The Abdus Salam
International Centre for Theoretical Physics

United Nations
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IAEA
International Atomic Energy Agency

SMR/1842-28

International Workshop on QCD at Cosmic Energies III

28 May - 1 June, 2007

Lecture Notes

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I t a l y

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Gamma-ray Astrophysics with AGILE and GLAST

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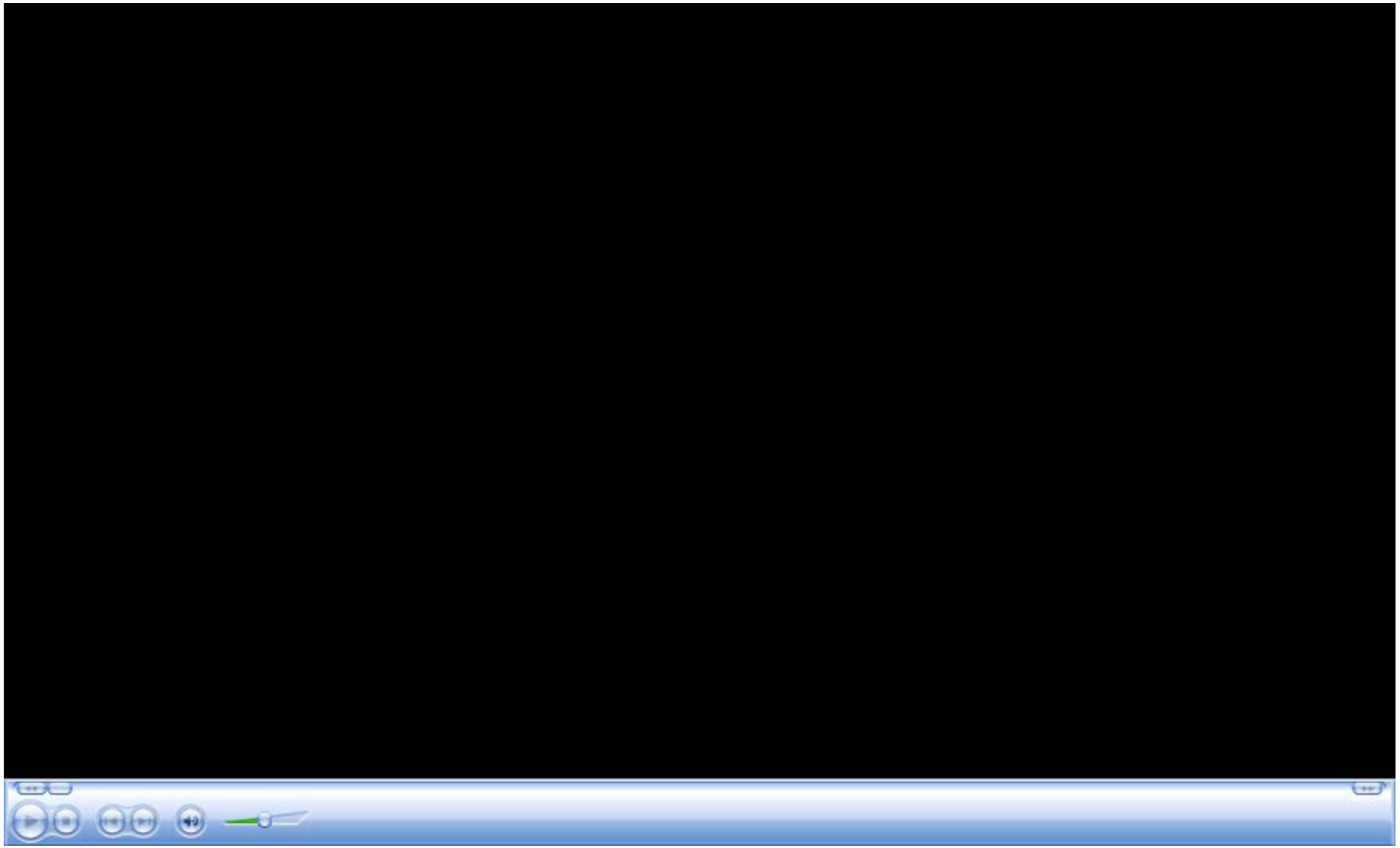
AGILE launch!!!

AGILE was successfully launched on April 23, 2007 by the Indian PSLV-C8 rocket from the Satish Dhawan Space Center SHAR, Sriharikota (Chennai-Madras).

The AGILE satellite orbit is equatorial (height: 540 km, inclination angle: 2.5 degrees)
The satellite is currently in the Commissioning Phase.
All test results are nominal.

AGILE launch!!!




AGILE

AGILE Detection

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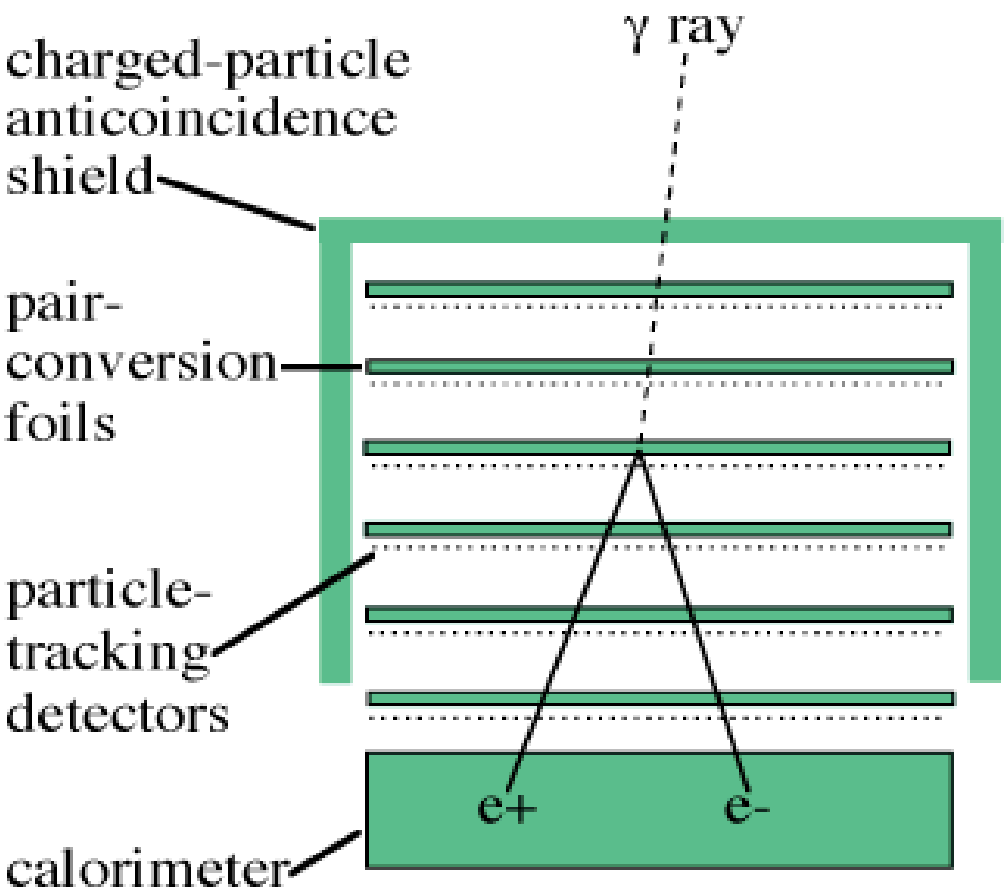
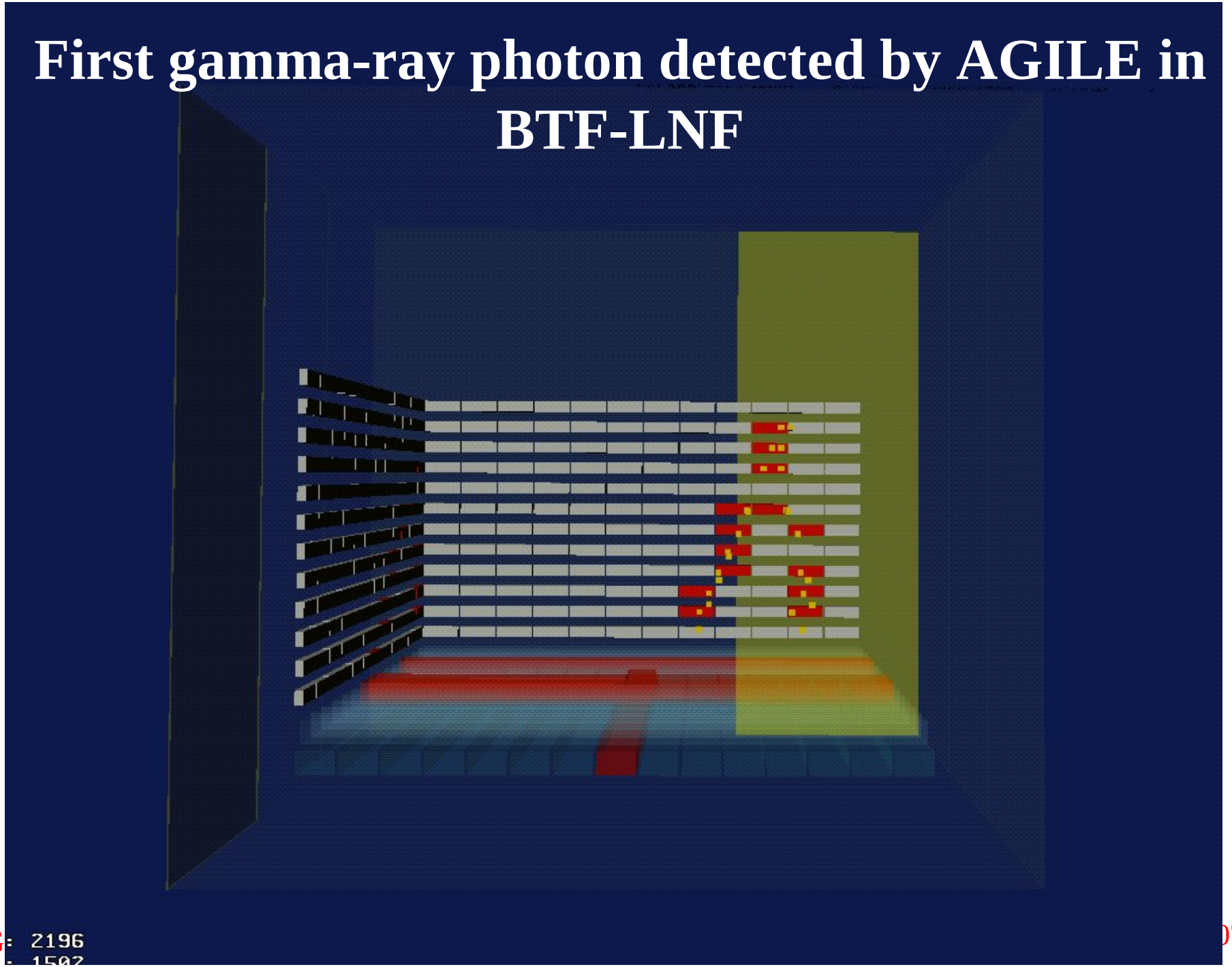
May 31, 2007

