

Space Physics, Aeronomy and Toolik Field Station:

What we do, why we do it, and why TFS.

Who is doing Physical
research at TFS?



Space Physics at Toolik

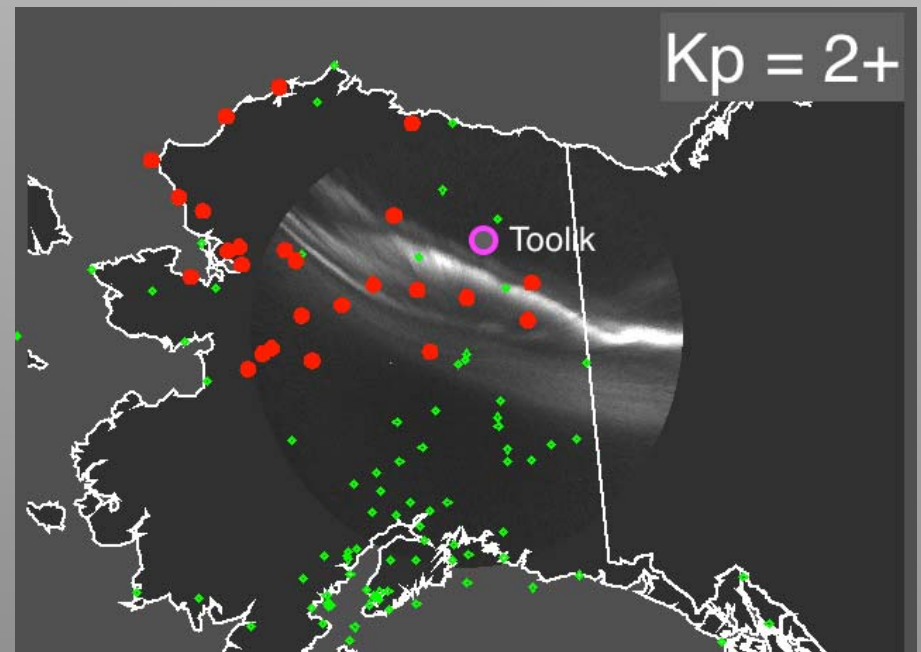
- There are three main space physics groups conducting research at Toolik
 - Conde Group:
 - All sky implemented Fabry-Perot Interferometry
 - Thermospheric wind velocity and temperature measurements
 - Rocket-based chemical release observations
 - Hampton Group:
 - Optical observations
 - Magnetic field measurements
 - Dual frequency GPS Scintillation measurements
 - Ad Hoc collaborative users:
 - Dartmouth Group : RF auroral signal collection (coregistered with other groups' work)
 - US Air Force Academy : High speed auroral scintillations
 - Tohoku University : Flickering Aurora
 - NASA Goddard Space Flight Center : Optical auroral studies in conjunction with sounding rockets and satellites

Why are we Researching at TFS?

