An X-ray imager based on silicon microstrip detector and coded mask

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Summary

Scientific requirements and constraints of the SuperAGILE instrument;

Coded aperture imaging technique;

SuperAGILE: detector, electronics, coded mask and collimator;

SuperAGILE: development and laboratory testing

SuperAGILE: imaging capability and scientific performances;

The AGILE payload and mission;

The AGILE scientific goals

Conclusions

Scientific requirements and tight constraints

(SuperAGILE was not included in the AGILE mission baseline)

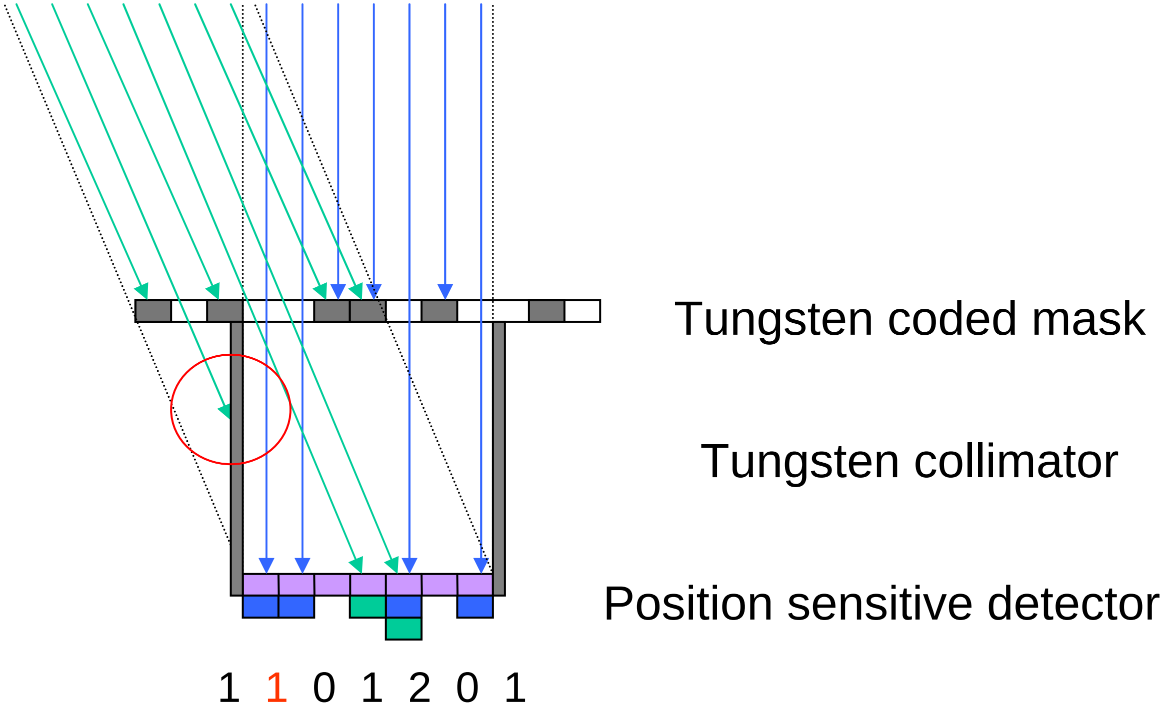
Constraints:

- it is in the field of view of a gamma ray instrument so it must be "transparent" to gamma rays;
- it is located inside the Anticoincidence shield (E_{min}>10 keV);
- it is a compact instrument with low power consumption (~12 W) and low mass (~10 kg);
- it is based on the same 1-D silicon microstrip detectors of the gamma ray instrument;

Scientific requirements:

- good angular resolution (~6 arcmin) in a wide field of view (~1 sr);
- sensitivity ~10 mCrab (~2 $\cdot 10^{-4}$ photons$\cdot$cm$^{-2}\cdot$s^{-1}) in the hard X-ray band (one day integration);
- high time resolution (~2 μs) and moderate spectral resolution (~7 – 8 keV).

