

# radiation flares from relativistic plasmoid reconnection

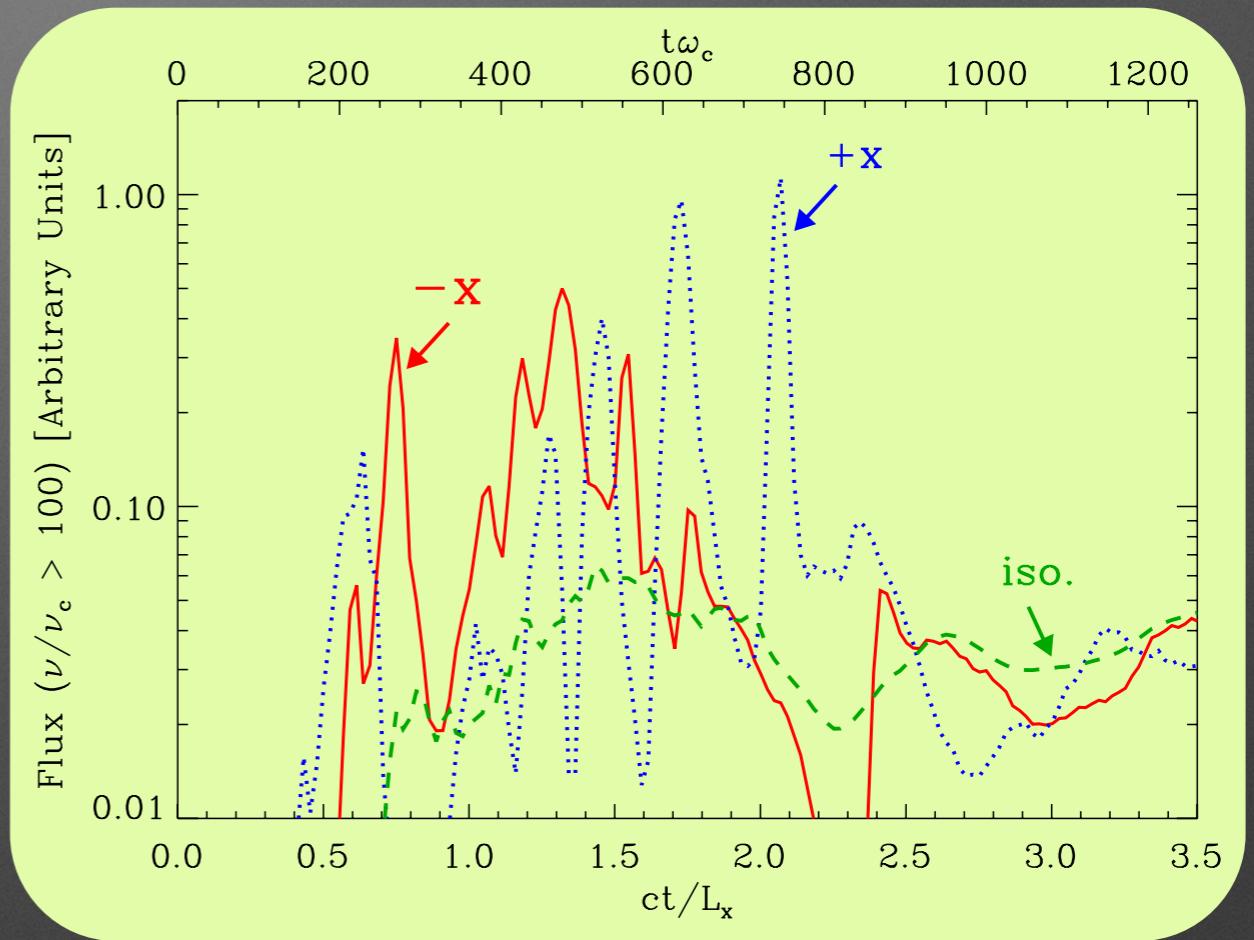
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Purdue University, May 13th, 2014

# high-energy flares potentially explained by relativistic reconnection

- gamma-ray bursts  
(Lyutikov)
- TeV blazars  
(Giannios et al.)
- Crab PWN  
(Cerutti et al.)



“kinetic beaming”  
 $t_{\text{var}} \ll L / c$

Cerutti et al. (2012)

# open questions

- exact location and evolution of the emitting regions
- the role of bulk kinematics and Doppler beaming
- origin of rapid variability:  
spatial bunching vs. swinging beams
- particle acceleration mechanisms:  
acceleration along E-fields (z)  
emission along the reconnection layer (x)

