The HAWC Observatory

Tyce DeYoung
Department of Physics
Pennsylvania State University
for the HAWC Collaboration

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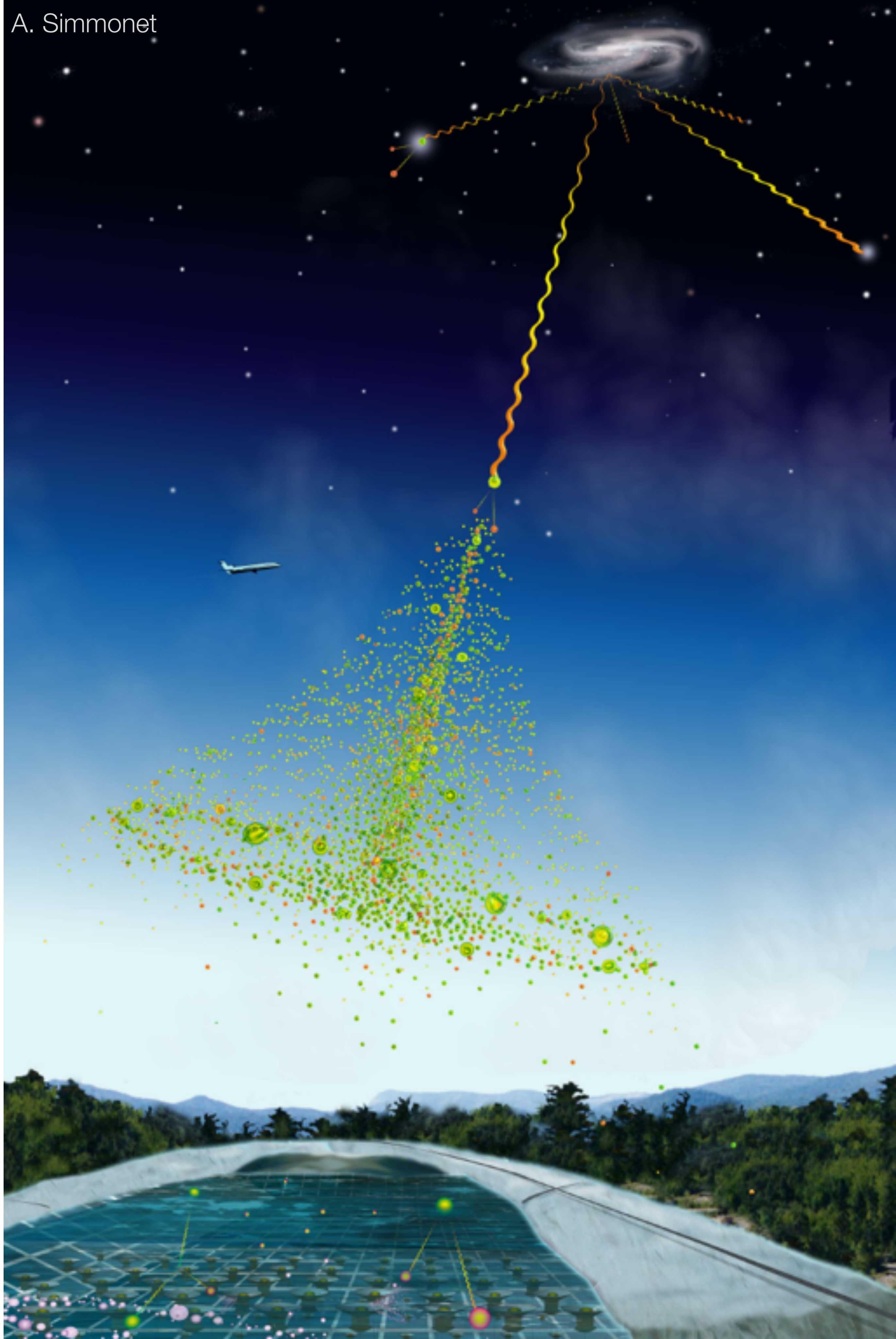
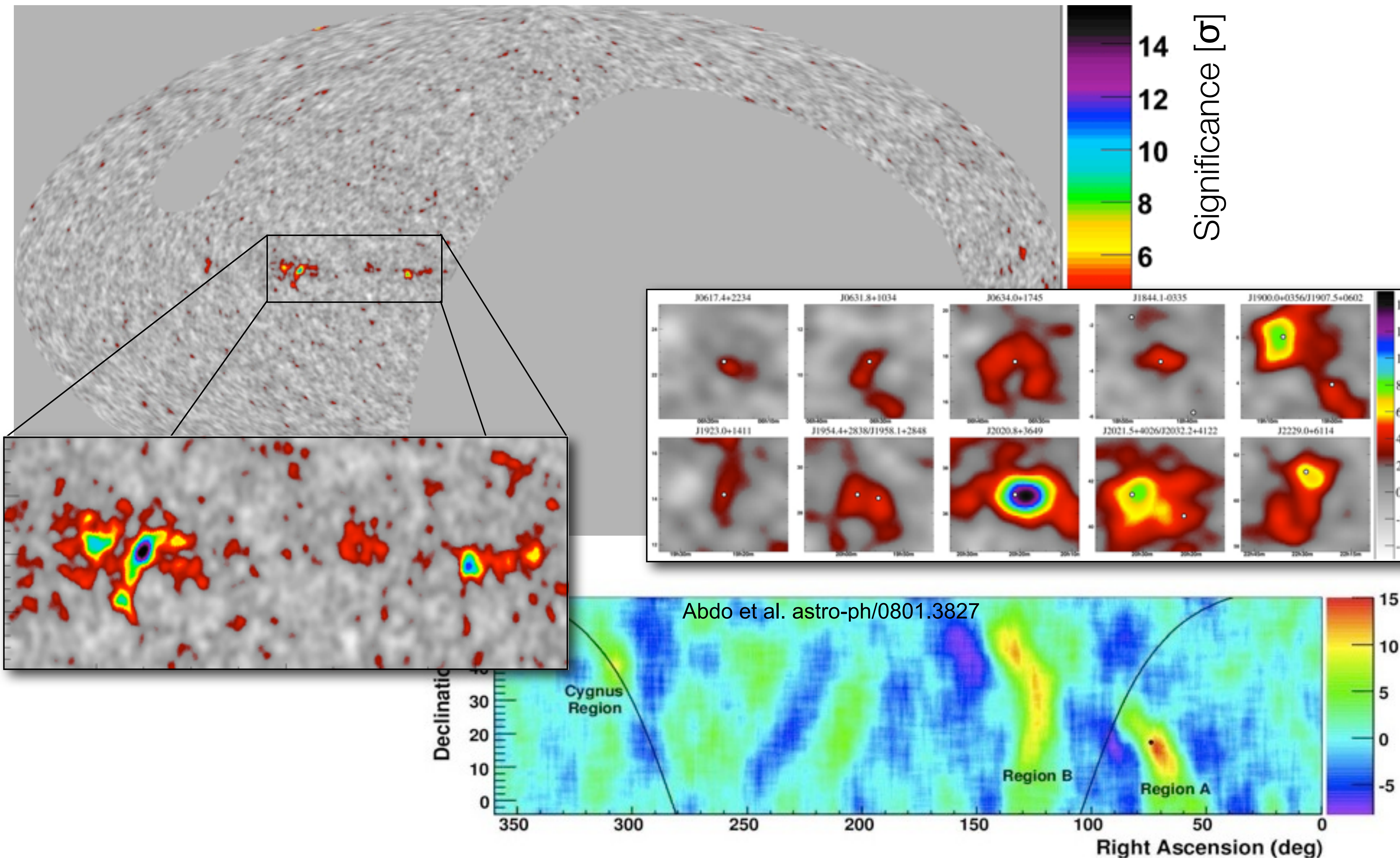
Extensive Air Shower Gamma Ray Telescopes

