

Filling Technological Gaps for Planetary Science Missions with Customized SRI Solutions

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SRI International for NASA Planetary Science Technology Showcase

SRI International®

Areas of SRI Expertise

- Incoherent Scatter Radars – For NSF anthony.vaneyken@sri.com
- Interferometric Synthetic Aperture Radar – Used on CubeSat SRI-CIRES NASA Earth Science troy.stevens@sri.com
- Ground Penetrating Radar – For DoD/DARPA jeffrey.harrington@sri.com
- UHF Antenna Design Erin.rivard@sri.com
- Robotic Mobility jesse.wodin@sri.com
- Optics Design and Fabrication john.tower@sri.com brian.slovick@sri.com
- Novel diamagnetically levitated optical beam steering technology marcus.bagnell@sri.com
- Highly stable, space rated lasers w/ micro-radians of precision shon.cook@sri.com
- Quantum Sensors and Semiconductors joseph.christesen@sri.com

Past Mission Involvement

- Parker Solar Probe (PSP) – Wide-Field Imager for Solar Probe (WISPR)
Uses SRI's Active CMOS Detectors, Jim Janesick, jim.janesick@sri.com
- SRI CubeSat Imaging Radar for Earth Science (SRI-CIRES)
Mike Huff michael.huff@sri.com
Utilizes Interferometric Synthetic Aperture Radar (InSAR)
- Cyclone Global Navigation Satellite System (CYGNSS)
Data Analysis, April Warnock, April Warnock april.warnock@sri.com
- Sun Radio Interferometer Space Experiment (SunRISE)
Scientific Analysis Pipeline Design, Alex Hegedus alex.hegedus@sri.com *
- Radio Aurora Explorer (RAX) CubeSat Scientific Payload
Tony van Eyken anthony.vaneyken@sri.com
- Farside Array for Radio Science Investigations of the Dark Ages and Exoplanets (FARSIDE)
Scientific Analysis Pipeline Design, Alex Hegedus alex.hegedus@sri.com *
- Advanced Modular Incoherent Scatter Radar (AMISR)
Asti Bhatt asti.bhatt@sri.com and Tony van Eyken anthony.vaneyken@sri.com

* Work done while employed at University of Michigan

Advanced Modular Incoherent Scatter Radar (AMISR)

