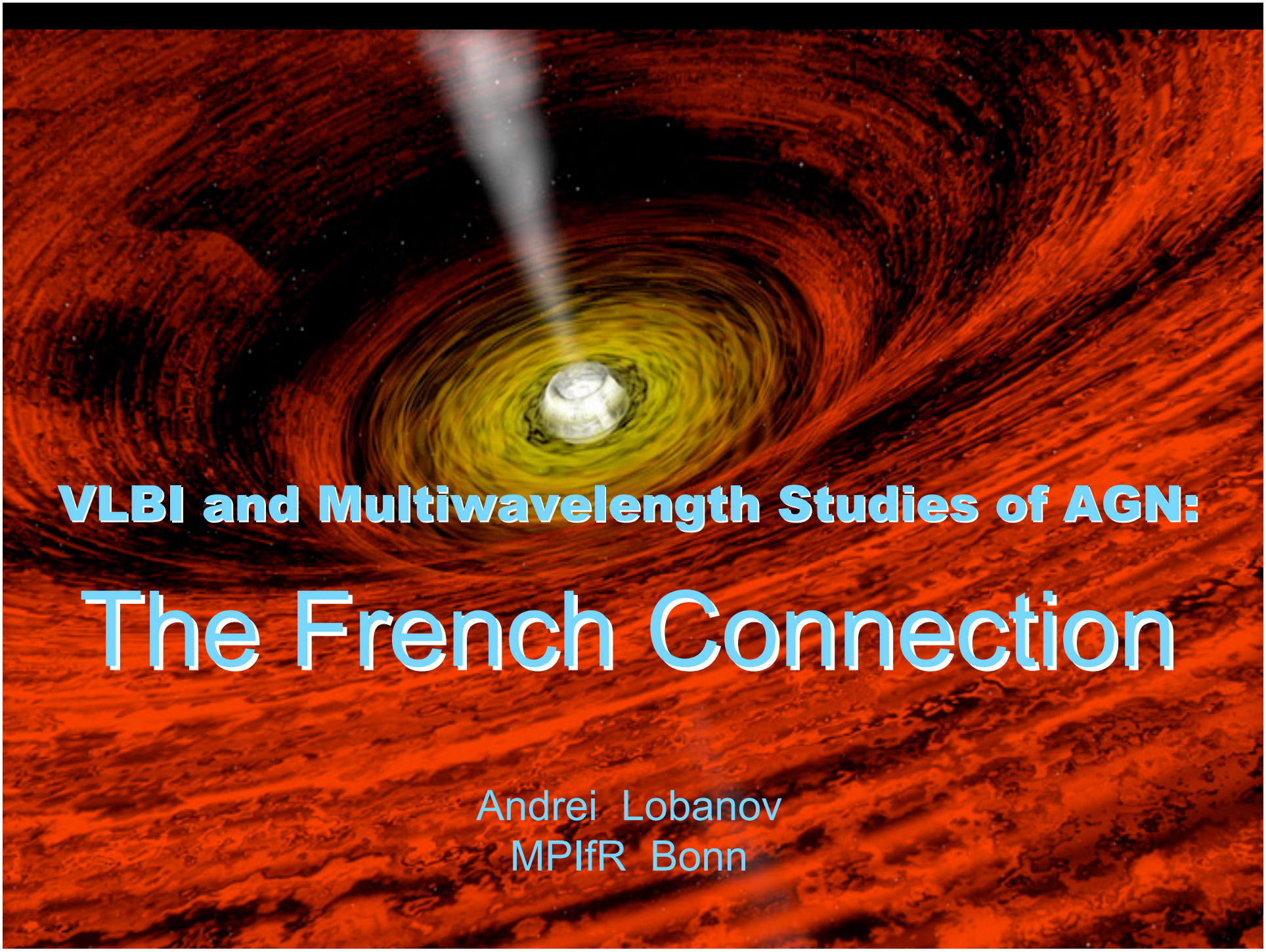

VLBI and Multiwavelength Studies of AGN:

The French Connection

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A Brief Status Summary

A. Lobanov

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- Production mechanism and primary location of γ-ray emission in AGN are both uncertain
- Multifrequency VLBI connections:
  - across the spectrum (mutual input for spectral fitting)
  - across the source (location of radio/γ-ray emission)
- „Usual suspects“ so far:
  - Radio continuum
  - Optical continuum and line flux
  - X-ray light curves, γ-ray events
  - Broad-band spectrum

- Why is it useful to connect to VLBI? – This helps a lot to correlate short term, broad-band events:

$$N_{\rm ev} = \frac{D_{\rm A}}{\tau_{\rm ev}\, c}\sqrt{\Theta_{\rm GLAST}\ \Theta_{\rm VLBI}}$$

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The Nuclear Region

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$M_{bh} = 5*10^8\ M_\odot$

❑ Event horizon:	1-2 R_g	10^{-5} pc
❑ Ergosphere:	1-2 R_g	10^{-5} pc
❑ Corona:	$10^1 – 10^2$ R_g	$10^{-4} – 10^{-3}$ pc
❑ Accretion disk:	$10^1 – 10^3$ R_g	$10^{-4} – 10^{-2}$ pc
❑ Broad line region:	$10^2 – 10^5$ R_g	$10^{-3} – 1$ pc
❑ Molecular torus:	$> 10^5$ R_g	> 1 pc
❑ Narrow line region:	$> 10^6$ R_g	> 10 pc

❑ Jet formation:	~ 10^2 R_g	~ 10^{-3} pc
❑ Jet visible in the radio:	> 10^3 R_g	> 10^{-2} pc.

