Can HOPE actually anticipate flares?

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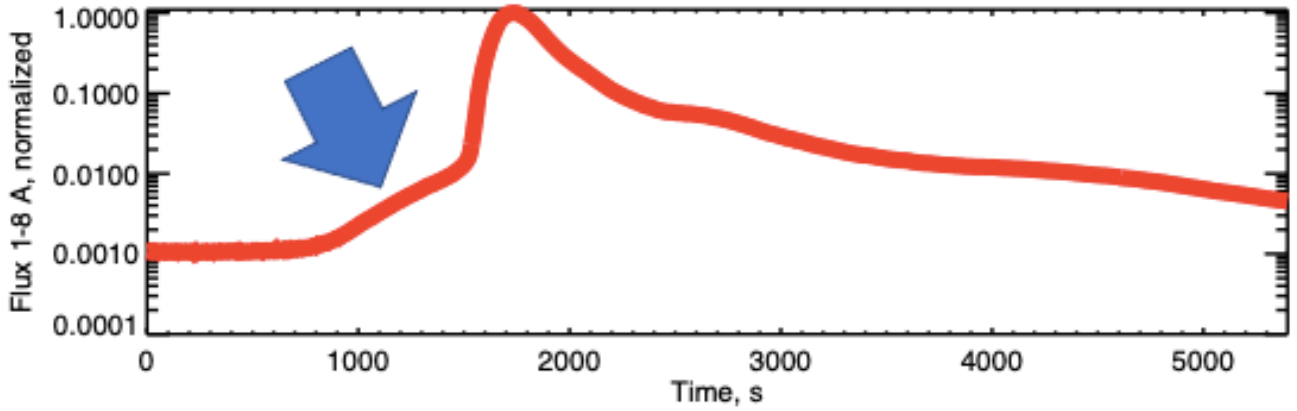
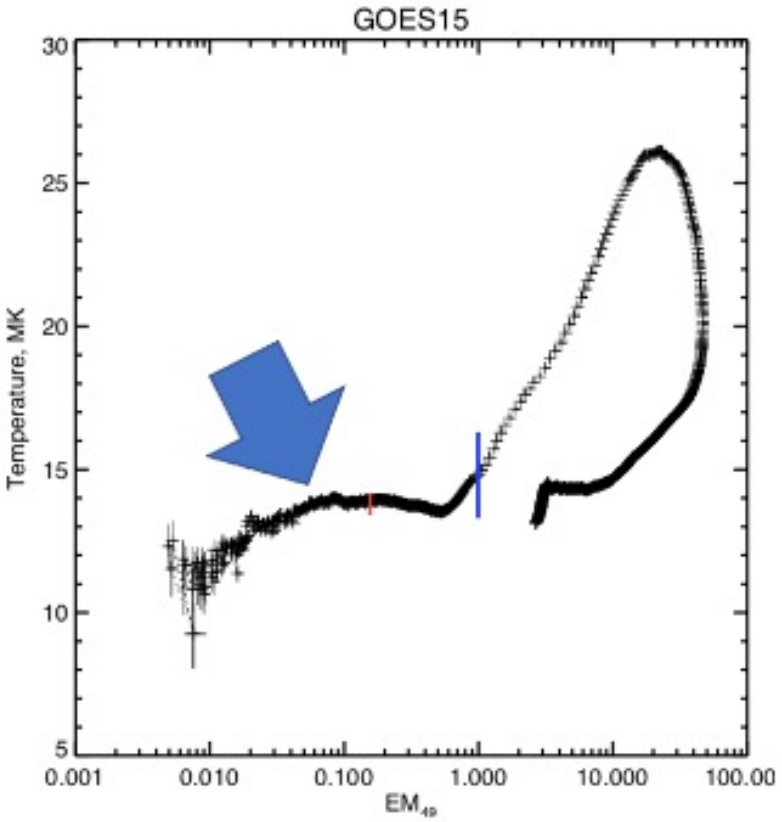
HOPE?

