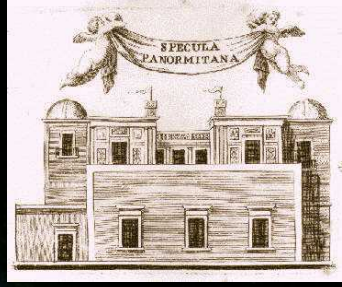

Analysis of time-resolved emission from bright hot pixels of an active region observed in the EUV band with SDO/AIA

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(ApJ, submitted)

Coronal loop workshop VII
Cambridge, 21-23 July 2015

Outline

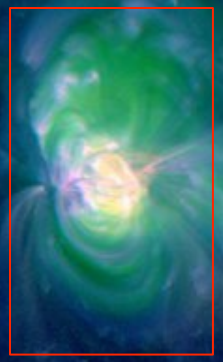
- Target: Active region with evidence of hot plasma
- Concept: analysis of light curves
- Analysis:
  - comparison with random combinations of pulse-heated strands
  - Modeling: loop 0D
  - Comparison: Artificial Neural Network/Cross Correlation
- Results…….

Evidence for very hot plasma: analysis of an AR observed with SDO (Reale et al. 2011)

Routine observation: 28 october 2010

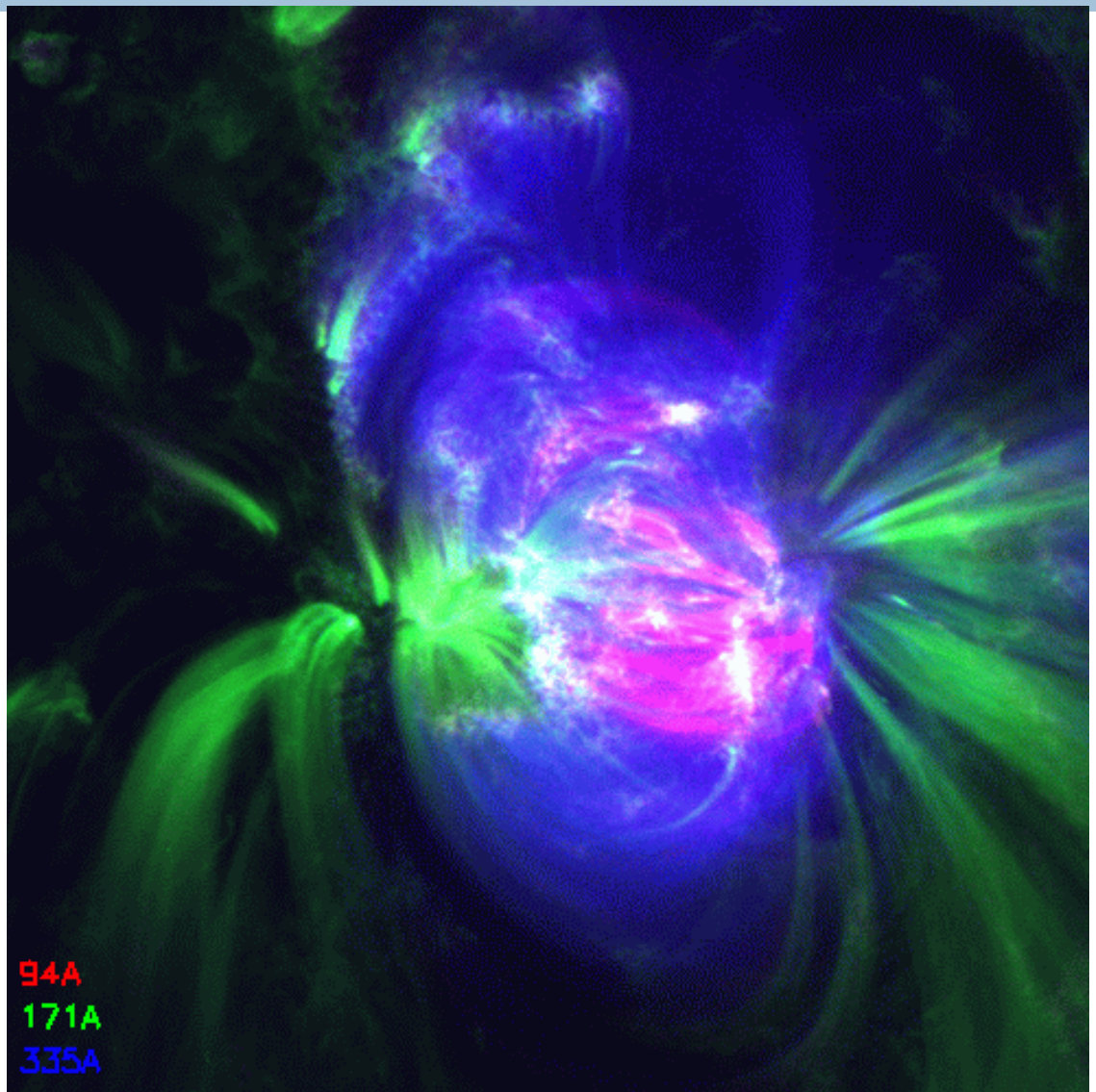
3 channels:

- 171 A (1 MK)
- 335 A (3 MK)
- 94 A (1+8 MK)



Very hot plasma in the core

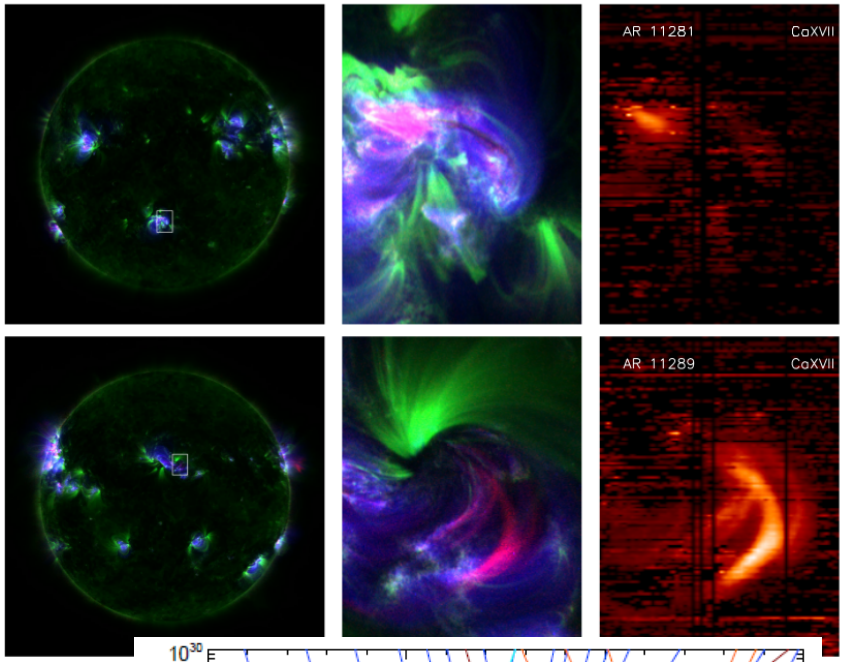
Color coding: pink is very hot (6-8 MK)



