

VERITAS DATA ANALYSES: PROGRESS WITH GAMMALIB & CTOOLS

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VERITAS

- * Gamma-Ray Observatory, Arizona
- * 85 GeV - 30 TeV
- * Images Particle Showers in the Atmosphere



VERITAS Software

VERITAS-Developed Software

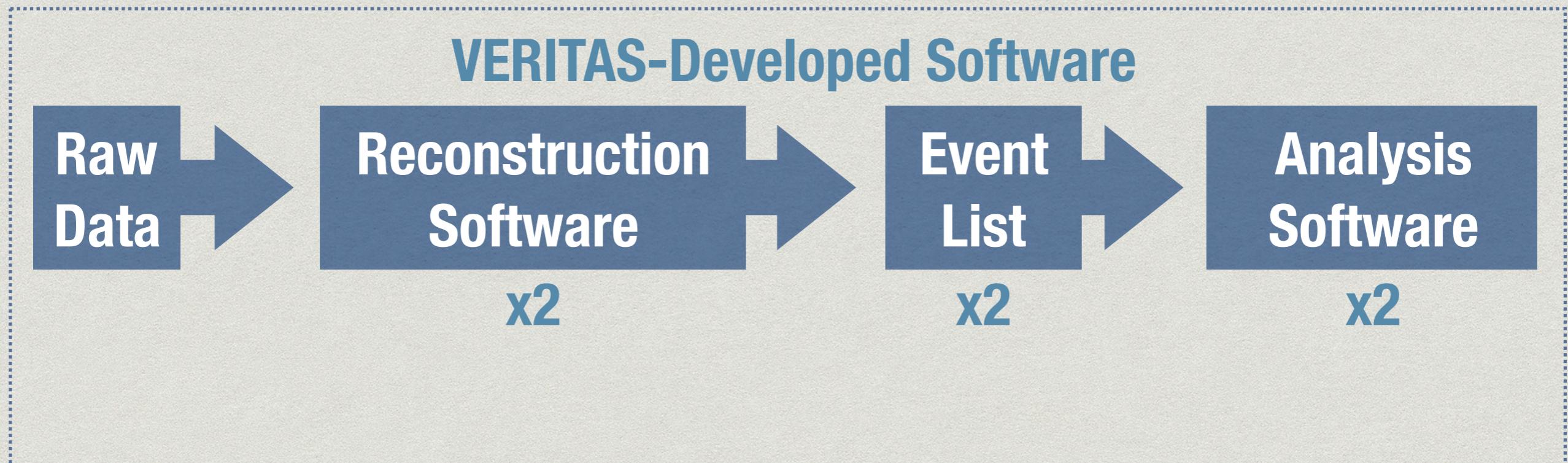
Raw
Data

Reconstruction
Software

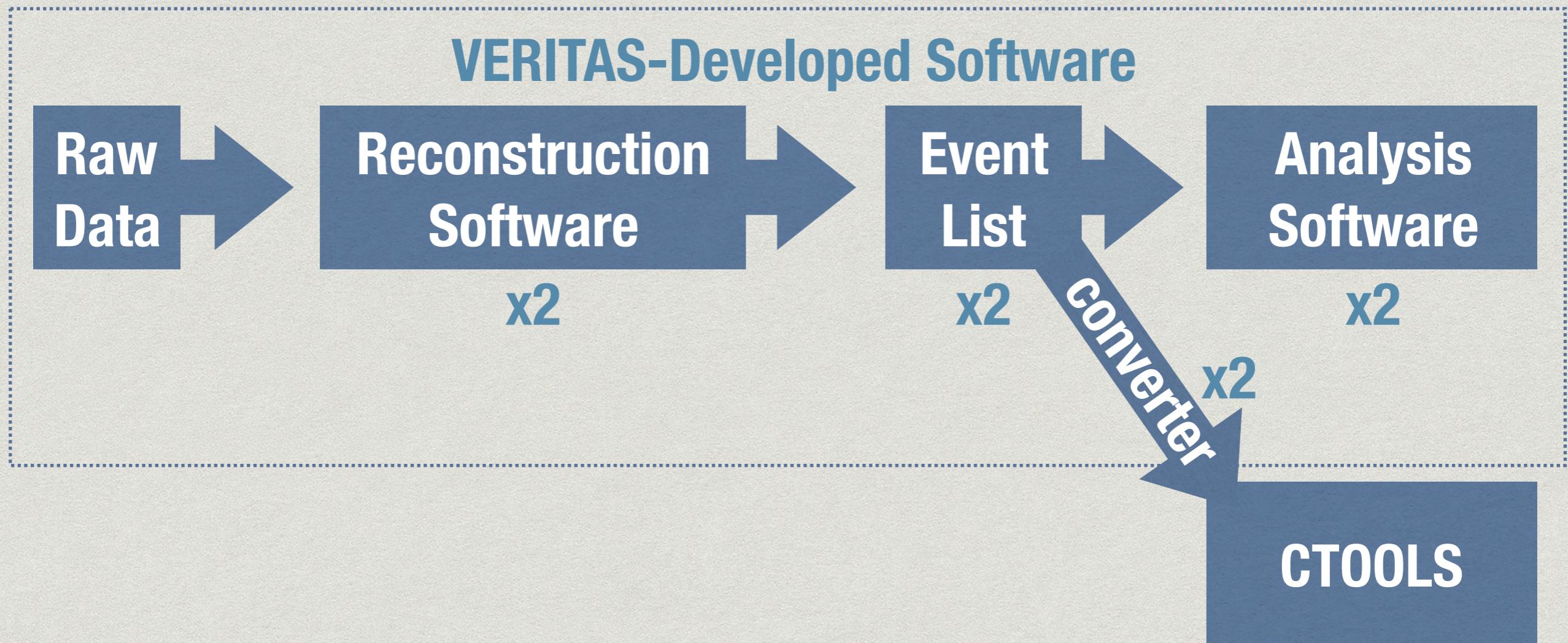
Event
List

Analysis
Software

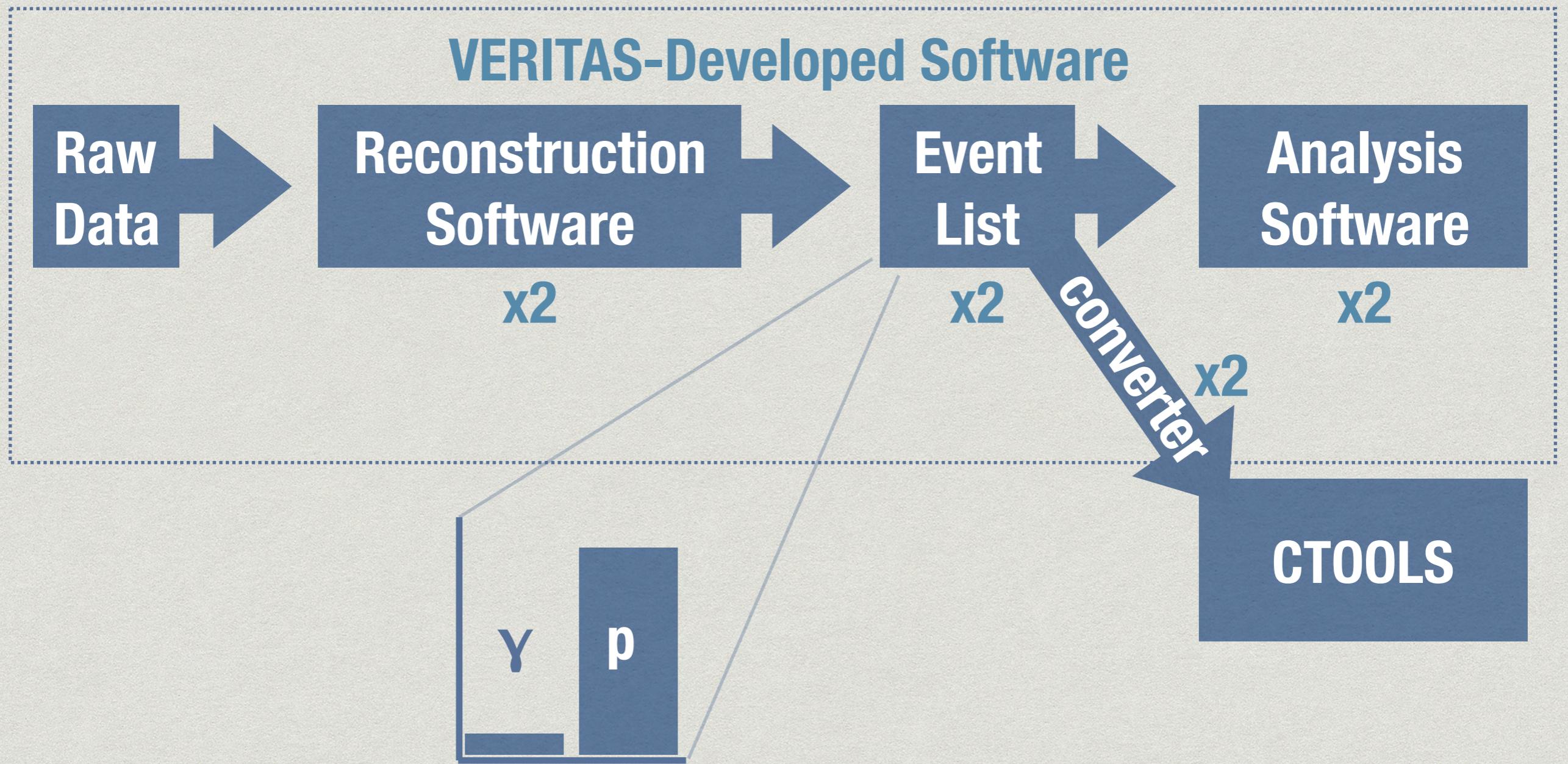
VERITAS Software



VERITAS Software

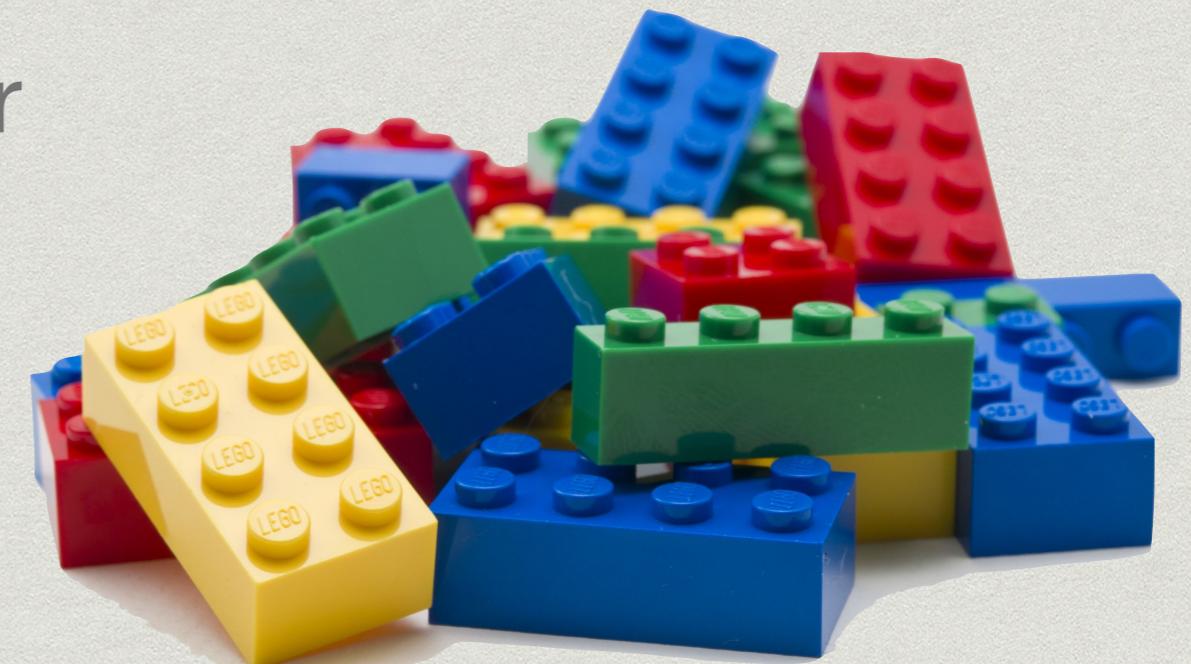


VERITAS Software



GAMMALIB/CTOOLS

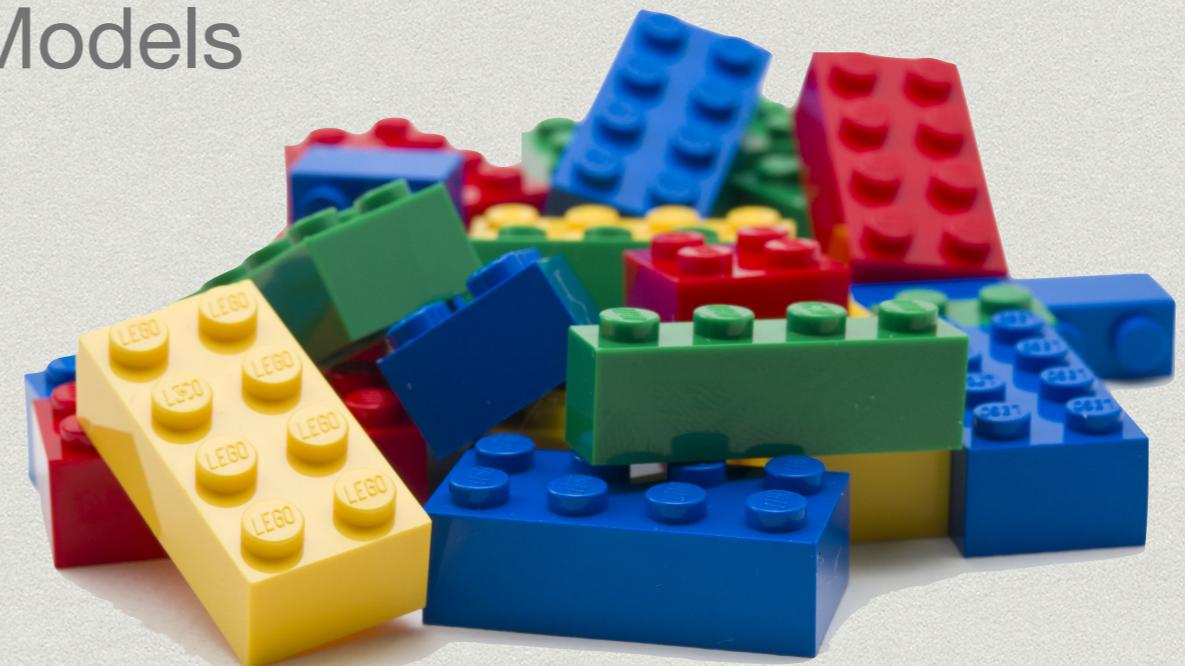
- * Astrophysics (X+Gamma) Analysis Package