Photo Credit : John Elliott University of Alaska Fairbanks

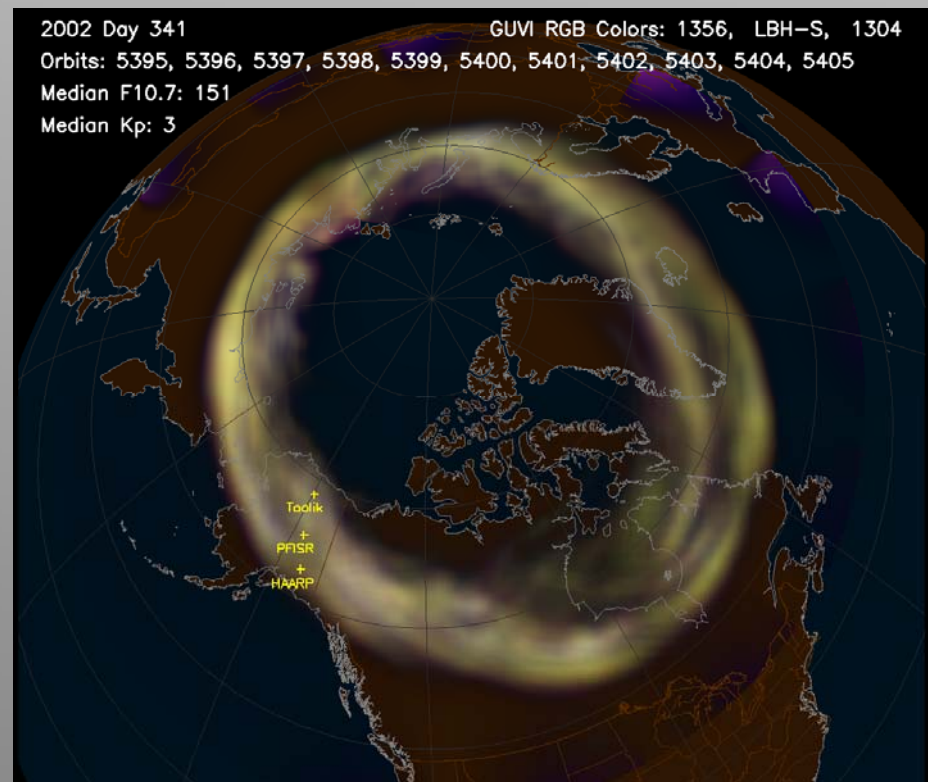
TFS: Ideal for Aeronomy Studies

- Optically clear
 - Relatively clearer skies on North side of Brooks mountain range
 - Lower levels of light pollution
 - Low population density (low variation of unknowns)
- Radio quiet
 - Very low levels of RF noise
- Infrastructure already established
 - Logistics support, electricity, network, ease of access to location



