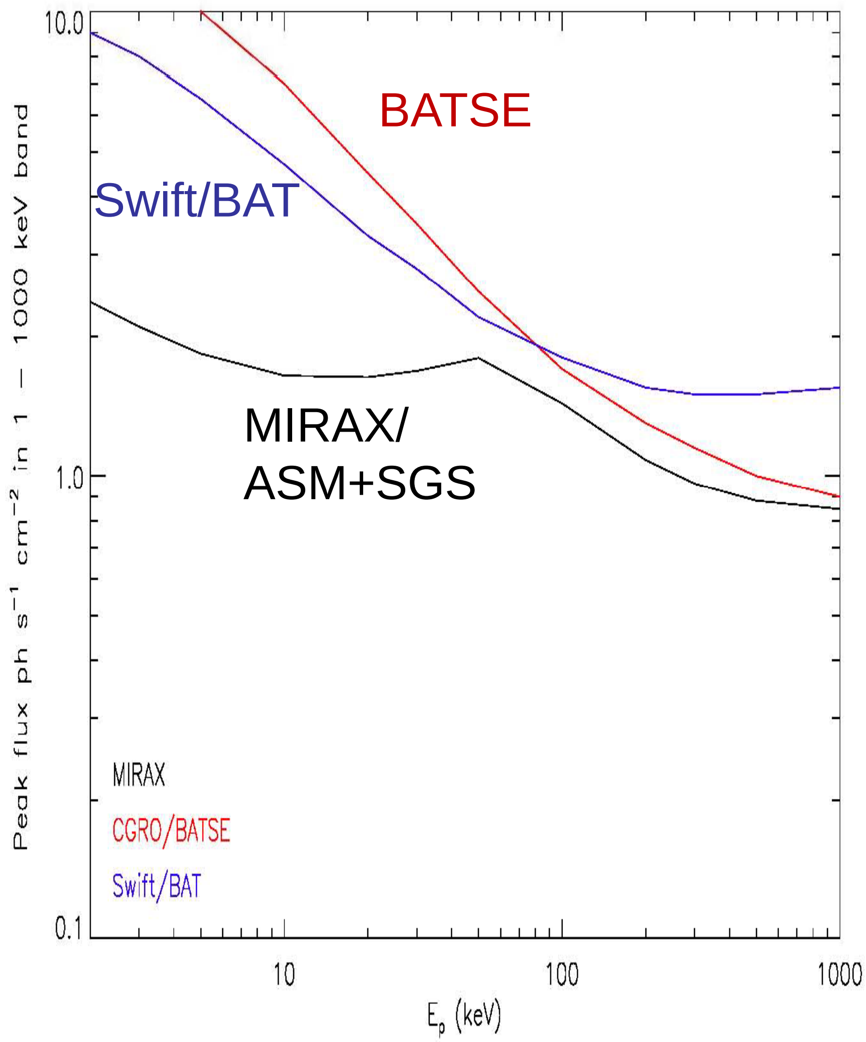
SGS

Broad Band Spectral Coverage

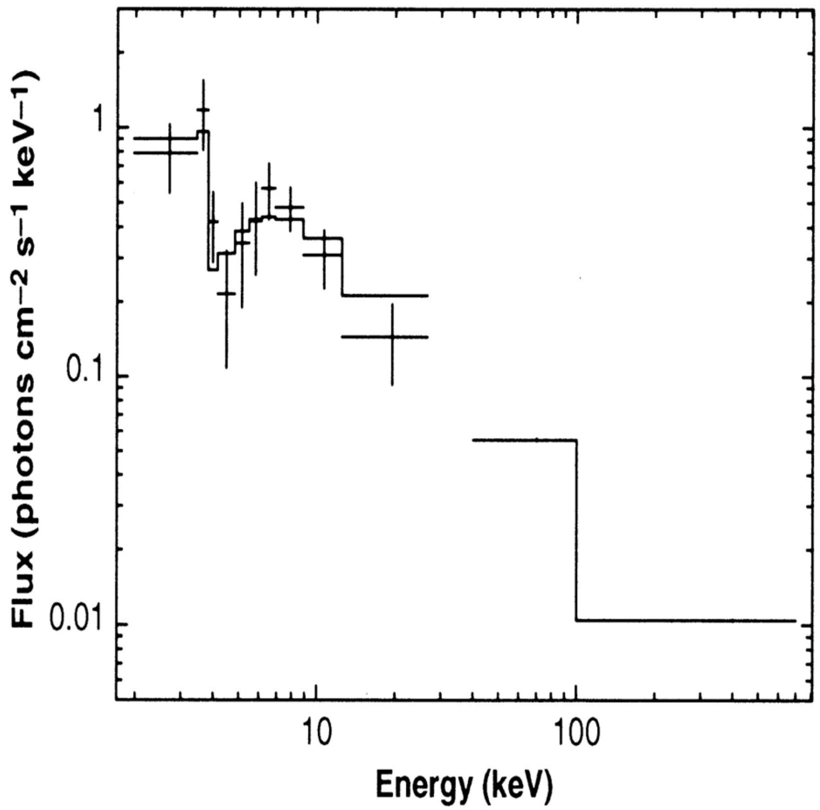


GRB trigger sensitivity

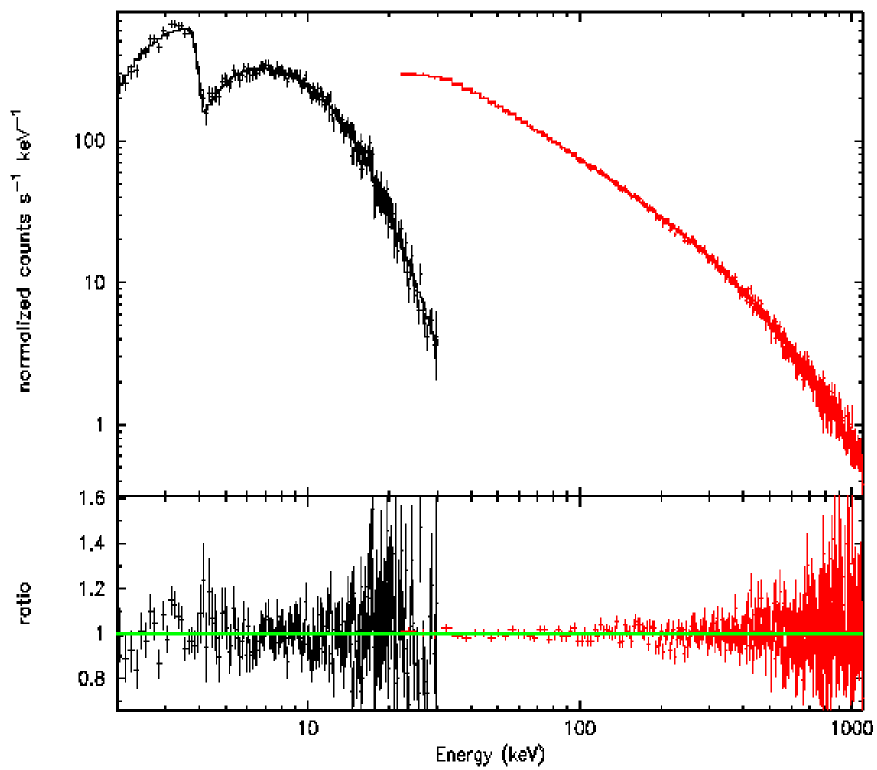




The energy spectrum of GRB990705 (k-edge)

