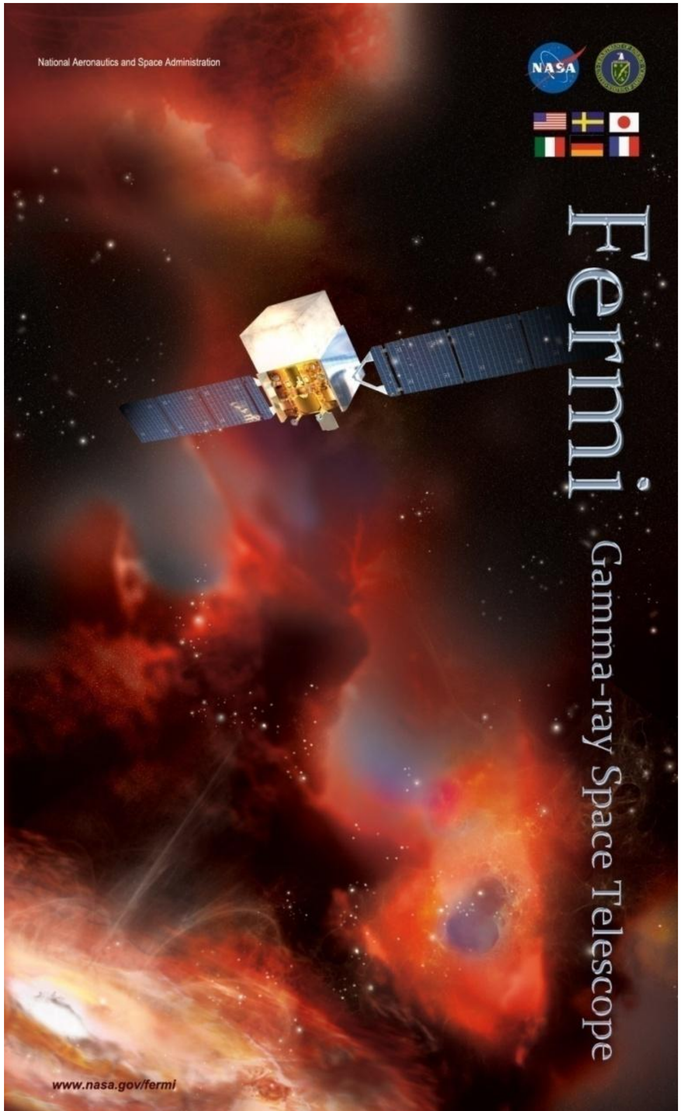
Fermi Gamma-ray Space Telescope

INAF Istituto di Radioastronomia

ALMA MATER STUDIORUM UNIVERSITÀ DI BOLOGNA



The Fermi LAT view of young radio sources

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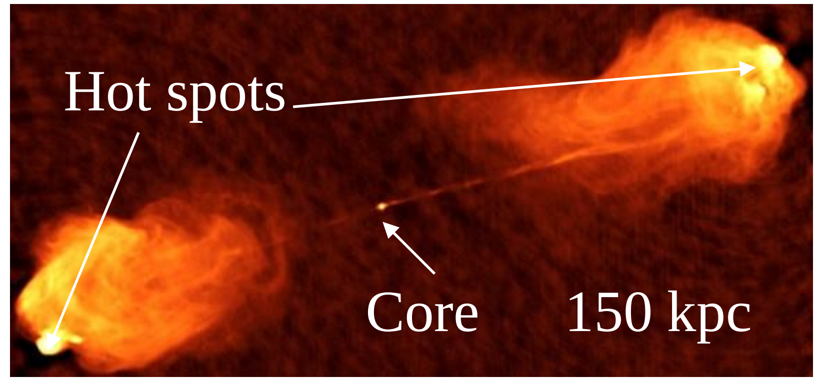
on behalf of the Fermi LAT Collaboration

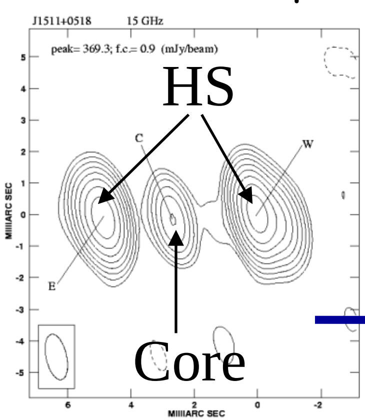
Young Radio Sources

Scaled-down version of the classical Extended Doubles: they should represent the young stage in radio source evolution



