AMEGO

ALL-SKY MEDIUM ENERGY GAMMA-RAY OBSERVATORY

Status of AMEGO

R. Caputo[a], for the AMEGO Team[b]

[a]UMD/NASA/GSFC, [b]https://asd.gsfc.nasa.gov/amego/

The team...

The AMEGO team is a cross-section of the high energy astrophysics community and includes experts on the technical and scientific of the mission. If you are interested in being involved in AMEGO, please contact Julie McEnery.

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

NASA/GSFC

- Julie McEnery (PI)
- Jeremy Perkins
- Liz Hays
- Judith Racusin
- Dave Thompson
- Alice Harding
- Brad Cenko
- Tonia Venters
- John Mitchell
- Georgia de Nolfo

NASA/GSFC/CRESST

- Alex Moiseev
- Regina Caputo
- Dan Castro
- Sara Buson
- Roopesh Ojha
- Elizabeth Ferrara
- Chris Shrader
- Amy Lien
- Bindu Rani
- Andy Inglis
- Lucas Uhm
- Eric Burns
- Sean Griffin
- Mark McConnell
- Peter Bloser

NASA/MSFC

- Colleen Wilson-Hodge
- Michelle Hui
- Dan Kocevski

UAH

- Michael Briggs

USRA

- Valerie Connaughton

OSU

- John Beacom

UIUC

- Brian Fields
- Xilu Wang

UNLV

- Bing Zhang

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- Jamie Holder

Georgia Tech

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Clemson University

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- Vaidehi S. Paliya

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Argonne National Lab

- Jessica Metcalfe

University of MD, College Park

- Peter Shawhan

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- Markos Georganopoulos
- Eileen Meyer

North West University, South Africa

- Zorawar Wadiasingh

Los Alamos National Lab

- Lisa Winter

University of Padova and INFN Padova

- Riccardo Rando

Rice University

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- Lisa Winter

Washington University in St Louis

- Fabian Kislat
- Henric Krawczynski

UNH

- Matthew Baring

Universidad Autónoma de Madrid

- Miguel A. Sánchez-Conde

Introduction to AMEGO

- ***Probe Concept: 2020 NASA Astrophysics Decadal Review***
- Observing strategy: survey
  - 80% sky/orbit, ~2.5 sr FoV
- Well ***understood***, ***tested*** technologies with ***space heritage***
- Science: pulsars/magnetars, gamma-ray bursts and multimessenger astrophysics, active galaxies, dark matter

AMEGO Science

Understanding Extreme Environments

Astrophysical Jets

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

Compact Objects

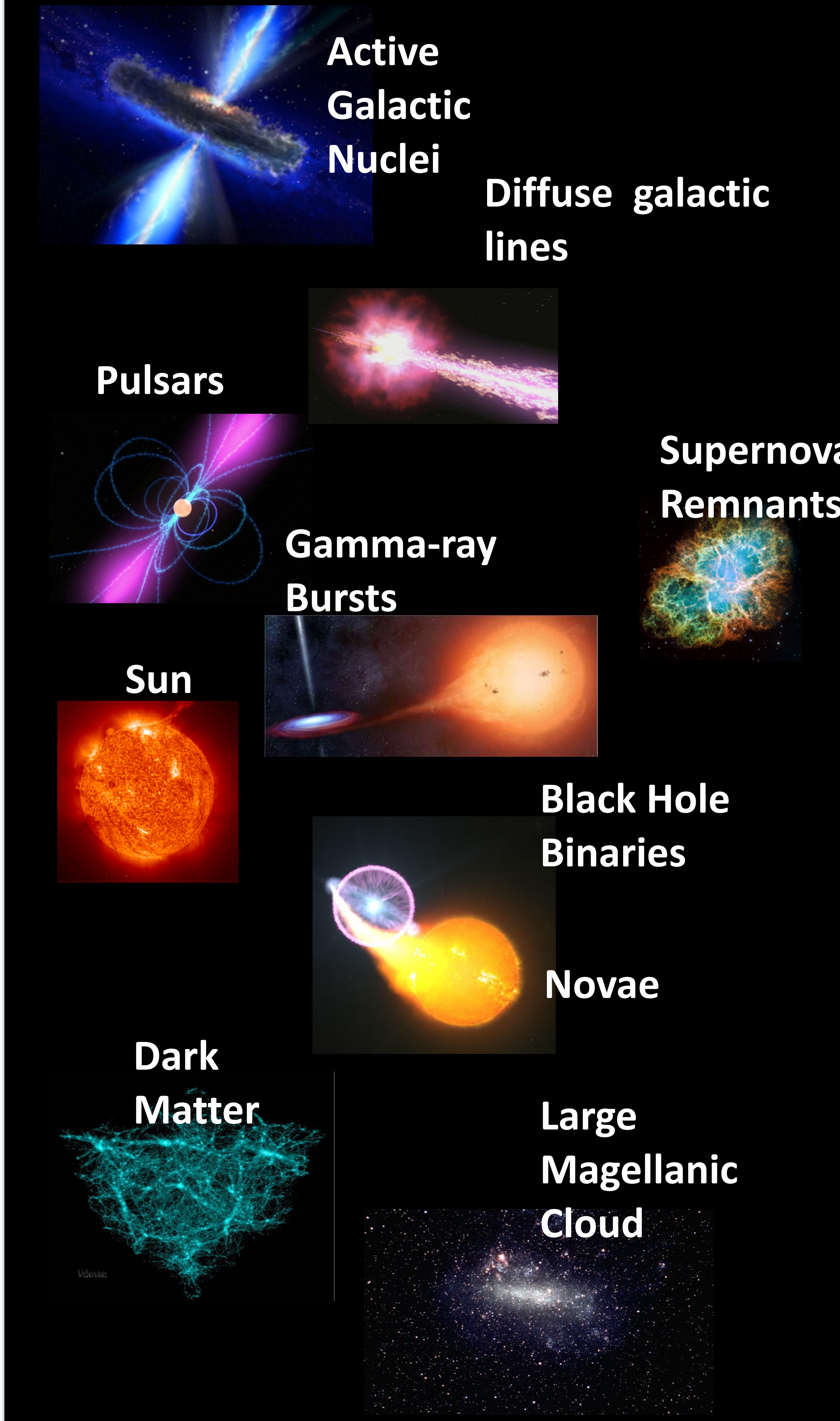
Identify the physical processes in the extreme conditions around compact objects

