

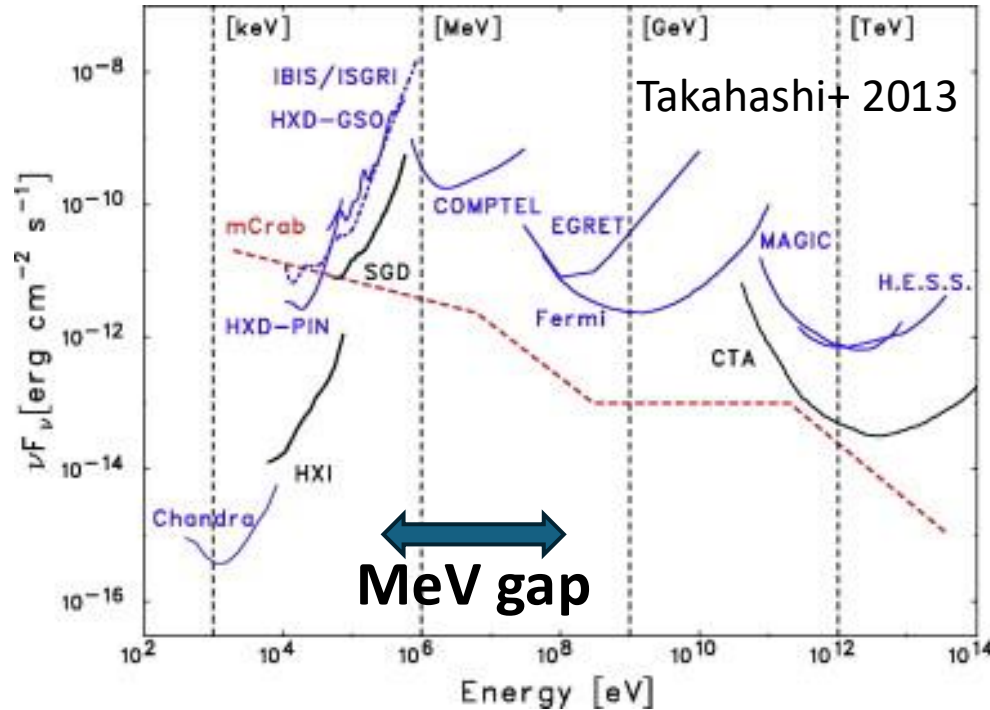
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Session: MM

Forecasting the MeV Gamma-ray Sky: A Predicted All-Sky Map and a Promising MeV Source Catalog

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MeV gamma-ray observation



Future mission

- COSI (to be launched in 2027)
- AMEGO-X
- newASTROGAM
- GRAMS

Sensitivity : $\sim 10^{-12} - 10^{-11}$ erg/cm²/s

Hard X-ray

Swift-BAT : **1888** sources

(Lien+2025)

MeV gamma-ray

CGRO/COMPTEL :
32 sources + **31** GRB
INTEGRAL/SPI :
4 sources + 0.511 MeV line

GeV gamma-ray

Fermi-LAT : **7220** sources

(Ballet+ 2026)

