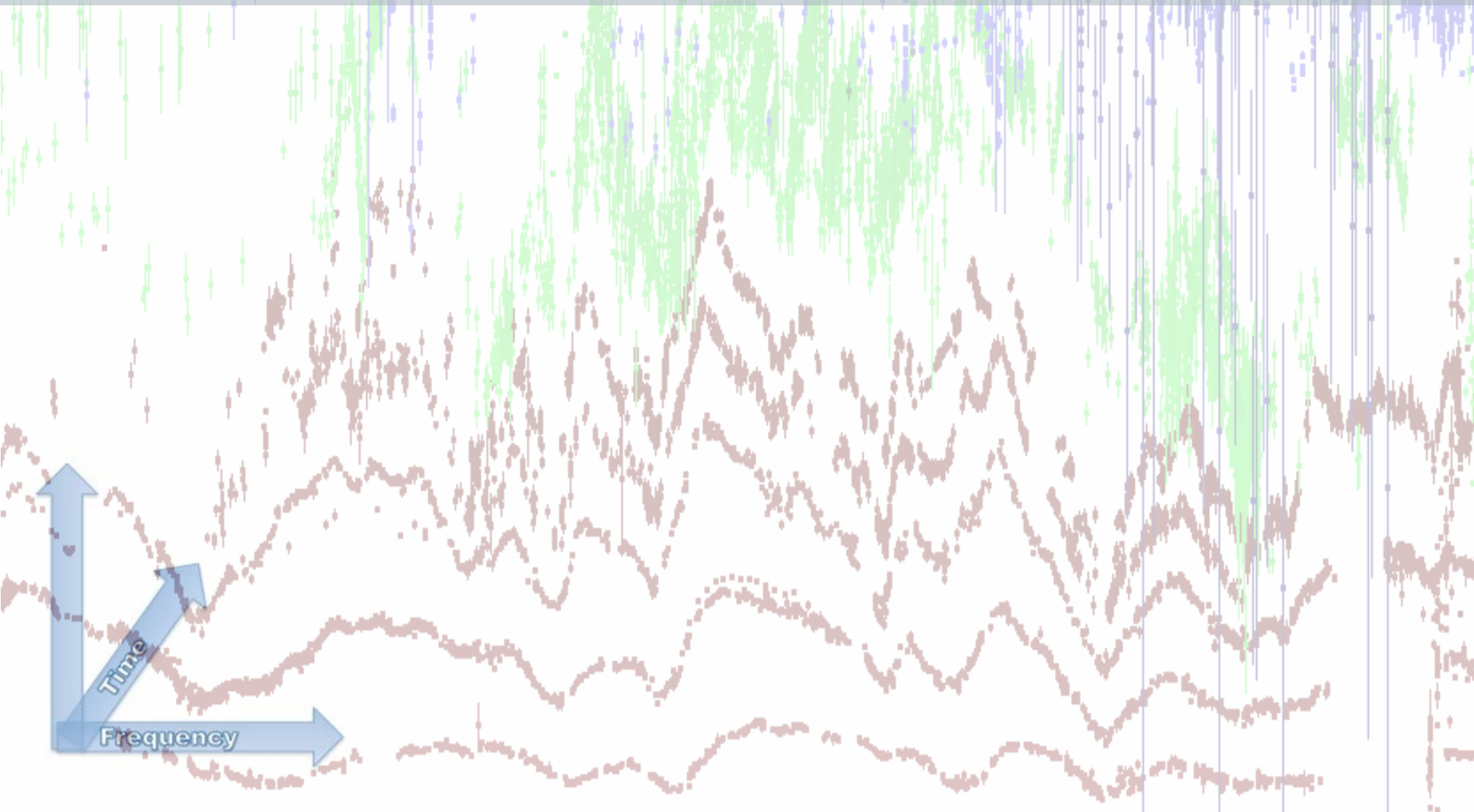
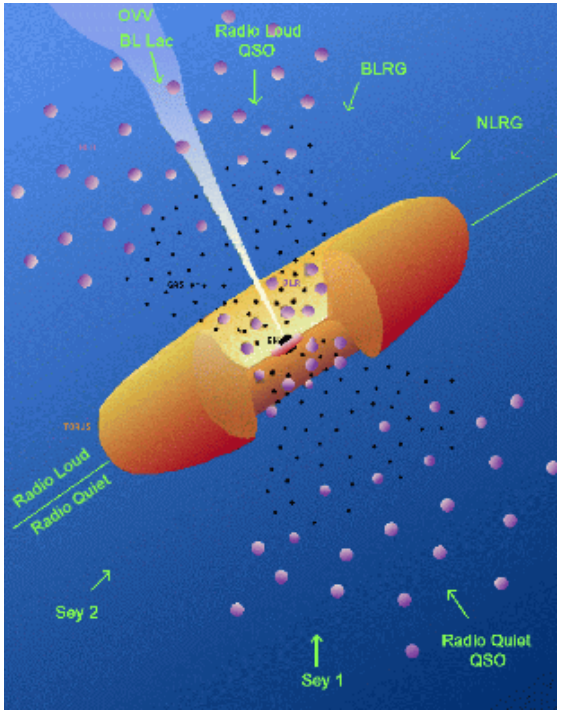
Multi-frequency, multi-temporal observations of blazars

Paolo Giommi





AGN : Two main categories

1. *Dominated by (mostly) thermal emission from accretion disk -*

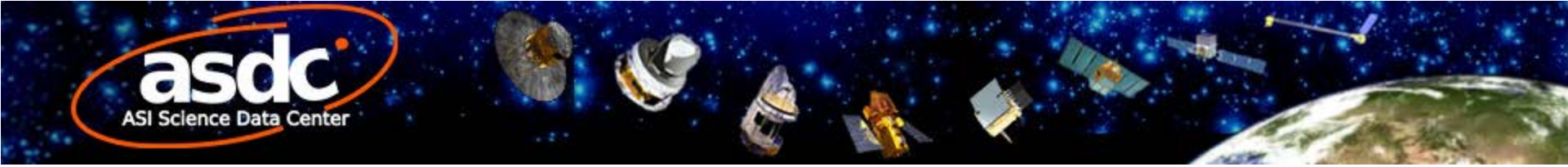
   Radio quiet AGN (>~90 %)

1. *Dominated by Non-Thermal radiation –*

   Jet dominated AGN (< 10%)

When $\Theta < \theta_{blazar}$ ⇒ **Blazar**

Planck and Fermi-LAT showed that Blazars are the most abundant type of sources in the high Galactic latitude μ–wave and γ-ray sky.



Planck, Swift Fermi observations of Radio and high-energy selected blazars

Planck Collaboration 2011, A&A 563, A16 and Giommi et al. A&A 2012, 514, 160

- **Large number of sources**:

  175 blazars observed by Swift when they were in the FOV of Planck: ~160 Swift ToOs

- **Simultaneous Planck Swift Fermi + ground based telescopes**

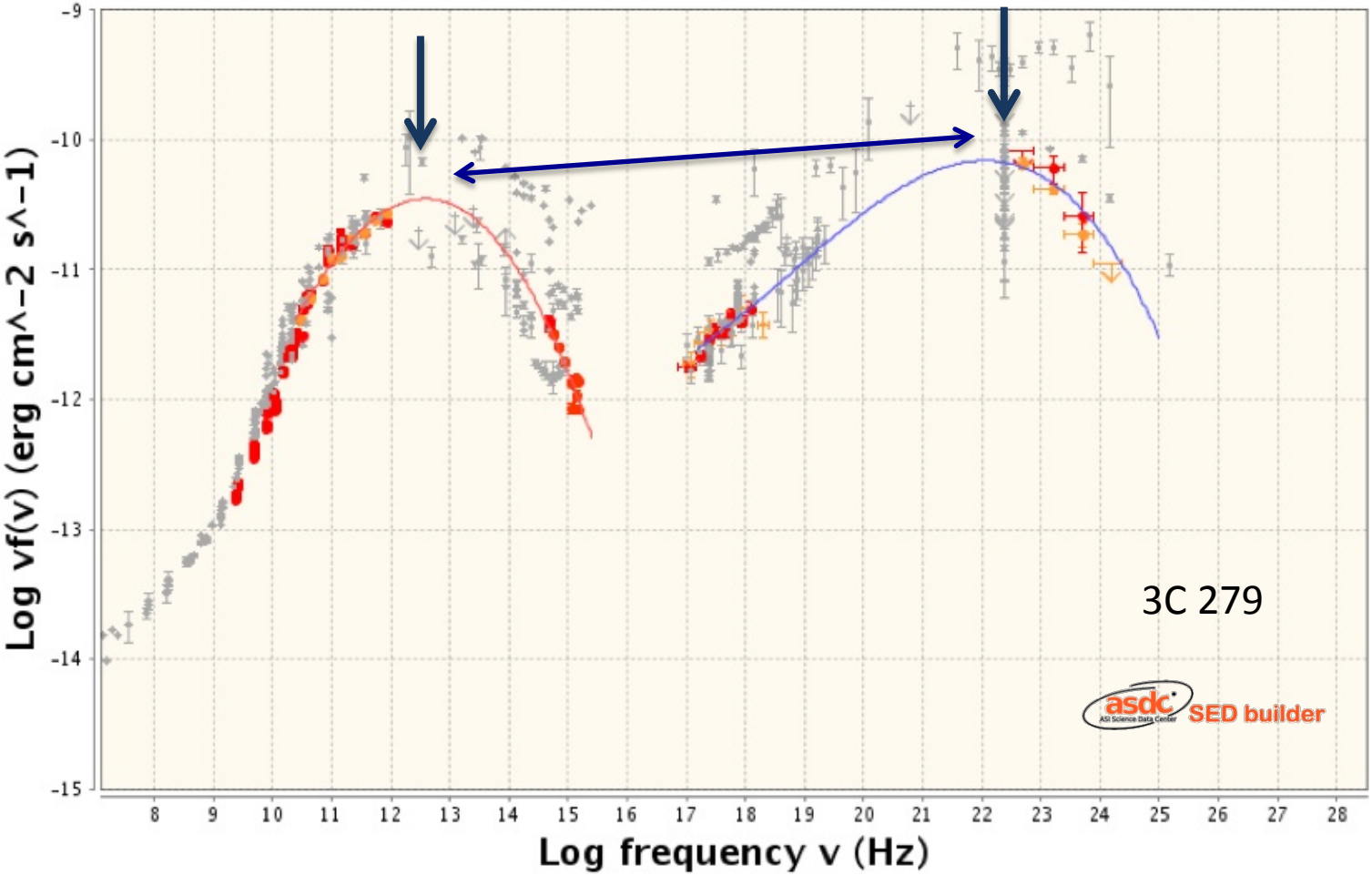
- **Multi-selection approach. Four flux-limited samples.**

  Radio (100 brightest northern sources)

