

Spectral Monitoring of Mrk 421 during 2004

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VERITAS Collaboration



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VERITAS Collaboration



- USA: Smithsonian Astrophysical Observatory
Purdue University, Iowa State University
Washington University, St. Louis
University of Chicago, University of Utah
University of California, Los Angeles
- CA: McGill University, Montreal
- UK: **University of Leeds**, Oxford University
- IE: National University of Ireland, Dublin
Galway-Mayo Institute of Technology
National University of Ireland, Galway

Overview:

Mrk 421 Activity in 2004



Mrk 421 host
elliptical galaxy
(Nordic Optical
Telescope)

- Closest ($z=0.031$) TeV blazar, detection by Whipple 10m in 1992
- Long-term **X-ray** and **TeV** monitoring from 1999 to 2005
- Shown repeated large month time-scale high flux states

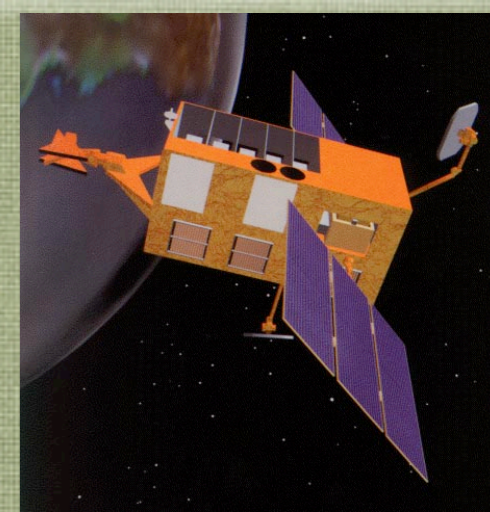
2003-2004 campaign

- **Radio, optical, X-ray, γ -ray** campaign from Dec. 2003 to May 2004
- Highest ever sustained X-ray & γ -ray flux level in April 2004

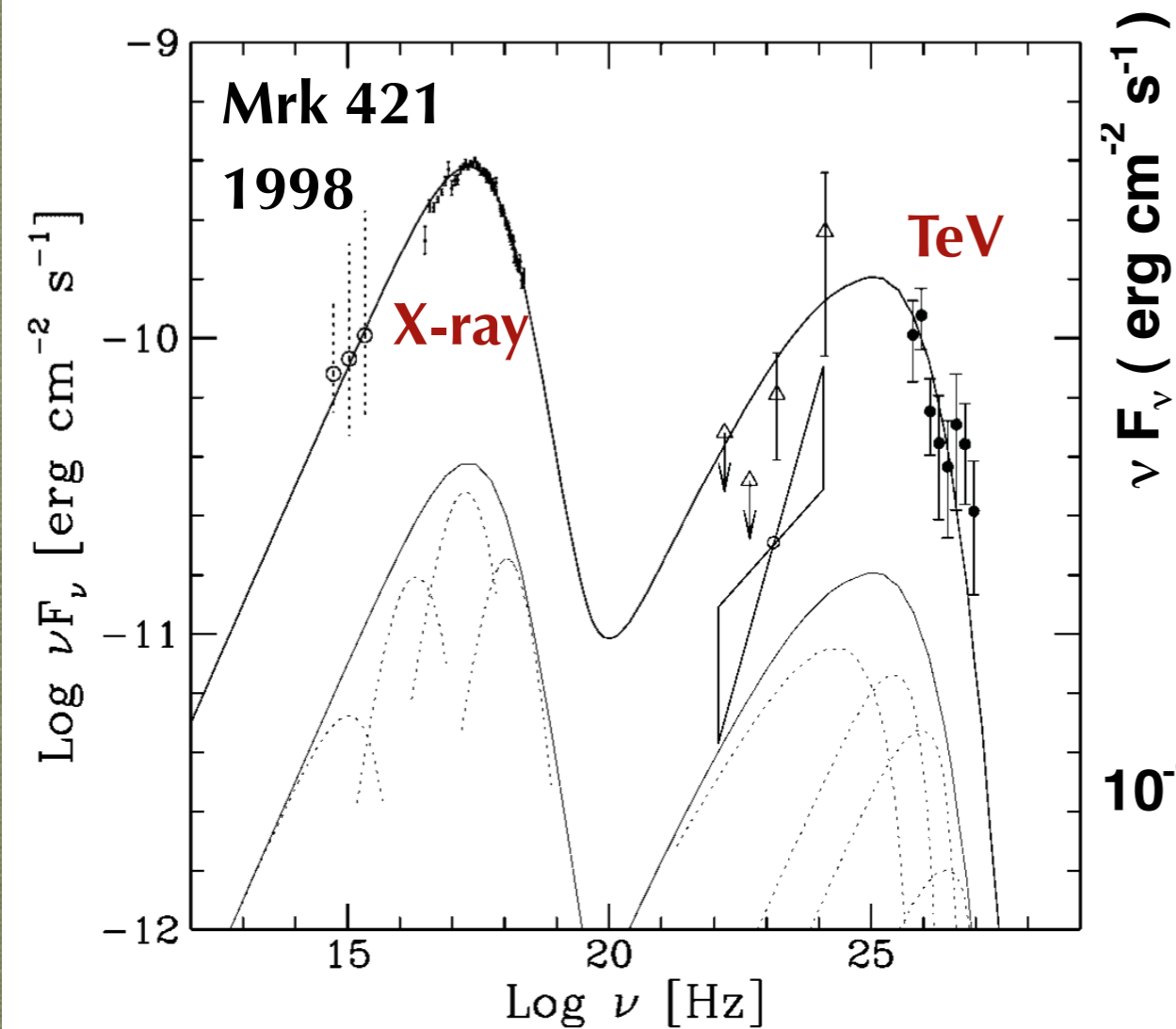
Results presented here

- RXTE **X-ray spectrum** resolved on daily time-scales
- Whipple 10m **γ -ray** integral flux and hardness ratios

