A bright gamma-ray flare from the blazar B2 1215+30 detected by VERITAS and *Fermi*-LAT

Floriana Zefi [1]

R.Mukherjee [2] for the **VERITAS** collaboration

1. LLR-Ecole Polytechnique, France
2. Barnard College, New York

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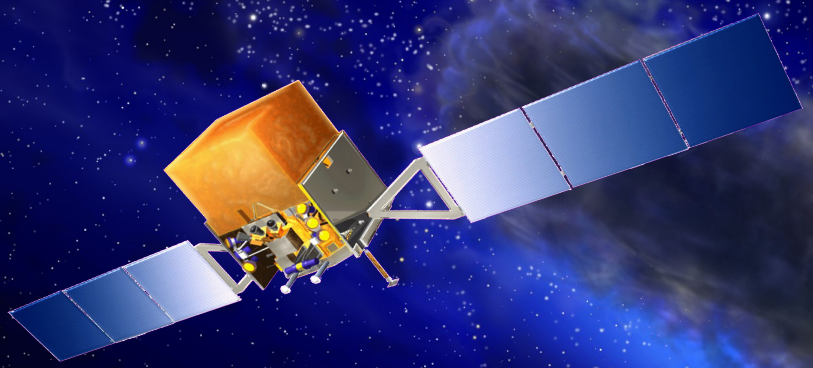
Laboratoire Leprince-Ringuet

Outline

- **VERITAS and *Fermi*-LAT detectors**
- **TeV Blazars**
- **B2 1215+30 analysis and results**
- **Size of the emission region estimation**
- **Summary and conclusions**

Detectors

Fermi-LAT



~ 20 MeV - 300 GeV

VERITAS

~ 85 GeV - <30 TeV

Data Analysis

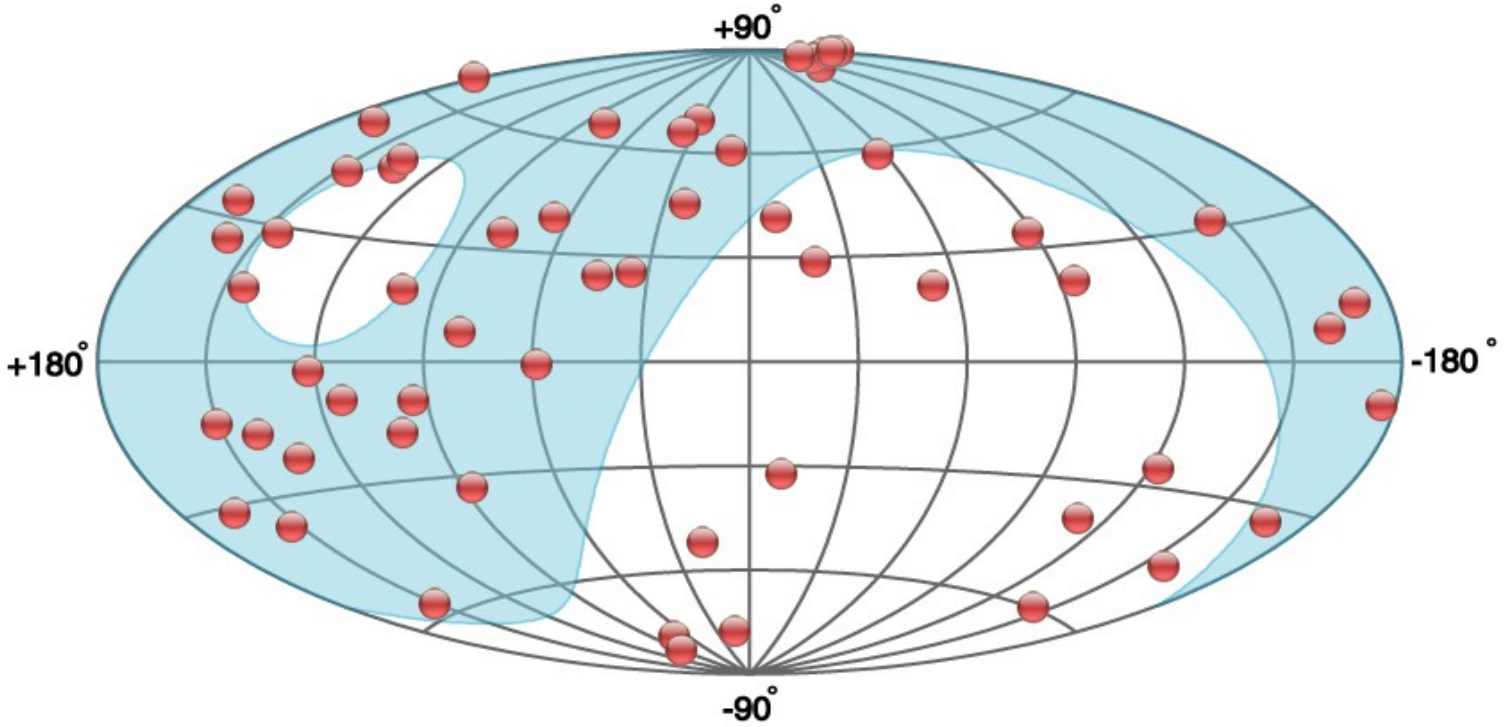
- Fermi Science Tools
- 1 Jan 2014 – May 2014
- 0.1-100 GeV

http://fermi.gsfc.nasa.gov/ssc/data/analysis/scitools.html

Data Analysis

- 29 Jan-25 May 2014 Exposure 748
- 8 Feb 2014 Exposure 45 min.
- "wobble" observation mode on 1ES 1218+304.
- Energy threshold 200 GeV

