



Matterhorn

Antimatterhorn



Nuclear Astrophysics in Würzburg

estd. August 2022



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in Japan

3rd yr

1st yr

1st yr

Papers in Submission

Astronomische Nachrichten
Proceeding

Search for Axion-like Particles from Massive Stars

Submission Status	Under Review	This submission is under consideration and cannot be edited. Further information will be emailed to you by the journal editorial office.
Manuscript ID	7784040	
Submitted On	18 July 2025 by Saurabh Mittal	
Submission Started	18 June 2025 by Saurabh Mittal	

Submission overview →

Astronomische Nachrichten
Proceeding

26Al from Massive Stars Observed with INTEGRAL/SPI: Towards Fitting the Orion-Eridanus Superbubble

Submission Status	In Screening	This submission is under consideration and cannot be edited
Manuscript ID	9678400	
Submitted On	19 July 2025 by Thomas Siegert	
Submission Started	12 June 2025 by Thomas Siegert	

Submission overview →

Astronomische Nachrichten
Proceeding

Calculation of Electron-Positron Pair Production from the Cosmic Photon Background as a Function of Redshift

Submission Status	Under Review	This submission is under consideration and cannot be edited
Manuscript ID	7381090	
Submitted On	18 July 2025 by Mika Gelowicz	
Submission Started	12 June 2025 by Mika Gelowicz	

Submission overview →

Astronomische Nachrichten
Proceeding

INTEGRAL/SPI Observations of the M31 Dark Matter Halo

Submission Status	In Screening	This submission is under consideration and cannot be edited
Manuscript ID	9982247	
Submitted On	21 July 2025 by Laura Eisenberger	
Submission Started	1 July 2025 by Laura Eisenberger	

Submission overview →

Astronomische Nachrichten
Proceeding

Time-variability in the All-Sky 511 keV Emission

Submission Status	In Screening	This submission is under consideration and cannot be edited
Manuscript ID	8715219	
Submitted On	20 July 2025 by Rudi Reinhardt	
Submission Started	1 July 2025 by Rudi Reinhardt	

Submission overview →

Astronomische Nachrichten
Proceeding

Contributions of massive stars and classical novae to Galactic 26Al

Submission Status	In Screening	This submission is under consideration and cannot be edited
Manuscript ID	3659163	
Submitted On	18 July 2025 by Manja Zimmerer	
Submission Started	1 July 2025 by Manja Zimmerer	

Submission overview →

Astronomische Nachrichten
Proceeding

Jupiter’s Atmospheric Scattering: A New Approach to Cosmic γ-Ray Background Studies

Submission Status	In Screening	This submission is under consideration and cannot be edited
Manuscript ID	9889784	
Submitted On	19 July 2025 by Dimitris Tsatsis	
Submission Started	18 June 2025 by Dimitris Tsatsis	

Submission overview →

Astronomische Nachrichten
Proceeding

Modeling the Response to Terrestrial Gamma-Ray Flashes at the Zugspitze Research Station

Submission Status	Under Review	This submission is under consideration and cannot be edited
Manuscript ID	7698952	
Submitted On	18 July 2025 by Patrik Ehrmann	
Submission Started	1 July 2025 by Patrik Ehrmann	

Submission overview →

Axion-like Particles (ALPs) in Stars

Betelgeuse (Xiao et al. 2022; soon to be updated)

ALP (a) production via:

- **Primakoff process:** $\gamma + Ze \rightarrow a + Ze$
- **Compton scattering:** $\gamma + e \rightarrow e + a$
- **Bremsstrahlung:** $e + Ze \rightarrow e + Ze + a$

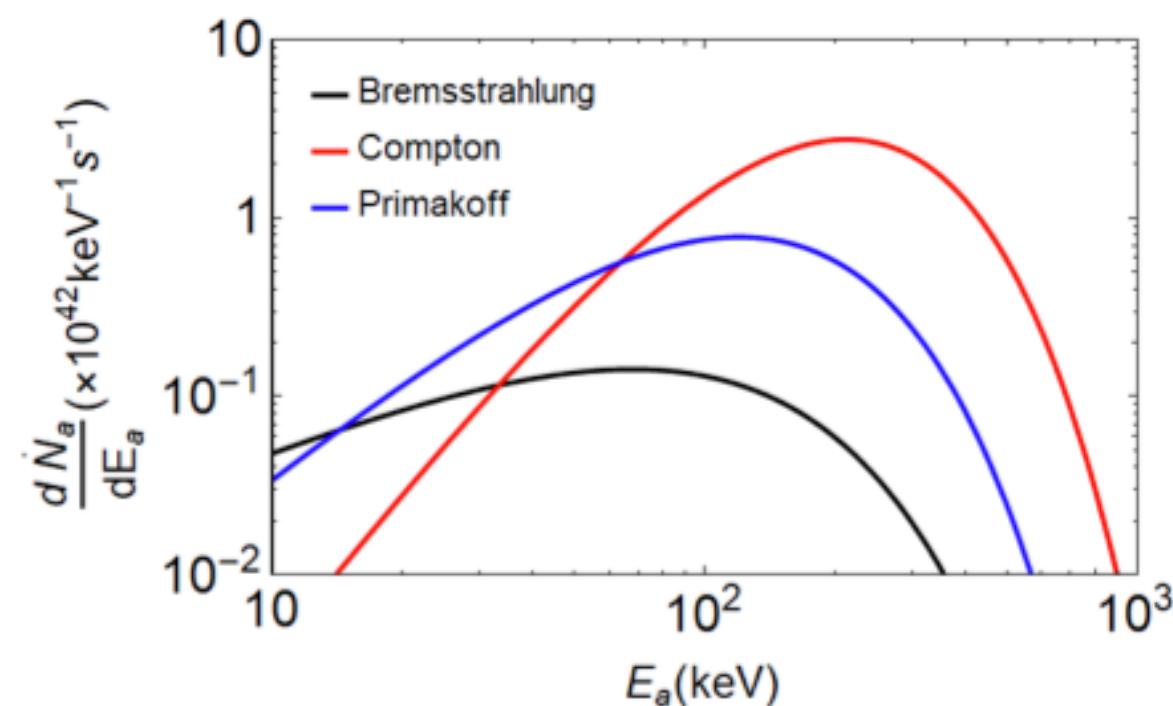
→ Total ALP spectrum is obtained by integrating reaction rates over the volume of a star.

→ **Use nearby massive star!**
Here: Betelgeuse



Model

$$\frac{d\dot{N}_a}{dE} = \frac{10^{42}}{\text{keV s}} \left[C^B g_{13}^2 \left(\frac{E}{E_0^B} \right)^{\beta^B} e^{-(\beta^B+1)E/E_0^B} + C^C g_{13}^2 \left(\frac{E}{E_0^C} \right)^{\beta^C} e^{-(\beta^C+1)E/E_0^C} + C^P g_{11}^2 \left(\frac{E}{E_0^P} \right)^{\beta^P} e^{-(\beta^P+1)E/E_0^P} \right],$$

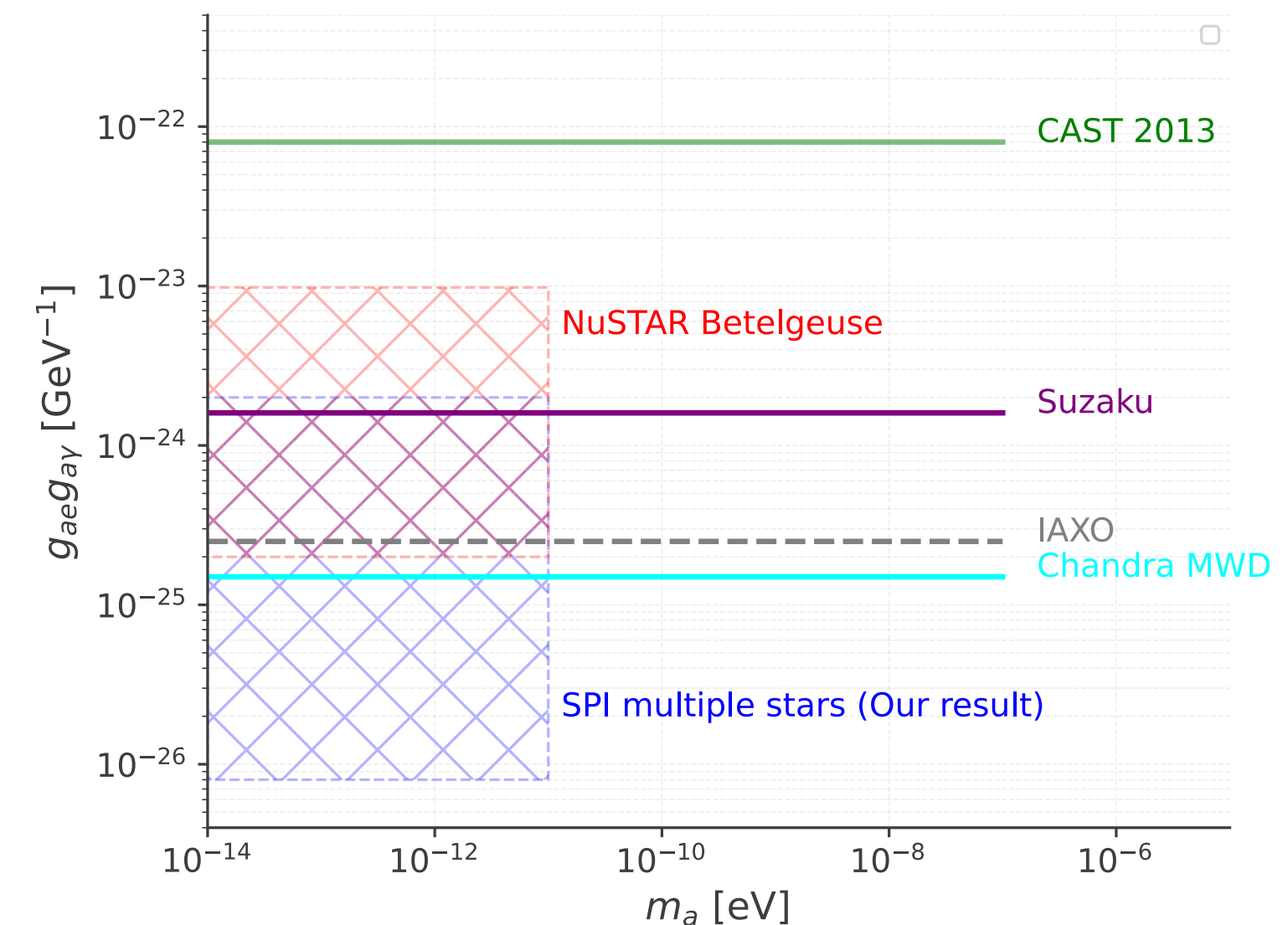
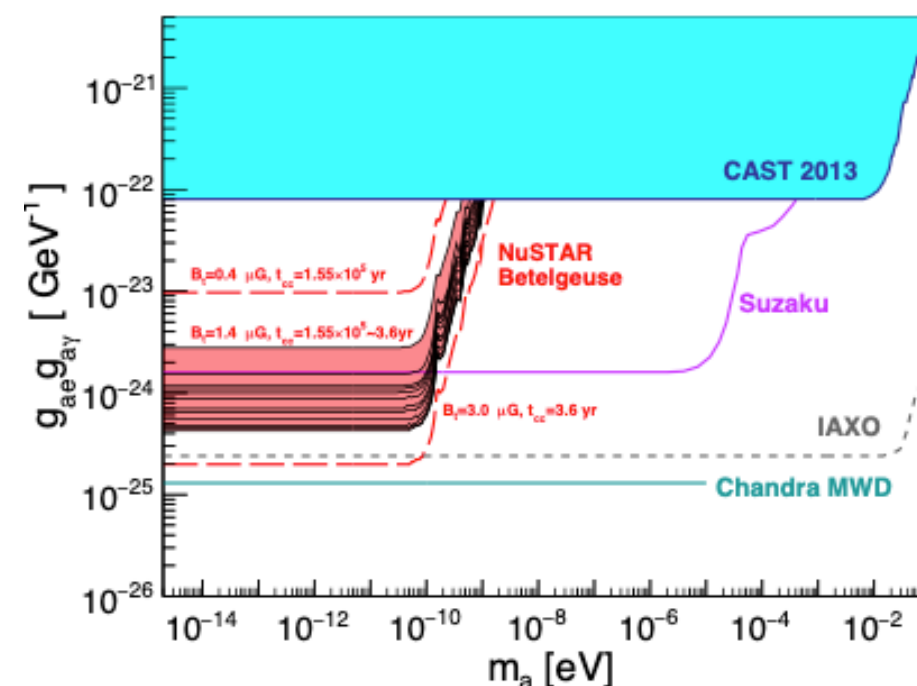


Measurements (NuSTAR)

Updated Measurements (INTEGRAL/SPI)

