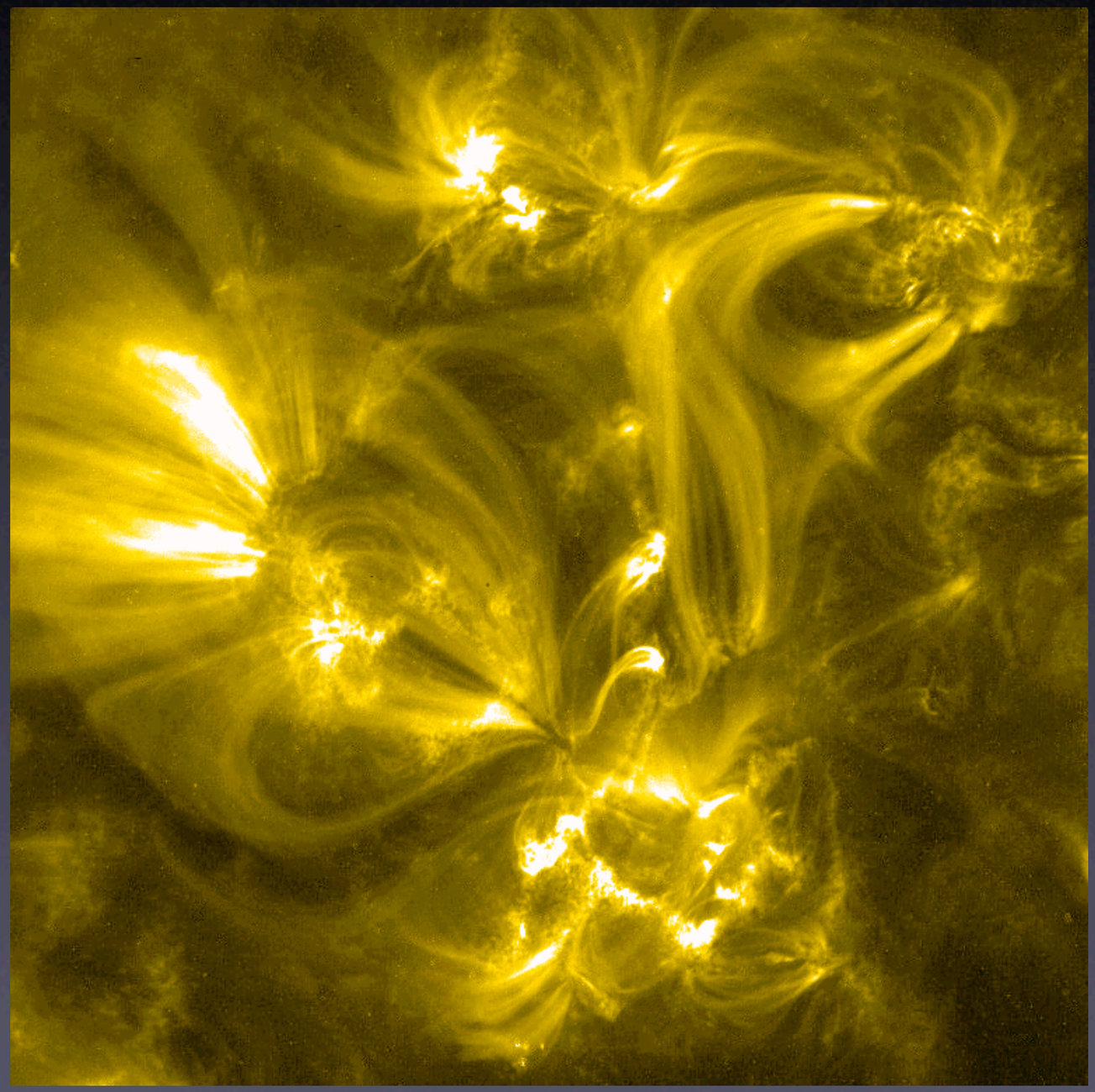
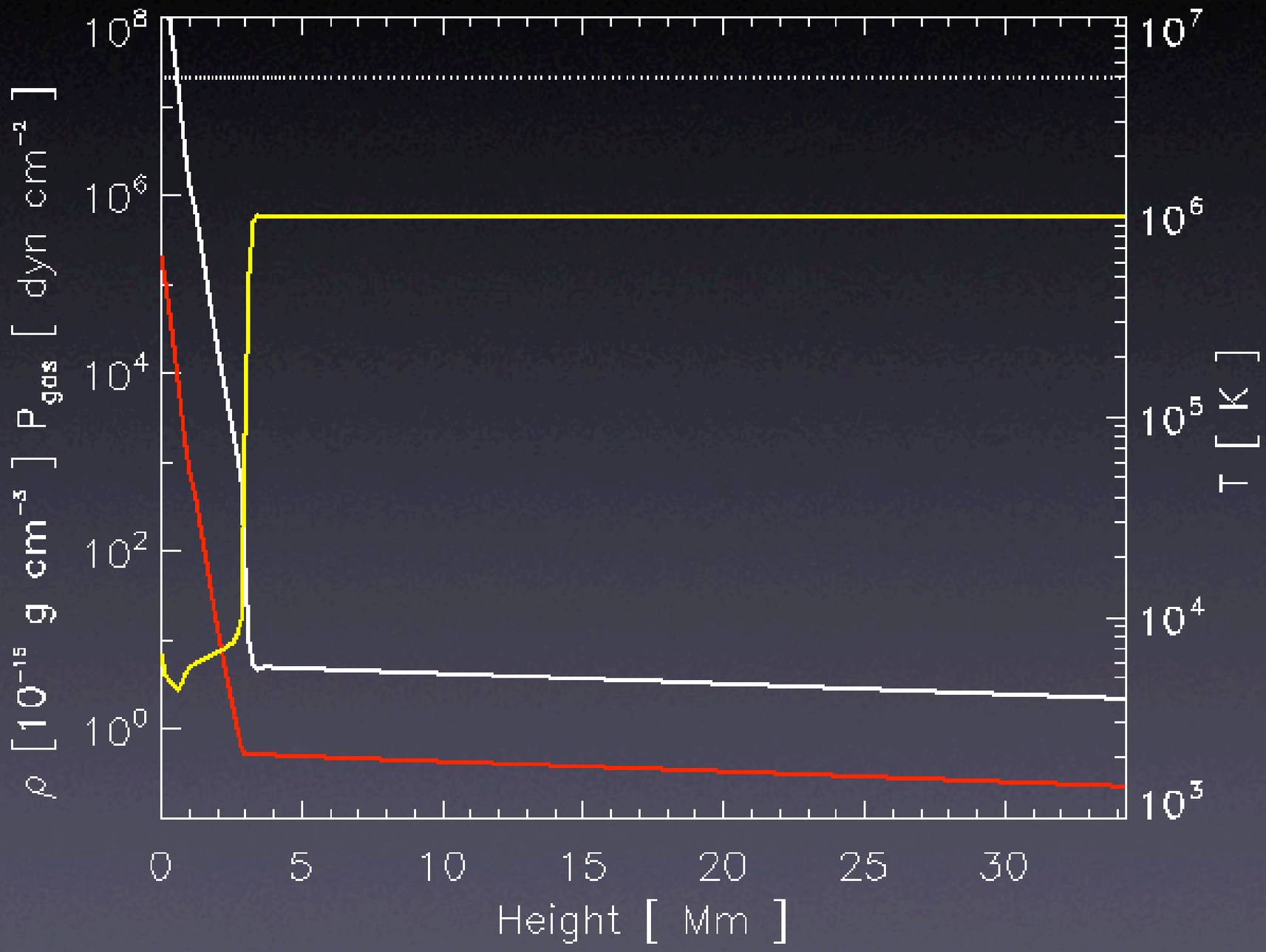