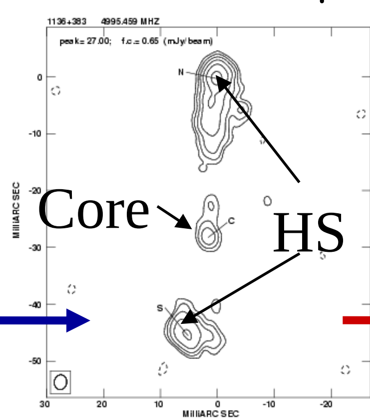
10^{6-7} yr

7 pc

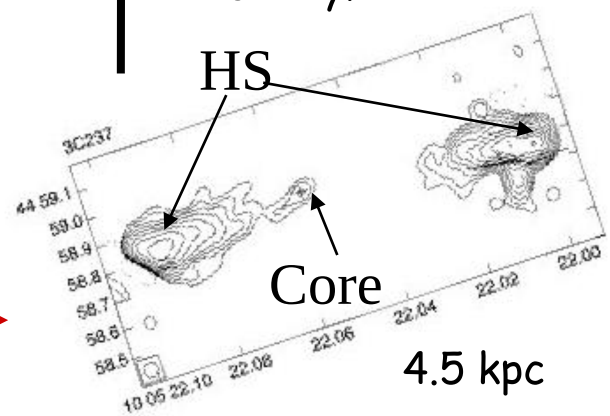


10^{2-3} yr

350 pc



10^{3-4} yr



4.5 kpc

10^{4-5} yr

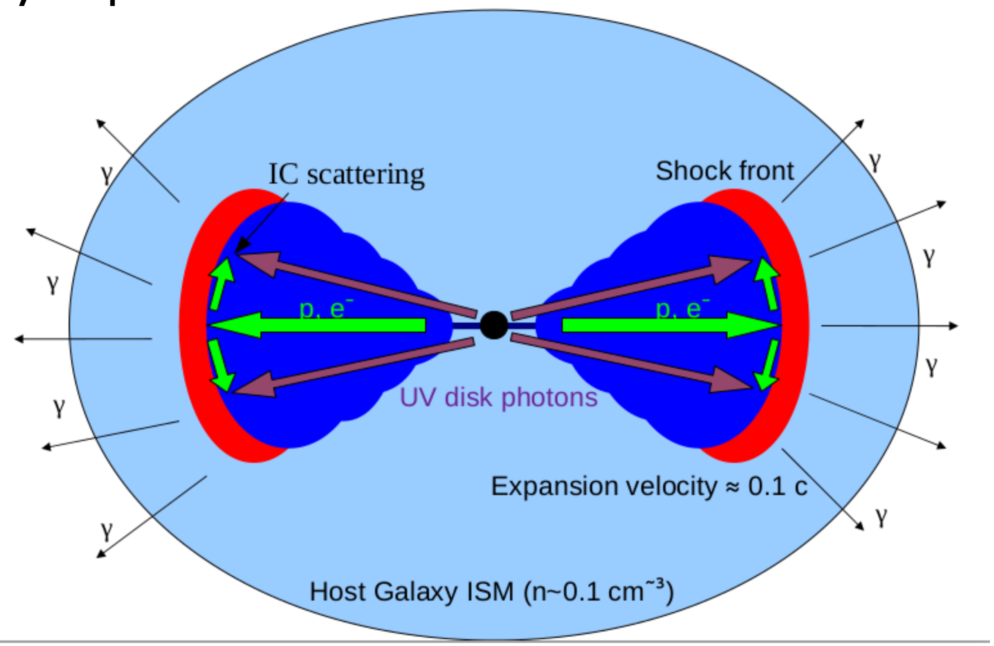
γ-ray emission: galaxy

Mainly due to Inverse Compton of the UV photons from the disk upscattered by the lobes' electrons (Stawarz+08)

$$\frac{\epsilon L_\epsilon}{10^{42}\mathrm{erg/s}} \sim 2\frac{\eta_e}{\eta_B}\left(\frac{L_{\rm jet}}{10^{45}\mathrm{erg/s}}\right)^{0.5}\left(\frac{LS}{100\mathrm{pc}}\right)^{-1}\frac{L_{UV}}{10^{46}\mathrm{erg/s}}\left(\frac{\epsilon}{1\mathrm{Gev}}\right)^{-0.25}$$

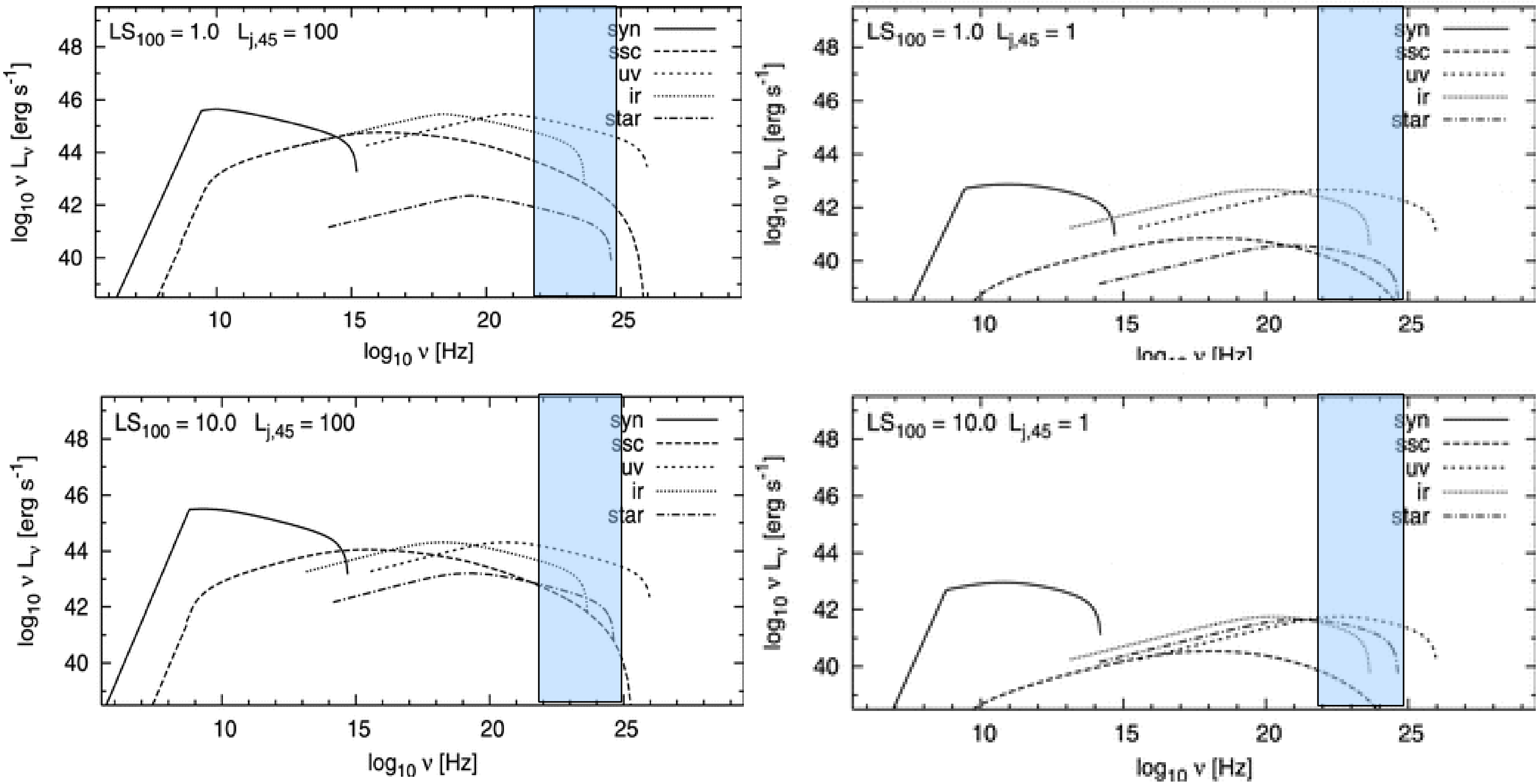
The high-energy luminosity strictly depends on:

