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Carlo Romoli, Andrew M. Taylor (Dublin Institute for Advanced Studies)
Jean-Philippe Lenain (LPNHE, Paris)
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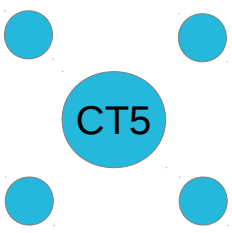
for the H.E.S.S. collaboration

AGN observations with < 100 GeV threshold using H.E.S.S. II

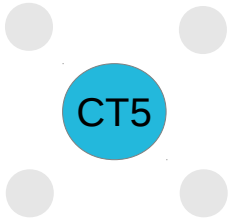
H.E.S.S. II

- H.E.S.S. Phase I (2002-2012) consisted of 4 Cherenkov telescopes of 12 m diameter (CT1-4)
- A fifth, 28 m telescope (CT5) was added in 2012 ==> H.E.S.S. Phase II
- Two types of triggers supported: Mono (CT5) and Stereo (any two or more telescopes in coincidence)
- Stereo data analysis similar to H.E.S.S. I (some adapatations to deal with two telescope types)
- Mono data analysis relies on the finely-pixelated CT5 camera images



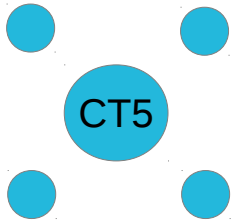
Mono vs. Stereo

CT5 Mono



- Low energy threshold
- Limited angular resolution and hadron rejection capabilities
- Poor sensitivity compared to Stereo analysis

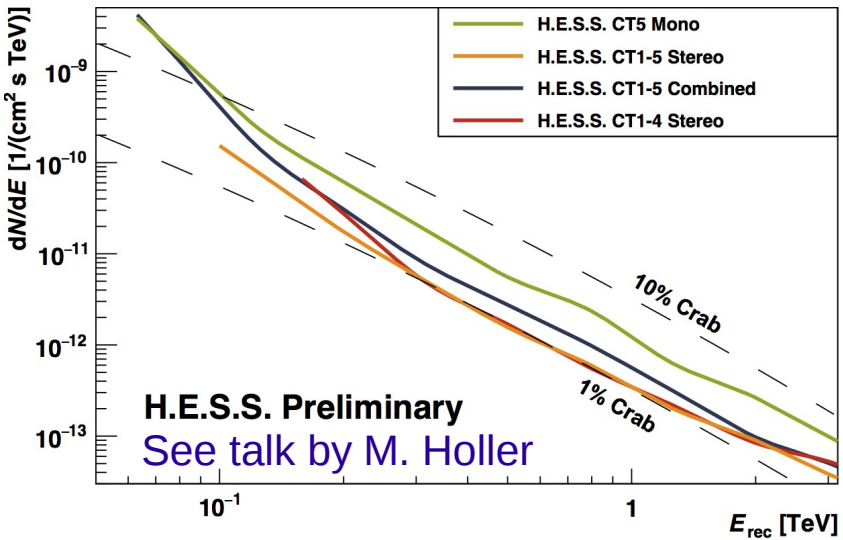
CT1-5 Stereo



- Higher threshold
- Excellent angular resolution and hadron rejection
- Excellent sensitivity

Best for:

- ✔ Pulsars (phasogram analysis)
- ✔ High redshift AGN, GRBs
- ✔ EBL at z > 1 (gamma-ray horizon)
- ✔ Spectral measurements at E < 100 GeV



See talk by M. Holler

Best for:

- ✔ Detection of weak sources
- ✔ Morphology studies
- ✔ Spectral measurements at E > 100 GeV

Goals and objects

Goals

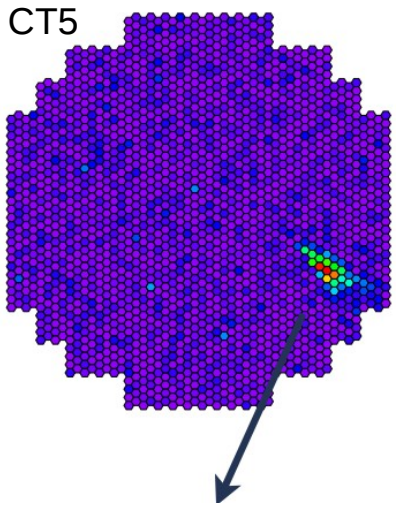
- Measure the SED of known AGN with a low energy threshold (< 100 GeV)
- Pave the way for further studies of these and other sources using H.E.S.S. II

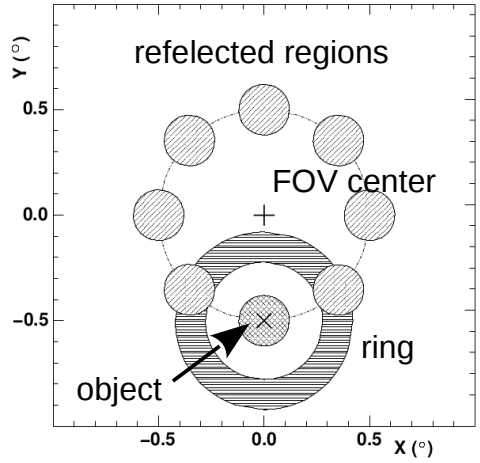
Objects

- PKS 2155-304
  - Bright HBL object at z = 0.116 (TeVCat value)
  - Regularly observed by H.E.S.S. since 2002
  - This work uses the 2013 and 2014 data (56 hr live time, median zenith angle = 16°)
- PG 1553+113
  - HBL object at uncertain redshift, 0.43 < z < 0.58 (*C.W. Danforth et al., ApJ 720 (2010) 976*)
  - Observed by H.E.S.S. since 2005
  - This work uses 2013 data (16.8 hr live time, zenith angle between 33° and 40°, May-August 2013)

