The Broadband SEDs of the MOJAVE sample

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The Emission of AGN Jets
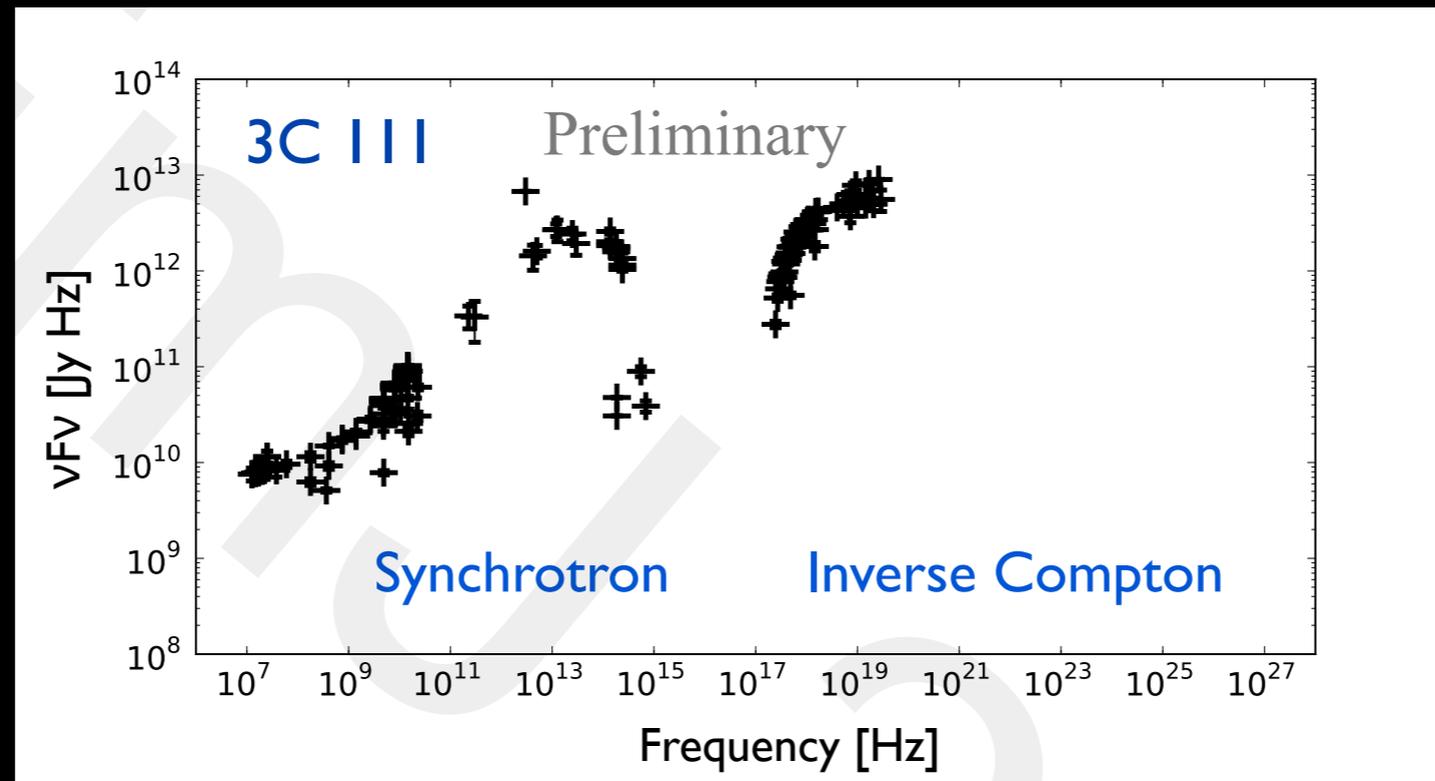
(Chang et al. in prep.)

- Open questions:

  - Where is the emission of AGN jets generated

  - What are the mechanisms to produce high-energy emission of blazars: leptonic (SSC, EIC), hadronic (photon-photon), or both?

Fermi's Impact
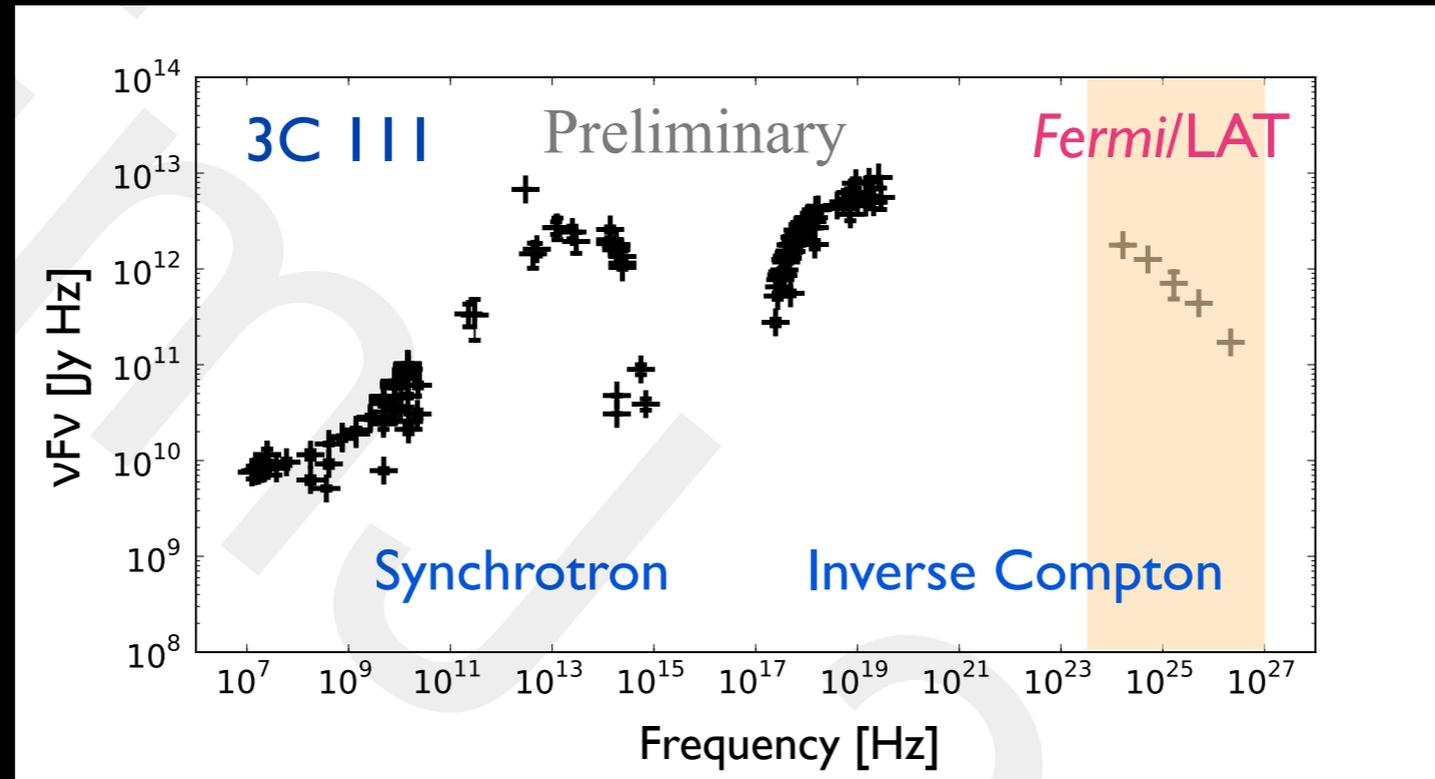
(Chang et al. in prep.)

- "The Spectral Energy Distribution of *Fermi* Bright Blazars" (Abdo et al. 2010, 716,30), a <u>γ-ray selected</u> sample was studied.

- We want to attack the problem using a <u>radio-selected</u> sample

The Broadband SED Catalog

- Construct a broadband SED catalog of 135 MOJAVE sources (statistically complete, see Lister, this conf.)