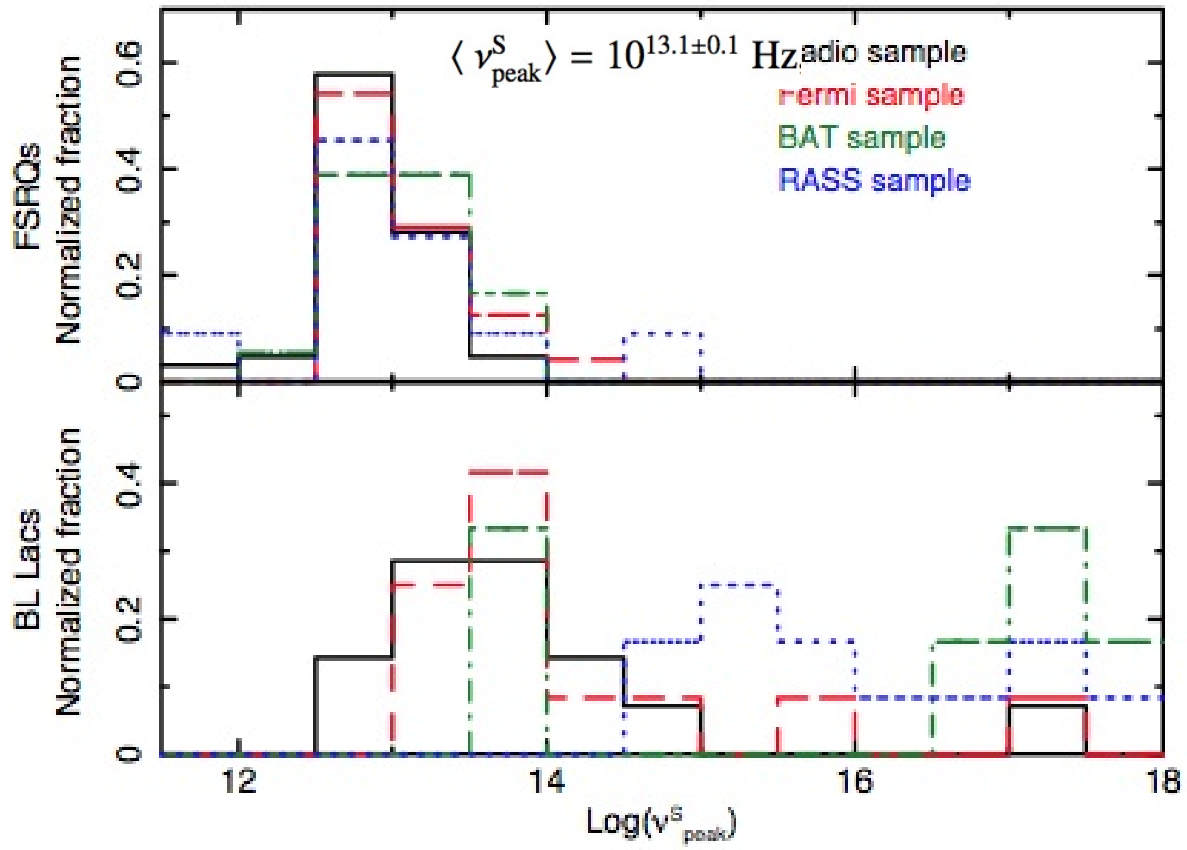
  Soft X-ray (RASS, sample)

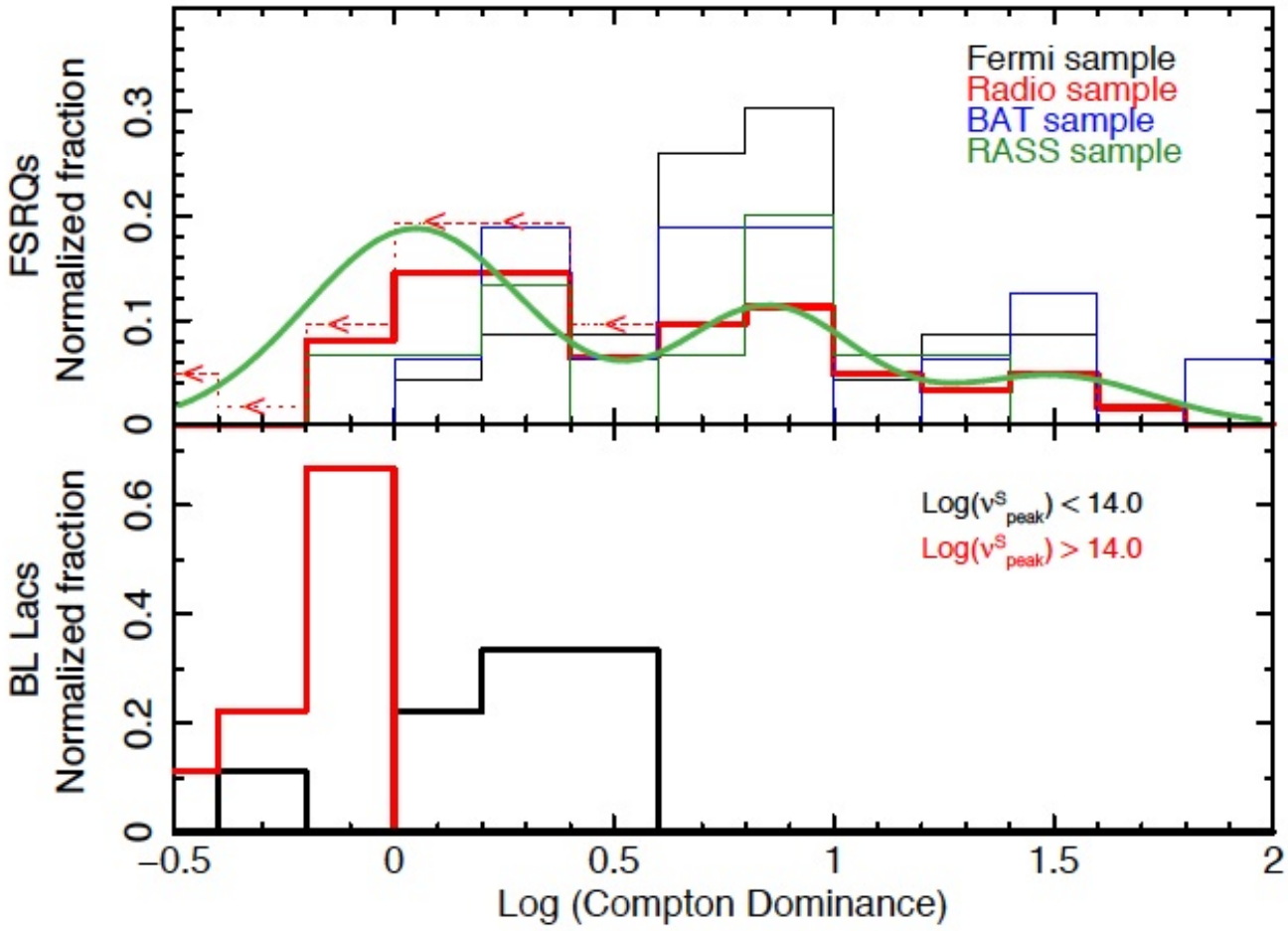
  Hard X-ray (Swift-BAT sample)

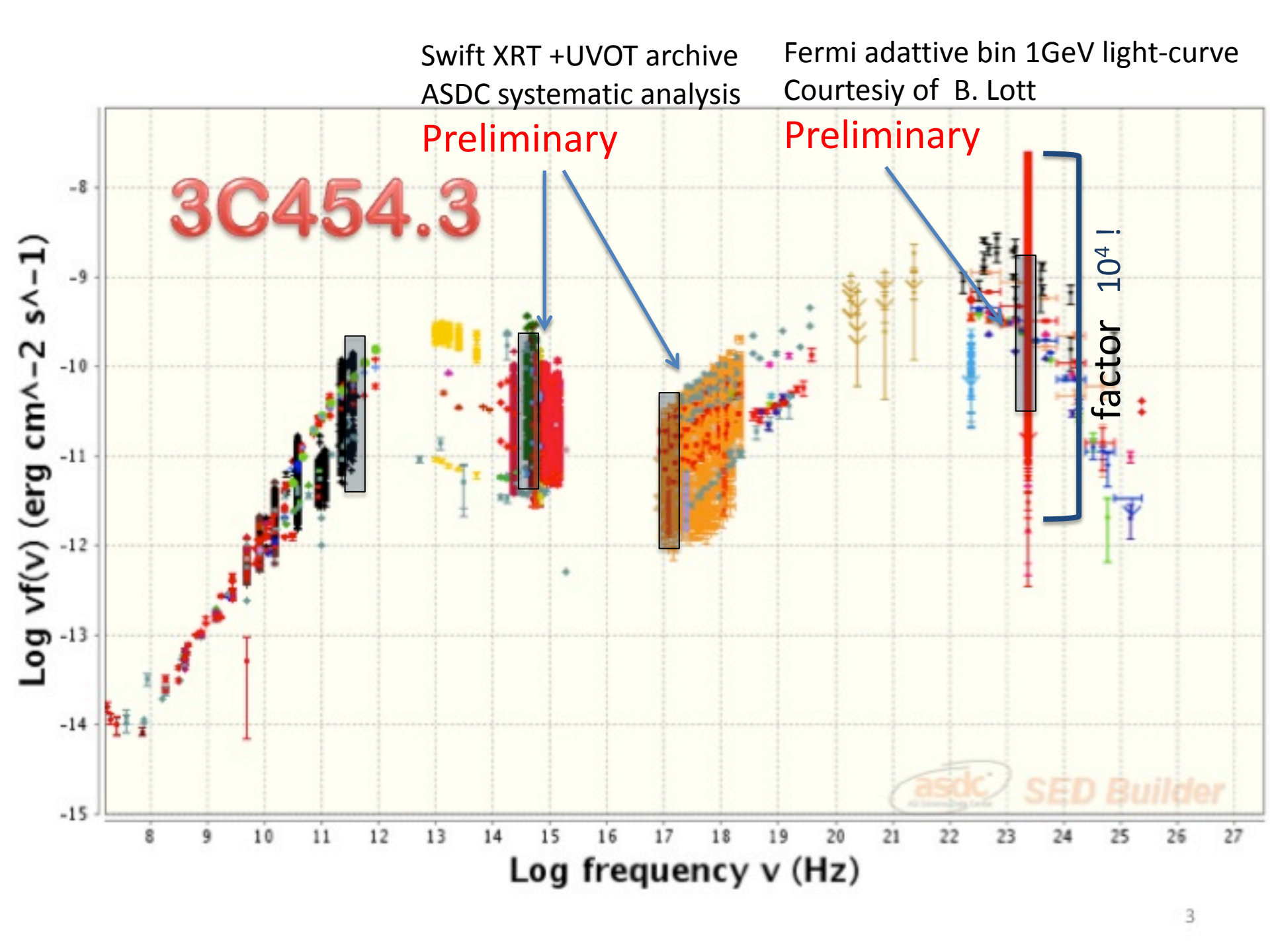
  γ-ray (Fermi sample)

