MHD modeling of coronal loops: Fe XIII

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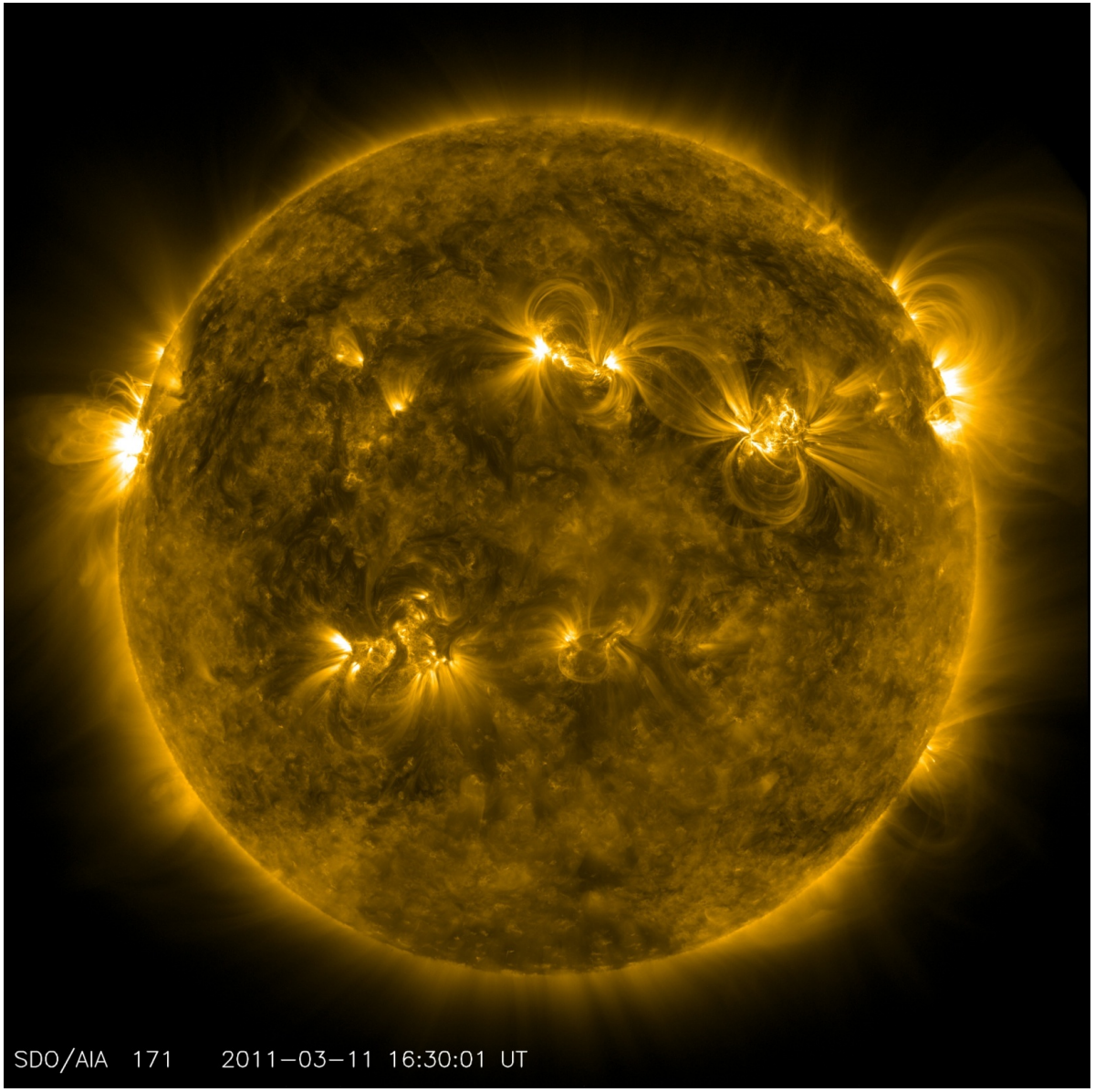
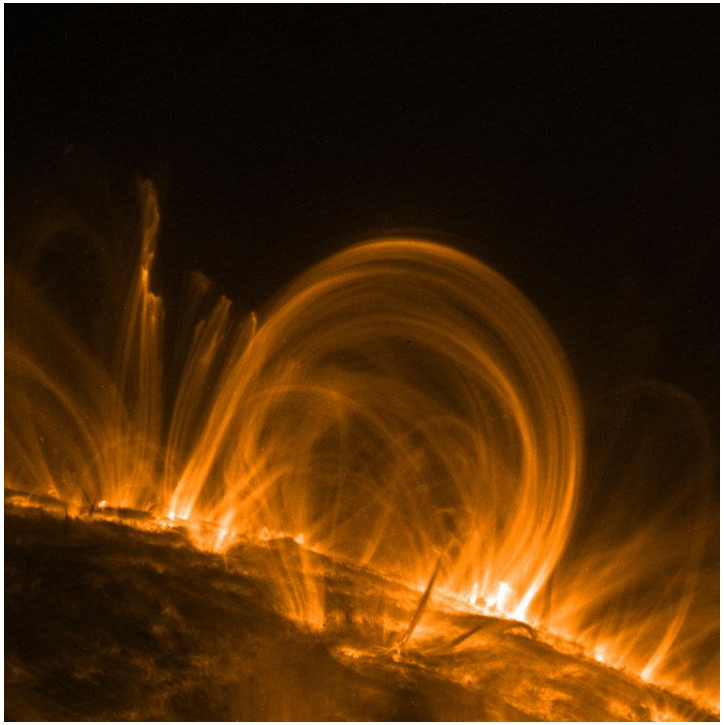
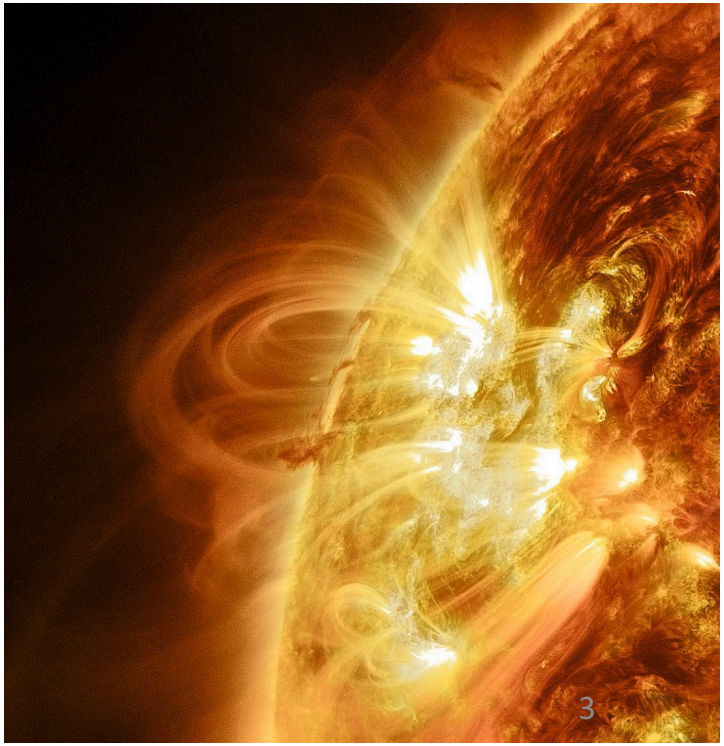
Solar corona



