正心問天 尋道興文

云南天文台
YUNNAN OBSERVATORY

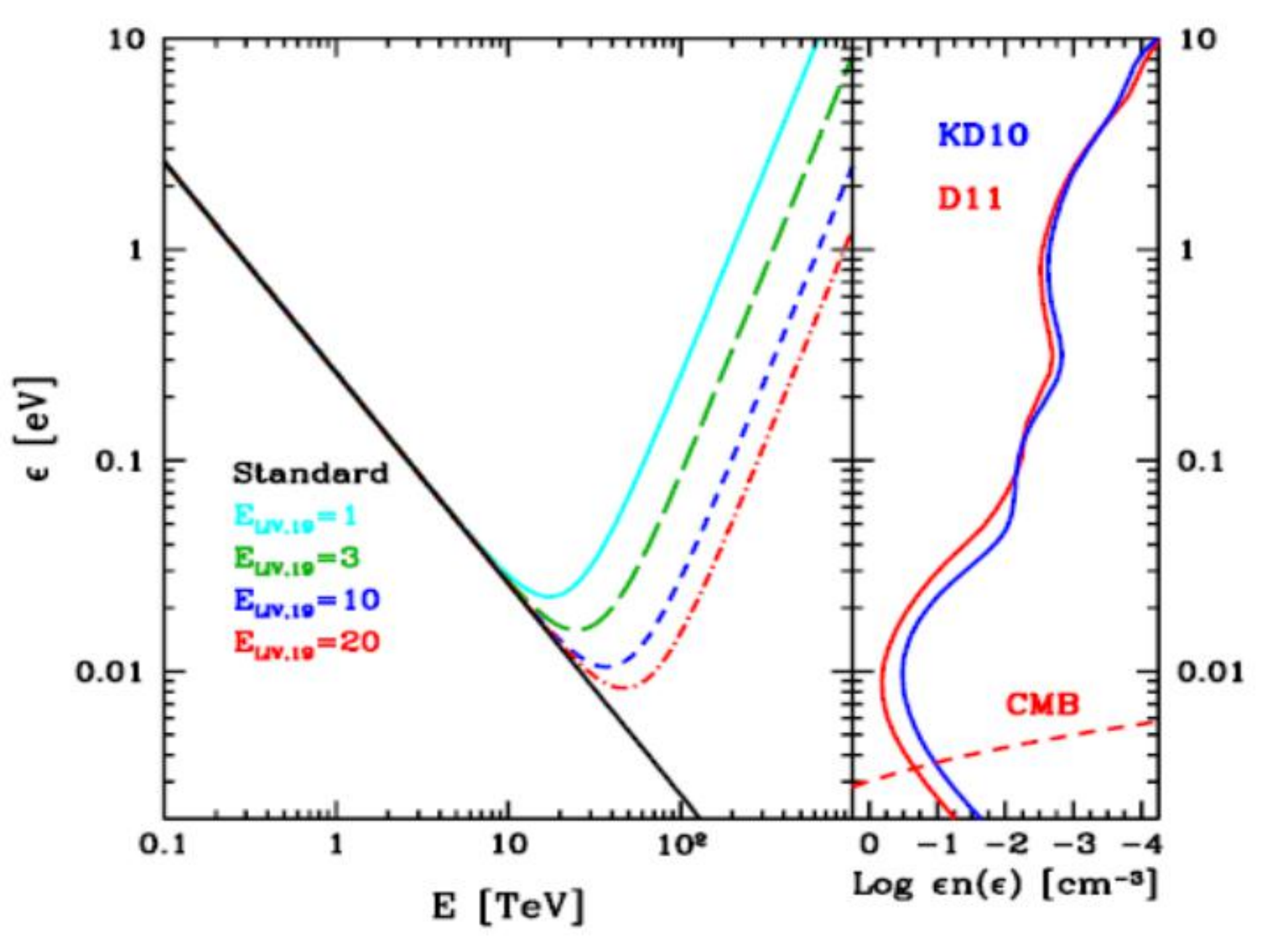
AGN的TeV观测研究进展

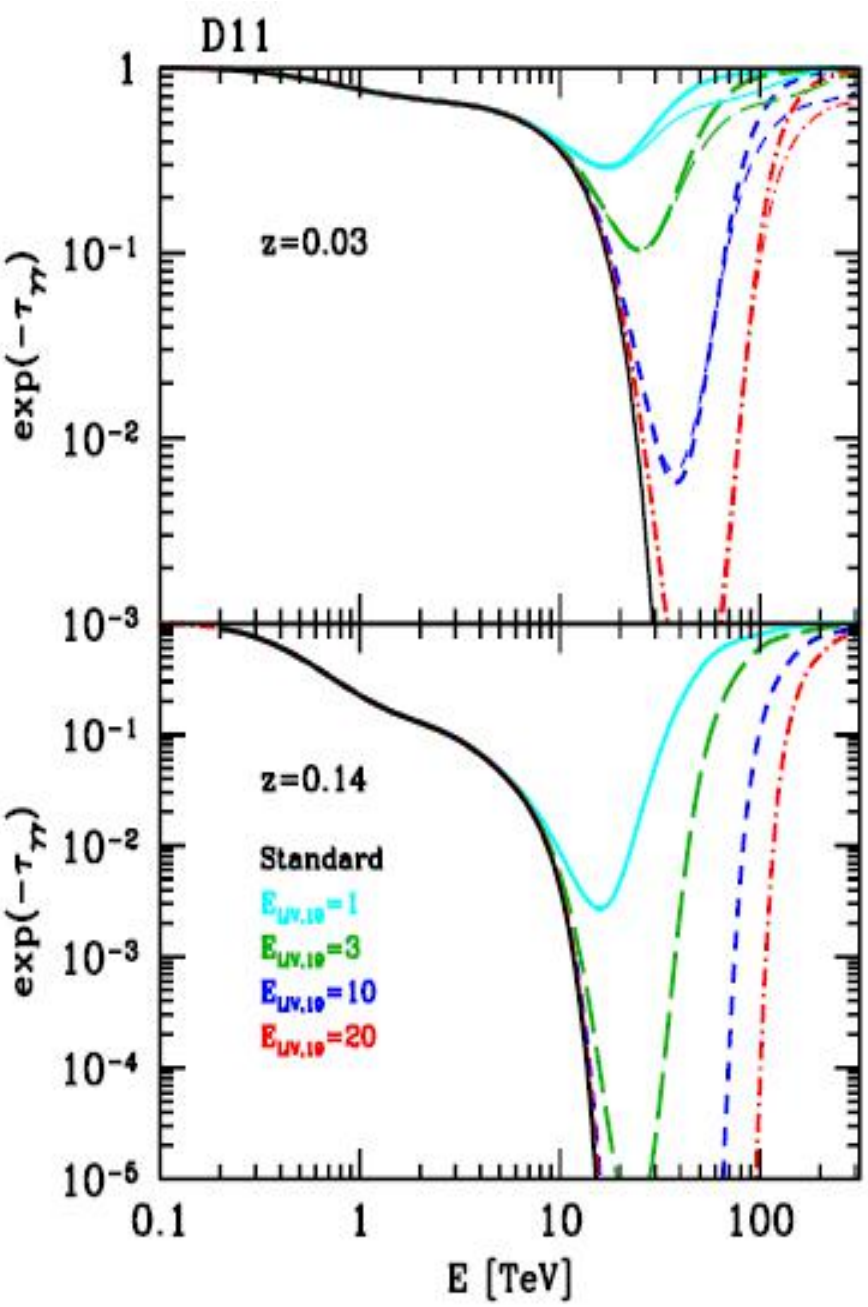
王建成

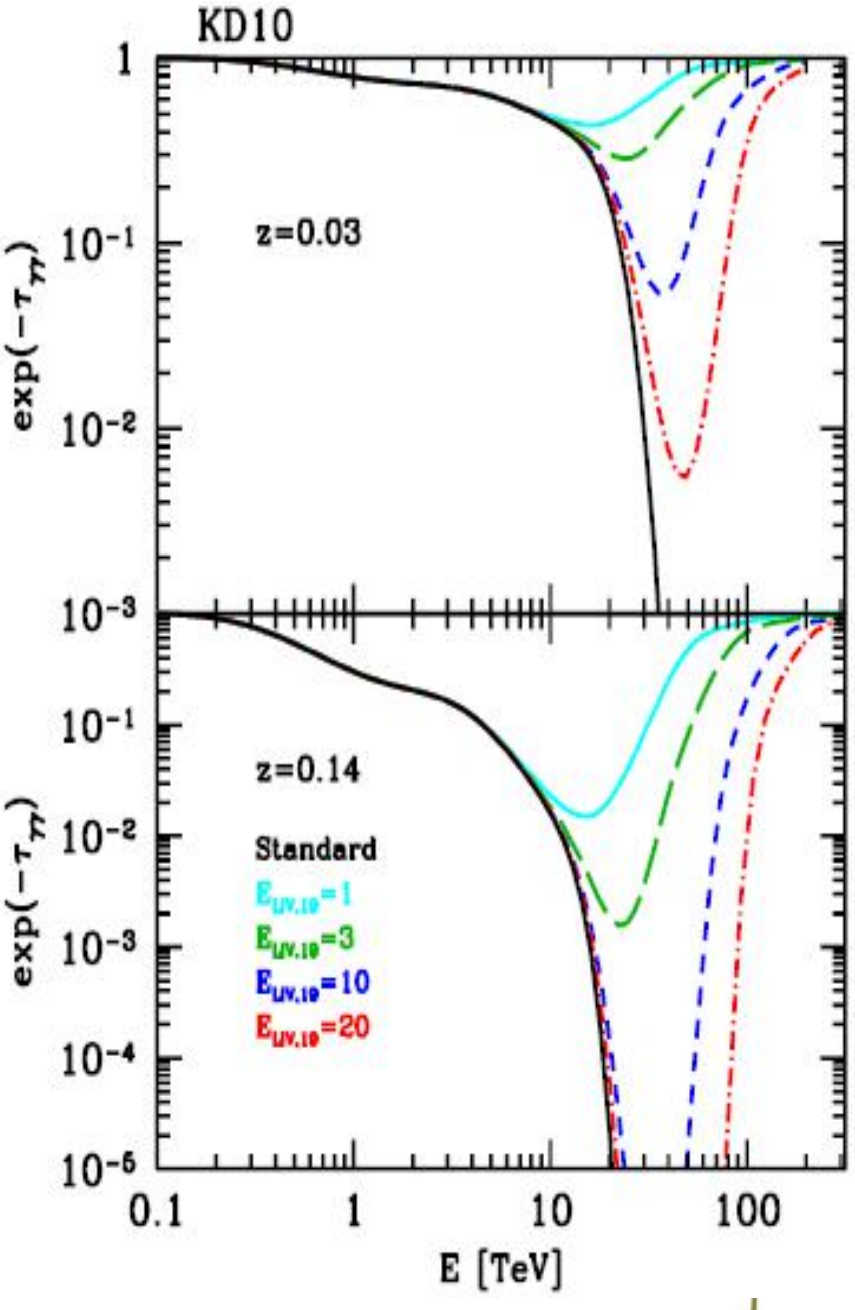
TeVblazar的观测检验LIV

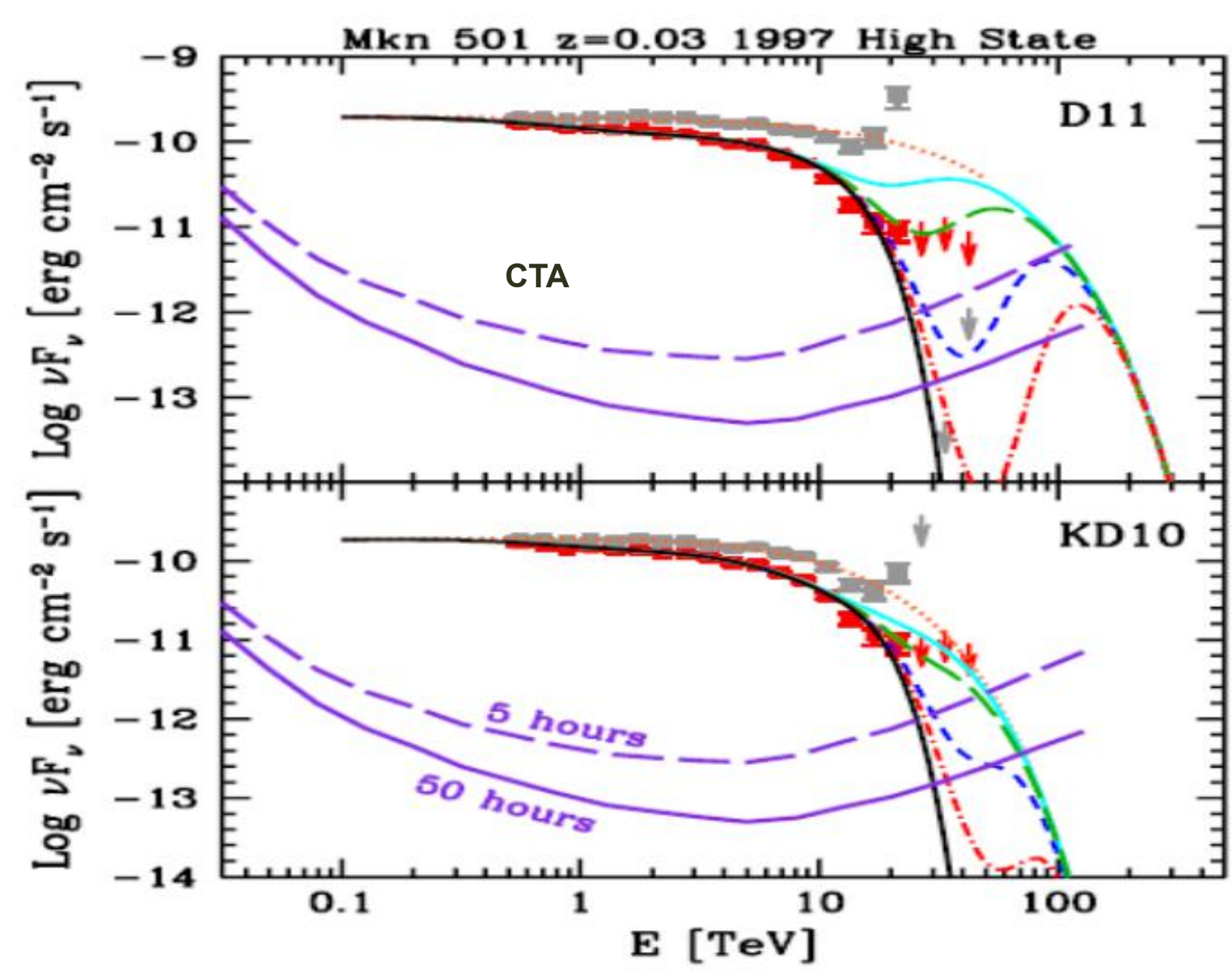
- 粒子物理和广义相对论可能是更基本物理理论的低能极限，LIV在高能可能违背。
- LIV影响$\gamma\gamma \rightarrow e^{-}e^{+}$的截面
