# Dynamics of Polar Jets from the Chromosphere to the Corona: Mass, Momentum and Energy Transfer

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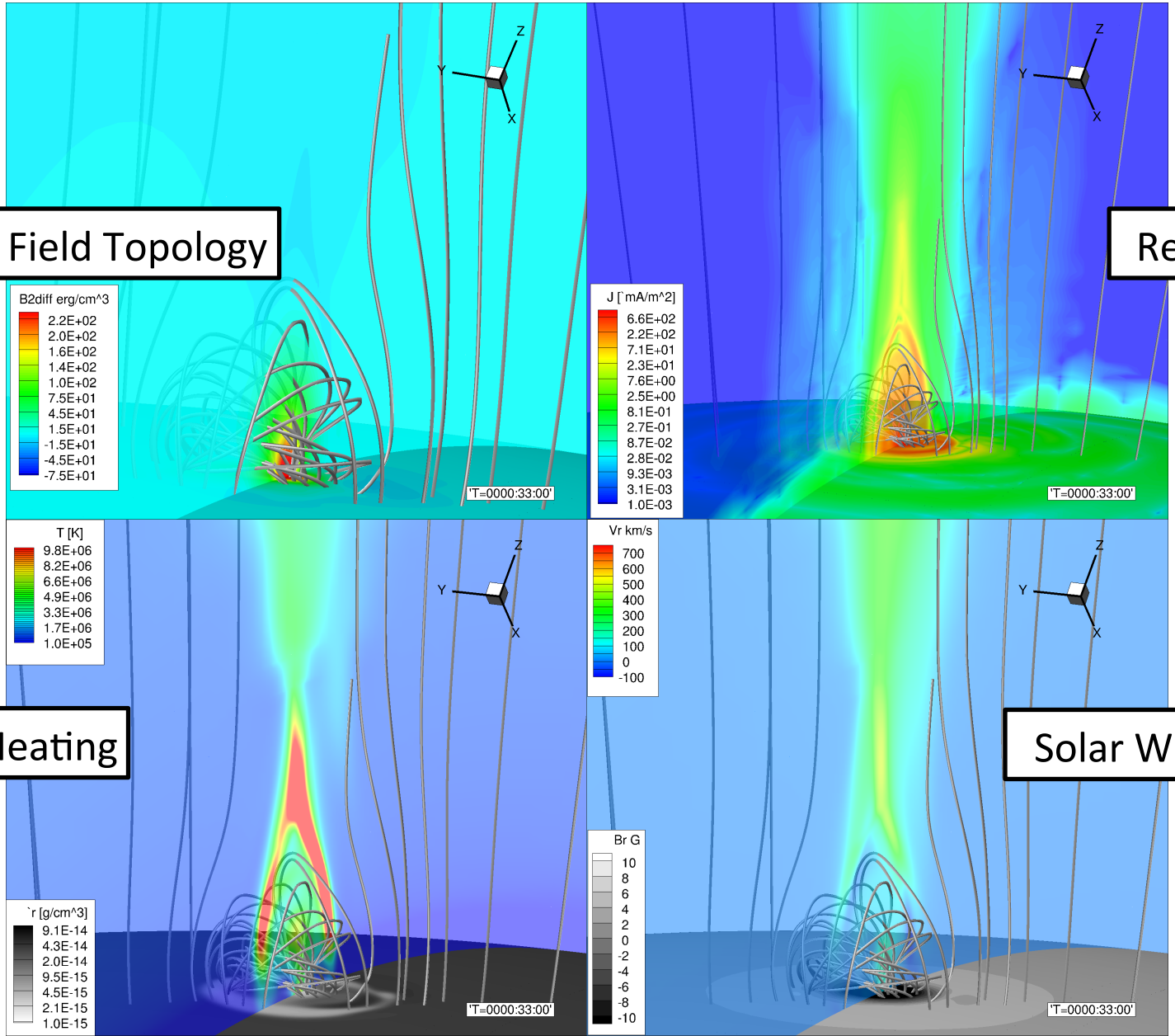
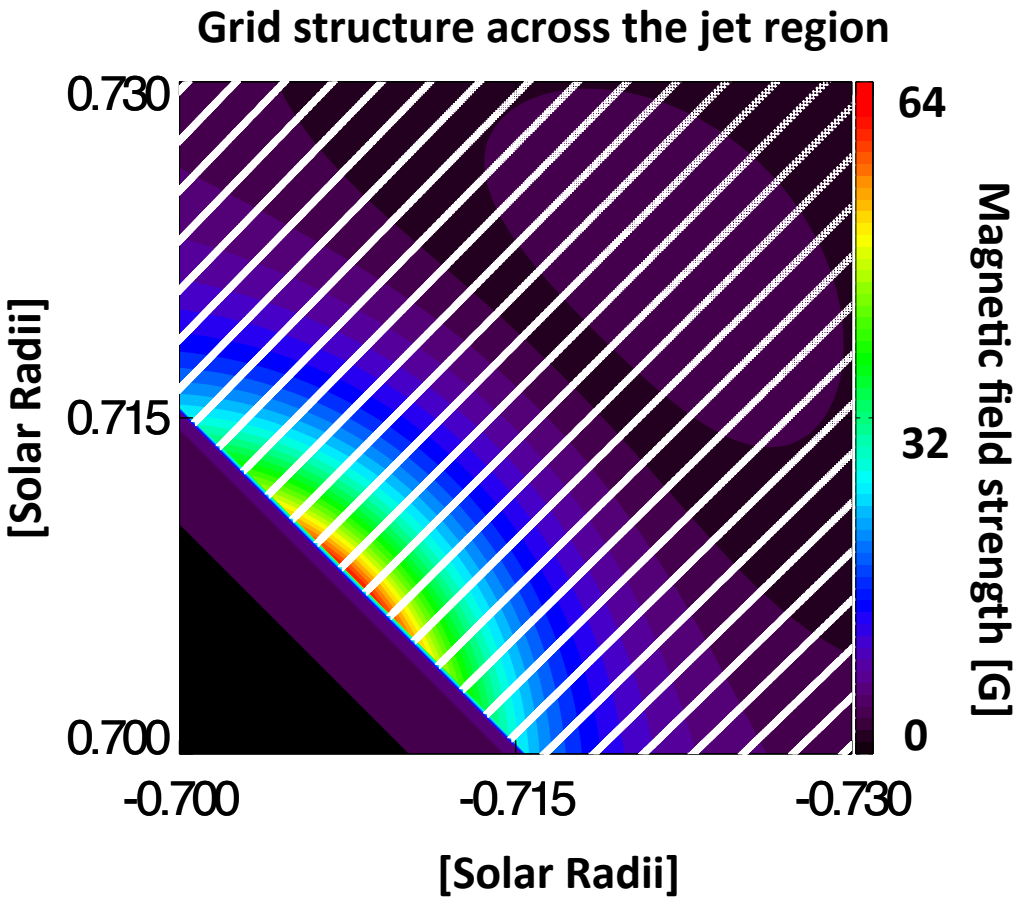
# Why Coronal Jets are Interesting?



