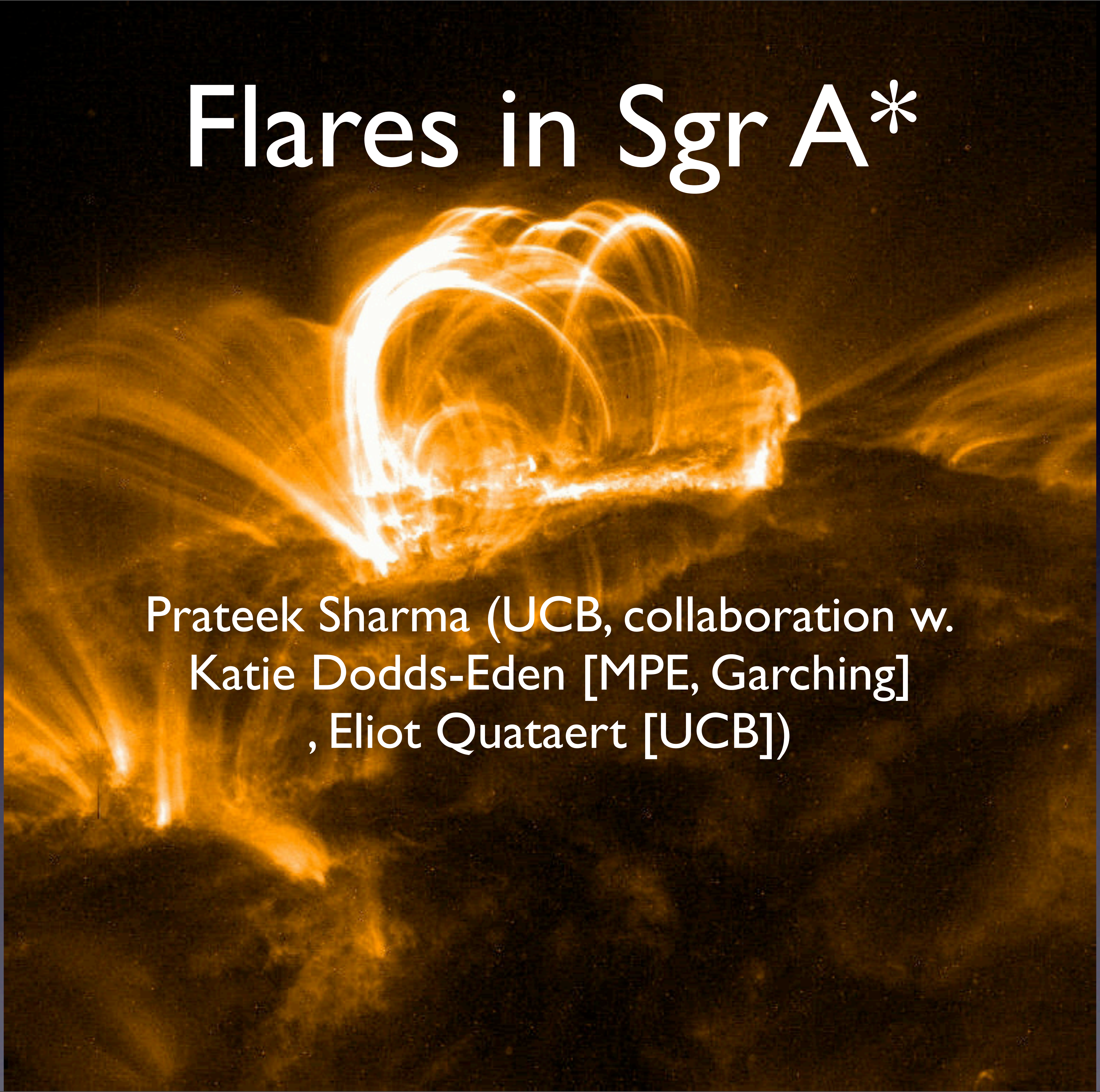
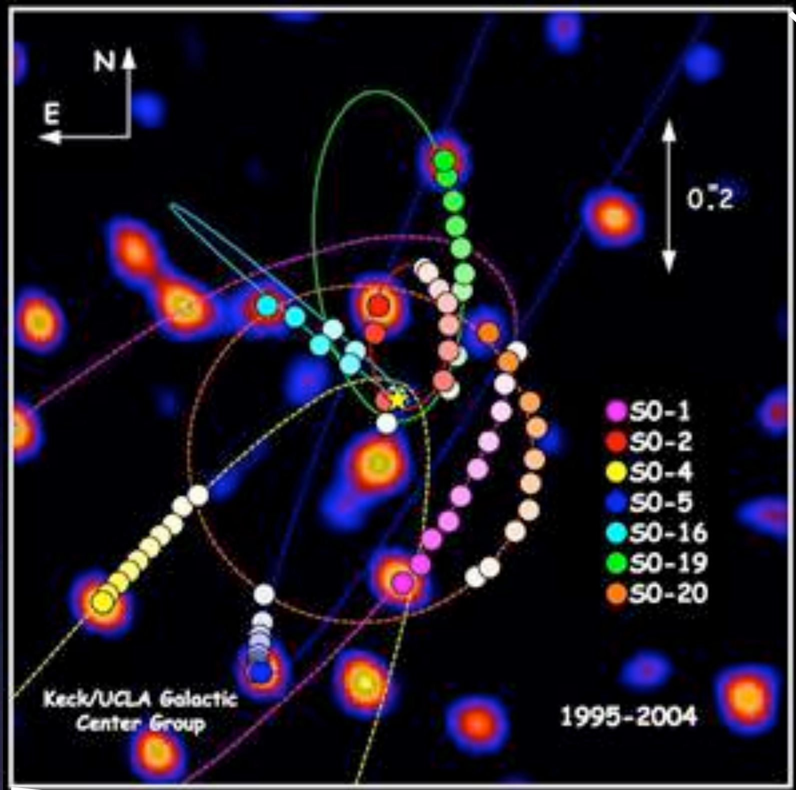
Flares in Sgr A*



Prateek Sharma (UCB, collaboration w. Katie Dodds-Eden [MPE, Garching] , Eliot Quataert [UCB])

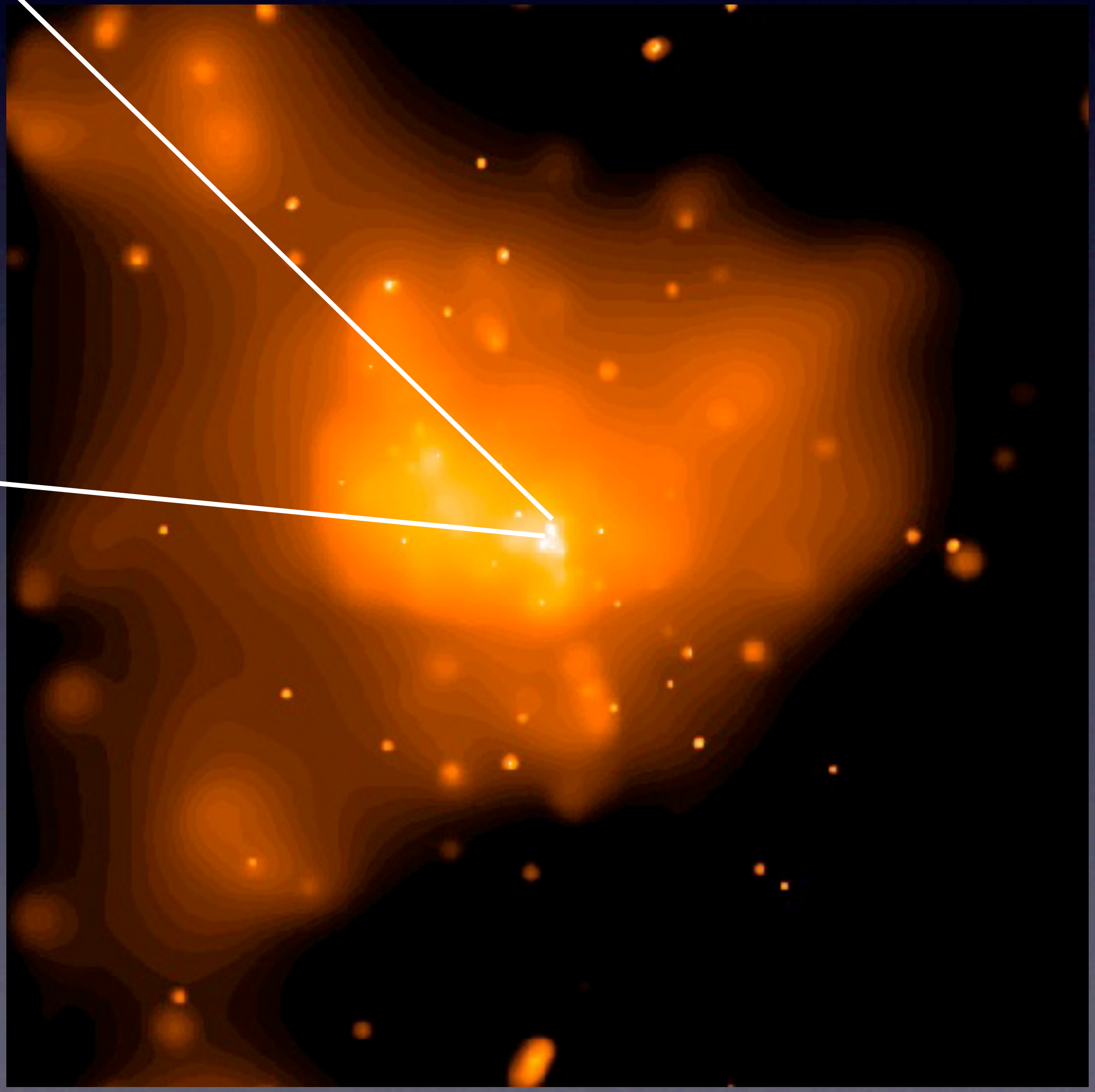
Sgr A*

[UCLA group, Genzel et al.]



0.05pc

Galactic supermassive BH ($4 \times 10^6 M_{sun}$)