Data Analysis

- Using the **CT5 Mono** data only
- **The Model Reconstruction** adapted for Mono
- Event selection **cuts optimized for soft spectrum** (photon index 3 or softer), giving consideration to systematic errors
- **Run Quality** selection includes meteo information, trigger rates, camera sanity and telescope tracking status
- Maps are generated using the **Ring Background** method
- θ^2 distribution and spectrum are obtained using the **Reflected Region** method



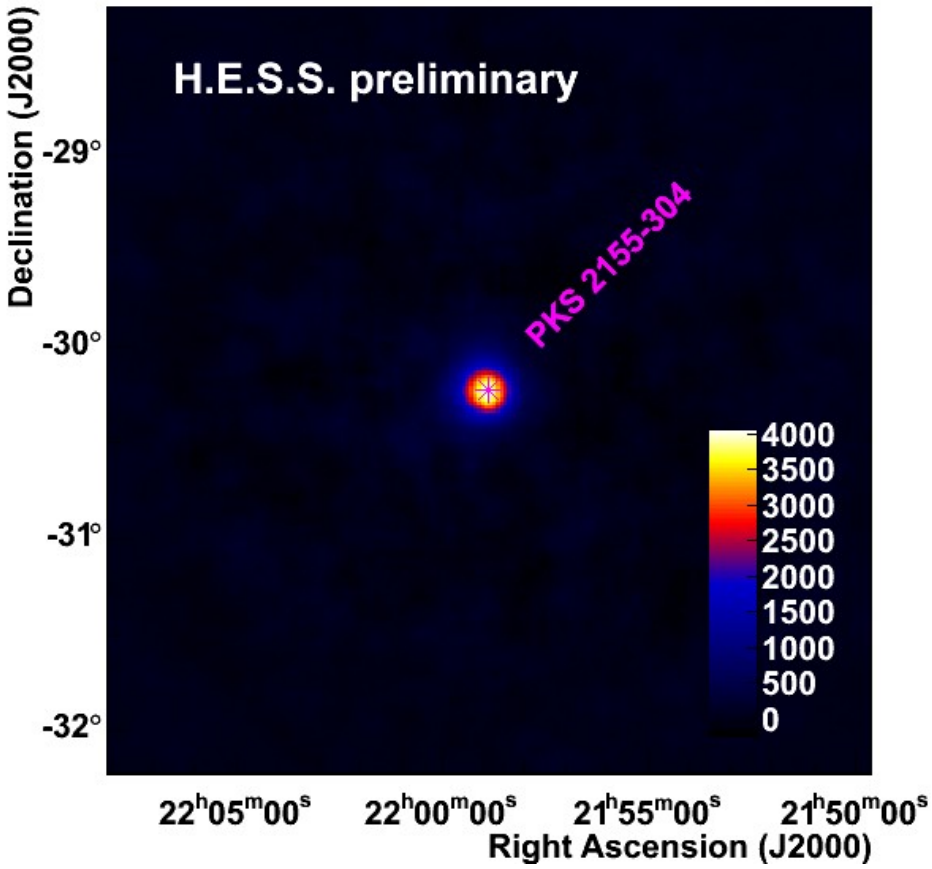


Fit image with model template
==> direction, energy, ...

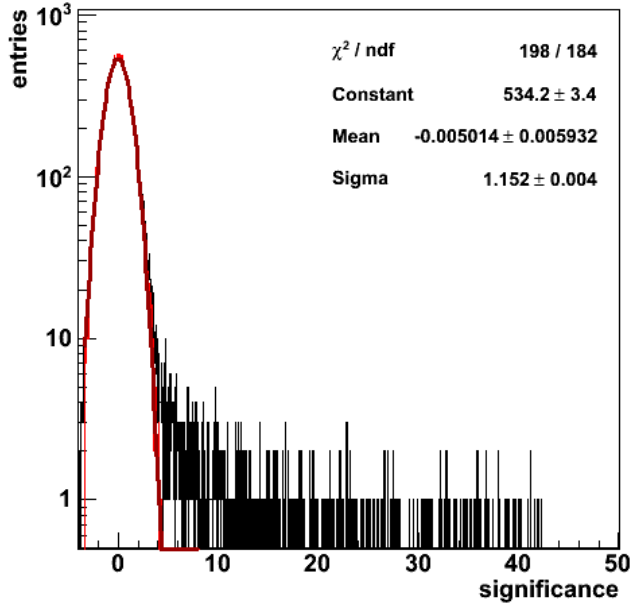
References:

- *M. de Naurois & L. Rolland, Astropart. Phys. 32 (2009) 231*
- *M. Holler et al., ICRC 2015 I/509 (poster)*
- *F. Aharonian et al., A&A 457 (2006) 899*

