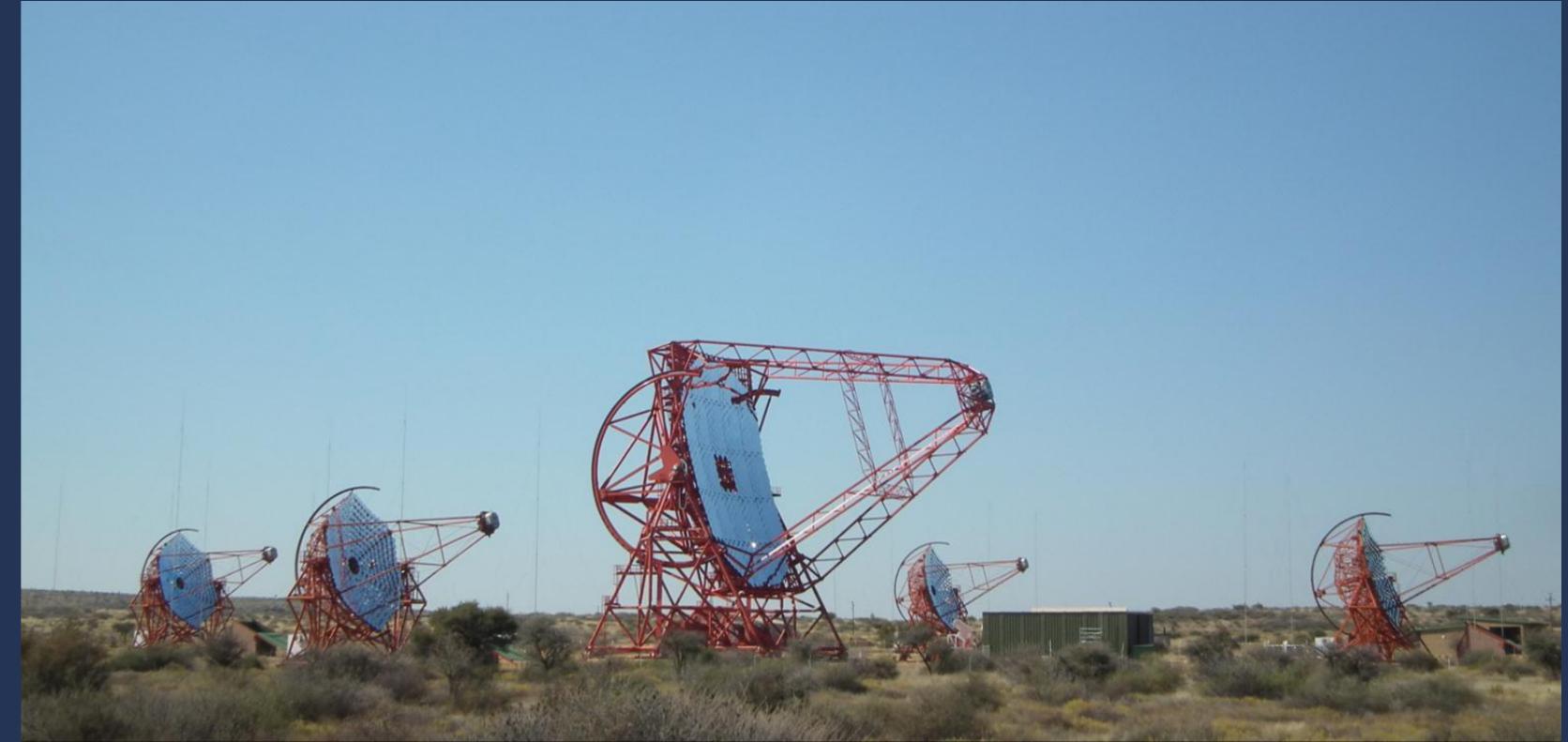


# After the H.E.S.S. I Legacy - Challenges and Prospects for the First Hybrid IACT Array

Markus Holler (Universität Innsbruck)  
ICRR Seminar  
柏 (東京), 2017年07月26日

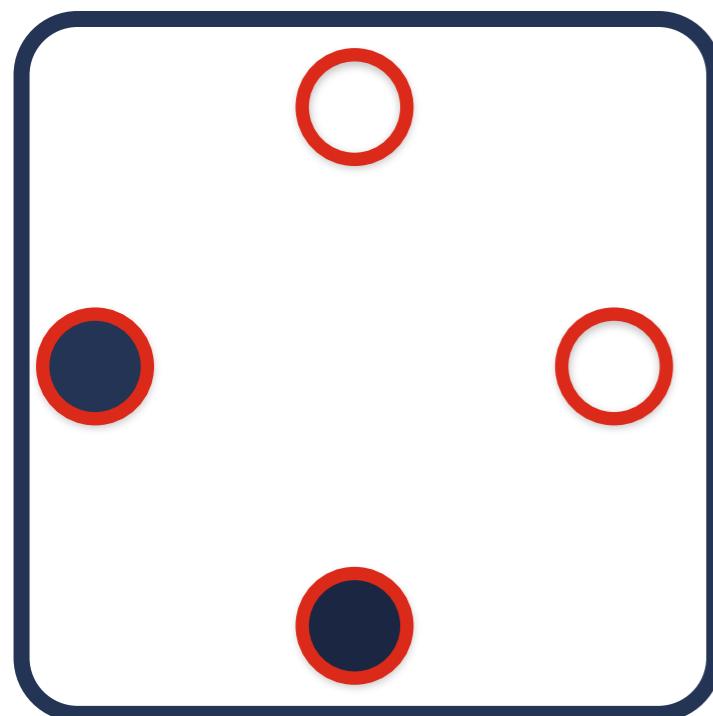


# H.E.S.S. I (2004-2012)

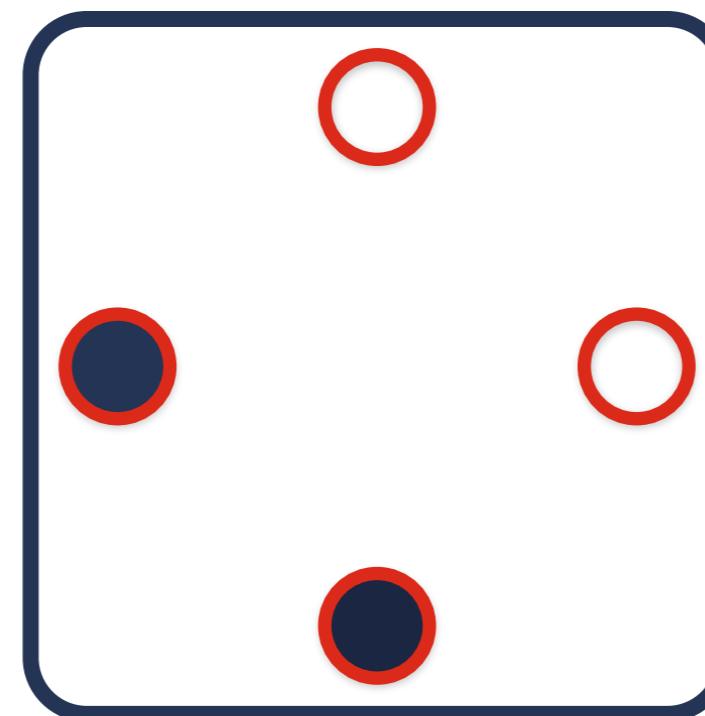


# Reconstruction & Analysis H.E.S.S. I (CT1-4) (2004-2012)

Trigger

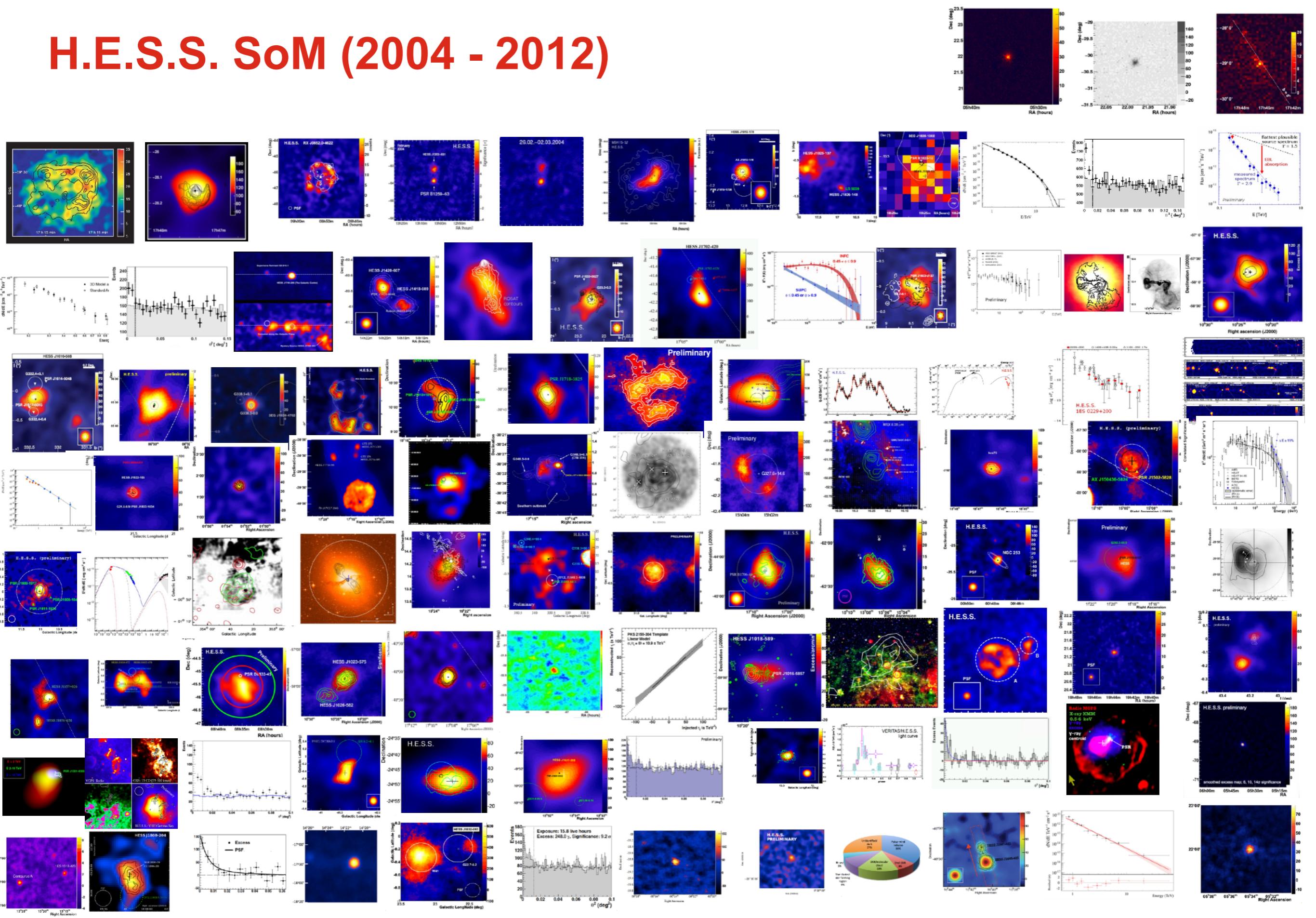


Reconstruction

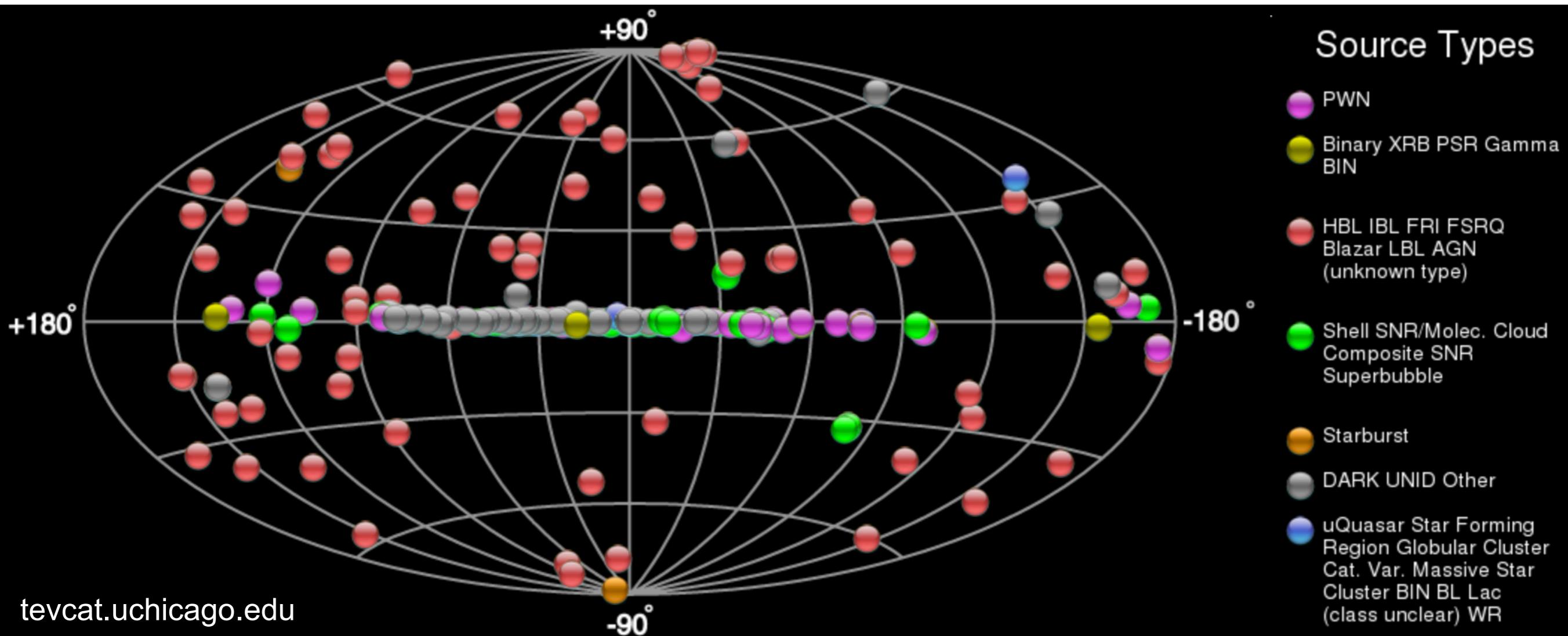


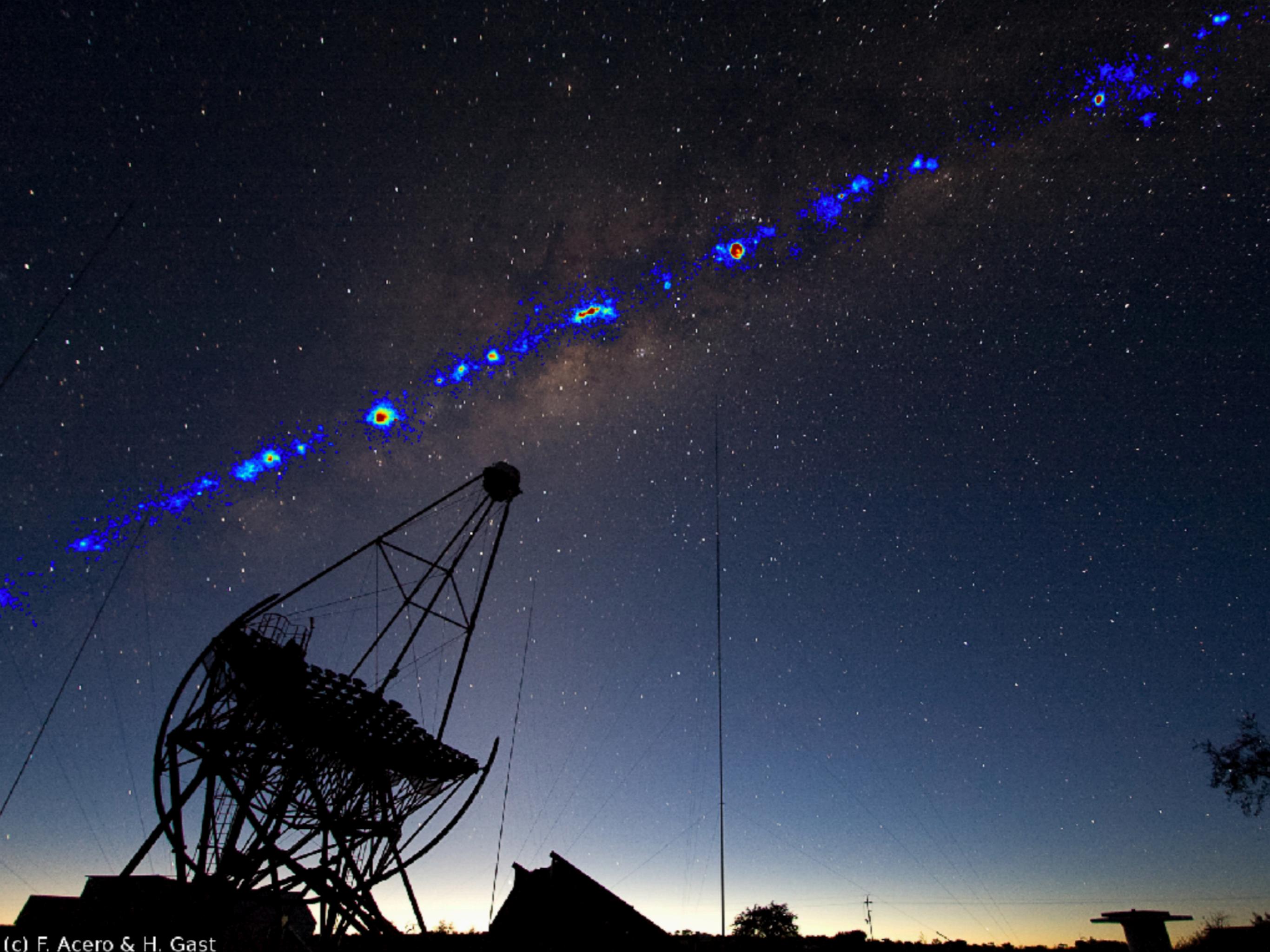
→ Stereo Analysis

# H.E.S.S. SoM (2004 - 2012)



# The VHE Gamma-Ray Sky

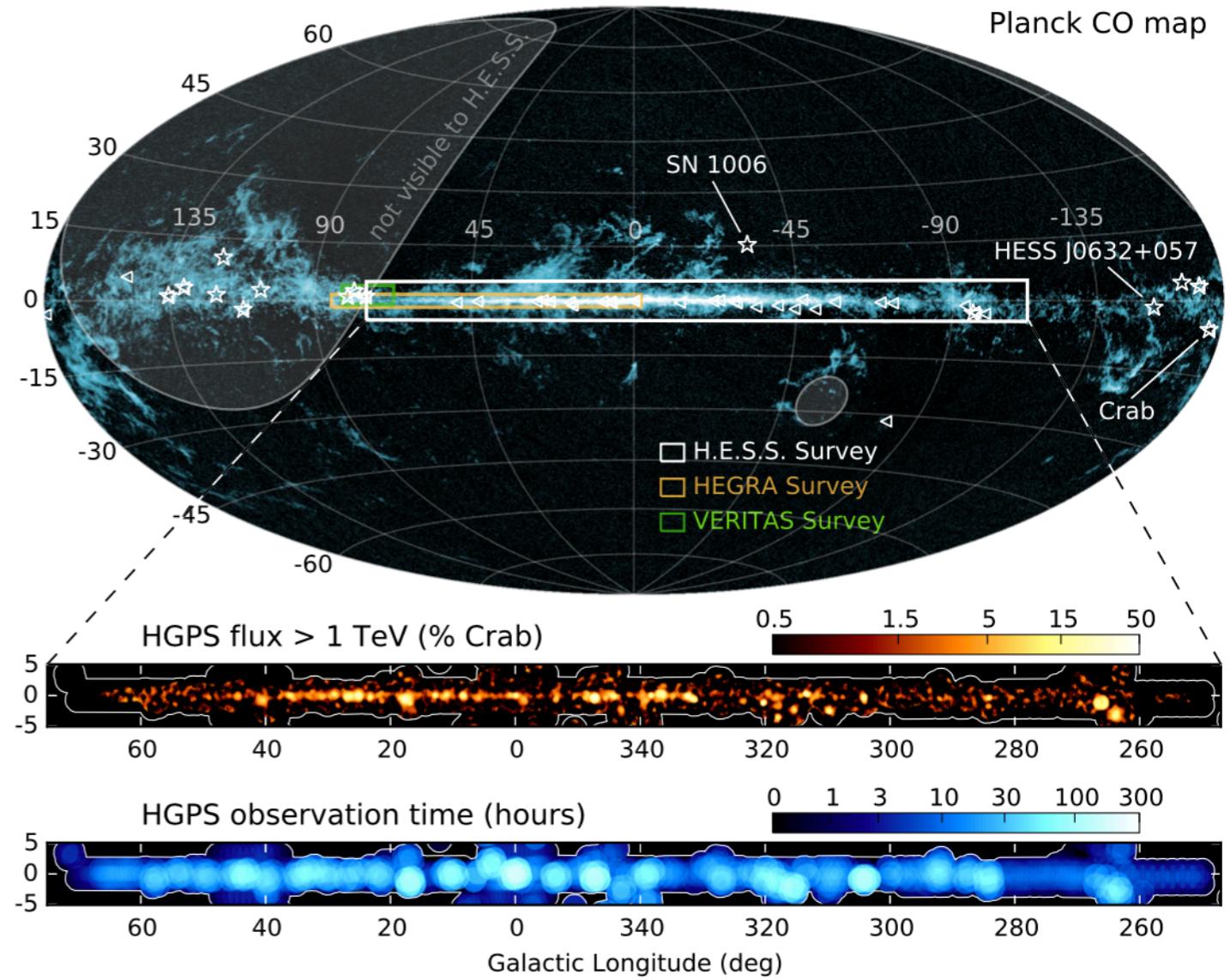
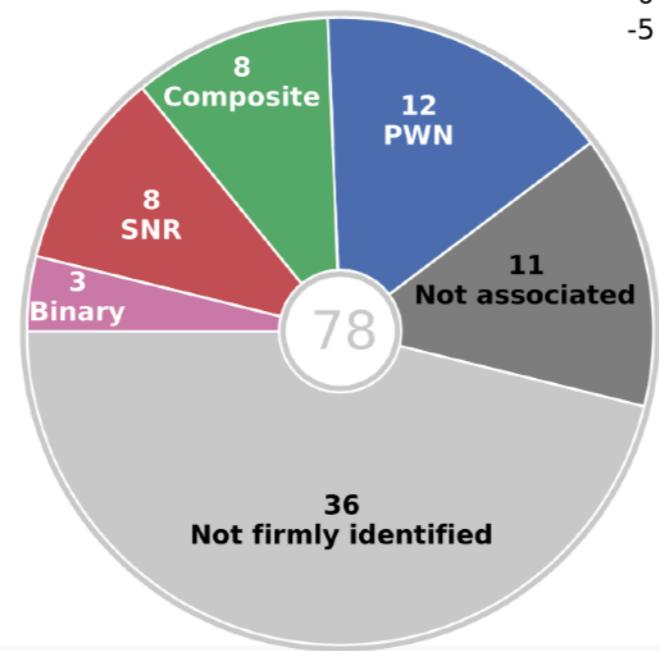