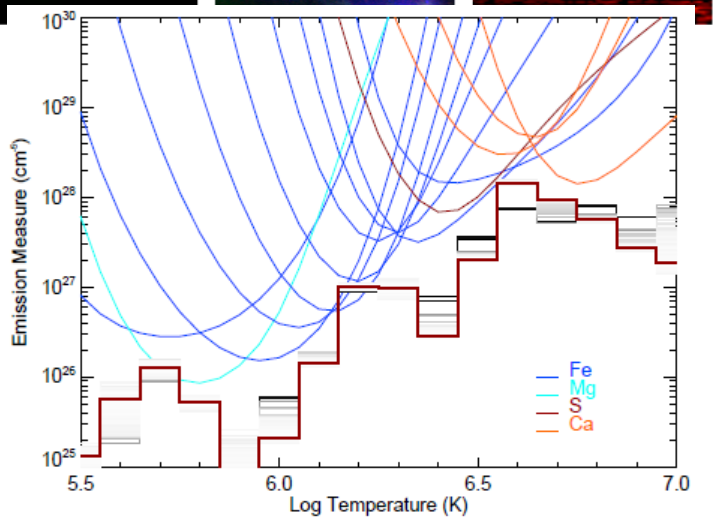
Very hot plasma

Support from spectroscopy

- Comparison with Hinode/EIS AR raster (Ca XVII line, ~6 MK): very similar morphology (Testa & Reale 2012)

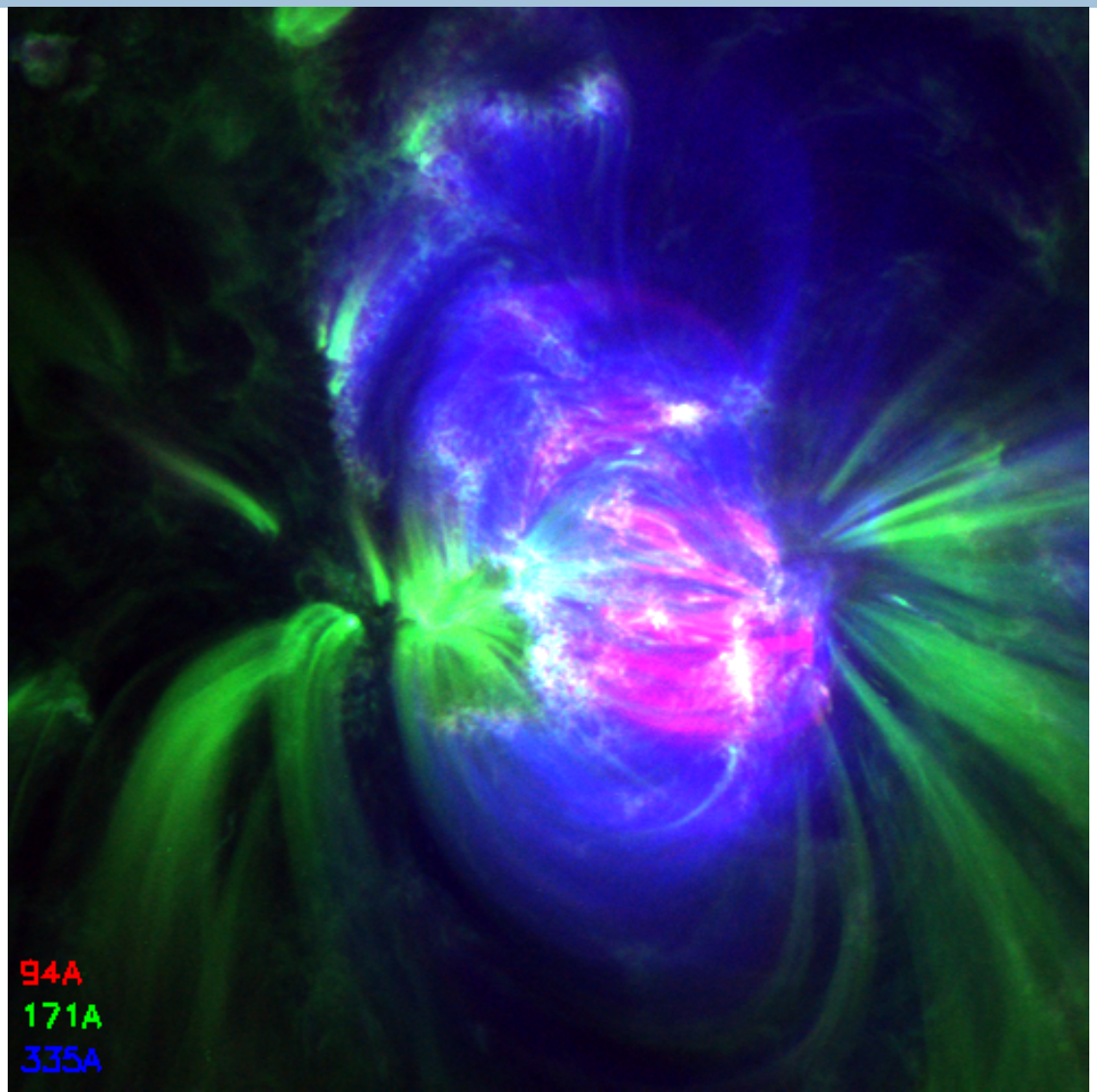


- Hot component from DEM reconstruction (Petralia+ 2014)

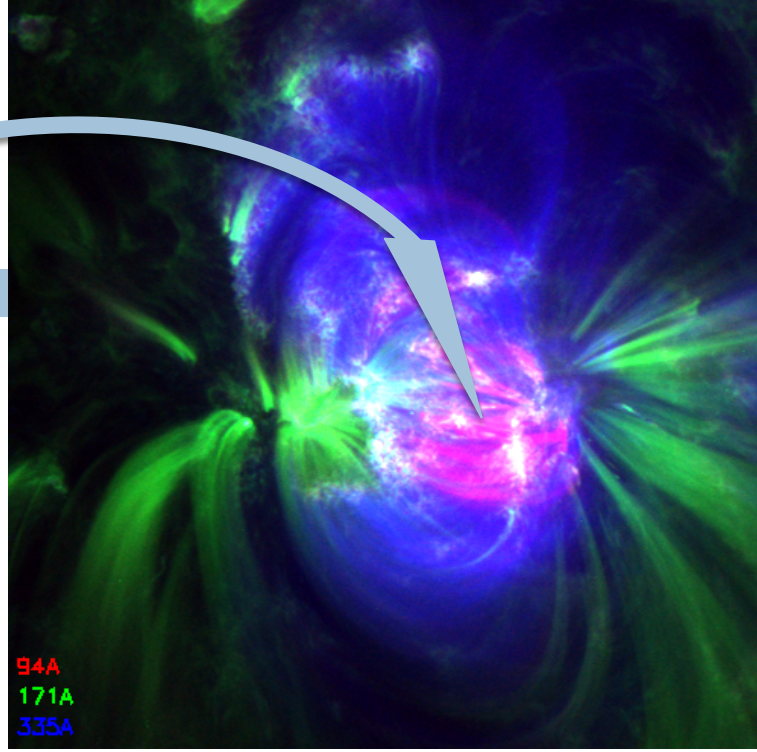


Next step: time evolution

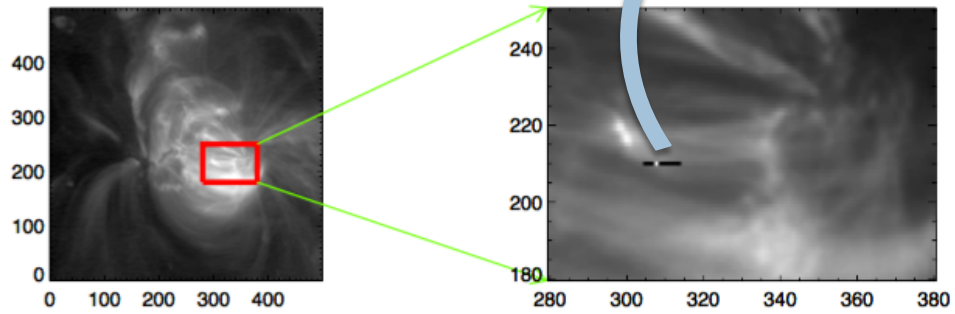
Starting point: same AR (Reale+ 2011)



