An unprecedentedly hard spectrum in VHE for the Extreme HBL 1ES 2344+51.4

Marina Manganaro
University of Rijeka, Department of Physics
marina.manganaro@phy.uniri.hr

For the team: Axel Arbet-Engels, Daniela Dorner, Vandad Fallah Ramazani, Adrian Biland

On behalf of the MAGIC and FACT collaborations

MWL collaborators: Claudia Raiteri, Valeri Larionov, Jose Acosta Pulido, Vitaliy Slyusar and Hovatta Talvikki

- - 23/01/2019 eXtreme 19, Padova - -

The MAGIC telescopes: eyes to the extreme Universe

La Palma, Roque de Los Muchachos: 2200 m a.s.l.

- each telescope mirror diameter: 17m
- field of view: 3.5 degree
- angular resolution: 0.1 degree
- energy range: 50 GeV to 50 TeV

FACT: monitoring at TeV energies since 2011

La Palma, Roque de Los Muchachos:
MAGIC's closest neighbor

- Mirror area: 9.5 sqm
- camera: 1440 pixels
- 4.5 degree FoV
- Silicon based photo sensors (G-APDs)

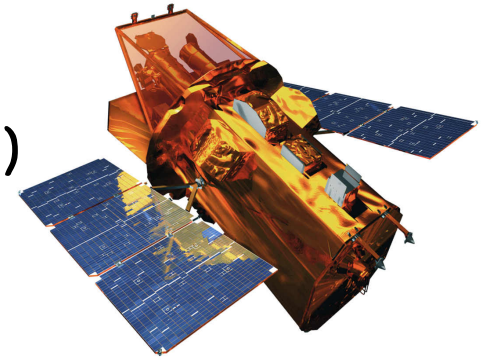
Unbiased monitoring:

- sources: brightest blazars e.g. Mrk 421, Mrk 501, 1ES 1959+650, 1ES 2344+51.4
- automatic quick-look analysis
- alerts sent in case of flares
- enhanced flux state of 1ES 2344+51.4 found in summer 2016 -> triggered MWL campaign

Multi-wavelength coverage

For the first time HE and VHE contemporaneous data!

Fermi-LAT (HE gamma rays)



Swift-XRT, Swift-UVOT (X-rays to UV)

Very variable spectrum!

GASP- WEBT, AZT-8, KVA (infrared and R-band)

OVRO (radio)

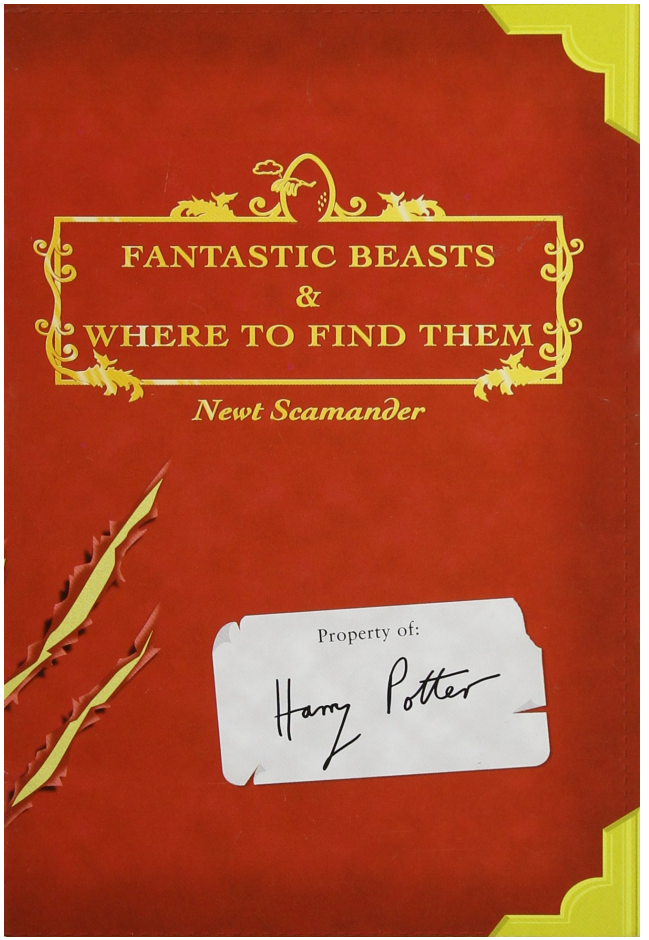
Extreme blazars and where to find them

- extremely energetic synchrotron emission

- very-high-energy emission extending to several TeV

-synchrotron peak location exceeding the soft X-ray band (ν_{peak} > 1 KeV)