- The MOJAVE sample has

  - **101** flat-spectrum radio quasars

  - **22** BL Lac objects

  - **8** radio galaxies, **4** unidentified objects

  Continuously monitored in the radio band

- Use simultaneous datasets from radio to γ-ray bands

Broadband SED data

- [γ-ray] *Fermi* LAT 1yr catalog data (Abdo et al. 2010, ApJ 715, 429) for 85 sources; upper-limits for 50 sources (M. Boeck et al.)

- *Swift* observations

  - [X-ray/Optical] XRT/UVOT: Dedicated program to observe MOJAVE sources, observations after August 2008

  - [Hard X-ray] BAT: 22-month catalog (J. Tueller et al. 2010, accepted by the ApJS)

- [Radio] MOJAVE program (Lister et al. 2009, ApJ 137, 3718)

- [Radio] UMRAO monitoring (Aller et al. 2003, ApJ 586, 33)

- [Radio] FGAMMA monitoring (Fuhrmann et al. & Angelakis et al. 2010, this conf.)

Broadband SED data

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  - [Hard X~~~~~~~~~~~~~~~~~~~~~~~~~et al. 2010, accepted ~~~

- [Radio] M~~~~~~~~~~~~~~~~~~, 3718)

- [Radio] U~~~~~~~~~~~~~~~~~~86, 33)

- [Radio] FC~~~~~~~~~~~~~~~~gelakis et al. 2010, this co~~~
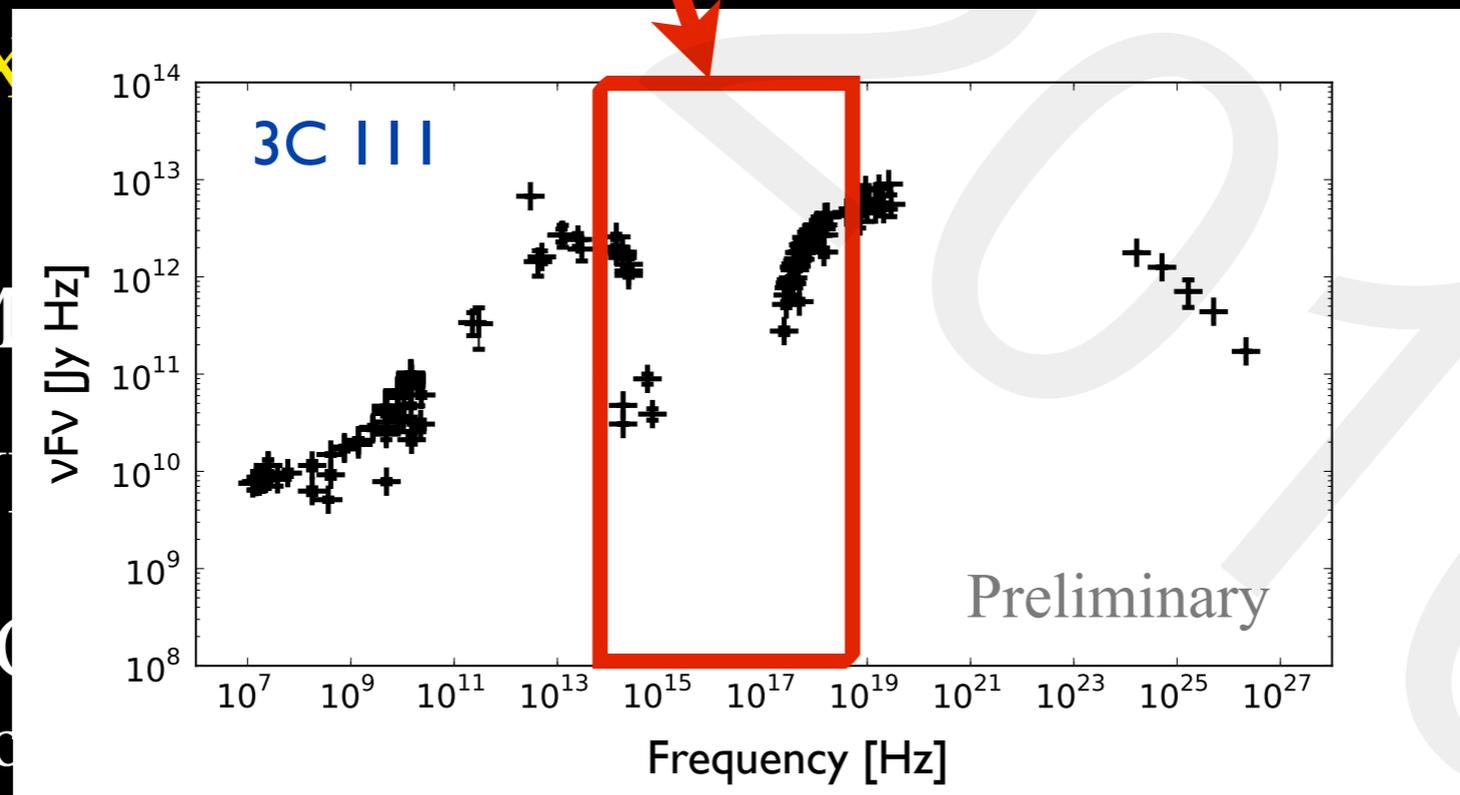
Swift simultaneous obs.

	0119+115	0730+504	1150+812	1637+574	1936-155	2121+053	1045-188	2134+004
	0224+671	0738+313	1213-172	1655+077	1957+405	2128-123	1417+385	0945+408
	0238-084	0804+499	1413+135	1741-038	2005+403	2136+141	1638+398	0742+103
0003-066	0333+321	0923+392	1458+718	1751+288	2008-159	2201+315	2021+317	0642+449
0007+106	0430+052	0955+476	1504-166	1800+440	2021+614	2216-038	1758+388	0552+398
0016+731	0607-157	1038+064	1538+149	1928+738	2037+511	1036+054	2243-123	2351+456
0048-097	0403-132	0605-085	0805-077	0906+015	1228+126	0109+224	0212+735	0234+28
0059+581	0415+379	0648-165	0808+019	0917+624	1253-055	0202+149	0215+015	1739+522
0106+013	0420-014	0716+714	0814+425	1055+018	1308+326	1611+343	1823+568	2201+171
0133+476	0422+004	0727-115	0823+033	1124-186	1324+224	1633+382	1828+487	2209+236
0202+319	0446+112	0735+178	0827+243	1127-145	1334-127	1641+399	1849+670	2223-052
0235+164	0458-020	0736+017	0829+046	1156+295	1502+106	1726+455	1958-179	2227-088
0300+470	0528+134	0748+126	0836+710	1219+044	1510-089	1730-130	2131-021	2230+114
0316+413	0529+075	0754+100	0838+133	1222+216	1546+027	1749+096	2145+067	2251+158
0336-019	0529+483		0851+202	1226+023	1548+056	1803+784	2155-152	2331+073
					1606+106	1807+698	2200+420	2345-167

Simultaneous *Swift* data

Fermi 1FGL

Non *Fermi* 1FGL

Currently using *Swift* data before Aug. 2008; will be completed by the dedicated *Swift* program

84% of MOJAVE source has broadband coverage of
radio, optical, X-ray and γ-ray

Data Analysis

- Typical exposure: 5-10 ks of *Swift*/XRT obs., providing good X-ray spectra

- *Swift*/XRT spectra fitted by an <u>absorbed power-law</u> model with a lower-limit of NH value measured by the LAB survey (Kalberla et al. 2005, A&A 440, 775)

