Multi-band time-lapse of the western jet of XTE J1550-564

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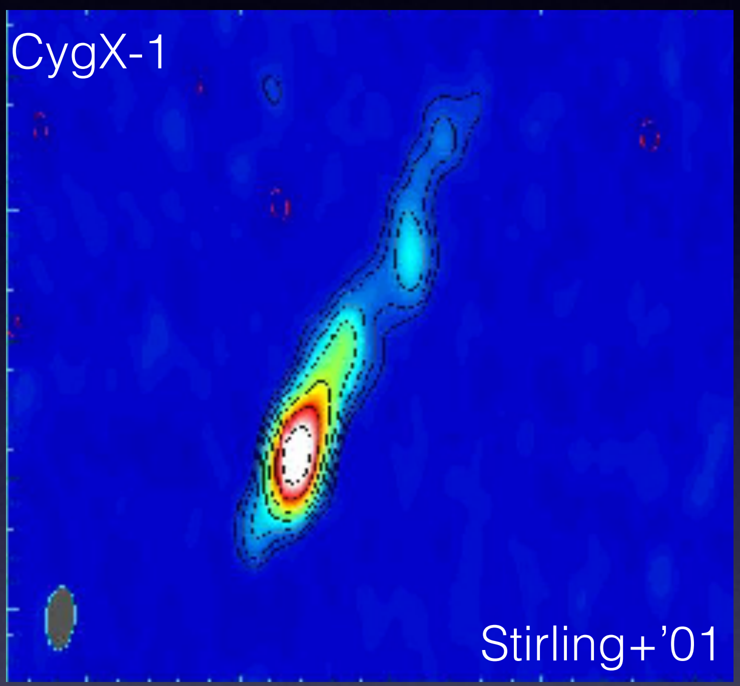
Jet flavors in X-ray binaries

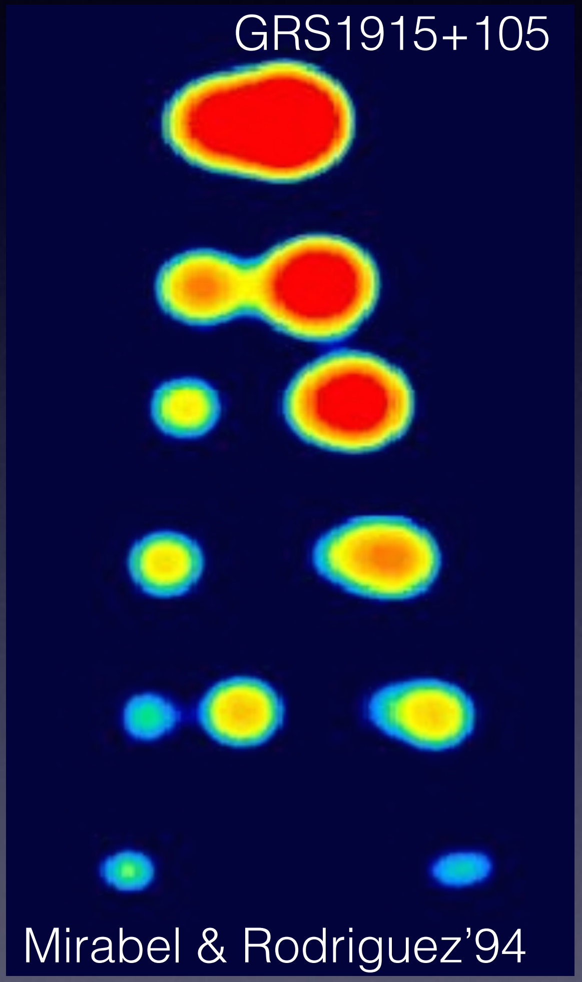
compact, persistent radio jets (~10 AU)

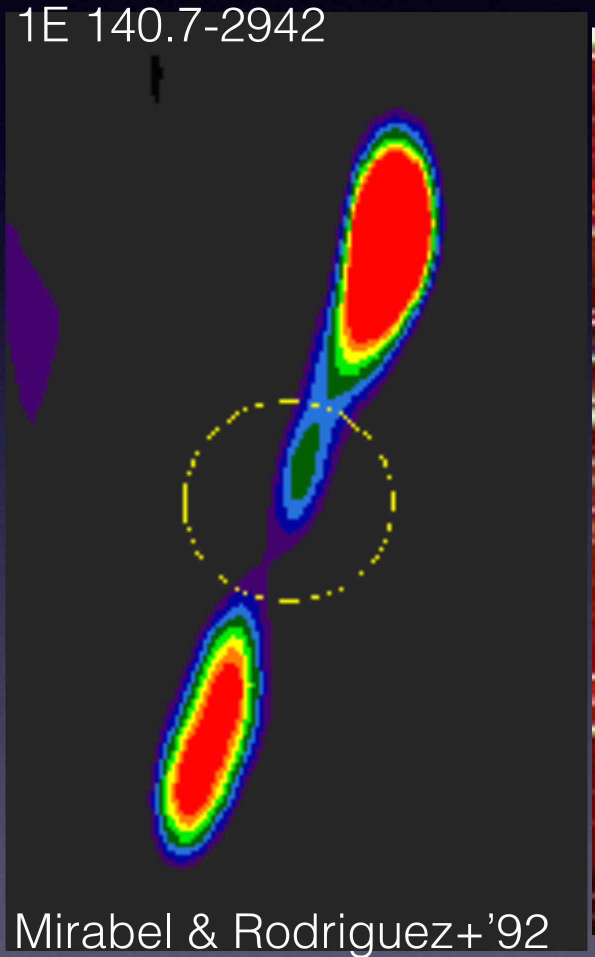
transient, relativistic radio jets (~100s AU)

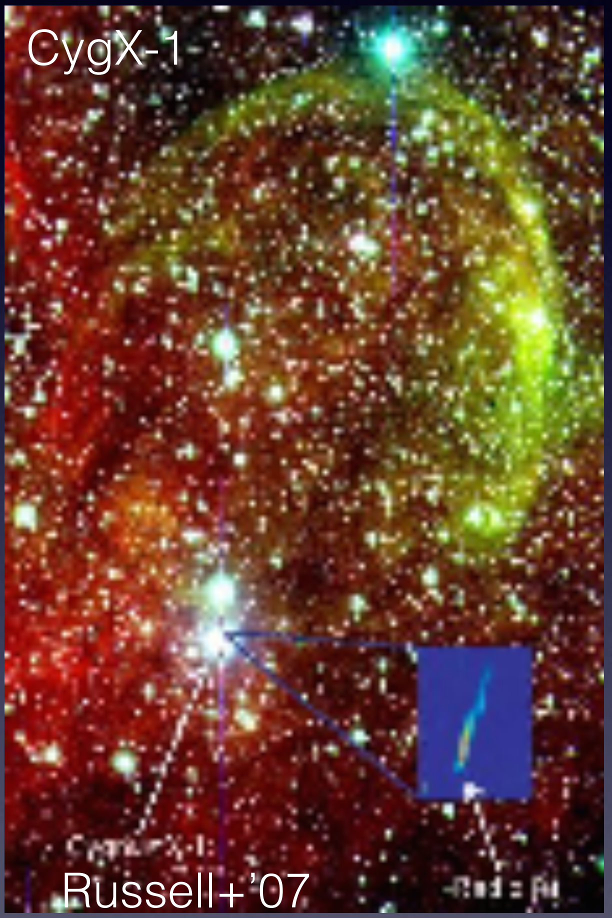
large scale jets (up to~10s pc)