Coded aperture imaging technique

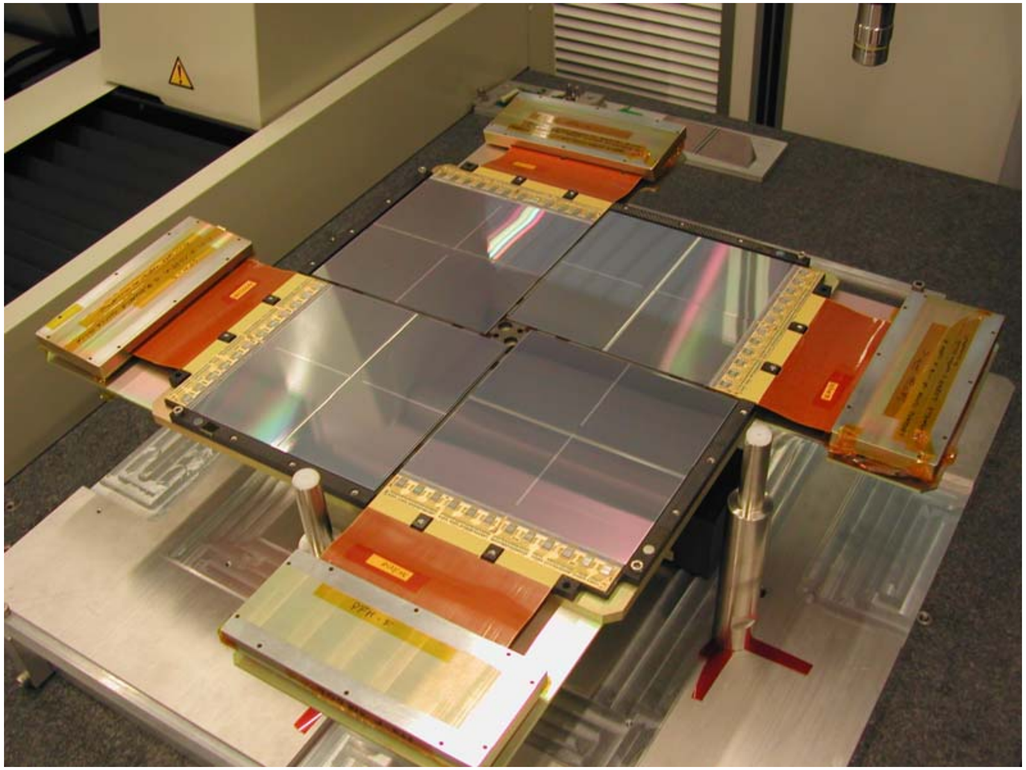


Coded aperture imaging is an effective technique to obtain the required field of view and angular resolution.

Coded aperture technique is a two-step imaging process:

1. photons are accumulated on the detector (detector image);
2. correlation between detector image and mask pattern is found (sky image).

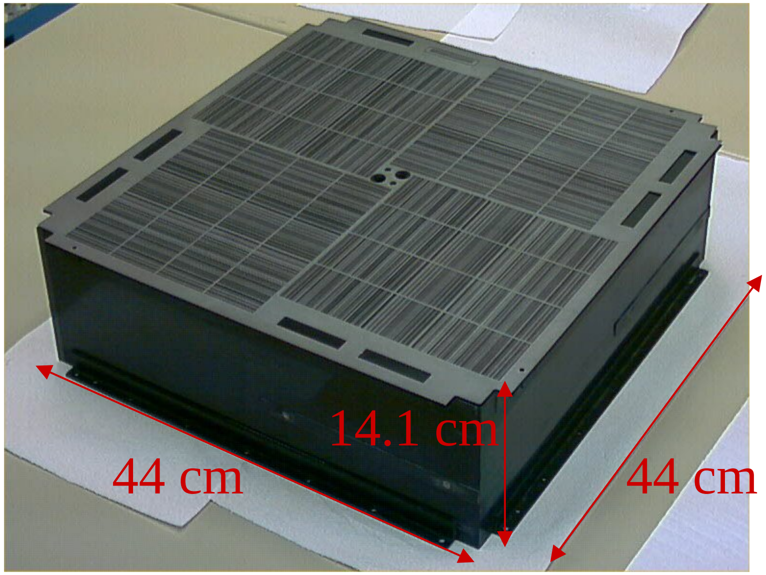
SuperAGILE: the detector and the electronics



