The AGILE Mission

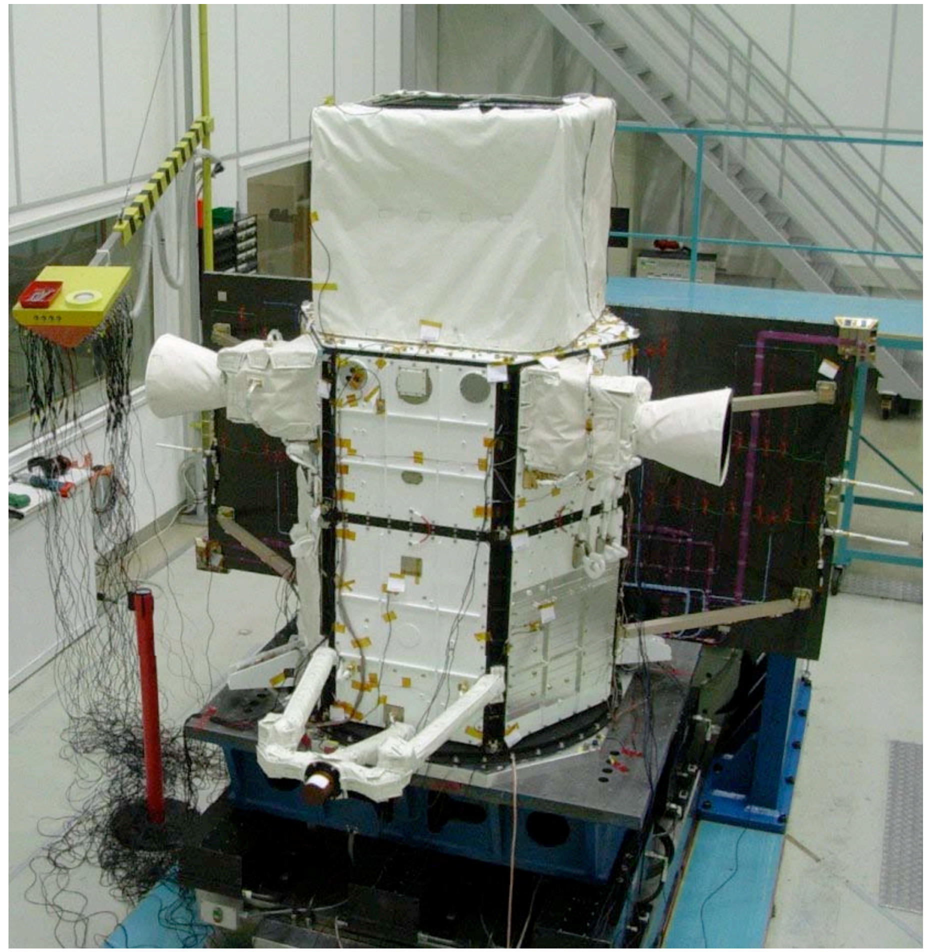
Francesco Longo

On behalf of the AGILE Team

AGILE current status

AGILE Satellite (Tortona, Dec. 27, 2006)

AGILE Satellite (IABG, Munich February, 2007)



AGILE team

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Experimental requirements

- Excellent gamma-ray imaging with a large FoV
- Simultaneous broad-band spectral information
- Microsecond timing
- Efficient Quicklook Analysis of gamma-ray data for transient detection and alerts

AGILE Mission

- **AGILE is an ASI Small Scientific Mission dedicated to gamma-ray astrophysics (Imaging 30 MeV-50 GeV, 15-45 keV)**
- **Planned to be operational in 2007**
- **Emphasis to rapid reaction to transients**
- **Multiwavelength follow-up program**
- **Small Mission with a Guest Observer Program**
- **Crucial participation by IASF/INAF, INFN, CIFS**
- **Main industrial contractors: Carlo Gavazzi Space, Alenia Spazio Laben, Oerlikon Contraves, Telespazio, Mipot**
- **ASI Observation of the Universe and AGILE ASI program office**

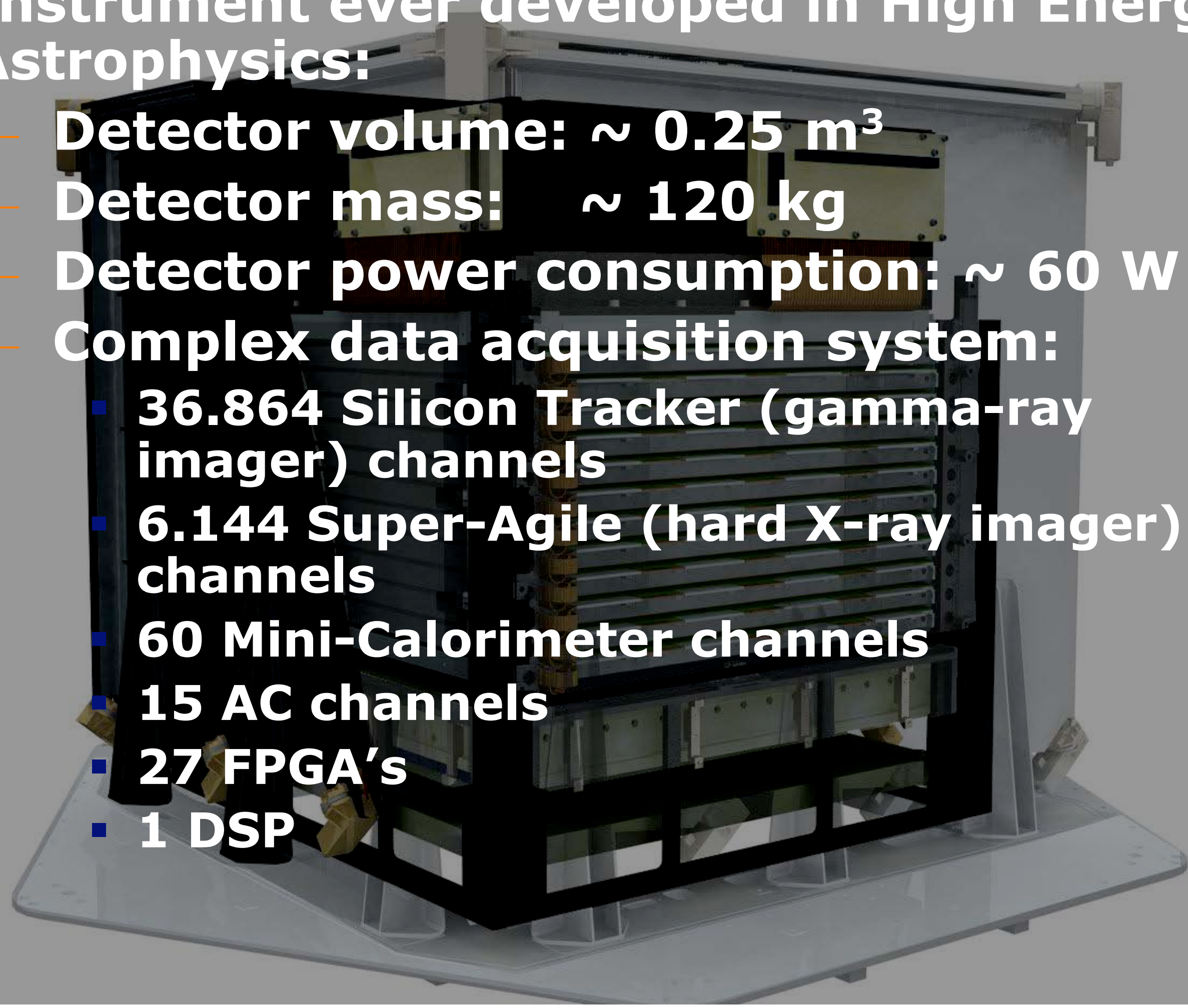
AGILE Mission status

- AGILE Mission currently in final testing phase (Payload already integrated with satellite)
- Launch planned end of march 2007 (PSLV, equatorial orbit 0-3 degree).
- Use of Ground Station in Malindi (Kenya).
- Mission Operations Center at TZP-Fucino.
- Quicklook and data archiving at ASDC.

Detector Characteristics

- Optimal gamma-ray imaging PSF (30 MeV-30 GeV) and large FOV (2.5 sr) combined with simultaneous X-ray imaging (15-45 keV, 1 sr FOV).
- Ultra-compact, ultra-light coded mask hard X-ray imager (15-45 keV)
- Microsecond time-tagging and wide GRB search dynamic range (15 - 60 keV, 0.3-10 MeV)

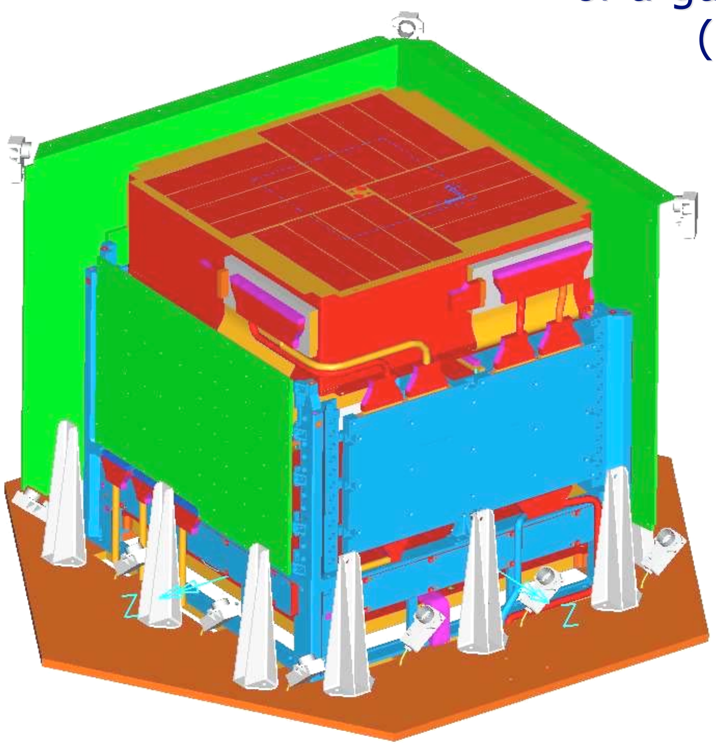
The AGILE Instrument

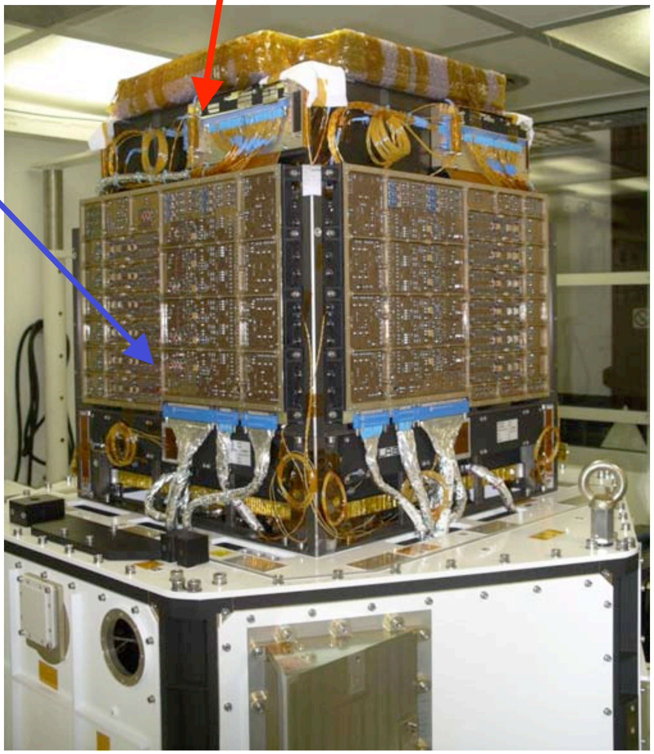


- The most compact and low-power Instrument ever developed in High Energy Astrophysics:
  - Detector volume: ~ 0.25 m^3
  - Detector mass: ~ 120 kg
  - Detector power consumption: ~ 60 W
  - Complex data acquisition system:
    - 36.864 Silicon Tracker (gamma-ray imager) channels
    - 6.144 Super-Agile (hard X-ray imager) channels
    - 60 Mini-Calorimeter channels
    - 15 AC channels
    - 27 FPGA’s
    - 1 DSP