radio lobes/ cavities



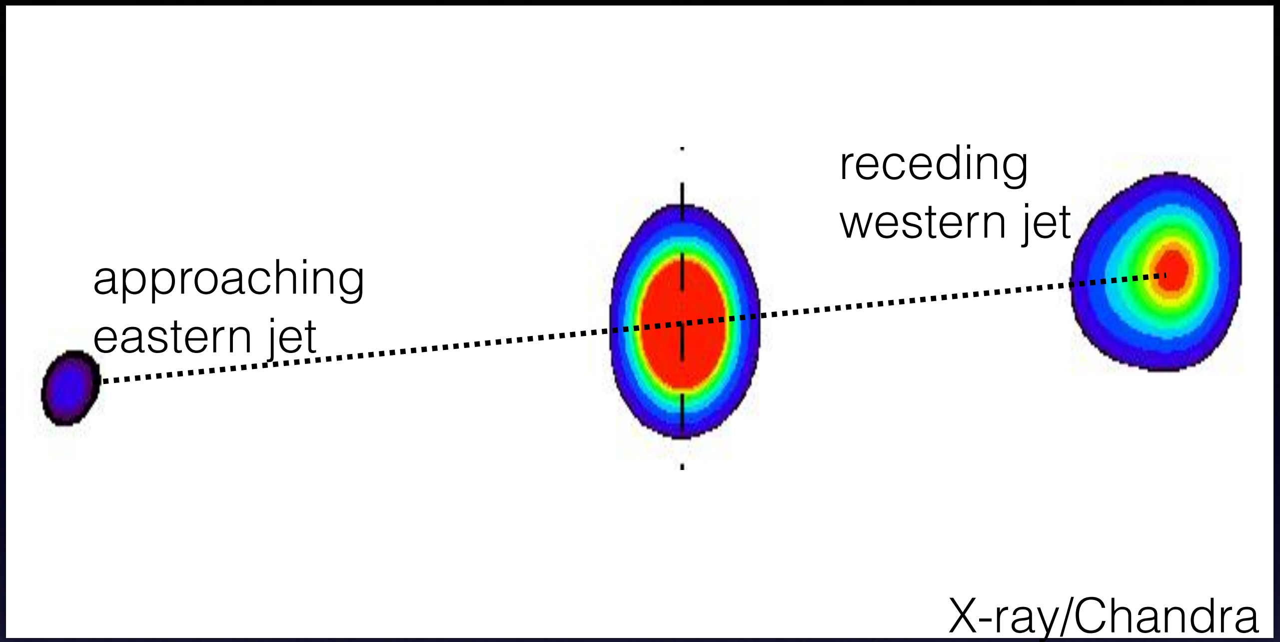






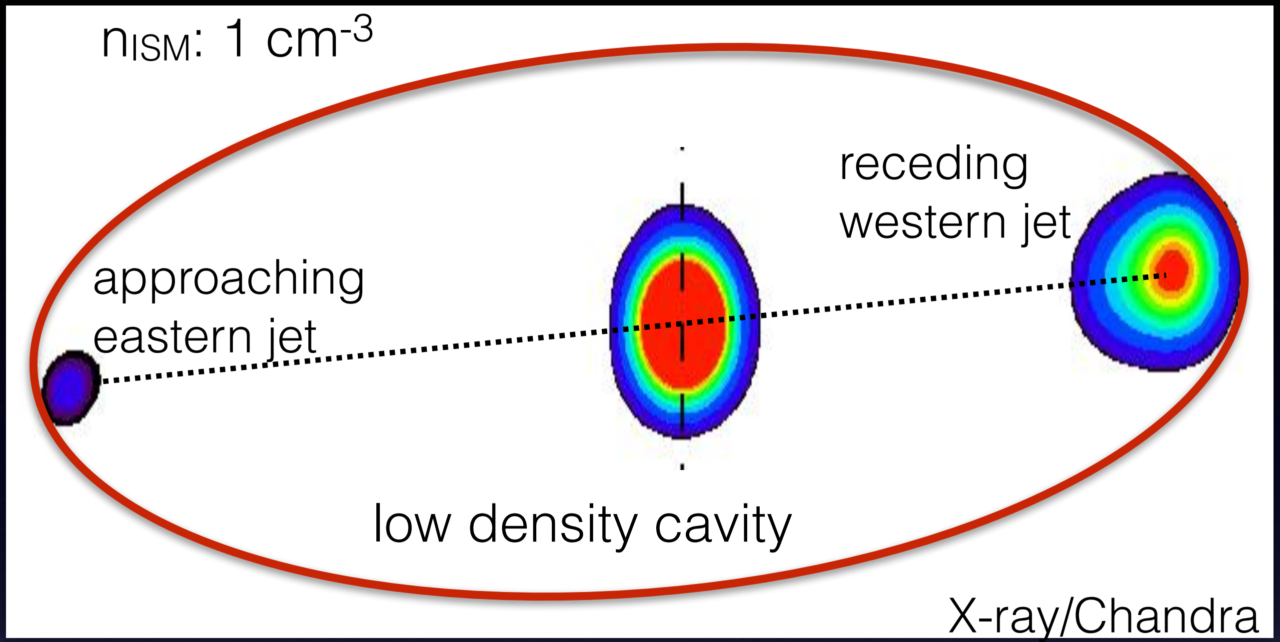
milli-arcsec arcsec arcmin

The large scale jets of XTE J1550-564



Low mass XRB **XTE J1550-564**:
Discovery of large scale (~0.5pc) decelerating jets following a major X-ray outburst in 1998 (Corbel+'02):
$<v_{app,eastjet}>$=1.0c to 0.1c;
$<v_{app,westjet}>$=0.55c to 0.4c.

The large scale jets of XTE J1550-564



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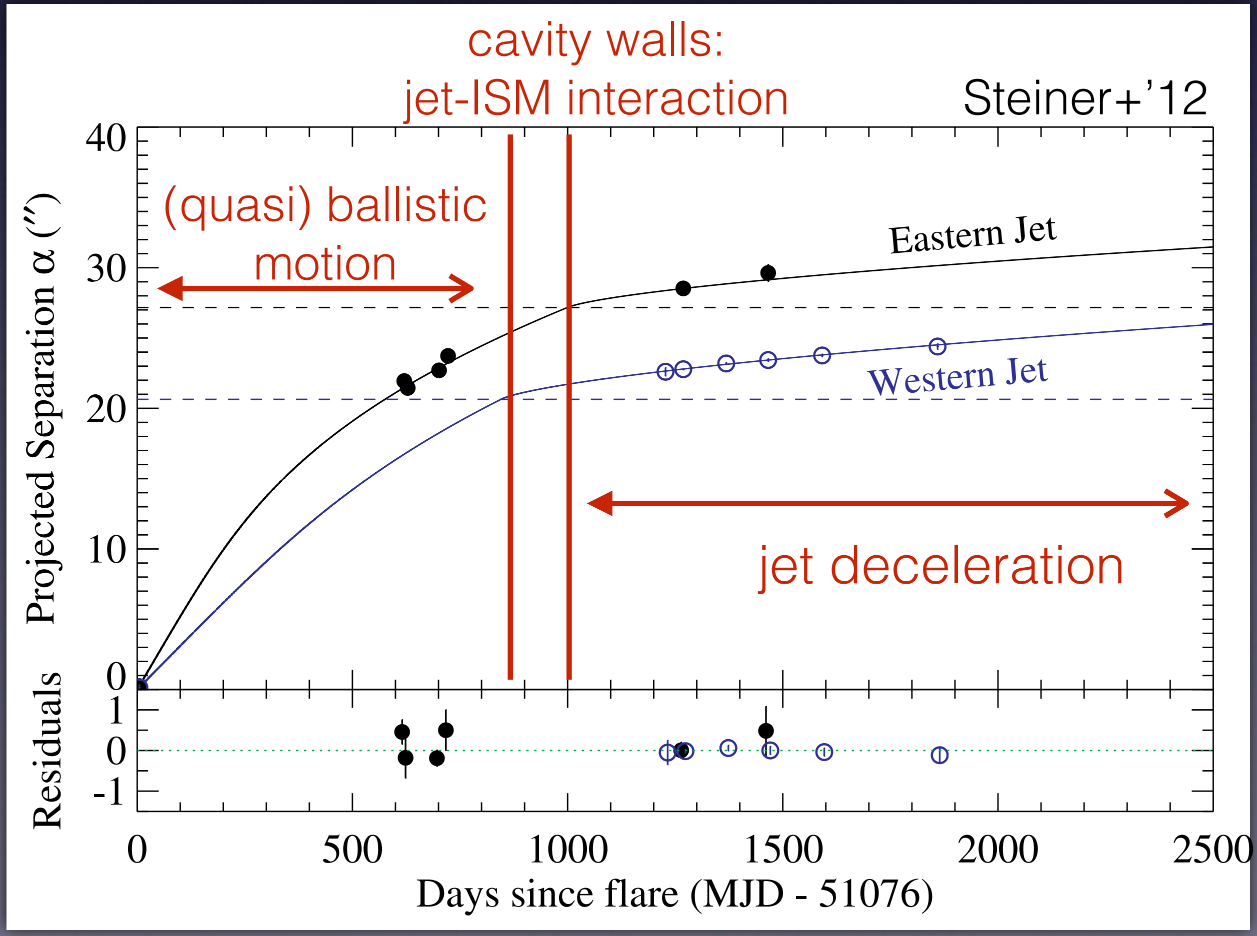


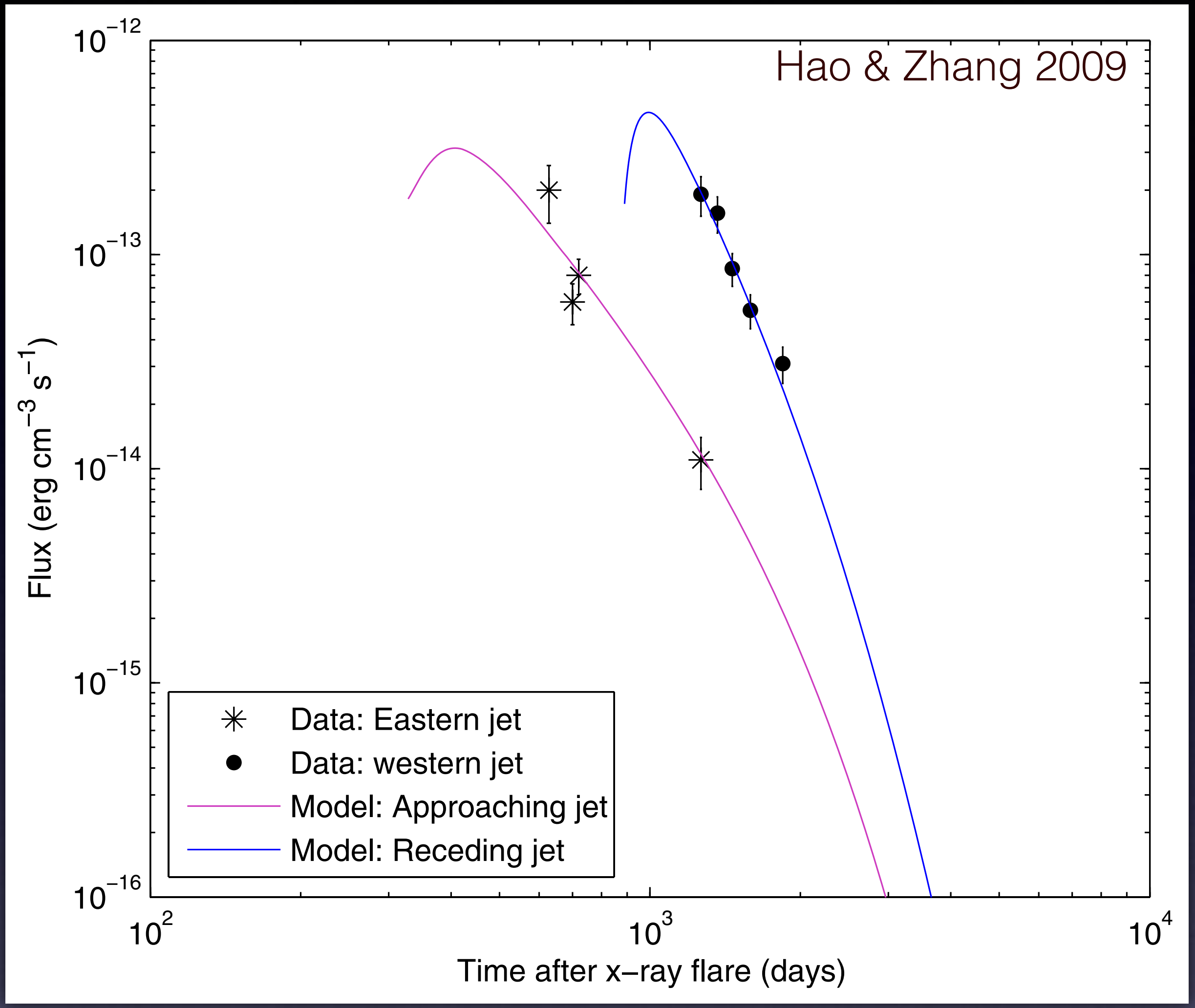
<u>Dynamical Model</u>:
the jets start to radiatively dissipate energy and decelerate when they reach the walls of the low-density cavity (Wang 2003;Hao&Zhang '09, Steiner+'12).