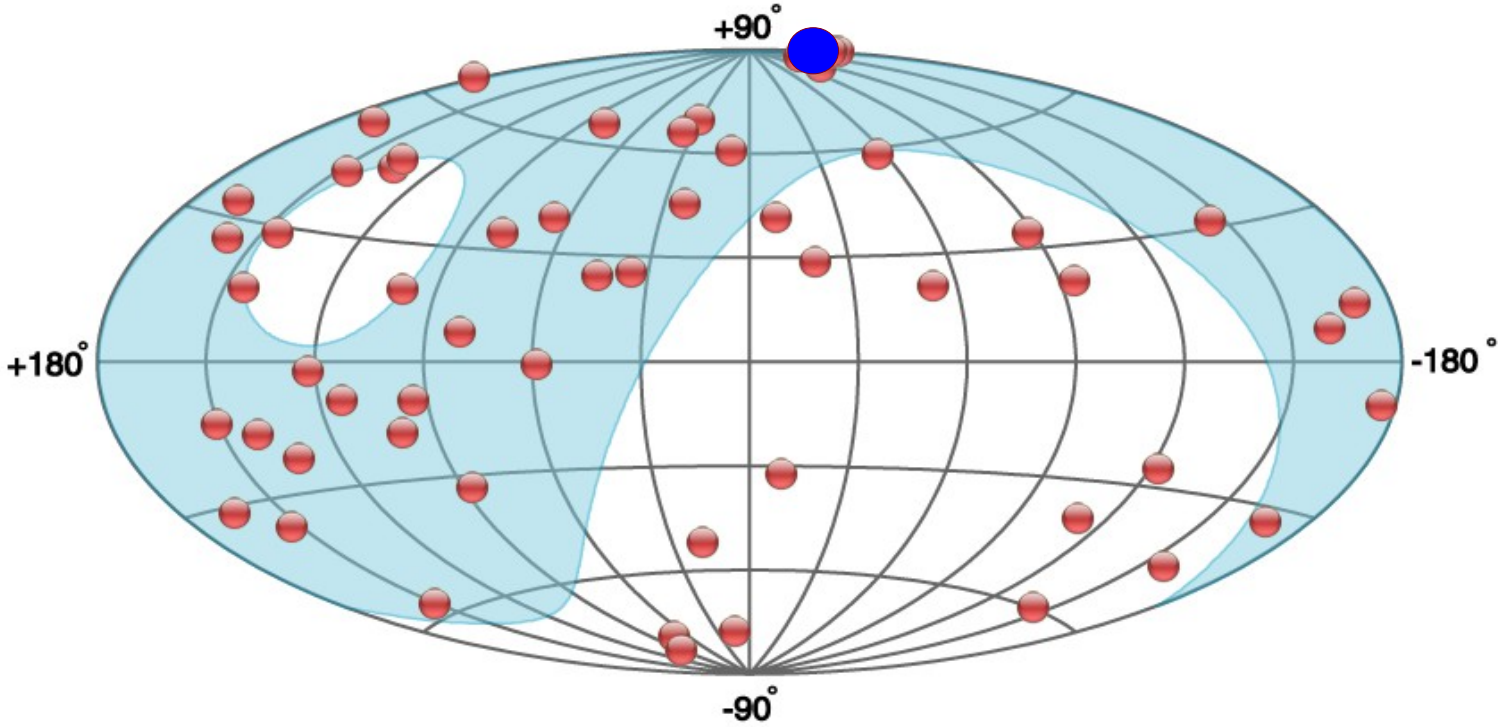
TeV Blazars



http://tevcat.uchicago.edu/

TeV Blazars

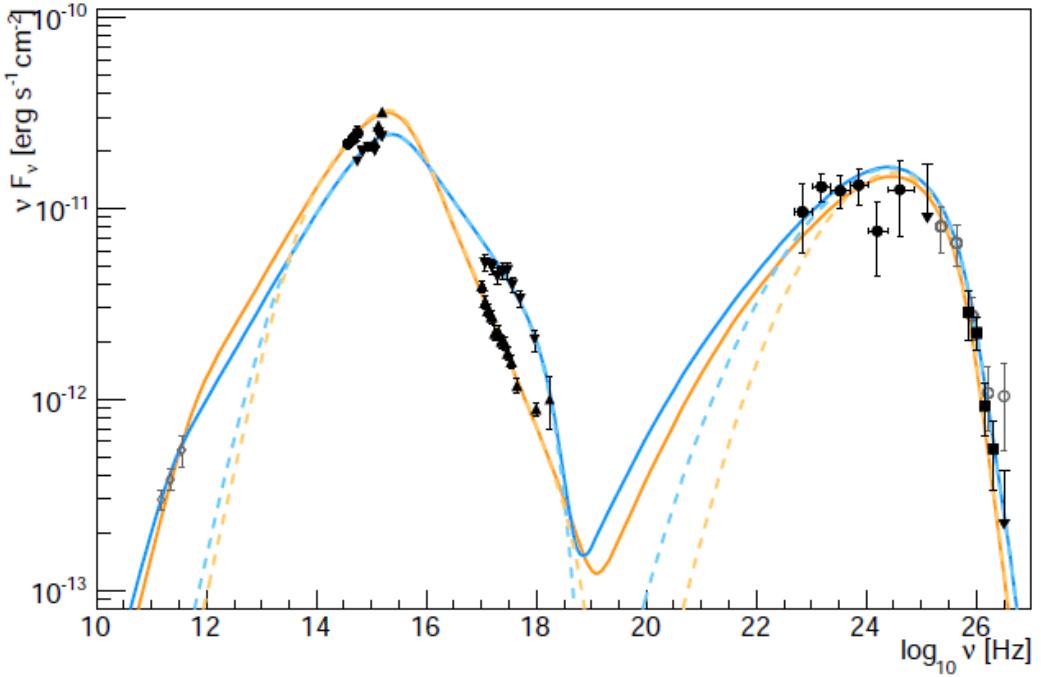
B2 1215+30 (R.A.:Dec)=(184.5:30.1)