- X-ray spectrum variability

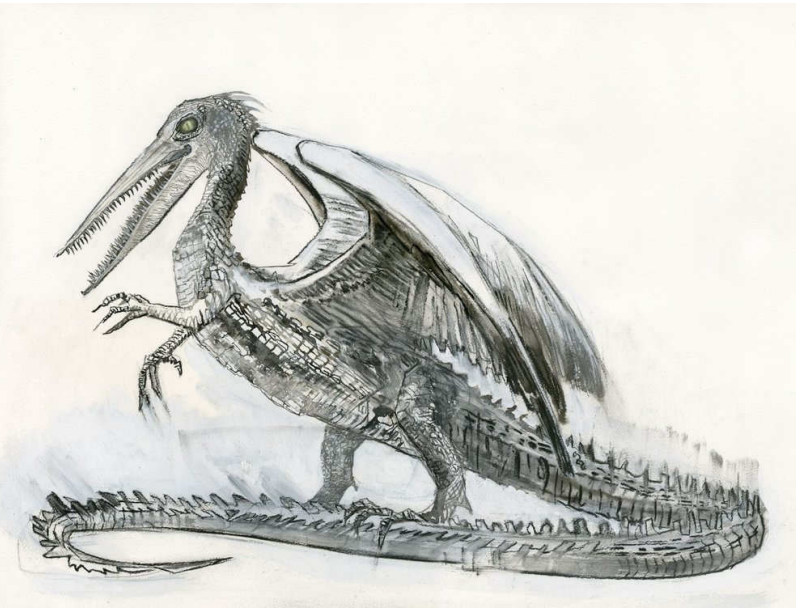


Credit: Harry Potter

Costamante et al., A&A 371, 512-526, (2001)

Extreme blazars and where to find them

EHBL 1ES 2344+51.4



A snallygaster, Credit: Newt Scamander

- Discovered in the VHE by Whipple in 1995*

- redshift z=0.044 (almost negligible EBL absorption)

- Flux: 63% of the Crab Nebula flux above 350 GeV when discovered in VHE (historical maximum)

- joins the extreme HBL blazar family in 2000 (high X-ray variability, shift of the synchrotron peak to 10KeV)**

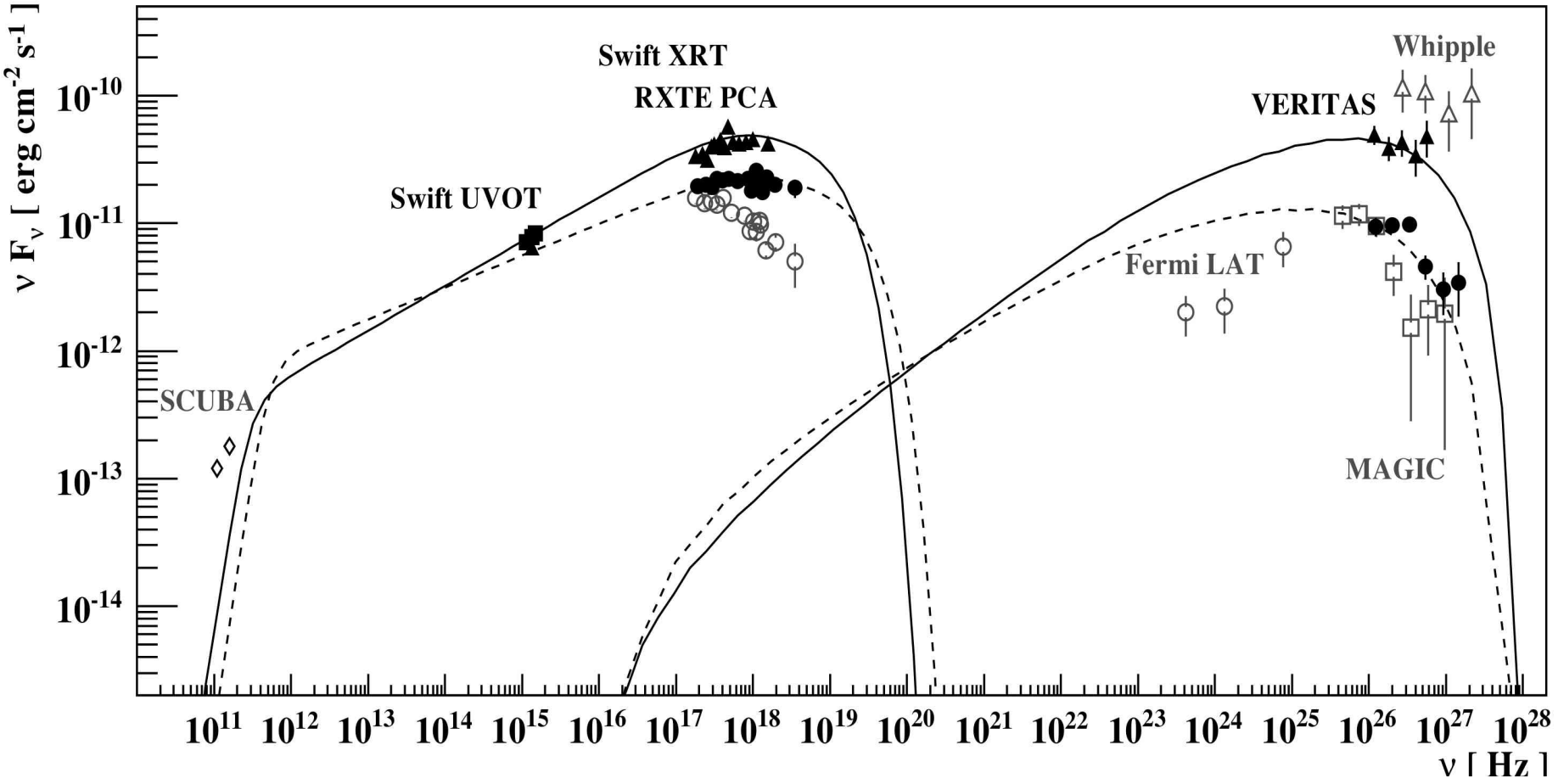
→ consequently, MWL campaigns have been organized in order to study its extremeness…

* Catanese et al., Astrophysical Journal, 501:616-623, (1998)