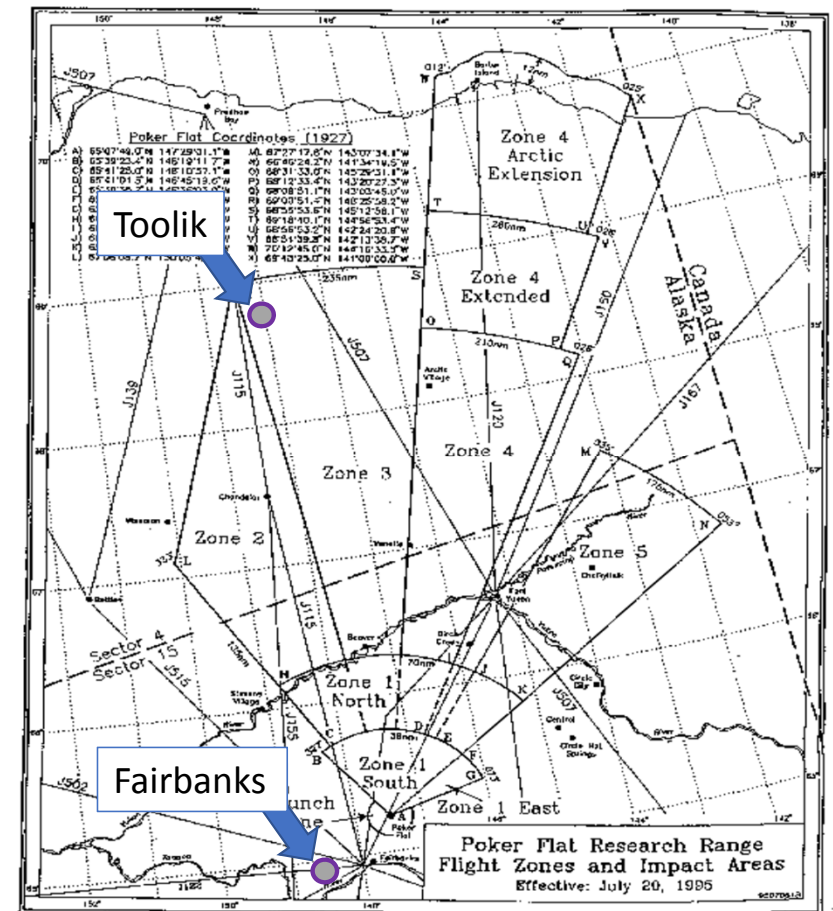
TFS: Ideal for Auroral Studies

- High frequency of auroral activity, particularly during periods of low geomagnetic activity. Broad range for low-level observations (Kp1-3+)
- Alaska is the only United States territory with frequent aurora
- Geography and climate permit relatively high probability of observing aurora nightly



TFS: Ideal for Rockets!

- Campaigns out of Poker Flat Research Range (PFRR) often require observation from multiple look directions
- TFS is ideal for meridional observations
- Combined location with optical quietness and existing infrastructure, TFS is perfectly situated for PFRR missions.



What are we Researching at TFS?

Photo Credit : John Elliott University of Alaska Fairbanks

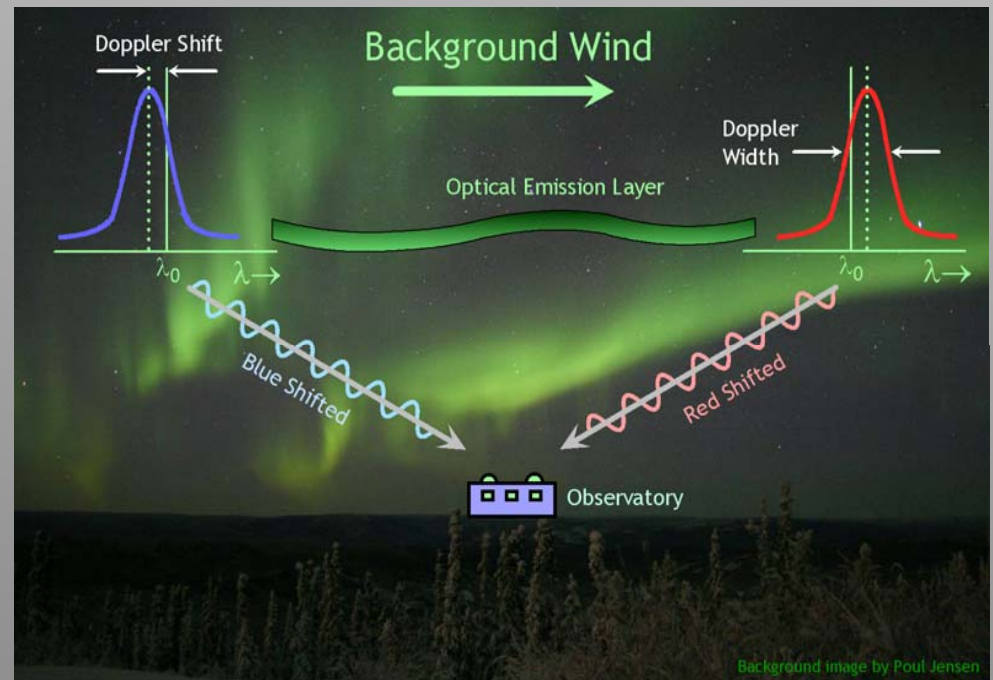
**Conde Group:
Fabry-Perot Interferometry and
Rocket-based chemical release
observations**

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Conde Group: Fabry-Perot Interferometry (FPI)

- Measuring airglow and auroral emission spectra in thermosphere
- Doppler shift gives line-of-sight speed from volume element to FPI
- Width of spectra defines temperature in thermospheric region of interest
- Green-line (5577Å) O⁺ and red-line (6300Å) O⁺ are measured with a spectral resolution of ~10 picometers (1/10 the diameter of an atom)