- “Hot Onset Precursor Event”
- Other precursor features include filament activation, dimming, line broadening, etc.
- HOPE is not part of standard flare theory, but it is ubiquitous

- Though we don’t yet understand it, it may be practically important

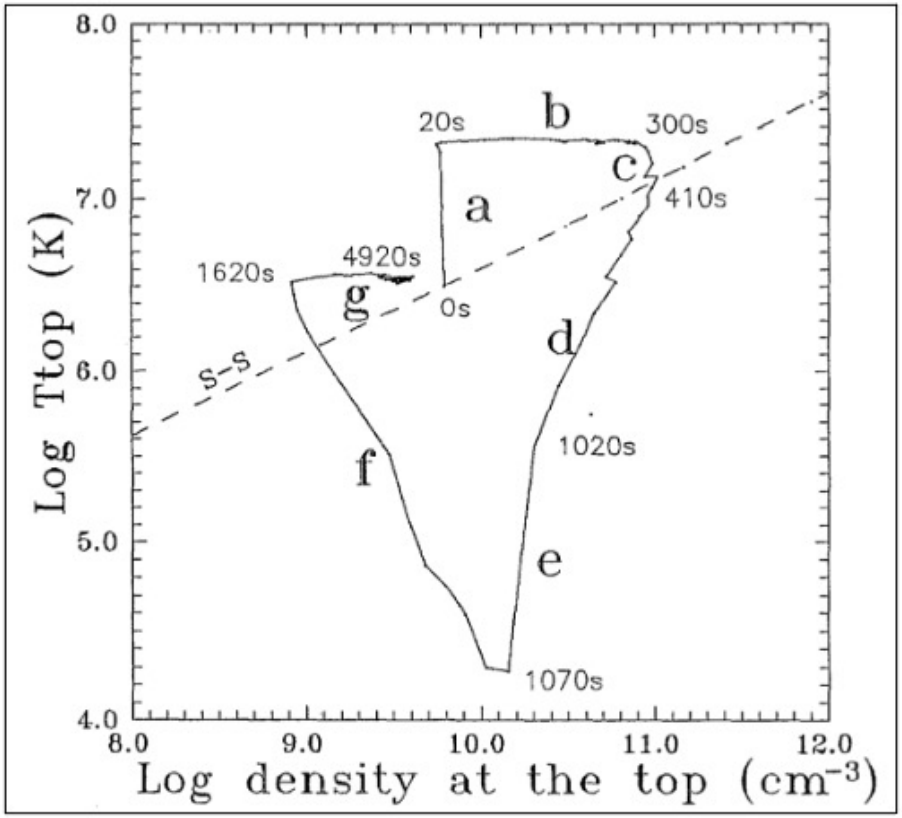
A slow HOPE



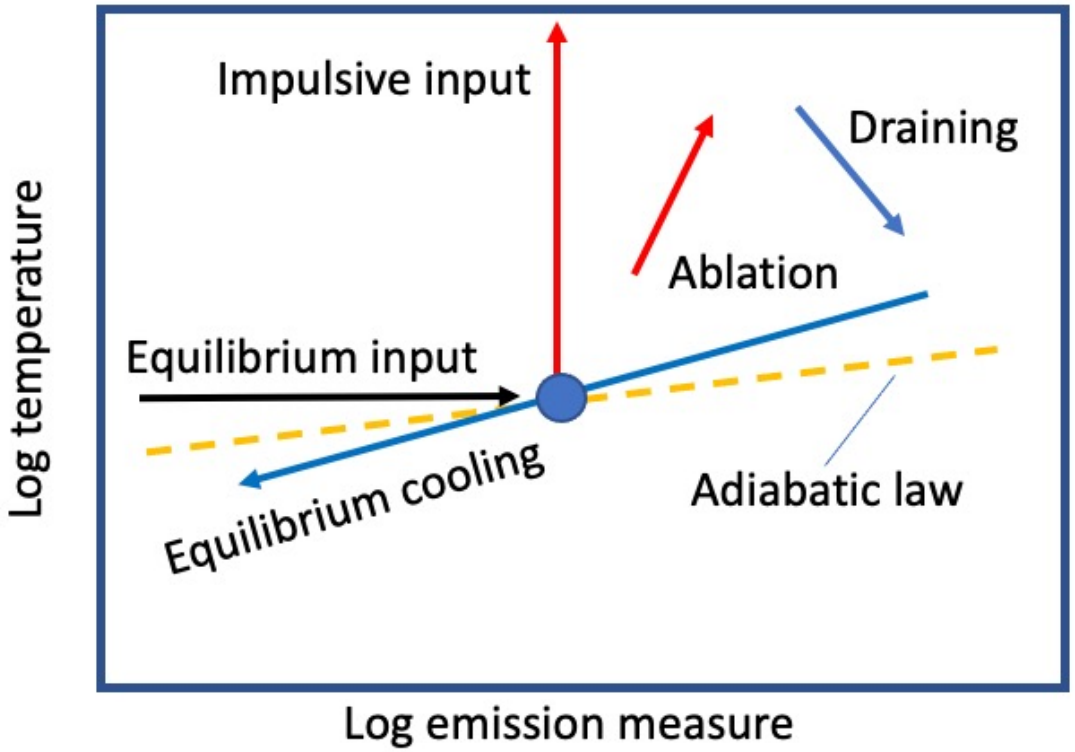


- SOL2011-08-09 (X6.9) has a HOPE lasting for minutes