# Goal of this study

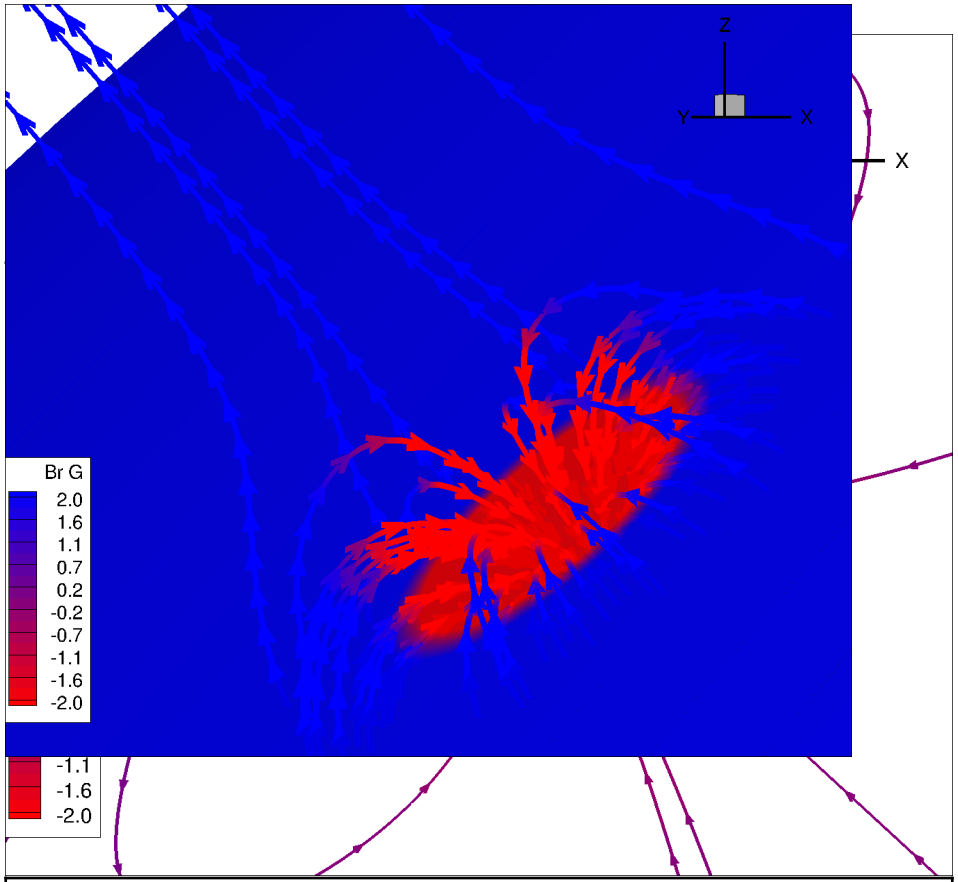
- Study transport due to jet
  - energy, momentum, mass
  - interaction with local plasma
- State of the art model
  - physically well-established two temperature coronal model: AWSoM
  - full 3D MHD corona (24 $R_\odot$)
  - fully resolved small-scale jet structure (0.013 $R_\odot$)



# Model Setup

- GLOBAL: Solar wind model
  - Chromospheric inner-boundary
  - Ambient dipole: -5.6 G at pole
  - Coronal heating and solar wind acceleration via Alfvén waves
- LOCAL: Jet model
  - Radial bipole under the surface
  - Rotating boundary condition around bipole axis
  - Magnetic latitude determines background field: open vs. closed

