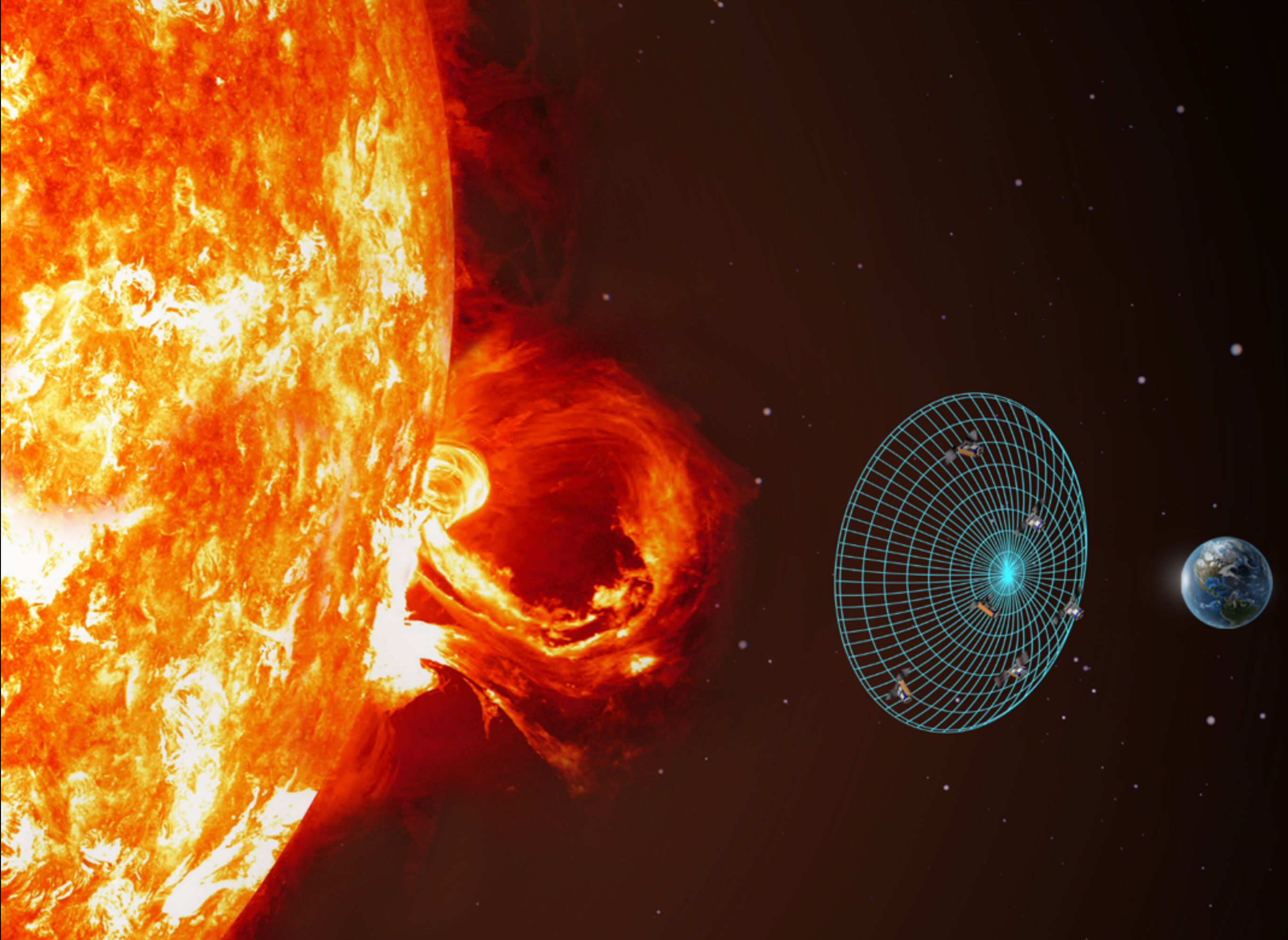

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Prospects for Low Frequency Radio Astronomy with the Sun Radio Interferometer Space Experiment

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SunRISE

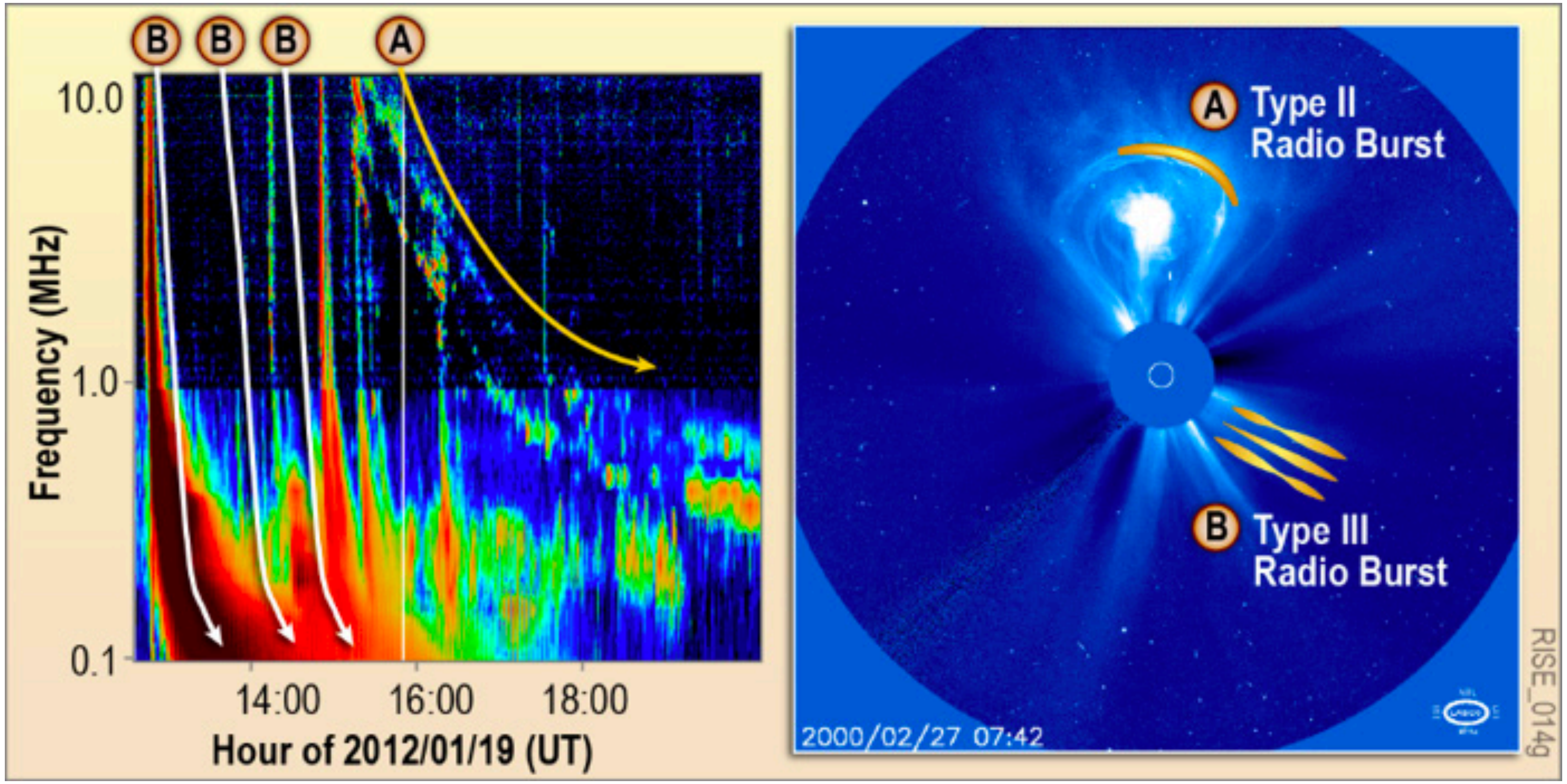
Sun Radio Interferometer Space Experiment

PRINCIPAL INVESTIGATOR: Justin C. Kasper (University of Michigan)

SunRISE Heliophysics Science

SunRISE
Sun Radio Interferometer Space Experiment

- SunRISE: Sun Radio Interferometer Space Experiment
- SunRISE localizes the radio emission as a function of time and frequency.
- Designed to discriminate competing hypotheses for:
  - The generation of solar energetic particles
  - The variable magnetic connection between active regions and the inner heliosphere.