- The GOES T vs. GOES EM "loopdeloop" plot has an apparently smooth "horizontal branch".

No-HOPE behavior (the Neupert effect)



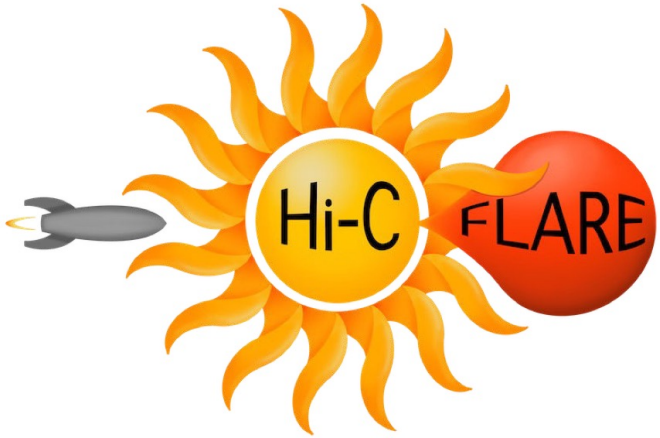
Sylwester (1996)



Explanations…

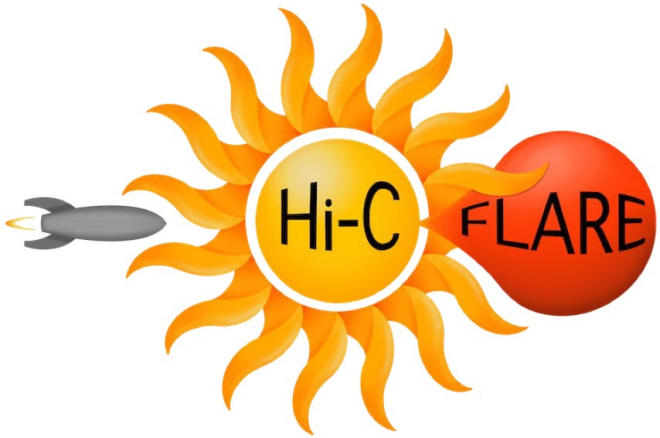
The NASA flare rockets

- FOXSI: hard X-ray focusing optics
- SNIFS: Integral field imaging spectroscopy
- Hi-C FLARE: Highest resolution