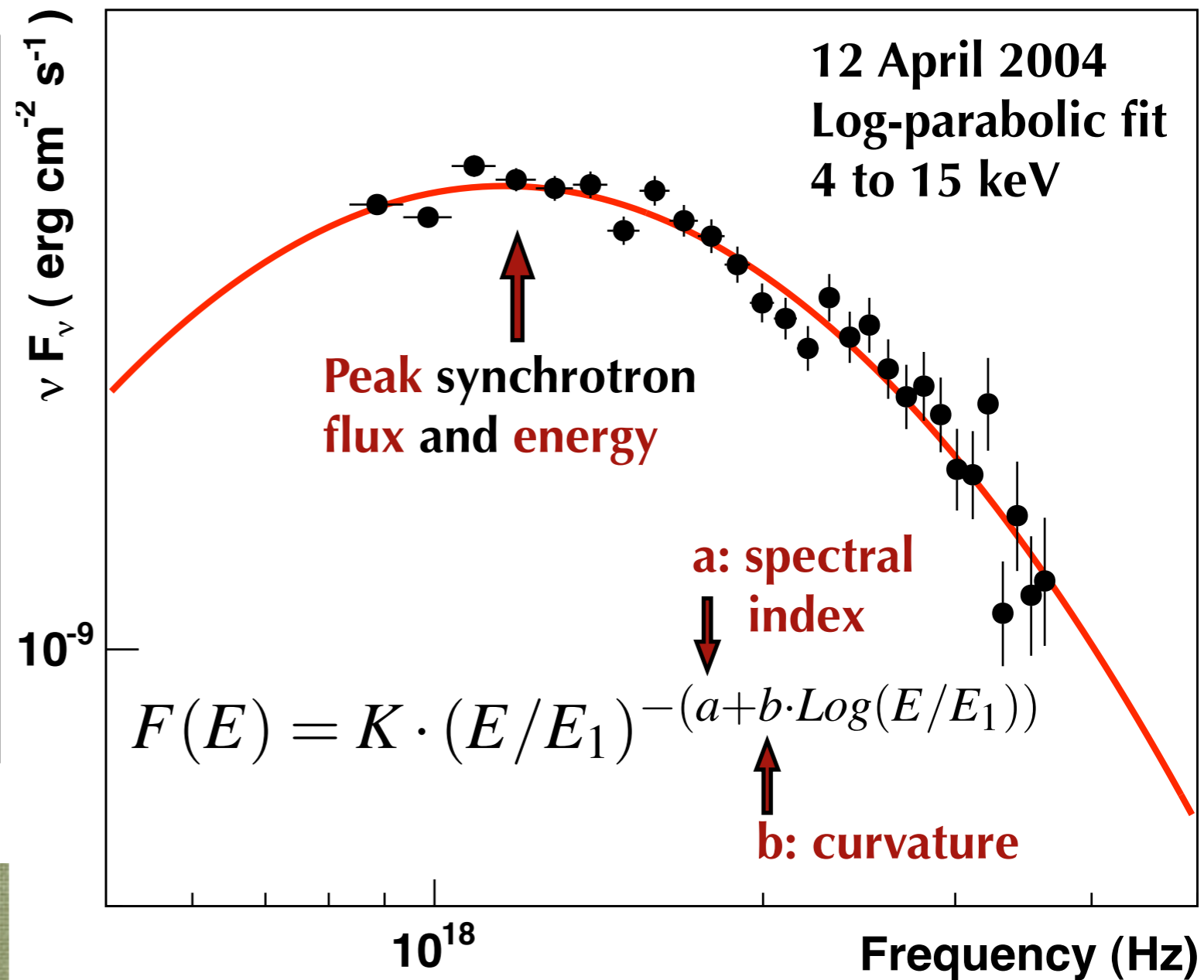
RXTE X-ray Observations & Data Analysis



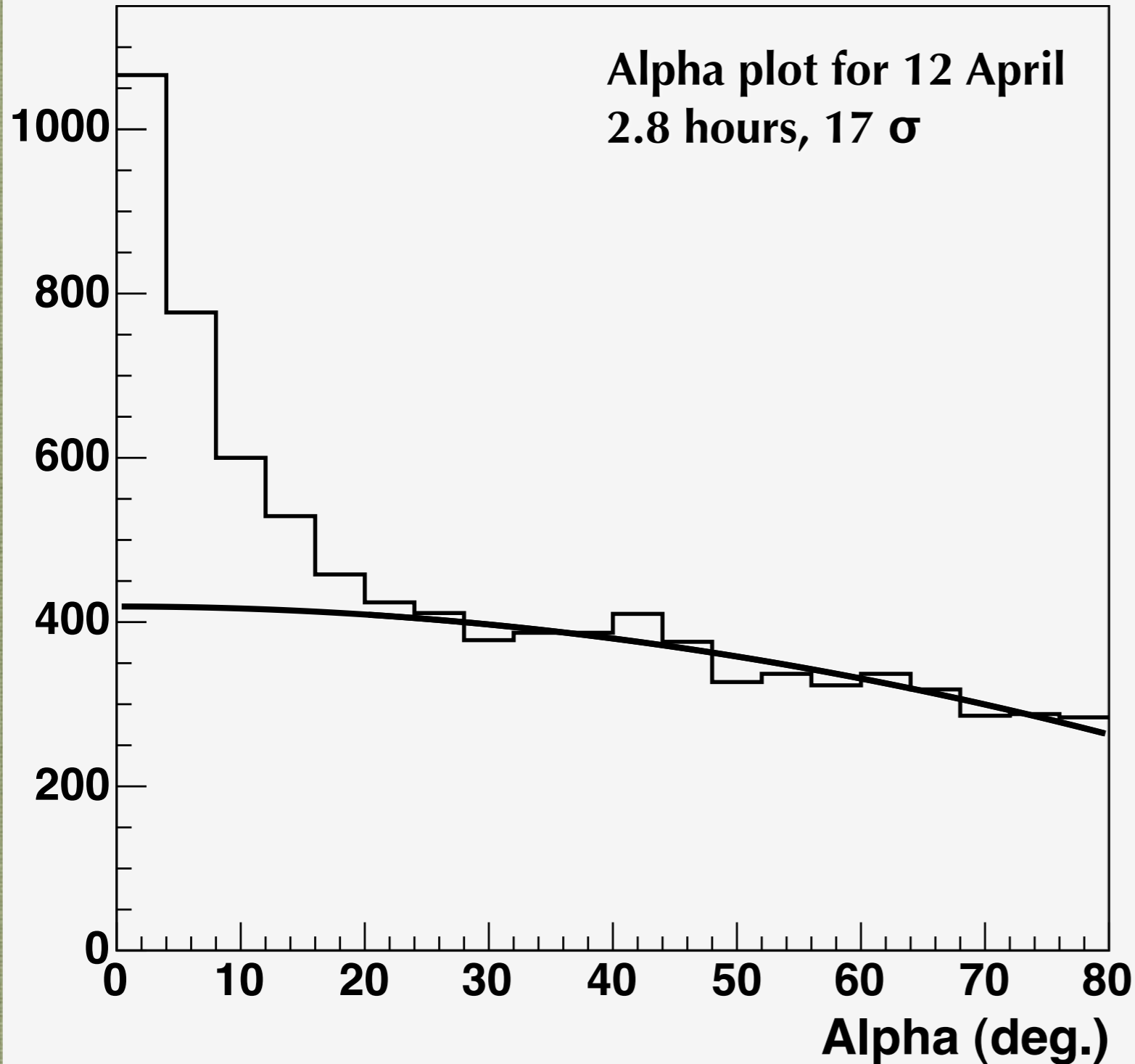
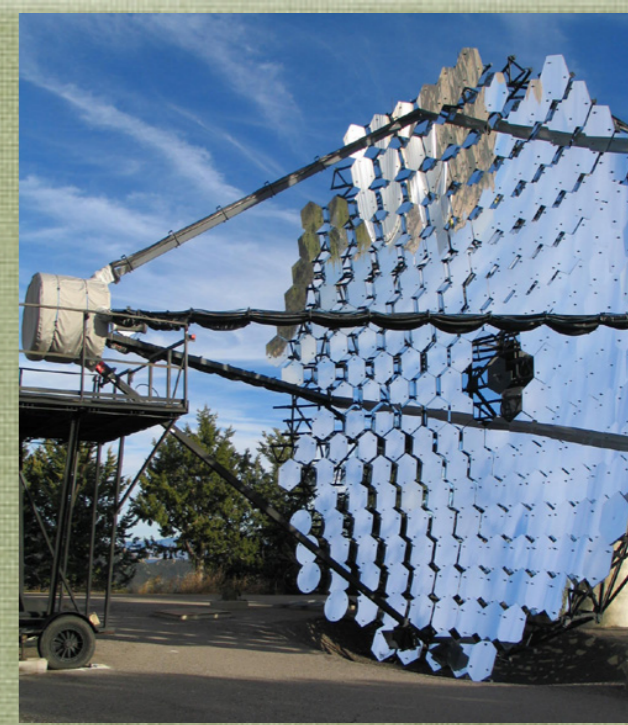
- **Daily** observations (0.6-16 ksec.)
- Tested 3 **fit models** → power law, cut-off power law, **log-parabolic** (all including fixed **absorption** from interstellar gas)



Spectral Energy Distribution
(Maraschi et al. 1999)