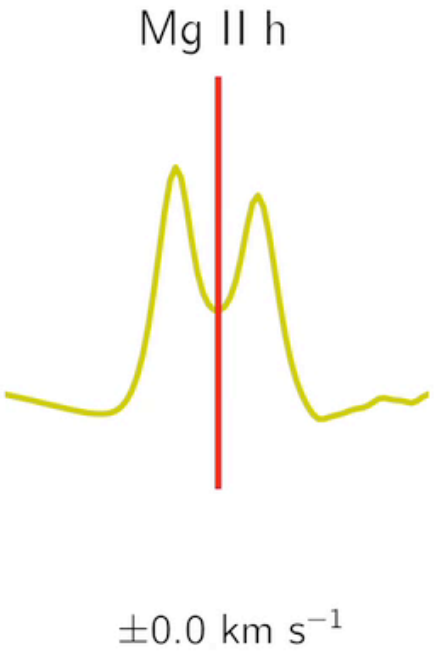
Coronal loops

- Early studies:
  - Most loops steady on times scales longer than cooling times
  - Loop scaling laws *(Rosner, Tucker & Vaiana 1978)*
  - *But evidence for dynamic energy release*

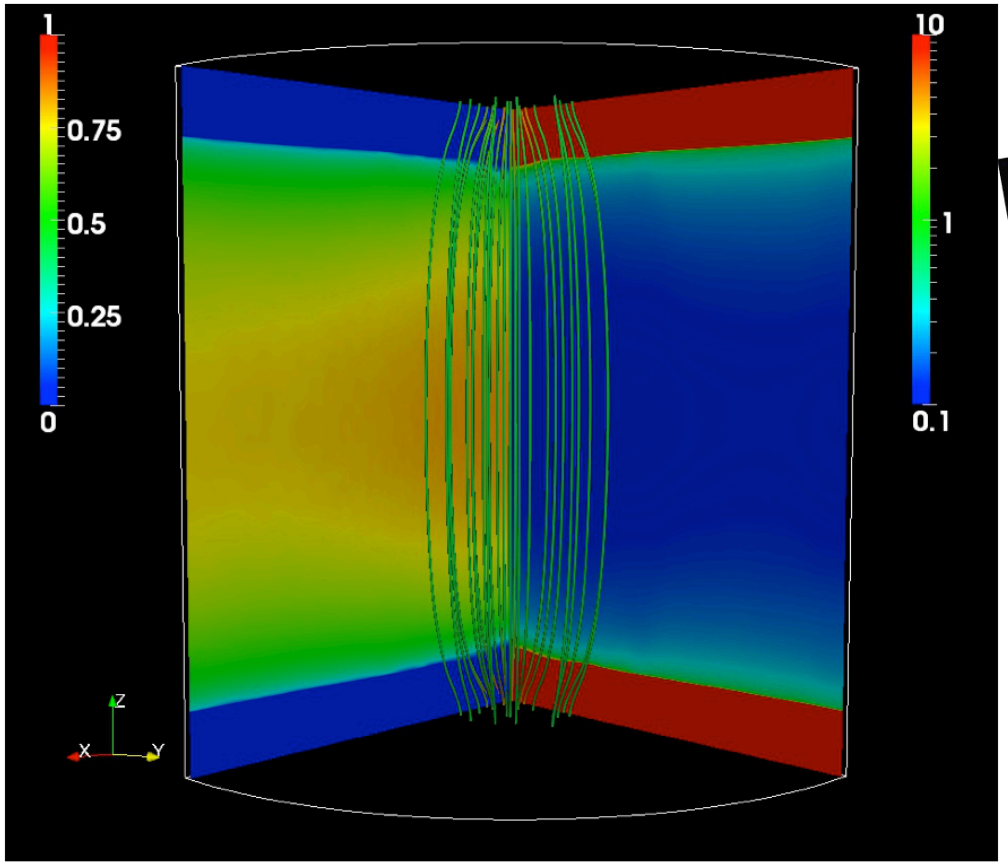


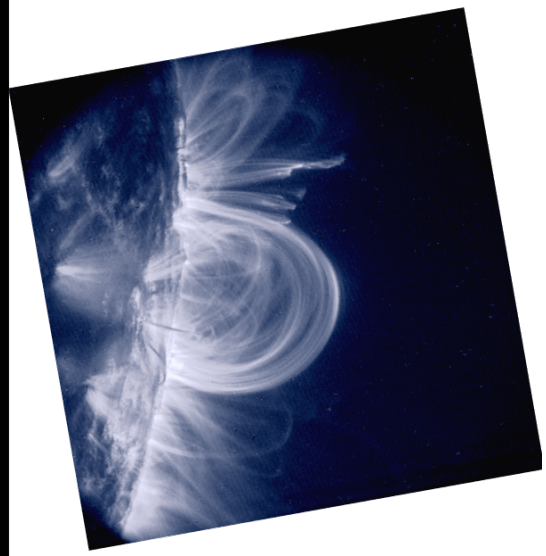


Widespread twisting
(DePontieu+, Science, 2014, Levens+, 2015)