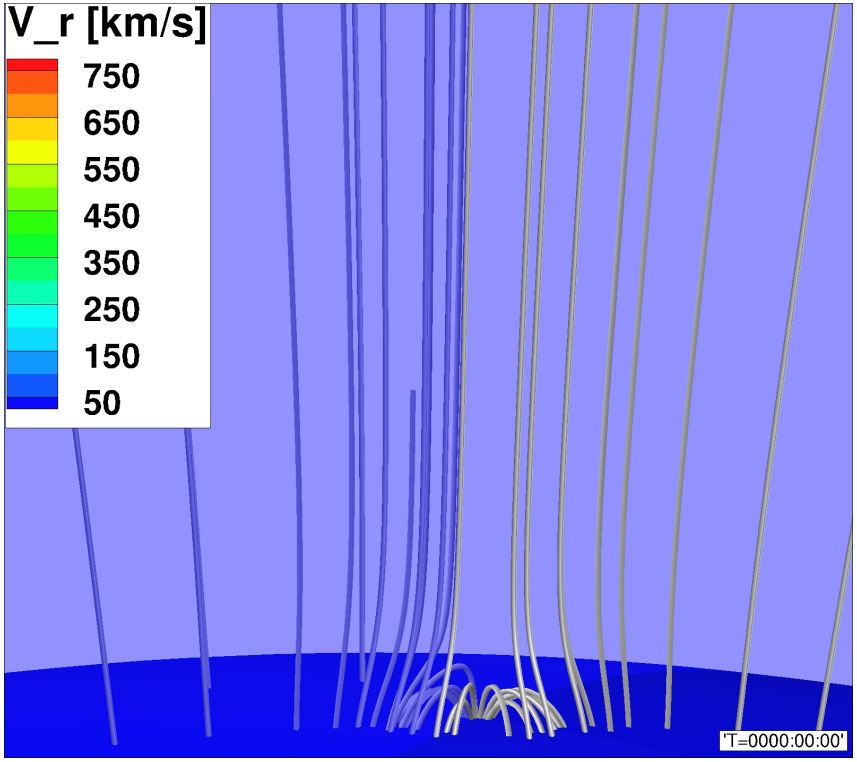
**This talk focuses on polar jets.**



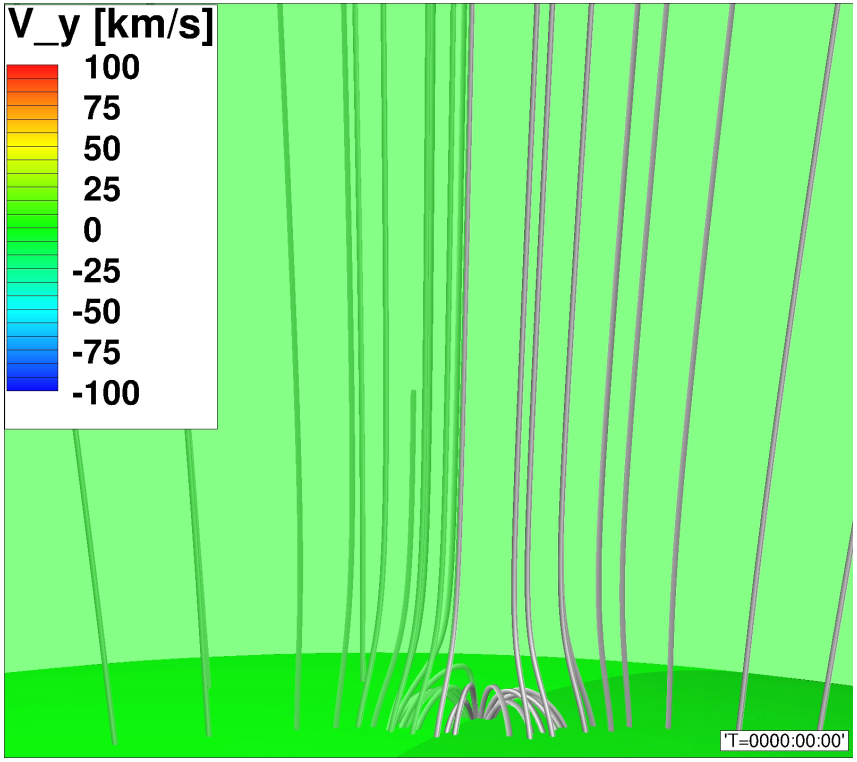

| Jet Model Parameters | |
|---|---|
| Strength at 1 $R_\odot$ | 70 G |
| Radius of rotation | 0.013 $R_\odot$ |
| Maximum speed | 30 km/s |

