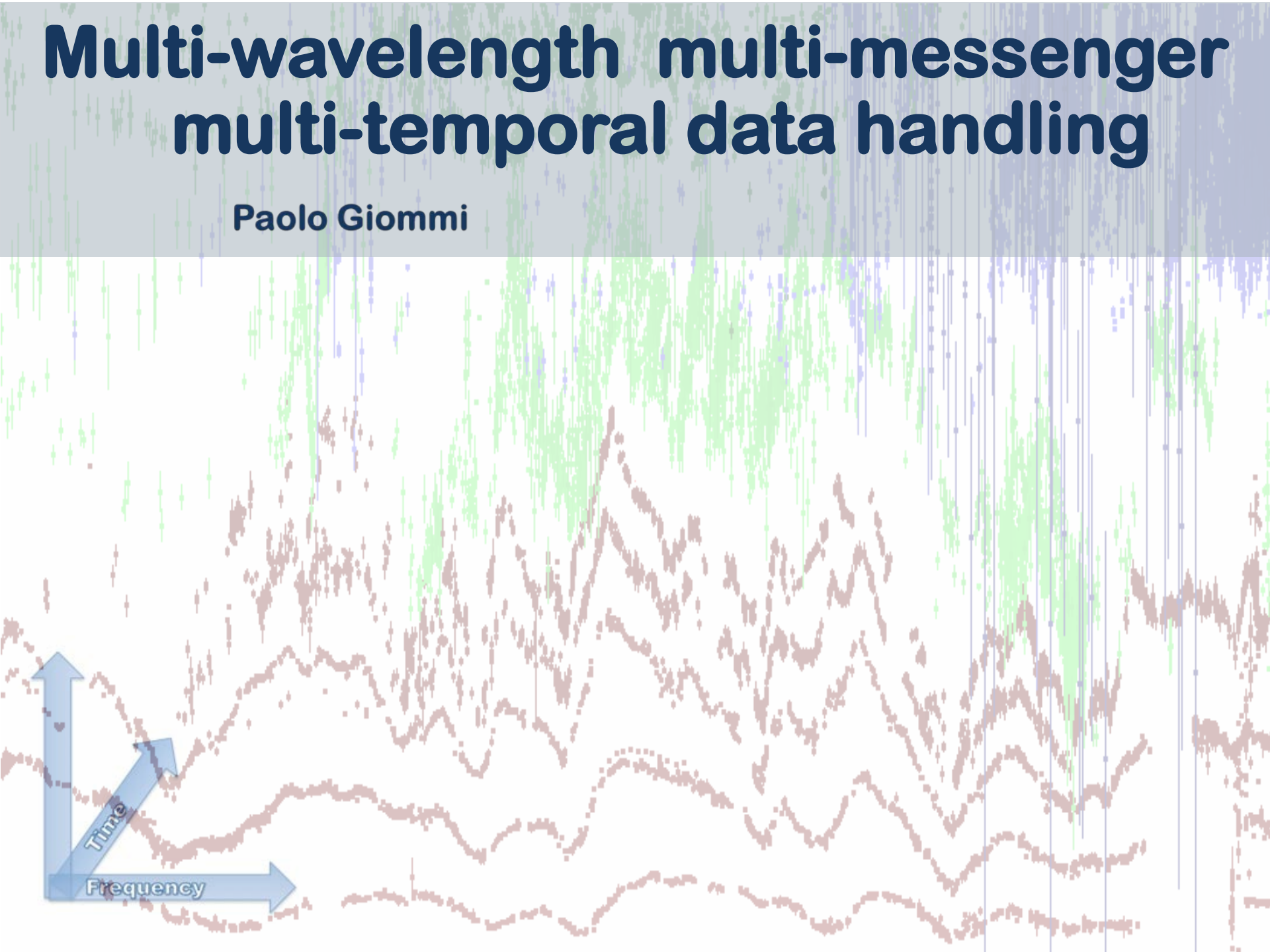
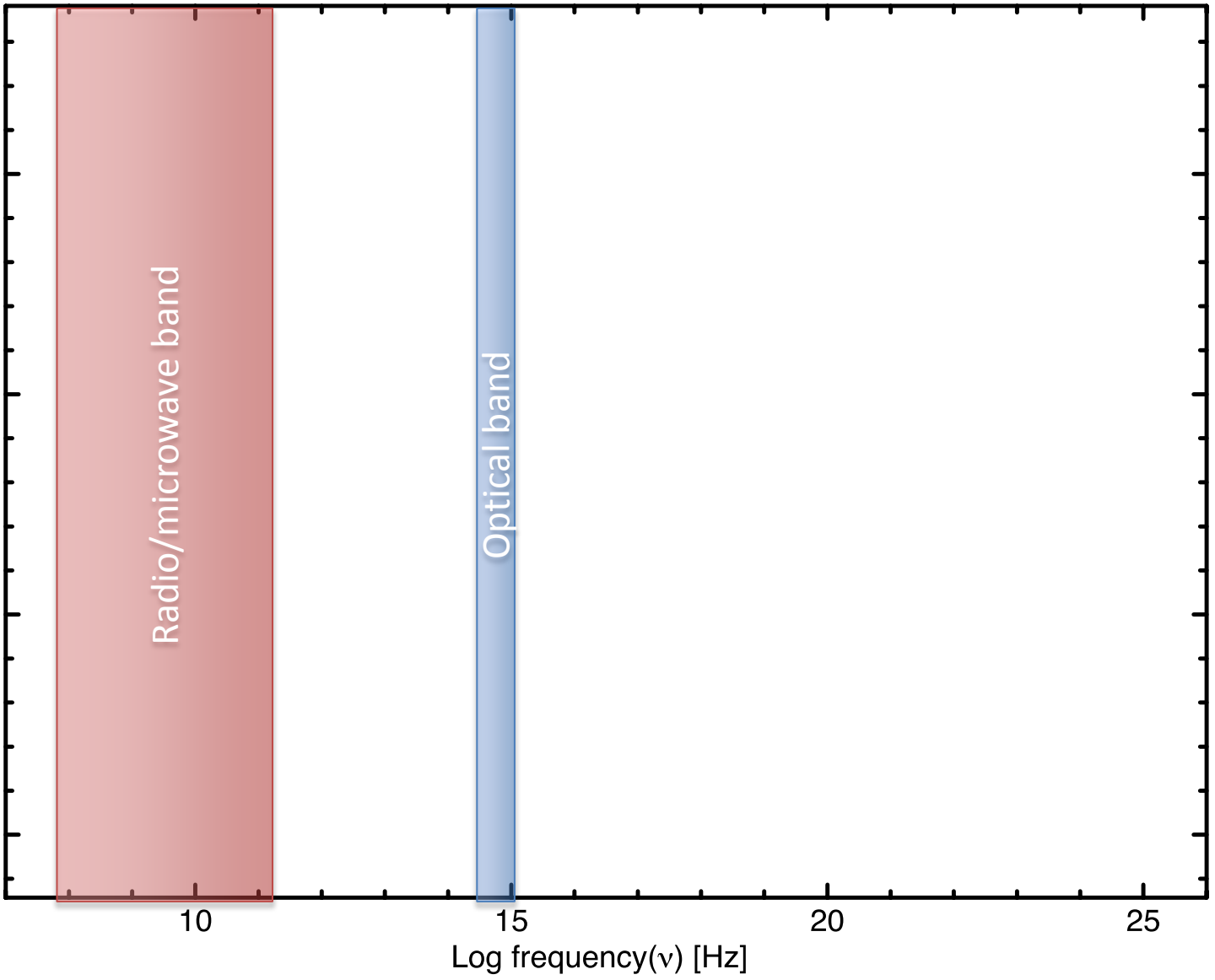
Multi-wavelength multi-messenger multi-temporal data handling

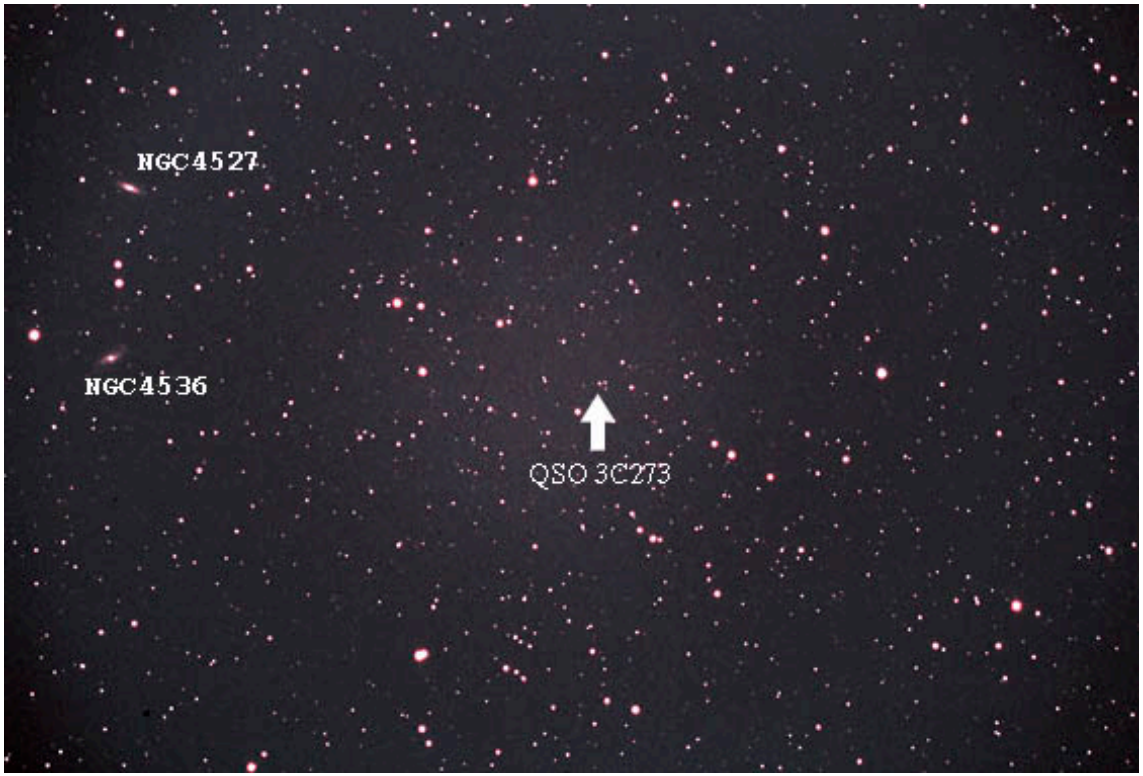
Paolo Giommi



The electromagnetic spectrum



z = 0.158



Quasar = quasi-stellar radio source

3C 273 : A STAR-LIKE OBJECT WITH LARGE RED-SHIFT

z = 0.158

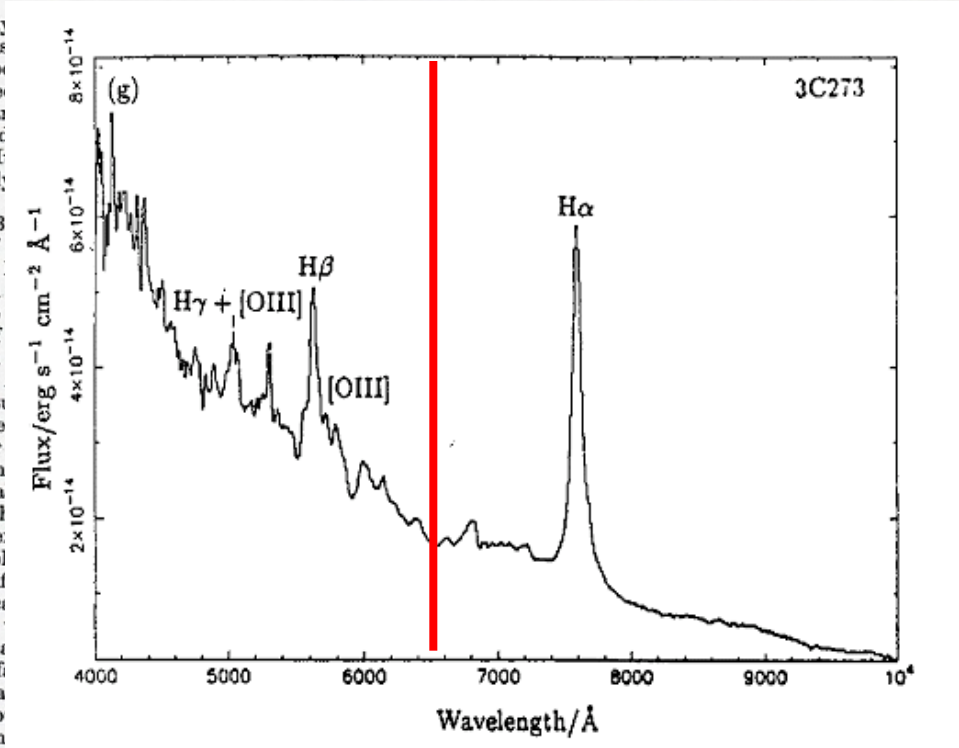
By Dr. M. SCHMIDT

Mount Wilson and Palomar Observatories, Carnegie Institution of Washington, California Institute of Technology, Pasadena

THE only
positions
3C 273 rep
in the prece
magnitude a
of 1″–2″ and
angle 43°. I
ends abruptl
star, kindly
12h 26m 33·3
or 1″ east of
of the jet is
tion between
is suggestive

Spectra of
spectrograph
400 and 190
emission feat
prominent fe
are, in order
These and oth
column of Ta
100–200 Å t

The only e
a considerabl
allows identif
lines, as indic
in agreement
based on the
2798 Å, thus f
sphere, and a
this basis ano
a strength on



detectability in the spectrum would be marginal. A weak emission band suspected at 5705 Å, or 4927 Å reduced for red-shift, does not fit the wave-length. No explanation is offered for the three very wide emission bands.