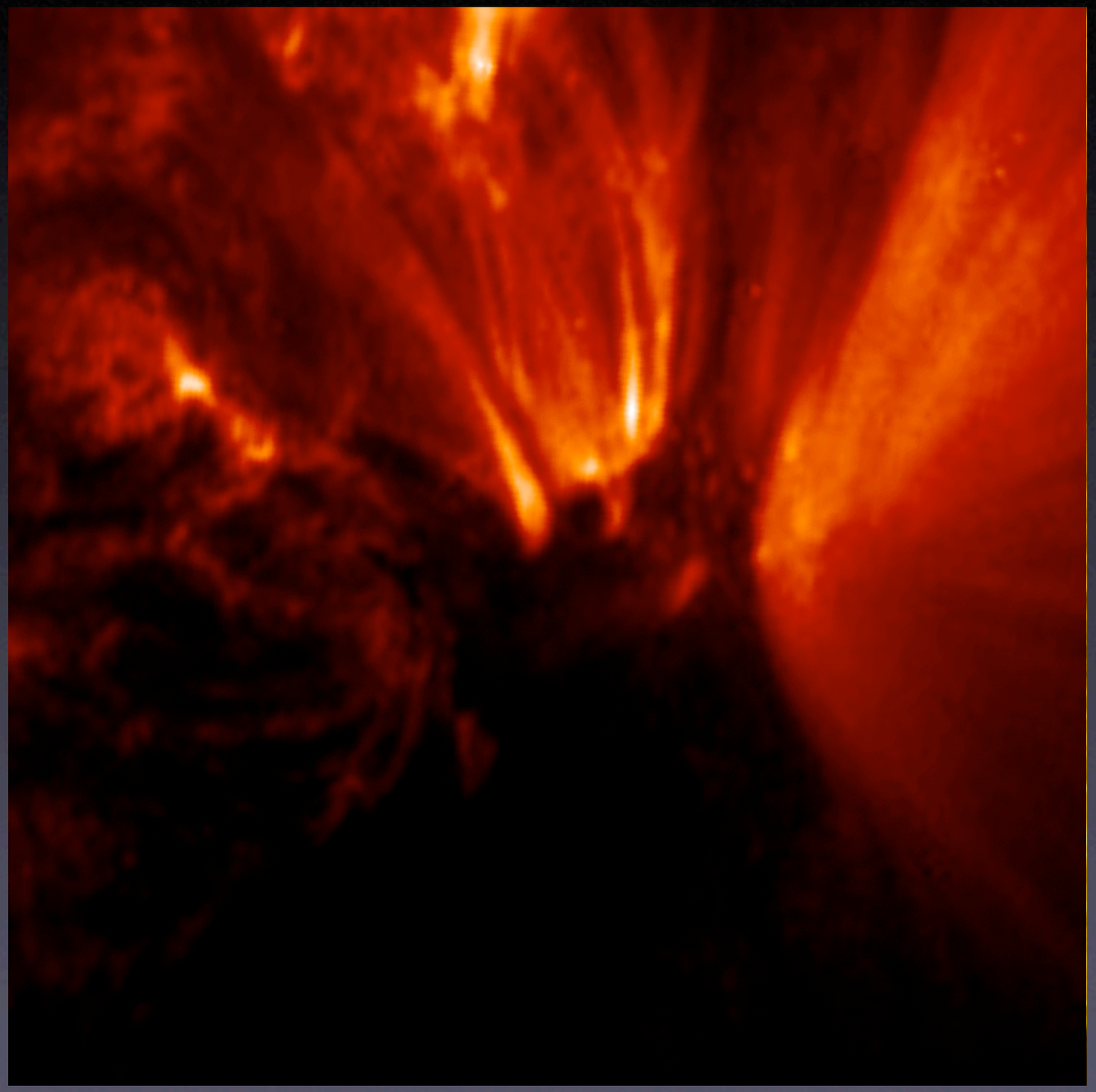
Heating of the solar Corona



