Jets in AGNs, GRBs and Microquasars

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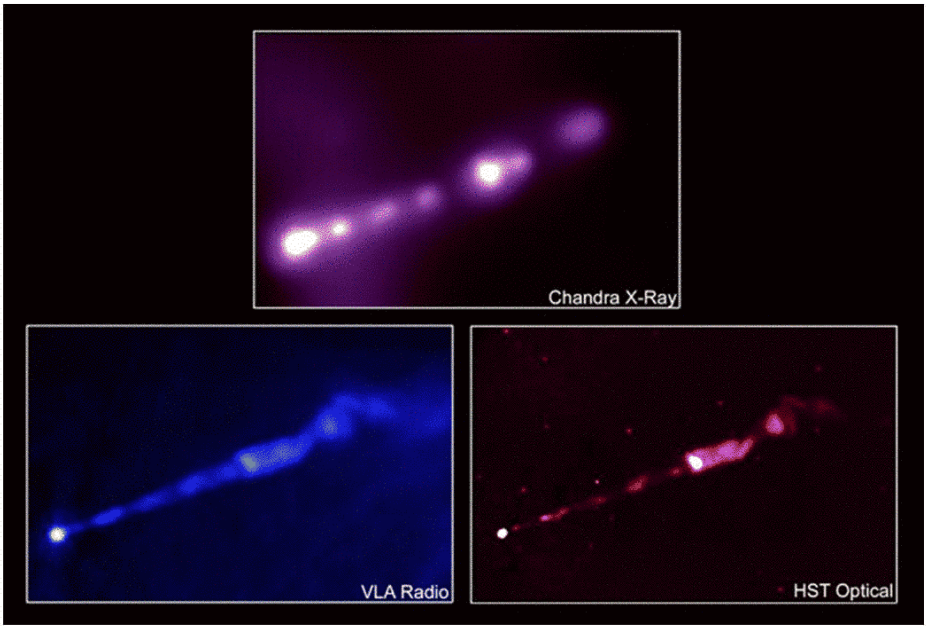
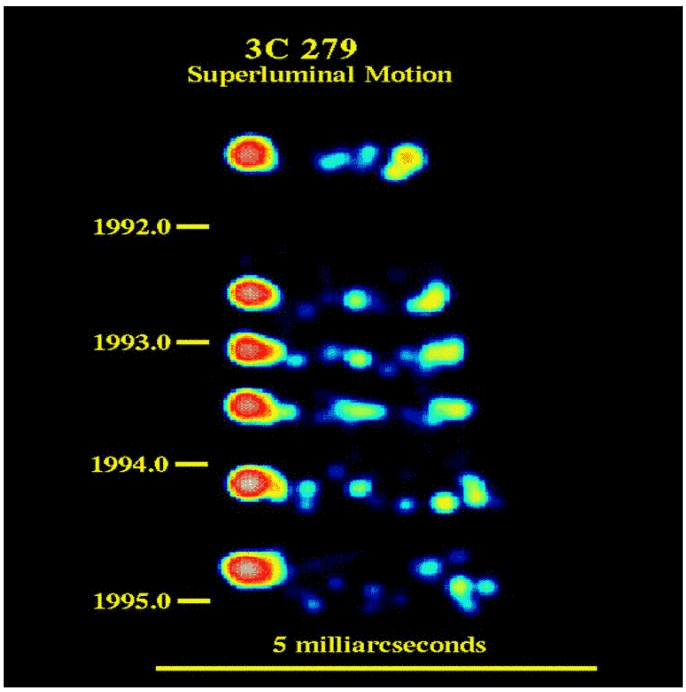
Overview

- Evidence for Jets
- Similarities and differences
- Physical implications
- More on GRB jets
- Discussion

