Activity cycles of blazars and quasars from the VLBI observations

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Max-Planck-Institute for Radioastronomy, Bonn

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Max-Planck-Institut für Radioastronomie

MAX-PLANCK-GESELLSCHAFT

Fulfilled projects

Collaborators

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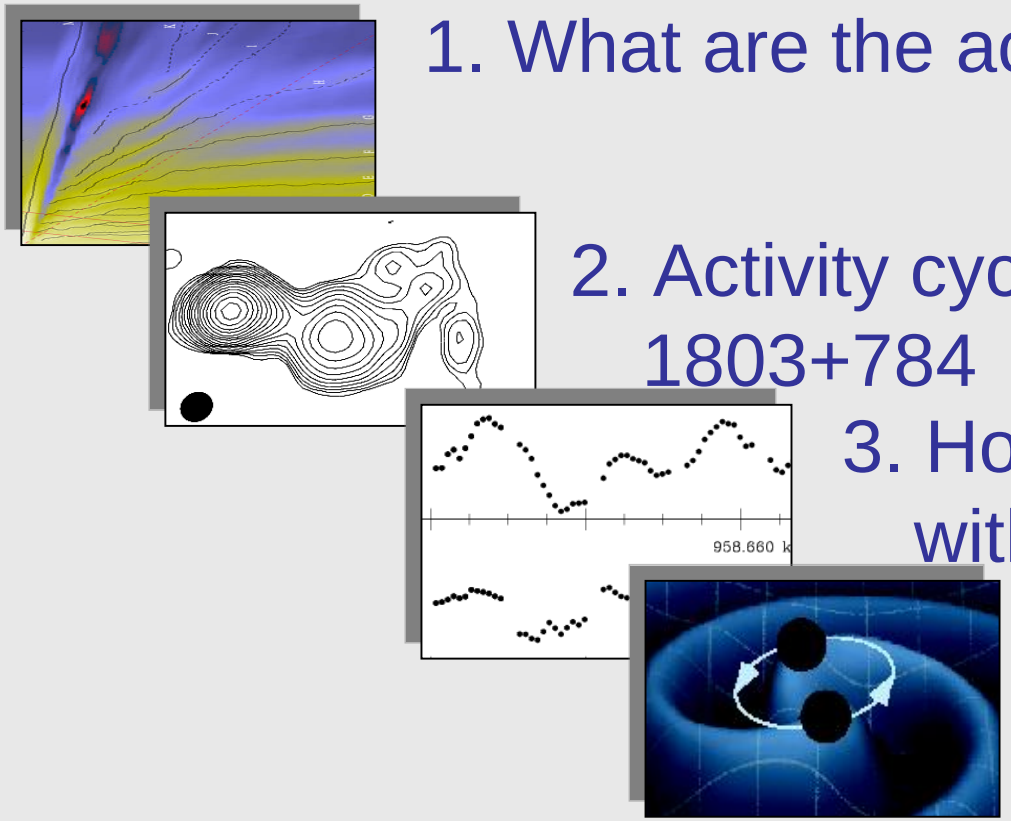
- Margo Aller, Hugh Aller (Uni. Michigan))
- Harri Teräsranta, Merja Tornikoski, Kaj Wiik, Tapio Pursimo, Liza Rastorgueva (Metsahovi Observatory, Tuorla Observatory)

Outline



1. What are the activity cycles?

2. Activity cycle of the blazar S5 1803+784

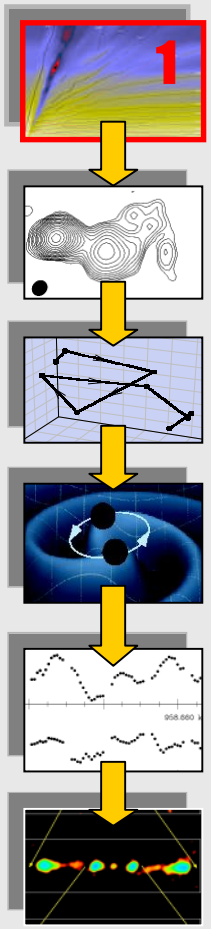
3. How the cycle evolves with time

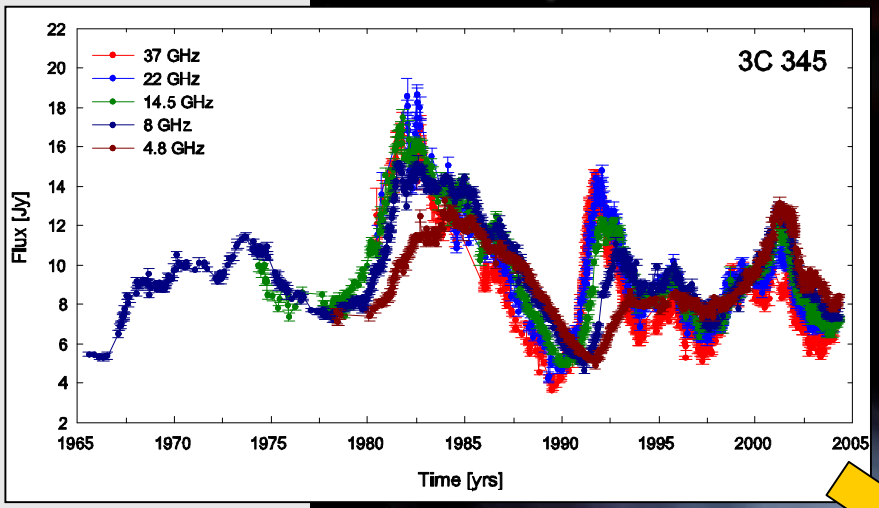
4. AGN with periodical light curves and periodical optically thick flares