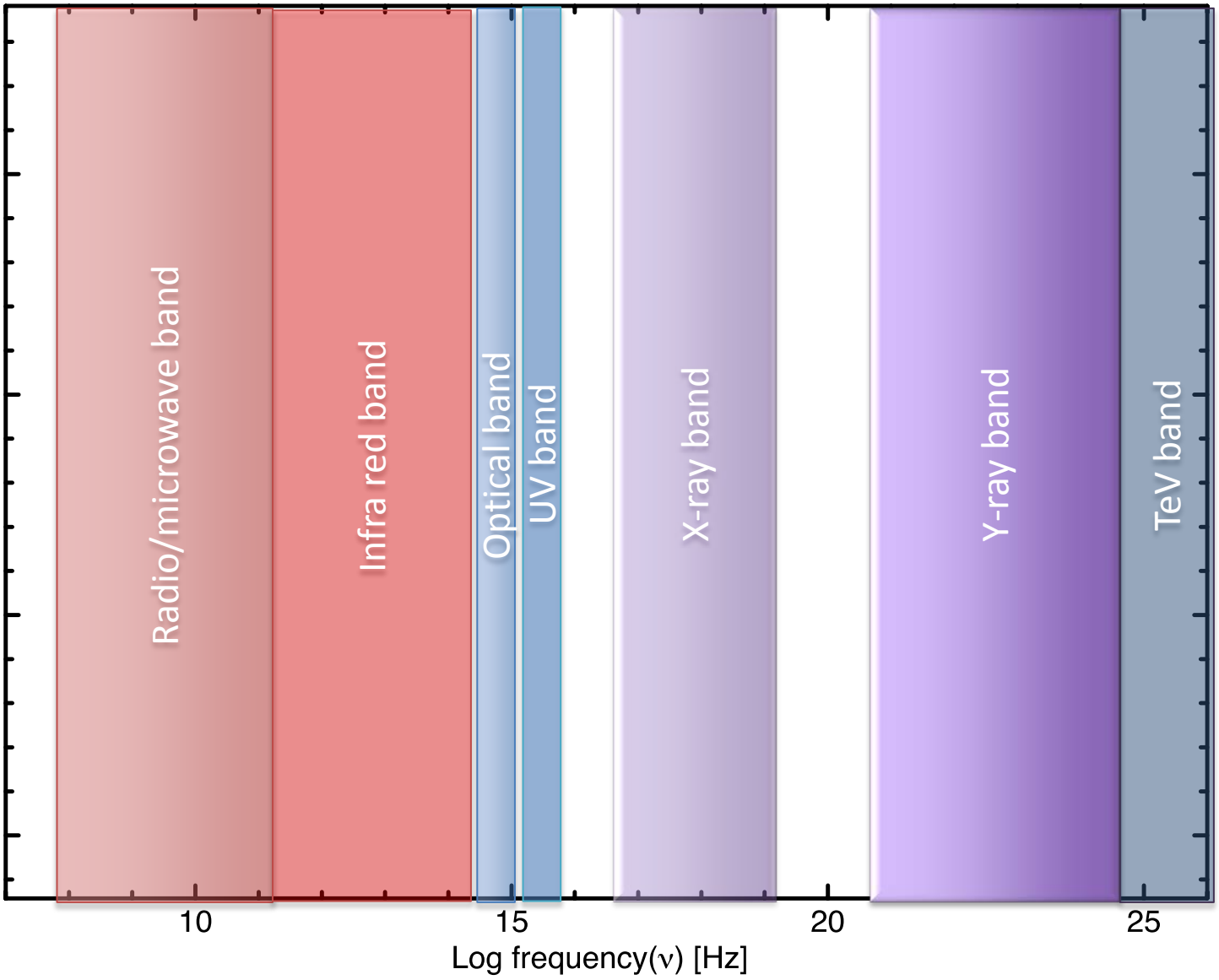
It thus appears that six emission bands with widths around 50 Å can be explained with a red-shift of 0·158. The differences between the observed and the expected wave-lengths amount to 6 Å at the most and can be entirely understood in terms of the uncertainty of the measured wave-lengths. The present explanation is supported by observations of the infra-red spectrum communicated by

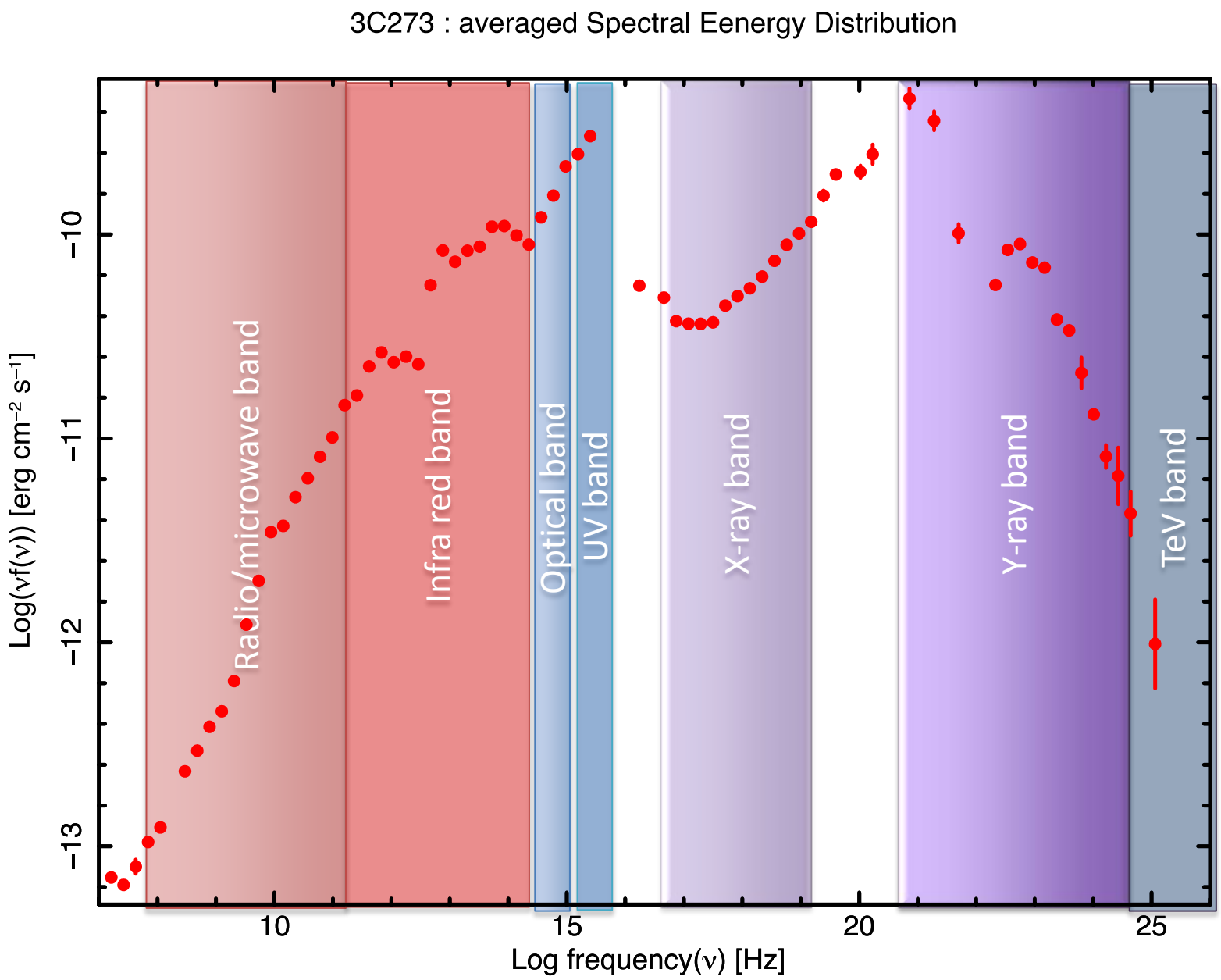
implying a time-scale in excess of 10^{8} years. The total energy radiated in the optical range at constant luminosity would be of the order of 10^{59} ergs.

Only the detection of an irrefutable proper motion or parallax would definitively establish 3C 273 as an object within our Galaxy. At the present time, however, the explanation in terms of an extragalactic origin seems most direct and least objectionable.

I thank Dr. T. A. Matthews, who directed my attention to the radio source, and Drs. Greenstein and Oke for valuable discussions.

The electromagnetic spectrum




3C273 : averaged Spectral Eenergy Distribution
Log(νf(ν)) [erg cm⁻² s⁻¹]
−10
−11
−12
−13
Radio/microwave band
Infra red band
Optical band
UV band
X-ray band
Y-ray band
TeV band
10
15
20
25
Log frequency(ν) [Hz]

SED(t) builder [V2.1]

a VO-compliant ASDC tool

Version 2.1.6

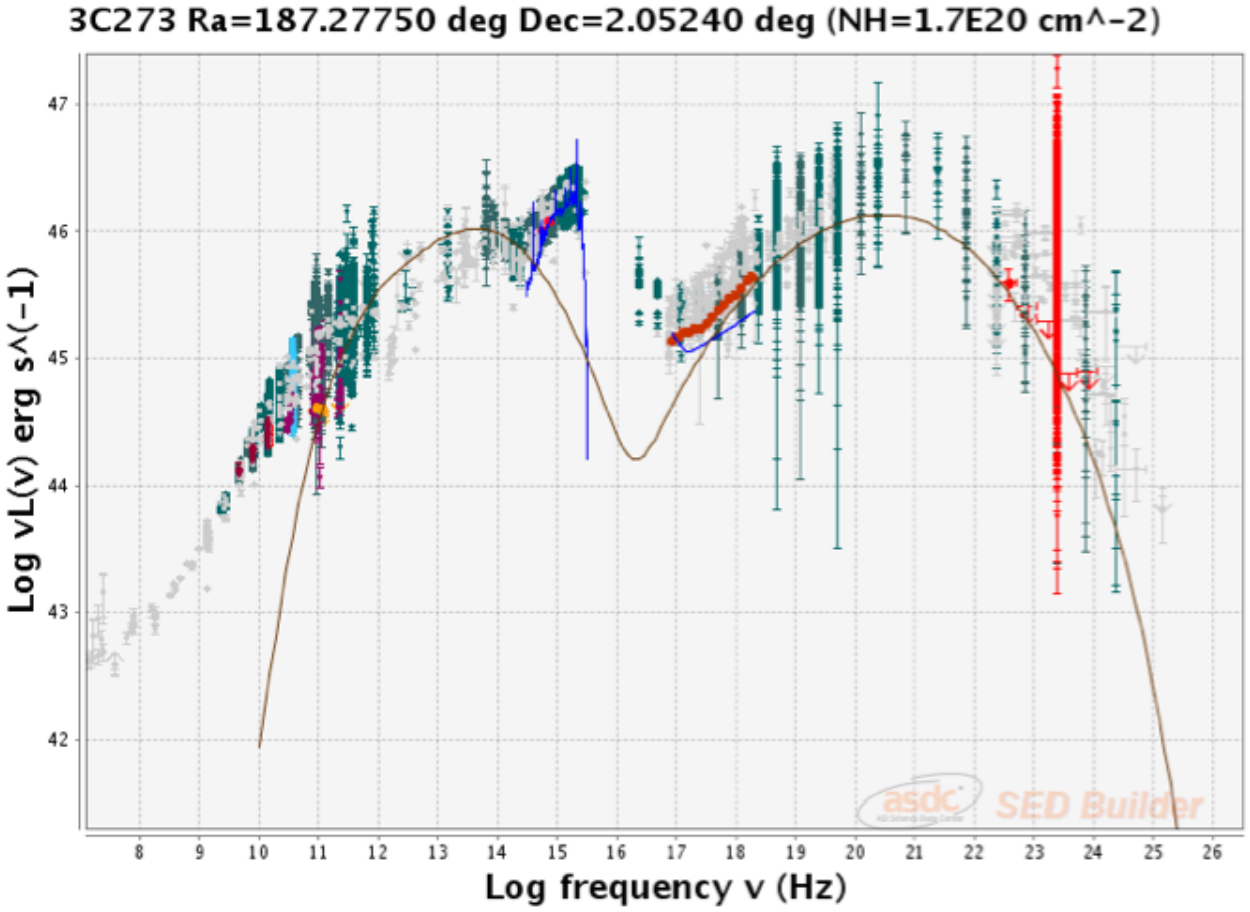
giommi (Logout) Feedback

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: 0.158 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

Caution.This is a Beta Version.