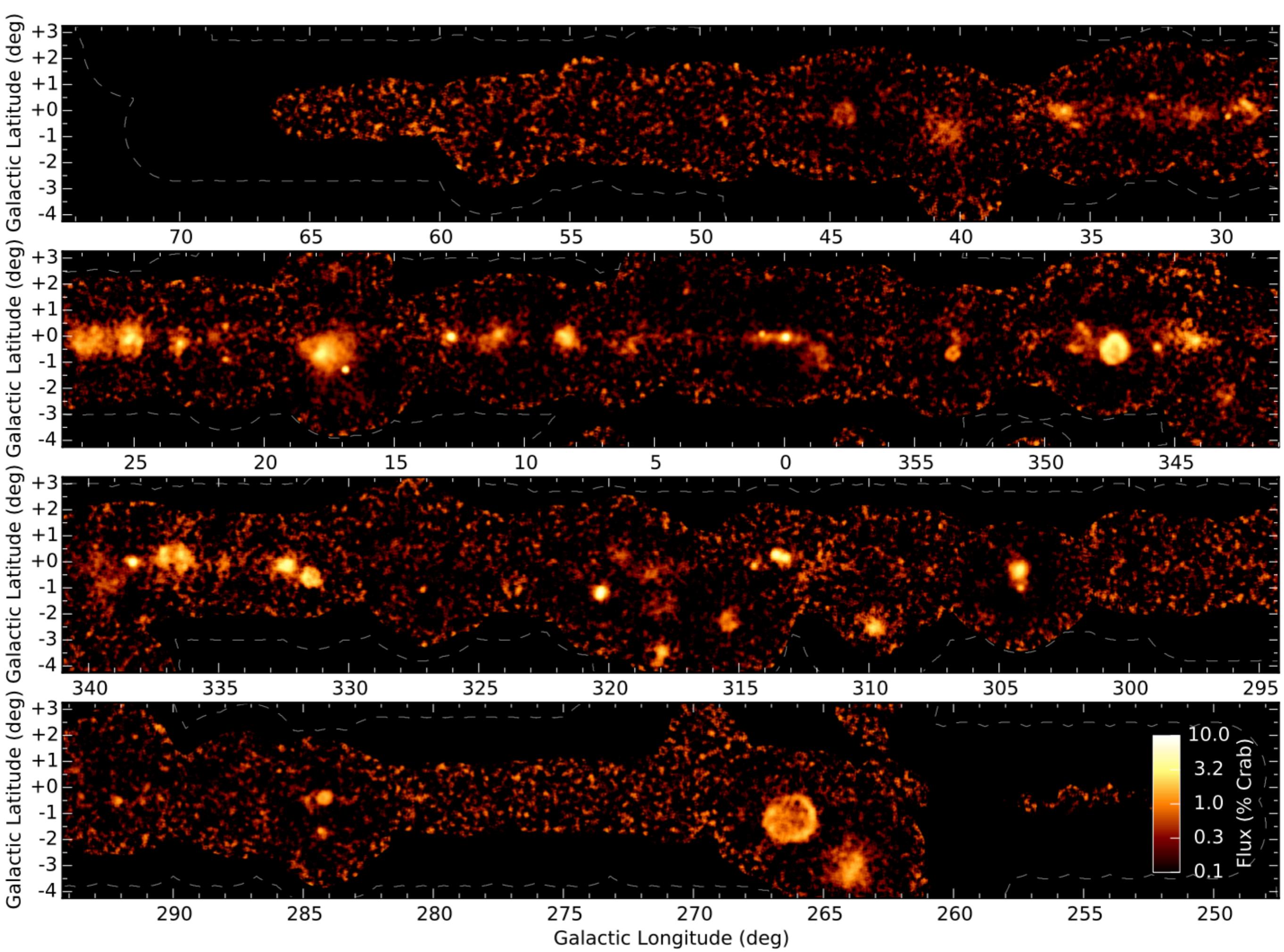
(c) F. Acero & H. Gast

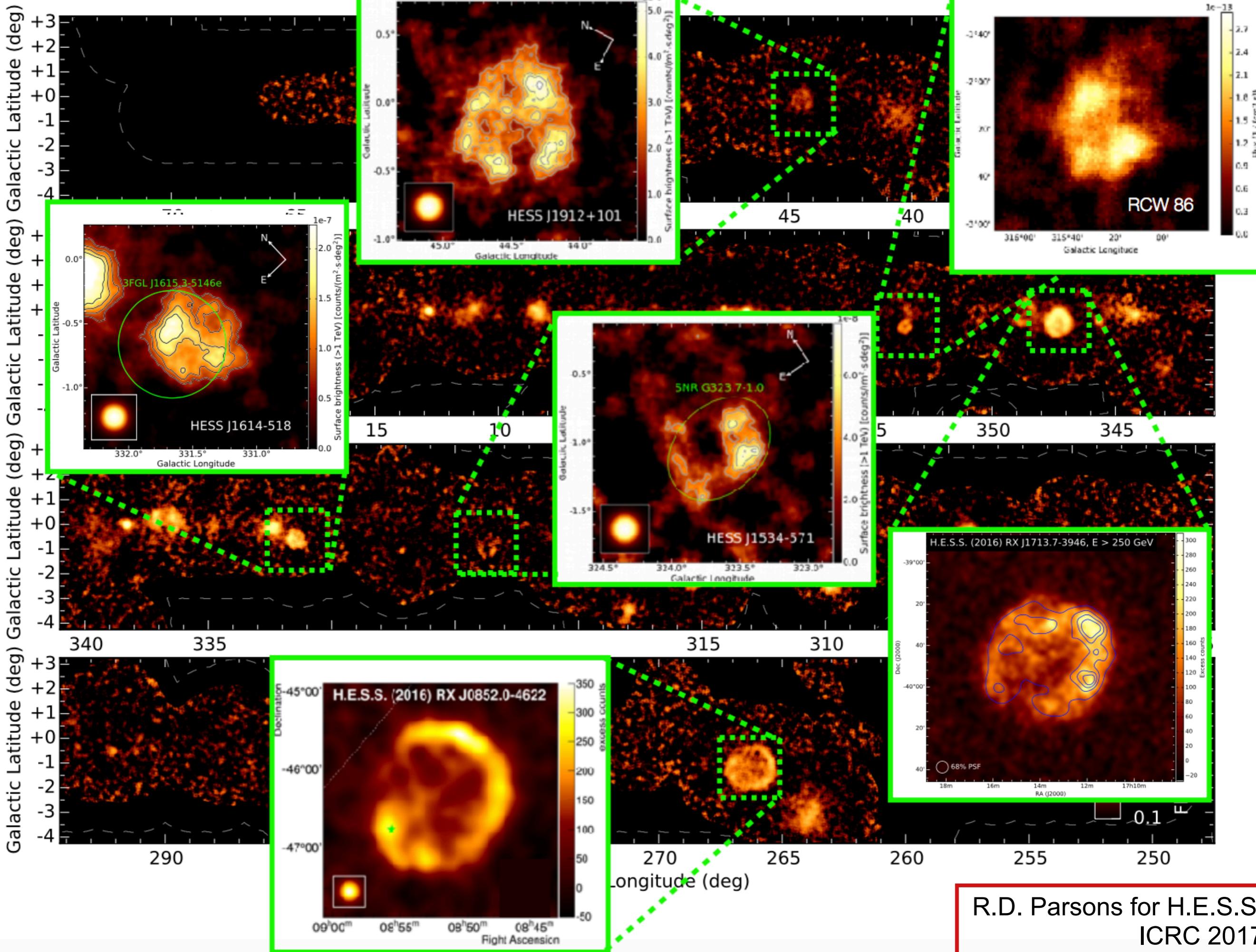
# H.E.S.S. Galactic Plane Survey

- ~ 3000 hours of observations on the Galactic plane conducted
- Used to compile a survey in gamma-rays
- 78 sources included in the upcoming paper



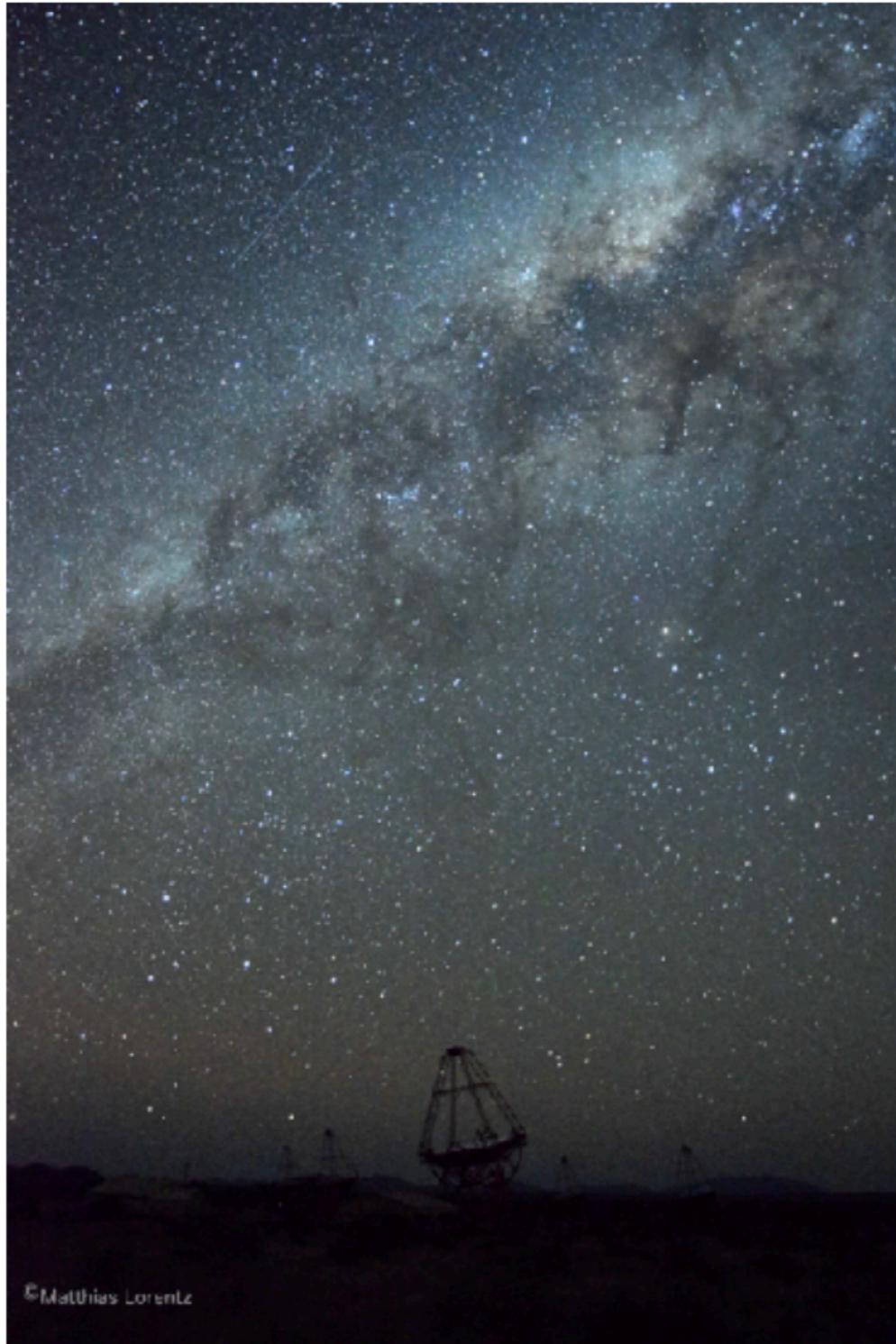
R.D. Parsons for H.E.S.S.  
ICRC 2017





R.D. Parsons for H.E.S.S.  
ICRC 2017

# Special Issue - The H.E.S.S. I Legacy (Released)



*Detailed spectral and morphological analysis of the shell type SNR RCW 86* - <http://adsabs.harvard.edu/abs/2016arXiv160104461H>

*Extended VHE gamma-ray emission towards SGR1806-20, LBV1806-20, and stellar cluster CI\*1806-20* - <http://adsabs.harvard.edu/abs/2016arXiv160605404A>

*A search for very high-energy flares from the microquasars GRS 1915+105, Circinus X-1, and V4641 Sgr using contemporaneous H.E.S.S. and RXTE observations* - <http://adsabs.harvard.edu/abs/2016arXiv160704613H>

*The supernova remnant W49B as seen with H.E.S.S. and Fermi-LAT* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1609.00600](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1609.00600)

*H.E.S.S. observations of RX J1713.7-3946 with improved angular and spectral resolution; evidence for gamma-ray emission extending beyond the X-ray emitting shell* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1609.08671](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1609.08671)

*Systematic search for very-high-energy gamma-ray emission from bow shocks of runaway stars* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1705.02263](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1705.02263)

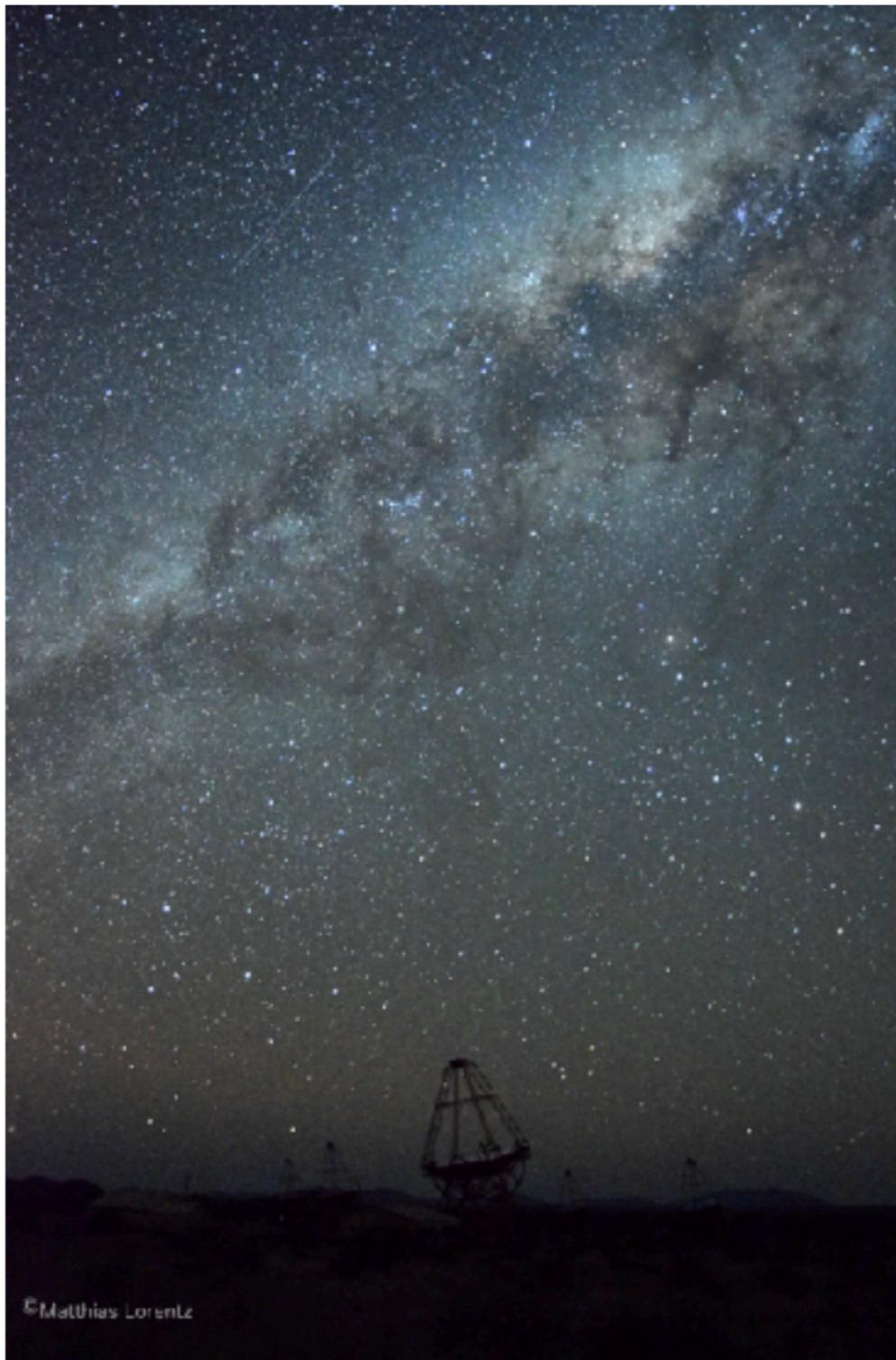
*The population of TeV pulsar wind nebulae in the H.E.S.S. Galactic Plane Survey* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1702.08280](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1702.08280)

*Deeper H.E.S.S. Observations of Vela Junior (RX J0852.0-4622): Morphology Studies and Resolved Spectroscopy* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1611.01863](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1611.01863)

*Characterising the VHE diffuse emission in the central 200 parsecs of our Galaxy with H.E.S.S.* - [http://adsabs.harvard.edu/cgi-bin/bib\\_query?arXiv:1706.04535](http://adsabs.harvard.edu/cgi-bin/bib_query?arXiv:1706.04535)

# Special Issue - The H.E.S.S. I Legacy (Coming Soon)

Astronomy  
&  
Astrophysics



*HESS J1741-302: an unidentified very high energy Gamma-ray source in the Galactic plane*

*Galactic Supernova Remnants Population Study at Very High Gamma-Ray Energies with H.E.S.S.*

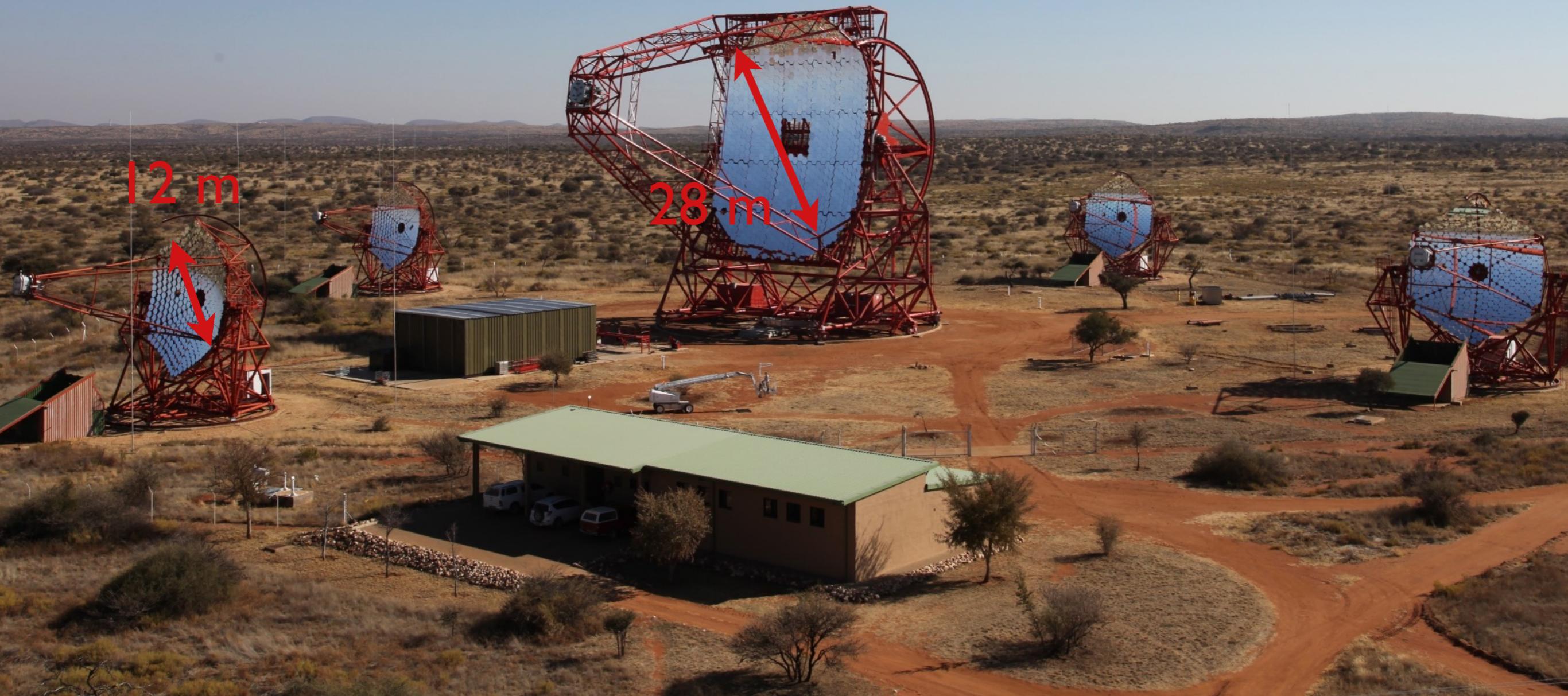
*Constraints on particle acceleration in SS433/W50 from MAGIC and H.E.S.S. observations*

***The H.E.S.S. Galactic Plane Survey***

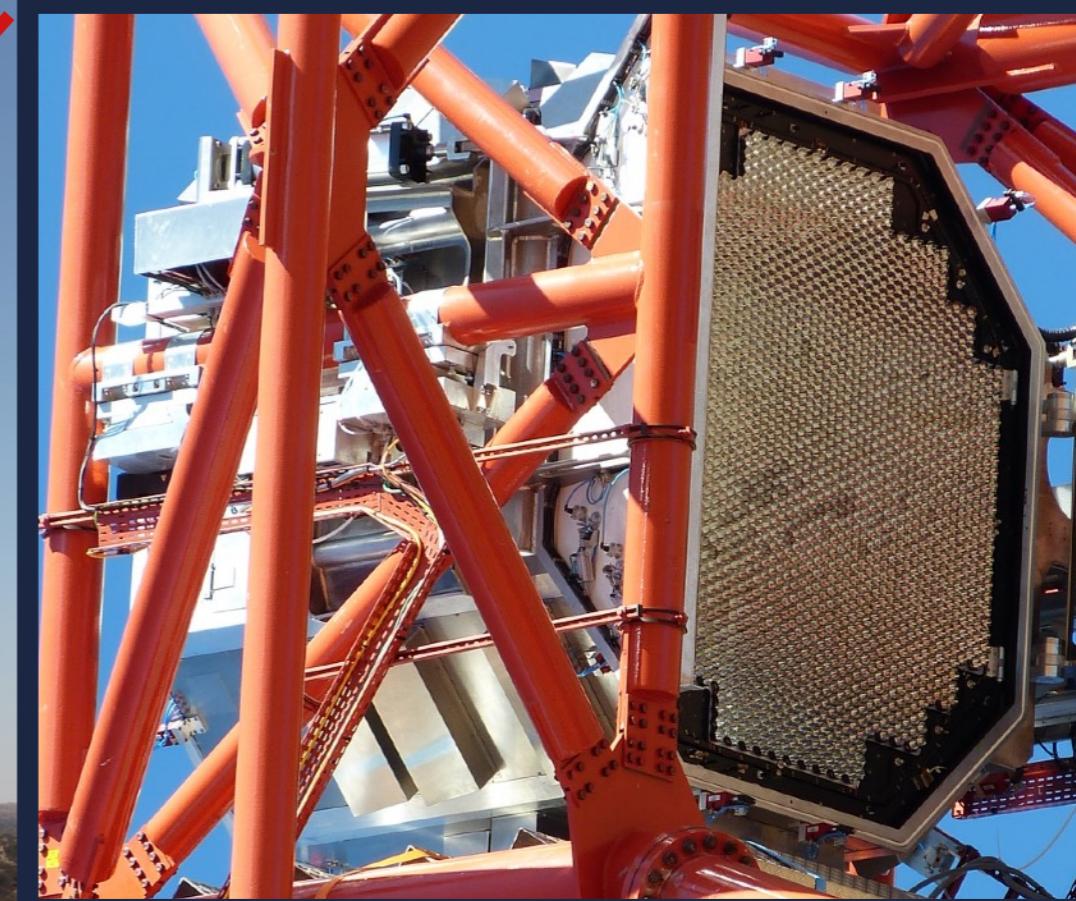
# H.E.S.S. II (since 2012)



