

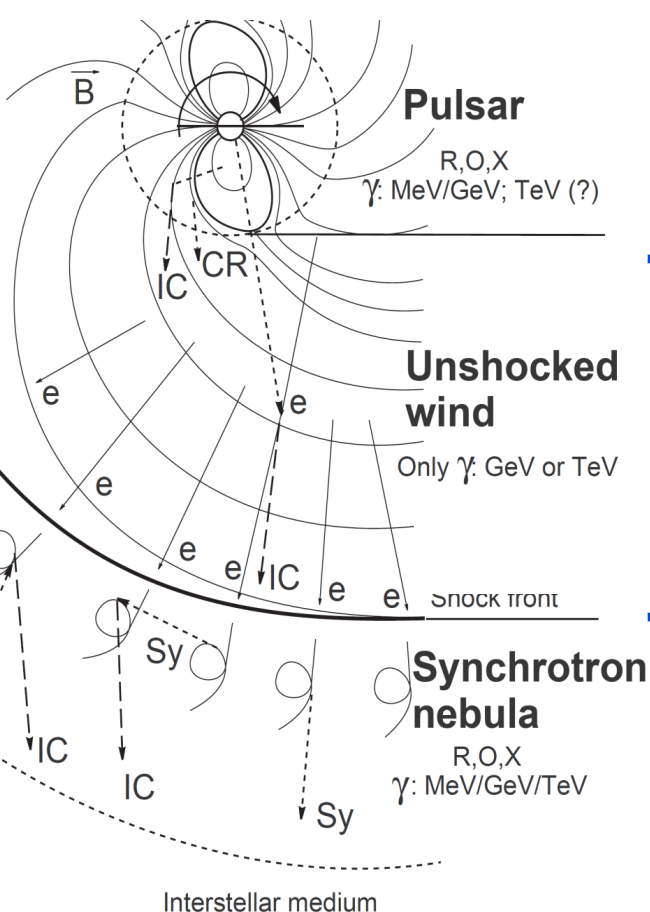


# Pulsations from the Vela Pulsar Down to 20 GeV with H.E.S.S. II



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on behalf of the H.E.S.S. Collaboration

# Origin of the gamma-ray pulsed emission and its detections



Pulsed  
inside LC

Year 2015: >160 HE pulsars,  
2 VHE pulsars

Pulsed  
outside LC

Detections by IACTs :

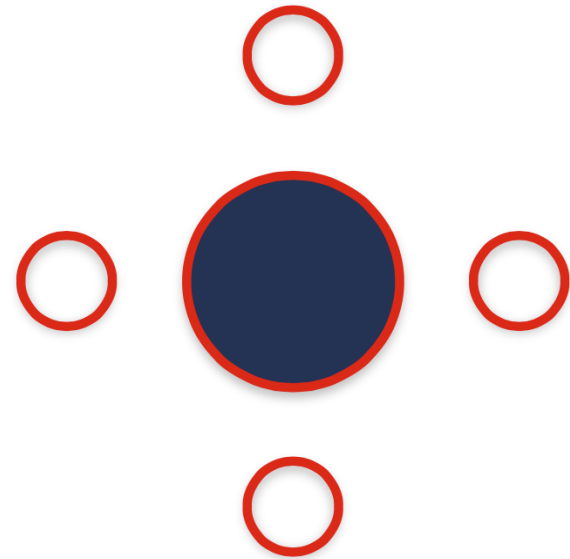
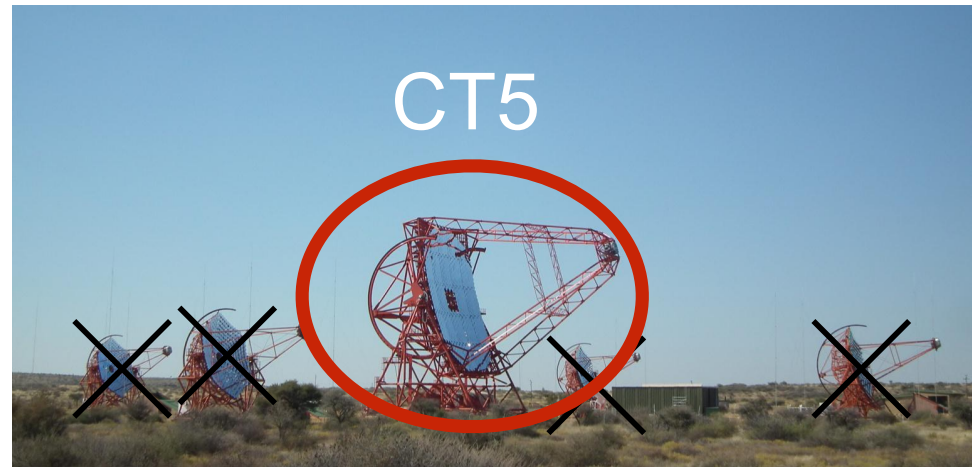
Crab: 25 GeV – 1.5 TeV  
(MAGIC, VERITAS)