# Radial and out-of plane velocity profile across the center of the jet

**Radial velocity with magnetic field**

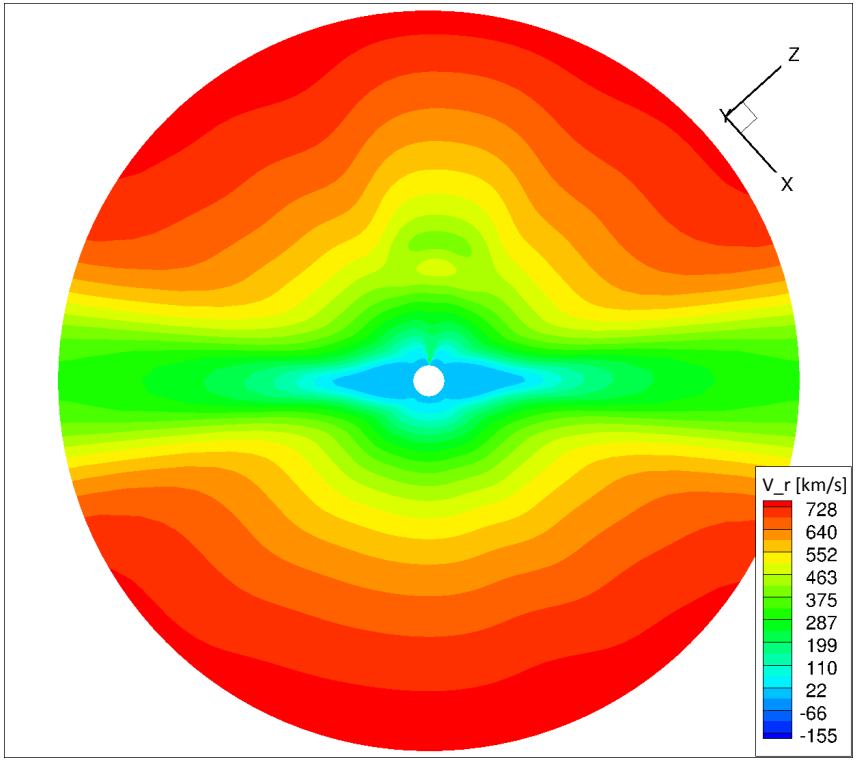



**Out-of plane velocity with magnetic field**

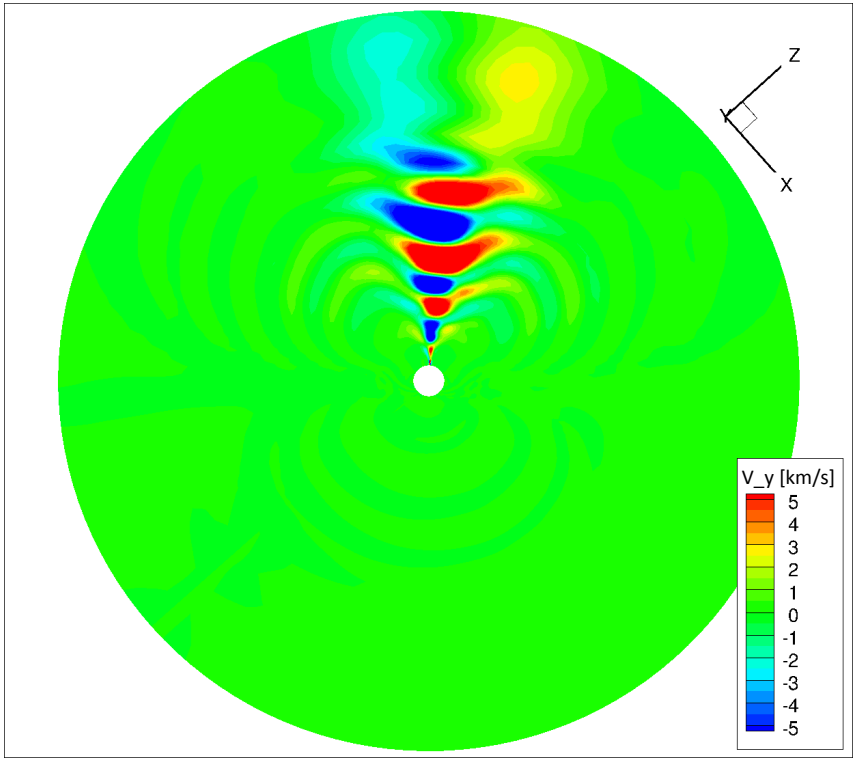


# Large scale velocity profiles (24 $R_\odot$) (t = 11040 s)

**Radial velocity**




**Out-of plane velocity**



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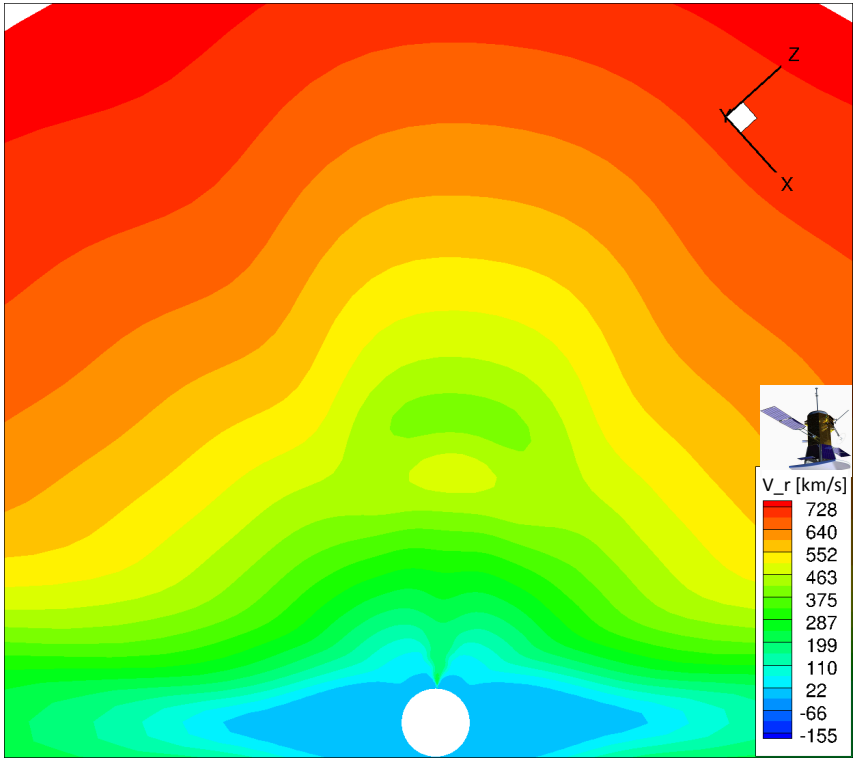
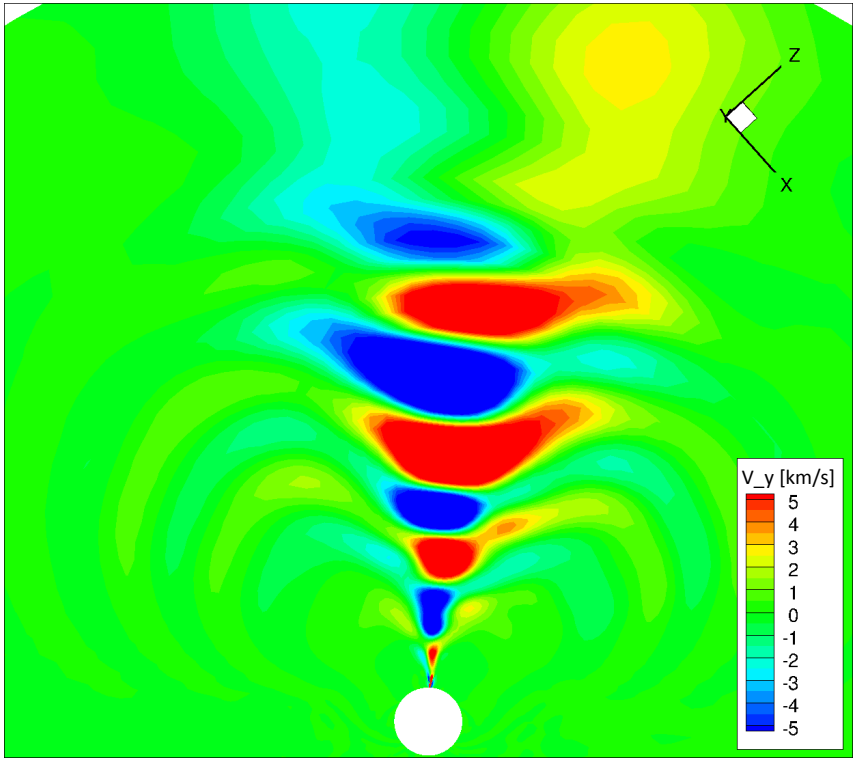