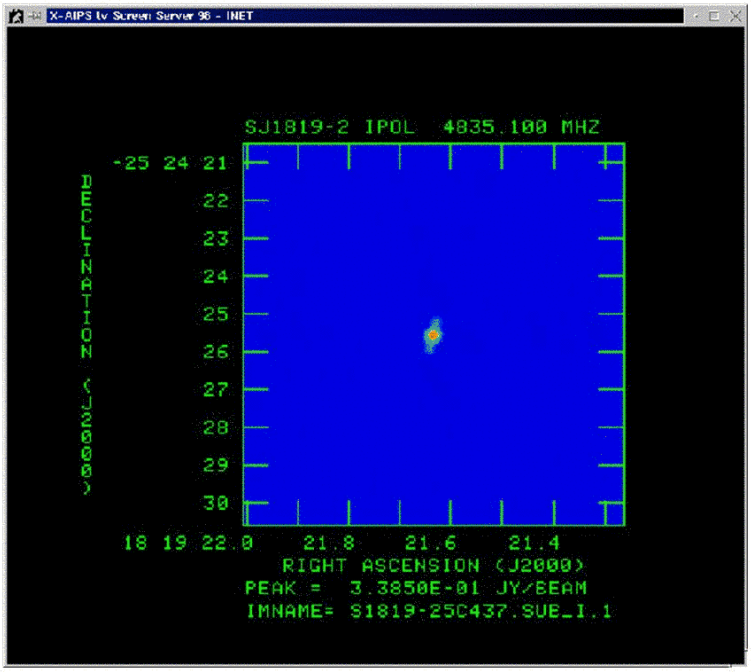
Evidence: AGNs



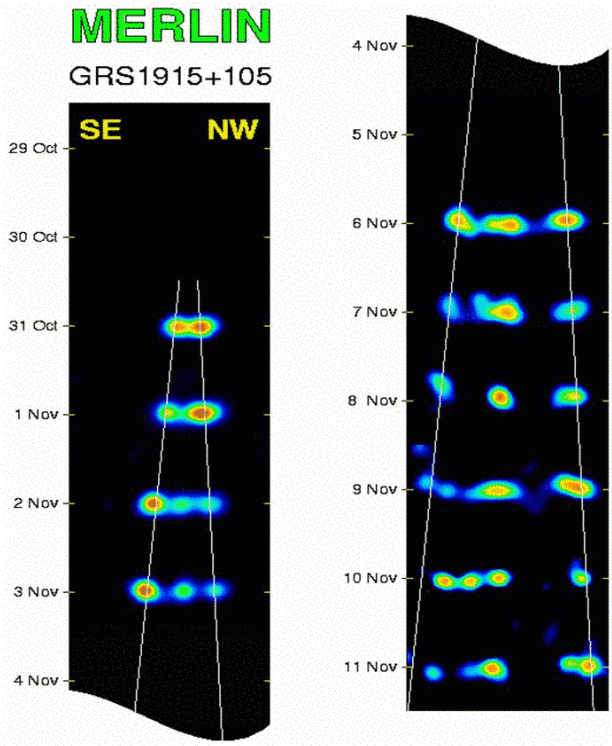
Evidence: AGNs

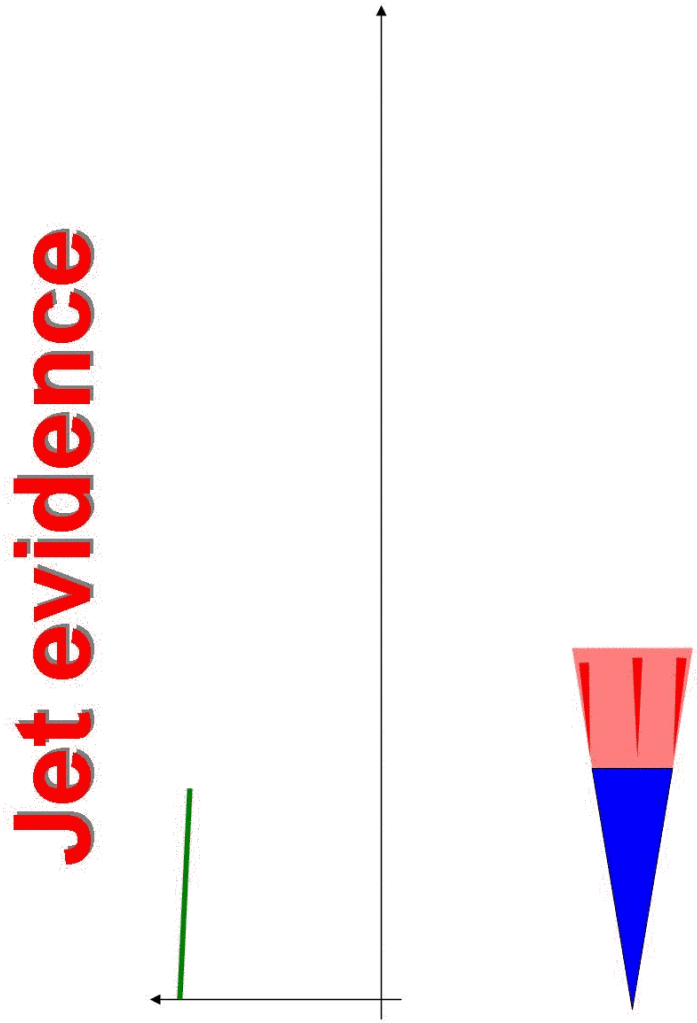