- Gamma ray interacts in the atmosphere, forms particle cascade
  - Particles produce Cherenkov light in water at ground level
- Reconstruct shower direction from timing of PMT hits across the detector
- Most triggers come from cosmic rays
- Field of view ~2 sr, typical duty factor >95%



Many interesting results from the current generation of EAS gamma ray telescopes



From Milagro to HAWC

- The High Altitude Water Cherenkov Observatory
- Redeploy Milagro detectors at Volcán Sierra Negra, México
  - Increase altitude from 2630 m to 4100 m
  - Increase area from 2,500 m^2 (bottom layer of pond) to 20,000 m^2
  - Segment the Cherenkov medium: separate tanks instead of a single pond
  - Better angular resolution and background rejection, lower energy threshold
- Achieve 10-15 x sensitivity of Milagro
  - Detect Crab at 5σ in 6 hours instead of 3 months
- Cost: ~$13M (NSF, DOE, CONACyT)

The HAWC Collaboration

USA

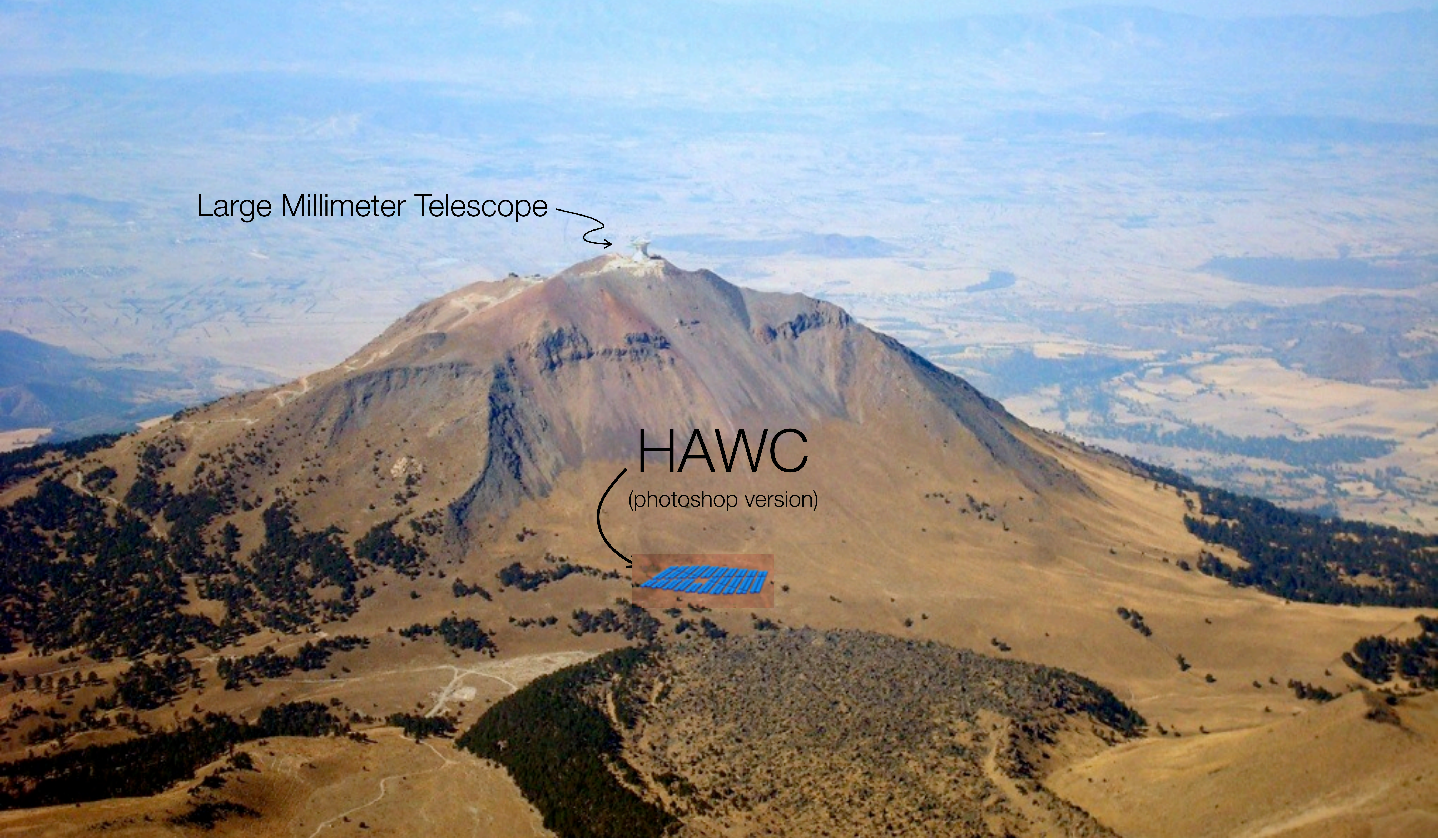
- University of Maryland
- Los Alamos National Laboratory
- University of Alabama
- University of California, Irvine
- University of California, Santa Cruz
- Colorado State University
- George Mason University
- Georgia Institute of Technology
- Goddard Space Flight Center
- Harvey Mudd College
- Michigan State University
- Michigan Technological University
- University of New Hampshire
- University of New Mexico
- Pennsylvania State University
- University of Utah
- University of Wisconsin, Madison

