# The Gamma Ray Imaging Detector of the AGILE satellite: a novel application of silicon trackers for detection of astrophysics high energy photons

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(on behalf of the AGILE collaboration)

**AGILE** is a project of Italian Space Agency (ASI) dedicated to

X ray (18 ÷ 60 keV) and
γ ray (30 MeV ÷ 50 GeV) astrophysics

The instrument is operating on a1 satellite, and was designed to satisfy many requirements:

- good angular resolution
- good time resolution
- large Field Of View (FOV)
- limited power consumption
- lightness and compactness
- long life
- resistance in space environment

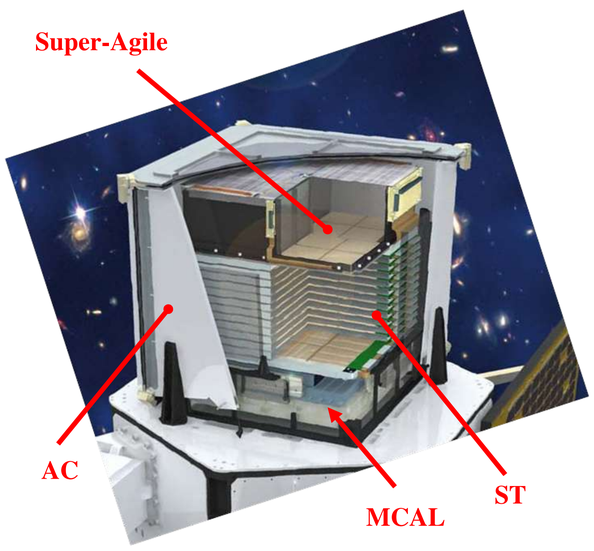
**These goals can be achieved using silicon detectors**

The instrument consists of:

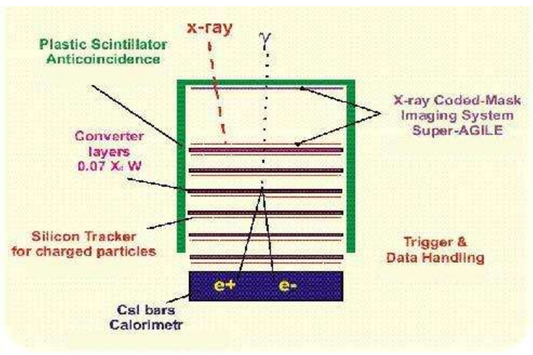
- X-ray coded-mask detector (**Super-Agile**)
- Gamma Ray Imaging Detector (**GRID**)

which consists of

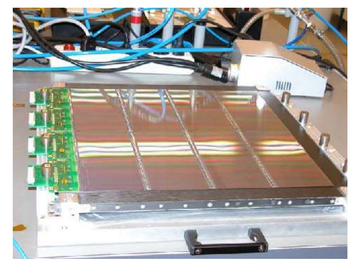
- Silicon tracker (**ST**)
- CsI bars calorimeter (**MCAL**)
- Plastic scintillators anticoincidence (**AC**)



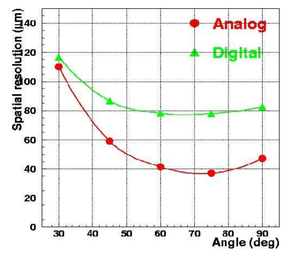

The γ ray detection (30 MeV – 50 GeV) in **GRID** is based on $e^+$ $e^-$ pair production inside the silicon telescope and reconstruction of their trajectories. This allows to determine the direction and the energy of the incident γ photon




Each plane of the telescope is composed of 16 silicon detector units, 410 μm thick and 9.5 x 9.5 $cm^2$ sized.
Each unit has 768 strips with 121 μm pitch.
Active strips are interleaved witch floating strips, resulting in a 384 strips readout with 242 μm pitch.
16 units are connected together to form a ***tray***
with 1536 parallel active strips (38x38 $cm^2$)



By mean of analogic readout, a spatial resolution as good as 40 μm is achieved

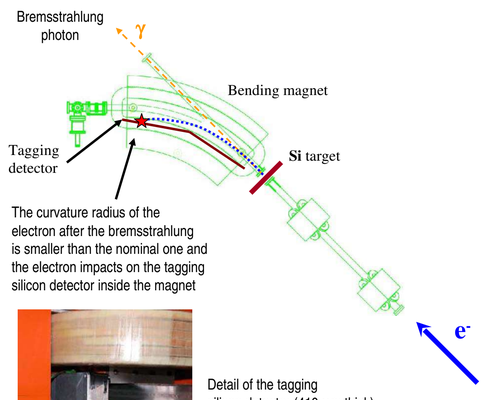



The telescope is composed of 12 planes (38 x 38 $cm^2$)
Each plane is made of 2 silicon ***trays*** (with *x*- and *y*-oriented strips) and a tungsten layer 245 μm thick (with a total of 0.07 $X_0$)

