AMEGO

ALL-SKY MEDIUM ENERGY GAMMA-RAY OBSERVATORY

Sylvain Guiriec

(George Washington University/NASA GSFC)

on behalf of the AMEGO team

https://asd.gsfc.nasa.gov/amego

THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

AMEGO Team

NASA/GSFC, George Wash. Univ., Clemson Univ., Naval Research Lab, UC Berkeley, Wash. Univ., University of New Hampshire, NASA/MSFC, University of Alabama, Huntsville, USRA, the Ohio State University, UIUC, UNLV, LANL, University of Delaware, UC Santa Cruz, SLAC, Argonne, Stanford University, University of North Florida, Yale University, Rice University, INFN, Pisa University, Padova University, INAF, Udine University, Rome University, Yale University, University of Maryland, Brookhaven National Lab

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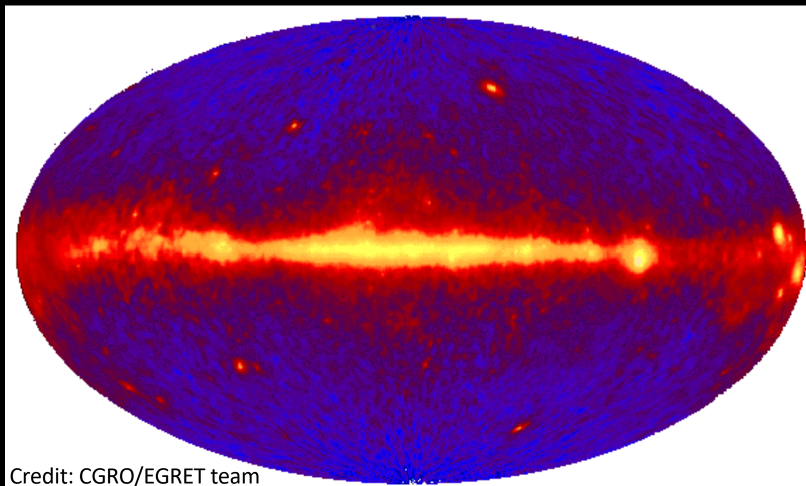
AM

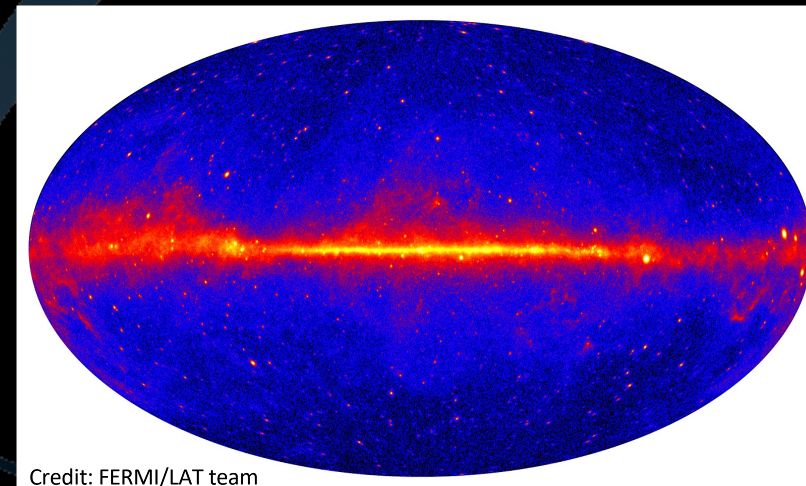
NASA/GSFC, George Wash. Un Naval Research Lab, UC Berkeley, Wash. Univ., Universi NASA/MSFC, University of Alabama, Huntsville UIUC, UNLV, LANL, University of Delawa Stanford University, University of Nor ersity, INFN, Pisa University, Padova me University, Yale University, ational Lab

This is a community effort. If you like the project and the idea, and want to join, please contact Julie McEnery (PI)

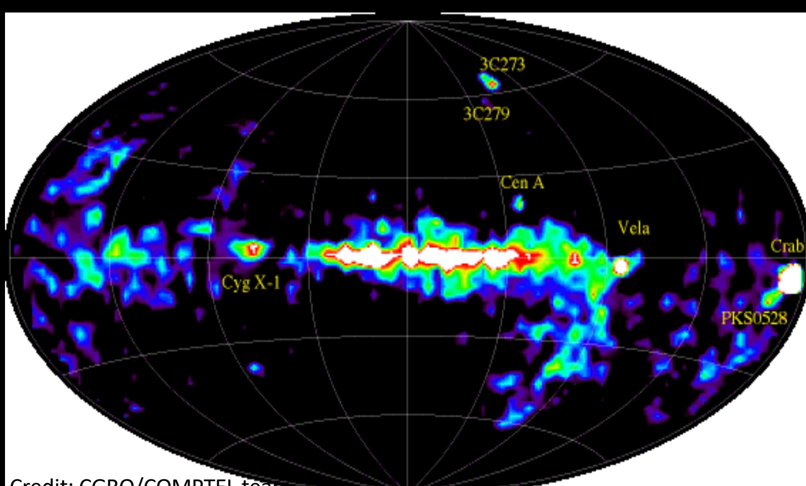
Why is MeV Astronomy Important?


Credit: CGRO/EGRET team

~300 sources detected


Credit: FERMI/LAT team

~3,000 sources detected



Credit: CGRO/COMPTEL team

Dozens sources detected

?

Guaranteed discovery space: zero risks

AMEGO Science

Understanding Extreme Environments:

- **Astrophysical Jets**

  Understand the formation, evolution, and acceleration mechanisms in astrophysical jets

- **Compact Objects**

  Identify the physical processes in the extreme conditions around compact objects

- **Dark Matter**

  Test models that predict dark matter signals in the MeV band

- **MeV Spectroscopy**

  Measure the properties of element formation in dynamic systems

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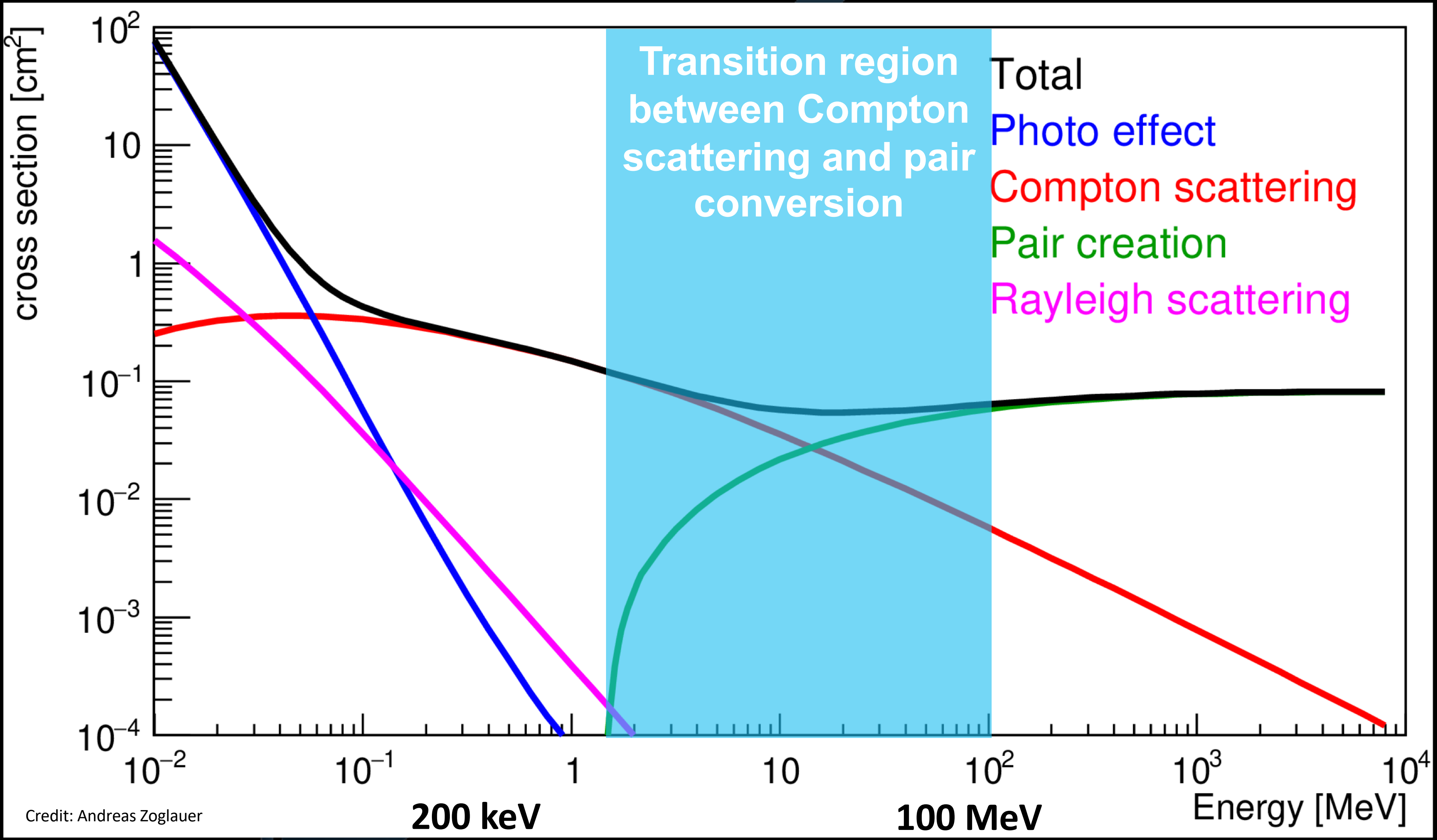
Why is the MeV Regime So Poorly Known?

