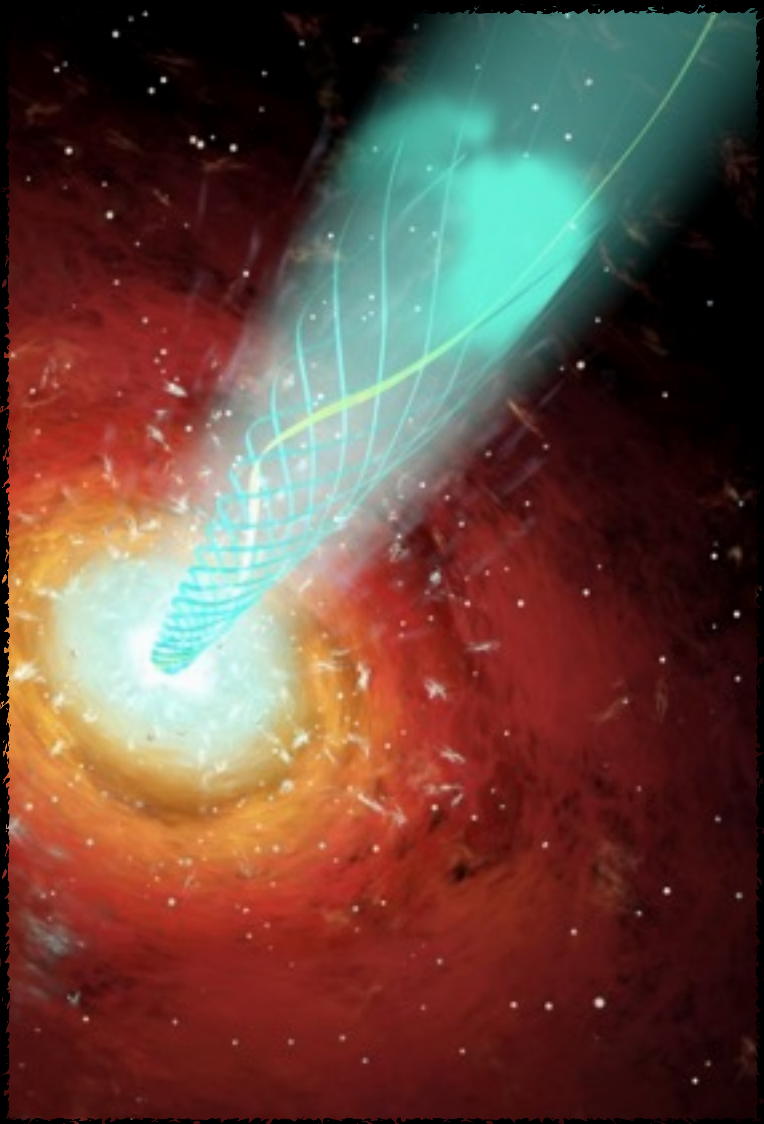

Source: COSMOVISION

Physics of extragalactic plasma elements

through high cadence, multi-frequency linear and circular radio polarization monitoring of blazars

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Collaborators
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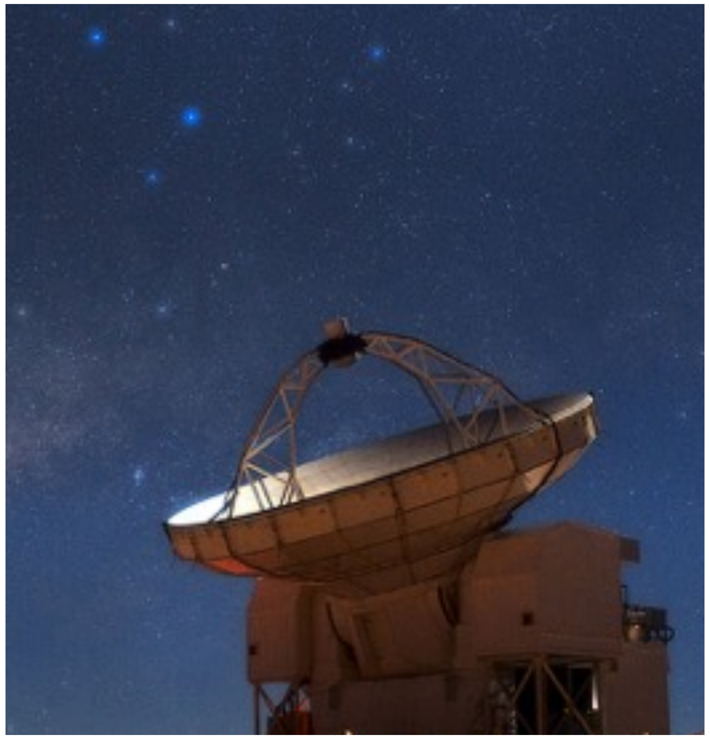
IMPRS astronomy & astrophysics Bonn and Cologne

MAX-PLANCK-GESELLSCHAFT

Max-Planck-Institut für Radioastronomie

the **RadioPol** program:



APEX

30 m IRAM

100 m Effelsberg

part of the **f-gamma** program**:**

- almost 90 mostly *Fermi* sources
- 2.64 - 142 GHz at 10 frequency steps **circularly polarized** feeds
- LP at **2.64, 4.85, 8.35, 10.45** and 14.6
- CP at 2.64, **4.85**, **8.35**, 10.45, 14.6, 23.05
- mean cadence 1.3 months
- uncertainty **0.13** (polarization degree units)

Angelakis et al. 2010, astro-ph.CO/1006.5610
Fuhrmann et al. 2007, 2007, AIP Conf. Series, Vol. 921, 249–251

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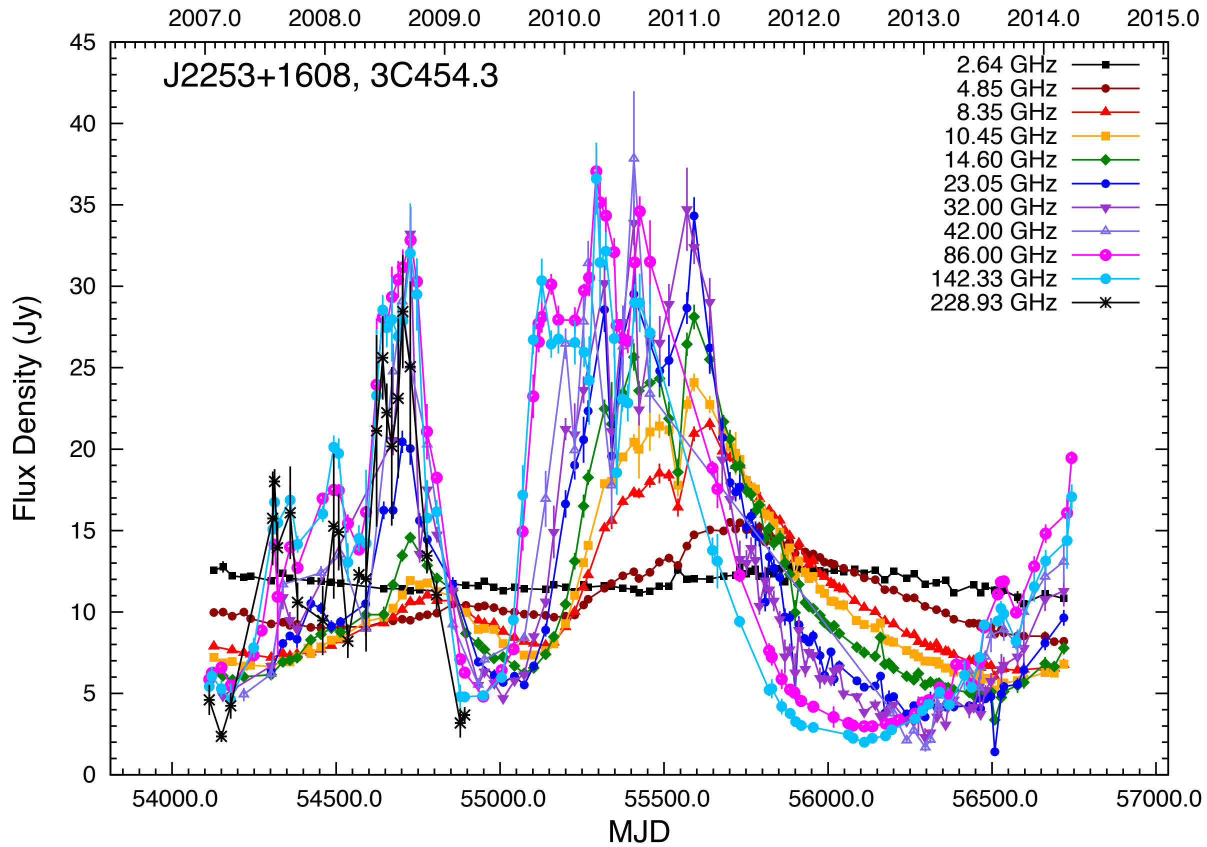

