

*The Cosmic-Ray Electron Spectrum
Measured with H.E.S.S.*

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Outline

- The H.E.S.S. Experiment
- The H.E.S.S. Electron Measurement
 - Gamma-Ray Background
 - Hadronic Background
 - Spectrum Determination
- Results
 - High-Energy Spectrum
 - Low-Energy Spectrum
- Conclusion

The High Energy Stereoscopic System

- Four Cherenkov telescopes in Namibia
- 13 m diameter mirrors (107 m²)
- Cameras: 5° diameter field of view
- Energy threshold > 100 GeV
(depending on event selection cuts and data set)

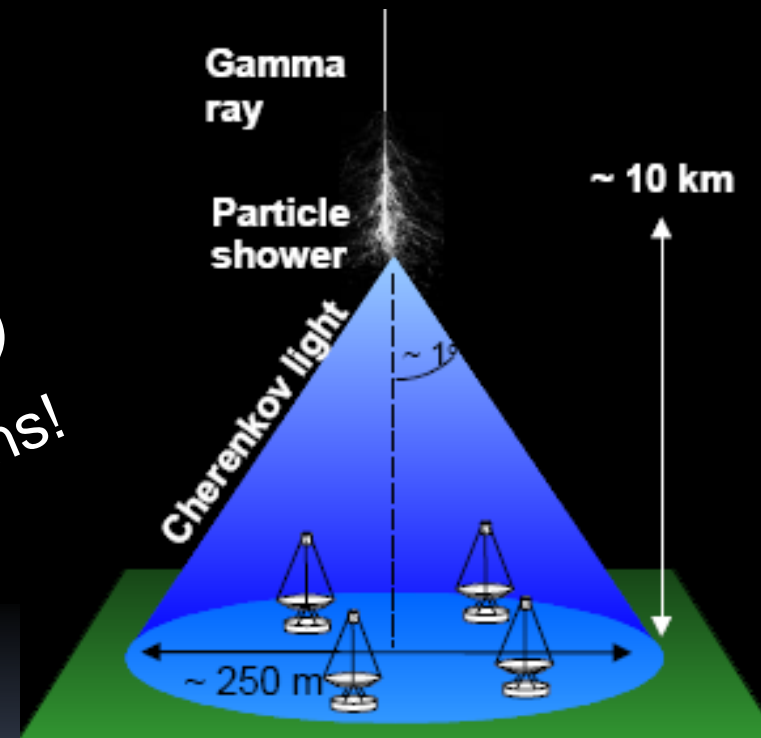


The H.E.S.S. Electron Measurement

- Indirect measurement via air showers in atmosphere
- Advantage:
large collection areas ($\approx 10^5 \text{ m}^2$)

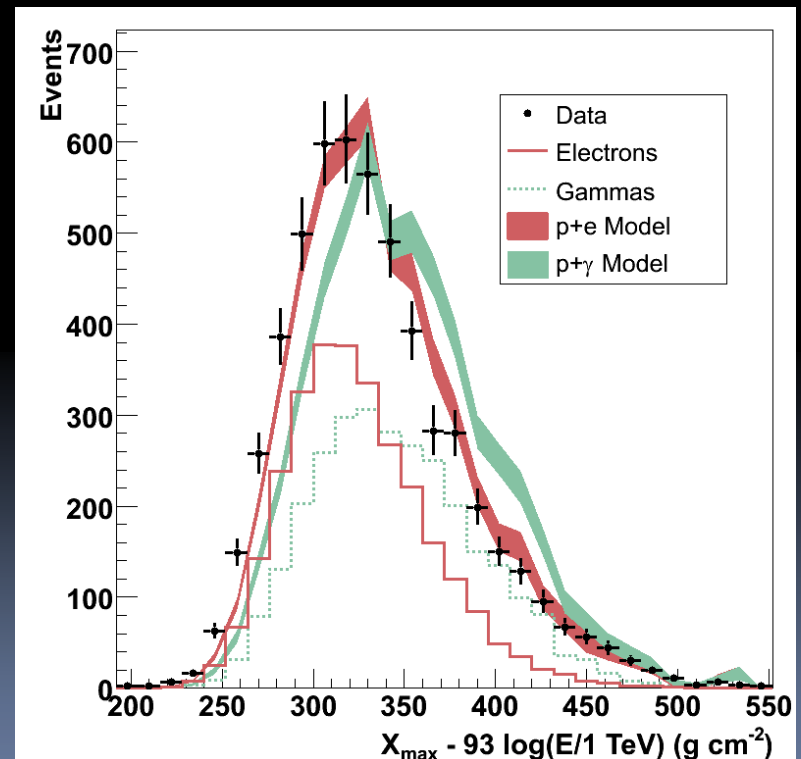
Dependence on
atmospheric conditions!