- LAAHSO 在10TeV以上有非常好的探测能力，一年的积分流量：$10^{-14} erg cm^{-2} s^{-1}$（ 50−100 TeV ）
- LIV谱特征非常窄，好的能谱分辨率非常重要

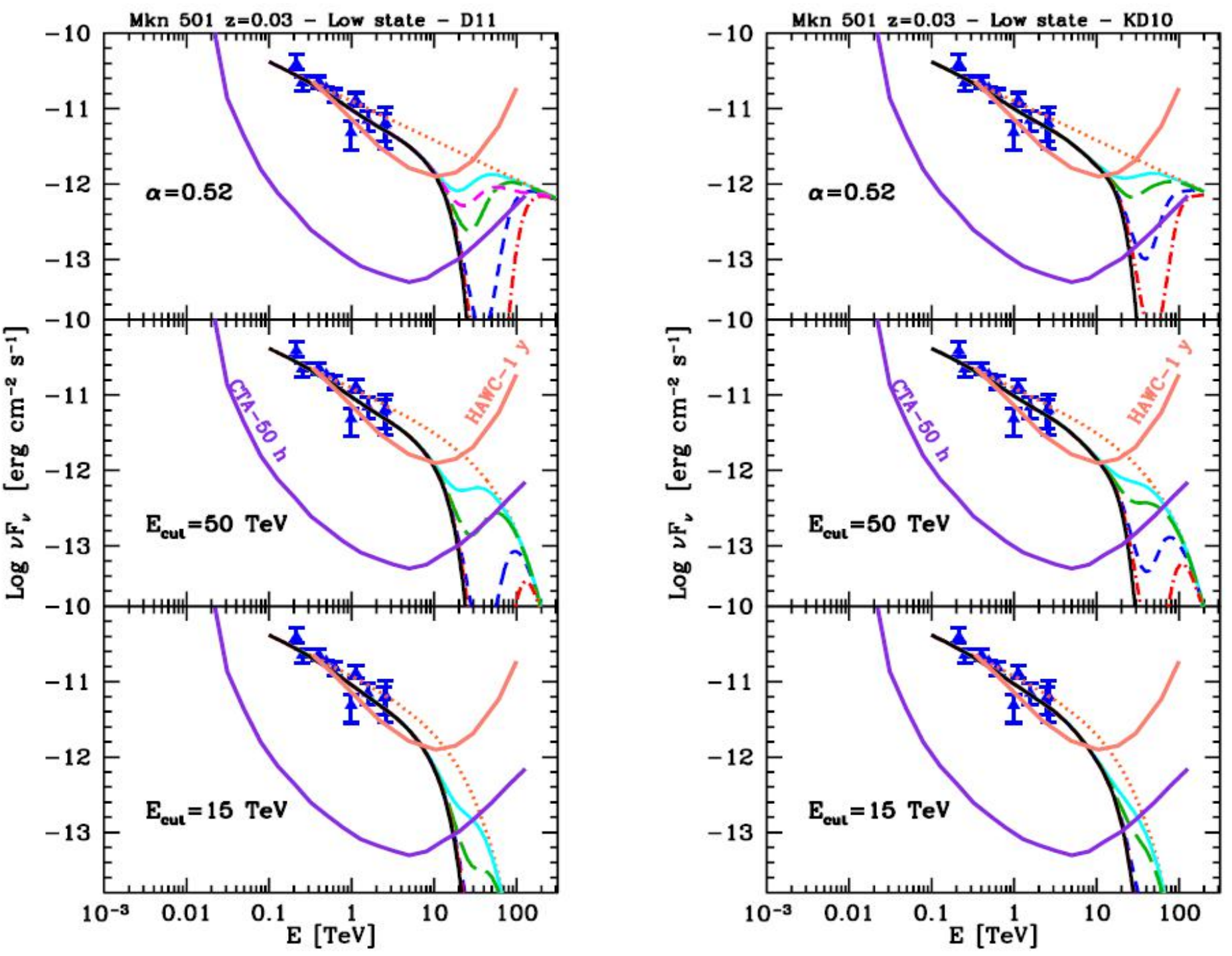
Tavecchiv, T. & Bonnoli, G. 2016, A&A, 585, A25

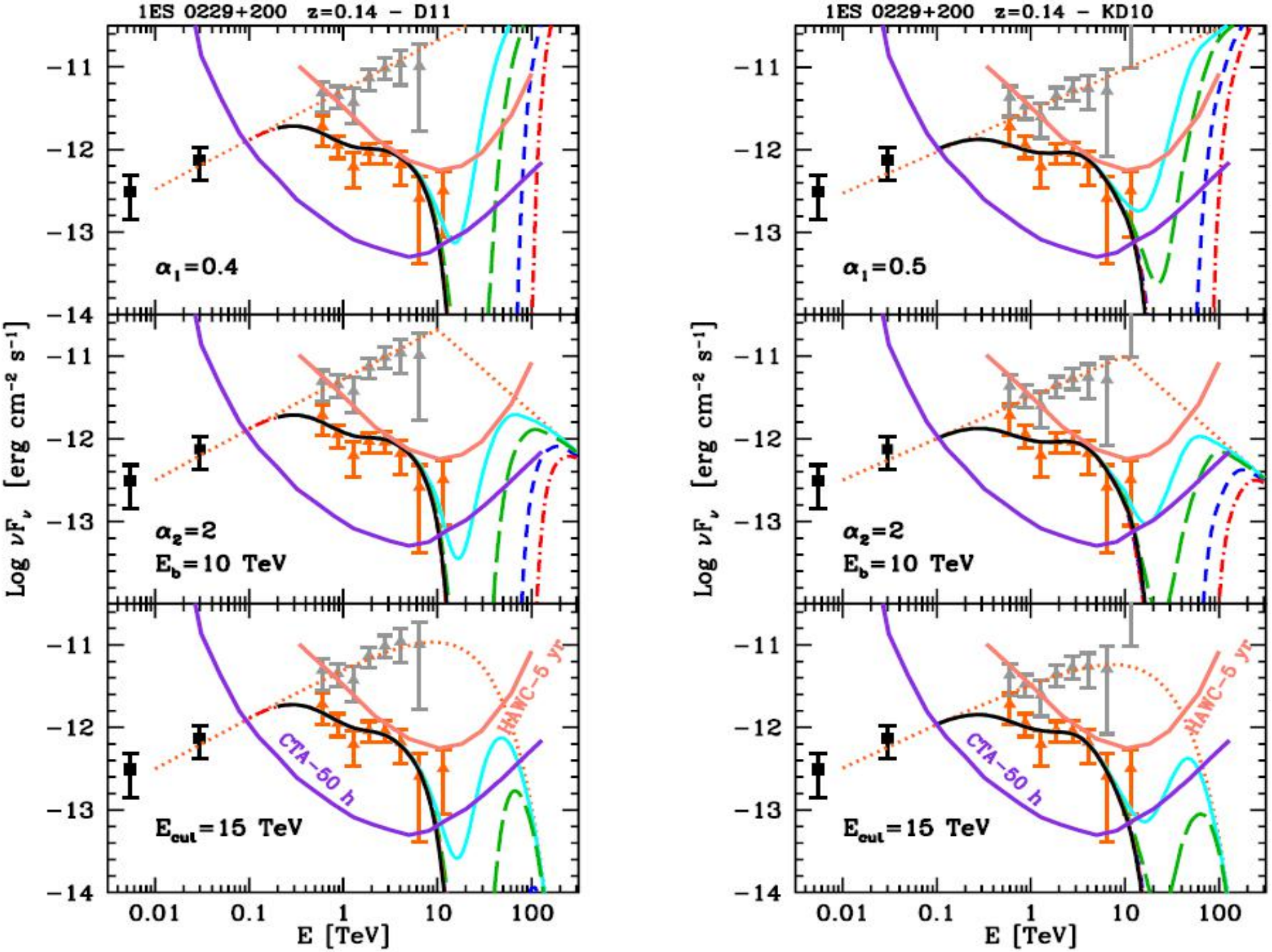

10
1
0.1
0.01
ϵ [eV]
0.1
1
10
10²
E [TeV]
Standard
E_UV,10=1
E_UV,10=3
E_UV,10=10
E_UV,10=20
KD10
D11
CMB
0
−1
−2
−3
−4
Log ϵn(ϵ) [cm⁻³]