Launch TOPCAT | Launch IRIS

Broadcast Type: SED 3D

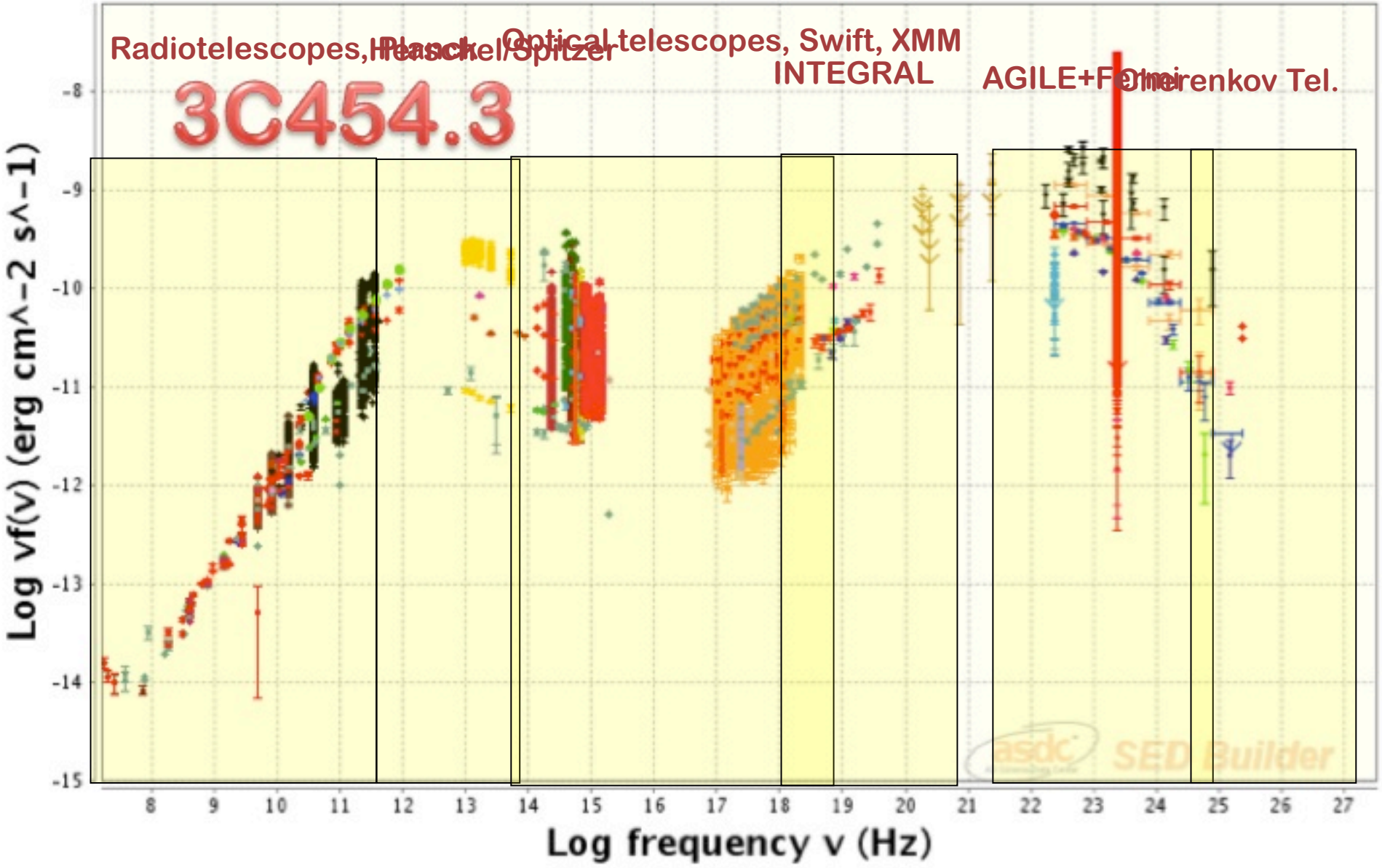
Register | Unregister Registered: Yes

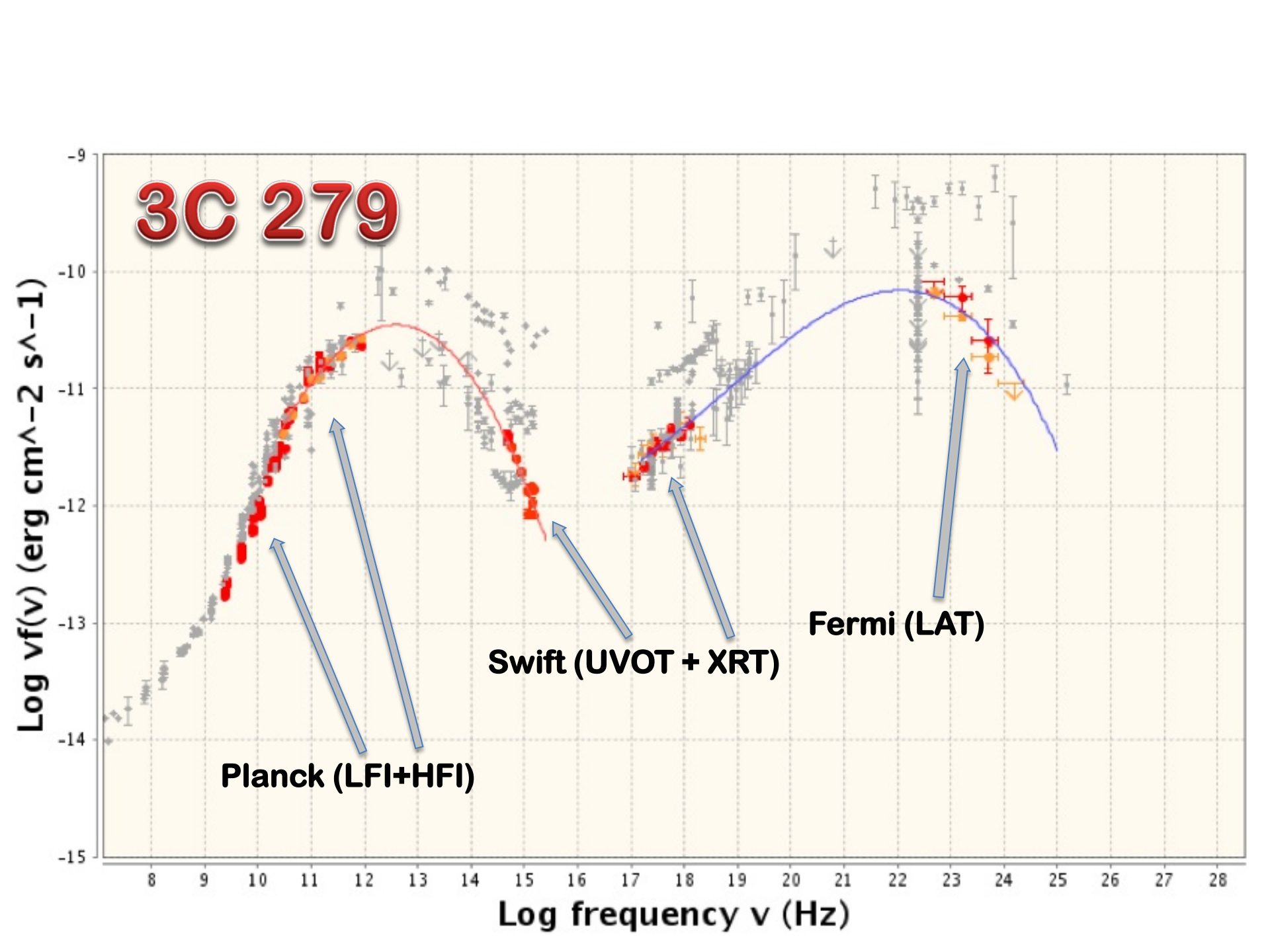
Registered Clients

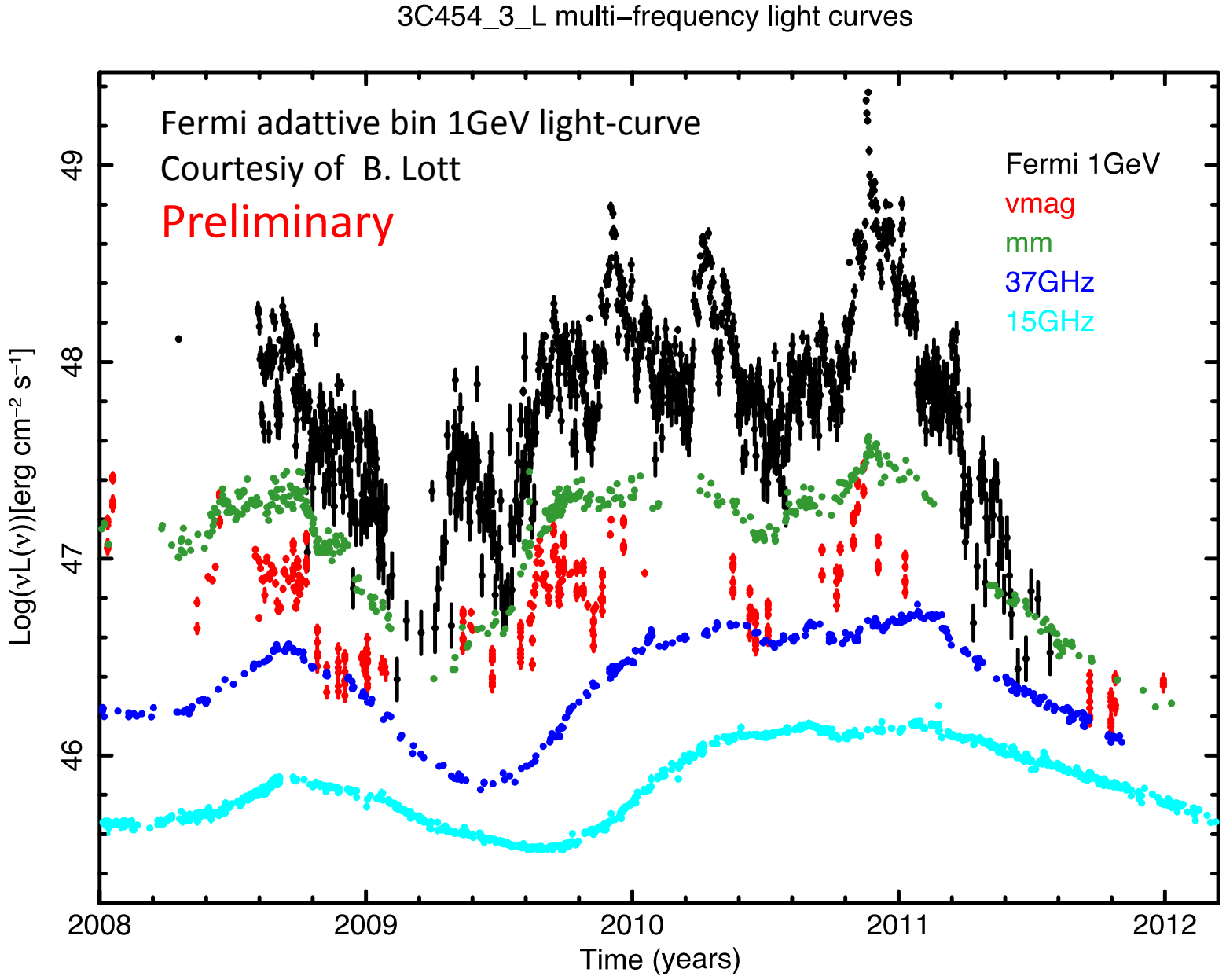
- Hub (meta+) (subs+)
- topcat (meta+) (subs+) Broadcast

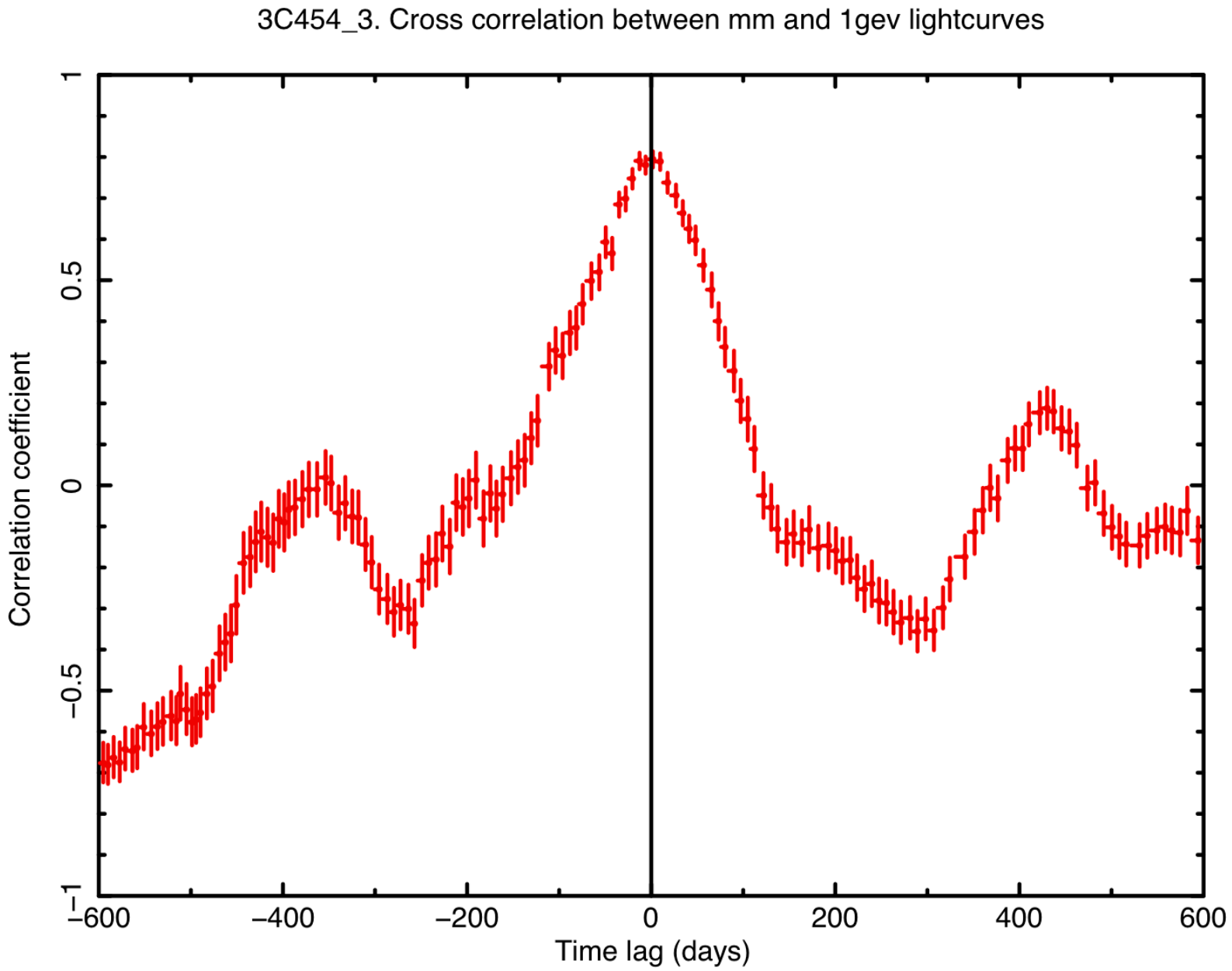
Typical Multi-Wavelength emitters:

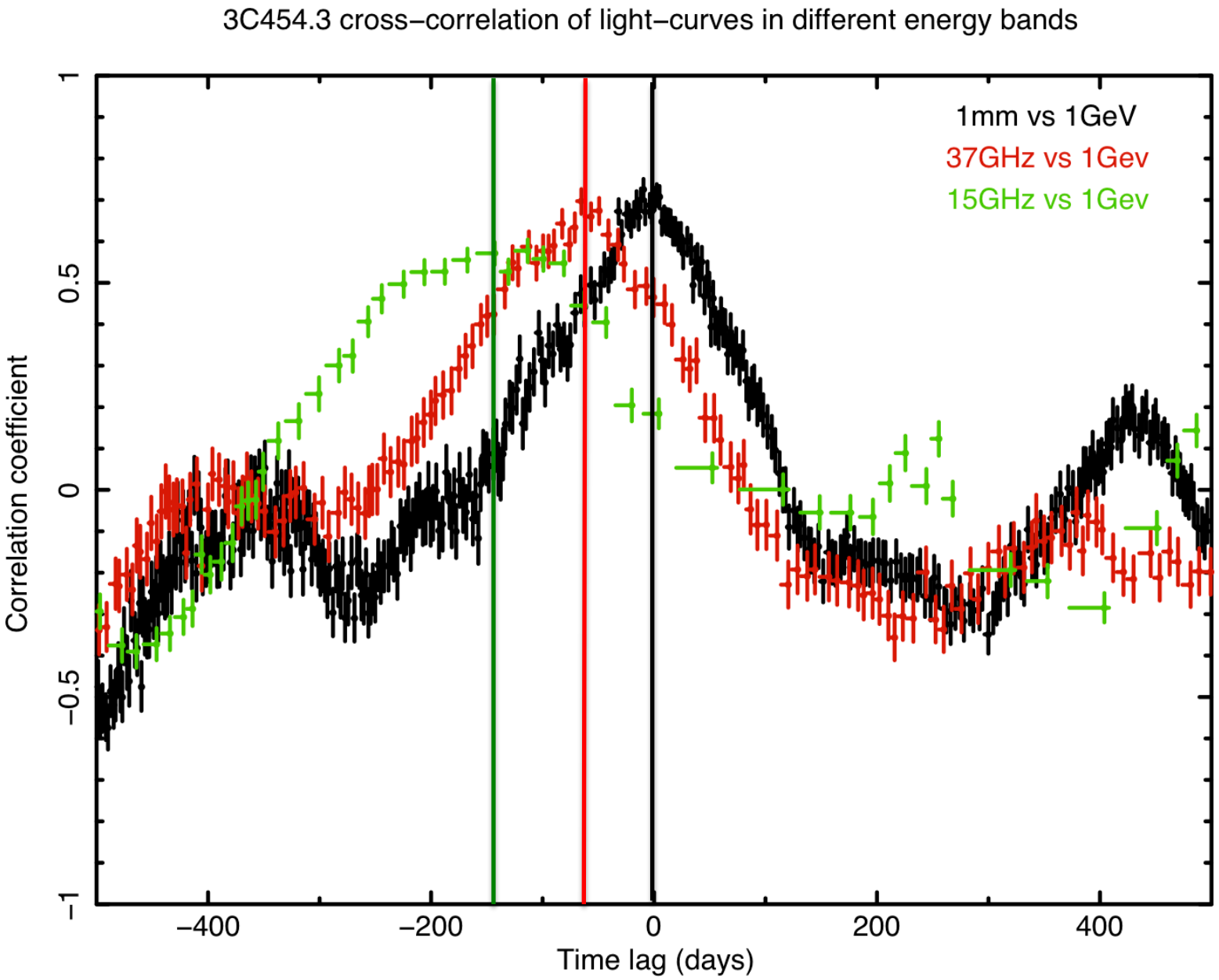
- Radio galaxies/Blazars
- Pulsars/Pulsar wind nebulae (e.g. Crab)
- GRBs

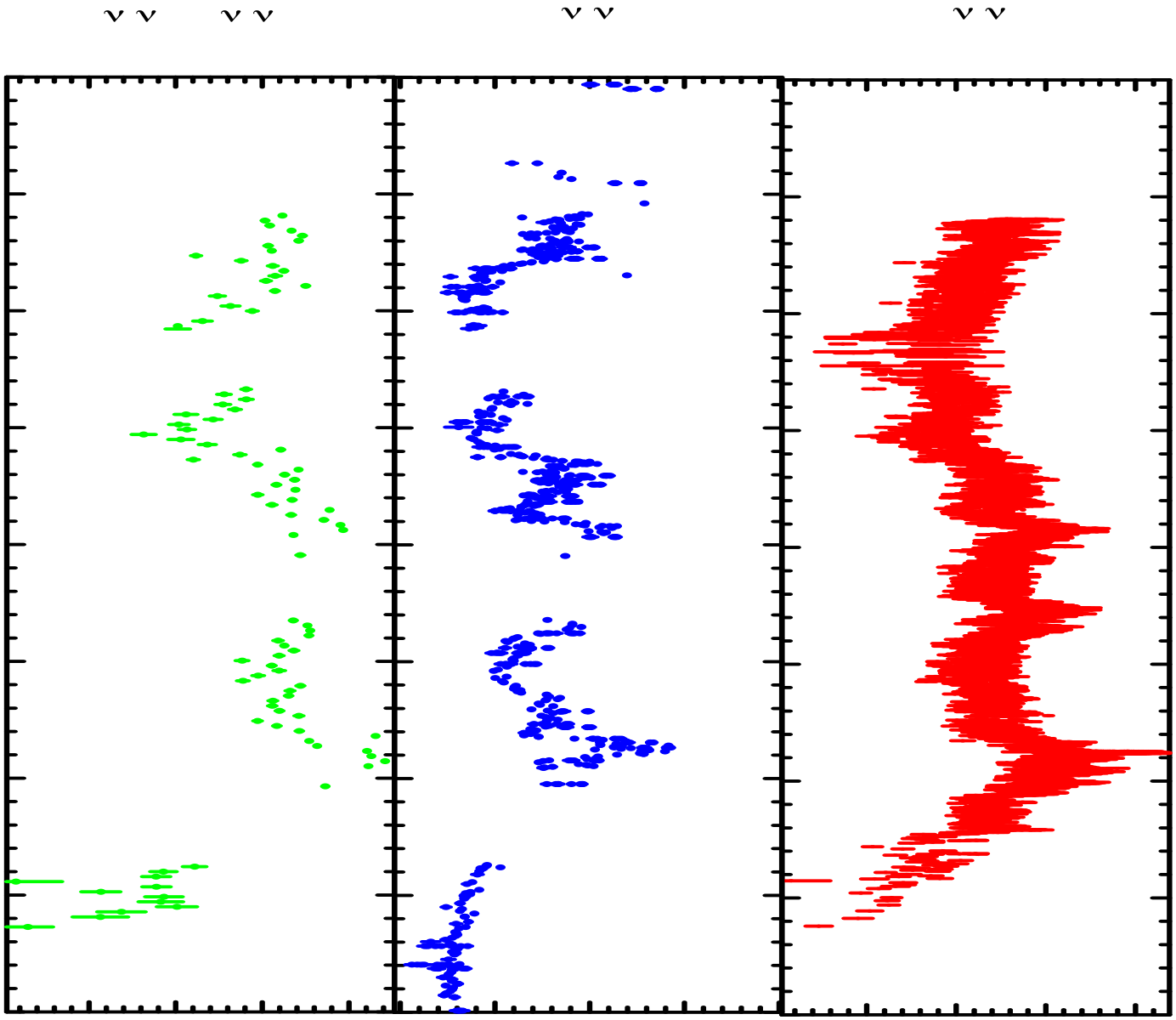

Radiotelescopes, Planck, Herschel/Spitzer
Optical telescopes, Swift, XMM
INTEGRAL
AGILE+Fermi
Cherenkov Tel.
3C454.3
Log vf(v) (erg cm^-2 s^-1)
Log frequency v (Hz)
asdc SED Builder