http://tevcat.uchicago.edu/

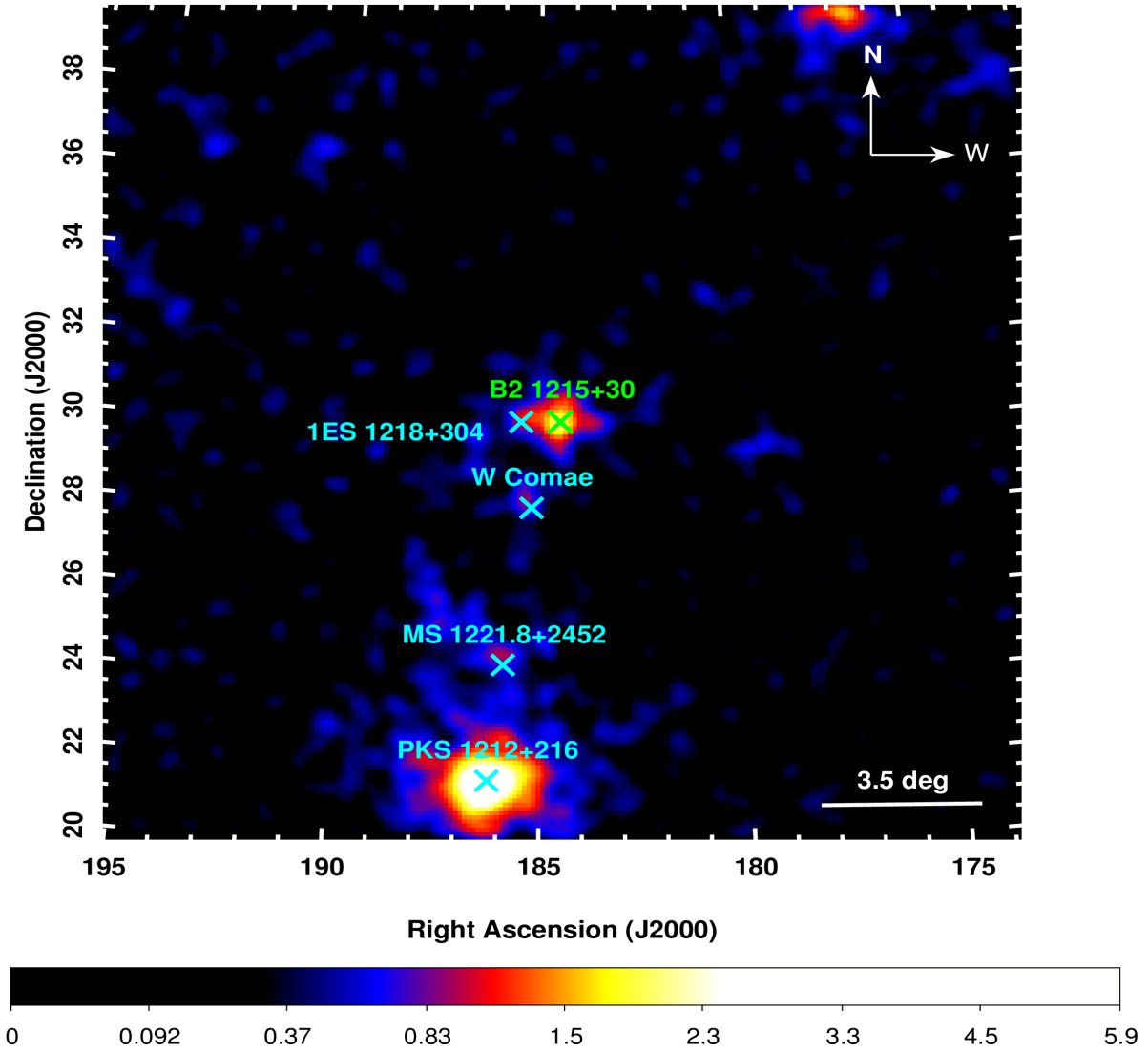
B2 1215+30

- **BL Lac object; also known as ON 325/1ES 1215+303.**
- **1970: 408 MHz survey conducted with the Bologna Northern cross telescope.**