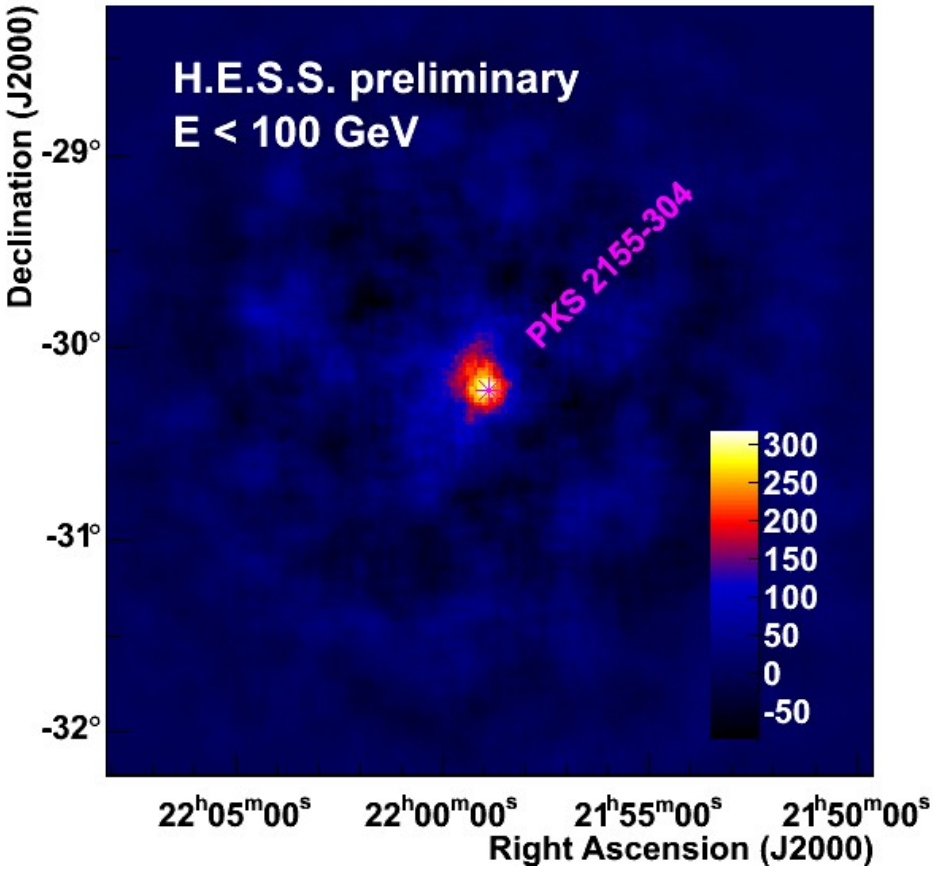
PKS 2155-304



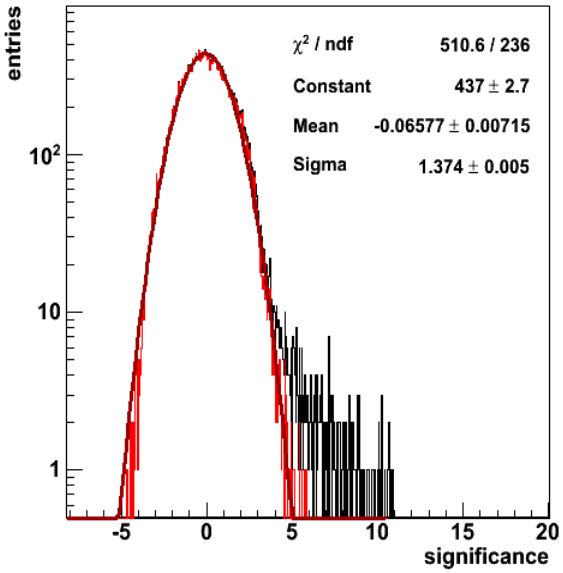
- The source is detected at ≈ 40 σ (CT5 Mono Standard cuts)
- The energy threshold is ≈ 80 GeV
- The significance distribution does not show any unexpected features



PKS 2155-304 at E < 100 GeV

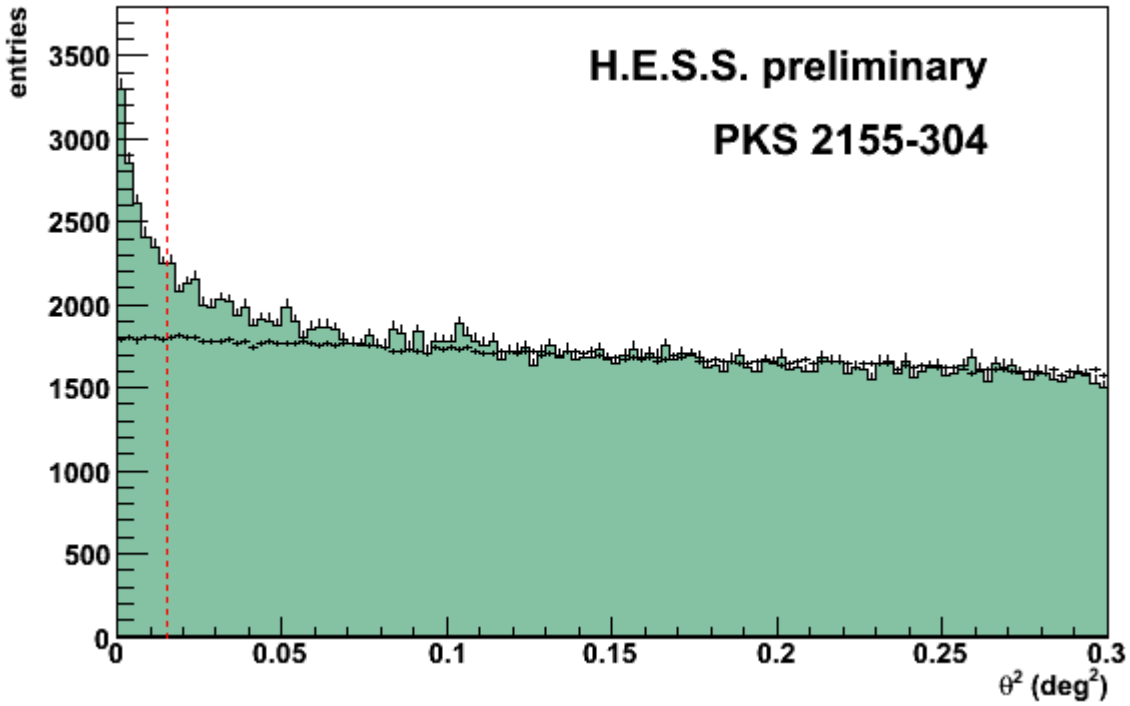


- Using only the gamma-like air shower events with reconstructed energy < 100 GeV, the source is detected at 10 σ
- The width of the significance distribution indicates the presence of a (small) systematic effect in background subtraction