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Jets in a Nutshell

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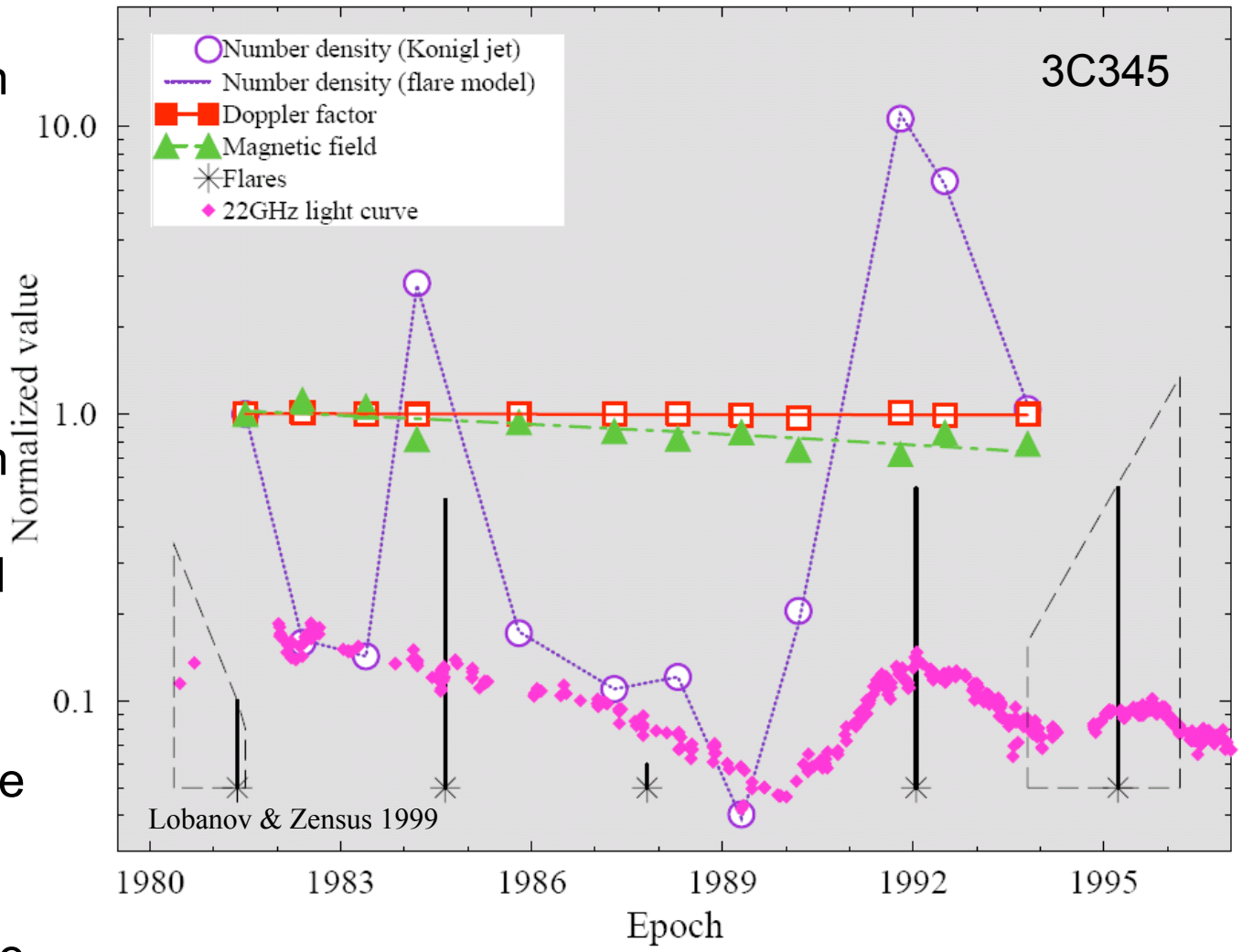
- **Anatomy of extragalactic jets:**
  - VLBI "cores"
  - collimation and acceleration scales (~10^3 R_g)
  - regions dominated by strong shocks (~10 pc)
  - dissipation of shocks and development of instabilities (~100 pc)
  - kiloparsec-scale jets
- **Relation between the jets and the nuclear environment in active galaxies:**
  - jets transport excess angular momentum and energy
  - jets are connected to accretion disks, BLR, coronae? sub-relativistic outflows?

