Experiments on satellites : status and future perspectives in connection with Neutrinos experiments

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Perspectives in Astroparticle physics from High Energy Neutrinos

PAHEN 2017, Napoli, 25-26 September 2017

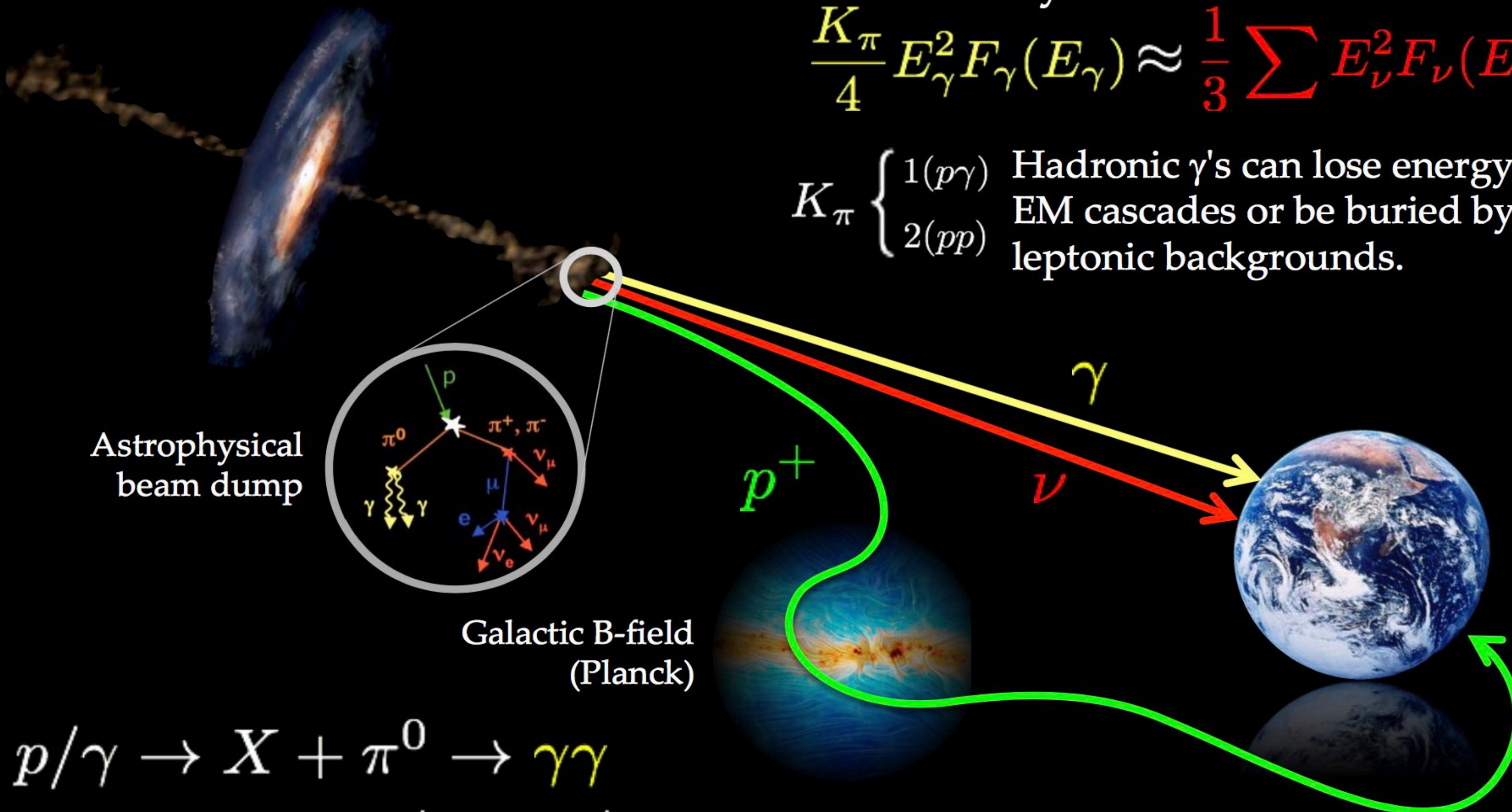
Neutrinos and Gamma Rays

Gamma-ray flux Neutrino flux

$$\frac{K_\pi}{4} E_\gamma^2 F_\gamma(E_\gamma) \approx \frac{1}{3} \sum E_\nu^2 F_\nu(E_\nu)$$

$$K_\pi \begin{cases} 1 (p\gamma) \\ 2 (pp) \end{cases}$$

Hadronic γ's can lose energy via EM cascades or be buried by leptonic backgrounds.

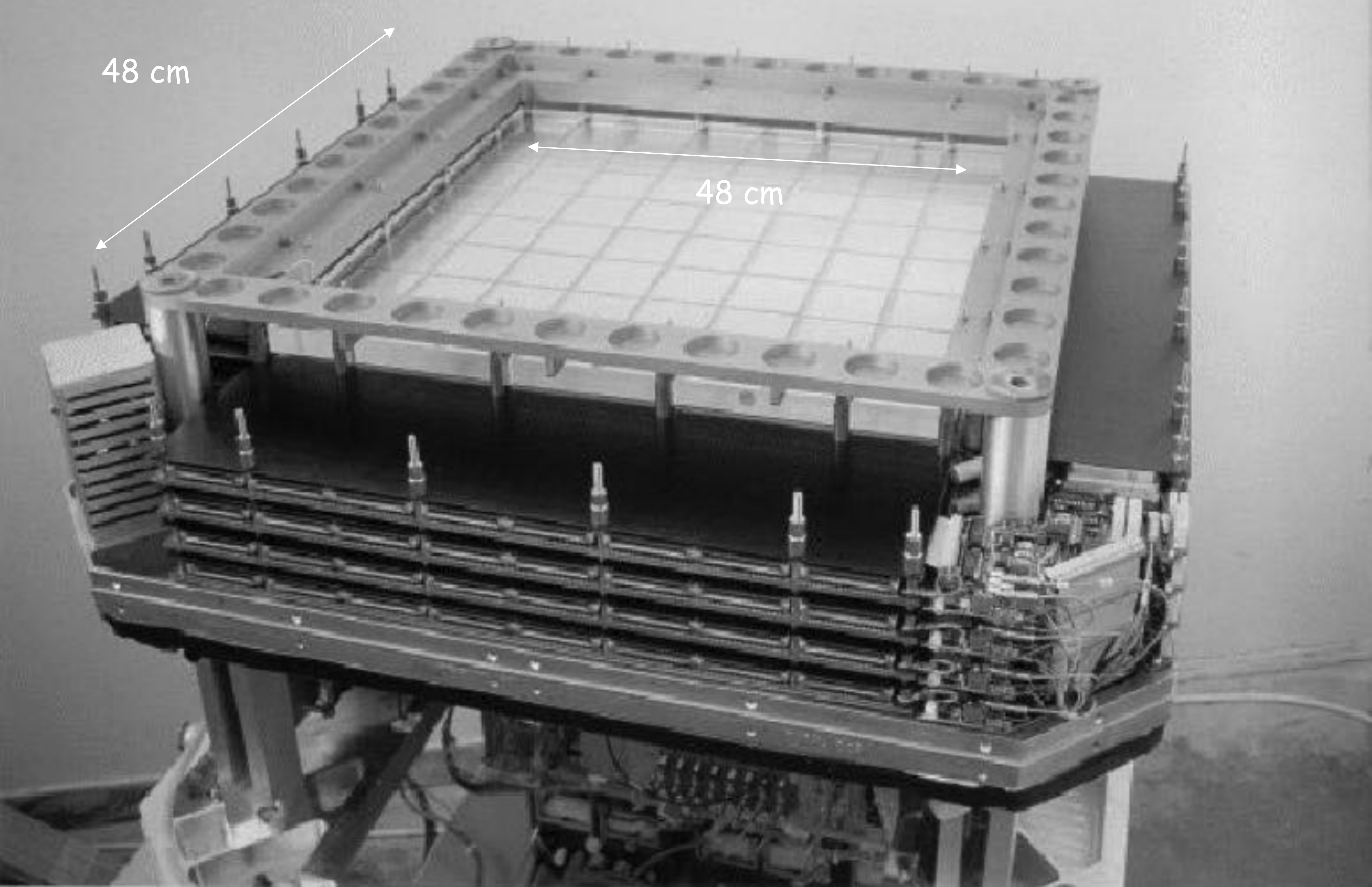


$$p + p/\gamma \rightarrow X + \pi^0 \rightarrow \gamma\gamma$$

$$\rightarrow X + \pi^+ \rightarrow \mu^+ + \nu_\mu$$

$$\mu^+ \rightarrow e^+ + \nu_e + \bar{\nu}_\mu$$ (oscillates to ~1:1:1)

The TS93 and CAPRICE silicon-tungsten imaging calorimeter.



N·H
ELSEVIER

Nuclear Instruments and Methods in Physics Research A 354 (1995) 547–552

NUCLEAR INSTRUMENTS & METHODS IN PHYSICS RESEARCH
Section A

The GILDA mission: a new technique for a gamma-ray telescope in the energy range 20 MeV–100 GeV

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[b] *Dept. of Physics, II Univ. of Rome "Tor Vergata" and INFN, Italy*
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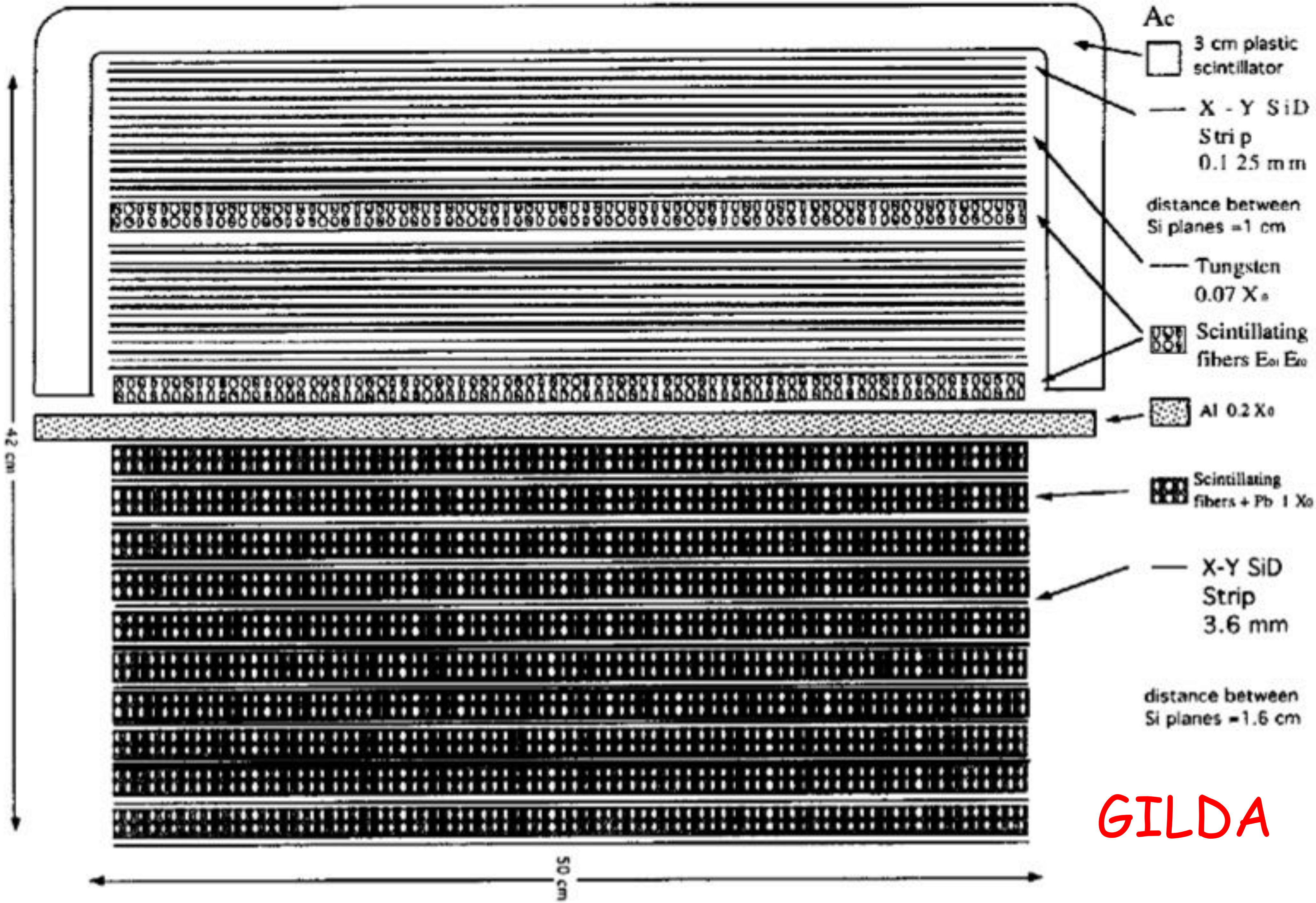
Received 5 August 1994

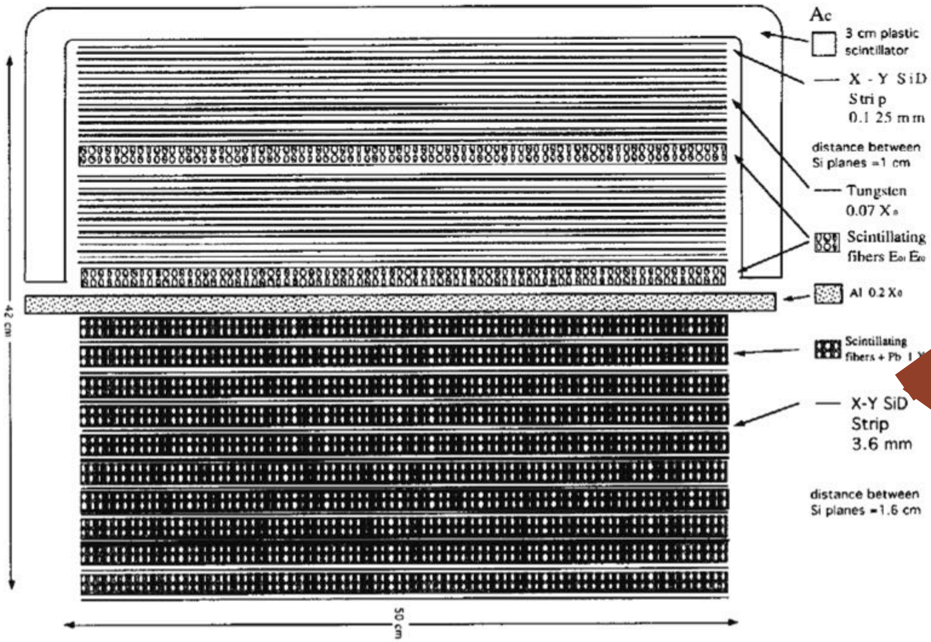
Abstract

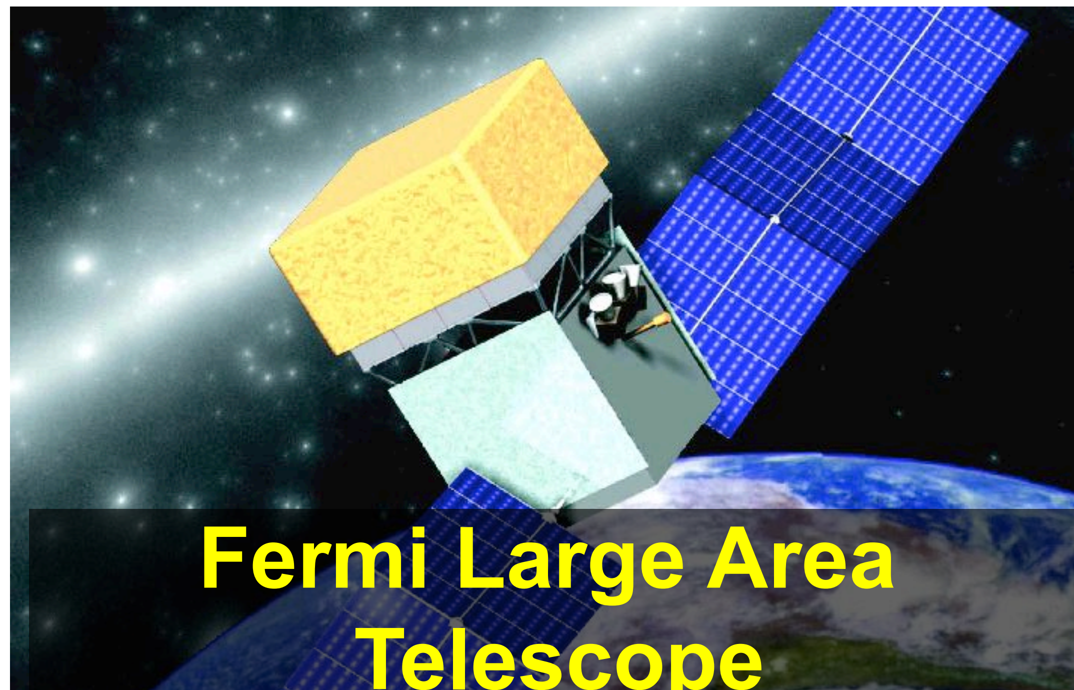
In this article a new technique for the realization of a high energy gamma-ray telescope is presented, based on the adoption of silicon strip detectors and lead scintillating fibers. The simulated performances of such an instrument (GILDA) are significatively better than those of EGRET, the last successful experiment of a high energy gamma-ray telescope, launched on the CGRO satellite, though having less volume and weight.

* Corresponding author.