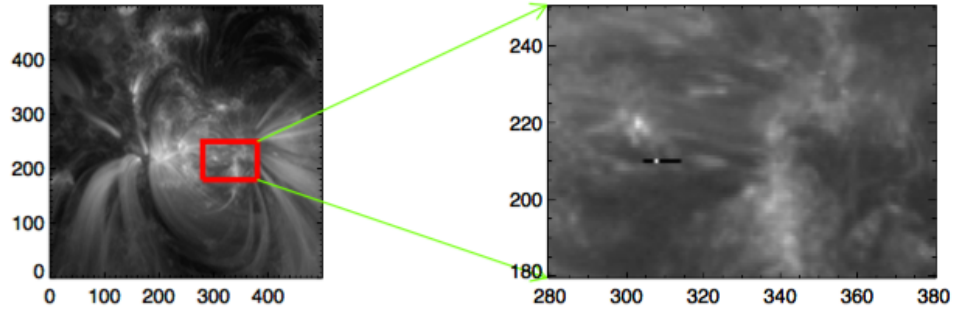
The active region



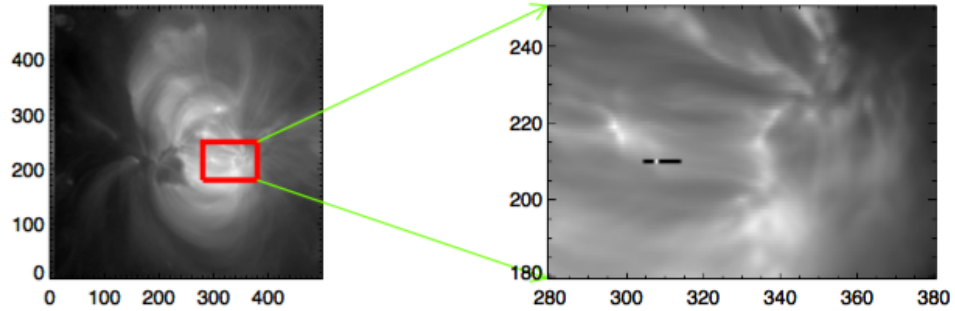
94A



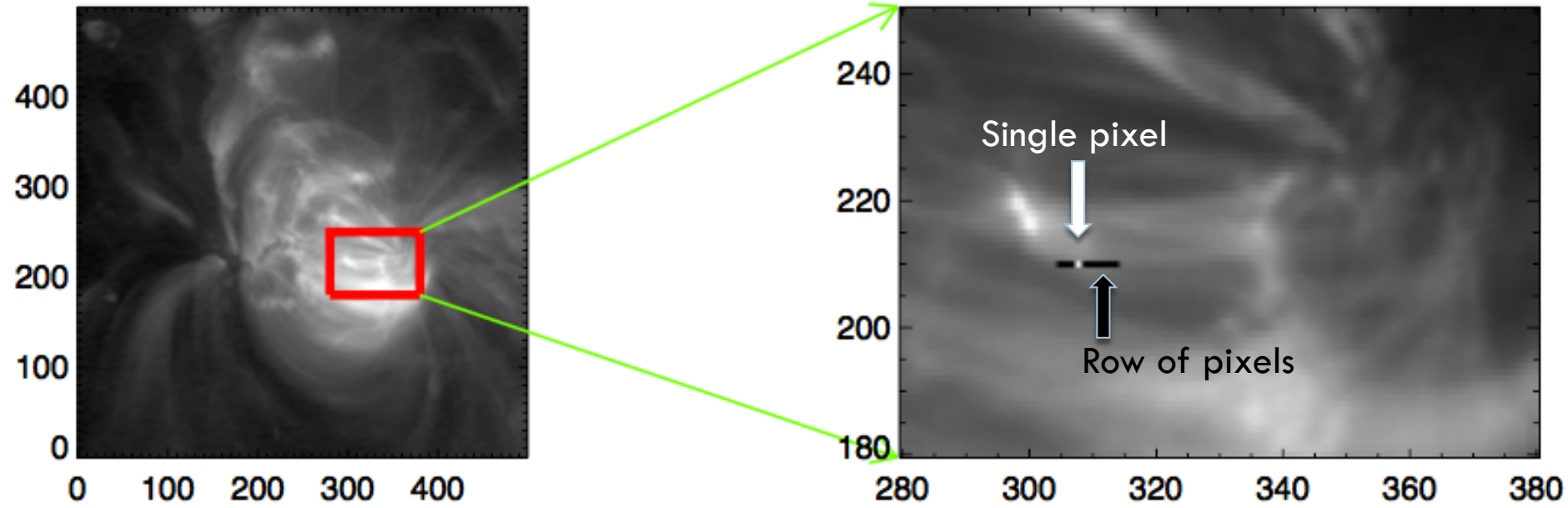
171A



335 A

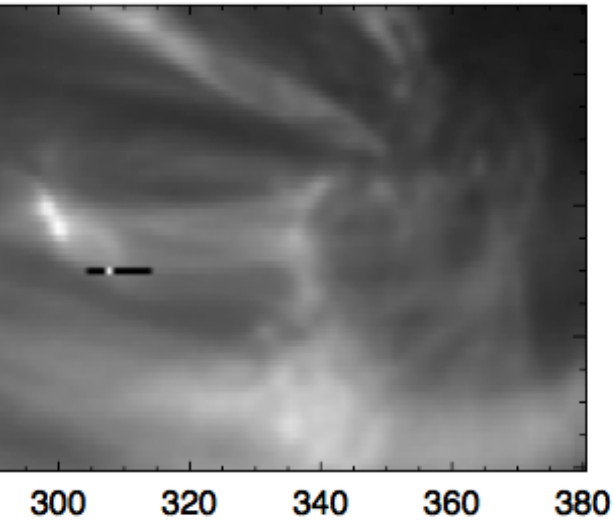


The active region: selection of pixels

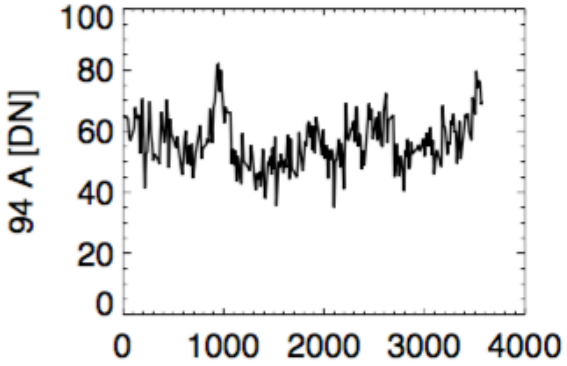


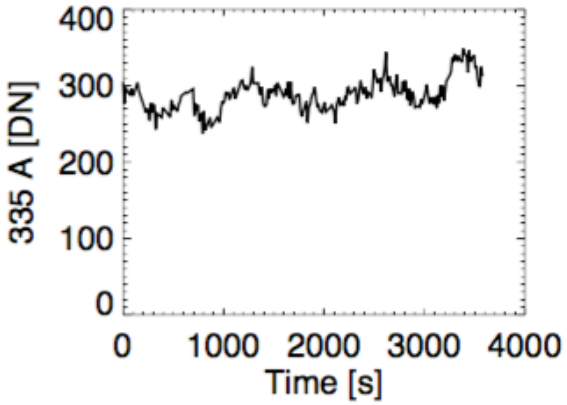
Single pixel: highest resolution
Row of pixels: high signal

