

# The Sun-as-a-Star: There is HOPE

Hugh Hudson, SSL and U of Glasgow

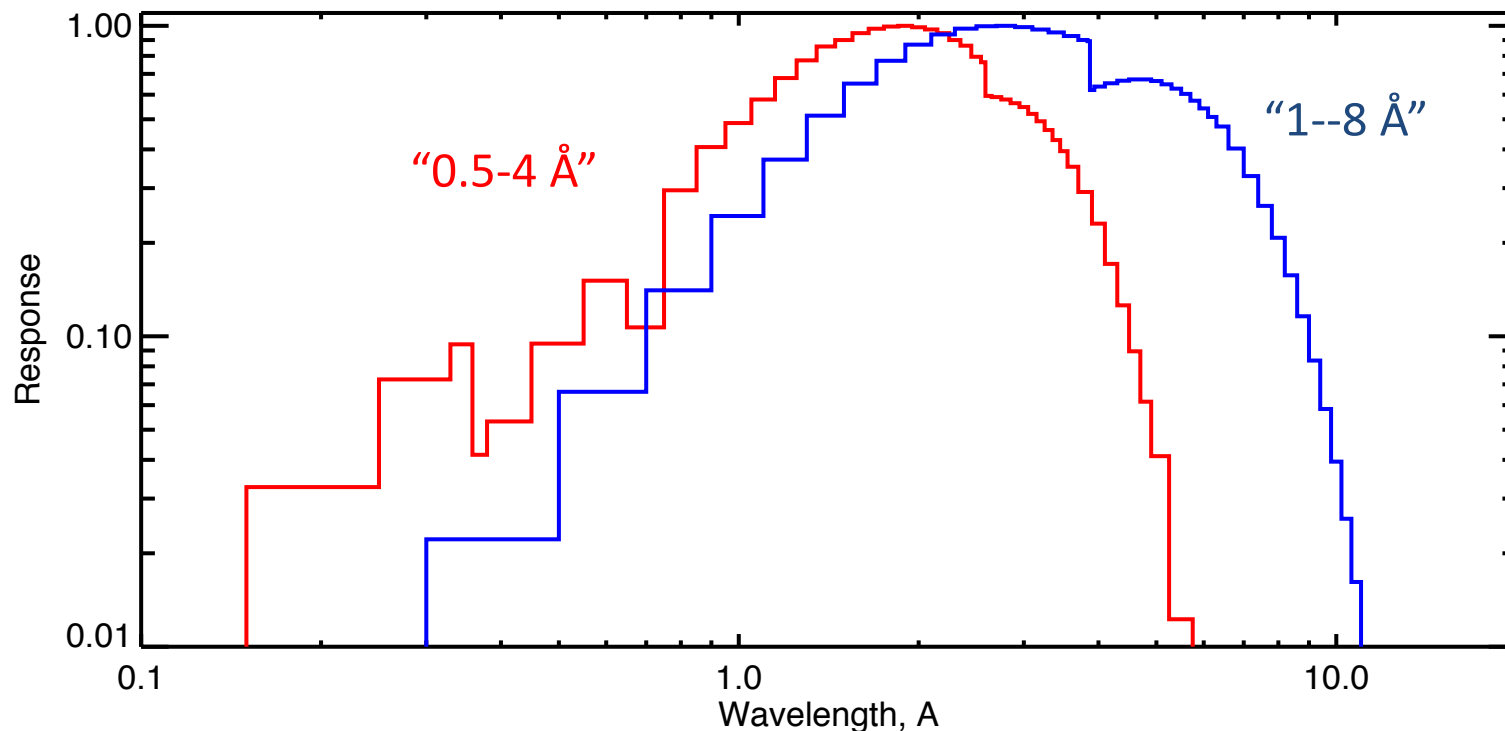
- Hot Onset Precursor Events (HOPEs; GOES)
  - MNRAS 501, 127, 2021
  - Slow HOPEs, SPHERE 2022
  - Tether-cutting? ISSI 2022

# Hot Onset Precursor Events

- All solar flares begin at high temperature; there is no “heating” phase.
- “Hot Onset Precursor Event” = HOPE
- This is a delayed discovery in the GOES soft X-ray data, which had been available at least from 1976.