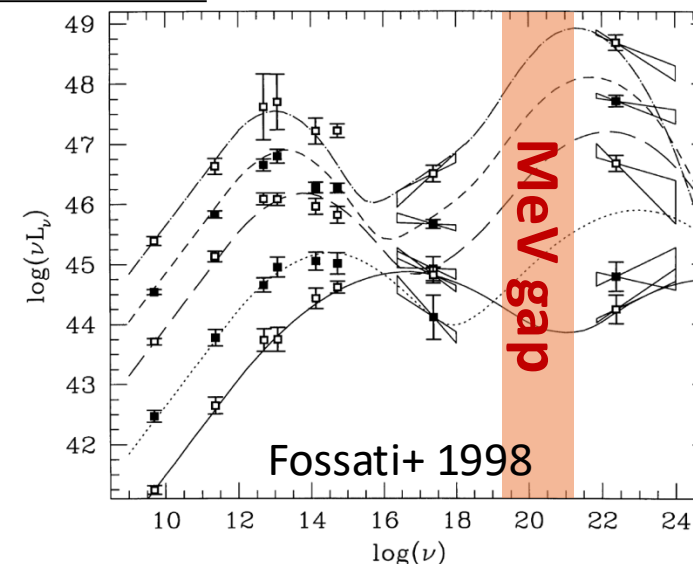
MeV gamma-ray science

- Measurement of Non-thermal emission
[PWN, SNR, AGN]
➡ **Particle acceleration**
- Measurement of gamma-ray line
[SN, NS merger]
➡ The key to **Nucleosynthesis processes**
- Origin of **Positron**
(Electron-Positron pair annihilation : 0.511 MeV)
- Nature of **Dark Matter**

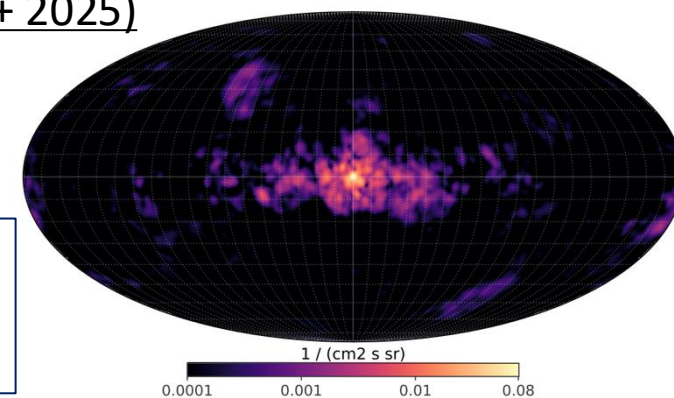
This work

Construct MeV gamma-ray source catalog and predict MeV all-sky

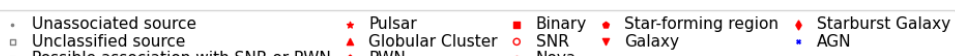
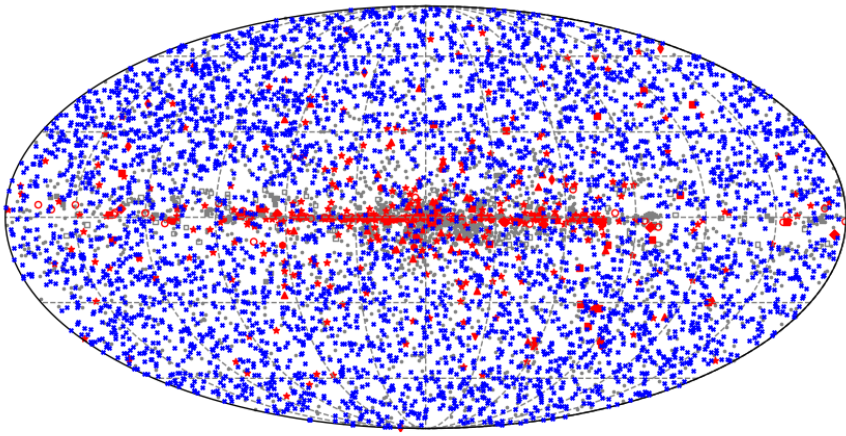
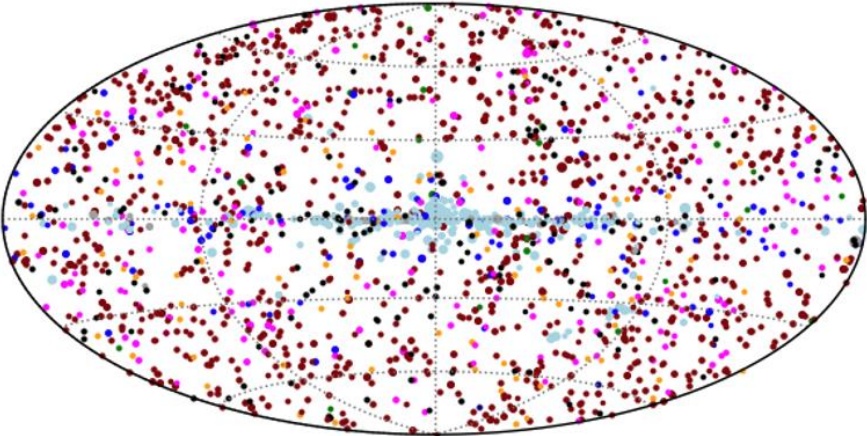
Spectrum of Non-thermal emission
from the Blazar