D11
z=0.03
z=0.14
Standard
E_UV,19=1
E_UV,19=3
E_UV,19=10
E_UV,19=20
exp(−τ_γγ)
E [TeV]

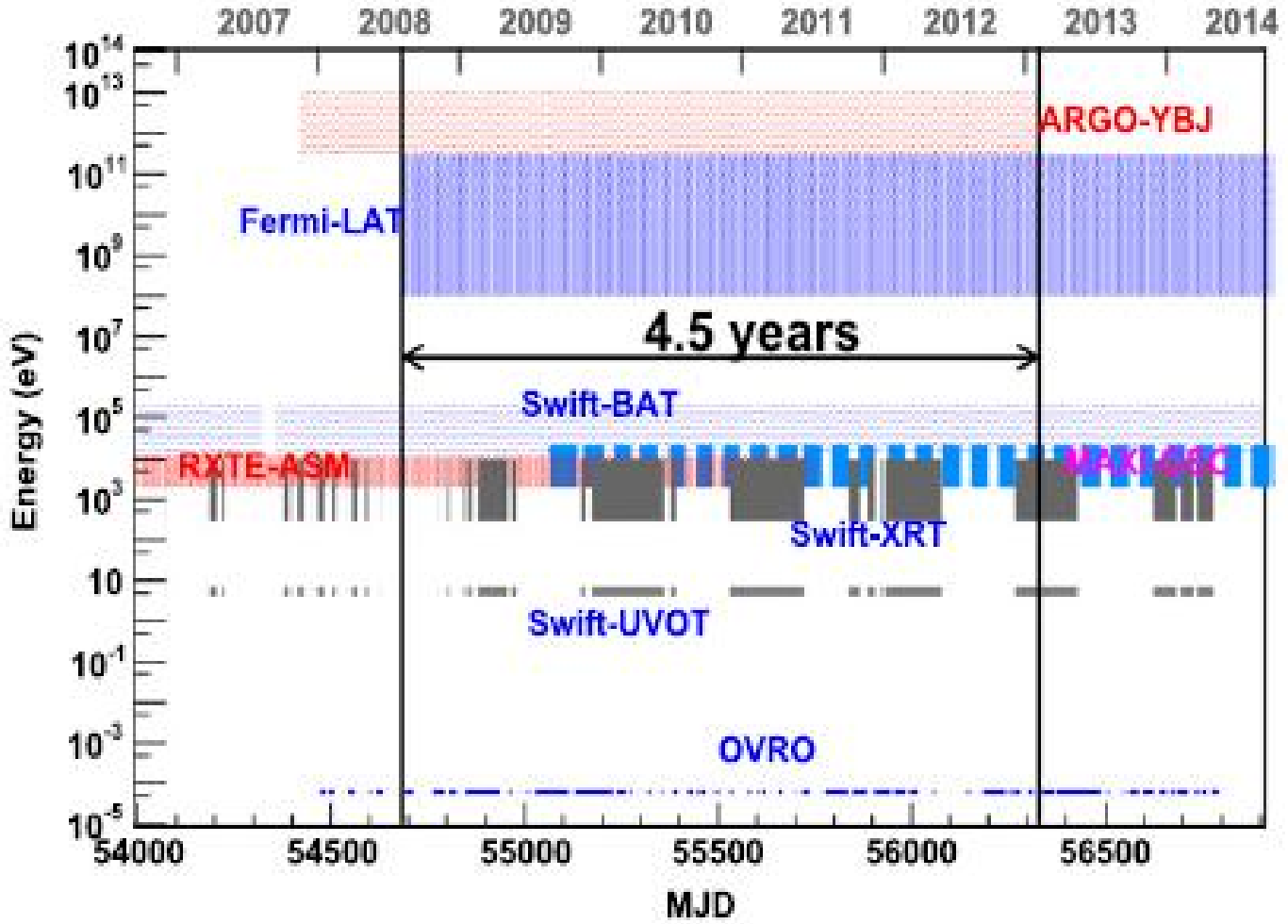

KD10
z=0.03
z=0.14
Standard
E_UV,19=1
E_UV,19=3
E_UV,19=10
E_UV,19=20
exp(−τ_γγ)
E [TeV]


Mkn 501 z=0.03 1997 High State
D11
KD10
CTA
5 hours
50 hours
Log νF_ν [erg cm^-2 s^-1]
E [TeV]
0.1
1
10
100
-9
-10
-11
-12
-13
-14

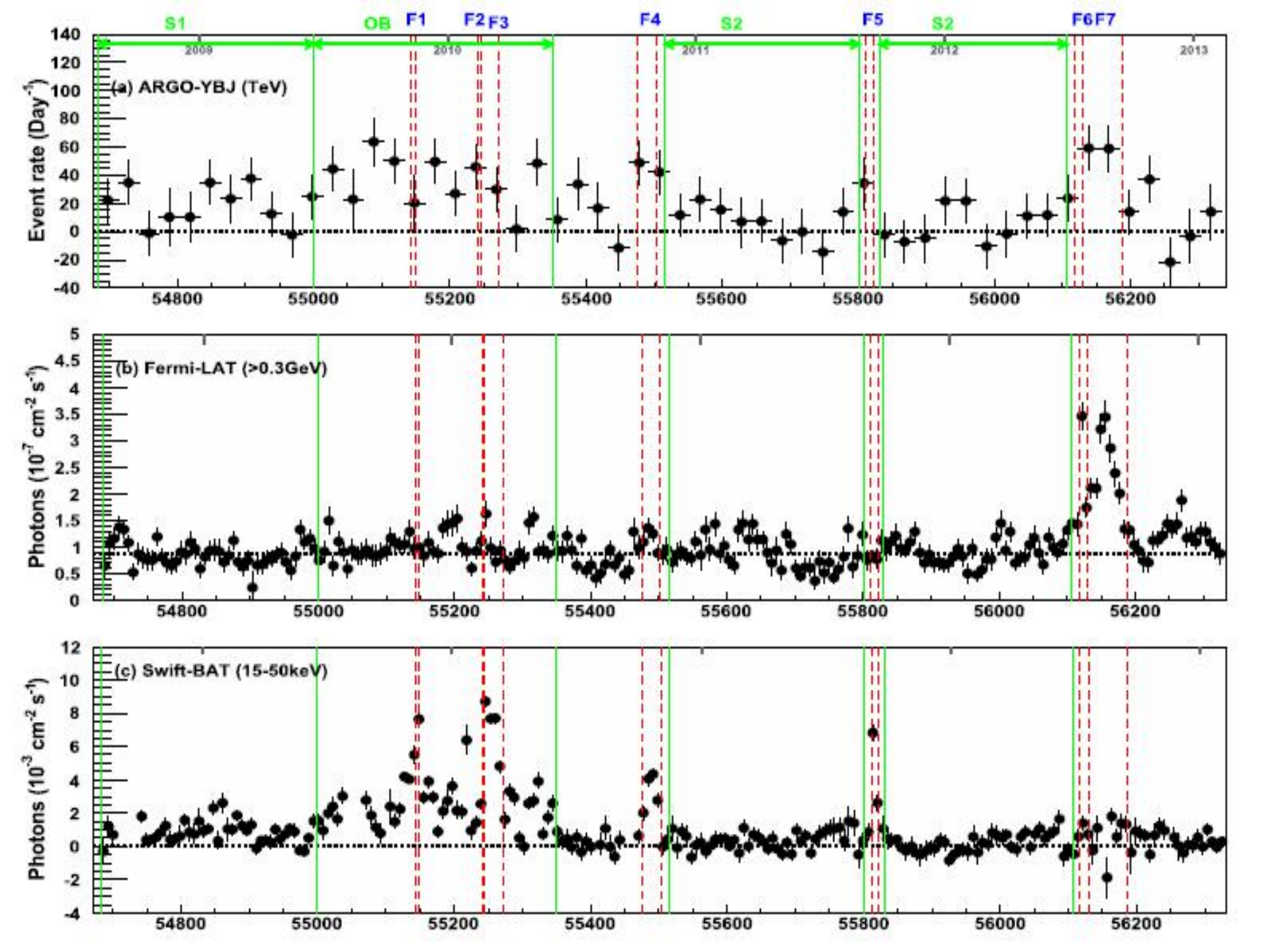

Mkn 501 z=0.03 – Low state – D11
Mkn 501 z=0.03 – Low state – KD10
α=0.52
E_cut=50 TeV
E_cut=15 TeV
CTA–50 h
HAWC–1 y
Log νF_ν [erg cm^-2 s^-1]
E [TeV]
10^-3
0.01
0.1
1
10
100
−10
−11
−12
−13

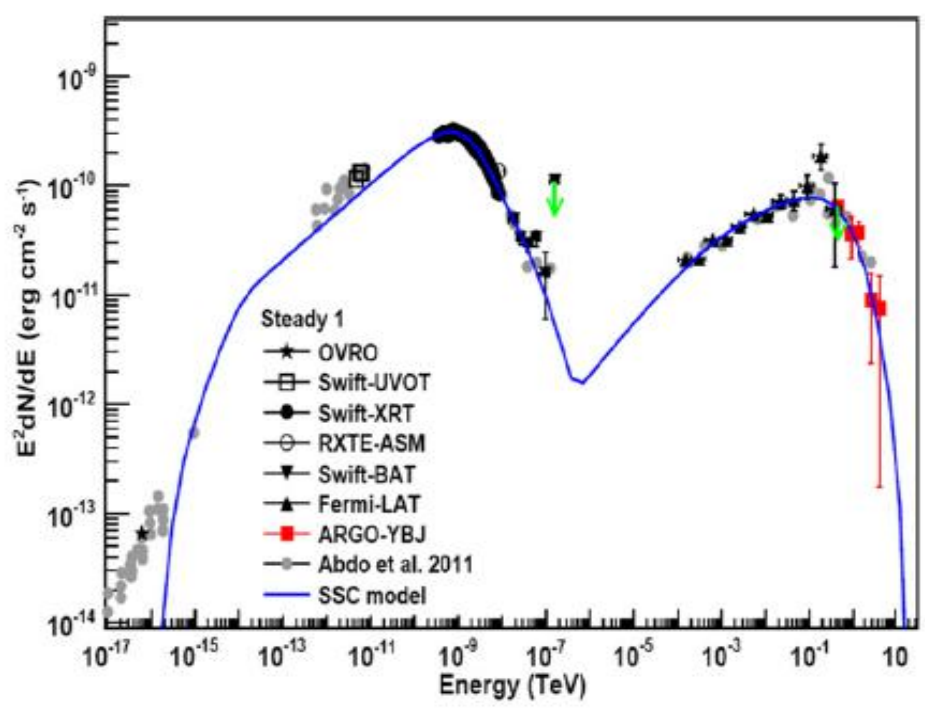

1ES 0229+200 z=0.14 – D11
1ES 0229+200 z=0.14 – KD10
Log νF_ν [erg cm^-2 s^-1]
E [TeV]
α_1=0.4
α_2=2
E_b=10 TeV
E_cut=15 TeV
α_1=0.5
CTA-50 h
HAWC-5 yr