The NASA flare rockets

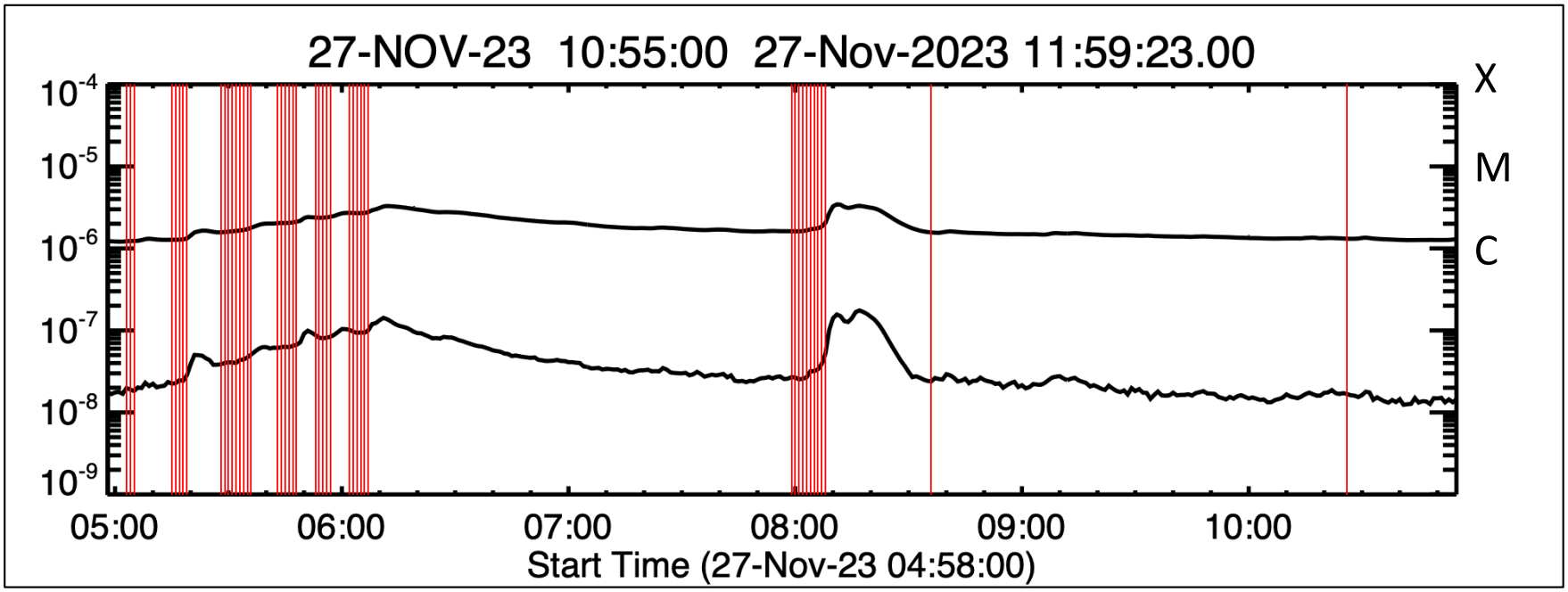
Since HOPE precedes a flare, and specifically the impulsive phase, can we use it to help the rocketeers push the (red?) launch button?



Capturing HOPE quantitatively

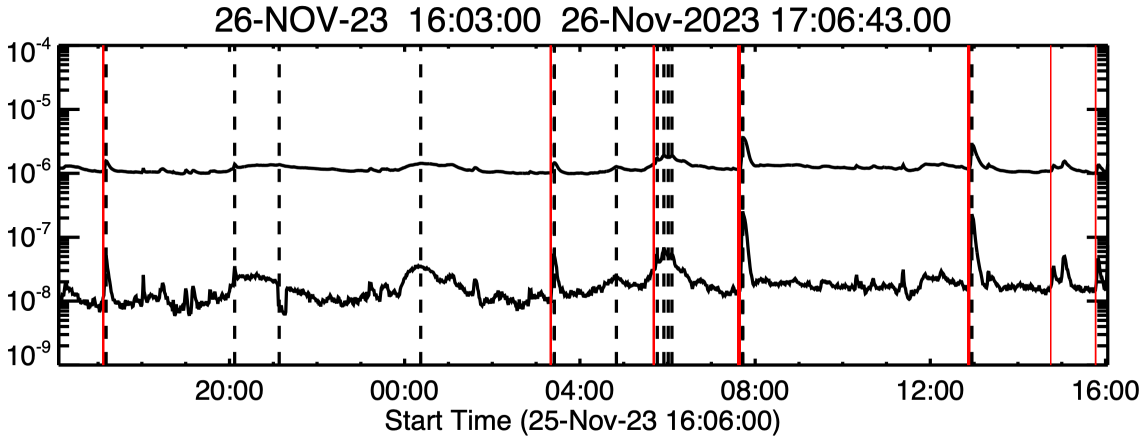
- Background subtraction is the key to characterizing flare behavior
- A difference time series will do
- Basic model parameters (5)
  - Integration time (nominally 1 min)
  - Difference time (default 5 min)
  - dEM (default 0.01 x 10^{49} cm^{-3})
  - Temperature range (default [6,14] MK)