0.511 MeV emission line map
(Yoneda+ 2025)



	Hard X-ray	GeV gamma-ray
Catalog	Swift/BAT 157-M	Fermi/LAT 4FGL-DR4
Observation Period	Dec 2004–Dec 2017	Aug 2008–Aug 2022
Energy band	14–195 keV	50 MeV–1 TeV
Number of sources	1888	7194
Reference	Lien et al. 2025	Ballet et al. 2024



MeV gamma-ray source catalog

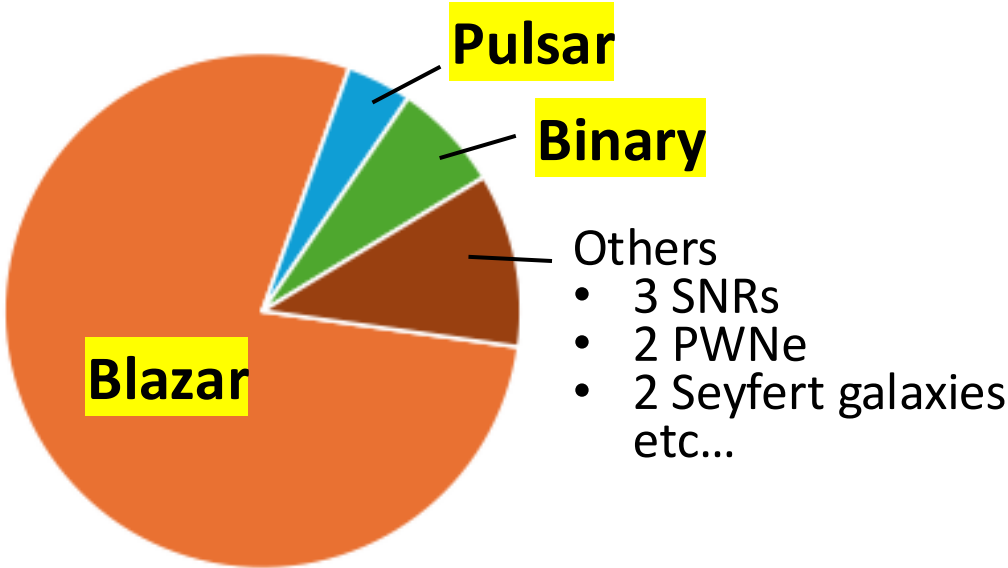
■ Catalog cross-match

Cross-match between Swift/BAT and Fermi/LAT catalogs
(Method of Tsuji et al. 2021)

- Spatial matching:
a LAT source within 0.08 deg of a BAT source
- Identification matching (SIMBAD)

→ 143 firmly matched

→ Blazars, Pulsars, Binaries account for ~90%
of the firmly matched sample



■ MeV gamma-ray source catalog (4625 sources)

	Swift/BAT	Fermi/LAT	Cross-match
Blazar	182	3993	115
Pulsar & MSP	26	320	6
Binary	244	30	10

*Includes other cross-matched source types beyond these three types (e.g. Radio galaxy, Cen A)

Spectral model

Cross-matched sample

- Log Parabola model (LP): default for blazars
- 2-component model: others
- Source dependent

