HAWC Blind Searches for Steady Sources

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for the HAWC Collaboration
November-12-2015
6th International Fermi Symposium

HAWC
High Altitude Water Cherenkov
Gamma-Ray Observatory

Mapping the Northern Sky in High-Energy Gamma Rays

HAWC Observatory

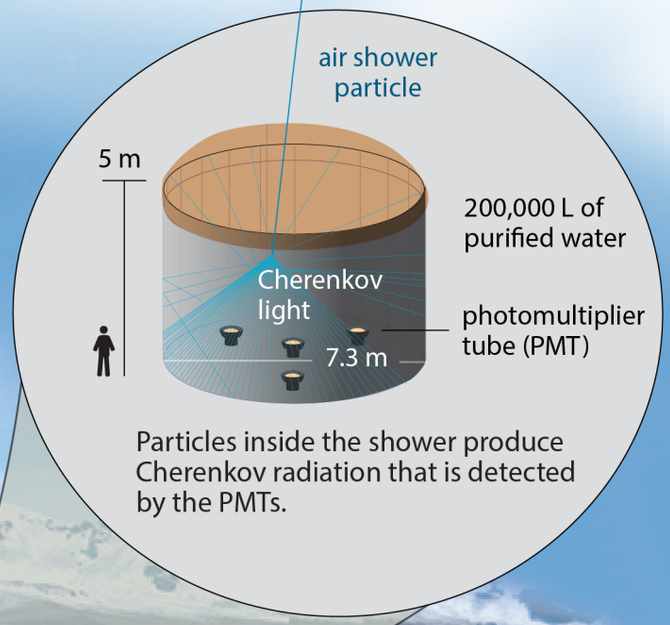
HAWC operates day and night, providing a large field of view for the observation of the highest energy gamma rays.

Pico de Orizaba
(5,626 m)

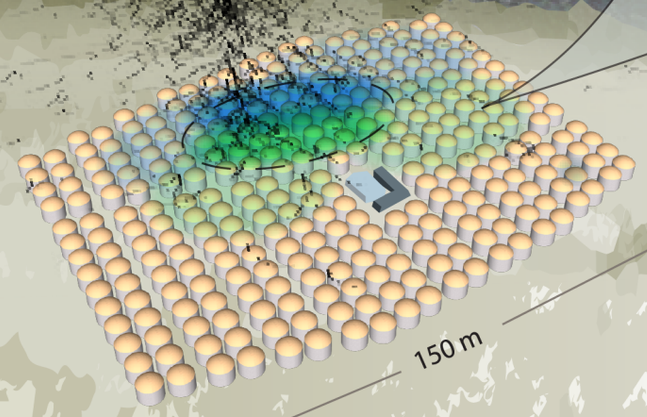
HAWC is located at 4,100 m above sea level, covering an area of 20,000 m^2.

Water Cherenkov tank

HAWC comprises an array of 300 tanks that record the particles created in gamma-ray and cosmic-ray showers.



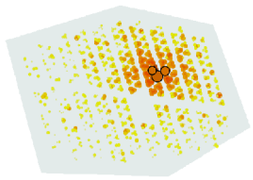
Particles inside the shower produce Cherenkov radiation that is detected by the PMTs.



Gamma rays vs cosmic rays

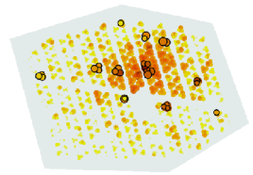
HAWC selects gamma rays from among a much more abundant background of cosmic rays.