** Giommi et al., MNRAS 317, 743-749 (2000)

EHBL 1ES 2344+51.4 in 2007–2008 MWL campaign *

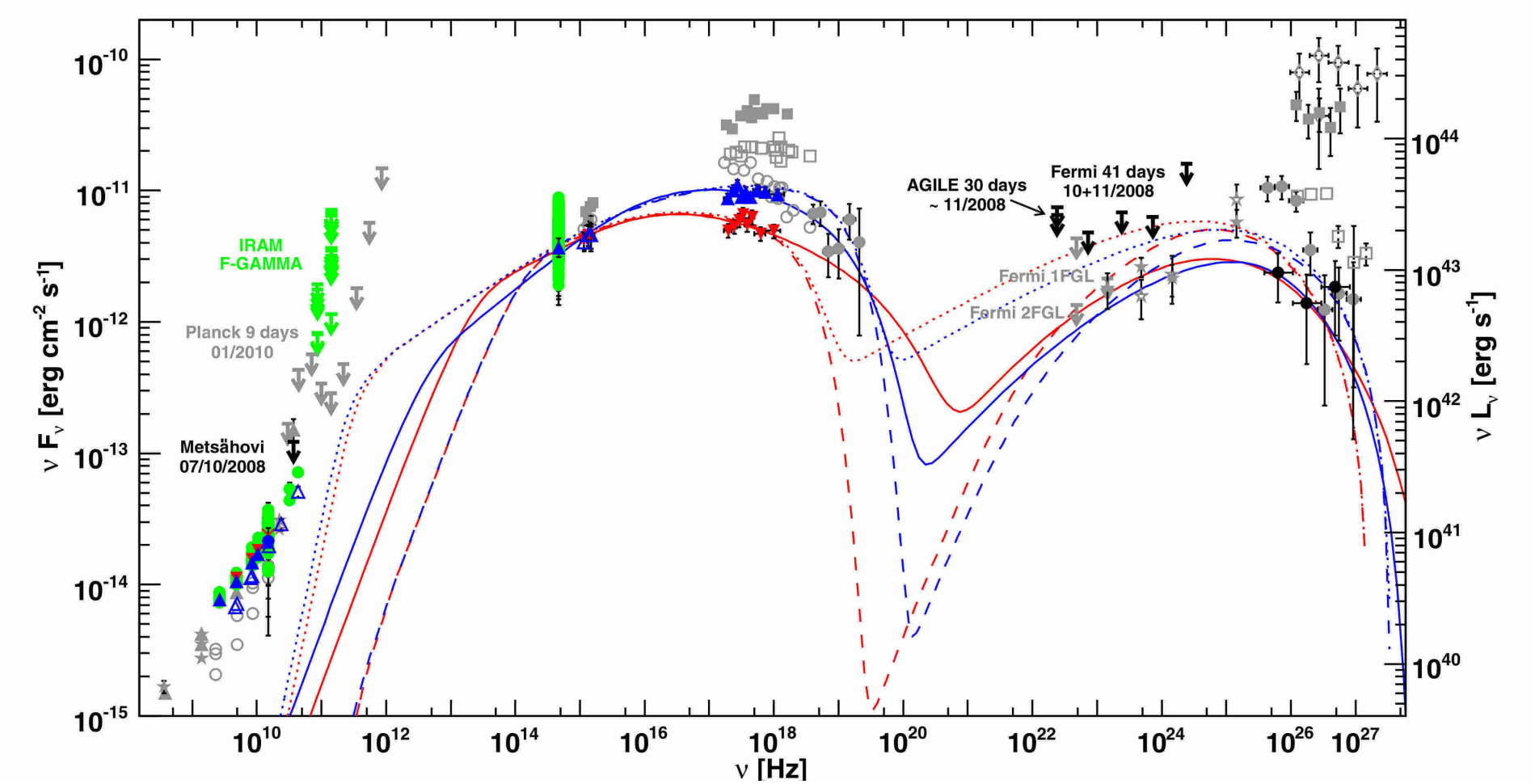
* Acciari et al., Astrophysical Journal, 738, 169, (2011)



Two different flux states (7.6% and 48% of the Crab Nebula flux > 300GeV)

EHBL 1ES 2344+51.4 in 2008 MWL campaign *

* Aleksić et al., A&A 556, A67 (2013)