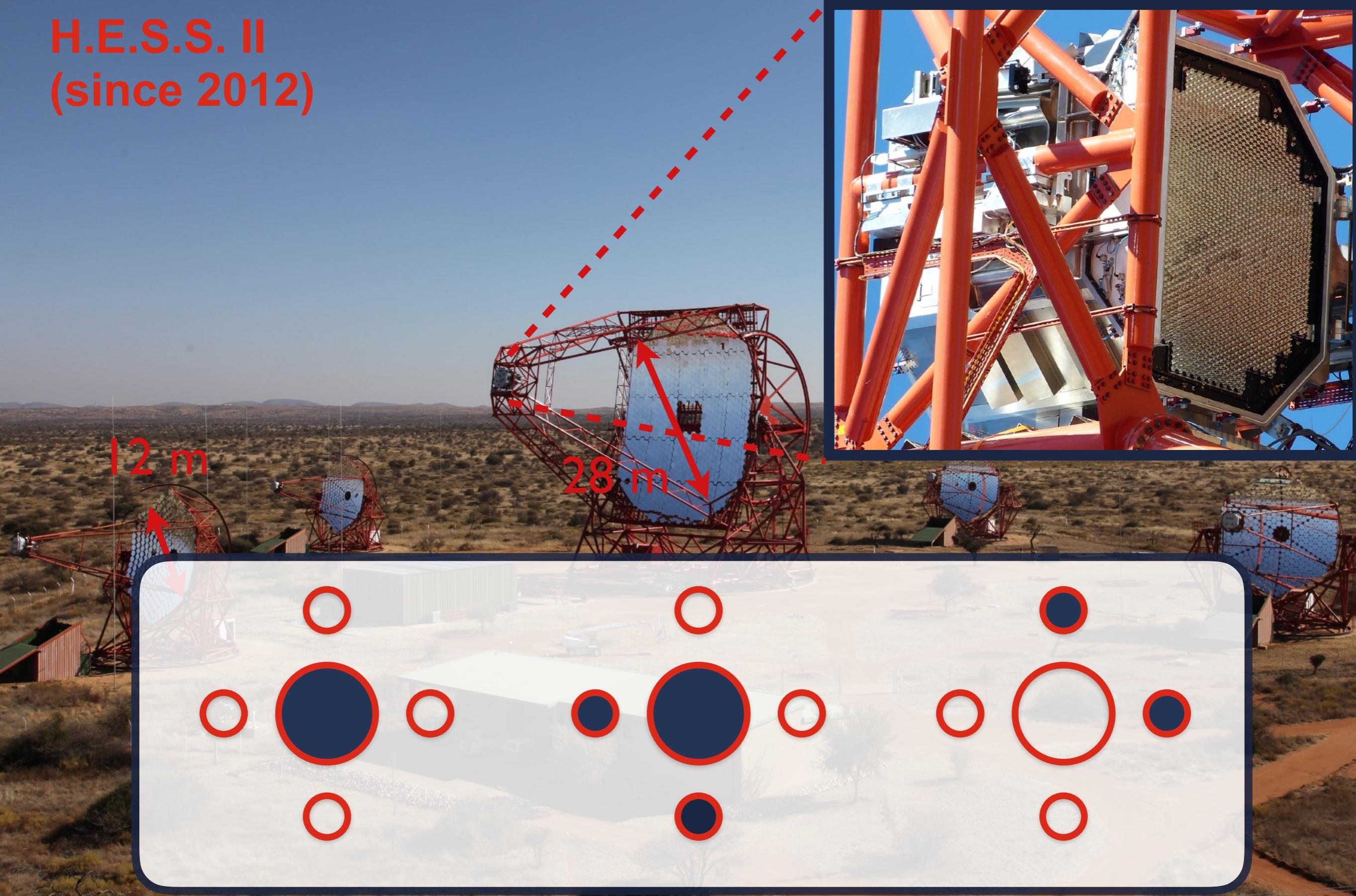
# H.E.S.S. II (since 2012)



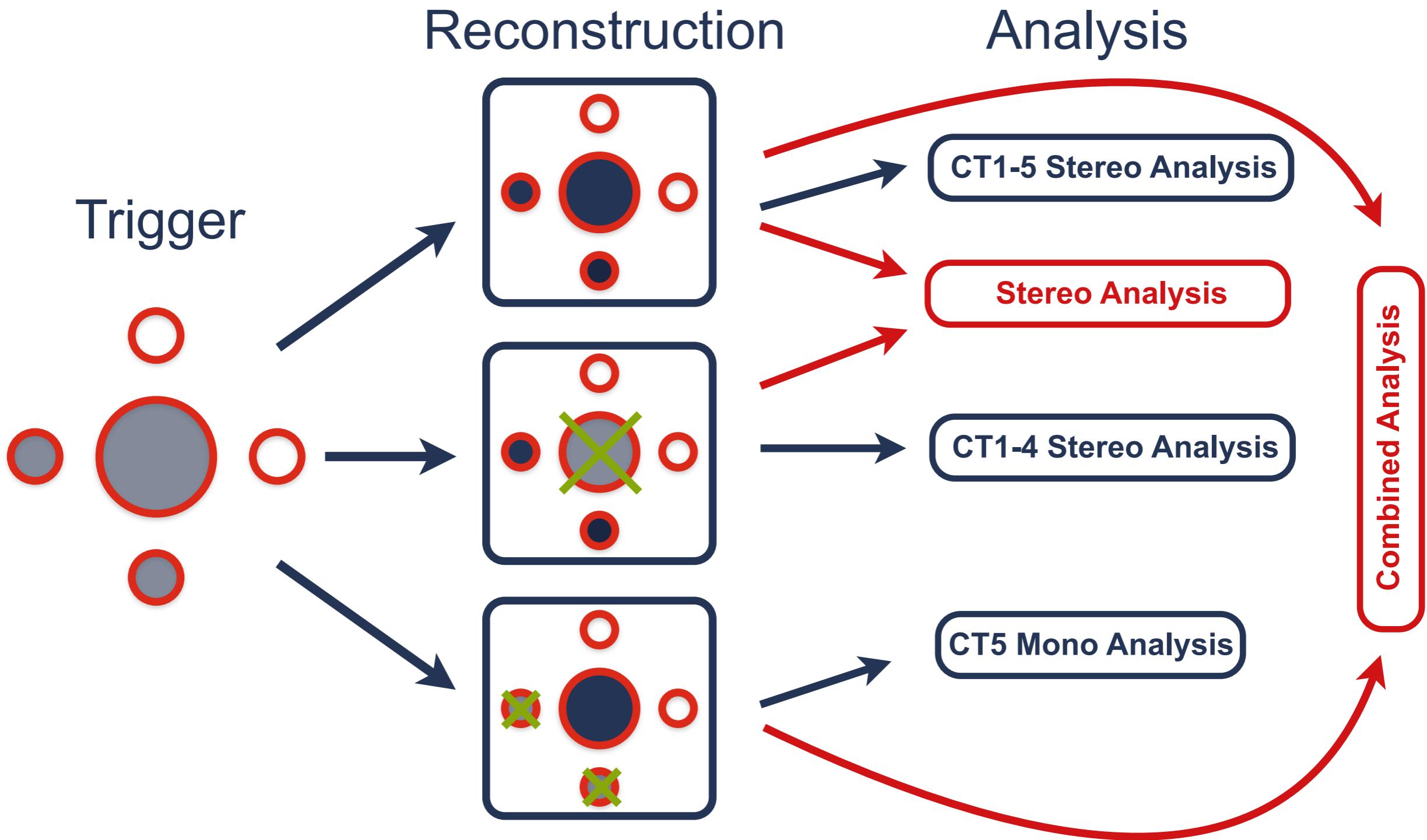
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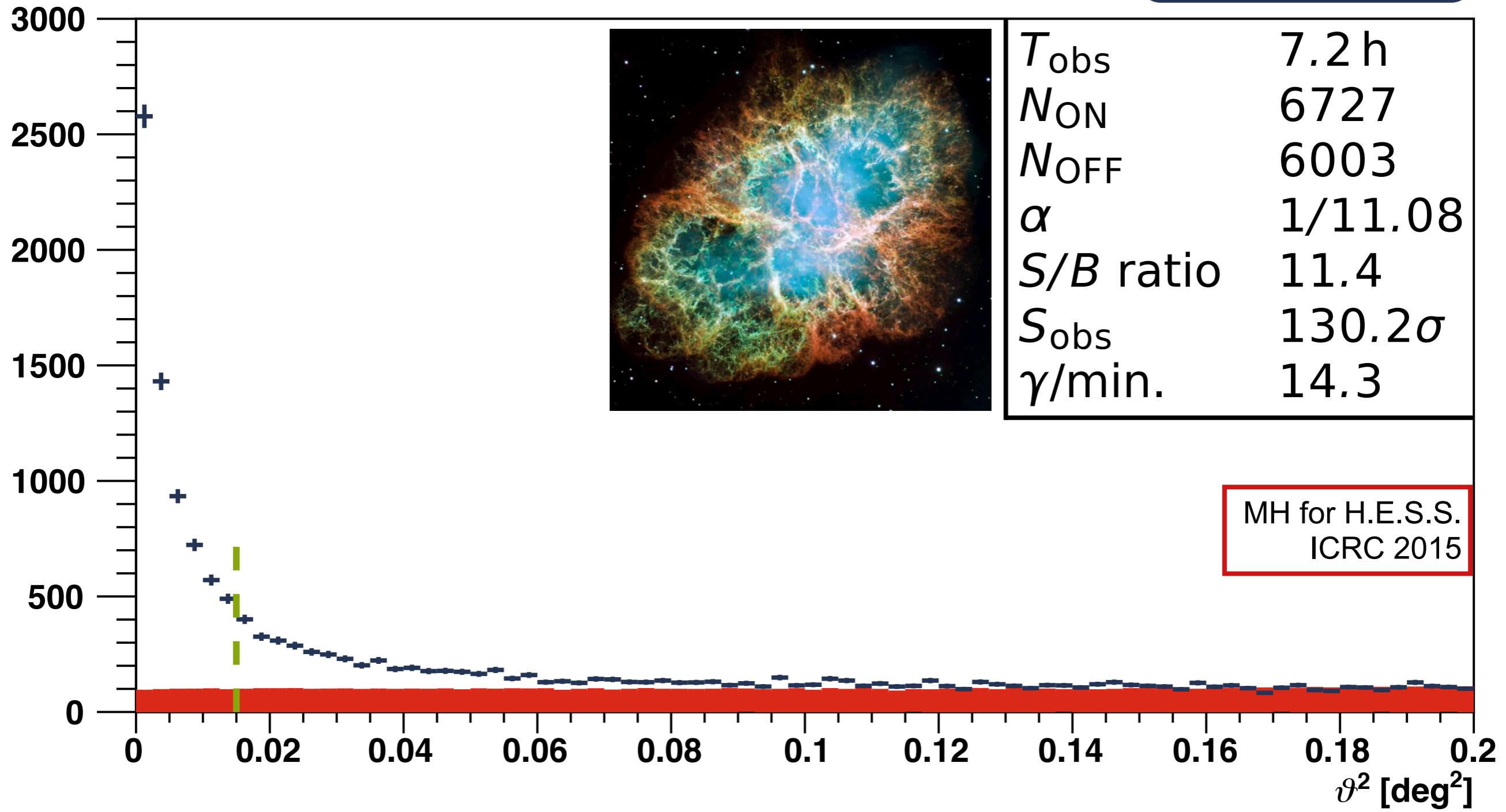
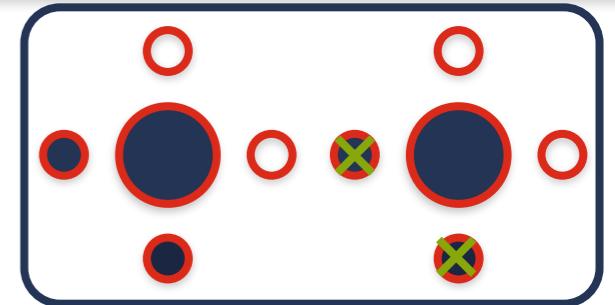
# H.E.S.S. II (since 2012)



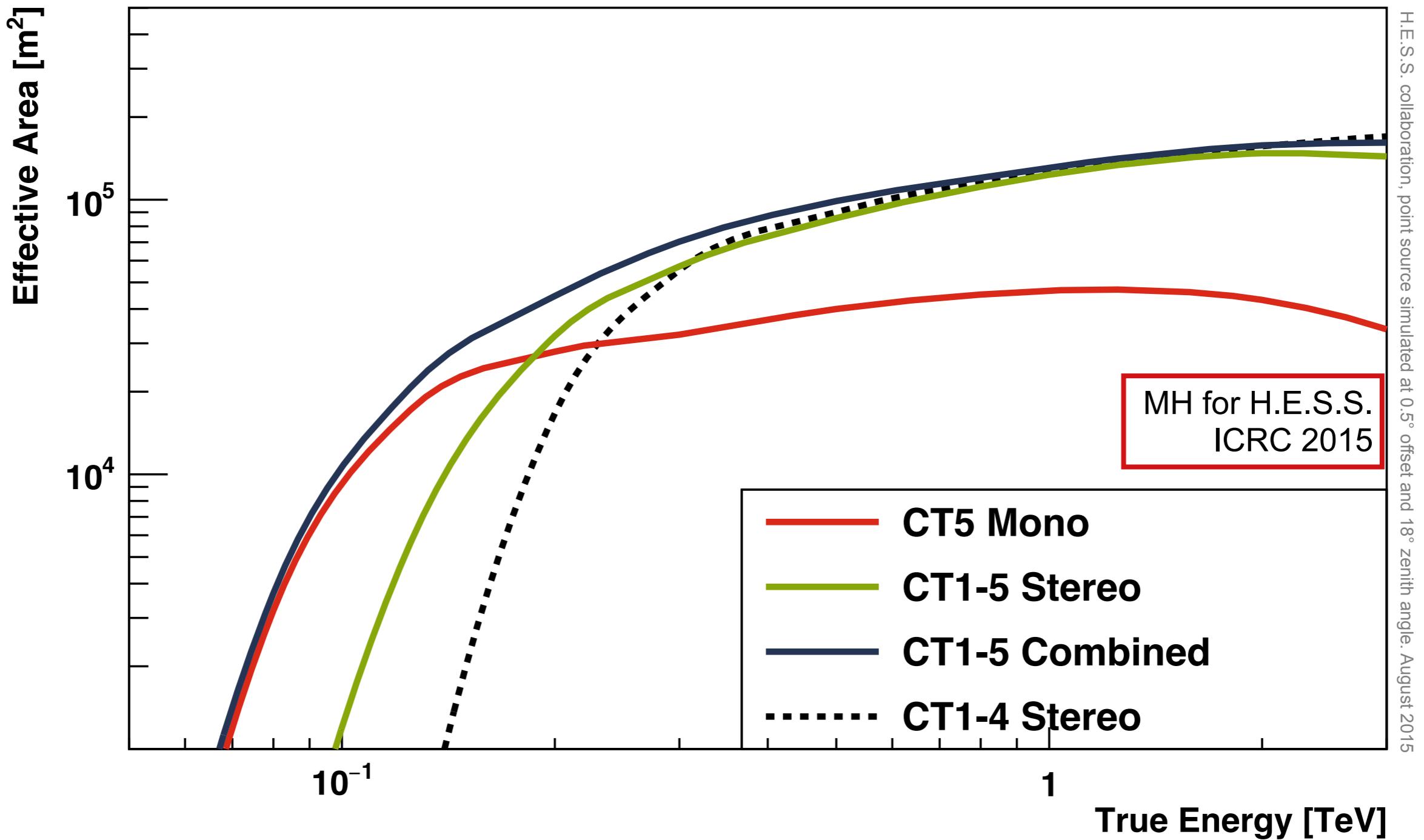
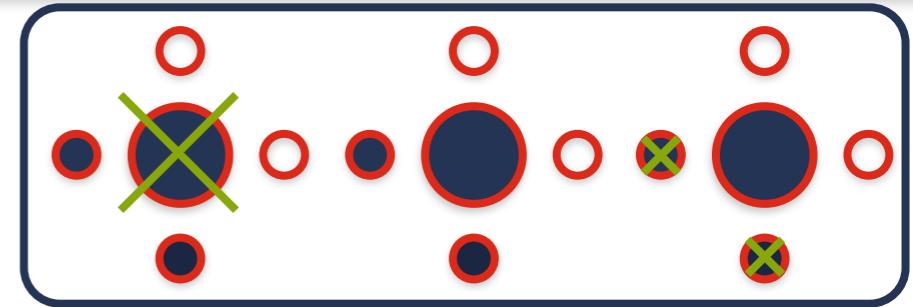
# Reconstruction/Analysis Modes H.E.S.S. II (CT1-5)