gamma-ray shower



"hot" spots concentrate around the core

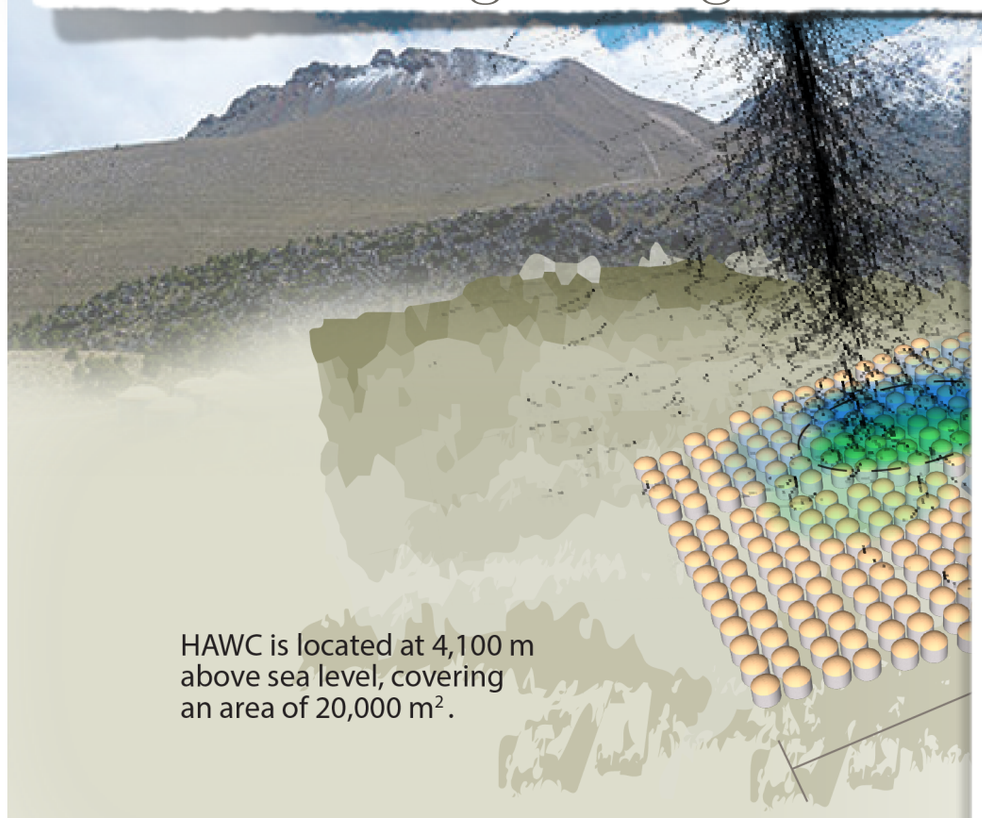
cosmic-ray shower



"hot" spots are more dispersed

HAWC is a good survey instrument

- >95% duty cycle
- Instantaneous field of view 2 sr
- Survey 2/3 of the sky, DEC -26 to +64 degrees, in 24 hours
- Sensitive to 100 GeV - 100 TeV gamma rays
- Greater than 5.5 sigma on Crab per day
- 0.4 - 1.3 degree angular resolution