México

- Instituto Nacional de Astrofísica Óptica y Electrónica (INAOE)
- Universidad Nacional Autónoma de México (UNAM)
- Universidad Autónoma de Chiapas
- Universidad de Guadalajara
- Universidad de Guanajuato
- Universidad Michoacana de San Nicolás de Hidalgo
- Centro de Investigación y Estúdios Avanzados (CINVESTAV)
- Benemérita Universidad de Puebla

HAWC Science Goals

- Origins of cosmic rays – measuring gamma ray spectra to 100 TeV
  - Hadronic accelerators should have unbroken spectra beyond 30-100 TeV
  - Galactic diffuse gamma rays probe the distant cosmic ray flux
- Particle acceleration in astrophysical systems – wide field of view, high duty factor observations
  - Measure Gamma Ray Burst spectra at highest energies
  - Trigger multi-wavelength/multi-messenger observations of flaring Active Galactic Nuclei (including TeV orphan flares)
- Unbiased survey of half the sky
  - Study the local TeV cosmic rays and their anisotropy
  - Increased understanding of TeV sources and search for new physics



HAWC

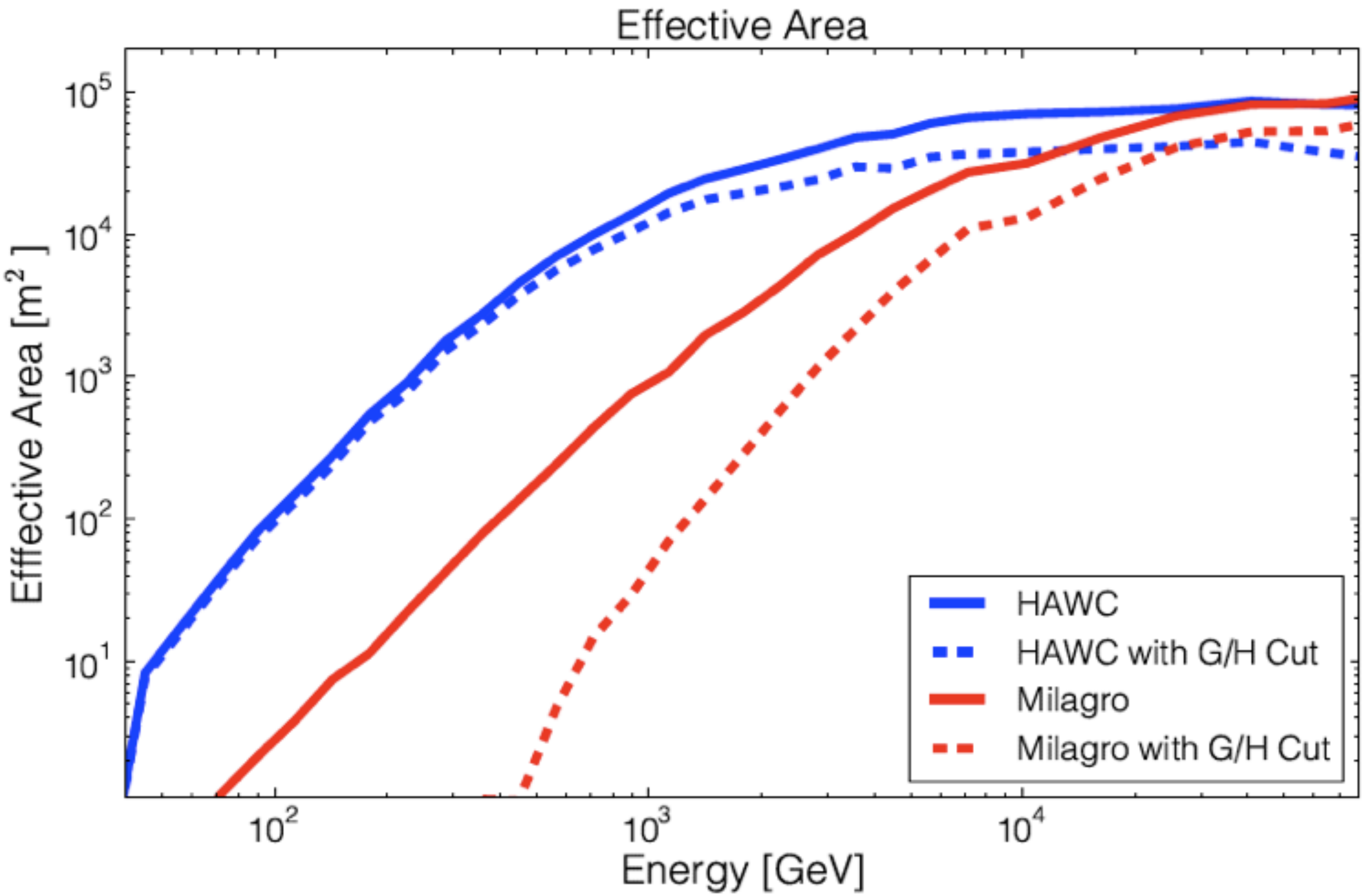
Pico de Orizaba, altitude 4100 m, latitude 18° 59’ N
Two hours drive from Puebla, four from México City
Site of Large Millimeter Telescope (existing infrastructure)


300 Water Cherenkov Detectors
7.2 m diameter x 4.3 m tall, containing 3 PMTs
20,000 m² area, 60% active Cherenkov volume
VAMOS
engineering array

