AMEGO

All-sky Medium Energy Gamma-ray Observatory

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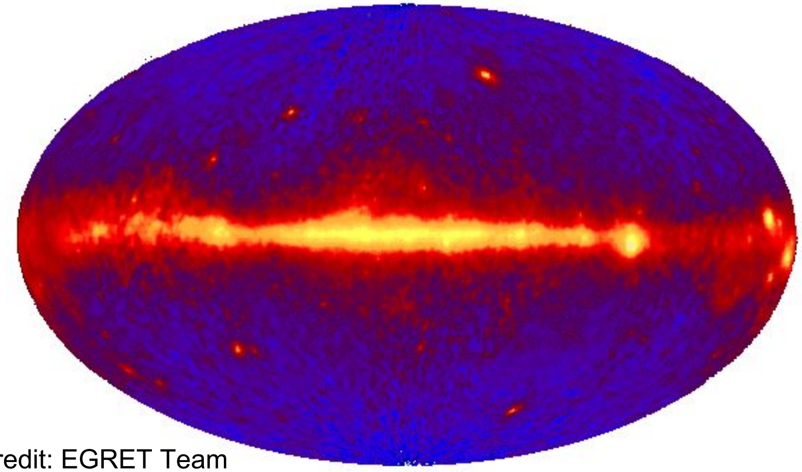
for the AMEGO Team
https://asd.gsfc.nasa.gov/amego

EGRET All-Sky Map Above 100 MeV

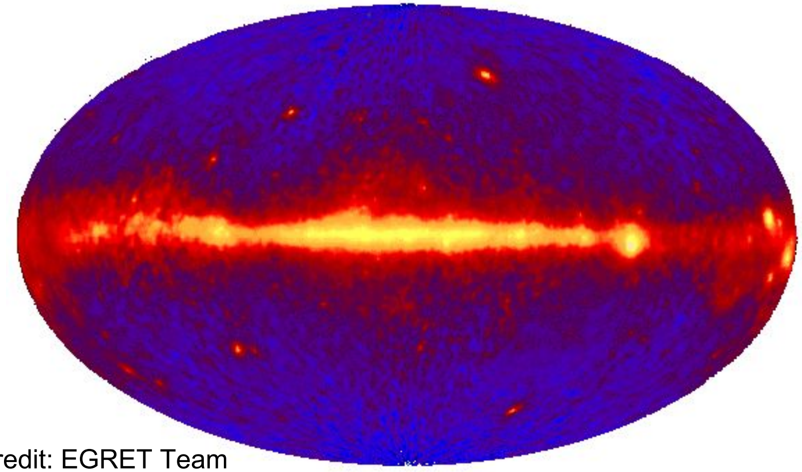


Credit: EGRET Team

~200 Sources Detected

Why Look in the MeV Range?

EGRET All-Sky Map Above 100 MeV



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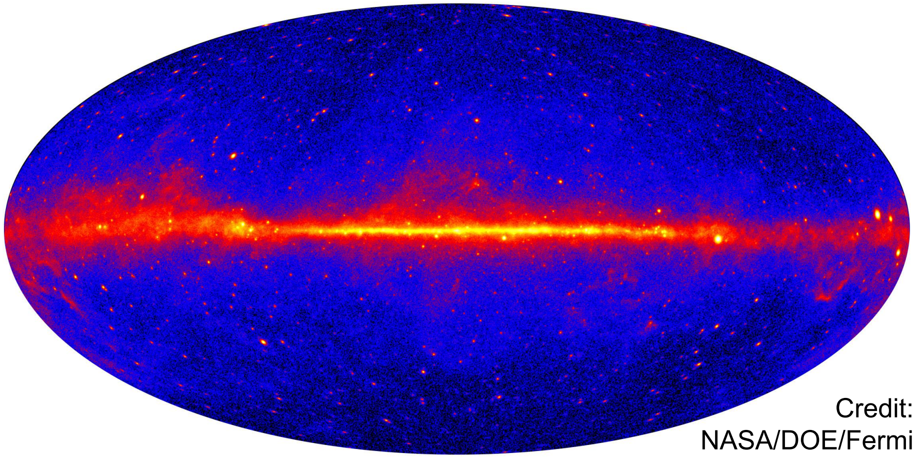
Fermi-LAT All-Sky Map Above 1 GeV



Credit: NASA/DOE/Fermi LAT Collaboration

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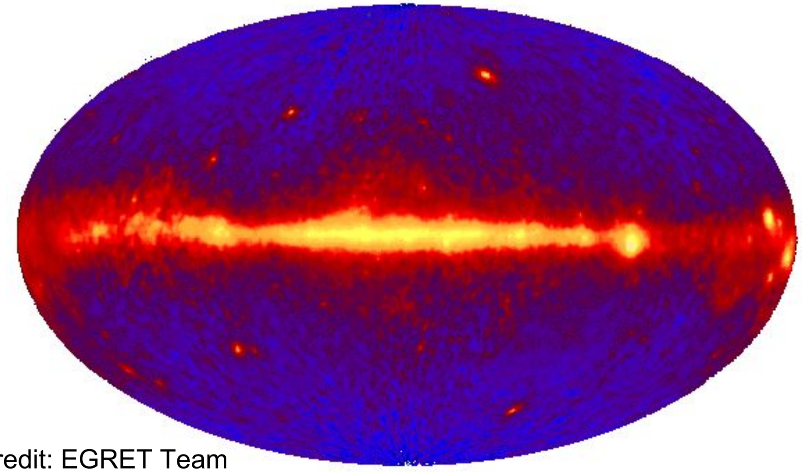

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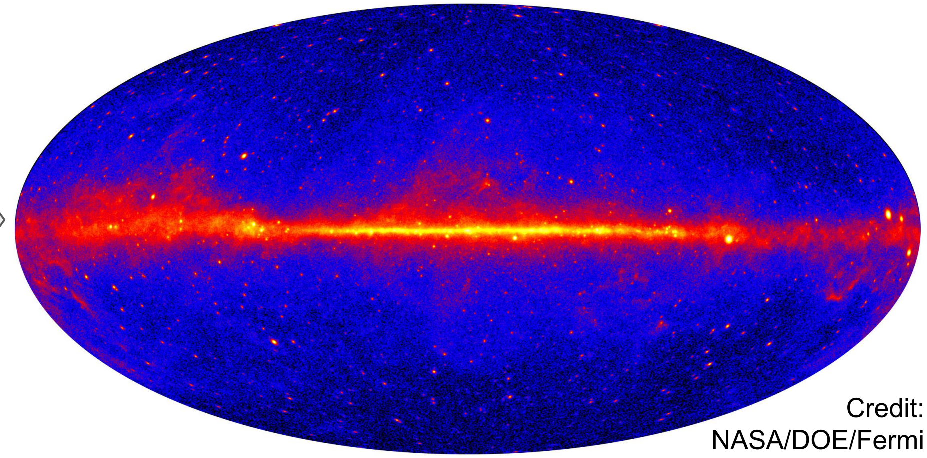
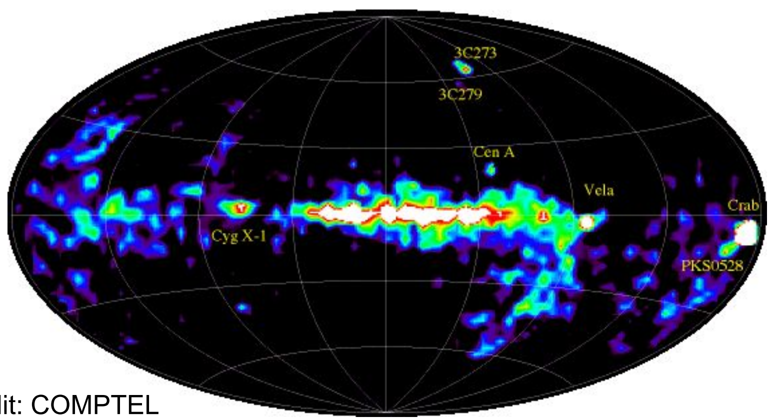


Credit: NASA/DOE/Fermi LAT Collaboration

~3000 Sources Detected

COMPTEL All-Sky Map 1 - 30 MeV



Credit: COMPTEL Collaboration

Tens of Sources Detected

Why Look in the MeV Range?