Ac
3 cm plastic scintillator
X - Y SiD Strip 0.125 mm
distance between Si planes =1 cm
Tungsten $0.07\ X_0$
Scintillating fibers
Al $0.2\ X_0$
Scintillating fibers + Pb $1\ X_0$
X-Y SiD Strip 3.6 mm
distance between Si planes =1.6 cm
42 cm
50 cm
GILDA

GILDA





Development of GLAST, a broadband High-Energy Gamma-Ray Telescope using Silicon Strip Detectors

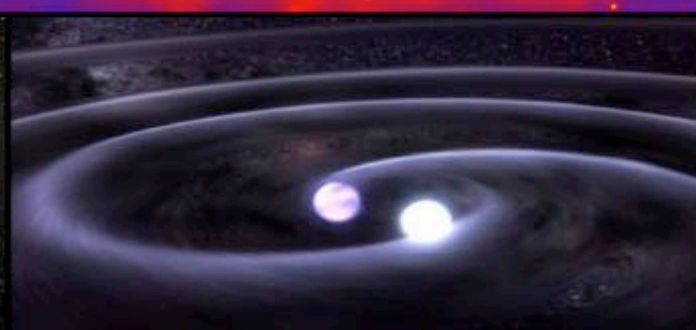
P.Michelson, W.Atwood, E.Bloom, G.Godfrey, Y.Lin, P.Nolan, D.Bertsch, N.Gehrels, R.Hartman, S.Hunter, J.Norris, J.Ormes, R.Streitmatter, D.Thompson, E.Grove, P.Hertz, W.N.Johnson, M.Lovellette, G.H.Share, M.Wolff, K.S.Wood, R.Johnson, C.Couvault, R.Ong, M.Oreglia, J.Mattox, T.Burnett, C.Chenette, G.Nakano, L.Cominsky, H.A.Mayer-Hasselwander, G.Barbiellini, A.Colavita, A.Morselli, T.Kamae, K.Kasahara

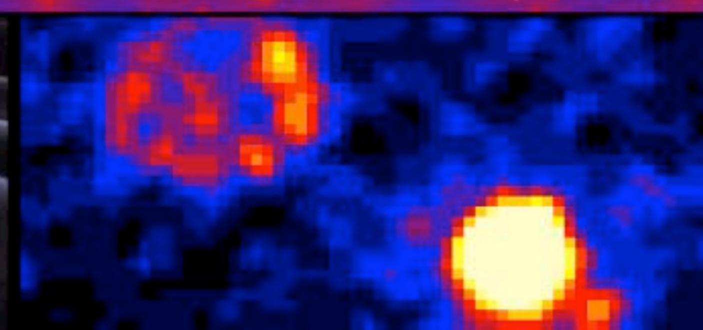
Proposal presented to NASA, Space Physics Division in response to "Proposal for High Energy Astrophysics Supporting Research and Technology Program", NRA 95-OSS-17


AGILE
23 April 2007
Happy 10th Birthday Agile !!

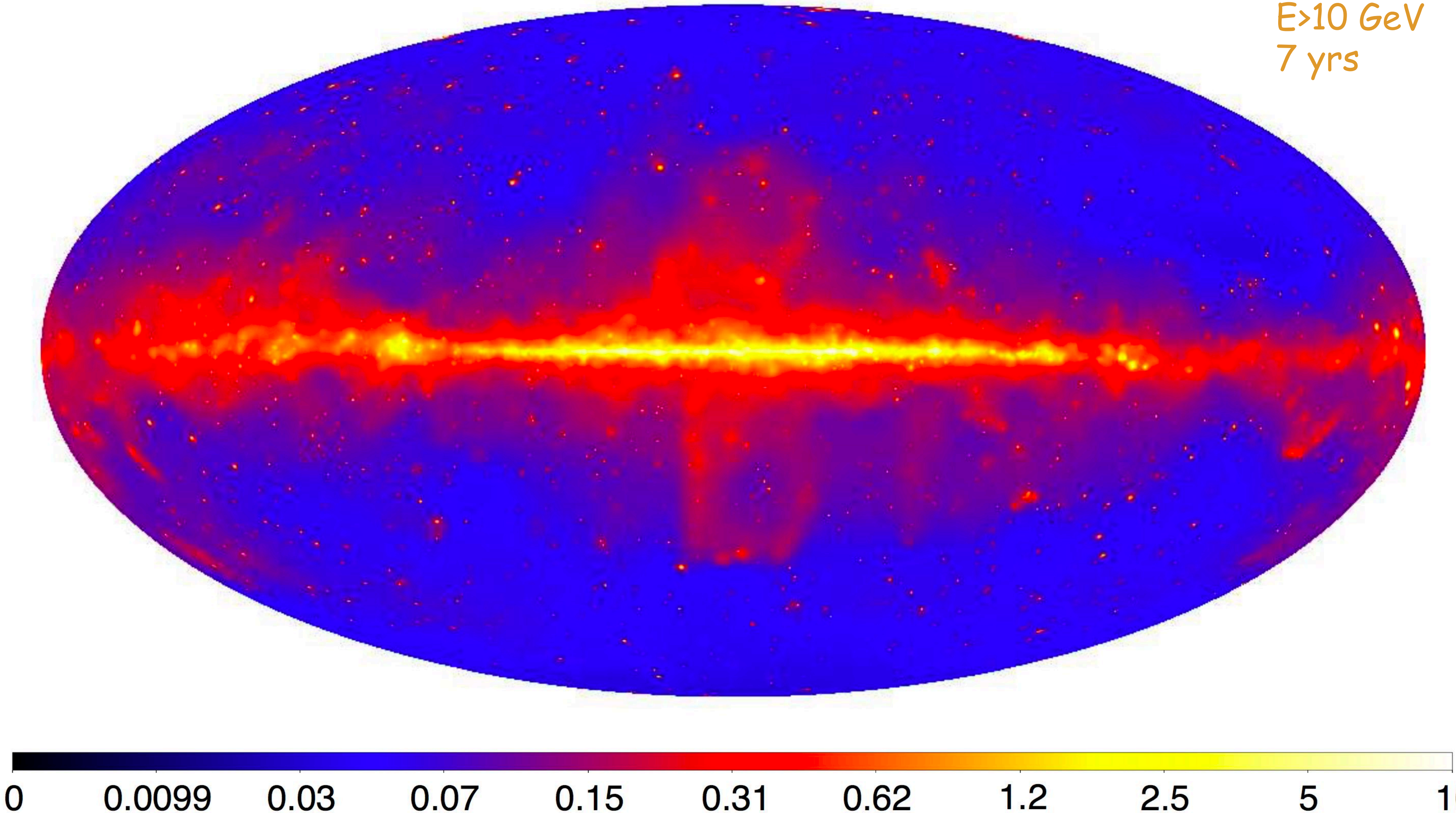
Fermi
Gamma-ray Space Telescope

Fermi Gamma-Ray Space Telescope



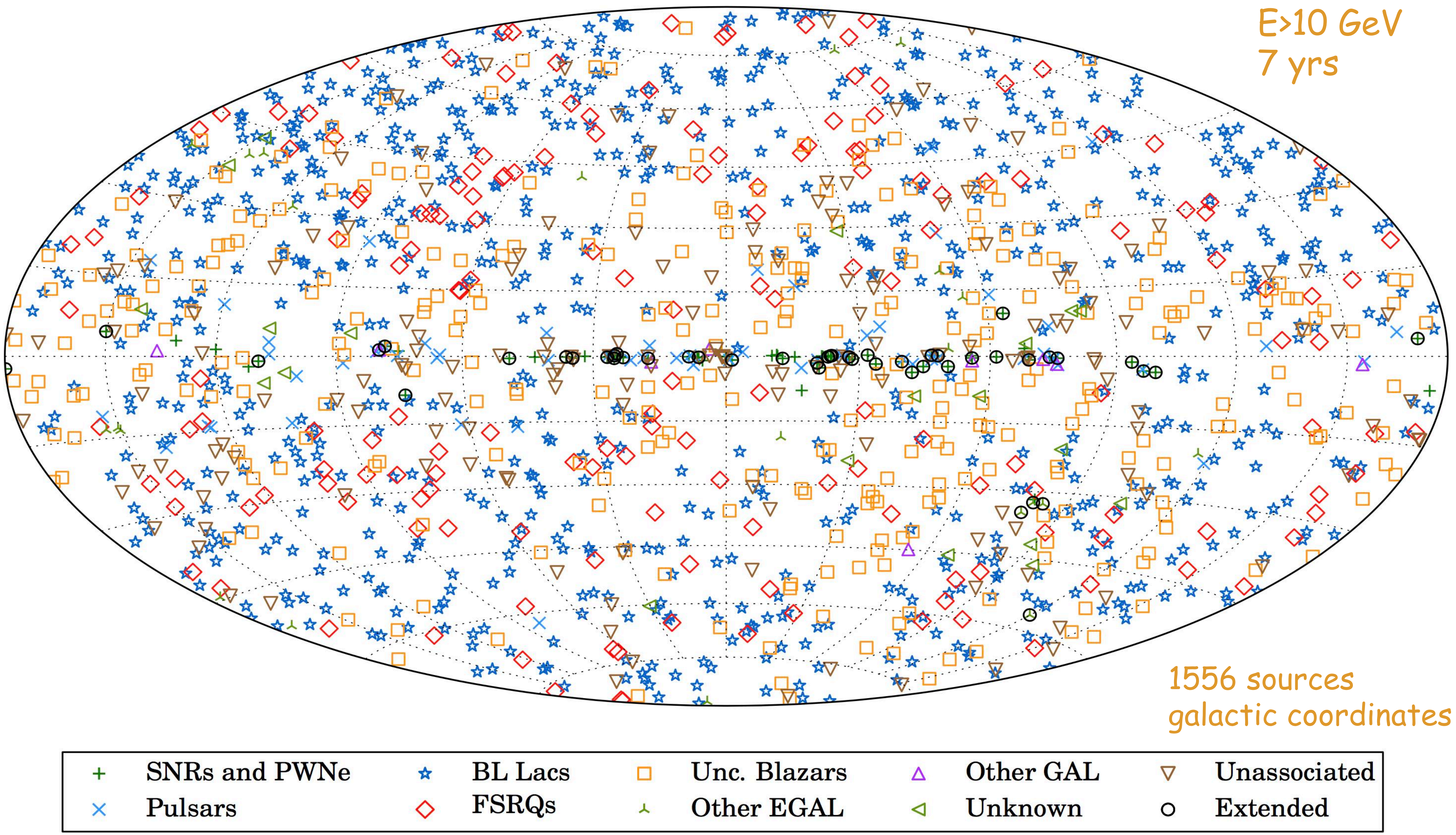


The sky in gamma-rays



M.Ackermann et al. [Fermi Coll.] 3FHL: The Third Catalog of Hard Fermi-LAT Sources arXiv:1702.00664

The sky in gamma-rays

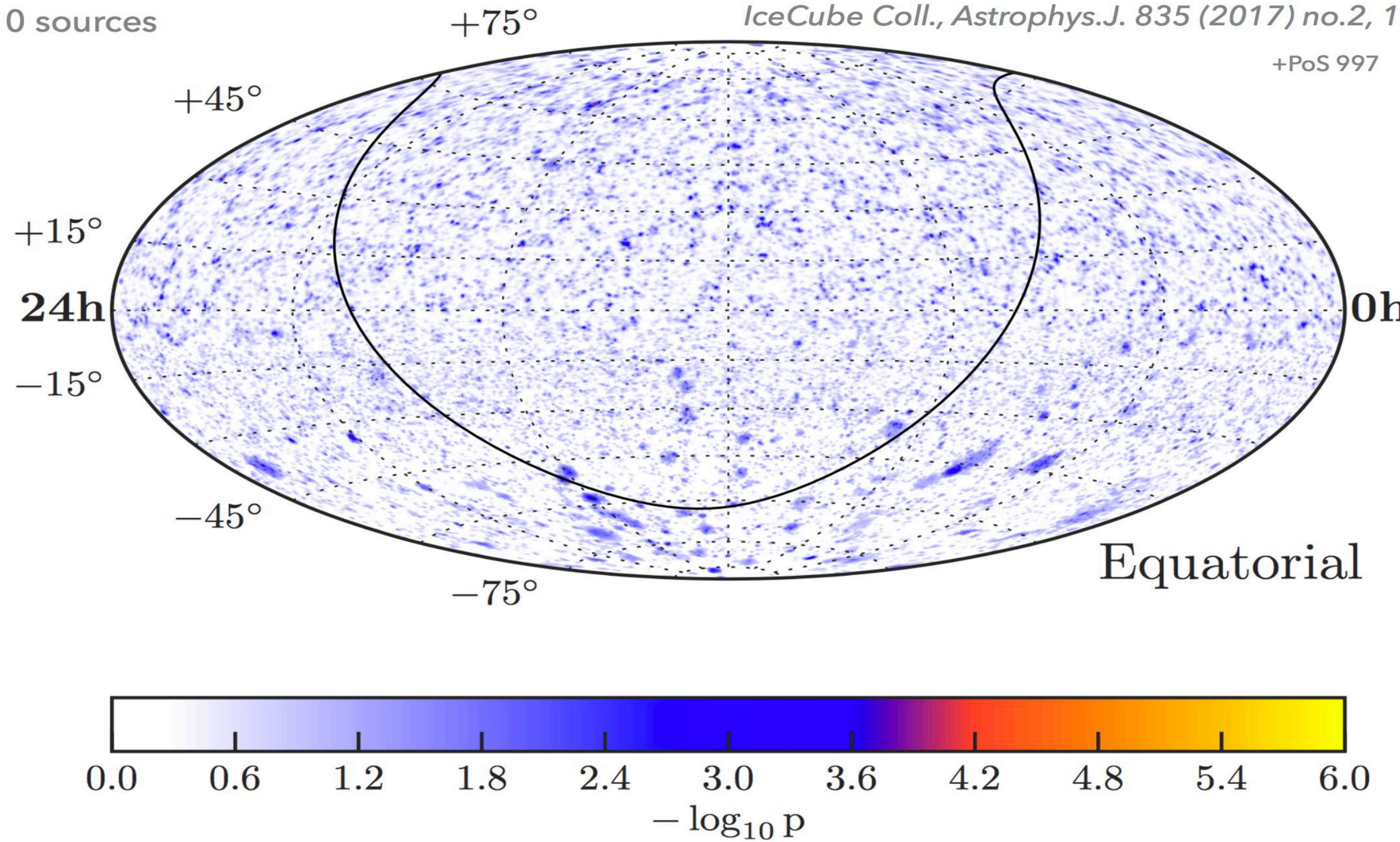


M.Ackermann et al. [Fermi Coll.] 3FHL: The Third Catalog of Hard Fermi-LAT Sources arXiv:1702.00664

10^{12}-10^{15} eV Sky in neutrinos

IceCube Coll., Astrophys.J. 835 (2017) no.2, 151

+PoS 997



Neutrino source candidates

- IceCube searches for point-like and extended sources of muon neutrinos found neither statistically-significant evidence for event clustering nor correlation of neutrinos with known astrophysical objects.
- Kadler et al. (2015) found one of the ICECUBE PeV-event was spatially and temporally coincident with a major gamma-ray outburst of the Flat Spectrum Radio Quasar (FSRQ) PKS B1424-418.
- Resconi et al. 2017 provide hints that HBL sub-class of blazars may be the sources of some of the ICECUBE HESE neutrinos and UHECRs seen by Auger/Telescope Array. (see Resconi talk)

ICECUBE-160731 event

- Extremely High Energy (EHE) neutrino detected by the ICECUBE experiment at

  T0=31/07/2016 01:55:04 UTC

- Announced by GCN/AMON notice 128290_6888376 (http://gcn.gsfc.nasa.gov/notices_amon/6888376_128290.amon).
- Reconstructed arrival direction:

  RA,DEC (J2000)=(214.54, -0.33) +/- 0.75 [deg]

  (90% stat+sys containement radius)

  Gal Coords. l,b=(343.68, +55.52) deg

AGILE investigations of ICECUBE-160731

- AGILE alert systems received automatically GCN/ AMON notice emitted by the ICECUBE Coll.
- No significant detection in the AGILE-GRID data was found around T0 at the ICECUBE coords.
- BUT … a gamma-ray excess above 100 MeV above 4 sigma was detected in the GRID data by the *AGILE QL* processing procedure a couple of days before, on a 48 hours integration between (T0 – 3; T0 – 1) days.

The AGILE AGL J1418+0008 transient

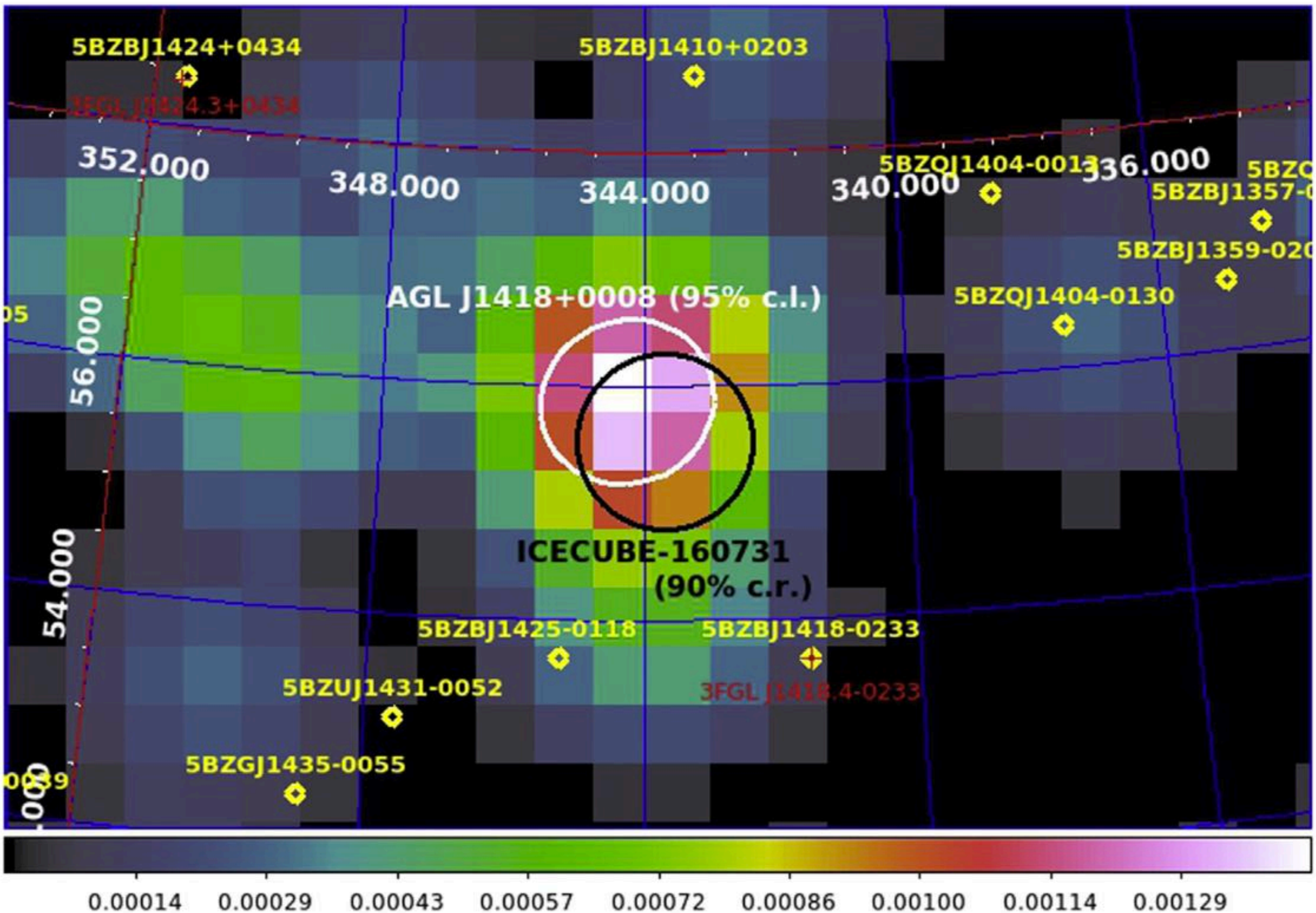
- **Very brief episode (1 – 1.5 days).**
- **4.1σ pre-trial significance on (T0 – 2; T0 - 1) days interval.**
- **Peak significance of 4.9σ on the 24 hours integration (T0 - 1.8; T0 - 0.8) days (peak flux (E>100 MeV)~3.5E-06 ph/cm2/s).**
- **Best-fit AGILE-GRID position:**

l,b=(344.26, 55.86) [deg] +/- 0.8 [deg] (95% stat. c.l.)