Water Cherenkov Detectors

- Steel shell, assembled in place, with a light-tight, black plastic bladder holding ultra-pure filtered and demineralized water
- Three 8” Hamamatsu PMTs at the bottom of each tank, looking upward

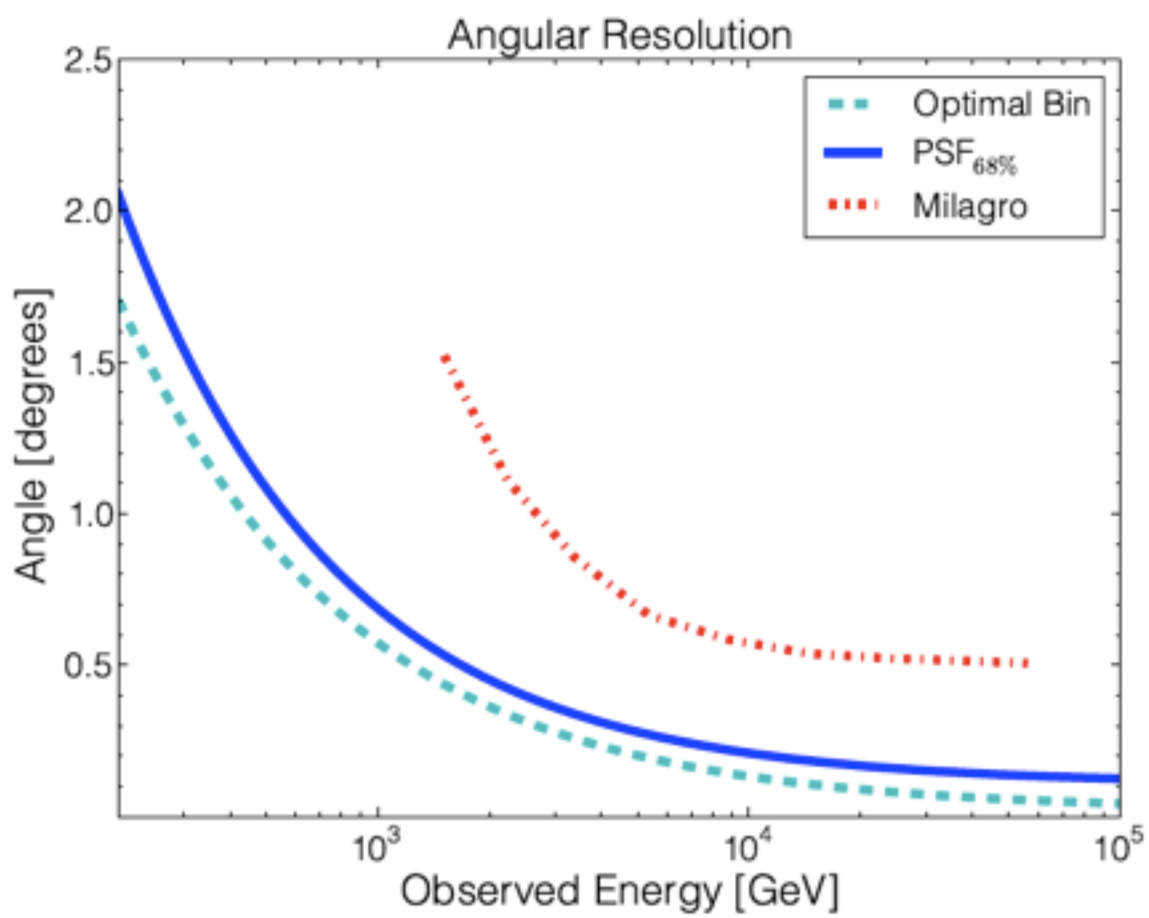
Effective Area and Energy Range

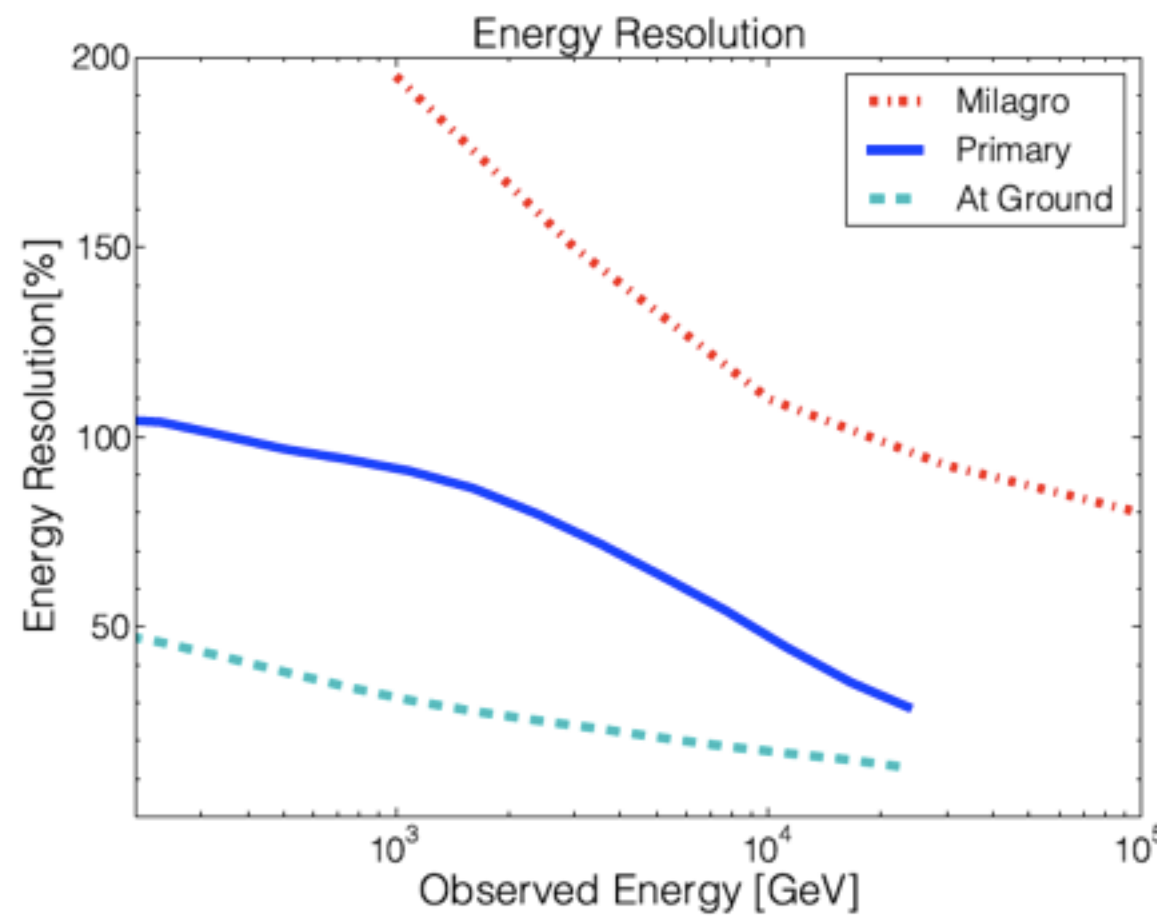


Significantly larger effective area than Milagro, especially at low energies

Still several m^2 effective area as low as 50 GeV