AGILE Instrument

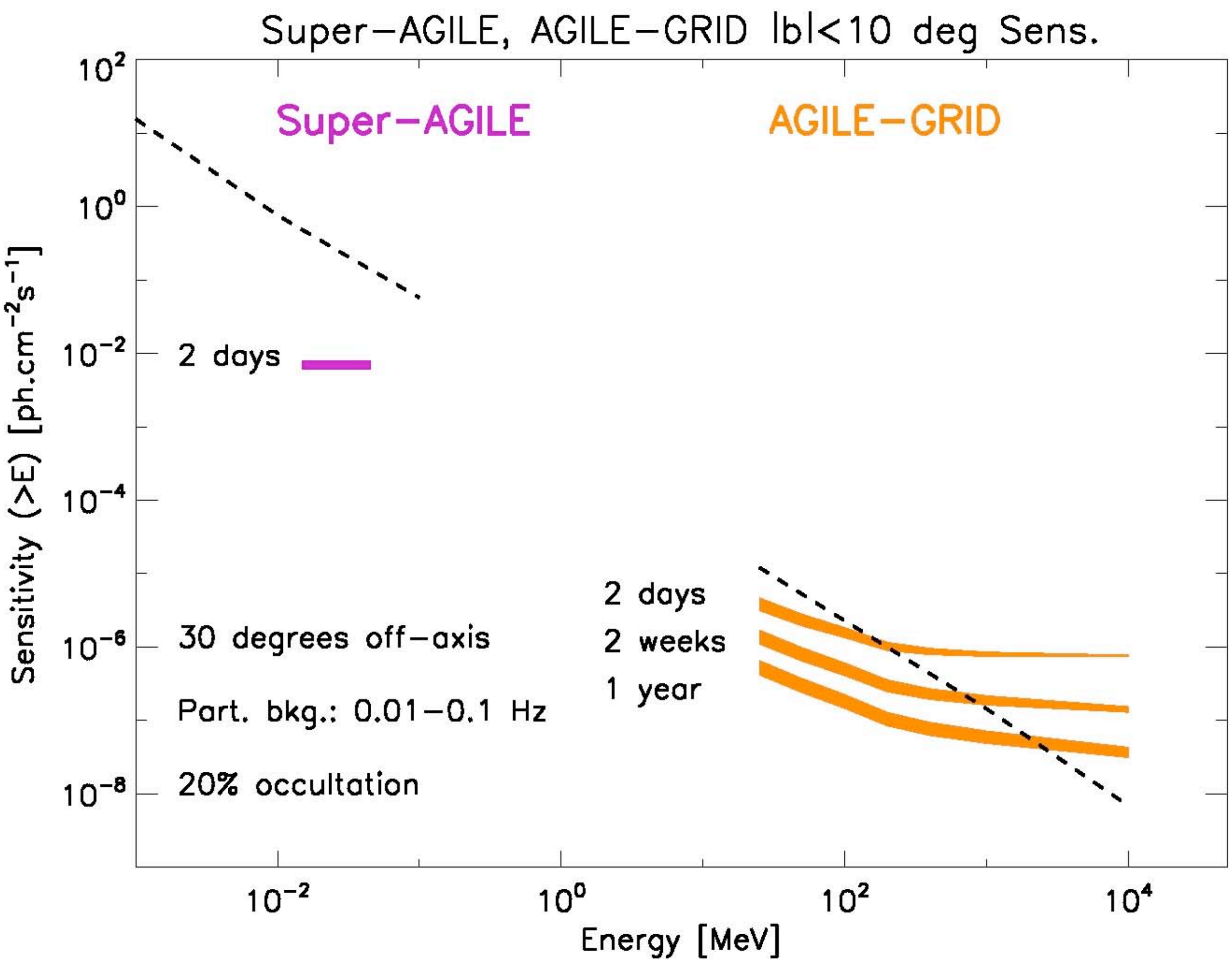
AGILE: first and unique combination
of a gamma-ray imager and a X-ray imager
(30 MeV-30 GeV) (15-45 keV)





AGILE Flight Model

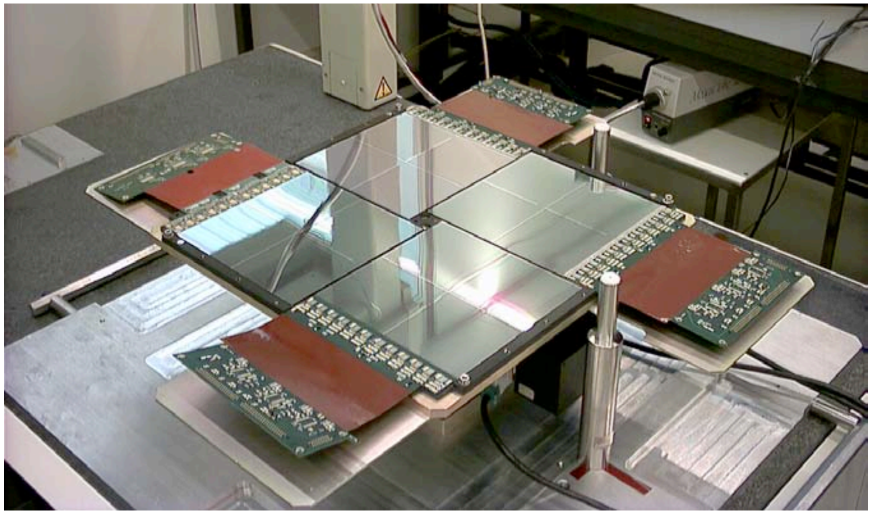
AGILE Sensitivity

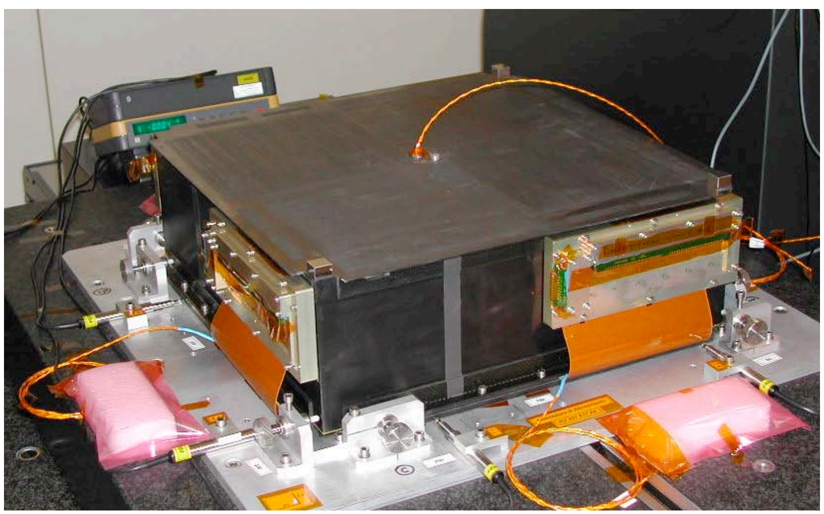


AGILE performance

Gamma-ray Imaging Detector (GRID)		
Energy Range	30 MeV – 50 GeV	
Field of view	~ 2.5 sr	
Flux sensitivity ($E > 100$ MeV) (ph cm^{-2} s^{-1})	3×10^{-7}	(5σ in 10^6 s)
Angular Resolution at 400 MeV	1.2 degrees	(68% cont. radius)
Source Location Accuracy (high Gal. latitudes)	$\sim$15 arcmin	(90% C.L.)
Energy Resolution	$\Delta E/E \sim 1$	at 400 MeV
Absolute Time Resolution	$\sim 2\,\mu$s	
Deadtime	$100 - 200\,\mu$s	
Hard X–ray Imaging Detector (Super-AGILE)		
Energy Range	15 – 45 keV	
Single (mono-dimensional) detector field of view	$107° \times 68°$	FW at Zero Sens.
Combined (bi-dimensional) detector field of view	$68° \times 68°$	FW at Zero Sens.
Sensitivity (at 15-45 keV)	$\sim$ 10 mCrab	(5σ in 1 day)
Angular Resolution (pixel size)	$\sim$ 6 arcmin	
Source Location Accuracy	$\sim$2-3 arcmin	S/N$\sim$10
Energy Resolution (FWHM)	$\Delta E <$ 8 keV	
Absolute time accuracy	$\sim 4\,\mu$s	
Mini-Calorimeter		
Energy Range	0.3 – 100 MeV	
Energy Resolution	13% FWHM	at 1.3 MeV
Absolute Time Resolution	$\sim 3\,\mu$s	
Deadtime (for each of the 30 CsI bars)	$\sim 20\,\mu$s	

Super-Agile





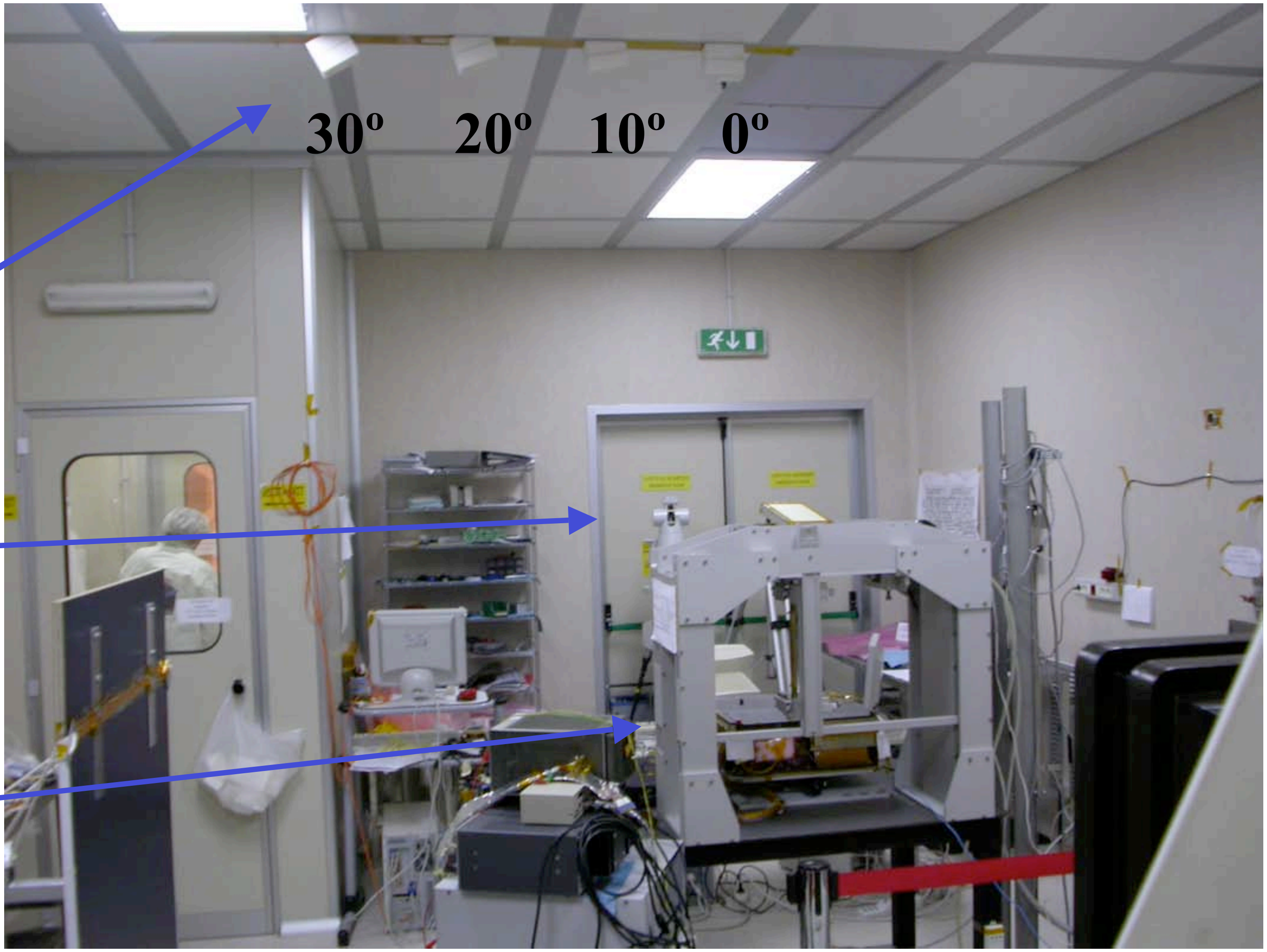
- Arcmin imager
- 15- 45 keV
- 2 x 1-D coded masks
  - 6′ pixel size
- Eff Area 300 cm^2 on axis (@15 keV)
- Large Field of View
  - ~ 1 sr
- ~6 keV FWHM
- Timing
  - < 5 μs accuracy
- Source localization
  - 1.5 arcmin for bright sources

Super-AGILE: Finite Distance Source Calibrations (Rome - August 2005)

Radioactive Sources

Laser Tracking

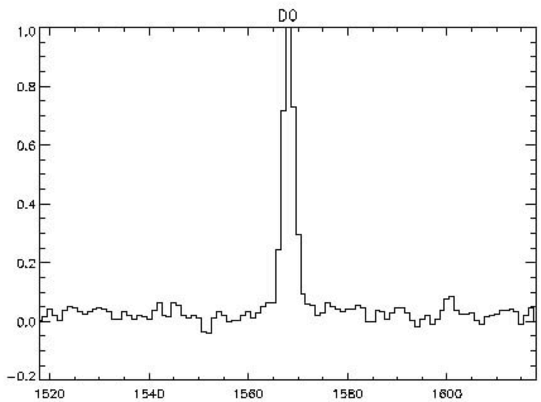
Instrument



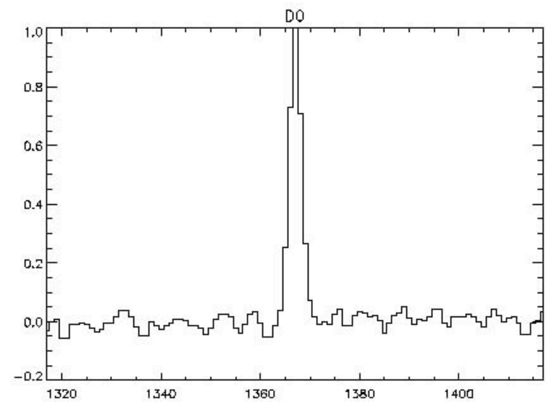
SA Finite Distance Source Calibration First Results

Sky Image of a Cd^{109} (22 keV)

