Max Planck Institute for Physics
The MAGIC Telescope

Detailed Characterization and Scientific Interpretation of the Broadband Emission of Mrk 421 during Flaring Activity in 2010

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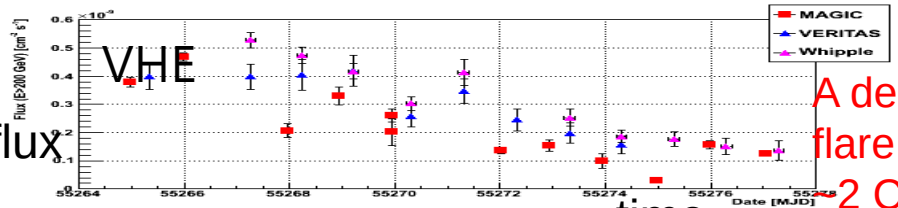
Nicola Galante , Matteo Perri

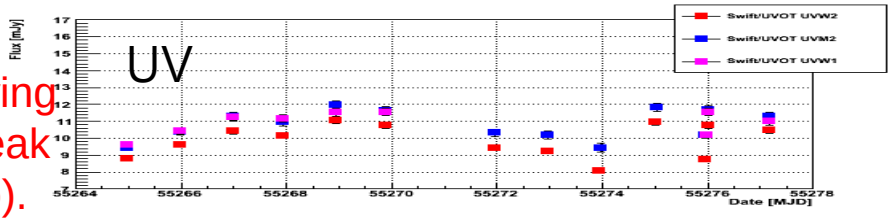
11_02_2013

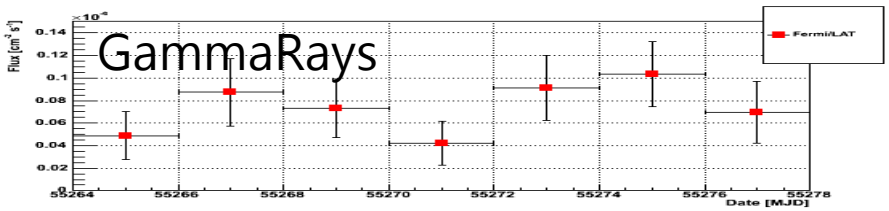


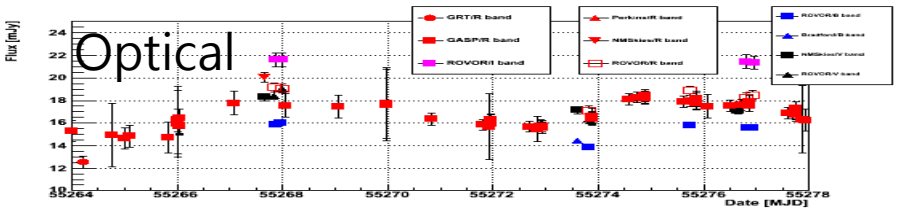
flux

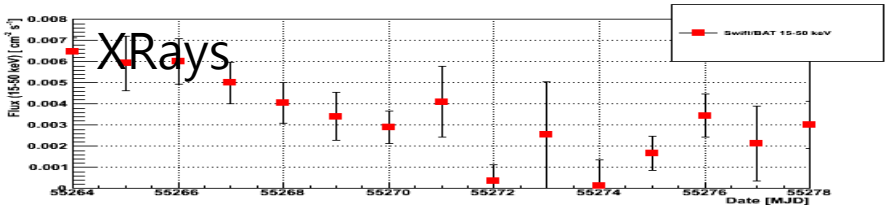
time

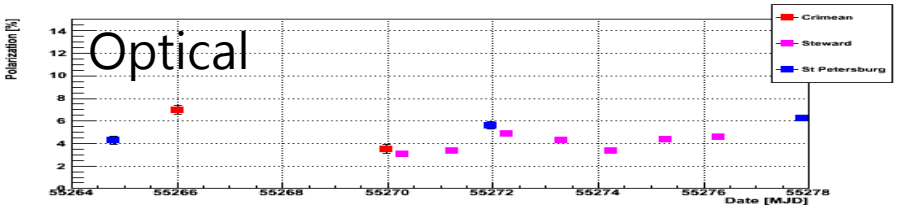
A decaying flare (peak ~2 Crab).

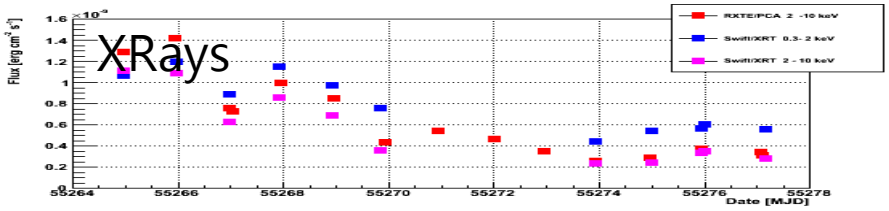


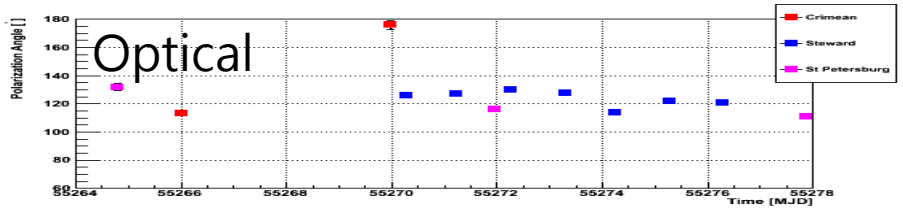


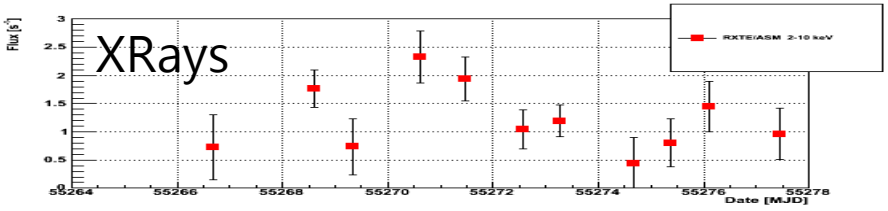


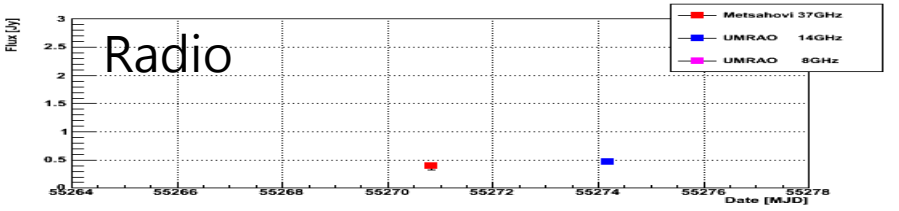


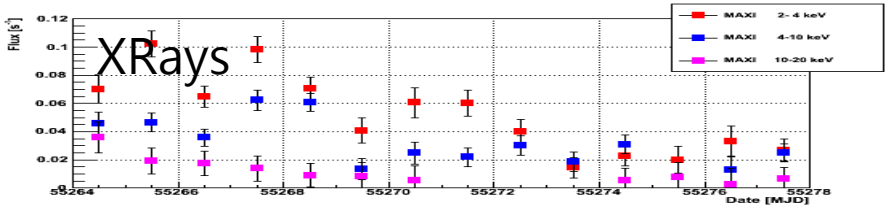












Mrk421 2010 March flare

MW light curves

What is new with respect to November collaboration meeting??

1. Original : 9 frames of daily MW SEDs (dates when there are MAGIC SEDs)
   MJD 55265 66 68 69 70 73 74 76 77

   This version: 4 frames added (use Fermi, RXTE, Swift, optical, radio)
   67 71 72 75
   and their one-zone, two-zone SSC model fittings

2. Original : low-variability SED points (UV(W2, M2, W1), optical I, R, V, B bands, radio(37, 14, 8 GHz)) : if no simultaneous observation, then use the average of 6-month data

   This version: use the observation on the closest date

What is new with respect to November collaboration meeting?? (II)

3. Original : Swift SED for tag MJD 55269 actually averages MJD 55269 and 55272

   This version: Matteo Perri re-analyzed and made separated SEDs (MJD 55269 and 55272)
   fitting modified