Light curves (~1hr): 94 A + 335 A

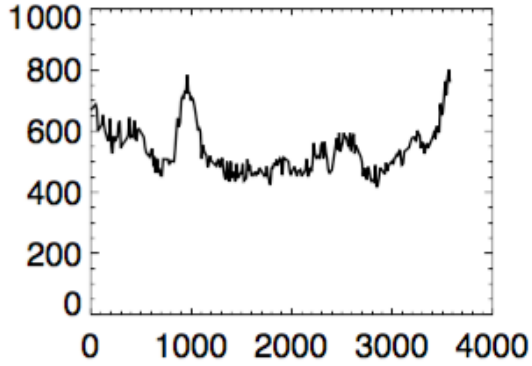


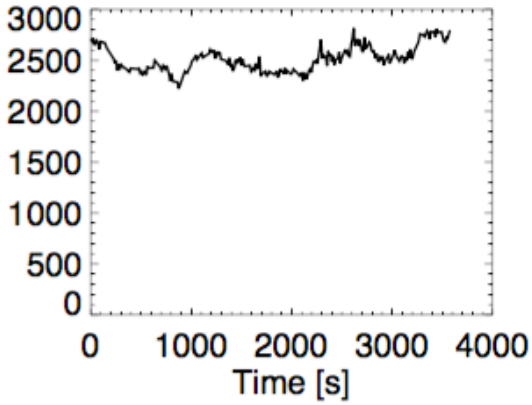
Single pixel





Row of pixels

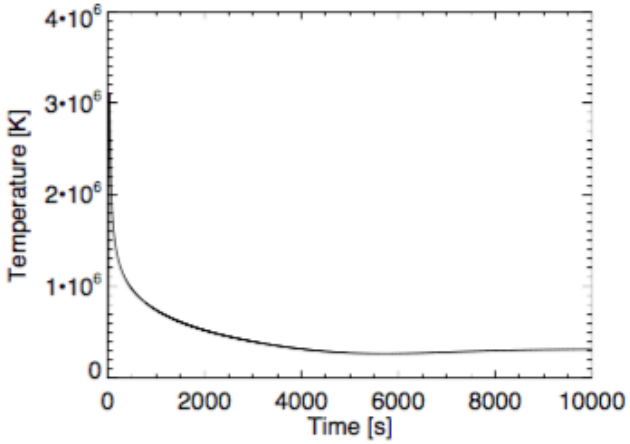




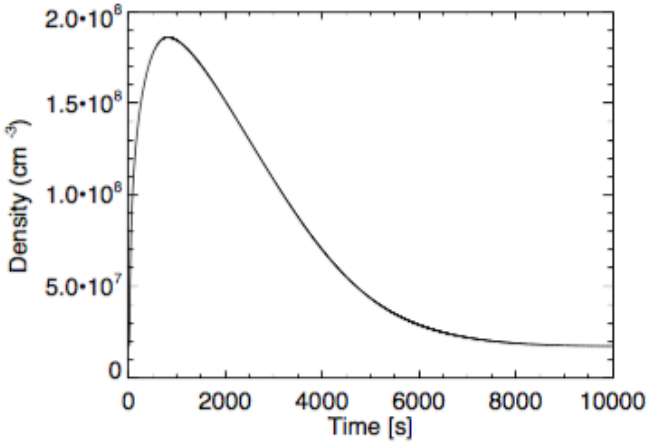
Example of pulse-heated strand evolution: 0D loop modeling (EBTEL, Klimchuk+ 2008, Cargill+ 2012)

Length: 50,000 km

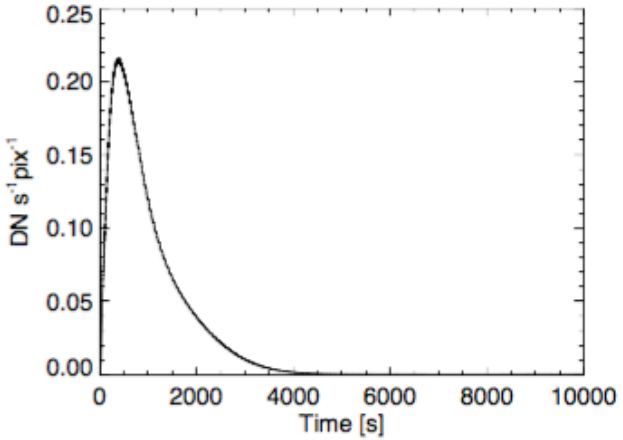
Heat pulse:
- 50 s
- 0.003 erg cm^3 s^{-1}
- T_{max} ~ 3 MK



(a)



(b)



(c)

Distributions of heat pulses:
power-laws and parameter space

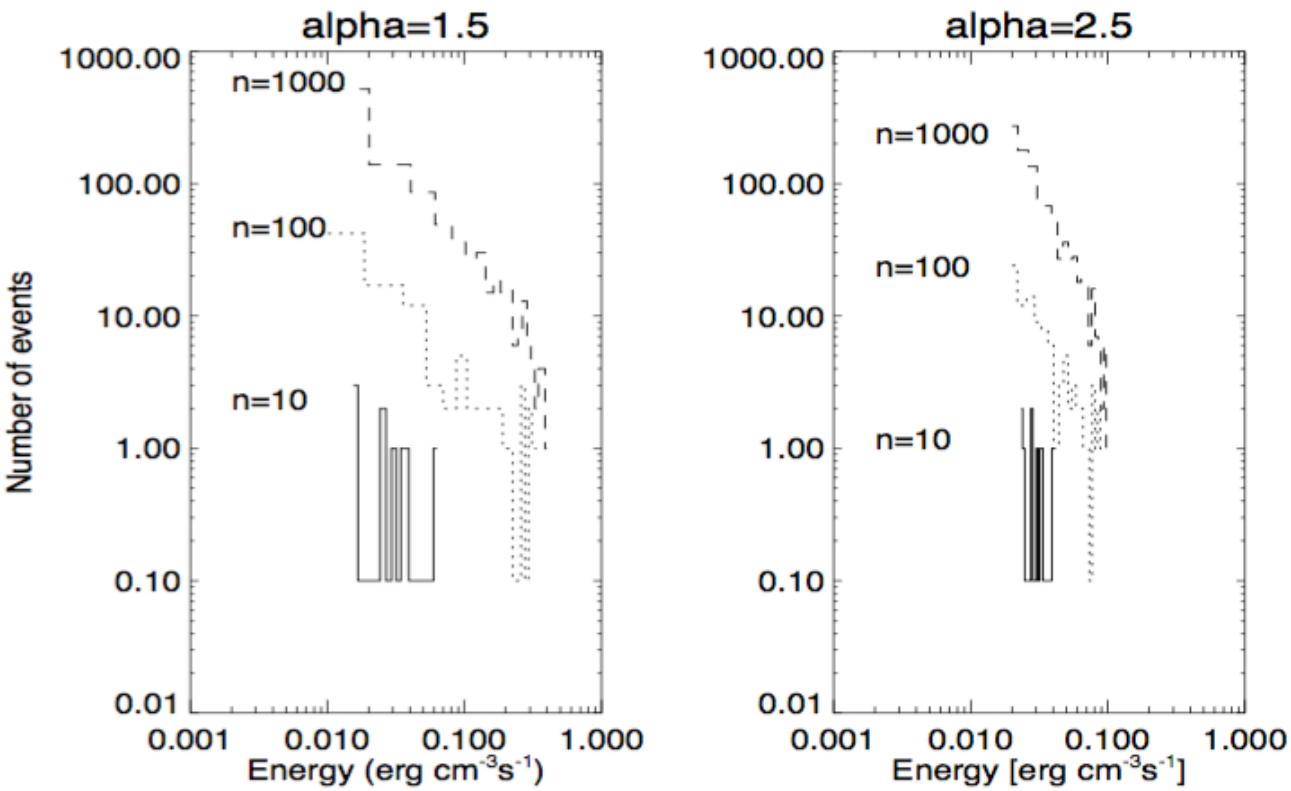
Power law for heating rate:

$dN = E^{-\alpha} dE$

<u>Grid of loop models:</u>

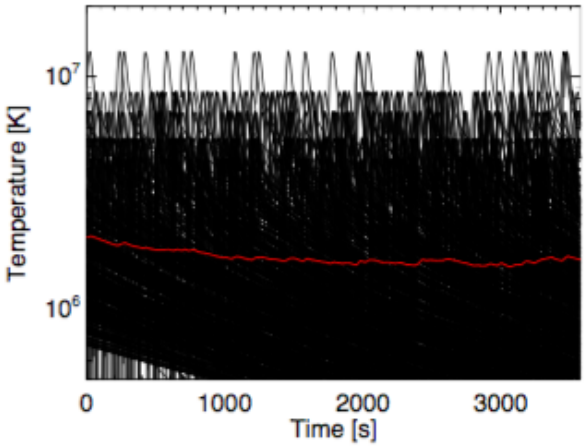
- Power law index
  - α=1.5, 2.5
- Pulse duration
  - τ=50, 500 s
- Number of strands
  - 10, 100, 1000

10,000 random realizations for each set of parameters

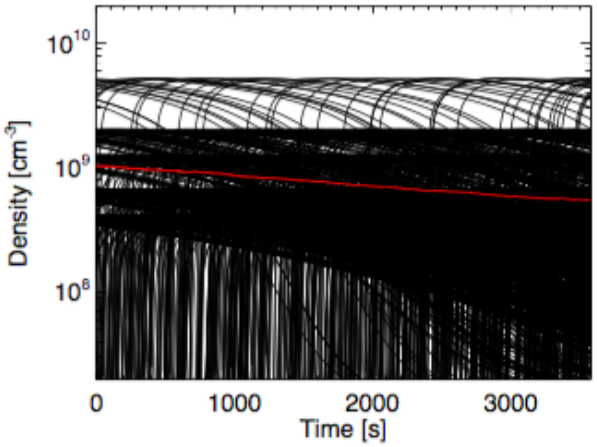


n = number of strands

Example of realization



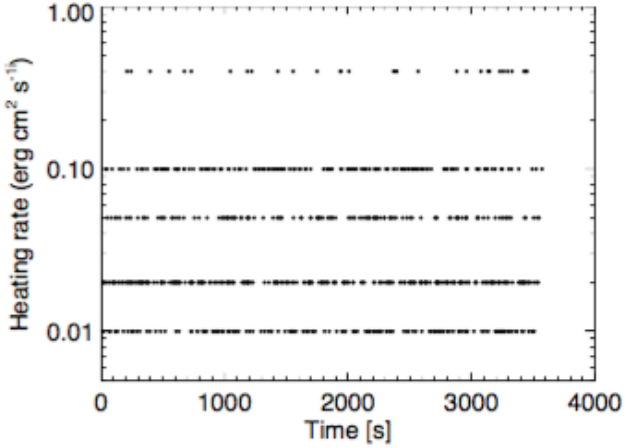
(a)



(b)

Example of realization with 1000 strands

Heat pulses



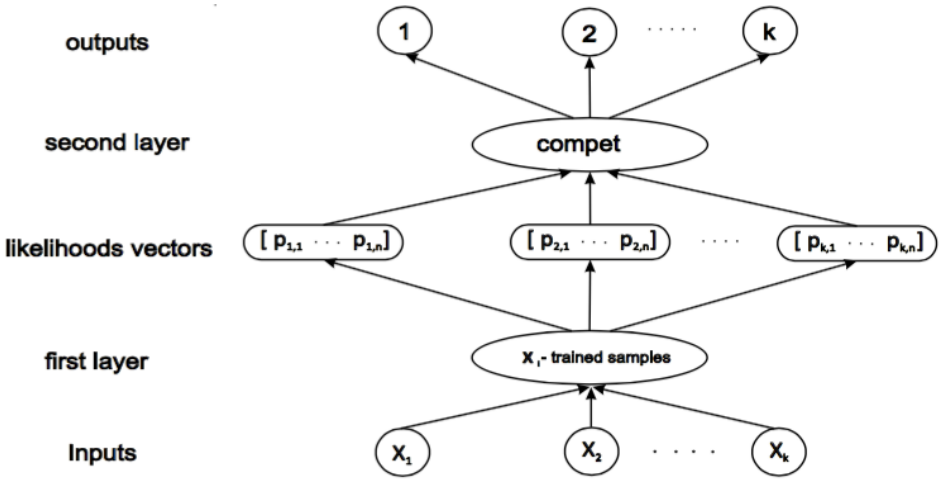
(c)

Comparison with the observation

We compare 10,000 realizations w/ 1 observation

New issue: simultaneous comparison 94A+335A

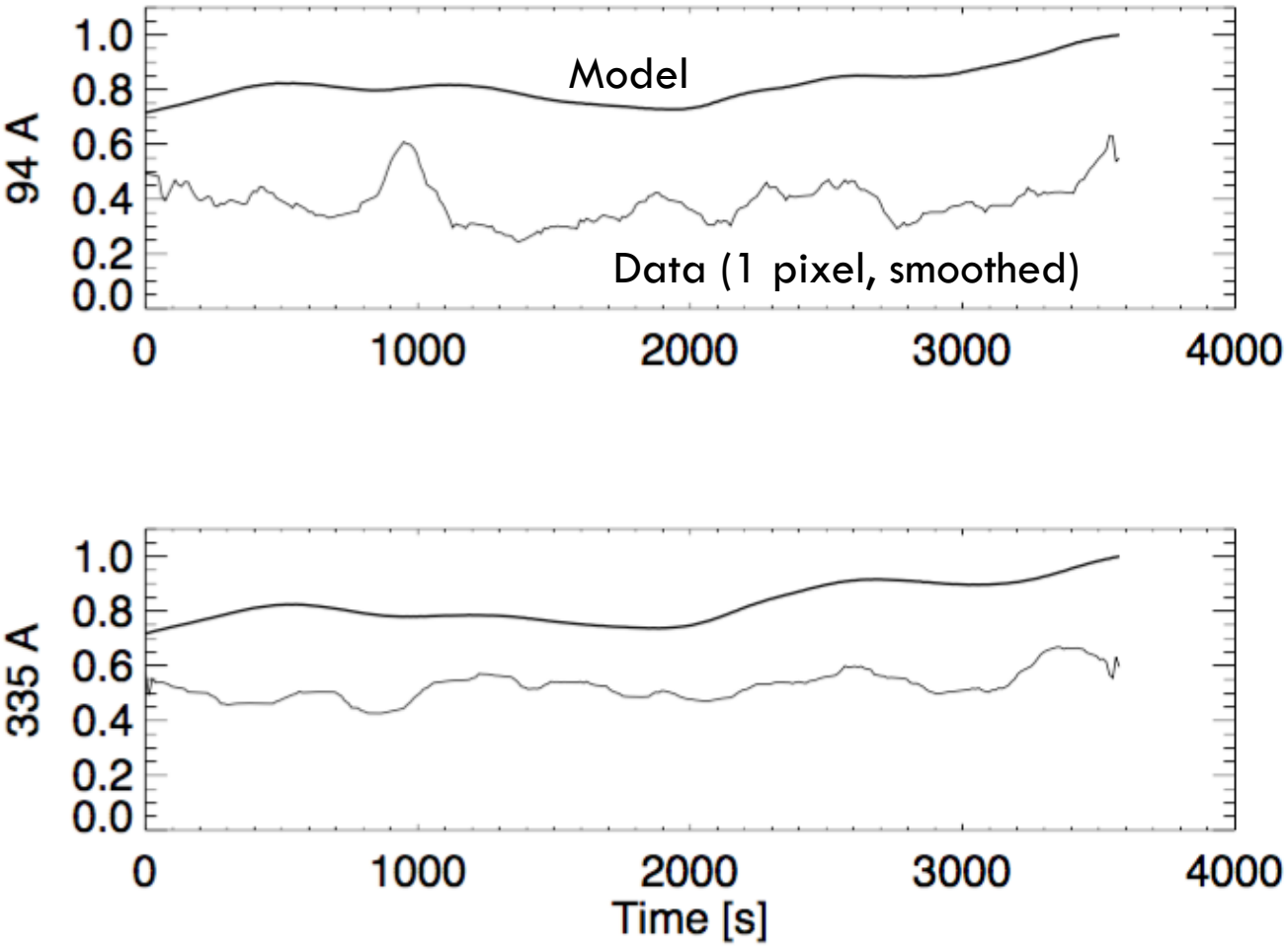
Two independent methods of comparison for cross-check:
1) Artificial neural network (sensitive to patterns)
2) Cross-correlation (sensitive to features)