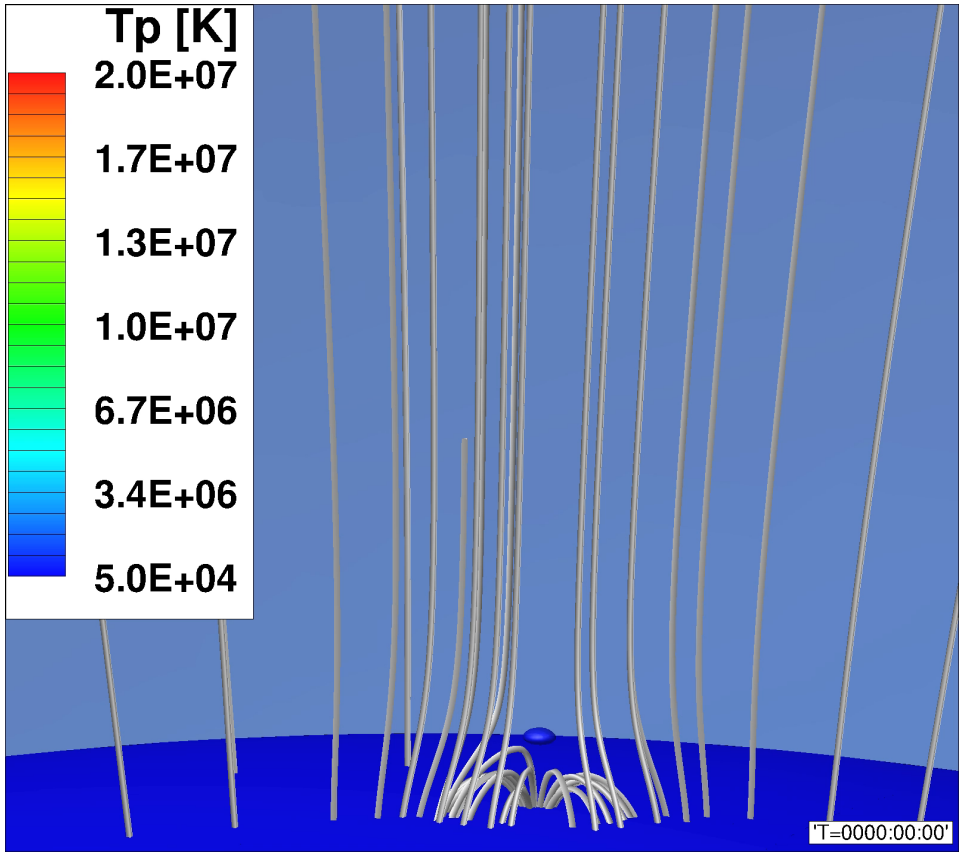

**Out-of plane velocity**



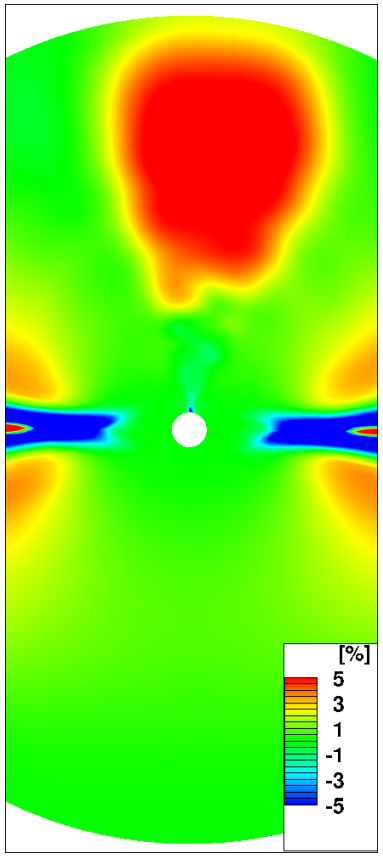
# Signatures in the magnetic field

**B=0 contour**

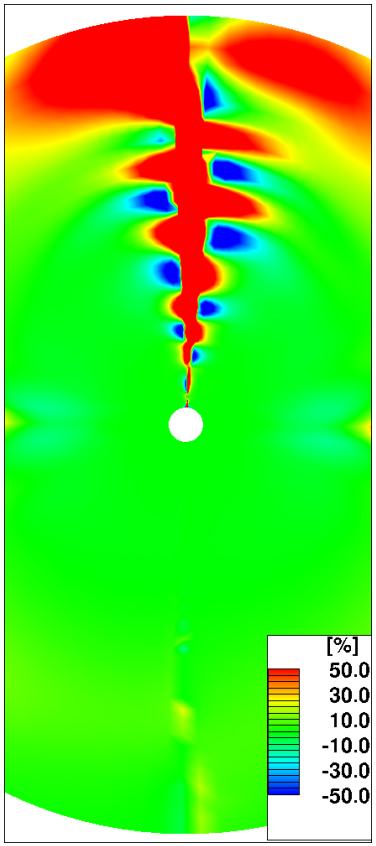
**(color indicates proton temperature)**