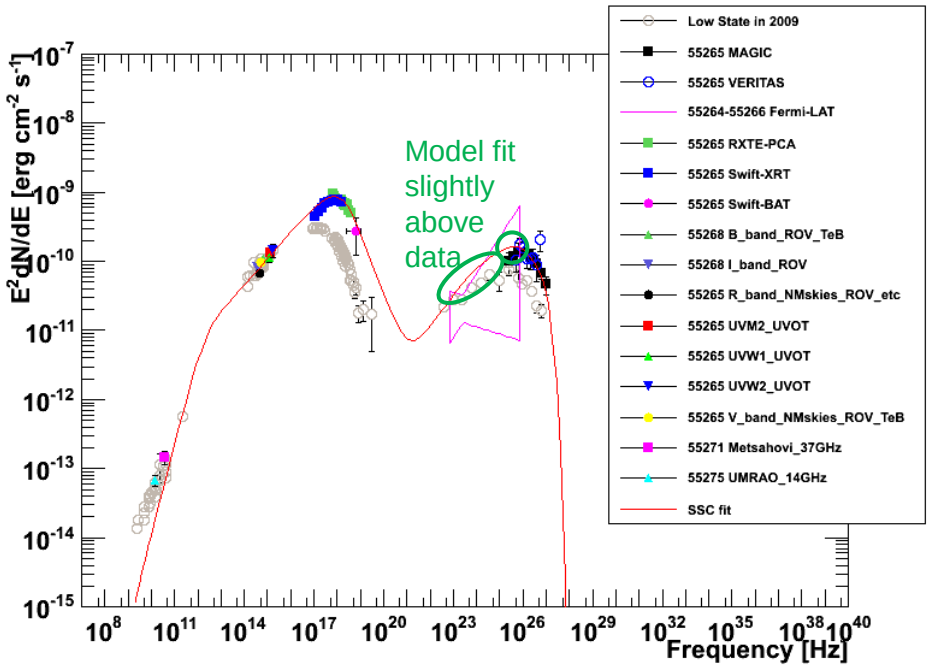
4. Original : no VERITAS daily SEDs

   This version: Nicola Galante provided 9 VERITAS daily SEDs
   fitting modified

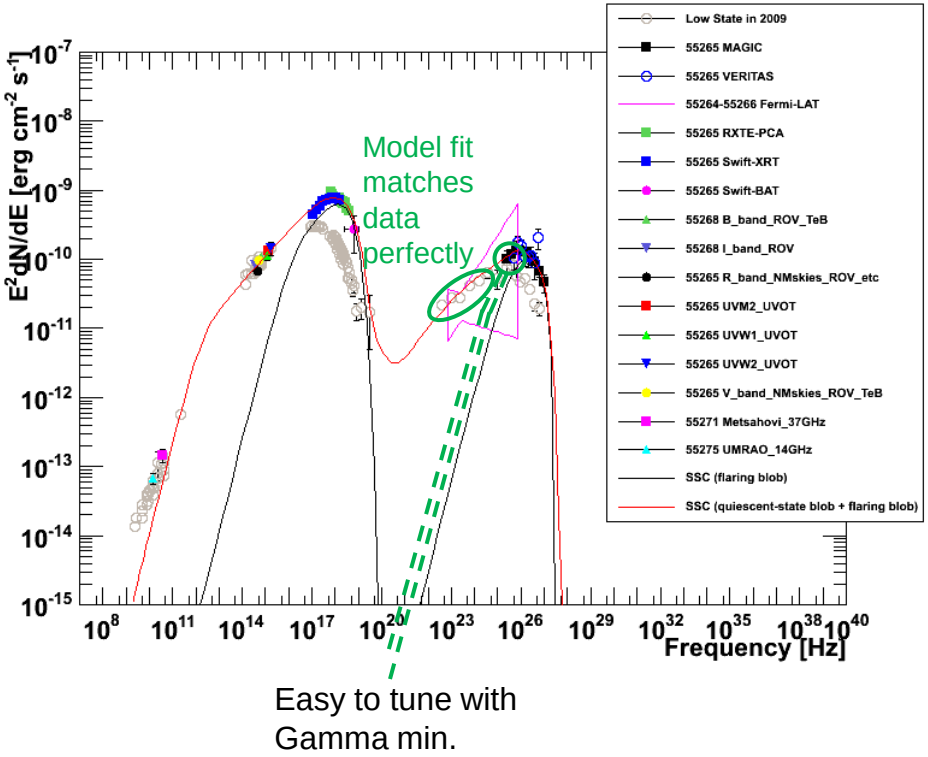
MAGIC, VERITAS, Fermi, RXTE, Swift,
many optical and radio instruments
***13 daily successive* frames of broadband MW**
SEDs depicts the flare : (following 13 pages)

Mrk421 MW 2010_03_10 (55265)

1 blob, 2 breaks



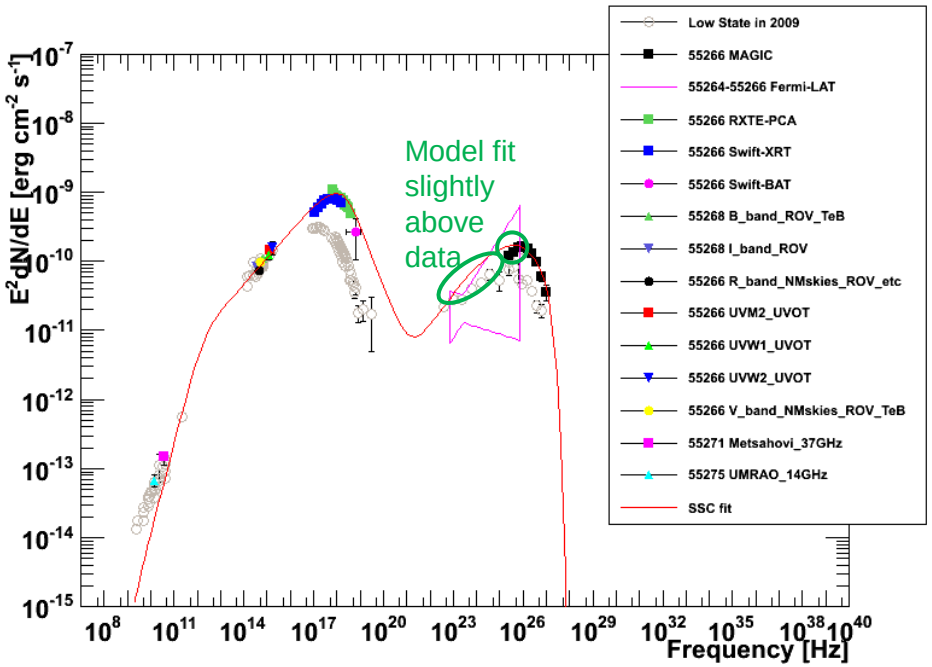
2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks



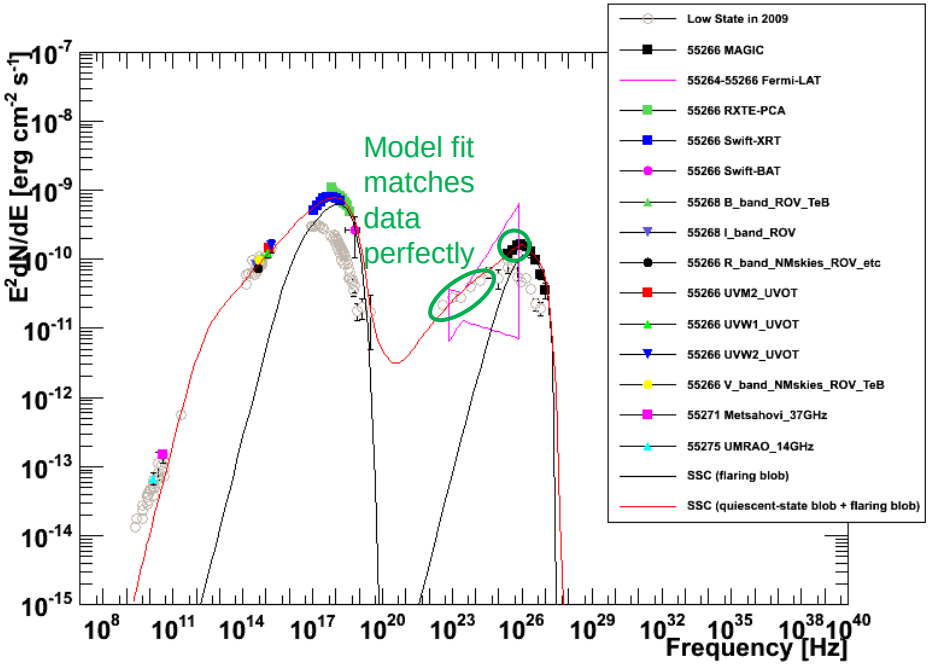
Easy to tune with Gamma min.

Mrk421 MW 2010_03_11 (55266)

1 blob, 2 breaks

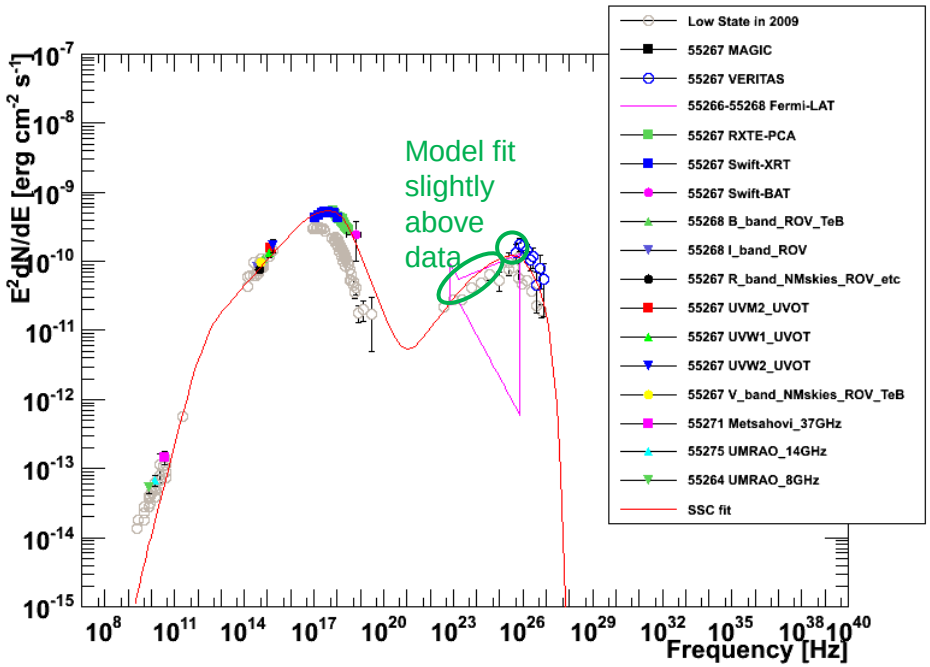


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

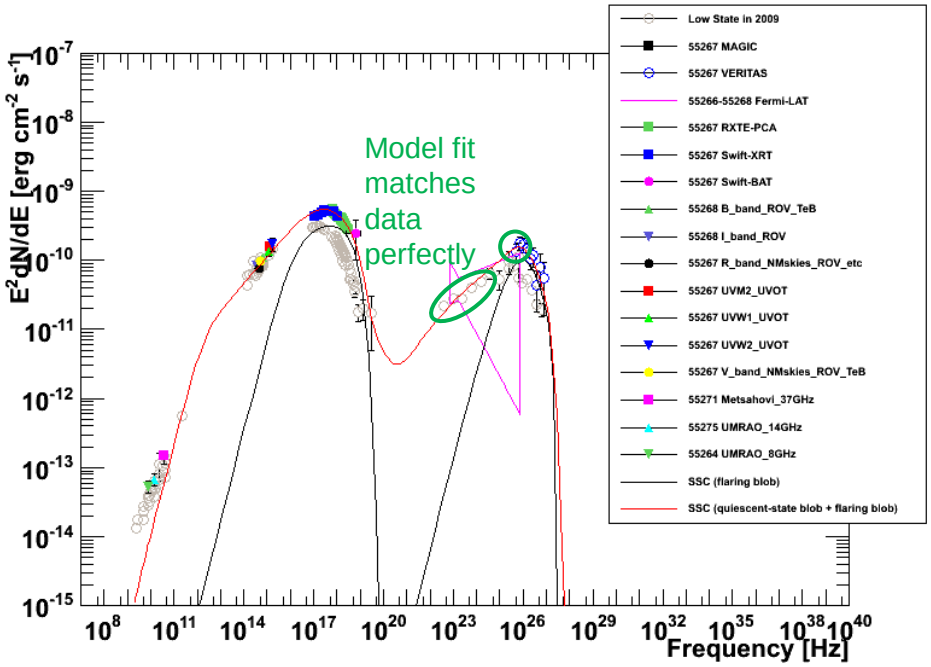


Mrk421 MW 2010_03_12 (55267)