- **Uncertain distance: z=0.130 (1.8 Gly) ; z=0.237 (2.6 Gly)**
- **First detection in TeV energies: MAGIC in 2011.**
- **IBL**

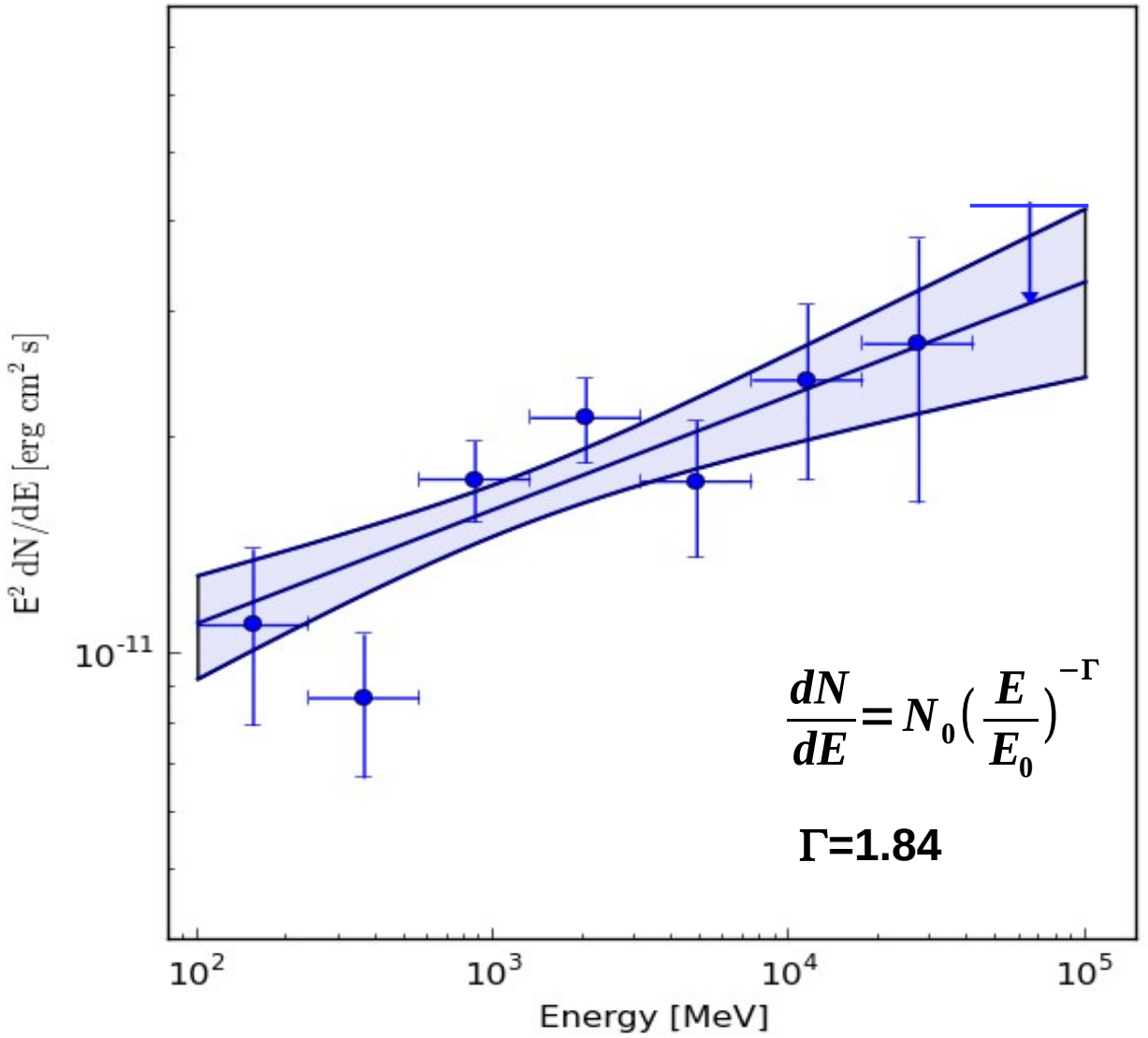


VERITAS archival SED of B2 1215+30 (Aliu et al.2013)

