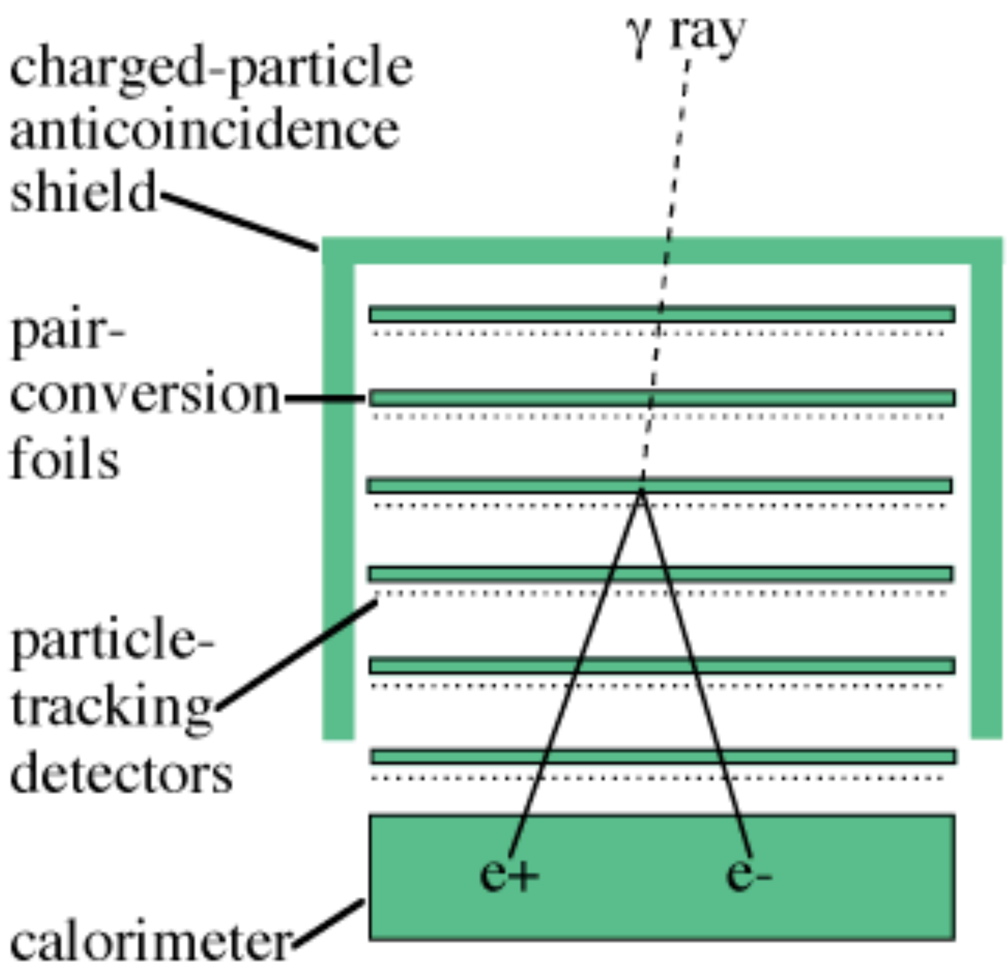
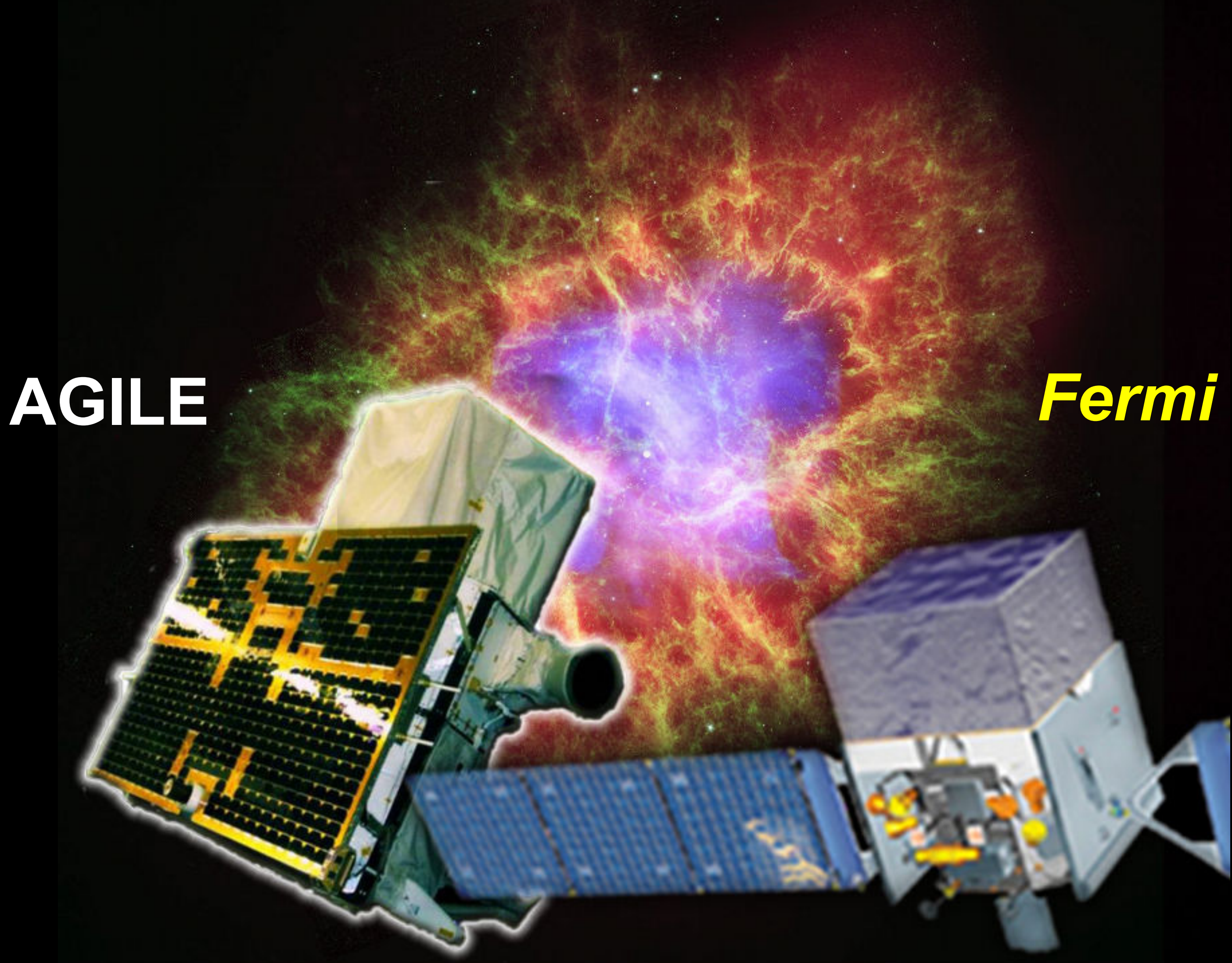
Astrofisica Nucleare e Subnucleare

GeV Astrophysics

Detector Project



Gamma-ray astrophysics above 100 MeV



Picture of the day, Feb. 28, 2011, NASA-HEASARC

Exercise #4

- Find the web sites of AGILE and Fermi/LAT
- Check the status of future gamma-ray detectors (CALET, DAMPE, Gamma-400, HERD)

AGILE

http://agile.rm.iasf.cnr.it/

AGILE

Space Science Data Center

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AGILE Science Data Center

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Welcome to the AGILE Data Center Home Page at SSDC

These pages provide updated information and services in support to the general scientific community for the mission AGILE, which is a small Scientific Mission of the Italian Space Agency (ASI) with participation of INFN, IASF/INAF and CIFS .

AGILE is devoted to gamma-ray astrophysics and it is a first and unique combination of a gamma-ray (AGILE-GRID) and a hard X-ray (SuperAGILE) instrument, for the simultaneous detection and imaging of photons in the 30 MeV - 50 GeV and in the 18 - 60 keV energy ranges. After more than 13 years of operations, AGILE is working nominally, providing valuable data and important scientific results.

AGILE operations:
Launch date 23 April, 2007
Planned Nominal Phase: 2 + 2 extended years
Elapsed: 13 years in orbit completed on 23 April, 2020
Current Extended Phase: ASI extended AGILE operations up to 31 May, 2022

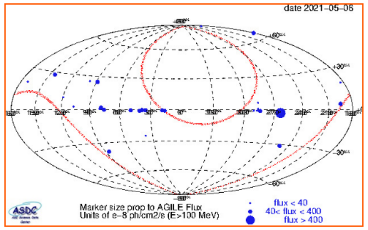
The AGILE Mission Board (AMB) has executive power overseeing all the scientific matters of the AGILE Mission and is composed of:

- AGILE Principal Investigator: Marco Tavani, INAF Rome (Chair)
- ASI Project Scientist: Paolo Giommi, ASI
- ASI Mission Director: Fabio D'Amico, ASI
  (Former ASI Mission Directors: Luca Salotti, up to September 20, 2010 and Giovanni Valentini up to January 22, 2015)
- AGILE Co-Principal Investigator: Guido Barbiellini, INFN Trieste
- 1 ASI representative: Elisabetta Tommasi di Vignano
  (Former ASI representative: Sergio Colafrancesco up to June, 2010)

- INAF Project Scientist: Carlotta Pittori (from November 10, 2020)

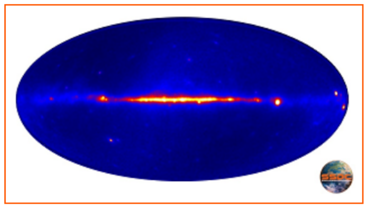
AGILE current spinning sky view

(Click here for previous pointing details)



Click here to access the AGILE Spinning FOV plotter

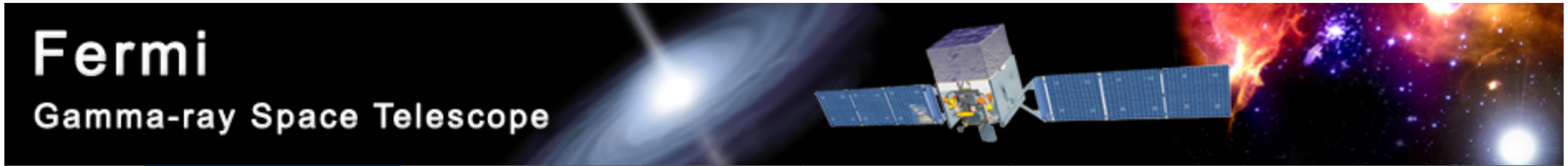
Click here to access the AGILE Real Data FOV Plotter



AGILE total intensity map up to Sep. 30, 2017.

https://agile.ssdc.asi.it/

Fermi/LAT



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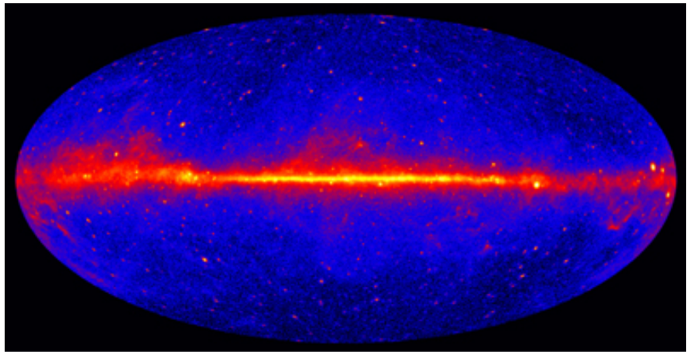
The Fermi Science Support Center (FSSC) runs the guest investigator program, creates and maintains the mission time line, provides analysis tools for the scientific community, and archives and serves the Fermi data. This web site is the portal to Fermi for all guest investigators.



This view shows the entire sky at energies greater than 1 GeV based on five years of data from the LAT instrument on NASA's Fermi Gamma-ray Space Telescope. Brighter colors indicate brighter gamma-ray sources.
Image Credit: NASA/DOE/Fermi LAT Collaboration

Look into the "Resources" section for finding schedules, publications, useful links etc. The "Proposals" section is where you will be able to find the relevant information and tools to prepare and submit proposals for guest investigator projects. At "Data" you will be able to access the Fermi databases and find the software to analyse them. Address all questions and requests to the helpdesk in "Help".

Fermi Observations for MW 675

Mission week 675 starts with a continuation of the asymmetric rocking +50/-60 profile from the previous week. On day of year 126 (2021-05-06) at 01:59 there is a 10 minute freeze observation during which an updated asymmetric profile is loaded. This profile continues until DOY 129 (2021-05-09) at 03:01 when there is a 10 minute freeze observation during which a symmetric +/-50 deg. profile is loaded. This profile continues until the end of the week. Note that positive rock angles are south, and negative angles are north.

» More Timeline Info

Latest News

» Fermi Sky Blog
» Fermi Blog

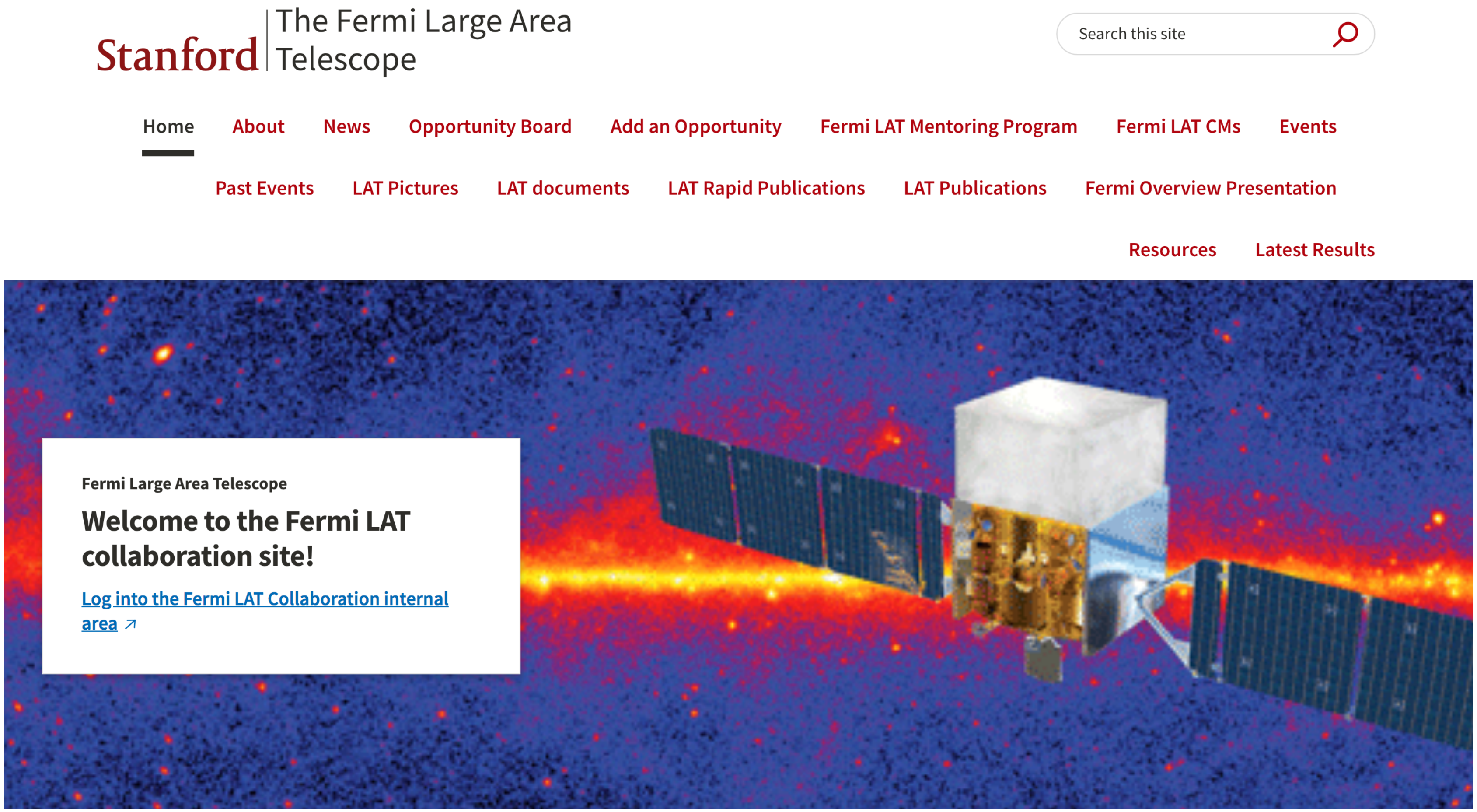
Apr 20, 2021

Updated Spacecraft Position and History Files Available

The updated files include the addition of the SC_VELOCITY column. This column contains a vector with the spacecraft velocity in meters per

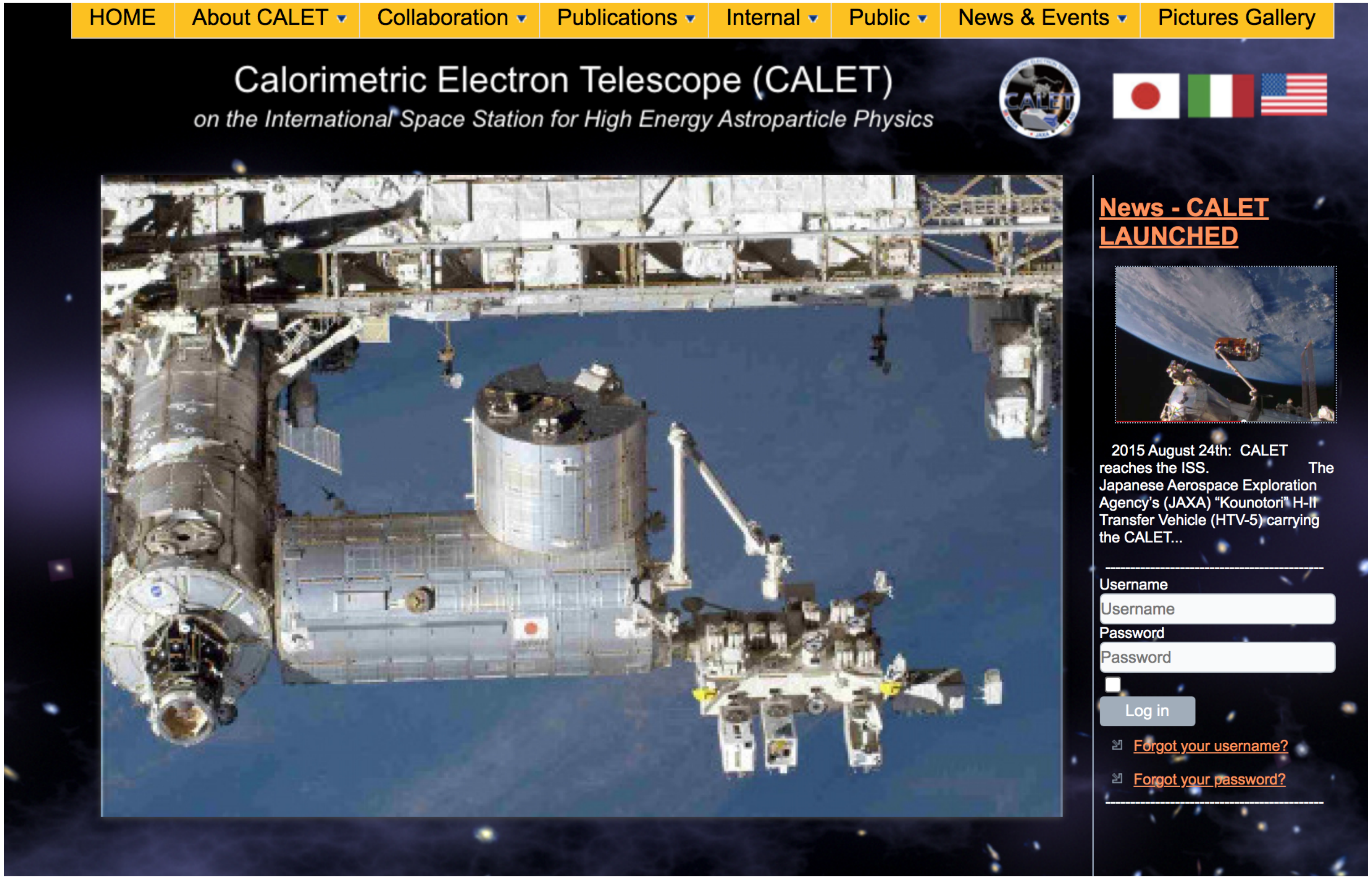
https://fermi.gsfc.nasa.gov/ssc/

Fermi/LAT



https://glast.sites.stanford.edu/

CALET



http://calet.pi.infn.it/

CALET

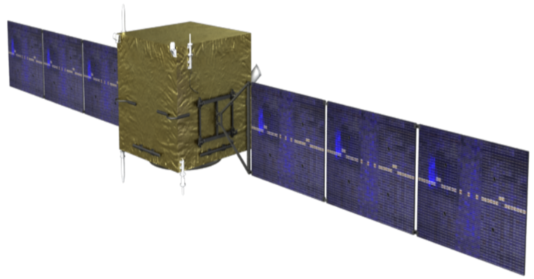
http://calet.phys.lsu.edu/

DAMPE

DArk Matter Particle Explorer

- Home
- PSD
- STK
- BGO
- NUD
- News
- Publication
- The DAMPE Collaboration

DAMPE has been launched the 17th December 2015 at 00:12 UTC!



http://dpnc.unige.ch/dampe/

HERD

HERD
The High Energy cosmic Radiation Detection facility

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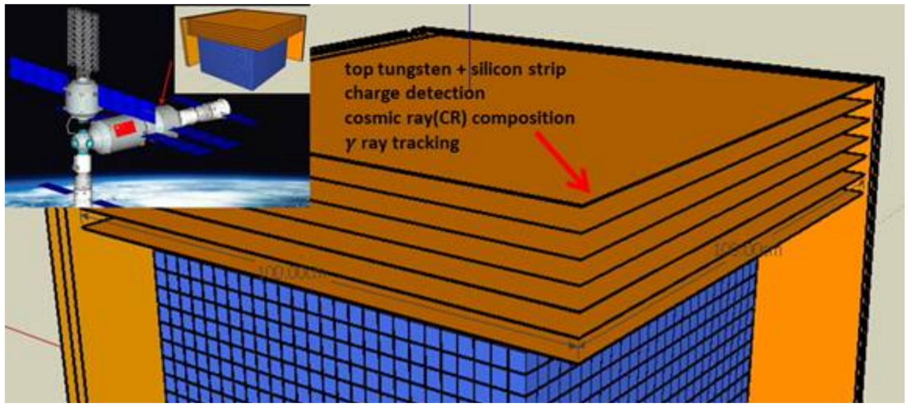
The High Energy cosmic Radiation Detection facility (HERD)

HERD(High Energy Cosmic Radiation Detection) facility is one of the Cosmic Lighthouse Program onboard China's Space Station, planned to be launched and assembled in 2020. The main science objectives of HERD onboard china's space station are detecting dark matter particle, study of cosmic ray composition and high energy gamma-ray observations. The main constraints imposed on HERD are: total weight less than around 2 tons and total power consumption less than around 2 kilowatts.

To achieve HERD's science objectives, HERD must have the capability of accurate electron and gamma-ray energy and direction measurement (tens of GeV – 10TeV), adequate cosmic ray energy measurement with charge determination (up to PeV).



News

The 3rd international workshop on HERD was held in Xi'an during Jan. 19-20, 2016.

External Links

- IHEP
- China Space Station wiki
- LHAASO
- CR observatory in Tibet
- HXMT
- POLAR

http://herd.ihep.ac.cn/

HERD

HERD

The High Energy Cosmic Radiation Detection Facility

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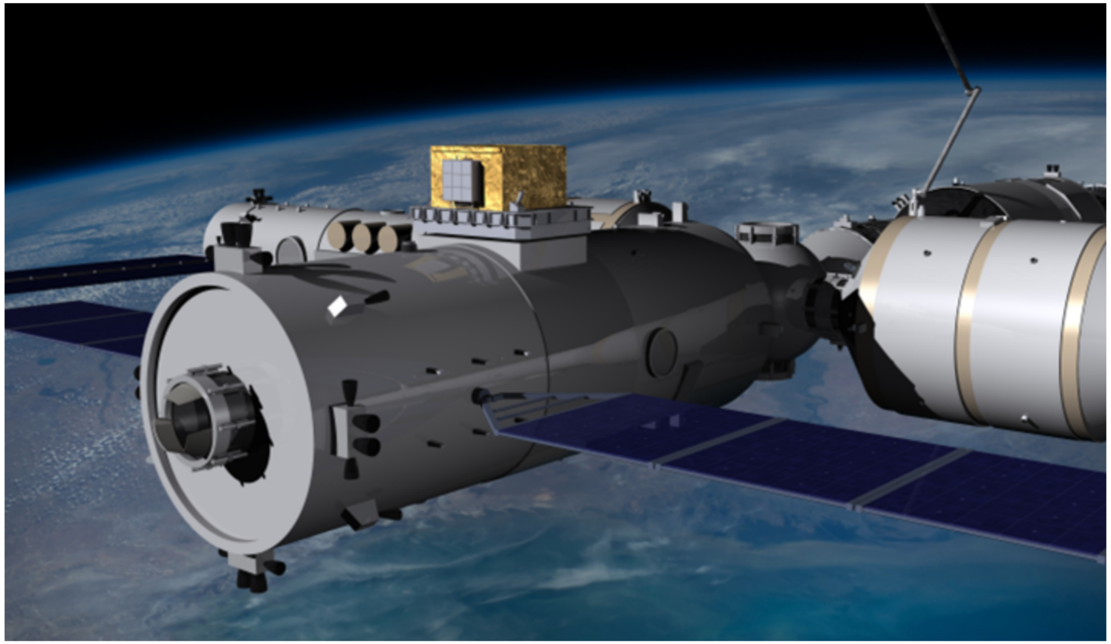

The High Energy cosmic-Radiation Detection (HERD) facility has been proposed as one of several space astronomy payloads onboard the future China's Space Station (CSS), planned for operation starting around 2027

Latest News More++

- “新型空间高能辐射探测的重要科学问…
- HERD特种像增强器合作协议在京签署
- Eighth HERD Workshop Held to Enhance …
- HERD束流实验总结和载荷方案研讨会…

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- China's Shenzhou-13 crew successfully co…
- China's Shenzhou-13 taikonauts complete …
- China embarks on longest-ever crewed mis…

Related Links More++

- HERD Indico @IHEP
- HERD Indico @INFN
- HERD DocDB

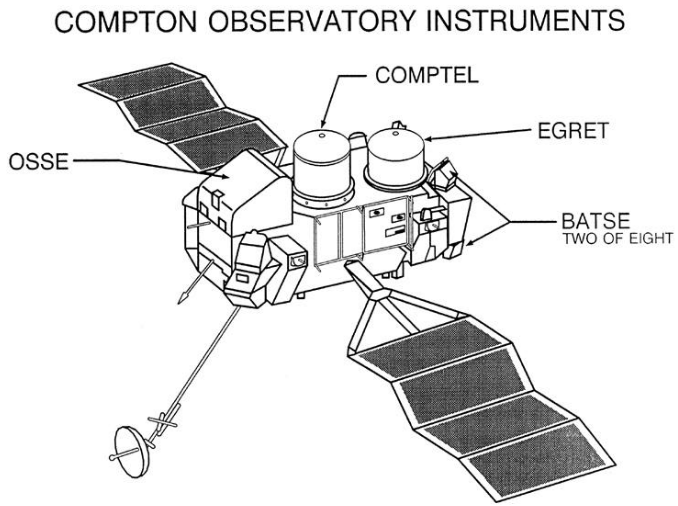
http://herd.ihep.ac.cn/

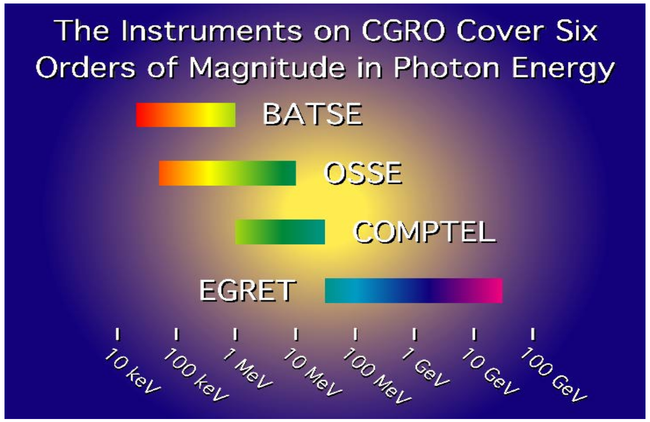
Gamma-400

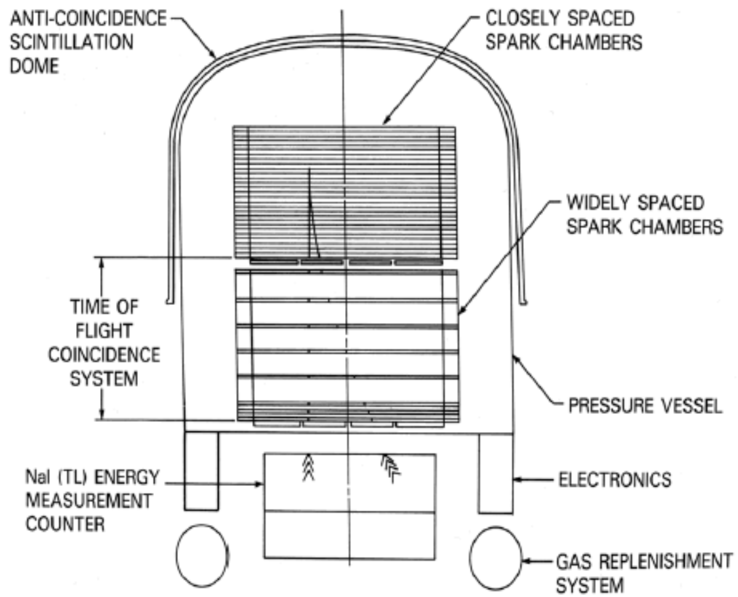
https://gamma400.lebedev.ru/indexeng.html

HE Gamma-ray Astrophysics
The EGRET legacy

EGRET



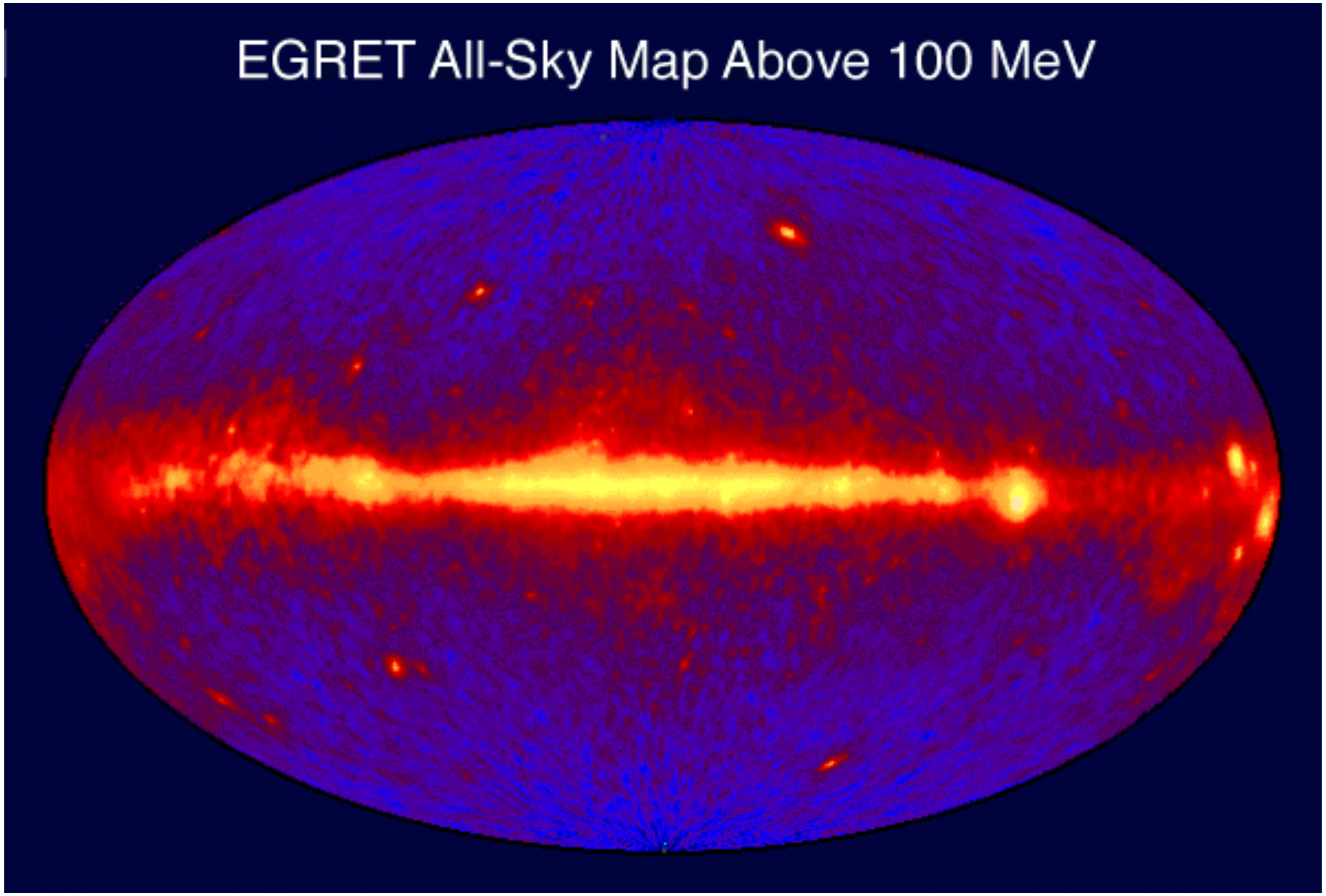




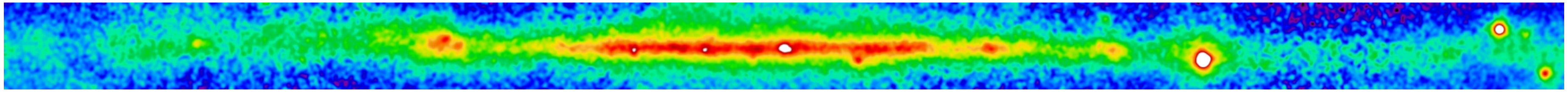
EGRET

- 1991-2000
- 30 MeV - 30 GeV
- AGN, GRB, Unidentified Sources, Diffuse Bkg

The HE sky from EGRET



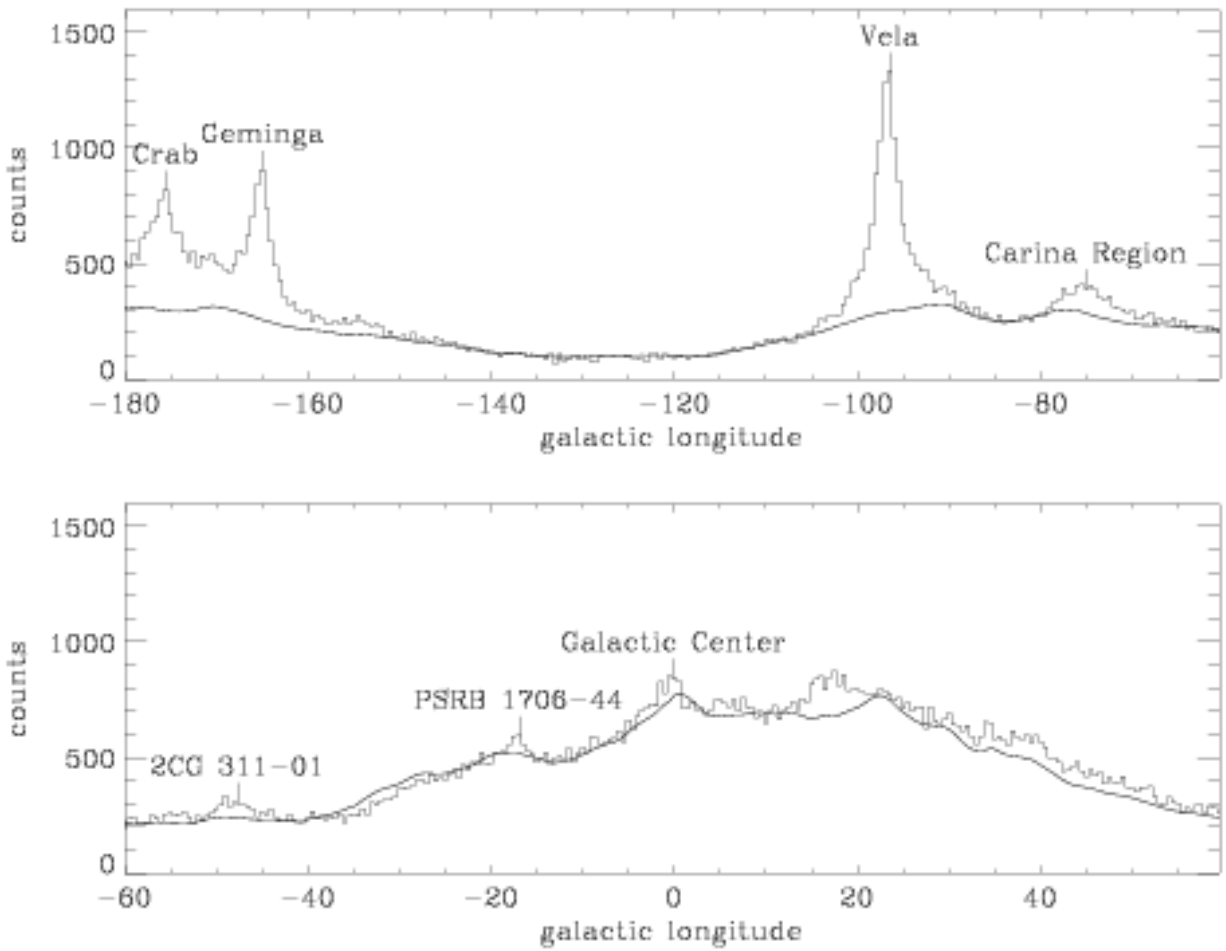
Analysis Topics



EGRET >300 MeV

- First a word about interstellar gamma-ray emission:
- Brightest at low latitudes, but detectable over the whole sky
- >60% of EGRET celestial gamma rays
- It fundamentally affects the approach to the analysis

Data Analysis



Analysis Topics: Source detection

- Source detection means at least 2 things:
  - Recognizing that you've detected a point source that you didn't know about (and defining its statistical significance and location on the sky)
  - Determining the significance of the detection of (or measuring an upper limit for) an already-known source

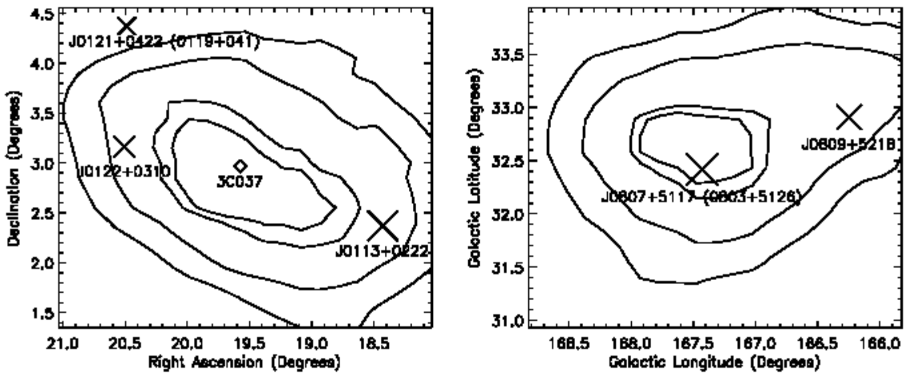


FIG. 3.—TS maps of possible composite 3EG sources. *Left*: 3EG J0118+0248. The 3EG identification 0119+041, the steep spectrum Mattox et al. (2001) counterpart 3C 037 (*diamond*), and our two new blazar counterparts (along the uncertainty region major axis) are shown. *Right*: 3EG J0808+5114. Again, two high-confidence identifications lie along the major axis.