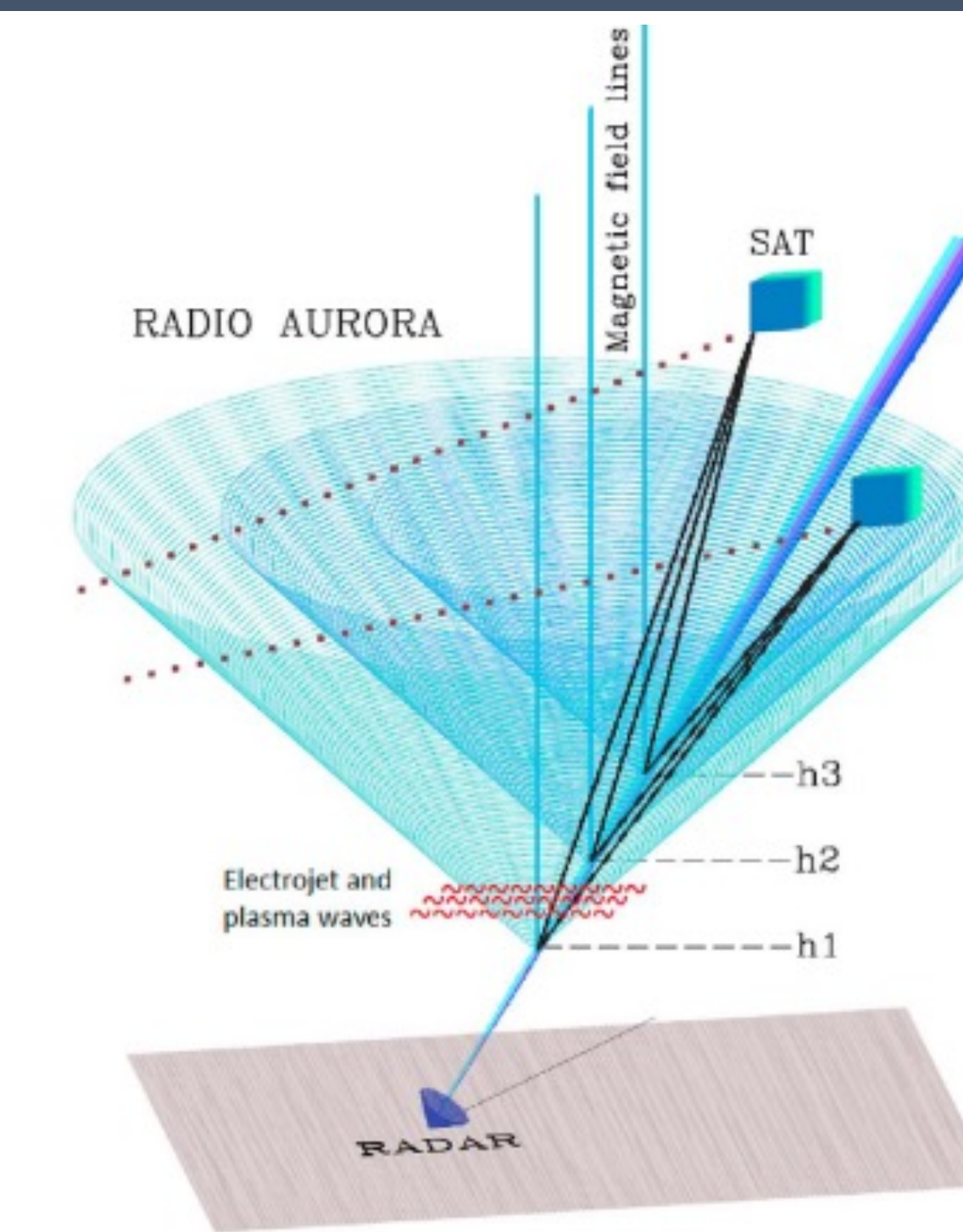
- AMISR designed and managed for the NSF
- Studies upper atmosphere and space weather events.
- Investigates the energy and momentum transfer among all layers of the Earth's upper atmosphere
- Provide scientists with the technology necessary to collect critical data and study global climate trends from year to year.
- Remote operation and instant electronic beam steering
- Modular design of AMISR enables relative ease of relocation
- Multiple designs & locations of AMISR: PFISR, RISR-N, RISR-C [4, 5, 6]



From [6], layout of PFISR, the AMISR face at Poker Flat, Alaska

Radio Aurora Explorer (RAX) CubeSat

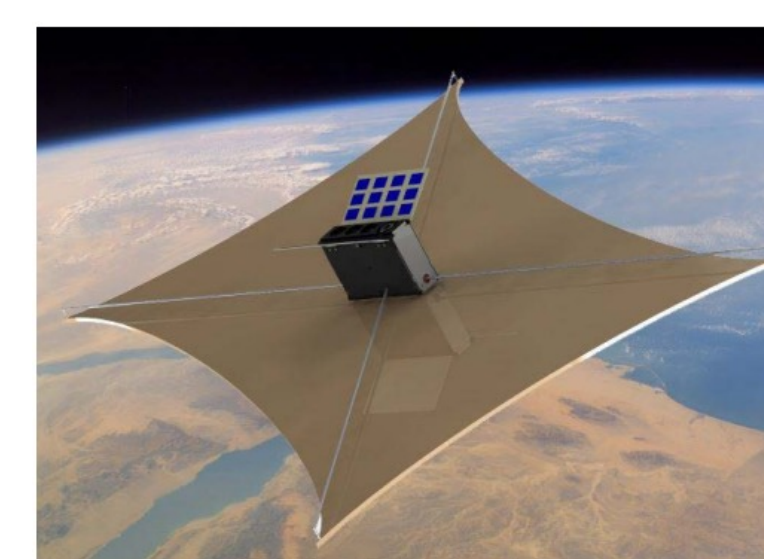
- Funded under the NSF CubeSat-based Space Weather and Atmospheric Research Program [1, 2]
- Ground-to-space bi-static radar to measure & understand causes of meter-scale ionospheric irregularities
- Orbits over PFISR to receive refracted radar signals
- Helps understand field-aligned irregularities (FAI), such non-thermal, coherent fluctuations of electron density
- FAI occur in response to strong ionospheric flows or plasma density gradients during geomagnetic disturbances
- FAI are considered a space weather concern due to disruption to communication and navigation signals