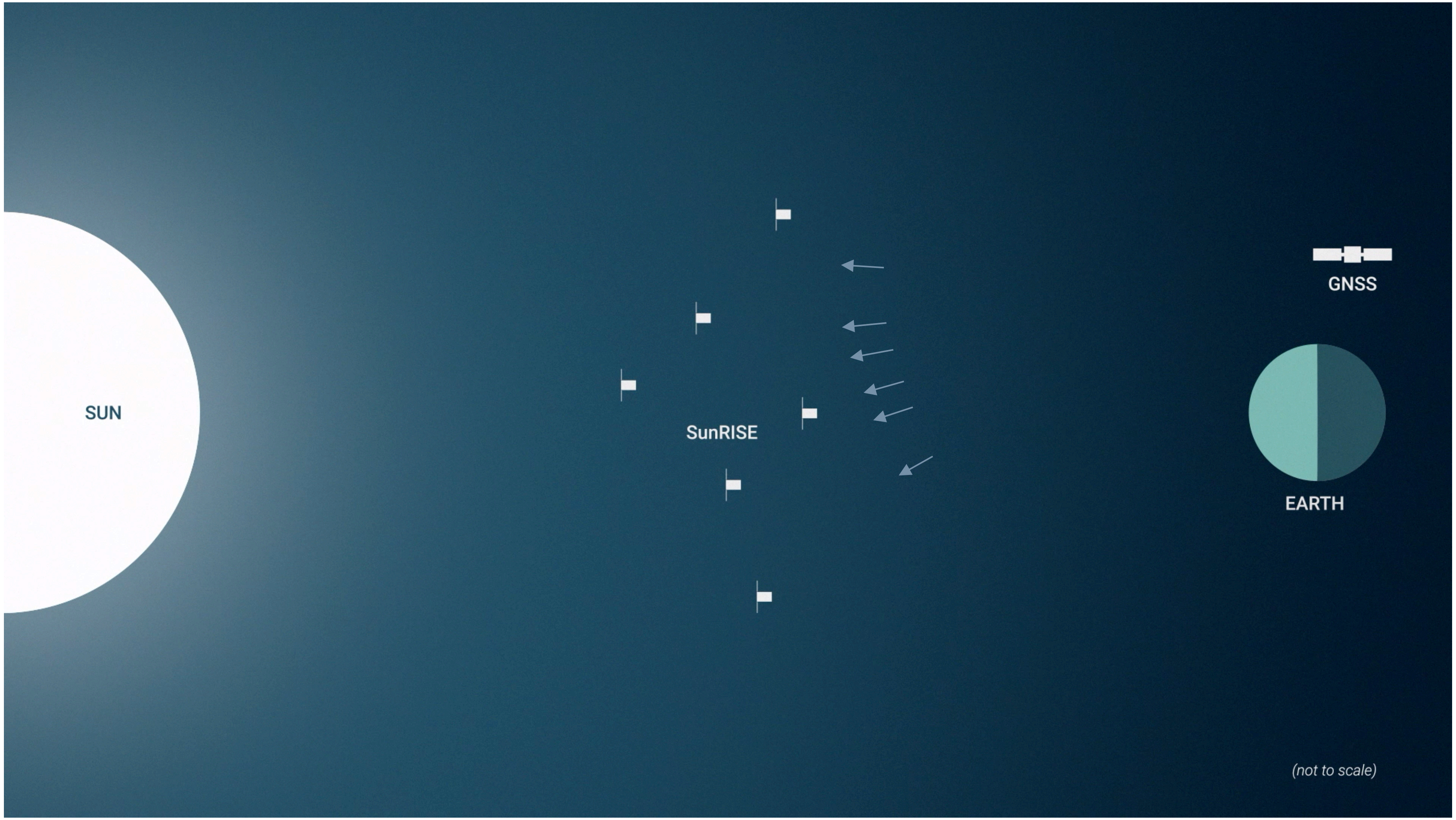


Observatory

GNSS provides ~1 m position accuracy on each spacecraft.

Supersynchronous orbit 37,000 km altitude.