PKS 2155-304

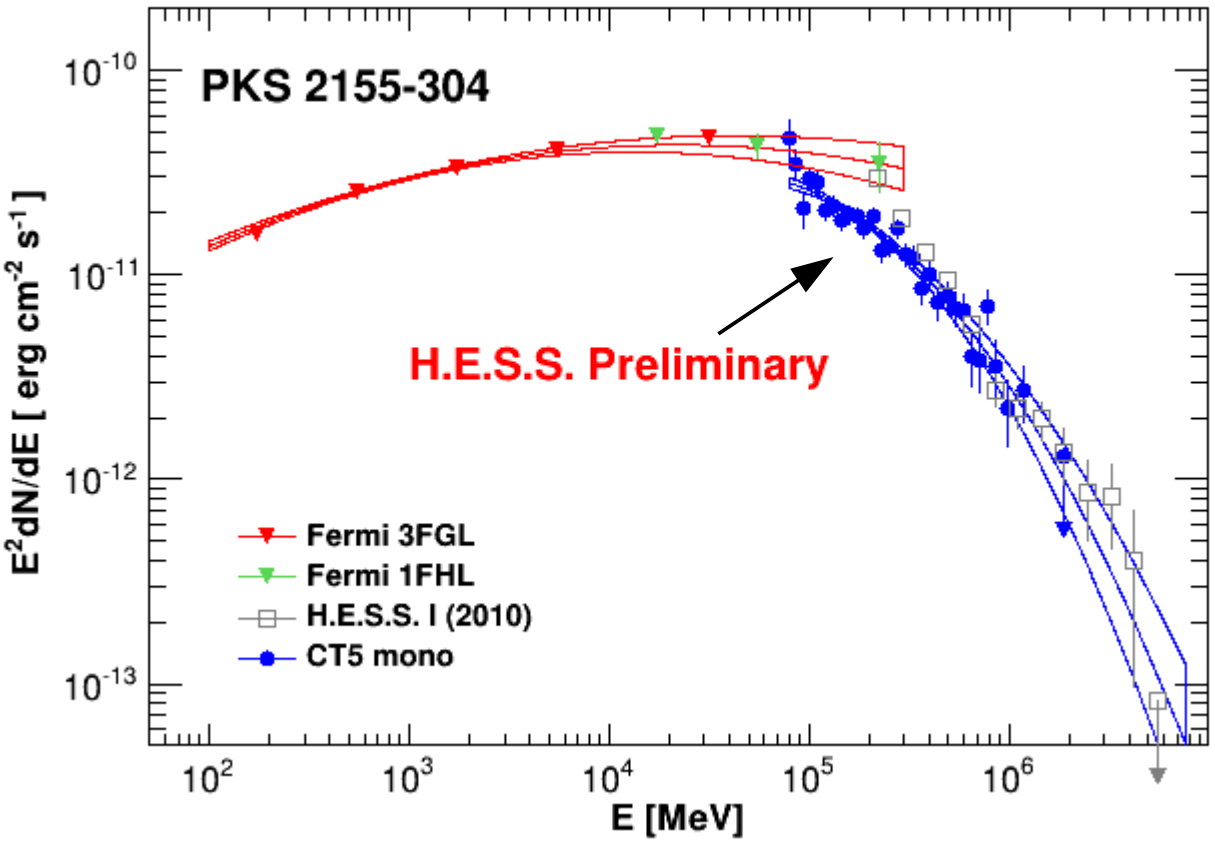
- Plot of θ^2 (squared angular distance from PKS 2155-304) obtained using the reflected background method (with multiple OFF regions)
- A 42.9 σ excess is observed within $\theta^2 < 0.015$ deg^2
- Excess rate: 1.5 event / min
- The reconstructed energy spectrum of the excess events is shown on next slide