Data analysis
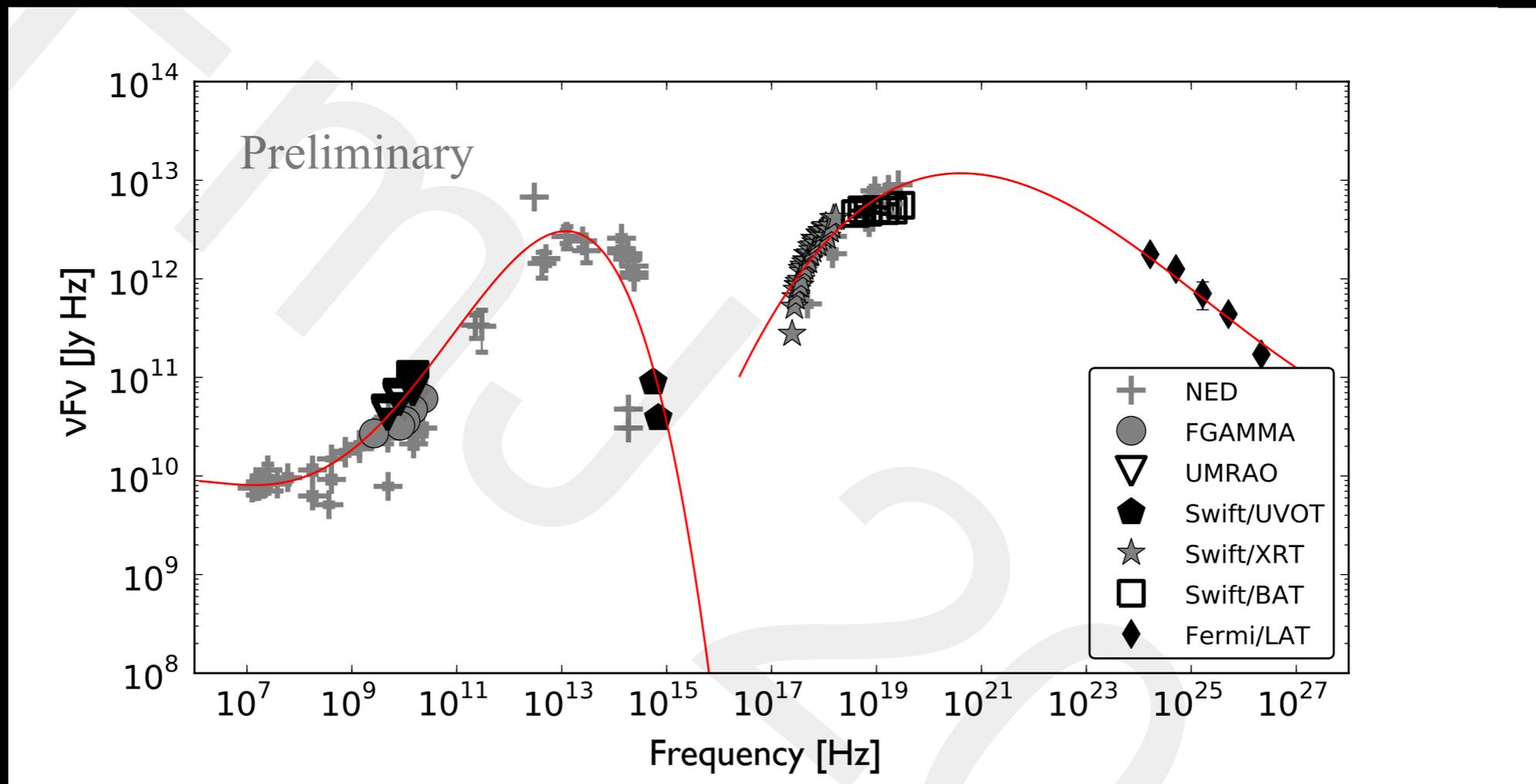
- A <u>polynomial model</u> is applied to all broadband SEDs (as a first approach)

Data analysis
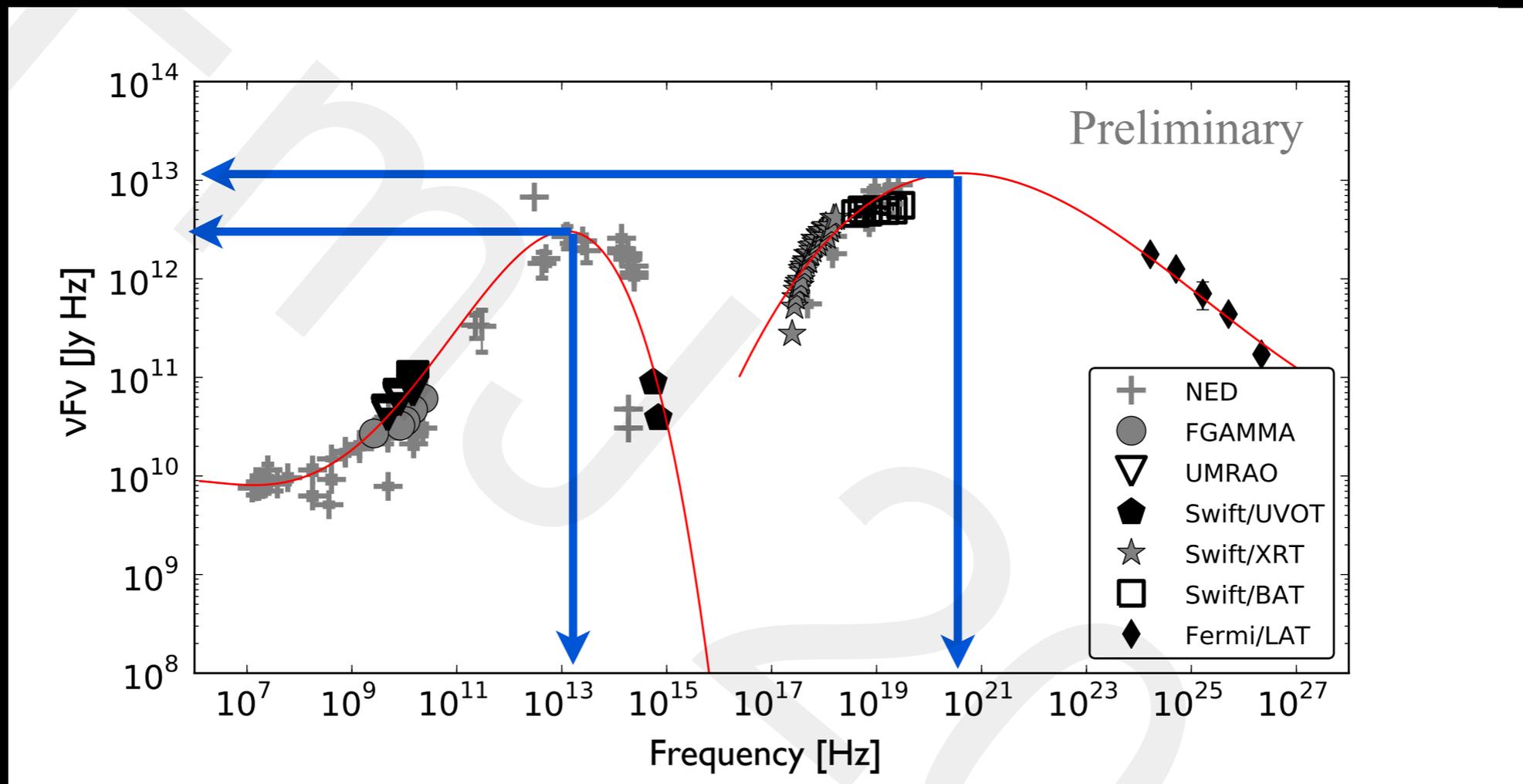
- A <u>polynomial model</u> is applied to all broadband SEDs (as a first approach)

- We estimated the <u>peak positions of the synchrotron and high-energy</u> humps

Correlation study

Lister et al. 2009, ApJ 696, L22
Kovalev et al. 2009, ApJ 696,L17
Savolainen et al. 2010, A&A 512, A24
Pushkarev et al. 2010, submitted to A&A
Boeck et al., this conf.