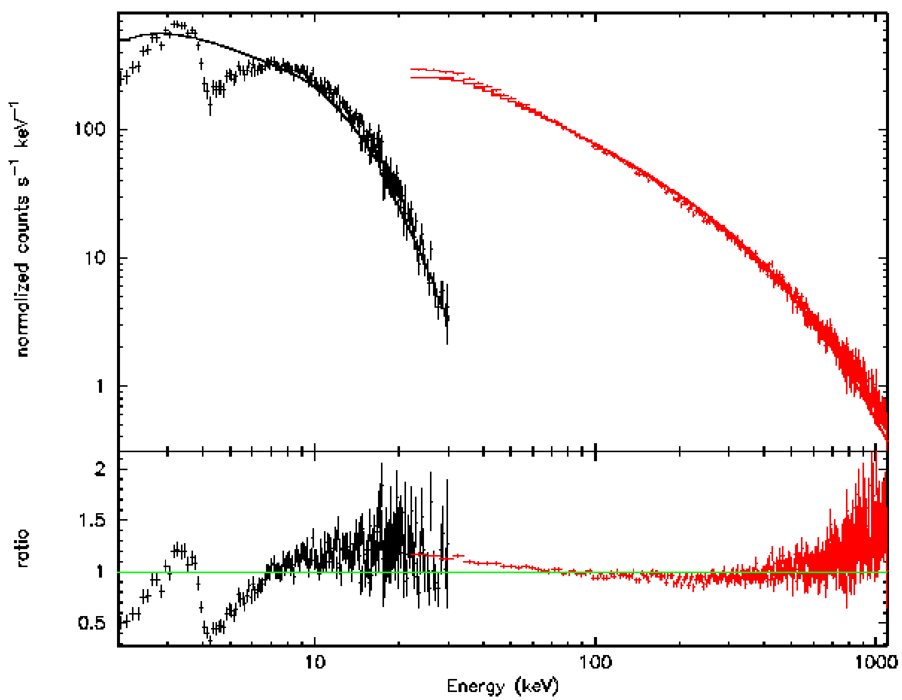


BeppoSAX WFC+ GRBM



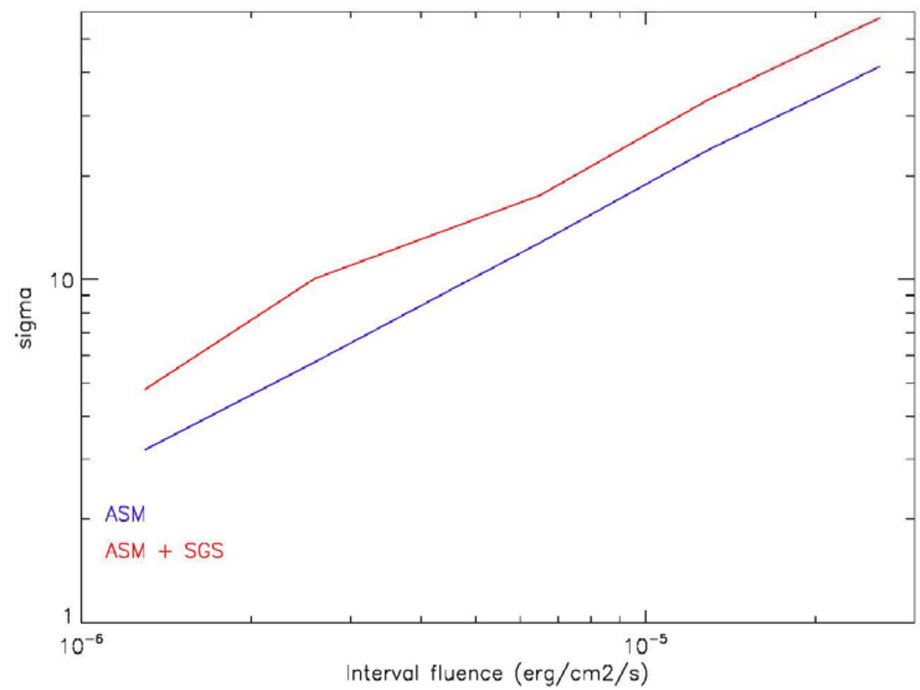
MIRAX ASM+SGS,

MIRAX Simulation of the energy spectrum observed from GRB990705 with BSAX/WFC



Spectrum ASM+SGS, fit with an absorbed Band law

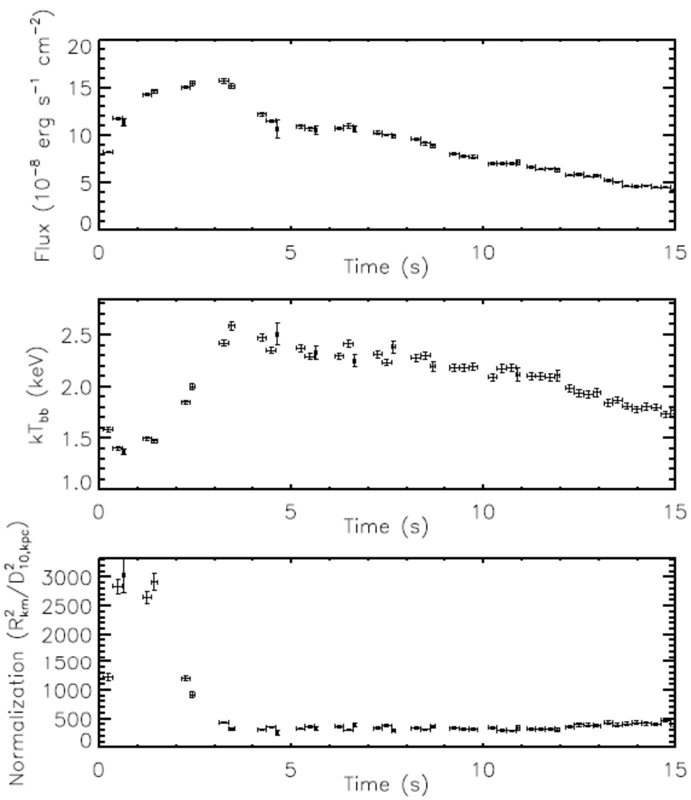
Sensitivity vs. GRB total fluence



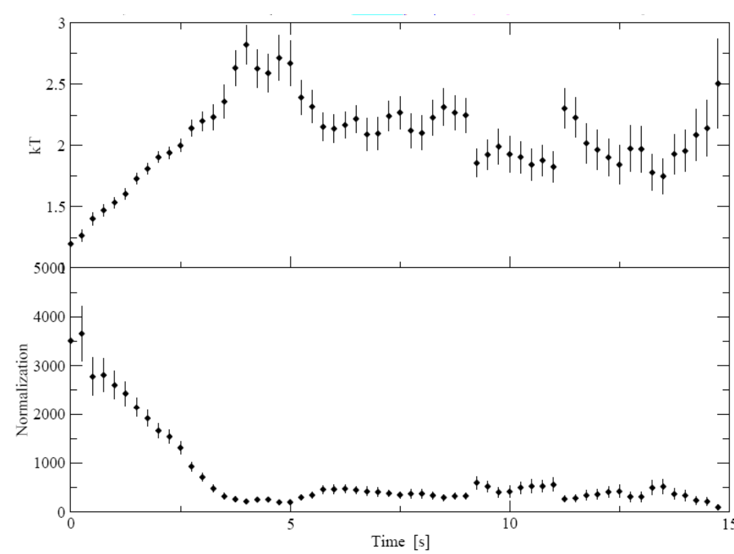
Assumption: the same spectral shape and K-edge optical depth (1.5) of GRB 990705

Constraints to NS Equations of State from thermonuclear PRE X-ray bursts in 4U 1608-52

In Low Mass X-ray Binaries with known distance, a time-resolved spectral modelling of PRE (Photospheric Radius Expansion) type I X-ray bursts can provide information about the Mass and the Radius of the Neutron Star (by measuring the “touchdown flux” and the BB normalization). Below the case of 4U 1608-52 as studied by Gruver et al. (ApJ 2010) with RXTE/PCA.



MIRAX Simulated Observation



The Microquasar GRS 1915+105

The Galactic microquasar GRS 1915+105 displays an unpredictable and largely not yet understood variabilty. Here the case of a simultaneous radio-X flare, observed with BepoSAX/NFI and Ryle Telescope. Spectral evolution is well described by the temporary emptying of the inner accretion disk during the X-ray dip following the flare, and coincident with the radio flare.

BeppoSAX/NFI

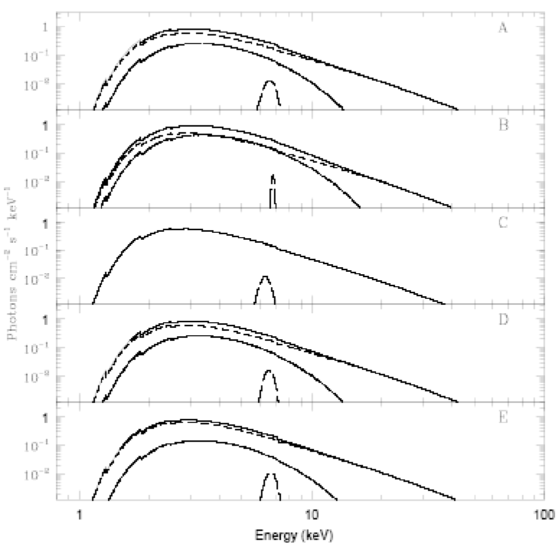


Fig. 4. Best fit models for the broad band BeppoSAX spectra in the five sections shown in Fig. 1. The model include an absorbed ($N_h \sim 5.6 \times 10^{22}$) power law with a high energy cut-off and a Compton reflection component from a disk (dashed curve), a multi-temperature disk blackbody (dot-dash), and an Iron line (long dash). The continuous line shows the sum of the various components.

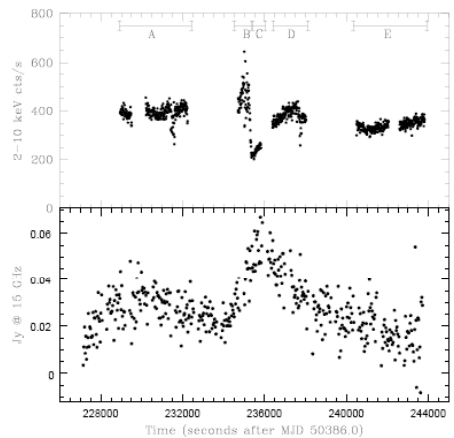
