The Refined AGILE Angular Resolution

S. Sabatini
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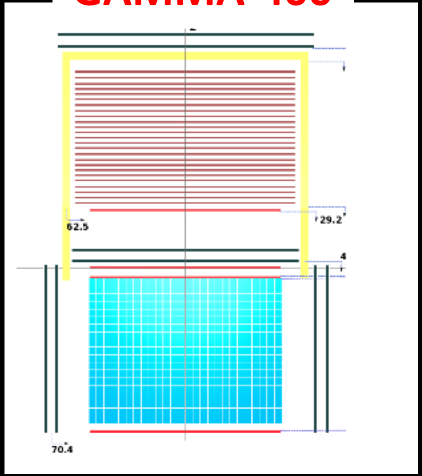
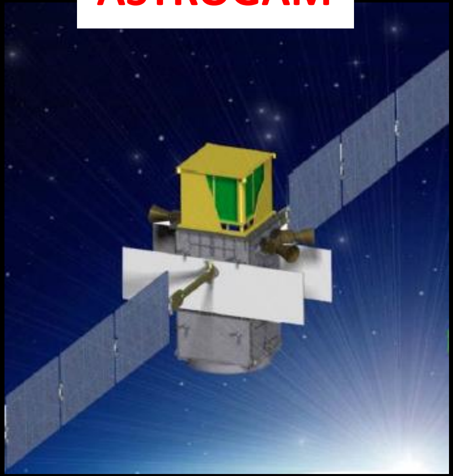
Motivation

- Perspectives for future instrumentation

GAMMA-400



ASTROGAM



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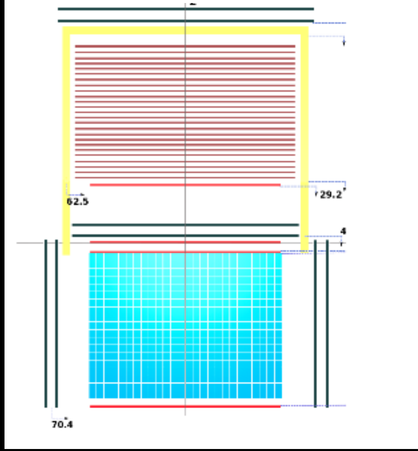
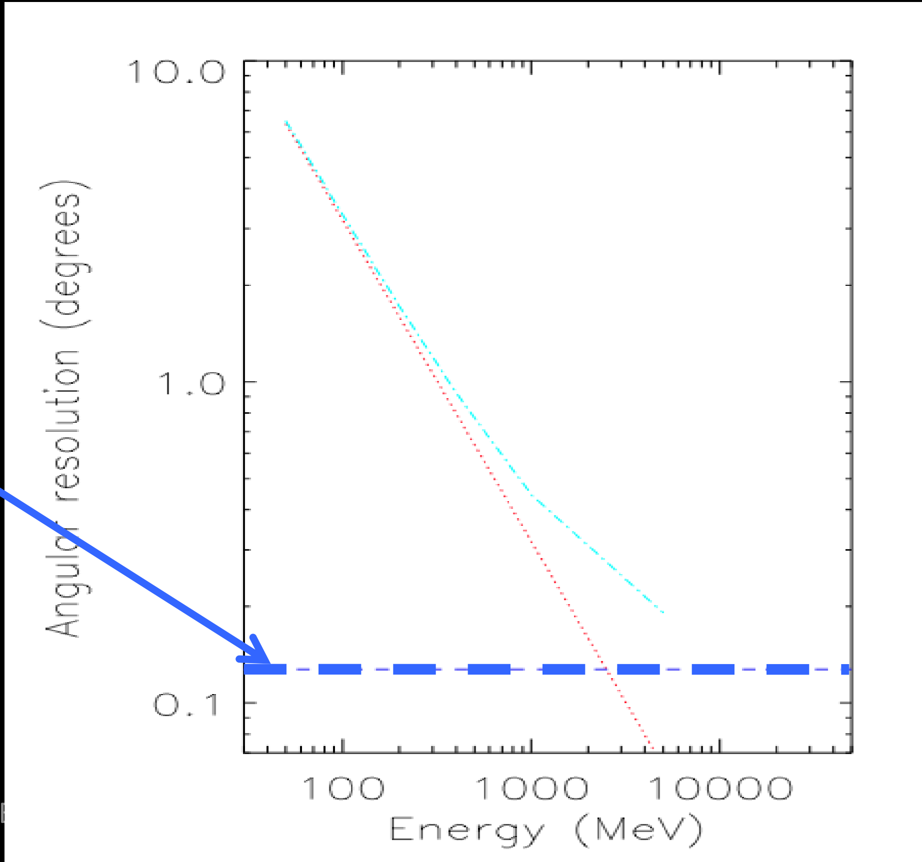


ASTROGAM

- Better understanding of the AGILE performances

Main configuration parameters affecting the angular resolution

- pitch (size of the silicon strip) and readout system
- distance between planes



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- pitch (size of the silicon strip) and readout system
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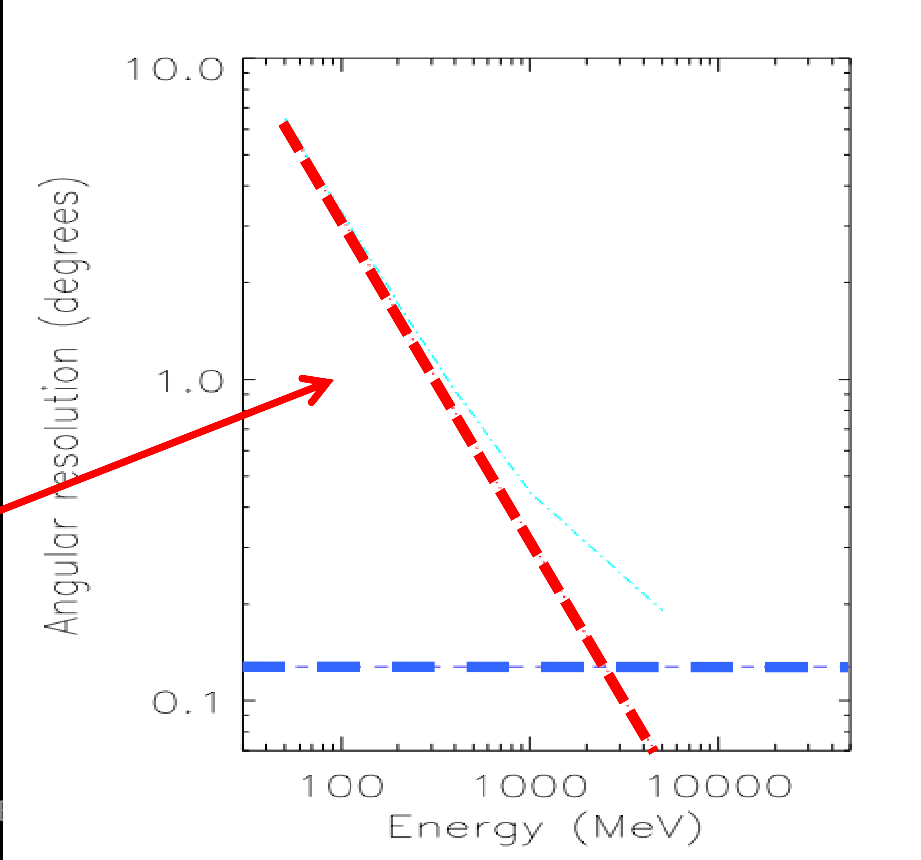

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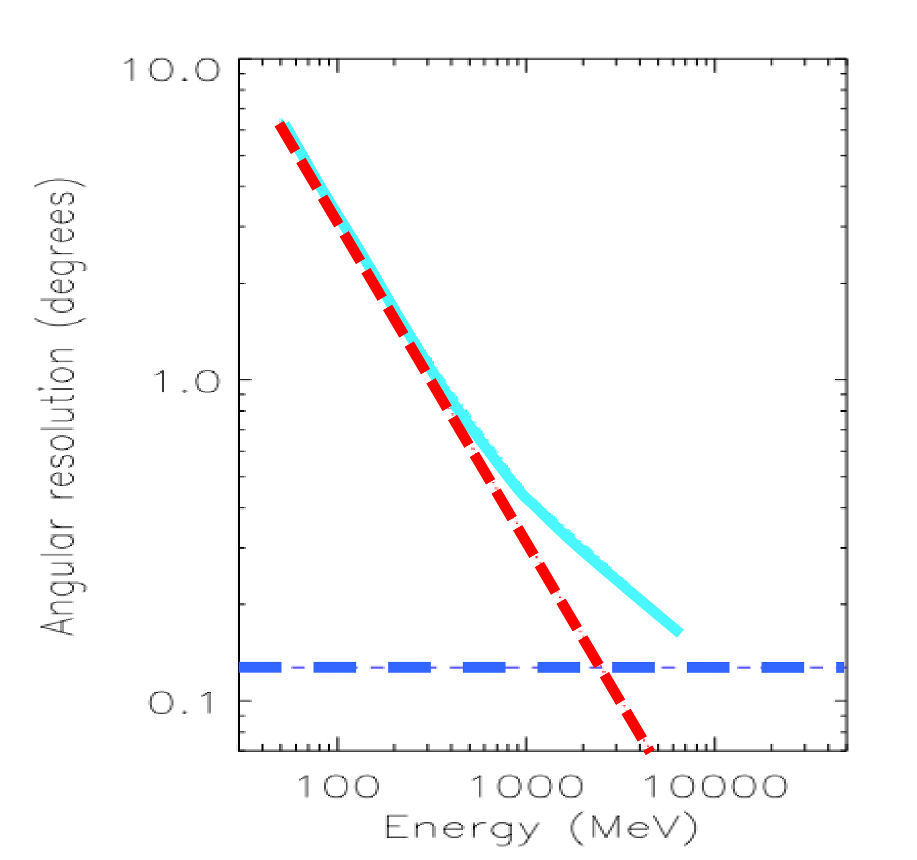
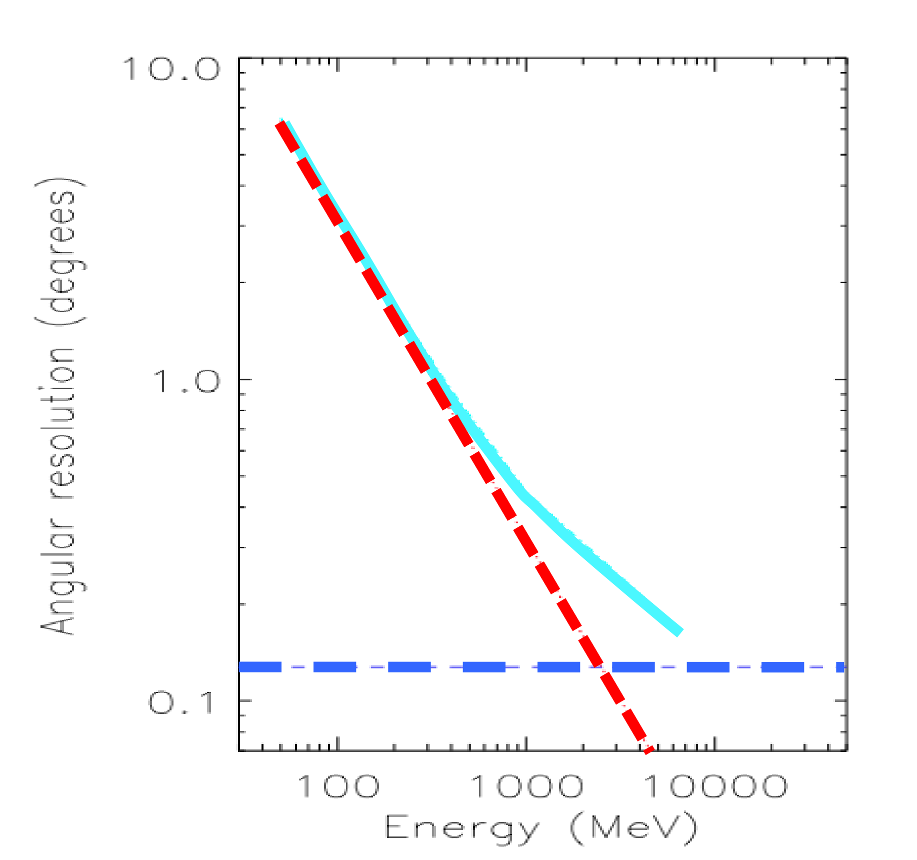