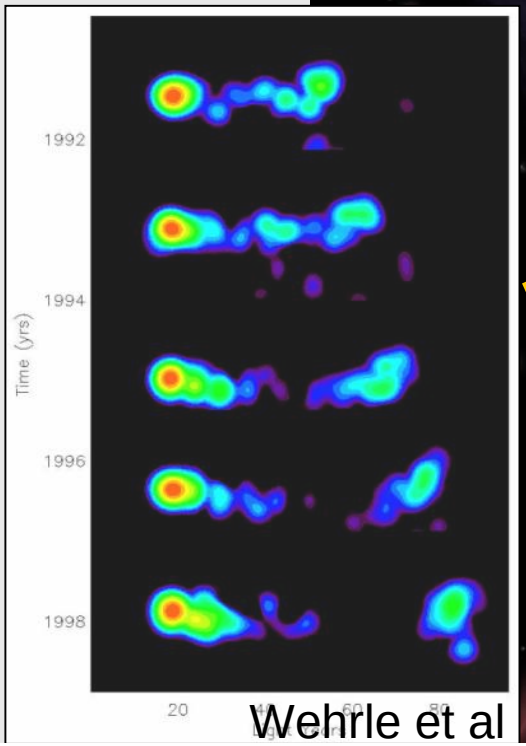
Summary

Activity cycles

1. Introduction





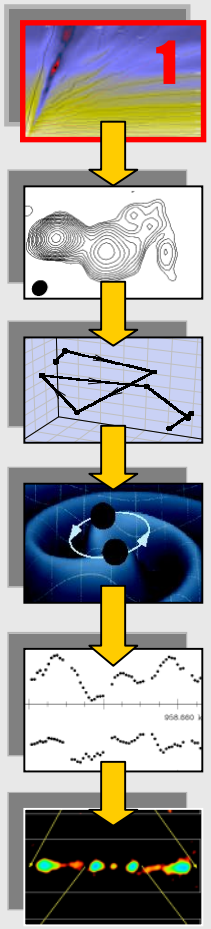


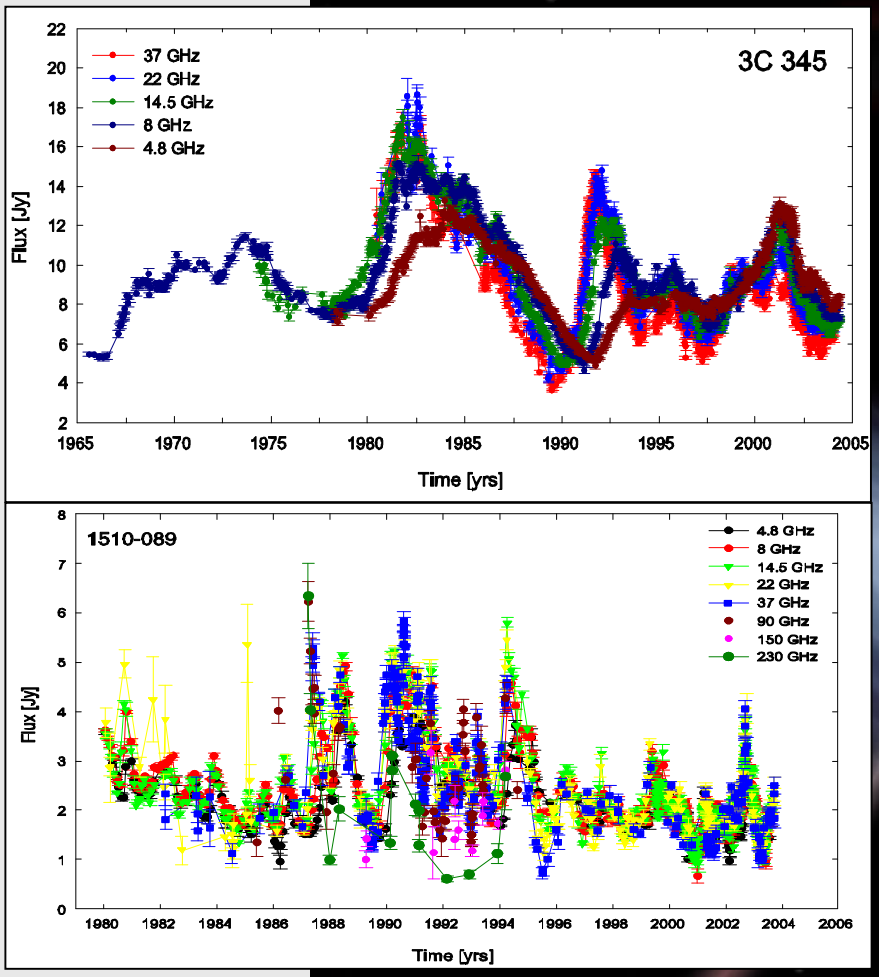
Wehrle et al

Active galactic nuclei

Activity cycles

1. Introduction

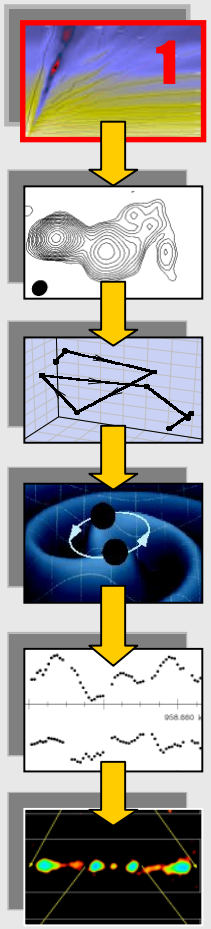


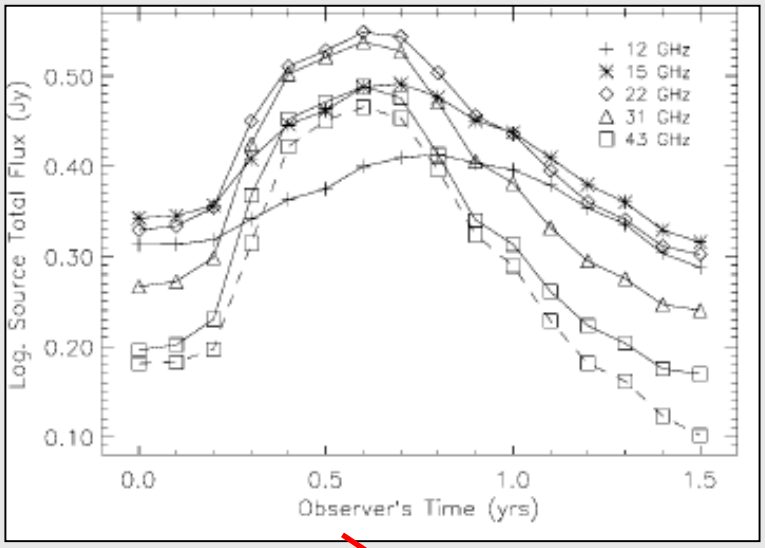


Variability of Active Galactic Nuclei is very complicated – many complex

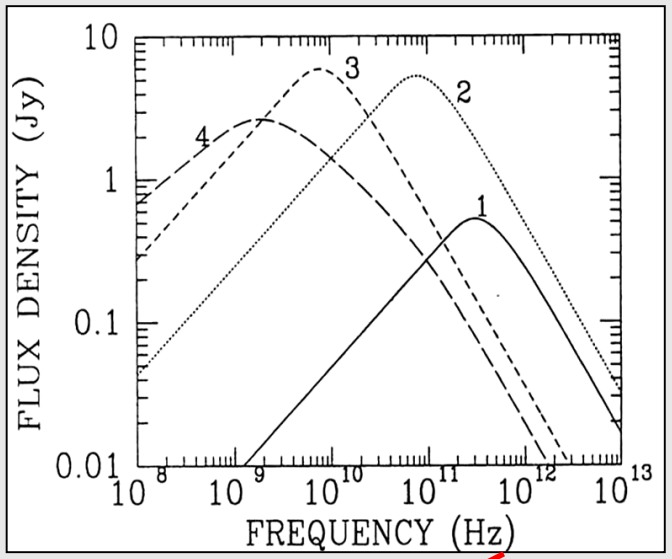
Activity cycles

Evolution of a primary perturbation in the base of the jet



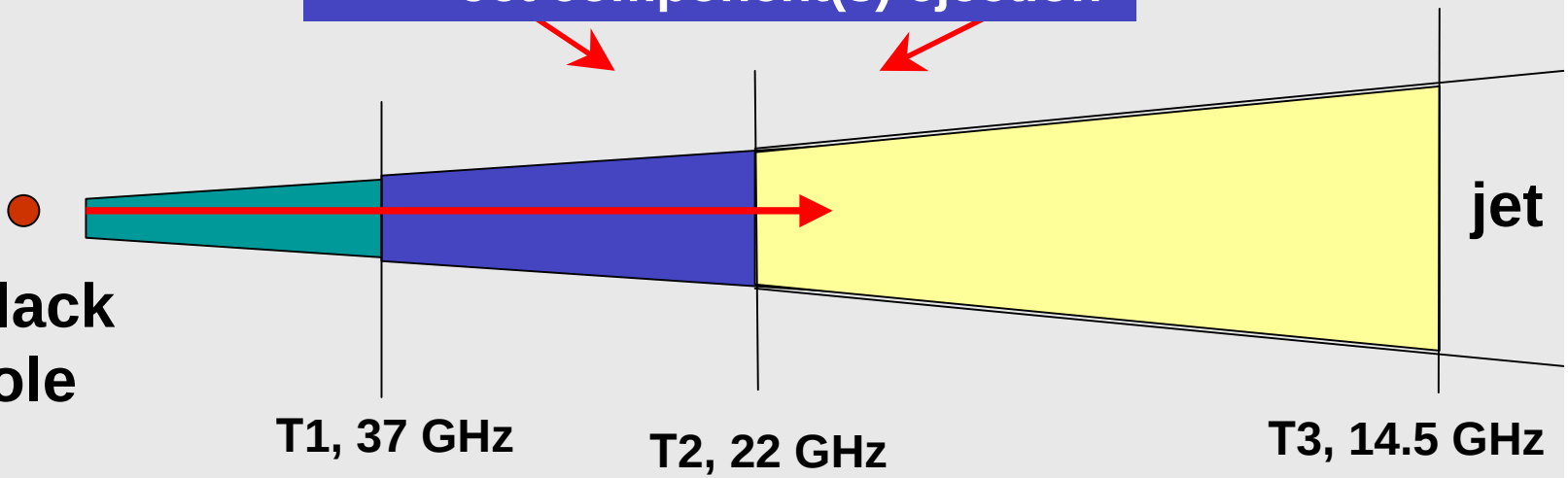


Gomez (1997)



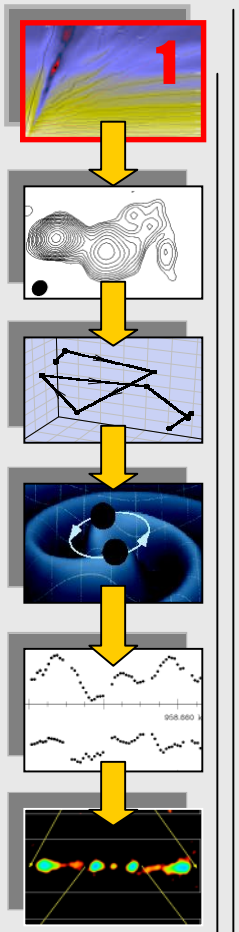
Marscher (1992)