1 blob, 2 breaks

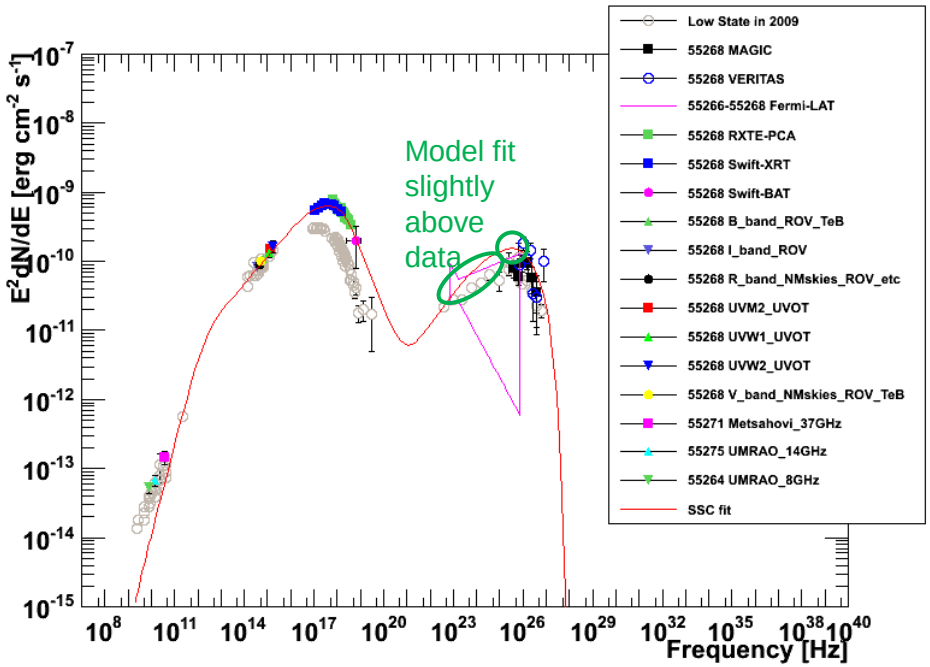


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

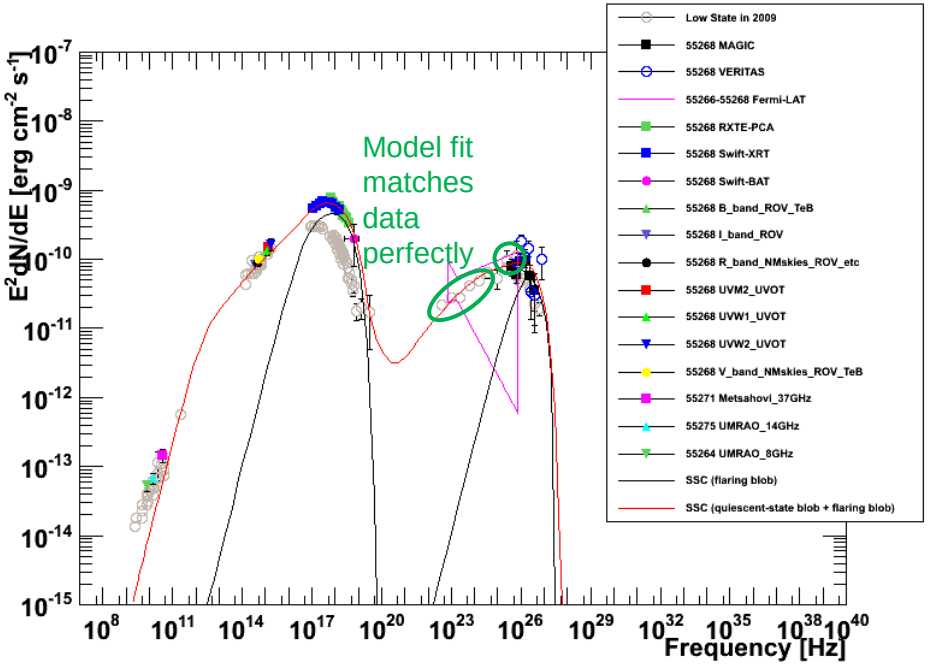


Mrk421 MW 2010_03_13 (55268)

1 blob, 2 breaks

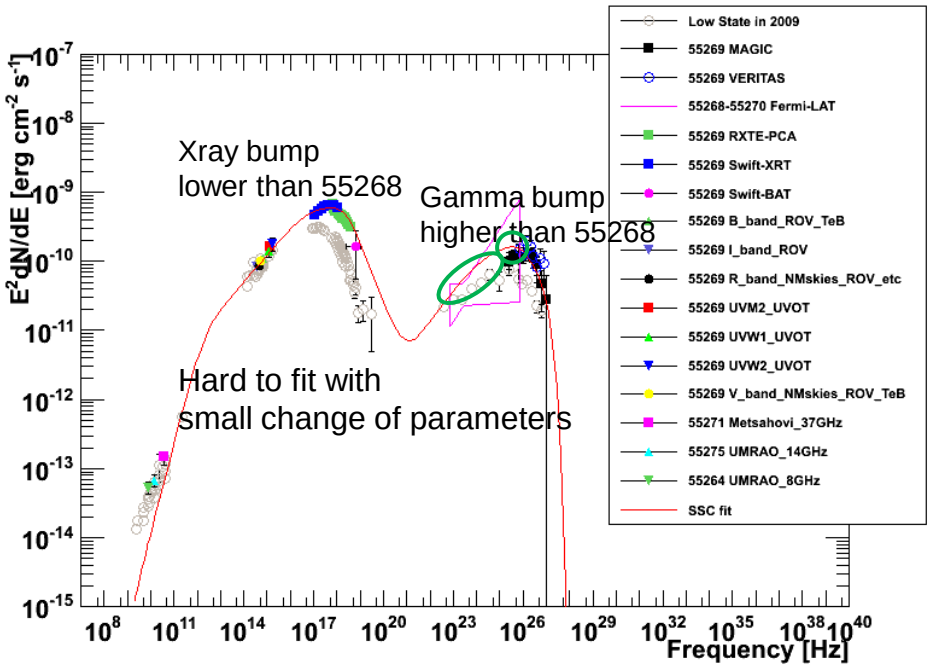


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

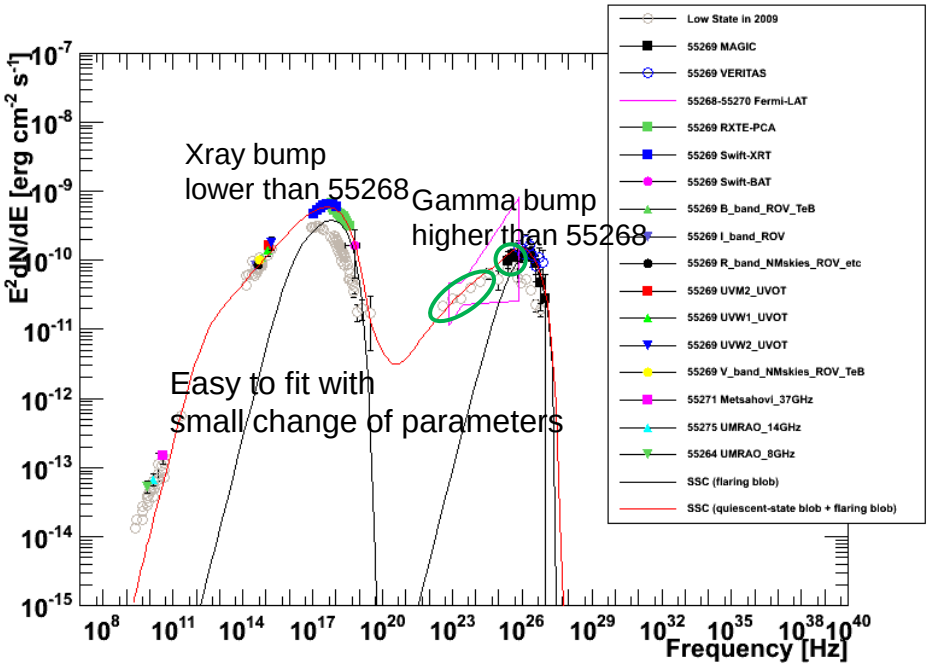


Mrk421 MW 2010_03_14 (55269)