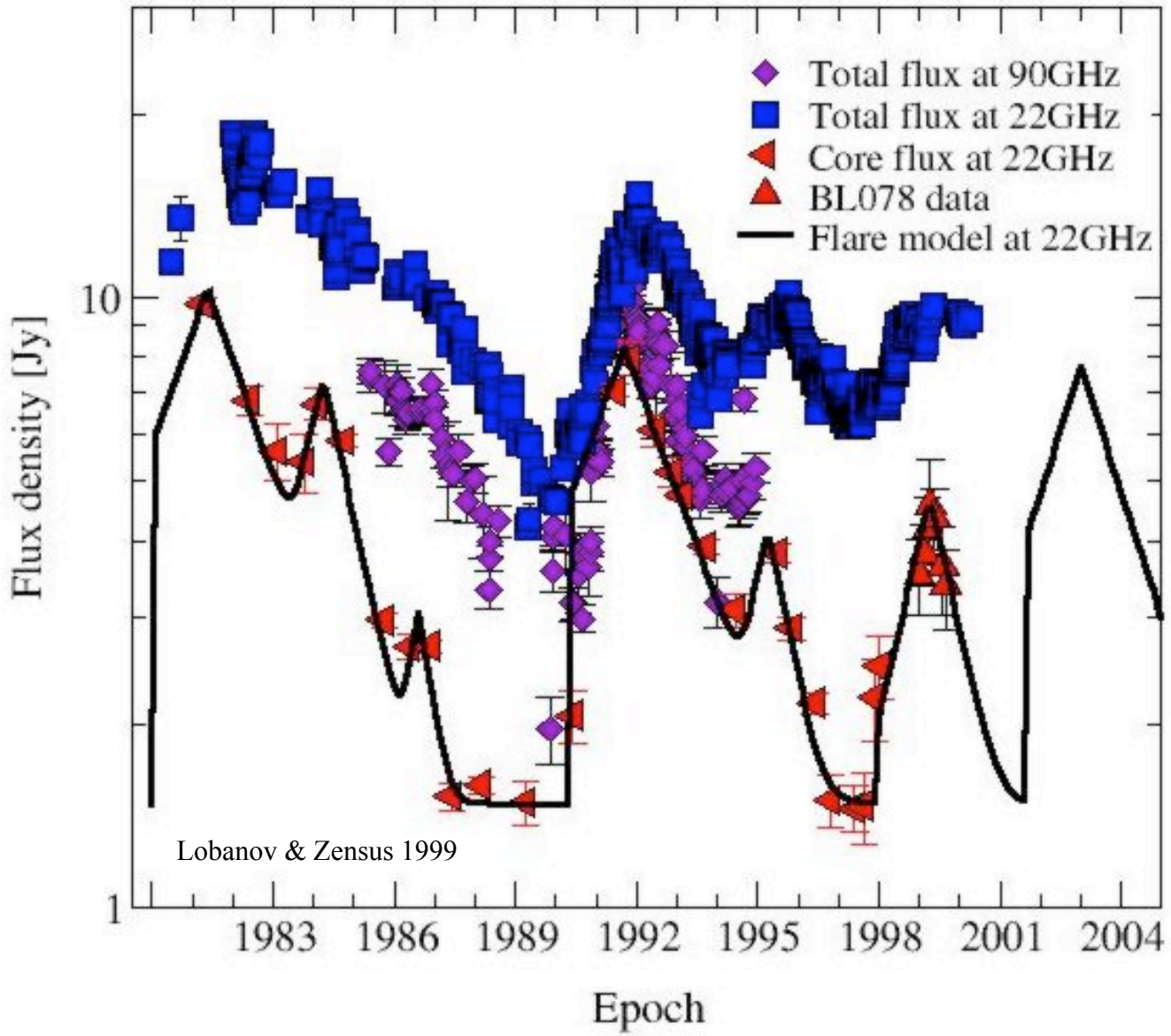
VLBI "Core"

- Location at which jets become visible in radio is most likely determined solely by the τ=1 condition for synchrotron emisson (Königl 1981).
- Nuclear flares can be described by relatively modest and smooth variations of particle density.
- Magnetic fields are either tangled or organized on scales much smaller than the resolution limit.



