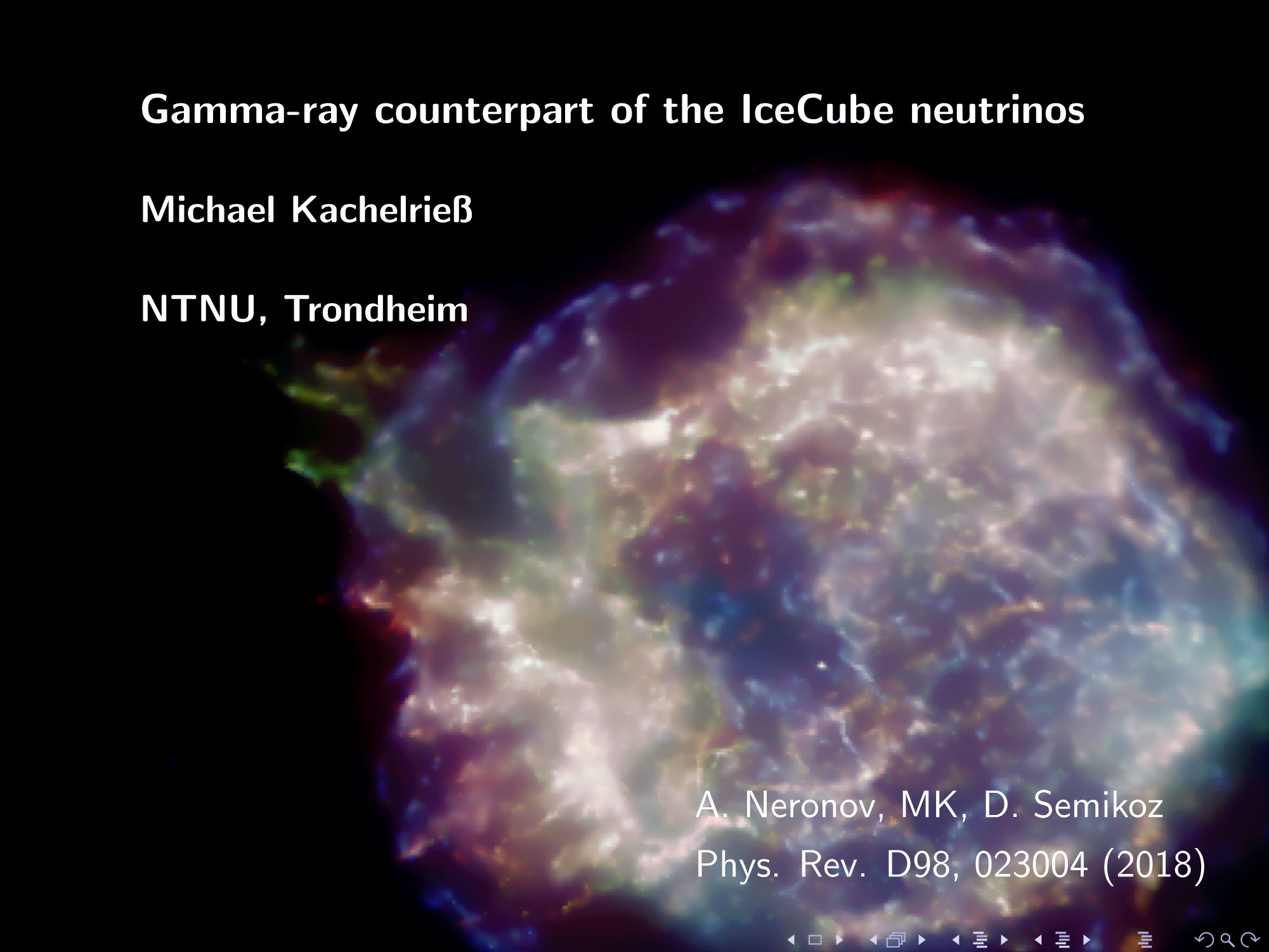
Gamma-ray counterpart of the IceCube neutrinos

Michael Kachelrieß

NTNU, Trondheim



A. Neronov, MK, D. Semikoz

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Outline of the talk

1. Introduction
   - Observations
   - Implications and cascade limit