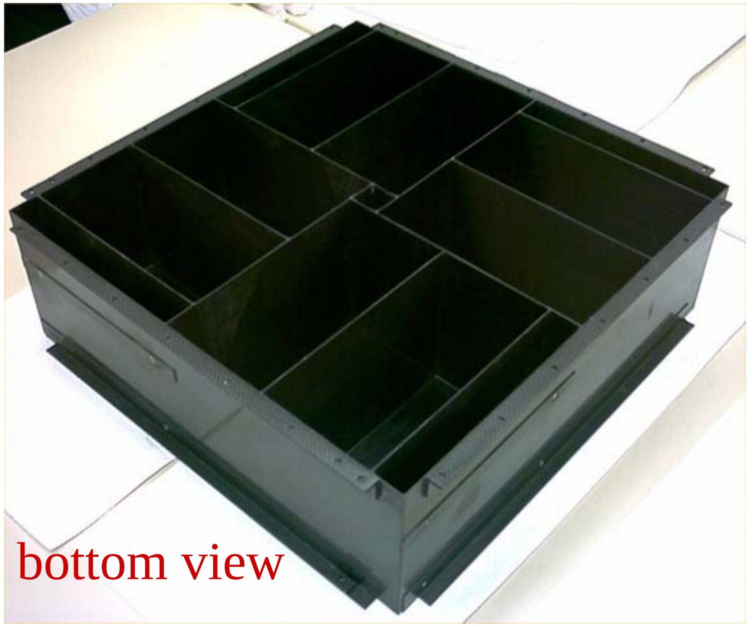
The SuperAGILE detector is composed of four modules of 1-D silicon microstrip detectors (Hamamatsu, 19×19 cm^2 area, 121 μm pitch and 410 μm thickness).

The front-end electronics is composed of 48 XAA1.2 ASIC circuits (Gamma Medica-Ideas, 128 input channels, ~1 mW/channel power consumption, ~900 e$^-$ ENC electronic noise).