The large scale jets of XTE J1550-564

A fast decaying X-ray emission

Radiative Model:

- particles accelerated by a reverse shock similar to GRB afterglows (Wang 2003; Hao & Zhang 2009);
- energy losses dominated by adiabatic expansion losses;

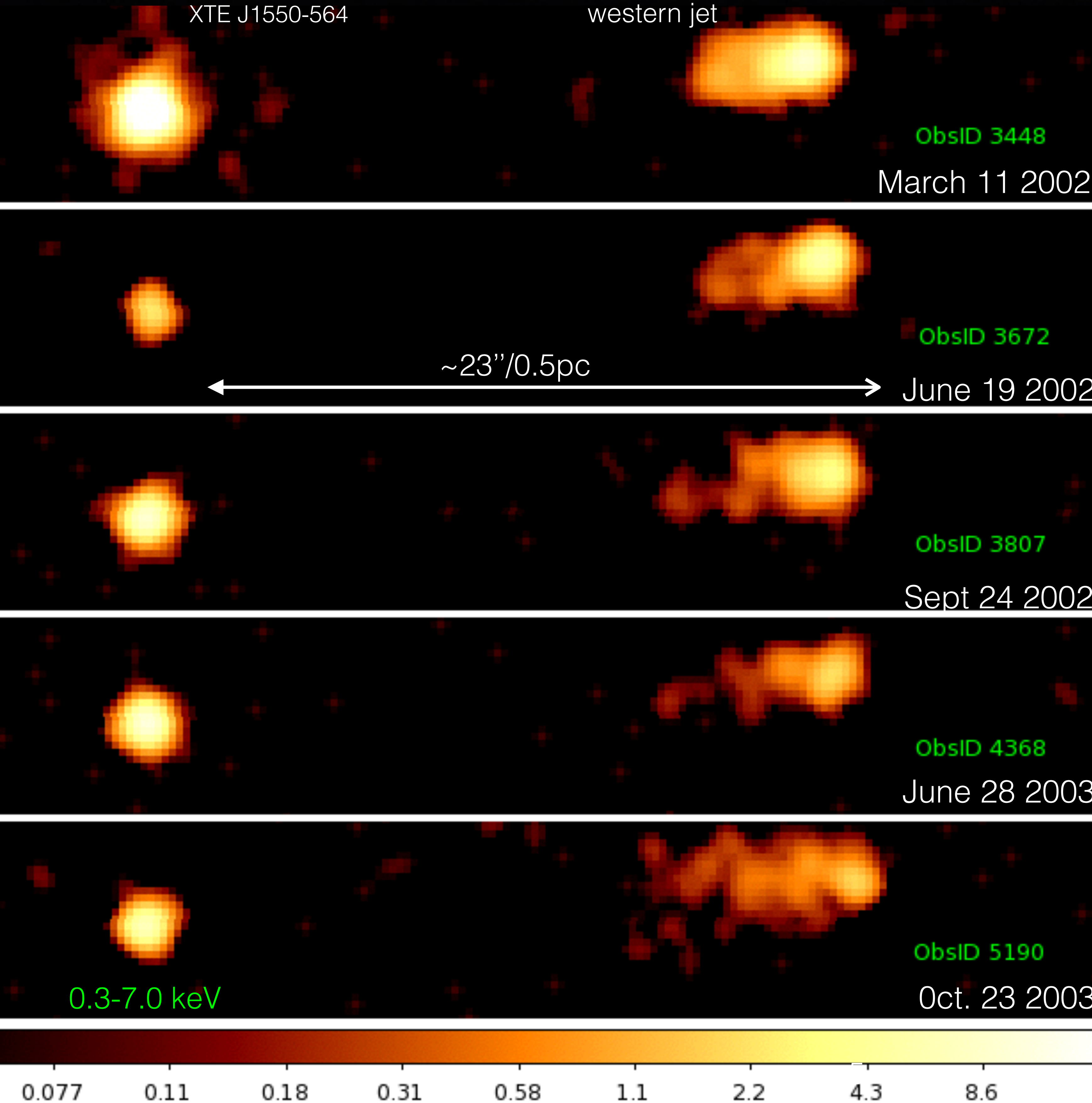


✓ X-ray follow-up: 8 Chandra observations;

★ Radio follow-up: 24 ATCA observations at 4 frequencies (1.4 GHz, 2.5 GHz, 4.8 GHz, 8.6 GHz).

In depth study of the western jet

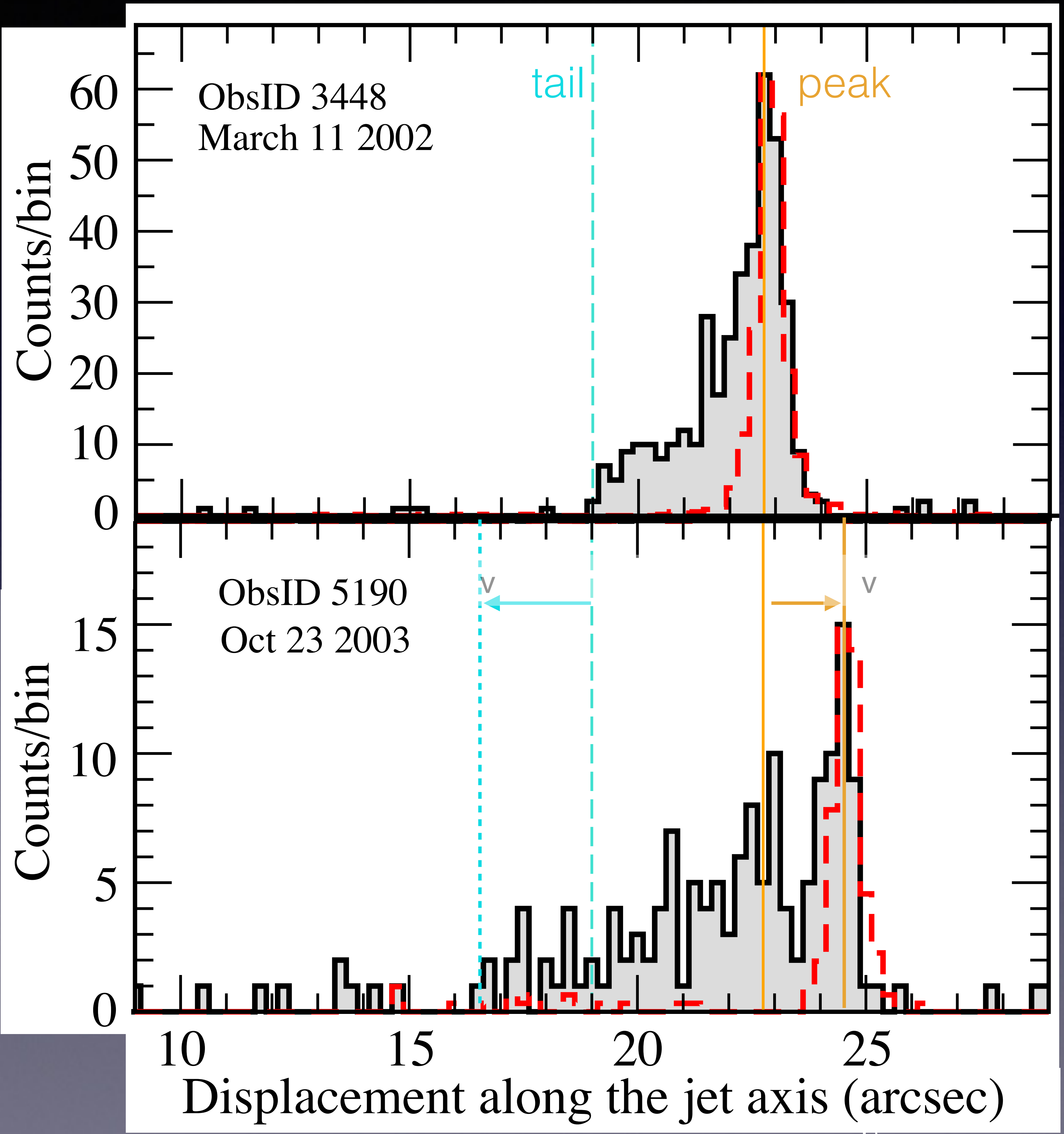
Western Jet: X-ray morphology



Evolution in ~1.5 yrs of the X-ray jet morphology:

- extended;
- helical structure? also observed in jets of XRBs and AGNs.

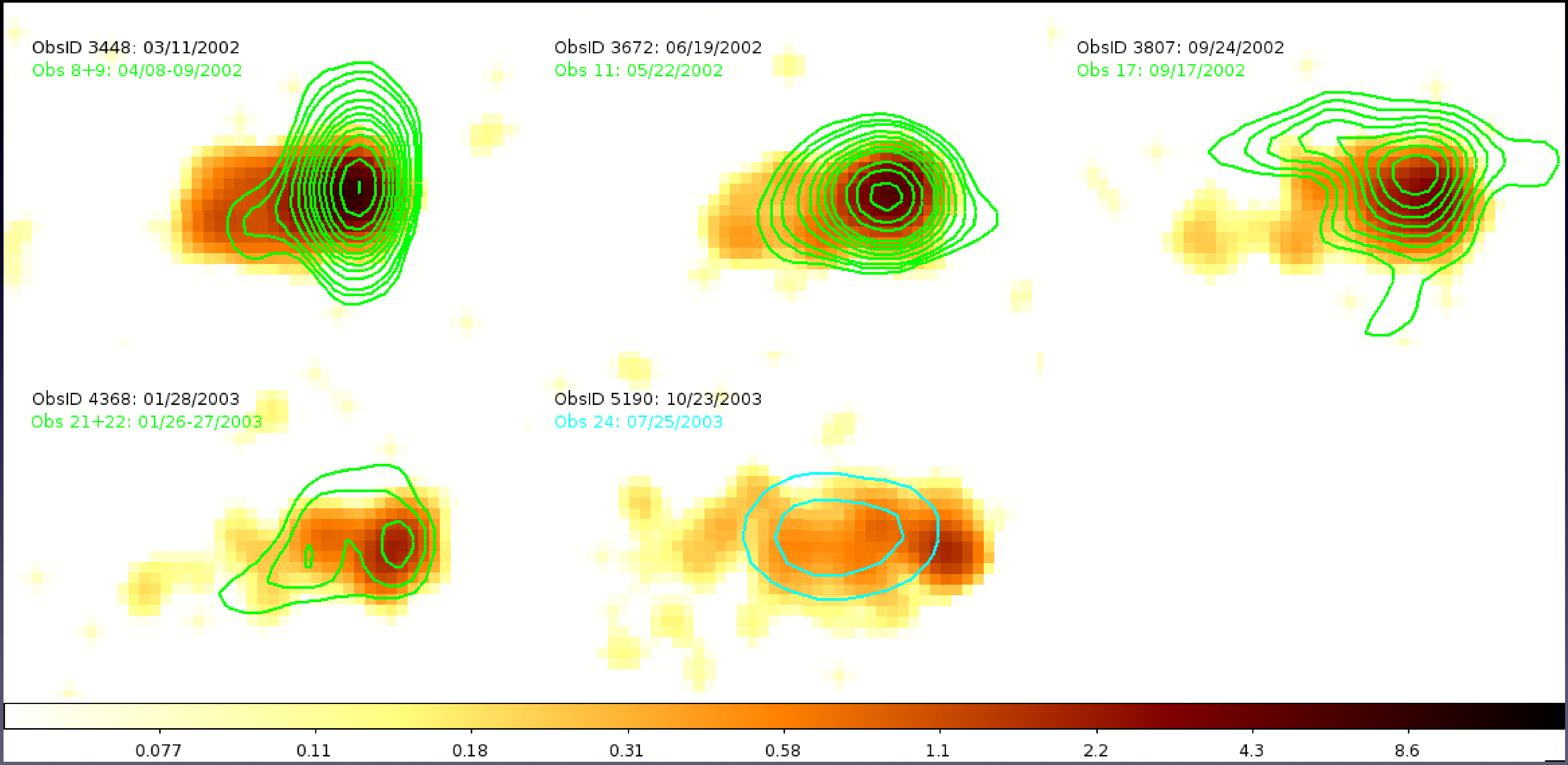
Western Jet: X-ray surface brightness



- extended X-ray profile
- progressive deceleration of the main peak;
- formation of a receding tail;