Main configuration parameters affecting the angular resolution

- pitch (size of the silicon strip) and readout system
- distance between planes
- thickness of tungsten layers
- **reconstruction and classification algorithms**



Approach: Simulations and in-flight data

- <u>Simulations</u>: monochromatic

  crab-like spectrum

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- In-flight data: AGILE vs Fermi (Crab < 30°)

AGILE vs Fermi

Parameter	AGILE-GRID	Fermi-LAT
Number of towers	1	16
Total number of Tracker planes	12	16
Vertical spacing (s) between adjacent planes	1.8 cm	3.2 cm
Silicon tile size	9.5x9.5 cm^2	8.95x8.95 cm^2
Silicon detector array for each plane	4x4	4x4
Silicon-strip pitch (δ_P)	121 μm	228 μm
Readout pitch	242 μm	228 μm
Signal readout	analog	digital
Ratio δ_P/s	0.007	0.007
Tungsten converter thickness per plane	0.07 X_o	0.03 X_o (front)
		0.18 (back)
Number of planes with W converter	10	12 (front)
		4 (back)
Average readout strip multiplicity per hit (0-30^o)	2-3	2-3
Effective spatial resolution, δ_x (0-30^o)	40 μm	130-200 μm
Ratio δ_x/s	0.002	0.004-0.006

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- Simulations: monochromatic

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- In-flight data: AGILE vs Fermi (Crab < 30°)
- SAME analysis for simulatead and real data

DATA ANALYSIS

1. GAMS : GEANT simulation of parallel beams of photons

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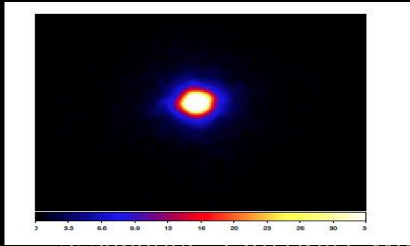
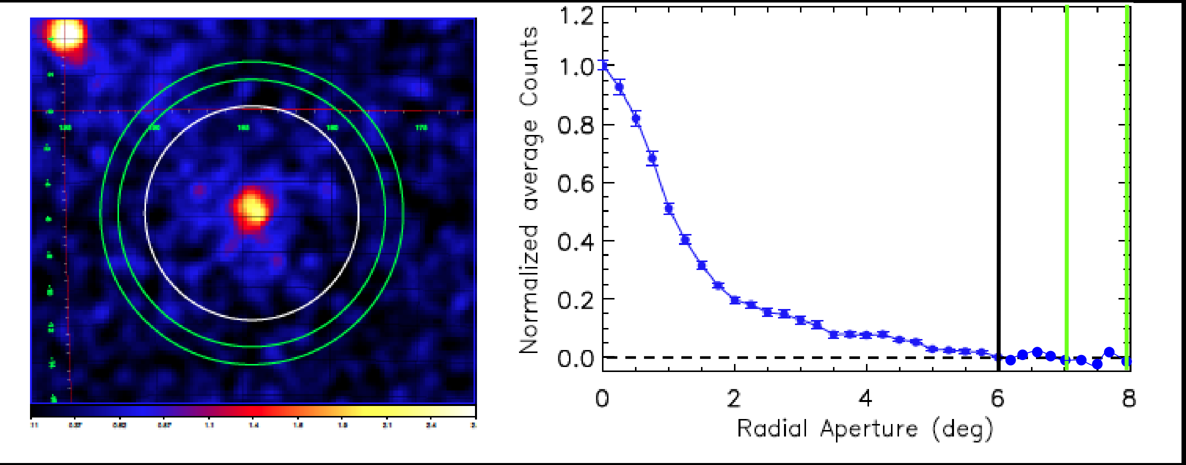
4. **IMAGE RECO:**



Angular Resolution determination: method



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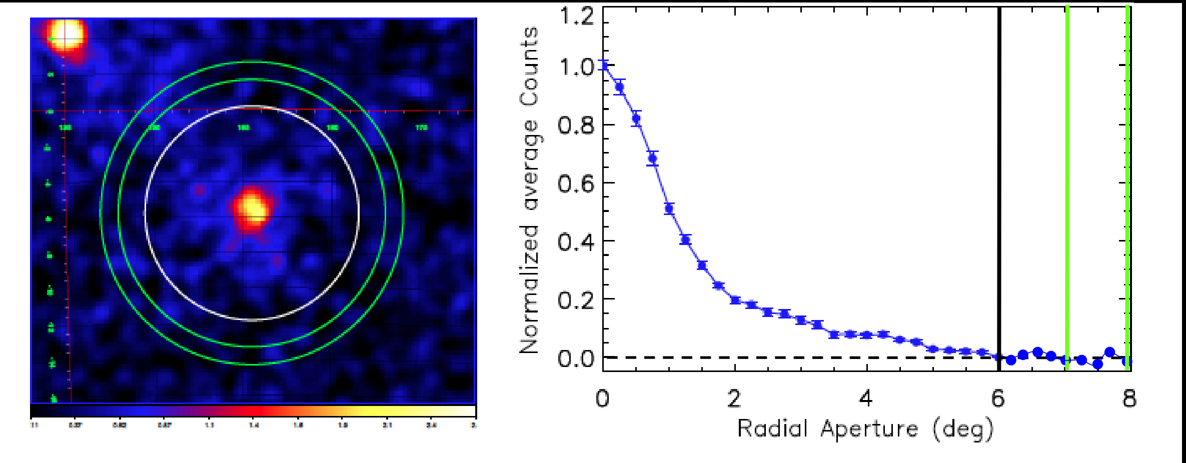

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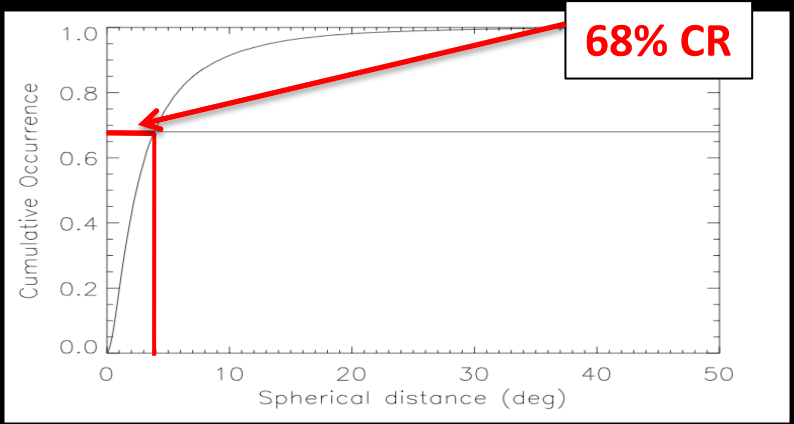

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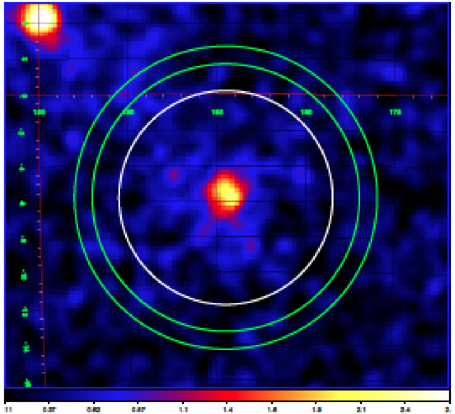

