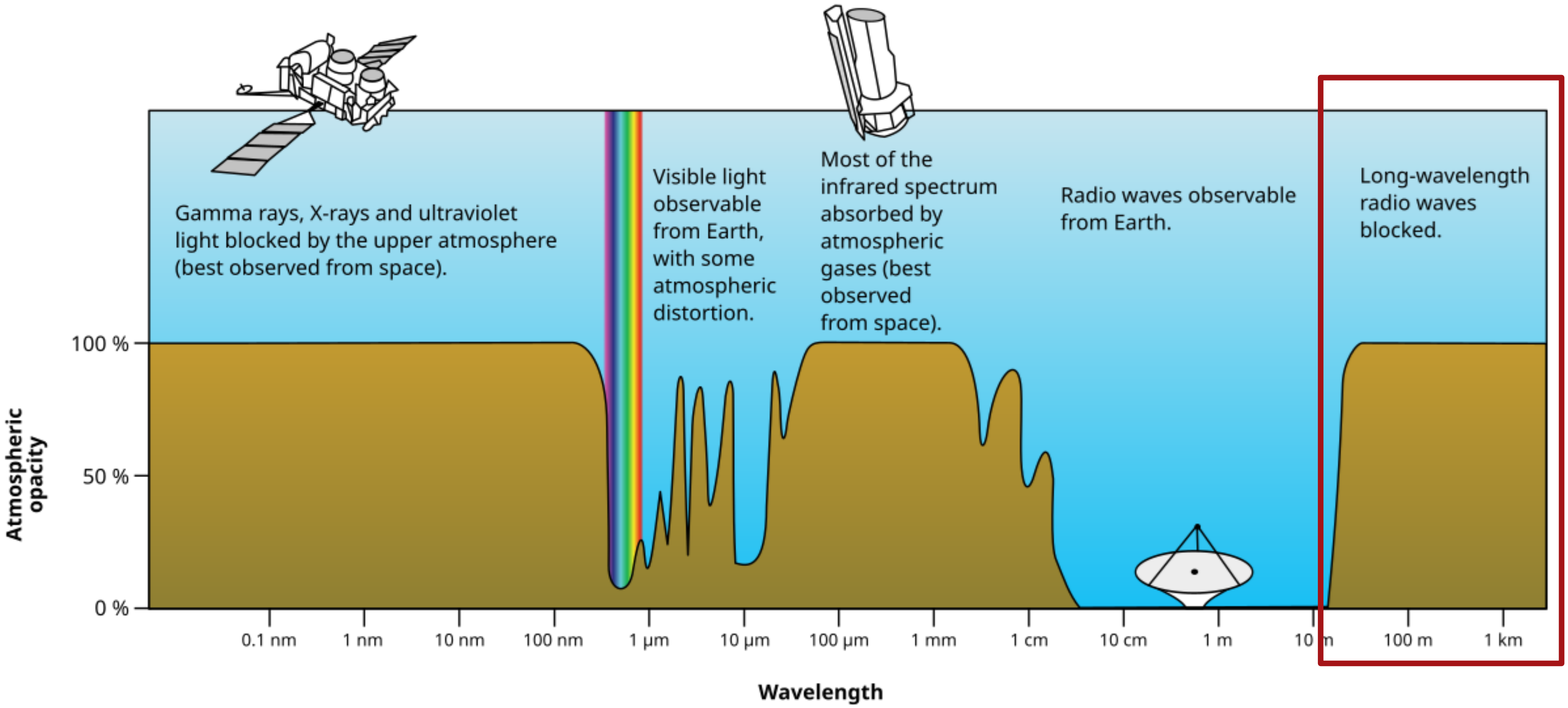
SPINOR Program Overview

Ben Cook, Sophie Fendler

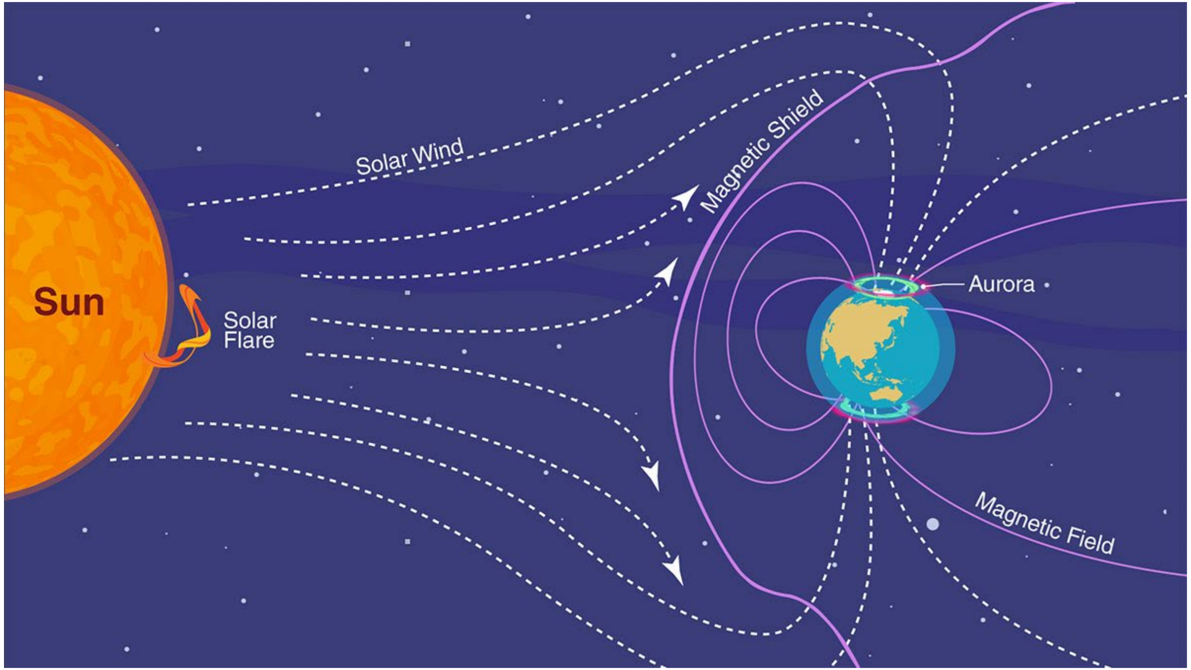