- * Python and C++
- * 50+ contributors, since 2008
- * A primary candidate for high-level CTA science analysis



<http://cta.irap.omp.eu/ctools>

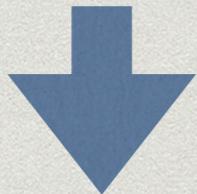
GAMMALIB/CTOOLS

- * Formatted FITS files are loaded into a gammalib **bucket**:
 - * Event Lists
 - * Instrument Response Functions
 - * Source & Background Models
- * CTOOLS are programs that operate on that **bucket**.

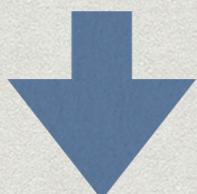


<http://cta.irap.omp.eu/ctools>

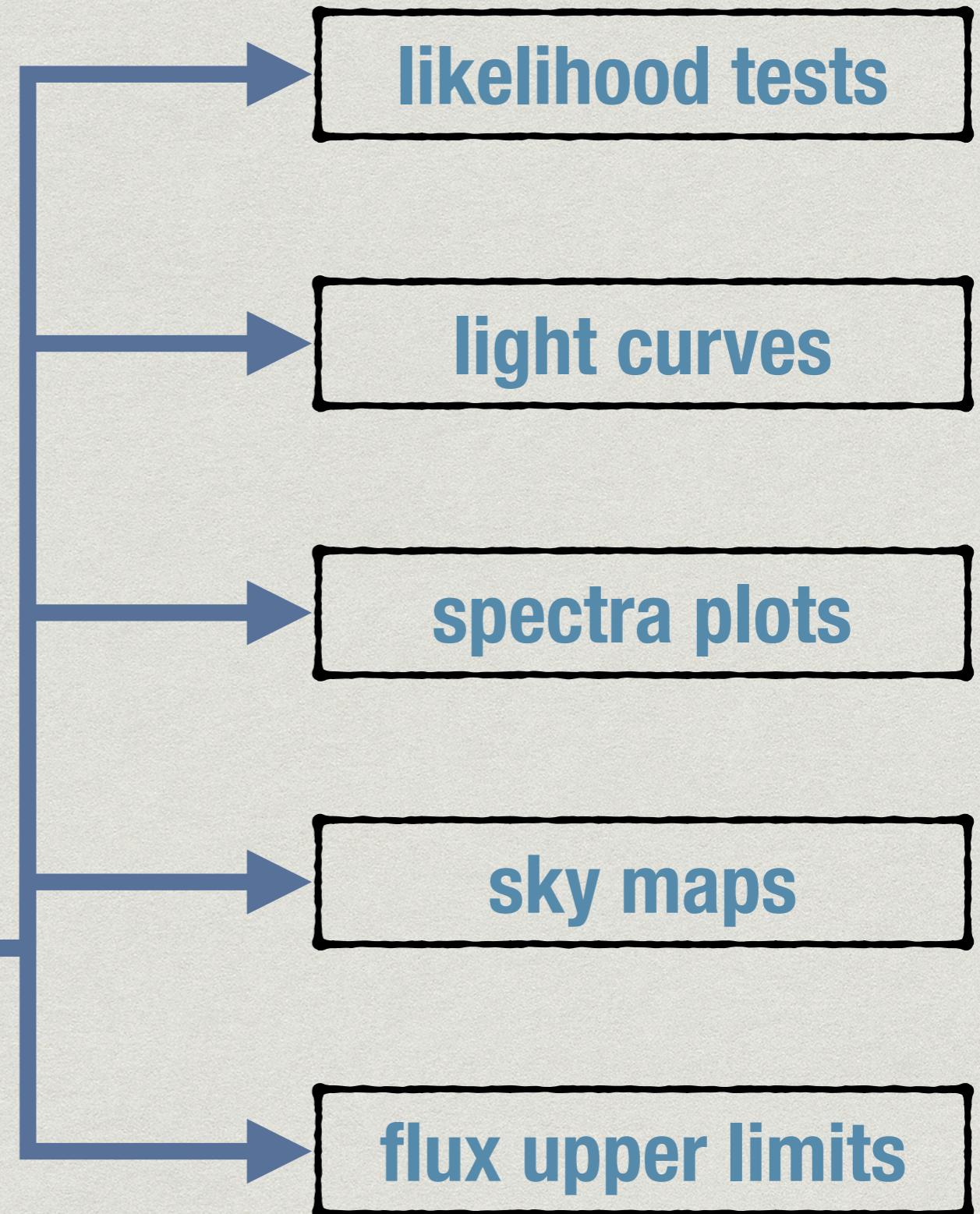
1. Convert Data to FITS



2. Fill the bucket



3. Science that bucket!



List of Ctools So Far...