A technically challenging energy band



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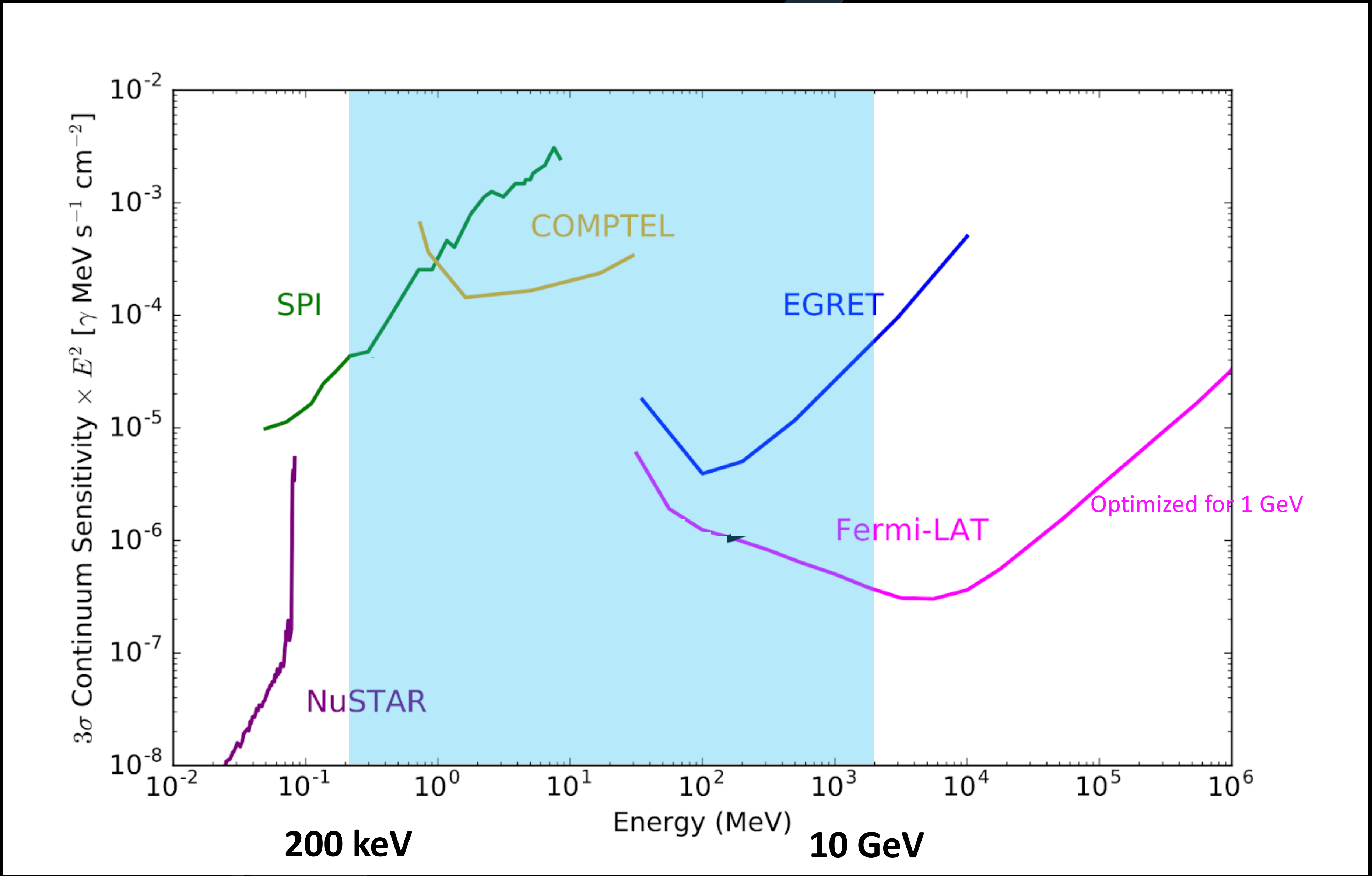

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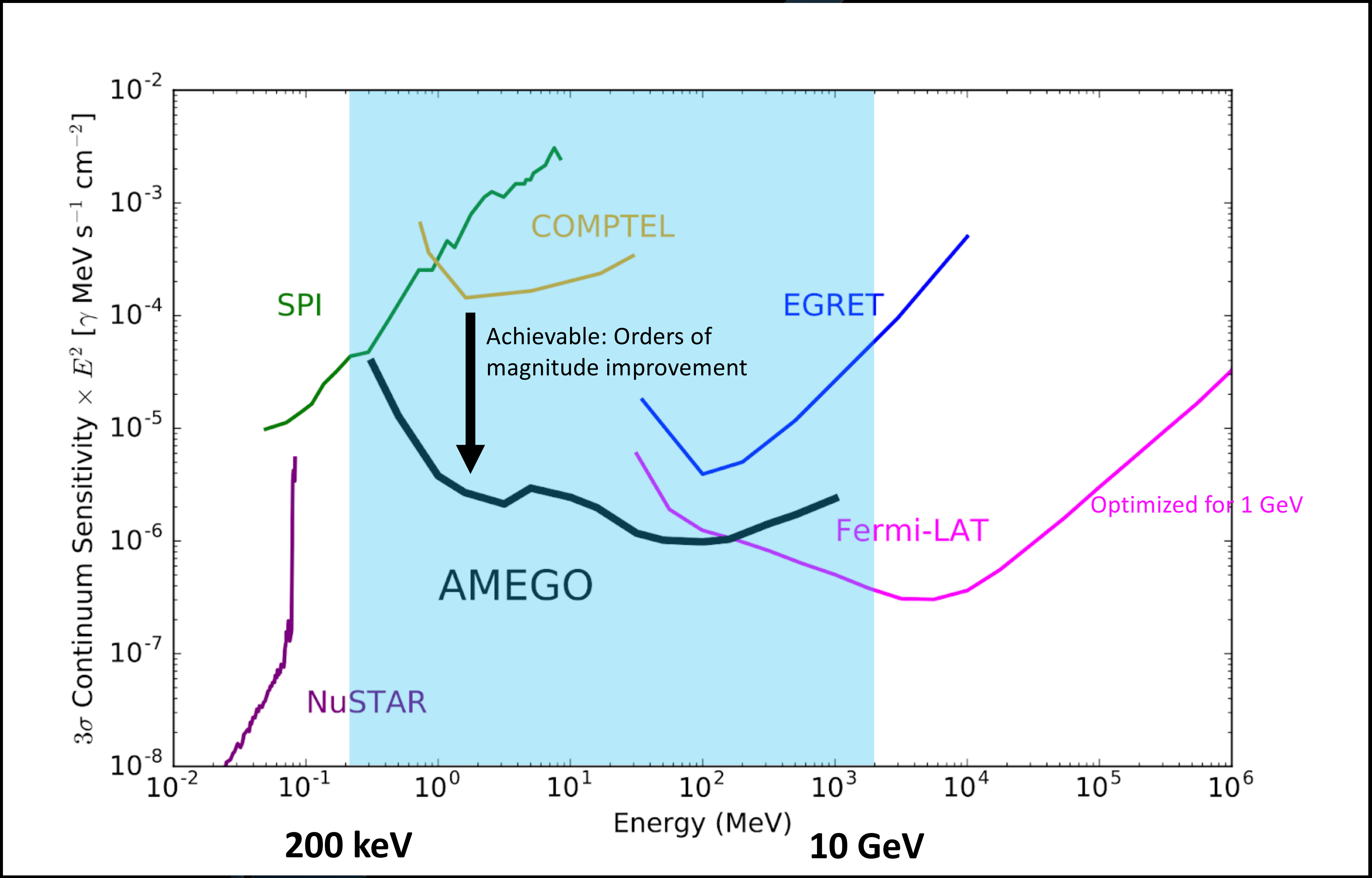
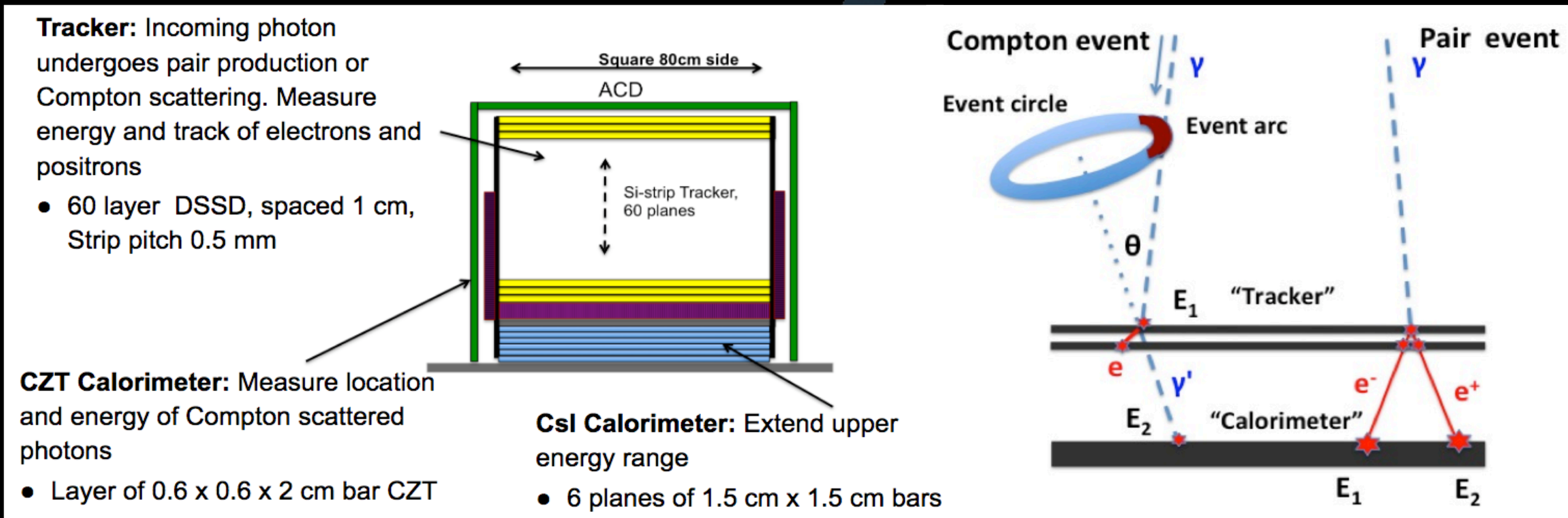