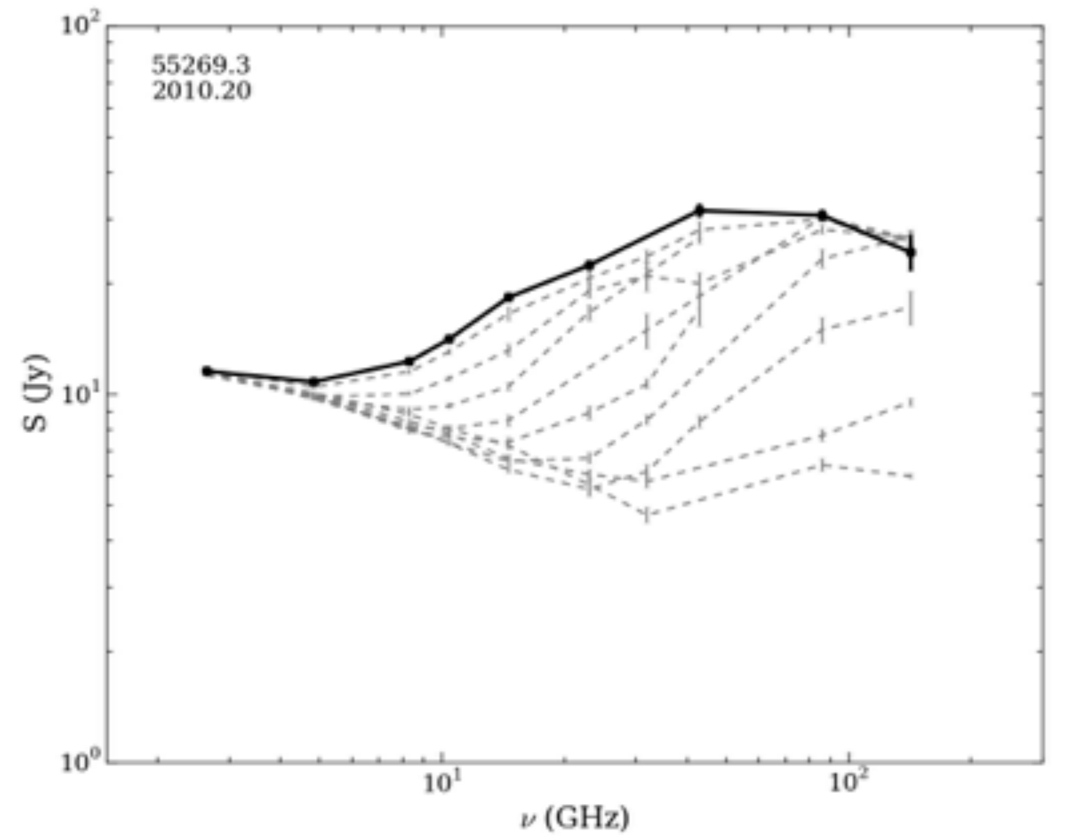

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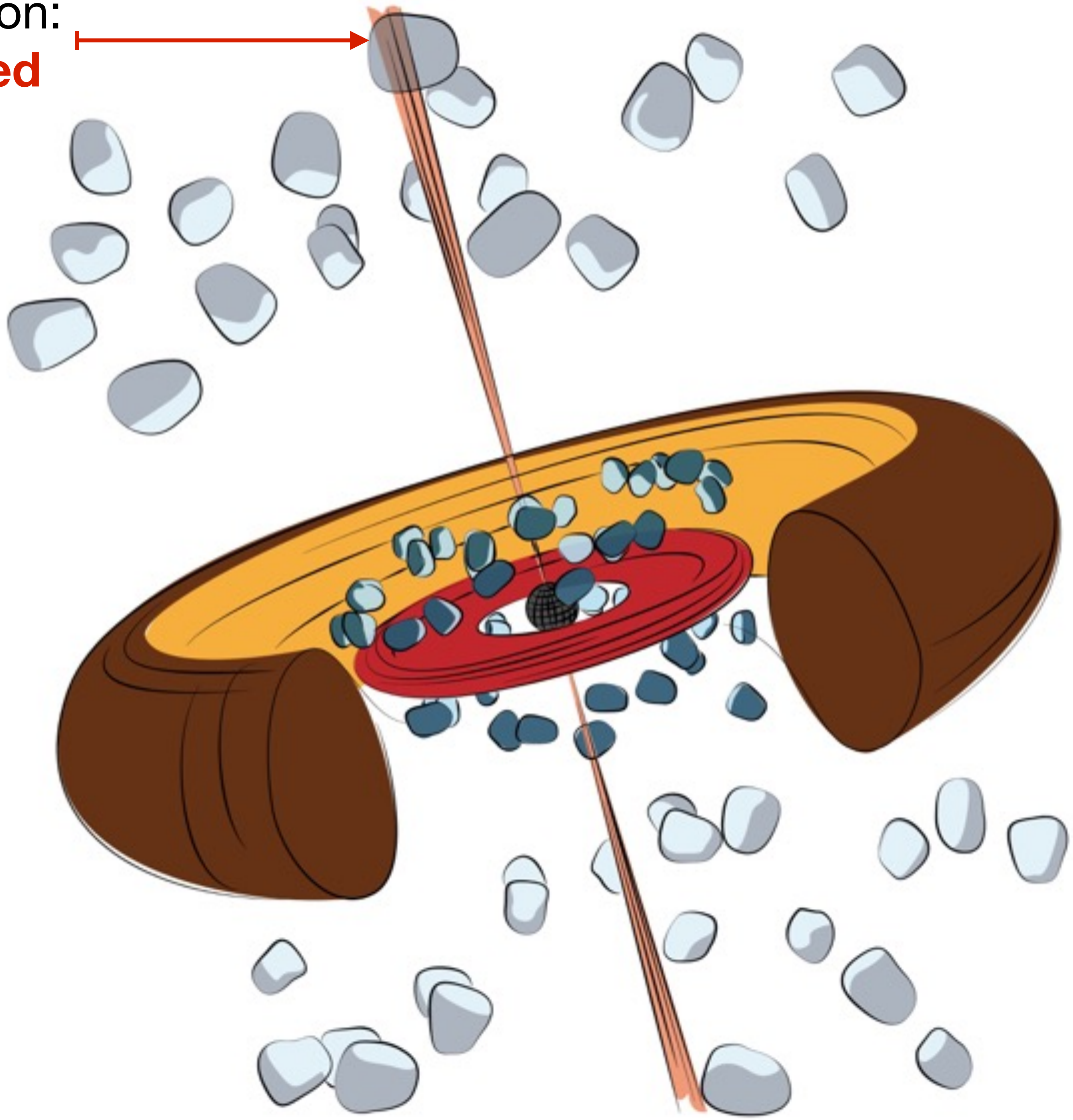
incoherent synchrotron:
intrinsically polarised