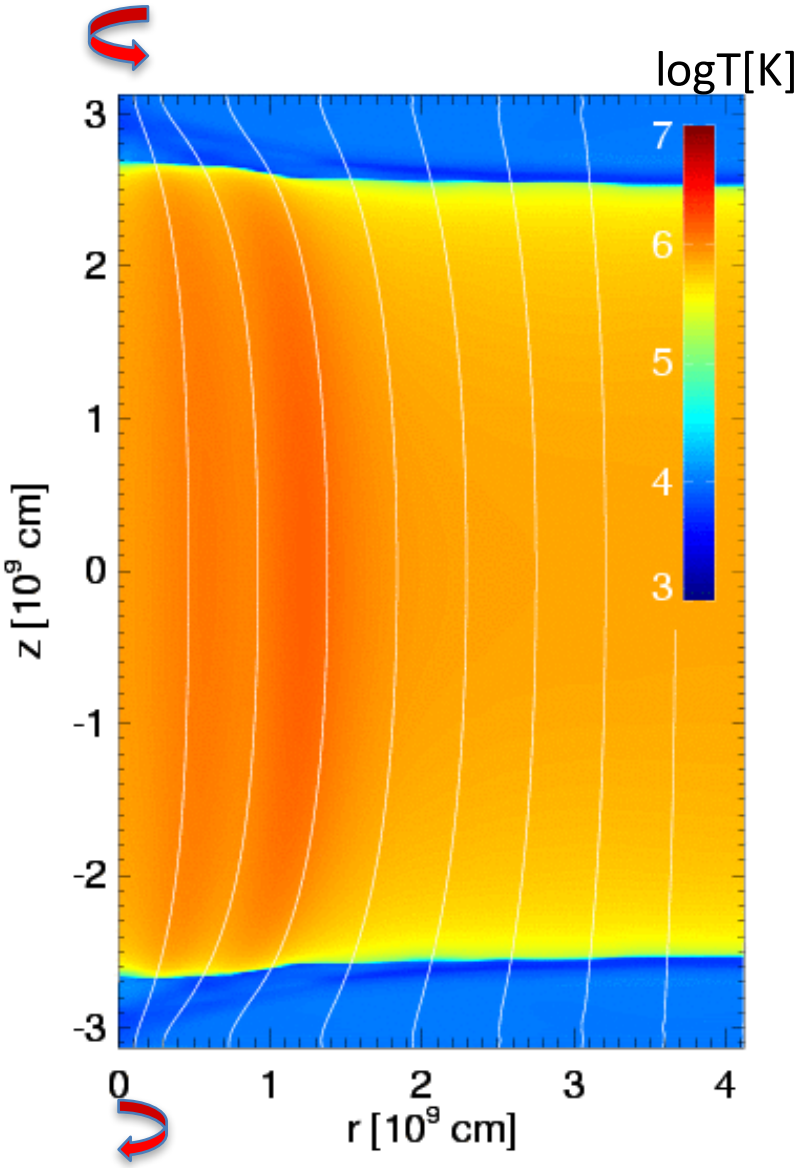
Initial conditions



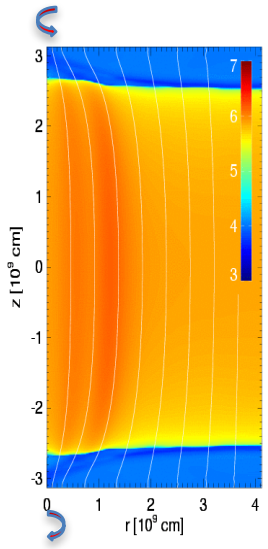


Switch-on resistivity

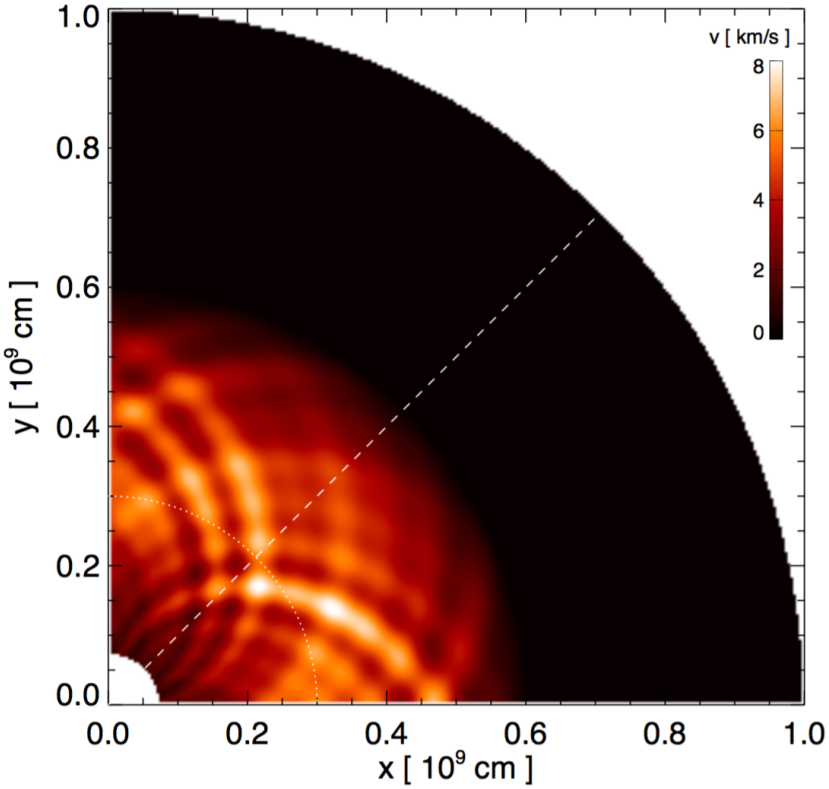
- “Switch-on” anomalous resistivity
  (Hood+ 2009, eq.7):
  - $\eta = 0$ for $J < J_{cr}$
  - $\eta = 10^{14}\ cm^2/s$ for $J > J_{cr}$
  - Threshold:
    - $J_{cr} = 75\ A/cm^2$ (from test simulations)
  - Minimum heating:
    - $H = \eta J_{cr}^2 \approx 10^{-1}\ erg\ cm^{-3}\ s^{-1}$