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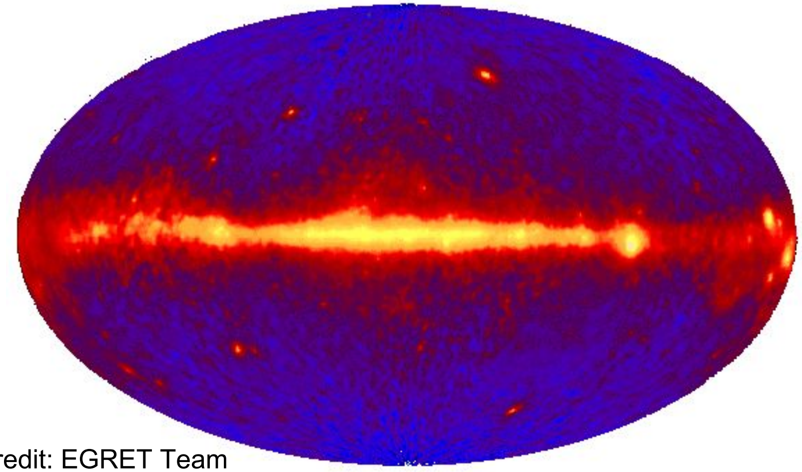

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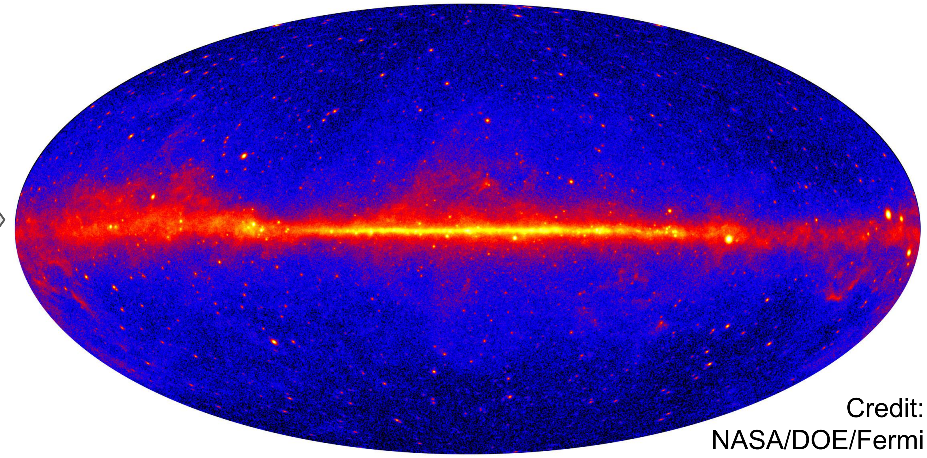

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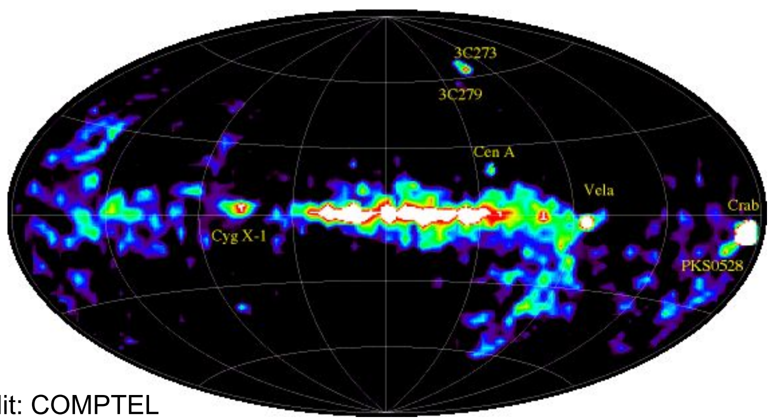

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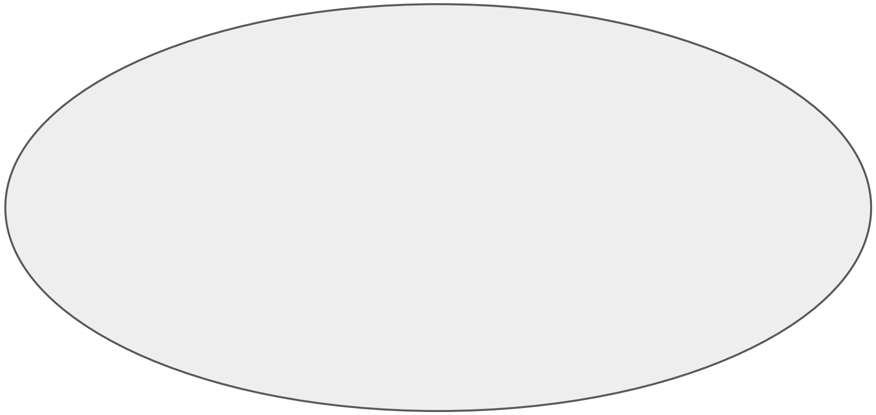
Tens of Sources Detected



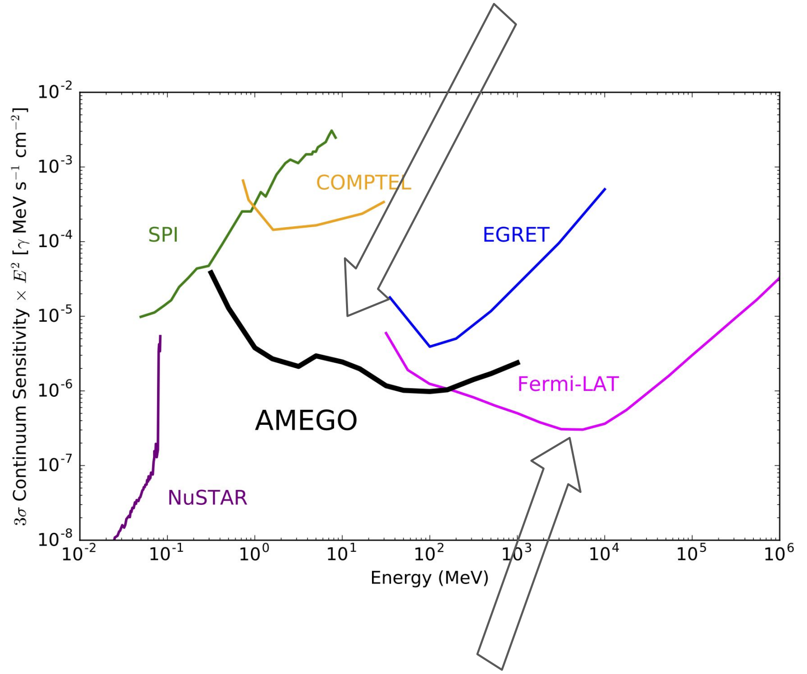
Why Look in the MeV Range?

Guaranteed Discovery Space

The MeV range is prime discovery space.

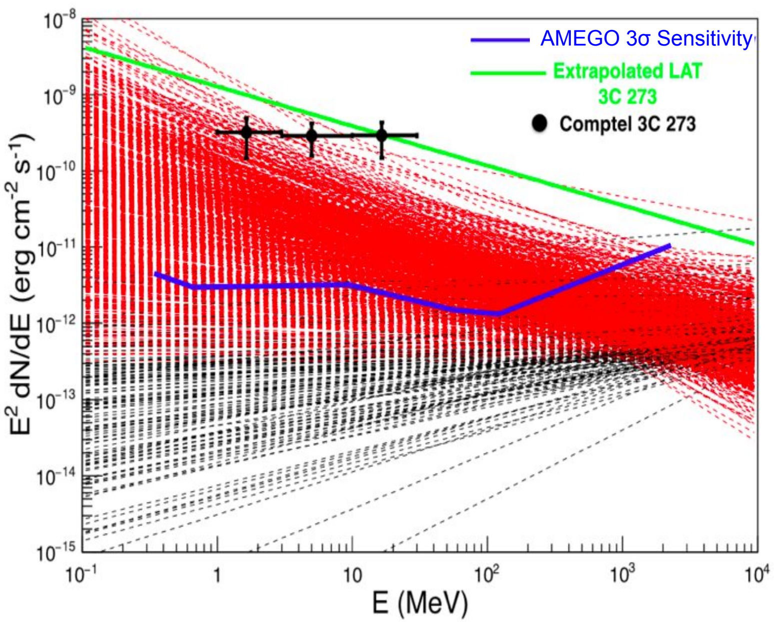
It is a key piece to the high-energy view of the Universe.