2. Galactic neutrinos?
   - TeV γ-ray excess in Fermi-LAT
   - Interpretations
3. Conclusions

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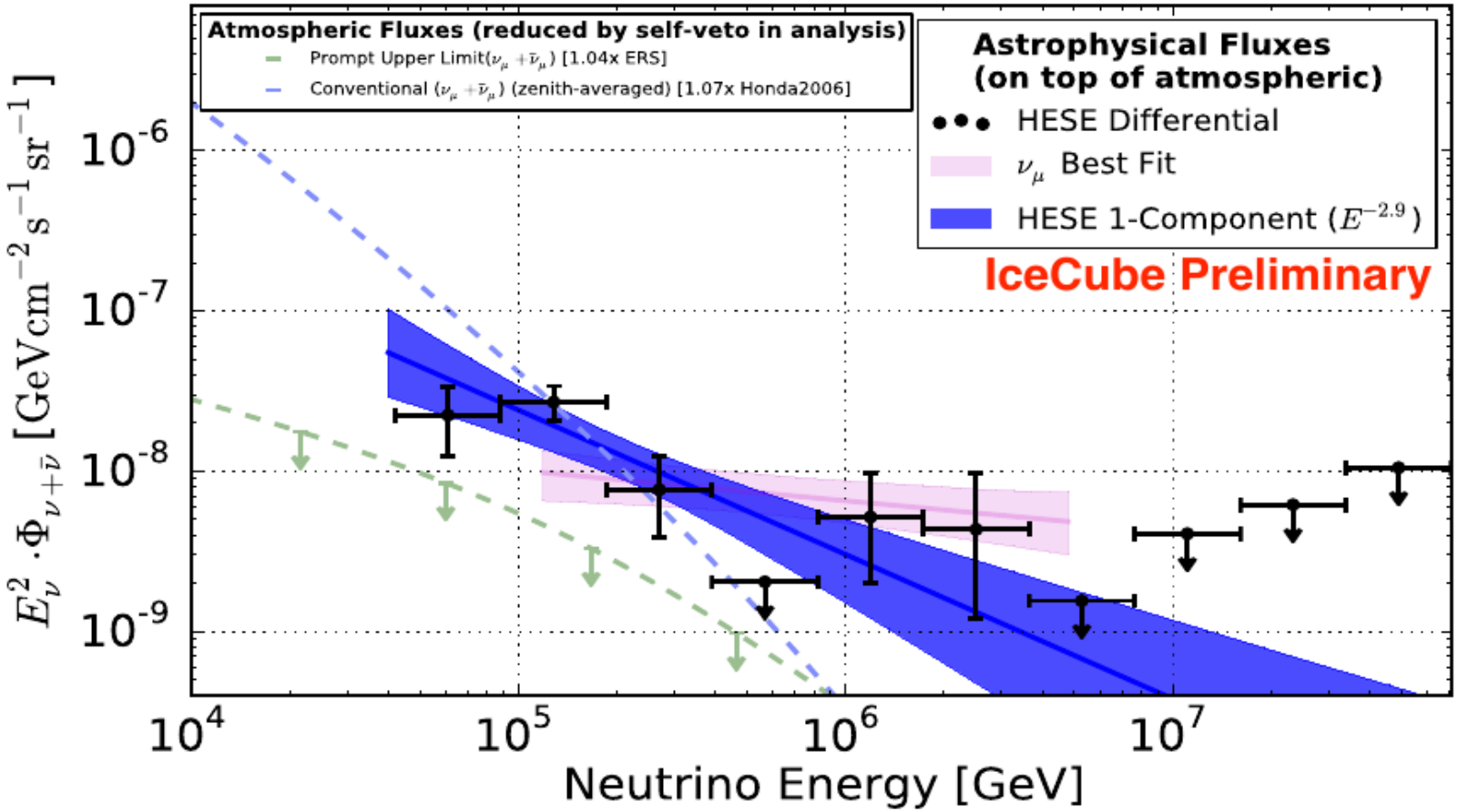
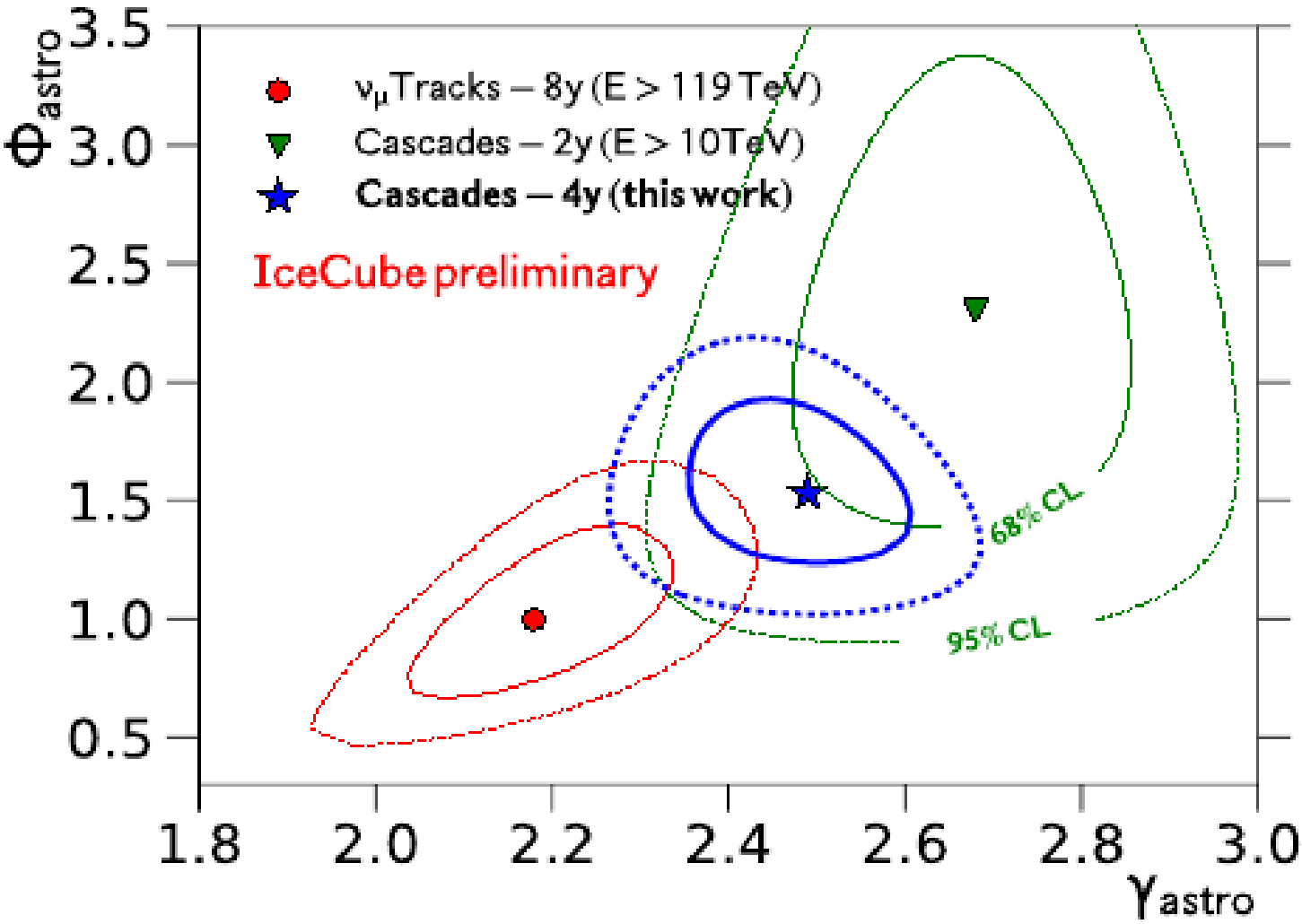
IceCube events: Soft "low-energy" spectrum?