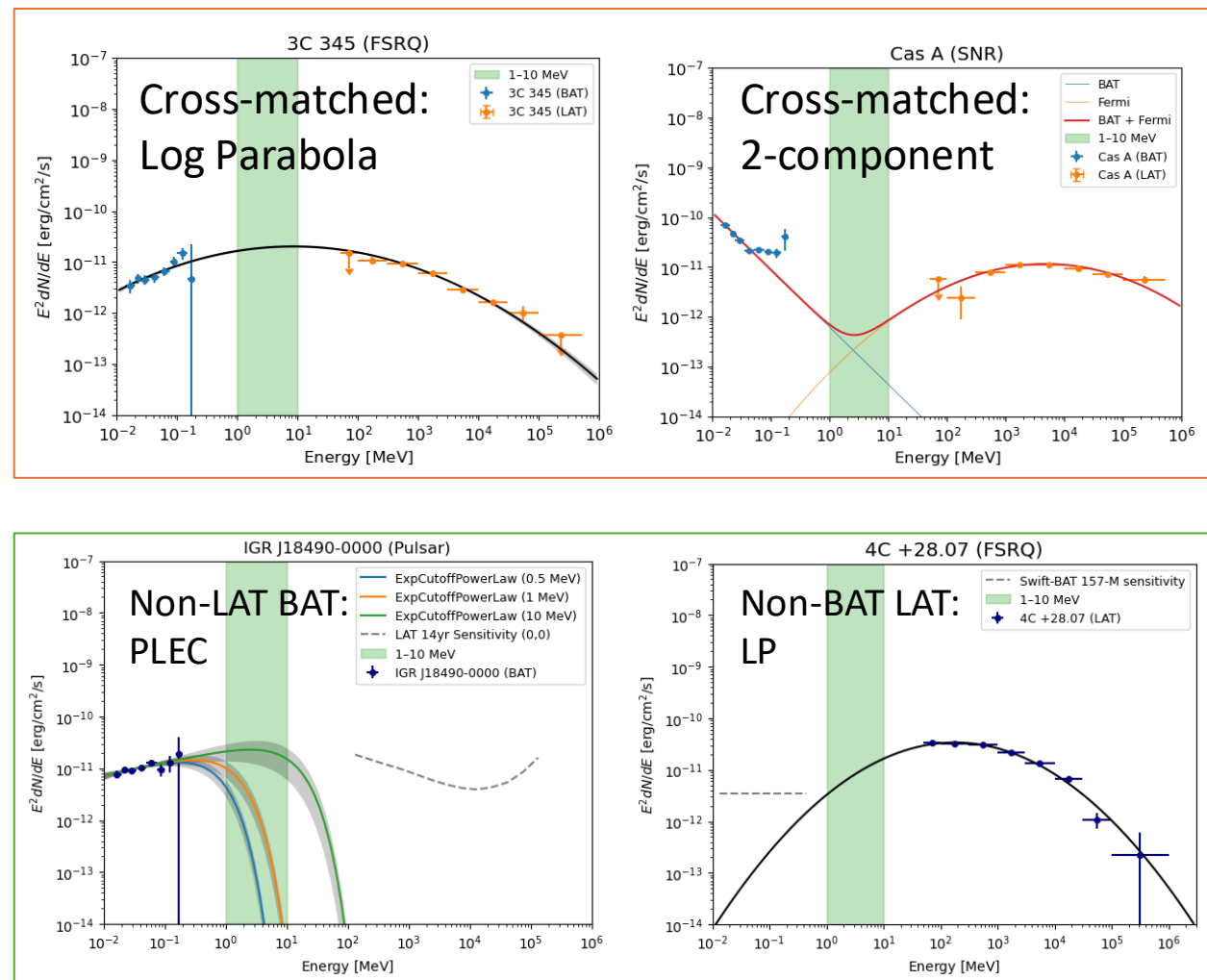
Non-LAT BAT sample

- Power Law with Exponential Cutoff model (PLEC)
 - E_{cut} is fixed at 0.5, 1, 10 MeV when a cutoff is not statistically detected within the BAT band

