

# B2 1215+30 Long Term Study with Fermi-LAT & VERITAS

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*VERITAS analysis by:* Giuliana Noto & Reshmi Mukherjee

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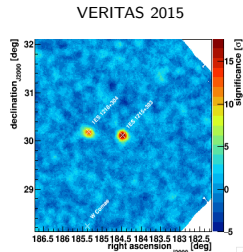
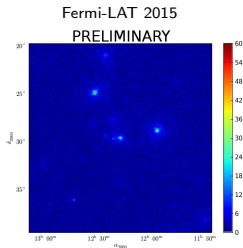
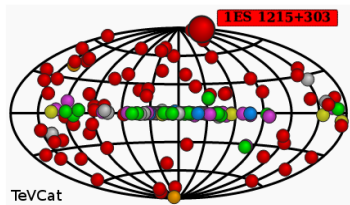
# Introduction

- 2015 analysis (internship)
  - 2016 analysis
- } VERITAS non-published data

⇒ **Long Term Analysis: 2008 (Fermi START) - 2016**

⇒ **Include 2017 data: big flares!**

**Work in progress...**



B2 1215+30 at the center

1ES 1215+303=B2 1215+30

- $z = 0.131$  by Paiano et al. 2017 (arXiv:1701.04305)
- High-frequency peaked BL Lac blazar.
- 1st detected in 1970 by Bologna Northern Cross telescope (B2 408 MHz)
- 1st detected at VHE by MAGIC in January 2011.

## Brightest flares at HE with Fermi-LAT:

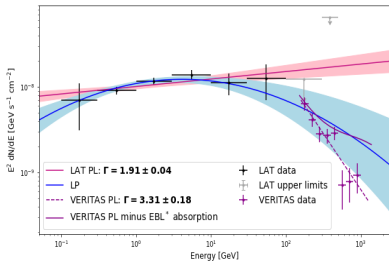
- ▶ 2008 Oct 10-15,  $\text{Flux}_{(E>300\text{MeV})} \sim 15 \times 10^{-8} \text{ cm}^{-2} \text{ s}^{-1}$  in a weekly LC.  
“ $\gamma$ -ray Light Curves and Variability of Bright FERMI-detected Blazars”, ApJ, 722:520-542, 2010.
- ▶ 2014 Feb 08, **with a coincident VERITAS flare (below)**.  
“A Luminous and Isolated  $\gamma$ -ray Flare from the Blazar B2 1215+30”, arXiv: 1701.01067v1, 2017.

## Brightest flares at VHE:

- ▶ 2013 Feb 07, (arXiv: 1701.01067v1, 2017)
- ▶ **2014 Feb 08**, (arXiv: 1701.01067v1, 2017)

## De-absorb EBL

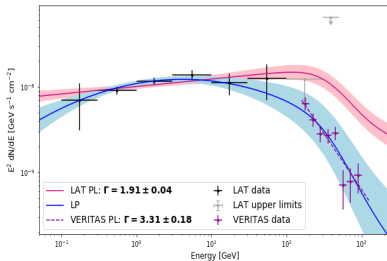
[PRELIMINARY] B2 1215+30 SED with Fermi-LAT & VERITAS: 2015



\* Franceschini's EBL model

## With EBL absorption

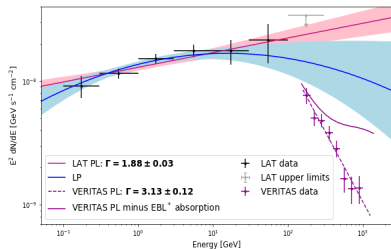
[PRELIMINARY] B2 1215+30 SED with Fermi-LAT & VERITAS: 2015