Source location contours for two 3EG sources (Hartman et al. 1999). Potential (additional) counterparts, unresolved by EGRET, are indicated

Sowards-Emmerd, Romani, & Michelson (2003, ApJ, 590, 109)

Analysis Topics: Spectral analysis

- Well, this means measuring spectra
  - Mostly power laws resulting from shock acceleration, which is scale free
  - Spectral breaks occur for physics reasons and measuring them is diagnostic of the sources.
- For EGRET, the analysis of source spectra was a 2-step process
  - Fluxes were derived for fairly broad ranges of energy independently
  - Then a spectral model was fit
- The complication was that the exposure for a broad energy range depends on the source spectrum, so the fitting process was iterative.

$$F_\gamma = (2.01 \pm 0.12) \times 10^{-6} (E/0.214\ \text{GeV})^{-2.18 \pm 0.08}\ \text{photon}\ (\text{cm}^2\ \text{s GeV})^{-1}\ .$$

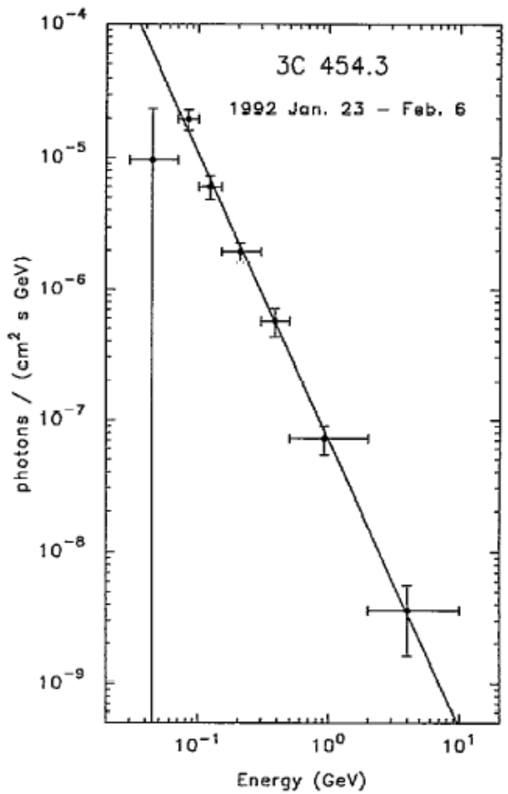
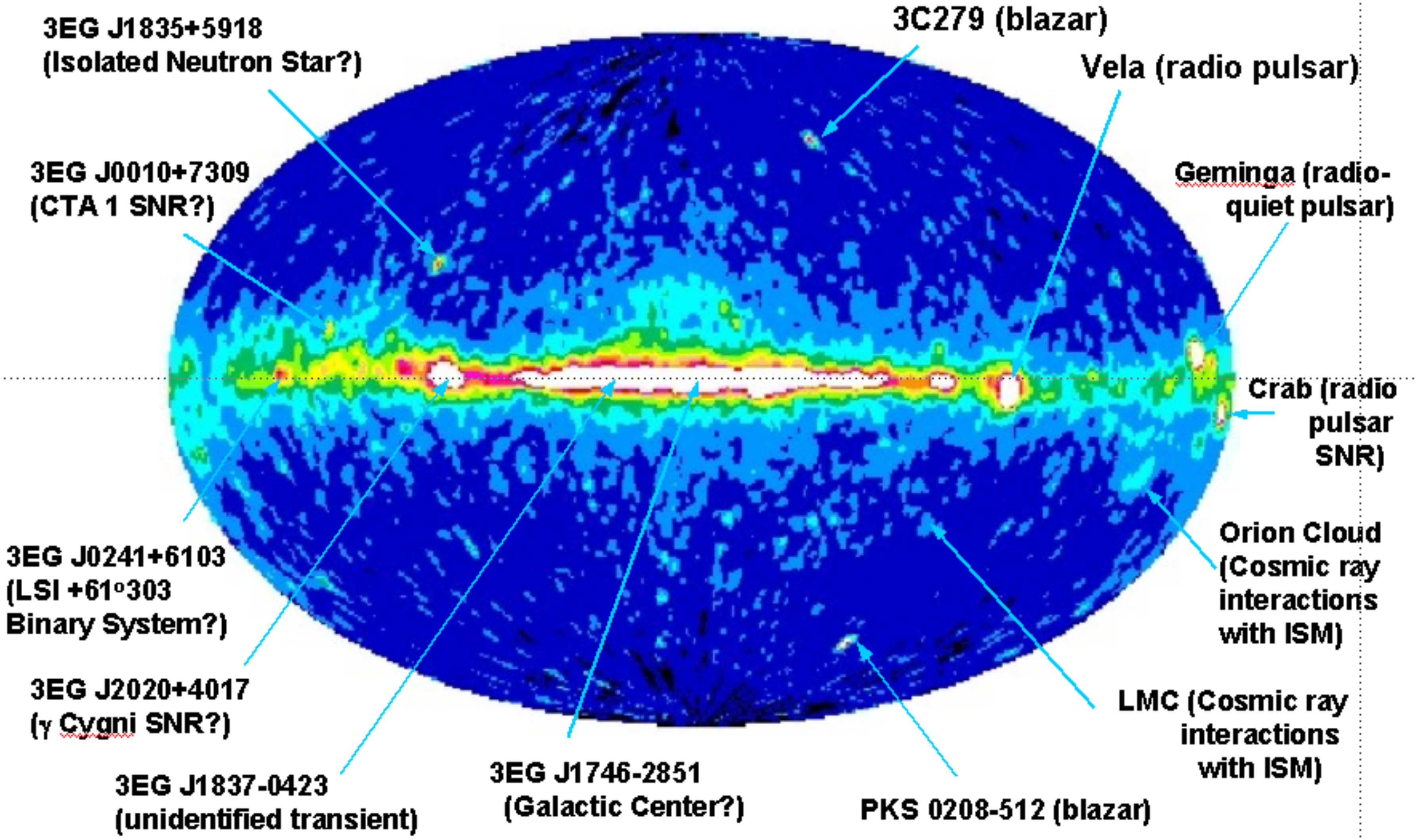


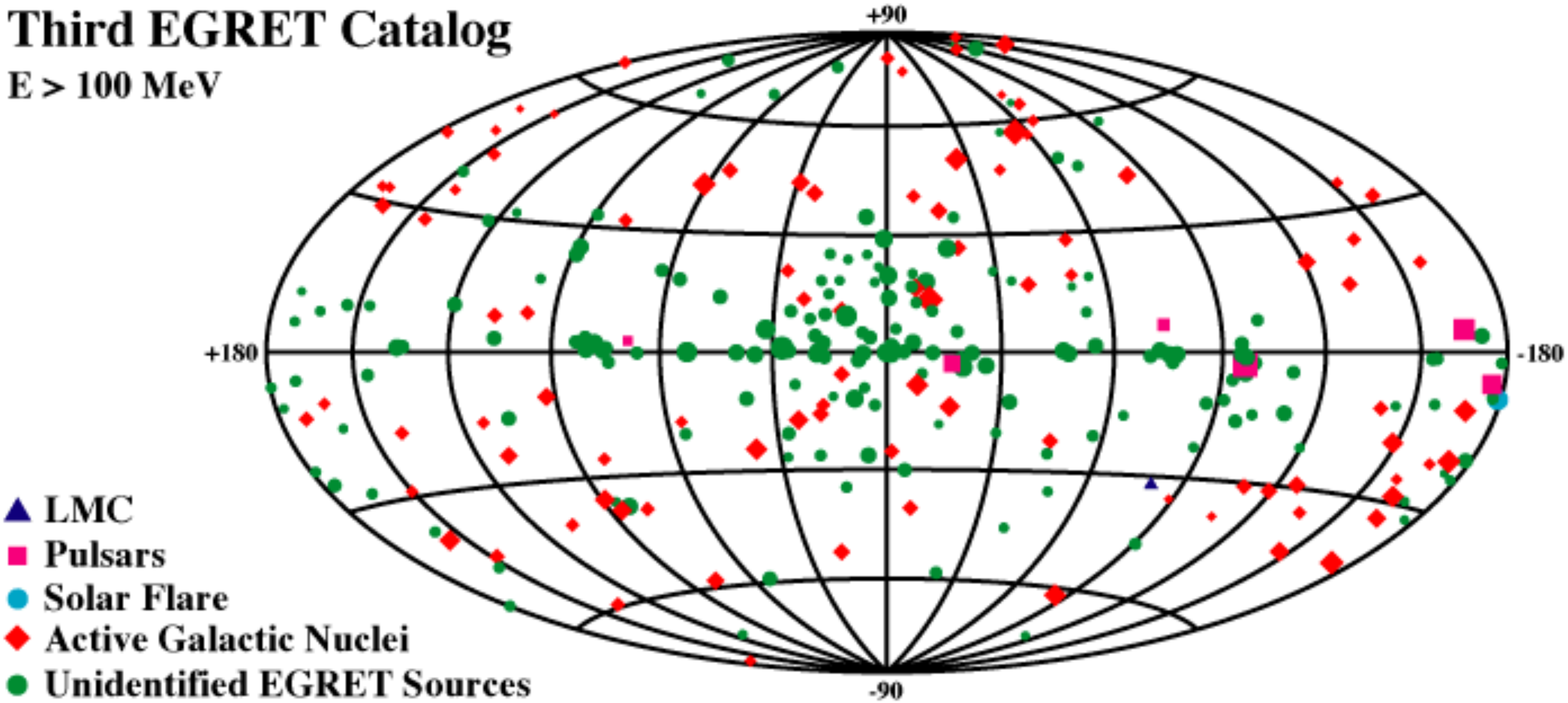
FIG. 3.—High-energy gamma ray spectrum of 3C 454.3 during the time interval 1992 January 23 to February 6. See text for comments on the 30–70 MeV point.

Hartman et al. 1993 (ApJ, 407,L41),

EGRET All Sky Map

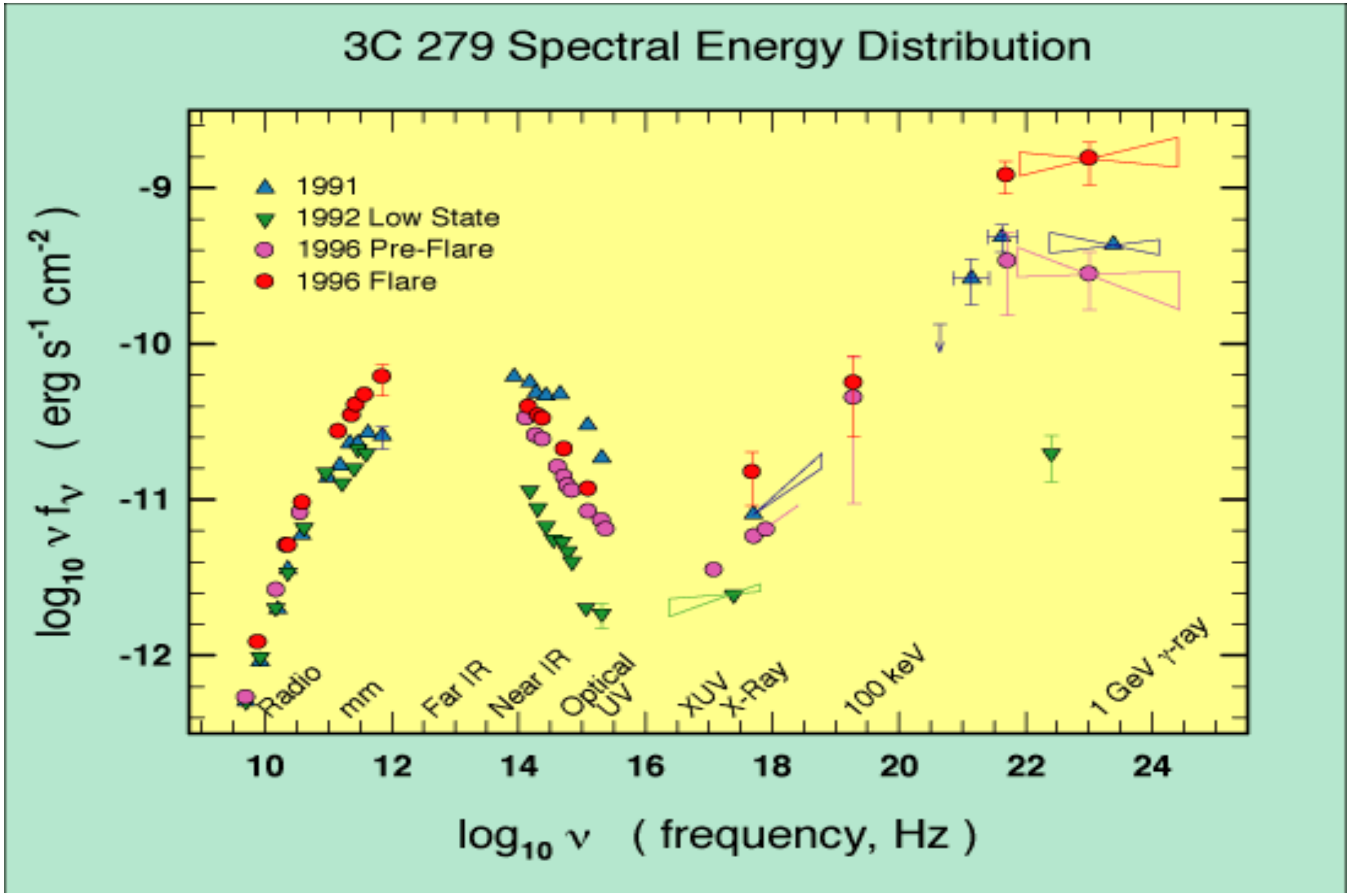


EGRET Gamma-ray Sources

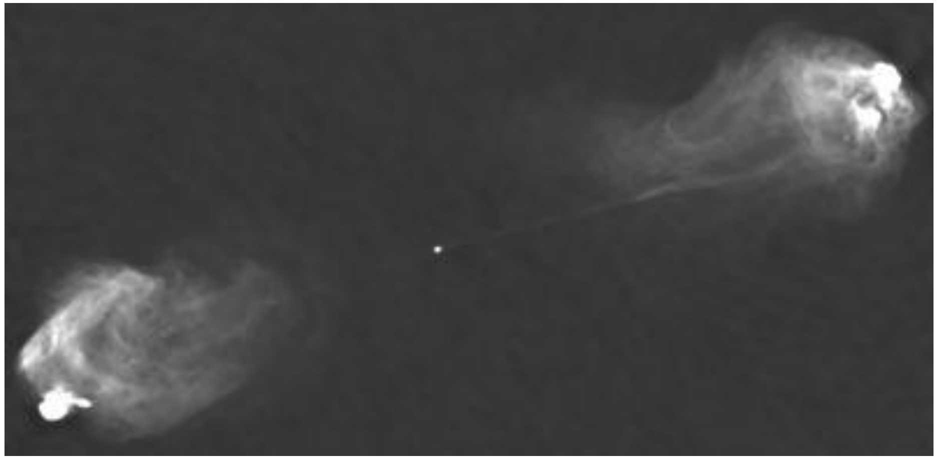


Challenge # 1

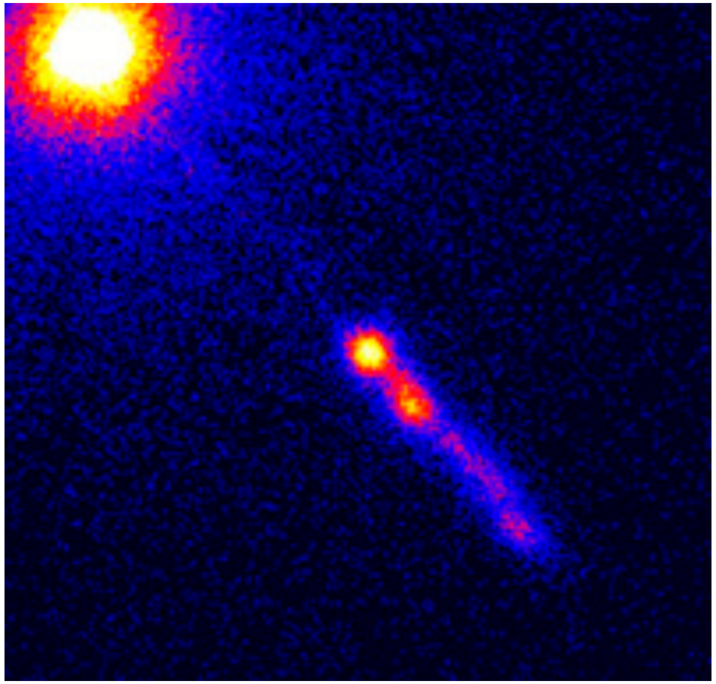
- Need simultaneous multiwavelength data to study variability and emission processes



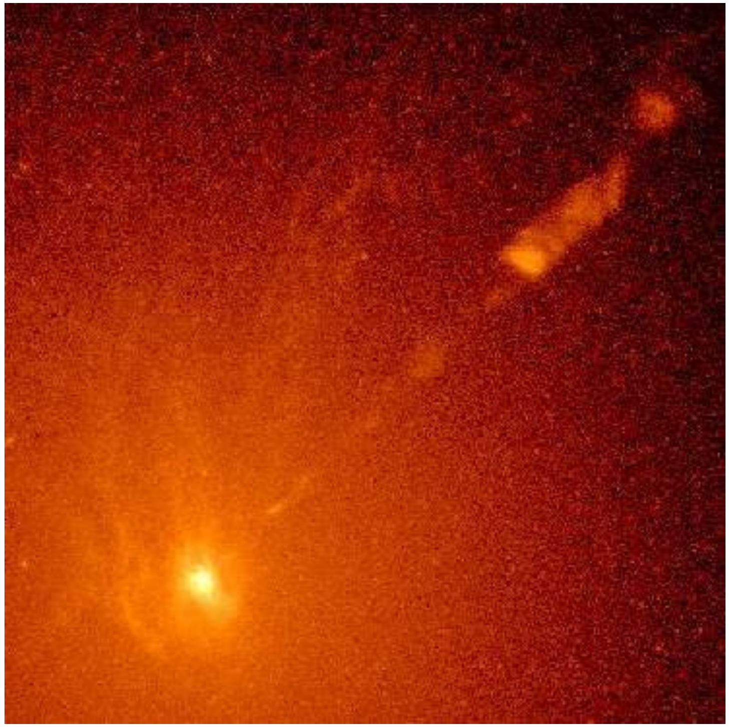
Active Galactic Nuclei



Radio

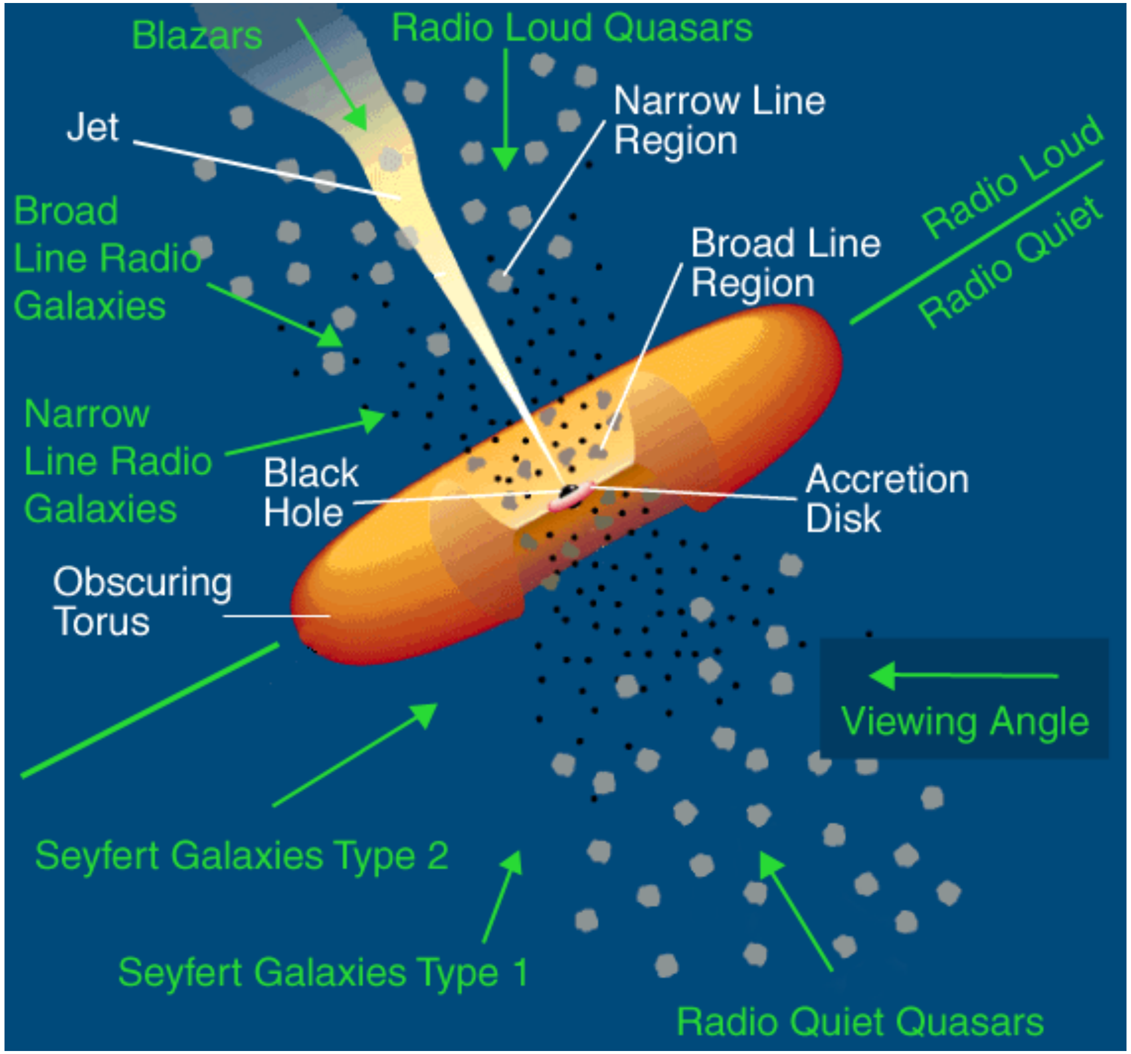


X-ray

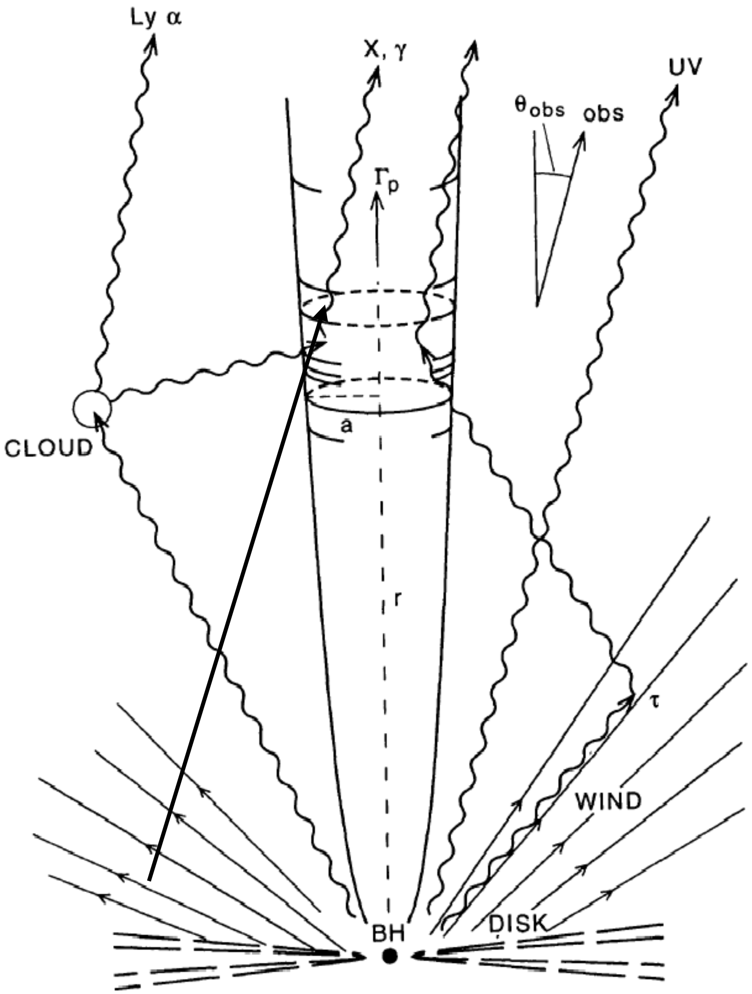


Optical

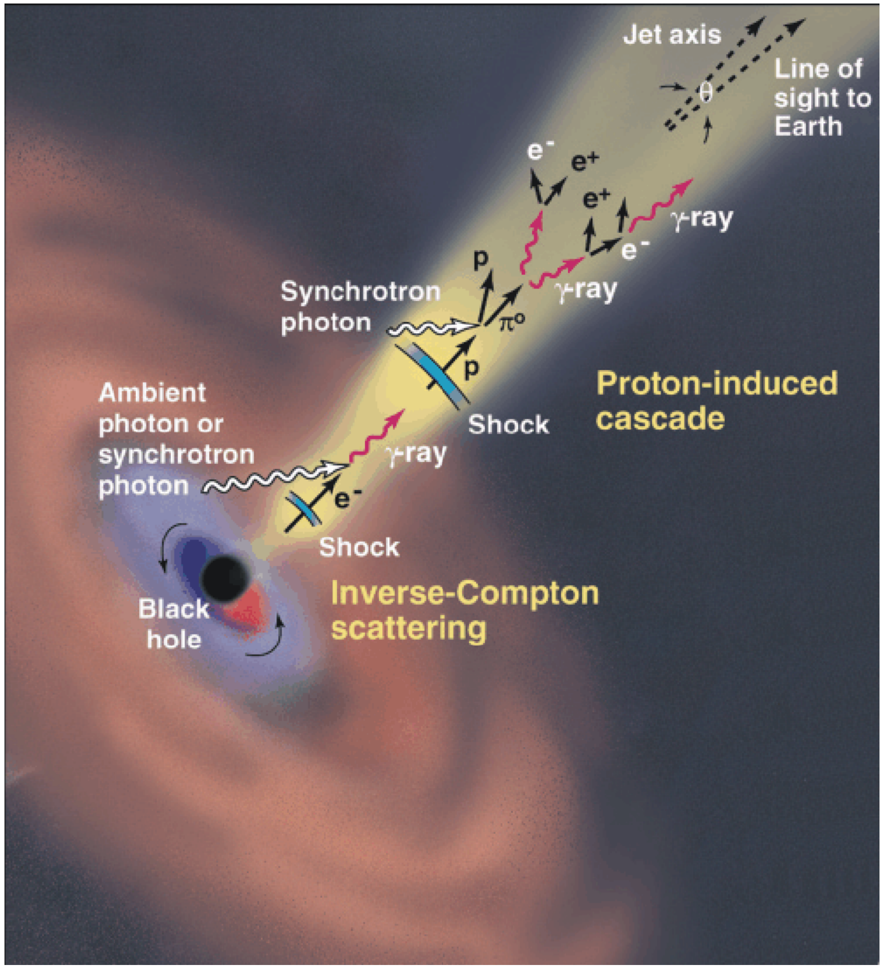
Active Galactic Nuclei



Models of AGN Gamma-ray Production

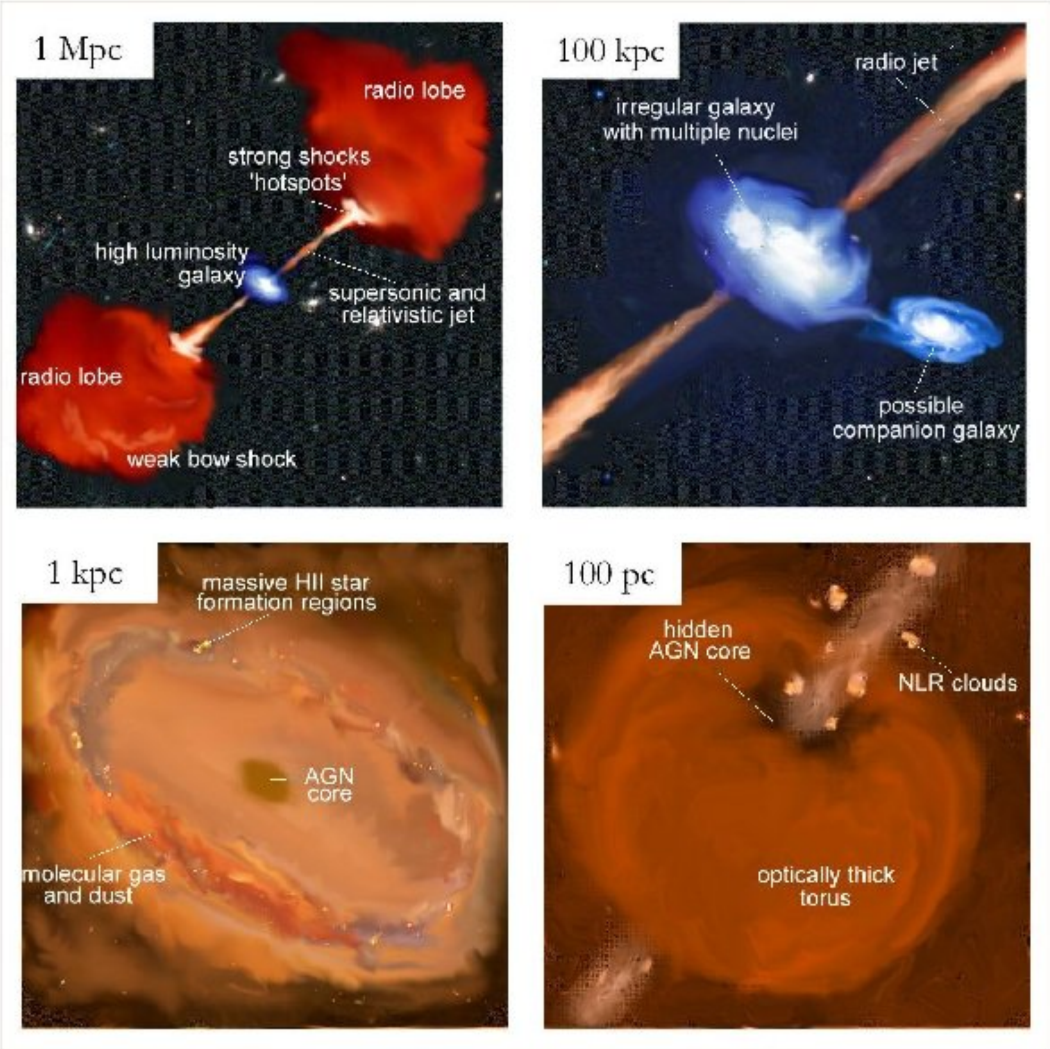


(from Sikora, Begelman, and Rees (1994))



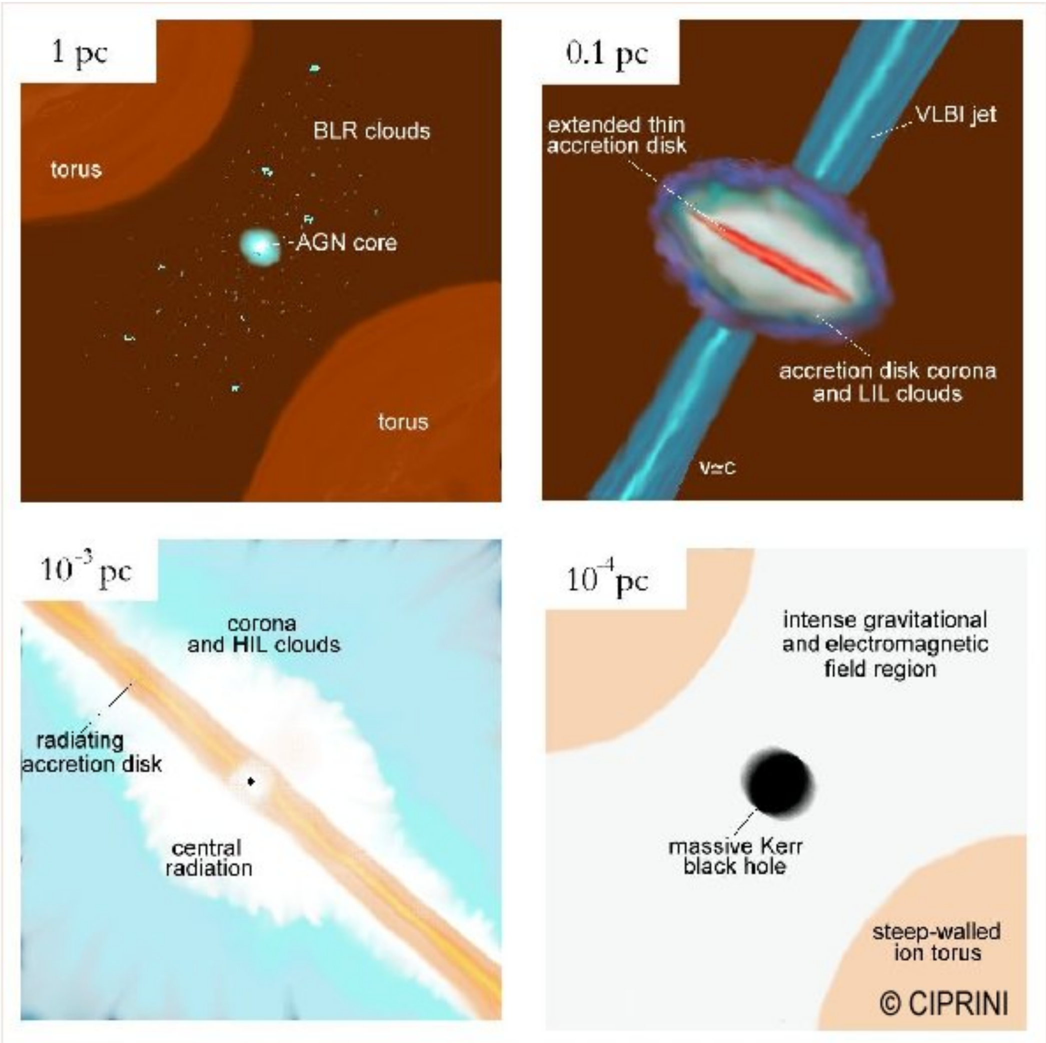
(credit:J. Buckley)

Active Galactic Nuclei



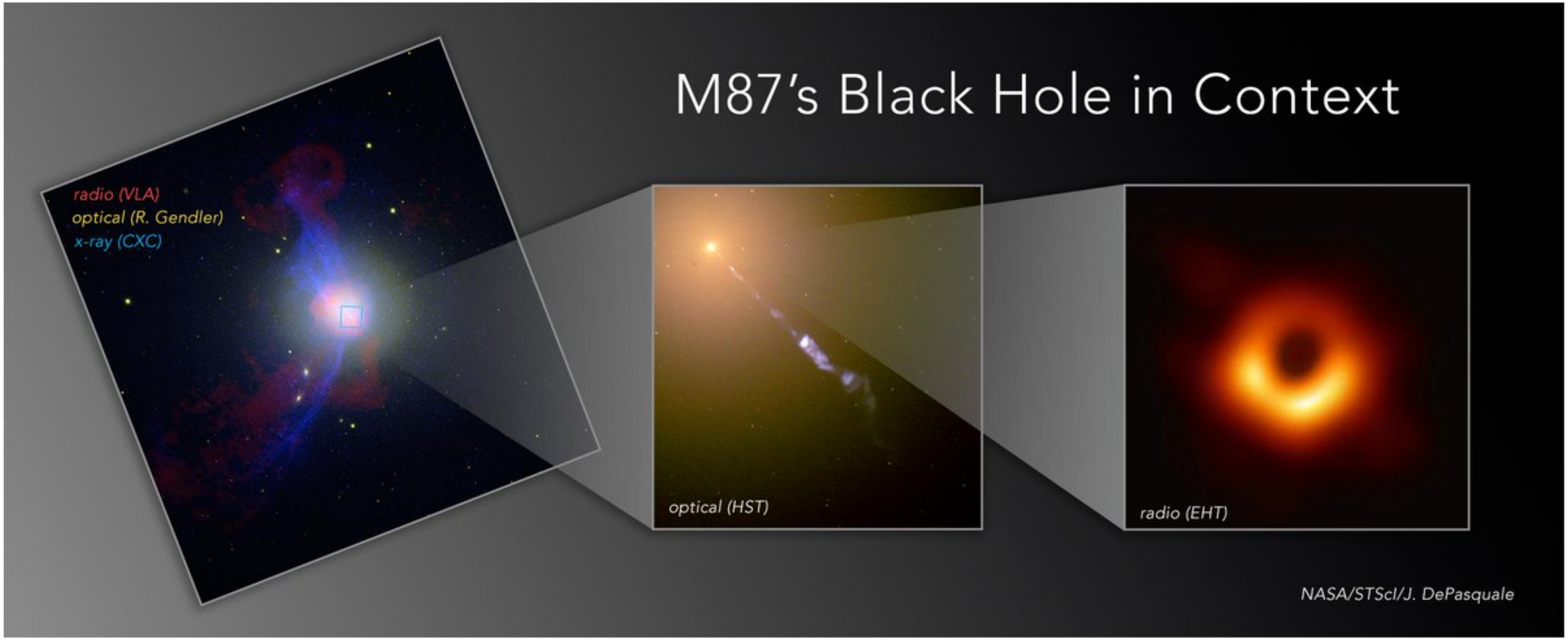
Artistic picture by S.Ciprini

Active Galactic Nuclei



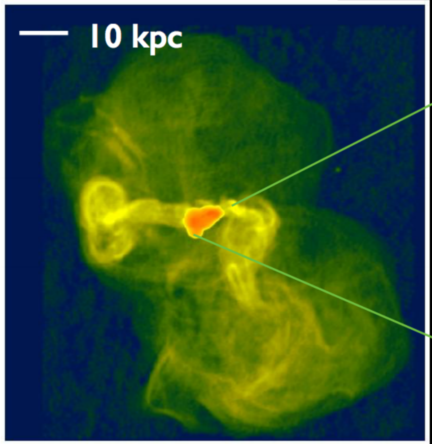
Artistic picture by S.Ciprini

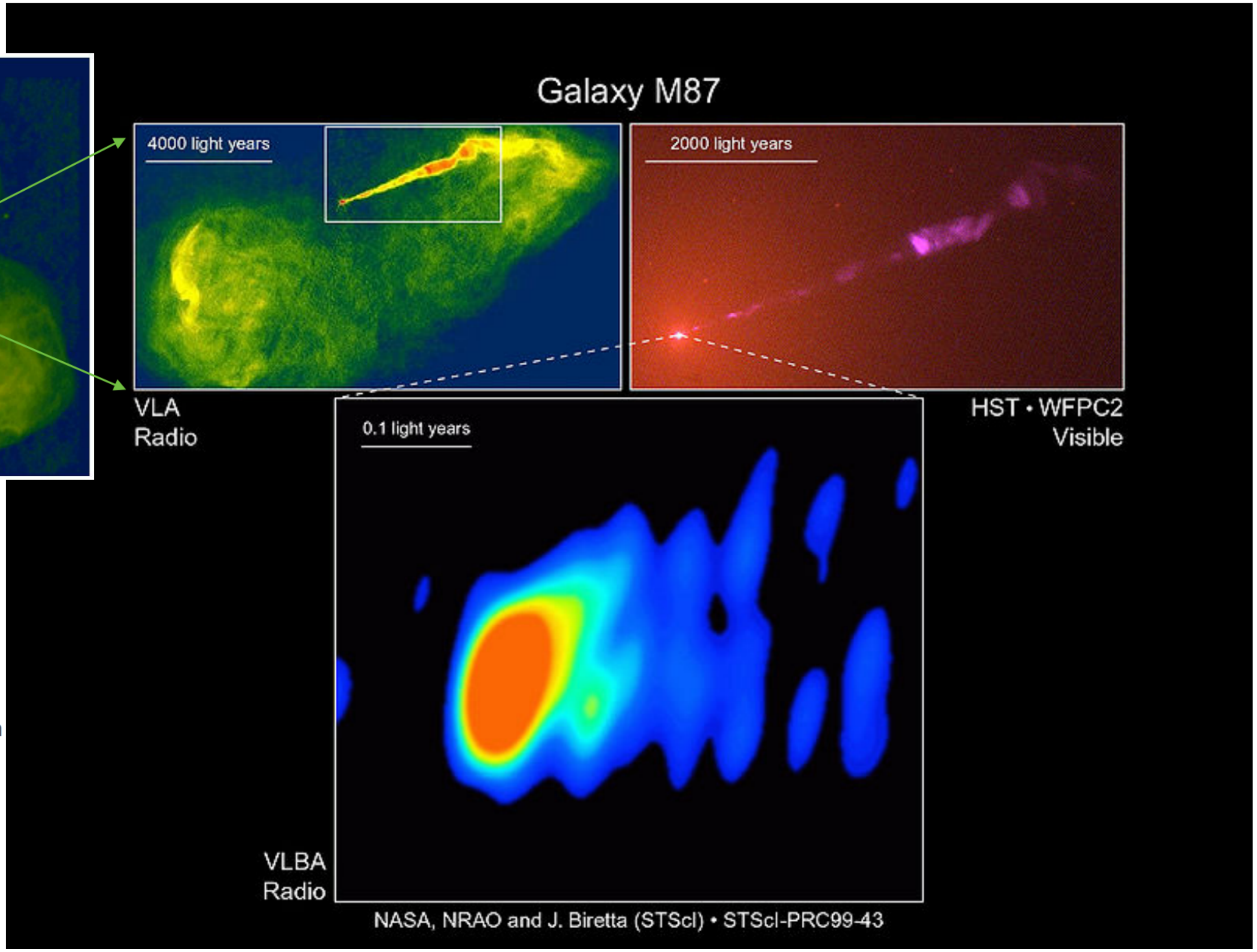
M87 scales…


M87's Black Hole in Context
radio (VLA)
optical (R. Gendler)
x-ray (CXC)
optical (HST)
radio (EHT)
NASA/STScI/J. DePasquale

M87 scales…

radio "bubbles"





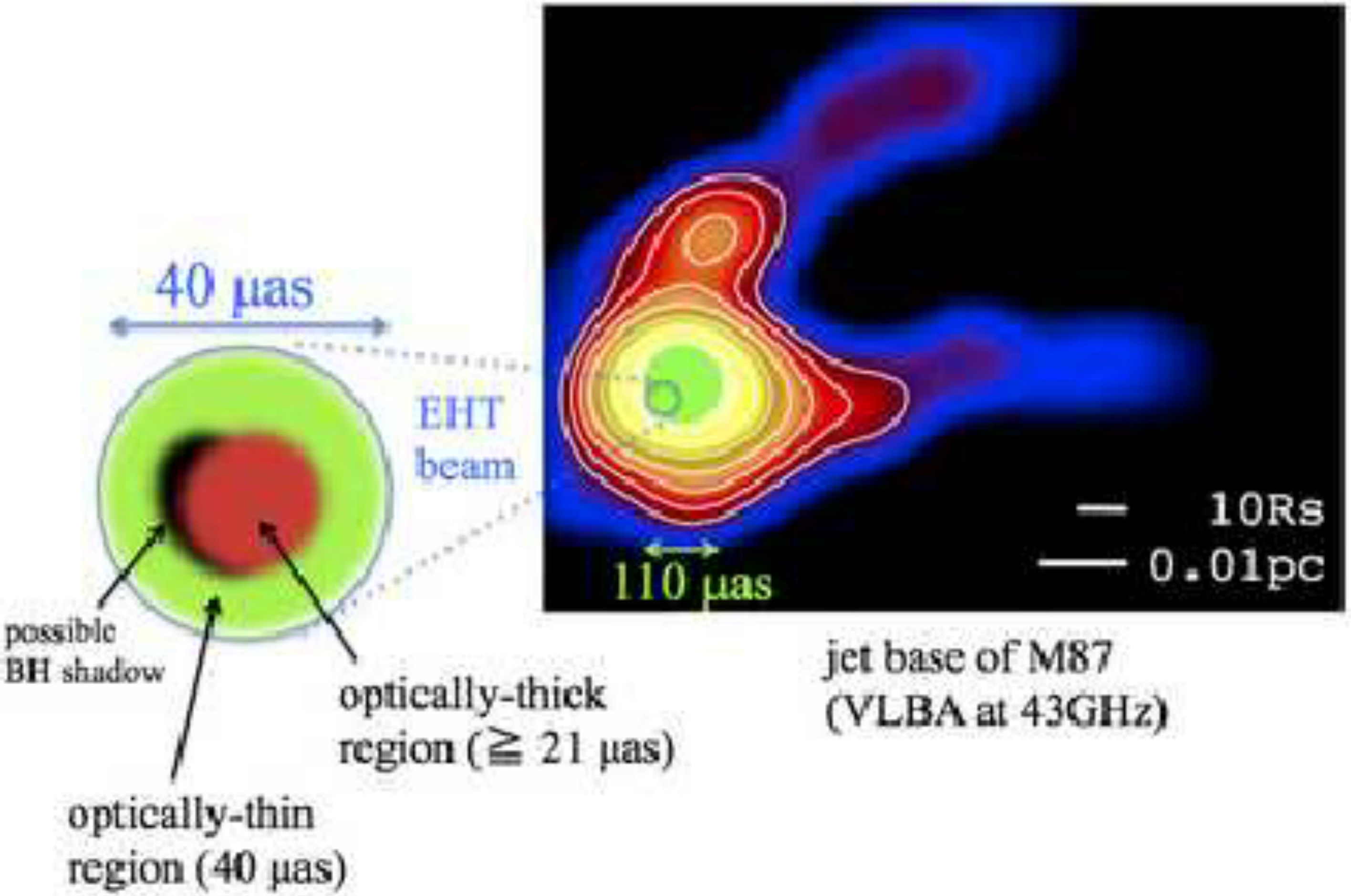
M87:

FR I radio galaxy

d~16 Mpc

$M_{BH}=(3\text{-}6)\times10^9\ M_{sun}$

M87 scales…



40 μas
EHT
beam
possible
BH shadow
optically-thin
region (40 μas)
optically-thick
region (≧ 21 μas)
10Rs
0.01pc
110 μas
jet base of M87
(VLBA at 43GHz)

M87 scales…

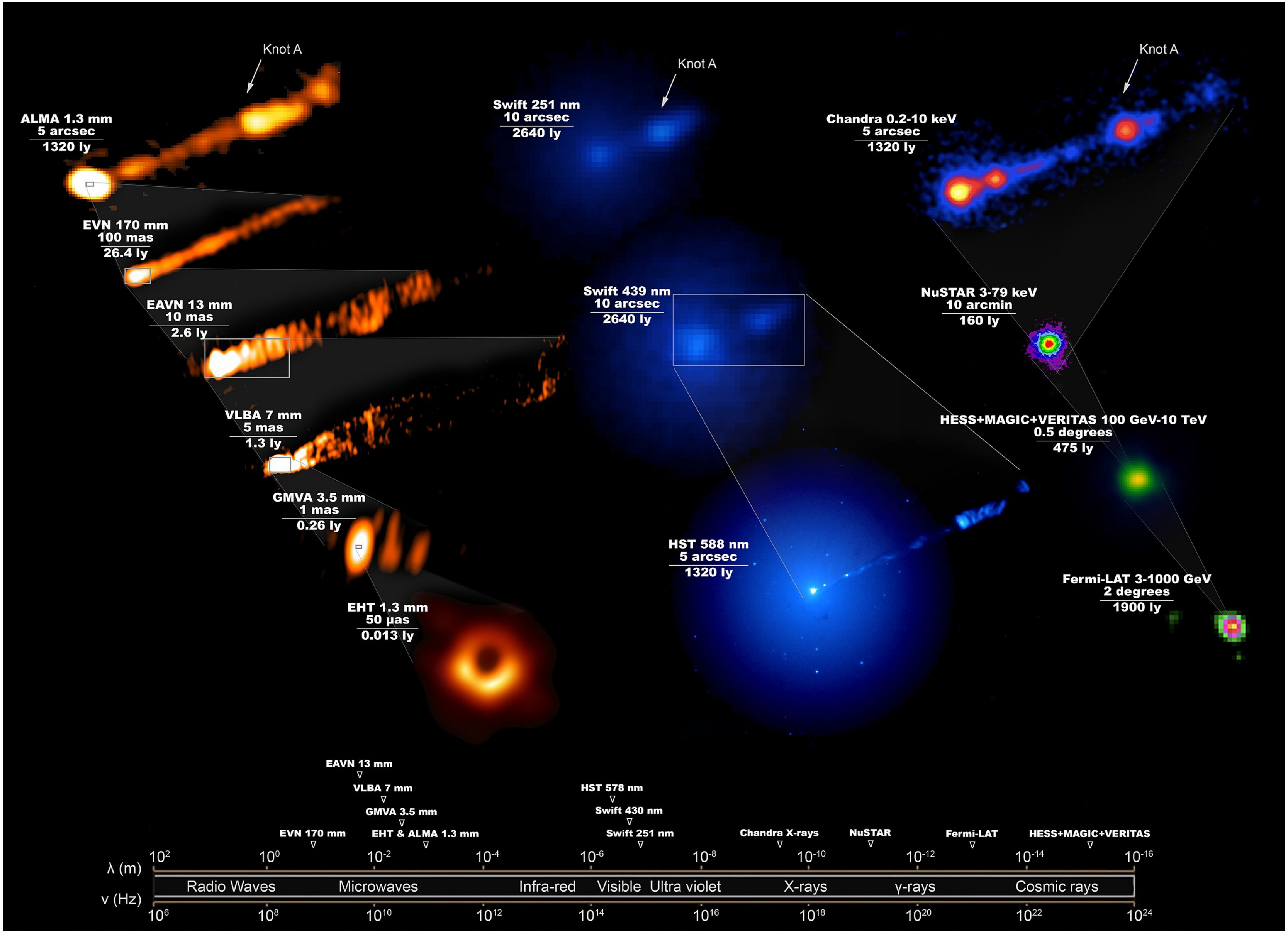
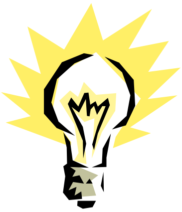


Image Credit: The EHT Multi-wavelength Science Working Group; the EHT Collaboration; ALMA (ESO/NAOJ/NRAO); the EVN; the EAVN Collaboration; VLBA (NRAO); the GMVA; the Hubble Space Telescope; the Neil Gehrels Swift Observatory; the Chandra X-ray Observatory; the Nuclear Spectroscopic Telescope Array; the Fermi-LAT Collaboration; the H.E.S.S collaboration; the MAGIC collaboration; the VERITAS collaboration; NASA and ESA. Composition by J. C. Algaba

AGN and the Extragalactic Background Light (EBL)

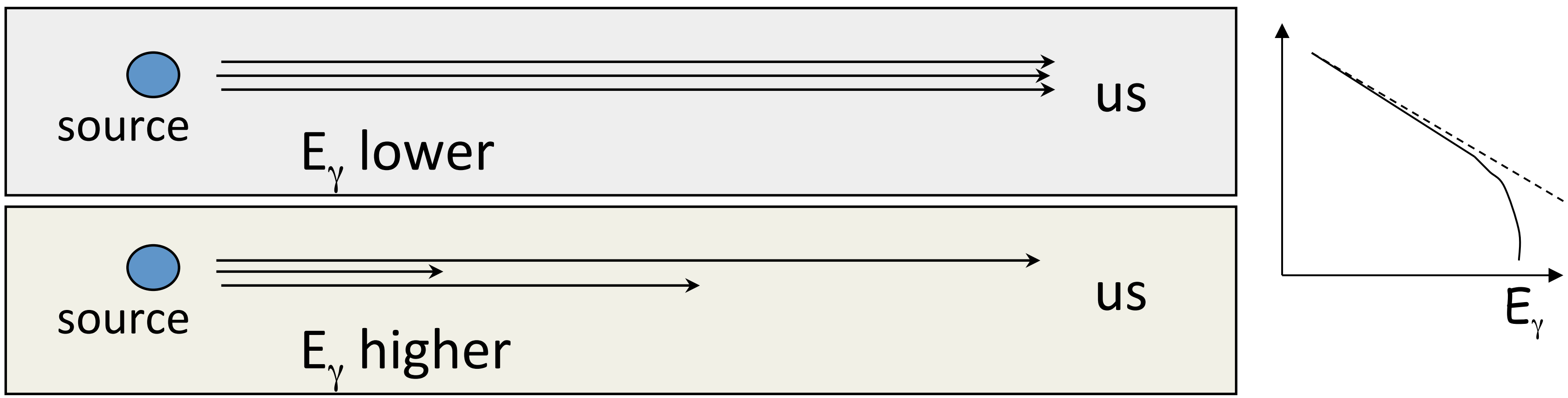


Look for roll-offs in blazar spectra due to attenuation:
(Stecker, De Jager & Salamon; Madau & Phinney; Macminn & Primack)
the start: A.I. Nikishov, Sov. Phys. JETP 14 (1962) 393.

If $\gamma\gamma$ c.m. energy > $2m_e$, pair creation will attenuate flux. For a flux of γ -rays with energy, E, this cross-section is maximized when the partner, ε, is

$$\epsilon \sim \frac{1}{3}(\frac{1TeV}{E})eV$$

For 10 GeV- 100 GeV γ - rays, this corresponds to a partner photon energy in the <u>optical - UV range</u>. Density is sensitive to time of galaxy formation.



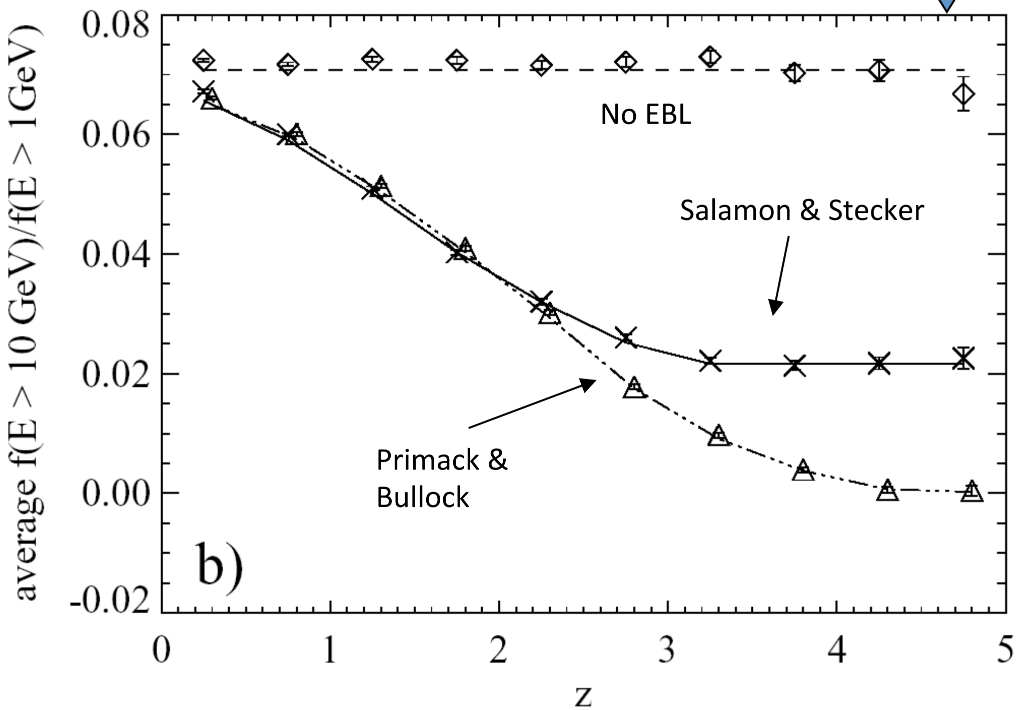
AGN and EBL

- **Important advances offered by Fermi:**

  (1) thousands of blazars - instead of peculiarities of individual sources, look for <u>systematic</u> <u>effects</u> vs redshift.

  (2) key energy range for cosmological distances (TeV-IR attenuation more local due to opacity).

- Effect is model-dependent (this is good):

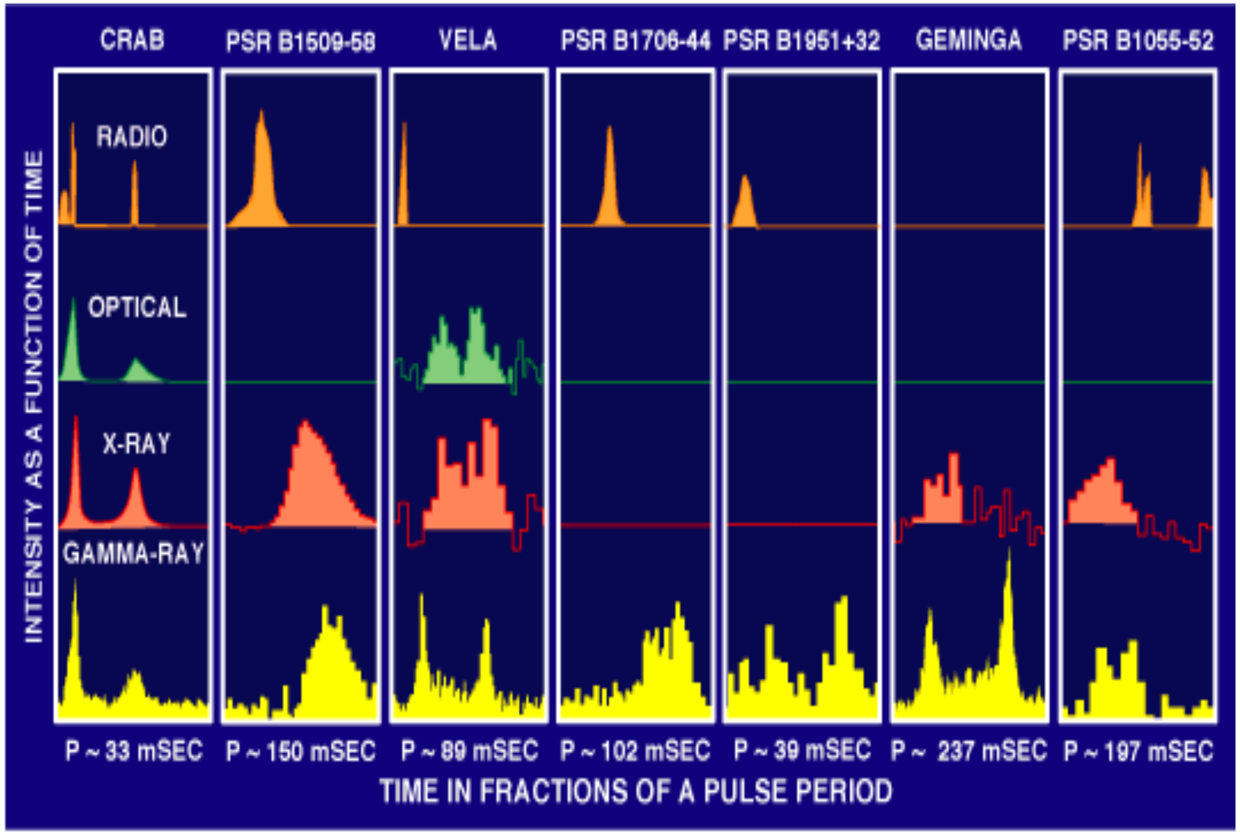


<u>Caveats</u>

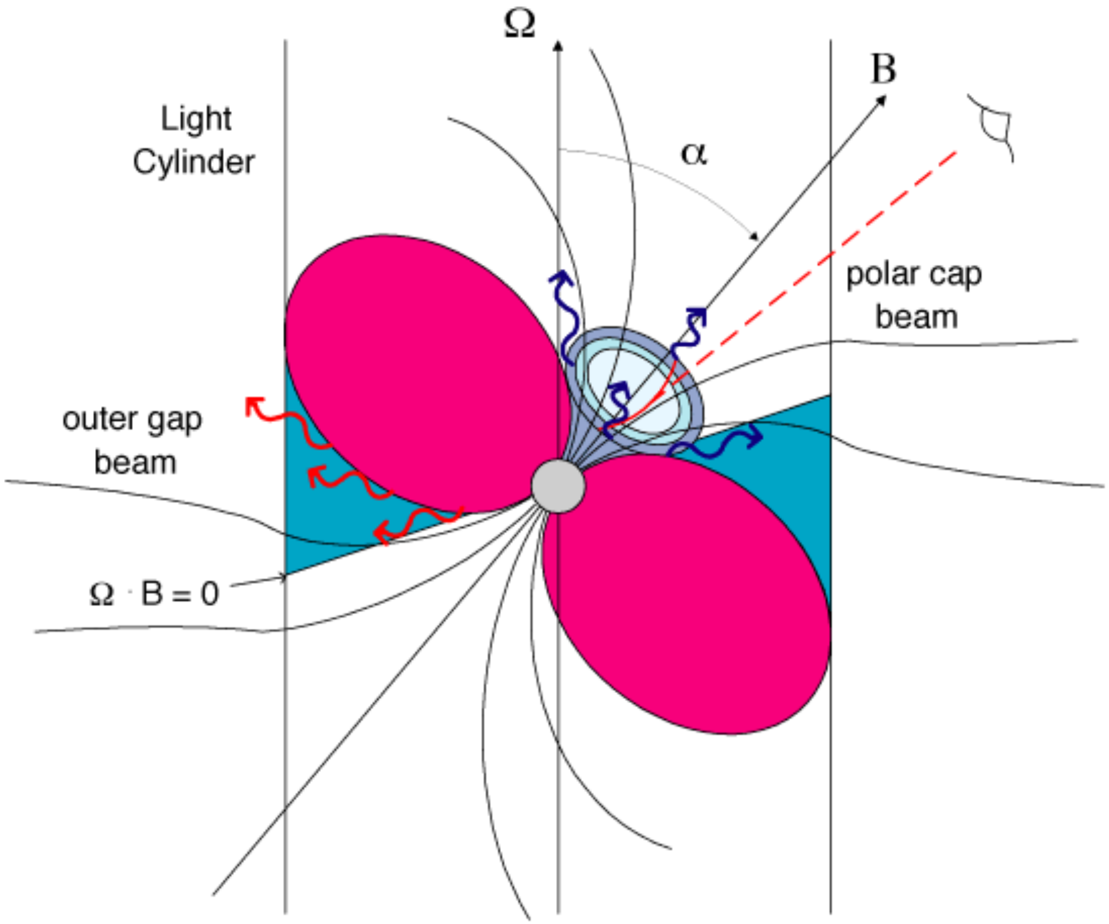
- How many blazars have intrinsic roll-offs in this energy range (10-100 GeV)? (An important question by itself for GLAST!)
- What if there is conspiratorial evolution in the intrinsic roll-of vs redshift? More difficult, however there may also be independent constraints (e.g., direct observation of integrated EBL).
- Must measure the redshifts for a large sample of these blazars!

Challenge # 2

- Need more exposure and optimal timing (and radio monitoring) to discover more gamma-ray PSRs.



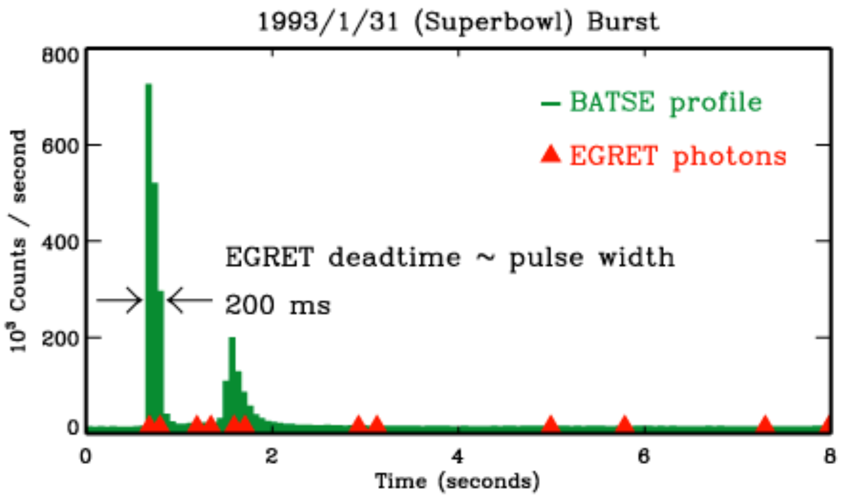
Pulsars



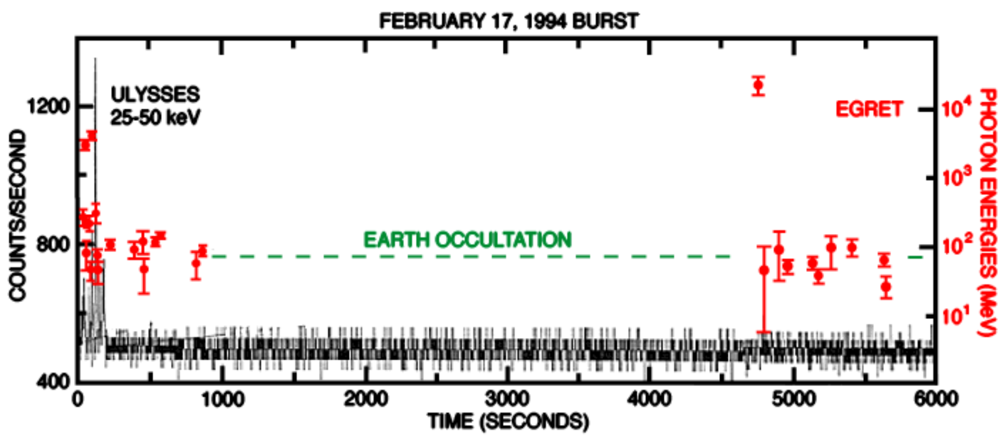
Challenge # 3

- Need fast timing for gamma-ray detection (improving EGRET deadtime, 100 msec → 100 microsec or less).

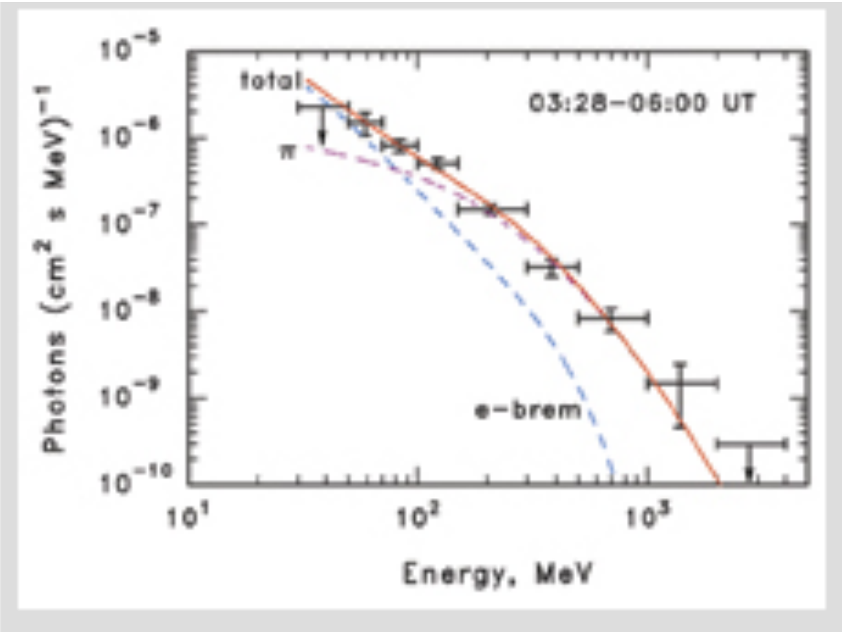
Prompt Emission (GRB 930131)

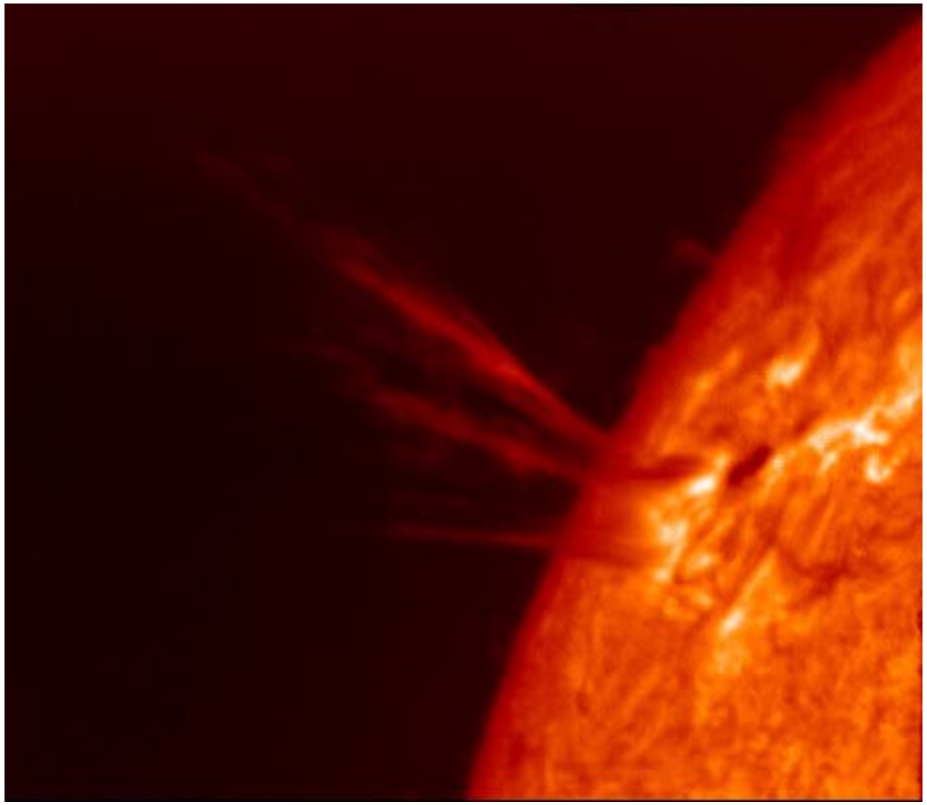


Delayed Emission (GRB 940217)

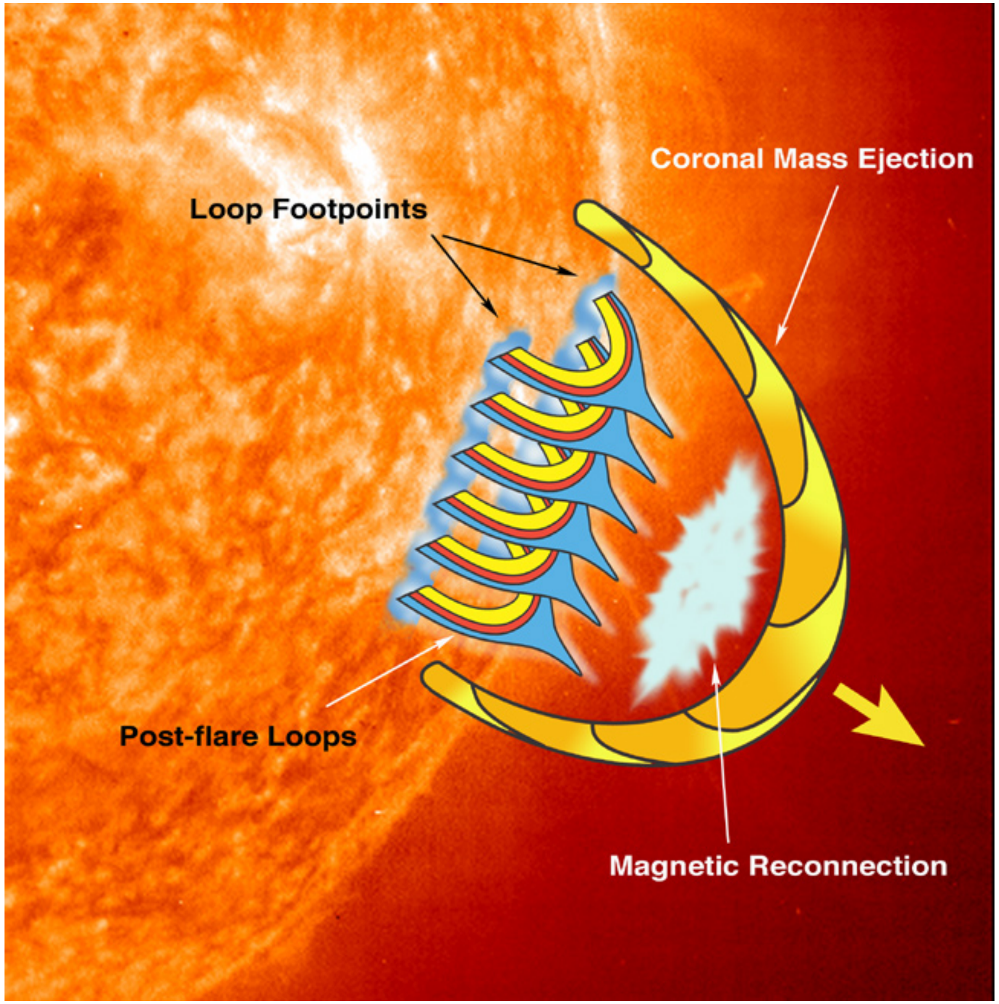


Solar flares



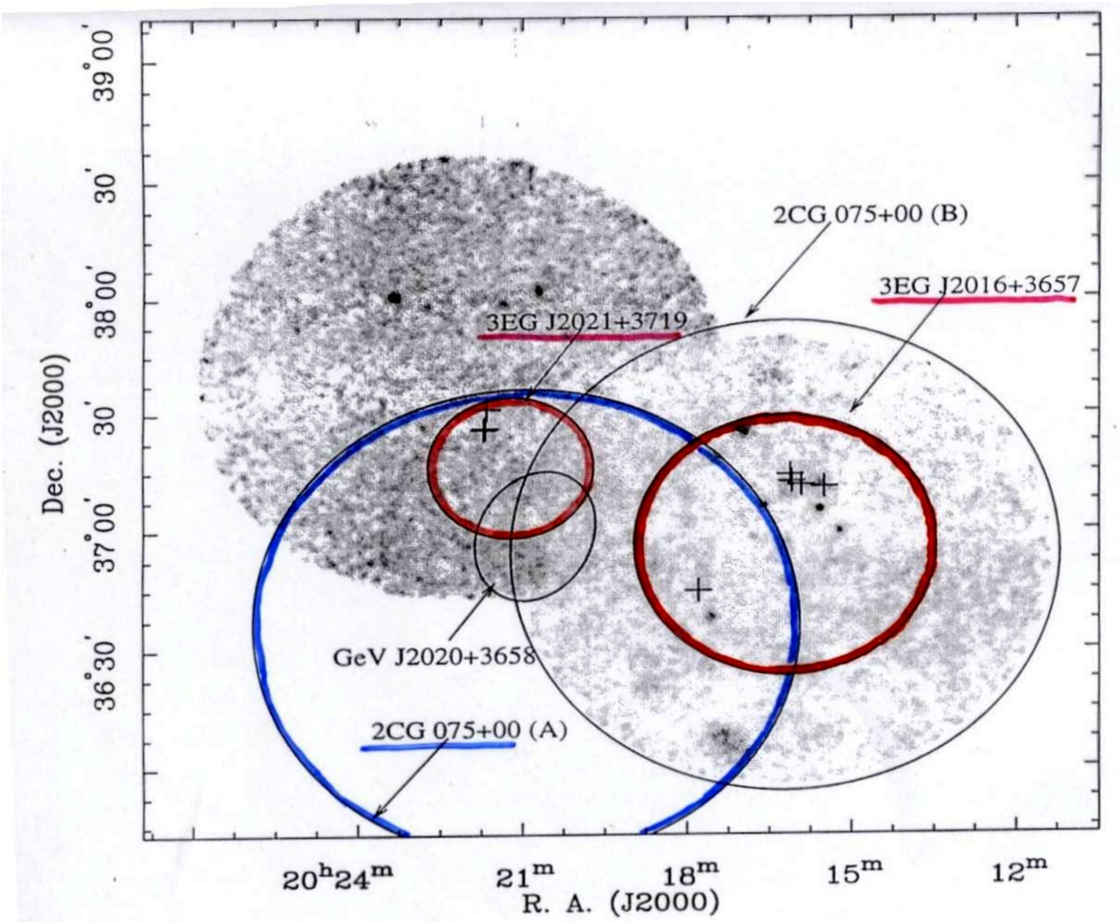


Solar Flares

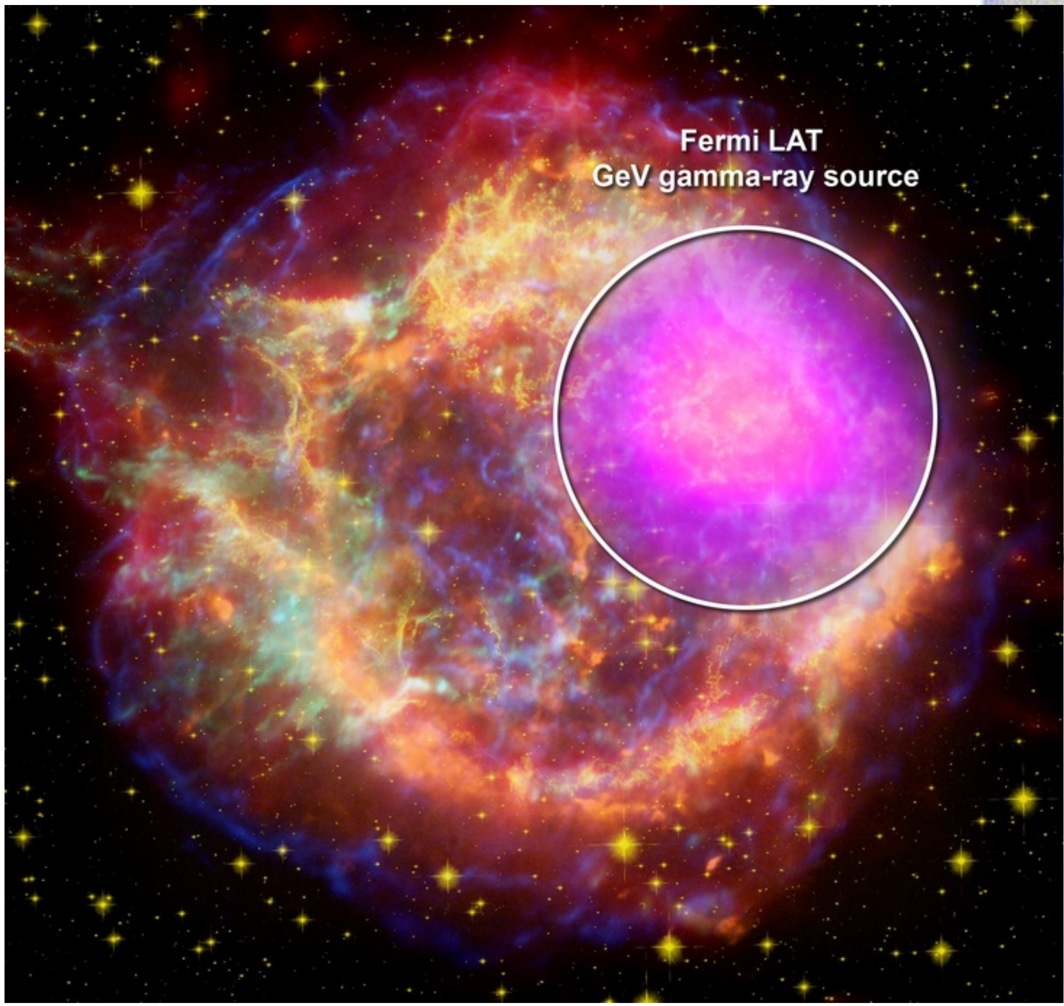


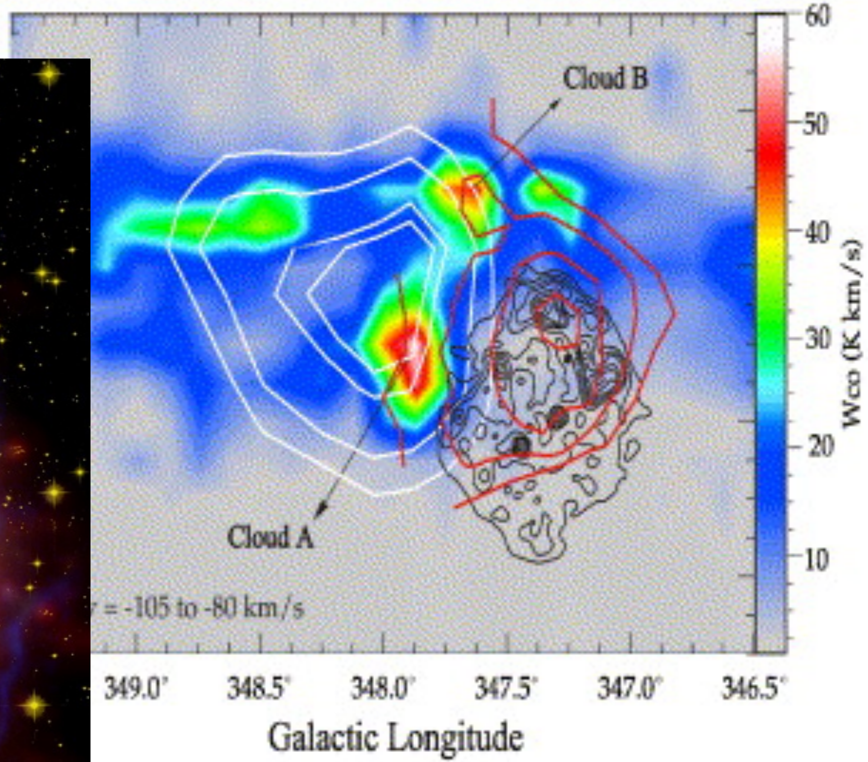
Challenge # 4

- Need arcminute positioning of gamma-ray sources (improving EGRET error box radii by a factor of 2-10).