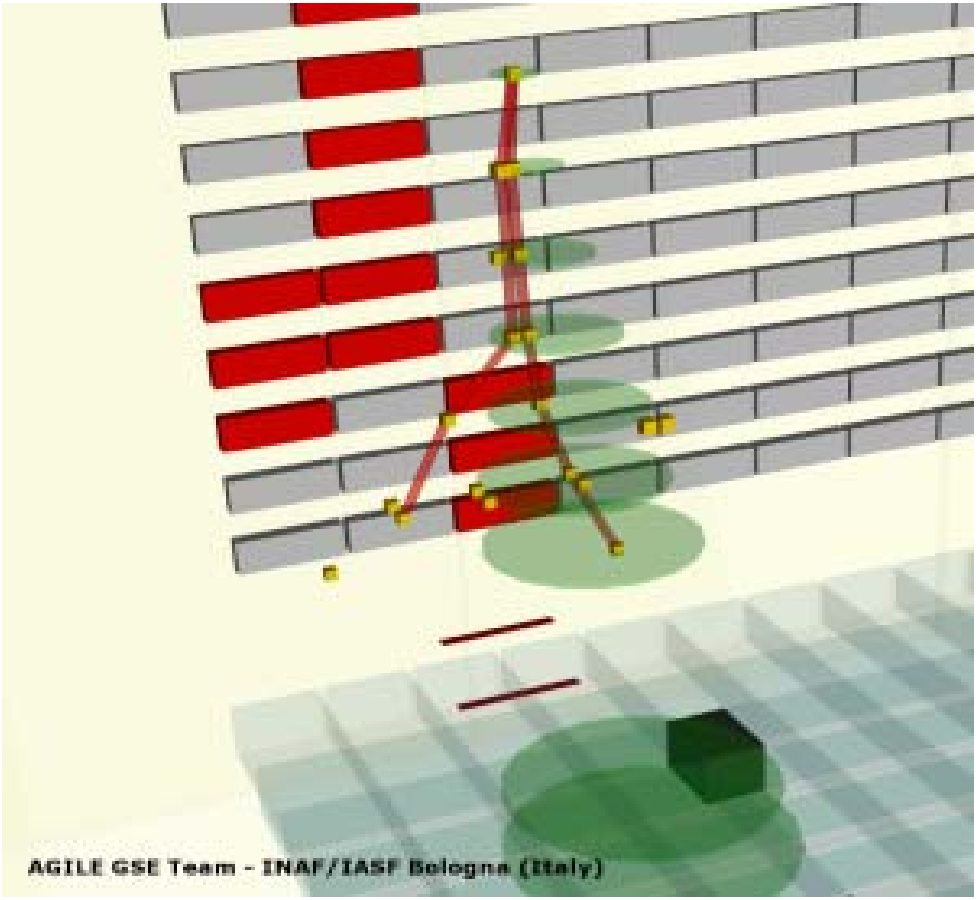
Detection Technique



First gamma-ray photon detected by AGILE in BTF-LNF



The Last Gamma on Earth



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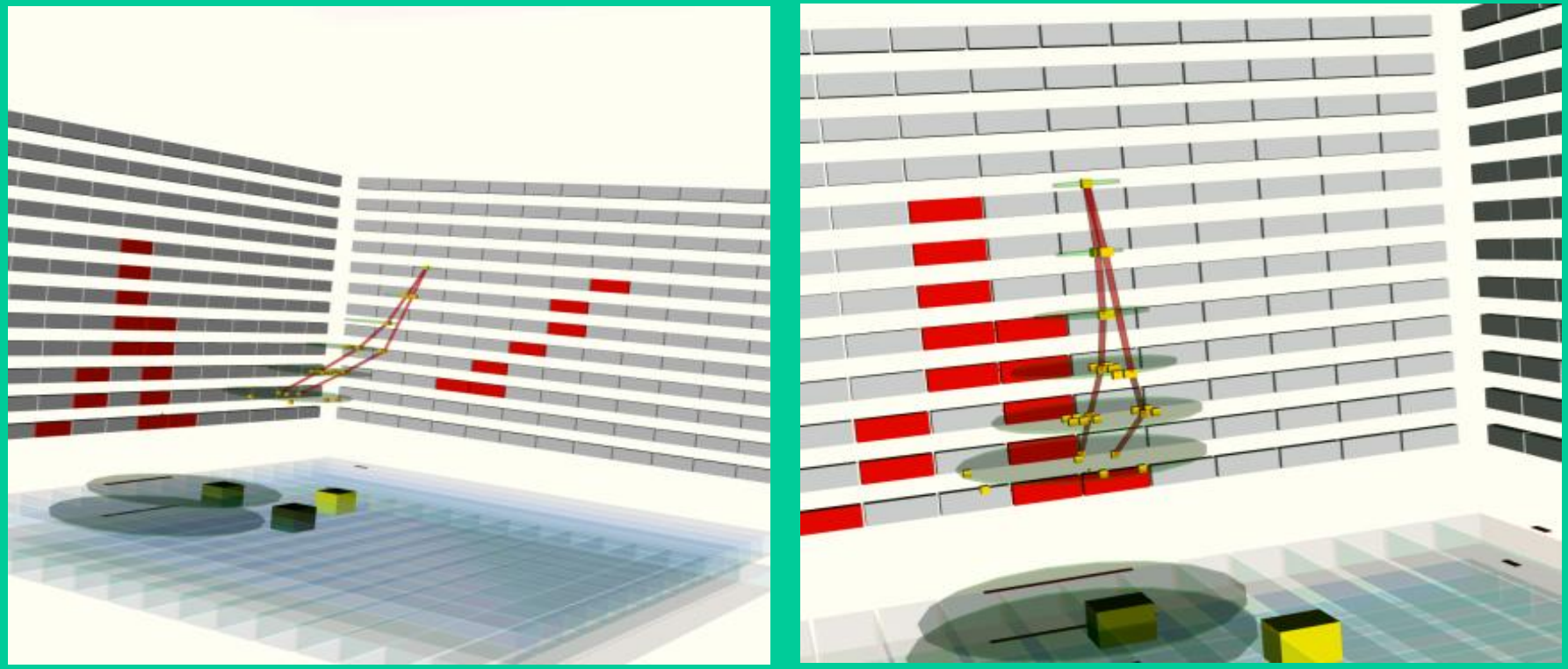
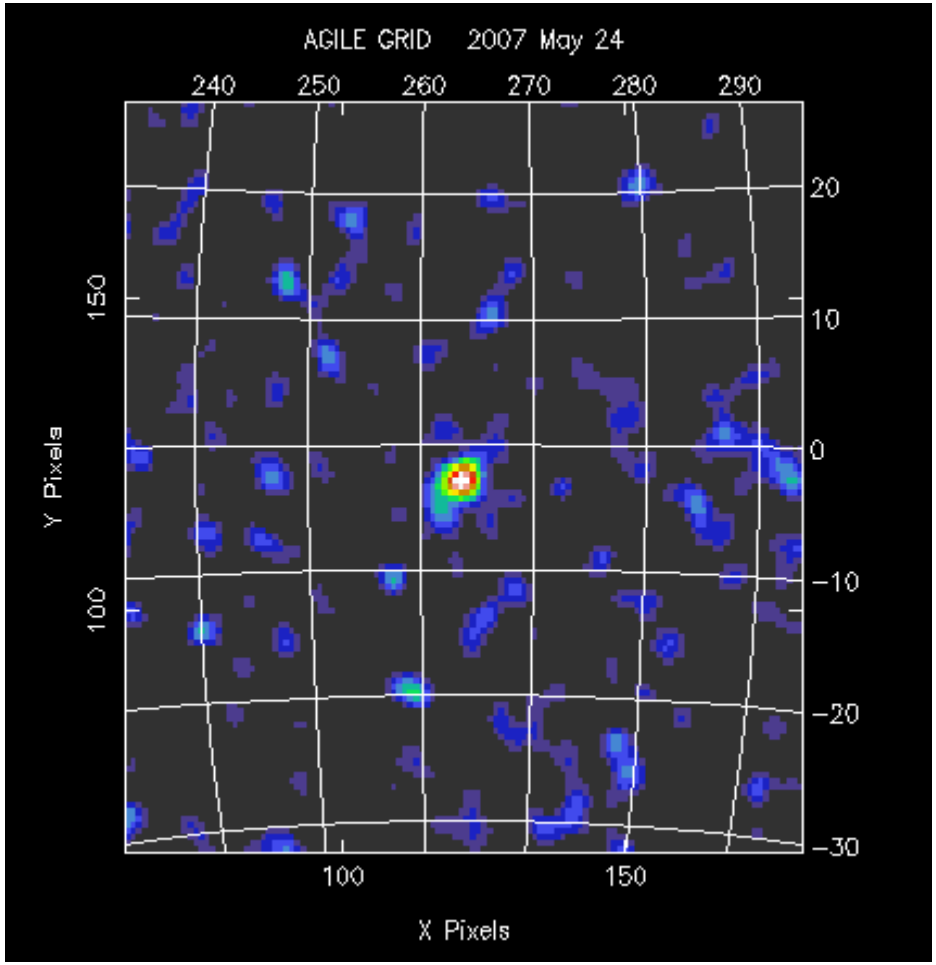
First gamma-ray photon detected by AGILE on Orbit