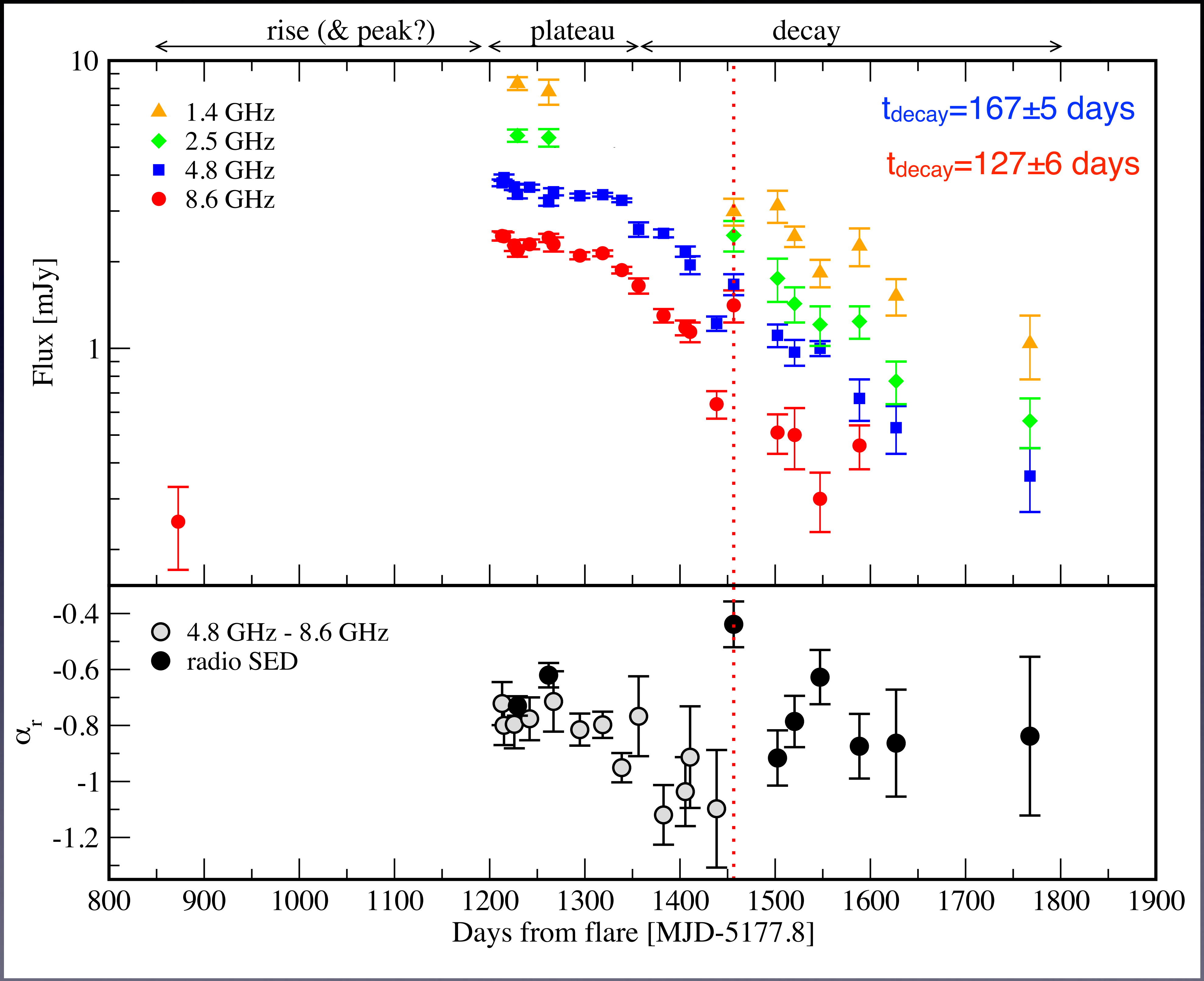
reverse shock propagation through the jet plasma?
or
colliding shells?

Western Jet: radio & X-ray morphology



some differences in the radio morphology (8.6 GHz, 4.8 GHz) but flux sensitivity was not optimal to map low-brightness features.

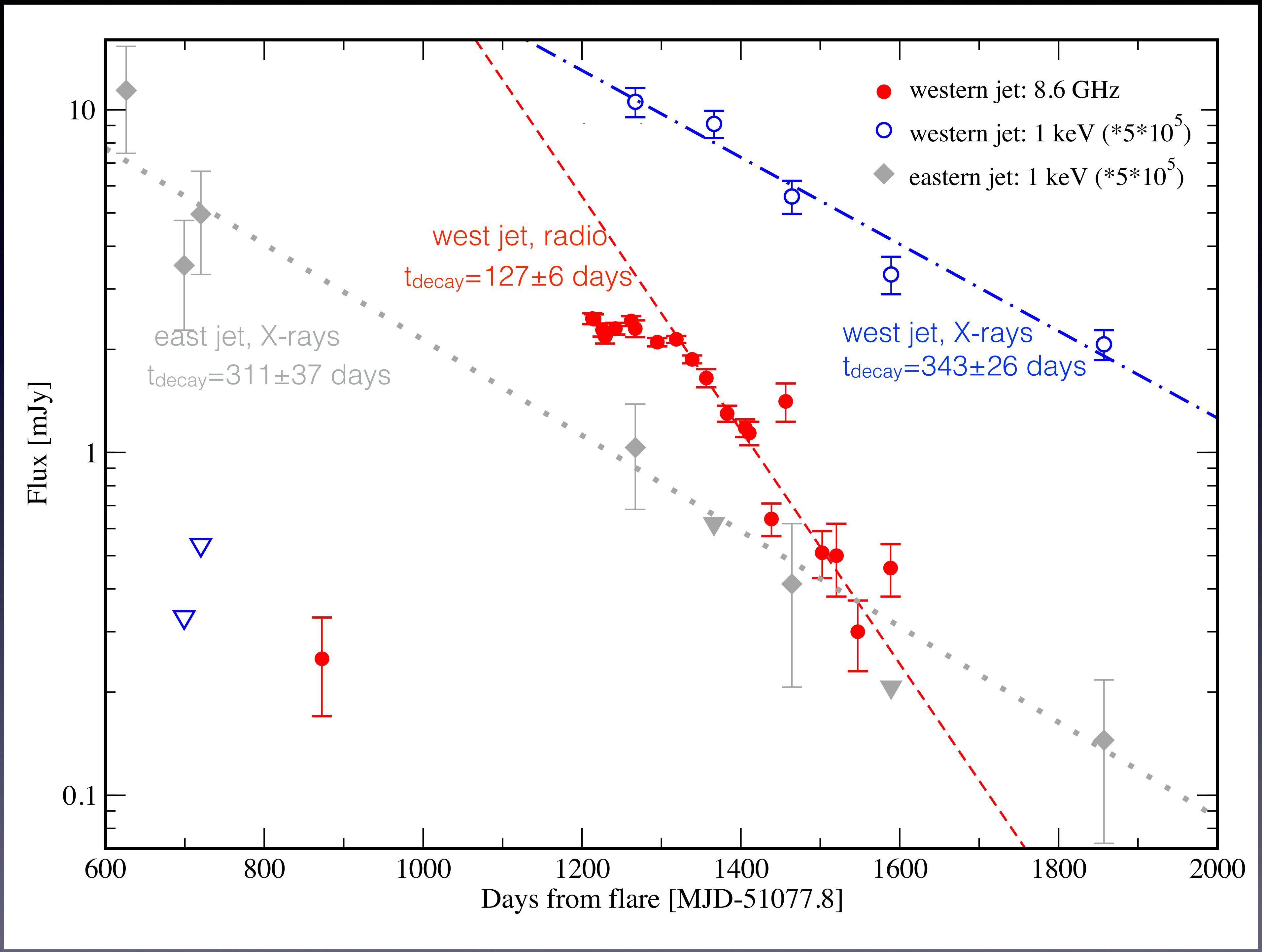
Chromatic decay of the emission: radio frequencies



Steep decay of the optically thin synch. emission

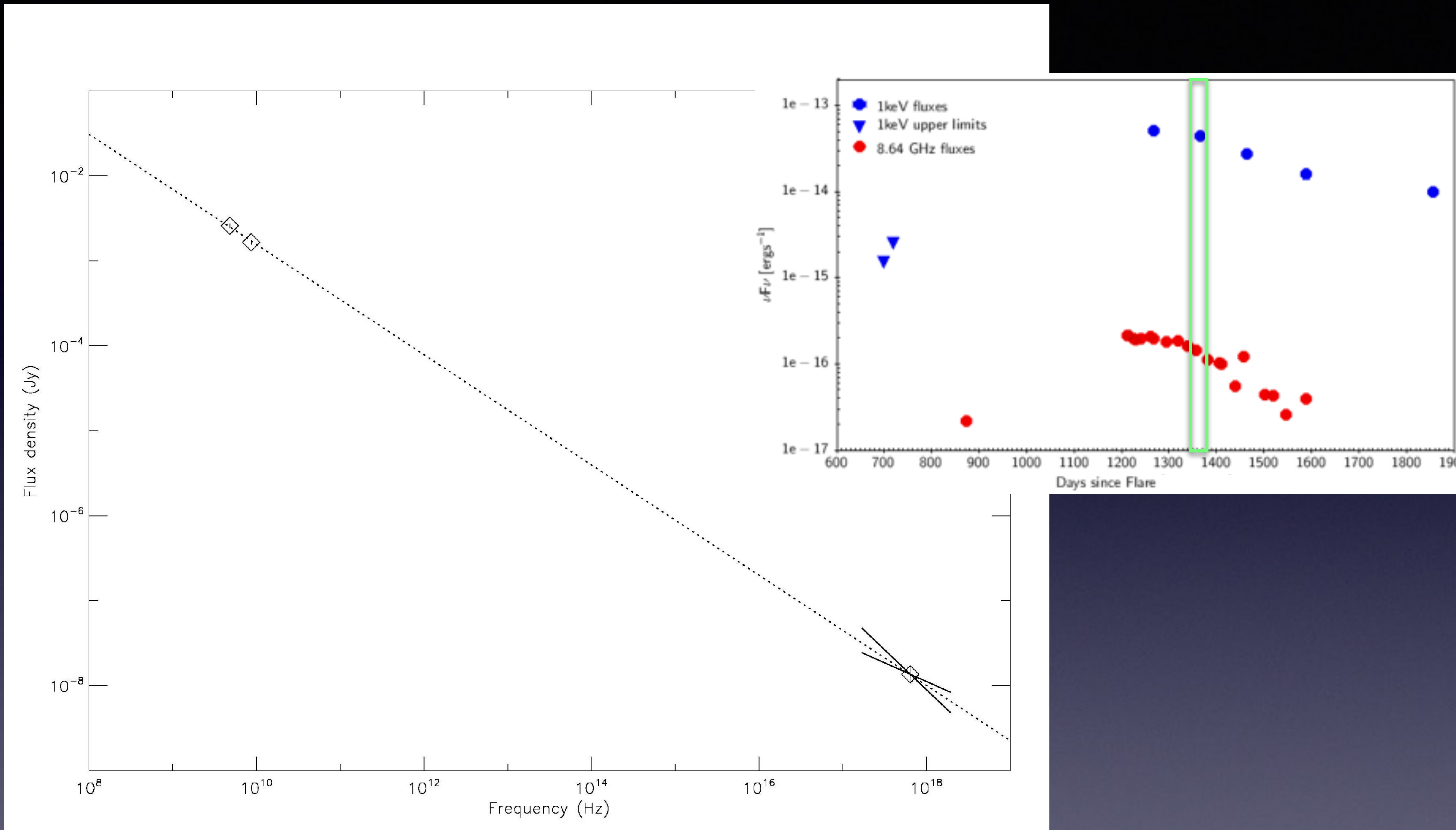
@8.6 GHz:
flux re-brightening + spectral flattening