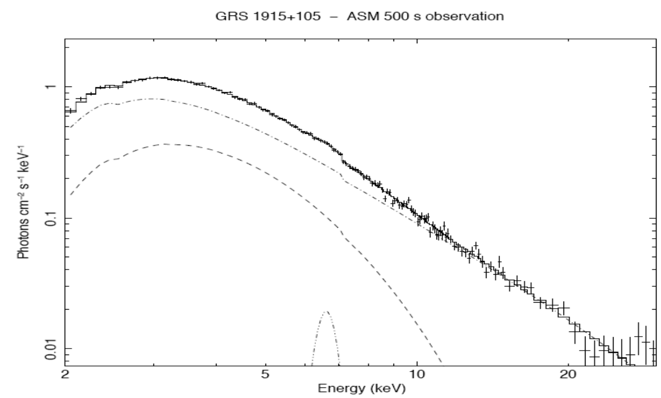


Fig. 2. BeppoSAX MECS (2–10 keV, bin size 10 s) and Ryle Telescope (15 GHz, 32 s bin size) light curve of the flare from GRS 1915+105.

MIRAX



Parameter	BSAX	MIRAX
kT	1.53±0.05	1.53±0.06
Γ	2.36±0.04	2.38±0.06
E_{line}	6.57±0.14	6.60±0.10
Integration Time	3500 s	500 s

Conclusions

MIRAX is a unique opportunity for the Italian high-energy astrophysics community (INAF, INFN, Univ.), allowing to:

- achieve primary scientific goals on GRBs and galactic sources and provide a fundamental service to the world-wide community (prompt emission of GRBs from 10 MeV down to 1 keV, X-Ray all-sky monitoring in 2-50 keV with unprecedented FOV and sensitivity)

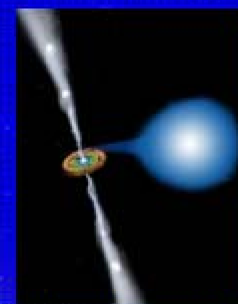
- exploit R&D activities supported by INAF, INFN, ASI and Universities (Ferrara, Pavia, …)

- exploit a unique launch opportunity in a short time scale (2015-2016) with bus, platform and sub-systems provided by Brazil

- fulfill existent agreements of collaboration in space programmes between Italy and Brazil, AEB and ASI

MIRAX ASM SCIENCE

Continuous imaging spectroscopy of a large source sample

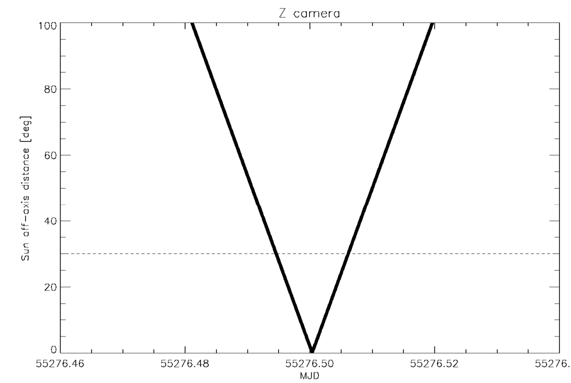


⇓

- Complete history of transient phenomena on X-ray sources
- Detailed characterization of X-ray non-thermal emission
- Spectral state transitions and evolution on accreting compact objects
- X-ray bursts – superburst recurrence times and emergence of normal bursts after superbursts
- Accretion torques on neutron stars
  ⇒ accreting pulsars, pulse period evolution, ms-pulsar recurrent outbursts
- Relativistic jets on microquasars and other systems
  ⇒ X-ray light curves during radio ejections
- Flaring X-ray sources and fast transients (many INTEGRAL sources)
- Gamma-ray bursts, especially XRFs
  ⇒ X-ray AGs seen immediately
- AGN variability

How about the Sun?