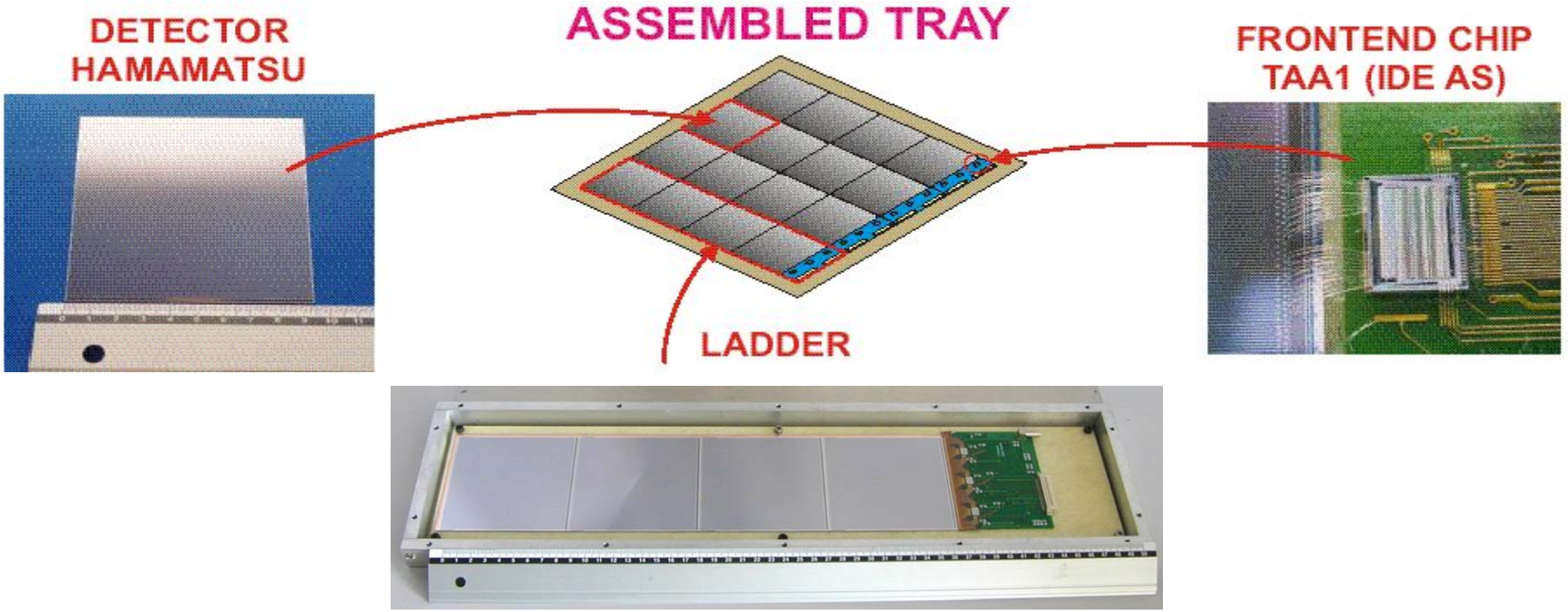
First Results
the VELA pulsar (calibration source)



PRELIMINARY

AGILE Detectors

Silicon Detectors



AGILE siicon tracker

The Silicon Tracker

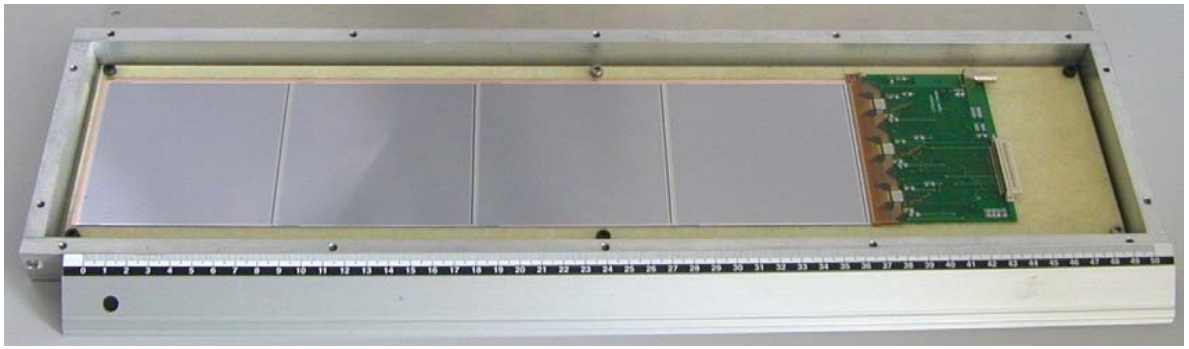
The AGILE silicon detectors

Detector specifications:

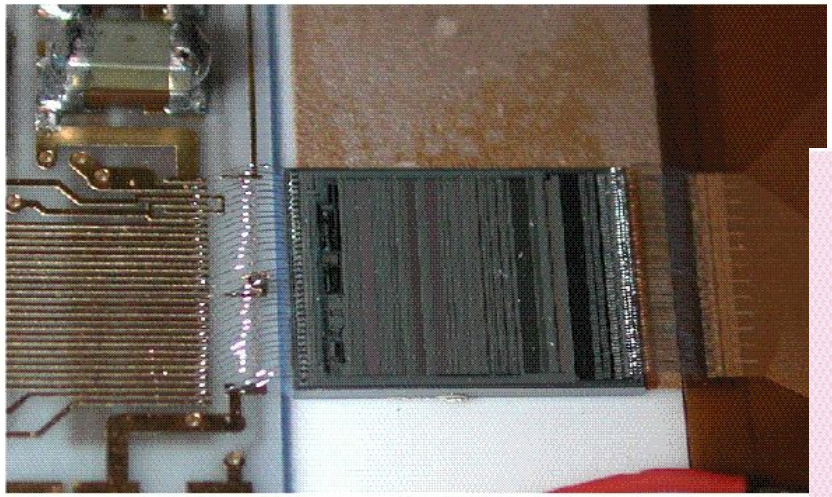
- dimension: 9.5x9.5 cm^2
- thickness: 410 μm (6 inch technology)
- readout pitch: 242 μm;
  physical pitch: 121 μm (one floating strip)
- number of strips/ladder: 384
- Single side and AC-coupled
- leakage current: 2 nA/cm^2 at Vbias=2.5*V_{FD} =200 V
- polarization resistor: 40 MΩ
- coupling capacitor: 55 pF/cm
- Al strip resistance: 4.3 Ω/cm
- max number of bad strips: <1%
- average number of bad strips: <0.5%

The AGILE frontend chip: TA1 → TAA1

- low noise, low power, SELF-TRIGGERING
- technology: 1.2 μ CMOS, double poly, double metal (final: 0.8 μ BiCMOS on epitaxial layer)
- features:
  - 128 channels
  - gain: 25 mV/fC; range: 18 fC
  - noise (e^- rms): 165+6.1/pF for T_{peak}=2 μs
  - power: <0.4 mW/channel
  - power rails: ±2 V
  - readout frequency: 5 Mhz
  - gain spread: <1.5%
  - threshold offset spread (TA1): 20% (in TAA1 will be implemented a 3 bit DAC per channel)



SuperAGILE X-ray detector



SUPER-AGILE

DETECTOR
- plane with 16 silicon tiles organized in 4 1D detectors
- each detector: 1536 readout strips (0.121mm pitch)
- a coded mask system

FRONTEND ELECTRONICS
- 12 self-triggering readout ASICs (128 channels each) per each detector, positioned on a kapton-FR4 hybrid

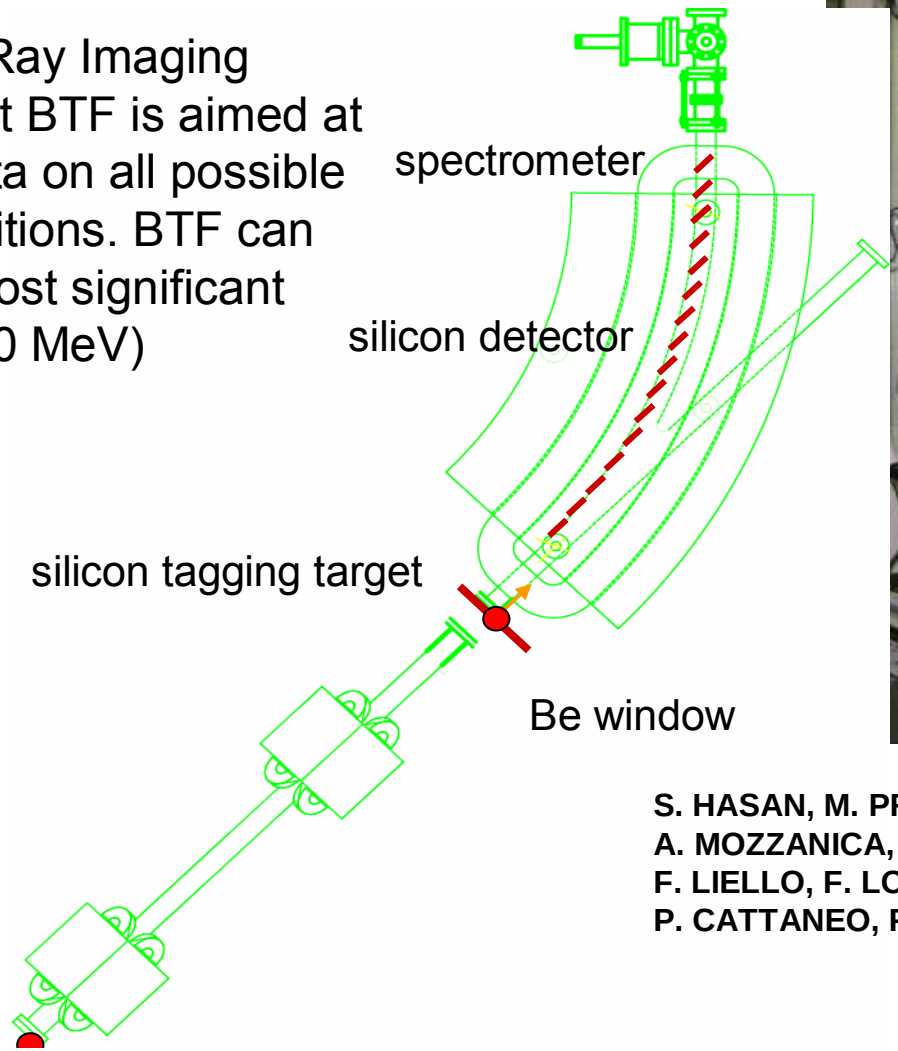
GOAL
measure X-rays in the energy range 10-40keV to detect GRBs, transients, galactic and extra-galactic sources

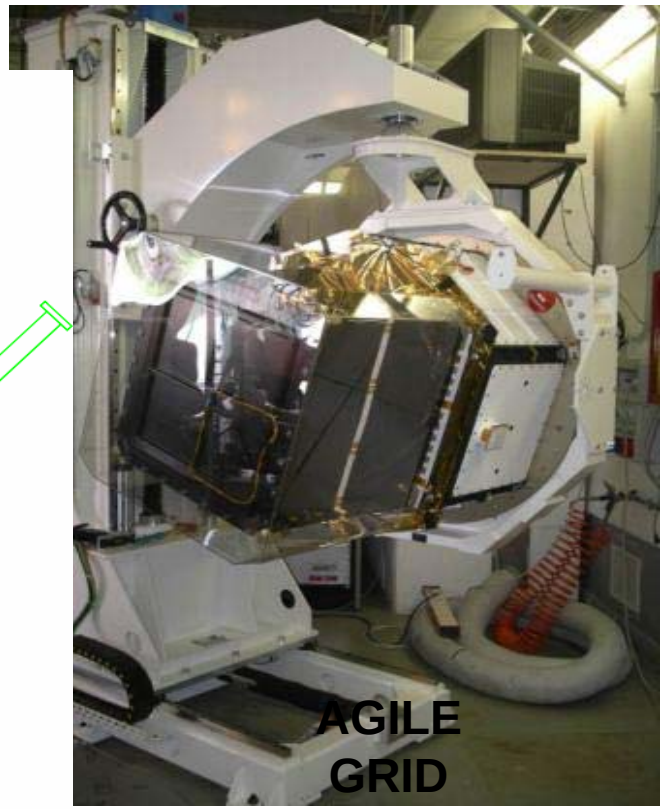
SCIENTIFIC FEATURES
- imaging: 1'-3' at ~20mCrab
- timing resolution: 5μs
- energy resolution: 4keV (FWHM)
- flux sensitivity: ~5mCrab (15keV)