1 blob, 2 breaks

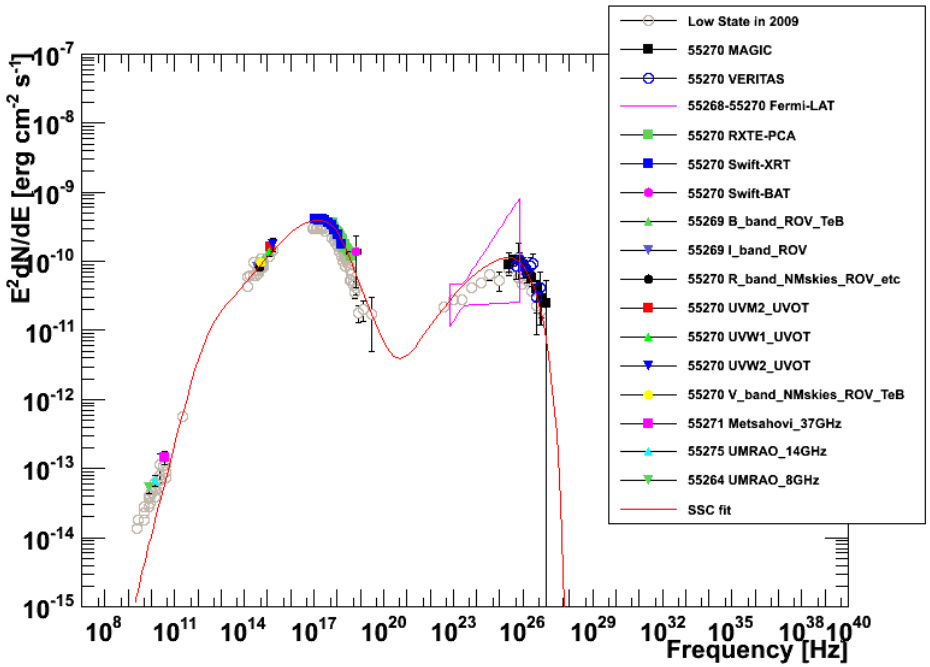


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks



Mrk421 MW 2010_03_15 (55270)

1 blob, 2 breaks



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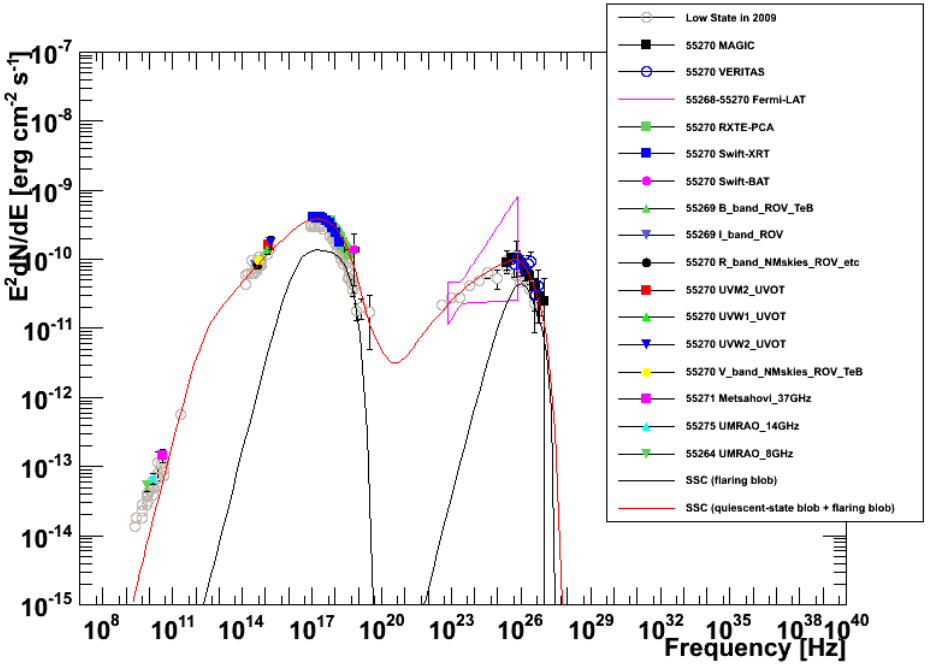
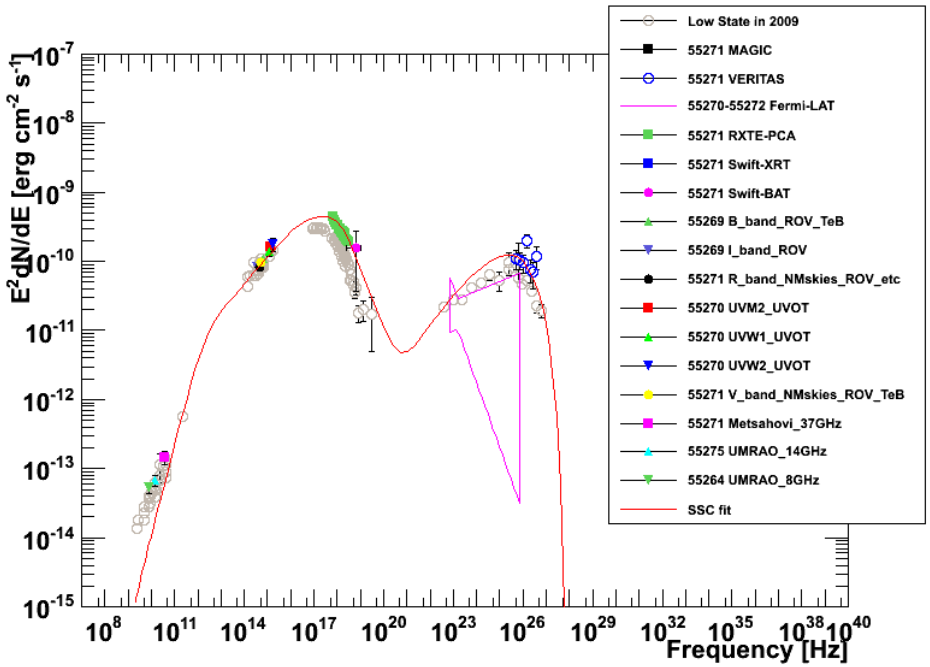
Quiescent blob: 2 breaks

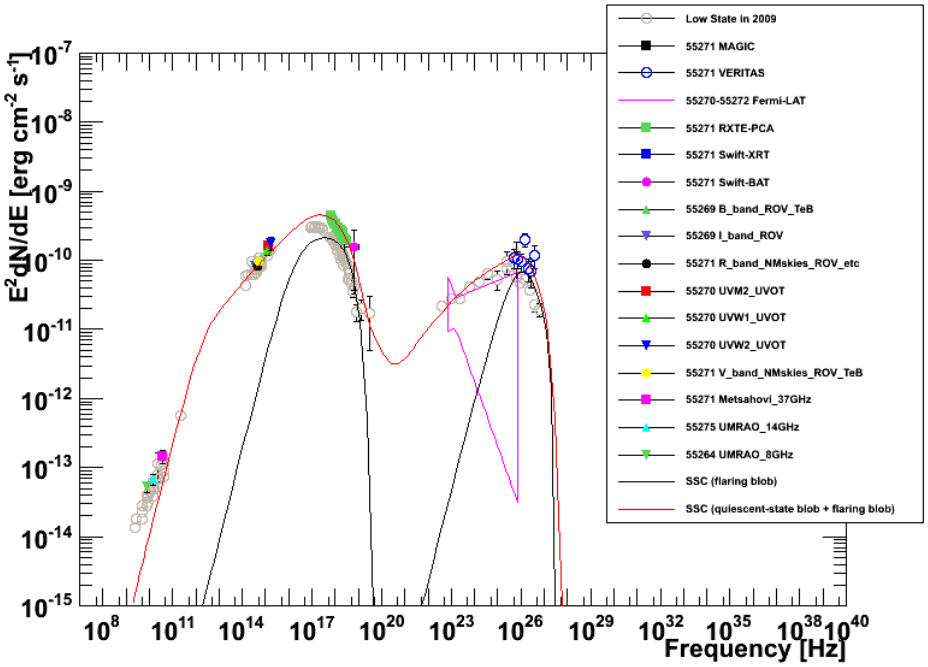


Mrk421 MW 2010_03_16 (55271)