Unpulsed

**Second VHE pulsar:**  
Vela: 20 – 120 GeV (H.E.S.S. II)

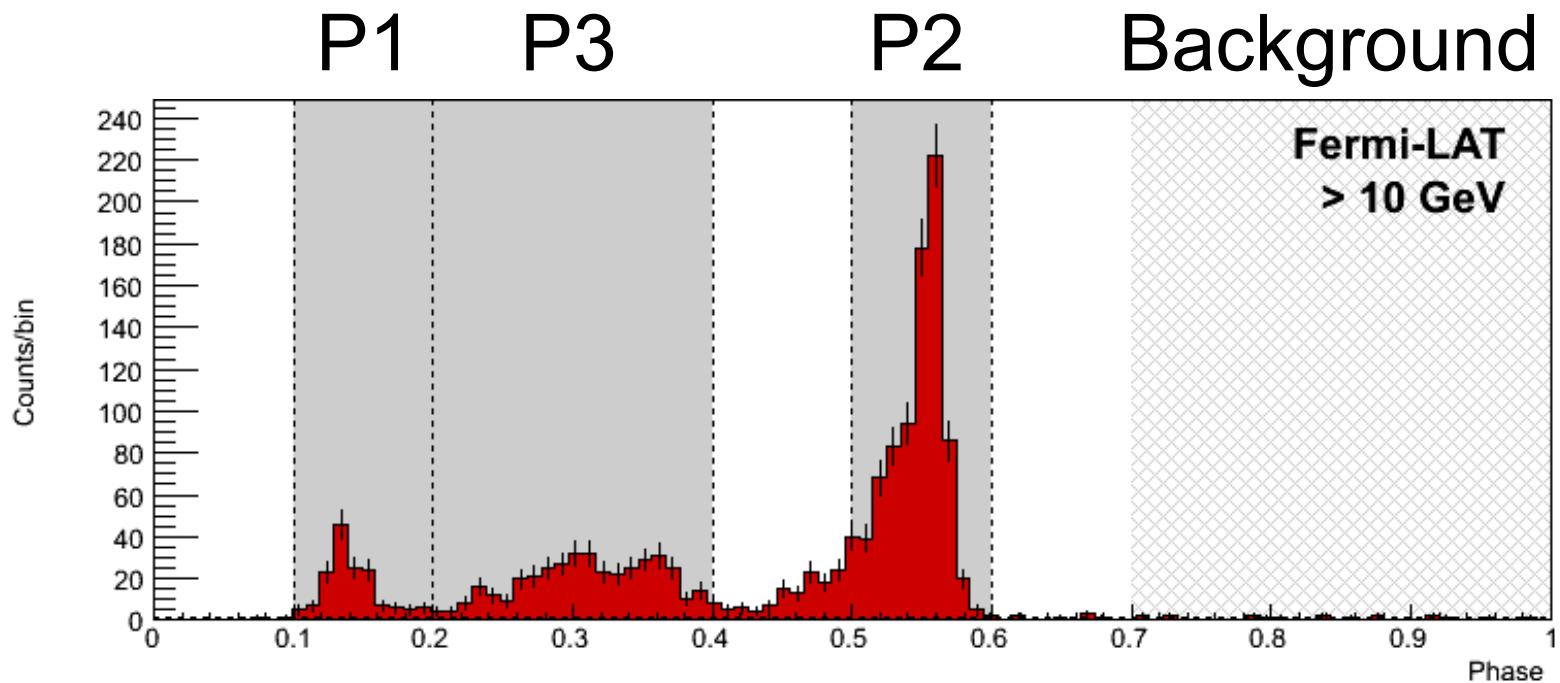
# Observations

- 24h high quality data collected in 2013 and 2014
- Zenith angle range [20° - 35°]
  - Mean 26°
- Disregarding information for CT 1-4
- Two glitches during observation period
  - MJD 55408
  - MJD 56555