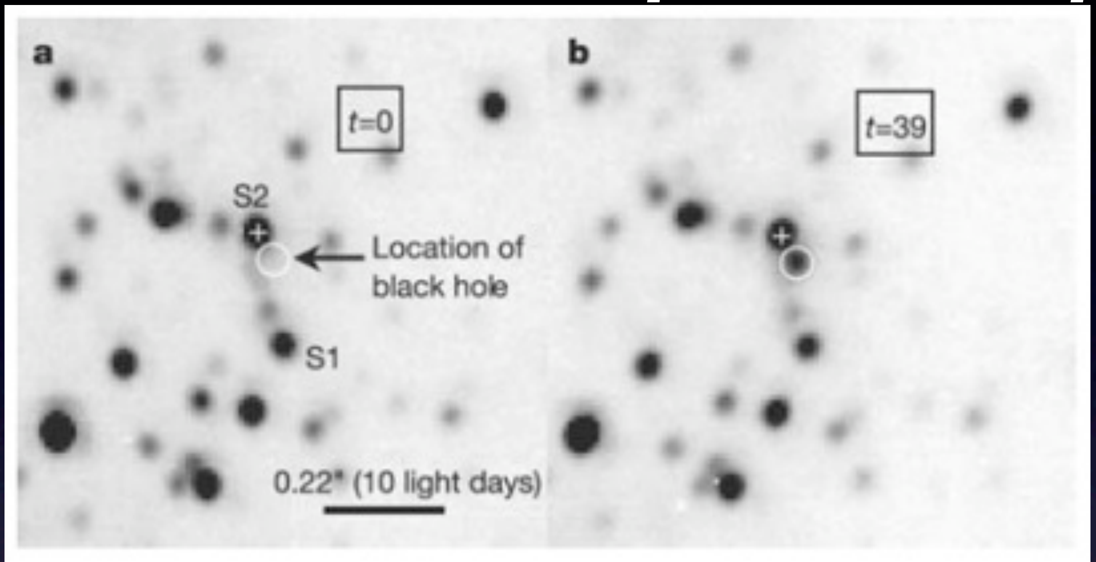


2.5pc

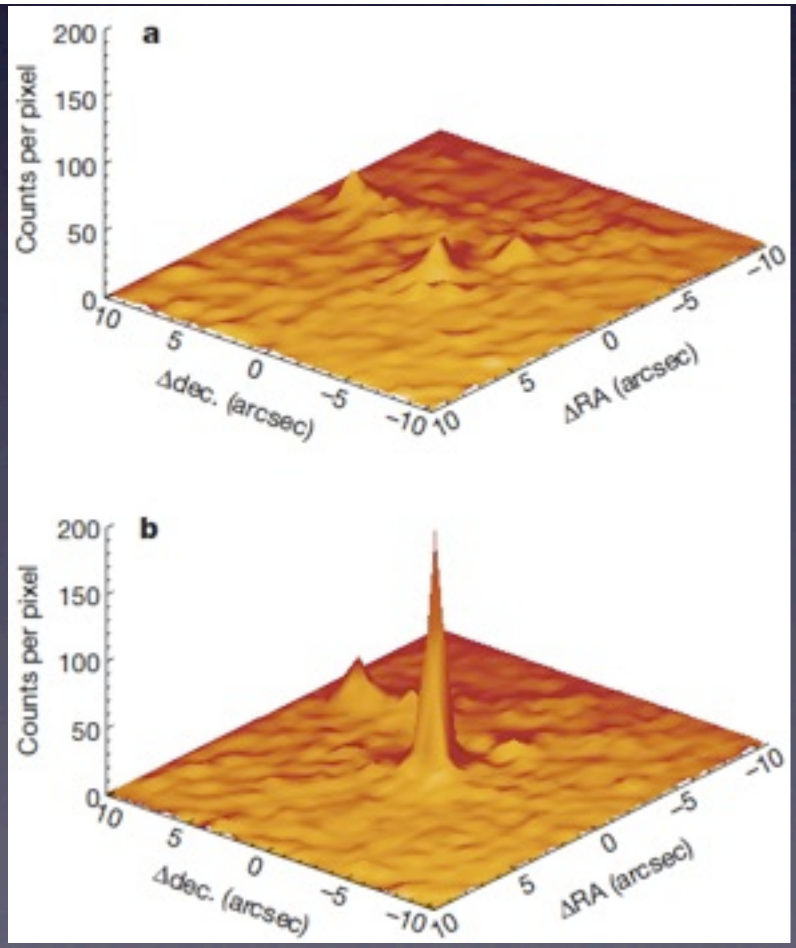
unremarkable in X-ray lum.
quiescent L ~ 10^{36} erg/s (radio dom.)
barely resolved by *Chandra*

Flares from Sgr A*

IR *[Genzel et al. 2003]*

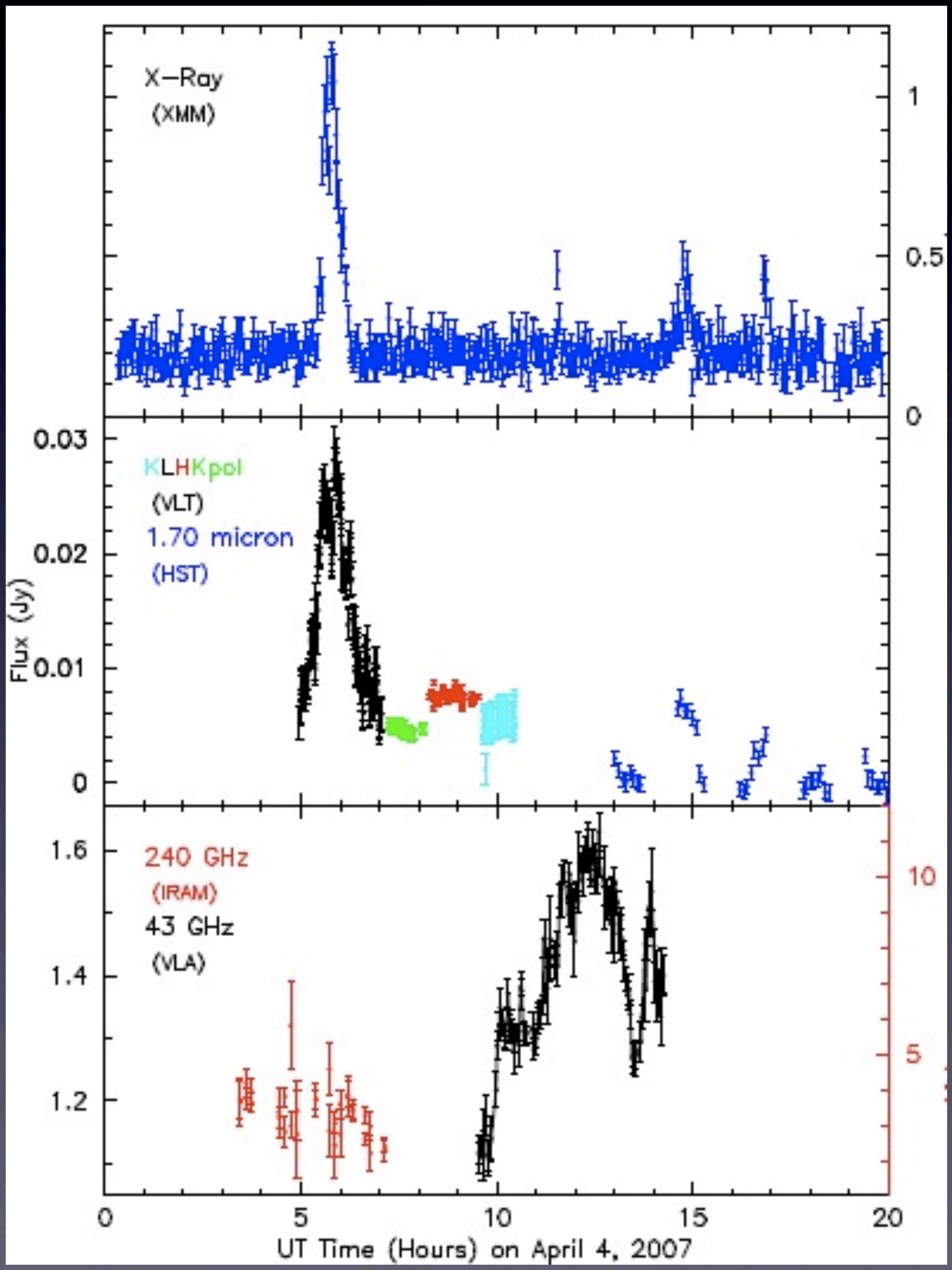


X-ray *[Baganoff et al. 2001]*



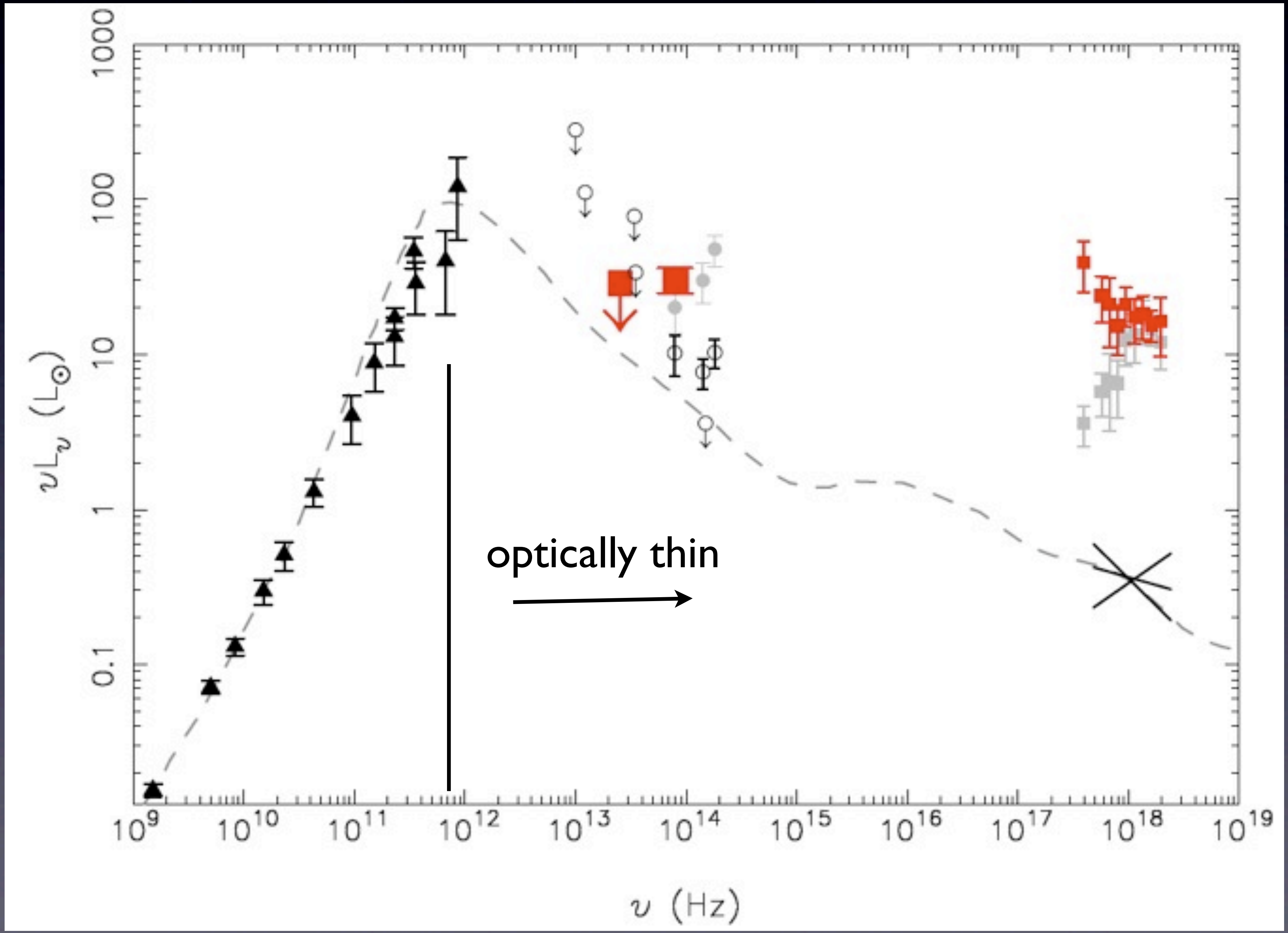
upto few/night
brighter rare

[Yusef-Zadeh et al. 2009]



Spectrum

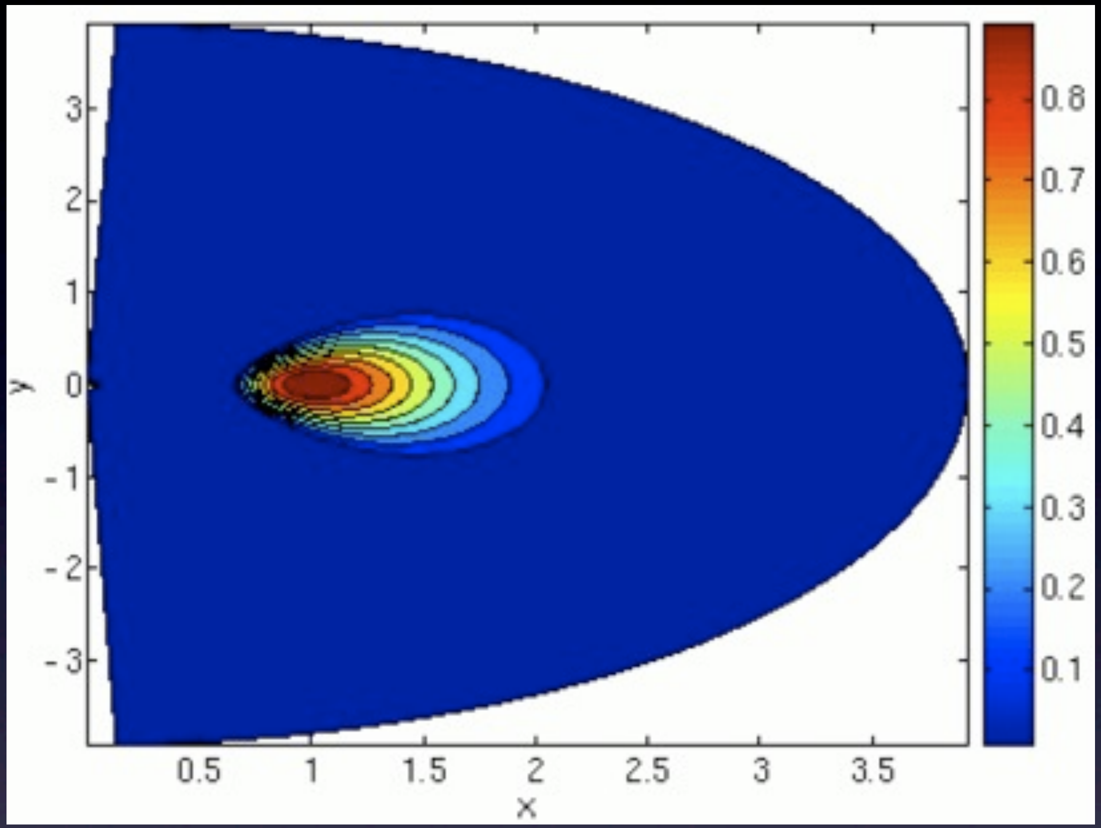
[Dodds-Eden et al. 2009]

