Blazar Optical Variability:
20 Years of Observations at Belogradchik Observatory

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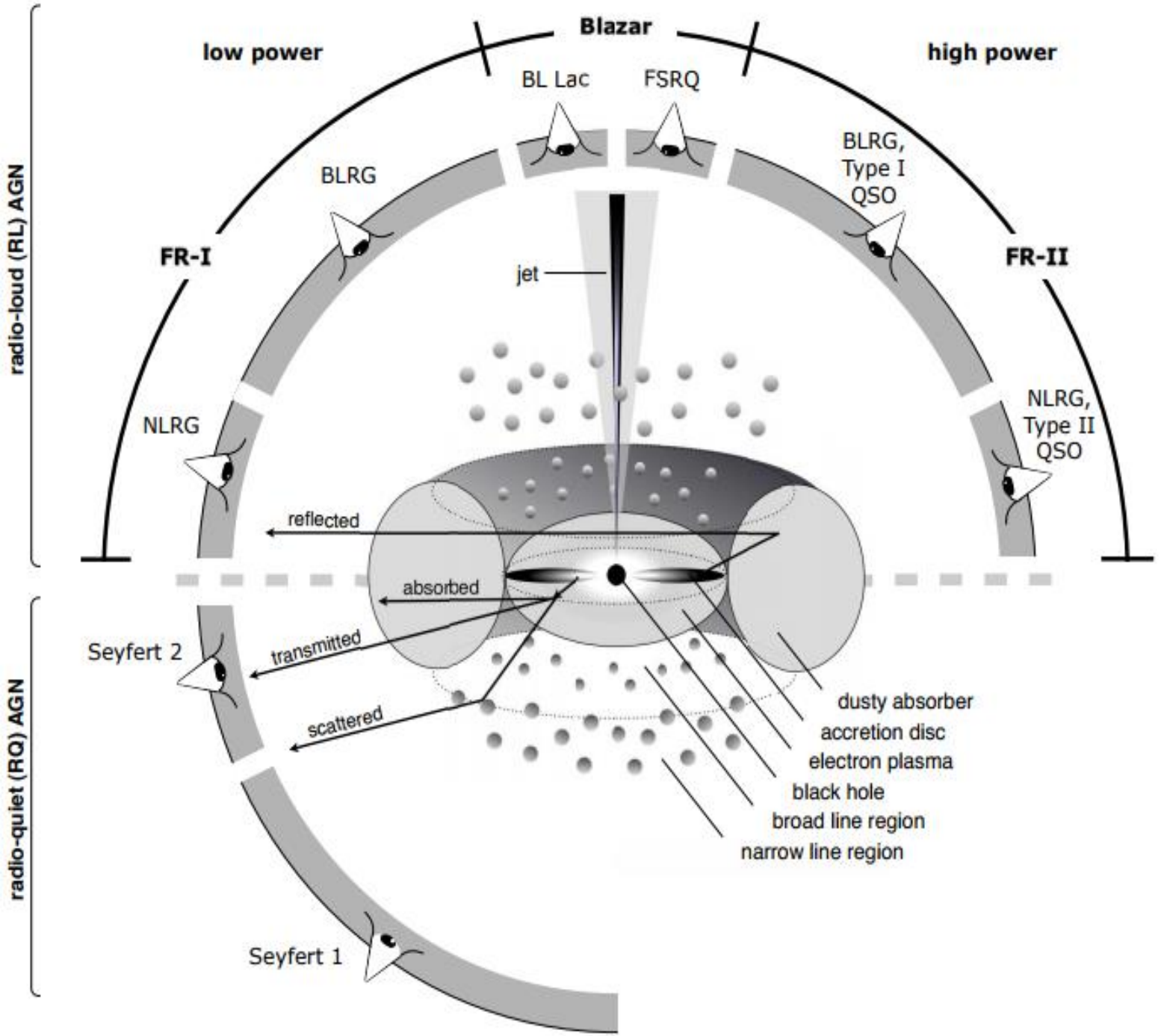
Blazars are a special type of AGN

- The term “blazar” was introduced 40 years ago
- Strong (and often – “superluminal”) radio-jets
- SED covering from radio to TeV energies
- Fast and significant variations at all energies/wavebands
- Residing mostly in early-type galaxies