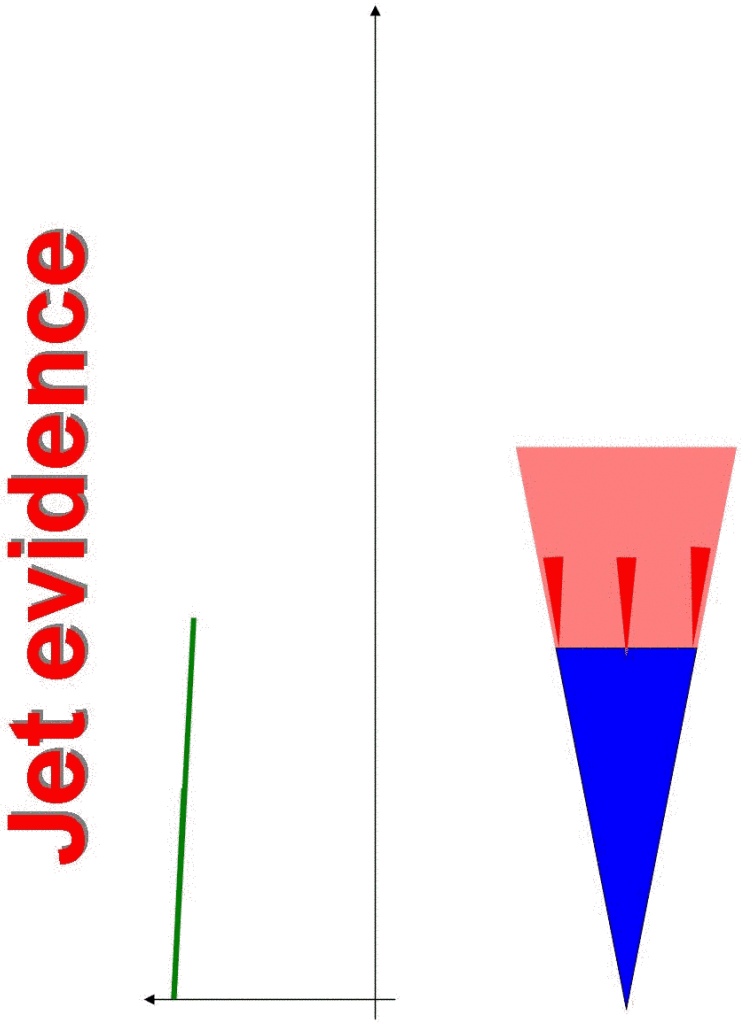
Evidence: Microquasars



Evidence: Microquasars




Jet evidence


Jet evidence