Active Region



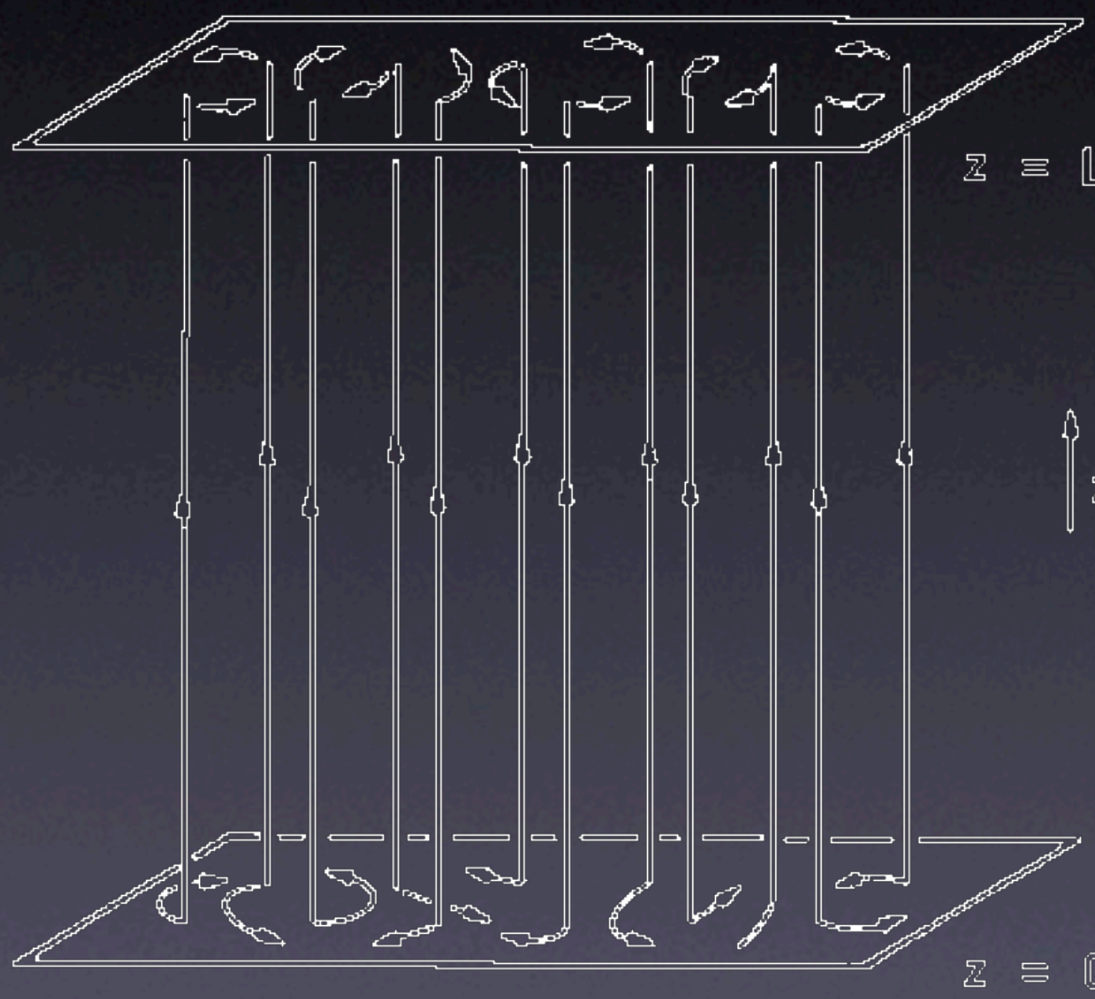
Active Region

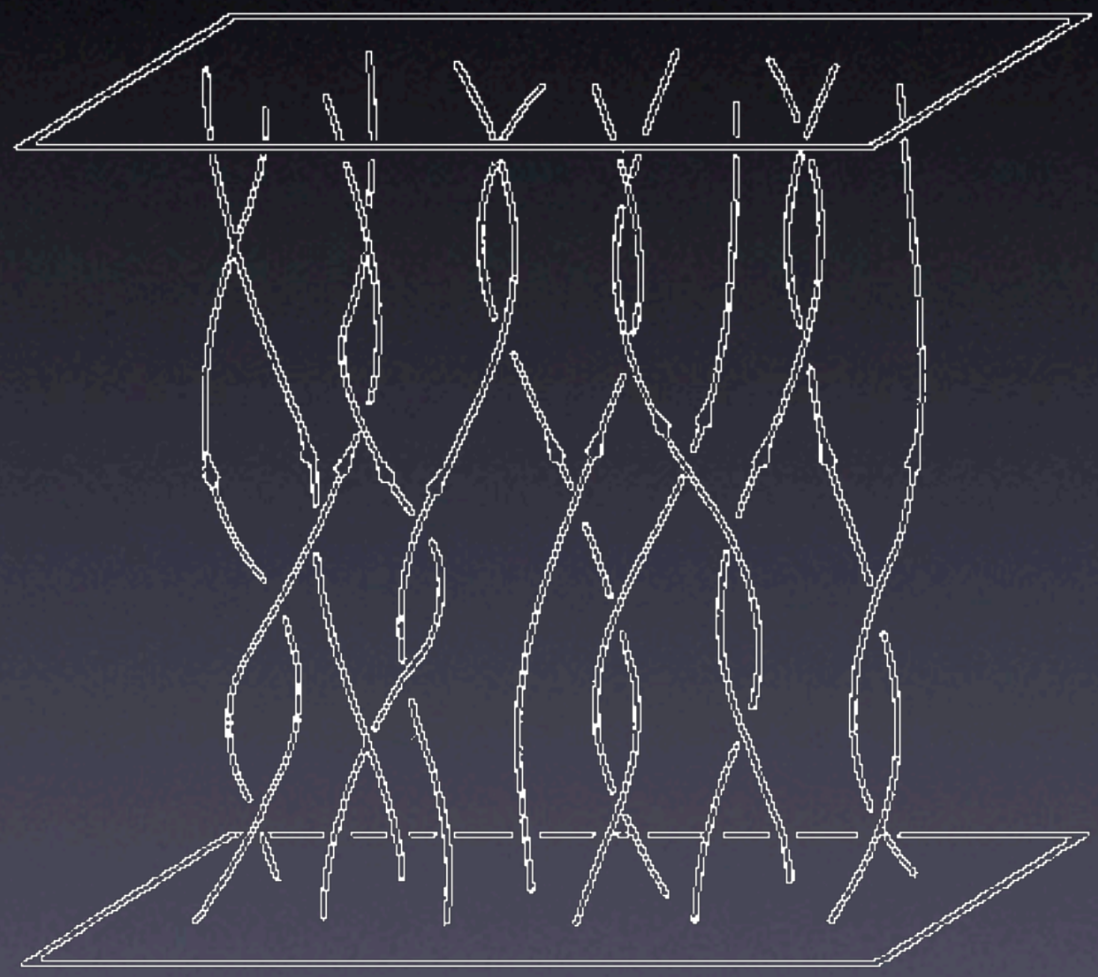


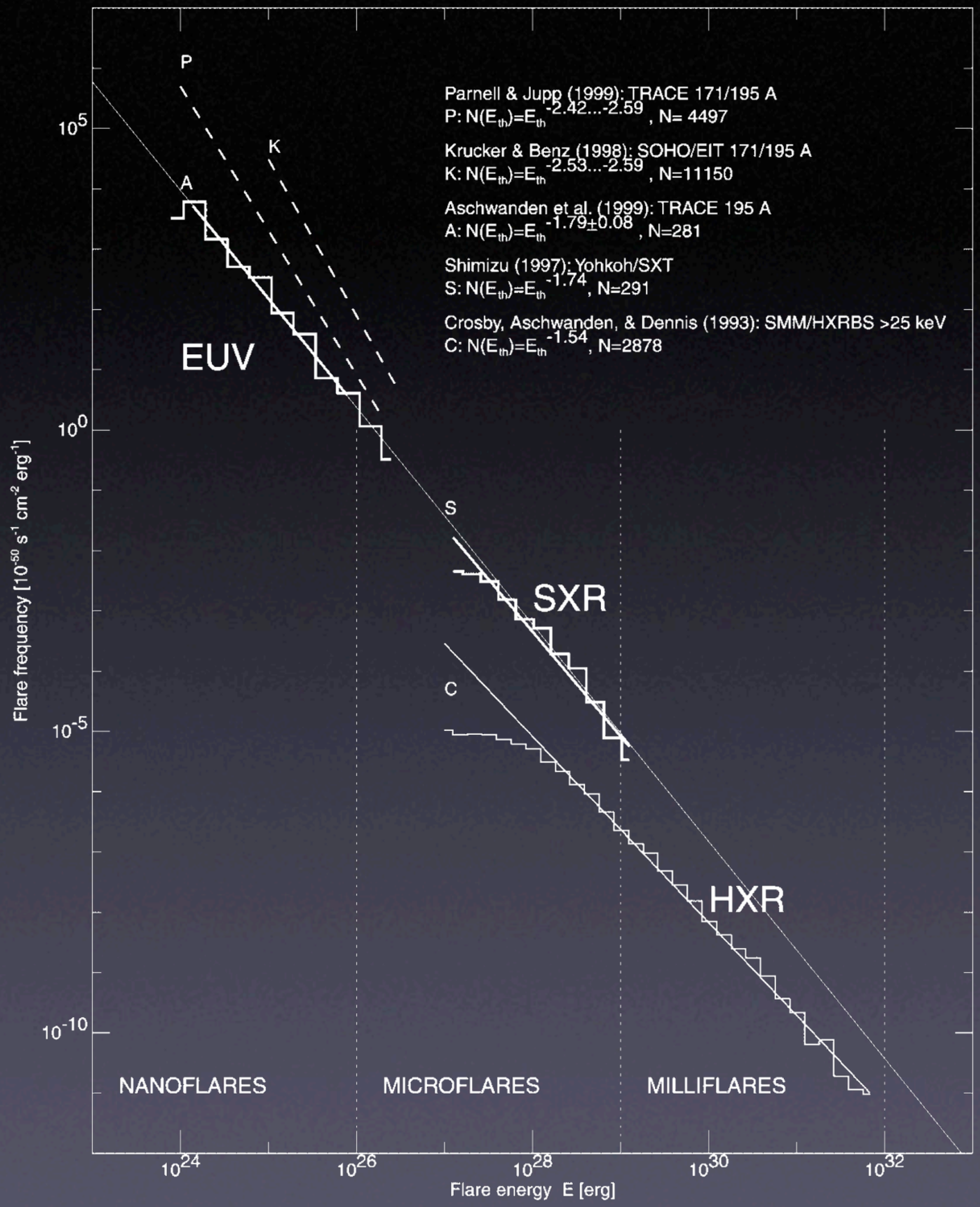
Heating Models

- AC
  - Alfvèn waves
  - Doppler signal, frequency .....
- DC
  - Large amount of reconnection events
  - Unknown observational effect

