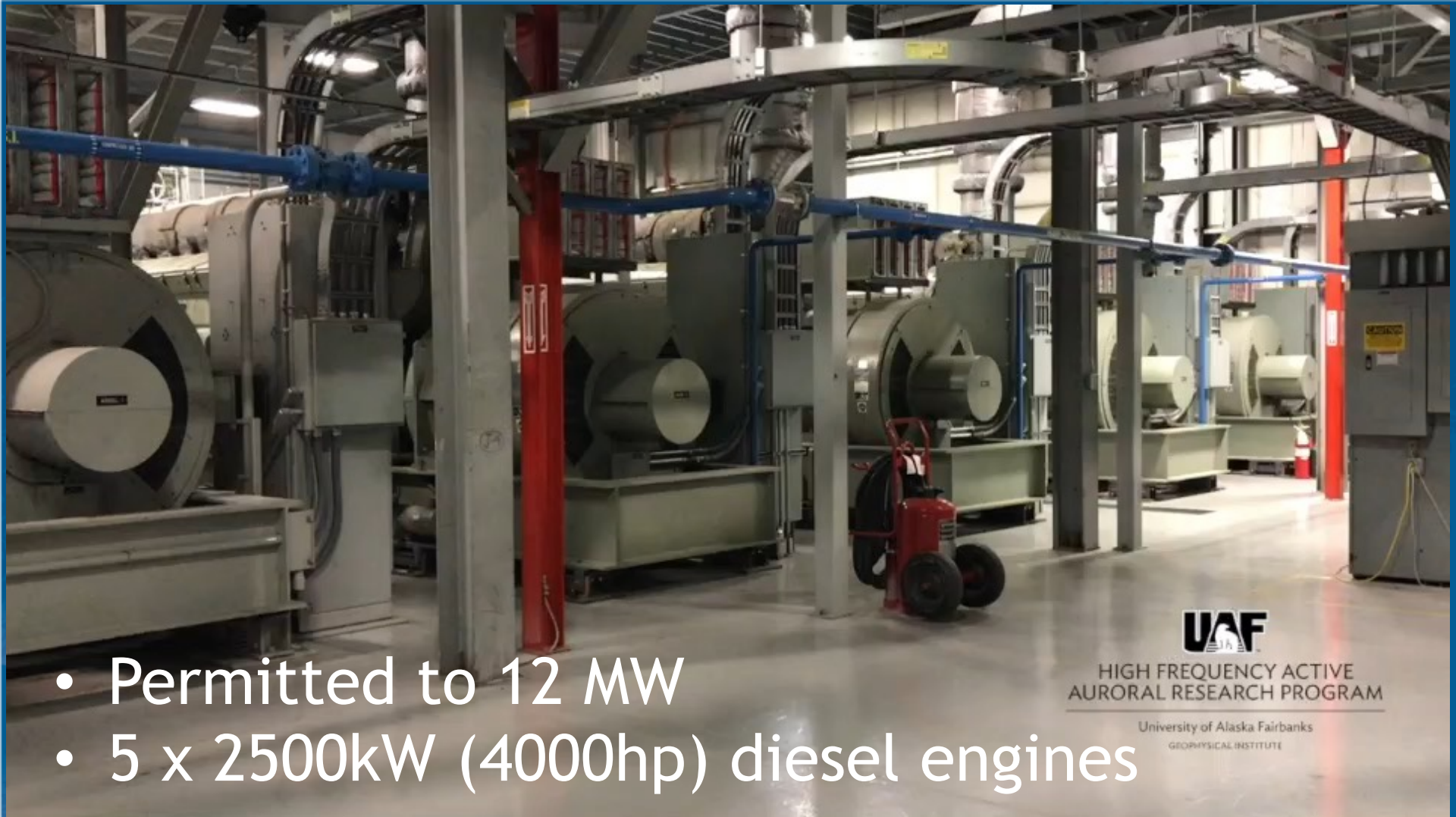


Using HAARP to build a Subauroral Geophysical Observatory in Gakona AK



- Gakona AK - 62.39 deg, 145.15 deg
- 33 acre phased HF transmitter array
- 5 x 4000 hp diesel engines; 12MW
- 2.8 to 10 MHz; 3.6 MW
- \$290M (half Congressional earmarks + half AFRL, ONR & DARPA)

Bob McCoy, Jessica Matthews
Geophysical Institute
University of Alaska Fairbanks
Dave Hysell
Cornell University



- Permitted to 12 MW
- 5 x 2500kW (4000hp) diesel engines



HIGH FREQUENCY ACTIVE
AURORAL RESEARCH PROGRAM

University of Alaska Fairbanks
GEOPHYSICAL INSTITUTE



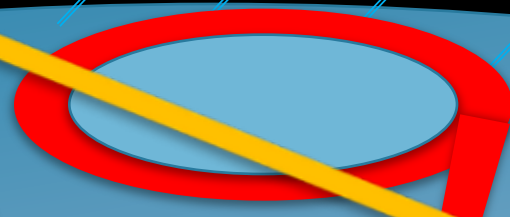
High-frequency Active Auroral Research Program (HAARP)