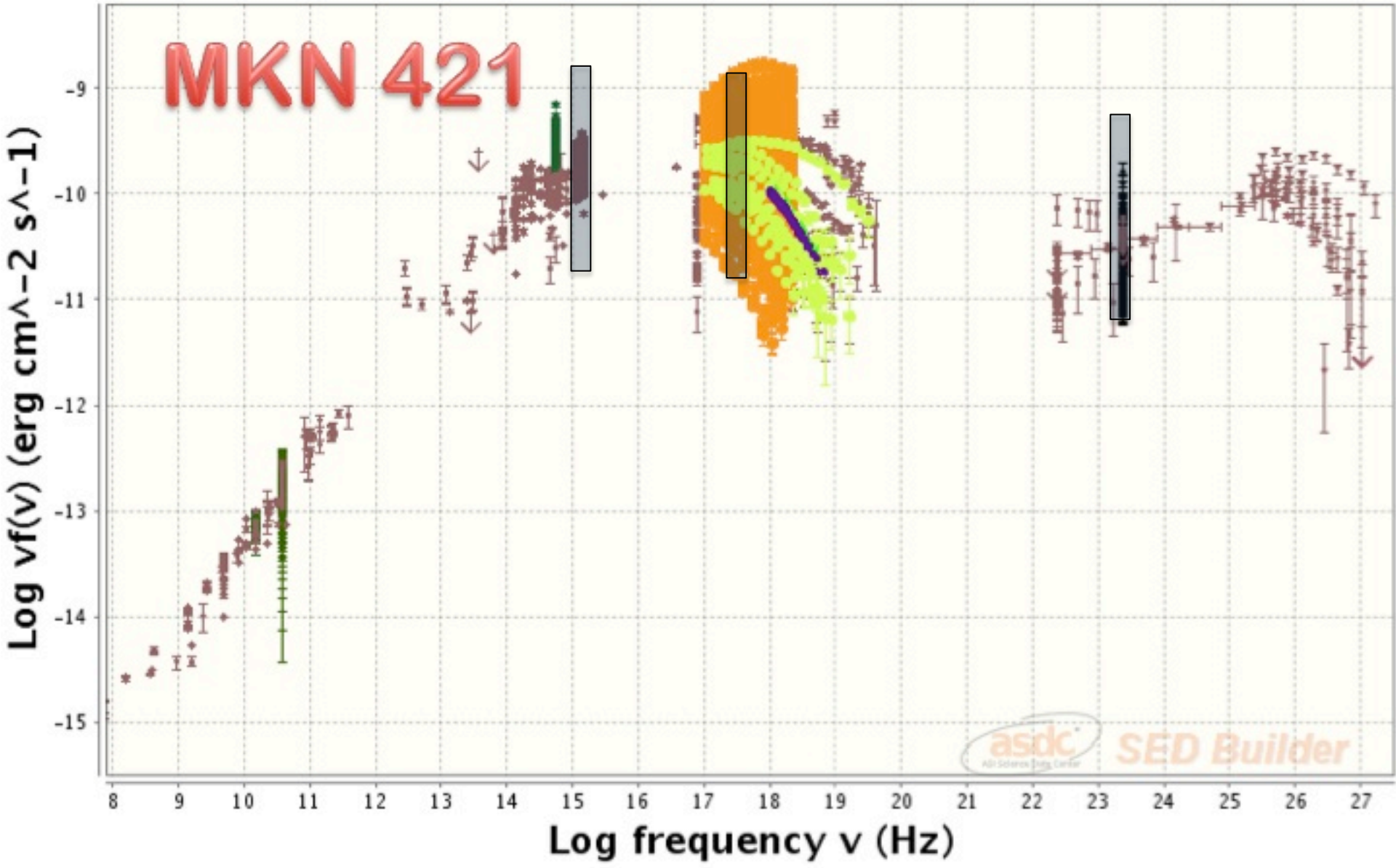

Log vf(v) (erg cm^-2 s^-1)
-9
-10
-11
-12
-13
-14
-15
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
Log frequency v (Hz)
3C 279
asdc SED builder

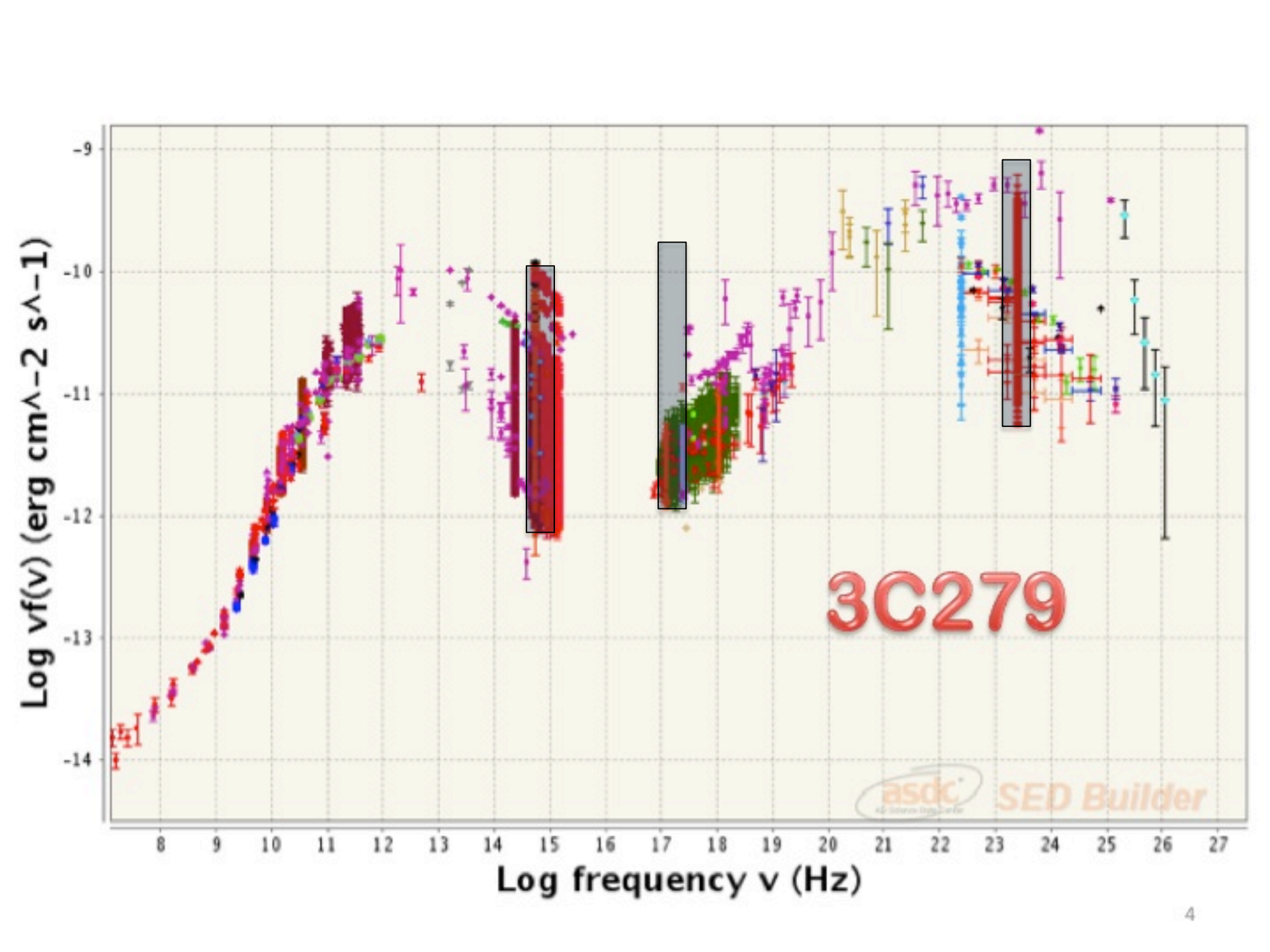
The distribution of synchrotron peak energies




FSRQs
Normalized fraction
0
0.1
0.2
0.3
Fermi sample
Radio sample
BAT sample
RASS sample
BL Lacs
Normalized fraction
0
0.2
0.4
0.6
Log(ν^S_peak) < 14.0
Log(ν^S_peak) > 14.0
−0.5
0
0.5
1
1.5
2
Log (Compton Dominance)


Swift XRT +UVOT archive
ASDC systematic analysis
Preliminary
Fermi adattive bin 1GeV light-curve
Courtesiy of B. Lott
Preliminary
3C454.3
factor 10⁴ !
Log vf(ν) (erg cm^-2 s^-1)
Log frequency ν (Hz)
asdc SED Builder


MKN 421
Log vf(v) (erg cm^-2 s^-1)
-9
-10
-11
-12
-13
-14
-15
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Log frequency v (Hz)
asdc
SED Builder