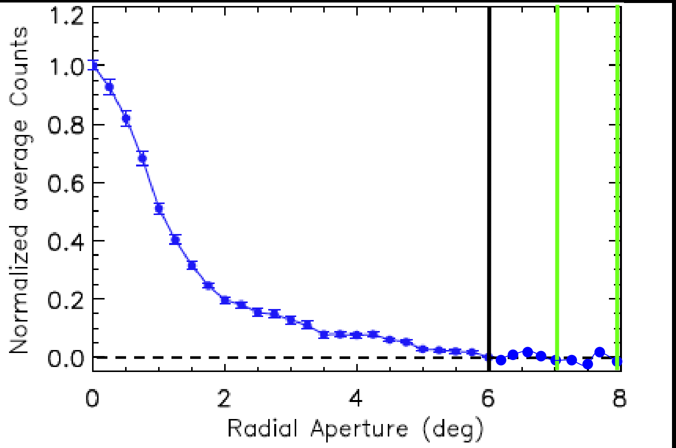

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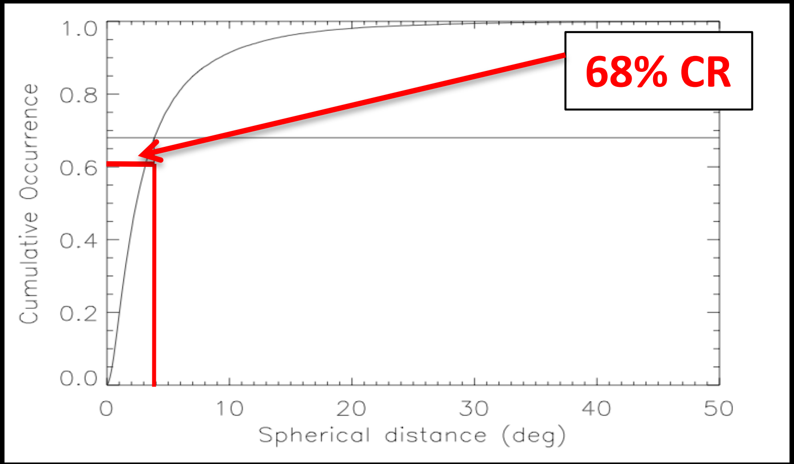

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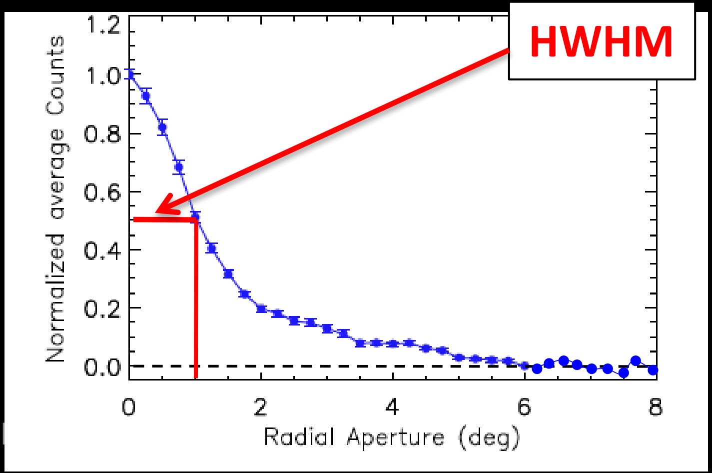

MONOCHROMATIC PHOTONS

Ideal Characterization of the instrument.

Parallel beam, 6x 10^7 photons, at different offaxis angles with energies:

50, 100, 200, 400, 1000 MeV

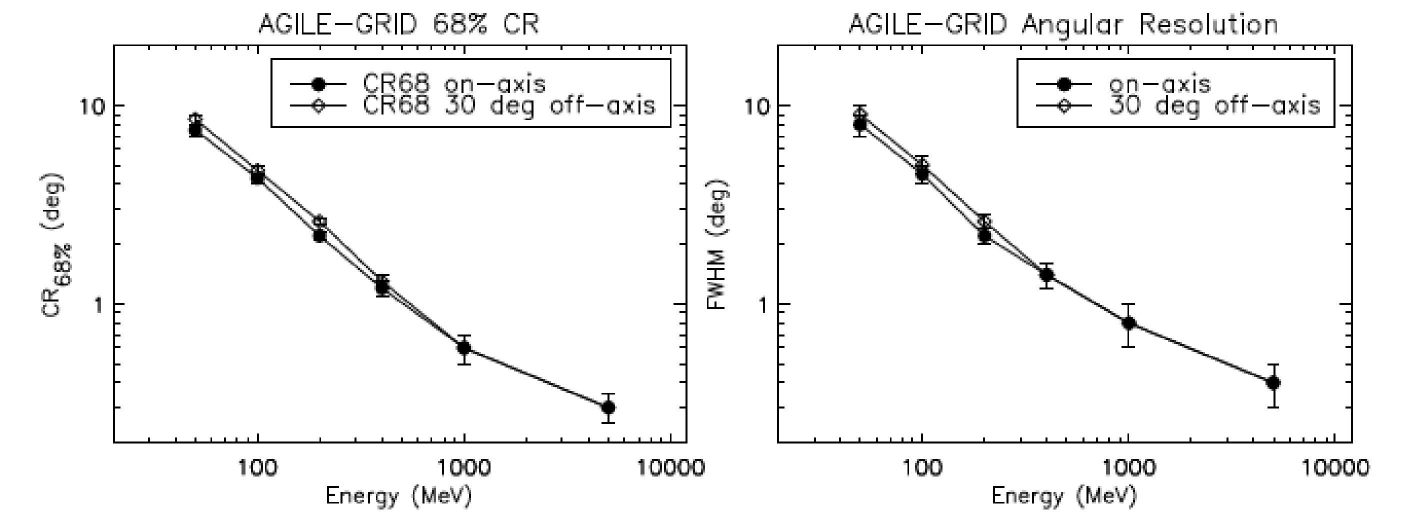

Fig. 1.— *Left panel:* AGILE-GRID 68% containment radius versus photon energy for simulated monochromatic photons of different incident angles. *Right panel:* angular resolution (FWHM) versus photon energy, shown for comparison to the CR68.

Sabatini et al. ,2015, ApJ, submitted

MONOCHROMATIC PHOTONS

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AGILE-GRID PSF HWHM

Centroid Energy (MeV)	Energy band (MeV)	$\theta = 1$ $\phi = 0$	$\theta = 1$ $\phi = 45$	$\theta = 30$ $\phi = 0$	$\theta = 30$ $\phi = 45$	Err
50	30 - 70	4.0	4.5	4.5	4.5	0.5
100	70 - 140	2.25	2.25	2.5	2.25	0.25
200	140 - 300	1.1	1.2	1.3	1.2	0.1
400	300 - 700	0.7	0.7	0.7	0.7	0.1
1000	700 - 1700	0.4	0.4	0.4	0.4	0.1
5000	1700 - 10000	0.2	0.2	0.2	0.2	0.05

monochromatic photons of different incident angles. *Right panel:* angular resolution (FWHM) versus photon energy, shown for comparison to the CR68.

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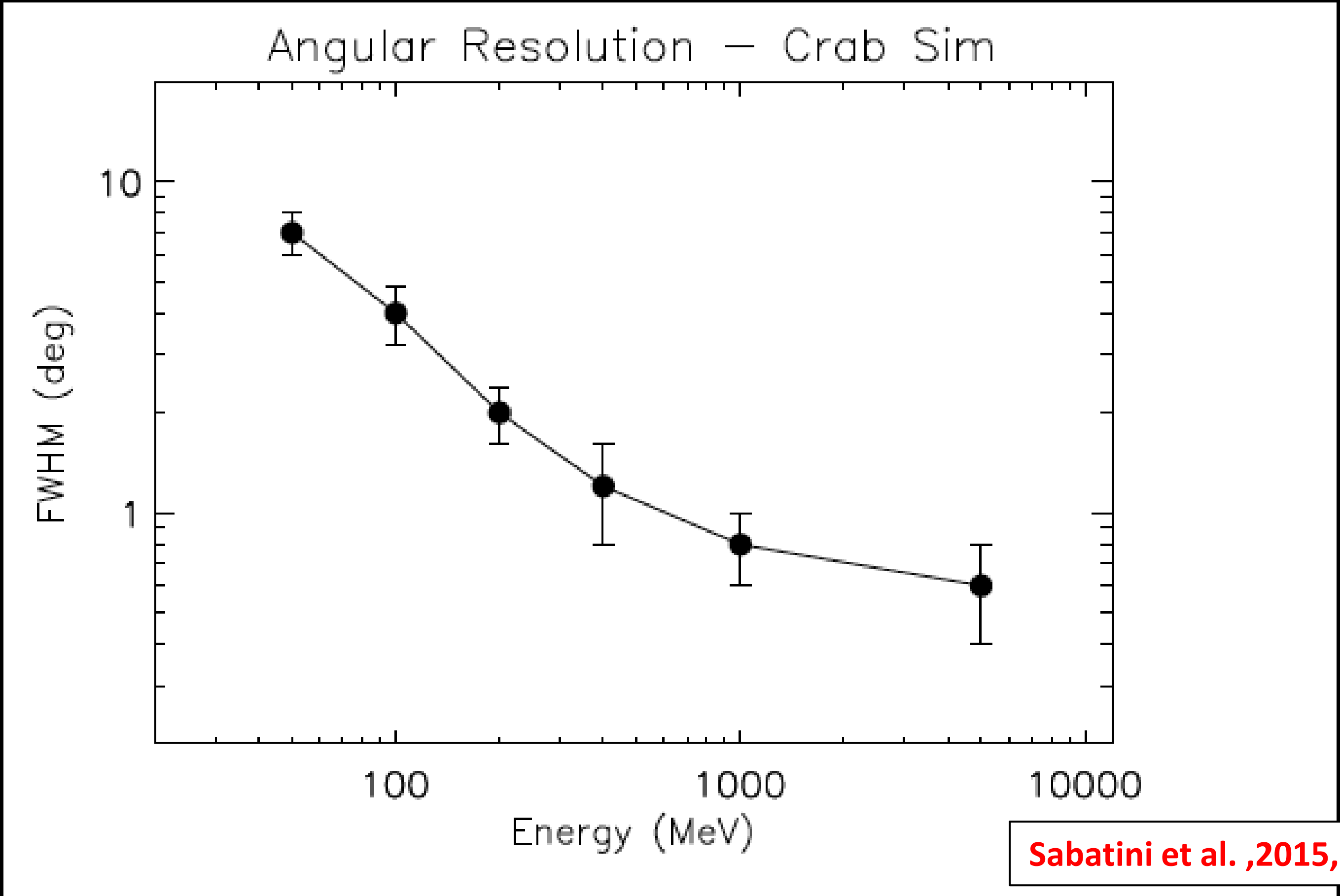
CRAB-LIKE SPECTRUM