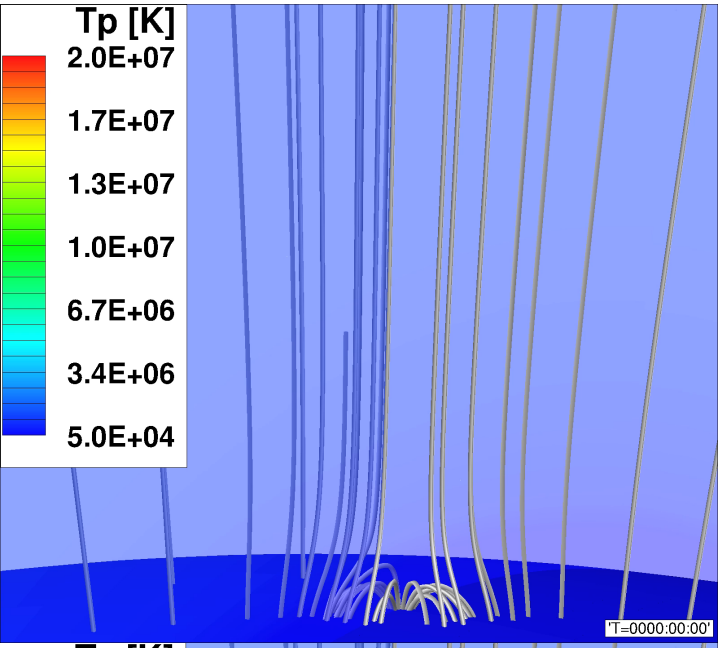

**Relative change in magnetic energy**

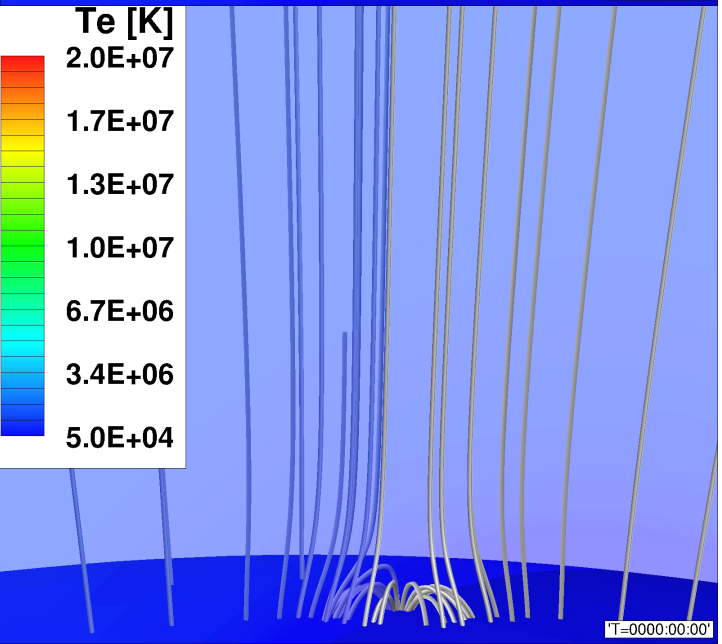


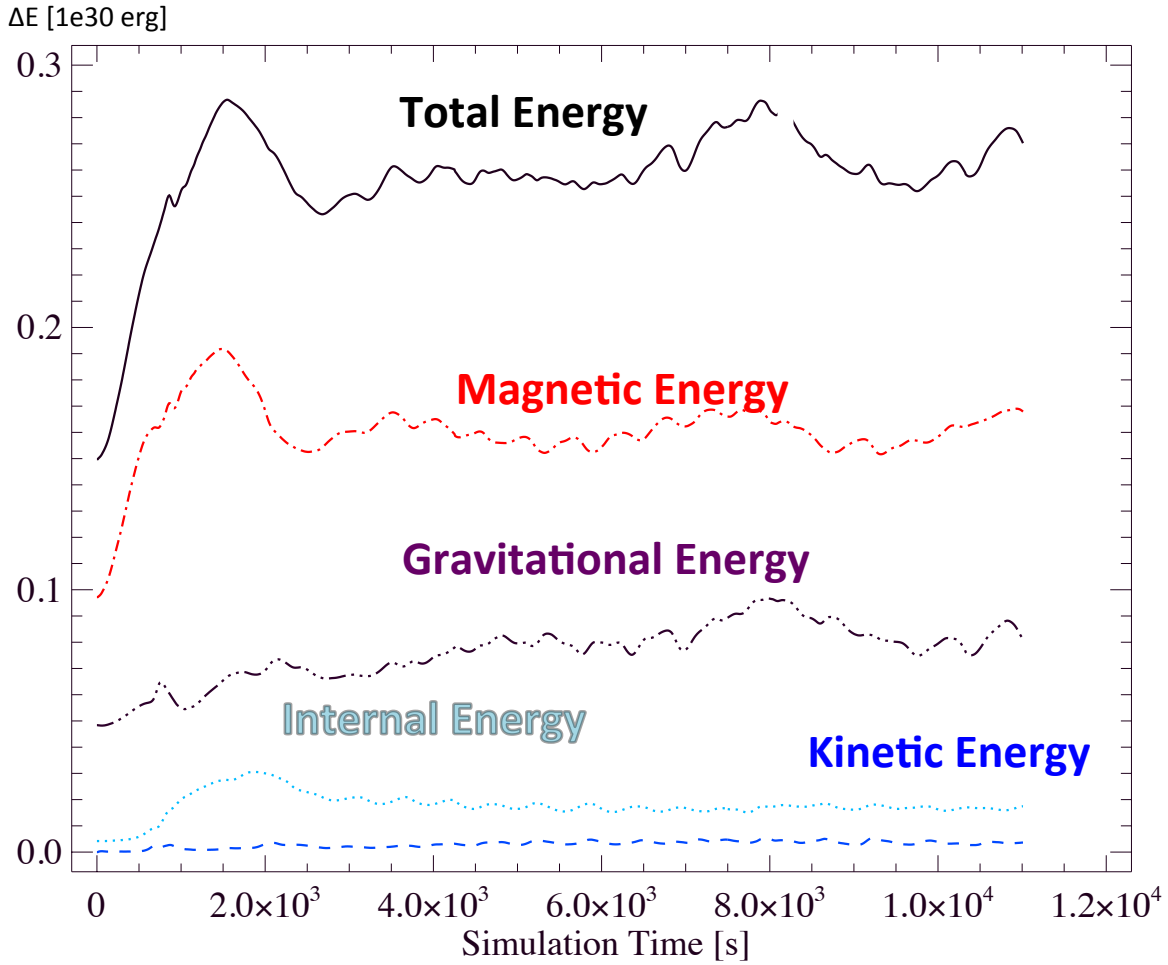

**Relative change in azimuthal magnetic field**



# Energetics in the jet's core

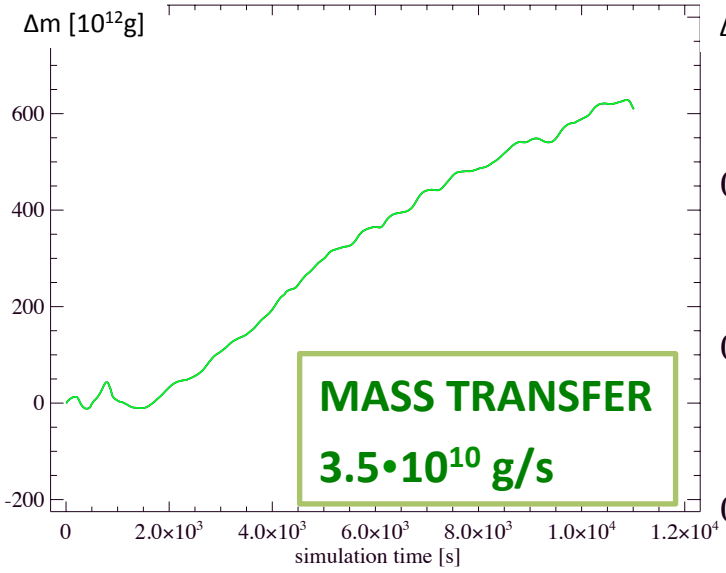