- Blazars – natural accelerators to VHE, where new/old physics can be tested



A typical AGN:

- Central SMBH
- Powered by accretion
- Axisymmetric structure
- Jets not always present

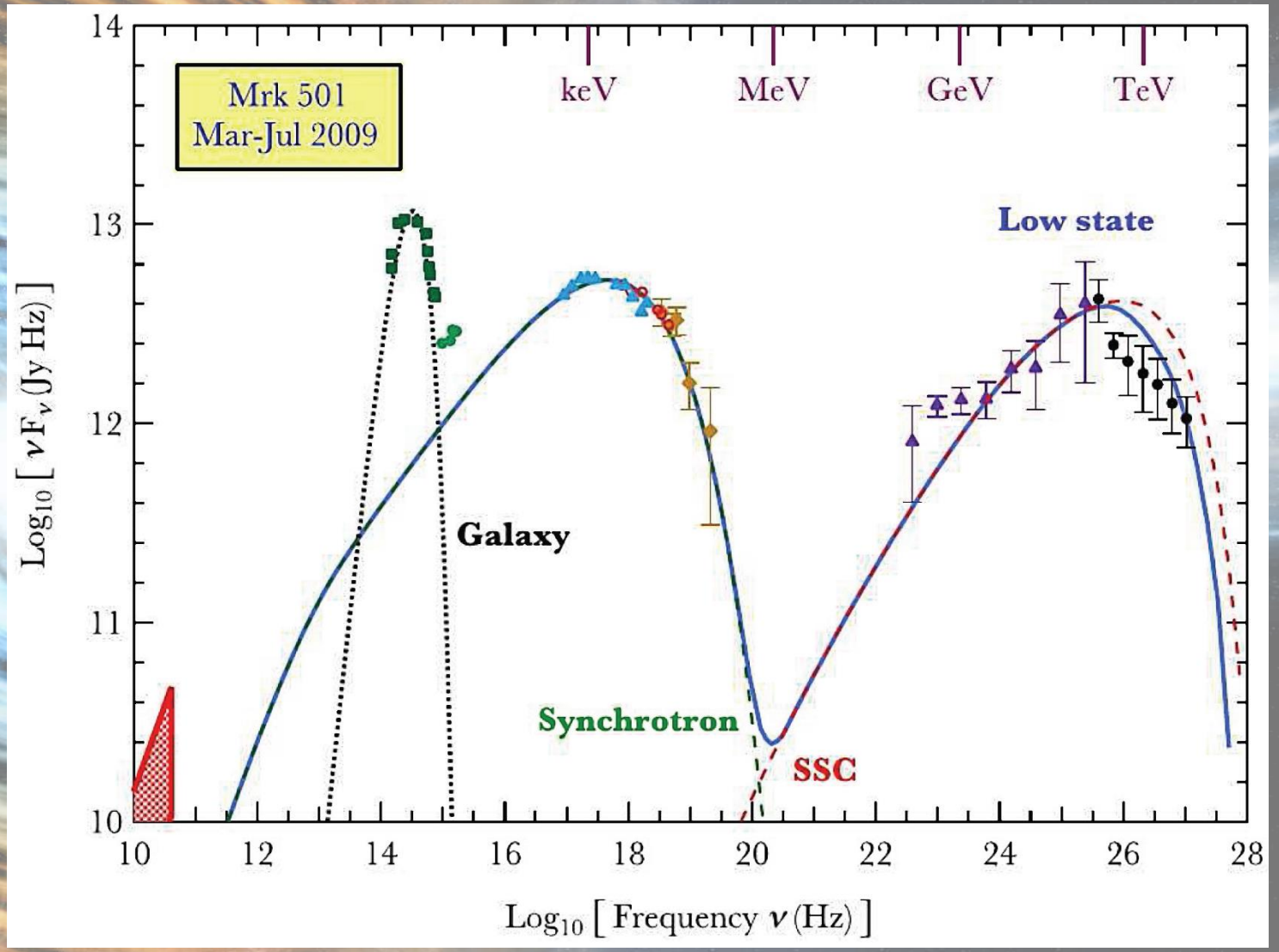
- A **blazar** – when the jet is aligned with the line of sight

(from Beckmann & Shrader, 2013)

Blazar SED (2 broad peaks):