1 blob, 2 breaks

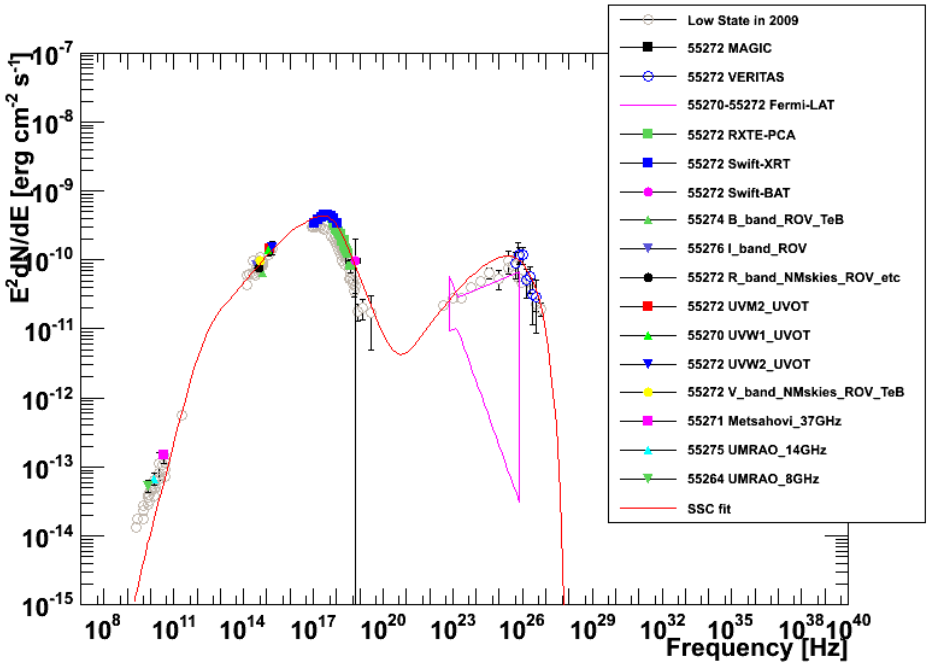


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

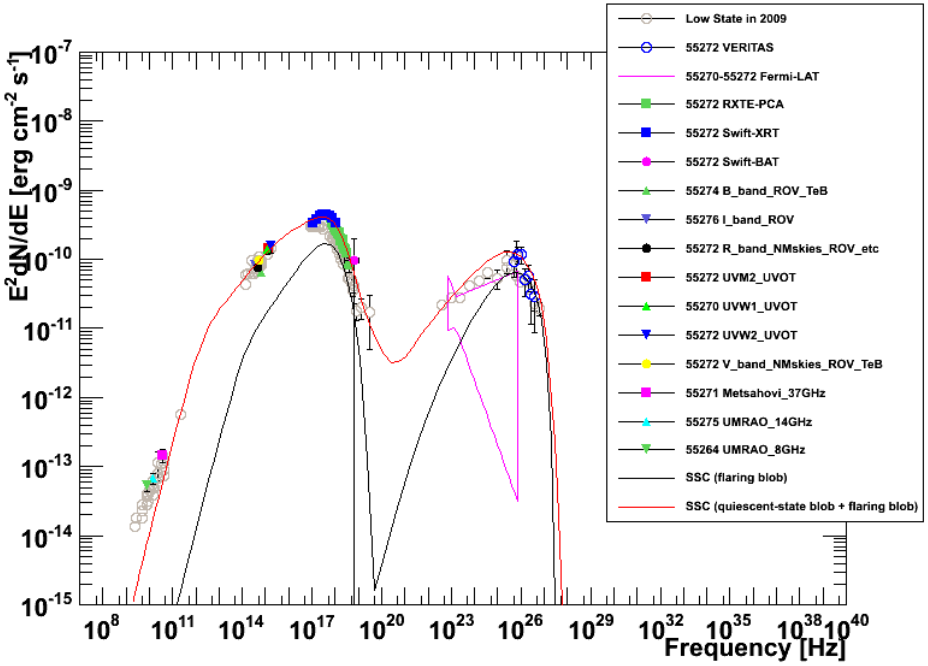


Mrk421 MW 2010_03_17 (55272)

1 blob, 2 breaks

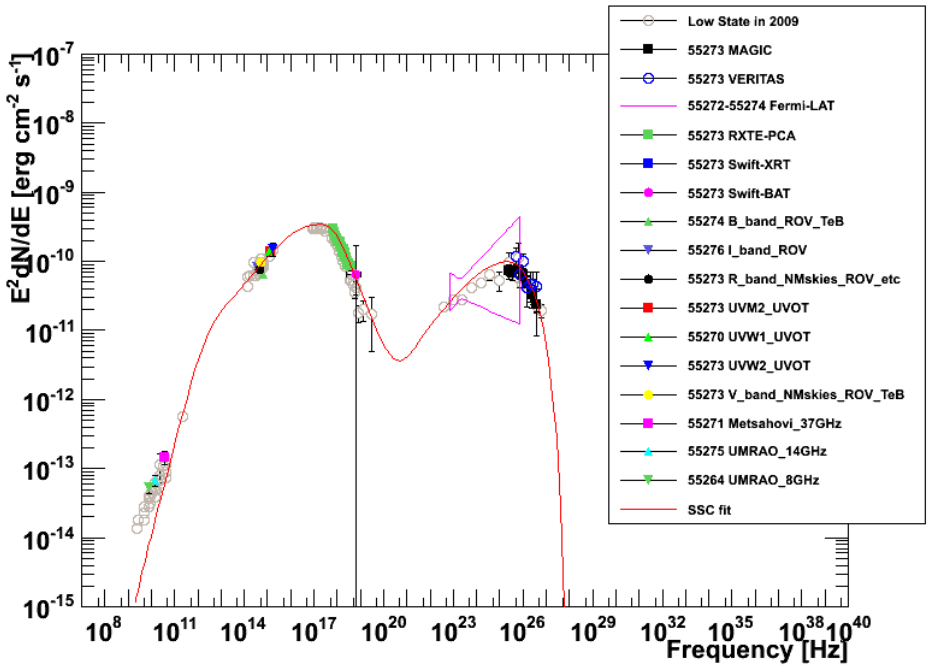


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

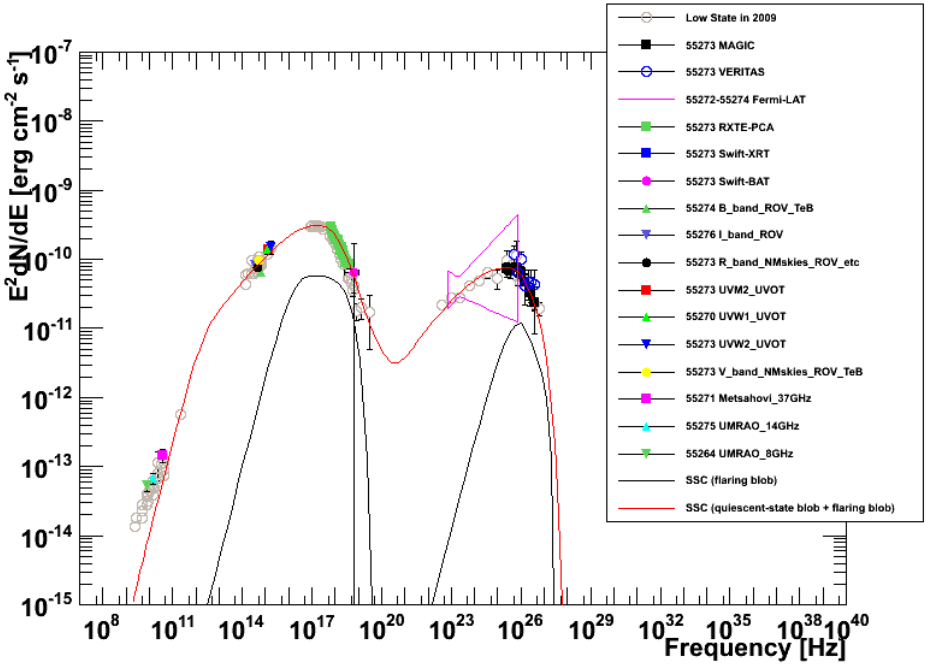


Mrk421 MW 2010_03_18 (55273)

1 blob, 2 breaks

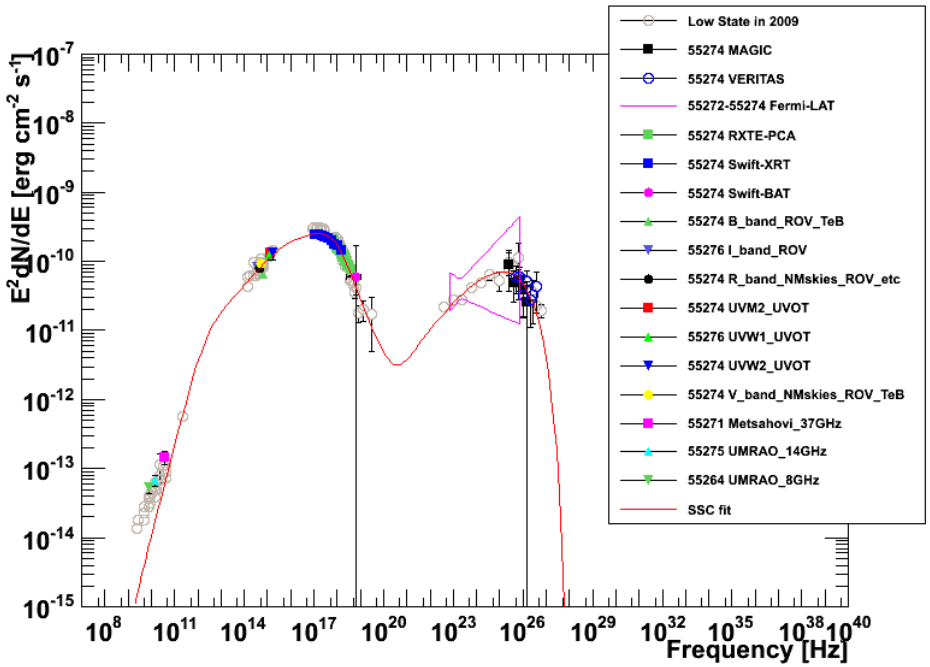


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks

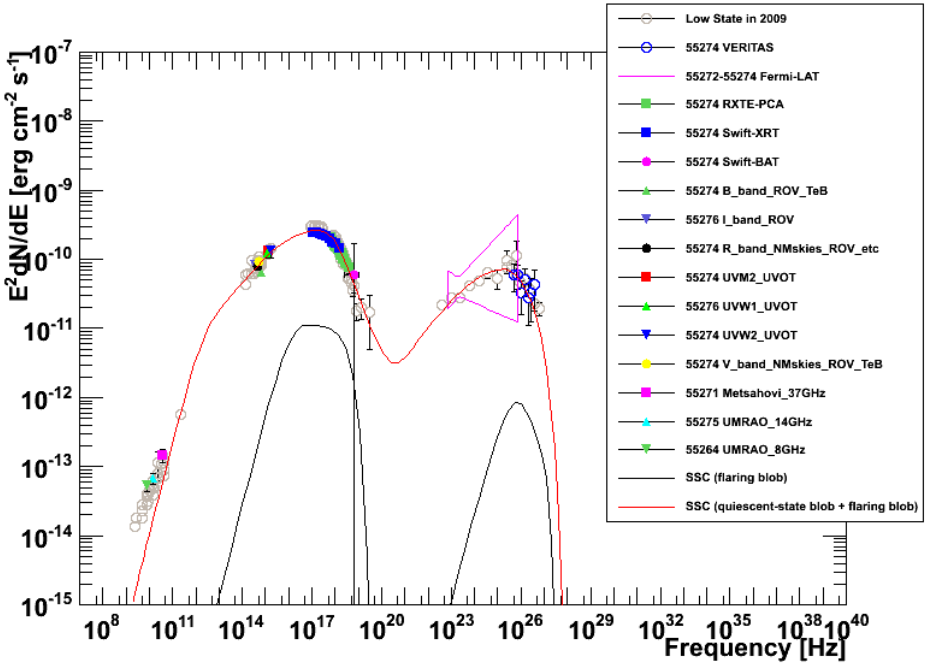


Mrk421 MW 2010_03_19 (55274)