Radio (VLBI):
Flux density
Spectral index
β_{app}
Doppler factor
Lorentz factor

γ-ray:
Flux
Luminosity
Photon index

Correlation study

SED:

$\nu_{sync,\ peak}$

$\nu F_{\nu\ sync,\ peak}$

$\nu_{IC,\ peak}$

$\nu F_{\nu\ IC,\ peak}$

Radio (VLBI):
Flux density
Spectral index
β_{app}
Doppler factor
Lorentz factor

X-ray:
Flux
Luminosity
Photon index

γ-ray:
Flux
Luminosity
Photon index

Preliminary

Results

- Broadband SED of 6 representative sources

  Quasars: NRAO 530, B2209+236 , 4C +71.07
 BL Lacs: 4C +47.08, B0754+100
  Radio galaxy: 3C 111

- Preliminary analysis

NRAO 530
High-polarized radio quasar
Swift obs. in June 2009 (5 ks)

1730-130

Legend:
- NED
- UMRAO
- Swift/UVOT
- Swift/XRT
- Fermi/LAT

Preliminary
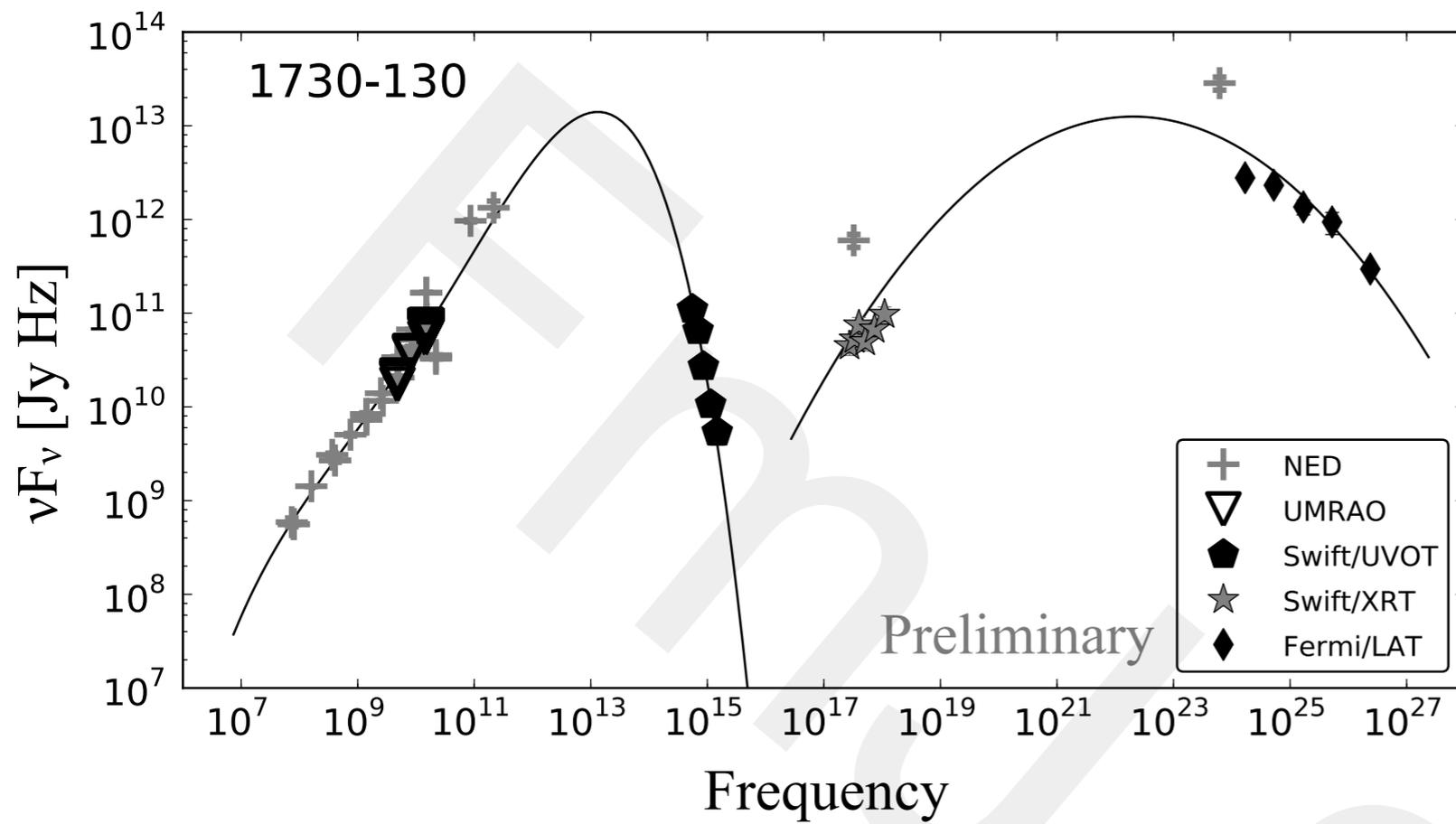
B2209+236
Flat-spectrum radio quasar
Swift obs. in April 2009 (9 ks)