Results

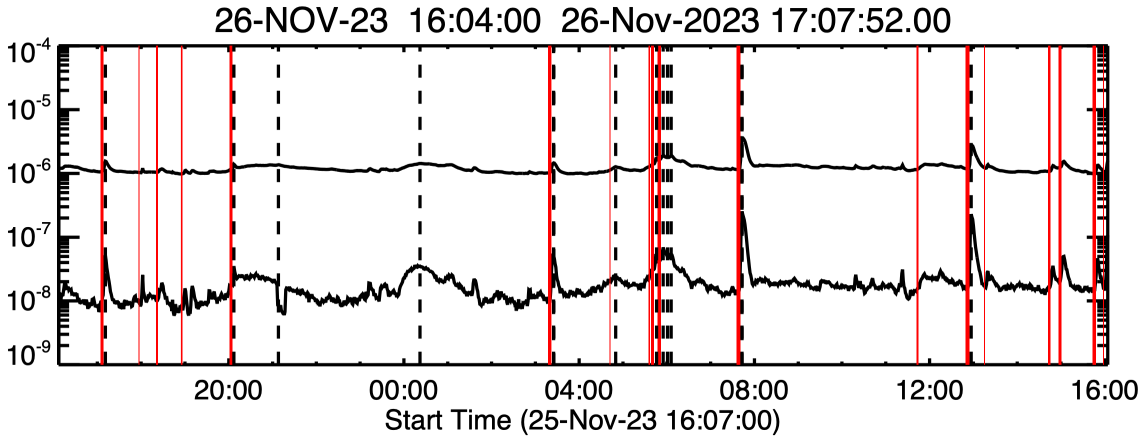


- Lines at 1-min step show HOPE criteria
- Well-defined anticipation of small flares
- HOPE is ubiquitous
- GOES latency 04:23 min in this case

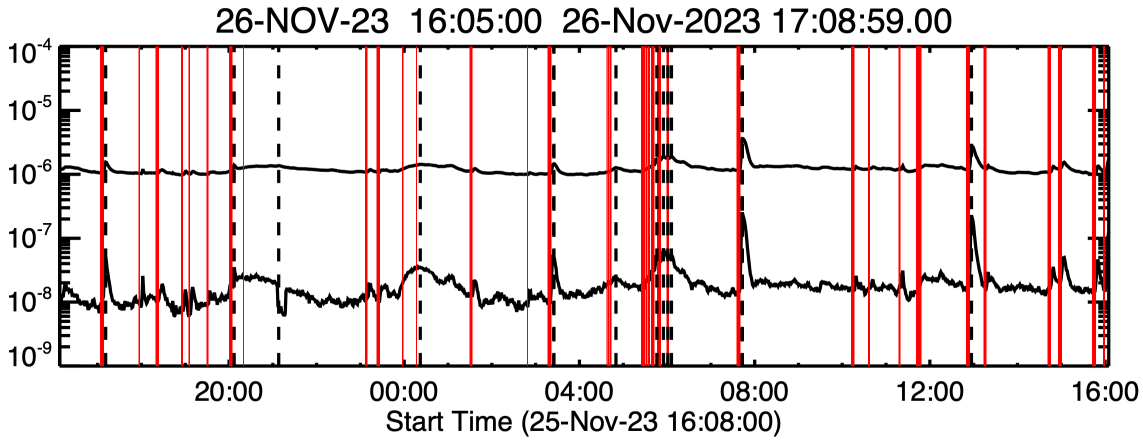
SSW ”Latest Events”
(Sam Freeland)