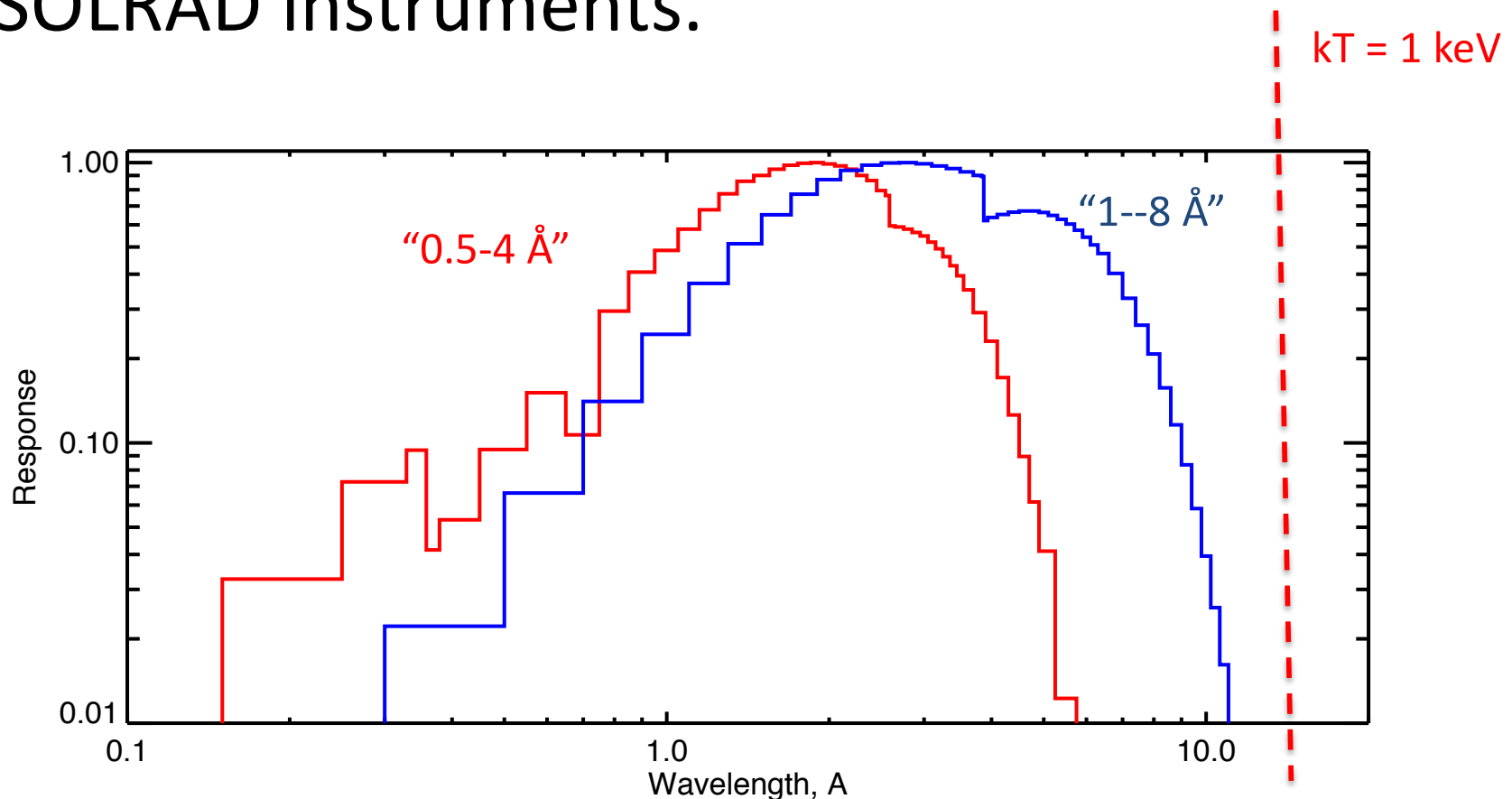
# What is GOES?

- To every flare researcher, GOES stands for its soft X-ray irradiance measurements. These started in 1976 and were preceded by similar SOLRAD instruments.