Architecture of Probabilistic Neural Network (Tajfirouze & Safari 2012)

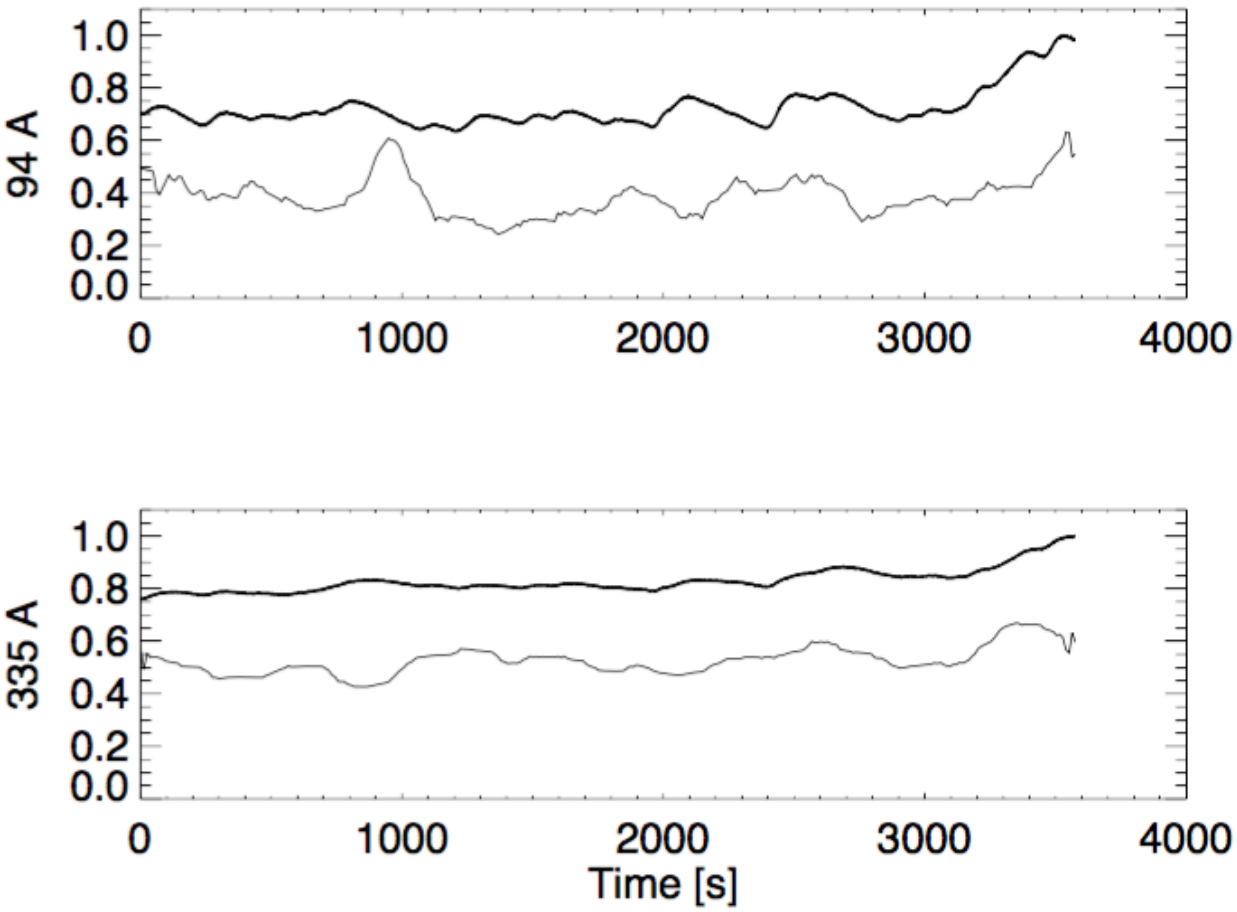
…not a good best match…

Power law index:
α=2.5
Pulse duration:
τ=500s
Number of strands:
1000



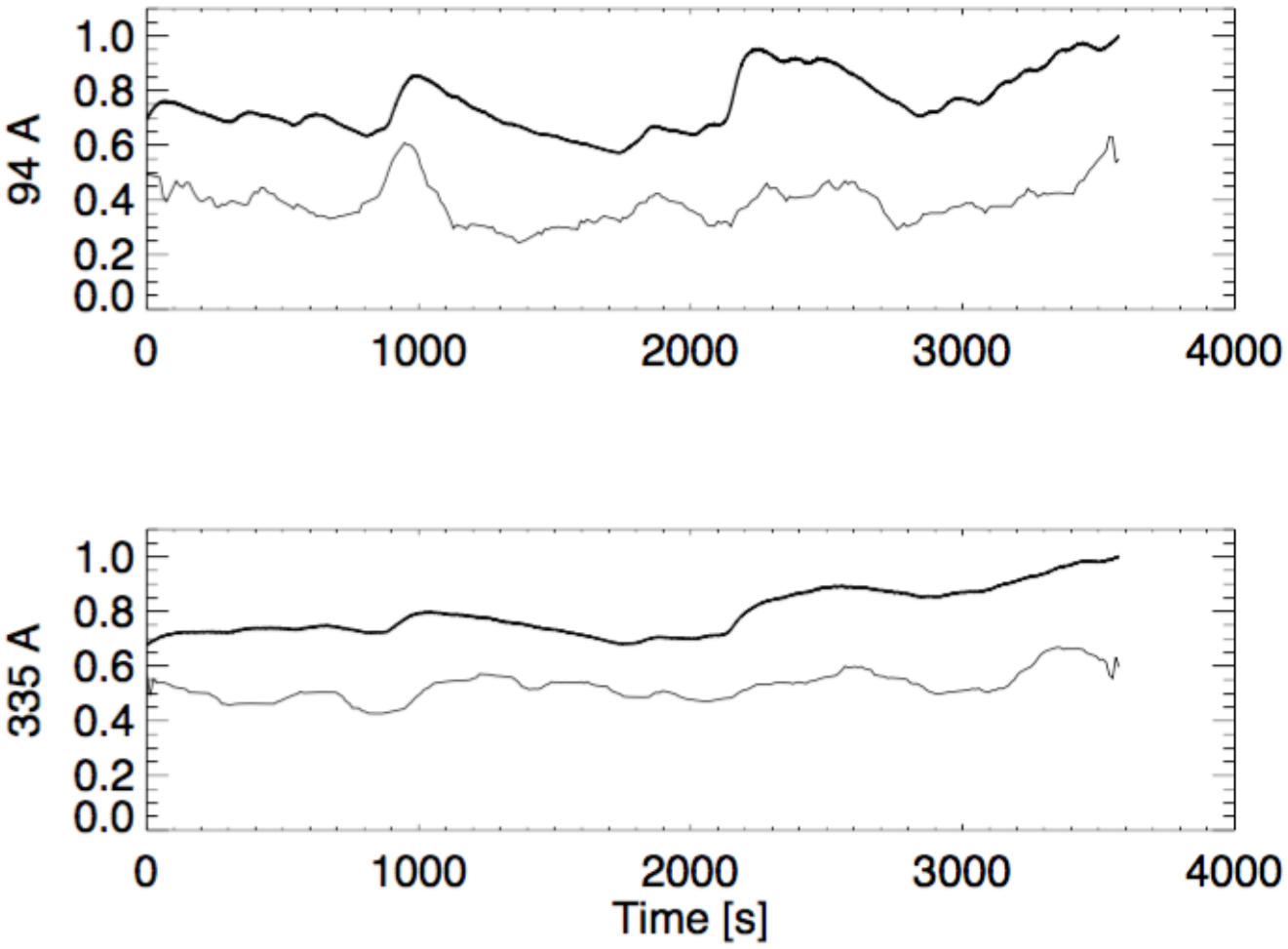
Best best match PNN

Power law index:
α=1.5
Pulse duration:
τ=50s
Number of strands:
1000



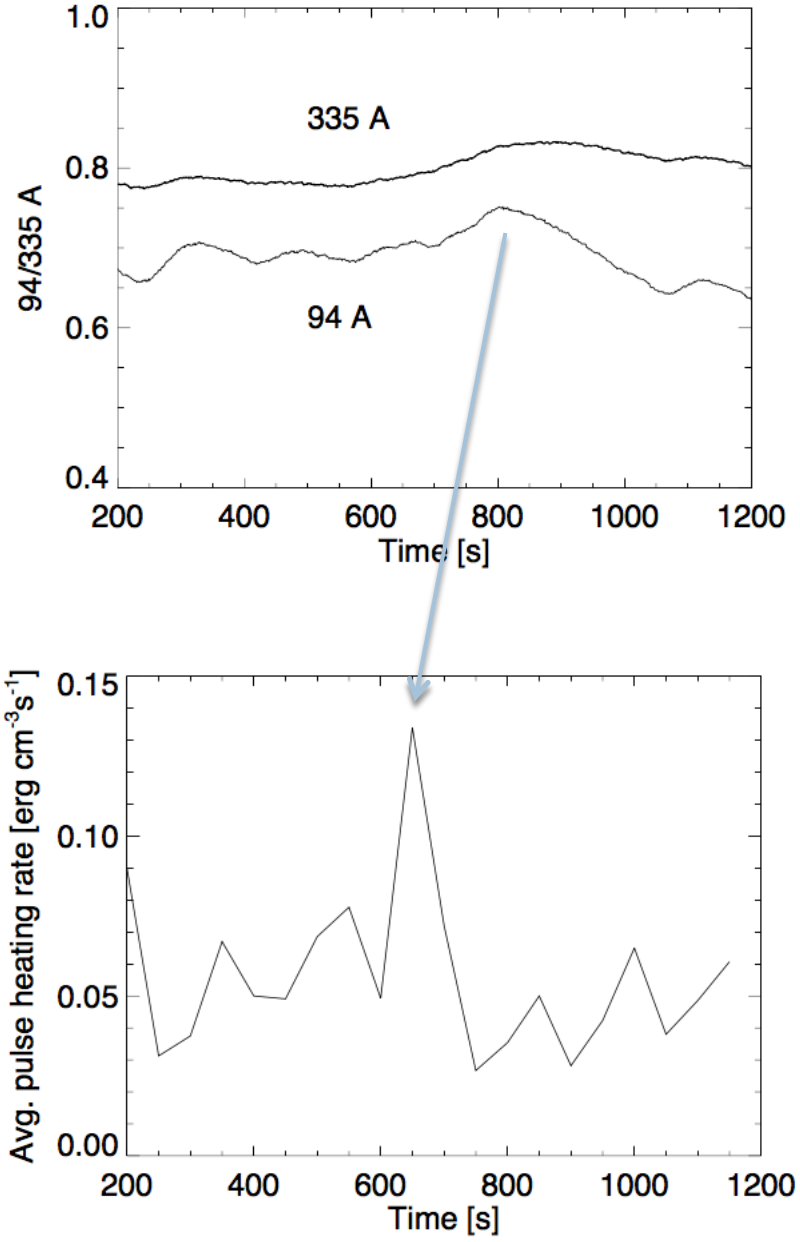
Maximum cross-correlation

Power law index:
α=1.5
Pulse duration:
τ=50s
Number of strands:
1000



Diagnostics

Bumps in 94 A: heating markers with delay (few minutes)



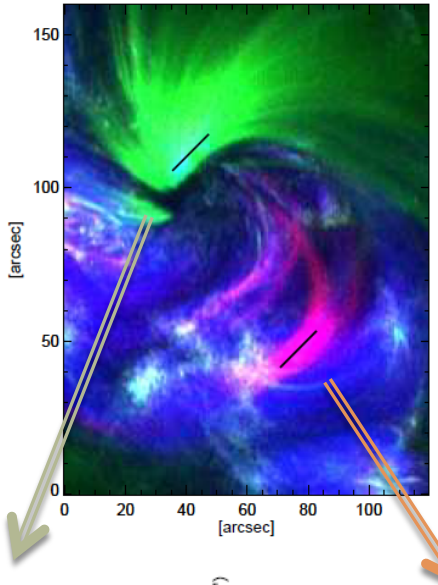