The perturbed twisting



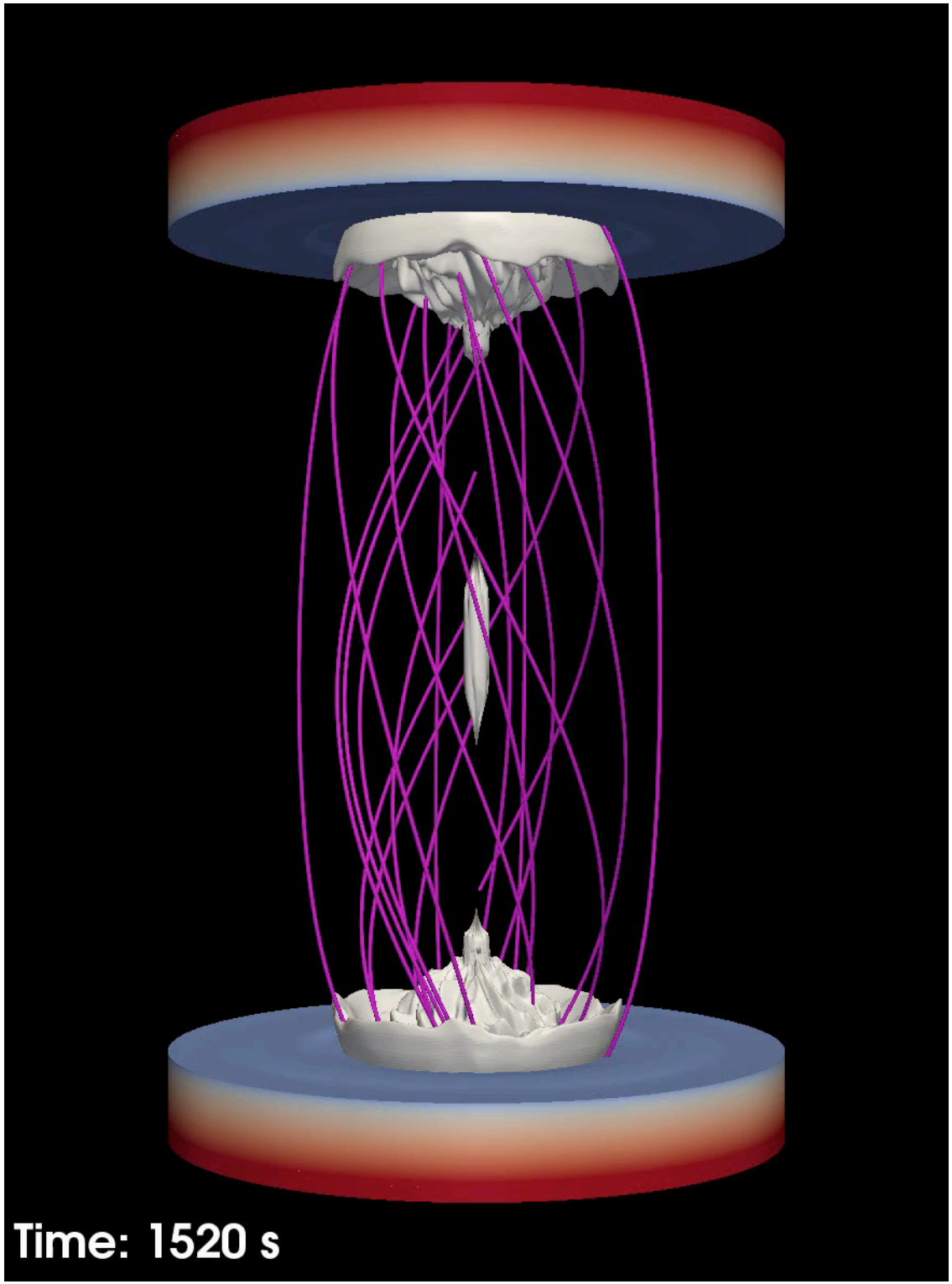
- Footpoint rotation (z-boundaries):
  - Profile: constant angular speed ω
  - Maximum: 5 km/s (both footpoints)
  - Radius: r = 3000 km
  - Linear reduction:
    ω ➔0: 3000 < r < 6000 km
  - **RANDOMLY PERTURBED VELOCITY AT THE FOOTPOINTS**



Current density

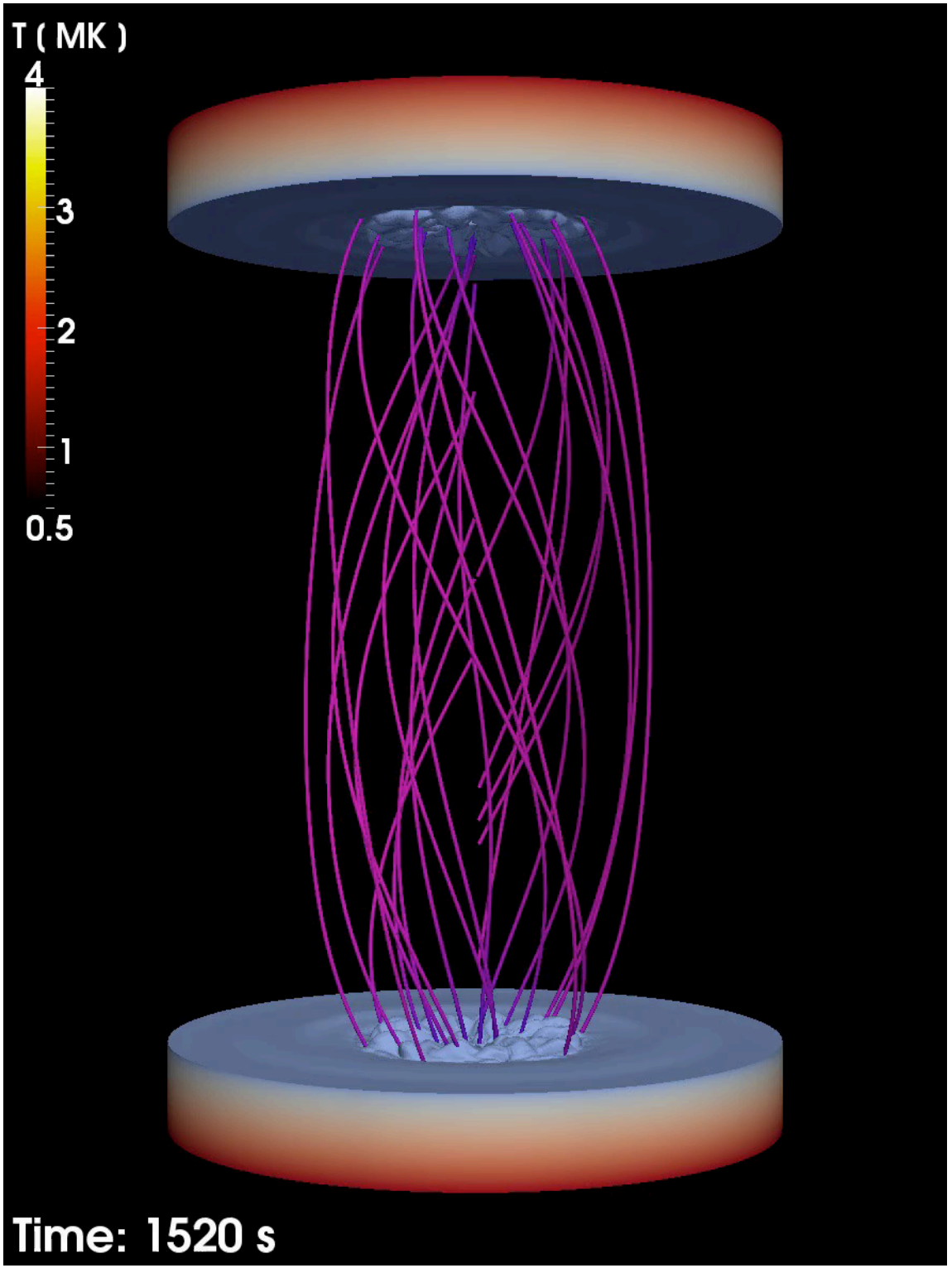
(+ field lines)