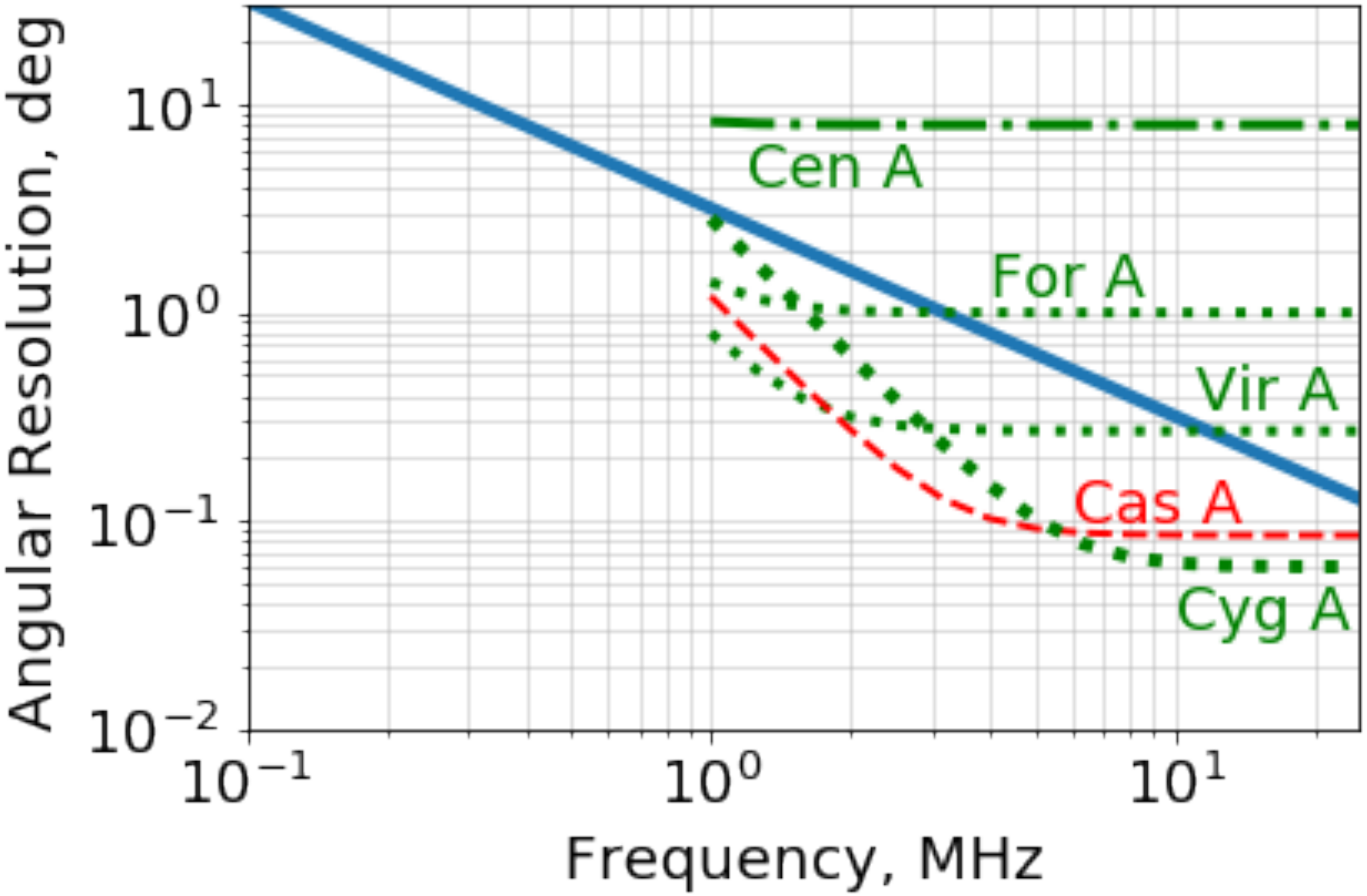
3-20 km spacecraft separations



Angular Resolution

SunRISE
Sun Radio Interferometer Space Experiment

- SunRISE angular resolution tuned for localization of solar radio bursts.
- Examples of easily detectable sources are shown for comparison (there may be other sources as well)
- Galactic free-free absorption becomes an issue for low Galactic latitude sources (e.g., Cas A and Cyg A) below about 3 MHz.



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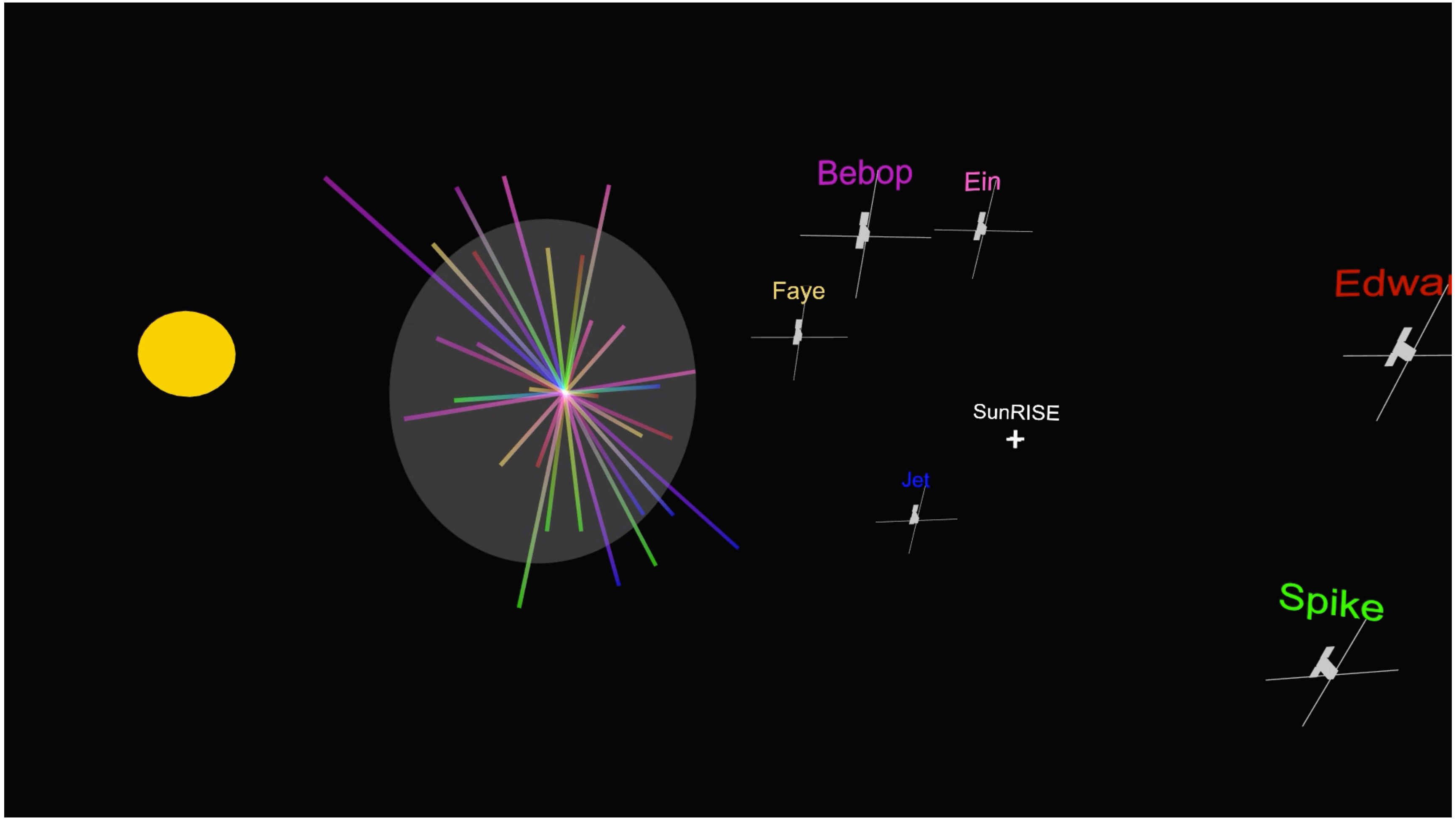
Orbits and Baseline Coverage

- 6.5 km radius disk in the projected plane of the Sun
- SunRISE orbits are designed so that 2 orthogonal projected baseline lengths are >6.5 km.
- This enables the resolution needed.
- SunRISE is a digitally steerable radio telescope allowing for comparable resolution anywhere in the sky.