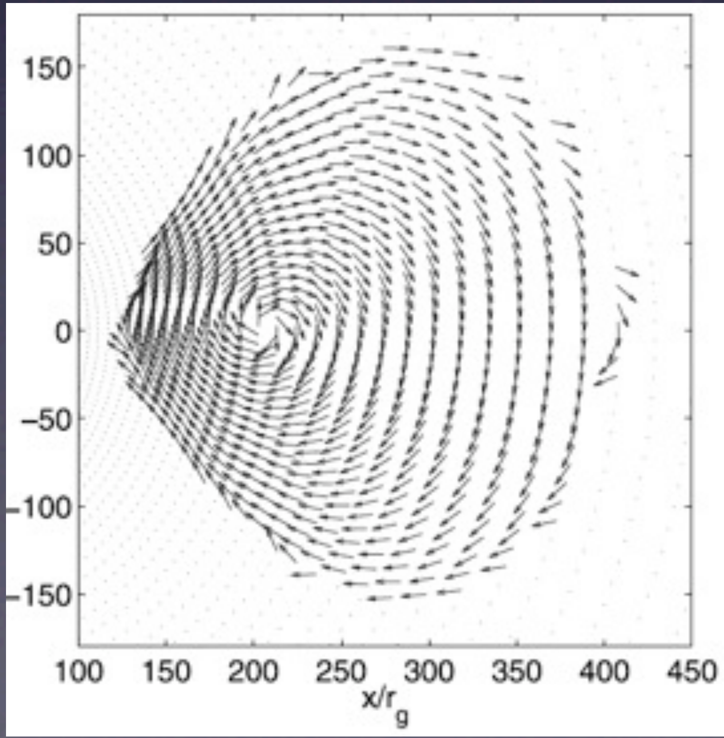


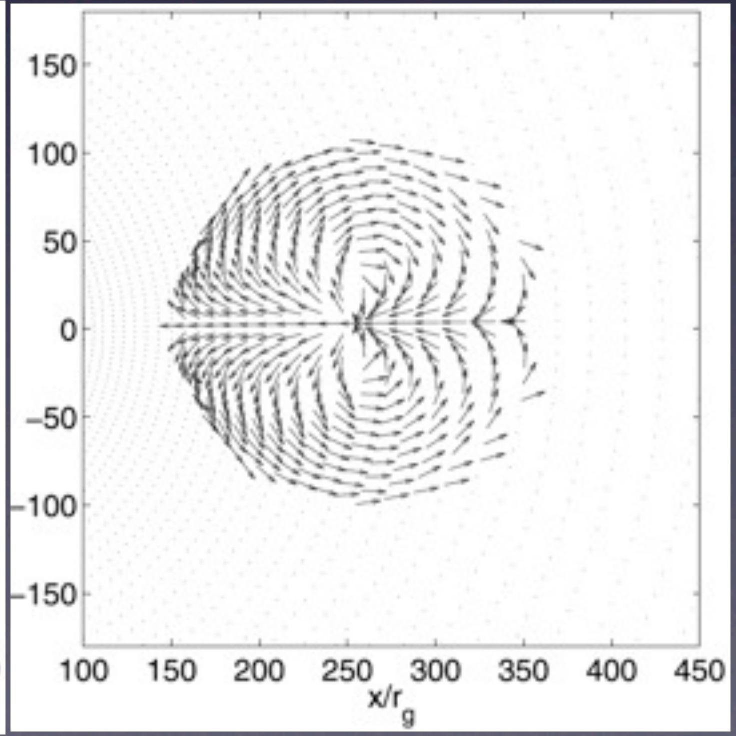
Generic Features

- IR flares most common; X-ray=>IR, not vice-versa
- only few simultaneous broad-band flares
- amplitude ↓ as ν ↓; highest amp. in X-ray, then IR, mm
- X-ray flare (20 min) ≤ IR (40 min) ≤ mm (few hrs)
- polarized IR (=>synchrotron), change in PA after peak

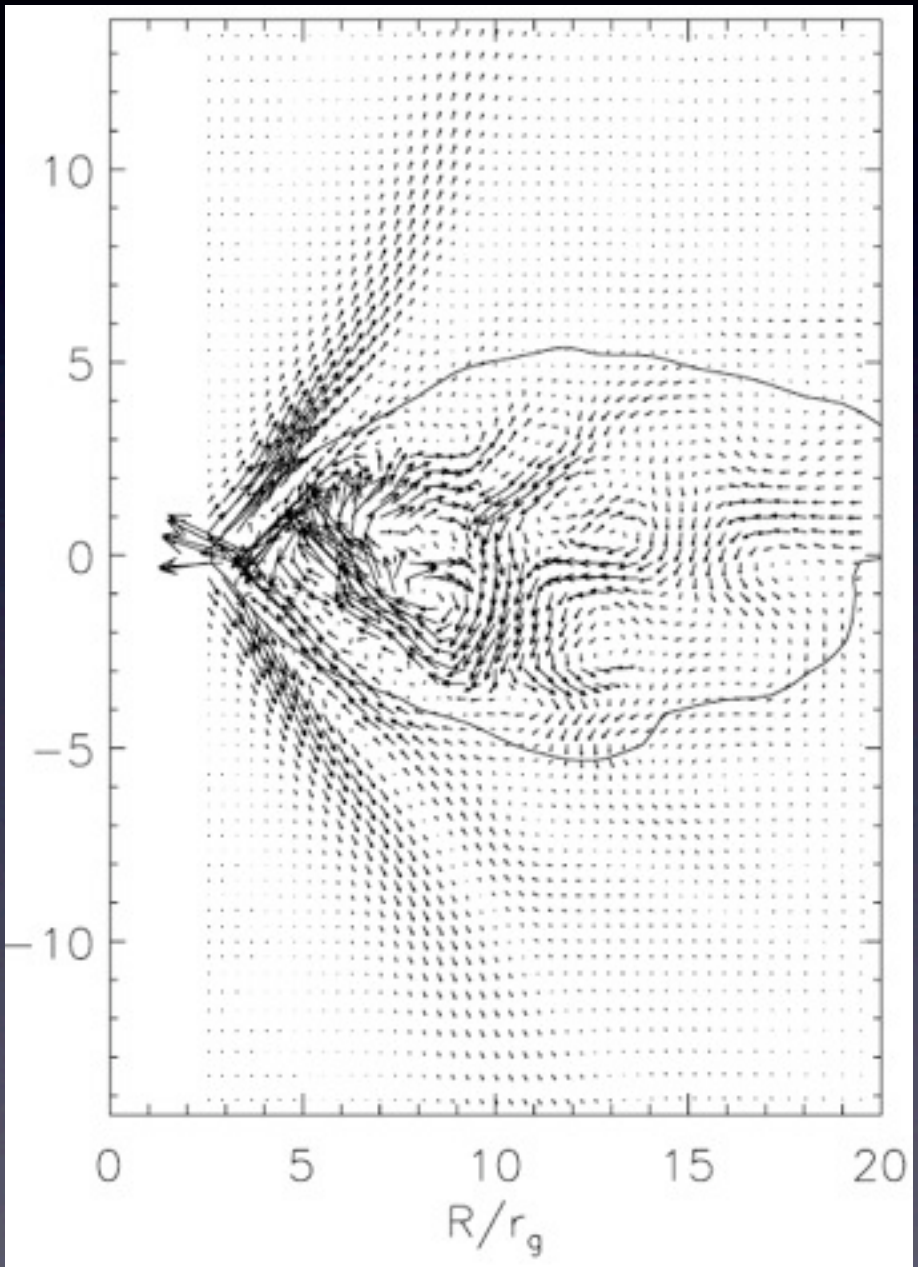
Hot Accretion sims.







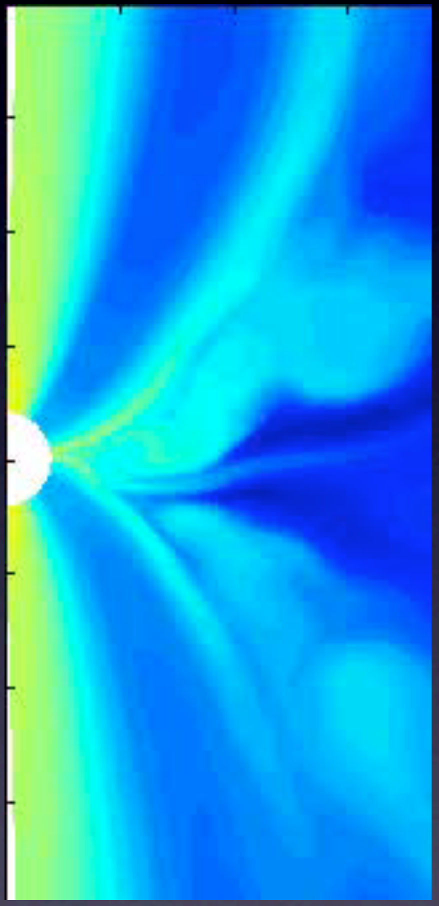
[Hawley & Balbus 2002]



MHD turbulence & transport

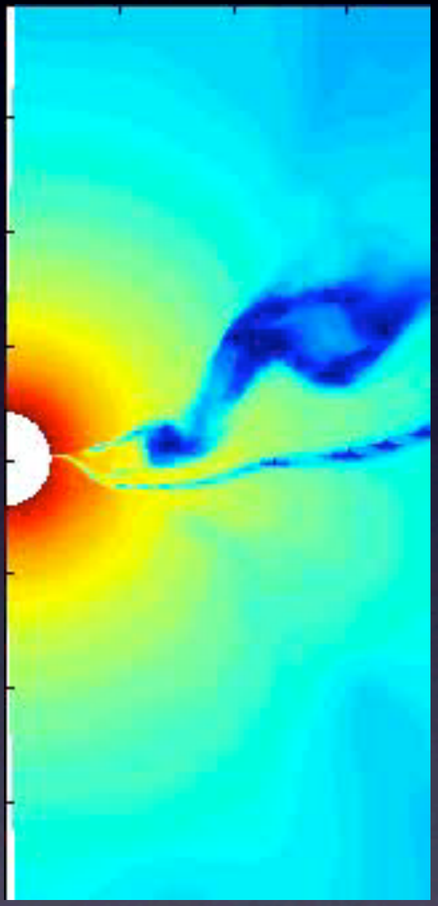
Flares in MHD sims?