# simulation setup

- 2D  $e^+e^-$  PIC with Zeltron

- $N = 2048^2$

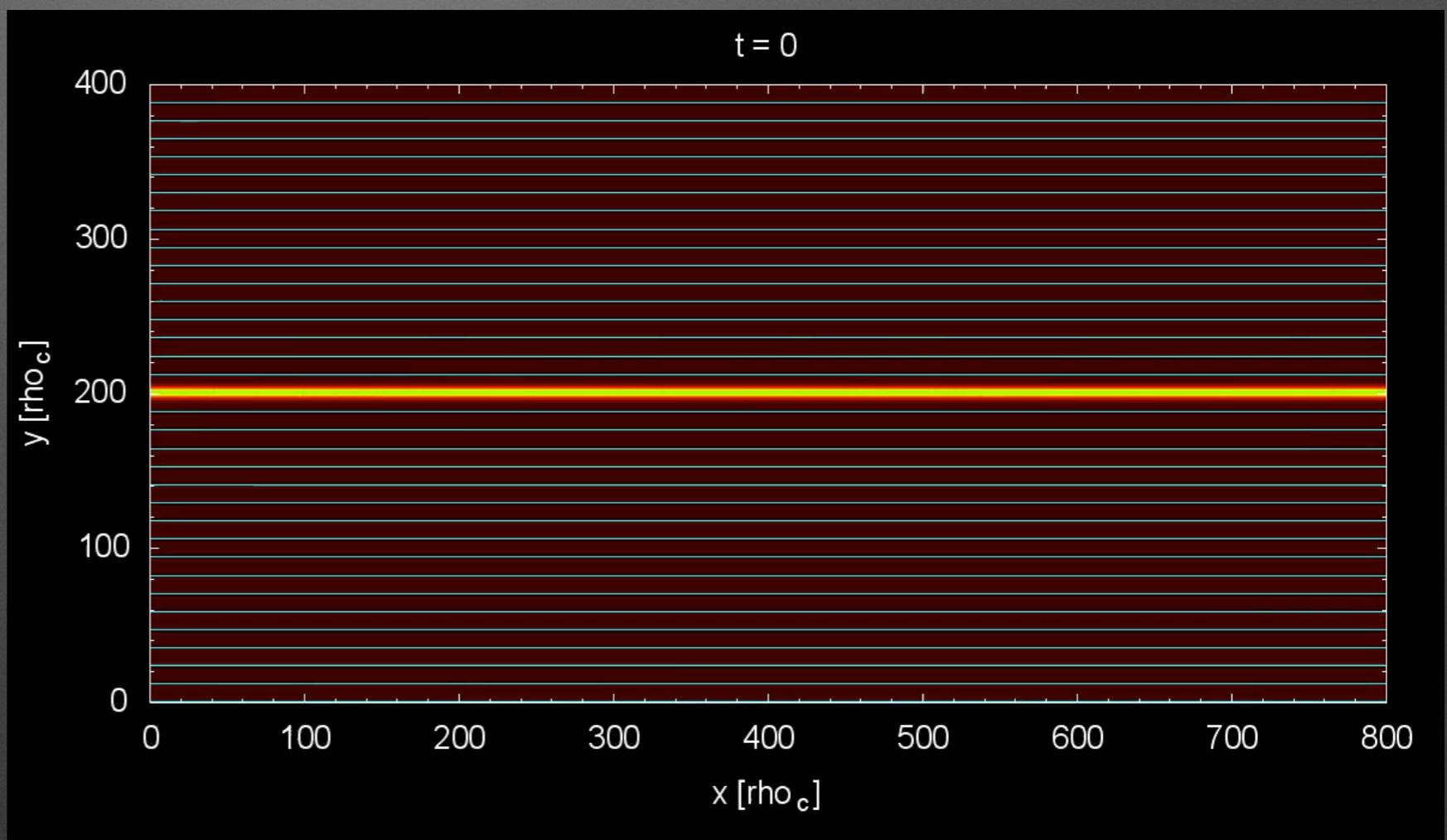
- 256 particles/cell

- doubly periodic

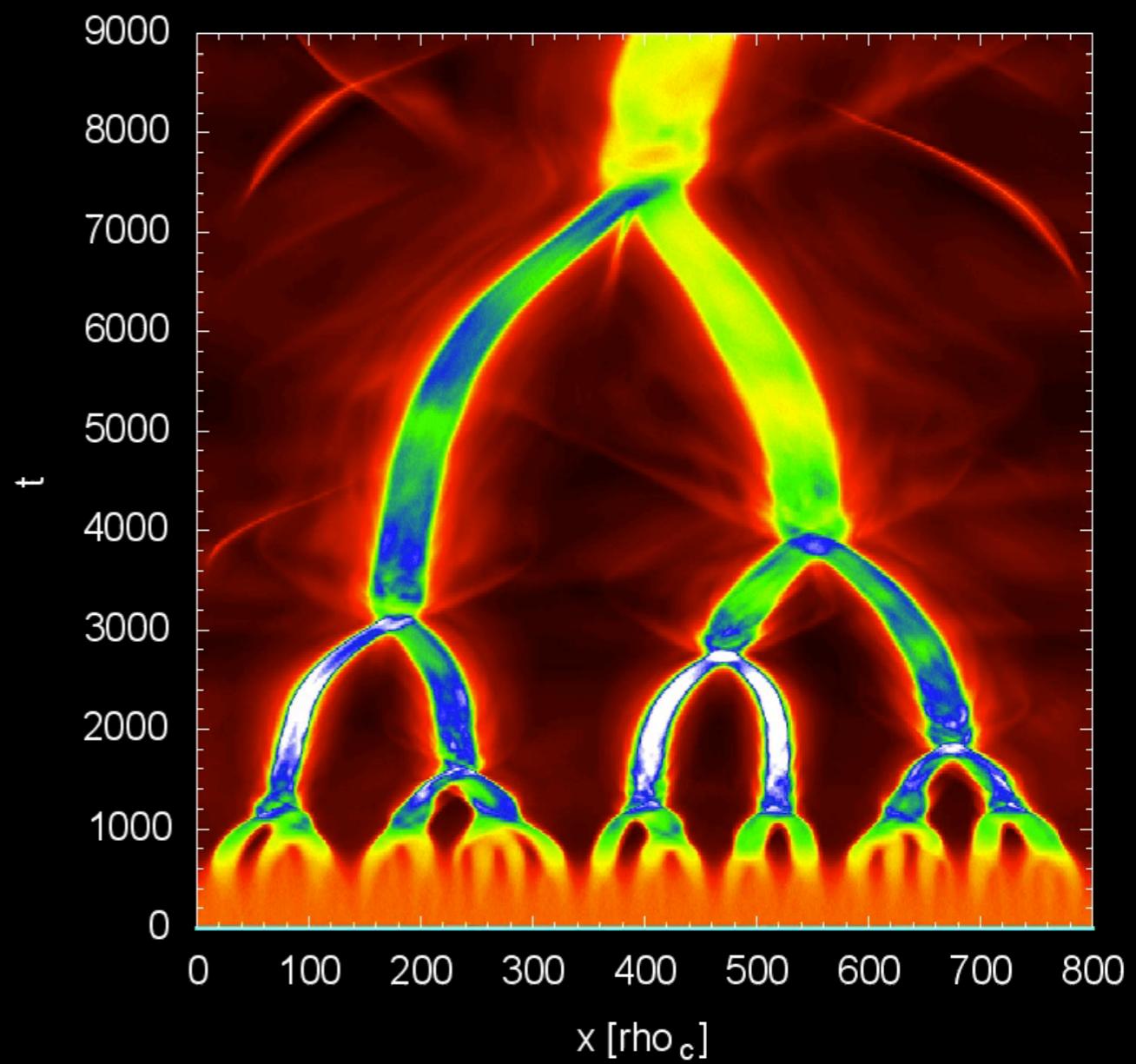
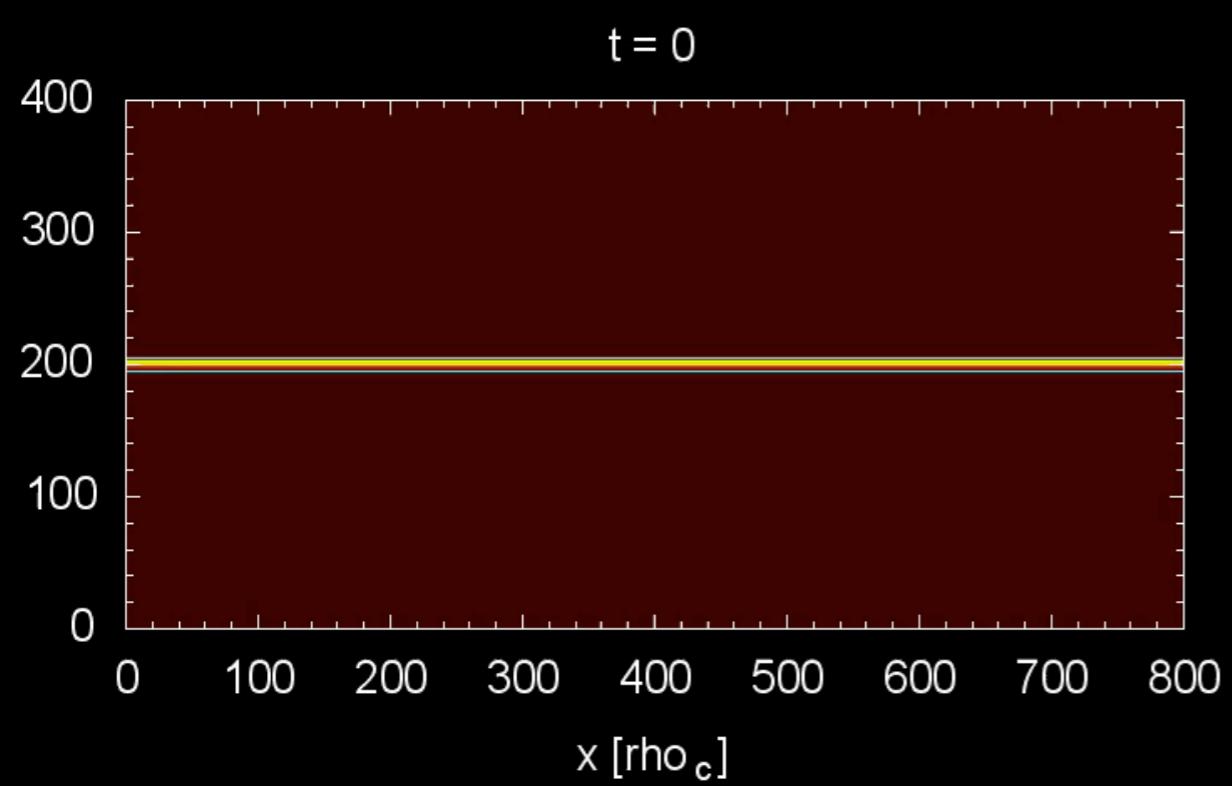
- no perturbation

- $\sigma = 16$

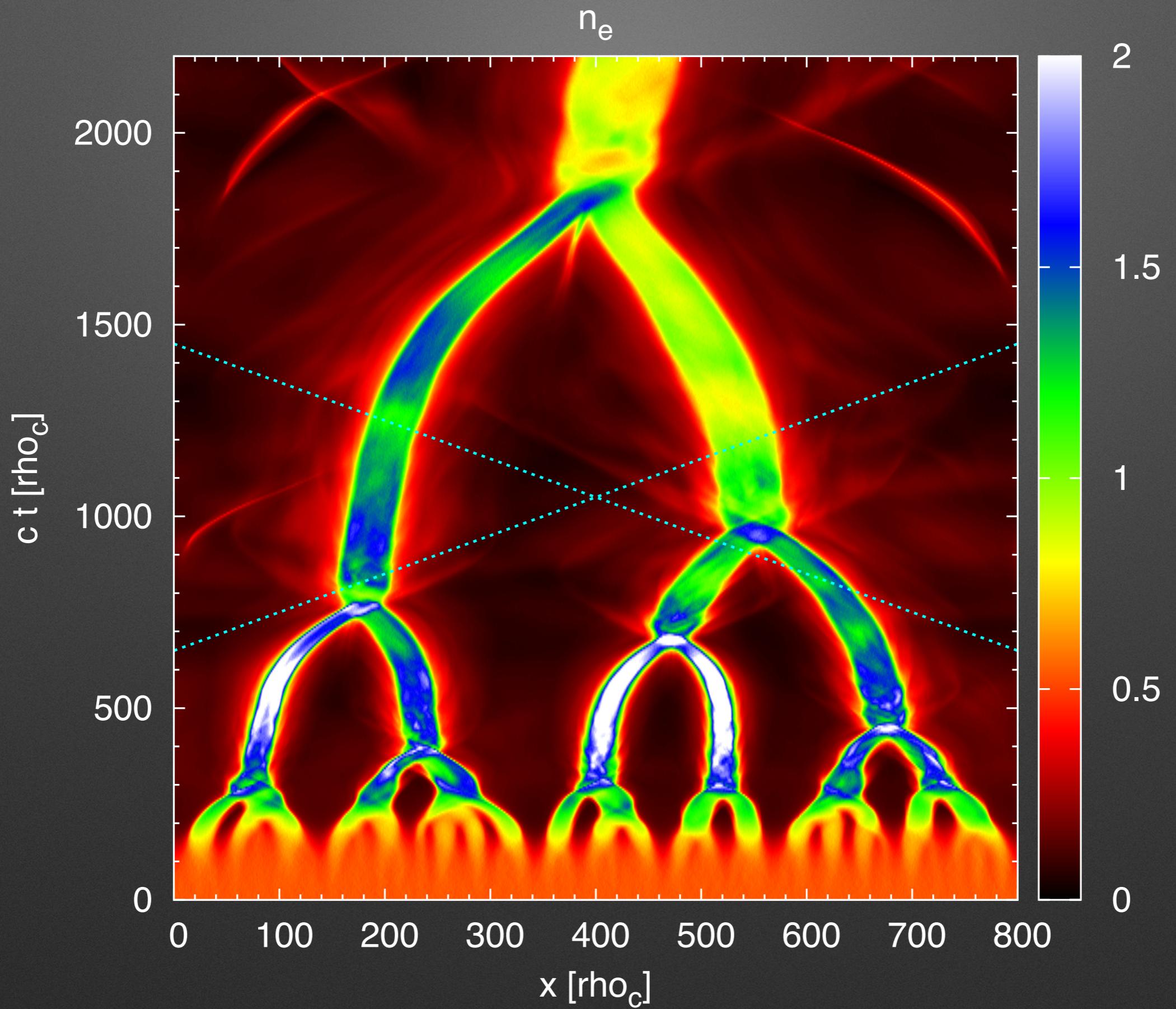
- $T_d = T_b = m_e c^2/k$  (negligible radiation reaction)