# Region of Interest

- 60 months of *Pass 8 Fermi-LAT* data were analysed
- Phase regions determined:



# Reconstruction and Analysis

- Multivariate analysis using *Hillas* parameters and parameters from a 3D model of the air shower
  - Lemoine-Goumard, Degrange, and Tluczykont 2006
- Analysis cuts optimised for  $\gamma$  ray events below 100 GeV to give the lowest energy threshold
- Effective area at 20 GeV and 20° zenith angle:

$$1.9 \times 10^3 \text{ m}^2$$

- Phasing of events done with an interface with the *Tempo2* package
- Use the phase background region to determine excess in the P2 phase region
- **Thanks** to Dr. Matthew Kerr of the *Fermi*-LAT collaboration for the pulsar timing solution



# Phase Profile

## ■ Pulse P2

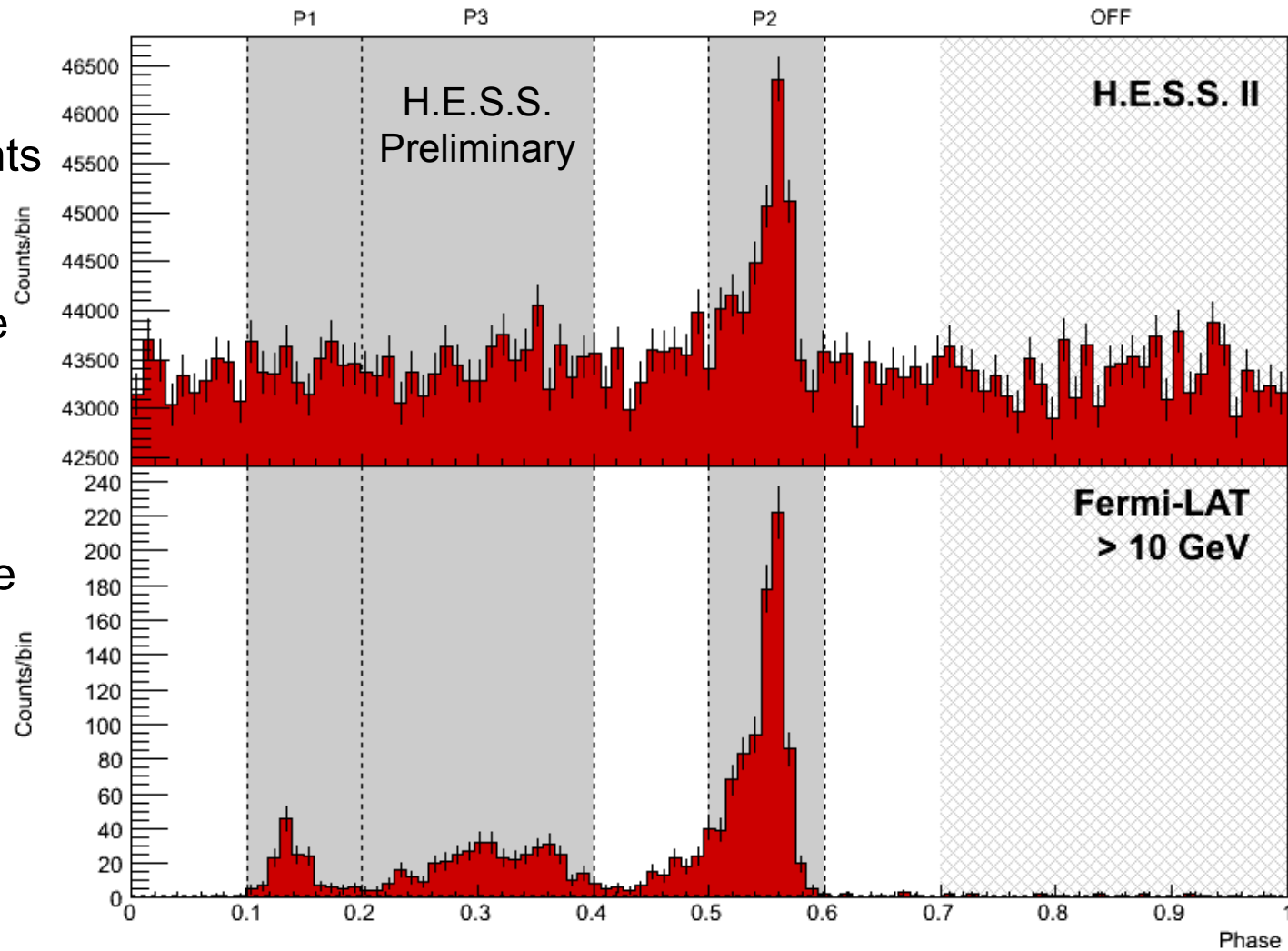
9838 excess events

H test significance

14.6 $\sigma$  (pre-trials)

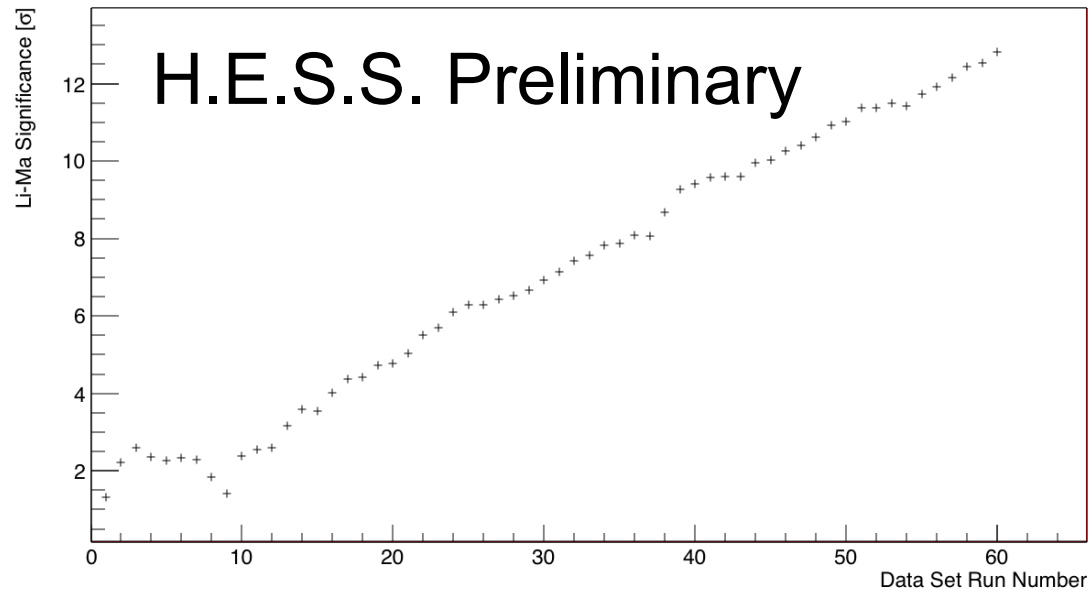
Li-Ma significance

12.8 $\sigma$  (pre-trials)