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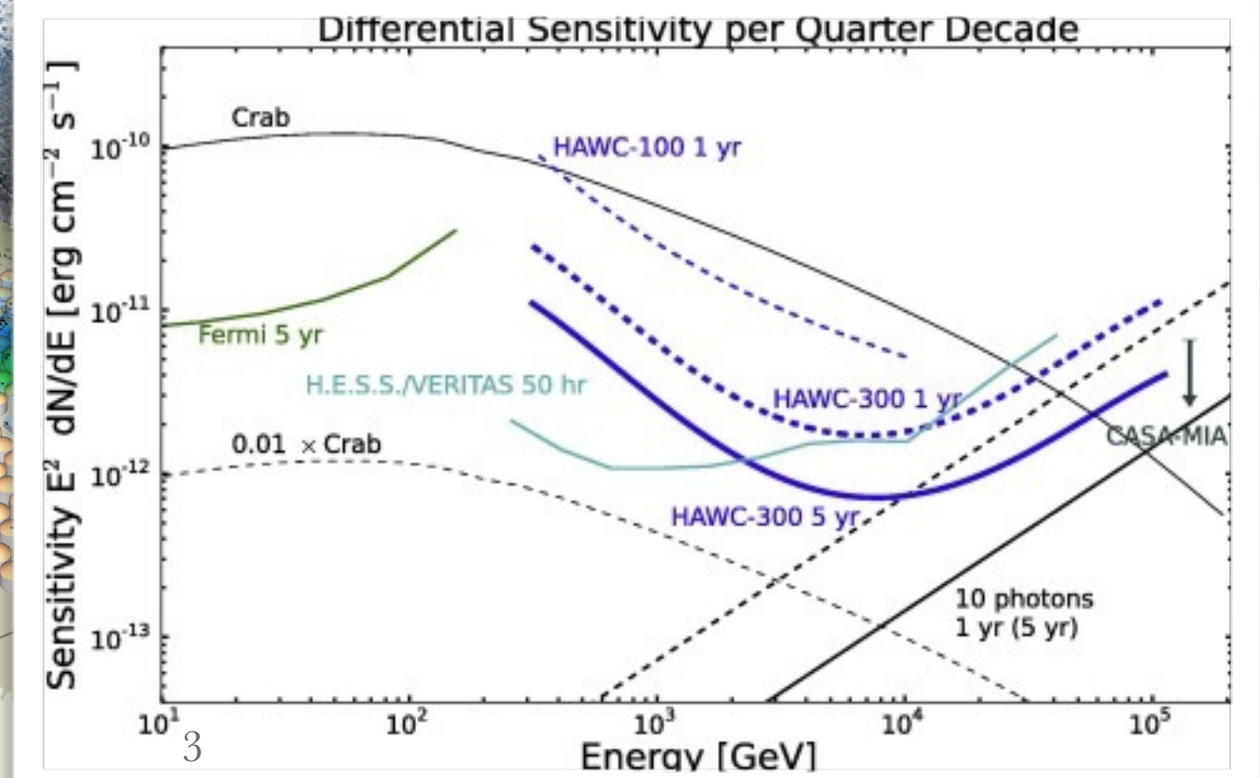
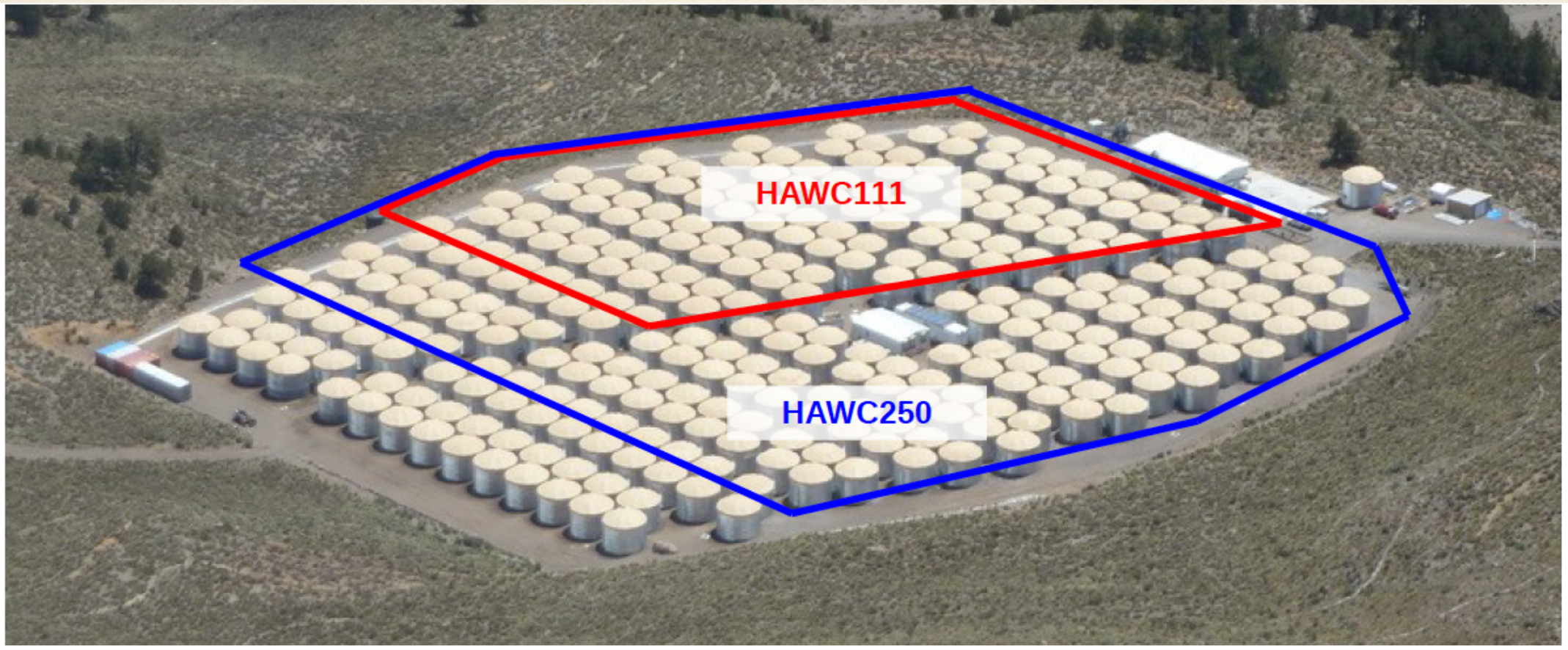