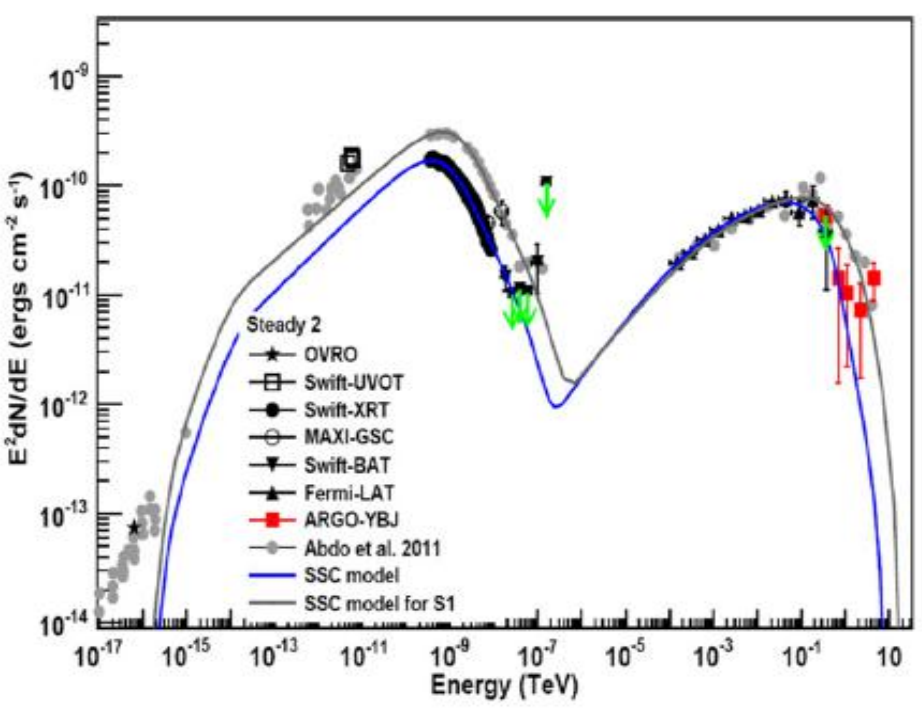
ARGO-YBJ和Fermi对Mrk 421的4.5年观测

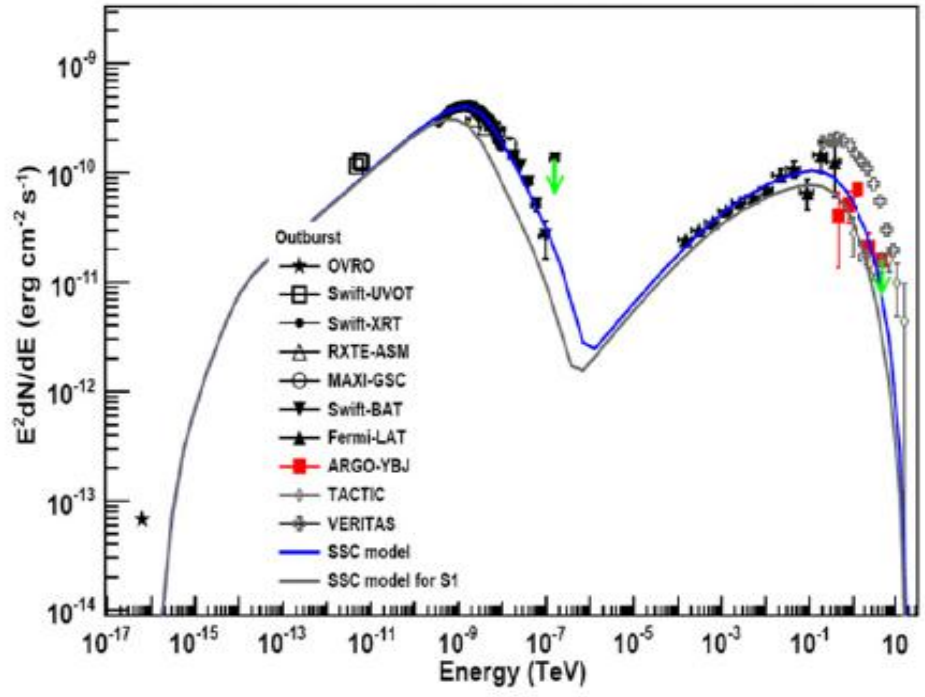


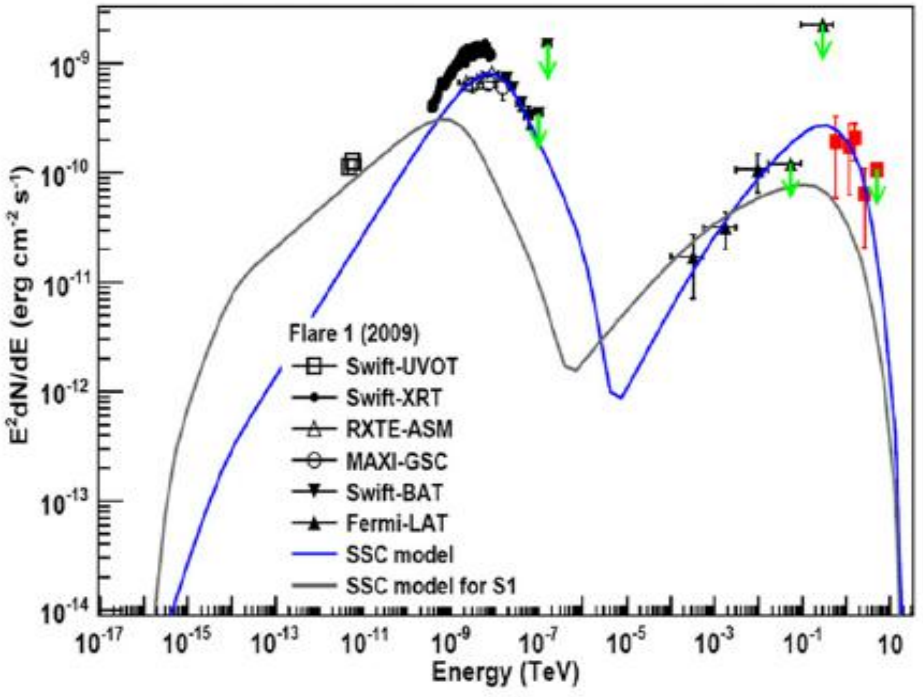
Bartoli, B. et al. 2016, ApJS, 222, 6


S1
OB
F1
F2
F3
F4
S2
F5
S2
F6
F7
2009
2010
2011
2012
2013
(a) ARGO-YBJ (TeV)
Event rate (Day^{-1})
(b) Fermi-LAT (>0.3GeV)
Photons (10^{-7} cm^{-2} s^{-1})
(c) Swift-BAT (15-50keV)
Photons (10^{-3} cm^{-2} s^{-1})
54800
55000
55200
55400
55600
55800
56000
56200


Steady 1
OVRO
Swift-UVOT
Swift-XRT
RXTE-ASM
Swift-BAT
Fermi-LAT
ARGO-YBJ
Abdo et al. 2011
SSC model
E²dN/dE (erg cm⁻² s⁻¹)
Energy (TeV)


Steady 2
OVRO
Swift-UVOT
Swift-XRT
MAXI-GSC
Swift-BAT
Fermi-LAT
ARGO-YBJ
Abdo et al. 2011
SSC model
SSC model for S1
E²dN/dE (ergs cm⁻² s⁻¹)
Energy (TeV)


Outburst
OVRO
Swift-UVOT
Swift-XRT
RXTE-ASM
MAXI-GSC
Swift-BAT
Fermi-LAT
ARGO-YBJ
TACTIC
VERITAS
SSC model
SSC model for S1
E²dN/dE (erg cm⁻² s⁻¹)
Energy (TeV)

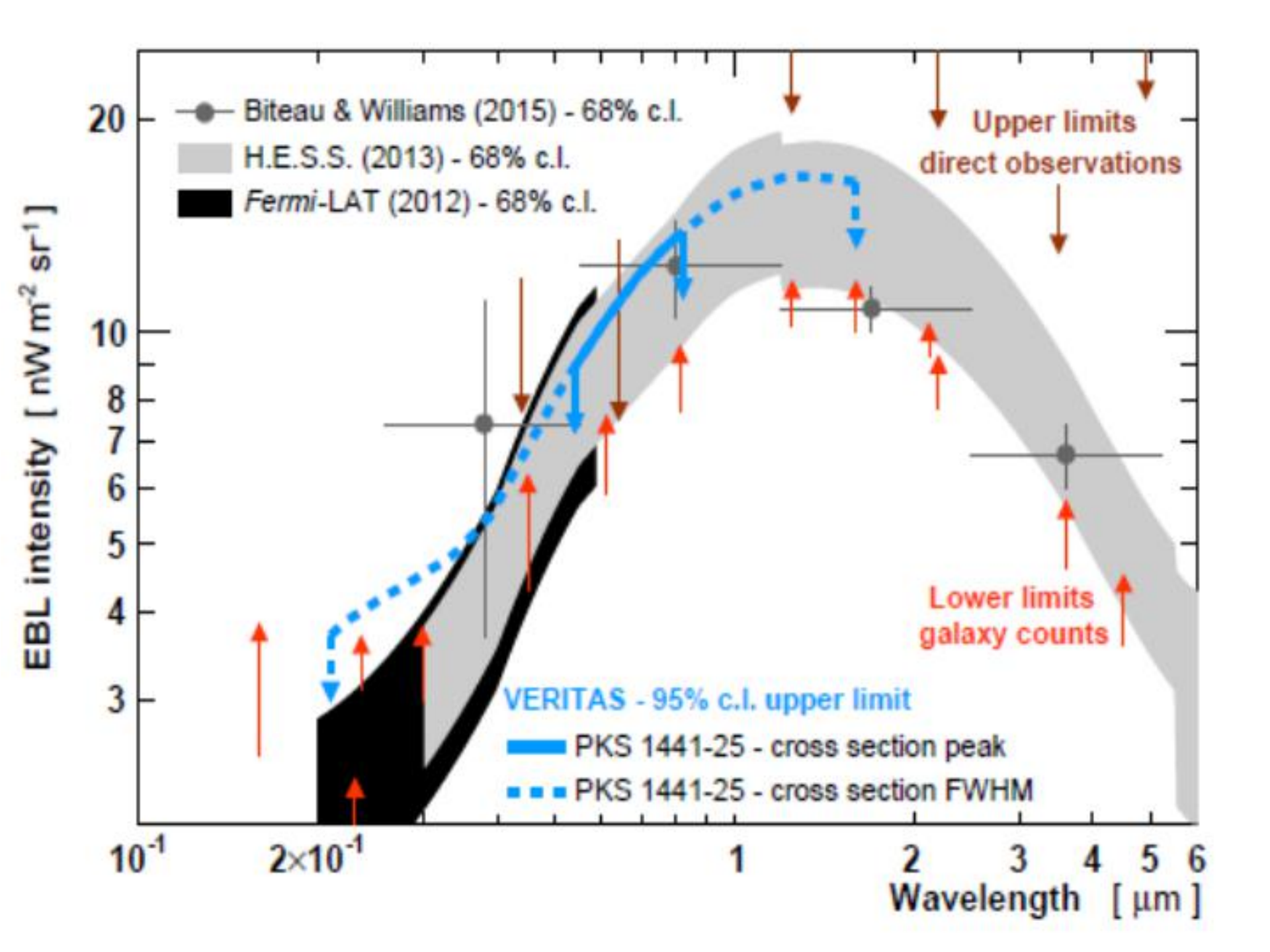

Flare 1 (2009)
Swift-UVOT
Swift-XRT
RXTE-ASM
MAXI-GSC
Swift-BAT
Fermi-LAT
SSC model
SSC model for S1
E²dN/dE (erg cm⁻² s⁻¹)
Energy (TeV)

Highlights from the VERITAS

- VERITAS comprises four 12 meter telescopes on an average baseline of 100 meters.
- Each telescope of Davies-Cotton design has a 3.5 FoV camera with 499 PMTs, currently 2.5 cm diameter Hamamatsu high quantum efficiency tubes with a 0.15^0 spacing.

