VERITAS:
better Science with better Simulations

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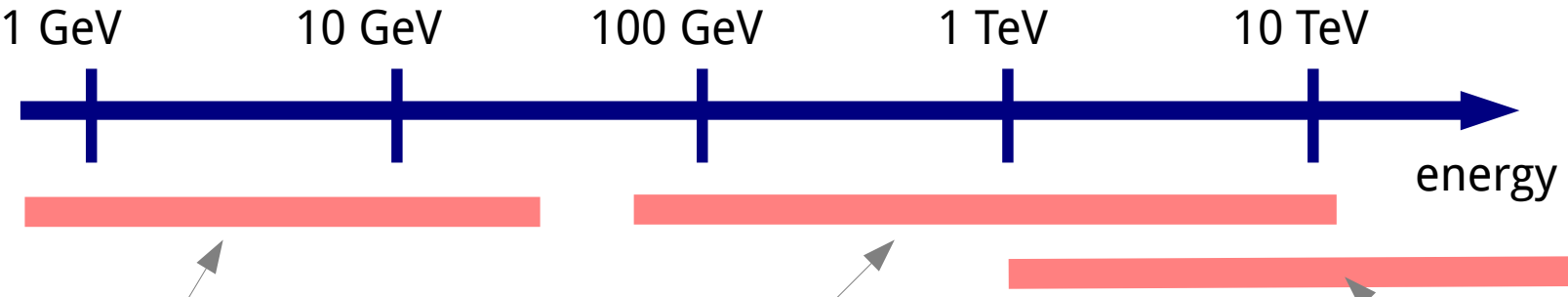
Gamma-Ray Instruments



Satellites: Fermi-LAT