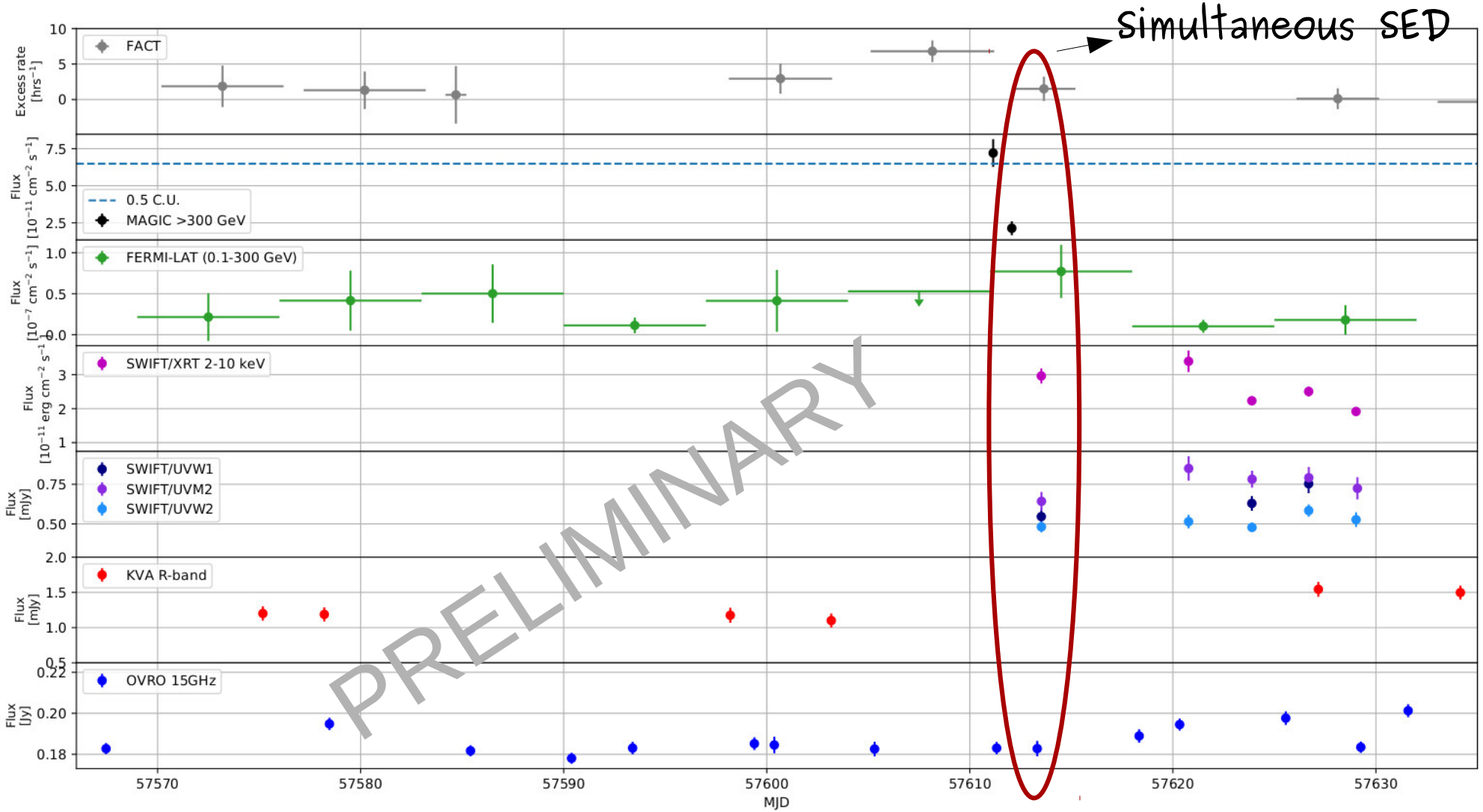


- low flux states in VHE and X-ray
- possibly quiescent state, but not for sure
- no visible shift of the synchrotron peak between the two states
- VHE spectrum 2.4