- Only above threshold shown, i.e. heating marker
- The blue surface is the boundary where the density is 10^9 cm^{-3}
- Most current sheets:
  - Close to axis
  - Close to footpoints
  - Lasting few frames: <1 min



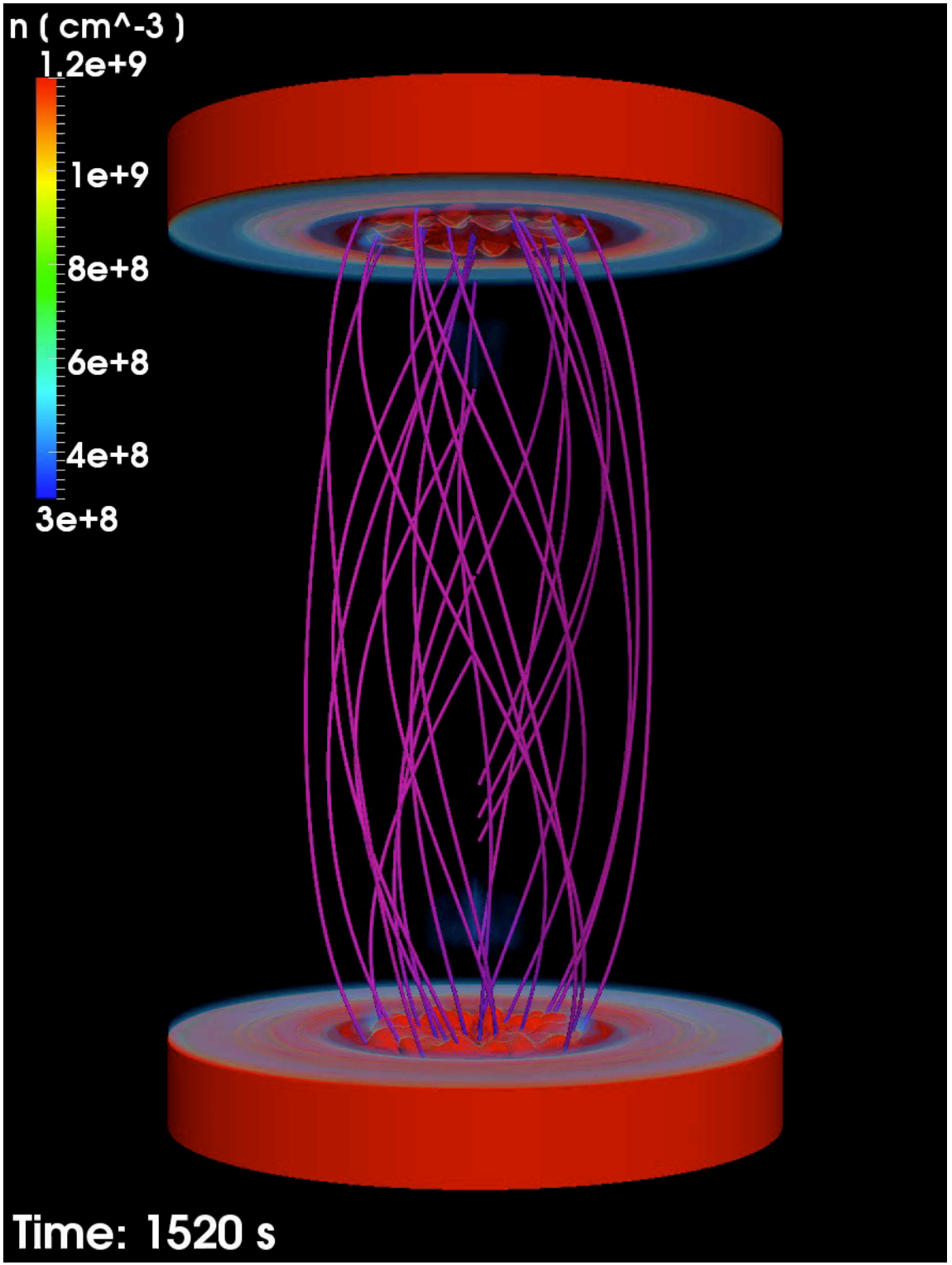
Temperature [MK] (+ field lines)

- Max T ~ 4 MK



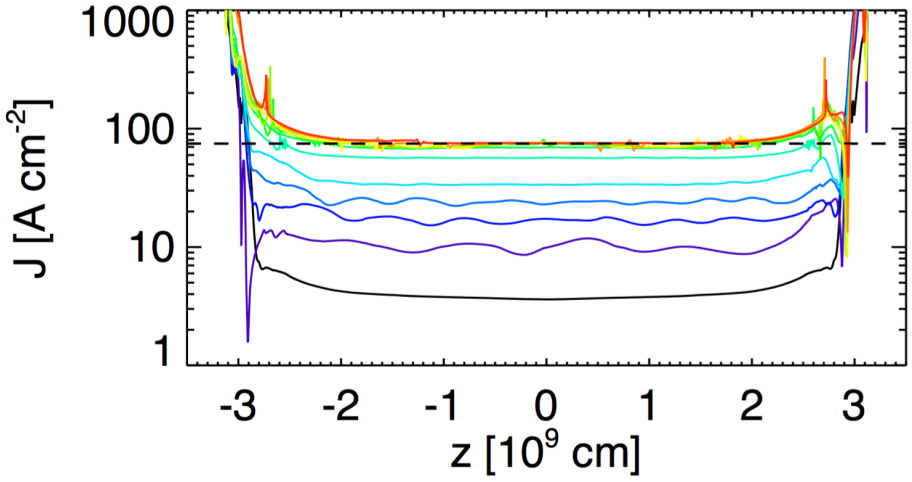
Density
(+ field lines)

