Joint HAWC-VERITAS Analysis

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Tom Weisgarber
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Joint Science Goals

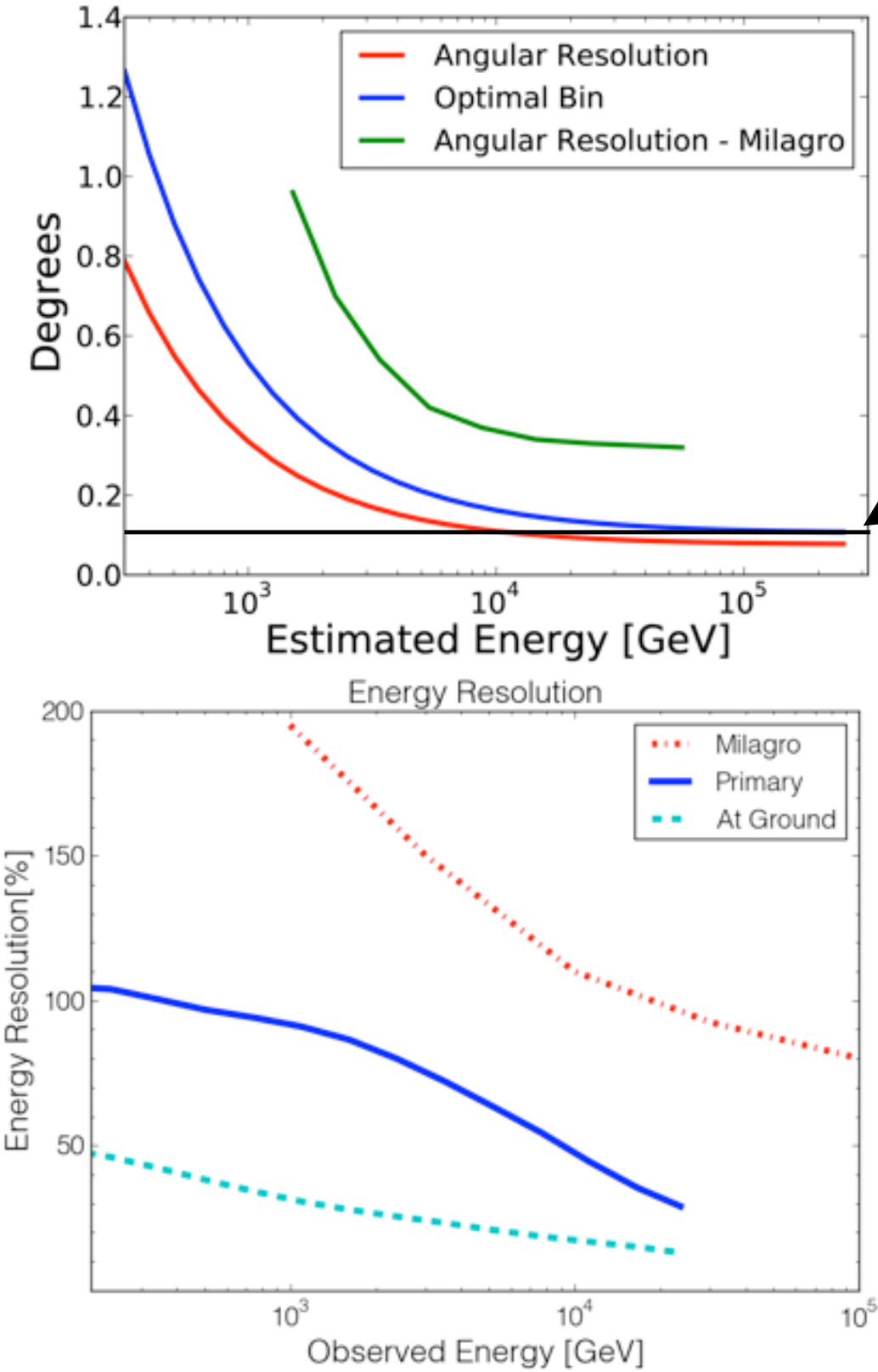
Galactic sources

- Pulsar wind nebulae
- Supernova remnants
  - CR acceleration
  - MC interactions
- TeV binaries
- Galactic diffuse
- Dark matter targets

Extragalactic sources

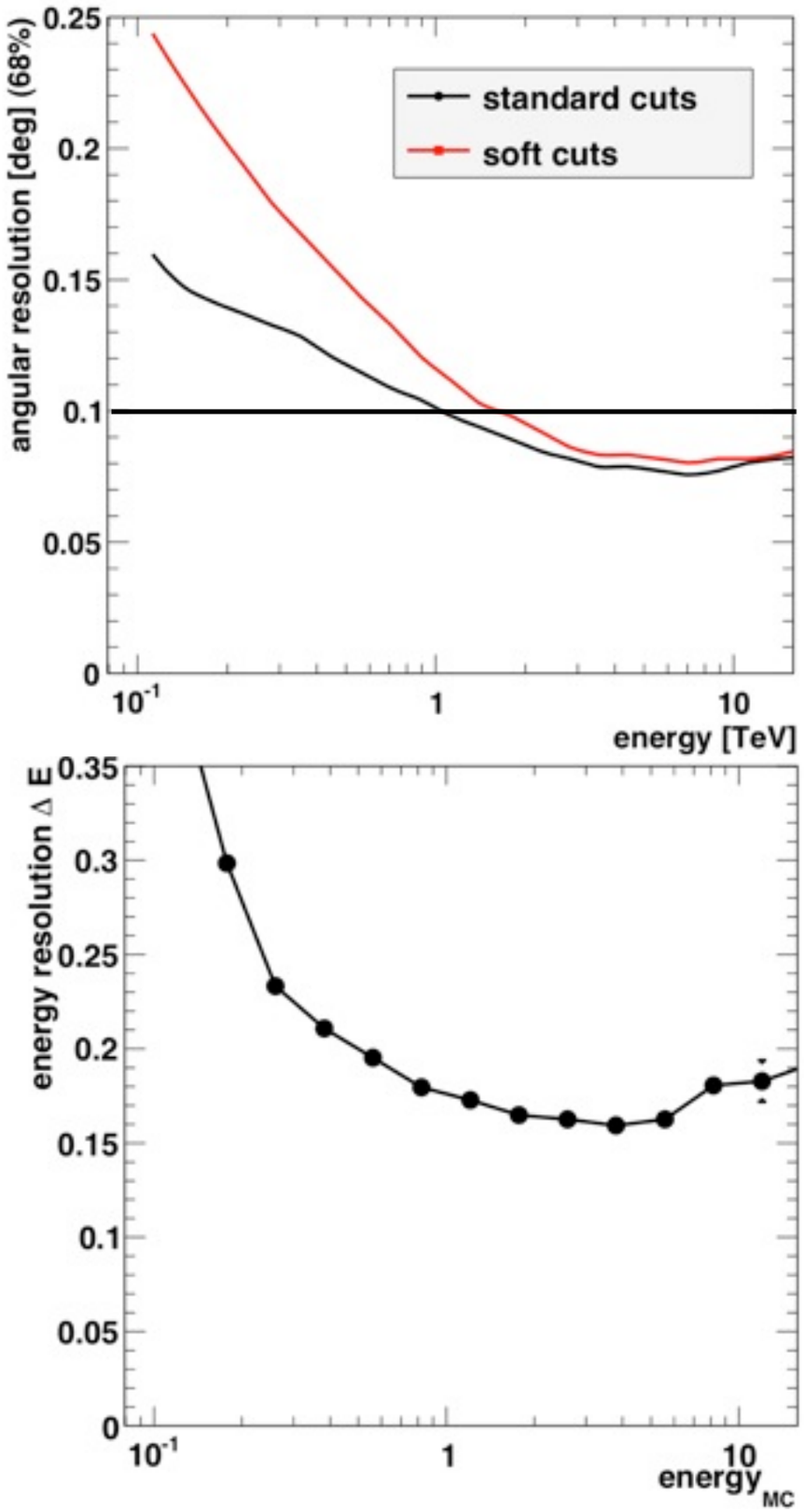
- Blazars
  - EBL studies
  - Flare-catching
  - IGMF
  - LIV
- Dark matter targets
- GRBs
  - LIV

Instrument Characteristics



0.1º (but note that this is sigma of 2D Gaussian)

HAWC energy resolution is in log scale



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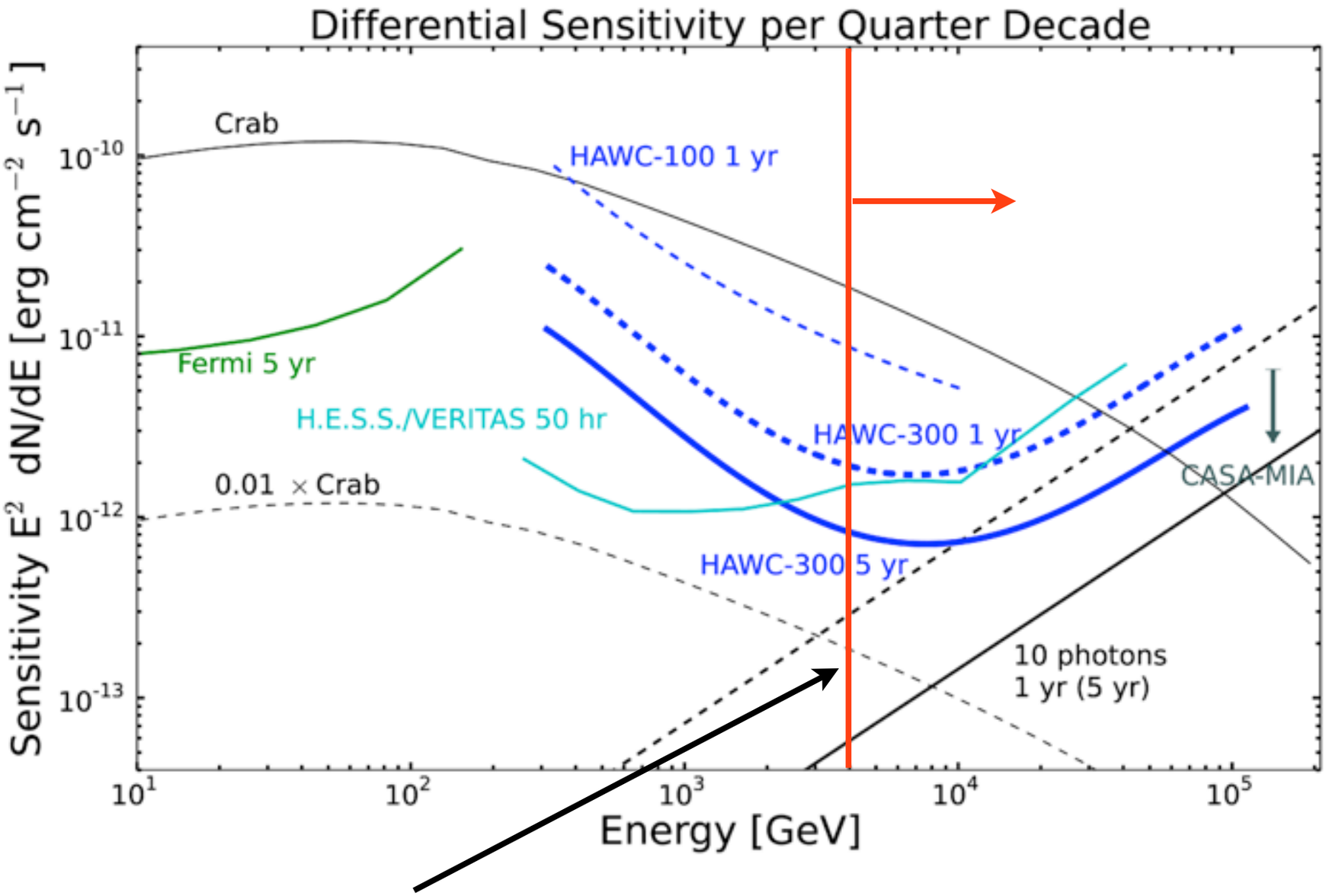
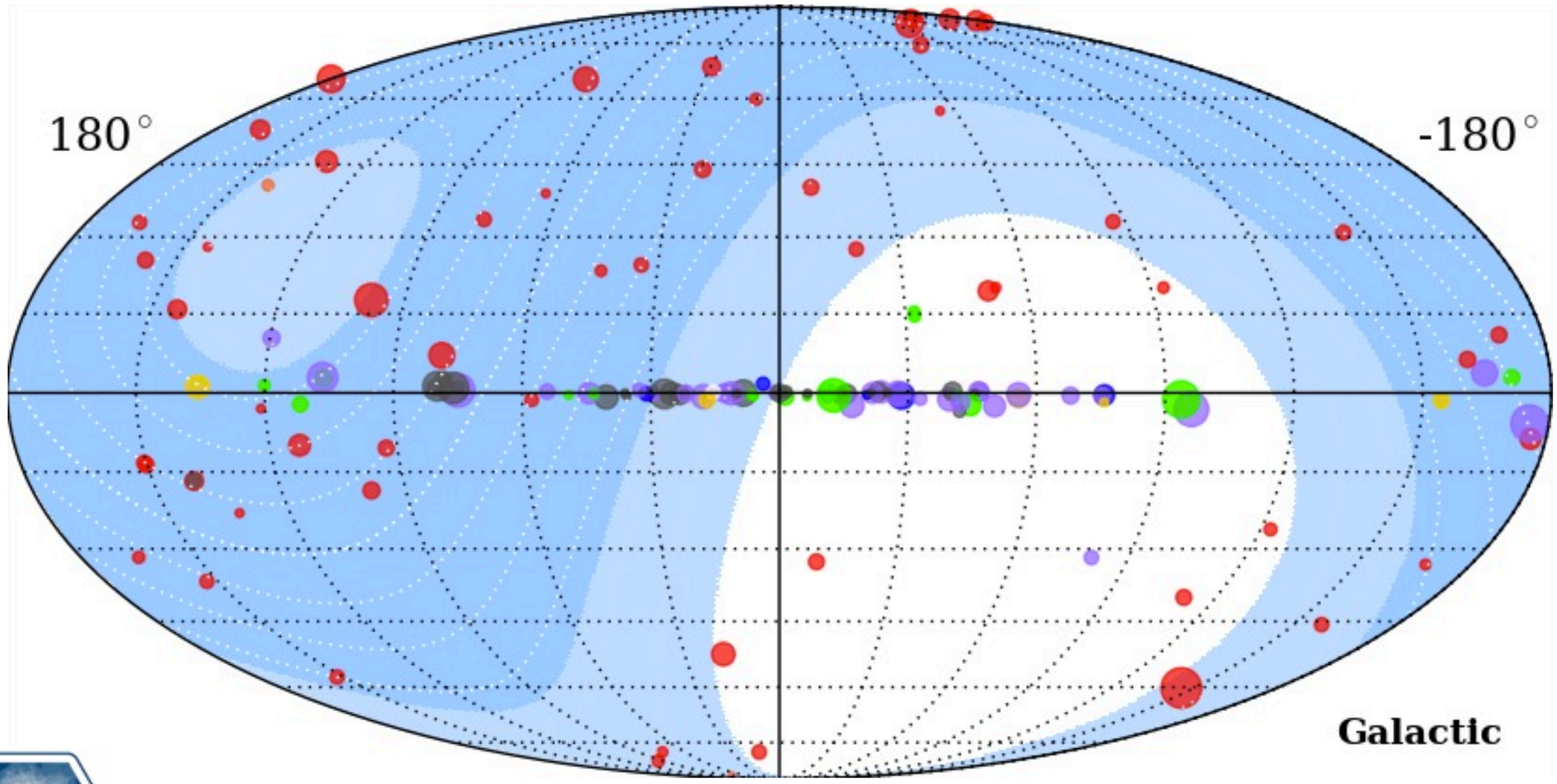


Equivalent of a 50-hour observation above 4 TeV on **every source** in 1 year.

