Measuring Soft X-Ray Variability During The First Sounding Rocket Flare Campaign

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Abstract

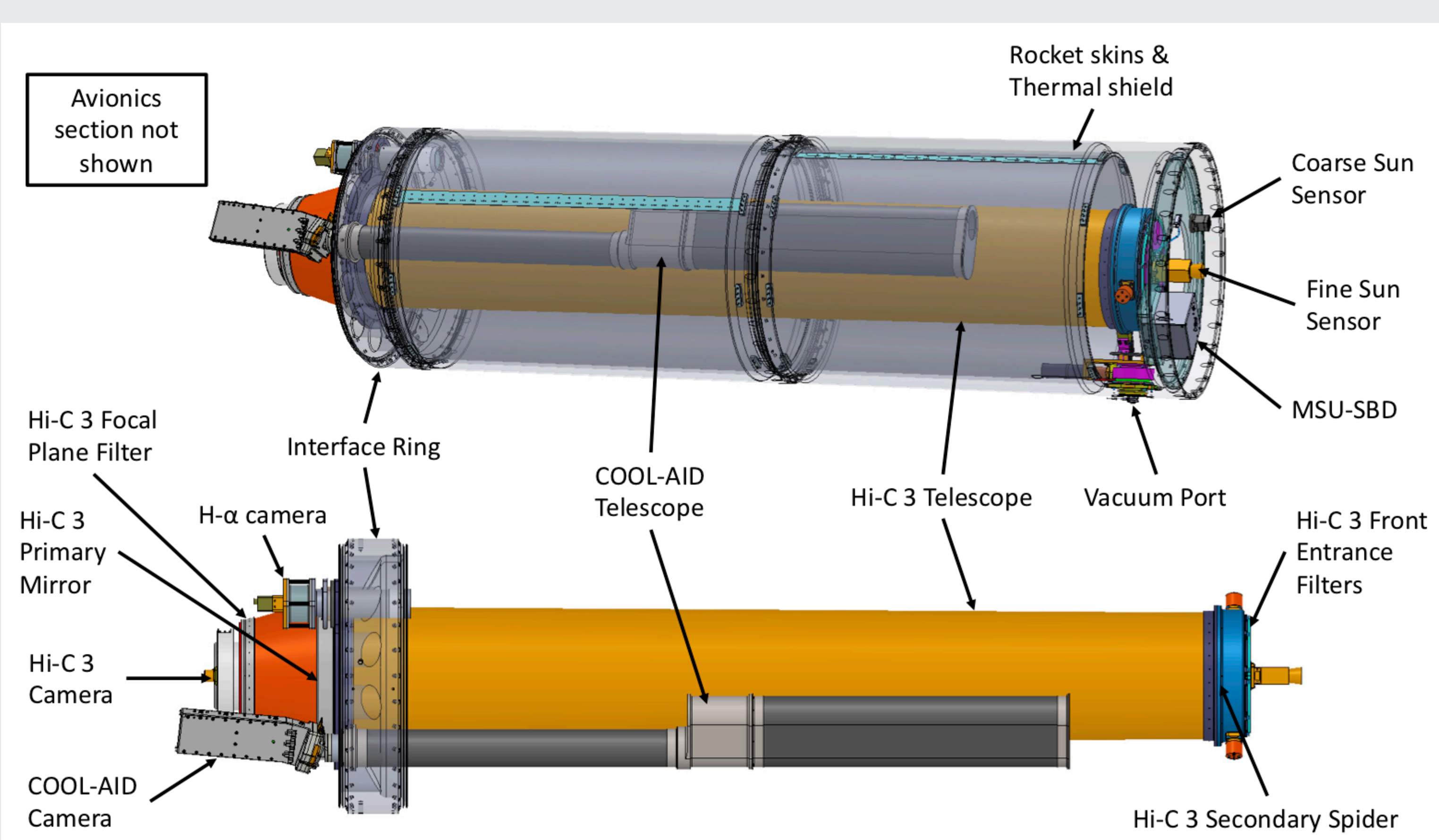
In March 2024, sounding rockets will be launched in response to a solar flare for the first time. The Hi-C Flare mission will be among the first to take advantage of this new observing campaign, which was instituted by the NASA Sounding Rocket Program Office in response to a 2019 white paper submitted by Winebarger, Glesener, and Reeves. A soft X-Ray radiometer in development at Montana State University is the smallest of three instruments that will fly on Hi-C Flare. We describe the motivation, prospects, and instrumentation for high speed (1 kHz) measurement of soft X-ray (SXR) variability in solar flares.

Sounding Rocket Flare Campaign

The first sounding rocket flare campaign is planned for March, 2024 at Poker Flat Research Range (Winebarger et al., 2019).