HAWC collected data using partially built detector

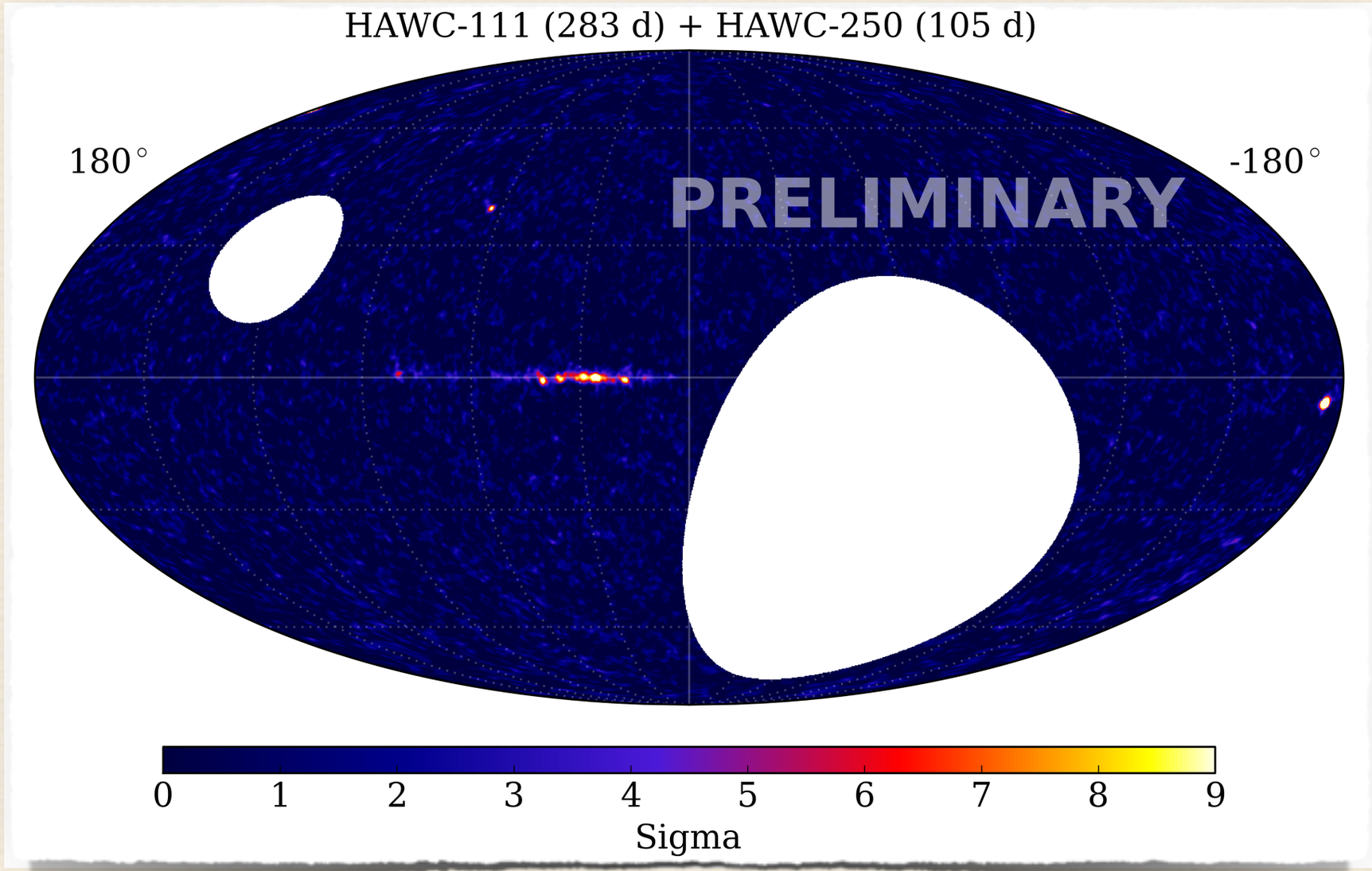


HAWC 111 - Aug/2/2013 — Jul/7/2014 (106 - 133 WCDs)
HAWC 250 - Nov/26/2014 — May/6/2015 (247 - 293 WCDs)
HAWC 300 - Inaugurated in March/19/2015 (300 WCDs)
Results from HAWC-111 configuration is already published.

arXiv:1509.05401
Search for TeV Gamma-Ray Emission from Point-like Sources in the Inner Galactic Plane with a Partial Configuration of the HAWC Observatory

HAWC time-integrated map

This is an ideal place to perform an unbiased blind search for new TeV source.



One interesting class of possible sources would be the sources are ones that do not have a low-energy counterpart.

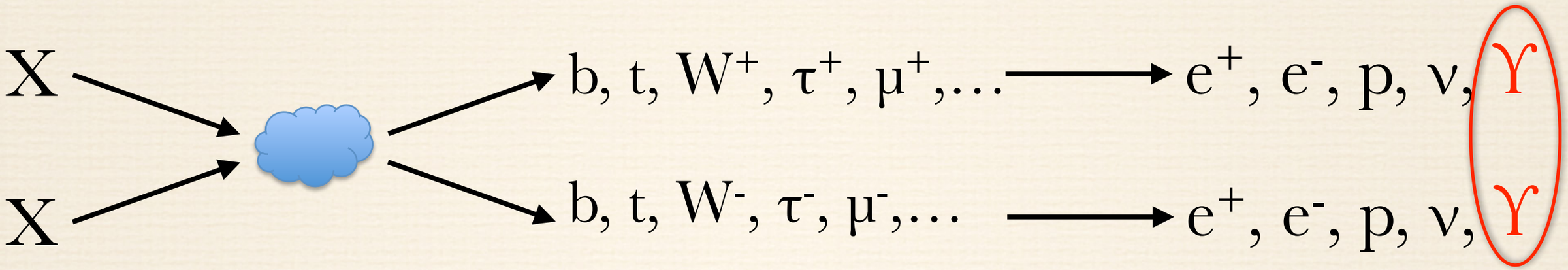
Possible Astrophysical sources for Indirect Dark Matter Detection

- High-latitude, TeV sources without low energy counter parts
- Dwarf galaxies
- The Milky Way Galactic Center
- Galaxies and Galaxy Clusters

HAWC will search for DM signature from every possible astrophysical source in the HAWC sky coverage.