Dark Matter

Test models that predict dark matter signals in the MeV band

MeV Spectroscopy

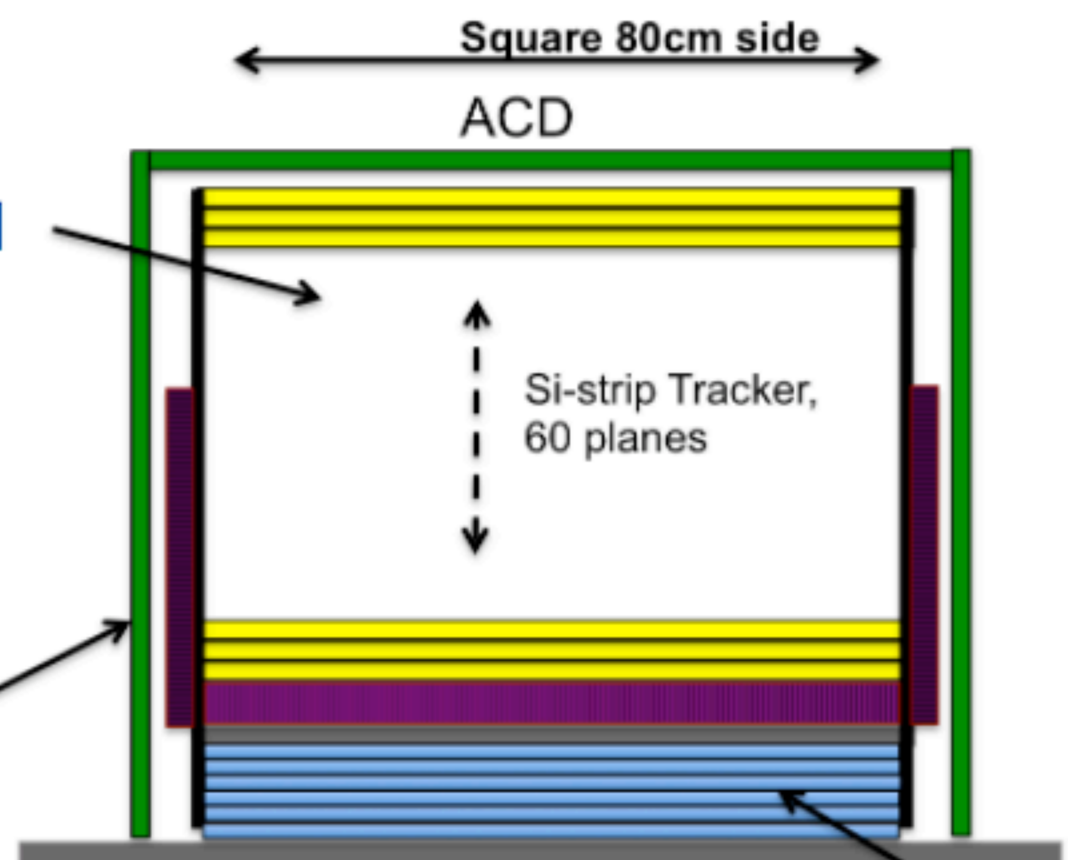
Measure the properties of element formation in dynamic systems



The Instrument

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



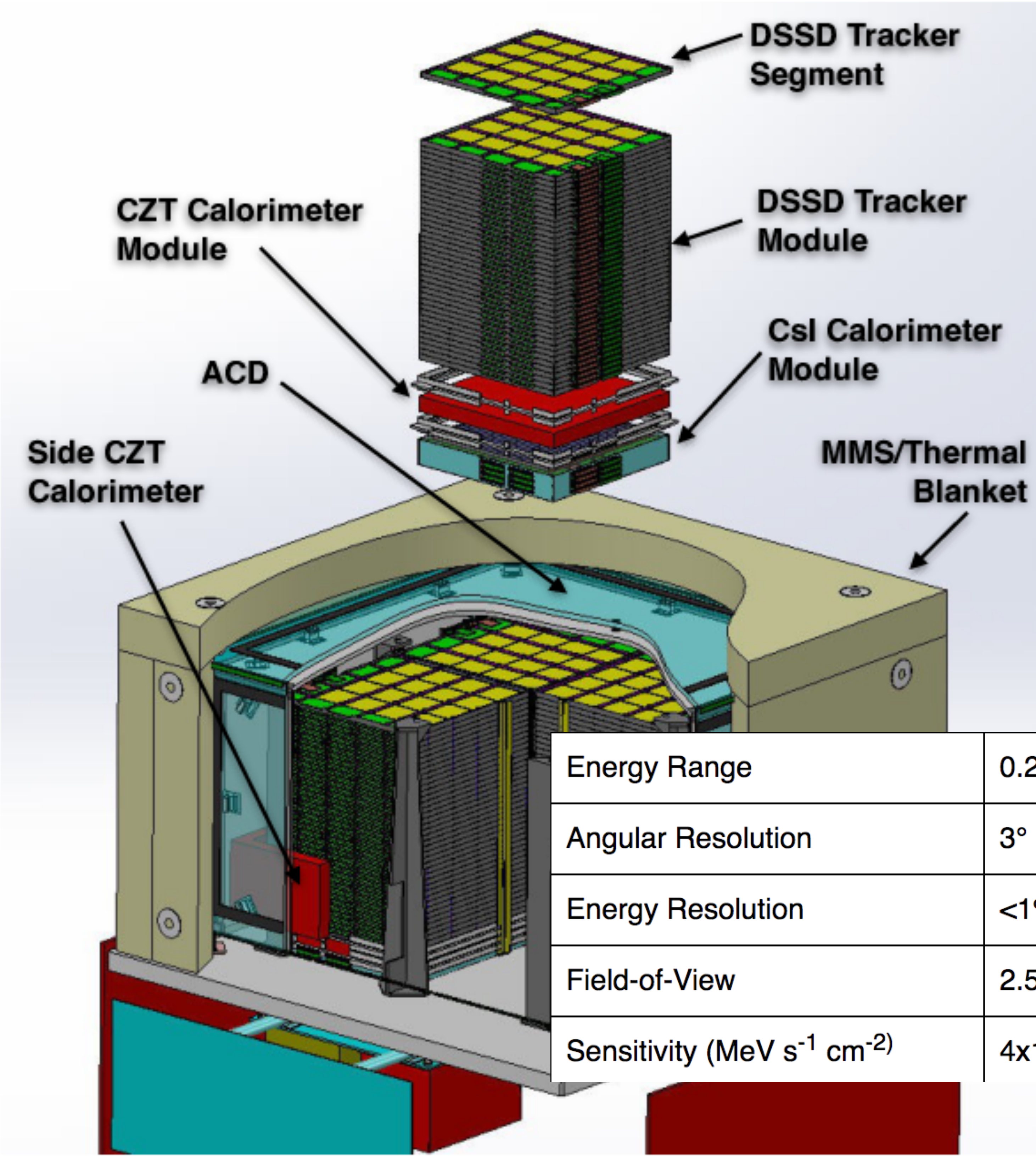
CZT Calorimeter: Measure location and energy of Compton scattered photons