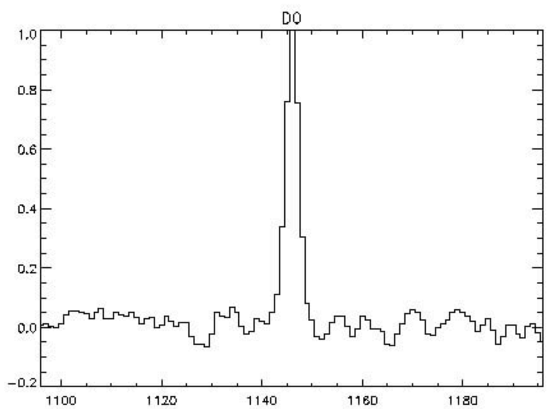
on-axis



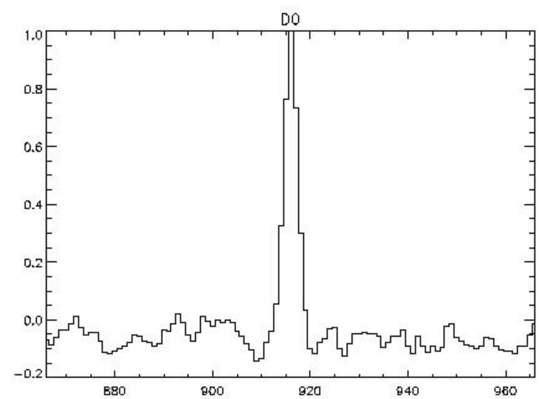
10º off-axis



20º off-axis

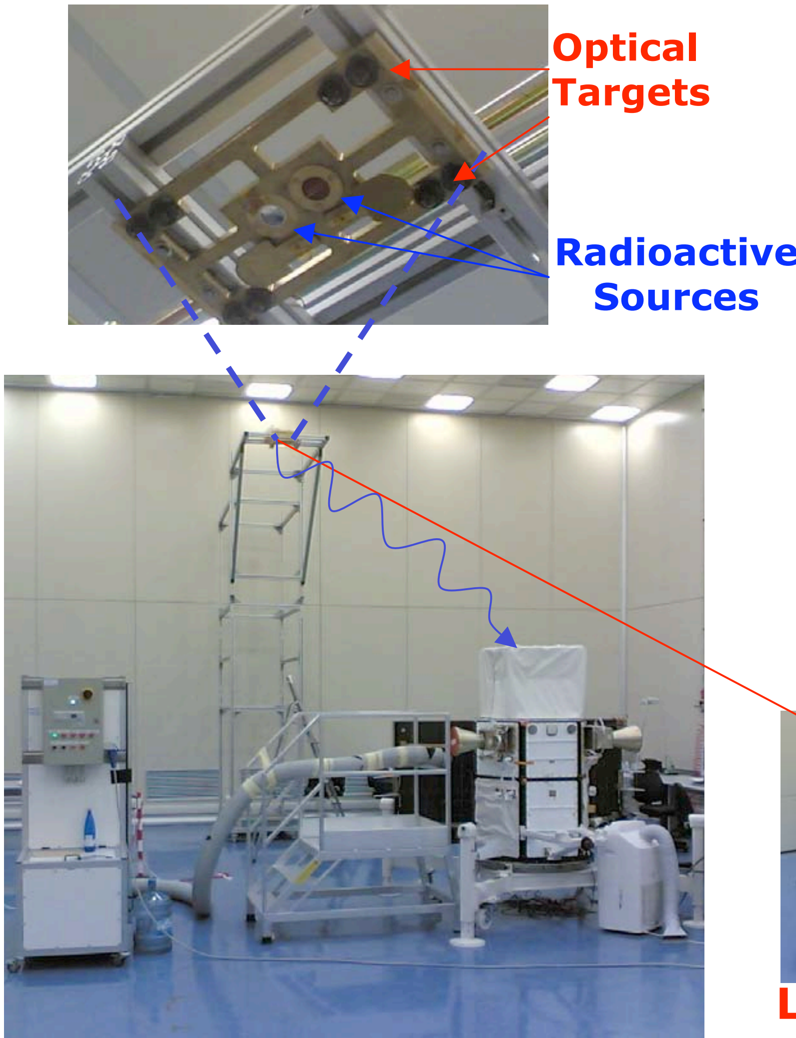


30º off-axis



Super-A Ground Calibration (Tortona, 2-7 Jan 2007)

AL - Experimental set-up



- SA was exposed to omnidirectional radioactive sources placed at several off-axis angles by using a custom-designed source holder (top left) and support structure (bottom left).

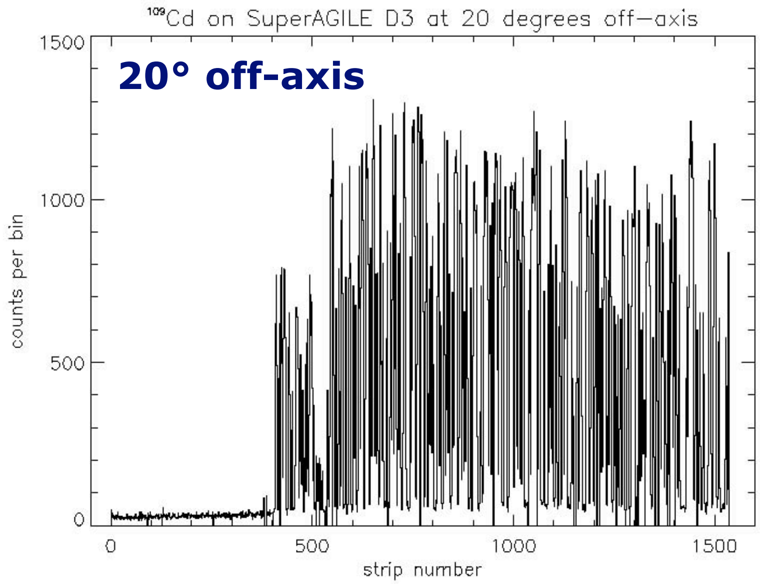
- The SA imaging response is calibrated versus micrometric source positions obtained by a Laser Tracker (bottom, center), pointing to 8 optical targets placed on the source holder.

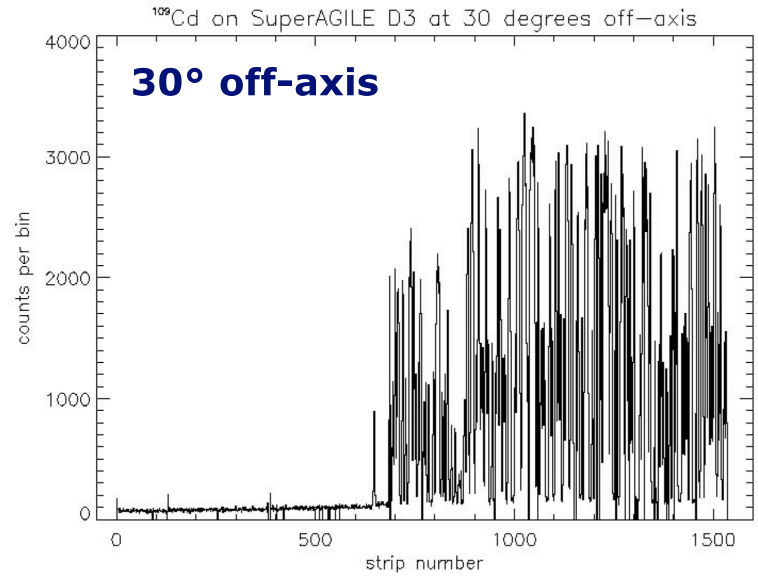
Laser Tracking of Source Position

INAF – IASF

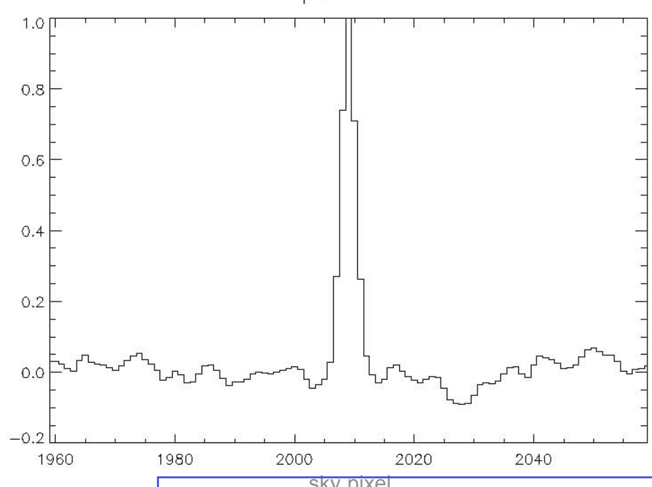
Roma ENEA, Frascati

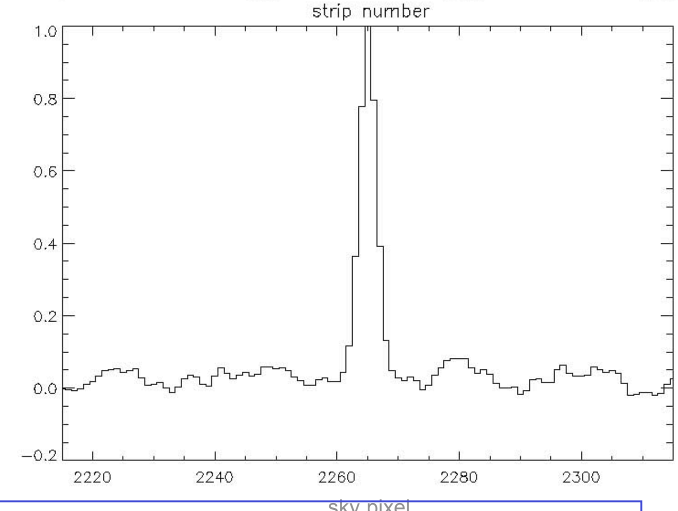
SA Calibration
Detector Images vs. Sky Images





Mask Modulation on Detector Images





Corrected and Deconvolved Source Images

(1 sky pixel = 3 arcmin)

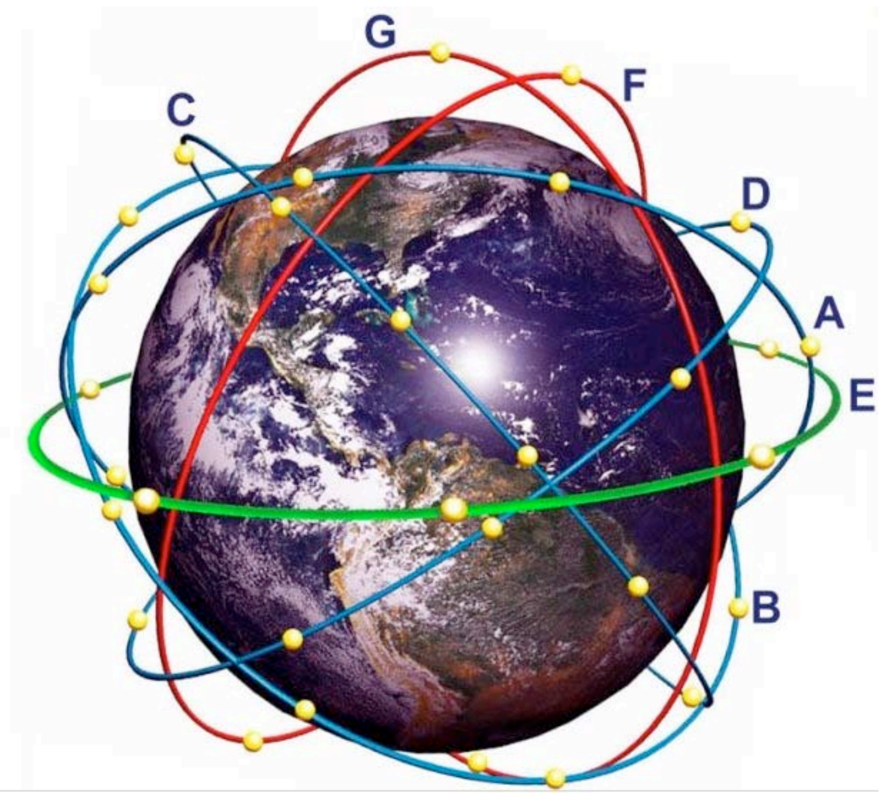
Preliminary Results: Cd^{109} (22 keV) source at 205 cm - D3 - S/N > 300

GRB Fast Link

- Super-AGILE is able to obtain on-board sky images and GRB positions within a few arcminutes in 10-15 seconds

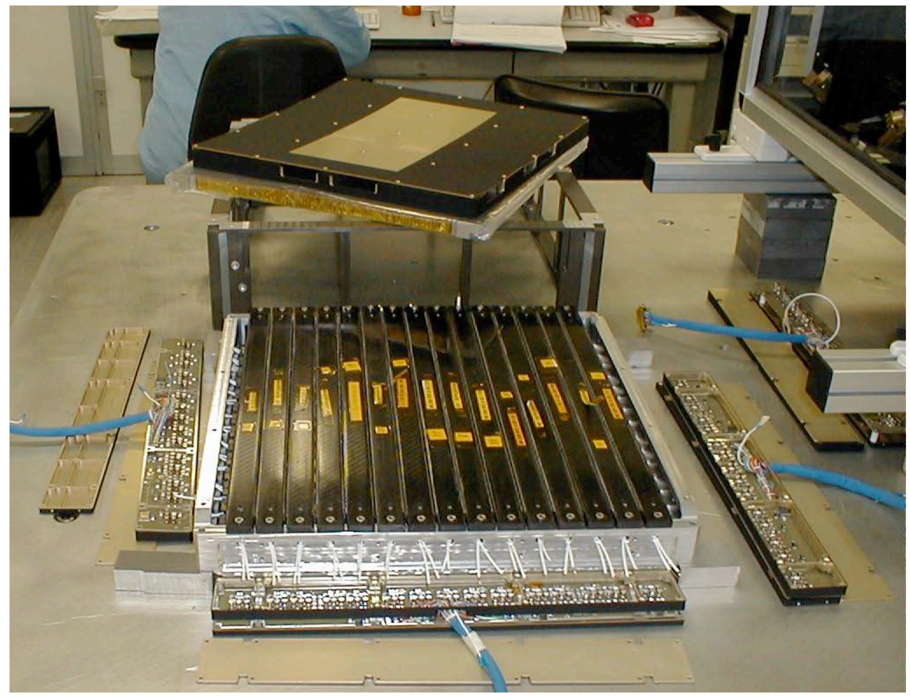
- A transeiver on board of AGILE would allow communication (ORBCOMM) of GRB coordinates