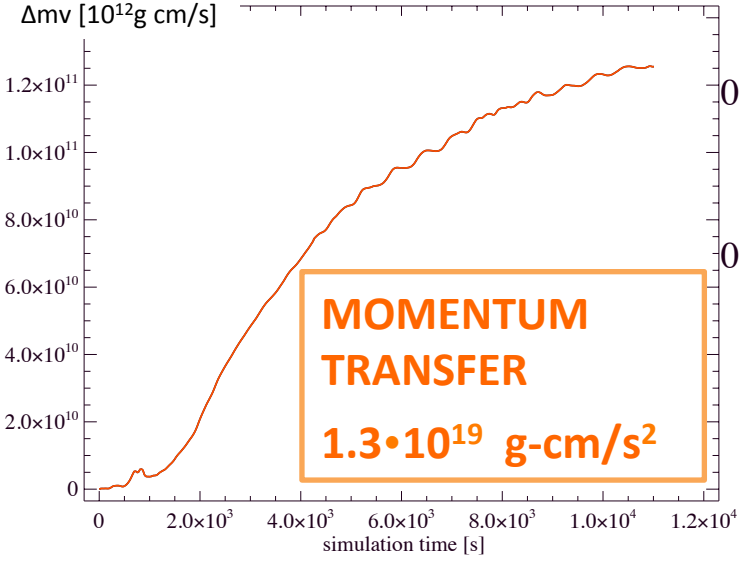



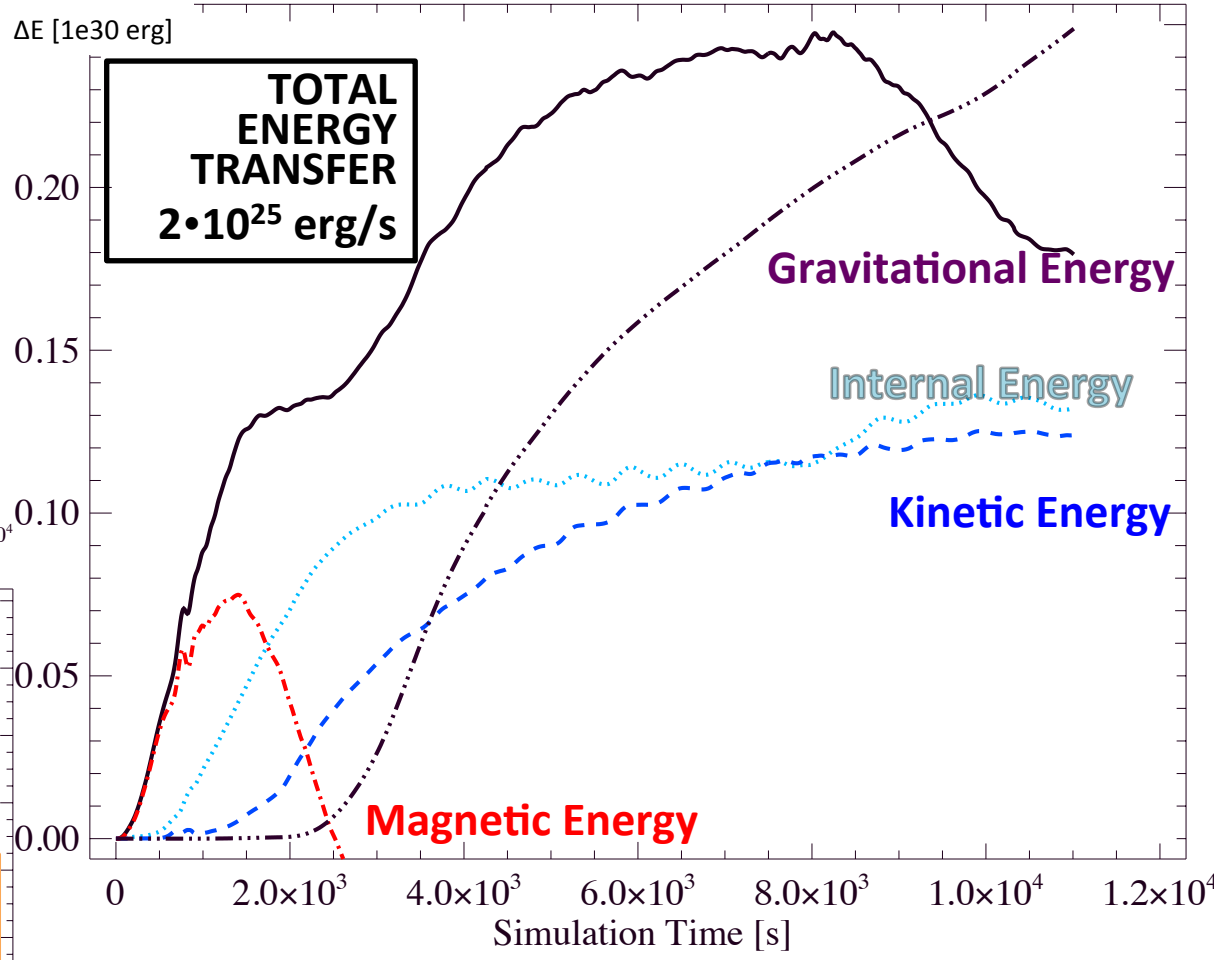




- the ion and electron temperatures show significant differences in the jet region
- magnetic energy is dominant in the core
- periodic changes