Field of View

blue bands: transits within 35° and 60° of zenith



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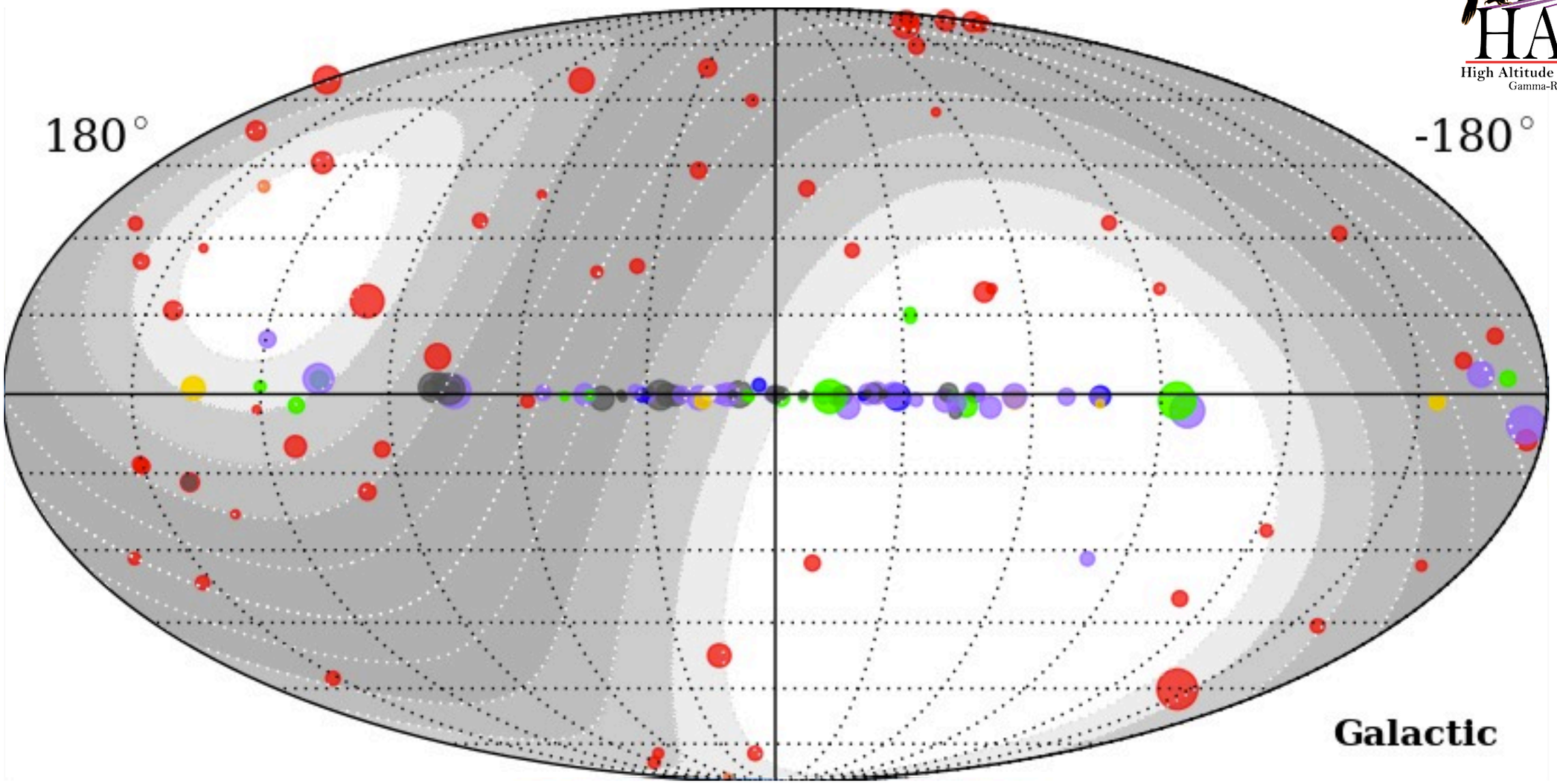
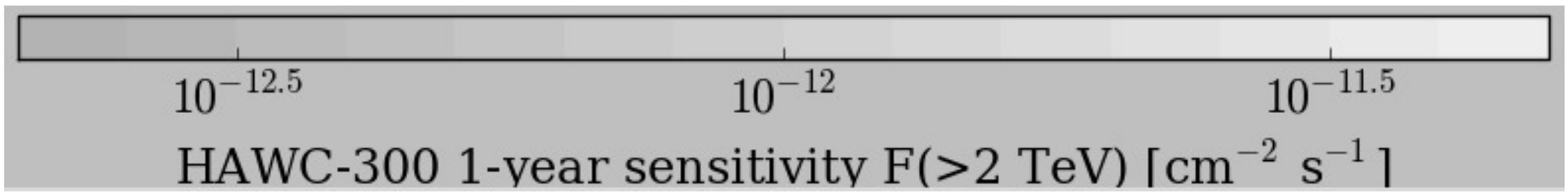
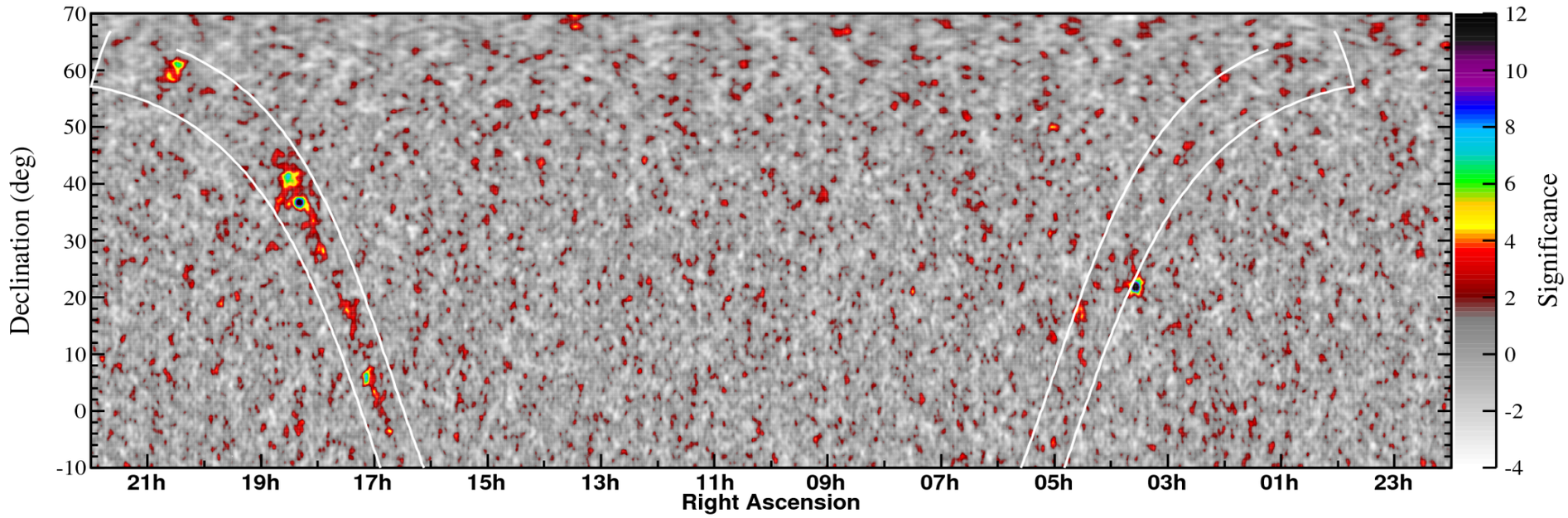
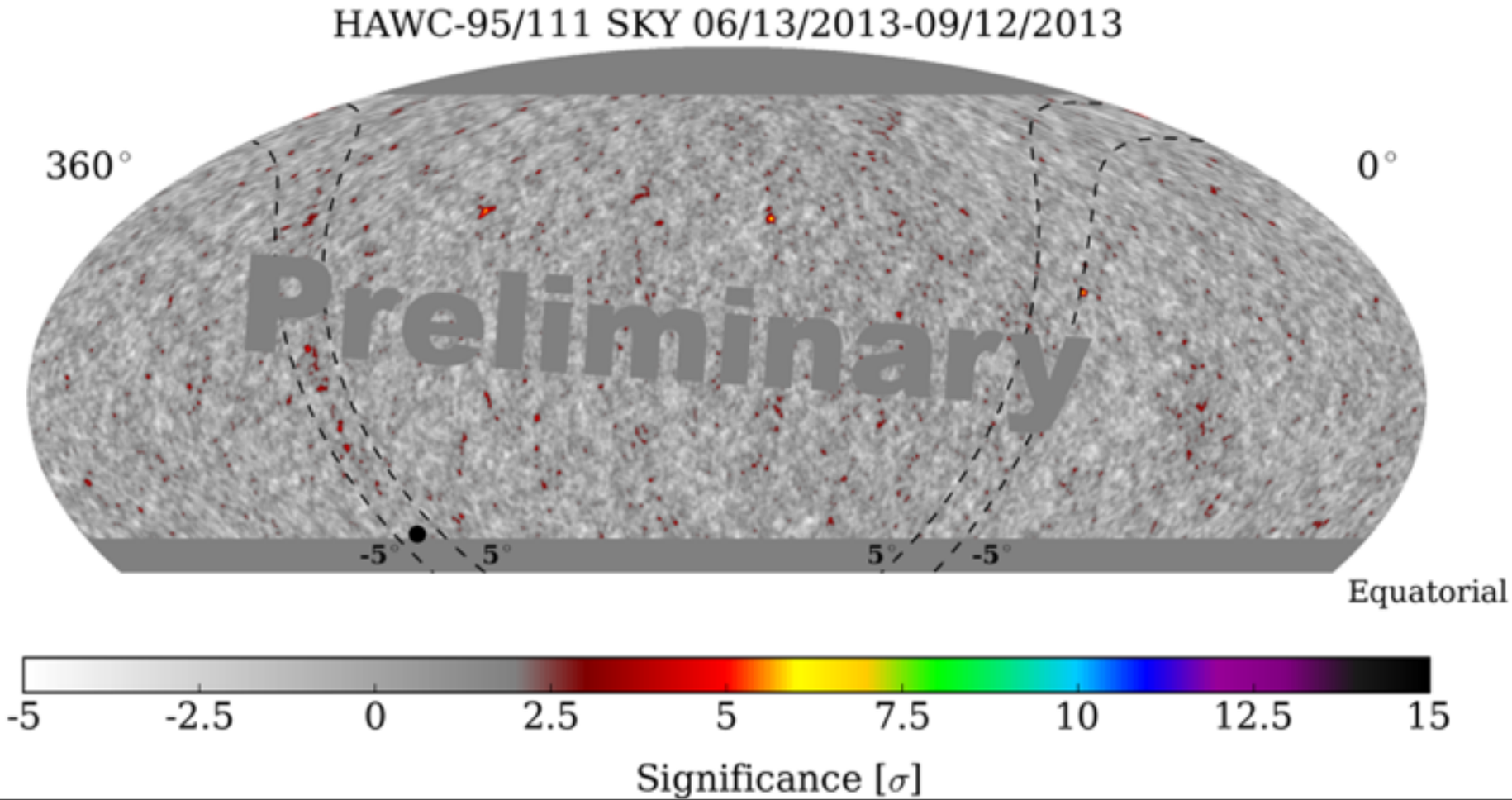




VERITAS follow-up of Milagro/HAWC sources

Galactic plane sources from Milagro sky survey



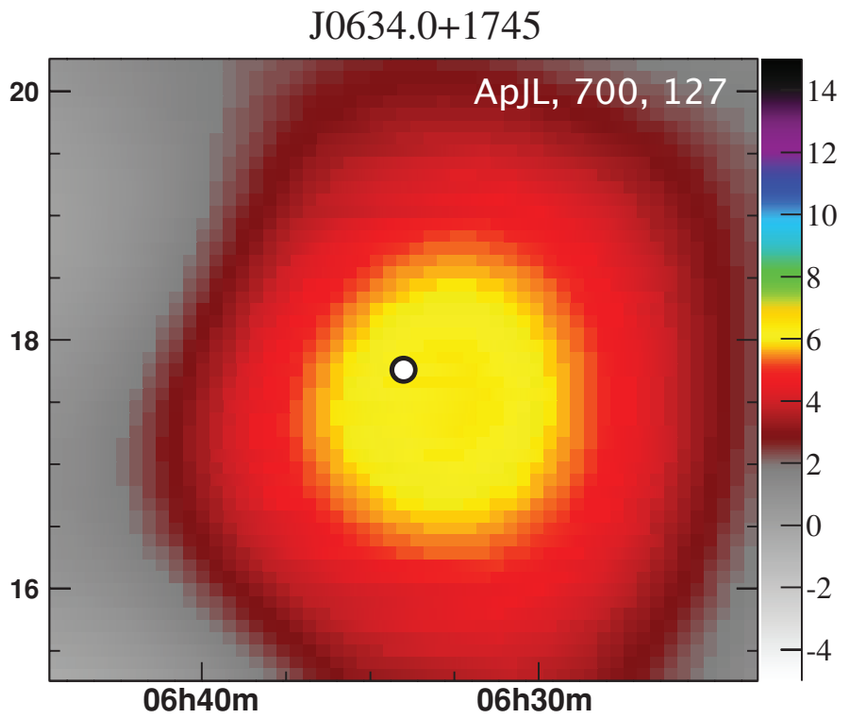


preliminary results from early HAWC operations (data taken with 95 and 111 tanks)

Galactic: SNRs and PWNs

Geminga

- very near (<200pc)
- not yet detected by VERITAS
- very extended in Milagro data
- can explain positron excess?