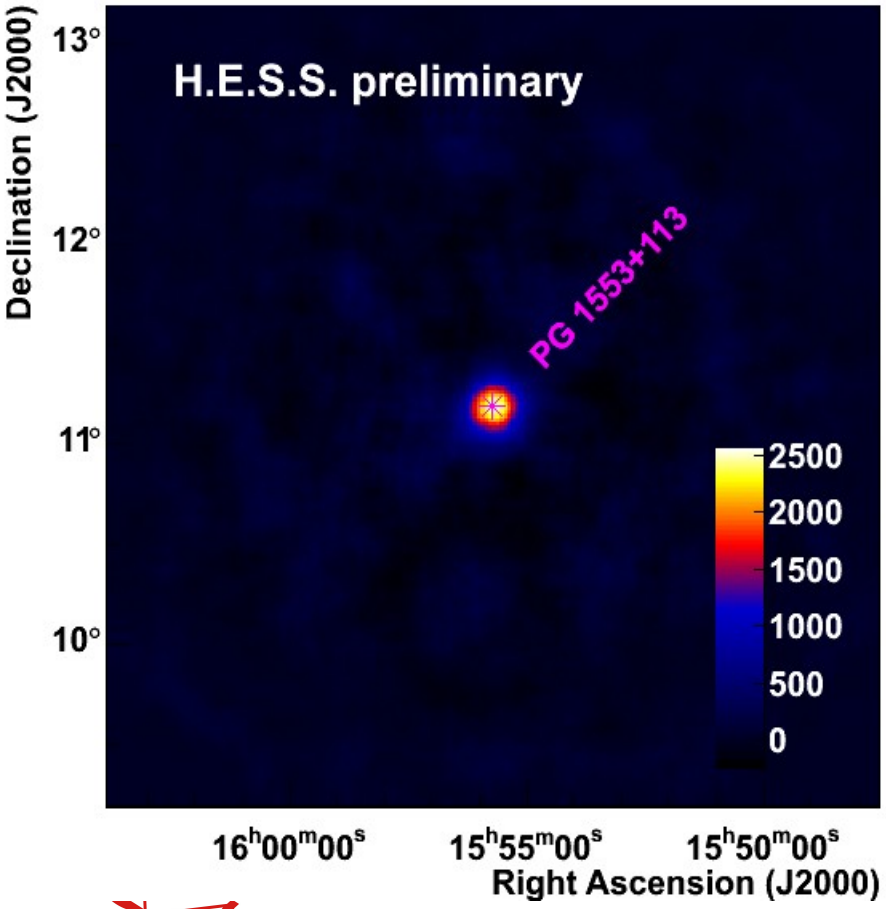
PKS 2155-304: SED

- Spectrum data points cover the energy range between 80 GeV and 1.2 TeV
- Log parabola is statitically preferred to simple power law
- At E > 300 GeV the new measurement approximately matches the 2005-2007 quiscent state spectrum reported by H.E.S.S. in *A. Abramowski et al, A&A 520 (2010) A83*
- At E < 300 GeV the new spectral fit lies below the Fermi 3FGL and 1FHL spectra

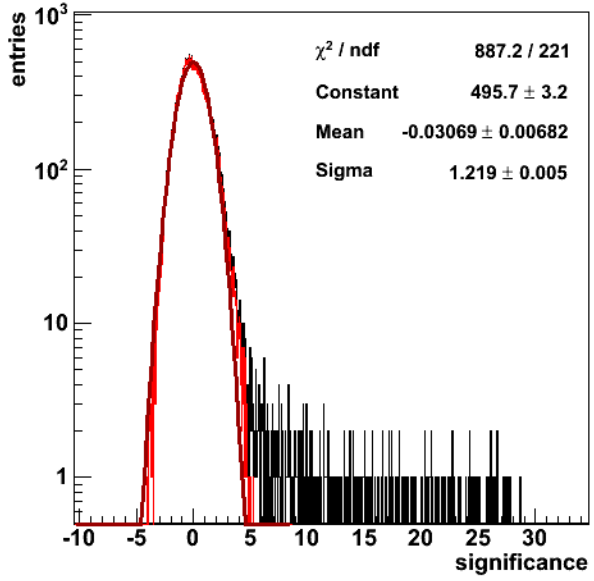
For numeric fit results
see the proceedings paper



