# The High Energy Electron Positron Spectrum measured by the MAGIC Telescopes





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# Origin

High energy Electrons are:

- Diffuse
- Contained in the galaxy

DUIERTEN

Measured over several decades in energy



- Previous measurements exceed GALPROP prediction for secondaries
- > Additional sources of primary electrons needed
- Predictions differ in the TeV regime
- Indirect, ground-based experiments, like Cherenkov Telescopes, can probe the TeV regime





### **Detection**

#### **Detection method:**

- Detections through Cherenkov light from air showers
- Background dominated by cosmic protons

#### Point-like source analysis:

- Direction information as strong discriminator between signal & background
- Background measured simultaneously

#### **Diffuse Analysis:**

- No discrimination on direction possible
- No Background measurement possible
- Custom method developed







## **Diffuse flux analysis**

- Electrons produce electromagnetic shower, shower image is elongated ellipse (diffuse gamma contribution is negligible)
- Protons create hadronic showers with irregular images
- Distinguish signal from background based on shower and image parameters





#### **Method: Random Forest**

- > Assigns value between 0 and 1 called Hadronness to classify the hadron likeness of an event
- Image & shower parameter used for training
- Trained on Monte Carlo protons & electrons, very good agreement with data needed



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### **Observational Data & Monte Carlo**

57h of extra galactic data taken in 2010 & 2011:

- Zenith below 32 degrees
- > 10 degrees of the Galactic Plane
- No detected gamma-ray sources in the FoV
- Strong data quality selection:
  - Low cloudiness
  - Low humidity
  - Constant data-taking rates
  - Good MC/data matching
- Background simulated with 6E9 MC Protons

Signal simulated with MC Electrons







### **BUT: Systematic Uncertainties are very large**

Hadronness (normalized in 0.4-0.75)



# **BUT: Systematic Uncertainties are very large (2)**

Spread and Mean of the hadronness distribution for SegueJ







## **BUT: Systematic Uncertainties are very large (2)**



Total uncertainty: >30% on Excess determination





### **Background statistics**





### **Summary of systematic Uncertainties**

- Day by Day variation in Hadronness shape ~ 10-15%
- Variation in Hadronness based on position in the sky exceeds 20%
- Background fluctuations small ~ few %, but simulated Background multiplied by a factor ~300
- > Full understanding and quantification of the systematics is ongoing

Strong variation in Flux normalisation:



e+e- Energy Density Spectrum



#### Effect on the point-source analysis

- The large systematics described above (for the electron analysis) do not apply to the regular analysis of gamma-ray sources
- Variation in the absolute number of of background events (given a cut in hadronness) have little effect on the reconstructed photon flux
- Performance paper published for all telescope configurations:
  - ApJ 674 (2008) 1037-1055
  - Astroparticle Physics 35 (2012) 435-448
  - Astroparticle Physics 72 (2016) 76-92

Systematic effect	Uncertainty
F-Factor	10% ES
atmospheric transmission	$\lesssim 10\%$ ES
mirror reflectivity	8% ES
PMT electron collection efficiency	5% ES
light collection in a Winston Cone	5% ES
PMT quantum efficiency	4% ES
signal extraction	3% ES
temperature dependence of gains	2% ES
charge flat-fielding	2-8% ES FN
analysis and MC discrepancies	$\lesssim$ 10-15% FN
background subtraction	1-8% FN
broken channels/pixels	3% FN
mispointing	1-4% FN
NSB	1-4% FN
trigger	1% FN
unfolding of energy spectra	0.1 SL
non-linearity of readout	0.04 SL





#### Conclusions

- A method to measure cosmic ray electrons has been developed within the MAGIC collaboration
- > We applied it in the 0.15-1.5 TeV energy range.
- The reconstructed electron spectra are affected by data-MC differences in the reconstructed hadronic background
- The reconstructed electron spectra are roughly in agreement with previous measurements done by Fermi, HESS, AMS and VERITAS, given the large systematic uncertainties of this complicated analysis
- A detailed investigation of the systematics and the quantification of their impact is ongoing