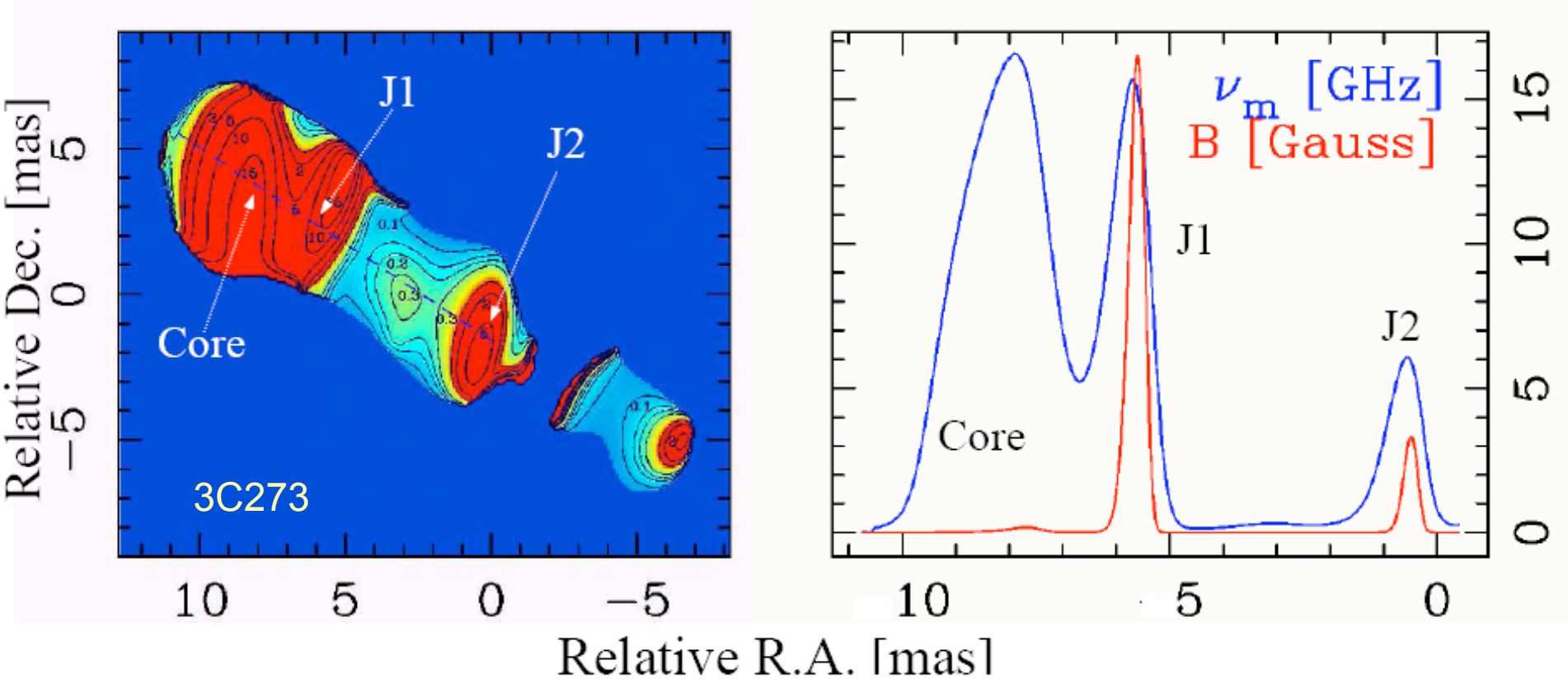
Nuclear Flares

- Sometimes can be detected only in VLBI data.
- Monitoring the rising stage is essential for modelling.

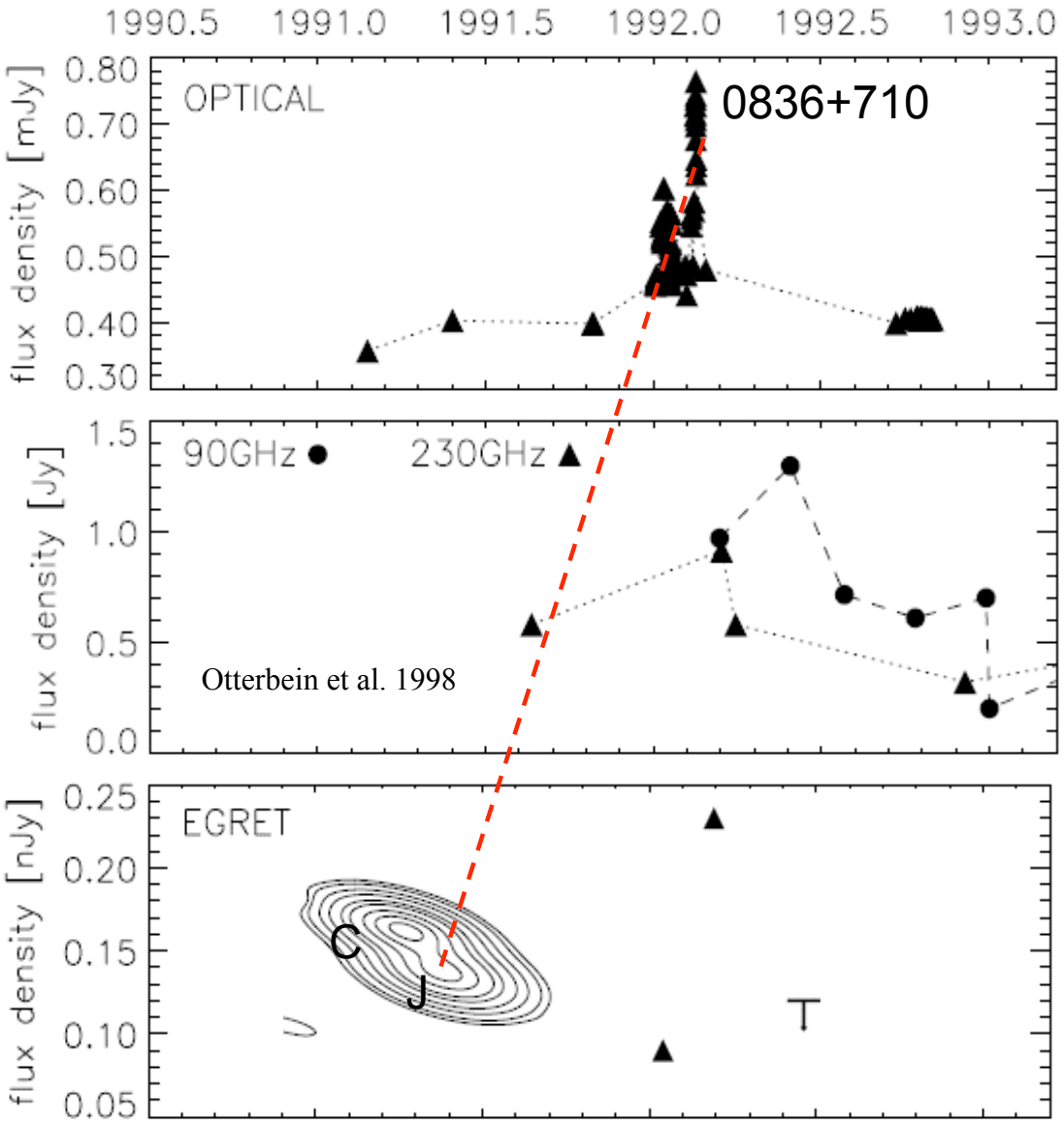


Parsec-Scale Jets

- Strong shocks are clearly present in jets on small scales (several decaparsecs) – from polarization and distribution of the synchrotron turnover frequency.