+ Jet component(s) ejection

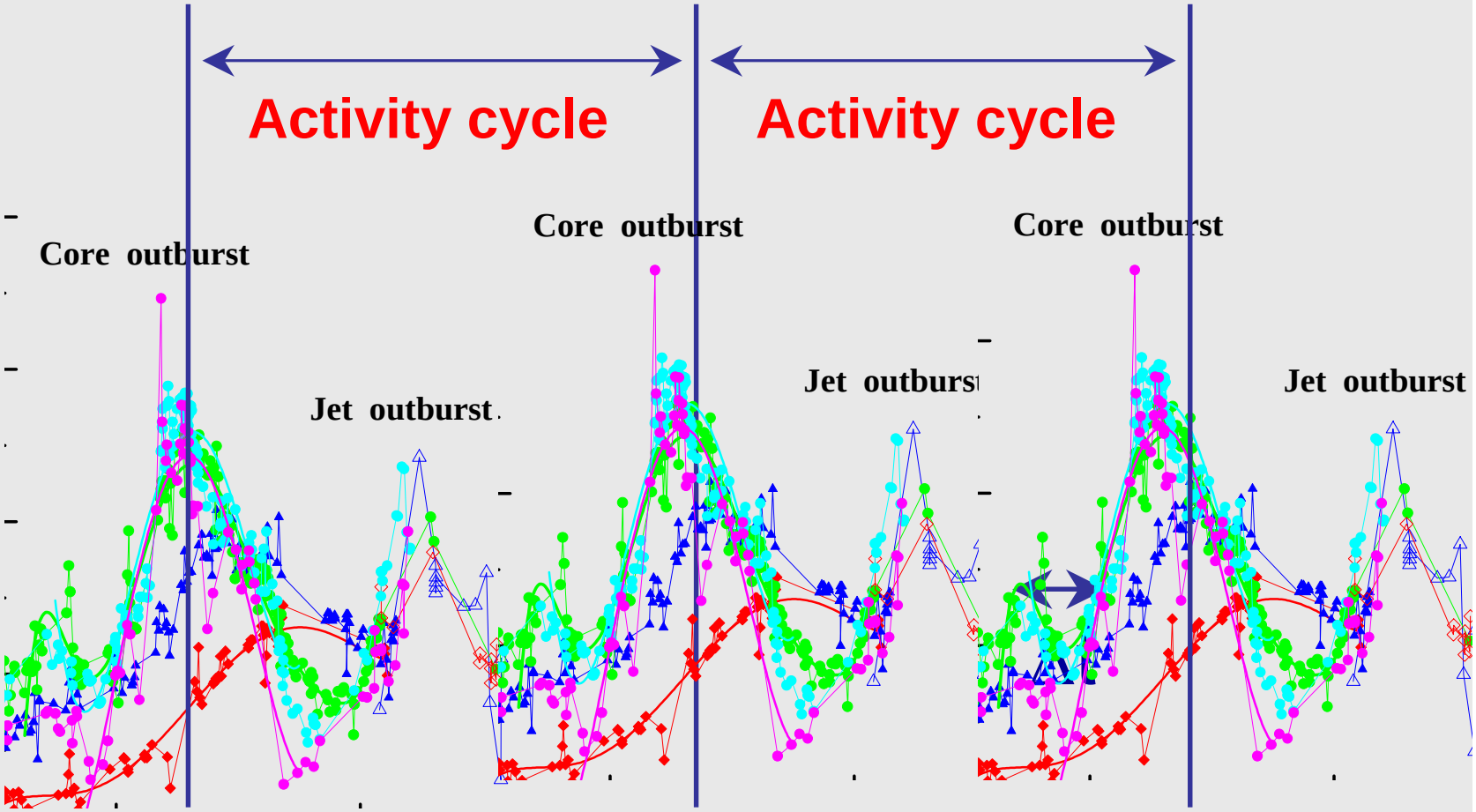


Activity cycles

Evolution of a primary perturbation in the base of the jet



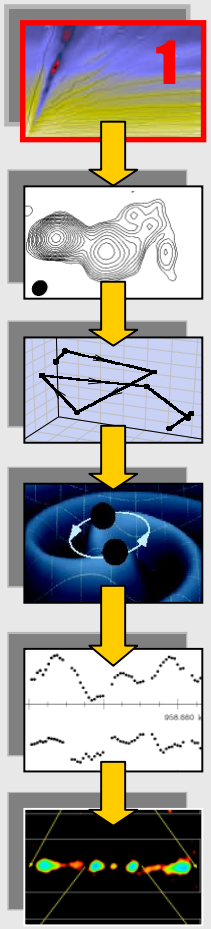
Activity cycle = Time between two flares with VLBI Component(s) ejections, large time delays, spectral evolution



Activity cycles

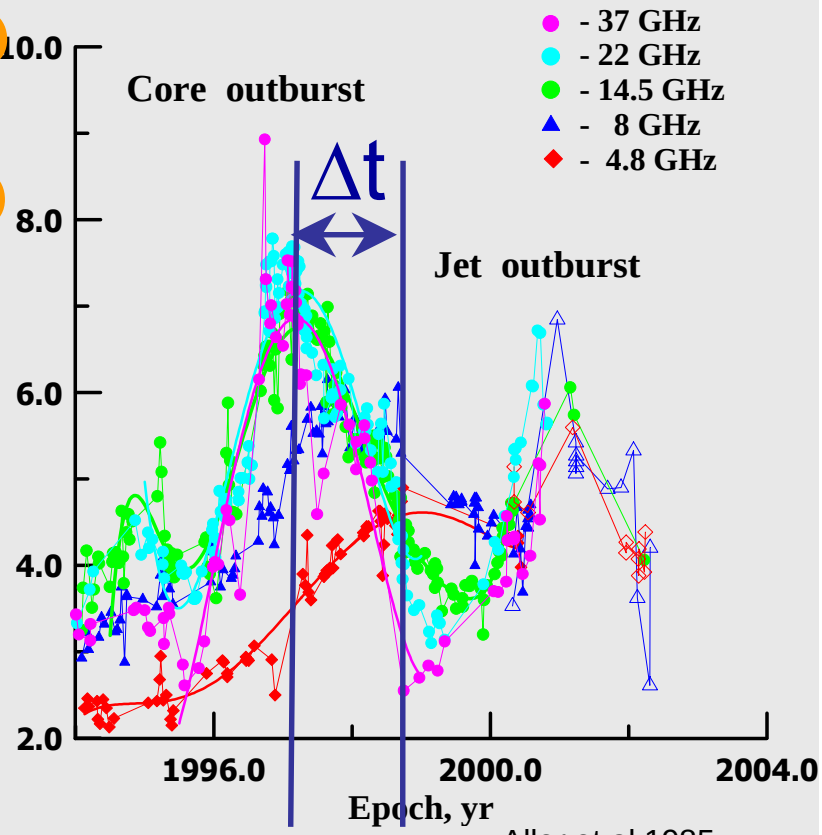
Observations

1741-038



- How the jet structure evolution is connected with outbursts?
- Which flares are coming from the core and which from the jet?
- How long are the

Calculated spectra, time lags, analyzed VLBI data, compared the total flux-density variability with the jet structure evolution



Aller et al 1985
Terasranta et al. 1995
Jorstad et al. 2001, 2002

43 GHz VLBI Monitoring + archival data

+

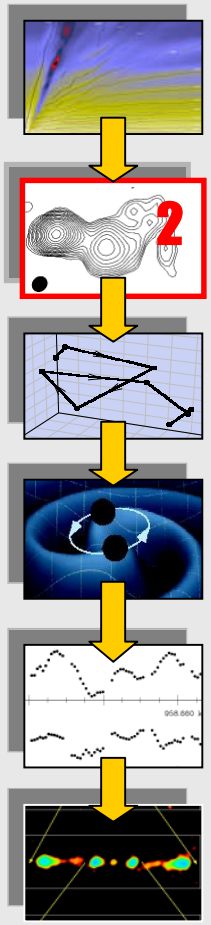
UMRAO Monitoring 4.8, 8, 14.5 GHz + archival data