The All-sky Medium Energy Gamma-ray Observatory (AMEGO)



- **< ~10 MeV :** ɣ Compton scatters a low-energy e- in Si-strip.
- **> ~10 MeV :** ɣ converts to pair (e-/e+) in a multi-layer Si-strip tracker (no additional conversion material).

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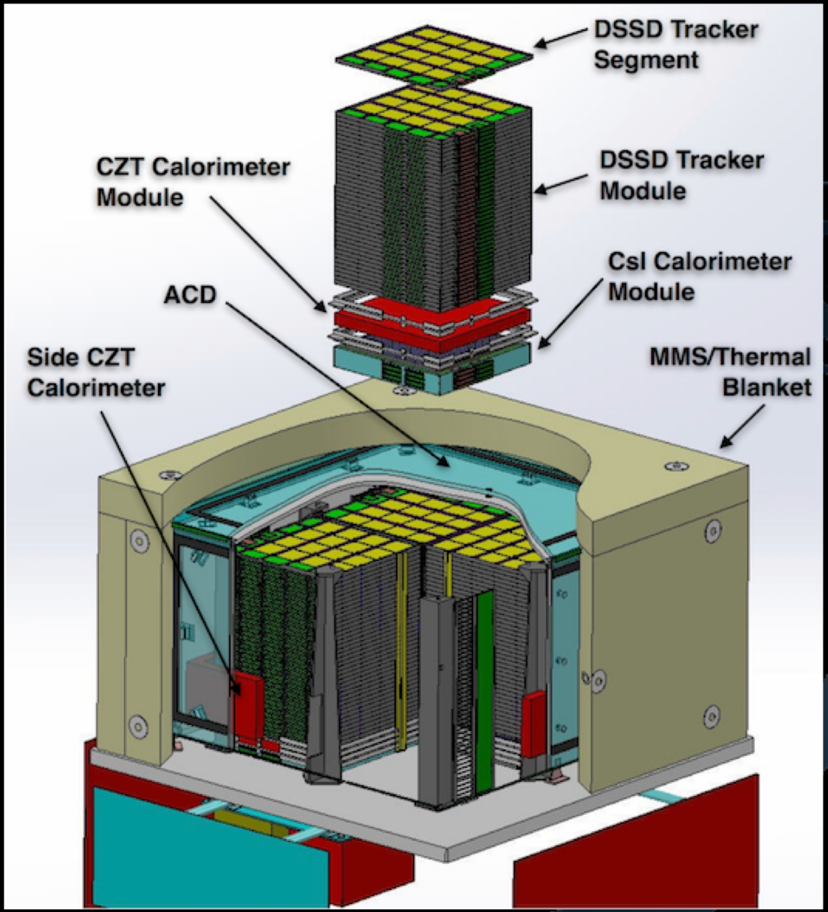

- Use of **well-tested, proven technologies** (Si tracker, CsI calorimeter, Plastic ACD, …)
- Fit within a probe class budget:
  Concept for the 2020 decadal review
- Designed to be **modular** for ease of development, testing, and integration.
- 10 year mission goal (similar to *Fermi*)

See Sean Griffin's poster: "Status of the AMEGO Subsystem Development"

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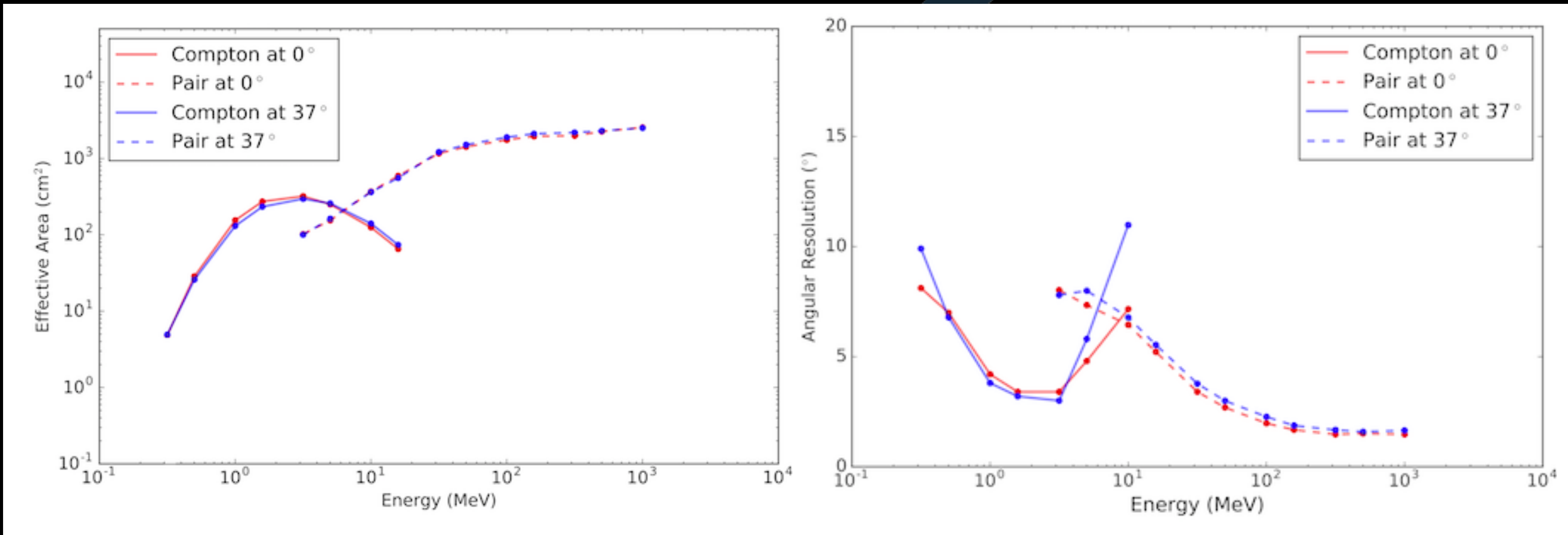
All-sky Medium Energy Gamma-ray Observatory

AMEGO Performances



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)