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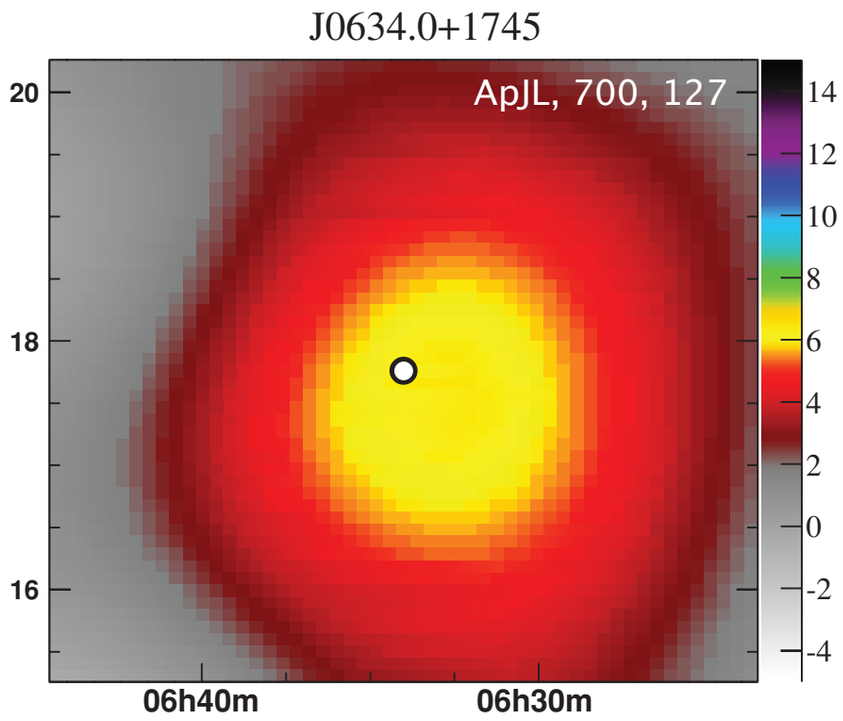
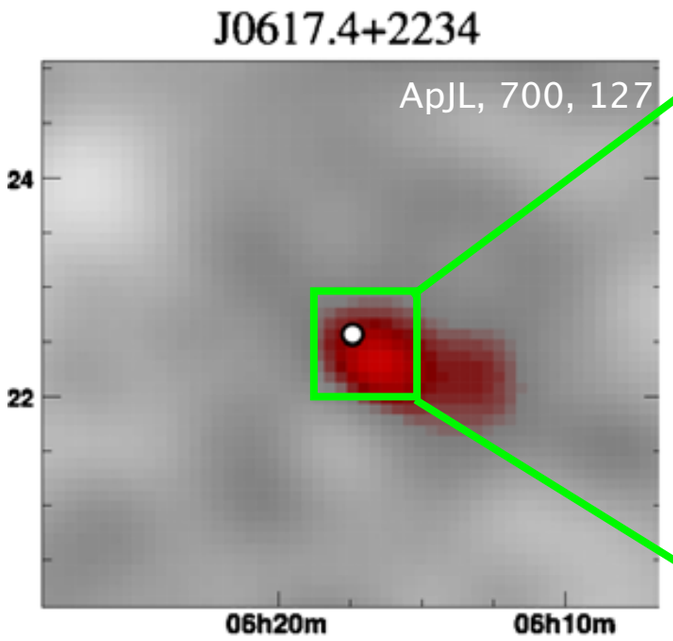
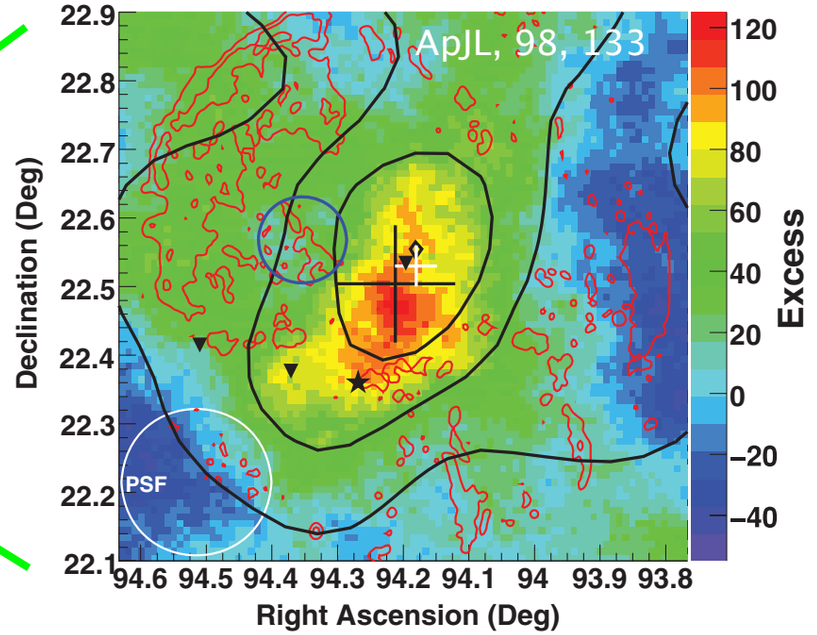


IC443

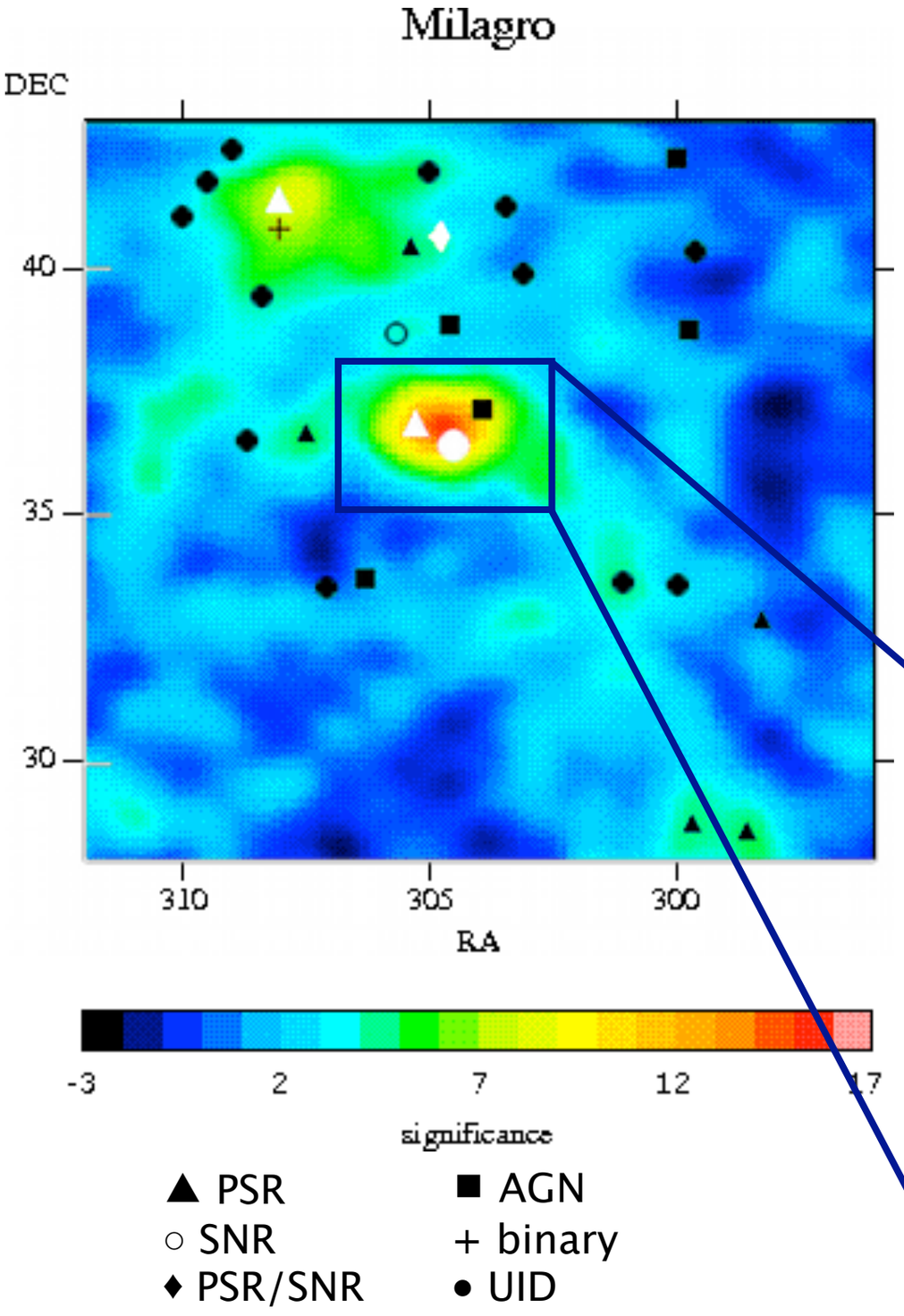
- flux implied by Milagro observation is 10x larger than extrapolated VERITAS spectrum
- more extended?