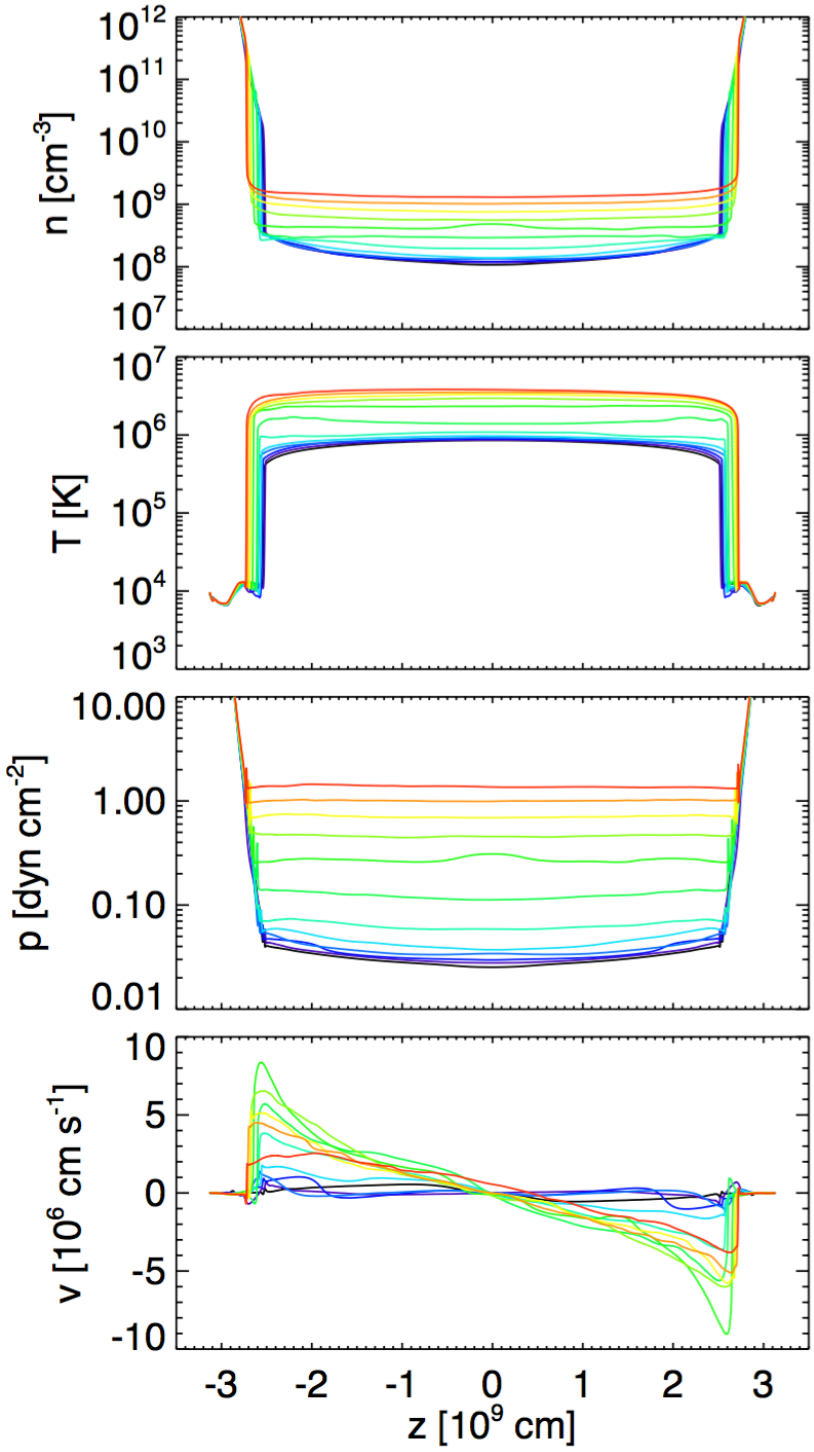
- Units: 10^9 cm^{-3}
- Evaporation along field lines



Loop evolution along z

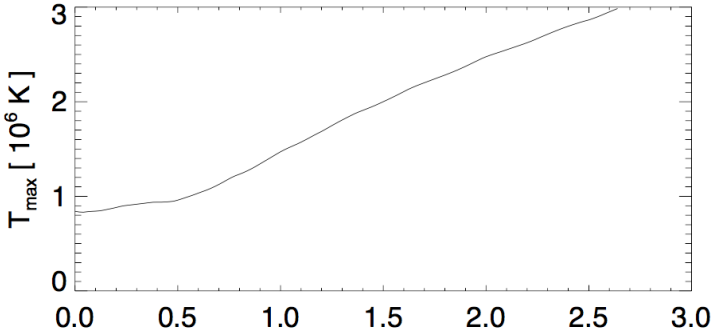
- Spaced every 200 s
- From blue (t=0) to red (t=2500 s)