Radio Astronomy is Blind Below 30 MHz



[1,2]

This Frequency Band Has New Science

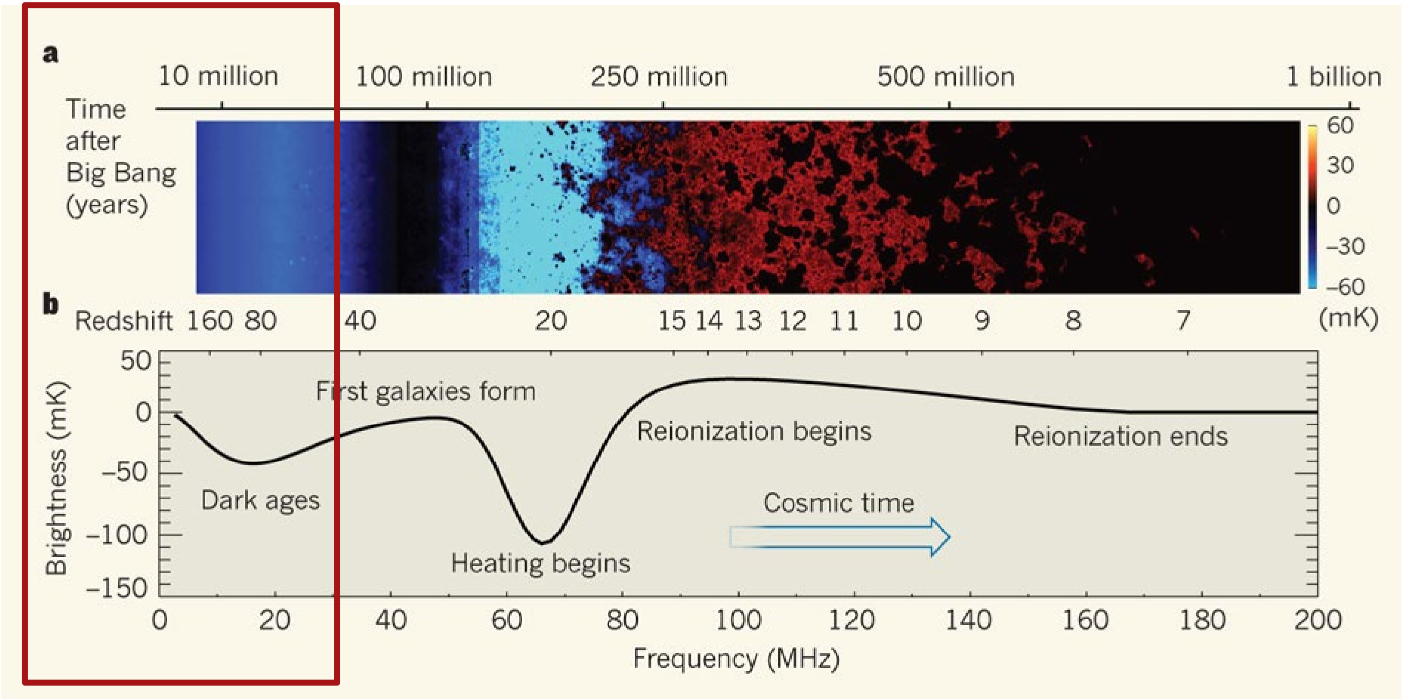
(1) The study of planetary magnetic fields