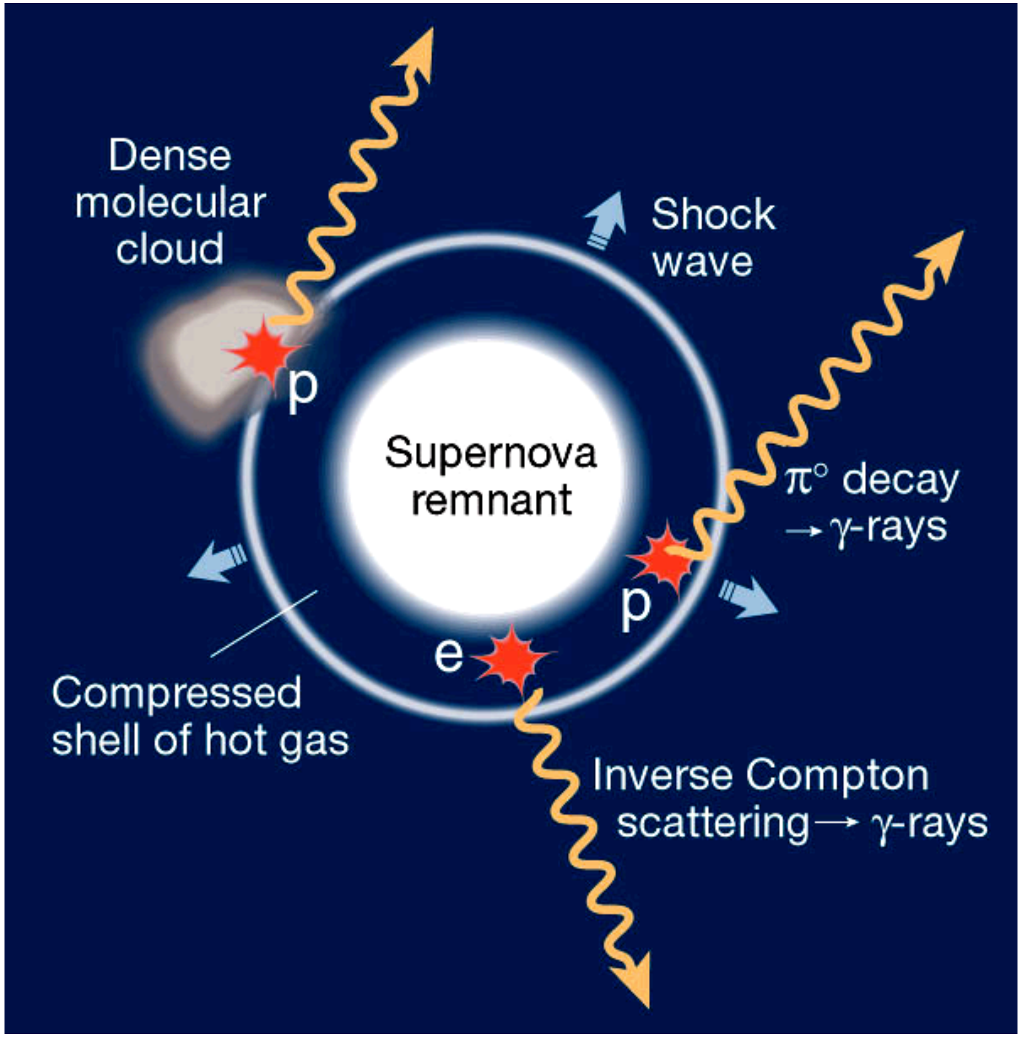


Supernova Remnants





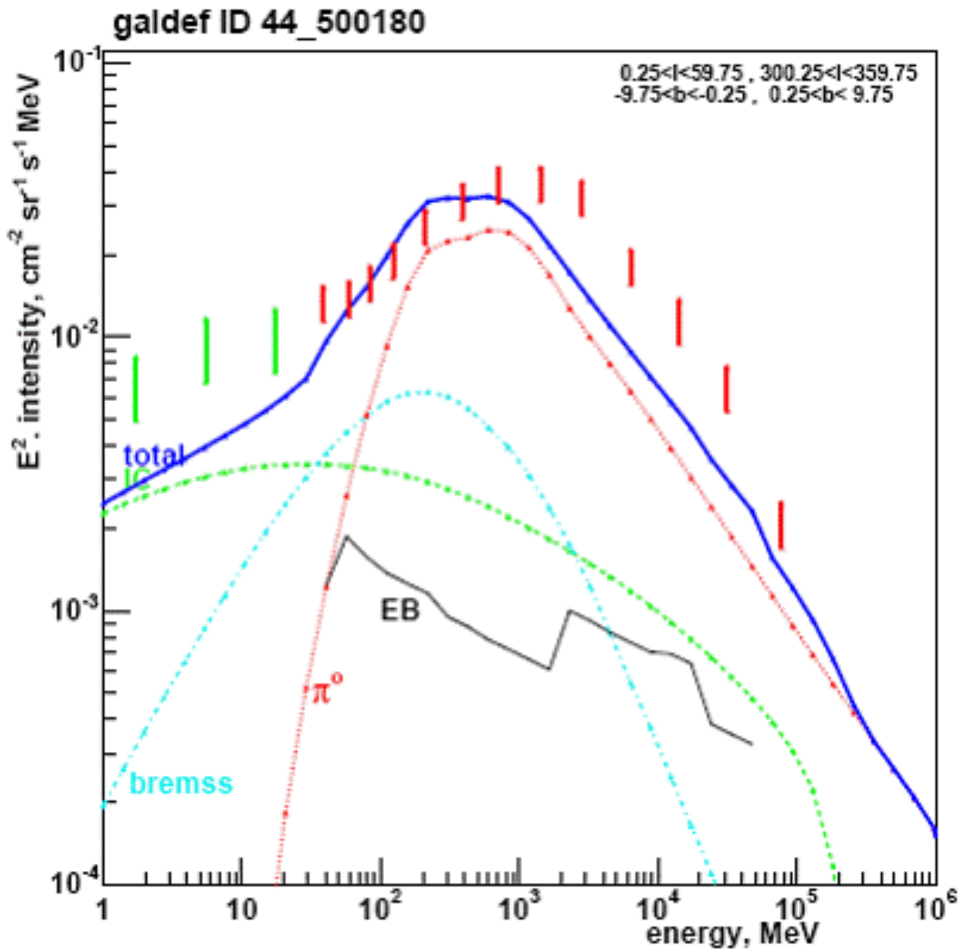
SNR



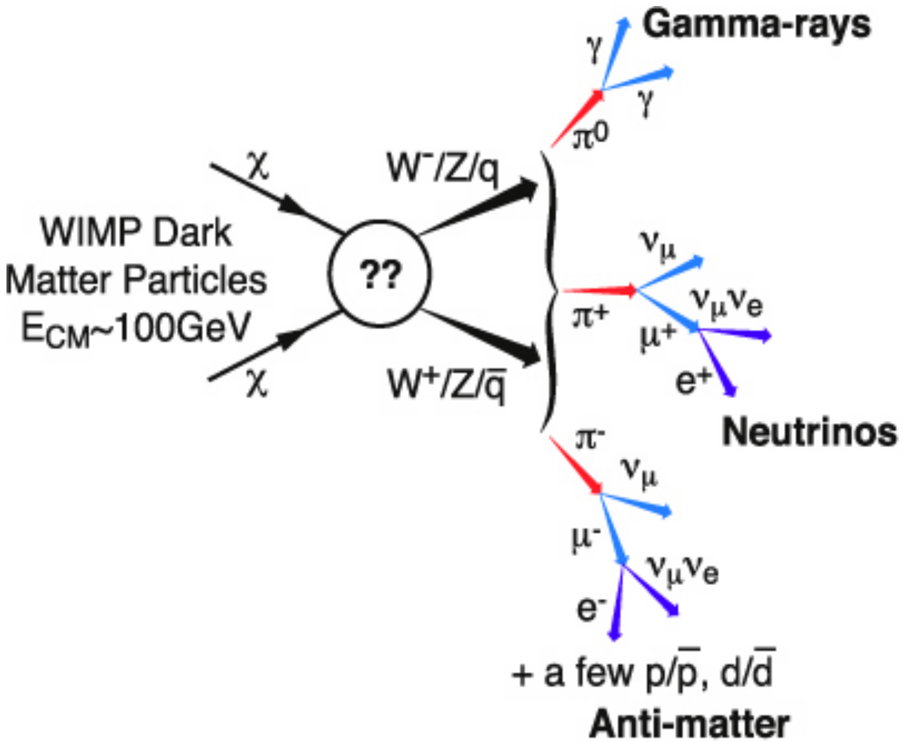
Dense molecular cloud
Shock wave
p
Supernova remnant
π° decay → γ-rays
p
e
Compressed shell of hot gas
Inverse Compton scattering → γ-rays

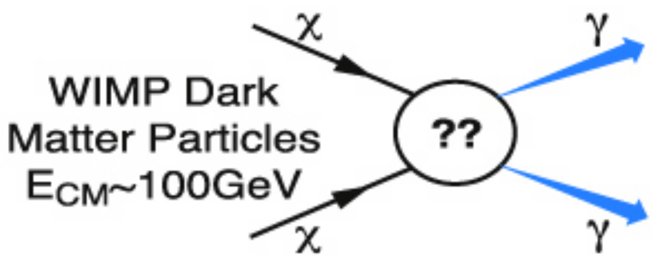
Challenge # 5

- Need improvements in Spectral Resolution fo check for DM signals



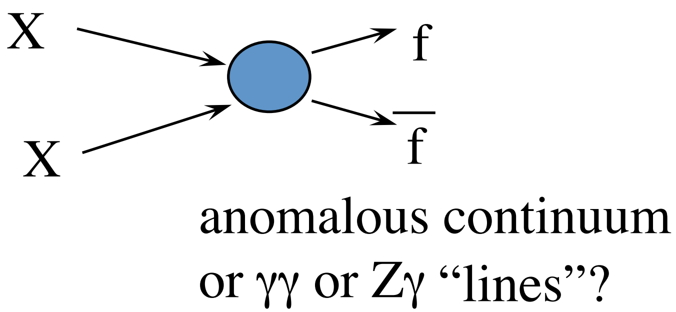
Dark Matter


Gamma-rays
γ
γ
π0
χ
W-/Z/q
WIMP Dark
Matter Particles
ECM~100GeV
??
χ
W+/Z/q̄
νμ
π+
νμνe
μ+
e+
Neutrinos
π-
νμ
μ-
νμνe
e-
+ a few p/p̄, d/d̄
Anti-matter


χ
γ
WIMP Dark
Matter Particles
ECM~100GeV
??
χ
γ

Particle Dark Matter

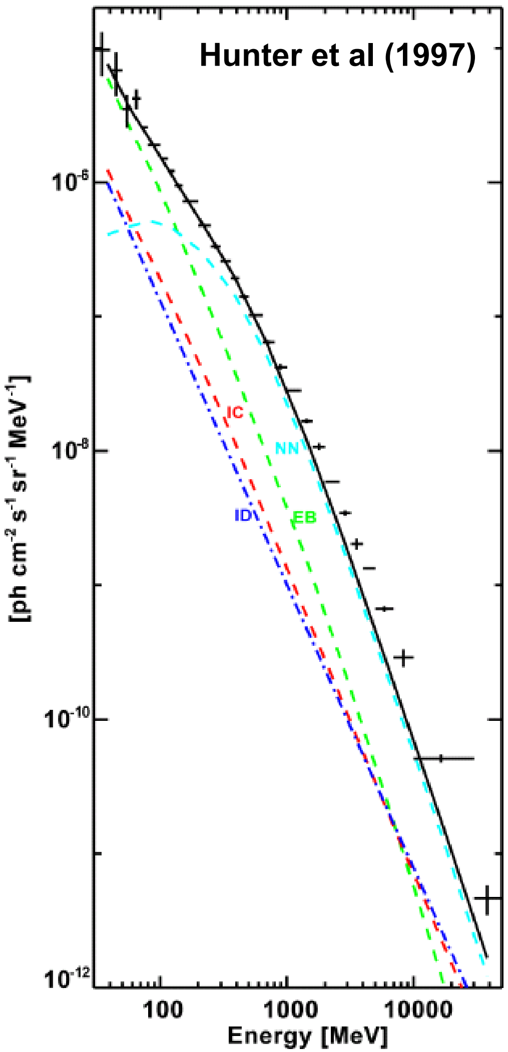
Some important models in particle physics could also solve the dark matter problem in astrophysics. If correct, these new particle interactions could produce an anomalous flux of gamma rays ("indirect detection").



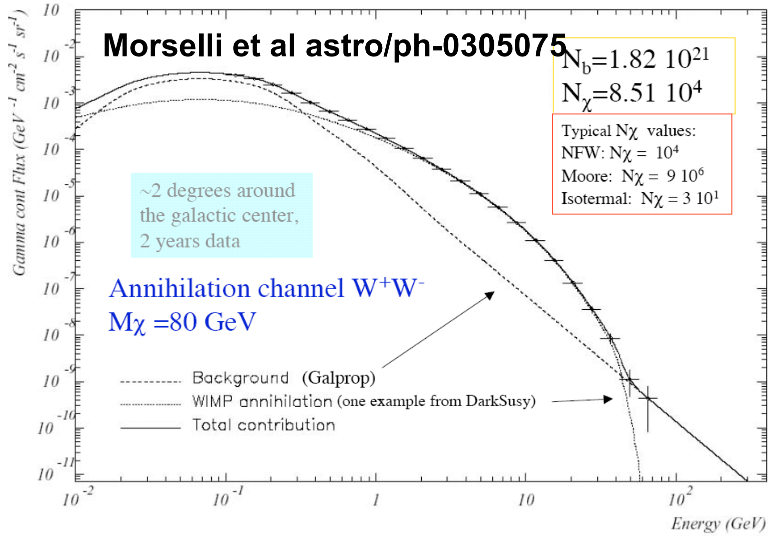
- Key interplay of techniques (see Baltz et al., astro/ph-0602187):
  - colliders (TeVatron, LHC, ILC)
  - direct detection experiments
  - indirect detection (best shot: gamma rays)
    - GLAST full sky coverage look for clumping throughout galactic halo, including off the galactic plane (if found, point the way for ground-based facilities)
    - Intensity highly model-dependent
    - Challenge is to separate signals from astrophysical backgrounds

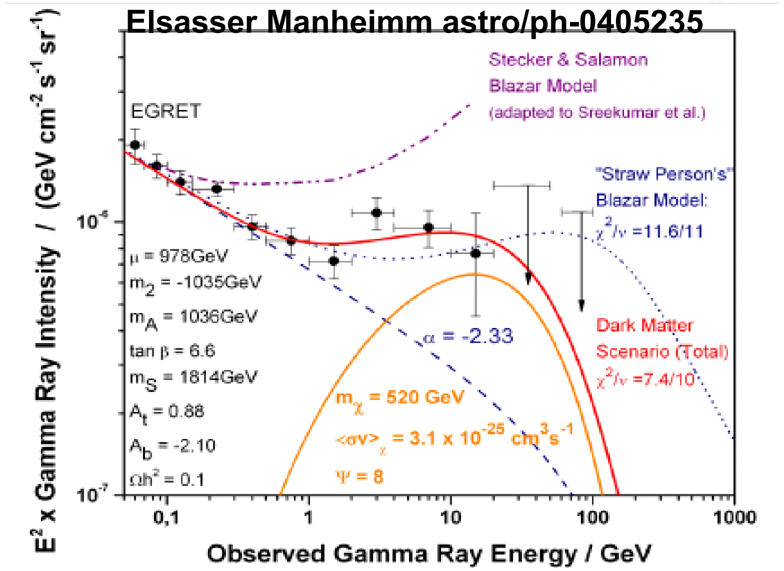
Just an example of what might be waiting for us to find!

Dark Matter Searches



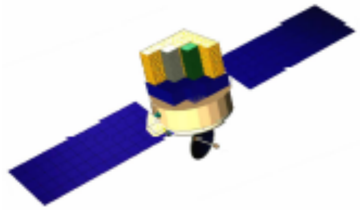
- WIMP annihilation in galactic centre or galactic halos
- Extragalactic WIMP annihilation relic
- SUSY dark matter
- Kaluza Klein dark matter





➢ this science require large sensitivity on a broad energy range, localization power, energy resolution, time resolution for variability search … key elements for the whole GLAST physics program

Detector Project



Sources Classes Predicted for GLAST

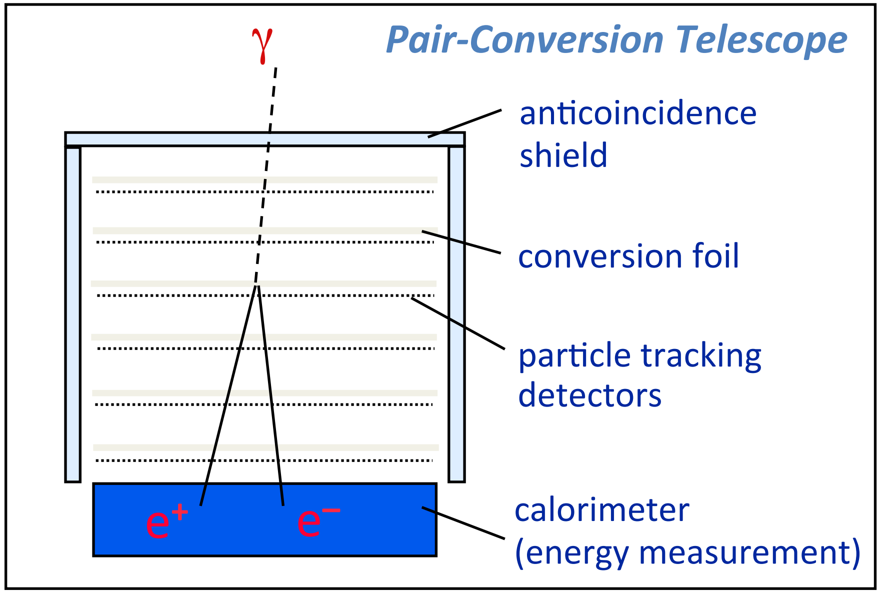
Source Class	Basis for Prediction
Active Galactic Nuclei (AGN)	EGRET quasars
Diffuse Cosmic Background	EGRET, Theory
Gamma Ray Bursts (GRBs)	EGRET, BATSE, Milagrito
Molecular Clouds, Supernova Remnants Normal Galaxies	COS-B, EGRET, Theory
Galactic Neutrons Stars (NS) & Black Holes (BHs)	COS-B, EGRET
Unidentified Gamma-ray Sources	COS-B, EGRET
Dark Matter	Theory

Detector Project

- Instrument must measure the direction, energy, and arrival time of high energy photons (from approximately 20 MeV to greater than 300 GeV):

  - photon interactions with matter in GLAST energy range dominated by pair conversion:
    determine photon direction
    clear signature for background rejection

  - limitations on angular resolution (PSF)
    low E: multiple scattering => many thin layers
    high E: hit precision & lever arm



Energy loss mechanisms:

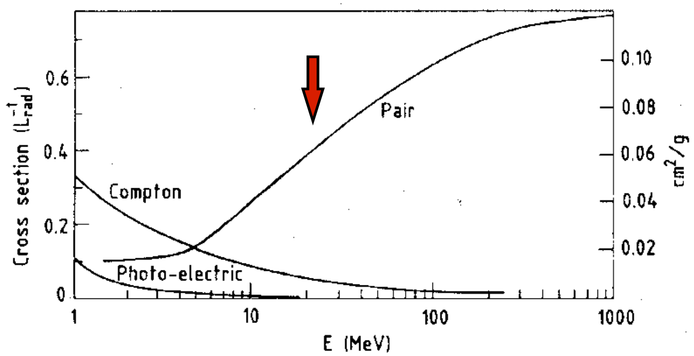


Fig. 2: Photon cross-section σ in lead as a function of photon energy. The intensity of photons can be expressed as $I = I_0 \exp(-\sigma x)$, where x is the path length in radiation lengths. (Review of Particle Properties, April 1980 edition).

- must detect γ-rays with high efficiency and reject the much larger (~10^4:1) flux of background cosmic-rays, etc.;
- energy resolution requires calorimeter of sufficient depth to measure buildup of the EM shower. Segmentation useful for resolution and background rejection.

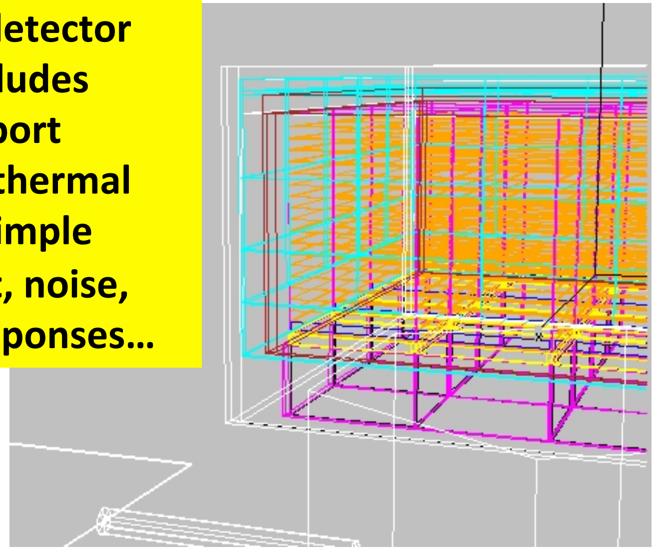
Detector Project

The LAT design is based on detailed Monte Carlo simulations.
Integral part of the project from the start.

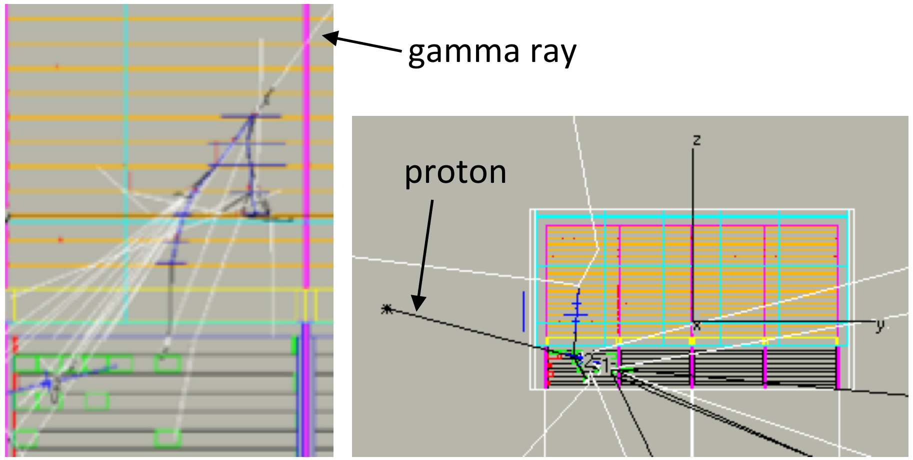
- **Background rejection**
- **Calculate effective area and resolutions (computer models now verified by beam tests). Current reconstruction algorithms are existence proofs -- many further improvements under development.**
- **Trigger design.**
- **Overall design optimization.**

Simulations and analyses are all C++, based on standard HEP packages.

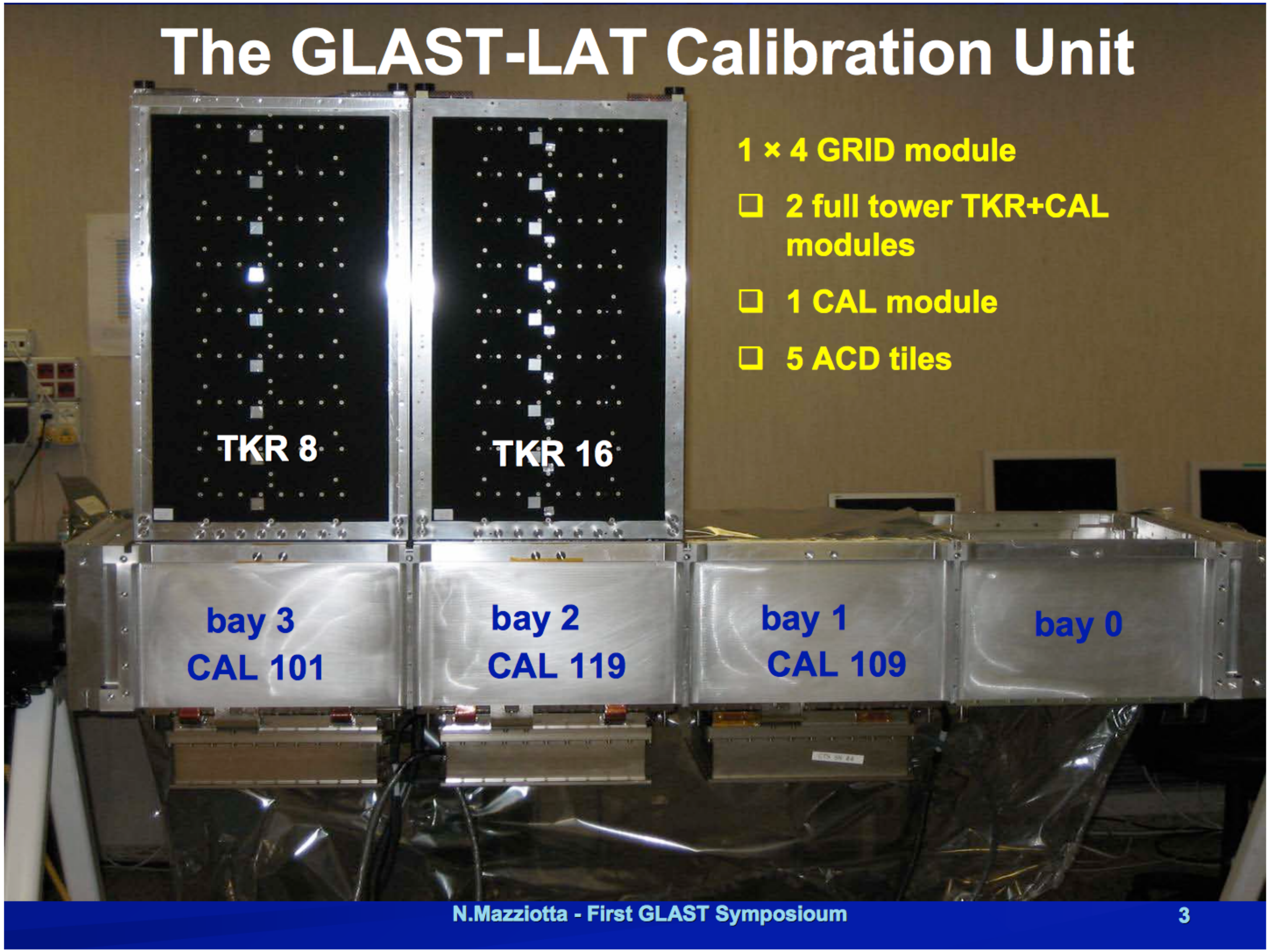
Detailed detector model includes gaps, support material, thermal blanket, simple spacecraft, noise, sensor responses…



Instrument naturally distinguishes gammas from backgrounds, but details matter.

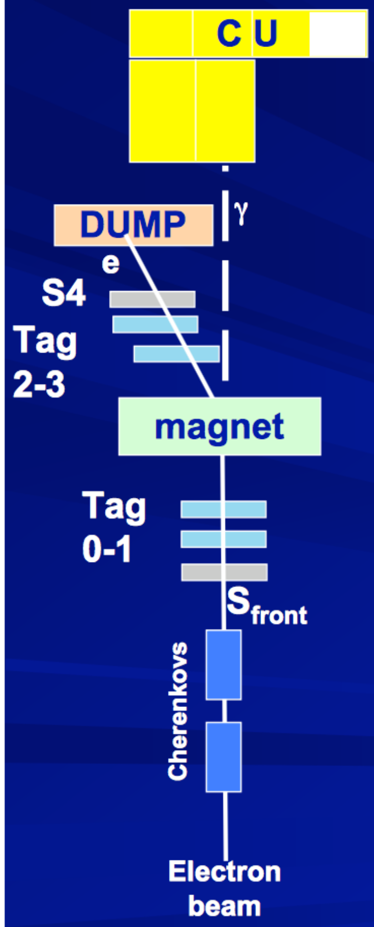


Beam test


The GLAST-LAT Calibration Unit
1 × 4 GRID module
2 full tower TKR+CAL modules
1 CAL module
5 ACD tiles
TKR 8
TKR 16
bay 3
CAL 101
bay 2
CAL 119
bay 1
CAL 109
bay 0
N.Mazziotta - First GLAST Symposioum
3

Beam test

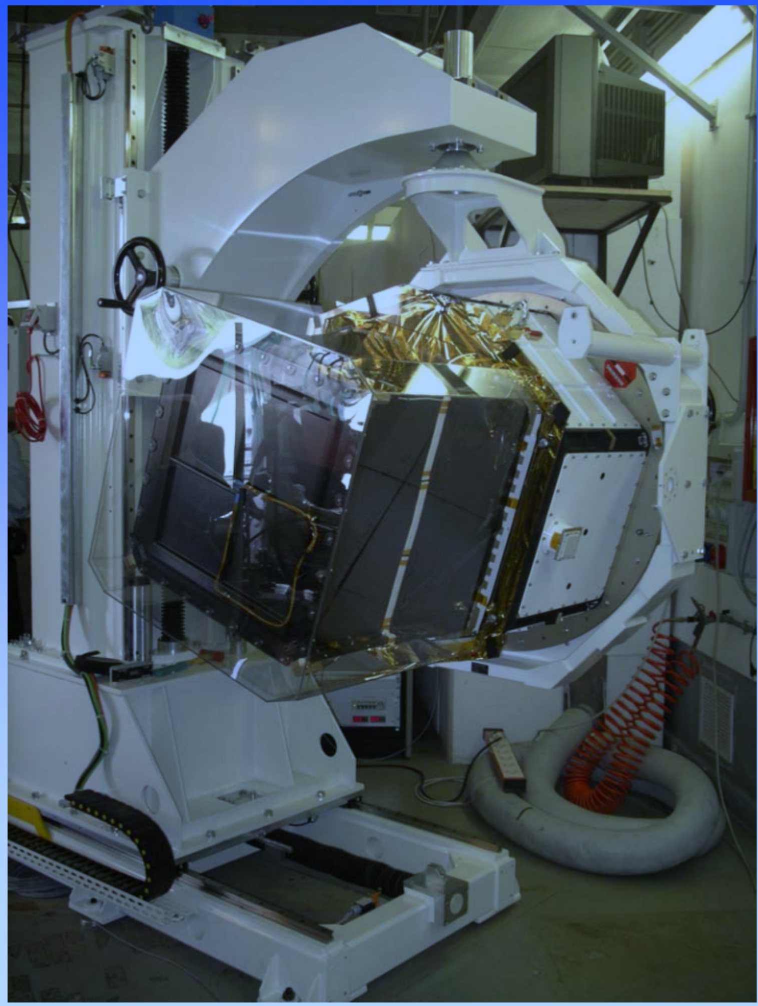
Photon configuration set-up



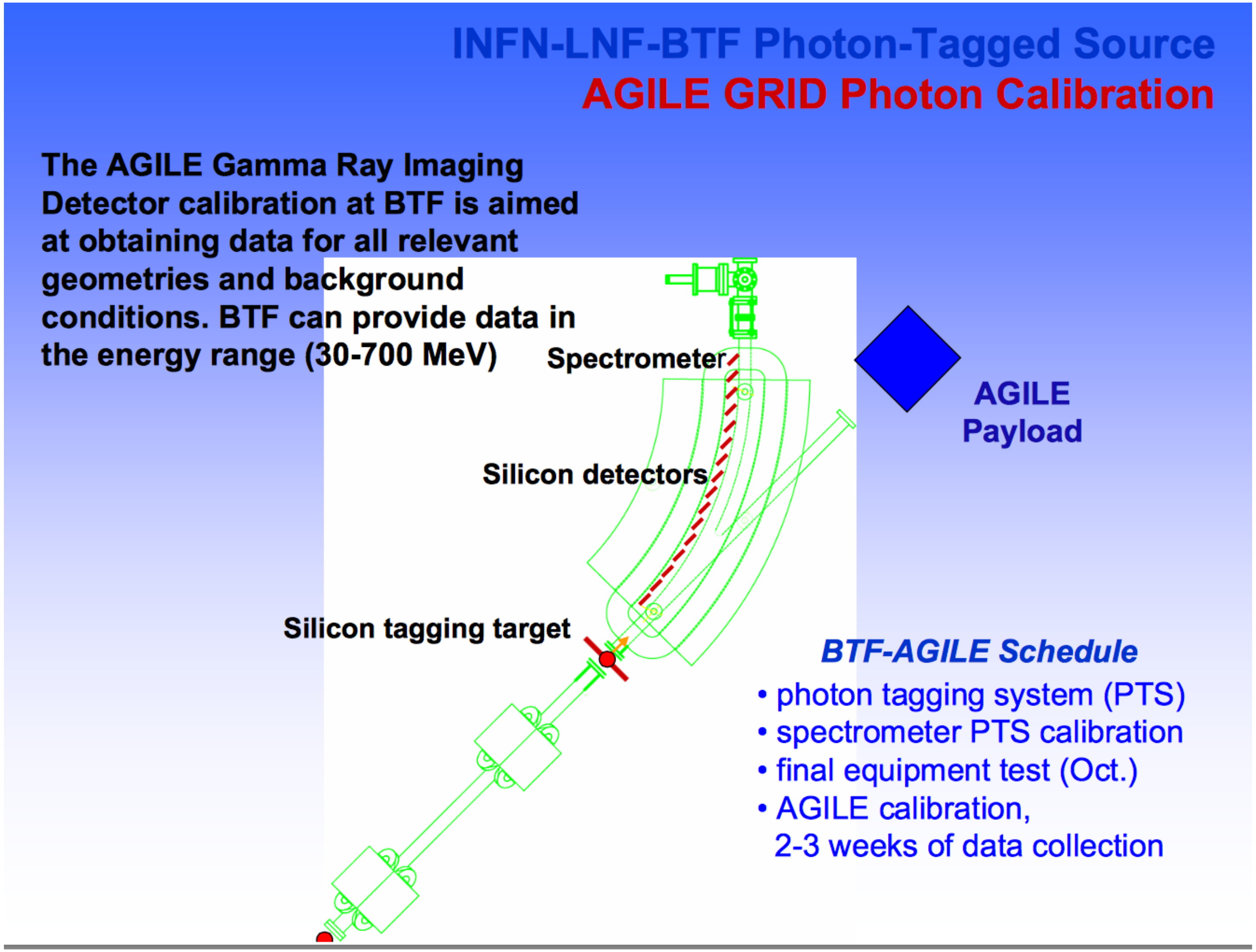
The gamma ray beam at the CERN PS T9 line was produced by bremsstrahlung between electrons and the upstream materials. A magnet has been used to well separate electrons from photons. Finally a beam dump has been used to stop electrons.

- Tagged photon beam
  - An external tracker (4 x-y view silicon strip detector) was used to track electrons upstream and downstream the magnet, read-out by means of an external DAQ
  - Trigger on S4&S_{front} & Cherenkovs
  - External DAQ was synchronized with the CU one, then the data have been merged with the CU one
  - Different electron beam energy in the range 0.5-2.5 GeV and magnetic field intensity have been used to provide a gamma spectrum to the CU below 2 GeV
- Not tagged photon beam
  - Trigger on S_{front} & Cherenkov
  - Full bremsstrahlung spectrum from 2.5GeV/c electron beam

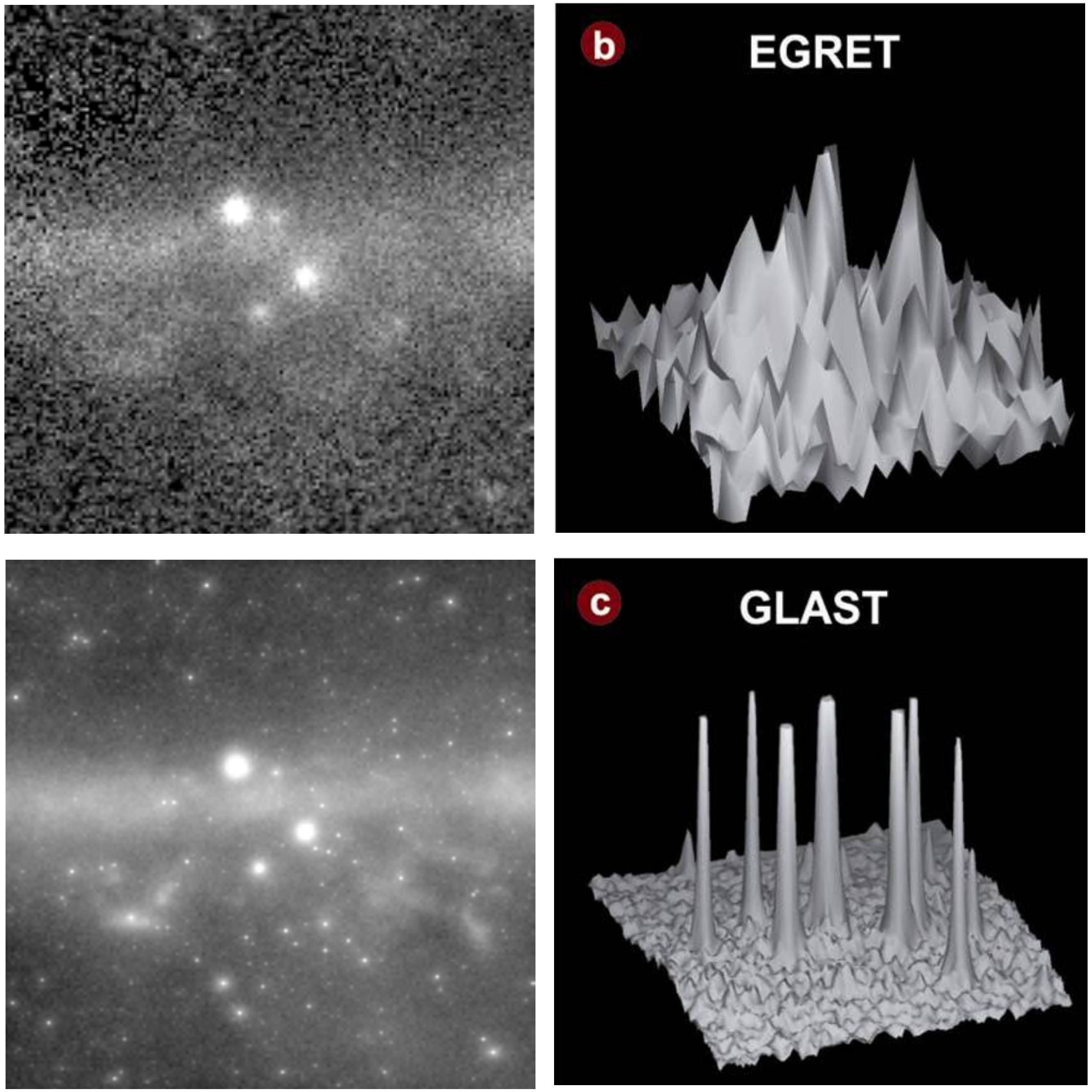
AGILE calibration



AGILE calibration



Technology impact -- PSF



Cygnus region (15^0 x 15^0), $E\gamma > 1$ GeV

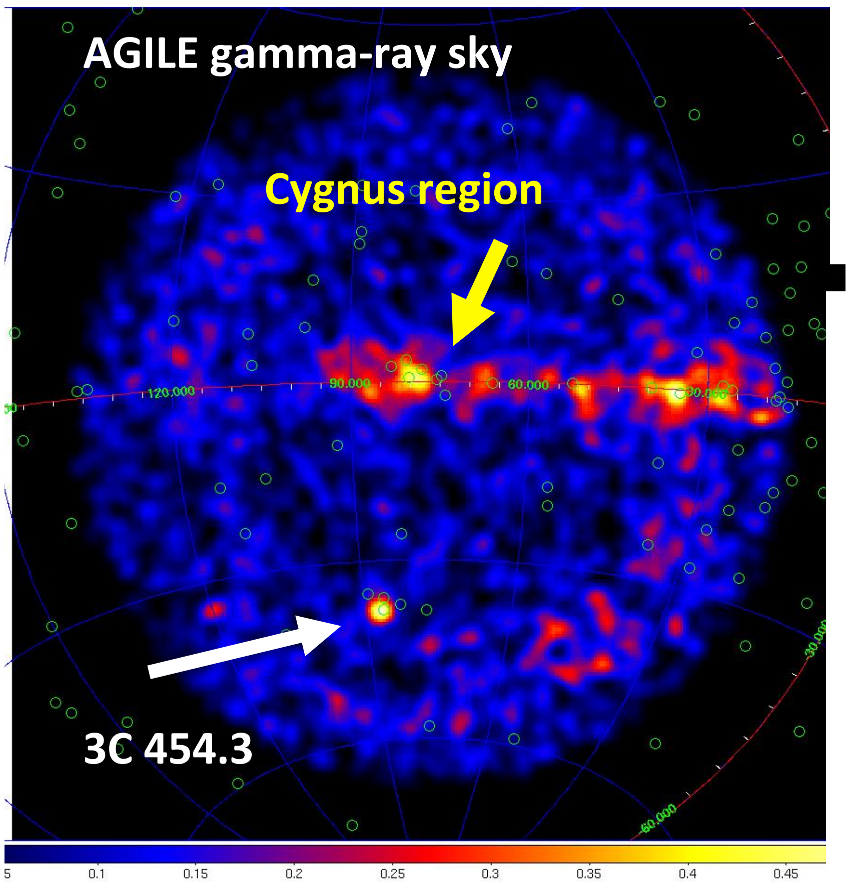
EGRET
(1991-2000)
Phases 1-5

Spark chamber
- **sense electrode spacing ~mm**
- **sensitive layer depth ~cm**
    - ***up to 28 hit over >1m***

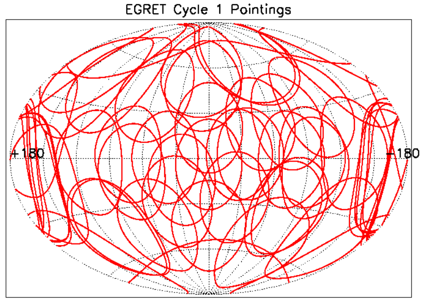
LAT
(2008- >2013)
1-yr simulation

Si-strip detectors
- **sense electrode spacing ~0.2mm**
    - ***better single hit resolution***
- **sensitive layer depth ~0.4mm**
    - ***up to 36 hit over 0.8m***
    - ***converter proximity to minimize MCS***

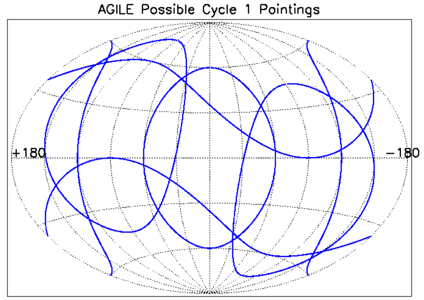
Technology impact - FoV

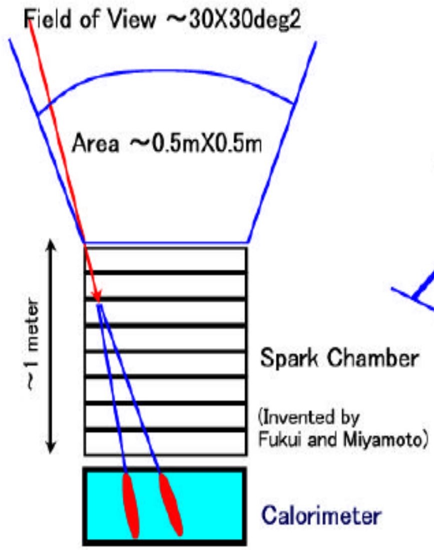


EGRET Cycle 1 Pointings

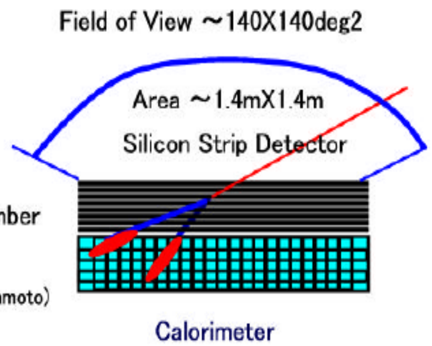


AGILE Possible Cycle 1 Pointings



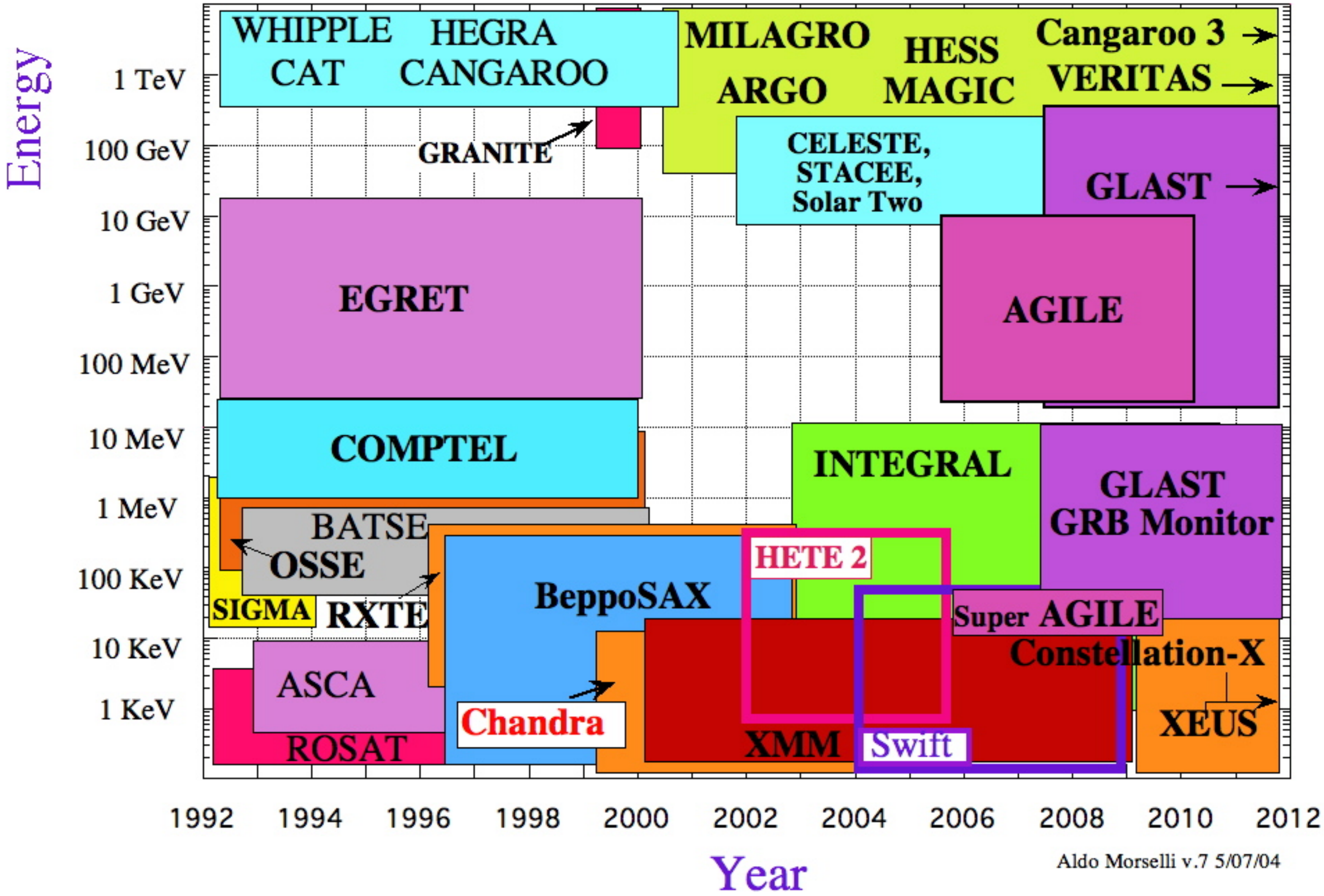


EGRET on Compton GRO



GLAST Large Area Telescope

After a long story ...