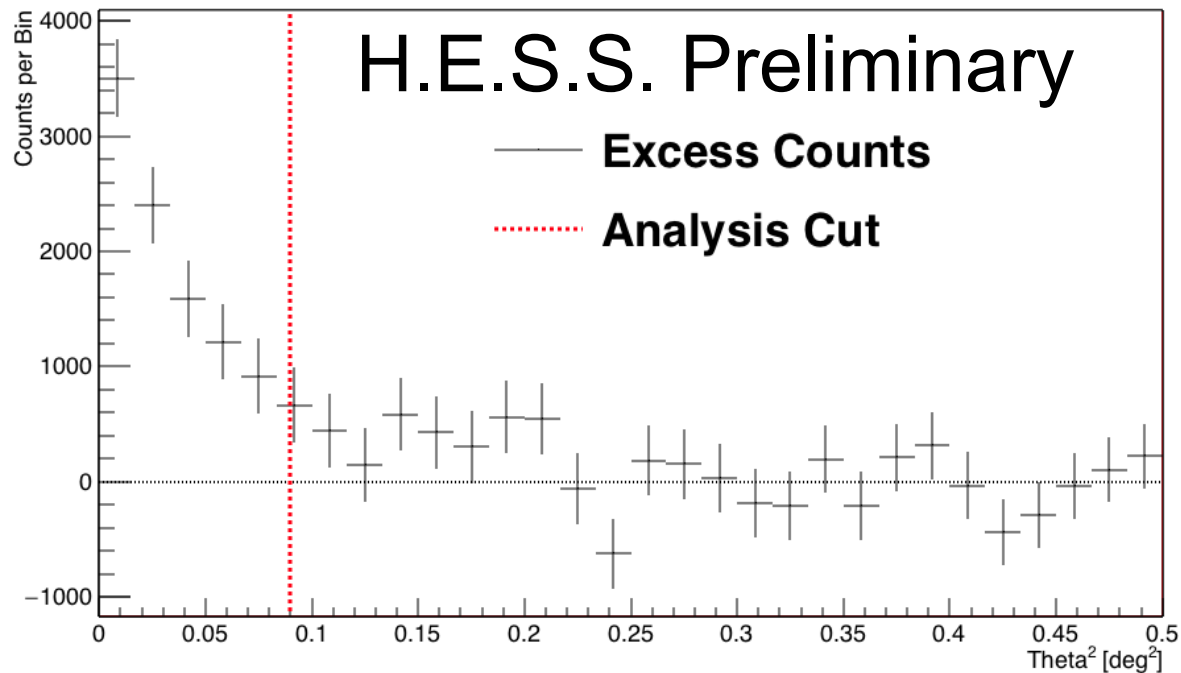
# Stability with Time

- Li-Ma significance against size of the data set
- Expected square root dependence is observed
- Steady increase in significance throughout the data set



# Stability in the Camera

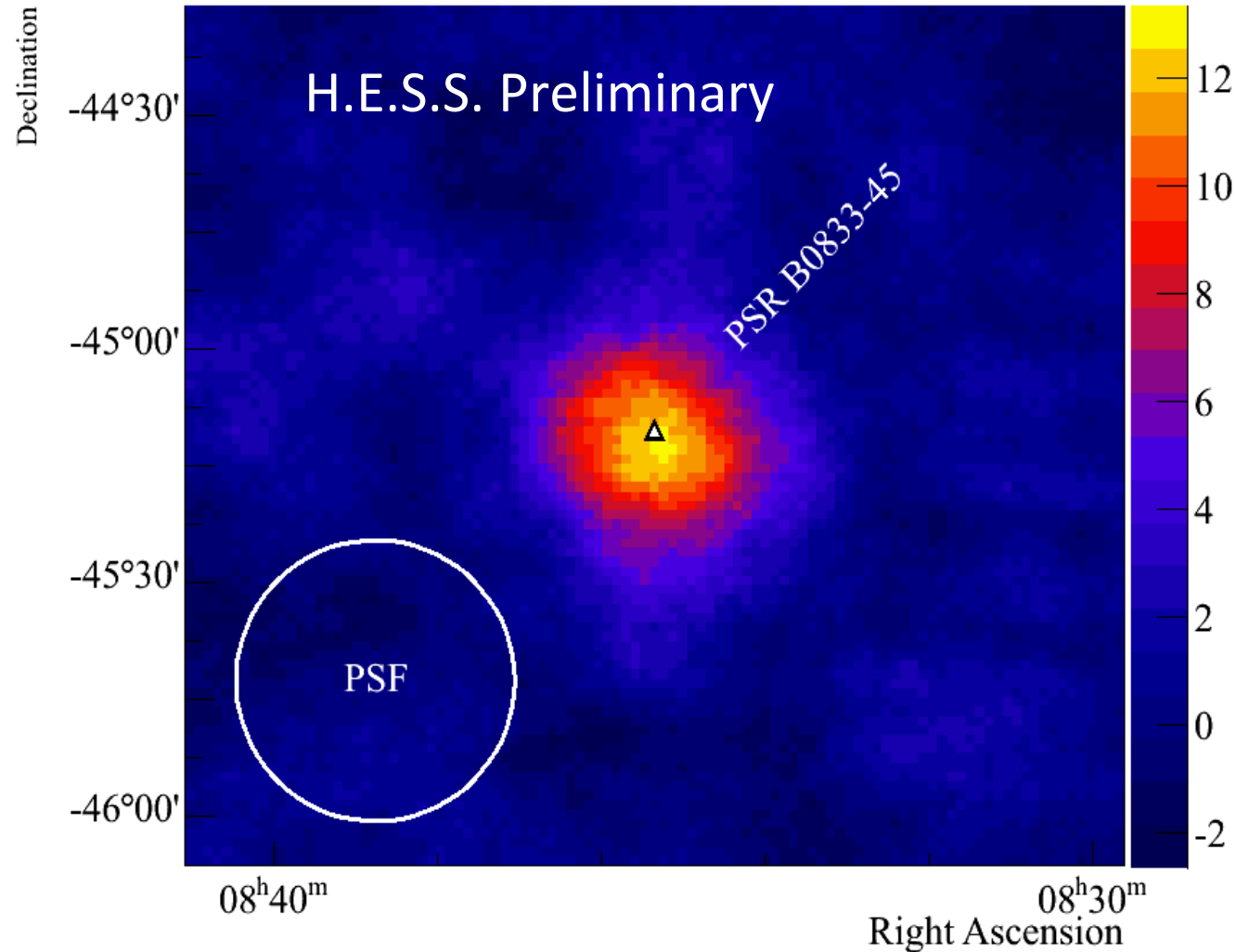
- Look at events from the complete field of view
- Consider the number of pulsed excess counts as a function of the angular distance from the pulsar in the sky
- Distinct excess at the test position in the sky