- Layer of 0.4x0.4 x 2 cm bar CZT

CsI Calorimeter: Extend upper energy range

- 6 planes of 1.5 cm x 1.5 cm bars

The Instrument



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)

Hardware Status

- Building a prototype
  - beam tests (planning stages)
  - balloon flight (2019)

- Made progress on all detector subsystems
  - discussing options with vendors
  - preliminary testing of individual subsystems

Simulation Overview

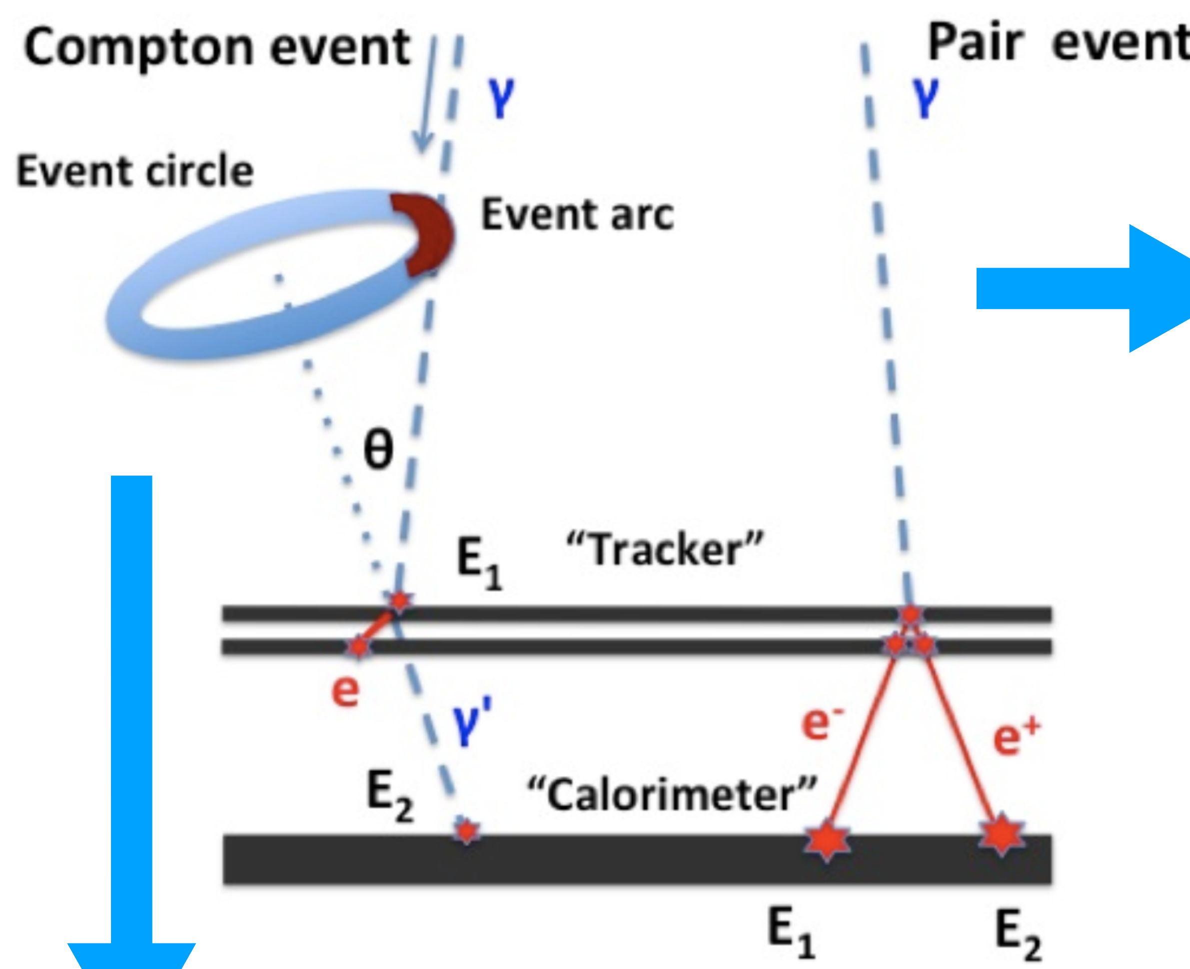
- Simulations performed using the MEGAlib toolkit
  - ROOT (v6), Geant4 (v10) (http://megalibtoolkit.com)

- Geometry built in Geomega

- Cosima simulations performed with 'FarFieldPointSource'
  - Mono-energetic beam, 100k triggers
  - Generated events: vs. energy, vs. incidence angle
  - Also 100% linearly polarized beam

- Event classes which are determined in Revan
  - Current: tracked Compton scattered, pair production
  - Future: untracked Compton scattered (low energies)

Simulation Overview



γ 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.
- γ direction is determined by measuring the position of the pair components as they pass through the Si-strip layers and a calorimeter.

γ 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 γ can be absorbed in the calorimeter