- Background contributions:
 - Gamma rays
 - Hadrons



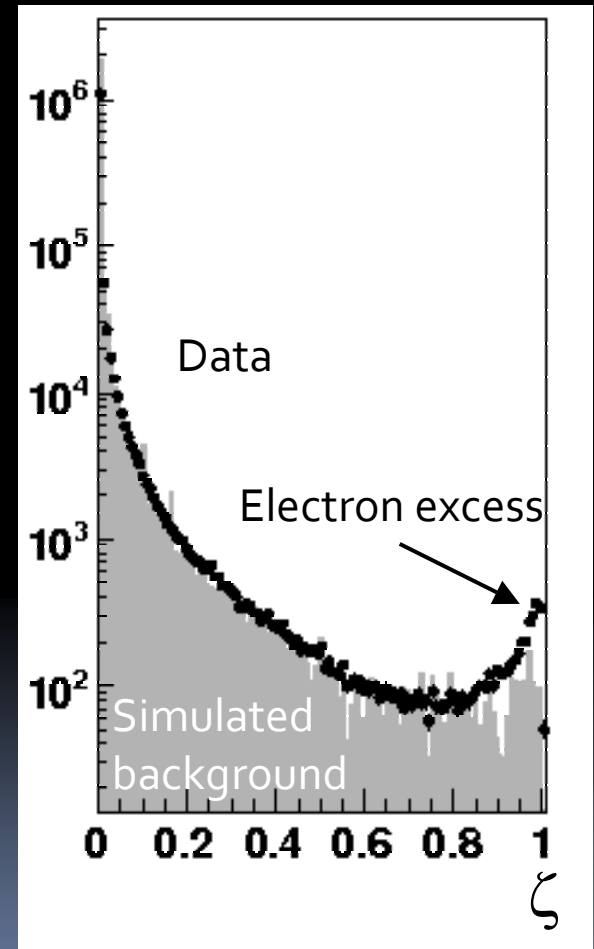
Gamma-Ray Background

- Very similar air showers
- Avoided by choice of data set: Galactic plane and potential gamma-ray sources are excluded
- Remaining background: diffuse extragalactic gammas
 - Very low fluxes are expected due to pair creation on radiation fields
 - Experimental discrimination: X_{\max}
 - Occurs $\frac{1}{2}$ radiation length higher for electrons
 - Cannot exclude maximum of 50% gamma contamination