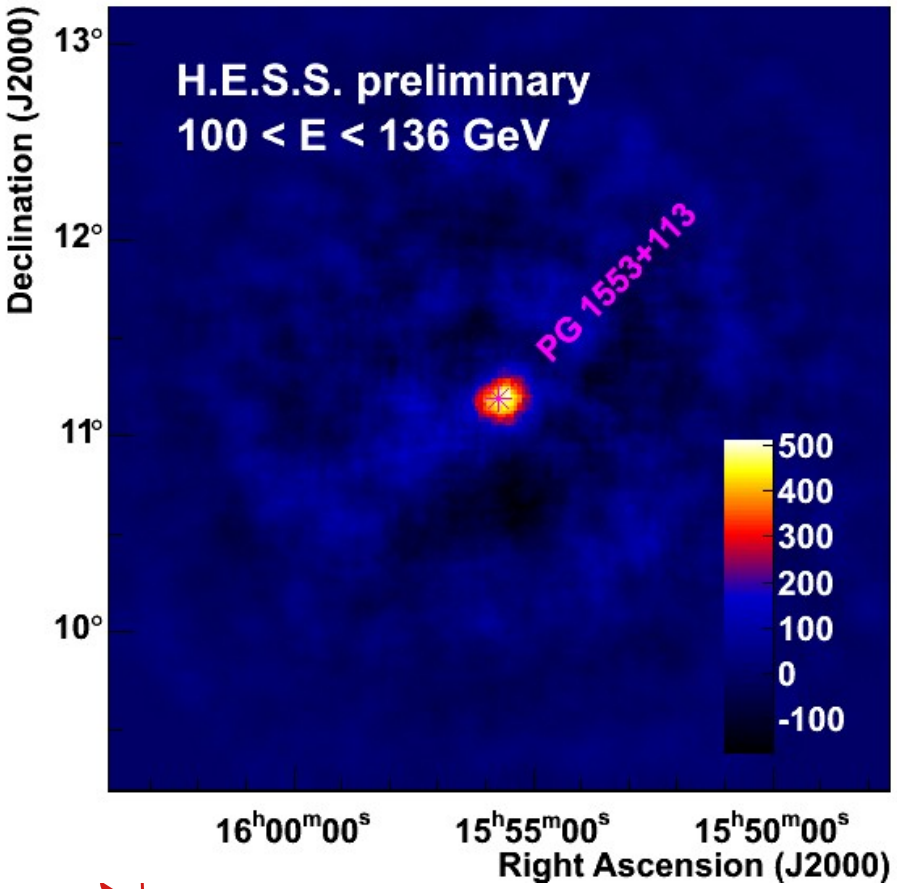
PG 1553+113



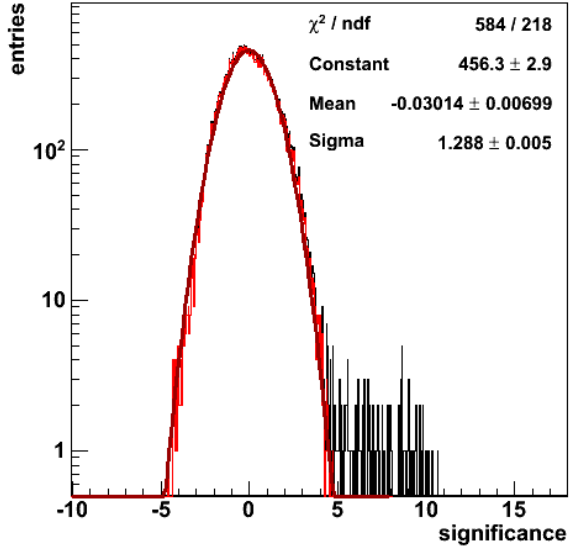
- The source is detected at > 25 σ (CT5 Mono Loose cuts)
- The energy threshold is ≈ 100 GeV
- The significance distribution does not show any unexpected features



PG 1553+113 at E ≈ 100 GeV

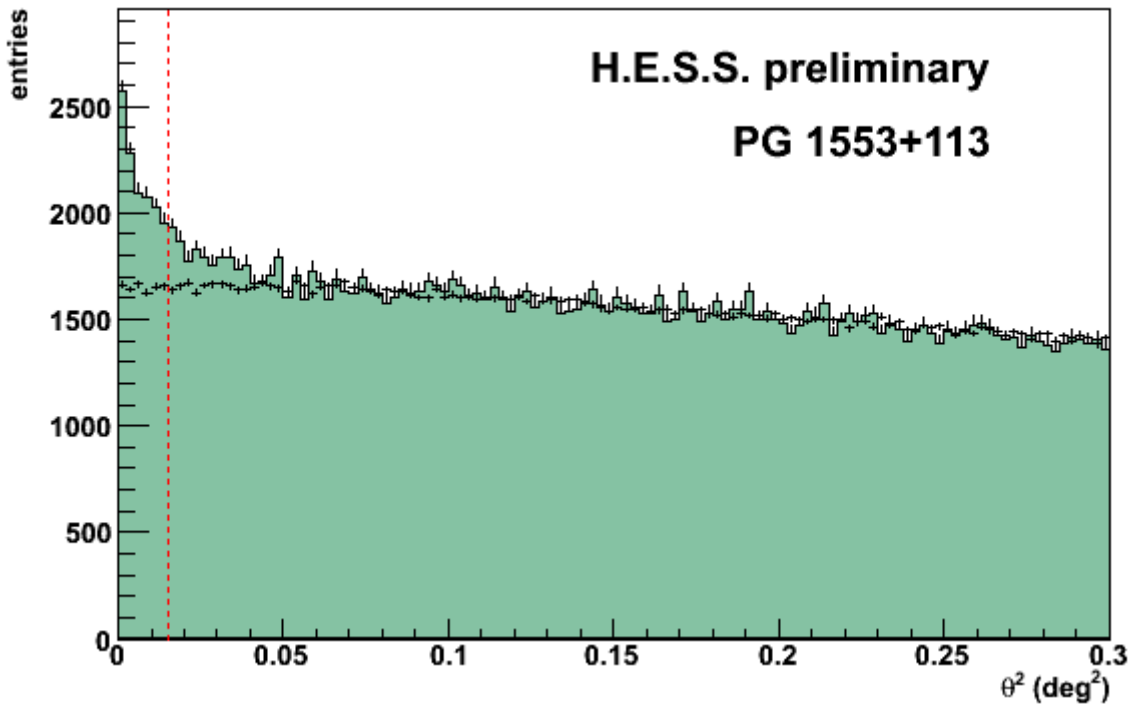


- The analysis was repeated in 3 energy bins equally spaced in logarithm of reconstructed energy between 100 and 250 GeV
- The source is detected at 10 σ in the first energy bin, and at > 15 σ in the second and third bins (only the first bin is shown here)



