FACT – Performance of the First Cherenkov Telescope Observing with SiPMs

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heasarc.gsfc.nasa.gov
Overview

The First G-APD Cherenkov Telescope

Analysis Methods

Performance Evaluation on Crab Nebula Observations

Conclusions
The First G-APD Cherenkov Telescope
FACT – The First G-APD Cherenkov Telescope

1 Pixel = 1 SiPM = 3600 G-APD cells

ø = 3.8 m

1440 Pixel
FoV: 4.5°

Roque de los Muchachos, La Palma
Analysis Methods
Datasets

Crab Nebula data

- October 2013 — February 2014
- Only dark night conditions
- Zenith distance $\leq 30^\circ$
- Good environmental conditions
- Observation time: 87.6 h

Monte-Carlo-Simulations:

- Shower Simulation with CORSIKA (MMCS)
- Mirror and electronics simulation with CERES
- Protons: $780 \times 10^6$ events
  100 GeV–200 TeV
- Gammas: $12 \times 10^6$ events
  200 GeV–50 TeV
Raw Data processing with FACT-Tools

github.com/fact-project

Analysis Methods
Higher Level Analysis

- Python tool-chain using `scikit-learn`, `pandas`, `astropy`
- `github.com/fact-project/classifier-tools`
- Random Forest Classifier for background suppression
- Random Forest Regressor for energy estimation
Energy Estimation Using a Random Forest

```
log_{10}(E_{true} / \text{GeV})
```

```
log_{10}(E_{est} / \text{GeV})
```

```
Bias
```

```
Resolution
```

Analysis Methods
Effective Area

\[
A_{\text{eff}} / \text{m}^2 = \begin{cases} 
\gamma_{\text{prediction}} \geq 0.0, & \theta^2 \leq 0.1 \text{ deg}^2 \\
\gamma_{\text{prediction}} \geq 0.7, & \theta^2 \leq 0.03 \text{ deg}^2 
\end{cases}
\]

- Cleaner sample for source detection
- More statistics for unfolding
Performance Evaluation on Crab Nebula Observations
Source Detection

Source: Crab, $t_{\text{obs}} = 91.1$ h

$N_{\text{On}} = 5910$, $N_{\text{Off}} = 14594$, $\alpha = 0.2$

$N_{\text{Exc}} = 2991.2 \pm 80.6$, $S_{\text{Li\&Ma}} = 43.3 \sigma$
Energy Spectrum of the Crab Nebula

\[
\frac{dN}{dE dA dt} / (\text{TeV}^{-1} \text{cm}^{-2} \text{s}^{-1})
\]

\begin{align*}
\text{log}_{10}(E / \text{GeV}) & \quad \text{MAGIC, JHEAP 5-6} \\
\text{HEGRA, APJ 539-1} & \\
\text{FACT Unfolding (this work)}
\end{align*}
Relative Sensitivity

5 $\sigma$ according to Li & Ma in 50 h of observation time.

Wobble-Mode using five off positions

Integrated sensitivity

$(0.137 \pm 0.004)$ C. U.
Conclusions

- Analysis software completely open source
- Only closed source software used: CORSIKA
- Clear detection of the Crab Nebula
- Energy spectrum of the Crab Nebula consistent with other Experiments
- Preliminary sensitivity of $(0.137 \pm 0.004)$ C. U.
- Still a lot of room for improvements
- Soon: Machine learning methods for directional reconstruction