

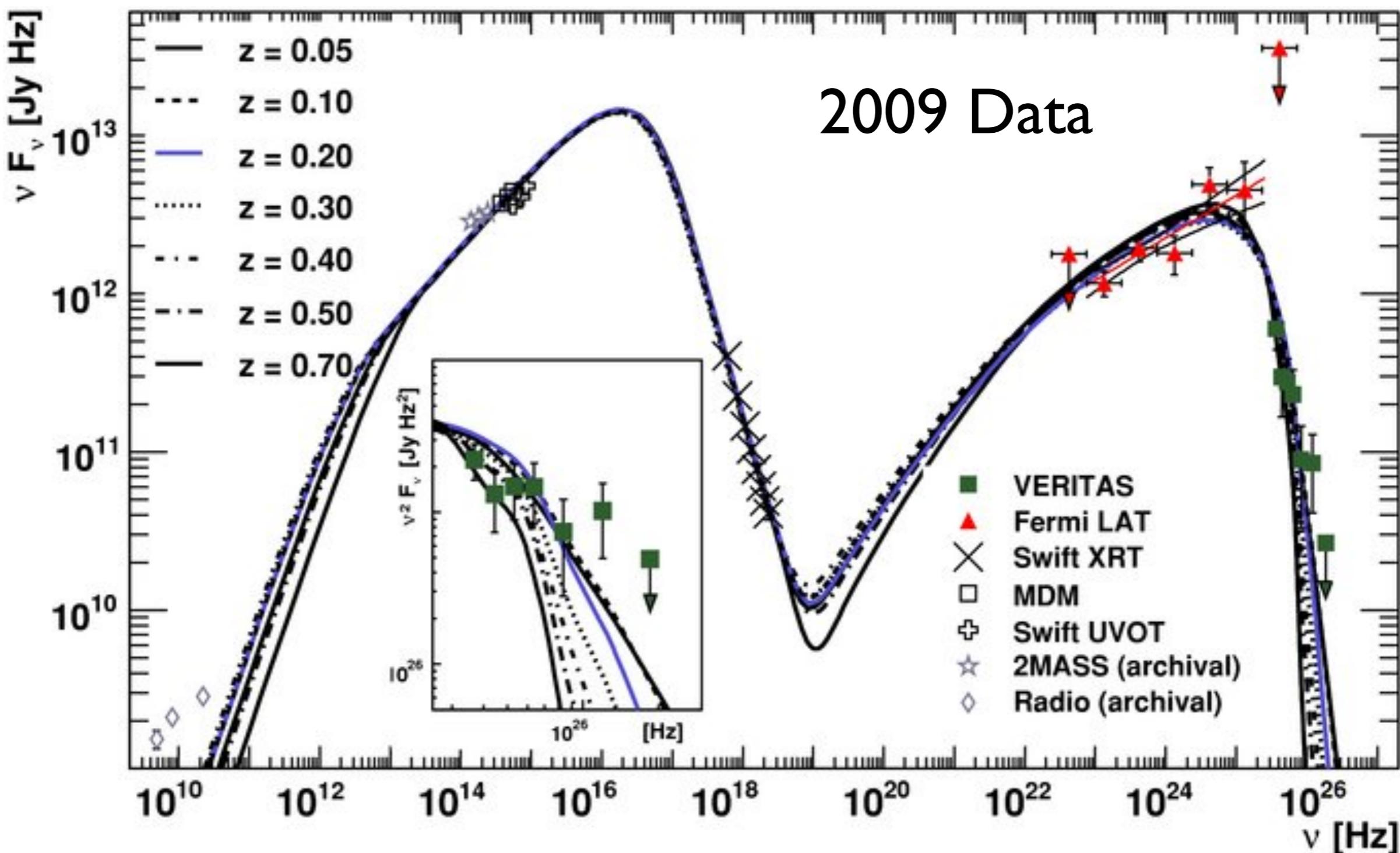
The Gamma-ray Spectrum of PKS 1424+240, the Most Distant TeV Source

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TeV Particle Astrophysics (TeVPA)

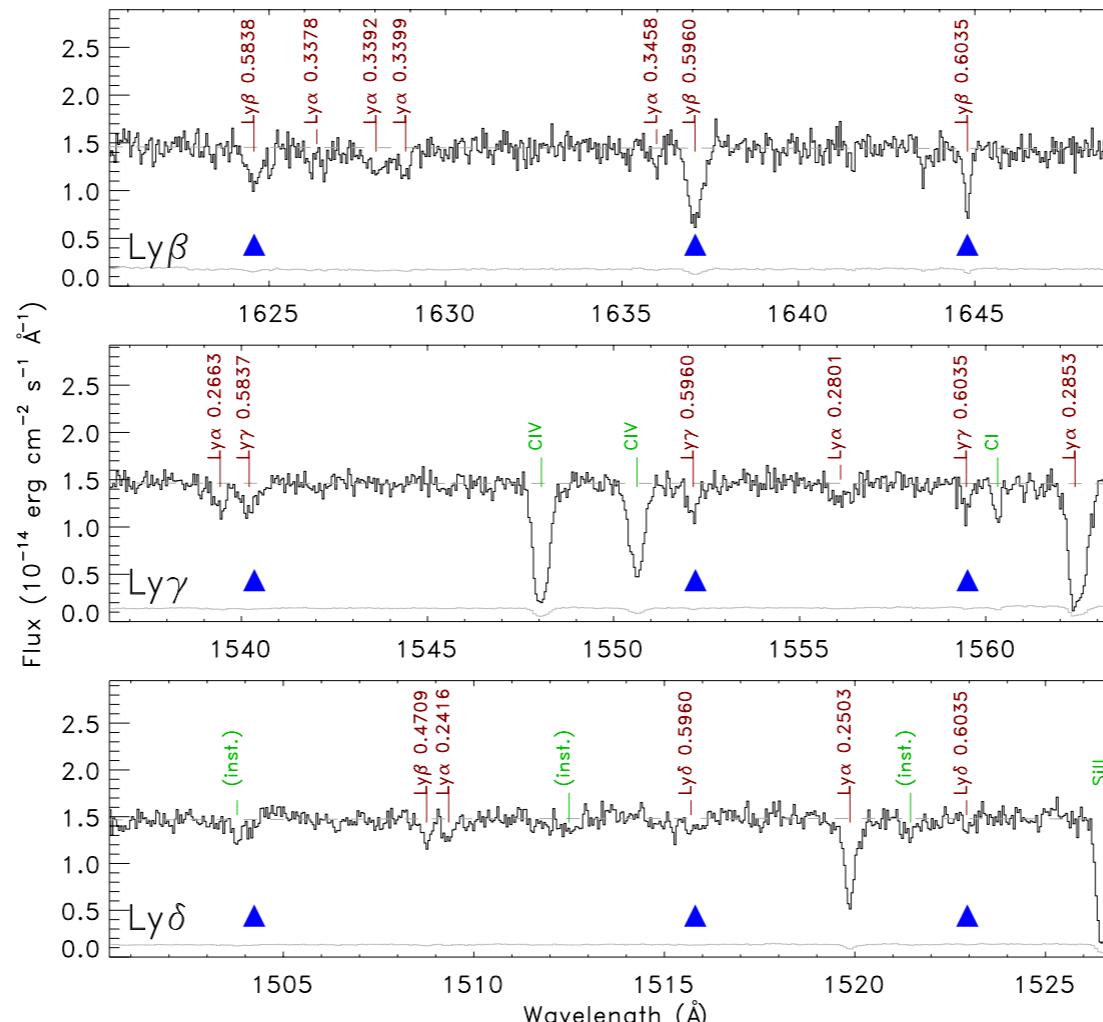
First VHE blazar found using Fermi-LAT observations