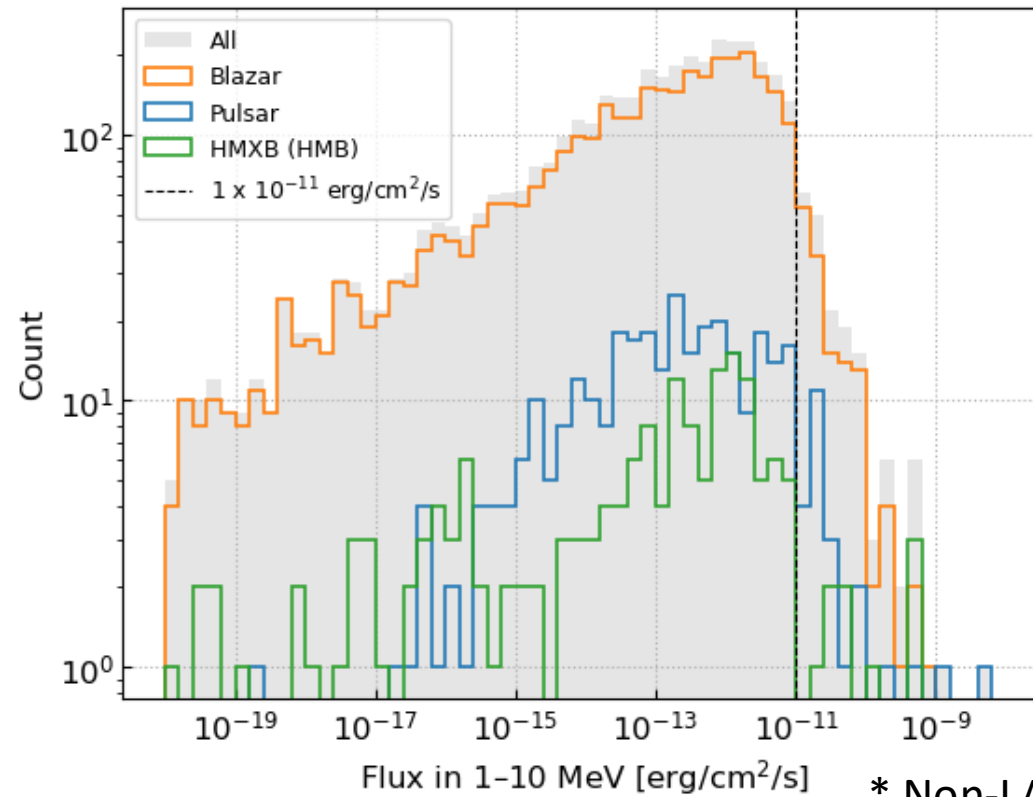
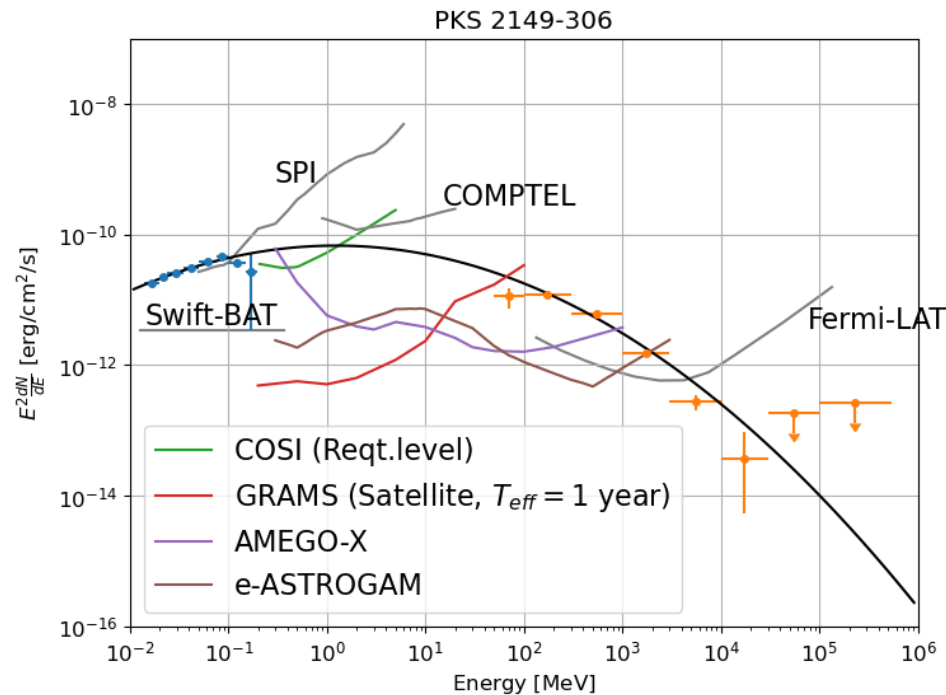
Non-BAT LAT sample