- GCN coordinates within few min

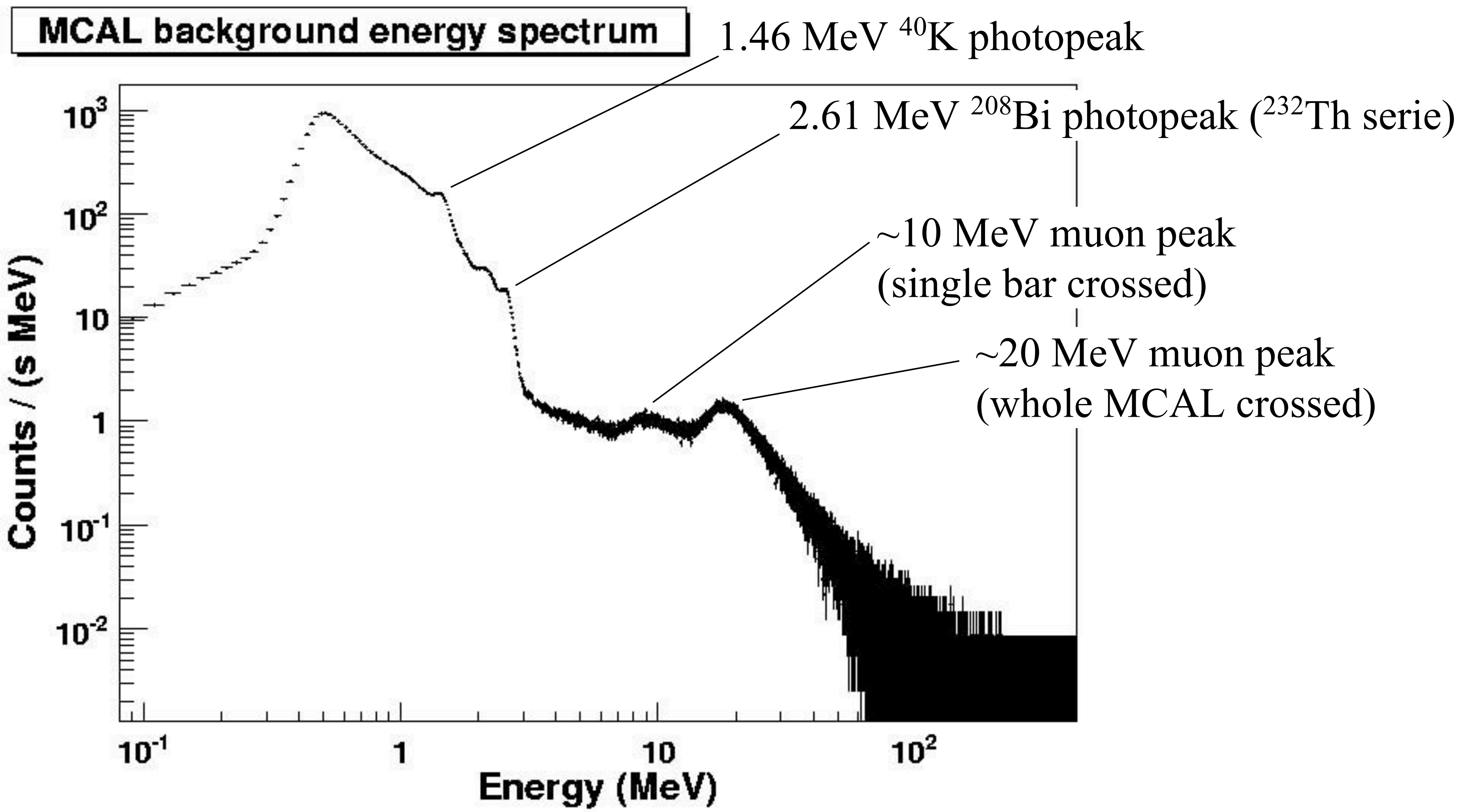


The Mini-Calorimeter

- 2 layers
  - 30 CsI bars
- A_{eff} ~ 400 cm²
  - (@1-10 MeV)
- Independent on-board trigger algorithm.
- Low-threshold in energy
  - (300-400 keV).
- Optimized in the range 1-10 MeV.
- Photon-by-photon acquisition following on-board trigger.
- Dedicated special memory buffer
  - ~200 sec data accumulation.



MCAL Energy Measurements: Radioactivity in Tortona

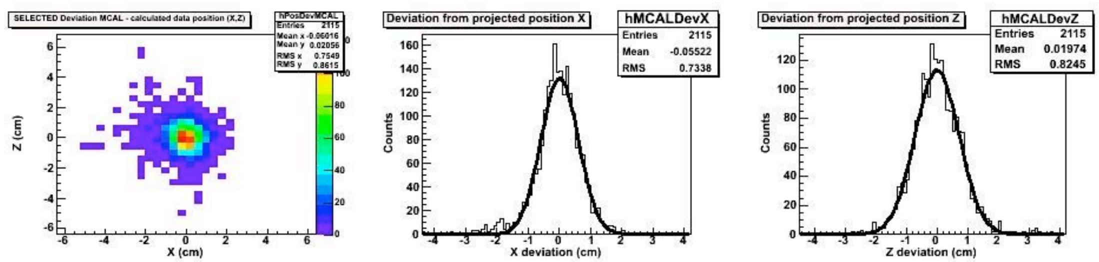


MCAL broad band background energy spectrum. Several features due to radioisotopes in the environment and atmospheric muons can be identified.

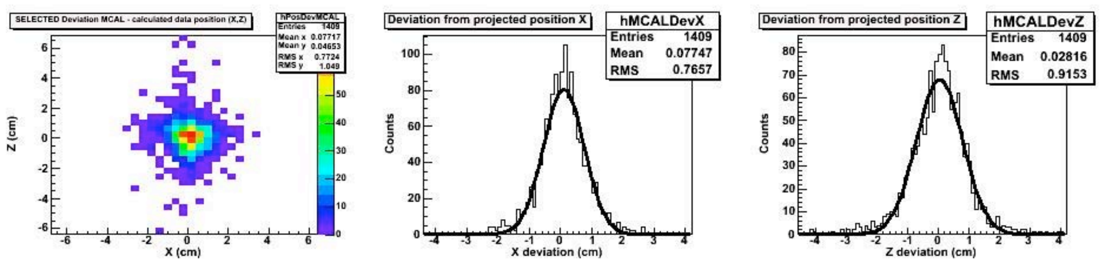
GRID mode Position Resolution

- **MCAL GRID events position deviation from expected position obtained projecting Silicon Tracker muon tracks onto MCAL.**

MCAL - 0° < θ < 10°

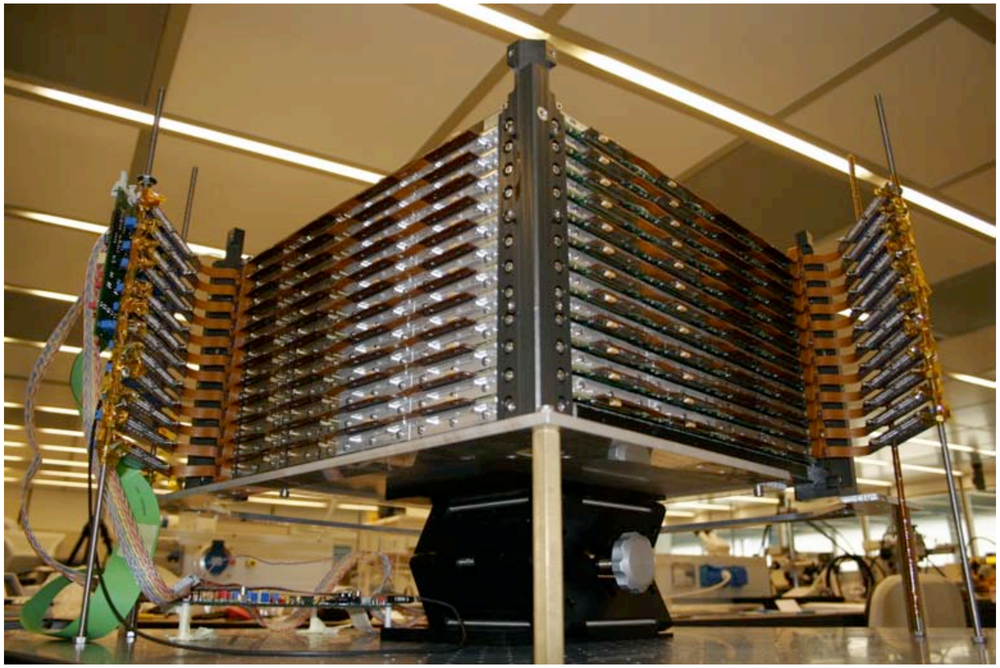


MCAL - 40° < θ < 50°



- **MCAL GRID mode position resolution is $\sigma_X = \sigma_Z$ = 7 mm at about 10 MeV for all the GRID field of view**

The Silicon Tracker

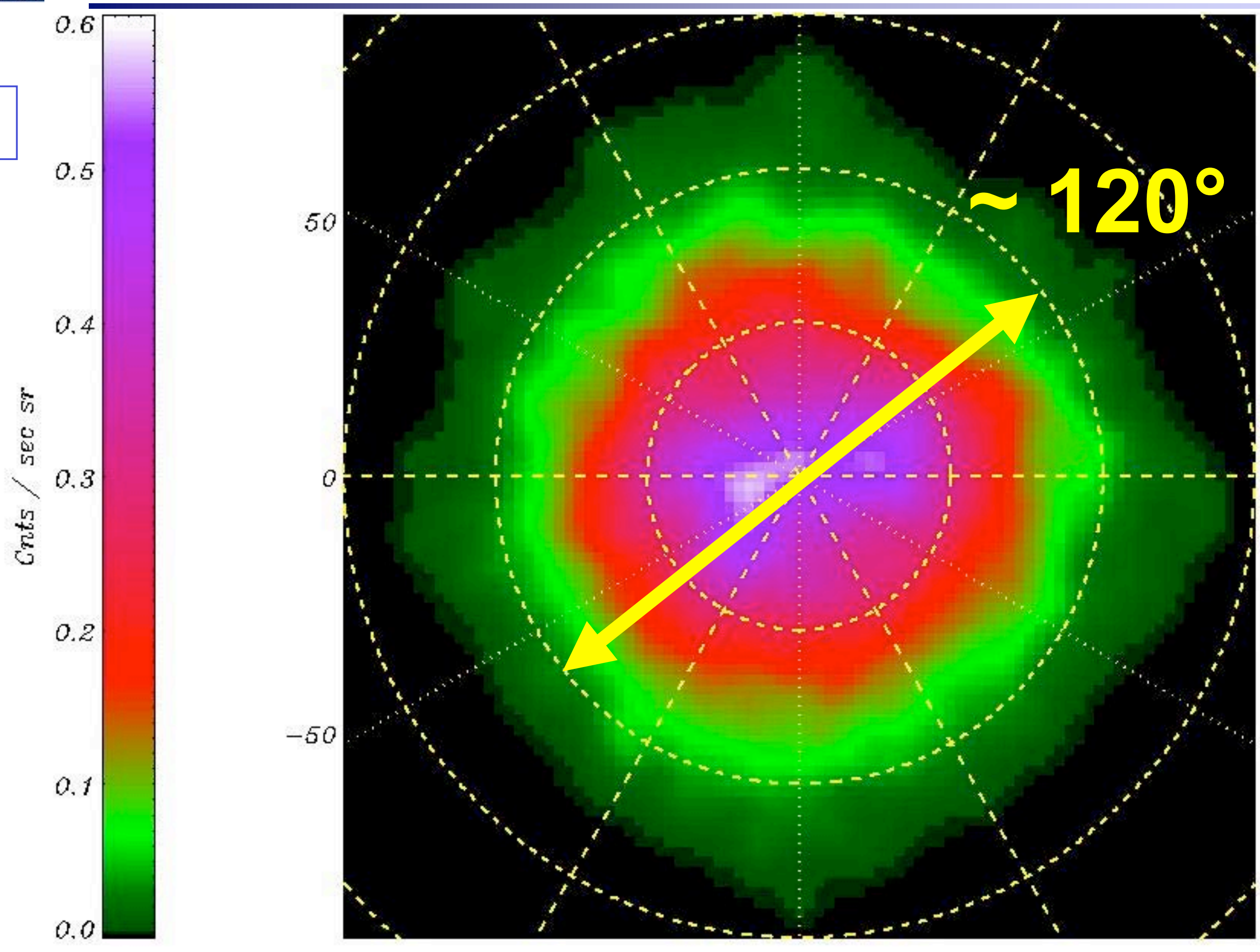


- 12 X-Y Silicon Microstrip Detector Planes
- 10 planes with tungsten
  - 0.07 X_0
- 40 micron resolution