- No redshift information
- On the ISP/HSP cusp
- Soft X-ray spectrum
- Used MWL data to show likely $z < 0.67$
- Used SSC SED modeling to show likely $z < 0.2$



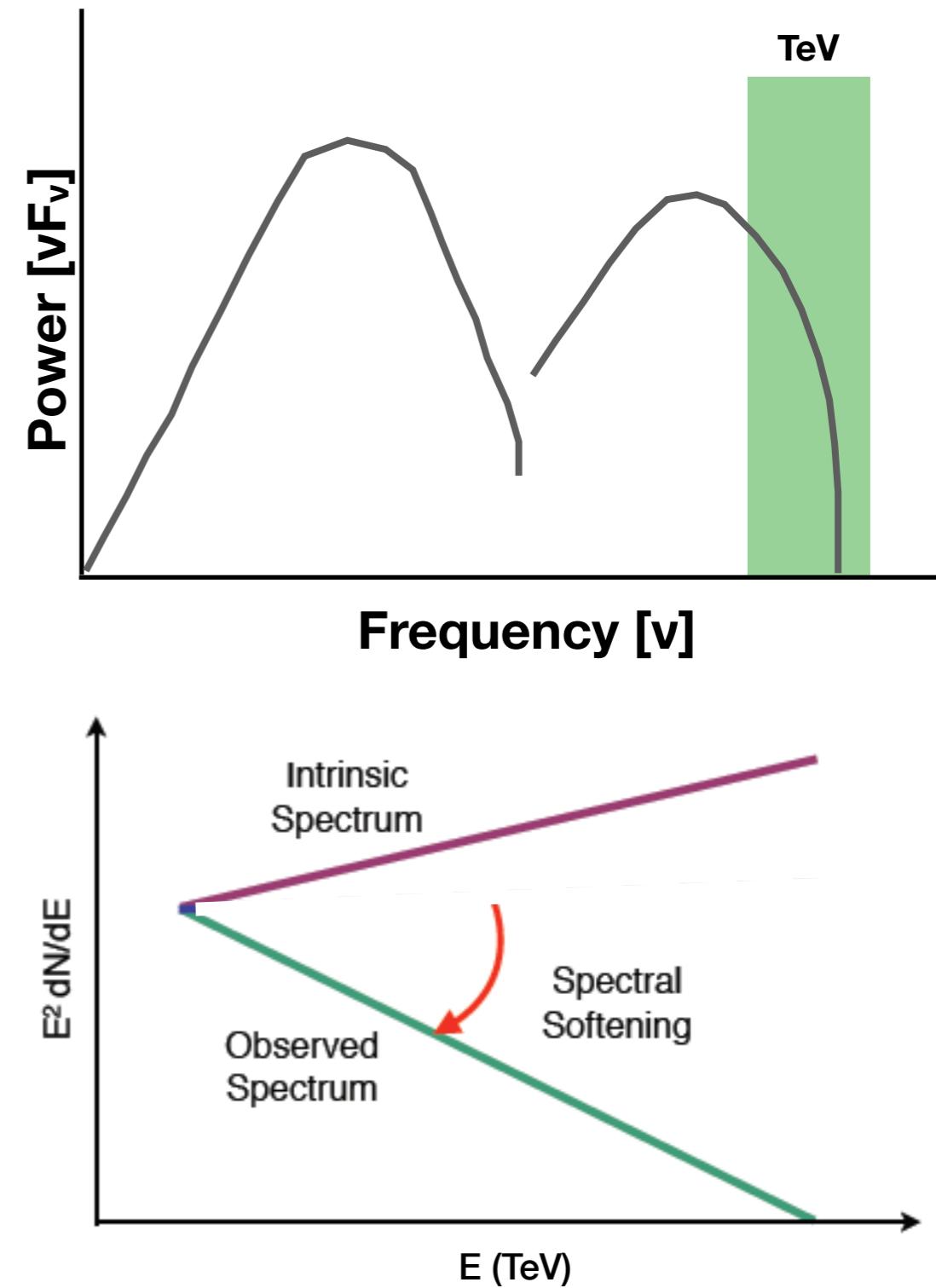
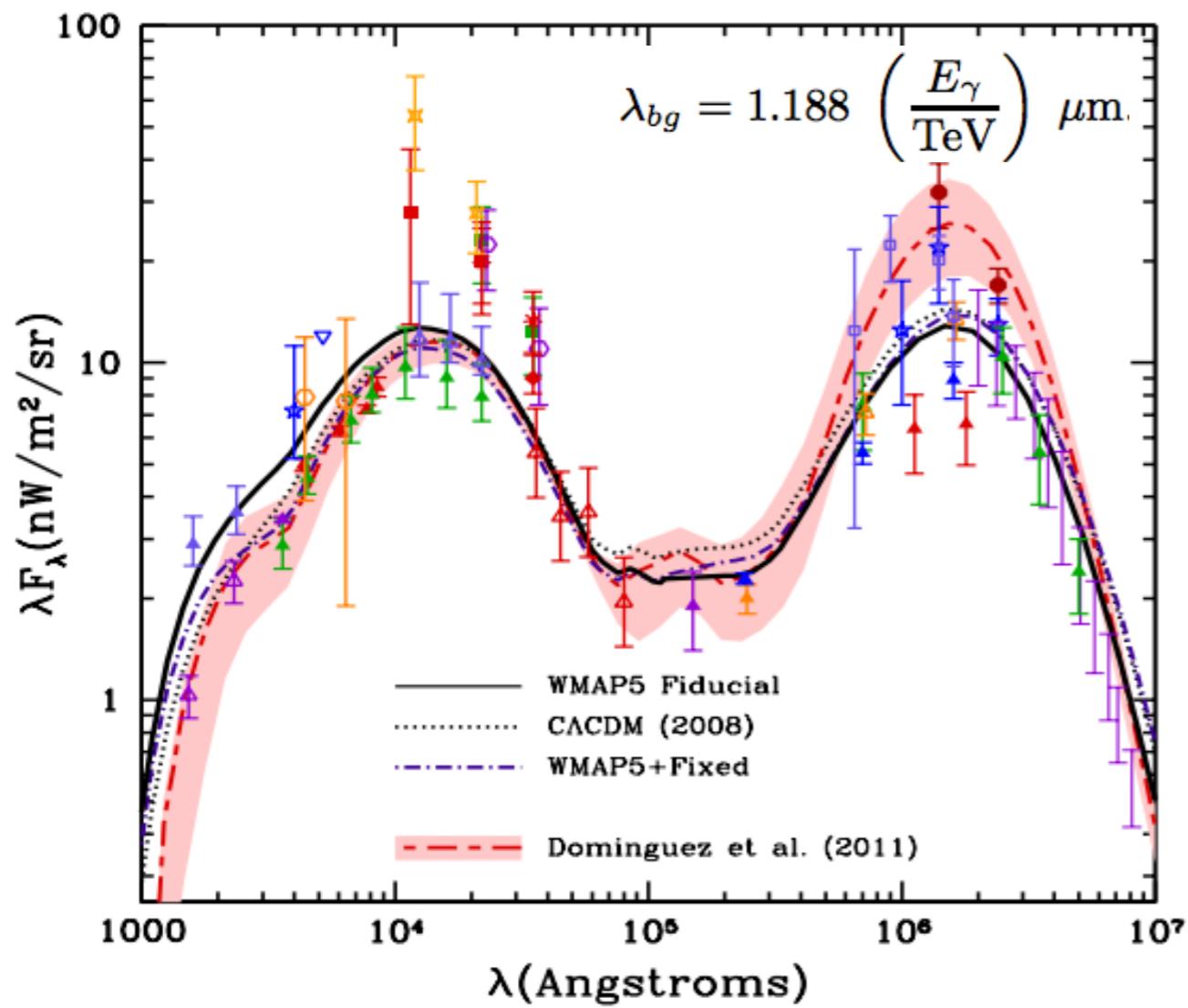
Redshift Lower Limit of PKS 1424+240 from Far UV Observations