The γ-ray Connection



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The γ-ray Connection

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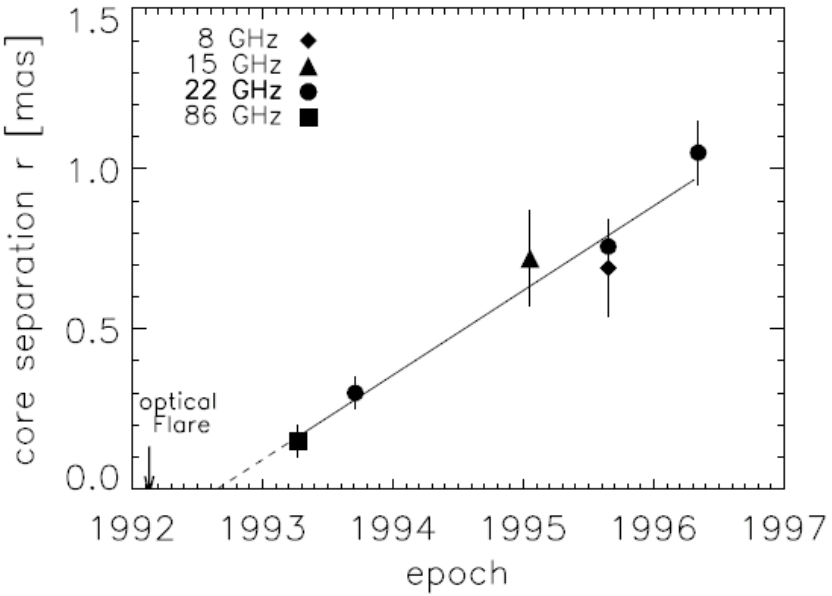
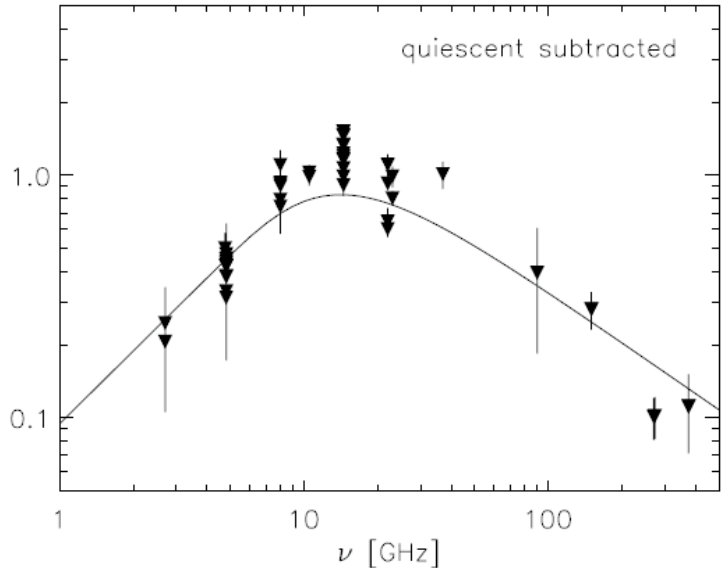
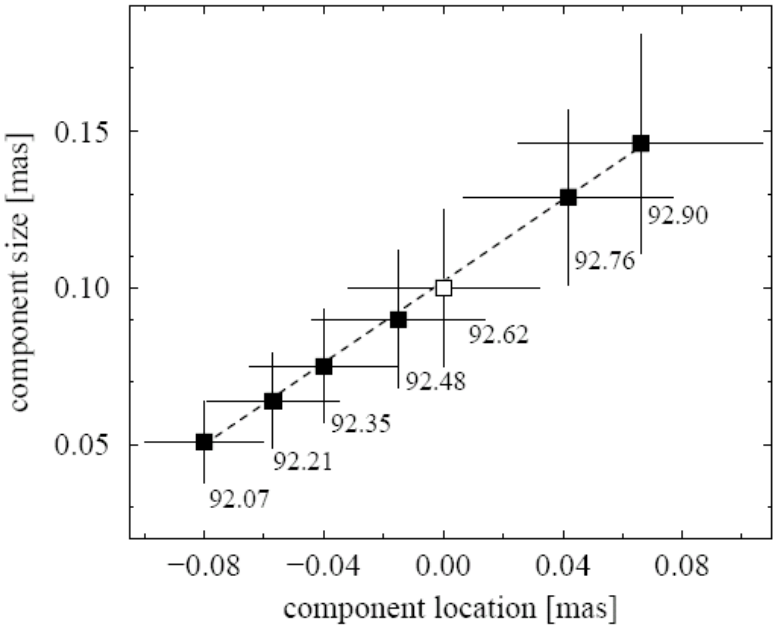




Lorentz factor, $\Gamma_j = 11.8$
Viewing angle, $\theta_j = 3.2$ deg
Doppler factor, $\delta_j = 16.4$
Opening angle, $\phi_j = 2.1$ deg
Magnetic field, $B_{core} = 0.2$ G