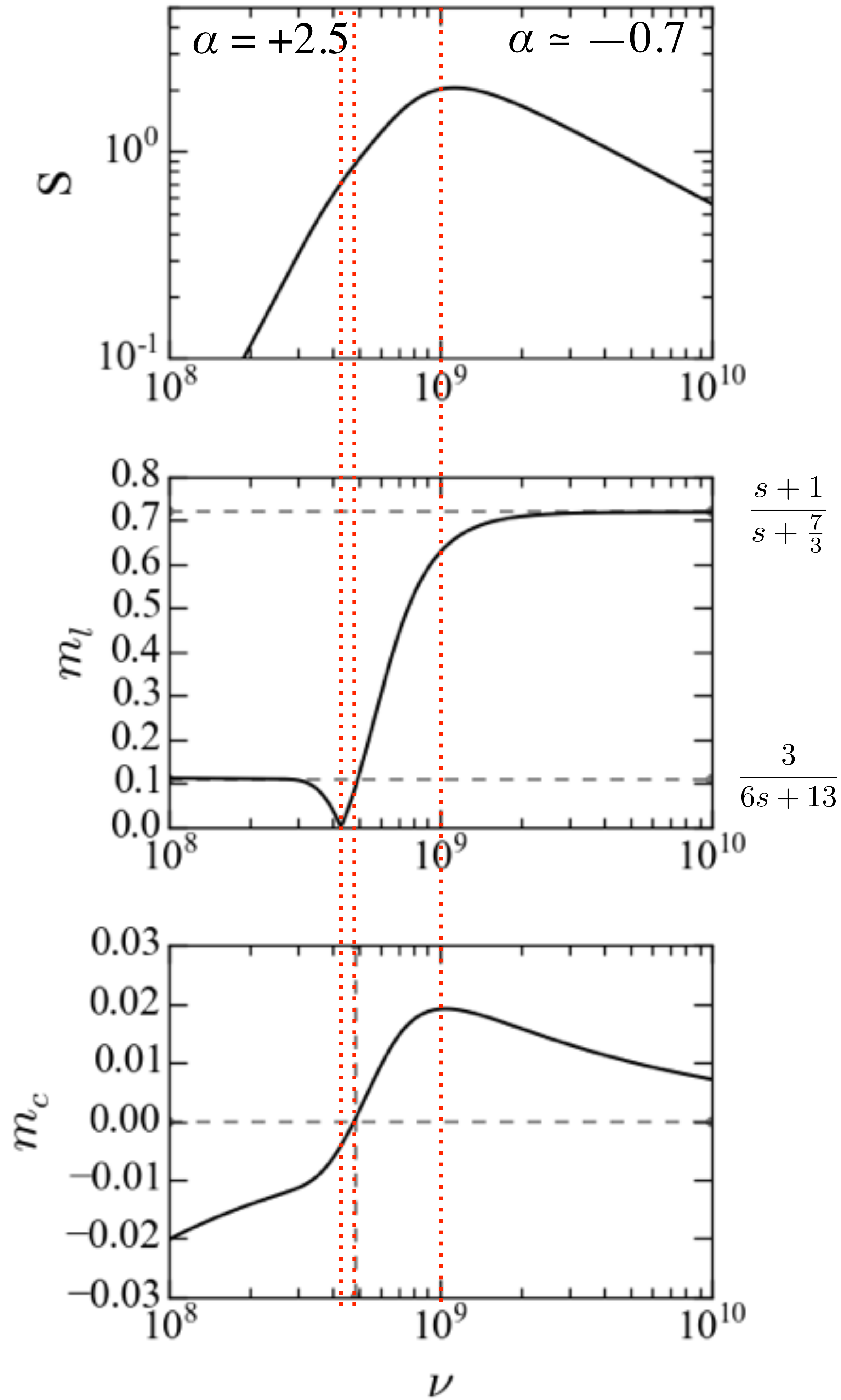


credit: S. Kiehlmann

relativistic magnetized plasma laboratories

Spectrdal index a determines:

- ➡ ν_m
- ➡ $\nu_V = 0.49\ \nu_m$
- ➡ $\nu_Q = 0.44\ \nu_m$
- ➡ $m_l \simeq 72\ \%$
- ➡ $m_c \simeq 11\ \%$



EVPA parallel to projected $\boldsymbol{B}$-field

EVPA perpendicular to projected $\boldsymbol{B}$-field

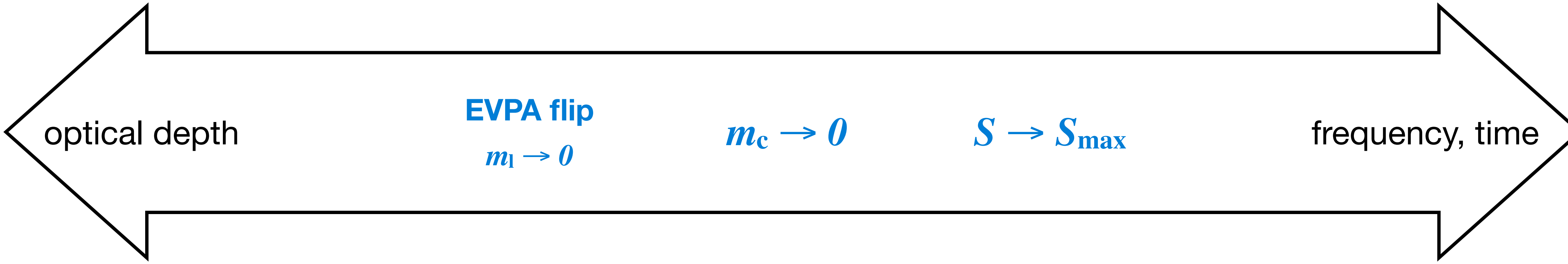
linear component:

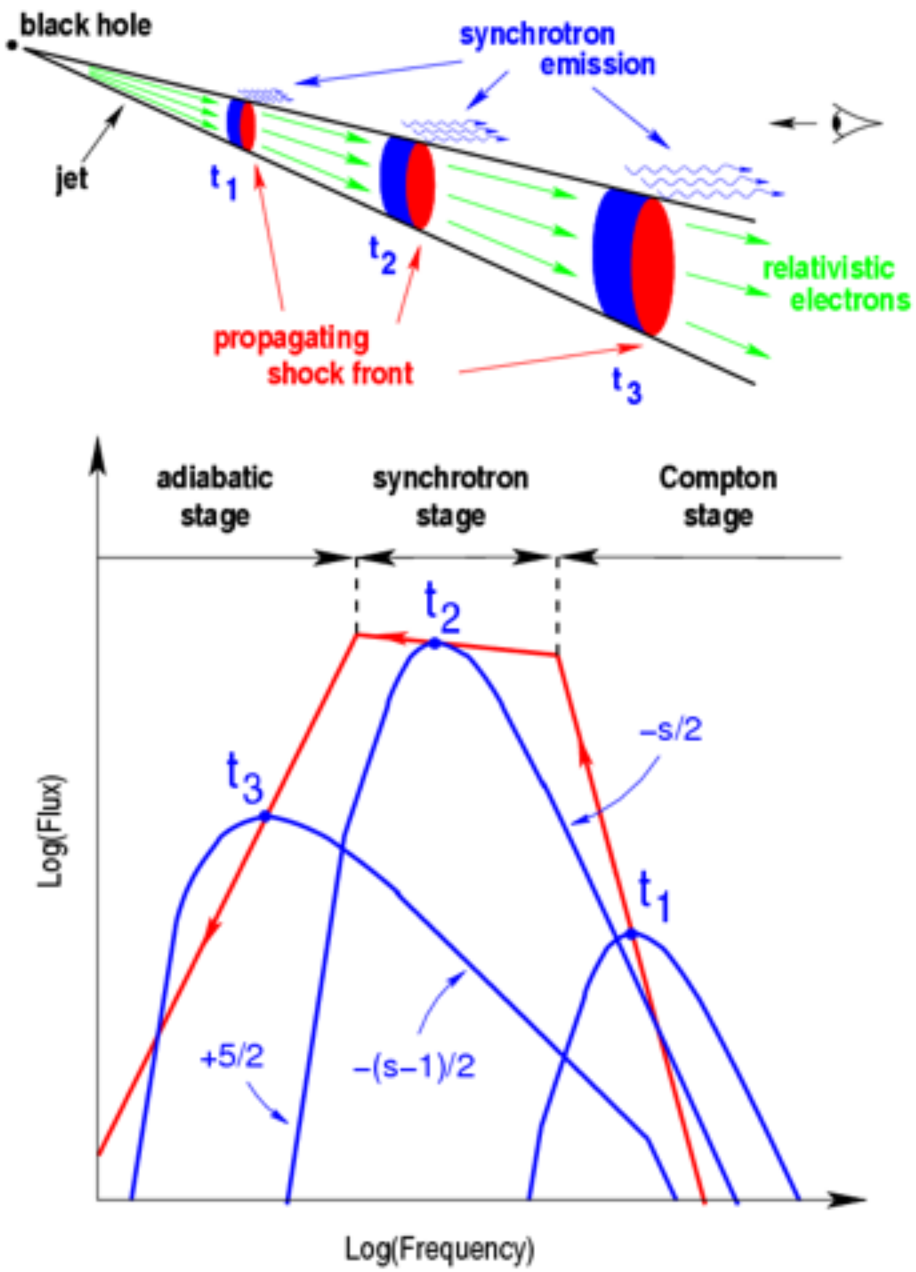
$\nu_Q=0.44\ \nu_m \rightarrow \tau \simeq 7$