- Bright, featureless blazars are also used as background sources to study the intergalactic medium
- Lower limit of blazar distance can be derived from observation of intervening Lyman absorption with HST/COS
- Observations of PKS 1424+240 on April 19, 2012 show higher-order Lyman absorption at $z=0.6035$



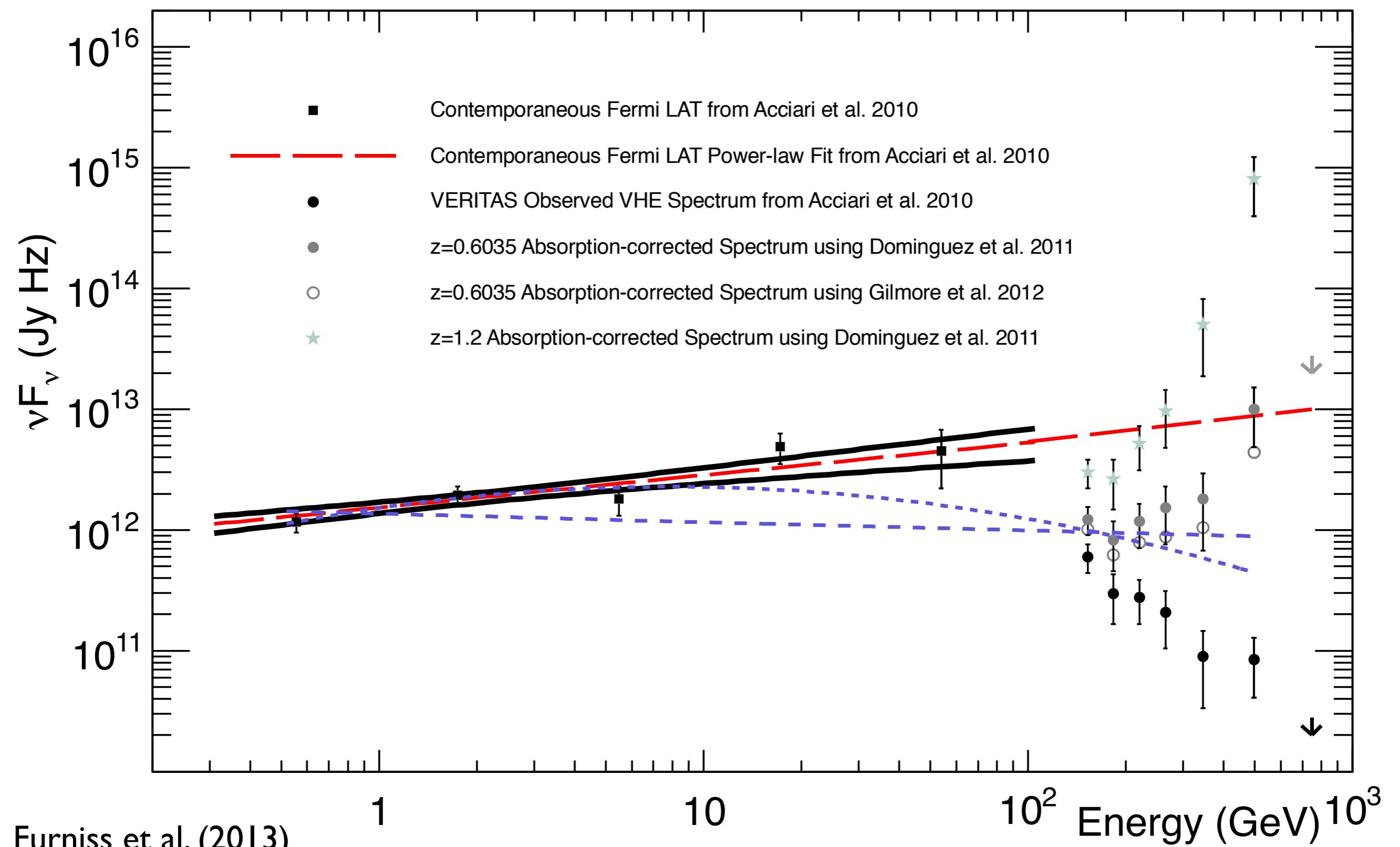
TeV-Emitting Blazars and the Extragalactic Background Light

- TeV photons interact with EBL
- EBL is the sum of all emitted and reprocessed starlight
- Interaction absorbs TeV flux
- Limits distance to which TeV emitters can be detected



Absorption-corrected Gamma-ray Emission

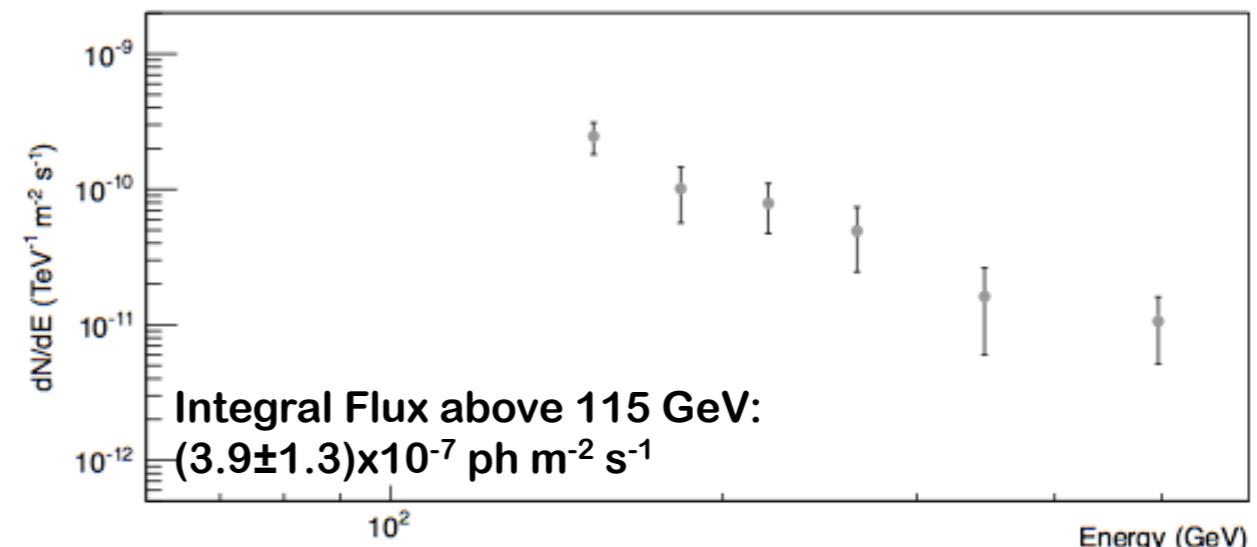
A First Look...