[4]

This Frequency Band Has New Science

(2) Extremely redshifted 21 cm hydrogen line



[5]

The Core Challenge is Physical

Resolution:

$$\theta \approx 1.22 \frac{\lambda}{D}$$

Sensitivity :

$$\mathrm{SEFD} = \frac{2kT_{\mathrm{sys}}}{A_{\mathrm{eff}}}$$

[7]

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$$\theta \approx 1.22\frac{\lambda}{\boxed{D}}$$

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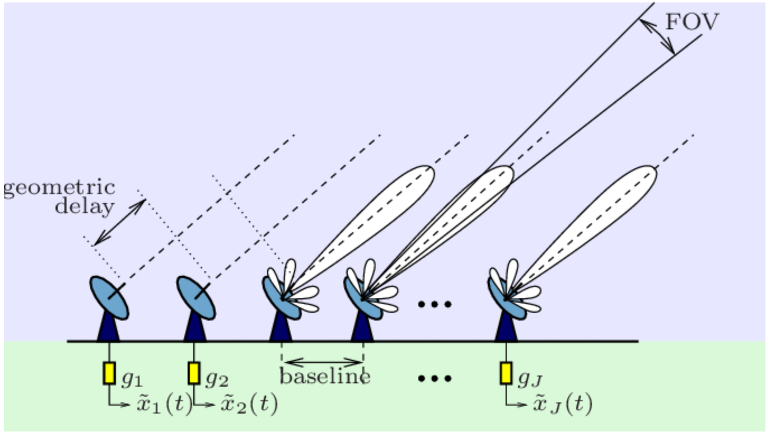
$$\mathrm{SEFD} = \frac{2kT_{\mathrm{sys}}}{\boxed{A_{\mathrm{eff}}}}$$

[7]

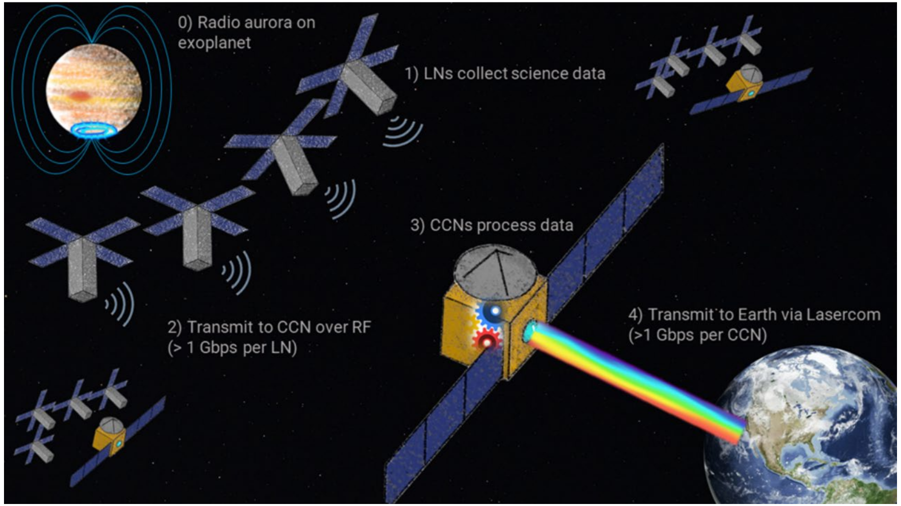
Interferometry: the Cornerstone of Modern Radio Astronomy