- source linear size
- jet power
- UV photons
- energy range
- equipartition condition



Model expectations for γ-ray emission

Stawarz+08



γ-ray emission: quasar

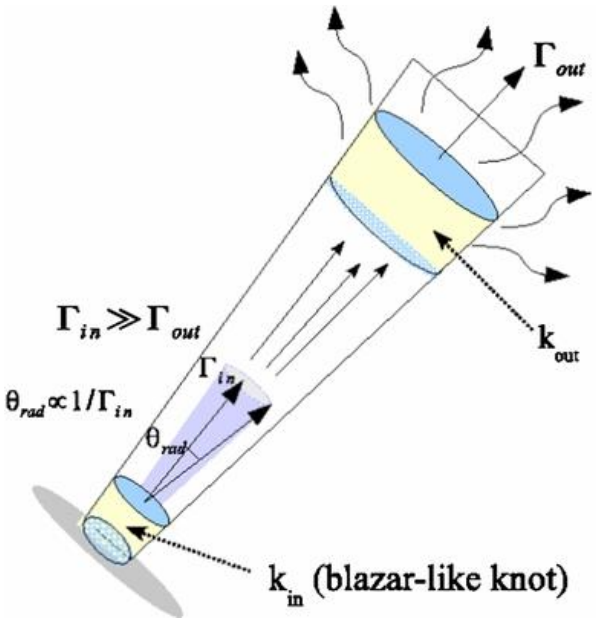
A structured jet with a gradient velocity: a jet with two emitting regions which are radiatively interacting (Migliori+12)

1) a fast blazar-like knot close to the center

2) a mildly relativistic knot outward

1) The central knot radiation is relativistically beamed for $\theta<1/\Gamma$ and illuminates the slower and further knot

2) The outer knot upscatters the synchrotron photons from the inner knot and radiates more isotropically



Centaurus A at the redshift of CSO

IC/CMB by the lobes' electrons

$S\gamma \sim 10^{-7}$ ph cm^{-2} s^{-1}

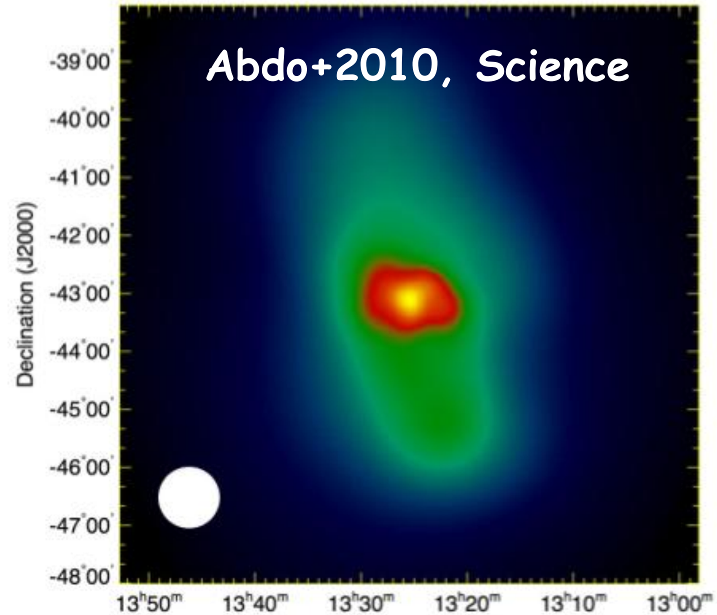
$L\gamma \sim 3\times10^{41}$ erg/s @ 3.7 Mpc

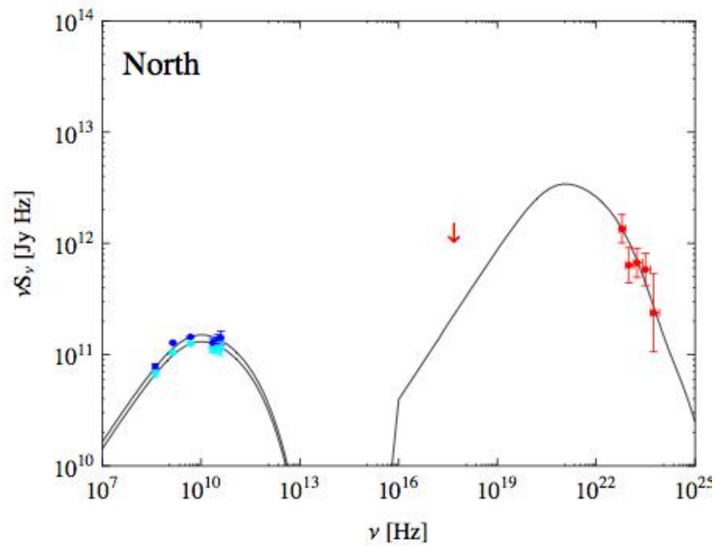
Same Lγ but higher z:

$z = 0.1$, $D_L = 454.8$ Mpc

$S\gamma = 1.2\times10^{-14}$ ph cm^{-2} s^{-1}

Far below the *Fermi*-LAT sensitivity limit!