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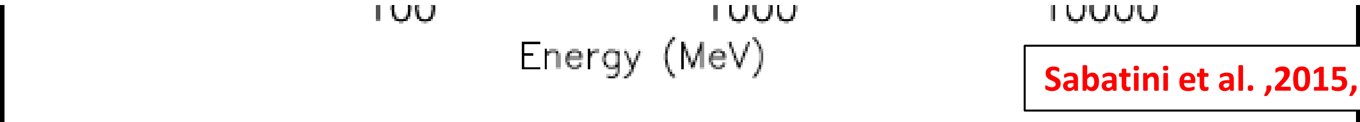
CRAB-LIKE SPECTRUM

HWHM for the Crab simulations

Centroid Energy (MeV)	Energy Band (MeV)	(θ, ϕ) (1,0)	(θ, ϕ) (1,45)	(θ, ϕ) (30,0)	(θ, ϕ) (30,45)	(θ, ϕ) (50,0)	(θ, ϕ) (50,45)	Err
50	30 - 70	3.5	3.5	3.0	3.0	3.0	4.0	0.5
100	70 - 140	2.0	2.0	2.0	2.0	2.4	2.4	0.4
200	140 - 300	1.0	1.2	1.2	1.2	1.4	1.4	0.2
400	300 - 700	0.6	0.6	0.8	0.8	0.8	0.8	0.2
1000	700 - 1700	0.4	0.4	0.4	0.4	0.4	0.4	0.1
5000	1700 - 10000	0.3	0.3	0.3	0.3	0.3	0.3	0.1
100 - 400	100 - 400	0.9	0.9	0.9	1.0	1.1	1.0	0.1
400 - 1000	400 - 1000	0.45	0.45	0.35	0.35	0.45	0.35	0.05
100 - 50000	100 - 50000	0.50	0.50	0.40	0.40	0.45	0.30	0.05



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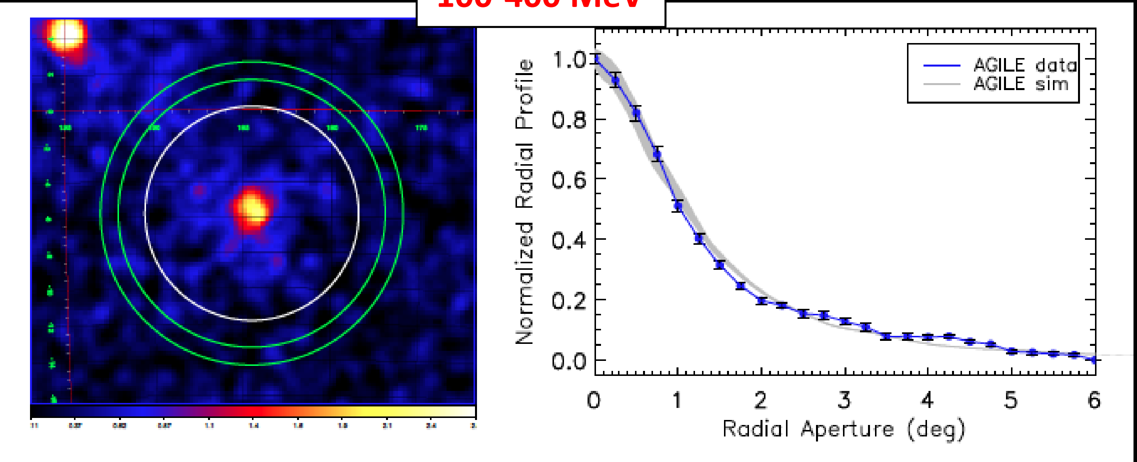
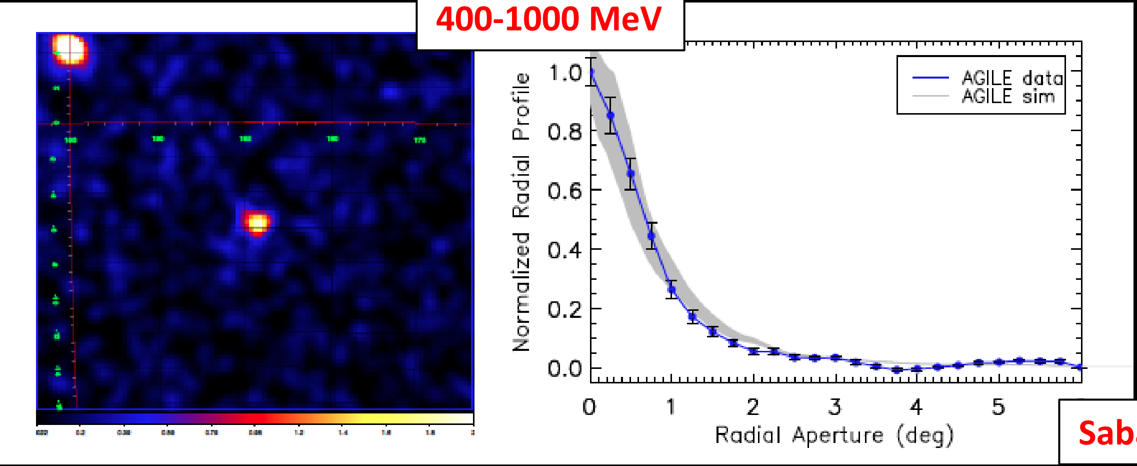
AGILE – REAL DATA (Crab)

100-400 MeV



FWHM: 2.5°

400-1000 MeV



FWHM: 1.2°

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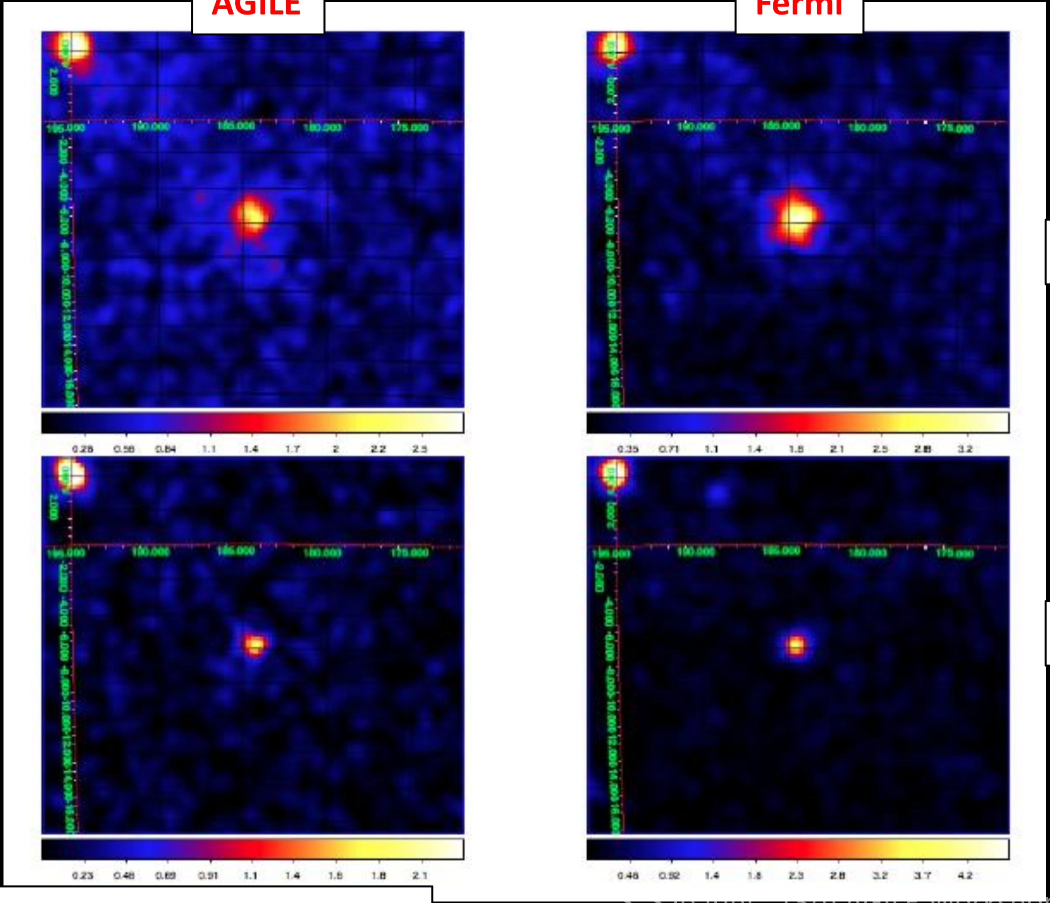
AGILE vs Fermi– REAL DATA (Crab)

AGILE

Fermi



100-400 MeV

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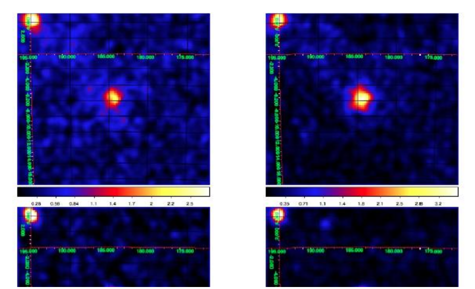
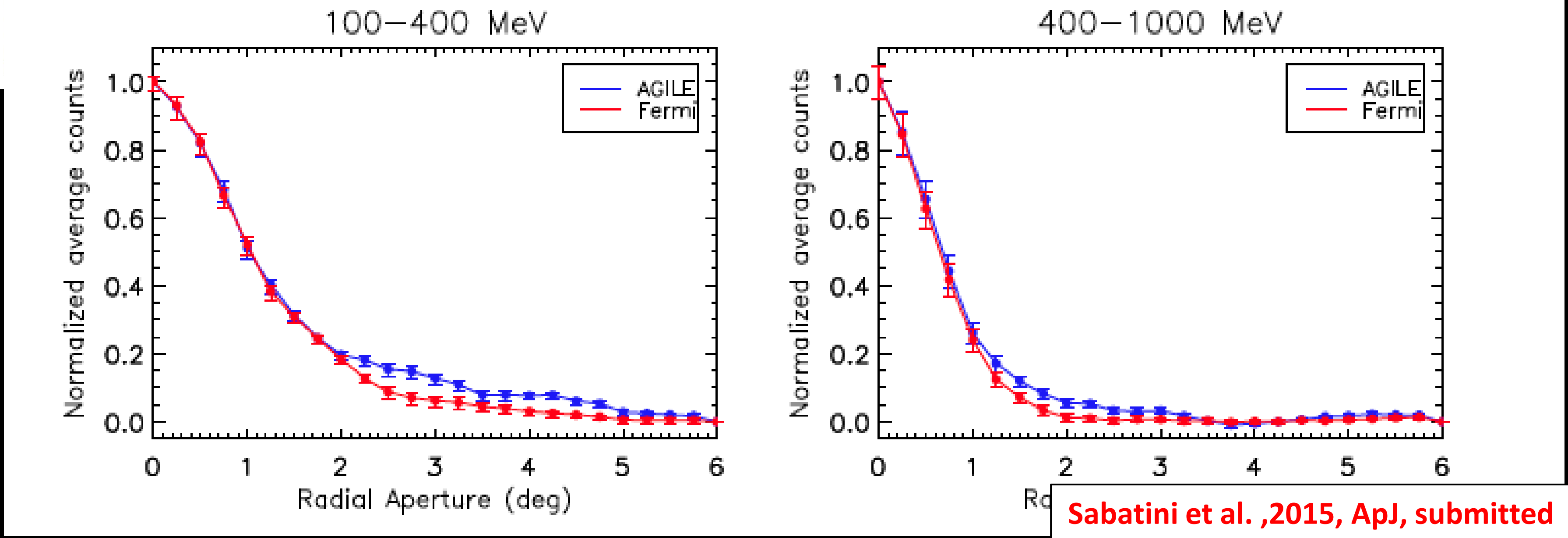


Same angular resolution within the errors!