1 blob, 2 breaks

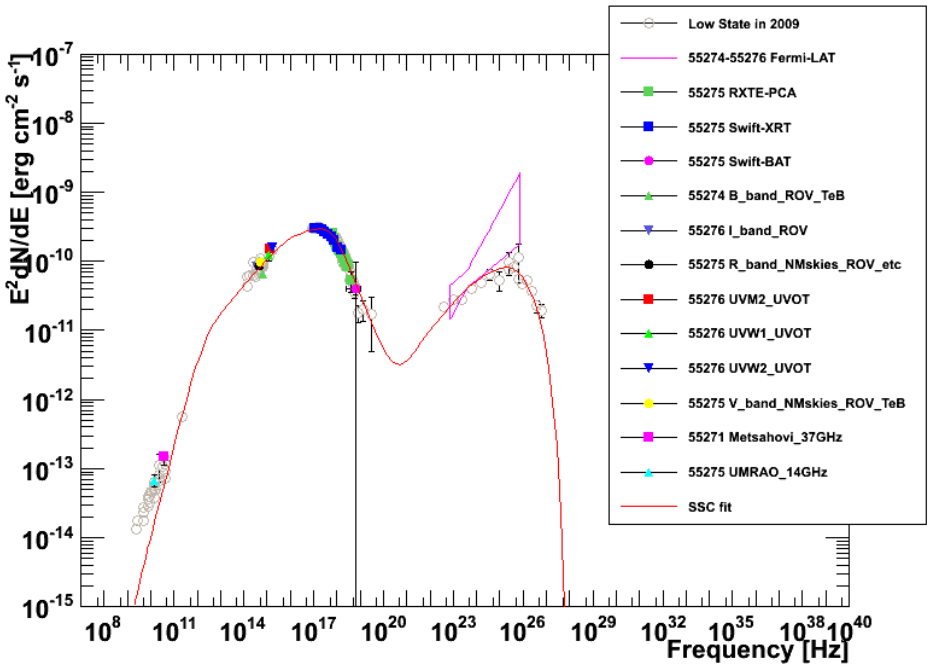


2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks



Mrk421 MW 2010_03_20 (55275)

1 blob, 2 breaks



2 blob:
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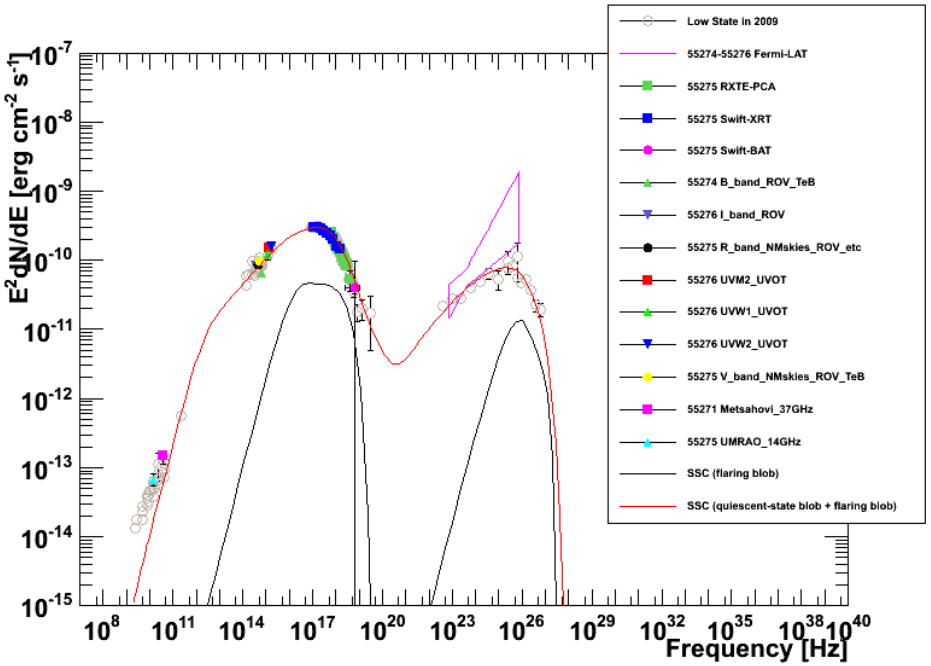
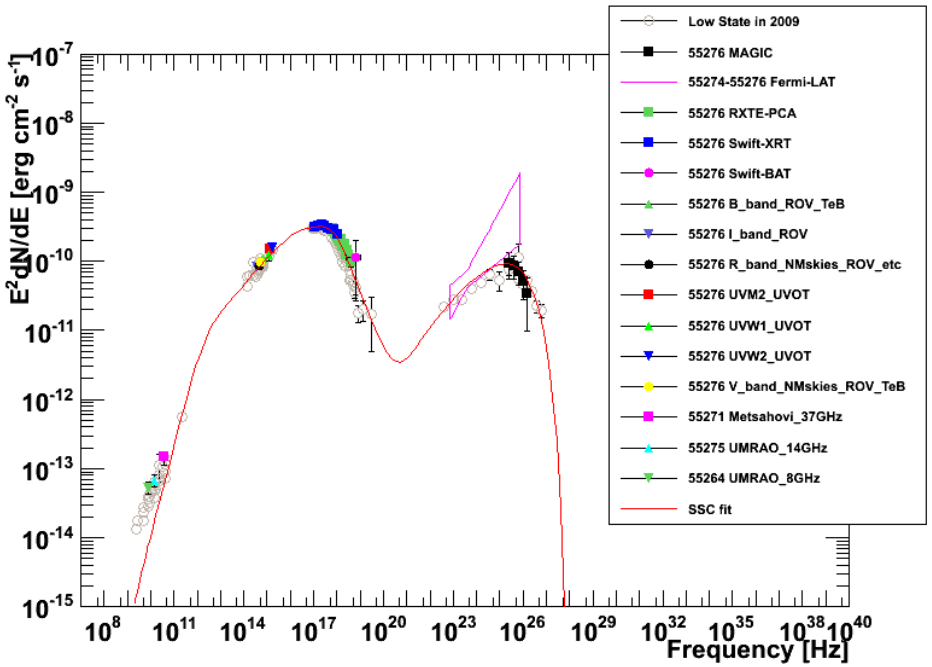
Quiescent blob: 2 breaks



Mrk421 MW 2010_03_21 (55276)

1 blob, 2 breaks



2 blob:
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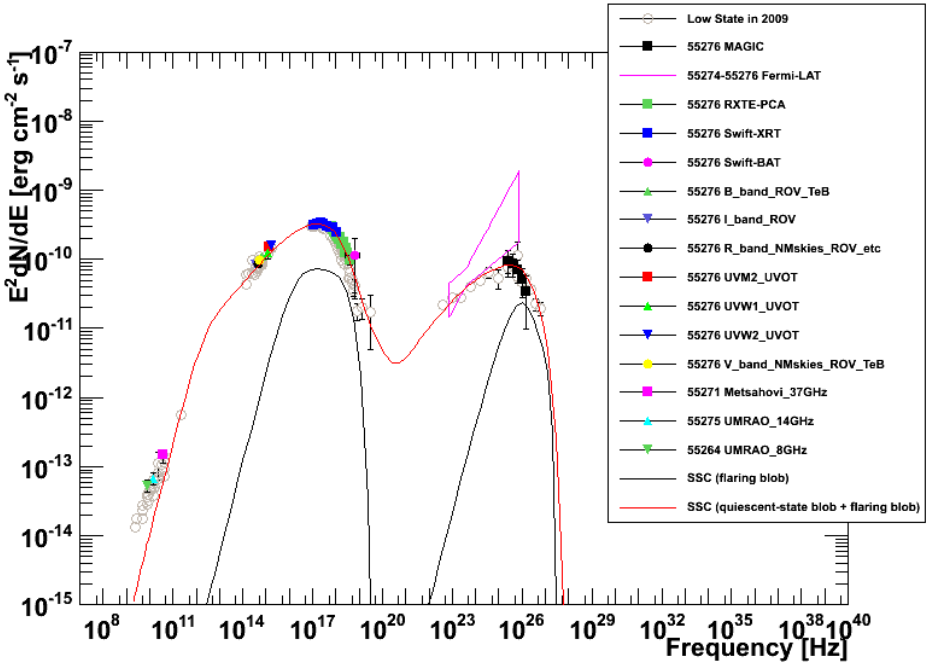
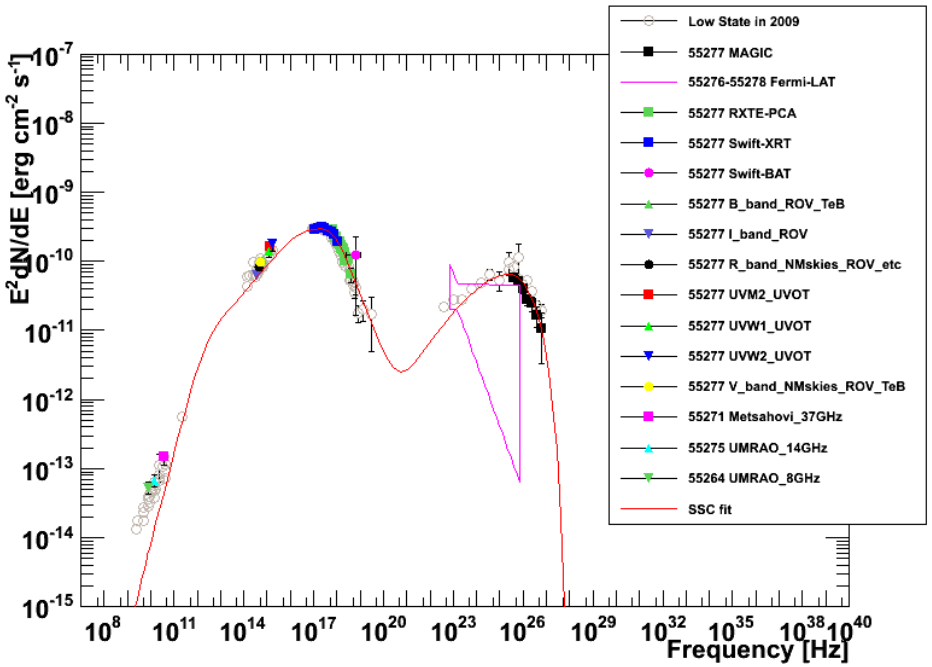
Quiescent blob: 2 breaks