Core Luminosity – Total Luminosity

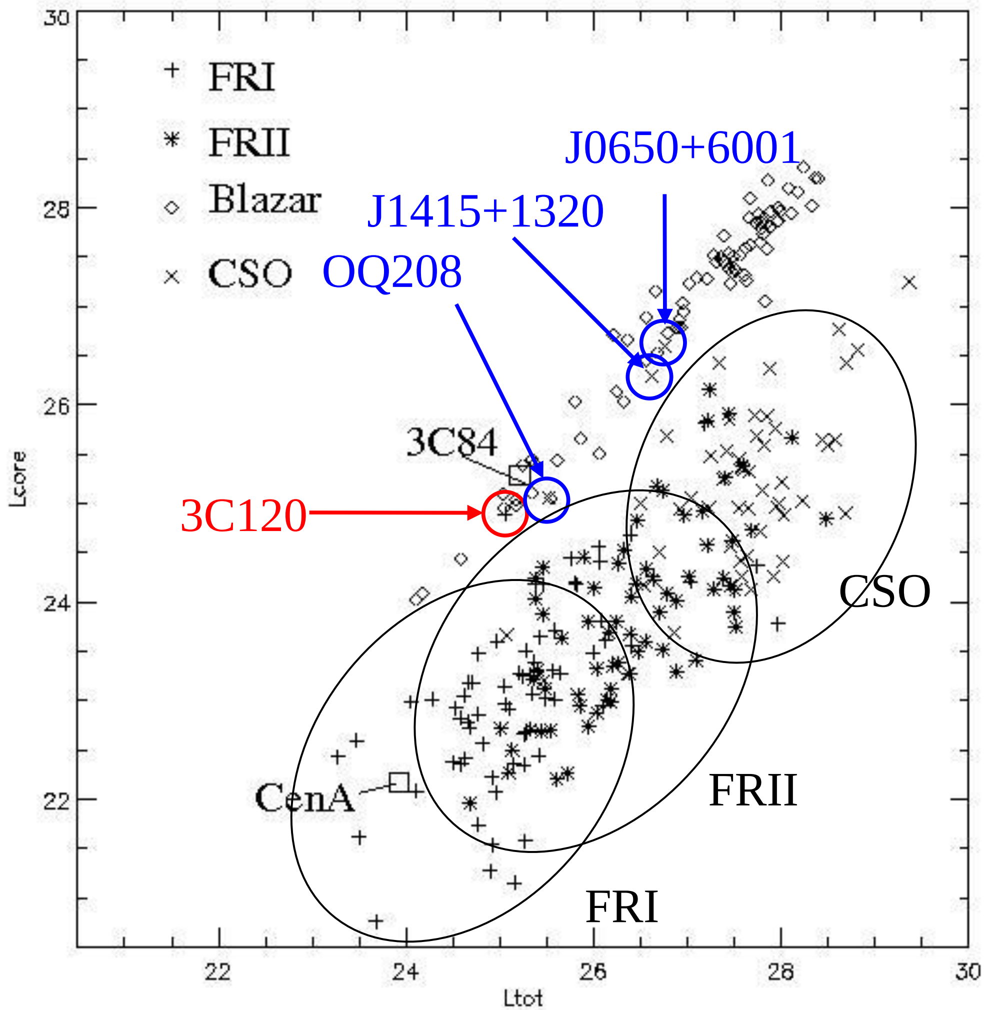
When compared with other radio source populations, CSO represent the high-luminosity tail of the FRII

3 objects are in the blazar region:

- the quasar J1415+1320

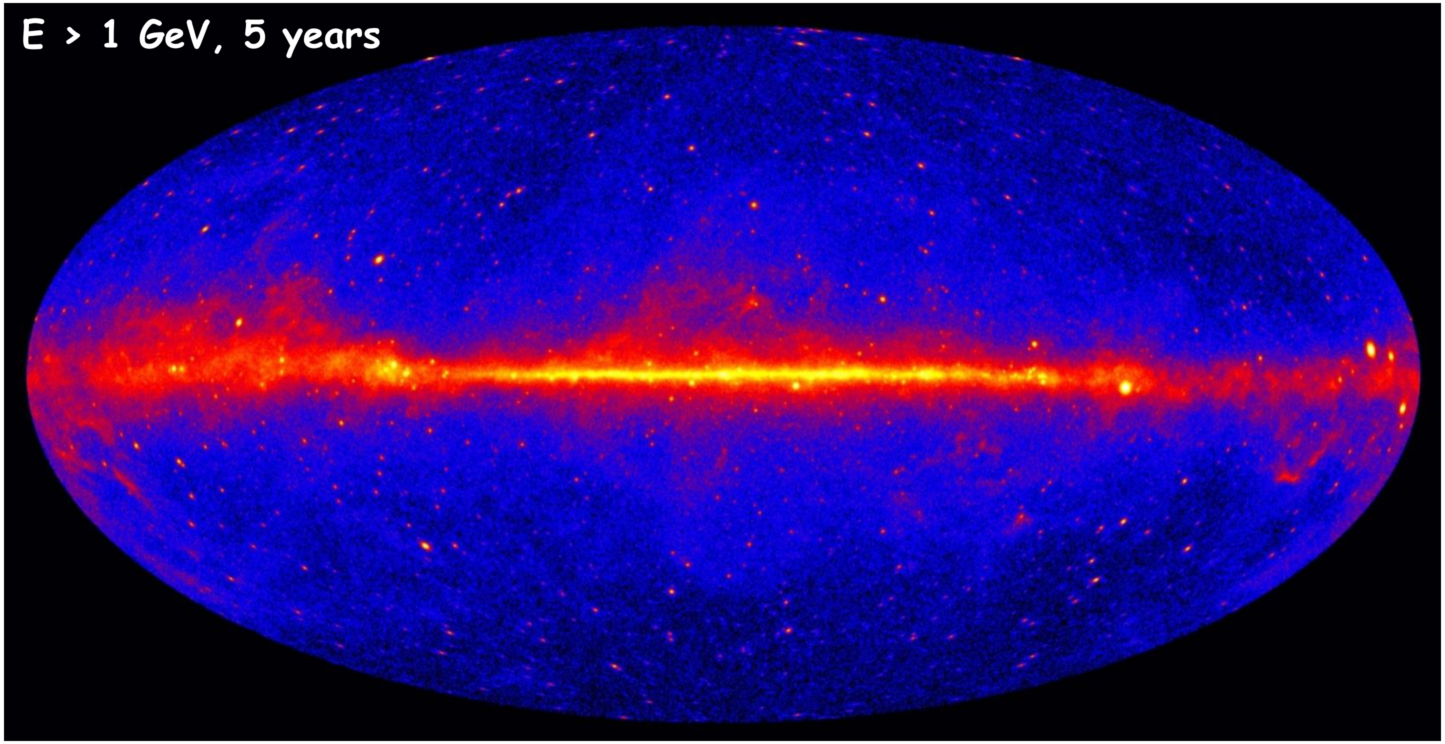
- the galaxy OQ208

- the quasar J0650+6001



Orienti+11

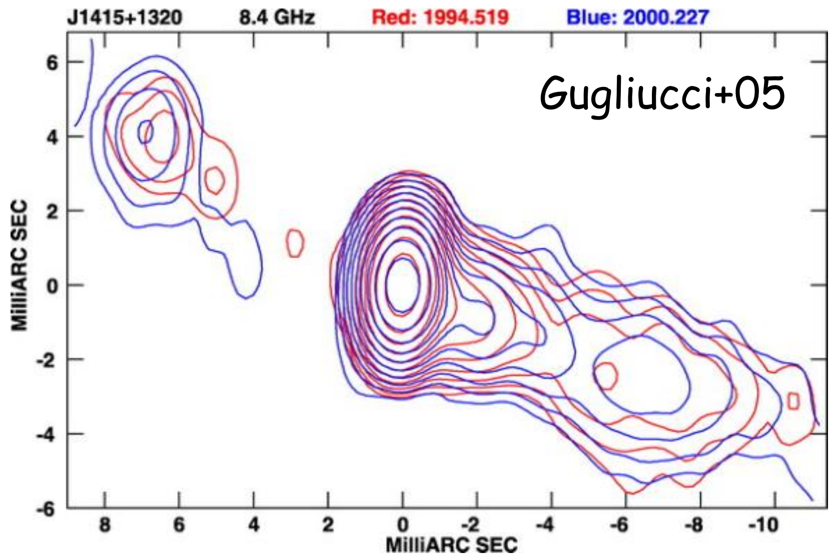
Young radio sources detected in γ-rays?



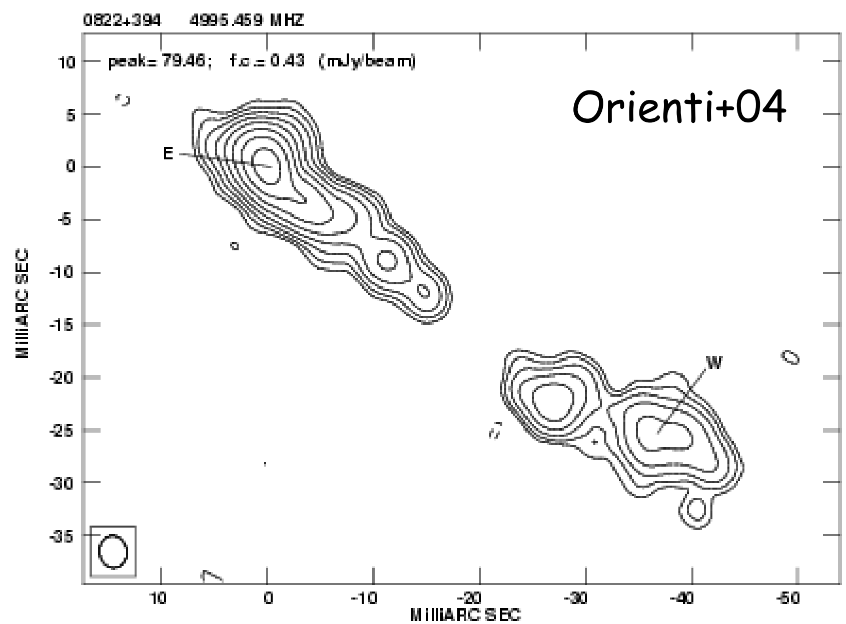
Credits: NASA/DOE/Fermi LAT Collaboration