GRID detection of natural bkg gamma-rays

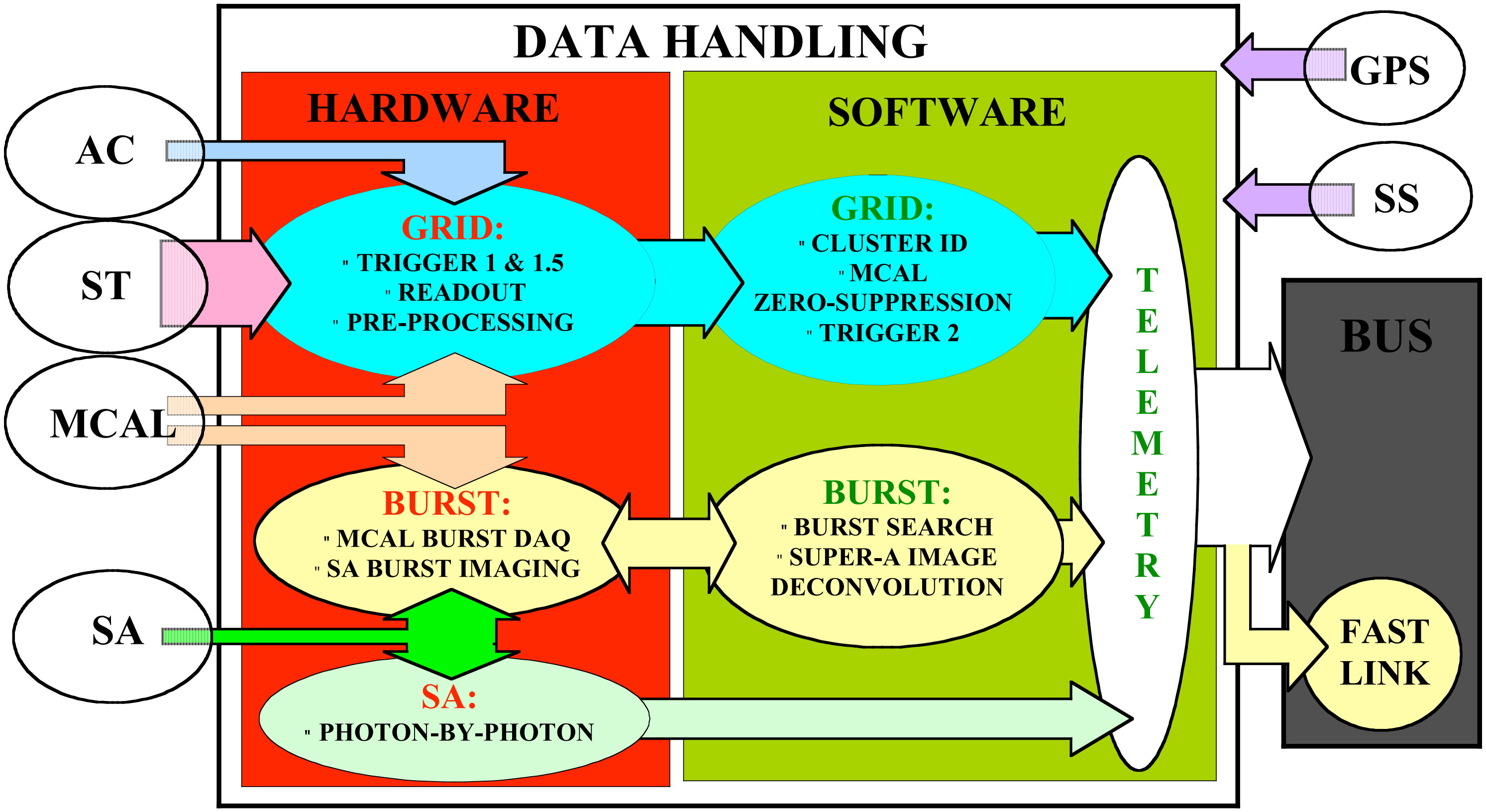
AGILE detection of the natural γ-ray background

Preliminary



Gamma-ray flux (E> 100 MeV, $\theta \leq 20°$): $(3 \pm 0.5) \times 10^{-4}$ ph. cm^{-2} s^{-1} sr^{-1}

AGILE DAQ

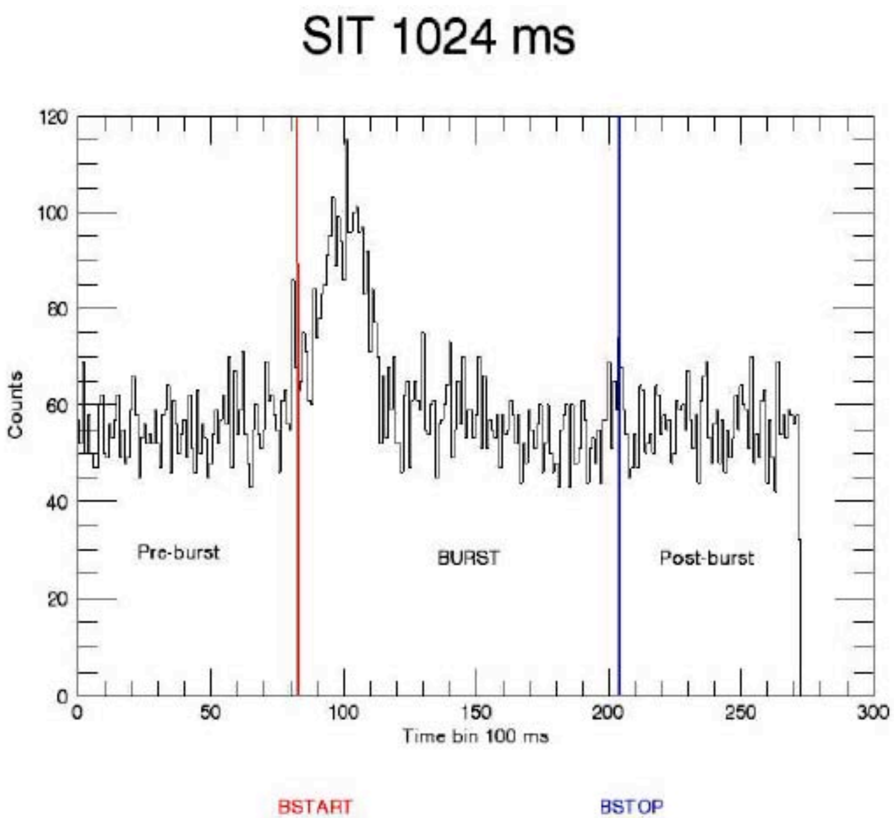


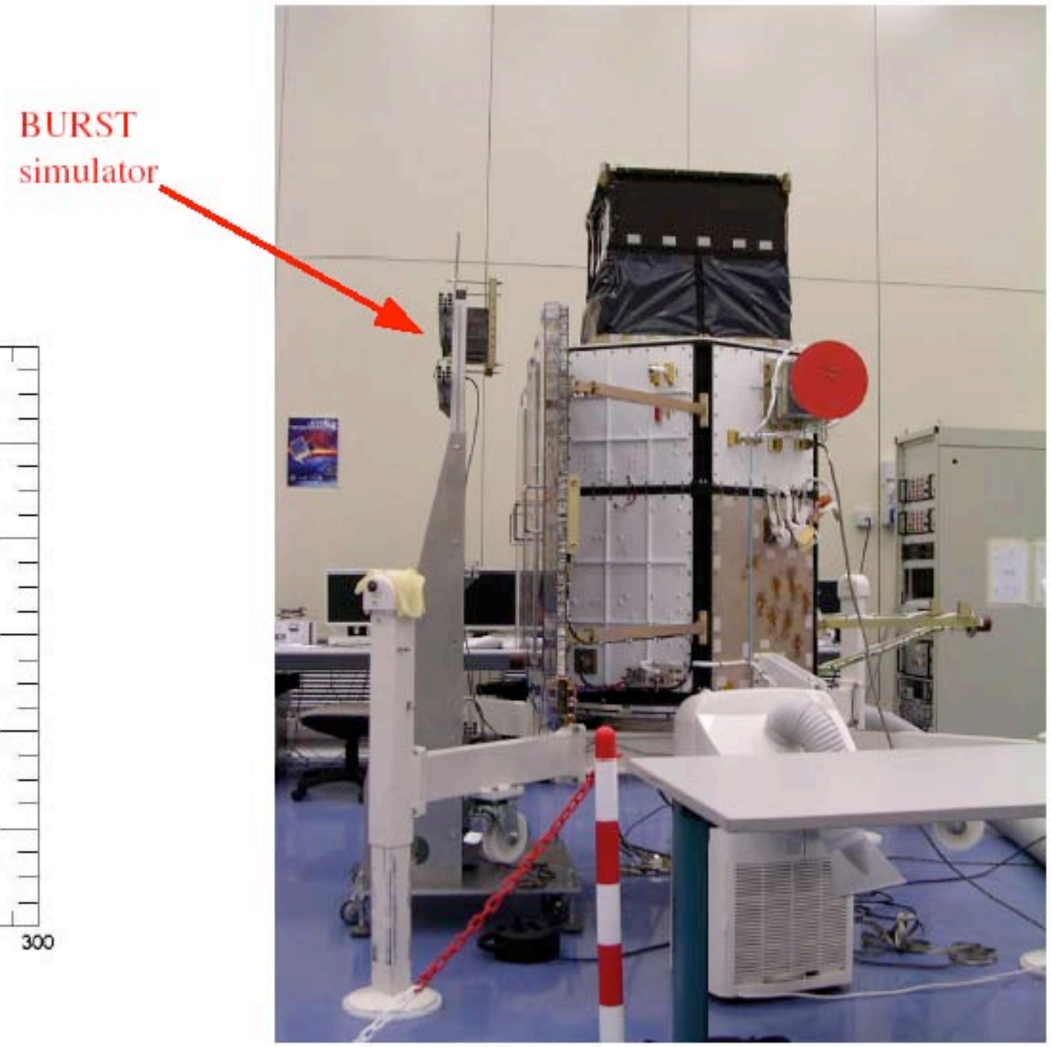
Silicon Tracker:	36844 channels	OBT (with respect to UTC): $\Delta t < 2\mu s$
Super-AGILE:	6144 channels	GRID time tagging: $\Delta t < 2\mu s$
Mini-Calorimeter:	60 channels	SA, MCAL time tagging: $\Delta t < 5\mu s$
Anticoincidence:	16 channels	Attitude reconstruction: ~ 1 arcmin.

GRB on-board Burst Search

- 1 msec – 8 s
- Special search for sub-ms events
- Independent Search for GRBs in
  - Super-AGILE (15 – 45 keV)
  - MCAL (300 – 400 keV – 100 MeV): trigger for photon-by-photon acquisition
- Super-AGILE on-board imaging
- Fast Link: communication of GRB coordinates

MCAL GRB search testing





Tortona, June 2006

In-flight scientific performance and Montecarlo validation

SIMULATIONS

Montecarlo of instrument and satellite
Simulations of data handling
Simulations of calibration facilities

SCIENTIFIC PERFORMANCE

CALIBRATIONS

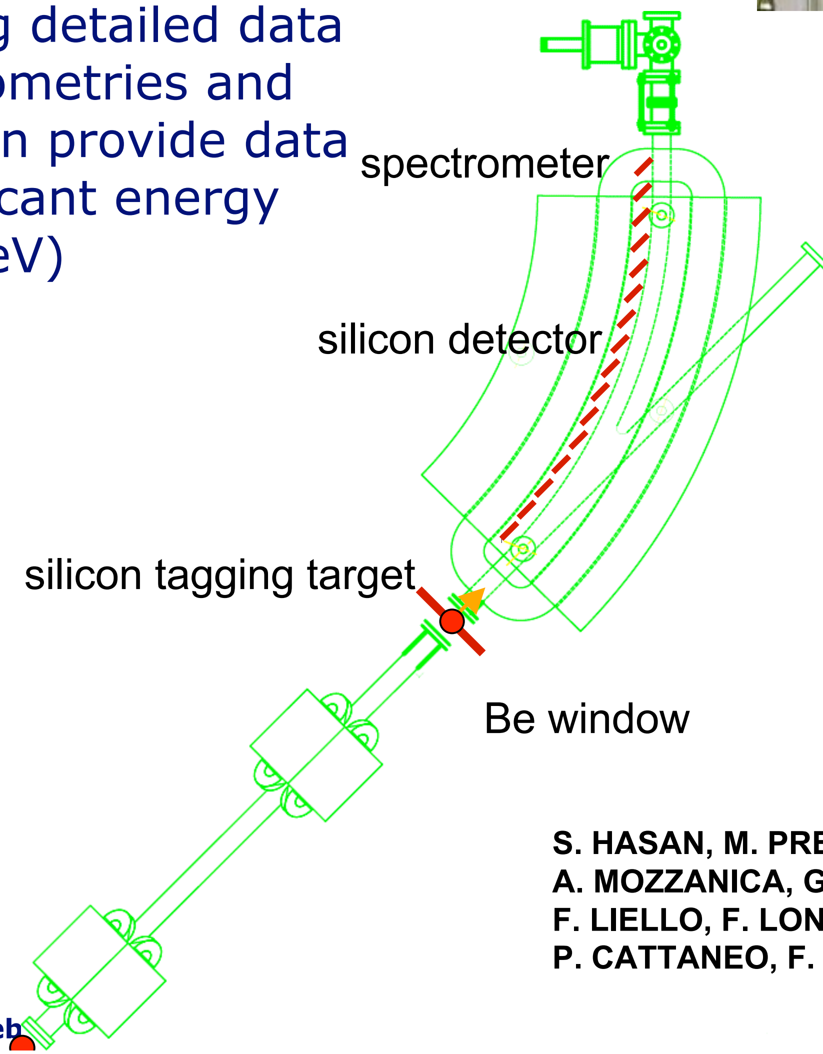
Calibrations and tests at sub-system level
Beam Tests at CERN
Calibrations at Frascati
Background acquisition runs