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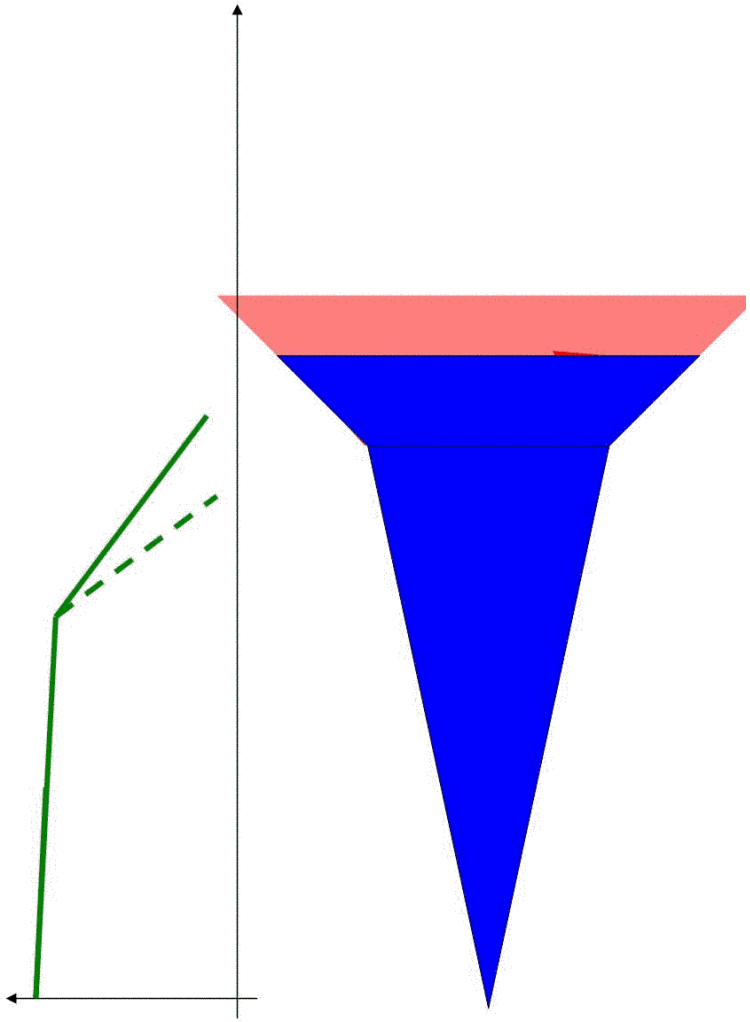
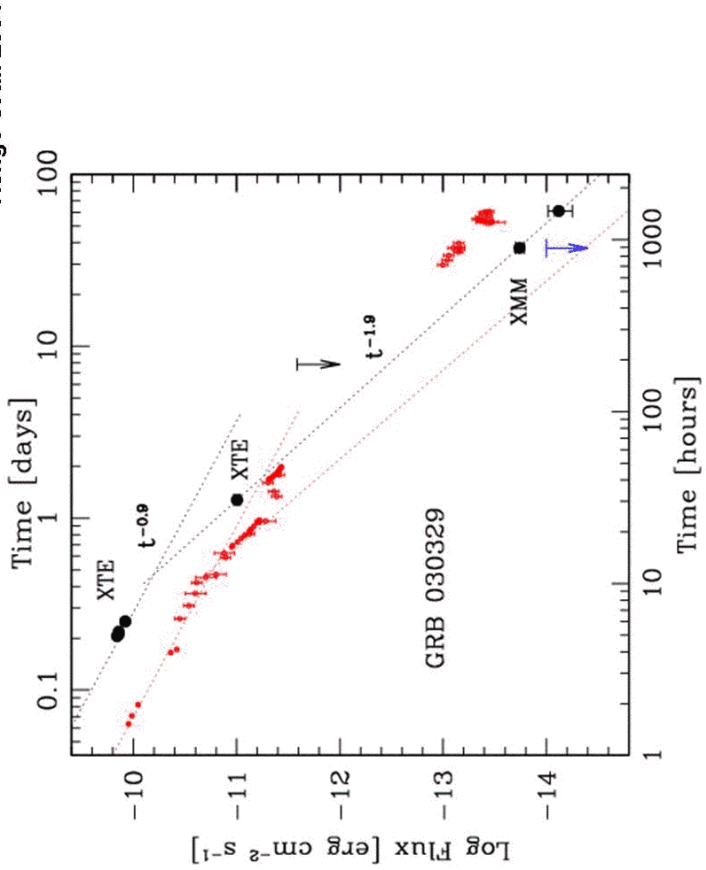