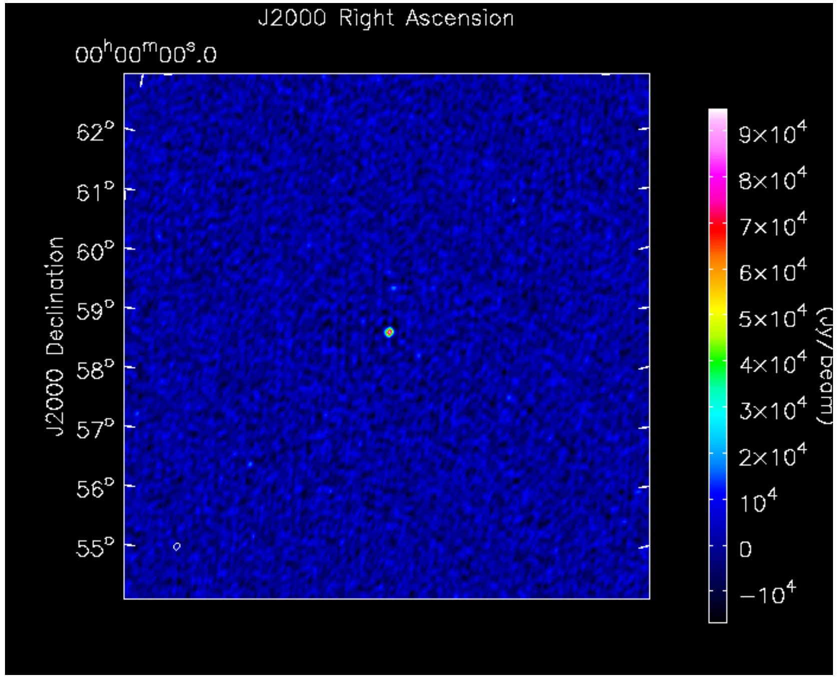


Spatial Resolution

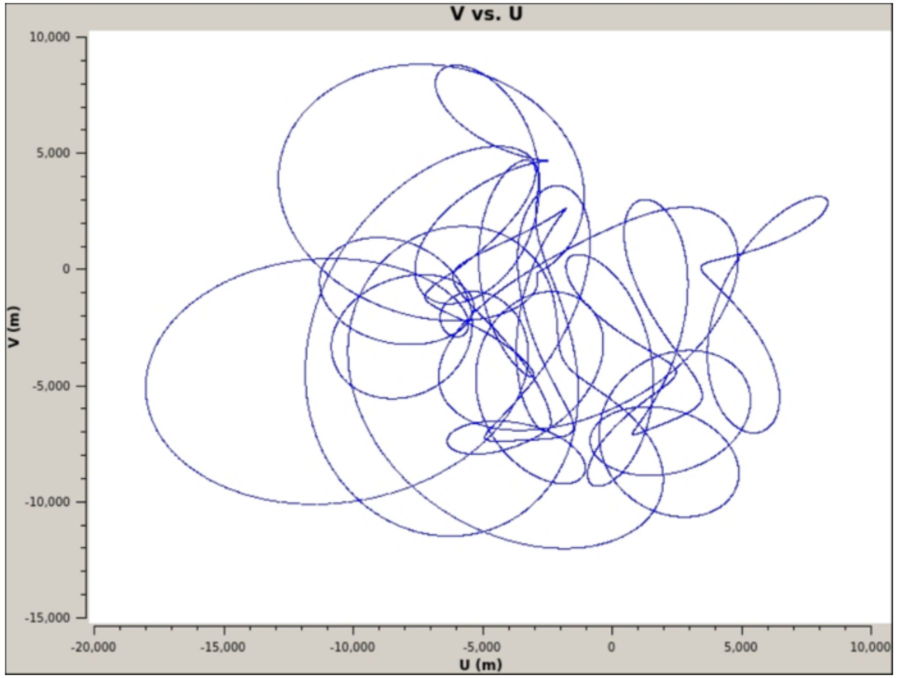
SunRISE
Sun Radio Interferometer Space Experiment

UV plane coverage sufficient for imaging bright point-like sources.

Noisy Cas A Image (10 MHz)



UV Coverage

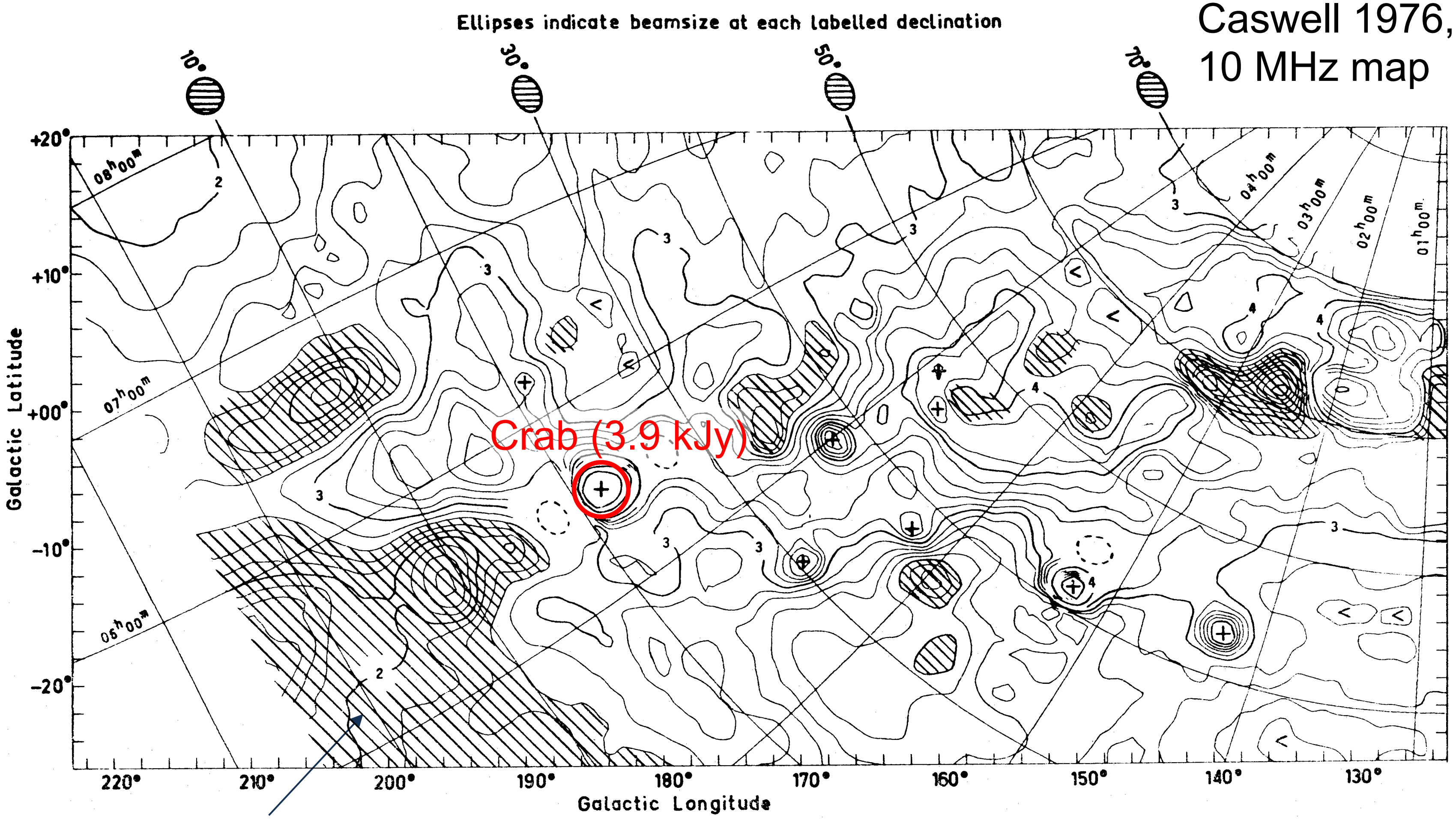


All Sky Maps

SunRISE
Sun Radio Interferometer Space Experiment

SunRISE could potentially produce all-sky maps with ~order of magnitude improvement in angular resolution from previous maps of Caswell 1976 (10 MHz) and Cane & Whitman 1976 (3.7 – 16.5 MHz).

Caswell 1976, 10 MHz map



Hatched areas indicate absorption features corresponding to large-diameter H II regions.
20,000 K contours, contour labels in units of 100,000 K.