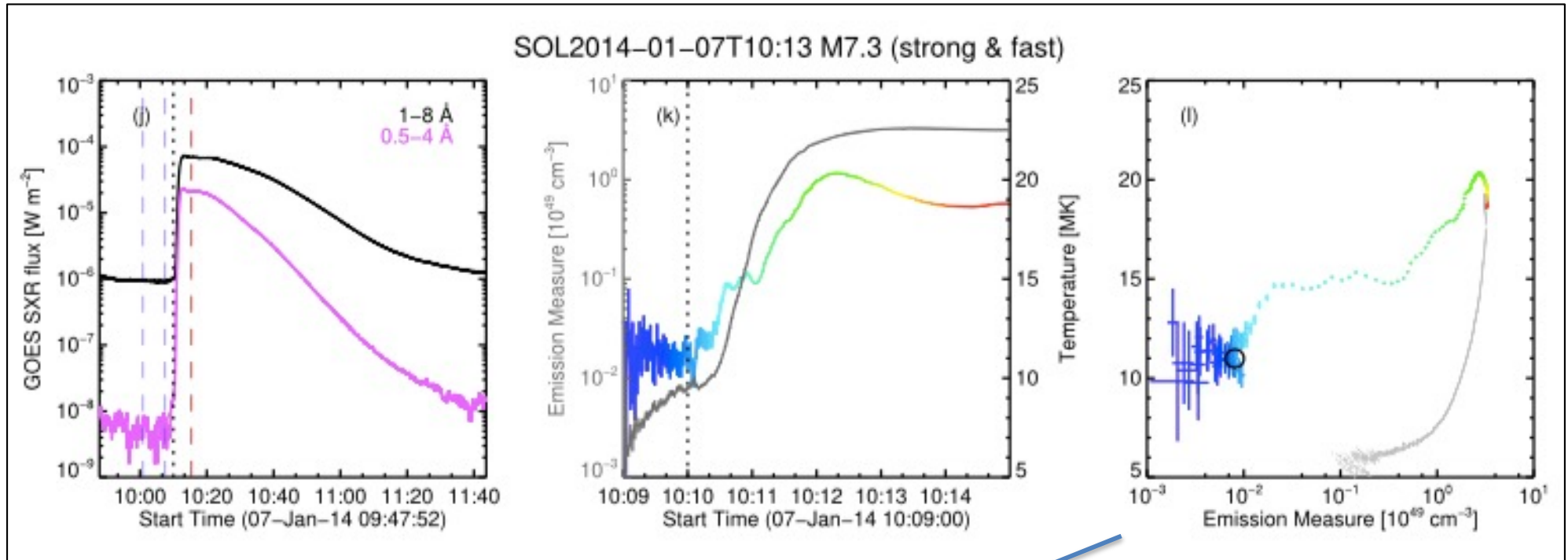


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# Representative HOPE



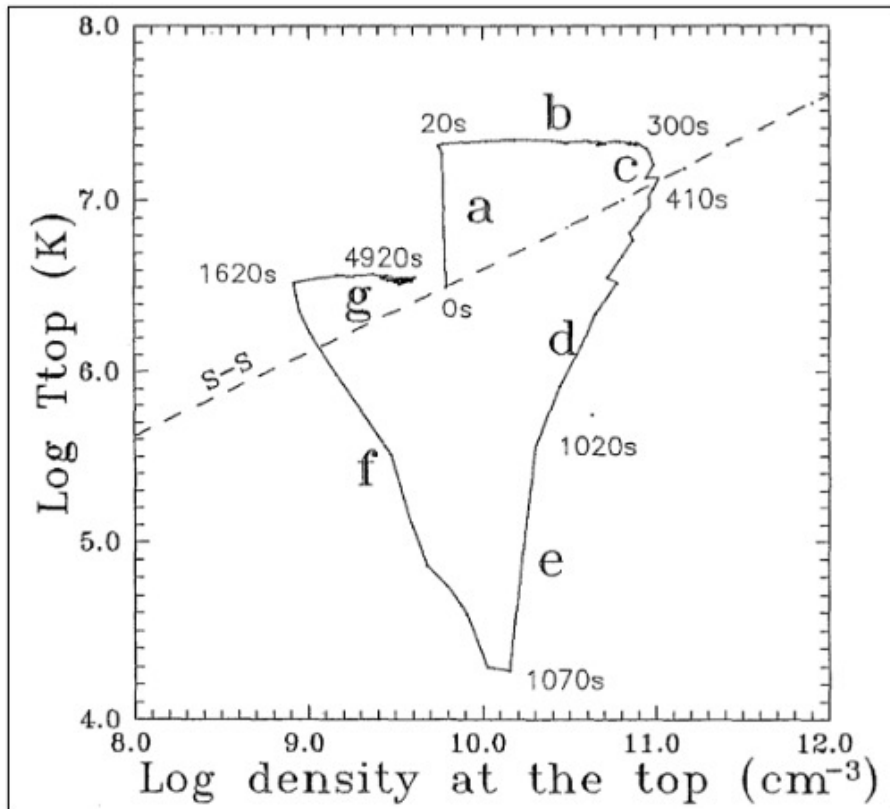
Fluxes

[T, EM]

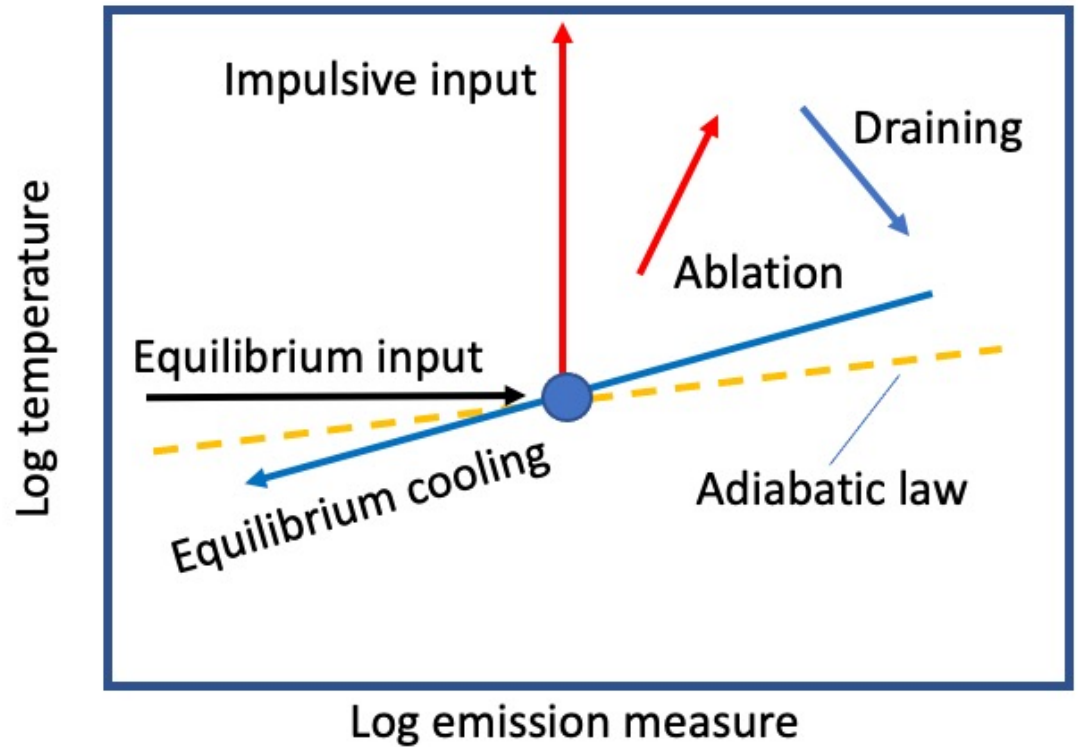
"Loopde loop"