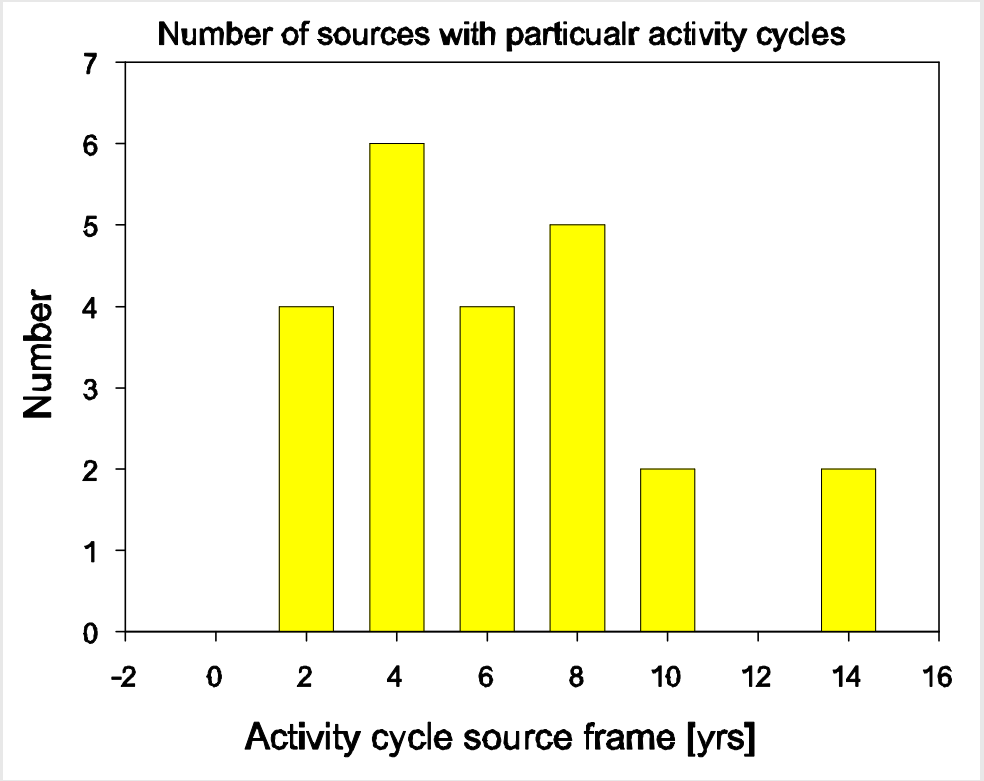
+

Metsahovi Monitoring 22, 37 GHz + archival data

Activity cycles

Average activity cycle duration





-- Analysed light curves and VLBI structure changes for 21 sources

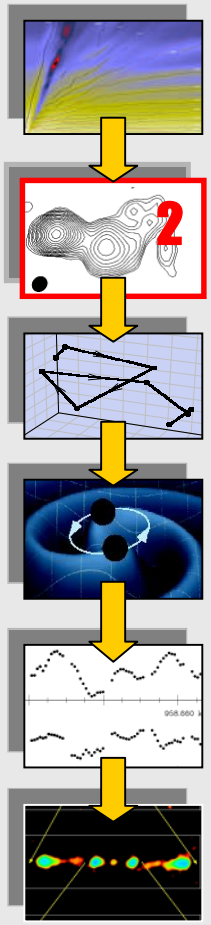
-- 15 quasars, 4 blazars and 1 radio galaxy

-- Activity cycles are

0059+581, 0133+476, 0202+149, 0316+413 (3C 84), 0458-020, 0528+134, 0735+178, 0923+392 (4C 39.25), 0945+408, 1308+326, 1510-089, 1641+399 (3C 345), 1730-130, 1739+522, 1741-038, 1803+784, 2145+067, 2223-052 (3C 446), 2230+114 (CTA 102), 2251+158 (3C 454.3)

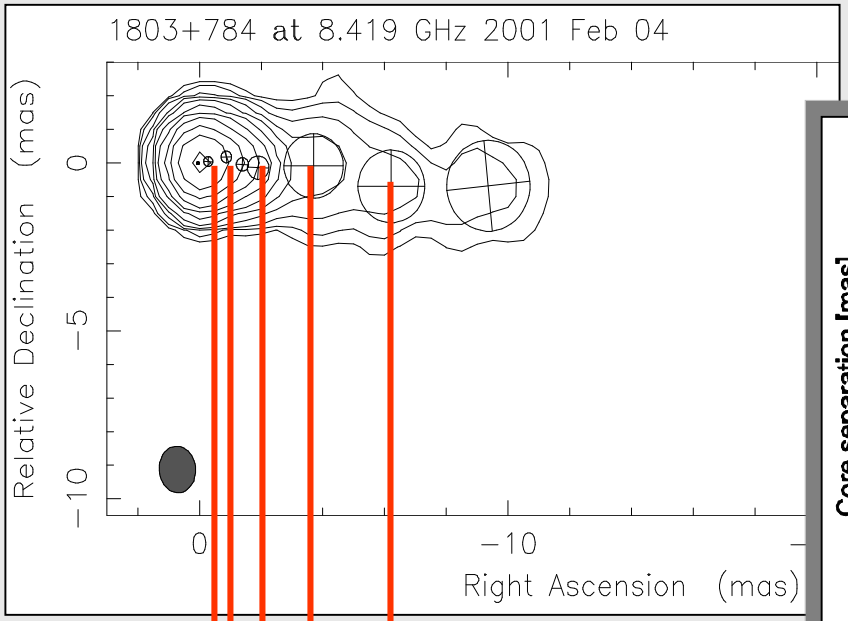
Activity cycles

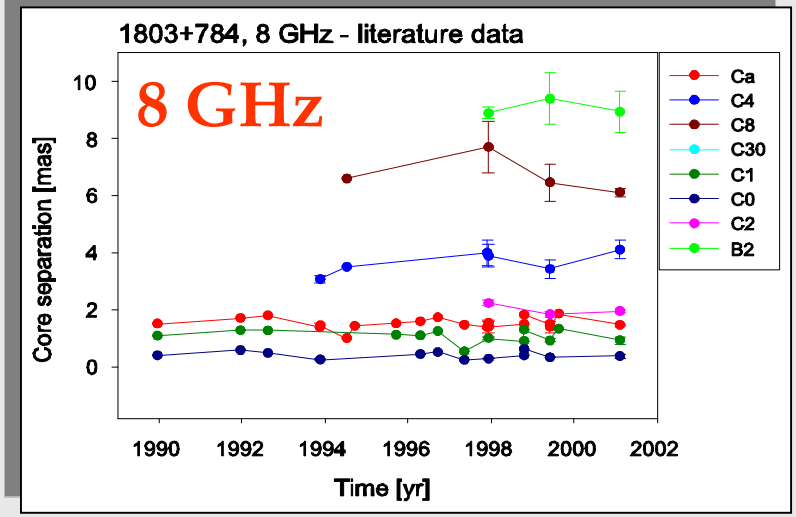
Kinematics of the blazar S5 1803+784

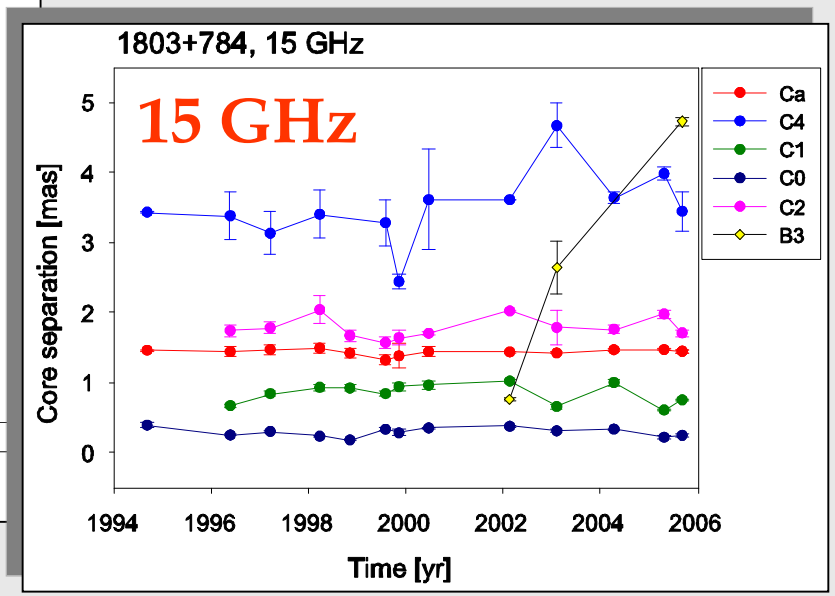


94 VLBI epochs at 1.6 GHz, 2.3 GHz, 5 GHz, 8 GHz, 15 GHz, 22 GHz

Marscher et al. 1985, Kellermann et al. 1998, Perez-Torres et al. 2000, Ros et al. 2000, 2001, Guirado et al. 2001, Britzen et al., 2005, Gurvits et al. priv. comm., Fey et al. 1996, Lobanov et al. 2000, Lister et al. 2001, Ros et al. 2001, Tateyama et al. 2002







