Constraining the Size and the Flare Activity of the γ-ray Regions in Misaligned AGN

Paola Grandi & Eleonora Torresi
INAF/IASF BOLOGNA, ITALY

on behalf of the FERMI-LAT Collaboration

Adriano De Rosa
INAF/IASF BOLOGNA, ITALY

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We also thank the Italian Super Computing Center (ISCRA) Cineca

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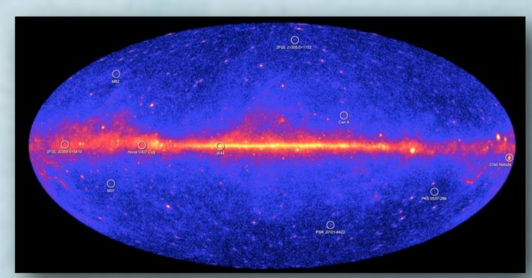


Misaligned AGN (MAGN)

With MAGNs we intend Radio Sources with the jet not directly pointed towards the observer.

MAGN

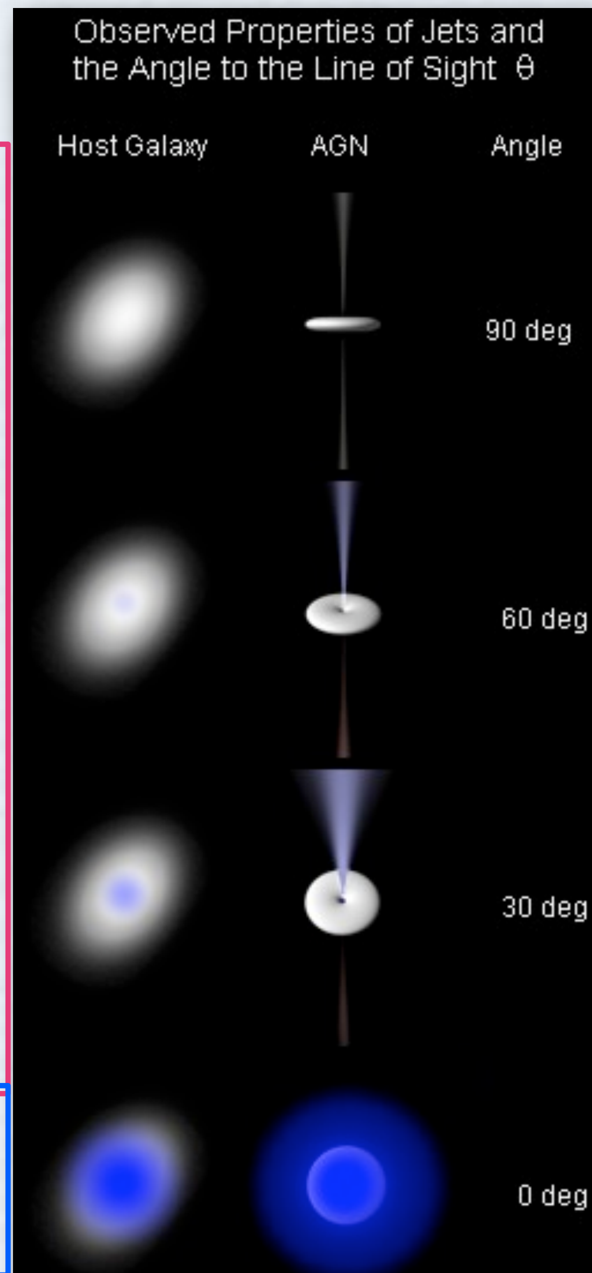
NLRG

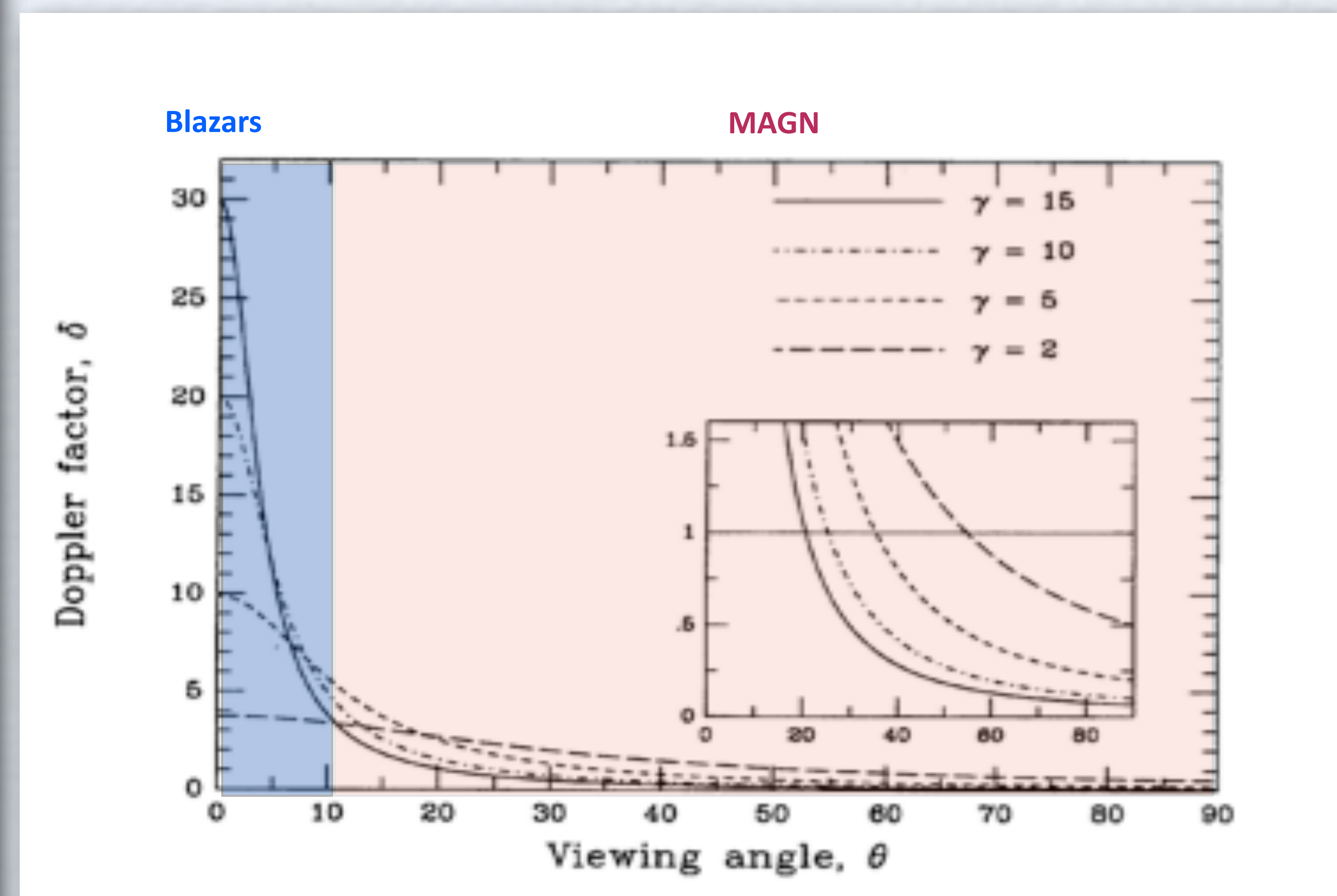
BLRG

SSRQ

Blazars

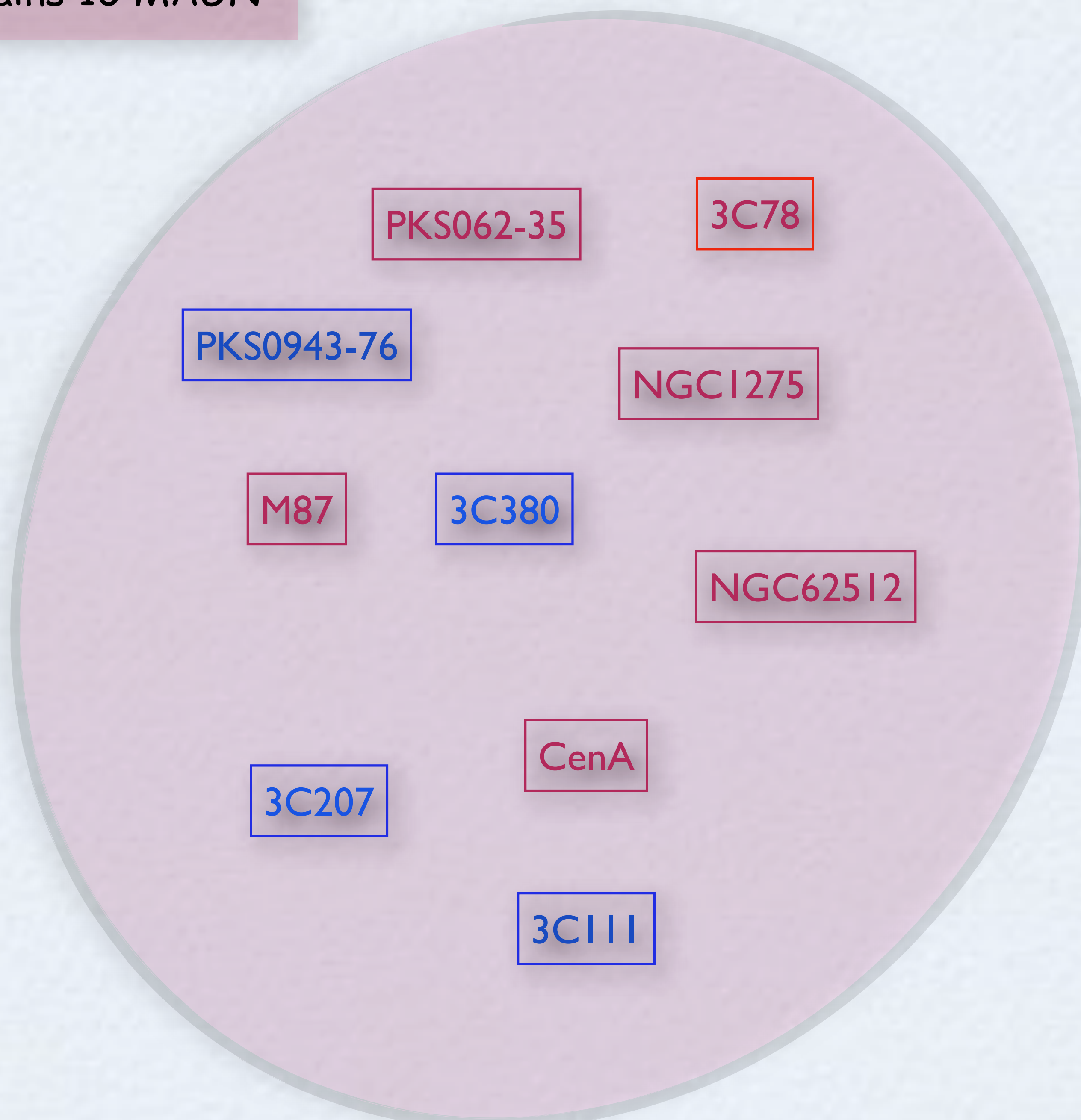
BL LAC
FSRQ





MAGN in the GeV sky

The First Catalog
of AGN (1LAC) contains 10 MAGN



FRI
FRII

MAGN in the GeV sky

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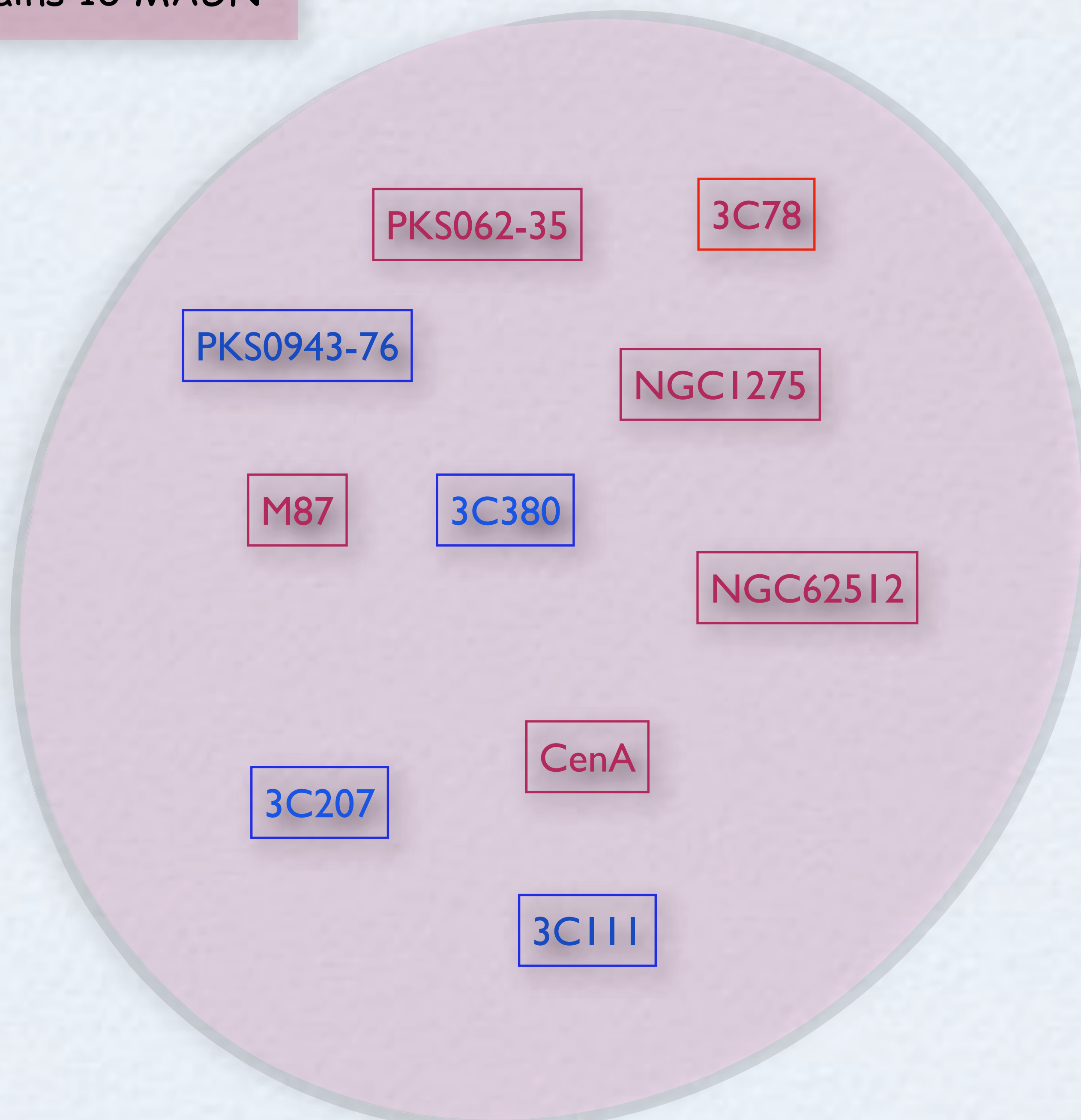