Achievable: Orders of magnitude improvement

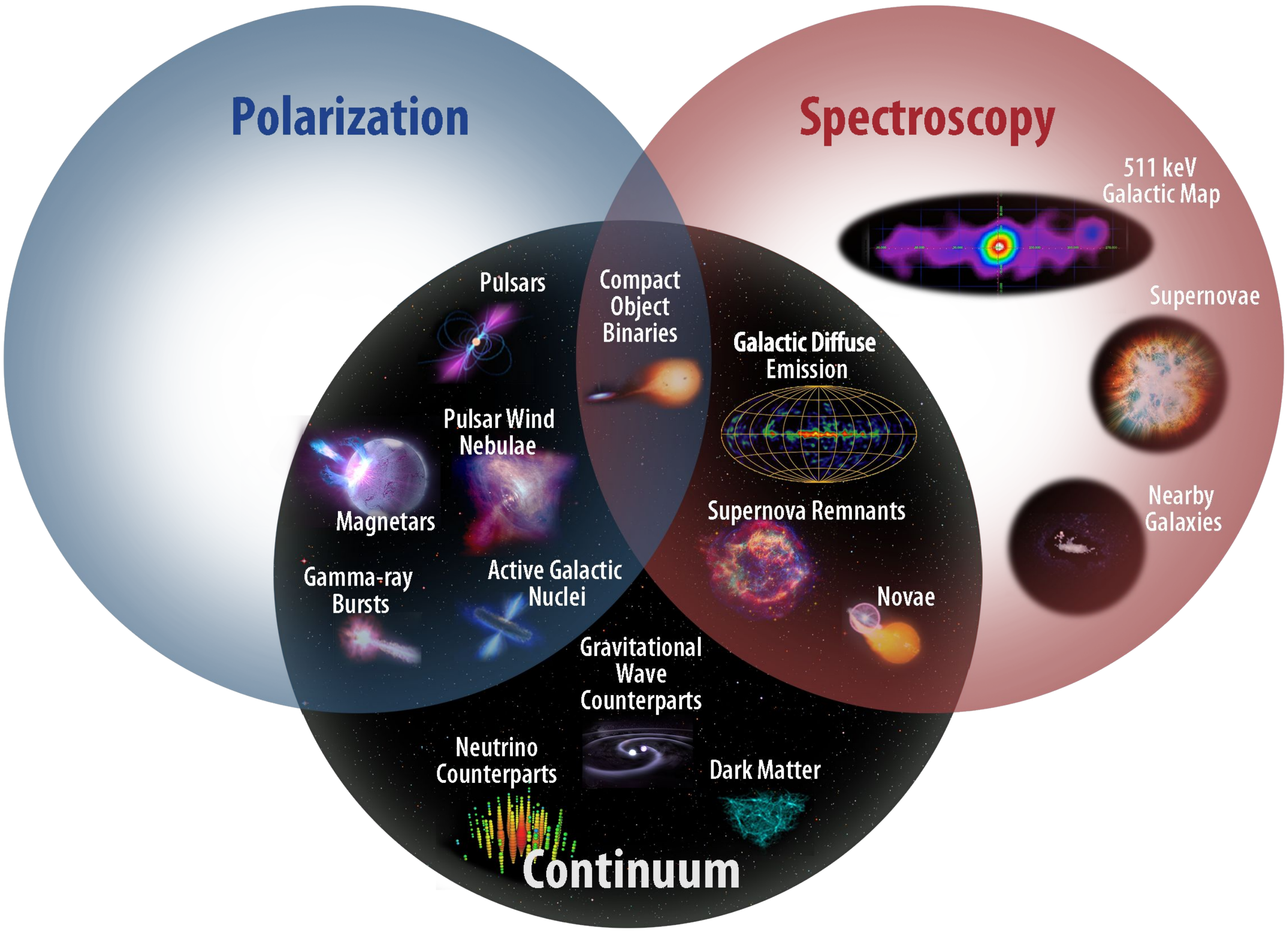


Note: *Fermi*-LAT optimized for 1 GeV

More than ⅓ of *Fermi*-LAT catalog sources peak below the *Fermi*-LAT band.



Below 200 MeV AMEGO will dramatically improve sensitivity and will open a new window in the spectrum leading to the discovery of new sources and new source classes.



AMEGO will provide a well rounded portfolio of capabilities

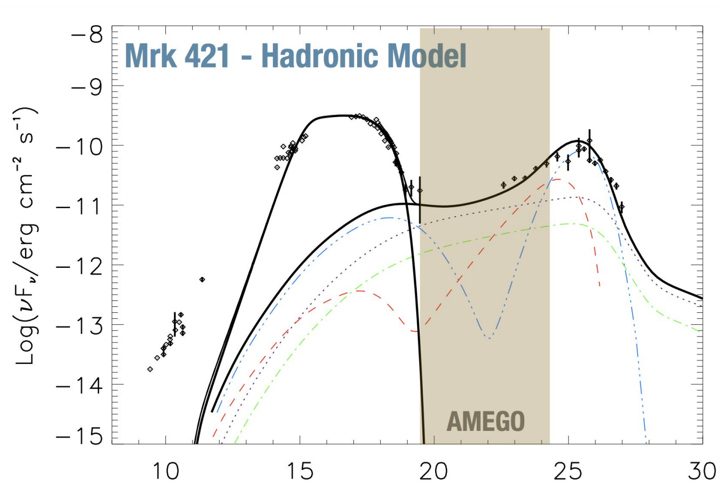
Jets: Formation, Evolution, and Acceleration

MeV blazars have their **peak power output** in the MeV Band and are **powerful probes of the growth** of supermassive black holes.

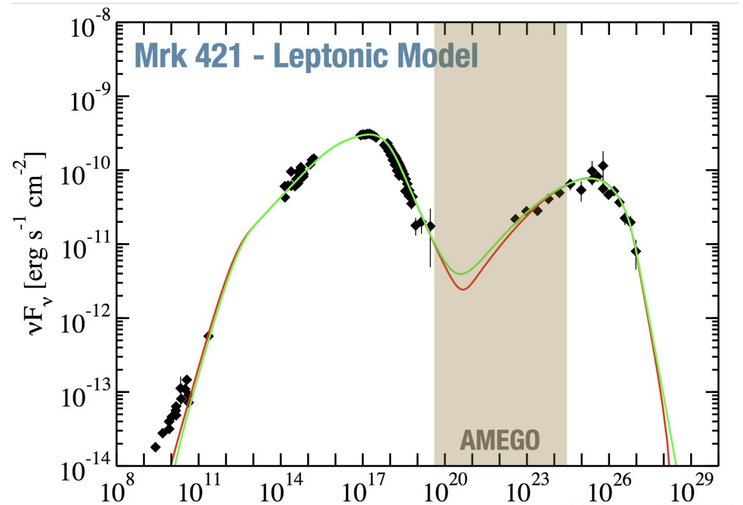
- Large jet power and accretion luminosity
- Often found at very large redshift
- Harbor massive black holes (10^9 $M_\odot$)

AMEGO will measure AGN spectral energy distributions and variability:

- Determine the **maximum particle energies**, study **magnetic field strength**, **jet content**, & the ɣ-ray **emission location**.
- Differentiate hadronic and leptonic models with **polarization**.