HF Ionospheric Heating

**ULF, ELF, VLF
wave injection**

- Heating
- Duct creation
- Airglow
- Wave generation
- Currents
- Chemistry
- Plasma resonances
- Instabilities
- Turbulence



**Rotating
beams**

**Multiple
beams**



**Submarine
Communication**

**Radiation Belt
Remediation**

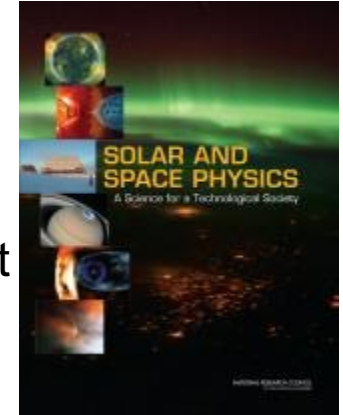
Magnetic Field Lines



2013: Two National Research Council Studies Involving HAARP

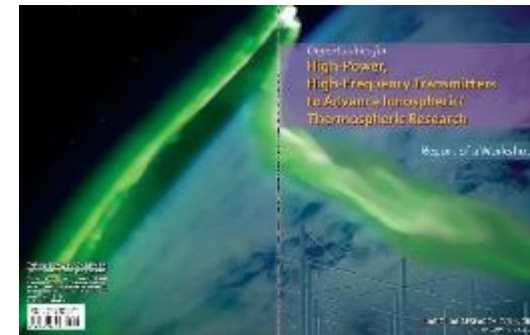
- **2013 Decadal Survey in Solar and Space Physics**

- Priority - Fully realize the potential of ionospheric modification techniques through collocation of modern heating facilities with a full complement of diagnostic instruments including incoherent scatter radars. This effort requires coordination between NSF and DOD agencies in planning and operation of existing and future ionospheric modification facilities.



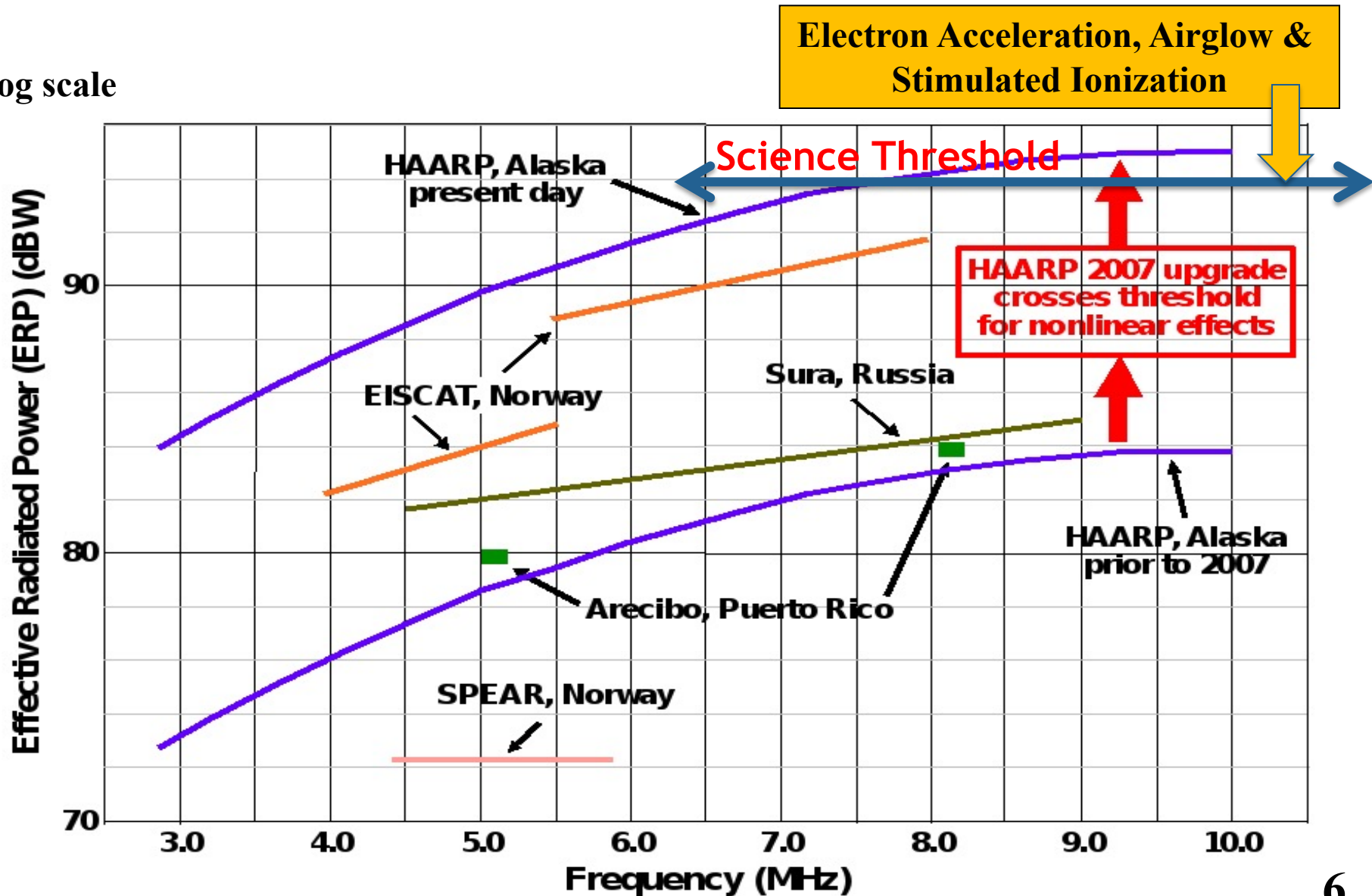
- **Mar 2013 - Workshop: Opportunities for High-Power, High-Frequency Transmitters to Advance Ionospheric/Thermospheric Research**