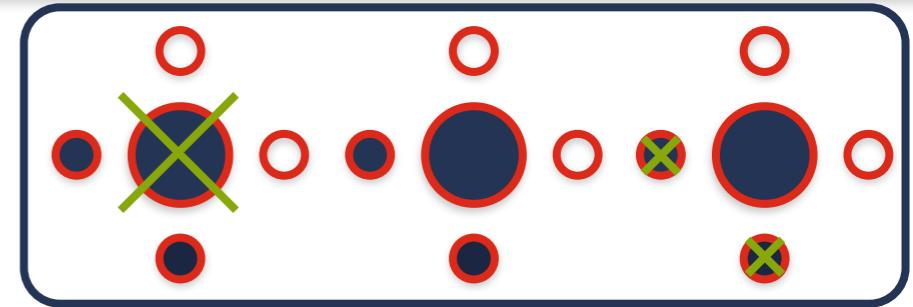
# The Crab Nebula in Combined Mode



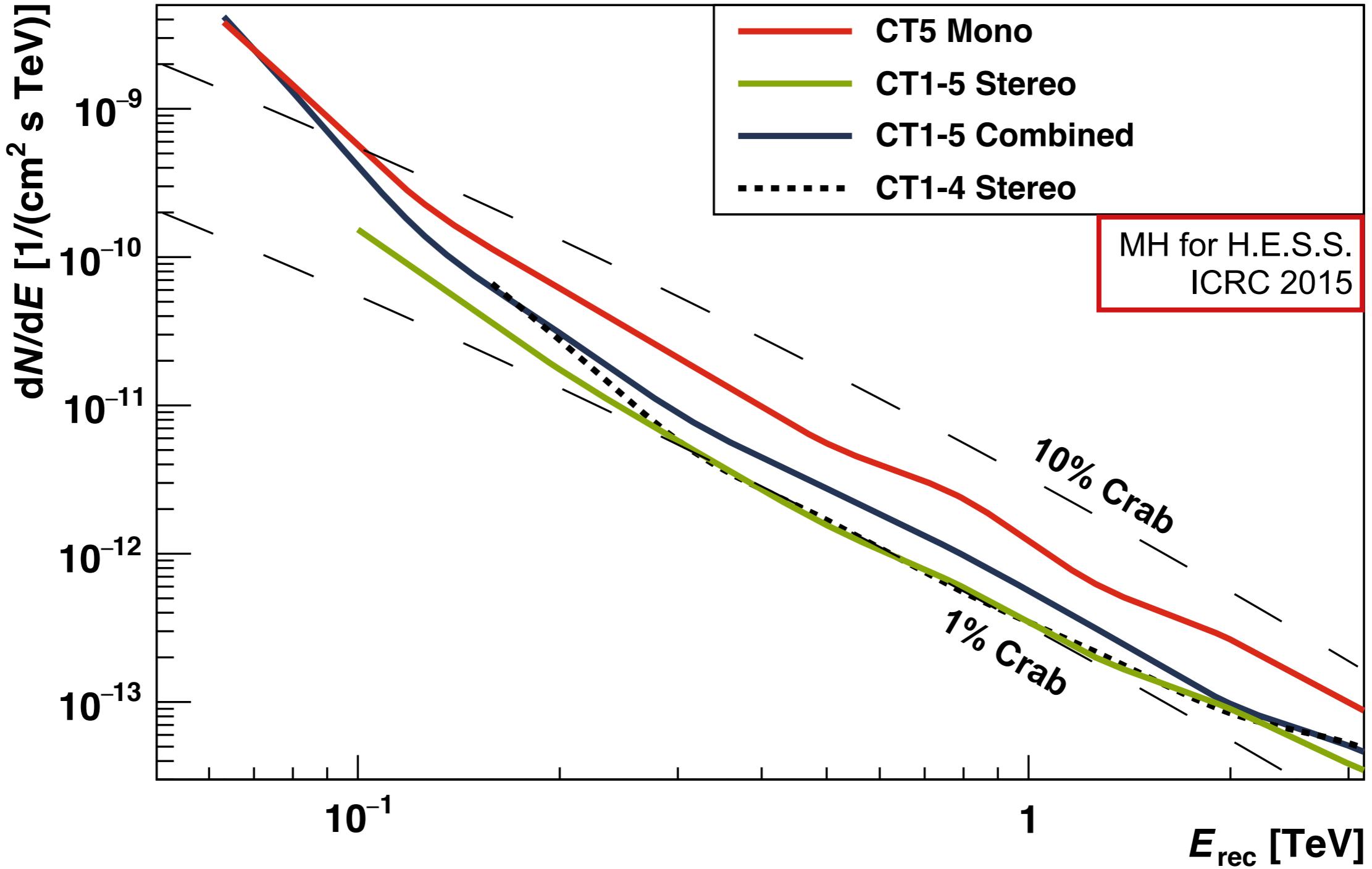
# Effective Area



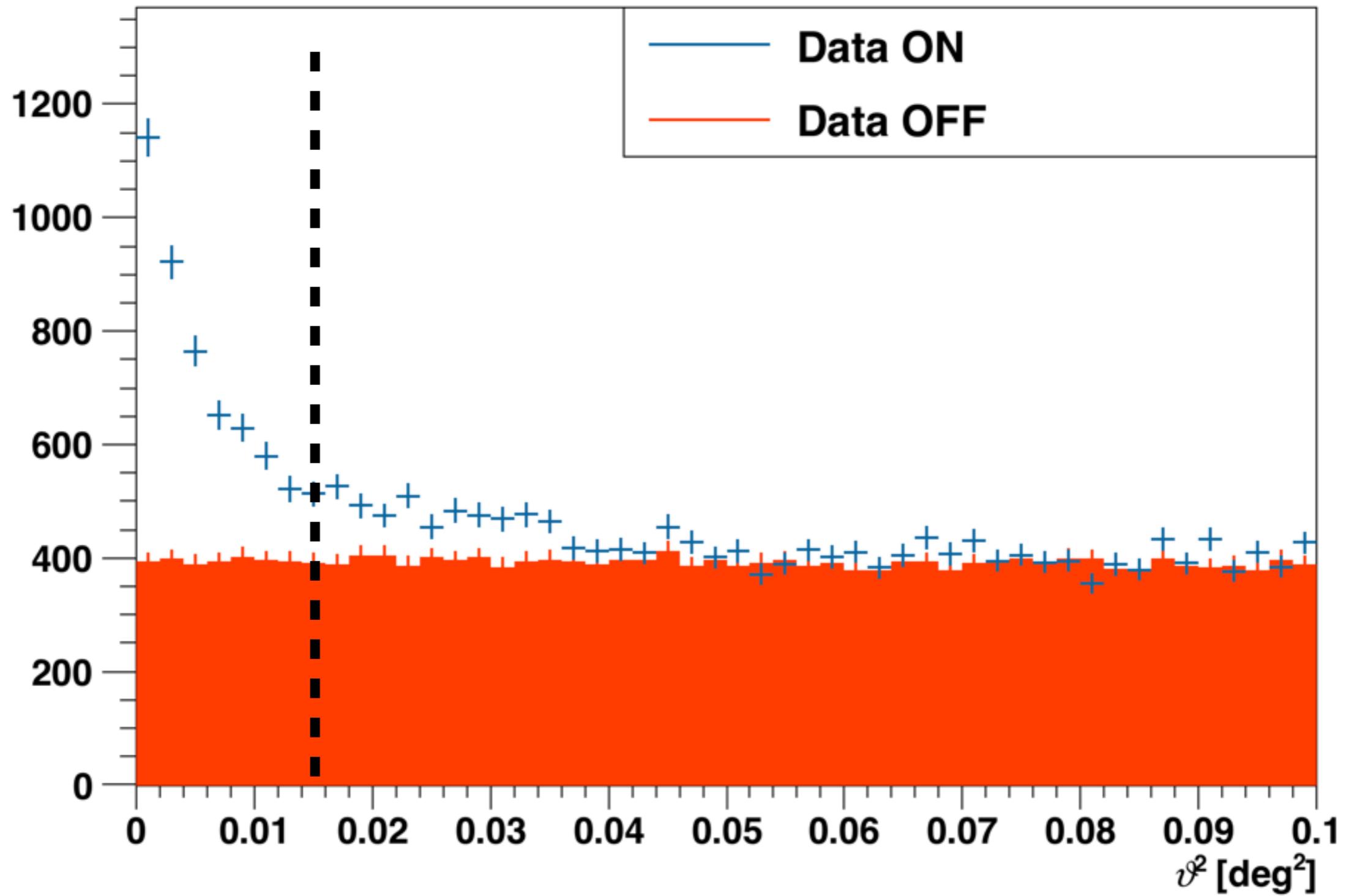
# Differential Sensitivity



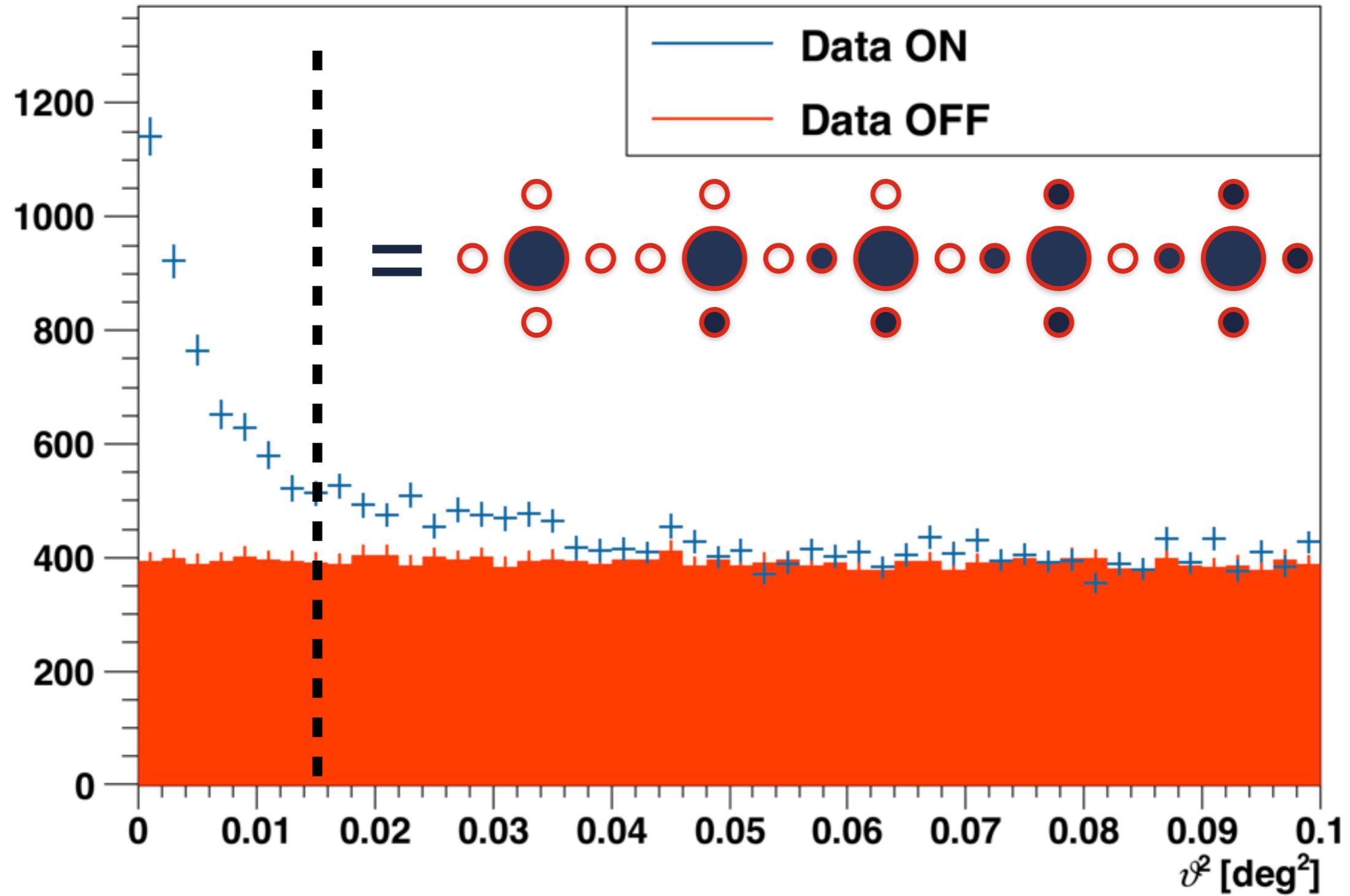
H.E.S.S. collaboration, point source simulated at 0.5° offset and 18° zenith angle. August 2015



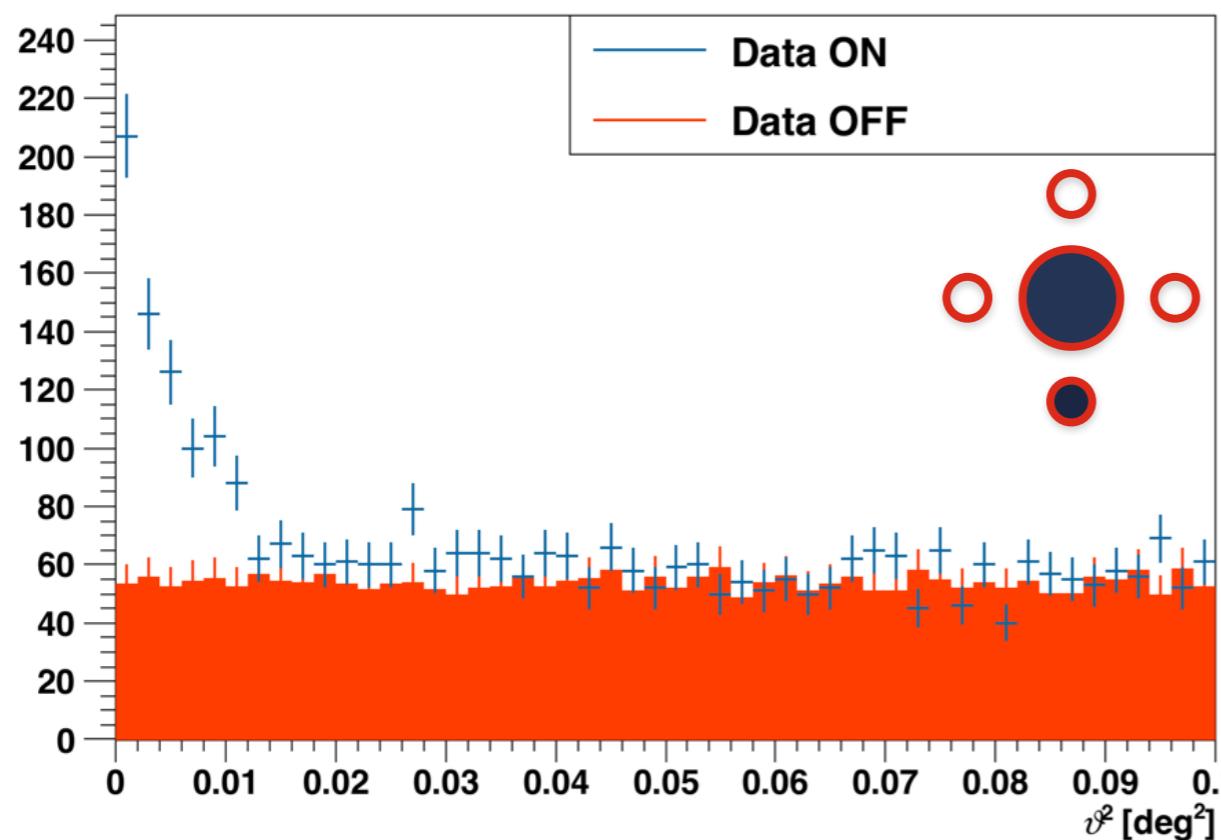
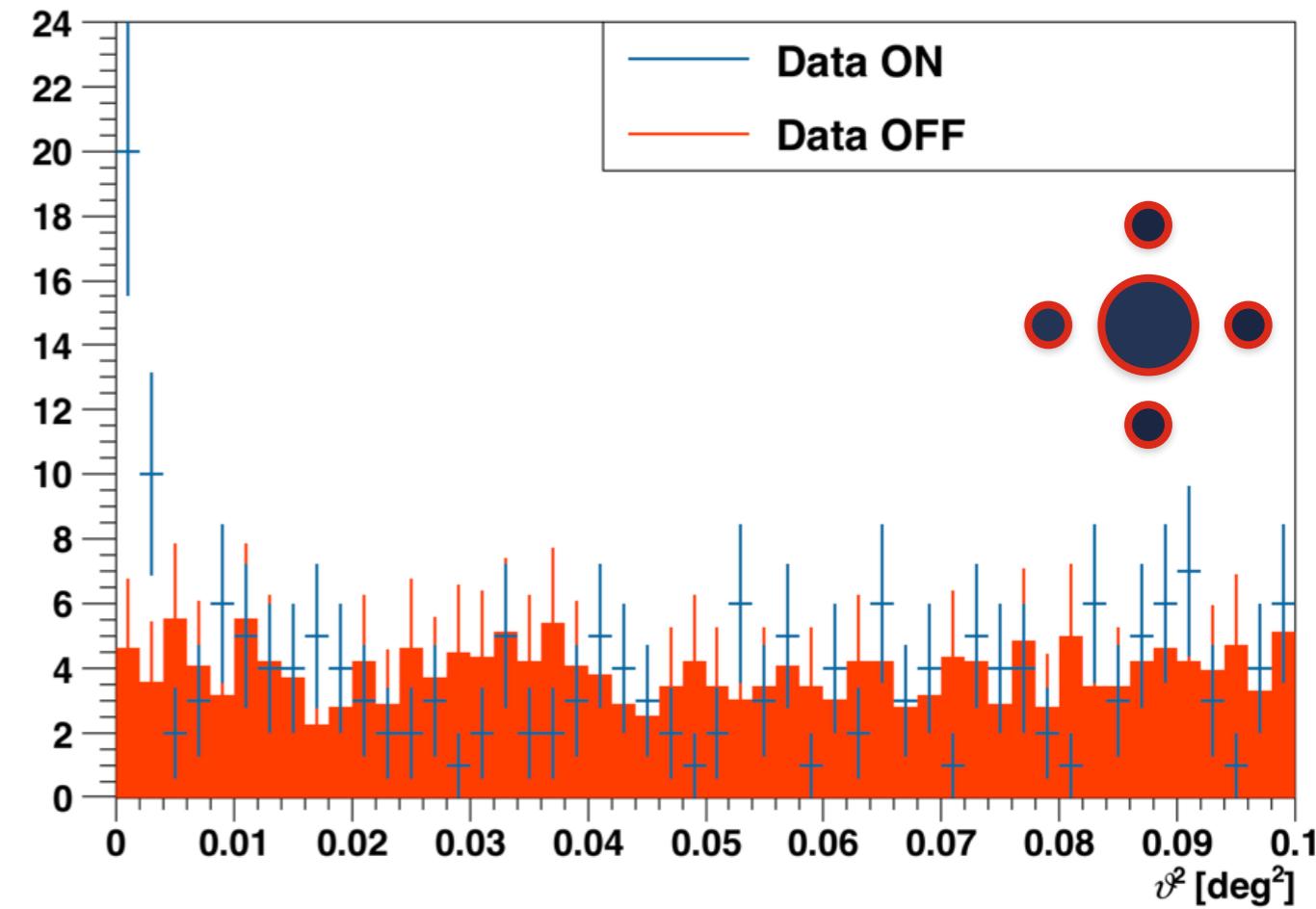
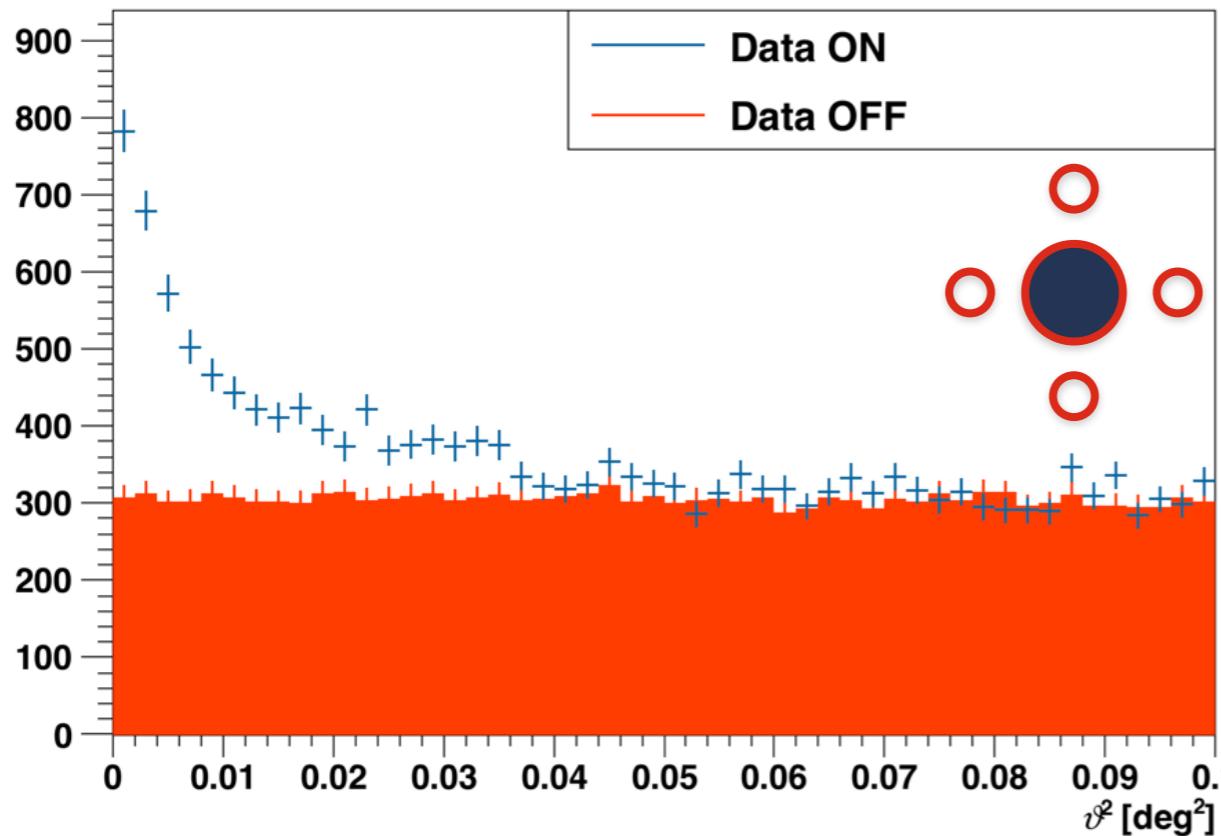
# Combining Mono & Stereo Events



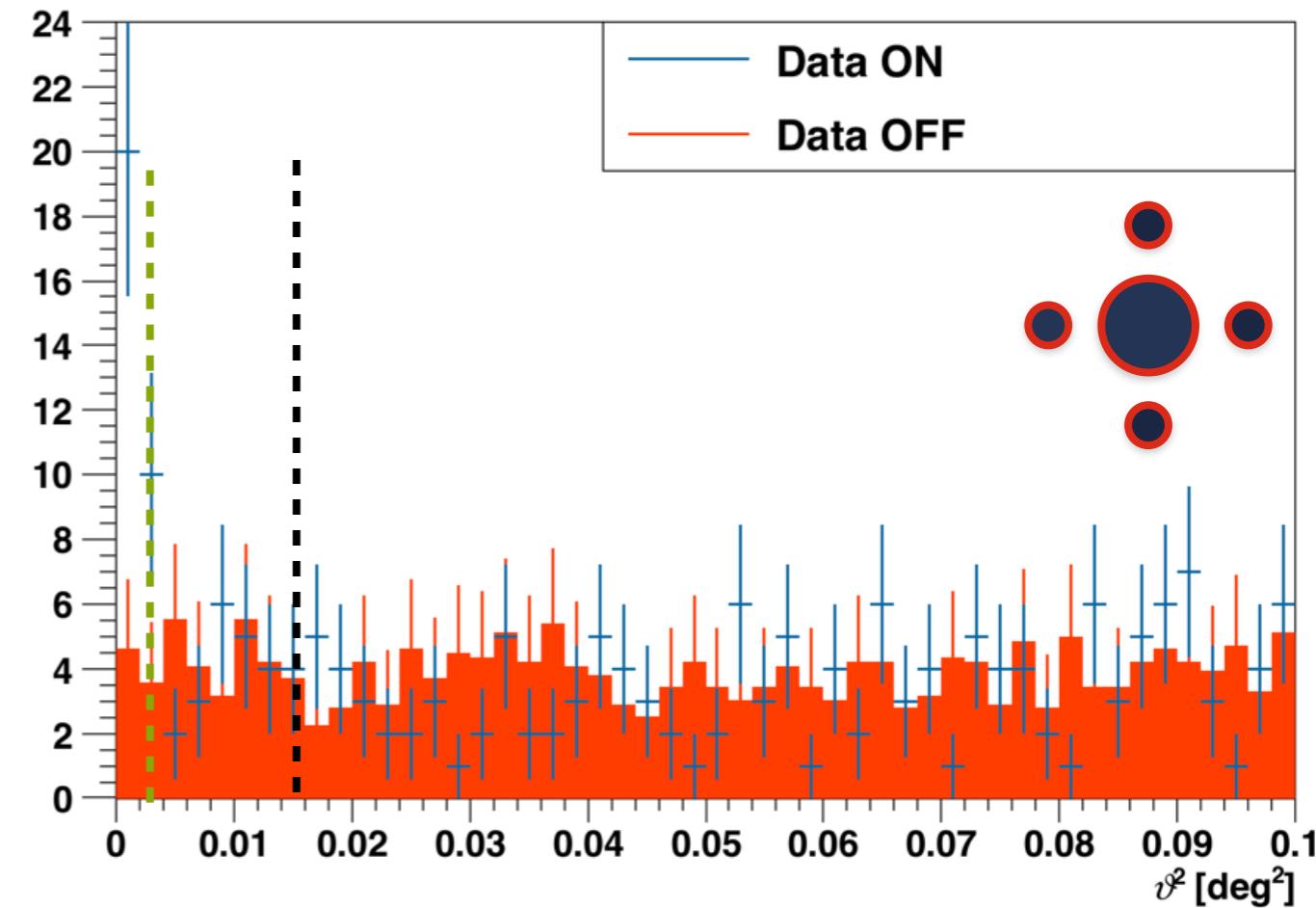
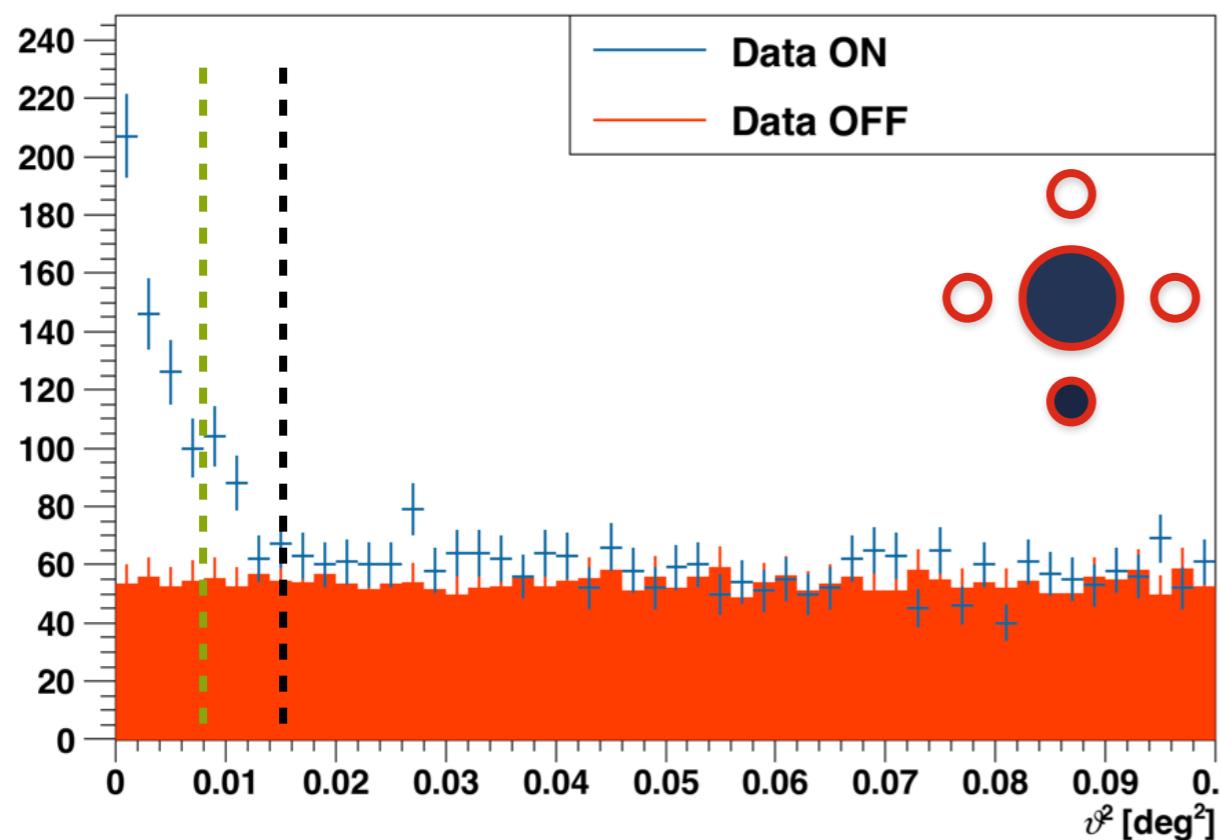
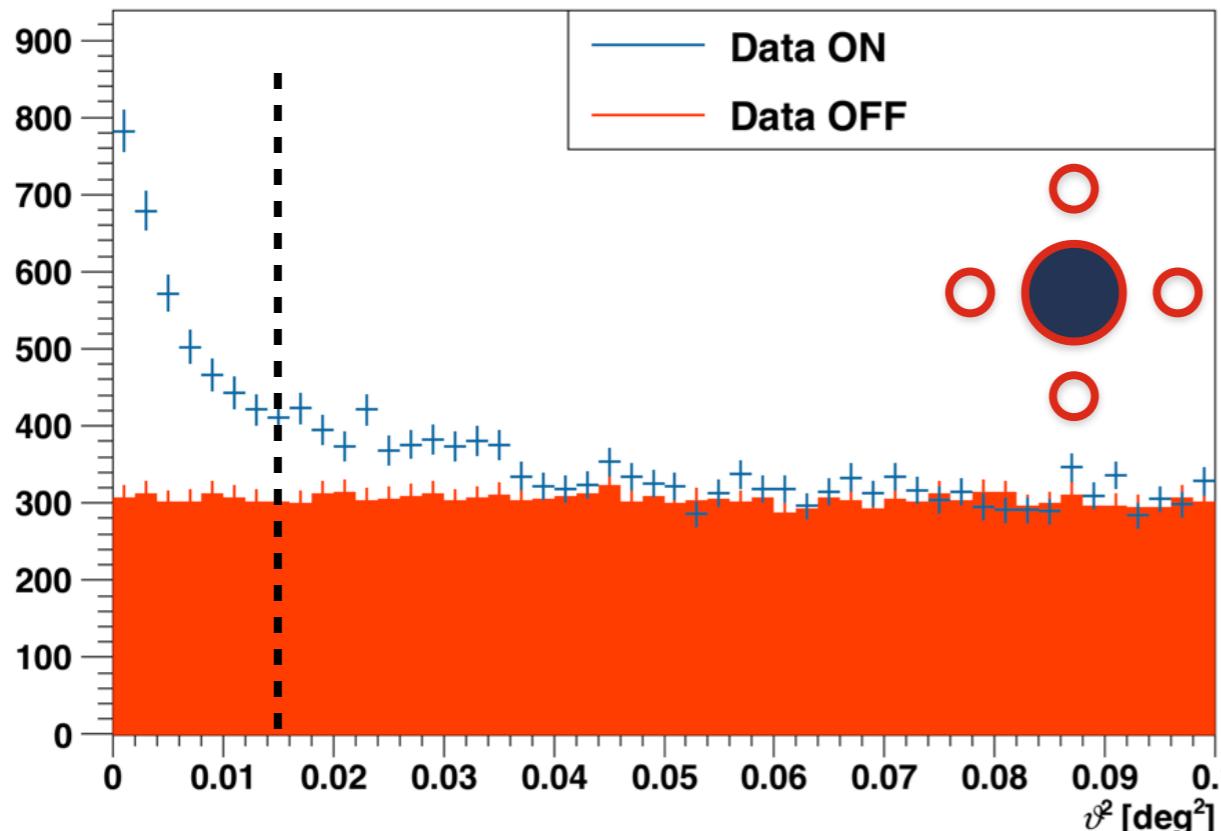
# Combining Mono & Stereo Events