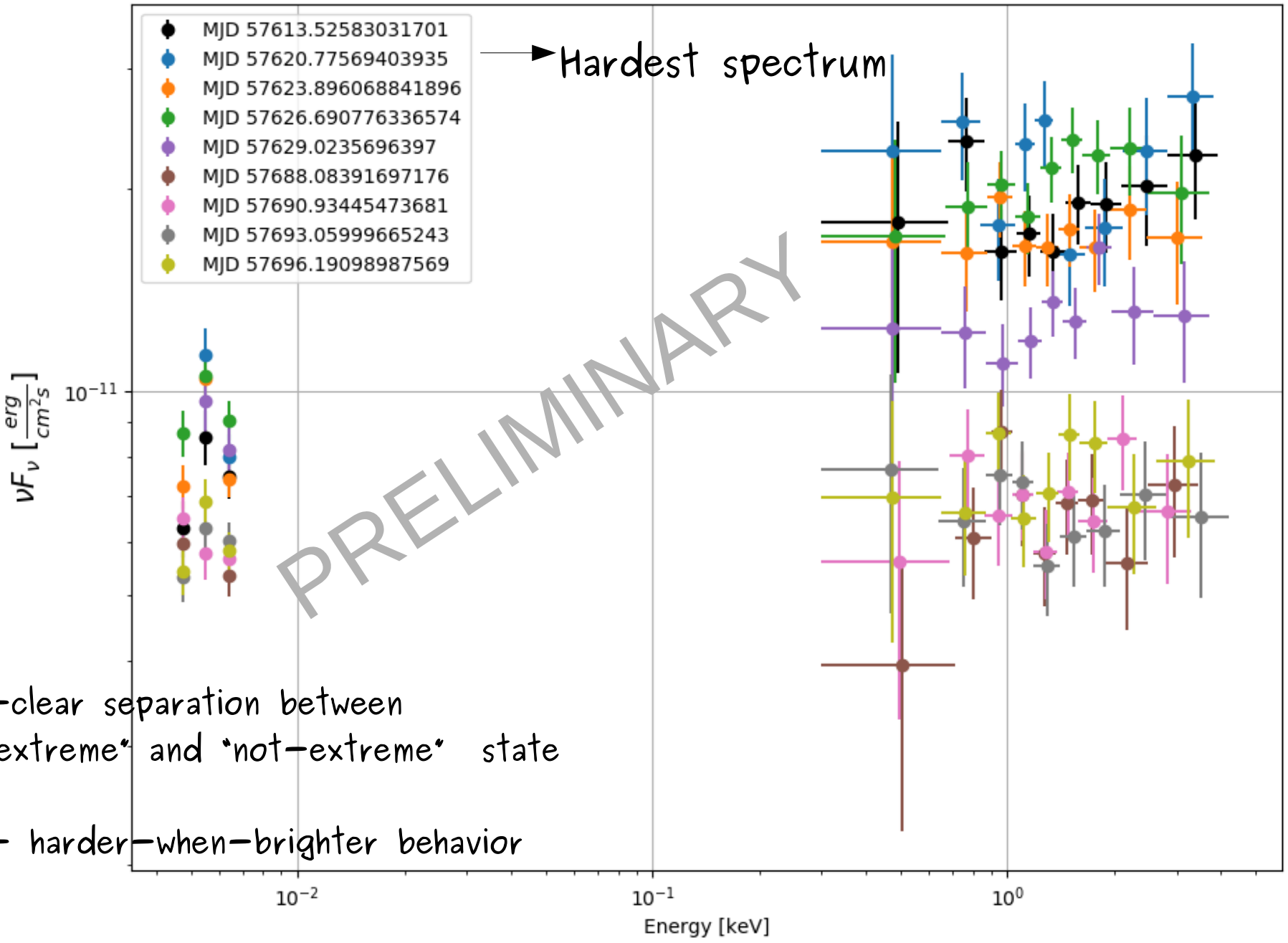
EHBL 1ES 2344+51.4 in 2016: our results

(Extreme again!)

EHBL 1ES 2344+51.4 in 2016: MWL lightcurve



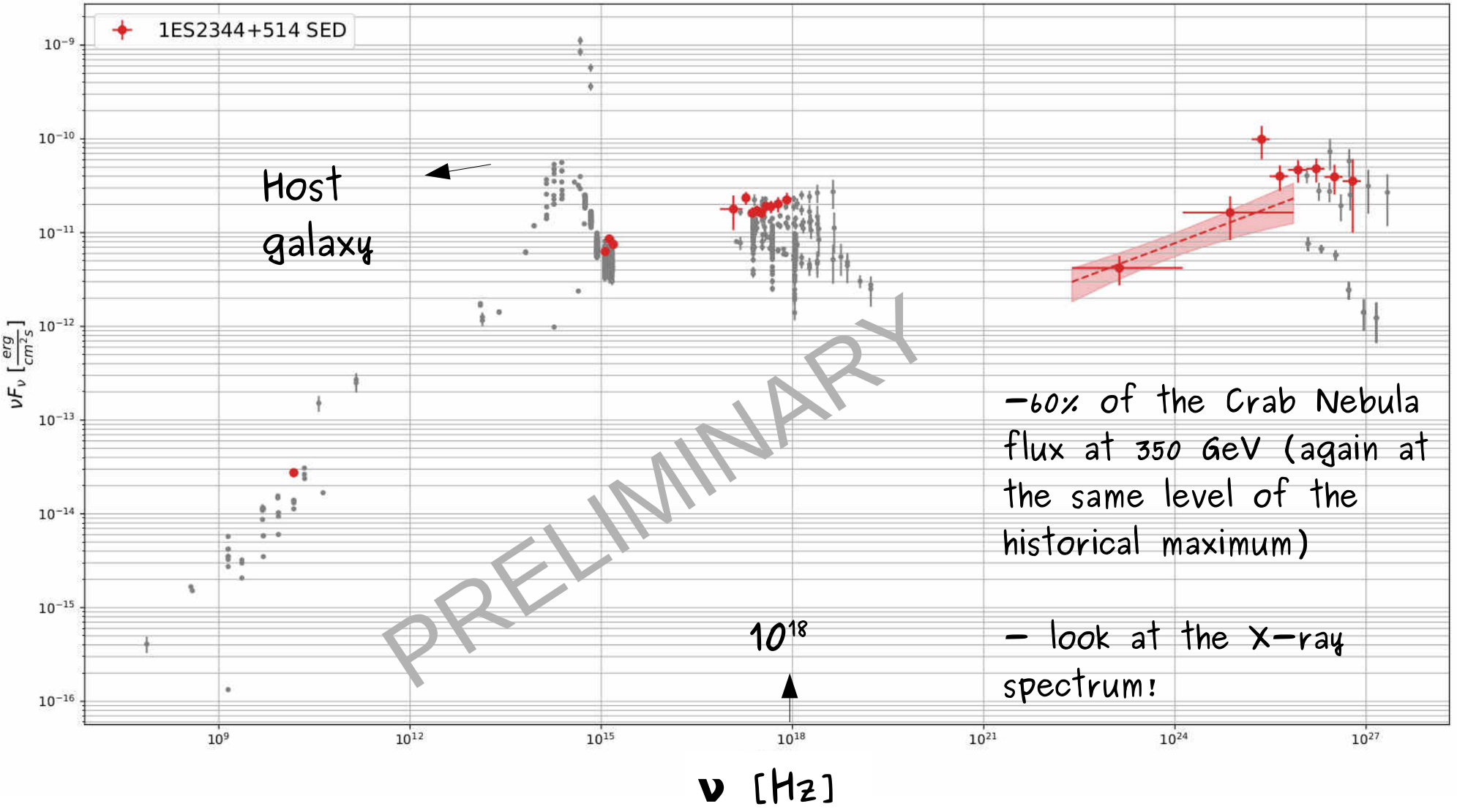
EHBL 1ES 2344+51.4 in 2016: X-ray variability