Hadronic Background

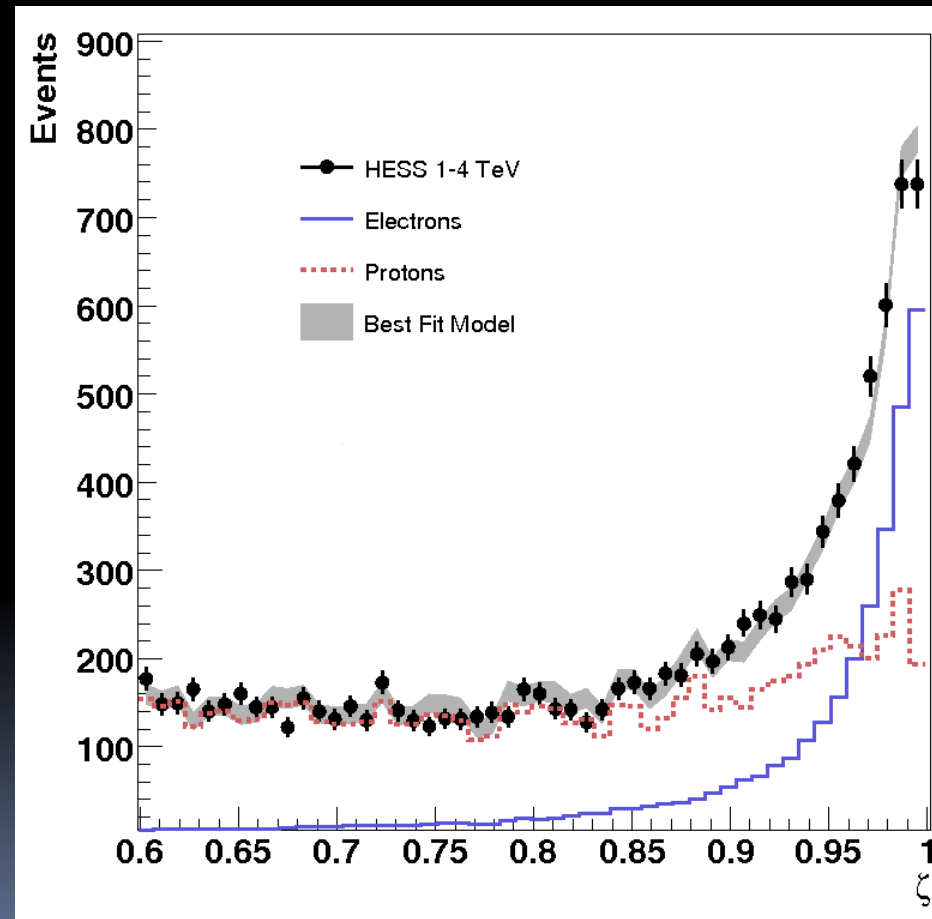
- Broader and less regular than electromagnetic showers
- Electron-hadron separation with the machine-learning algorithm **Random Forest (RF)**
- RF converts image parameters into output parameter $\zeta \in [0,1]$:
 - $\zeta=1$: electron-like
 - $\zeta=0$: background
- ζ describes *electron-likeness* of an event
- Cut $\zeta > 0.6$ is applied for a 98-99.5% background suppression



Hadronic Background

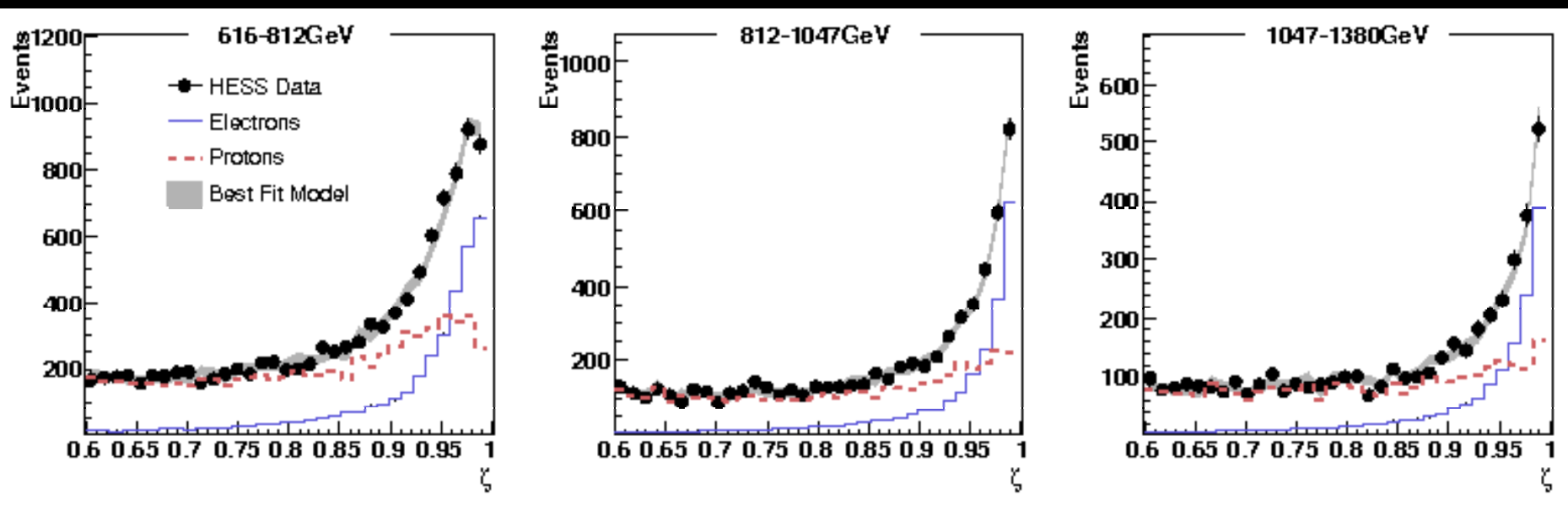
- Remaining background level determined by a fit in ζ with electron and proton simulations
- The hadronic background can be modelled with protons only because heavier nuclei are sufficiently suppressed by ζ cut