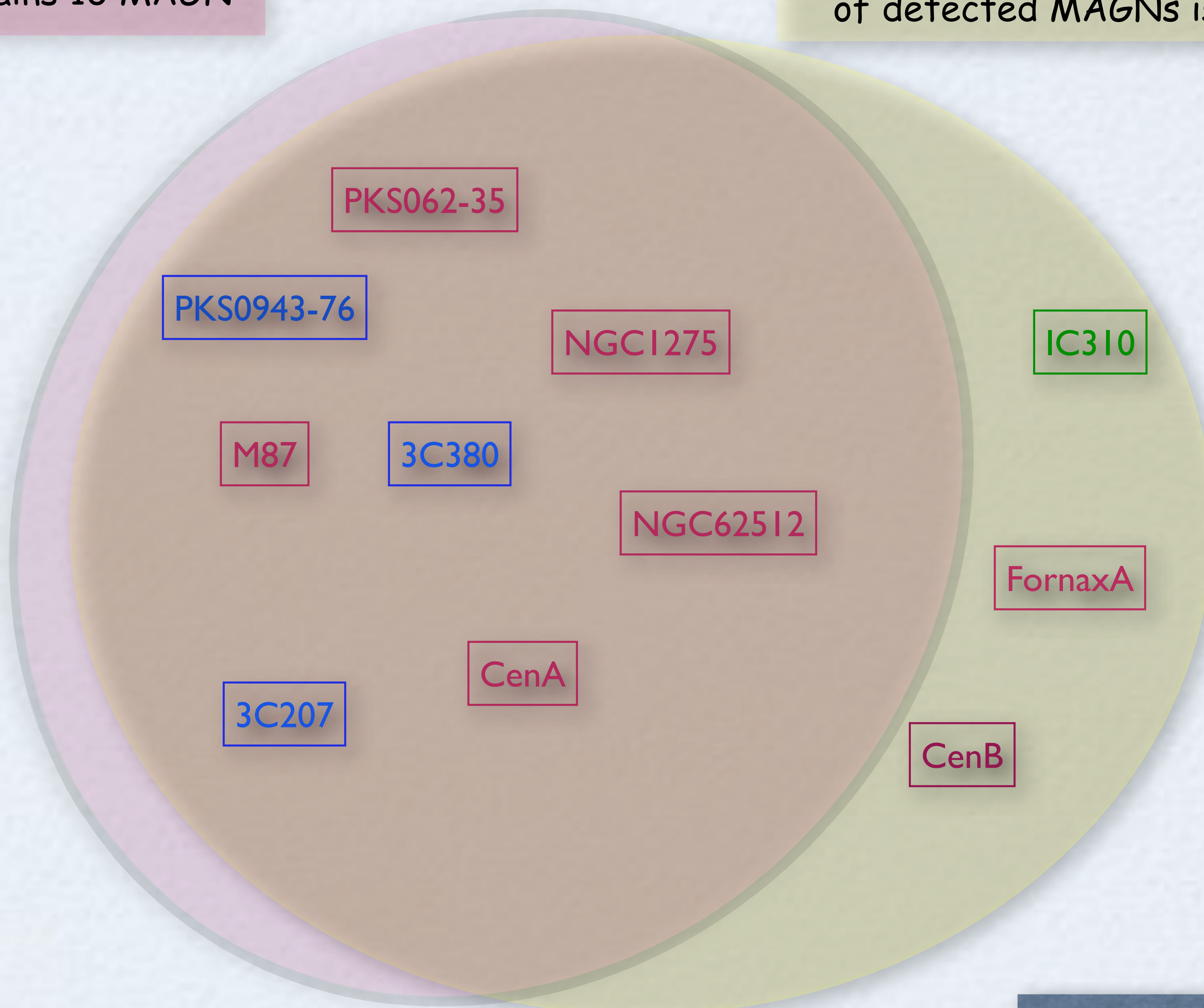
FRI
FRII

The MAGN 15-month sample includes 3C 120

MAGN in the GeV sky

The First Catalog of AGN (1LAC) contains 10 MAGN

In the Second Catalog of AGN (2LAC), the number of detected MAGNs is 11



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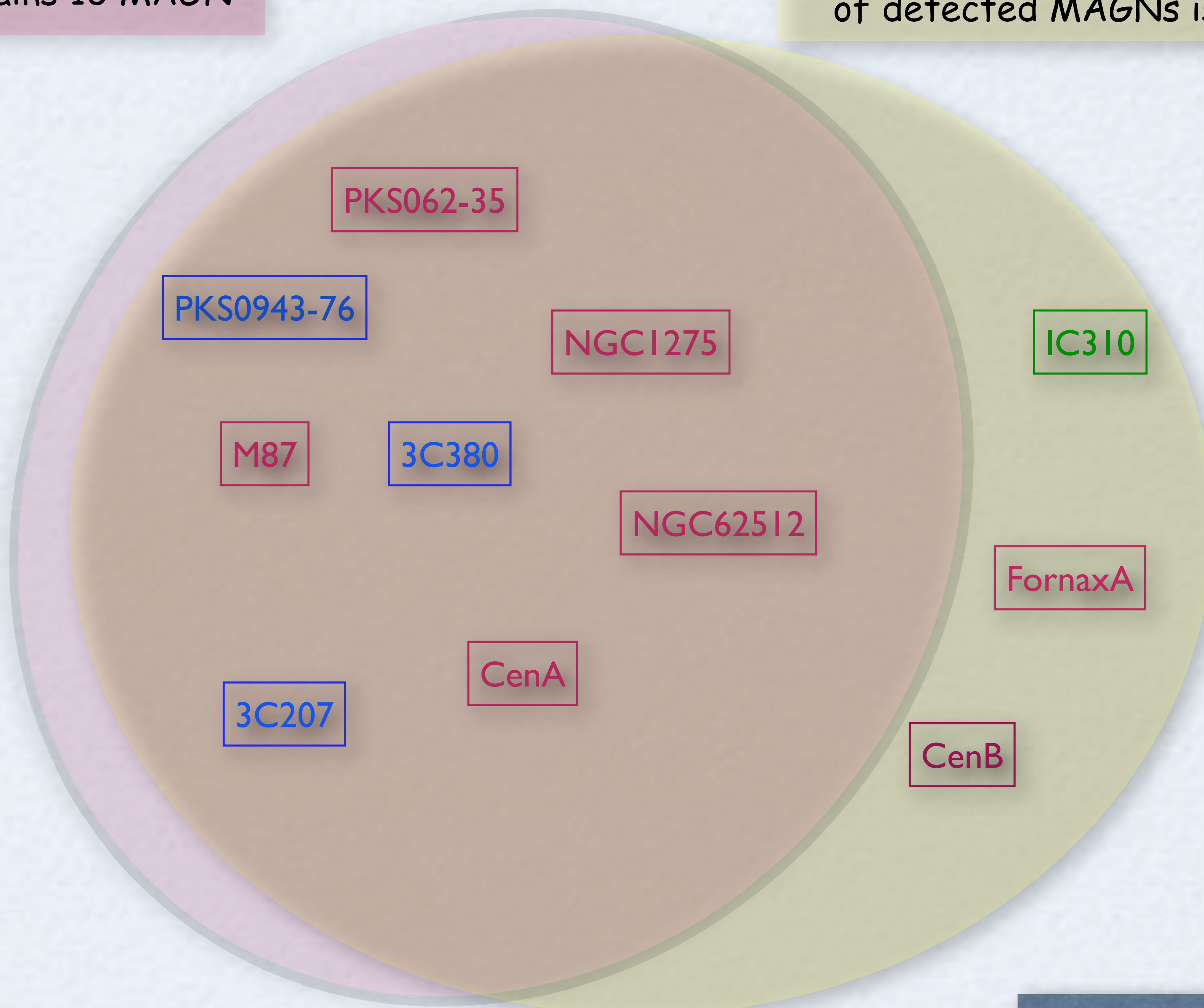
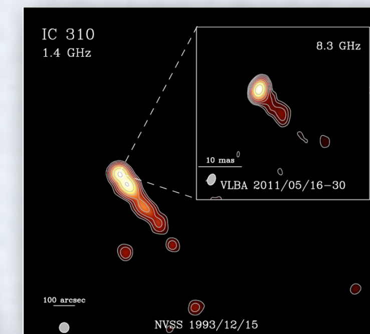


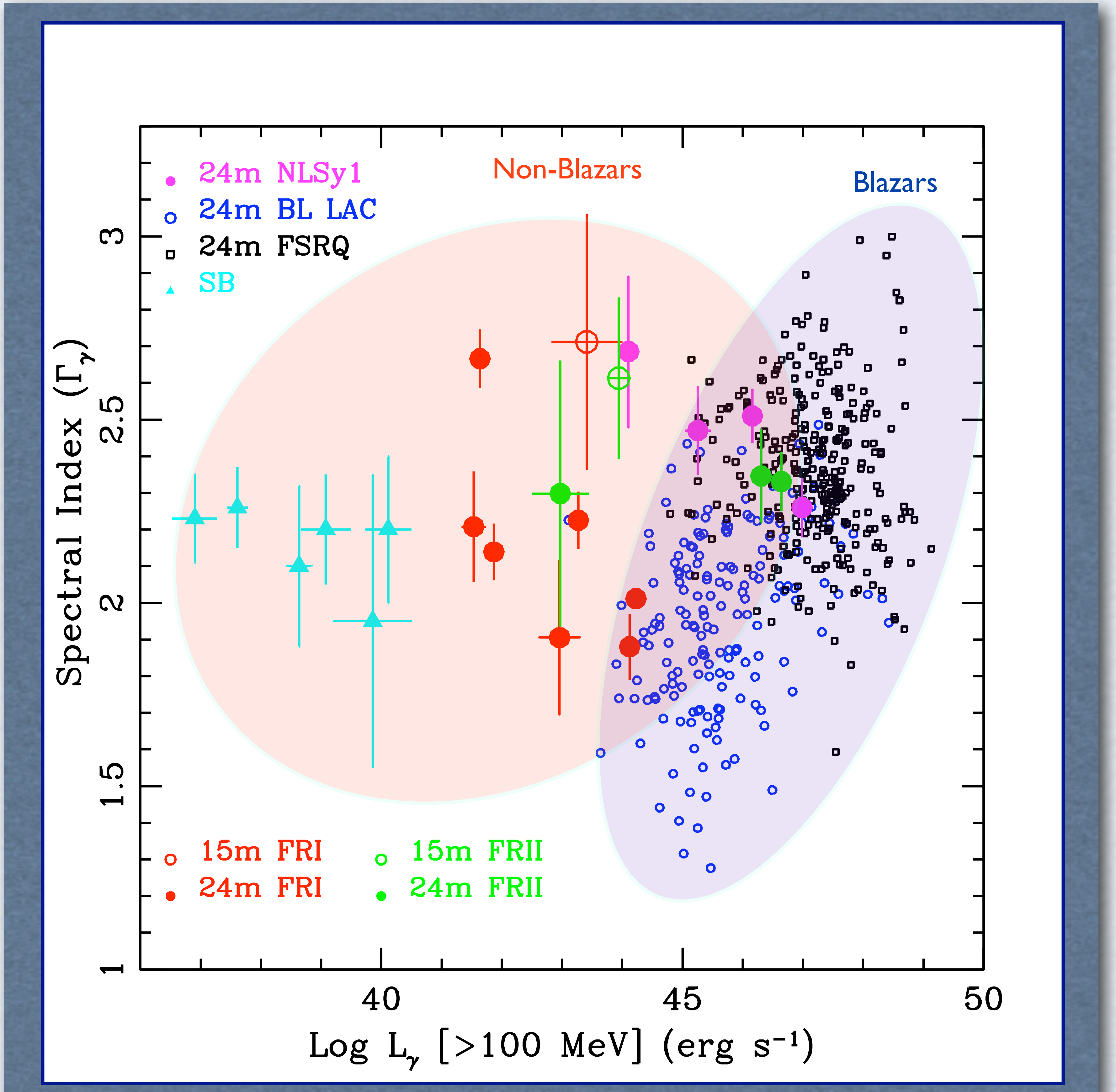


Kadler et al. 2012, A&A, 538, L1

FRI
FRII

The MAGN 15-month sample includes 3C 120

After 24 months of sky survey



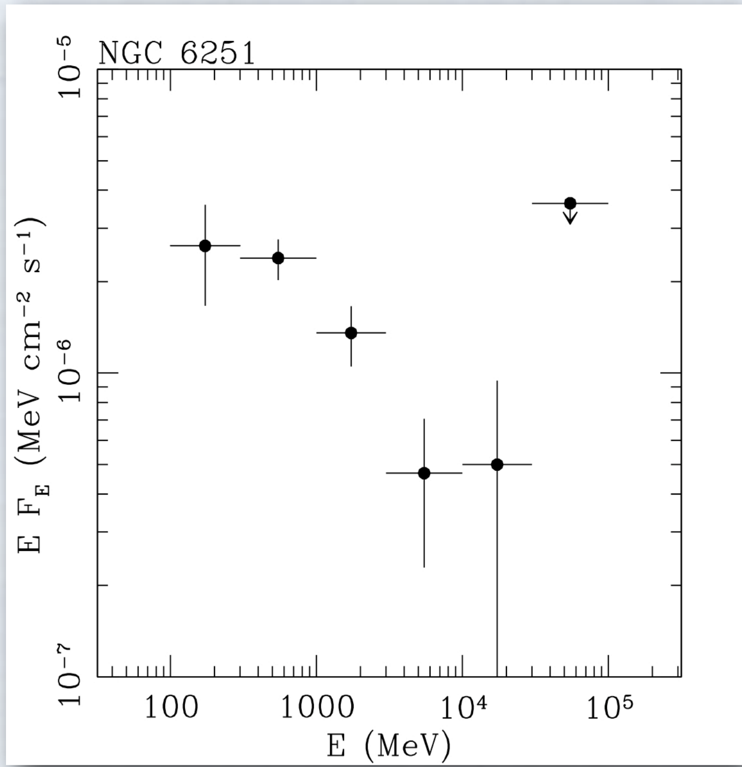
MAGN (15 MONTH-DATA)