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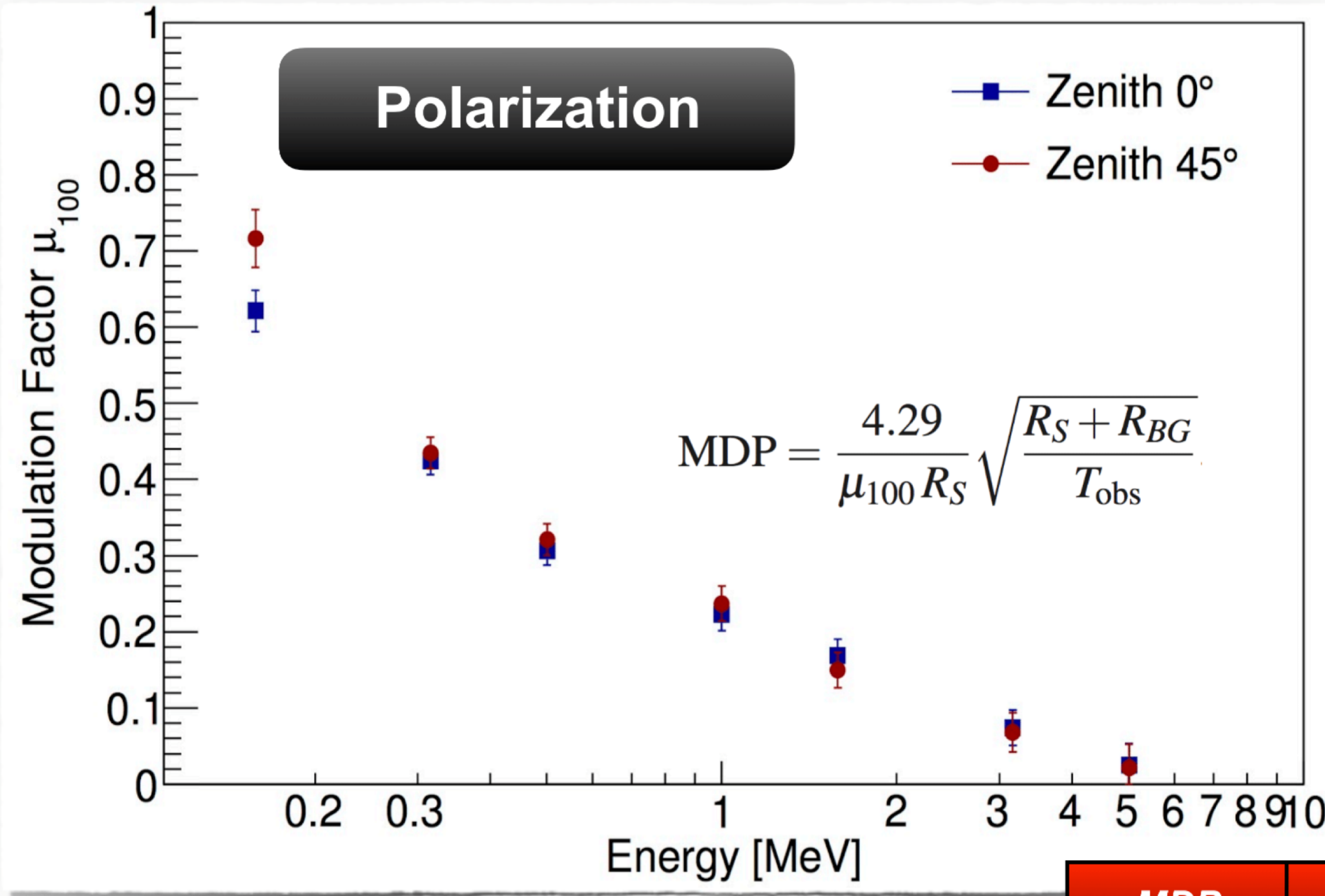
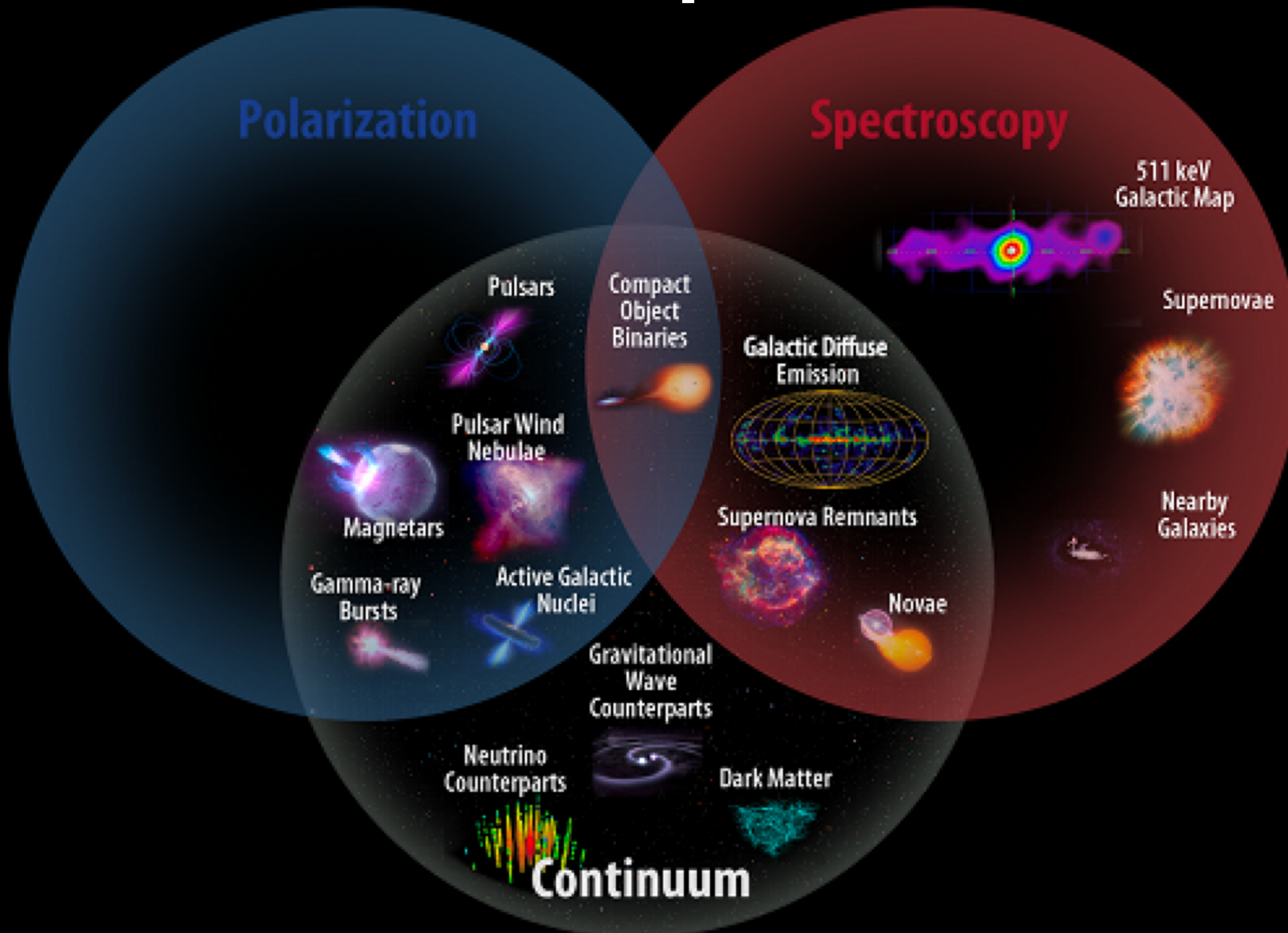
Polarization



Polarization: simulated polarized source is fit to a sin function. Determine amplitude of azimuthal modulation (μ_{100}) (top left) vs. energy. Calculate minimal detectable polarization (MDP) for the signal (R_S), background (R_{BG}) and observation time (T_{obs}) (see equation inset and table on the right)