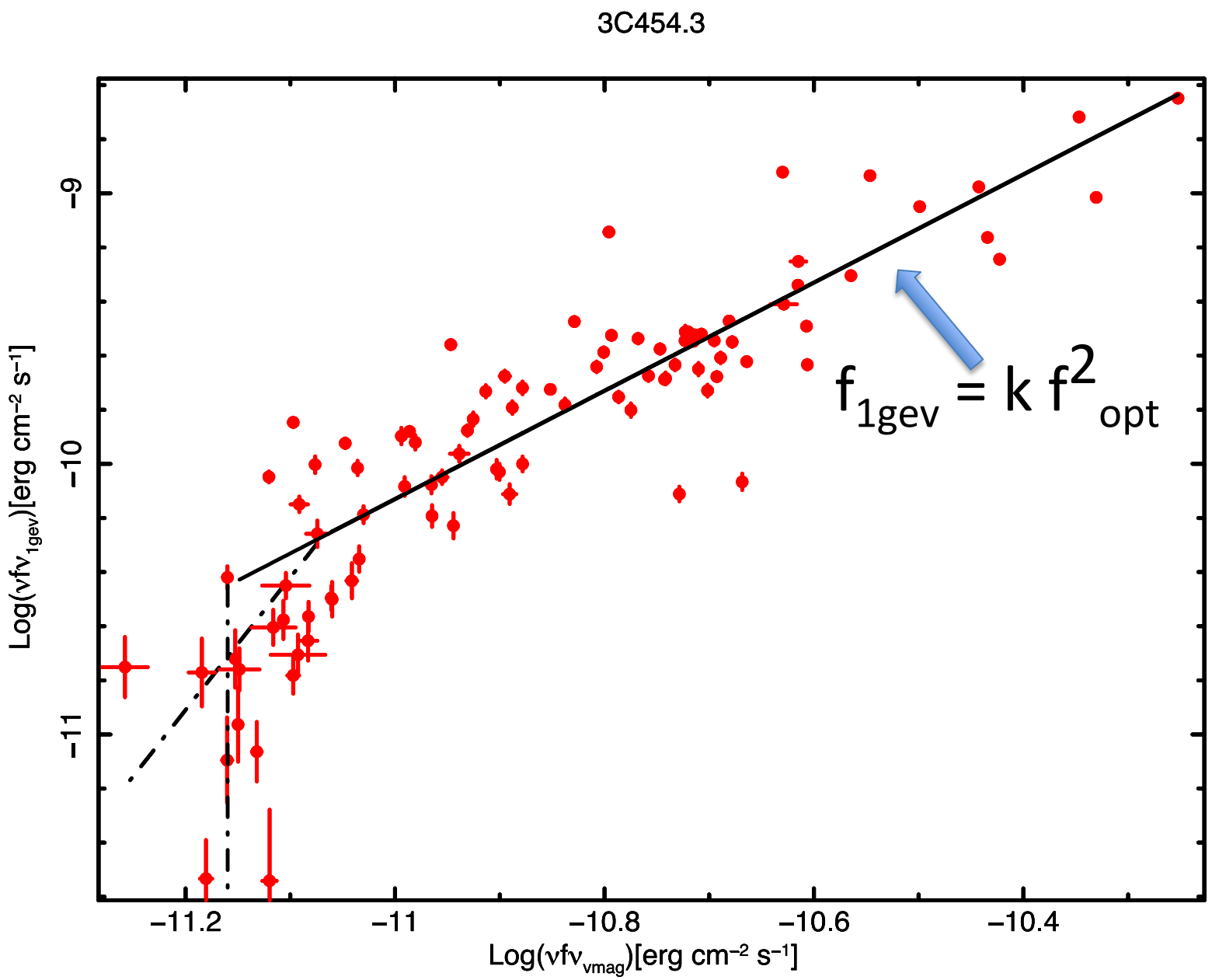

3C 279
Planck (LFI+HFI)
Swift (UVOT + XRT)
Fermi (LAT)
Log vf(v) (erg cm^-2 s^-1)
Log frequency v (Hz)
-9
-10
-11
-12
-13
-14
-15
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28


3C454_3_L multi–frequency light curves
Fermi adattive bin 1GeV light-curve
Courtesiy of B. Lott
Preliminary
Fermi 1GeV
vmag
mm
37GHz
15GHz
Log(νL(ν))[erg cm⁻² s⁻¹]
46
47
48
49
2008
2009
2010
2011
2012
Time (years)

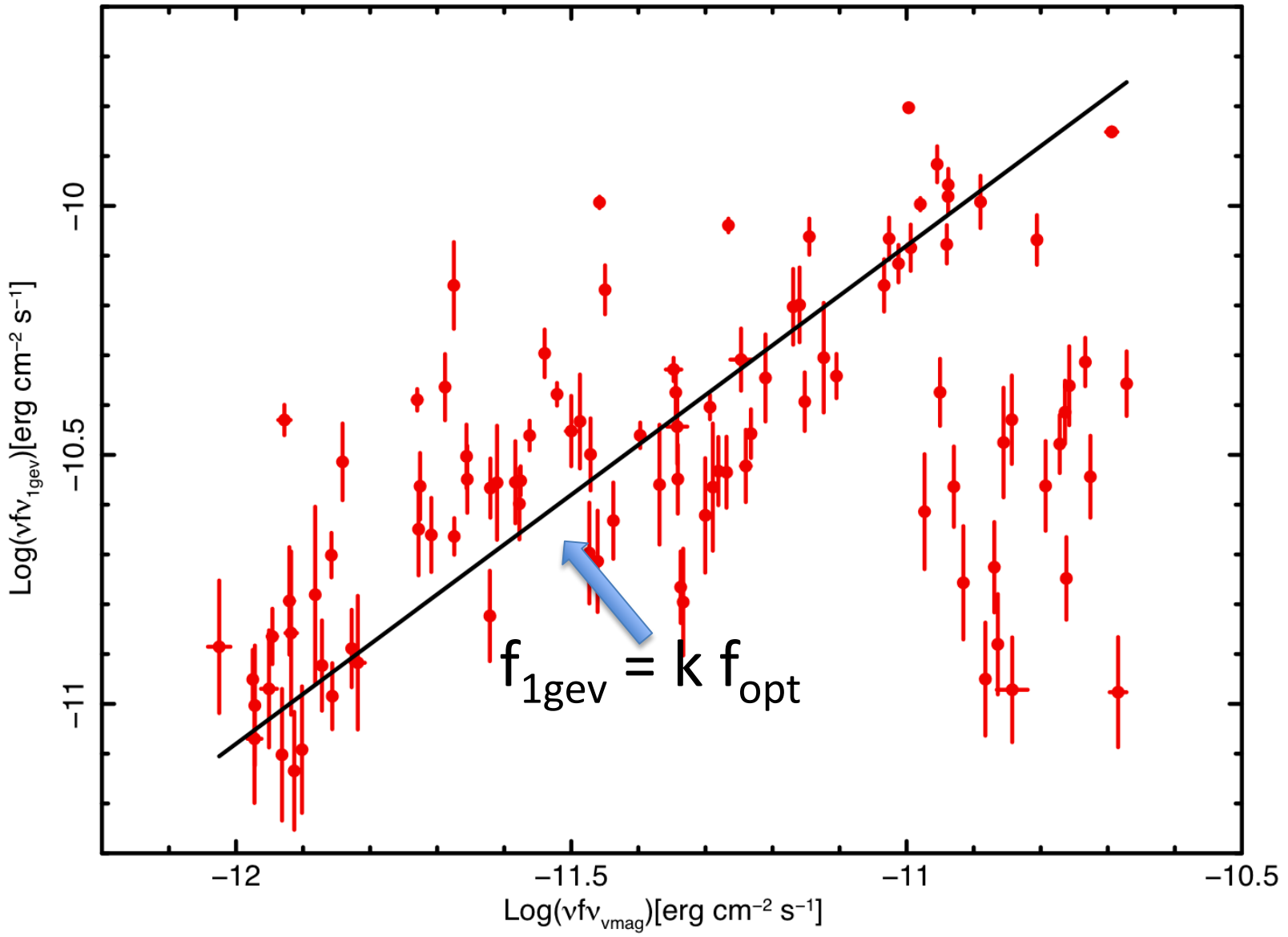

3C454_3. Cross correlation between mm and 1gev lightcurves
Correlation coefficient
1
0.5
0
−0.5
−1
−600
−400
−200
0
200
400
600
Time lag (days)


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)

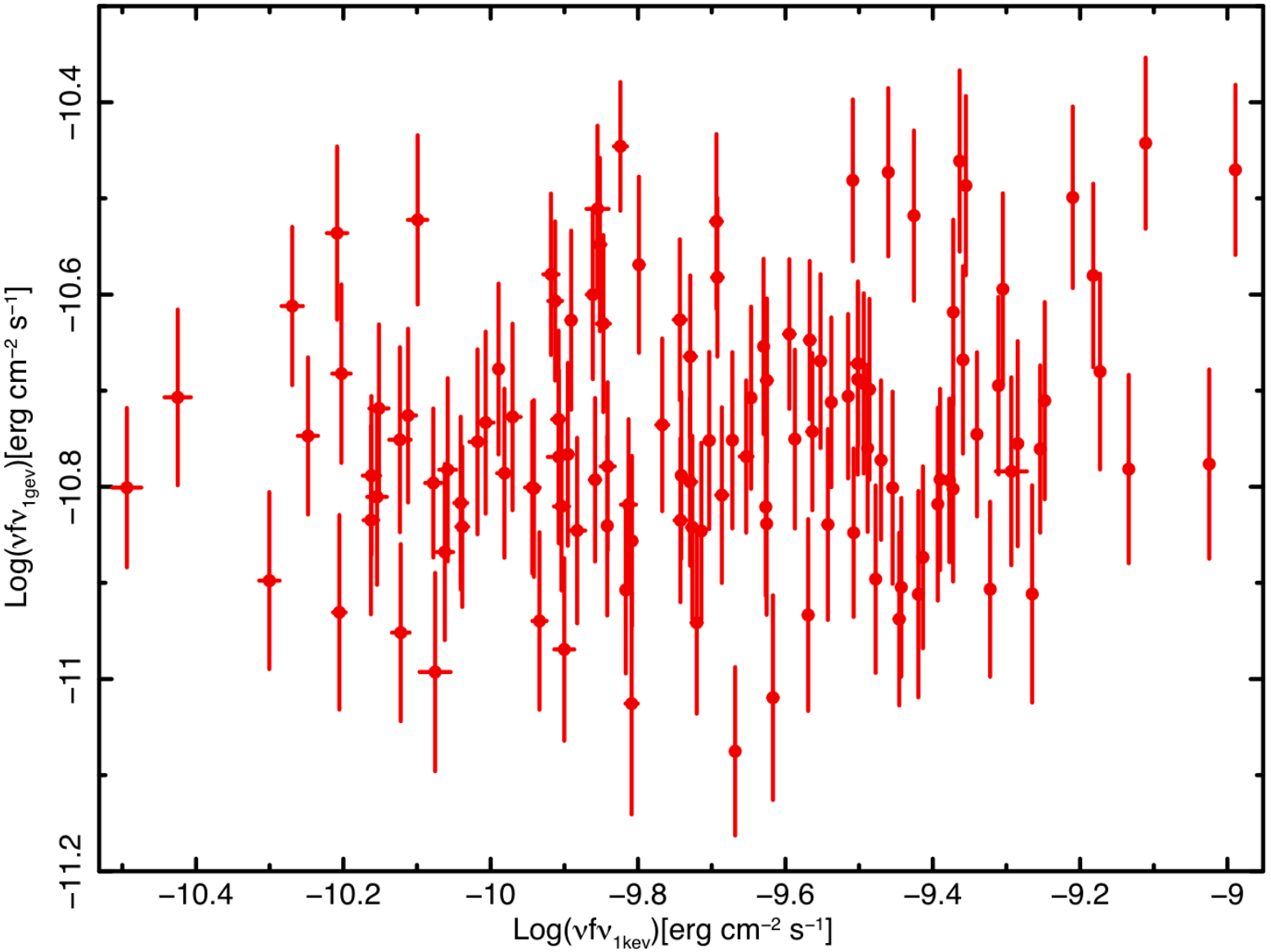


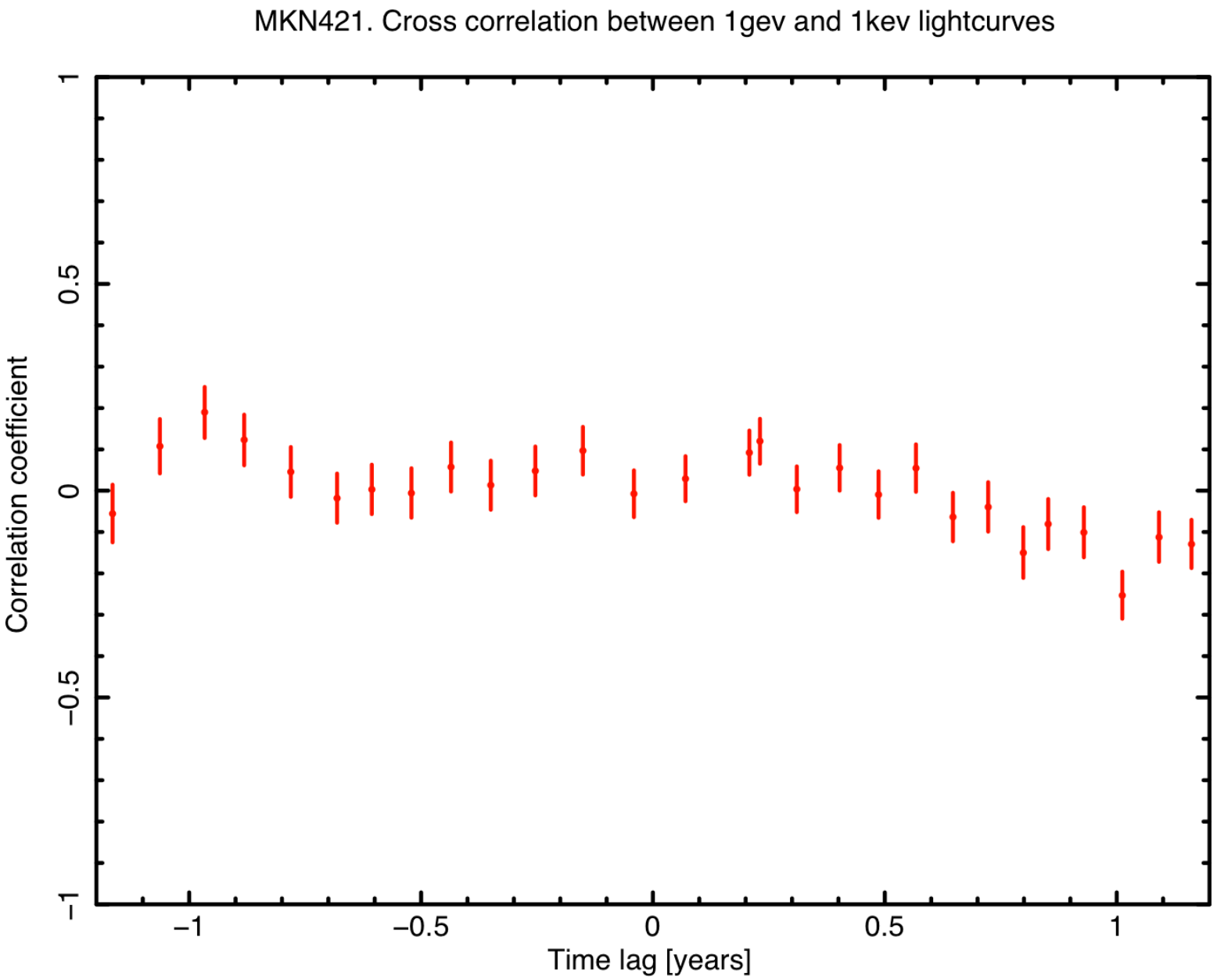

3C454.3
−9
−10
−11
Log(νfν1gev)[erg cm−2 s−1]
−11.2
−11
−10.8
−10.6
−10.4
Log(νfνvmag)[erg cm−2 s−1]
f1gev = k f2opt