Perspectives

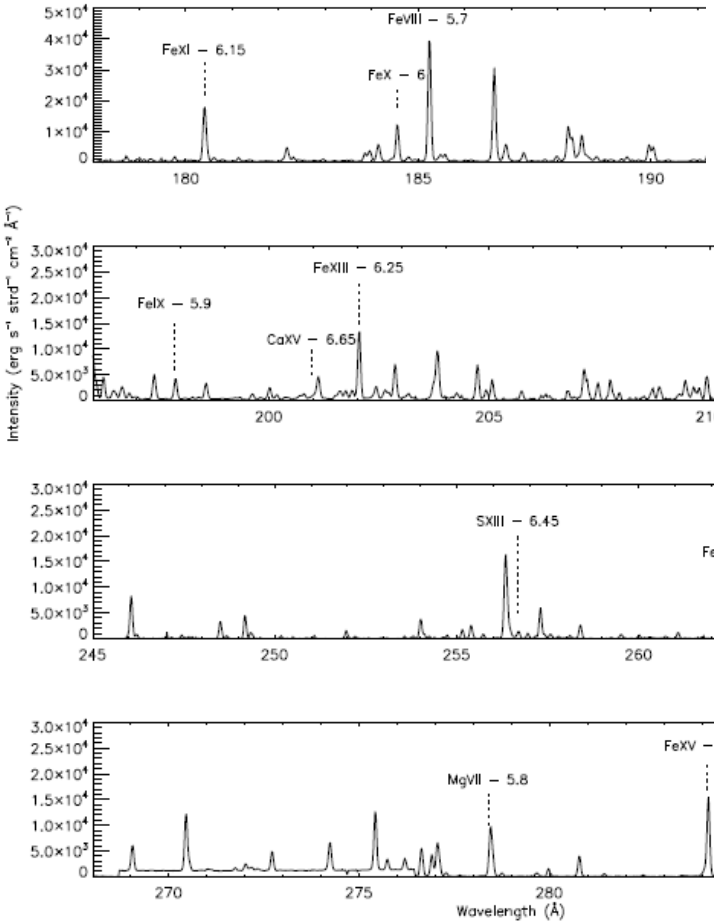
- Simultaneous very hot plasma and steady emission indicate storms of events with a broad range of energy distribution
- best match: shallow power law index ($\alpha = 1.5$), short pulse duration (50 s), large number of strands (1000, cross-section radius ~ 100 km).
- Not steep power law: very localised region, homogeneous emitting plasma
- strong fluctuations in the 94 A channel mark a previous increment of heating episodes with a delay of a few minutes
- Next step: spatially resolved time analysis (1D loop modeling)