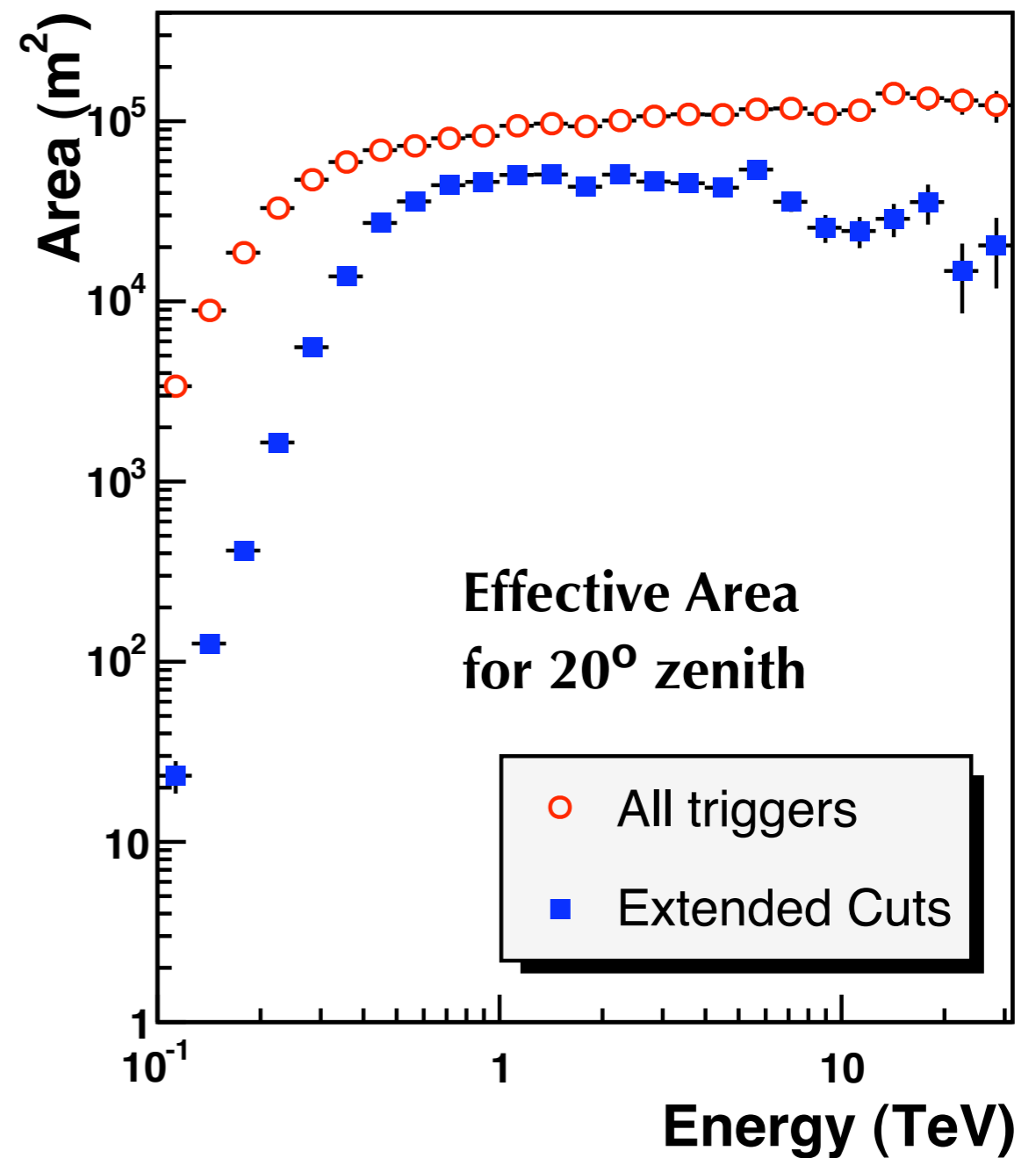
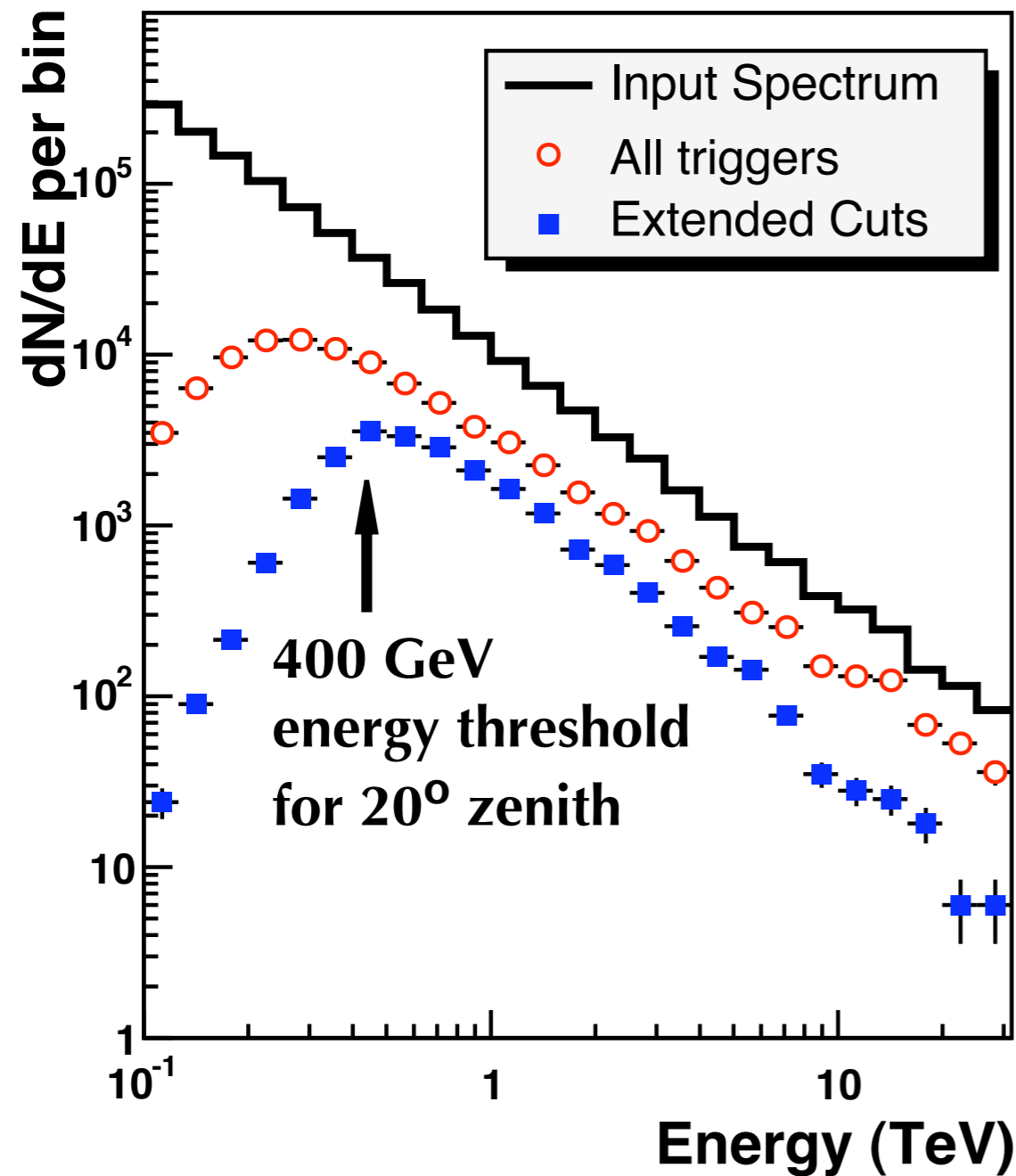