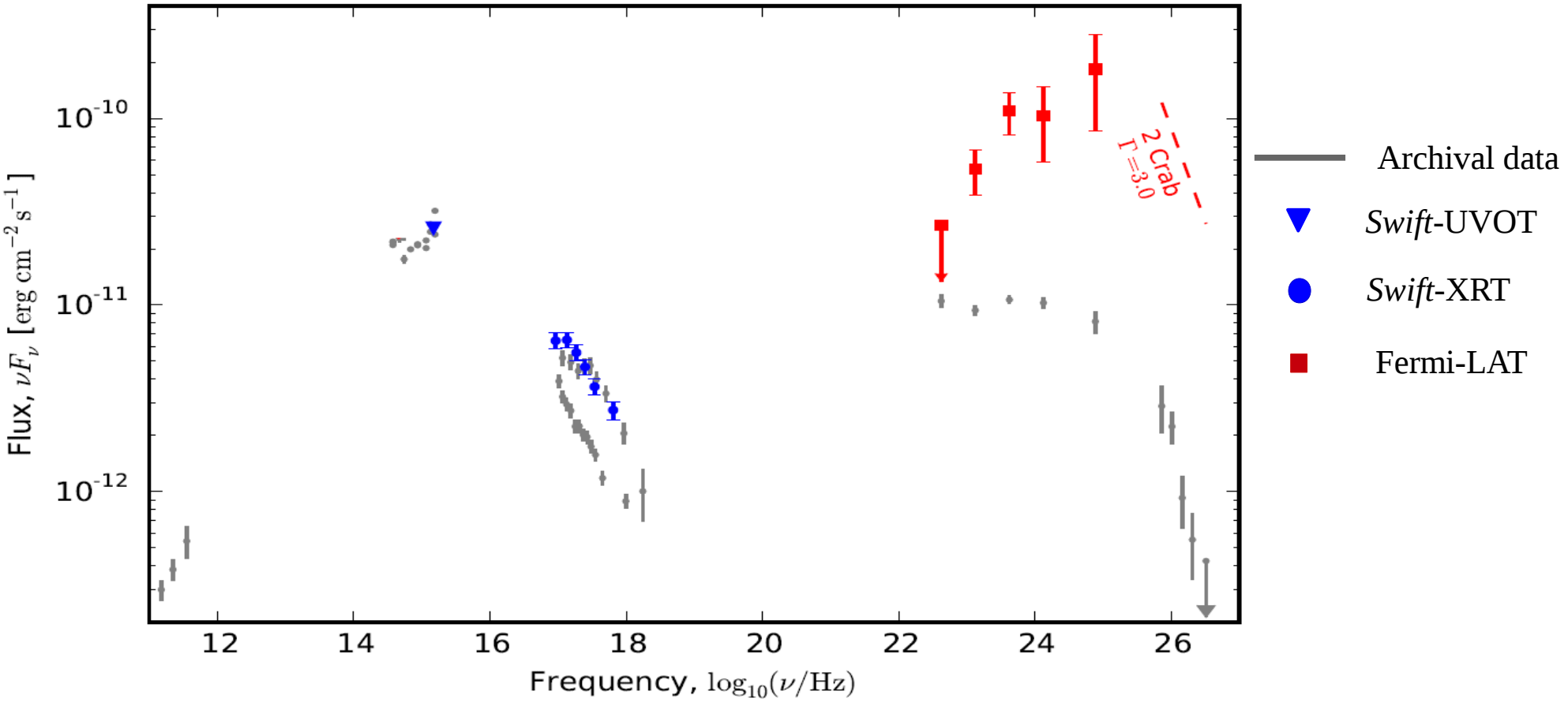
Fermi-LAT counts map



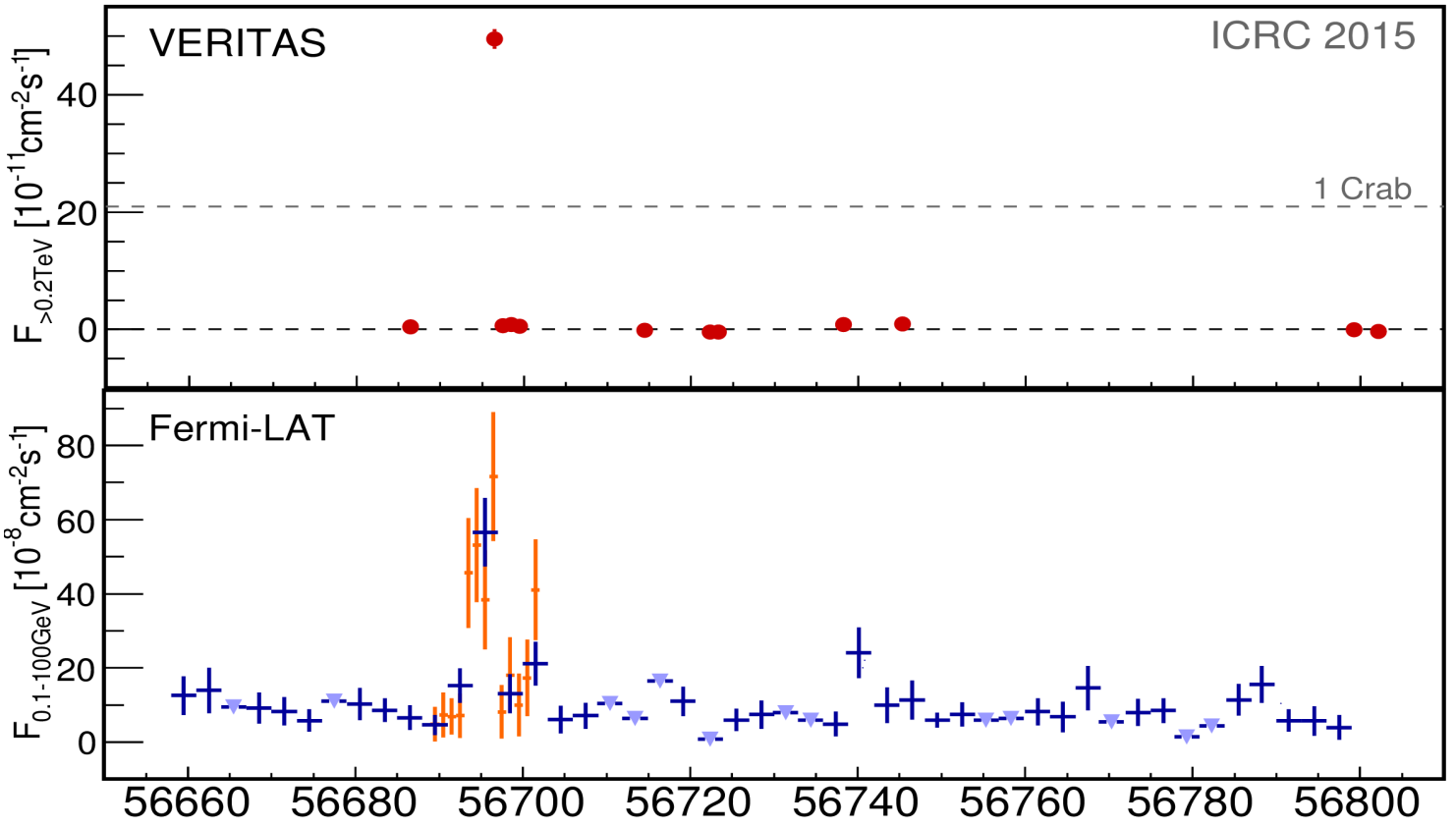
Fermi-LAT Spectrum



SED of B2 1215+30



Fermi-VERITAS light curve



1-day time bin

1 Crab Flux

3-day time bin

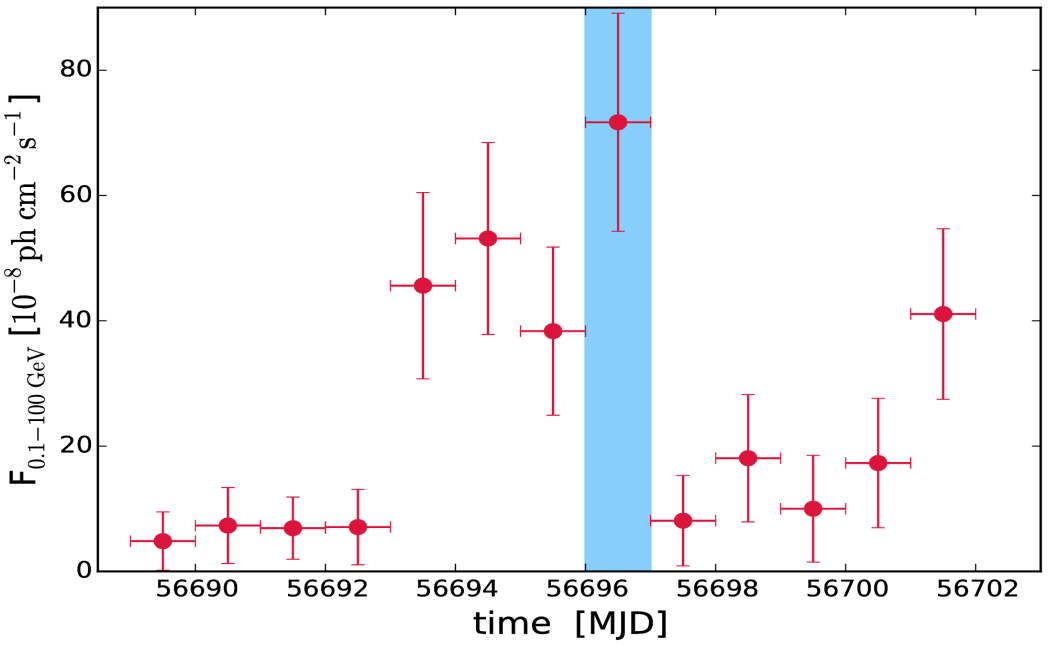
1-day time bin

Upper limits for a detection significance $<2\sigma$

Instrument	Energy range	Observation time	Signal	Multiple Flux
***Fermi*-LAT**	0.1-100 GeV	2014 Jan 01-May 25	23.6σ	x16
VERITAS	>0.2 TeV	2014 Jan 29-May 25	26.6σ	*x*60