Fortsan, L. et al. 2016, Journal of Physics, 718, 052013

- The VERITAS blazar program has detected 34 of the 50 northern hemisphere known VHE AGN including seven IBLs, two FSRQs and two FR 1 galaxies.
- Twelve of these detections are VERITAS discoveries.

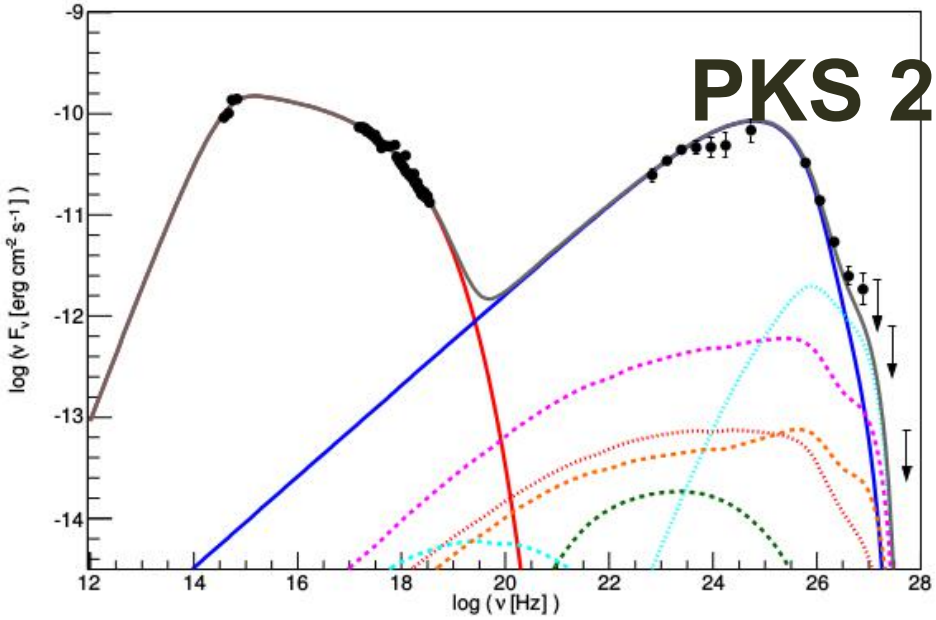

Biteau & Williams (2015) - 68% c.l.
H.E.S.S. (2013) - 68% c.l.
Fermi-LAT (2012) - 68% c.l.
Upper limits
direct observations
Lower limits
galaxy counts
VERITAS - 95% c.l. upper limit
PKS 1441-25 - cross section peak
PKS 1441-25 - cross section FWHM
EBL intensity [nW m-2 sr-1]
Wavelength [μm]
20
10
8
7
6
5
4
3
10-1
2×10-1
1
2
3
4
5
6

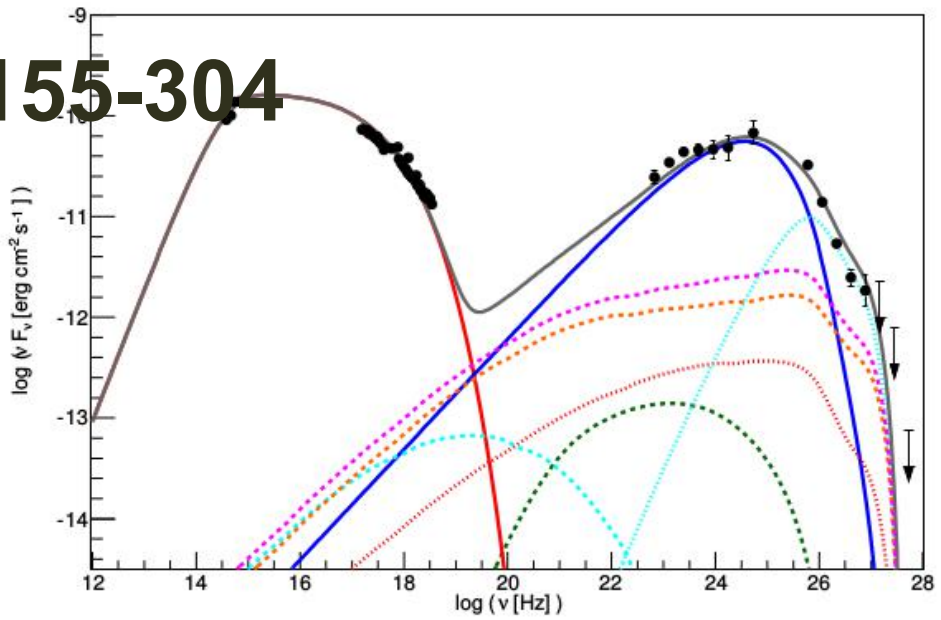
Testing hadronic model

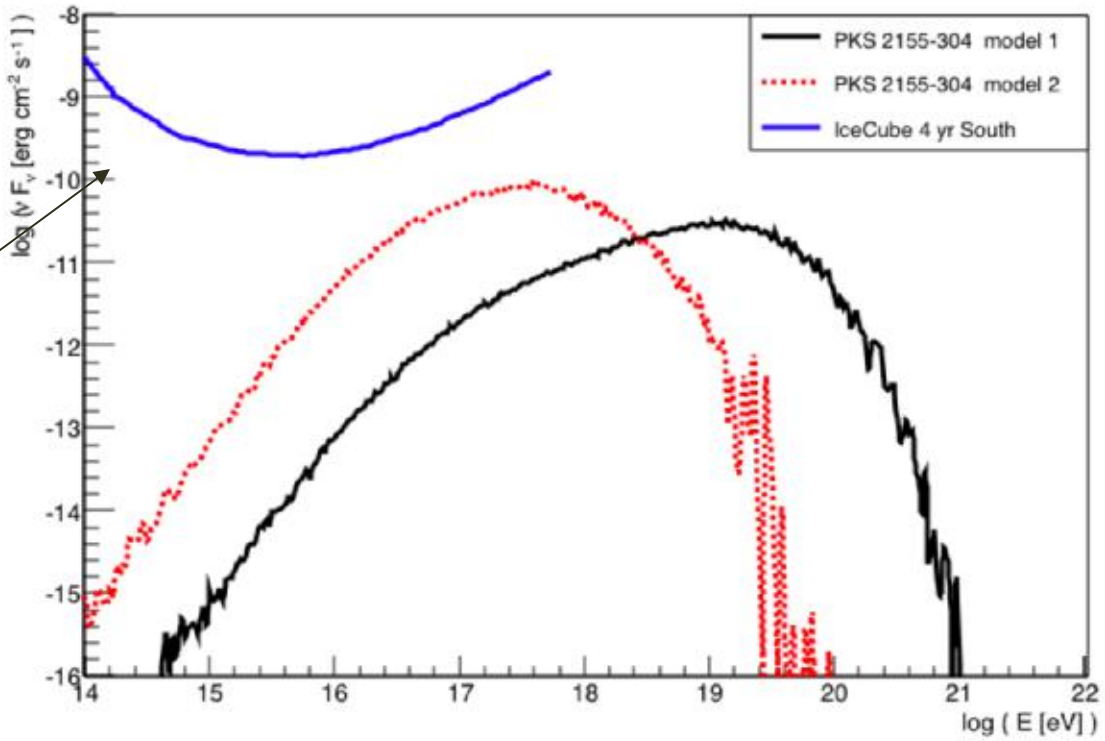
- Blazar emission models are usually divided leptonic and hadronic
- Leptonic models have been successful in explaining the gamma-ray emission from most blazars.
- Hadronic models still present an intriguing alternative. They have the unique advantage to link the emission of photons, neutrinos, and cosmic rays from blazars.

Cerruti, M. et al. 2016, arXiv1610.0255

PKS 2155-304

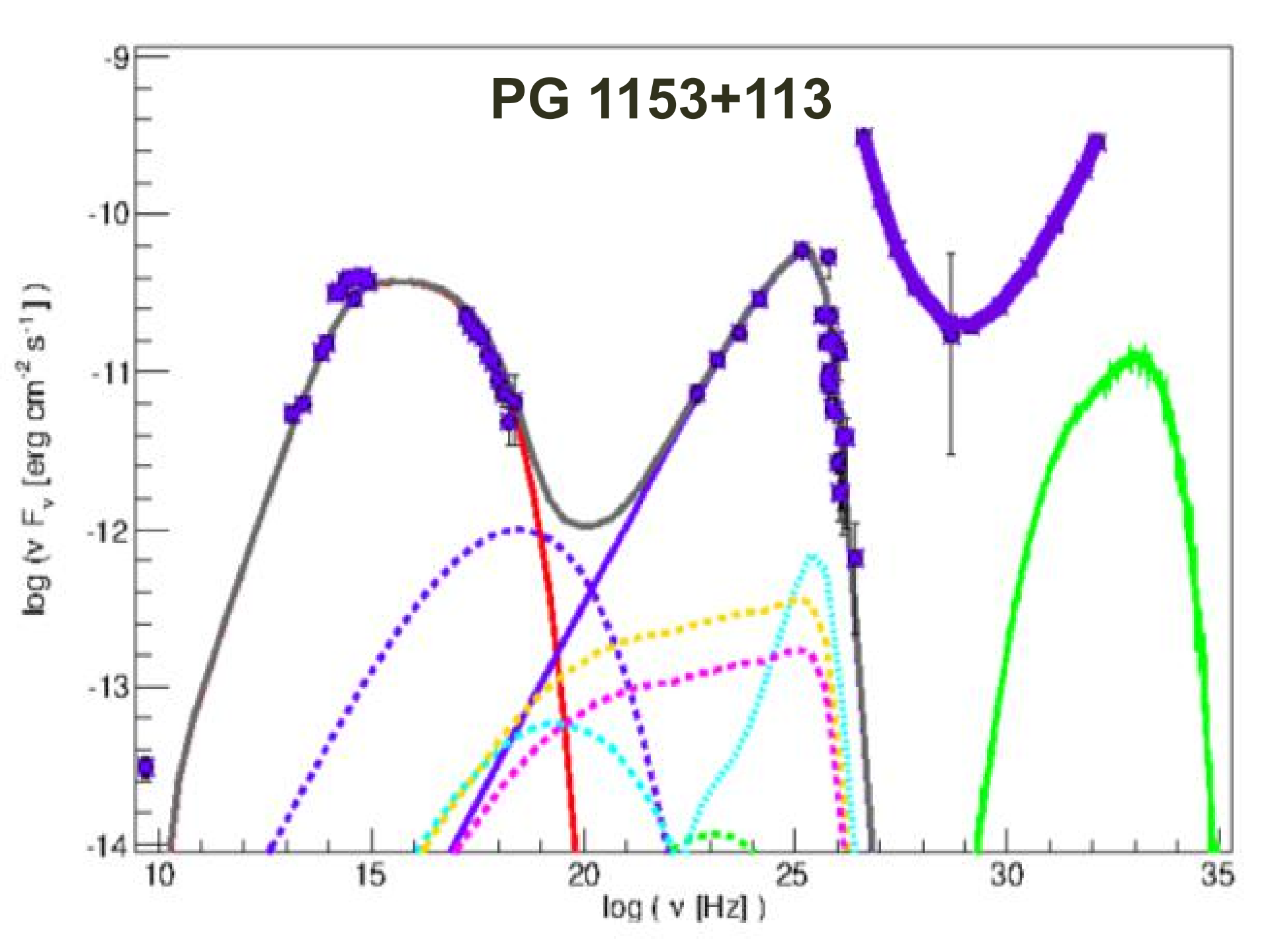






IceCube 4 year Obs.