- PLEC model : for pulsar
- LP model: others

(Note) Spectral models are constrained not to exceed the LAT or BAT sensitivity



Predicted flux in 1–10 MeV

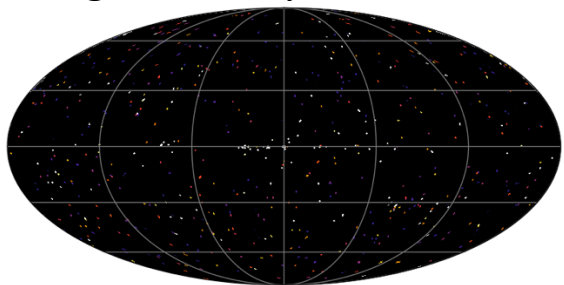


- Future MeV mission sensitivity: $\sim 10^{-12}$ – 10^{-11} erg/cm²/s
- Estimate flux in 1–10 MeV based on spectral model
- Flux in 1–10 MeV $> 10^{-11}$ erg/cm²/s: **~200** sources

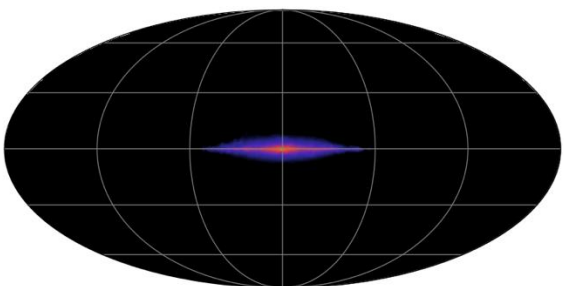
* Non-LAT BAT:
 $E_{cut} = 1$ MeV fixed

All-sky map in 1–10 MeV

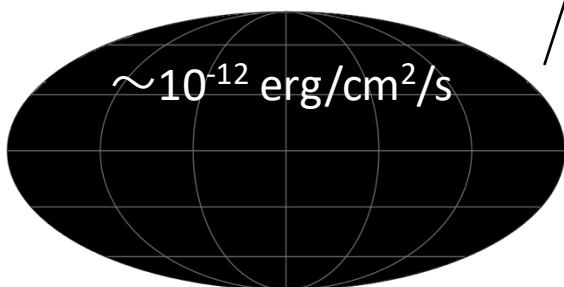
MeV gamma-ray sources



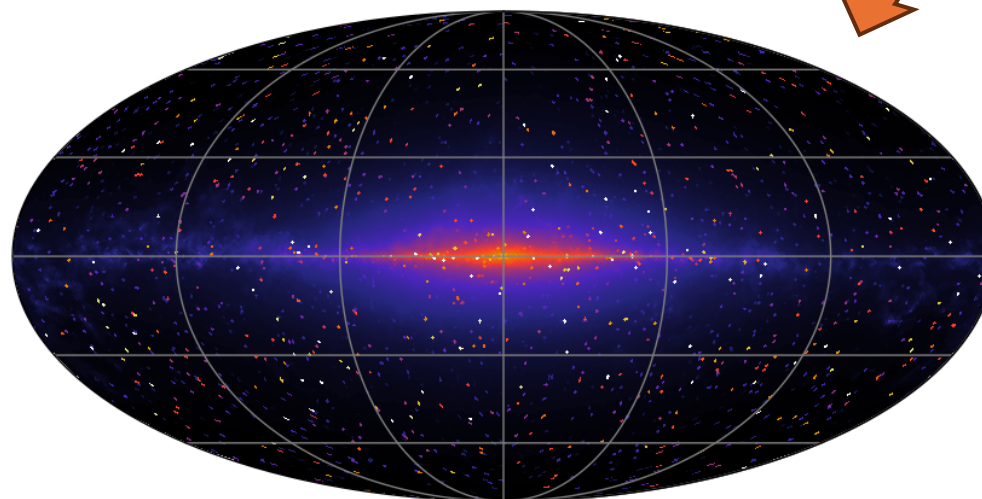
Galactic Diffuse Emission (GDE)
(Ackermann+2012; Orlando+2018)