➔ new AGILE transients: AGL J1418+0008

AGL J1418+008 possible gamma-ray precursor of the ICECUBE-160731 event (?)

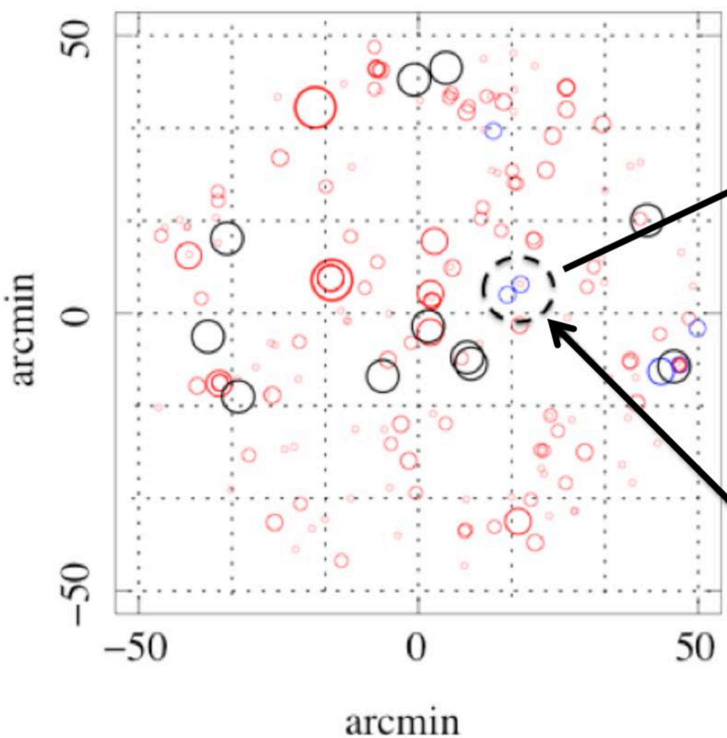
The AGILE AGL J1418+0008 transient



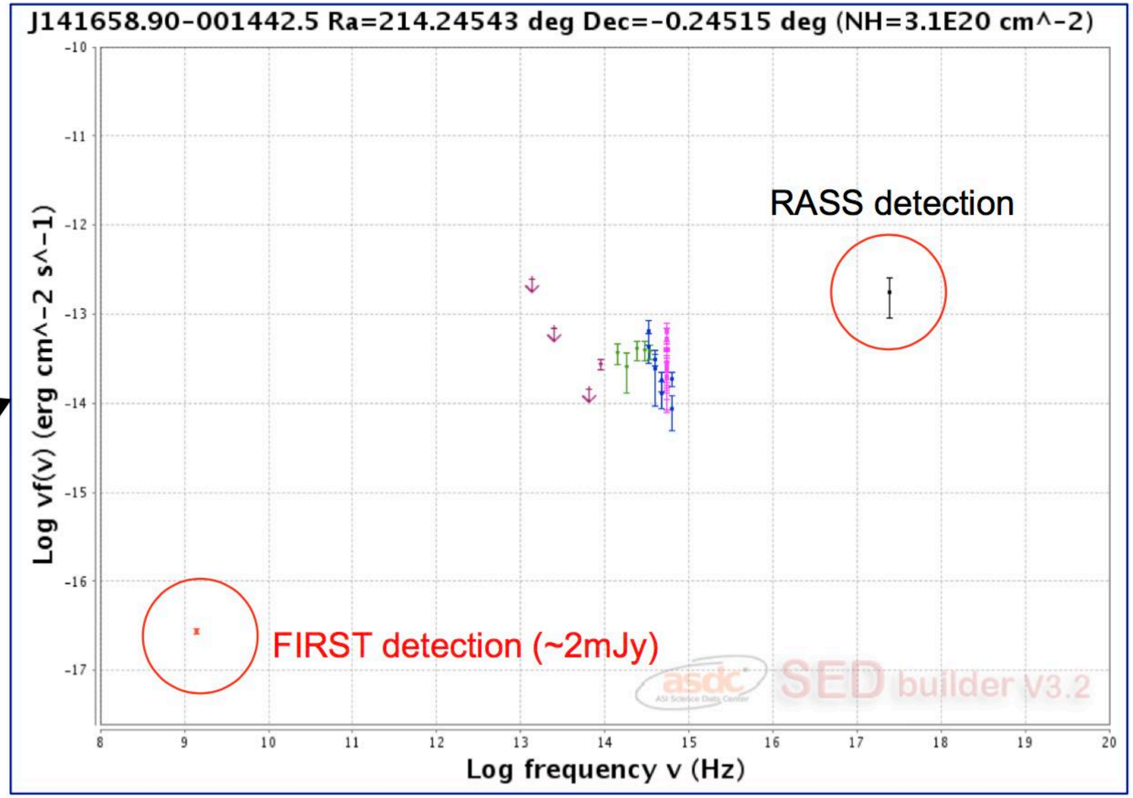
F. Lucarelli et al. Agile Coll. Apj, 2017, 846:121 [arXiv:1707.08599]

a possible candidate for ICECUBE-160731

Search around ICECUBE-160731/AGL J1418 using ASDC ***SkyExplorer*** tool



ASDC SEDBuilder Tool

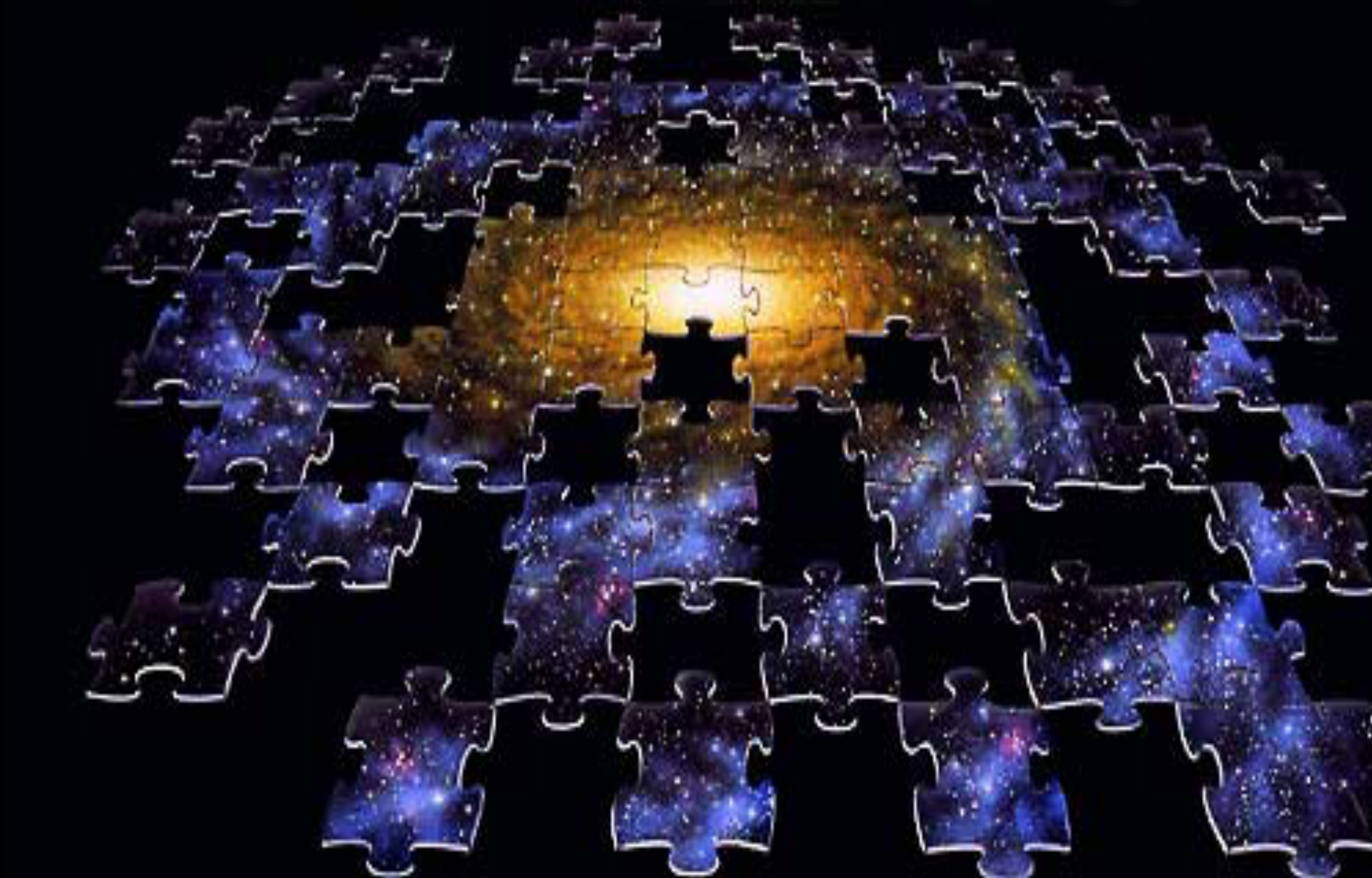


1RXS J141658-00144:
possible HBL blazar candidate ➔
ICECUBE-160731 emitter candidate?

F. Lucarelli et al. Agile Coll. Apj, 2017, 846:121 [arXiv:1707.08599]

Another gamma- ν connection: Search for Dark Matter

Another gamma- ν connection: Search for Dark Matter

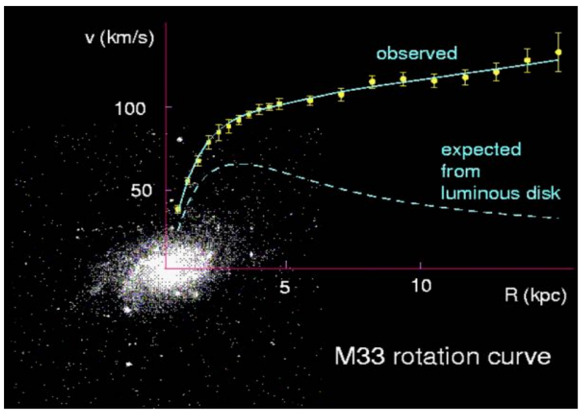


Dark Matter EVIDENCE

In 1933, the astronomer Zwicky realized that the mass of the luminous matter in the Coma cluster was much smaller than its total mass implied by the motion of cluster member galaxies.

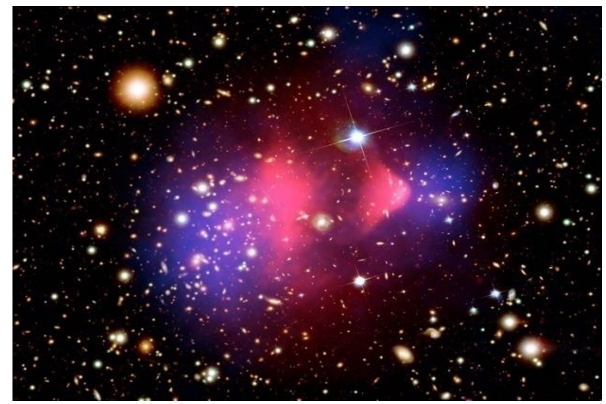
Since then, even more evidence:

Rotation curves of galaxies

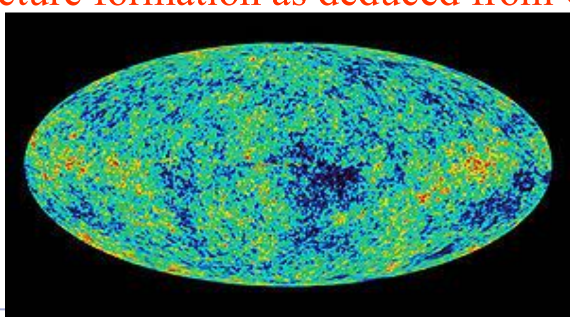


Gravitational lensing

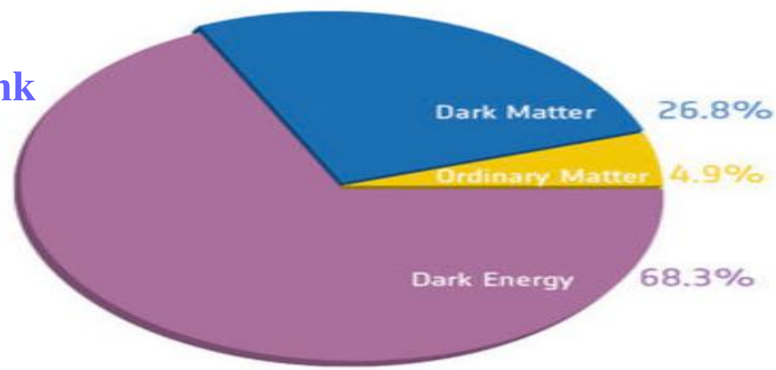
Bullet cluster



Structure formation as deduced from CMB



Data by Plank imply:



$\Omega_{DM} \approx 26.8\%$

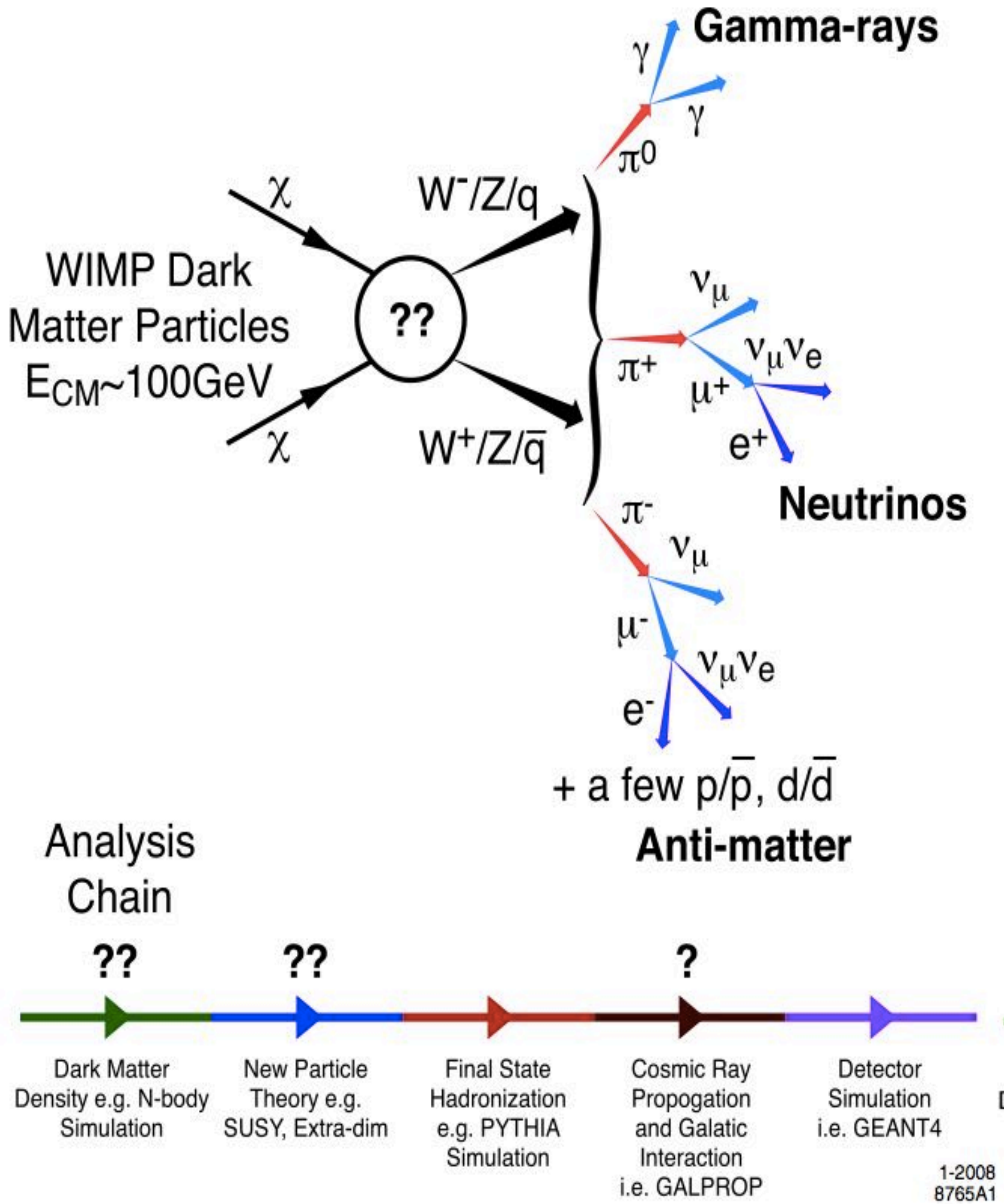
$\Omega_{M} \approx 4.9\%$

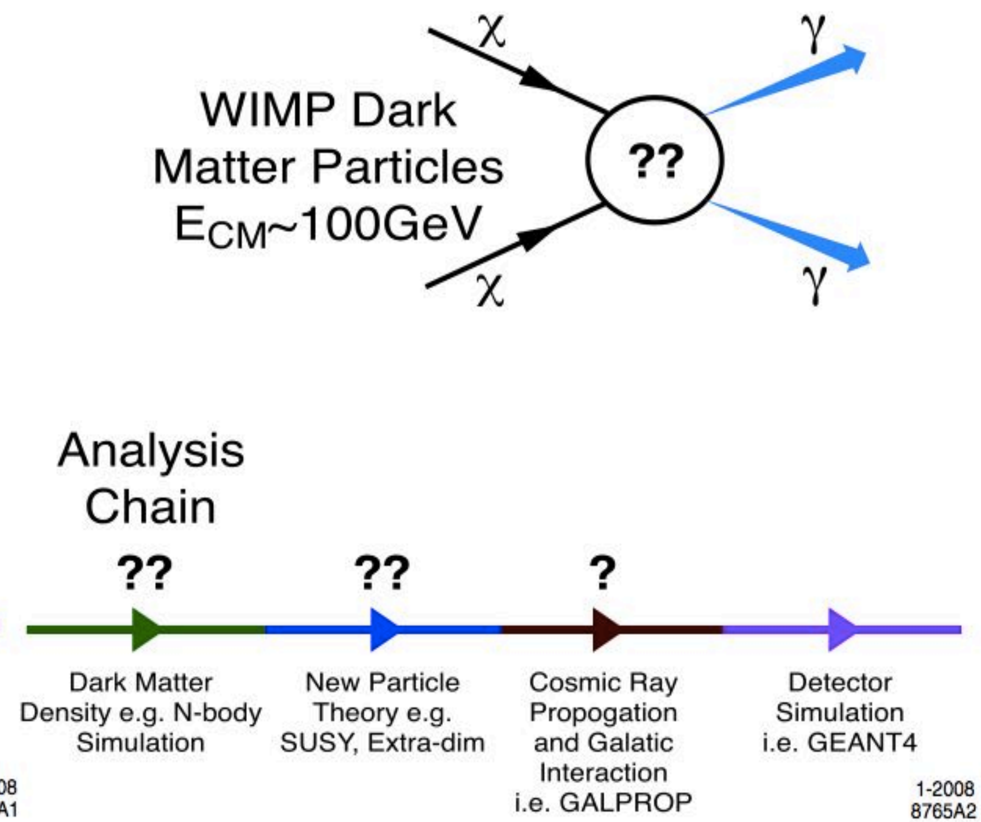
Neutralino WIMPs

Assume χ present in the Galactic halo

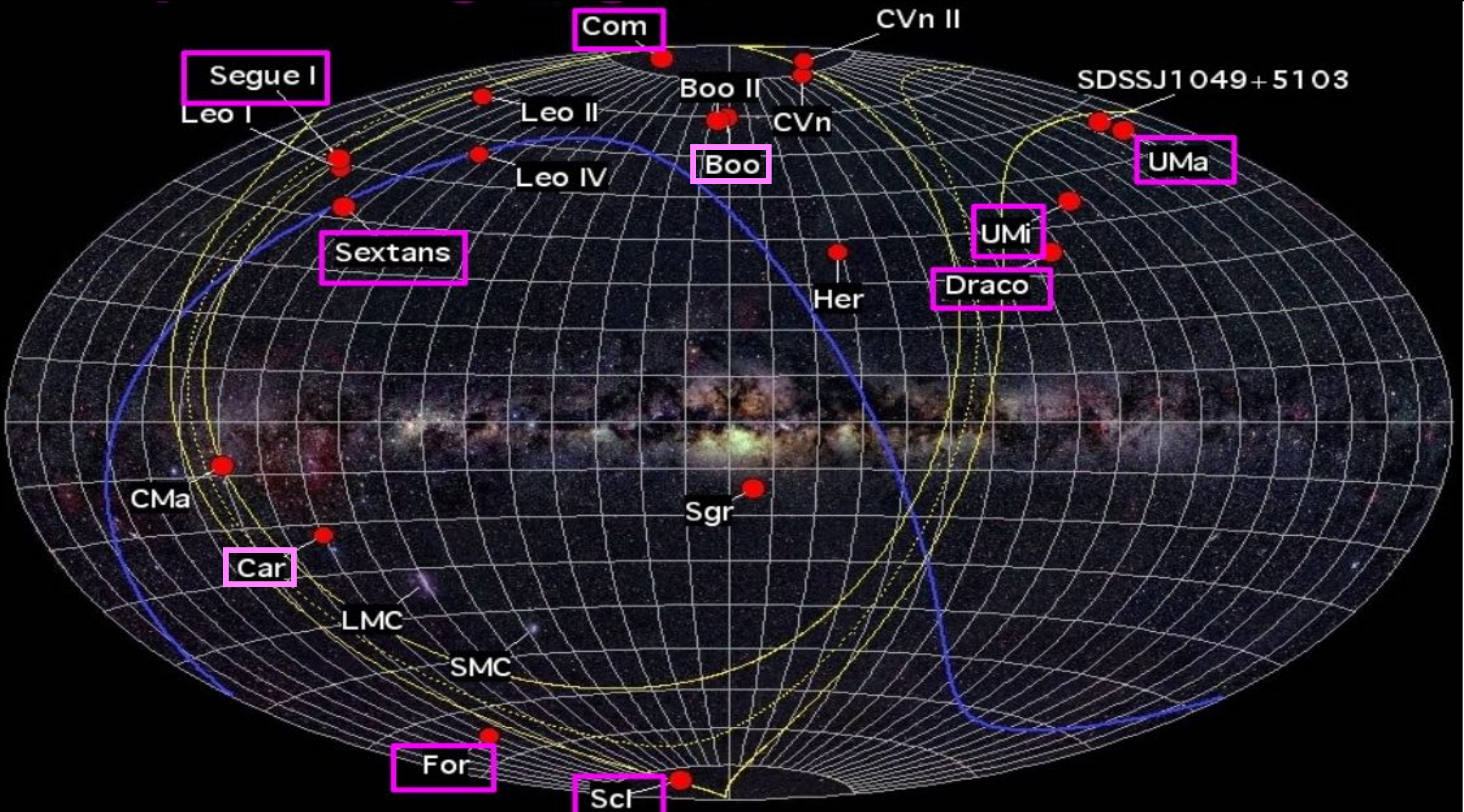
- χ is its own antiparticle **=>** can annihilate in galactic halo producing gamma-rays, antiprotons, positrons….
- Antimatter not produced in large quantities through standard processes (secondary production through p + p **-->** anti p + X)
- So, any extra contribution from exotic sources ($\chi\,\chi$ annihilation) is an interesting signature
- ie: $\chi\,\chi$ --> anti p + X
- Produced from (e. g.) $\chi\,\chi$ **-->** q / g / gauge boson / Higgs boson and subsequent decay and/ or hadronisation.

Annihilation channels



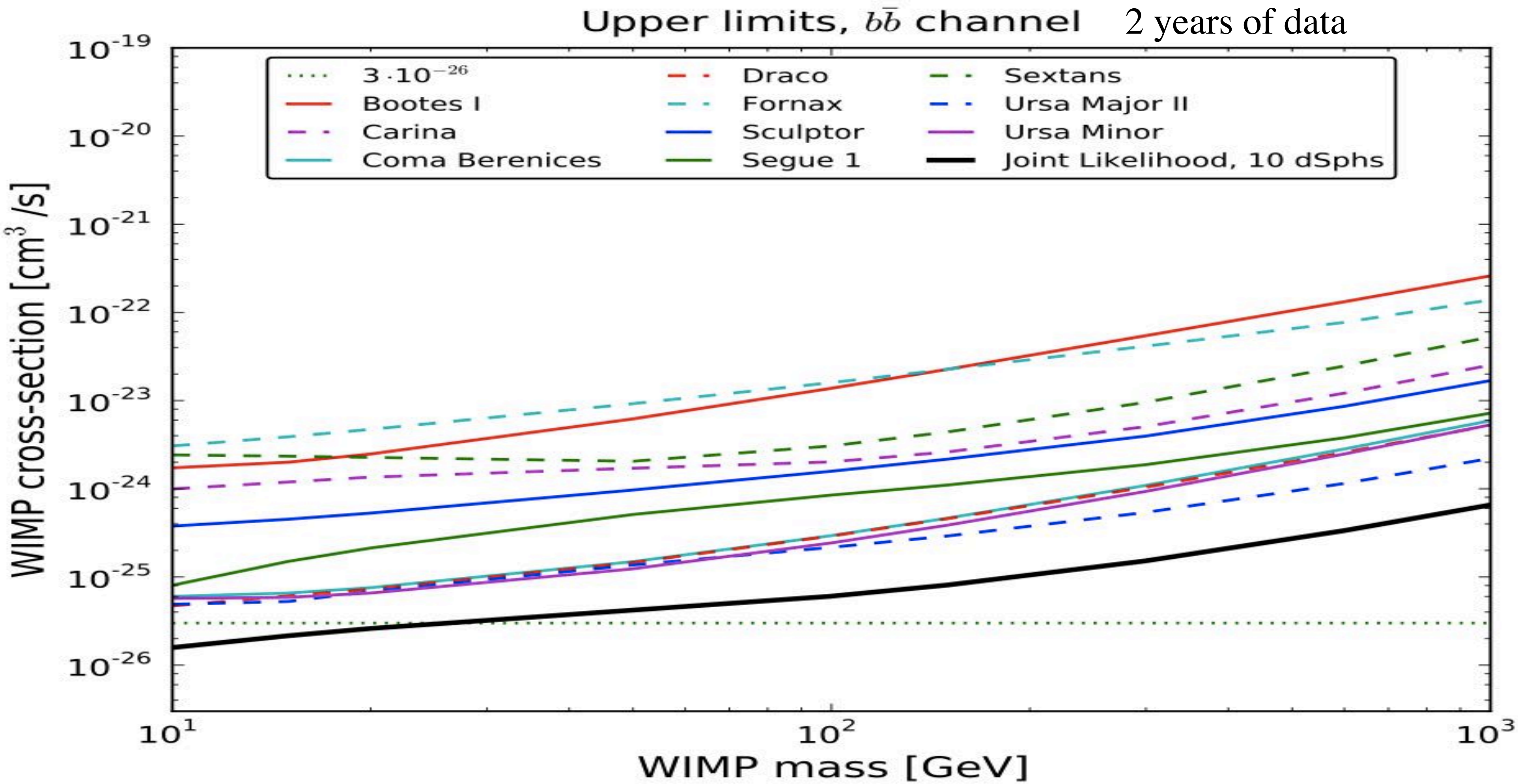


Dwarf spheroidal galaxies (dSph) : promising targets for DM detection



Dwarf Spheroidal Galaxies combined analysis

2 years of data

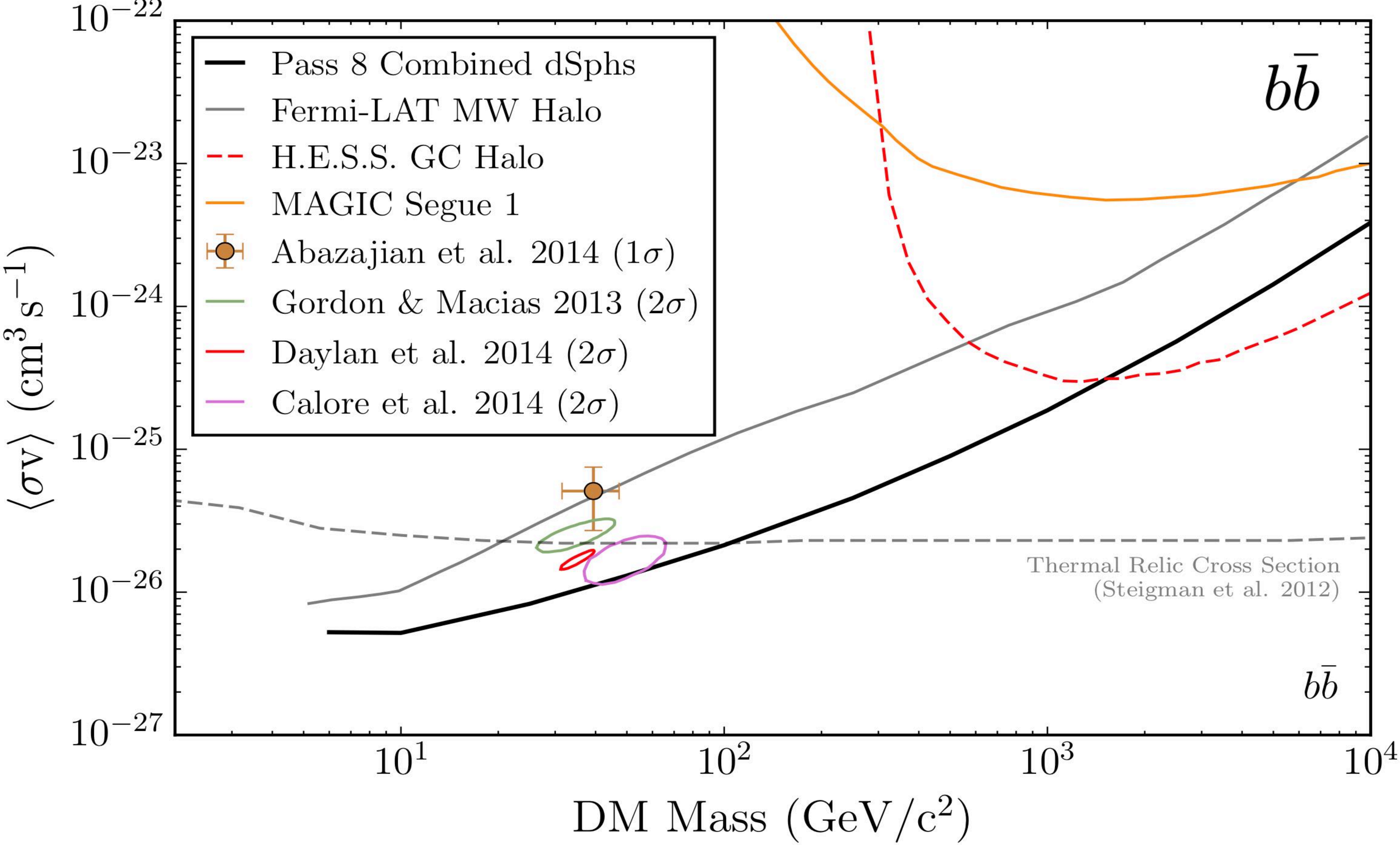


robust constraints including J-factor uncertainties from the stellar data statistical analysis

NFW. For cored dark matter profile, the J-factors for most of the dSphs would either increase or not change much

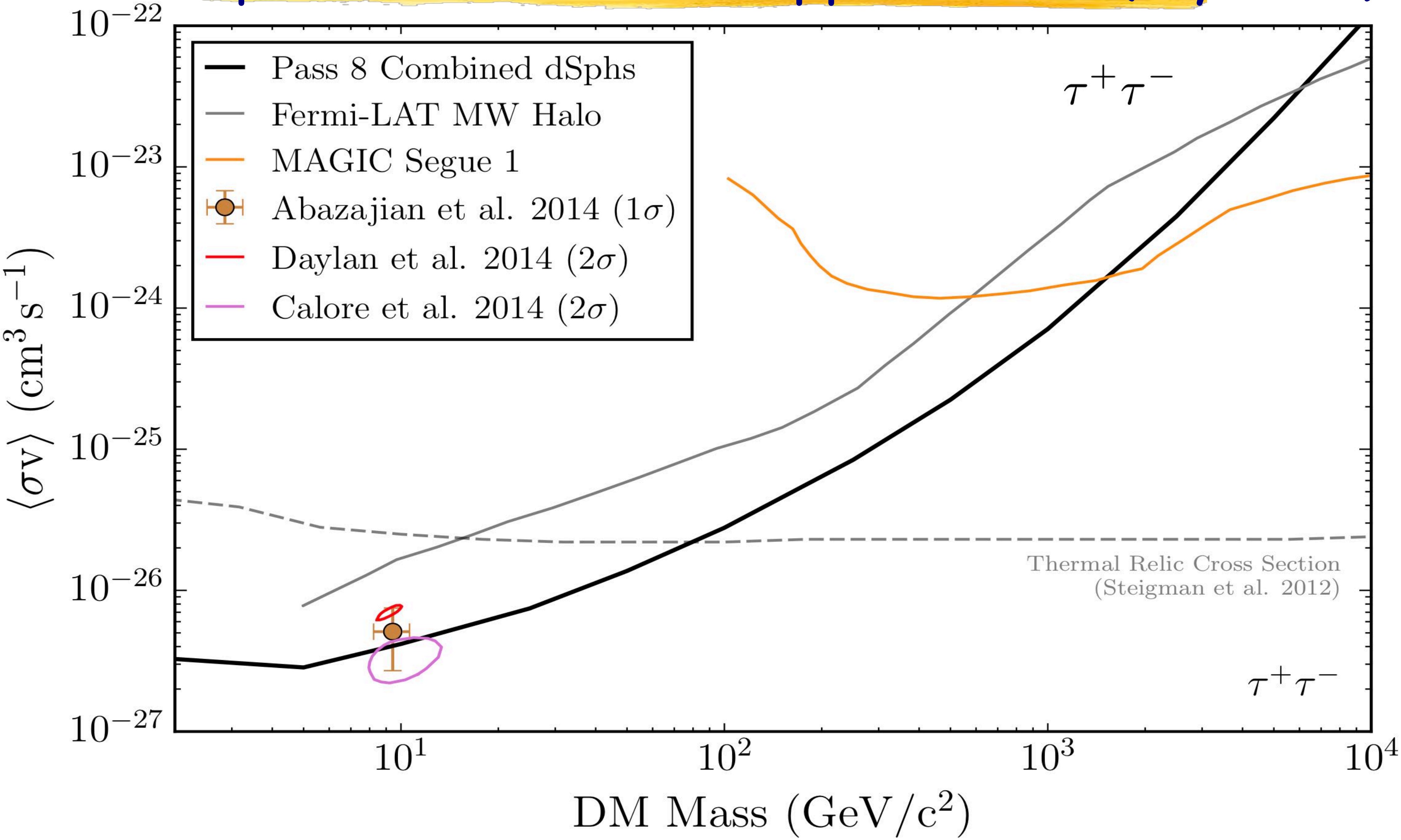
Fermi Lat Coll., PRL 107, 241302 (2011) [arXiv:1108.3546]

Dwarf Spheroidal Galaxies upper-limits (6 years)



M.Ackermann et al., [Fermi Coll.] PRL 115, 231301 (2015) [arXiv:1503.02641]