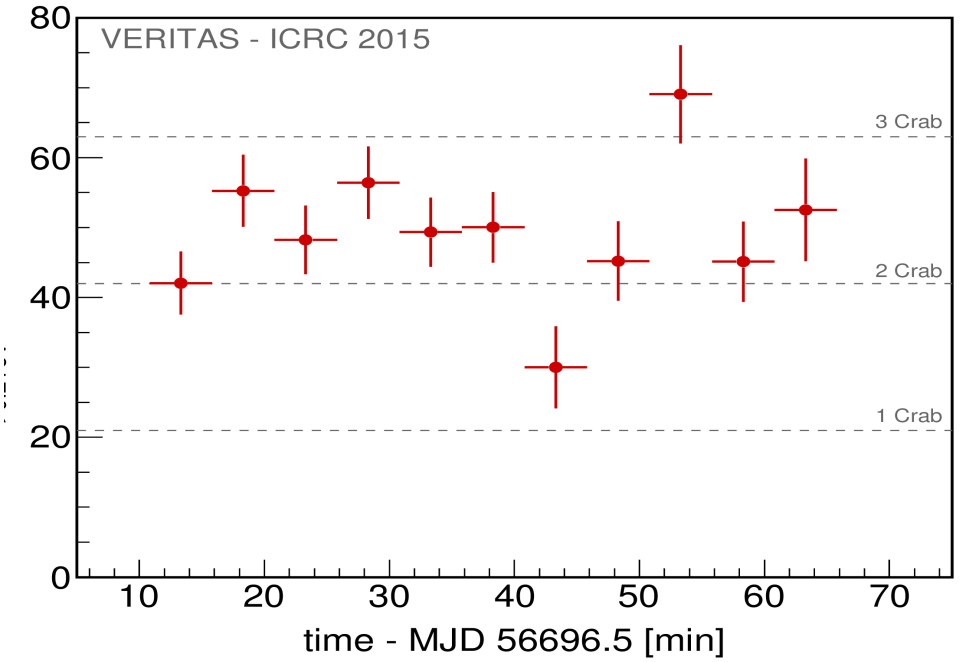
Fermi-VERITAS light curve

100 MeV < E < 100 GeV



1-day time bin

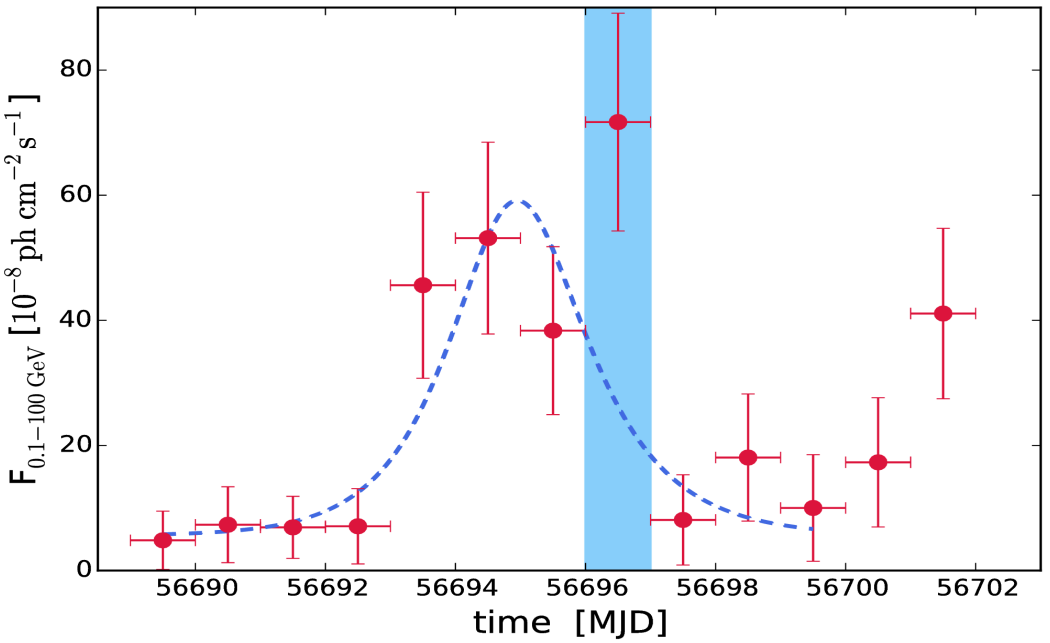
E > 200 GeV



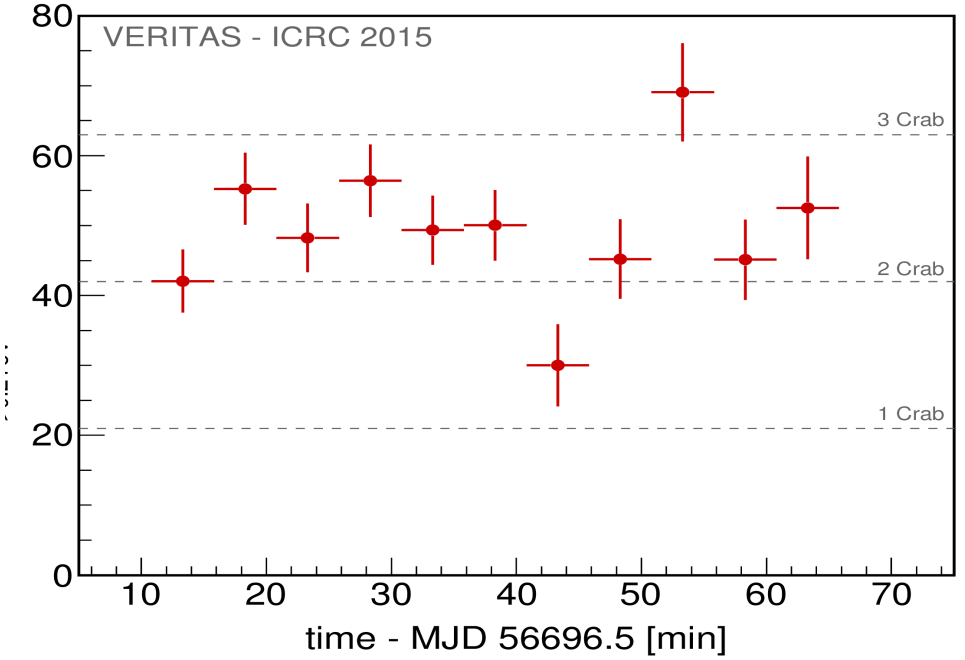
5-minute time bin

Fermi-VERITAS light curve

100 MeV < E < 100 GeV



E > 200 GeV



$$F(t) = F_C + F_0 \cdot \left(e^{\frac{(t_0 - t)}{T_r}} + e^{\frac{(t - t_0)}{T_d}} \right)^{-1}$$ (equation 6, Abdo et al.2010)

$$t_{var} = (0.18 \pm 0.09)\, d$$

Emission region size

$$\begin{cases} F_{>200\ GeV} = (2.4 \pm 0.2)\, x\, 10^{-11}\ ph/cm^2/s \\ z = 0.130 \end{cases} \rightarrow \boxed{L = 1.5\, x\, 10^{46}\ erg\ s^{-1}}$$

$$\begin{cases} t_{var} = 4.5\ h \\ R \leq \dfrac{c \cdot t_{var}}{1+z}\delta \end{cases} \rightarrow \boxed{\delta R \leq 4.3\, x\, 10^{14}\ cm}$$

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Size of the Solar System: ~ $5.9\, x\, 10^{14}\ cm$

Luminosity of the Milky Way: L ~ $10^{44}\ erg \cdot s^{-1}$

$$R \leq \frac{c \cdot t_{var} \cdot \delta}{1+z}$$

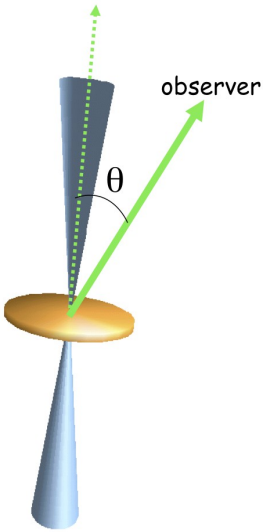
The Doppler factor is a measure of the strength of the beaming $\delta = [\Gamma(1 - \beta \cos\theta)]^{-1}$

Jet Doppler factor

Pair-production optical depth (Dondi et al. 1995)

- High energy gamma rays collide with softer photons $\gamma + \gamma \rightarrow e^+ + e^-$