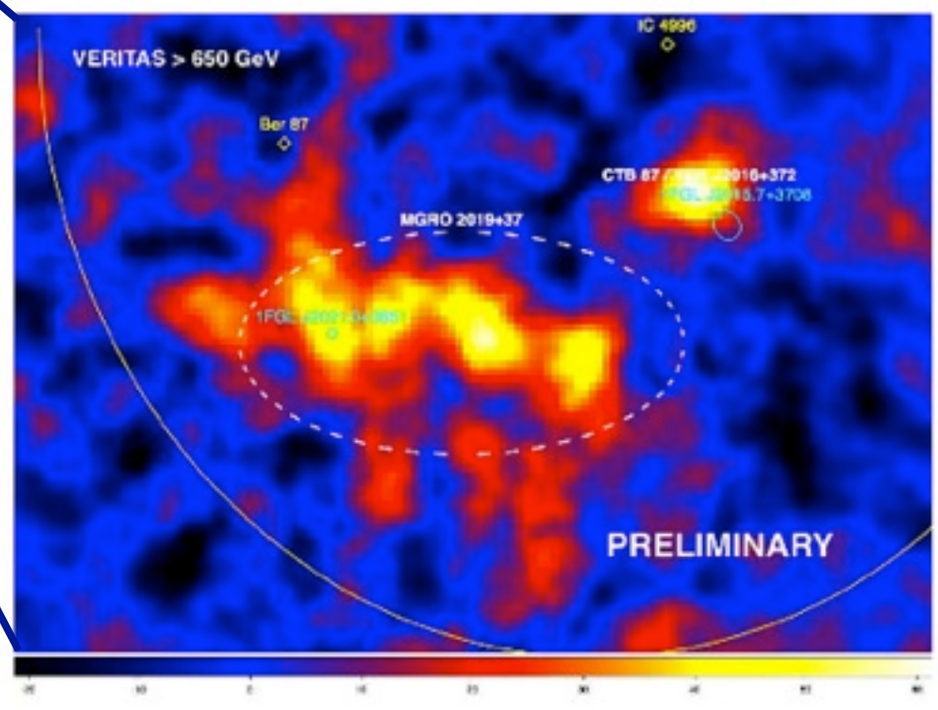




Galactic: SNRs and PWNs

- morphology
- source identification
- spectral modeling
- high-energy cutoff





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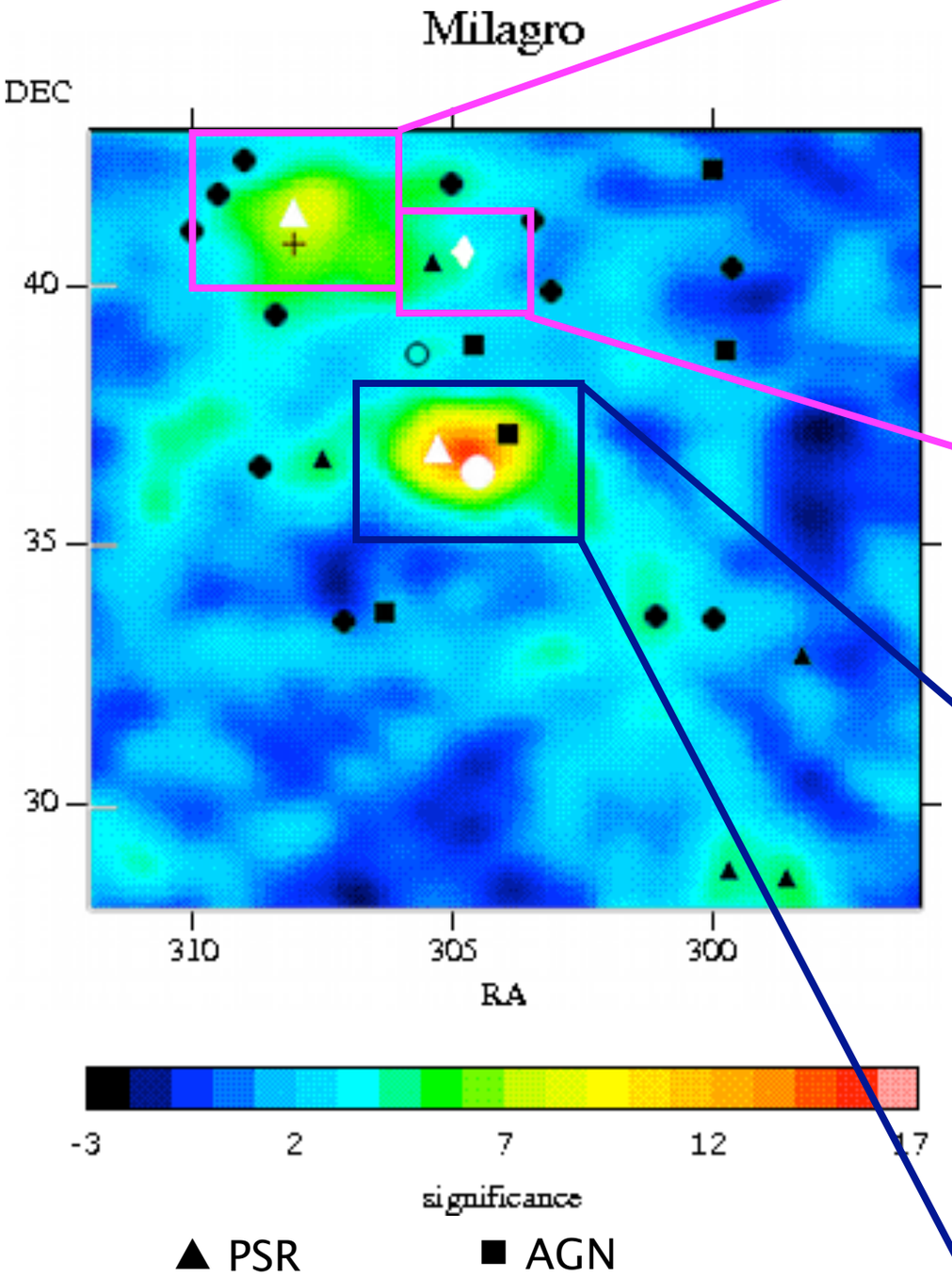
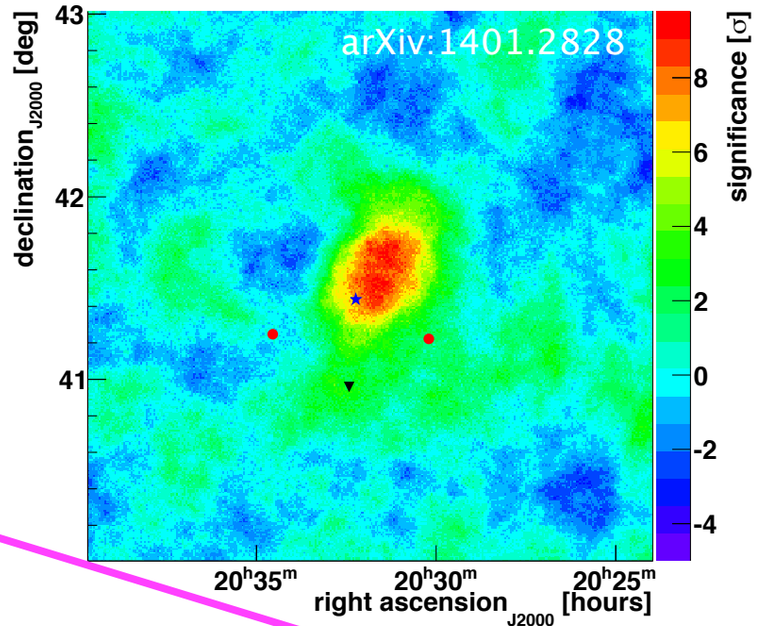
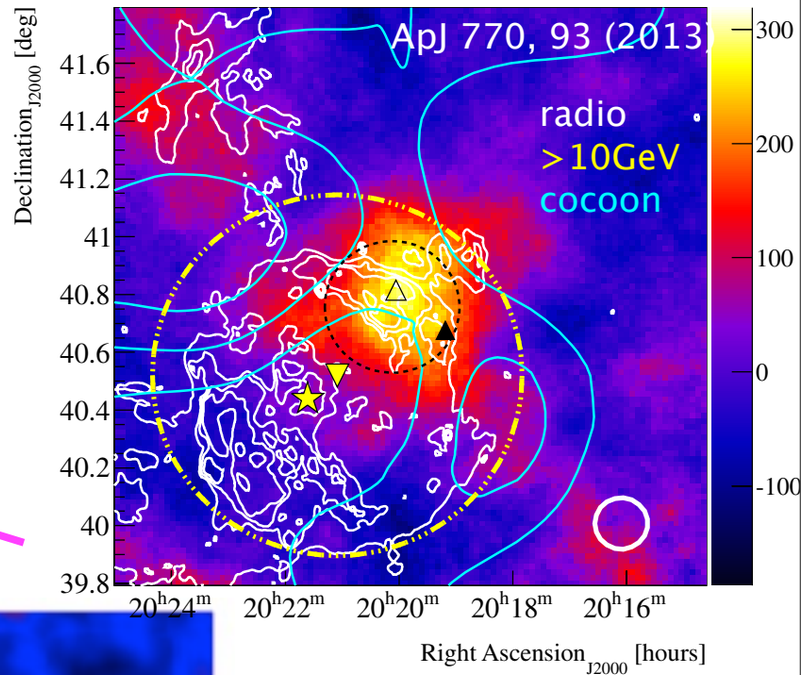
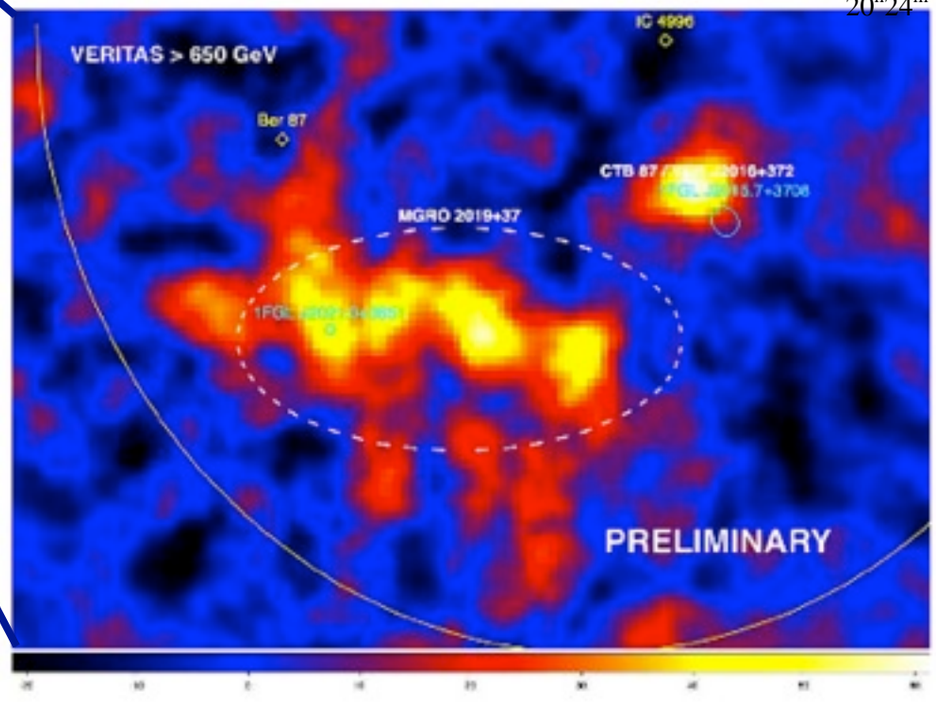