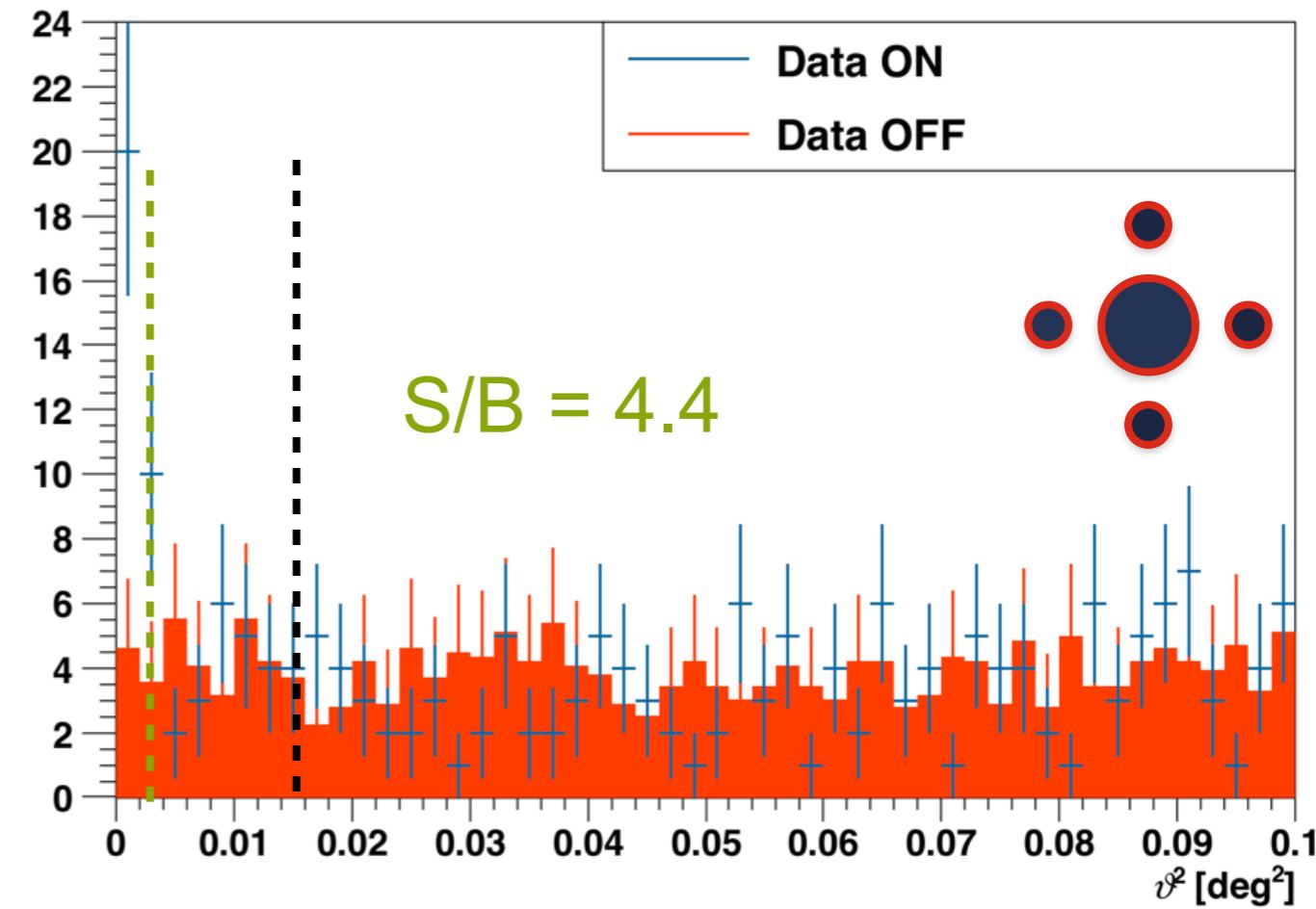
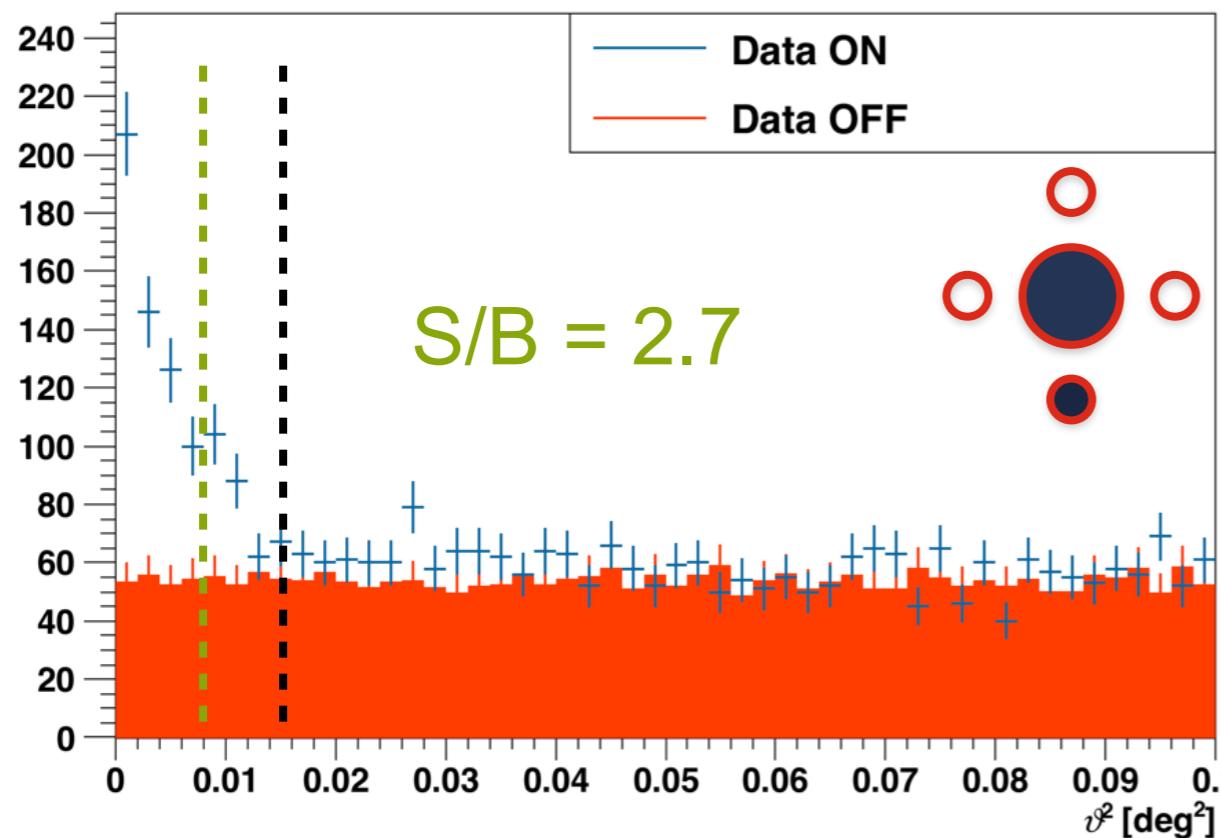
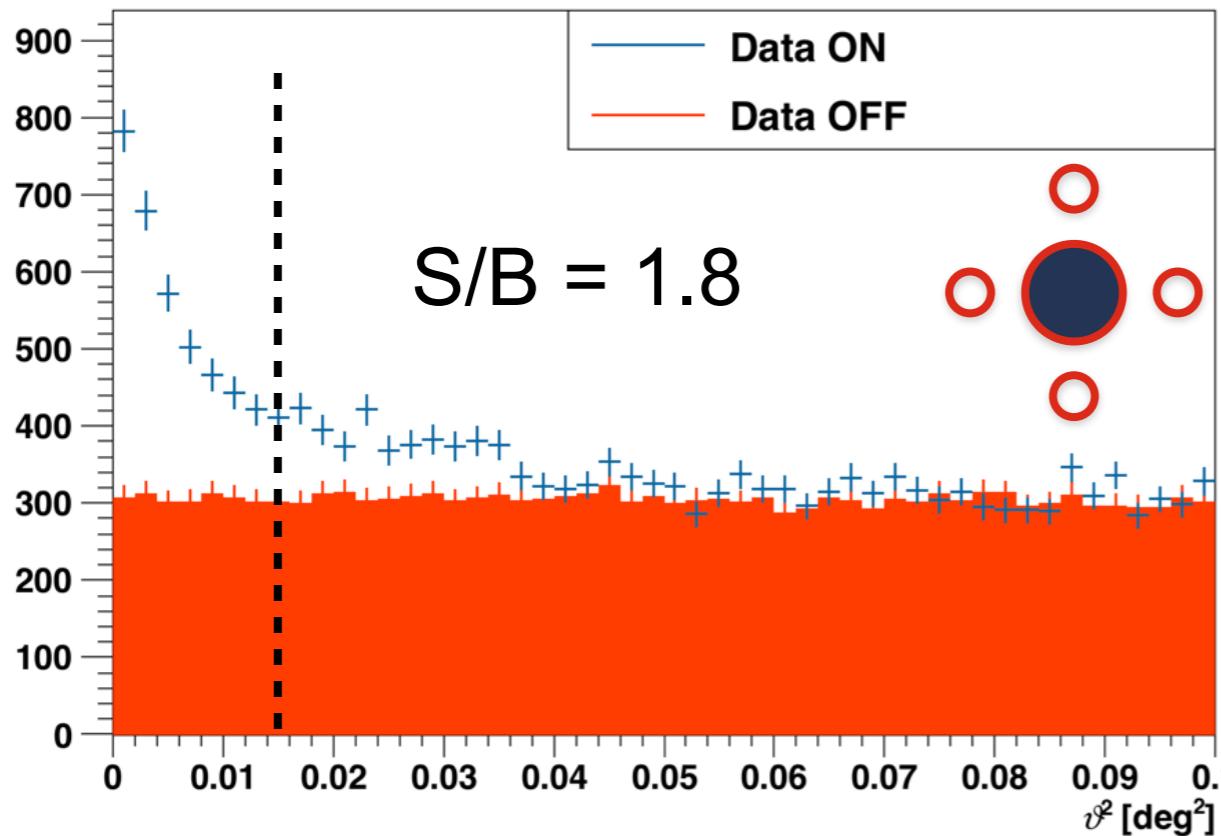
# Combining Mono & Stereo Events



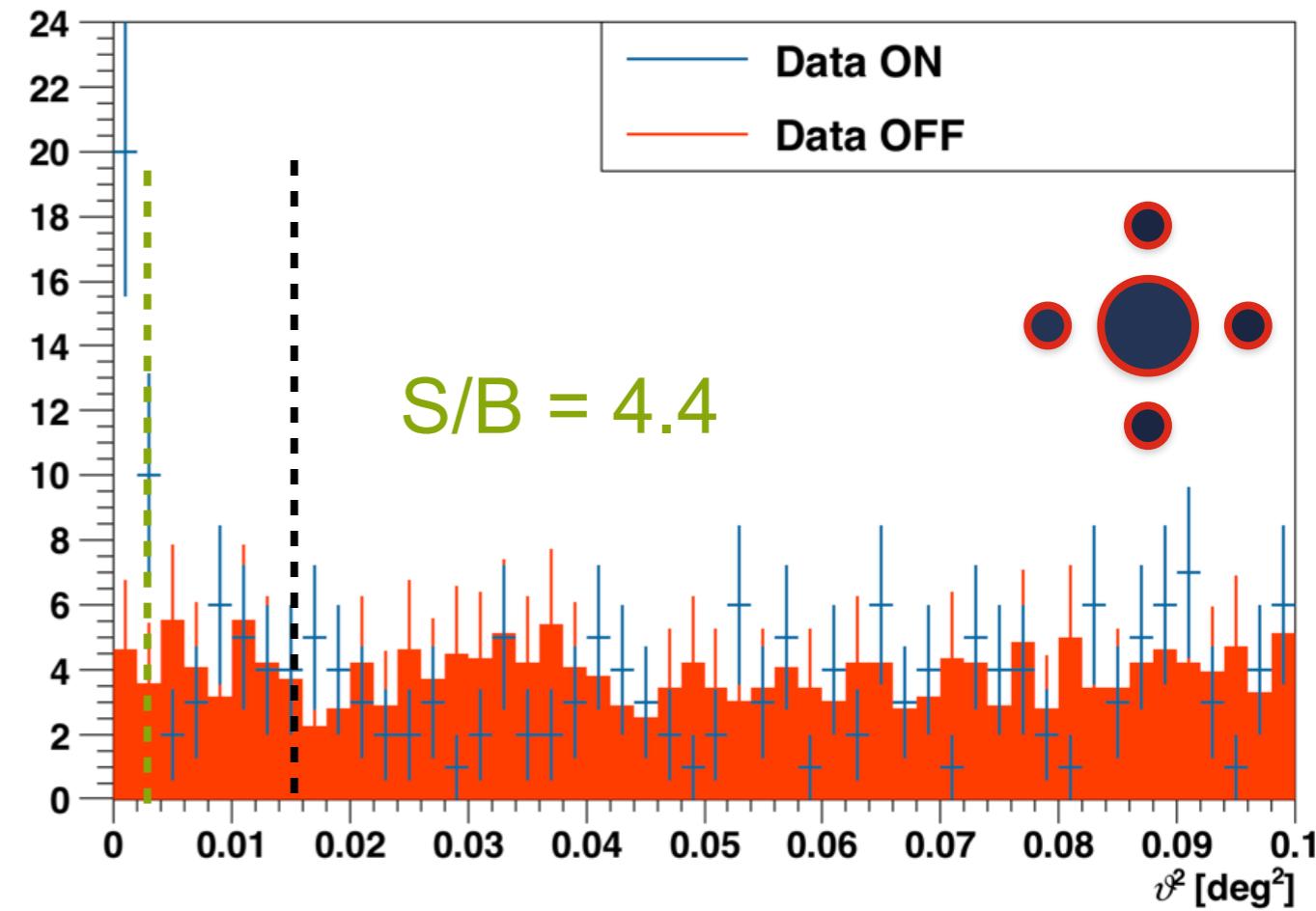
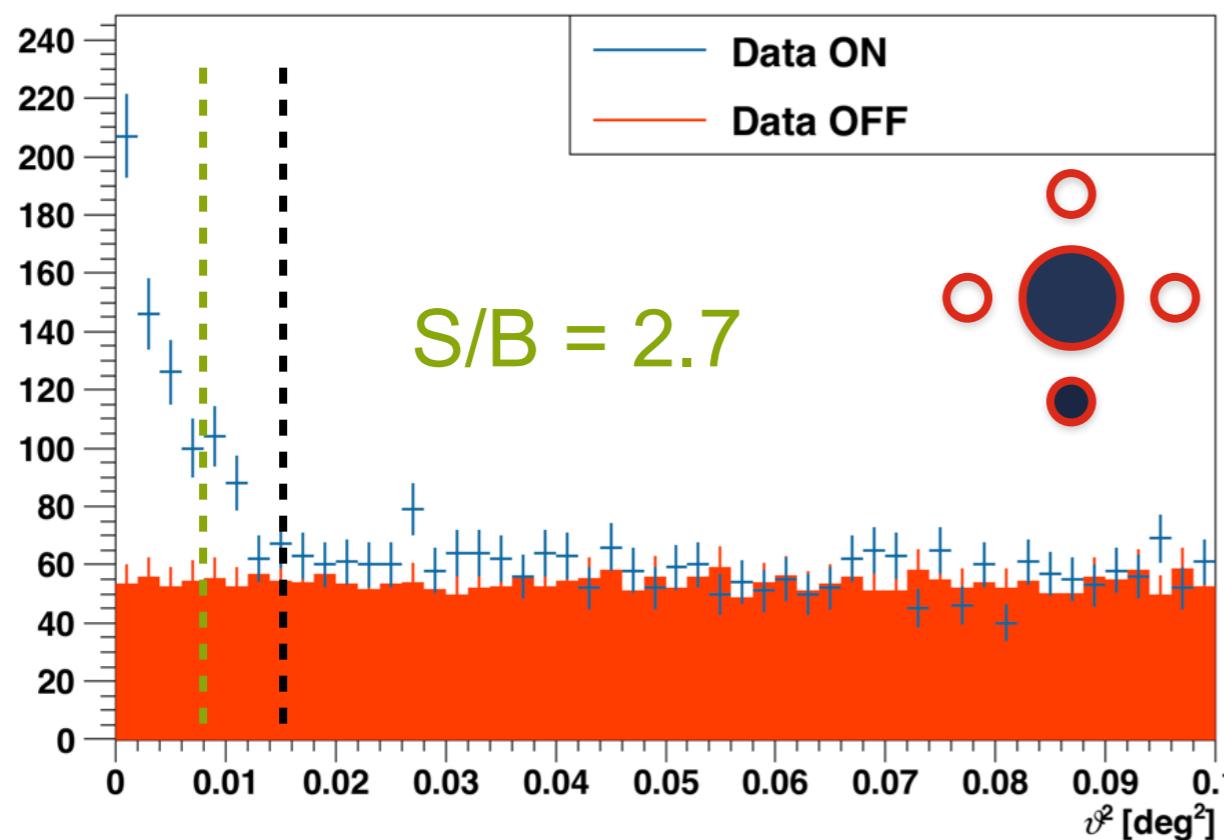
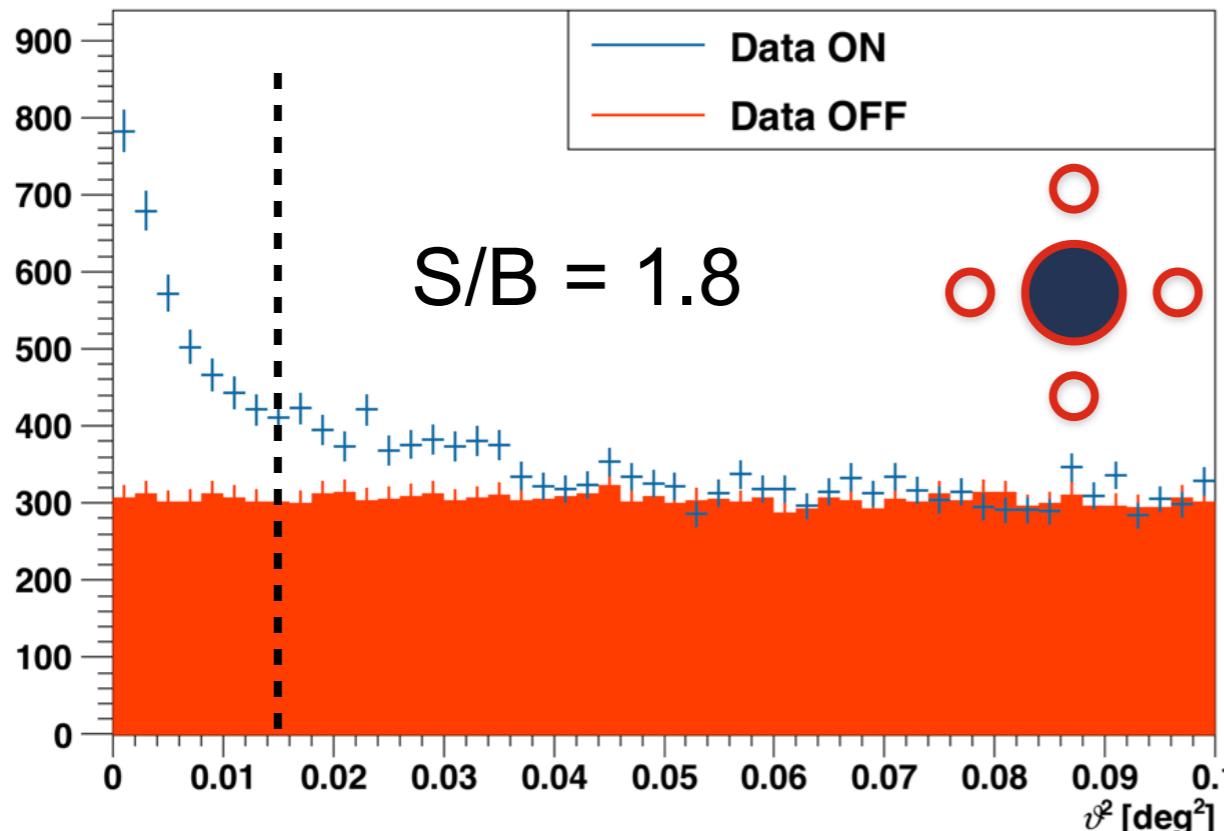
# Combining Mono & Stereo Events