- 4C 55.71
- J1415+1320
- 4C +39.23B
- PMN J1603-4904

J1415+1320 and 4C +39.23B

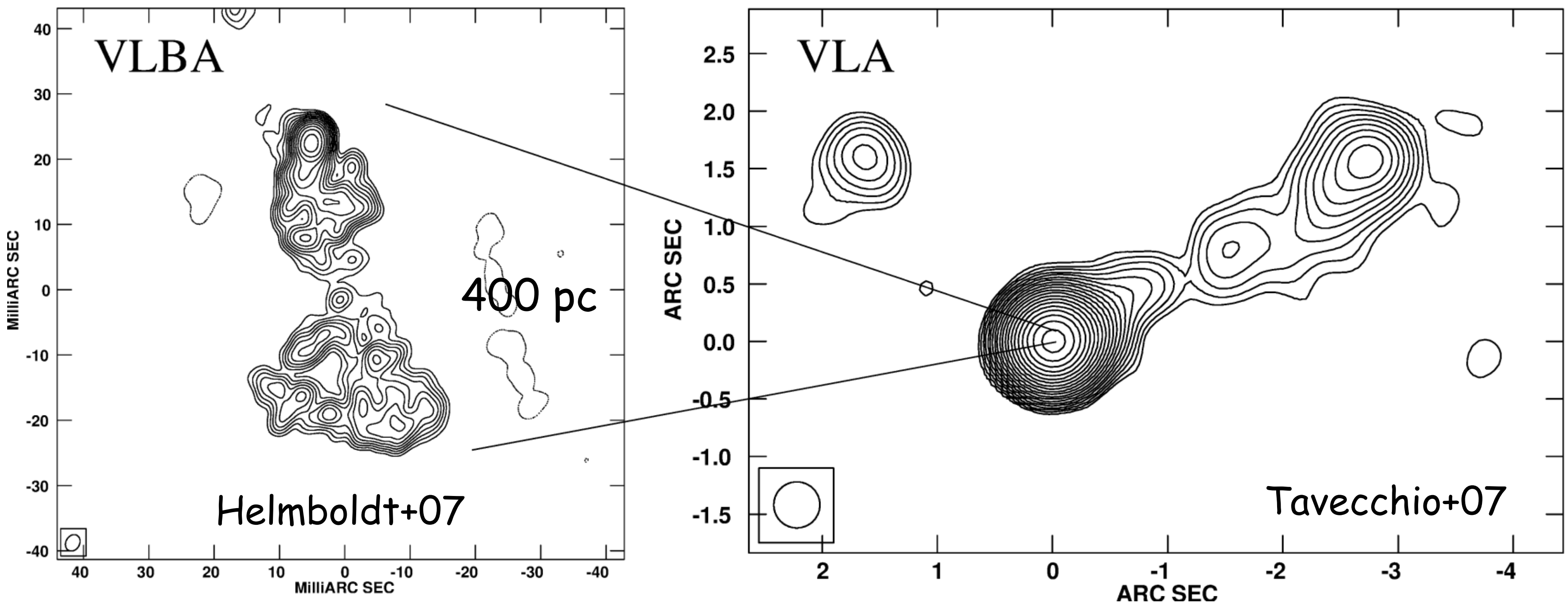


J1415+1320 is a quasar with superluminal jet motion



4C +39.23B is reported in the 3LAC, but with a double association, (the other association being the FSRQ blazar 4C +39.23) so it is not in the Clean Sample

4C +55.71: young radio source or blazar?

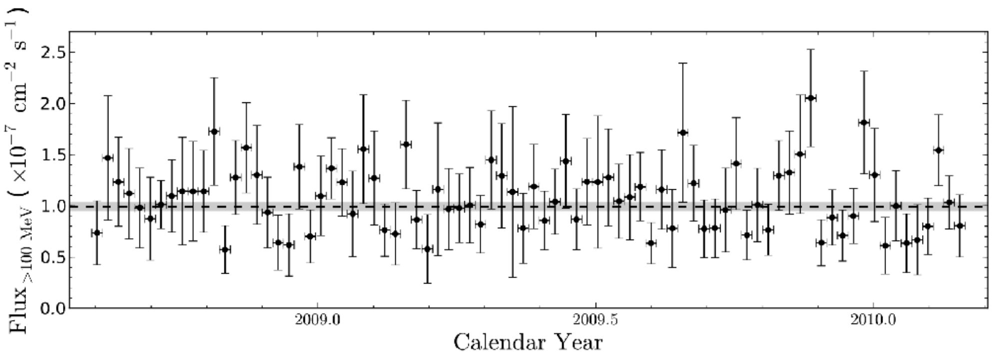


4C+55.17 (z=0.896) first appeared as a γ-ray source during the EGRET era (2EG J0957+5515, 3EG J0952+5501, EGR J0957+5513). Tentative association, due to poor EGRET localization, confirmed by Fermi-LAT

Resolved & extended radio morphology

Exhibits characteristics of both blazar and medium symmetric object (MSO)

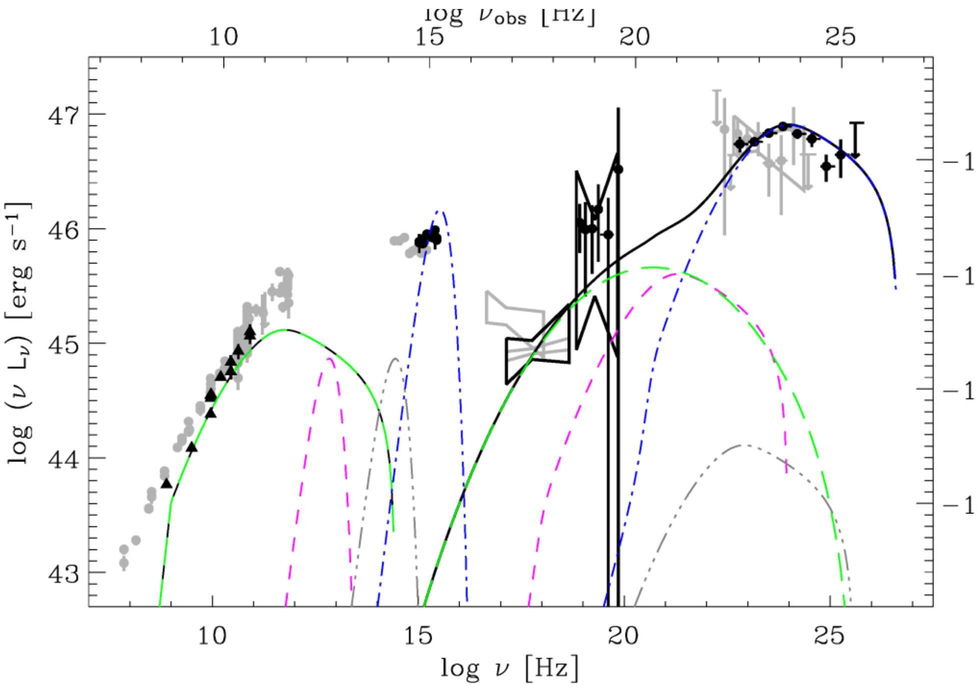
4C +55.71: young radio source or blazar?