# Mass, momentum and energy transfer through the jet into the corona



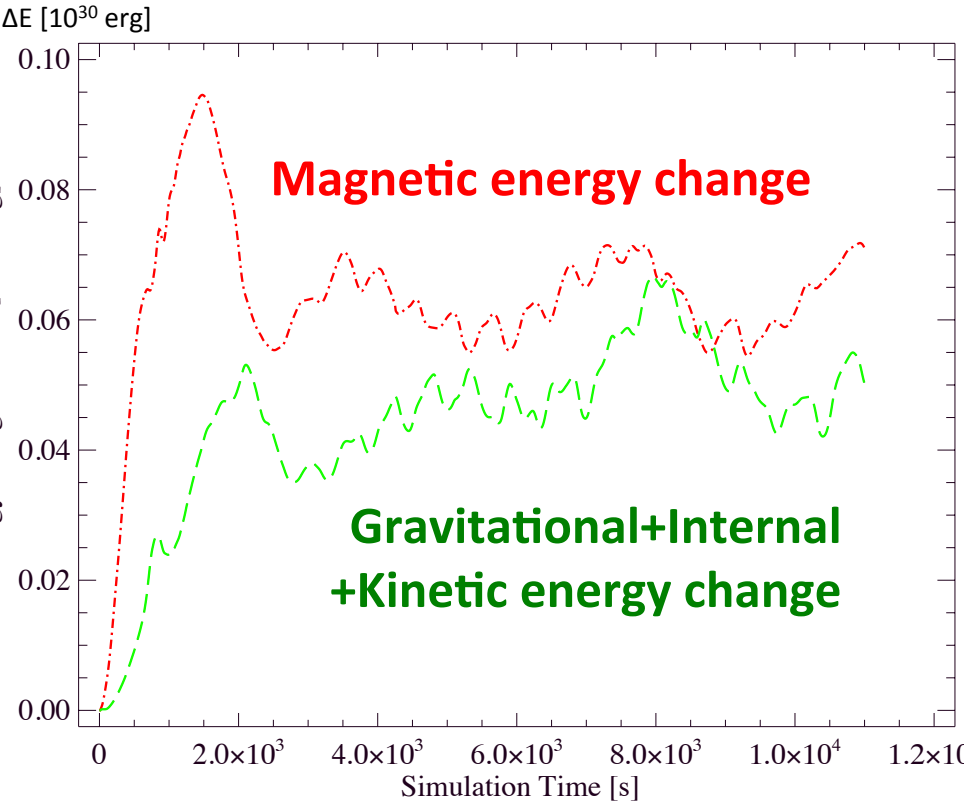



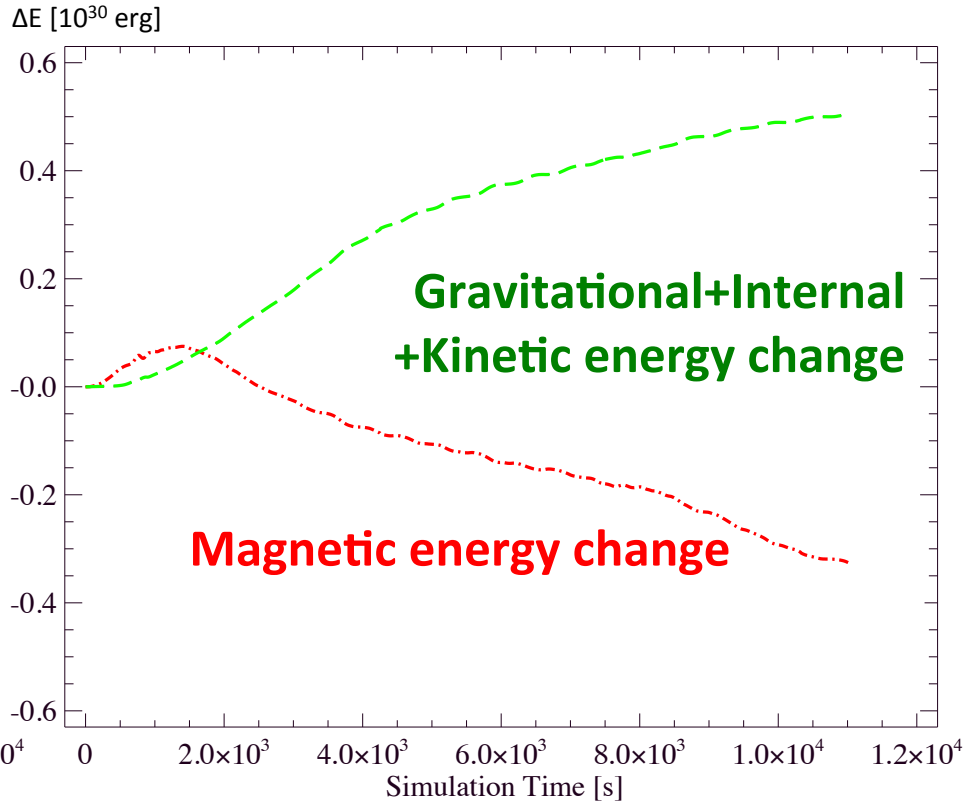

- magnetic energy is dominant only in the beginning
- gravitational energy change is dominant
- mass and momentum transport is significant compared to region with no jet

# Energetics of the jet

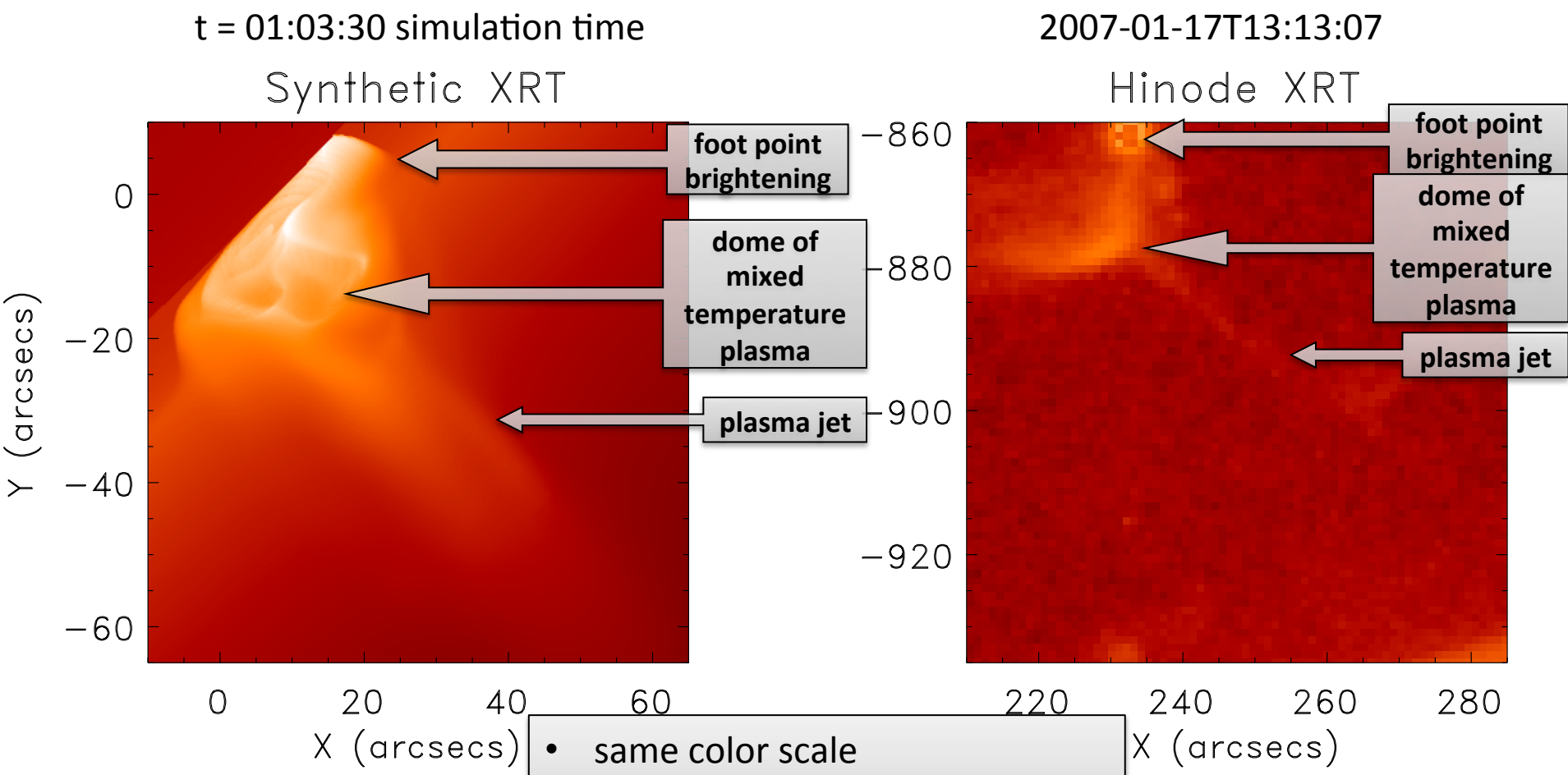
## Local Scale: Jet core




## Global Scale: Total Jet



# Comparison of X-ray synthetic images to Hinode-XRT observations shows similarities




- same color scale
- same spatial scale
- also simulated AIA's EUV bands

# Conclusions

- The modeled jet compares well with observations.
- Inside perturbed corona up to 24 $R_\odot$ (relative to initial value)
  - **energy** transport: **$2 \cdot 10^{25}$ erg/s**

    (12% increase in 3 hours)
  - **momentum** transport: **$1.3 \cdot 10^{19}$ g-cm/s$^2$**

    (102% increase in 3 hours)
  - **mass** transport: **$3.5 \cdot 10^{10}$ g/s**

    (55% increase in 3 hours)
- Small local phenomena like a jet can produce global effects.
- We predict observable signatures for Solar Probe Plus.