Whipple 10m Observations & Data Analysis



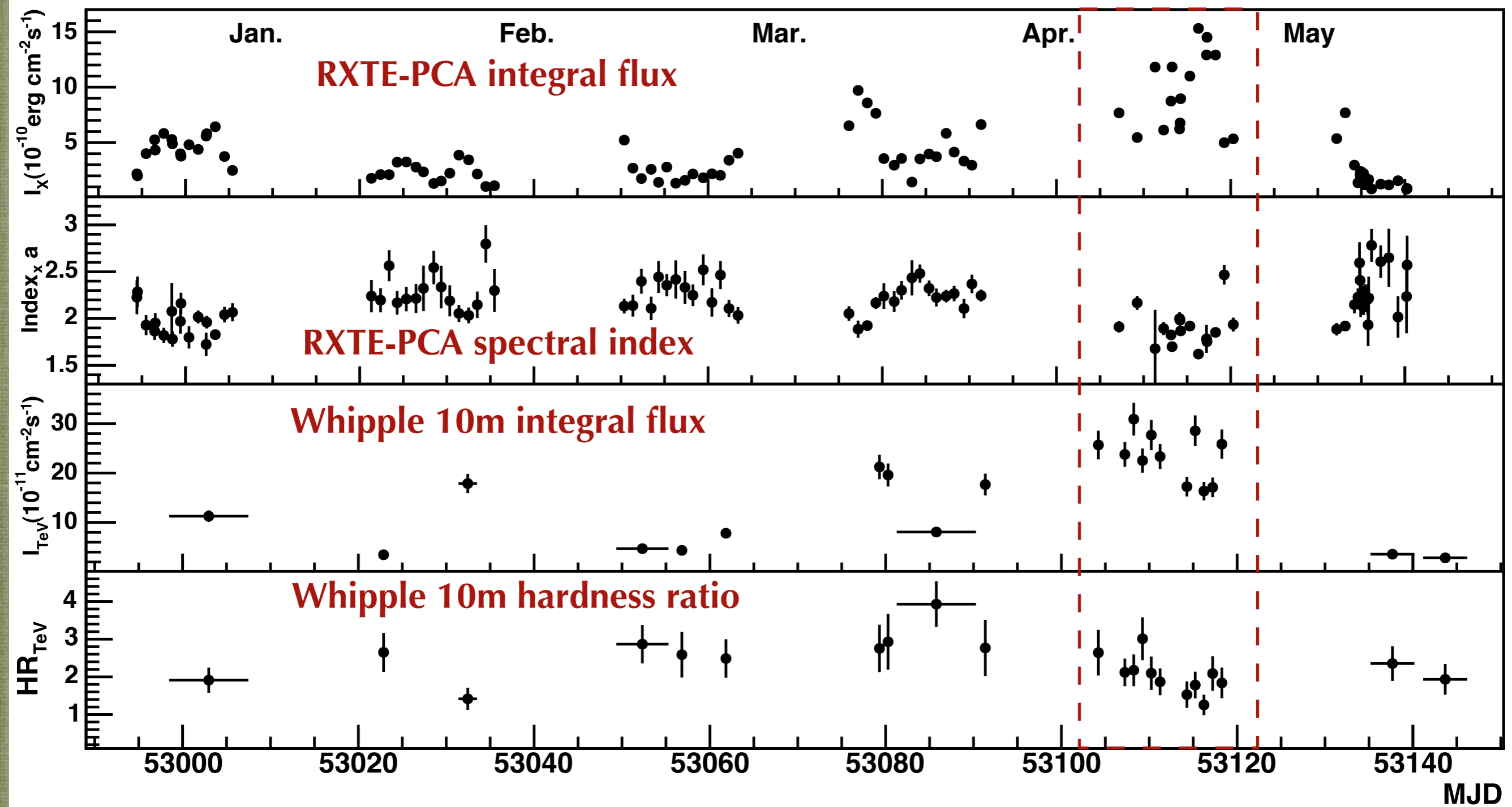
- 379 pixel, 2.6° f.o.v. camera
- **Total of 141 runs** (each 28 min.)
from **Dec. 2003 to May 2004**
- Zenith $< 28^\circ$ for all observations
- **Background** estimated from
ON source alpha plot