IceCube events: power-law fit of energy spectrum



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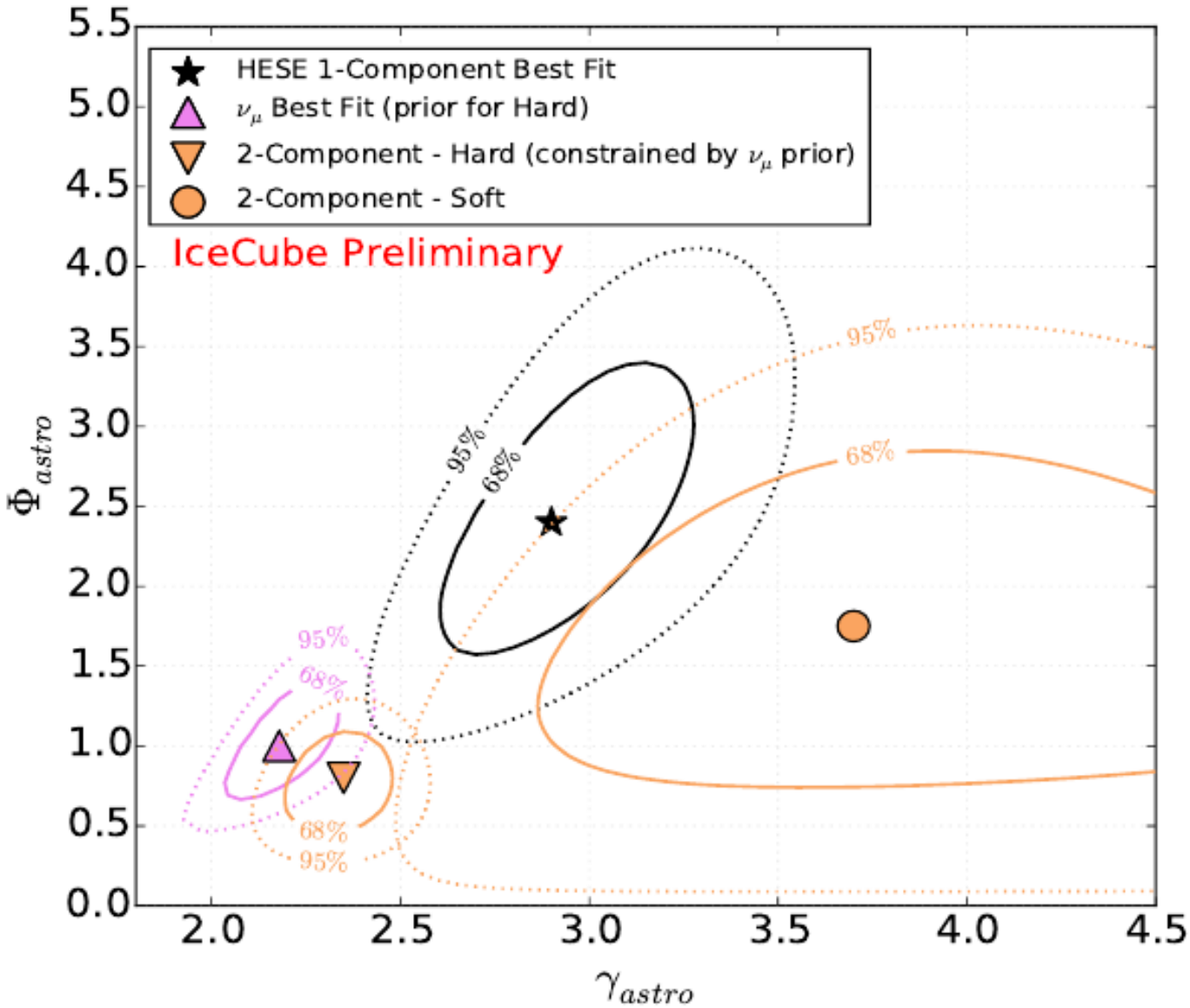
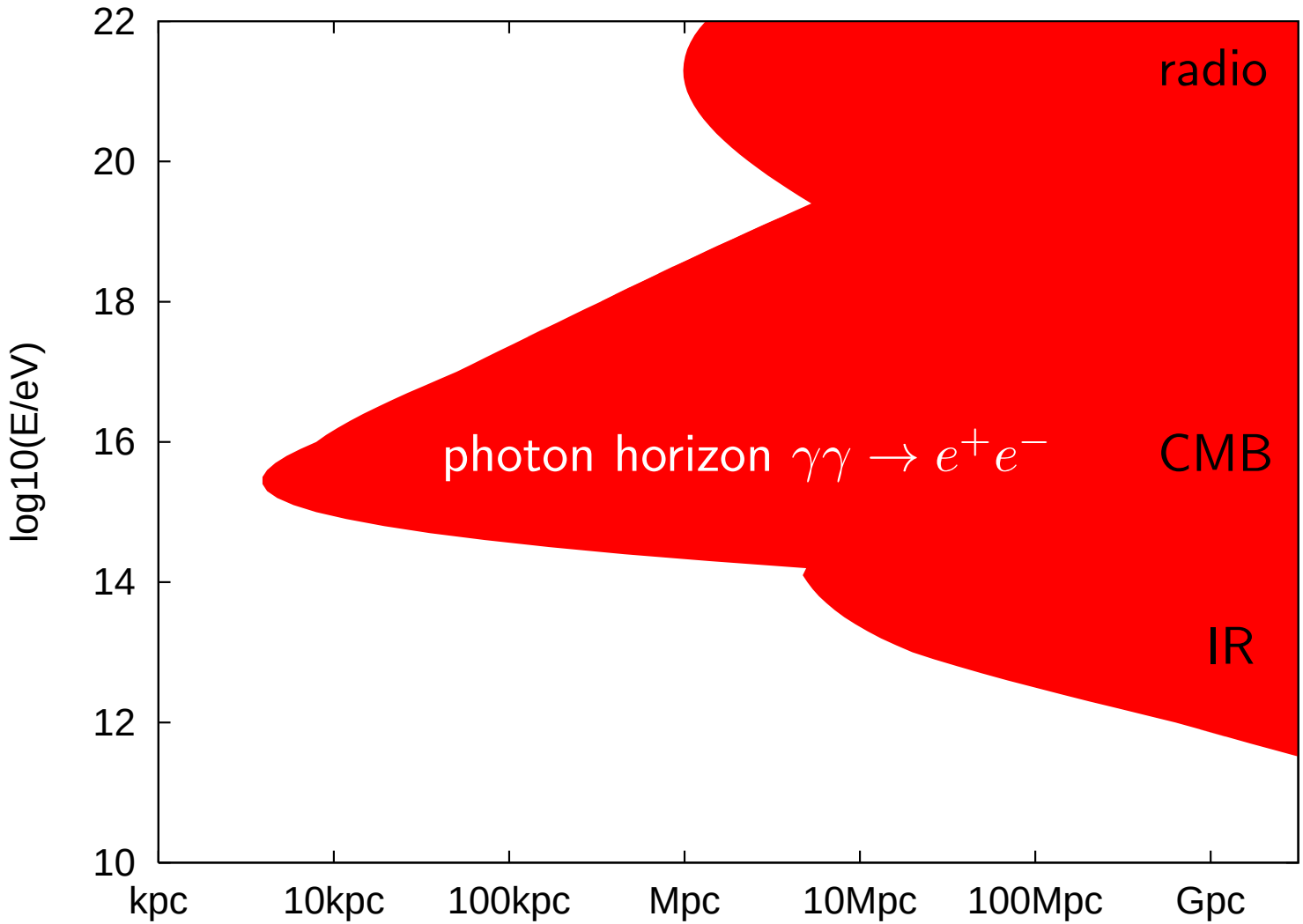
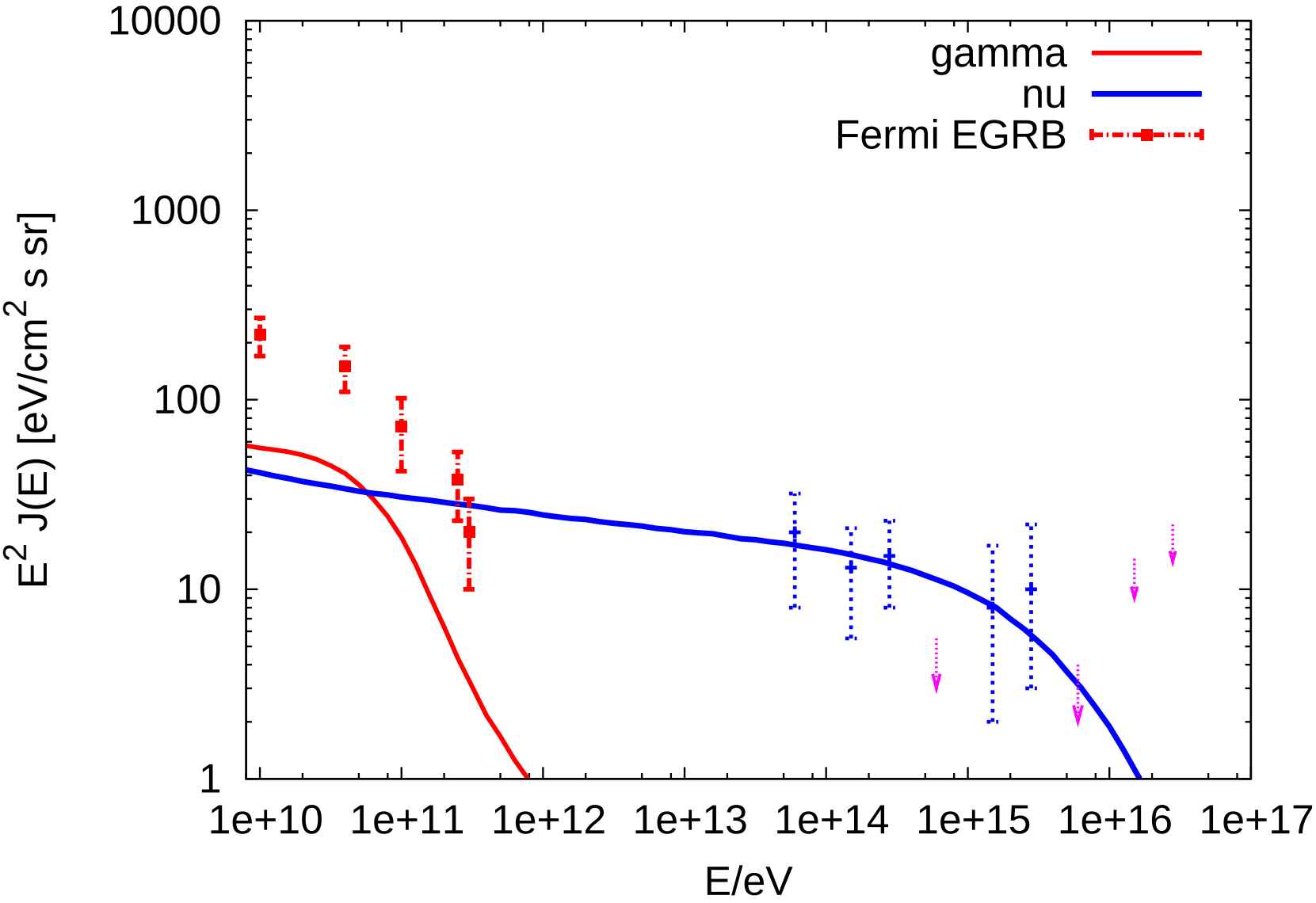