Jet evidence

Tiengo et al. 2004



Jet duration

- In AGNs the jet lasts for a long time, affects the surroundings and creates a new equilibrium
- In Microquasars, jetted emission last for a long time but is likely intermittent, at least in some cases
- In GRBs the jet emission lasts a long time in the engine time scale, a short time in the environment time scale

Jet duration

- In AGNs, $t_{life} \sim 10^7$ years (10^{11} dynamical time scales)
- In Microquasars, same duration, at least potentially (10^{19} dyn times cales)
- In GRBs, t_{life} = 1-1000 seconds (10^6 dyn time scales). The jet becomes a flying pancake in the afterglow phase.

Lorentz factor

- In AGNs, from superluminal speed, Γ=10-30
- In Microquasars, from superluminal speed, Γ=2.5-10
- In GRBs, from opacity considerations, Γ>100. In afterglow phase Γ decreases.

Luminosity

- Beaming corrections, radiative efficiency and uncertain composition make the measurement difficult
- AGNs: 10^{43}-10^{48} erg/s
- Microquasars: 10^{38}-10^{40} erg/s
- GRBs: 10^{49}-10^{51} erg/s

Engine

- MBH: 10^8-10^9 M_{sun} for AGNs, 10 M_{sun} for microquasars and GRBs
- Maximum rotational energy: 10^{62} erg for AGNs, 5×10^{54} erg for GRBs and MQ
- Disk luminosity 10^{42}-10^{47} erg/s for AGNs, 10^{38}-10^{39} for MQ

Powering the jet

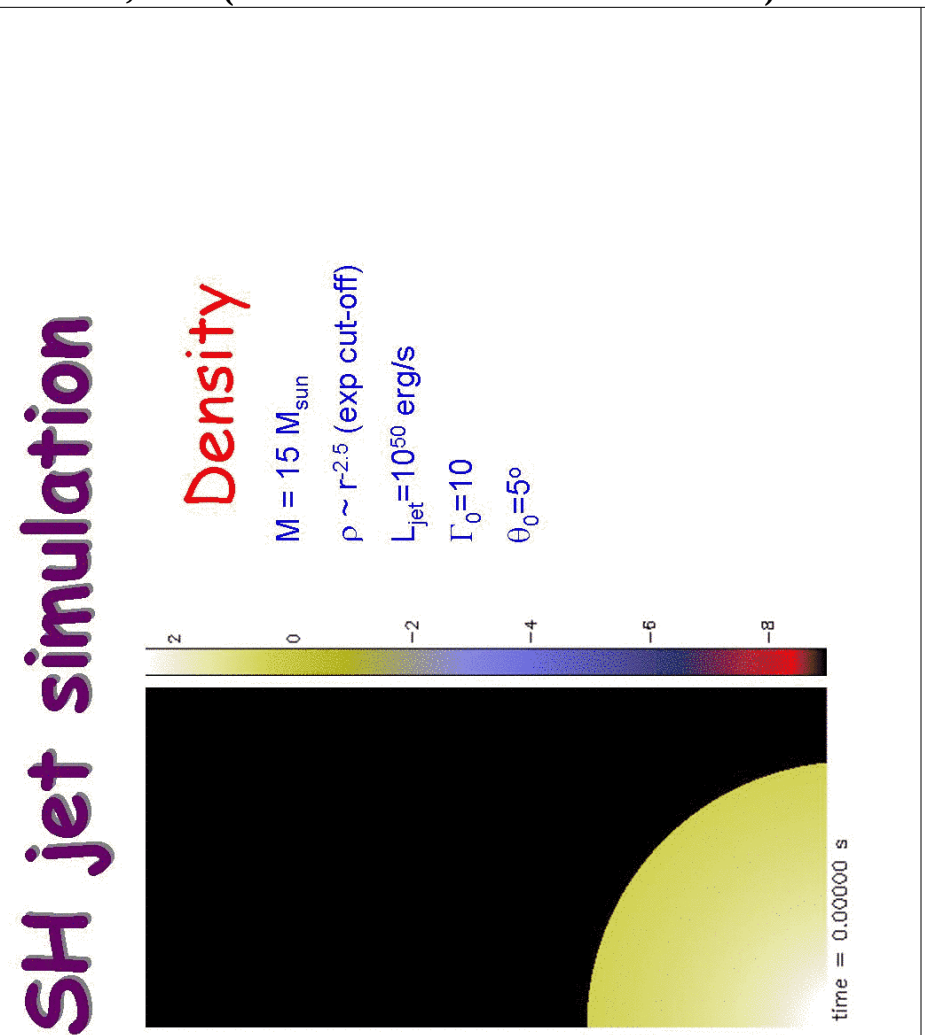
- Assume that B has a dominant role in powering the jet
- If this is through tapping of rotational energy of the BH, then (e.g. BZ) allows to compute required B field
- AGNs: 10^4; MQ: 5×10^8; GRBs: 10^{15}