Full view of AGILE detectors before the integration on the satellite

## On-ground calibration of the silicon tracker

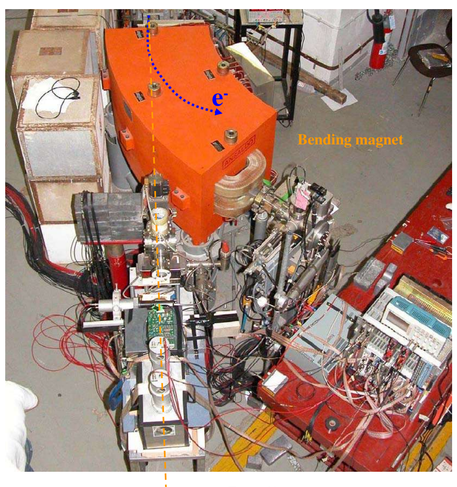
A tagged photon beam was implemented at Frascati INFN laboratory (LNF), using the 450 MeV electron beam of Beam Test Facility (BTF)




Detail of the tagging silicon detector (410 μm thick) (total of 4608 readout strips with 300 μm pitch)

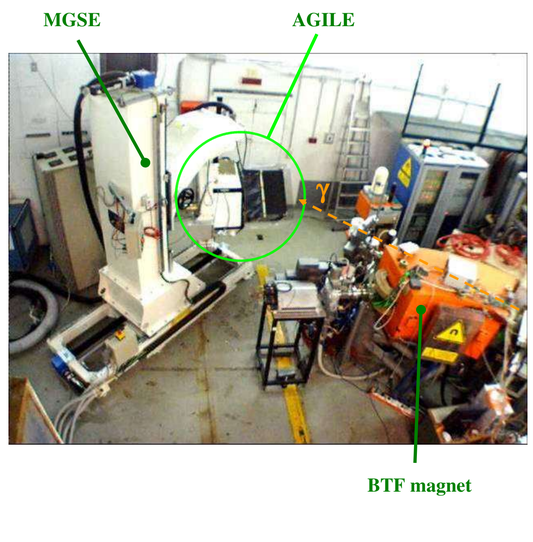
The position of the electron impact depends on its residual momentum, from which the energy of the tagged photon can be calculated

View of the tagged photons beam implemented at BTF

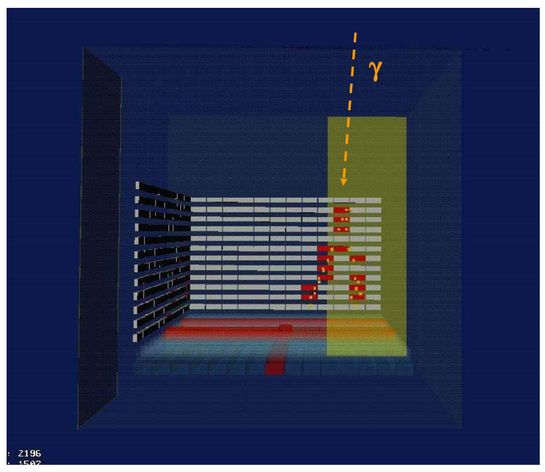



When the electrons of BTF beam interact into the Si target (not shown), produce bremsstrahlung photons. In this case they are deflected on the tagging detector placed inside the bending magnet.

During the calibration run at BTF, the **AGILE** instrument was placed on a specially designed mechanical support (MGSE), suitable for setting any position and direction of the instrument with respect of the tagged photon beam



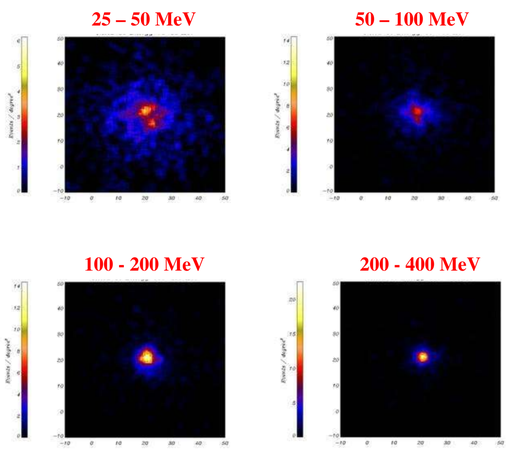

## AGILE GRID calibration at BTF




The first reconstructed tagged photon

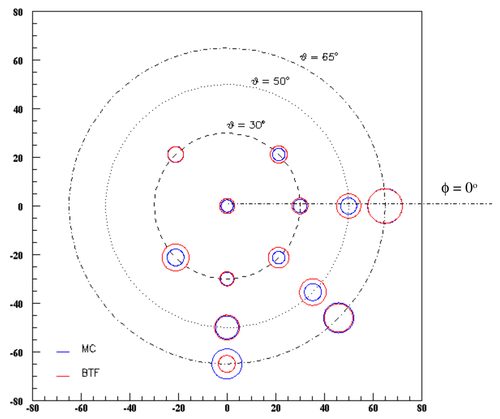
The $e^+$ $e^-$ pair is well visible on most of the silicon tracker planes