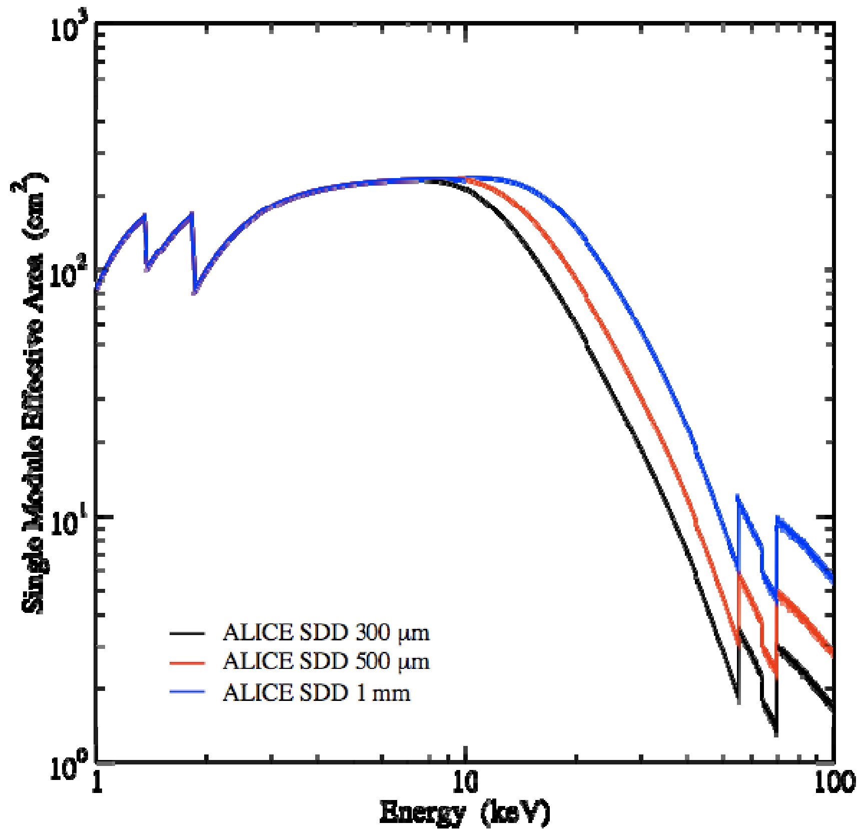
X-ray fluxes from the Sun (assuming a thermal bremsstrahlung spectrum with temperatures of 2×10^6 K , 5×10^6 K and 8×10^6 K, normalized to the non-flaring emission of 10^{-5} erg/cm^2/s). Energy bins with Sun flux above 1000 mCrab are highlighted in red.

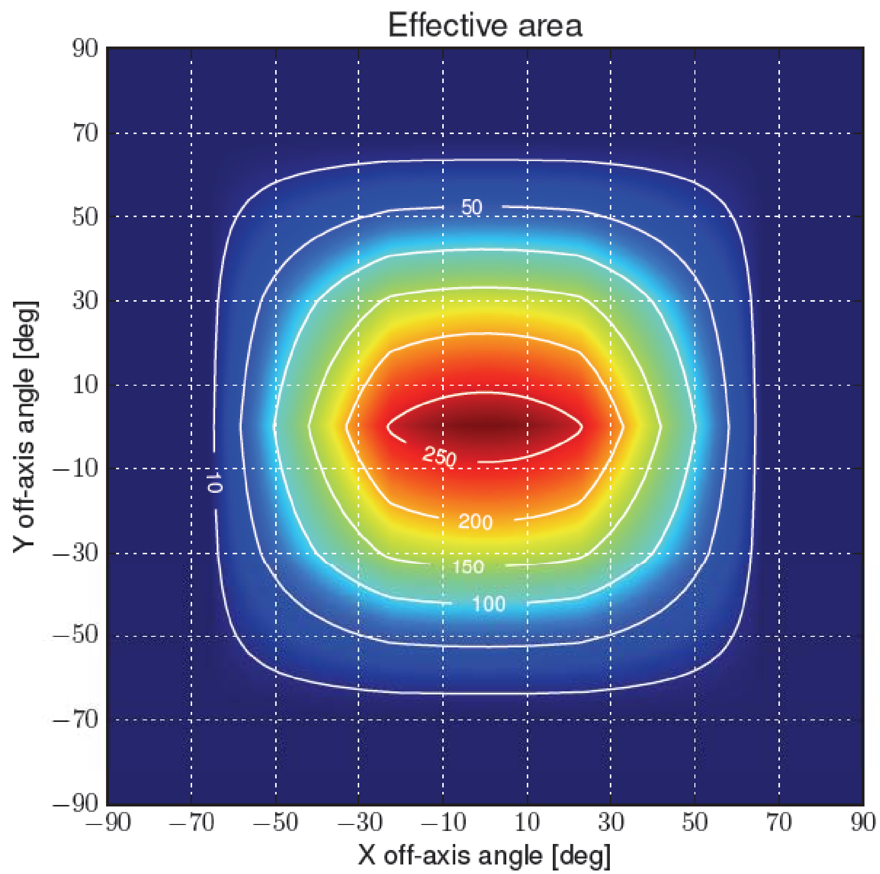


Date	Orbit fraction with the Sun inside the Z camera [%]
1 January	11.0
1 February	14.0
1 March	16.2
21 March	16.7
1 April	16.5
1 May	14.5
1 June	11.6
21 June	10.7
1 July	11.0
1 August	13.6
1 September	16.1
23 September	16.7
1 October	16.6
1 November	14.8
1 December	11.7
21 December	10.7