SuperAGILE: the coded mask and the collimator

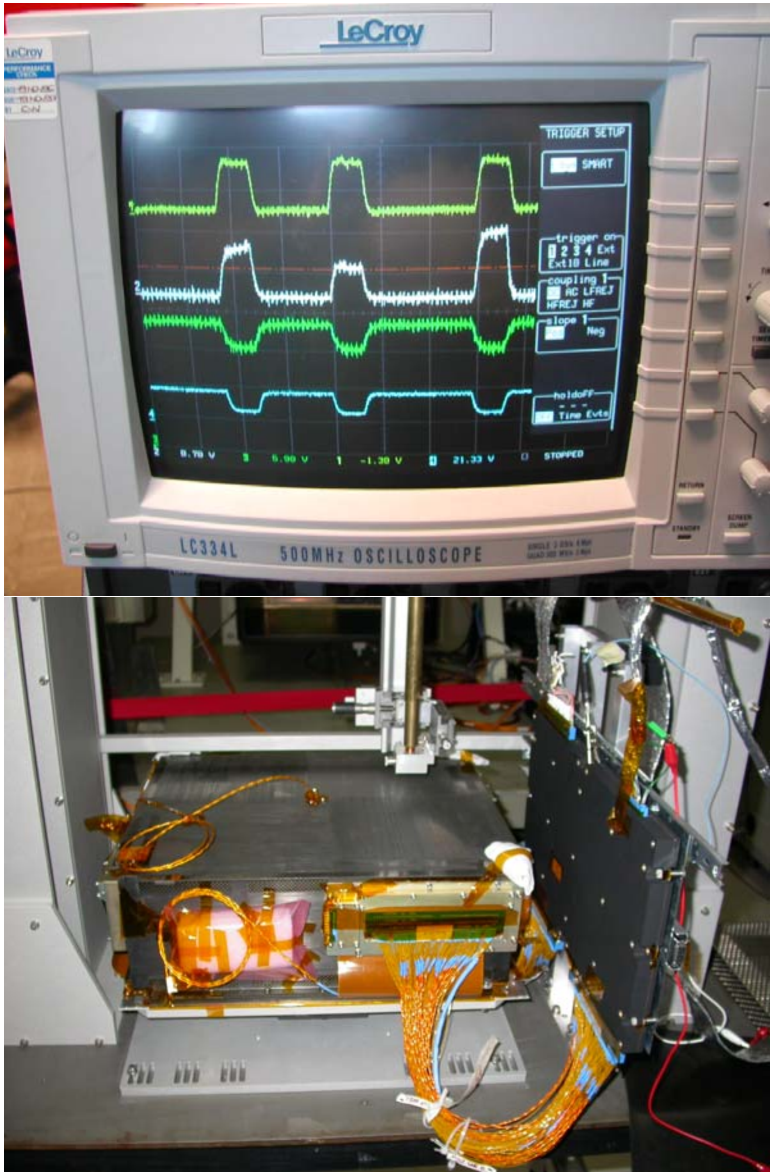


The SuperAGILE coded mask (50 % transparency) is composed of four modules of 787 1-D strips (19 cm × 242 μm) manufactured on a single chemically etched tungsten plate (120 μm thickness) glued on 500 μm thick carbon fiber.



The collimator defines the instrument field of view and is manufactured with 100 μm thick tungsten glued on 500 μm thick carbon fiber. The collimator dimensions are 14.1 cm × 44 cm × 44 cm.