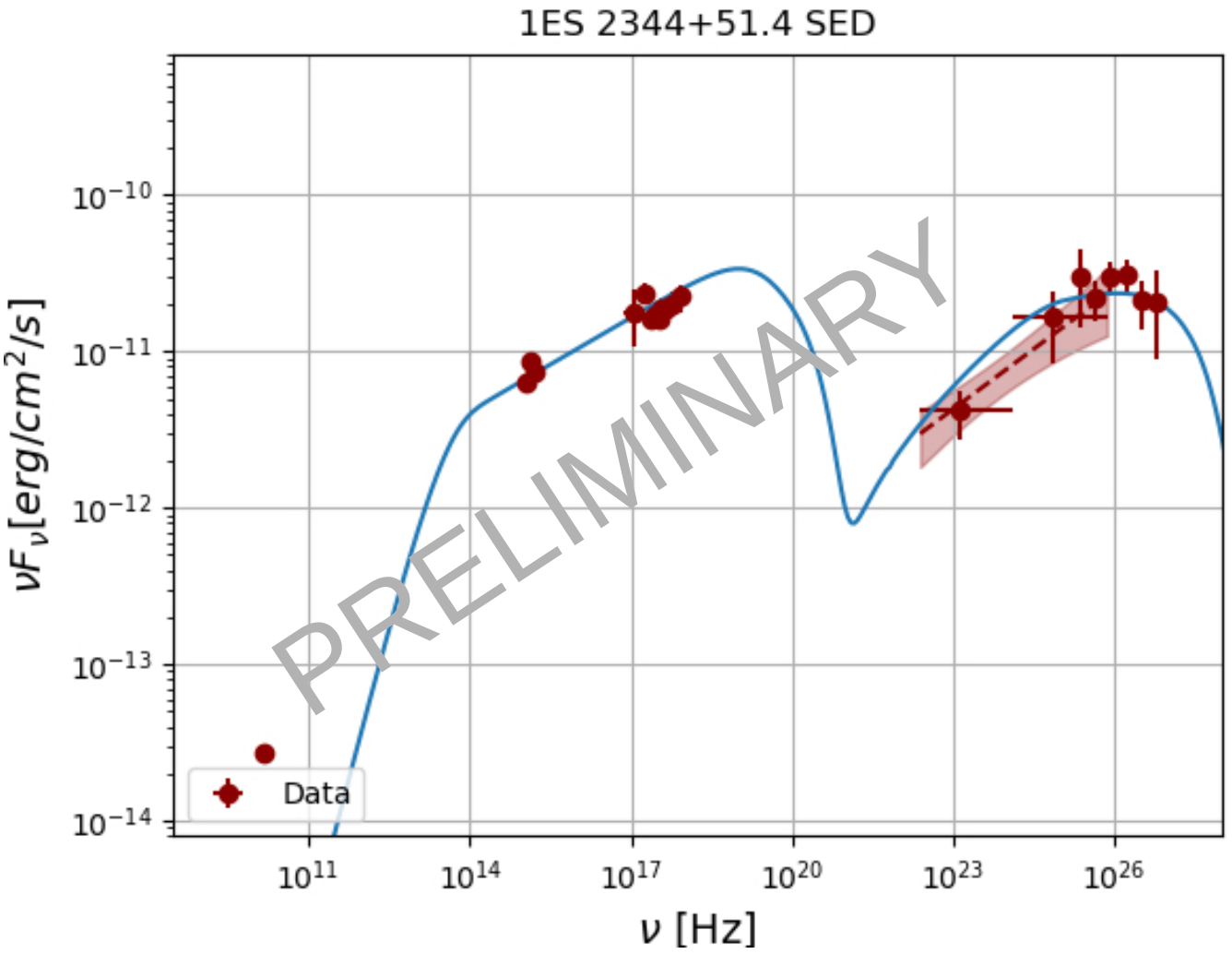
- clear separation between "extreme" and "not-extreme" state