Energy range [keV]	Flux 2×10^6 K [erg/cm^2/s ; mCrab]	Flux 5×10^6 K [erg/cm^2/s ; mCrab]	Flux 8×10^6 K [erg/cm^2/s ; mCrab]
2 – 3	5.4×10^{-7} ; 98182	2.7×10^{-6} ; 490909	3.6×10^{-6} ; 654545
3 – 5	1.5×10^{-9} ; 211	2.5×10^{-7} ; 35211	9.0×10^{-7} ; 126760
5 – 7	2.1×10^{-14}	2.5×10^{-9} ; 531	4.5×10^{-8} ; 9574
7 – 10	0	2.2×10^{-11} ; 4	2.4×10^{-9} ; 490
10 – 15	0	1.9×10^{-14}	2.8×10^{-11} ; 5
15 – 20	0	0	2.9×10^{-14}
20 – 30	0	0	0
30 – 50	0	0	0

All Sky Monitor experiment





Efficiency ~1 up to 10 keV, can be increased in the range 20-100 keV with thicker detectors

Effective area versus off-axis angle

“Italians who??” *Background & Expertise*

X-/Gamma-ray Astronomy:

- Balloon Flights (70’s-80’s: FIGARO, LAPEX, …)
- Spectrum-X-Γ/Stellar X-ray Polarimeter (90’s, CoI, never flown)
- BeppoSAX/ PDS & GRBM (1996-2002, PI)
- INTEGRAL IBIS/PICsIT (2002- ….., PI)
- INTEGRAL JEM-X (2002-….., CoI)
- AGILE/SuperAGILE (2007-…., PI)
- AGILE/MCAL (2007-…., PI)
- AGILE Program Manager

Particle & Astroparticle Physics:

- Pamela
- LHC/ALICE-ITS

The Basic Idea

Despite the severe limitations at design and development level, SuperAGILE is able to perform ~arcmin imaging of the X-ray sky over a ~steradian field of view, with less than ~10 kg, ~10 W and ~0.03 m^3.

It demontrates reasonable to work for the design an All Sky X-ray imaging experiment employing small resources

What Silicon Detector?

- SuperAGILE employs Silicon microstrips: cover large areas (monolithic 100 cm^2) with small number of channels.

  Noise performance directly related to the strip length, due to strip capacitance, and then to geometric area:

  large areas imply high discrimination thresholds (SuperAGILE 18 keV).

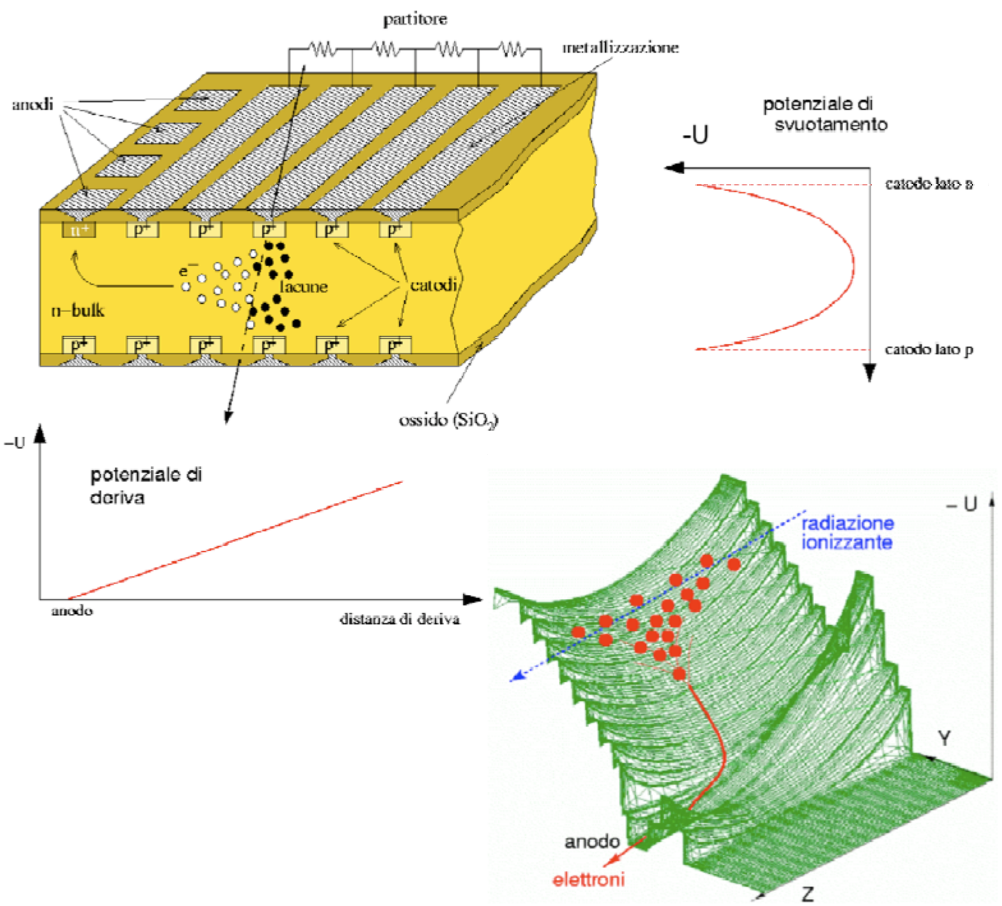
- Silicon Drift Chambers (SDCs) allow to obtain a noise performance (nearly) independent of the detector active area, by drifting the charge to small anodes. Usually available in small areas and pixel-design (2D read-out problem).

- ALICE-like SDCs exploits the drift concept in a multi-linear design, like in the microstrip (1D read-out), and with 53 cm^2 monolithic detectors.

  Large areas with low discrimination thresholds (~1-2 keV).

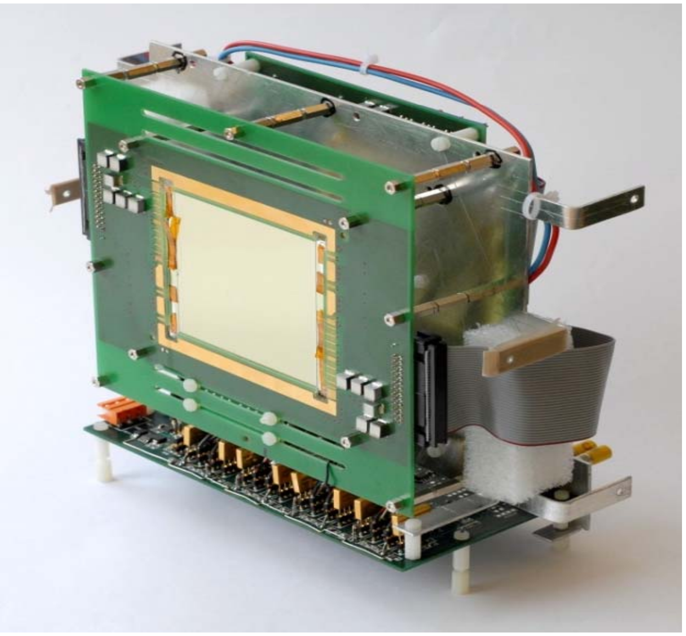
The “ALICE-like” Silicon Drift Detector

- A series of cathodes create a linear electric drift field towards a series of anodes
- Incident X-rays create electron-hole pairs
- Electrons are focused on the middle plane of the detector and drift towards the anodes
- Large collecting area, low output capacity