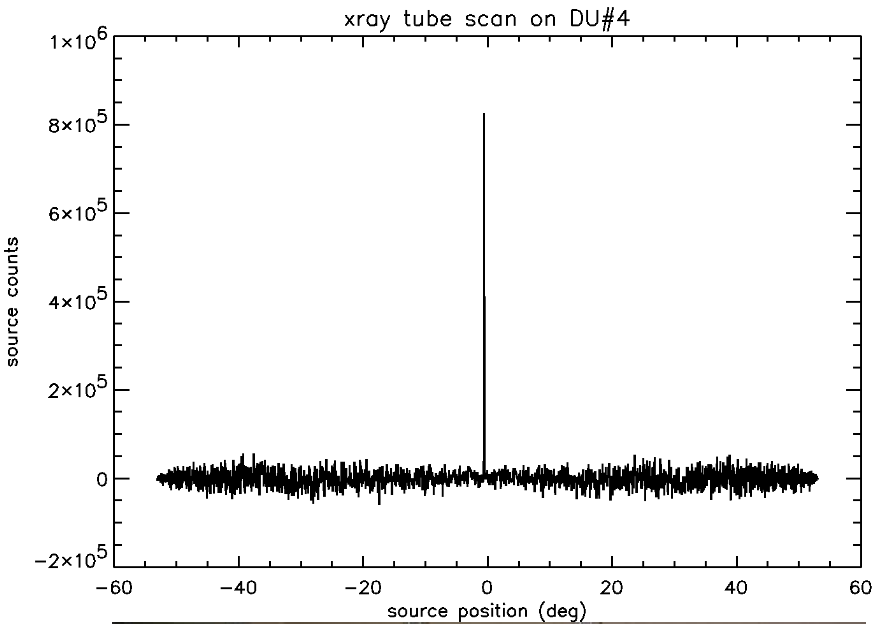
SuperAGILE: laboratory testing

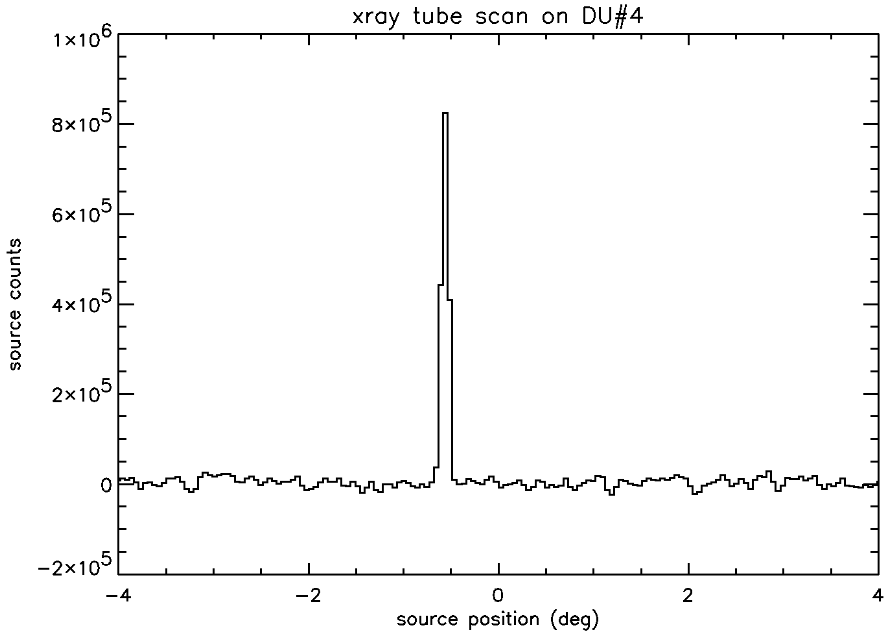


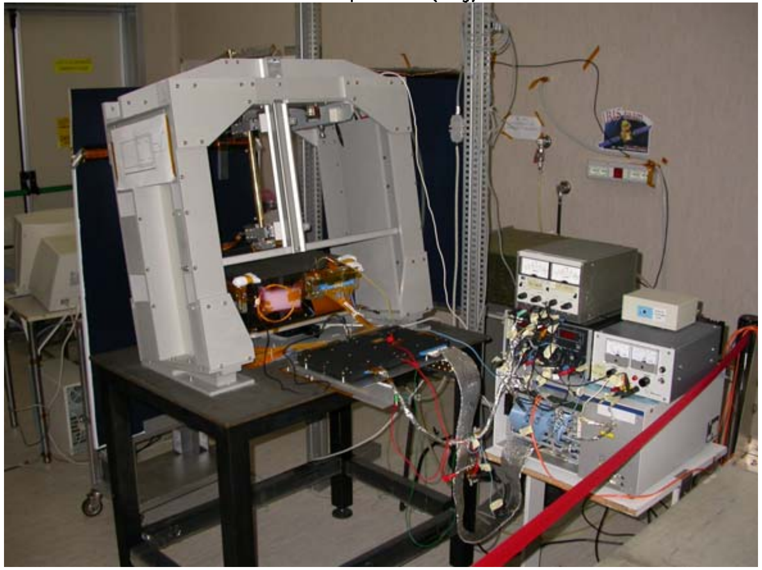
Laboratory development and testing :

- electronic noise evaluation by means of electronic pulse measurements and photons acquisitions;
- electronic noise reduction by adjusting the analogue signal shape;
- testing of the Single Event Effect and Total Ionizing Dose sensitivity of the front-end electronics (SIRAD facility at INFN in Legnaro);
- assembly and testing of the whole instrument;
- threshold evaluation and equalization.