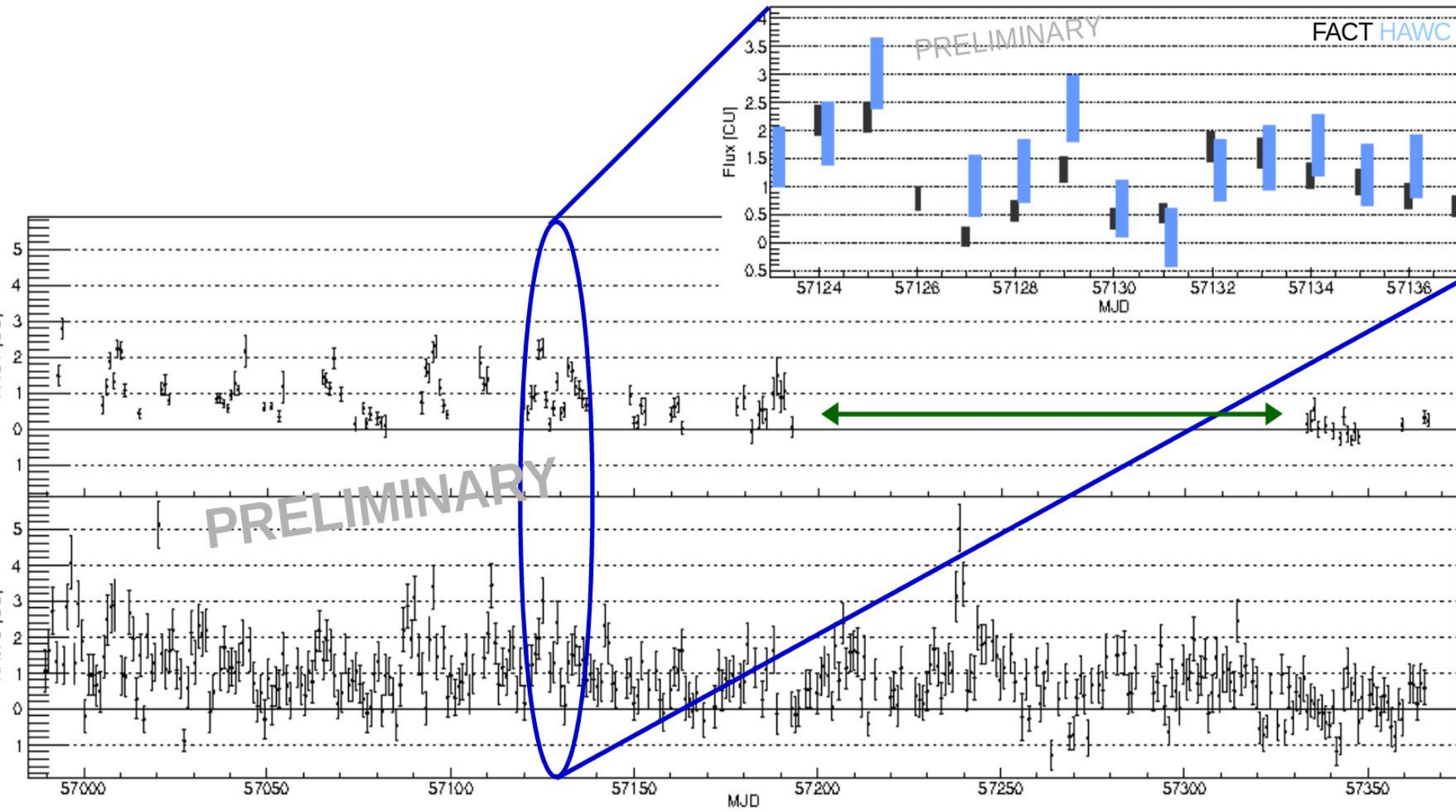
Neutrino emission


PG 1153+113
log (ν F_ν [erg cm^-2 s^-1])
log (ν [Hz])
-9
-10
-11
-12
-13
-14
10
15
20
25
30
35

Blazar Light Curves with FACT and HAWC

- First G-APD Cherenkov Telescope (FACT)
- ✓ It is the first telescope using silicon based photosensors (SiPM, Geiger-mode Avalanche Photo-Diodes (G-APDs)) with a reflective area of 9.5 sqm,
- ✓ A trigger threshold of 350 GeV and an analysis threshold of 750 GeV are reached.

- High Altitude Water Cherenkov (HAWC) Observatory
- ✓ It has been operating since March 2015 in its 300 Water Cherenkov Detectors (WCDs) that instrument an area of 22,000 m2.
- ✓ The array is sensitive to gamma rays with energies from 100 GeV to 100 TeV with a peak sensitivity in the range 2 to 10 TeV, depending on source declinations and spectra.



88 nights from Mrk 421 and 120 nights of Mrk 501

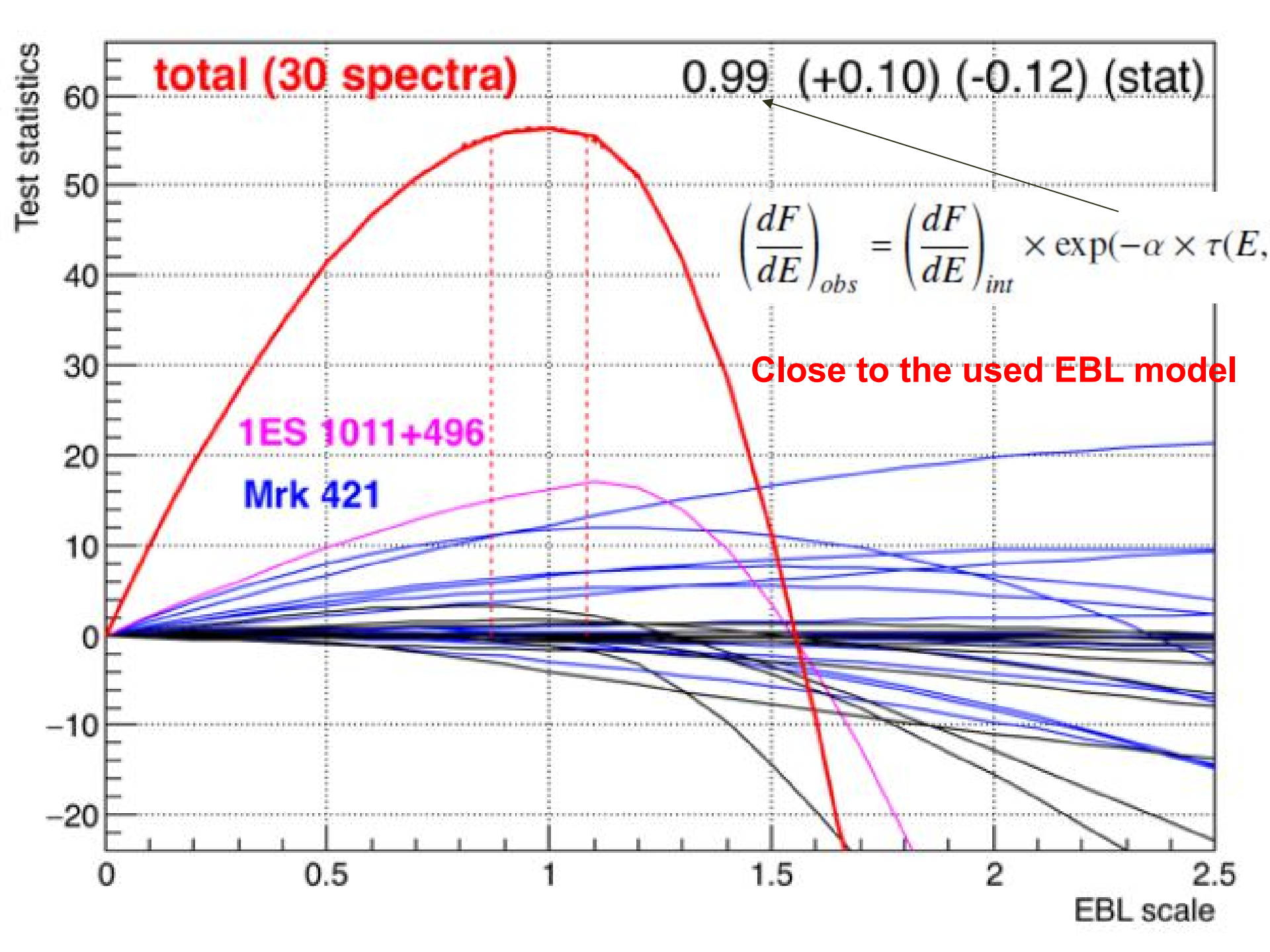
Dorner, D. et al. 2016, arXiv 1610.0662

EBL Constraints Using a Sample of TeV blazars with the MAGIC Telescopes

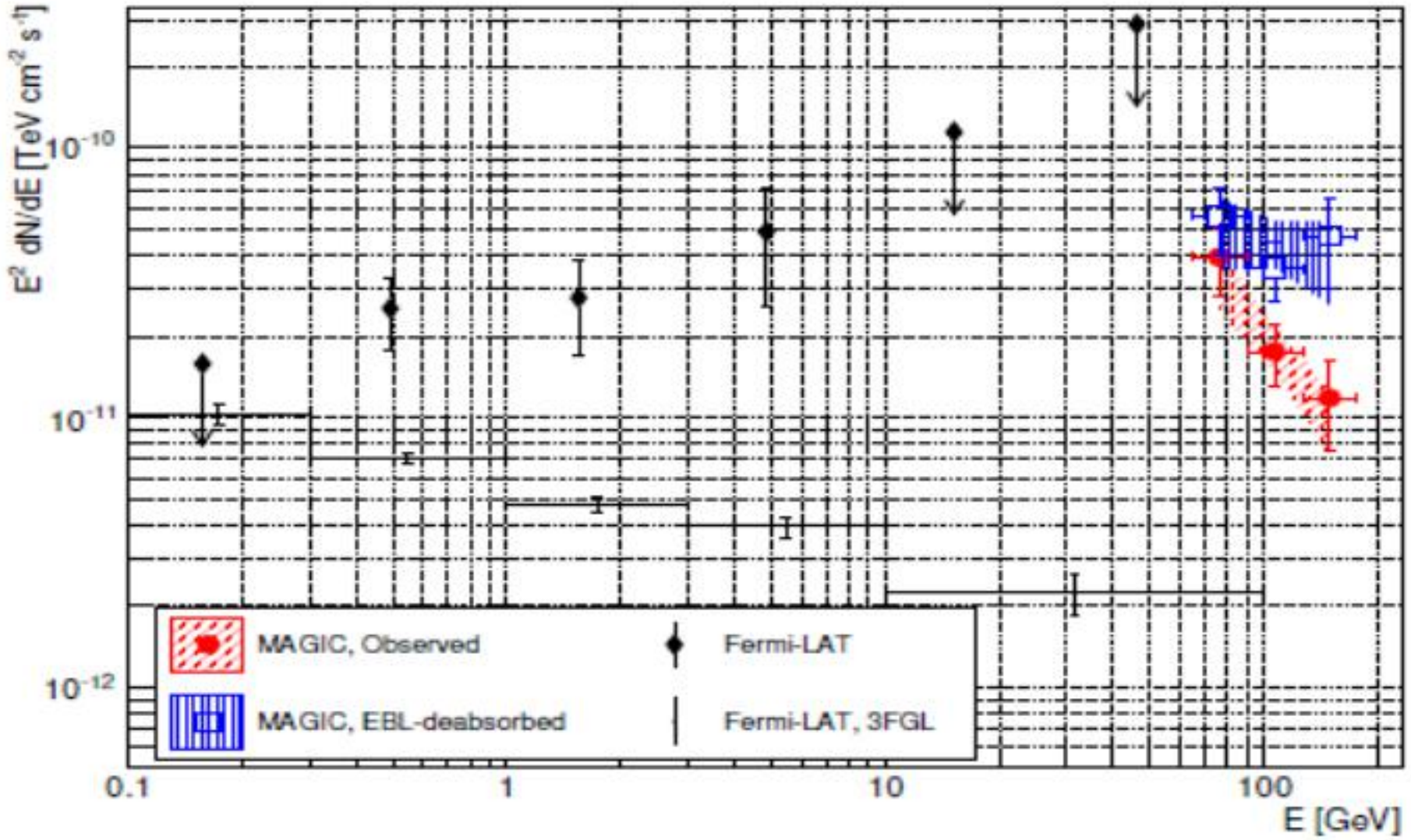
TABLE 1. The data set used in this analysis.