Dependence on
hadronic model!



Spectrum Determination

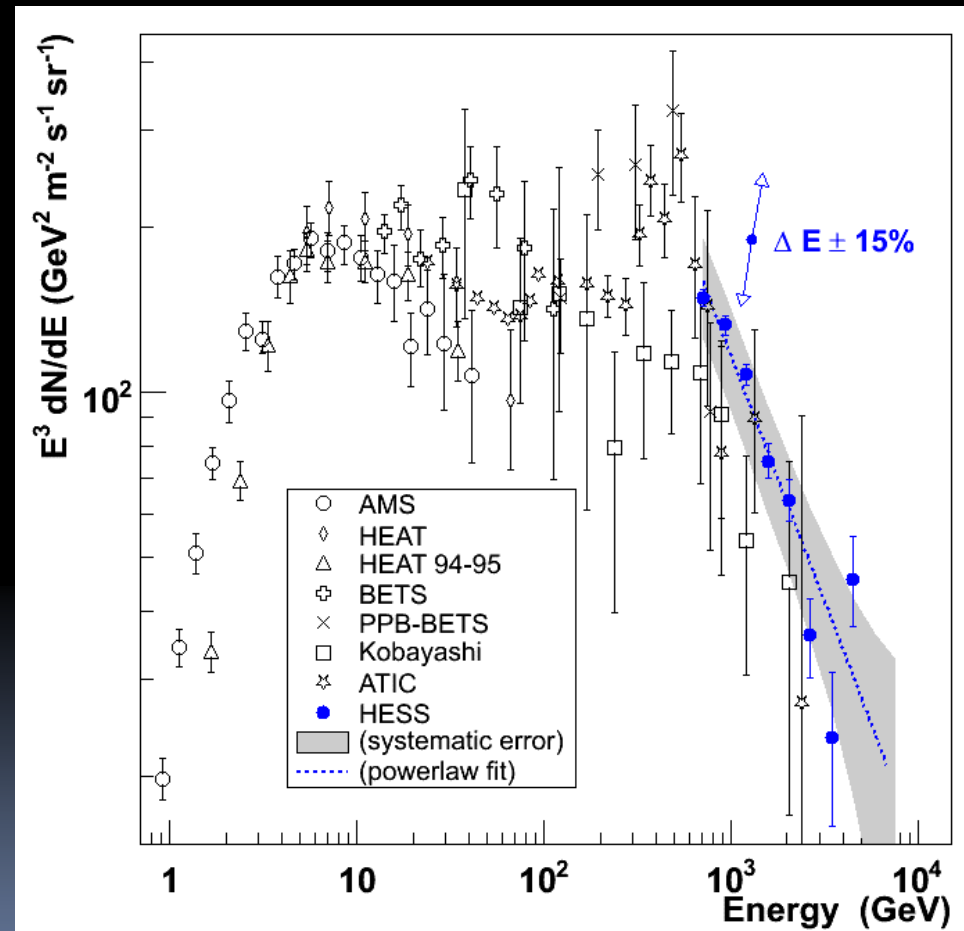
- Fit in ζ in independent energy bands
⇒ determine number of electrons N_e in each band



$$\Rightarrow dN/dE = N_e / (A_{\text{eff}} \times T_{\text{live}} \times \Omega \times \Delta E)$$

Results: High-Energy Spectrum

- Cuts:
 - impact distance < 200 m
 - image size in each camera > 200 photo electrons
- Syst. uncertainty: atmospheric variations + model dependence of proton simulations (SIBYLL vs. QGSJET-II)
- H.E.S.S. energy scale uncertainty of 15%
- Spectral index: $3.9 \pm 0.1_{\text{stat.}} \pm 0.3_{\text{syst.}}$