Whipple 10m Observations & Data Analysis



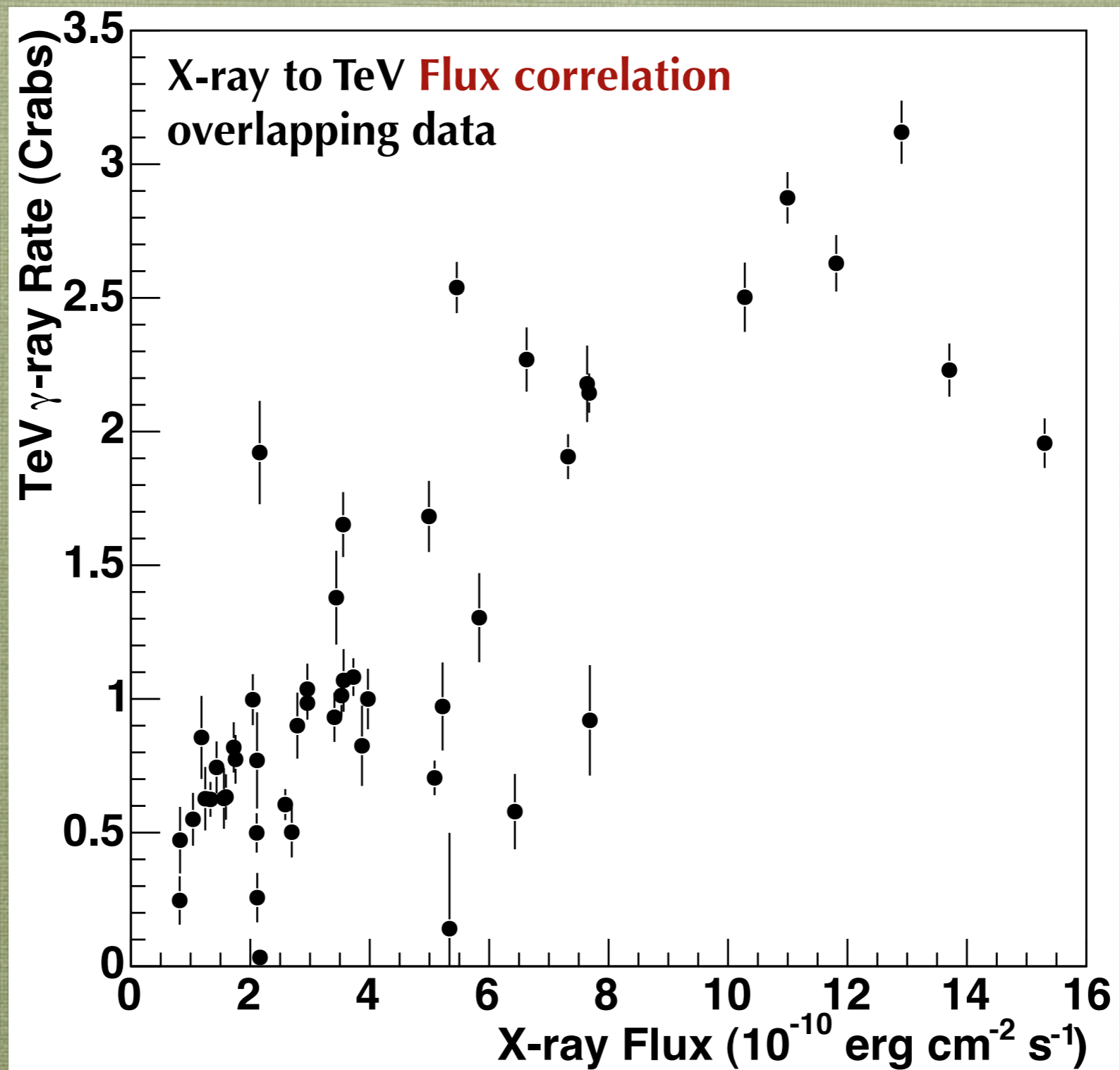
- **Effective Area** roughly flat above 500 GeV
integral flux less dependent on spectral **shape**