Chromatic decay of the emission: radio vs. X-rays



The flux decays slower in X-rays than in radio: not expected if adiabatic losses are dominant.

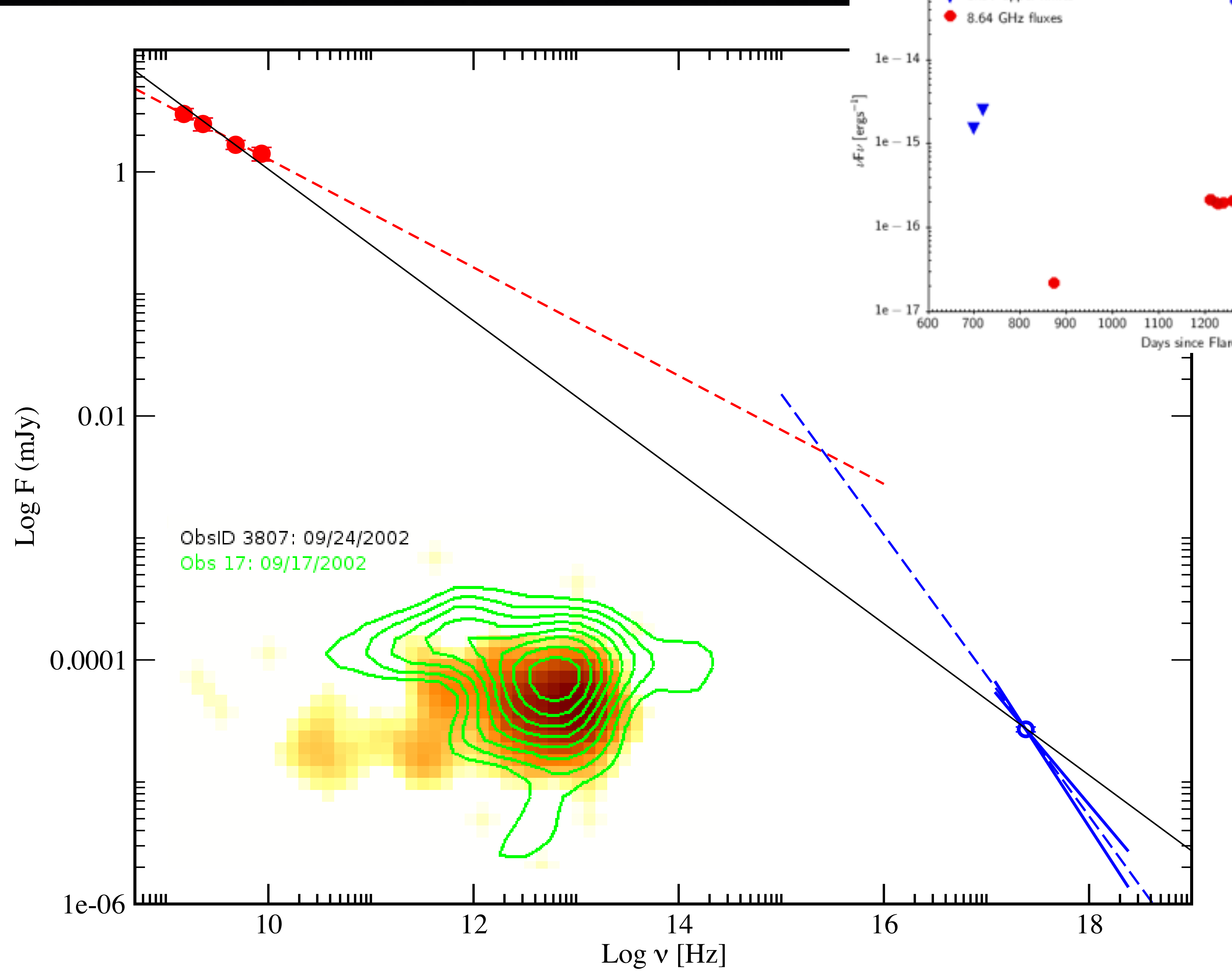
Radio-X-rays SED: synchrotron emission

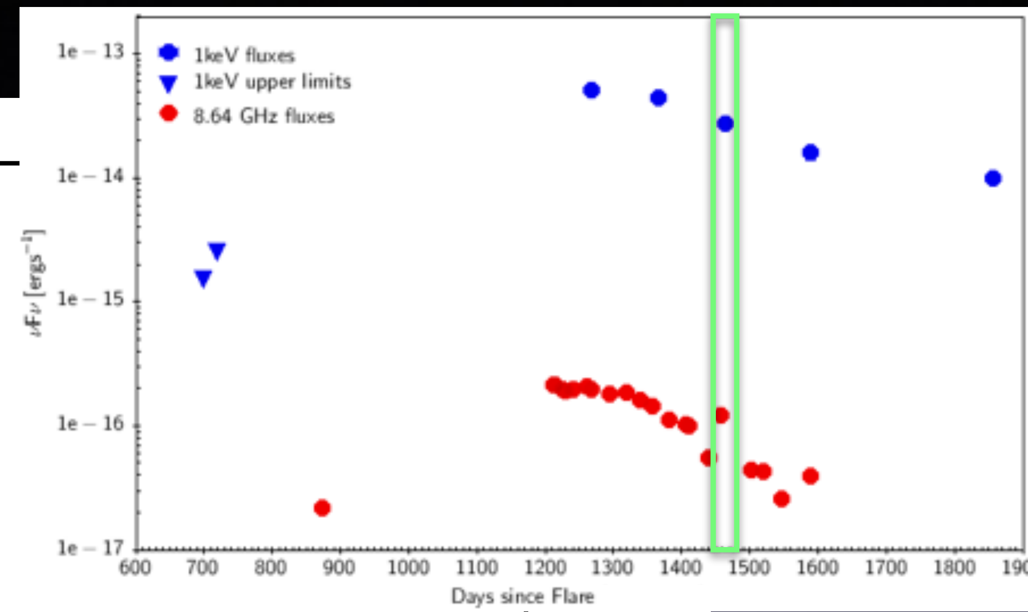


- X-ray emission on the extrapolation of the radio spectrum (4/5 obs.);
- bremss. origin requires too large masses (>10^{28} gr) for accretion and entrainment;

X-rays from synchrotron emission

Radio-X-rays SED: reflare

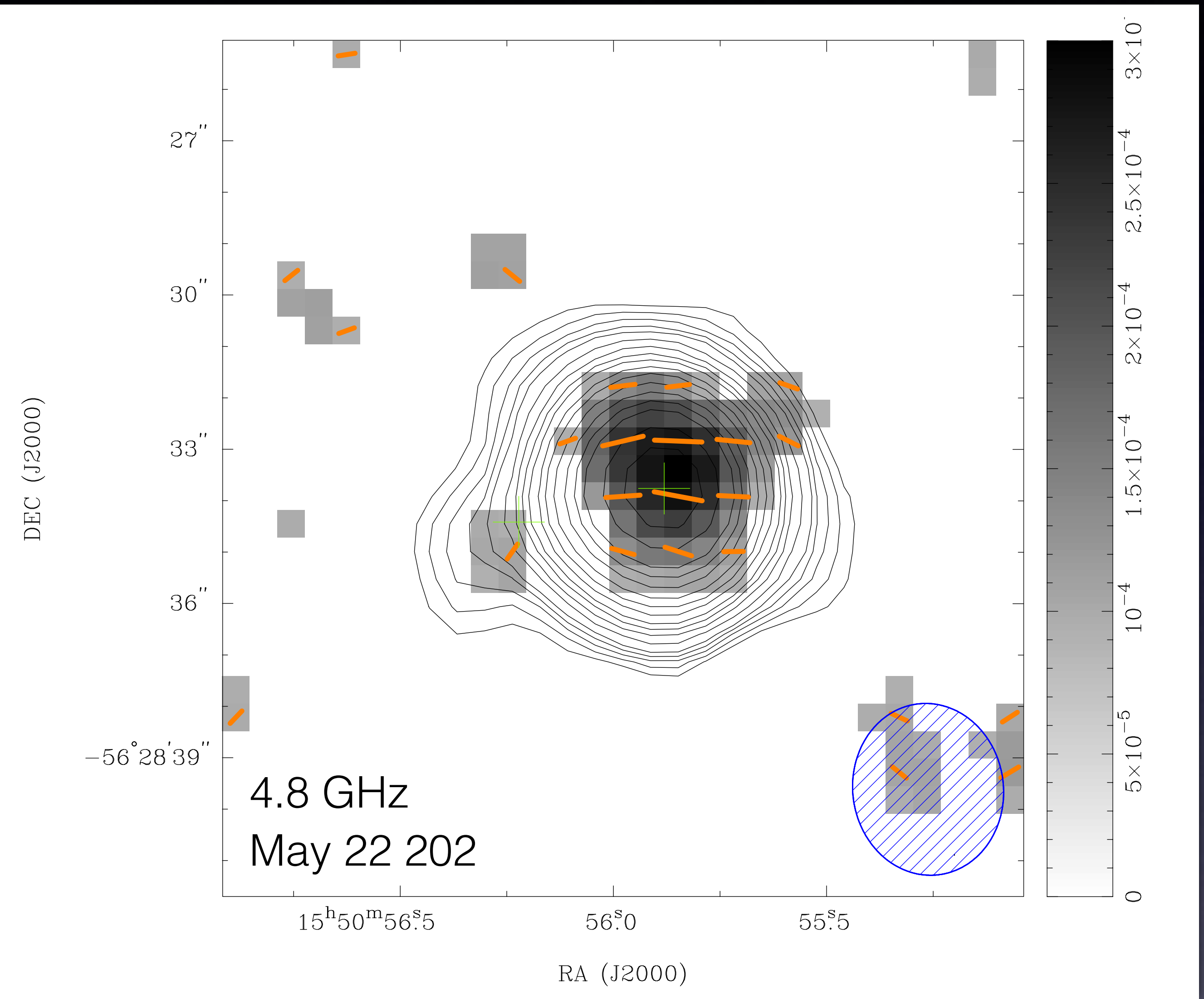




- spectral changes at the radio re-flare;
- different radio and X-ray morphologies;