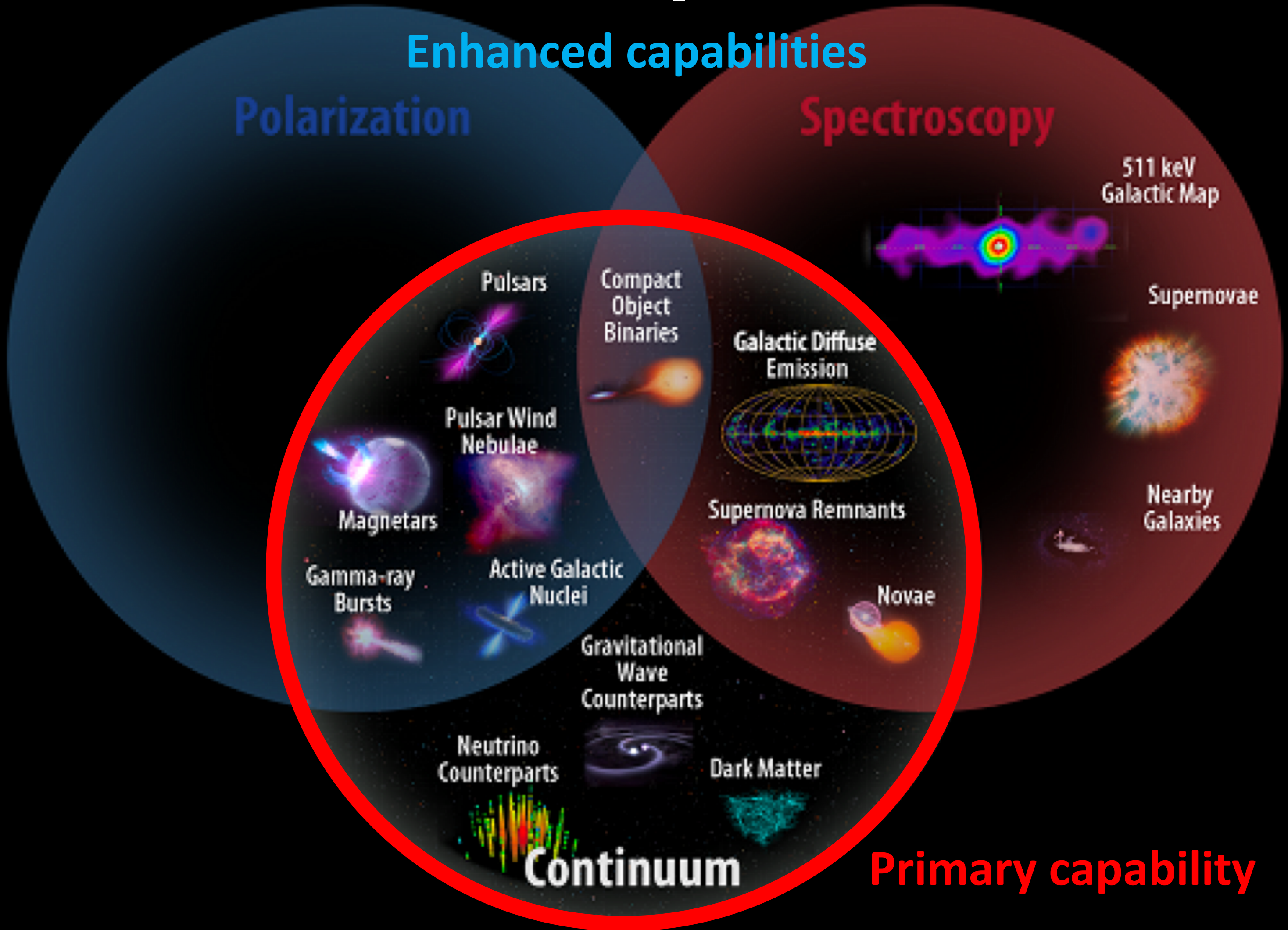
MDP	***Energy (MeV)***
5%	0.5-1
12%	1-2

AMEGO Capabilities



- **Sensitive continuum spectral studies**
- **Polarization**
- **Nuclear line spectroscopy**

AMEGO Capabilities



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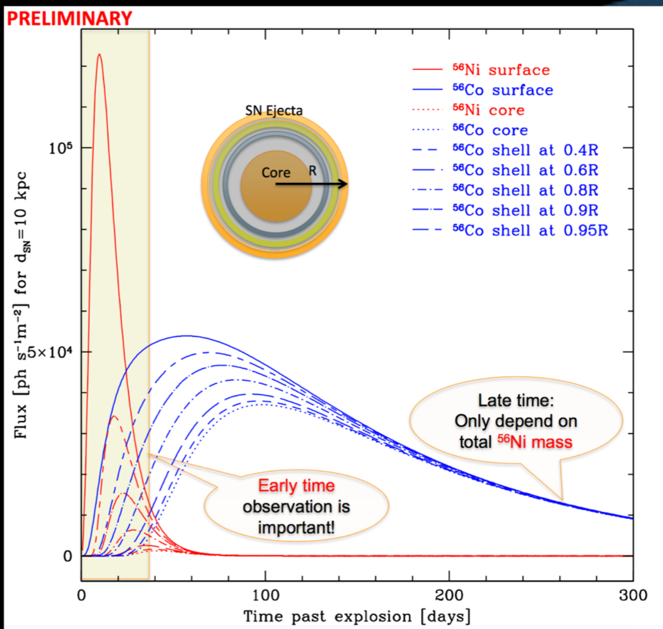
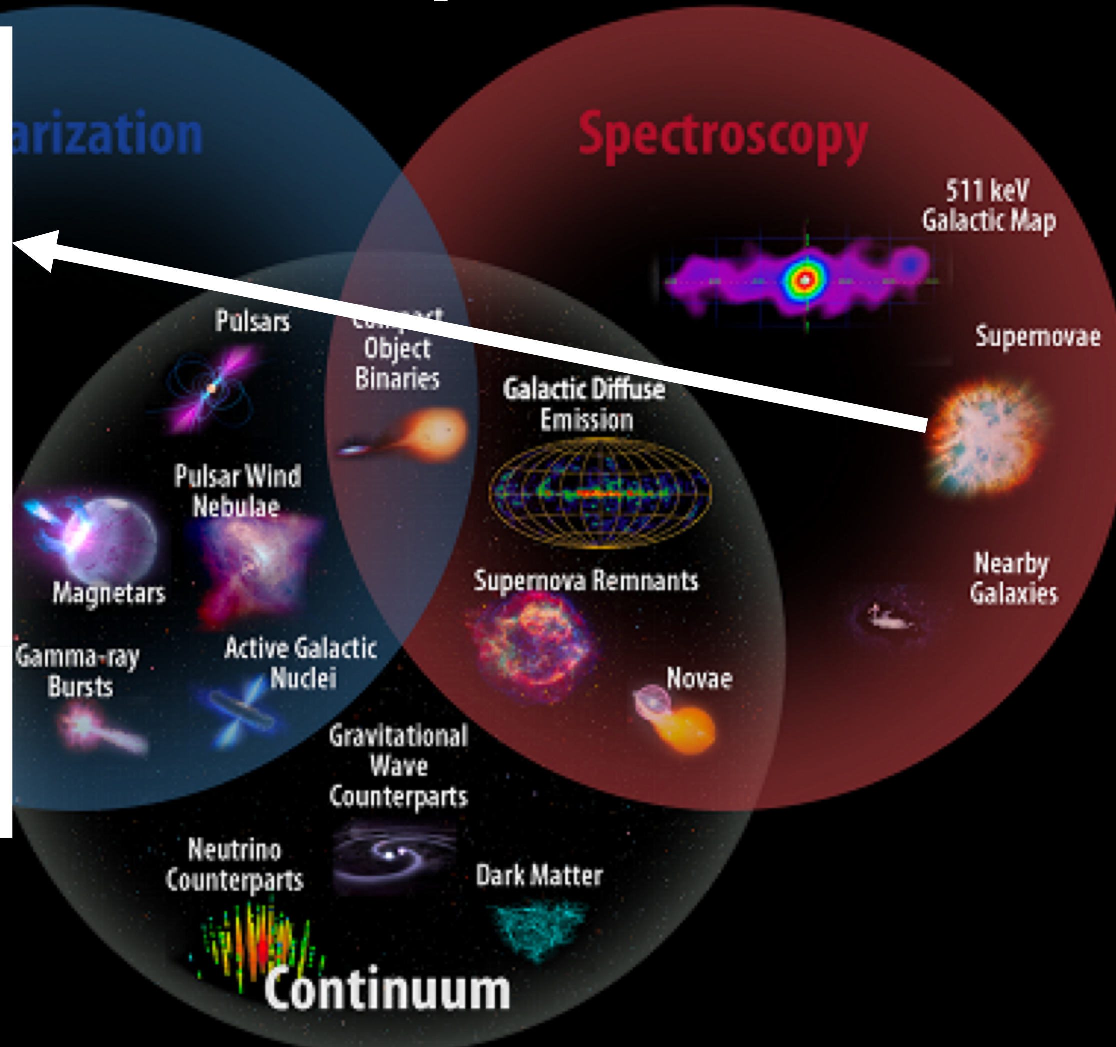


$$^{56}Ni \xrightarrow{t=8.8 days} {}^{56}Co + g$$

$$^{56}Co \xrightarrow{t=111.3 days} {}^{56}Fe + g$$



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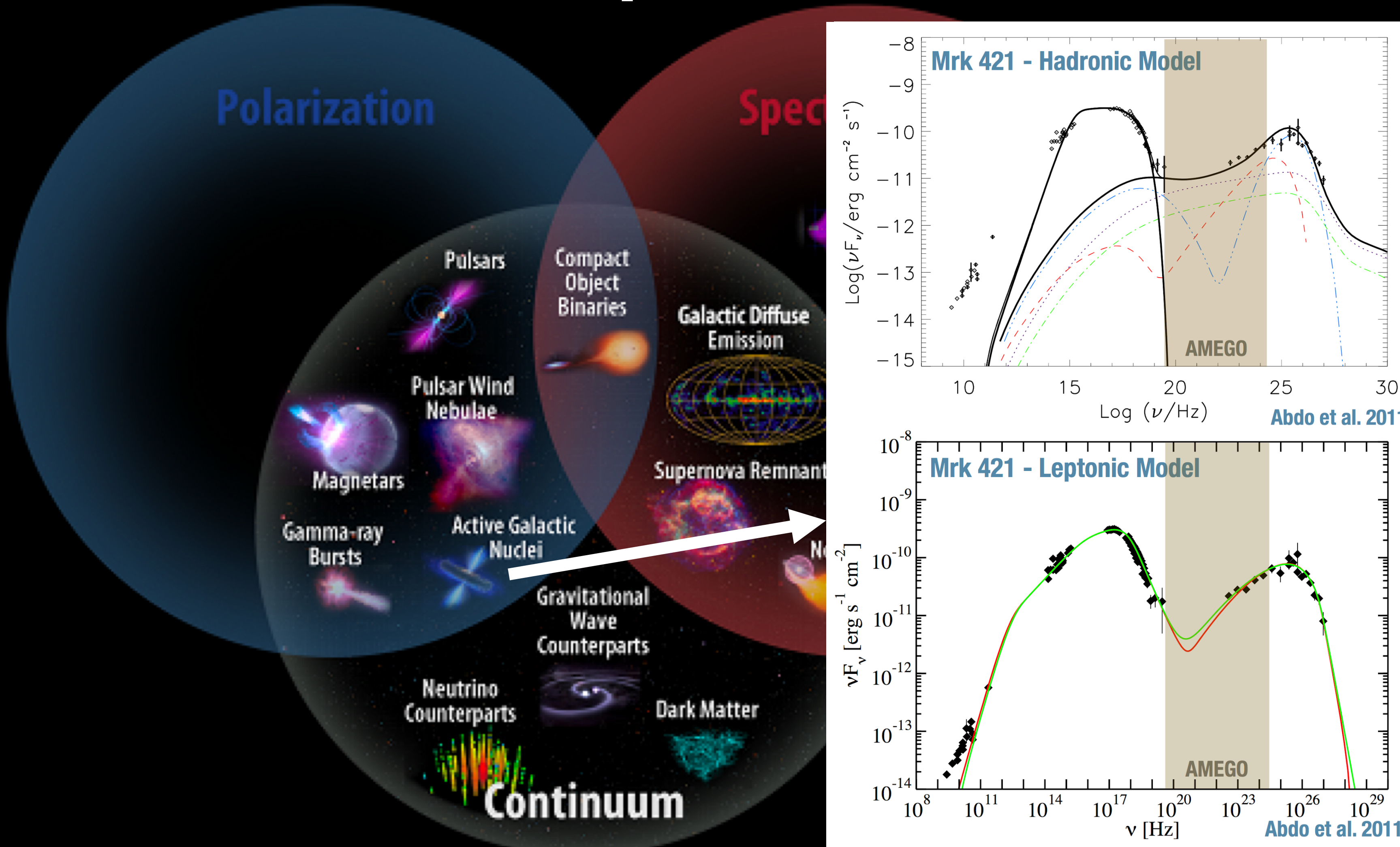