Limits

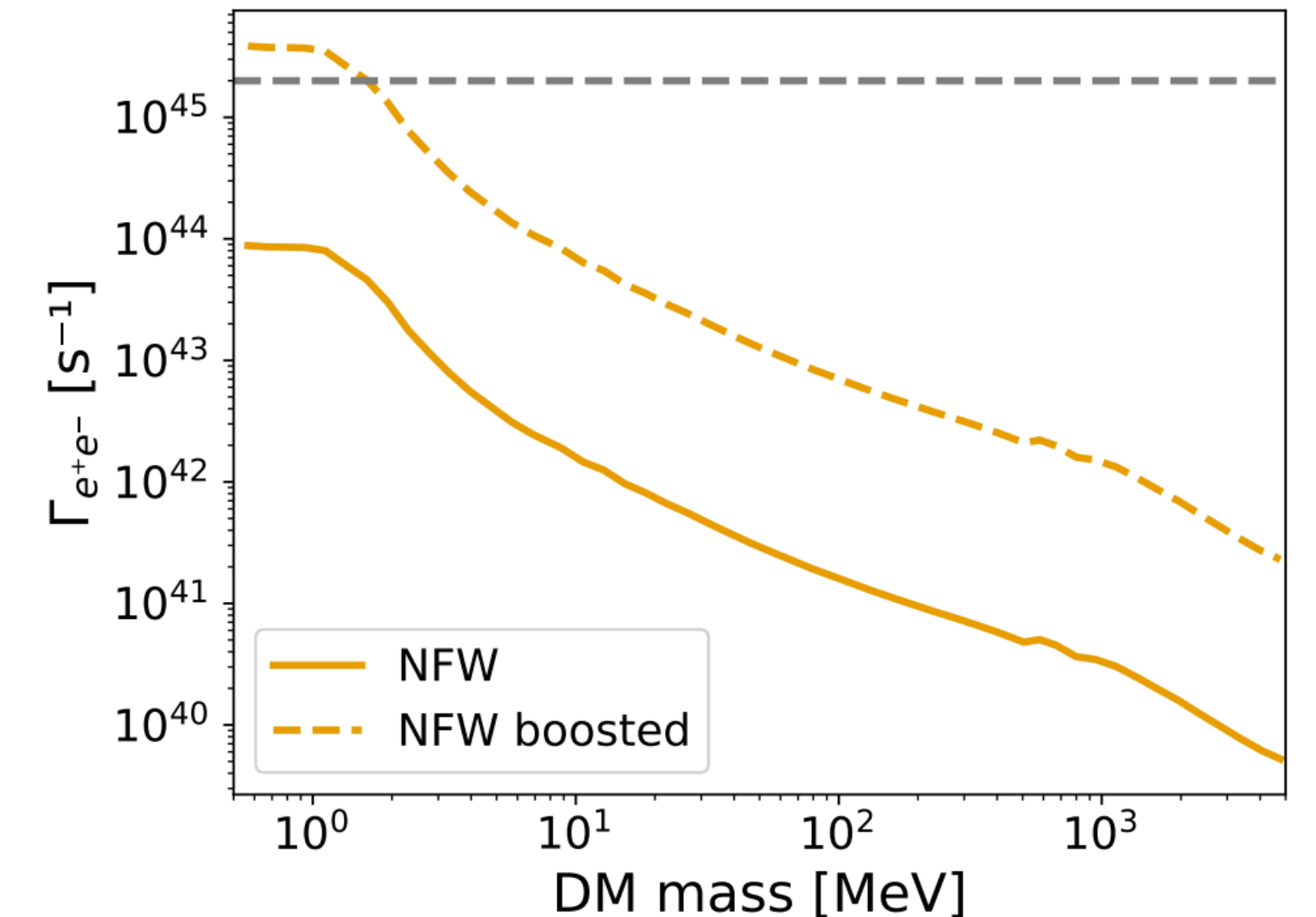
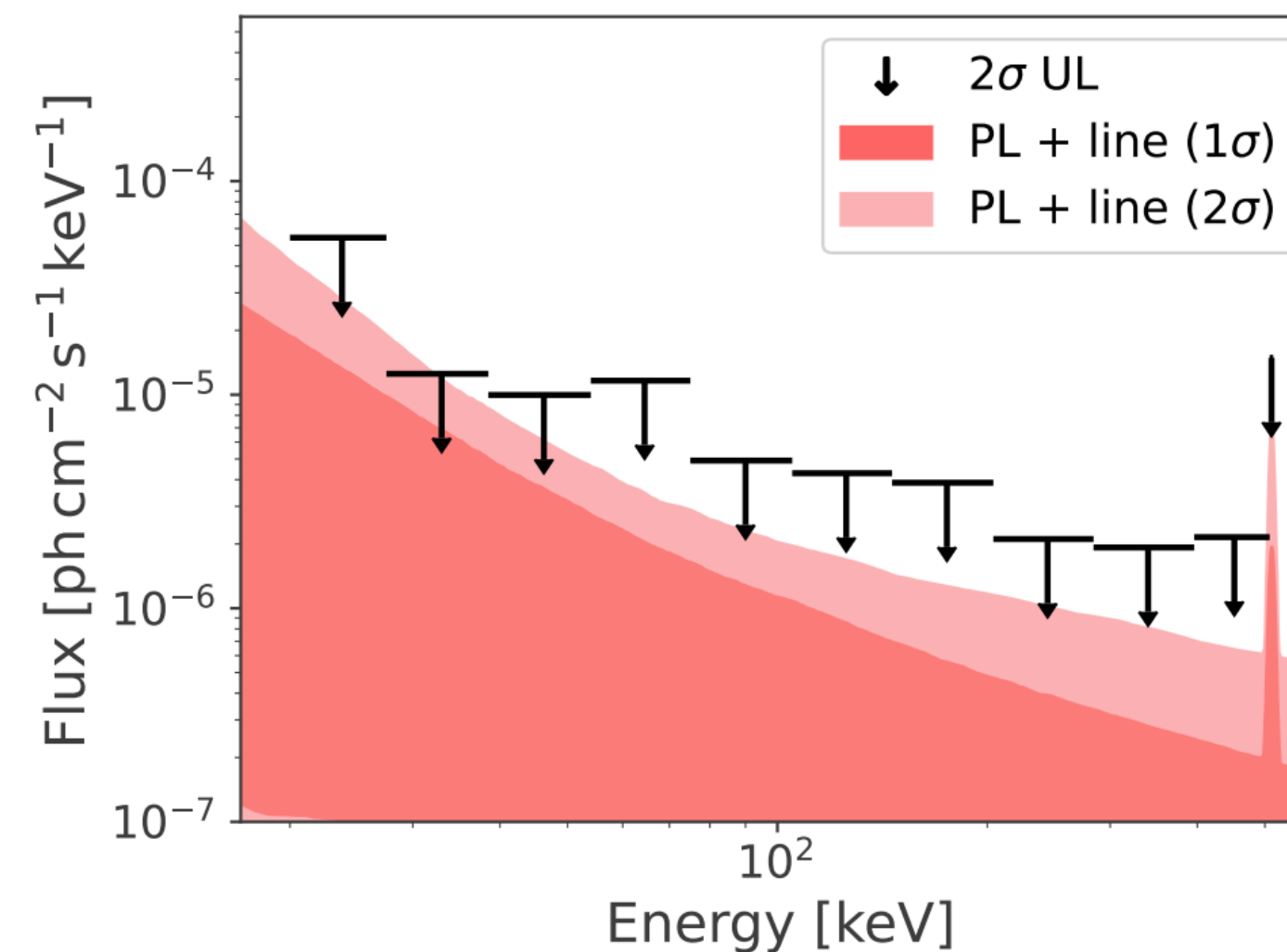
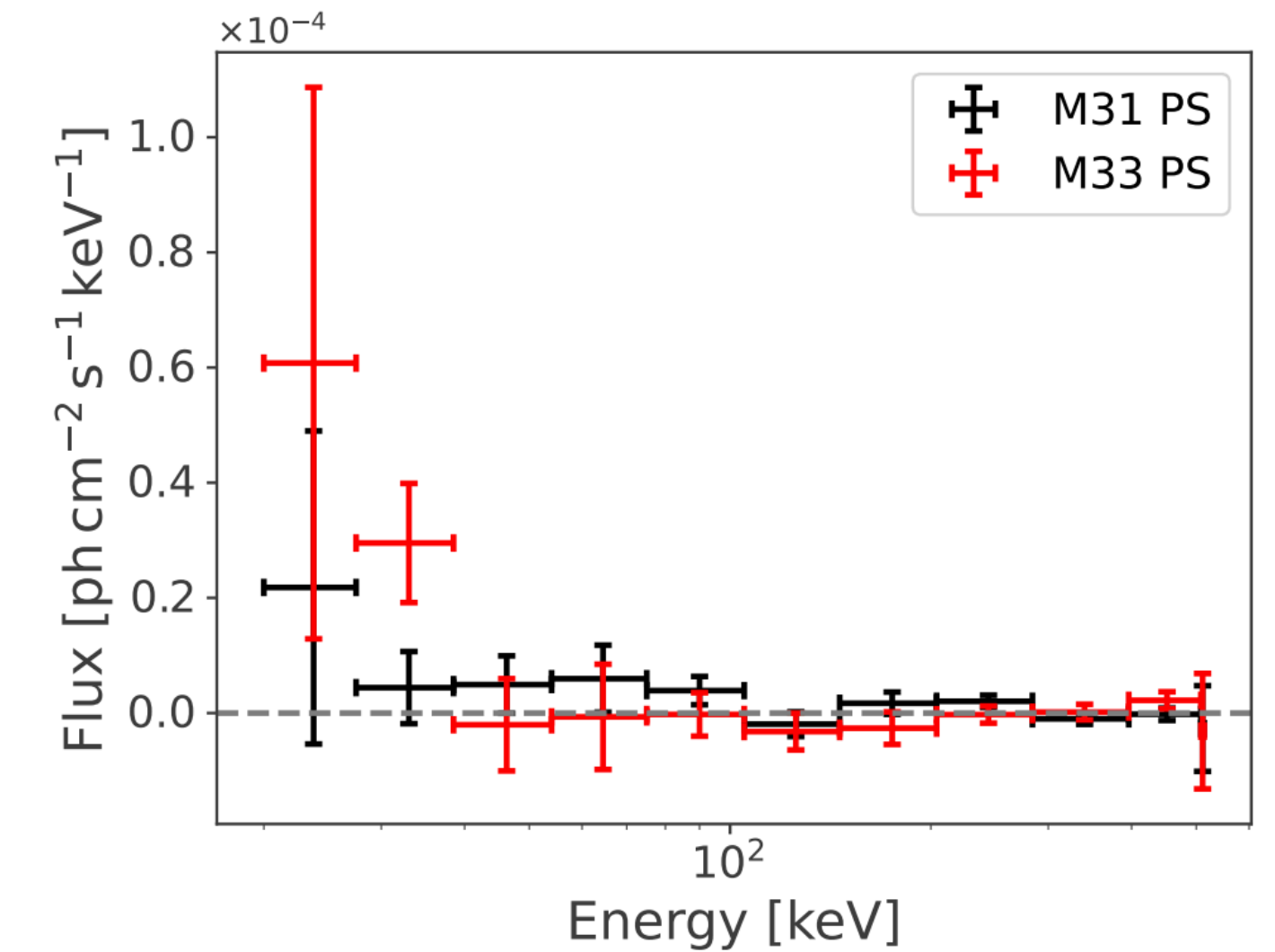
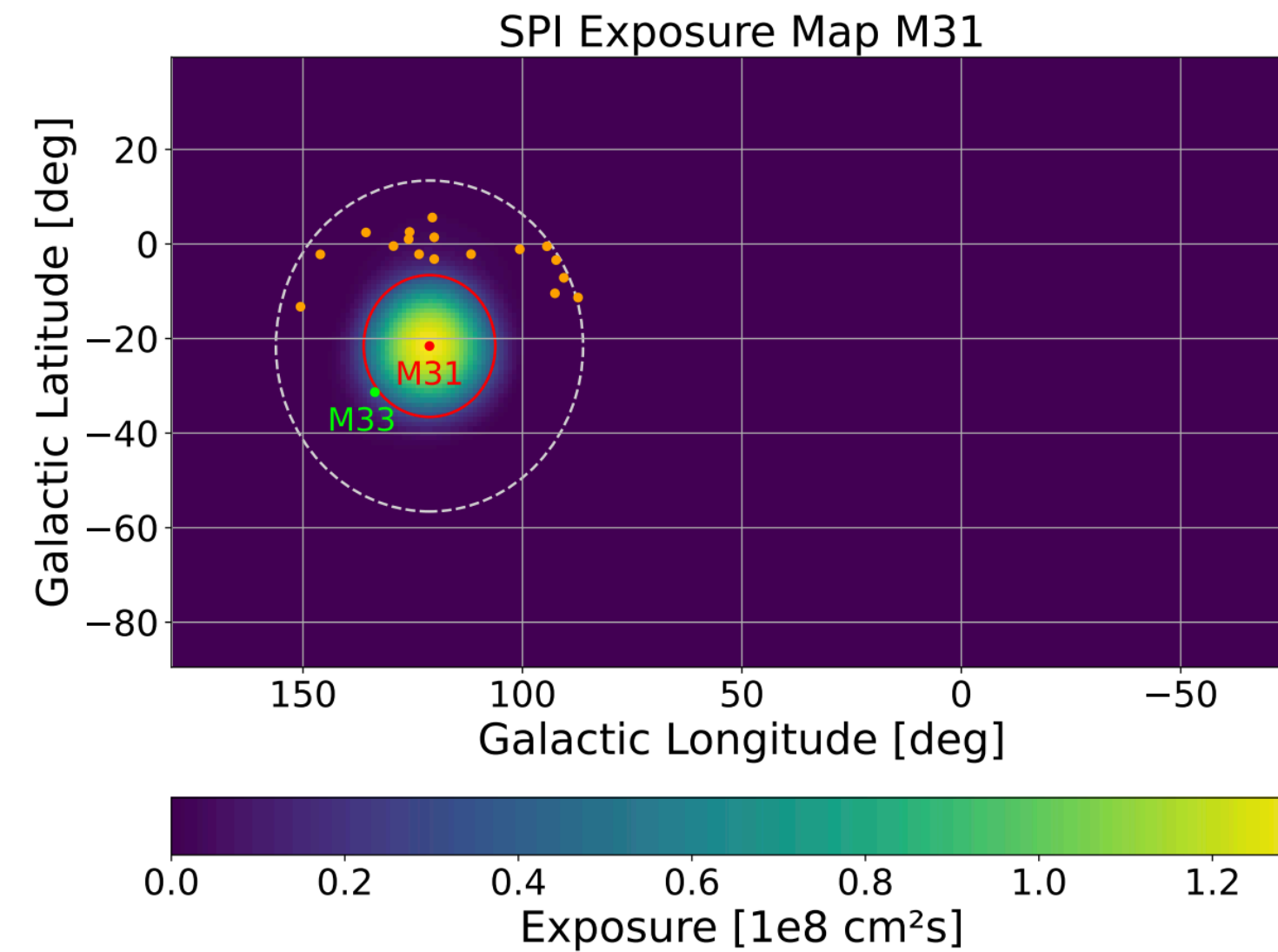
Coupling constants
VS.
ALP mass





INTEGRAL/SPI observations of M31 DM Halo

- M31, indirect search for DM
- Prelim. Spectra consistent with zero
- UL: constrain DM models
- Estimate pair-production rate in M31
- Future: test more DM models