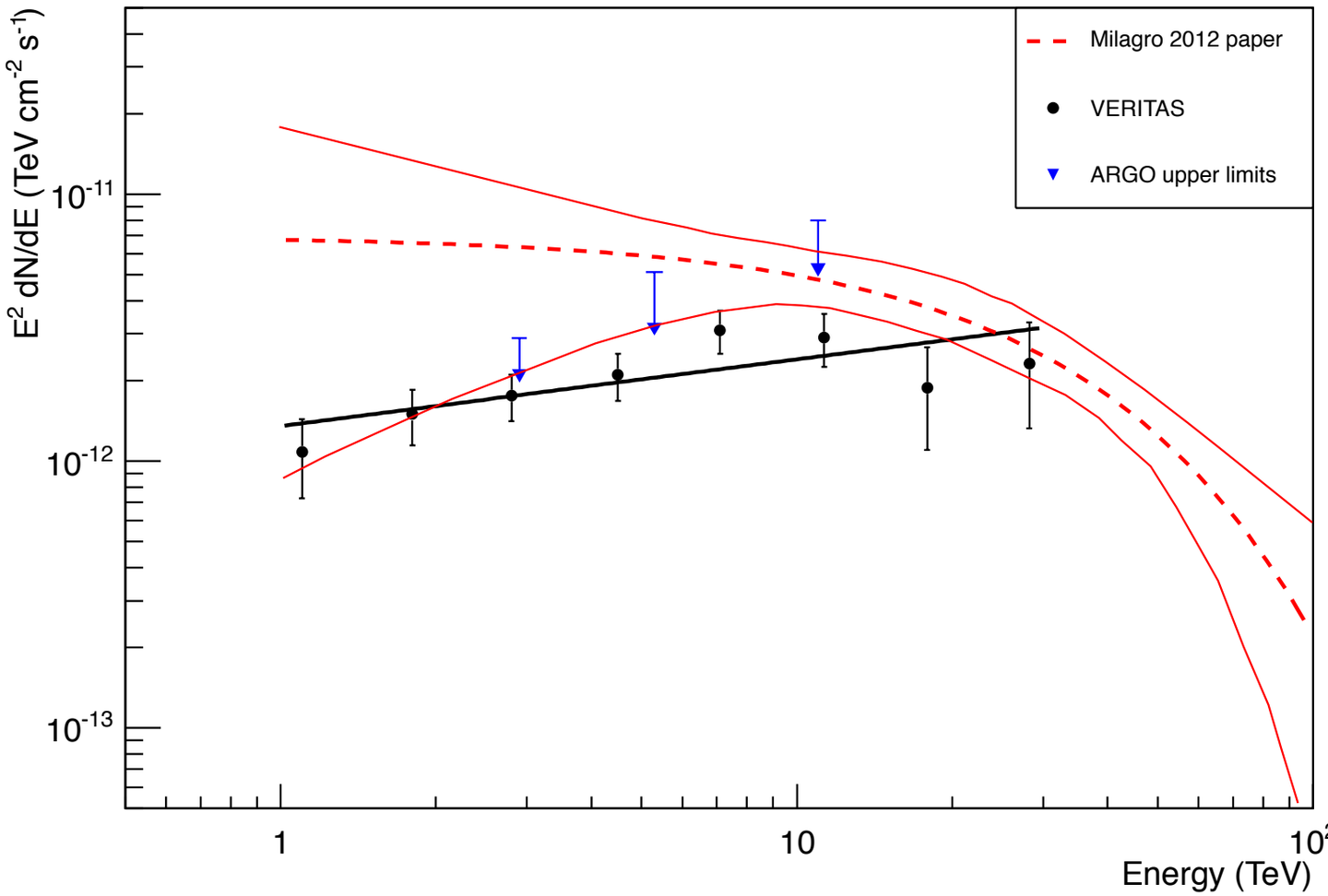






Galactic: SNRs and PWNs

spectral constraint with high-energy cutoff



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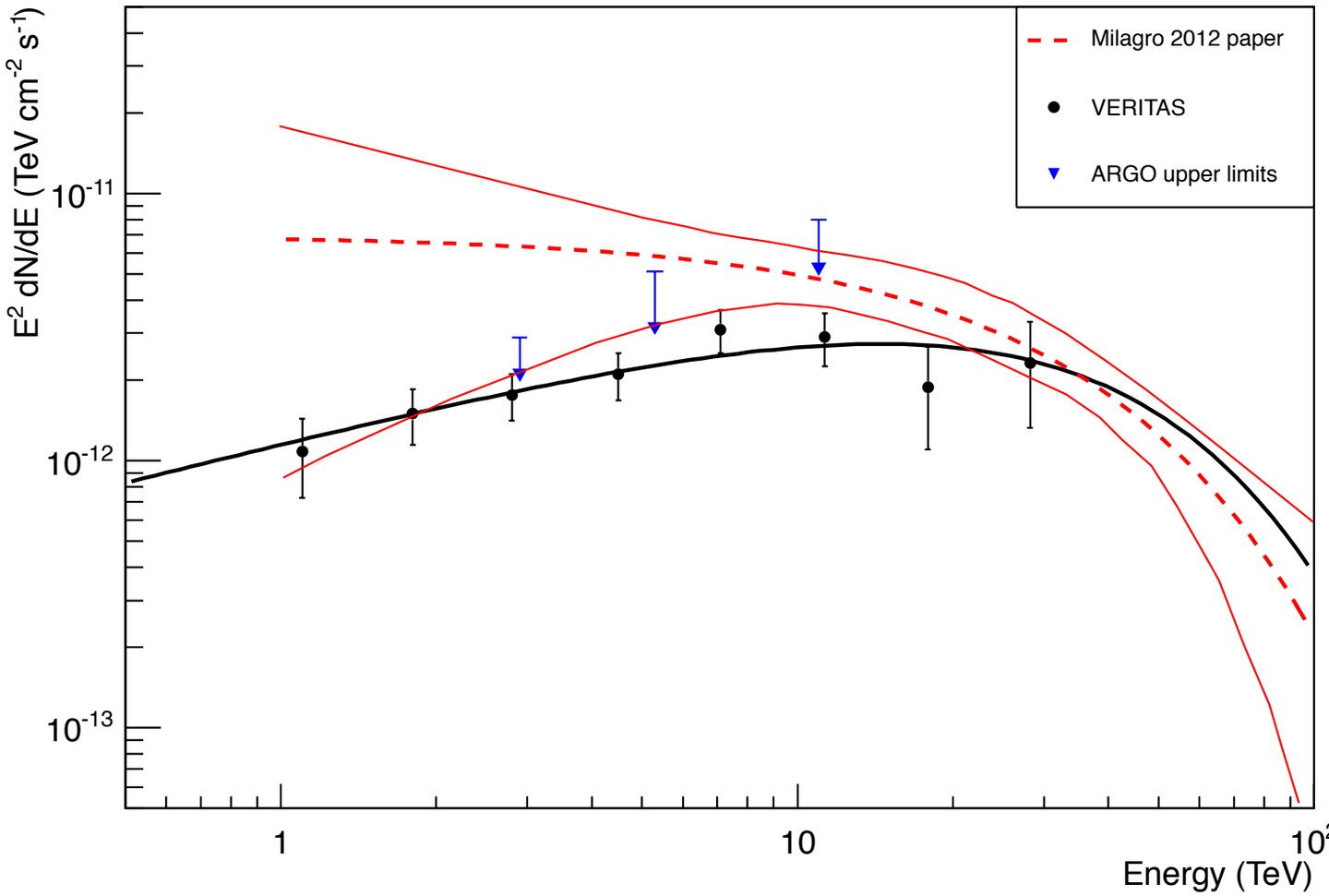
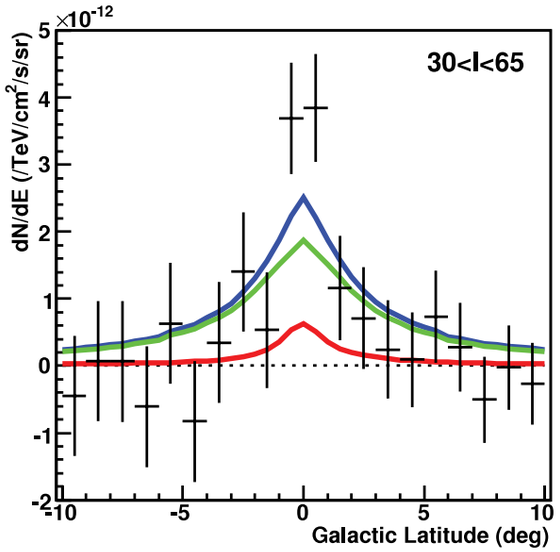
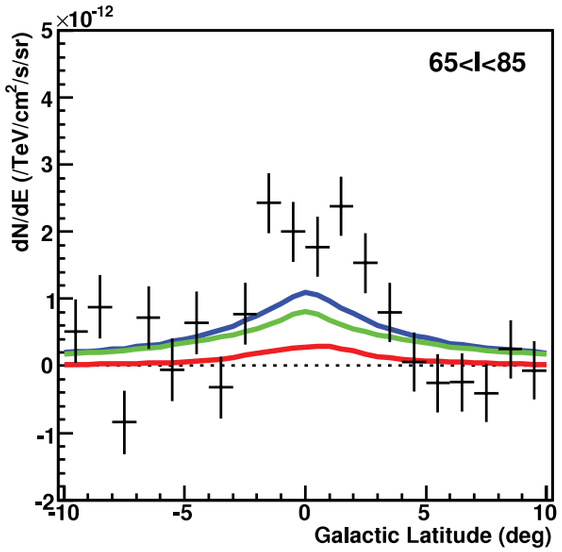
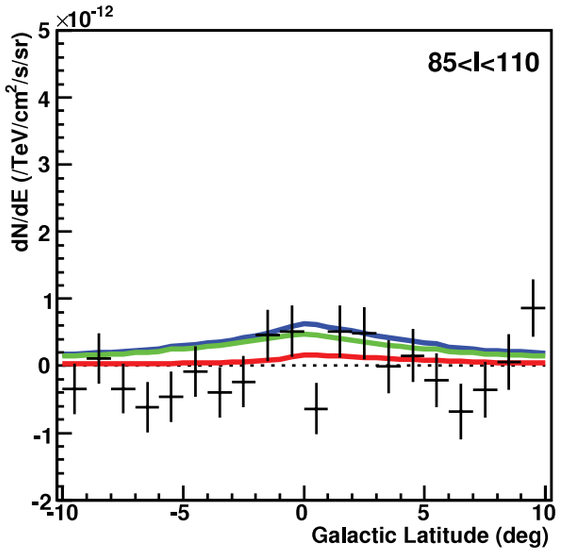


Galactic Diffuse

Milagro source-subtracted profile + GALPROP model

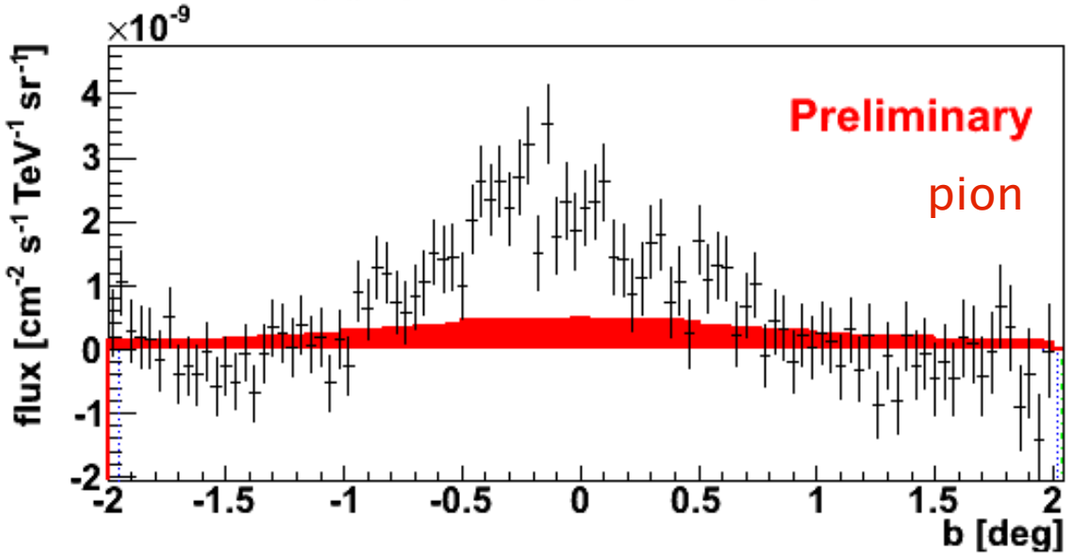






GALPROP:
pion, IC, total

HESS diffuse emission



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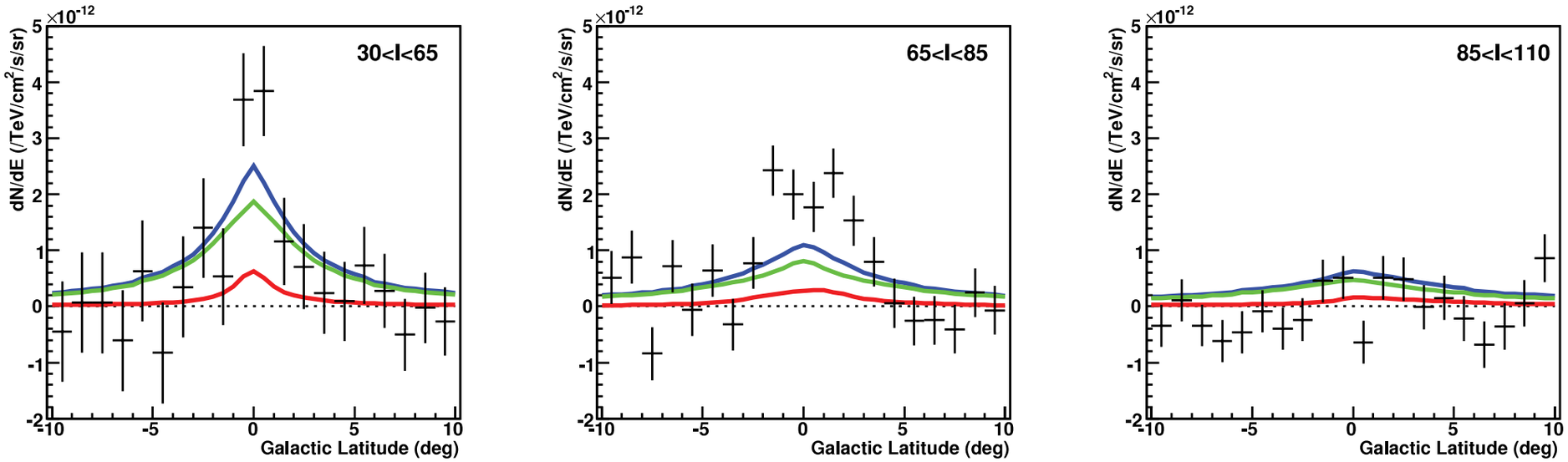

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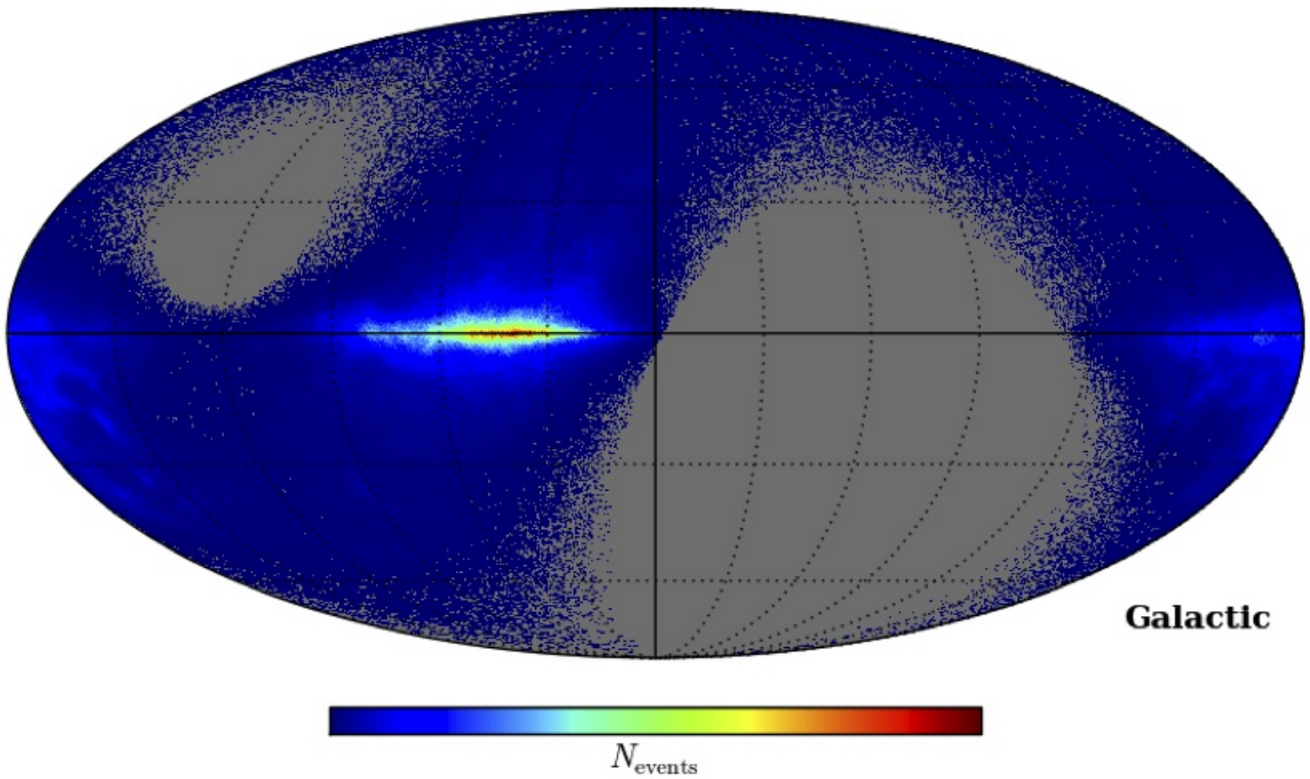
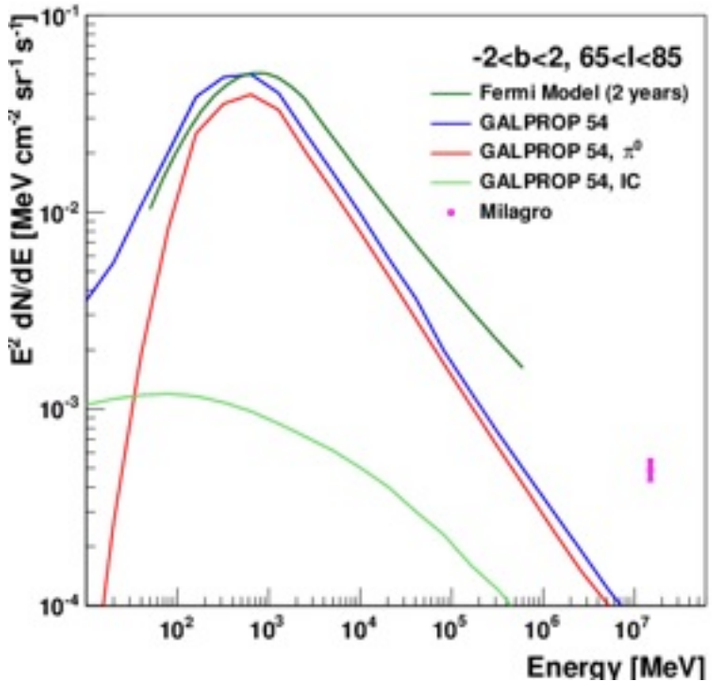


simulated diffuse emission seen by HAWC after 1 year

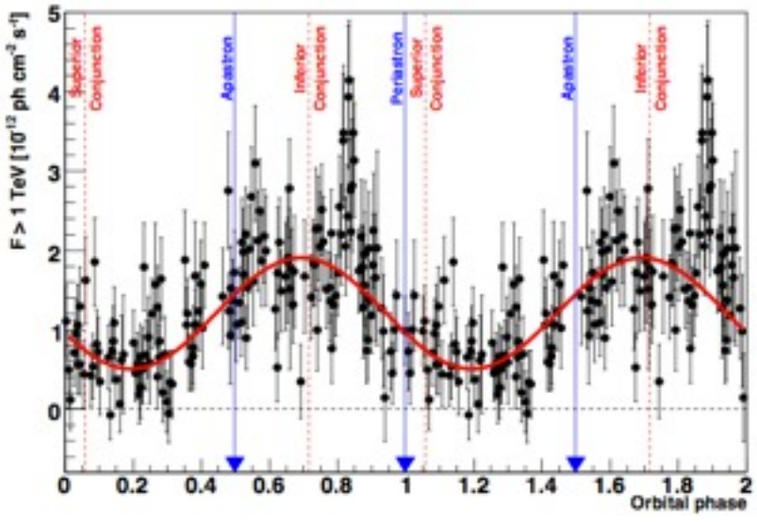


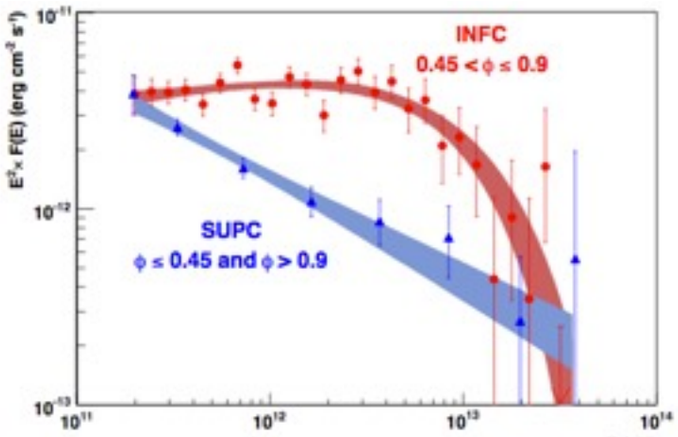
joint fit using HAWC, VERITAS, and Fermi data?