## Reconstruction of the BTF photon beam for different energy ranges




## Angular resolution of AGILE GRID

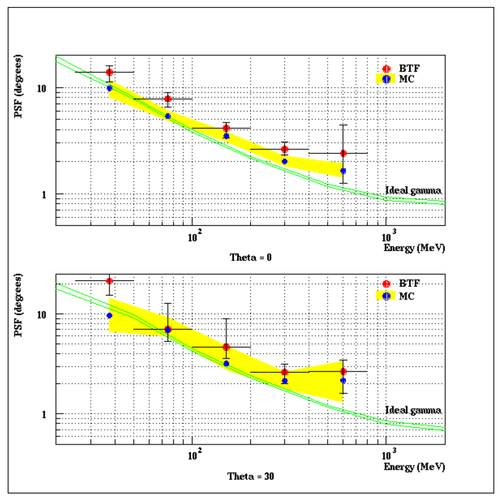
The Point Spread Function (PSF) is used, defined as the angular aperture that contains the 68 % of the reconstructed tracks, around the "true" direction
It depends on the pointing direction (θ, ϕ)




The measured PSF ranges from ~ 3° (θ = 0°; ϕ = 0°)
to ~ 7° (θ = 65°)

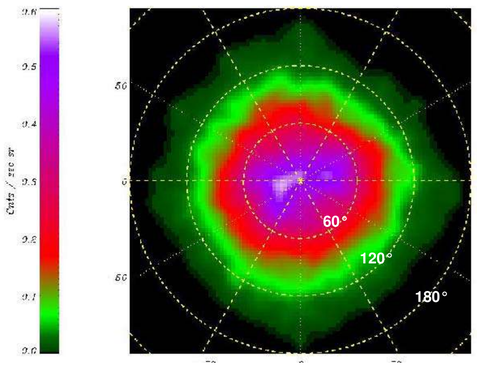
The found values are in good agreement with the Montecarlo predictions (also shown)

## Evaluation of PSF as a function of photon energy




Comparison of the PSF measured on the real data (BTF) and the one calculated on simulated beam (MC).
The green lines represent the ideal case of simulated monochromatic and collimated photons , with a very large statistics.

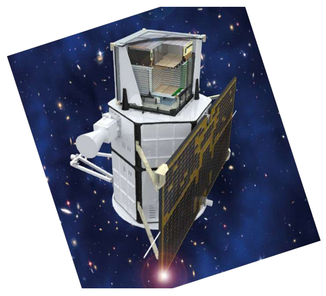
## Effective FOV of AGILE GRID determined on natural γ-ray background



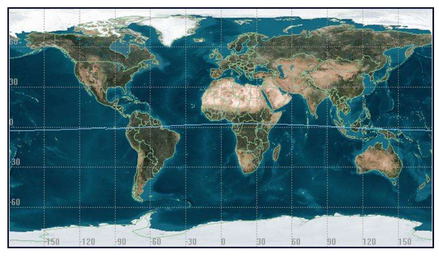

FOV ~ 120°

## AGILE in operation

The satellite was launched on April 23, 2007 from the Indian Space Research Organisation base of Sriharikota (Chennai-Madras)

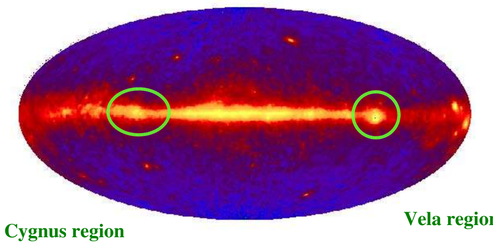


The AGILE satellite orbit is equatorial (altitude = 540 km; inclination = 2.5°)
The best orbit ever obtained for γ-ray astrophysics (very low particle background)

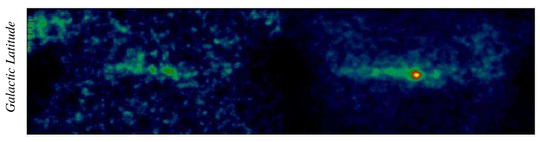


## First AGILE results

GRO-EGRET γ-ray sky above 100 MeV




High resolution image of AGILE γ-ray sky




Preliminary results !