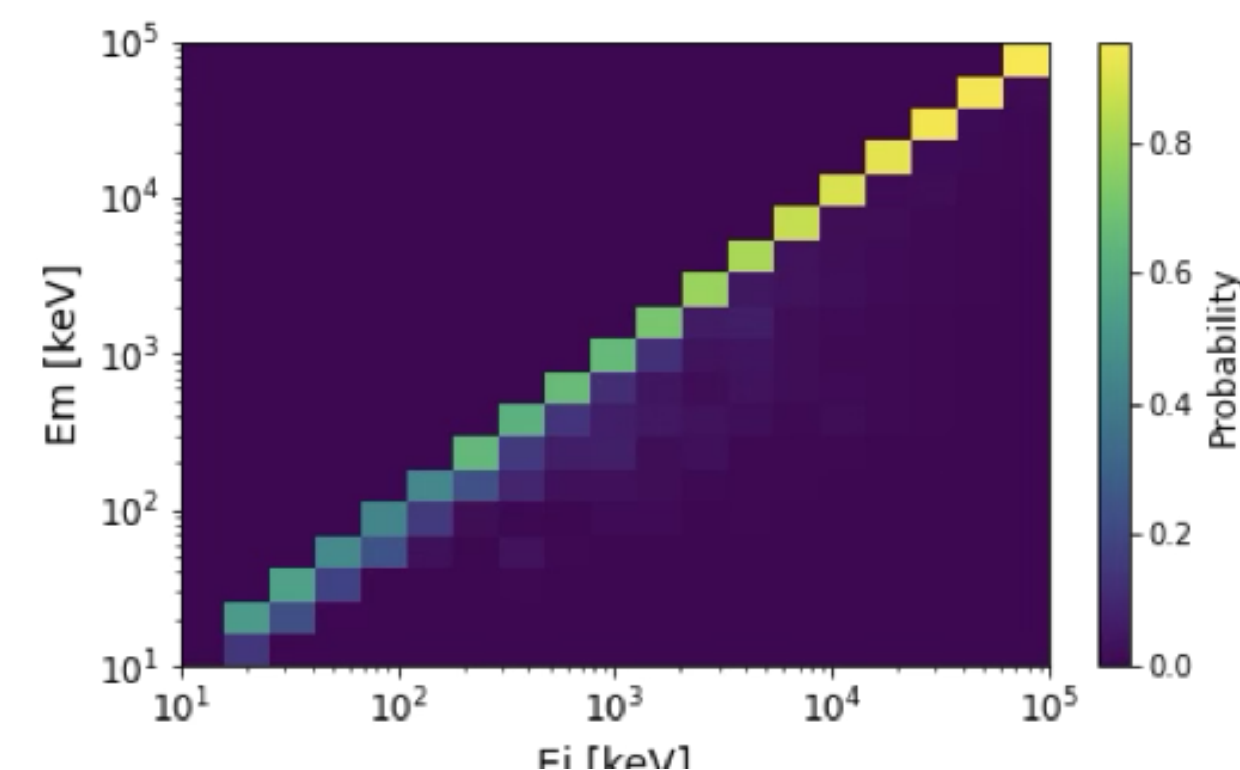
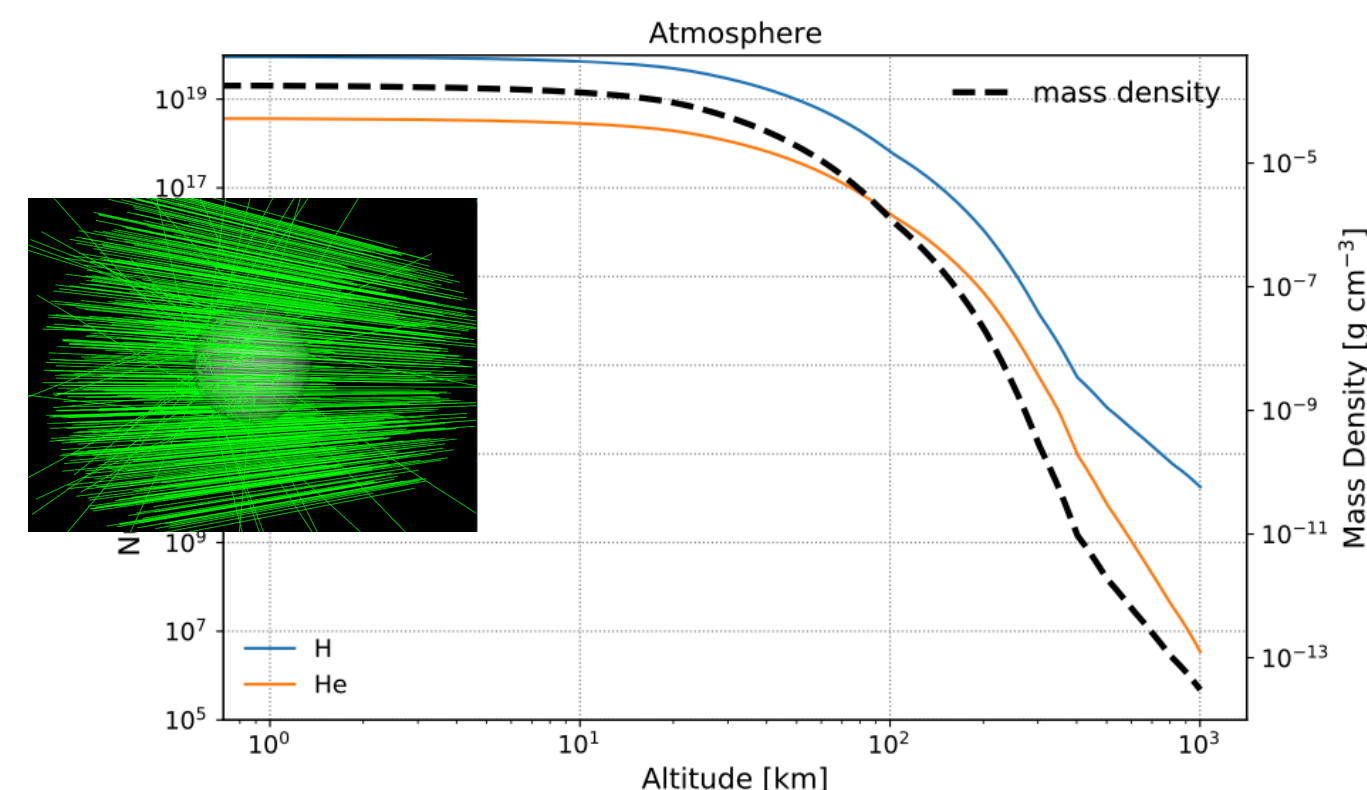
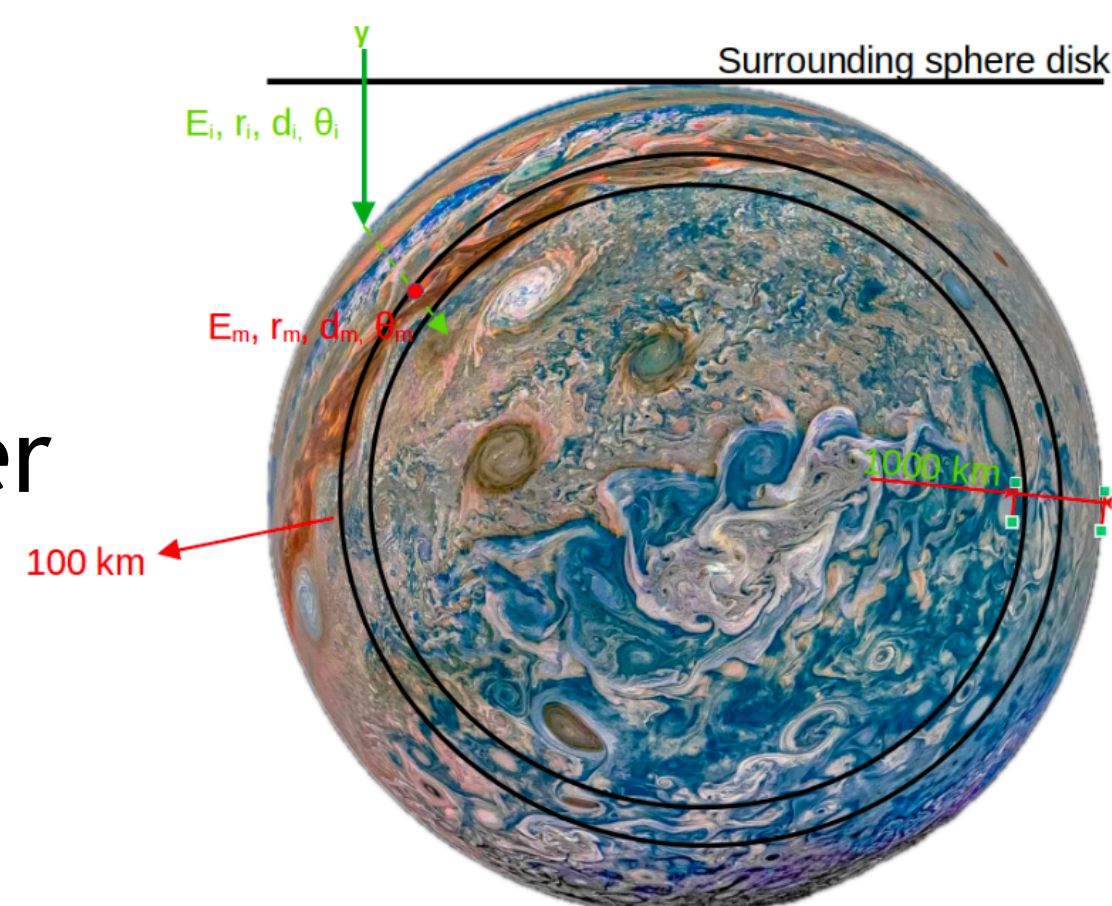




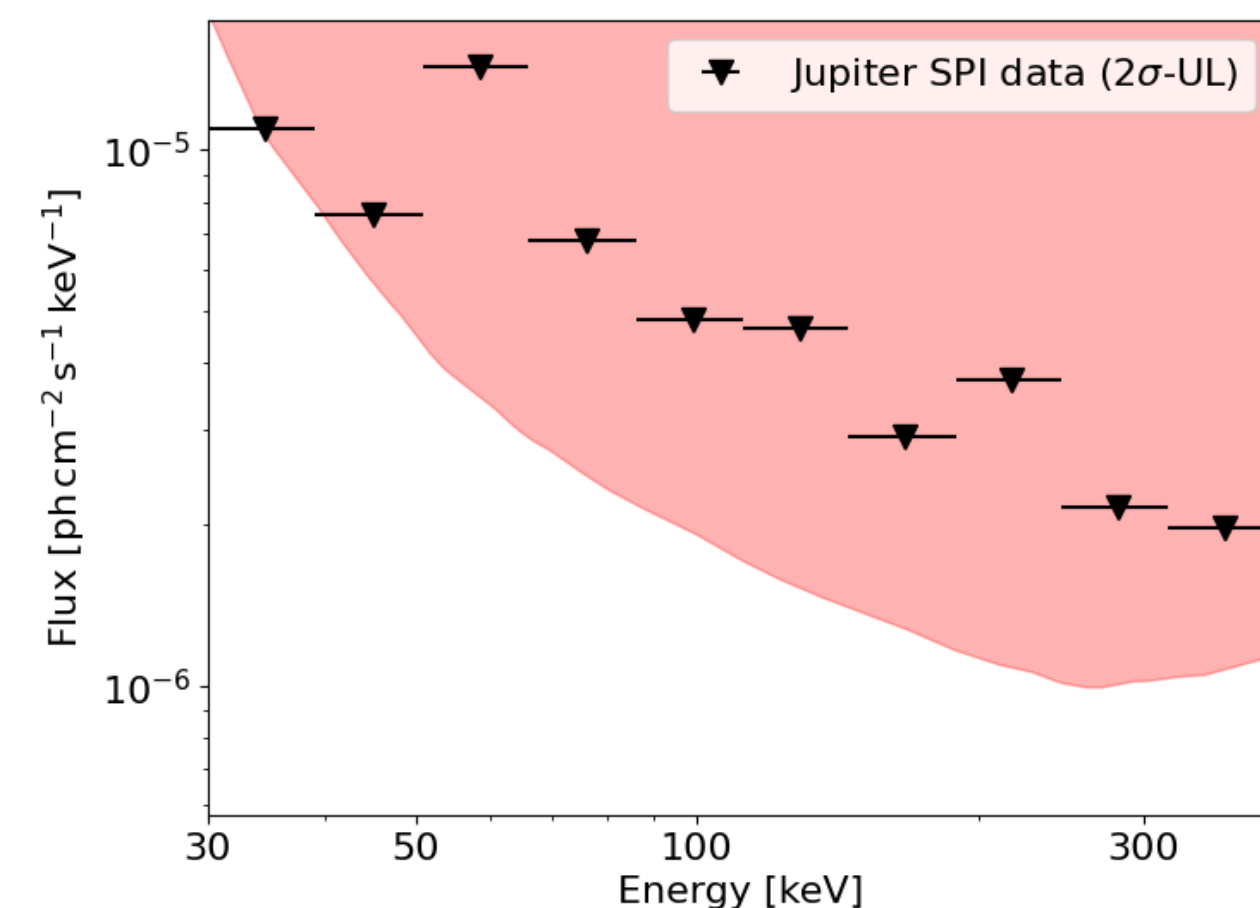
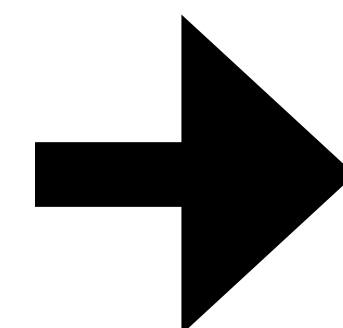
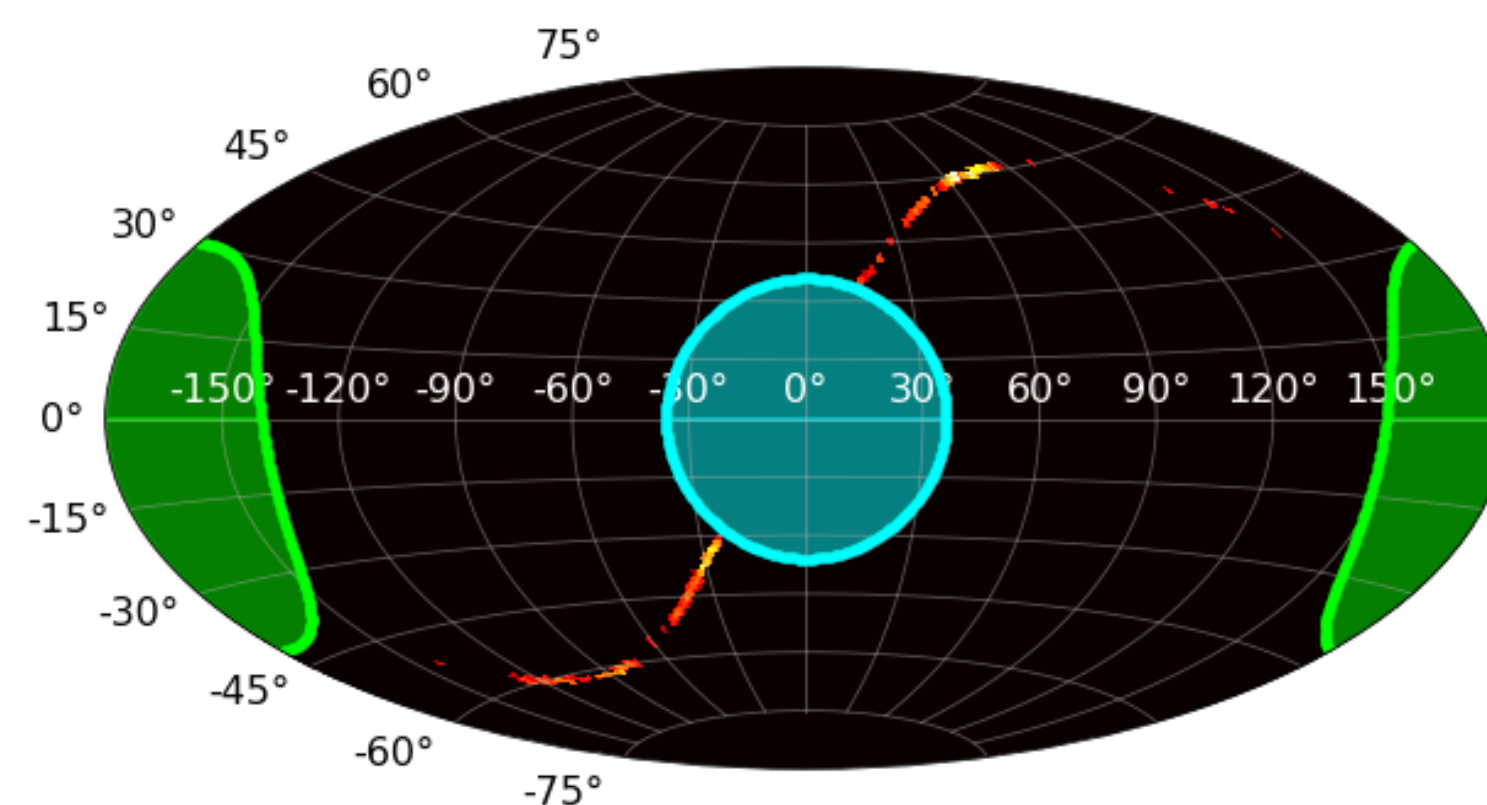
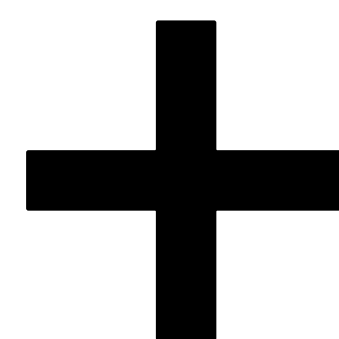
MeV Emission from Jupiter