# Combining Mono & Stereo Events

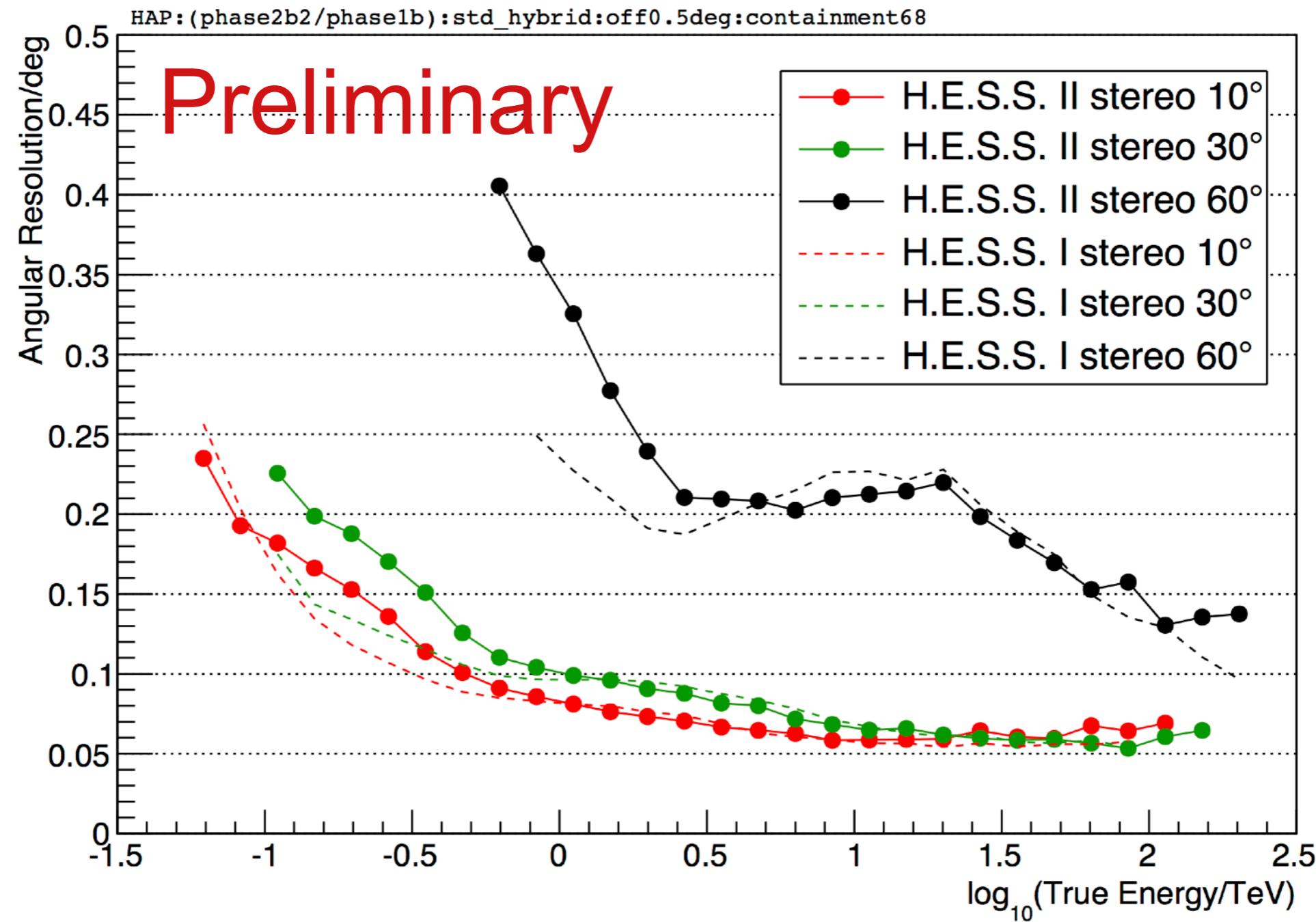


# Combining Mono & Stereo Events



Clearly need a better way of combining events!

# CT1-4 Stereo vs. CT1-5 Stereo





## The Current Perspective for H.E.S.S. (+ other IACTs)

- The *easy analysis - high scientific output* times are mostly over (until CTA arrives)
- Still some time left until CTA will be competitive
- The existing data likely contains a lot of yet undiscovered physics
- How to find it:
  - Study systematics
  - Think differently
  - Improve simulation/analysis techniques

# Study Systematics (Eta Carinae)

- Eta Car: Colliding-wind binary, detected in HE gamma-rays with Fermi
- Extreme night-sky background (NSB) conditions make a measurement for H.E.S.S. very complicated

E. Leser for H.E.S.S.  
ICRC 2017

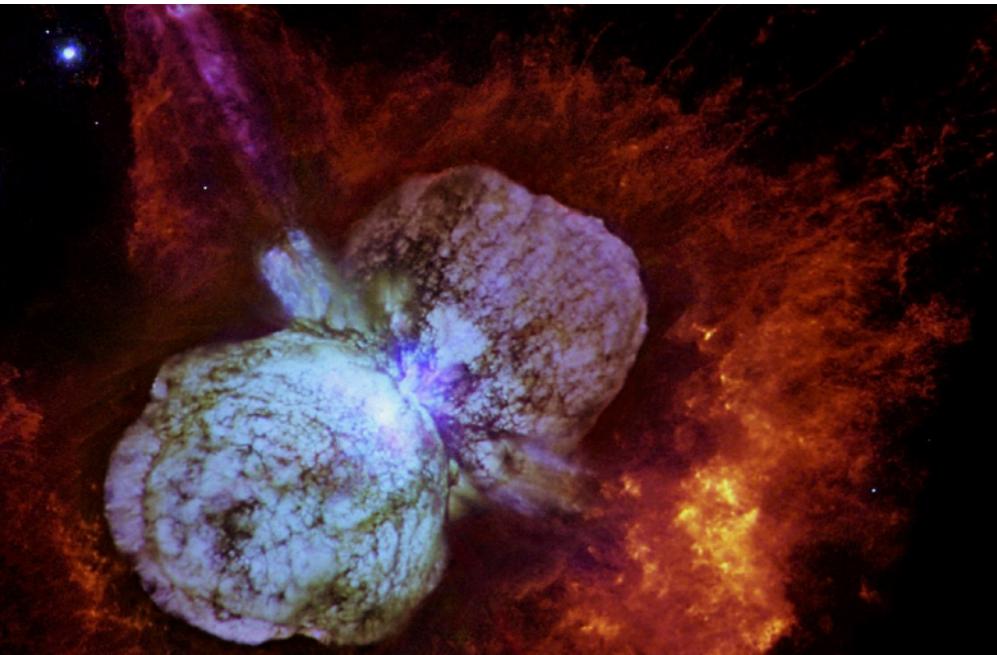
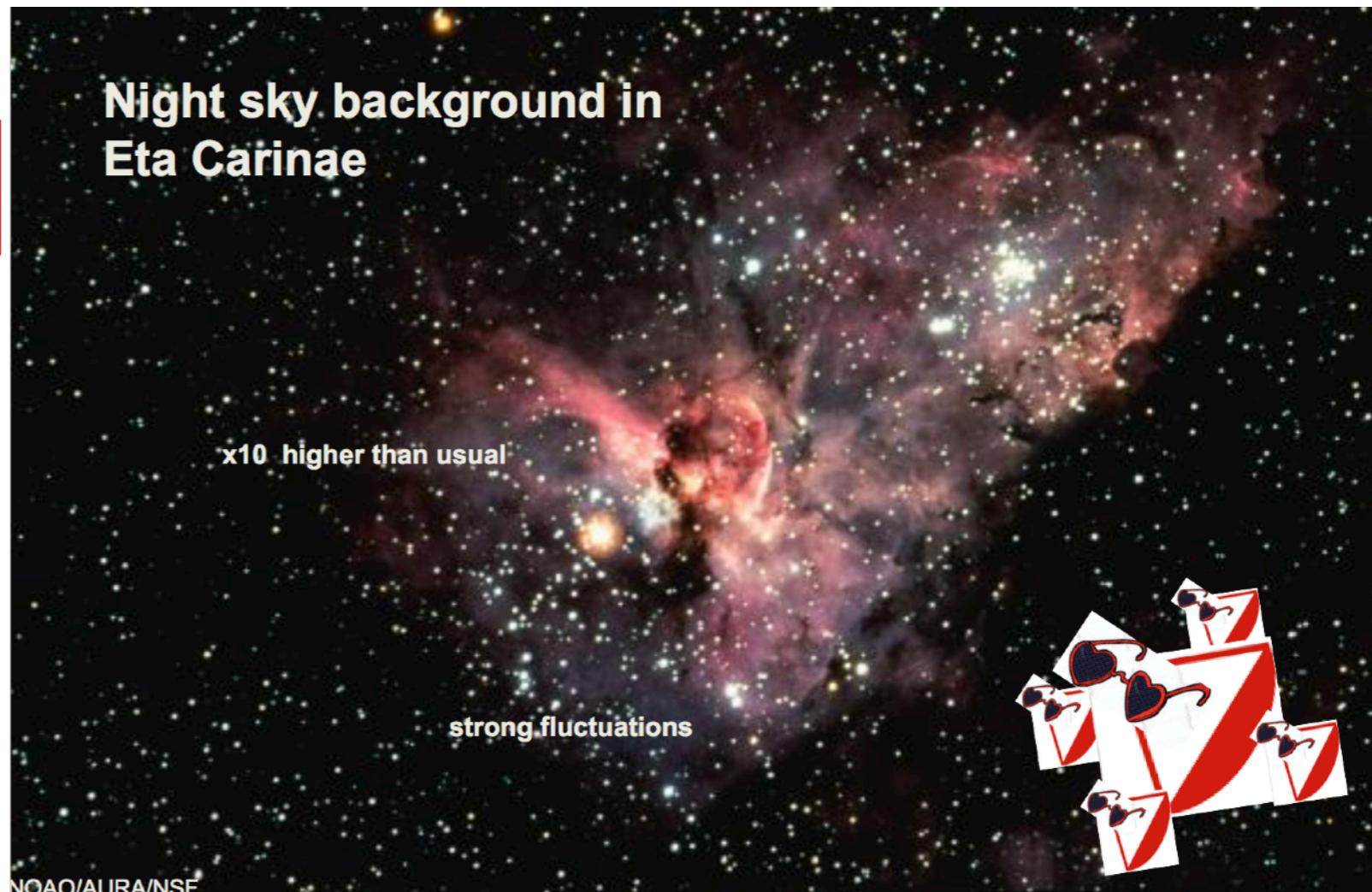
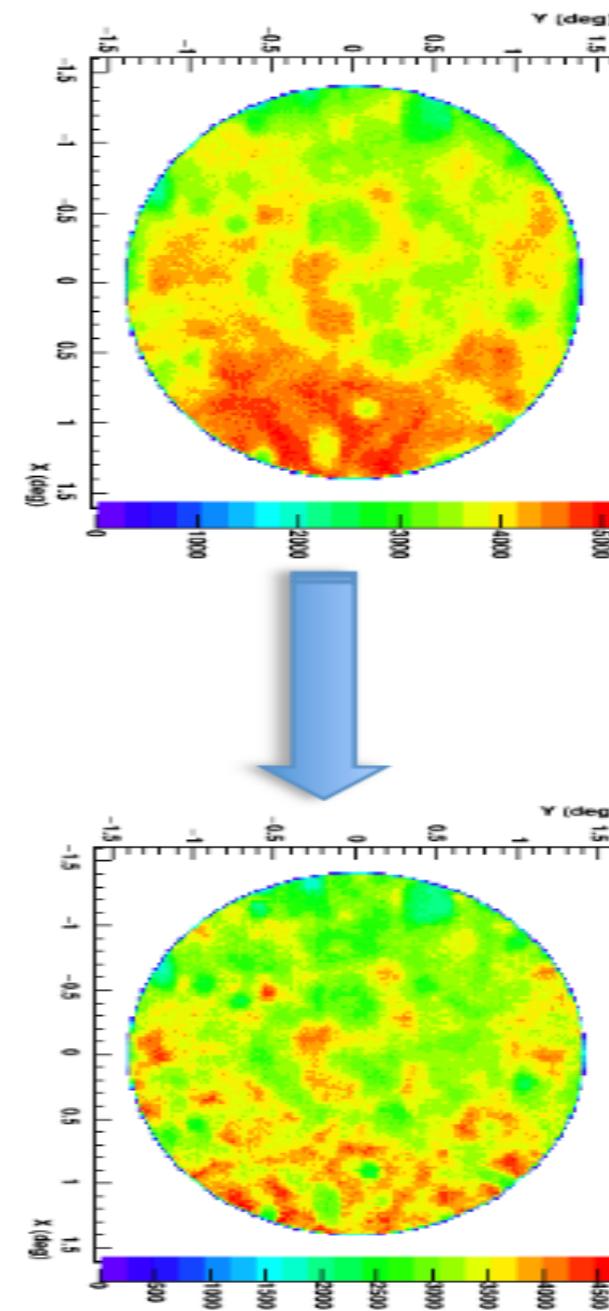
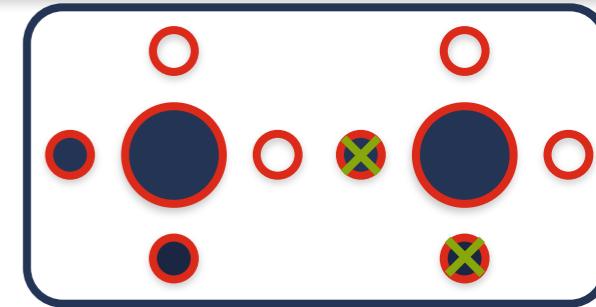


Image by Nathan Smith (University of Berkeley) and NASA



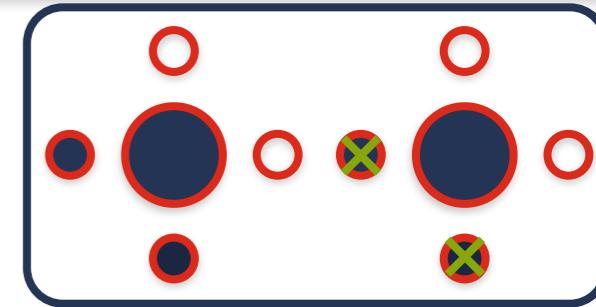
# Study Systematics (Eta Carinae)

- Study NSB impact on instrument:  
Increase trigger settings
- Low-level data analysis: Increase image  
cleaning
- Remaining noise: Use run-wise MC  
simulations (see later slide)



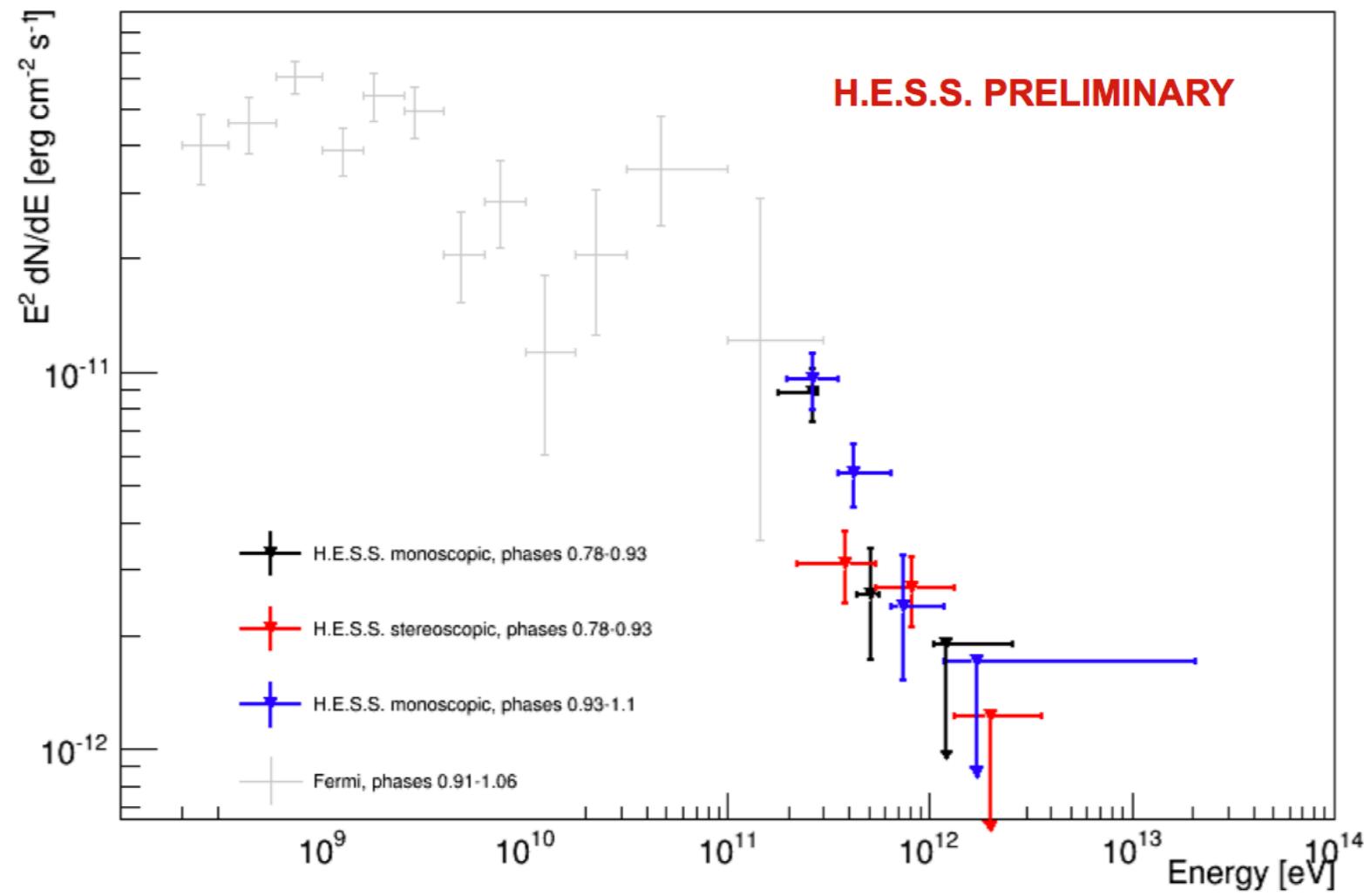
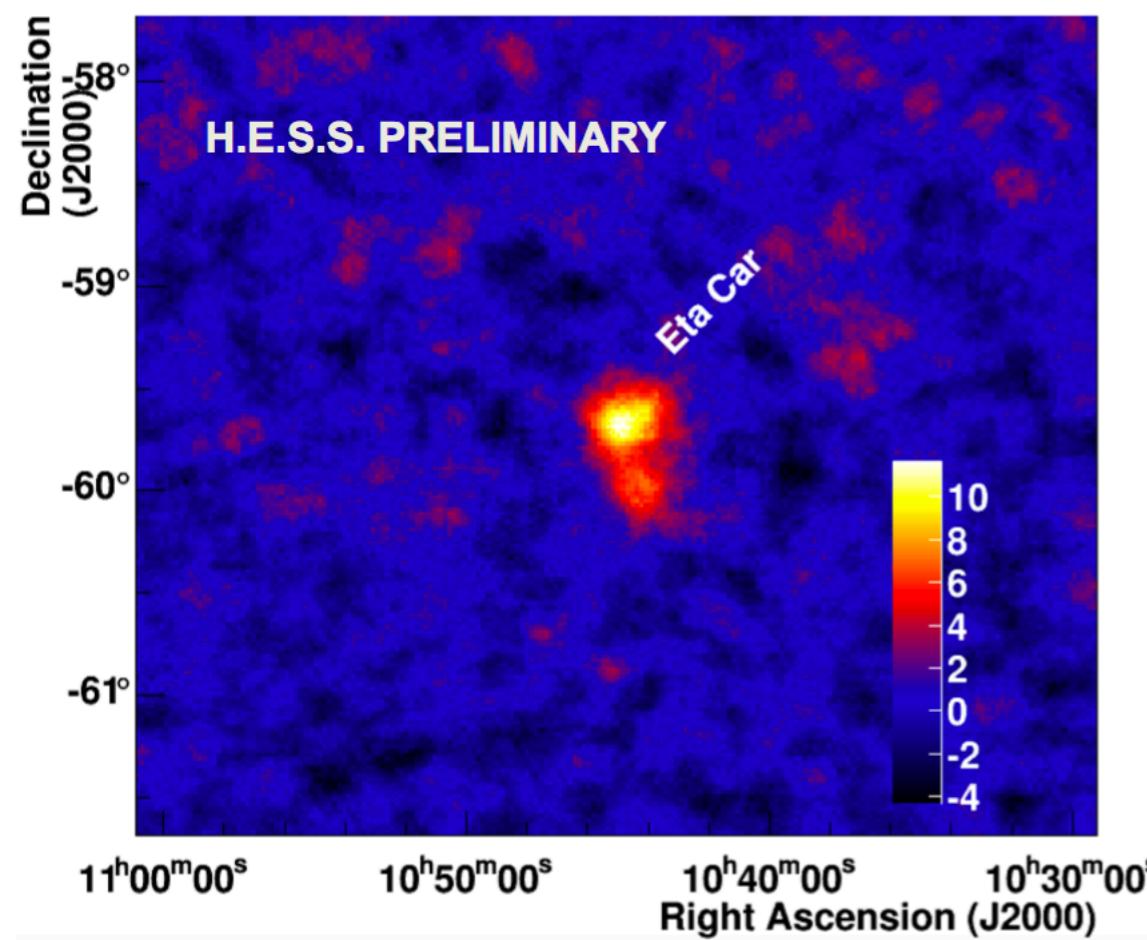
E. Leser for H.E.S.S.  
ICRC 2017