AGILE calibrations

BTF photon tagged source
AGILE GRID photon calibration

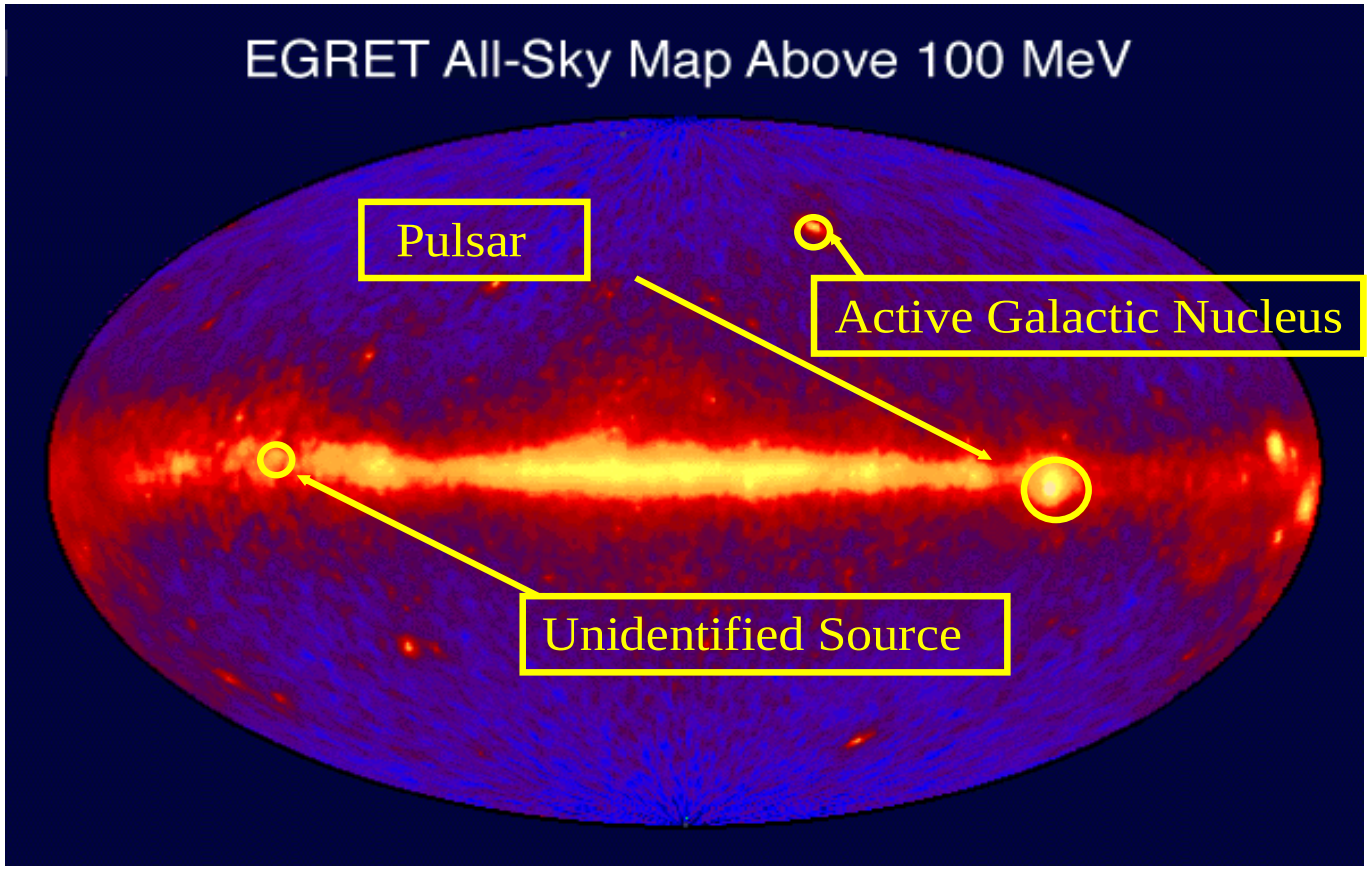
The AGILE Gamma Ray Imaging Detector calibration at BTF is aimed at obtaining detailed data on all possible geometries and conditions. BTF can provide data in the most significant energy region (20-700 MeV)



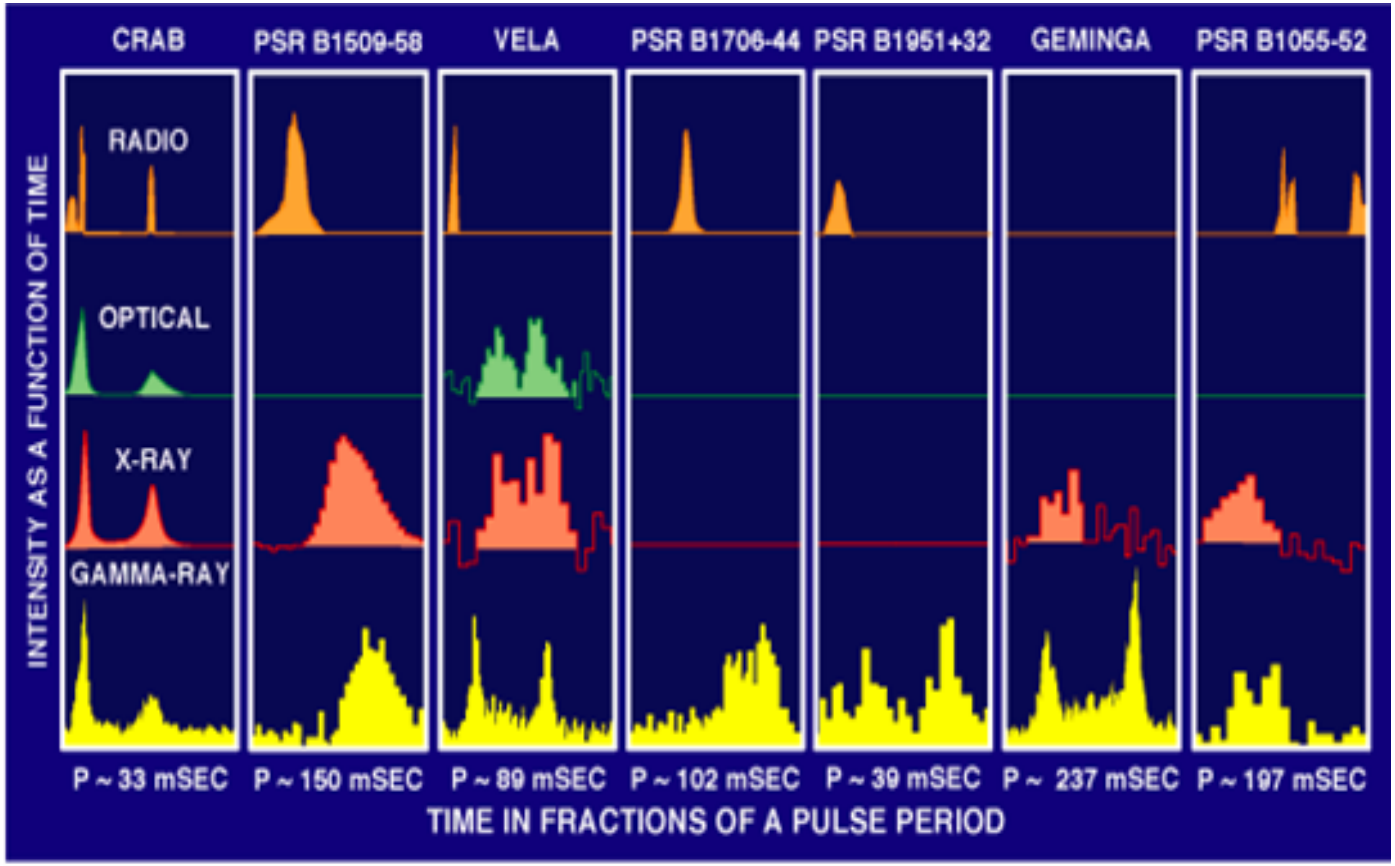


S. HASAN, M. PREST, L. FOGGETTA, C. PONTONI, A. MOZZANICA, G. BARBIELLINI, M. BASSET, F. LIELLO, F. LONGO, E. VALLAZZA, F. BOFFELLI, P. CATTANEO, F. MAURI and AGILE Collaboration