Log(T)



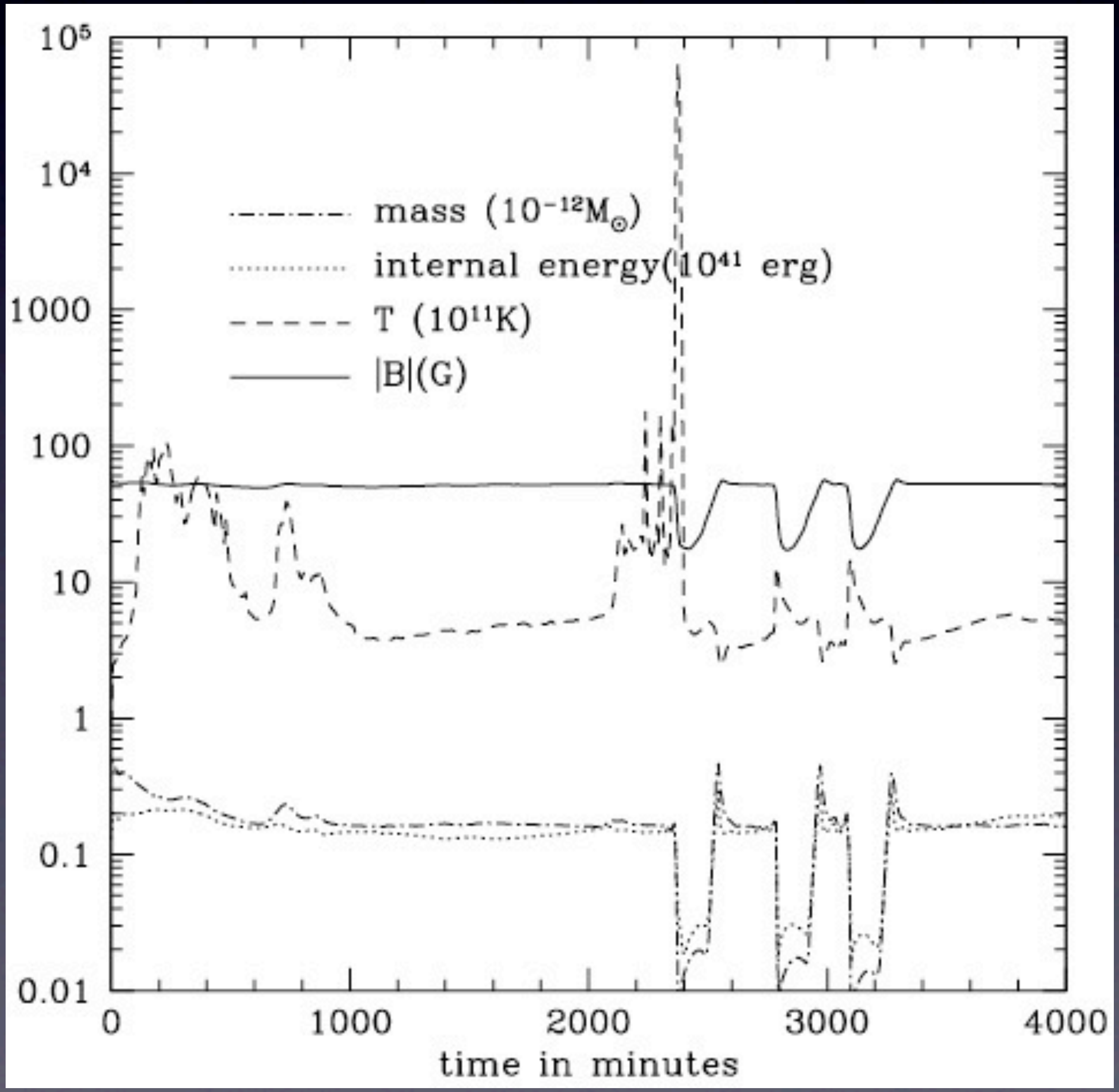
20r_g

Log($B^2/8\pi$)



20r_g

volume avg. over 6r_g

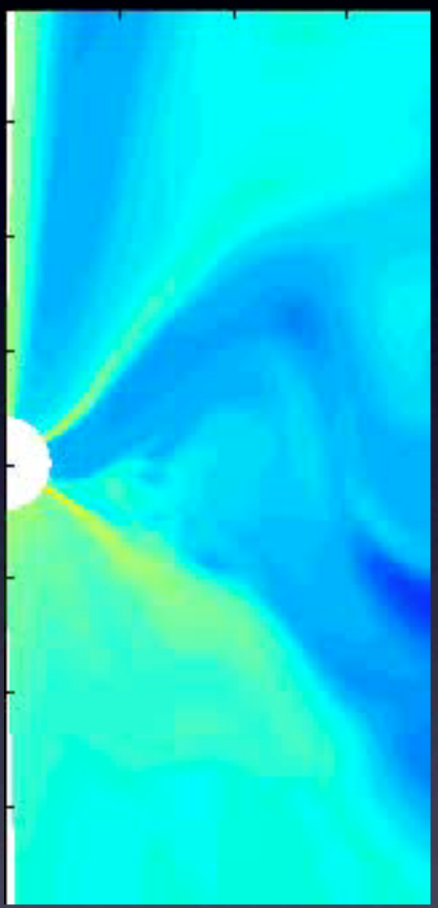


single initial loop, current sheet at equator

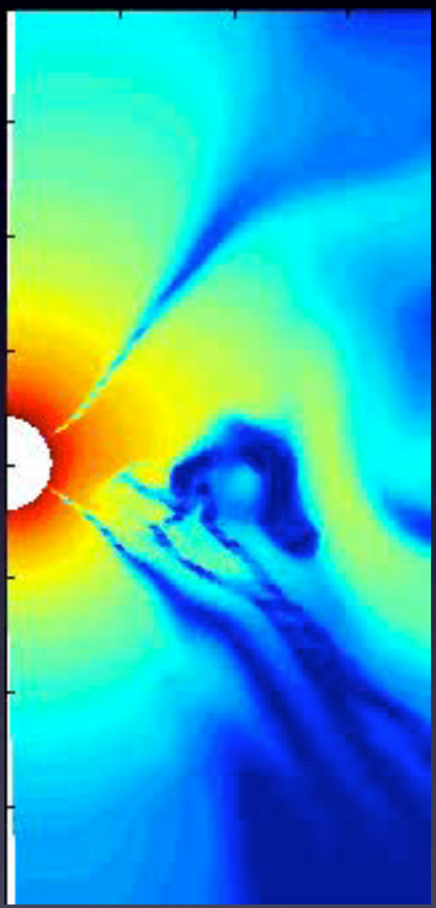
must look at short time (sampled at 8 min.), small volume

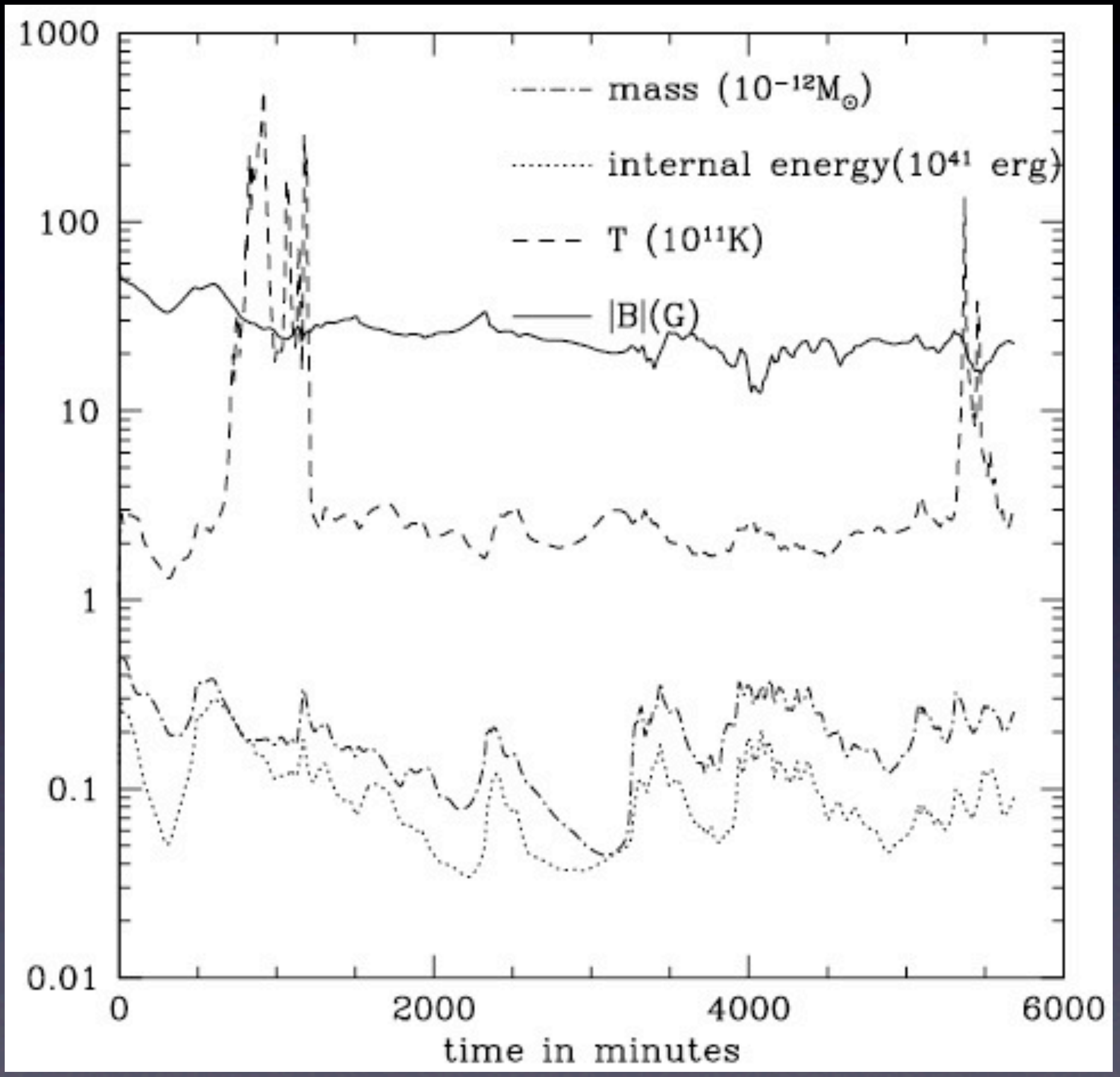
Initial B-geometry

Log(T)