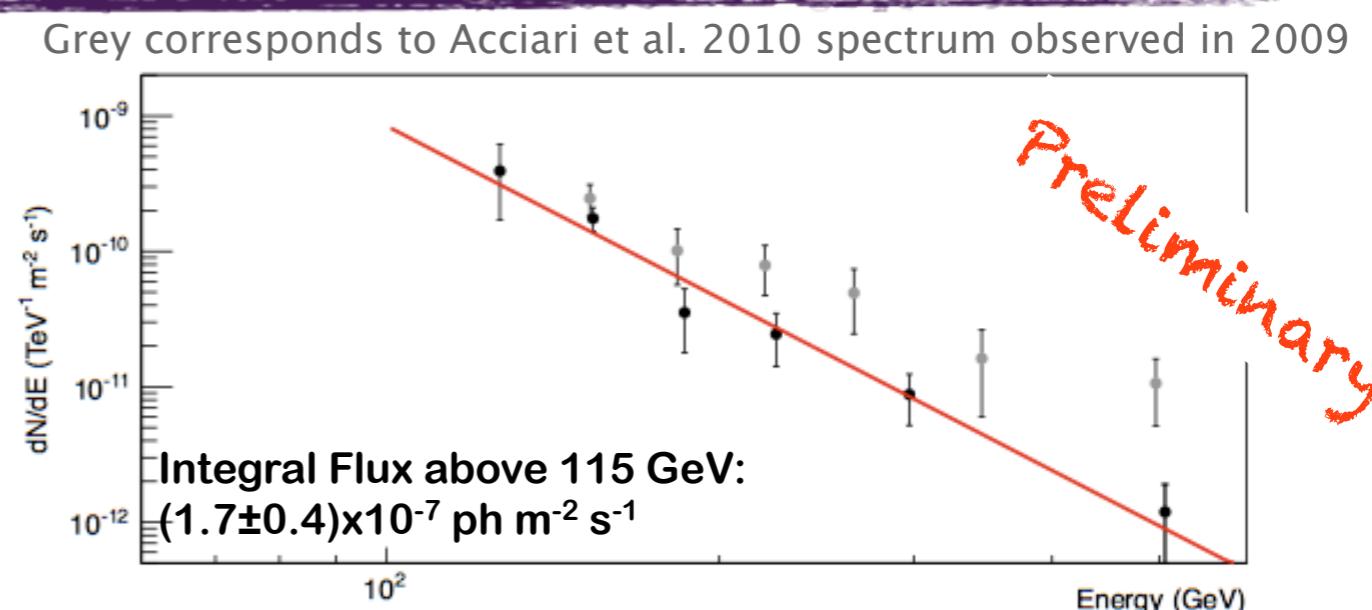
VERITAS Observations by Year

- 2009
- 25 hours
 - 8.5 sigma
 - 140 GeV threshold
 - $\Gamma=3.8\pm0.5$ (~8% Crab above 115 GeV)

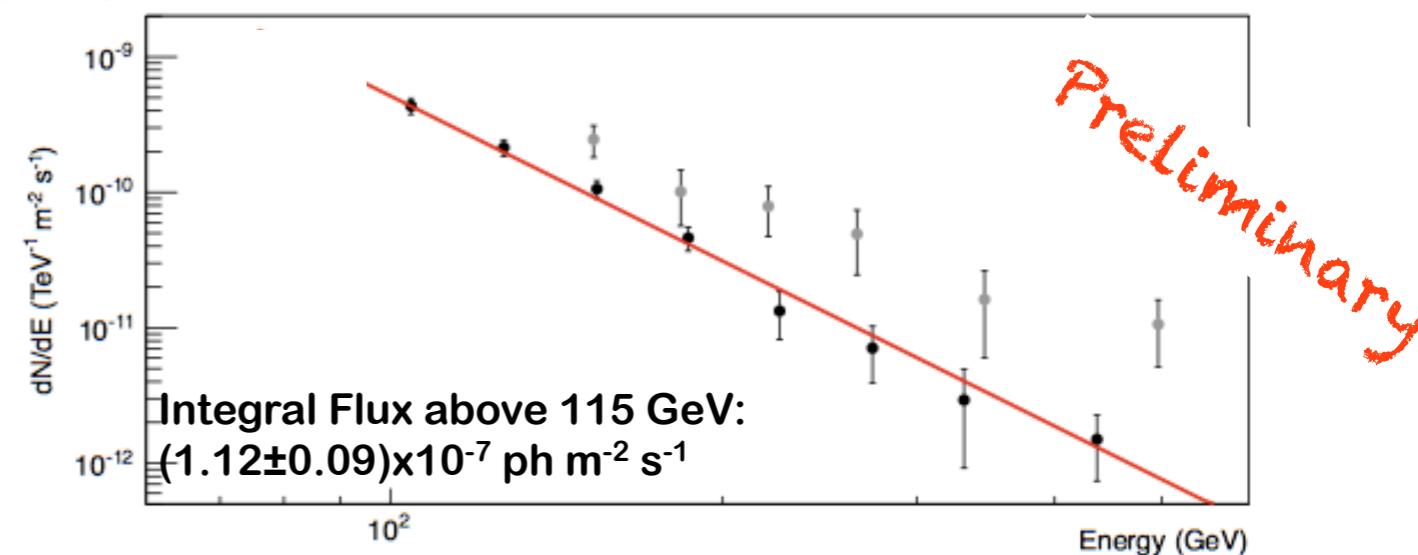
From Acciari et al. (2010)