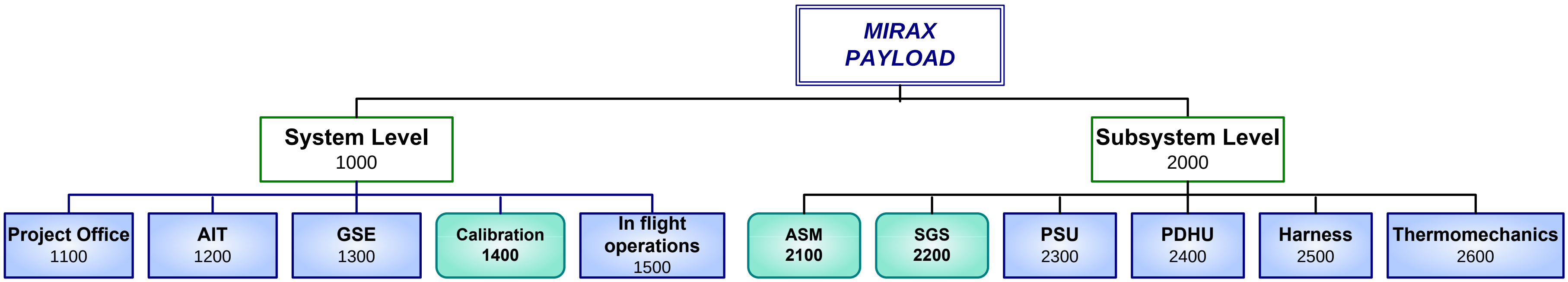
X-ray spectroscopy tests with two lab prototypes

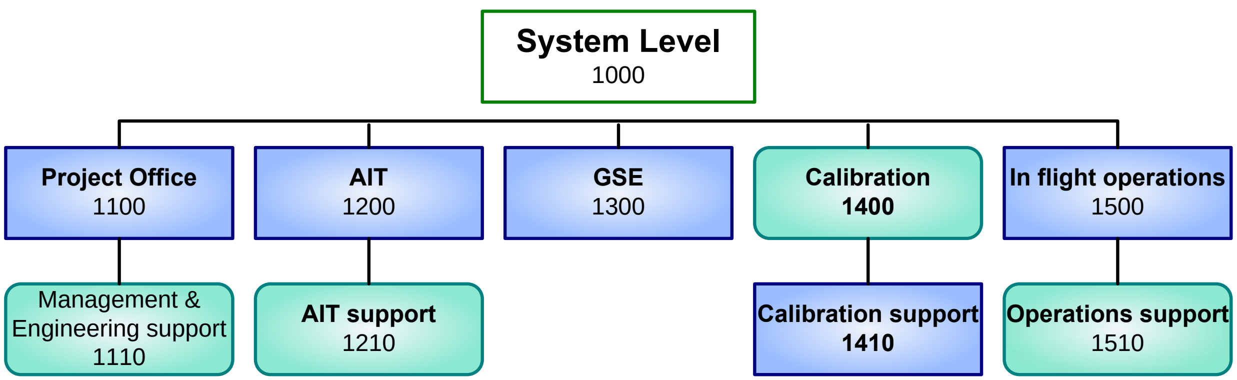
- Tests with a 4-anode channel first prototype
  1. Reached a lower energy threshold of 1-2 keV
  2. Resolution of 500 eV FWHM at 6 keV at room temperature
- Tests with 8 single anode channels prototype
  1. Reduction of common mode noise using many channels
  2. Resolution of 270 eV FWHM at 6 keV at room temperature for “single” events (i.e. with all the charge deposited on a single anode)



The 8 single-anode channels laboratory prototype
with discrete front-end electronics
(the flight version will be MUCH more compact!)

WBS – Work Breakdown Structure





MIRAX baseline parameters

Mission and spacecraft parameters	
Mass	~500 kg (PMM total), ~100 kg (MIRAX payload)
Power	~240 W (total), ~90 W (MIRAX payload)
Orbit	Near equatorial , circular, ~600 km, 4 years
Telemetry	Telemetry: S-band, ~1.5 Mbps
Launch	not earlier than 2014; launcher to be selected
Instrument parameters	Soft X-ray Imager (2-4 units) Soft Gamma-ray Spectrometer (4-6 units)
Energy range	2-5000 keV
Angular Resolution	<5 arcmin
Spectral resolution	< 0.5 kev @ 2-30 keV (FWHM)
Localization	< 1 arcmin (10σ)
Field-of-view	> 2 steradians
Sensitivity	< 2 mCrab (1 day, 5 σ)

Development of Dedicated SDD cameras

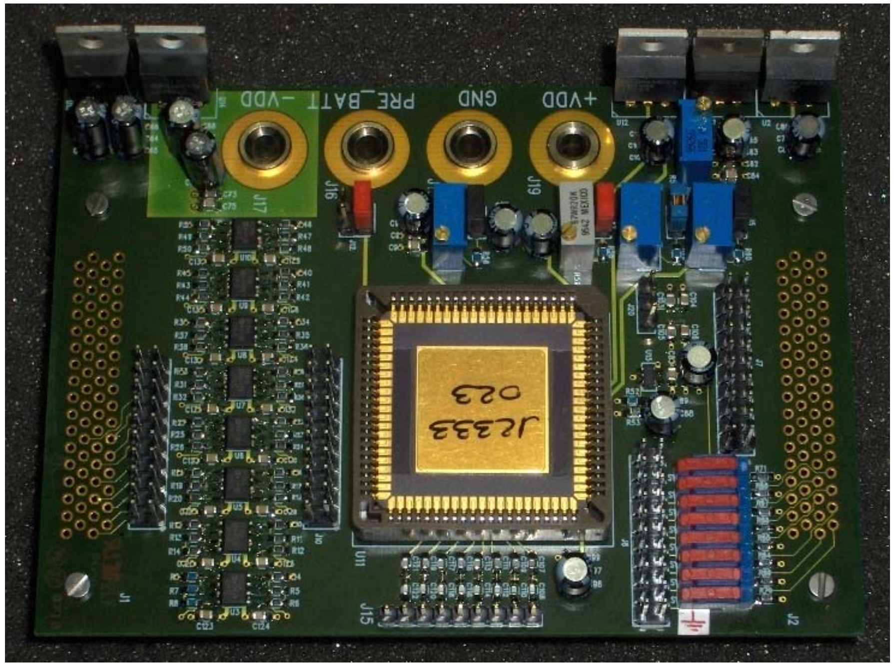
The current detector is a spare model of the ALICE-ITS production, not intended for X-ray spectroscopy applications.

The production of new models, with changes to the design aimed at optimizing the X-ray spectroscopy performance and the power consumption has been submitted.