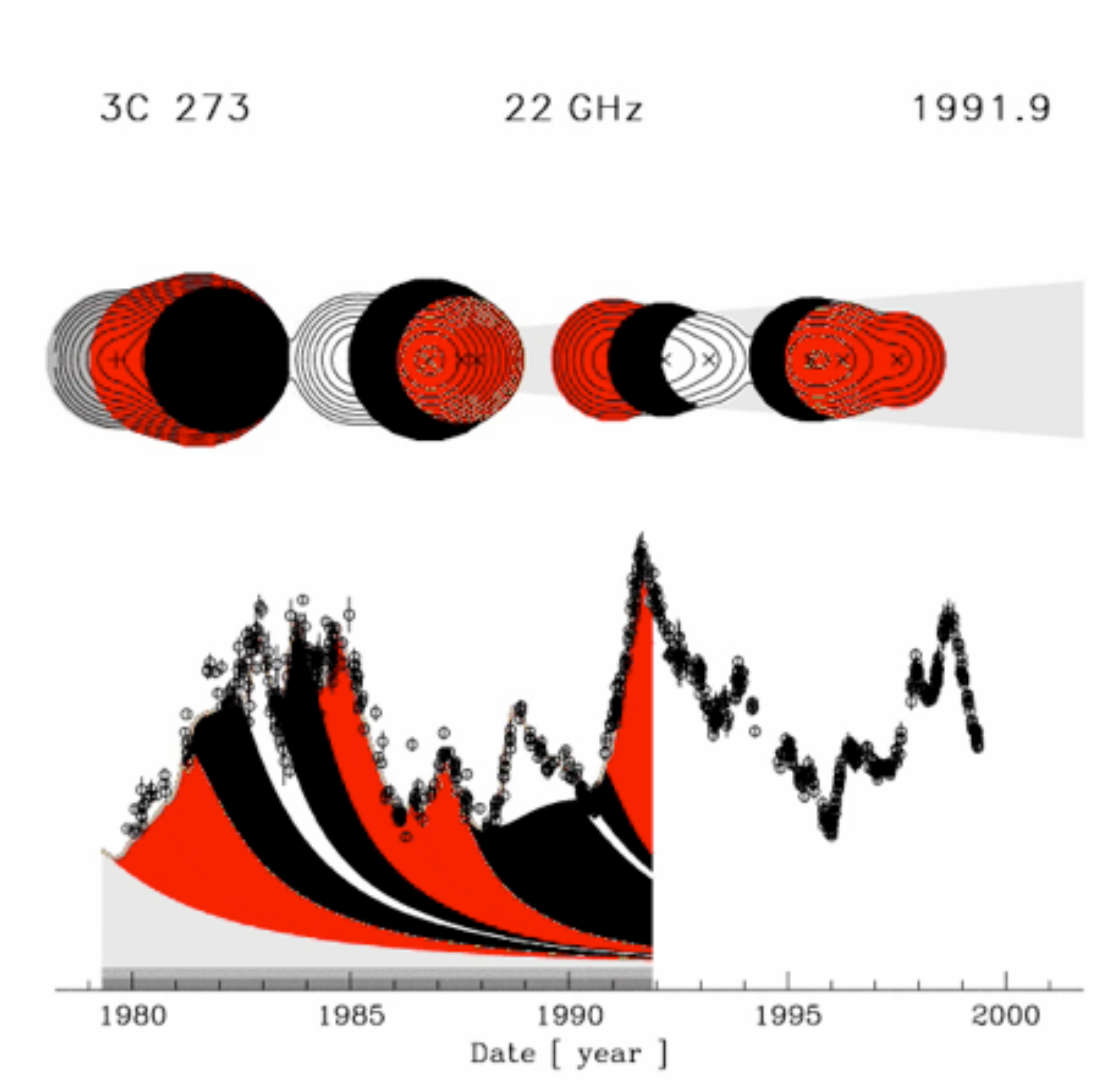
circular component:

$\nu_V=0.49\ \nu_m \rightarrow \tau \simeq 5$

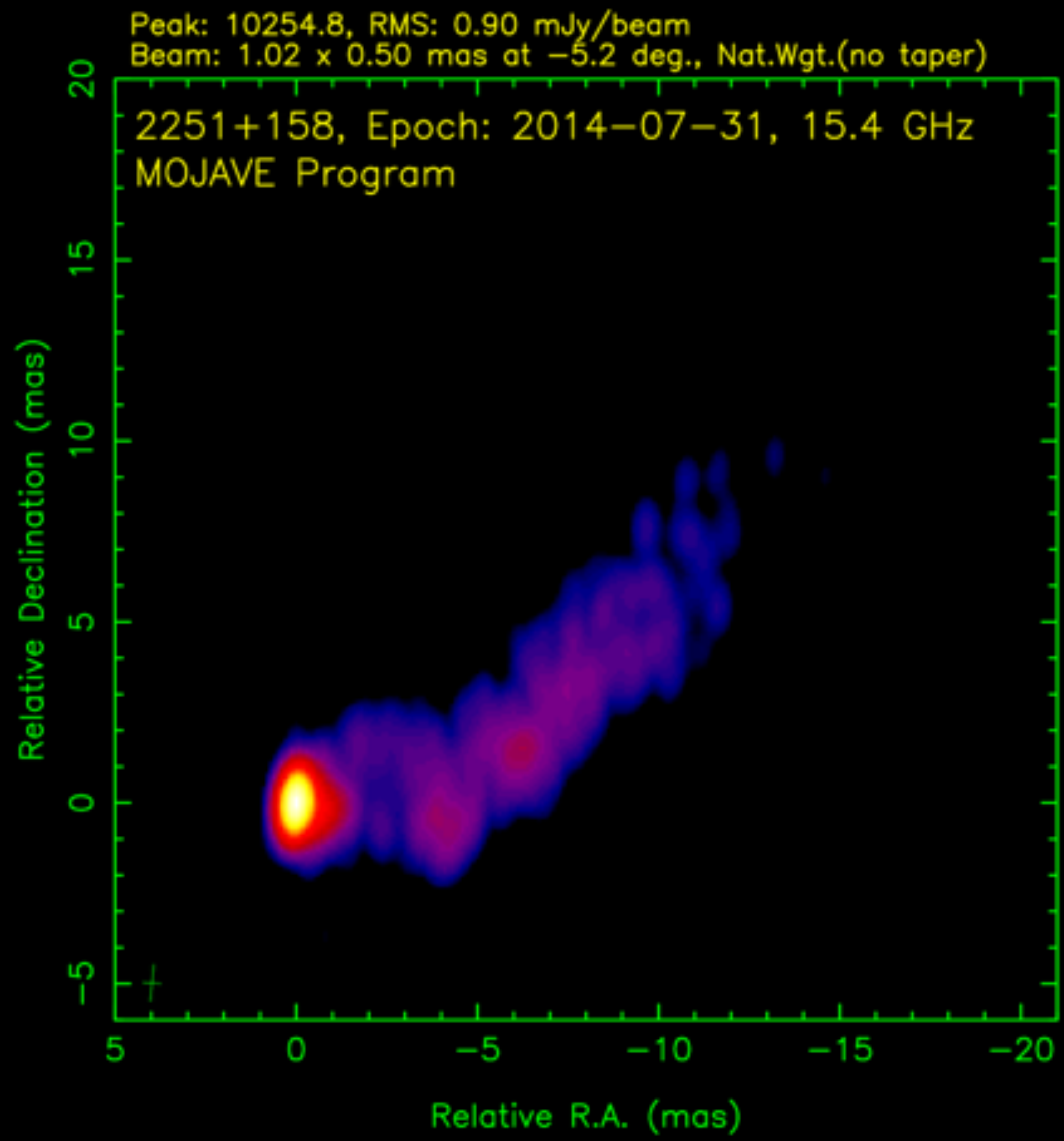
Pacholczyk Pergamon Press, 1977

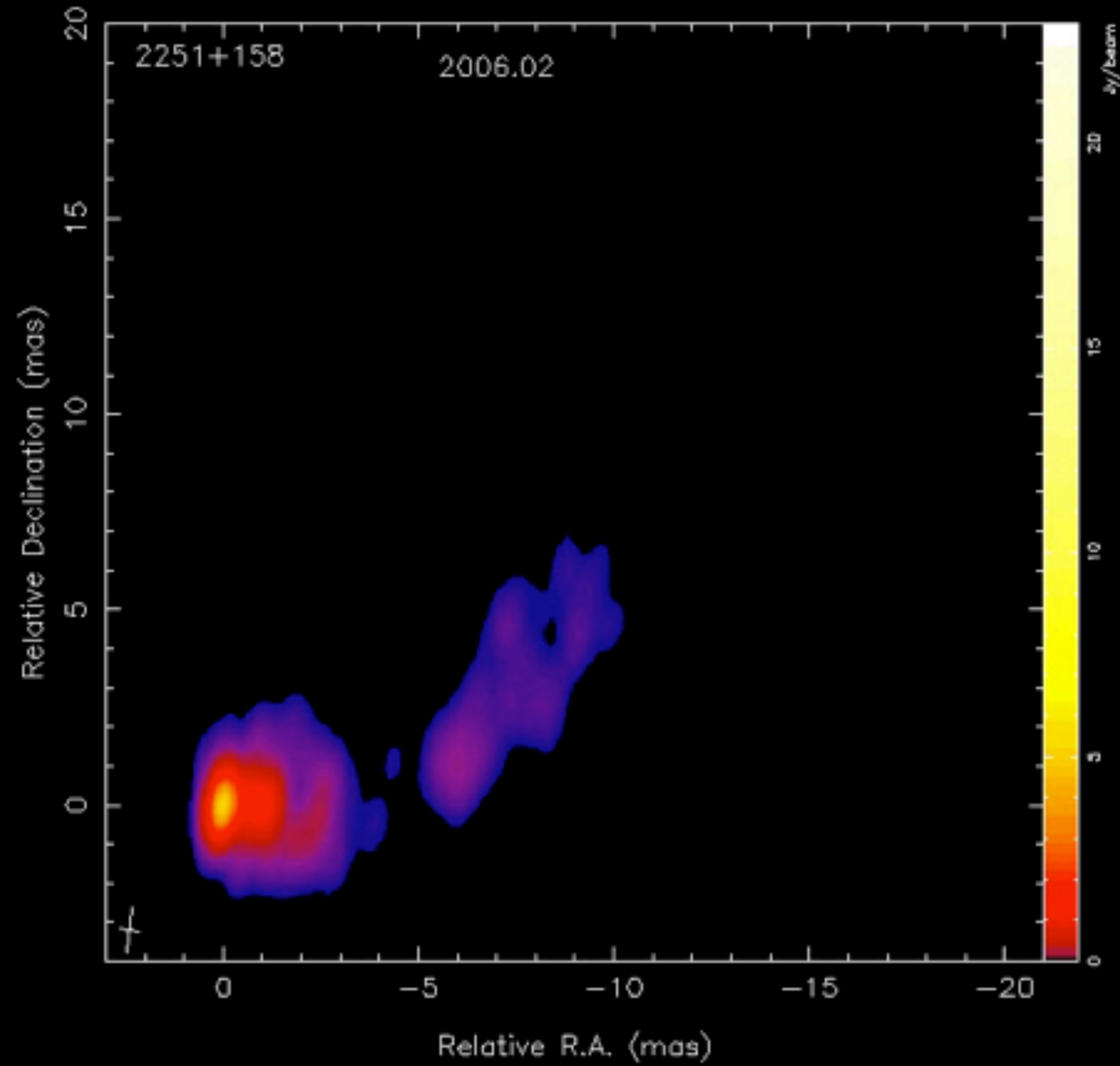






M. Turler et al. 2000; Marscher & Gear, 1985ApJ...298..114M
http://www.isdc.unige.ch/~turler/jets/