Simulate Data
`ctobsdef, ctobssim`

Slice Data
`ctselect`

Bin Data
`ctbin, ctcubemask, ctexpcube,`
`ctpsfcube, ctbgkcube`

Analyses:

Timing
`cslightcrv`

Imaging
`ctskymap`

Spectral
`csspec`

Likelihood
`ctlike, ctbutterfly,`
`ctulimit, cterror,`
`cttsmap, ctmodel,`
`csresmap`



VERITAS Data Conversion

- * VERITAS raw data saved in 30min data files
- * For CTOOLS: Pack N-minute data to one fits file
 - * IRFs included in fits file
 - * special loading of **bucket**
 - * very simple organisation
 - * *tiny* file size (30min data < 1MB, with IRFs)

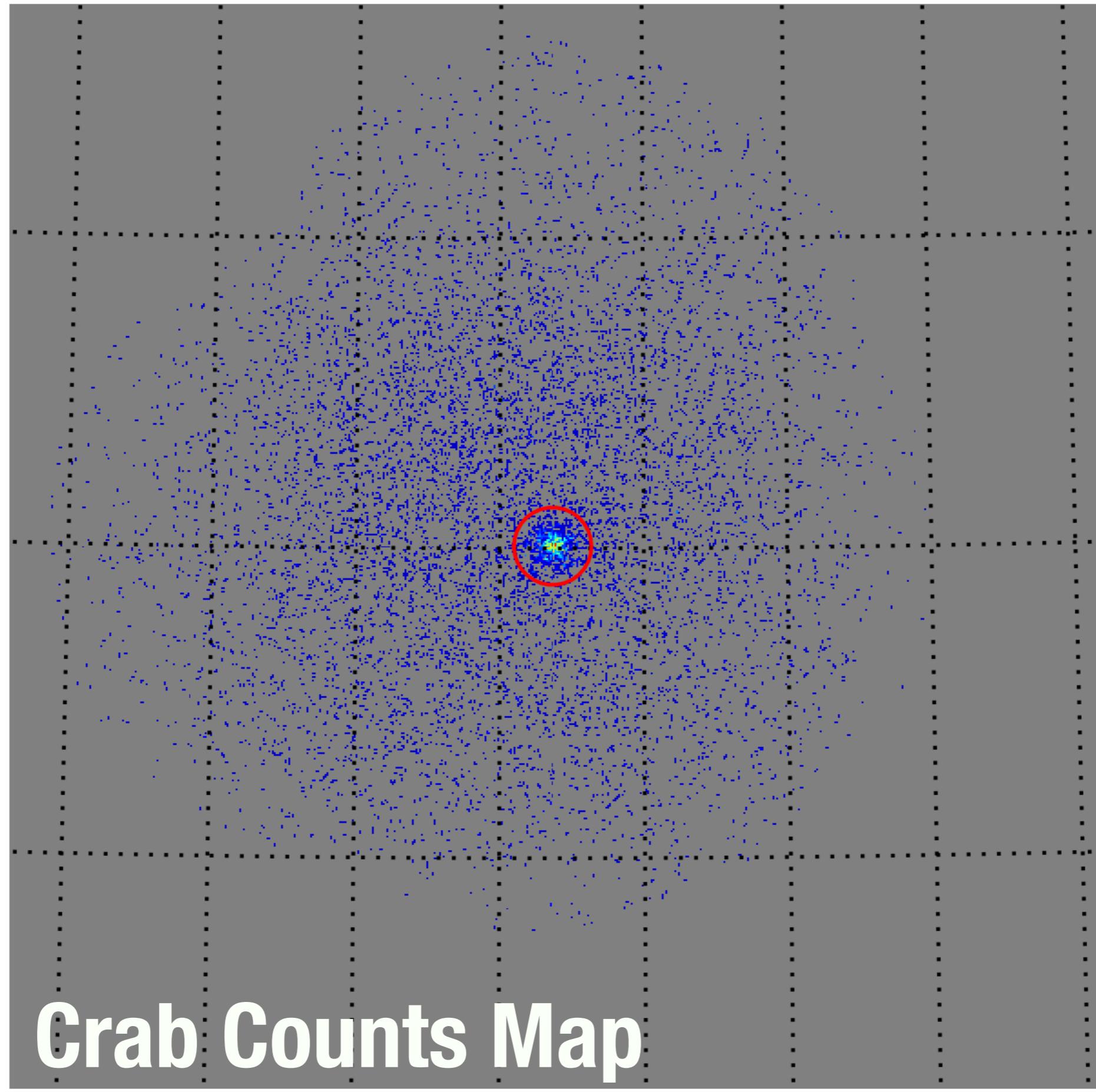
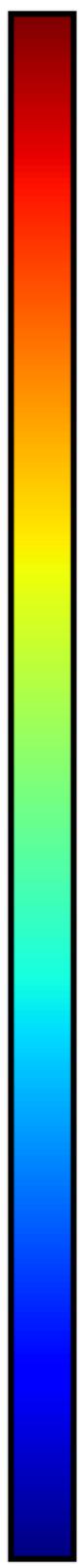
Conversion Progress

- * VERITAS Data Converter almost compete
 - * Event Lists done
 - * IRF's nearly done, being verified:
 - GCTAPsfKing
 - GCTAAeff2D
 - GCTABackground3D
- * Compare non-ctools analysis of 39 sources to ctools results

VERIPY

- * Auxiliary python module for VERITAS
VERITAS members only (sorry)
- * Load fits files to CTOOLS **bucket** with special function
- * host for private VERITAS functionality
- * *Not* a layer between VERITAS and CTOOLS