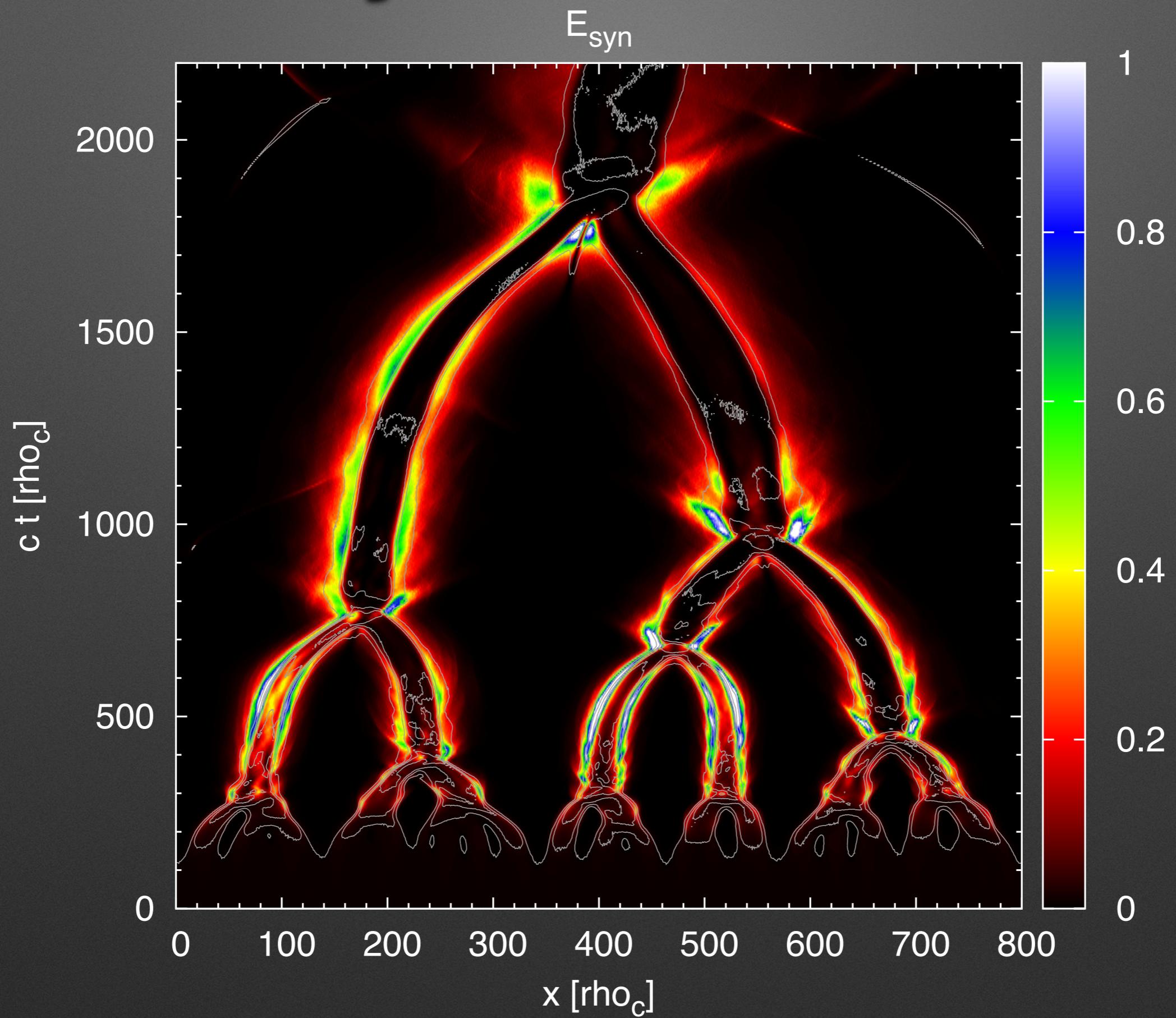
# spacetime diagram



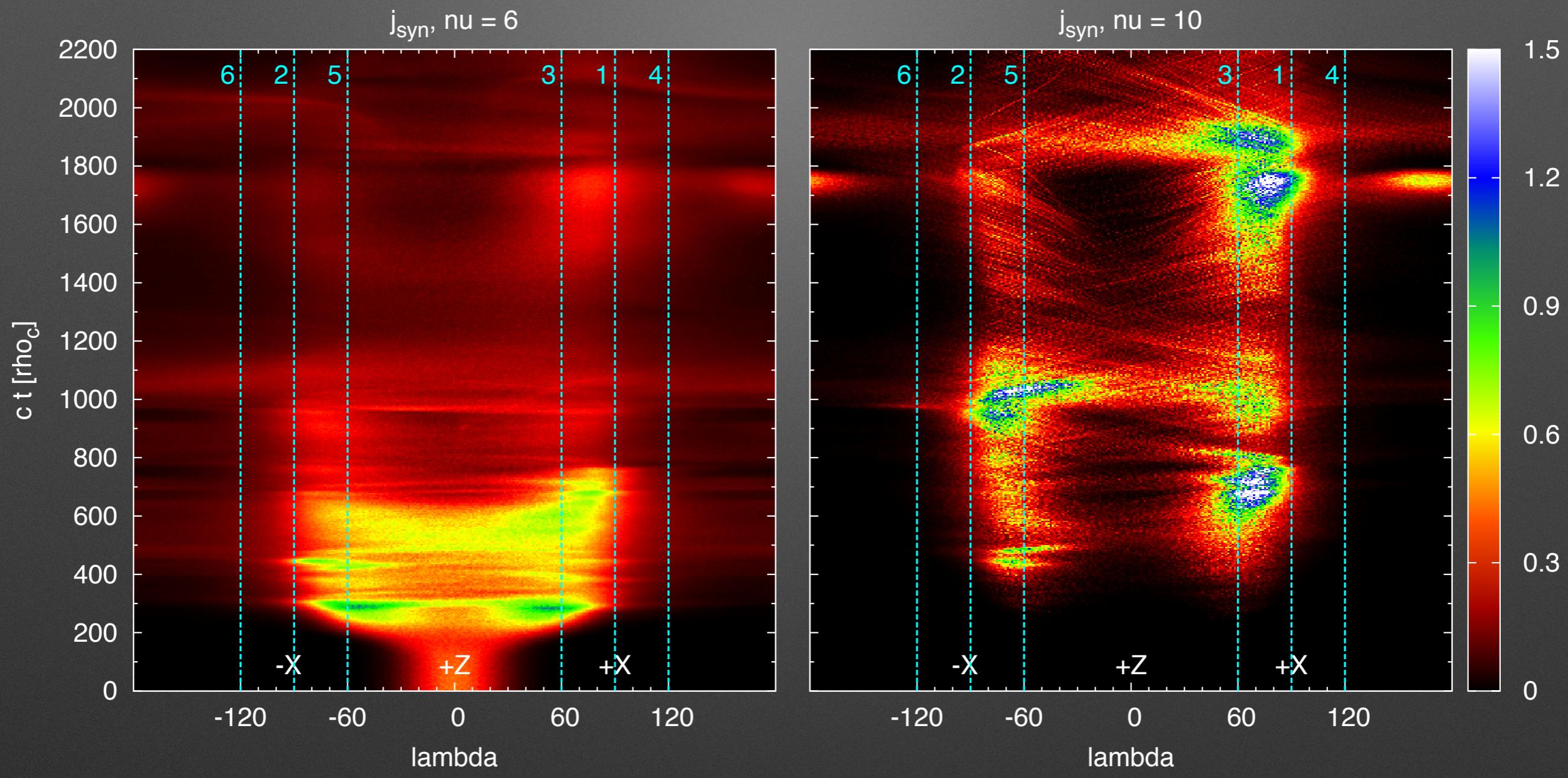
# particle density



# total synchrotron losses



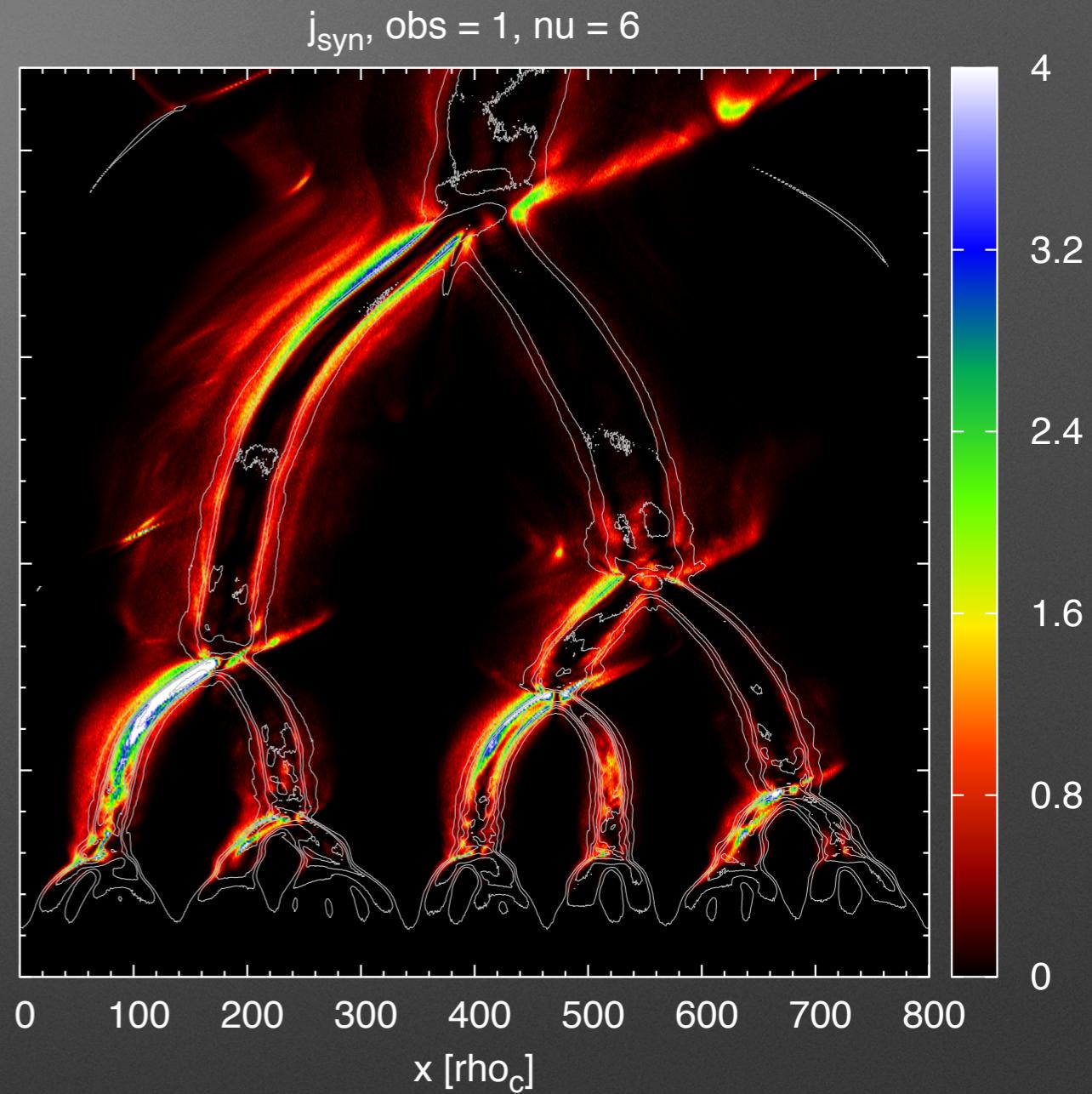
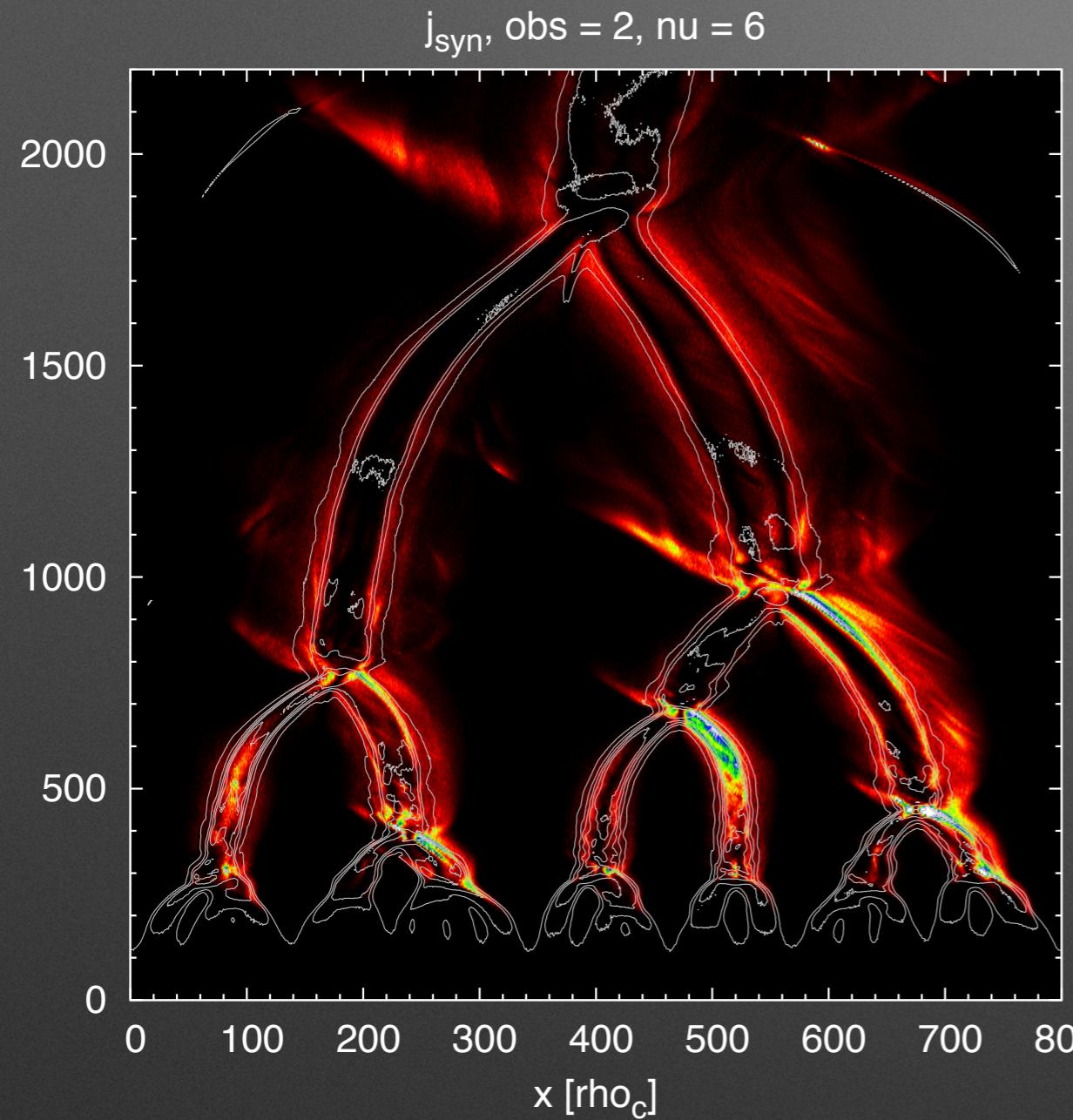
# radiation anisotropy