SuperAGILE: the imaging



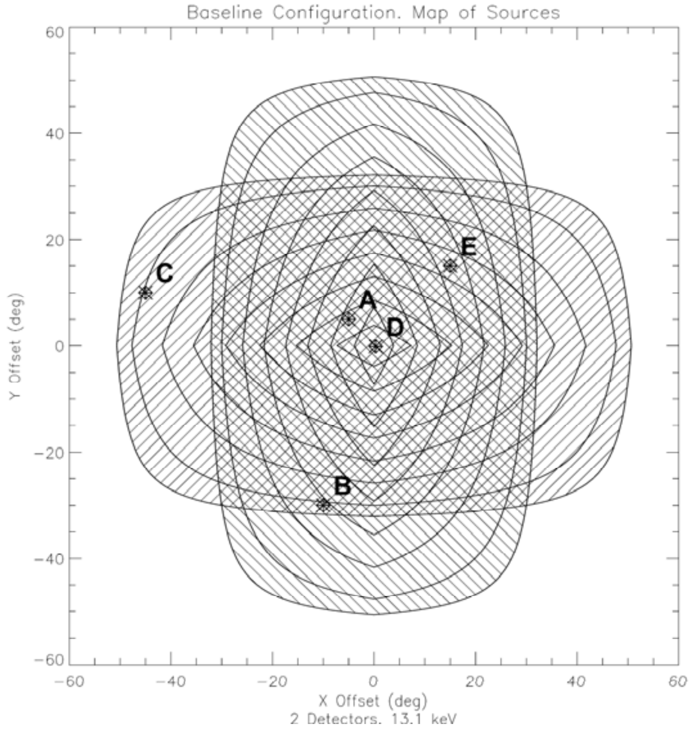




Reconstructed image (top left) of the X-ray pencil beam on-axis (set-up image in bottom left). The image Point Spread Function (top right) is 3 arcmin.

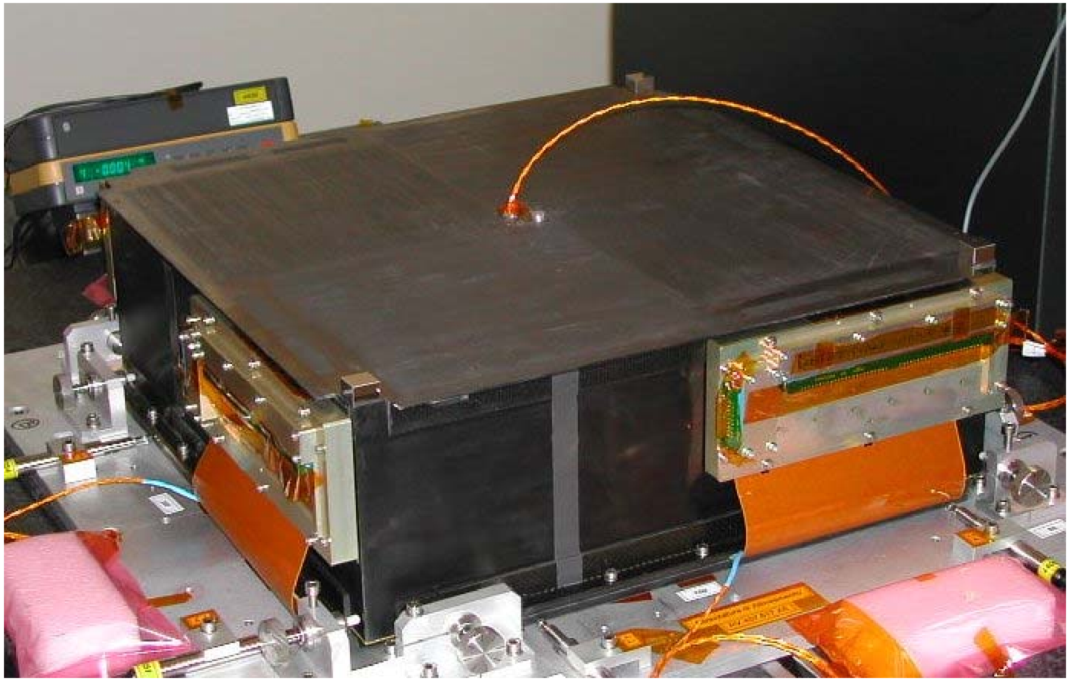
SuperAGILE: the sensitivity and the FoV

The Field of View is composed of two 1-D rectangular areas of 68º×107º.



Sensitivity (in mCrab) in the 15-45 keV band with 2 detectors and 50 ks integration.

SuperAGILE: scientific performances



SuperAGILE can image photons between 15 and 45 keV with about 10 mCrab sensitivity ($2 \cdot 10^{-4}$ photons$\cdot$cm$^{-2} \cdot$ s^{-1}) in one-day integration.