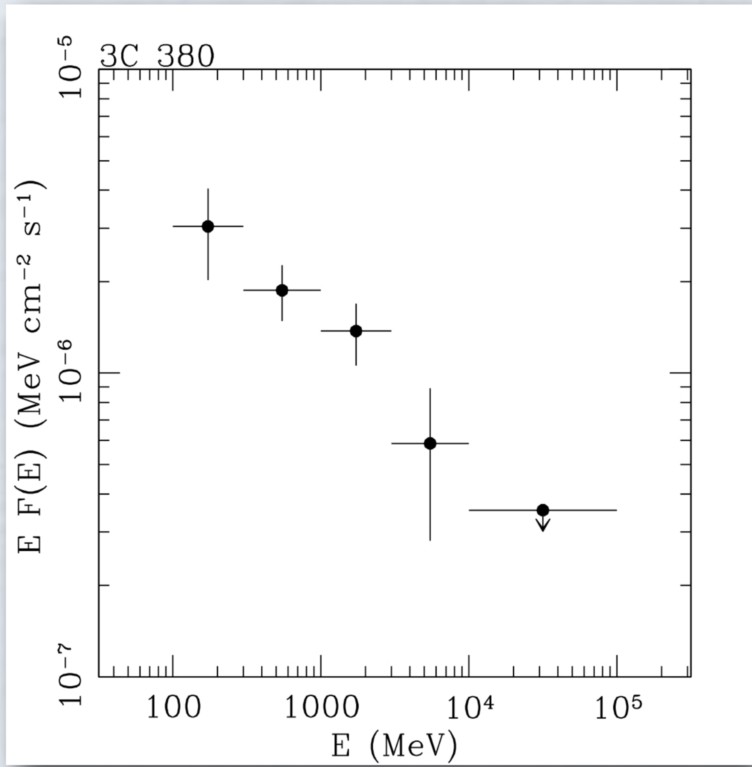
MAGN are generally
faint and soft sources

F(>0.1 GeV)~10^{-8} Phot.cm^{-1} s^{-2}
$\Gamma \sim 2.4$

Abdo, A. A., et al. 2010, ApJ, 720, 912 (MAGN)

FR I Radio Galaxy

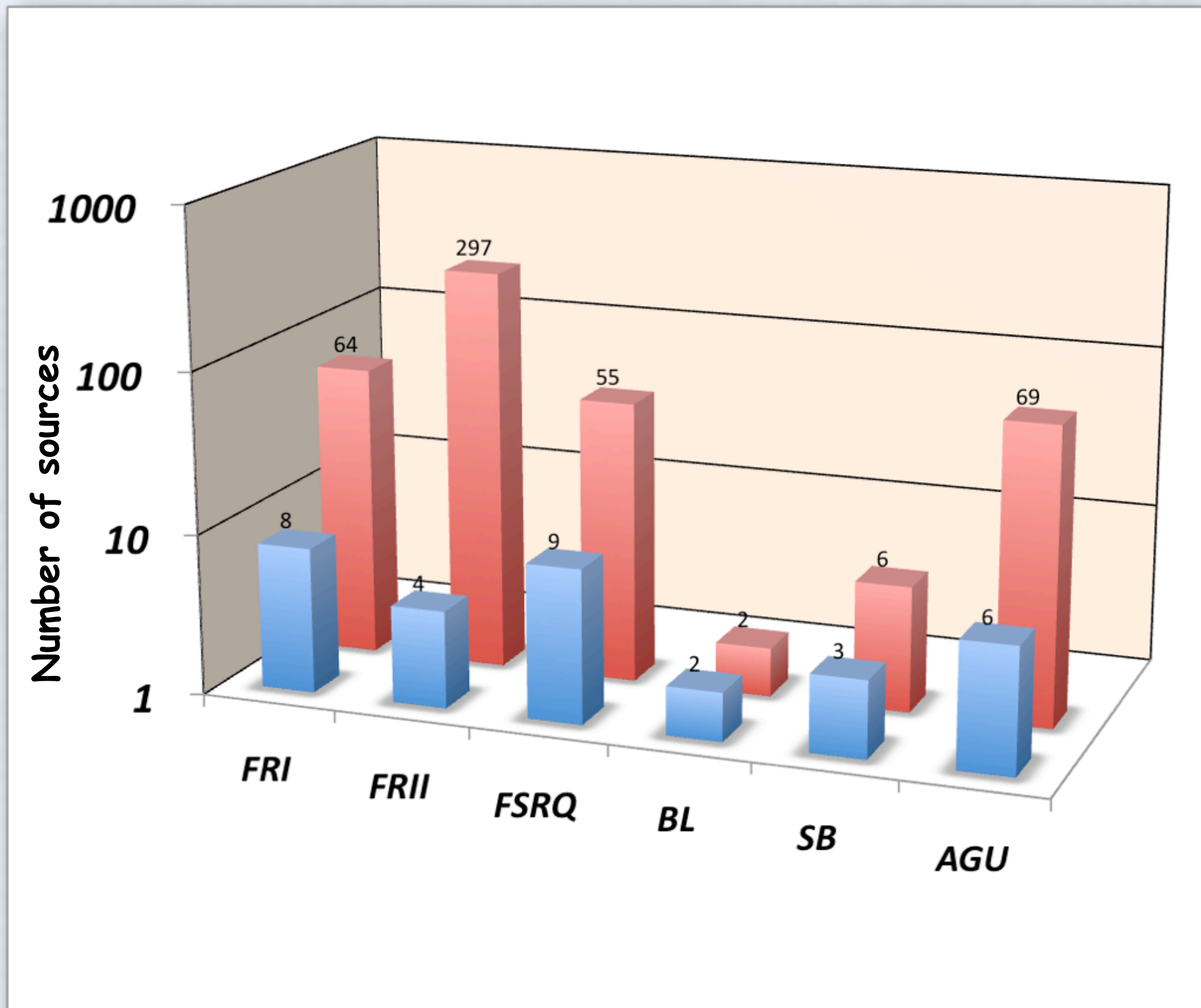




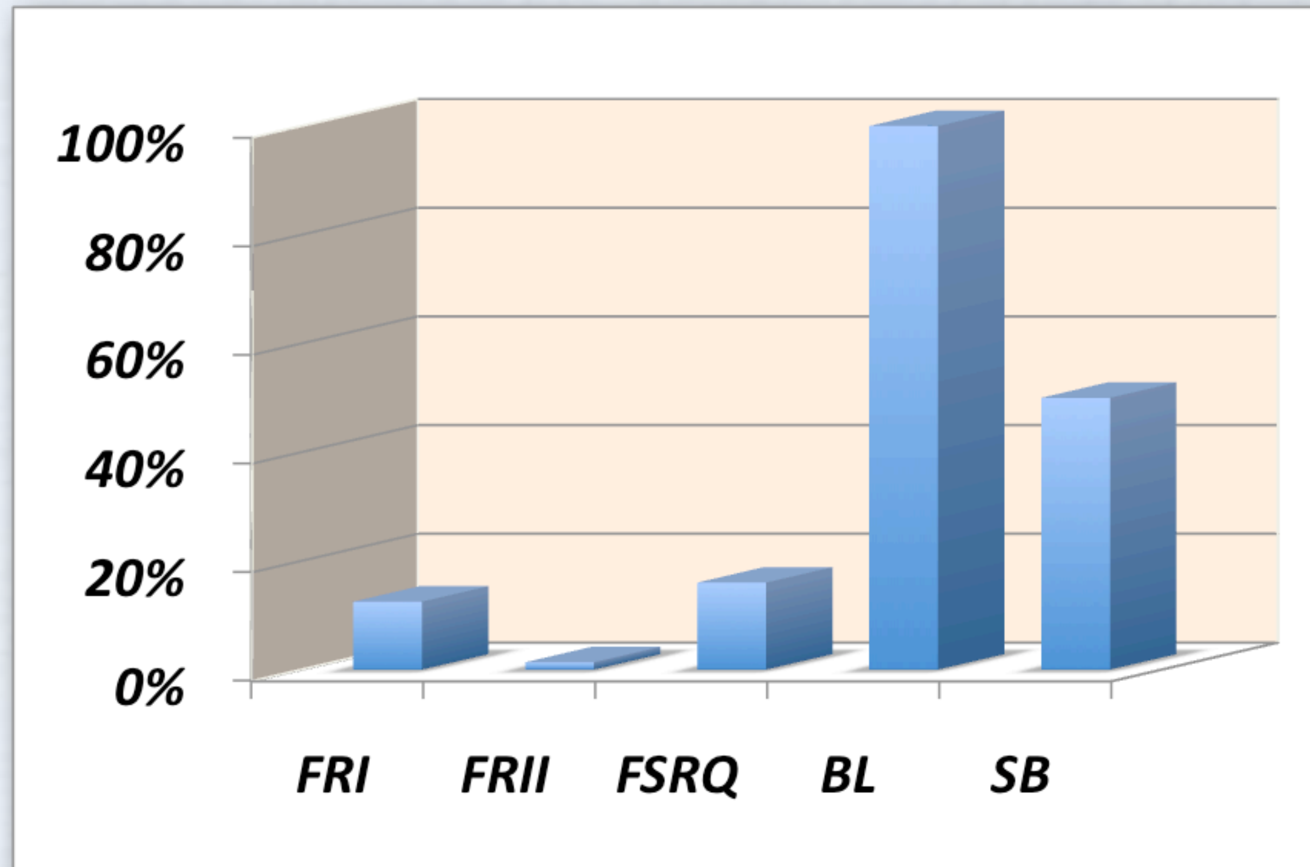
FRII SSRQ

LAT misses FRII radio galaxies

Radio Sources of 3CRR+3CR+2Jy+MS4 catalogs



Percentage of radio sources with γ-ray emission



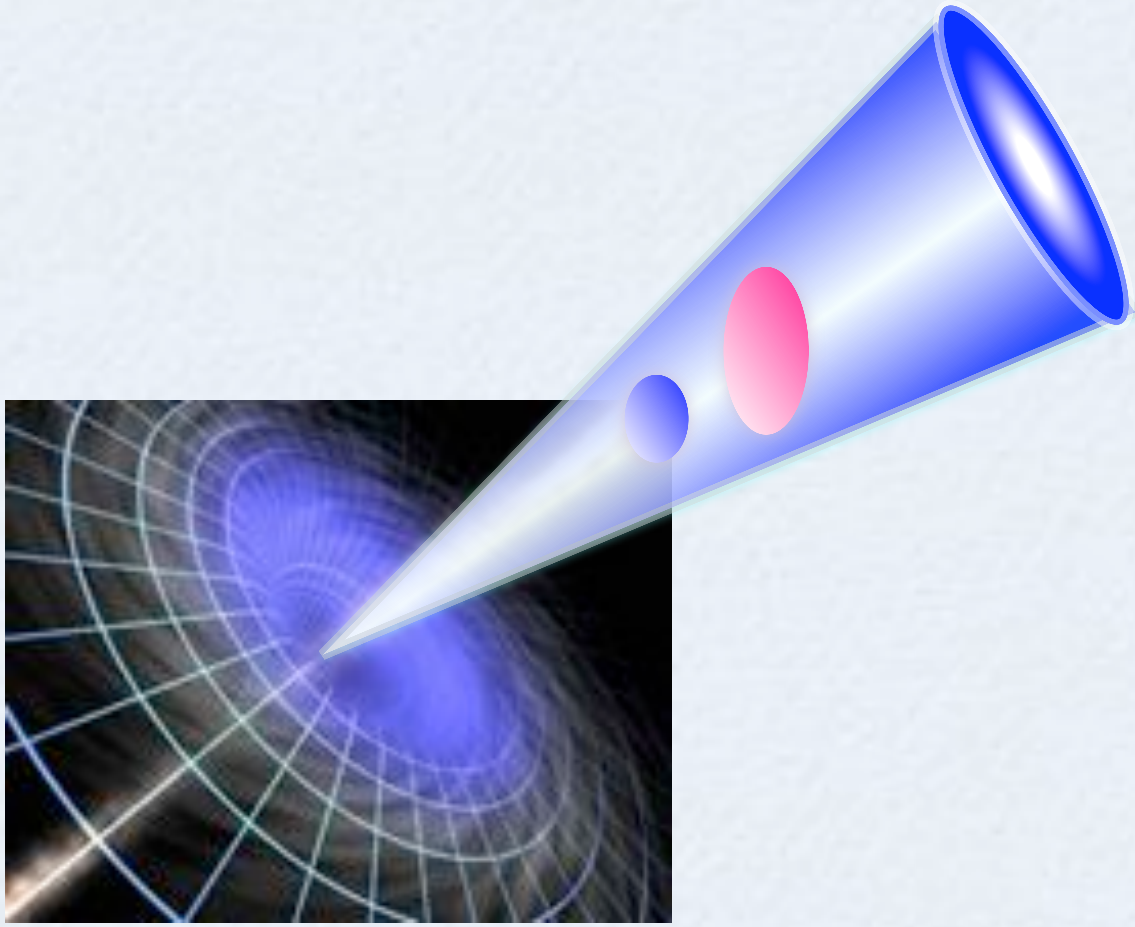
The jet could be structured in FRI

Possible solutions to the problems (not the only ones)