medium frequency

high frequency

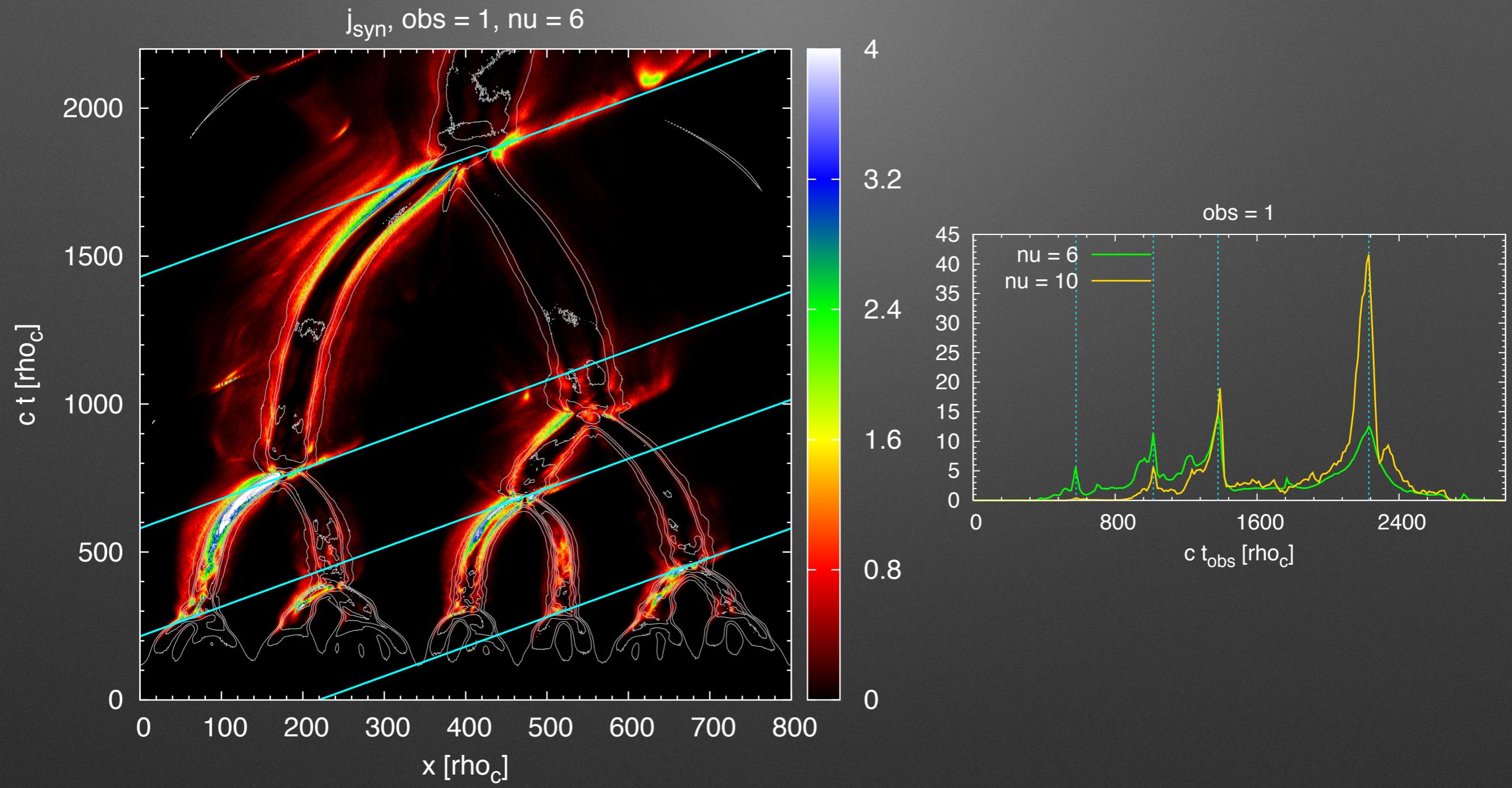
# synchrotron emissivity



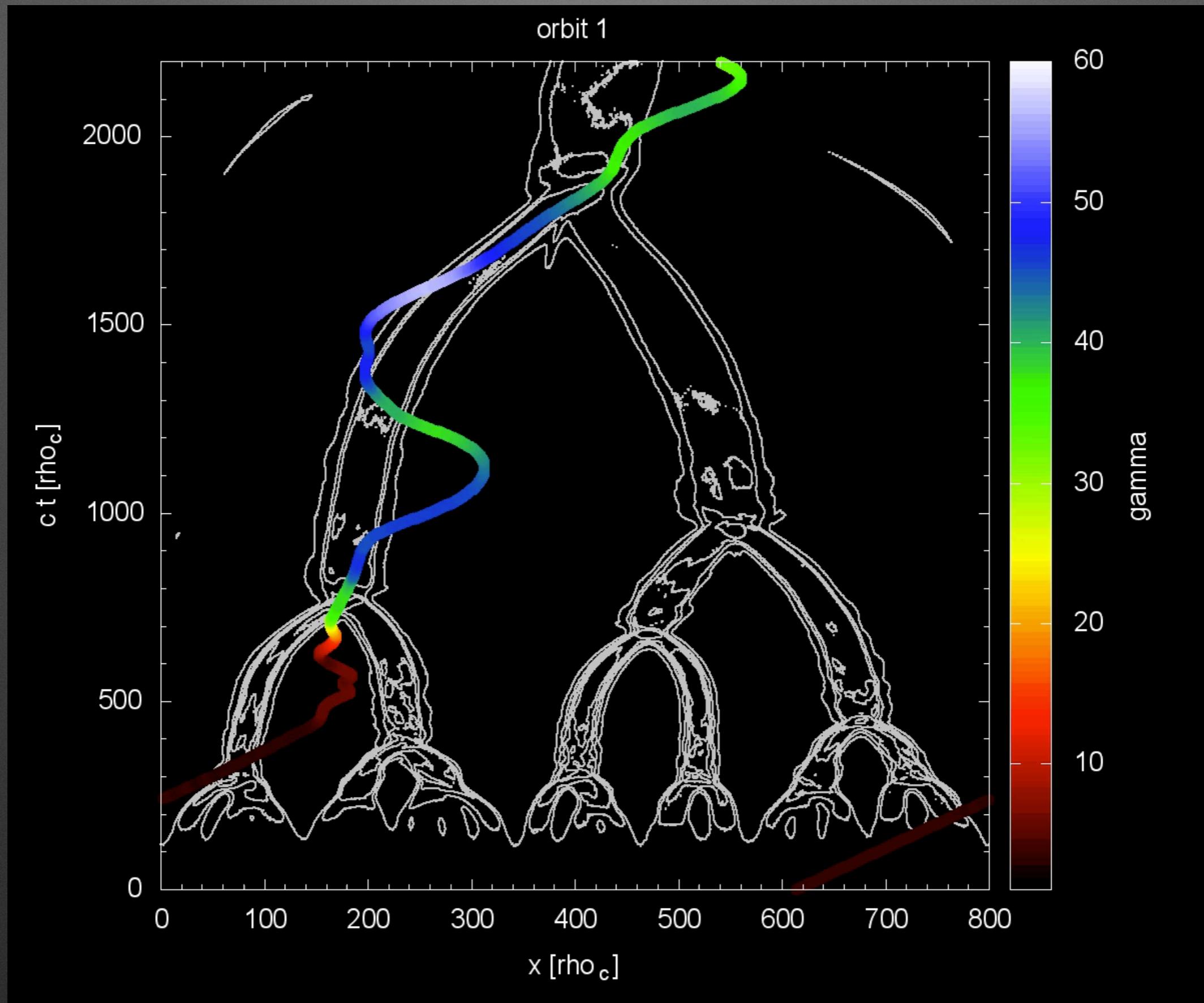
looking from the left

looking from the right