- NRC Workshops do not provide recommendations but report contains 72 pages of HAARP science
- Themes: Geospace and space weather; Stimulated emission and radiation belts; radio science, communications, and radar
- Strong recommendation to co-locate incoherent scatter radar



HAARP Compared to EISCAT, Sura & Arecibo

Log scale



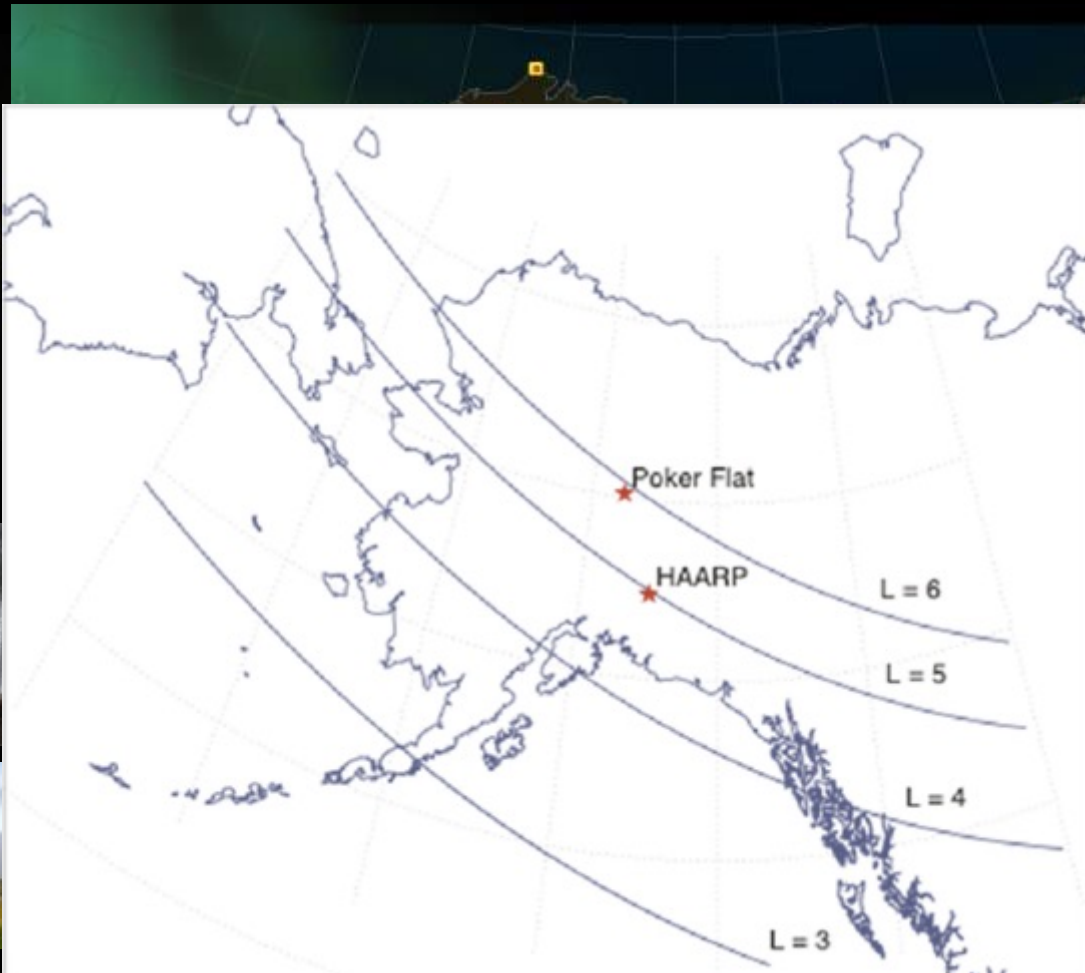
Alaska Ionospheric Infrastructure



All-Sky



PFISR



SuperDARN



Diagnostics

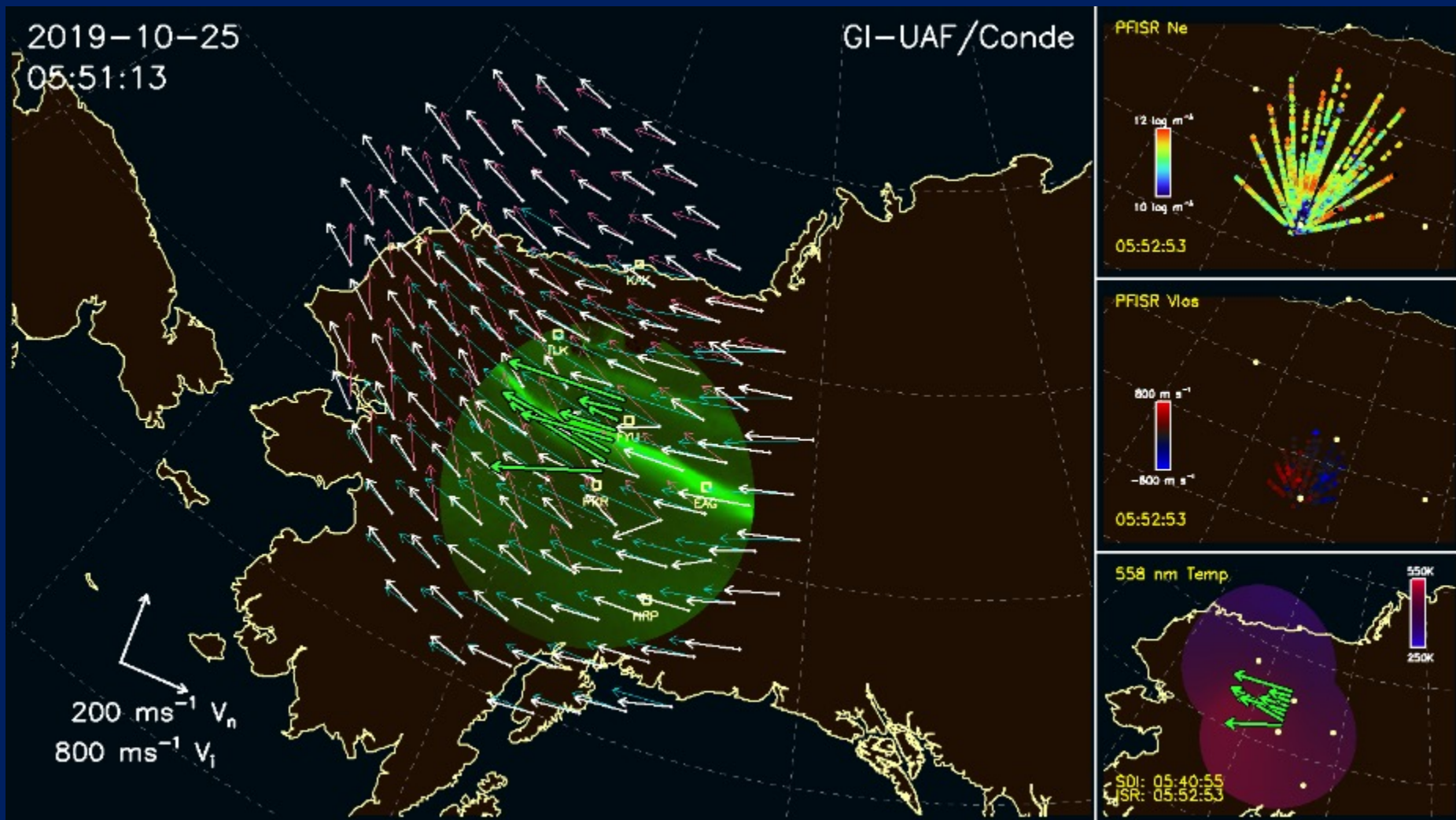
Organization	PI	Instruments
Johns Hopkins APL	Syau- Yun Hsieh	GPS Septentrio Receiver
		Optics
Nagoya University (JAPAN)	Shin Oyama	Riometer
		Magnetometer
		All Sky Camera
		VLF Receiver
Cornell	Dave Hysell	Photometer
		Astra CASES GPS Receiver
		Inverted V HF Dipole (temp i
University of California Berkeley	Harald Frey	THEMIS GBO
US Array, IRIS, EarthScope	Bob Woodward	Seismometer
University of Colorado	Jade Morton, Steve Taylor	GNSS(1/3)
		GNSS (2/3)
		GNSS (3/3)
MIT	Don Hampton	GPS Septentrio Receiver
Reeve Obs	Whitham Reeve	Radio Jove
		TCI Ant
		Lightning Detection
		Weather Station

Diagnostics

Organization	PI	Instruments
UAF	Rich Collins	LIDAR
NRL	Paul Bernhardt	TCI-540 Transmitter
AVO	John Paskievitch	WAZA
UAF HAARP	HAARP	Digisonde
UAF GI	Don Hampton	Magnetometer
		All Sky Imager
UAF HAARP	HAARP	ITS-30 Satellite Receiver
UAF GI	Jeffrey Freymueller	GNSS Crustal Deformation
UAF HAARP	HAARP	HF Spectrum Receiver and Spectrum Analyzer
UAF HAARP	HAARP	HF Dipole

Modular UHF Ionospheric Radar (MUIR)