- ∼ 2-week launch window
- Overlap PSP Perihelion #19
- 2 rockets: *Hi-C Flare* and *FOXSI*
- Launch within minutes of C+ flare

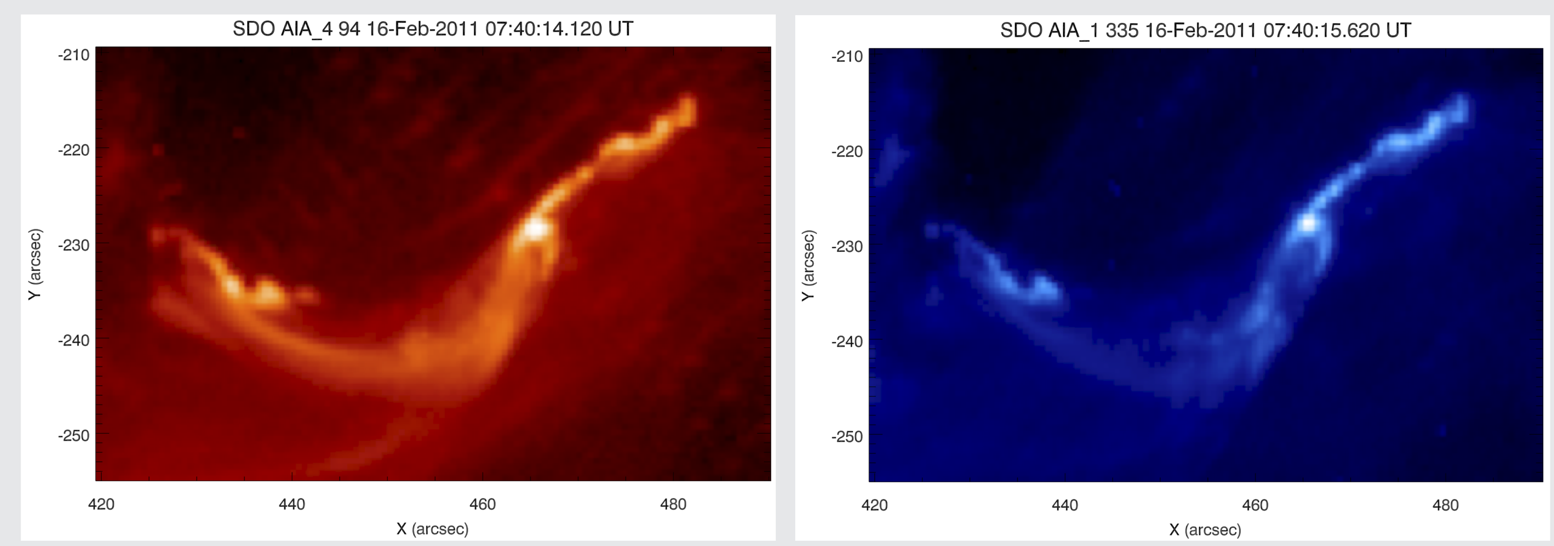
The Hi-C Flare Payload



Hi-C Flare Instruments

Rapid Energy Release

Historically, when we observe the Sun at faster cadence in any wavelength range, new phenomena are discovered. Quasi-periodic pulsations have been measured with periods of tens of seconds in soft and hard X-rays (Simões et al., 2015), as well as in decimetric radio (Bastian et al., 1998). Millisecond pulses are observed in microwaves (Tan & Tan, 2012).



Log intensity; flare kernel described by Young et al. (2013).

Why might we expect rapid soft X-ray (SXR) variability? Flare kernels are often smaller than 400 km, and routinely outshine the Sun in SXR. For comparison, the size of small photospheric magnetic elements is ∼ 100-600 km. A plausible range of timescales for flare kernels in the low corona is:

$$\Delta t = \frac{L}{v_A} = \frac{100\text{-}600\,km}{1000\,\mathrm{km/s}} = 0.1\text{-}0.6\,s.$$

This is 3-20× the GOES SXR sample rate.