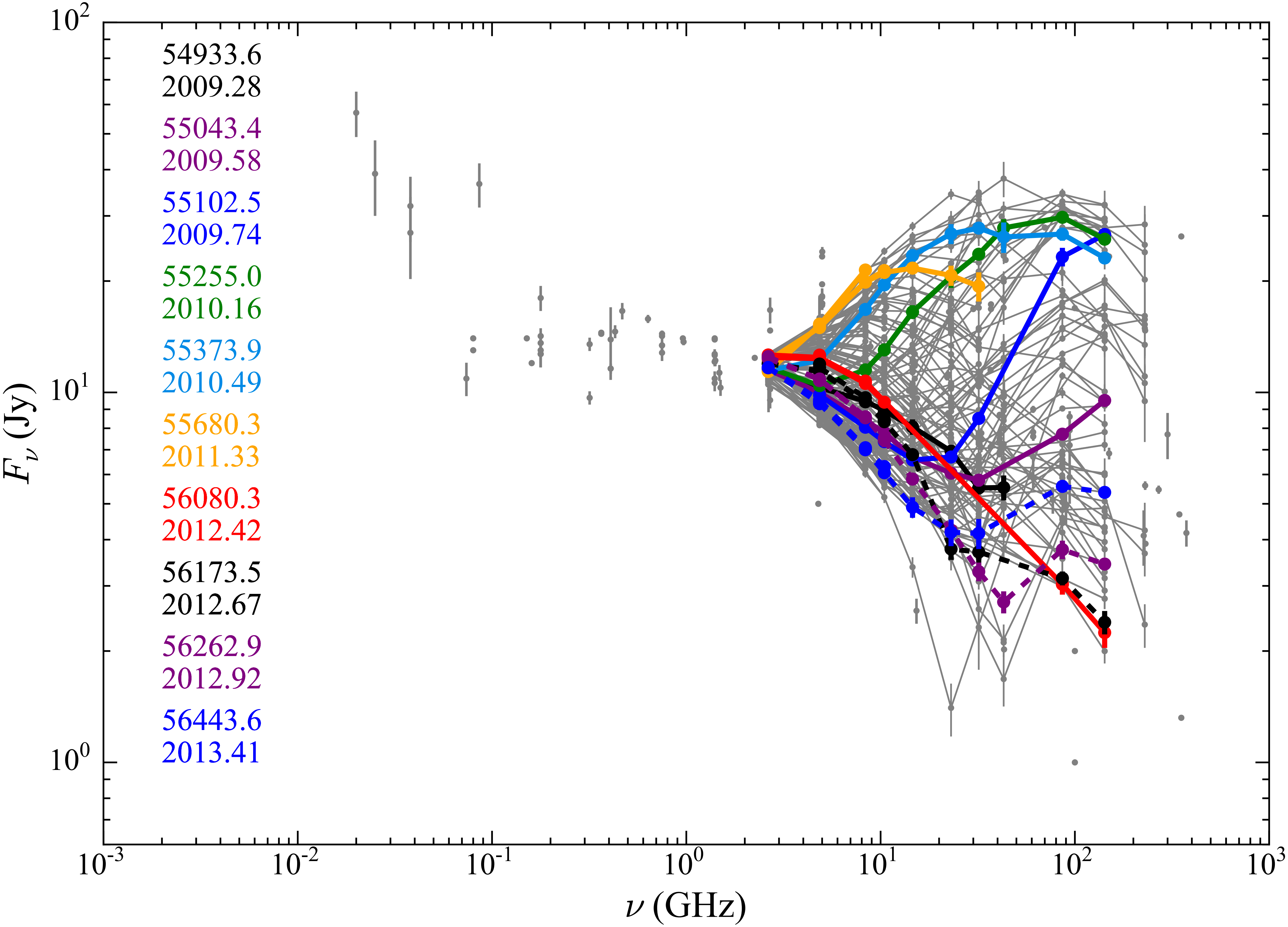


MOJAVE survey at ~15 GHz

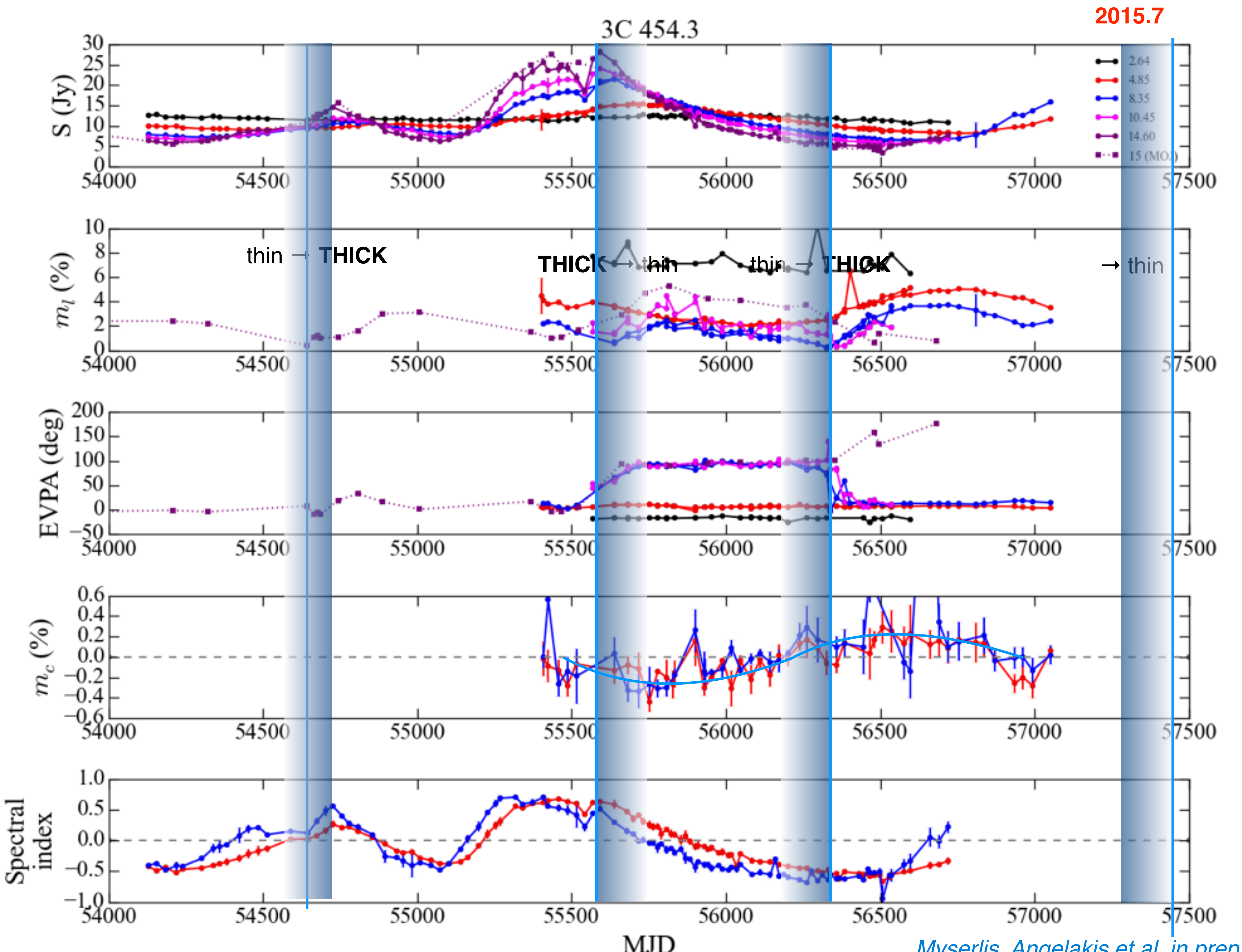
J2253+1608 (3C454.3)

- Flat Spectrum Radio Quasar
- z = 0.859
- Luminosity distance: 5489 Mpc

3C454.3 broadband SED

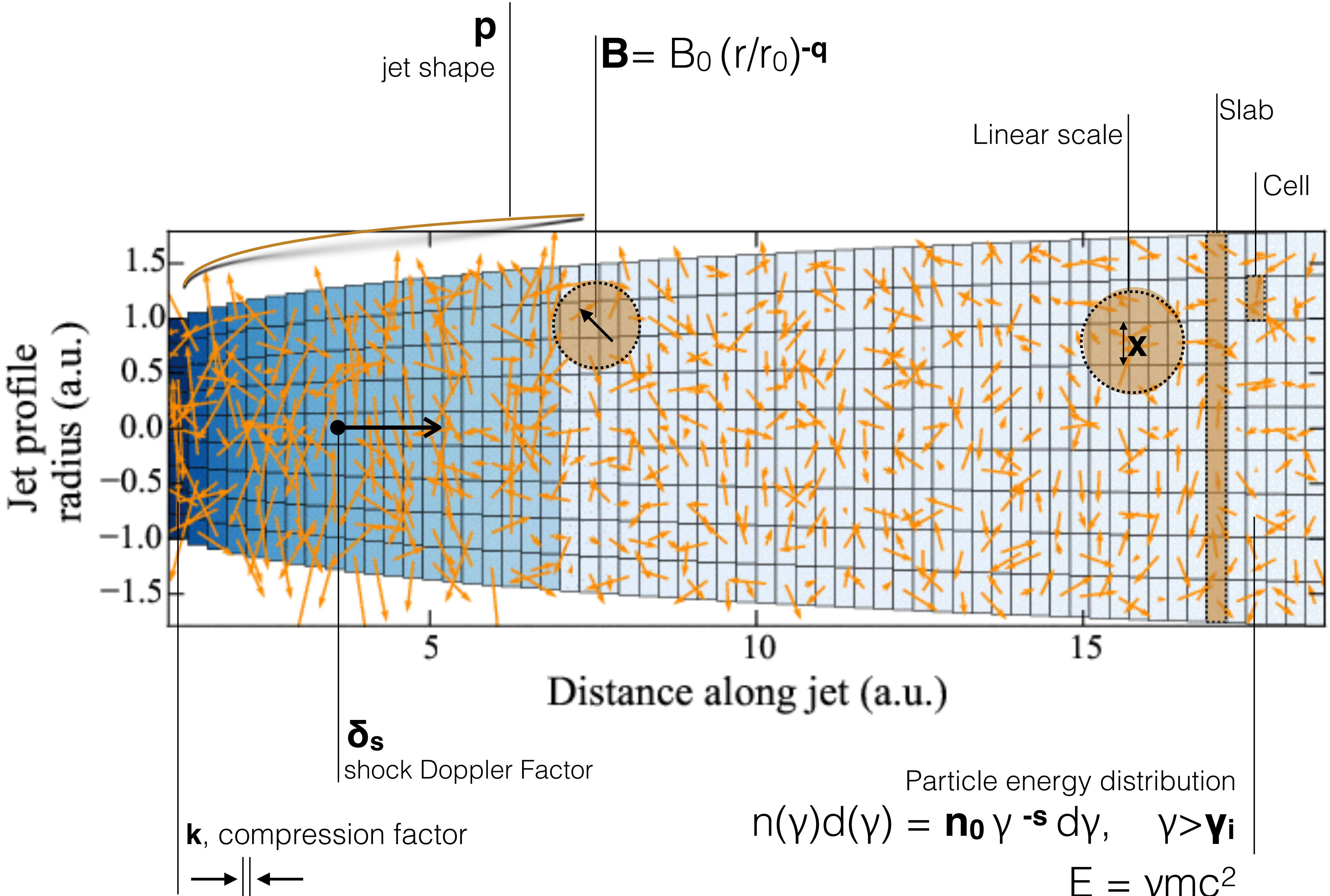


Myserlis, Angelakis et al. in prep.