Cherenkov telescopes:
like VERITAS and CTA

Water Cherenkov detectors: HAWC

Imaging Atmospheric Cherenkov Technique

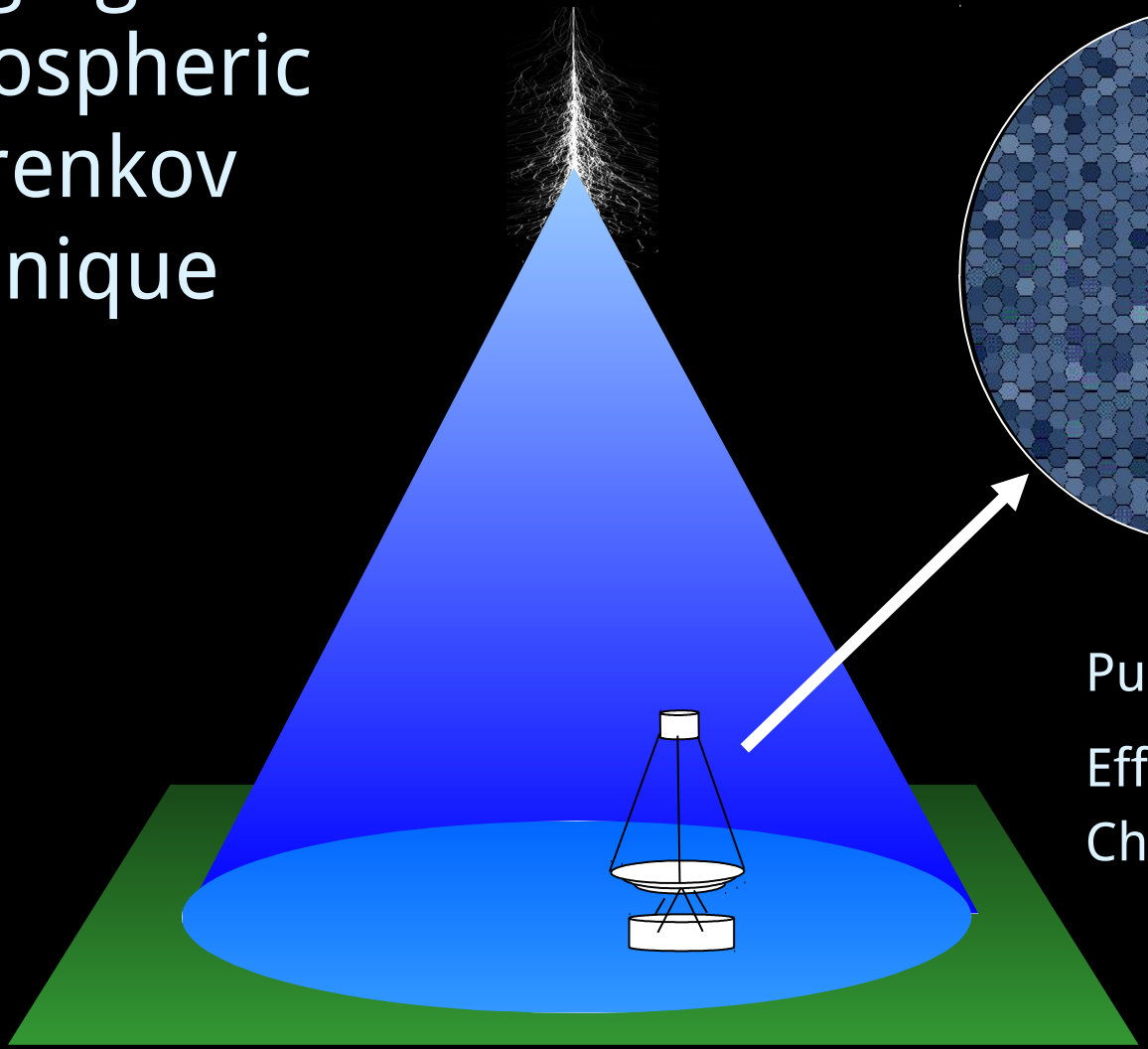
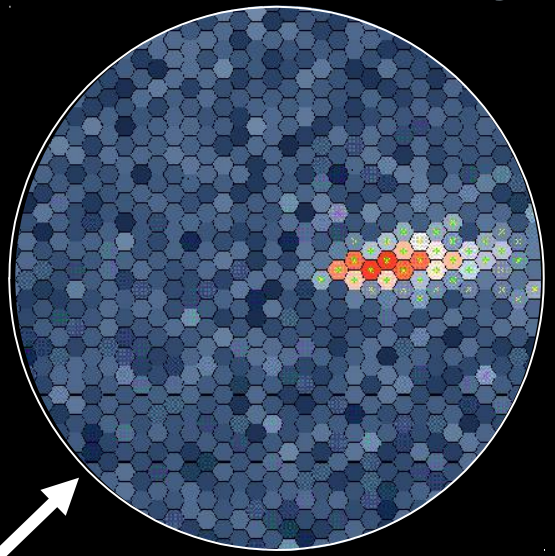