Angular and Energy Resolution





- Resolution much better than with Milagro
  - Higher altitude means more particles reach the detector
  - Improvements in analysis of energy spectra
- Energy resolution dominated by fluctuations in shower development, not detector response

Cosmic Ray Background Rejection

γ

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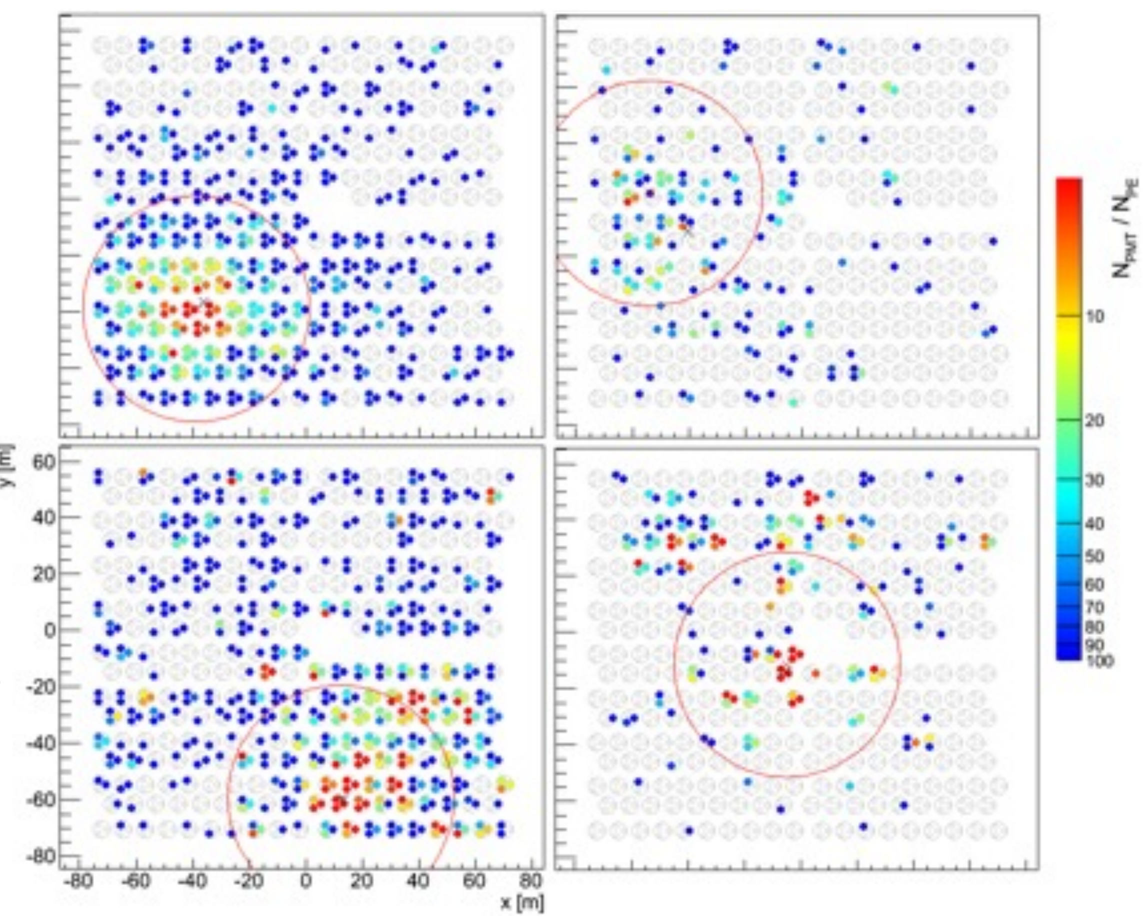
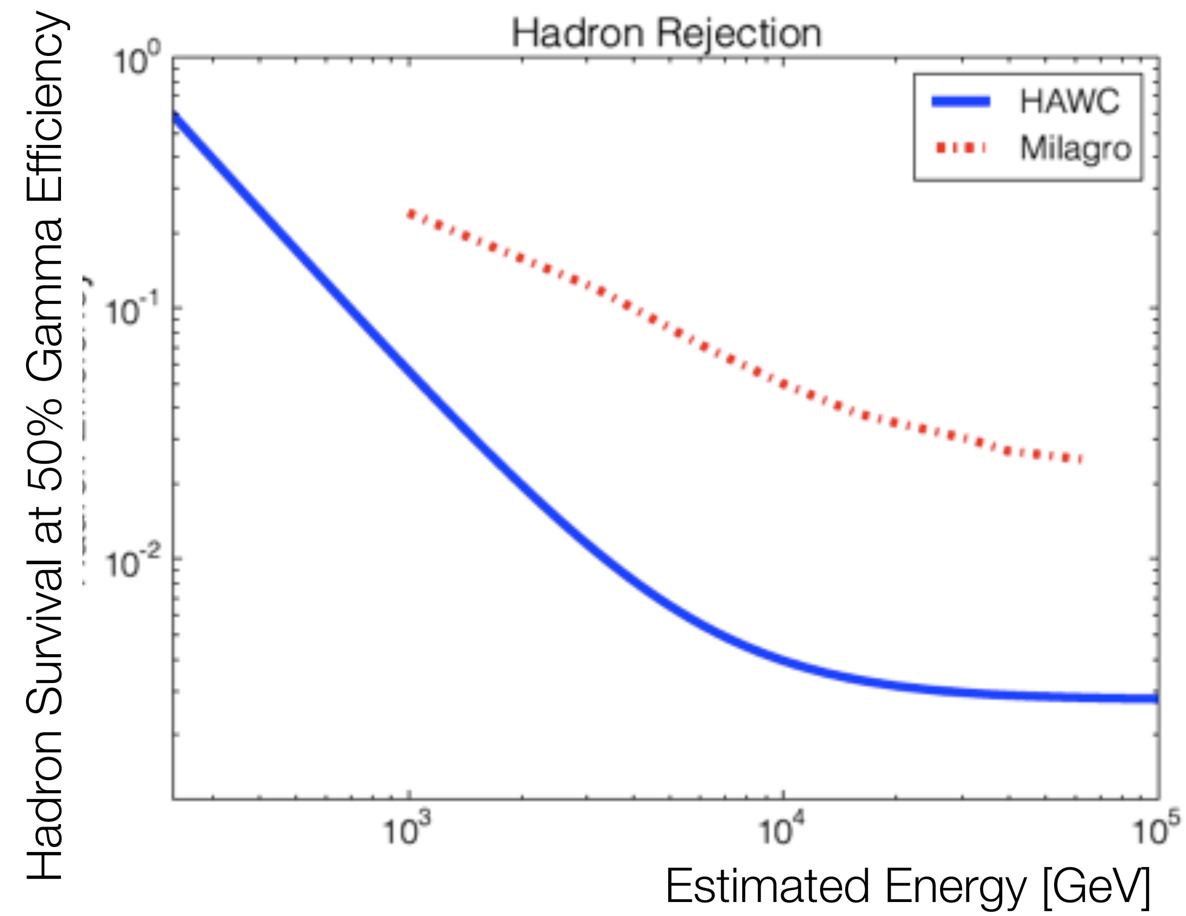