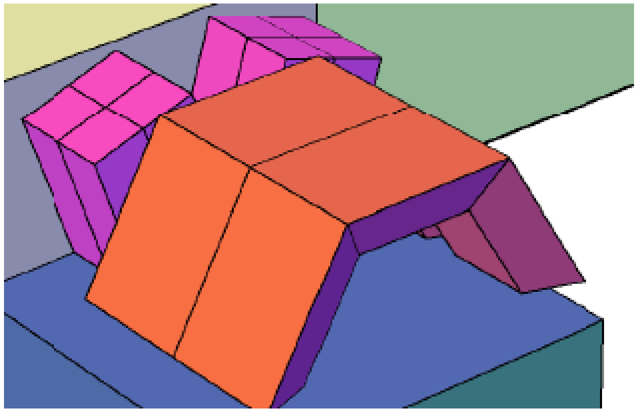
Thickness 450 µm.

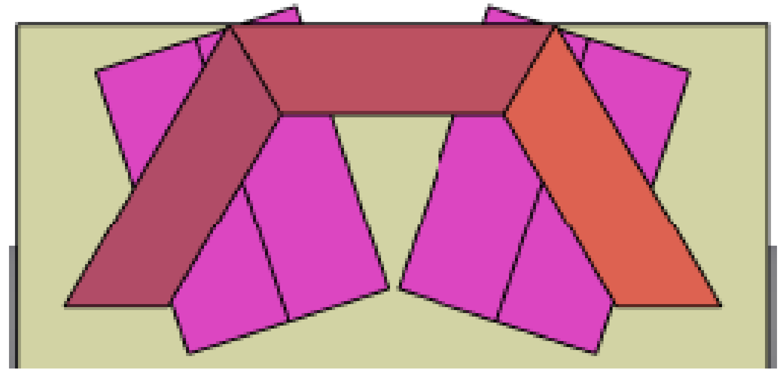
First prototypes expected for delivery in September 2010

Development of a Dedicated ASIC chip



A possible ASM Experiment Performance





Crab rate [counts cm^{-2} s^{-1}]:	1.7880000
Background rate [counts cm^{-2} s^{-1} sr^{-1}]:	2.8920000
Crab rate on-axis [cps]:	489.73
Background rate [cps]:	4529.38
On-axis sensitivity [mCrab/s, 5sigma]:	687.12
Transit time in fully-coded FoV [s]:	678.59
On-axis sensitivity [mCrab/orbit, 5sigma]:	26.38
On-axis sensitivity [mCrab/50ks 5sigma]:	3.0
Crab obs. telemetry (128bit/event) [kbit]:	642.45
Weight/unit (kg)	<10 kg
Power/unit (W)	<10 W