The key finding is that there is a horizontal branch in the [T, EM] diagram. T remains roughly constant, while EM increases linearly.

# No-HOPE behavior (the Neupert effect)



Barbara Sylwester original (1974?)

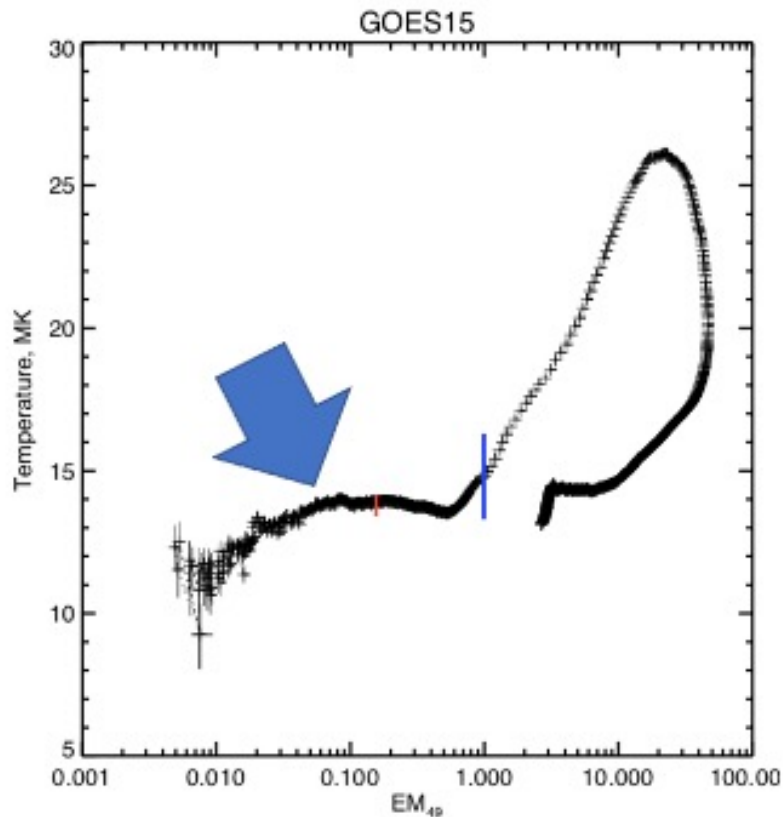
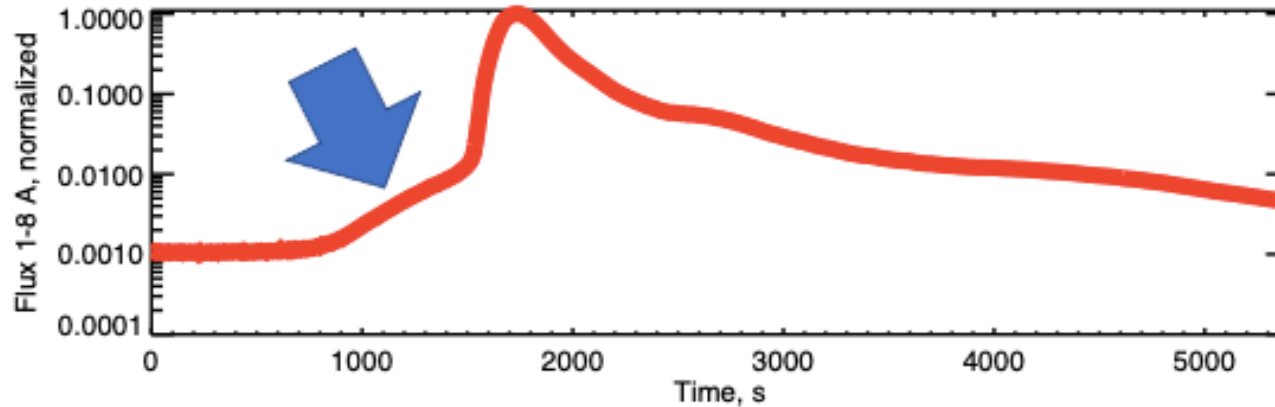