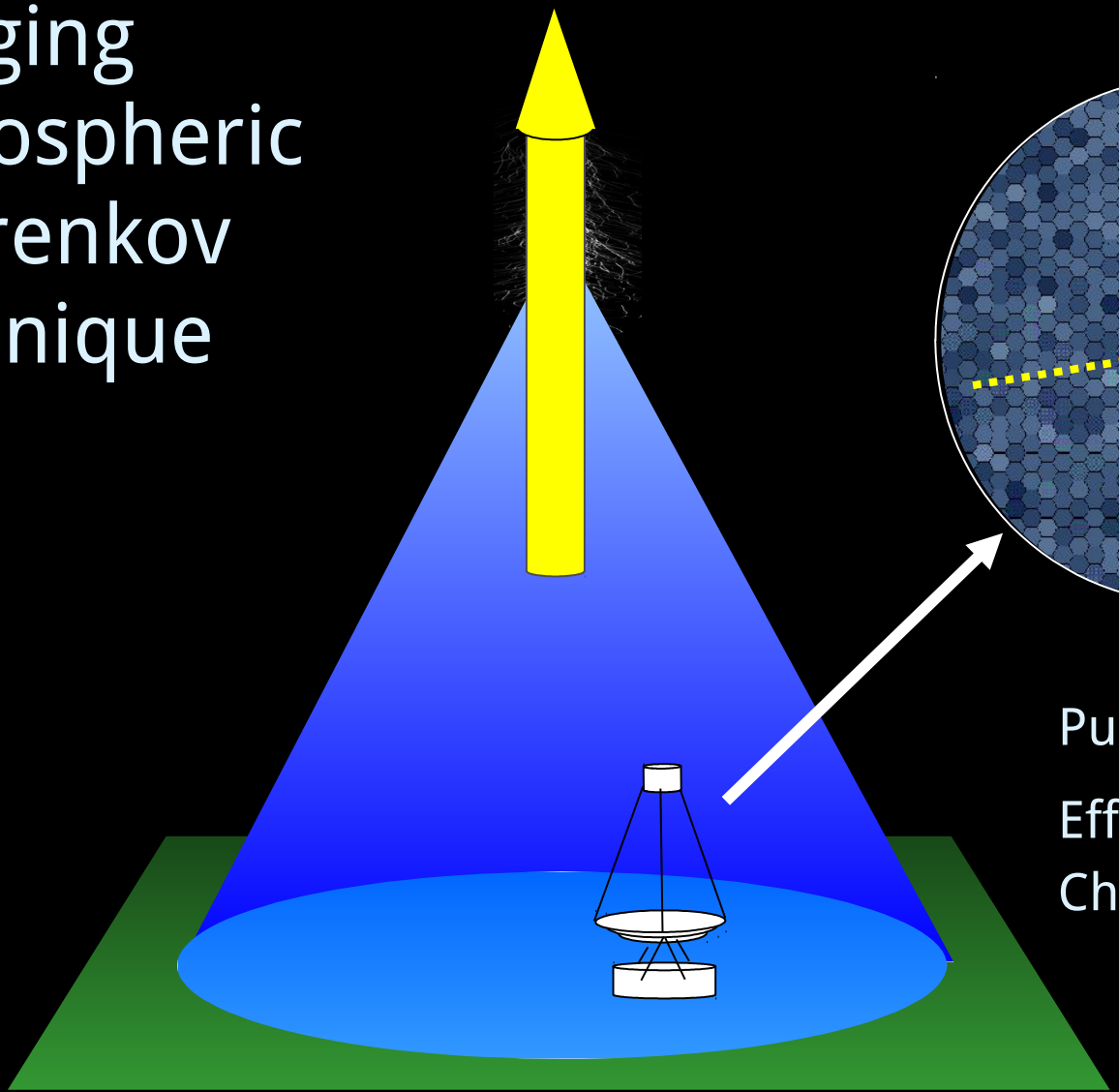
Image in camera



Pulse lasts a few nanoseconds

Effective area =
Cherenkov light pool~10^5 m^2!

Imaging Atmospheric Cherenkov Technique



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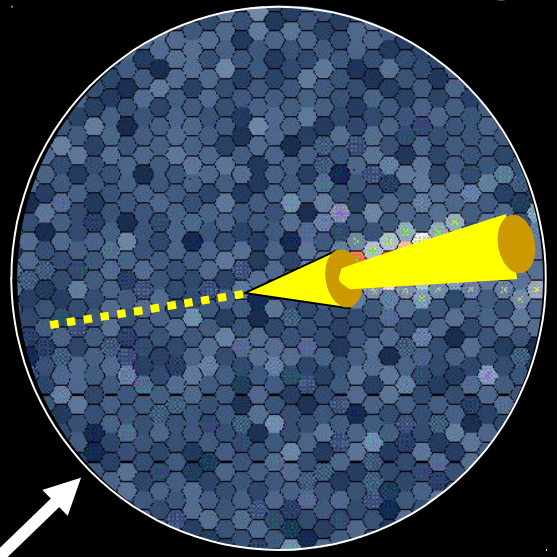