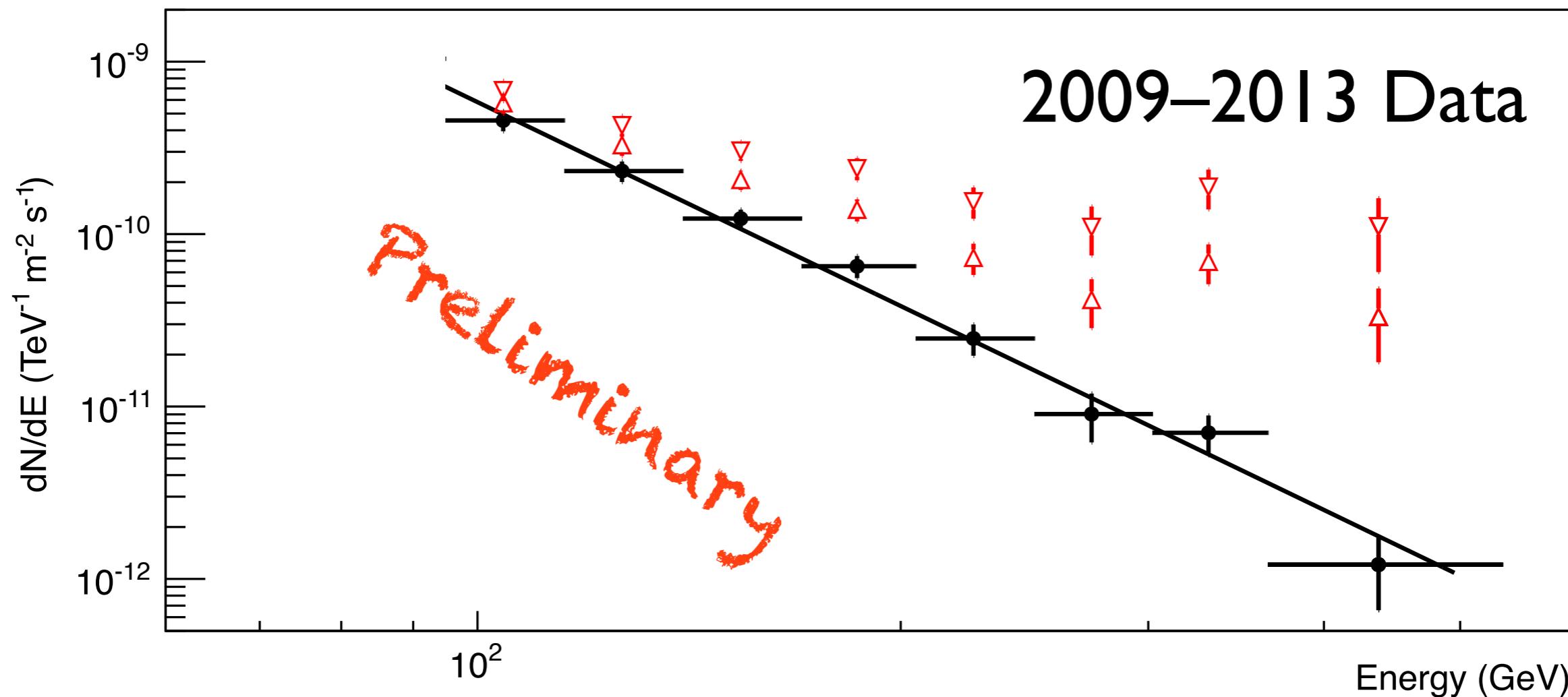
- 2011
- 14 hours
 - 8.5 sigma
 - 115 GeV threshold
 - $\Gamma=4.4\pm0.6$ (~4% Crab above 115 GeV)



- 2013
- 67 hours
 - 16.4 sigma
 - 75 GeV threshold
 - $\Gamma=3.9\pm0.2$ (~2% Crab above 115 GeV)