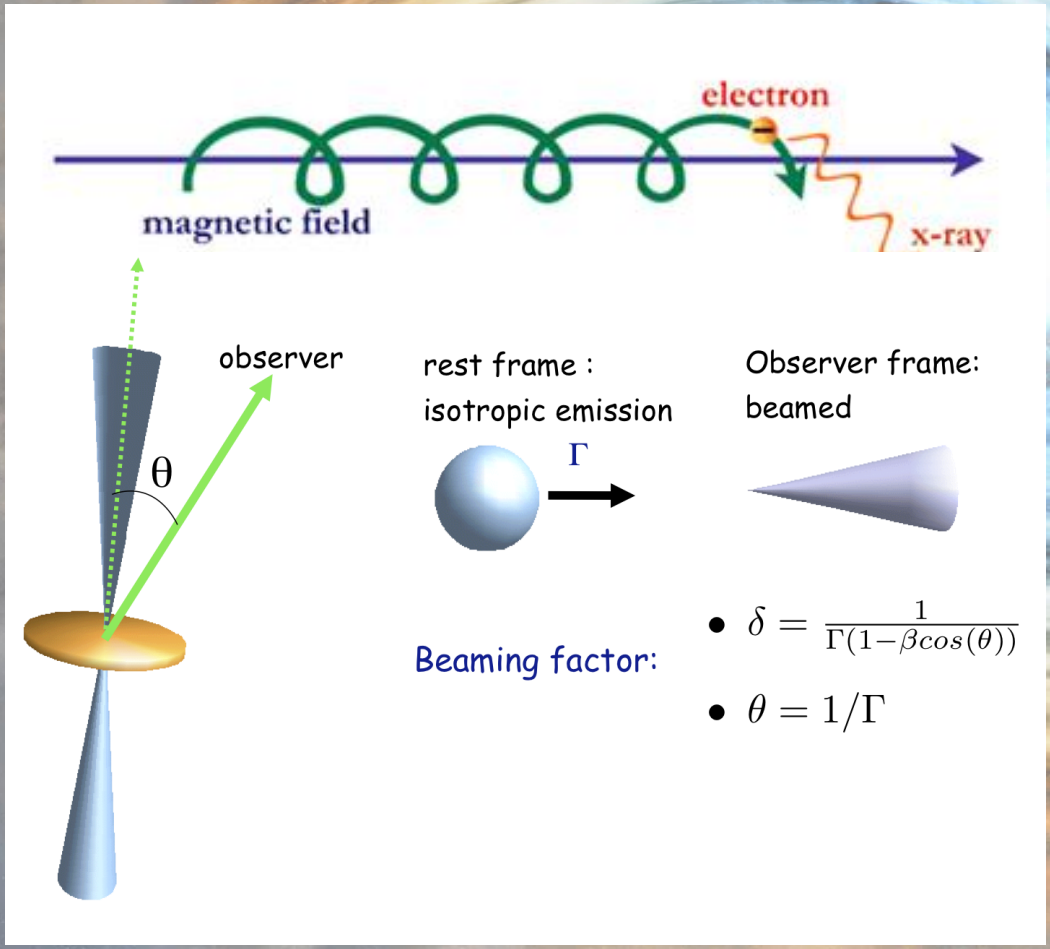
- **Synchrotron peak**: optical emission (radio to UV/X rays)

- **Inverse Compton (SSC/EC) peak**: gamma rays (MeV to TeV energies)

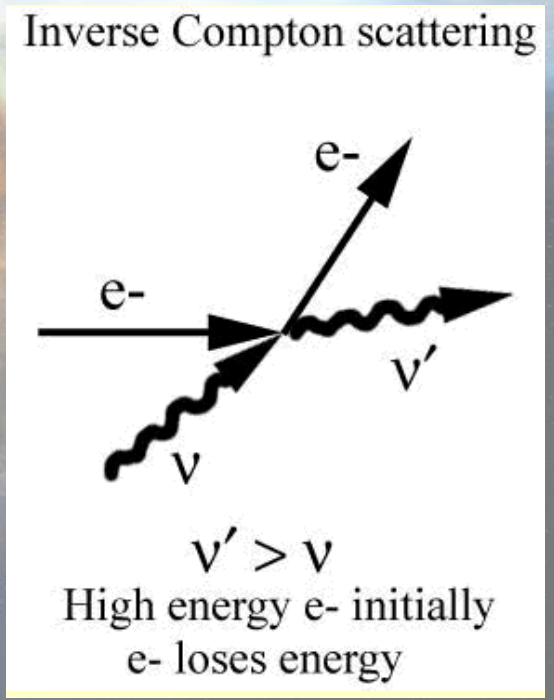


Emission mechanisms:

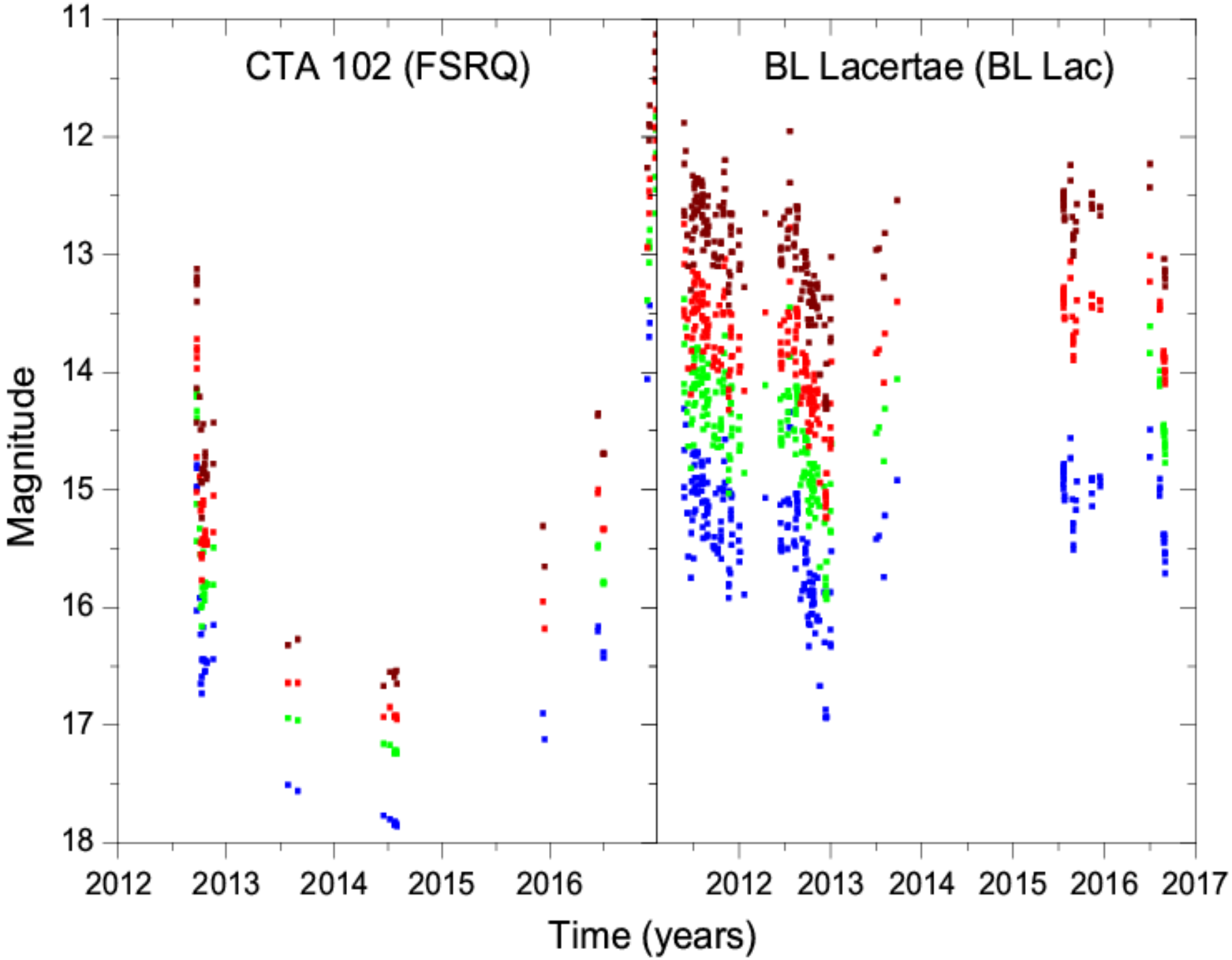
- **Synchrotron** emission is highly beamed for the relativistic case



- (Inverse) **Compton** photon source:
  - Synchrotron photons (SSC)
  - External photons (EC) from the accretion disk, broad line region, etc.