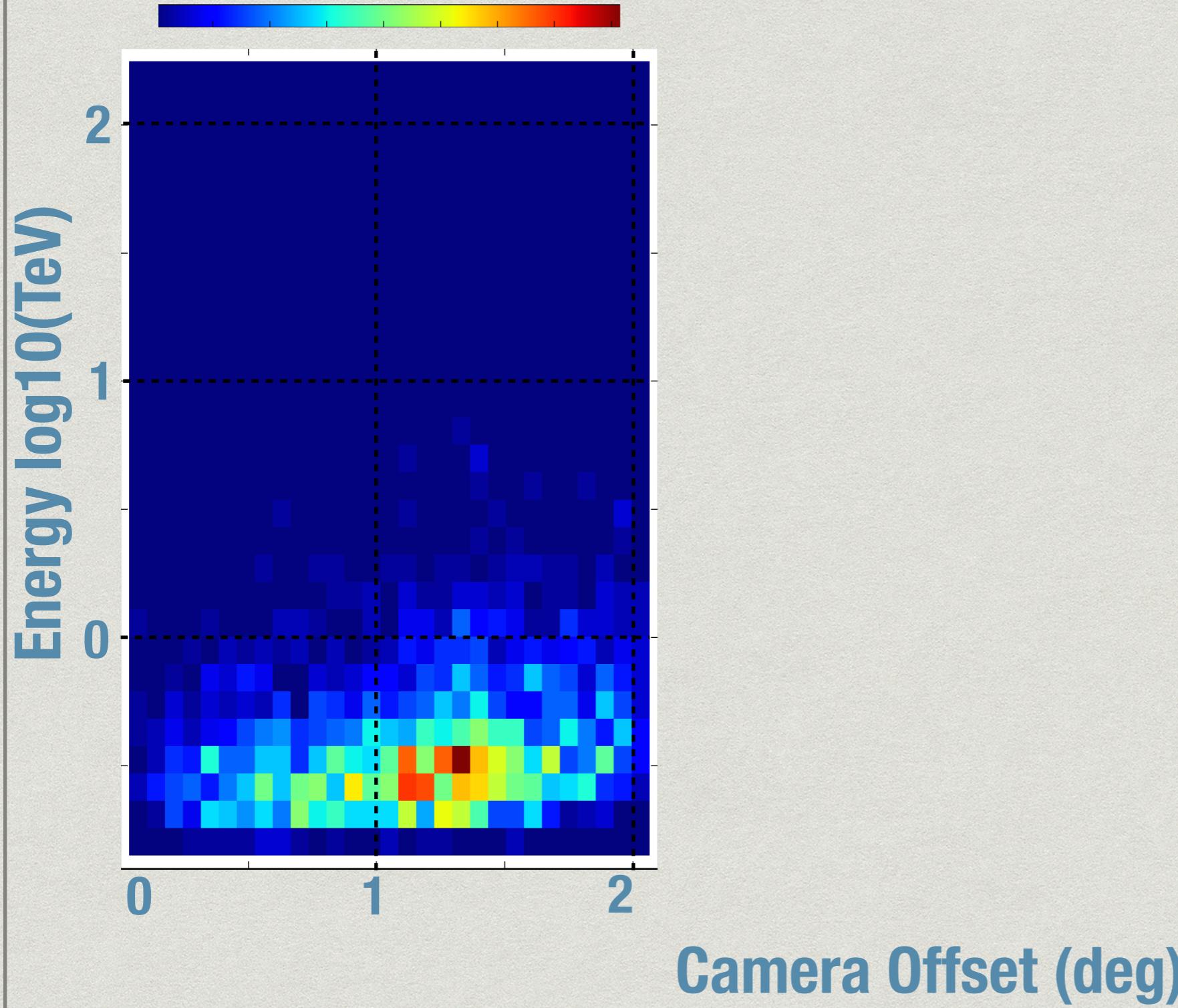
Many



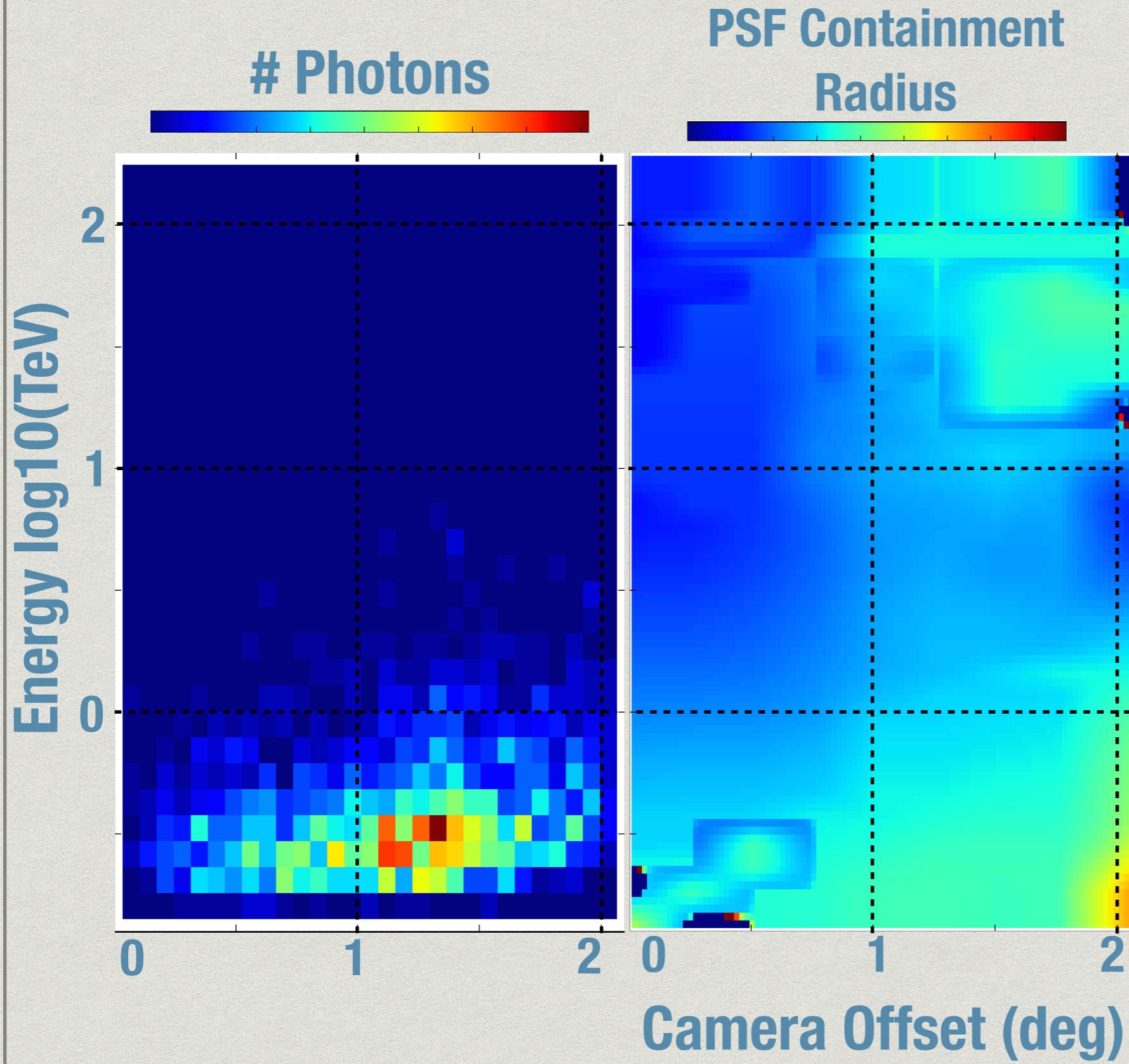
Crab Counts Map

IRFs

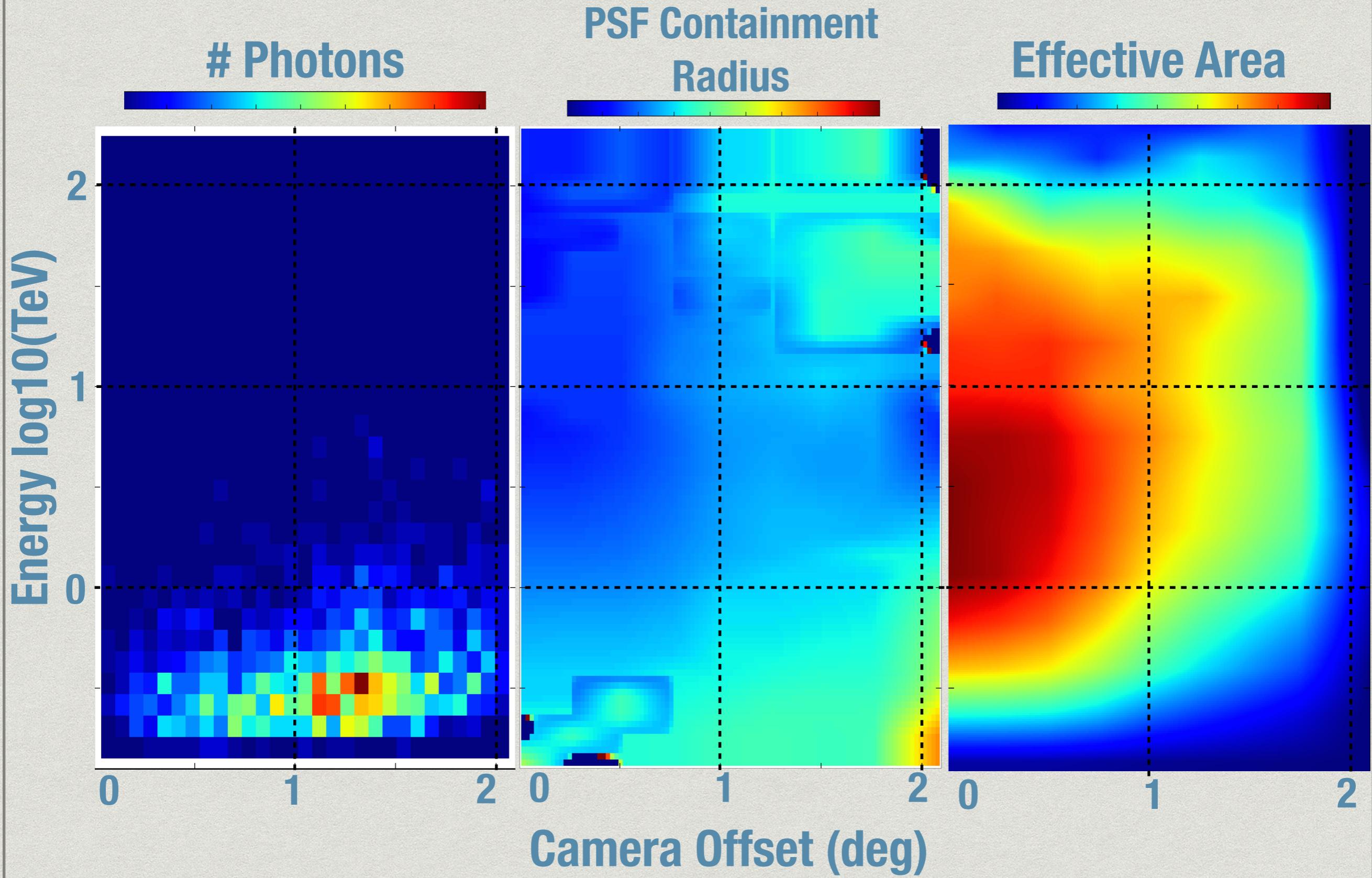
Photons



IRFs

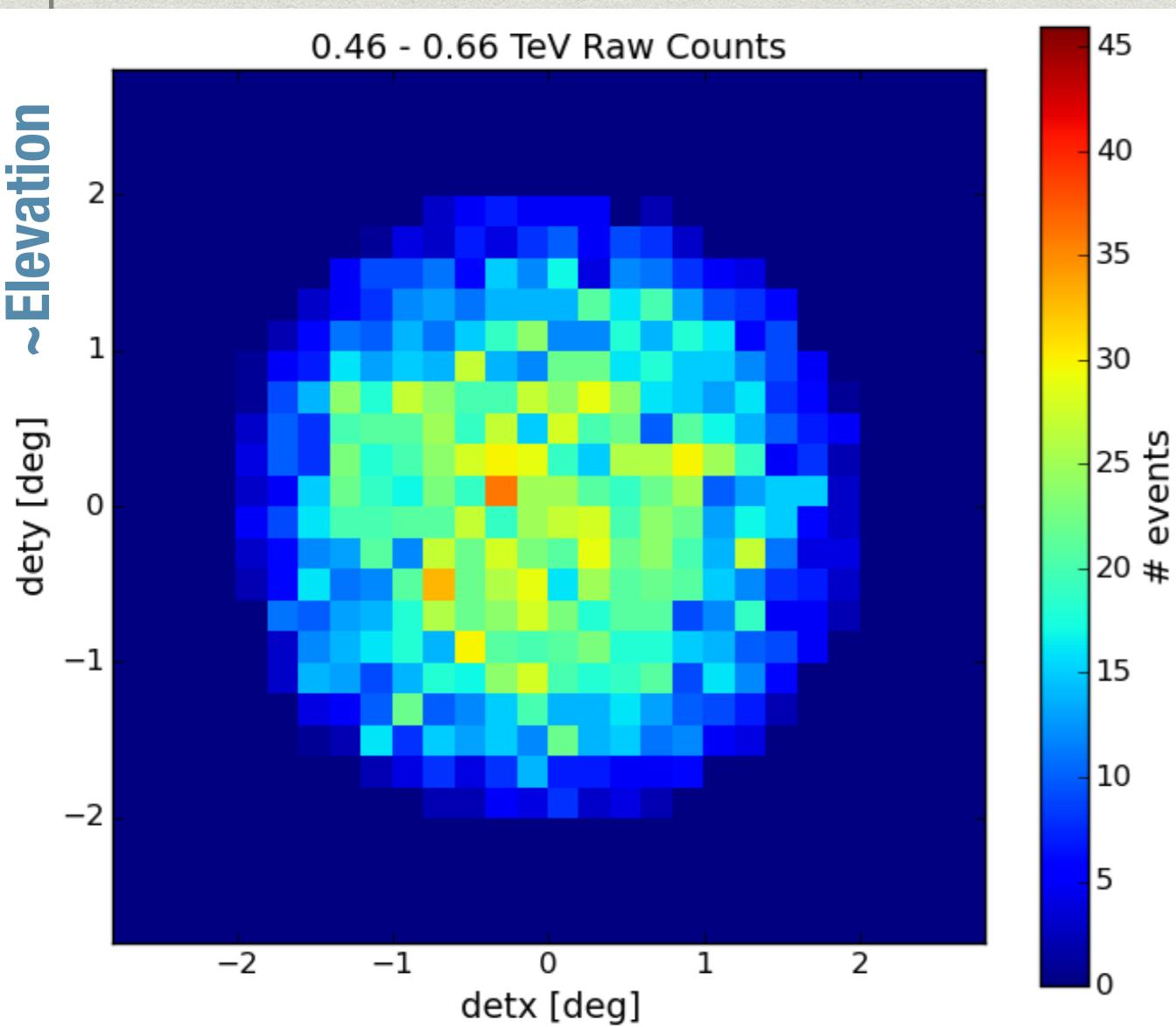


IRFs



IRFs

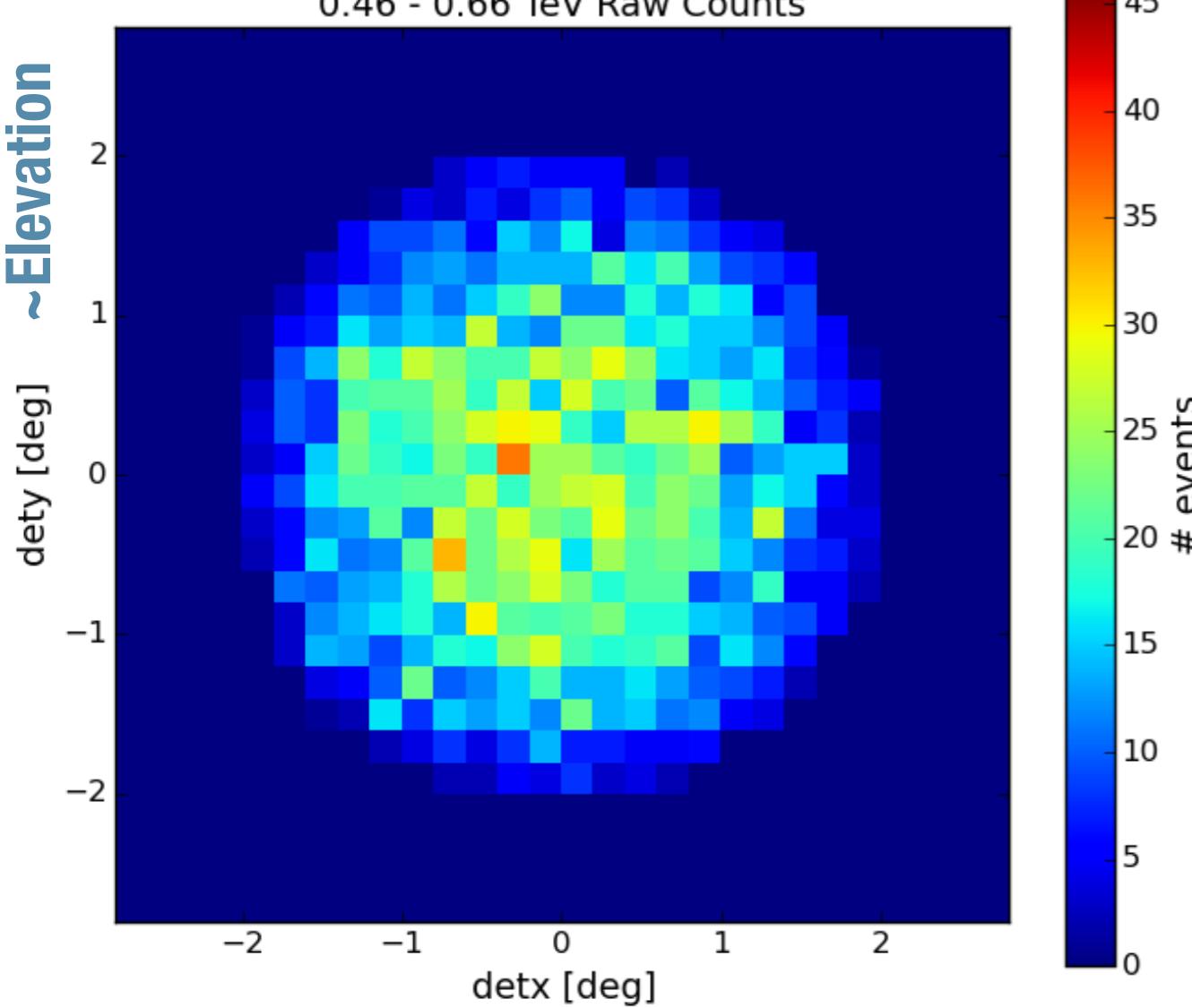