Abdo et al. 2011



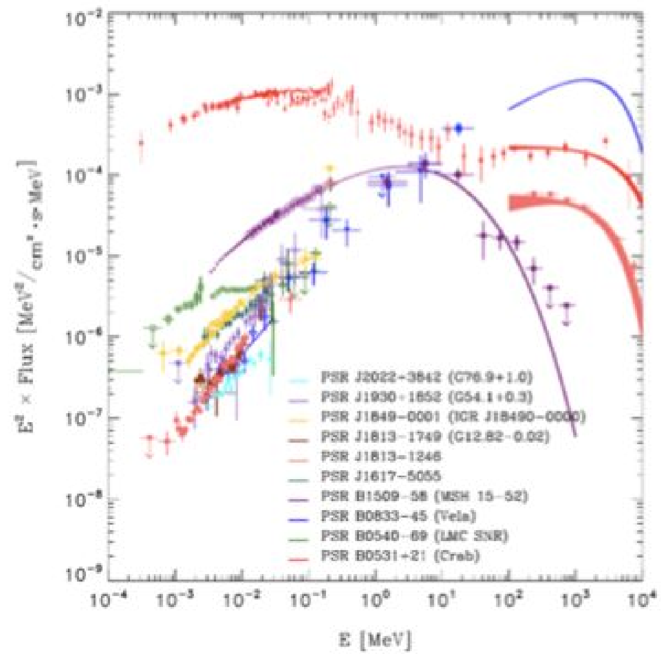
Abdo et al. 2011

See T. Venters' talk at 17:00 today (8/10)

Extreme Conditions Around Compact Objects

Example 1: *Soft Gamma-ray Pulsars*

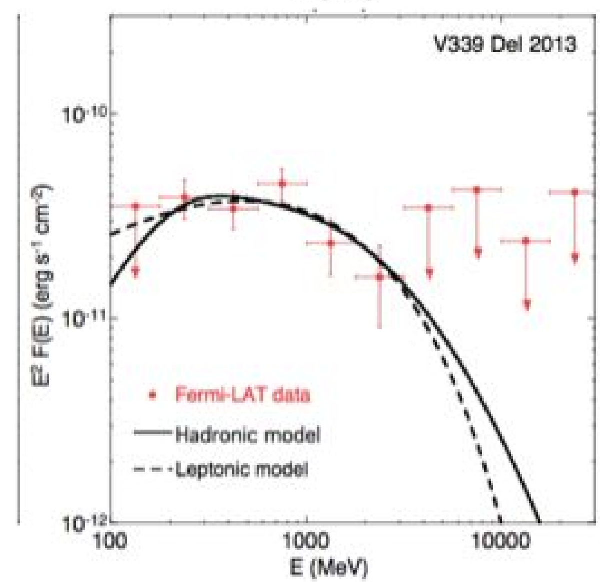
- Seen in hard X-ray but not *Fermi*-LAT, **peak lies in MeV band**
- 11 MeV pulsars known
  - Extremely energetic Edot > 10^{36} erg
- Possible “hidden” population of energetic soft gamma emitting pulsars



Example 2: *Novae*

- How do close binary star systems like classical novae eject mass during outbursts?
- Shocks in the expanding nova envelope produce gamma rays.

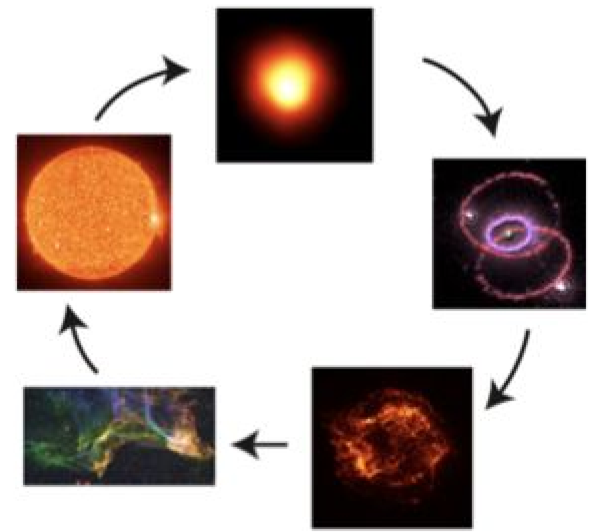
AMEGO will measure the energy spectrum below 100 MeV to **determine the shock properties** and **identify novae** missed by optical observations.



Element Formation in Dynamic Systems

Nuclear lines explore Galactic chemical evolution and sites of explosive element synthesis (SNe)

- Electron-positron annihilation radiation
  - $e^+ + e^-$ -> 2g (0.511 MeV)
- Nucleosynthesis
  - Giants, CCSNe (^{26}Al)
  - Supernovae (^{56}Ni, ^{57}Ni,^{44}Ti)
  - ISM (^{26}Al, ^{60}Fe)
- Cosmic-ray induced lines
  - Sun
  - ISM



56Ni: 158 keV 812 keV (6 d)
56Co: 847 keV, 1238 keV (77 d)
57Co: 122 keV (270 d)
44Ti: 1.157 MeV (78 yr)
26Al: 1.809 MeV (0.7 Myr)
60Fe: 1.173, 1.332 MeV (2.6 Myr)

See X. Wang's talk at 14:30 on Friday (8/11)

Searching for Dark Matter Signals

Example: *Axions*

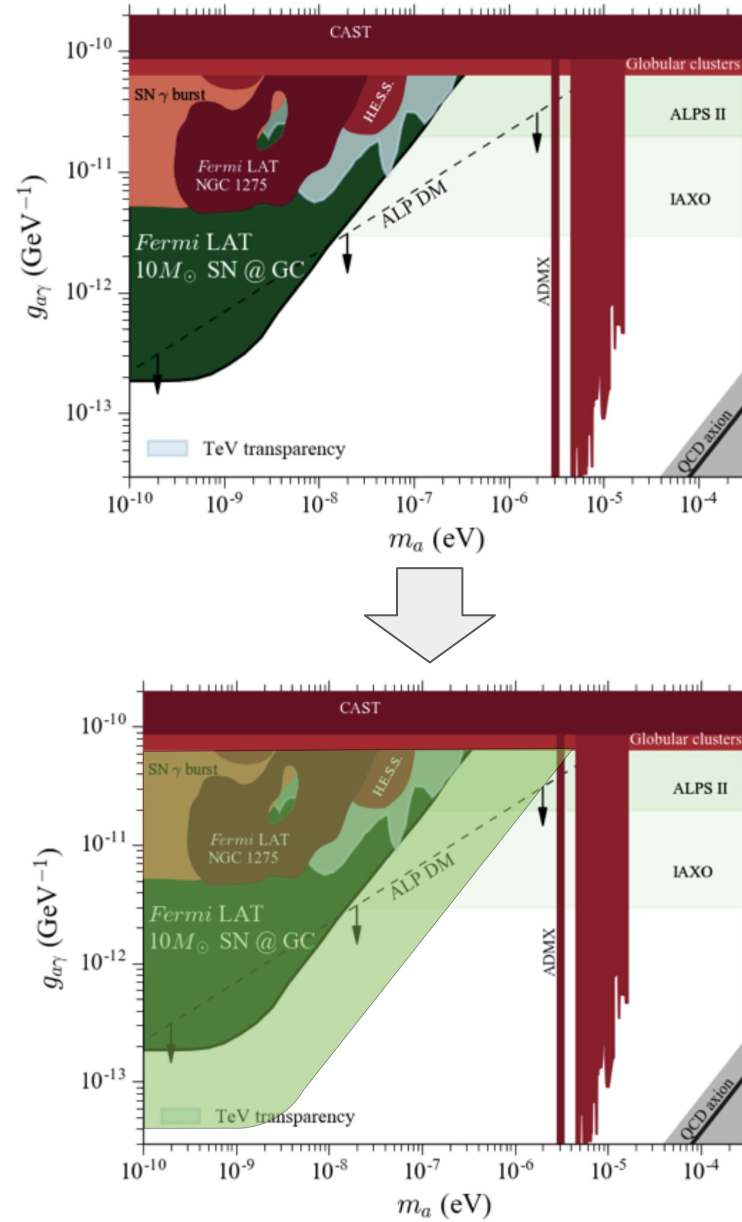
Axions in neutron stars (hep-ph/0505090)

- emission process for axions with mass up to a few MeV
- production in Gamma Ray Bursts

Axions produced in supernovae (arXiv:1410.3747)

- core collapse supernova (SN1987A)