The field of view is 68°×68° (2×1-D) with 6 arcmin pixel size and 2-3 arcmin angular resolution for intense sources.

The FWHM in the spectra is ~7.5 keV and the dead time is ~5 µs with 2 µs resolution.

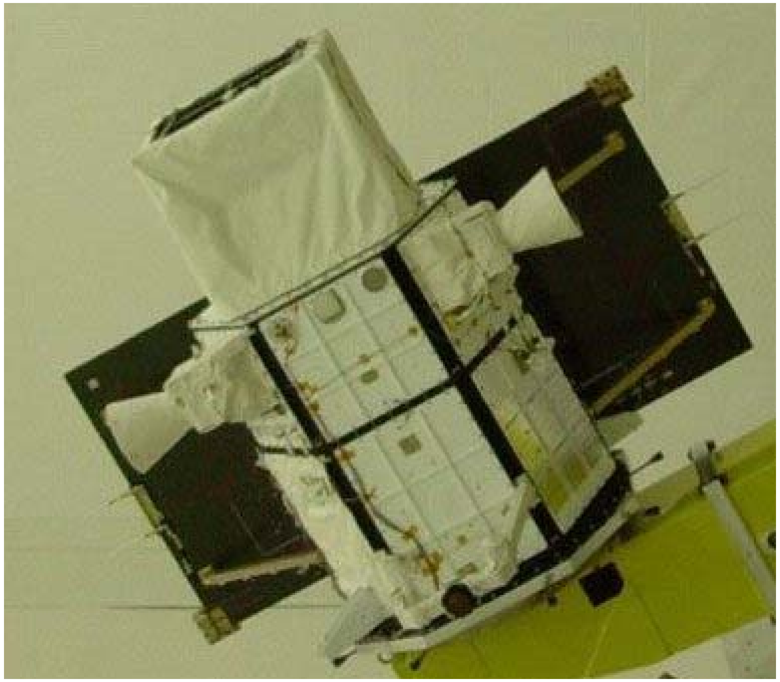
AGILE: the mission

First Small Scientific Mission of the Italian Space Agency ASI (approved 1998);
Currently in payload+spacecraft qualification phase;
Launch (with PSLV) in 2007 in equatorial orbit (560 km, ≤10° inclination);
Instrumentation:

- Silicon microstrip Tracker (ST)
- CsI Minicalorimeter (MCAL)
- Plastic Anticoincidence (AC)
- SuperAGILE