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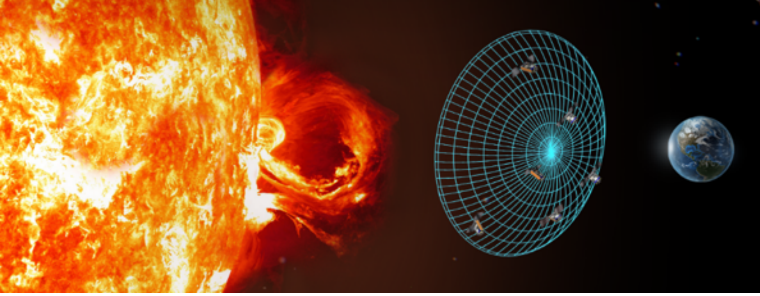
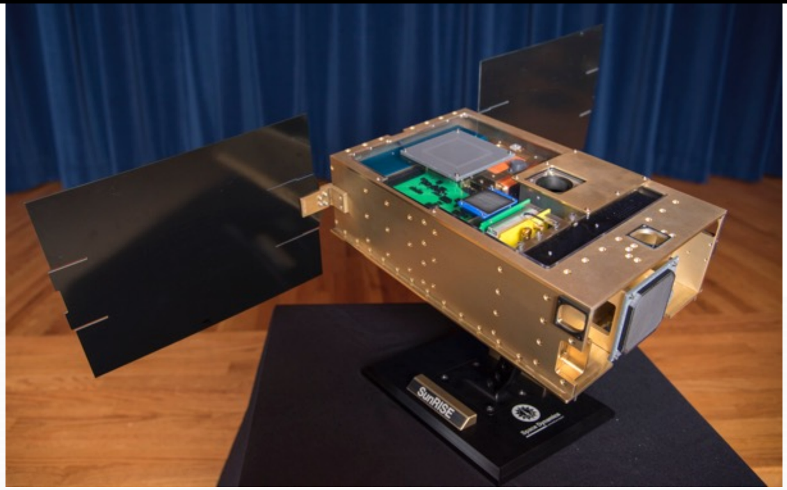
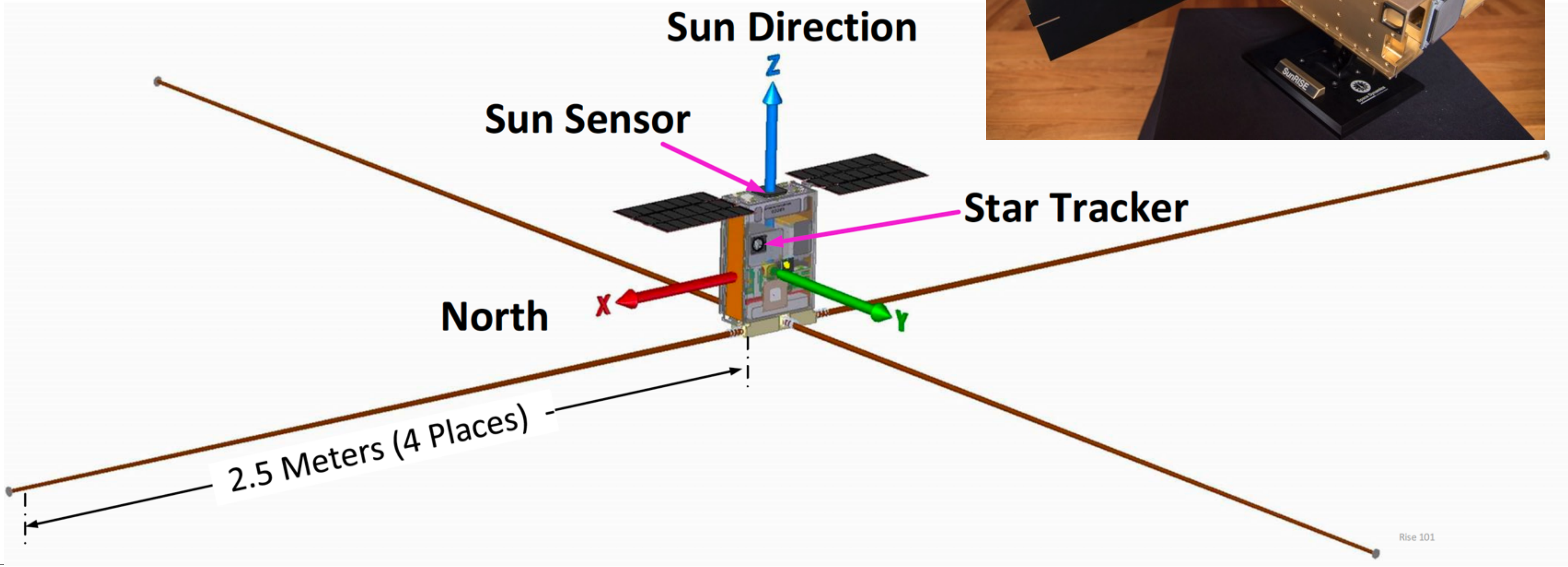
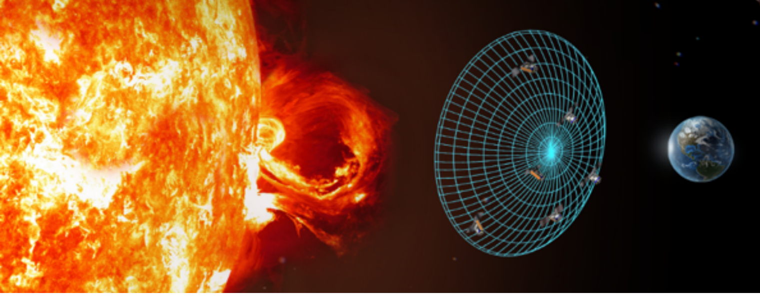


SunRISE Spacecraft

- Electrically short antenna for 0.1-25 MHz deca-hectometric (DH) receiver.
- Dual-polarized receiver.
- Integrated DH and GNSS receiver fits in 6U CubeSat form factor.