Absorption-Corrected VHE Spectrum

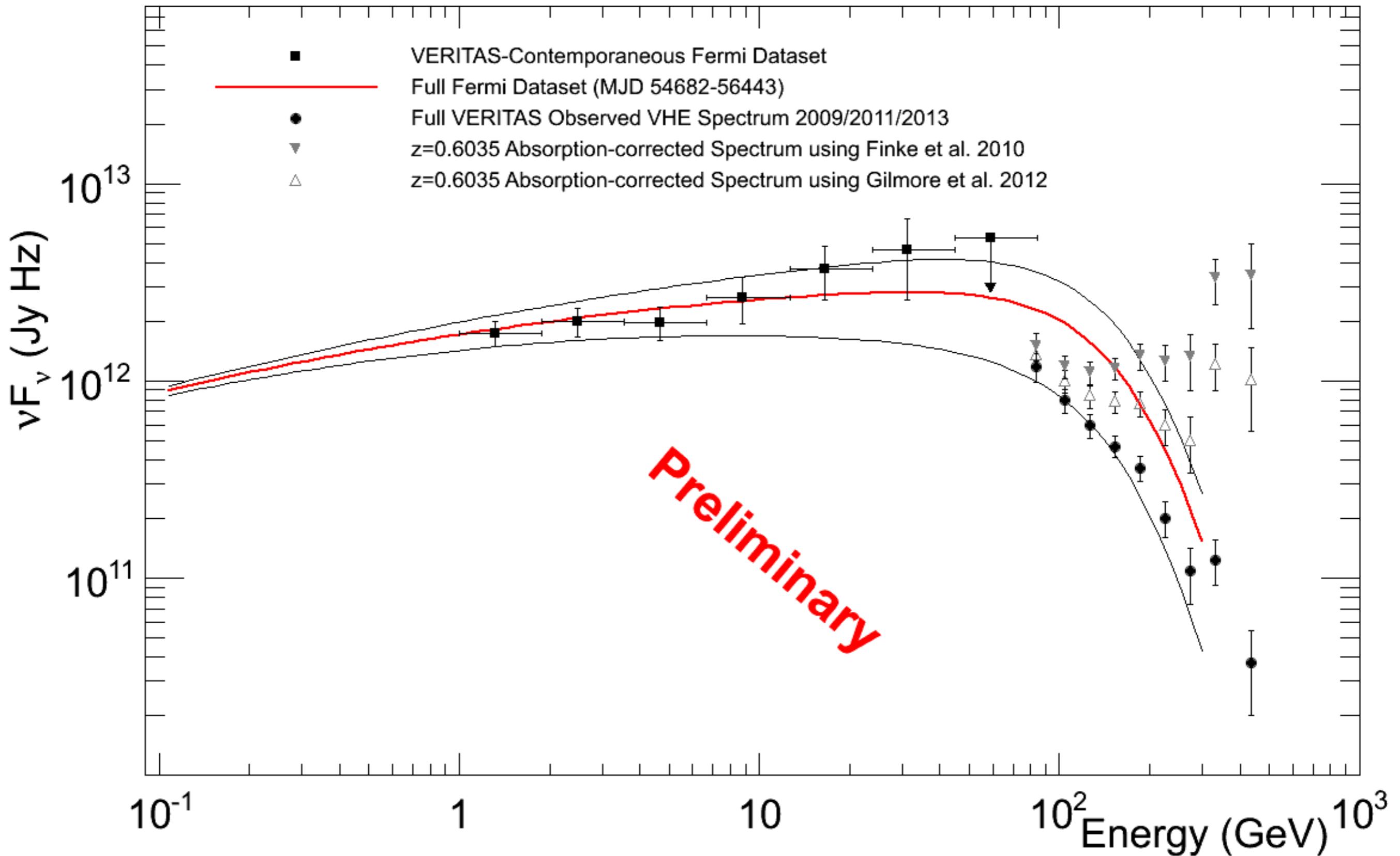


Δ Gilmore: $\Gamma = 2.4 \pm 0.2$

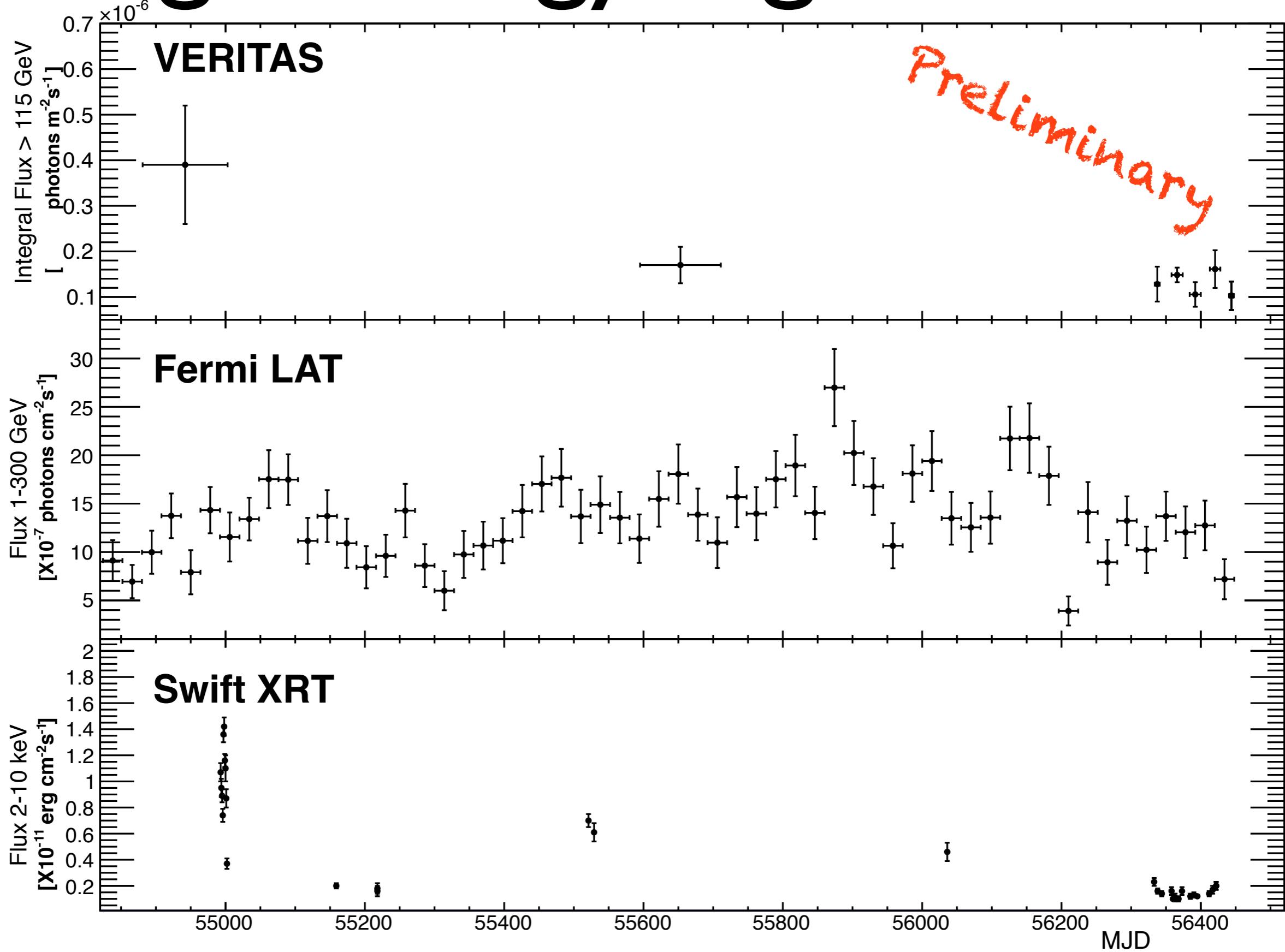
∇ Finke: $\Gamma = 1.7 \pm 0.2$

Neither is harder than standard $\Gamma = 1.5$ limit, but the spectral shape starts to harden above 300 GeV with even the lowest density EBL models