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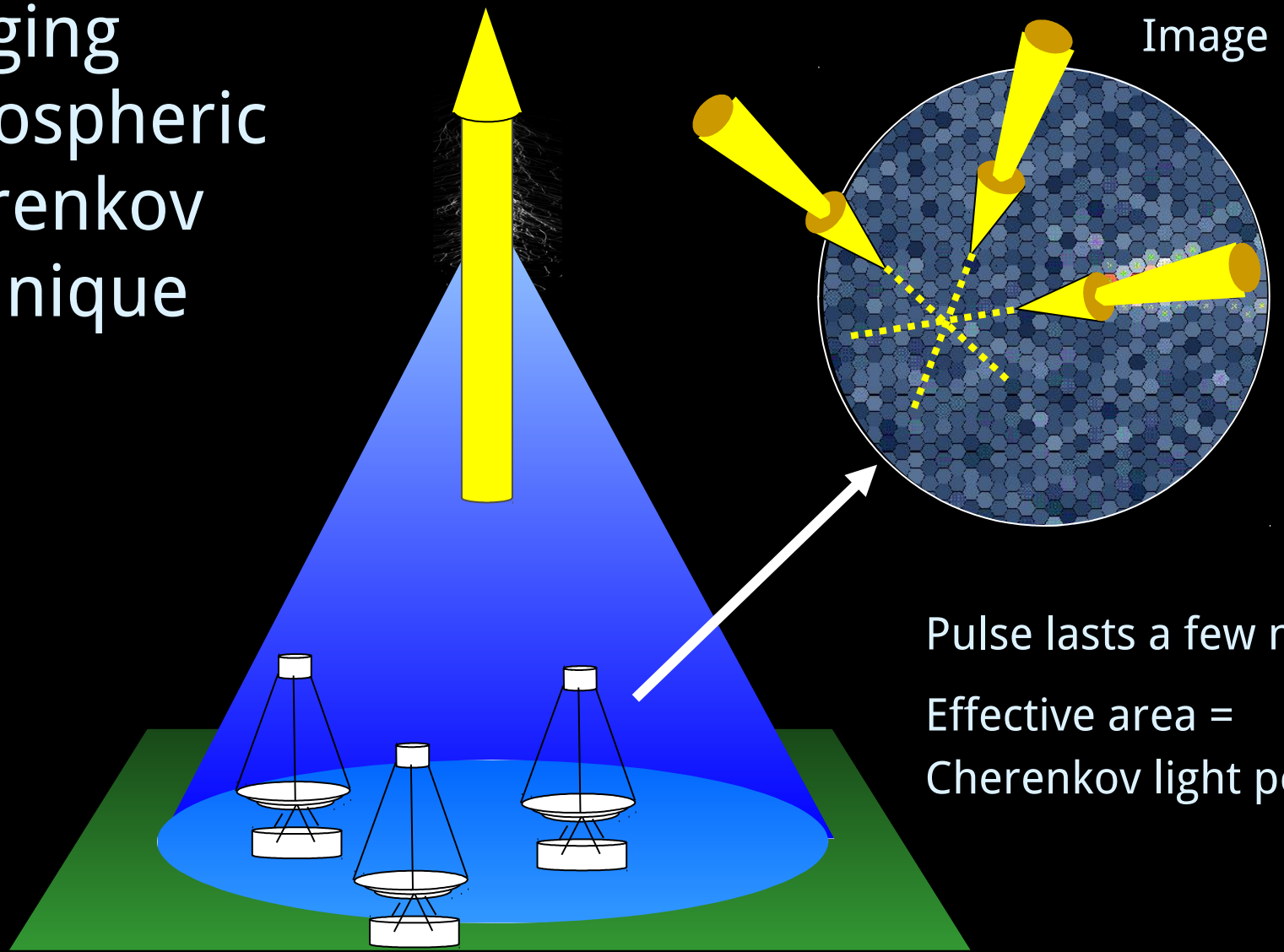

Image in camera

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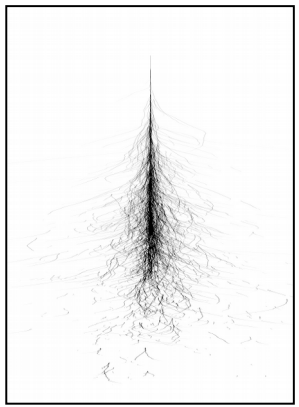
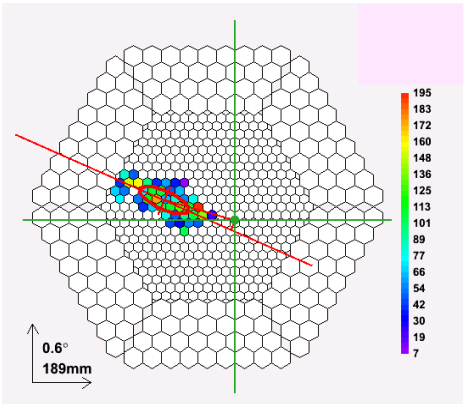
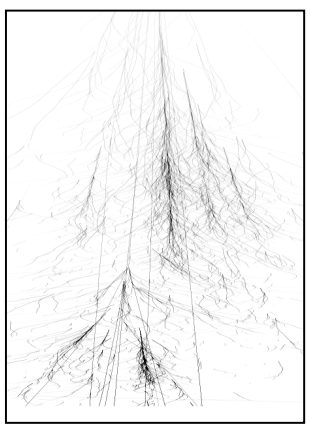
Background Rejection