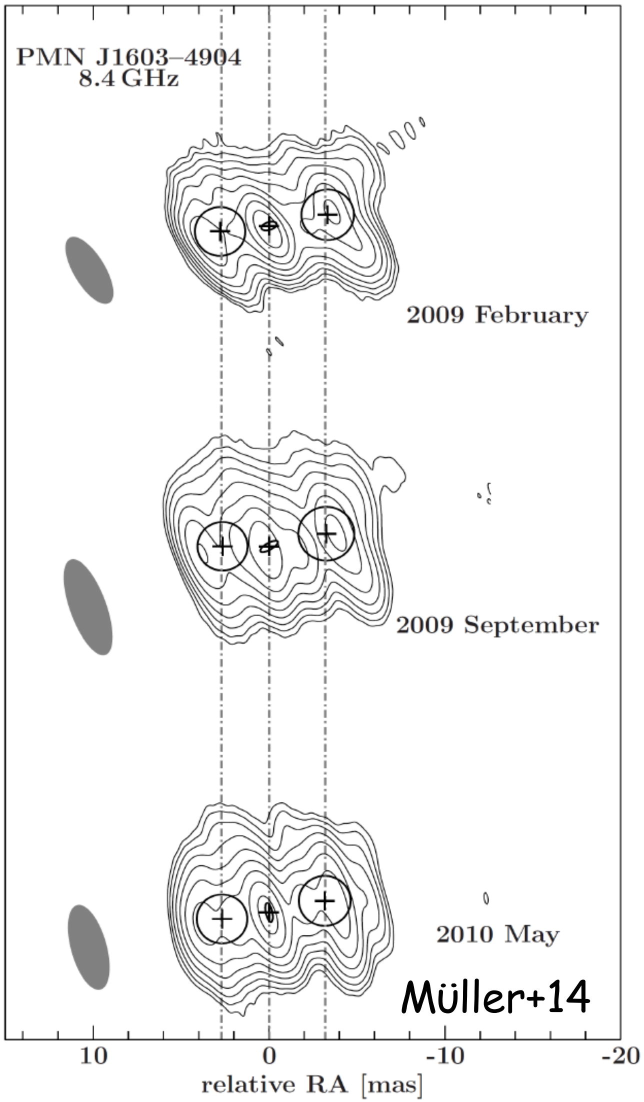
McConville+11

No evidence of γ-ray variability over 19 months of LAT data

- No evidence of flaring activity at any wavelength
- No clear evidence of relativistic beaming
- hard LAT spectrum for a FSRQ
- the SED is modelled by both the blazar and CSS scenario



Radio properties of PMN J1603-4904



No significant apparent motion

Symmetric brightness distribution at 8.4 GHz on milliarcsecond scales

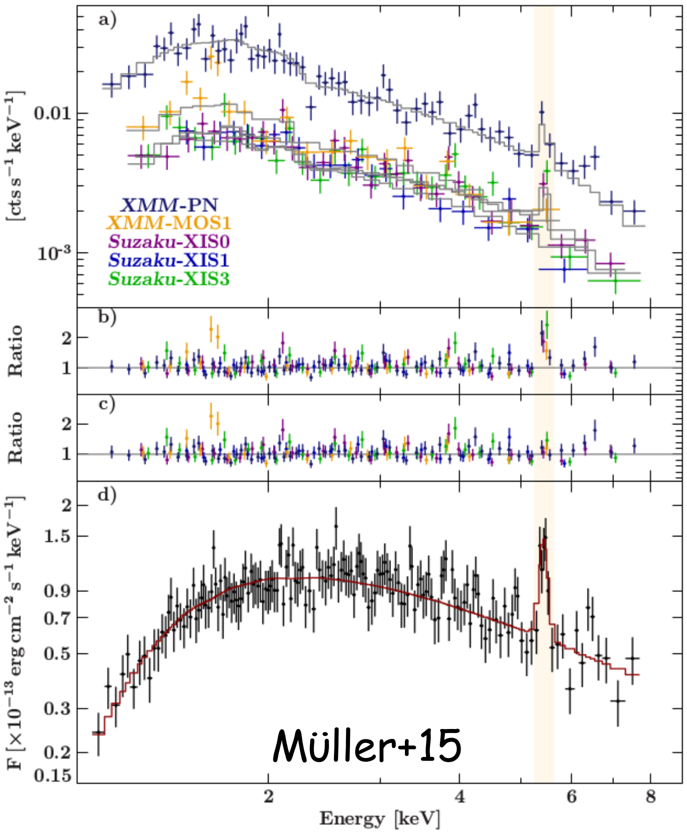
The brightest and most compact component is in the center of the emission region