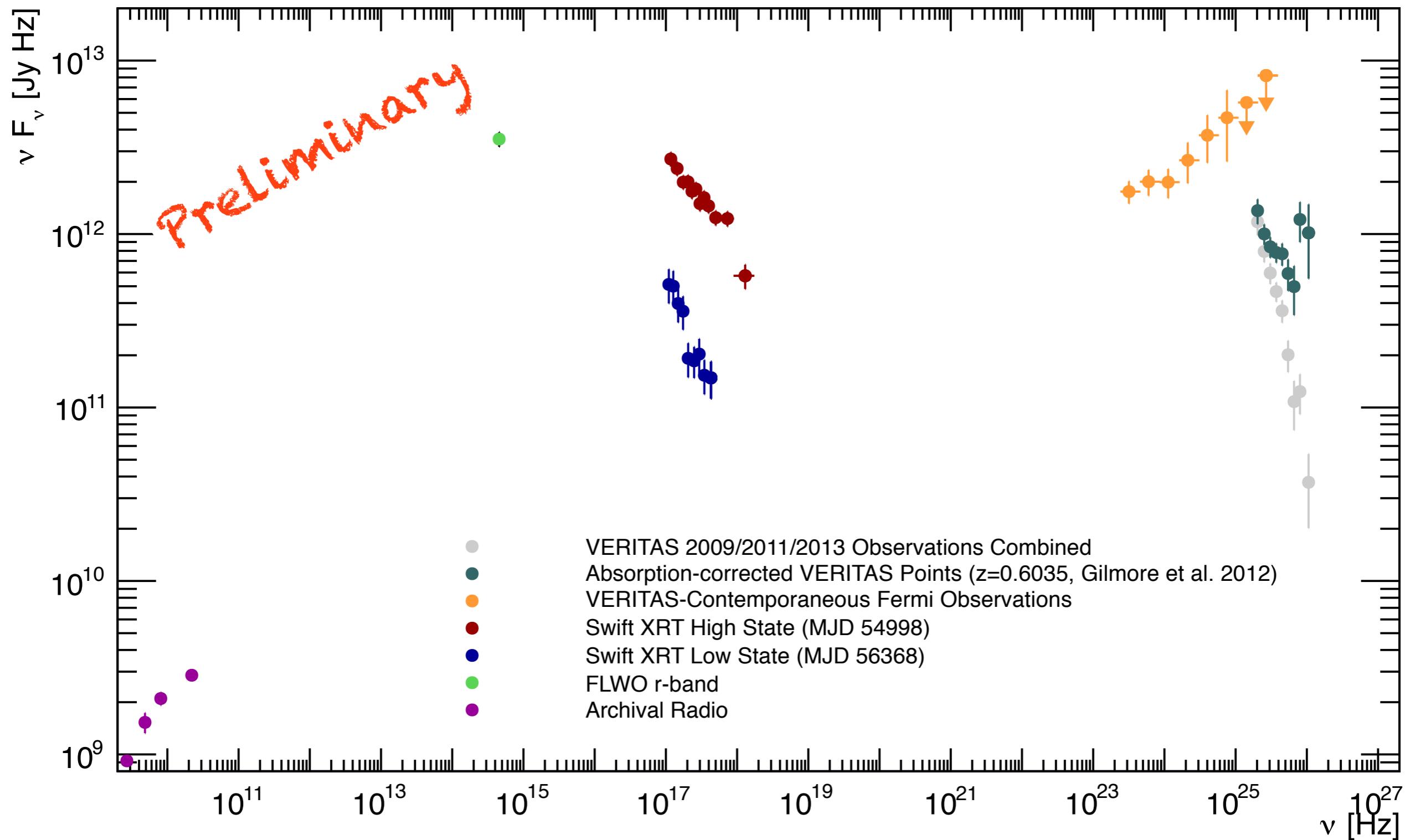
Gamma-ray SED Peak



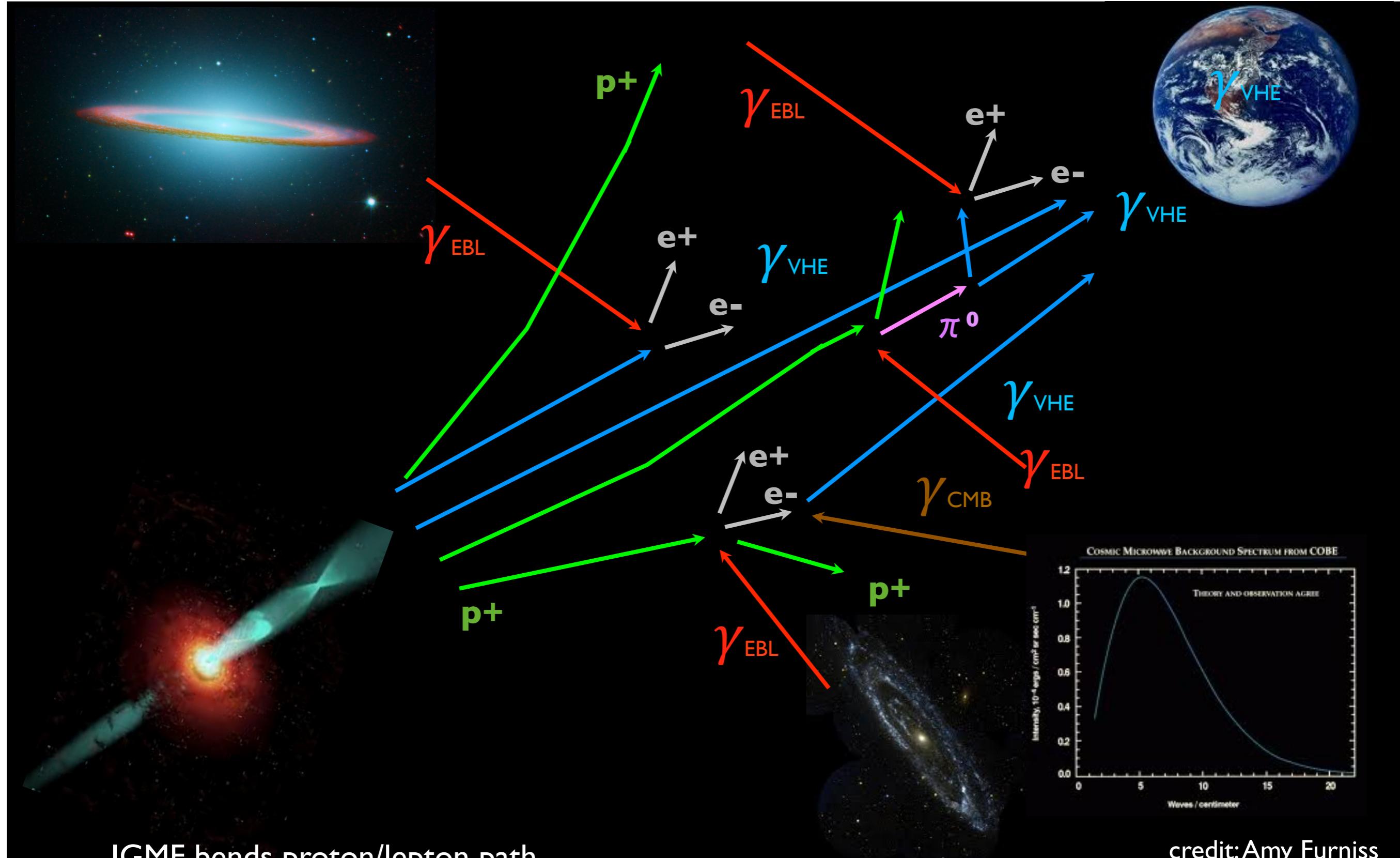
High Energy Light Curve



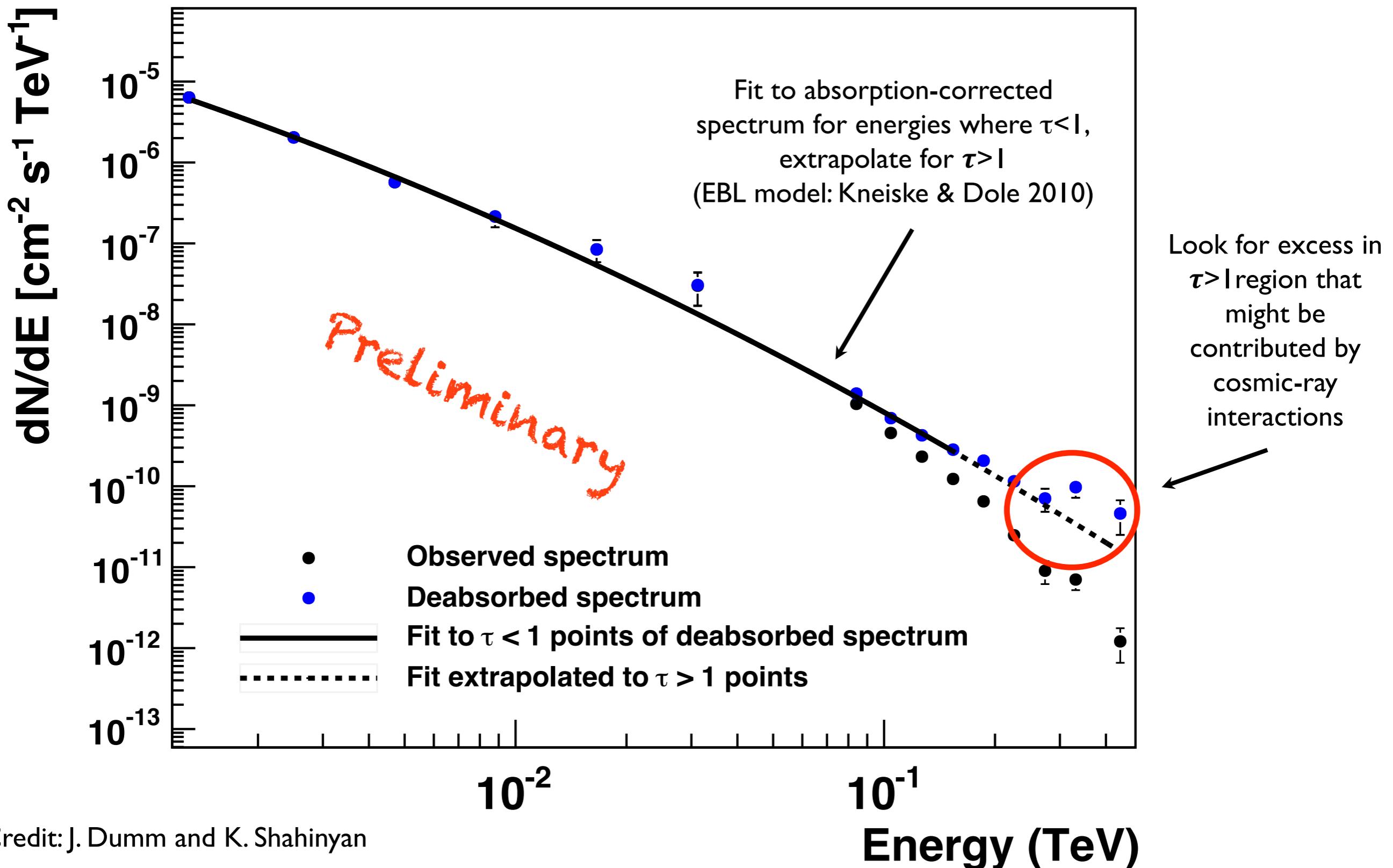
Broadband Absorption-corrected SED Modeling In Progress....