Log vf(v) (erg cm^-2 s^-1)
-9
-10
-11
-12
-13
-14
8
9
10
11
12
13
14
15
16
17
18
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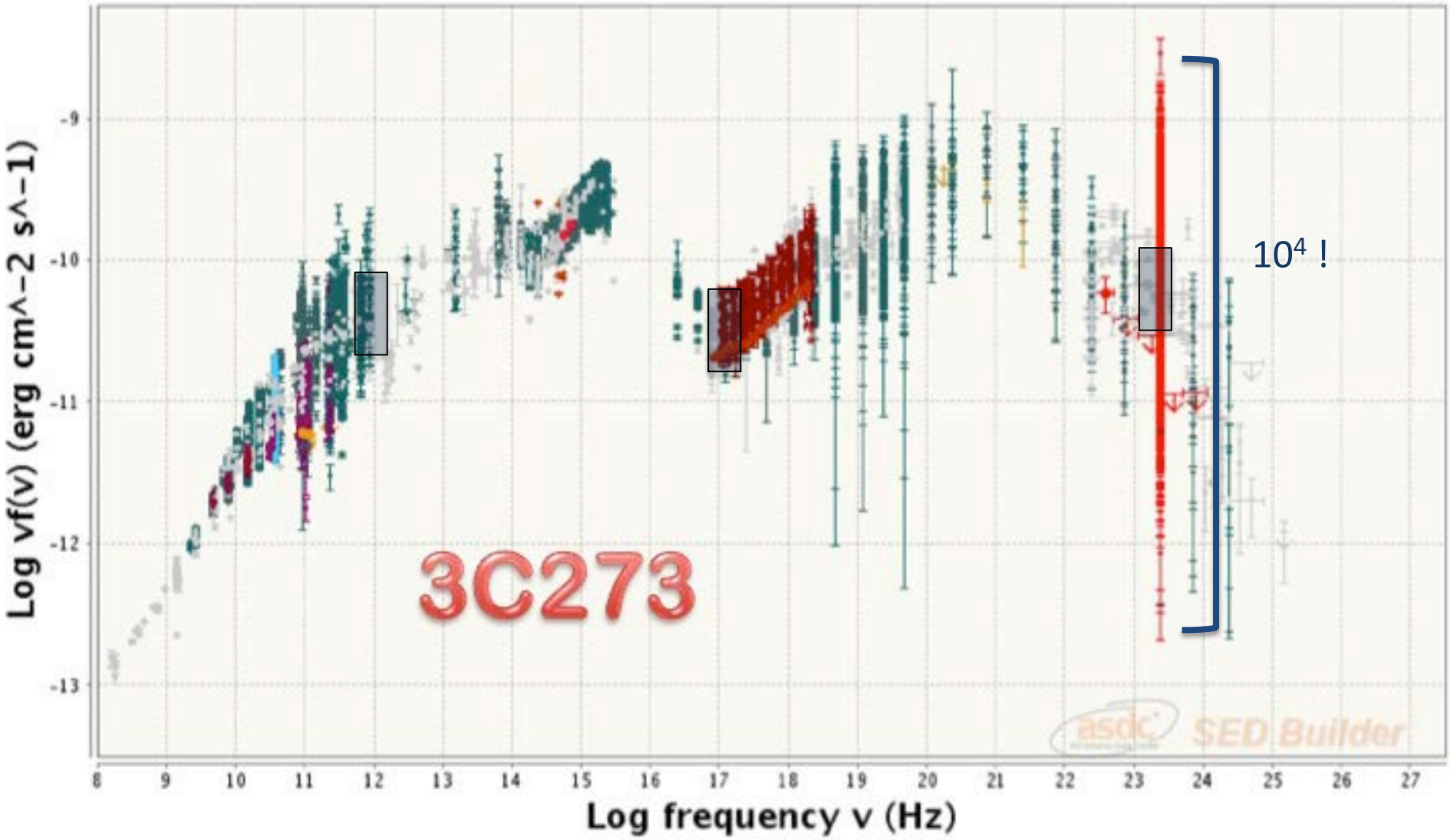
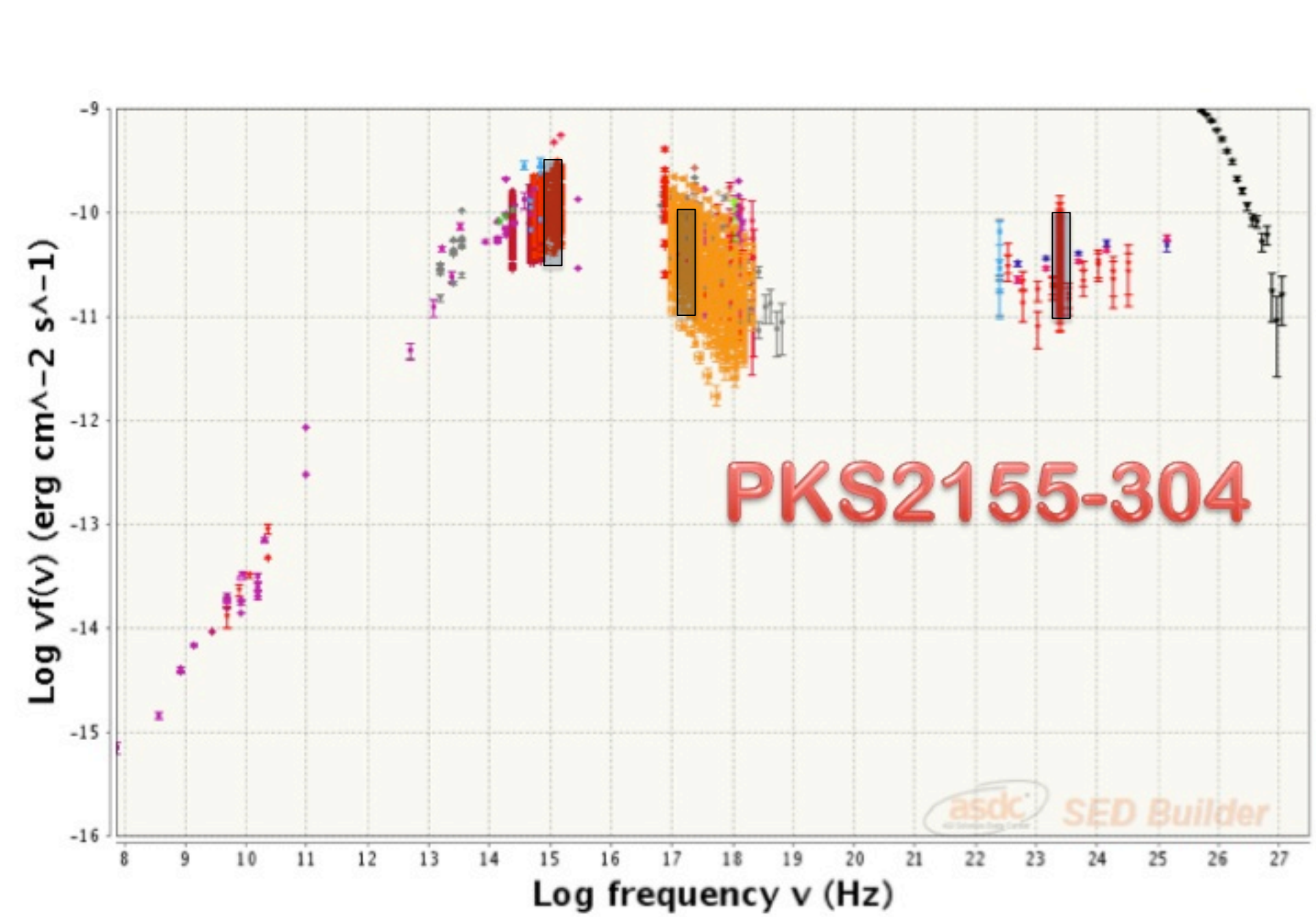
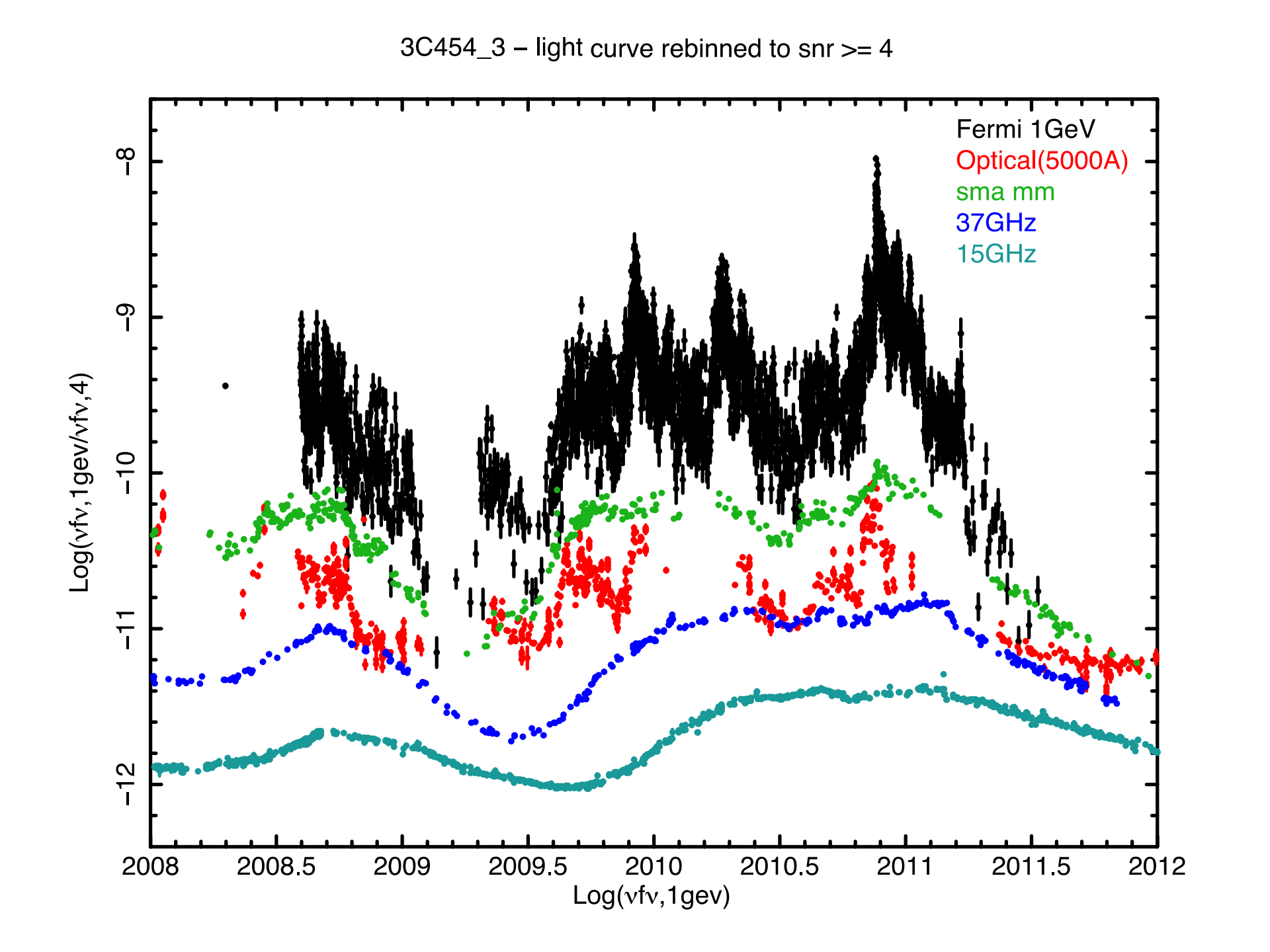
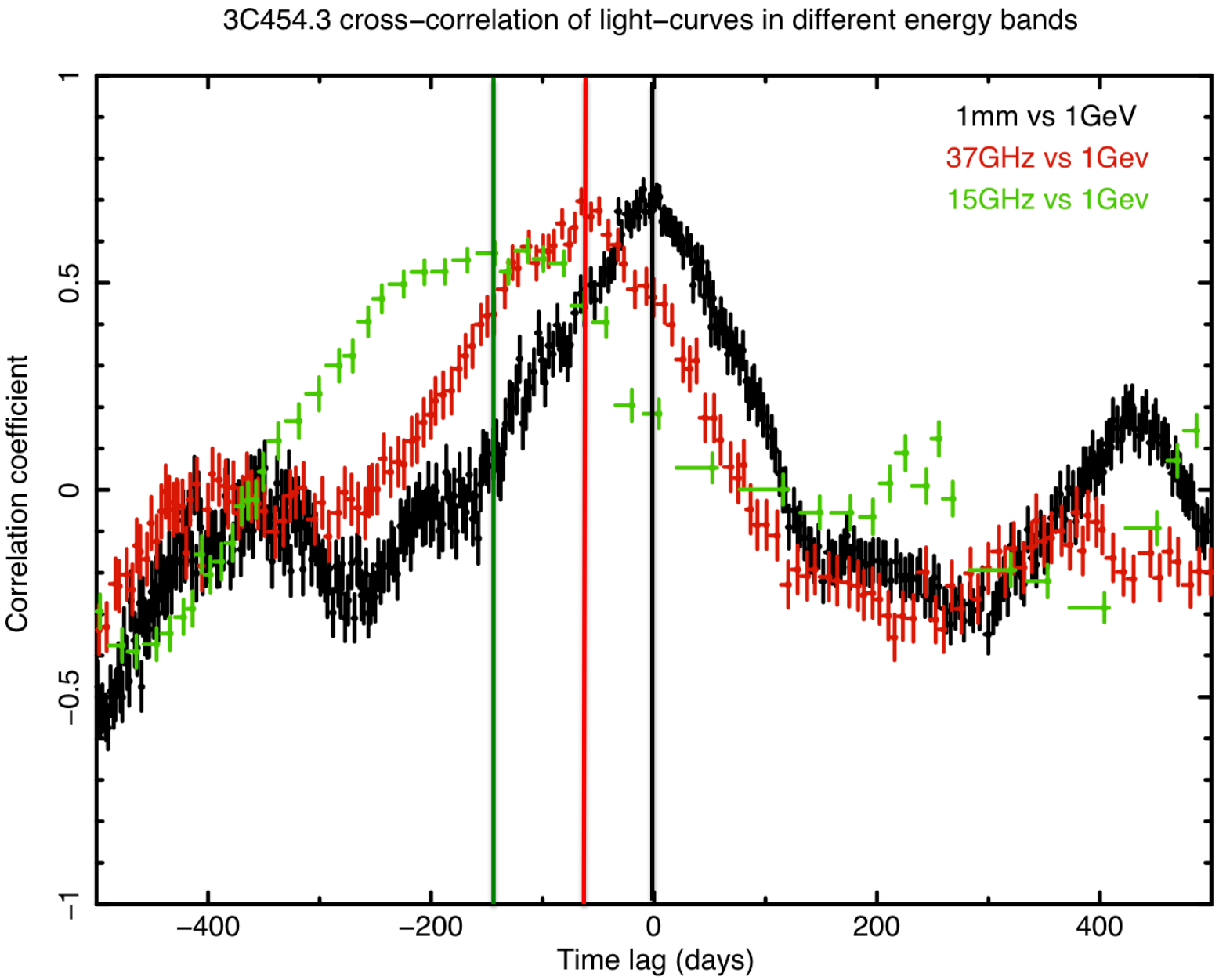
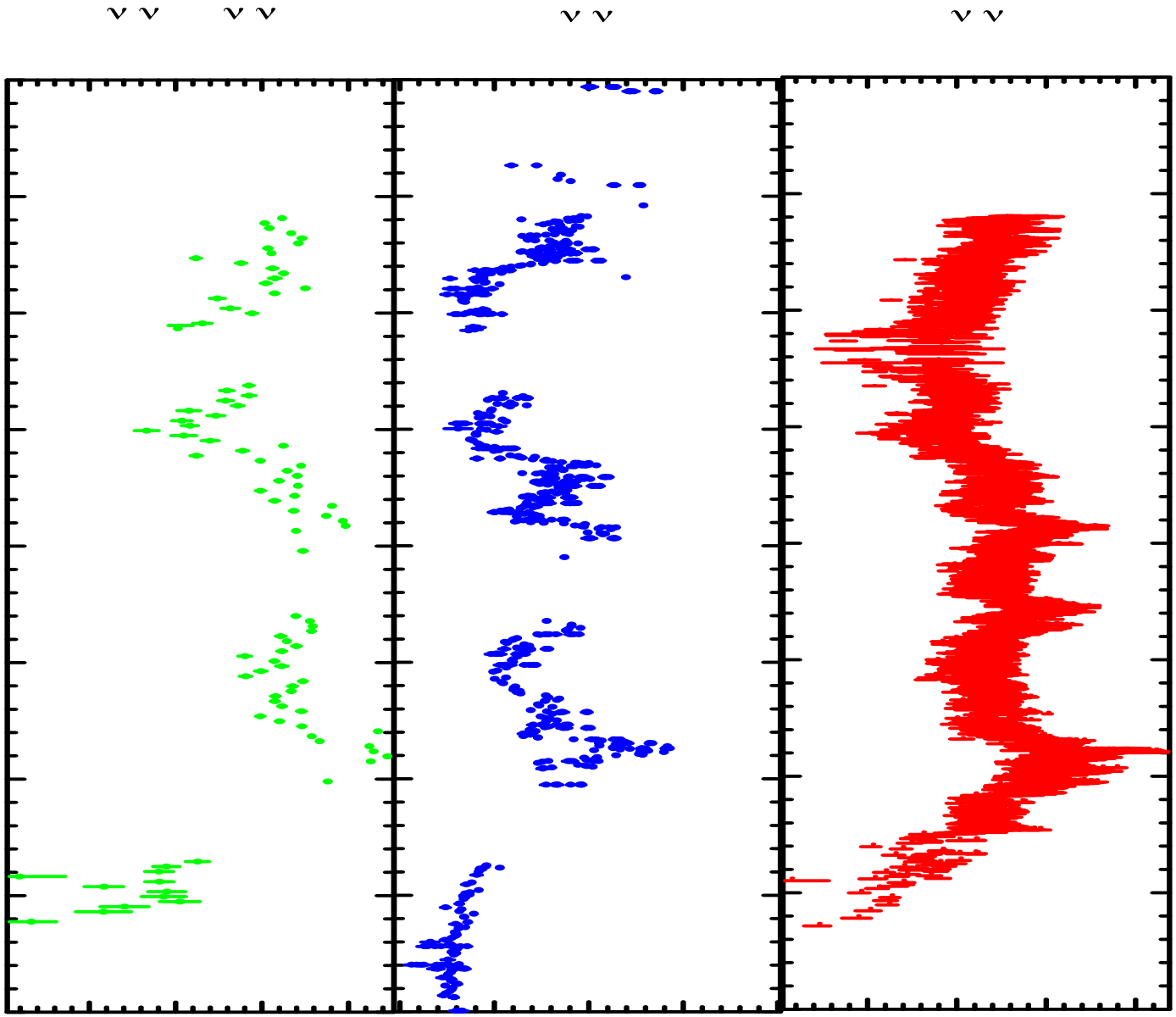
20
21
22
23
24
25
26
27
Log frequency v (Hz)
3C279
asdc
SED Builder