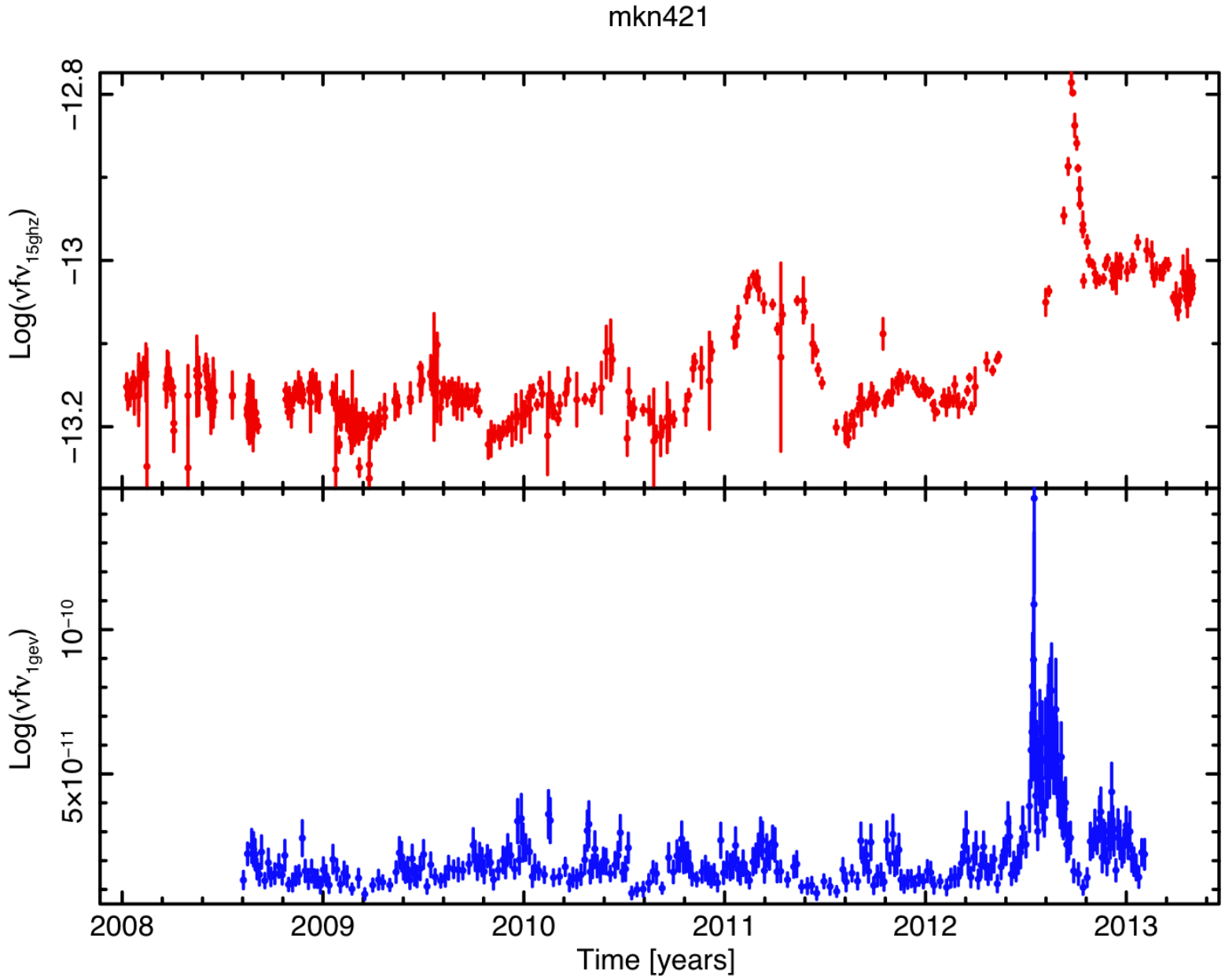
3C279



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


−10.4
−10.6
−10.8
−11
−11.2
−10.4
−10.2
−10
−9.8
−9.6
−9.4
−9.2
−9
Log(νfν1gev)[erg cm−2 s−1]
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]

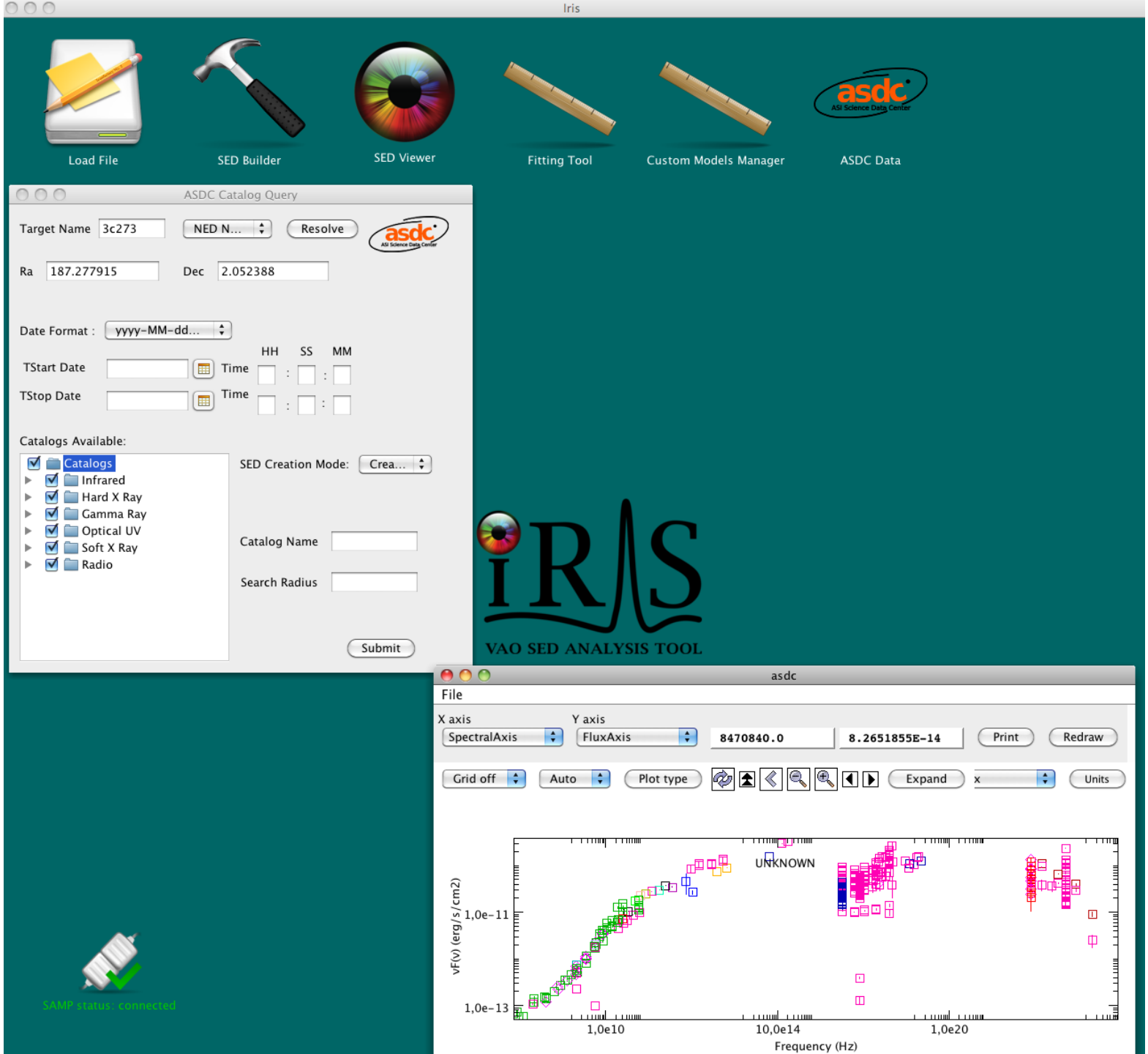

mkn421
−12.8
−13
−13.2
Log(νfν15ghz)
10−10
5x10−11
Log(νfν1gev)
2008
2009
2010
2011
2012
2013
Time [years]

Multi-frequency astronomy is now a lot easier than in the past thanks to the many data centers that provide data, software and calibration for most existing observational facilities

AND

International **V**irtual **O**bservatory **A**lliance

The International Virtual Observatory Alliance (IVOA) was formed in June 2002 with a mission to *"facilitate the international coordination and collaboration necessary for the development and deployment of the tools, systems and organizational structures necessary to enable the international utilization of astronomical archives as an integrated and interoperating virtual observatory."* The IVOA now comprises 20 VO programs from

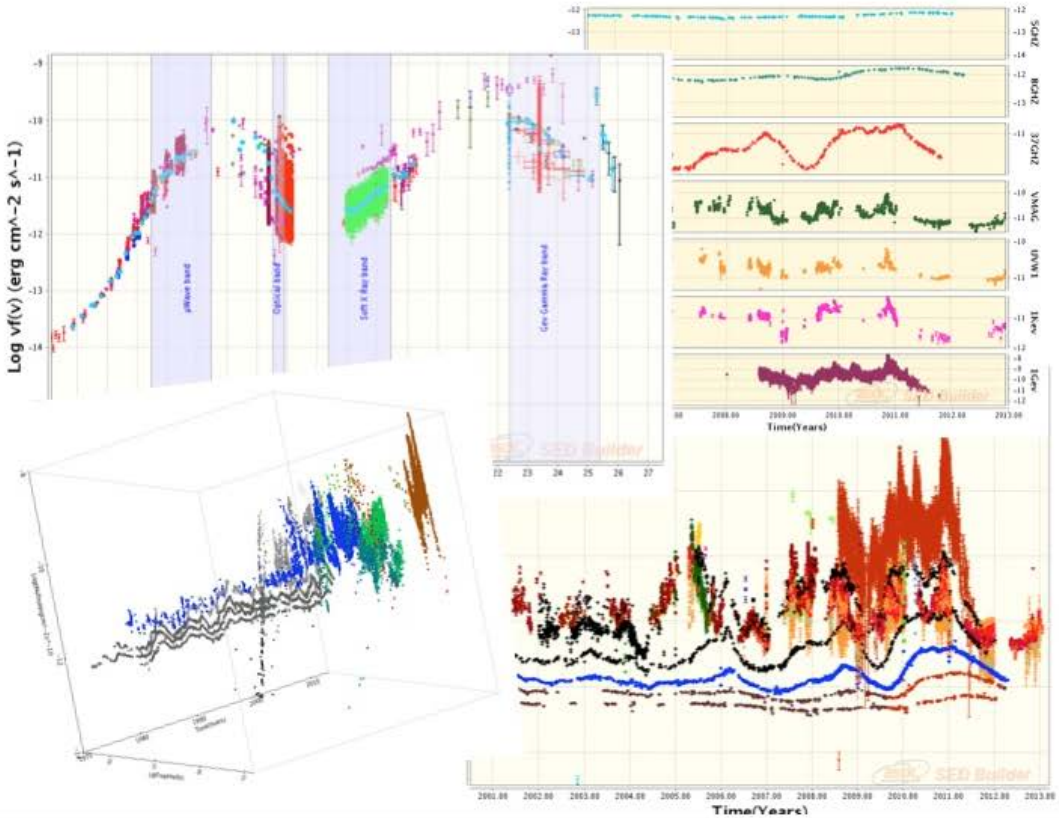

Iris
Load File
SED Builder
SED Viewer
Fitting Tool
Custom Models Manager
ASDC Data
ASDC Catalog Query
Target Name
3c273
NED N...
Resolve
Ra
187.277915
Dec
2.052388
Date Format :
yyyy-MM-dd...
HH
SS
MM
TStart Date
Time
TStop Date
Time
Catalogs Available:
Catalogs
Infrared
Hard X Ray
Gamma Ray
Optical 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)

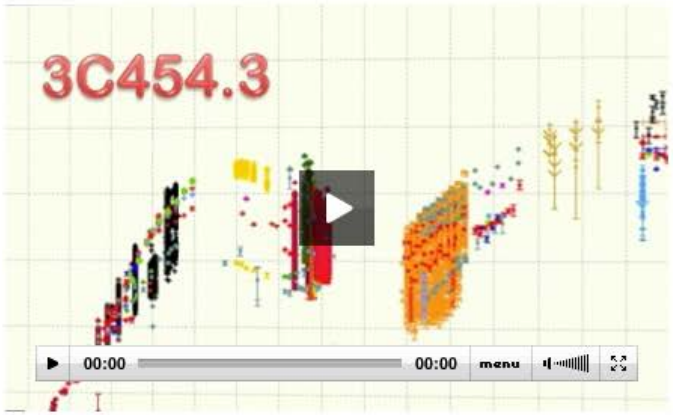
SED(t) builder V3.0

A tool to build and handle Spectral Energy Distributions, time-resolved SEDs and multi-frequency light-curves

Version 3.0.1
giommi (Logout) Feedback
Tutorial DATA EXPLORER
User Data Existing SEDs
Current SED Search and build new SEDs

asdc ASI Science Data Center





SED

The ASDC table of WISE select... | hotel paseo de la florida madri... | ASDC – ASI Science Data Cente... | ASDC – ASDC Tools | SED | ASDC – ASI Science Data Cente...

tools.asdc.asi.it/SED/sed.jsp?ra=253.4676&dec=39.76017&q=MRK501&random=0.020011830592187696

hotel florida norte madrid

Google Calendar | Ultime notizie | Notizie | ASI-ASDC | Fermi | Bibliography | Google Maps | Menu Segnalibri | Trenitalia | NuSTAR | e-mail | EVO, The World ...