From [1], drawing of how RAX measures radio aurora (cones)

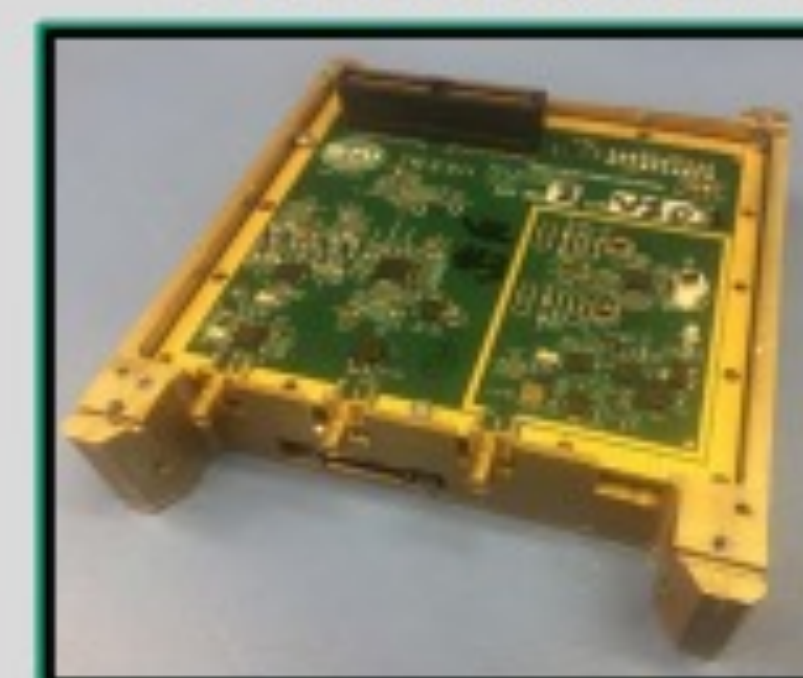
Interferometric Synthetic Aperture Radar (InSAR) in CubeSats

- SRI CubeSat Imaging Radar for Earth Science (SRI-CIRES) funded by Earth Science Technology Office's Instrument Incubator Program (ESTO-IIP) [7]
- 5 meter resolution in a CubeSat form factor with deployable ~6.5 m² phased array antenna