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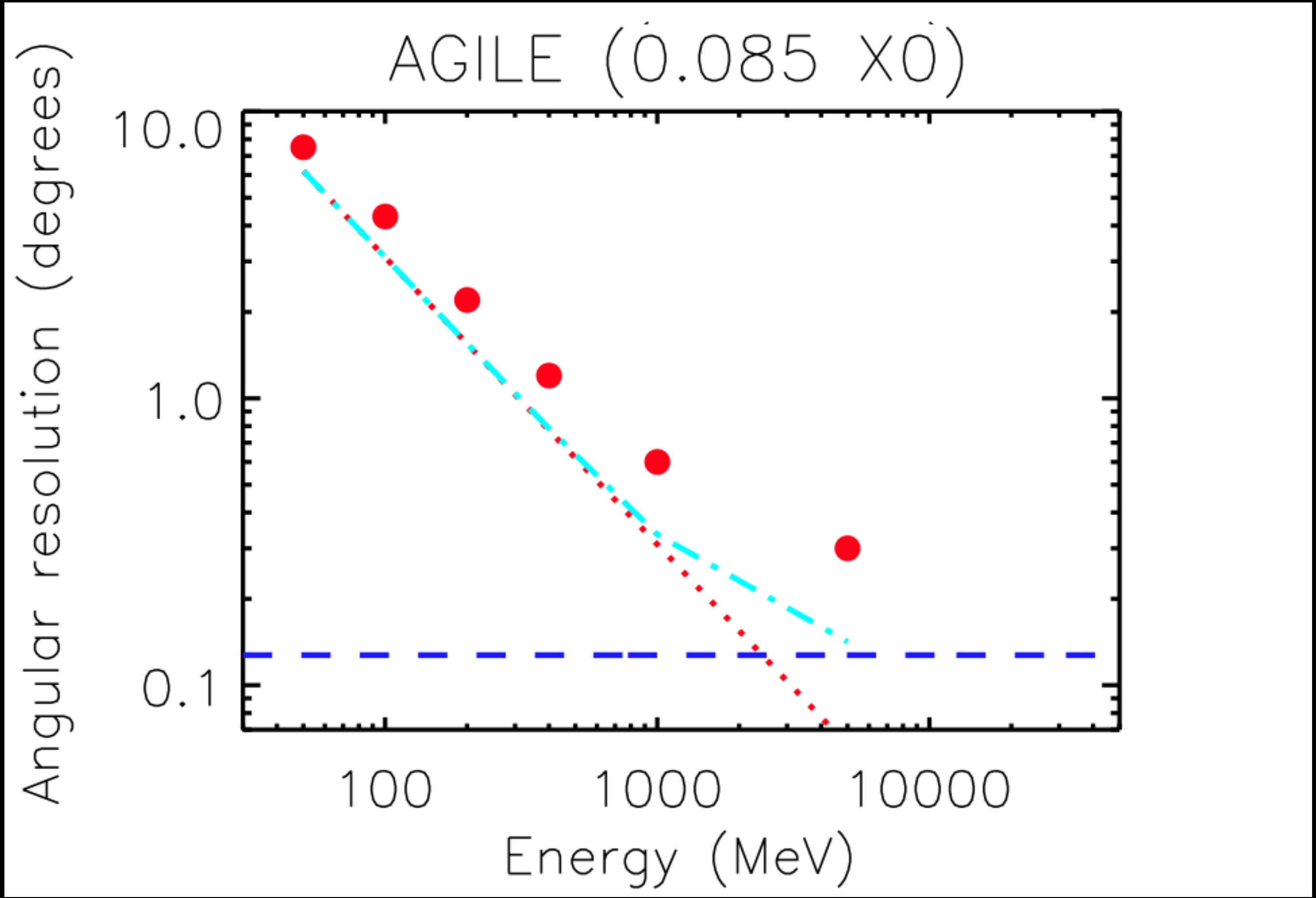
EXPECTED vs MEASURED values



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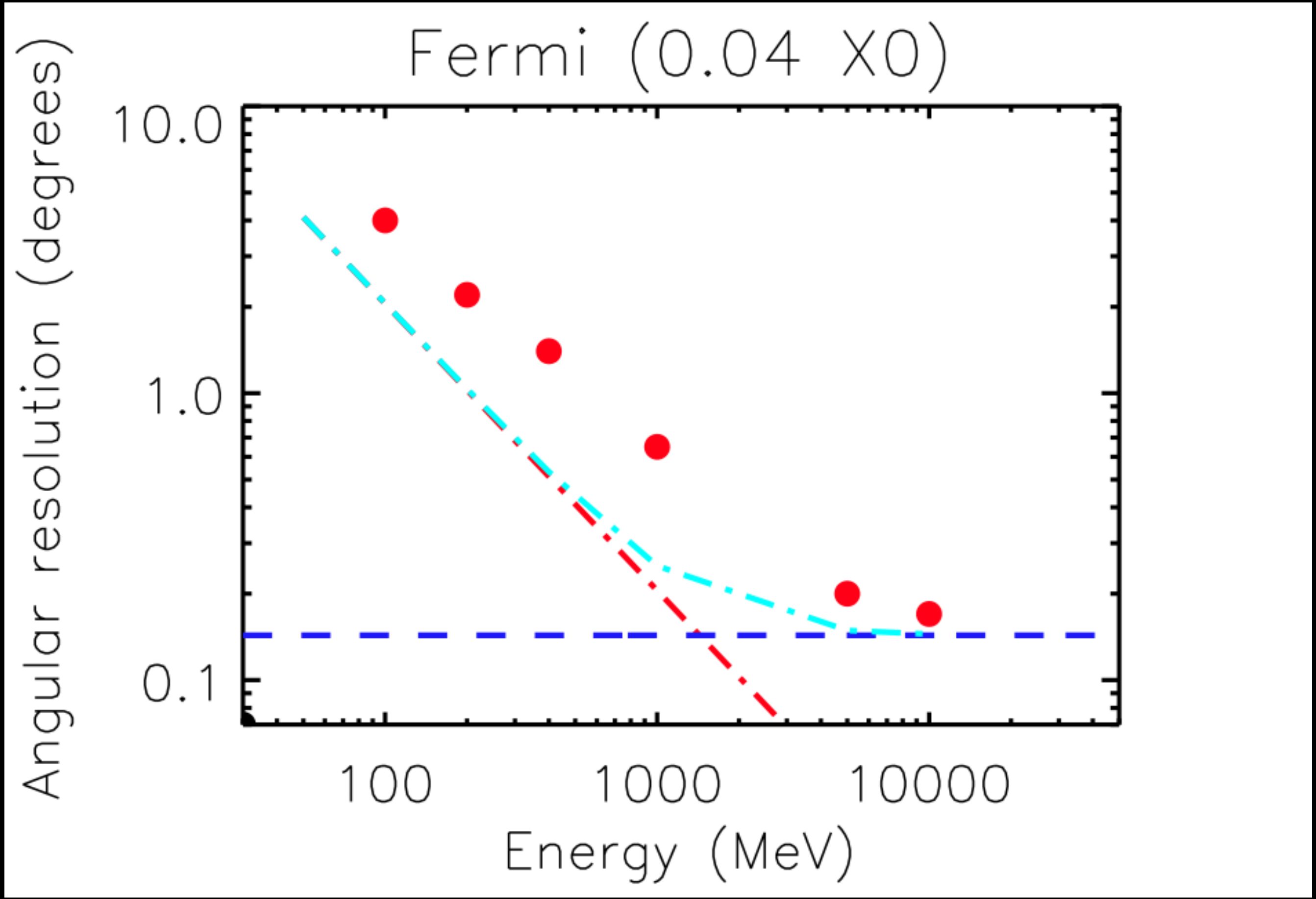