2209+236

Legend:
- NED
- UMRAO
- Swift/UVOT
- Swift/XRT
- Fermi/LAT

Preliminary
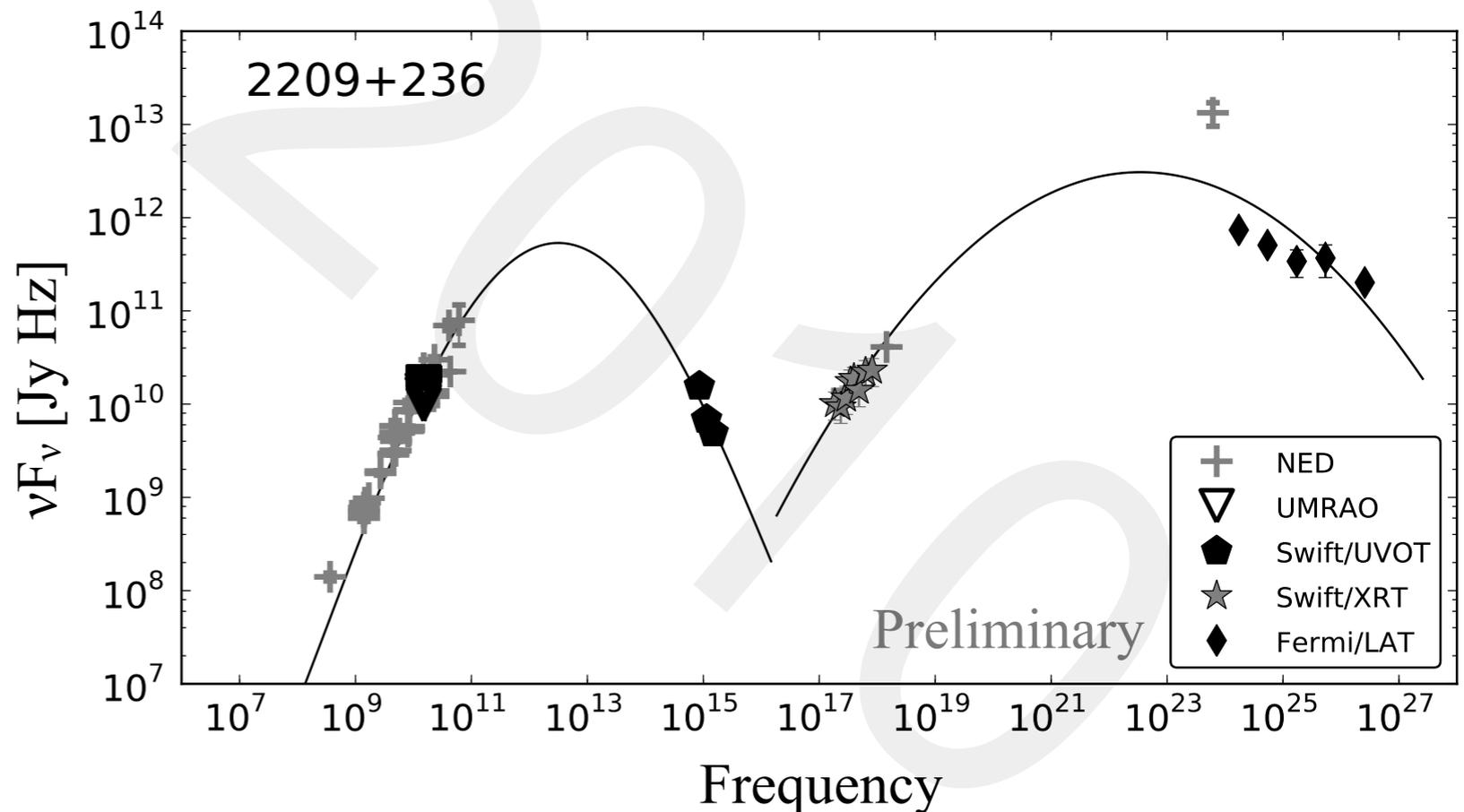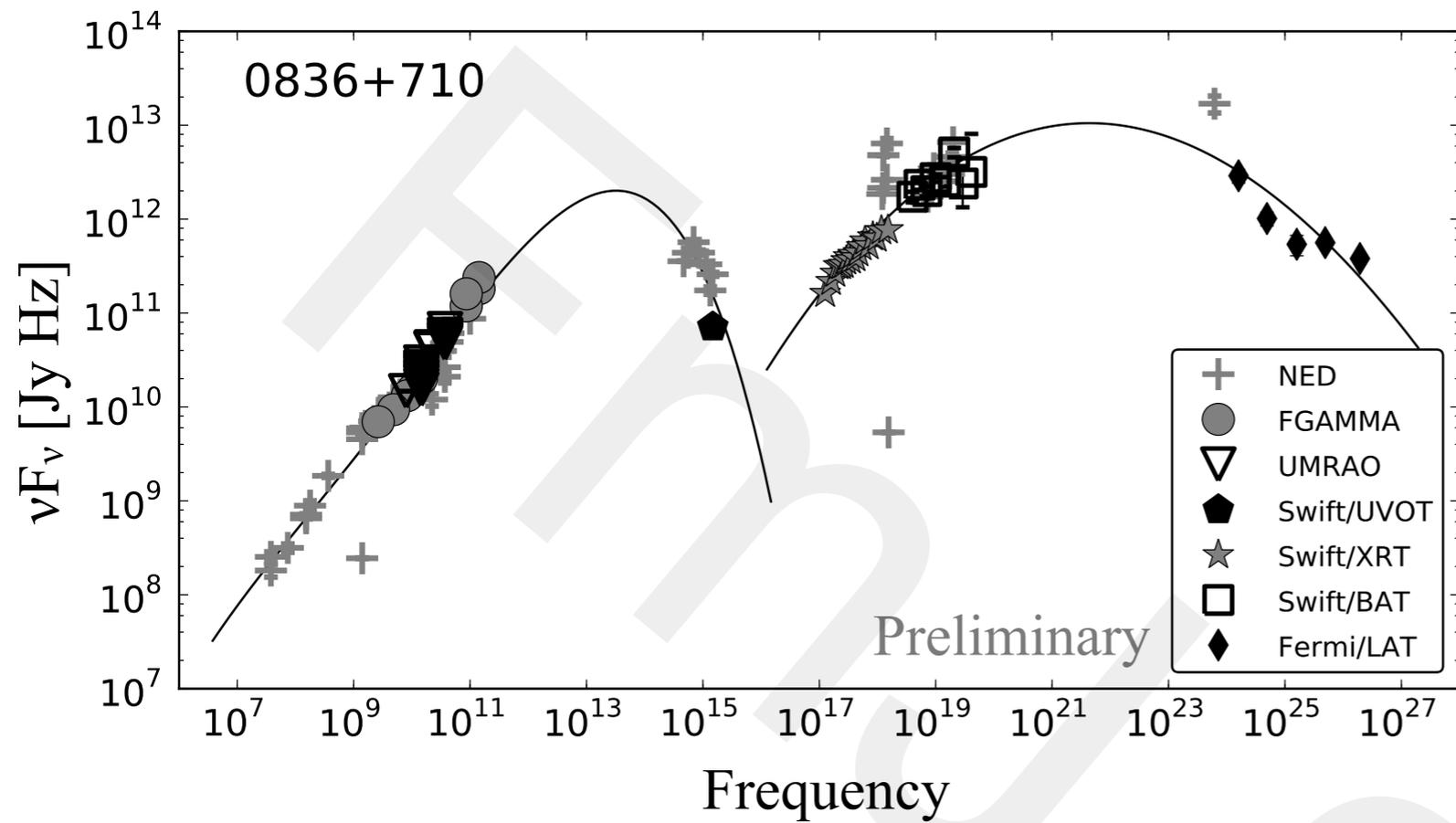
4C +71.07
Quasar
Swift obs. in February 2010 (9 ks)