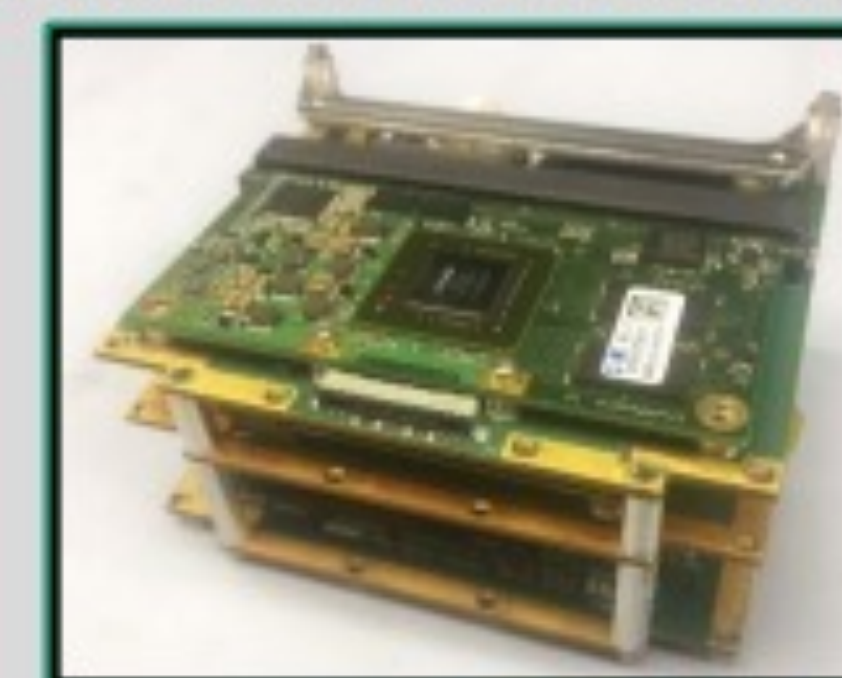


Figures from [7], showing design of SRI-CIRES

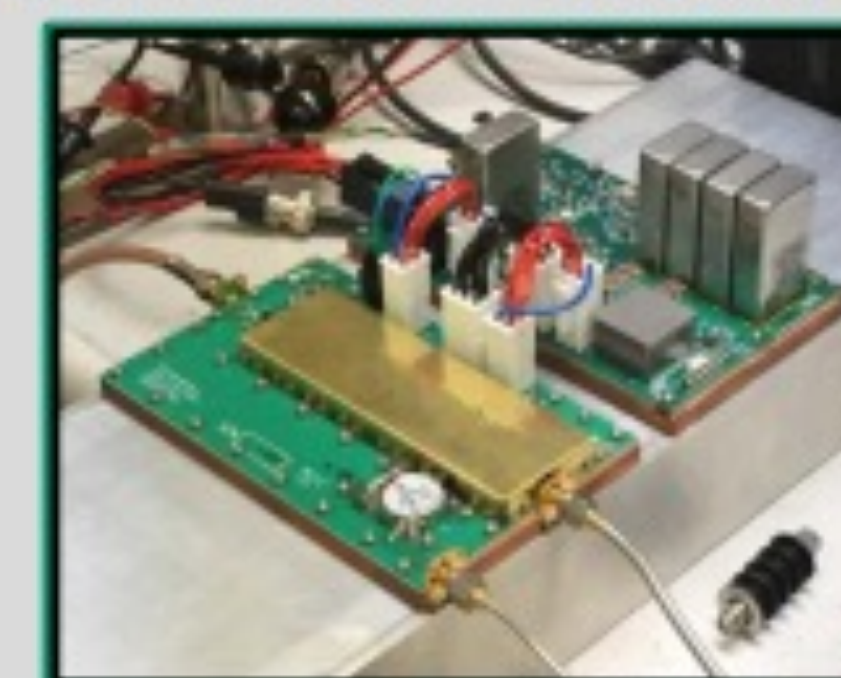
CubeSat SAR Payload advanced to 5 m resolution and extended up to 3.5 GHz



Tx/Rx Module: Transmit and Receive RF analog chains, calibration loopback circuits, integrated ADC and DAC capability.



High Speed Processor Module: Power Regulation, FPGA, Data Storage, Multi-core Processor; >250 MB/s write-speed to > 1 TB non-volatile storage; >500 GFLOPs on-board processing



PA Module: 600 W peak (60 W avg), includes internal power regulation, power driver stages and RF power amplification (supports 2.9-3.1 GHz or 3-3.5 GHz)