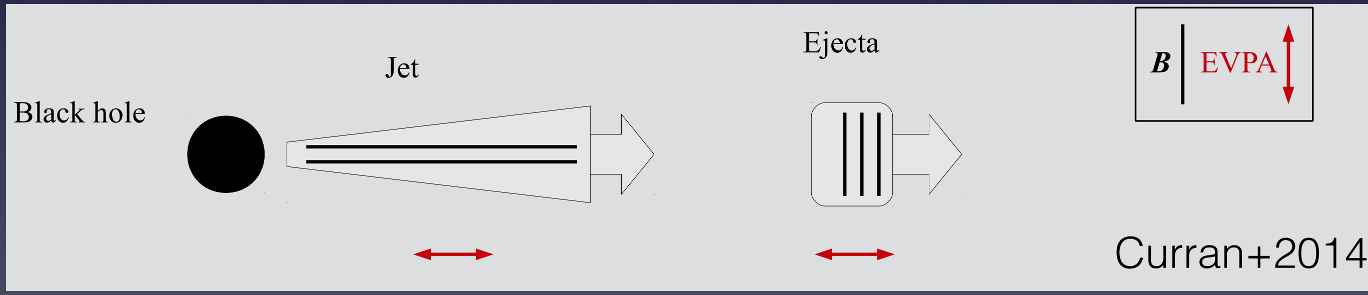
newly accelerated low-energy particles?

Linear polarization



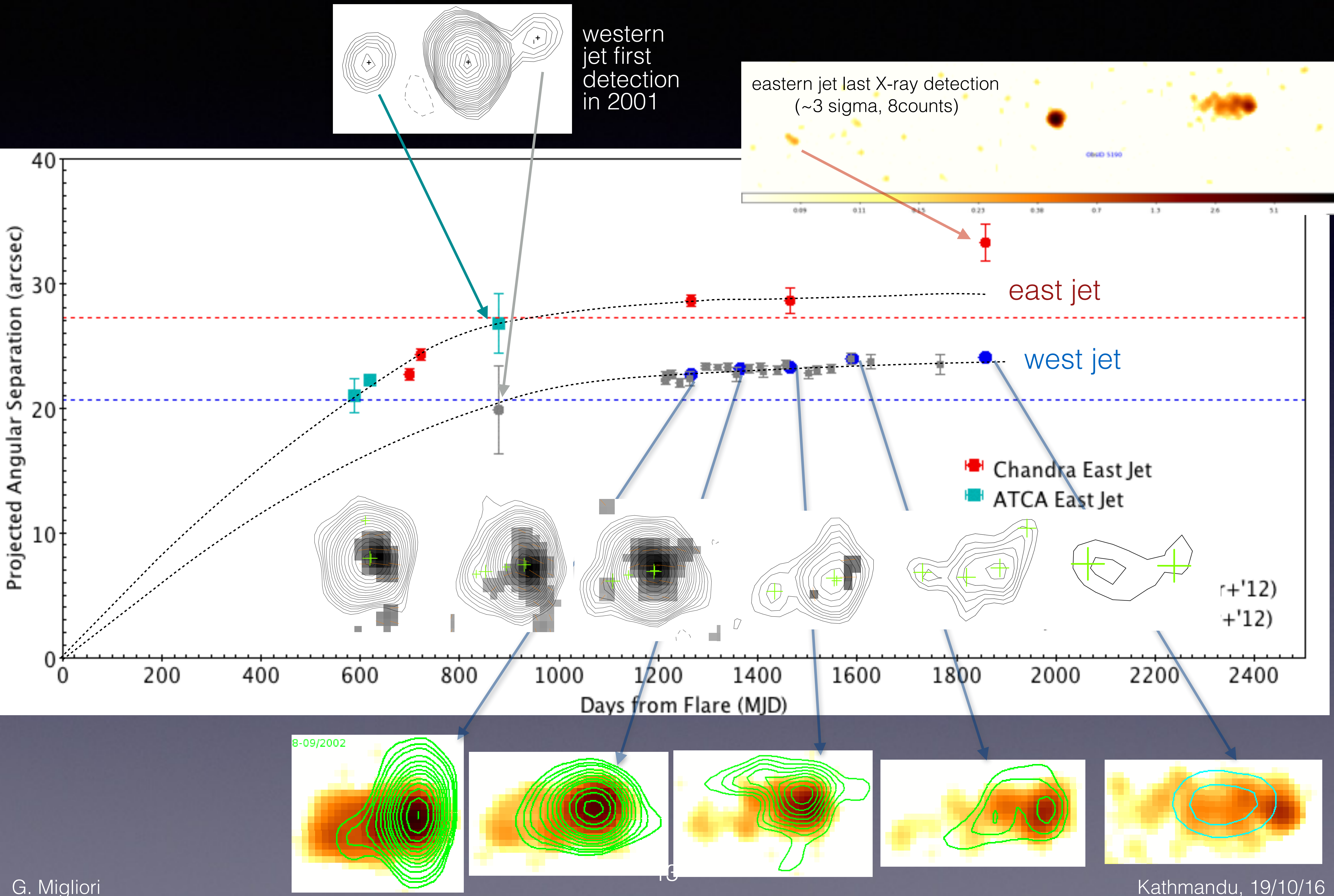
- 10%-15% linear polarization @4.8 GHz and 8.6 GHz;
- E vector parallel to the jet axis

reverse shock model => polarized emission probes the jet's B field:



shock-compressed B field

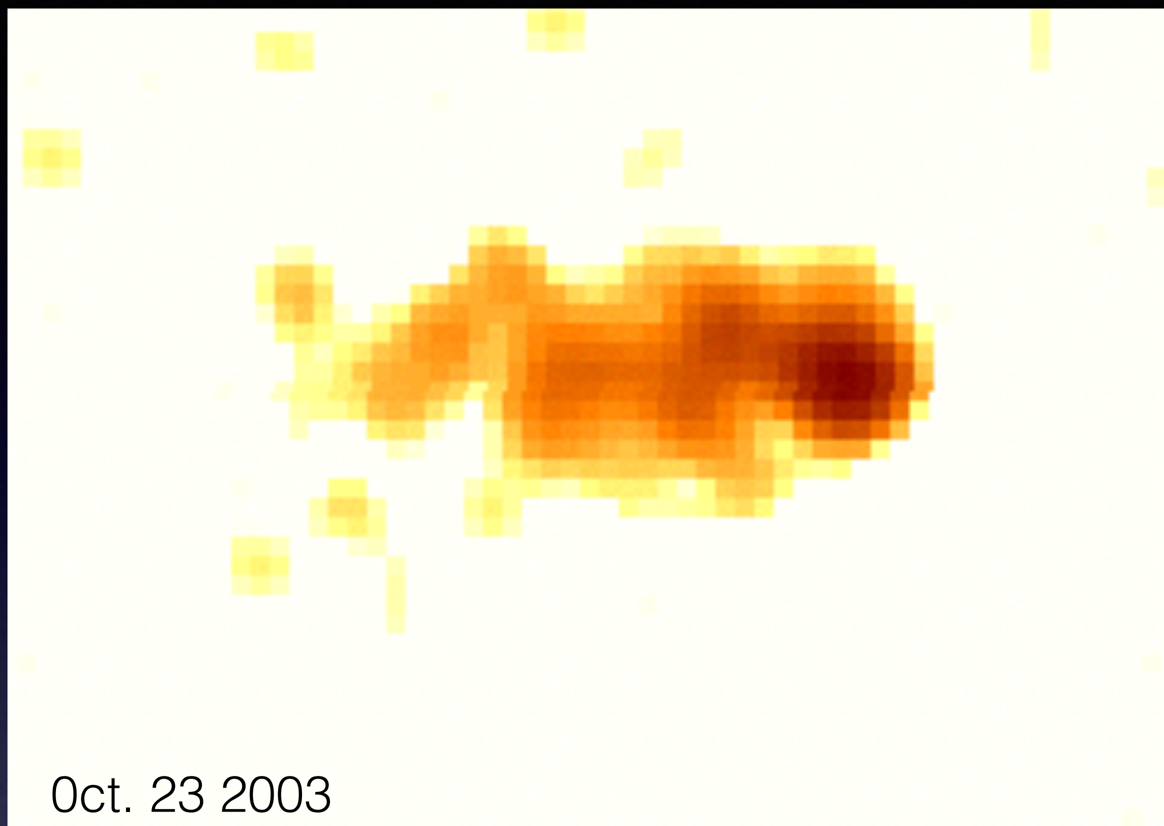
Jets' dynamics

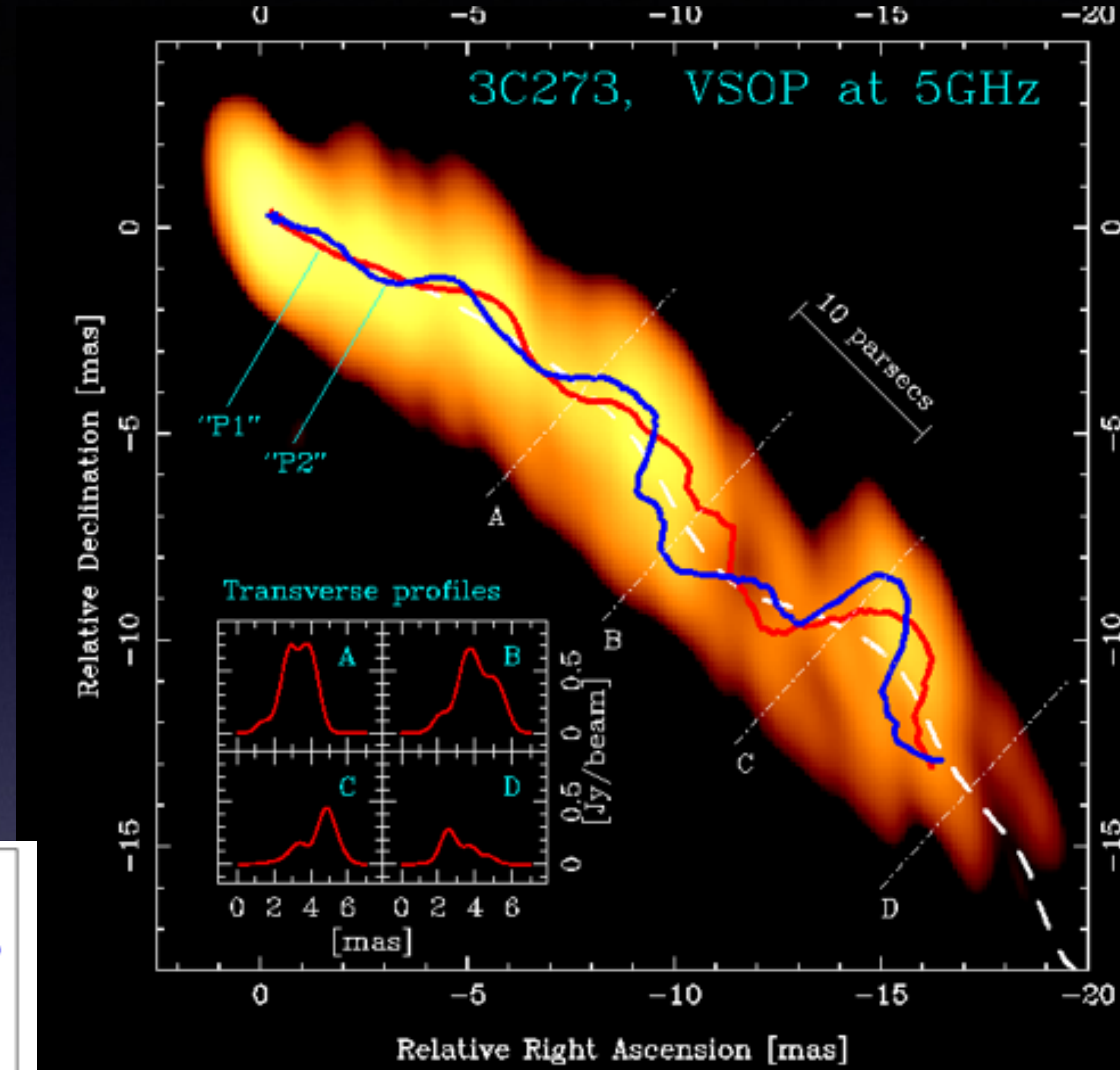


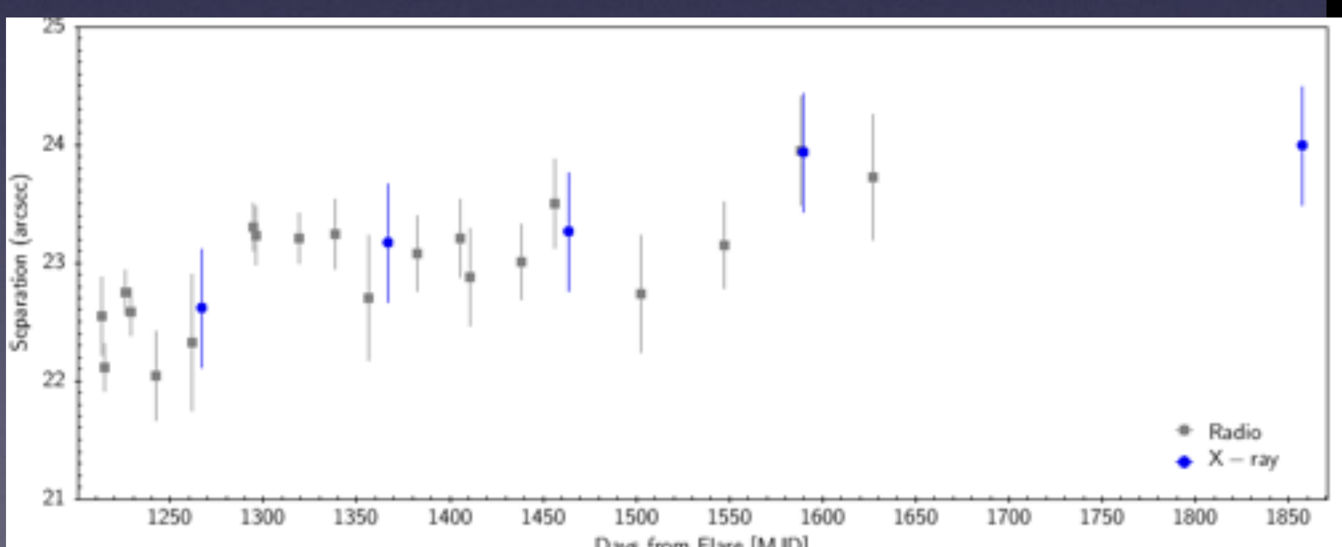
Conclusions

- evolution of structure of the X-ray western jet:
  - trailing tail extending backwards: a signature of the reverse shock passing through the jet plasma?
- radio to X-ray synchrotron emission:
  - different decay times of the radio and X-ray fluxes: not consistent with dominant adiabatic losses => need ad-hoc modeling;
  - variation of the spectral shape during the radio re-brightening=> new acceleration episode?
- jet motion as seen in radio consistent with the dynamical models of jets in a cavity.

