Joint analysis of TeV blazar light curves with FACT and HAWC

Robert Lauer, University of New Mexico
Daniela Dorner, Universität Würzburg
Unbiased Monitoring
at TeV Energies

HAWC

FACT
Unbiased Monitoring at TeV Energies

HAWC

High Altitude Water-Cherenkov Observatory

http://www.hawc-observatory.org/
The HAWC Observatory

High Altitude Water Cherenkov (HAWC) Gamma-Ray Observatory
22,000 m² air shower array, completed in March 2015

300 water Cherenkov detectors (WCD):
- 200,000 liters of purified water per WCD
- 4 PMTs per WCD (3x8" from Milagro + 1x 10" high QE)
Unbiased Monitoring at TeV Energies

2200 m a.s.l., Observatorio del Roque de los Muchachos, La Palma

Photo: Thomas Krähenbühl

FACT
First G-APD Cherenkov Telescope

- Operational since Oct 2011
- 9.5 m² mirror area
- Camera: Silicon based photosensors (SiPM), 4.5° FoV, 1440 pixels à 0.11°
- Energy range: > 300 GeV

More information

H Anderhub et al 2013 JINST 8 P06008
A Biland et al 2014 JINST 9 P10012
Unbiased Monitoring at TeV Energies

HAWC

FACT
Unbiased Monitoring at TeV Energies

- Water Cherenkov Technique
- Independent of
  - Weather
  - Sun
- Larger duty cycle → More continuous coverage

- Imaging Air Cherenkov Technique
- Lower energy threshold
- Better sensitivity → Finer timing resolution
Observations at TeV Energies

Offset of sites: 5.3 hours → Coverage of up to 12 hours
FACT Monitoring

Mrk 421

Flux > 750 GeV [$10^{−11}$ cm$^2$/s] vs. Modified Julian Date

- 2012
- 2013
- 2014
- 2015
- 2016
- 2017

FACT Preliminary
FACT Monitoring

June 2016: Common ATel #9137
FACT Monitoring

Mrk 501

Flux > 750 GeV [10^{-11} cm^{-2} s^{-1}]

Modified Julian Date

2012  2013  2014  2015  2016  2017

FACT Preliminary
FACT Monitoring

Flux > 750 GeV [10^{-4} cm^{2} / s]

Modified Julian Date

2012 2013 2014 2015 2016 2017

Mrk 501
HAWC Monitoring

Mrk 421: daily light curve

Nov 26, 2014 – Apr 20, 2016

Bayesian Blocks: 19 distinct flux states

(5% false positive probability)

HAWC Monitoring

Mrk 501: daily light curve

Nov 26, 2014 – Apr 20, 2016

Bayesian Blocks: 14 distinct flux states
(5% false positive probability)

Correlations

Mrk 421

FACT flux > 0.75 TeV [CU]

HAWC flux > 0.75 TeV [CU]

Mrk 501

FACT flux > 0.75 TeV [CU]

HAWC flux > 0.75 TeV [CU]
Zoom to Flaring Activity

April 2015, Mrk 501

HAWC: Fitted spectra per bayesian block
FACT: Study intra-night variability
Zoom to Flaring Activity

HAWC: Fitted spectra per bayesian block – harder spectra
FACT: Study intra-night variability – changing flux
Conclusions and Outlook

- Combining HAWC and FACT data
  - Unbiased Monitoring at TeV Energies
  - Coverage of up to 12 hours
- Comparison of TeV fluxes from water and air Cherenkov technique
  - Very similar flux measurements above common threshold
  - Correlation between HAWC and FACT fluxes
  - Periods of variability in flux and in spectral shape for nights with differences in flux