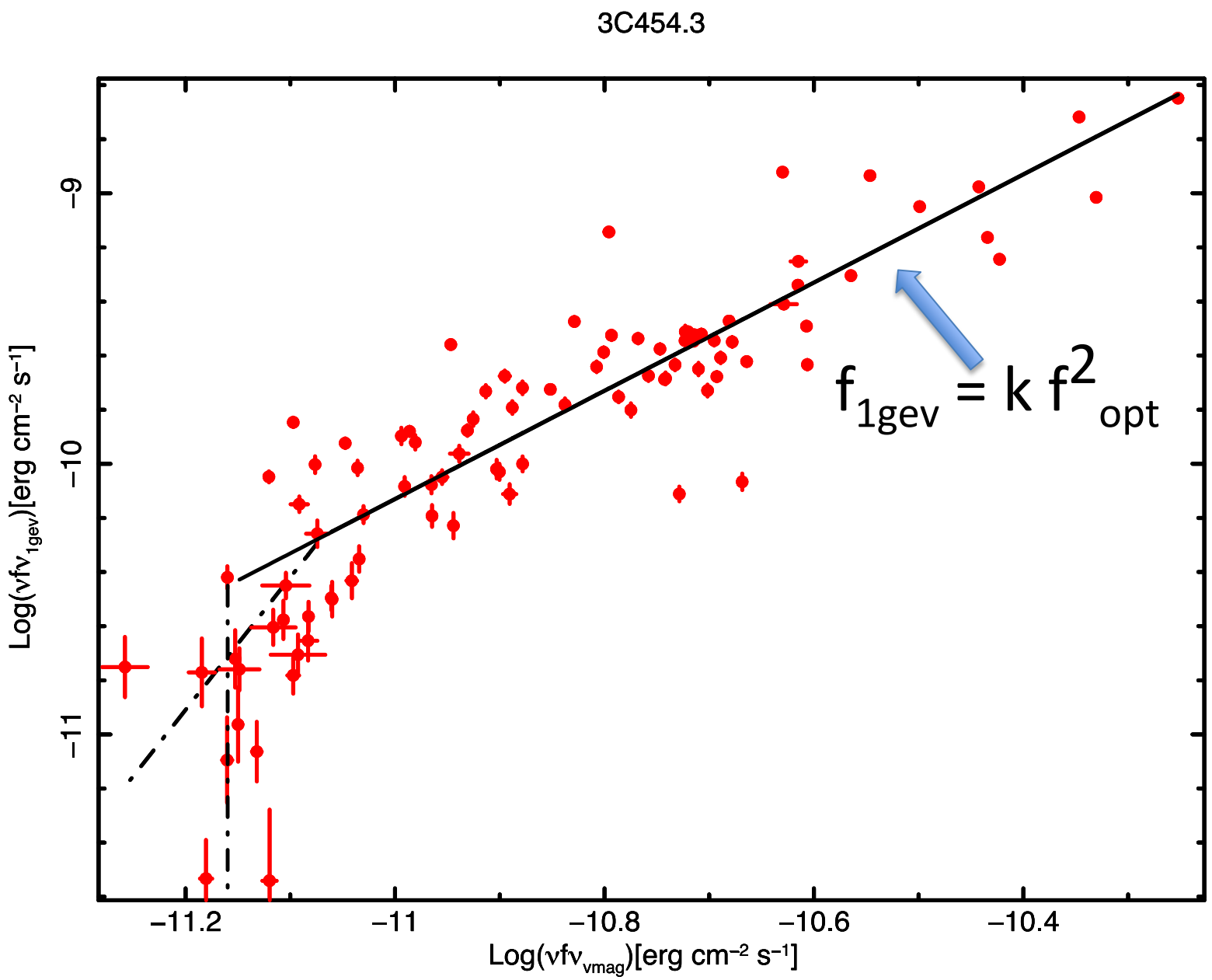

3C273
10^4 !
Log vf(v) (erg cm^-2 s^-1)
Log frequency v (Hz)
-9
-10
-11
-12
-13
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
asdc SED Builder

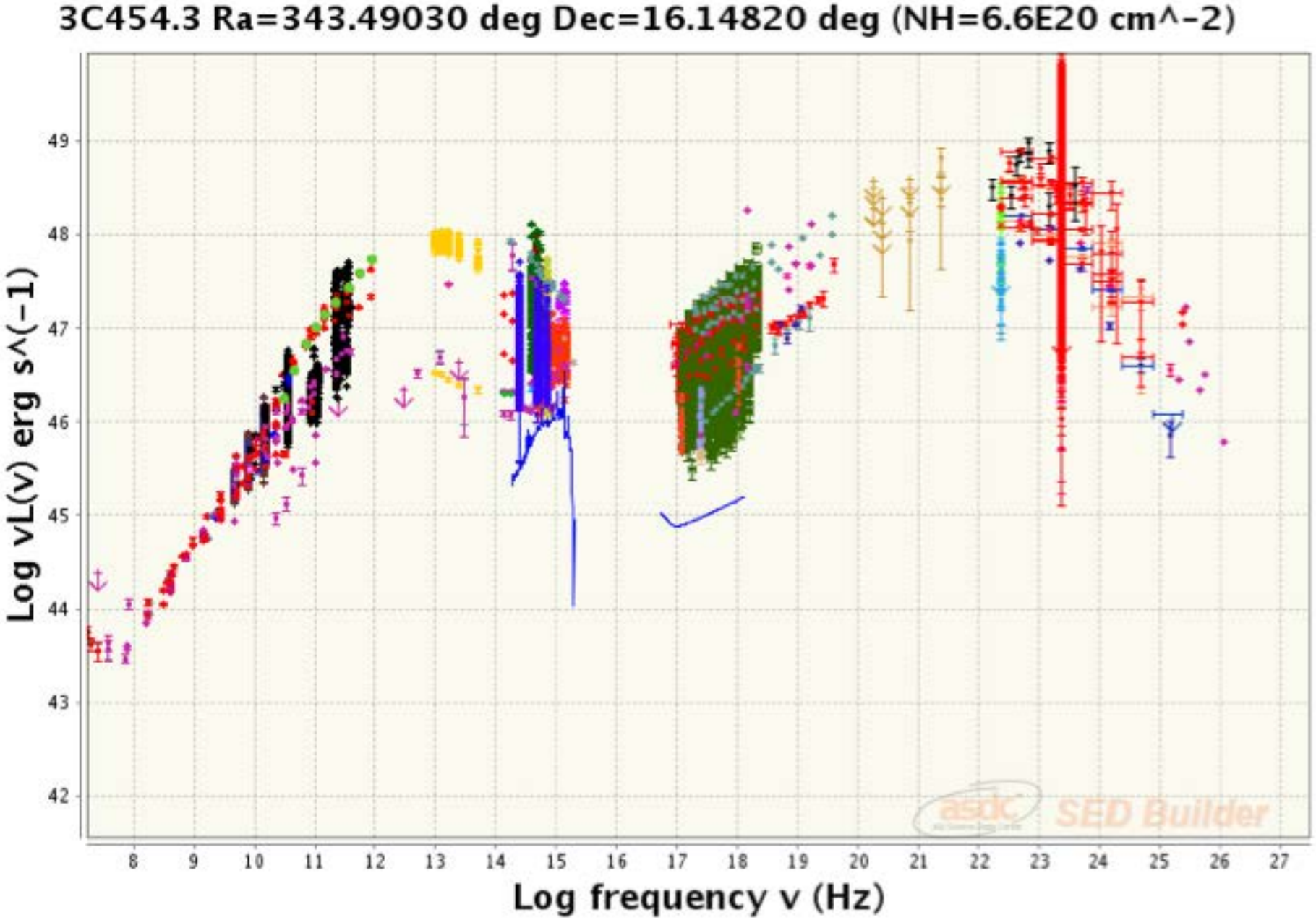

PKS2155-304
Log vf(v) (erg cm^-2 s^-1)
Log frequency v (Hz)
-9
-10
-11
-12
-13
-14
-15
-16
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
asdc
SED Builder


3C454_3 – light curve rebinned to snr >= 4
Fermi 1GeV
Optical(5000A)
sma mm
37GHz
15GHz
Log(νfν,1gev/νfν,4)
Log(νfν,1gev)
−8
−9
−10
−11
−12
2008
2008.5
2009
2009.5
2010
2010.5
2011
2011.5
2012