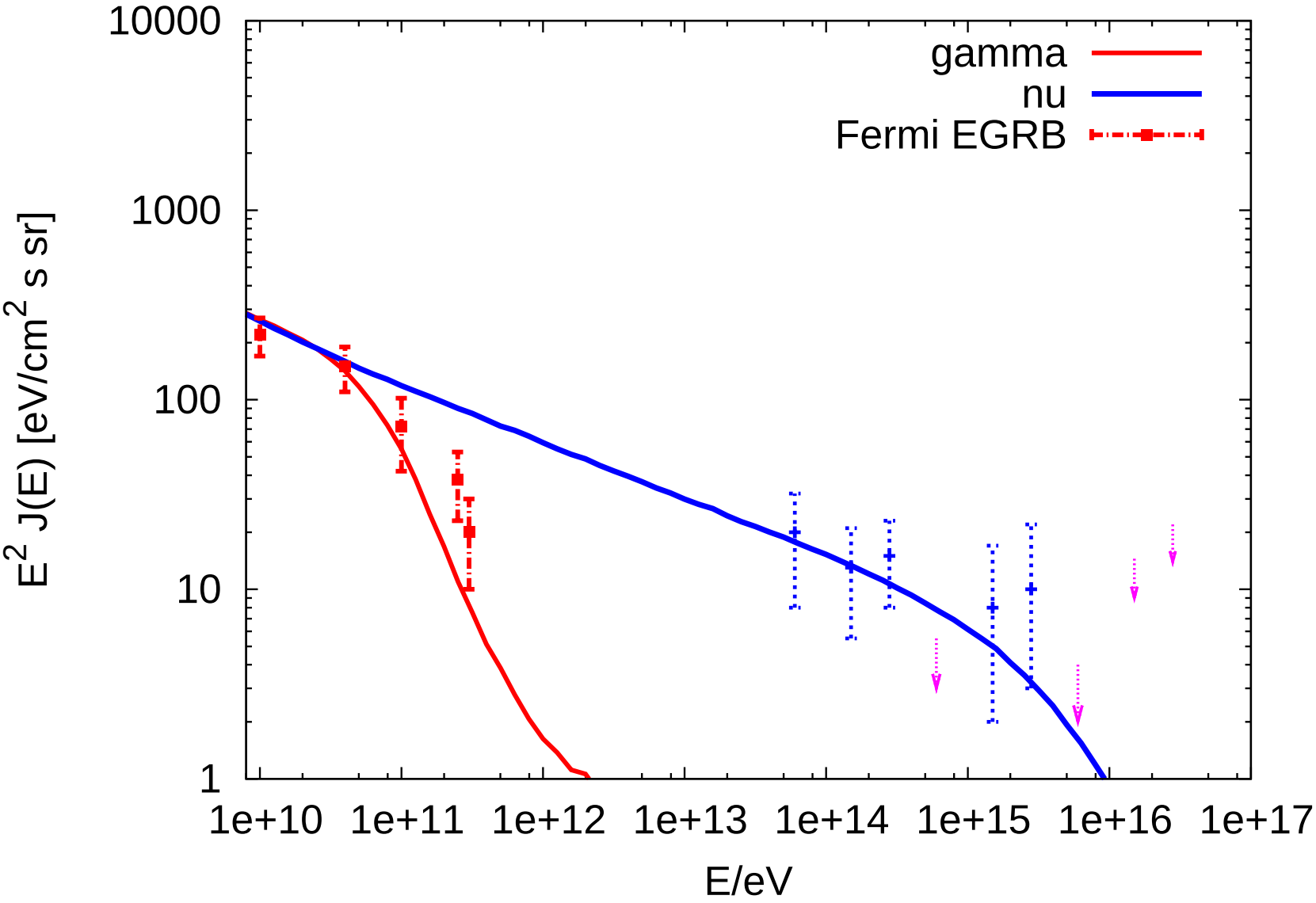
The photon horizon



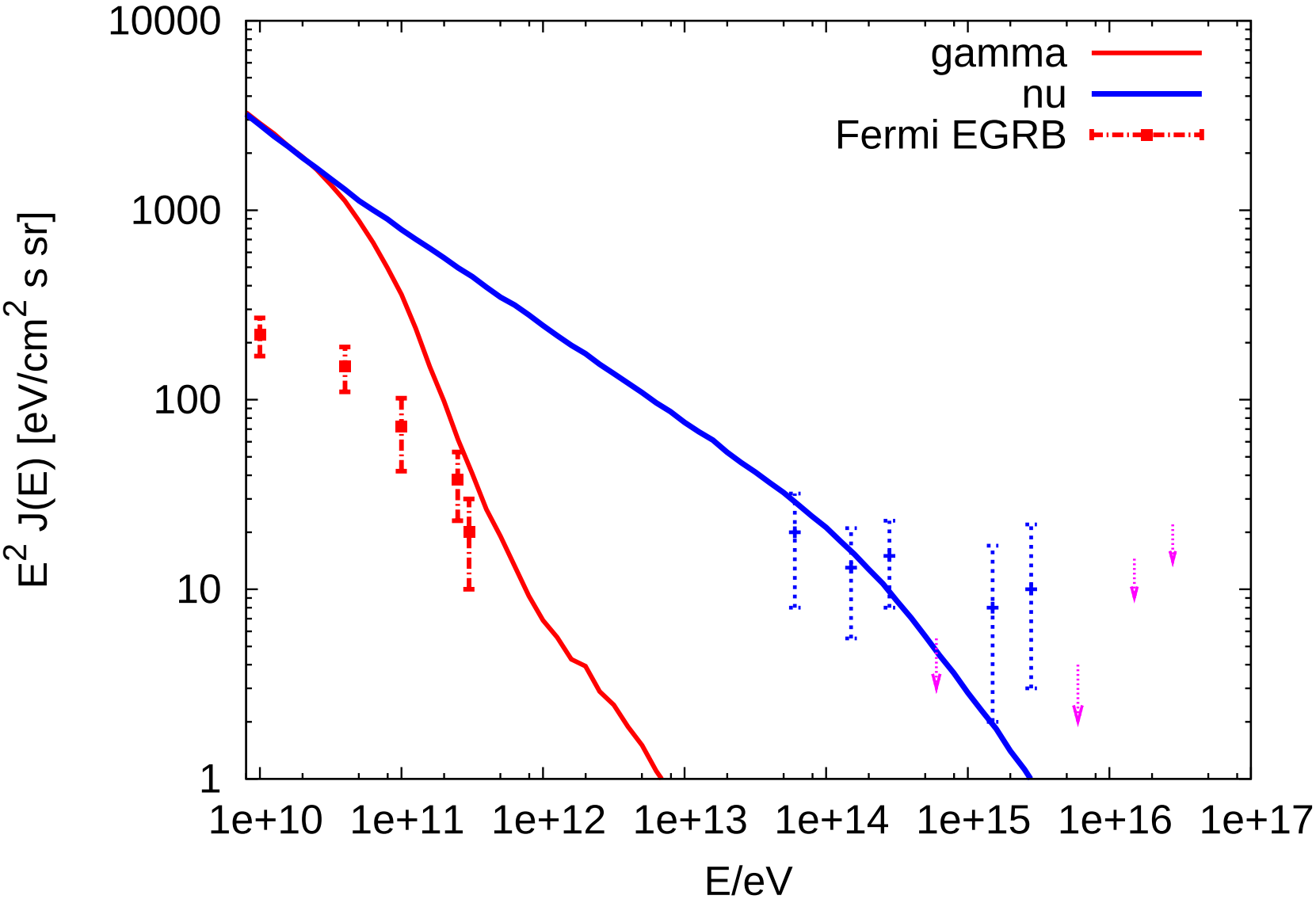
Cascade limit: $\alpha = 2.1$



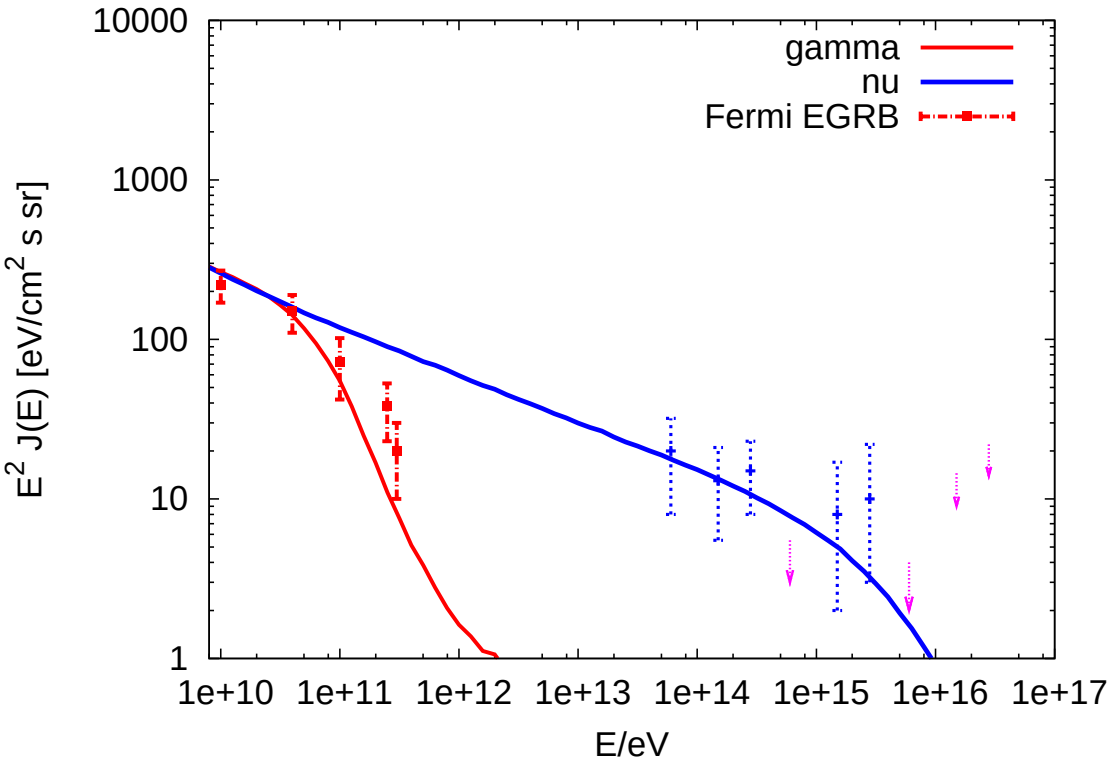
Cascade limit: $\alpha = 2.3$



Cascade limit: $\alpha = 2.5$



Cascade limit:

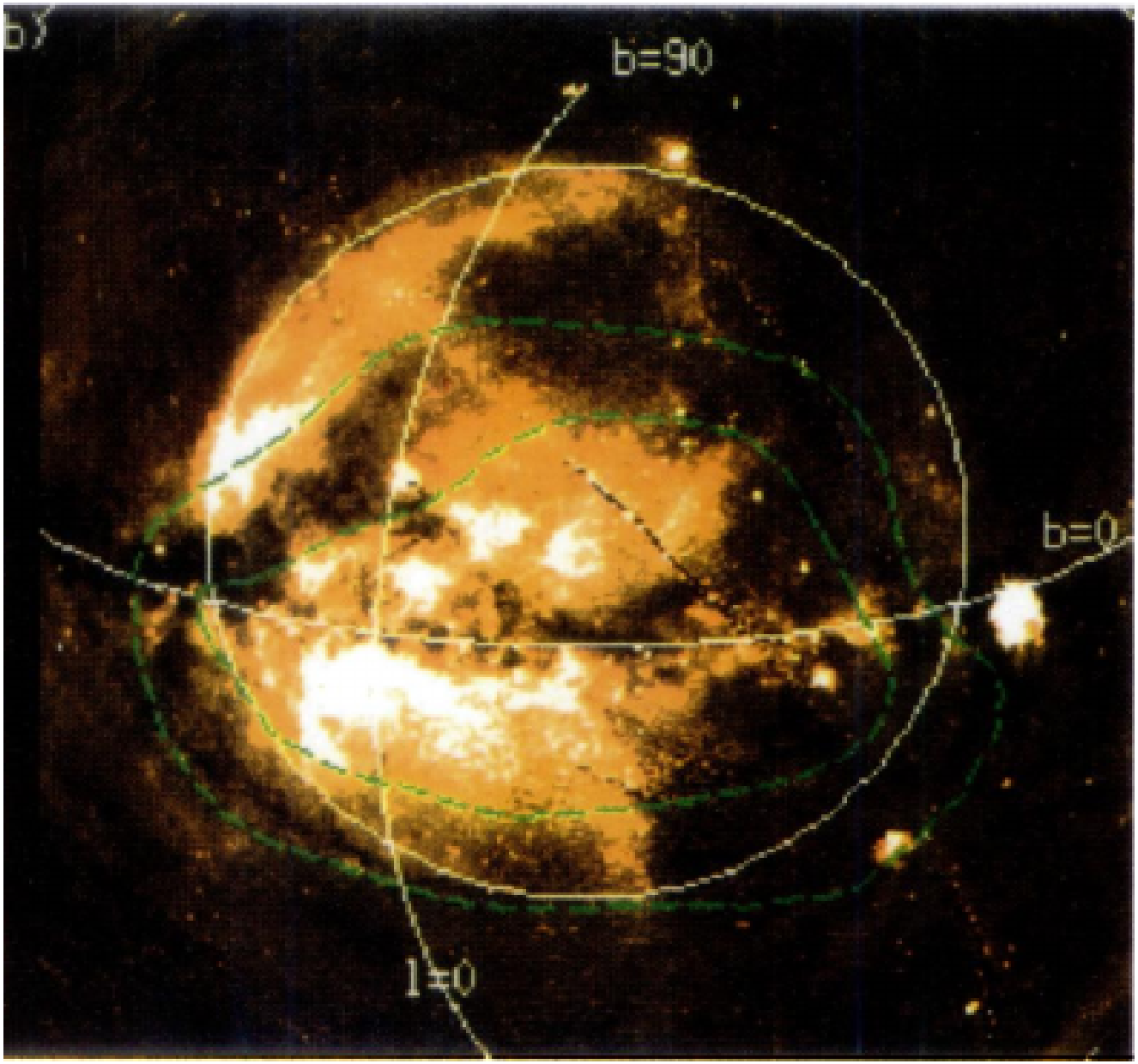


Slope $\alpha \gtrsim 2.2$

- requires "hidden sources" or
- Galactic origin

Galactic origin?

[*Andersen, MK, Semikoz '17*]



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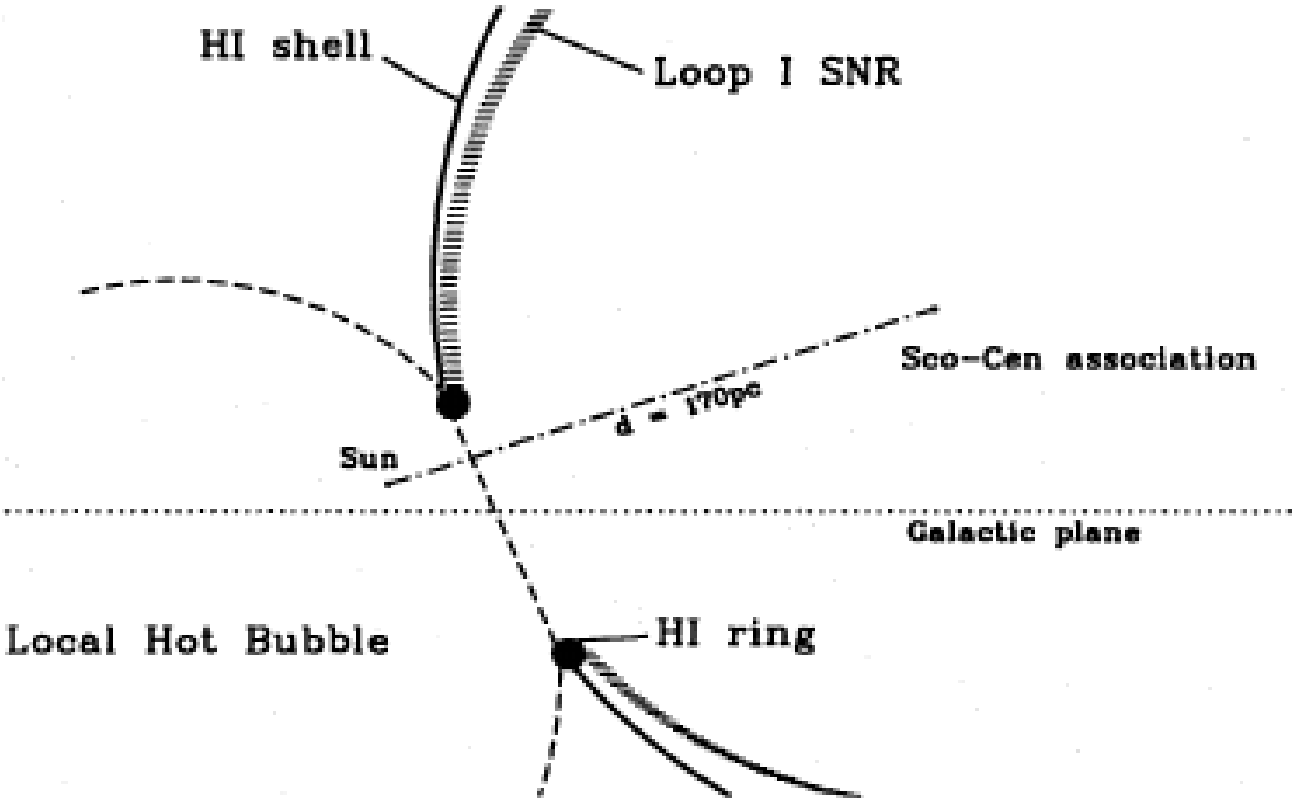
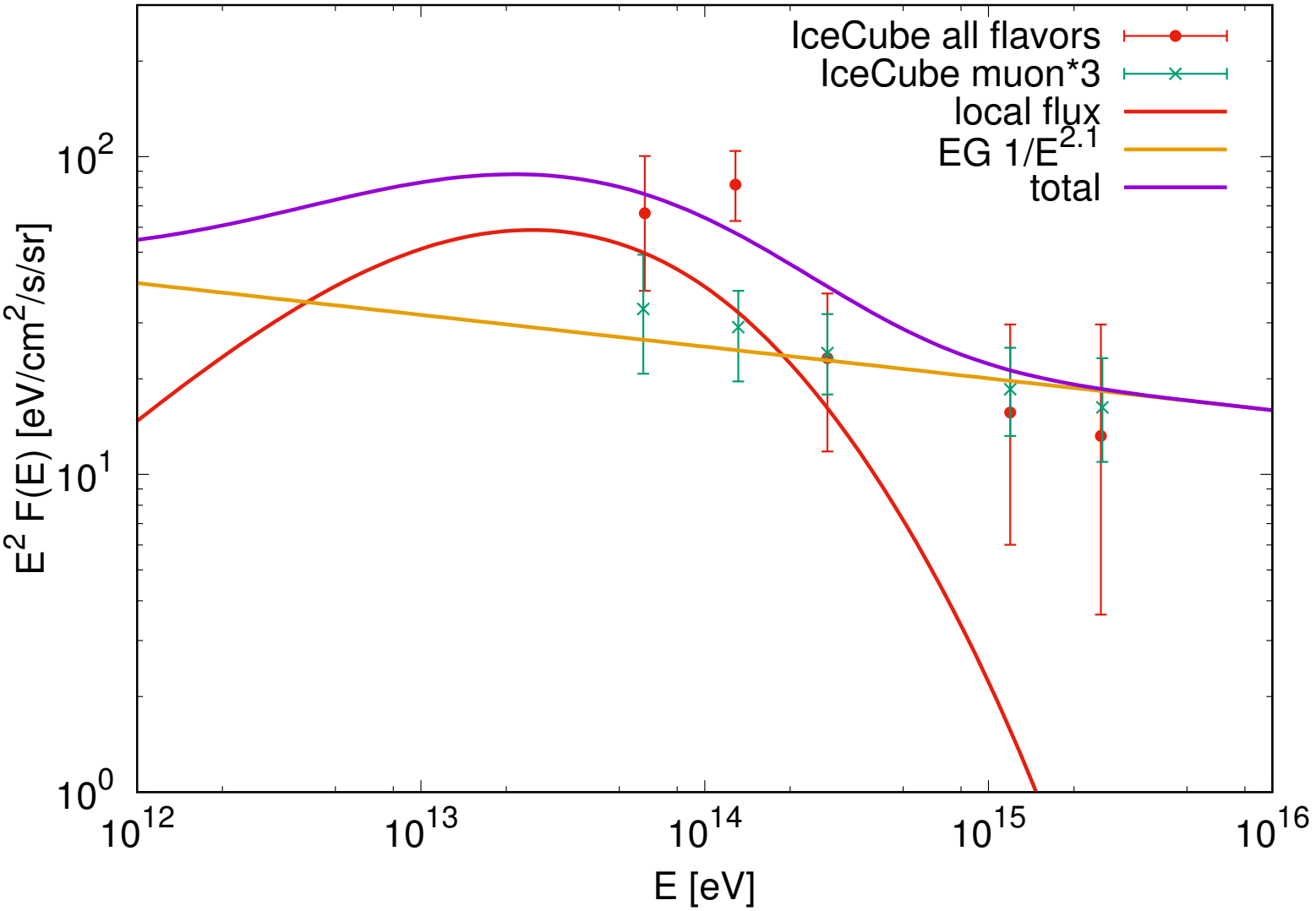


Galactic origin?