Cosmic-ray Contribution?

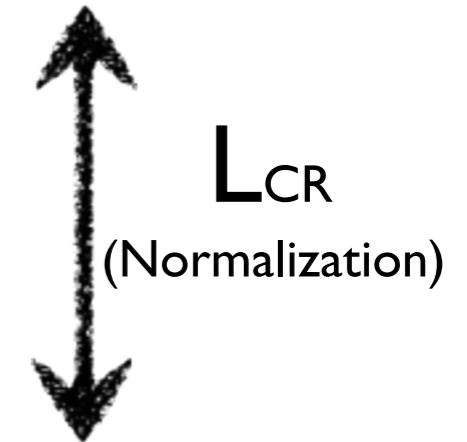
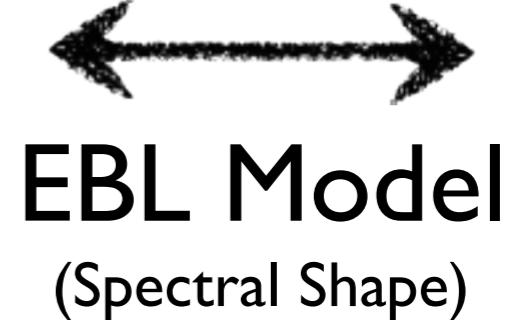
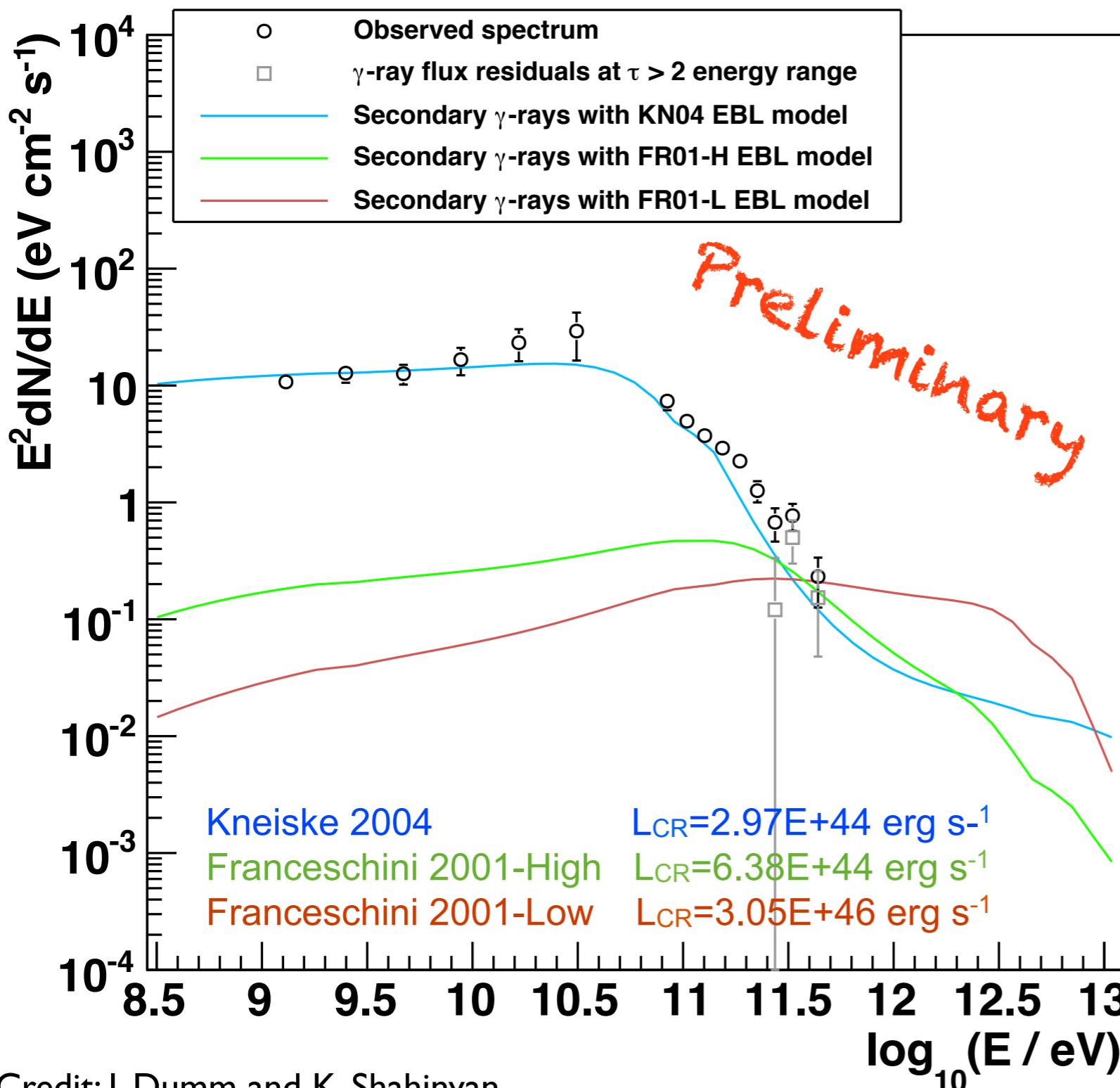


Quantifying High Energy “Excess”



Cosmic-ray Contributions

Use residuals to normalize secondary gamma-ray contribution



Public code:
https://crpropa.desy.de/Main_Page
<http://arxiv.org/abs/1206.3132>

Conclusions

- PKS 1424+240 shows some gamma-ray variability and considerable X-ray variability
- The EBL density is not immediately constrained by standard limits on the spectral hardness from shock acceleration
- The gamma-ray spectrum has an atypical shape which might indicate a higher redshift
- If the source resides at $z > 0.6$, the spectrum will probably require a more complicated explanation than EBL absorption of a smooth spectrum
- Possible that we are seeing a natural signature of cascade emission initiated by PeV proton photo-pion production
 - See talks in this session by Hajime Takami and Warren Essey
- Upcoming HST/STIS observations of this source may push the redshift limit higher and will provide an upper limit as well
- Independent of what the explanation for the intrinsic SED, PKS 1424+240 is a unique blazar that will benefit from continued studies

Stay tuned....