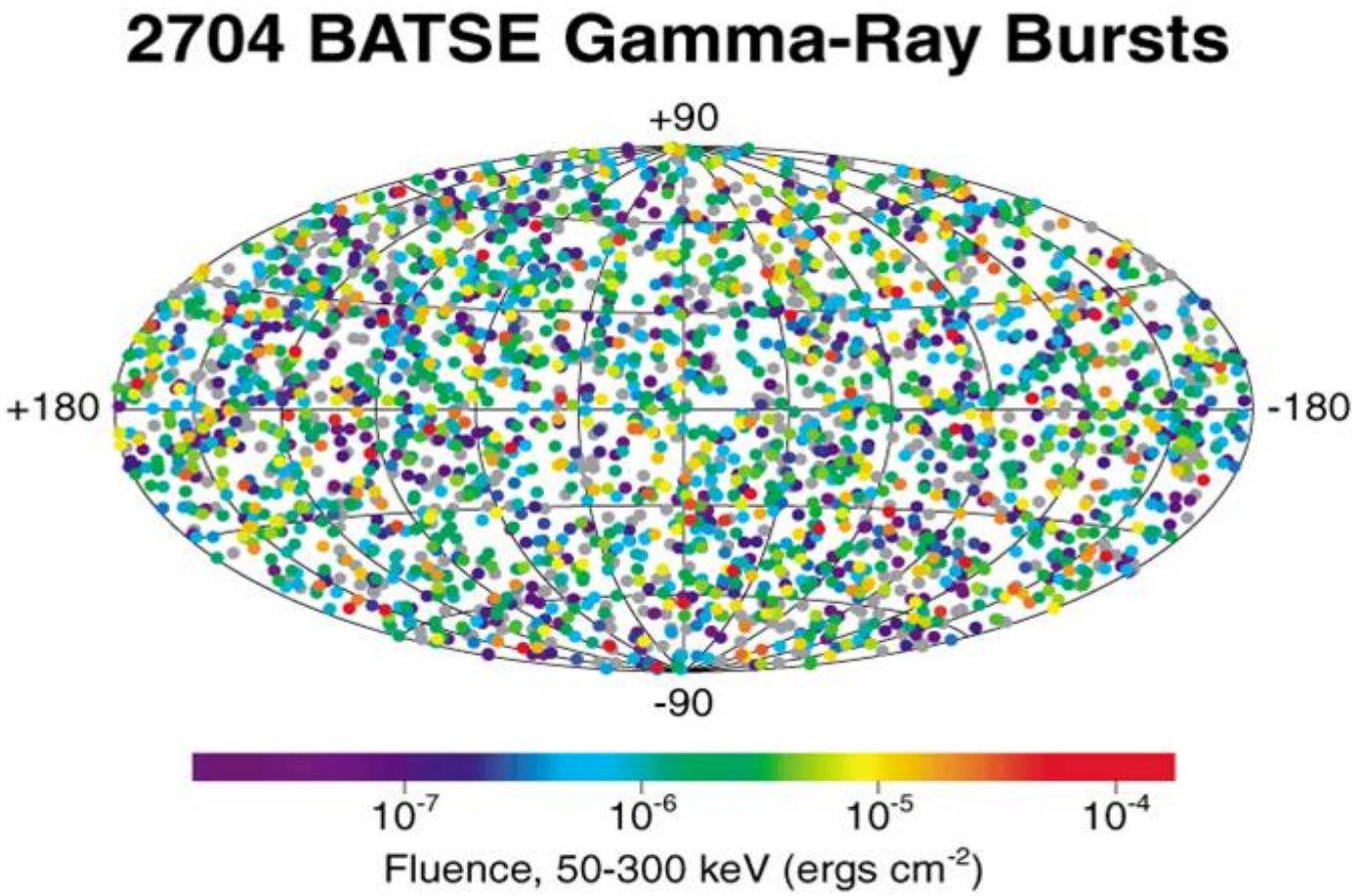
Why Gamma-ray Astrophysics? (I)



Why Gamma-ray Astrophysics? (II)

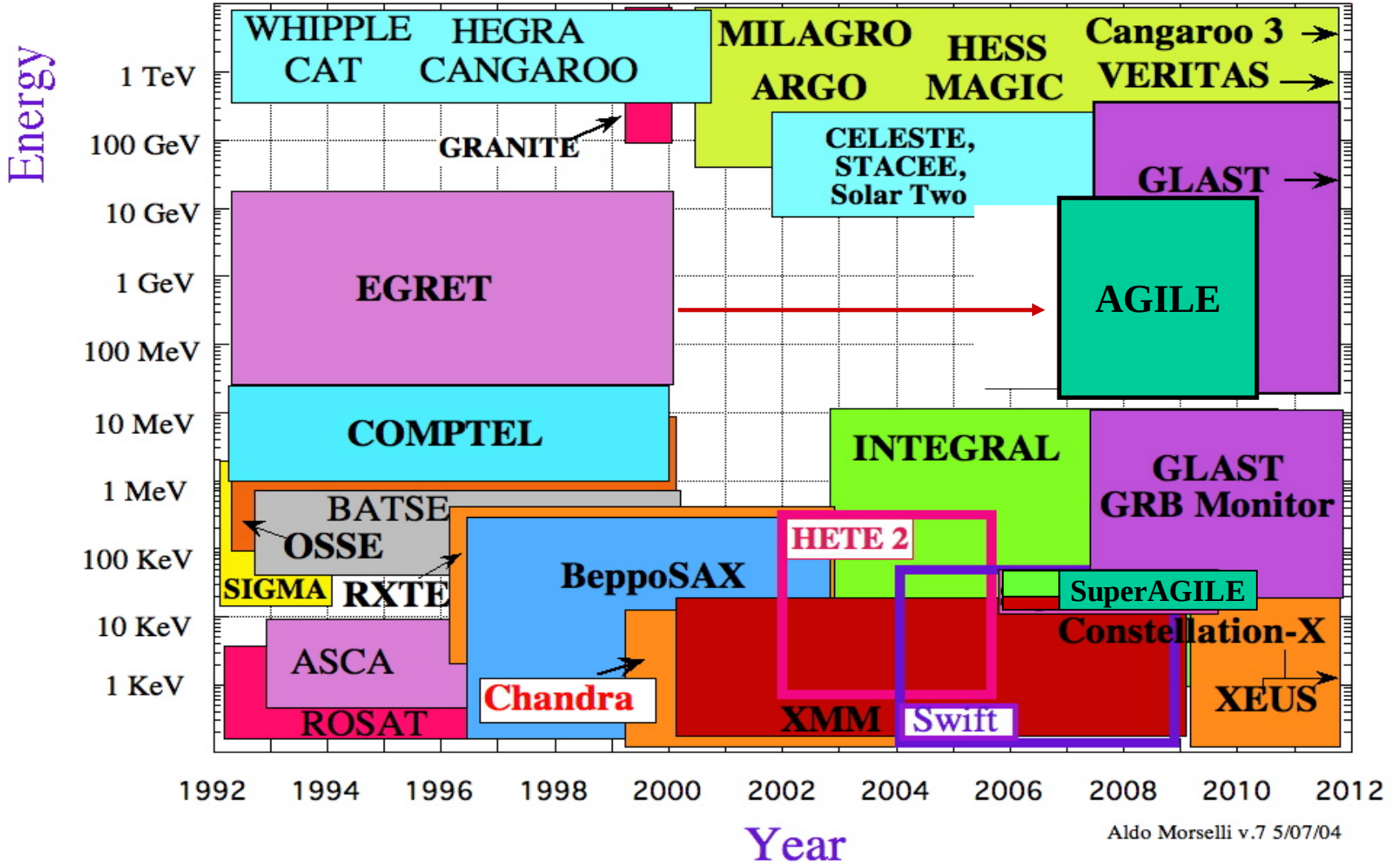


Why Gamma-ray Astrophysics? (III)