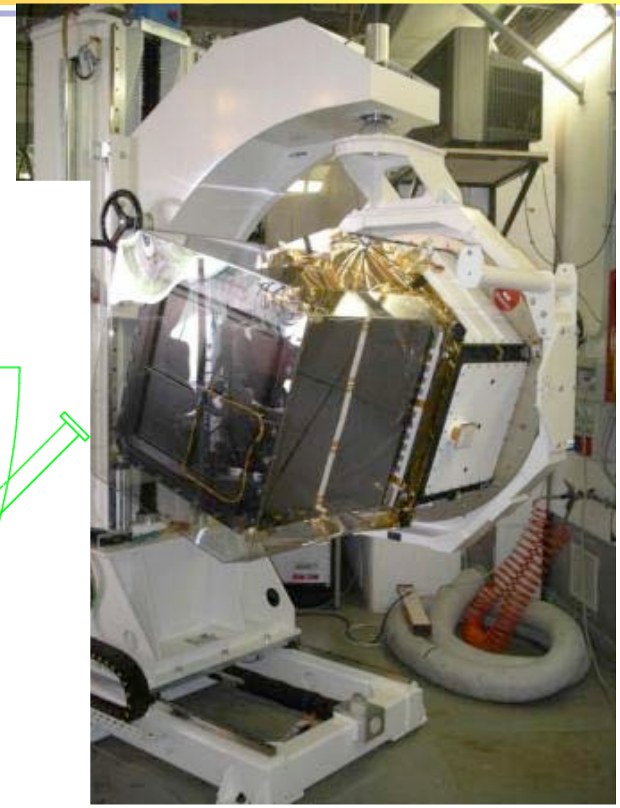
Scientific performances of gamma-ray telescopes can only be assessed by a combination of simulations and calibrations.

- **Ground calibrations cannot adequately reproduce the flight conditions, therefore they cannot be used directly to determine the scientific performance.**
- **Ground calibrations are used to validate the Montecarlo simulation of the instrument and for specific applications (e.g., PSF).**
- **The expected in-flight scientific performance is derived from the Montecarlo**

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)



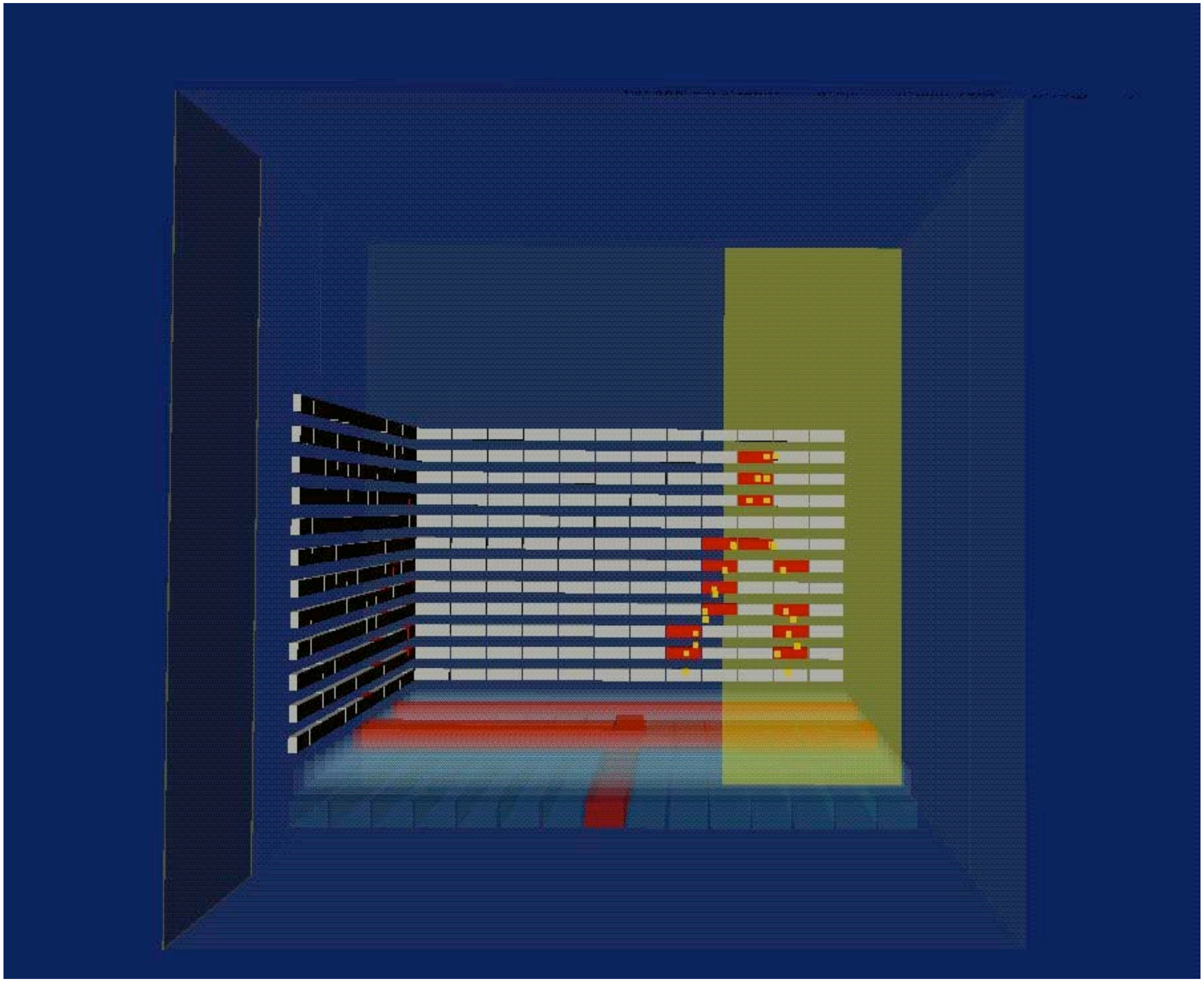


AGILE GRID

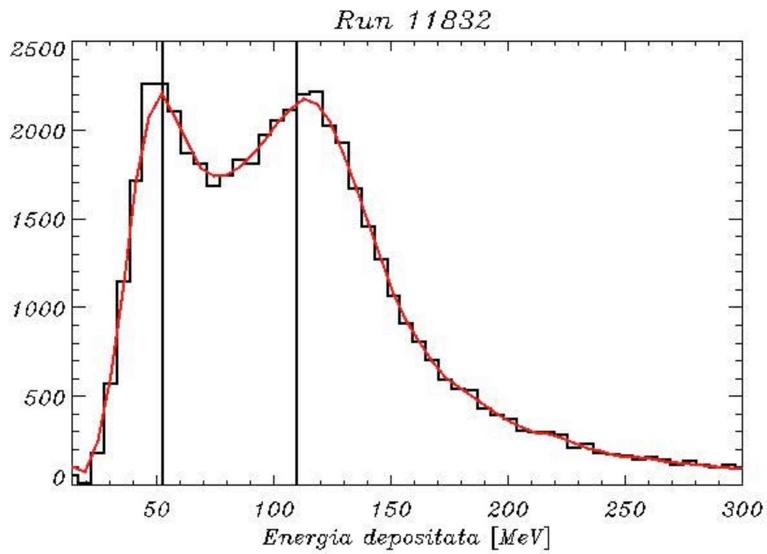
S. HASAN, M. PREST, L. FOGGETTA, C. PONTONI, A. MOZZANICA, G. BARBIELLINI, M. BASSET, F. LIELLO, F. LONGO, E. VALLAZZA, F. BOFFELLI, P. CATTANEO, F. MAURI and AGILE Collaboration

The DAΦNE Beam Test Facility & AGILE Calibration

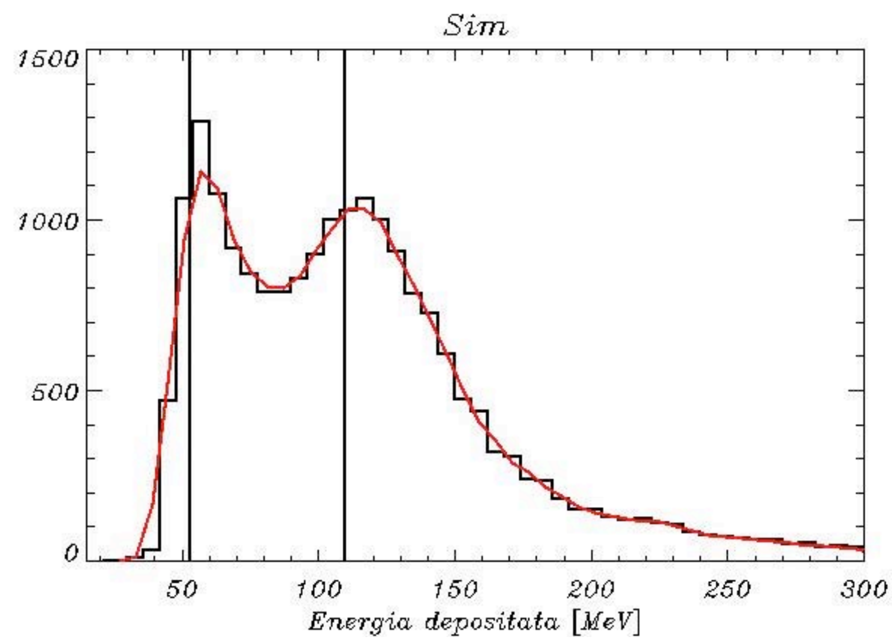
First gamma-ray photon detected by AGILE in BTF-LNF