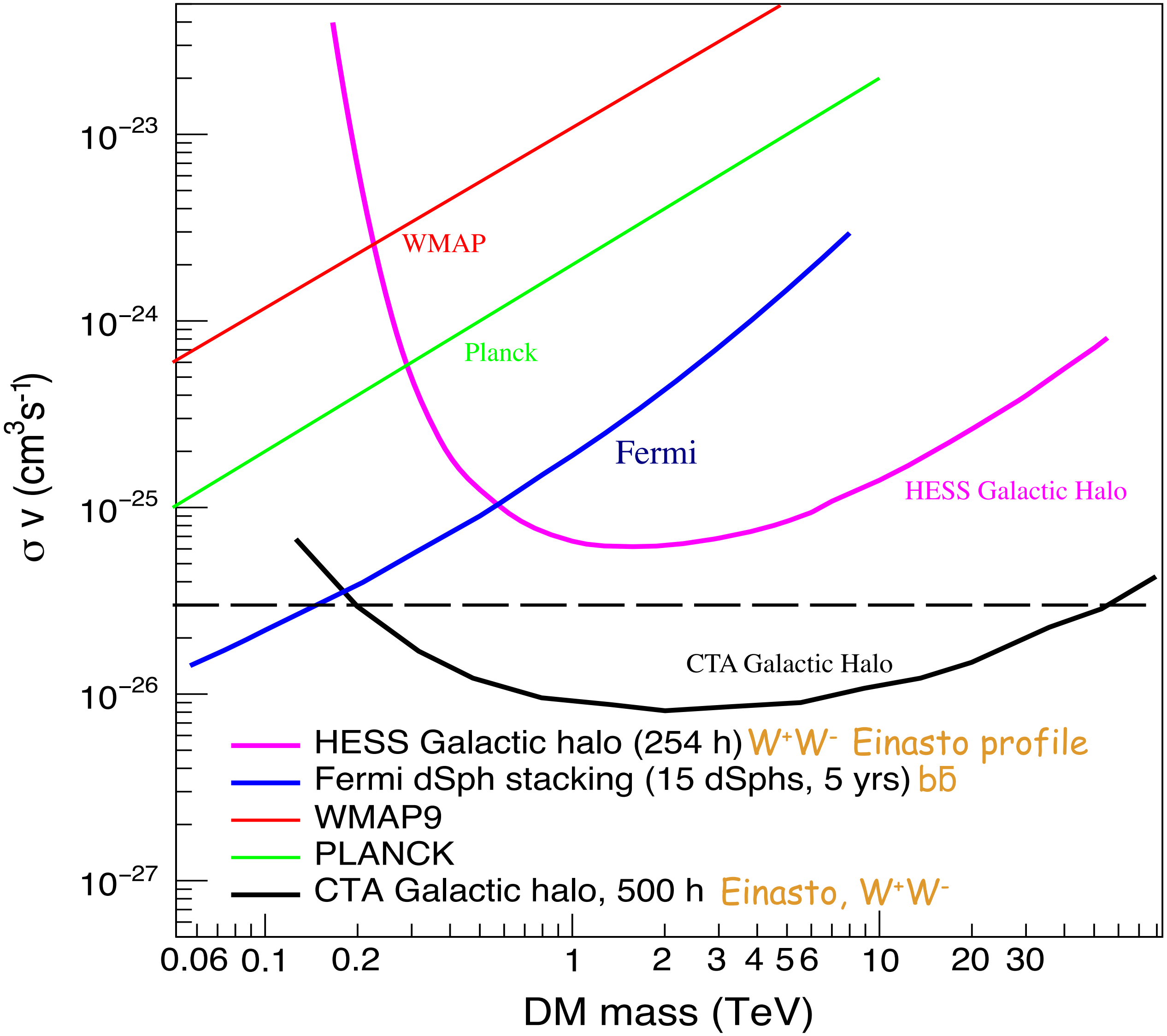
Dwarf Spheroidal Galaxies upper-limits (6 years)



M.Ackermann et al., [Fermi Coll.] PRL 115, 231301 (2015) [arXiv:1503.02641]

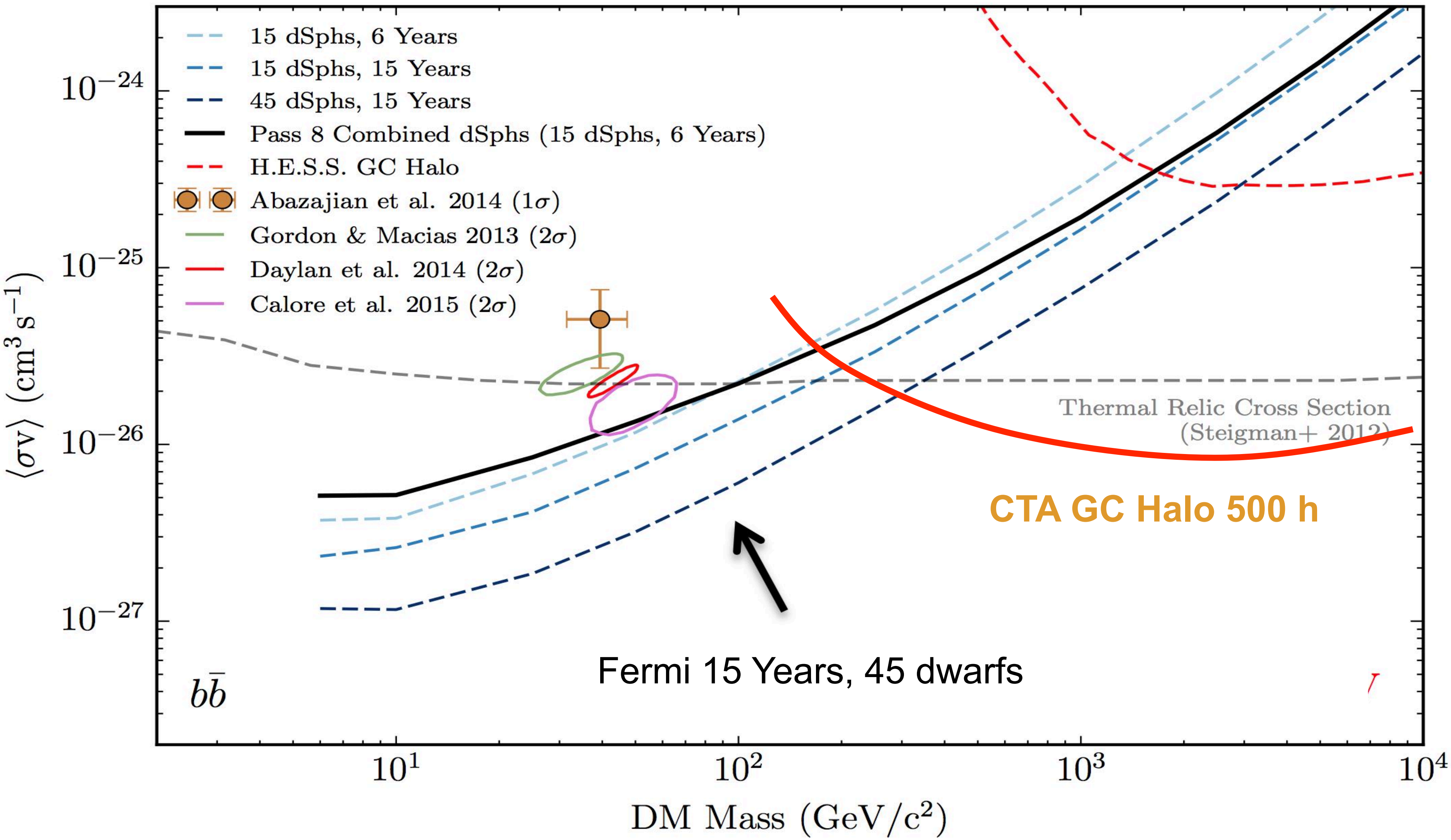
CTA, HESS, FERMI, PLANK DM upper-limits

Together Fermi and CTA will probe most of the space of WIMP models with thermal relic annihilation cross section
The expectation for CTA is for the Einasto profile and is optimistic as includes only statistical errors.
The effect of the Galactic diffuse emission can affect the results by ~ 50%



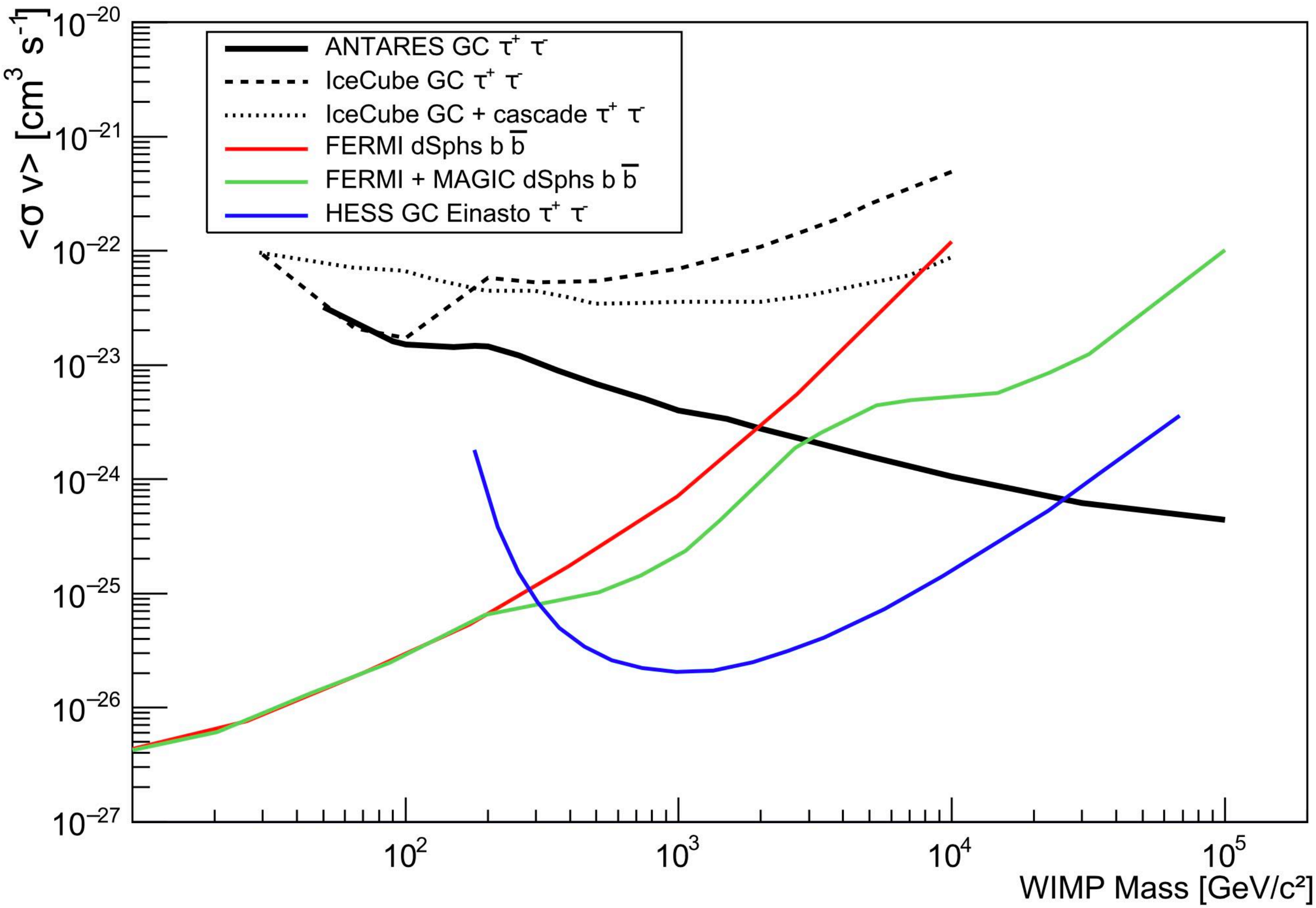
A.Morselli for the CTA Consortium PoS(ICRC2017)921 [arXiv:1709.01483]

DM limit improvement estimate in 15 years (2008- 2023)



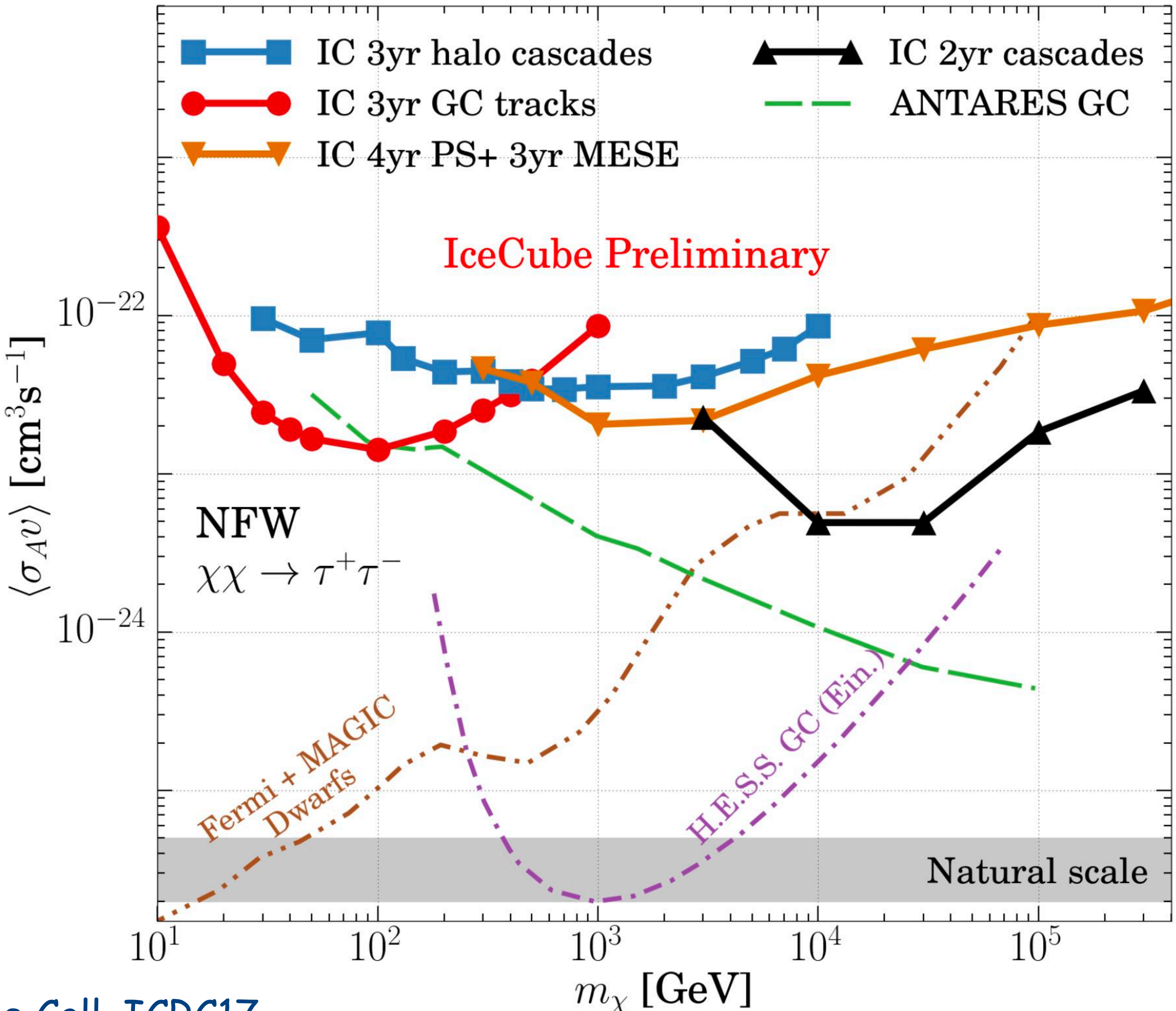
Together Fermi and CTA will probe most of the space of WIMP models with thermal relic annihilation cross section