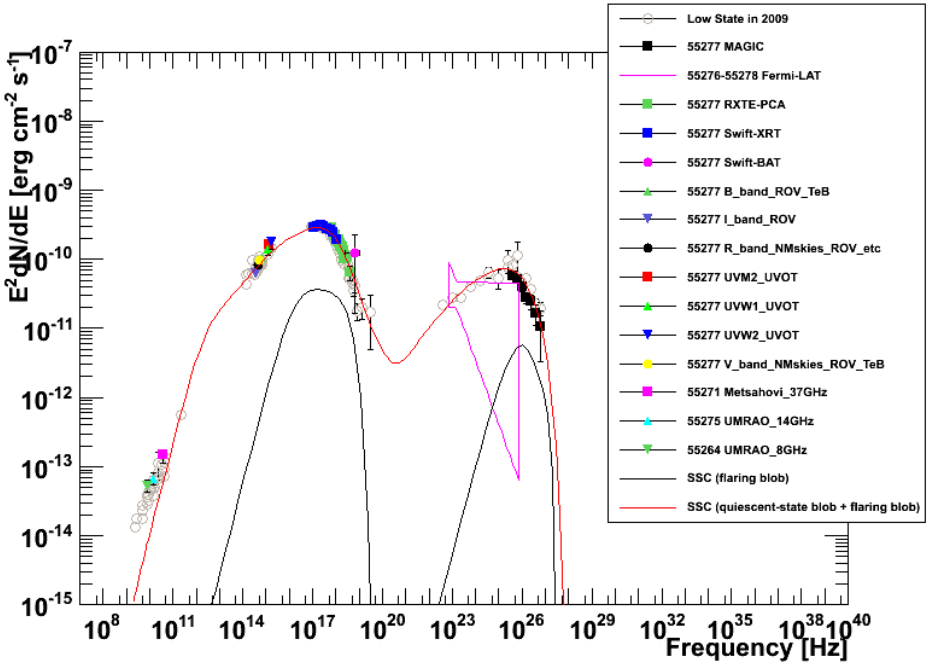


Mrk421 MW 2010_03_22 (55277)

1 blob, 2 breaks



2 blob:
Flaring blob:1 break
Quiescent blob: 2 breaks



1-blob Model

Table 2. Integral Flux and Fit Parameters of One-zone SSC Model

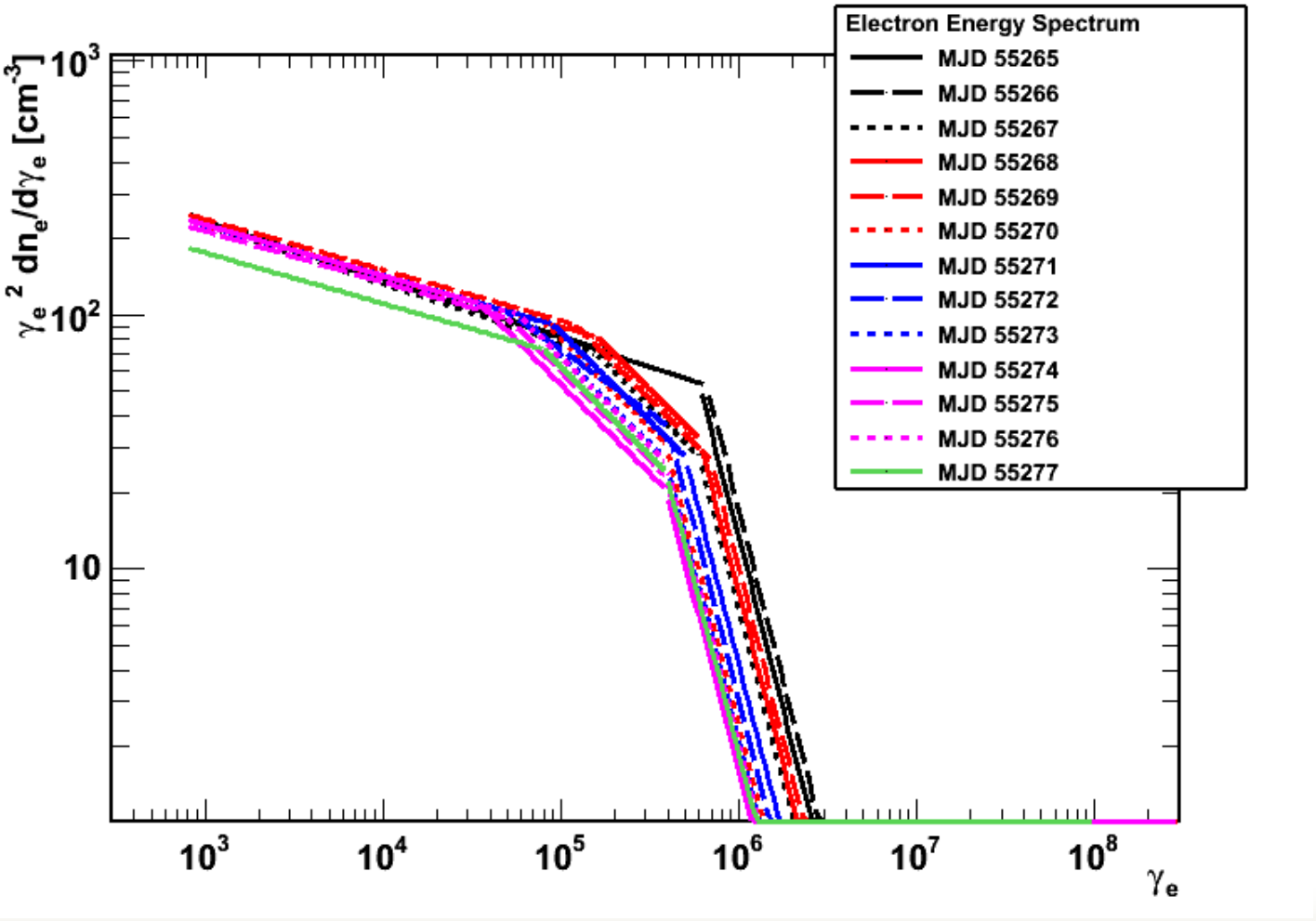
Date[MJD]	Flux($E > 200GeV$)$[cm^{-2}s^{-1}]$	γ_{min}	γ_{max}	γ_{break1}	γ_{break2}	s_1	s_2	s_3	$n_e[cm^{-3}]$	$B[mG]$	$log(R[cm])$	δ
55265	3.8×10^{-10}	8.e2.	1.e8.	6.e5.	6.e5.	2.23	2.23	4.7	1.14e3.	38.	16.72	21.
55266	4.7×10^{-10}	8.e2.	1.e8.	6.6e5.	6.6e5.	2.23	2.23	4.7	1.16e3.	38.	16.72	21.
55267	4.0×10^{-10}	8.e2.	1.e8.	1.6e5.	6.e5.	2.23	2.7	4.7	1.1e3.	38.	16.72	21.
55268	2.1×10^{-10}	8.e2.	1.e8.	1.6e5.	6.e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
55269	3.3×10^{-10}	8.e2.	1.e8.	1.2e5.	7.e5.	2.2	2.7	4.7	0.95e3.	38.	16.72	21.
55270	2.3×10^{-10}	8.e2.	1.e8.	8.e4.	3.9e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
55271	3.5×10^{-10}	8.e2.	1.e8.	9.e4.	5.e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
55272	1.4×10^{-10}	8.e2.	1.e8.	5.e4.	4.e5.	2.2	2.5	4.7	0.9e3.	38.	16.72	21.
55273	1.5×10^{-10}	8.e2.	1.e8.	6.e4.	3.9e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21
55274	9.9×10^{-11}	8.e2.	1.e8.	3.5e4.	3.9e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
55275	1.8×10^{-10}	8.e2.	1.e8.	5.e4.	3.9e5.	2.2	2.7	4.7	0.85e3.	38.	16.72	21.
55276	1.6×10^{-10}	8.e2.	1.e8.	5.7e4.	3.9e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
55277	1.2×10^{-10}	8.e2.	1.e8.	8.0e4.	3.9e5.	2.2	2.7	4.7	0.7e3.	38.	16.72	21.