3C 111
Broad-line FR II radio galaxy
Swift obs. in January 2010 (9 ks)
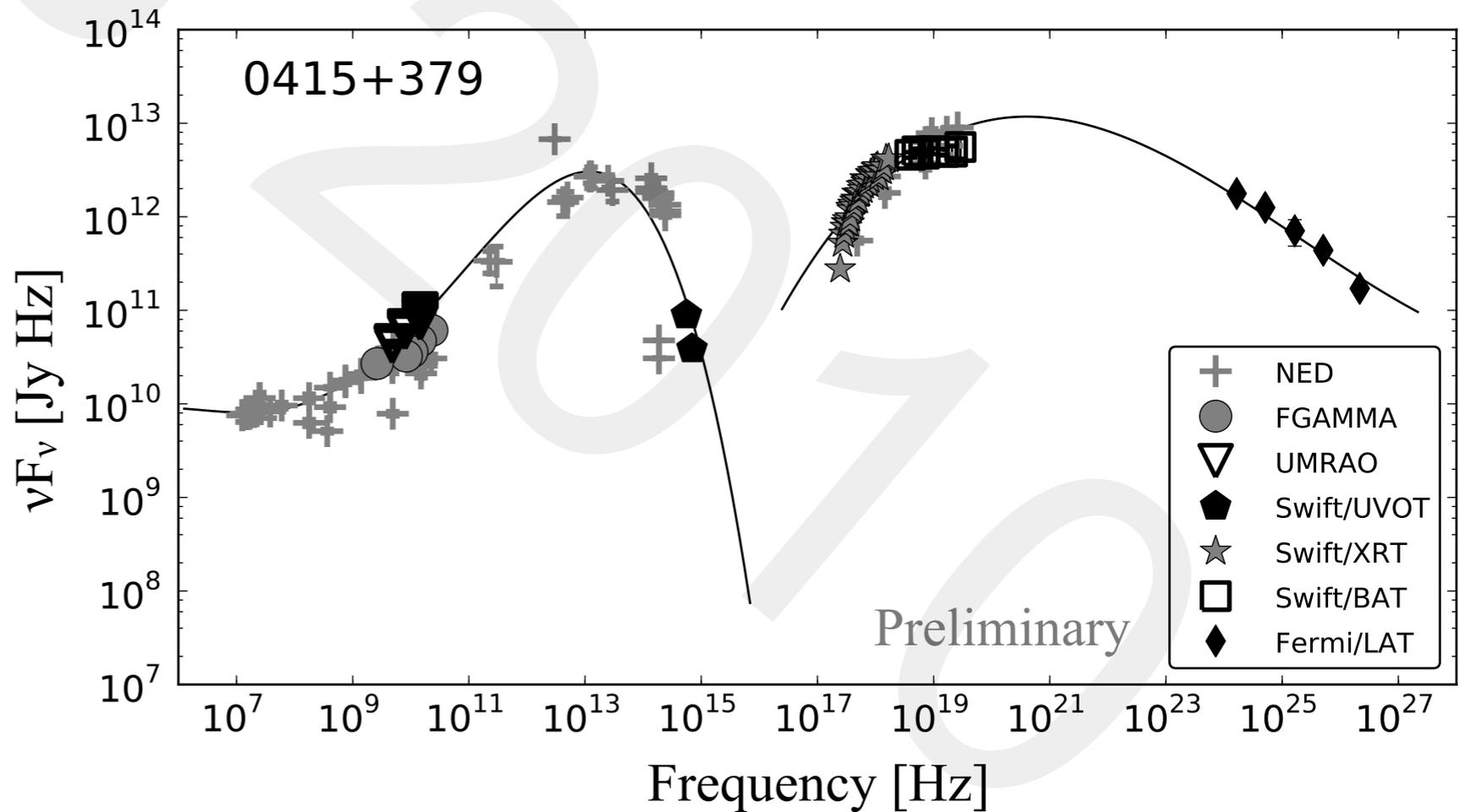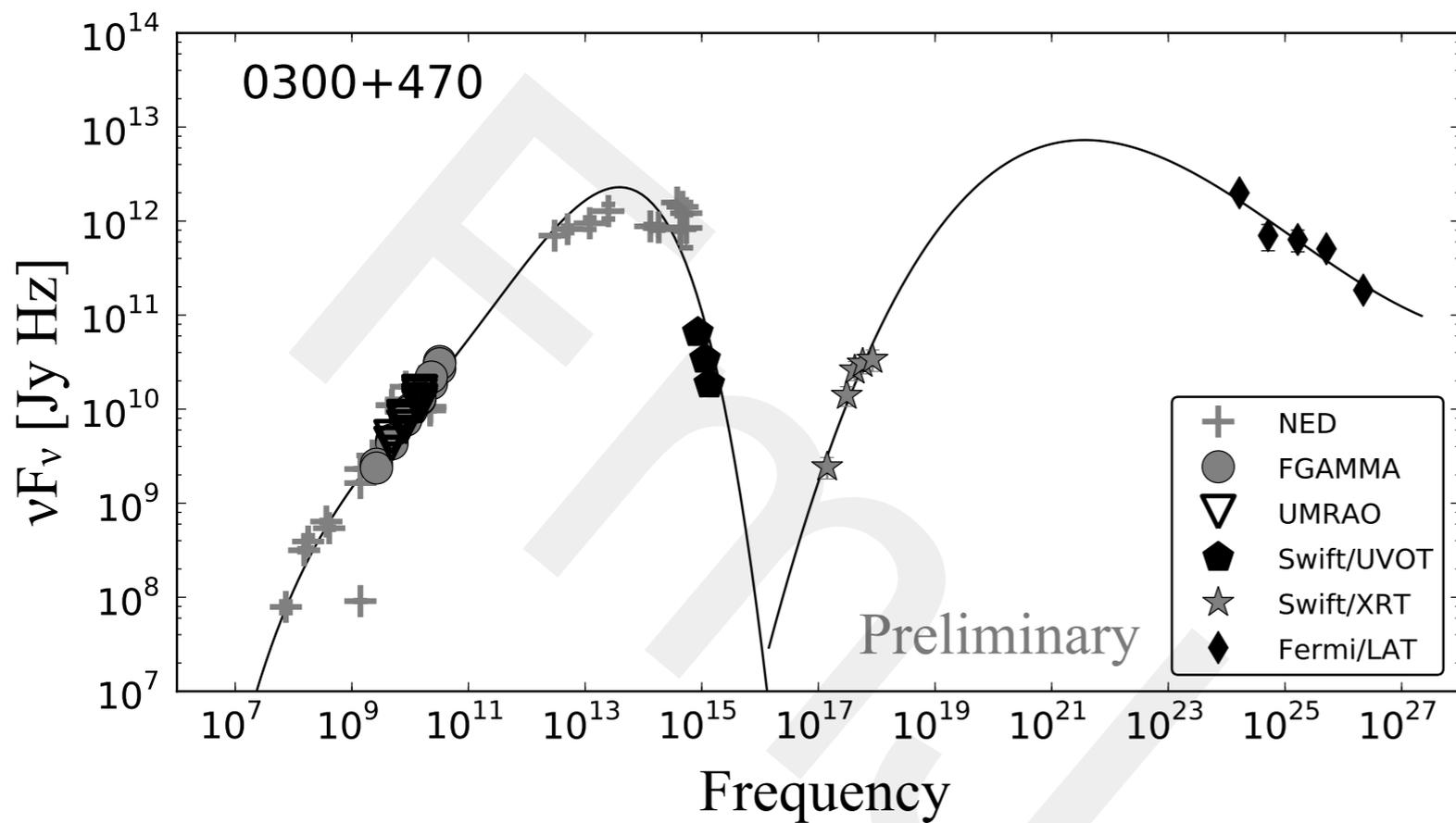
4C +47.08
BL Lac object
Swift obs. in September
2008 (7 ks)