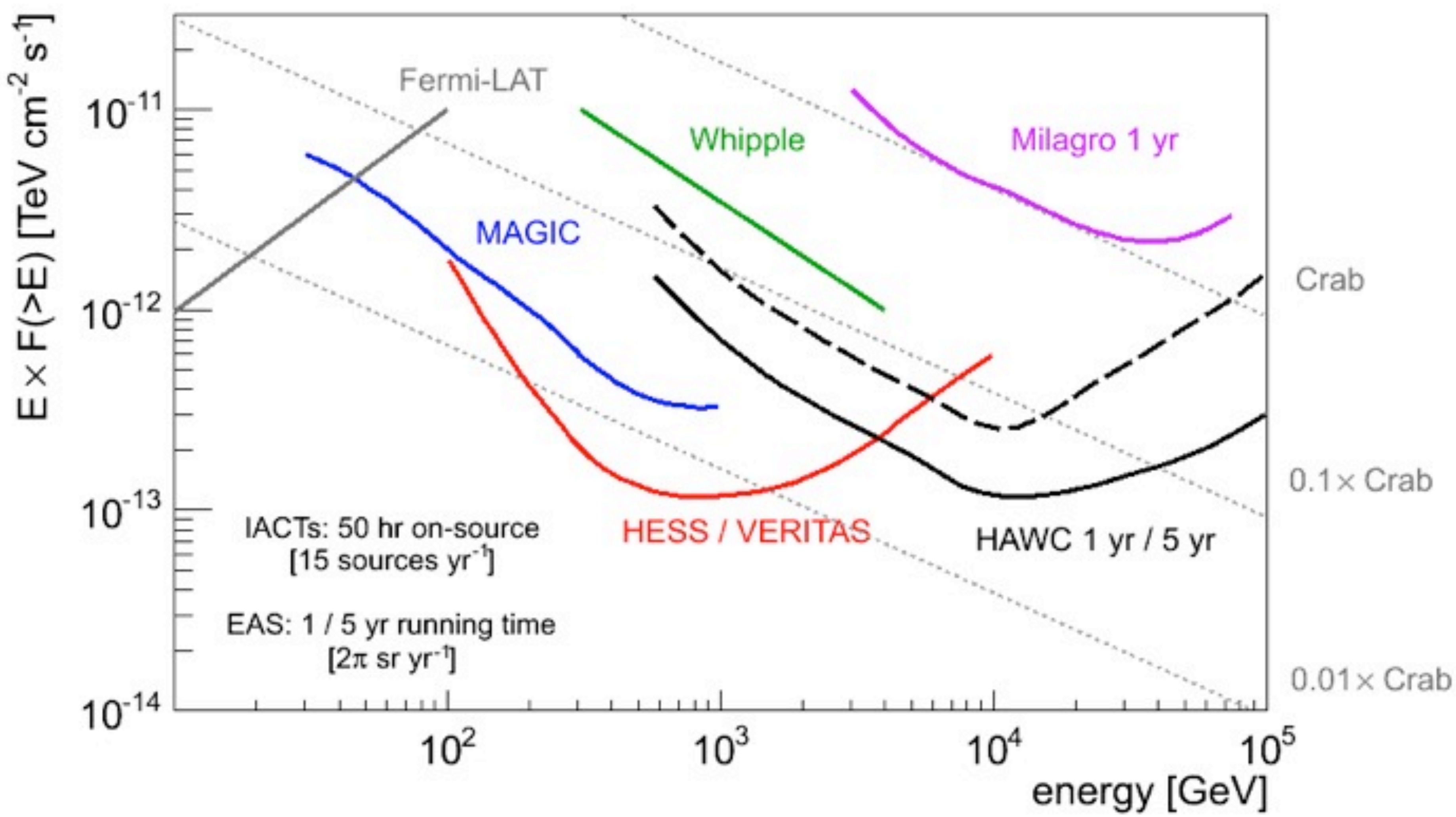


- Hadronic showers produce muons with significant p_T
  - Reject events with large amplitude hits at considerable distance from core
- Larger detector size increases power of this technique
  - Nearly an order of magnitude improvement over Milagro