Indirect detection of dark matter

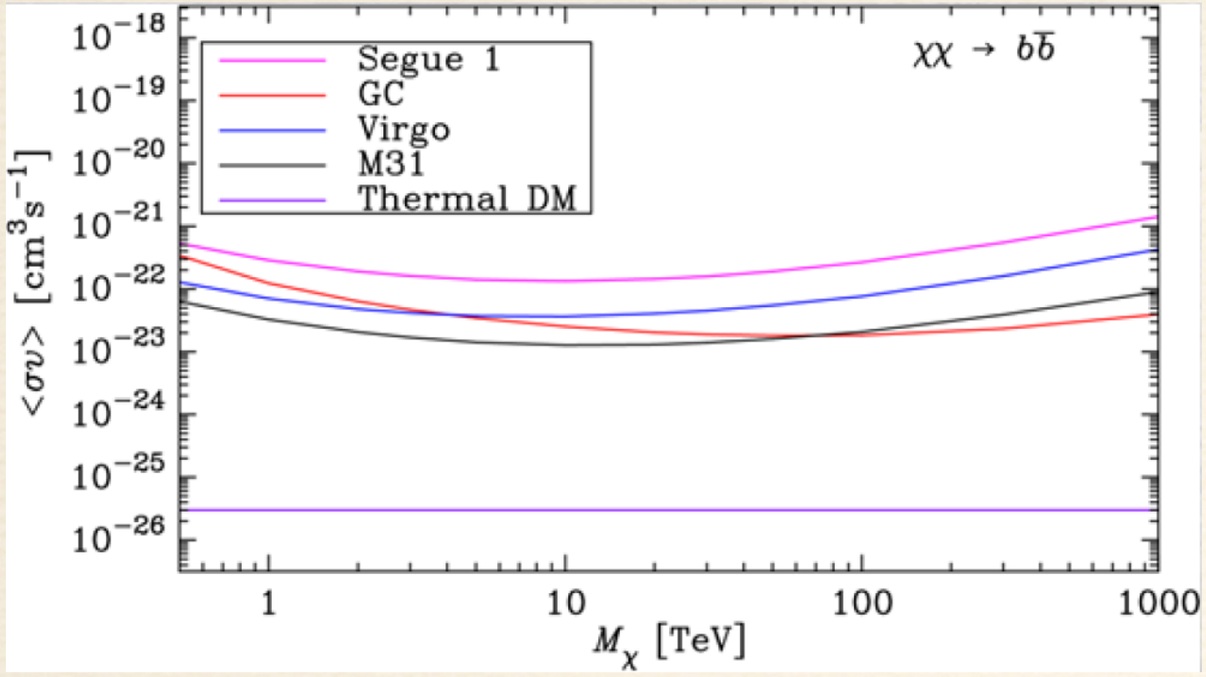
TeV mass WIMP (Weakly Interacting Massive particles) could produce Very High Energy gamma rays during their annihilations and decays.