❖ Decelerating jet (Georganopoulos & Kazanas 2003)

❖ Structured (spine +slower layers) jet (Ghisellini, Tavecchio & Chiaberge 2005)

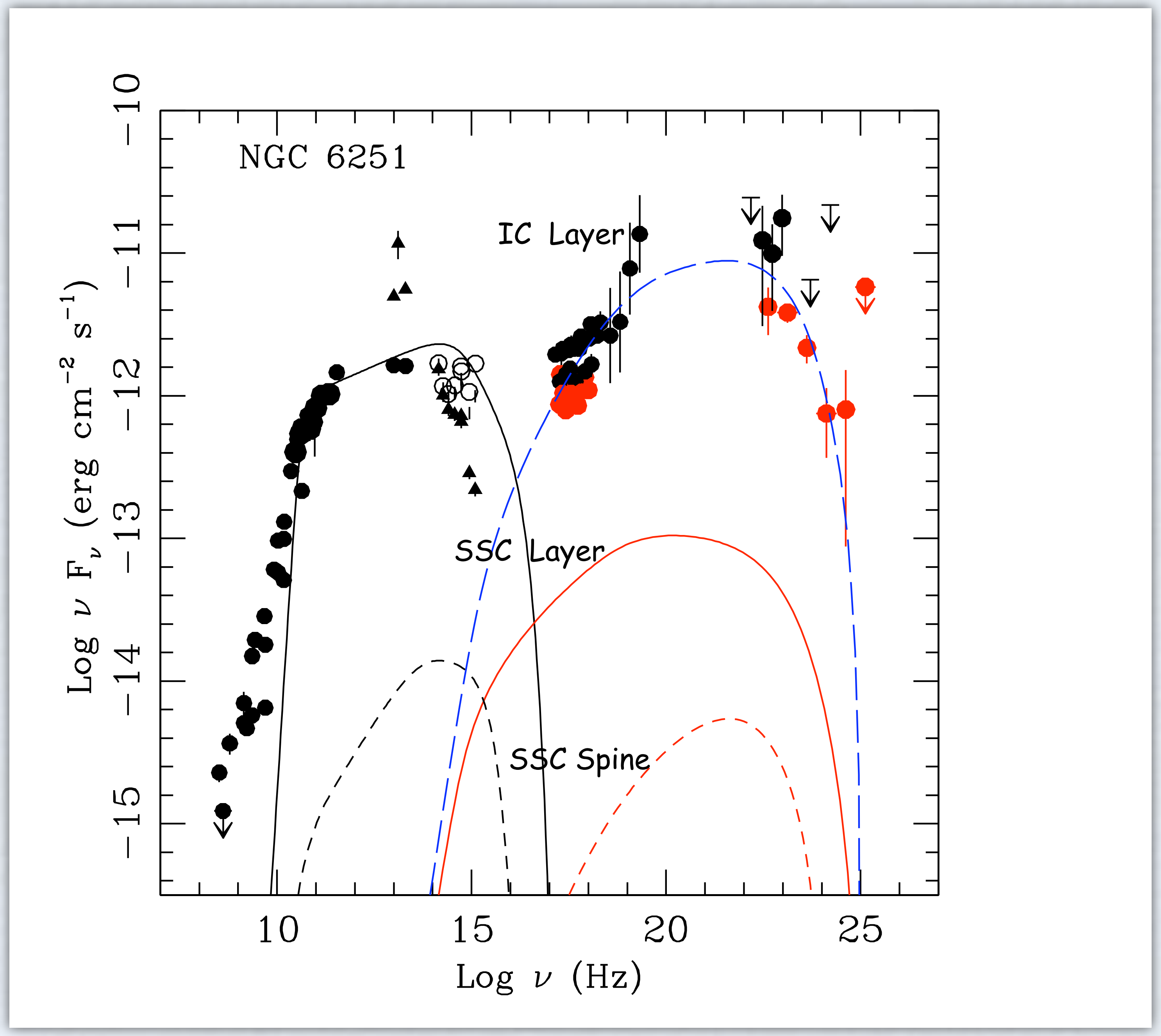
❖Colliding shells (Bottcher & Dermer 2010)



The hypothesis of homogeneity is relaxed and more regions at different velocities are assumed.

These models can generally fit pretty well the SEDs of FRI radio galaxies.

(Migliori et al. 2011)



Structured Jet

$\Theta = 25°$

$\Gamma_{Layer} = 2.4$

$\Gamma_{Spine} = 15$

In the spine-layer and decelerating models there is an efficient (radiative) feedback between different regions in the jet that increases the IC emission.

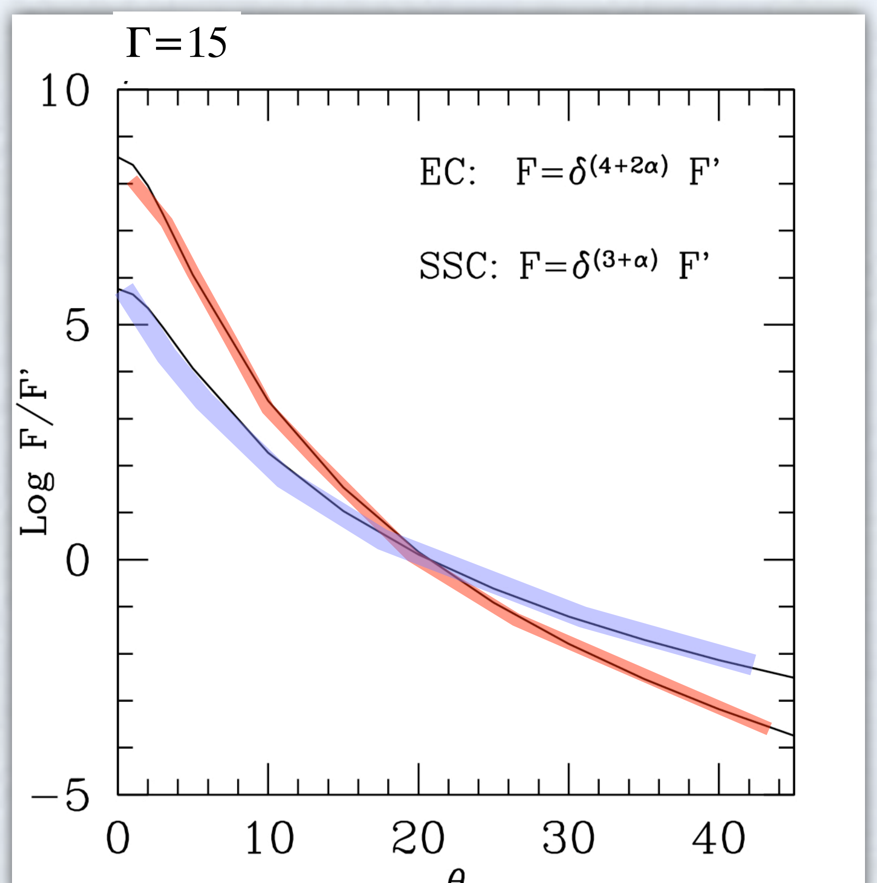
Models can fit the Spectral Energy Distributions of FRIs.

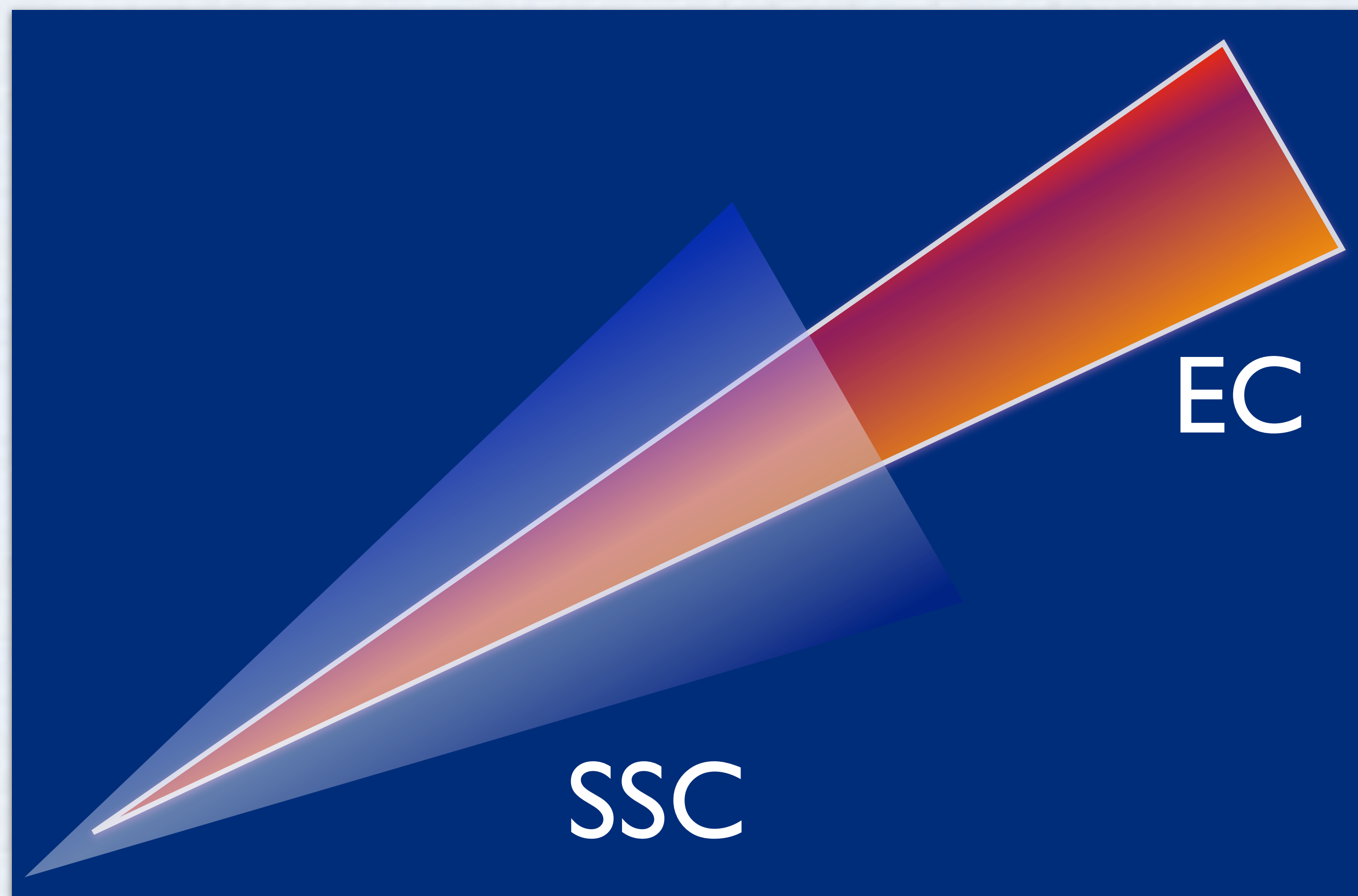
In FRII the jet could be not structured. The external layers could be less prominent

and/or

In FRII the high energy emission cone could narrower.

In FRII the jet propagates through a photon rich environment (Torresi et al. 2012) => EC dominant mechanism .
EC emission is narrower in the beaming direction than the SSC radiation (Dermer 1995, ApJ, 446, L63)



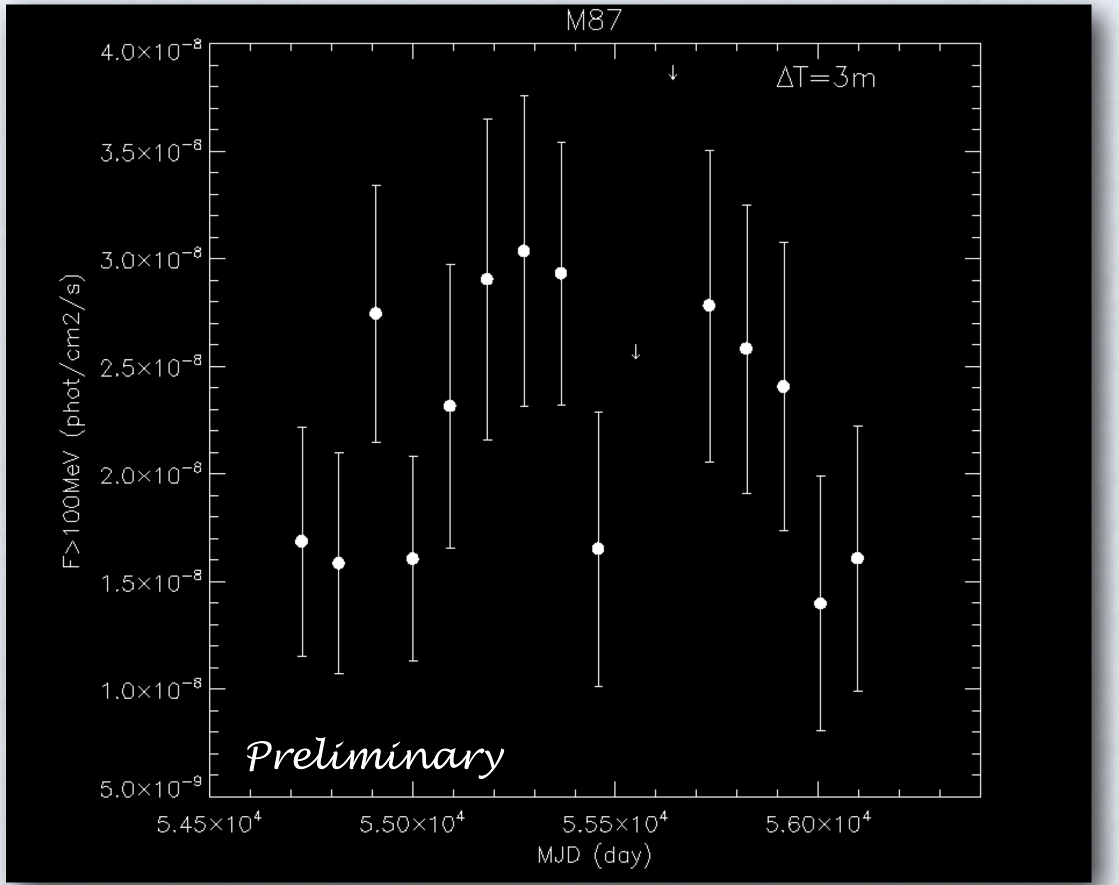


In any case, the question is still open!