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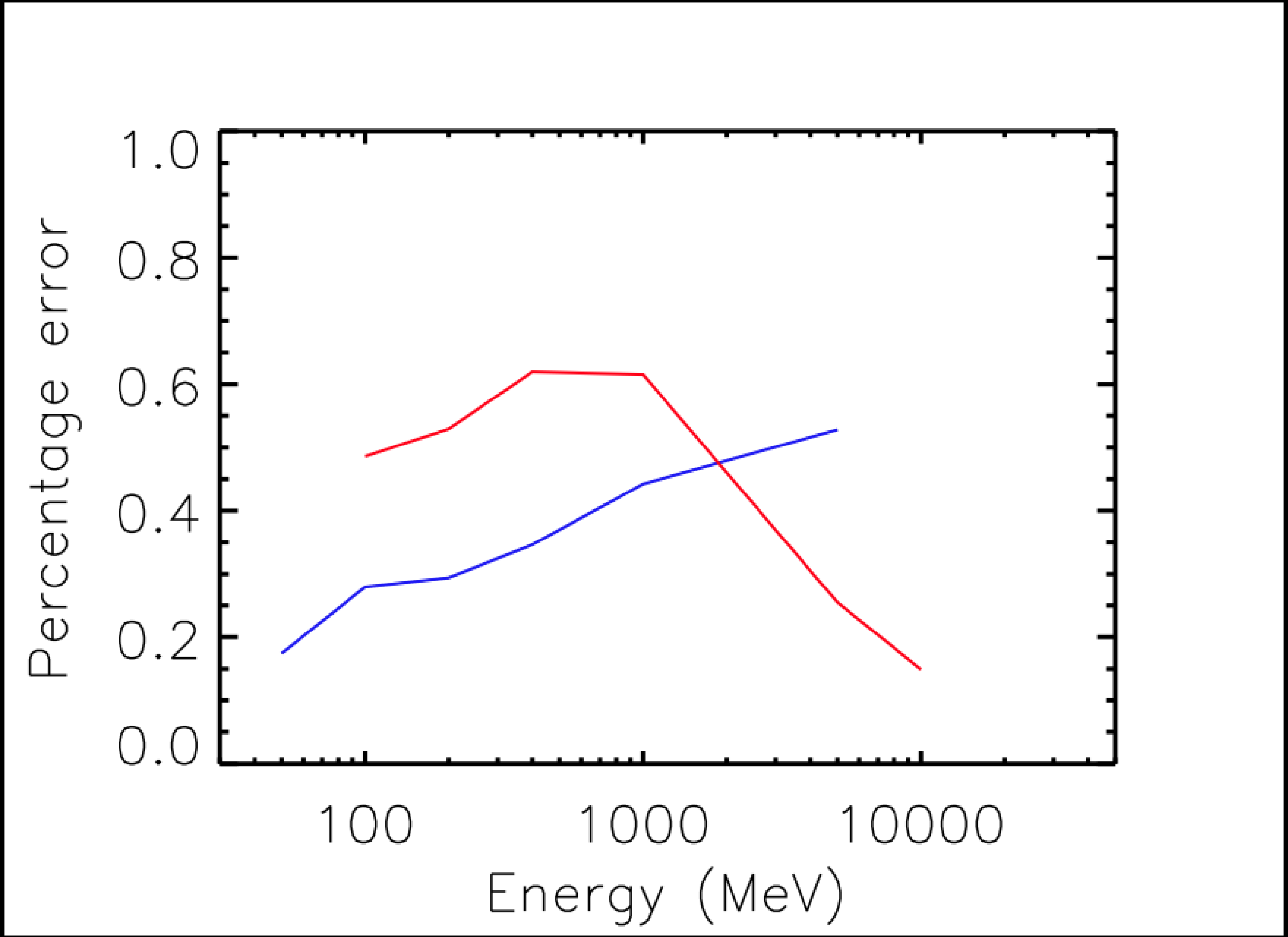
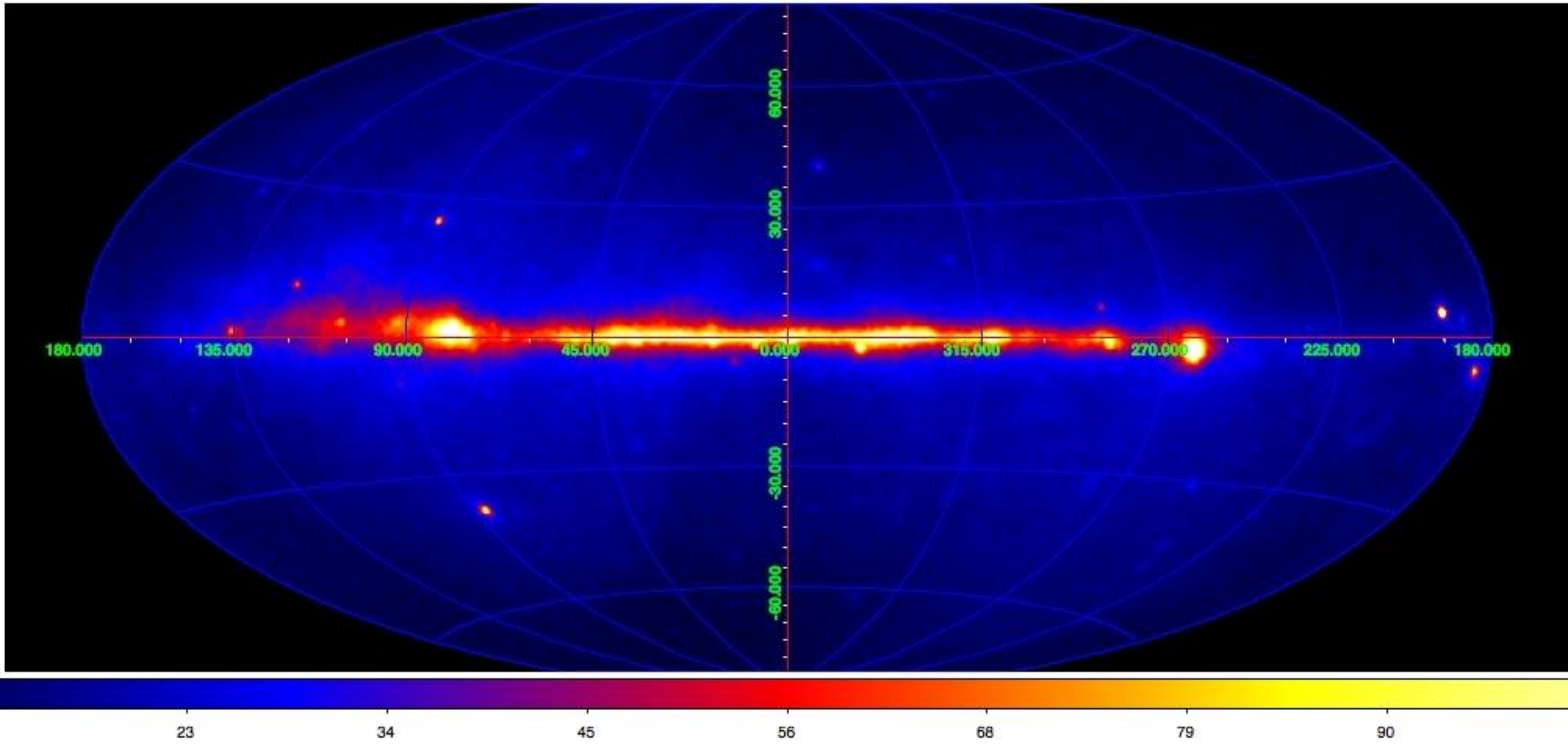


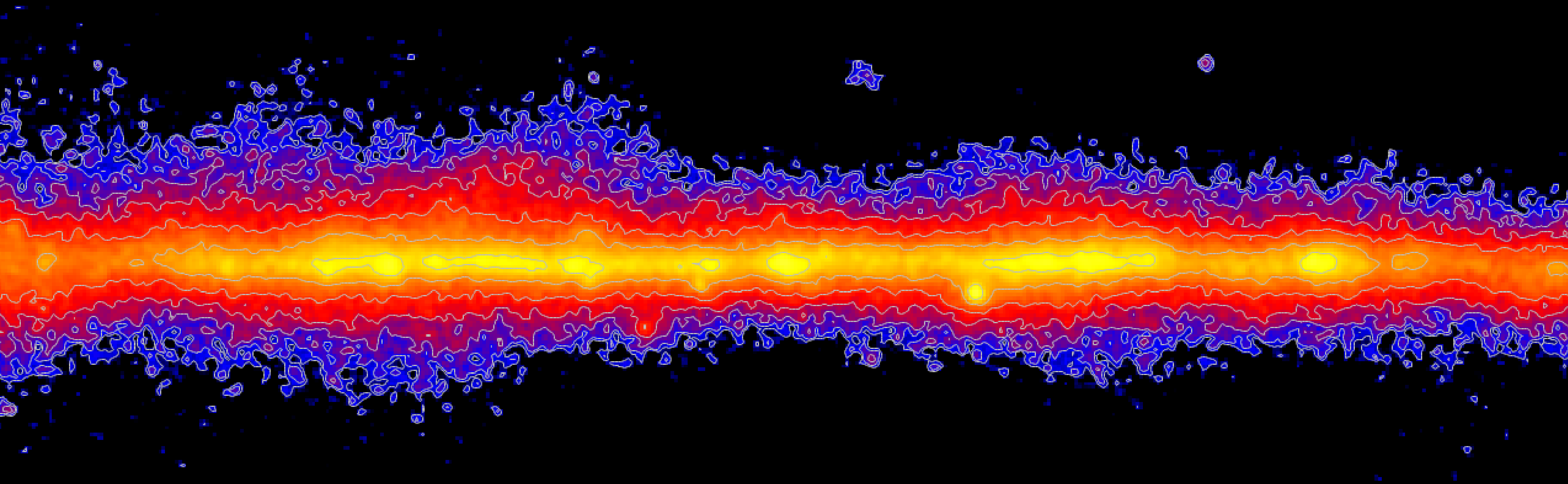
PERSPECTIVES

- The consolidated AGILE angular resolution, allows to carry out a complete **tomography of the Galactic Plane** -> diffuse emission, cat2, low energy CR (ASTROGAM)