- Understanding MeV CGB
- Gamma-ray emission from Jupiter's atmosphere
- Simulations to model the response of Jupiter
- 22 year SPI data
- ULs in the 30-400 keV range
- Consistent with known sources and Fermi data at higher energies
- Future:
 - CR interactions
 - Solar cycle modulation

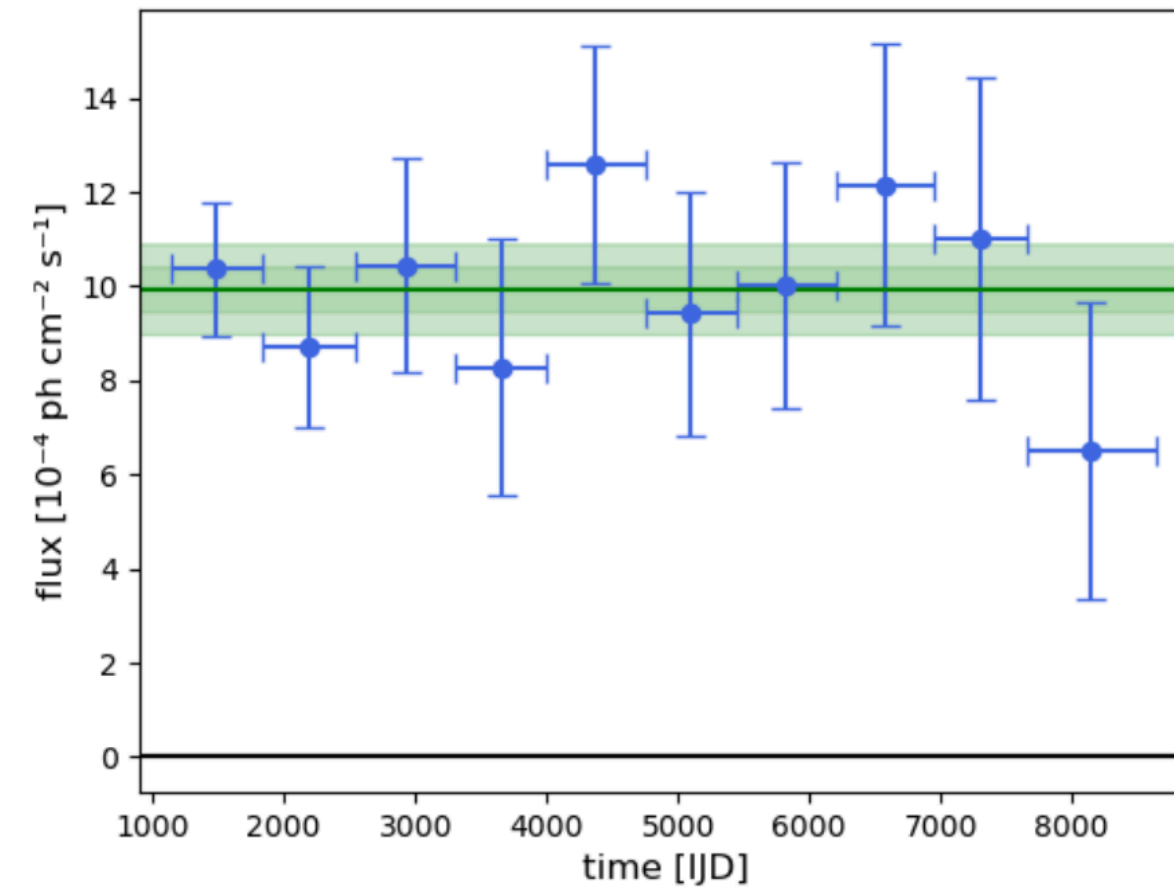
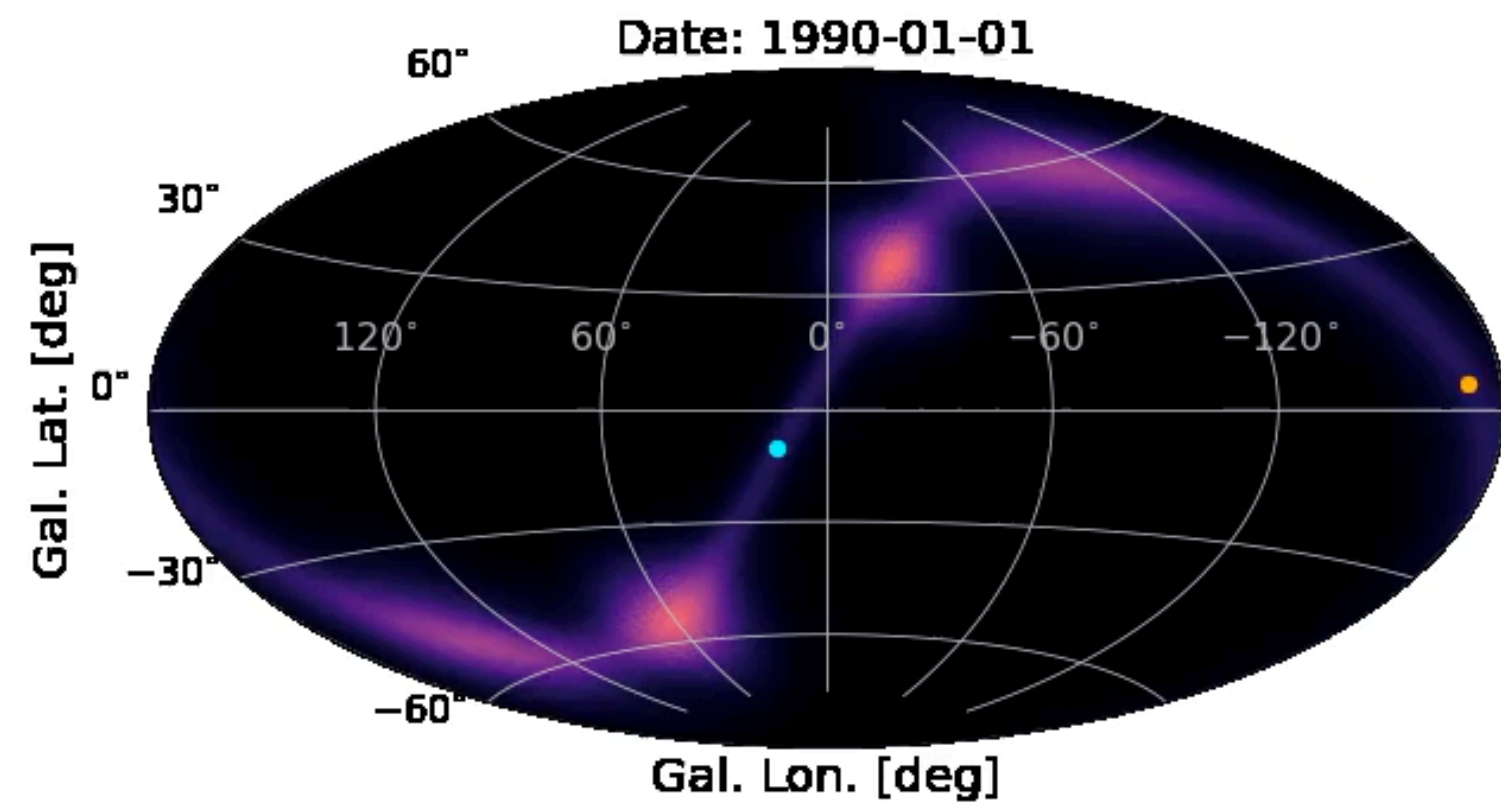
Reflection of the Cosmic Gamma-ray Background Cosmic-Ray Particle Interactions



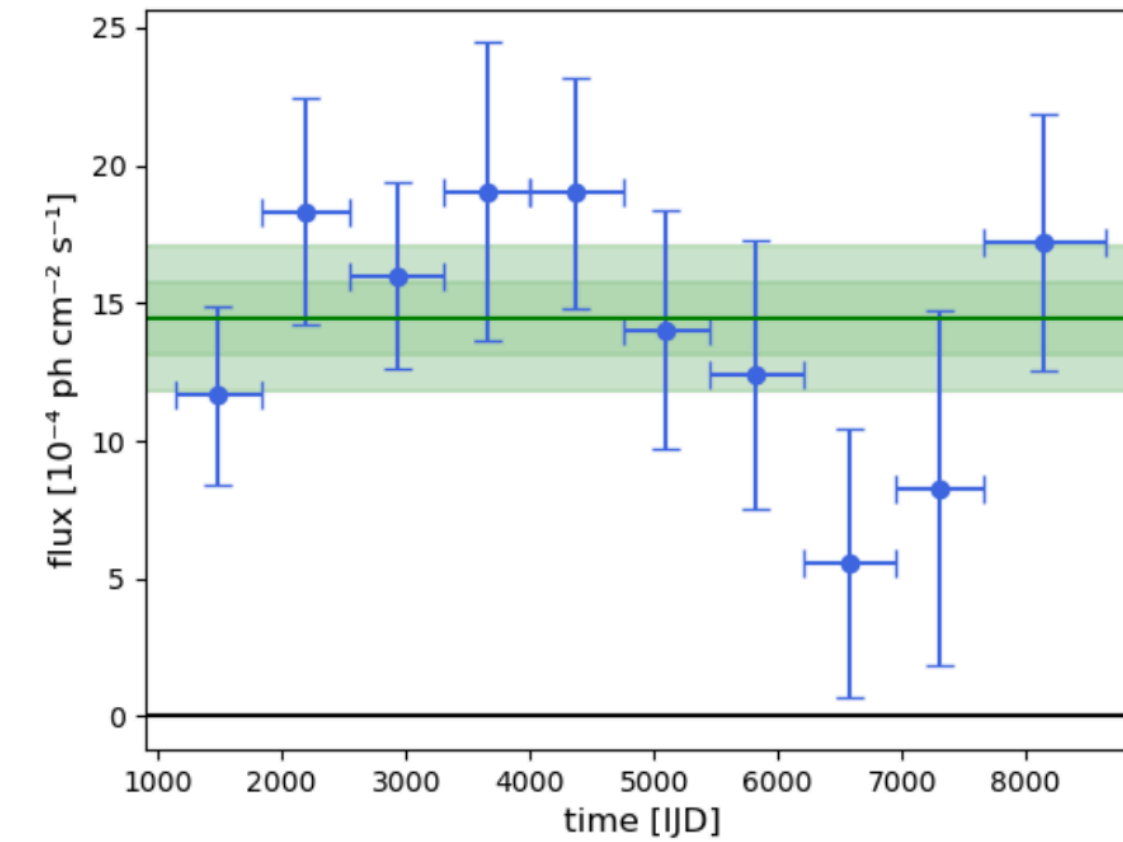
Data Analysis with INTEGRAL/SPI



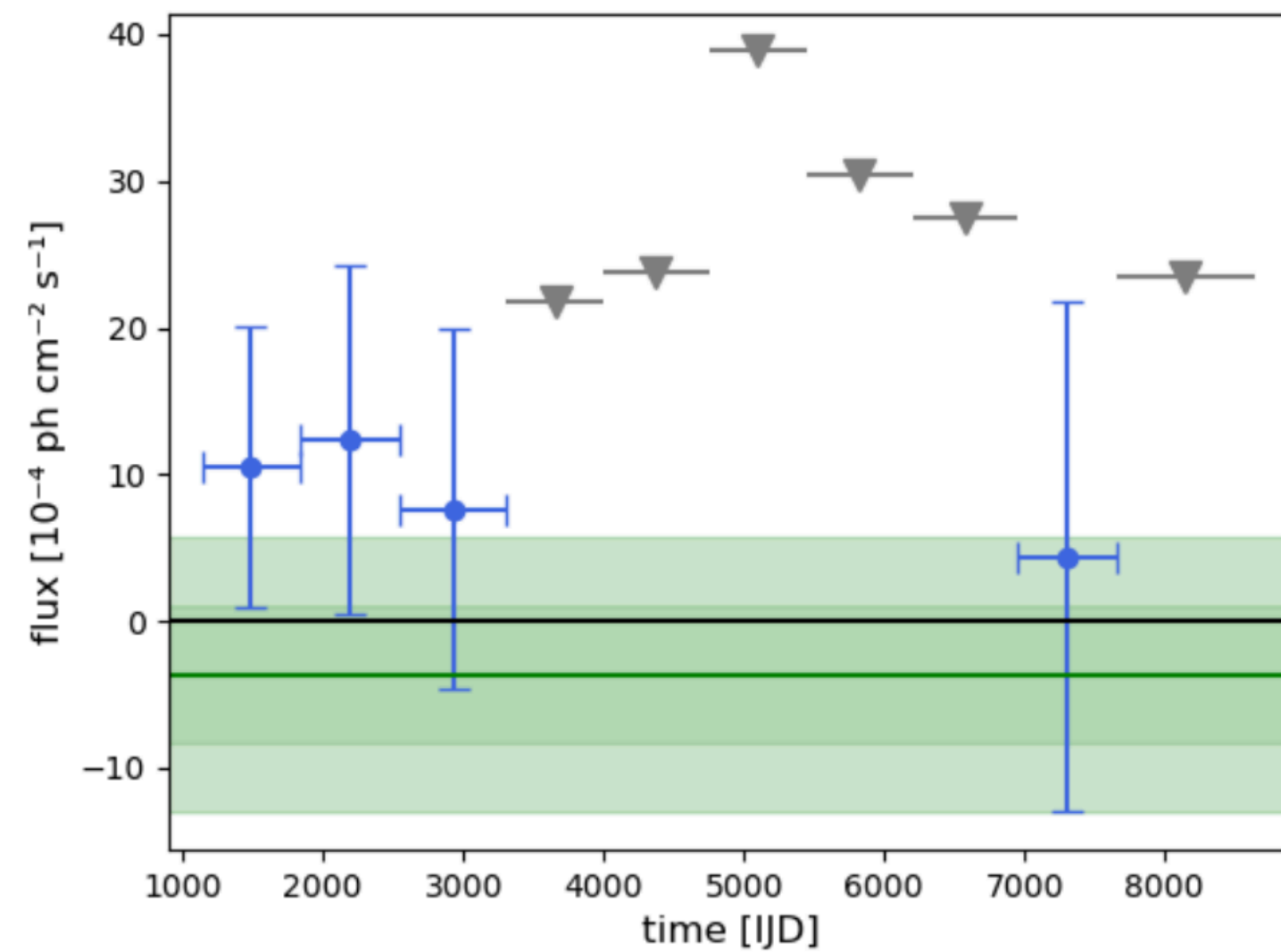
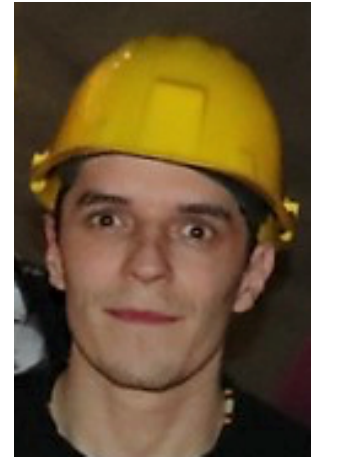
Time Variability in All-Sky 511 keV emission