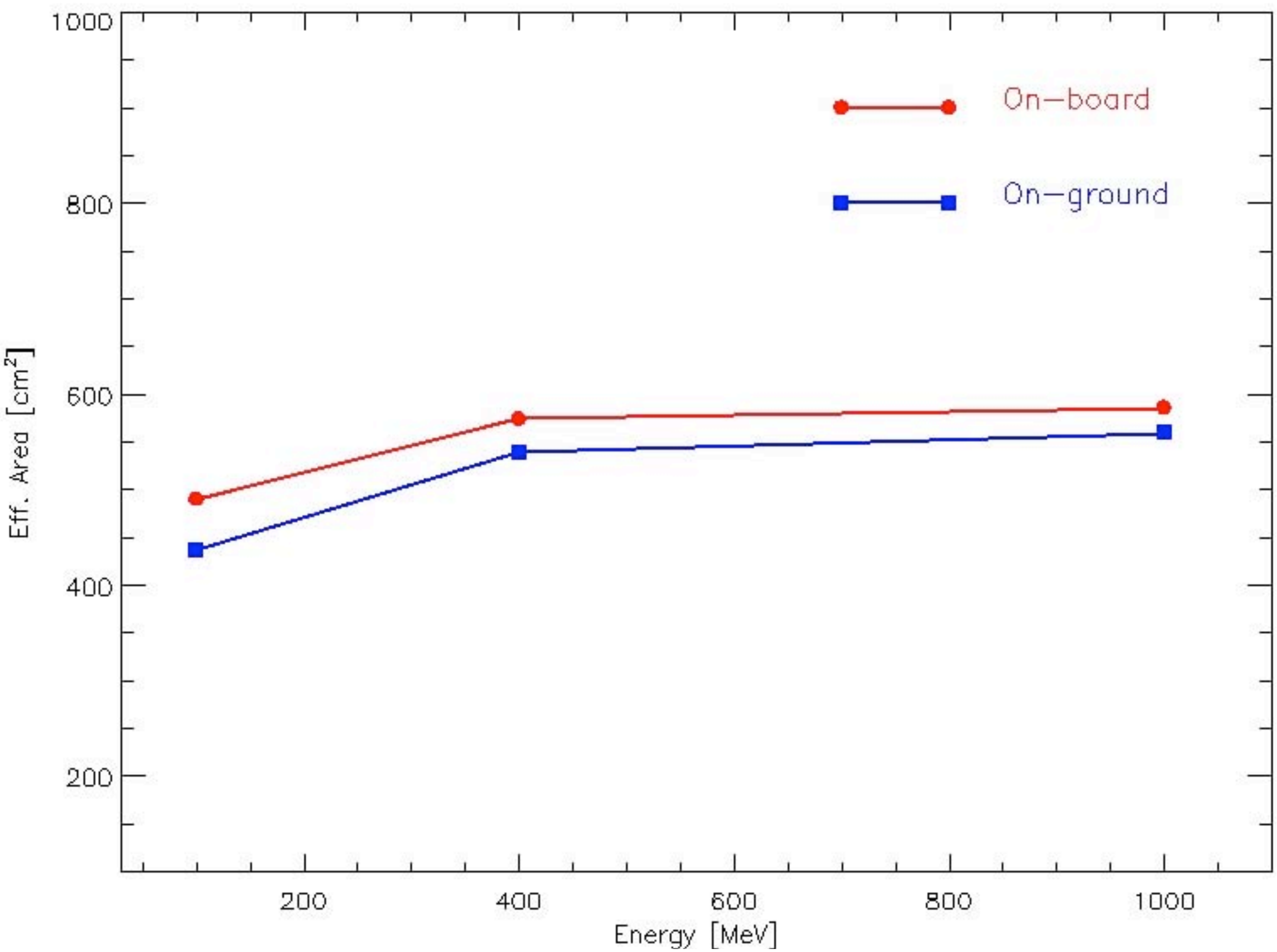
Muons: Simul. vs. Data



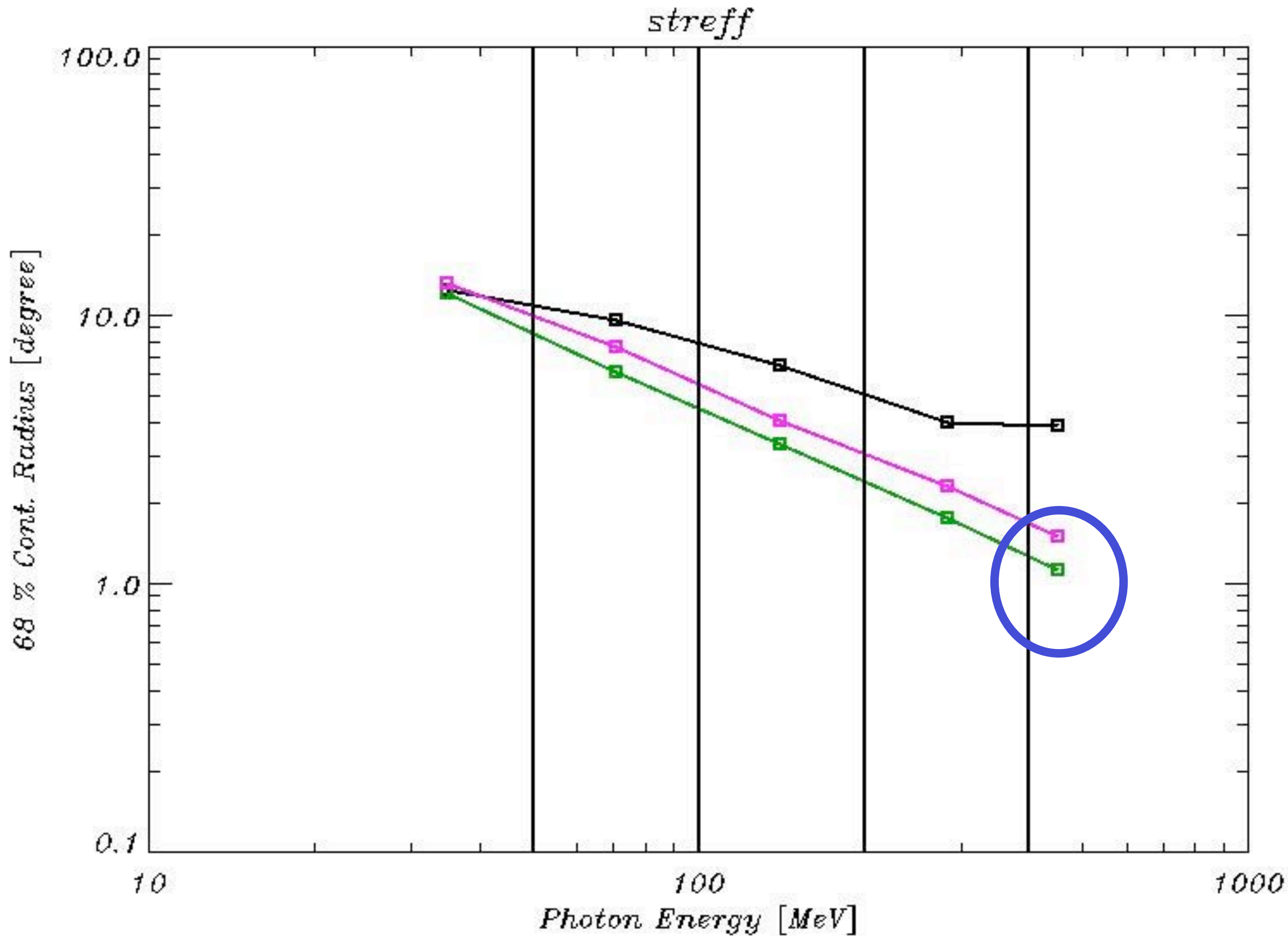
Distribution of the cluster central strip (C3)



GRID Effective Area

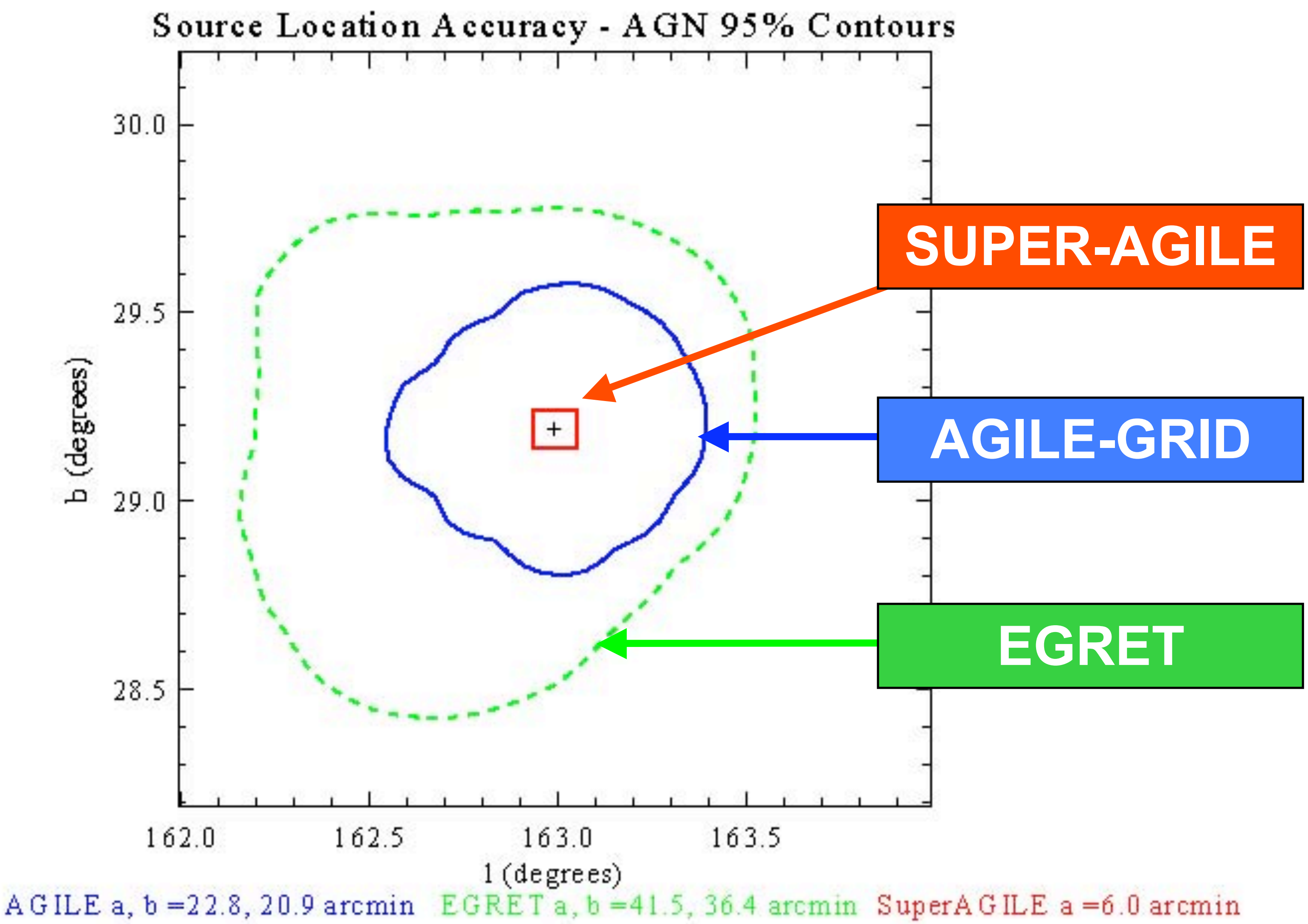


PSF study from calibration data



Beam and Electronics description

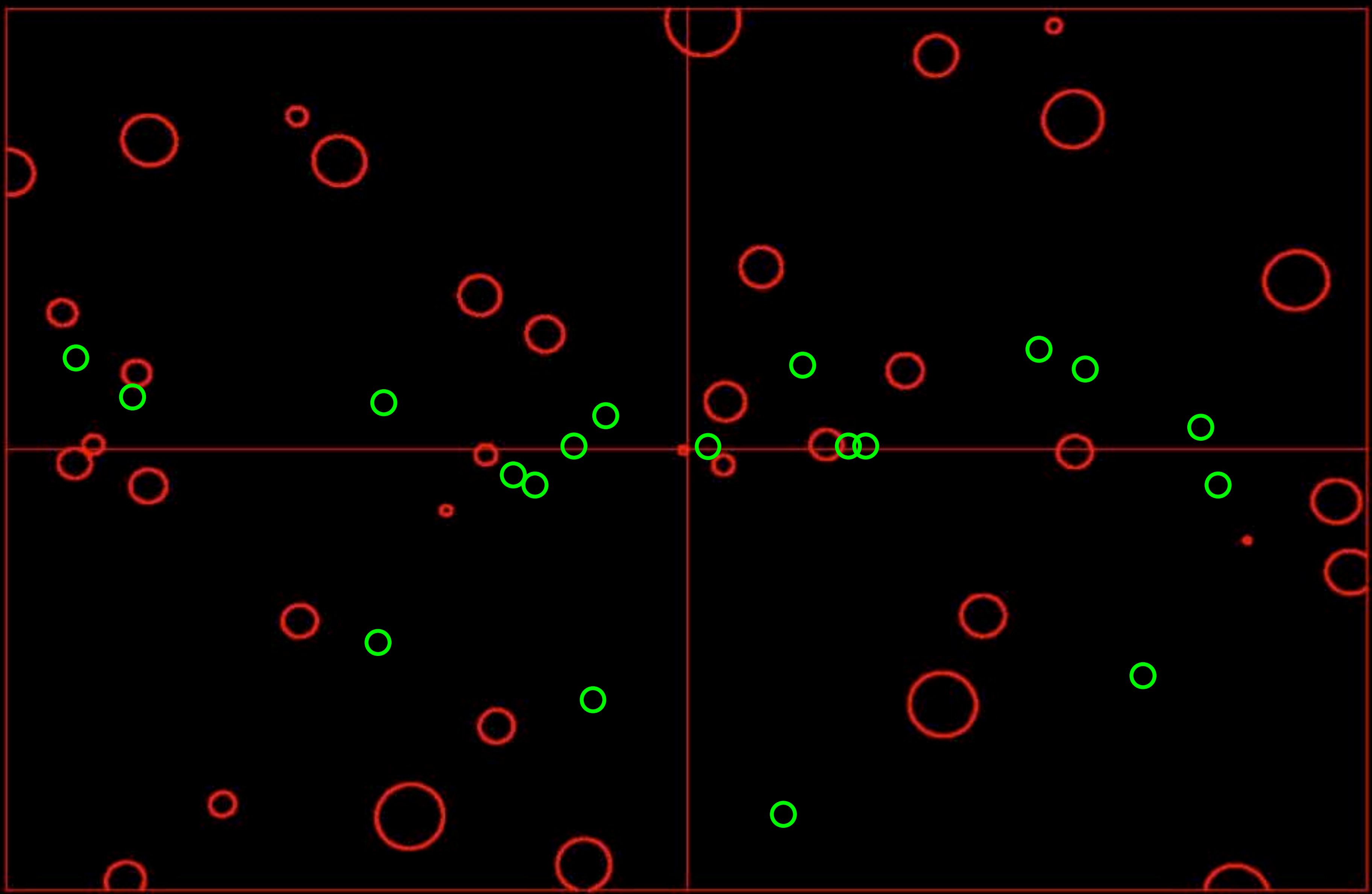
Gamma-ray source positioning (example: off-axis AGN)



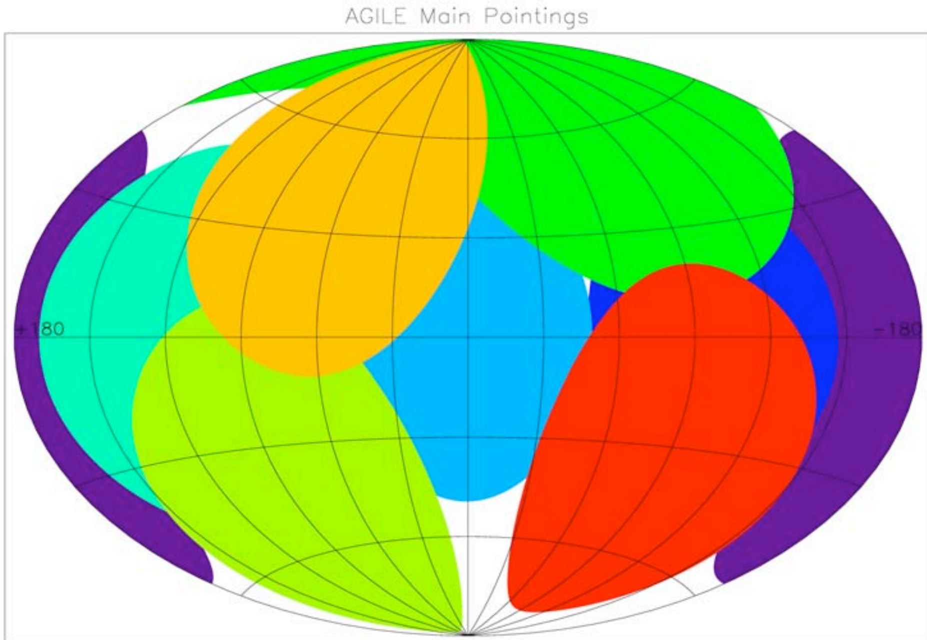
AGILE science topics

- Active Galactic Nuclei
- Gamma-Ray Bursts
- Pulsars
- TeV sources
- SNR and origin of cosmic rays
- Diffuse Galactic gamma-ray background
- Unidentified gamma-ray sources
- Microquasars
- Galactic Neutron Stars and Black Holes
- Fundamental Physics: Quantum Gravity