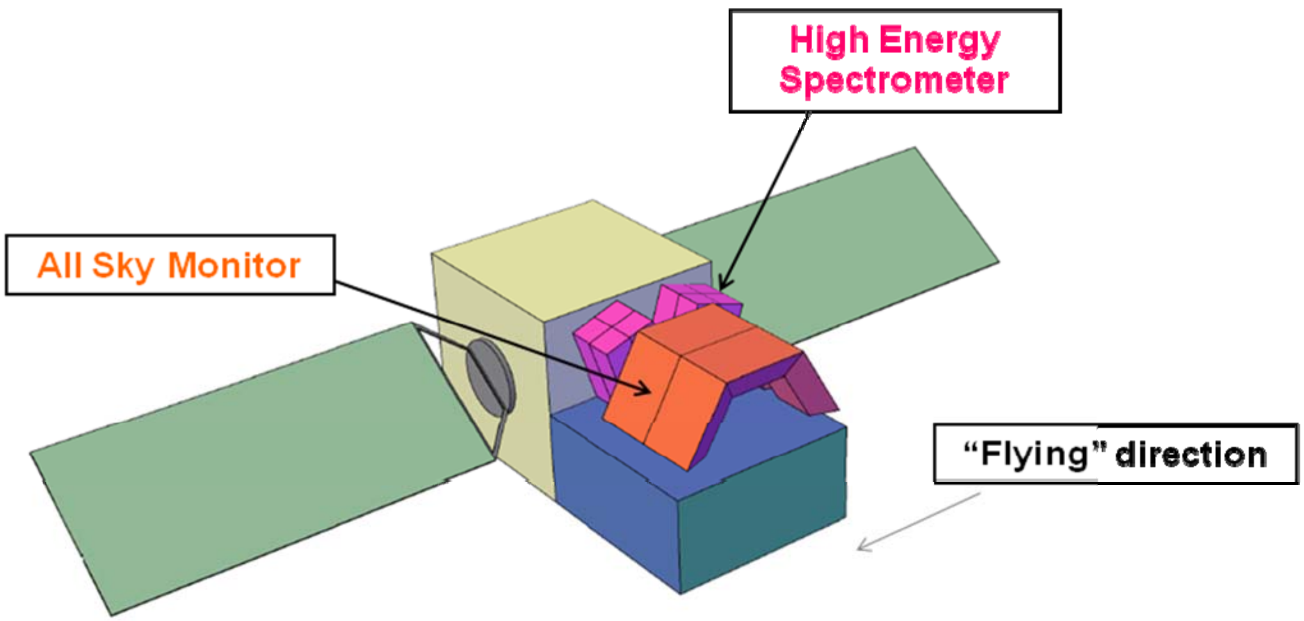
The Soft Gamma-ray Spectrometer

SGS (HE-spectrometer) main features

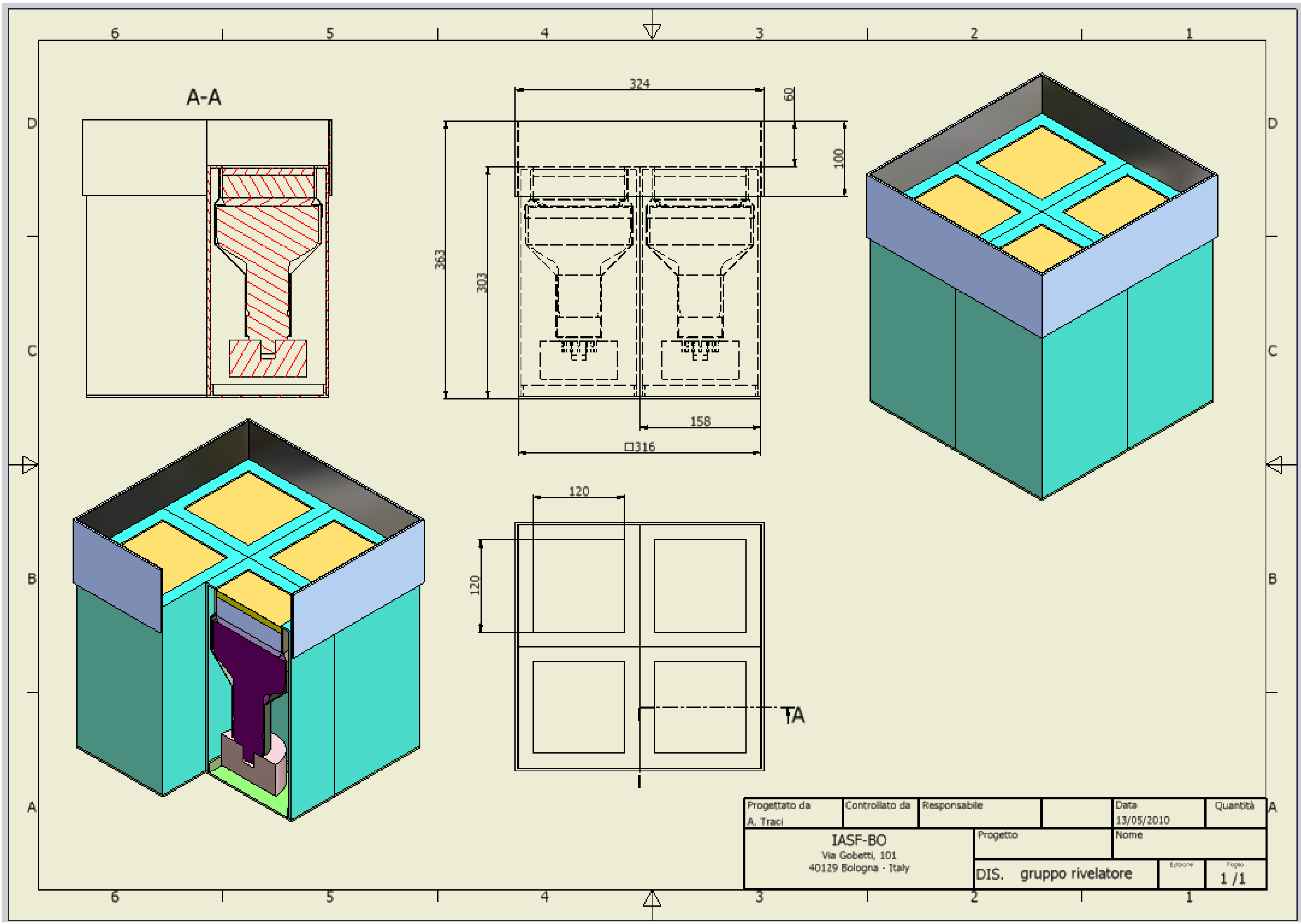
Energy band	20 – 5000 keV
Effective area	~ 1000 cm^2 up to 200 keV ~ 500 cm^2 up to 1 MeV
Field of view	~ 2.5 sr
Background minimisation up to	~ 200 keV
Energy resolution	15% @ 60 keV 8% @ 661 keV
Time resolution	< 10 us
Gain control system	Yes
In-flight calibration system	Yes

SGS system architecture

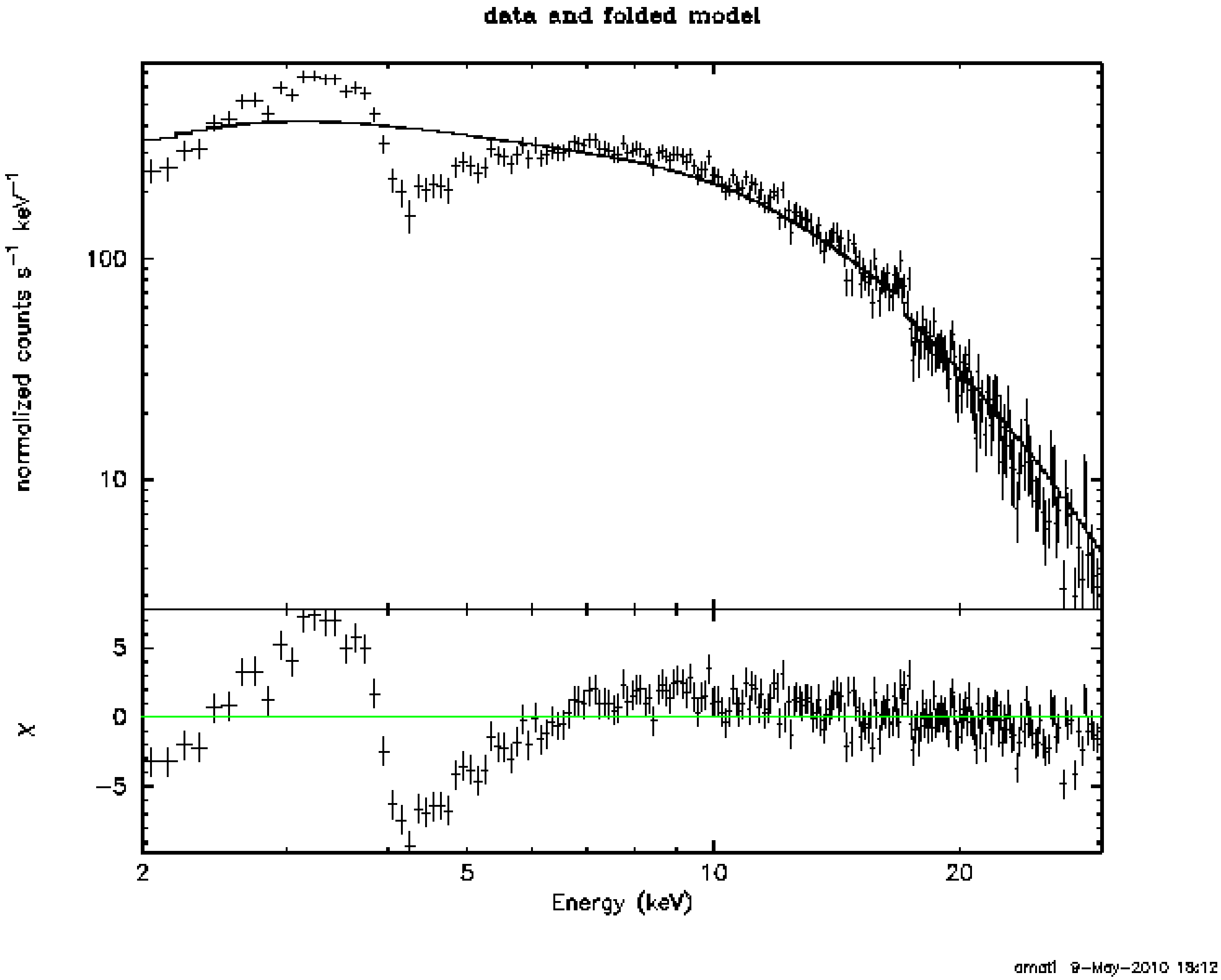
- 8 detection units
- 2 detector group each one consisting of 4 detection units
- 1 passive collimator for each group
- Front-End / Back-End Electronics (FEE and BEE, divided in 8 units)
- A system generating events for gain stability control and calibration



SGS system architecture



Expected count spectrum with MIRAX assuming the K-edge observed from GRB990705 with BSAX/WFC



Expected deconvolved spectrum assuming K-edge from GRB990705