SED(t) builder V3.0

A tool to build and handle Spectral Energy Distributions, time-resolved SEDs and multi-frequency light-curves

Version 3.0.1

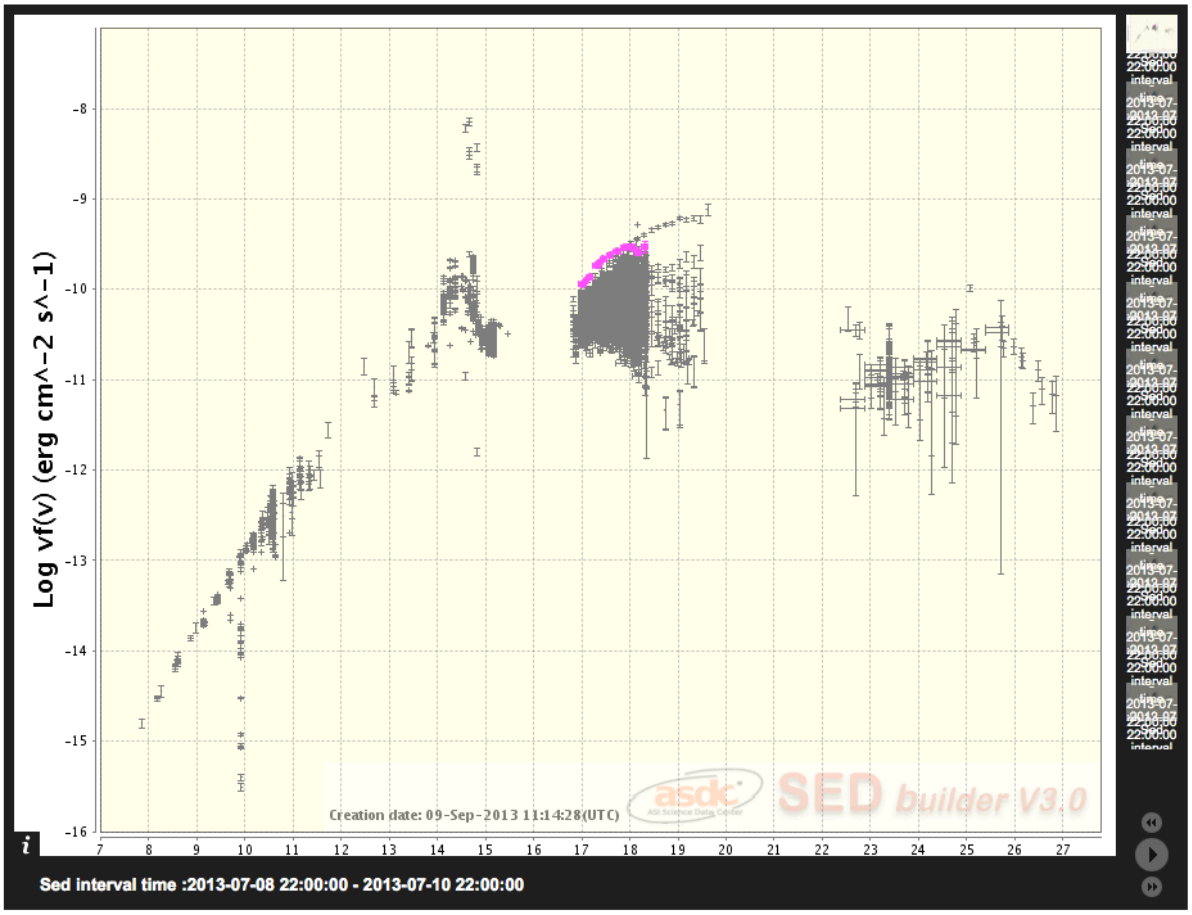
giommi (Logout) Feedback

Tutorial DATA EXPLORER

User Data Existing SEDs

Current SED Search and build new SEDs

asdc ASI Science Data Center



Load Data | Show Data

Save | Duplicate Sed

Redshift: 0.0 Frame: Observed

X Axis: Frequency (Hz) Y Axis: nuFnu (erg/cm2/s)

Plot Type: Sequence Plot

Update Plot

Input Data | Time Filtering | Energy Filtering | Plot options

Existing SEDs | Export | VO Tools

Time Resolved Plot

All

MJD format: Calendar format:

	From:	To:
☑	01/07/2013 00:00:00	03/07/2013 00:00:00
☑	03/07/2013 00:00:01	05/07/2013 00:00:00
☑	05/07/2013 00:00:01	07/07/2013 00:00:00
☑	07/07/2013 00:00:01	09/07/2013 00:00:00
☑	09/07/2013 00:00:01	11/07/2013 00:00:00
☑	11/07/2013 00:00:01	13/07/2013 00:00:00
☑	13/07/2013 00:00:01	15/07/2013 00:00:00
☑	15/07/2013 00:00:01	17/07/2013 00:00:00
☑	17/07/2013 00:00:01	19/07/2013 00:00:00
☑	19/07/2013 00:00:01	21/07/2013 00:00:00
☑	21/07/2013 00:00:01	23/07/2013 00:00:00
☑	23/07/2013 00:00:01	25/07/2013 00:00:00
☑	25/07/2013 00:00:01	27/07/2013 00:00:00
☑	27/07/2013 00:00:01	29/07/2013 00:00:00
☑	29/07/2013 00:00:01	31/07/2013 00:00:00
☑	31/07/2013 00:00:01	02/08/2013 00:00:00
☑	02/08/2013 00:00:01	04/08/2013 00:00:00
☑	04/08/2013 00:00:01	06/08/2013 00:00:00
☑	06/08/2013 00:00:01	08/08/2013 00:00:00

SED

The ASDC table of WISE select... | hotel paseo de la florida madri... | ASDC – ASI Science Data Cente... | ASDC – ASDC Tools | SED | ASDC – ASI Science Data Cente...

tools.asdc.asi.it/SED/sed.jsp?ra=253.4676&dec=39.76017&q=MRK501&random=0.020011830592187696

hotel florida norte madrid

Google Calendar | Ultime notizie | Notizie | ASI-ASDC | Fermi | Bibliography | Google Maps | Menu Segnalibri | Trenitalia | NuSTAR | e-mail | EVO, The World ...

SED(t) builder V3.0

A tool to build and handle Spectral Energy Distributions, time-resolved SEDs and multi-frequency light-curves

Version 3.0.1

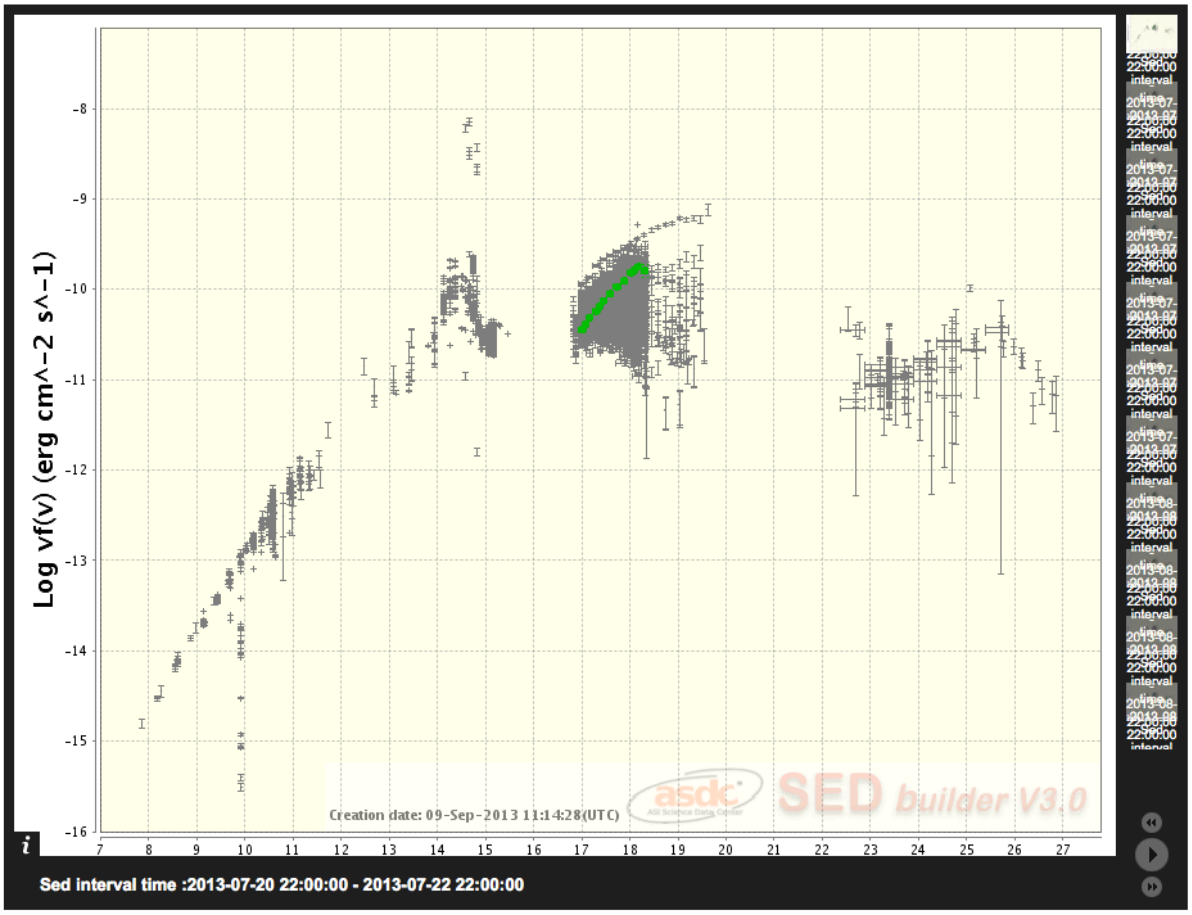
giommi (Logout) Feedback

Tutorial DATA EXPLORER

User Data Existing SEDs

Current SED Search and build new SEDs

asdc ASI Science Data Center



Load Data | Show Data

Save | Duplicate Sed

Redshift: 0.0 Frame: Observed

X Axis: Frequency (Hz) Y Axis: nuFnu (erg/cm2/s)

Plot Type: Sequence Plot

Update Plot

Input Data | Time Filtering | Energy Filtering | Plot options

Existing SEDs | Export | VO Tools

Time Resolved Plot

All

MJD format: Calendar format:

	From:	To:
☑	01/07/2013 00:00:00	03/07/2013 00:00:00
☑	03/07/2013 00:00:01	05/07/2013 00:00:00
☑	05/07/2013 00:00:01	07/07/2013 00:00:00
☑	07/07/2013 00:00:01	09/07/2013 00:00:00
☑	09/07/2013 00:00:01	11/07/2013 00:00:00
☑	11/07/2013 00:00:01	13/07/2013 00:00:00
☑	13/07/2013 00:00:01	15/07/2013 00:00:00
☑	15/07/2013 00:00:01	17/07/2013 00:00:00
☑	17/07/2013 00:00:01	19/07/2013 00:00:00
☑	19/07/2013 00:00:01	21/07/2013 00:00:00
☑	21/07/2013 00:00:01	23/07/2013 00:00:00
☑	23/07/2013 00:00:01	25/07/2013 00:00:00
☑	25/07/2013 00:00:01	27/07/2013 00:00:00
☑	27/07/2013 00:00:01	29/07/2013 00:00:00
☑	29/07/2013 00:00:01	31/07/2013 00:00:00
☑	31/07/2013 00:00:01	02/08/2013 00:00:00
☑	02/08/2013 00:00:01	04/08/2013 00:00:00
☑	04/08/2013 00:00:01	06/08/2013 00:00:00
☑	06/08/2013 00:00:01	08/08/2013 00:00:00

SED

The ASDC table of WISE select... | hotel paseo de la florida madri... | ASDC – ASI Science Data Cente... | ASDC – ASDC Tools | SED | ASDC – ASI Science Data Cente...

tools.asdc.asi.it/SED/sed.jsp?ra=253.4676&dec=39.76017&q=MRK501&random=0.020011830592187696

hotel florida norte madrid

Google Calendar | Ultime notizie | Notizie | ASI-ASDC | Fermi | Bibliography | Google Maps | Menu Segnalibri | Trenitalia | NuSTAR | e-mail | EVO, The World ...

SED(t) builder V3.0

A tool to build and handle Spectral Energy Distributions, time-resolved SEDs and multi-frequency light-curves

Version 3.0.1

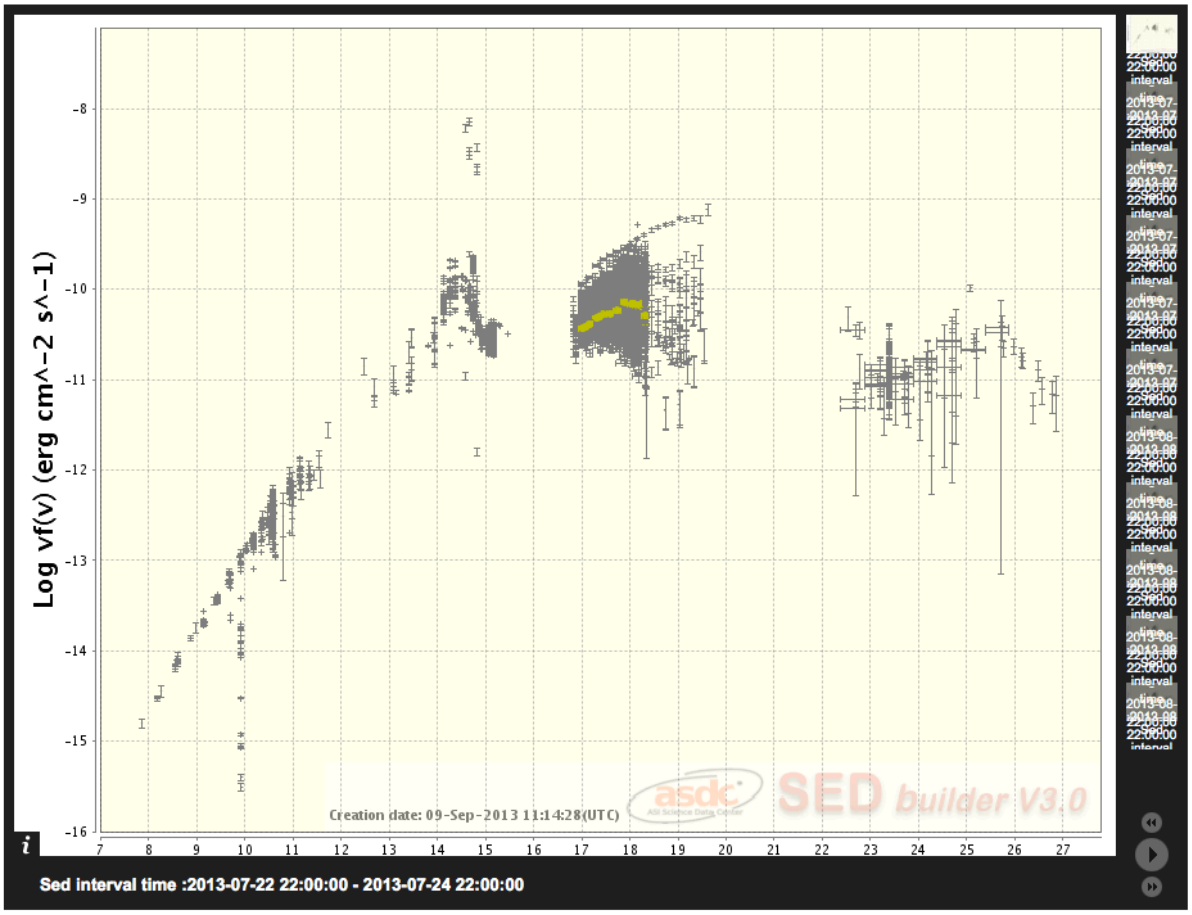
giommi (Logout) Feedback

Tutorial DATA EXPLORER

User Data Existing SEDs

Current SED Search and build new SEDs

asdc ASI Science Data Center



Load Data | Show Data | Save | Duplicate Sed

Redshift: 0.0 Frame: Observed

X Axis: Frequency (Hz) Y Axis: nuFnu (erg/cm2/s)