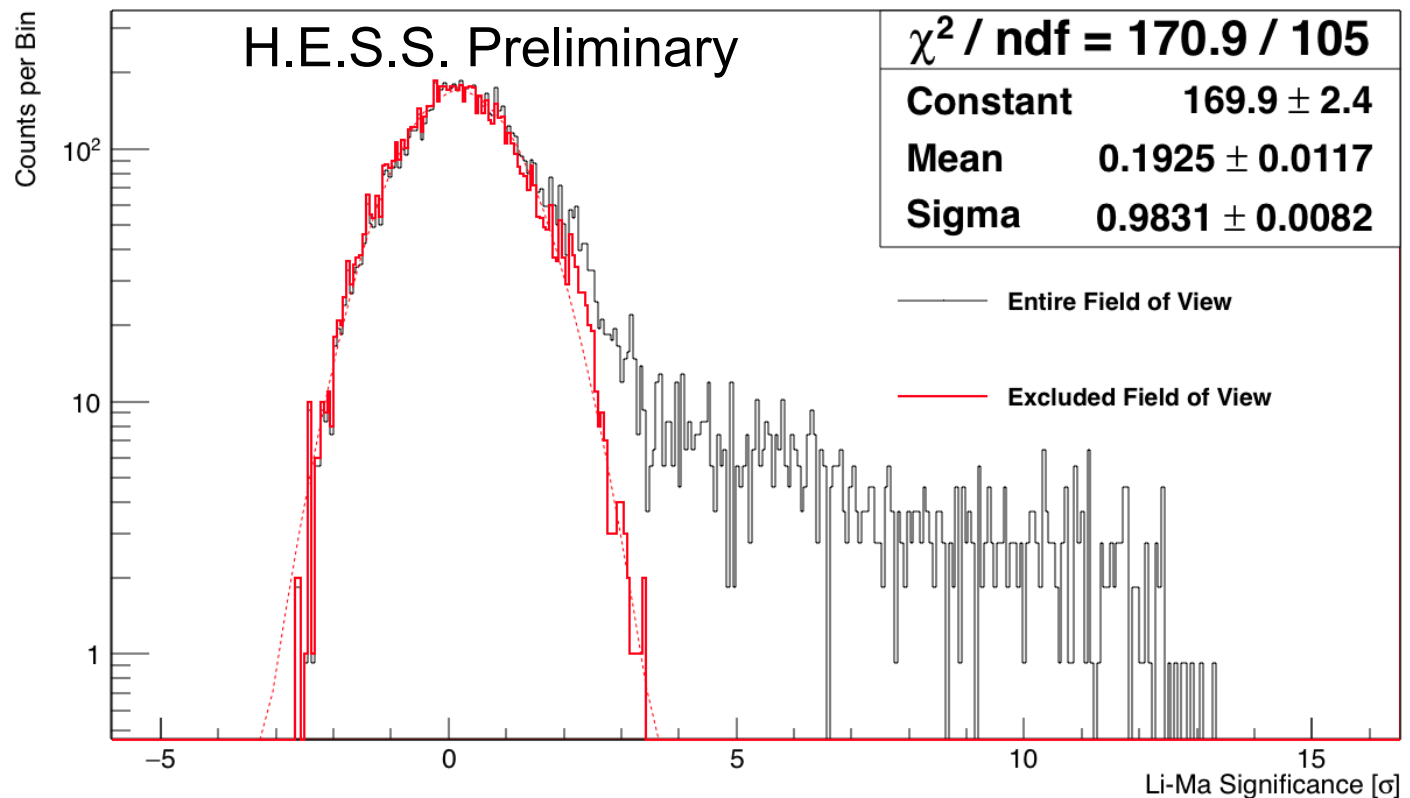
# Pulsed Li-Ma Significance Sky Map

- Compatible with a point source located at the position of the Vela pulsar from Radio observations
  - RA 08h 35m 21s
  - DEC  $-45^{\circ} 10' 35''$