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

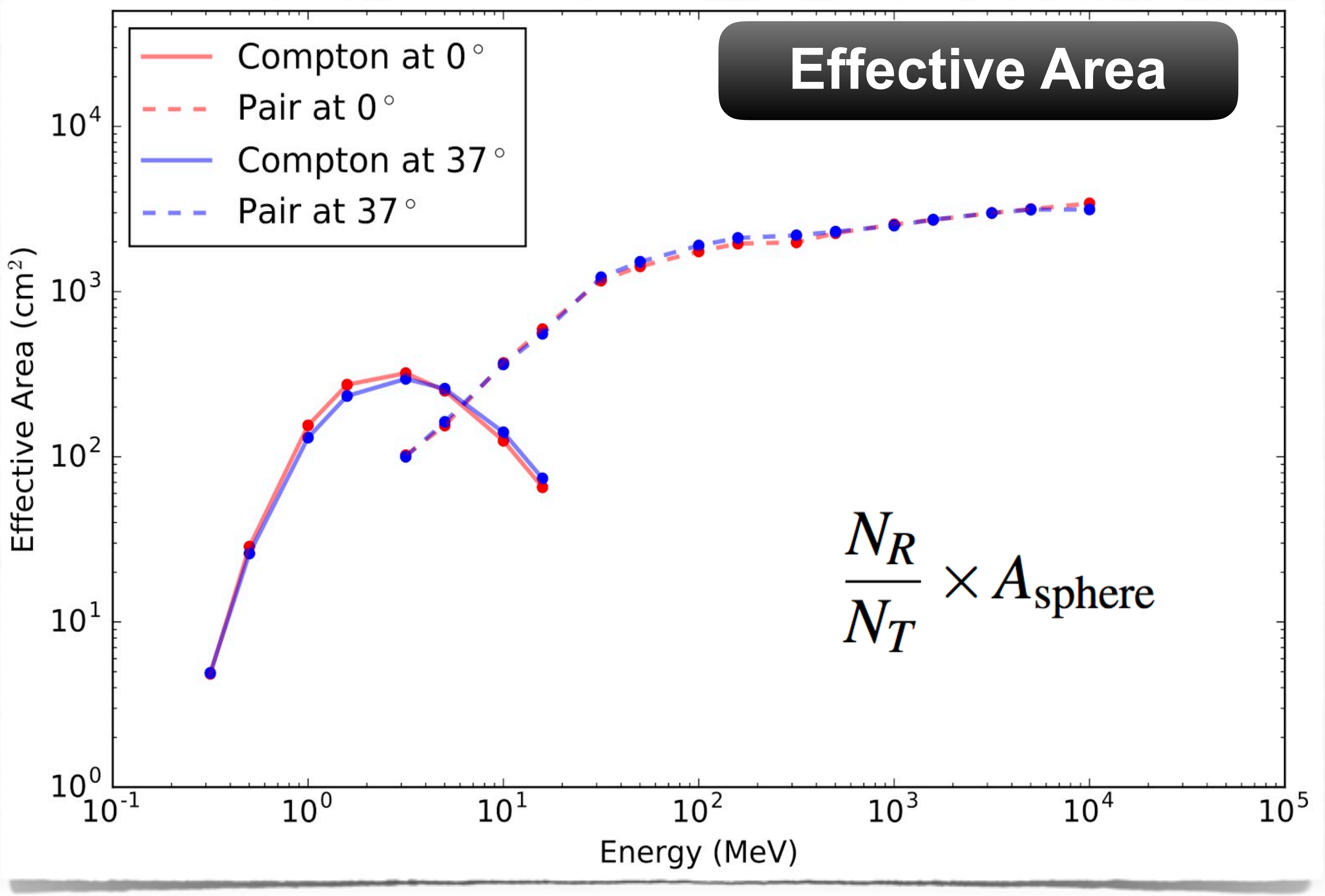
Simulation Status

- Developing Response Functions
  - responsegenerator/responsecreator
    - 1st generation of 1M events True vs. Reco Energy
  - investigating COSI model which converts into XPEC
  - similar to LAT - for ease of use with IACT/Fermi tools

- Developing a Suite of Science Simulations
  - Light curves for GRBs, Spectra for solar flares, blazars… etc

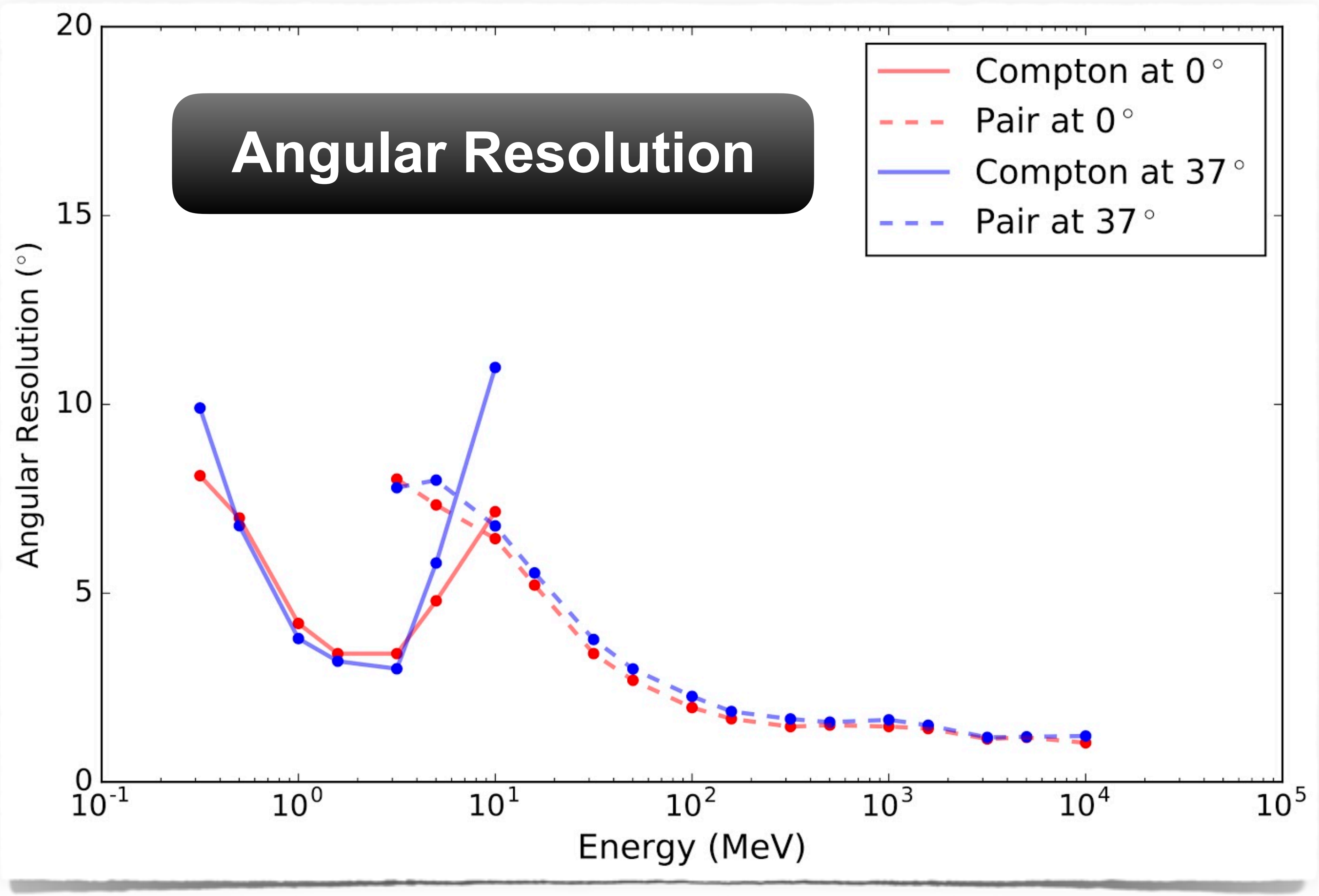
- Developing code framework
  - gammapy: http://docs.gammapy.org/en/latest/
- Event reconstruction
  - pair-events/energy reconstruction