HESS, FERMI, Ice Cube, ANTARES Dark Matter upper-limits



A. Albert, et al. ANTARES Coll. Physics Letters B 769 (2017) 249–254

HESS, FERMI, Ice Cube, ANTARES Dark Matter upper-limits update



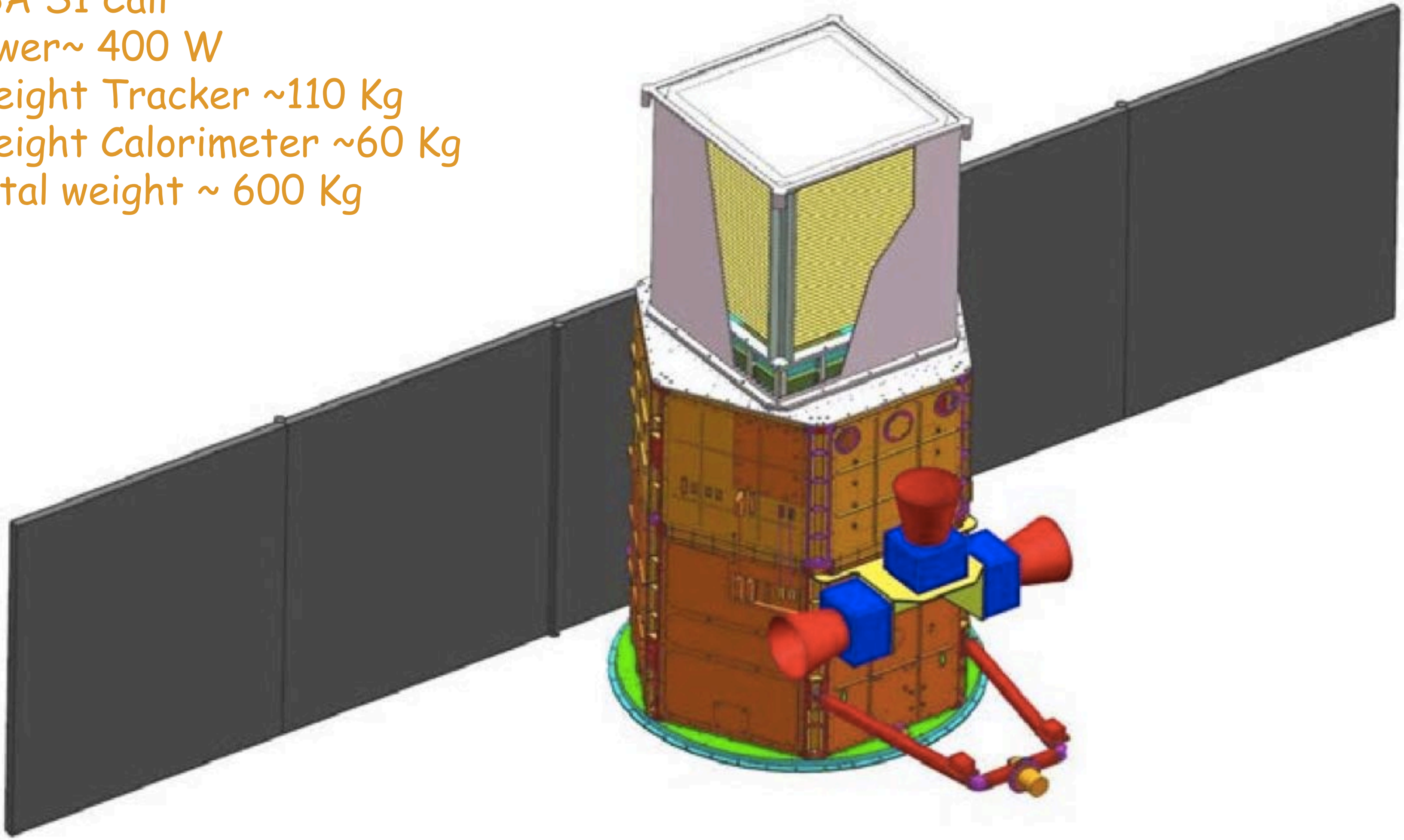
S.Flis for the Ice Cube Coll. ICRC17

The Low Energy Frontier

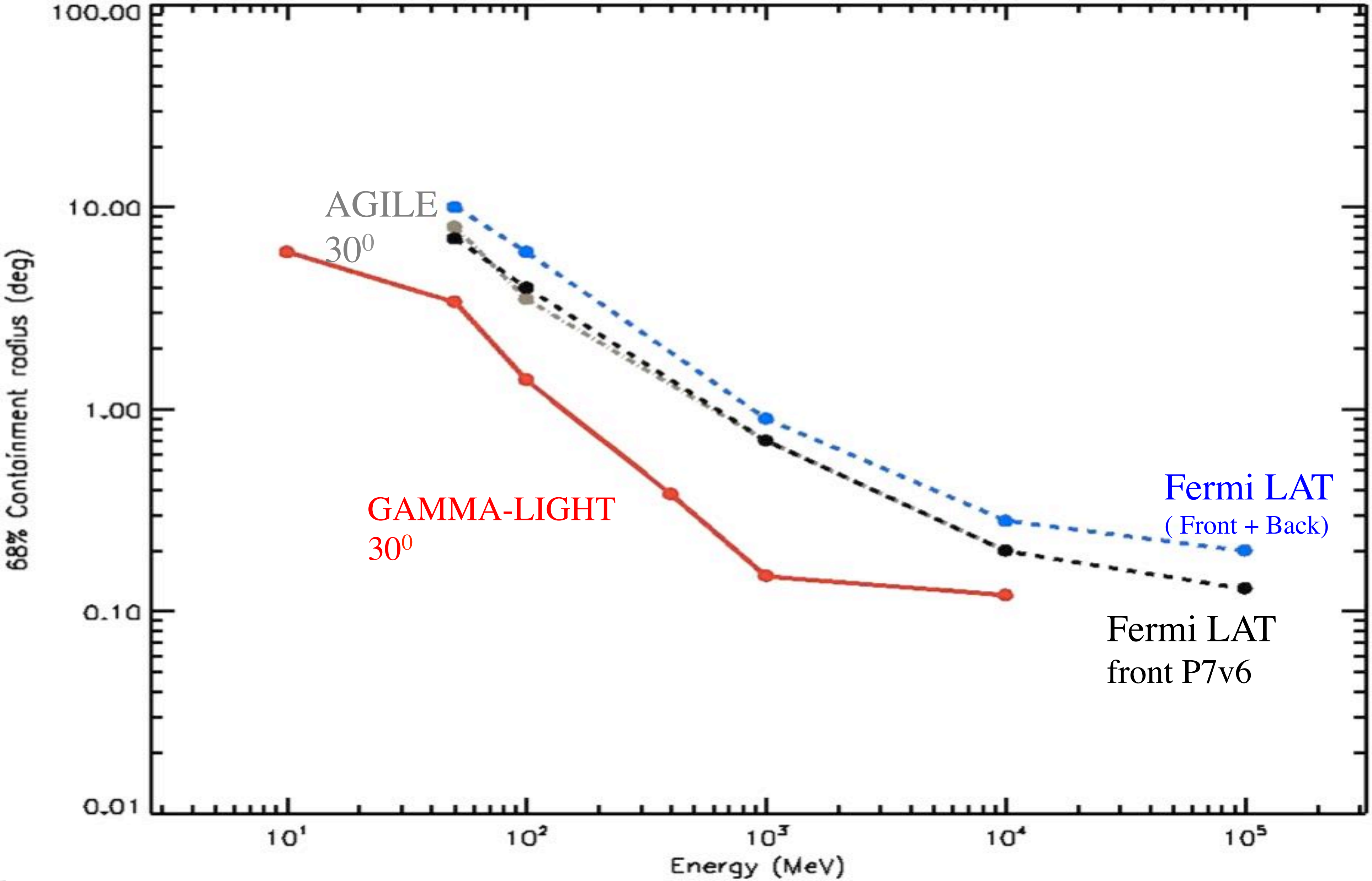
- 1-100 MeV unexplored domain for
  - Dark Matter searches
  - Galactic compact stars and nucleosynthesis
  - Cosmic rays
  - Relativistic jets, microquasars
  - Blazars
  - Gamma-Ray Bursts
  - Solar physics
- and…
  - Terrestrial Gamma-Ray Flashes

Gamma-light project

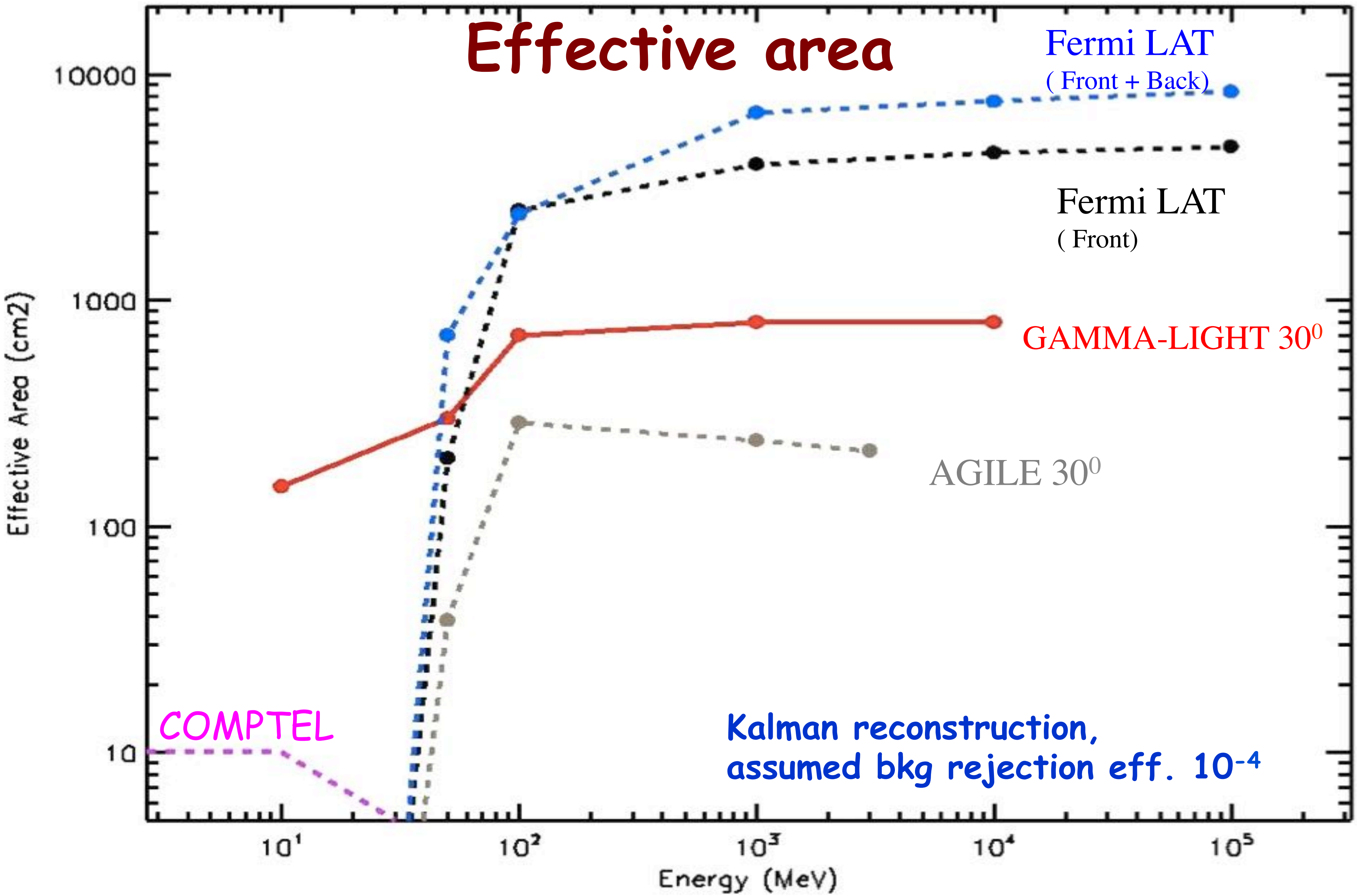
ESA S1 Call
Power~ 400 W
Weight Tracker ~110 Kg
Weight Calorimeter ~60 Kg
Total weight ~ 600 Kg



Gamma-Light Point Spread Function (angular resolution)



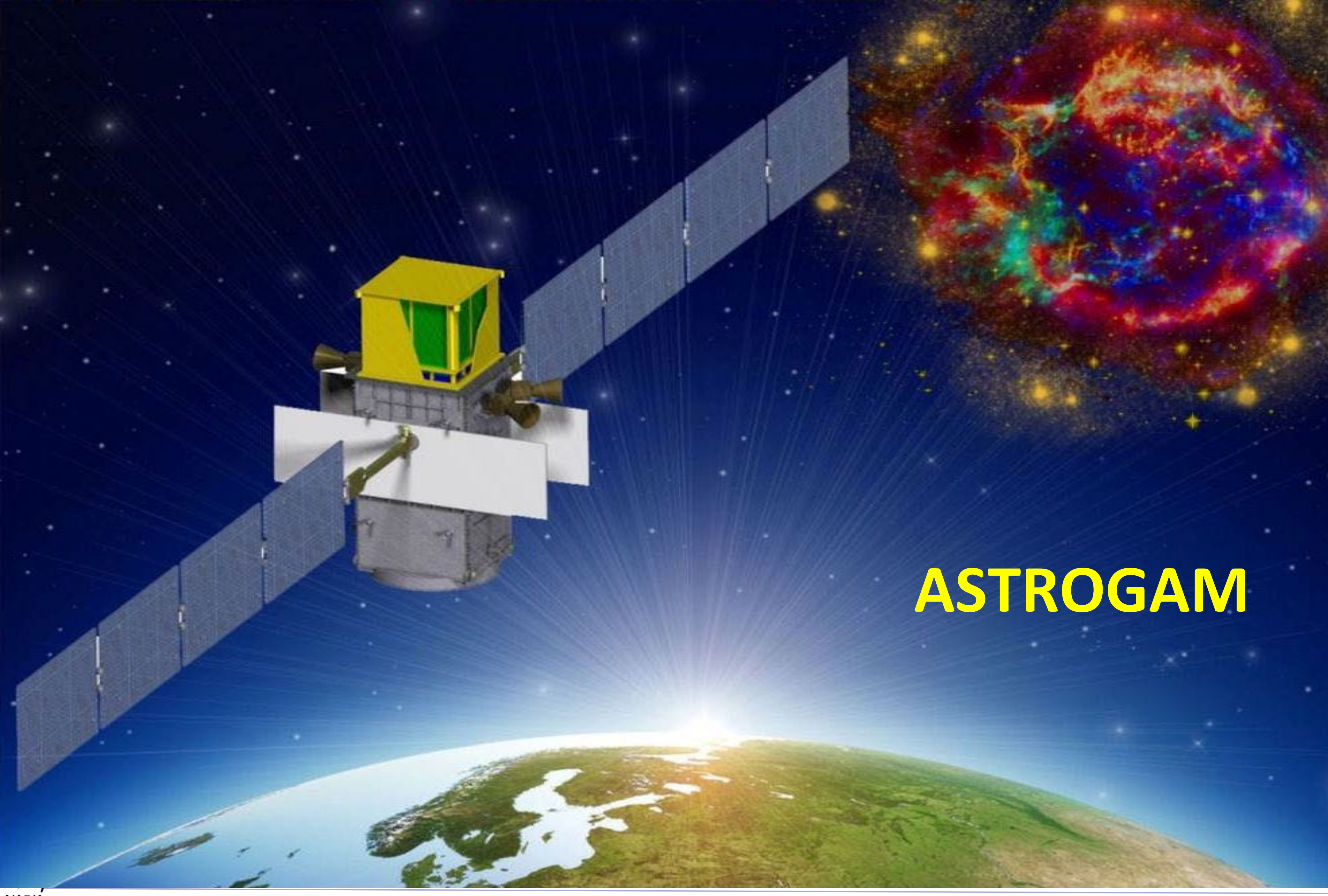
A.Morselli et al. , Nuclear Physics B Proc. Supp. 239–240 (2013) 193-198 [arXiv:1406.1071]



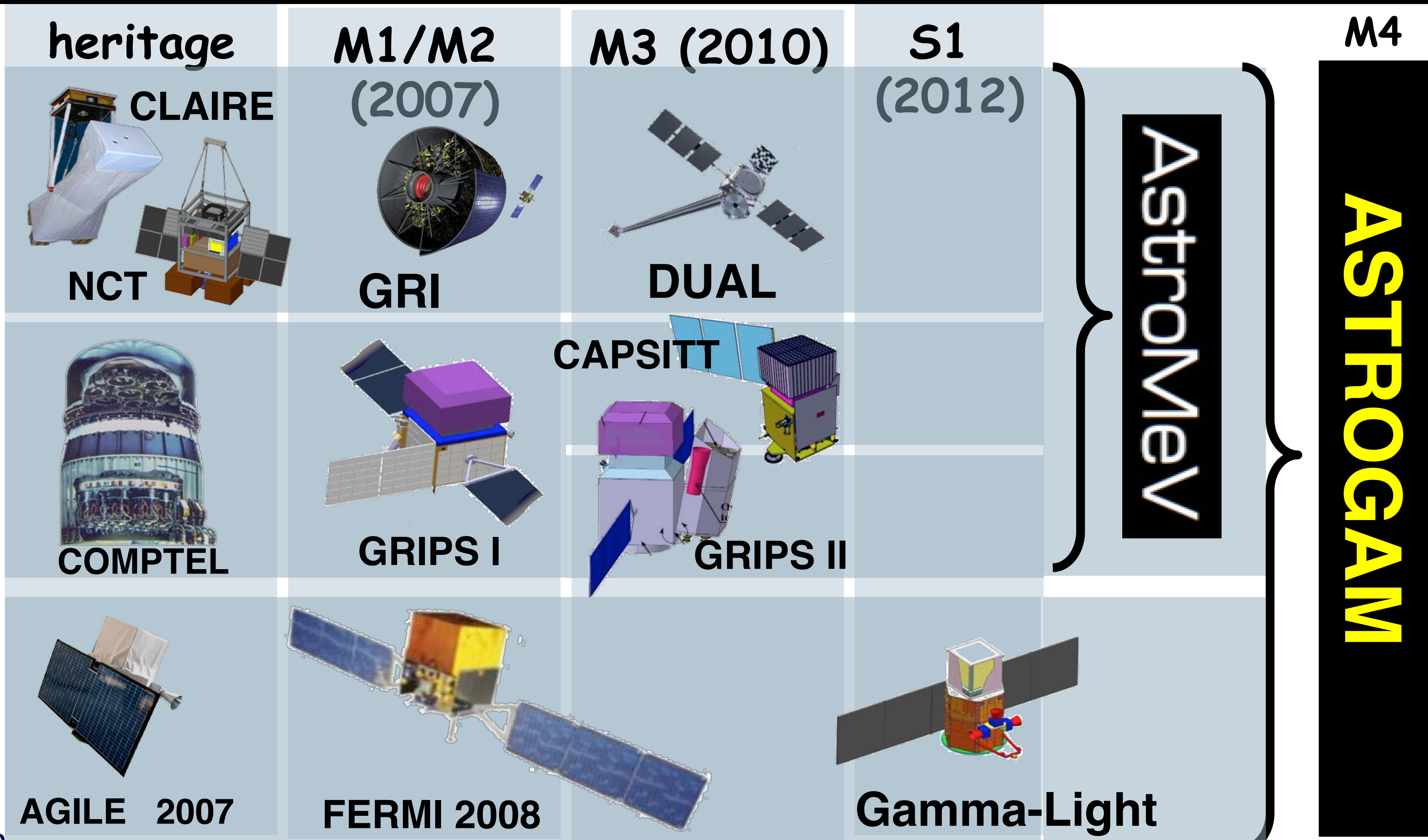
A.Morselli et al. , Nuclear Physics B Proc. Supp. 239–240 (2013) 193-198 [arXiv:1406.1071]

ESA M-4 Call

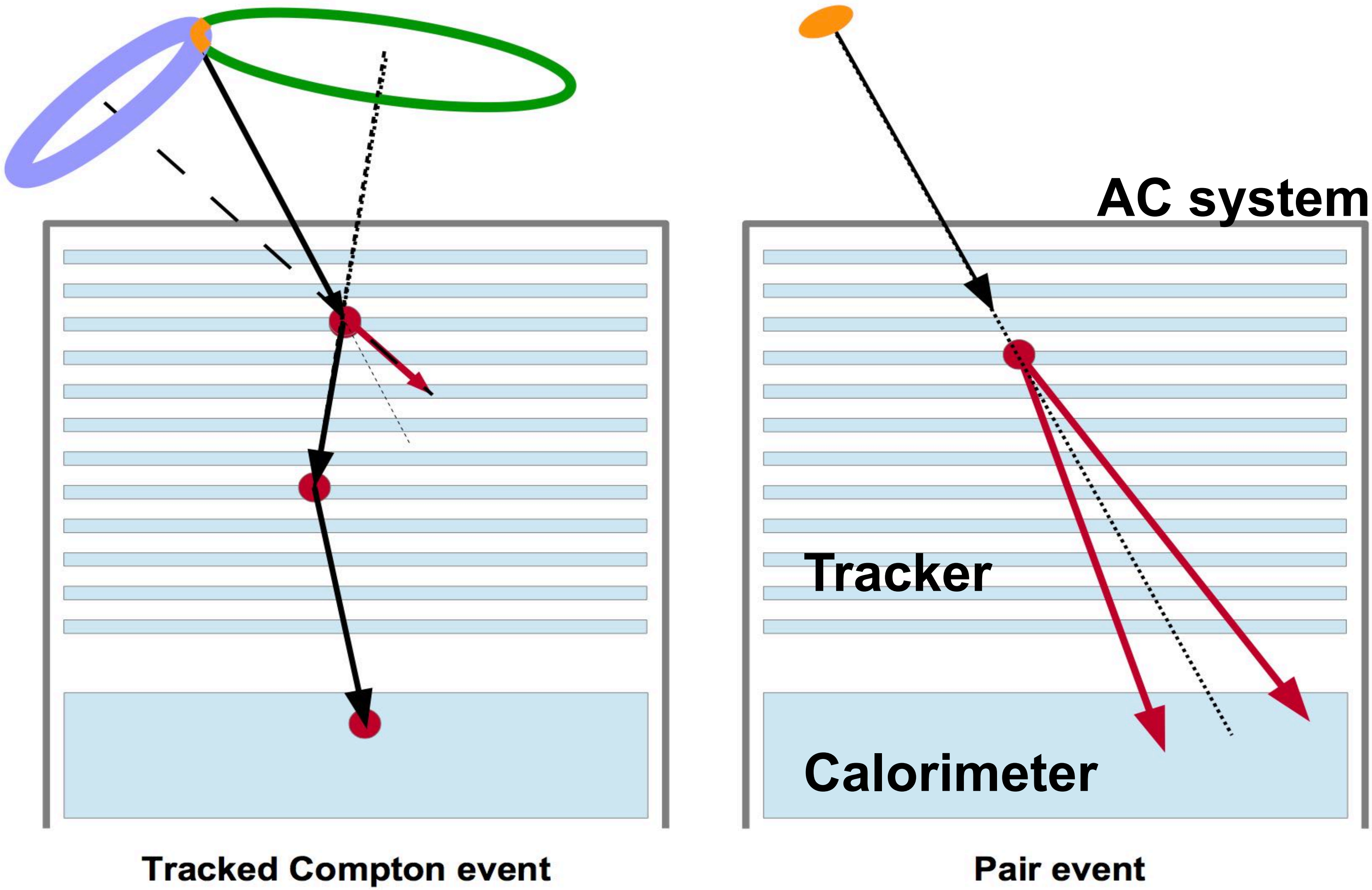
- quite different from previous Medium-sized Mission Calls (Solar Orbiter, EUCLID, PLATO);
- total ESA budget: 450 Meuro.
- guidelines for an ‘‘ESA-only’’ mission:
  - Payload mass: 300 kg;
  - total spacecraft mass: 800 kg.