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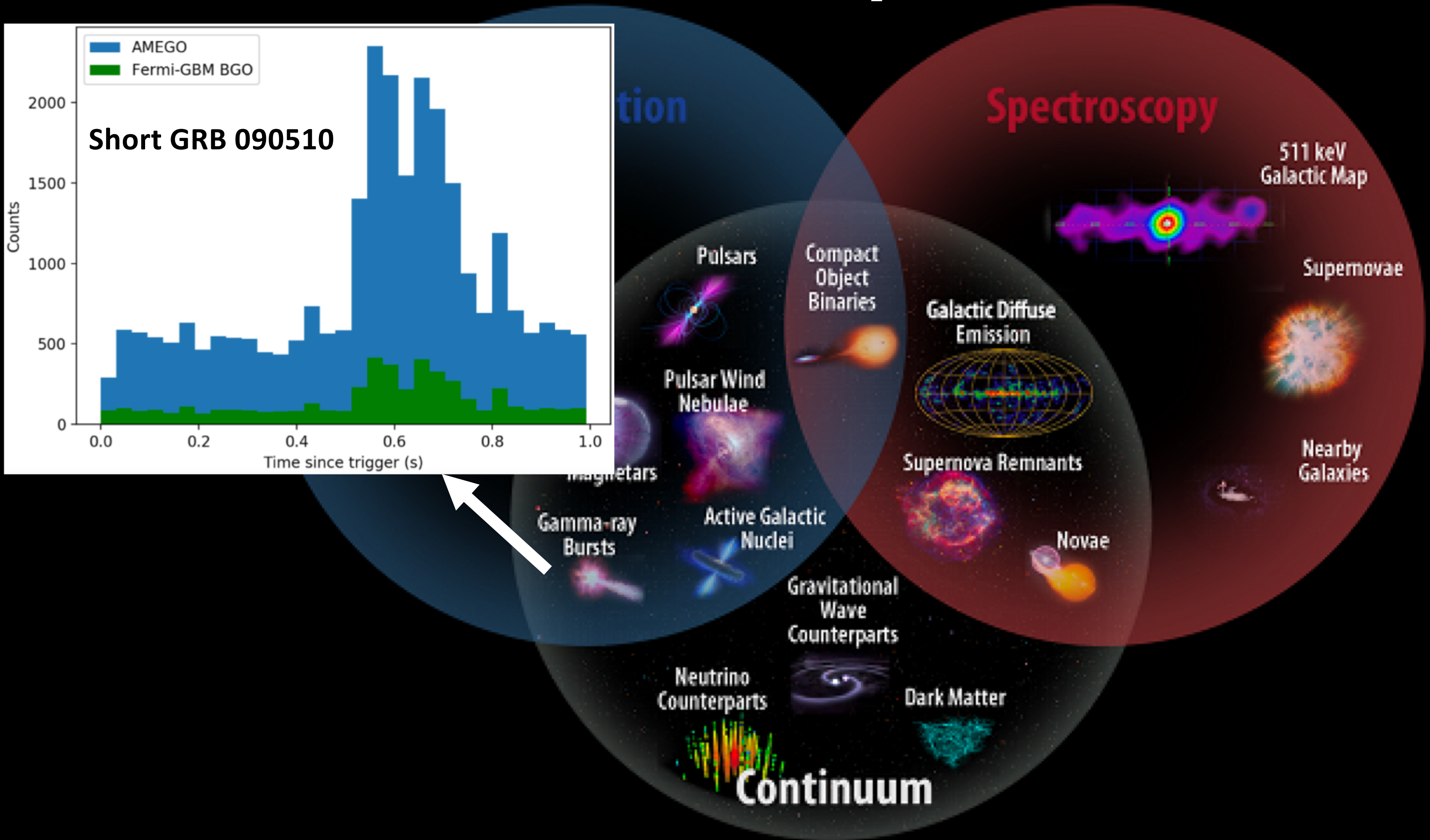

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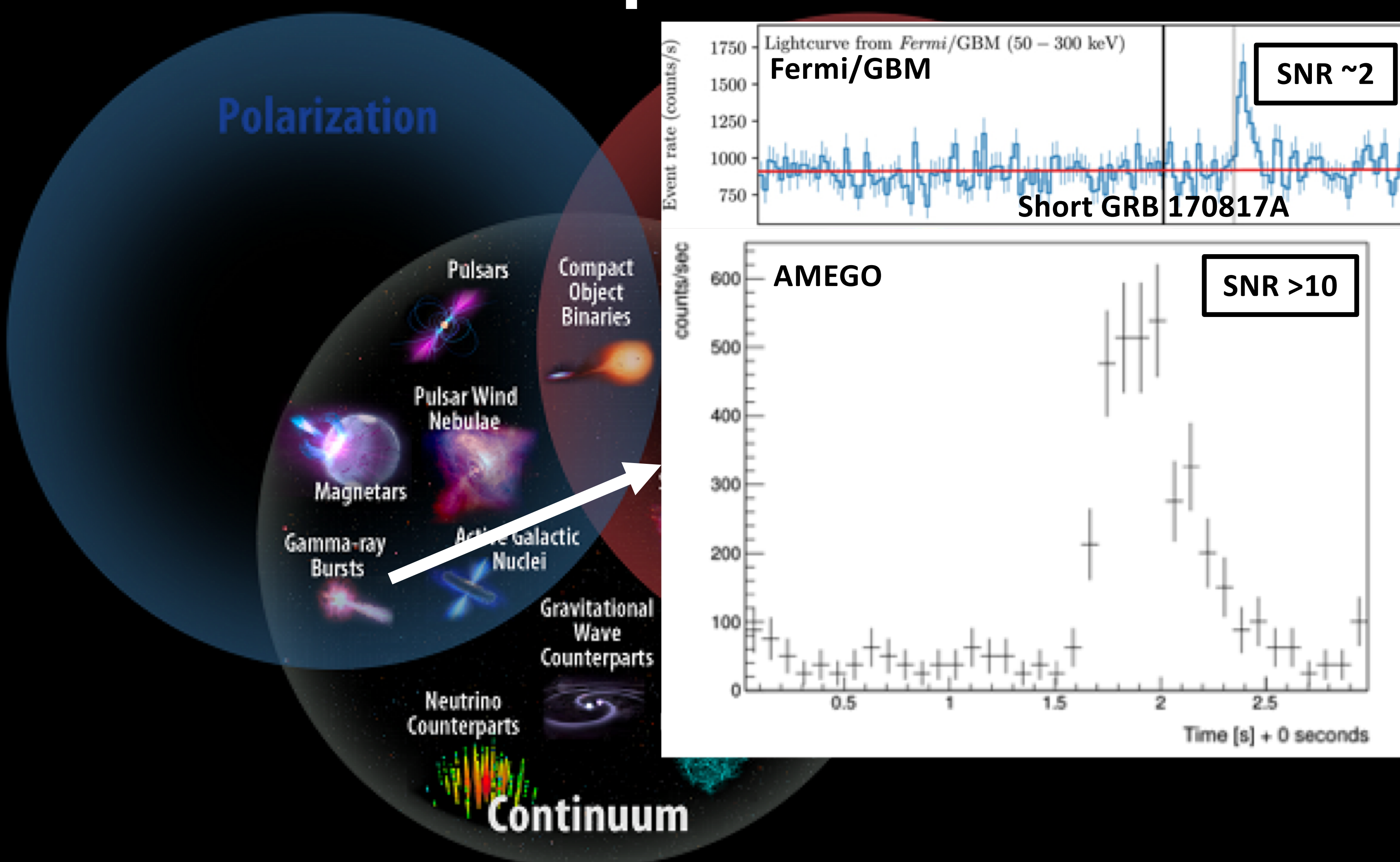