- Optical depth: $\tau_e \sim \frac{\sigma_T}{5} \cdot N \cdot X_{target} \cdot R$
- The criterion for gammas to escape the source: $\tau \ll 1$

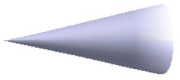
$$\delta \geq \left[\frac{\sigma_T \cdot d_L^2}{5 h c^2} (1+z)^{2\alpha} \frac{F_{1\,keV}}{t_{var}} \left(\frac{E_\gamma}{GeV} \right)^{\alpha} \right]^{\frac{1}{(4+2\alpha)}}$$



rest frame : isotropic emission

Γ

Observer frame: beamed



Beaming factor:

- $\delta = \frac{1}{\Gamma(1-\beta cos(\theta))}$
- $\theta = 1/\Gamma$

$$\begin{cases} F_{0.3-10\,keV} = 1.28\,erg\,cm^{-2}\,s^{-1} \\ \alpha = 2.54 \\ d_L = 592\,Mpc \\ z = 0.13 \\ E = 73.6\,GeV \end{cases}$$

$\rightarrow$

$$\delta \geq 5.7$$

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Summary

- **Fermi-LAT and VERITAS detected a simultaneous flare from B2 1215+30 on 08 February 2014.**
- **The measured TeV flux *x*60 brighter than the yearly average flux.**
- ***x*35 Crab flux if was at the distance of the Mrk 421.**
- **The variability time scale derived from Fermi-LAT light curve** $t_{var} = 4.5\ h$
- **Using pair production optical depth arguments, the minimum Doppler factor of the relativistic jet is estimated to be $\delta > 5.7$.**

Publication with final numbers in preparation

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Thank You!