Background From Data



~Azimuth

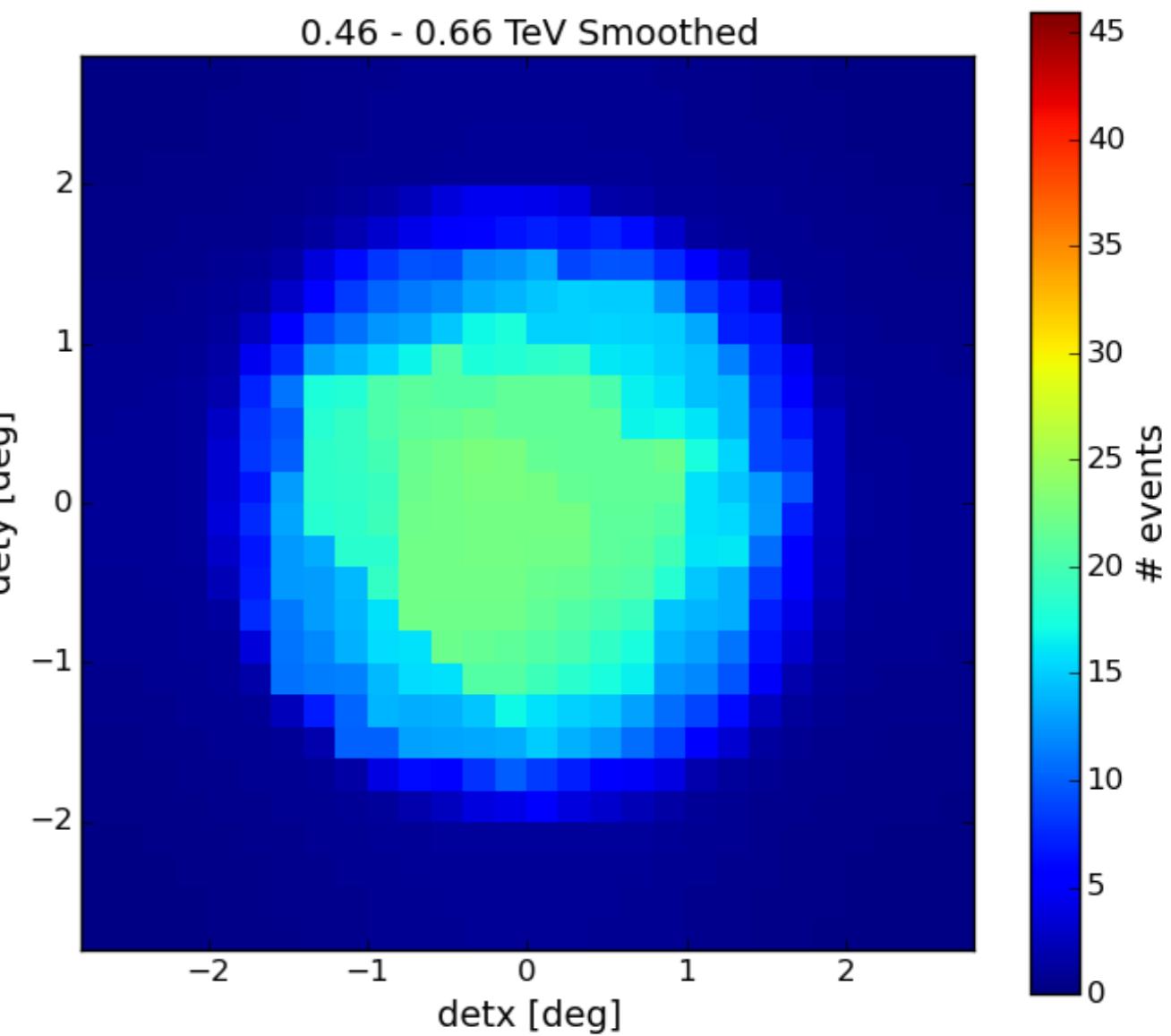
IRFs

Background From Data



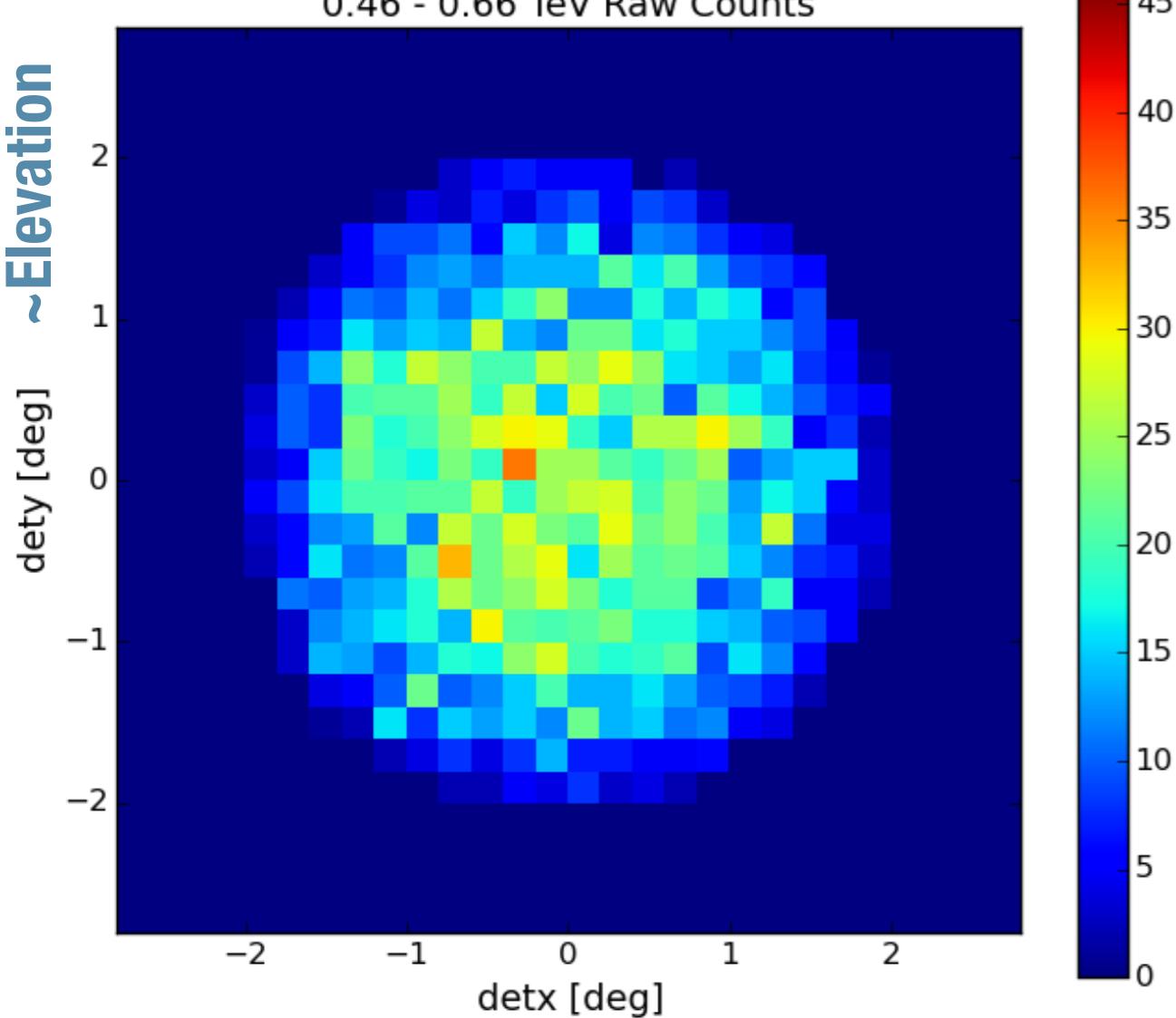
~Azimuth

After 'Total Variation' Smoothing

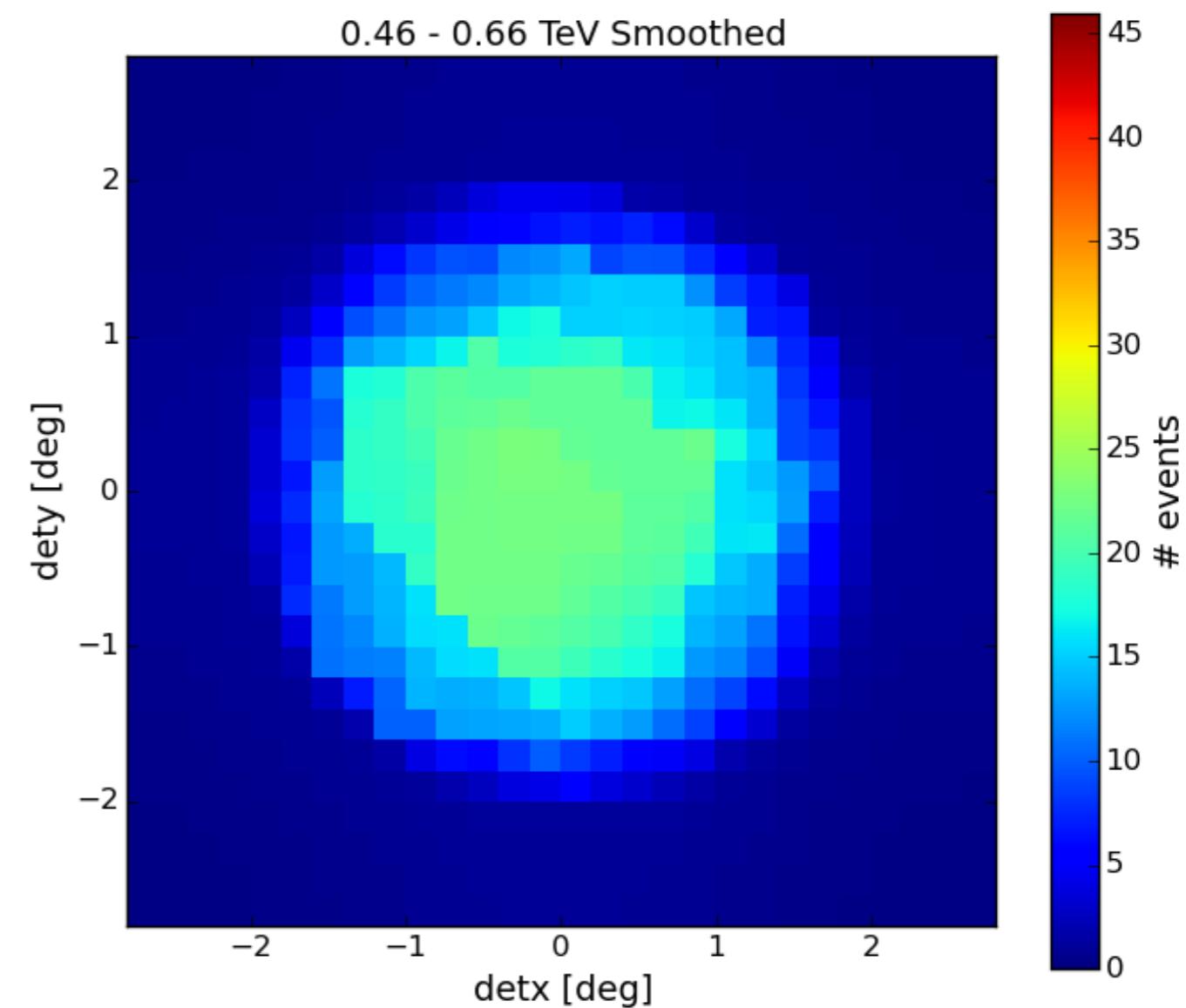


IRFs

Background From Data