Performance Plots



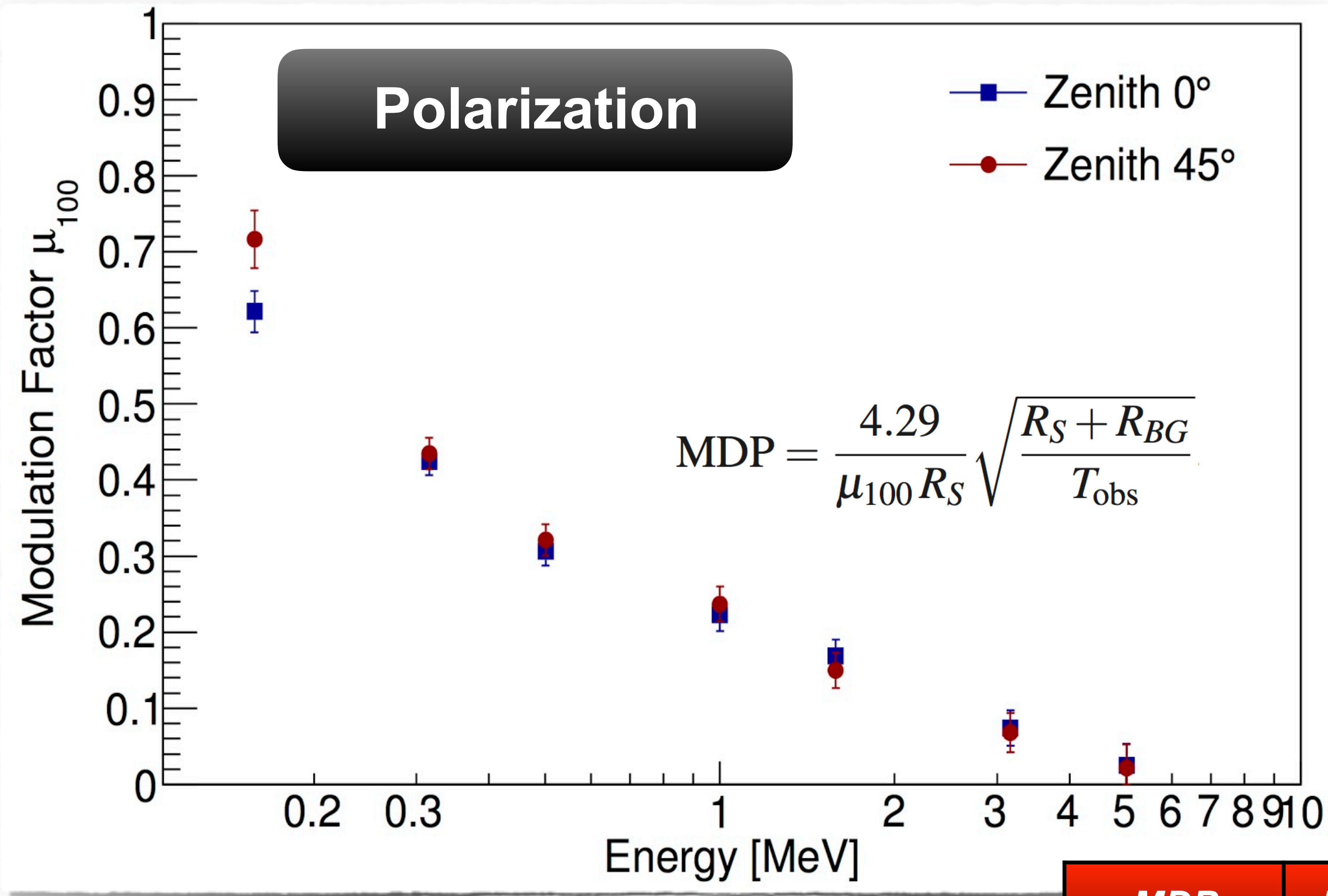
Effective area: ratio of the reconstructed (N_R) and generated (N_T) events times the total area (A_{sphere}) vs. energy. Relatively constant vs. incidence angle.

Performance Plots



Angular resolution: angular distance from true direction to outer edge of Compton cone (Compton events), bisect angle of the electron/positron vectors weighted by energy (pair events) vs. energy. Also relatively constant vs. incidence angle.