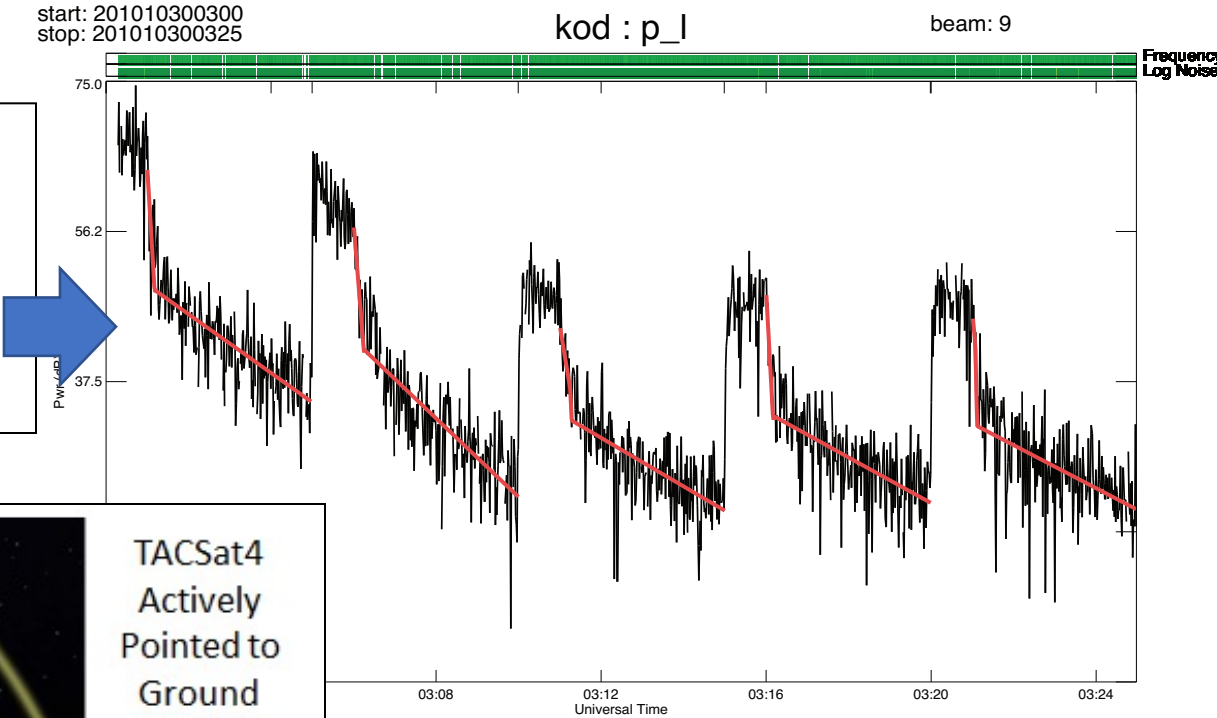




Snapshot of a real-time composite space-weather status display from the night of October 25, 2019 during a G2 class magnetic storm, and shortly before a substantial increase in magnetic activity began over Alaska. The main panel shows SDI winds, a mapped all-sky camera image, and PFISR ion convection arrows.

Previous HAARP Results

Bristow – Decay rates of scattered power related diffusion of the neutral atmosphere.



COMMX Working with HAARP

TACSat4 Actively Pointed to Ground Receiver

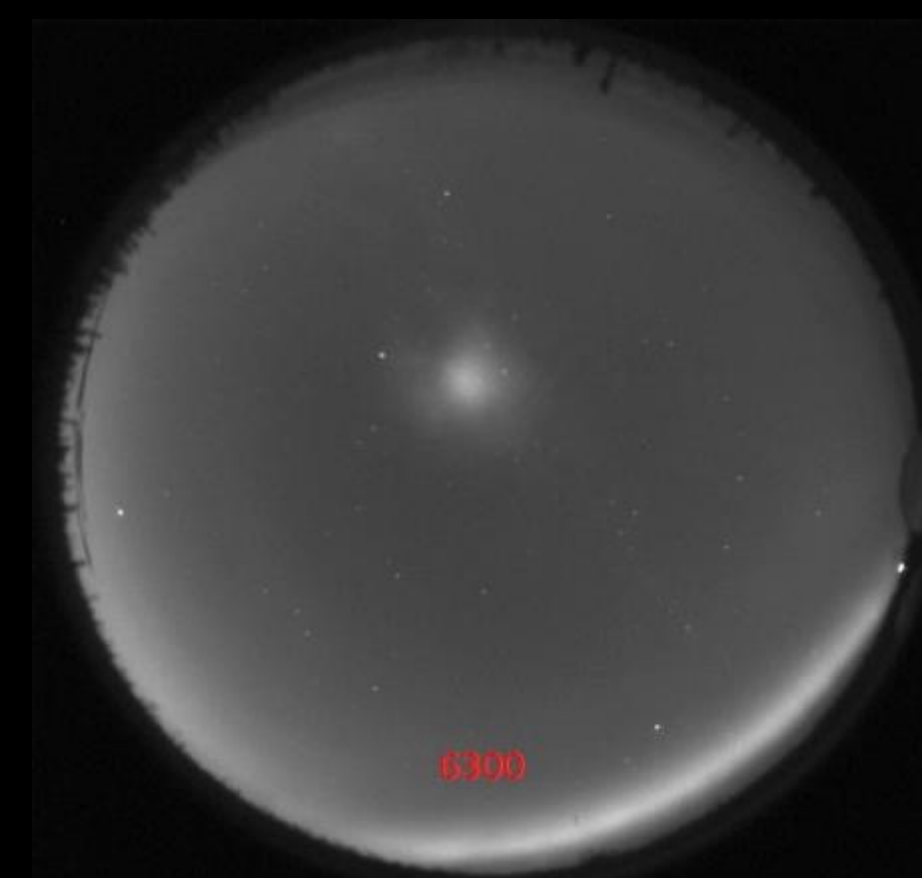
Modified Region

F-Layer Ionosphere

Courtesy Paul Bernhardt
NRL

Bernhardt – Triggered scintillation used to server space-to-ground UHF communication