AGILE

AGILE

agenzia spaziale italiana

INAF

INFN

CARLO GAVAZZI
Carlo Gavazzi Space SpA

OERLIKON CONTRAVES

ALCATEL ALENIA SPACE
An Alcatel/Finmeccanica company

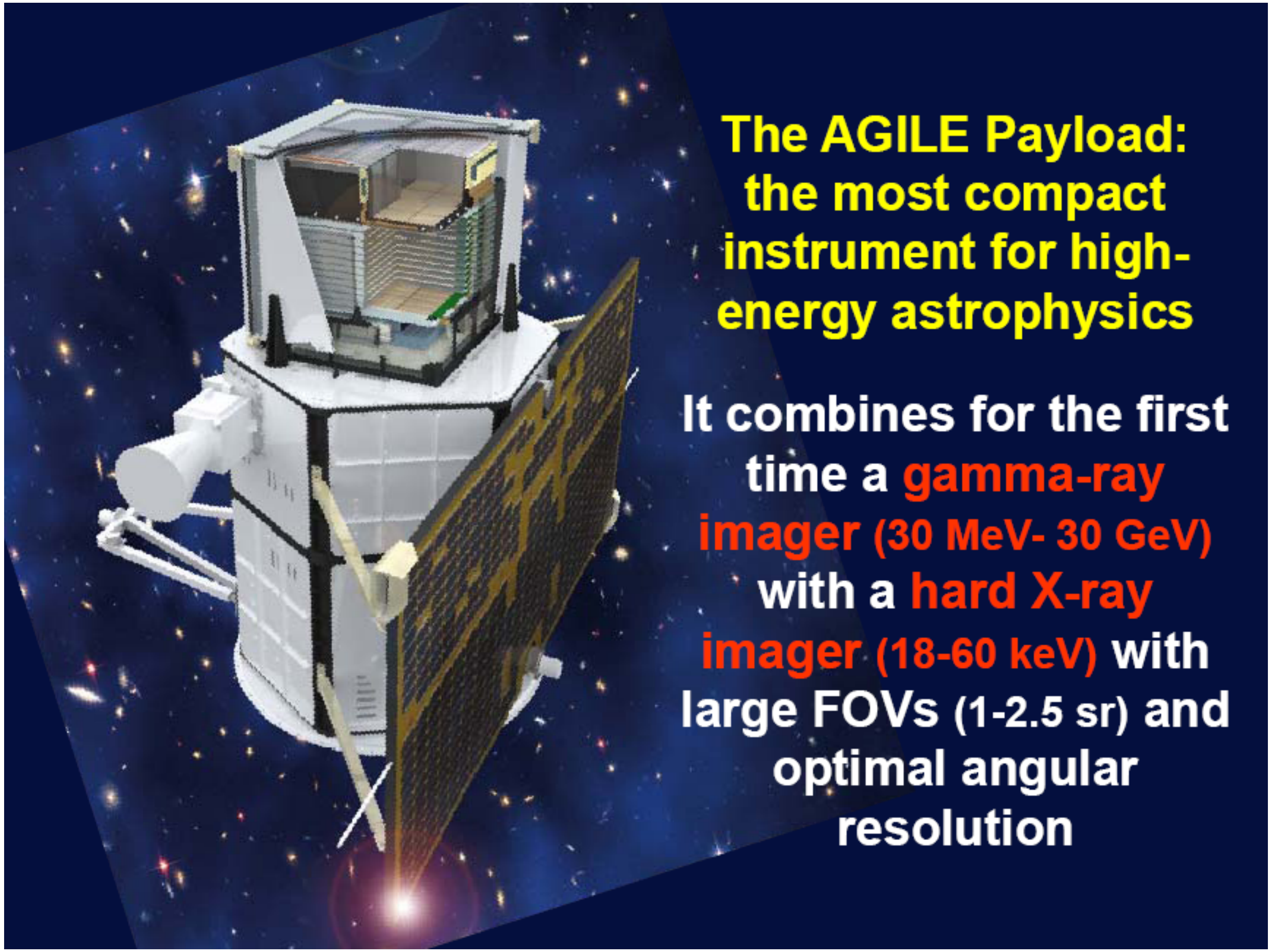
telespazio
A Finmeccanica/Alcatel company

Galileo Avionica

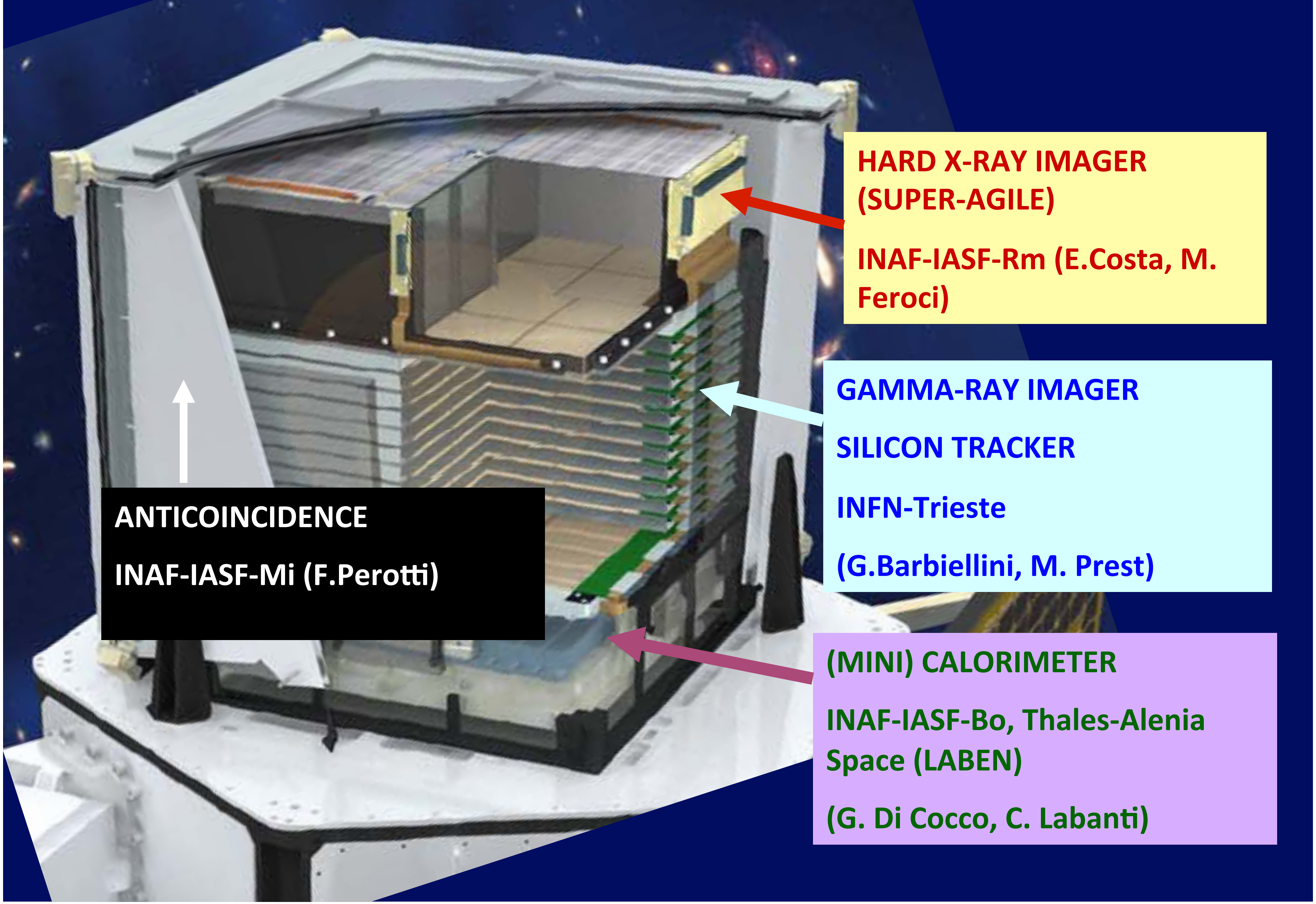
MIPOT

ENEA

AGILE instrument



AGILE: inside the cube…



The Silicon Tracker

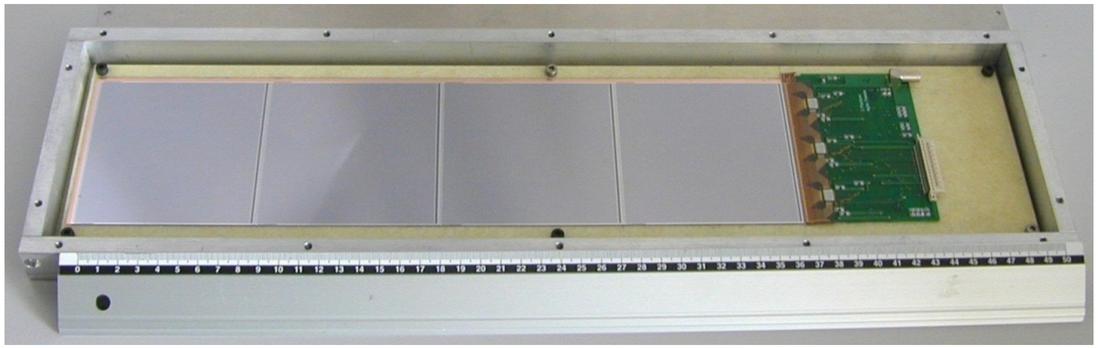
The AGILE silicon detectors

Detector specifications:

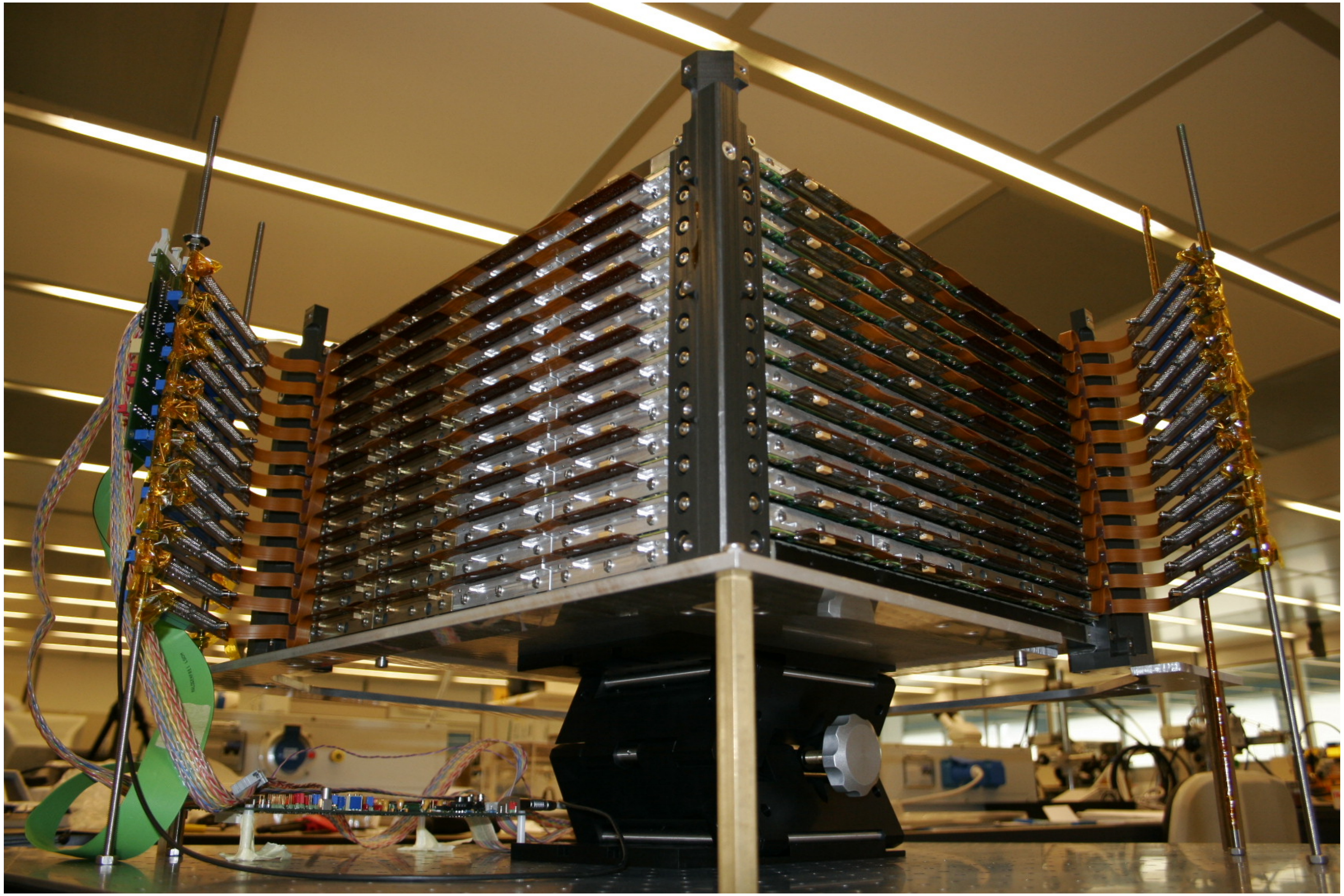
- dimension: 9.5x9.5 cm^2
- thickness: 410 μm (6 inch technology)
- readout pitch: 242 μm;
  physical pitch: 121 μm (one floating strip)
- number of strips/ladder: 384
- Single side and AC-coupled
- leakage current: 2 nA/cm^2 at Vbias=2.5*V_{FD} =200 V
- polarization resistor: 40 MΩ
- coupling capacitor: 55 pF/cm
- Al strip resistance: 4.3 Ω/cm
- max number of bad strips: <1%
- average number of bad strips: <0.5%

The AGILE frontend chip: TA1 $\rightarrow$ TAA1

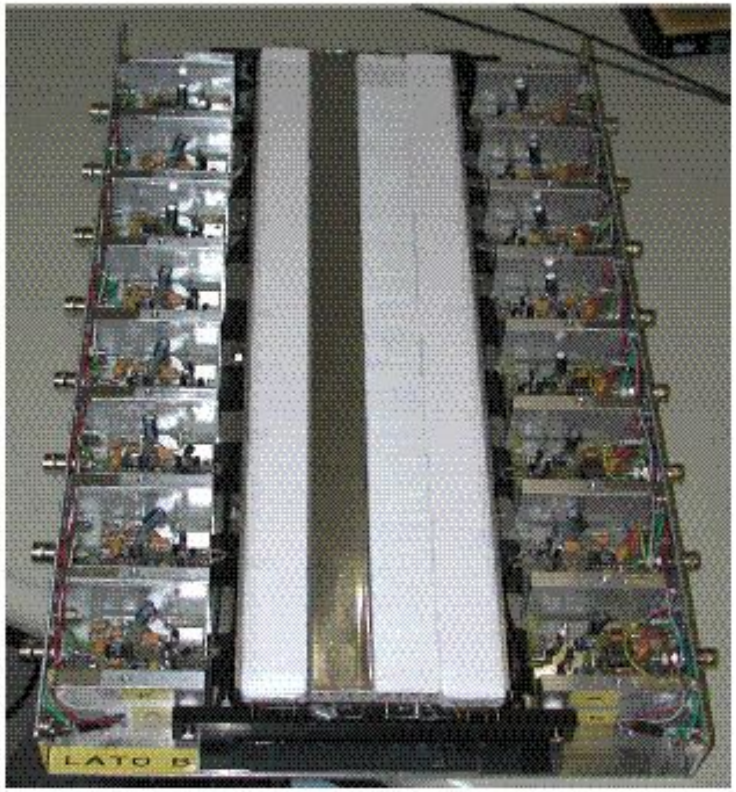
- low noise, low power, SELF-TRIGGERING
- technology: 1.2 μ CMOS, double poly, double metal (final: 0.8 μ BiCMOS on epitaxial layer)
- features:
  - 128 channels
  - gain: 25 mV/fC; range: 18 fC
  - noise (e^- rms): 165+6.1/pF for T_{peak}=2 μs
  - power: <0.4 mW/channel
  - power rails: $\pm$2 V
  - readout frequency: 5 Mhz
  - gain spread: <1.5%
  - threshold offset spread (TA1): 20% (in TAA1 will be implemented a 3 bit DAC per channel)



The AGILE TRK



The CsI Mini-Calorimeter



MINI-CALORIMETER

DETECTOR

30 CsI bars wrapped with tight diffusion material organized in 2 orthogonal trays

- bar dimension: 40x2.3x1.5 cm^3
- total radiation length: $1.5X_0$ (in axis)

FRONTEND ELECTRONICS

- 1 photodiode on each side of the bar
- optically coupled

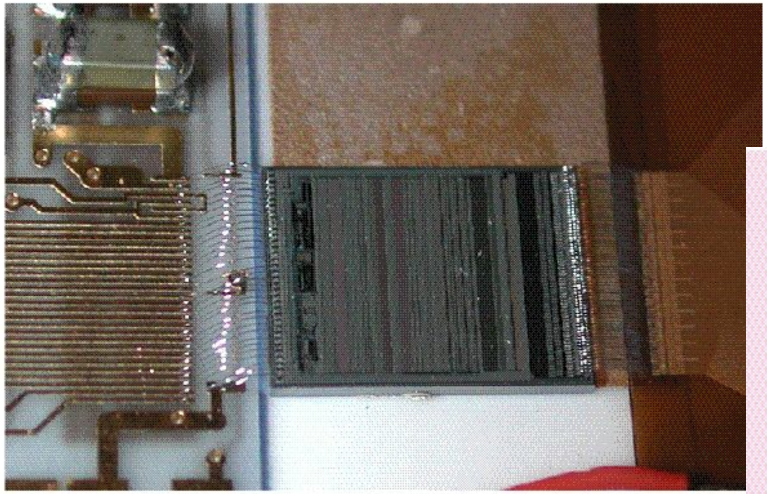
GOAL

- measure energy deposit of the photon conversion pair (GRID mode)
- detect GRBs and transients in the range 0.25-250MeV (BURST mode)

SCIENTIFIC FEATURES

- energy resolution: 22-24%(FWHM) @ 1MeV
  0.7% @ 100MeV
- spatial resolution: 15mm @ 1MeV
  2mm @ 100MeV
- timing resolution: 2μs (BURST mode)

SuperAGILE X-ray detector



SUPER-AGILE

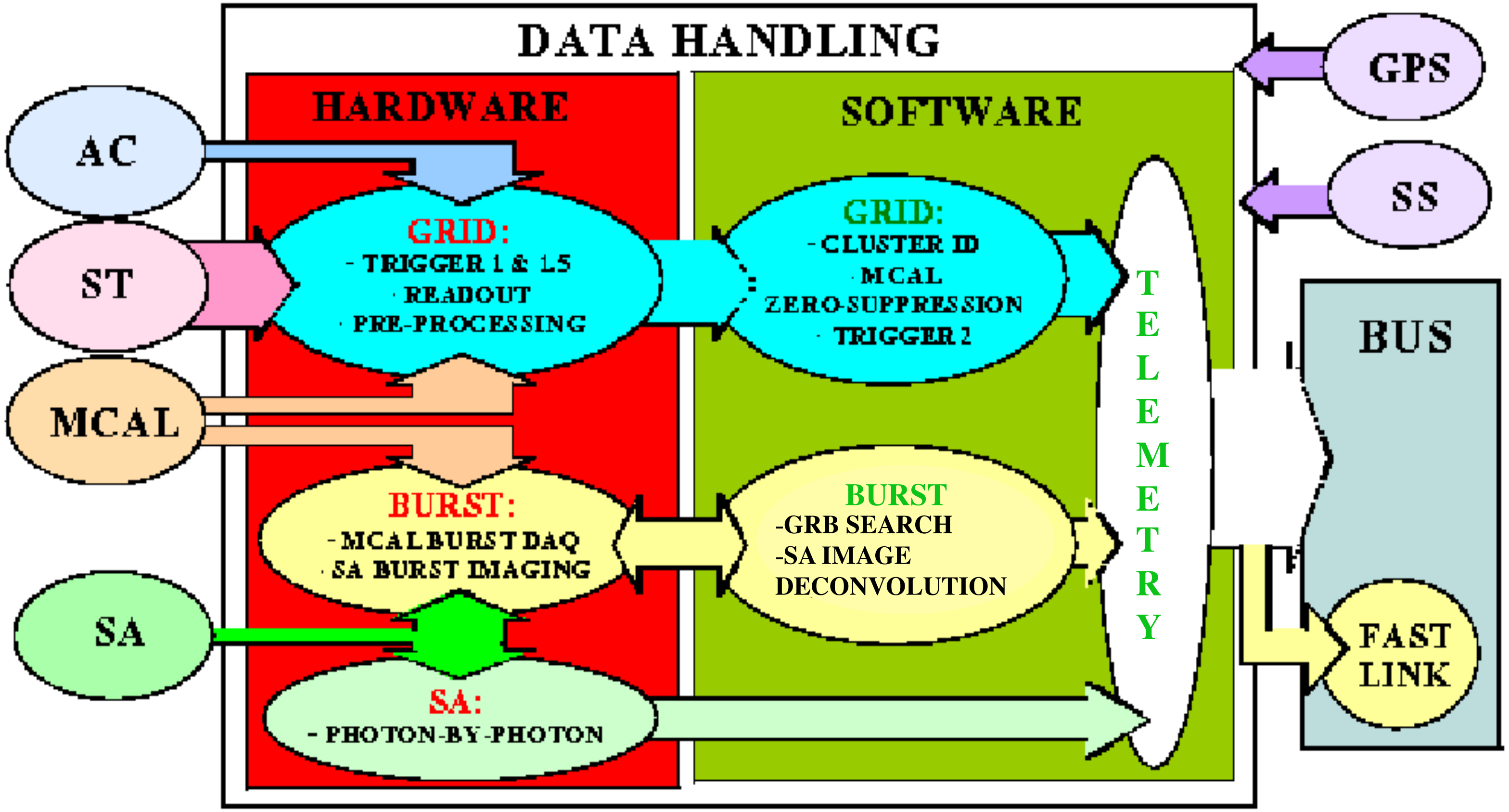
DETECTOR
- plane with 16 silicon tiles organized in 4 1D detectors
- each detector: 1536 readout strips (0.121mm pitch)
- a coded mask system

FRONTEND ELECTRONICS
- 12 self-triggering readout ASICs (128 channels each) per each detector, positioned on a kapton-FR4 hybrid

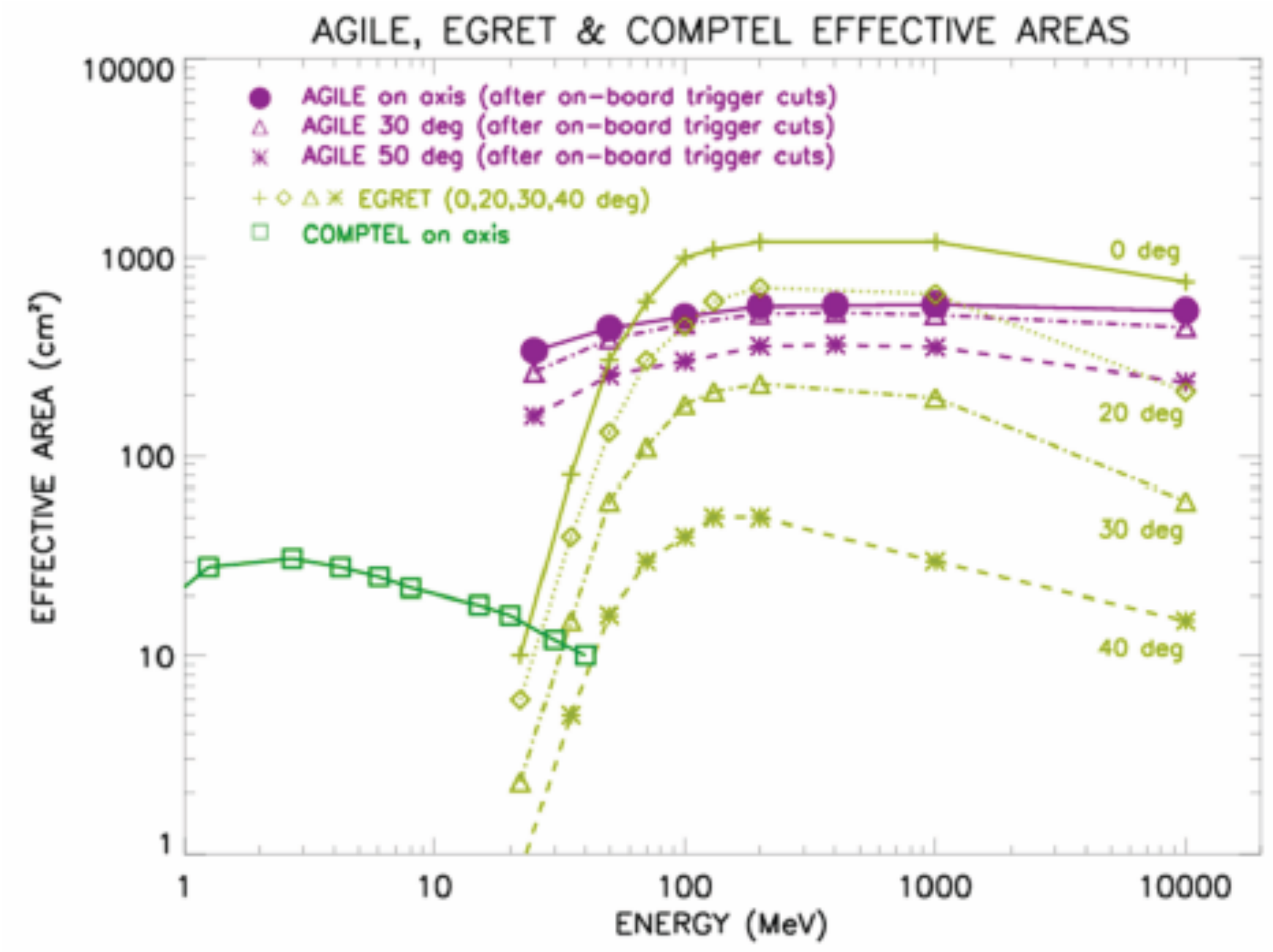
GOAL
measure X-rays in the energy range 10-40keV to detect GRBs, transients, galactic and extra-galactic sources

SCIENTIFIC FEATURES
- imaging: 1'-3' at ~20mCrab
- timing resolution: 5μs
- energy resolution: 4keV (FWHM)
- flux sensitivity: ~5mCrab (15keV)