After ‘Total Variation’ Smoothing



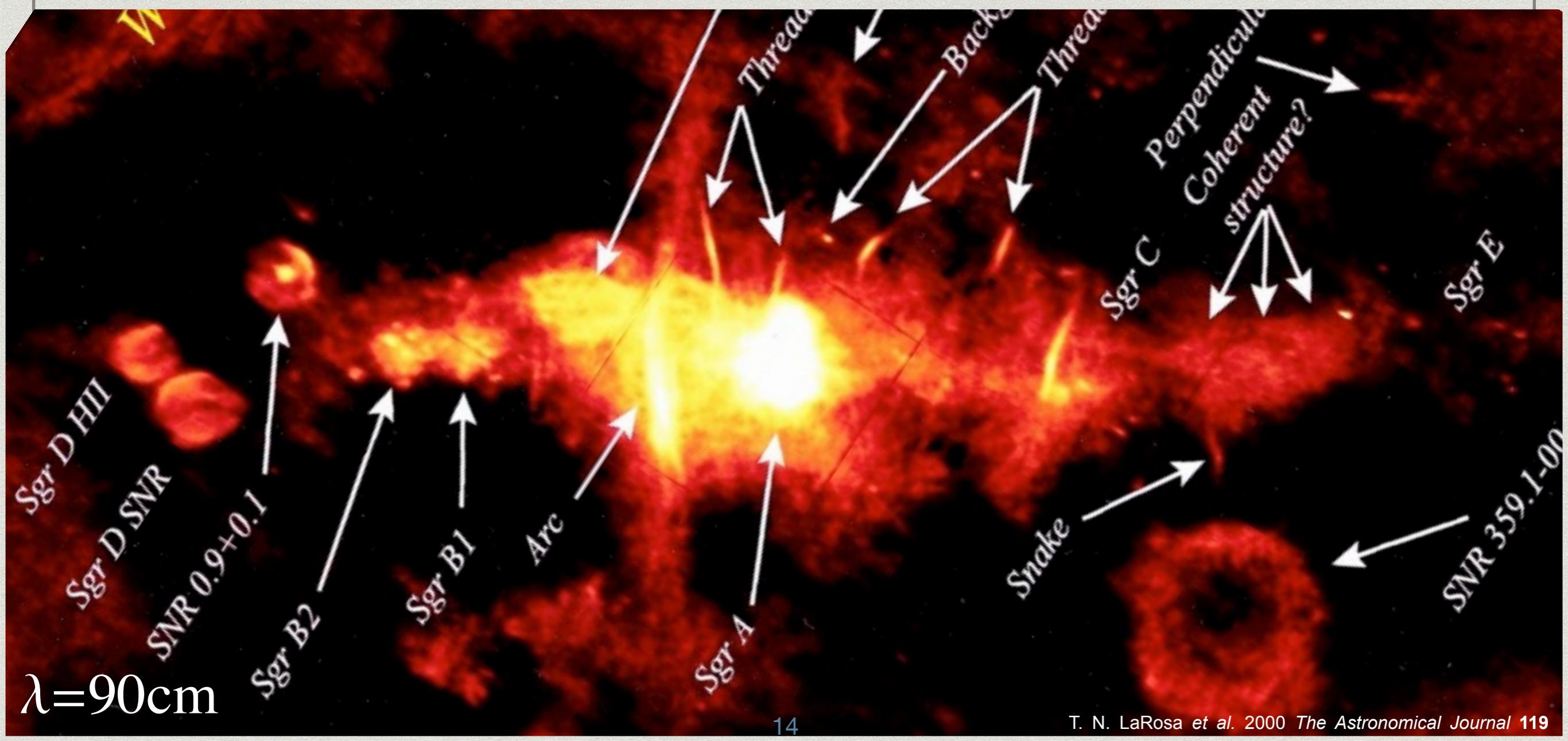
~Azimuth

https://en.wikipedia.org/wiki/Total_variation_denoising

denoise_tv_chambolle_2d(): https://github.com/scikit-image/scikit-image/blob/master/skimage/restoration/_denoise.py