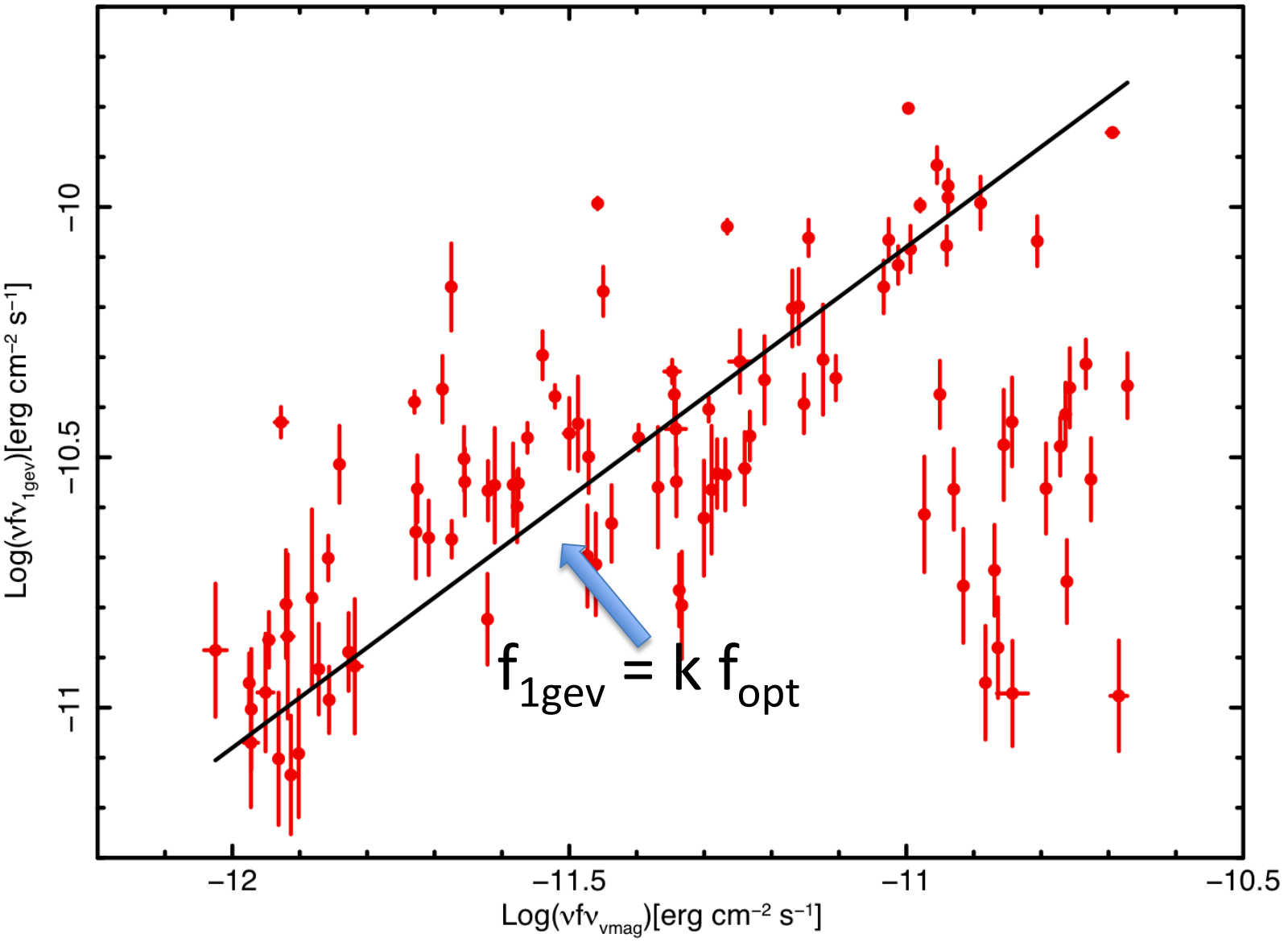

3C454.3 cross−correlation of light−curves in different energy bands
1mm vs 1GeV
37GHz vs 1Gev
15GHz vs 1Gev
Correlation coefficient
1
0.5
0
−0.5
−1
−400
−200
0
200
400
Time lag (days)



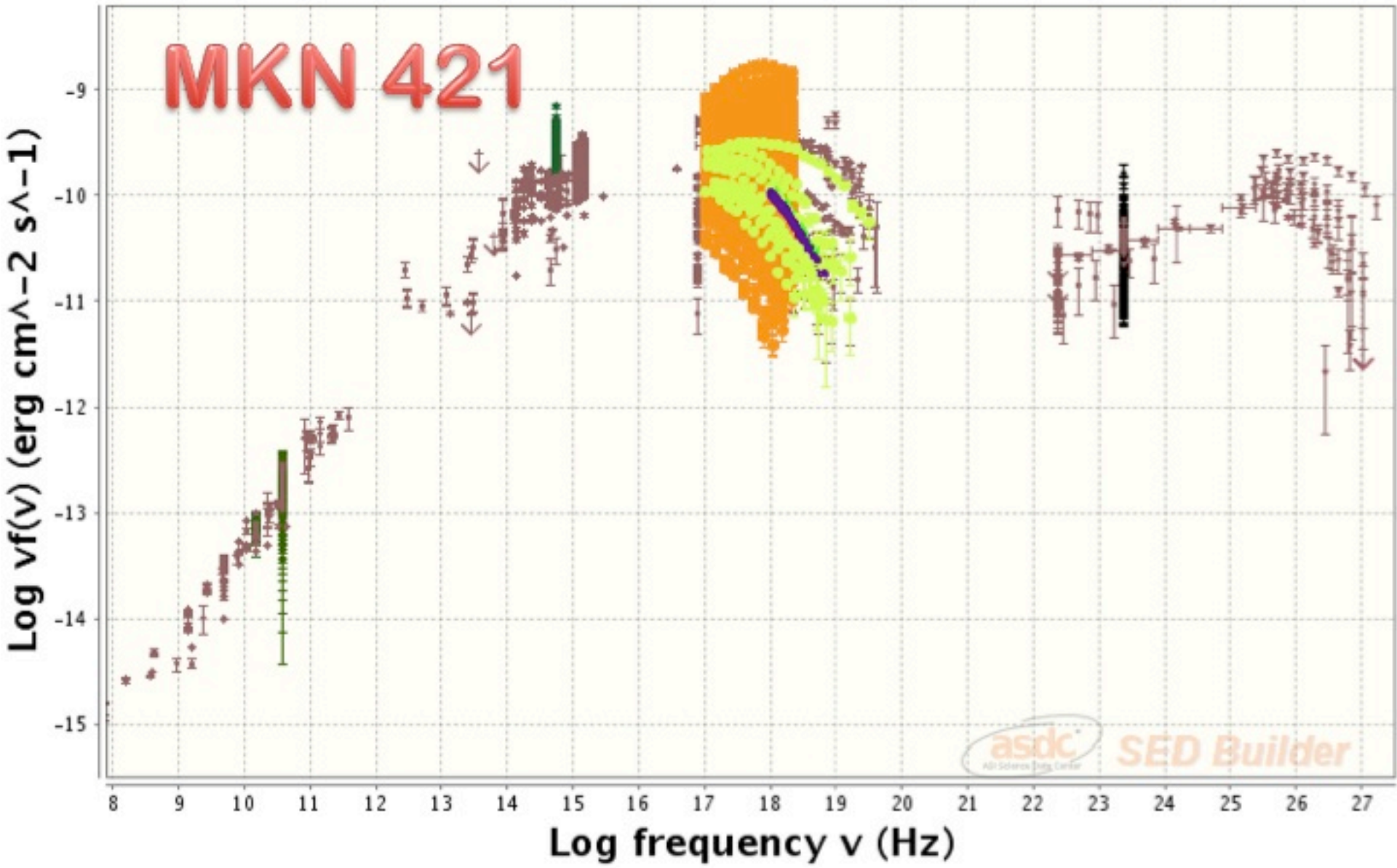

3C454.3
−9
−10
−11
Log(νfν1gev)[erg cm−2 s−1]
−11.2
−11
−10.8
−10.6
−10.4
Log(νfνvmag)[erg cm−2 s−1]
f1gev = k f2opt

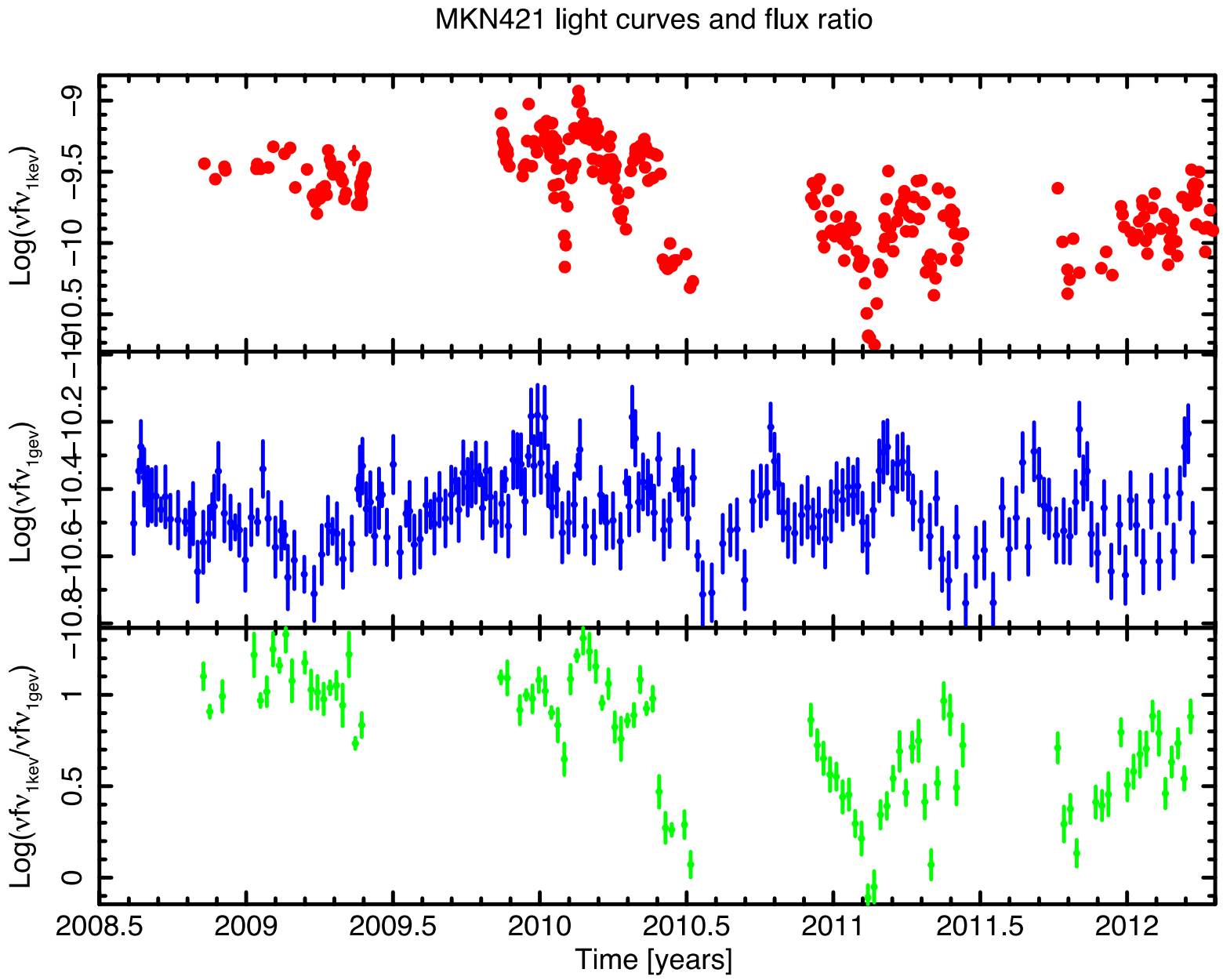

3C454.3 Ra=343.49030 deg Dec=16.14820 deg (NH=6.6E20 cm^-2)
Log νL(ν) erg s^(-1)
Log frequency ν (Hz)
49
48
47
46
45
44
43
42
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
asdc
SED Builder