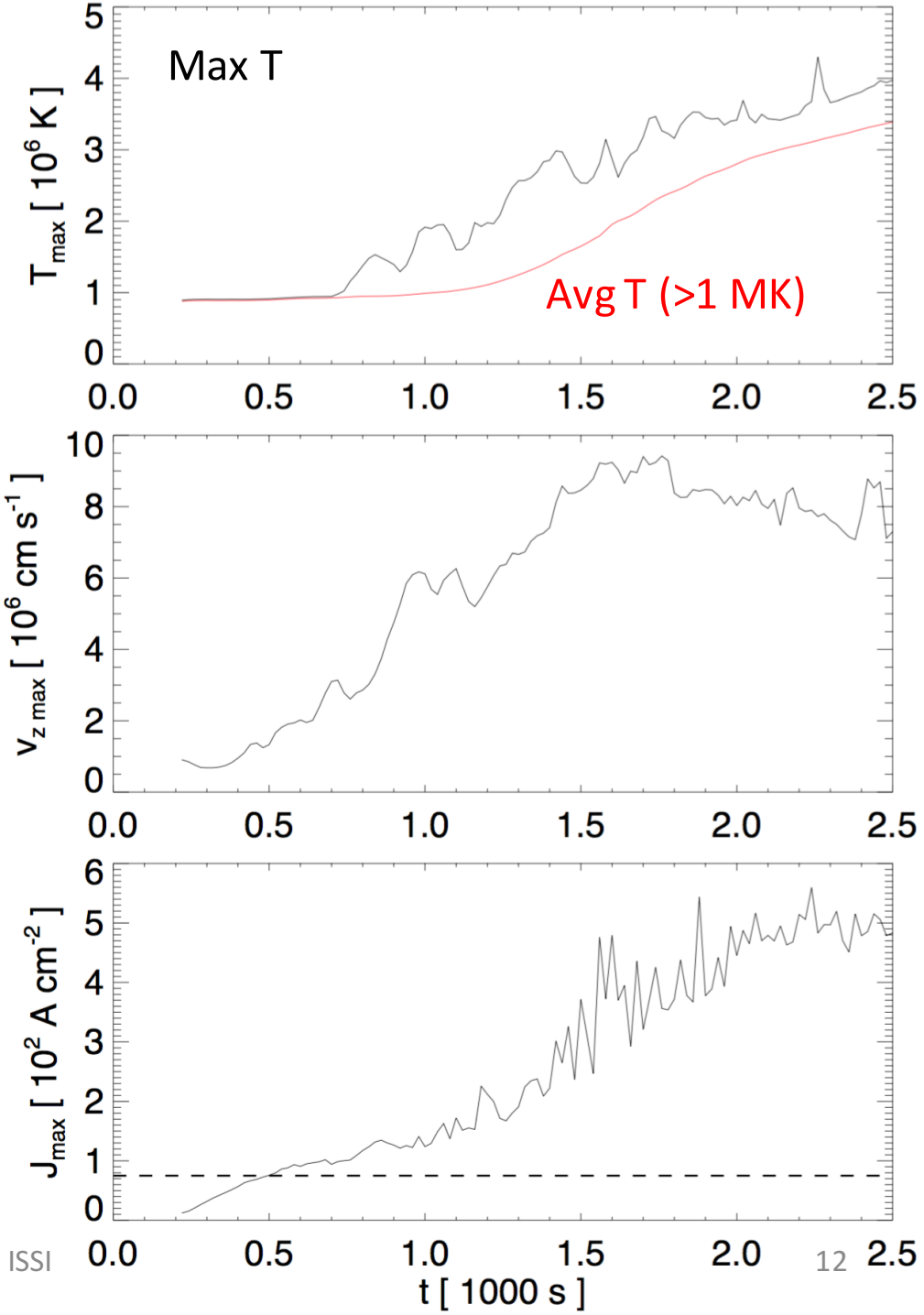




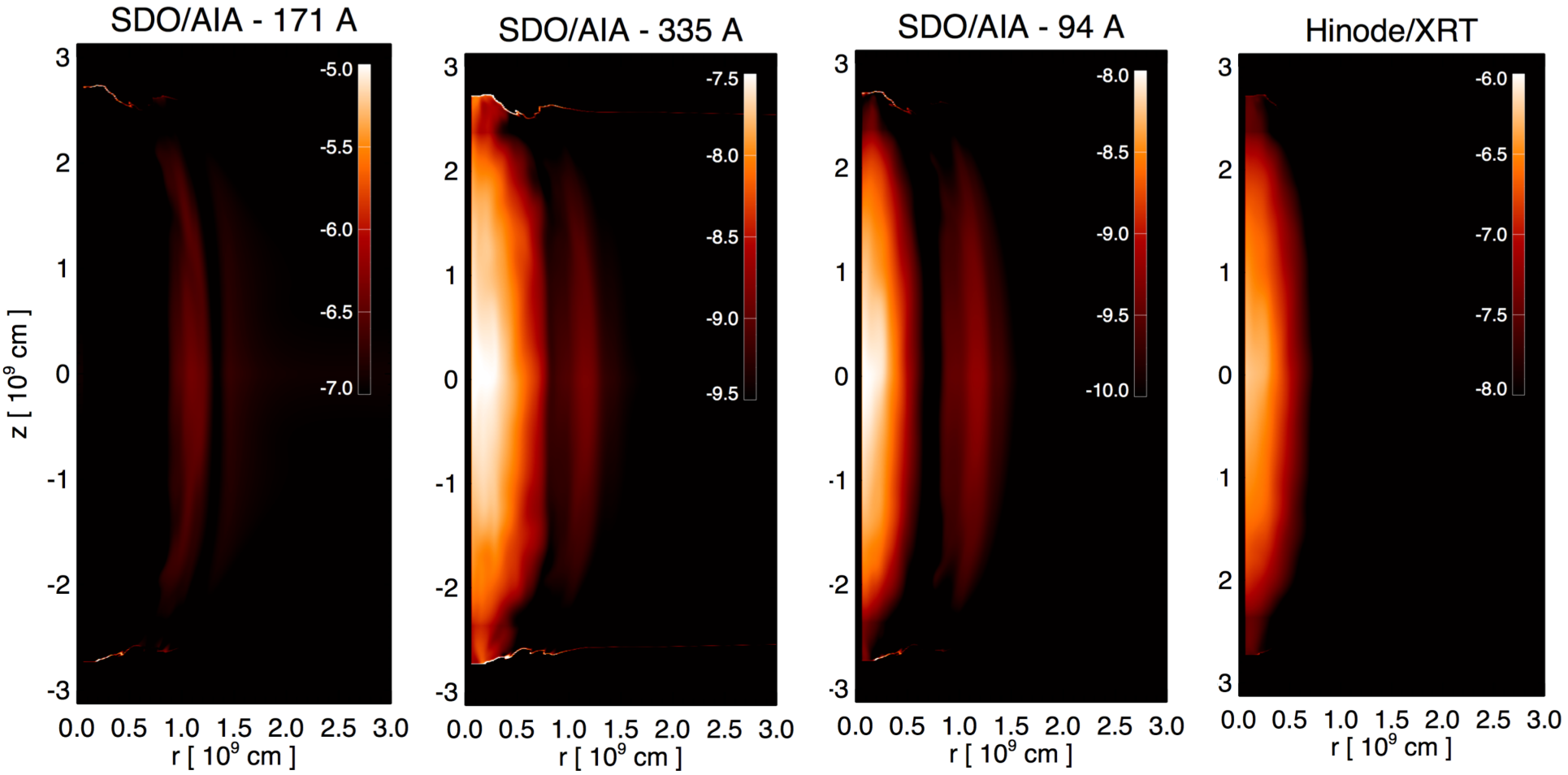
Max vs time

The maximum temperature shows a "turbulent" evolution

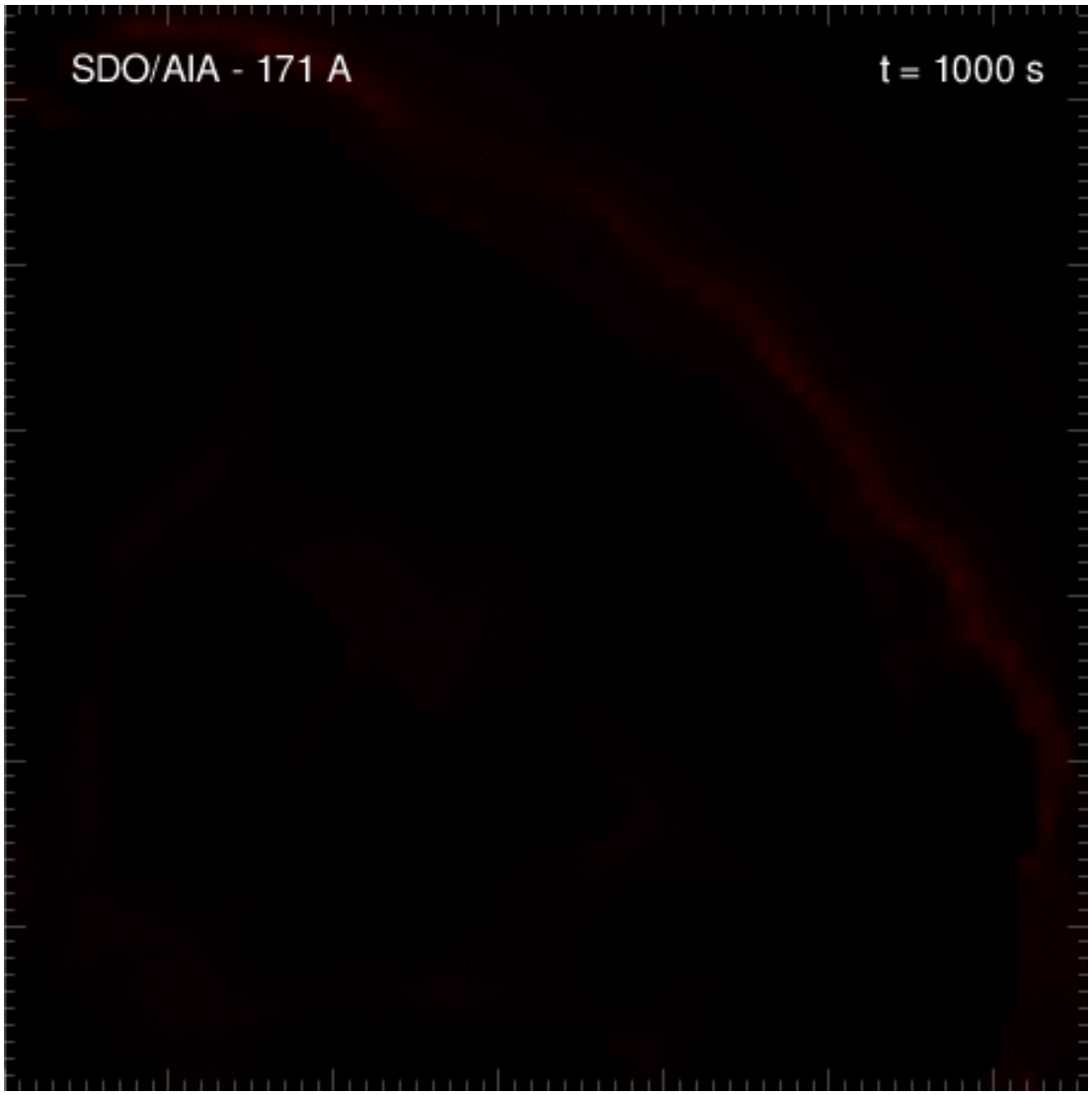




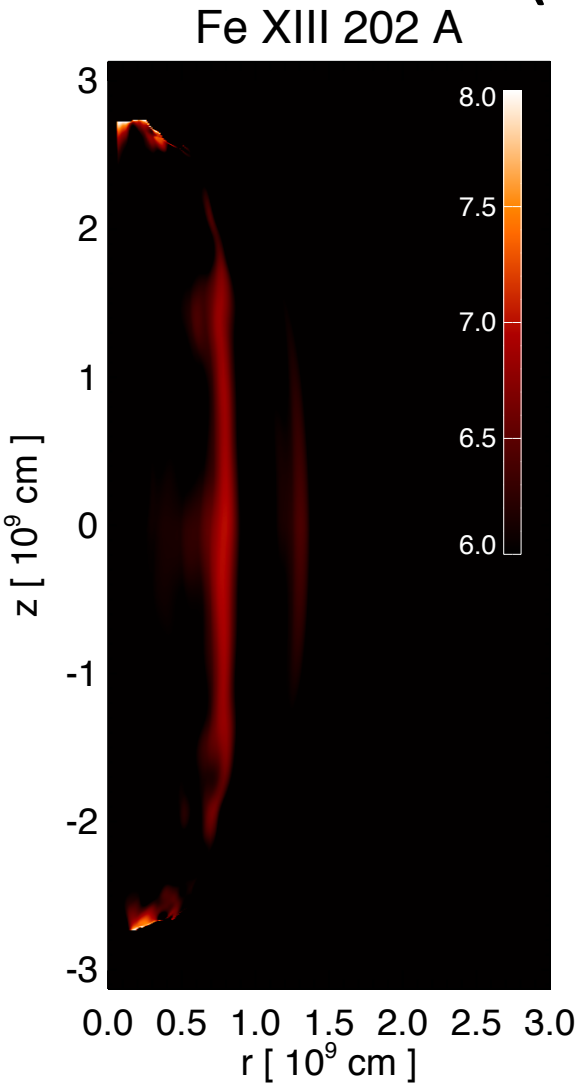
Emission