2004 Mrk 421 Light curve

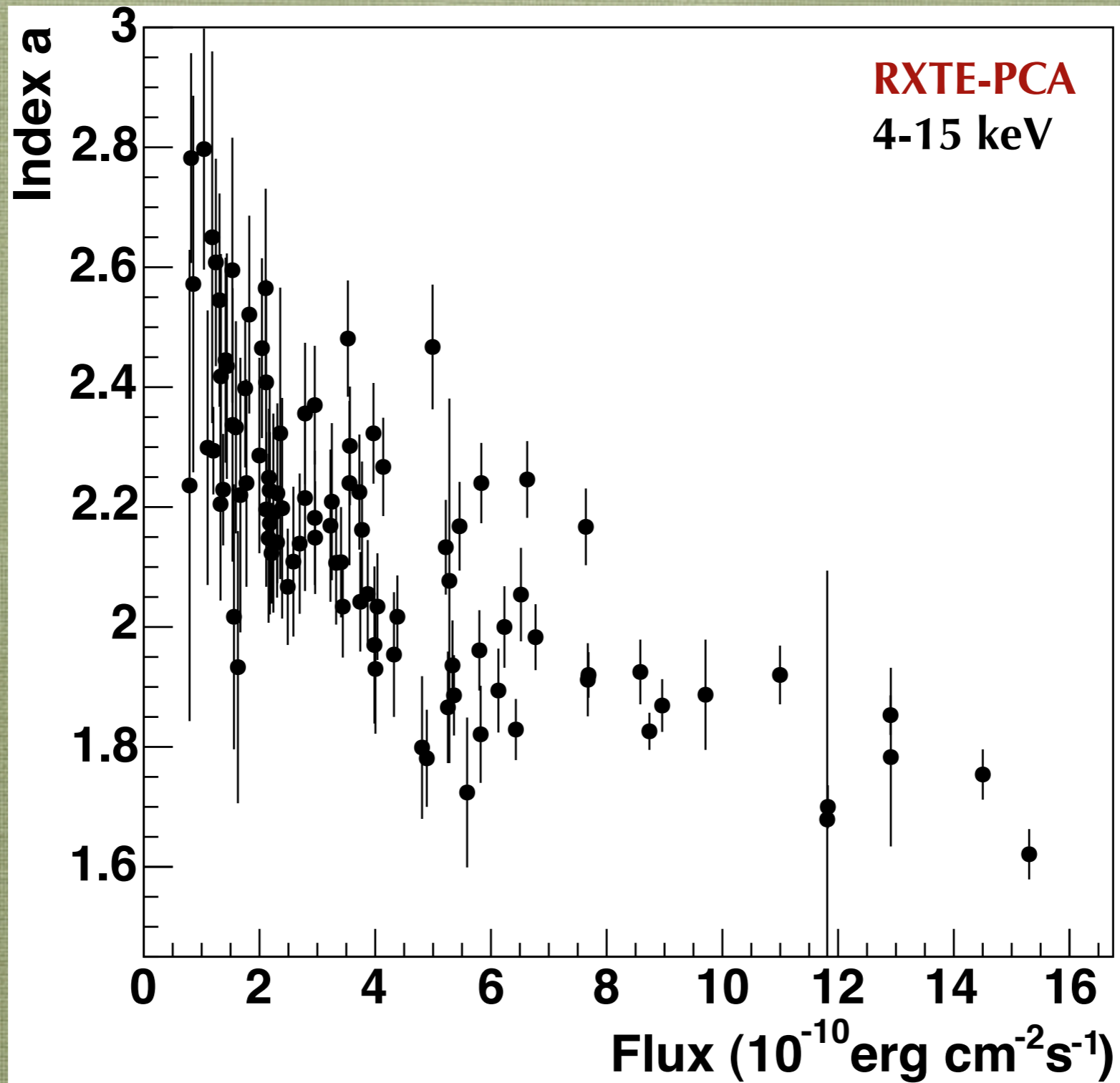


- Whipple 10m hardness ratios are $I(0.5-1 \text{ TeV})/I(1-9 \text{ TeV})$
- As a reference, power law indices ($\Gamma = 2.0, 2.5, 3.0$) would yield hardness ratios ($\text{HR}=1.1, 1.9, 3.0$) over this range