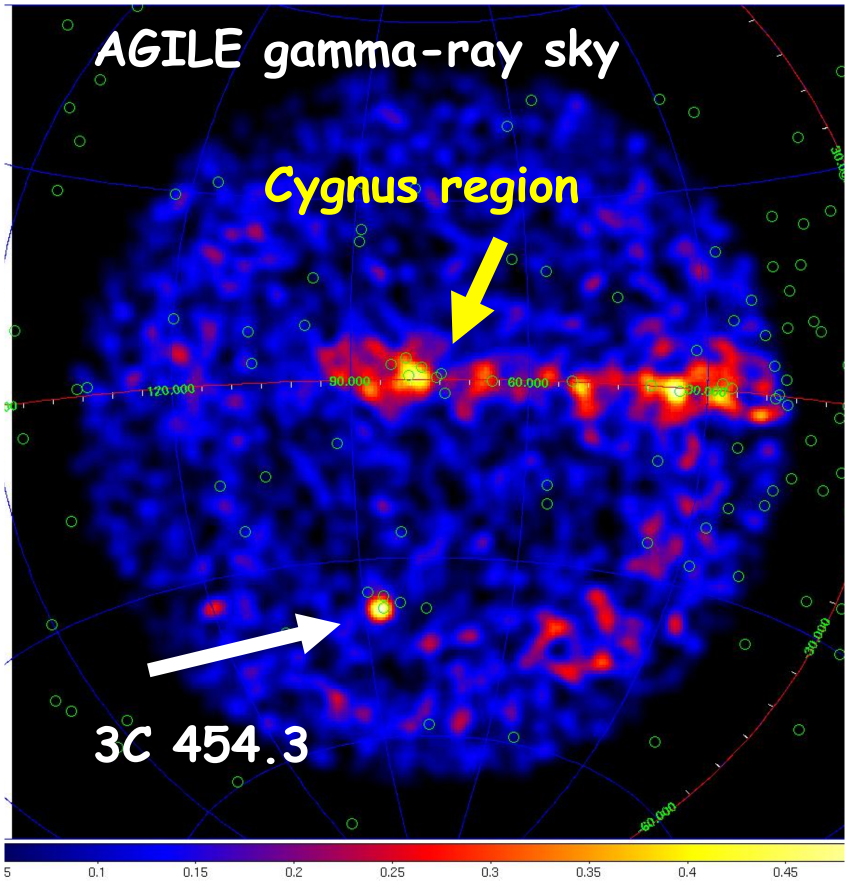
On Board AGILE Trigger

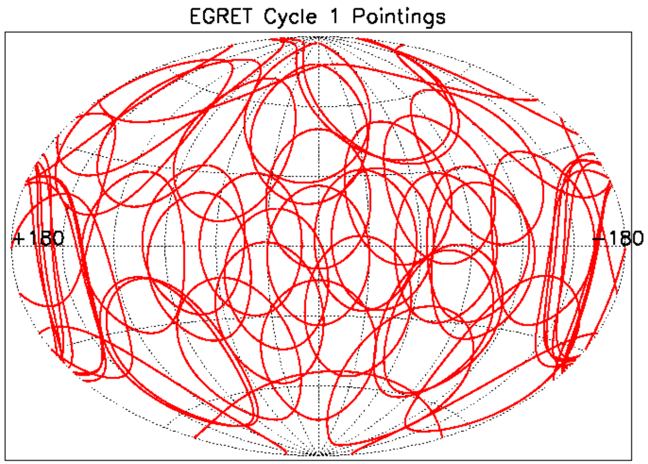


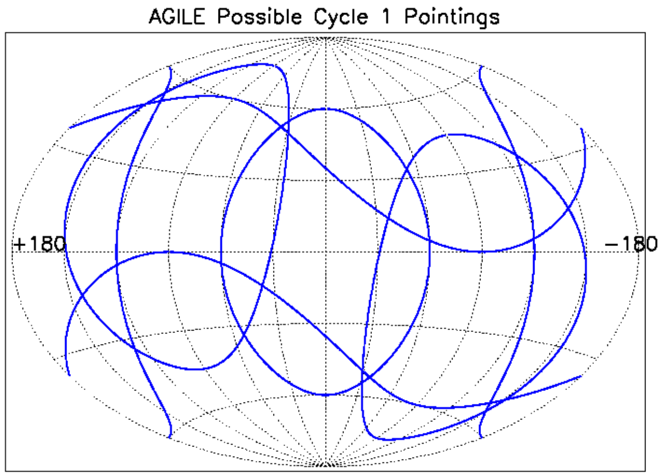
Performance



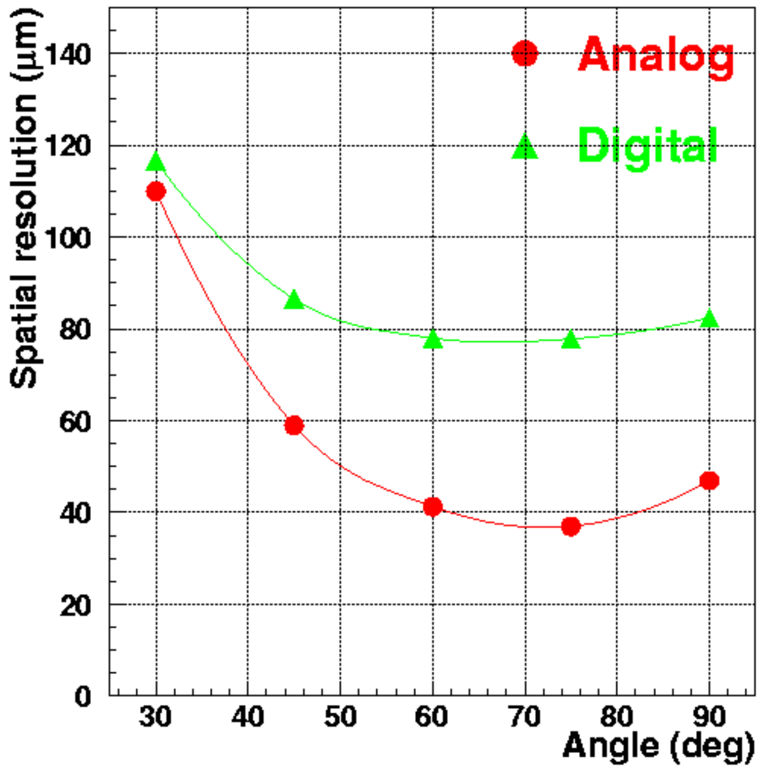
Si Self Trigger and FoV

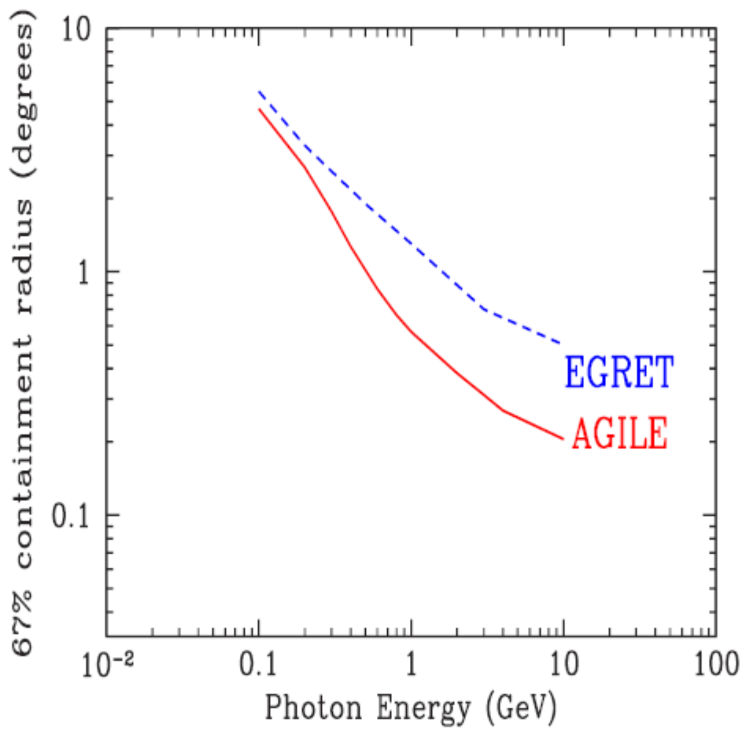






Analog readout and PSF

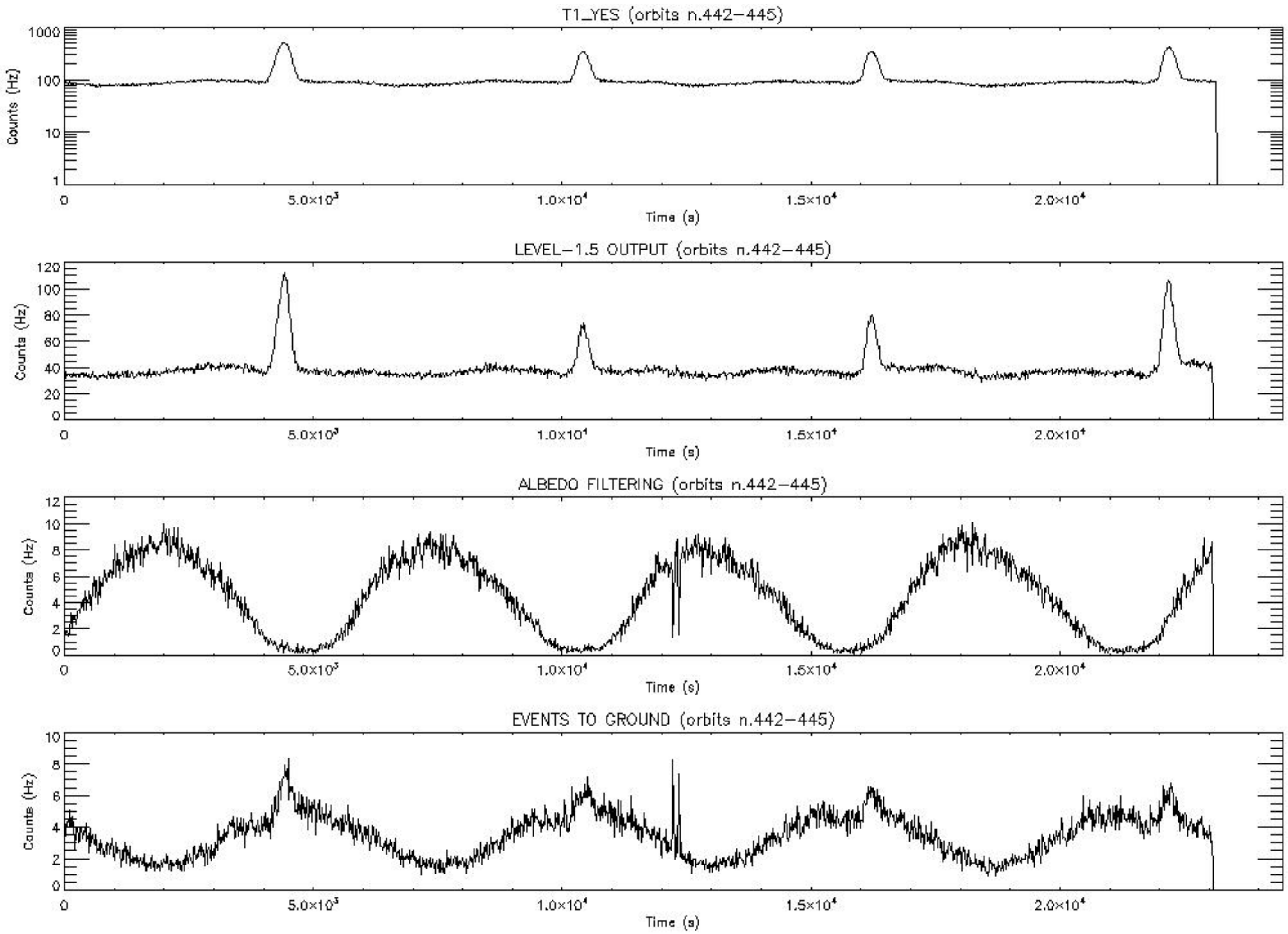




The AGILE launch

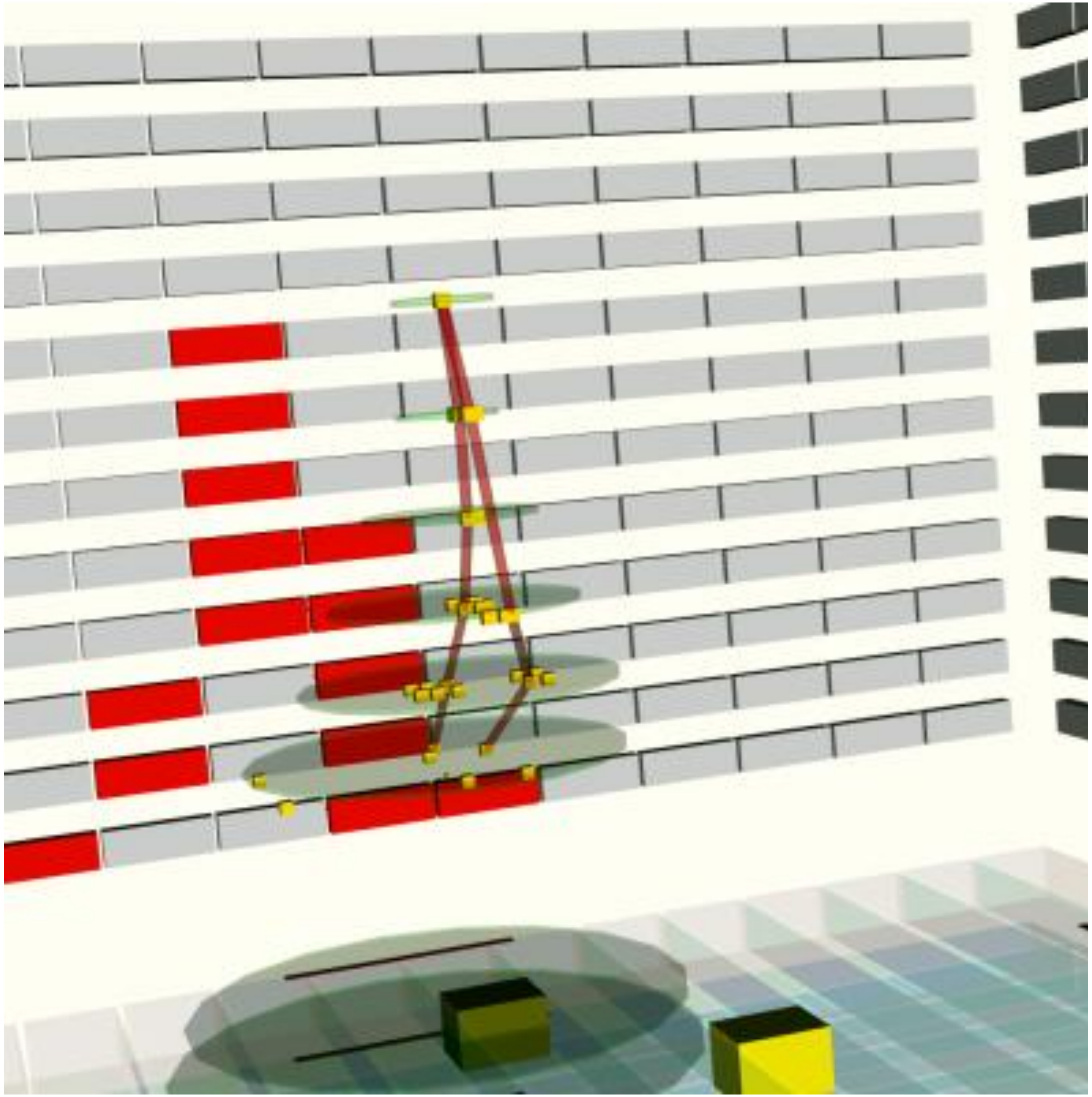
AGILE in orbit

AGILE in orbit

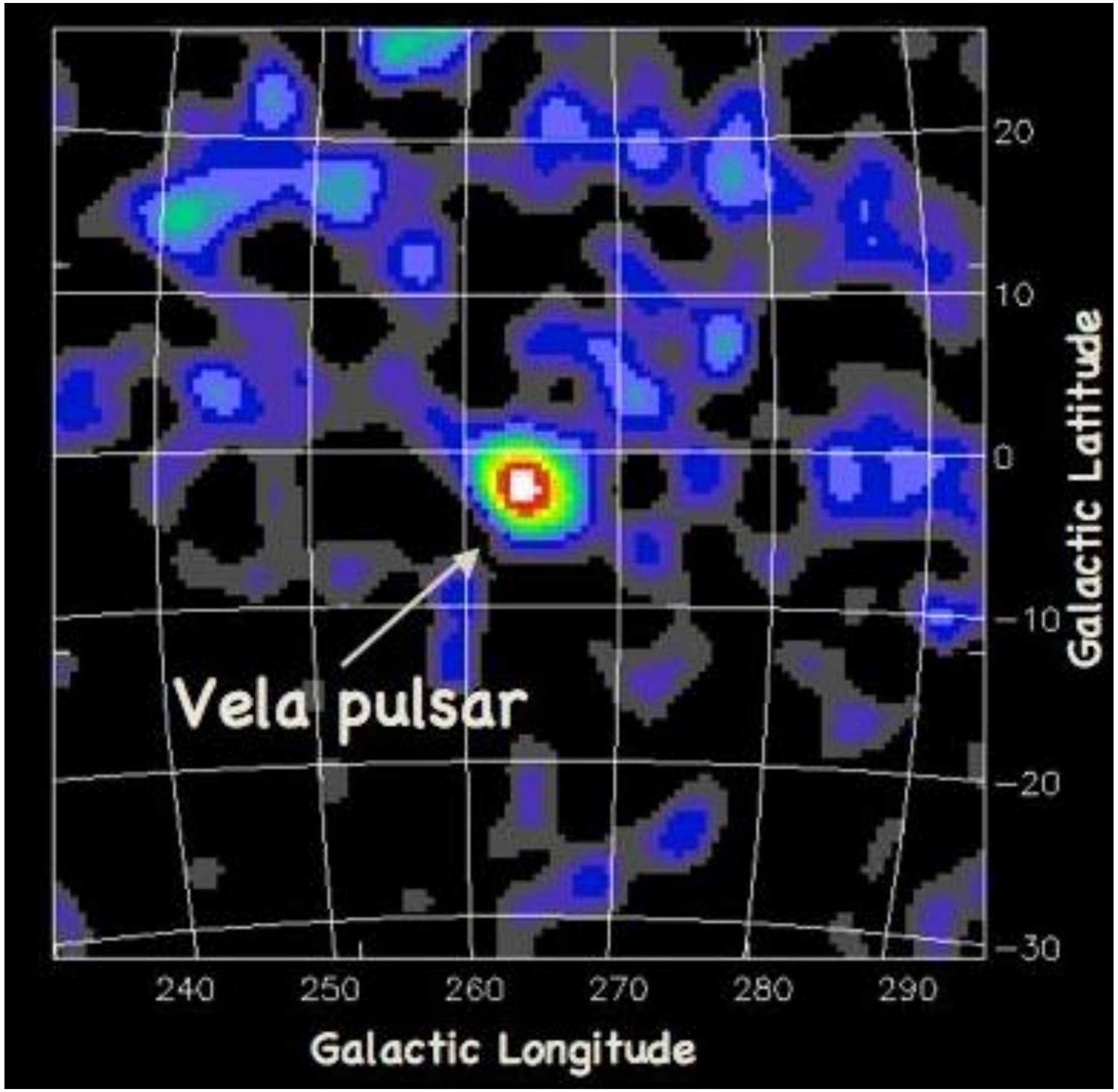


On Orbit Trigger Rates

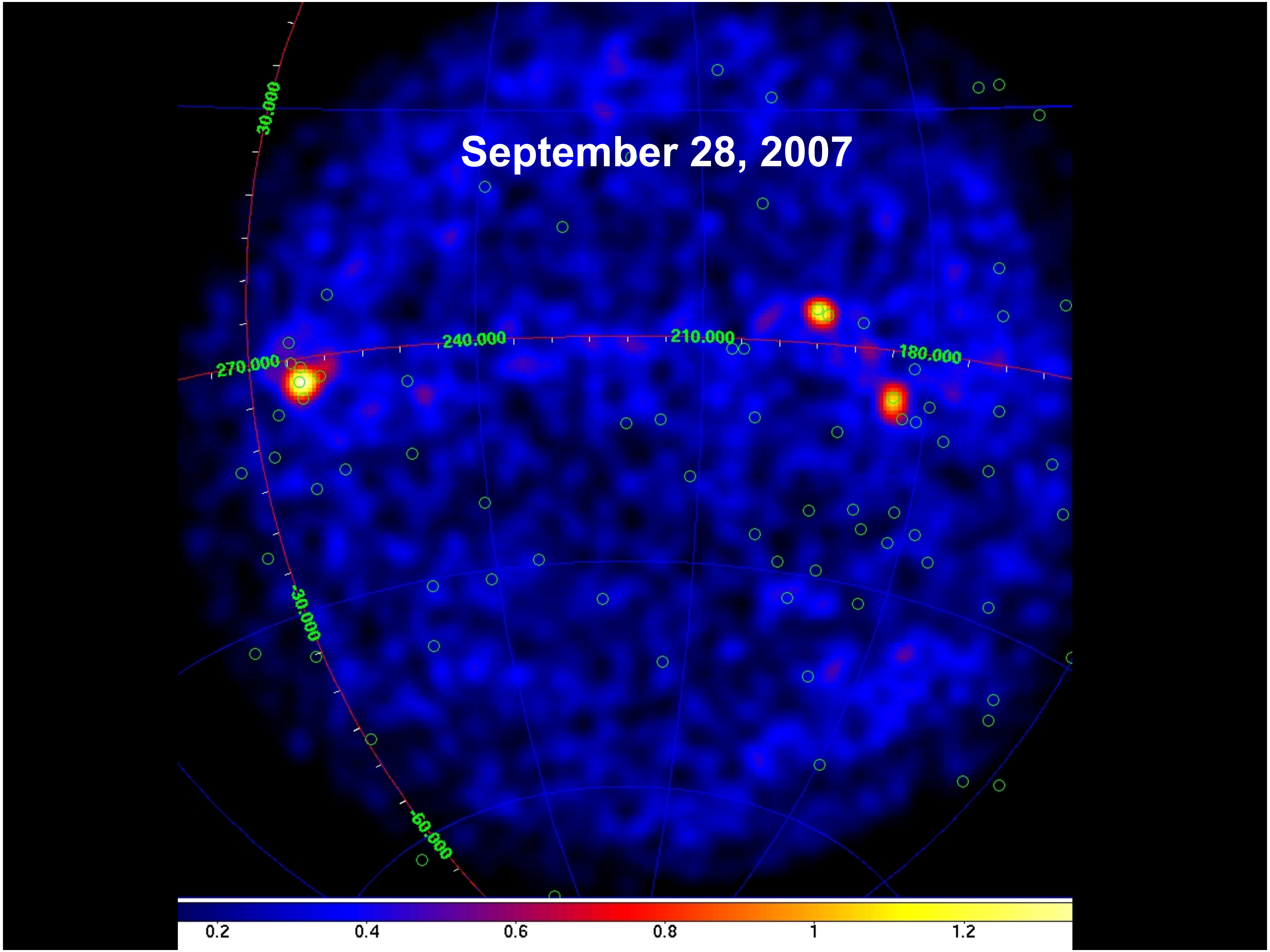
First gamma-ray detected in orbit with the nominal GRID trigger configuration (May 10, 2007)



First Light



Vela pulsar
20
10
0
−10
−20
−30
Galactic Latitude
240
250
260
270
280
290
Galactic Longitude

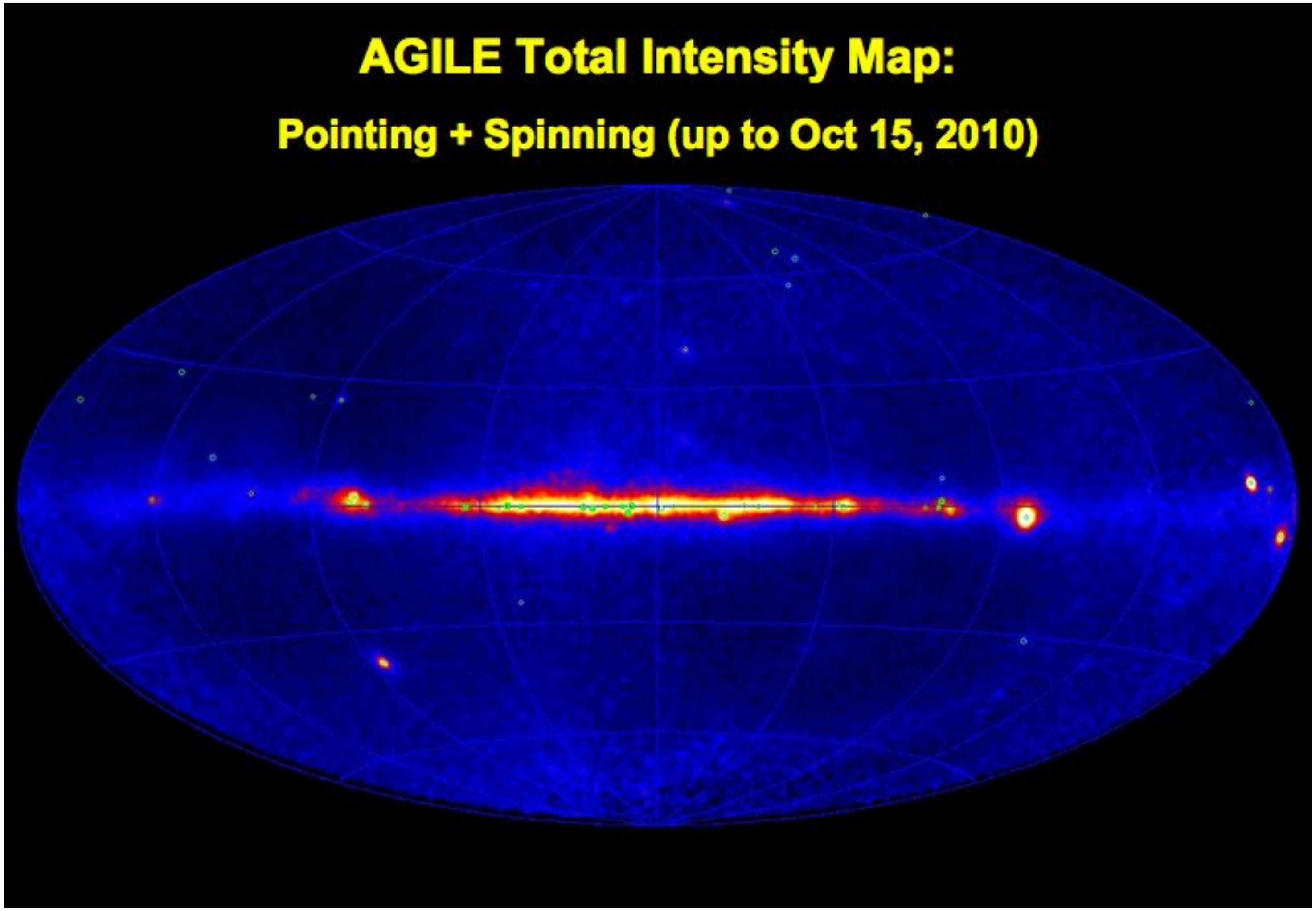


September 28, 2007
30.000
270.000
240.000
210.000
180.000
-30.000
-60.000
0.2
0.4
0.6
0.8
1
1.2

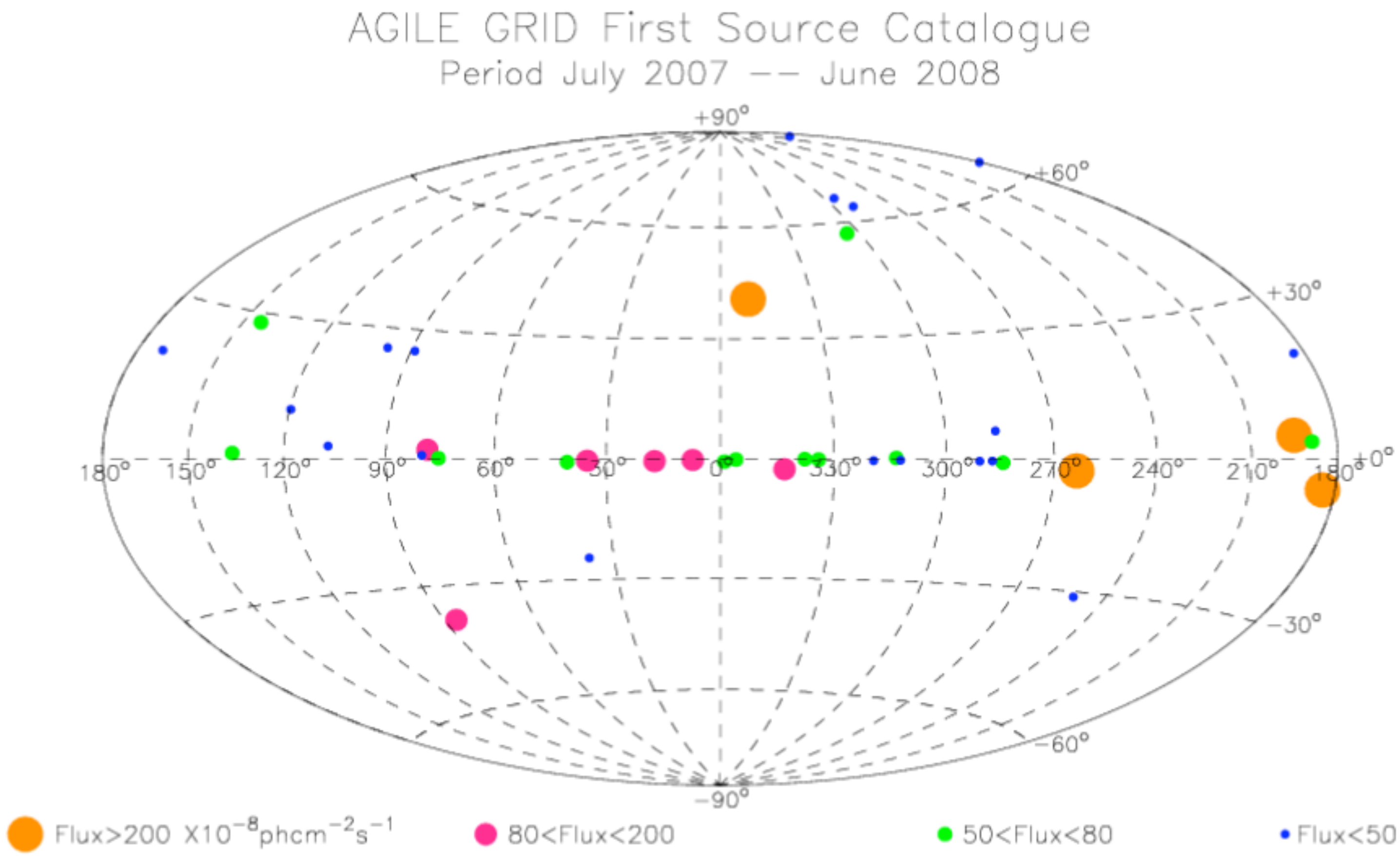
AGILE two lifes

	pointing-AGILE	spinning-AGILE
time period	Jul.07 – Oct.09	Nov. 2010 -
attitude	fixed	variable (spinning, 1°/sec)
sky coverage	1/5	~ 70%
source livetime fraction	~ 0.5	~ 0.2
1-day exposure (30 degree off-axis, 100 MeV)	~ 2 10^7 (cm^2 sec)	(0.5-1) 10^7 (cm^2 sec)

The AGILE sky

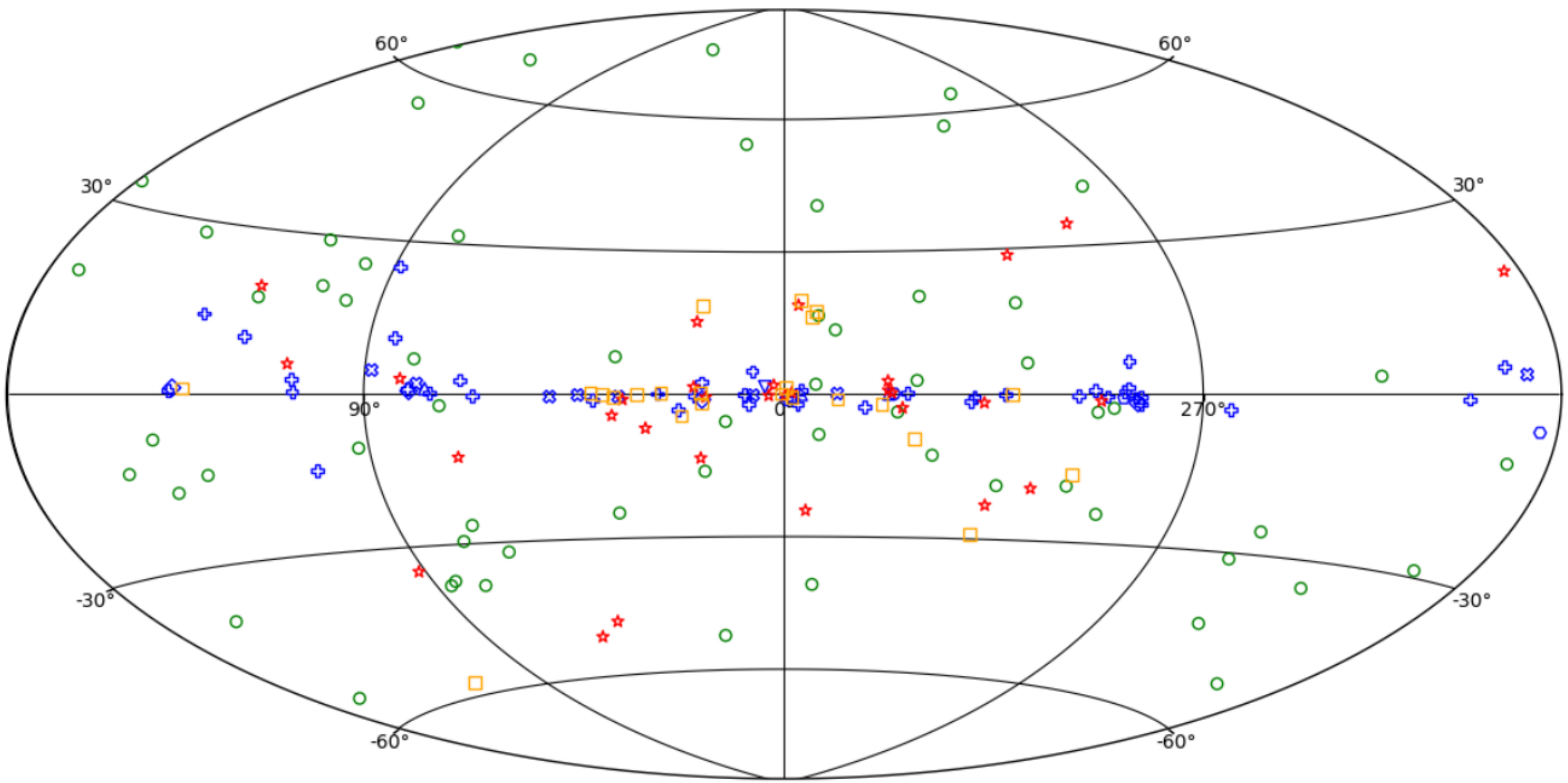


AGILE sources



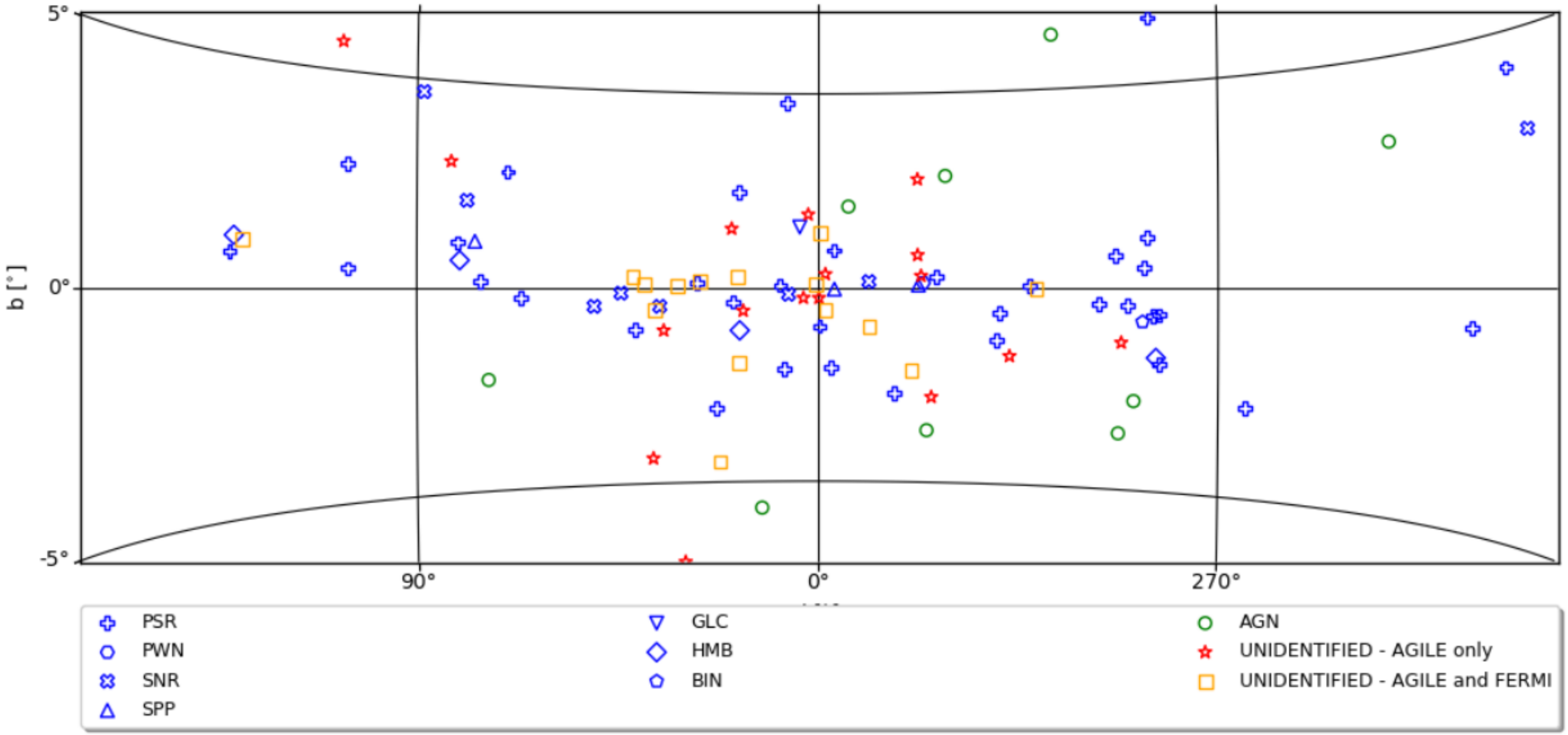
Pittori et al. 2009

AGILE sources



Bulgarelli et al. 2019

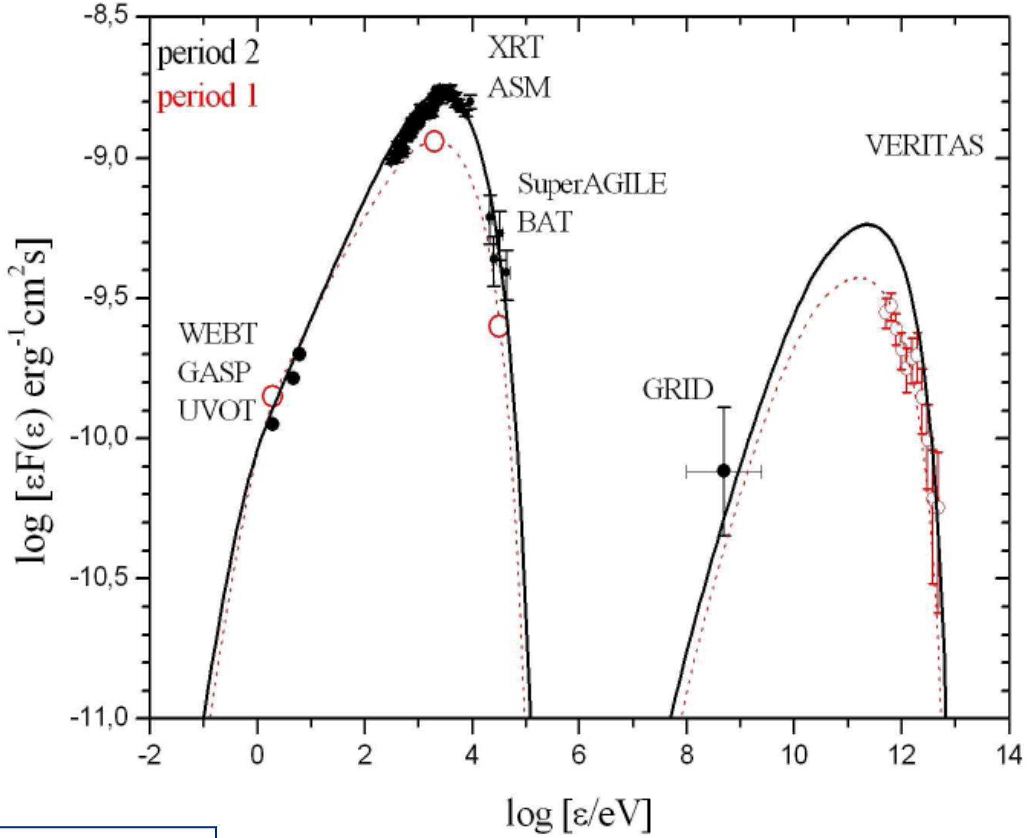
AGILE sources



Bulgarelli et al. 2019

Challenge # 1 – AGN

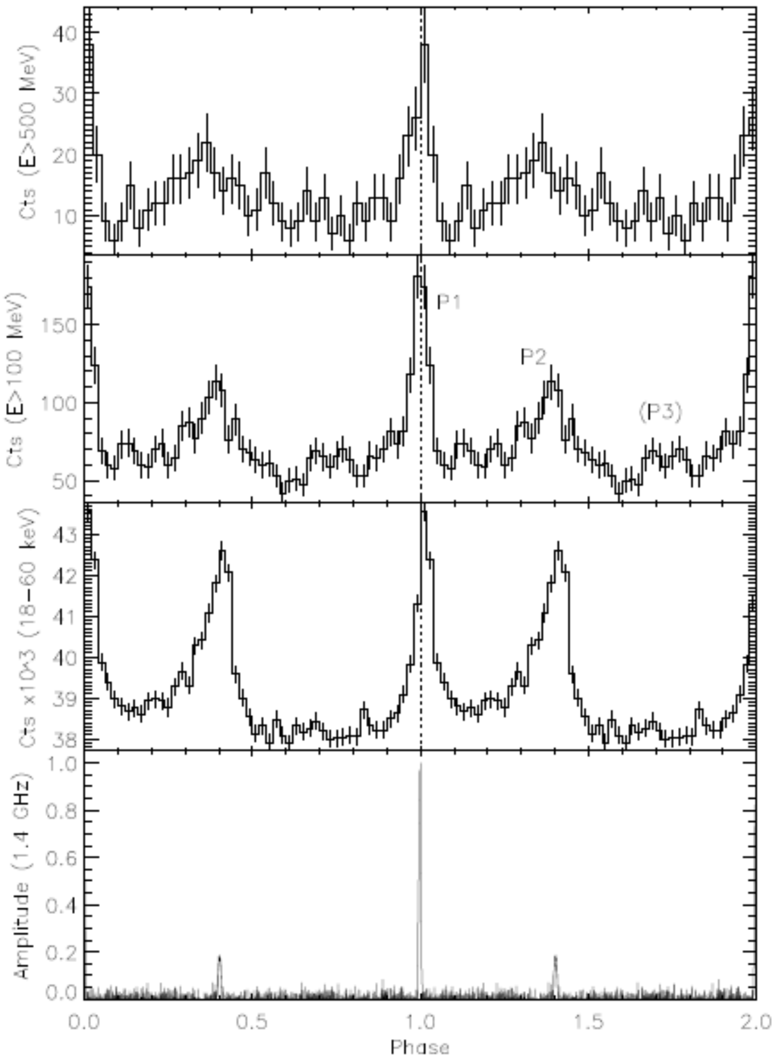
Joint campaign with MAGIC and VERITAS on Mkn 421



Donnarumma et al. 2009

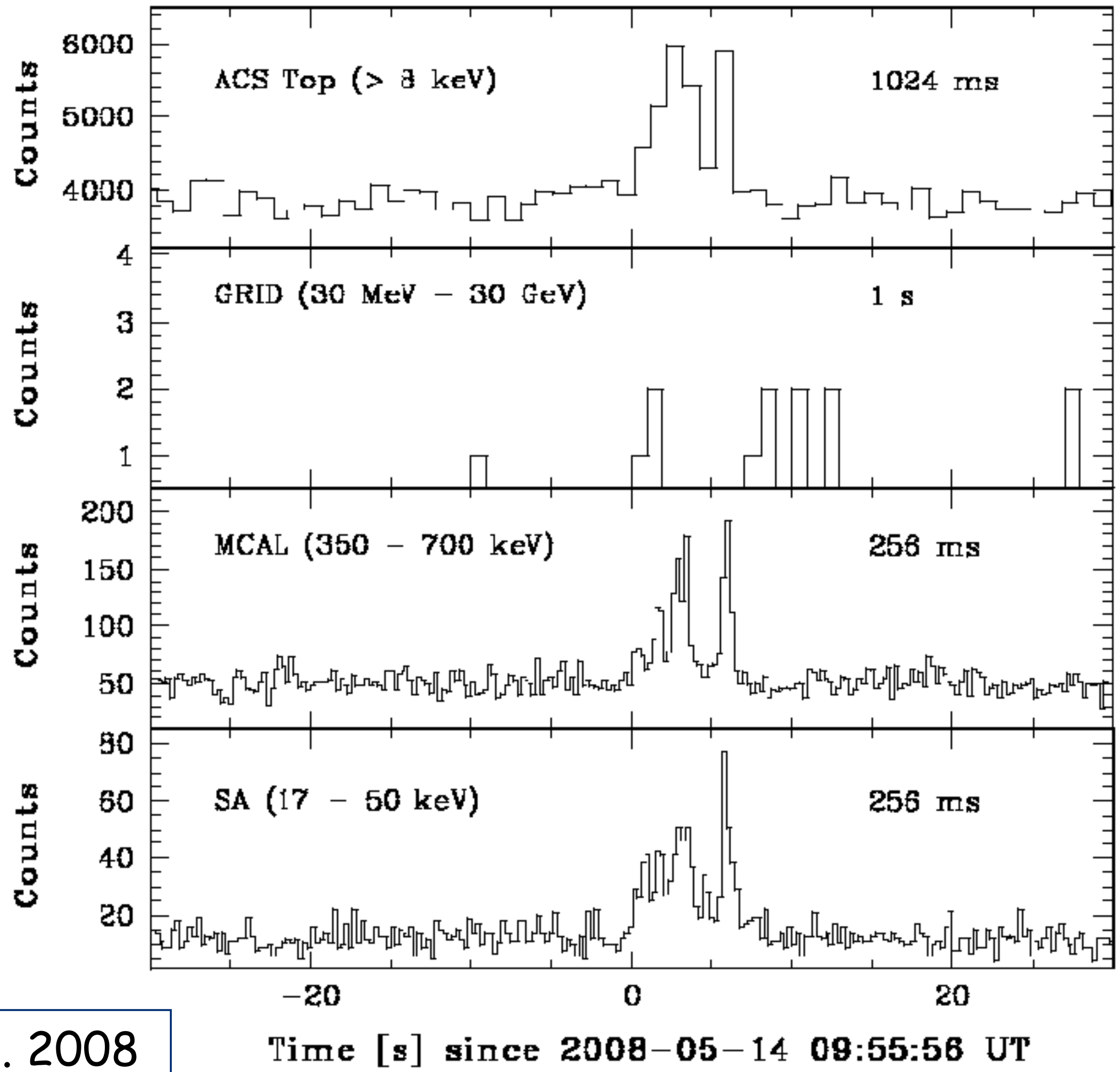
Challenge # 2 – Pulsar

High Precision Timing (eg. Crab PSR)