- harder-when-brighter behavior

EHBL 1ES 2344+51.4 in 2016: broadband SED



EHBL 1ES 2344+51.4 in 2016: broadband SED

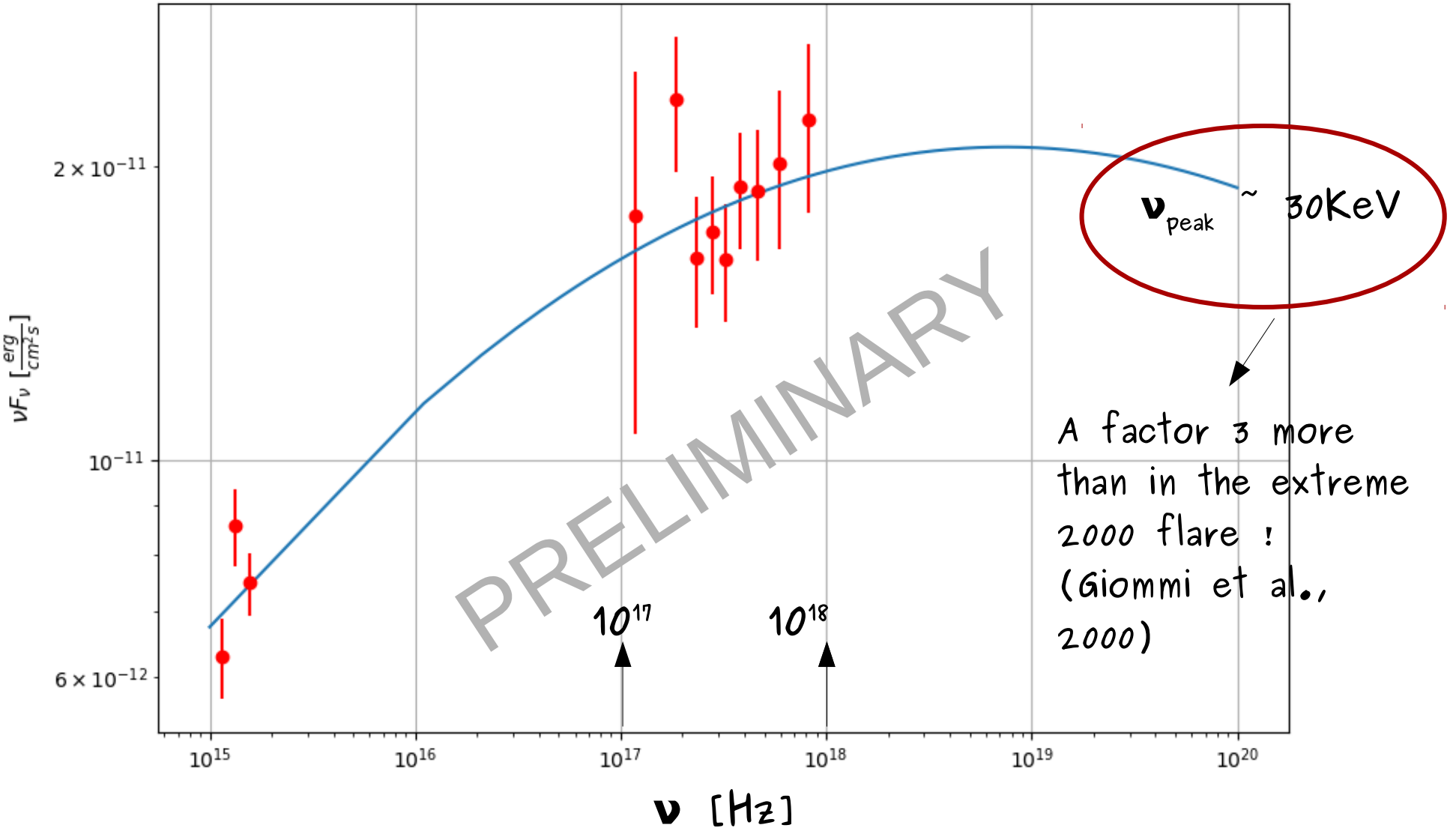


- SSC model

- simultaneous optical and UV data to be added after the host galaxy correction

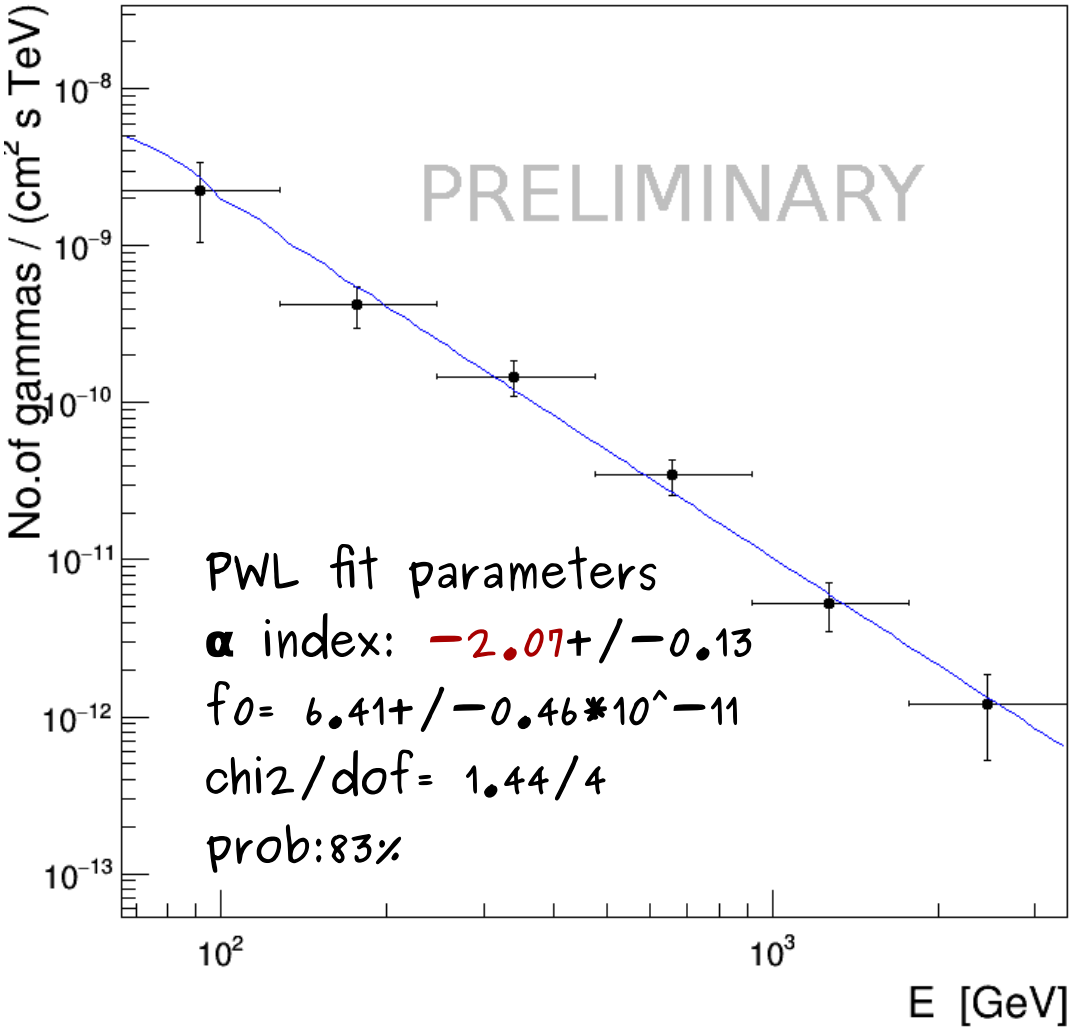
- let's have a look to the synchrotron peak...