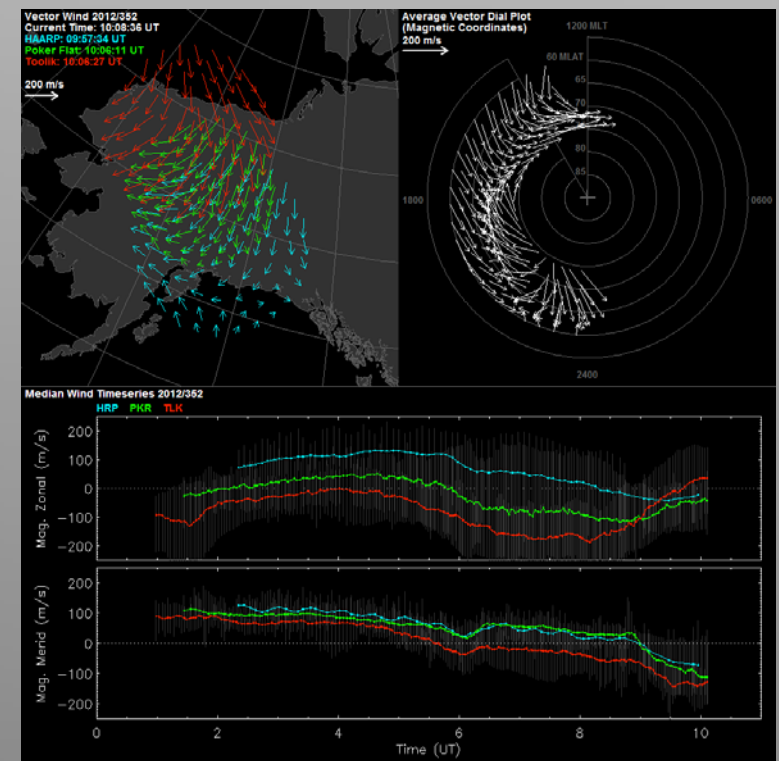
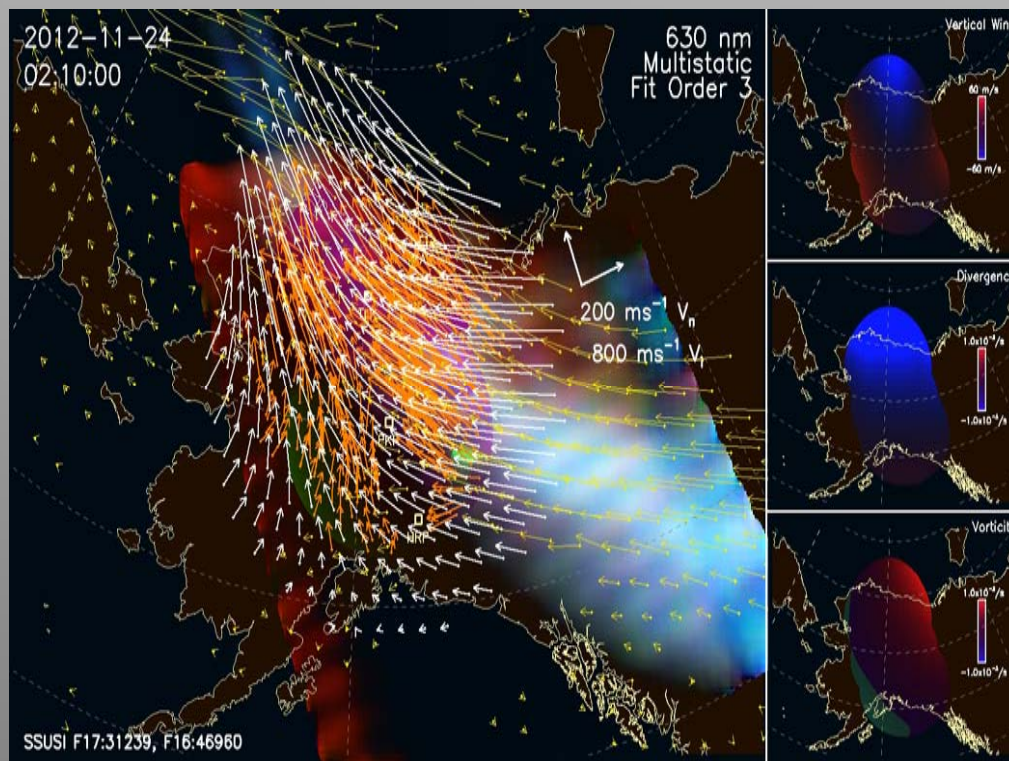
Scanning Doppler Imager (SDI), A new FPI