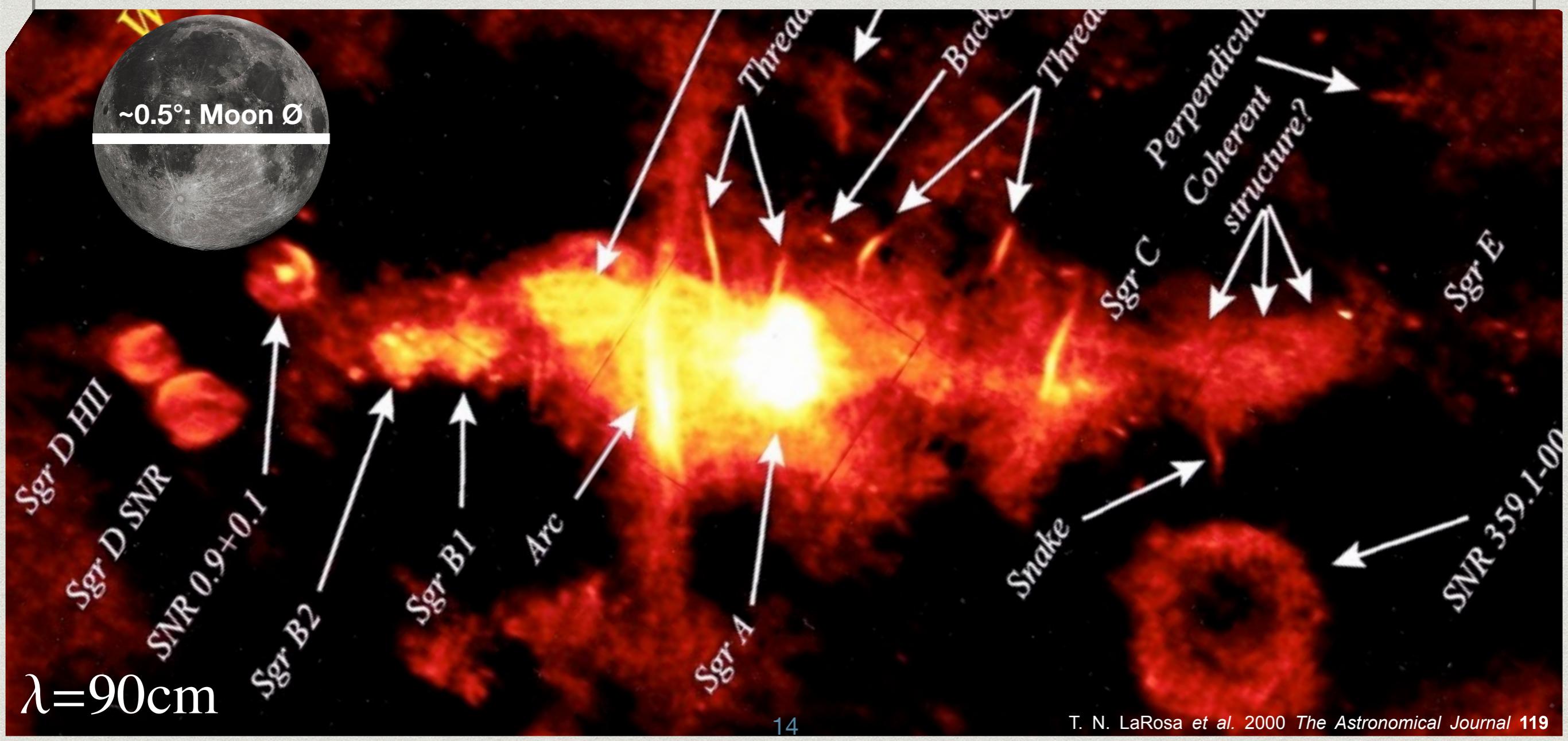
VERITAS+CTOOLS Projects

- * Galactic Center Dark Matter Halo Search



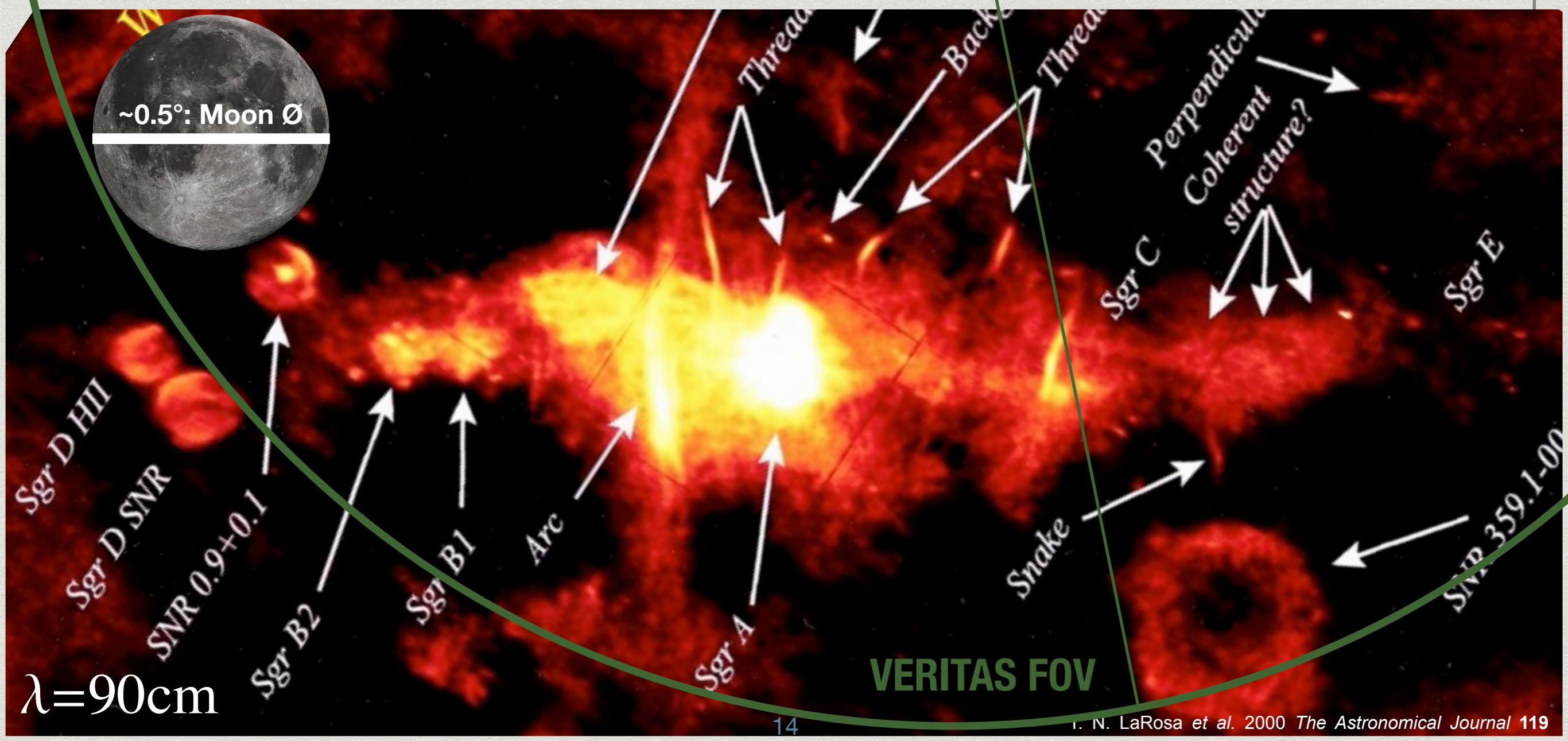
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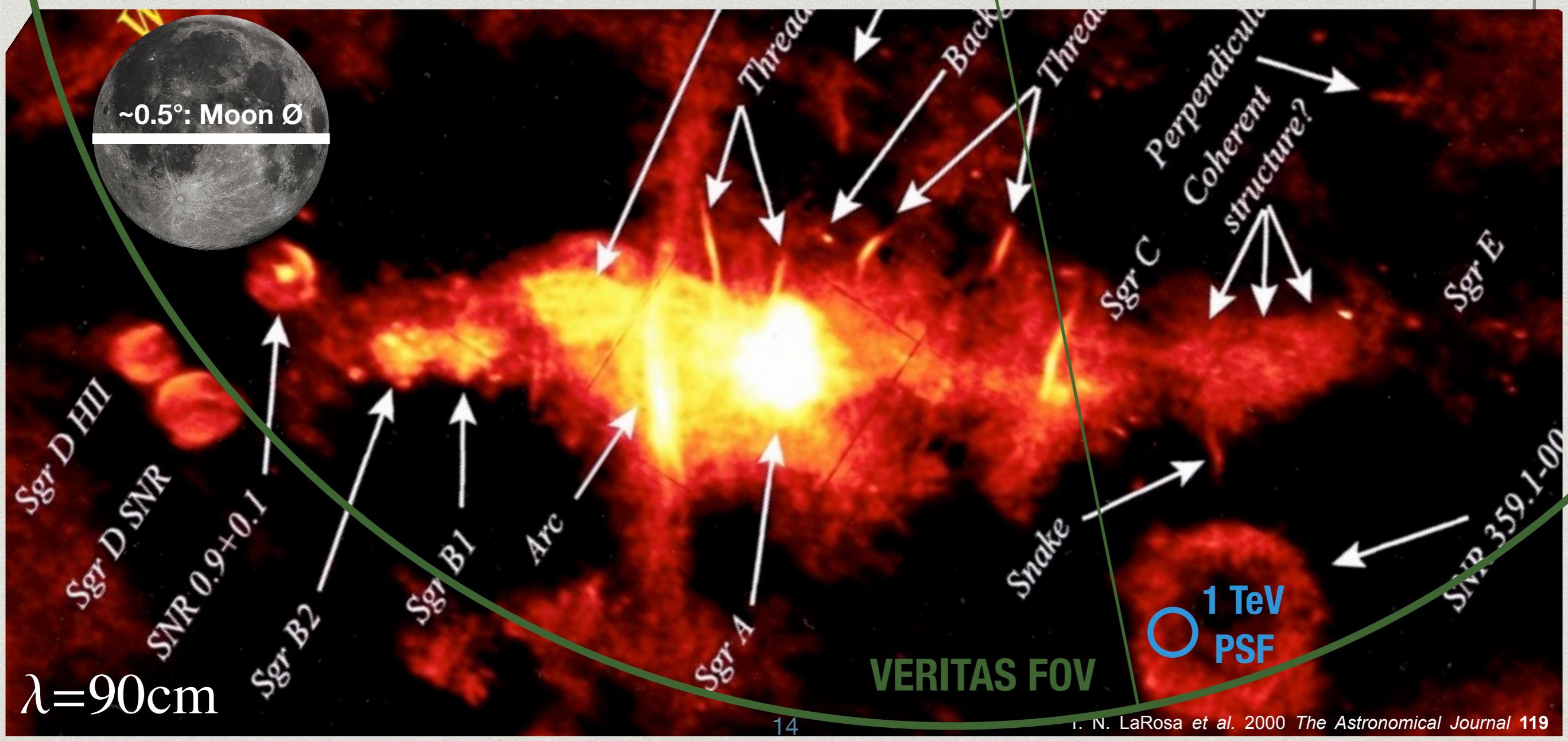
VERITAS+CTOOLS Projects