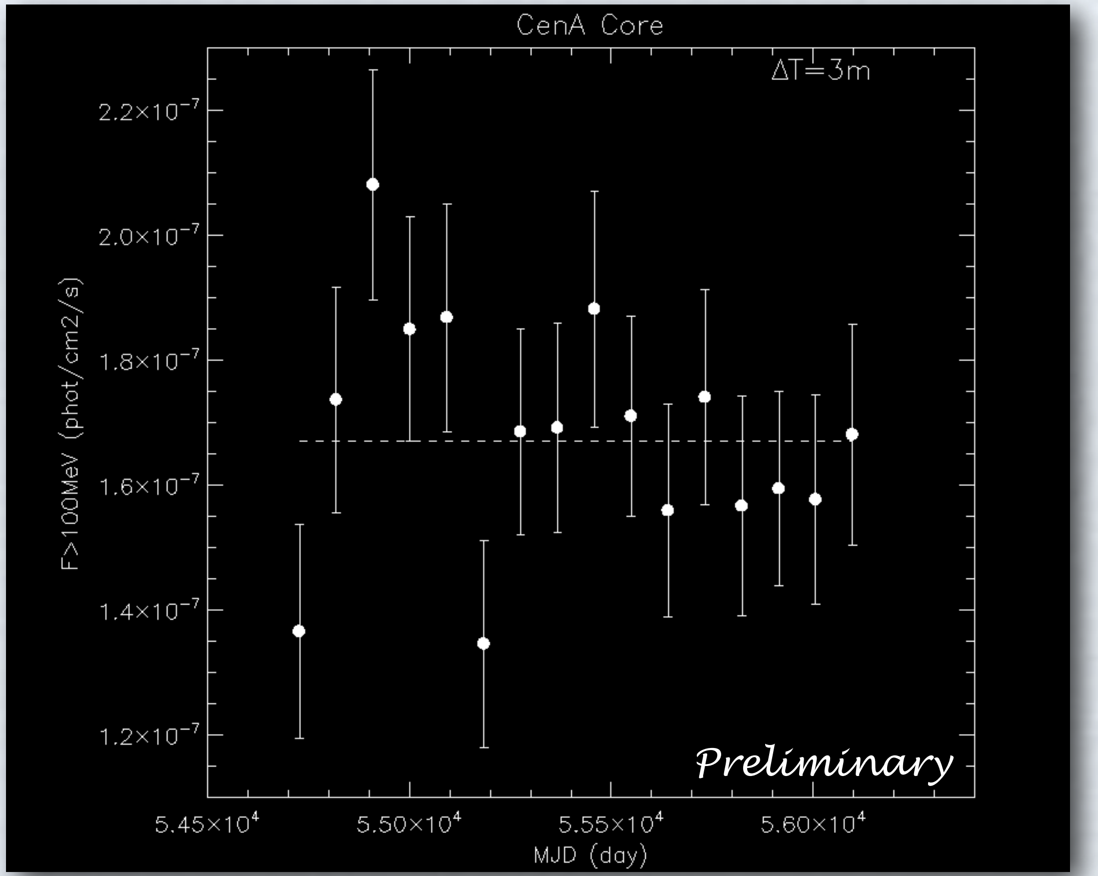
GeV variability studies of MAGN
can help in addressing this issue