Plot Type: Sequence Plot

Update Plot

Input Data | Time Filtering | Energy Filtering | Plot options

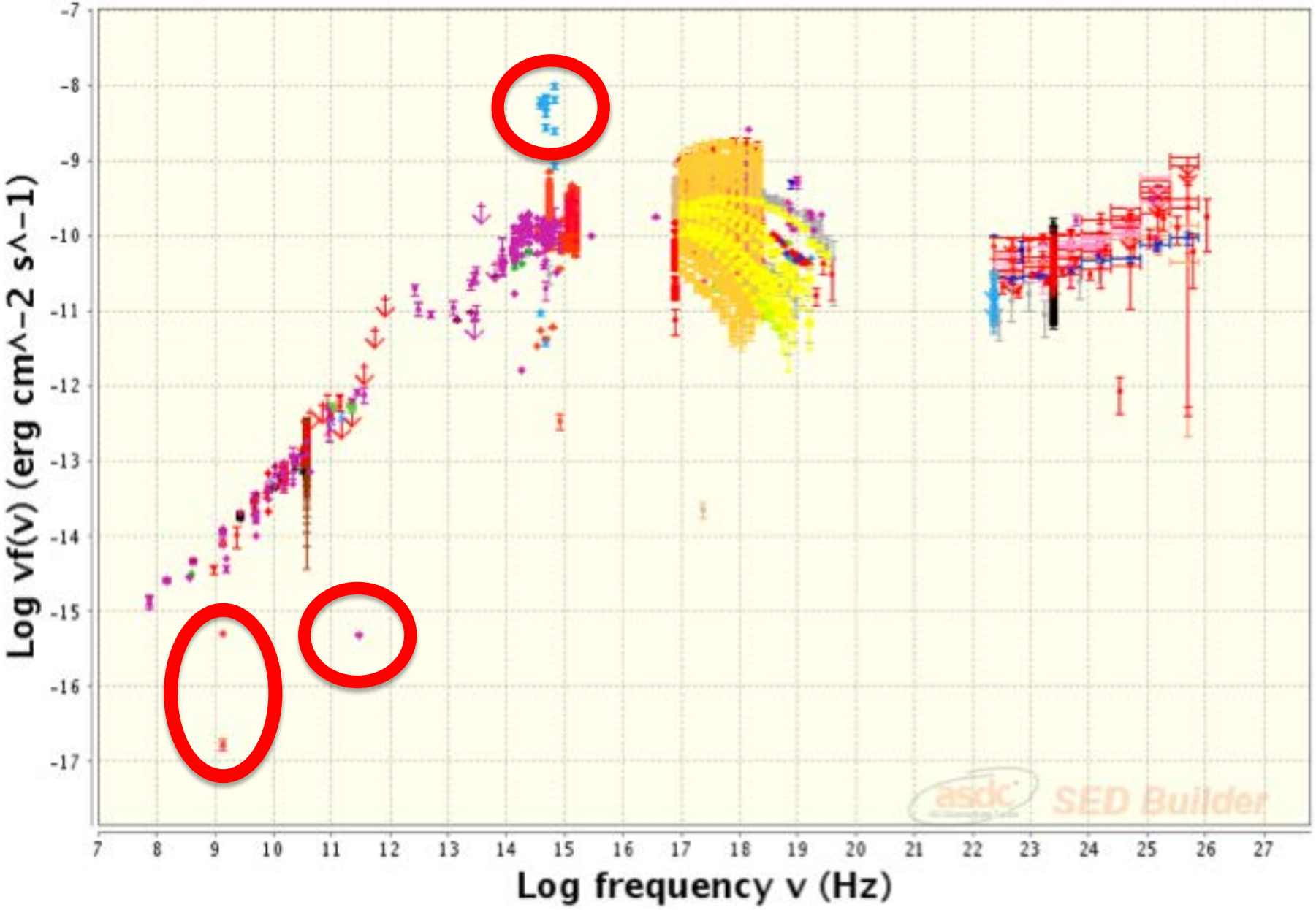
Existing SEDs | Export | VO Tools

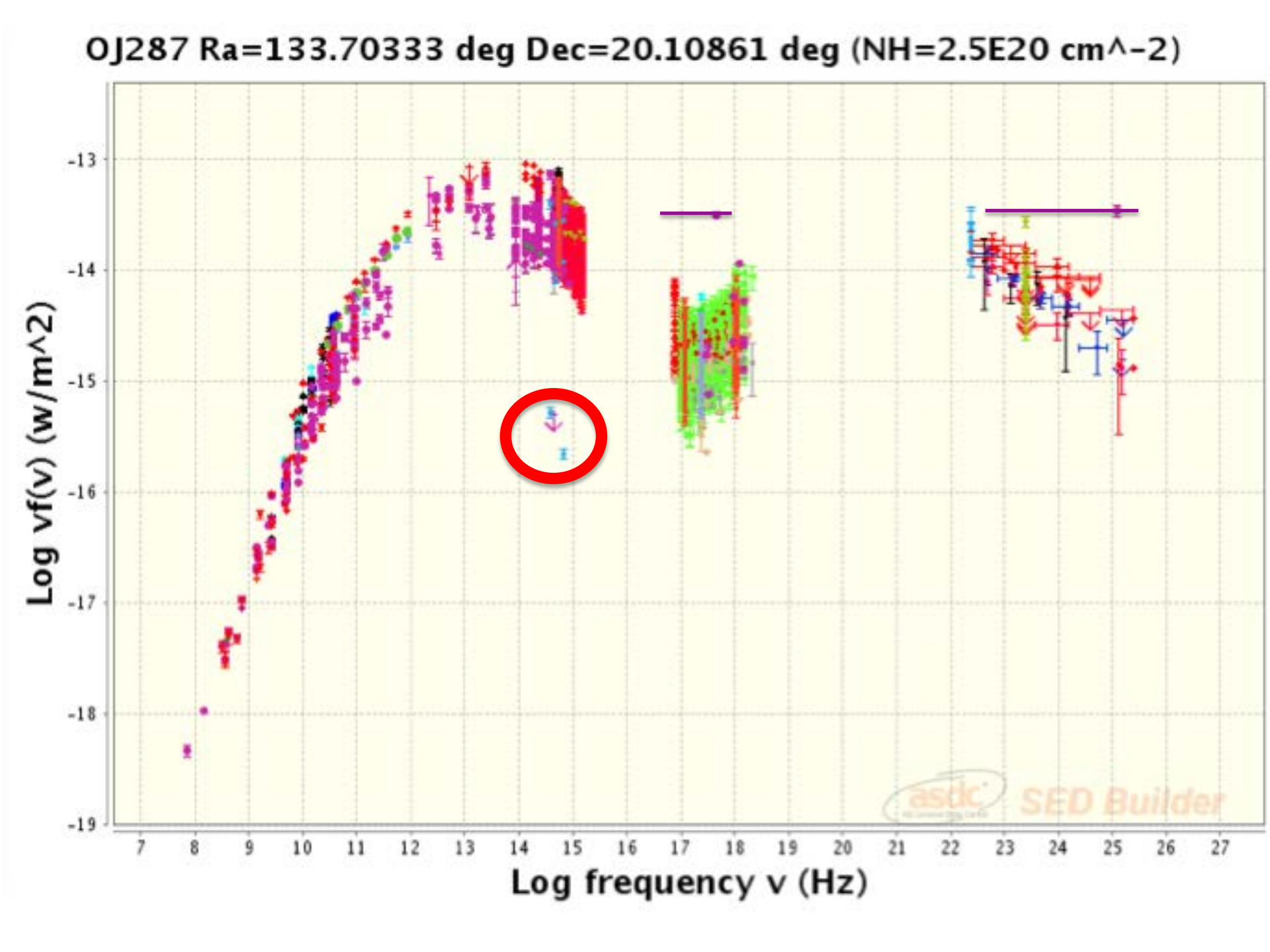
Time Resolved Plot

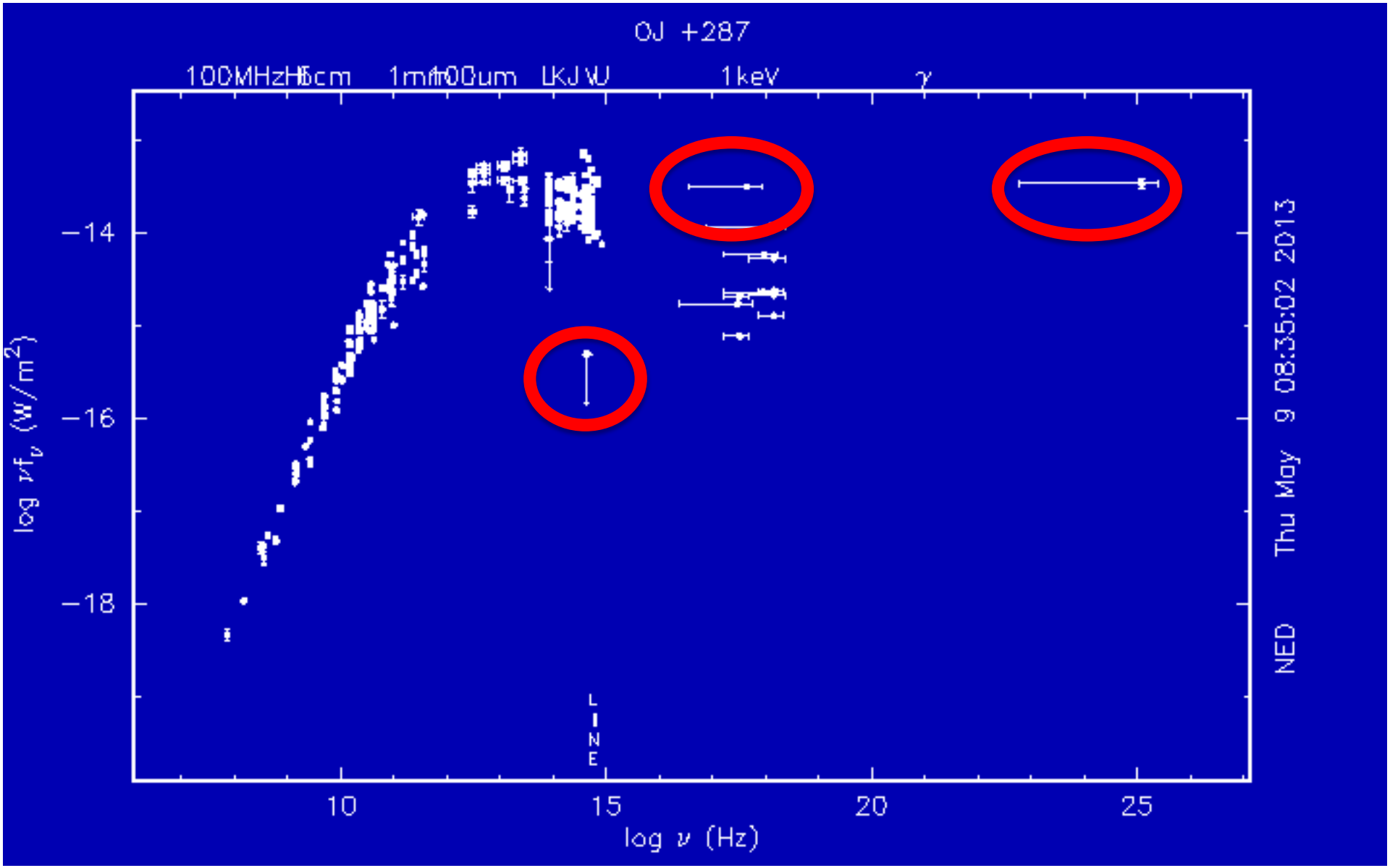
All

MJD format: Calendar format:

	From:	To:
☑	01/07/2013 00:00:00	03/07/2013 00:00:00
☑	03/07/2013 00:00:01	05/07/2013 00:00:00
☑	05/07/2013 00:00:01	07/07/2013 00:00:00
☑	07/07/2013 00:00:01	09/07/2013 00:00:00
☑	09/07/2013 00:00:01	11/07/2013 00:00:00
☑	11/07/2013 00:00:01	13/07/2013 00:00:00
☑	13/07/2013 00:00:01	15/07/2013 00:00:00
☑	15/07/2013 00:00:01	17/07/2013 00:00:00
☑	17/07/2013 00:00:01	19/07/2013 00:00:00
☑	19/07/2013 00:00:01	21/07/2013 00:00:00
☑	21/07/2013 00:00:01	23/07/2013 00:00:00
☑	23/07/2013 00:00:01	25/07/2013 00:00:00
☑	25/07/2013 00:00:01	27/07/2013 00:00:00
☑	27/07/2013 00:00:01	29/07/2013 00:00:00
☑	29/07/2013 00:00:01	31/07/2013 00:00:00
☑	31/07/2013 00:00:01	02/08/2013 00:00:00
☑	02/08/2013 00:00:01	04/08/2013 00:00:00
☑	04/08/2013 00:00:01	06/08/2013 00:00:00
☑	06/08/2013 00:00:01	08/08/2013 00:00:00


MKN421 Ra=166.11354 deg Dec=38.20856 deg (NH=1.9E20 cm^-2)
Log vf(v) (erg cm^-2 s^-1)
-7
-8
-9
-10
-11
-12
-13
-14
-15
-16
-17
7
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


OJ287 Ra=133.70333 deg Dec=20.10861 deg (NH=2.5E20 cm^-2)
Log vf(v) (w/m^2)
-13
-14
-15
-16
-17
-18
-19
7
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


OJ +287
100MHz
1cm
1mm
100um
UKJVU
1keV
γ
−14
−16
−18
log νf_ν (W/m^2)
LINE
10
15
20
25
log ν (Hz)
NED Thu May 9 08:35:02 2013

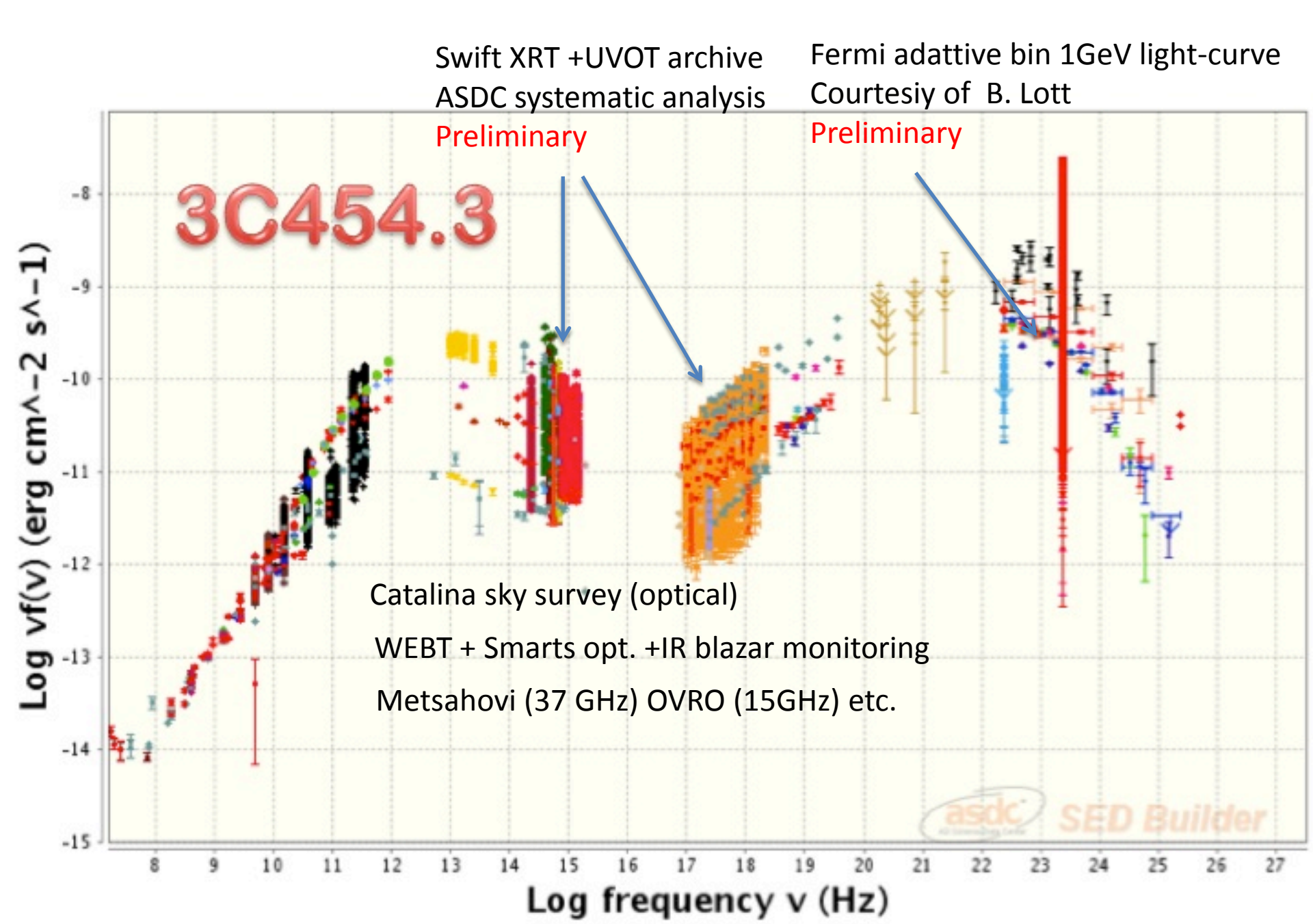
An X-ray spectral database of the blazars most frequently observed by Swift.