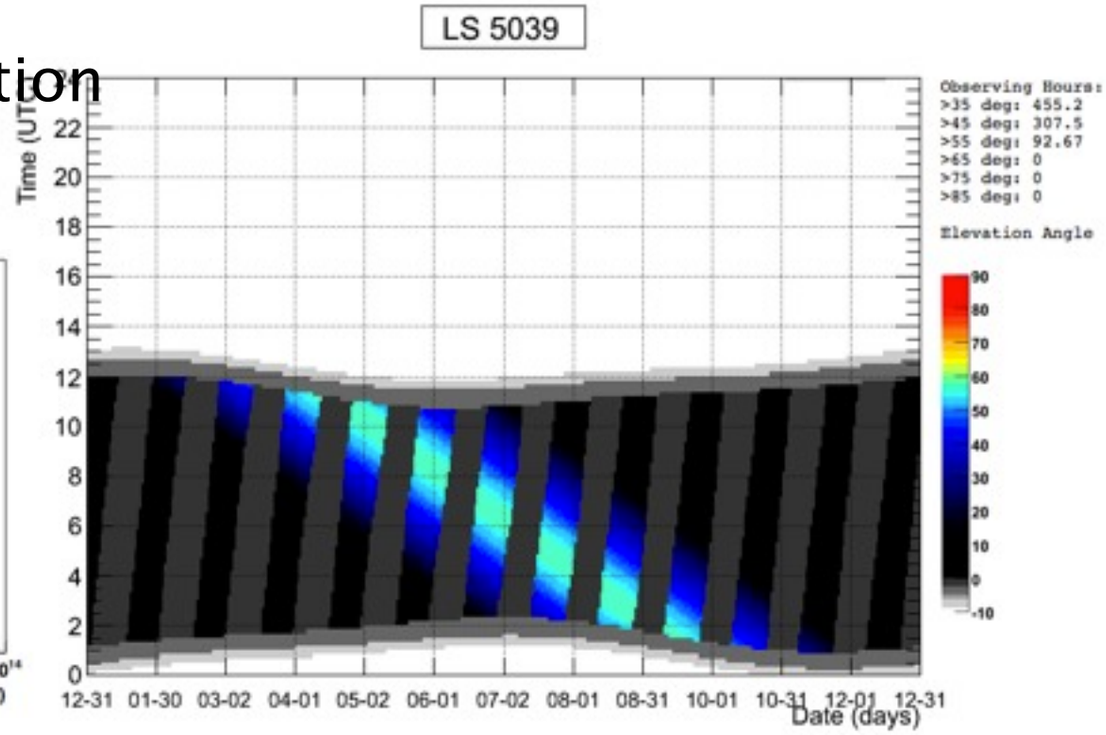
Hawk

Galactic: TeV Binaries

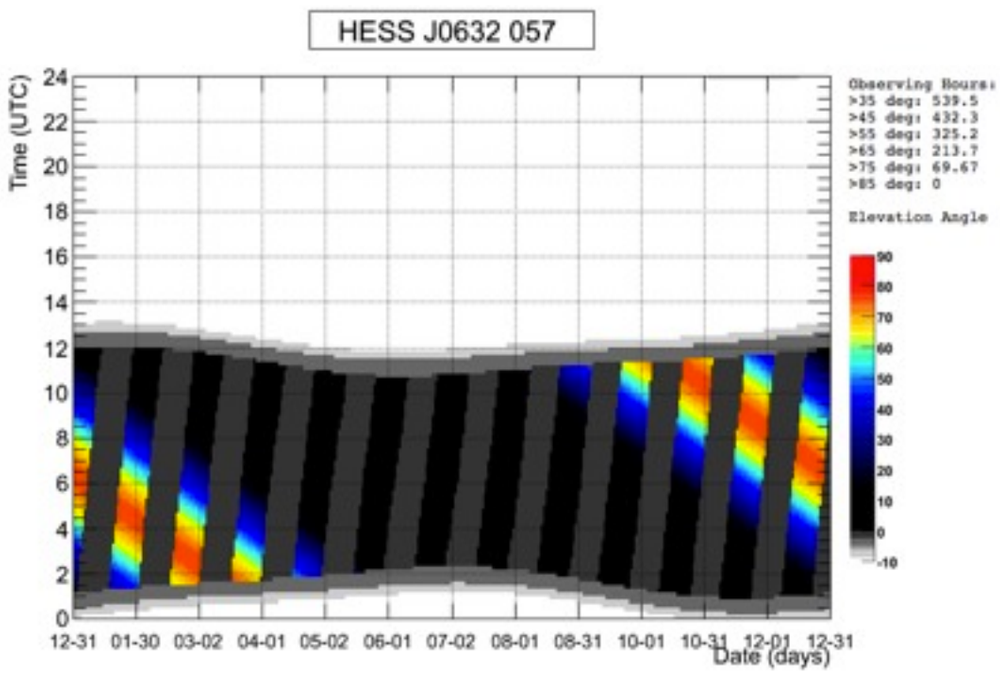
LS 5039: orbital period 3.9 days
reach for VERITAS: culmination at < 45° elevation

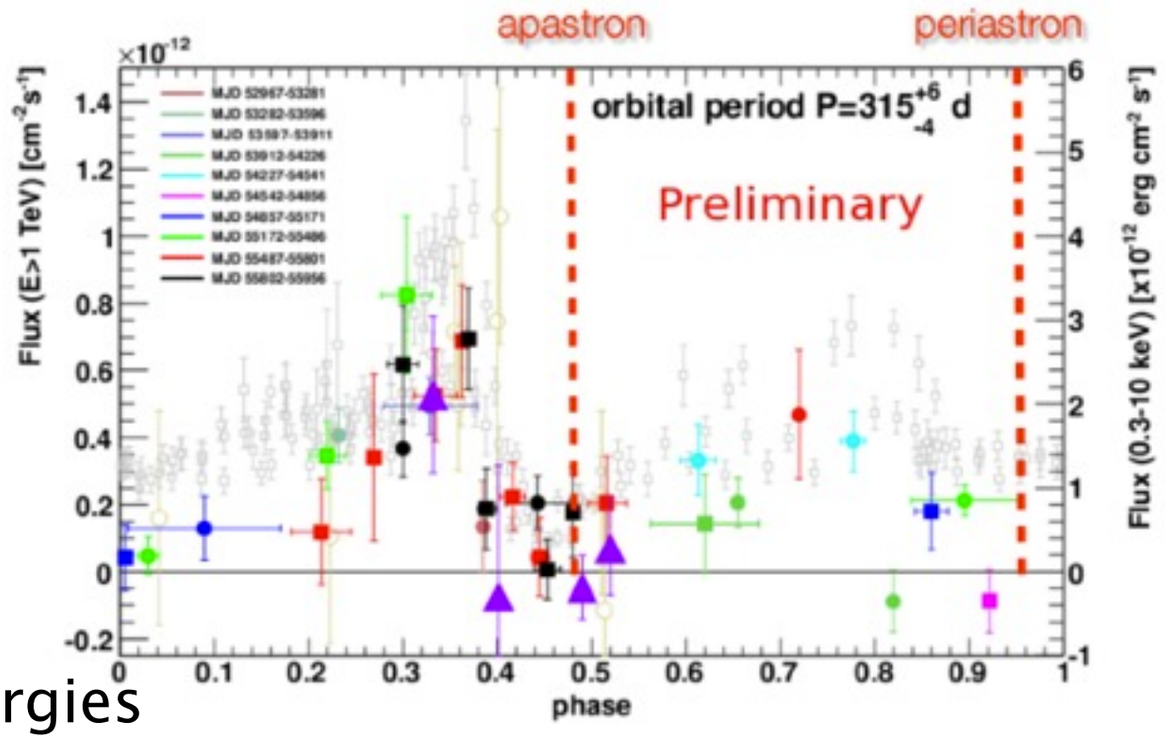






HESS J0632+057: orbital period ~315 days





- HAWC can monitor emission to highest energies
- identify other potential TeV binary targets

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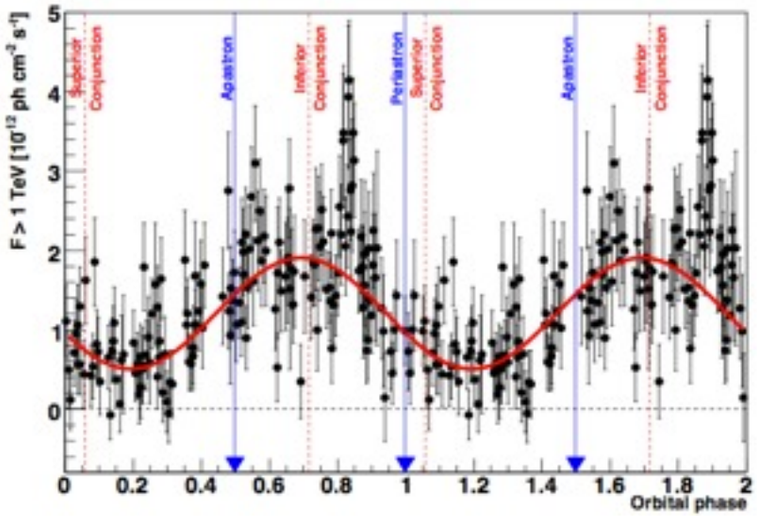