GLAST

High Energy Gamma Experiments



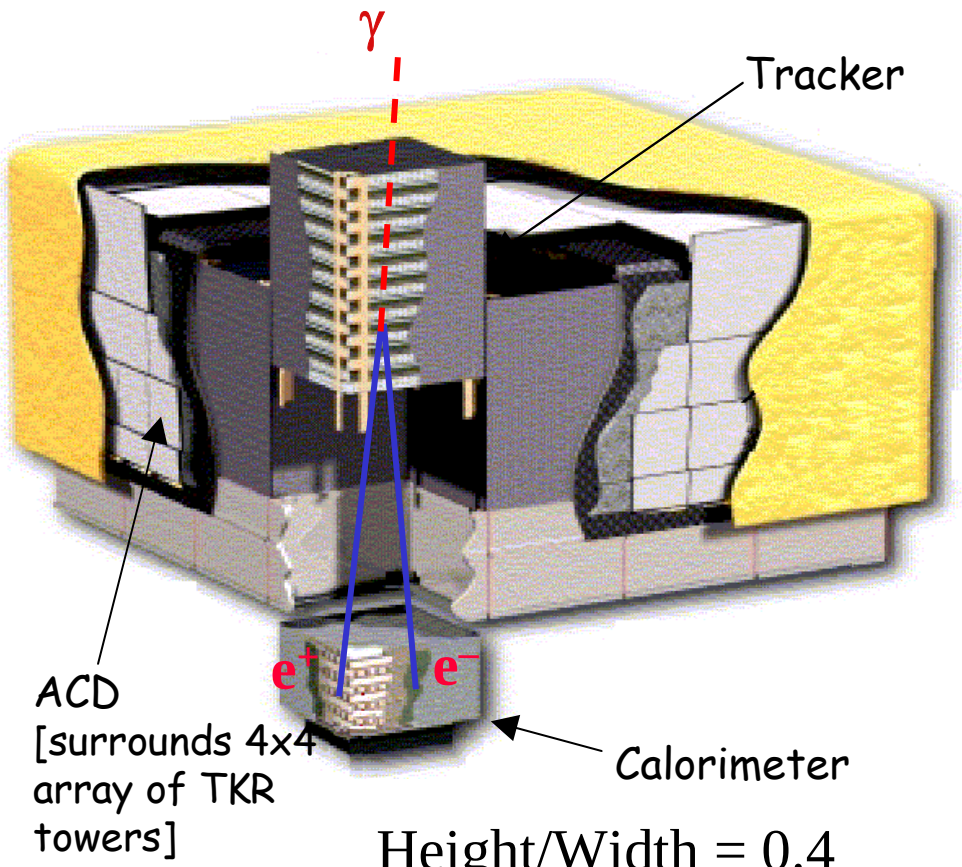
The GLAST Large Area Telescope

- **Precision Si-strip Tracker (TKR)** 18
  XY tracking planes. 228 μm pitch). High efficiency. Good position resolution (ang. resolution at high energy) 12 x 0.03 X_0 front end => reduce multiple scattering. 4 x 0.18 X_0 back-end => increase sensitivity >1GeV

- **CsI Calorimeter(CAL)**
  Array of 1536 CsI(Tl) crystals in 8 layers.
  Hodoscopic => Cosmic ray rejection.
  => shower leakage correction.
  8.5 X_0 => Shower max contained <100 GeV

- **Anticoincidence Detector (ACD)**
  Segmented (89 plastic scintillator tiles)
  => minimize self veto,
  Reject background of charged cosmic rays;

- **Electronics System** Includes flexible, robust hardware trigger and software filters.



Height/Width = 0.4
=> Large field of view

Systems work together to identify and measure the flux of cosmic gamma rays with energy 20 MeV - >300 GeV.

The LAT instrument: how we built it

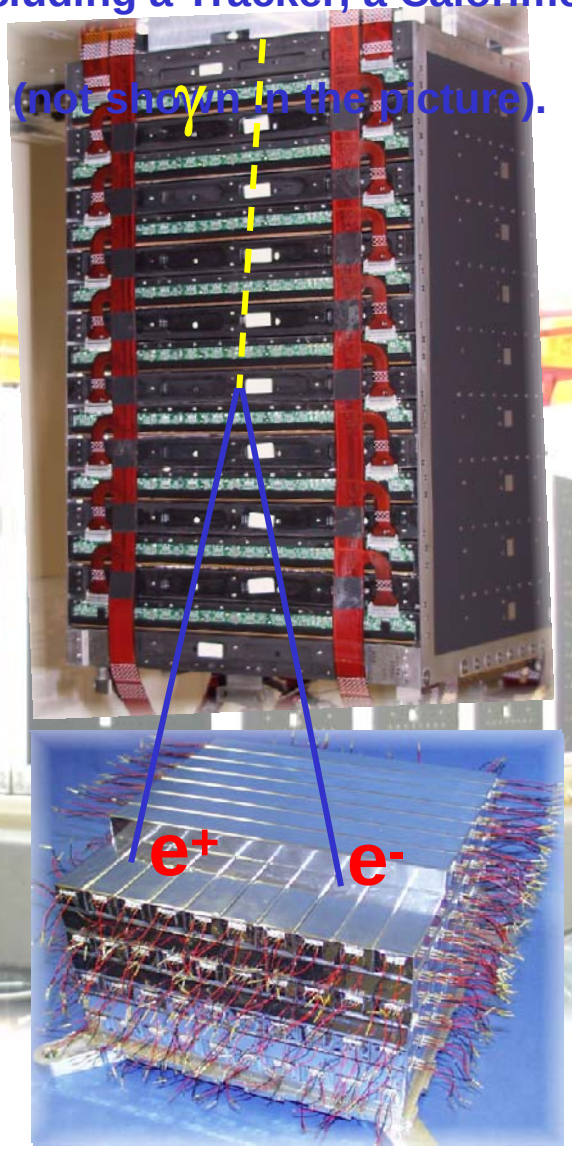
Overall modular design:

✓ 4x4 array of identical towers - each one including a Tracker, a Calorimeter and an Electronics Module.

✓ Surrounded by an Anti-Coincidence shield (not shown in the picture).

Anti-Coincidence (ACD):

- ✓ Segmented (89 tiles)
- ✓ Self-veto @ high energy limited
- ✓ 0.9997 detection efficiency (overall)



Tracker/Converter (TKR):

- ✓ Silicon strip detectors (single sided, each layer is rotated by 90 degrees with respect to the previous one)
- ✓ W conversion foils
- ✓ ~80 m^2 of silicon
- ✓ ~10^6 electronics chans
- ✓ fully digital electronics
- ✓ High precision tracking, small dead time

Calorimeter (CAL):

- ✓1536 CsI crystals
- ✓Analog 4 range readout
- ✓ 8.5 X0
- ✓ Hodoscopic
- ✓ Shower profile reconstruction (leakage correction)

GLAST

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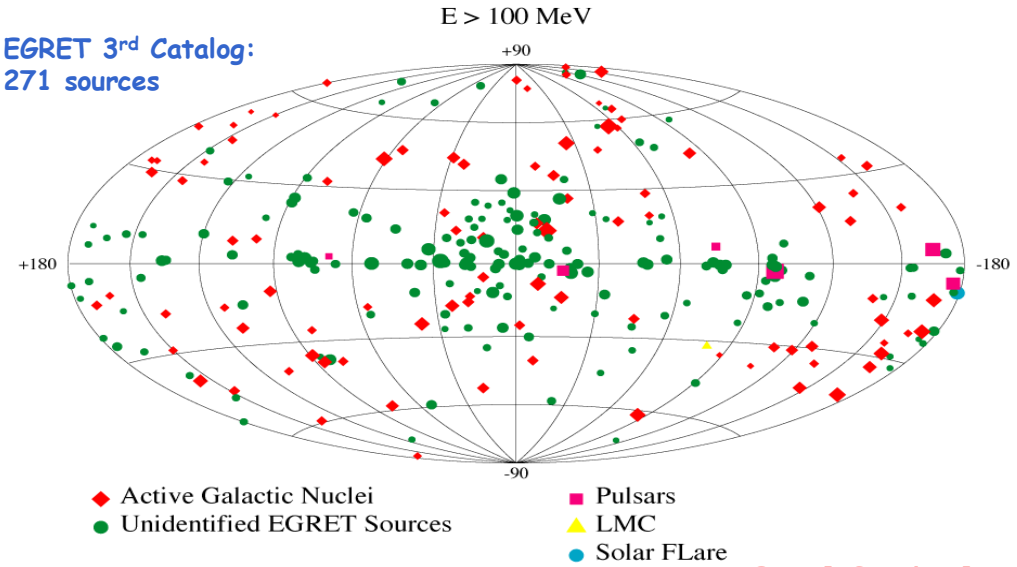
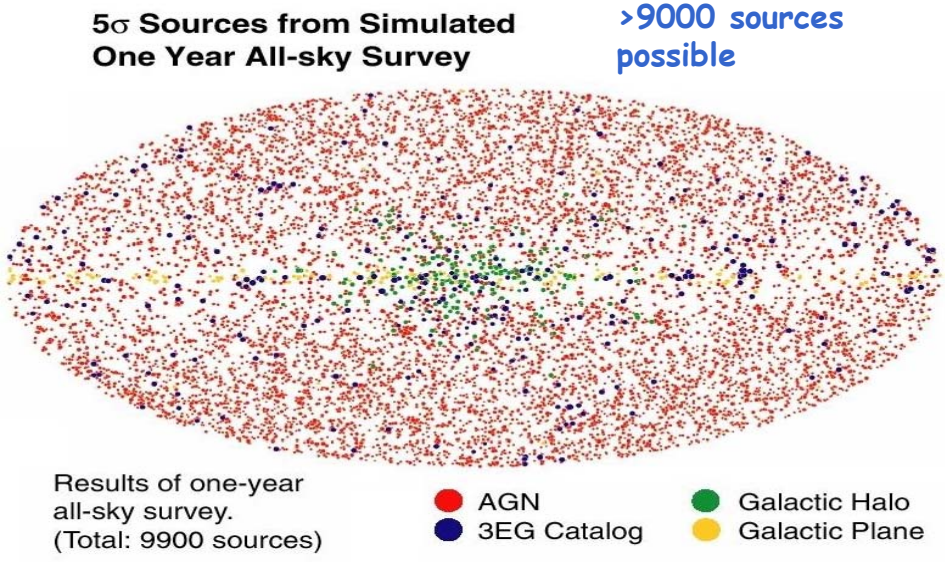
EGRET → GLAST