Activity cycles

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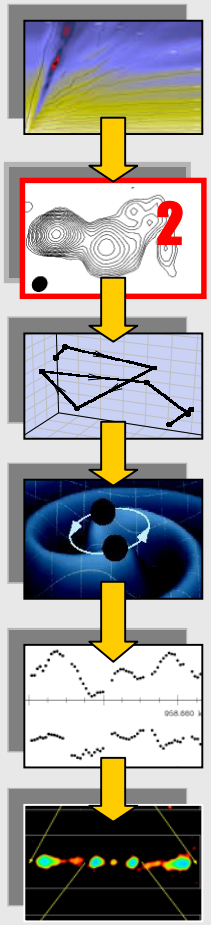
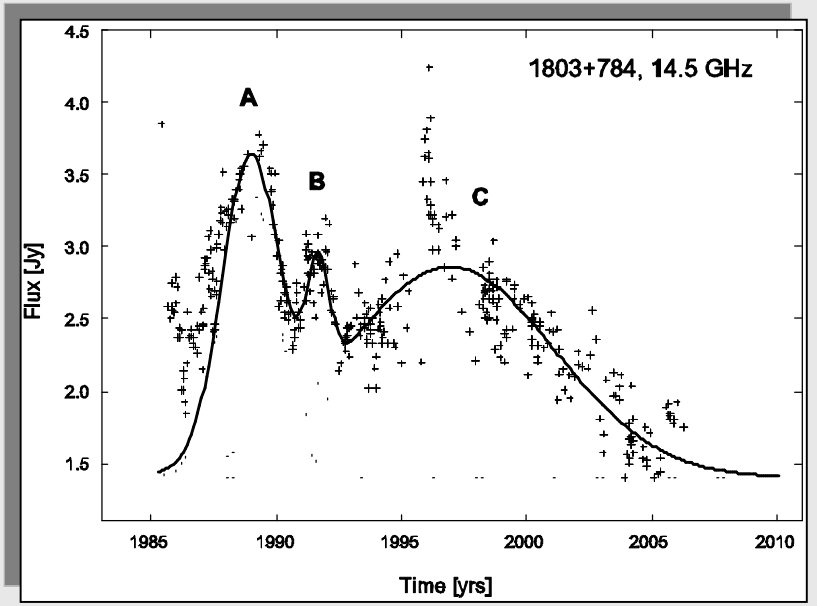
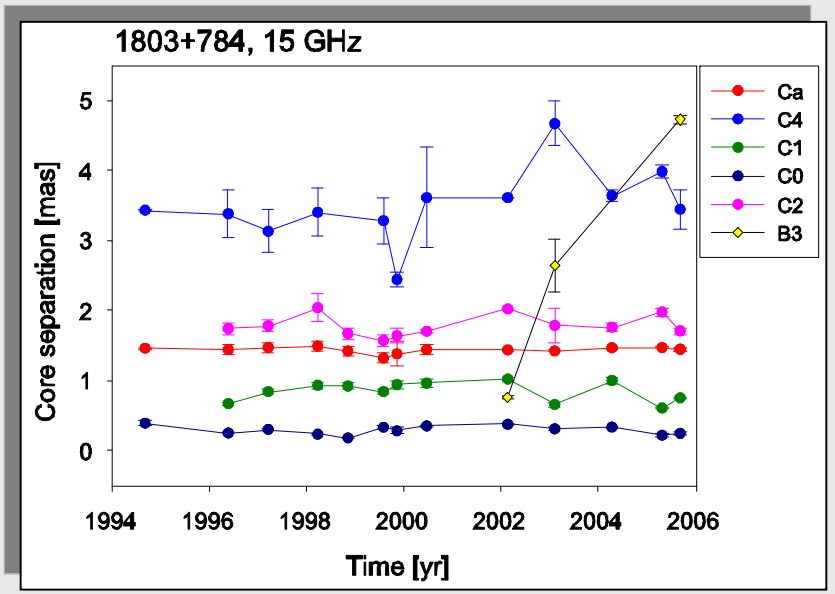


Seven jet components which remain stationary over 25 years.
Only one flare, last broad outburst C shows large opacity and time delays

→

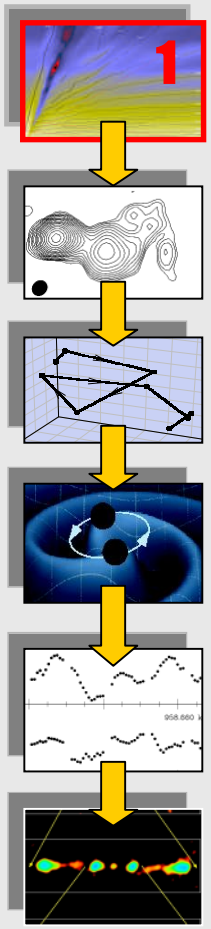
Activity cycle of S5 1803+784 is more than 25 years

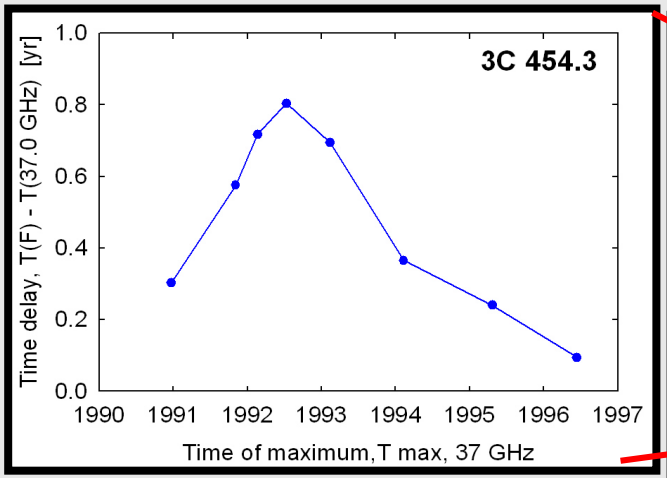


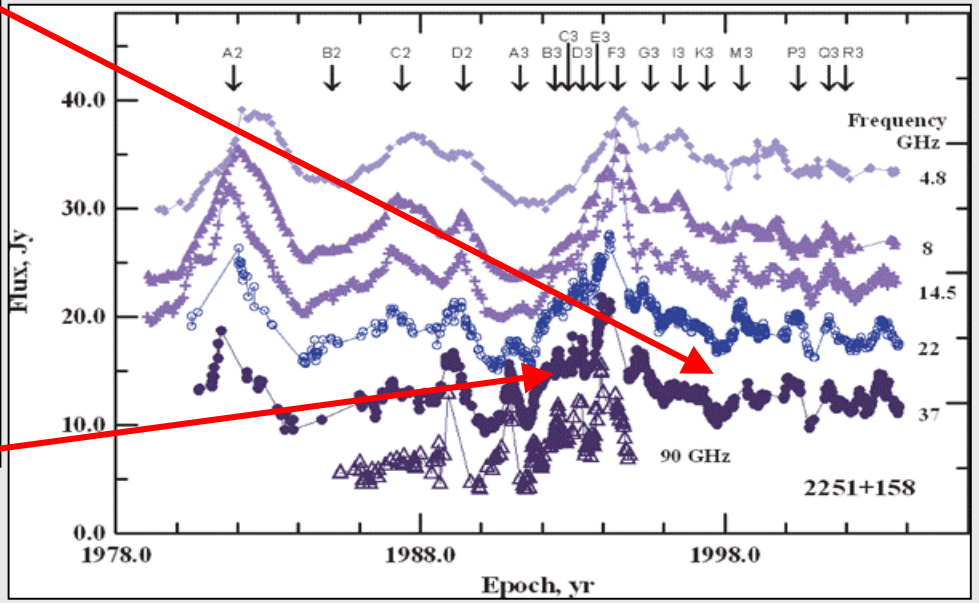


Activity cycles

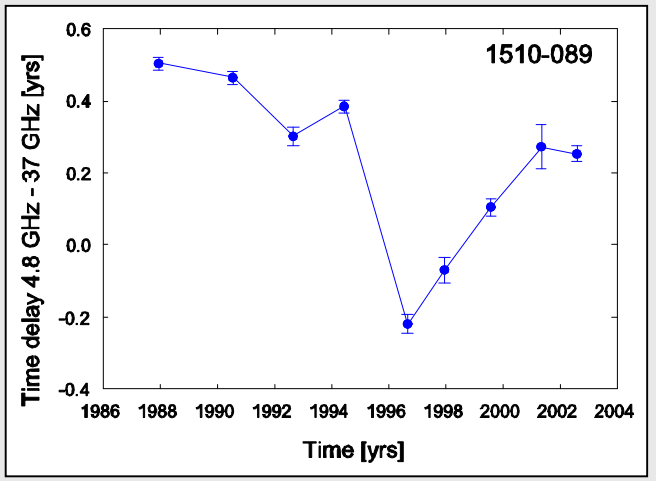
How an activity cycle evolve with time





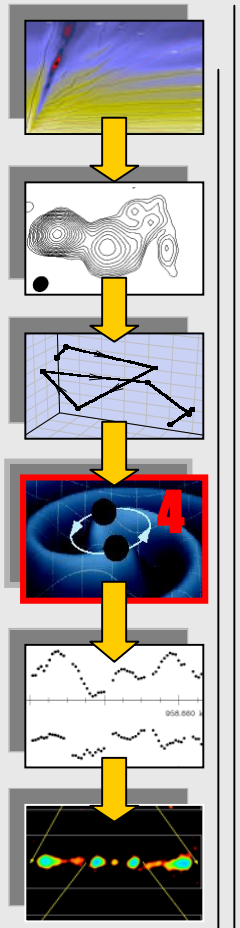


- **Time delays, spectra, amplitude and width of the flares changing gradually and accompanied with the jet component ejections after the maximum for 2145+067, 3C 446 (2223-052), 3C 454.3, 0133+476**
- **→ these outburst is an evolution of one perturbation in the base of**