- c.1990 the Geophysical Institute began construction a new FPI design
- SDI is an all-sky implemented FPI capable of observing 115 near temporally-simultaneous geographically independent measurements of LOS winds and temperatures
- Two networks of 6 SDIs have been constructed to date
 - 4 overlapping SDIs in Alaska (Toolik, PFRR, Eagle, Kaktovik)
 - 460 geographically overlapping temporally pseudo-simultaneous measurements
 - 2 in Antarctica (South Pole, McMurdo)
 - 230 geographically independent temporally pseudo-simultaneous measurements



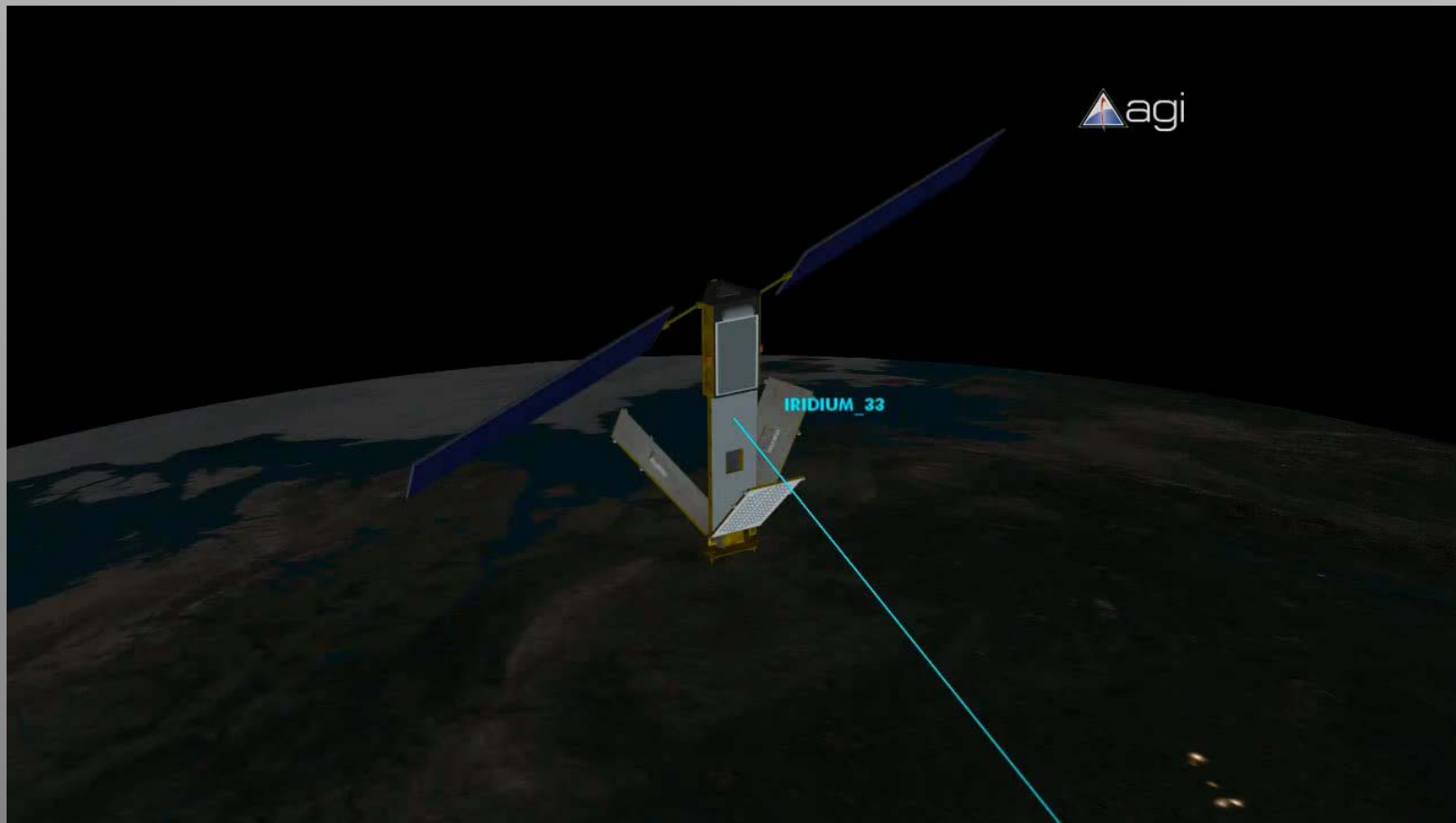
Image courtesy of Mark Conde , UAF

SDI Results : A New View of the thermosphere over Alaska



Video and Image courtesy of Mark Conde , UAF

Why is this Important? A lesson from Iridium



Video courtesy of Mark Conde , UAF

Conde Group : Sounding Rocket Missions

- Validation of thermospheric wind inference models made in-situ with sounding rockets
- Altitudes between 100km – 900km are investigated from PFRR (250km typical)
- Thermospheric measurements are made by dispersing trimethylaluminum (TMA) for neutral winds or a mix of principally Barium for ions and neutrals
- Launch missions often have requisite observations needed. Toolik provides meridional regime



Video courtesy of Mark Conde , UAF

Hampton Group: Poker Flat Downrange Optical Capabilities

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Downrange PFRR Optical Instruments