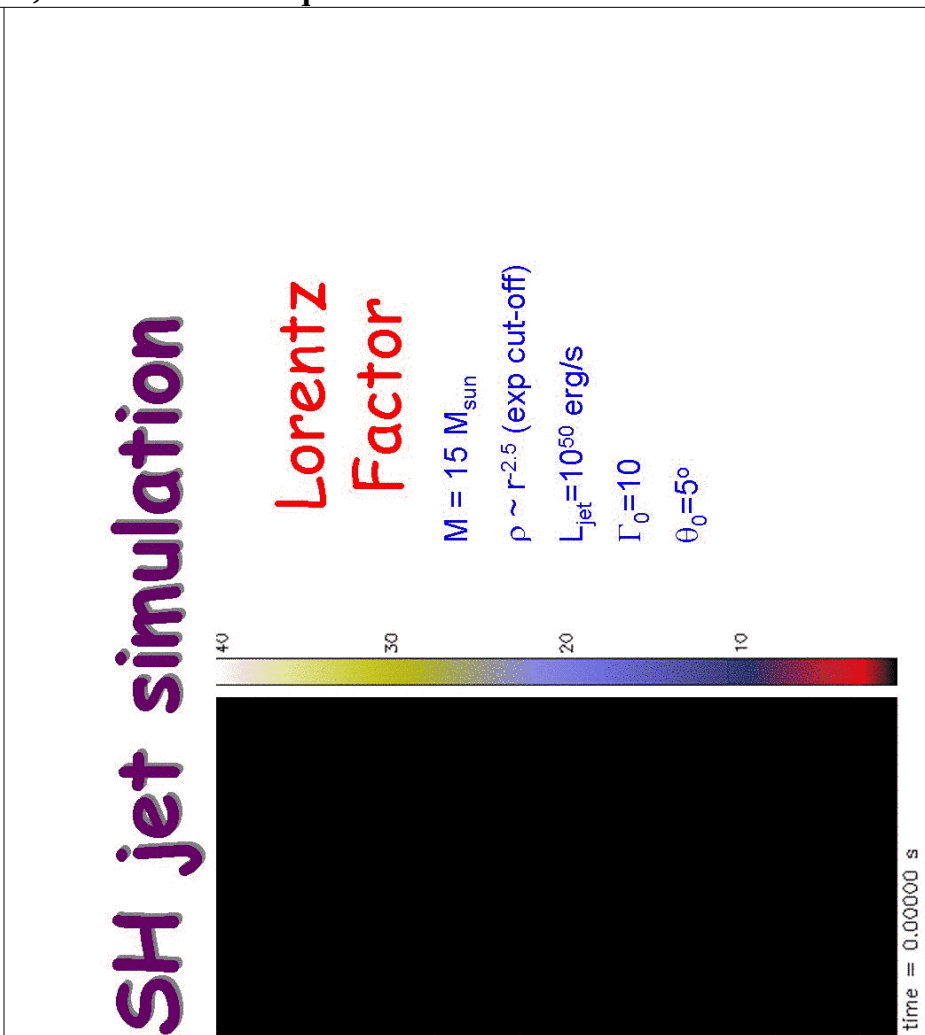
Powering the jet

- B can be computed also under the assumption that it is in equilibrium with matter density at marginal stable orbit
- n is computed from disk luminosity and BH mass (in GRBs assume all mass accreted in T_{GRB})
- Obtained magnetic field is in good agreement with previous estimate

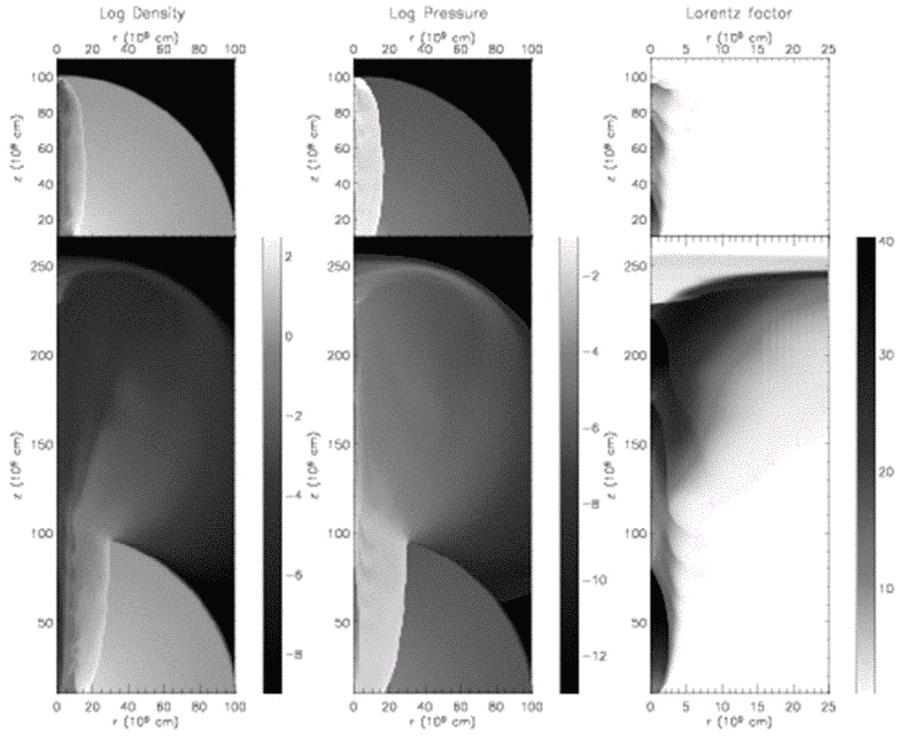
Dissipation

- Once the jet is launched how is radiation produced (without destroying the jet)?
- For hydro jets, shocks (under the forms of internal of propagating shock)
- Interaction with external photon field
- For B dominated jets, B is dissipated through reconnection


FLASH jet simulation
Density
M = 15 M_{sun}
$\rho \sim r^{-2.5}$ (exp cut-off)
$L_{jet}=10^{50}$ erg/s
$\Gamma_0=10$
$\theta_0=5°$
2
0
−2
−4
−6
−8
time = 0.00000 s


FLASH jet simulation
Lorentz Factor
M = 15 M_{sun}
$\rho \sim r^{-2.5}$ (exp cut-off)
$L_{jet}=10^{50}$ erg/s
$\Gamma_0=10$
$\theta_0=5°$
40
30
20
10
time = 0.00000 s

FLASH jet simulation



Discussion

- Comparison of jets in different classes of sources can give insight in the physics of jet launching and emission of radiation
- Luminosities and properties of engine vary widely
- Lorentz factor seem not to be simply related to engine properties (e.g. M, B)
- A common property is that B/ε is roughly constant (more related to disks?)