ASTROGAM

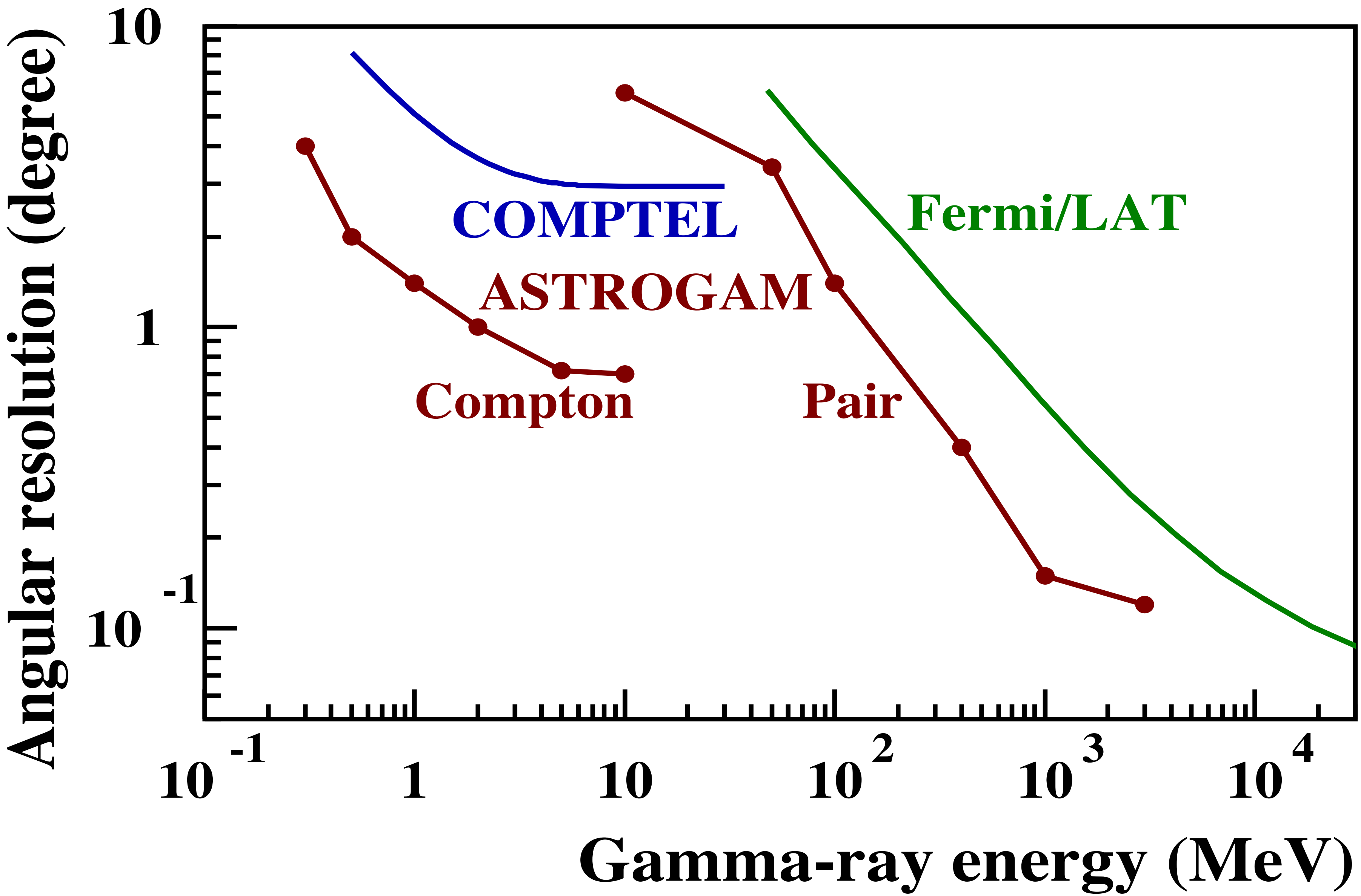
ASTROGAM a unified proposal from the entire gamma-ray community



An instrument that combine two detection techniques

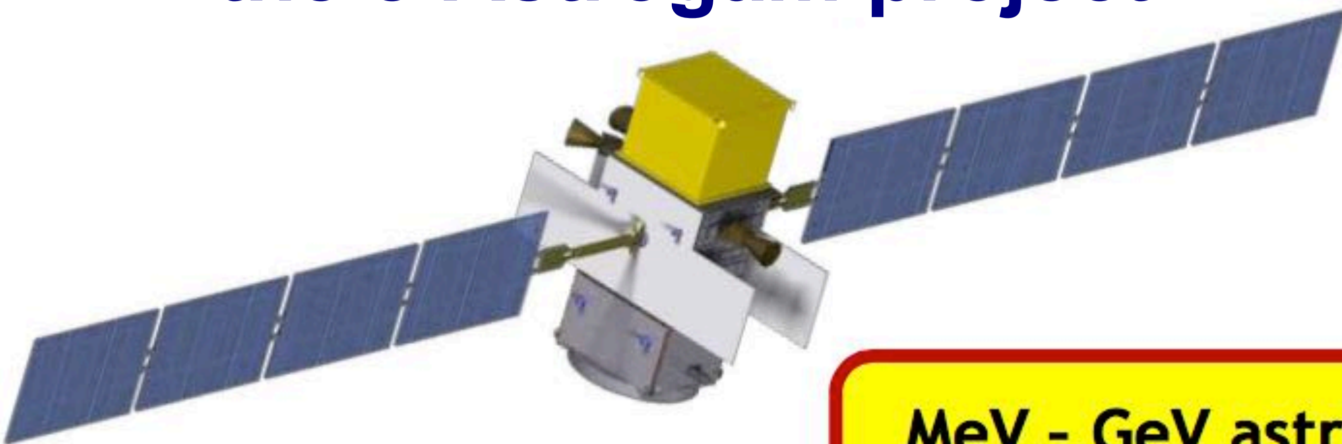


ASTROGAM Angular Resolution



The next gamma-ray MeV-GeV mission:

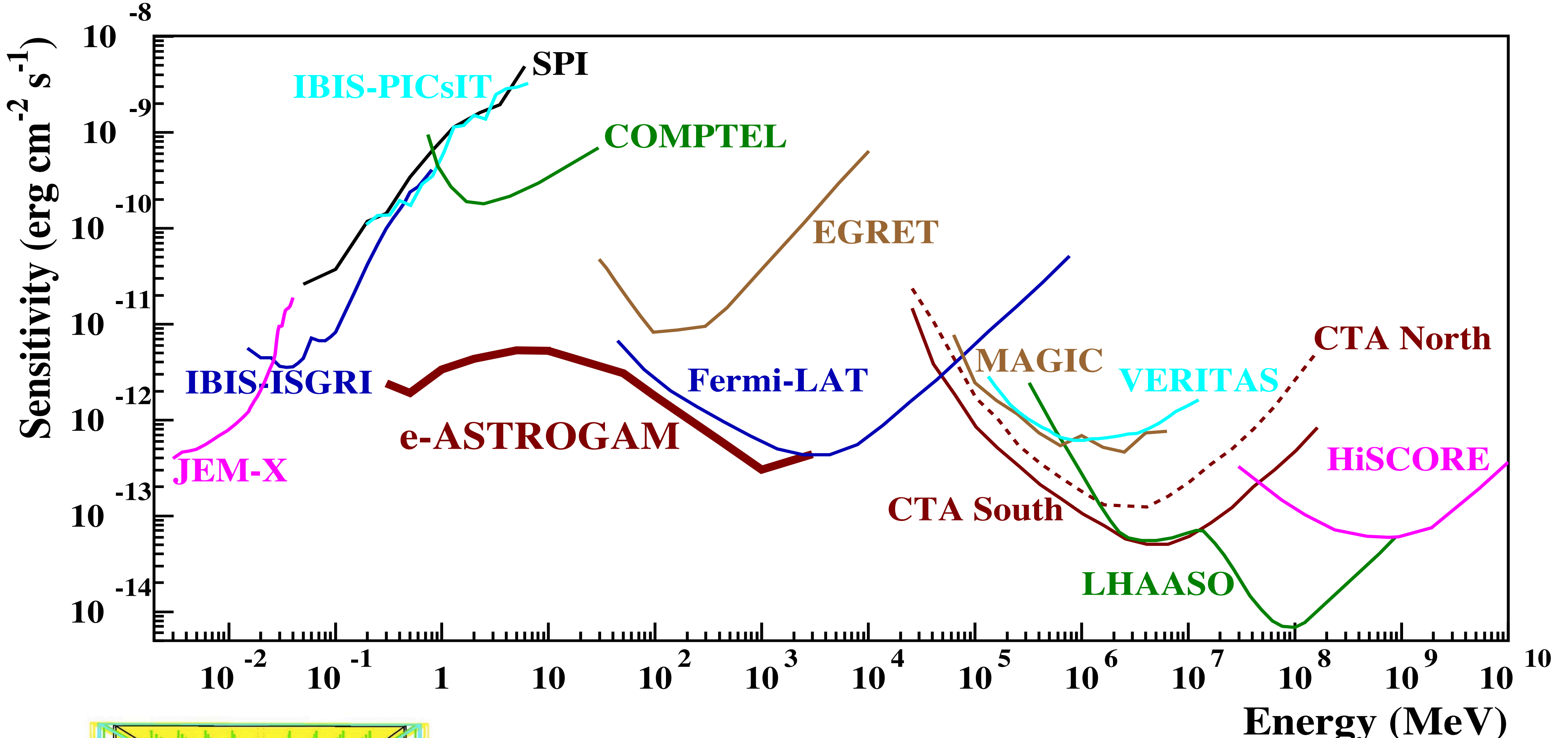
the e-Astrogam project

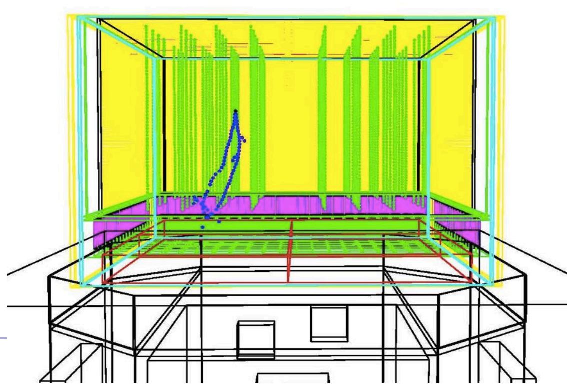


MeV - GeV astrophysics
MeV - GeV community

Proposed for the ESA M4 call; currently under study for enhancement and reconfiguration for the ESA M5 call. ASTROGAM is **focused on gamma-ray astrophysics in the range 0.3-100 MeV** with excellent capability also at GeV energies.

Performance assessment



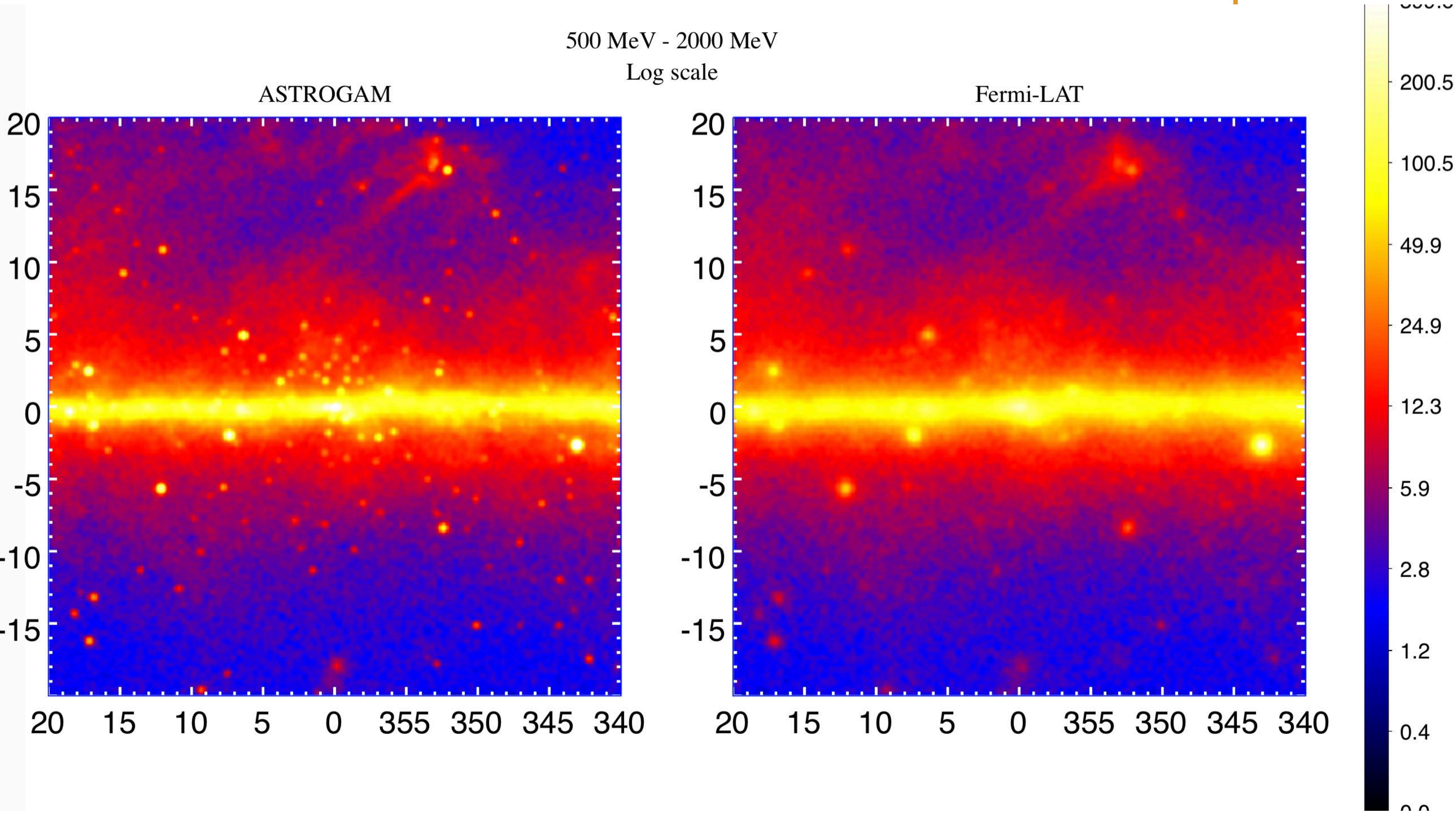


- e-ASTROGAM performance evaluated with **MEGAlib** and – both tools based on Geant4 – and a detailed numerical mass model of the gamma-ray instrument