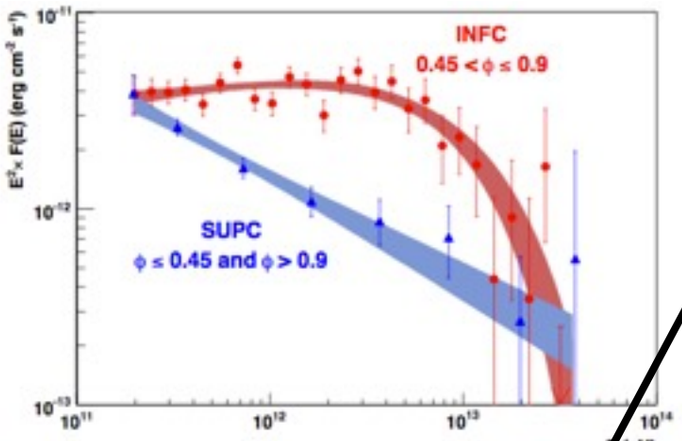

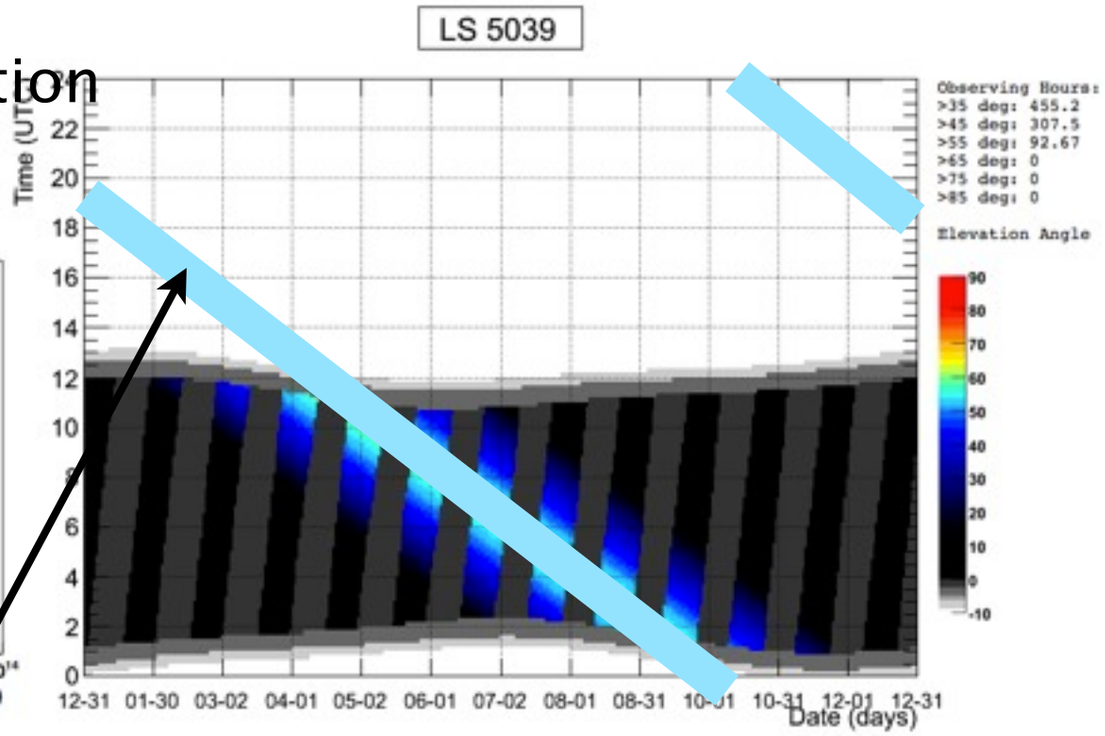

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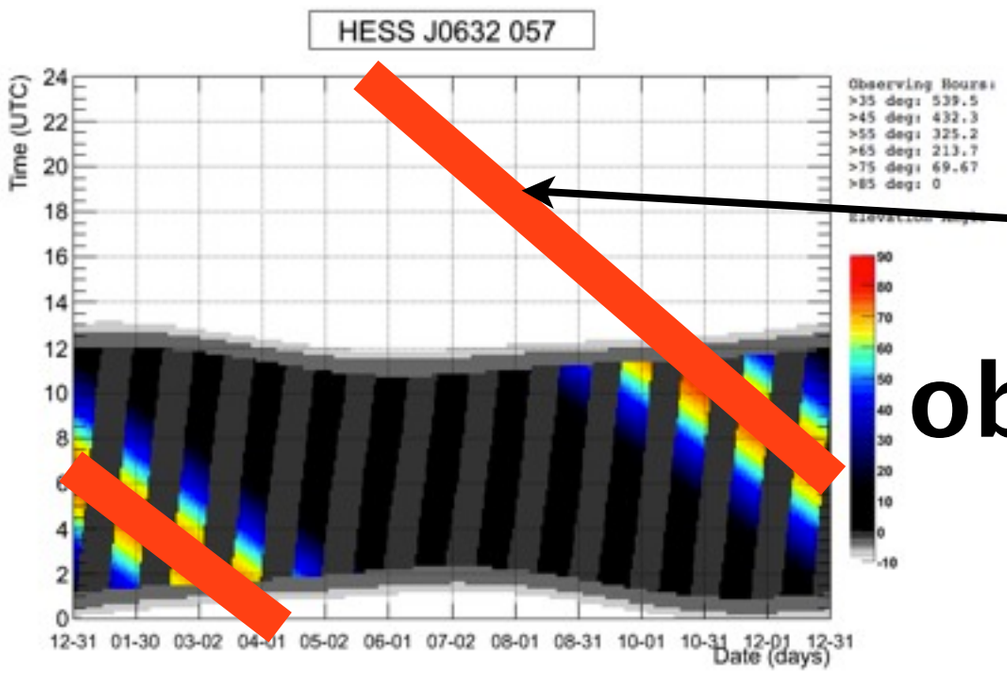
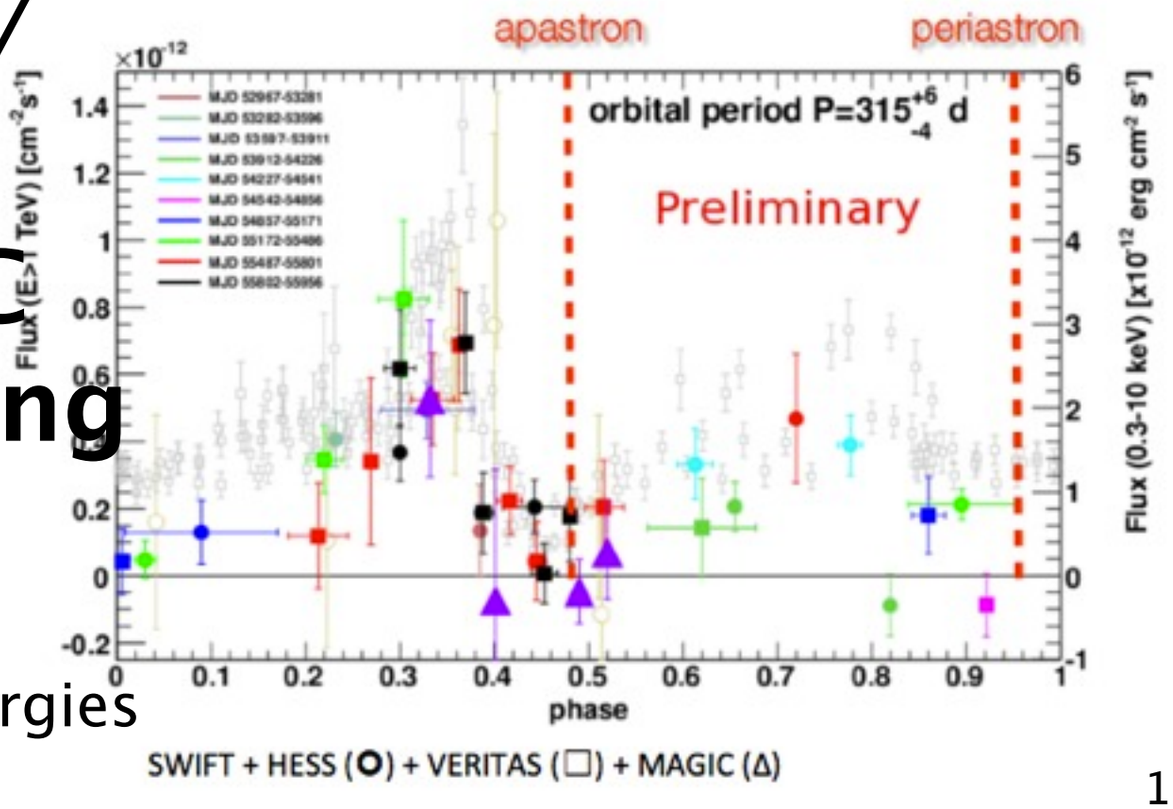


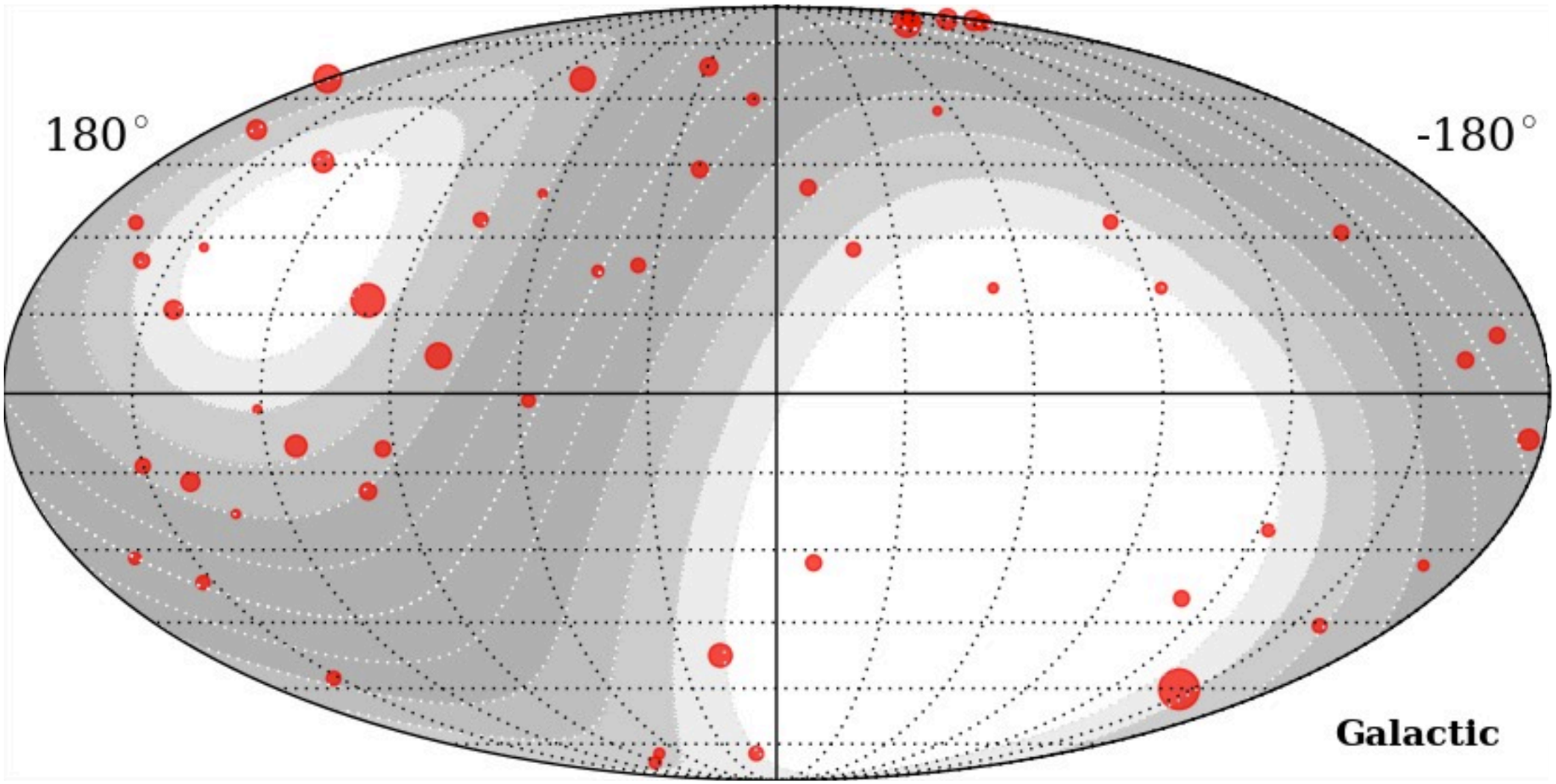
HAWC observing



- HAWC can monitor emission to highest energies
- identify other potential TeV binary targets

Extragalactic: Blazars

HAWC can contribute to blazar population studies by providing unbiased measurements of steady-state quiescent emission, flare strength and frequency, etc.



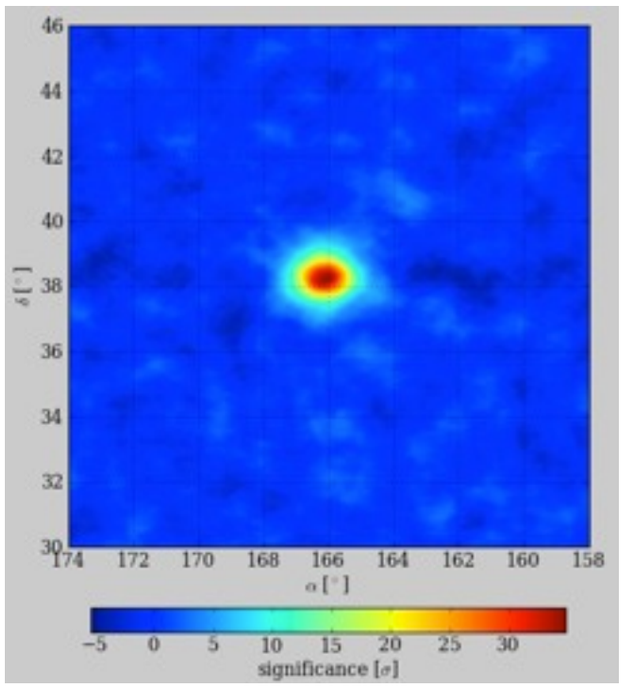
Many known TeV blazars in HAWC's field of view; possibility for new discoveries with detailed VERITAS follow-up observations. It's worth thinking now about how to define our follow-up strategy.

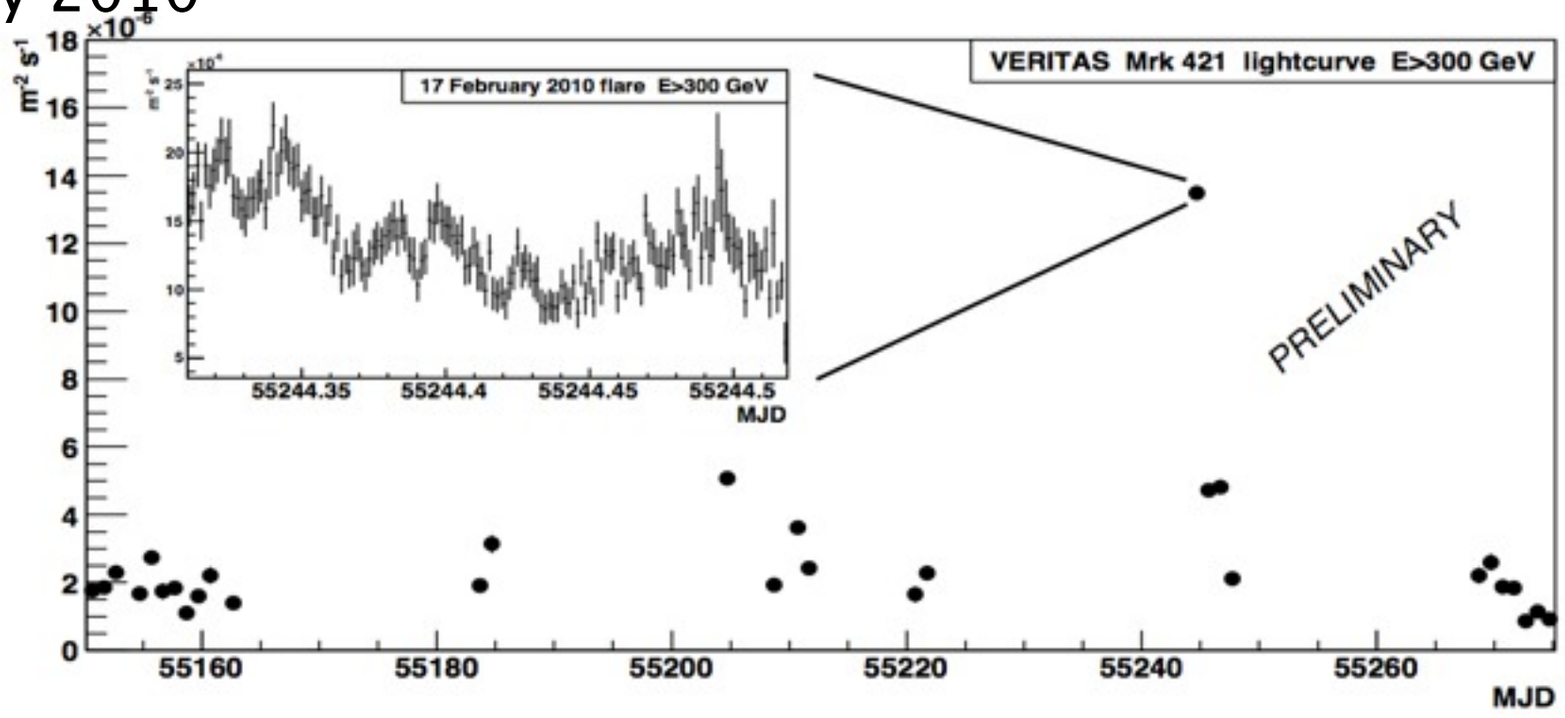
Extragalactic: Blazars

- HAWC can trigger VERITAS observations of especially bright flares (see Asif's talk later today)
- HAWC can monitor VERITAS-detected flares to determine the average flux over multi-day timescales