Steep eastern/western components

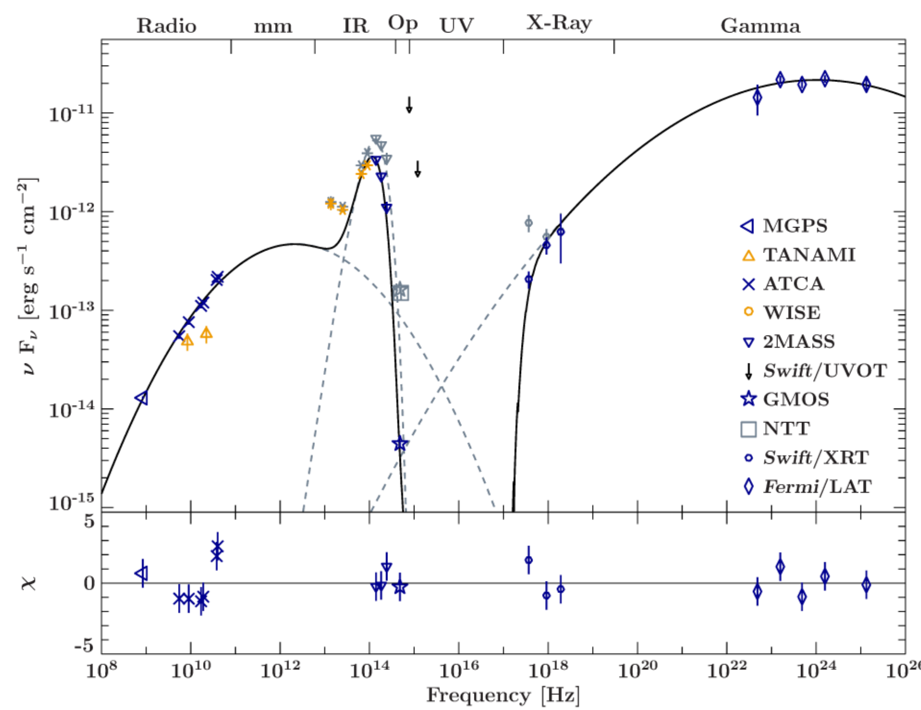
Overall radio spectral index -0.4

Brightness temperature of 3-4x10^8 K

MWL observations of PMN J1603-4904



The detection of a redshifted Iron line suggests that the source is observed at a larger viewing angle than expected for blazars



The source is bright and variable in γ-rays. The SED shows a high Compton dominance and a peculiar IR excess with T = 1600 K

Searching for young radio sources in γ-rays

The sample: 60 bona fide objects selected by Orienti & Dallacasa (2014)

- associated with galaxies or SSRQ to avoid boosting
- known redshift
- core detection

The analysis: we analyzed 6 years of LAT data (Pass7REP) in the 0.1-10 GeV energy range

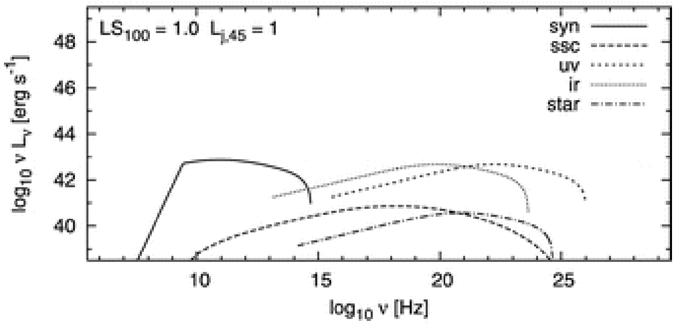
Preliminary results: no significant (TS > 25) detection over 6 years for the sources analyzed so far, with a 2σ upper limit ranging between (0.7 -9.4)e-9 ph cm^{-2} s^{-1}

Next step: repeat the analysis with the LAT Pass 8 data

Young radio sources not detected by LAT

Galaxies: $L_{UV} = L_{IR} = 10^{46}$ erg/s $L_{jet} = 10^{45}$ erg/s

Stawarz+08



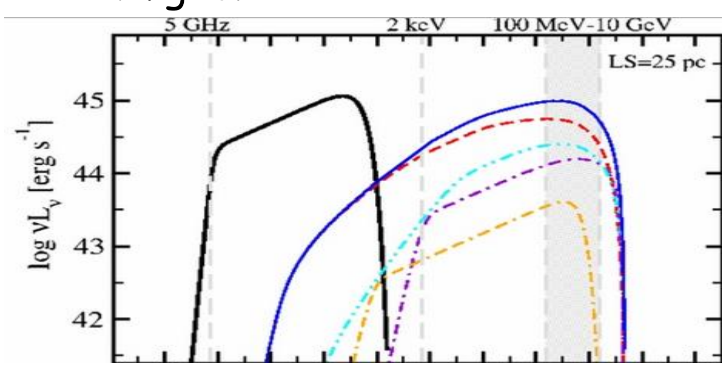
4C 31.04 @ z = 0.06

$S_{exp} = 4\times10^{-13}$ erg/cm^2/s

$S_{UL} < 2.4\times10^{-12}$ erg/cm^2/s

Quasars: $L_{jet} = L_{disk} = 10^{46}$ erg/s $\theta = 30^\circ$, $\Gamma = 2.0$

Migliori+14



J0650+6001 @ z=0.455

$S_{exp} \sim 10^{-11}$ erg/cm^2/s

$S_{UL} < 1.8\times10^{-12}$ erg/cm^2/s

Summary and Open Questions

- Two possible young radio sources detected by *Fermi*-LAT up to now (but their nature is not completely confirmed)

- The number of CSO detected in γ-rays is significantly lower than what was expected from a theoretical perspective

- Jet luminosity/UV photons are overestimated?

- Strong intrinsic γ-γ opacity in CSO?

- Is γ-ray emission in CSO mainly below 100 MeV?

- We plan to study the emission of a complete sample of CSO in the 0.1-10 GeV energy range (and below) thanks to the LAT Pass 8 data

Thanks for your attention!