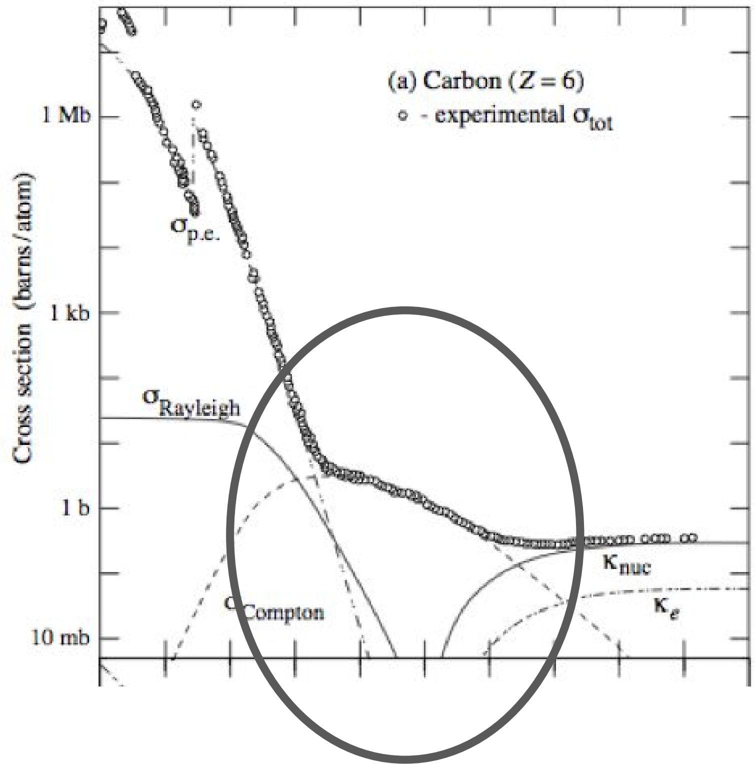
Current upper limits would be limited by the PSF below 100 MeV



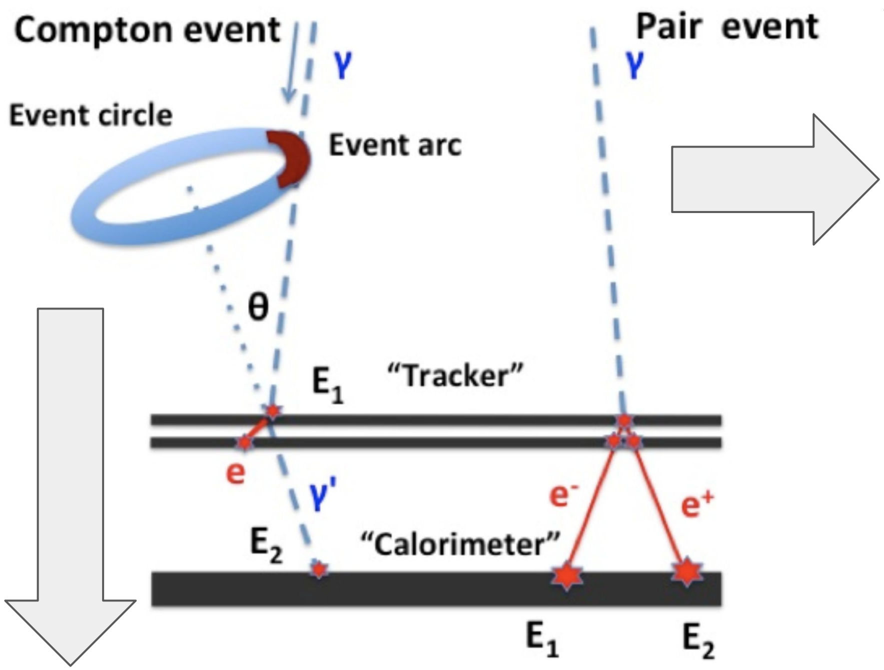
See M. Meyer's talk at 17:00 on Friday (8/11)

Challenges

Additionally, large backgrounds exist in this energy range.



From ~0.1 - 100 MeV two photon interaction processes compete: Compton scattering and pair production cross sections intersect at ~10 MeV

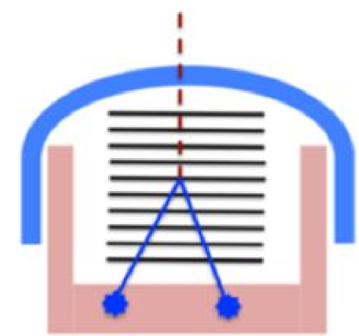


Ɣ converts to pair (e-/e+) in a multi-layer Si-strip tracker (no additional conversion material).

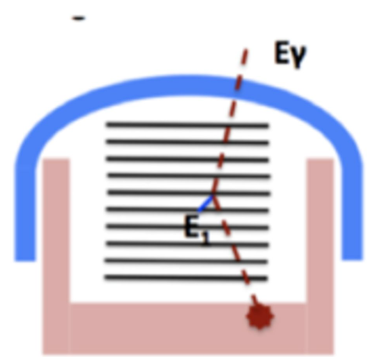
- Trigger on signals in 2 consecutive Si-strip layers in coincidence with energy deposit in a calorimeter.
- Ɣ direction is determined by measuring the position of the pair components as they pass through the Si-strip layers and a calorimeter.
- Ɣ energy is determined by evaluating the energy deposited in the Si-strips and in the calorimeter.

Photon scatters a low-energy e- in Si-strip. Scattered Ɣ can be absorbed in the calorimeter.

- Trigger on signal in Si-strip in coincidence with energy deposit in the calorimeter.
- Ɣ direction constrained to a circle or arc on the sky. Determined by position and energy measurements of a low-energy e- and absorbed Ɣ.
- Ɣ energy is determined by evaluating the energy deposited in the Si-strips and in the calorimeter.



a) Pair production event

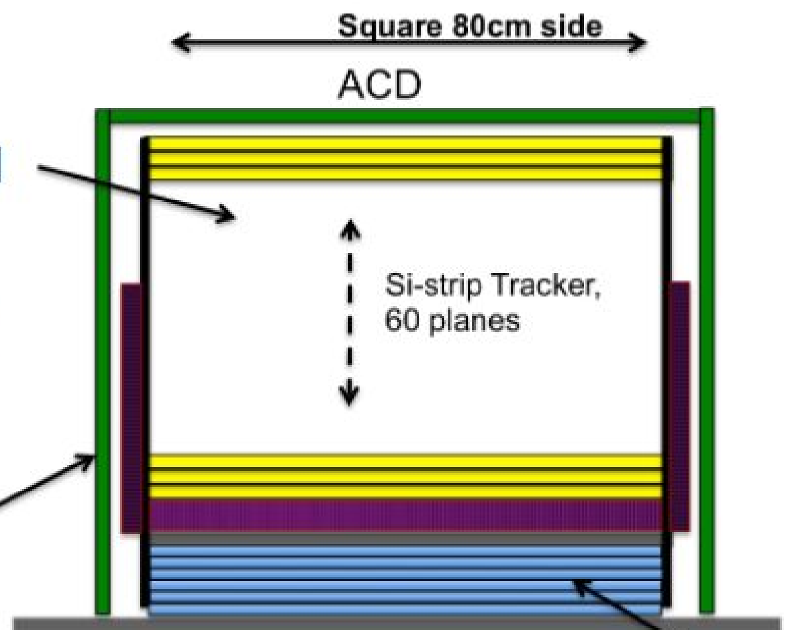


b) Compton event, 1 hit in Tracker

AMEGO Schematic

Tracker: Incoming photon undergoes pair production or Compton scattering. Measure energy and track of electrons and positrons

- 60 layer DSSD, spaced 1 cm, Strip pitch 0.5 mm



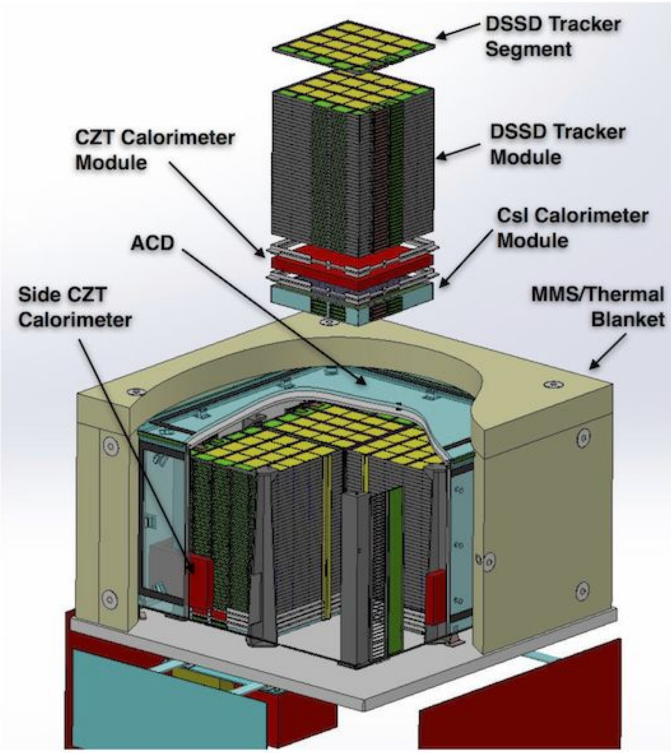
CZT Calorimeter: Measure location and energy of Compton scattered photons