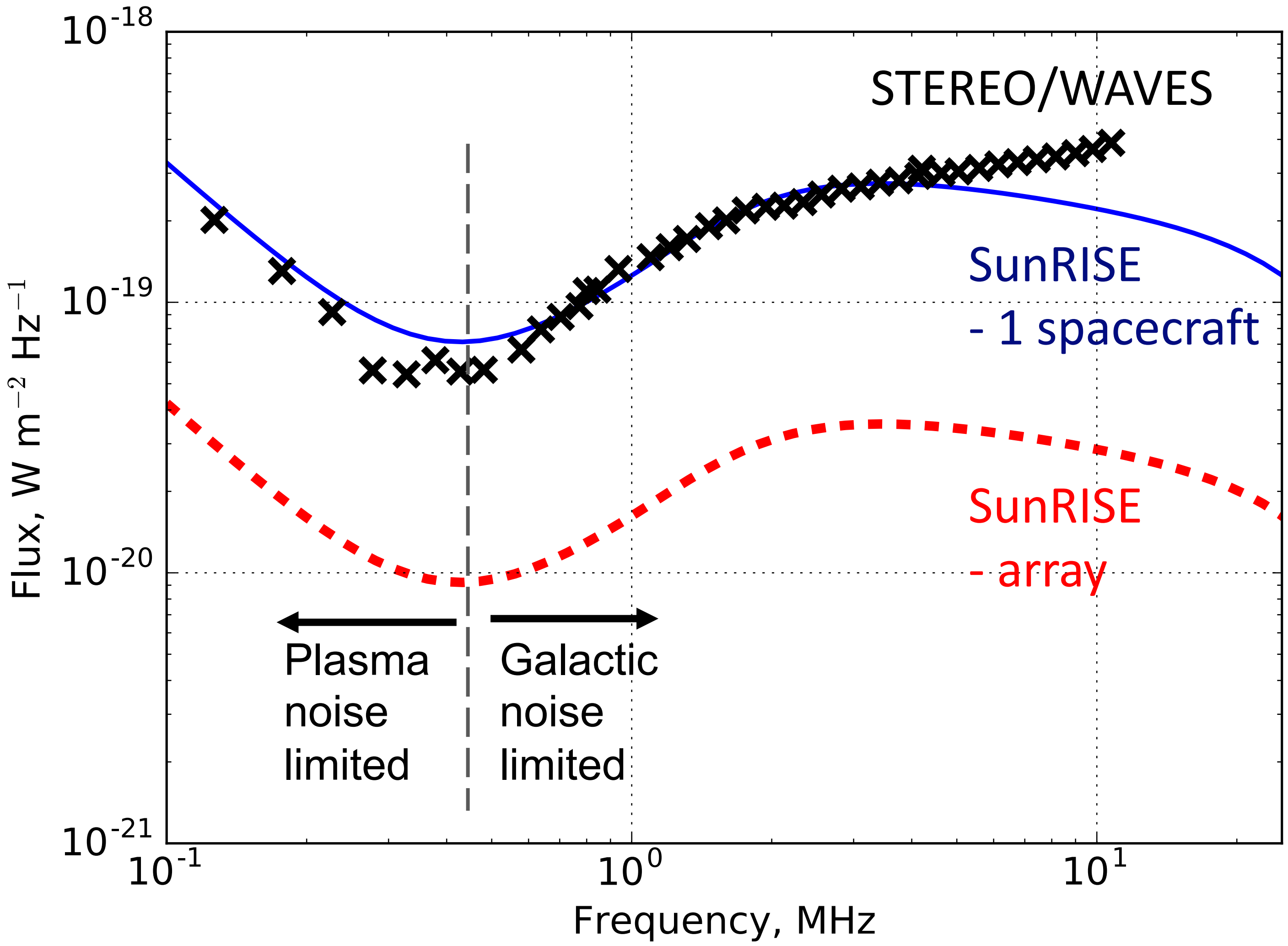




Sensitivity

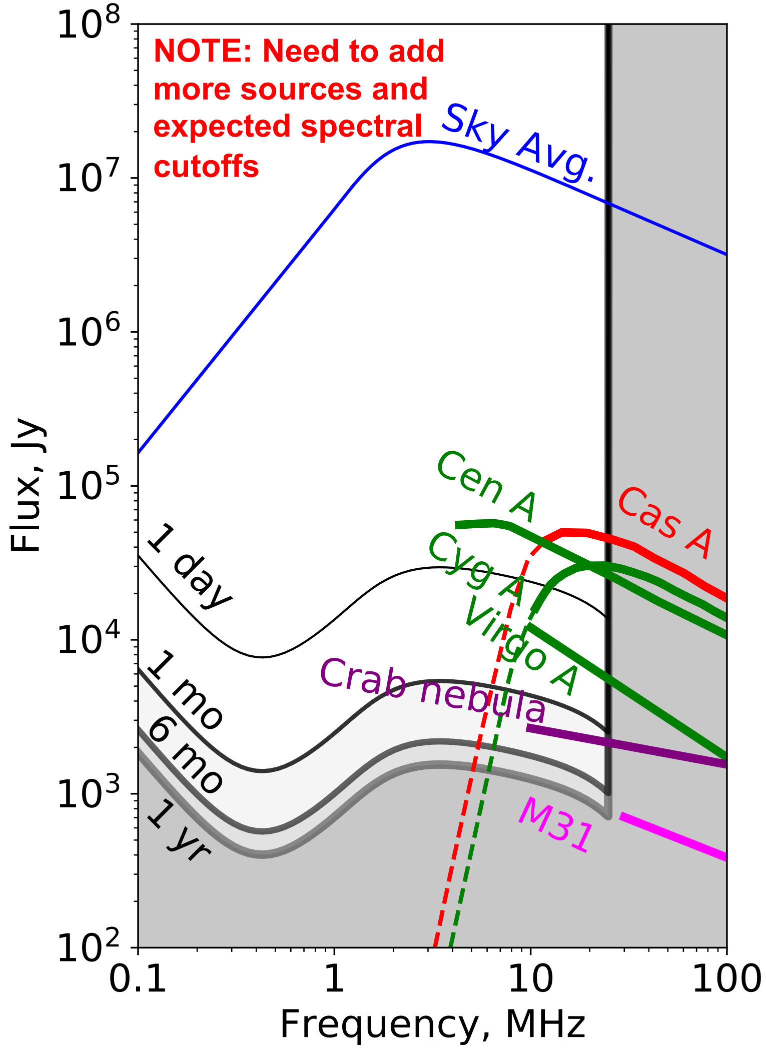
SunRISE
Sun Radio Interferometer Space Experiment

- Each “snapshot” (0.66 ms integration time, 6.1 kHz bandwidth) is background noise limited.
- SunRISE sensitivity is comparable to Wind/WAVES and the STEREO/WAVES receivers.
- Array: 6 spacecraft, 2 polarizations improves the sensitivity by a factor of 8.5



Sensitivity

- SunRISE integrated sensitivity would be capable of imaging the A-team sources at frequencies below the ionospheric cutoff.
- Cas A and Cyg A expected to be absorbed at frequencies <10 MHz due to low Galactic latitudes.