Explanations

# About HOPEs

- Virtually every flare shows this behavior
- The initial temperatures (the “horizontal branch”) tend to be at 10-15 MK
- The HOPE precedes the hard X-ray “impulsive phase” (Kane) and represents different plasma physics
- It is not “pre-heating”; we can’t measure  $dT/dt$

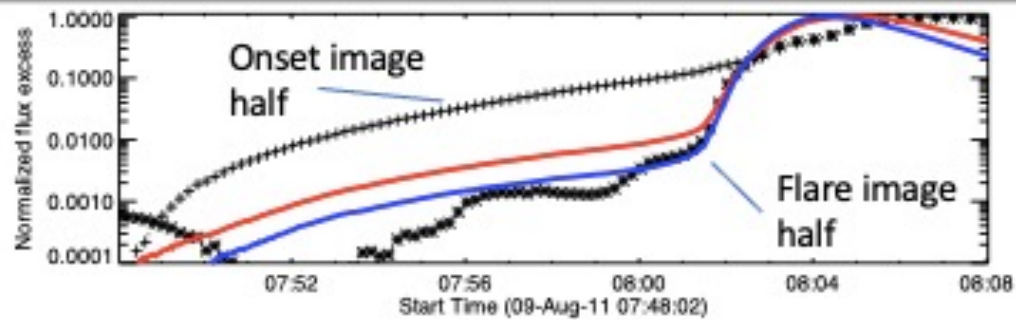
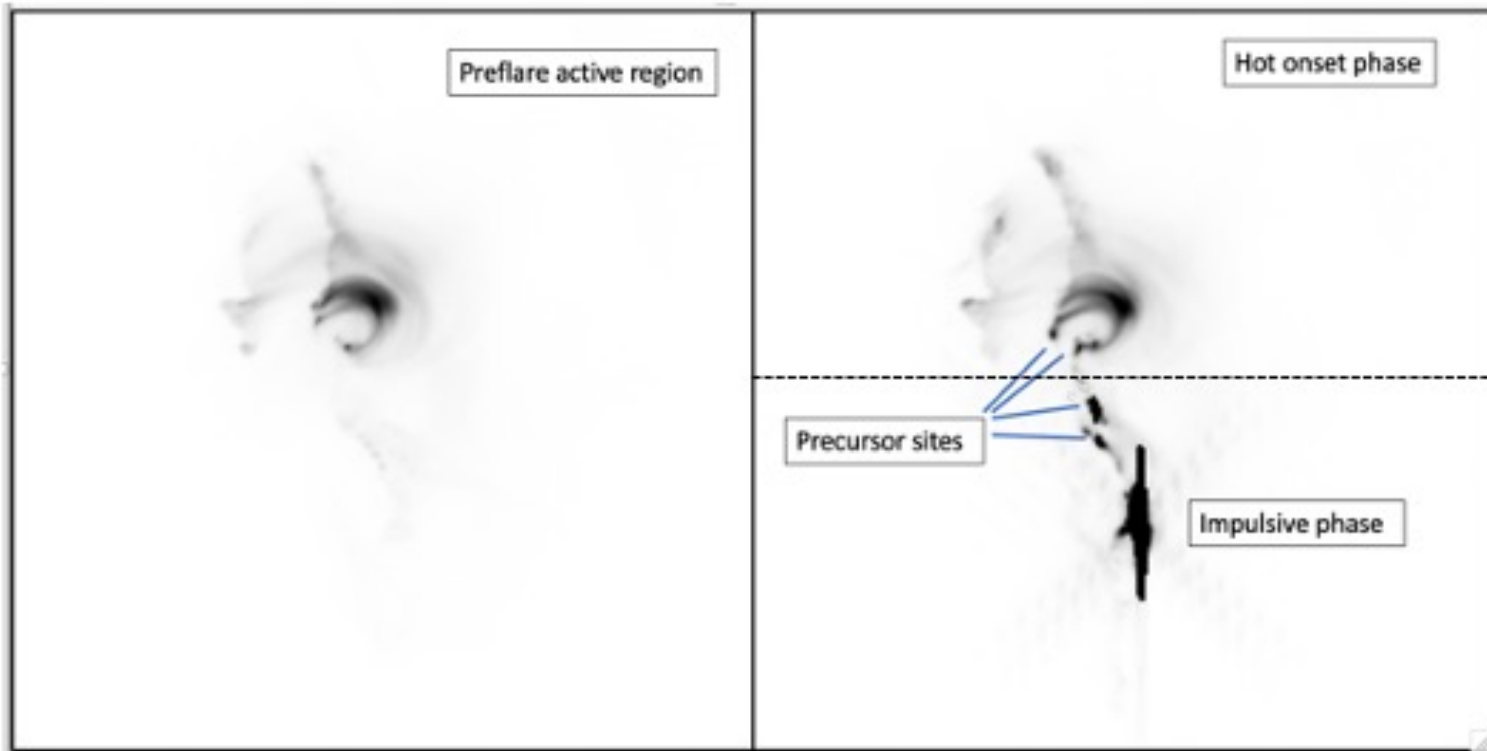
# A “Slow HOPE”