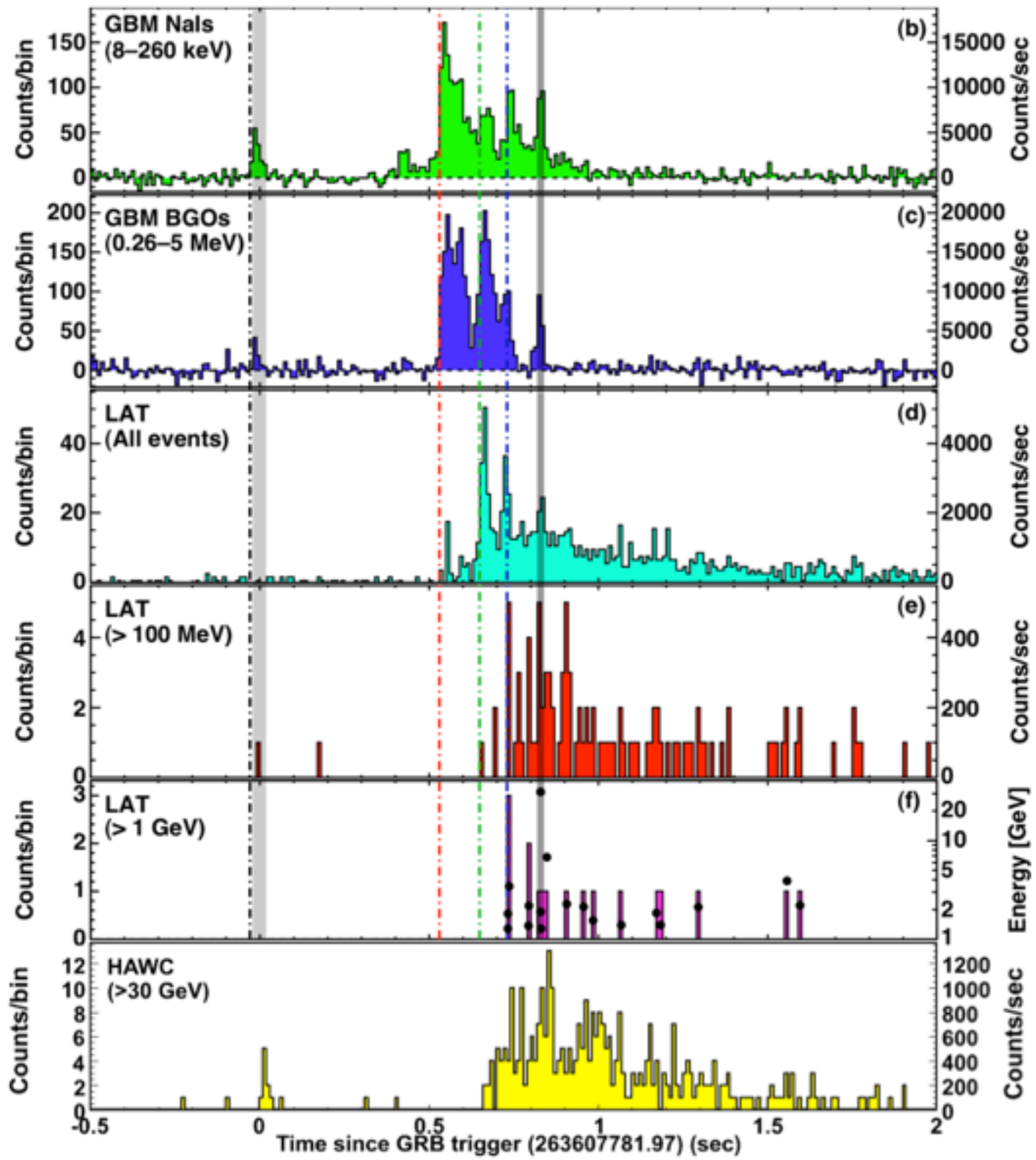
source strength	HAWC-111 time to 5 sigma	HAWC-300 time to 5 sigma	VERITAS time to 5 sigma
0.3 Crab	~1 month	<2 days	~10 minutes
1 Crab	~4 days	~4 hours	< 1 minute
3 Crab	~10 hours	~30 minutes	~6 seconds

HAWC-300 simulation of light curve from Mrk 421 flare in February 2010





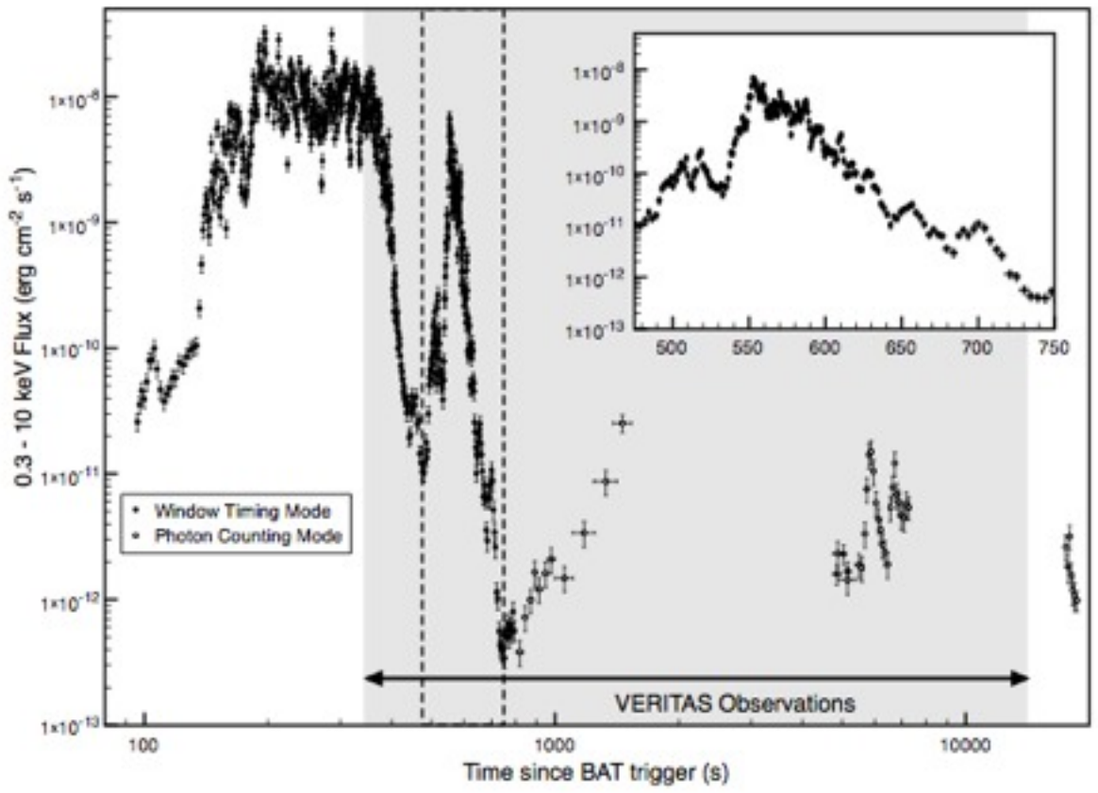
Extragalactic: GRBs



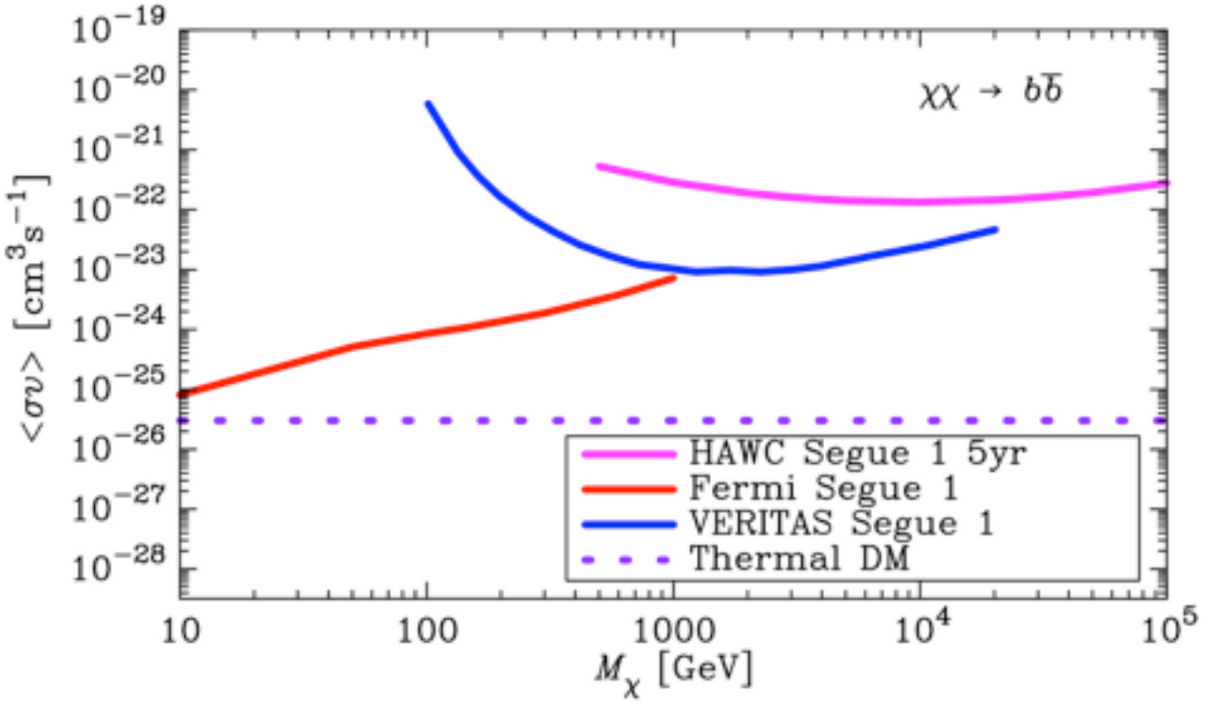
GRB 090510 (HAWC simulated)

- joint VERITAS–HAWC analysis can constrain the time profile of any high-energy emission

GRB 080310

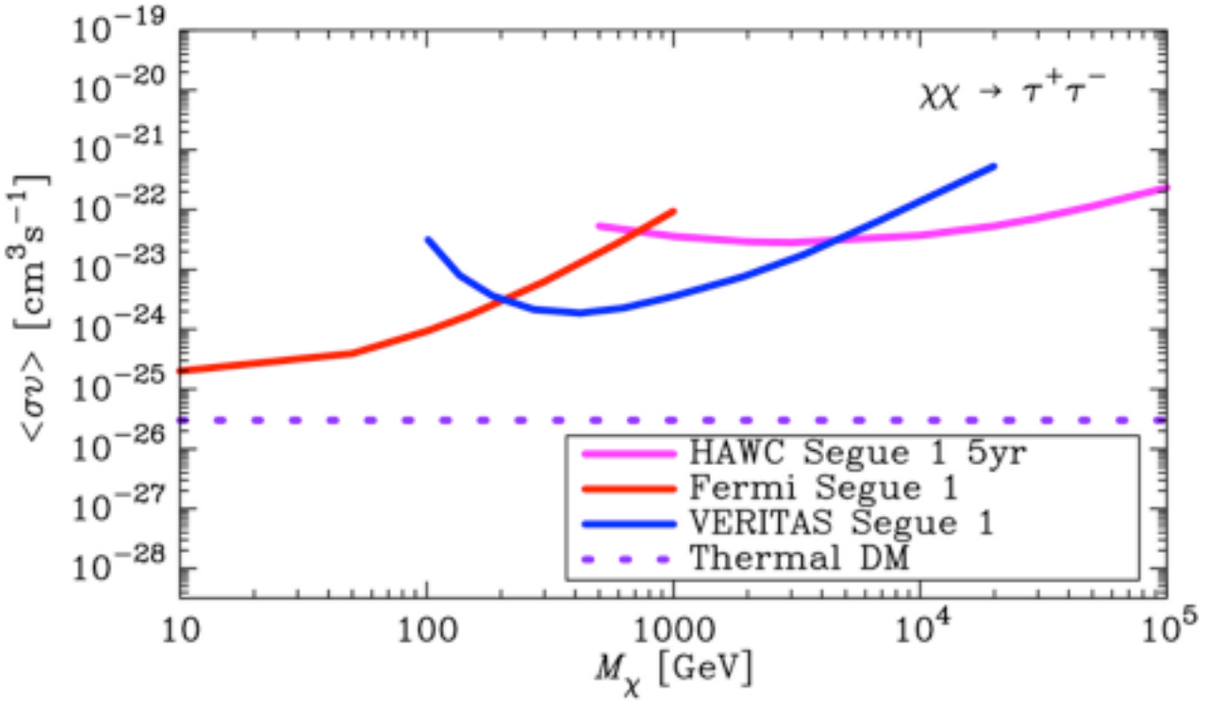


Dark Matter



HAWC 5-year limit to Segue 1, complementing Fermi and VERITAS limits.

bbar channel



tau channel

see Pat Harding's talk later today

Outlook

- Complementary instruments
  - VERITAS for in-depth analysis on sources
  - HAWC for triggering and monitoring many sources

- Galactic science
  - source morphology
  - spectral modeling, including high-energy cutoff
  - TeV binaries: emission characteristics by phase

- Extragalactic science
  - long-term blazar monitoring
  - flare alerts
  - GRB spectral and time-domain analysis

- Dark matter
  - jointly cover mass range from 100 GeV to 100 TeV

- Many opportunities for HAWC-VERITAS collaboration