Tangling





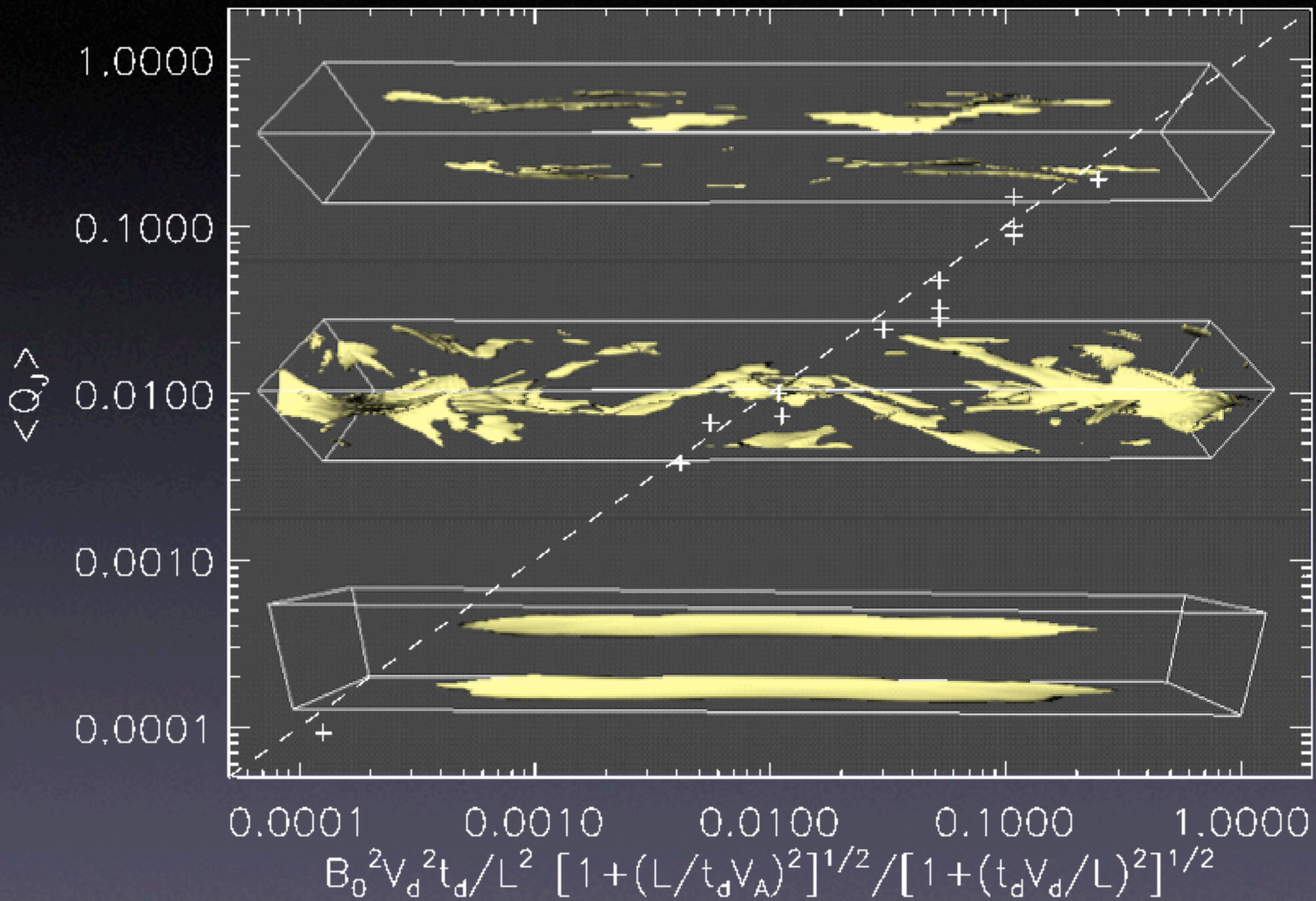

Parnell & Jupp (1999): TRACE 171/195 A
P: N(E_th)=E_th^-2.42...-2.59 , N= 4497
Krucker & Benz (1998): SOHO/EIT 171/195 A
K: N(E_th)=E_th^-2.53...-2.59 , N=11150
Aschwanden et al. (1999): TRACE 195 A
A: N(E_th)=E_th^-1.79±0.08 , N=281
Shimizu (1997): Yohkoh/SXT
S: N(E_th)=E_th^-1.74, N=291
Crosby, Aschwanden, & Dennis (1993): SMM/HXRBS >25 keV
C: N(E_th)=E_th^-1.54, N=2878
P
K
A
S
C
EUV
SXR
HXR
NANOFLARES
MICROFLARES
MILLIFLARES
Flare frequency [10^-50 s^-1 cm^-2 erg^-1]
Flare energy E [erg]
10^5
10^0
10^-5
10^-10
10^24
10^26
10^28
10^30
10^32

Attacking the Problem

- Full Atmosphere (Aschwanden '01)
- Time Dependent (Kuperus '81)
- Correct Driving
- Minimal Assumptions

Complications

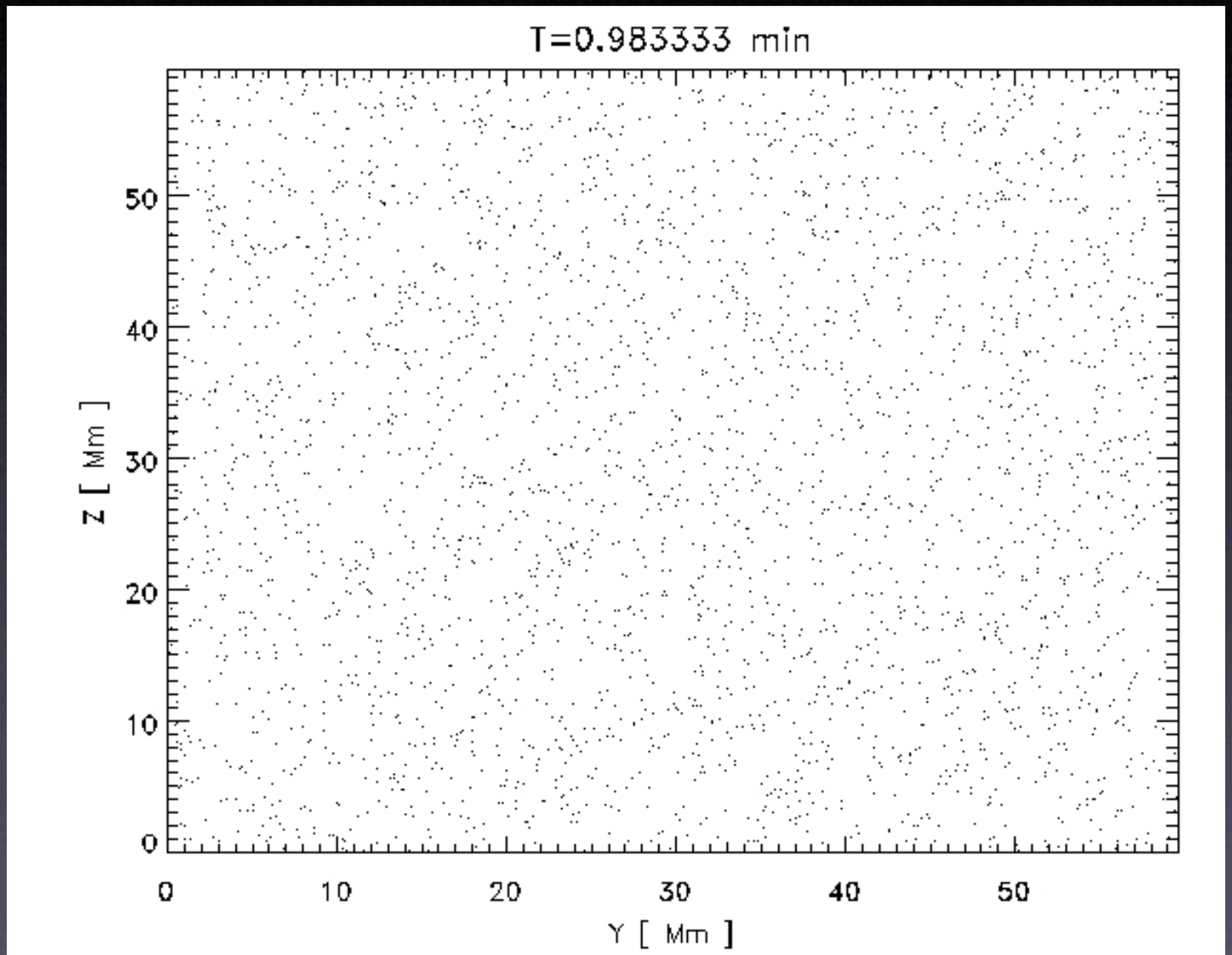
- Scale complications
  - Length scales
  - Time scales
- Thermal conduction
- Non-Specific