[Andersen, MK, Semikoz '17]



Fermi data analysis at multi-TeV?

[*Neronov, MK, Semikoz '18*]

Caveats Analyzing LAT Pass 8 Data:

- " Either because the disagreement between data and the IRFs prediction is too large or because the validation process was hampered by lack of statistics, using data below 30 MeV or above 1 TeV is strongly discouraged."

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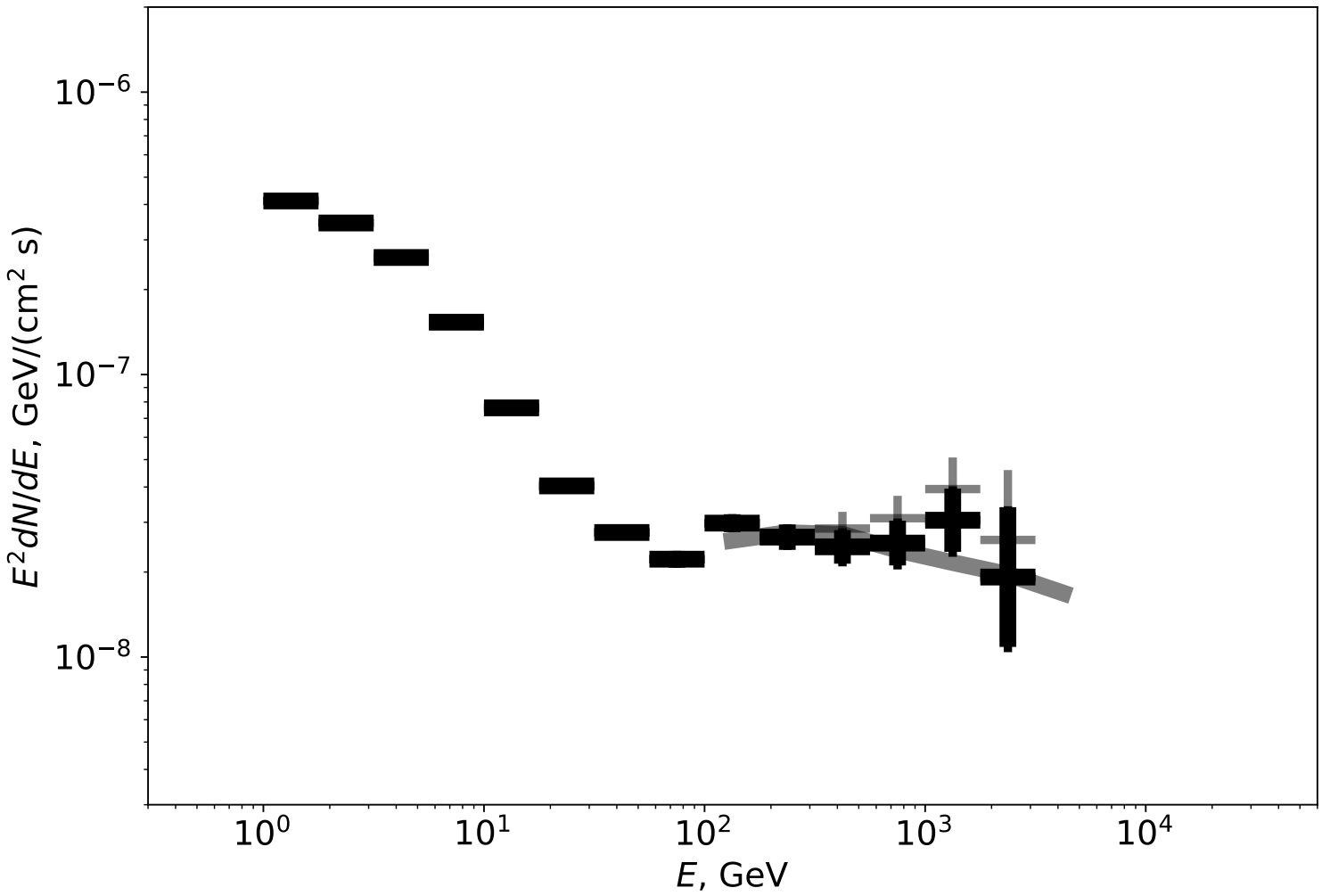
- *gtlike* tool has limit 850 GeV
- eff. area & energy resolution up to 3.2 TeV: 15% at 1 TeV & 25% at 3 TeV

$\Rightarrow$ aperture photometry possible

Cross calibration with IACT:

- stack spectrum of steady sources with clear spatial morphology:
  - Crab, Vela Jr, Vela X, RX J1713.7-3946, HESS J1825-137
- Fermi signal from circle incl. source plus Fermi PSR
- bkgrd from circle shifted along $b = \mathrm{const.}$

Cross calibration with IACT:



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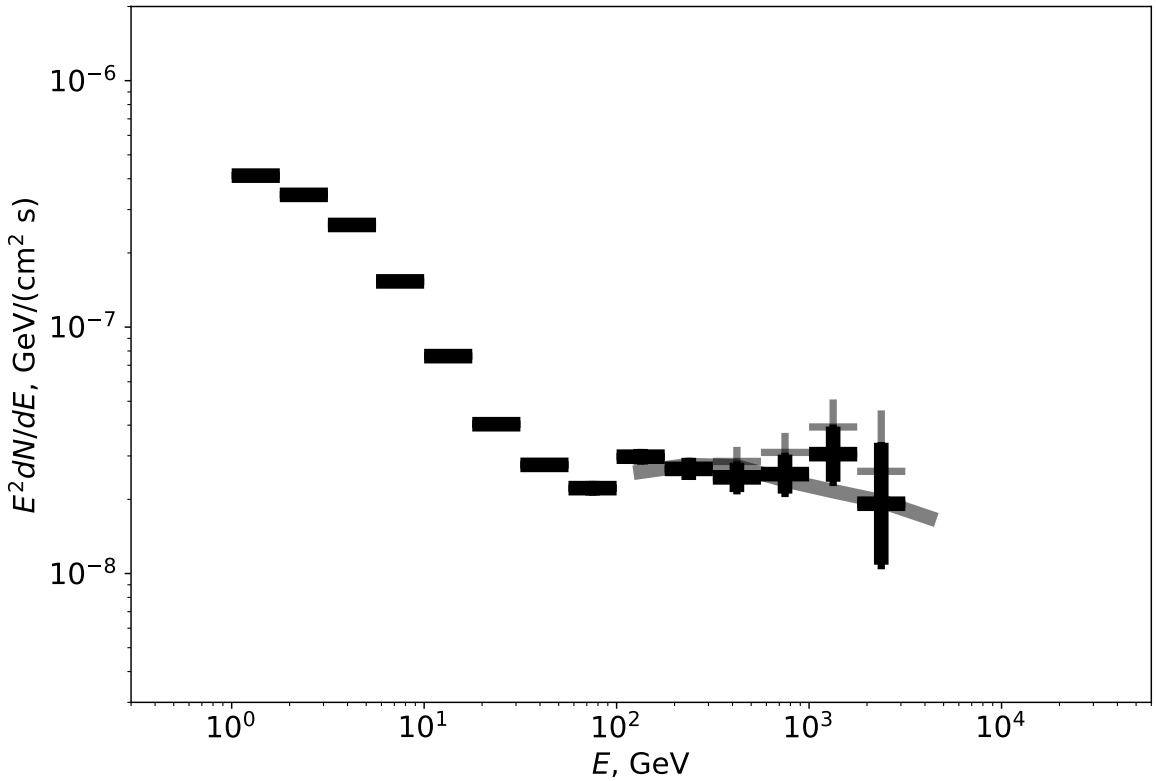
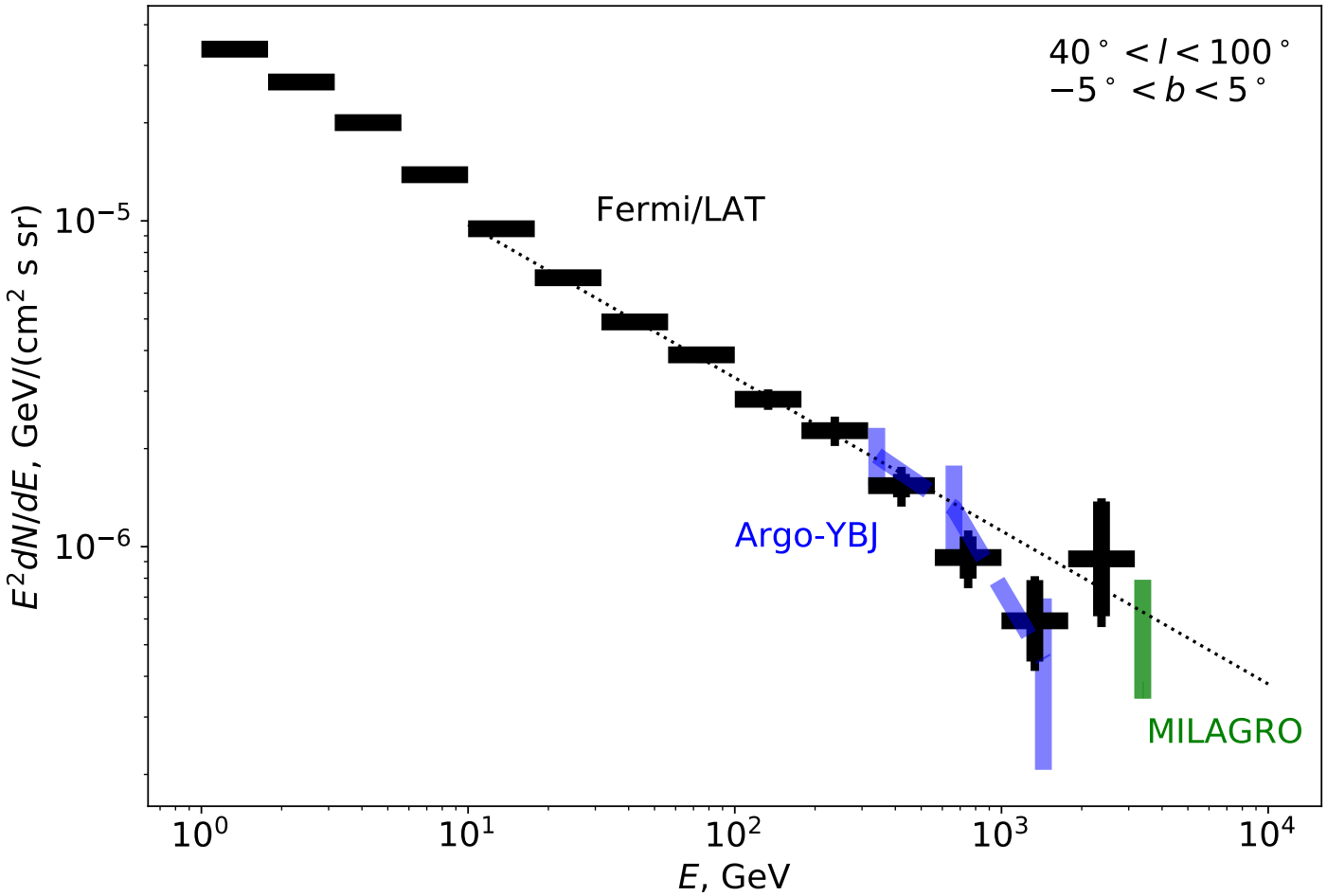