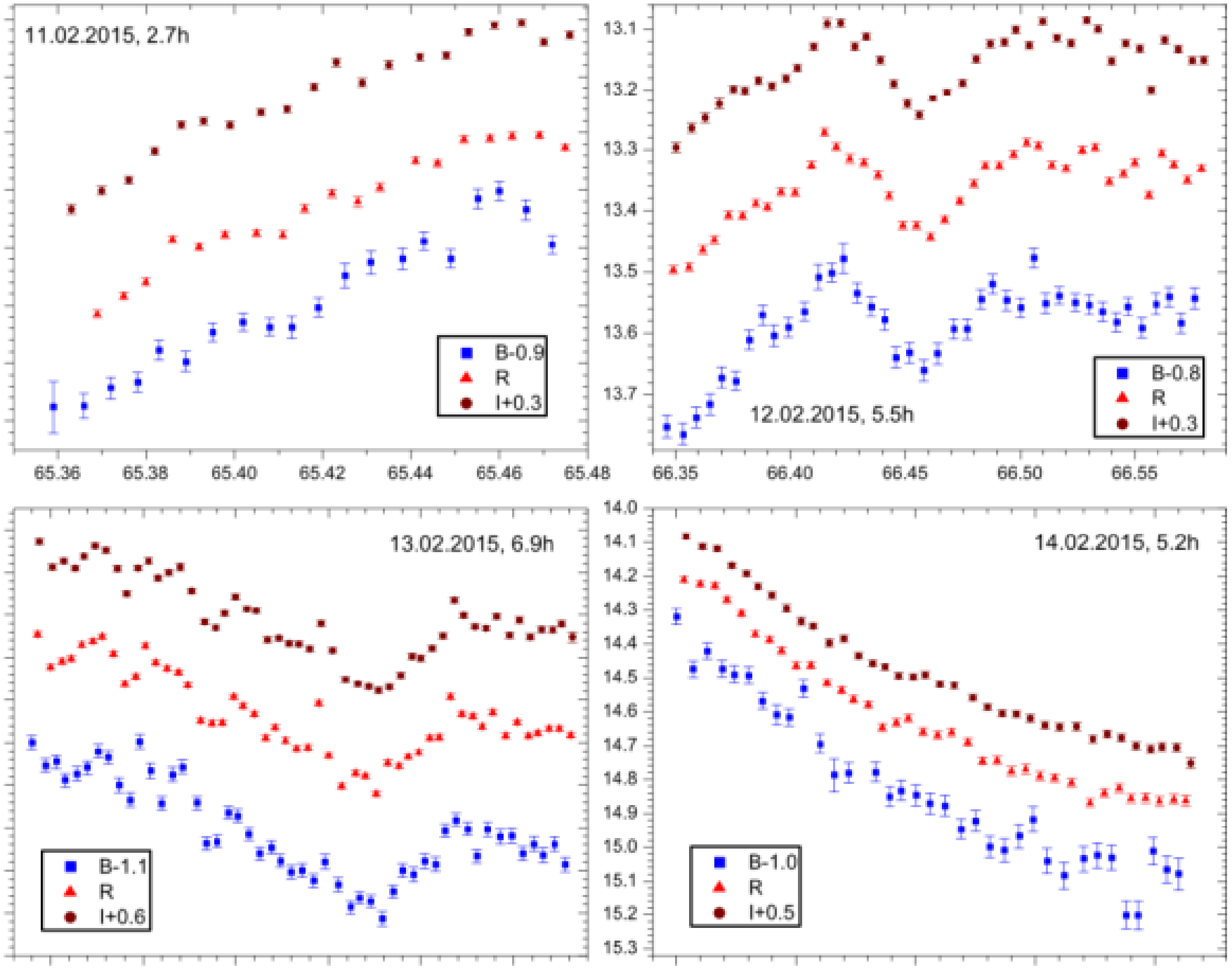
Blazar optical (synchrotron peak) variability: long-term