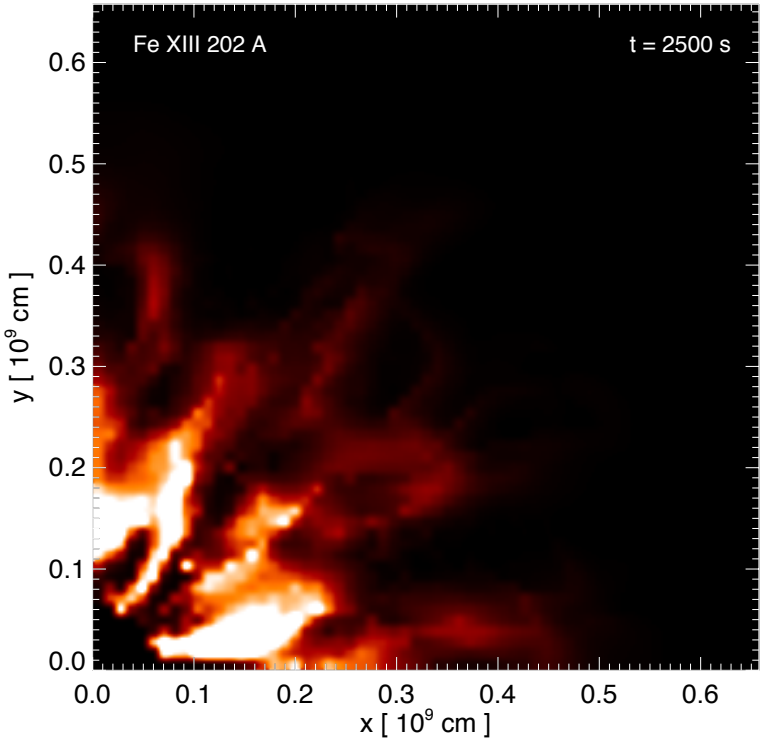

SDO/AIA - 171 A
SDO/AIA - 335 A
SDO/AIA - 94 A
Hinode/XRT
z [10^9 cm]
r [10^9 cm]
-5.0
-5.5
-6.0
-6.5
-7.0
-7.5
-8.0
-8.5
-9.0
-9.5
-10.0

The moss



Fe XIII 202.04
(Chianti 8.0.1, log p=16)





Density vs Fe XIII (>10% max)