References

Bastian, T. S., Benz, A. O., & Gary, D. E. 1998, Ann. Rev. Astron. Astrophys., 36, 131

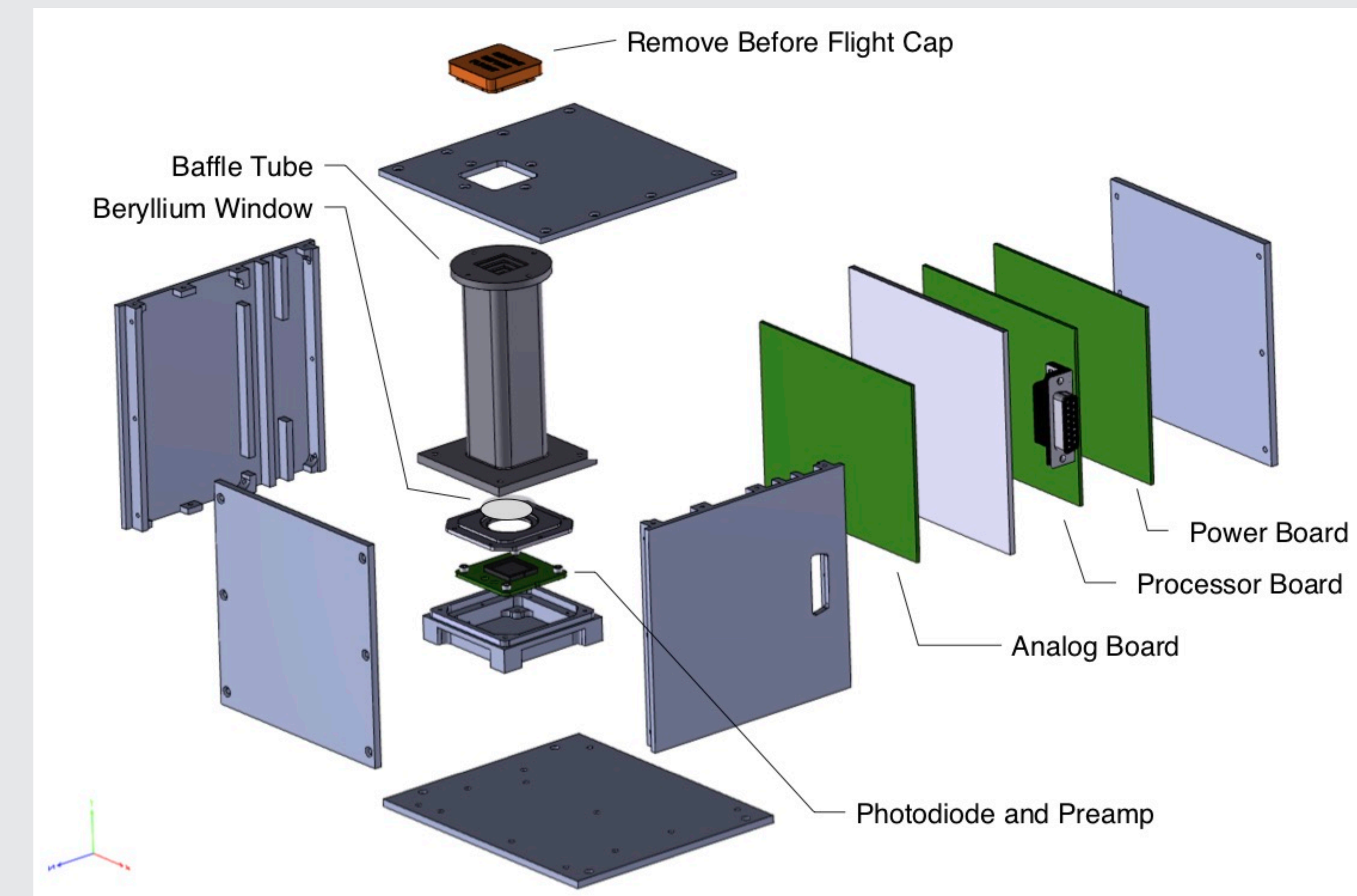
Simões, P. J. A., Hudson, H. S., & Fletcher, L. 2015, Sol. Phys., 290, 3625

Tan, B., & Tan, C. 2012, Astrophys. J., 749, 28

Winebarger, A., Glesener, L., & Reeves, K. 2019, Solar Flare Sounding Rocket Campaign. `https://rscience.gsfc.nasa.gov/keydocs/SolarFlareCampaign.pdf`

Young, P. R., Doschek, G. A., Warren, H. P., & Hara, H. 2013, Astrophys. J., 766, 127

Instrument Concept



Student Built X-Ray Detector (MSU)

Field of view	Full Sun (integrated)
Sample Rate	1 kHz
Passband	∼ 1-8 Å, 1.5-12 keV (∼ GOES Long)
Sensitivity	$0.002\,\mathrm{A\,m^2\,W^{-1}}$
Min. Signal	27 pA, $250\,\gamma\,\mathrm{ms^{-1}}$ (GOES A1.5)
Saturation	$1.8\,\mu\mathrm{A}$, $1.7\times10^7\,\gamma\,\mathrm{ms^{-1}}$ (GOES X10)
Dynamic Range	48 dB (16 bits)

MSU Instrument Team

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