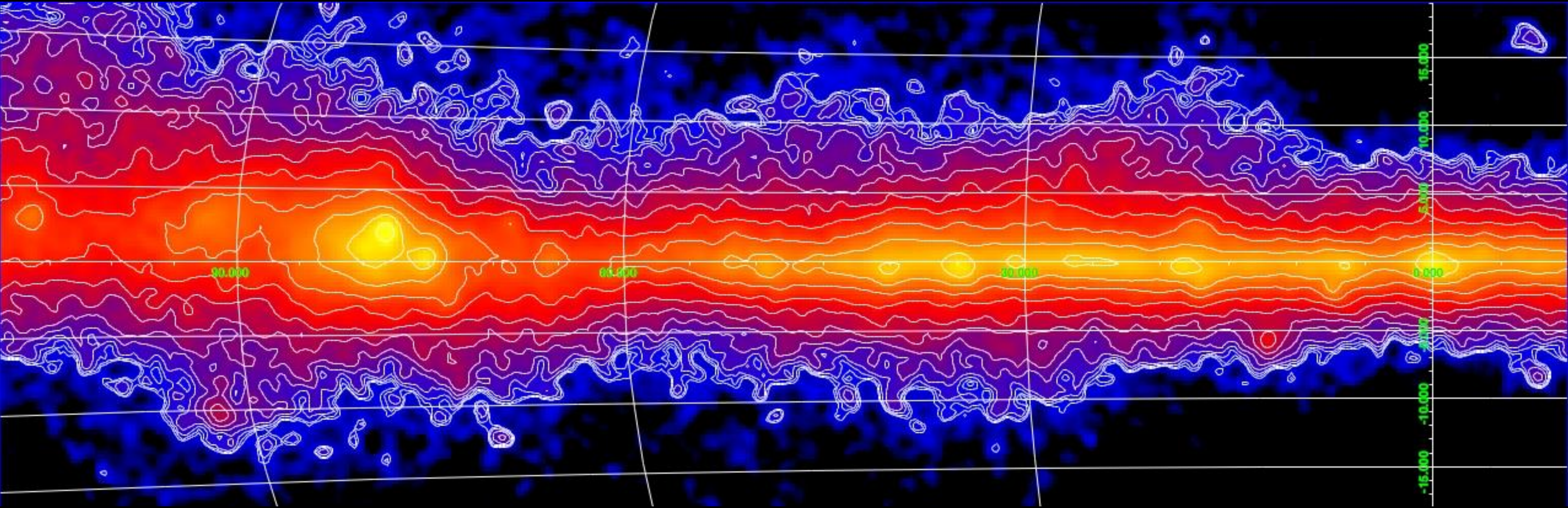
AGILE deep 8 yrs integrated count map



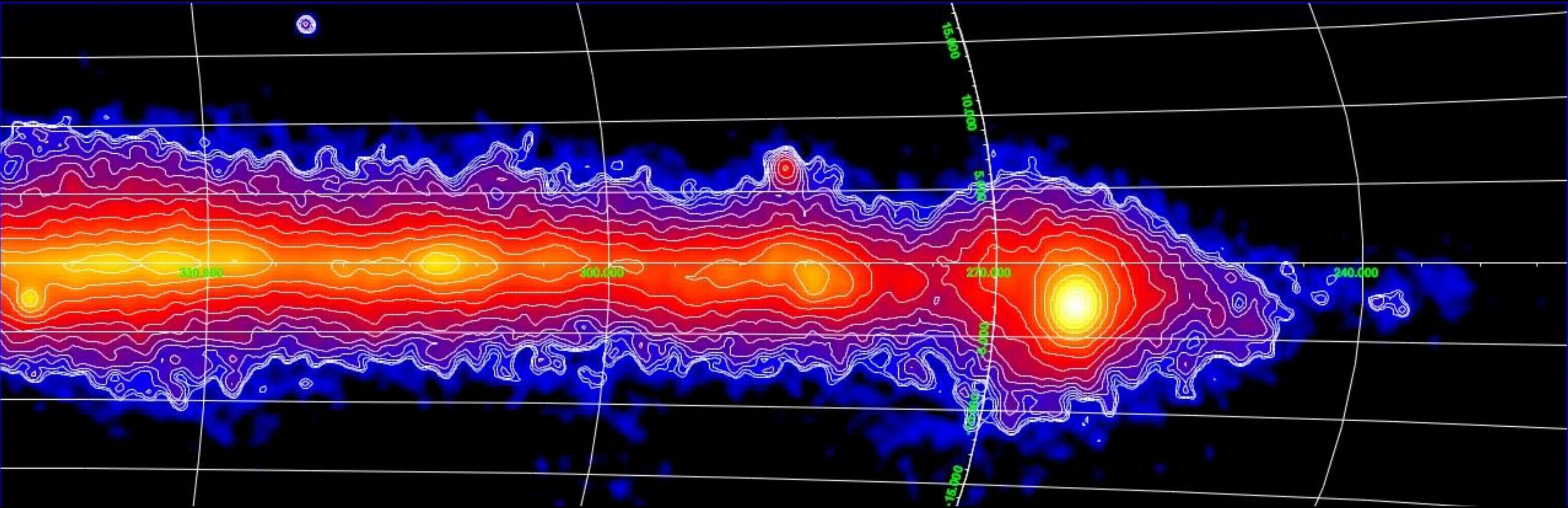
Inner Galaxy



Cygnus Region



Carina Region

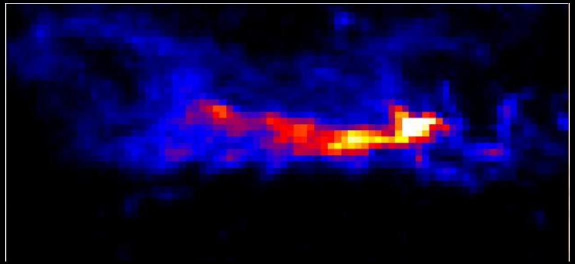


PERSPECTIVES

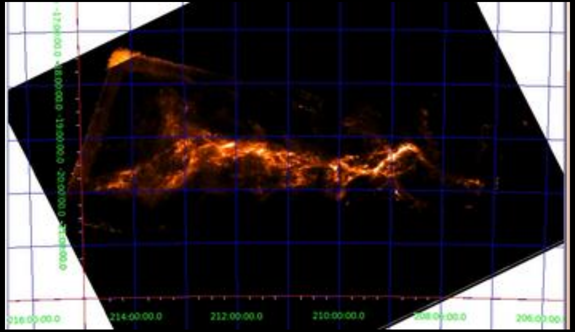
- The consolidated AGILE angular resolution, allows carry out a complete **tomography of the Galactic Plane** -> diffuse emission, cat2, low energy CR (ASTROGAM)

- Cross-correlation with other catalogues, new use of AGILE data :
  - star formation (HERSCHEL)
  - high energy neutrino sources (ICECUBE)

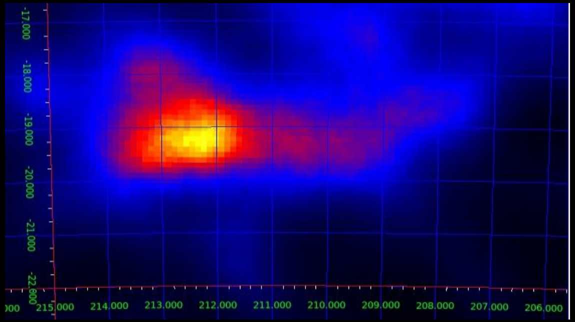
AGILE vs HERSCHEL: Mapping the effects of cosmic ray flux on the SFR



CO emission in Orion A (Dame et al., 2001)

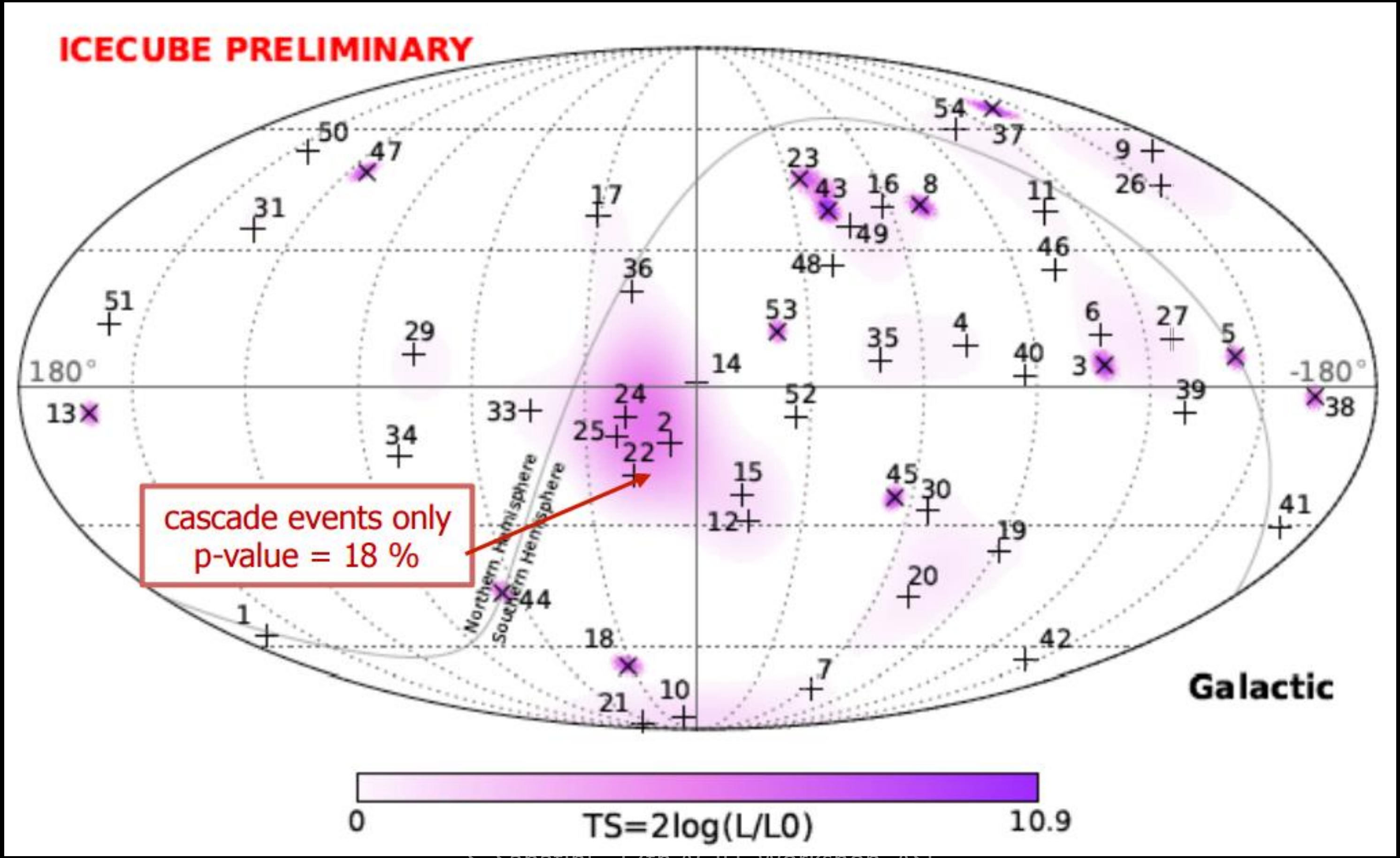


Integrated column density (NH) (Herschel data)