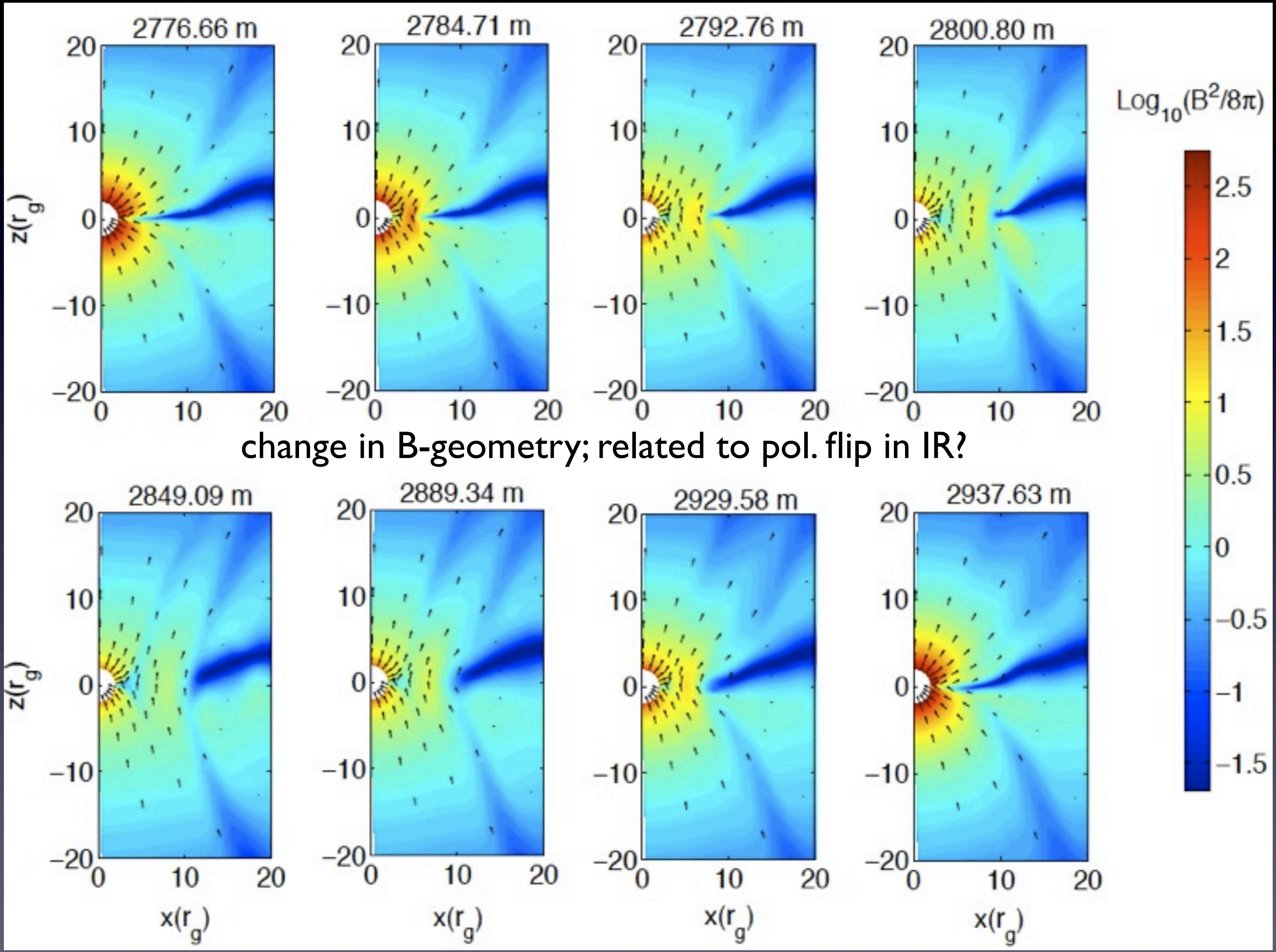
Log($B^2/8\pi$)





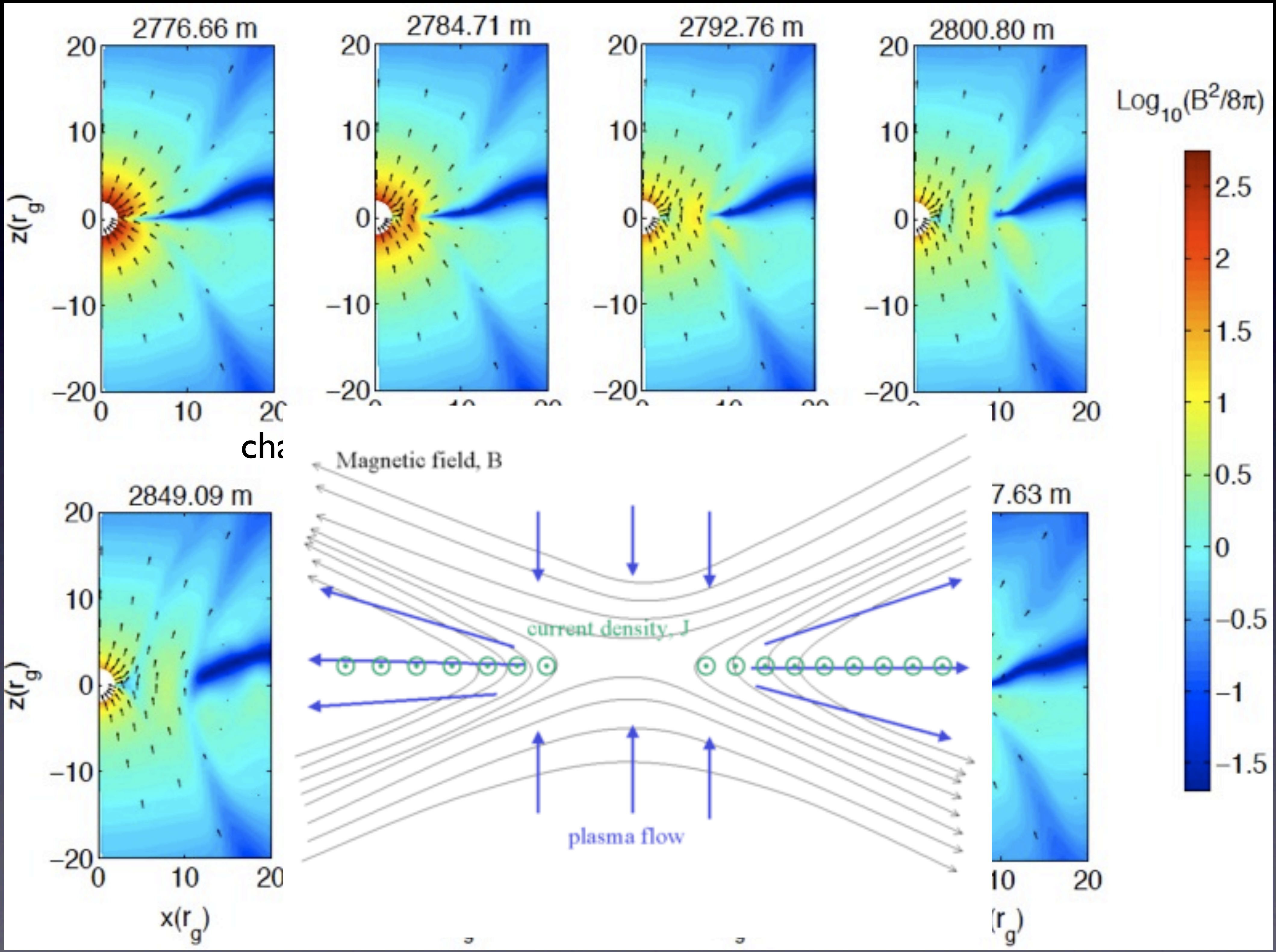
two initial loops, current sheets above/below equator
much more turbulent, thicker disk
less dramatic flares, still related to drop in B & rise in T

really Reconnection?



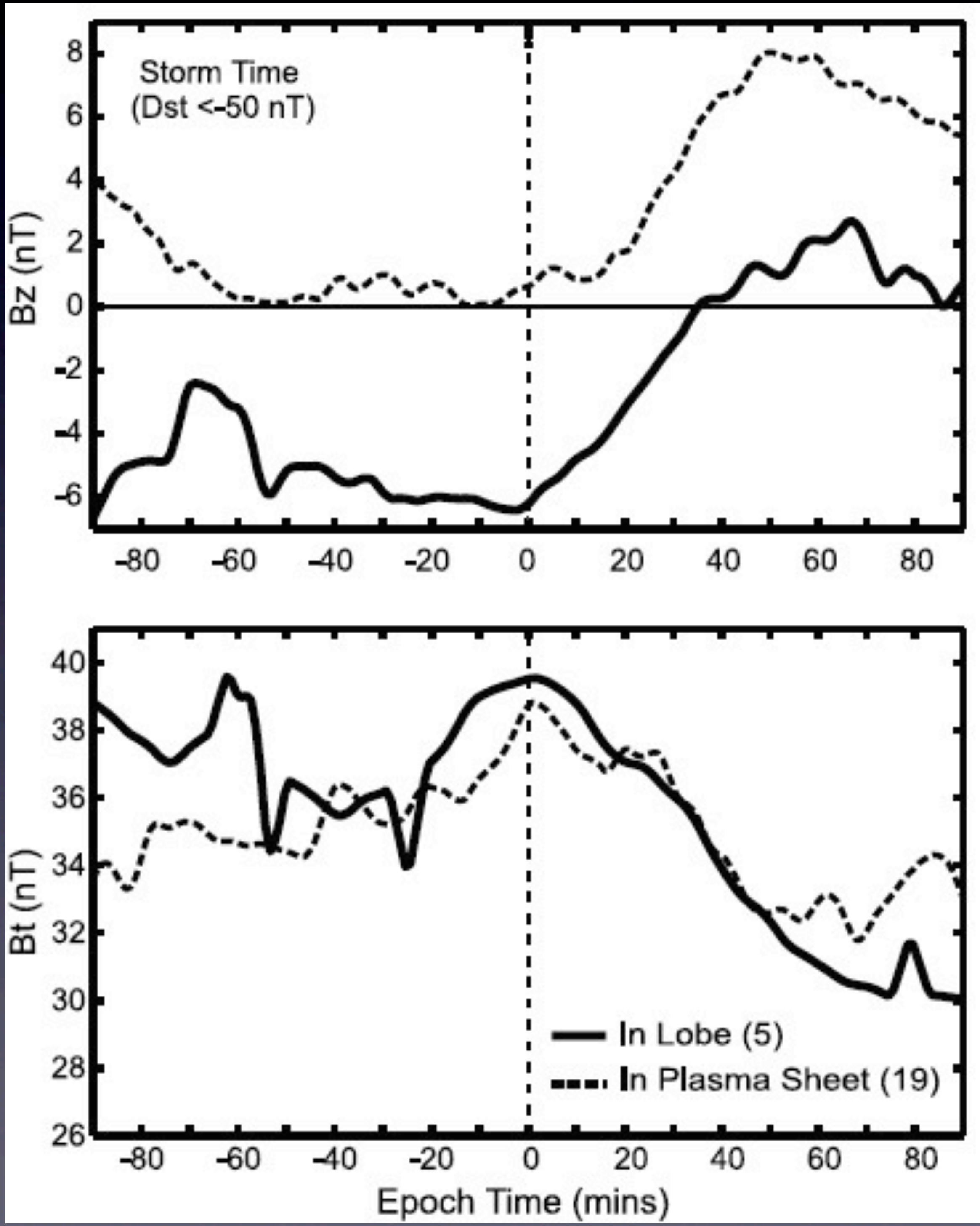
change in B-geometry; related to pol. flip in IR?

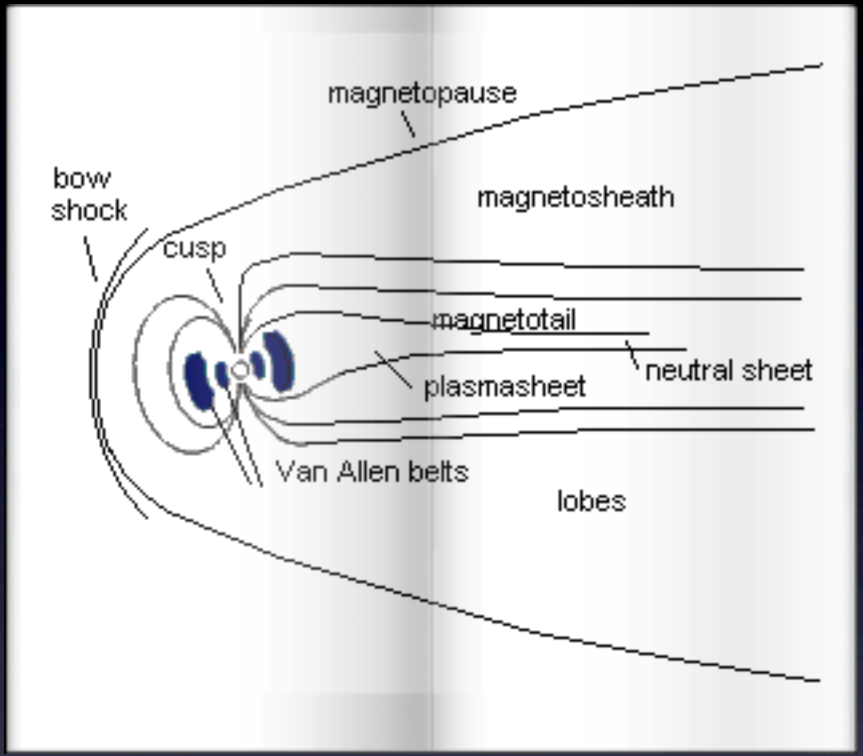
really Reconnection?