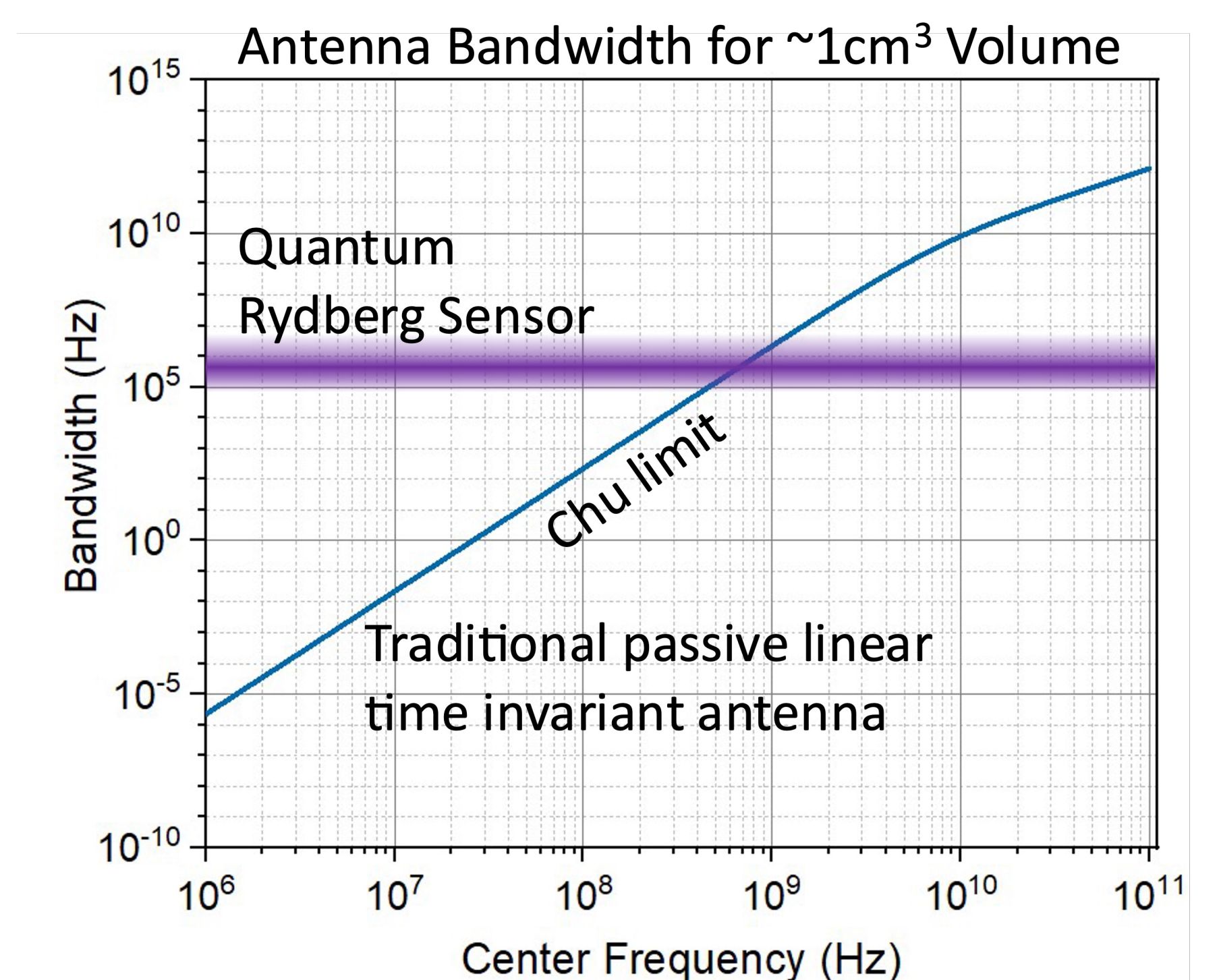
CubeSat SWaP: Radar payload electronics packaged into 1.3U CubeSat form factor

Quantum Receivers

Approach: Use Rydberg atoms to convert RF to optical signals with high sensitivity. Each atom acts like an independent "antenna", imprinting baseband of an incident RF carrier onto an optical signal. [3]

Advantages:

1. Resonant access to HF to sub-THz bands: SRI approach allows access to wide range of resonances, in some cases beating the Chu limit
2. All-dielectric construction/optical control and preparation. Minimizes perturbations
3. Dynamic range: Receiver may be "turned off" via preparation lasers
4. Approach uses all-NIR lasers compatible with long fiber lengths and mature photonic integrated circuit (PIC) technology



References

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7. Wye et al., "SRI CubeSat Imaging Radar for Earth Science (SRI-CIRES): Initial Flight Demonstrations", Earth Science Technology Forum June 14, 2018. Accessed 12/21/22. <https://www.earth-science-technology.com/2018/06/14/initial-flight-demonstrations/>

Acknowledgements

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The Resolute Bay Incoherent Scatter Radar (RISR-N) is operated by SRI International on behalf of the U.S. National Science Foundation under NSF Cooperative Agreement AGS-1133009