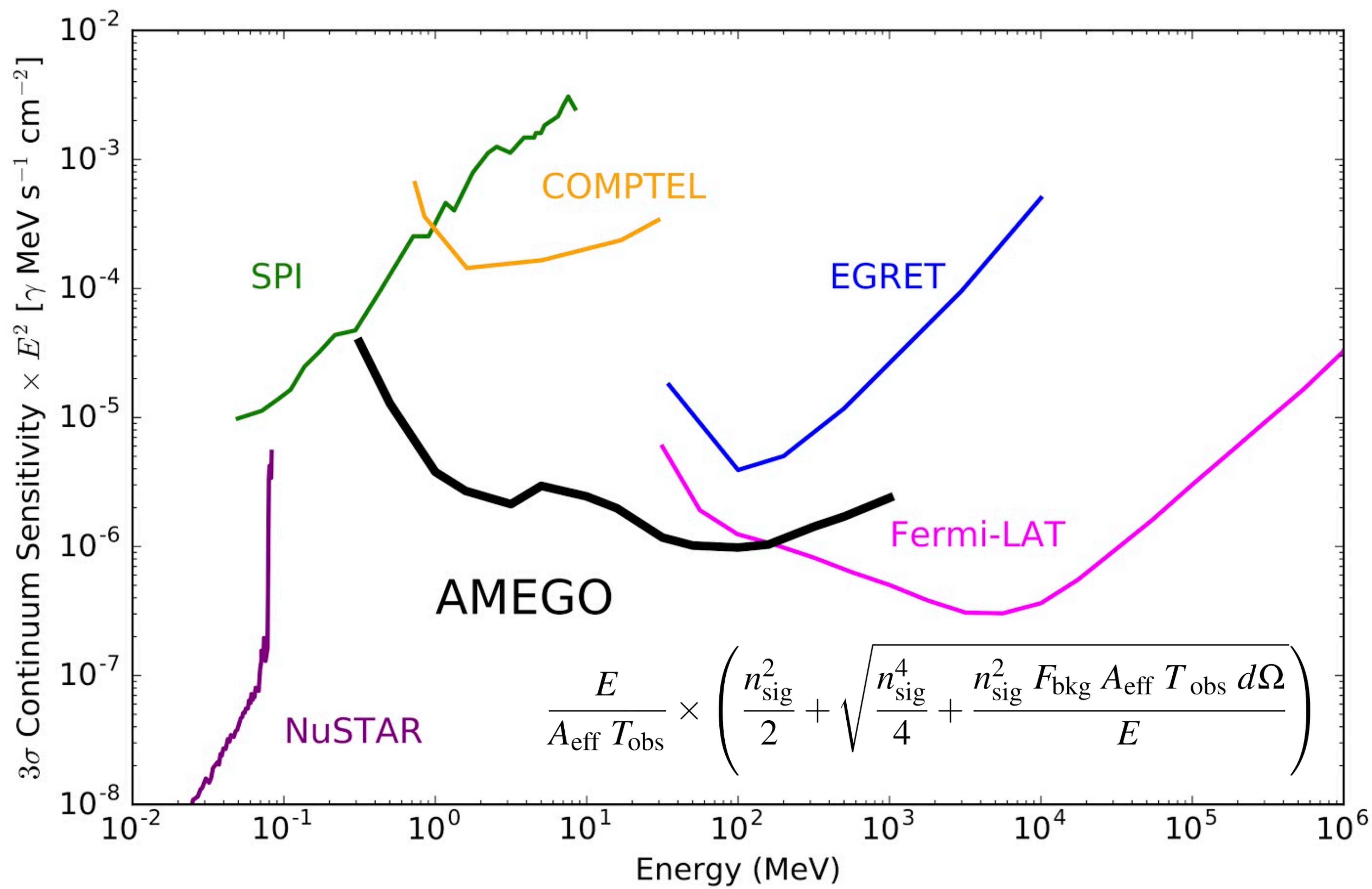
Performance Plots



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

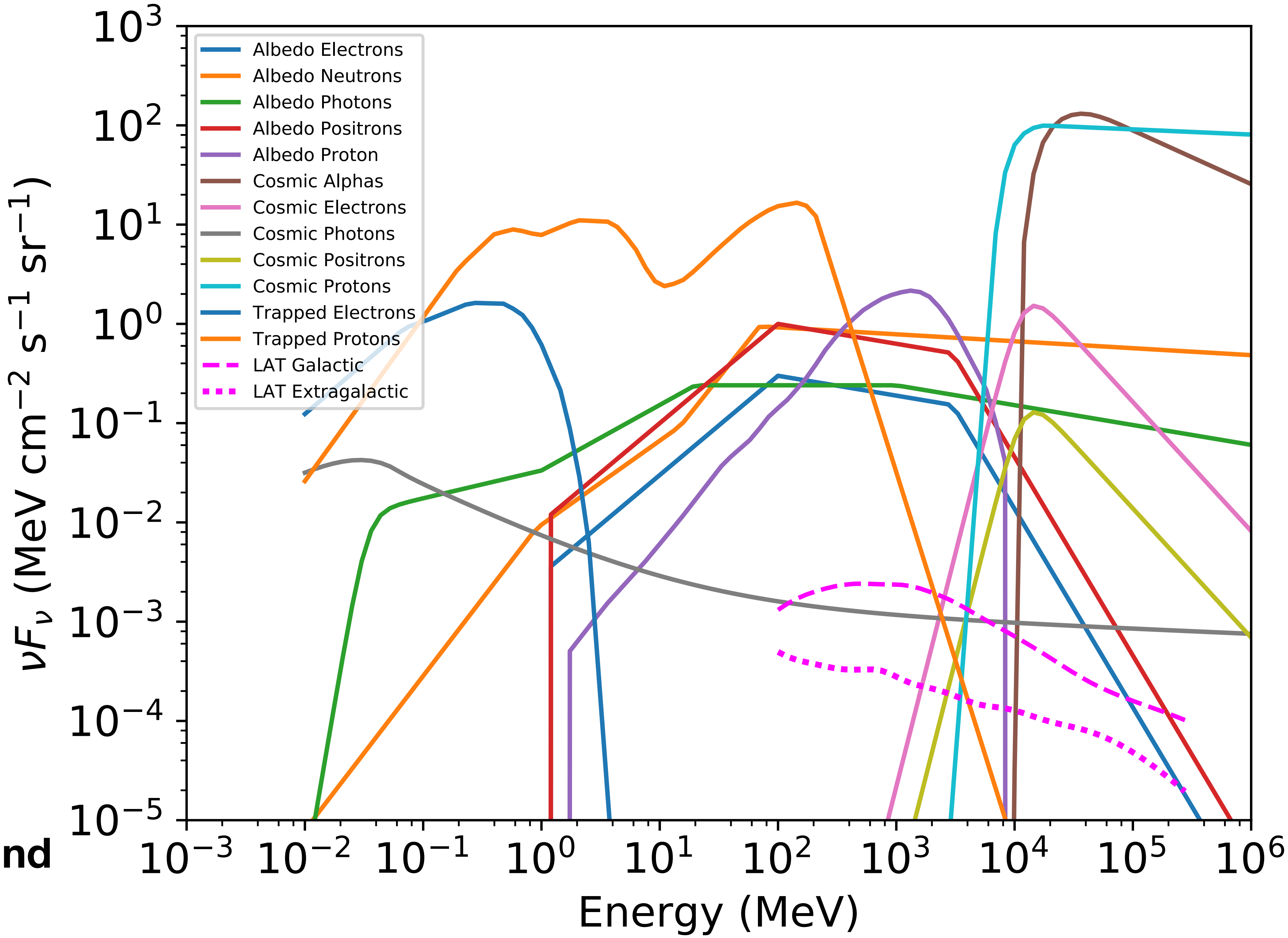
Polarization: simulated polarized source is fit to a sin function. Determine amplitude of azimuthal modulation (μ_{100}) (top left) vs. energy. Calculate minimal detectable polarization (MDP) for the signal (R_S), background (R_{BG}) and observation time (T_{obs}) (see equation inset and table on the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

3σ CONTINUUM SENSITIVITY



3-year mission (20% efficiency for FOV/SAA) assuming the background on next slide. In the compton regime, the backgrounds are scaled up by x10, which we found to be conservative. Fermi-LAT (5-year mission), COMPTEL and EGRET (2 week pointing), and NuSTAR and SPI (10^6 s live time) are also shown for comparison. These choices reflect the observing strategy and preliminary approximated mission duration. In the energy band ~1 to ~100 MeV AMEGO is at least an order of magnitude more sensitive, due mainly to the increased effective area and angular resolution. Comparing a 2 week AMEGO exposure, AMEGO is ~10x more sensitive than COMPTEL.