\* Franceschini's EBL model

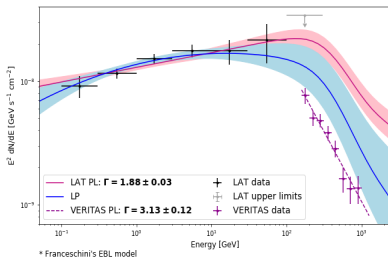
## De-absorb EBL

[PRELIMINARY] B2 1215+30 SED with Fermi-LAT &amp; VERITAS: 2016



## With EBL absorption

[PRELIMINARY] B2 1215+30 SED with Fermi-LAT &amp; VERITAS: 2016



# Long Term study SED with Fermi-LAT

[PRELIMINARY] B2 1215+30 SED with Fermi-LAT: 04 Aug 2008 - 30 Jun 2016

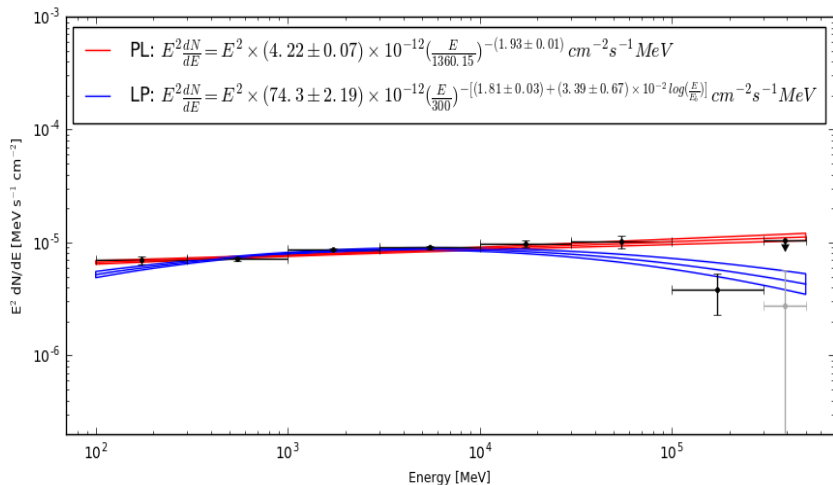


Figure 1:  $5.26\sigma$  rejection of the PL in favor of the LP model!

# 2015 and 2016 lightcurves

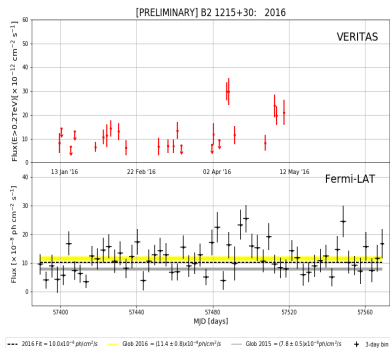
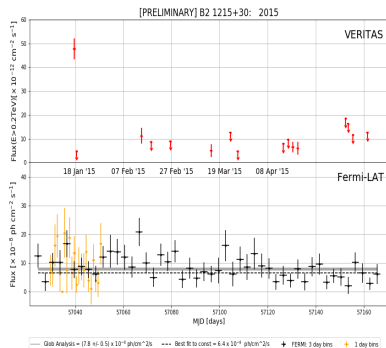
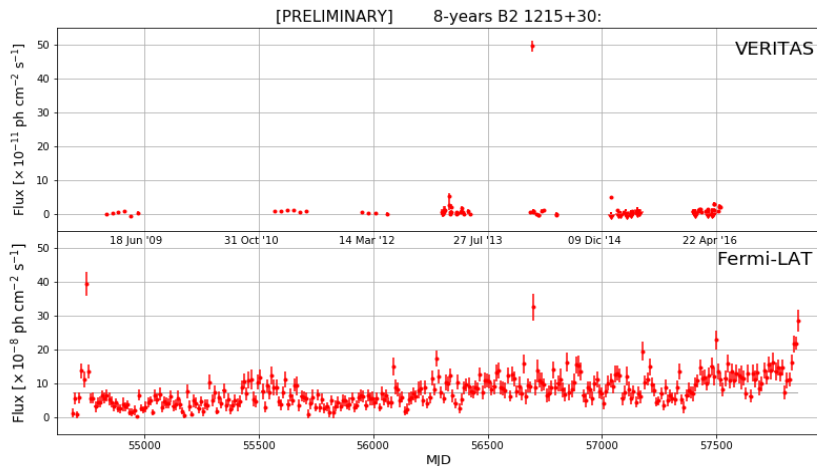