Chris Fallen Experiment: First simultaneous high-power HF radio aurora and SSTV broadcast, Sep 2017



Twitter, Inc.

 **Walter Salmaniw**
@VolodyaVik [Follow](#)

Replying to @ctfallen

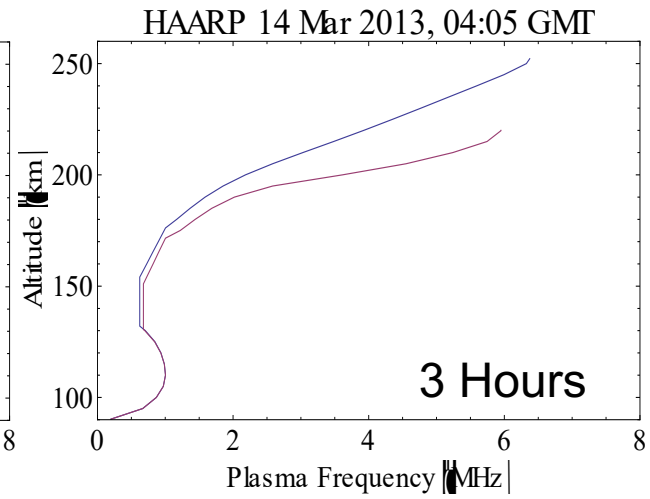
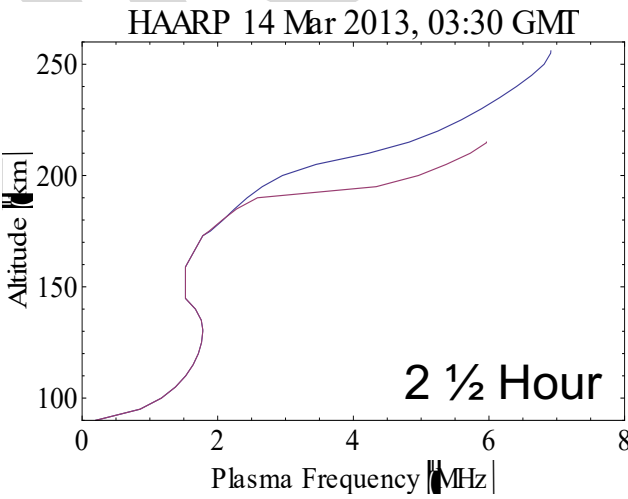
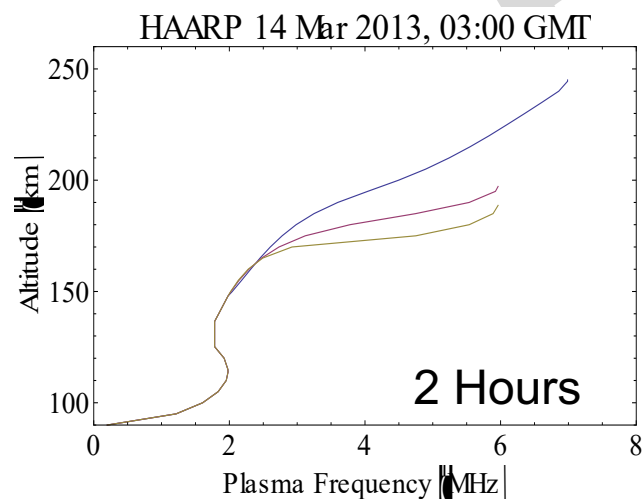
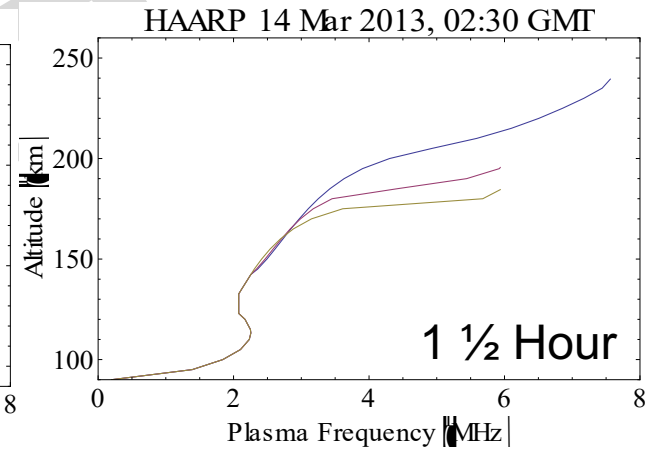
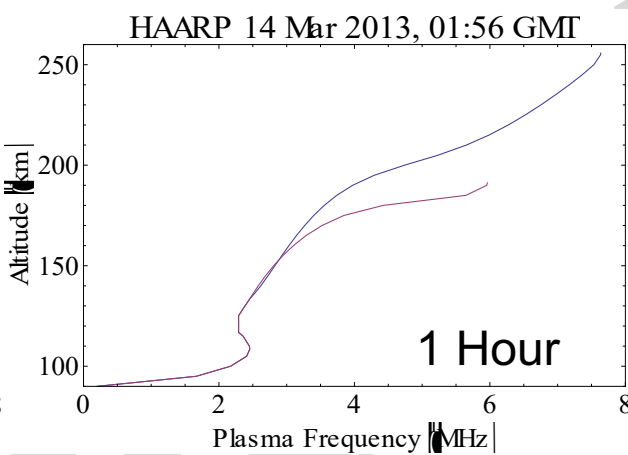
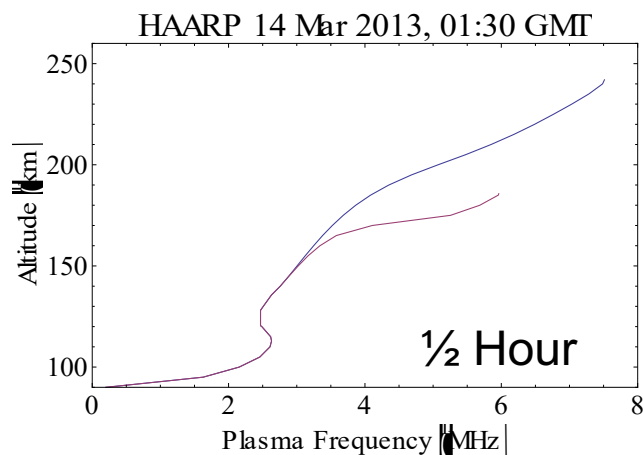
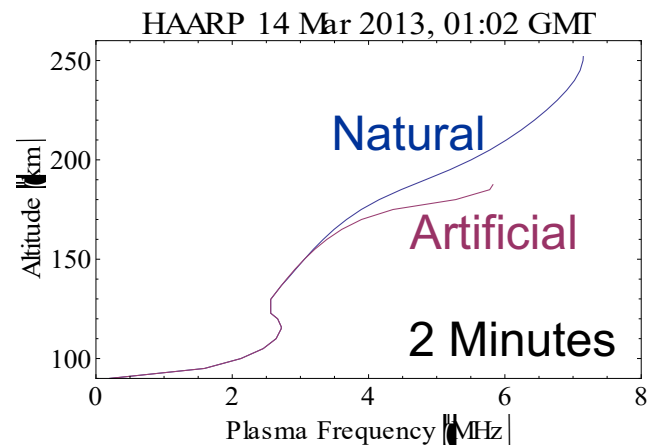
05:41, 05:44 and 05:53 recorded by my MixW program. Nice reception, indeed, from Victoria, BC