# Study Systematics (Eta Carinae)

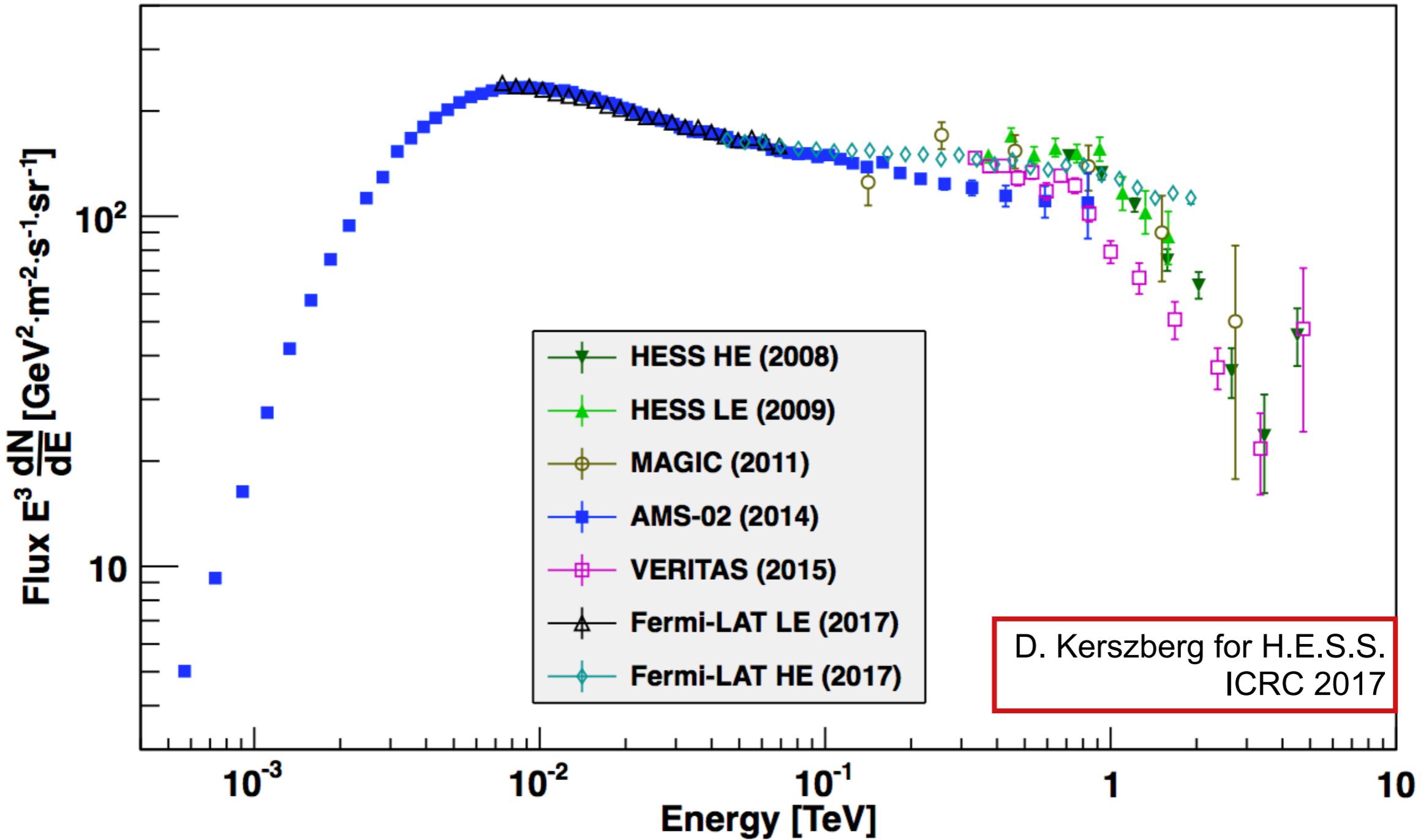


- First detection of a colliding-wind binary in VHE gamma-rays

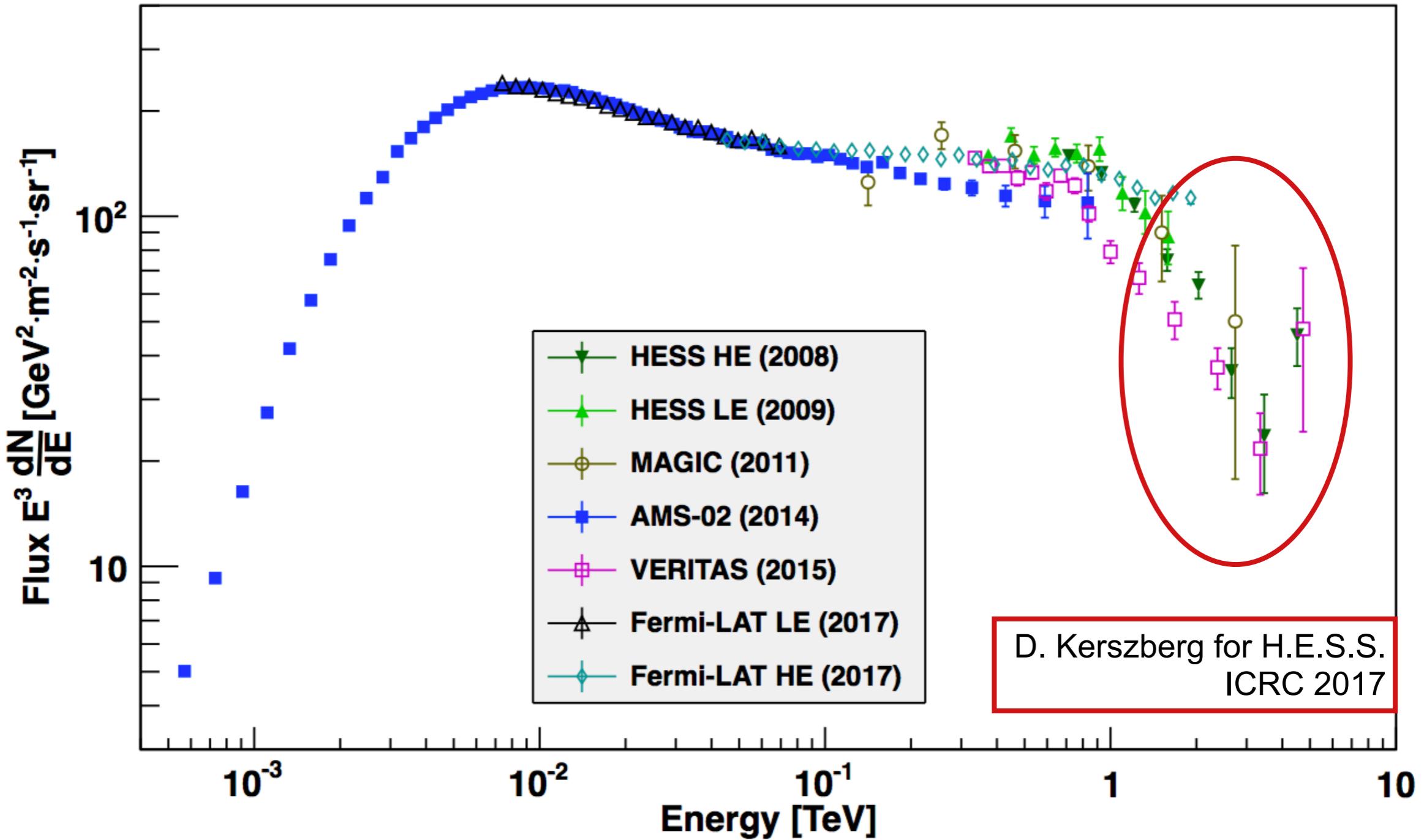
E. Leser for H.E.S.S.  
ICRC 2017



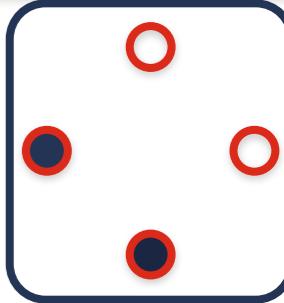
# The Cosmic-Ray Electron Spectrum before the ICRC 2017



# The Cosmic-Ray Electron Spectrum before the ICRC 2017

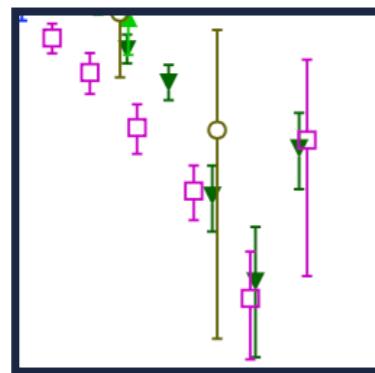


# Think Differently



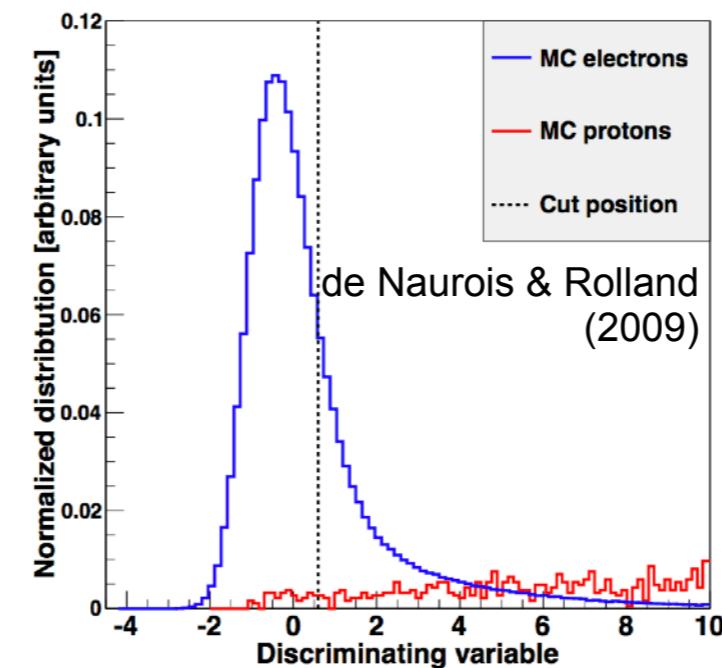
## Old Approach (same as for Veritas)

- Use multi-variate techniques to filter protons (background) from electrons
- Relying on interaction models provided by collider experiments



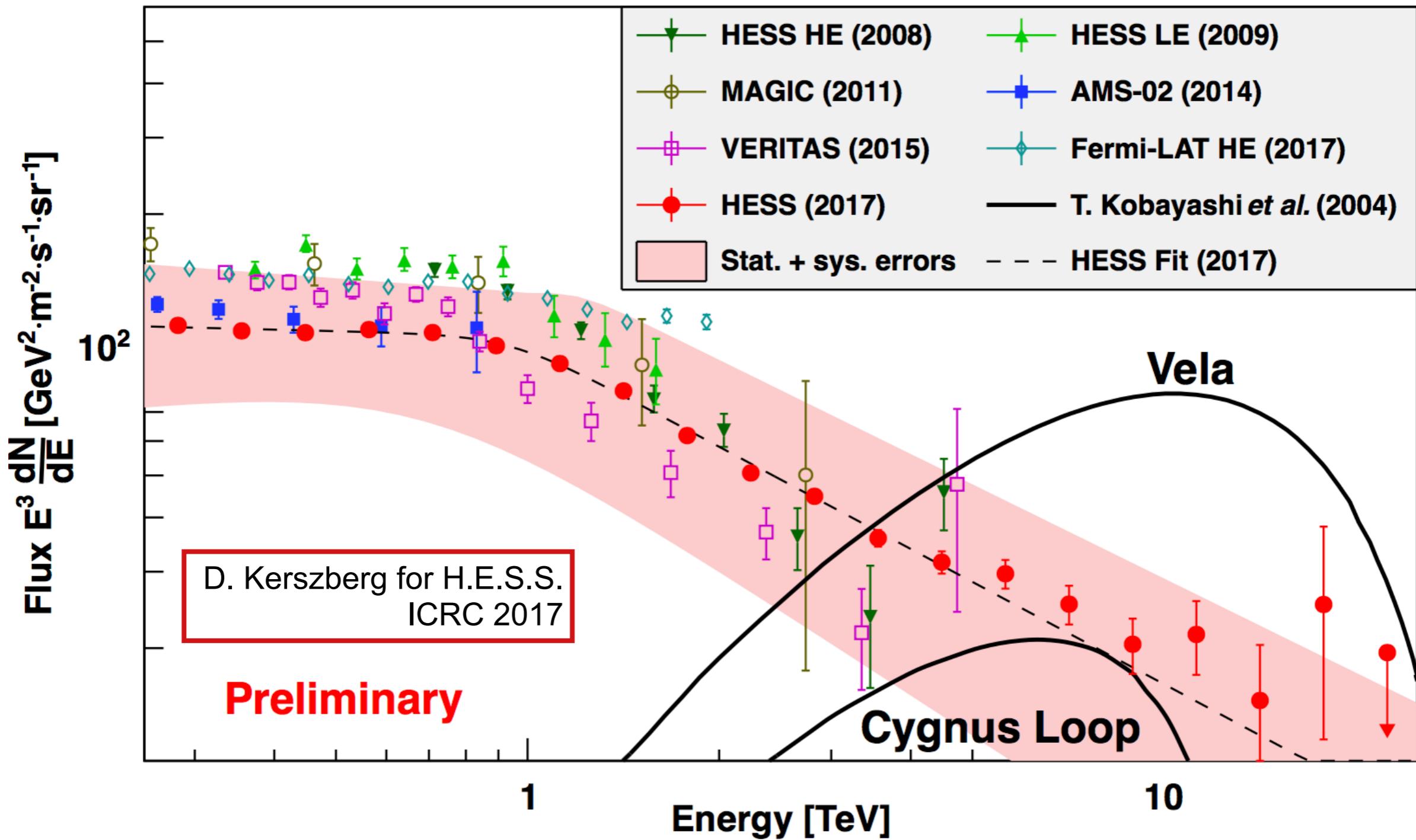
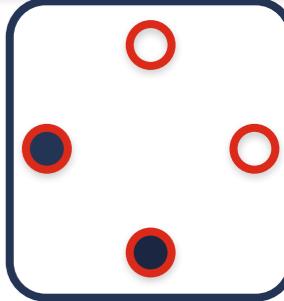
## New Approach

- Cut down hadronic background by relying on powerful discriminating variable from standard analysis
- Accept potential hardening of spectrum due to contamination



Energy	Expected contamination from protons
1 TeV	~ 15%
2 TeV	~ 7%
> 5 TeV	< 10%

# The New Cosmic-Ray Electron Spectrum (since ICRC 2017)

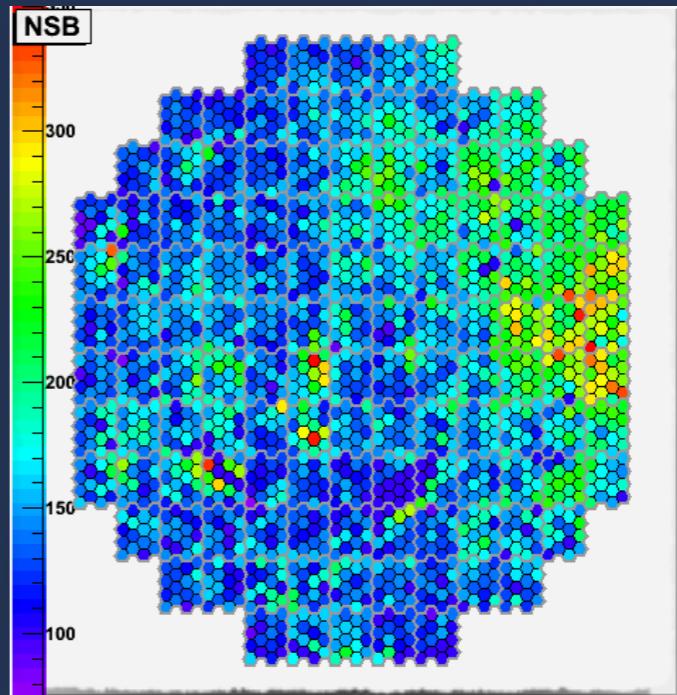


Black model curves from Kobayashi et. al. (2004)

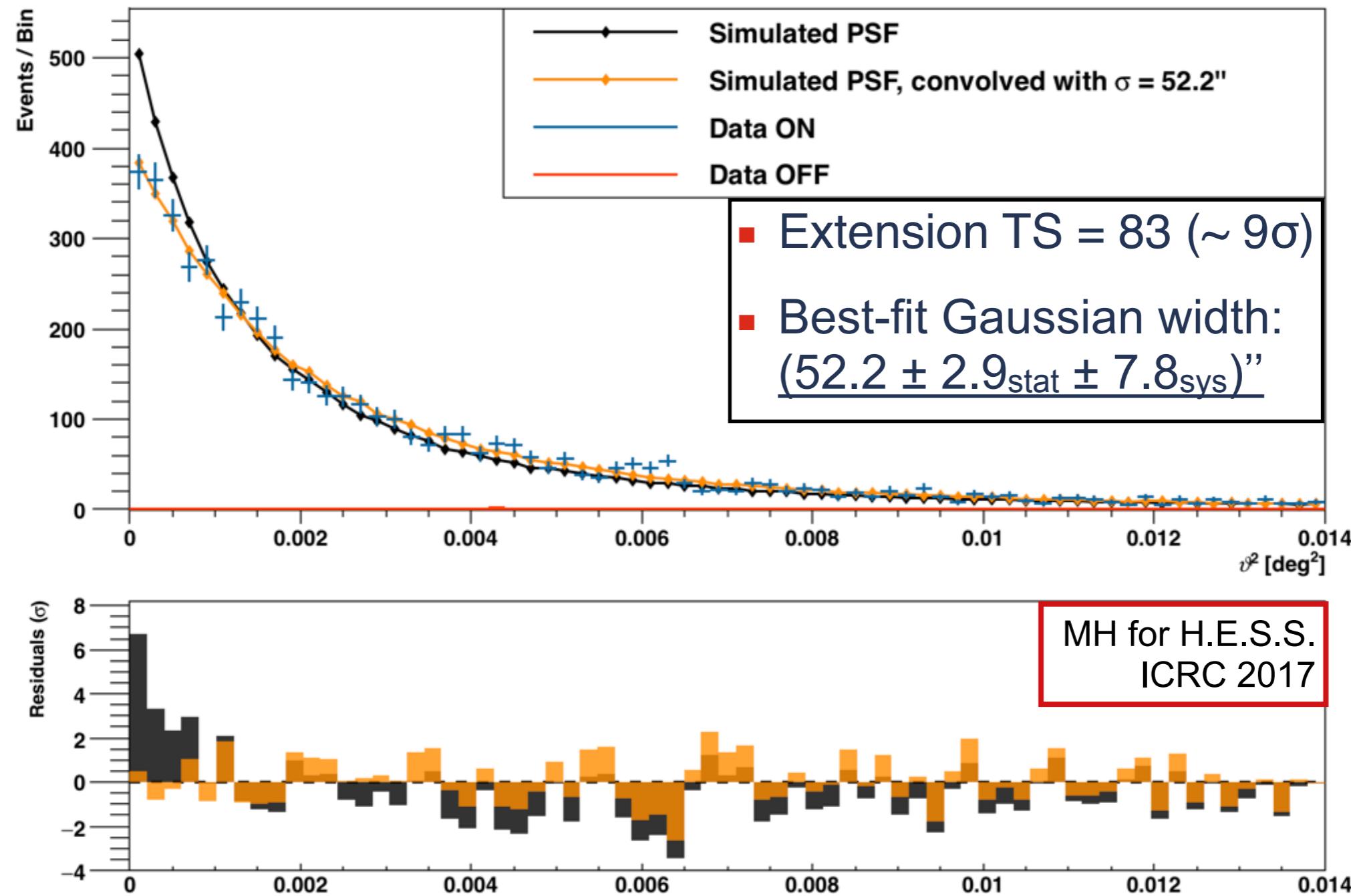
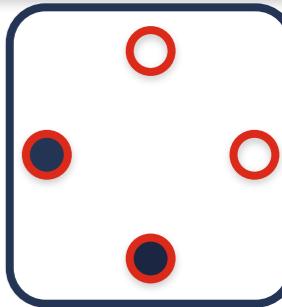
# Improve Simulation/ Analysis Techniques

- New simulation approach (MH et al., ICRC 2017)
  - Simulating each observation run of a data set
  - Using actual observation and instrument conditions
- Provides more realistic description of taken data
- Example of improvement: Extension measurements