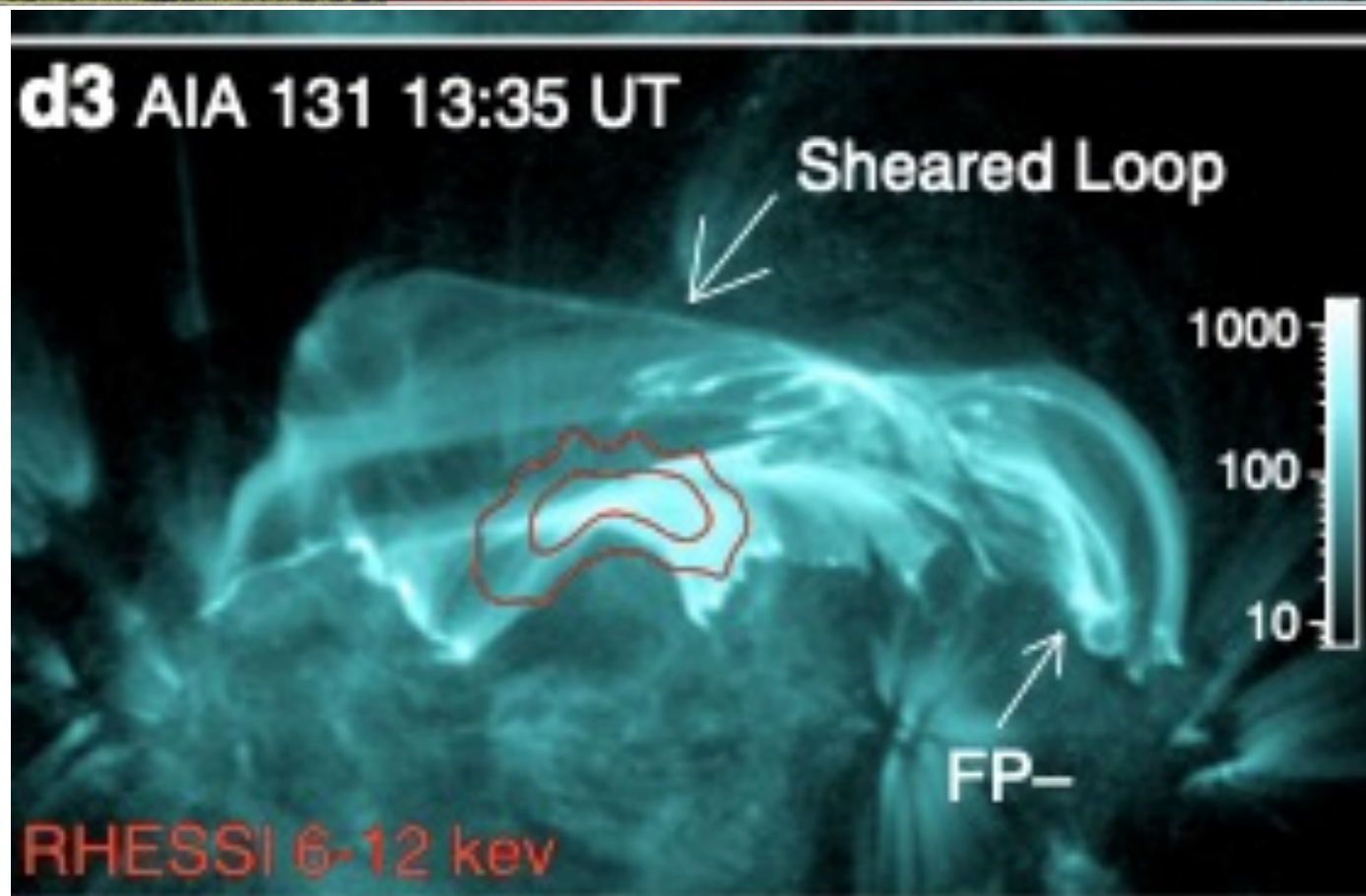
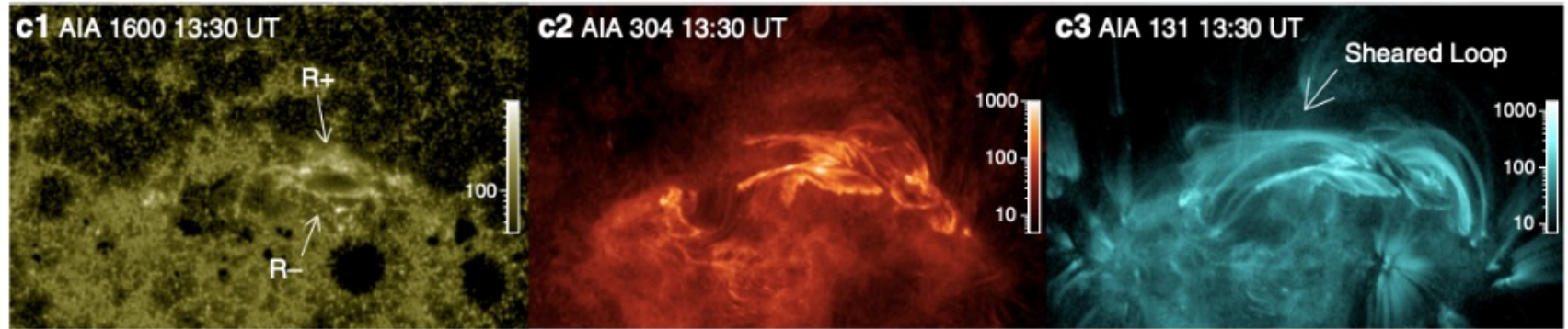
- SOL2011-08-09 (X6.9) has a HOPE lasting for minutes
- The GOES T vs. GOES EM “loopde loop” plot has an apparently smooth horizontal branch.