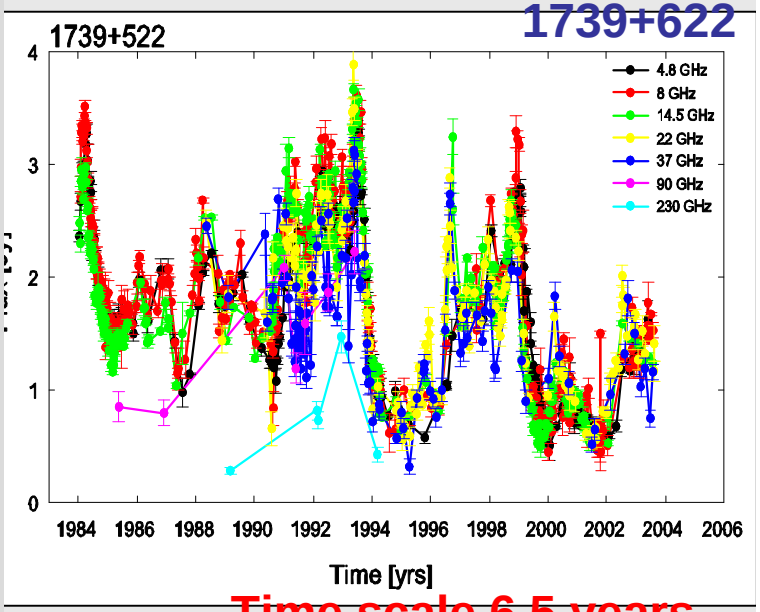
Activity cycles

AGN with periodical light curves



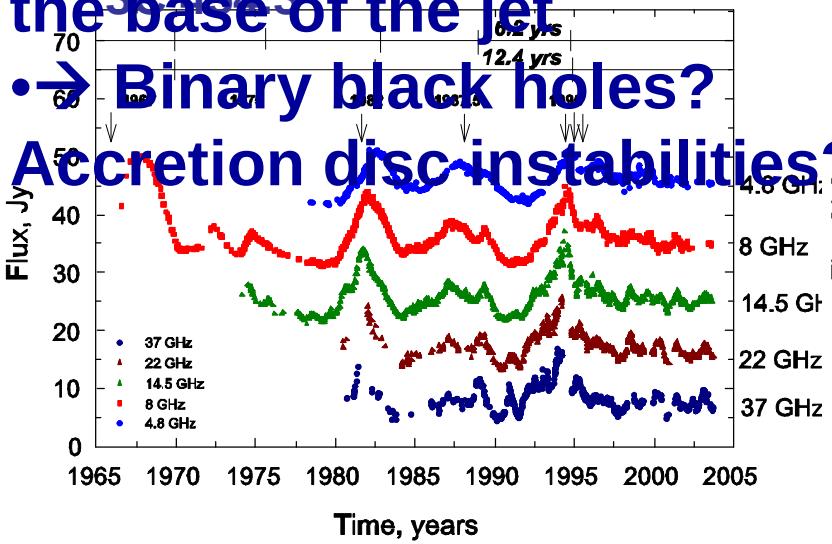
- For four sources we found that activity cycles coincides with periodicity in the total flux-density variability and VLBI structure changes
- → Something causes periodical perturbations of the base of the jet
- → Binary black holes? Accretion disc instabilities?

1739+622



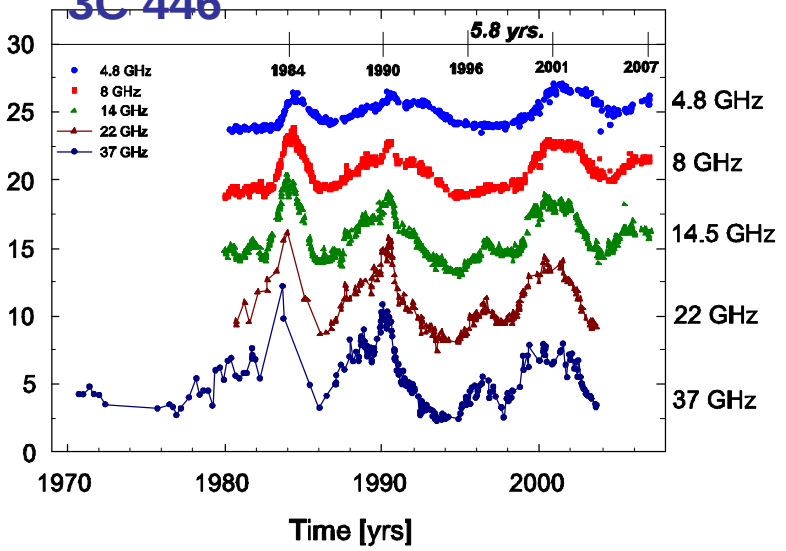
Time scale 6.5 years

3C 454.3



Time scale 12.4 years

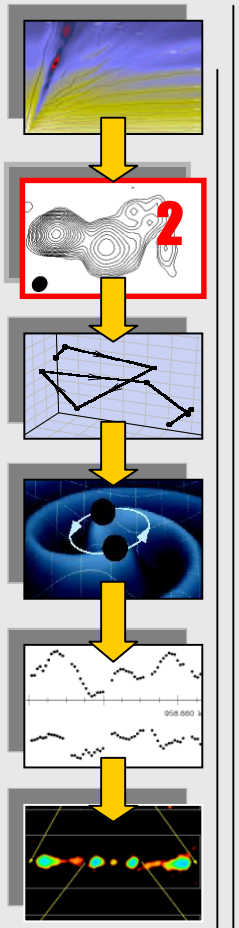
3C 446



Time scale 6.8 years

Activity cycles

Summary



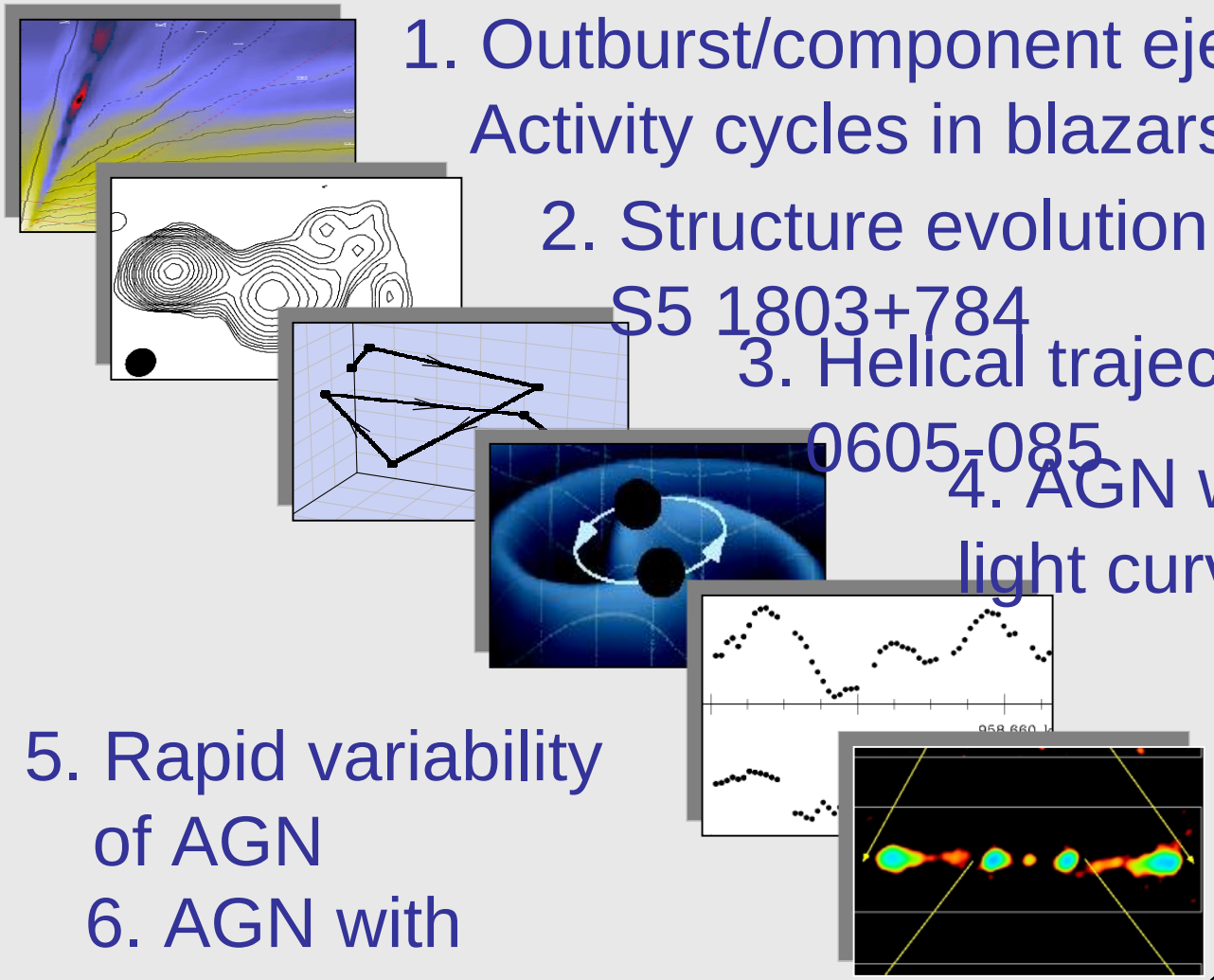
Kudryavtseva et al. 2007, Kudryavtseva & Pyatunina 2006, Britzen, Kudryavtseva, Witzel et al. 2008, Kudryavtseva et al. 2008 PhD thesis, Pyatunina, Kudryavtseva, Gabuzda et al. 2006, 2007