Extragalactic background (EGB)
(Watanabe 2000; Weidenspointner 2000)

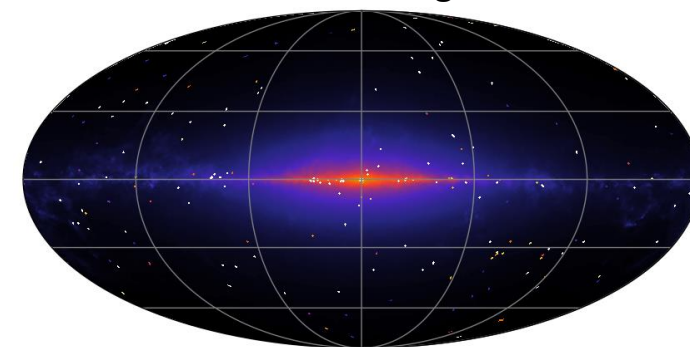


~200 sources exceed 10^{-11} erg/cm²/s



Update!

Only cross-matched sources:
87 exceed 10^{-11} erg/cm²/s



Tsuji et al. ICRC 2023

■ All-sky map = Sources + GDE + EGB

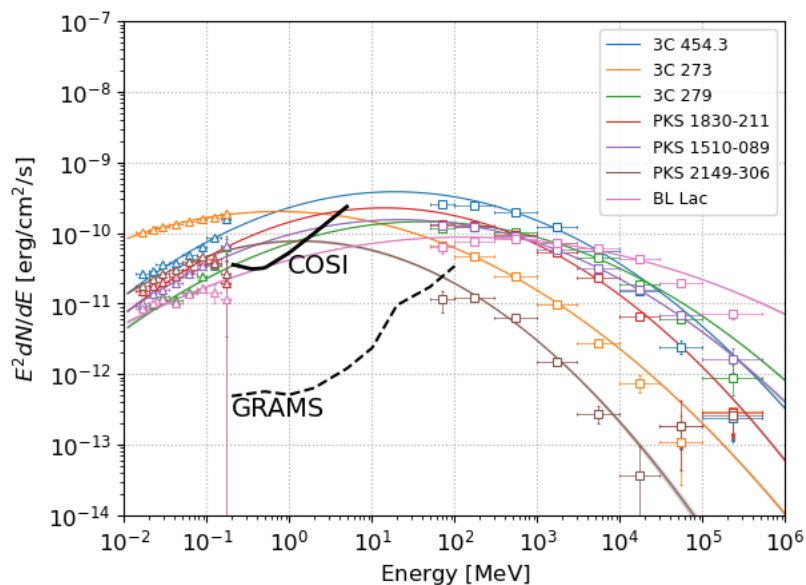
- Flux (Source) > Flux (GDE+EGB) x 3 : ~**150–300** sources*
- Flux (Source) > Flux (GDE+EGB) x 10: ~**45–85** sources*