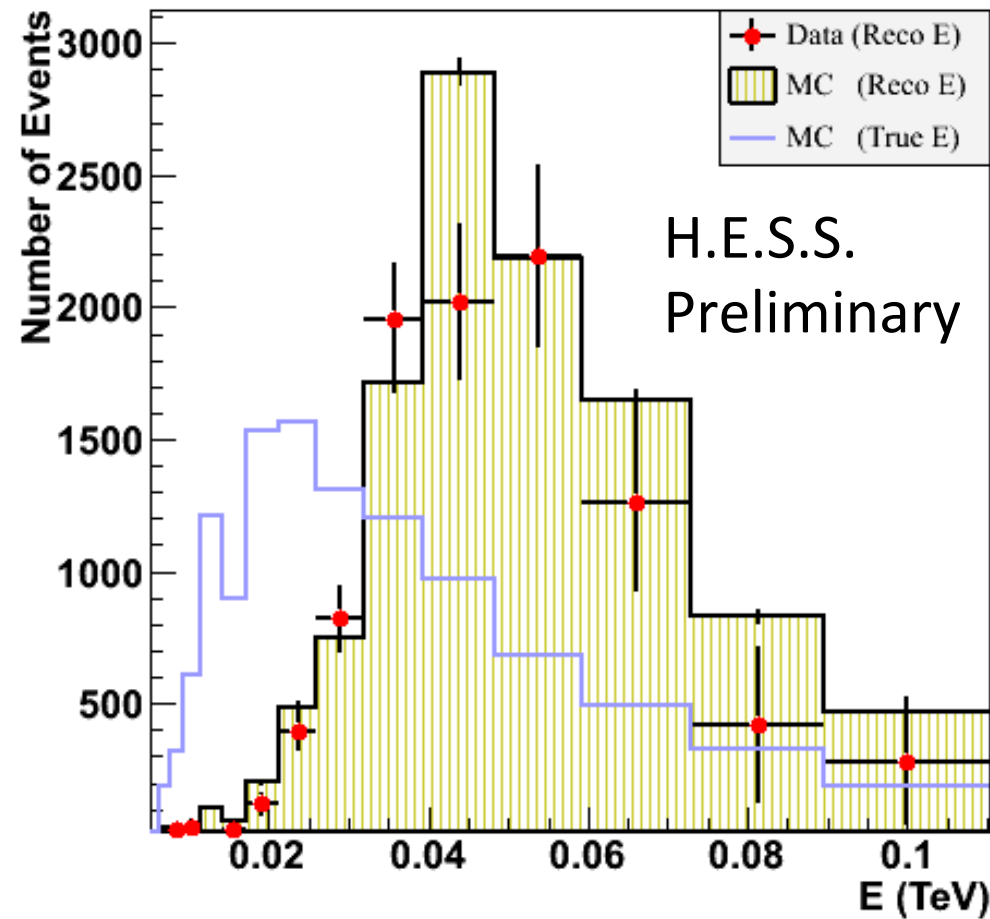
# Pulsed Li-Ma Significance Distribution

- Consider the significance value over the entire sky map (previous slide)
- Excluding the gamma-ray source (outside the red line) gives good agreement with standard normal distribution