B0754+100
Low-frequency peaked
BL Lac objects (LBL)
*Swift* obs. in February
2010 (9 ks)
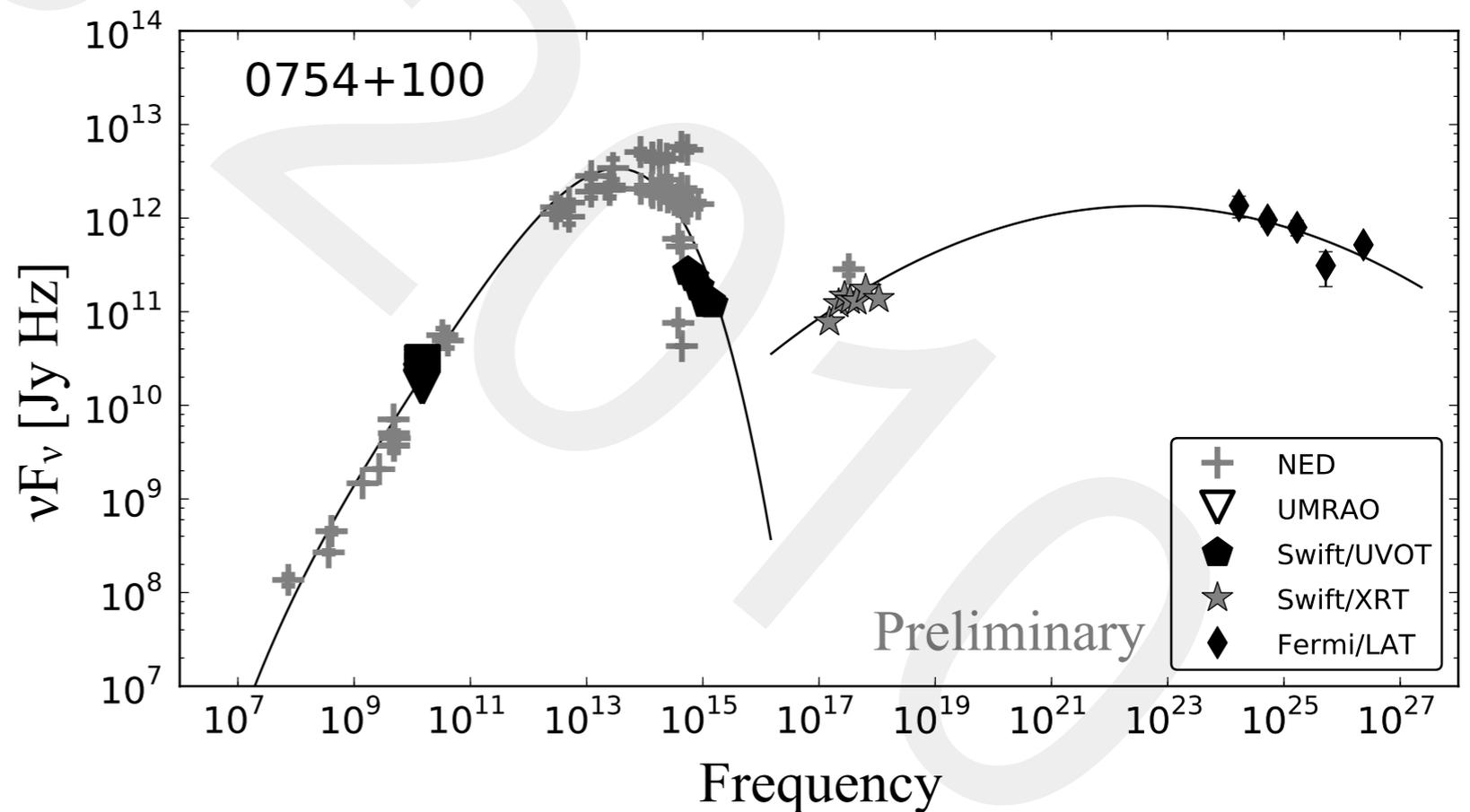
Preliminary
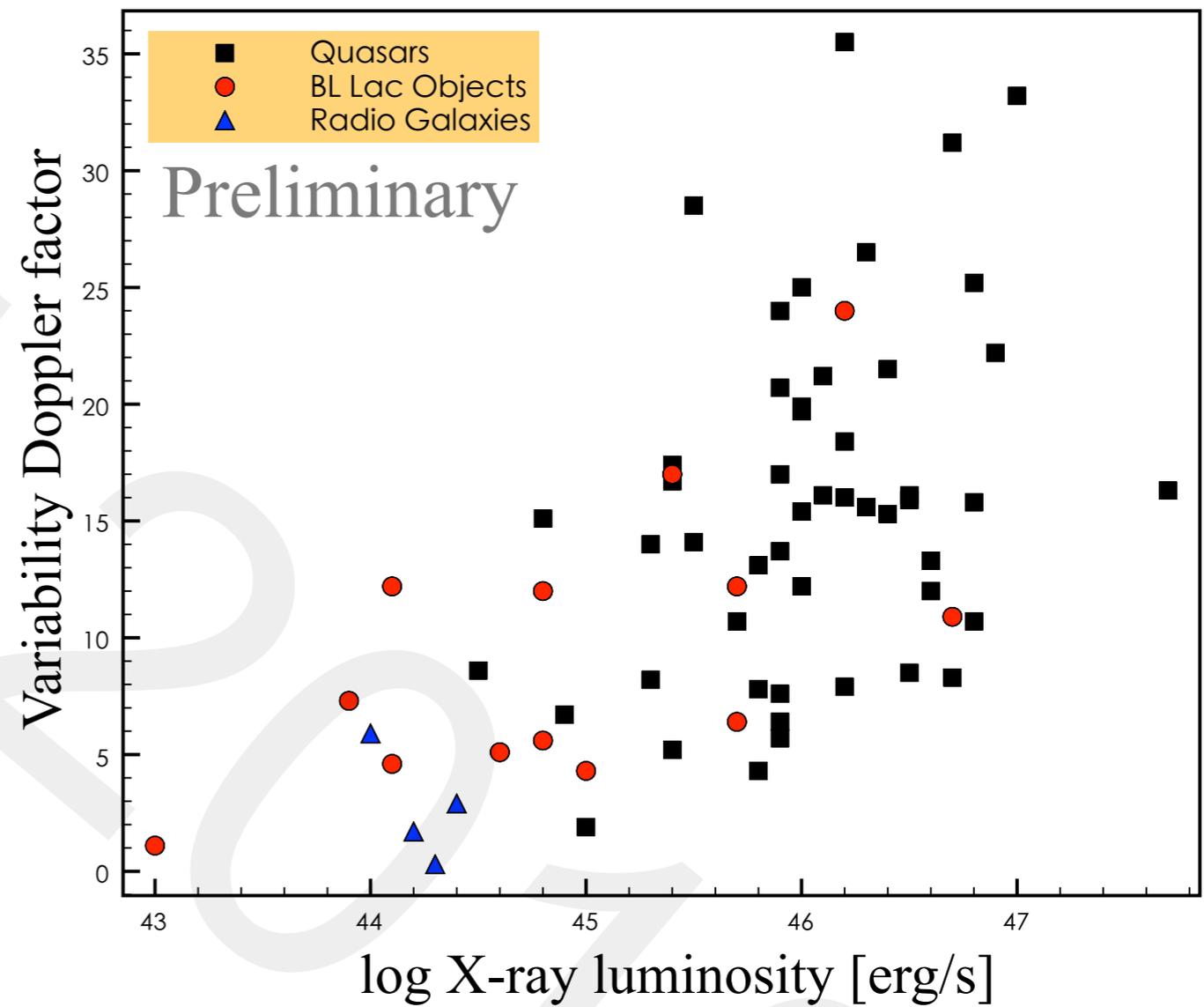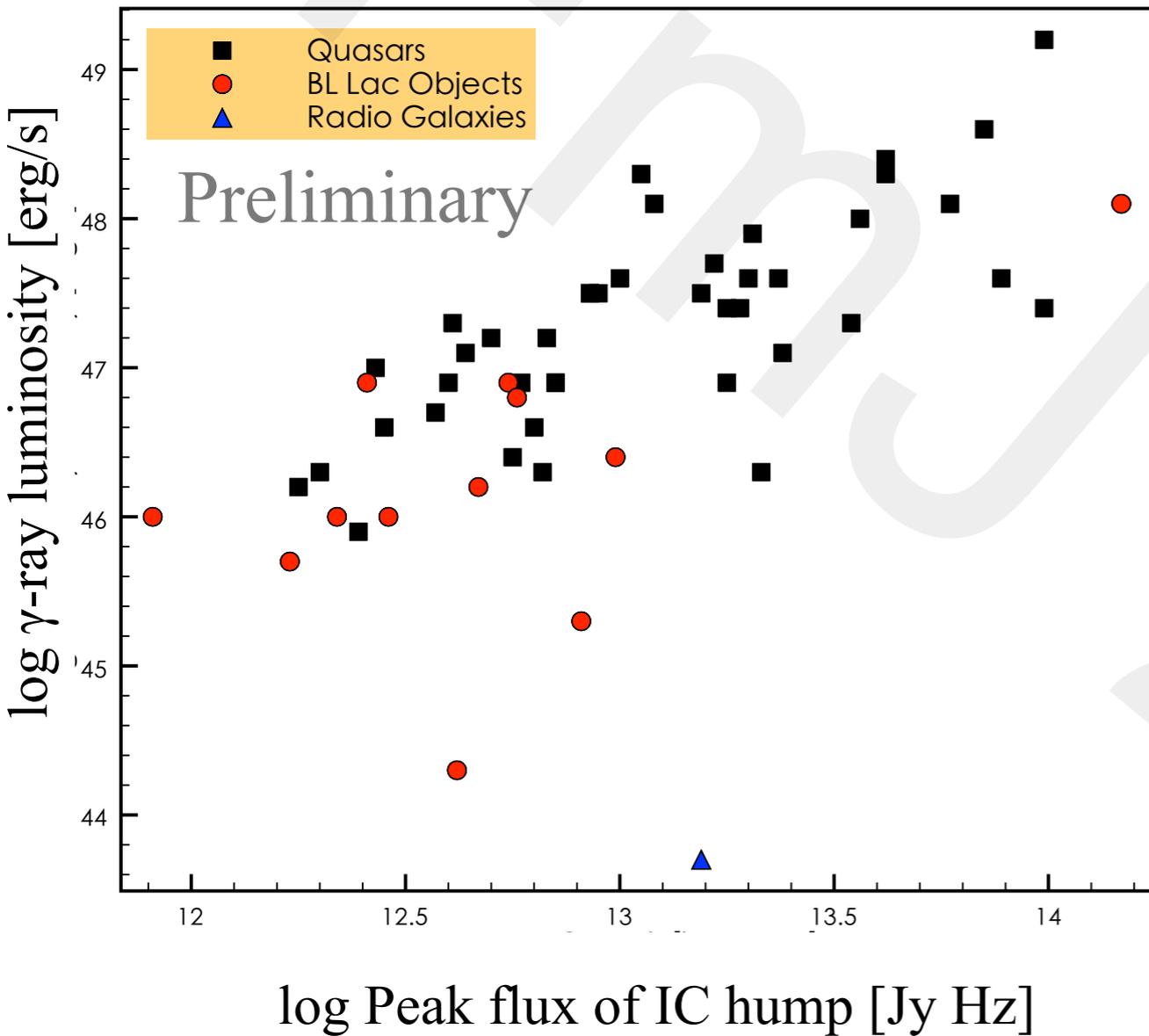
Variability Doppler factor: Hovatta et al. 2009, A&A 494, 527