3C279

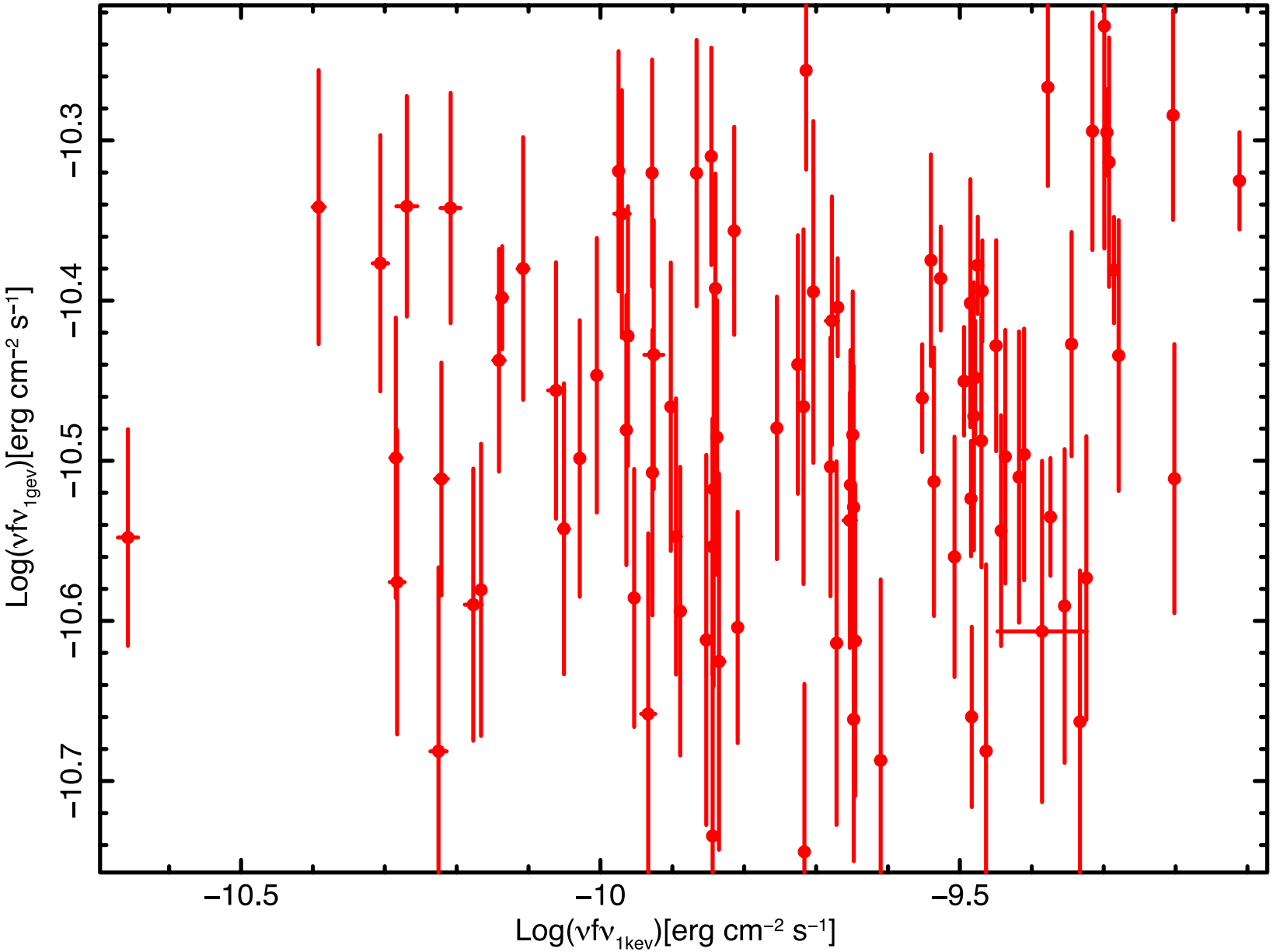


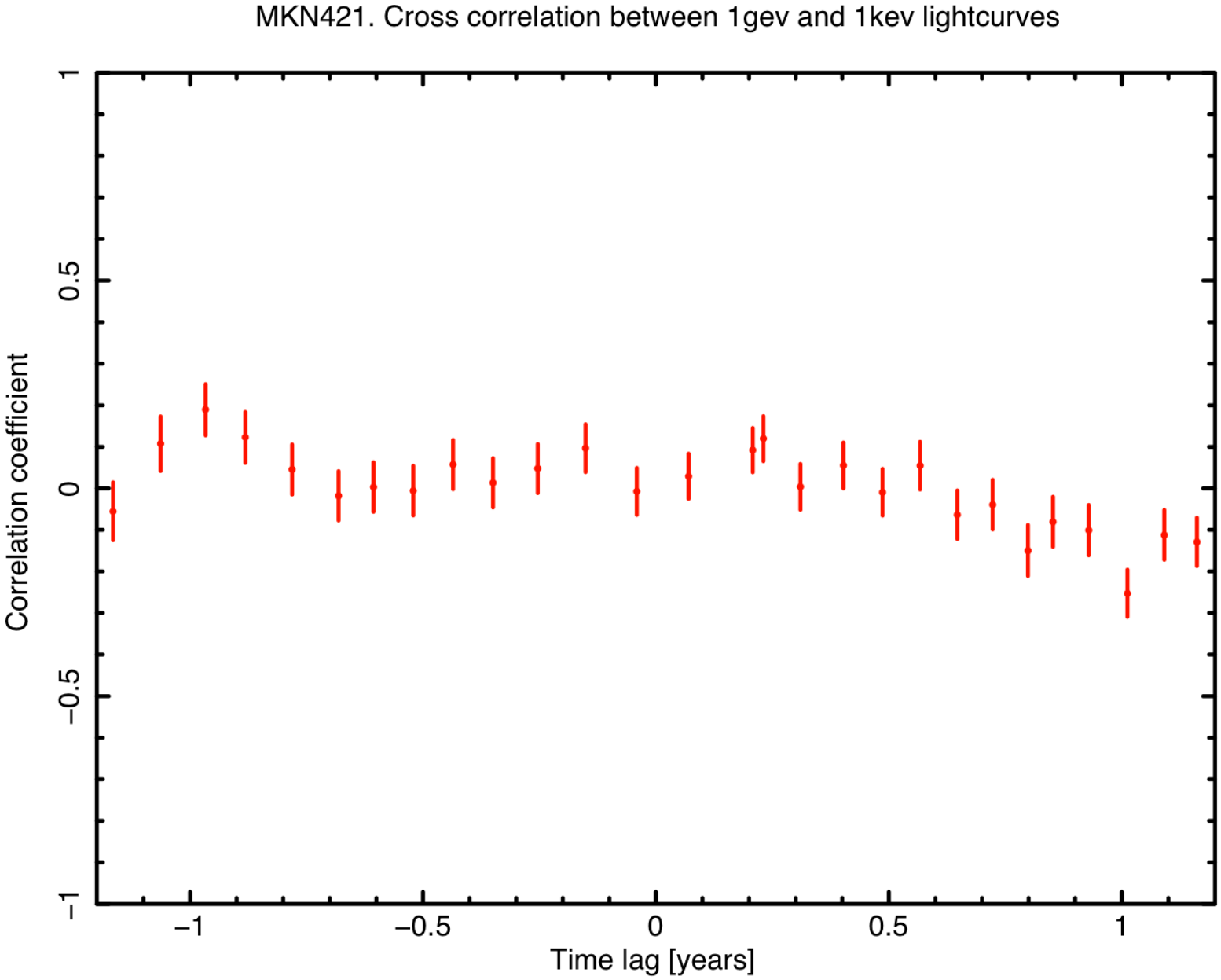
LI= 1.000 , CO= 0.9200 , WV= 6539. , N= 101.0


MKN 421
Log vf(v) (erg cm^-2 s^-1)
-9
-10
-11
-12
-13
-14
-15
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
Log frequency v (Hz)
asdc
SED Builder


MKN421 light curves and flux ratio
Log(νfν1kev)
−9
−9.5
−10
−10.5
−11
Log(νfν1gev)
−10.2
−10.4
−10.6
−10.8
Log(νfν1kev/νfν1gev)
1
0.5
0
2008.5
2009
2009.5
2010
2010.5
2011
2011.5
2012
Time [years]

MKN421


−10.3
−10.4
−10.5
−10.6
−10.7
Log(νfν1gev)[erg cm−2 s−1]
−10.5
−10
−9.5
Log(νfν1kev)[erg cm−2 s−1]

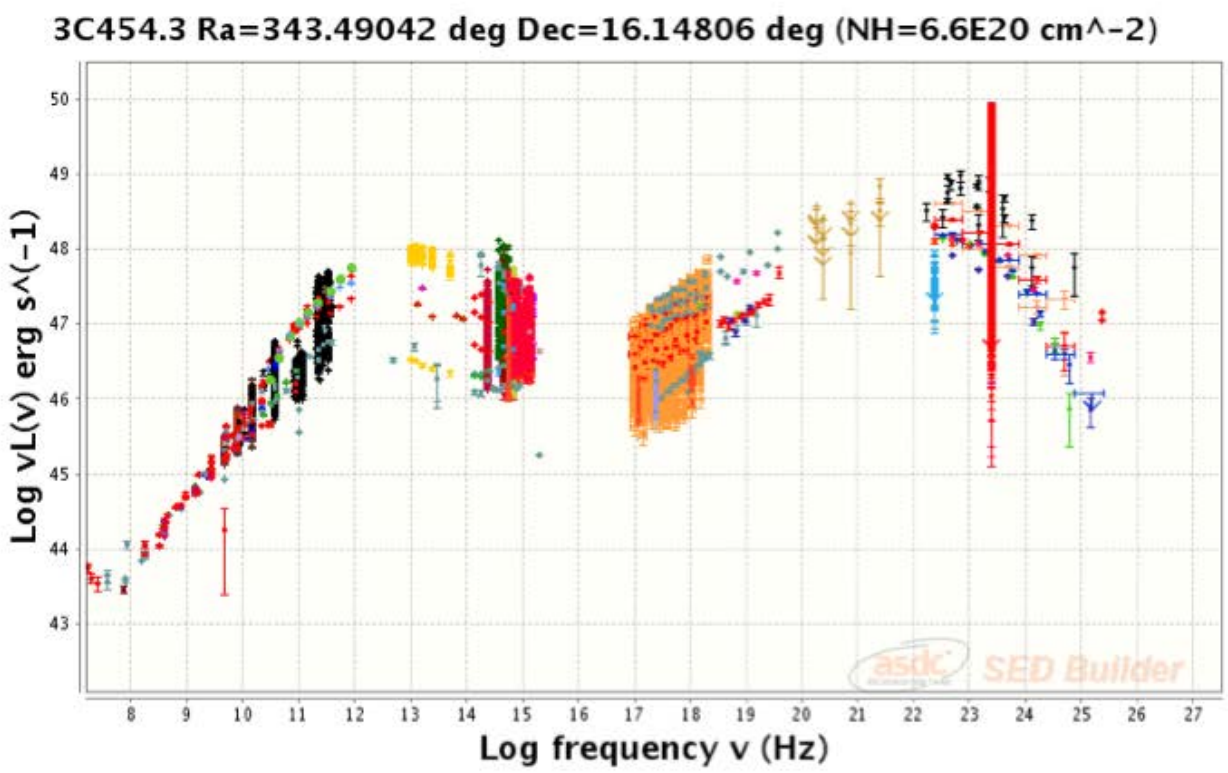

MKN421. Cross correlation between 1gev and 1kev lightcurves
Correlation coefficient
1
0.5
0
−0.5
−1
−1
−0.5
0
0.5
1
Time lag [years]

http://tools.asdc.asi.it/SED

asdc
ASI Science Data Center

SED(t) builder [V2.2]

a VO-compliant ASDC tool



Version 2.2
giommi (Logout) Feedback
Tutorial DATA EXPLORER
User Data Existing SEDs
Current SED Search and build new SEDs
Edit SED properties