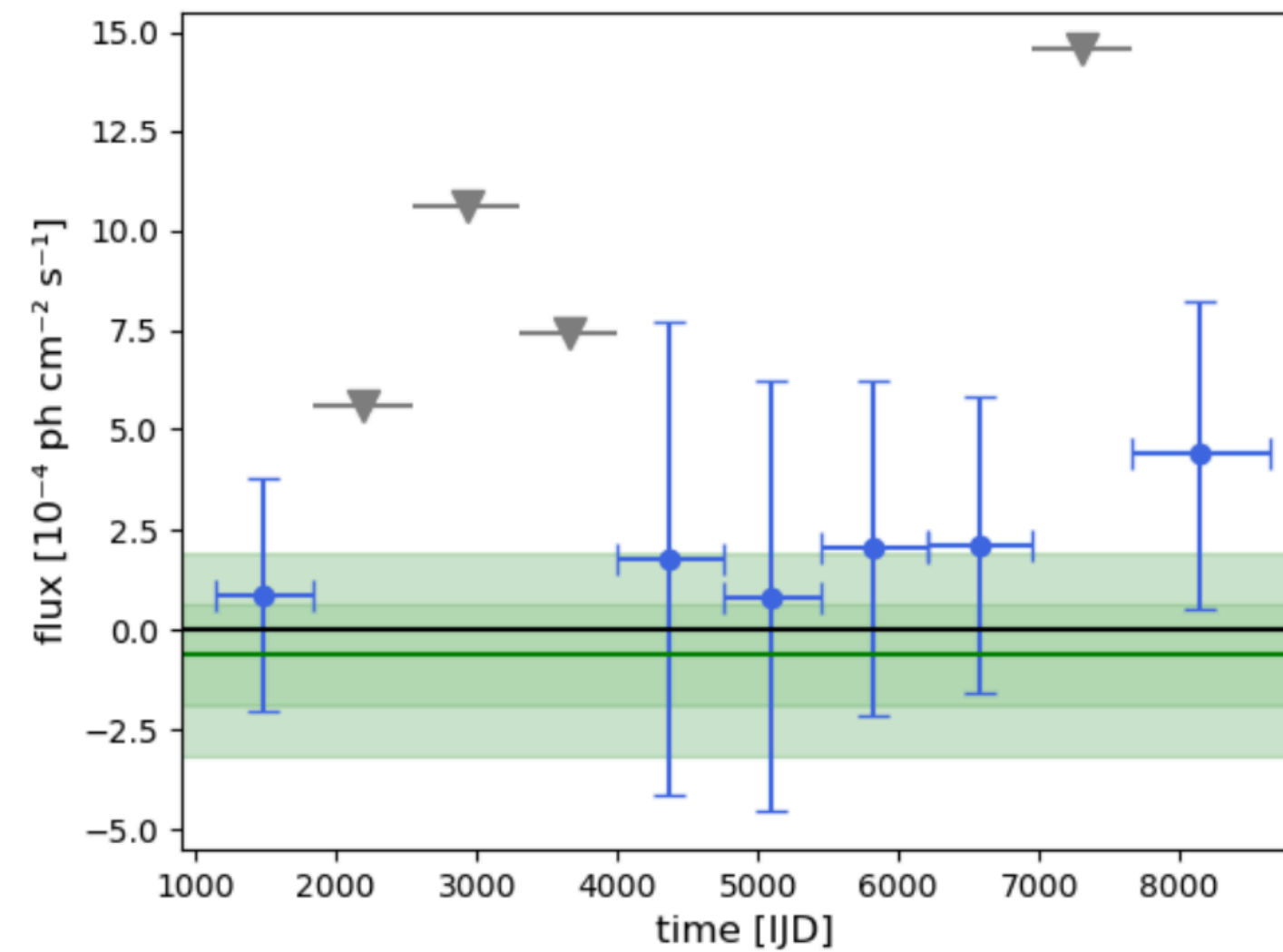
Galactic Bulge



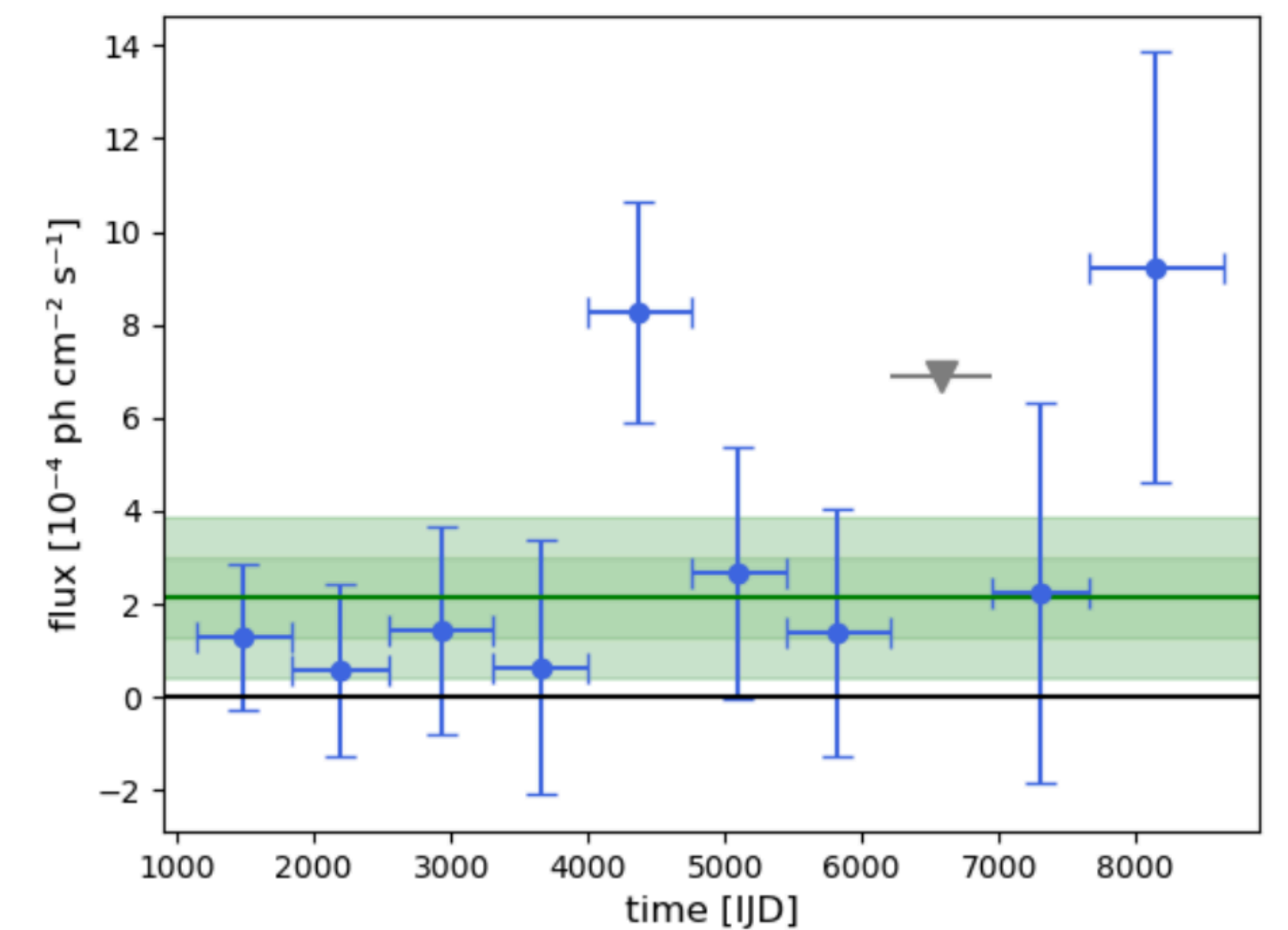
Galactic Disk



Kuiper Belt Objects

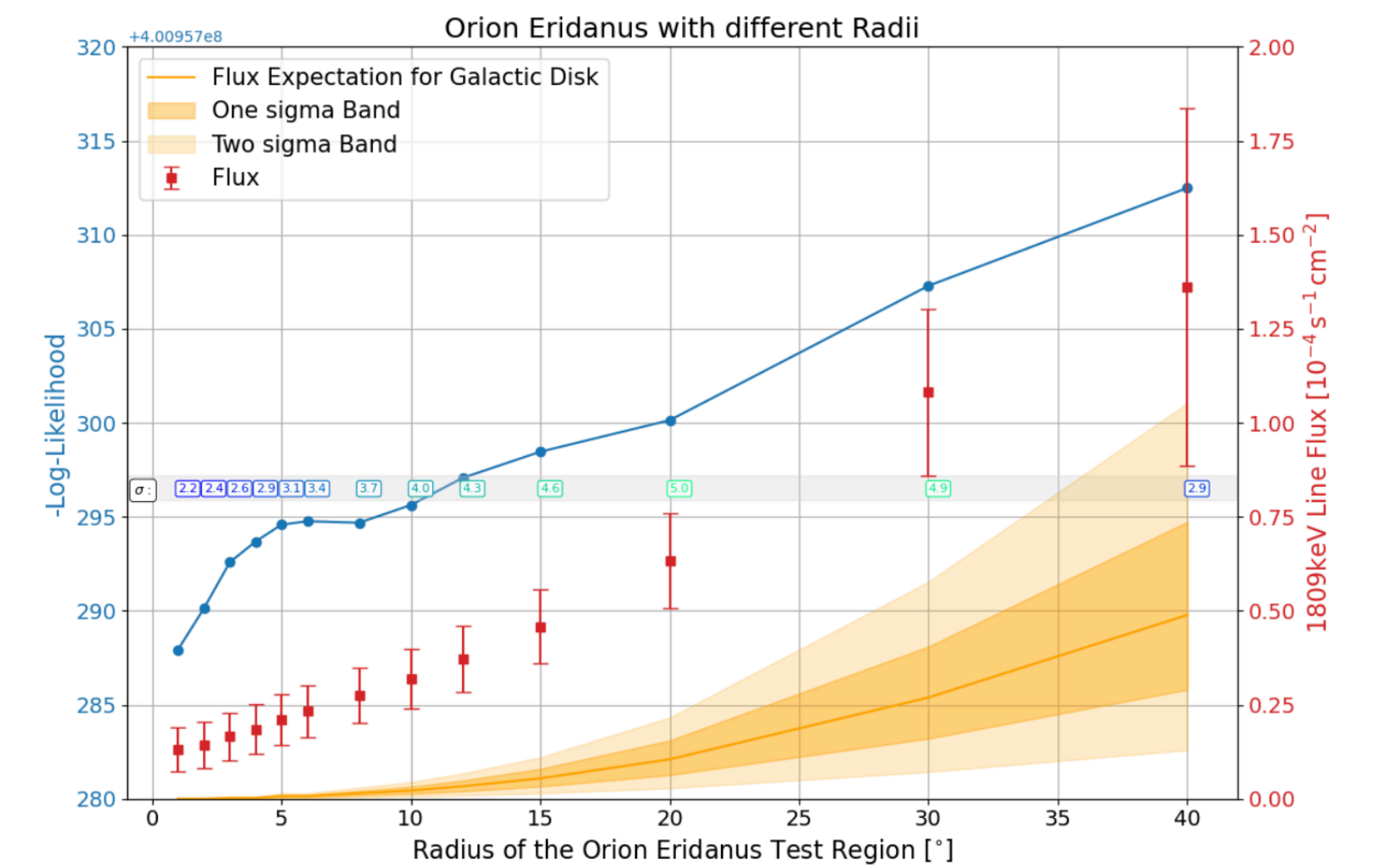