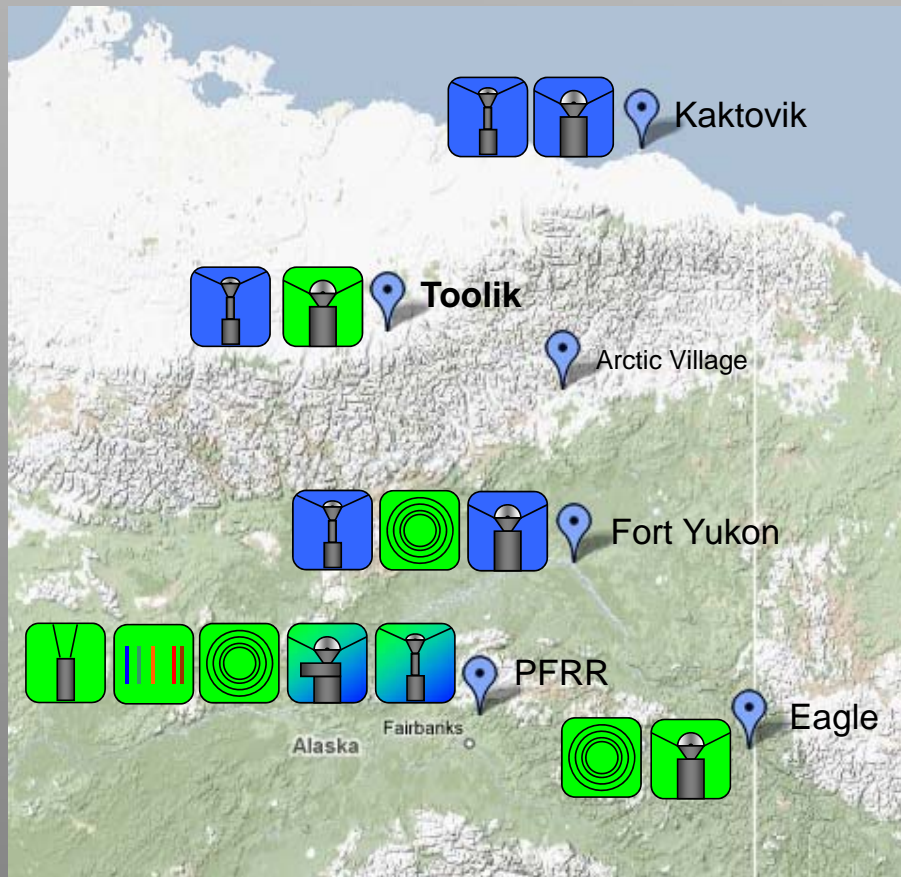










Image courtesy of Don Hampton, UAF

Key	
	PFRR
	PFISR Instrument
	Poker Filtered Digital All-sky
	Meridian Spectrograph
	Downrange Digital All-sky
	PFISR Fabry-Perot
	Narrow-field spectrograph
	Filtered Narrow-field Imager

Optical Assets

(U.S. Funded and operated)

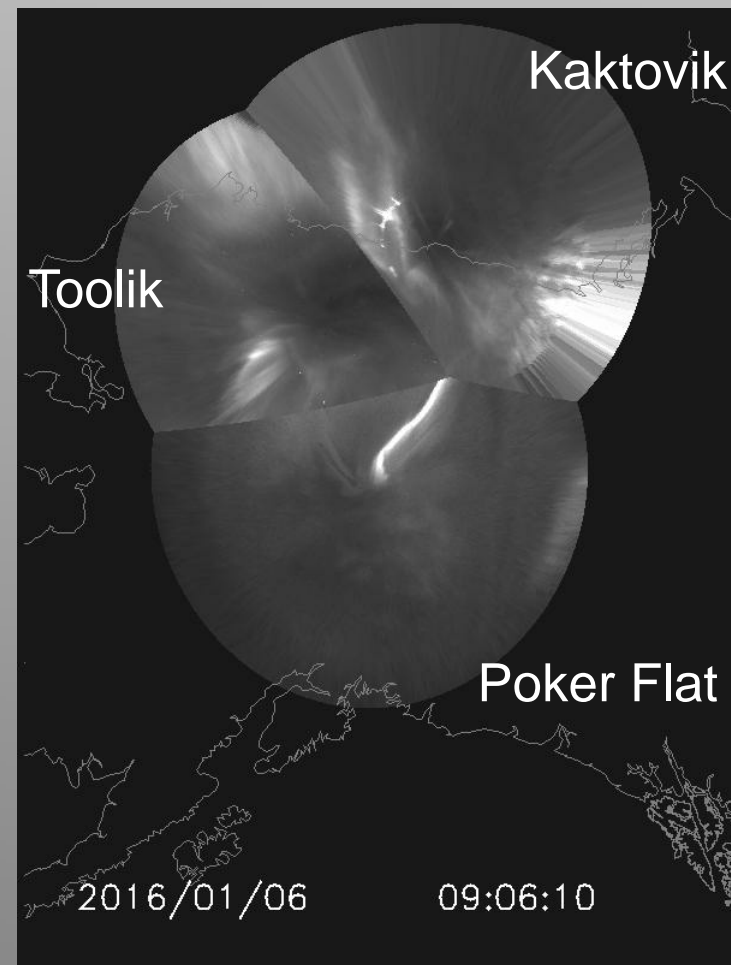
Station	GPS	Digital ASC	Meridian Spectrometer	Narrowfield Imager	Narrowfield Spectrometer	Fabry- Perot	Magnet- ometer
Poker Flat	Y	Y	High-res Meridian Spectrograph	ICCD, EMCCD, (MOOSE)	BUNS Aerospace Photometer	SDI AMISR	Y
Fort Yukon	Y	Y	Y	Campaign	N Aerospace Photometer	AMISR	Y
Eagle	Y	Y	N	Campaign	N	SDI AMISR	Y
Toolik	Y	Y	Y	Campaign	N	SDI	Y
Kaktovik	Y	Y	Y	Campaign	N	SDI	Y