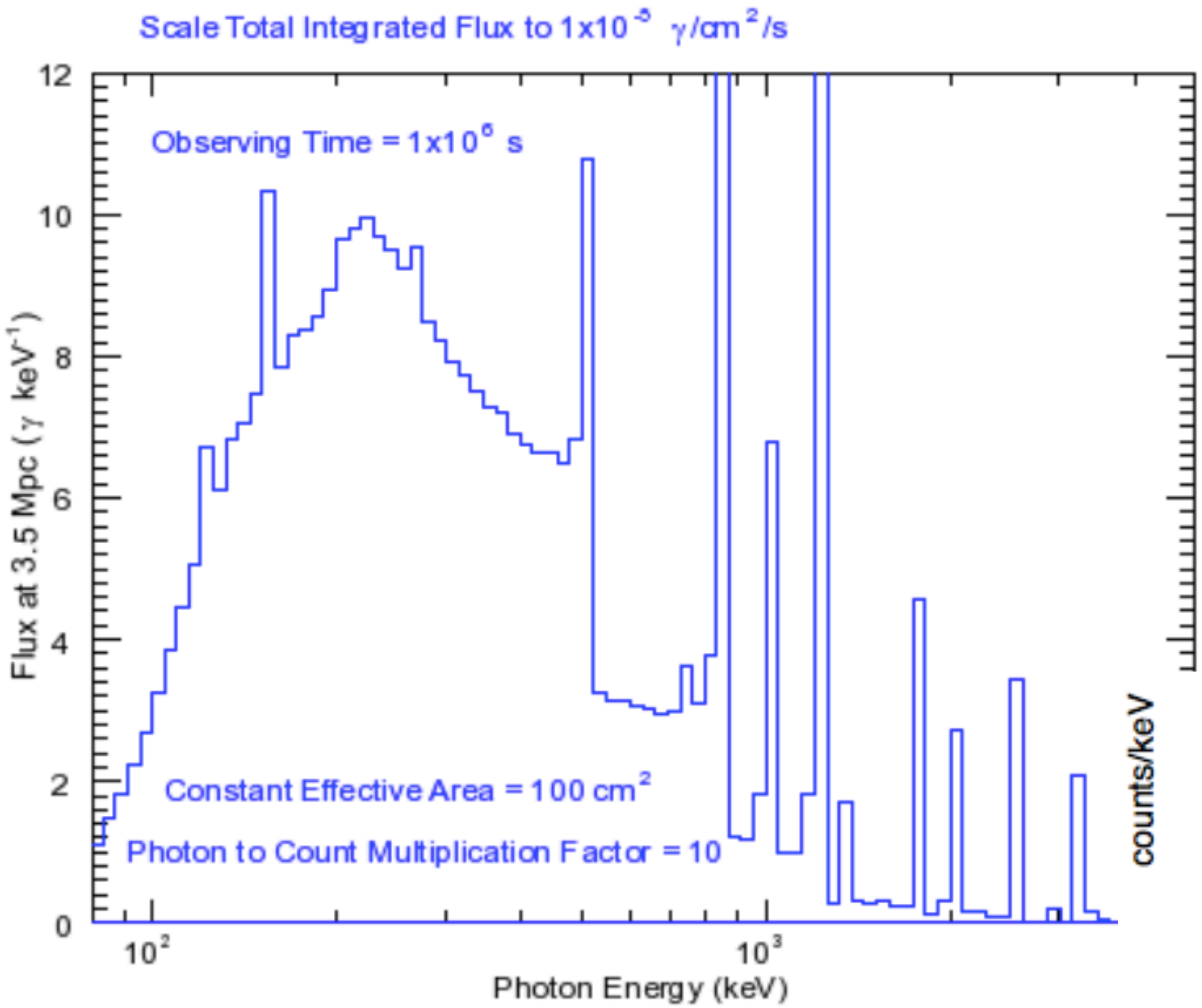
Backgrounds from a NuStar-like Orbit



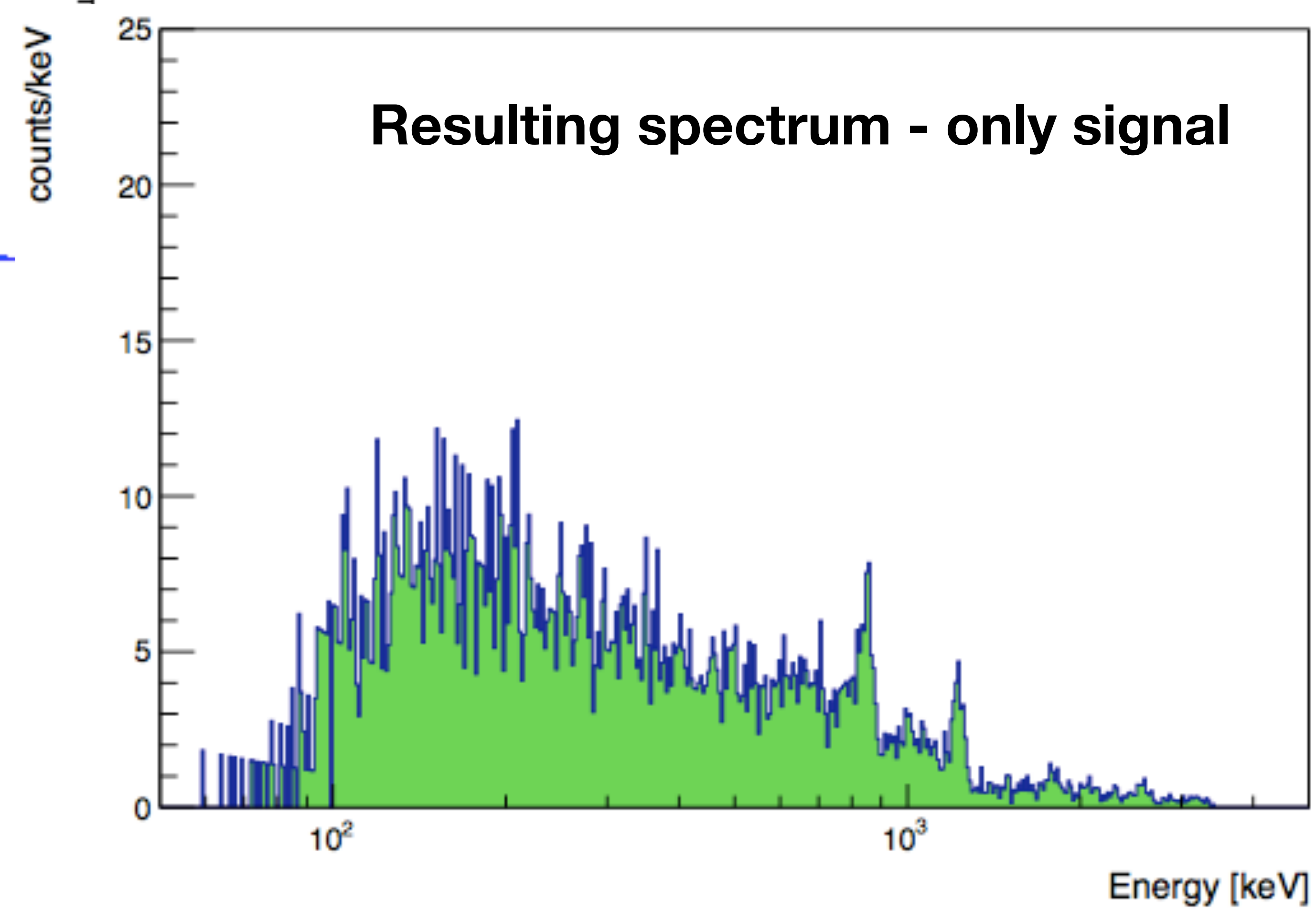
From Background Generator (in MEGAlib)