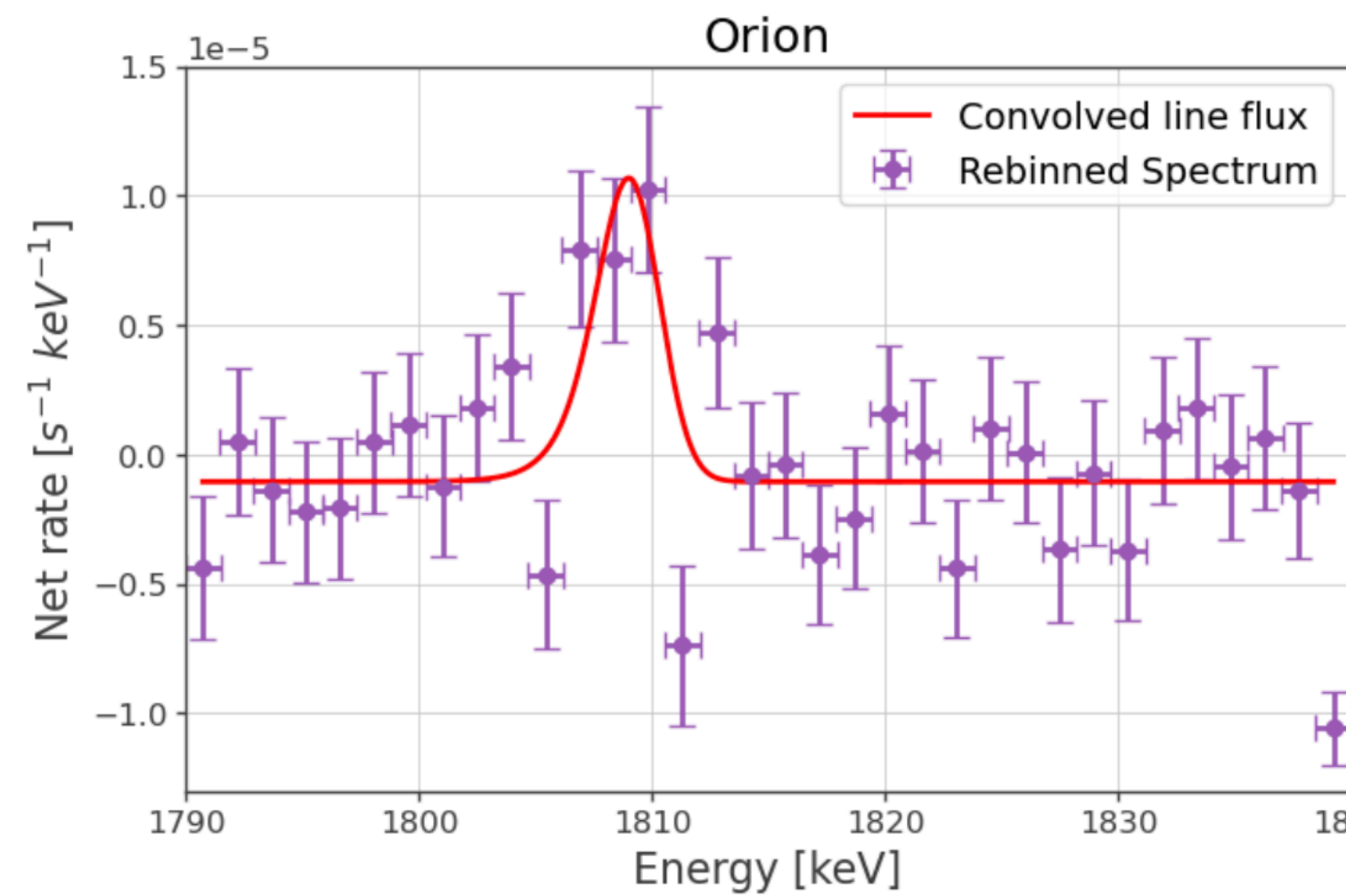
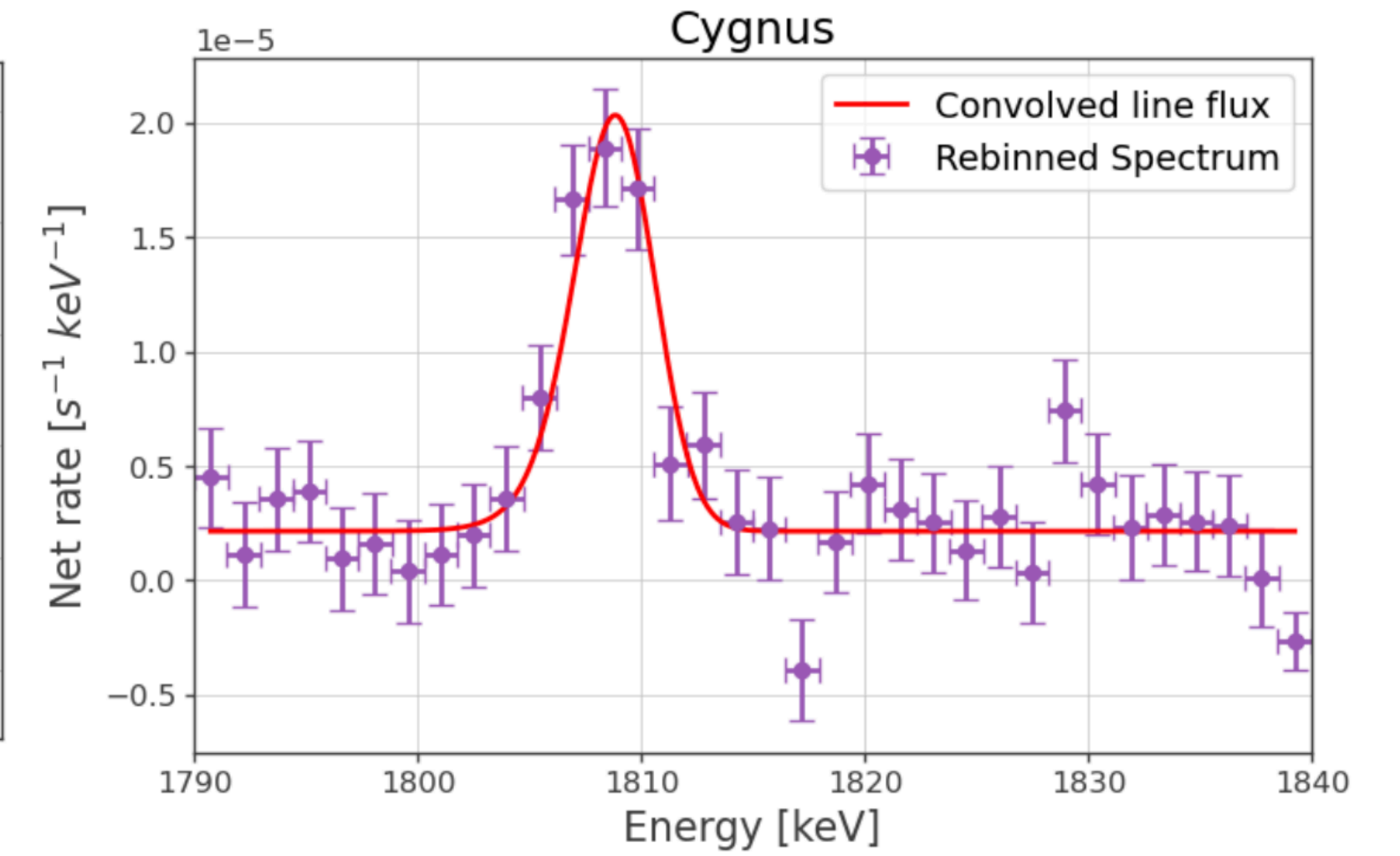
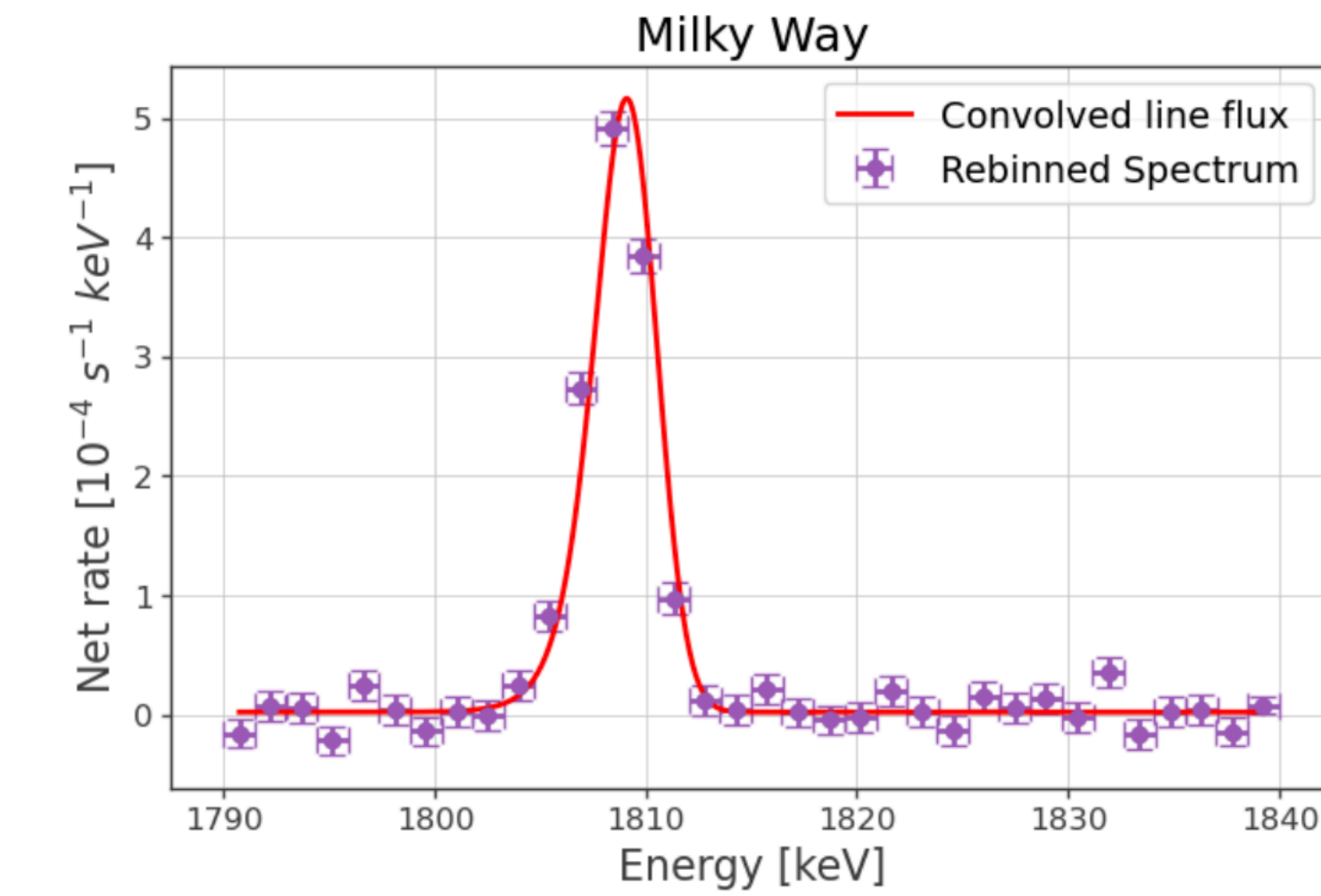
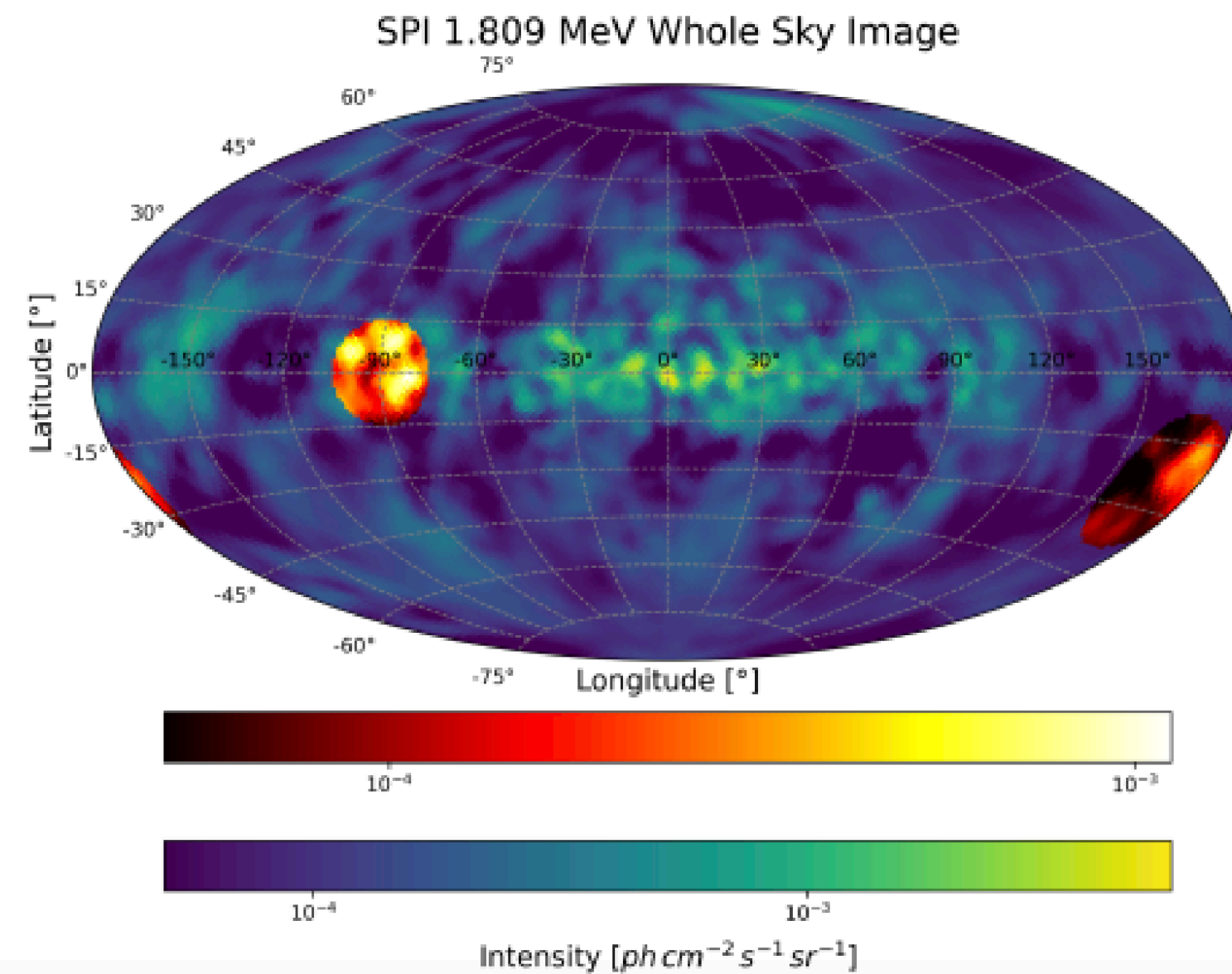