Myserlis, Angelakis et al. in prep.

Shock-in-jet model



Particle energy distribution

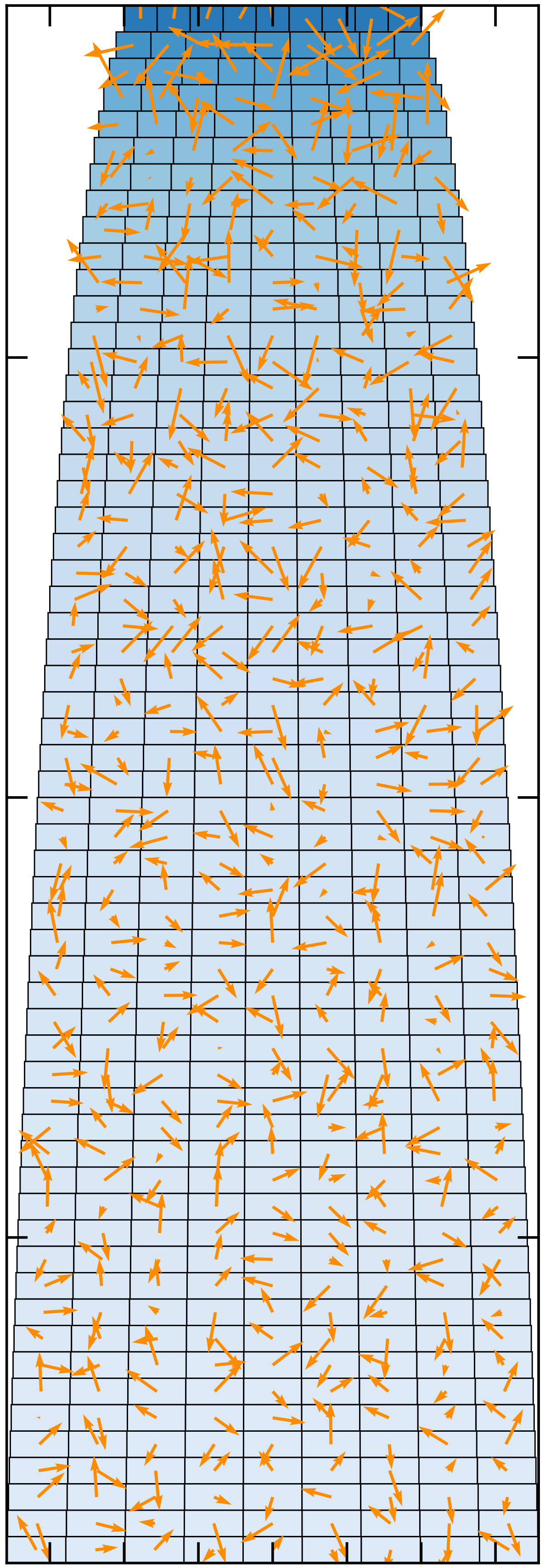
$$n(\gamma)d(\gamma) = \mathbf{n_0}\,\gamma^{\,\mathbf{-s}}\,d\gamma, \quad \gamma>\boldsymbol{\gamma_i}$$

$$E = \gamma mc^2$$

Myserlis, Angelakis et al. in prep.

Fine-tuning the shock-in-jet model on 3C454.3

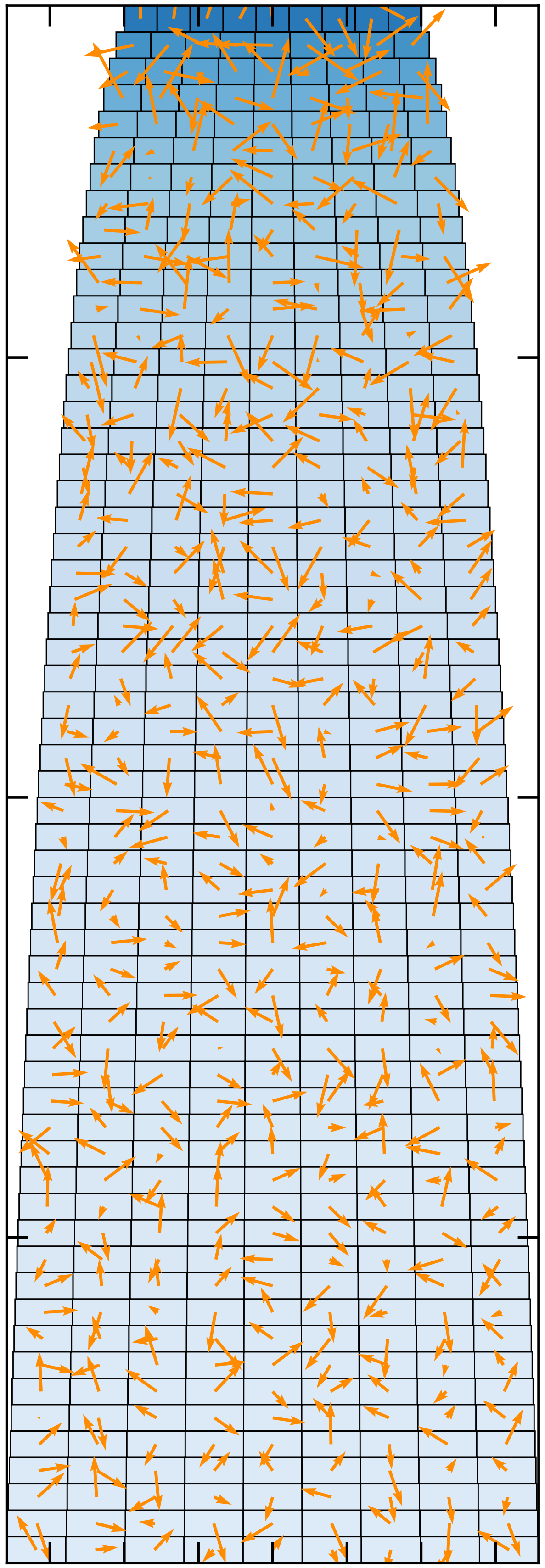
- Typical parameters
  - Shape parameter, $\boldsymbol{p}$ **= 0.2**
  - B-filed strength gradient, $\boldsymbol{q}$ **= 1**
  - Particle energy power-law distribution index, $\boldsymbol{s}$ **= 2.4**
    $\alpha = (s - 1)/2 = 0.7$
- Degenerate set of parameters: size (l), density (n_0), magnetic field strength (B)
  - VLBI maps provide size upper limits. $\boldsymbol{l}$ **= 850 pc** de-projected using $\theta_{obs} = 1.3^{o}$ (*Hovatta et al. 2009*)
  - Median circular polarization degree: 0.12 and 0.14 % at 4.85 and 8.35 GHz respectively. $\boldsymbol{\langle B_{larmor} \rangle = 3.85}$ **mG**
  - Using the above and for a quiescent flux of 4-5 Jy at 15 GHz, we estimate the density $\boldsymbol{n_0 = 10^1 - 10^2}$ $\mathbf{cm^{-3}}$



Myserlis, Angelakis et al. in prep.