(from Bachev, 2018)

Blazar optical variability: short-term

(CTA 102 example)



(from Bachev et al., 2016)

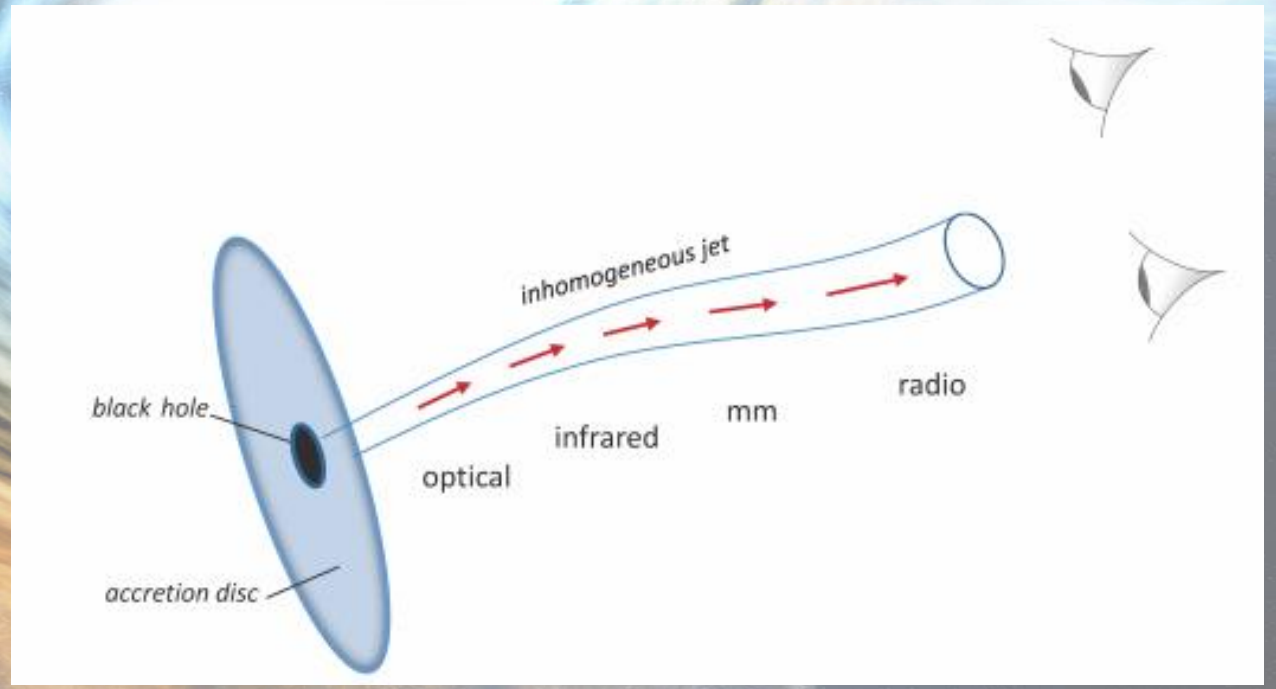
Explaining blazar fast variability

- Fast changing Doppler beaming factor (curved jet)?
- Fast electron energy-density evolution (acceleration/energy losses)?
- Microlensing?

- Tests:
  - Time delays between light curves
  - Time asymmetry of the light curves
  - Simultaneous monitoring at different energies/wavebands
  - Model comparison

Explaining blazar fast variability: Changing Doppler factor – the best explanation so far

- $D = \frac{1}{\Gamma(1-\beta cos\theta)}$; $\mathrm{F}_{obs} \propto D^{3+\alpha}$
- Changing θ from 4 to 0 degrees can change the observed flux 100 times!



(from Raiteri et al., 2017)

Belogradchik observations of blazar variability

- Belogradchik: 620m altitude; 60 cm telescope + SBIG ST8 / FLI PL9000 CCD's; ~150 clear night/yr (~75 usable)
- Blazars observations since 1998 (more actively after 2008)
- Over 1000 single BVRI estimates (50+ objects) + over 500h of monitoring
- Collaborations: India, WEBT, GASP, MAGIC, etc.
- 40+ publications (ApJ, A&A, MNRAS, Nature) on blazar variability with the participation of Belogradchik for the period 2007-2017

Thank you!