FRI RADIO GALAXIES

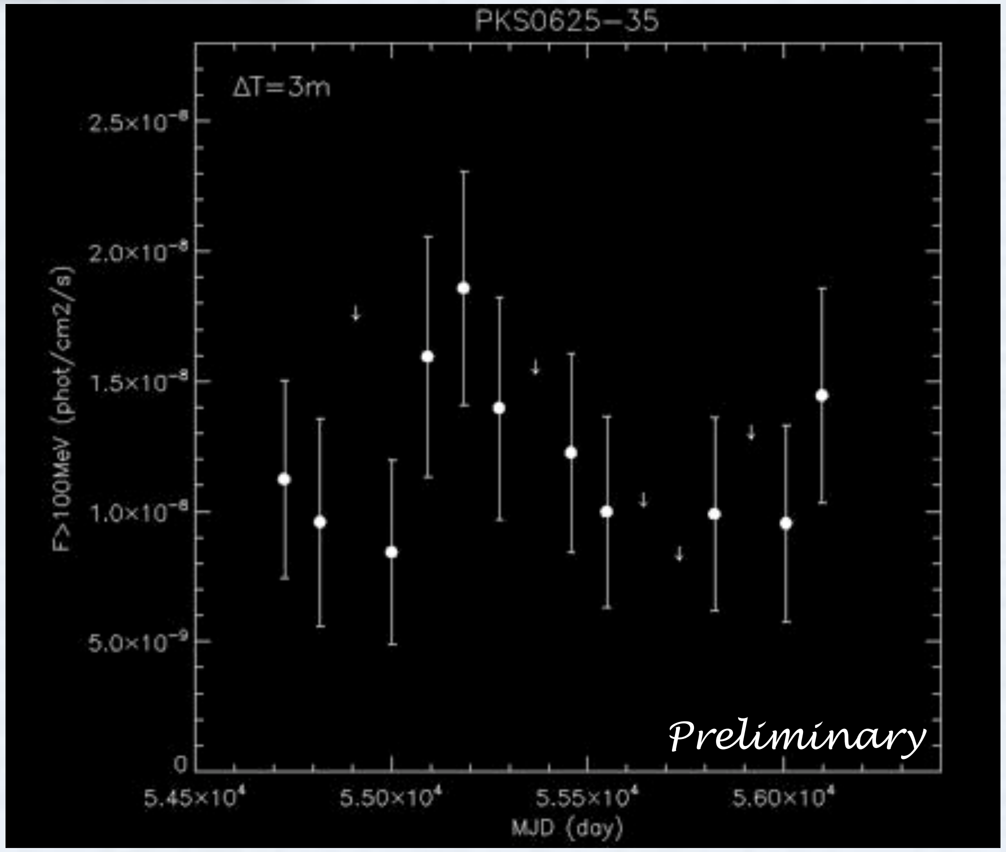
M87



Cen A core

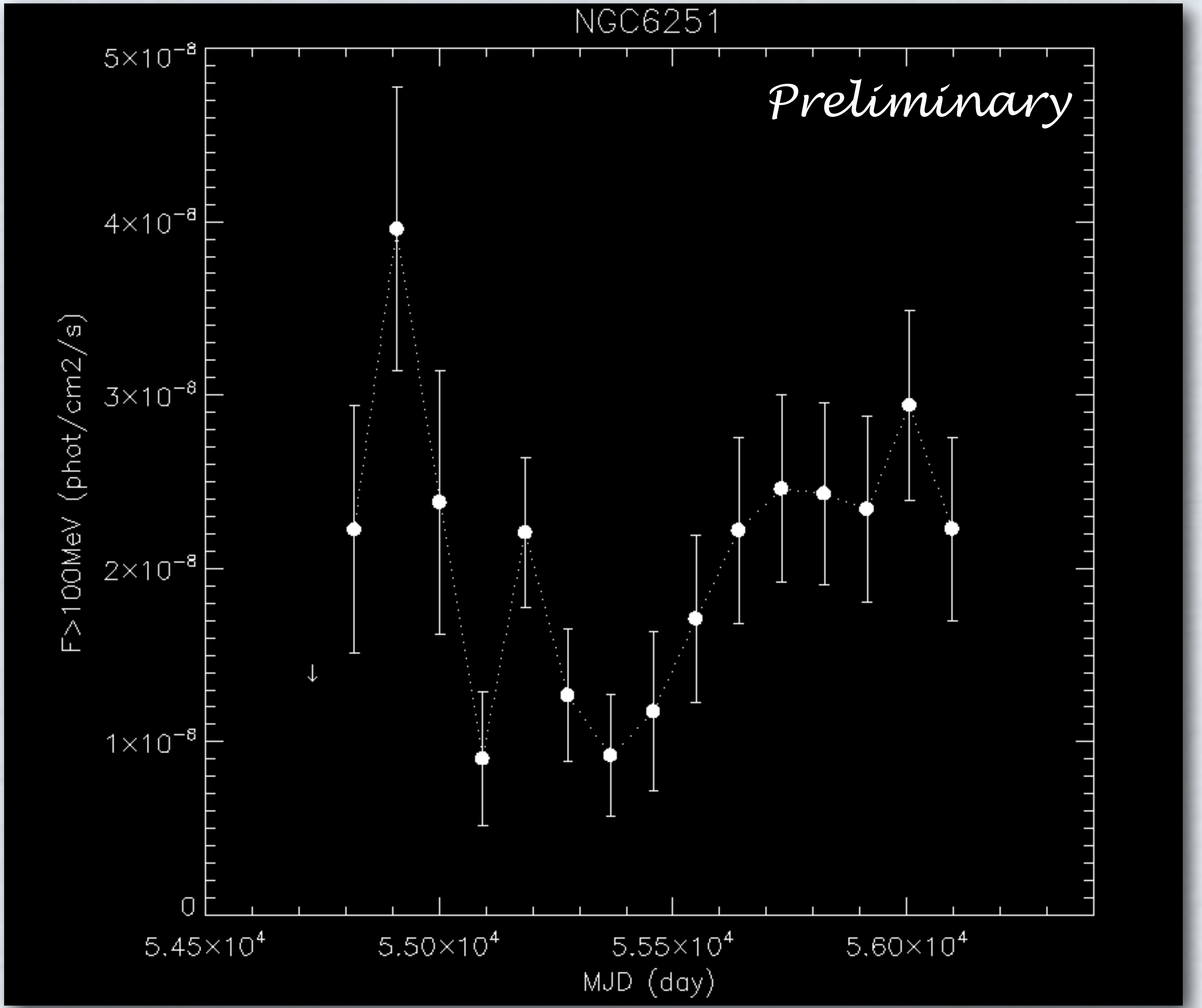


PKS 0625-35



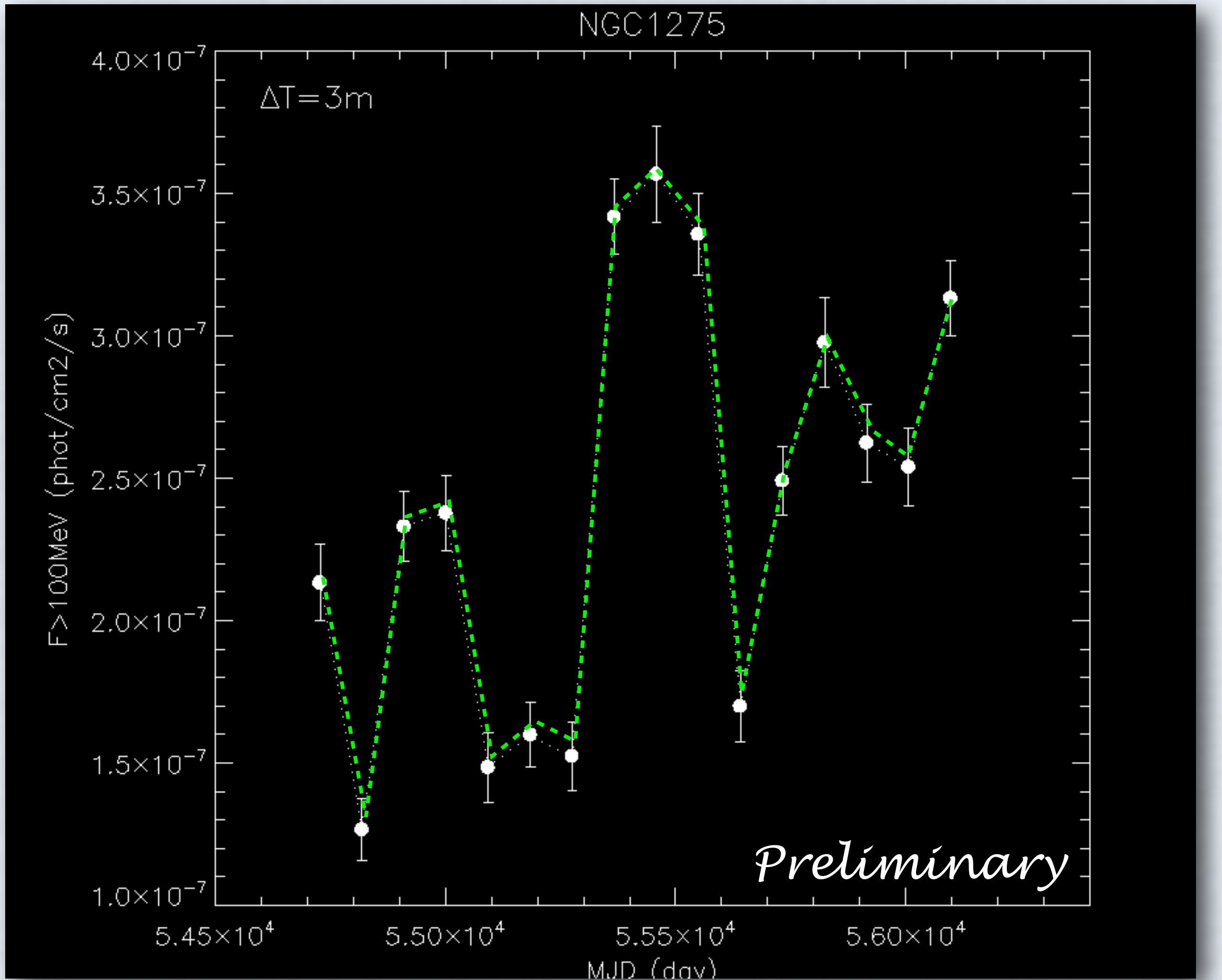
FRI: NGC6251

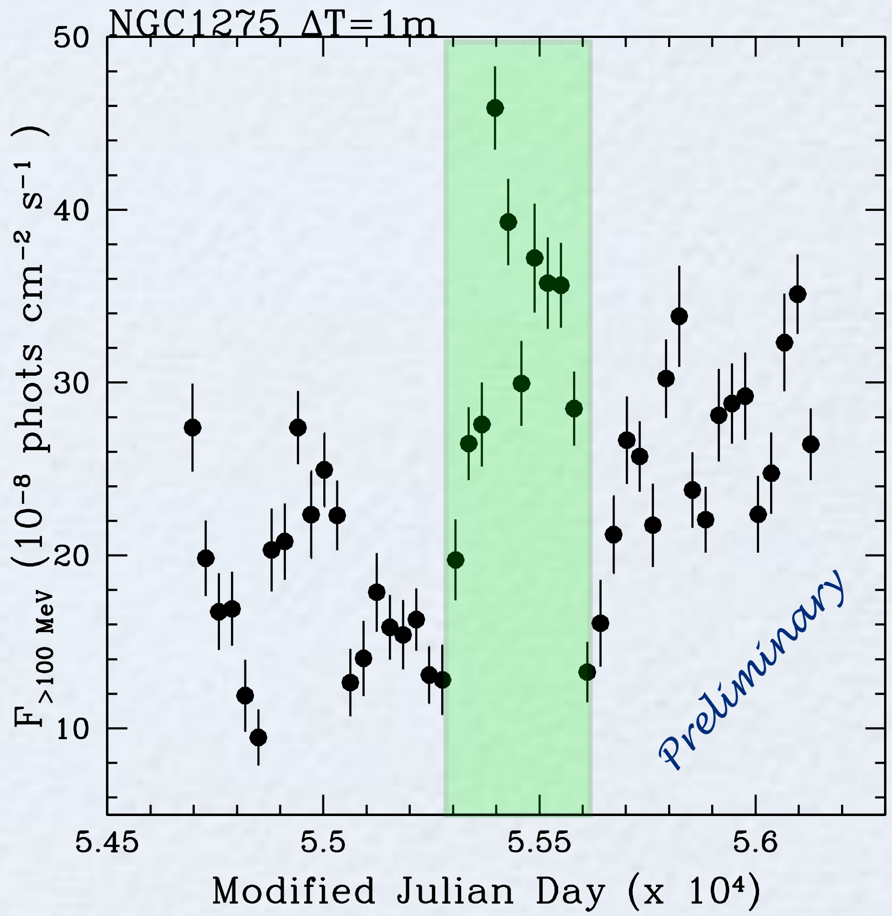
$P_{\chi 2}$ (constant) ~2×10^{-3}

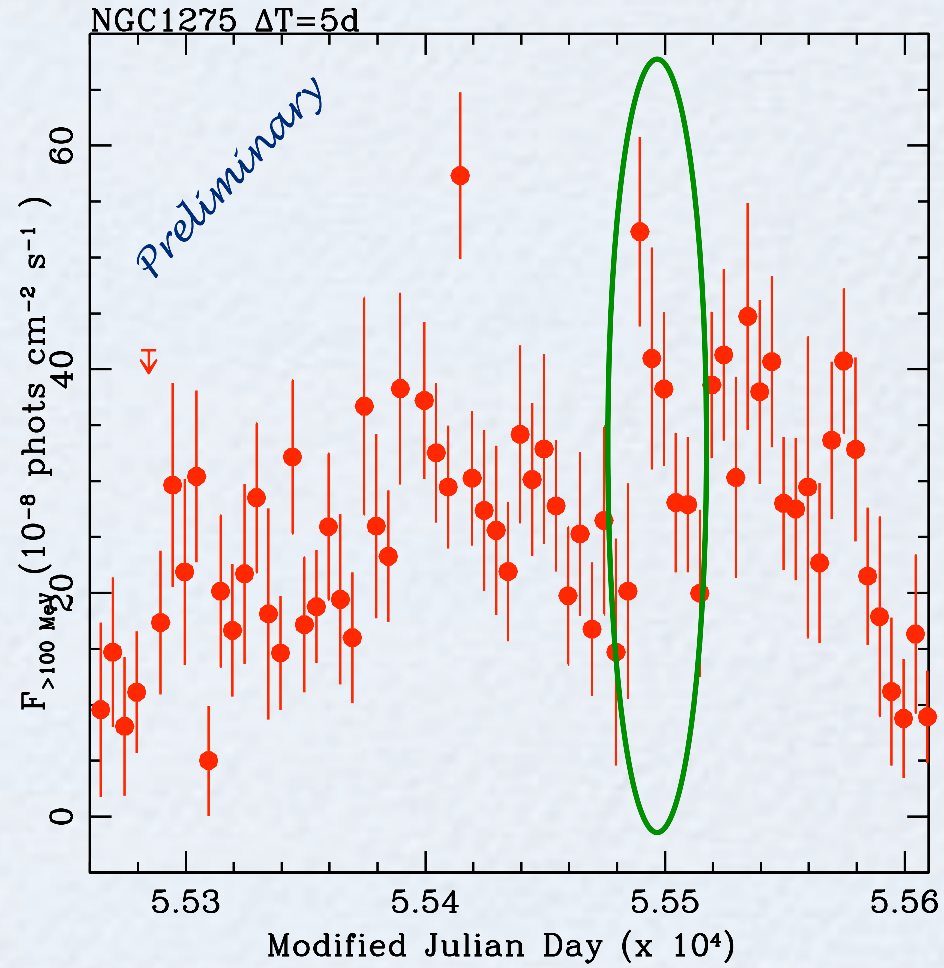


FRI : NGC 1275

the source remains in a high state for about 9 months





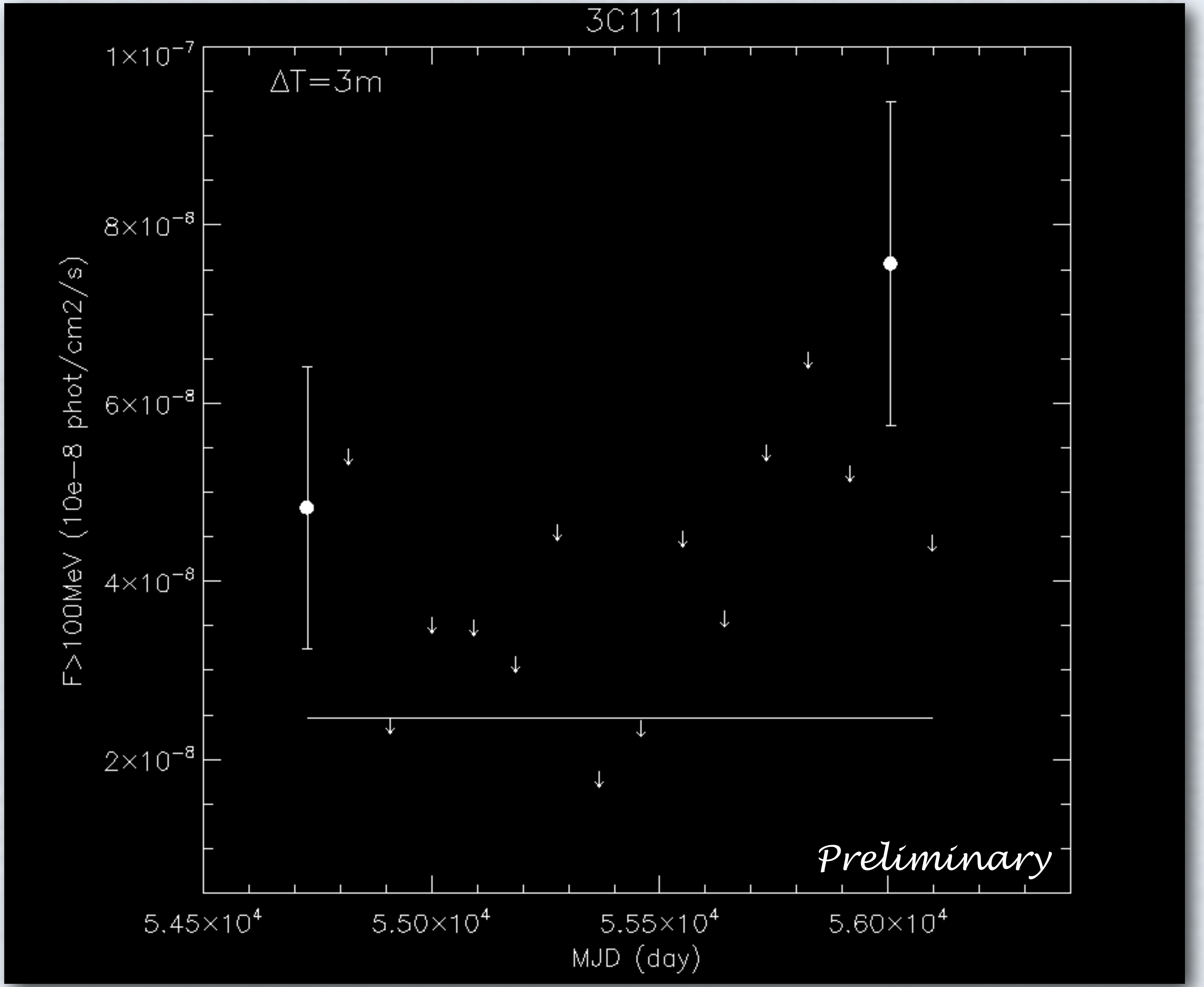


- FRIs are on average detected (TS>10) for 80% of time (in 48 months considering a bin time of 3 months);

- FRI sources seems to be generally quiet;

- When a flare occurs, FRIs can remain in a high state for several months;

FRII : 3C 111

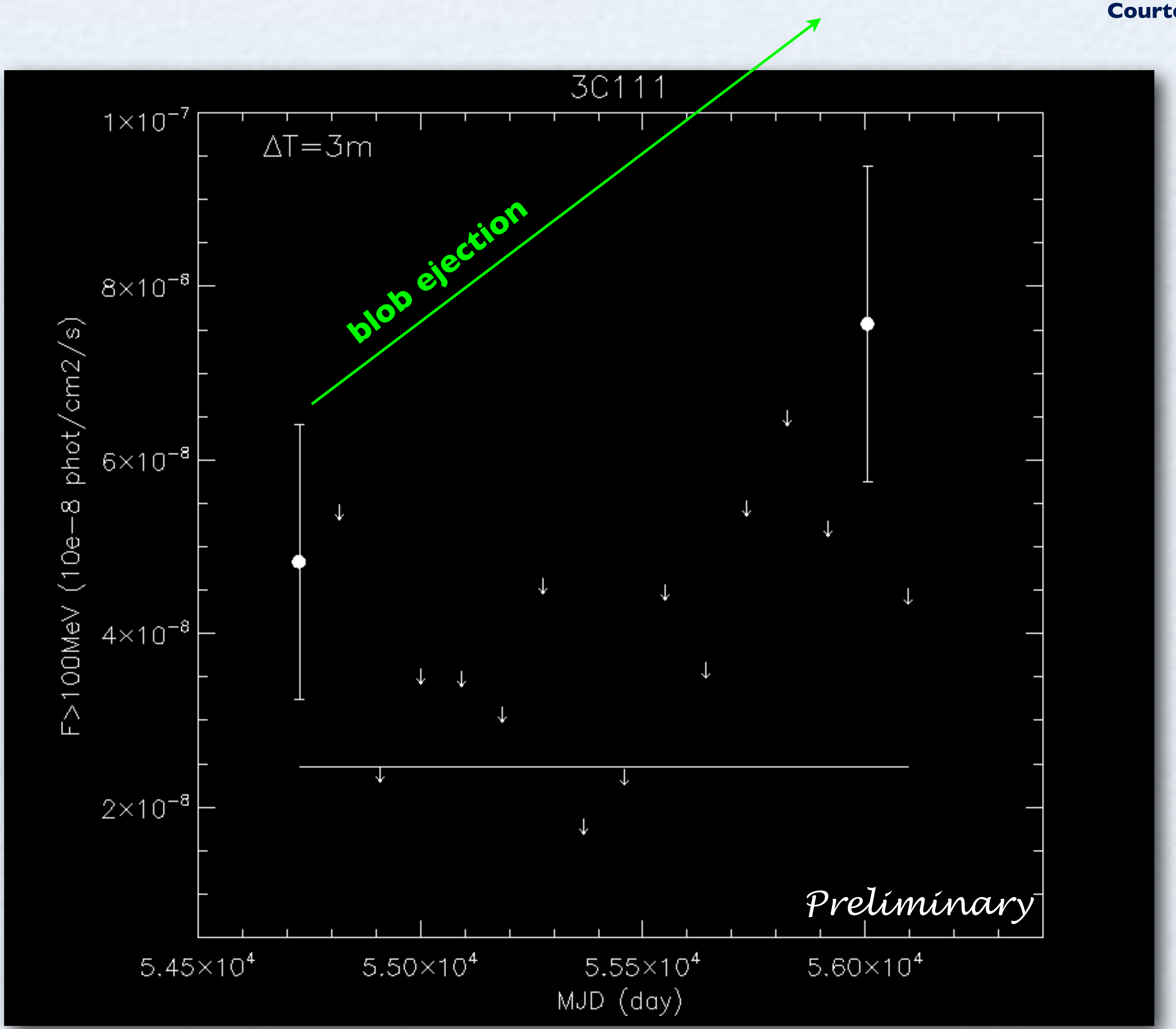


Intense but short flares

FRII : 3C 111

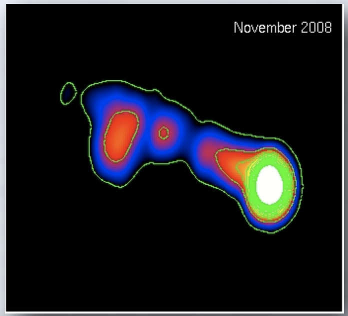
Grandi, Torresi & Stanghellini 2012.