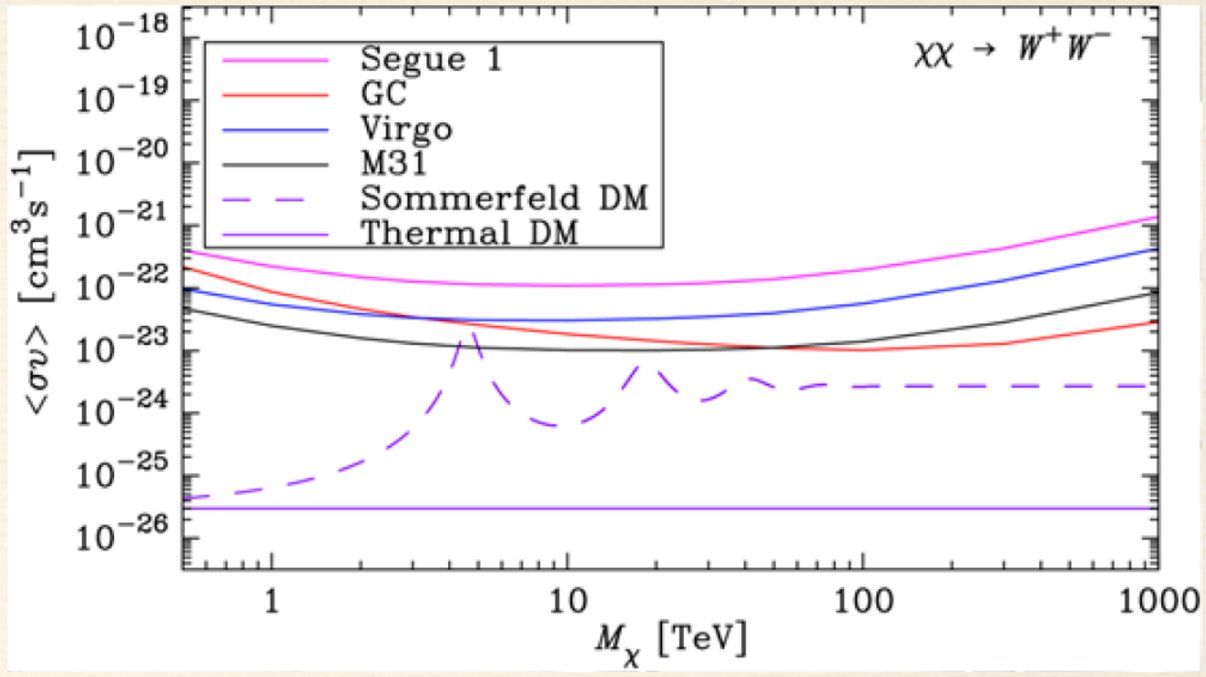


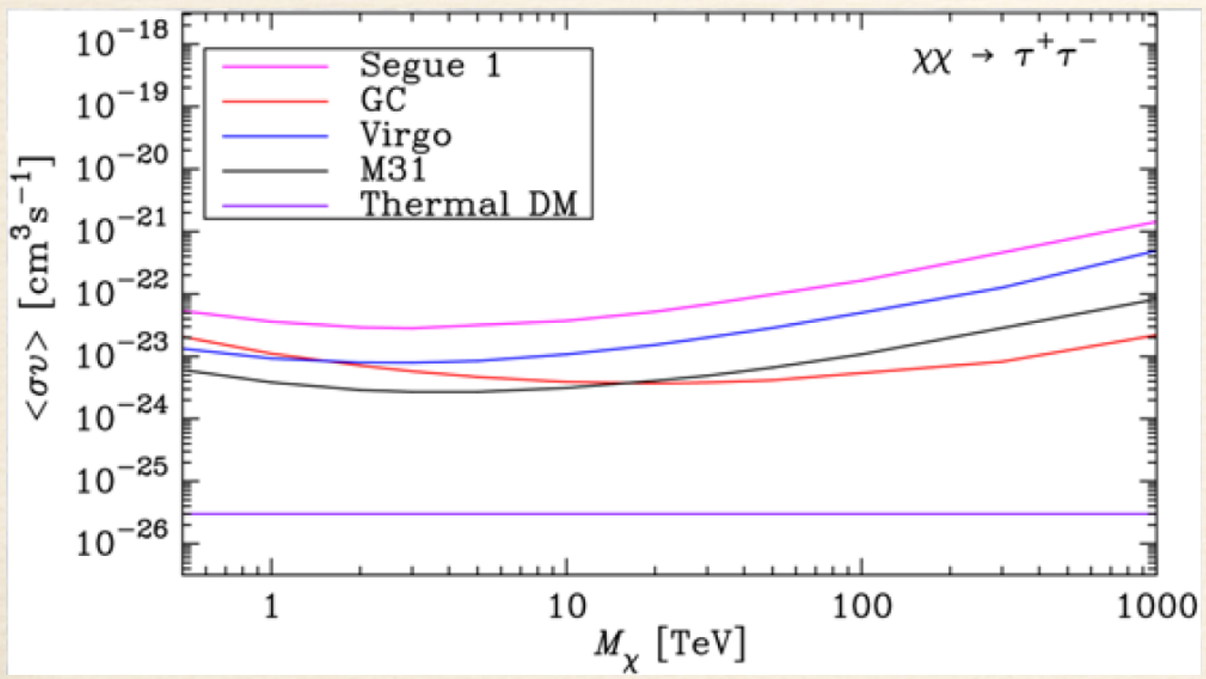
F gamma ray depends on

- Dark Matter particle mass
- Dark Matter particle lifetime
- Dark Matter density
- Gamma rays produced per decay
- Velocity Averaged Annihilation Cross section