P. Giommi[1,2] and M. Perri[1,3], M. Capalbi[4], V. D'Elia[1,3], F. Verrecchia et al.[1,3]

ASI Science Data Center, ASDC, Agenzia Spaziale Italiana, via del Politecnico, 00133 Roma, Italy
e-mail: paolo.giommi@asdc.asi.it

2013 in preparation

Homogeneous analysis of ~ 5,000 Swift XRT spectra of 122 Blazars


Swift XRT +UVOT archive
ASDC systematic analysis
Preliminary
Fermi adattive bin 1GeV light-curve
Courtesiy of B. Lott
Preliminary
3C454.3
Catalina sky survey (optical)
WEBT + Smarts opt. +IR blazar monitoring
Metsahovi (37 GHz) OVRO (15GHz) etc.
asdc SED Builder
Log vf(v) (erg cm^-2 s^-1)
Log frequency v (Hz)
-8
-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

The Astrophysical Multimessenger Observatory Network (AMON)

M. W. E. Smith[a,b,*], D. B. Fox[c,b], D. F. Cowen[a,c,b], P. Mészáros[a,c,b], G. Tešić[a,b], J. Fixelle[c], I. Bartos[d], P. Sommers[a,c,b], Abhay Ashtekar[a,b], G. Jogesh Babu[e,c], S. D. Barthelmy[f], S. Coutu[a,b], T. DeYoung[a,b], A. D. Falcone[c,b], L. S. Finn[a,c,b], Shan Gao[a,b], B. Hashemi[a], A. Homeier[g], S. Márka[d], B. J. Owen[a,b], I. Taboada[h]

1. Introduction

We stand at the dawn of multimessenger astrophysics – a quest to use the messenger particles of all four of nature's fundamental forces to explore the most violent phenomena in the universe. Observatories first imagined a generation ago are finally being realized, including the Advanced LIGO [1] and Virgo [2] gravitational-wave detectors, the ANTARES [3] and IceCube

Enabling multi-messenger astronomy with gravitational waves

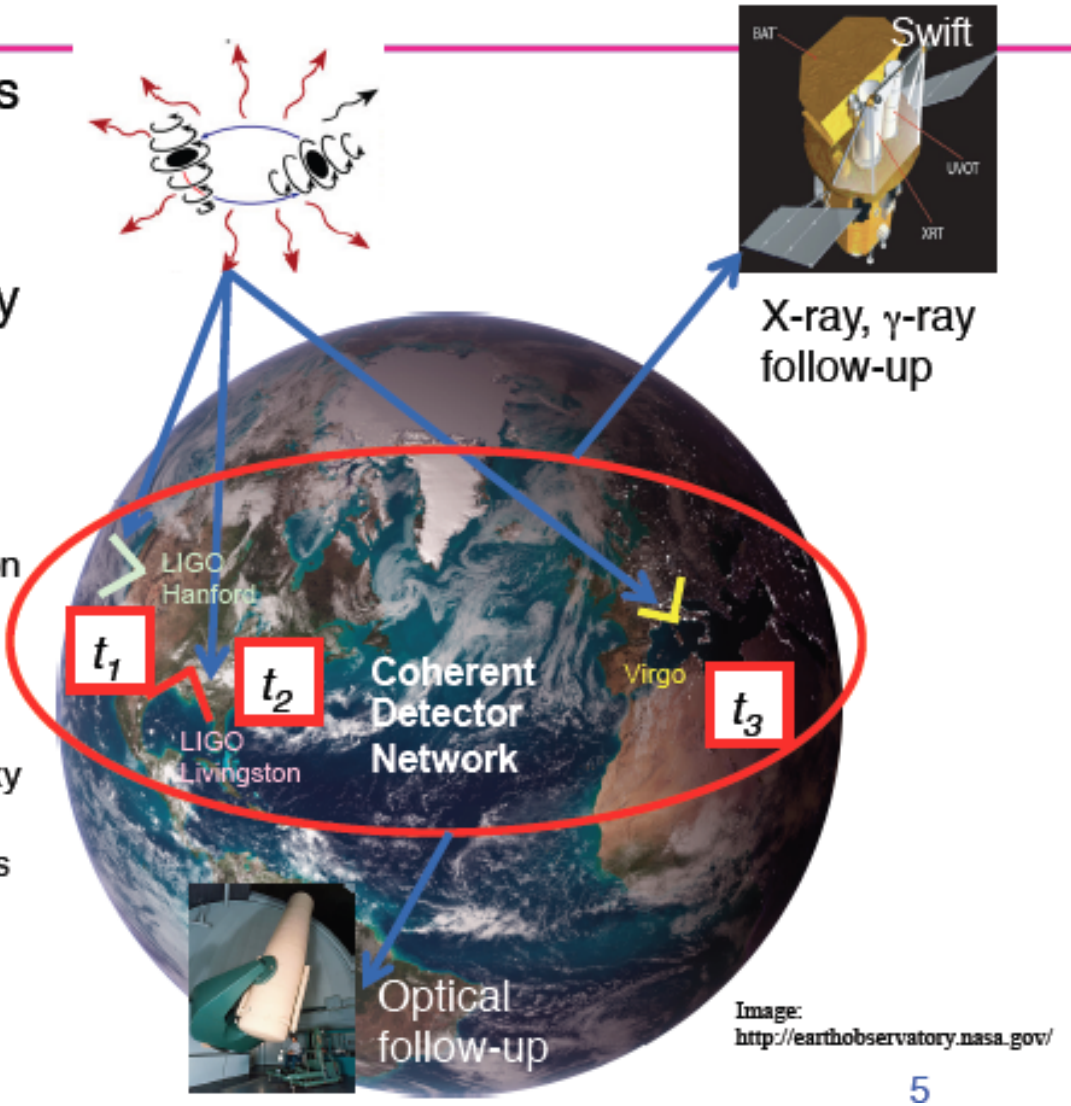
- Many GWs transient sources are likely to radiate in the electromagnetic spectrum
- GW astronomy is *enabled* by having *a global network of interferometers*
- GW 'Aperture synthesis'
  - » Crude estimate of angular resolution

$$\theta_{GW} \sim \lambda_{GW} / d \sim \text{few degrees}$$

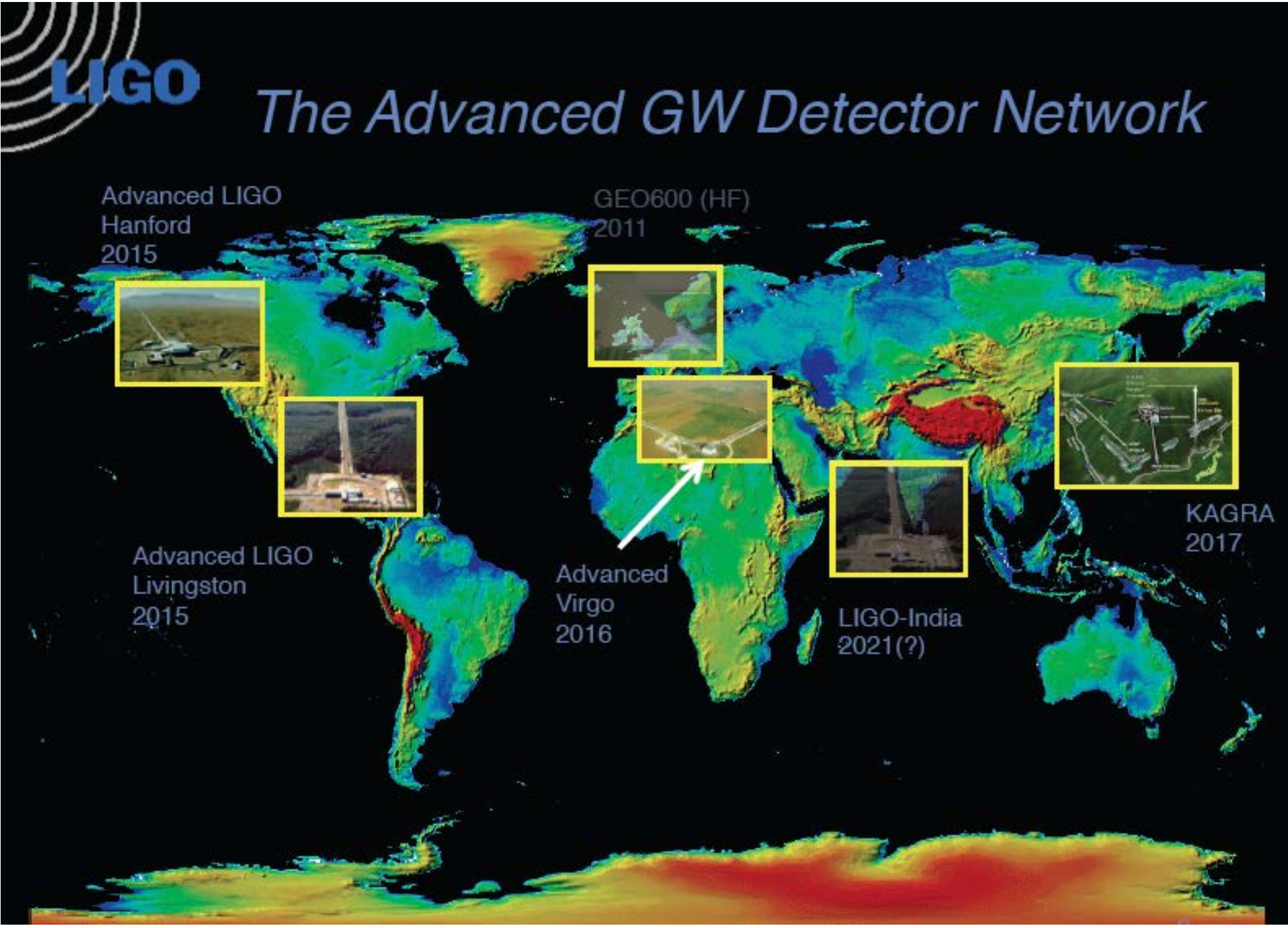
  - » Angular resolution depends on source frequency, network SNR, sky location, number of detectors
    - – Can be as large as 100s of degrees

→ Need wide field telescopes

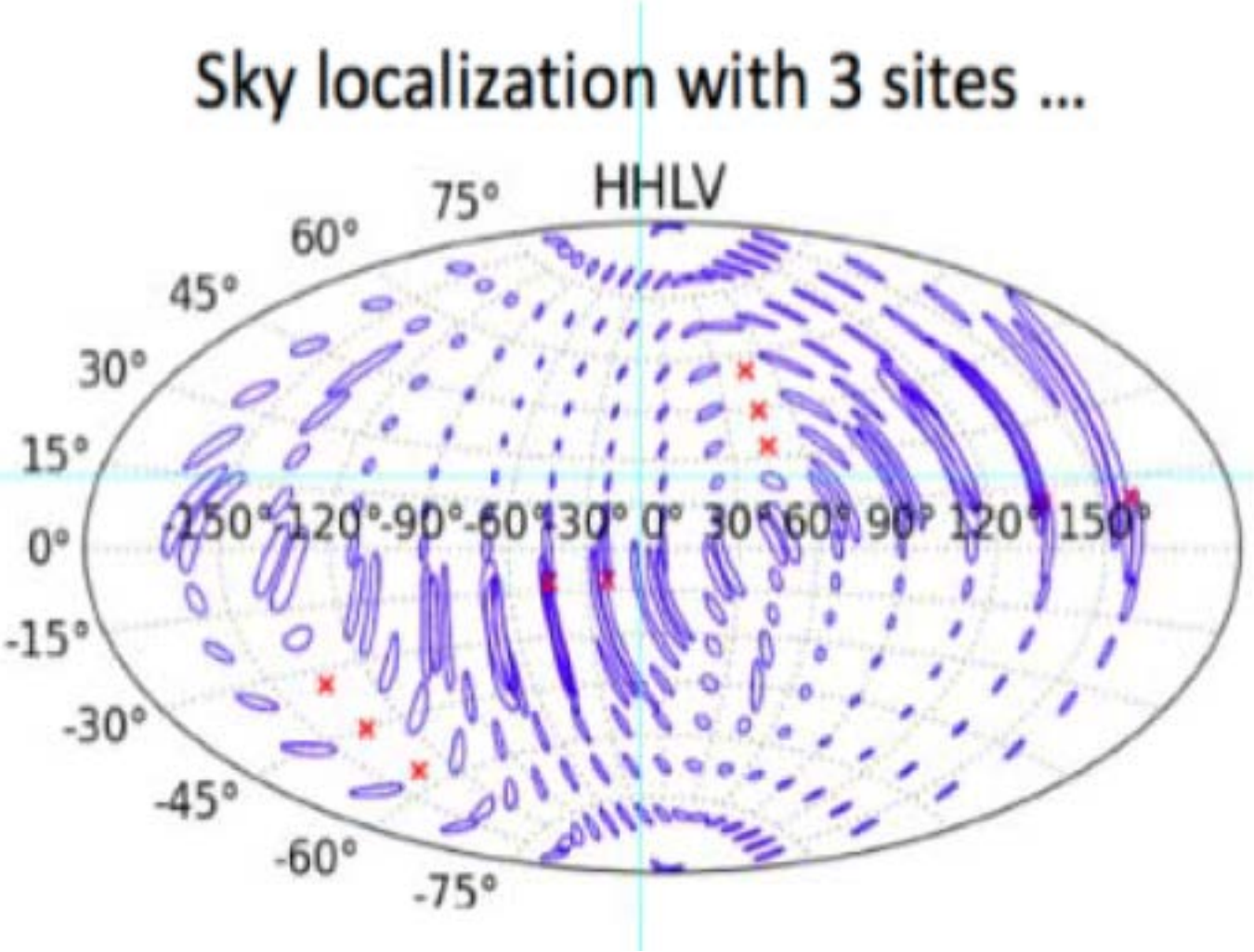
+ Image tiling + Galaxy weighting

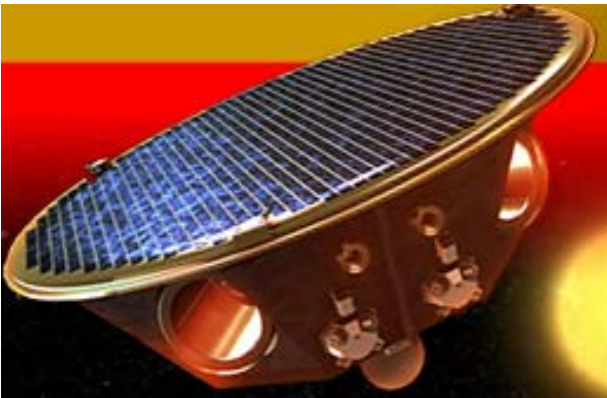


The Advanced GW Detector Network



GW Followup: Error Boxes





Gravitational Wave Astronomy in Space

eLISA/NGO

New eLISA Working Groups

Science

Summary

Mission

eLISA/NGO

Mission

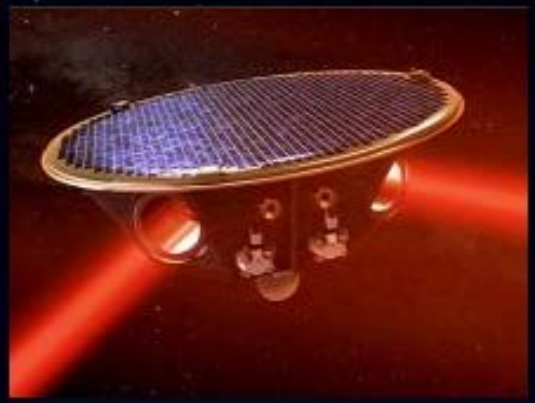
eLISA/NGO | Measuring GWs | Mission concept | Sensitivity | Sciencecraft

Key features | Drag free operation | Distance measurement | Data analysis

The eLISA/NGO mission

Gravitational waves are fundamentally different from electromagnetic waves.

Electromagnetic waves, created by the acceleration of electrical charges, propagate in the framework of space and time. Gravitational waves in contrast, created by the acceleration of



Artist's impression of an eLISA