1.0000
0.1000
0.0100
0.0010
0.0001
<Q_J>
0.0001
0.0010
0.0100
0.1000
1.0000
B0^2Vd^2td/L^2 [1+(L/tdVA)^2]^1/2/[1+(tdVd/L)^2]^1/2

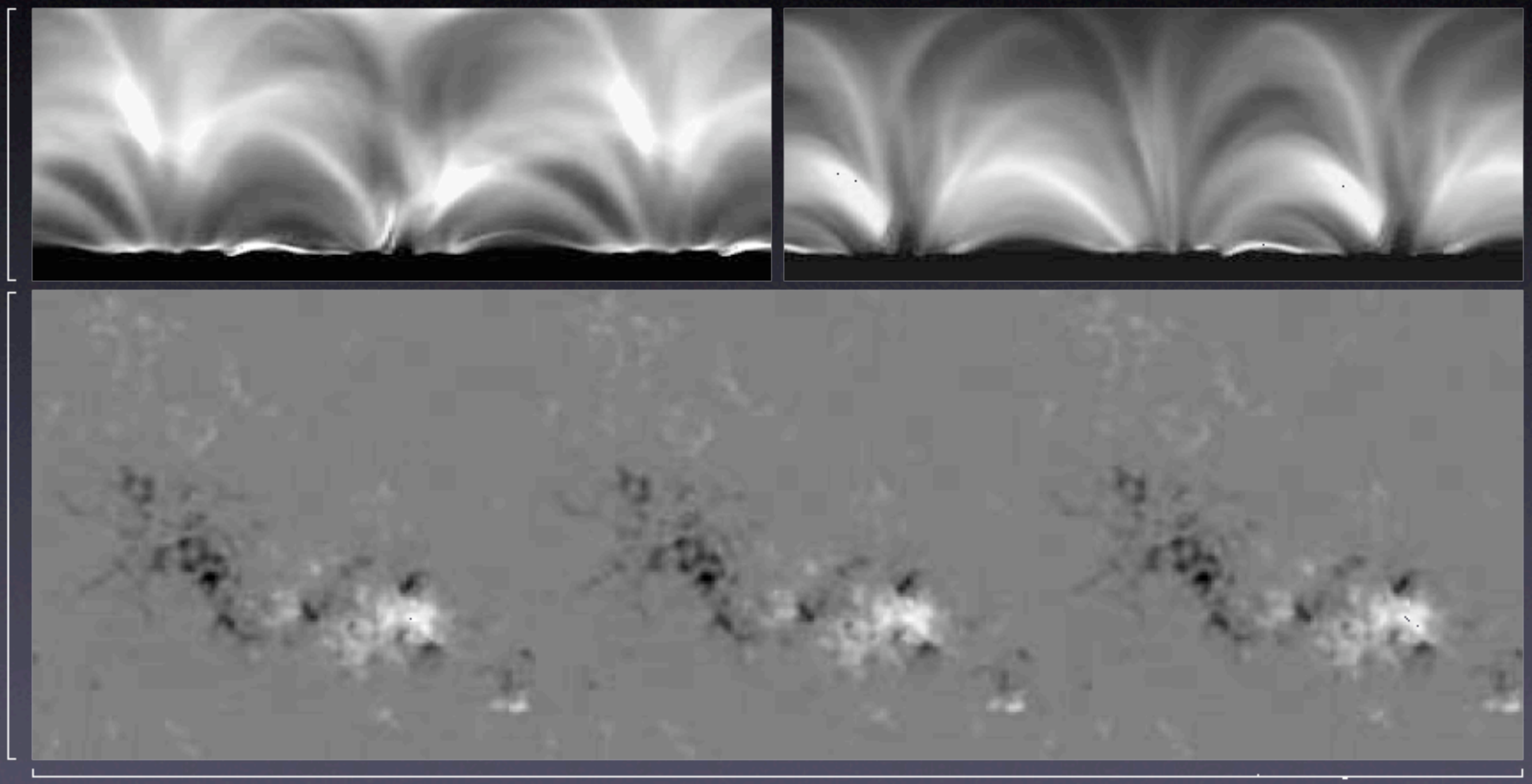
3D MHD

- Full atmosphere
- ‘Standard’ active region
- Typical magnetic field
- Optically thin radiative cooling
- Spitzer conductivity
- General photospheric driver