Sensitivity to Point Sources

- Long integration times lead to excellent sensitivity at highest energies (> few TeV)

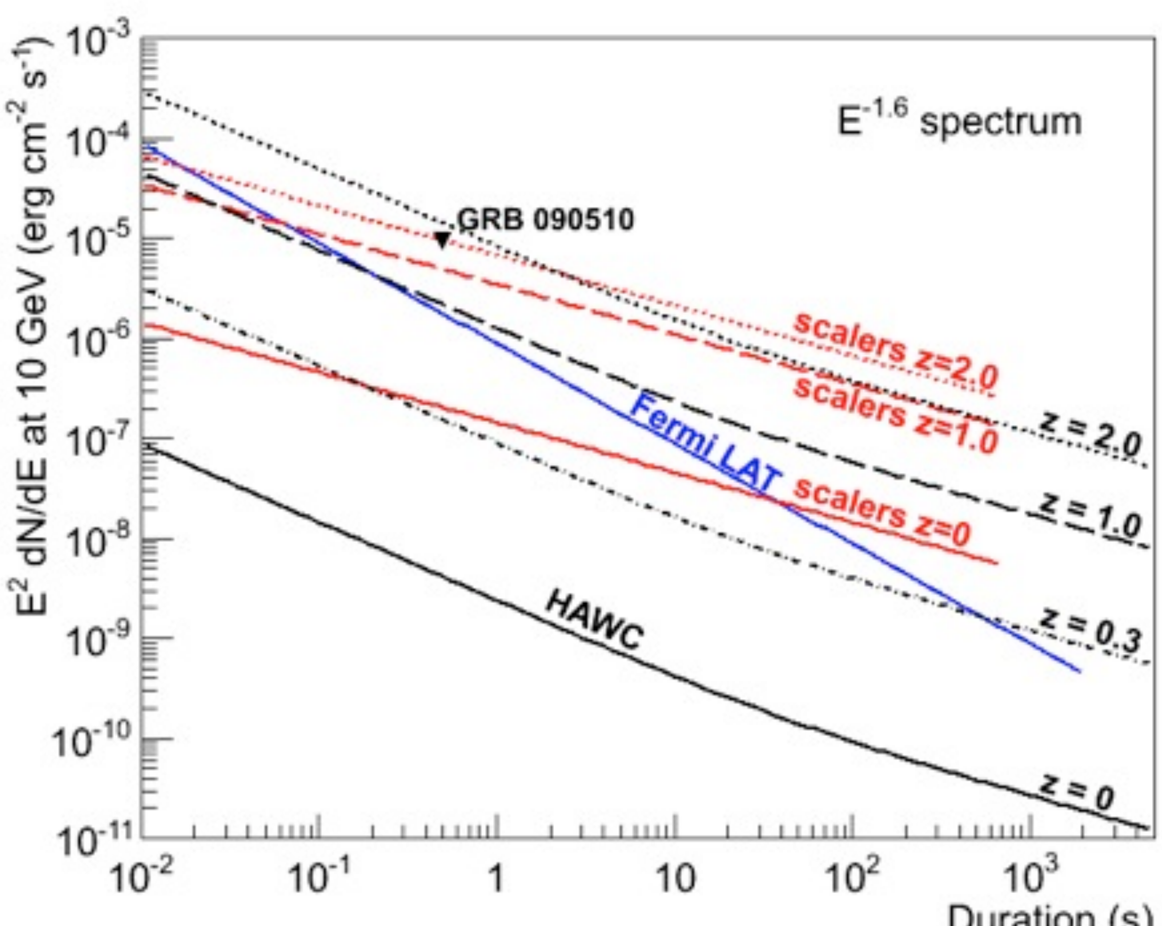
- 5σ sensitivity to:
  10 Crab in 3 min
  1 Crab in 5 hr
  0.1 Crab in ⅓ year