Preliminary
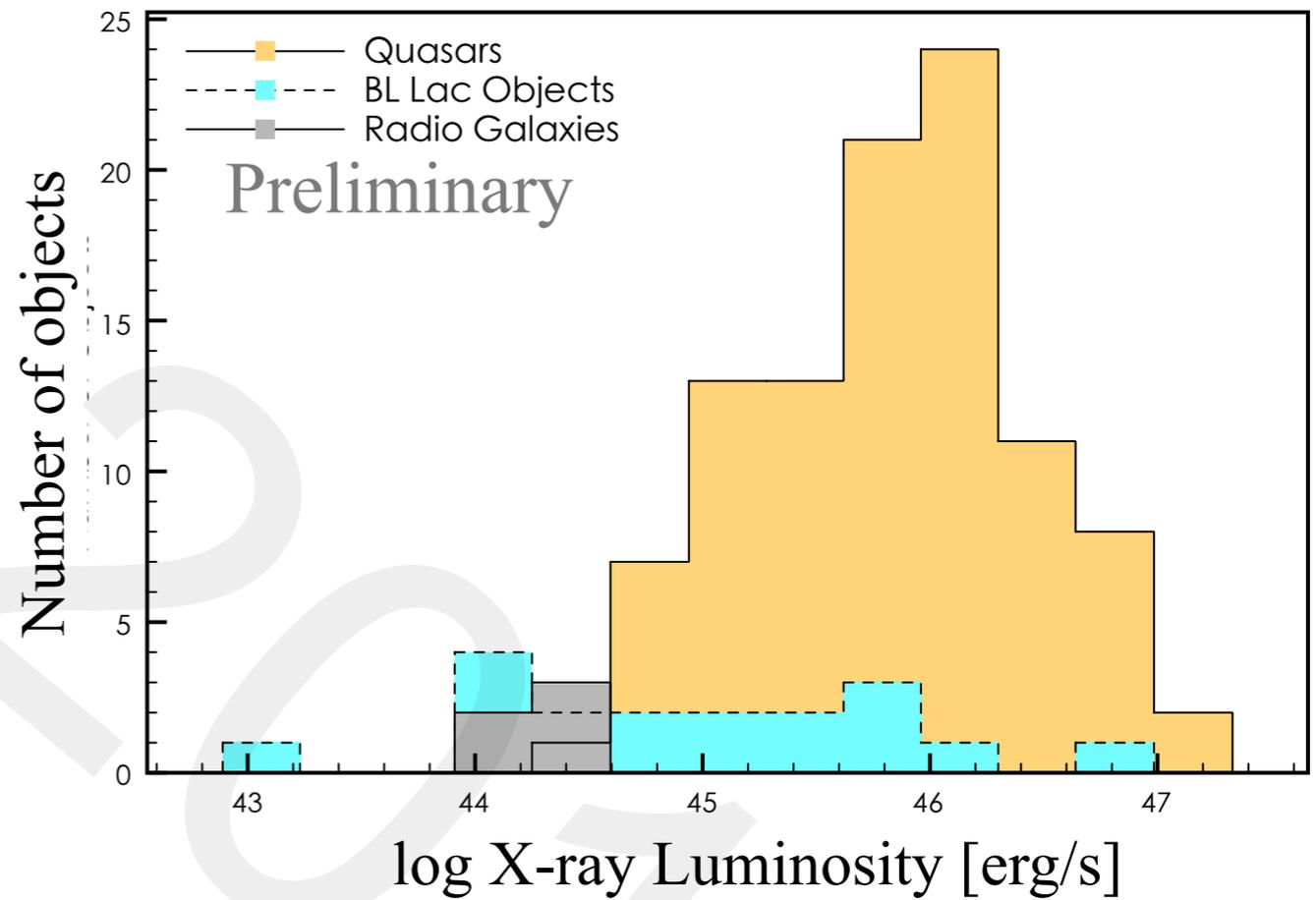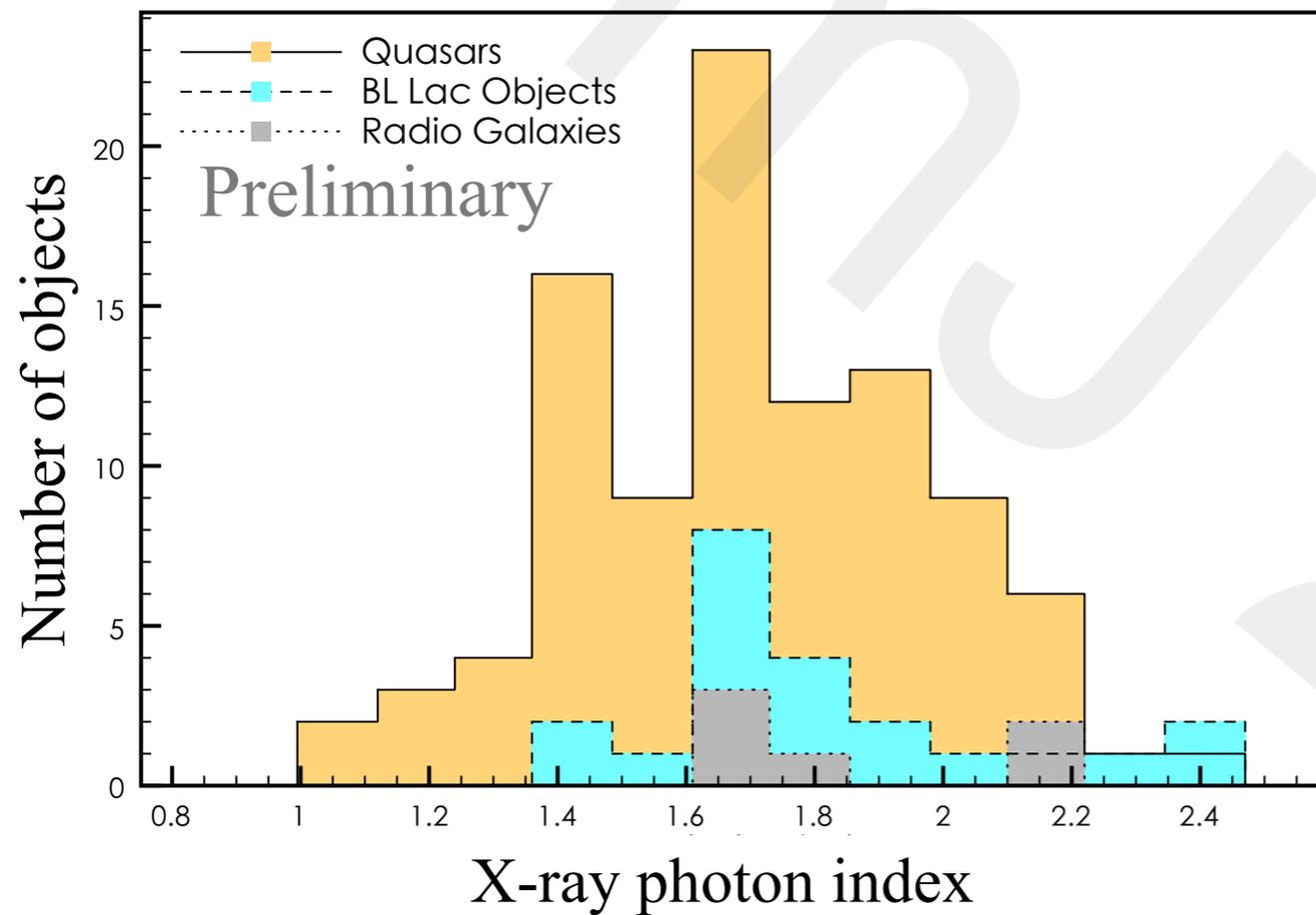
Summary

- We have constructed a (quasi-)simultaneous broadband SED catalog for a radio-selected AGN sample of 135 sources

- We estimated the peak positions of the synchrotron and inverse Compton humps

- We are investigating possible correlations of

    - e.g. γ-ray luminosity - Peak flux of IC hump

Next Steps

- Statistical tests will be performed to confirm our findings

- Variability study of broadband SED of individual sources

- Physical modeling of the broadband SEDs