# observed light curves

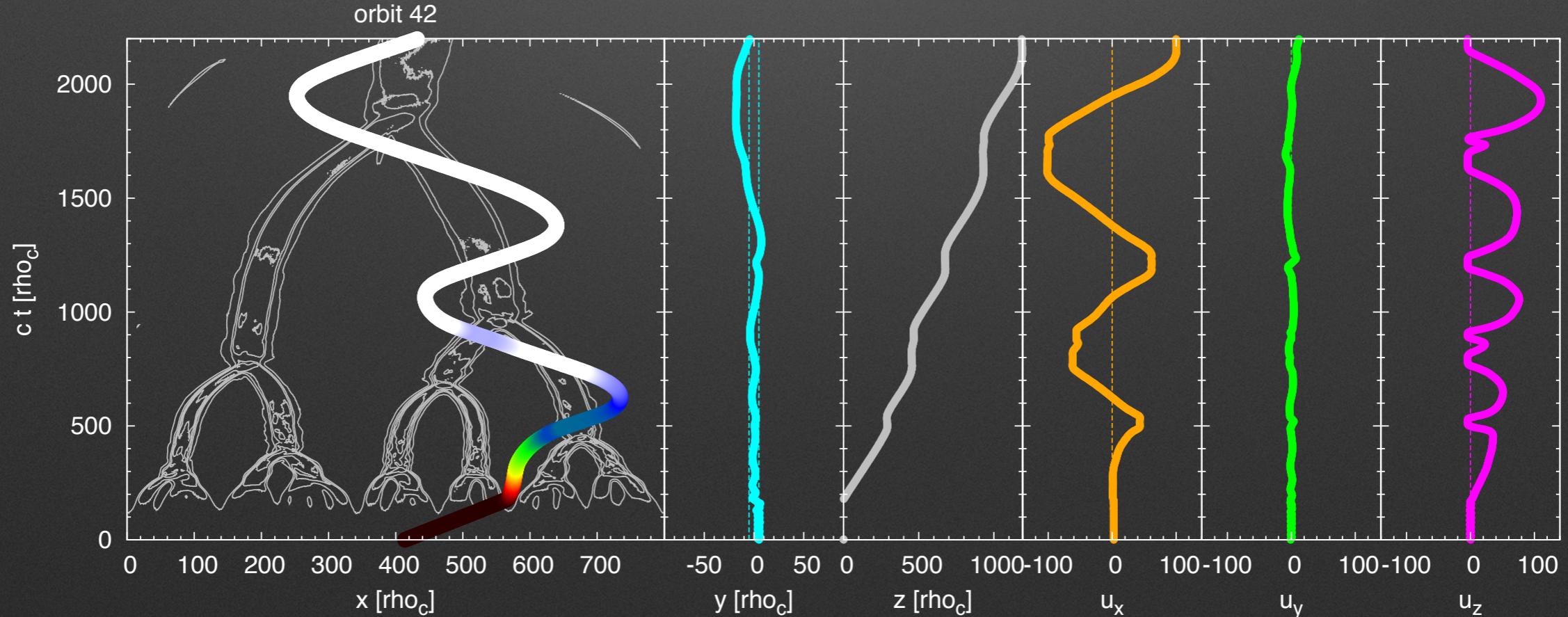
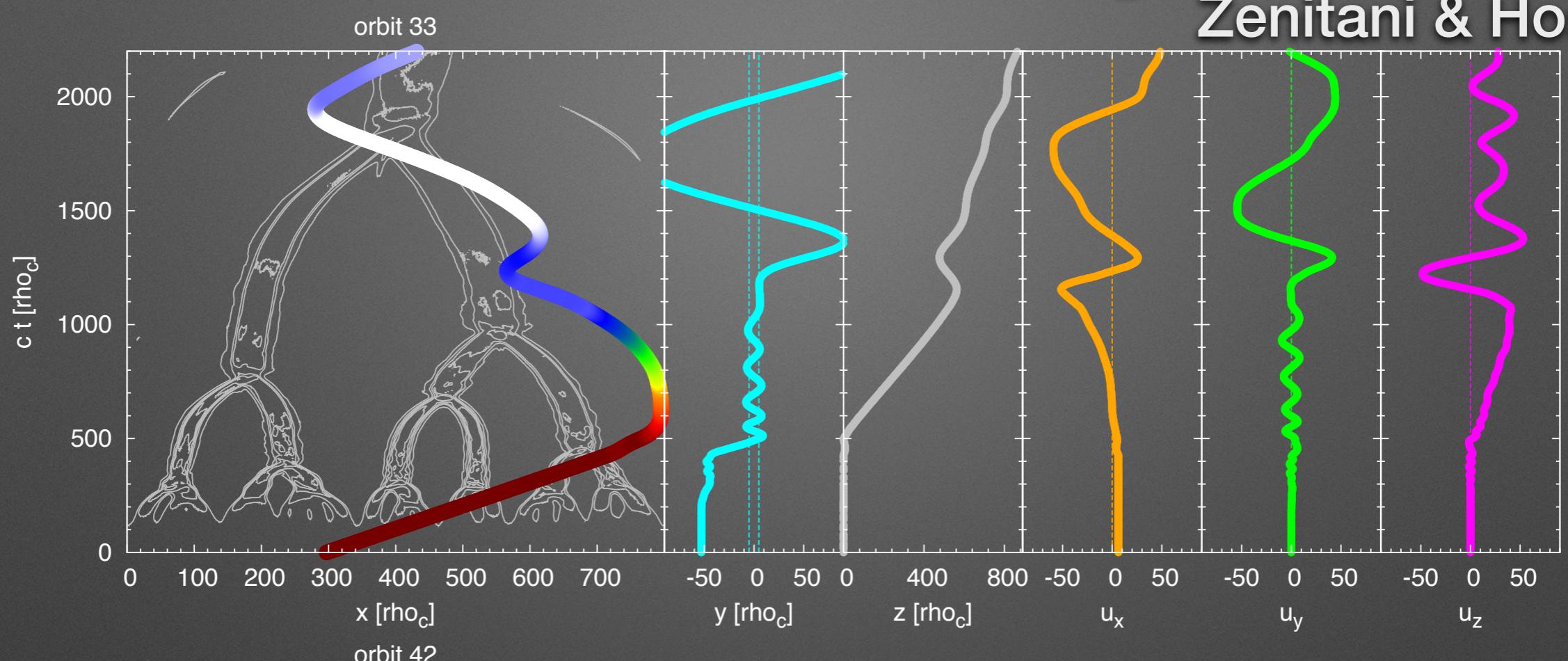


# particle acceleration



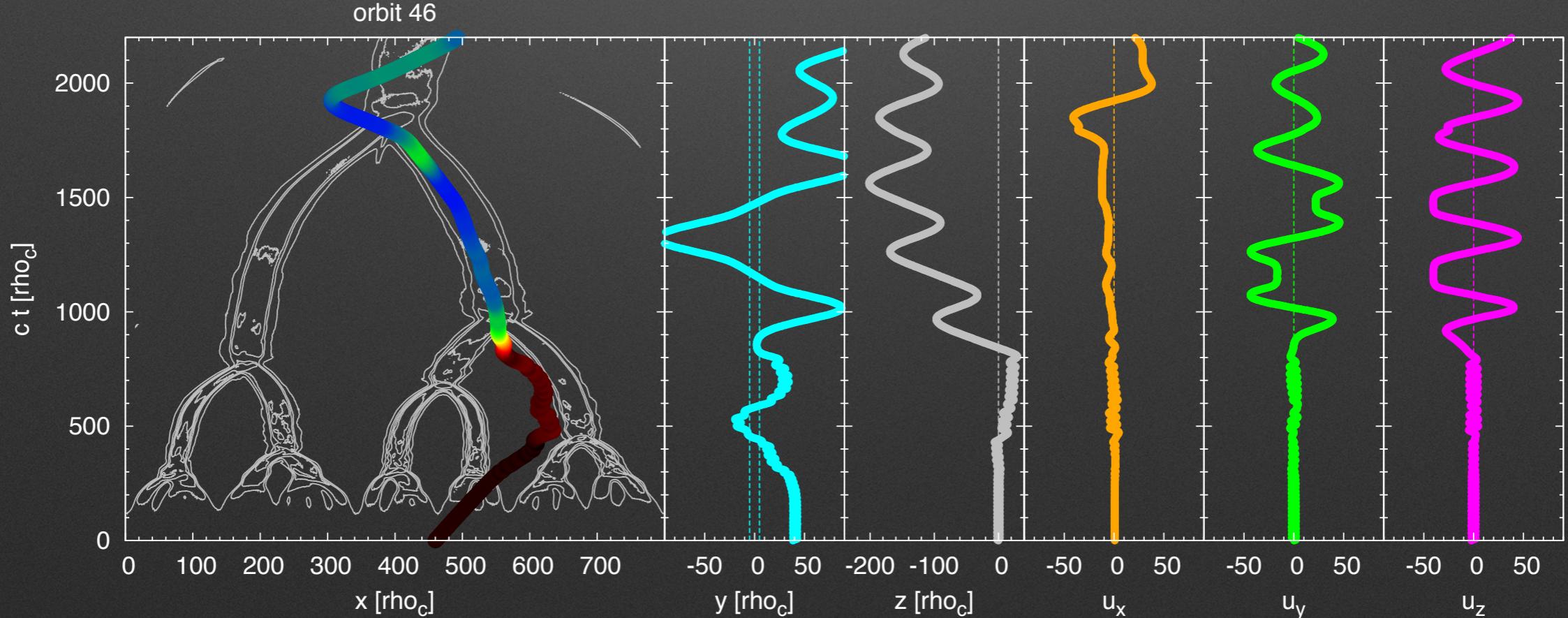
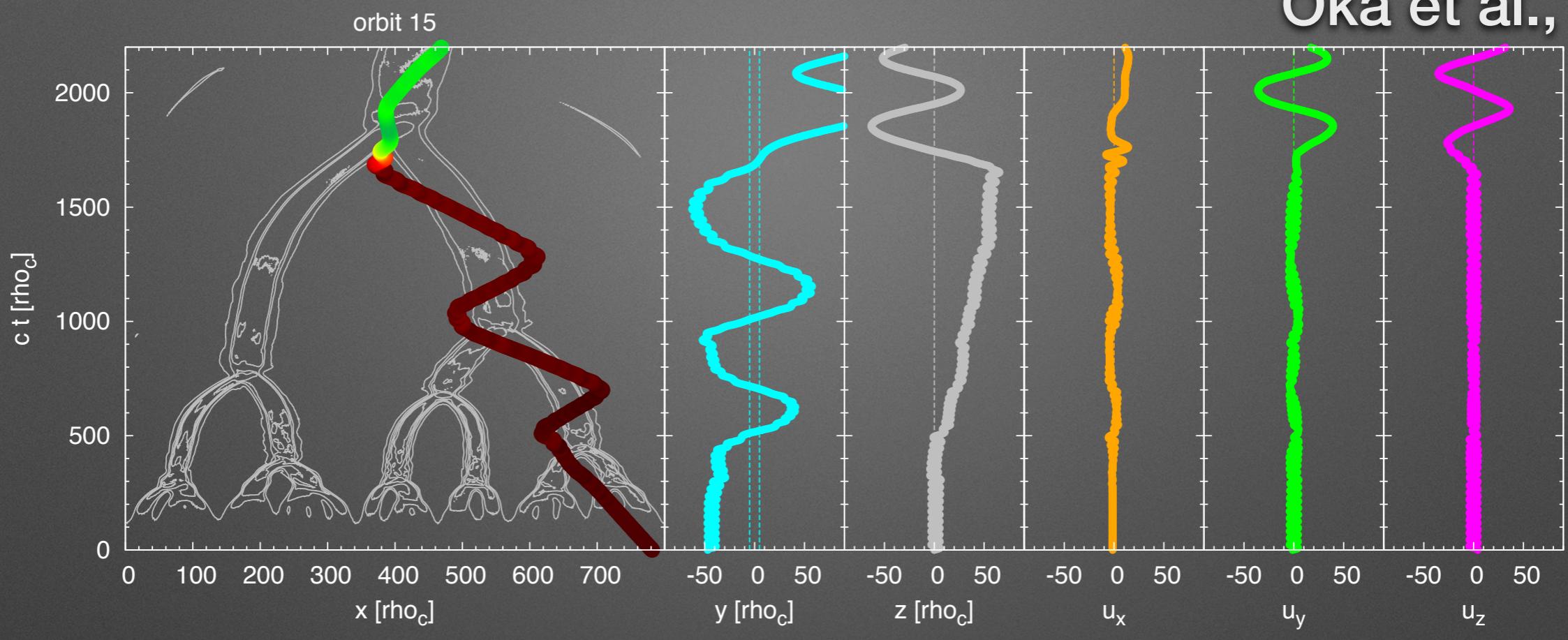
# acceleration at X-points