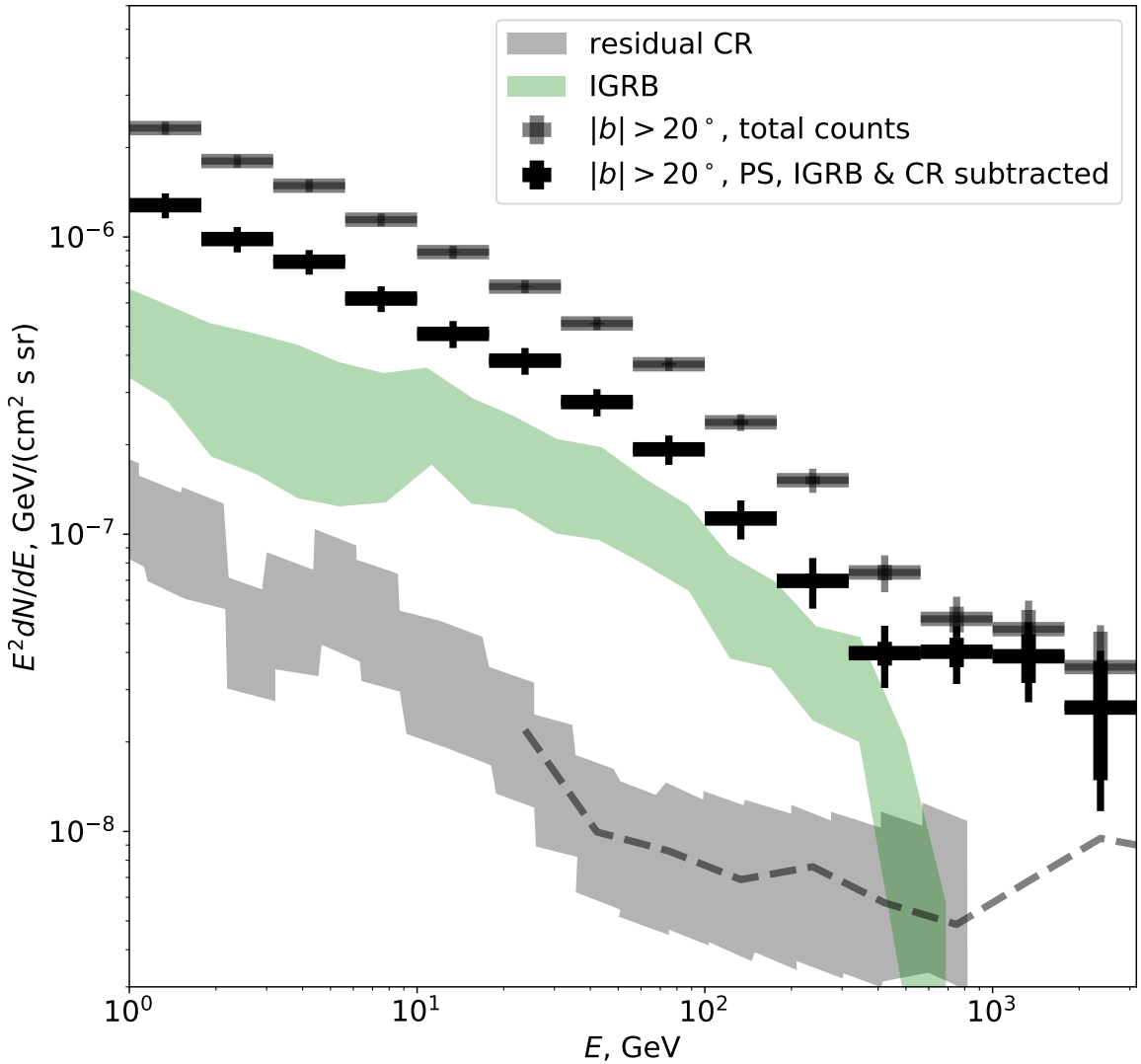
- grey crosses: nominal $A_{\rm eff}$ from *gtexposure*
- black crosses: renormalised with $\kappa = 1 - c\log(E/100\mathrm{GeV})$ and $c = 0.25$ for $E > 300\,\mathrm{GeV}$

Cross calibration test: Galactic plane

- Galactic plane ($|b| < 5^\circ$ and $40^\circ < l < 100^\circ$) spectrum from ARGO-YBJ and Milagro



Extension to 3 TeV for $|b| > 20°$:



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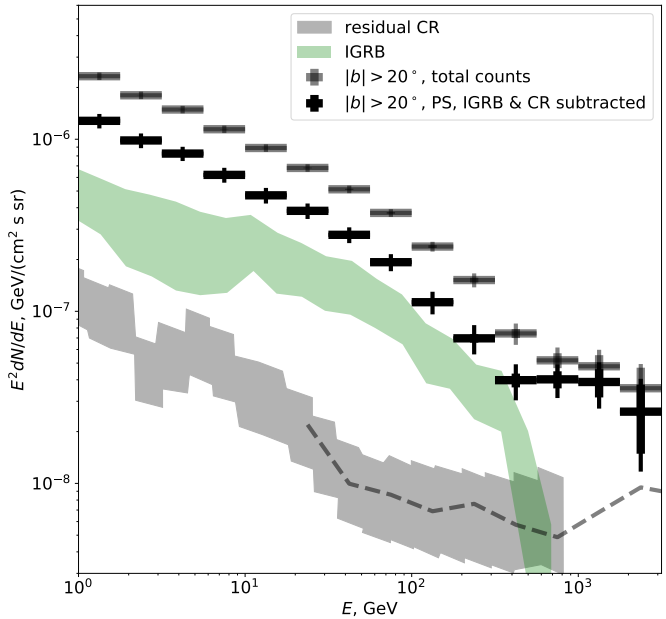
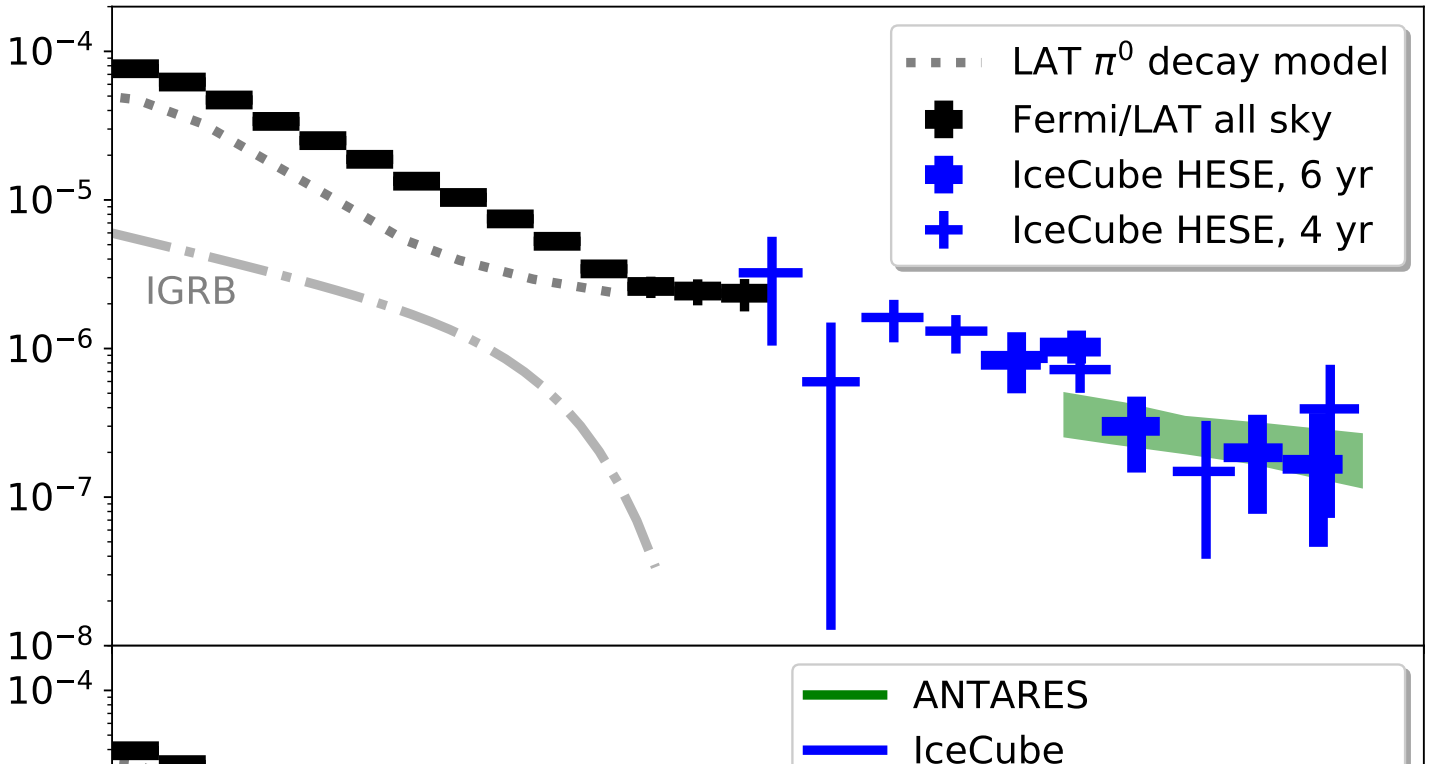


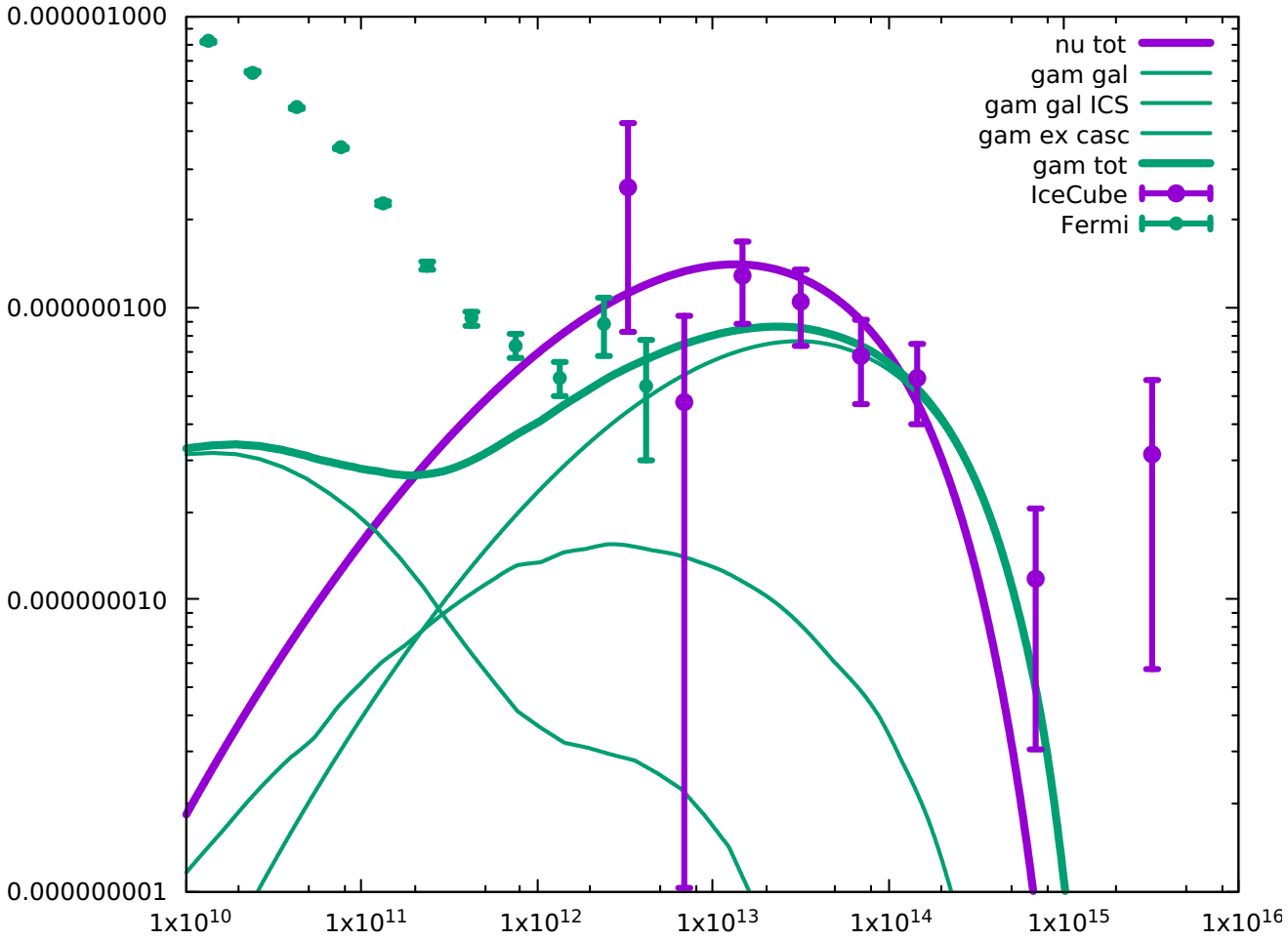
- bin 1–1.7 TeV: expected 14 (18.5) for nominal (renormalised) exposure

  observed (after subtr. CR): 47
- bin 1.7–3 TeV: expected 2.4 (3.5.5), observed 17

Adding neutrinos:



Possible explanations: heavy dark matter



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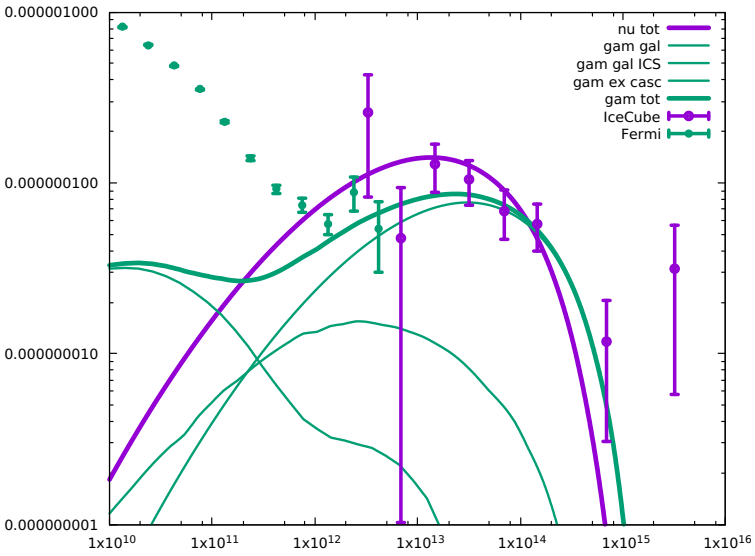

- extended CR halo

[Taylor, Gabici, Aharonian '14]

- interface Loop I/local superbubble: strong dipole?

Summary

1. EGRB constrains stronly neutrino sources:
   - slope of extragal. neutrino $\alpha \lesssim 2.2$
   - neutrino sources are not main source class of EGRB
2. neutrino signal in IceCube:
   - isotropy: extragalactic or large Galactic halo
   - TeV γ-ray excess consistent with neutrino flux
   - Galactic component may explain soft component