* Depend on GDE and EGB models

Promising sources

Blazar

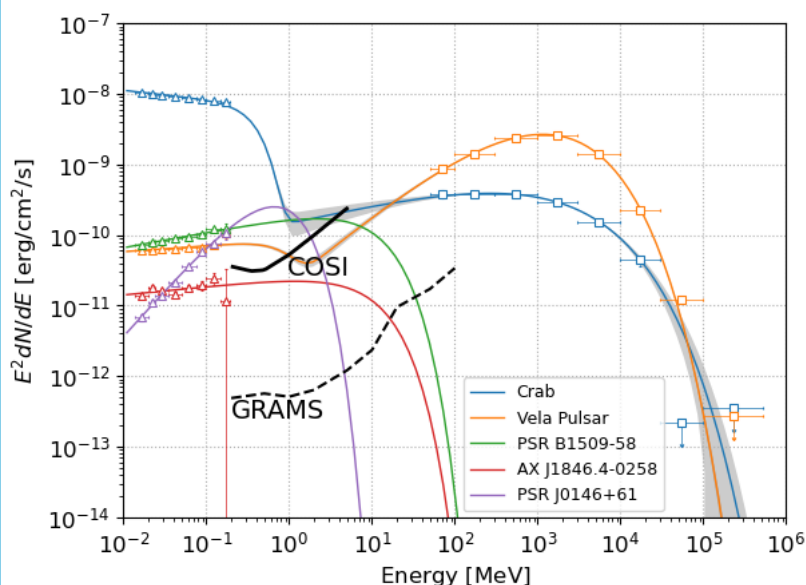
- 3C 454.3
- 3C 273
- 3C 279*
- PKS 1830-211*
- PKS 1510-089*
- PKS 2149-306*
- BL Lac*



* Not detected by COMPTEL

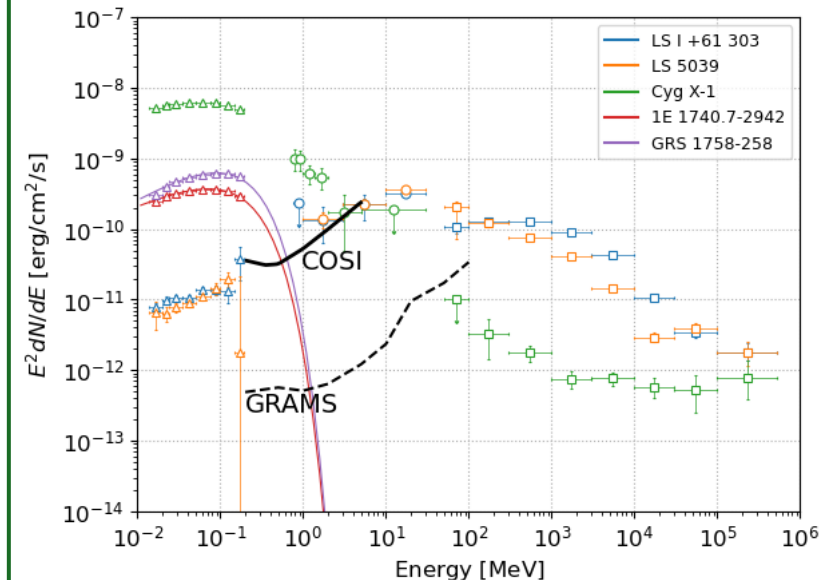
Pulsar

- Crab
- Vela
- PSR B1509-58
- AX J1846.4-0258*
- PSR J0146+61*



Binary

- LS I +61 303
- LS 5039
- Cyg X-1
- 1E 1740.7-2942*
- GRS 1758-258*



△: BAT, □: LAT, ○: COMPTEL

Summary

- Built the MeV gamma-ray source catalog (4625 sources):
 - **Blazars, Pulsars, and Binaries** in Swift/BAT and Fermi/LAT, plus other cross-matched source types such as radio galaxies (e.g., Cen A)
- Produced MeV all-sky map in 1–10 MeV (Sources + GDE + EGB)
- Estimated 1–10 MeV flux: **~200** sources exceed 10^{-11} erg/cm²/s
- Promising sources (Non-detected by COMPTEL):
 - 3C 279, PKS 1510-089 (Blazar),
 - AX J1846.4-0258, PSR J0146+61 (Pulsar),
 - 1E 1740.7-2942, GRS 1758-258 (Binary)