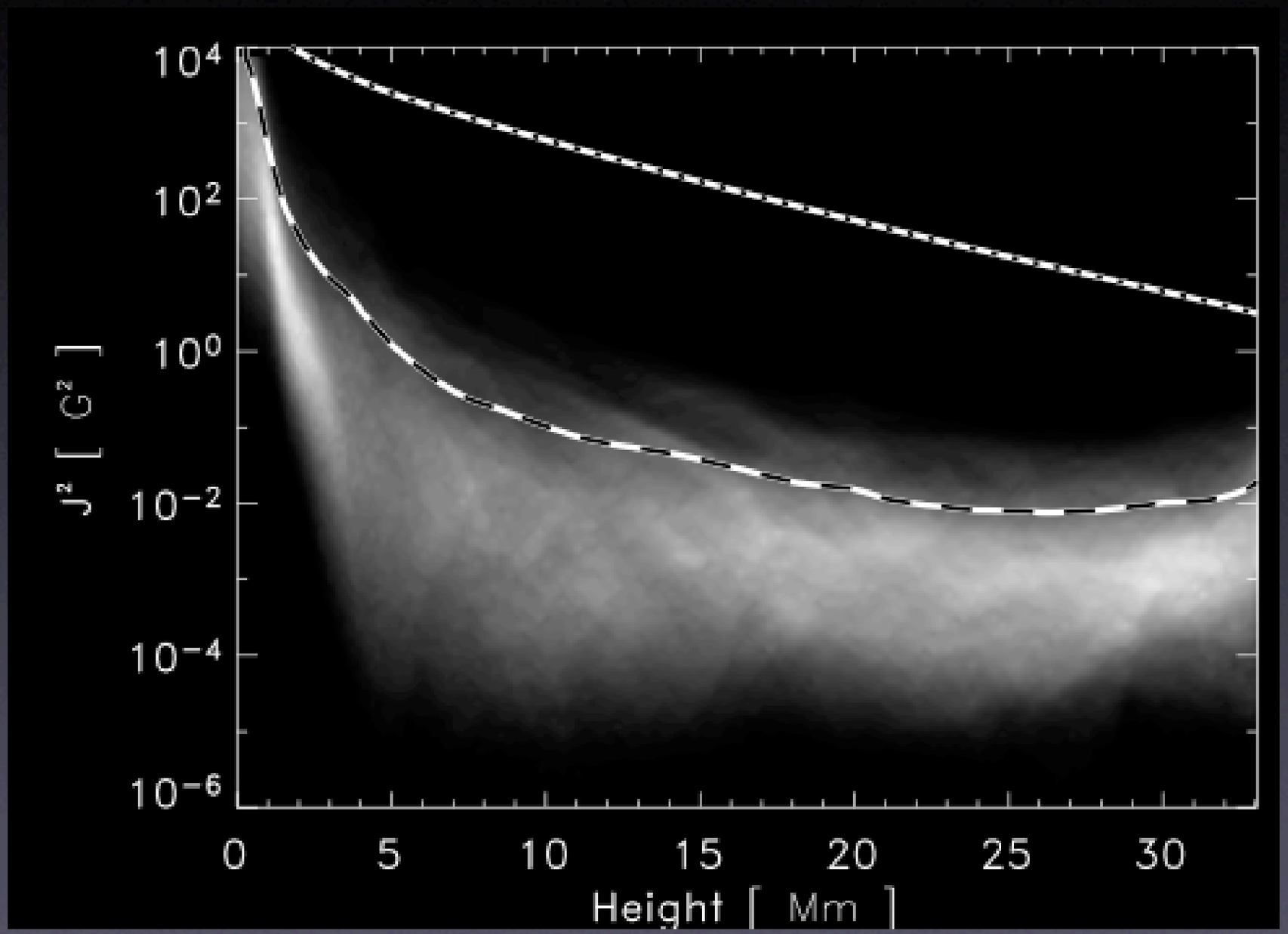
Driver



Full Corona



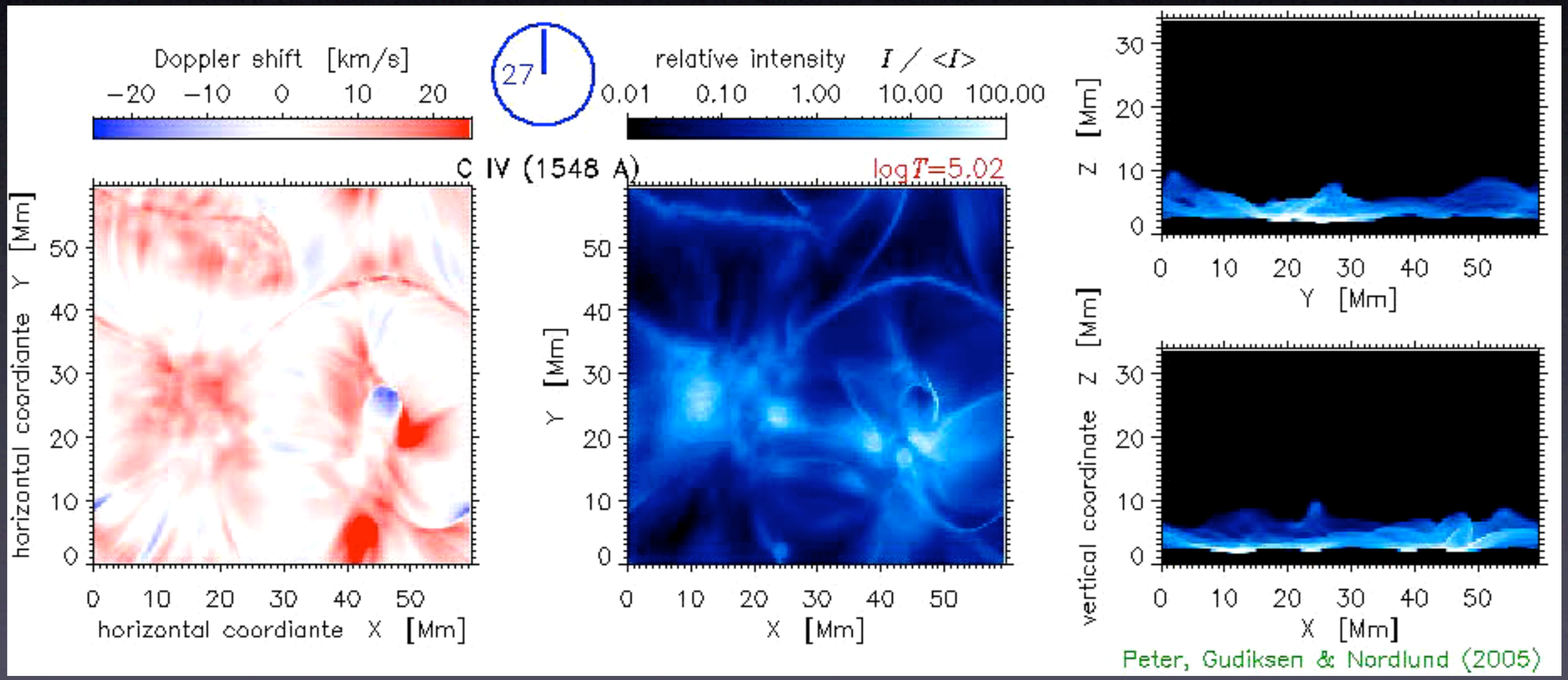
Heating By Currents



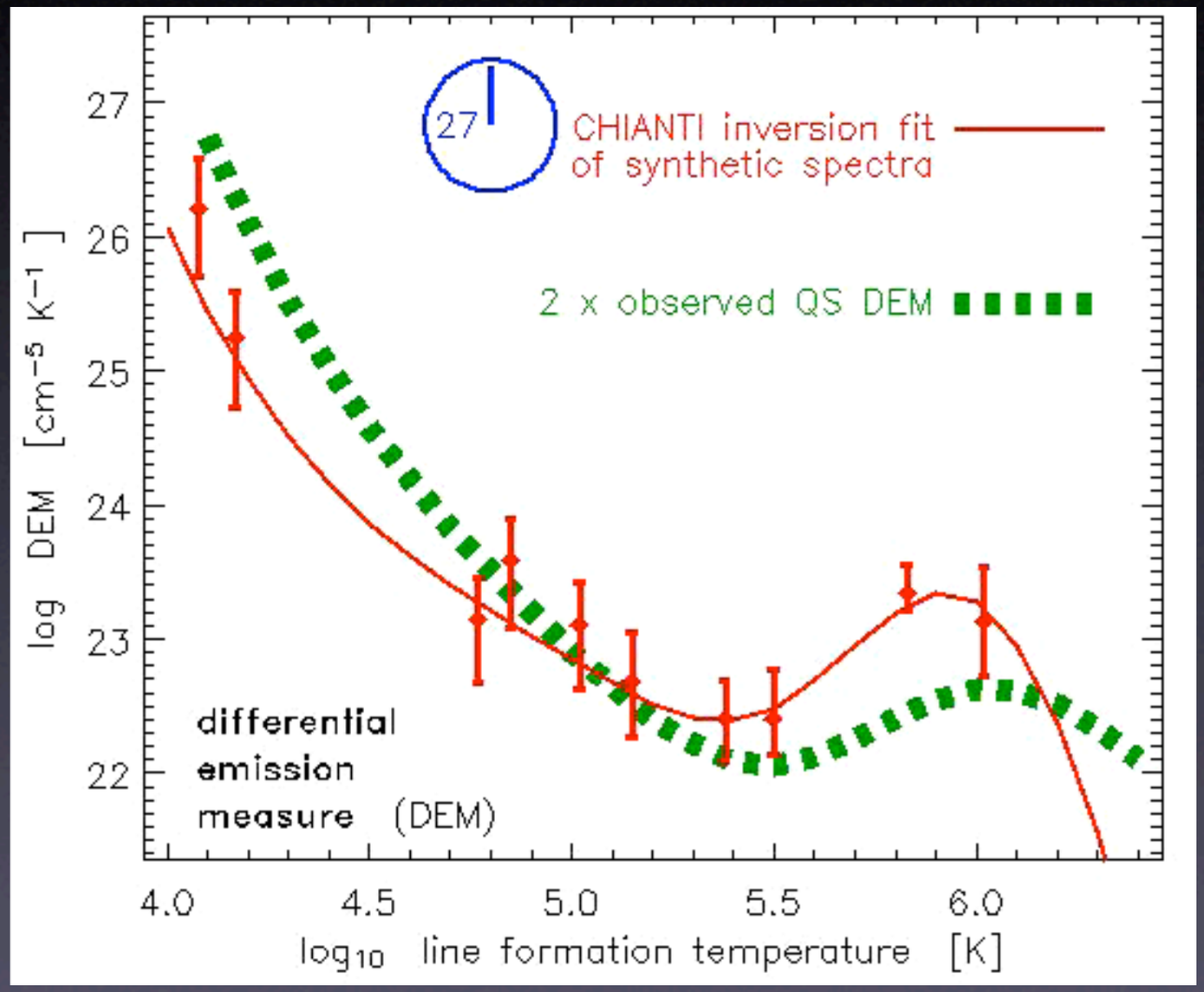
Model Diagnostics

- Heating rate is sufficient
- TRACE DN Counts reproduced
- Loops are readily produced

Forward Modeling



DEM


27
CHIANTI inversion fit
of synthetic spectra
2 x observed QS DEM
log DEM [cm⁻⁵ K⁻¹]
27
26
25
24
23
22
differential
emission
measure (DEM)
4.0
4.5
5.0
5.5
6.0
log10 line formation temperature [K]

Conclusions

- The Model Seems to reproduce the Sun
  - DEM curve Reproduced
  - Heating rate Reproduced
  - TRACE DN-numbers Reproduced
  - Loops are Readily Produced

BUT.....

- Optically thick atmosphere
- Transition Region
- Emerging Flux
- Quiet Sun
- Real active region
- Other Stars