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Jet-Disk Connection

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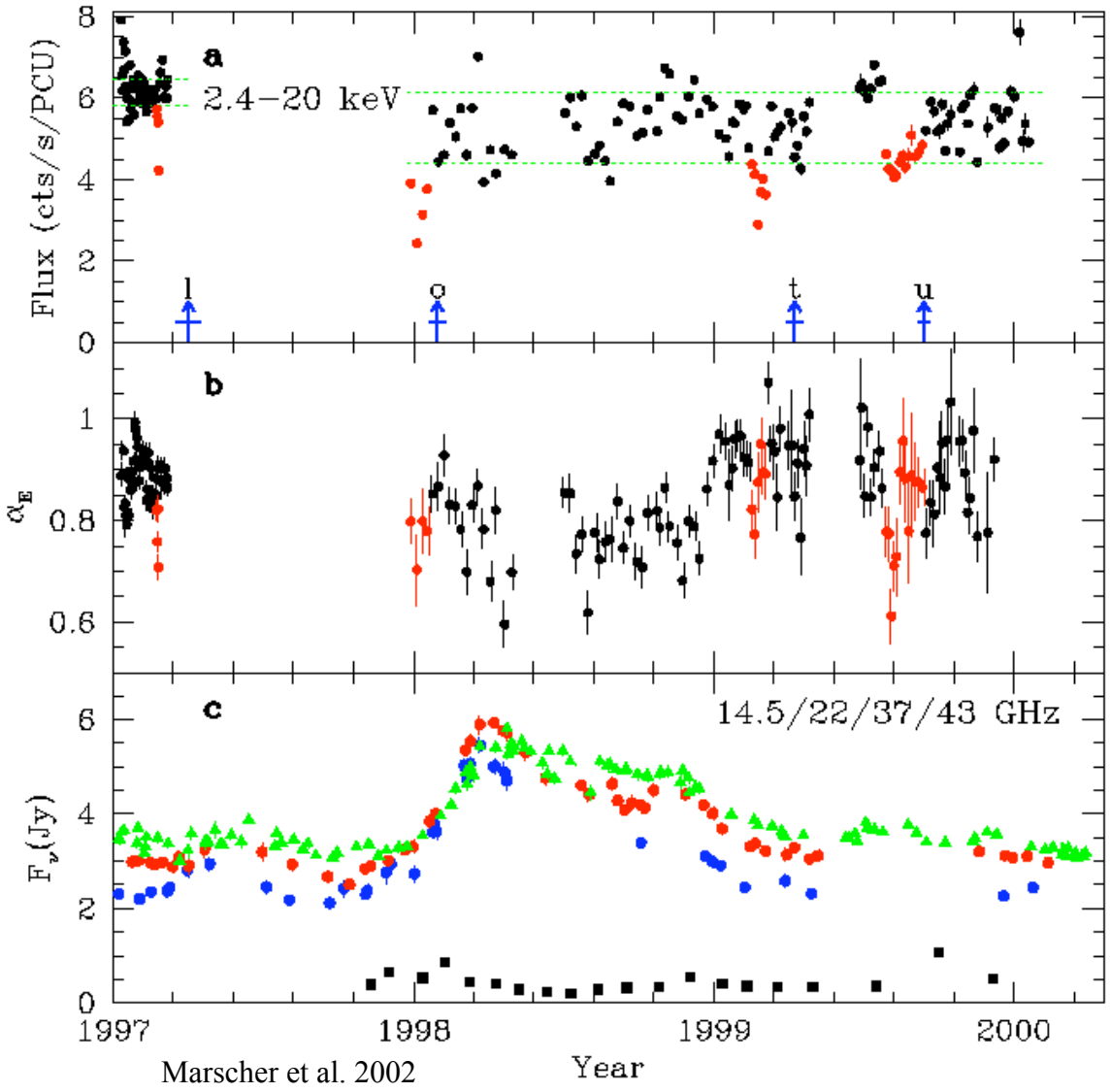
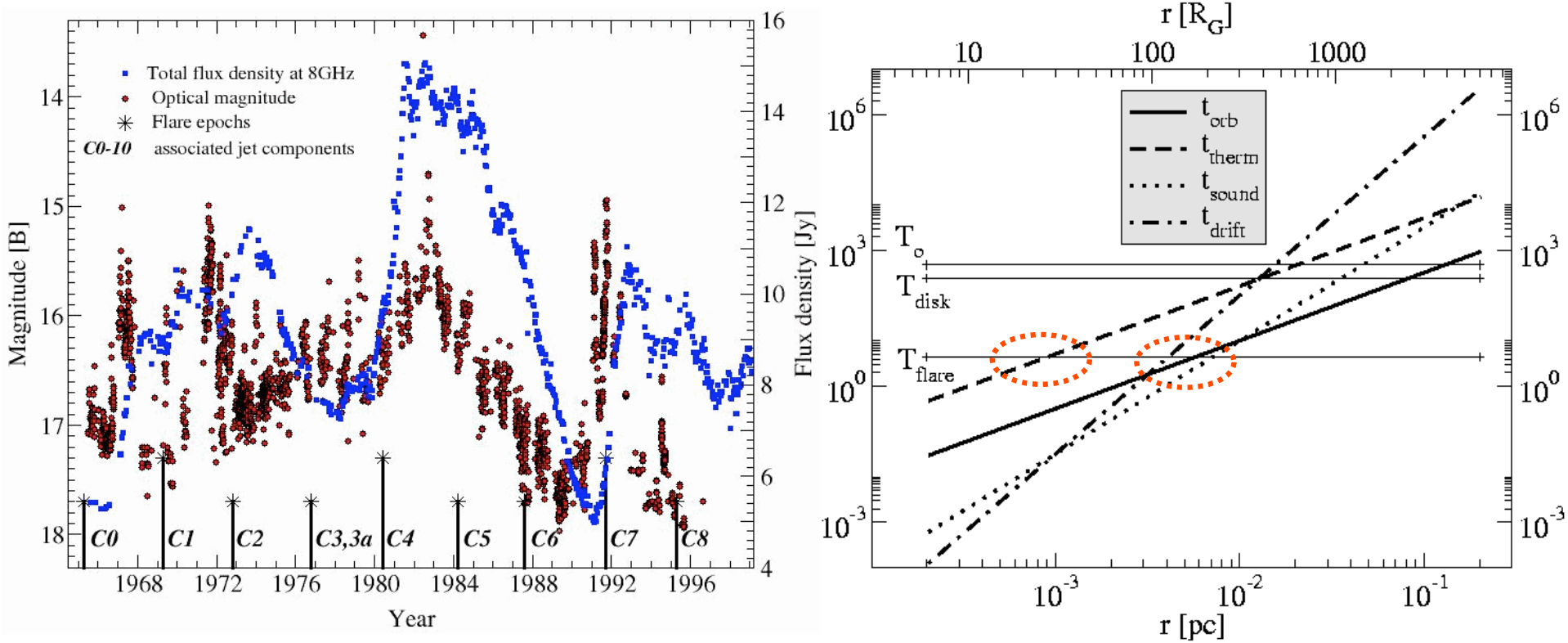