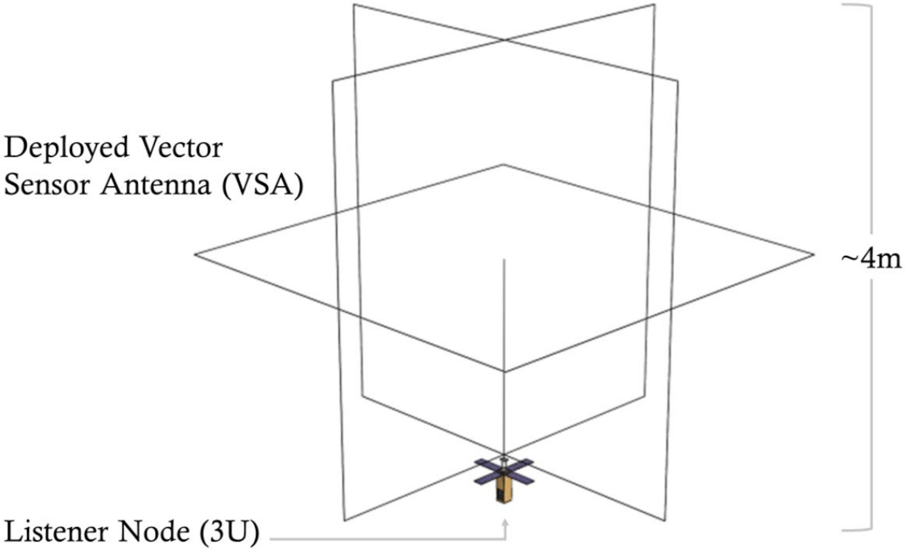
[8]

[9]

The MIT Haystack Observatory GO - LoW Proposal



[3]



[3]

Antenna Selection Priorities

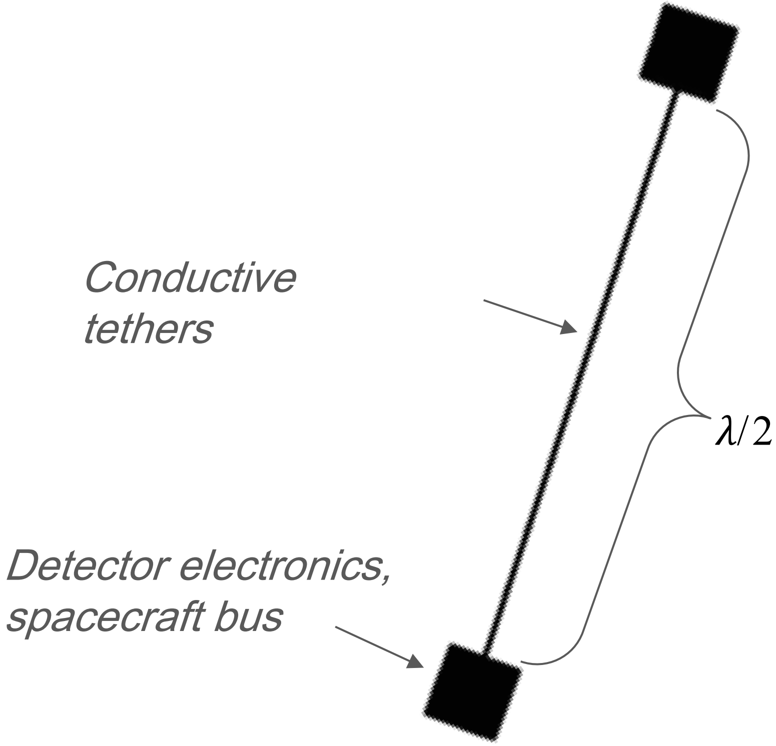
GO-LoW's choice – the vector sensor

	directionality	sensitivity	bandwidth	polarization	risk/TRL	SWaP	cost	total
weight	1	2	1	1	1	2	1	
electrically short antennas								
crossed dipole variants	3	3	1	3	1	1	1	17
tripole variants	3	3	1	2	1	1	1	16
vector sensor	2	2.5	1	1	2	1	2	15
resonant antennas								
crossed dipole variants	3	1	3	3	1	2	1	17
tripole variants	3	1	3	2	1	2	1	16
dish reflector - folding	1	1	2	1	3	3	3	18
dish reflector - inflatable	1	1	2	1	3	3	3	16
patch	2	1	3	1	3	3	3	20
horn & corugated variants	2	1	2	1	3	3	3	19
quadrifilar helix	2	1	3	1	2	3	2	18
log-periodic	2	1	1	1	2	3	2	16