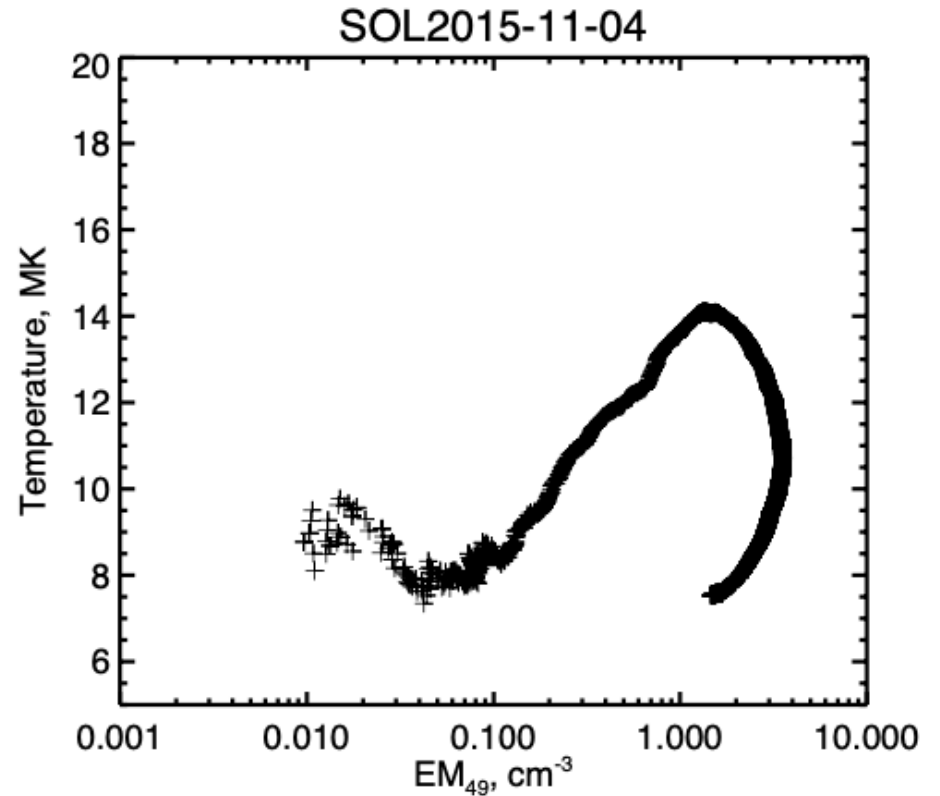
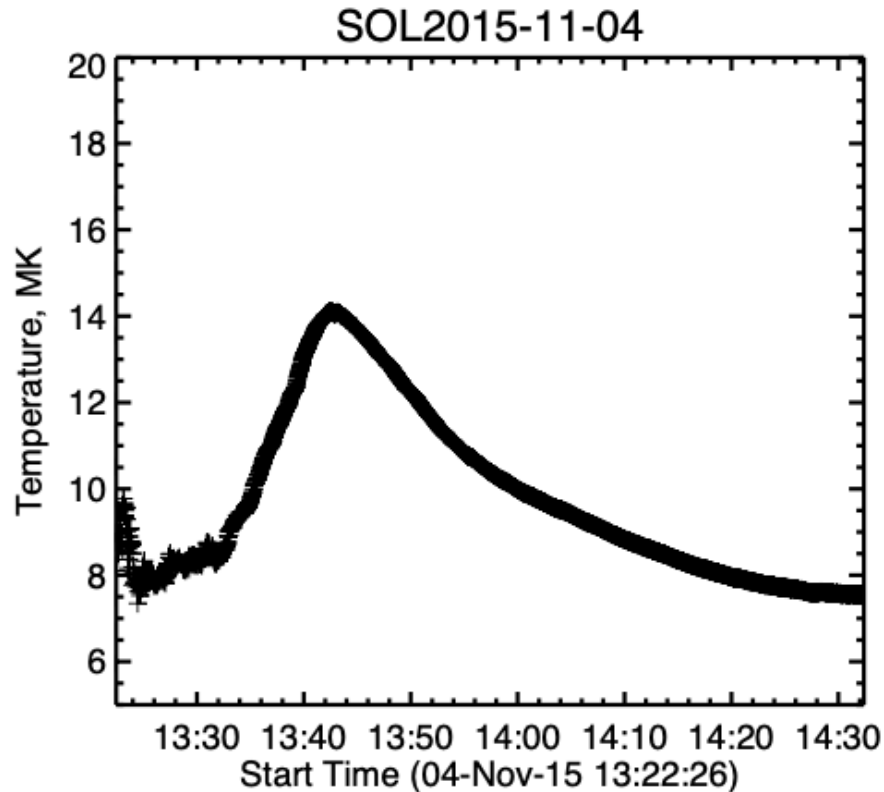
# What does AIA say?