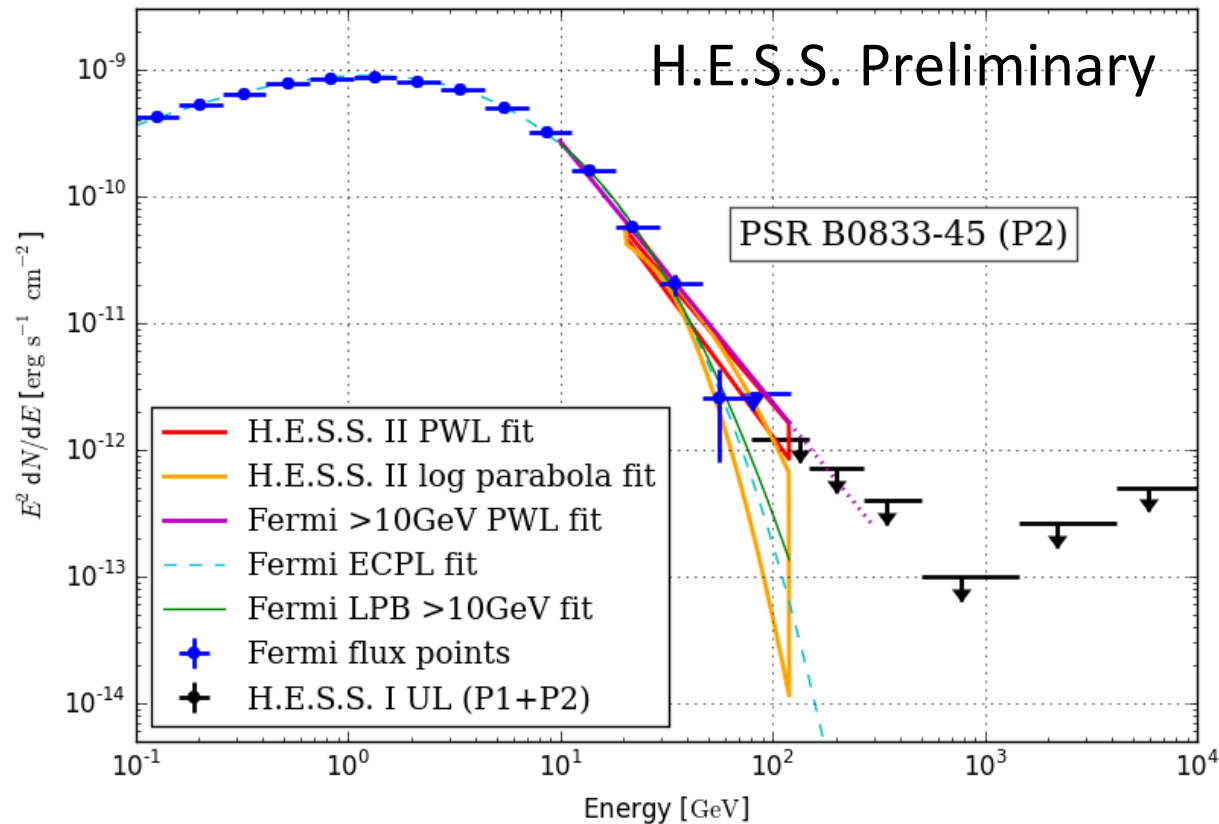
# Energy Distribution

- Reconstructed energy distribution of pulsed excess events
- Expected distributions from Monte Carlo for a source with a power law spectrum with index  $-4.1$
- Excellent data-Monte Carlo agreement
- The true energy (light violet) extends below 20 GeV



# Spectral Energy Distribution of P2

- H.E.S.S. I ULs and Fermi last energy bin UL constrain the power law obtained from Fermi Pass 8 and HESS II
- H.E.S.S. II energy range  
20 GeV – 120 GeV
- Systematics are under study
- H.E.S.S. II curved fit > 10 GeV is compatible with Fermi broadband fit and >10 GeV fit. But statistics above 10 GeV limit definite distinction between log parabola and power law



# Conclusions

- High significance detection of the P2 pulse from the Vela pulsar with H.E.S.S. II
- CT5 able to operate down to **20 GeV** using the phase to determine background rate
- Excellent agreement between H.E.S.S. II and *Fermi*-LAT
- Vela P2 peak spectrum measured up to **120 GeV**
- These results will soon be submitted to a journal