12:10 AM - 26 Sep 2017

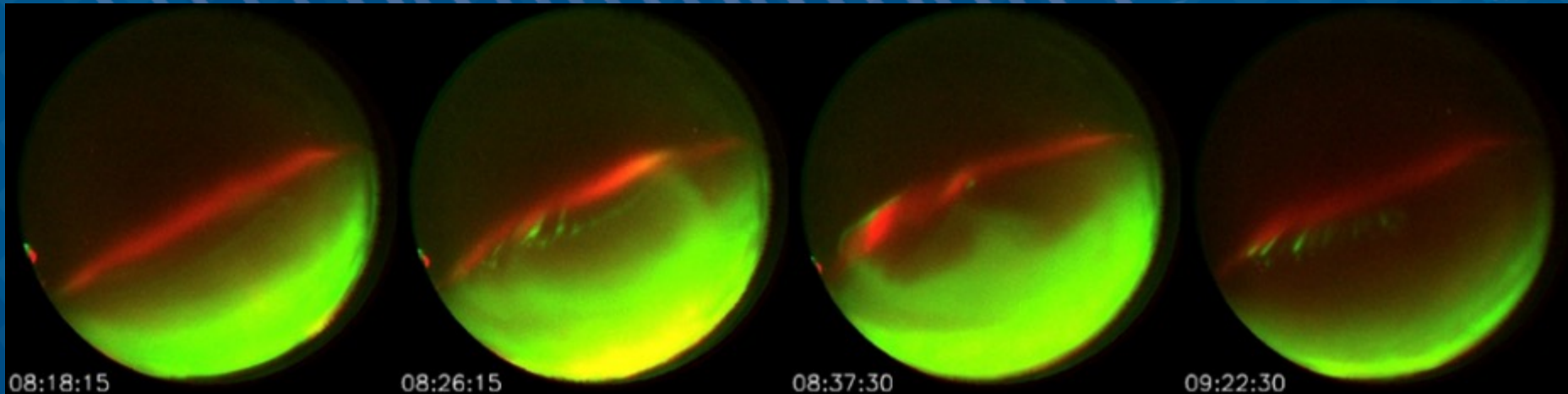
14 March 2013 01:30 to 04:00 GMT Extended Artificial Ionization with 5.8 MHz Twisted Beam