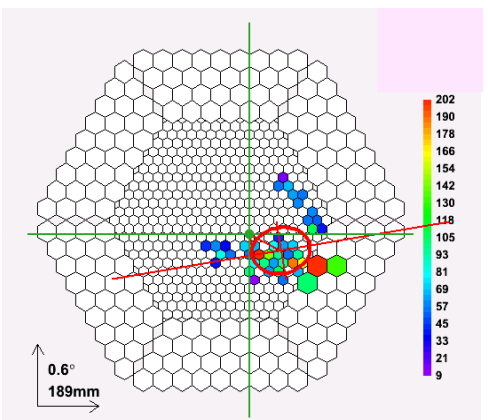
γ–ray shower





hadron shower (background)





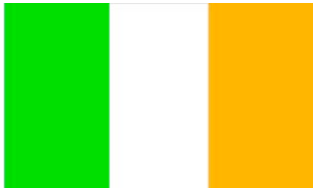
Main background:

- cosmic ray (hadron) showers
- 10^3...10^4 times more abundant than γ-ray showers
- rejection based on
  - shower shape (hadrons are broader and longer)
  - orientation of the image

Performance of rejection depends on:

- Resolution of image
- Investment in Computing

The VERITAS Collaboration

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~100 members, 20 institutions

24 non-affiliated members

+35 associate members

Smithsonian Astrophysical Observatory
Adler Planetarium
Argonne National Lab
Barnard College / Columbia University
Bartol Research Institute / University of Delaware
Georgia Institute of Technology
Iowa State University
Purdue University
University of California, Los Angeles
University of California, Santa Cruz
University of Chicago
University of Iowa
University of Minnesota
University of Utah
Washington University in St. Louis
McGill University, Montreal
University College Dublin
Cork Institute of Technology
Galway-Mayo Institute of Technology
National University of Ireland, Galway

U.S. DEPARTMENT OF ENERGY
Office of Science

VERITAS in a Nutshell

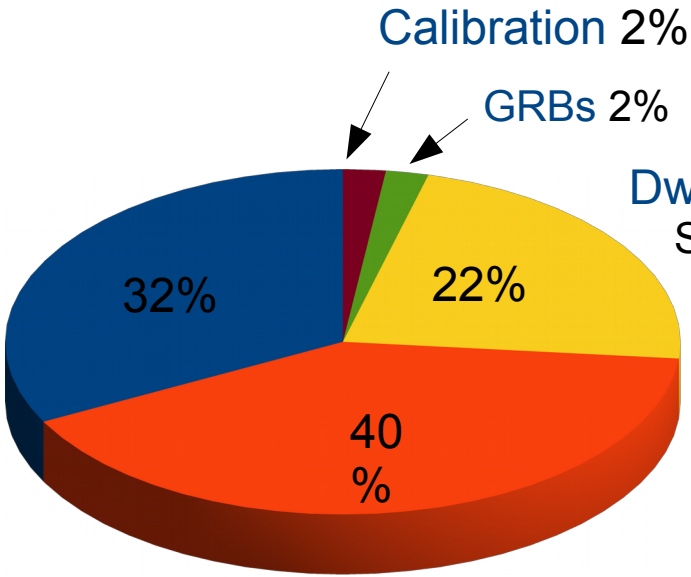
- Four 12 m Cherenkov telescopes in southern Arizona
- 499 high efficiency PMTs per camera
- 3.5° field of view
- Energy range from ~85 GeV to >10 TeV
- Sensitivity of 1% Crab in < 24 hours
- ~1400 hours of observations per year (including observation under bright moon light)
- Stable instrument performance over timescales of years