e-Astrogam: arXiv:1611.02232

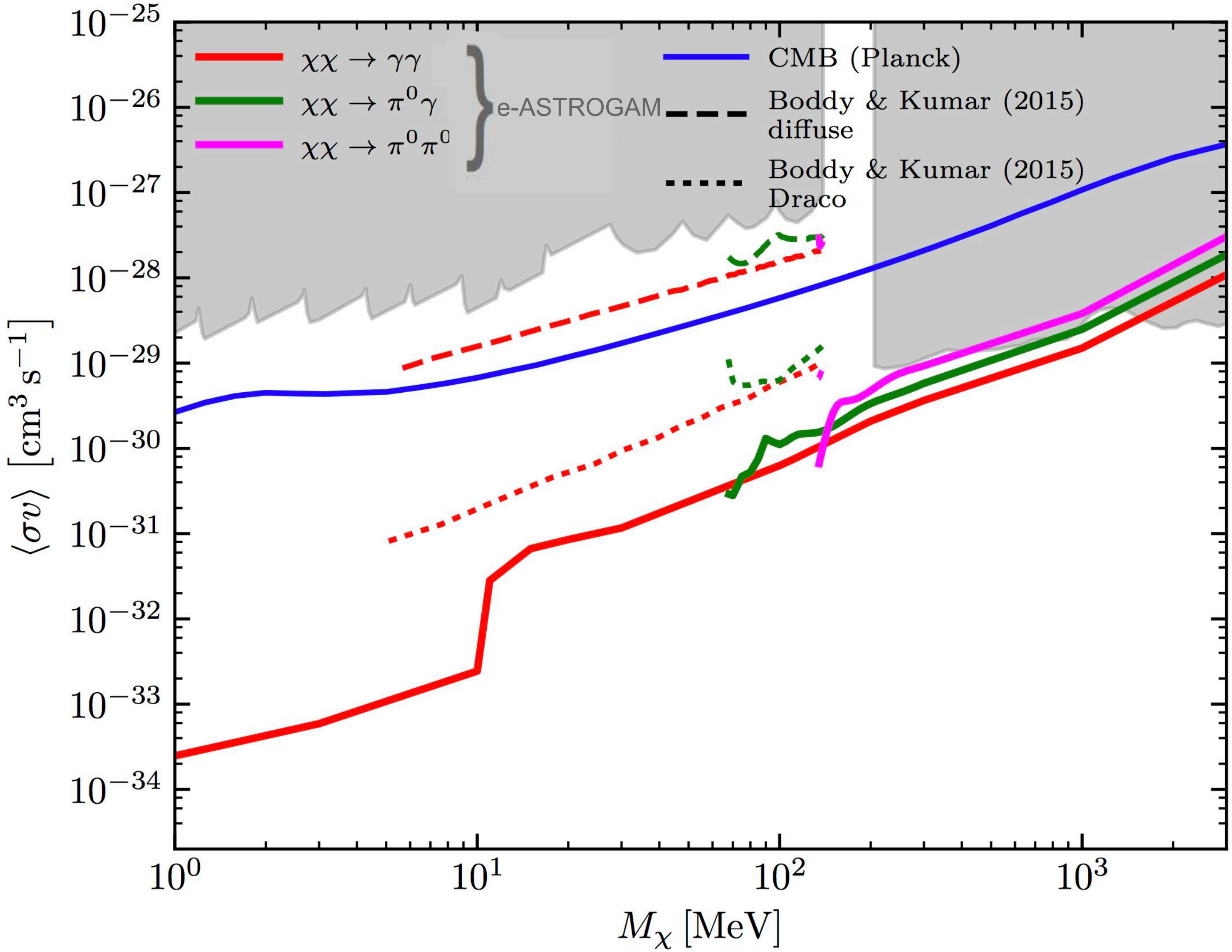
Galactic Center Region 0.5-2 GeV

Fermi PSF Pass7 rep v15 source



Morselli, Gomez Vargas, preliminary

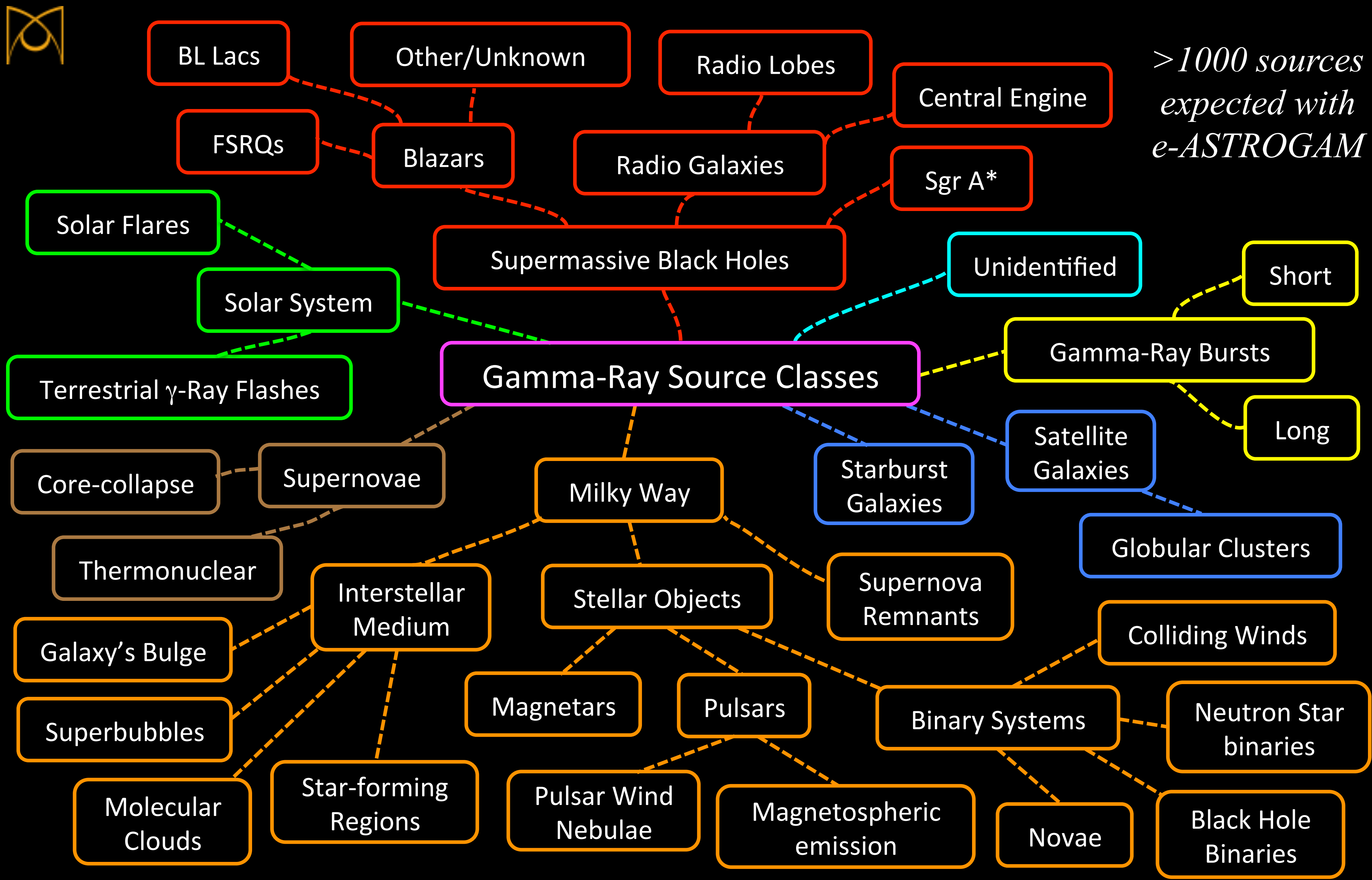
DM limits with e-ASTROGAM in the MeV region



R.Bartels et al. arXiv:1703.02546

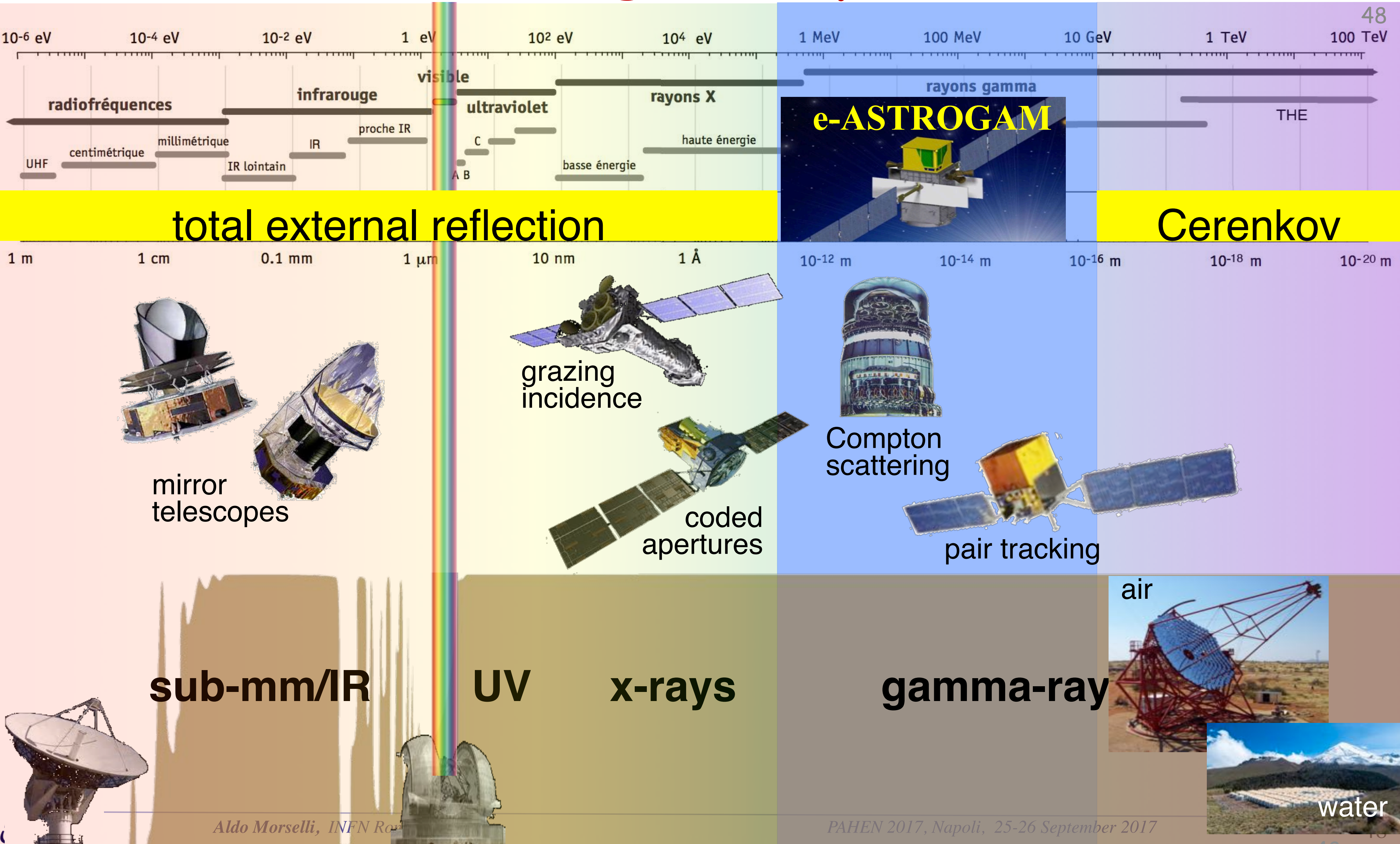
Why eAstrogam is important for IceCube and KM3Net

- Wide FoV (> 2.5 sr at 10 MeV) in survey mode.
- Sources of astrophysical neutrinos detected by IceCube may be opaque to 1–100 GeV gamma-rays but bright in the MeV domains (expecially if the neutrino flux originates from photo-hadronic processes)
- eAstrogam can select the best blazar candidates for a neutrino emission (looking at the MeV hump of the double-humped spectral energy distribution)
- Can constrain the population models of the EGB helping to discriminate between pγ or pp processes

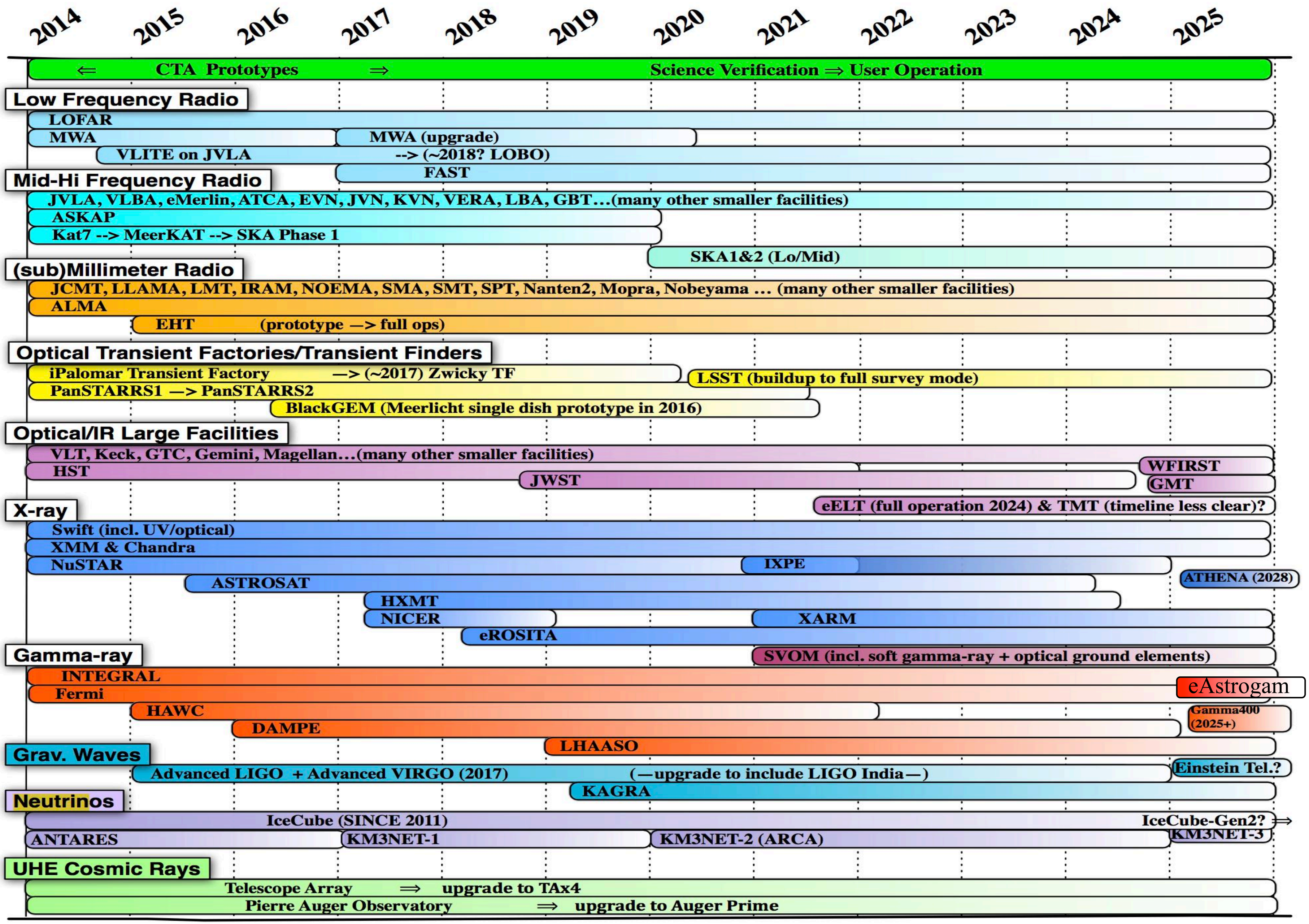


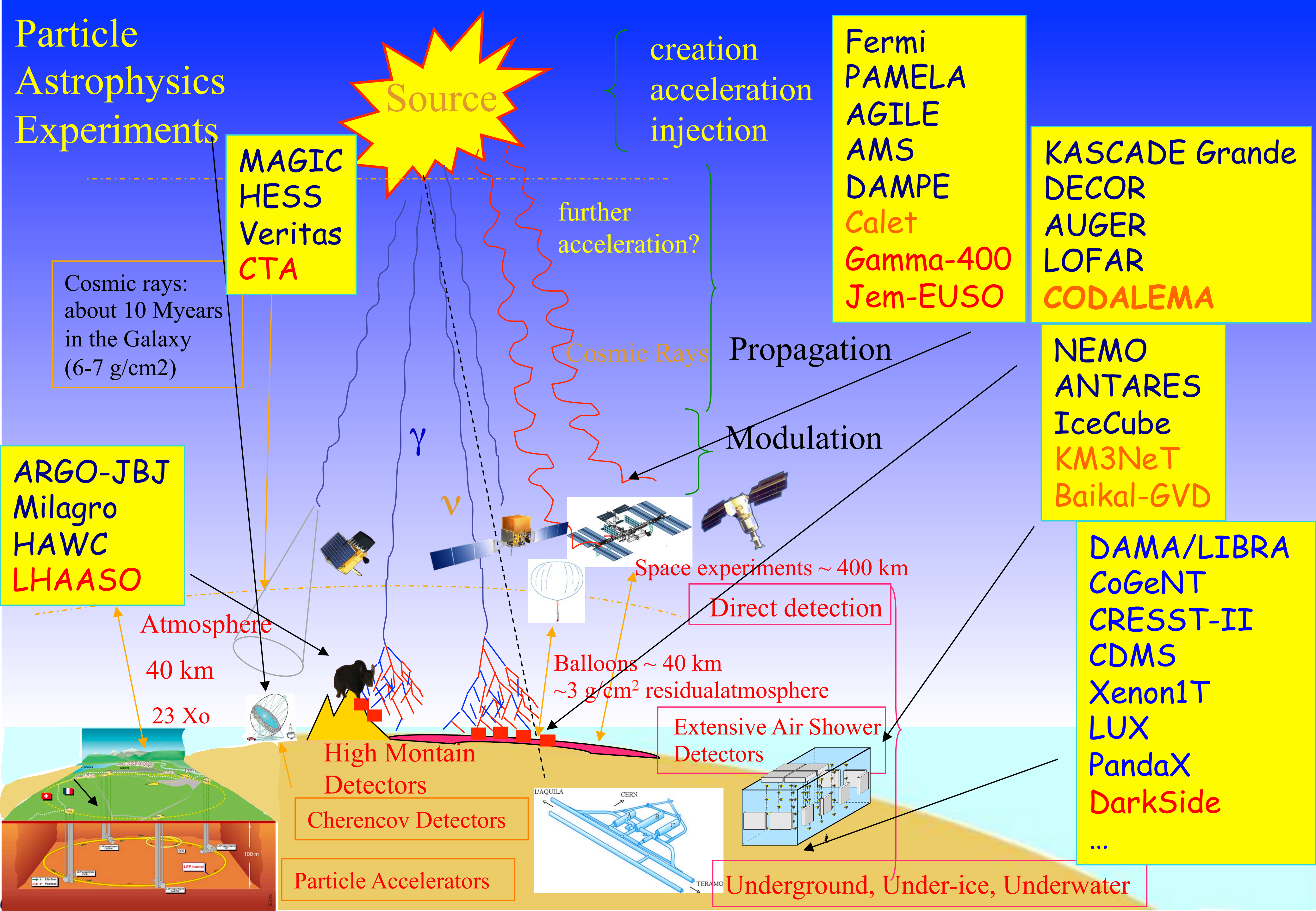
>1000 sources expected with e-ASTROGAM

An instrument to complete the coverage of the electromagnetic spectrum



multi-wavelength/multi-messenger facilities over the next decade





Particle Astrophysics Experiments
Source
creation
acceleration
injection
Fermi
PAMELA
AGILE
AMS
DAMPE
Calet
Gamma-400
Jem-EUSO
KASCADE Grande
DECOR
AUGER
LOFAR
CODALEMA
MAGIC
HESS
Veritas
CTA
further acceleration?
Cosmic rays: about 10 Myears in the Galaxy (6-7 g/cm2)
Cosmic Rays
Propagation
Modulation
NEMO
ANTARES
IceCube
KM3NeT
Baikal-GVD
γ
ν
ARGO-JBJ
Milagro
HAWC
LHAASO
Space experiments ~ 400 km
DAMA/LIBRA
CoGeNT
CRESST-II
CDMS
Xenon1T
LUX
PandaX
DarkSide
…
Direct detection
Atmosphere
40 km
23 Xo
Balloons ~ 40 km
~3 g/cm² residualatmosphere
Extensive Air Shower Detectors
High Montain Detectors
Cherencov Detectors
Particle Accelerators
L'AQUILA
CERN
TERAMO
Underground, Under-ice, Underwater

Through most of history, the cosmos has been viewed as eternally tranquil

During the 20th century the quest to broaden our view of the universe has shown us the vastness of the Universe and revealed violent cosmic phenomena and mysteries


The future?
Thank you !