Zenitani & Hoshino



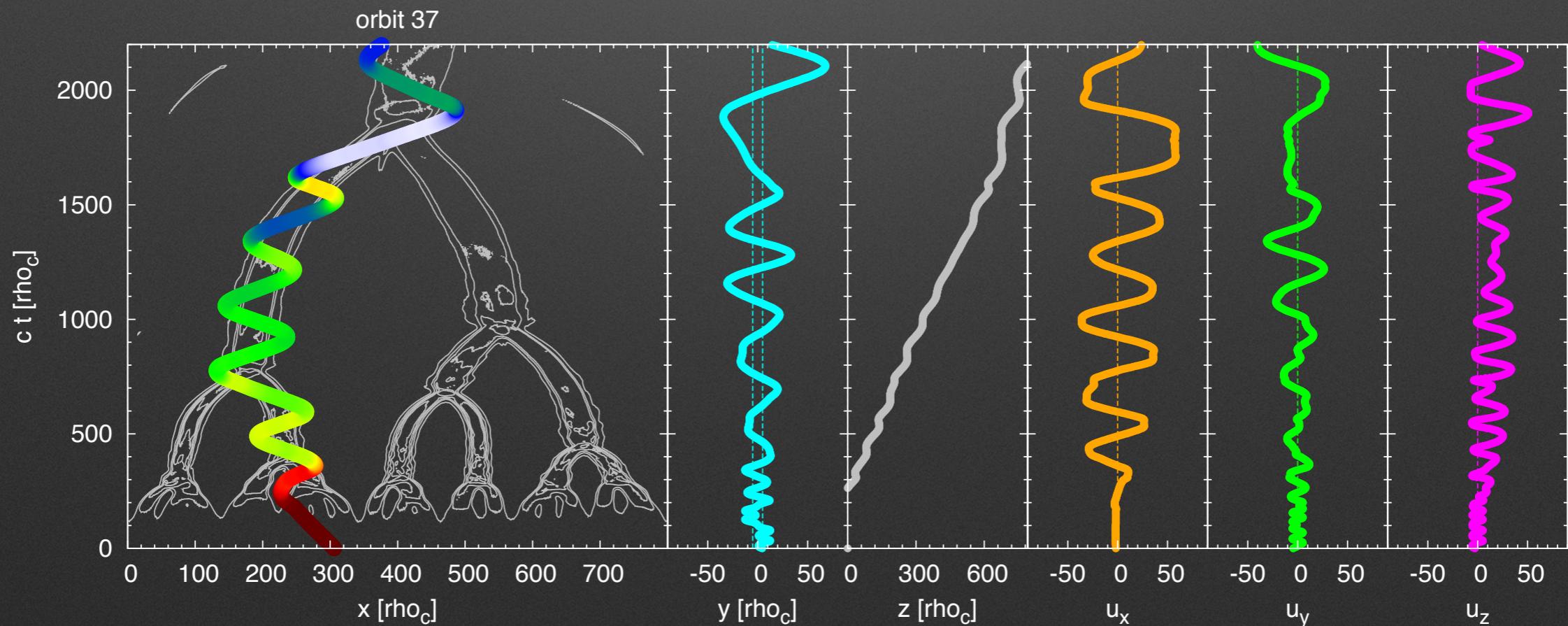
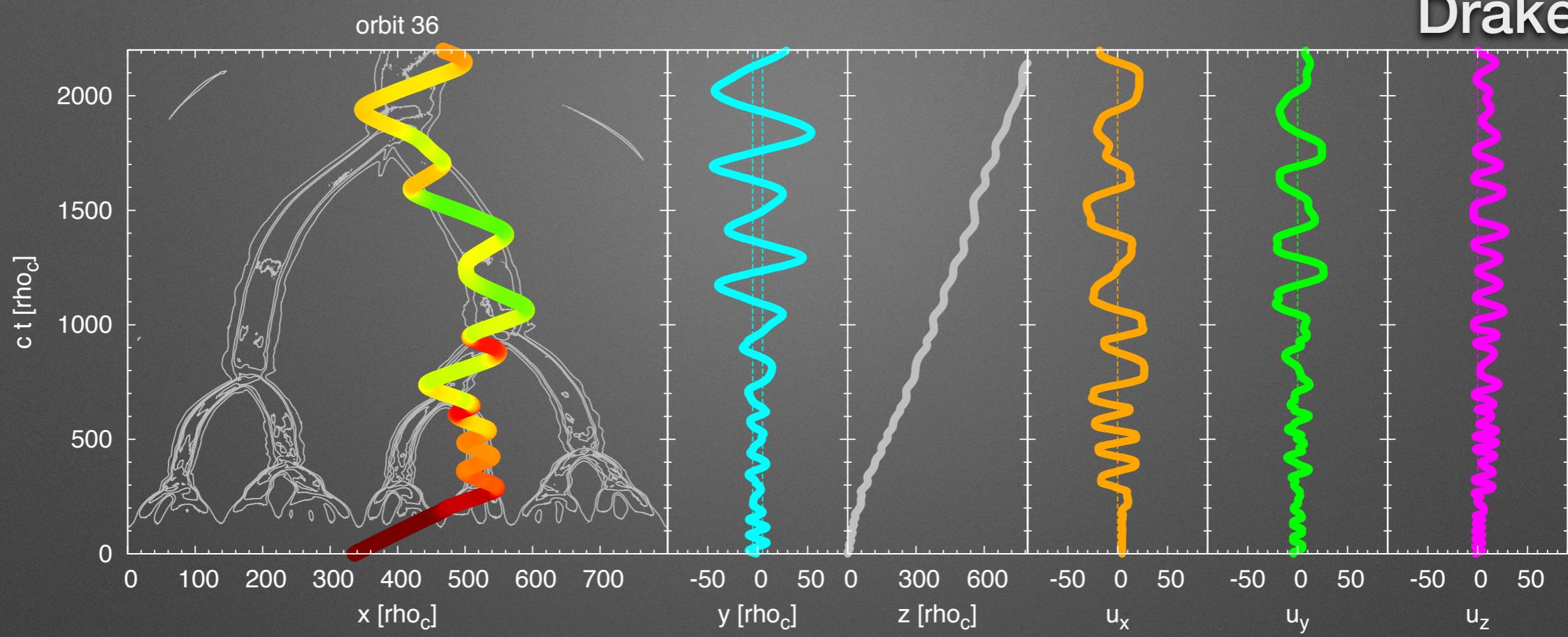
# acceleration at mergers