Gamma-ray emission (AGILE)

AGILE vs ICECUBE: Investigating the origin of neutrino sources



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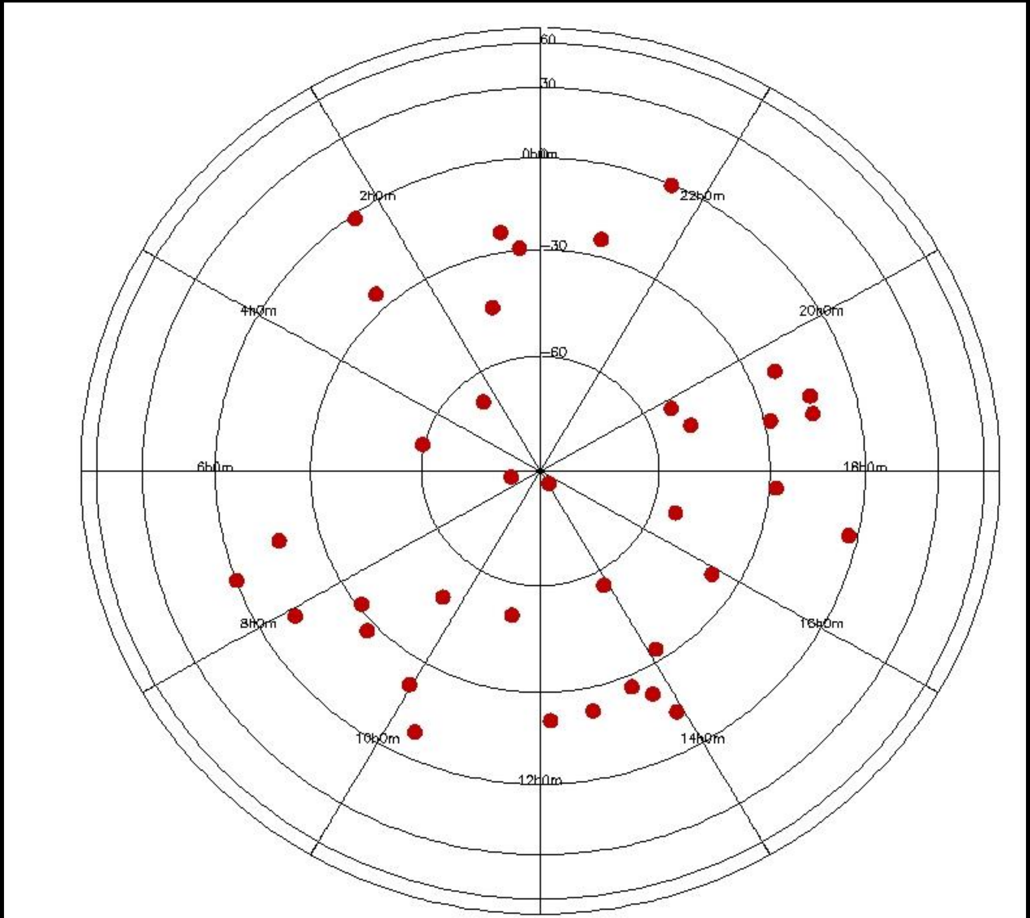

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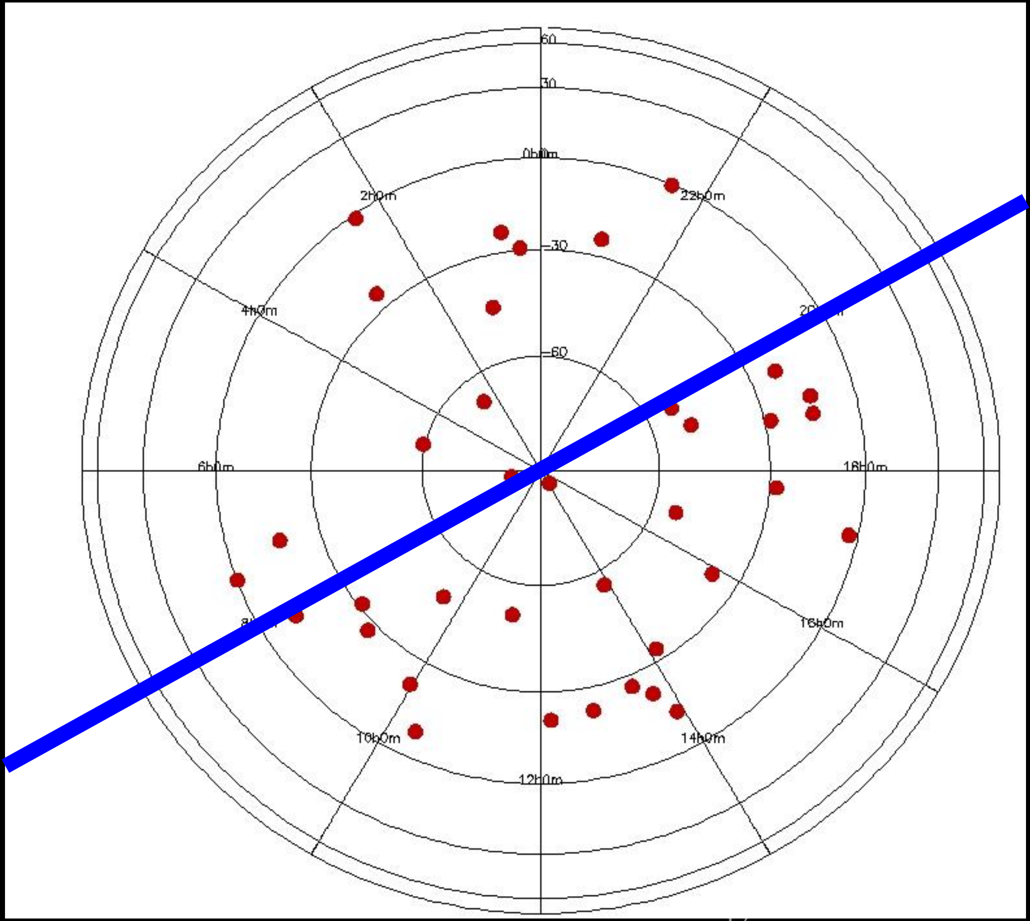

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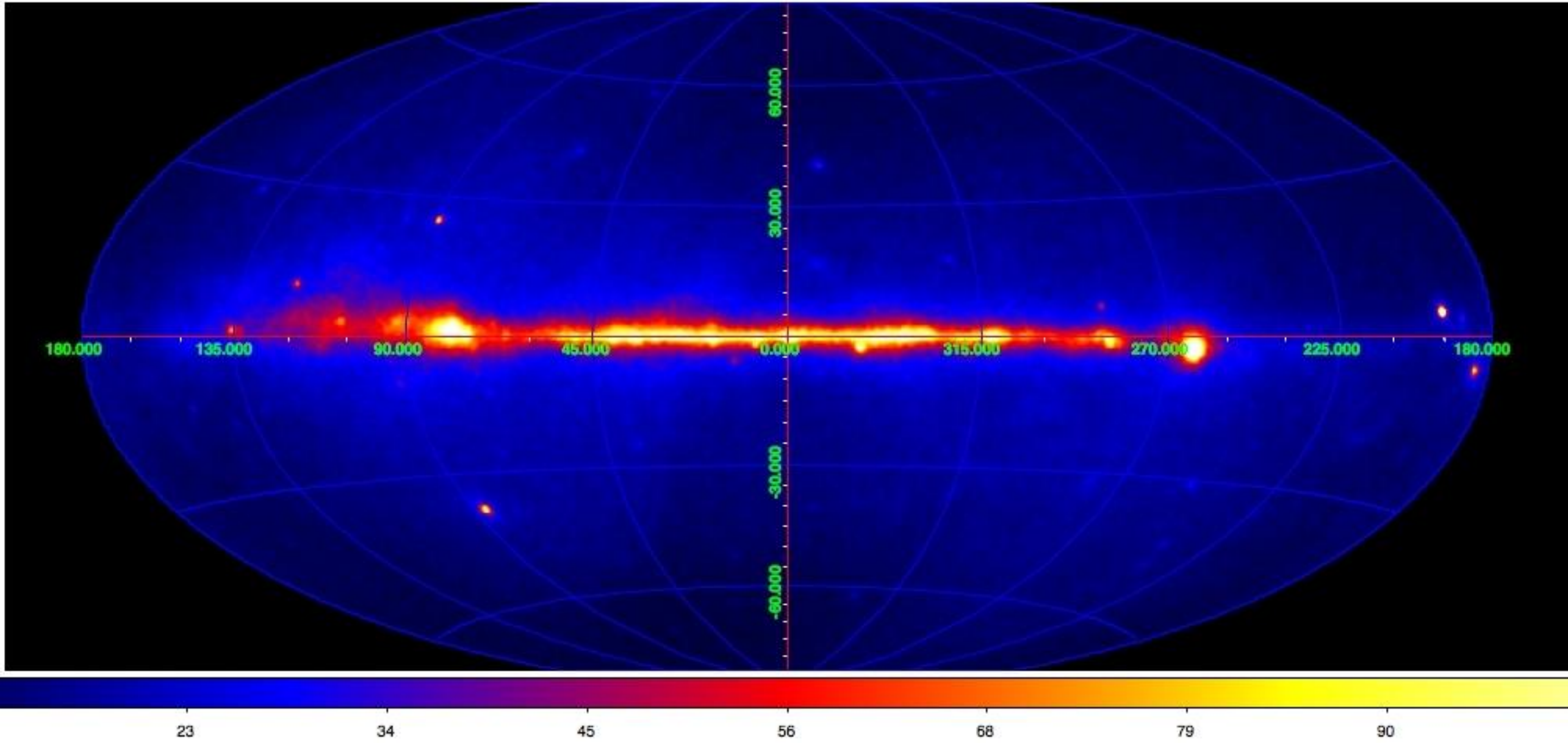

CONCLUSIONS

- AGILE angular resolution very good, unique in the low energy band.
- Angular resolution stable across the filed of view, ensures stable performances also in spinning.
- Read-out system and reconstruction algorithms crucial in defining the final angular resolution.

- Works in progress: cross-correlation with other catalogues, new use of AGILE data:
  - star formation (HERSCHEL)
  - high energy neutrino sources (ICECUBE)