Tail reconnection

[McPherron & Hsu]

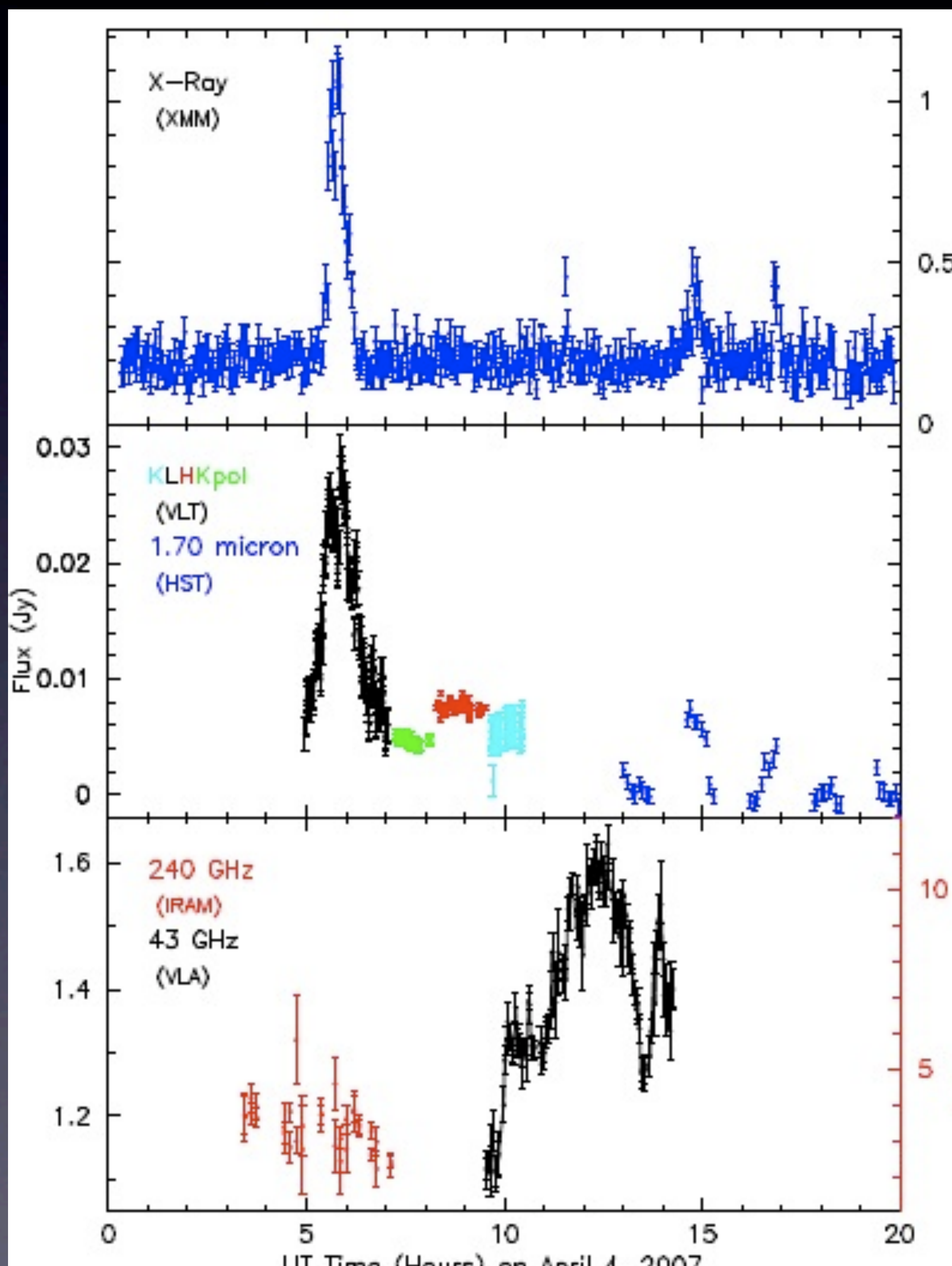




energy stored in B, suddenly released
change in B-geometry (B_z)
almost like the accretion flare!

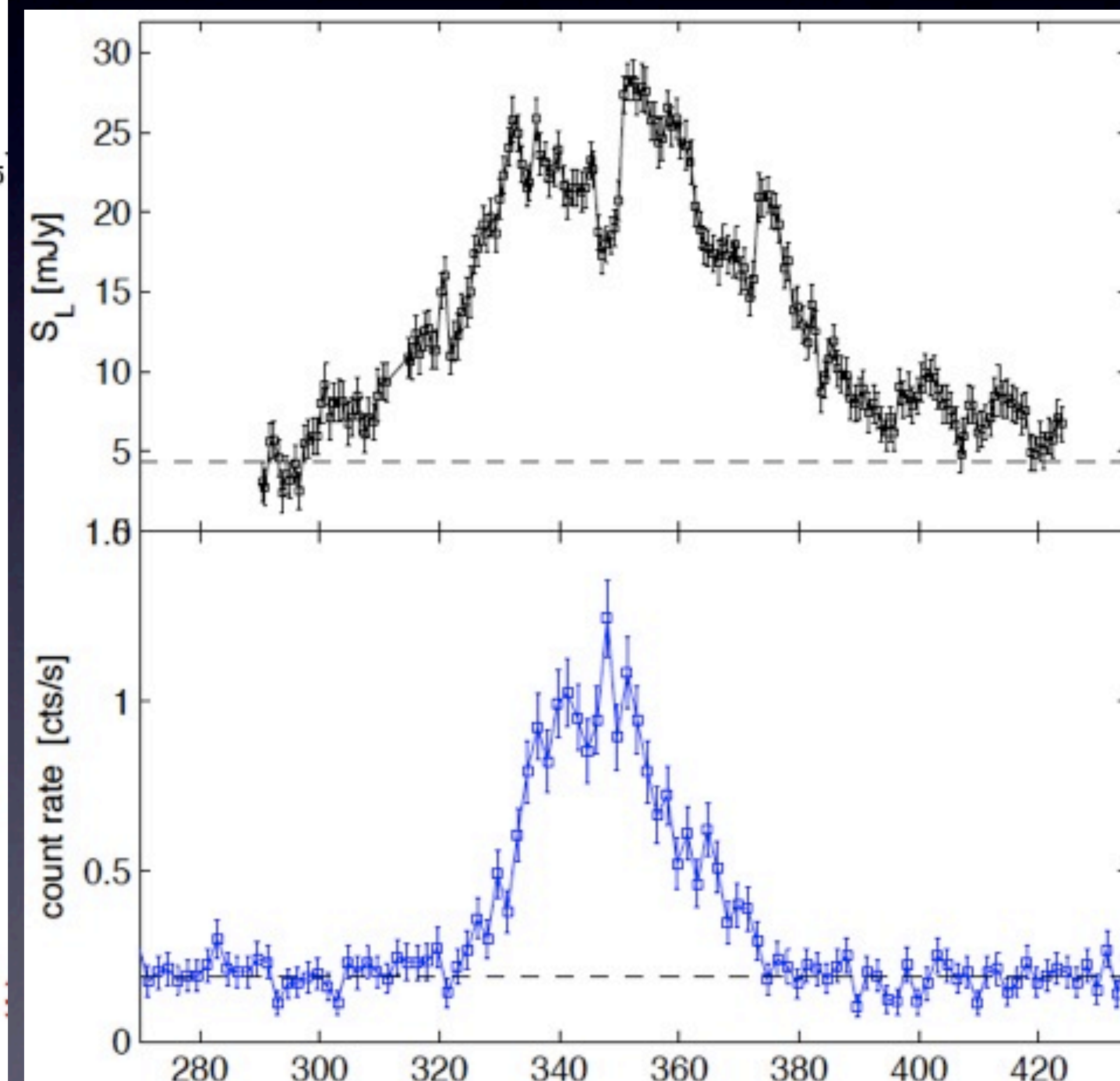
A multi-λ flare

[Yusef-Zadeh et al. 2009]



short $\Delta t \Rightarrow R_F \leq R_S$

[Dodds-Eden et al. 2009]



minutes

Modeling

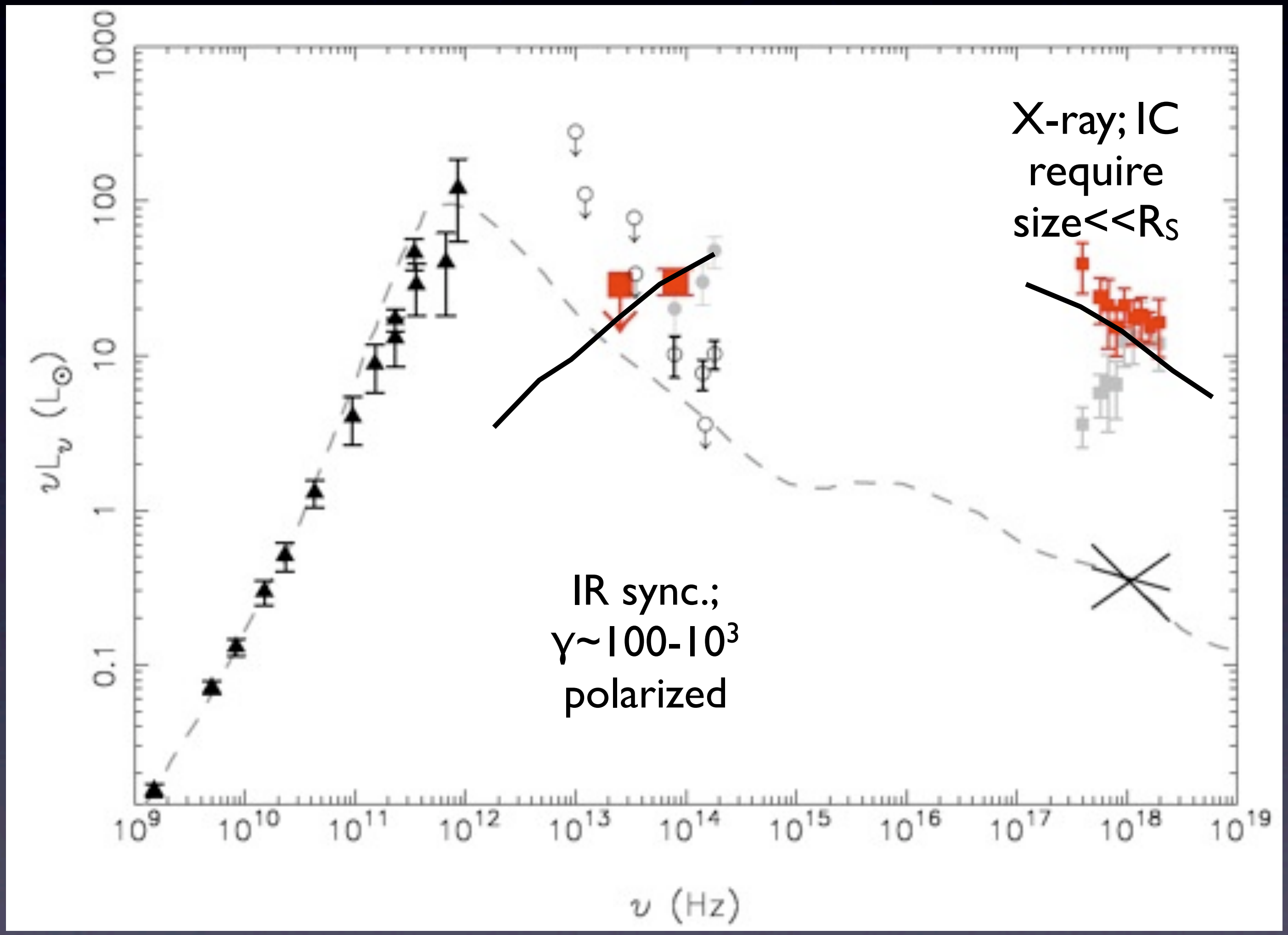
$$L_{\rm synch} \propto N\theta_E^2 B^2$$