Marscher et al. 2002

Jet-Disk Connection

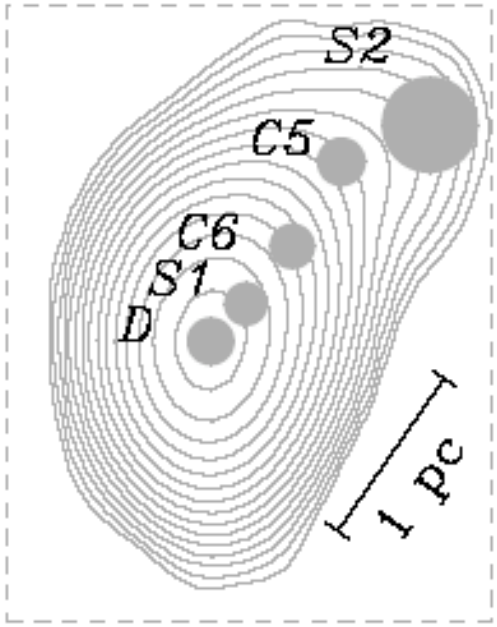
- Flares and ejections of new jet components in 3C345 may be related to the characterstic instability timescales in the disk at 20-200 R_g



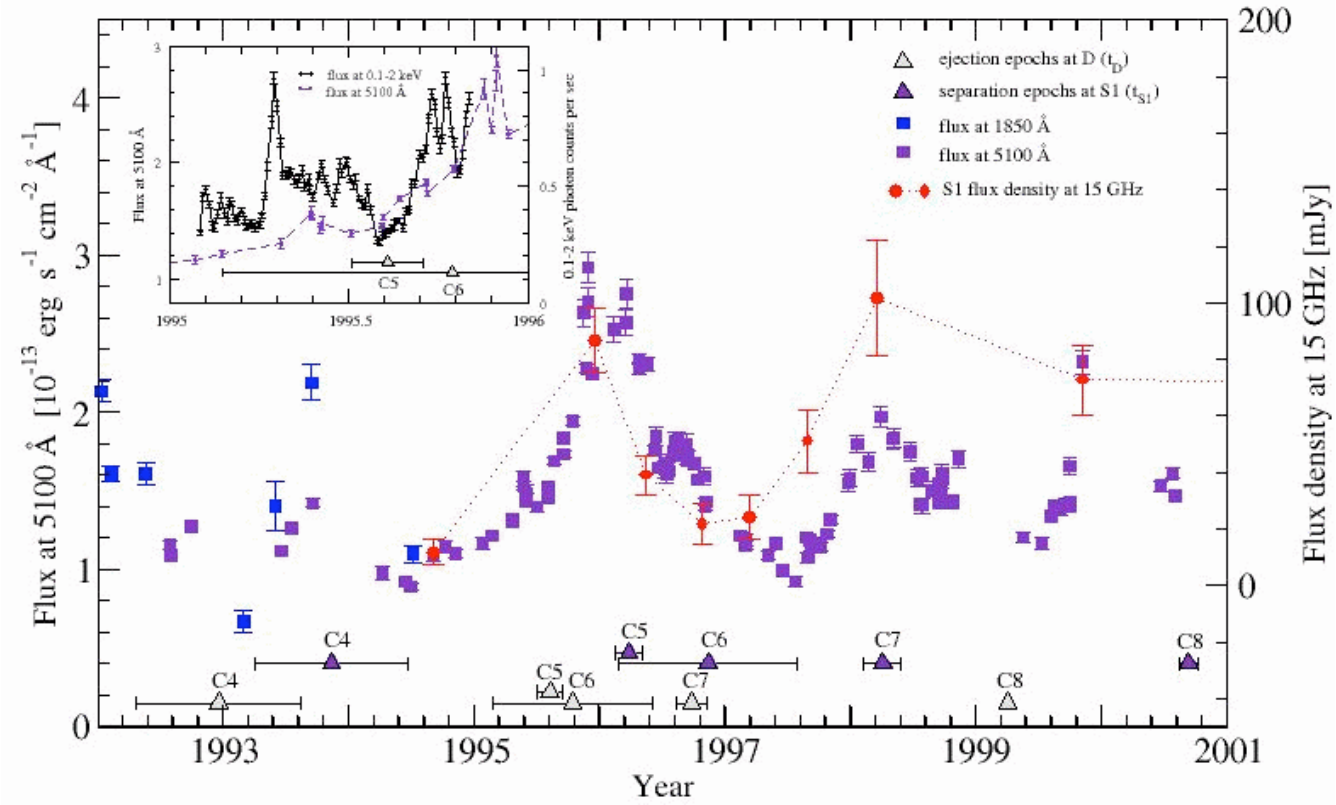
Lobanov & Roland 2005

Jet-BLR Connection

- BLRG 3C390.3: jet can produce a large fraction of non-thermal continuum
- Optical maxima correlate with the passages of relativistic plasma through S1
- An X-ray minimum is found close to the ejection epochs of C5 and C6

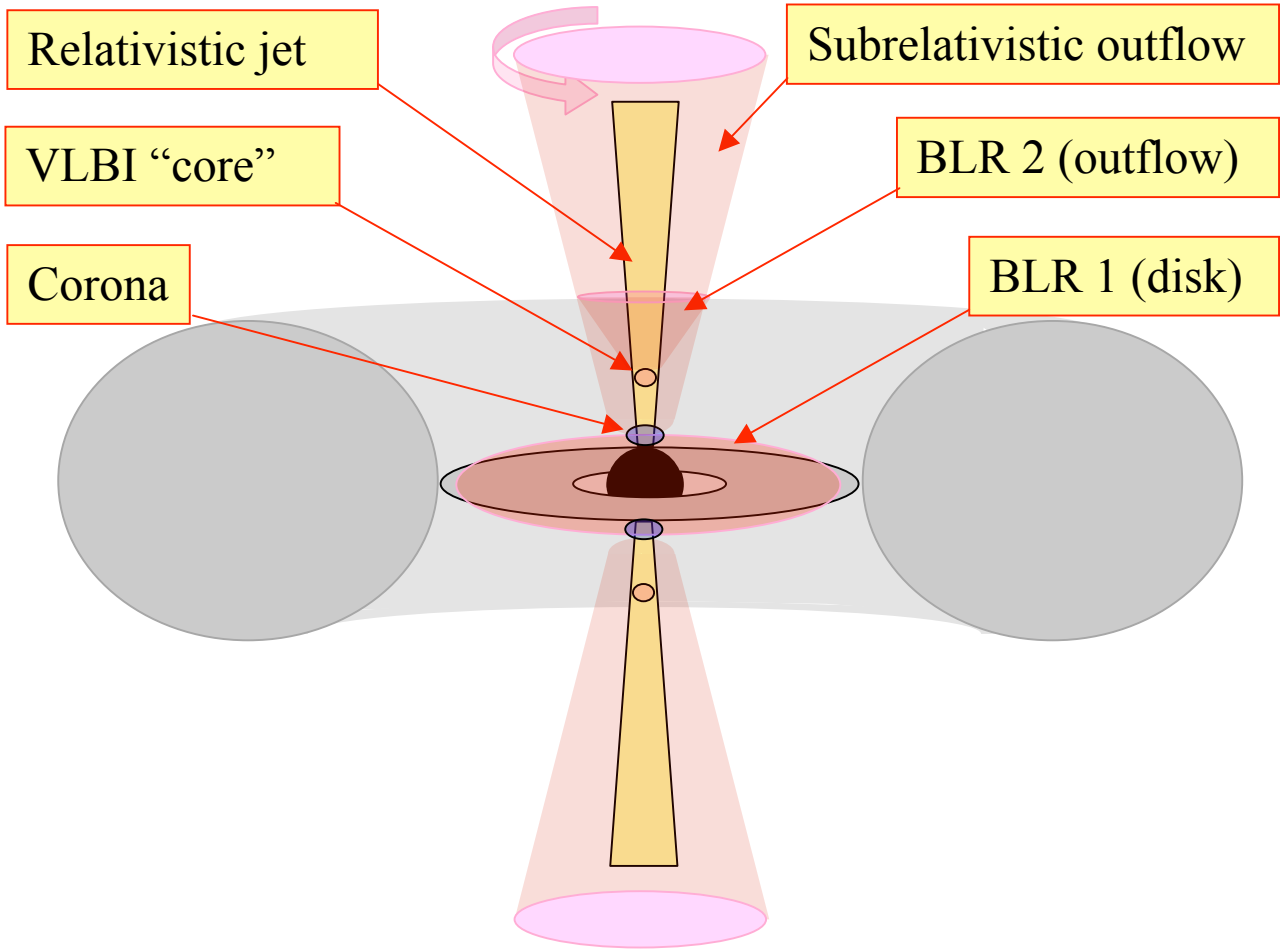


Arshakian et al. 2006



Jet-BLR Connection

- The jet in 3C390.3 may power a BLR associated with a subrelativistic outflow from the nucleus.



Summary

- Large amount of good work is already done for connecting VLBI to multifrequency observations
- Exploring VLBI-GLAST connection is really a must
- Most promising approaches:
  - statistical studies of VLBI/GLAST data on well-defined samples
  - „case studies“ of flaring events in selected prominent objects
- Essentials of a „case study“: 1) early trigger; 2) BB spectra at three selected epochs; 3) γ-ray, X-ray, optical and radio light curves; 4) dense VLBI monitoring.