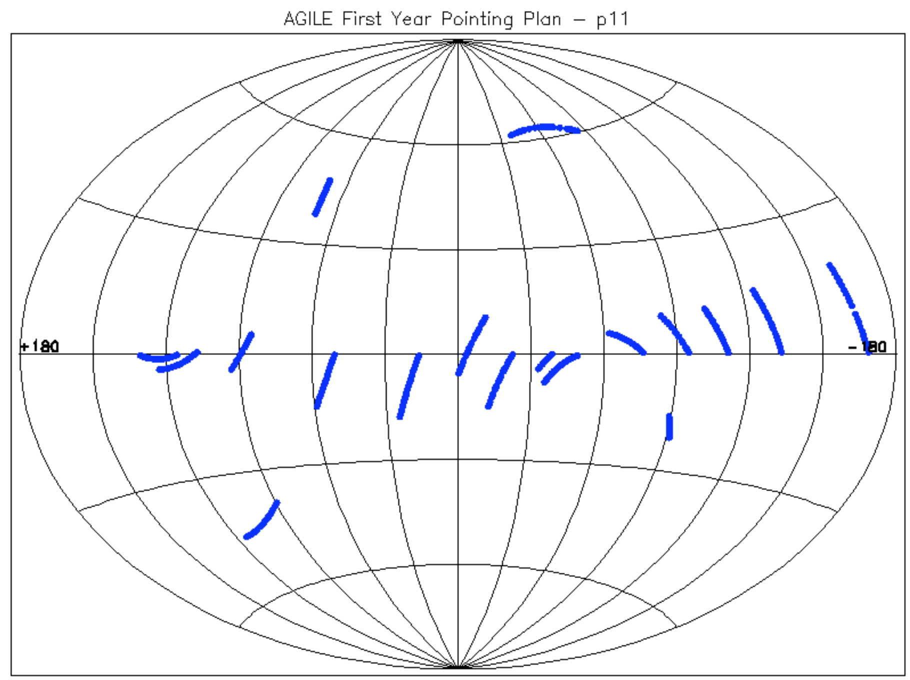
AGILE gamma/hard X-ray sources near the GC (40^{o}x30^o) [simulated]



AGILE pointing program

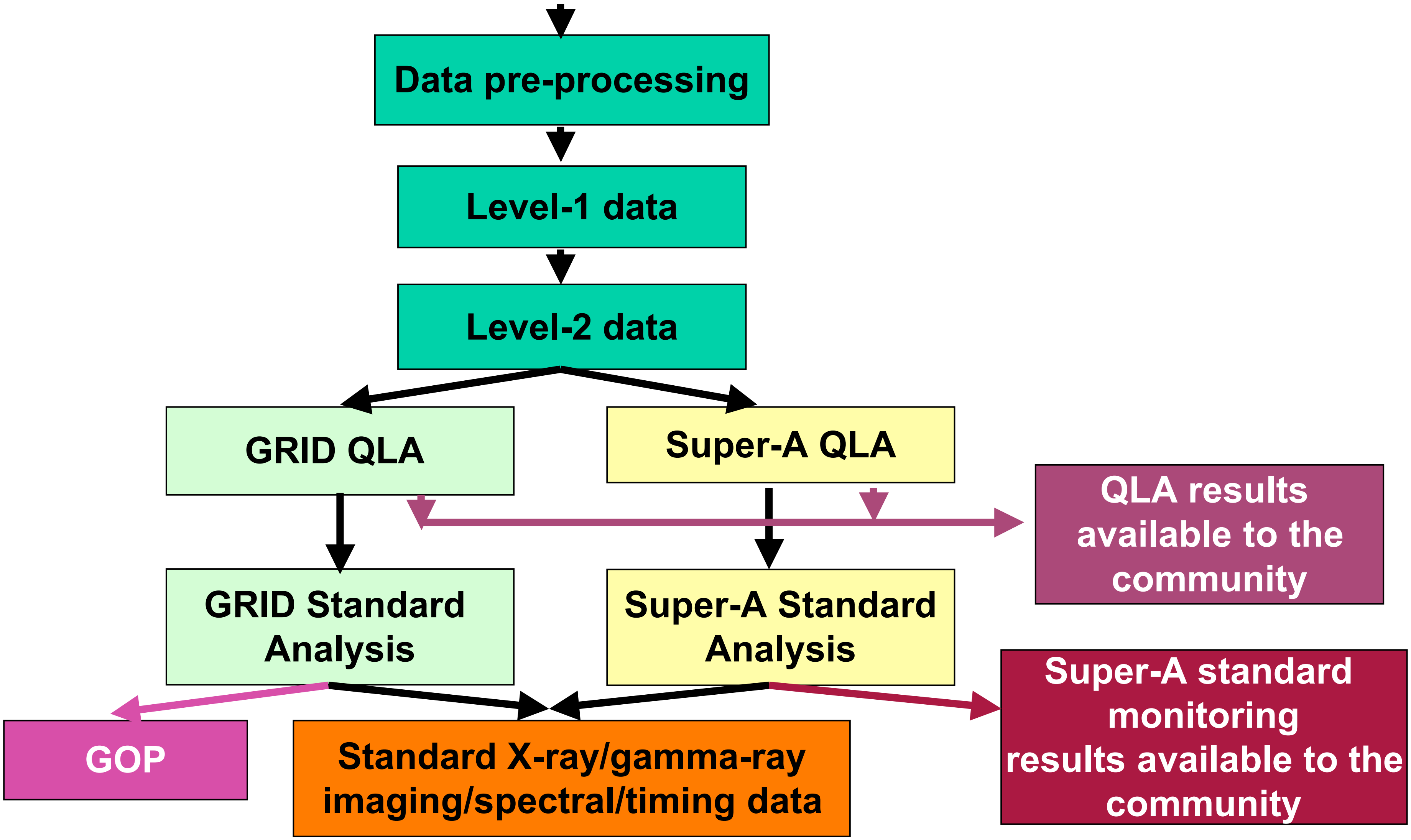


Example of sequence of pointings



Preliminary pointing program

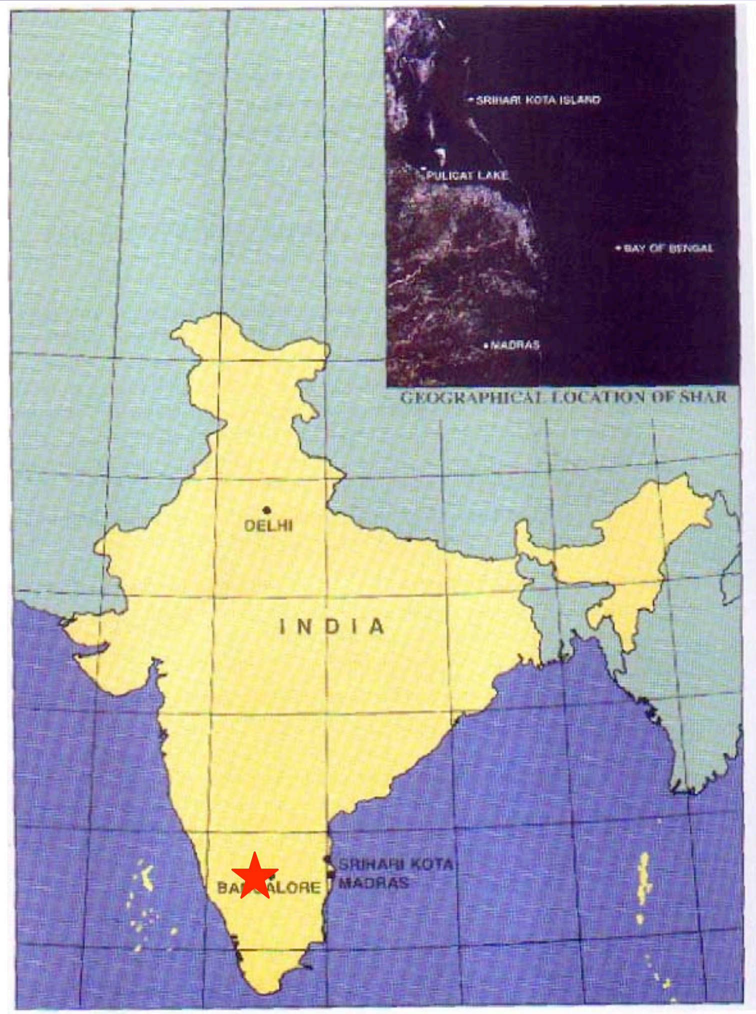
AGILE data flow



Conclusions

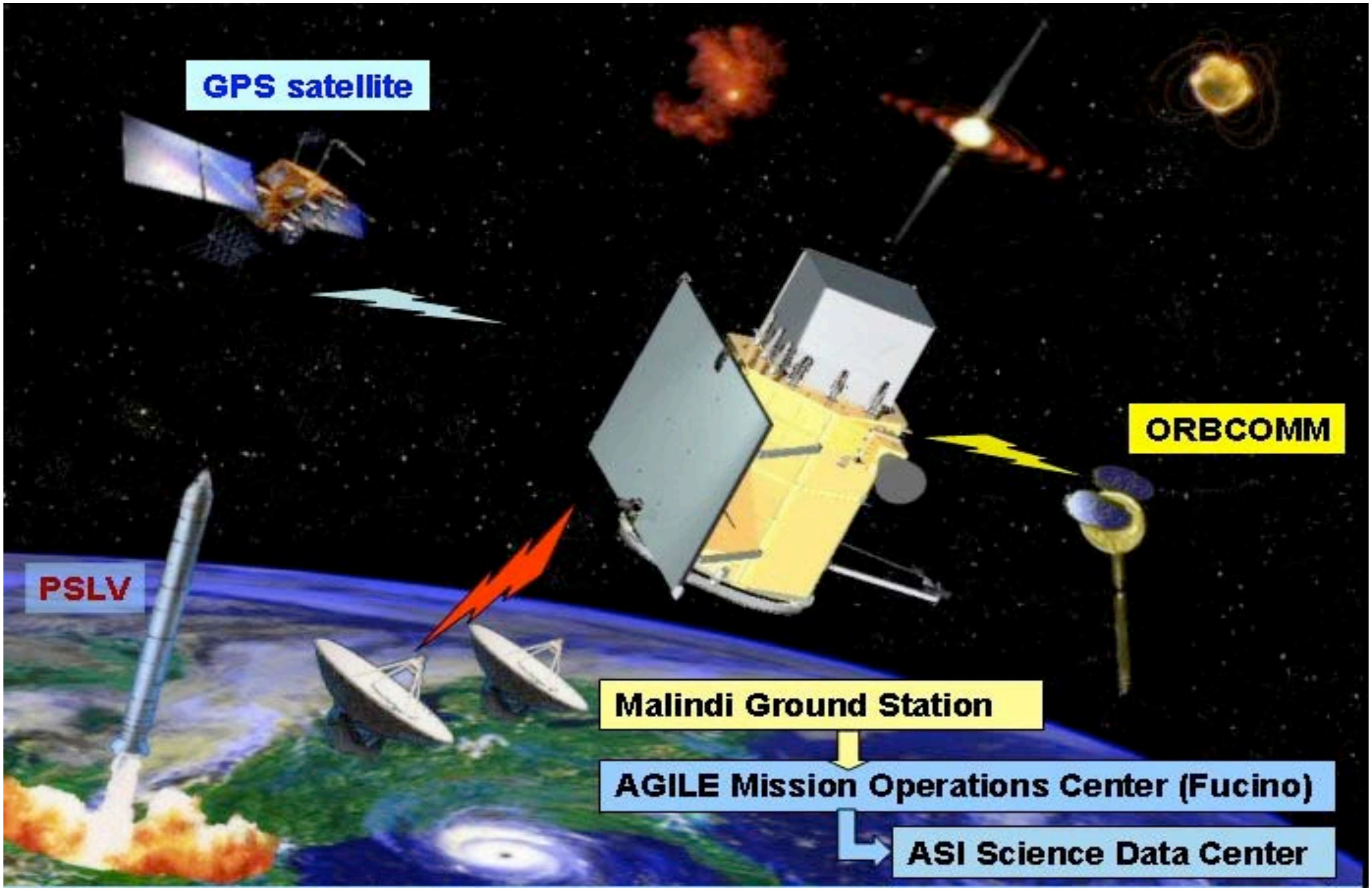
- AGILE is confirmed to be a unique satellite obtaining crucial simultaneous information in the gamma-ray and hard X-ray bands with good angular resol. and very large FOVs.
- Optimal to detect transients (GRBs, AGNs or Galactic transients).
- Complementary and synergic to GLAST.
- March 31 current baseline launch date
- Commissioning & Science verification phase spring – early summer
- Science Data Taking starting late Summer
- Guest Observer open for study of point like gamma-sources
- Scientific Meeting for AGILE first light in September
- Scientific Workshop on X-Gamma Astrophysics with AGILE next january - february

PLSV launcher



- Minimize particle background
- Use of the ASI Malindi ground station

AGILE mission



http://agile.iasf-roma.inaf.it