VLBA 43 GHz
Courtesy of BU blazar group



Intense but short flares ?

FRII : 3C 111



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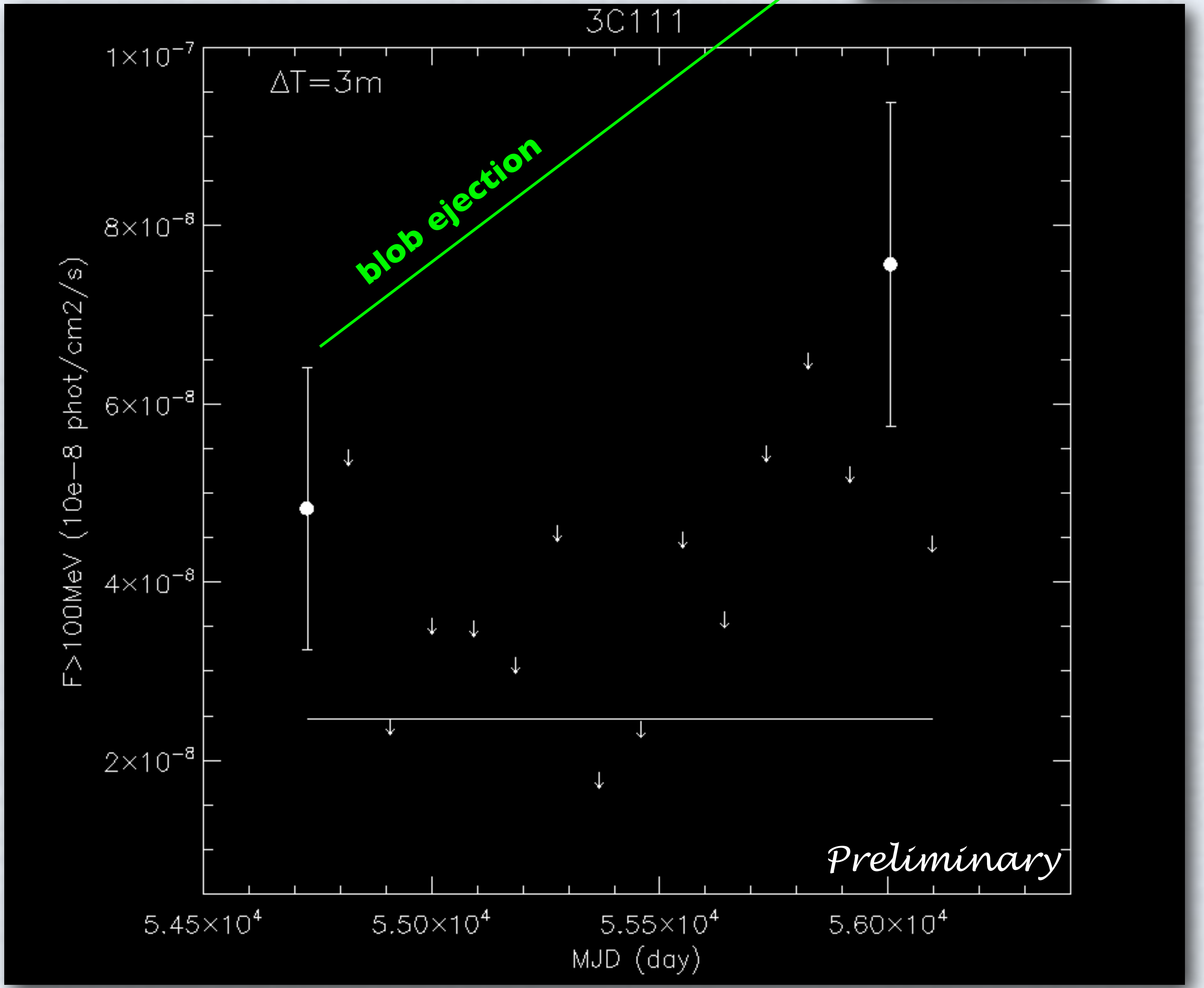
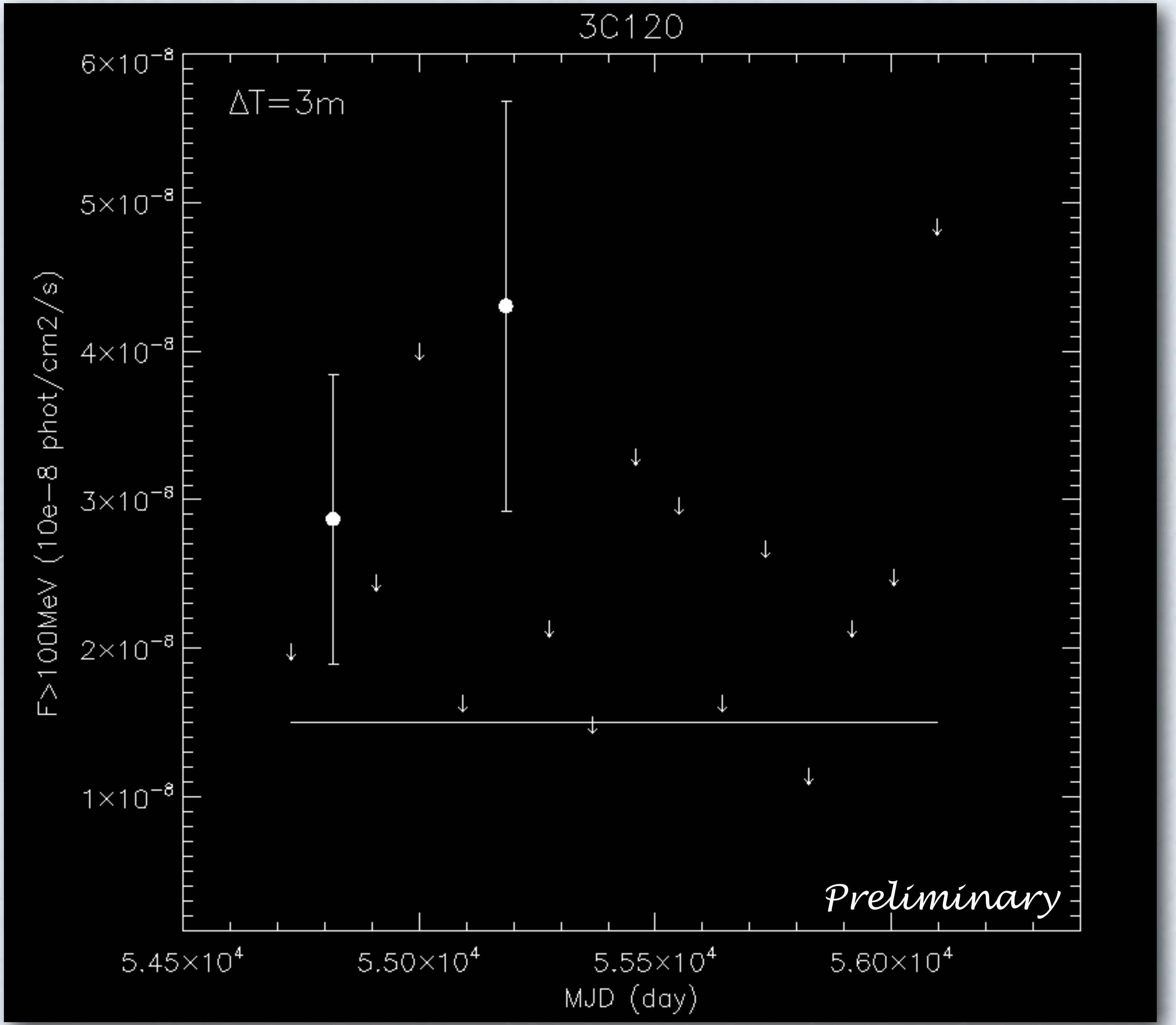
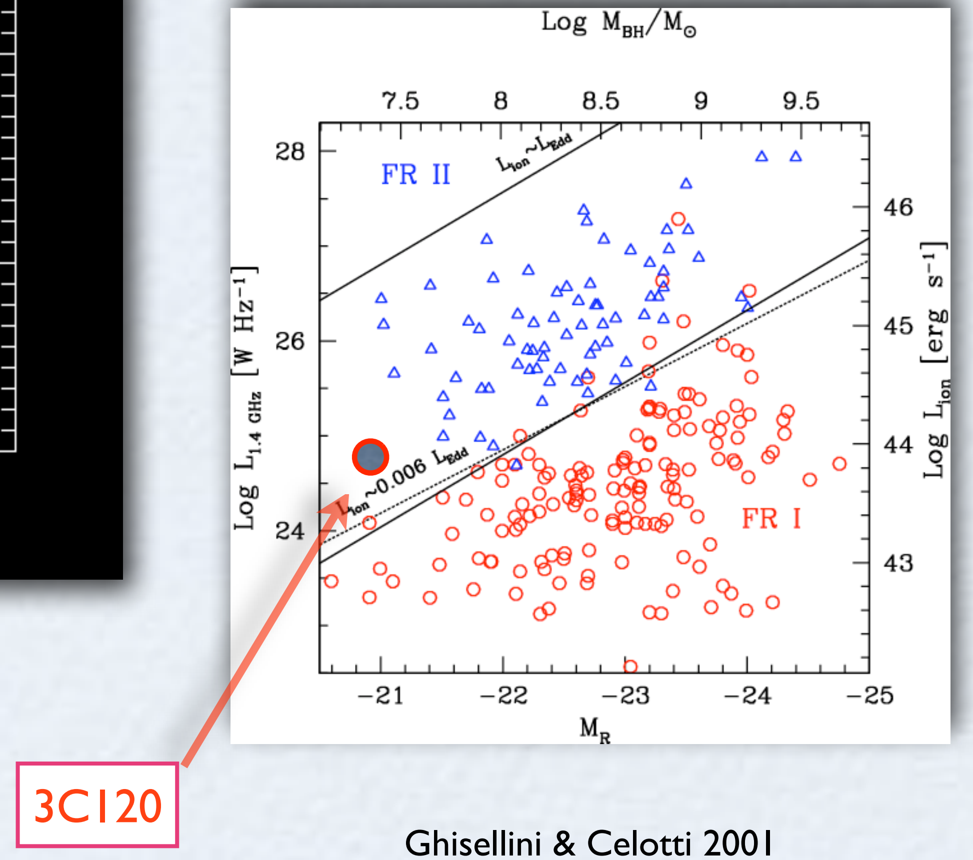


Intense but short flares ?

FRI with efficient accretion disk: 3C 120

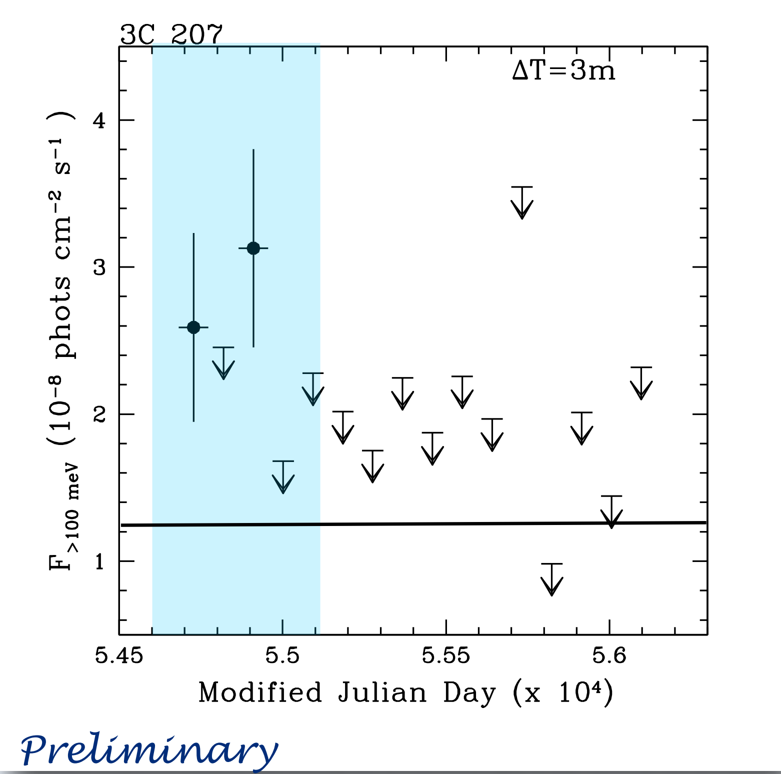


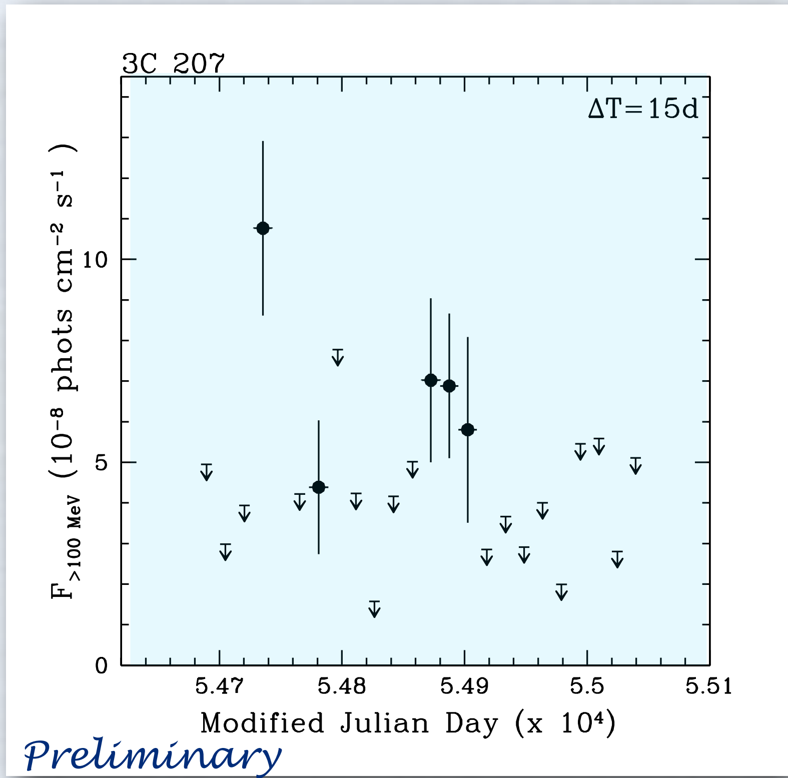
Temporal behavior similar to 3C 111?