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)

Science Simulations



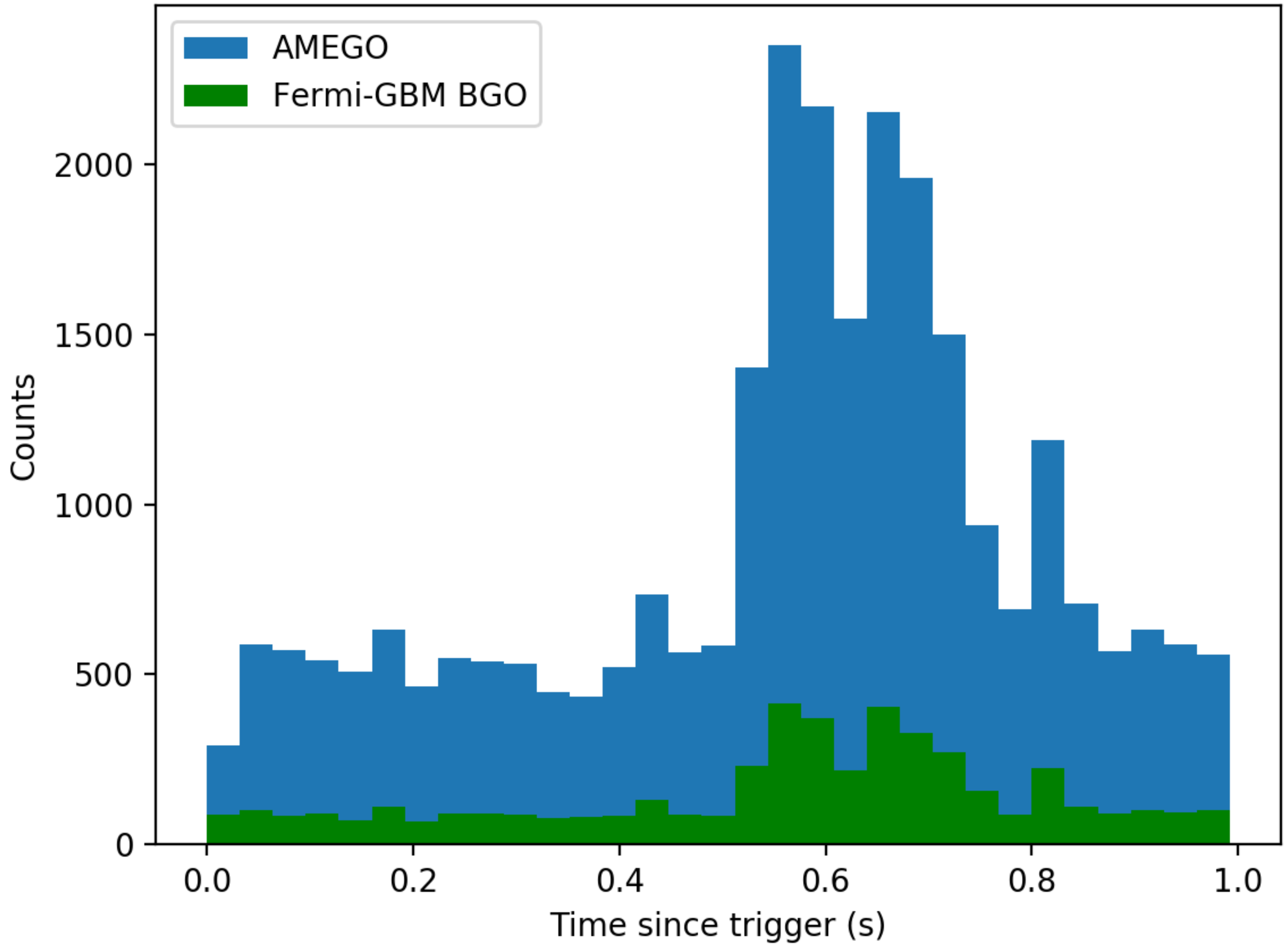
SN1a
Input Spectrum provided by Lih-sin The @ Clemson



Gamma-ray flux from deflagration model W7 at day 60 at a distance of 3.5 Mpc (M82) (The & Burrows 2014)

Science Simulations

- GRB 090510
  - detected by Fermi GBM, LAT, Swift BAT, XRT, UVOT
  - brightest short GRB ever detect (z=0.9)
- Simulated AMEGO from GBM-BGO light curve
  - Note AMEGO background will be lower than GBM, simulation used background as input
  - Scales by effective area



Summary

- Hardware team is preparing for prototype
- Developing instrument response functions is the highest priority for simulation team
- Science team is helping build simulations for science case
- Still a lot of work to do… happy to collaborate

backups

Simulation Overview