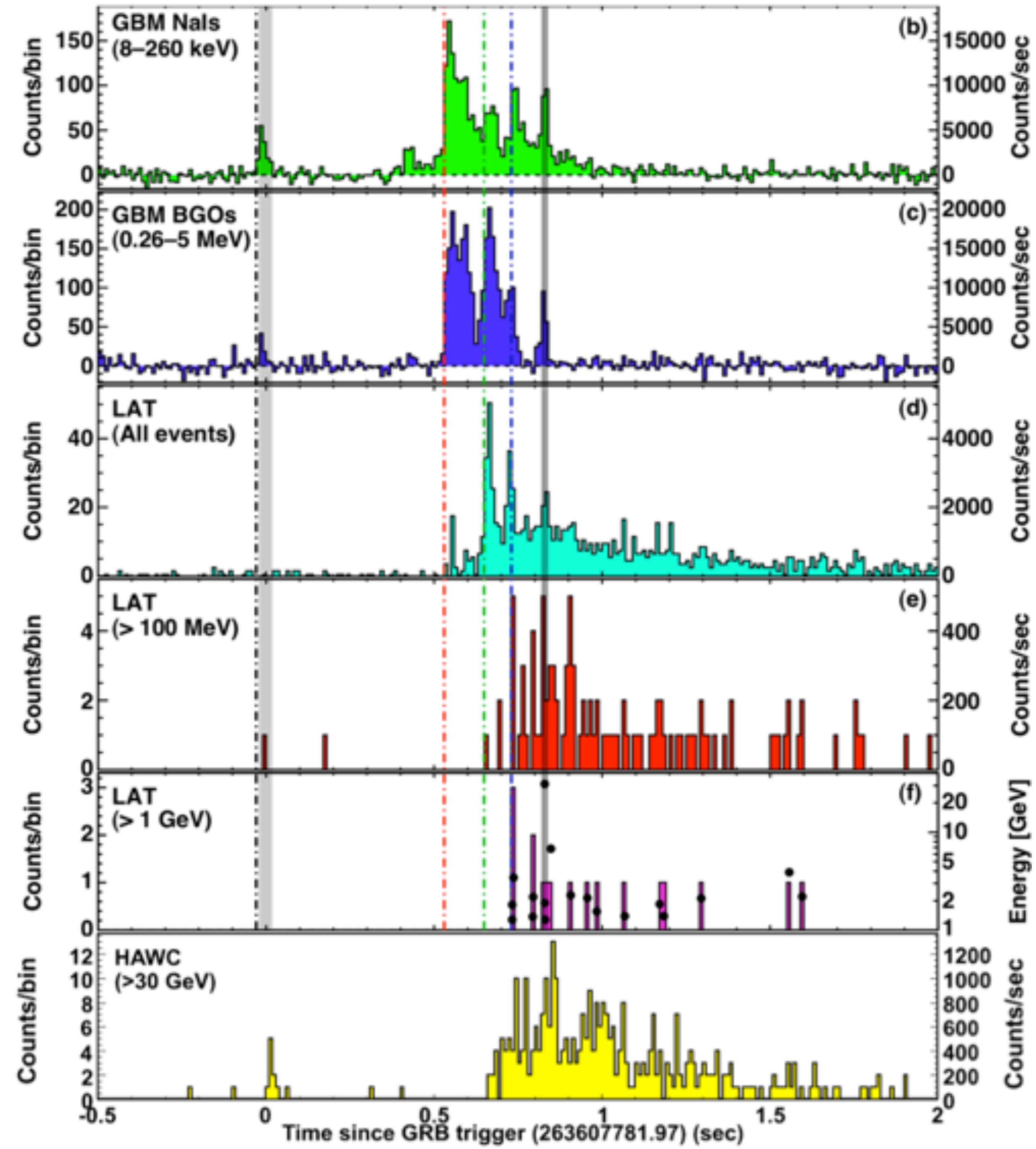
- Around 15x the sensitivity of Milagro

Sensitivity to GRBs

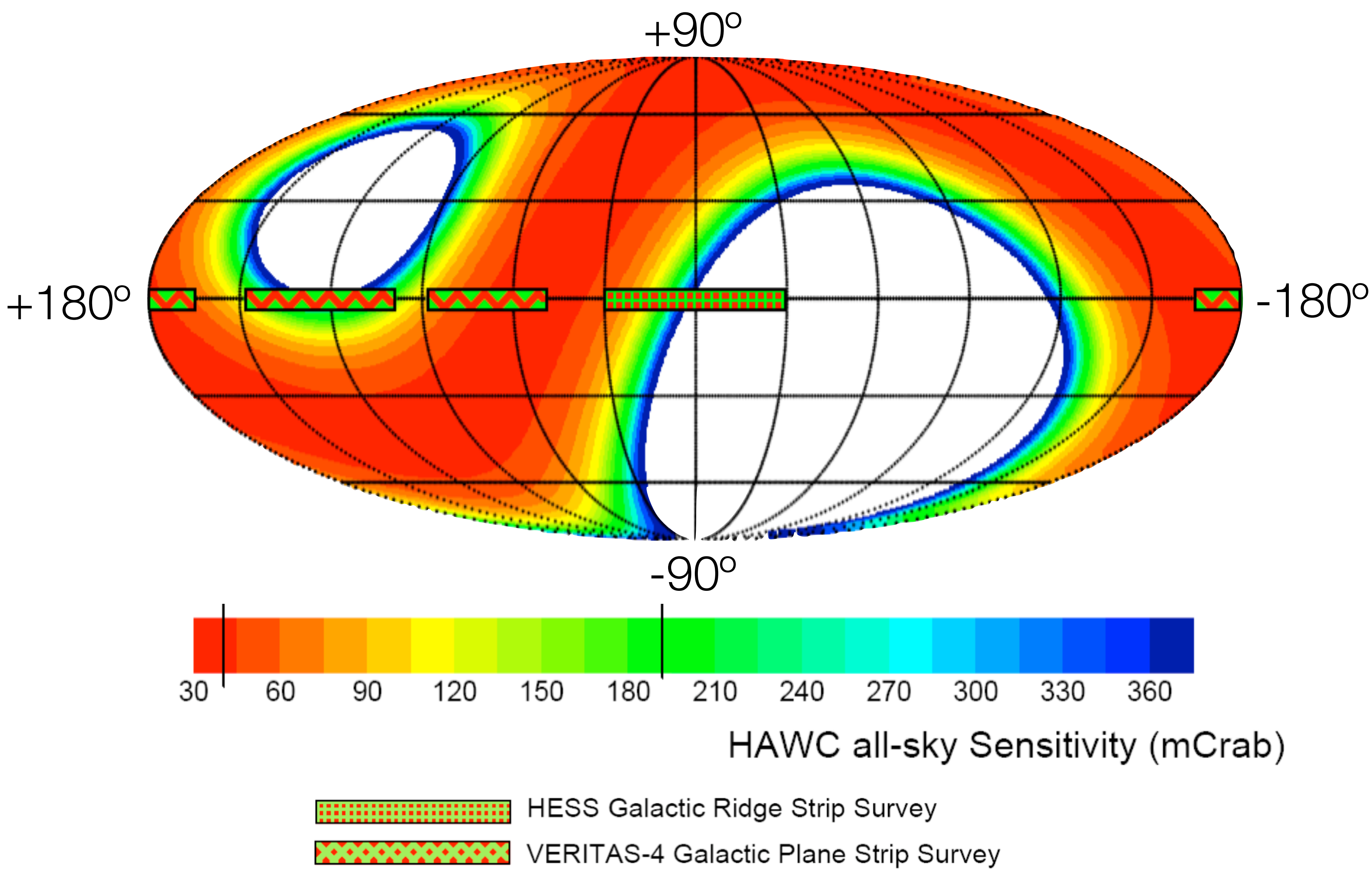
- HAWC will search for VHE emission from GRBs
  - Sensitivity comparable to LAT, especially for short bursts, but in higher energy band



Simulated HAWC Response to GRB 090510



Survey of the TeV Sky



Approximately 2 sr instantaneous field of view, limited by atmospheric depth

Will survey half the sky to 50 mCrab sensitivity within a few years

HAWC Construction Schedule

- Construction began February 2011
- Spring 2012: 30 Tanks
  - Sensitivity comparable to Milagro
- Spring 2013: 100 Tanks
  - Begin full-time operations
- Fall 2014: 300 Tanks (construction complete)