Main results:

- Applied a new method of calculating activity cycles from total flux-density analysis and VLBI structure changes
- Calculated activity cycles of 21 blazars and quasars
- Activity cycles are long – are in average 4-8 years in source frame
- Can last for more than 25 years with one jet component ejection per 25 years
- During the cycle the frequency-dependent time lags, opacity, amplitudes of the flares and widths are changing gradually → jet component(s) are ejected during the maximum opacity which can be explained with the shock-in-jet model

Fulfilled projects

Research experience



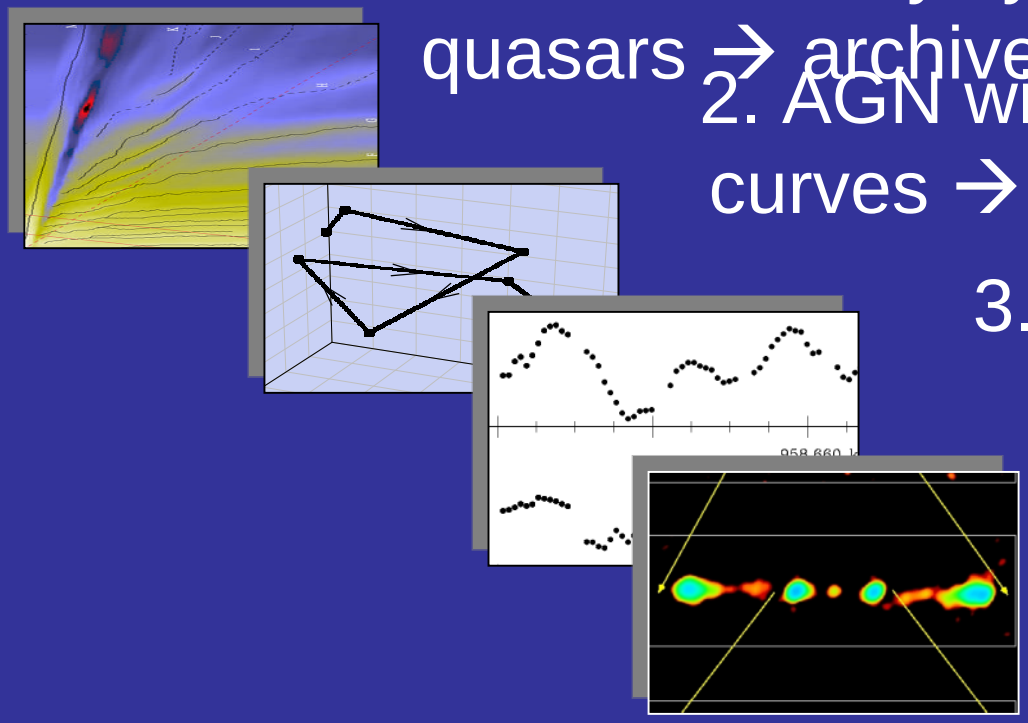
1. Outburst/component ejection relation. Activity cycles in blazars and quasars
2. Structure evolution of the blazar S5 1803+784
3. Helical trajectory in 0605-085
4. AGN with periodical light curves
5. Rapid variability of AGN
6. AGN with restarted activity

Proposed projects

Fulfilled projects

Proposed projects

1. Outburst/component ejection relation. Activity cycles in blazars and quasars → archives, EVN, VLBA

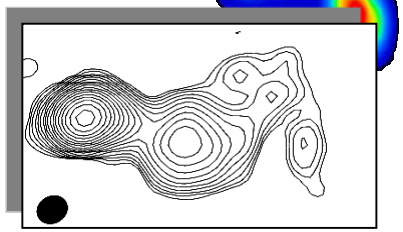


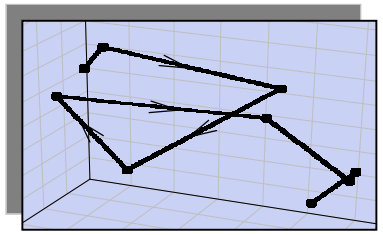
2. AGN with periodical light curves → WSRT, EVN

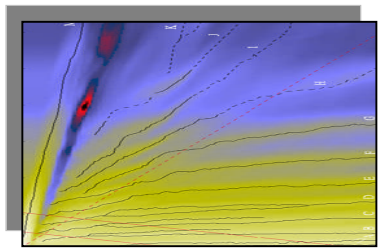
3. Rapid variability of AGN → WSRT, Lofar