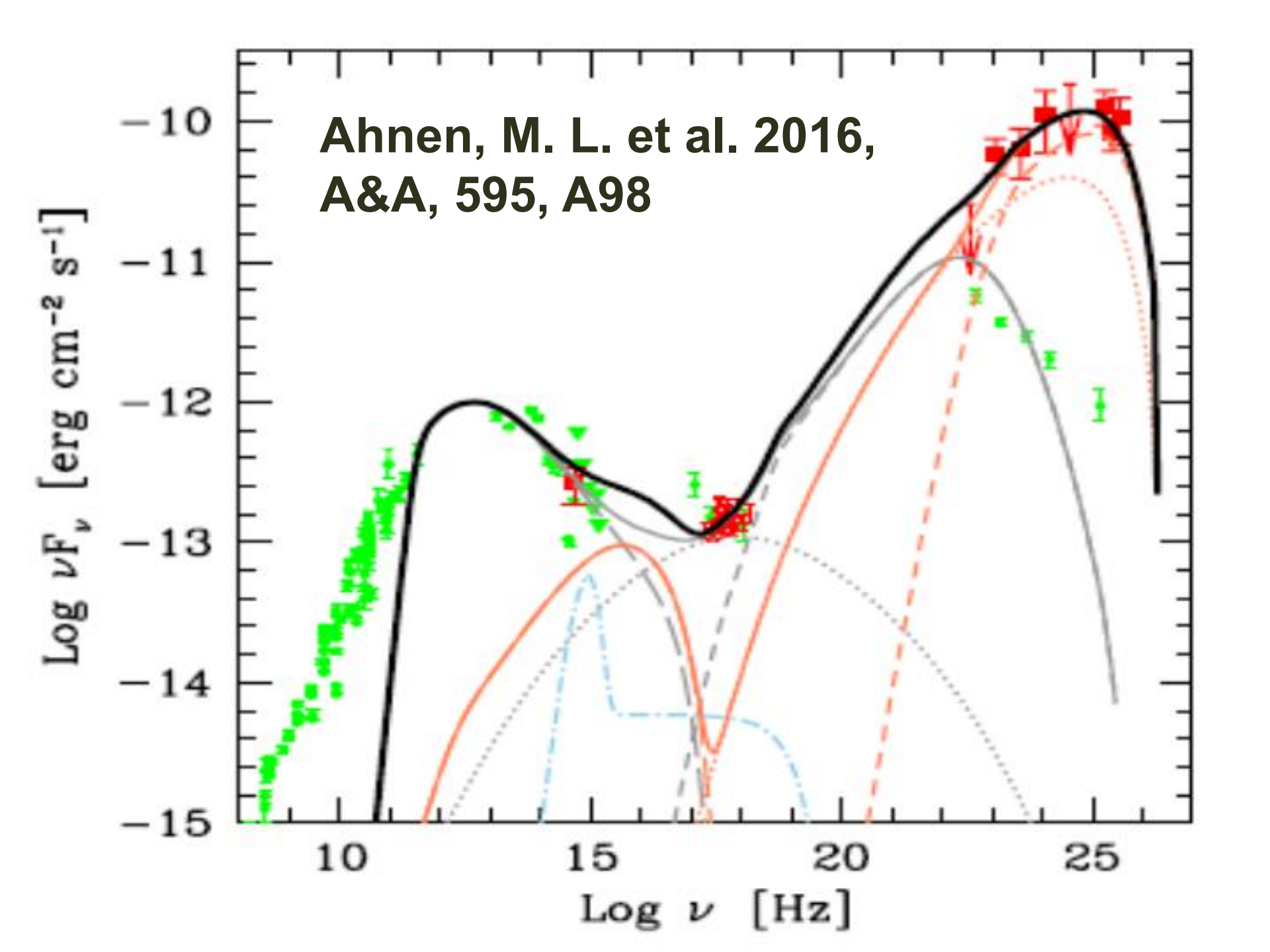
Source Name	AGN Type	Redshift z	Data Taken Period	Effective Time (h)
Mrk 421	HBL	0.031	2013 Apr 10-19, 2014 Apr 26	40.4
1ES 1959+650	HBL	0.048	2015 Nov 6-18	4.8
OT 546 (1ES 1727+502)	HBL	0.055	2015 Oct 11 - Nov 2	6.4
BL Lacertae	HBL	0.069	2015 June 15	1.0
1ES 0229+200	HBL	0.140	2012 - 2015	105.2
1ES 1011+496	HBL	0.212	2014 Feb - Mar 7	11.8
PKS 1510-089	FSRQ	0.361	2015 May 18 - 19	2.4
PKS 1222+216	FSRQ	0.432	2010 Jun 18	0.5
PG 1553+113	HBL	0.43-0.58	2012 - 2016	66.3
PKS 1424+240	HBL	0.601	2014 Mar 24 - Jun 18	28.2
PKS 1441+25	FSRQ	0.939	2015 Apr 18 - 23	20.1
B 0218+35	FSRQ	0.944	2014 Jul 25 - 26	2.1
Total				**289.2**

Mazin, D. et al. 2016, arXiv 1610.09633

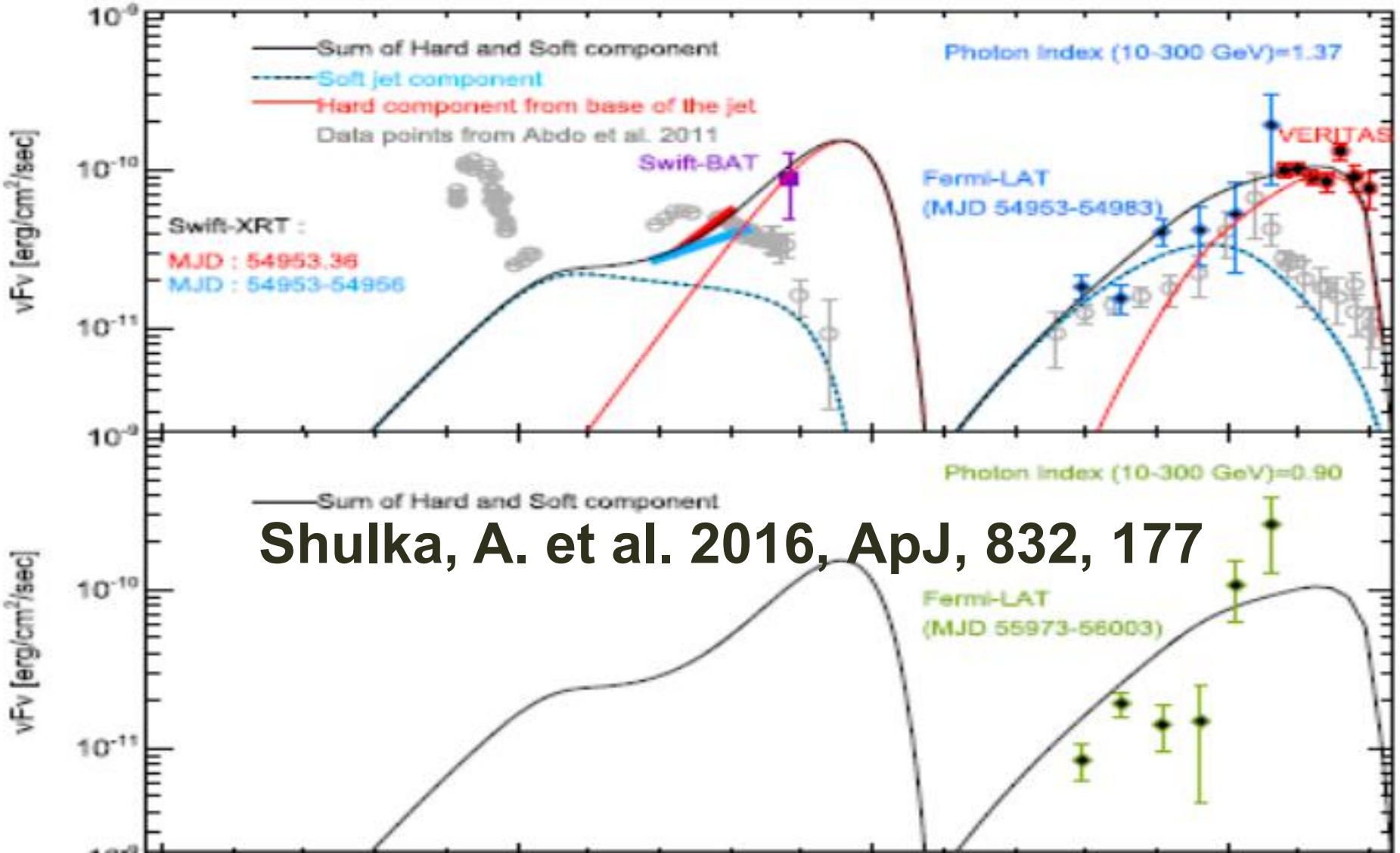

total (30 spectra)
0.99 (+0.10) (-0.12) (stat)
$\left(\frac{dF}{dE}\right)_{obs} = \left(\frac{dF}{dE}\right)_{int} \times \exp(-\alpha \times \tau(E,$
Close to the used EBL model
1ES 1011+496
Mrk 421
Test statistics
EBL scale
60
50
40
30
20
10
0
−10
−20
0
0.5
1
1.5
2
2.5

VHE emission of lensed blazar QSO B0218+357 with MAGIC




Ahnen, M. L. et al. 2016,
A&A, 595, A98
−10
−11
−12
−13
−14
−15
Log νF_ν [erg cm⁻² s⁻¹]
10
15
20
25
Log ν [Hz]