EHBL 1ES 2344+51.4 in 2016: synchrotron peak



Log-parabolic power-law fit as in Aleksić et al. (2013)

EHBL 1ES 2344+51.4 in 2016: unprecedentedly hard spectrum in VHE



-Spectral Properties:

From Allen et al. (2017):
- Spectral index for different observation periods:
... 2007-2008: 2.43 +/- 0.09(stat)
... 2008-2015: 2.63 +/- 0.14(stat)
... 2007-2015: 2.46 +/- 0.06(stat)
. the systematic error is 0.20

From Acciari et al. (2011):
- Spectral index (flare): 2.43 +/- 0.22(stat) +/- 0.15(syst)
- Spectral index (time-averaged): 2.78 +/- 0.09(stat) +/- 0.15(syst)

From Albert et al. (2007):
- Spectral index: 2.95 +/- 0.12(stat) +/- 0.2(syst)

From Schroedter et al. (2005):
- Spectral index: 2.54 +/- 0.17(stat) +/- 0.07(syst)

Summary

-VHE Flux again to the historical maximum (60% Crab Nebula above 350 GeV)

-The source is again extreme as in Costamante et al. (2001)

-Being extreme looks like a temporary characteristic of this source as Mrk 501 recently showed (and also predicted in Costamante et al. 2001)

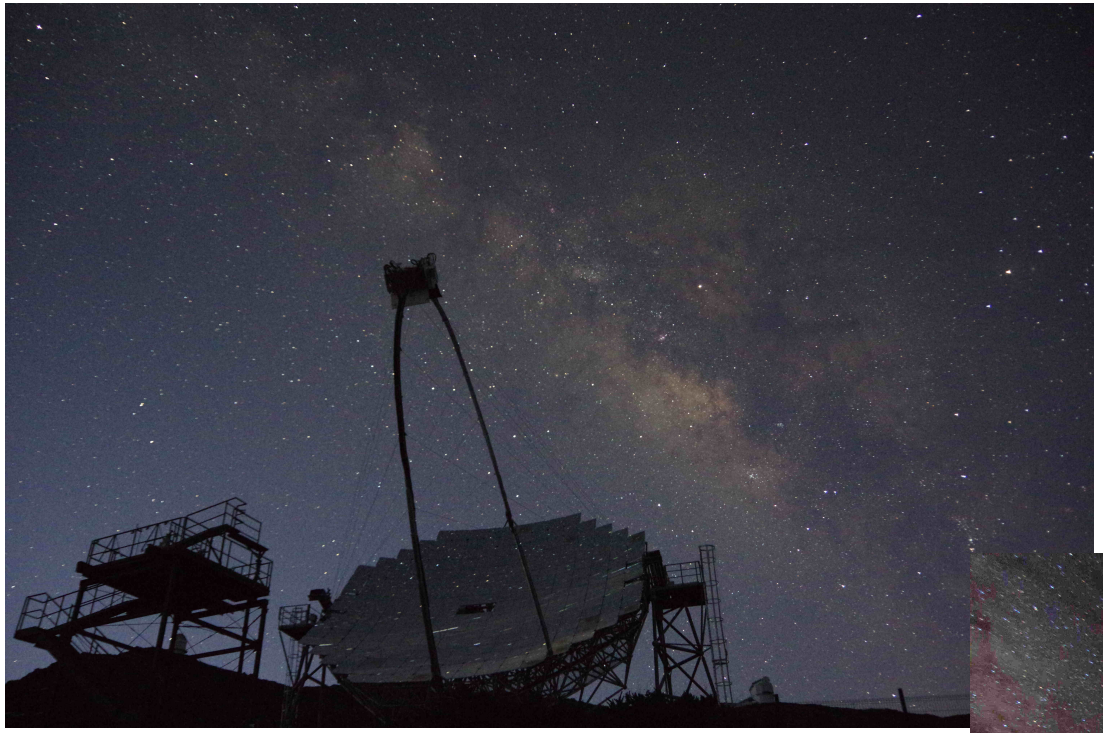
-MAGIC unprecedented hard spectrum (alpha index ~2)

-Possible intra-night variability for MAGIC light curve (to be confirmed)

-Variability of the X-ray spectra

-Constraining for the first time the IC peak with simultaneous data (First time Fermi and MAGIC data are used for the modeling of the IC peak)

-Modeling on going, SSC looks describing well the data but interesting EHBL models are also attractive



Credit: Daniela Dorner

MAGIC

Major Atmospheric

Gamma Imaging

Cerenkov Telescopes

Credit: Chiara Righi

Visit us!

@magic_telescopes