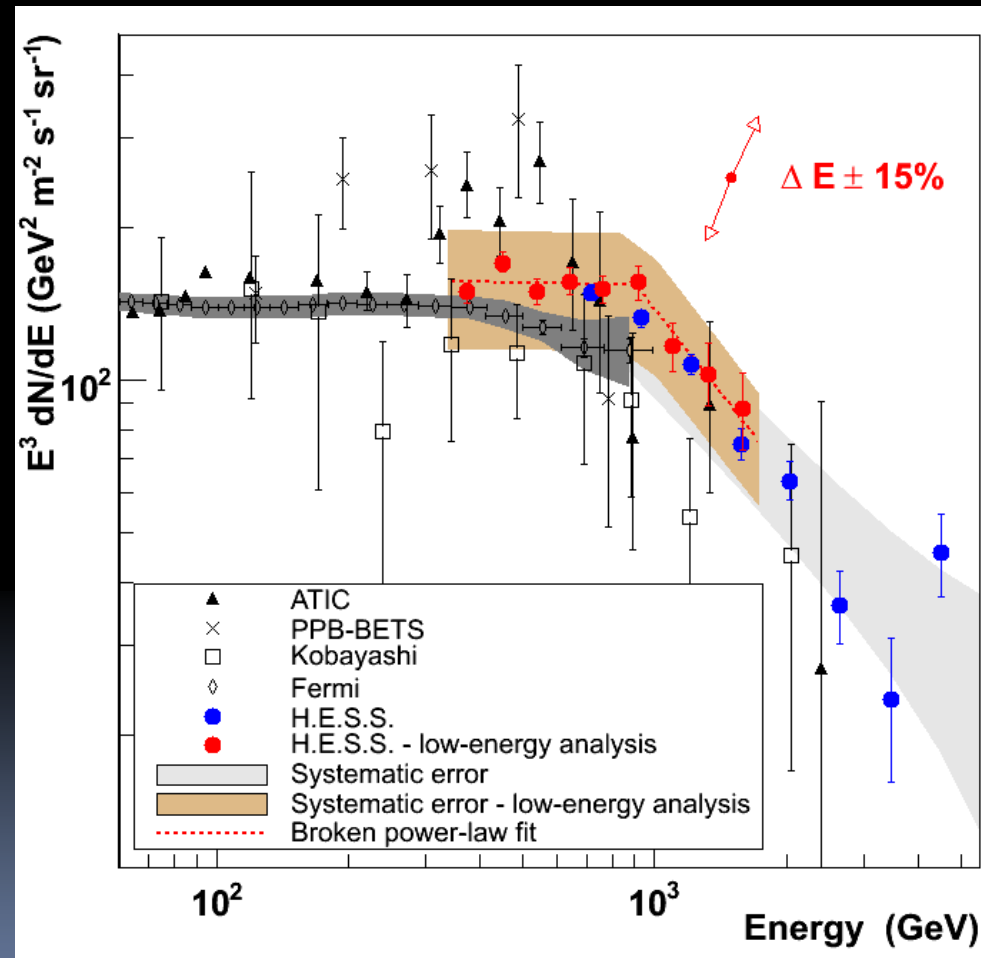


Results: Low-Energy Spectrum

- Cuts:
 - ▣ impact distance < 100 m
 - ▣ image size in each camera > 80 photo electrons
 - ▣ Data set of 2004/2005
- Syst. uncertainty: atmospheric variations + model dependence of proton simulations (SIBYLL vs. QGSJET-II)
- Spectral index:

$$\Gamma_1 = 3.0 \pm 0.1_{\text{stat.}} \pm 0.3_{\text{syst.}}$$

$$\Gamma_2 = 4.1 \pm 0.3_{\text{stat.}} \pm 0.3_{\text{syst.}}$$



Conclusion

- H.E.S.S. has measured cosmic-ray electrons between 340 GeV and 5 TeV
- Systematic uncertainties include atmospheric variations, uncertainties in hadronic interaction models and H.E.S.S. energy scale uncertainty
- Smooth spectrum that steepens at 0.9 TeV