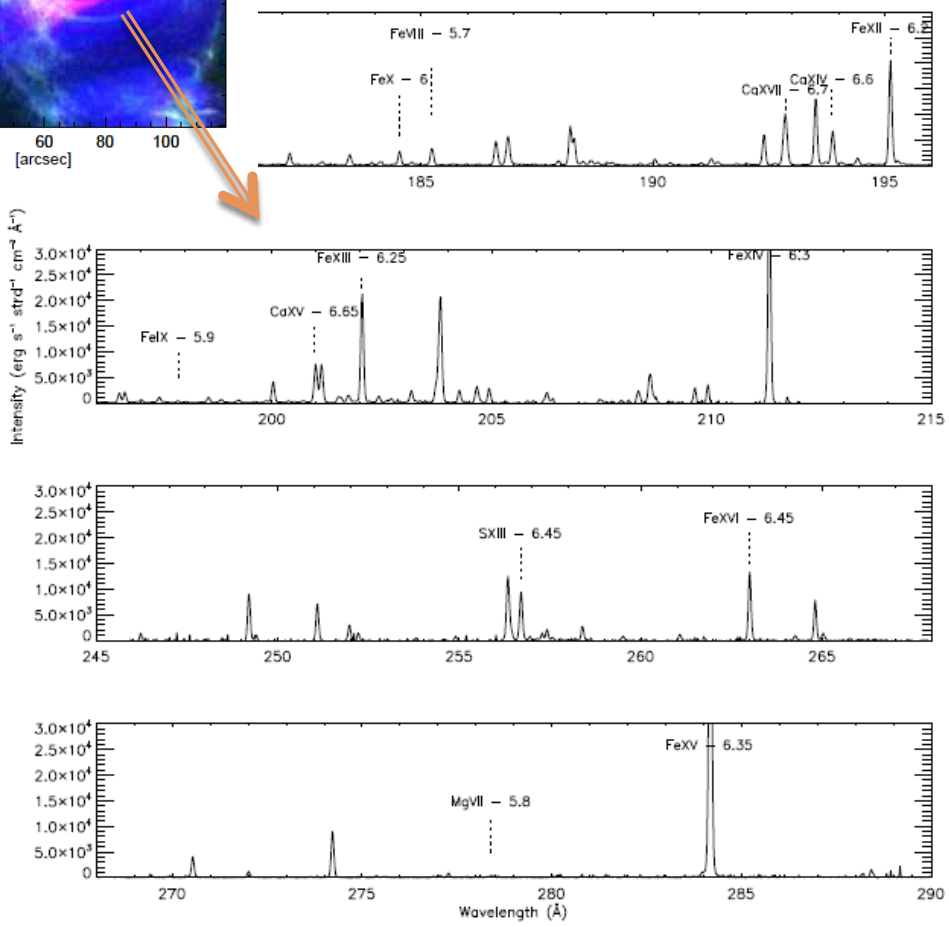
Spectra

Cold region

Hot region

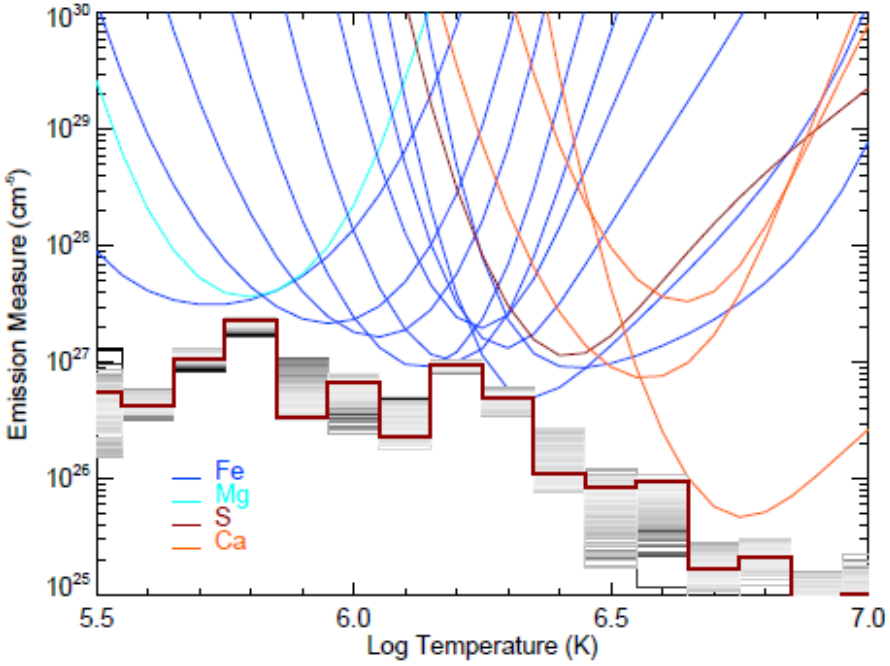




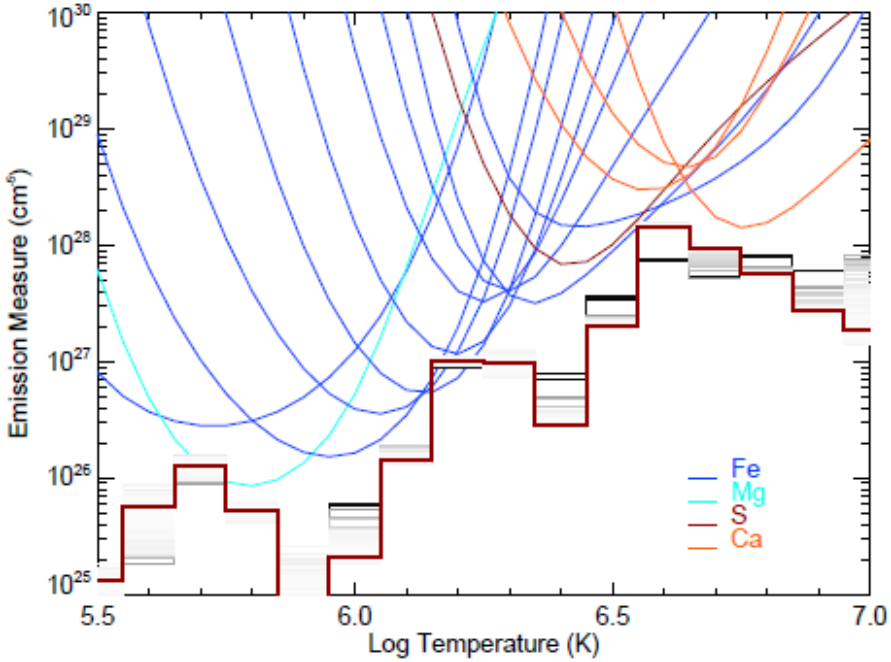


DEM reconstruction: MCMC, 14 lines

Cold region



Hot region



Space of the parameters

- 3 parameters
  - Power law index: α=1.5, 2.5
  - Pulse duration: τ=50, 500 s
  - Number of strands: 10, 100, 1000