Courtesy Paul Bernhardt
NRL



SAGO – A great place to study STEVE

Don Hampton

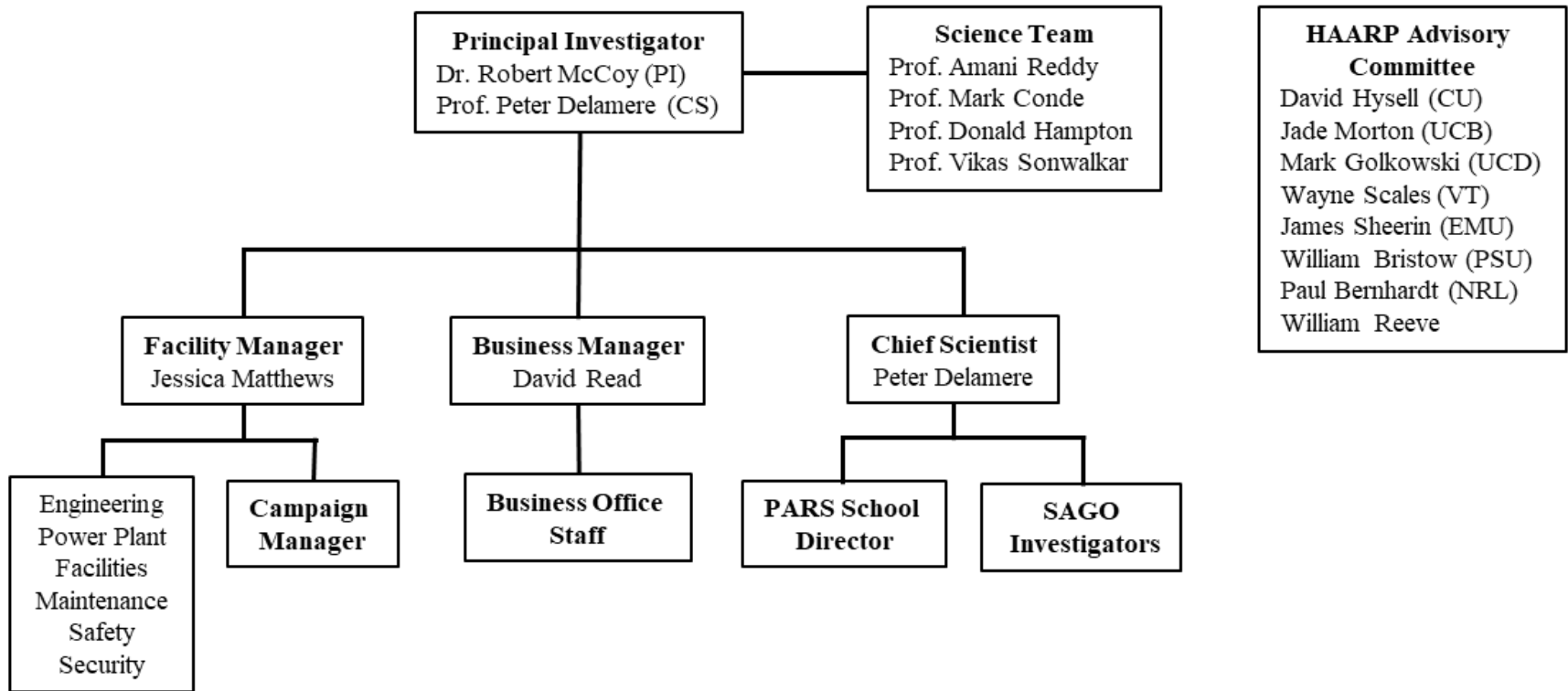


Four snapshots from a filtered all-sky imager at Gakona showing the dynamics of a STEVE event and associated picket fence structures. The two colors are the auroral red line (630.0 nm) and green line (557.7 nm) of atomic oxygen. In this display N is to the bottom and E is to the right, as if looking up in the sky. The images show that SAGO is an ideal site for examining these intriguing features.

Strong Thermal Emission Velocity Enhancement (STEVE)

Subauroral Geophysical Observatory (SAGO) 2021 NSF Award

Subauroral Geophysical Observatory Management



Iron Resonance Wind-Temperature LIDAR (IRWTL) for HAARP

- Solid-state laser 372 nm will be built at PFRR with existing IRWTL before being moved to HAARP
- Collaboration UAF, GATS and German Aerospace Center (DLR) Collins, Thorsen, Li, Williams & Kaifler
 - Combining lidar & radar to yield accurate D-region electron density estimates and ELF/VLF generation processes
 - PMC-PMSE ice particle charging processes
 - Processes determining E-region winds
- Postdoc Opportunity - Contact Richard Collins at rcollins@alaska.edu



NSF #204862



Reinstitute Polar Aeronomy and Radio Science (PARS)

- Faculty & graduate student
- Classes, tours & HAARP experiments
- Alaska experience





**June
2021**