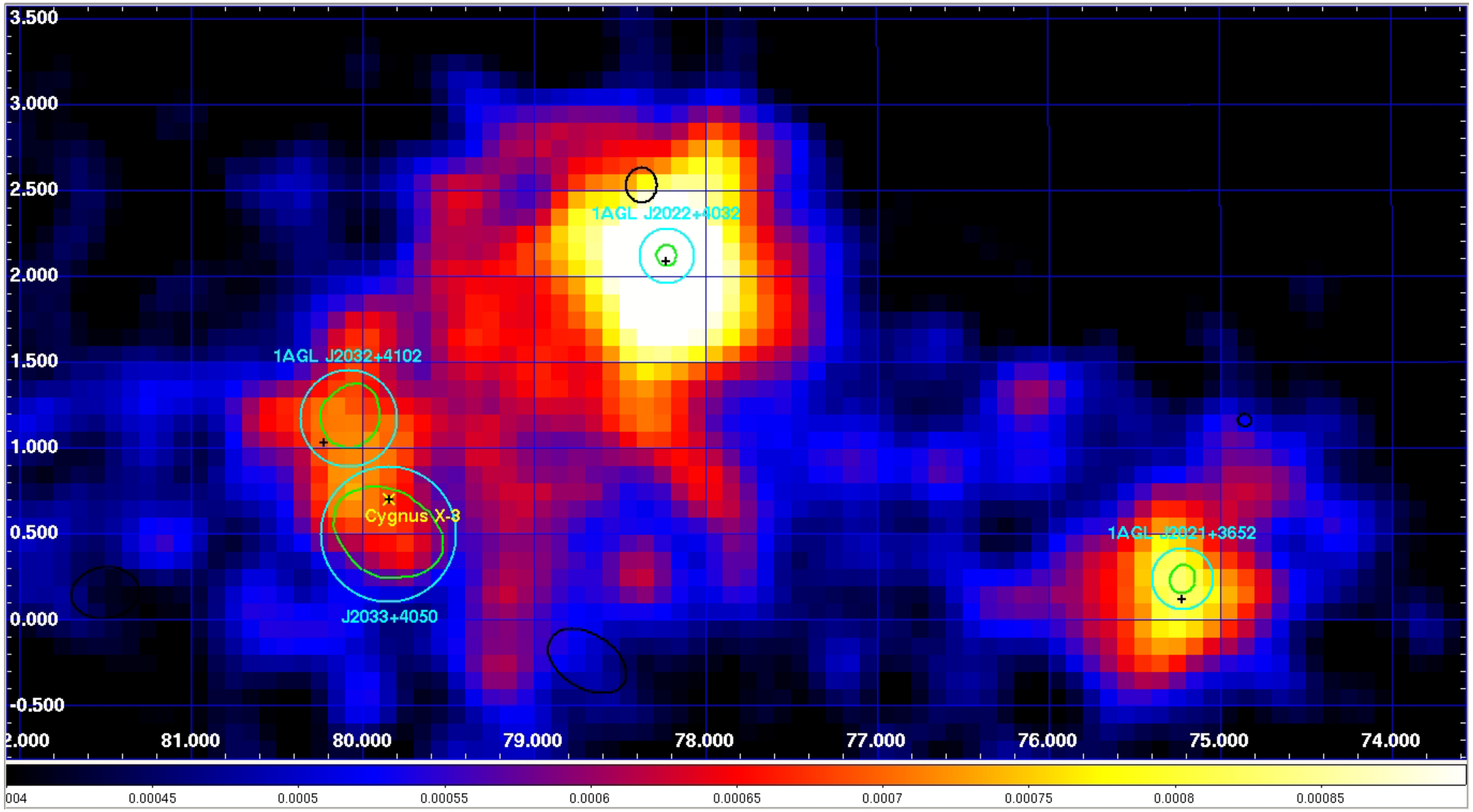
Pellizzoni et al. 2009

Challenge # 3 – GRB



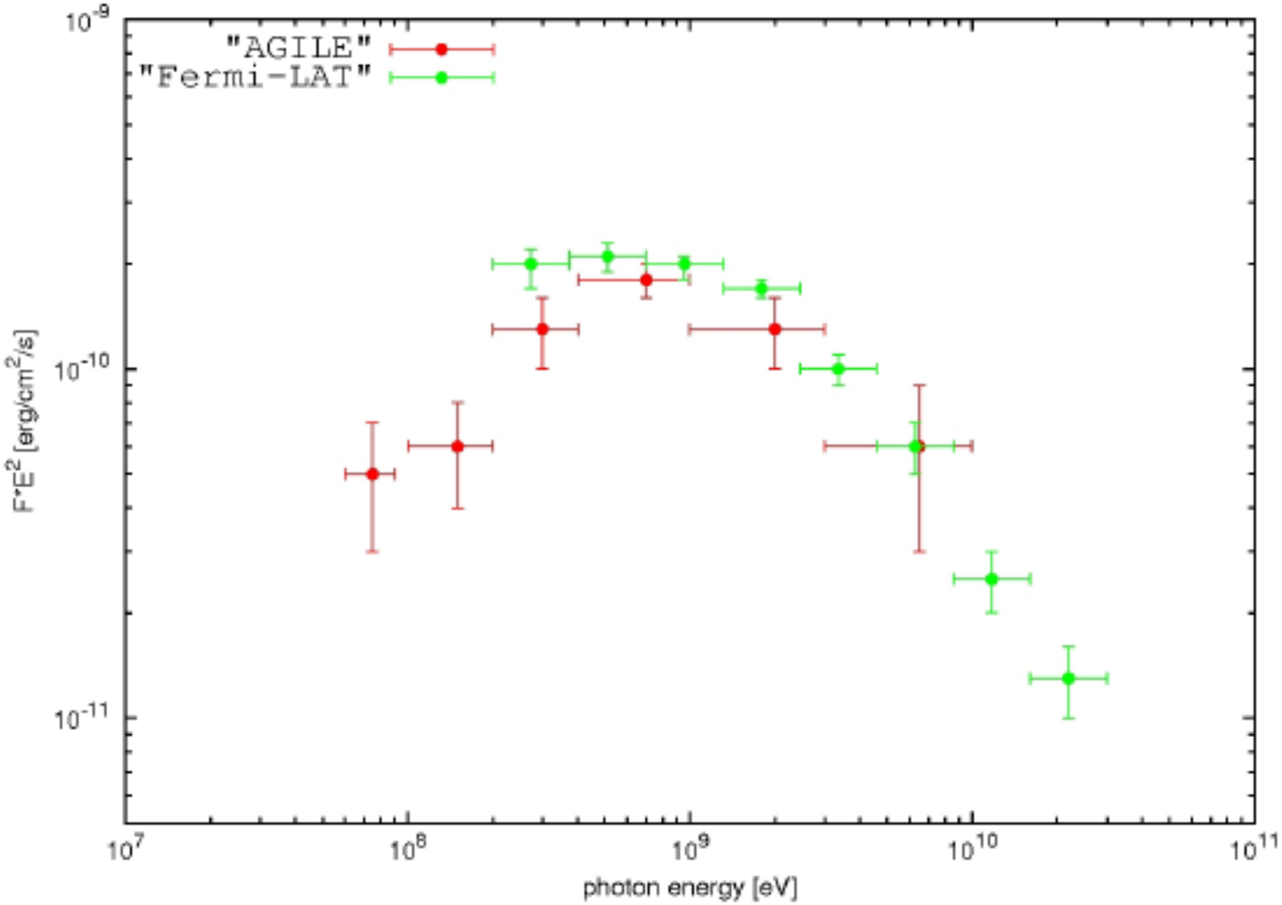
Giuliani et al. 2008

Challenge # 4 – Unidentified



Chen et al. 2011

Challenge # 5 – Spectral resolution

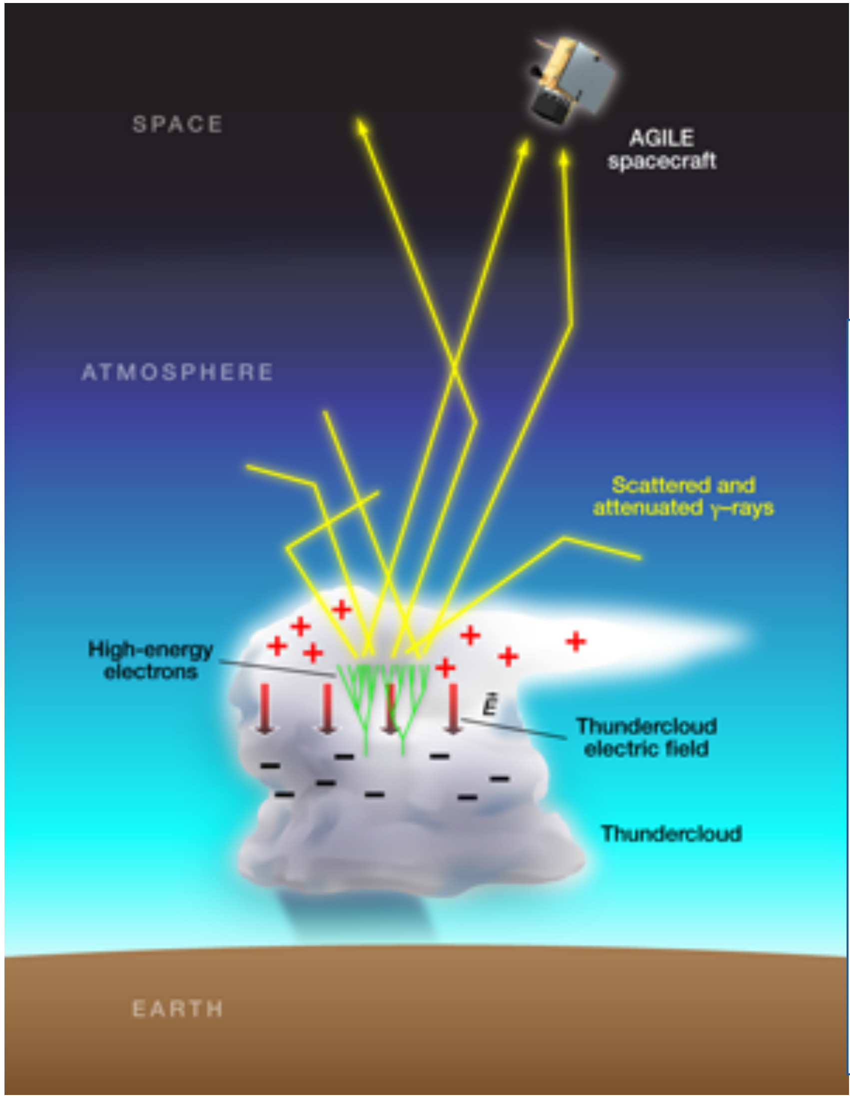


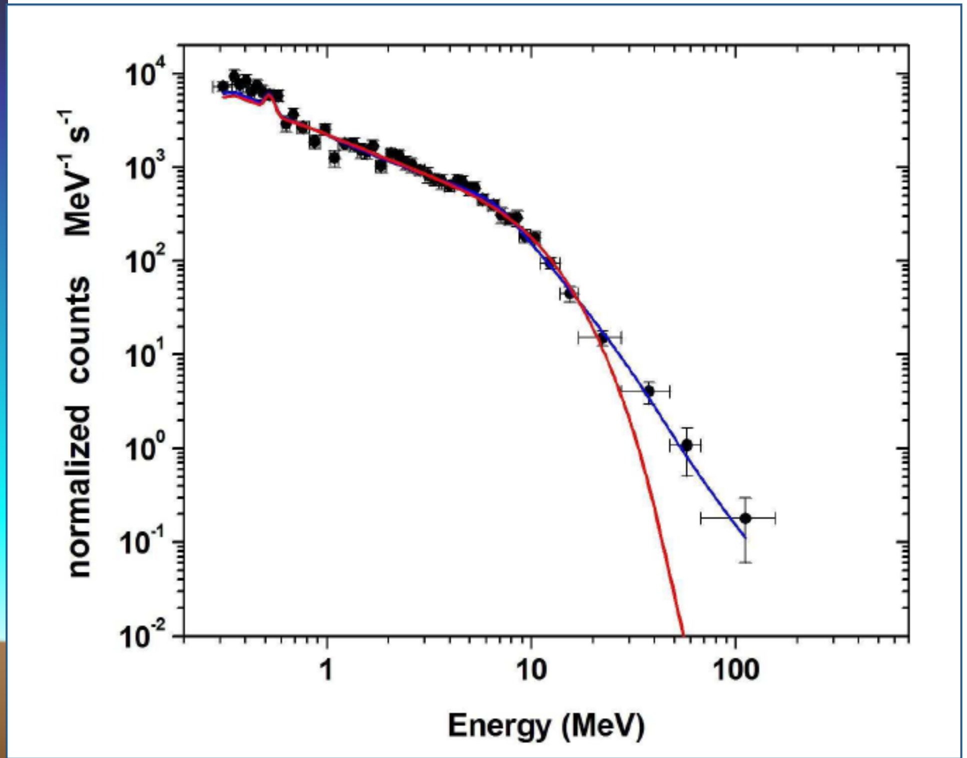
Giuliani et al. 2011

Key AGILE results

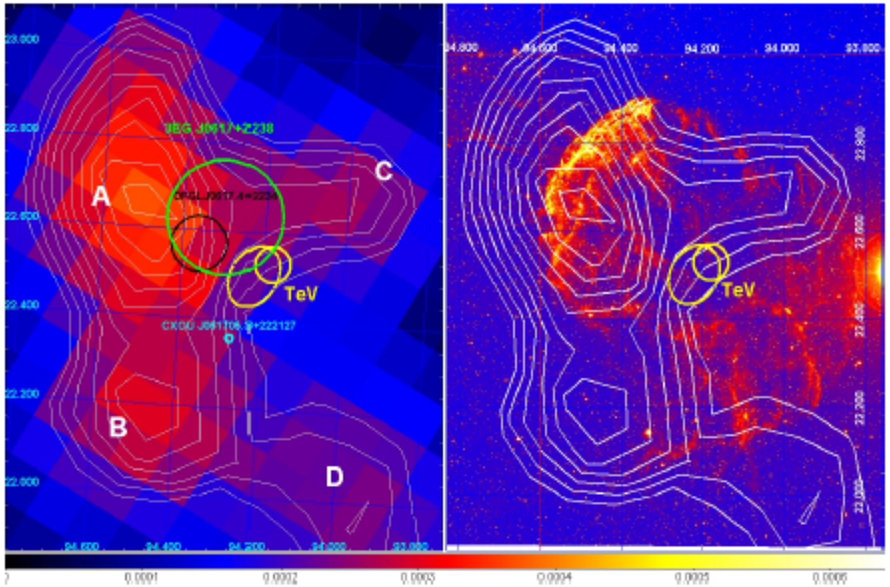
Terrestrial Gamma Ray Flashes

Marisaldi et al. 2010

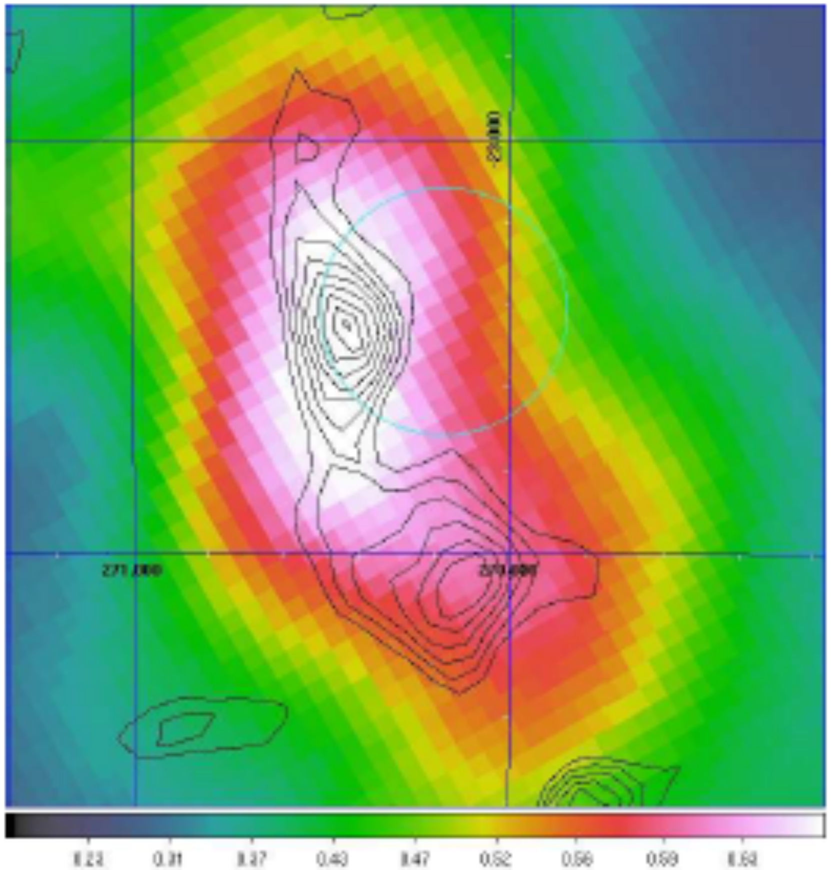




Supernova Remnants

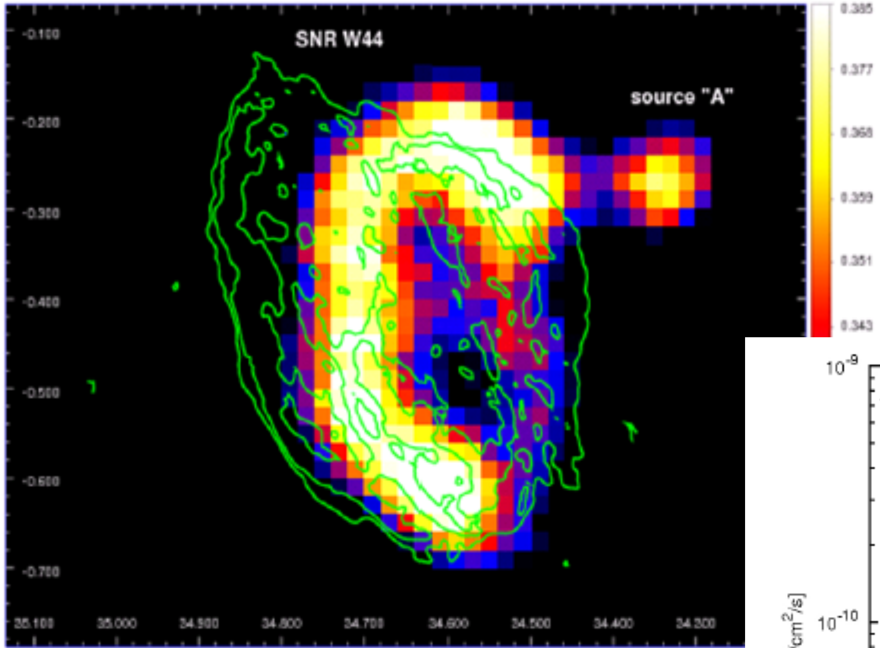


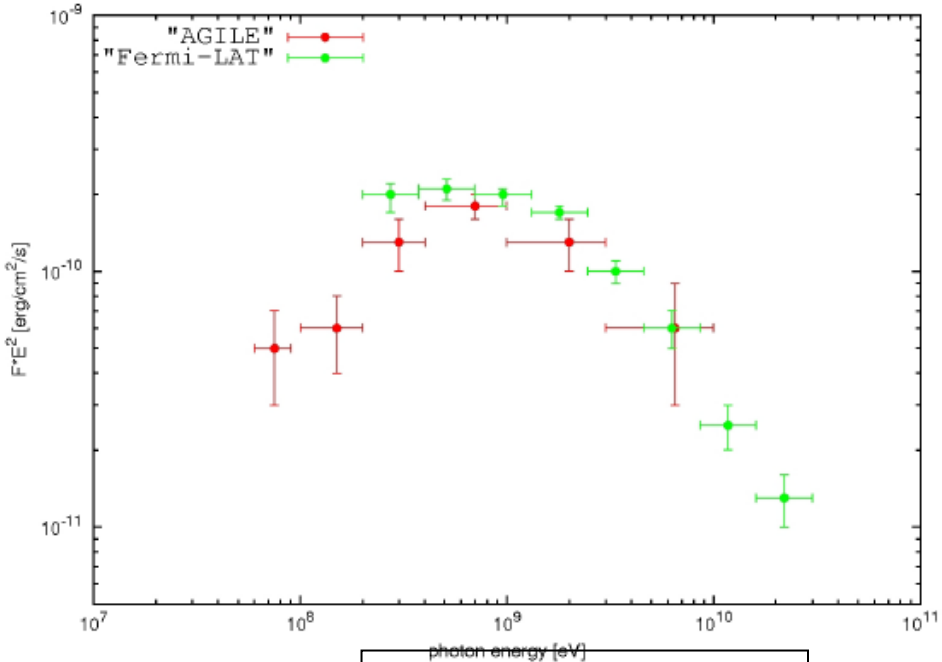
Tavani et al. 2010



Giuliani et al. 2010

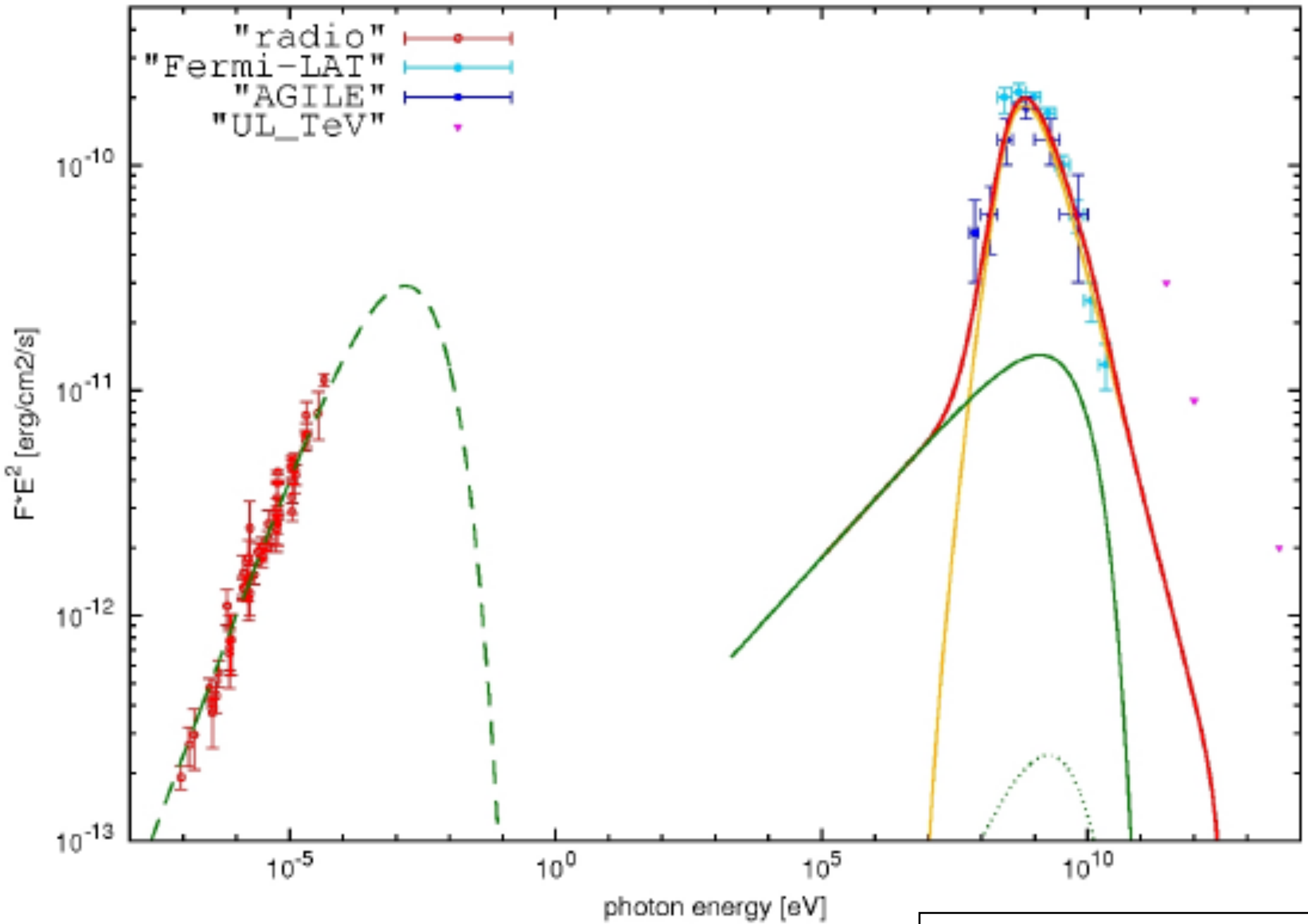
SNR W44





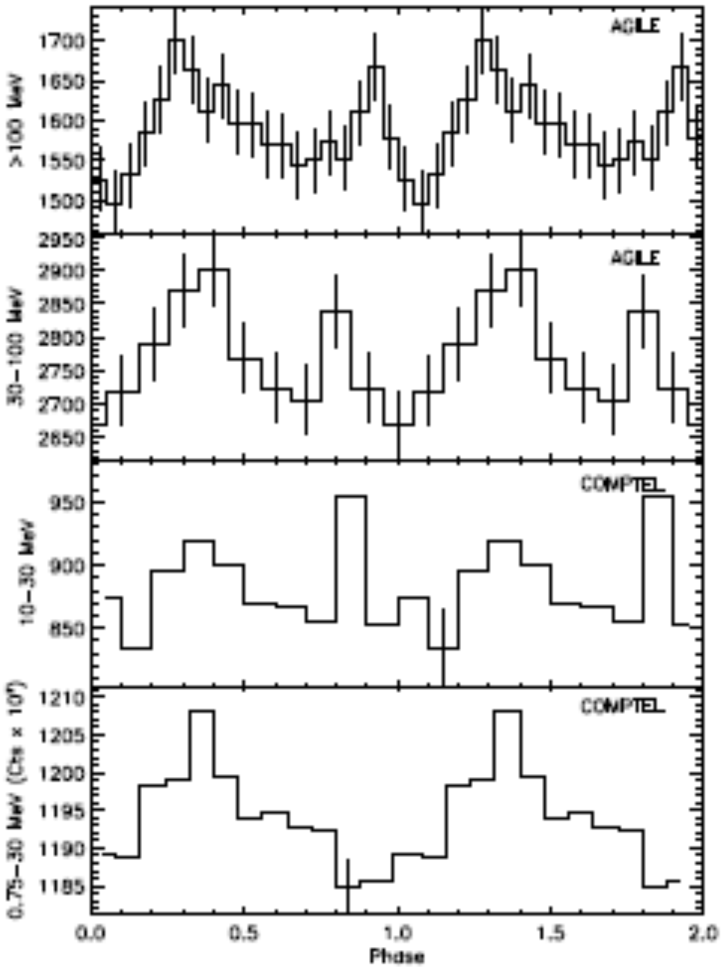
Giuliani et al. 2011

SNR W44

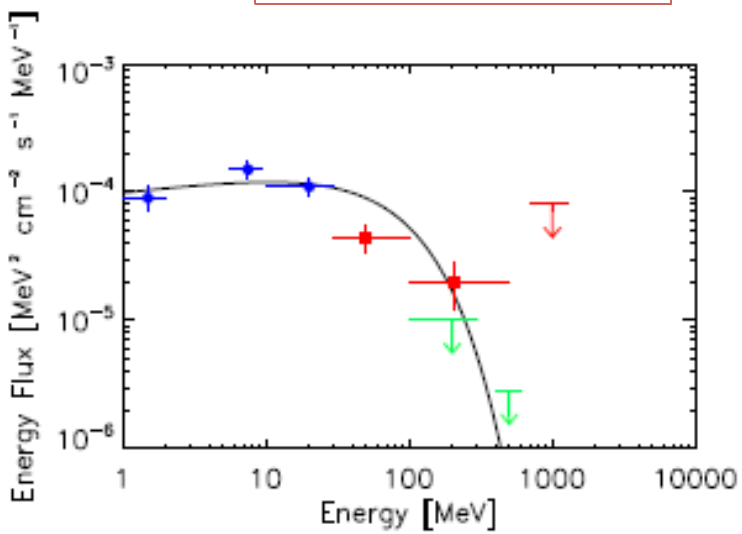


Giuliani et al. 2011

Low Energy Pulsars



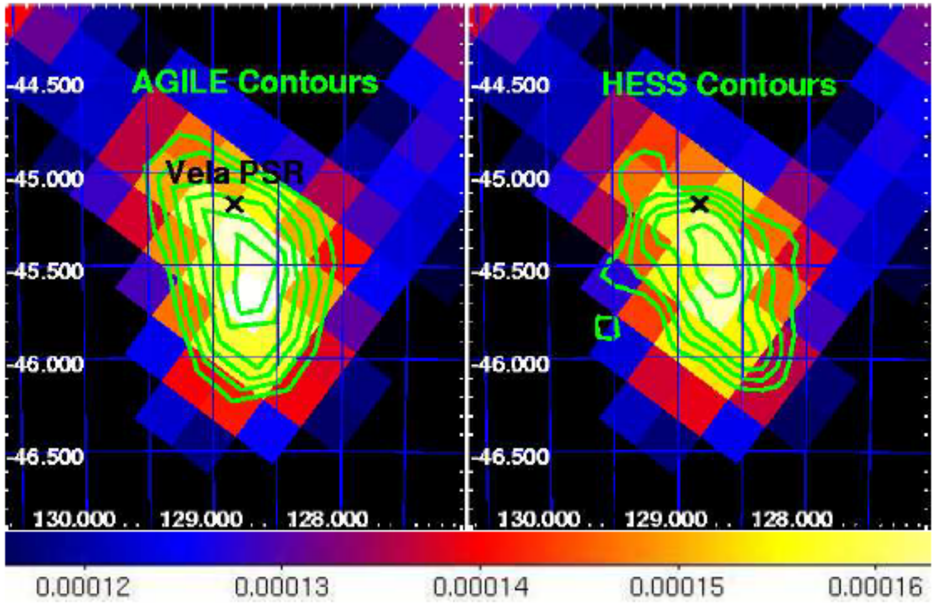
PSR B1509-58



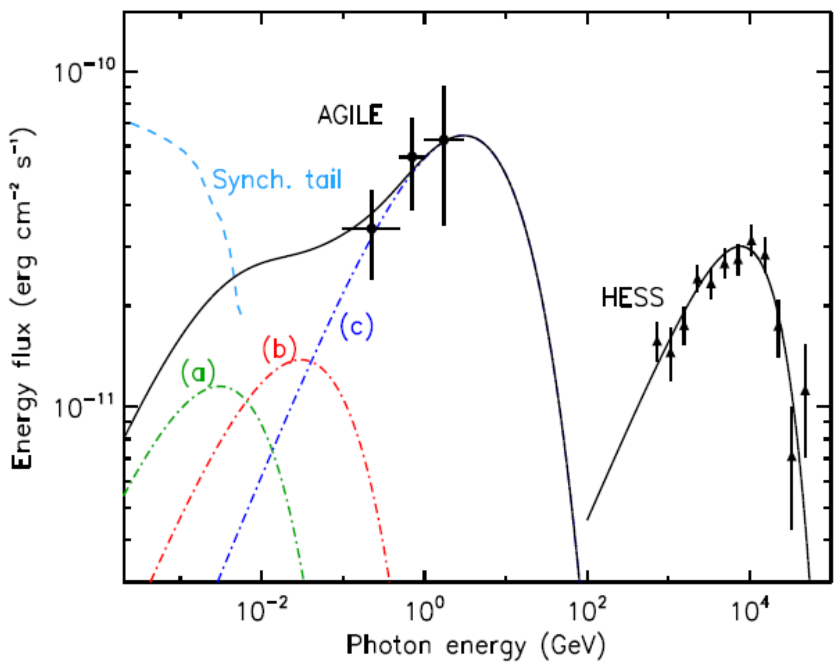
Pilia et al. 2011

Pulsar Wind Nebulae

Pellizzoni et al. 2010

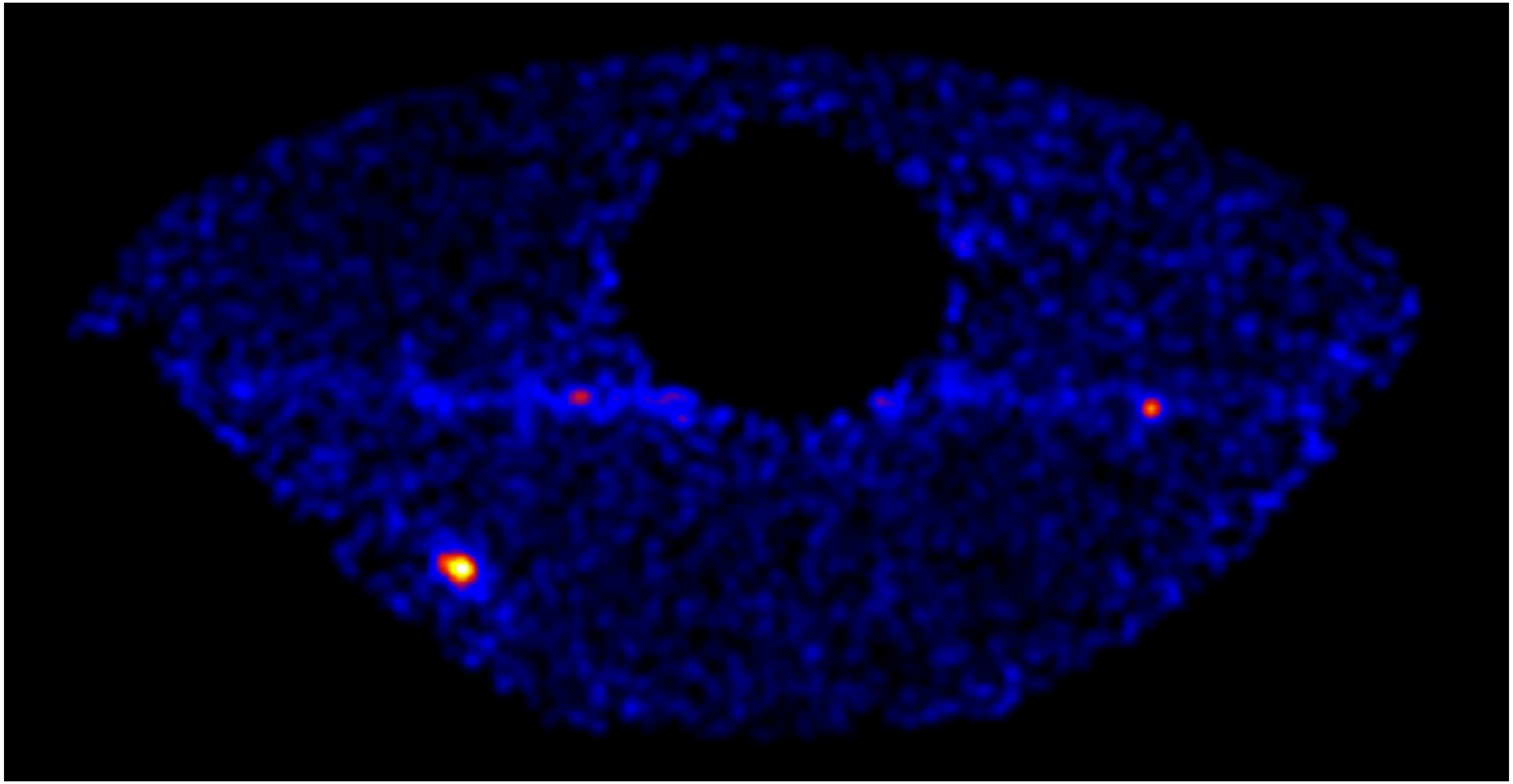


Vela X PWN



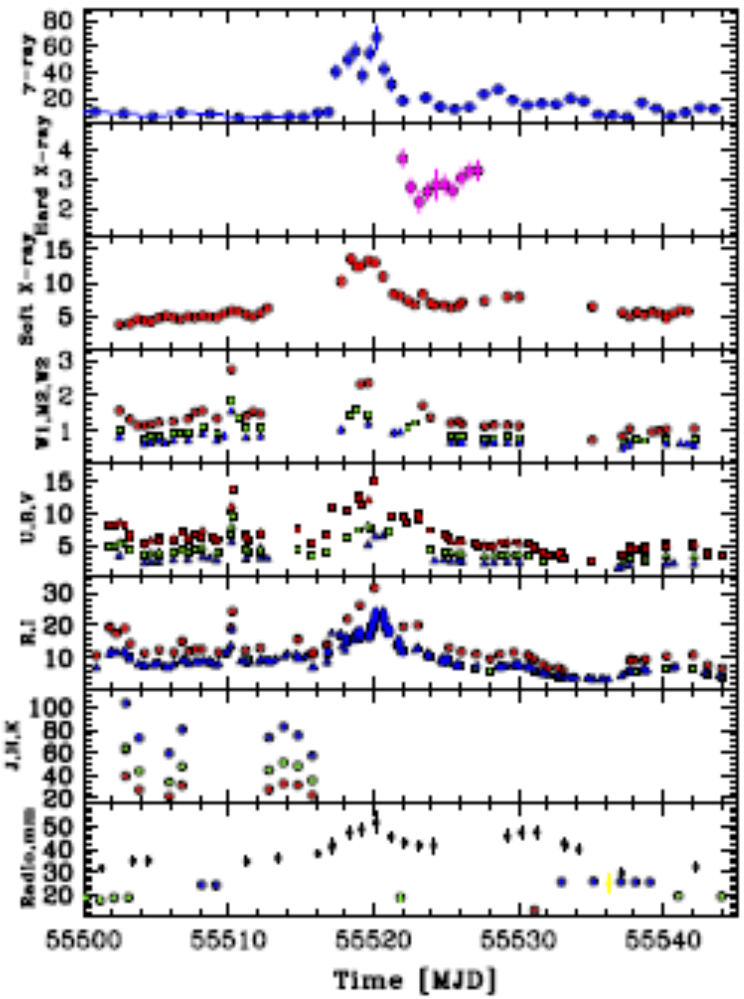
The Flaring 3C454.3

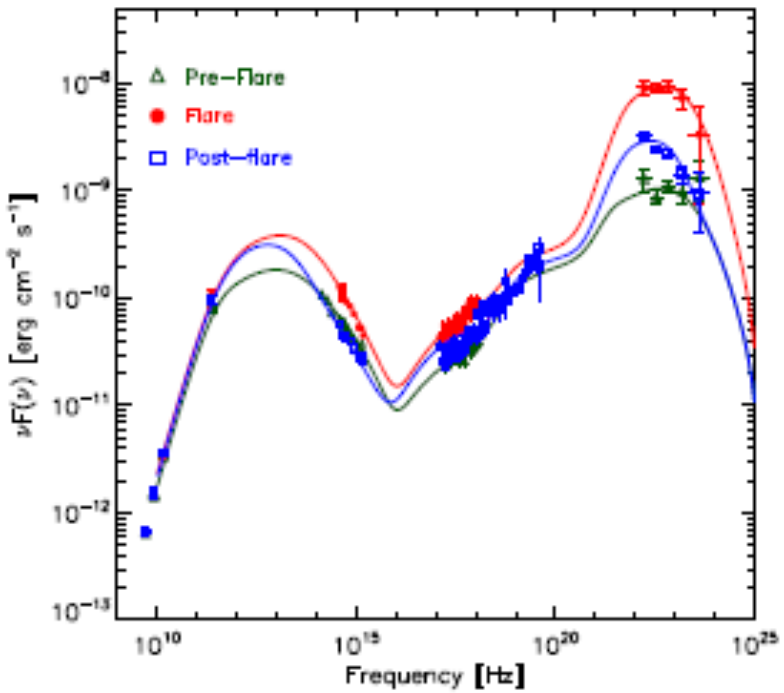
Vercellone et al. 2010



Blazar 3C454.3

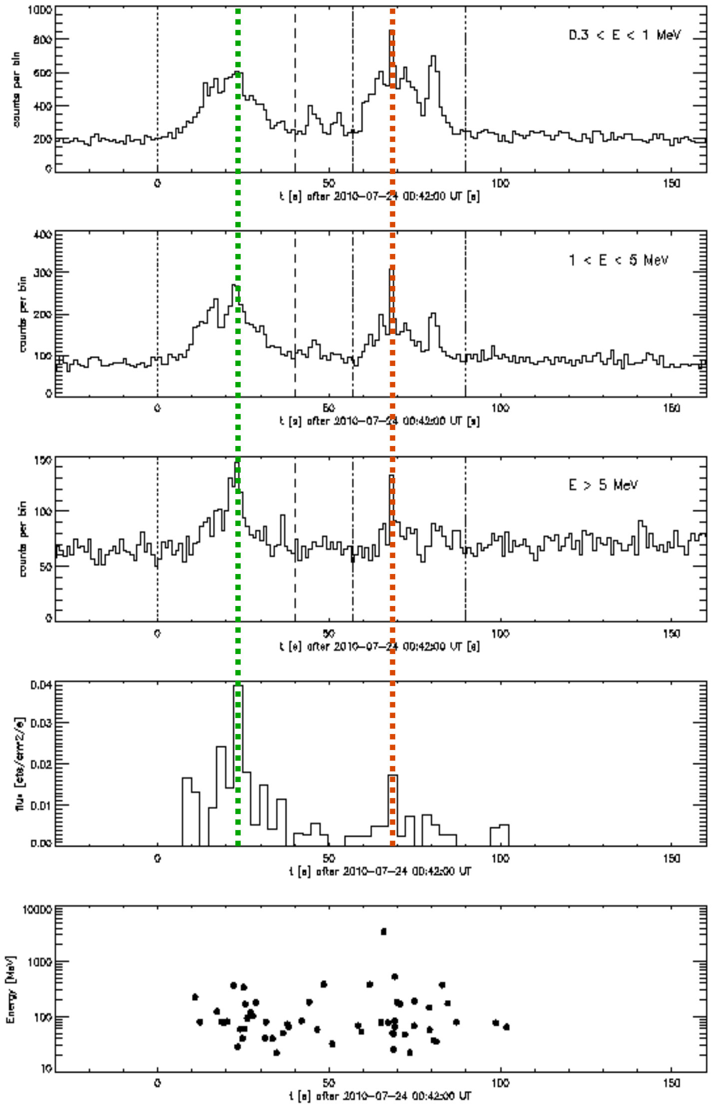
Vercellone et al. 2011





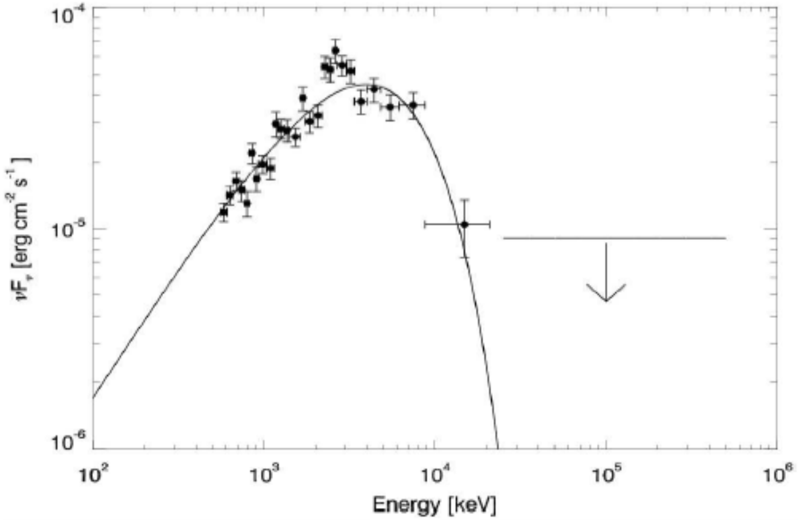
Gamma Ray Bursts

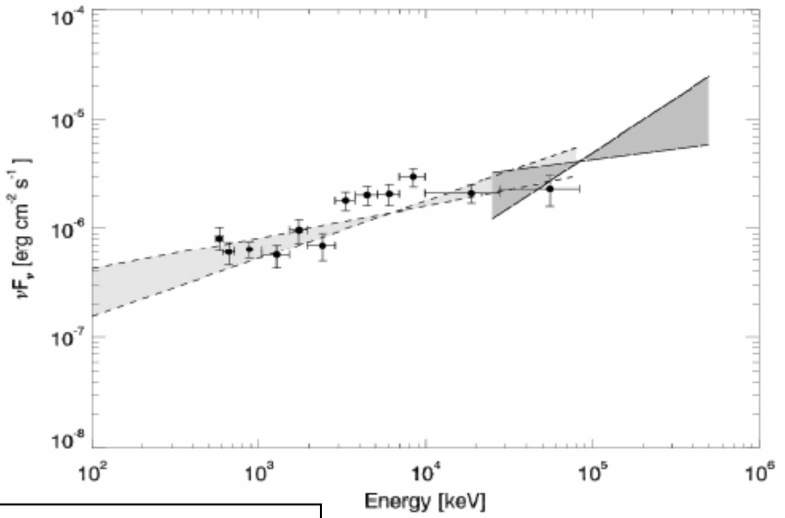
GRB 100724B



GRB 090510

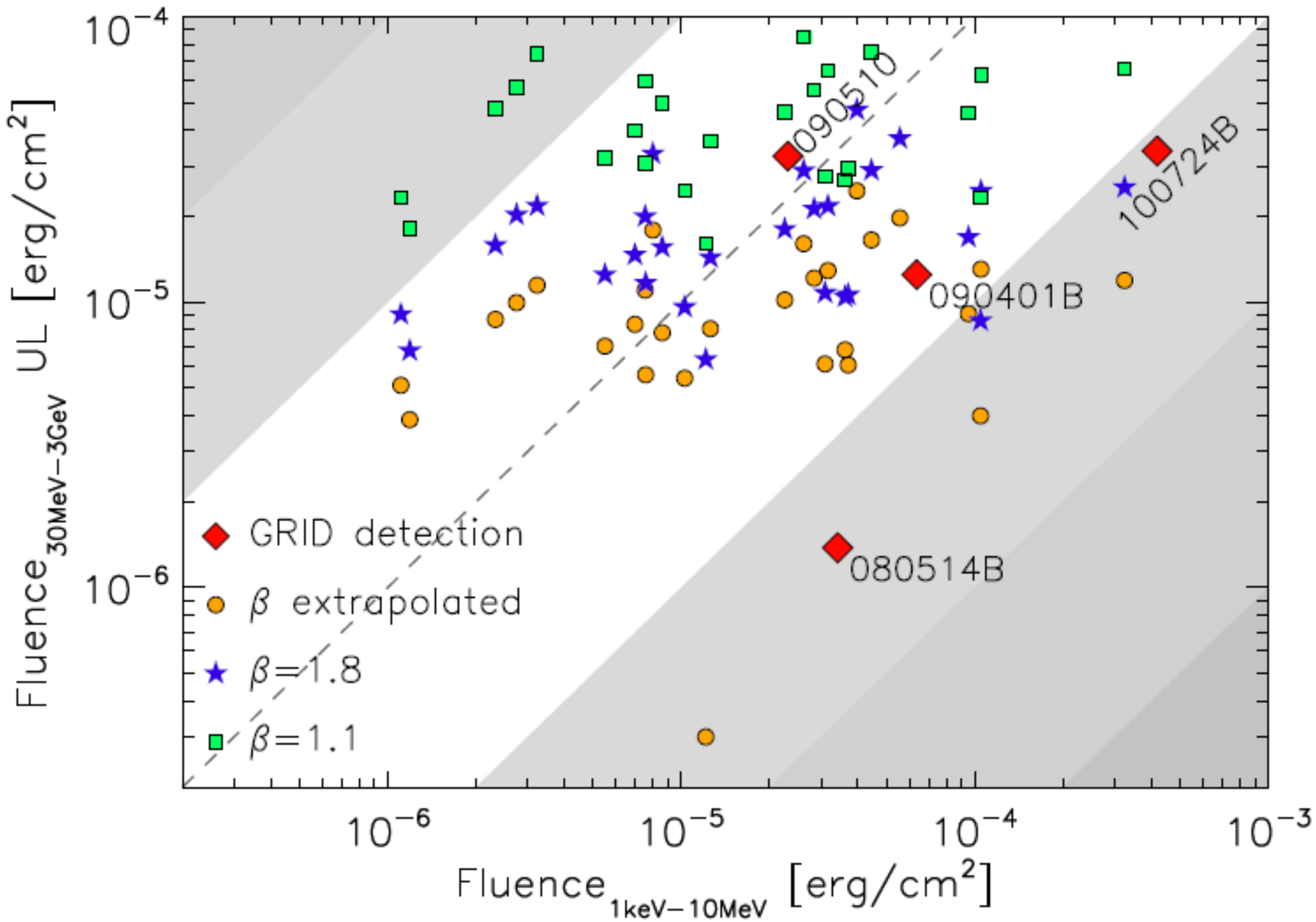
Giuliani et al. 2010





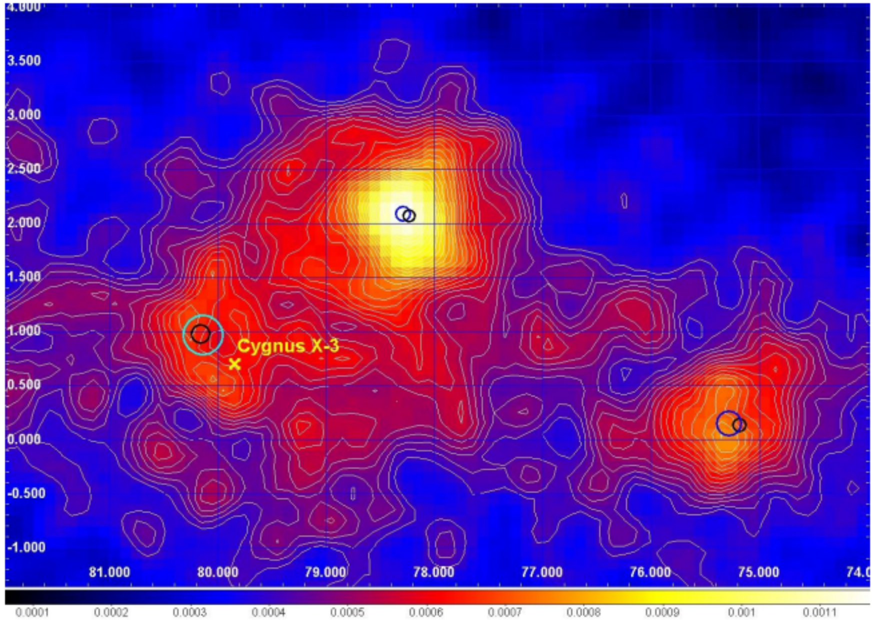
Del Monte et al. 2011

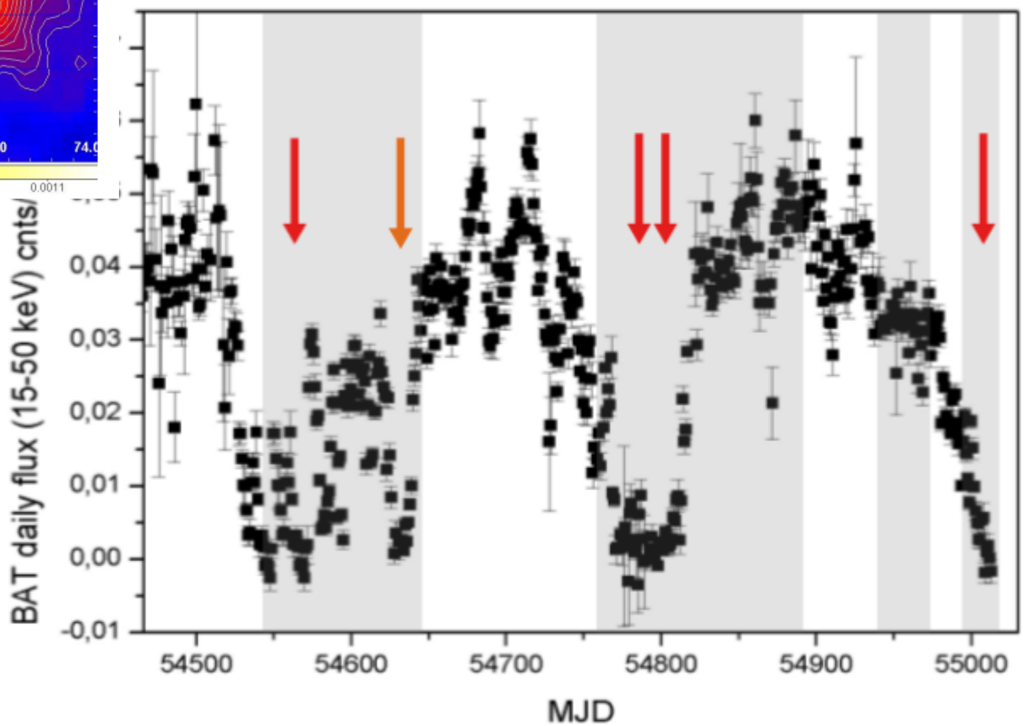
Upper limits in GRB



Longo et al. 2012

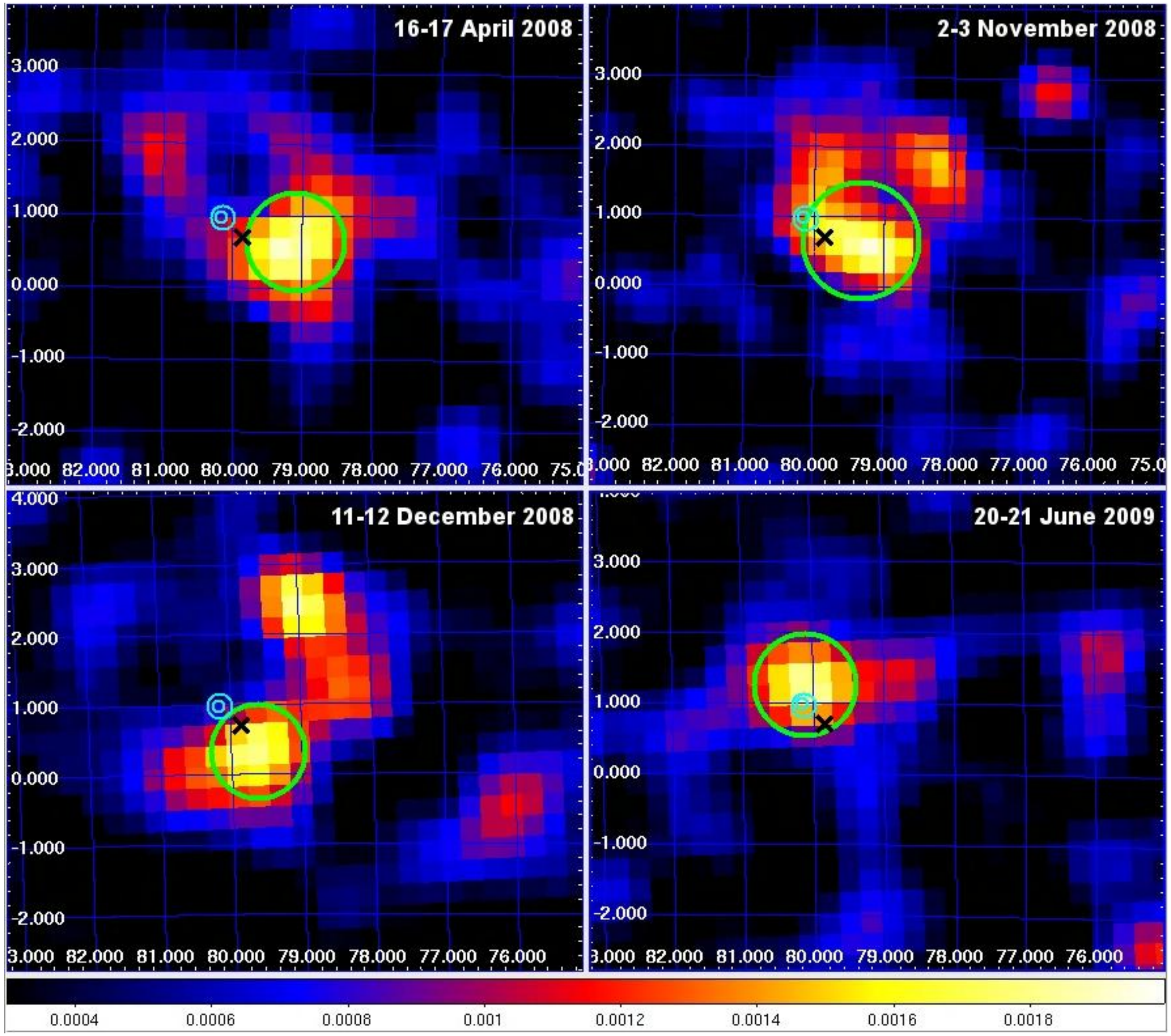
Galactic Transients: Cygnus X3





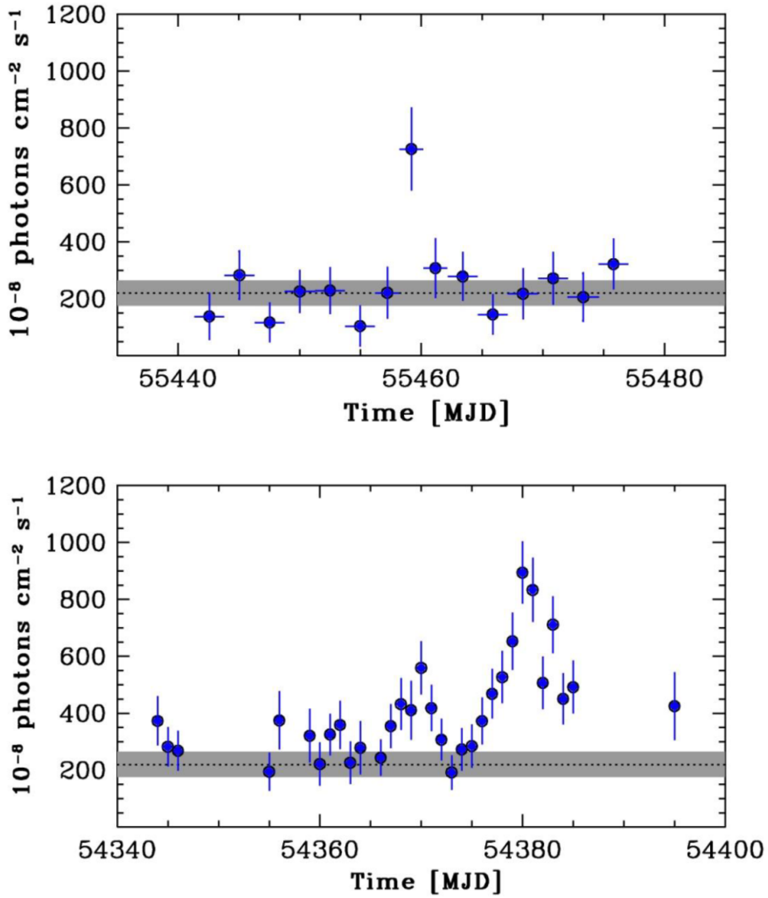
Tavani et al. 2009

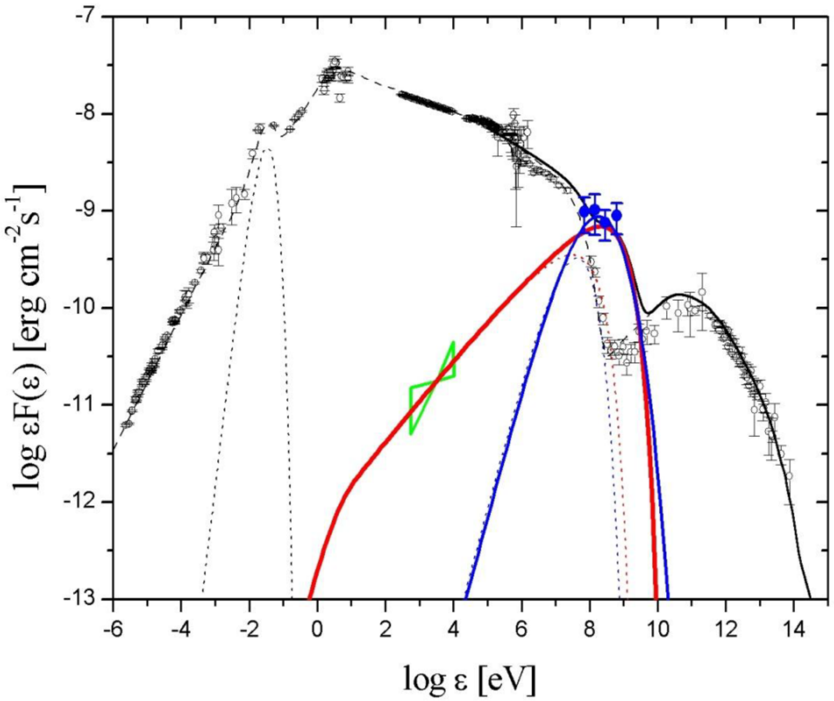
AGILE discovery of transient gamma-ray emission from Cygnus X-3



Galactic Transients: The Flaring Crab

Tavani et al. 2011





The Flaring Crab

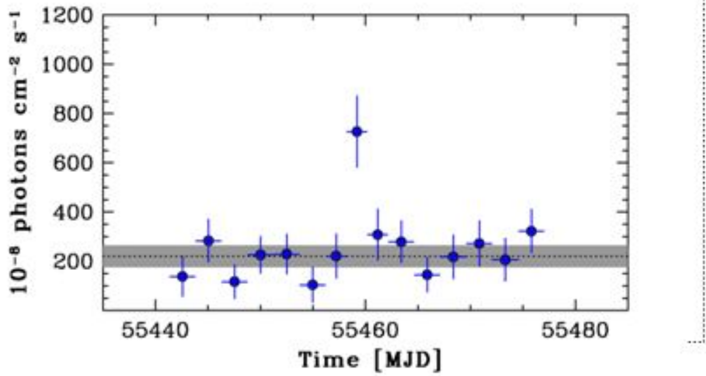
AGILE detection of enhanced gamma-ray emission from the Crab Nebula region

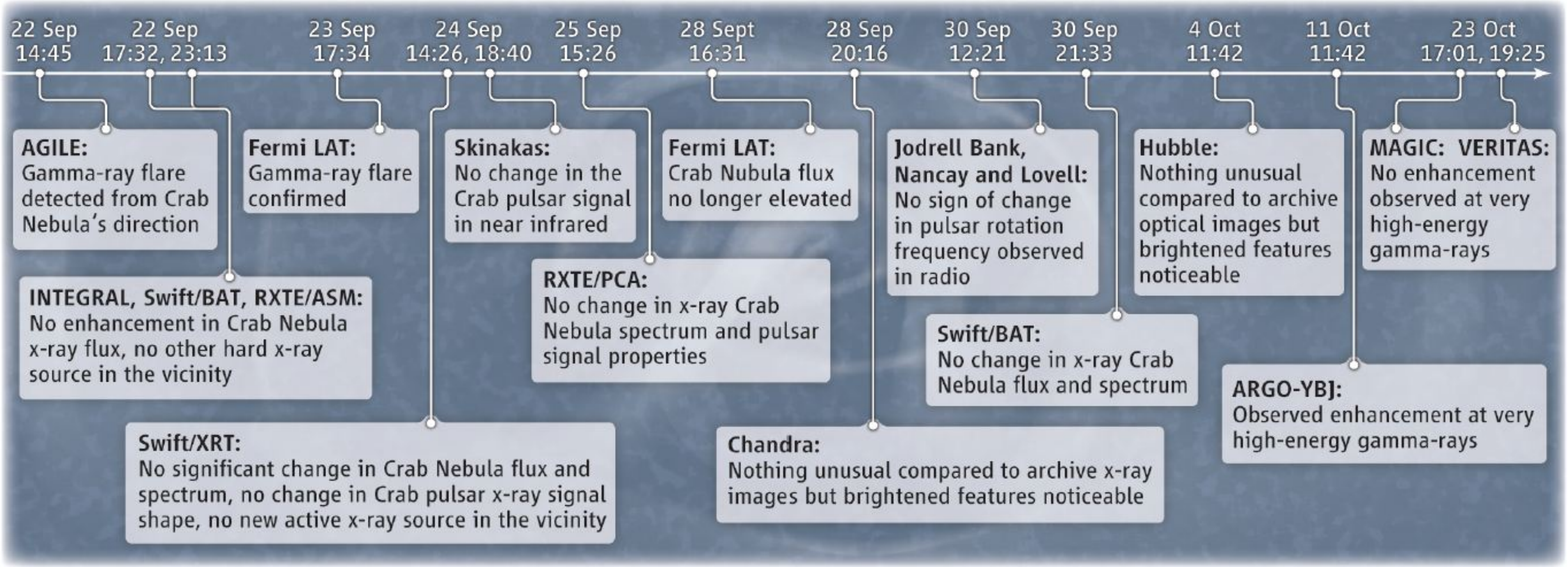