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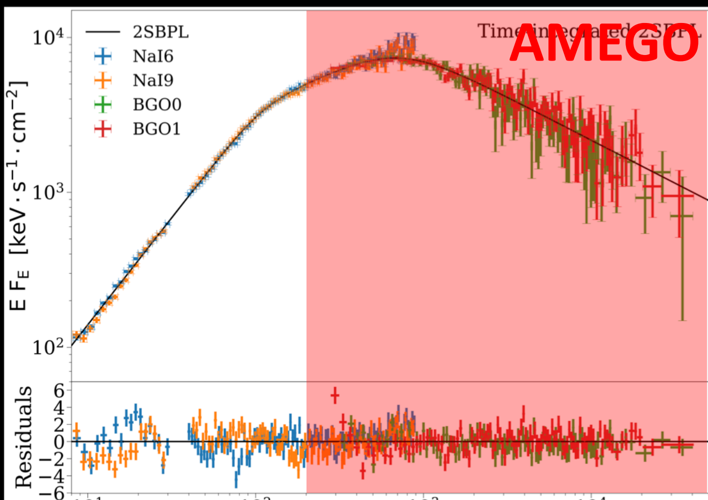
- **Polarization**
- **Nuclear line spectroscopy**

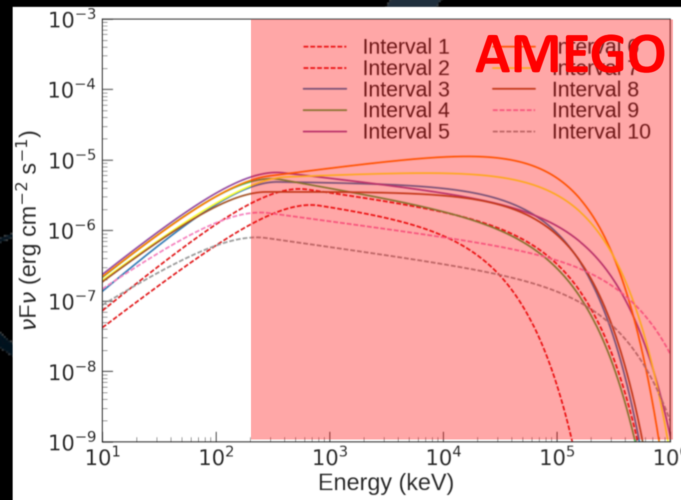
Example: GRB Spectroscopy with AMEGO

Synchrotron



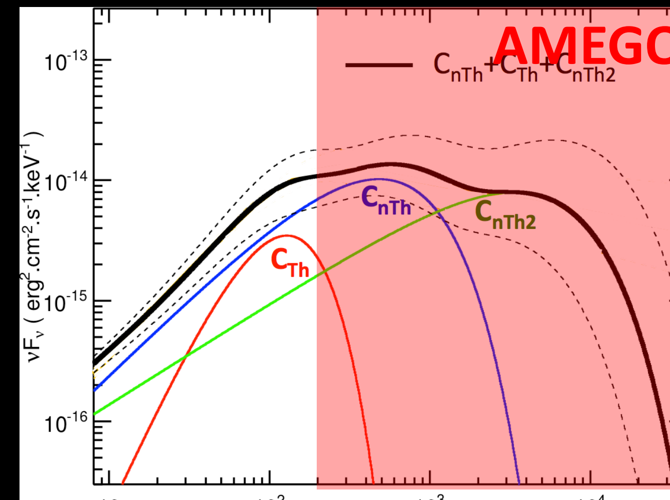
(Ravasio et al. 2018)

$\gamma-\gamma$ opacity



(Vianello et al. 2018)

Photospheric + synchrotron



(Guiriec et al. 2018)

Study of the prompt emission spectral shape:

- Electron distribution
- Lorentz factor
- Emission mechanisms
- Magnetization
- …

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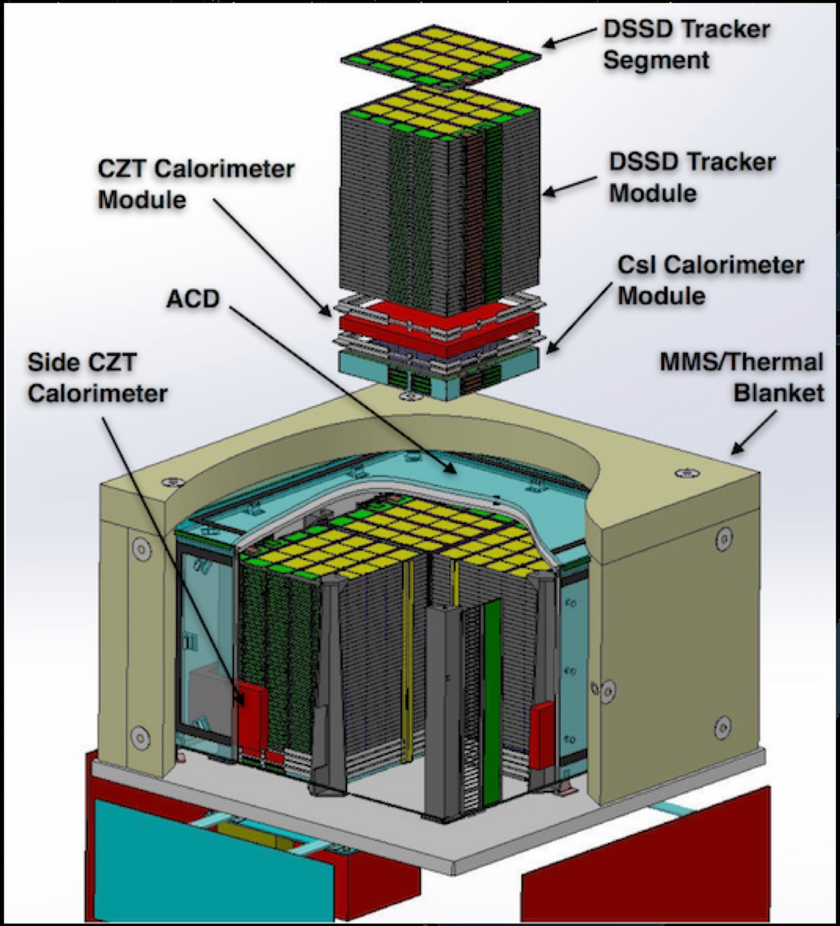

- AMEGO will reveal physics in an unexplored and important energy band
- Well tested and proven technology
- Balloon flight in 2019
- Fit within a probe class budget
- Concept for the 2020 Decadal Review

Don't Forget!