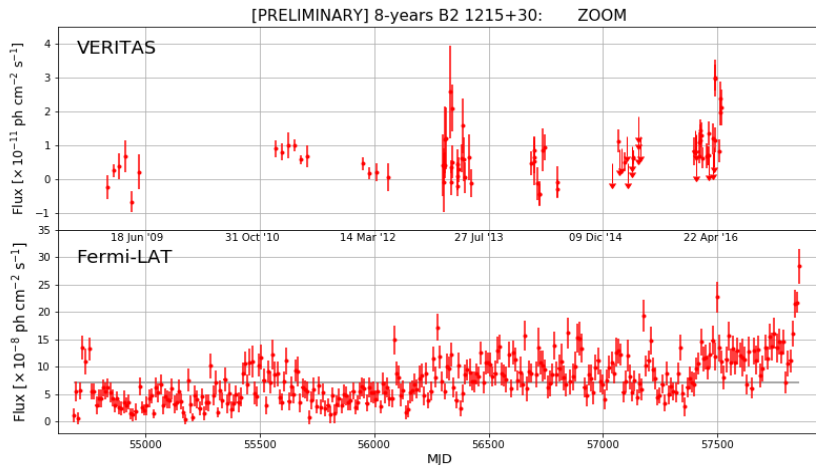
Figure 2: *VERITAS* and *Fermi-LAT* joint lightcurves.

# Fermi-LAT and VERITAS Long term LC





# Zoom: Increasing flux pattern



# 2017 Flares!

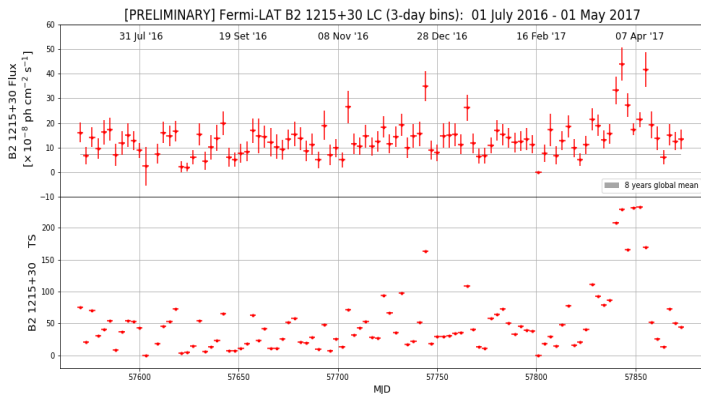
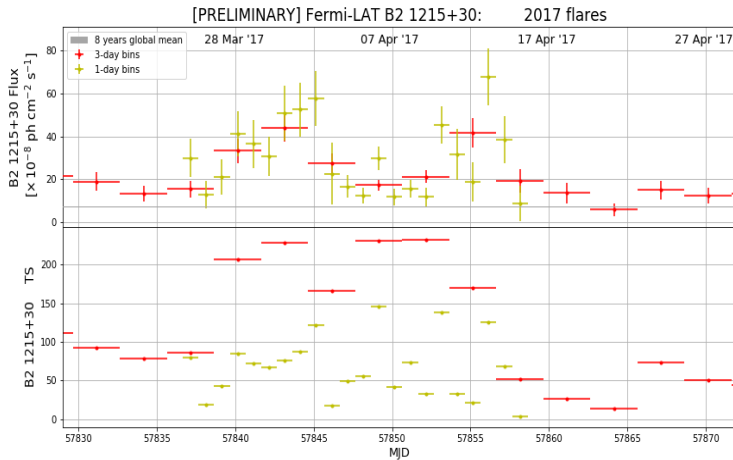


Figure 3: Coincidental VERITAS flare on Apr 1st. Includes Apr 13th ATel#10270.

# 2017 Flares: 1-day bins



# Summary of results

Table 1: Preliminary GeV TeV results for B2 1215+30

Instrument	Energy range	Dates	Live time	Sign.	$\Gamma$	Flux [ $\text{ph cm}^{-2}\text{s}^{-1}$ ]
VERITAS	>0.2 TeV	2015 Jan 17 – 2015 May 19	979.4 min	$17.1\sigma$		
		2016 Jan 12 – 2016 May 09	1324 min	$26.4\sigma$		
		2015 Jan 17	114.3 min	$17.1\sigma$		$(4.7\pm 0.5)\times 10^{-11}$
		2016 Apr 09	120.1 min	$13.4\sigma$		$(2.3\pm 0.4)\times 10^{-11}$
Fermi-LAT	0.1 – 500 GeV	2015 Jan 01 – 2015 Jun 30		$37.4\sigma$	$1.91\pm 0.04$	$(9.1\pm 0.7)\times 10^{-8}$
		2016 Jan 01 – 2015 Jun 30		$44.4\sigma$	$1.88\pm 0.03$	$(11.2\pm 0.8)\times 10^{-8}$
		2008 Aug 04 – 2016 Jun 30		$119\sigma$	$1.93\pm 0.01$	$(7.1\pm 0.2)\times 10^{-8}$
		2017 Apr 01-02		$11.2\sigma$	$1.75 \pm 0.15$	$(4.9\pm 1.4)\times 10^{-7}$
		2017 Apr 12-13		$11.5\sigma$	$1.78 \pm 0.14$	$(5.9\pm 1.4)\times 10^{-7}$

That's it, thank you!