VERITAS Science

A mix of astrophysics and particle astrophysics

Galactic sources

- Acceleration
- SNRs and PWNe
- Pulsars
- Binary Systems
- Galactic Center



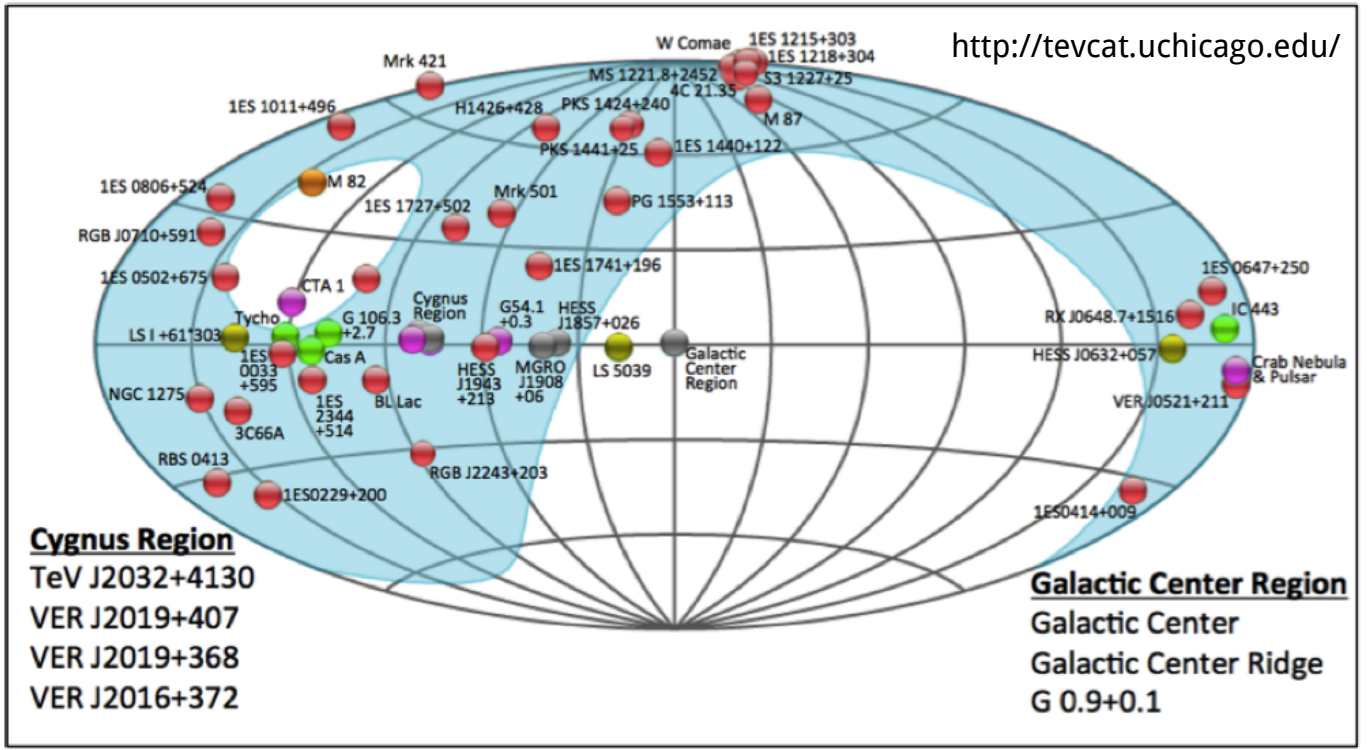
Untargetted

- Cosmic Ray Electrons
- Primordial Black Holes

Time Allocation

70% for “long term plan”
30% for proposals (time allocation committee) and director's discretionary time