PG 1553+113

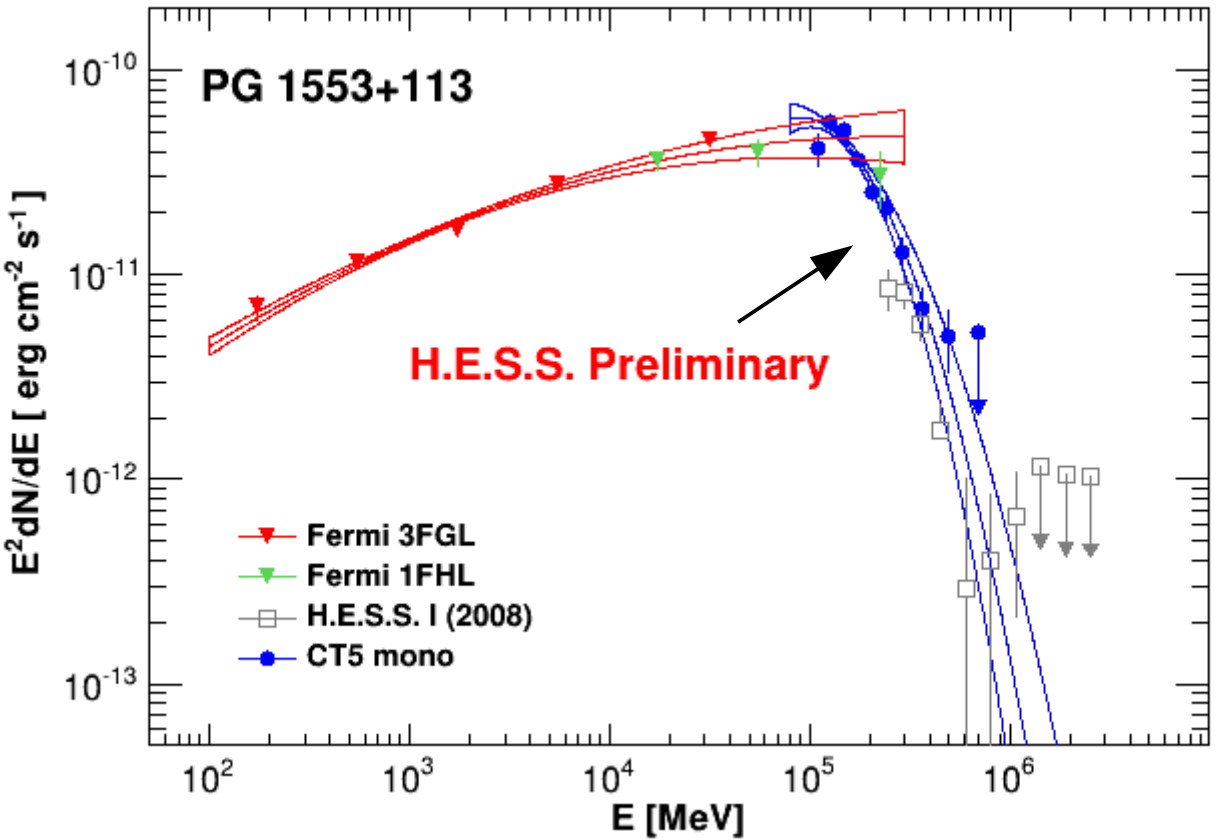
- A 27.4 σ excess is observed using the reflected background method with θ^2 cut at 0.015 deg^2
- Excess rate: 3 events / min
- The reconstructed spectrum of the excess is shown on next slide



PG 1553+113

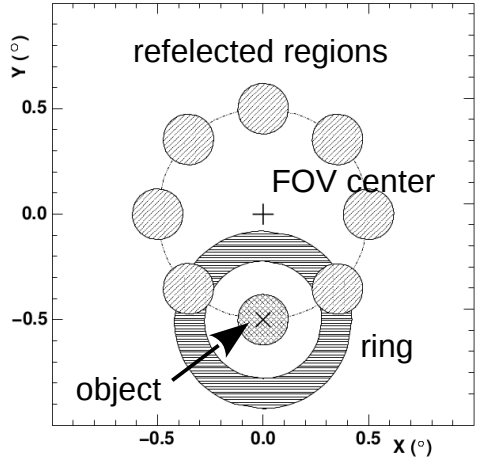
- Spectrum data points cover energy range from 100 to 500 GeV
- Spectrum is well fitted with log parabola
- The new measurement is in reasonable agreement with the earlier measurement by H.E.S.S. (*F. Aharonian et al., A&A 477 (2008) 481-489*) as well as Fermi catalogs

For numeric fit results
see the proceedings paper



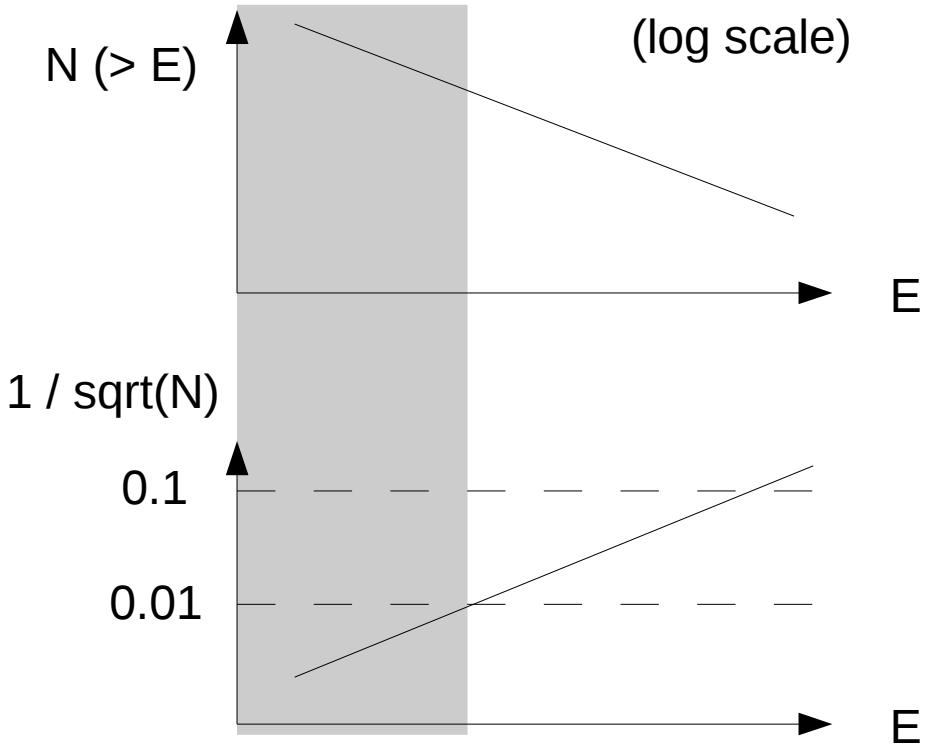
Additional checks

- The uniformity of the camera acceptance was verified by applying a likelihood ratio test to the event counts in the OFF regions; the results were found consistent with a uniform camera acceptance
- Stereoscopic analysis was used to cross-check the obtained spectrum at E > 150 GeV; the spectra were found consistent
- A cross-check analysis using an alternative reconstruction method (See p*oster by Parsons, Gajdus & Murach, ICRC 2015-I/559*) was applied to the same data set; all results, including spectra, were found consistent with what is presented here