[3]

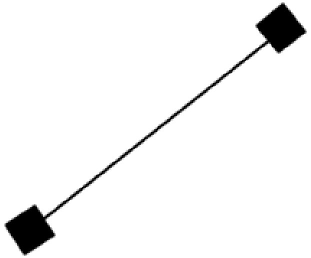
Spinning Past - Ionosphere Networked Observers for Radio

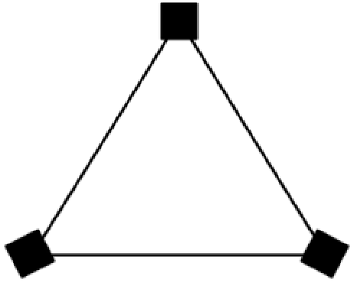
- Conductive tethers are $\lambda/2$ resonant antennas
- Rotation + precession passively stabilizes the structure and sweeps the sky
- Deconvolving creates a full-sky background intensity map from set of measured intensities
- Tether can be unwound to change frequency



Some SPINOR Configurations

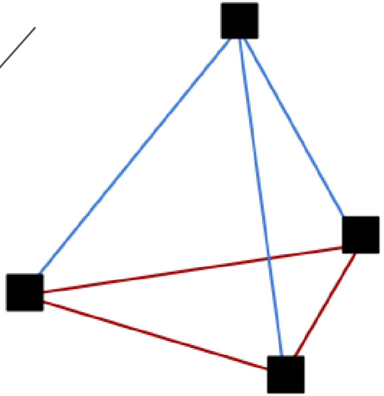
Monopole

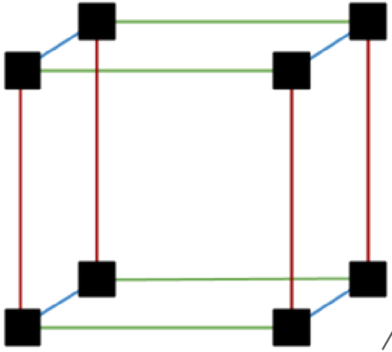




3-element phased array

Vector sensor





3x 4-element phased array

Tether Strength and Sensitivity

Momentum Conserved

$$T \propto \omega^2 L$$

$$\omega \propto \frac{1}{L^2}$$

$$T \propto \left(\frac{1}{L^4}\right)(L)$$

$$T \propto \frac{1}{L^3}$$

Sensitivity

$$\mathrm{SEFD} = \frac{2kT_{\mathrm{sys}}}{A_{\mathrm{eff}}}$$

$$A_e = \frac{\lambda^2}{4\pi} G$$

Antenna Selection Priorities

SPINOR potential – tetrahedron vector sensor

	directionality	sensitivity	bandwidth	polarization	risk/TRL	SWaP	cost	total
weight	1	2	1	1	1	2	1	
electrically short antennas								
crossed dipole variants	3	3	1	3	1	1	1	17
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tetrahedron vector sensor	2	1	2	1	2	2	2	15

[3]

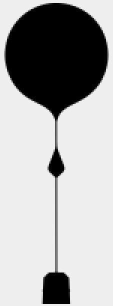
Key Technical Challenges

- Deconvolving will amplify any system errors (electrical noise, beamform inaccuracy, pointing error)
- Tethers must have high tensile strength-to-weight, be conductive, hold strength in vacuum and radiation, and withstand fatigue
- Suppression of solar and terrestrial radio interference
- Long-range communication to spinning system and data transfer across interferometric nodes

Technology Development Pathway

Sounding Rocket/Balloon

Test deployment in microgravity, examine ionospheric propagation.



[10]

Low Earth orbit

Demonstrate longevity, collect varied ionospheric science.

[11]

Cislunar orbit

Zero interference for optimal sky imaging.

[12]

Upcoming Analysis + Next Steps

1. Mission analysis (SWaP, sensitivity) for a baseline 6U tetrahedron in MEO
2. Mission concept paper publication
3. Future high altitude balloon deployment demonstration flight

Thank You!

Questions?

Ben Cook - b.j.cook@wustl.edu
Electrical & Systems Engineering

Sophie Fendler - a.fendler@wustl.edu
Physics

WashUSatellite.com

Contact us at: satelliteteam@wustl.edu

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