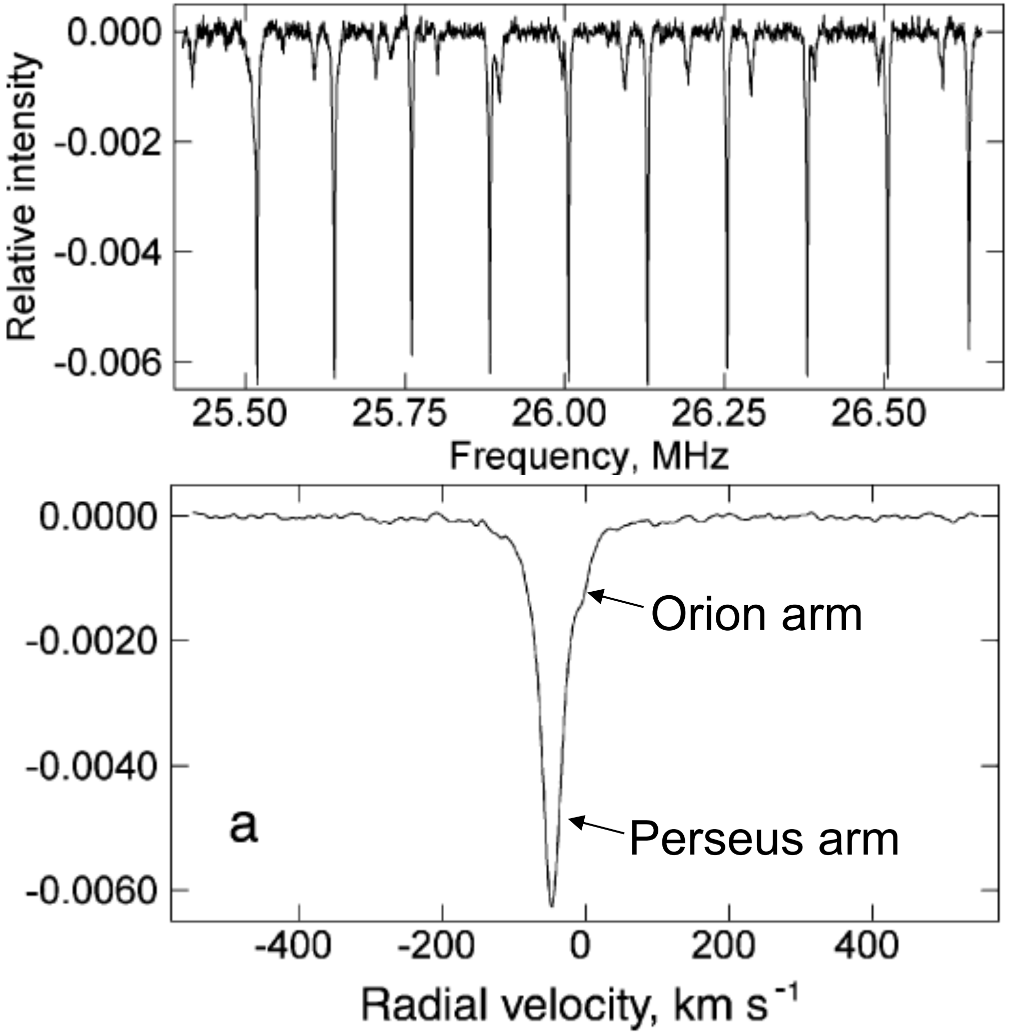


Radio Recombination Lines

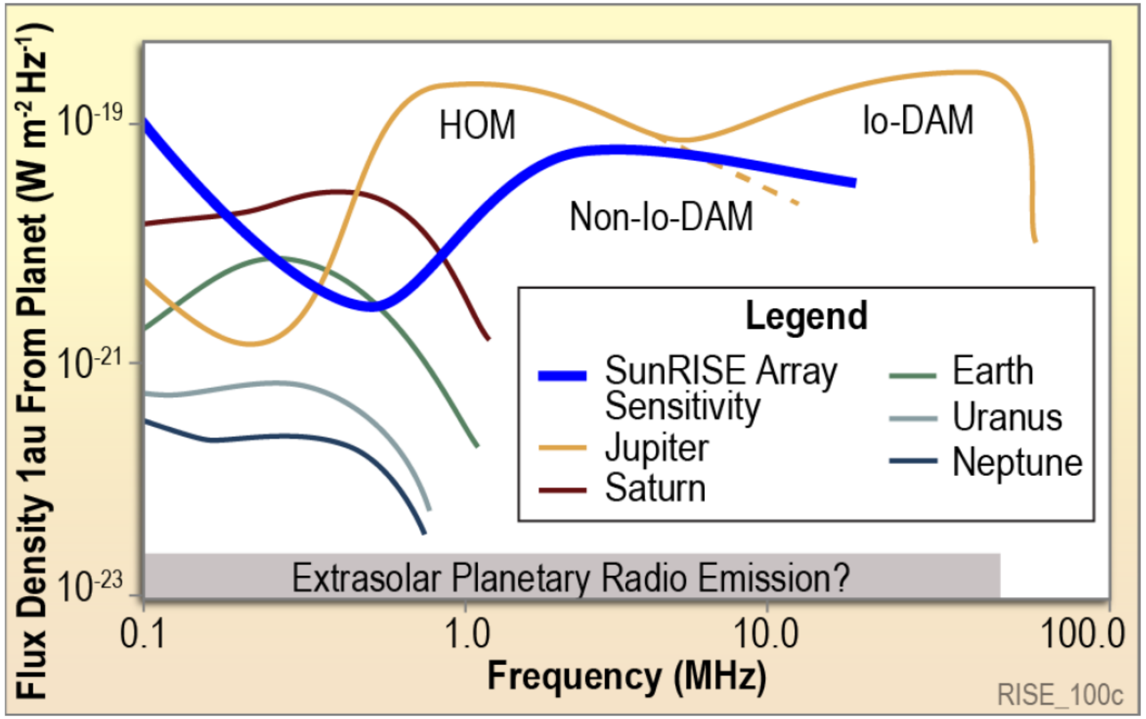
SunRISE
Sun Radio Interferometer Space Experiment

- SunRISE would search for radio recombination lines at frequencies below 25 MHz.

- Using Cas A as an illumination source and stacking the comb structure of radio recombination lines could enable a 5 σ detection of line depths of $\gtrsim 2.5\times10^{-3}$ or greater.



Planetary Science

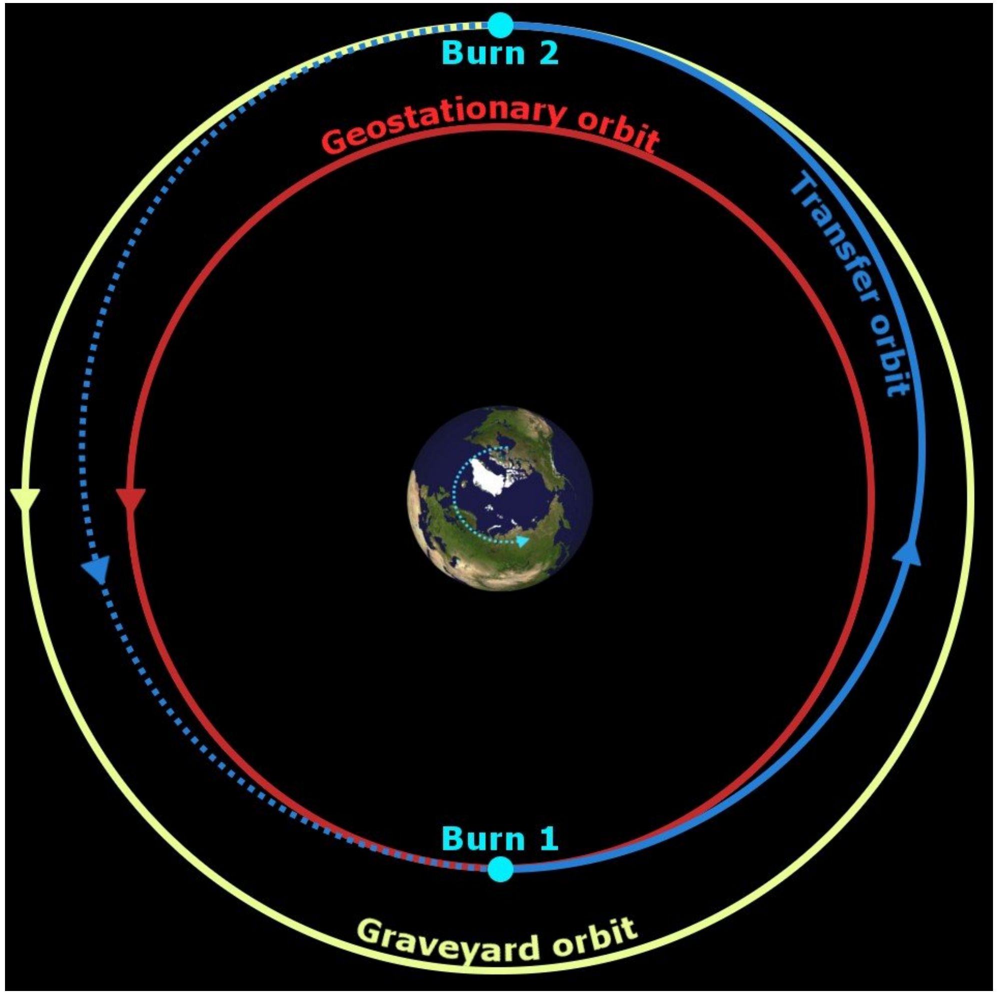


- Typical planetary radio emission seen from 1 au distance compared to SunRISE sensitivity in 1 second, 1 Hz measurement. Ten minute, 2 MHz integrations would be up to10,000x more sensitive
- Jupiter should be detectable most of the time
- Saturn, Uranus, and Neptune are a stretch but would be very exciting if detected

Observing with Ground-Based Telescopes

SunRISE
Sun Radio Interferometer
Space Experiment

- SunRISE is in a ~37,000 km altitude Supersynchronous orbit (a.k.a. GEO graveyard orbit).
- 25 hour period means SunRISE shifts 0.6° / hour with respect to a point on the ground.
- Potential for synchronized observations with ground based telescopes.
- Data type is an amplitude and phase with 6.1 kHz bandwidth acquired every 100 ms.