$$L_{\rm IC} \propto N\theta_E^2 R_Q^{-2}$$

$$L_{\rm SSC} \propto N^2\theta_E^4 B^2 R_F^{-2}$$

$$\nu_{IC} = \gamma^2 \nu_{seed}$$

$$\nu_c = 4.2 \times 10^6 B\gamma^2$$

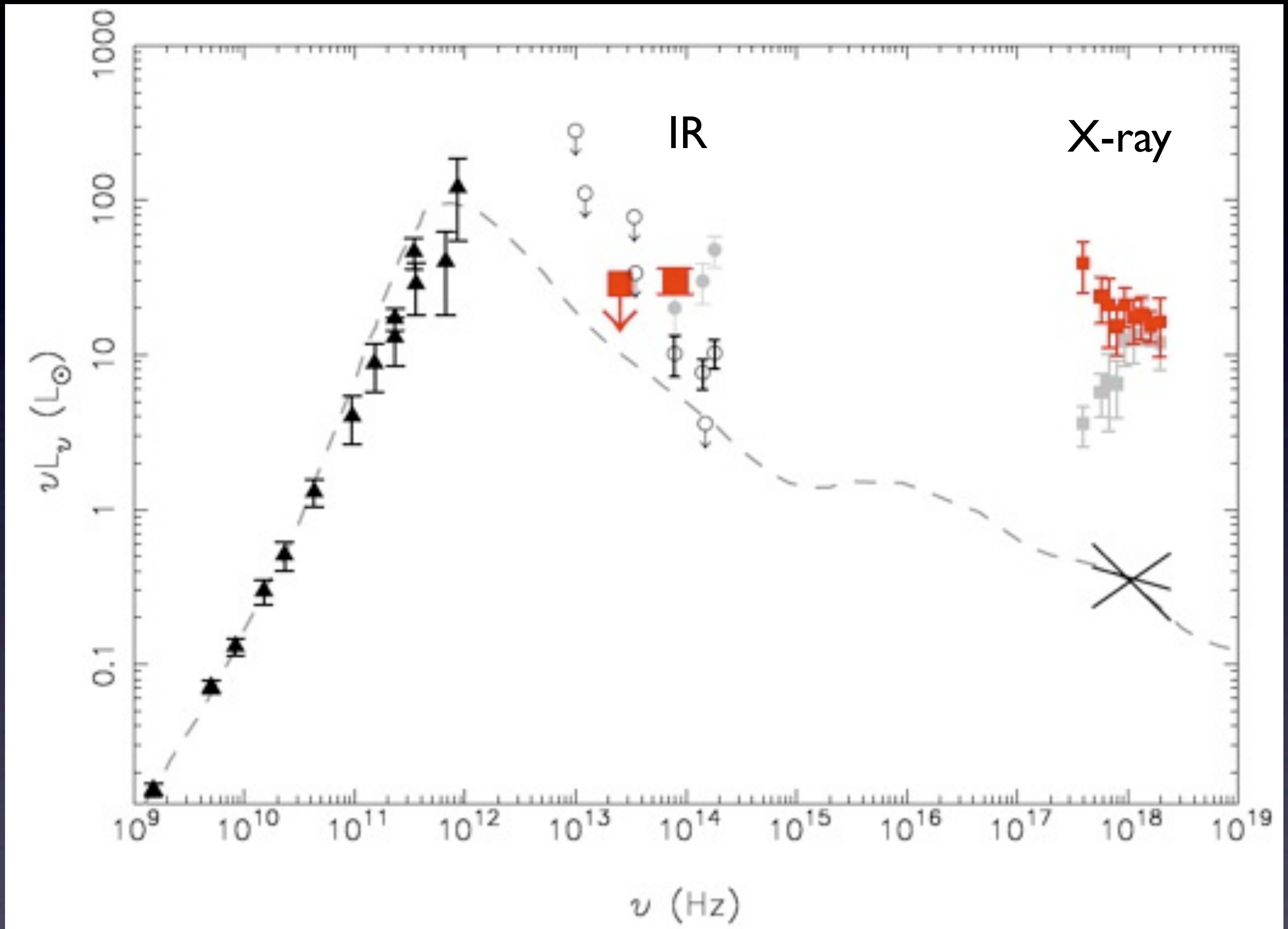


IC: R_Q too small (contradicts size mm.), << R_S

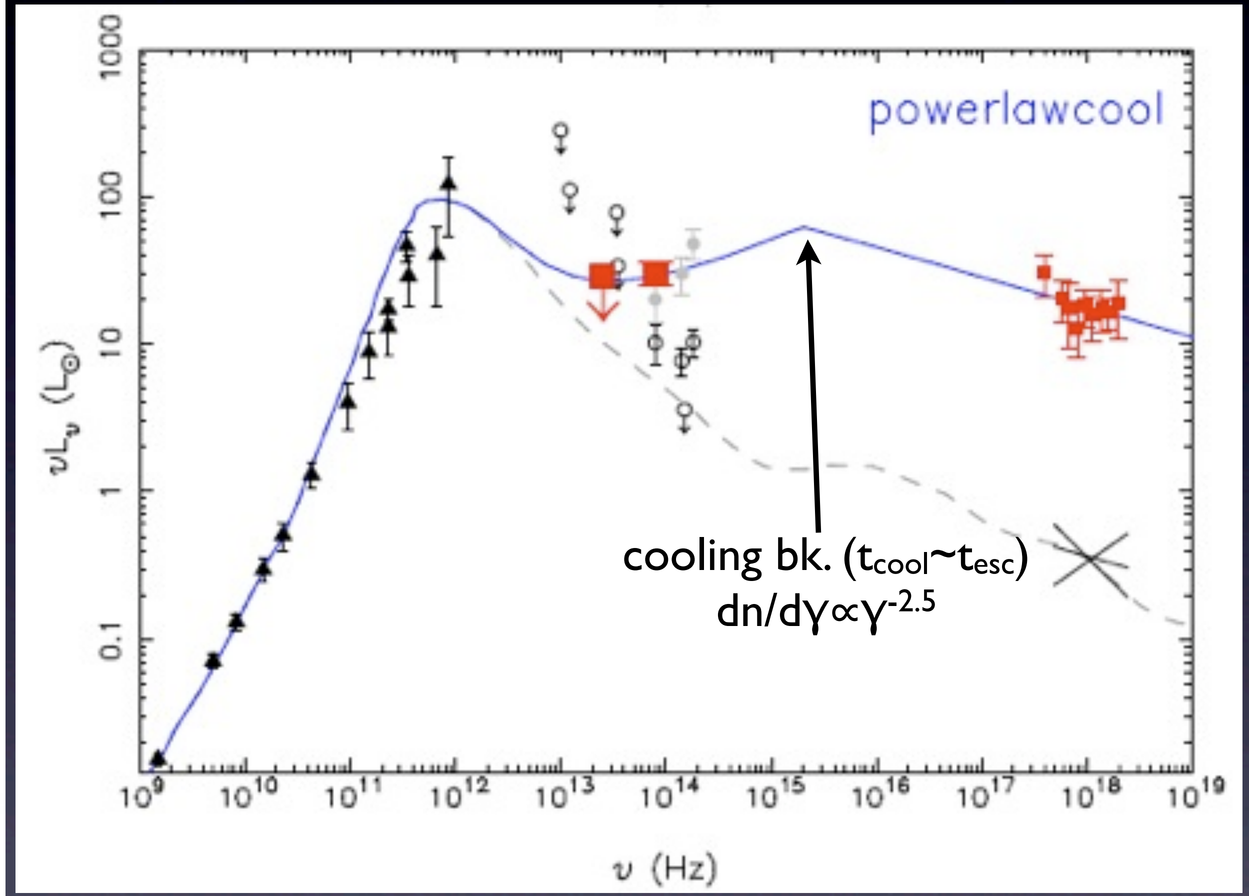
SSC: B too large

IC/SSC may apply for other flares where IR is softer and X-ray harder

Synchrotron+cooling



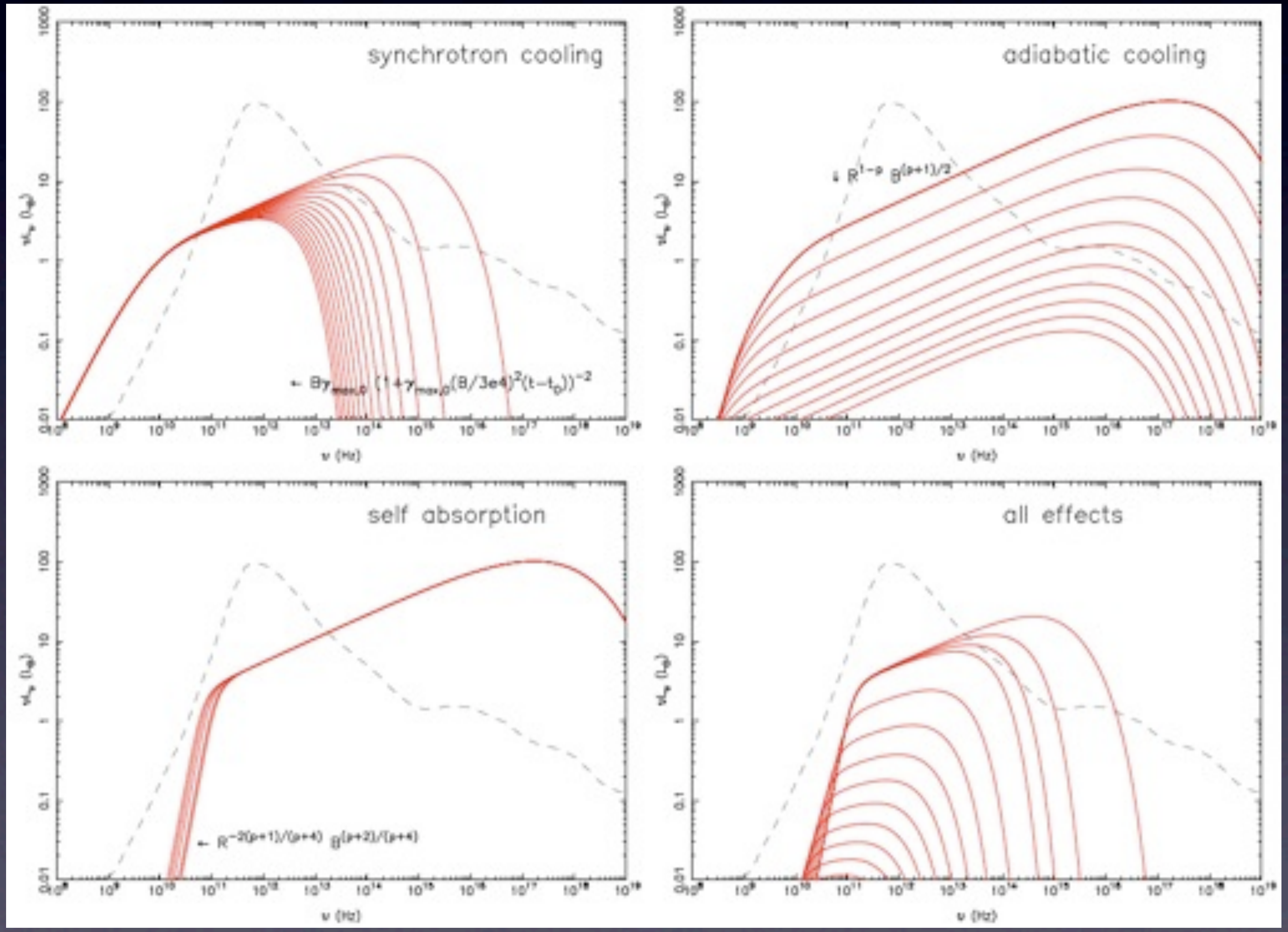
[Dodds-Eden et al. 2009]