Systematic uncertainties (standard Mono analysis)

- Spectral measurements with H.E.S.S. II are subject to systematic uncertainties similar to H.E.S.S. I
- Detailed re-evaluation of the uncertainties for H.E.S.S. II is a work in progress
- Background subtraction is a dominant source of uncertainties in the Mono analysis at low energy (this does not apply to pulsar phasogram analyses)



Quantitative estimates of systematic uncertainties will be reported elsewhere

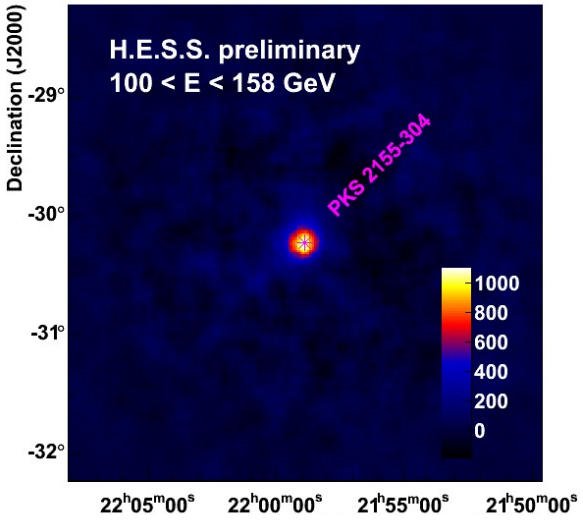
Conclusion

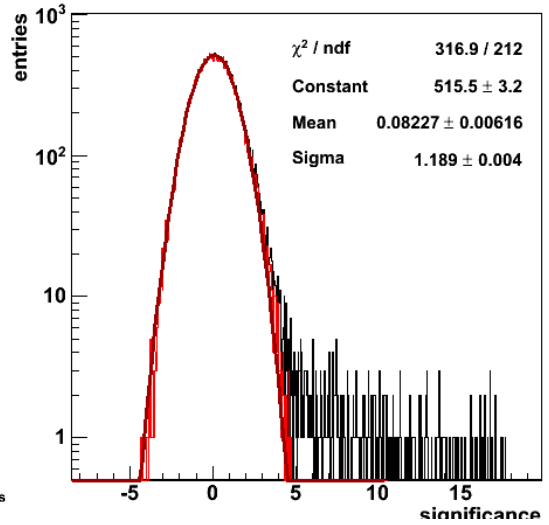
- An analysis of two bright AGN, PKS 2155-304 and PG 1553+113, using the H.E.S.S. CT5 data has been presented
- Both sources are detected with high significance, with an energy threshold of ≈ 80 and 100 GeV for PKS 2155-304 and PG 1553+113, respectively
- Spectral curvature has been observed for both sources
- The measured spectrum of PKS 2155-304, using the 2013 and 2014 H.E.S.S. data, is approximately consistent with the quiescent spectrum reported earlier by H.E.S.S., as well as the Fermi 3FGL and 1FHL catalogs
- The obtained PG 1553+113 spectrum is in good agreement with earlier H.E.S.S. measurements and the Fermi catalogs

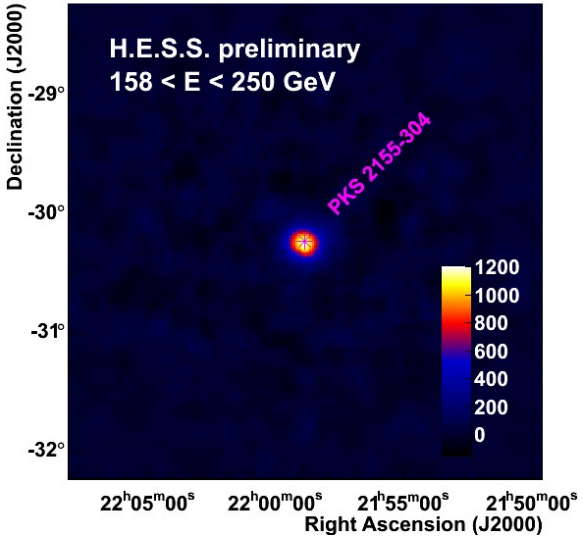
Backup slides

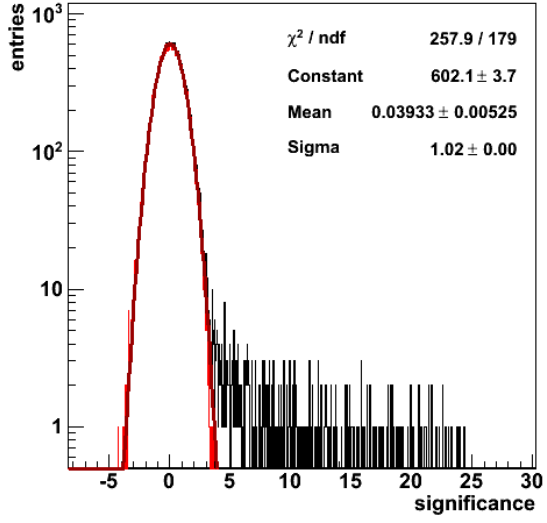
PKS 2155-304

- Analysis in energy bins









PG 1553+113

- Analysis in energy bins