2-blob Model

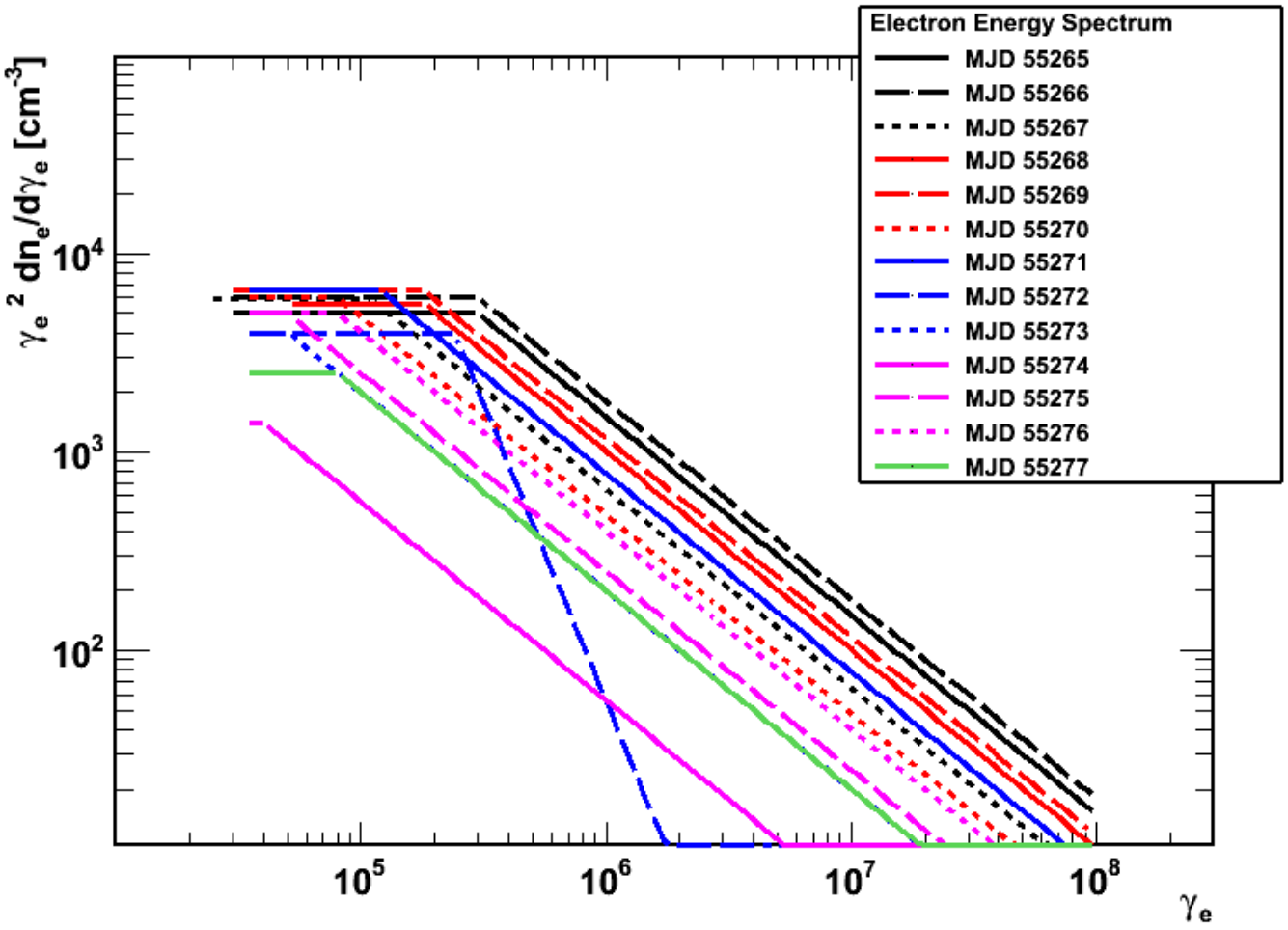
Table 3. Integral Flux and Fit Parameters of Two-zone SSC Model

Date[MJD]	Flux($E > 200GeV$)$[cm^{-2}s^{-1}]$	γ_{min}	γ_{max}	γ_{break1}	γ_{break2}	s_1	s_2	s_3	$n_e[cm^{-3}]$	$B[mG]$	$log(R[cm])$	δ
					the quiescent blob							
for all dates	- -	8.e2.	1.e8.	3.5e4.	3.9e5.	2.2	2.7	4.7	0.9e3.	38.	16.72	21.
					the flaring blob							
55265	3.8×10^{-10}	3.e4.	6.e5.	3.e5.	- -	2.0	3.0	- -	5.0e3.	105.	15.51	35.
55266	4.7×10^{-10}	3.e4.	6.e5.	3.e5.	- -	2.0	3.0	- -	6.0e3.	100.	15.51	35.
55267	4.0×10^{-10}	2.5e4.	6.e5.	1.1e5.	- -	2.0	3.0	- -	5.9e3.	100.	15.51	35.
55268	2.1×10^{-10}	5.3e4.	6.e5.	1.8e5.	- -	2.0	3.0	- -	5.6e3.	100.	15.51	35.
55269	3.3×10^{-10}	3.e4.	6.e5.	1.8e5.	- -	2.0	3.0	- -	6.5e3.	85.	15.51	35.
55270	2.3×10^{-10}	3.5e4.	6.e5.	8.e4.	- -	2.0	3.0	- -	6.e3.	75.	15.51	35.
55271	3.5×10^{-10}	3.5e4.	6.e5.	1.2e5.	- -	2.0	3.0	- -	6.5e3.	75.	15.51	35.
55272	1.4×10^{-10}	3.5e4.	6.e5.	2.4e5.	- -	2.0	5.0	- -	4.e3.	75.	15.51	35.
55273	1.5×10^{-10}	3.5e4.	6.e5.	5.e4.	- -	2.0	3.0	- -	4.e3.	75.	15.51	35.
55274	9.9×10^{-11}	3.5e4.	6.e5.	4.e4.	- -	2.0	3.0	- -	1.4e3.	60.	15.51	35.
55275	1.8×10^{-10}	3.5e4.	6.e5.	5.e4.	- -	2.0	3.0	- -	5.e3.	60.	15.51	35.
55276	1.6×10^{-10}	3.5e4.	6.e5.	8.e4.	- -	2.0	3.0	- -	5.e3.	60.	15.51	35.
55277	1.2×10^{-10}	3.5e4.	6.e5.	8.e4.	- -	2.0	3.0	- -	2.5e3.	60.	15.51	35.

1-blob Model


Electron Energy Spectrum
MJD 55265
MJD 55266
MJD 55267
MJD 55268
MJD 55269
MJD 55270
MJD 55271
MJD 55272
MJD 55273
MJD 55274
MJD 55275
MJD 55276
MJD 55277
$\gamma_e^2\, dn_e/d\gamma_e$ [cm^{-3}]
10^3
10^2
10
10^3
10^4
10^5
10^6
10^7
10^8
γ_e

2-blob Model


Electron Energy Spectrum
MJD 55265
MJD 55266
MJD 55267
MJD 55268
MJD 55269
MJD 55270
MJD 55271
MJD 55272
MJD 55273
MJD 55274
MJD 55275
MJD 55276
MJD 55277
$\gamma_e^2\, dn_e/d\gamma_e$ [cm^{-3}]
10^4
10^3
10^2
10^5
10^6
10^7
10^8
γ_e

Paper for this study

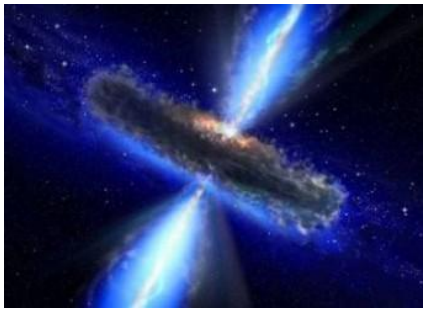
0. Missing part: cross-check on MAGIC SEDs of MJD 55265 55272. Nijil is going to finish them.
1. Preliminary draft v5.
2. “Discussion on modeling” to be modified: corresponding to the addition of VERITAS SEDs and modification of Swift SEDs
3. Maybe ask Nicola (in VERITAS) to reduce the number of SED points to reduce the statistical error
4. Polish the draft and then circulate it in our AGN group

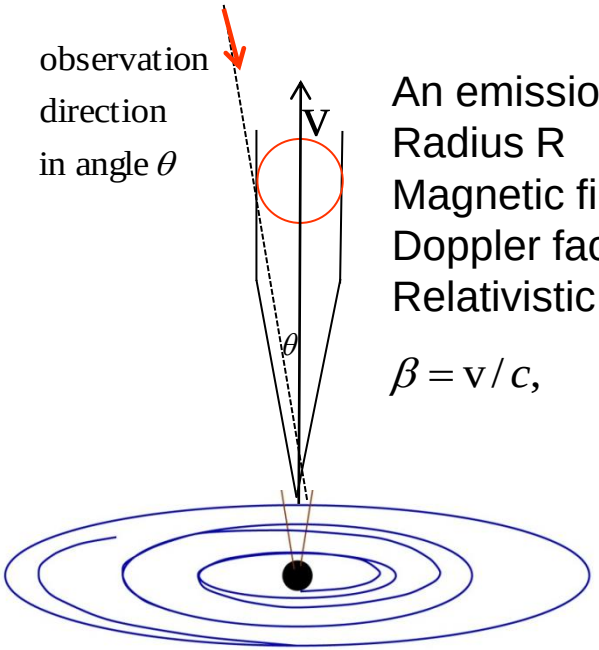
Backup Slides

Describe Spectra with One-Zone Synchrotron Self-Compton Model

electron energy spectrum parameters	Environmental parameters

$\gamma_{\min}, \gamma_{\max}, \gamma_{break}, s_1, s_2, n_e\,[\mathrm{cm}^{-3}]$, B[mG], log(R[cm]), δ





An emission blob with:
Radius R
Magnetic field B
Doppler factor δ
Relativistic electrons

$$\beta = \mathrm{v}/c, \qquad \gamma = (1-\beta^2)^{-1/2}, \qquad \delta = \gamma^{-1}(1-\beta\cos\theta)^{-1}$$

electron enrergy spectrum$(n_e, s_1, s_2, \gamma_{\min}, \gamma_{break}, \gamma_{\max})$

$$\frac{dN}{d\gamma} = \begin{cases} (\,for\ \gamma_{\min} < \gamma < \gamma_{break1})\ n_e\gamma^{-s_1} \\ (\,for\ \gamma_{break1} < \gamma < \gamma_{break2})\ n_e\gamma^{-s_2}\gamma_{break}^{s_2-s_1} \end{cases}$$

Using Hajime Takami ‘s SSC code
Monthly Notices of the Royal Astronomical Society (2011)
Volume 413, Issue 3, pp. 1845-1851

2-blob SSC Model

quiescent blob
(parameter stay the same during the whole activity. Choose the lowest state, MJD 55274, even lower than 2009 average)

flaring blob
(changing day by day, size smaller but B changed faster)

total