HAWC Sensitivity to Dark Matter

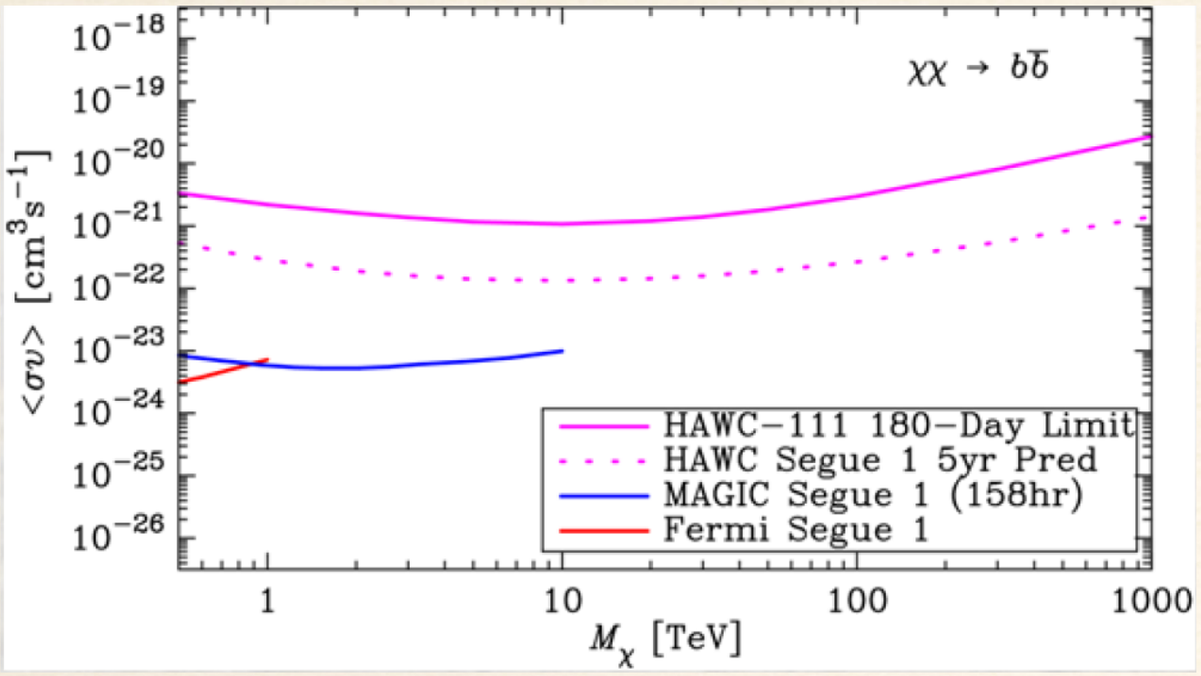


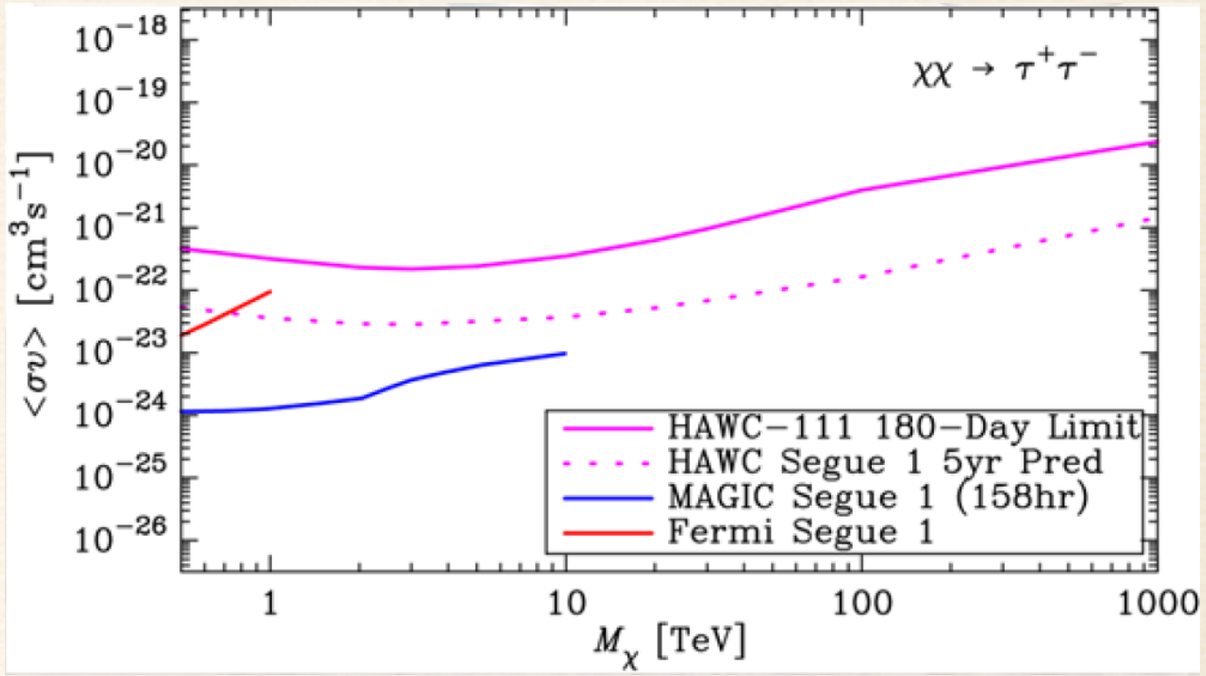




HAWC will search for dark matter from other sources too, including diffuse gamma-ray background and near by dark matter substructures.
Refer : arXiv:1508.04352