- Layer of 0.6 x 0.6 x 2 cm bar CZT

CsI Calorimeter: Extend upper energy range

- 6 planes of 1.5 cm x 1.5 cm bars

AMEGO Details



- Use of **well-tested, proven technologies** (Si tracker, CsI calorimeter, Plastic ACD, …)
- Designed to fit within a probe class budget:
  - Concept for the 2020 decadal review
- Designed to be **modular** for ease of development, testing, and integration.
- 10 year mission goal (similar to *Fermi*)

Energy Range	0.2 MeV -> 10 GeV
Angular Resolution	3° (1 MeV), 10° (10 MeV)
Energy Resolution	<1% below 2 MeV; 1-5% at 2-100 MeV; ~10% at 1 GeV
Field-of-View	2.5 sr
Sensitivity (MeV s^{-1} cm^{-2})	4×10^{-6}(1 MeV); 4.8×10^{-6}(10 MeV); 1×10^{-6}(100 MeV)

AMEGO

ALL-SKY MEDIUM ENERGY GAMMA-RAY OBSERVATORY

The MeV gamma-ray band has enormous scientific potential.

AMEGO is a probe class survey mission in consideration for the 2020 decadal review with sensitivity between **0.2 MeV and 10 GeV**.

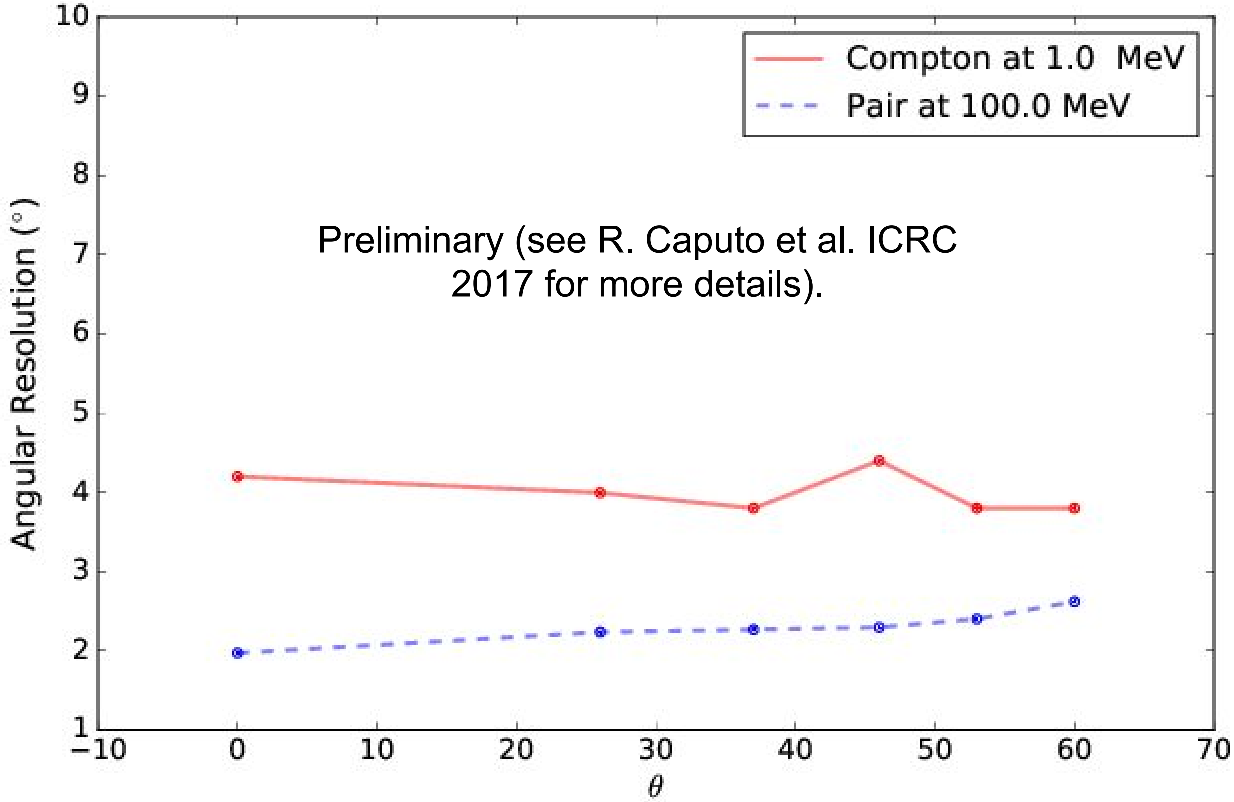
Detects MeV gamma-rays via pair production and Compton scattering and performs **continuum, spectroscopy and polarization** measurements.

AMEGO will open up **a new window on the MeV sky** and explore:

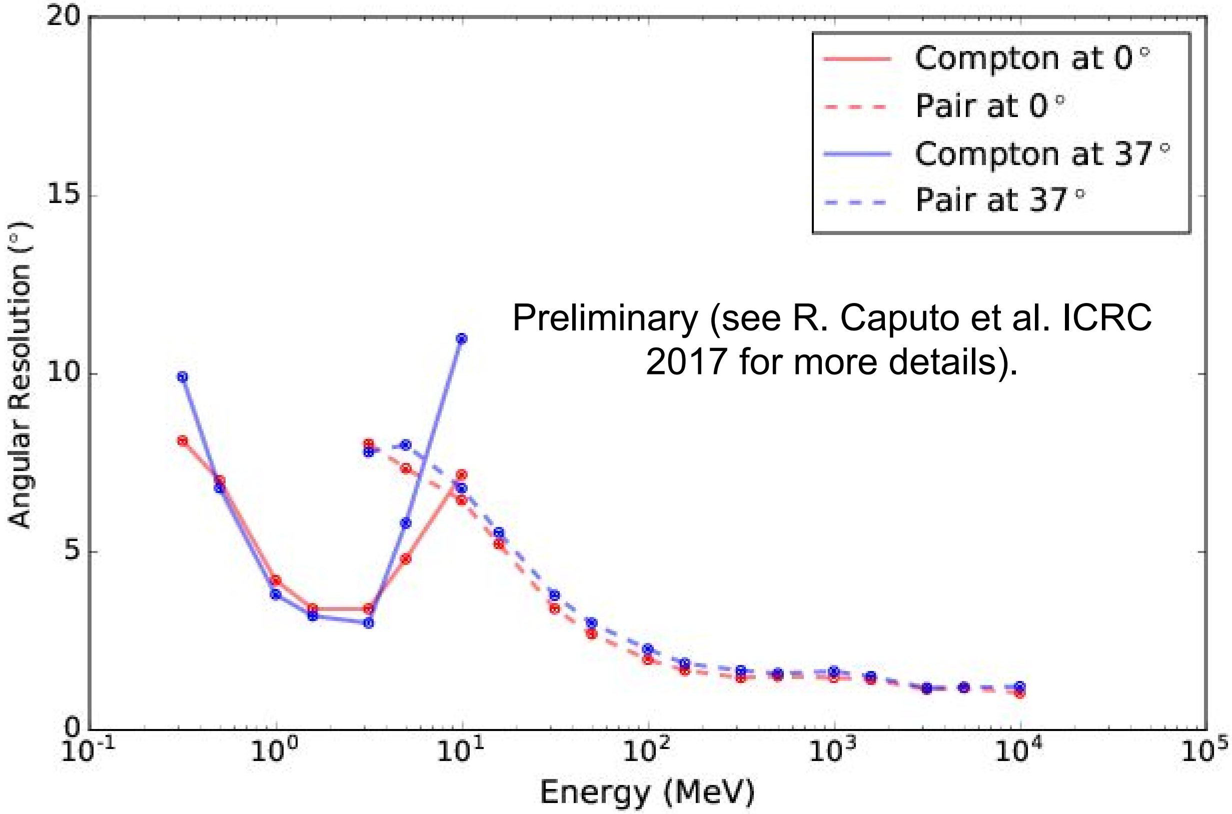
- Jets: Formation, Evolution, and Acceleration
- Extreme Conditions Around Compact Objects
- Element Formation in Dynamic Systems
- Dark Matter Signals

See talks by T. Venters, M. Meyer, and X. Wang for more details.