# Long Term study

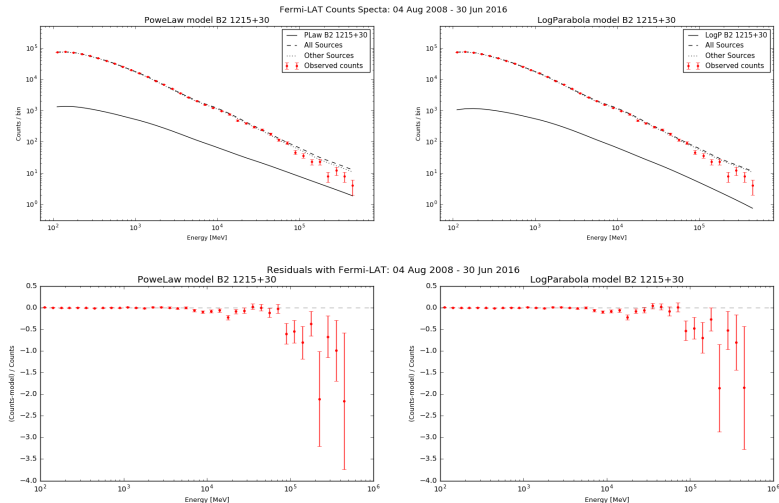
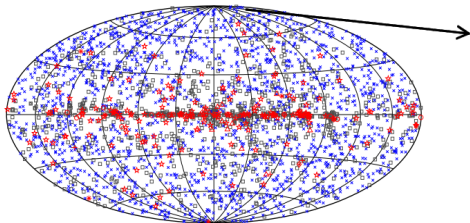


Figure 4: *Counts Spectra and residuals of B2 1215+30*

# Data and model

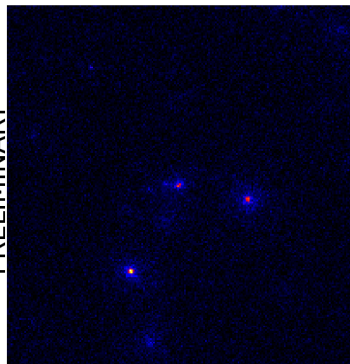
3FGL



□ No association	■ Possible association with SNR or PWN	● AGN
★ Pulsar	▲ Globular cluster	● Starburst Galaxy
● Binary	● Galaxy	● SNR
● Star-forming region		● Nova

- Aug. 2008-July 2012: 3033 sources.
- > 1100 blazars
- 660 BL Lacs.
- 1010 unassociated sources.
- $TS > 4\sigma$

PRELIMINARY

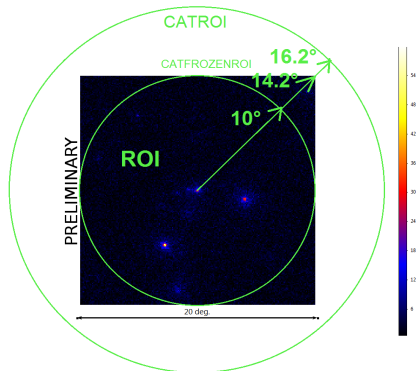
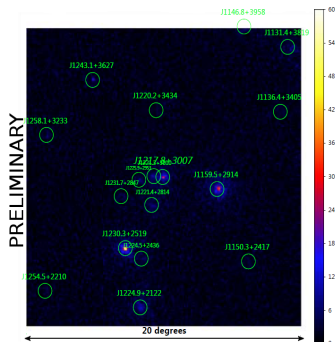


20 deg.

data around  
**B2 1215+30**

2015 Counts map

# Data and Model



Maximum likelihood fit to 3FGL model:  
127 sources considered in the region.

- 117 PowerLaw modeled sources
- 8 LogParabola modeled sources
- 2 diffuse sources

\* 44 srcs have free parameters.

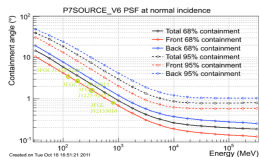


Figure 5: Point Spread Function at normal incidence