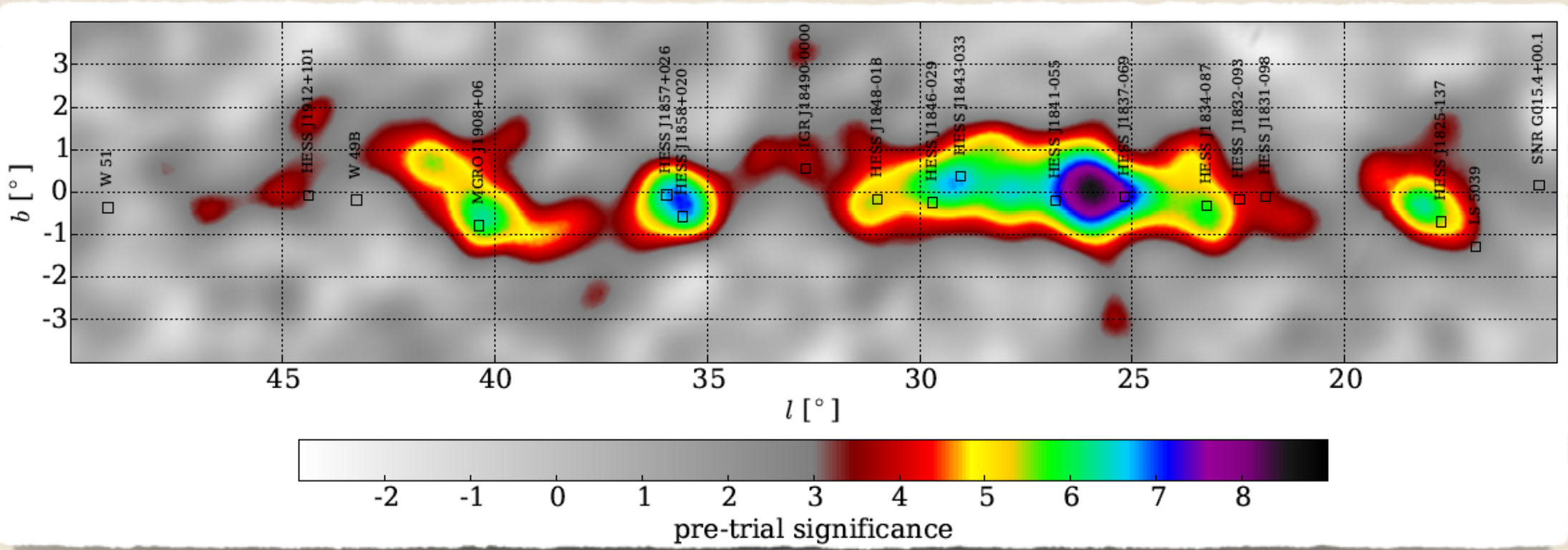
HAWC Measured limits on dark matter cross section





Limits on the dark matter cross section was placed using 180 days of HAWC 111 (1/3 of the detector) data.
Refer : arXiv:1508.04470

Hunting for new sources



- We, search for TeV Gamma-Ray Emission from Point-like Sources in the Inner Galactic Plane with HAWC-111 configuration.
- Results are published in arXiv:1509.05401
- Flux measurements for 10 detections and candidates are published

Partnership with IACTs

What HAWC could improve joining with IACTs

HAWC

IACT

Good for surveying

- Large FOV
- Duty cycle > 95%
- <50% Energy resolution
- 0.4 - 1.3 Angular resolution
- 5.5 sigma from Crab per transit

Good for detailed pointed observations

- 15% Energy resolution
- 0.1 - 0.14 Angular resolution
- 5 sigma from Crab in few minutes

First Follow-up Observation of HWC candidates are performed by IACTs

- 1HWC J1904+080c has a post-trials significance of 3.9 sigma
- No previously reported GeV-TeV detection associated with this source
- HAWC measured flux is, 1.38 x 10^{-11} $cm^{-2}s^{-1}$ above 350 GeV
- For this data set (1/3 of the HAWC detector) the HAWC PSF measured using Crab Nebula varies from 2.5 to 0.6 degrees

VERITAS follow up observation

- Exposure 150 minutes
- No detection of a point source at this location
- 99% CI flux upper limit is 1.81 x 10^{-12} $cm^{-2}s^{-1}$ above 350 GeV
- VERITAS PSF is 0.1 degree at 1 TeV
- It is possible
  - that HAWC J1904+080c is a background fluctuation in HAWC 111 data set
  - that the source candidate has an extent larger that VERITAS PSF

MAGIC follow-up observations

1HWC J1904+080c

- Exposure 5.44 hours
- No detection of a point like source
- 95% CI upper limit integral flux is 3.7×10^{-12} cm^{-2} s^{-1}
  - above 300 GeV
  - assuming a point like source
  - at the HAWC nominal position
  - for a Crab-like spectrum

Another hotspot

- Exposure 1.5 hours
- No detection of a point like source
- 95% CI upper limit integral flux 5.1×10^{-12} cm^{-2} s^{-1}
  - above 300 GeV
  - assuming a point like source
  - at the HAWC nominal position
  - for a Crab-like spectrum

Conclusions

- HAWC is running getting data
- HAWC partially built array proved that it could provide DM limits
- HAWC IACT partnership will increases the discovery potential
- HAWC IACT partnership is already active

"Thank you, questions?"