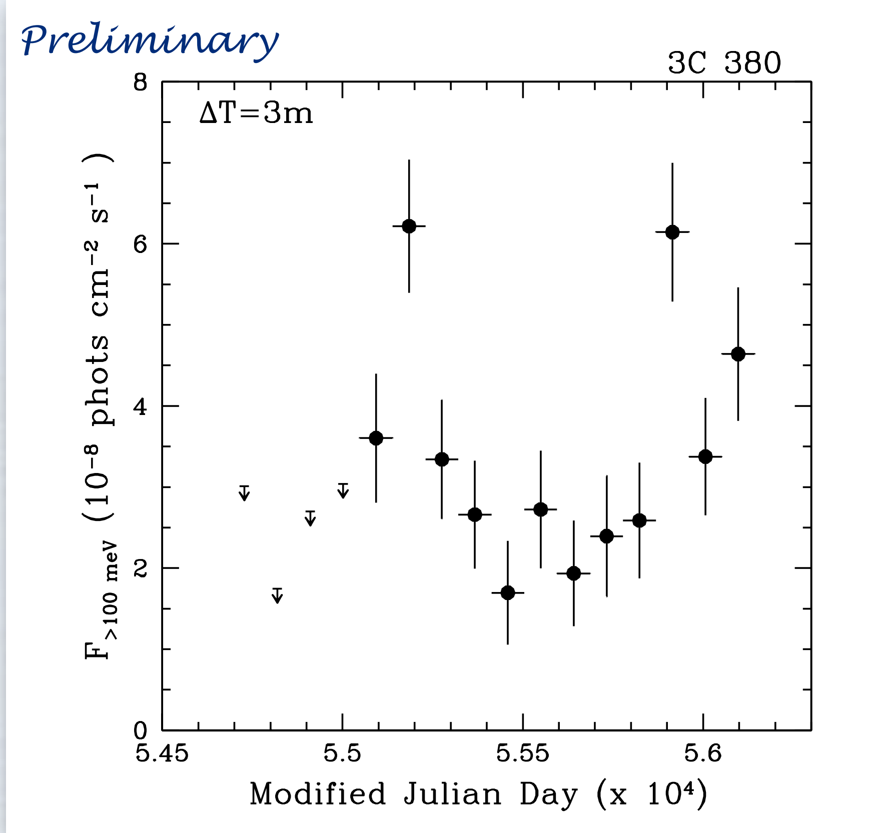
Ghisellini & Celotti 2001

FRII: 3C 207





FRII: 3C 380



Intense and rapid flares

In summary:

- FRIs are on average detected (TS>10) for 80% of time (in 48 months considering a bin time of 3 months);

- flux variations are not prominent in sources with inefficient accretion disk (FRIs). However FRIs can remain in a flare state for several months.

- FRIIs are on average detected for only 30% of time (in 48 months considering a bin time of 3 months);

- in MAGN with powerful accretion disk, e.g. FRIIs, the flares are short and intense (more boosted? spine dominated?).

Where are γ-rays are produced ?

Multiwavelength observations are necessary to **localize where the gamma-ray photons are produced** (while gamma-ray variability studies alone can provide information on the size of this emitting region).

The case of 3C 111

Gamma-ray flare simultaneous to mm-optical-X-ray outbursts

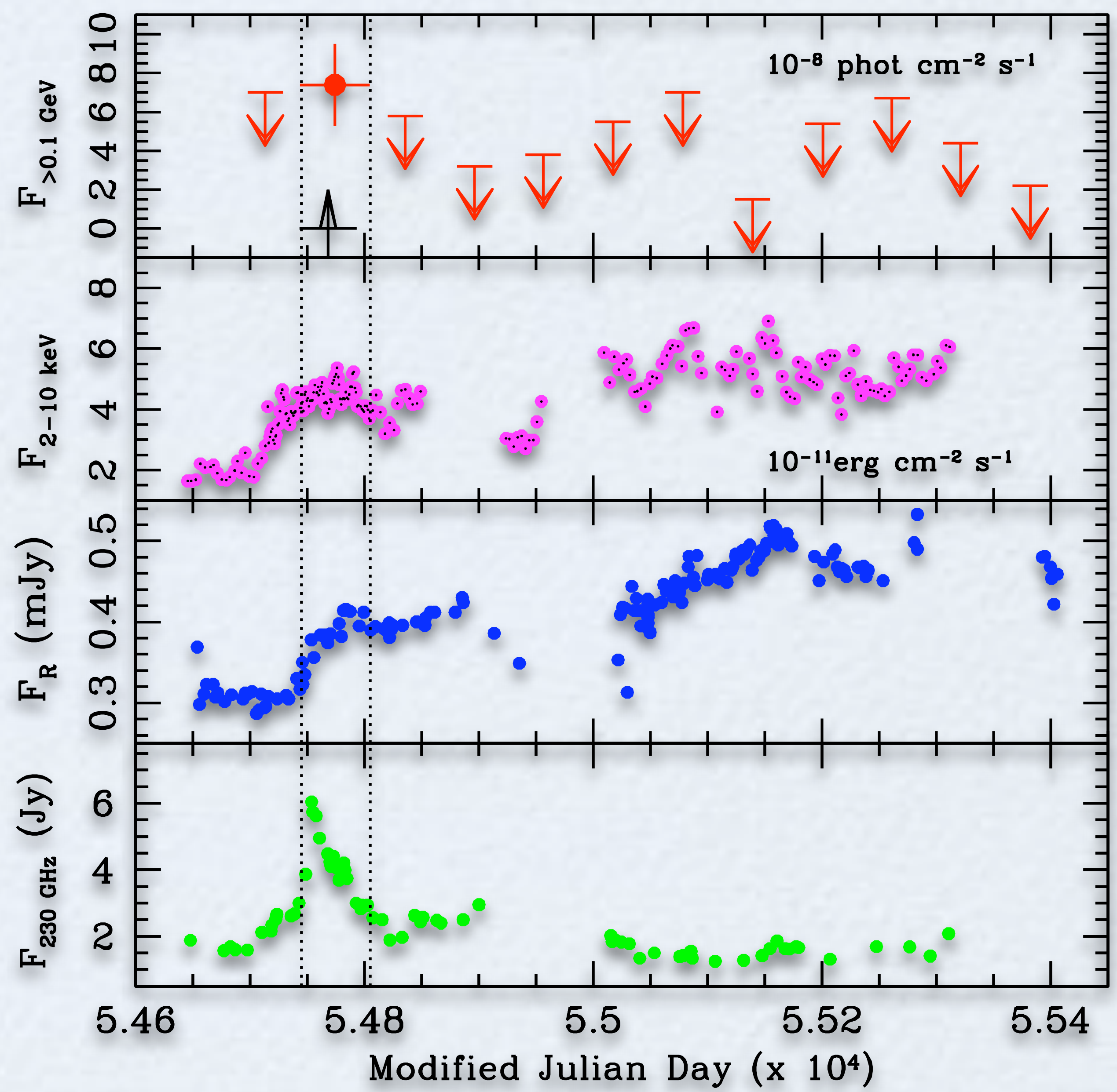
Co-spatiality of the event

Radio knot ejection

The gamma-ray source must be **in the radio core region**: R_{core} < 0.3 pc

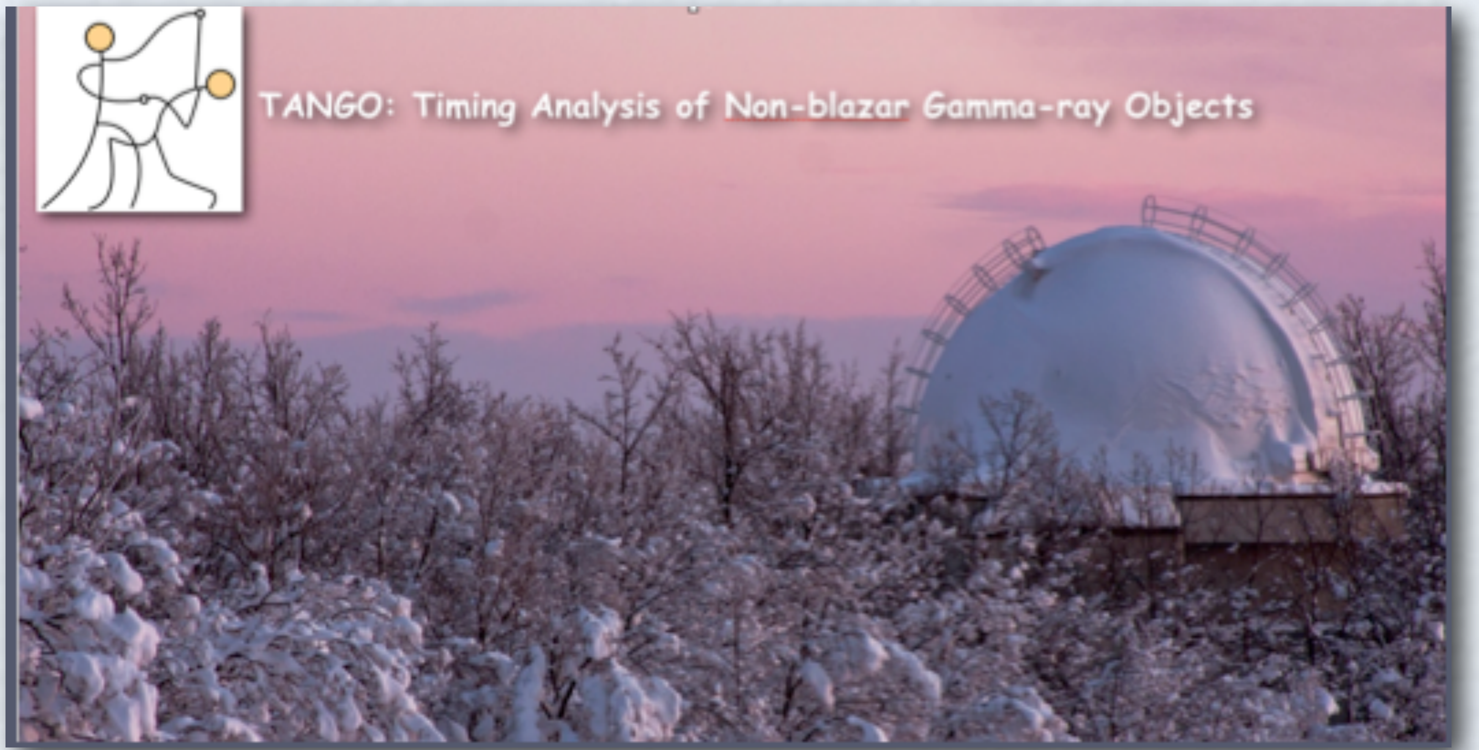
24-month light curve

bin=2 months



Grandi, Torresi & Stanghellini 2012.

TANGO: Timing Analysis of Non-blazar Gamma-ray Objects



Confluence page: https://confluence.slac.stanford.edu/display/SCIGRPS/TANGO++Timining+Analysis+of+Non+blazar+Gamma+ray+Objects+%28MAGN%29

Web page: https://hangar.iasfbo.inaf.it/tango/index.html

Observing period from February 2012 to 2022 (?)

TANGO: Timing Analysis of Non-blazar Gamma-ray Objects

see Torresi’s poster

Confluence page: https://confluence.slac.stanford.edu/display/SCIGRPS/TANGO++Timining+Analysis+of+Non+blazar+Gamma+ray+Objects+%28MAGN%29

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Observing period from February 2012 to 2022 (?)

SOURCE	Type	z	gamma	$< F_{>100\ MeV} >$ ph cm^{-2} s^{-1} 12m	$< F_{>100\ MeV} >$ ph cm^{-2} s^{-1} 3m	% detection T =3m	P_{chi2} 3m 12m		Gamma-ray size	Variability DeltaT=3m	M
3C78	FRI	0.0286	1.9	4.7E-09(f) 0.3E0-9	0.88e-8[#] 0.01e-8	6%		-	0.07pc(delta) 730 Rs (delta)	3m	9.5x 10^8
M87	FRI	0.004	2.2	2.1e-8 0.4e-8	2.2E-08 0.2E-08	88%	0.47 0.26	0.03c		slow	12m
3C111	FRII	0.049	2.6	2.4(0.3)e-8	2.47E-08[n] 0.41e-8	12%		5.86c		fast	2m
3C120	FRI	0.033	2.45	1.3e-8 0.15e-8	1.5E-08[#] 0.2e-8	12%		5.34c		fast	3m
PKS0625-354	FRI	0.055	1.79	0.84e-8 0.38e-8	1.2(0.3)E-08 1.14 (0.09)E-8[#]	69%	0.17			slow	6m
3C207	FRII	0.681	2.4	1.41(0.13)e-8	1.23(0.17)e-8[#]	13%		12.92c		fast	15d
PKS0943-76	FRII		2.4			19%					
NGC1275	FRI	0.018	2.05 (0.04)	2.3(0.5)e-7	2.4(0.7)e-7	100%		0.31c		slow/fast	10d
IC310			2.0			13%		-			
CENA	FRI	0.0009	2.6-2.8	1.69(0.09)e-7	1.68(0.2)e-7	100%	0.68			slow	6m
NGC6251	FRI	0.024	2.0-2.4	1.9(0.49)e-8	2.0E-08 0.2E-08	94%	0.998	-		slow	3m
3C380	FRII	0.692	2.5	2.7(1.8)e-8	3.10(0.35)e-8	75%	0.999976	13.65c		slow	3m
FornaxA	FRI				1.10E-08	6%				-	-
CenB											

SINCE A CENSORED POINT WAS CHANGED TO A DETECTION, nTHE MEAN ESTIMATE IS BIASED.