EGRET 3rd Catalog:
271 sources

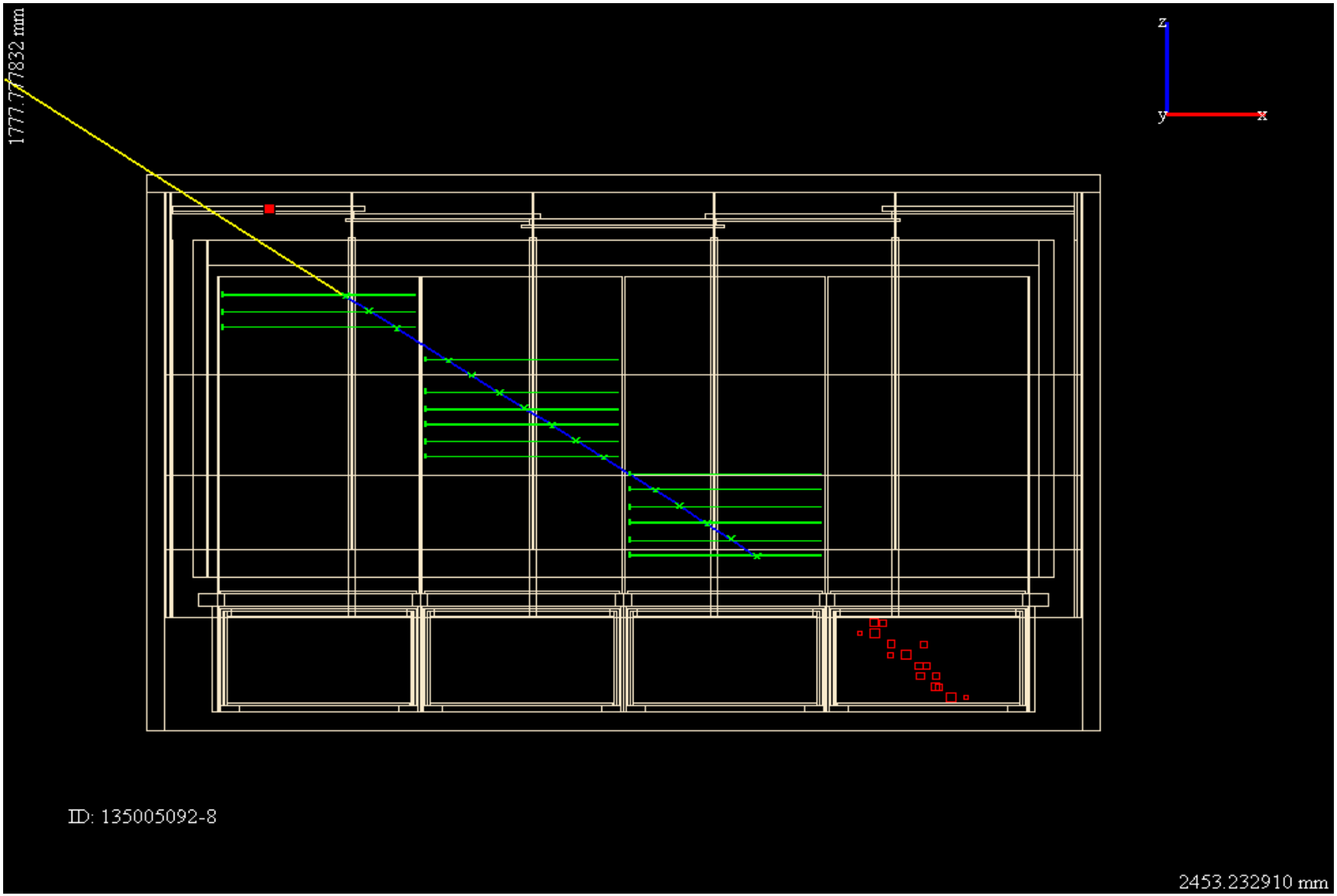


LAT 1st Catalog:
>9000 sources
possible



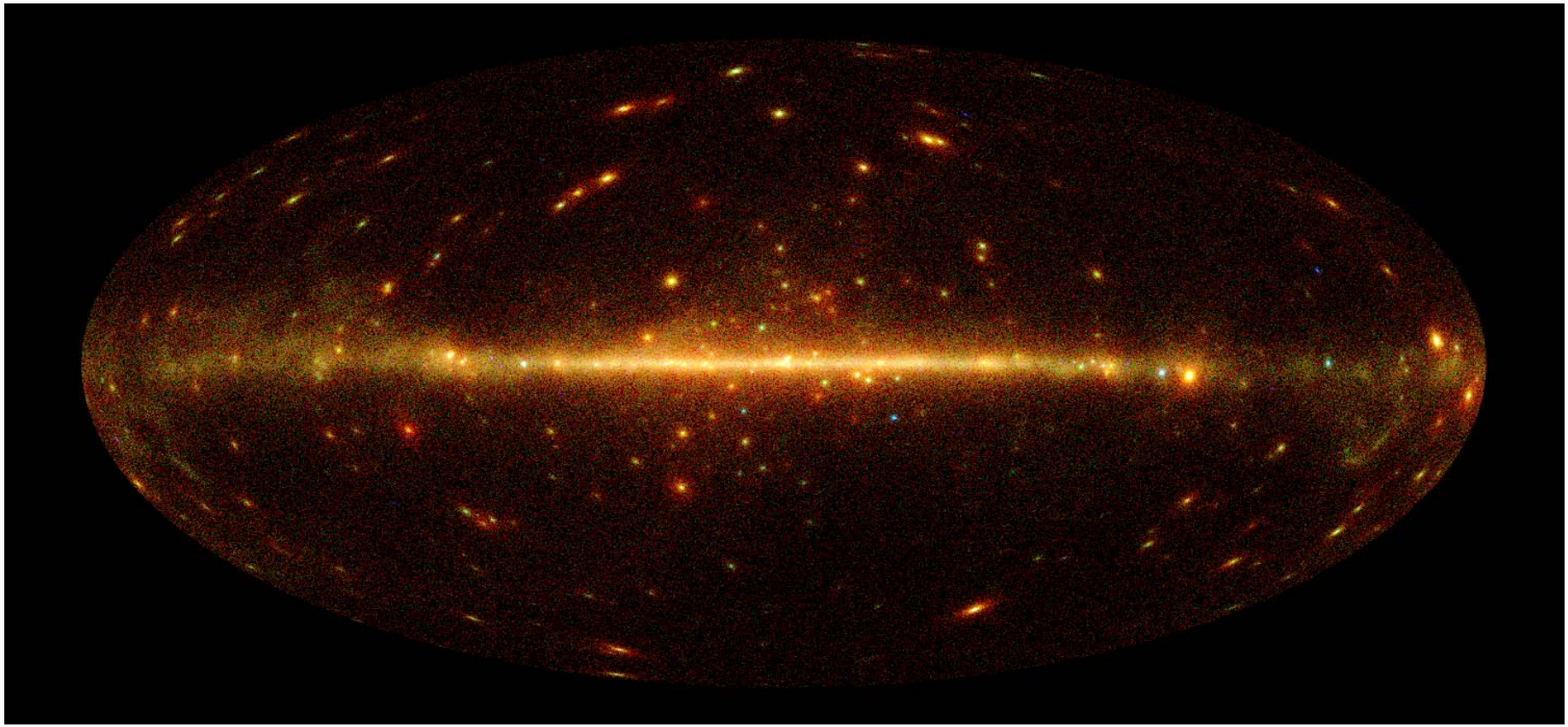
	GLAST/LAT (requirements)		EGRET
Energy Range	20 MeV - >300 GeV		30 MeV – 30 GeV
Energy Resolution	0.1		0.1
Effective Area	8000 cm^2		1500 cm^2
Field of View	2 sr.		0.5 sr.
Angular Resolution	3.5 @ 100 MeV GeV	0.1@10	5.8@100 MeV 0.5@10 GeV
Sensitivity	$3x10^{-9}$ cm^{-2} s^{-1}		~10^{-7} cm^{-2} s^{-1}
Deadtime	<100 μs		100ms

16 Towers with ACD



GLAST gamma-ray sky

- 55 GLAST simulated sky in galactic coordinates



Plot by Seth Digel