Oka et al., Sironi

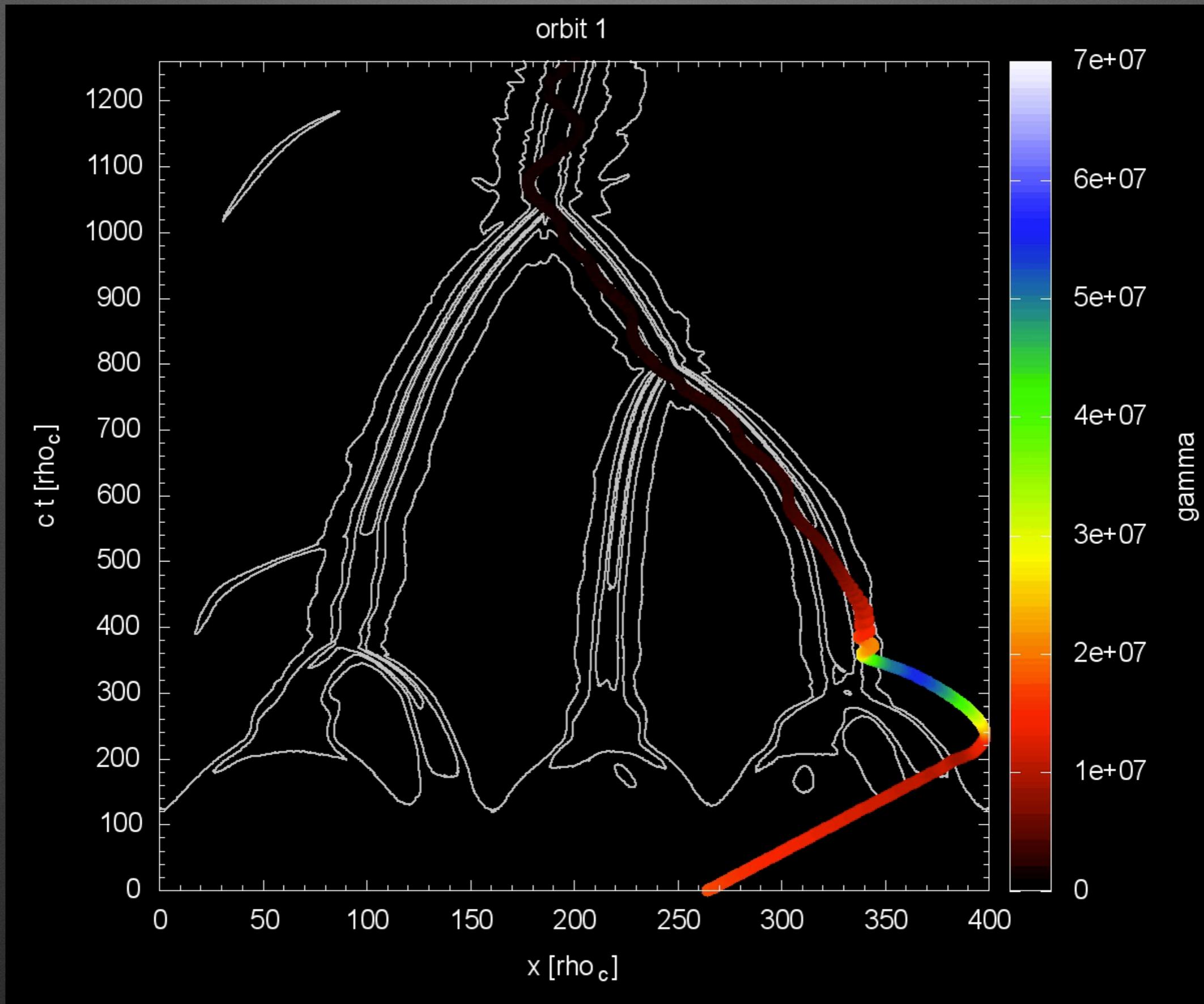


# acceleration in plasmoids

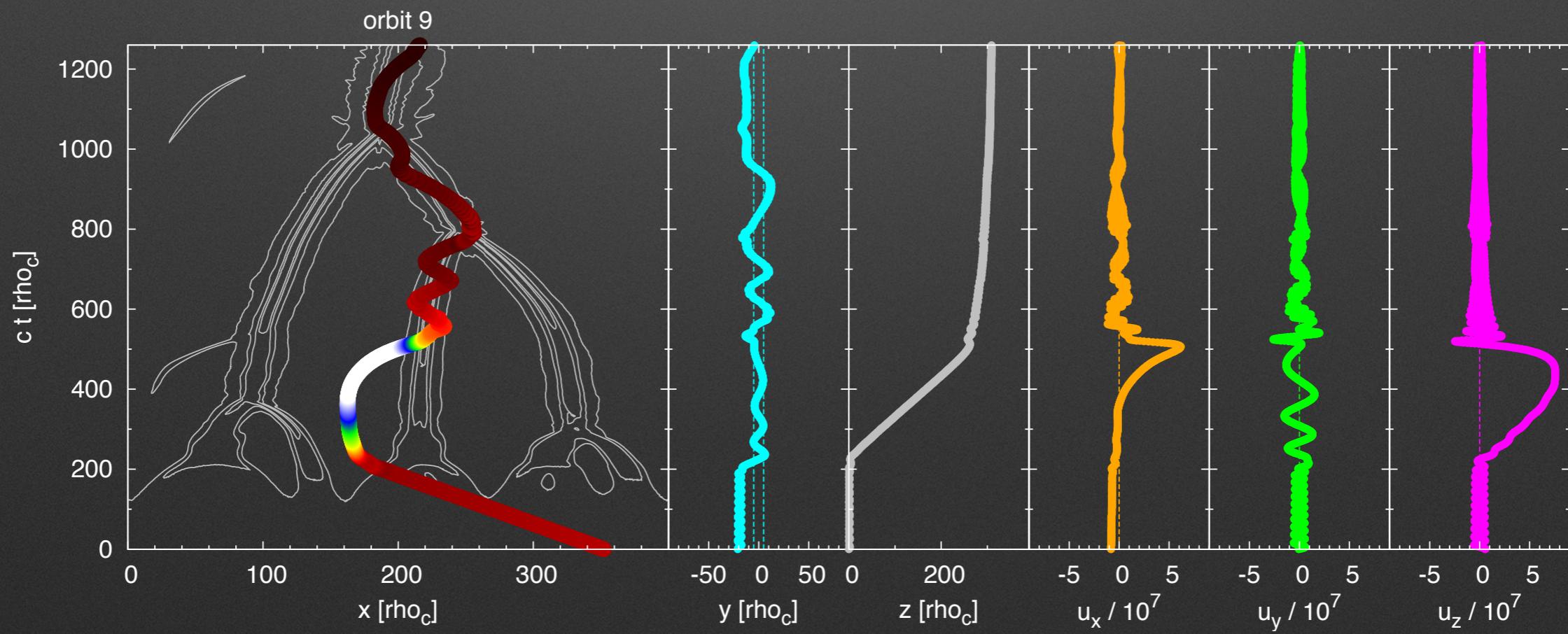
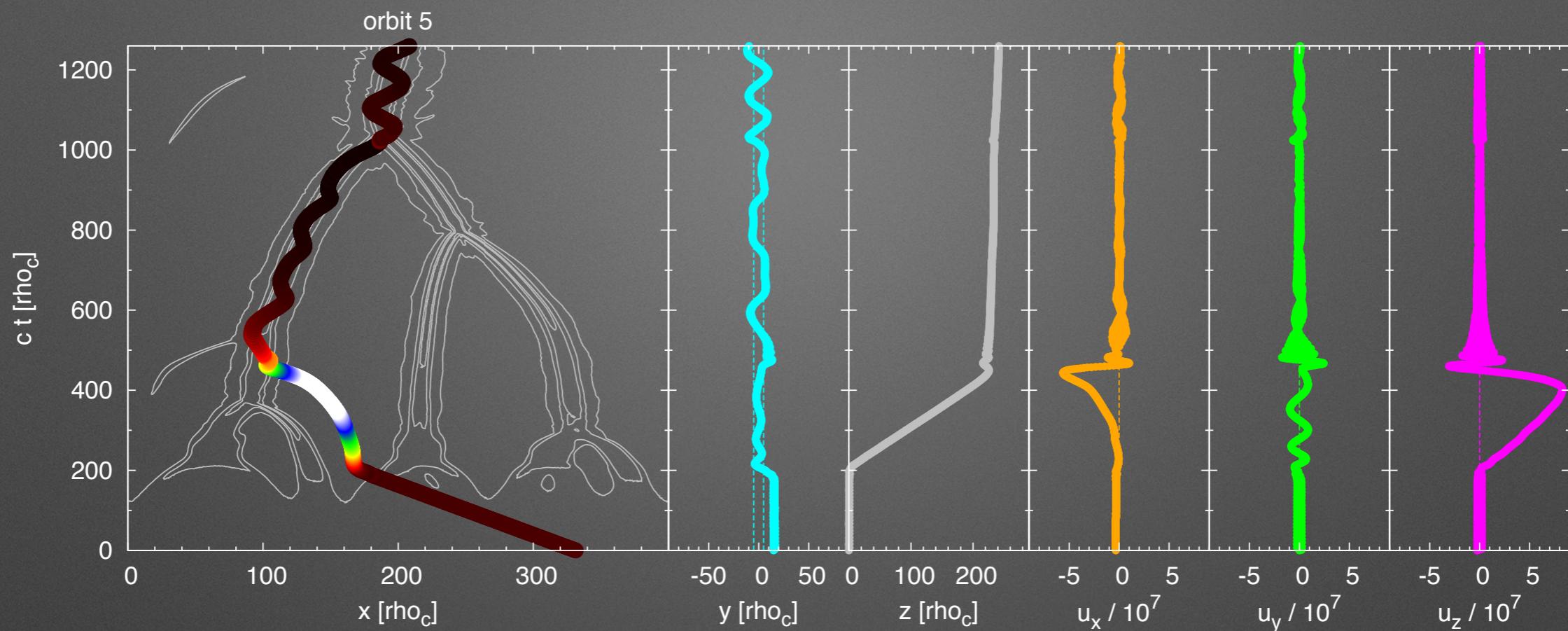
Drake et al.



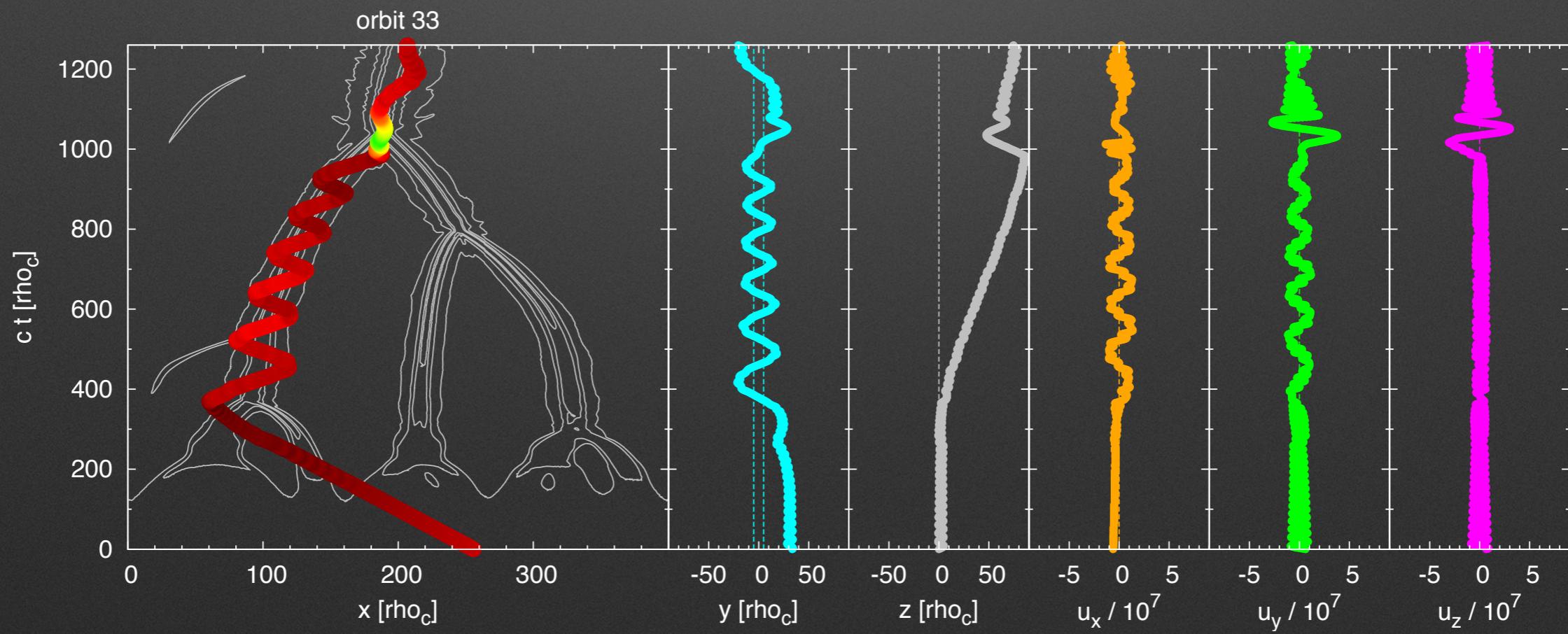
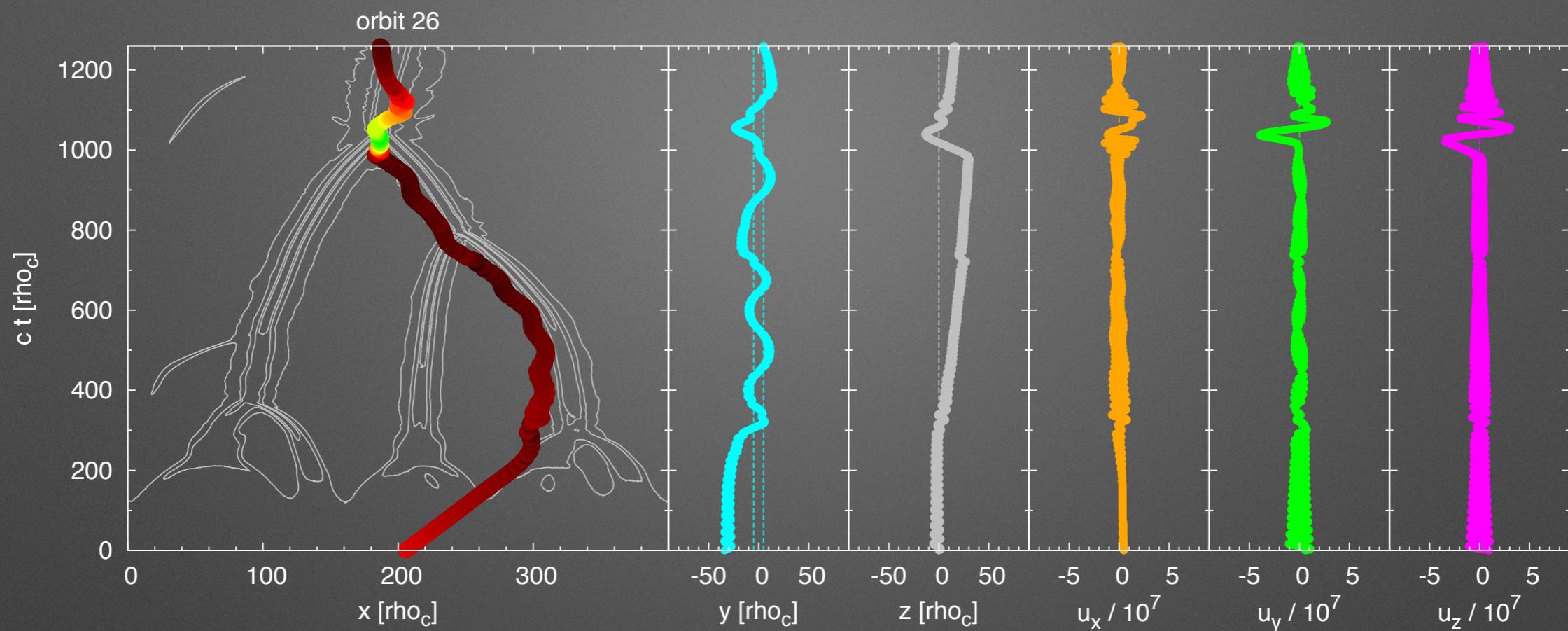
# effect of radiation reaction