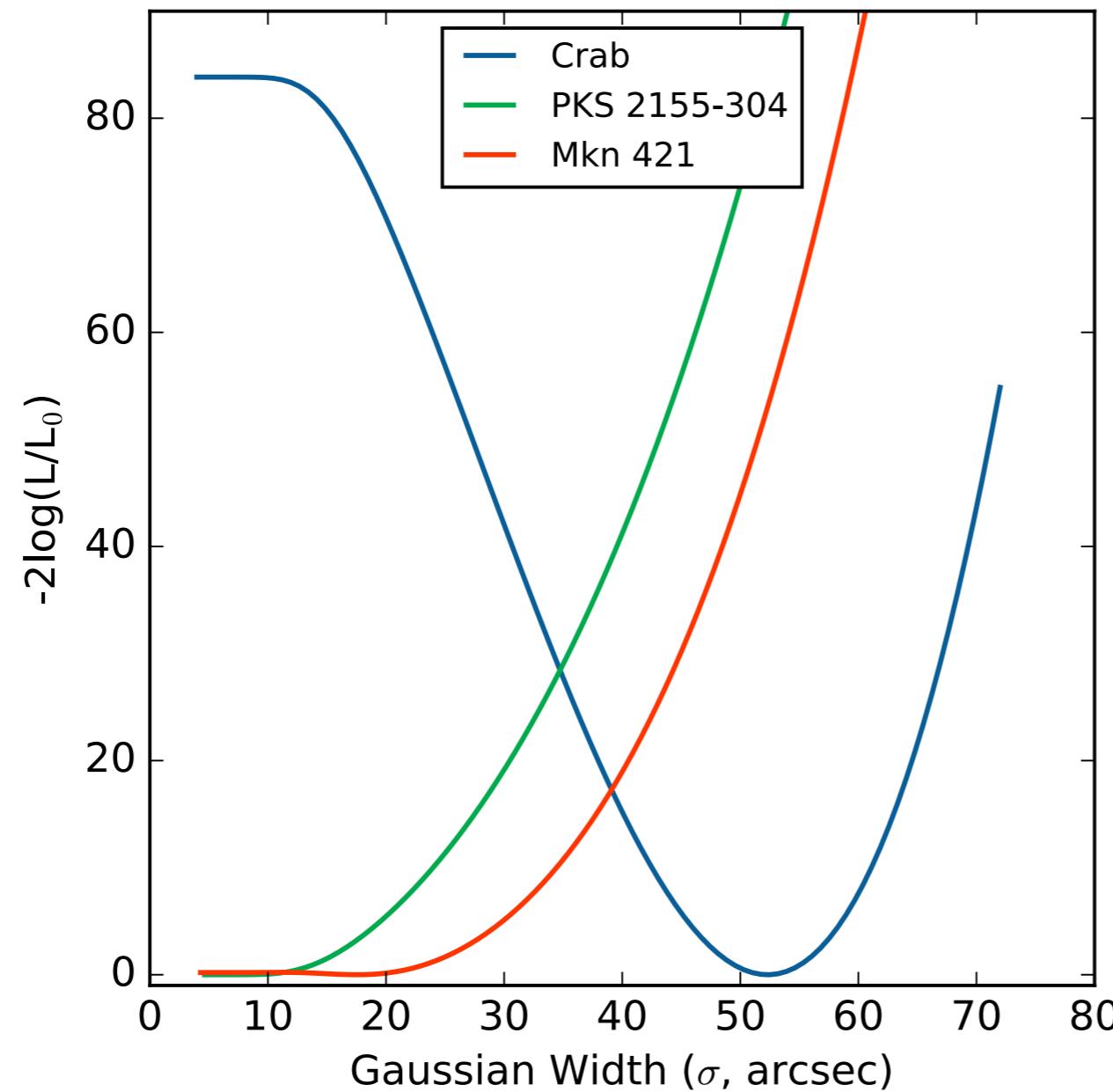
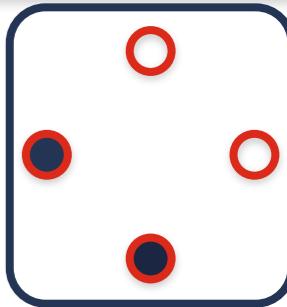
Quantity	Type (per pixel, telescope, or for array)
Active IACTs	-
Telescope Tracking	array
Source Position	array
Optical Efficiency $\epsilon$	telescope
Transparency	array
Camera Focus	telescope
Trigger Settings	telescope
Live-Time fraction	telescope
Broken Pixels	pixel
PMT Gain	pixel
Hi-Lo Ratio	pixel
Flatfield Coefficient	pixel
Night-Sky Background	pixel
Pointing Uncertainties	telescope



# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)

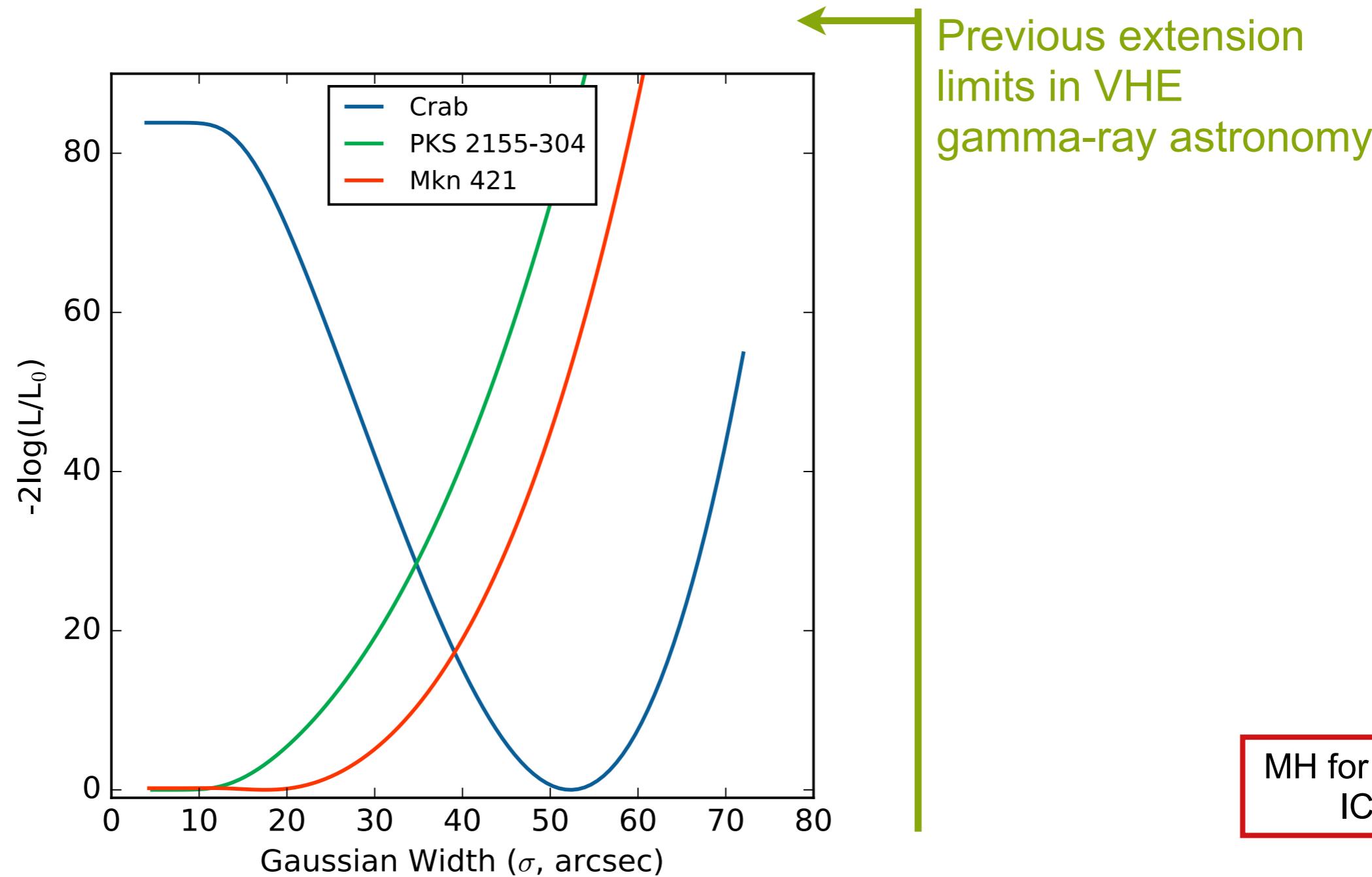
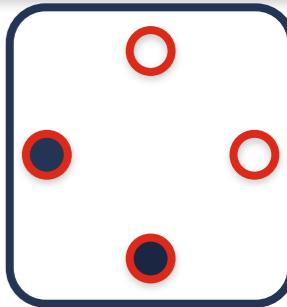


# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)

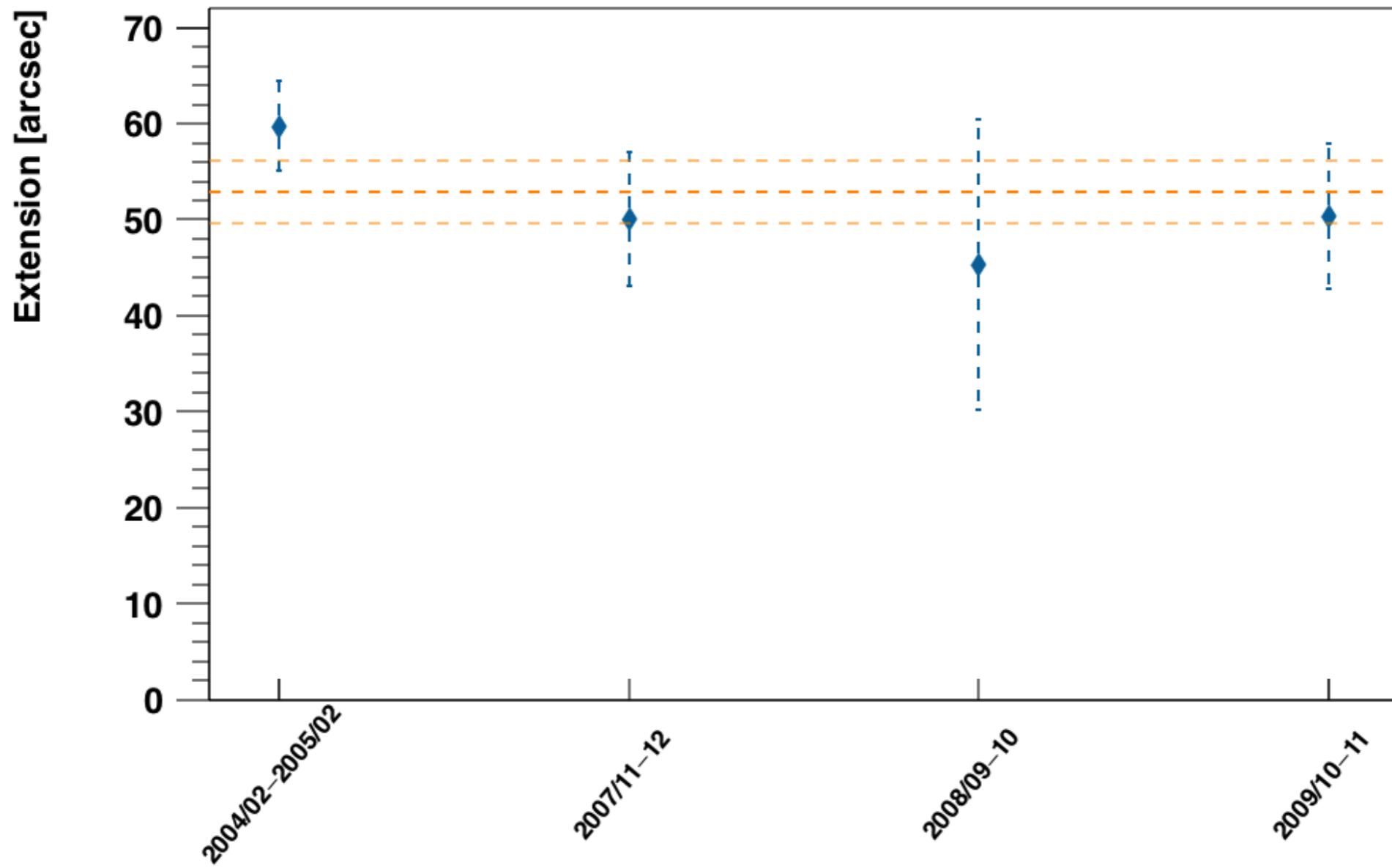
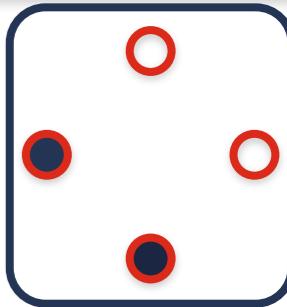


MH for H.E.S.S.  
ICRC 2017

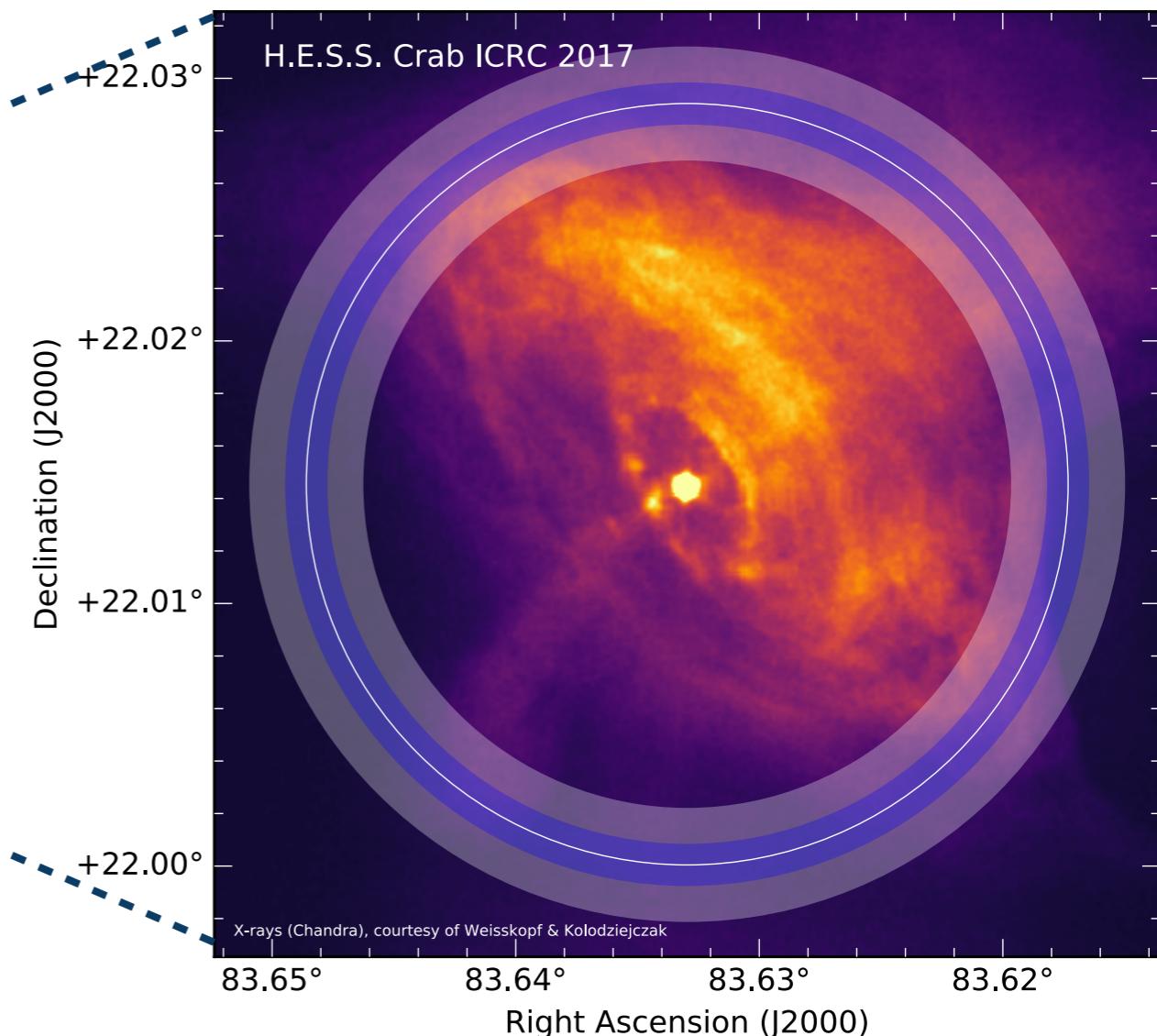
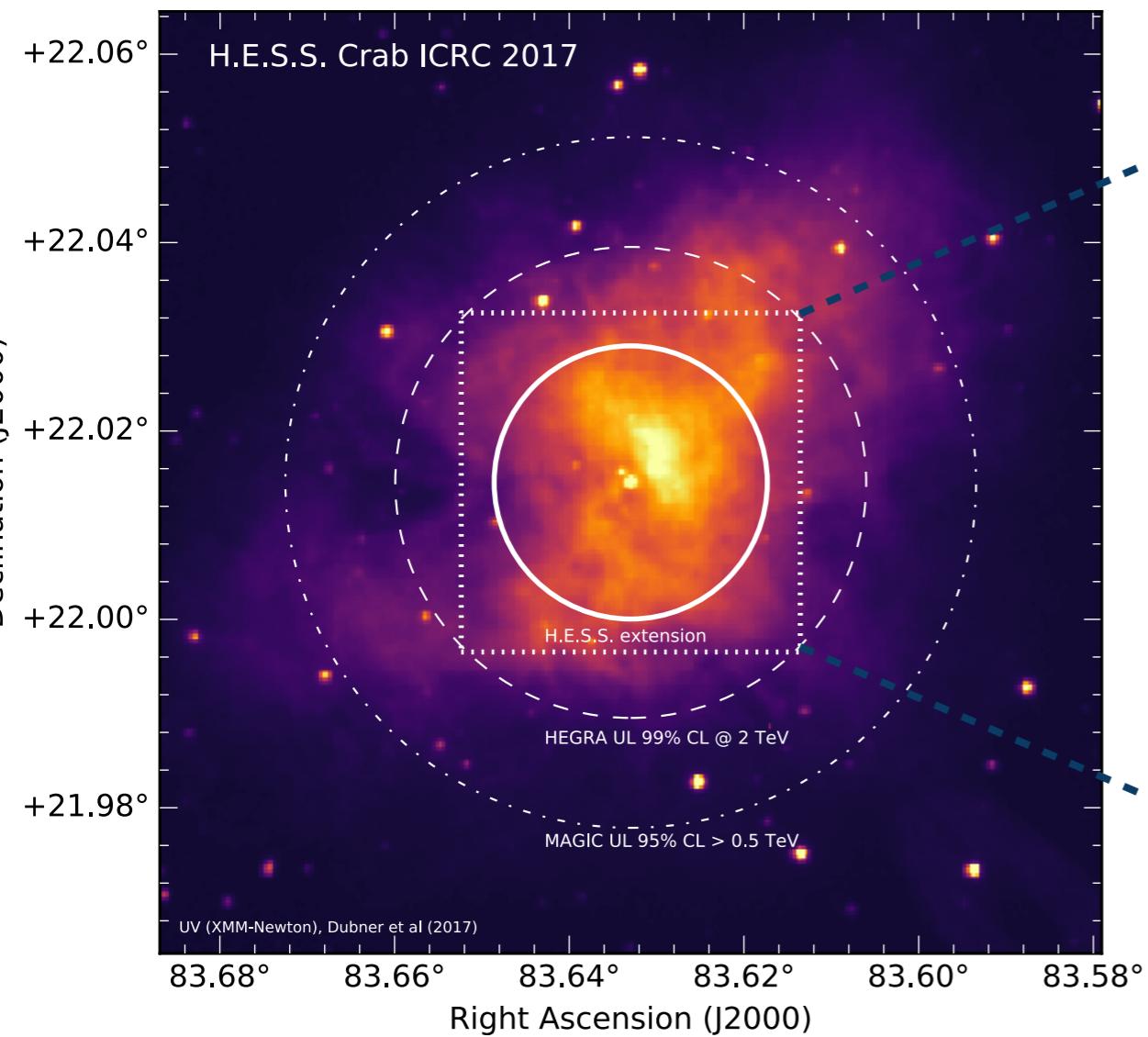
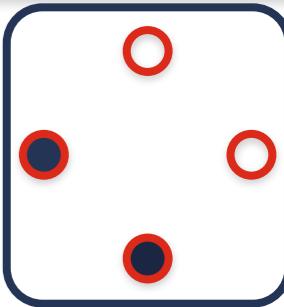
# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)



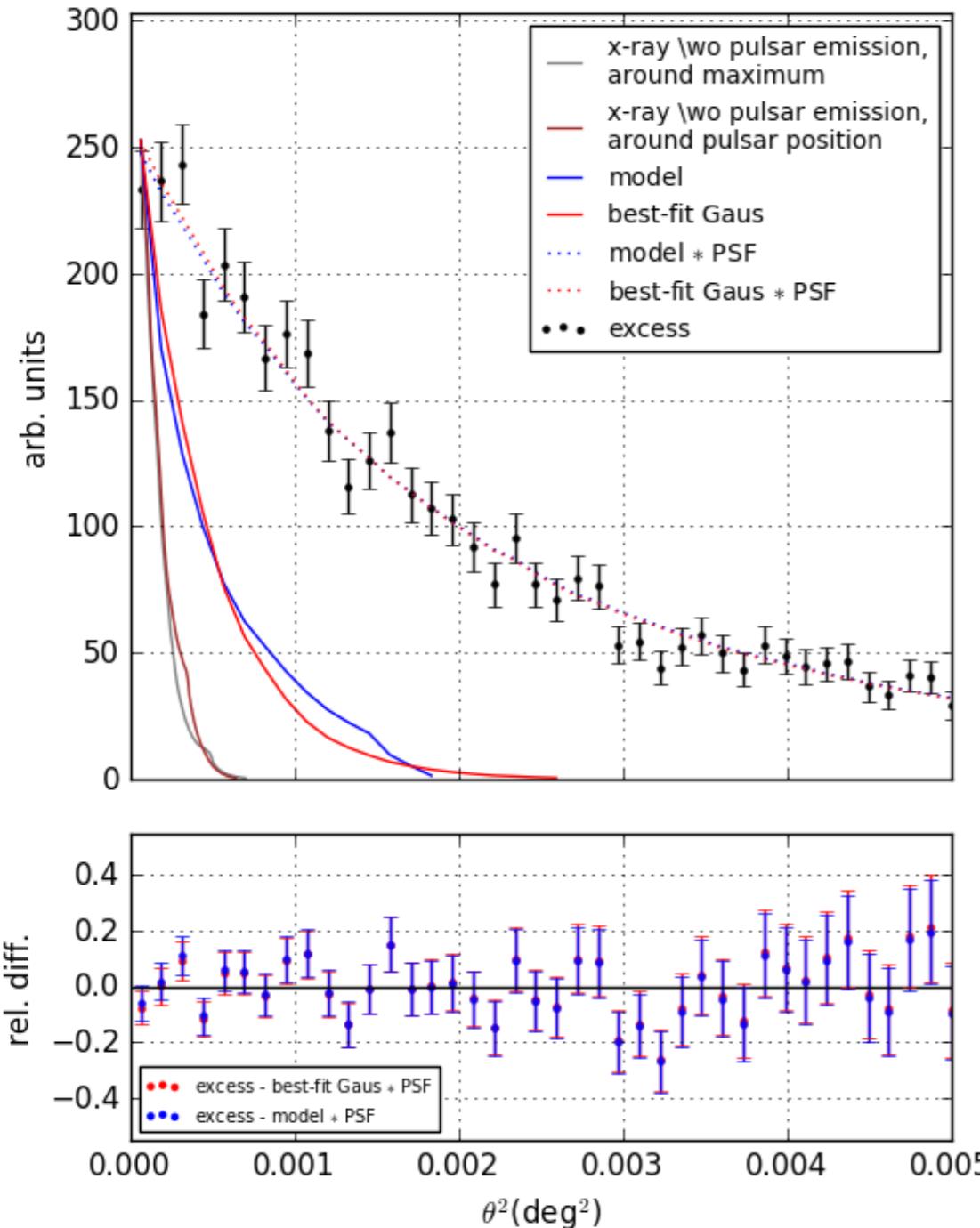
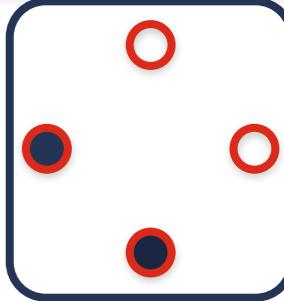
# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)



# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)



# Improve Simulation/Analysis Techniques (The Crab Nebula Extension)



- Used updated model from Kennel & Coroniti, assuming magnetisation parameter of 0.01
- $r_{\text{TS}} = 0.15$  pc (in line with newer measurements)
- Observed extension can be well reproduced

# Conclusions

- H.E.S.S. continues to deliver important results to VHE gamma-ray astronomy (and also cosmic-ray physics)
- Analysis phase space largely increased/complicated
- Development of new techniques necessary
- Working on H.E.S.S. II data automatically implies gaining valuable information for CTA

どうもありがとうございました