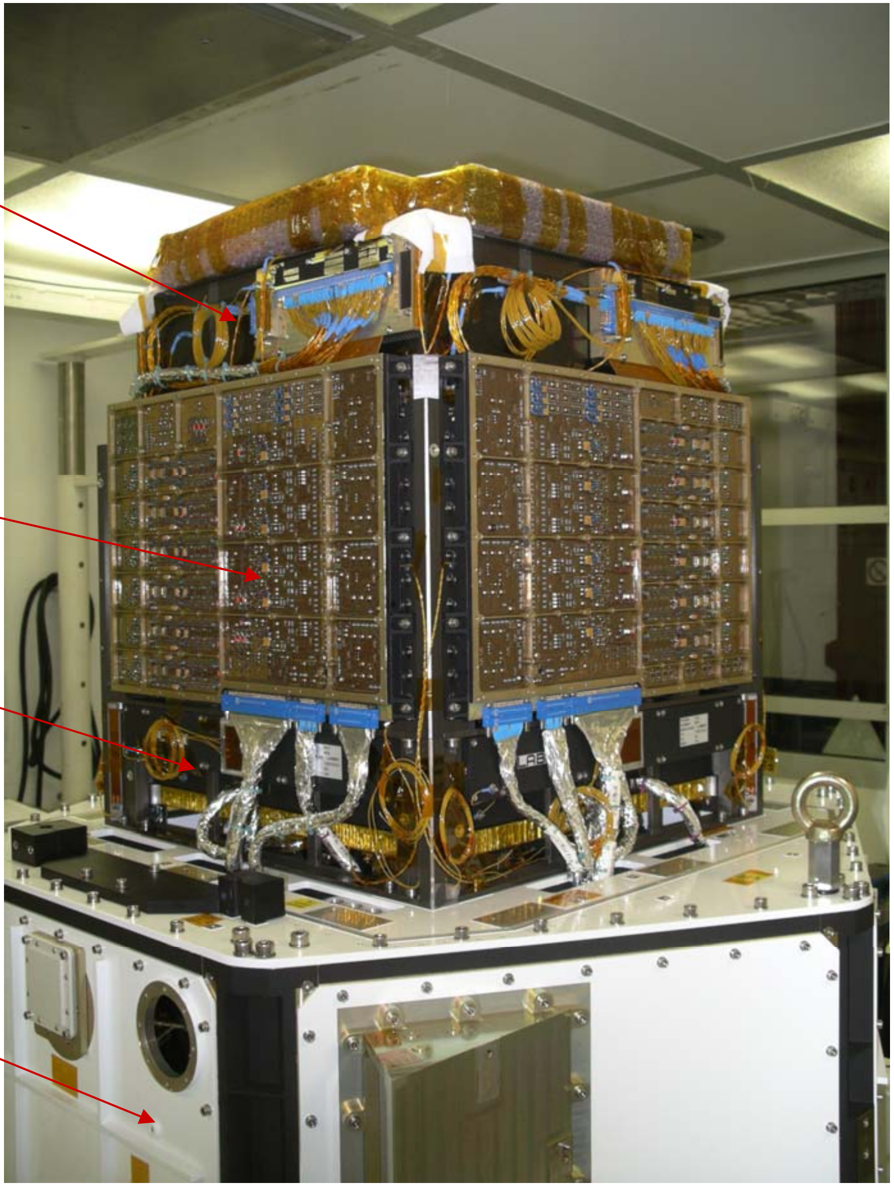
$\left.\begin{array}{l}\text{Silicon microstrip Tracker (ST)}\\ \text{CsI Minicalorimeter (MCAL)}\\ \text{Plastic Anticoincidence (AC)}\end{array}\right\}$ Gamma Ray Imaging Detector (GRID)

Energy Ranges: 30 MeV – 50 GeV (GRID)
300 keV – 10 MeV (MCAL)
15-45 keV (SuperAGILE)



payload+shell weight and power:
~190 kg and ~135 W

AGILE: the payload



SuperAGILE
(INAF IASF Roma)

Silicon Tracker
(INFN Trieste)

Minicalorimeter
(INAF IASF Bologna
and AASI-Laben)

Satellite bus
(Carlo Gavazzi Space)

Anticoincidence shield
(INAF IASF Milano)

AGILE: scientific goals

Gamma Ray Bursts:

25 events/year expected in the hard X-ray band and 5-10 events/year in the gamma-ray band;

on-board localization and rapid communication of coordinates and quicklook results (via the ORBCOMM satellite constellation);

study with μs time resolution;

Active Galactic Nuclei:

survey and observations in a sr field of view with a good angular resolution (~6 arcmin in hard X-rays and ~1° in gamma rays);

study with μs time resolution of the transient events;

broad band spectral observations (hard X-rays and gamma rays);

Compact Galactic Sources:

period searches for galactic unidentified sources;

study with μs time resolution of known and transient sources;

Conclusions

SuperAGILE is a compact, light and low power consuming hard X-ray instrument;

the energy band is 15-45 keV with about 10 mCrab sensitivity ($2 \cdot 10^{-4}$ photons$\cdot$cm$^{-2} \cdot$ s^{-1}) in one-day integration;

the field of view is 68°×68° (2×1-D) with 6 arcmin pixel size and 2-3 arcmin angular resolution for intense sources;

the FWHM in the spectra is ~7.5 keV and the time resolution is 2 μs;

SuperAGILE scientific goals include GRB, bright AGN and Galactic Sources;

GRB and other transients will be imaged on-board and their coordinates will be rapidly transmitted to Earth;

SuperAGILE measured fluxes will be publicly available on a web page (XTE-ASM like) at the ASI Science Data Center.