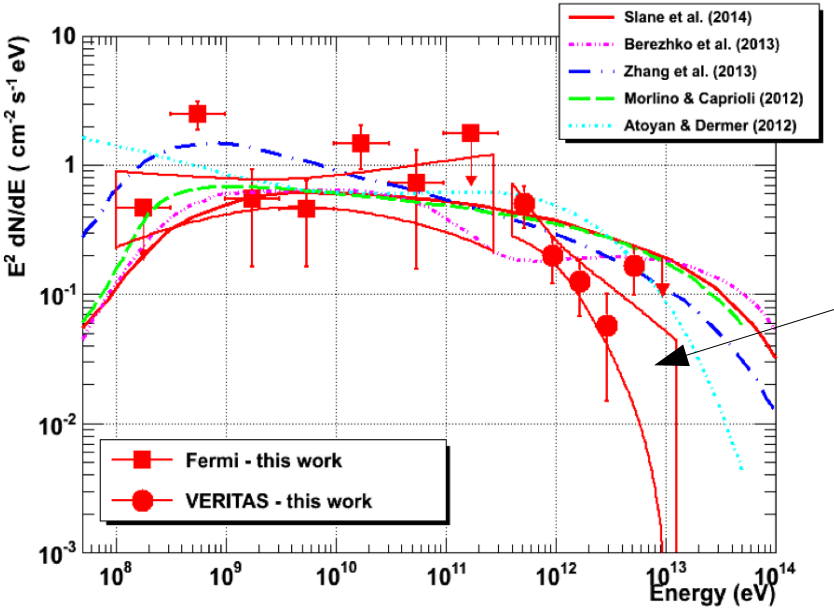
VERITAS Catalog



56 detections, representing at least 8 source classes

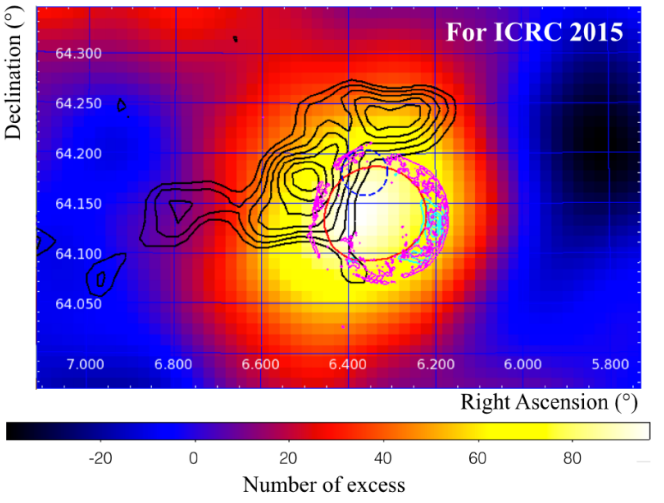
36 Extragalactic (64%): 33 blazars, 2 radio galaxies & a starburst galaxy (M82)!
20 Galactic (36%): Crab pulsar, 3 gamma-ray binaries, 7 pulsar wind nebulae, 3 SNRs, and 6 unidentified objects

Tycho: Historical 1A SNR



What is the maximum particle / gamma-ray energy?

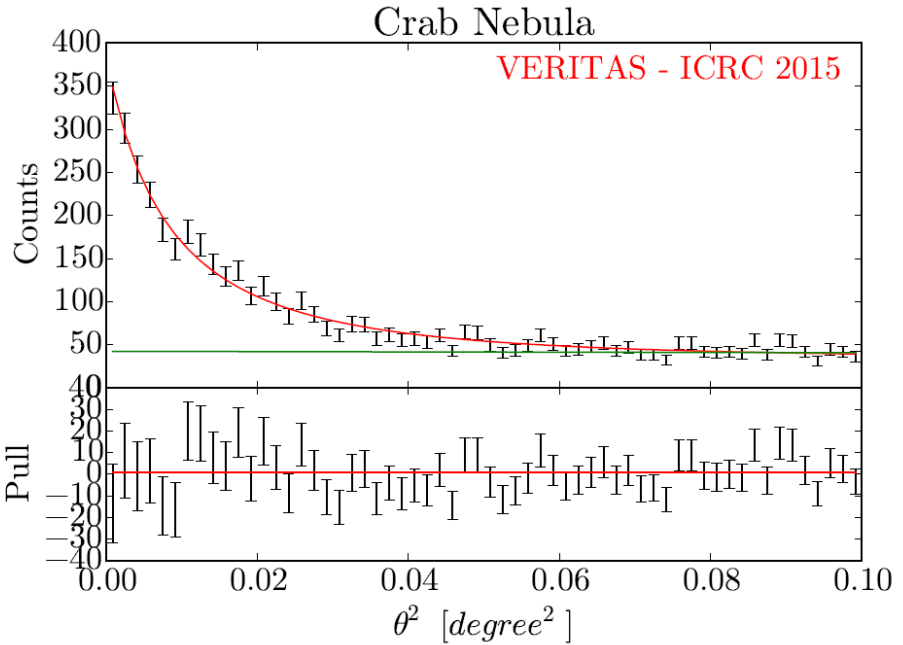
- Good candidate for hadronic emission scenarios
  - exploded in a clean environment
  - young and well-observed at other wavelengths