dEM = 0.02



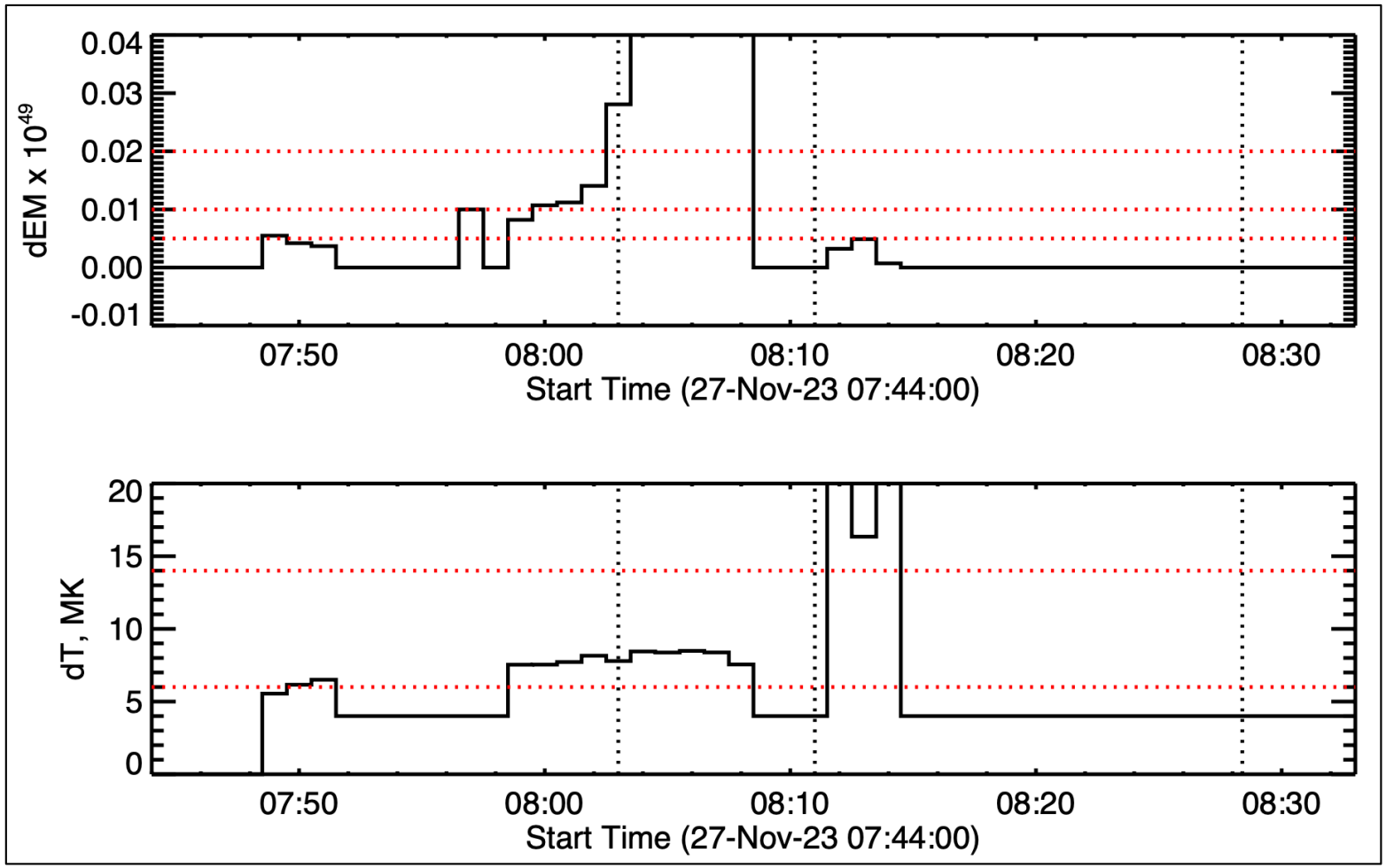
dEM = 0.01



dEM = 0.005

How the criteria work:

SOL2023-11-27T08:11 (C3.4) …



GOES event times (start, max, end) vertical …

Conclusions

- The HOPE criteria work perfectly to anticipate flares of all magnitudes
- The dEM parameter “predicts” GOES class
- Other parameters remain to be explored

- Sven points out… robust warnings on few-minute time scales might be helpful for many kinds of flare campaign programs (SST?)

Remarks

- GOES anticipates well, but doesn't image
- The anticipation time is variable, so statistical work needs to be done
- GOES latency is not good
- AIA should be able to provide the same anticipation capability
- Radio???? Van Hoven & Hurford 1986; see also

  https://research.ssl.berkeley.edu/~hhudson/presentations/spd.230816/

Other side of coin

- Nobody knows much about HOPE physics, and it is a fundamental property of flares
- This rocket campaign is giving us a good excuse to do some important HOPE research