Jovian Trojans



Neptunian Trojans

^{26}Al from Massive Stars

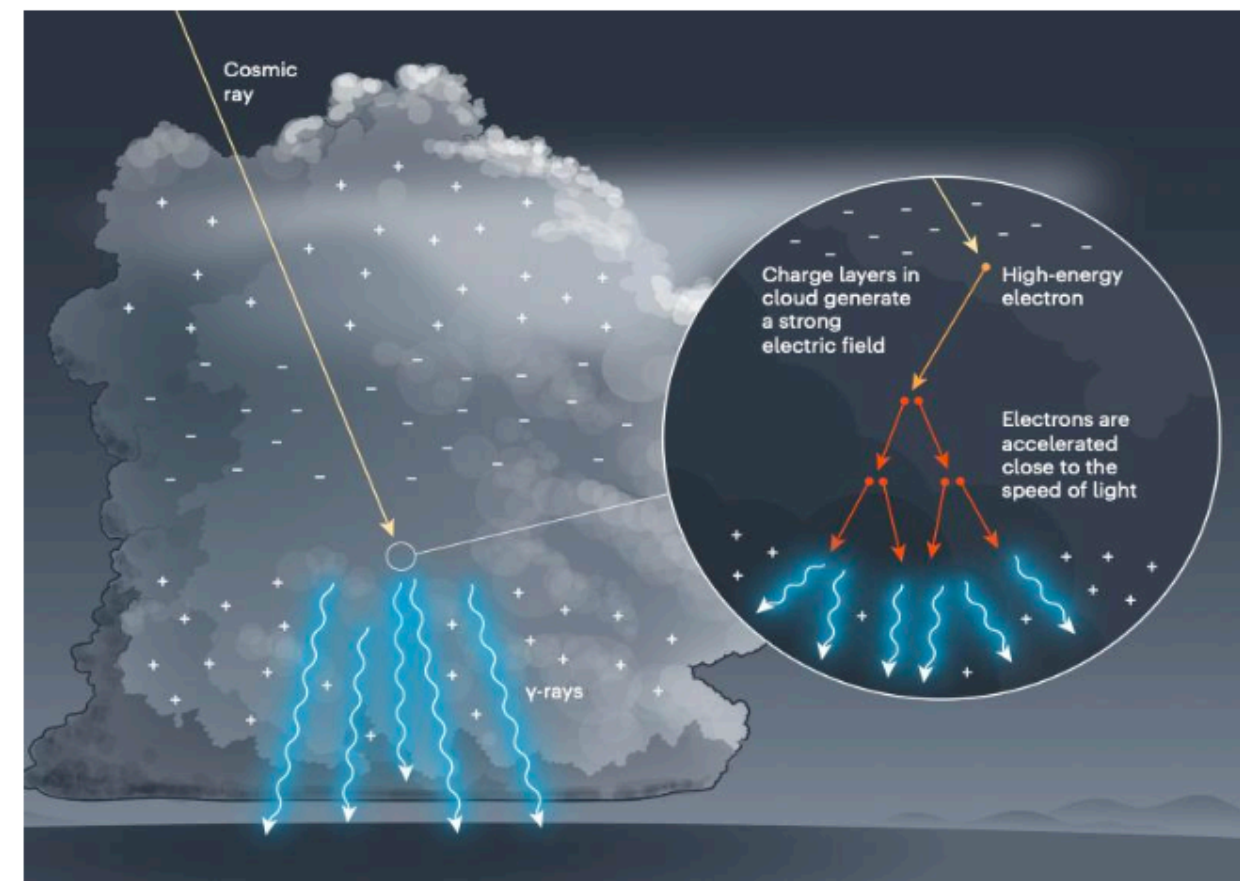


Terrestrial Gamma-Ray flashes

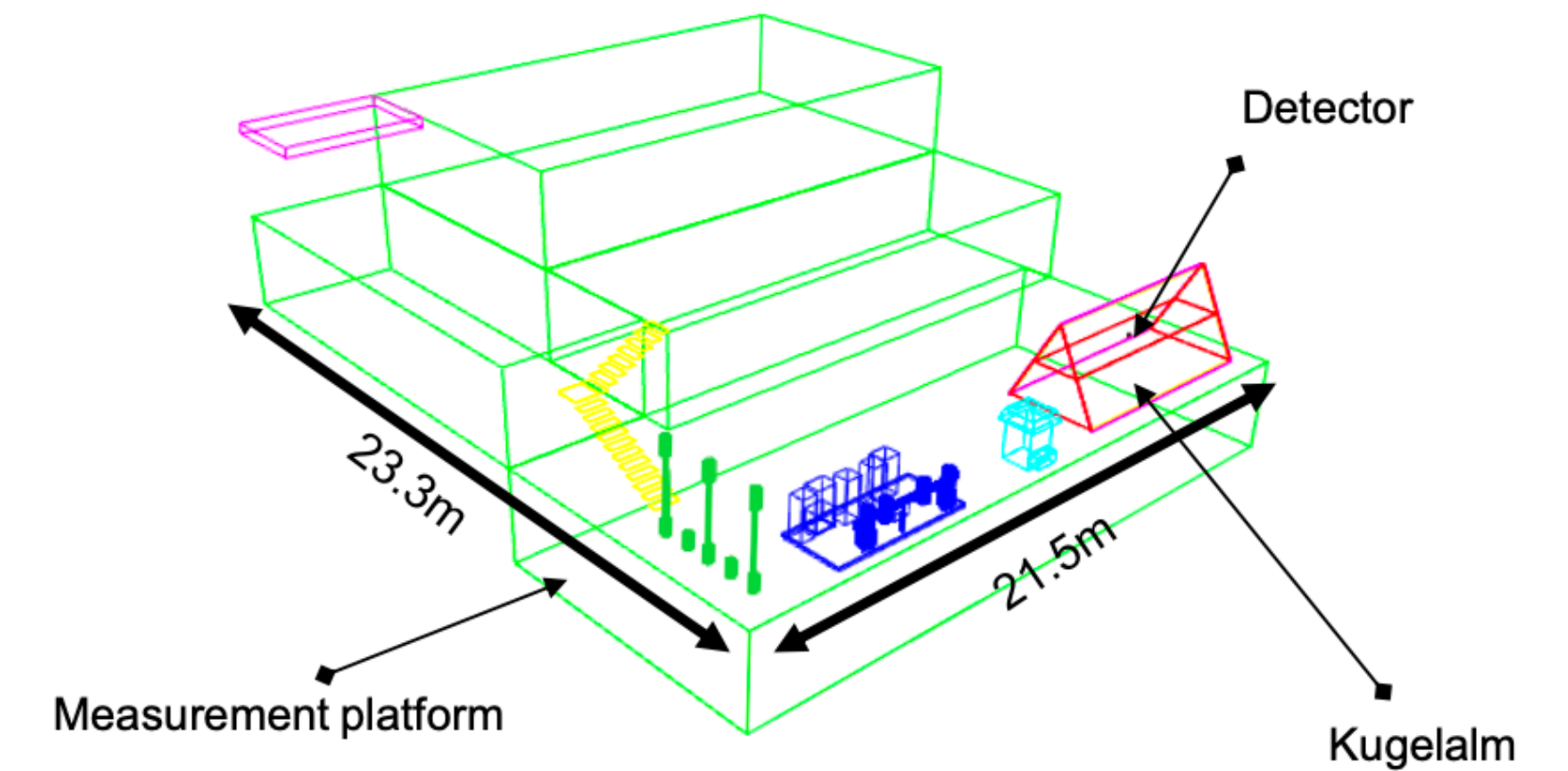


- Thunderstorms
- Simulations:
 - Different detector material
 - Different shielding
- Directional response
- Spectral response
- Transmissivity

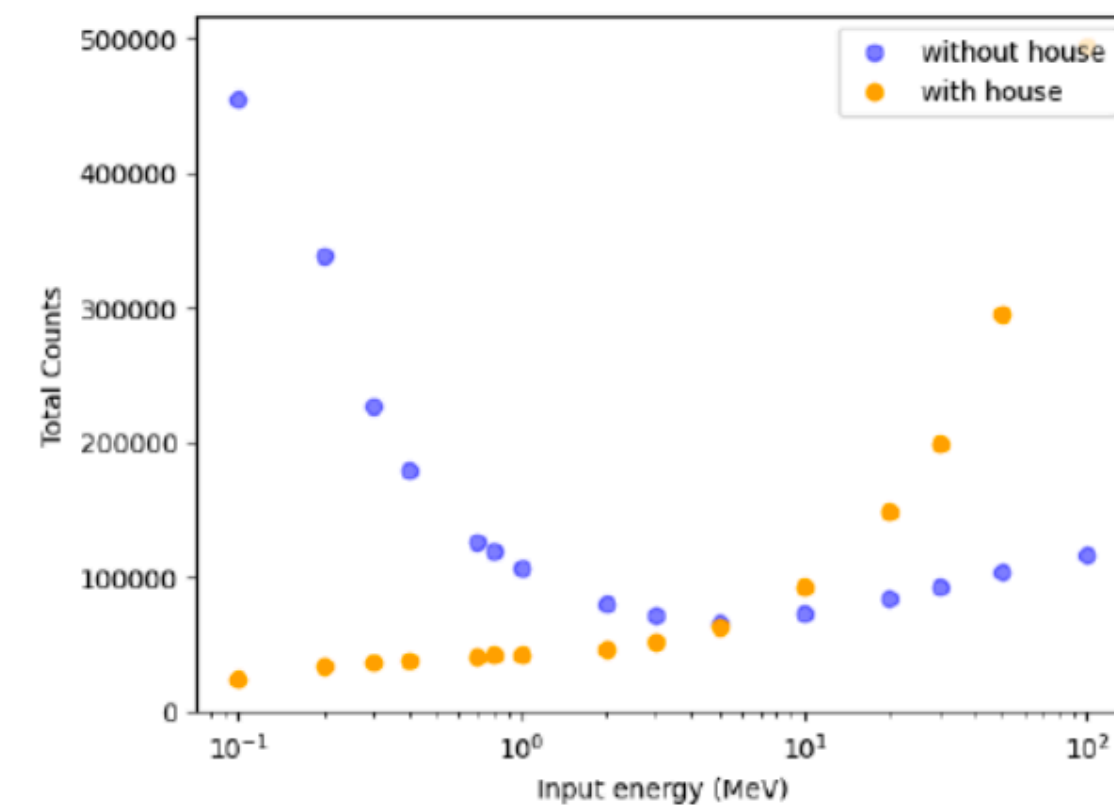
Avalanche model for TGF creation:



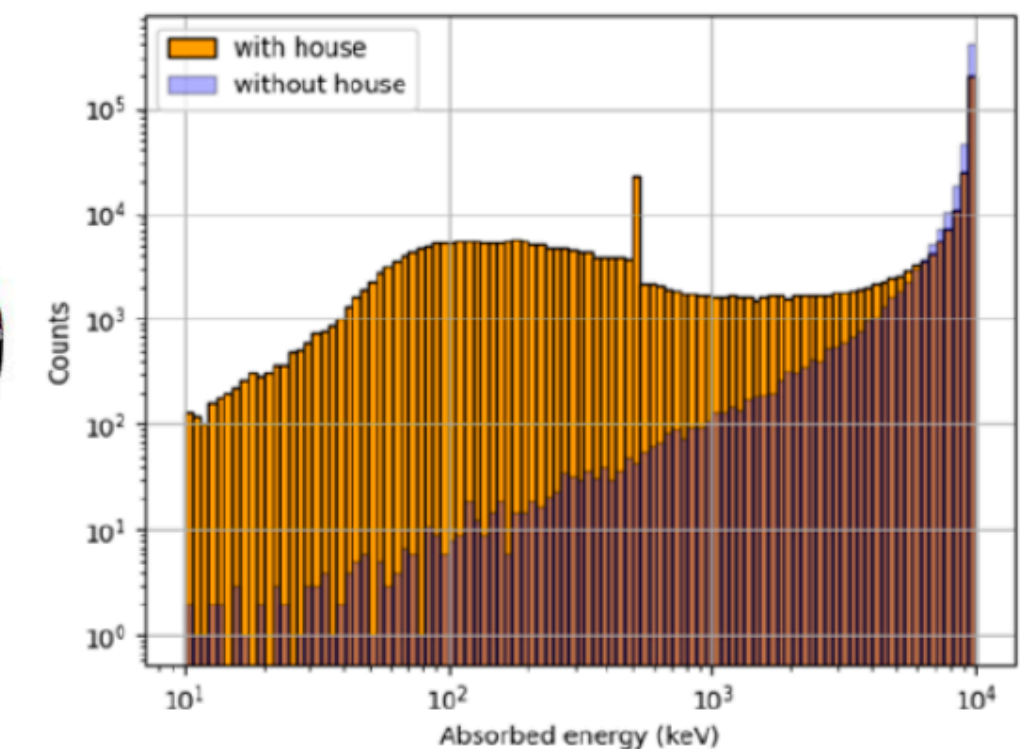
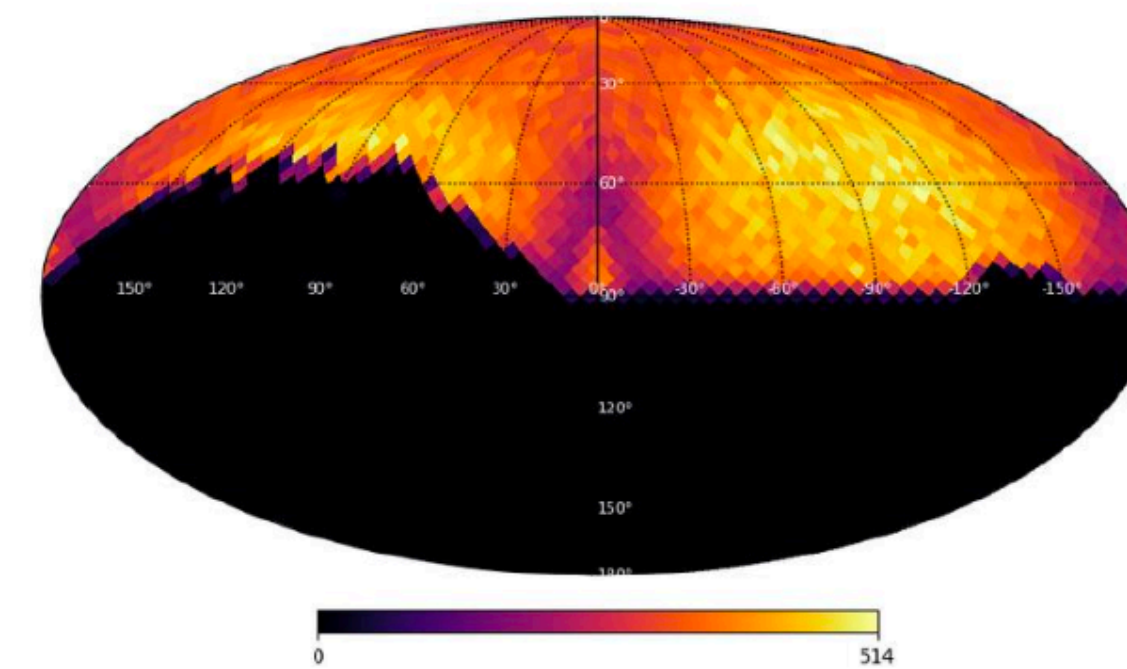
Geomega mass model:



Total detected counts for a NaI detector:



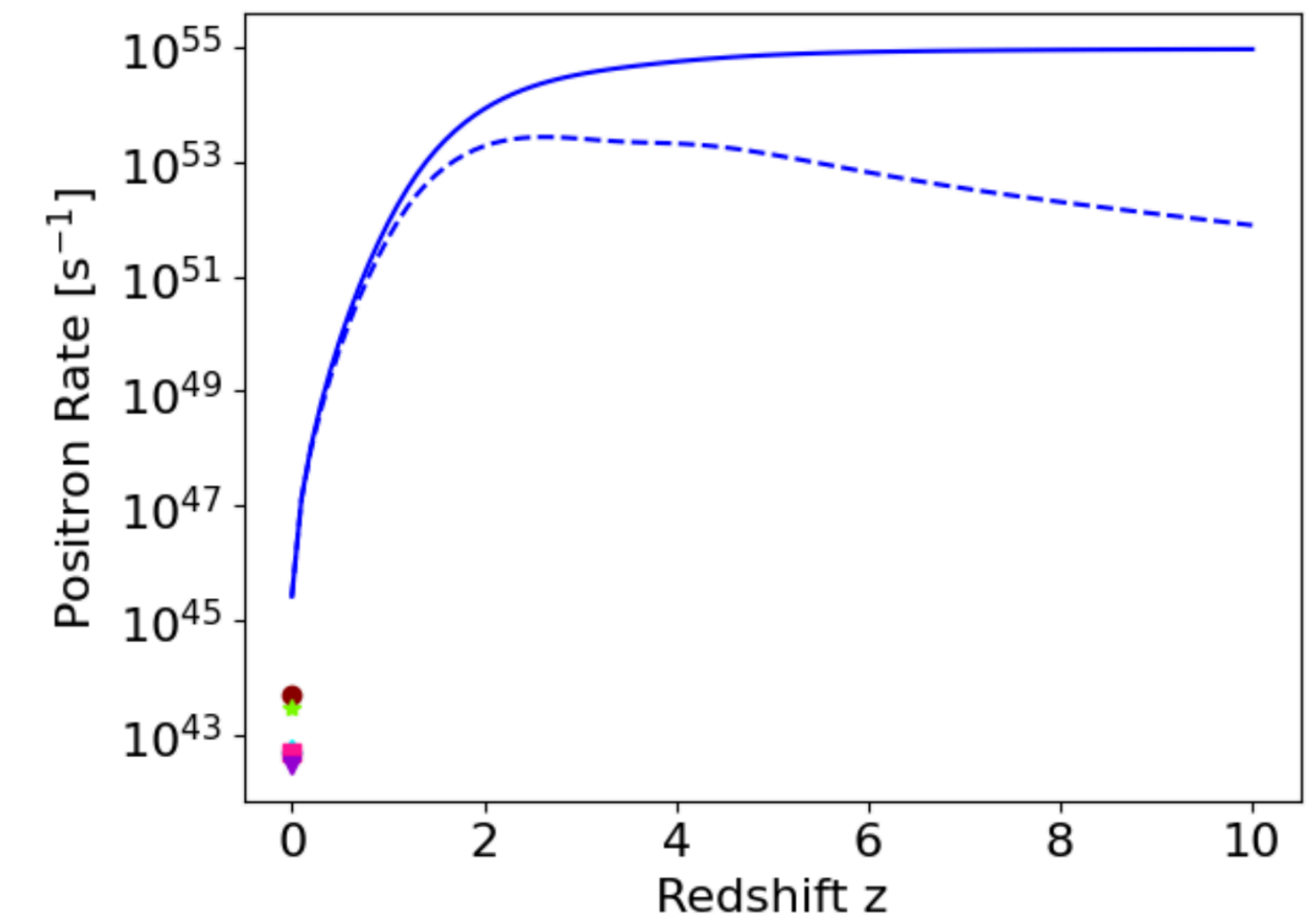
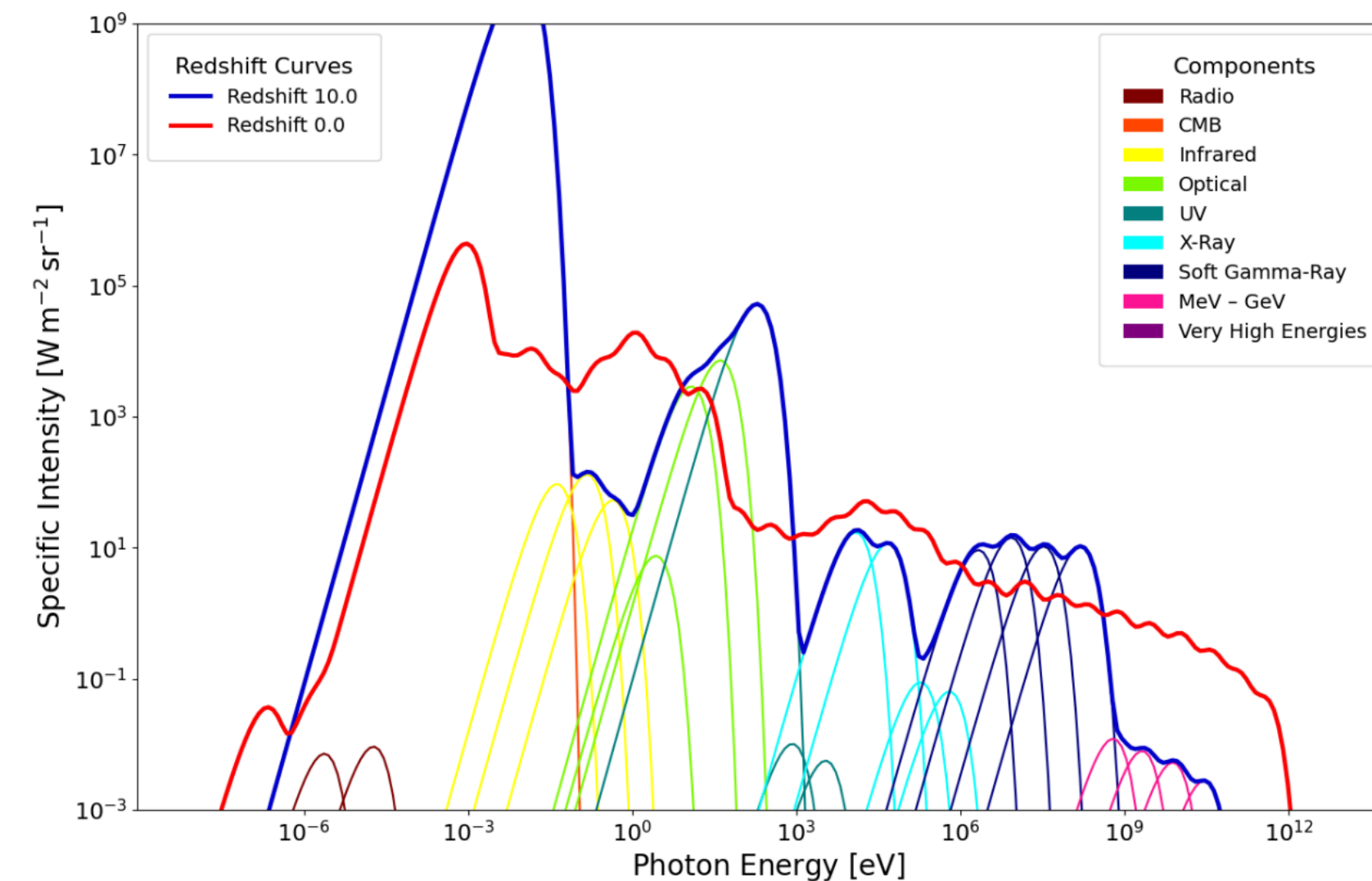
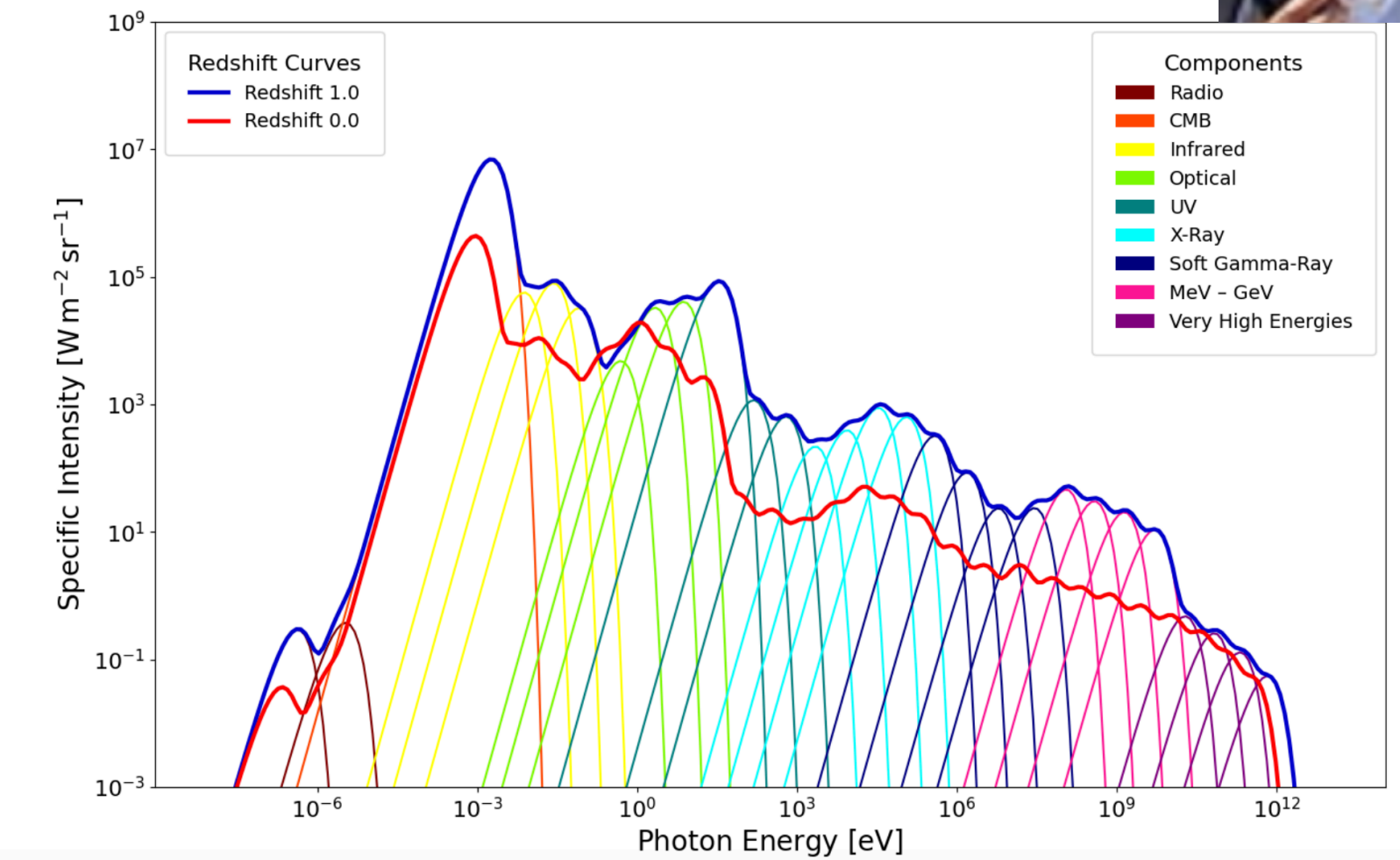
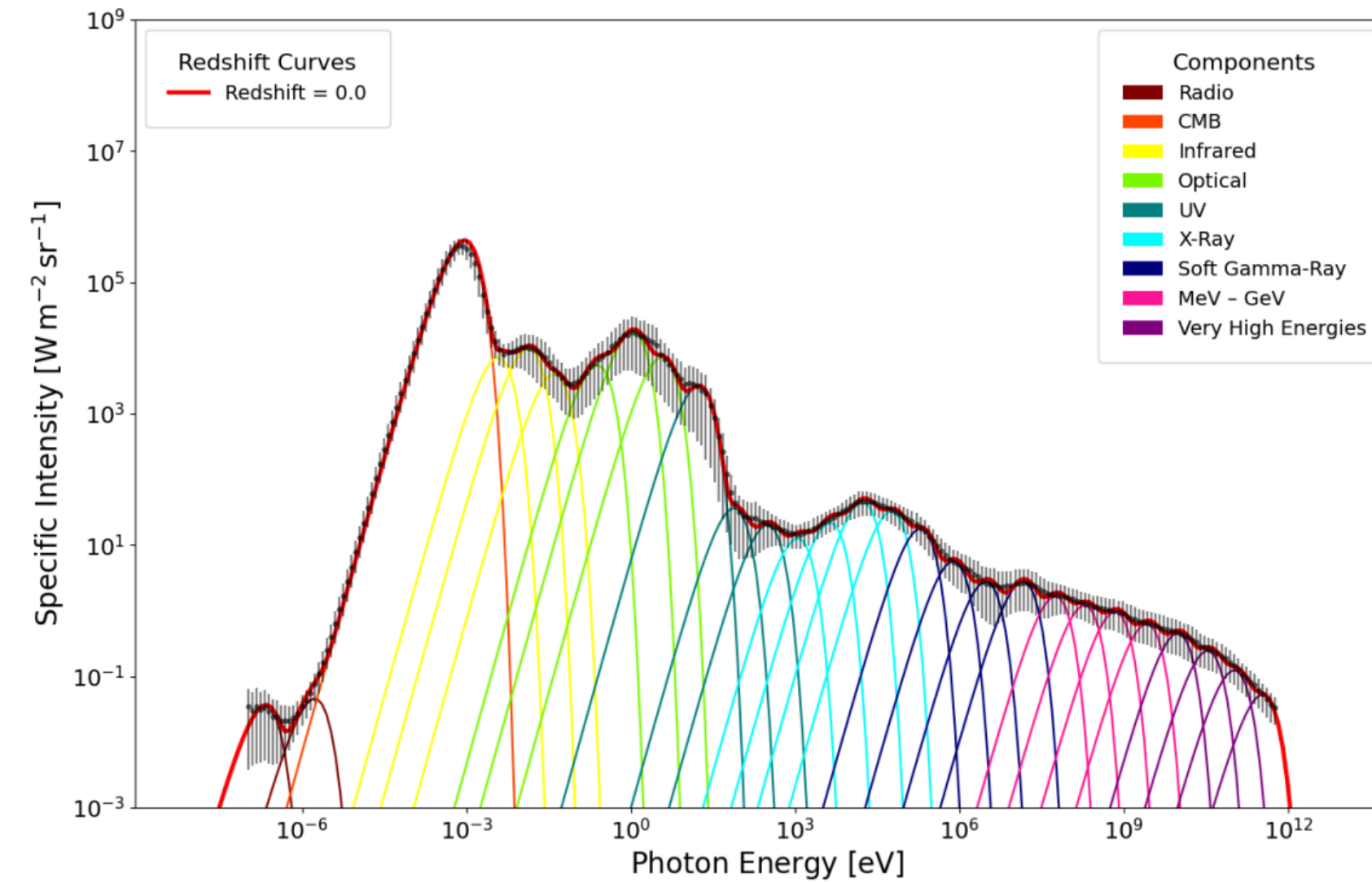
Directional and spectral response for E=1MeV:



Pair Production from Cosmic Photon Background



- Model CPB as a combination of BBs
- Pair production rate
- Redshift evolution:
 - Shifts to higher E
 - Changing intensity
- Positron production rate increased sharply up to $z \sim 2.7$



Classical Novae

- Surface explosion on white dwarfs
- Responsible (supposedly) for ${}^7\text{Li}$ in the Galaxy
- Explosive burning has many **uncertainties**:
(cross sections, astro setup, WD composition, mixing, rates, ...)
- Interesting γ -ray signals:
 - ${}^7\text{Be} \Rightarrow {}^7\text{Li}$: 478 keV, $\tau = 76$ days
 - ${}^{22}\text{Na} \Rightarrow {}^{22}\text{Ne}$: 1275 keV, $\tau = 3.5$ yr
 - ${}^{13}\text{N}$, ${}^{15}\text{O}$, ${}^{18}\text{F}$ β^+ -decay: 511 keV + continuum, $\tau = \text{O}(\text{min})$
 - ${}^{26}\text{Al} \Rightarrow {}^{26}\text{Mg}$: 1809 keV, $\tau = 1.04$ Myr
- Observed γ -ray emission: **None**