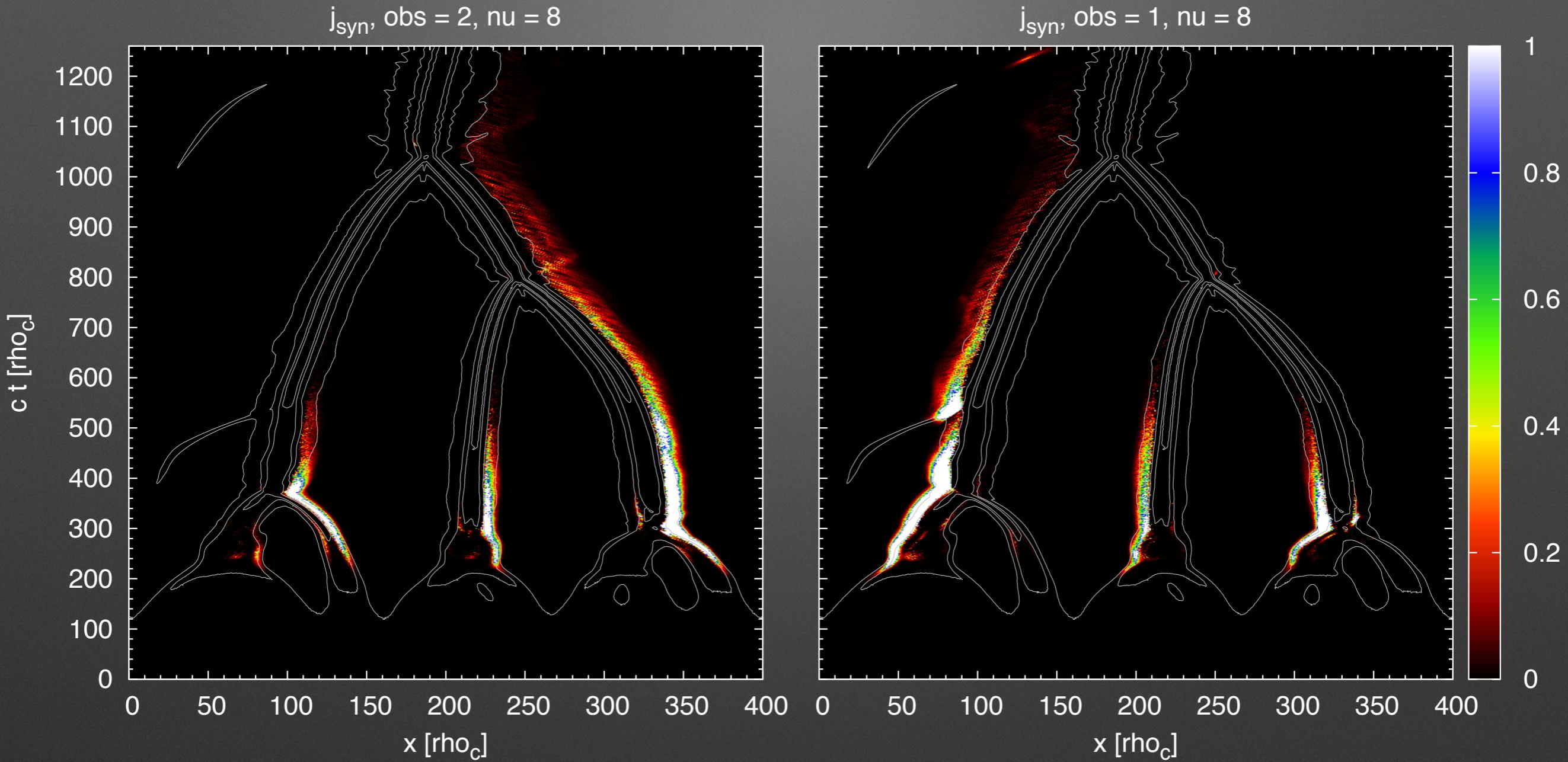
# acceleration at X-points



# acceleration at mergers



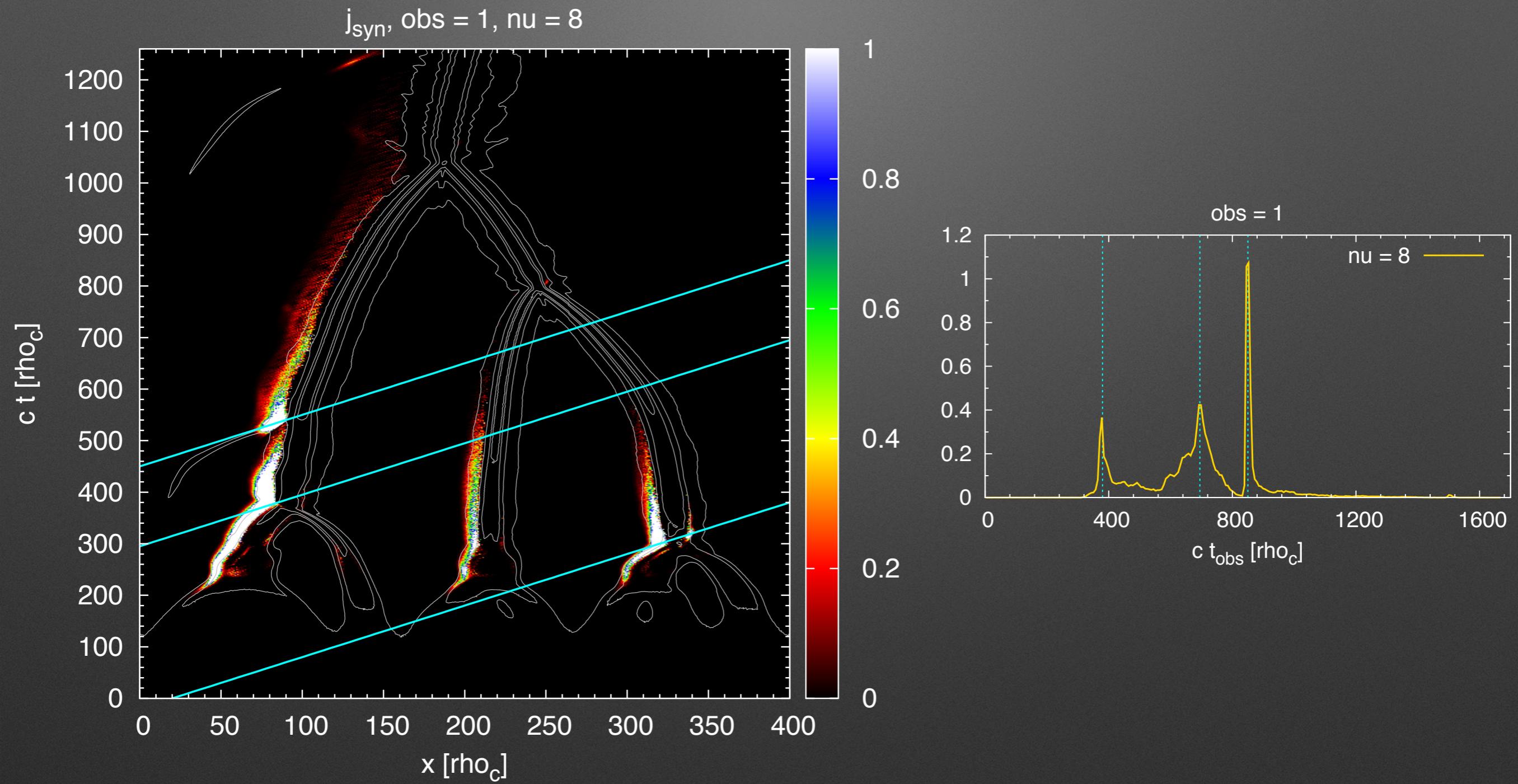
# synchrotron emissivity



looking from the left

looking from the right

# observed light curves



# summary

- rapid flares of synchrotron radiation from simulated plasmoid-dominated relativistic reconnection (Cerutti et al. 2012)
- synchrotron radiation is produced mainly at the edges of plasmoids
- strong anisotropy even with mildly relativistic bulk motions
- compact sizes, bulk motion, and limited lifetime of plasmoids determine the short observed variability time scale
- in the case of negligible radiation reaction, at least 3 particle acceleration mechanisms operate simultaneously in plasmoid reconnection; acceleration in plasmoids co-spatial with emitting regions
- in the case of strong radiation reaction, acceleration proceeds only at X-points; energetic particles showing strong affinity to plasmoids