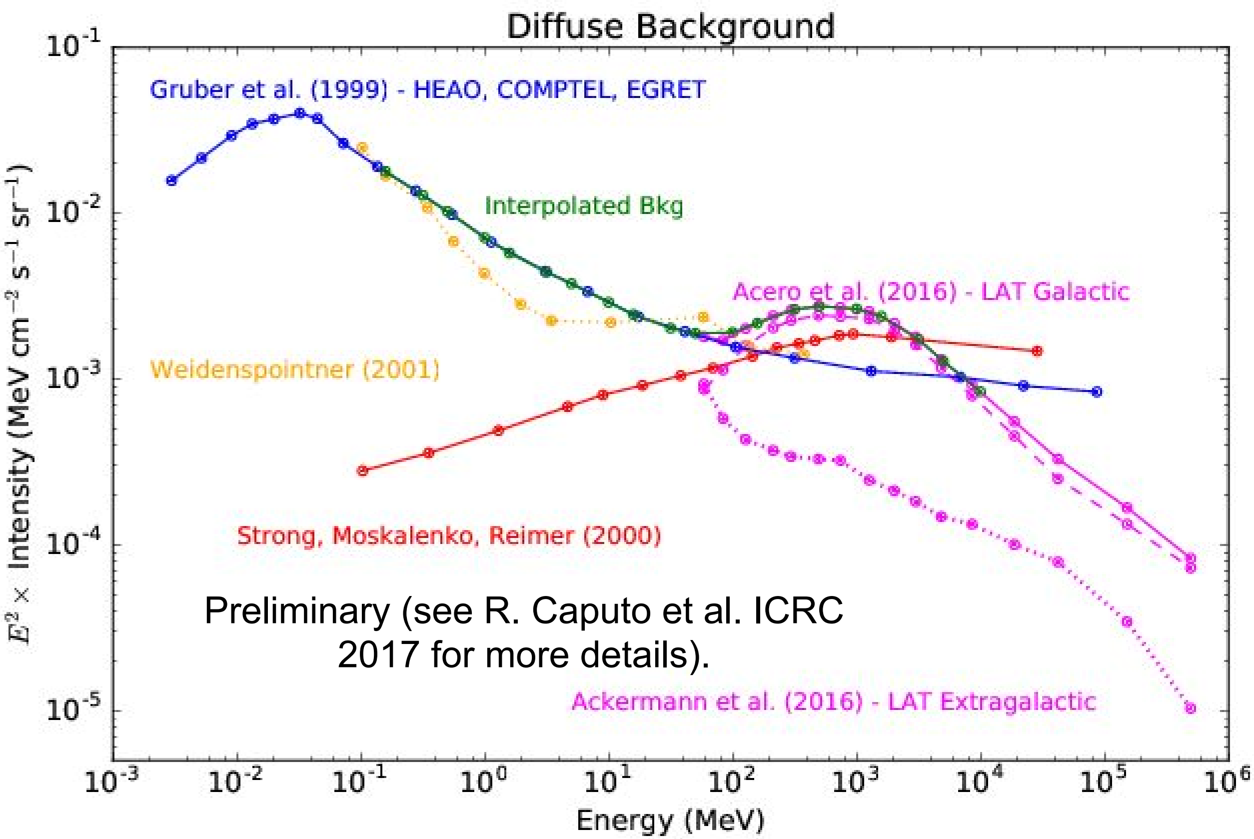
Backup Slides



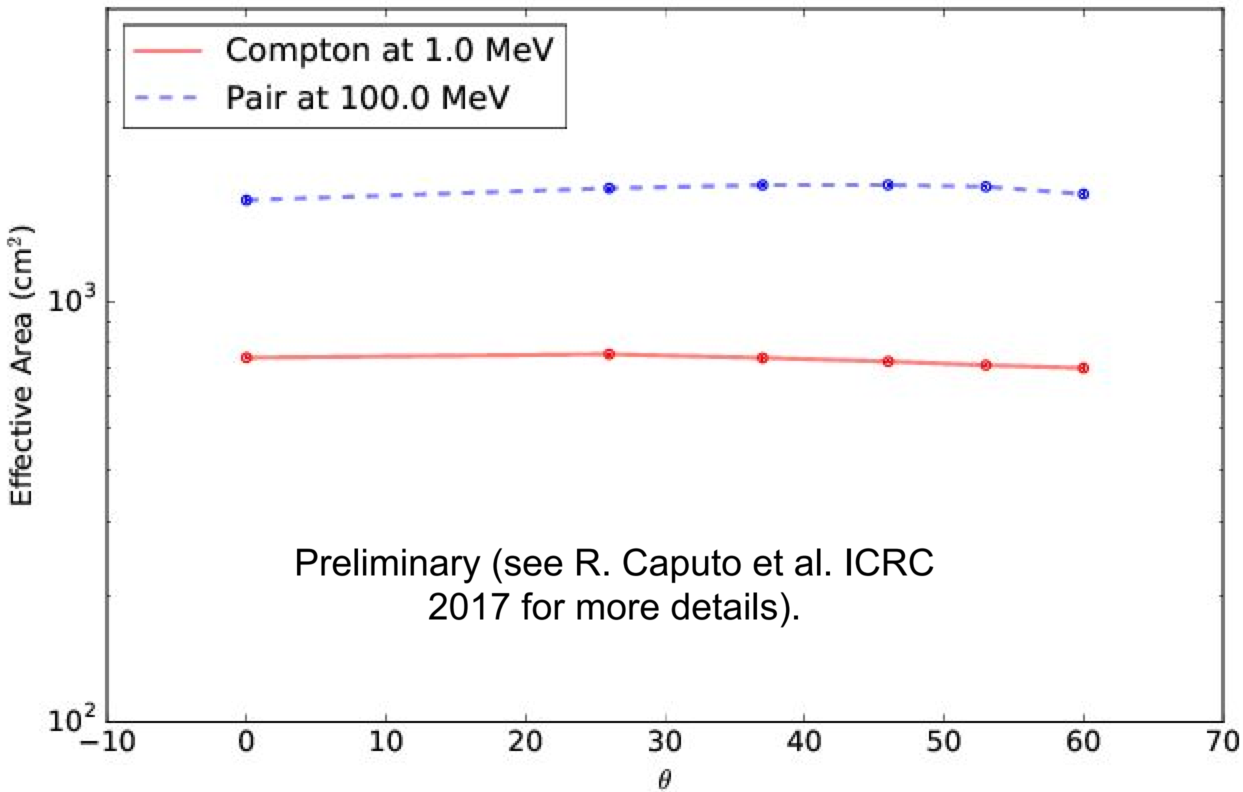
Angular Resolution vs. Theta



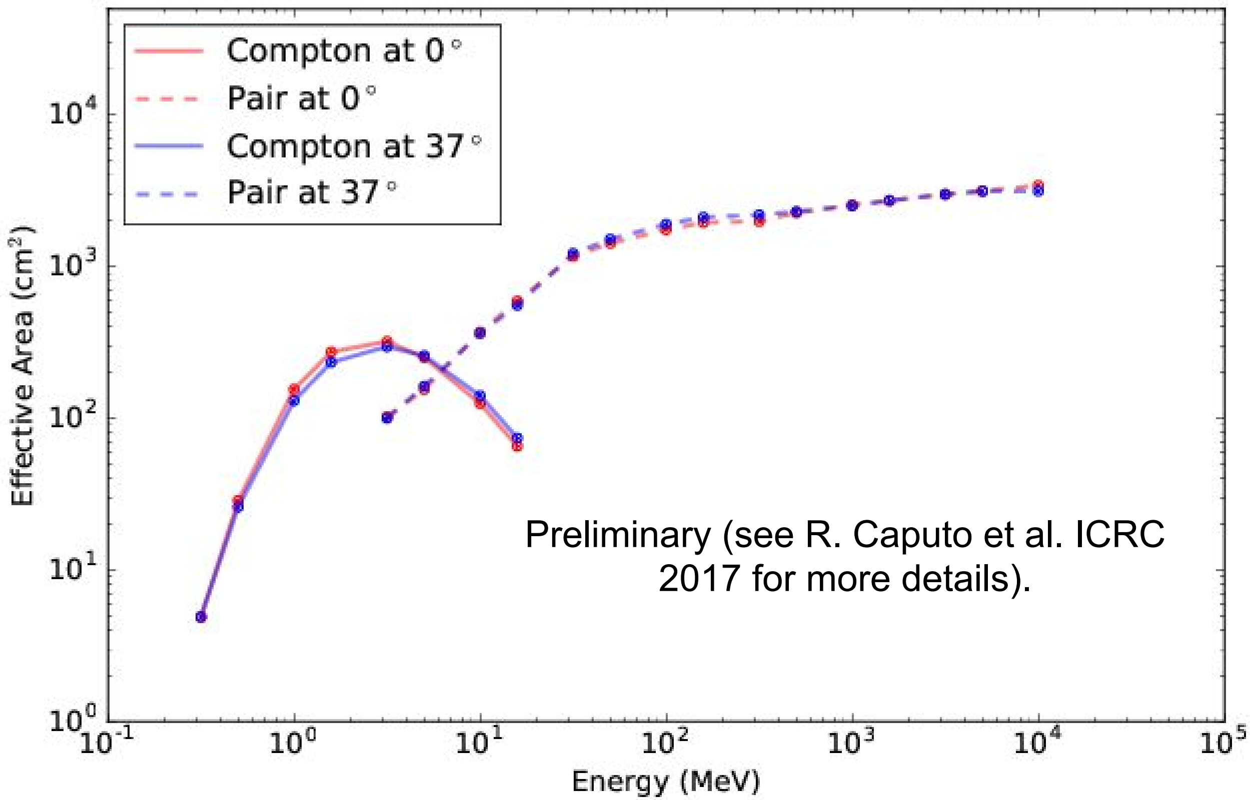
Angular Resolution vs. Energy



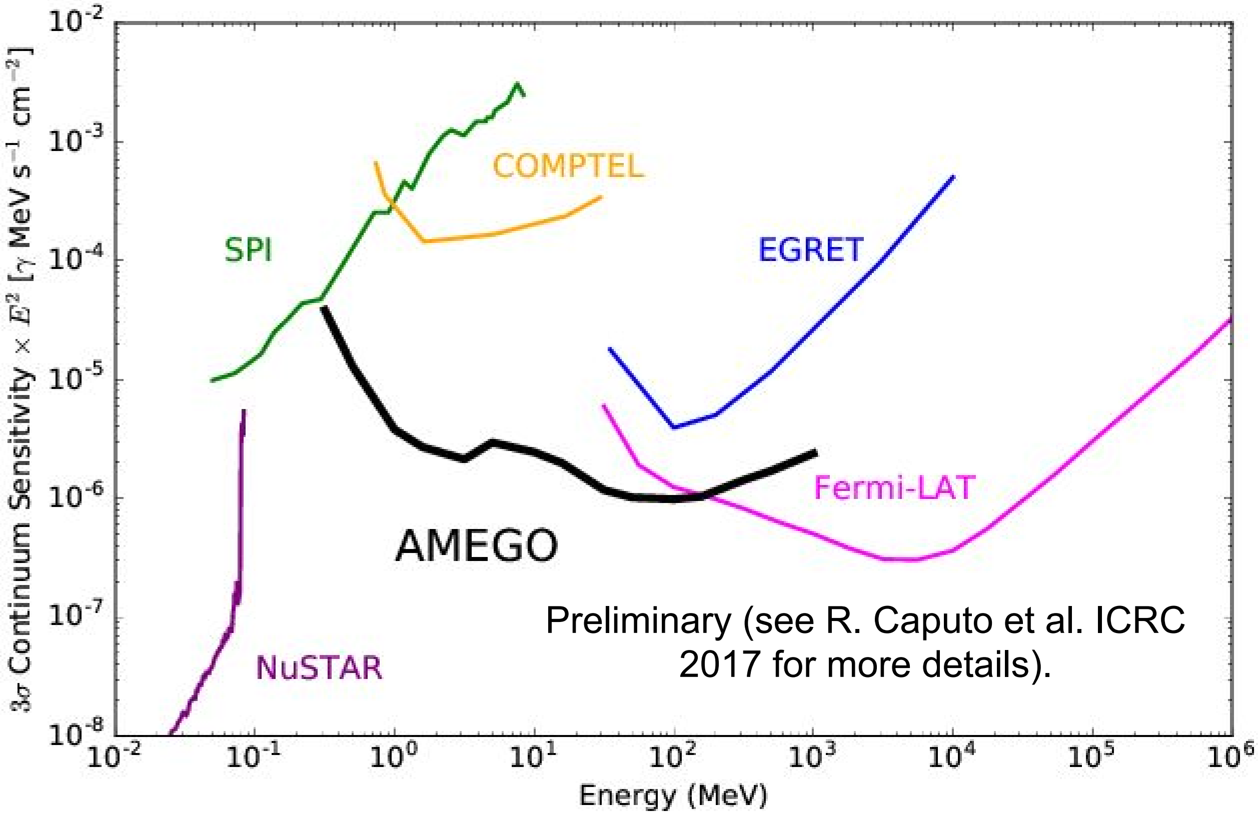
Diffuse Backgrounds



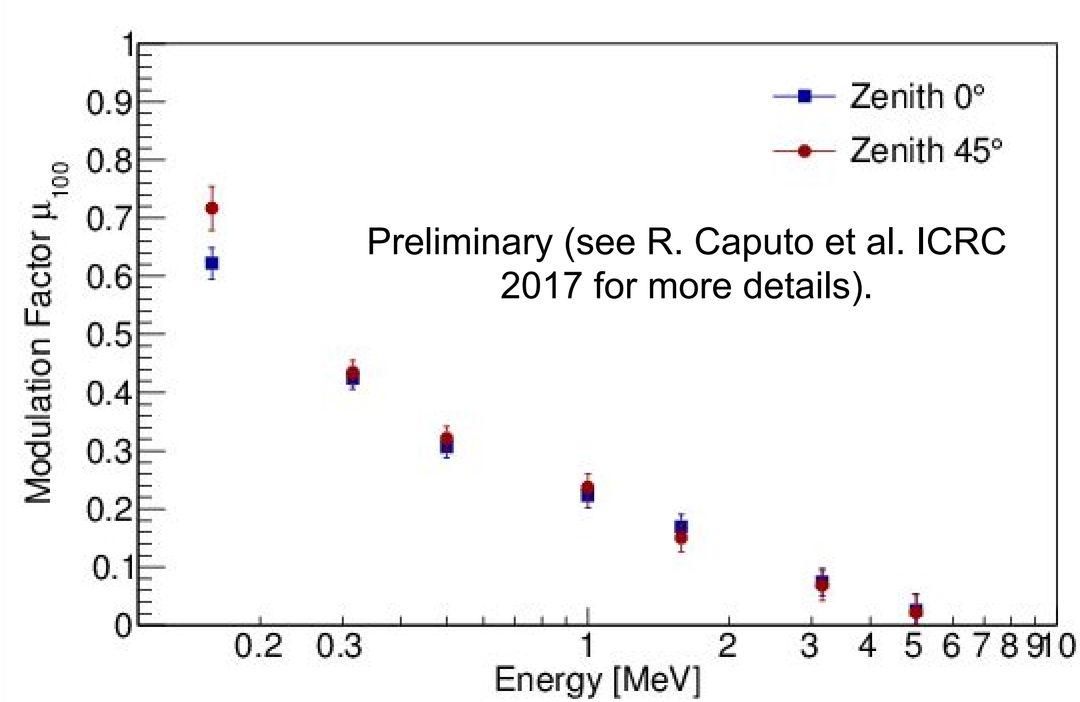
Effective Area vs. Theta



Effective Area vs. Energy



Sensitivity



$$\mathrm{MDP} = \frac{4.29}{\mu_{100} R_S} \sqrt{\frac{R_S + R_{BG}}{T_{\mathrm{obs}}}}$$

In one week, assuming that the source is in the field of view for 10% of the time, AMEGO reaches an MDP of 5% (12%) in the 0.5 - 1 MeV (1 - 2 MeV) energy range.

Polarization