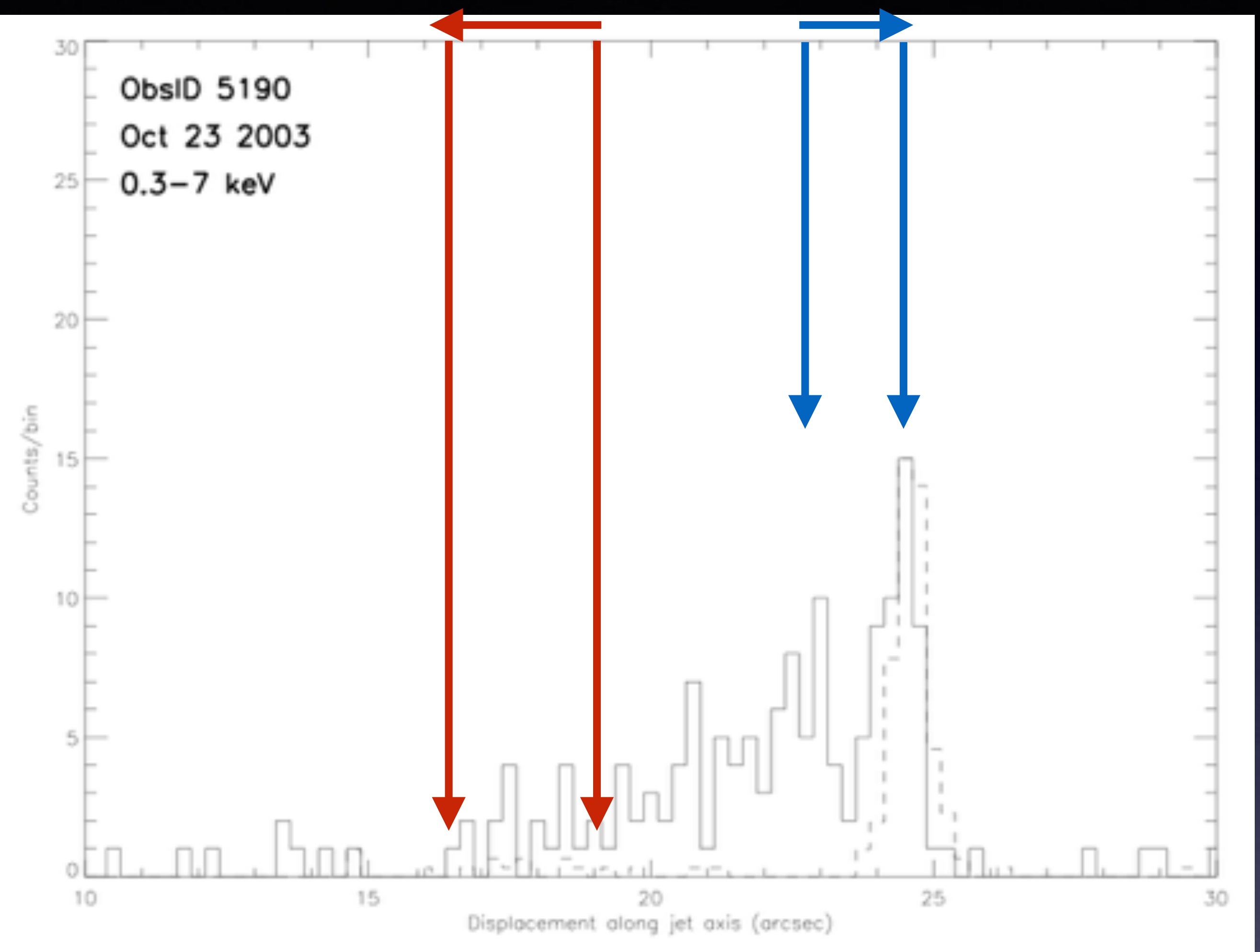
Western Jet: X-ray morphology

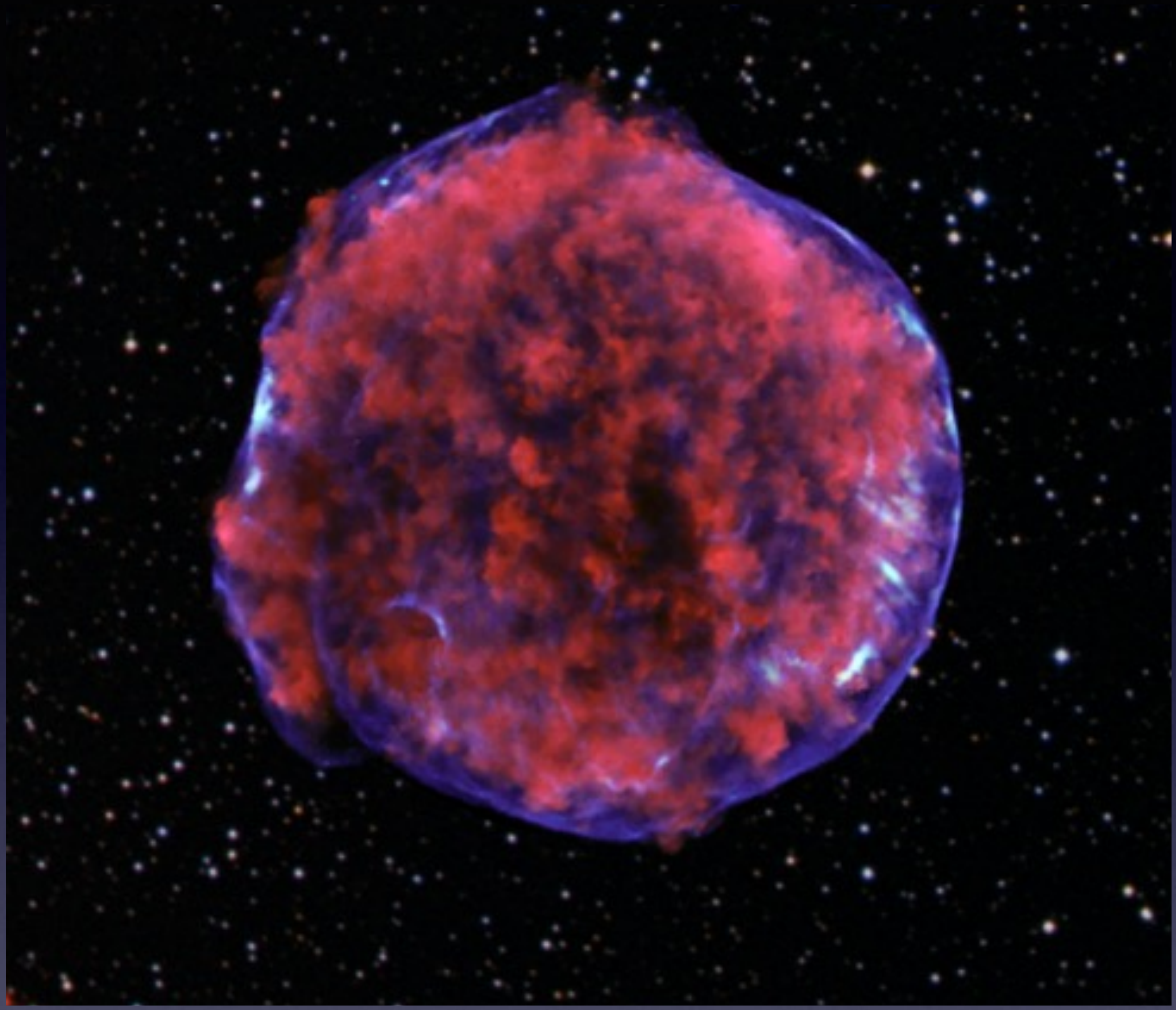






Helical pattern in 3C273 radio jet:
KH instabilities from the jet-ISM interaction
+
initial perturbation





Reverse shock propagation through the jet plasma?

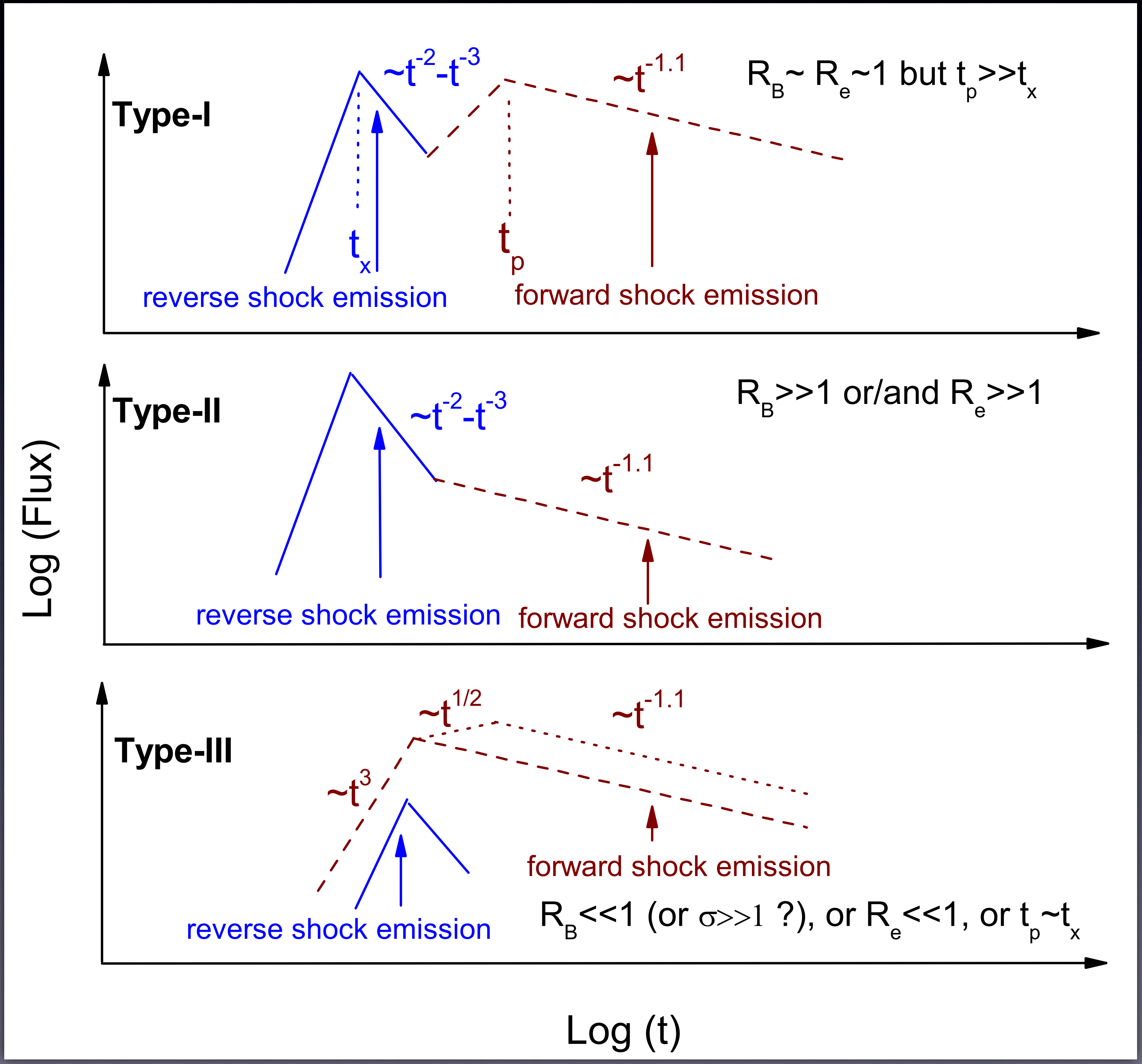
Backwards motion of the reverse shock is observed in SN remnants (in Tycho SNR, Yamaguchi et al. 2014) => <u>non-relativistic shock</u>

GRB afterglow models: forward & reverse shock emission

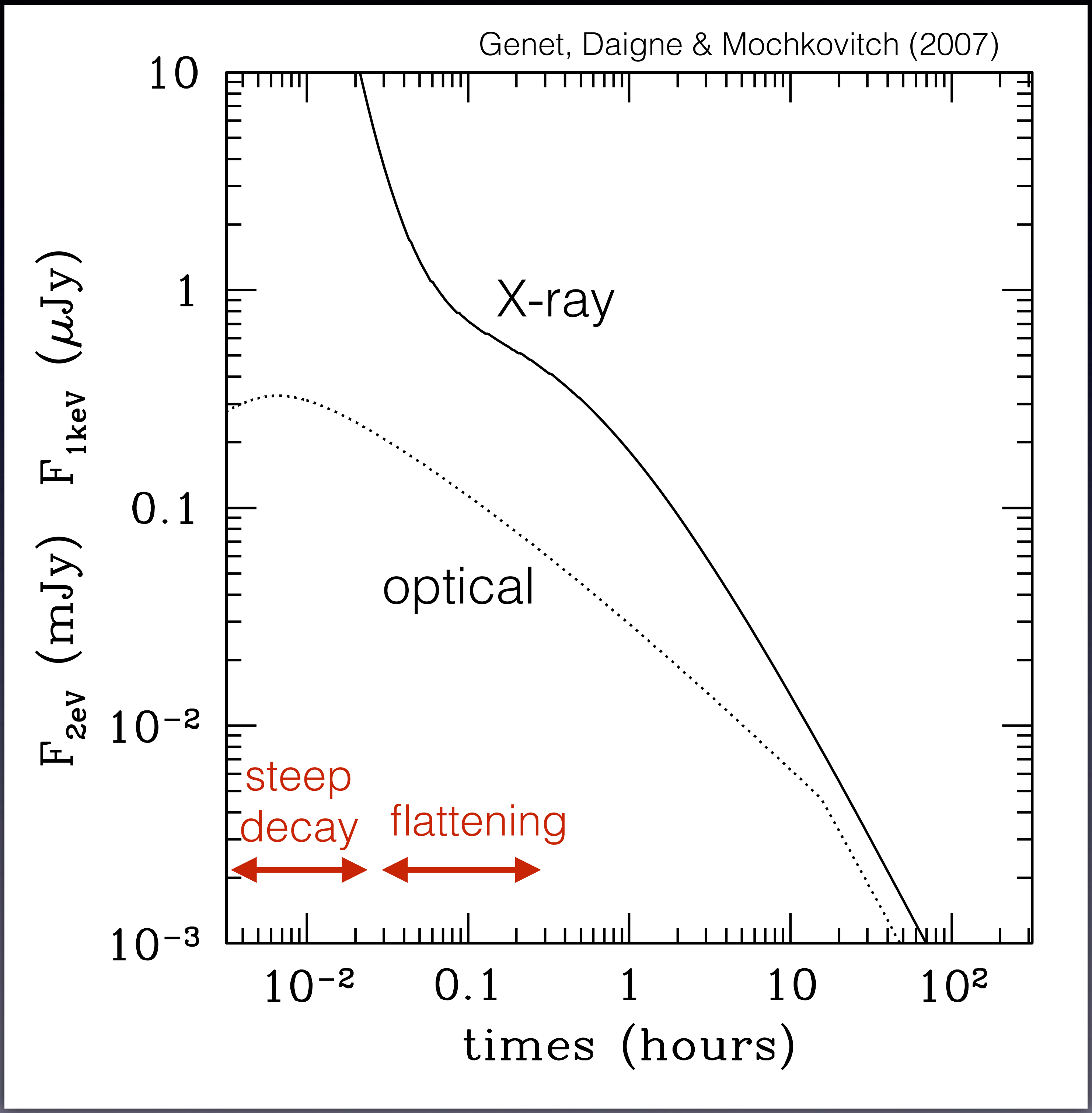
early afterglow:

reverse shock dominated

forward shock dominated



GRB afterglow models:
reverse shock dominated X-ray emission



Steep decay + late flattening if:

- Lorentz factor of the late ejecta <10;
- large part of the shock-dissipated energy goes into a small fraction of e^-;

+

conditions on the ISM:
inefficient energy transfert to the particles/B field in the plasma crossed by the forward shock