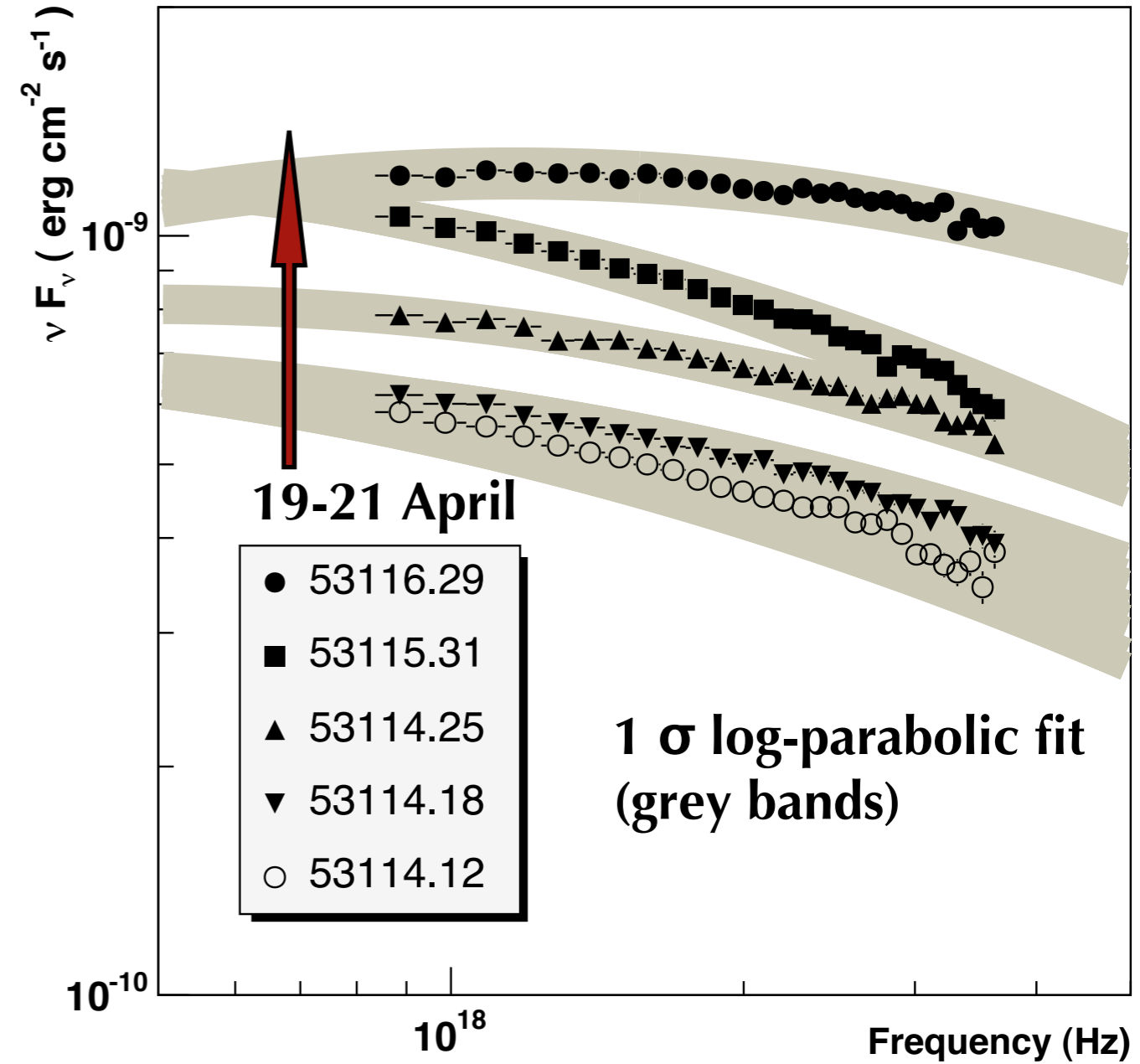
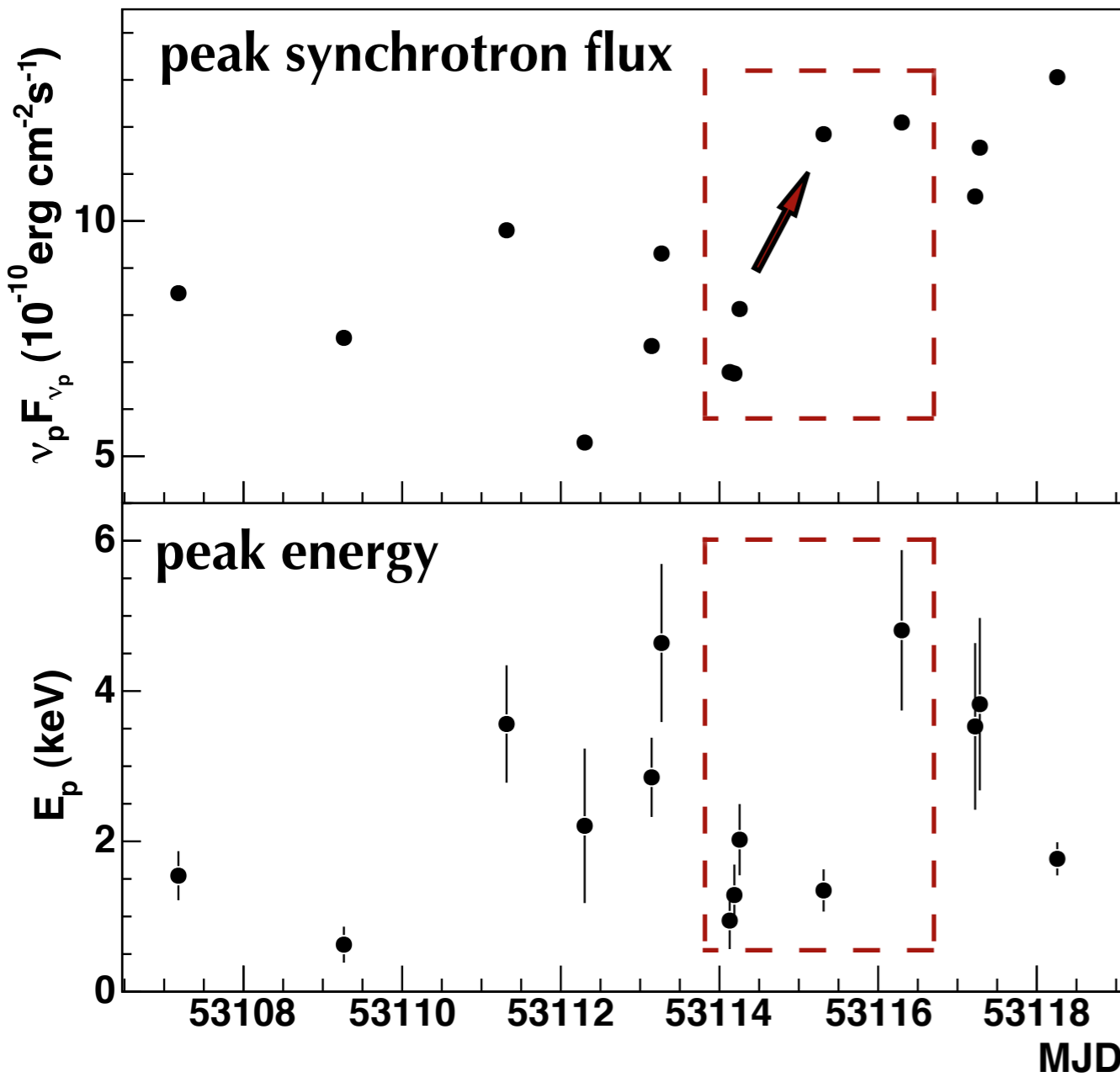
Flux Correlation Study



X-ray Spectral Index vs. Flux



Daily Evolution in the X-ray Spectrum



Conclusions

2003-2004 campaign

- Mrk 421 in extreme flux state in April 2004.
- Dynamic **range** in both **X-ray & γ -ray fluxes** ~ 1 order magnitude
- **Shift** in synchrotron **peak energy** to **$E_p > 2$ keV** during high flux state
- **Long-term** monitoring shows **month time-scale** flux variability
- **Flaring** time-scale **under-sampled** by sparse, short observations

Future campaigns

- Dedicated **Whipple 10m** monitoring for **2005 to 2006**
- **Continuous XMM & VERITAS** campaign **awaits** high flux trigger
- Simultaneous **X-ray** and **γ -ray** spectrum resolved on **hour** time-scales