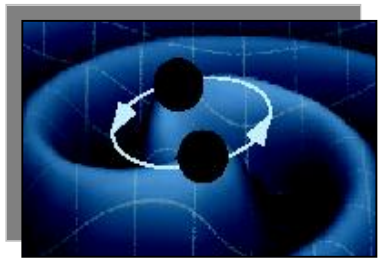
4. AGN with restarted activity → Lofar

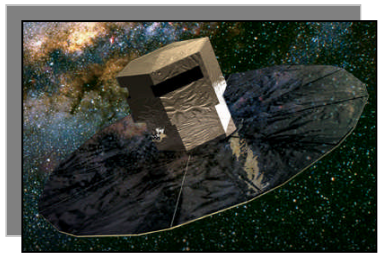
Outline











Outburst/component ejection relation

Activity cycles in blazars and quasars

~~Structure evolution of the~~ blazar

S5 1803+784: observations vs. theory

~~Helical trajectory in 0605-085~~

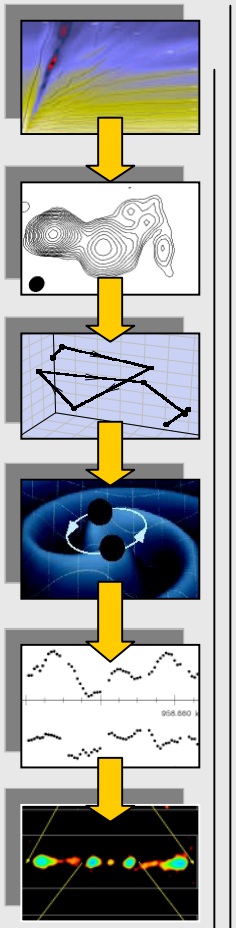
AGN with periodical light curves

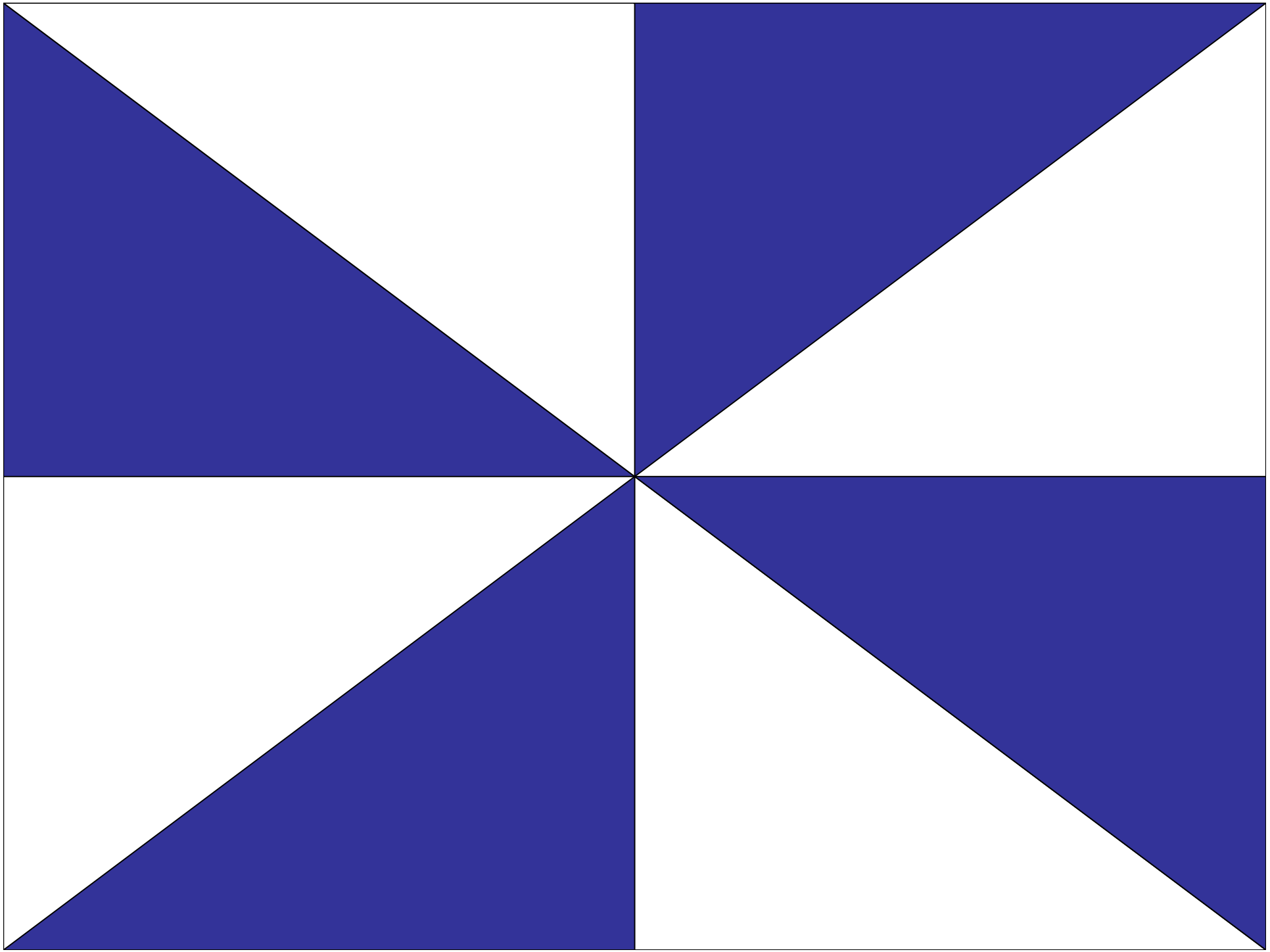
Rapid variability of AGN

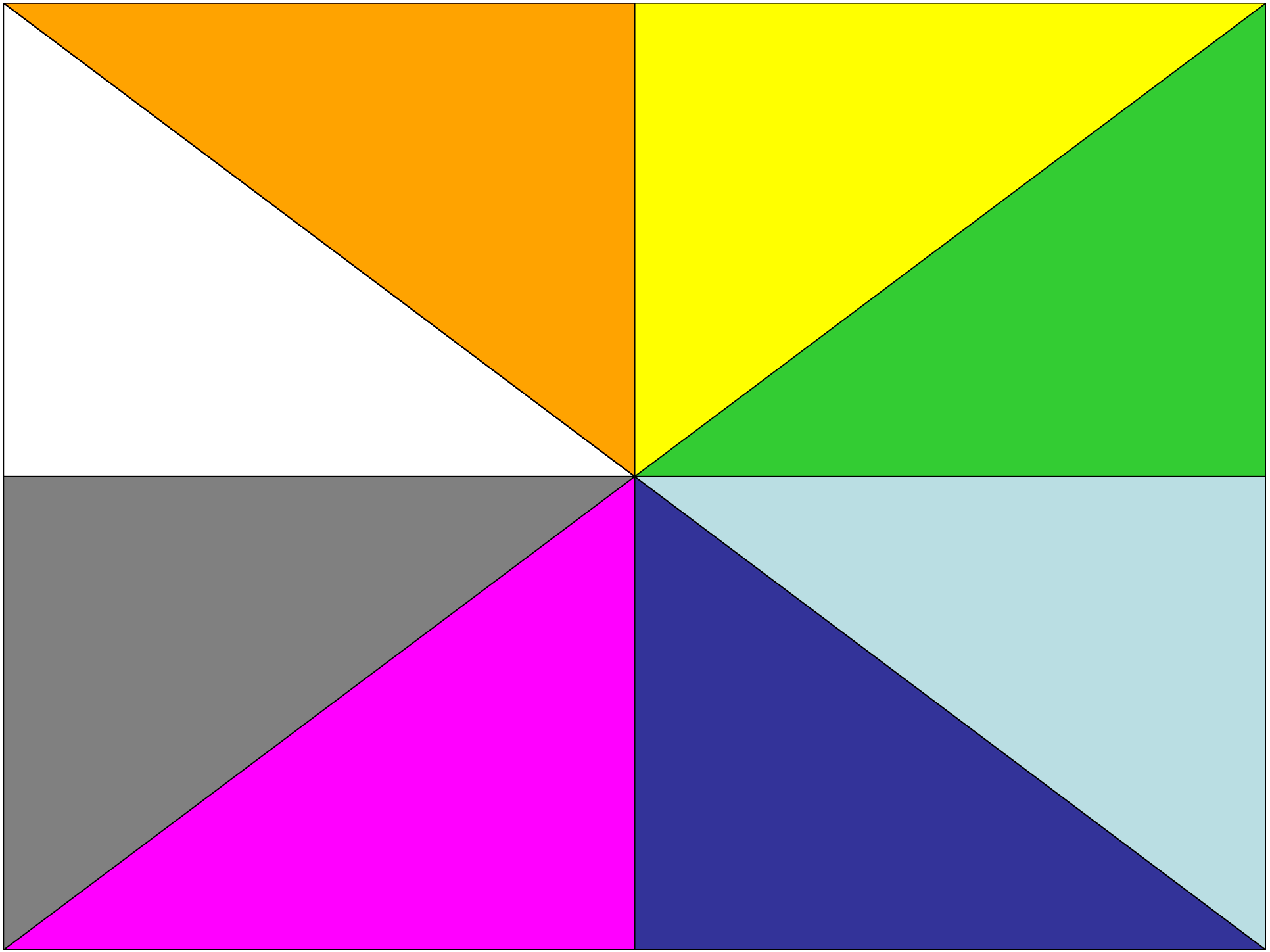
~~AGN with restarted activity~~

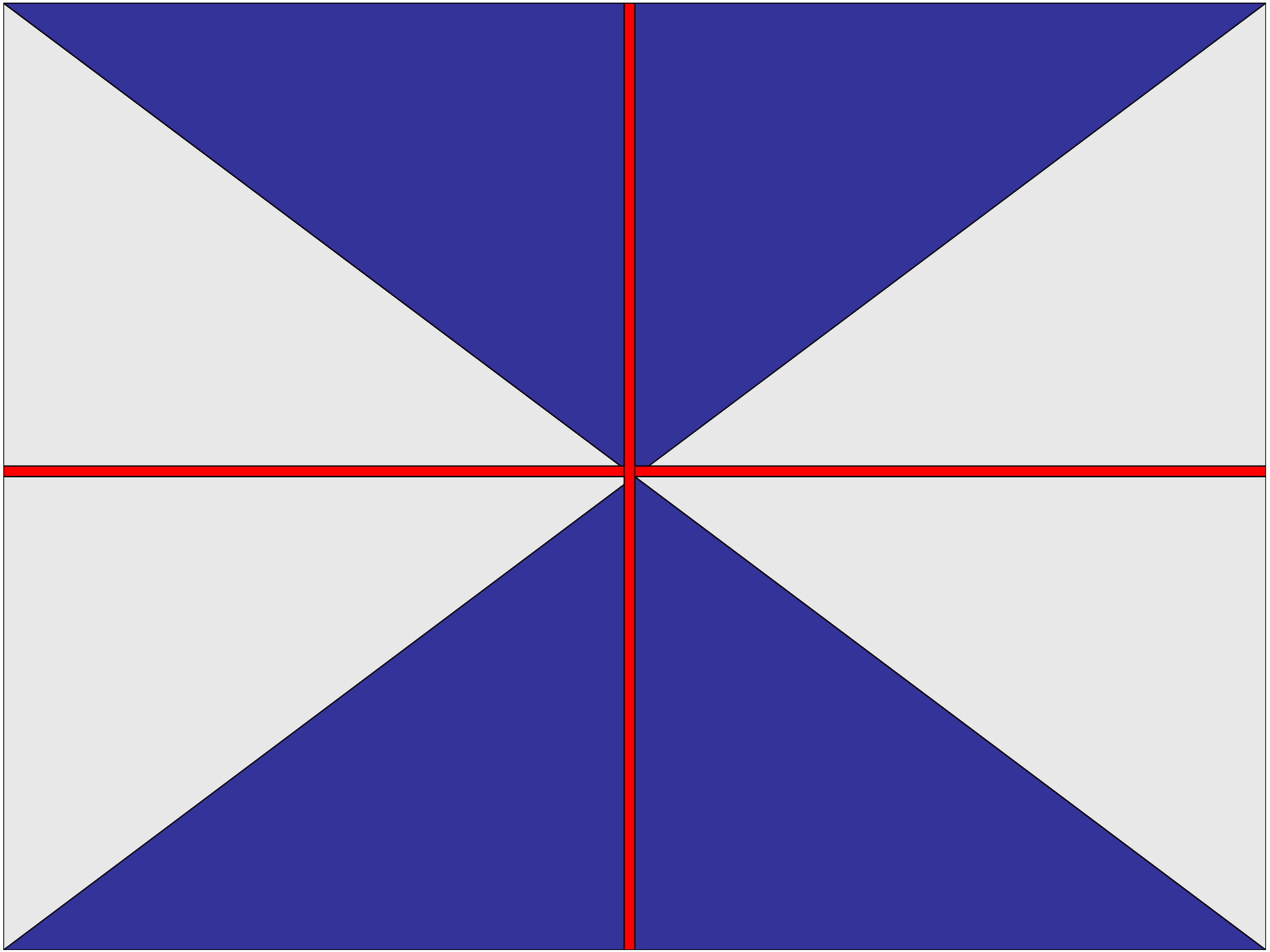
Fulfilled projects

1. Outburst/component ejection relation. Activity cycles in blazars and quasars









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