Very Hard γ-ray Spectrum in Mrk501

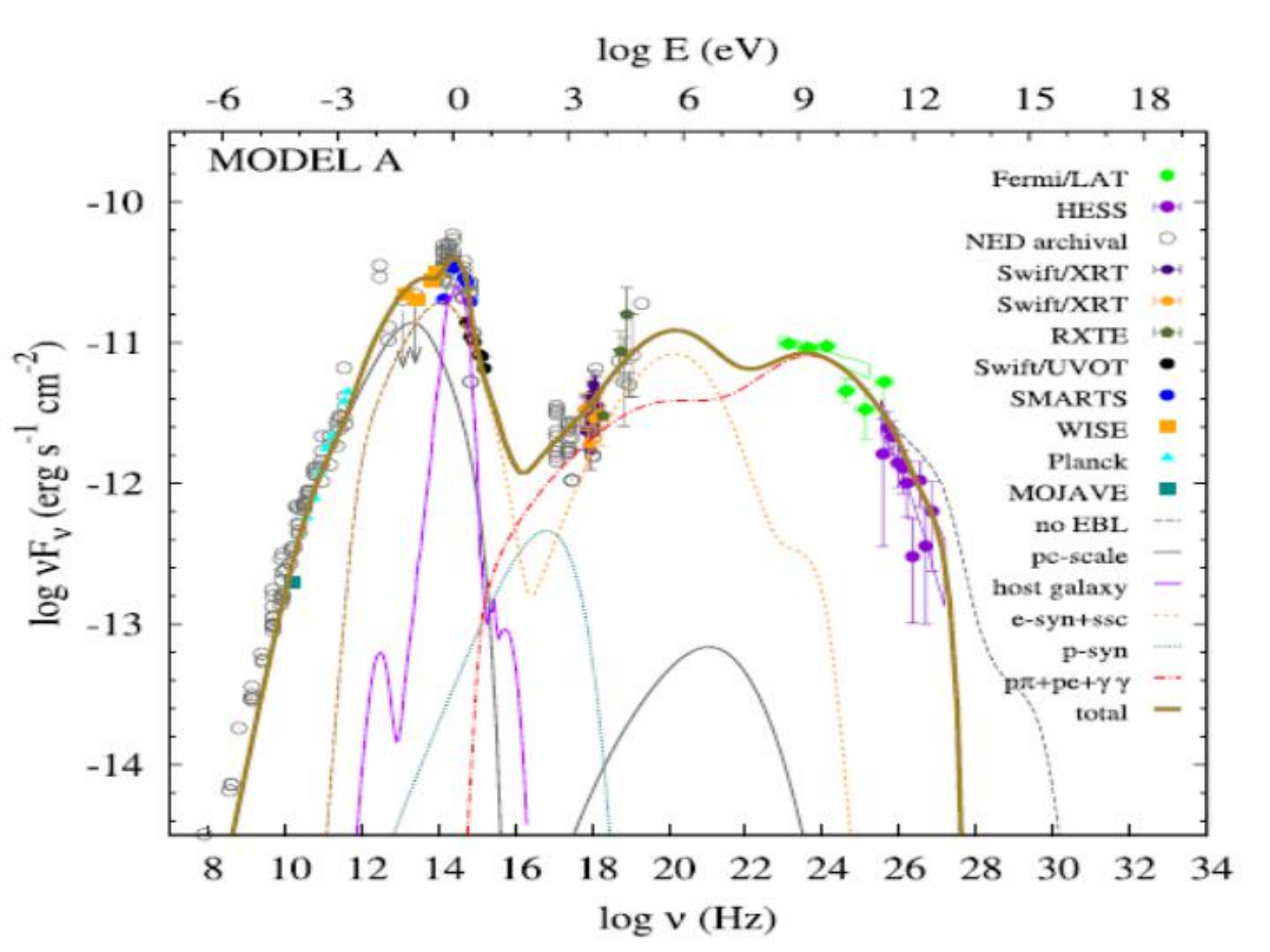


Shulka, A. et al. 2016, ApJ, 832, 177

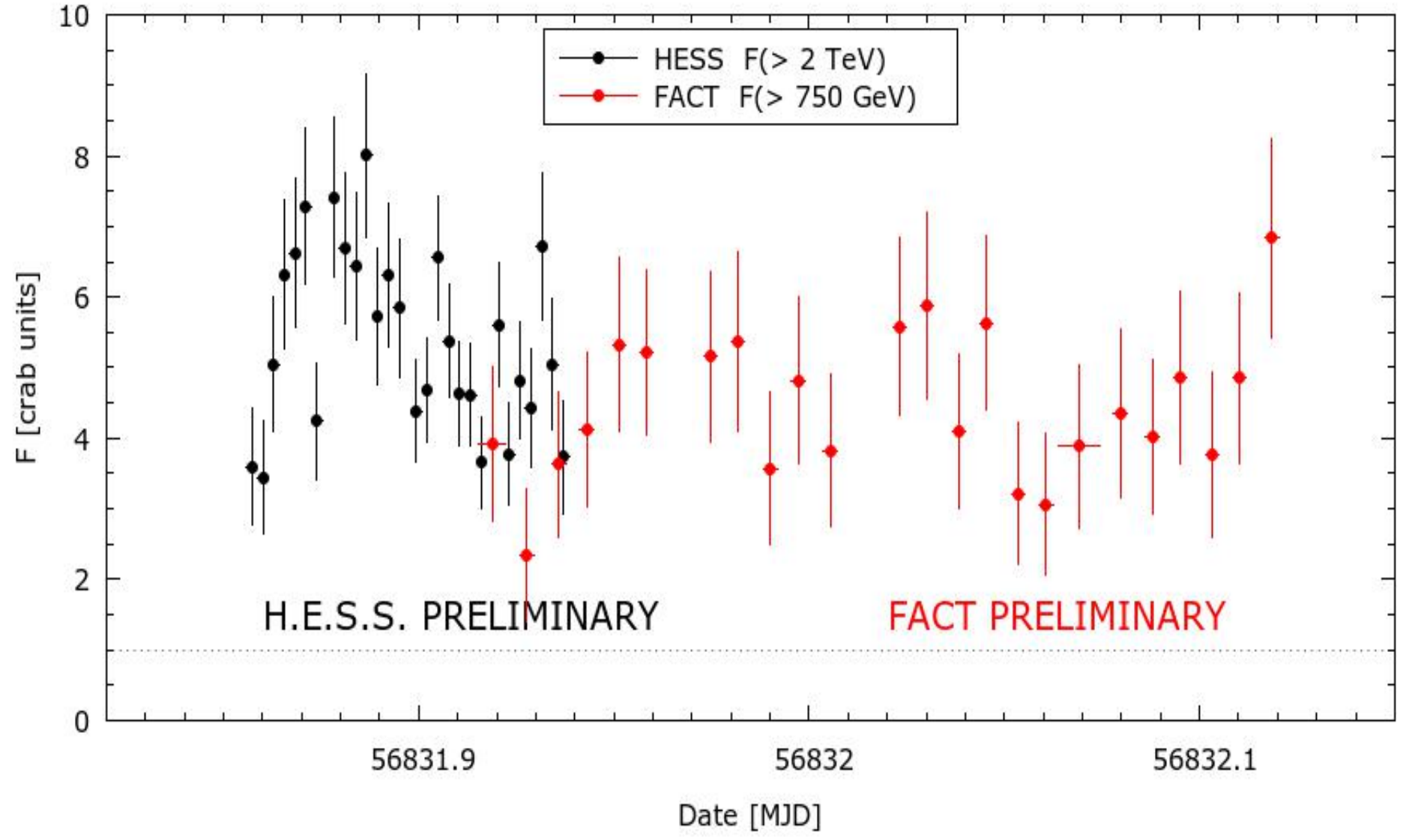
The TeV emission of Ap Librae: a hadronic interpretation

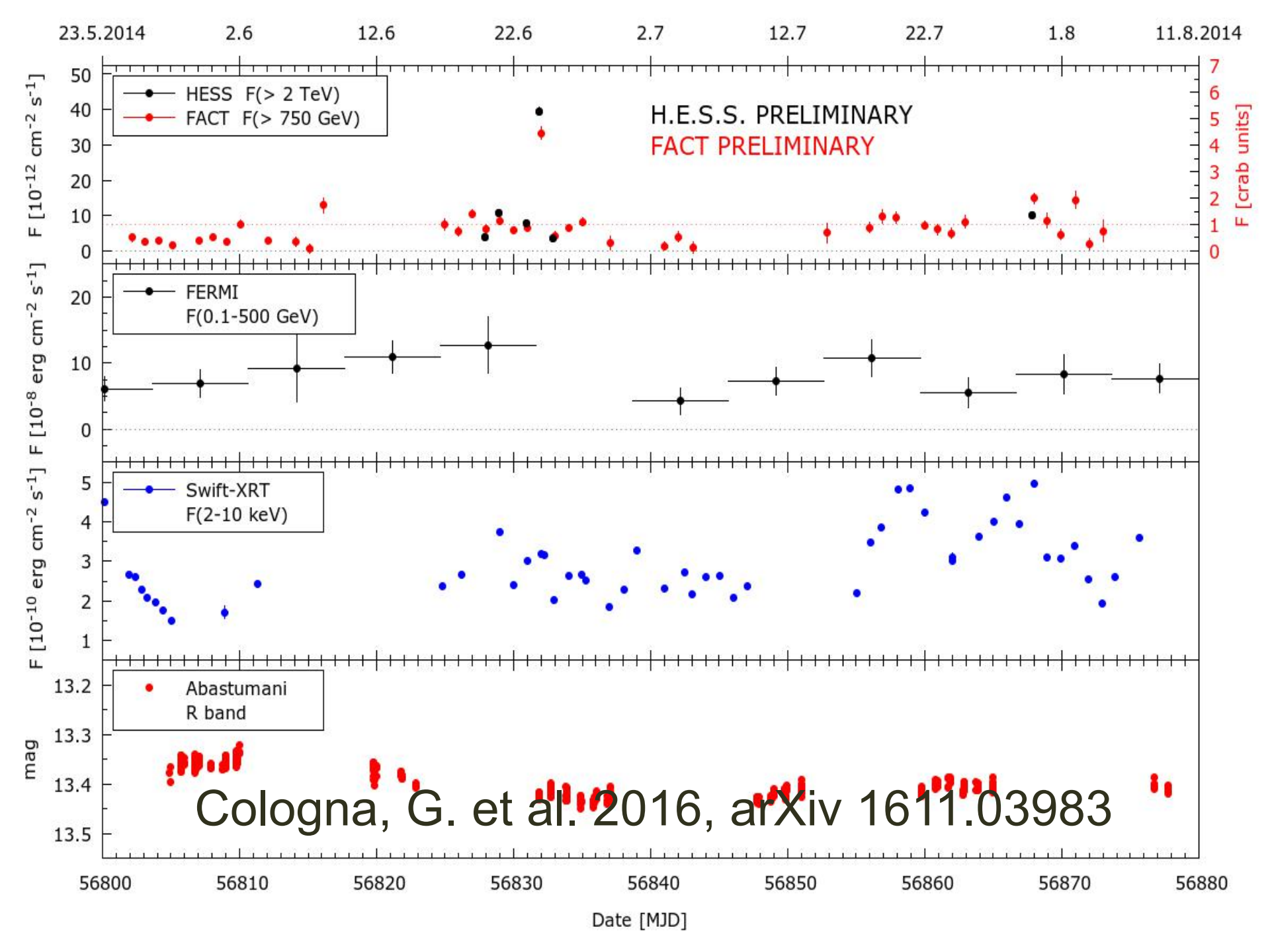
- Ap Librae is LBL detected at TeV γ -rays and the only one with an identified X-ray jet
- The presence of a broad HE component that extends more than nine orders of magnitude in energy (from X-rays to TeV γ –rays) (Leptonic model?)
- Hadronic model can explain the γ -ray emission of Ap Librae.
- **VHE Variability?(CAT,LASSHO)**

Petropoulou, M. et al. 2016, MNRAS, 464, 2213


log E (eV)
-6
-3
0
3
6
9
12
15
18
MODEL A
-10
-11
-12
-13
-14
log νF$_\nu$ (erg s^{-1} cm^{-2})
Fermi/LAT
HESS
NED archival
Swift/XRT
Swift/XRT
RXTE
Swift/UVOT
SMARTS
WISE
Planck
MOJAVE
no EBL
pc-scale
host galaxy
e-syn+ssc
p-syn
pπ+pe+γγ
total
8
10
12
14
16
18
20
22
24
26
28
30
32
34
log ν (Hz)

The Exceptional Flare of Mrk 501 in 2014 with H.E.S.S. and FACT




23.5.2014
2.6
12.6
22.6
2.7
12.7
22.7
1.8
11.8.2014
HESS F(> 2 TeV)
FACT F(> 750 GeV)
H.E.S.S. PRELIMINARY
FACT PRELIMINARY
F [10^-12 cm^-2 s^-1]
F [crab units]
FERMI
F(0.1-500 GeV)
F [10^-8 erg cm^-2 s^-1]
Swift-XRT
F(2-10 keV)
F [10^-10 erg cm^-2 s^-1]
Abastumani
R band
mag
Cologna, G. et al. 2016, arXiv 1611.03983
Date [MJD]