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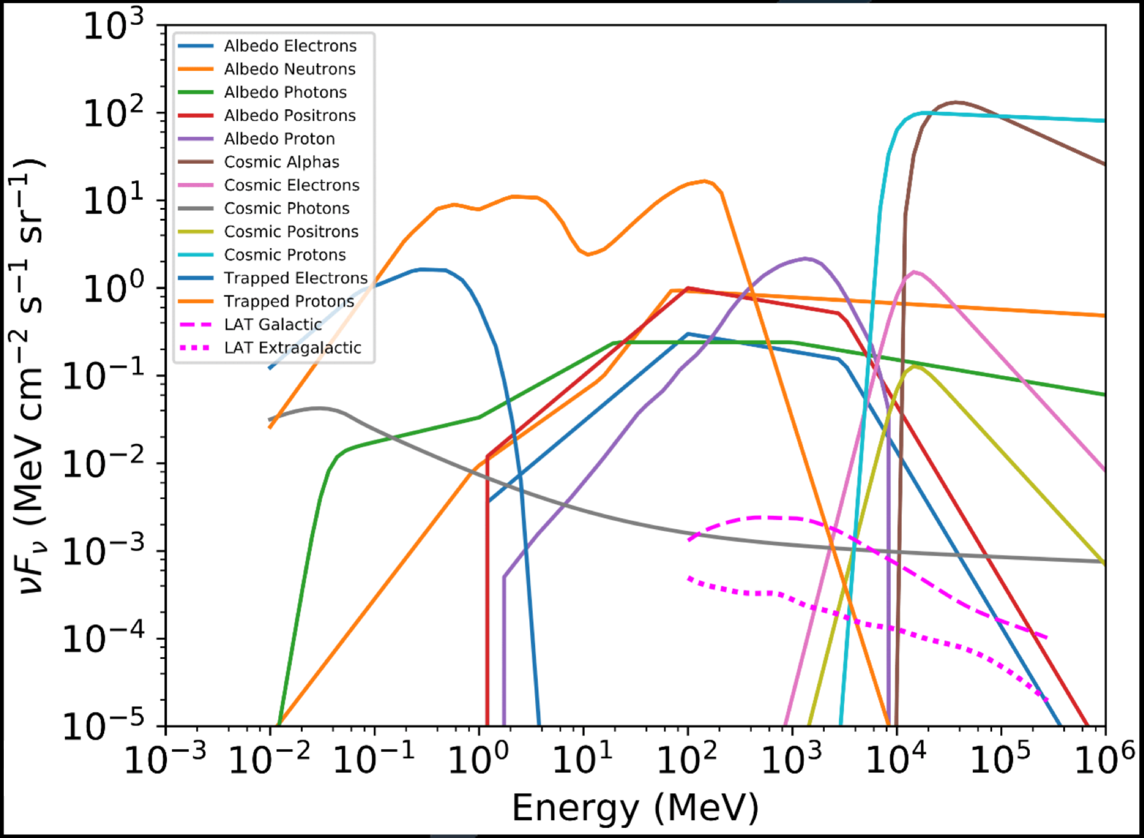
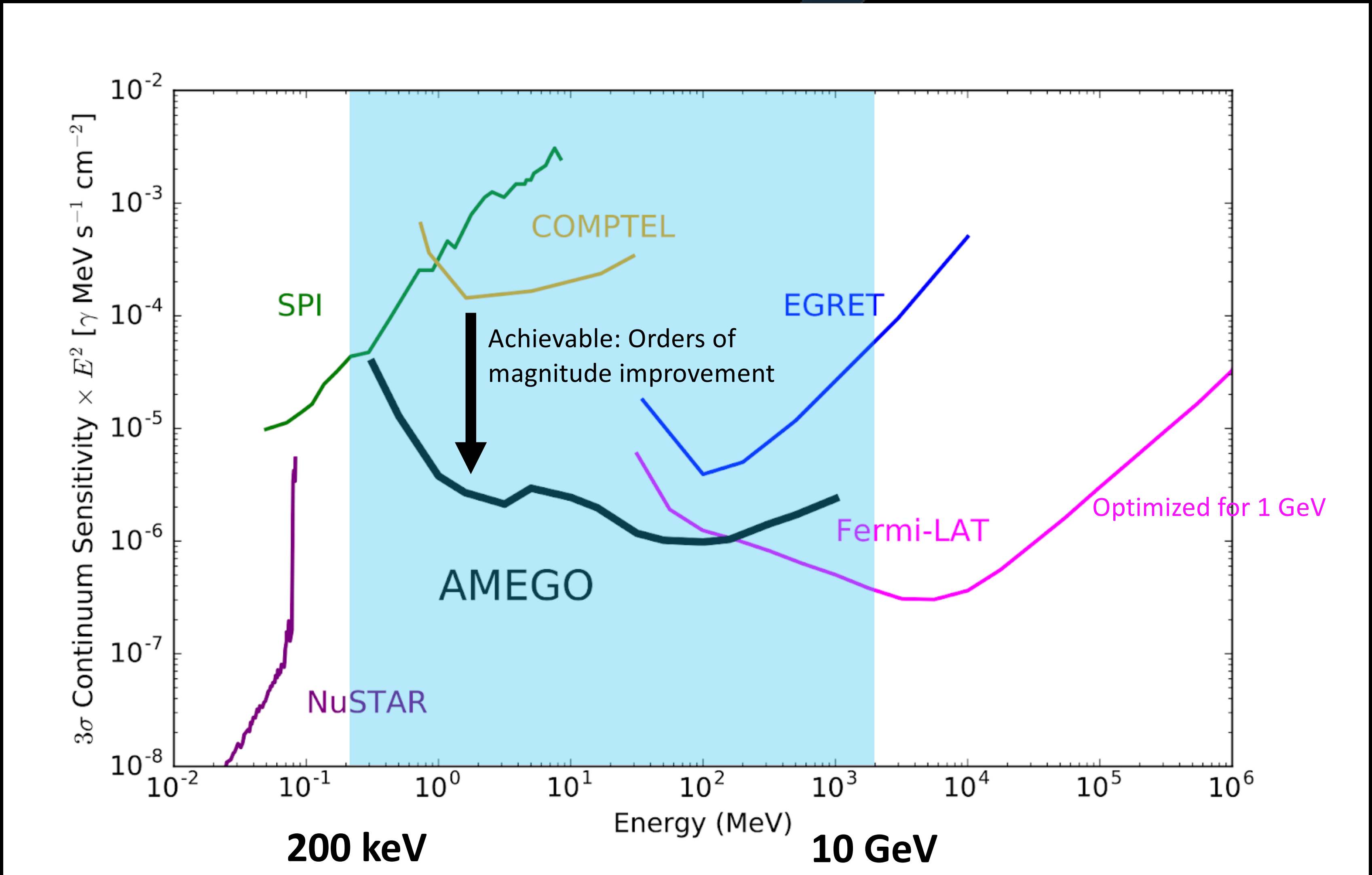
BACKUP

Background



- **Backgrounds from a NuStar-like Orbit**
- **Sources of Backgrounds: cosmic photon sources (Galactic and Isotropic), charged particles from cosmic sources and the Earth's Albedo, atmospheric secondary gamma rays, internal instrument backgrounds and from SAA.**
- **Backgrounds in analysis: Gruber et al. (1999) in blue x10 and Acero et al. (2016)**

Why is the MeV Regime So Poorly Known?



3-year mission (3 years with 20% efficiency for FOV and SAA) assuming the background available in a backup slide. In the Compton regime, the backgrounds are scaled up by x10 (conservative). Fermi/LAT (5 years), COMPTEL and EGRET (2 weeks exposure), and NuSTAR and SPI (10^6 s exposure).

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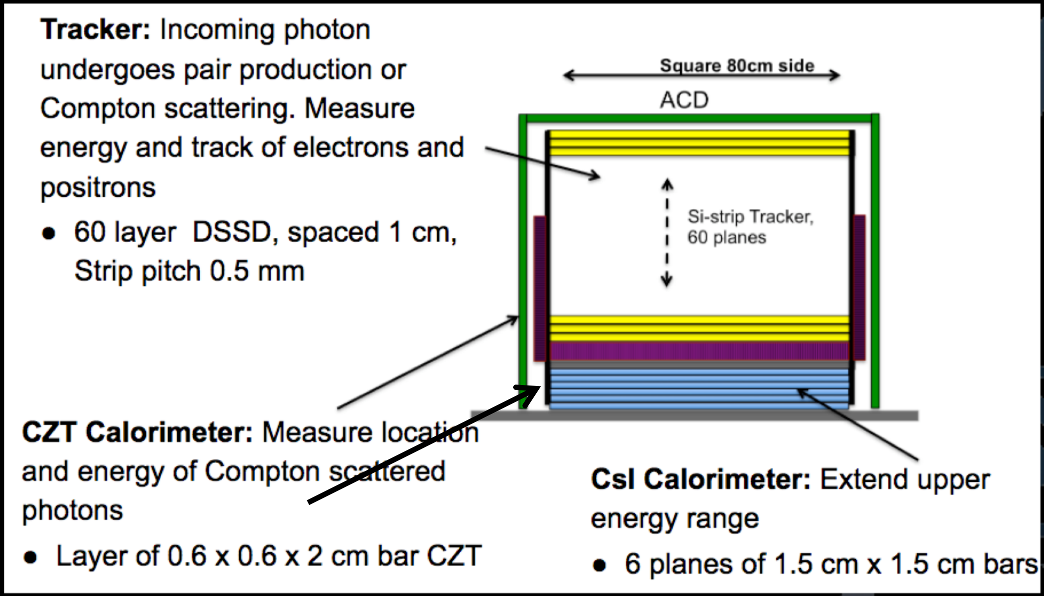

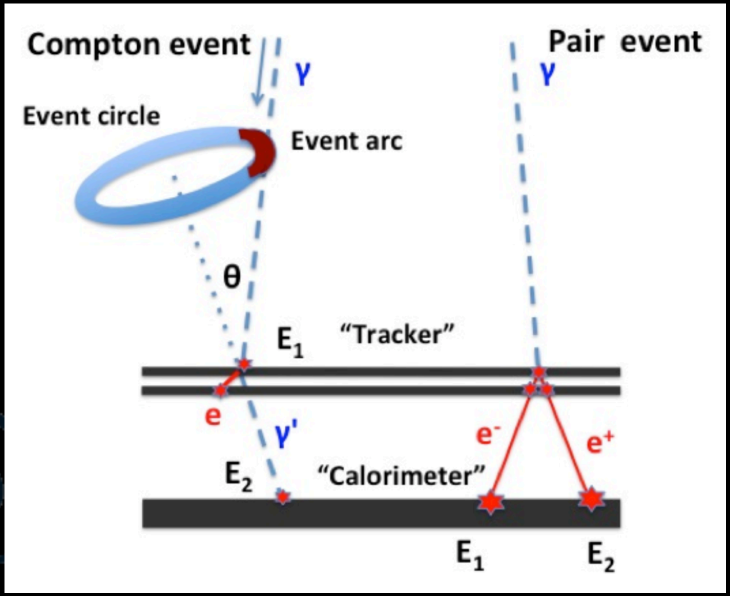

<u>Below ~10MeV:</u> ɣ Compton scatters a low-energy e- in Si-strip. Scattered ɣ can be absorbed in a calorimeter.

- ɣ direction is a circle or arc on the sky determined by position and energy measurements of the low-energy e- and absorbed ɣ.
- ɣ energy is determined by evaluating the energy deposited in the Si-strips and in a calorimeter.

<u>Above ~10MeV</u>: ɣ converts to pair (e-/e+) in a multi-layer Si-strip tracker (no additional conversion material).

- 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.