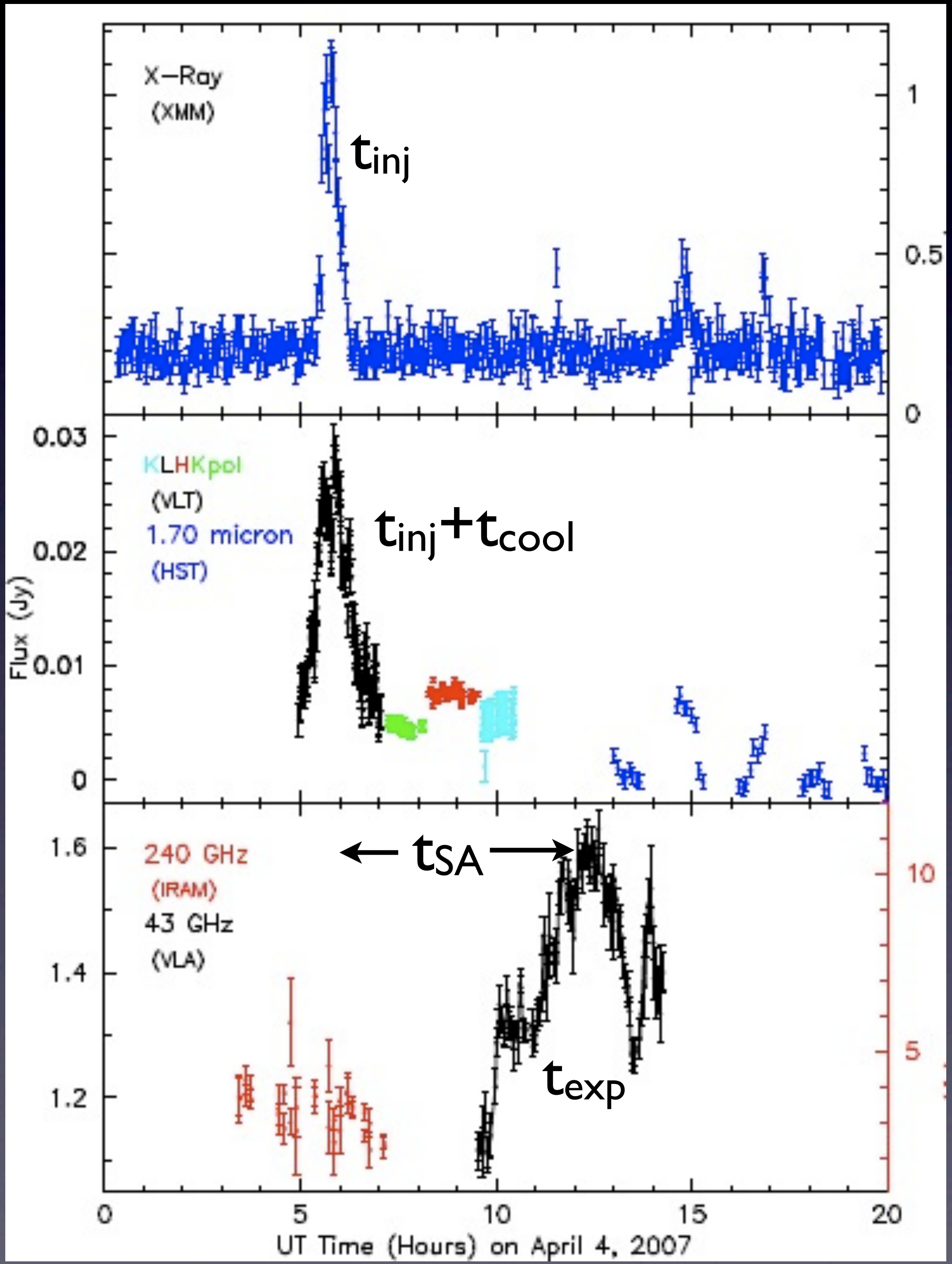


B~30G from Faraday RM constrains
agree w. global MHD sims.
constrains on peaks of IR/X-ray spec.=>
optically thin synchrotron from IR to X-ray

$$\tau_{cool} = 8 \left(\frac{B}{30\ \mathrm{G}}\right)^{-3/2} \left(\frac{\nu}{10^{14}\ \mathrm{Hz}}\right)^{-1/2}\ \mathrm{min}$$

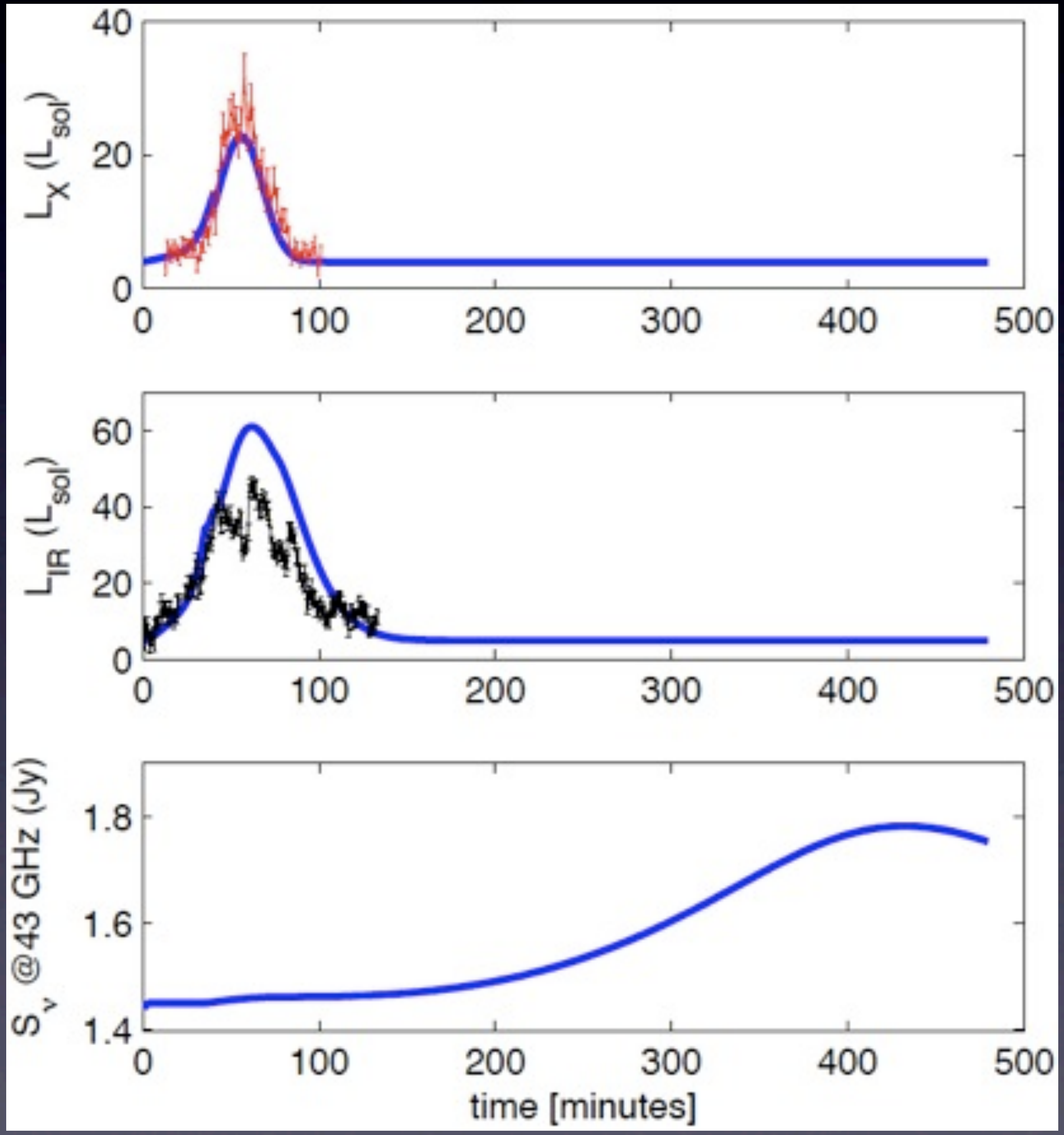
Time-dependent model

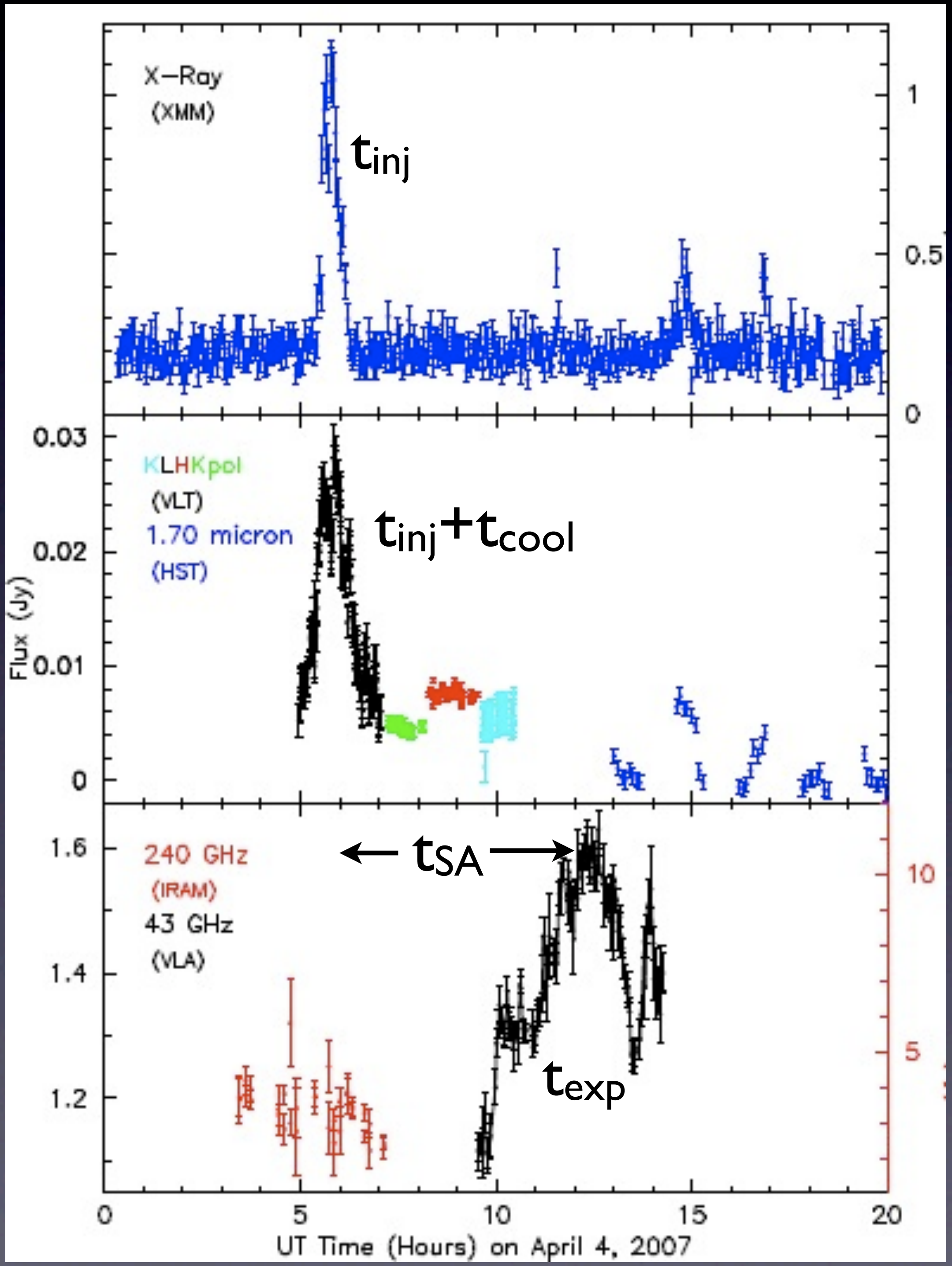




Time-dependent model

[preliminary]





Future

- Modeling:
    - GRMHD flares in 3-D; resistivity??
    - better radiation transfer; GR, inclination/spin effects
    - effect of initial B-field configurations
- Observations:
    - time resolved spectra of bigger flares
    - better statistics; is sync. soft X-ray blue IR or IC/SSC needed?
    - polarization, Faraday rotation during flares
    - X-ray, IR cleaner than radio/sub-mm (turbulent fluctuations, association w. X-ray, IR flares?)