ATel #2855; M. Tavani (INAF/IASF Roma), E. Striani (Univ. Tor Vergata), A. Bulgarelli (INAF/IASF Bologna), F. Gianotti, M. Trifoglio (INAF/IASF Bologna), C. Pittori, F. Verrecchia (ASDC), A. Argan, A. Trois, G. De Paris, V. Vittorini, F. D'Ammando, S. Sabatini, G. Piano, E. Costa, I. Donnarumma, M. Feroci, L. Pacciani, E. Del Monte, F. Lazzarotto, P. Soffitta, Y. Evangelista, I. Lapshov (INAF-IASF-Rm), A. Chen, A. Giuliani(INAF-IASF-Milano), M. Marisaldi, G. Di Cocco, C. Labanti, F. Fuschino,M. Galli (INAF/IASF Bologna), P. Caraveo, S. Mereghetti, F. Perotti (INAF/IASF Milano), G. Pucella, M. Rapisarda (ENEA-Roma), S. Vercellone (IASF-Pa), A. Pellizzoni, M. Pilia (INAF/OA-Cagliari), G. Barbiellini, F. Longo (INFN Trieste), P. Picozza, A. Morselli (INFN and Univ. Tor Vergata), M. Prest (Universita` dell'Insubria), P. Lipari, D. Zanello (INFN Roma-1), P.W. Cattaneo, A. Rappoldi (INFN Pavia), P. Giommi, P. Santolamazza, F. Lucarelli, S. Colafrancesco (ASDC), L. Salotti (ASI)

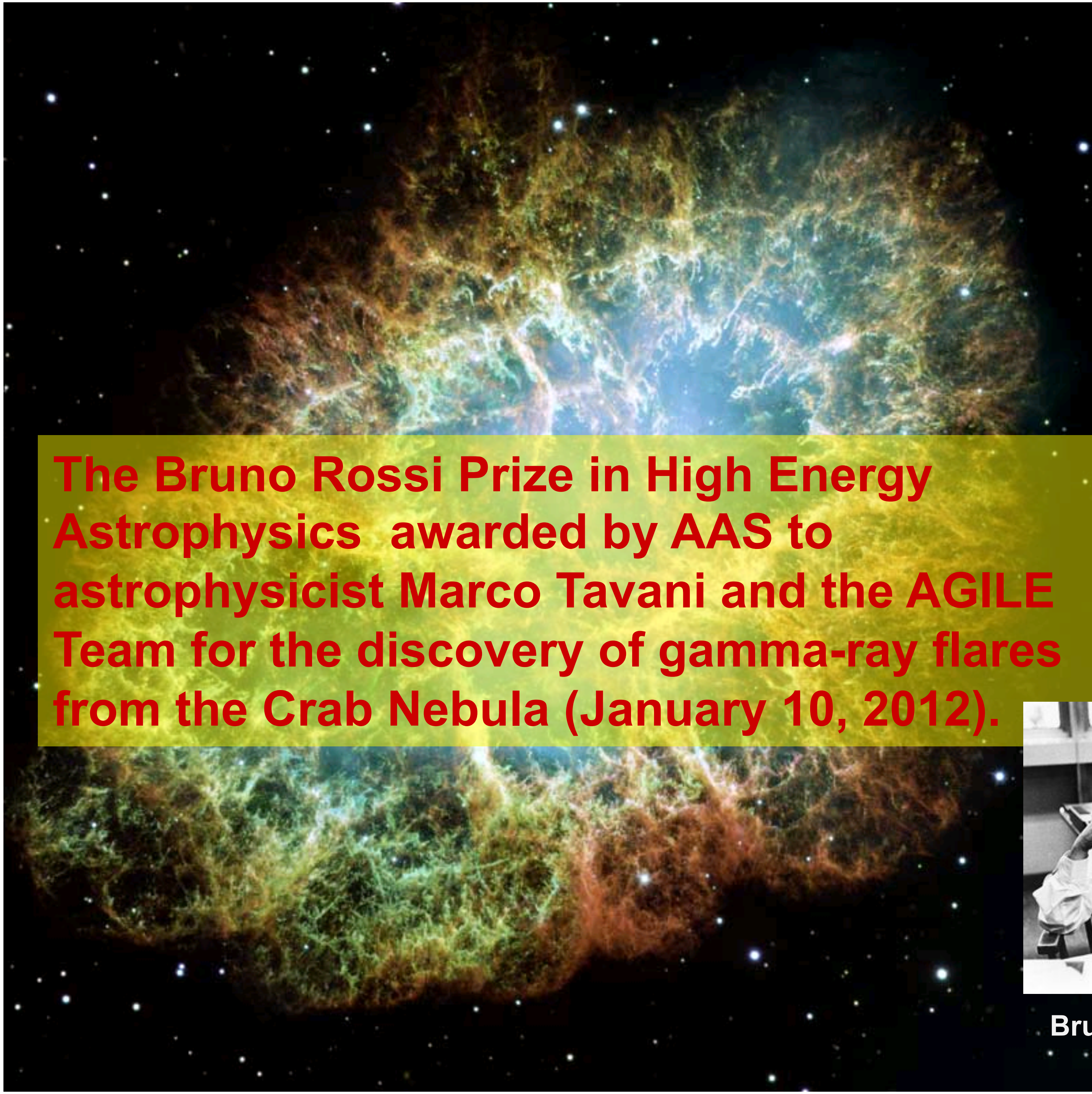
on 22 Sep 2010; 14:45 UT

Distributed as an Instant Email Notice (Transients)

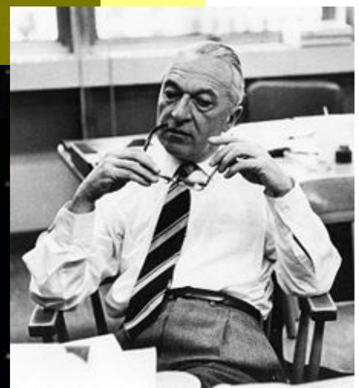
Password Certification: Marco Tavani (tavani@iasf-roma.inaf.it)





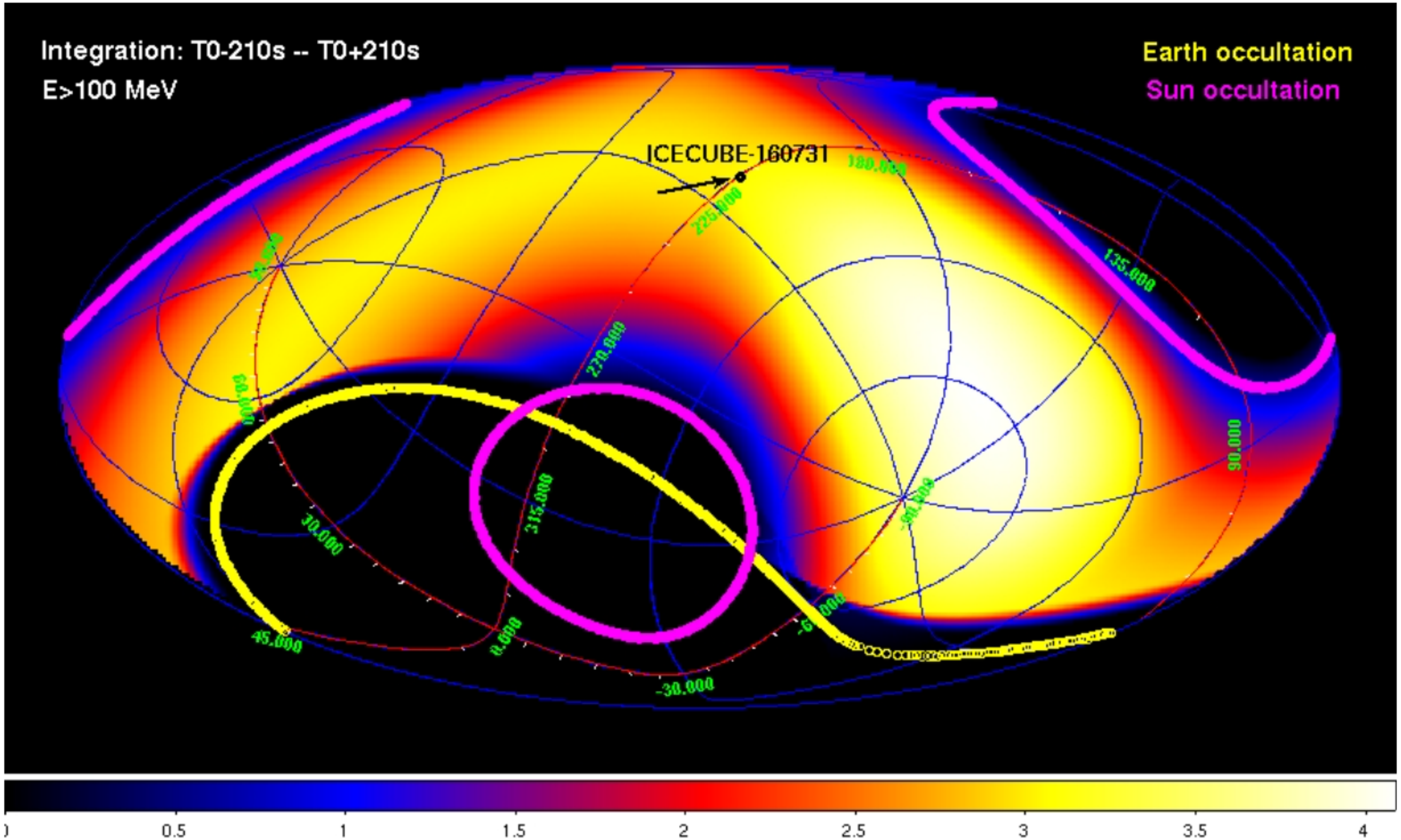


The Bruno Rossi Prize in High Energy Astrophysics awarded by AAS to astrophysicist Marco Tavani and the AGILE Team for the discovery of gamma-ray flares from the Crab Nebula (January 10, 2012).



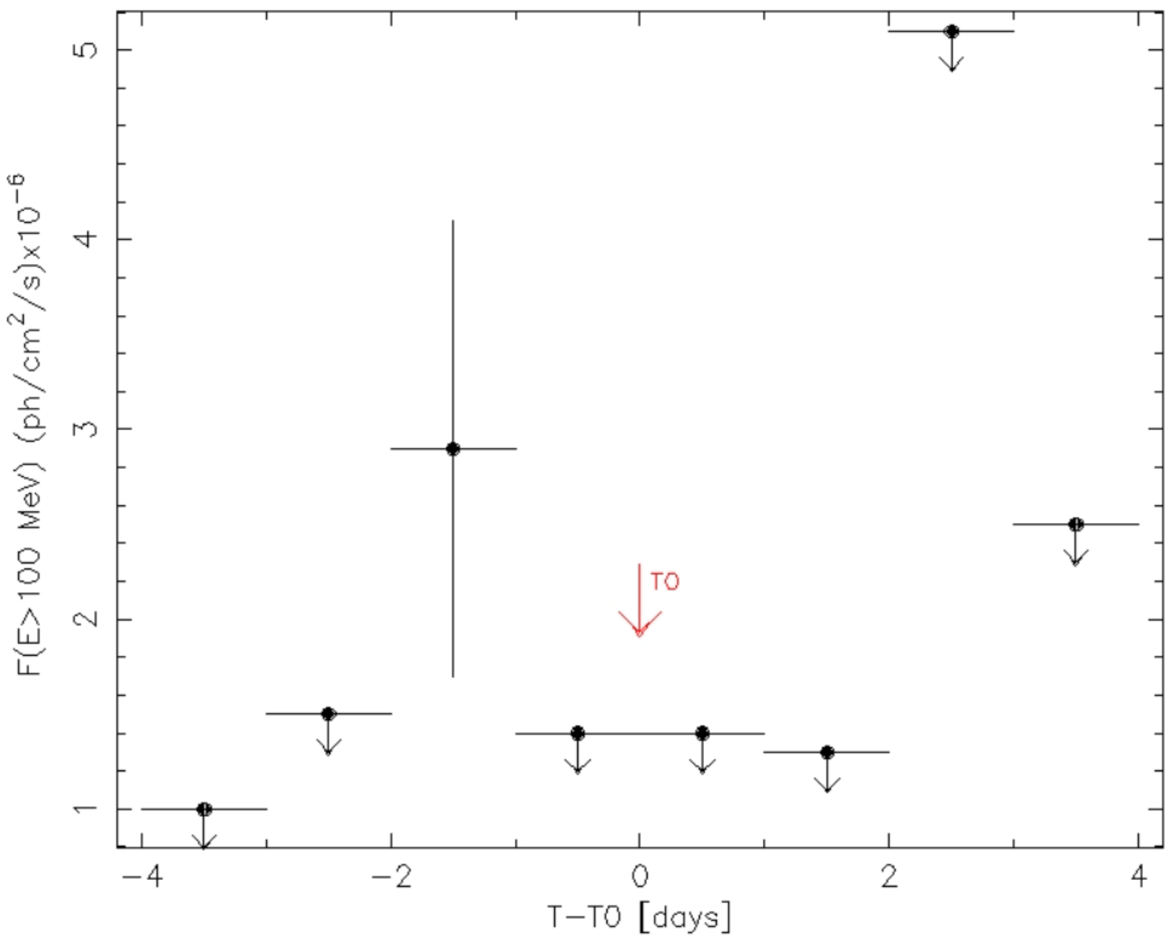
Bruno B. Rossi

New!! Follow up of Neutrino events



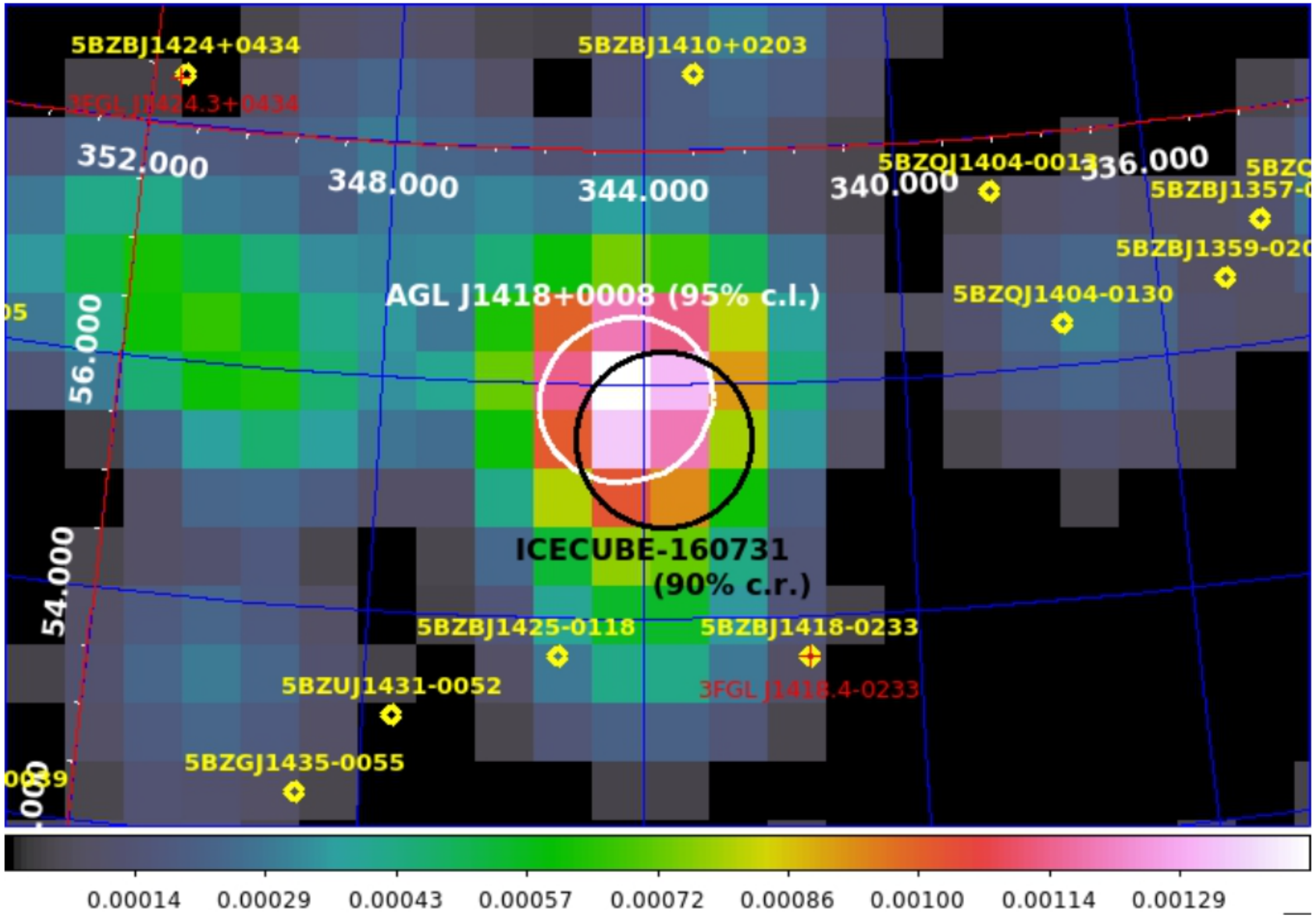
Lucarelli et al 2017

New!! Follow up of Neutrino events



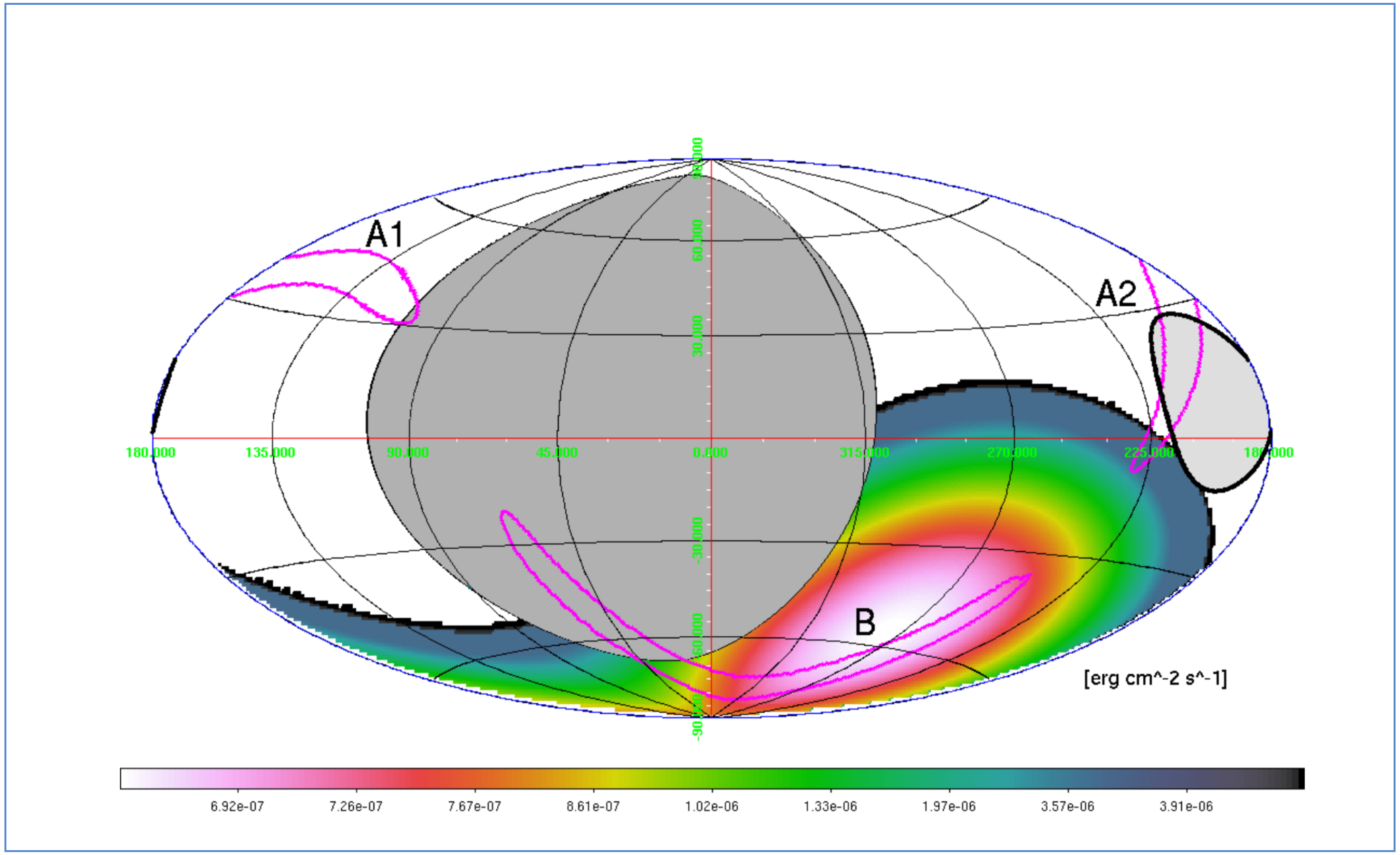
Lucarelli et al 2017

New!! Follow up of Neutrino events



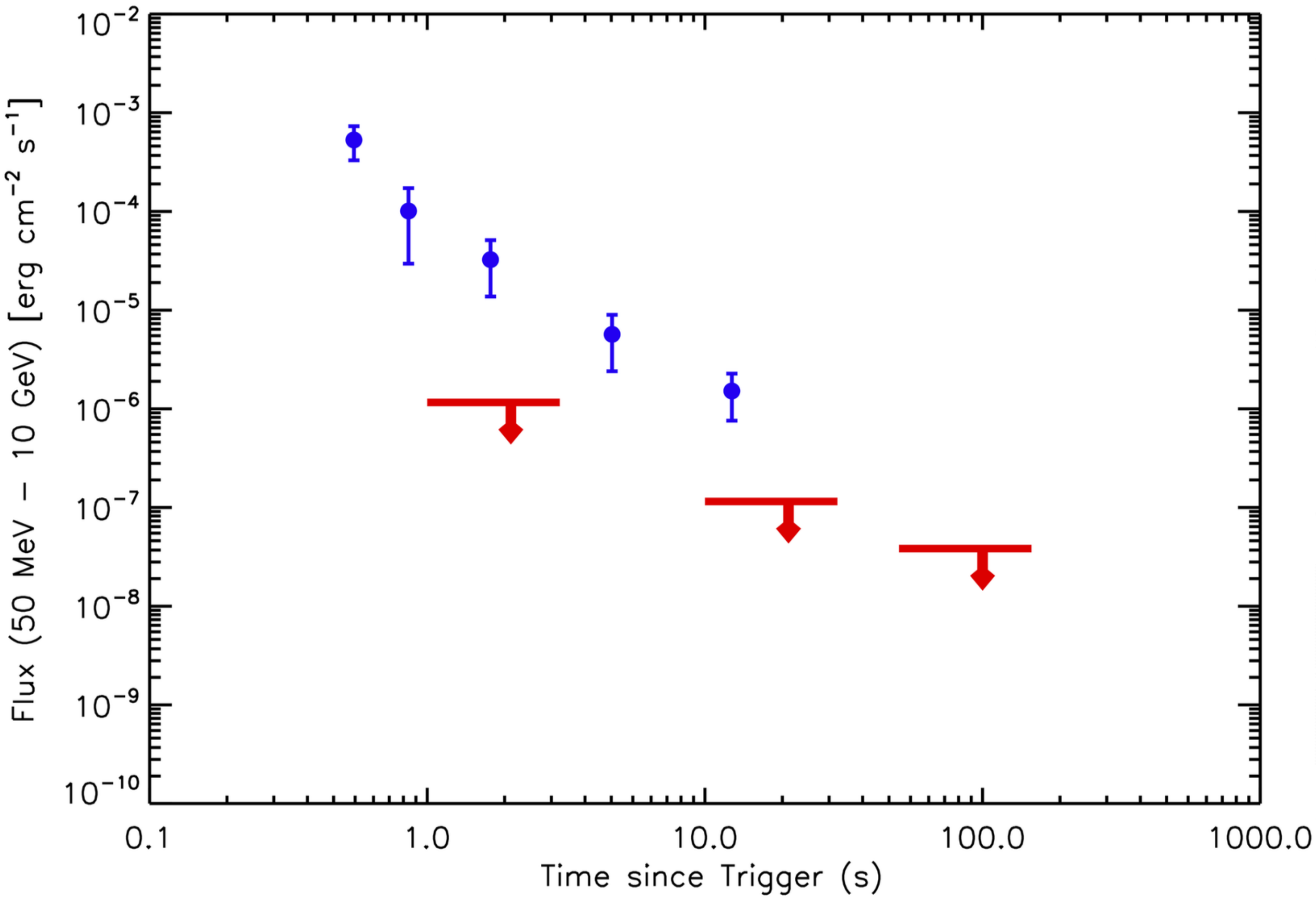
Lucarelli et al 2017

New!! Follow up of GW events



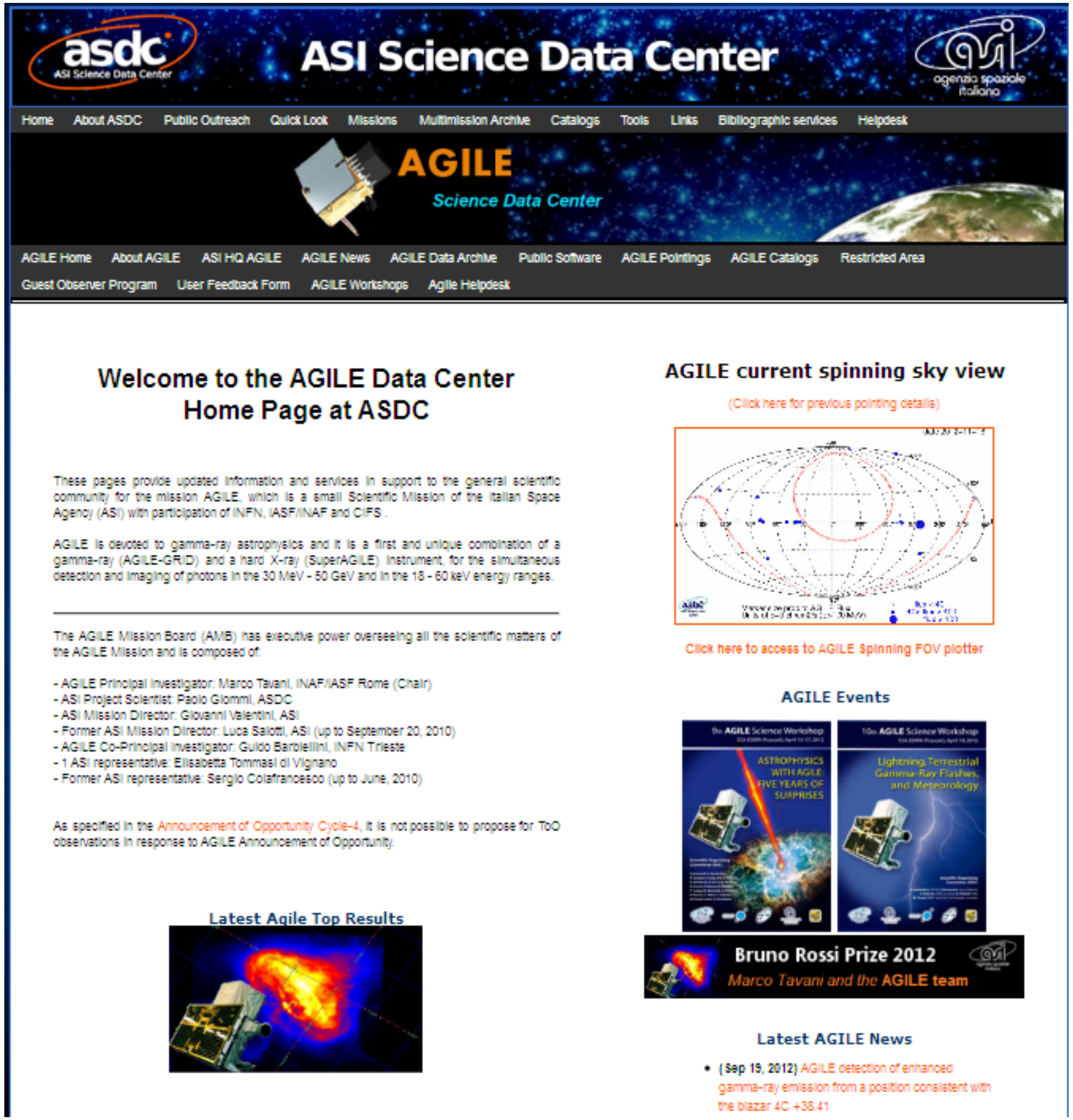
Verrecchia et al 2017

New!! Follow up of GW events



Verrecchia et al 2017

Where to find data?



https://agile.ssdc.asi.it/

Conclusions

- AGILE crucial contributions to testing particle acceleration theories, plasma instabilities in the Universe and on the Earth !
  - Big surprise: discovery of gamma-ray flares from the Crab Nebula: 2012 Bruno Rossi Prize
  - Origin of cosmic rays, SNR W44, first direct evidence of neutral pion emission
  - Relativistic jets in microquasars and blazars
  - Gamma-ray emission up to 100 MeV from Terrestrial Gamma-Ray Flashes