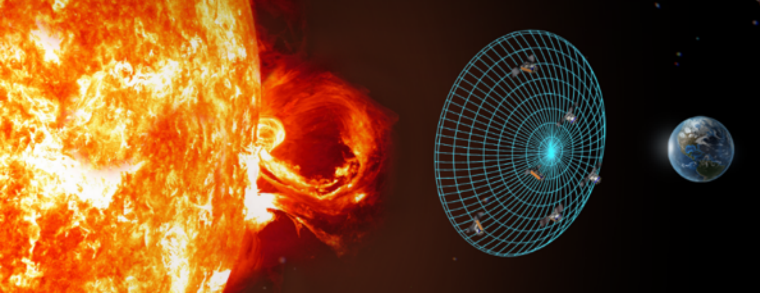


Conclusions

- The SunRISE observatory could be a first of a kind deca-hectometric (DH 0.1-25 MHz) radio space-based interferometer, enabling radio astronomical observations below the ionospheric cutoff.
- The SunRISE observatory would make the first images of DH (0.1-25 MHz) radio emission from solar flares and CMEs.
- See also:
  - Poster by Joseph Lazio on the SunRISE mission.

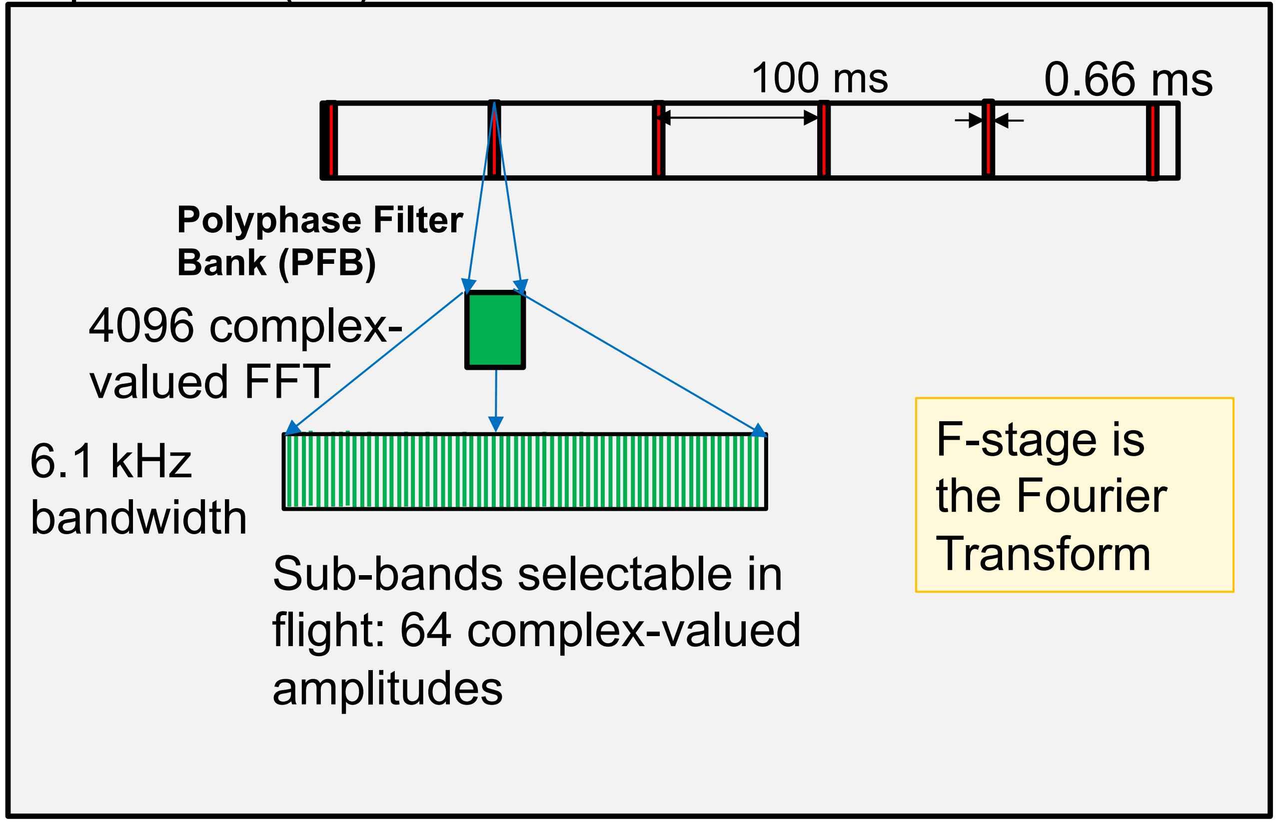
Part of this research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration.

BACKUP



FX Correlation

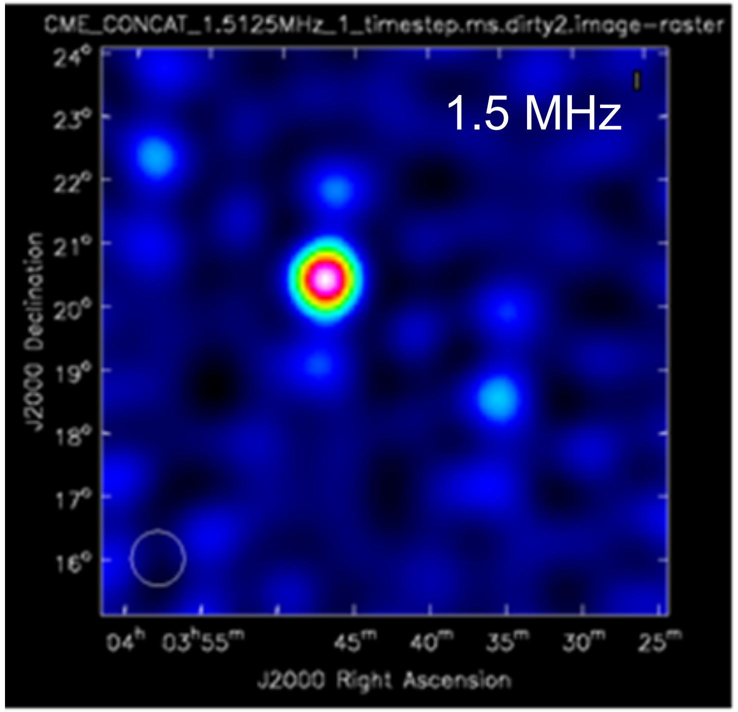
Spacecraft (×**6**)



All spacecraft synchronized by GNSS.

Data telemetered to ground

Fourier amplitudes are combined to form visibilities to form the CLEANed image.



X-stage is the Correlation