Systematic uncertainties above 10 TeV complicate comparisons with models

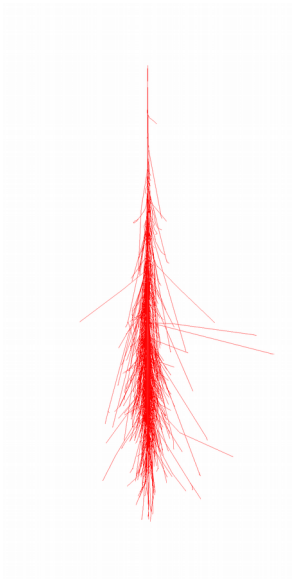
Gamma-Ray Extension of the Crab Nebula

- Size of emission region expected to be 1 arcminute
- Results in slight enlargement of spatial gamma-ray excess
- Limited by simplifications in existing Monte Carlo simulations



Simulation Chain

Air Shower (particle physics)



Telescope Optics (ray tracing)

Camera Response (electronics)

New Monte Carlo Production

- More statistics above 10 TeV
- Includes saturation of signal chain
- Better description of trigger
- Better description of optics
- Simulation of night sky background photon fields

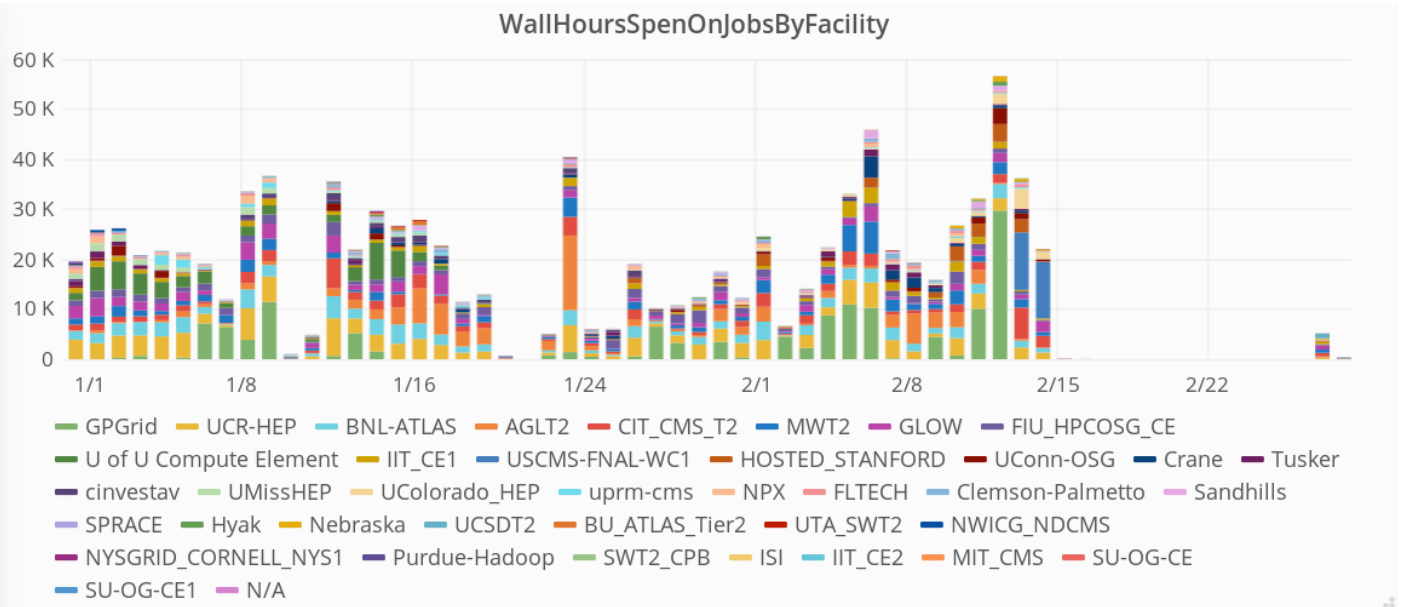
10^9 particle showers, 10^7 CPU hours, 400 TB

Need large scale computing infrastructure

Experience with OSG

- Great support setting up simulation chain
- Per CPU performance on Stampede is twice what I get on OSG
- Average 20k hours per day → ~1,000 cores → less than what I can get at our Georgia Tech cluster.

We need ten times the resources to finish production in a reasonable time!



Summary

- VERITAS is one of the worlds best gamma-ray instruments.
- The instruments runs very smoothly.
- Moving into an era where systematics dominate.
- New Monte Carlo Simulations allow us to extract more science from our data.
- Freely available resources on OSG are not sufficient