Fine-tuning the shock-in-jet model on 3C454.3

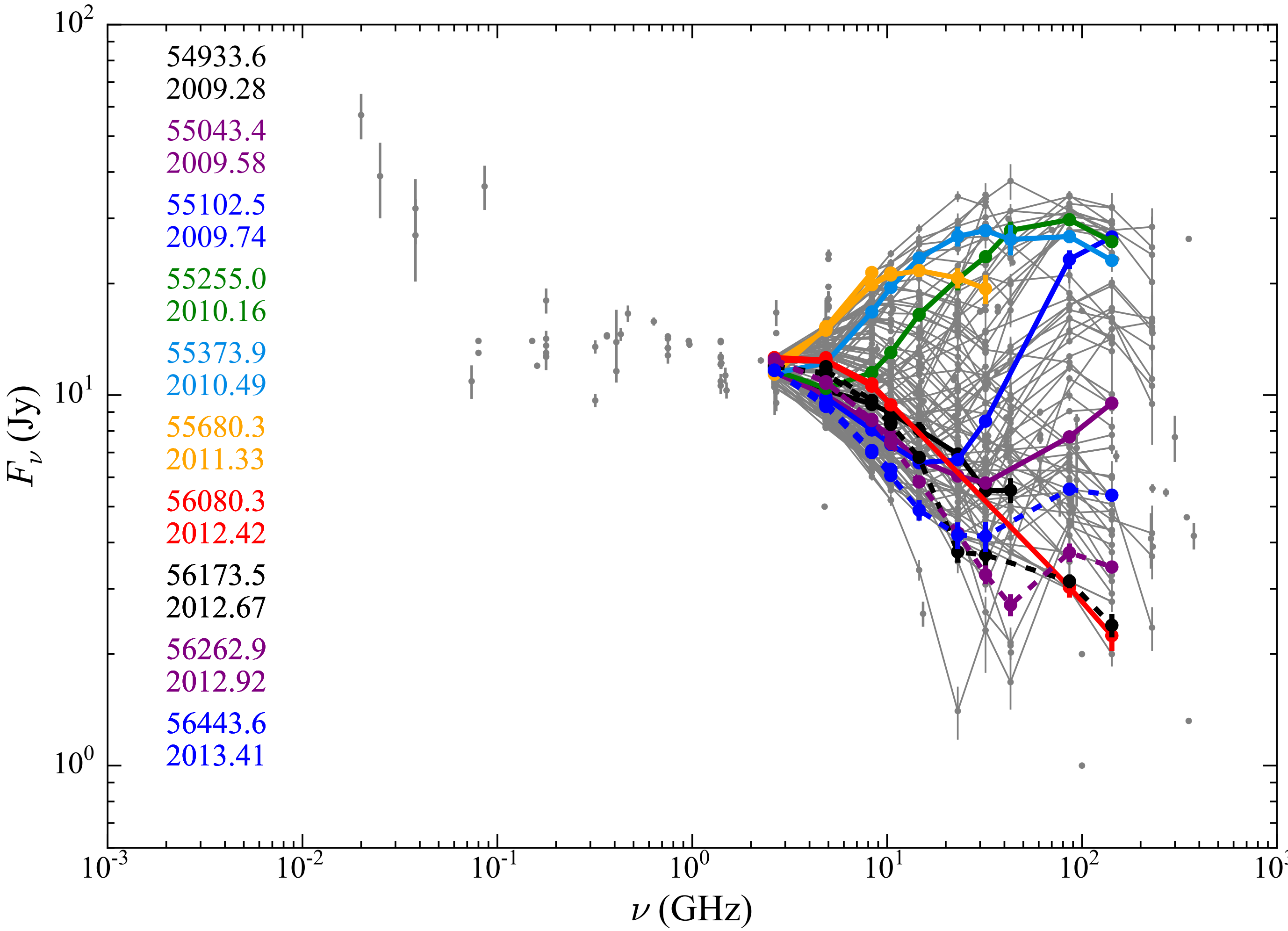
- B-field uniformity using the linear polarization degree
  - Optically thin: 3.1 ± 1.3 %
  - Optically thick: 1.3 ± 0.6 %
  - Total number of cells: $(m_l/\Pi)^2$ = **510**
  - Total number of slabs: **59**
  - **59x9** cells of linear size **15 pc** each

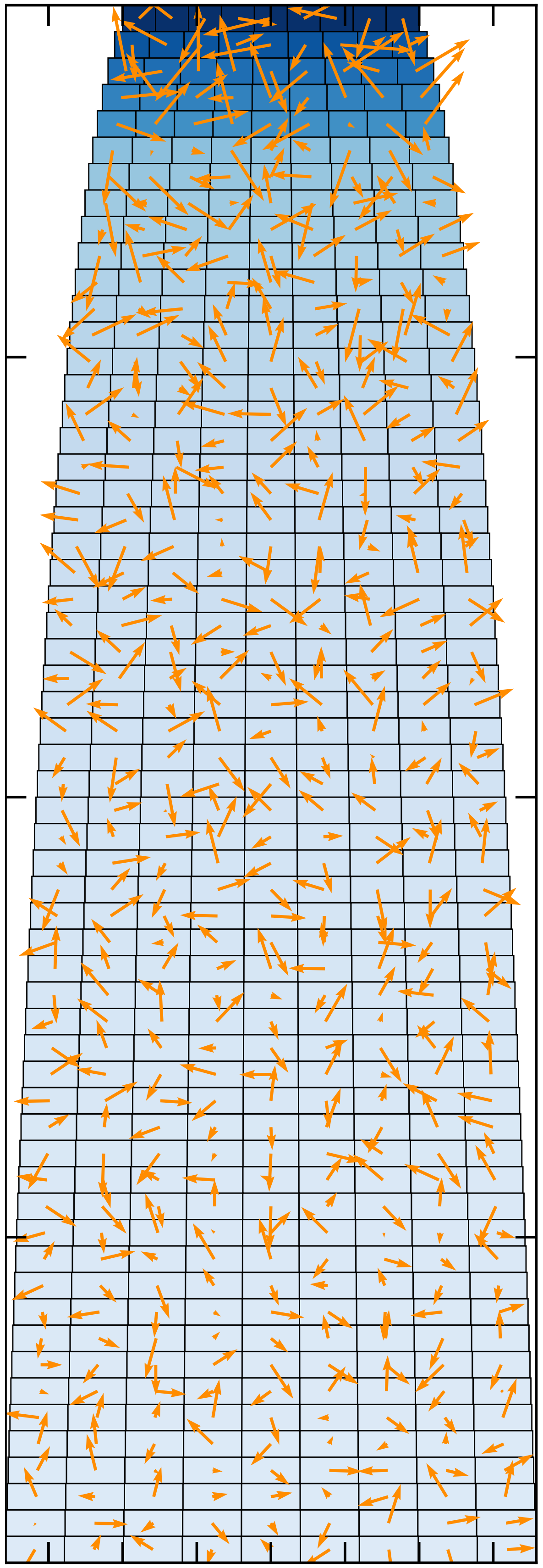


Myserlis, Angelakis et al. in prep.

Fine-tuning the shock-in-jet model on 3C454.3

- Traveling shock
  - max(m_l) = 6 %, ***k* = 0.8**
  - Variability frequency range: 20 - 150 GHz, $\boldsymbol{\delta_s >= 30}$
  - But, extremely high flux density due to doppler boosting ($\delta_s{}^3$)
- Thus we cannot reproduce the spectra of the variable component starting from one like the quiescent one
  - Several possible explanations/solutions: e.g. lowering the density 2-3 order of magnitude, we get into observable regimes





Myserlis, Angelakis et al. in prep.

Summary & Conclusions

- ➡ a rich dataset of polarization data is available (RadioPol / F-GAMMA):
  - ➡ 90 most fermi bright sources
  - ➡ 8 years with cadence 1 — 1.3 months
  - ➡ 8 frequencies
  - ➡ uncertainty 0.13 (polarization degree units)
- ➡ within the framework of traveling shocks we can constrain a number of physical parameters
  - ➡ Size upper limit ***l* = 850 pc**
  - ➡ B-field magnitude **<*B*> = 3.85 mG**
  - ➡ Density $\boldsymbol{n_0 = 10^1 - 10^2}$ $\mathbf{cm^{-3}}$
  - ➡ Modeled jet size: **59x9 cells** of linear size **15 pc each** (B-field *coherence length*)
  - ➡ Shock compression ***k* = 0.8** and Doppler factor $\boldsymbol{\delta_s >= 30}$
- ➡ within this framework/model or methodology we can also study:
  - ➡ Faraday conversion and rotation coefficients to estimate the thermal content of the plasma *(Jones & O' Dell 1977)*
  - ➡ Jet composition (e^{+-} vs e - ion) from the enhancement of polarization *(Jones 1988)*