# Wang et al. 2017, SOL2015-11-04

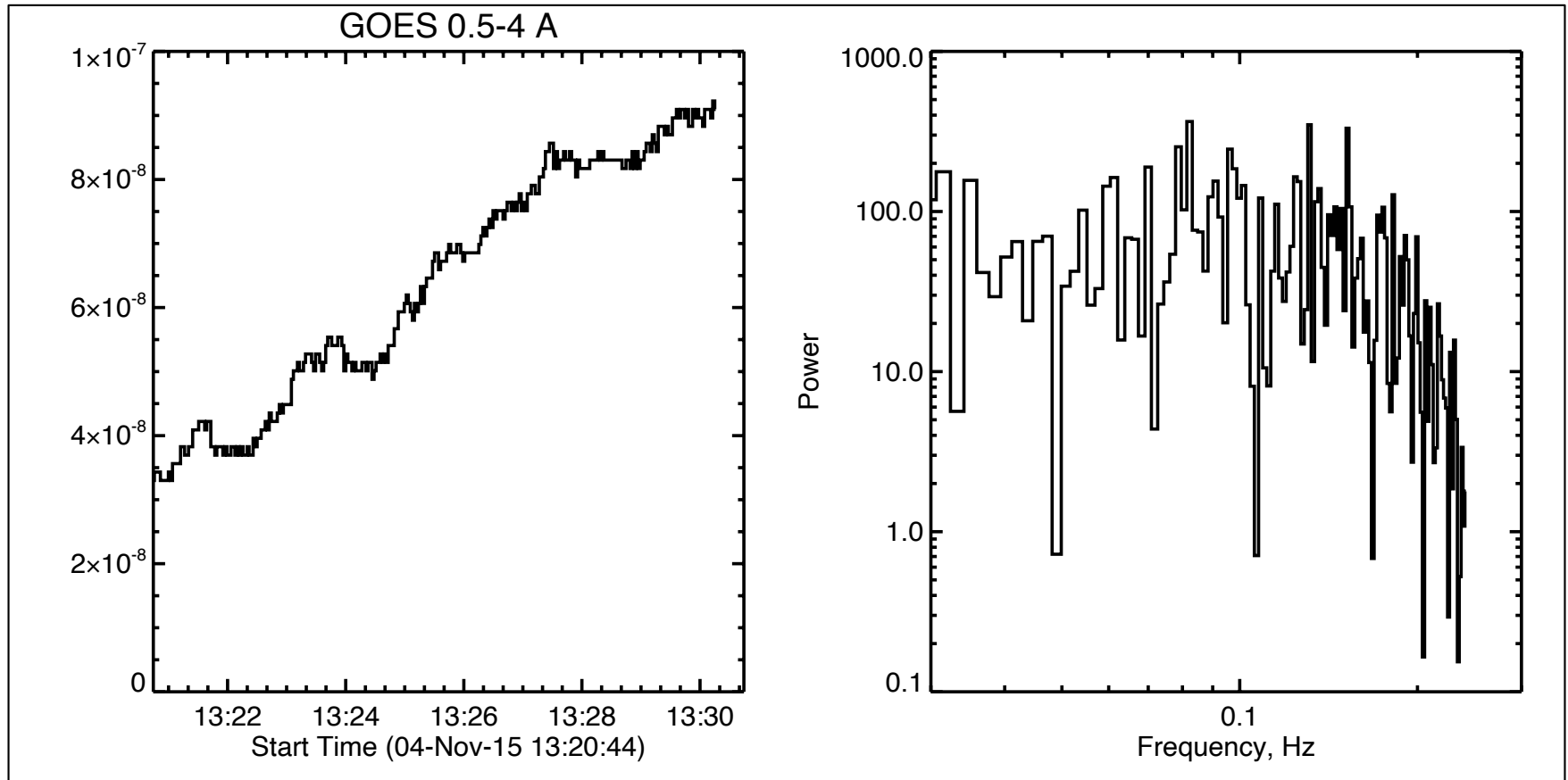


# SOL2015-11-04 is a slow HOPE



- Is the HOPE phase describable as tether-cutting?
- Is it punctuated by episodic heating?

# SOL2015-11-04 HOPE analysis



- Yes perhaps it's snipping tethers?
- If so, its shot-noise timescale is about 5 s

# Slow HOPE Conclusions

- Based on two events, the speculation is that the HOPE phenomenon represents activation of a filament channel remote from the flare site, but connected somehow.
- “Tether-cutting”? Might be.