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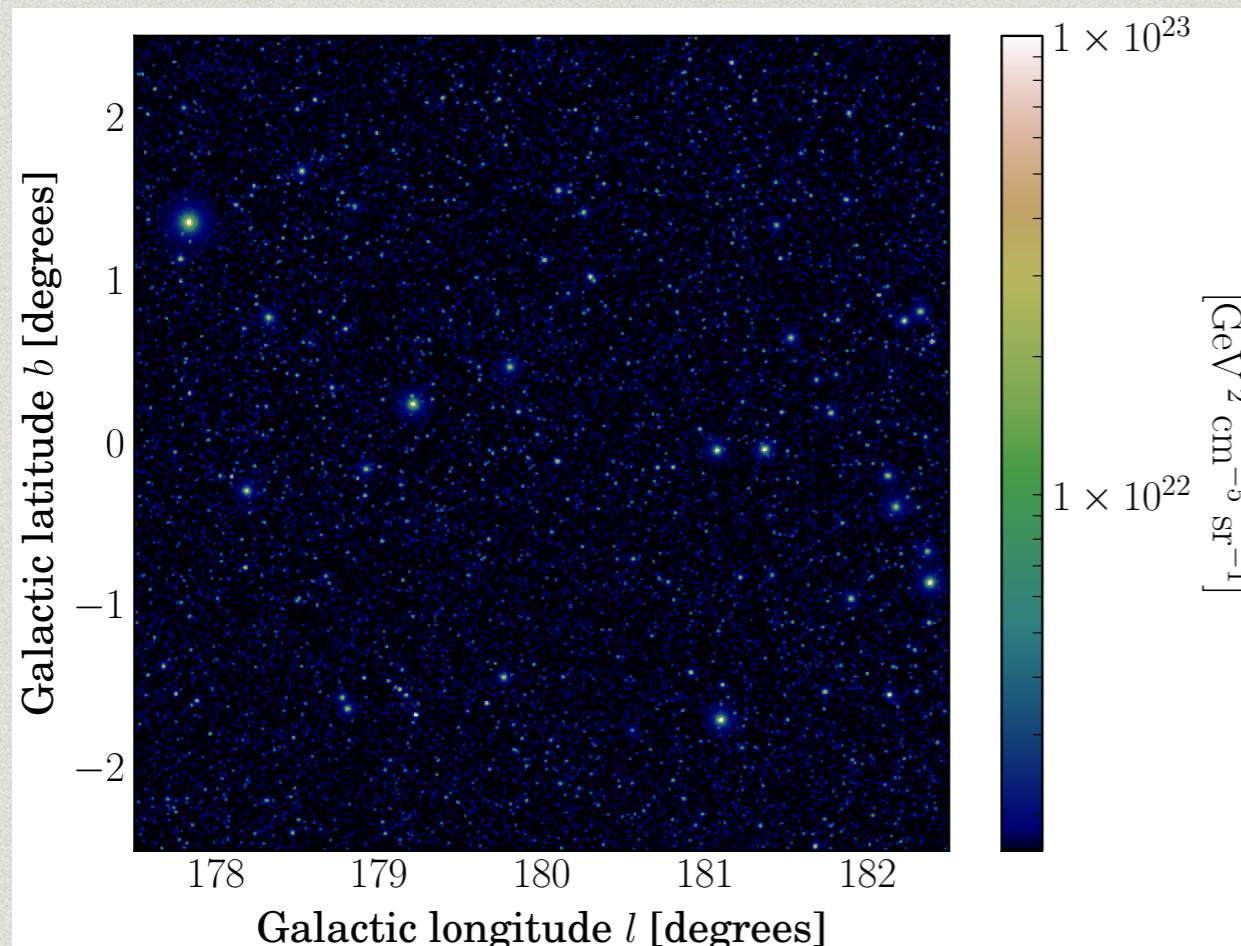


VERITAS+CTOOLS Projects

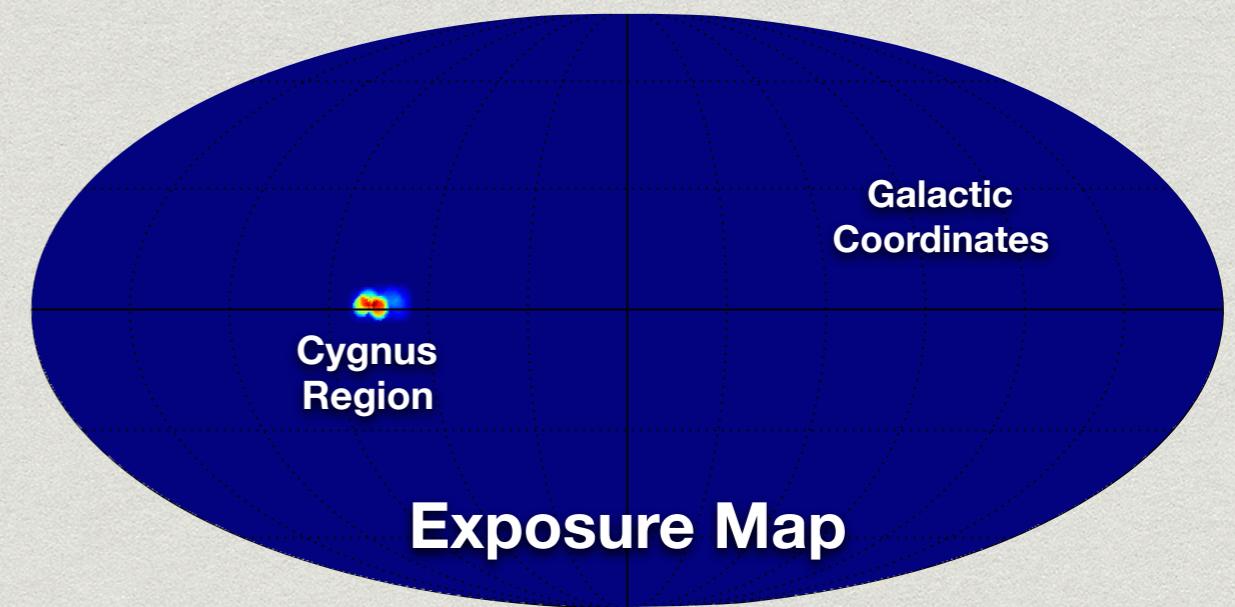
- * Galactic Center Dark Matter Halo Search



VERITAS+CTOOLS Projects



Dark Matter Clump Searches
Moritz Huetten



Cygnus Region
Extended Emission Search
Maria Krause

2nd CTOOLS Converter

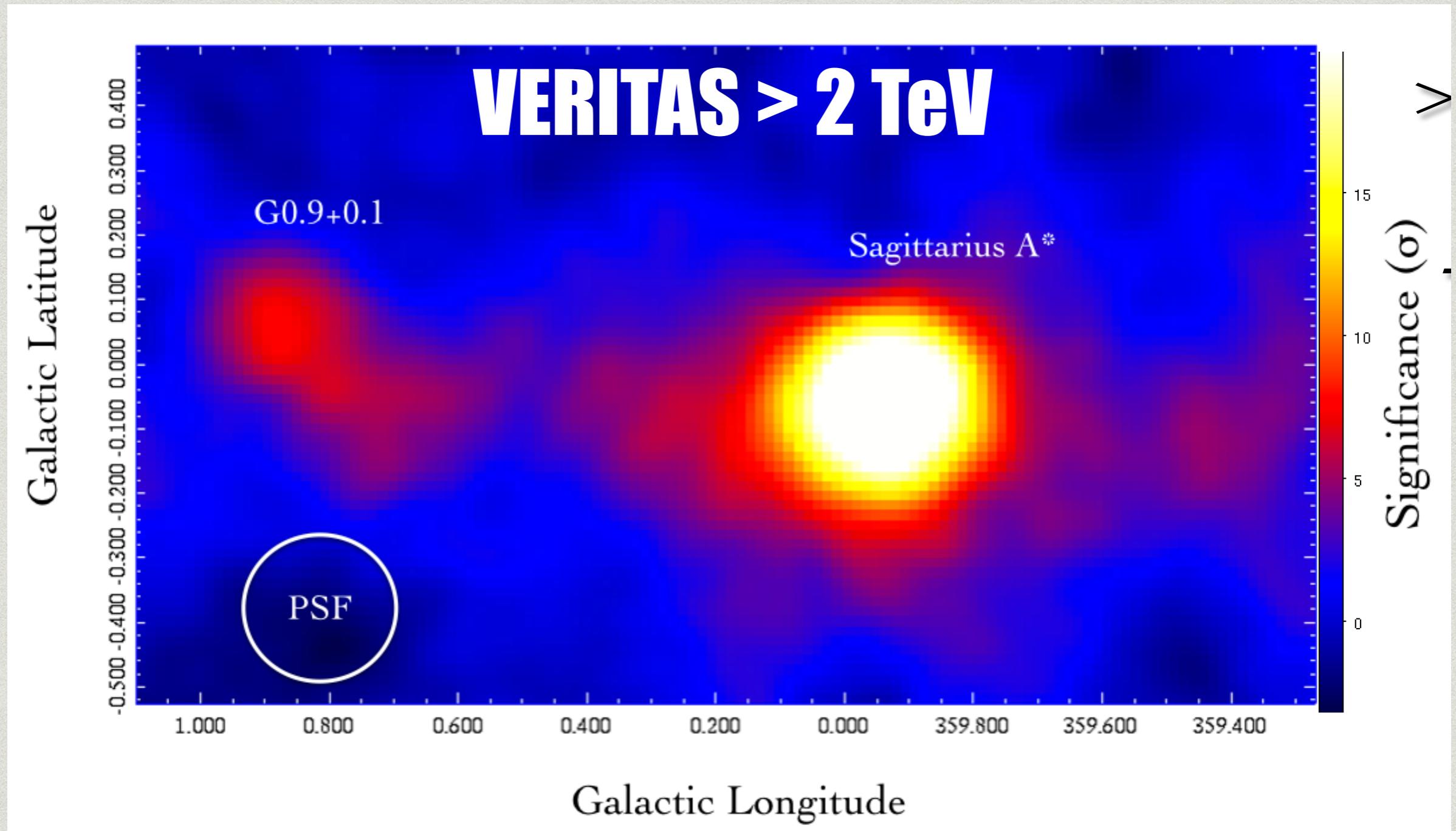
- * Worked on by Hugh Dickinson
(hughd@iastate.edu)
- * VTOOLS: branch/fork of CTOOLS for VERITAS
- * Event Lists and IRFs complete
(with extra IRF dimension for NSB Noise)
- * Currently working on multi-observation and multi-instrument likelihood tools

Conclusions

- * Verify development continues
- * Conversion of VERITAS data/IRFs to CTOOLS nearly complete
- * Next Steps:
 - * Comparison analysis for 39 VERITAS sources
 - * Galactic Center Dark Matter Halo Search

Backup Slides

Galactic Center



A. W. Smith, ICRC 2015