Load Data | Show Data
Save | Duplicate Sed

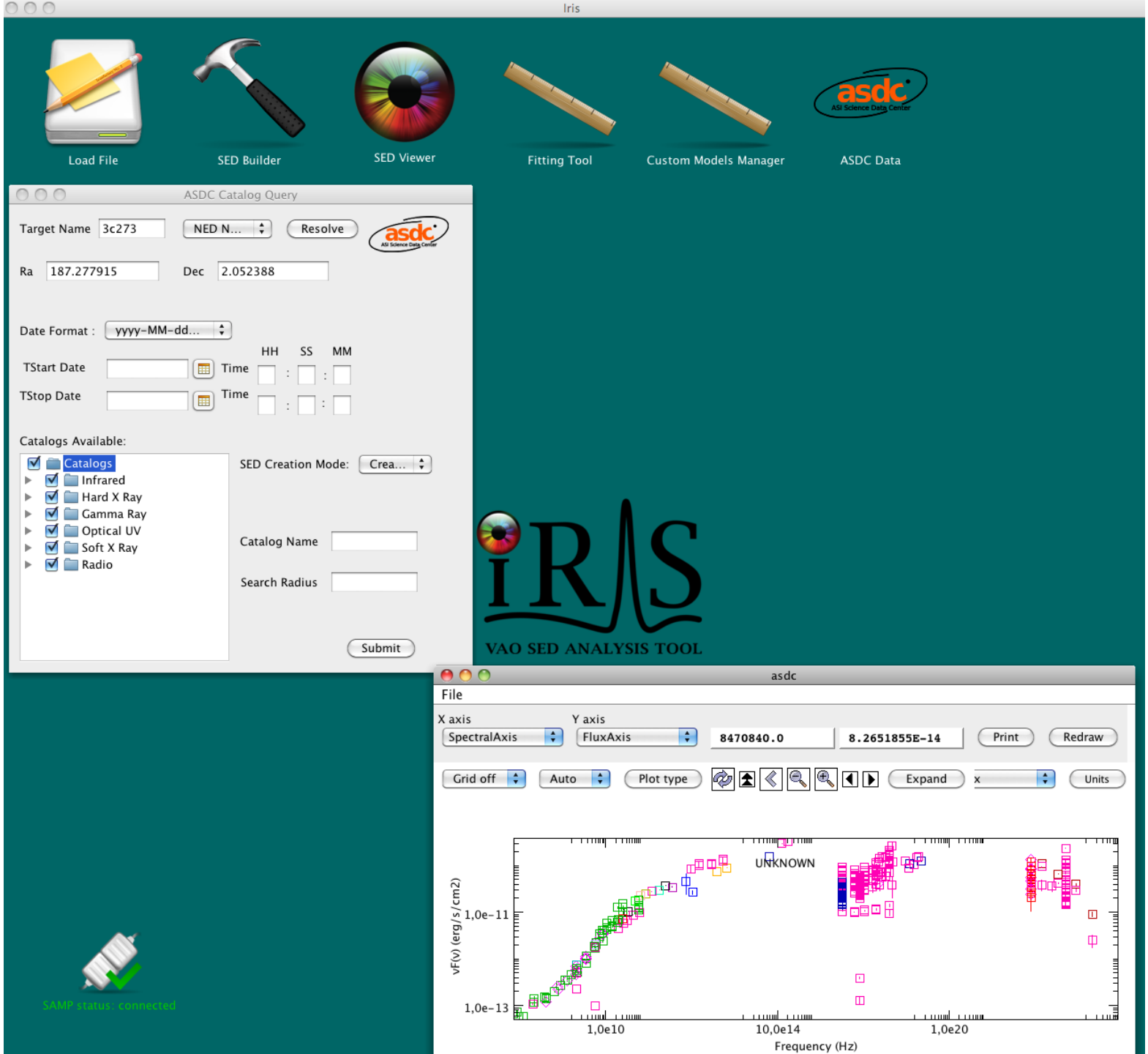
Redshift: 0.859 Frame: Observed
X Axis: Frequency (Hz)
Y Axis: nuLnu (erg/s)
Update Plot

Input Data | Models | Fit Functions
Templates | Instr Sensitivity | Plot options
Existing SEDs | Export | VO Tools

+ Time Filtering

ASDC Catalogs

Type
+ Radio
+ Infrared
+ Optical UV
+ Soft X Ray
+ Hard X Ray


Iris
Load File
SED Builder
SED Viewer
Fitting Tool
Custom Models Manager
ASDC Data
ASDC Catalog Query
Target Name
3c273
NED N...
Resolve
Ra
187.277915
Dec
2.052388
Date Format :
yyyy-MM-dd...
HH
SS
MM
TStart Date
Time
TStop Date
Time
Catalogs Available:
Catalogs
Infrared
Hard X Ray
Gamma Ray
Optical UV
Soft X Ray
Radio
SED Creation Mode:
Crea...
Catalog Name
Search Radius
Submit
iRAS
VAO SED ANALYSIS TOOL
SAMP status: connected
asdc
File
X axis
Y axis
SpectralAxis
FluxAxis
8470840.0
8.2651855E-14
Print
Redraw
Grid off
Auto
Plot type
Expand
x
Units
UNKNOWN
vF(v) (erg/s/cm2)
1,0e-11
1,0e-13
1,0e10
10,0e14
1,0e20
Frequency (Hz)

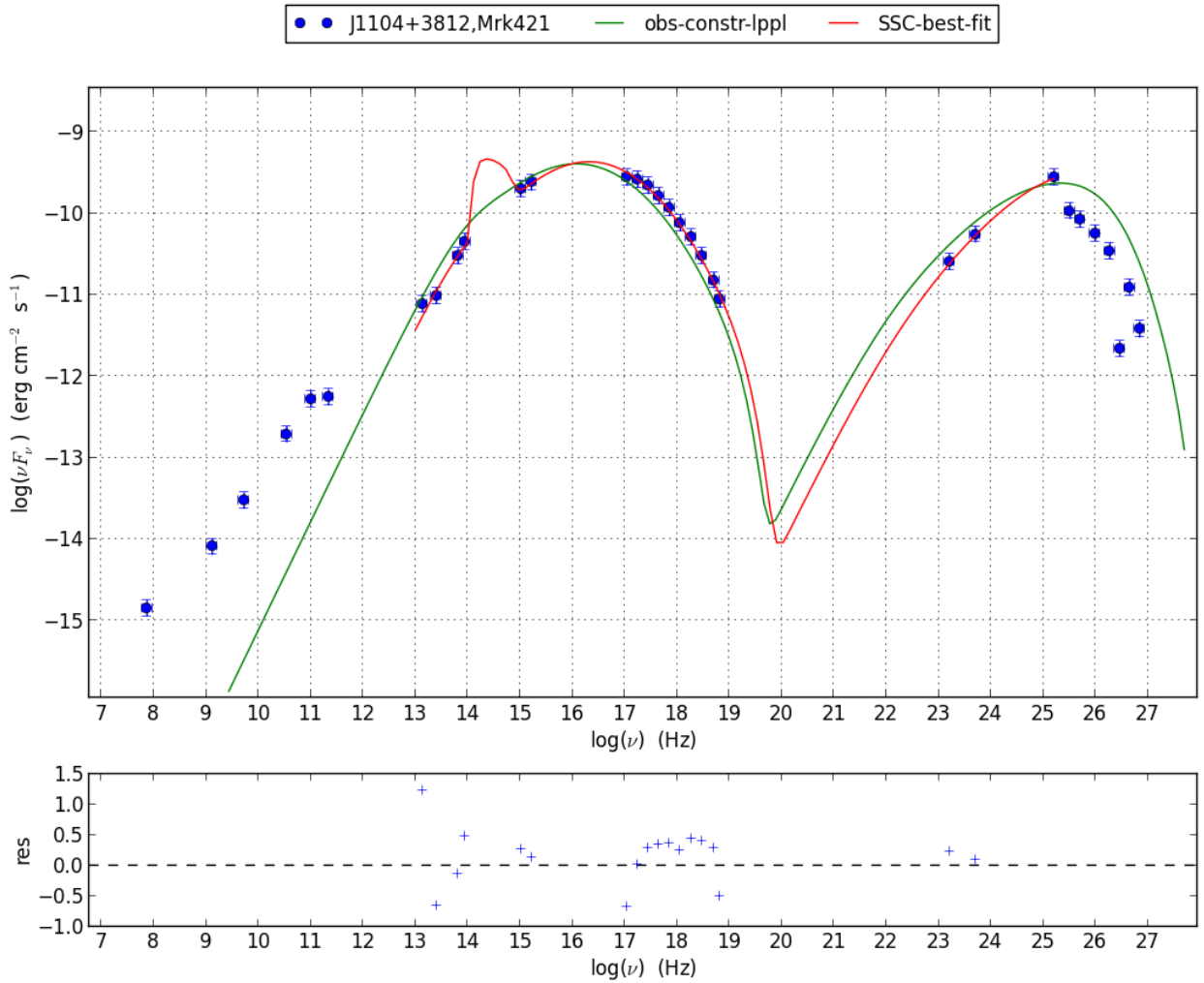
Polynomial + physical model fitting tool
Courtesy of Andrea Tramacere, ISDC

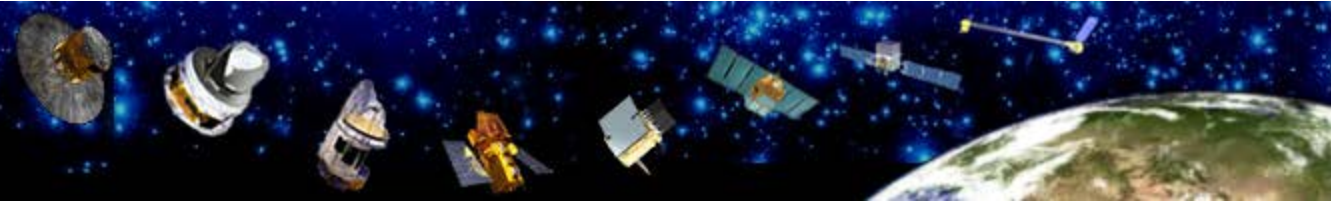
SSC/EC Simulator
author:
andrea.tramacere@unige.ch

SED tool

1e+16
R (cm)
0.1
B (G)
0.1 z
(red shift)
10.0
Γ (Bulk Lorentz Factor)
3.5 θ
(viewing angle)

n(γ)
10.0
N
10.0
γ_min
100000.0
γ_max
log-par+pl elec
distr
1.6 r
2.0 s
10000.0





Conclusions

- A large amount of new data has been accumulated recently on blazars thanks to several space and ground-based facilities (Planck, Swift, Fermi, NuSTAR, Optcal/IR, TeV/Cherenkov telescopes, etc.)
- These multi-frequency, multi-temporal data are quickly becoming available through new services and the Virtual Observatory
- New tools for visualizing and analysing data are necessary. Some are being developed within the VO
- Blazars show a wide variety of behaviour in different energy bands: a new approach to data analysis
- Expanding SED studies in the time domain is crucial for a proper understanding of the physical mechanisms behind e.m. emission in blazars