Digital All-sky Camera

- ATIK 314+ Sony ICX285AL
 - Monochrome

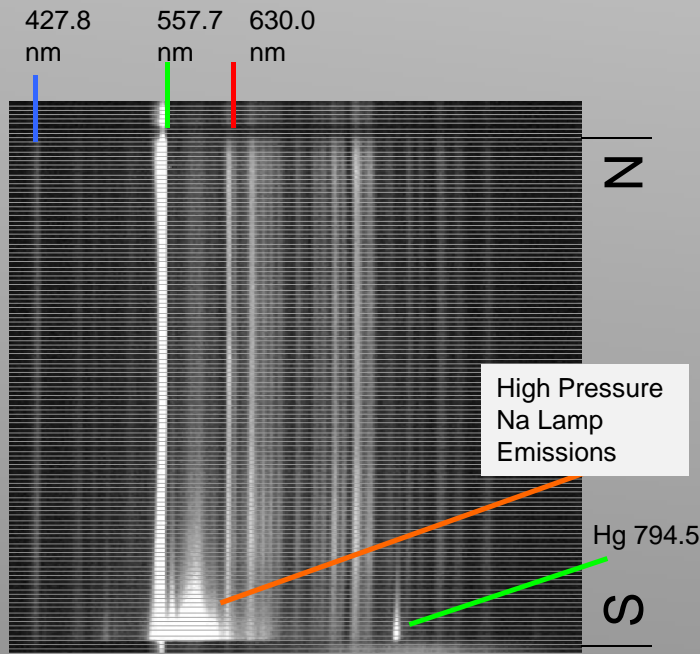
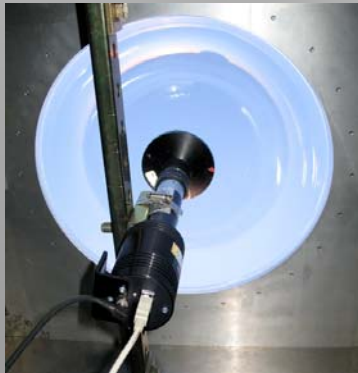


- Part of a network of all-sky cameras used for sounding rocket and Space Weather research

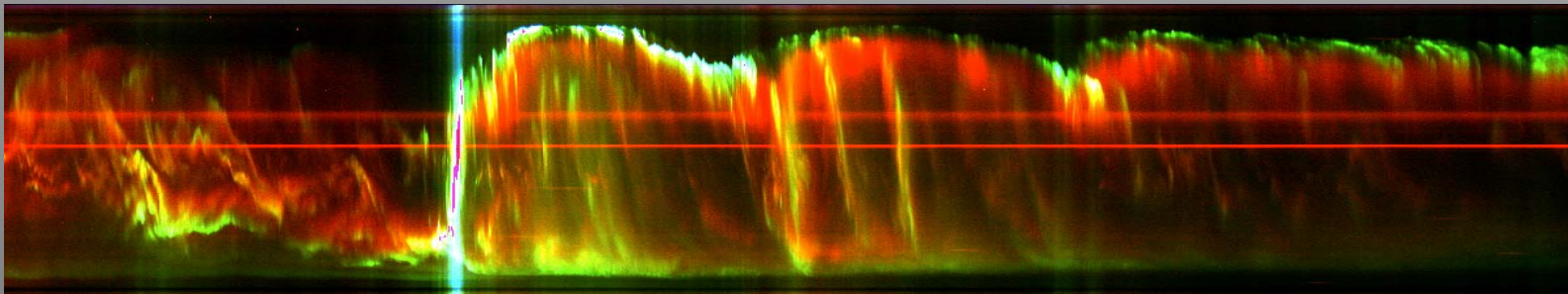


Video and Image courtesy of Don Hampton, UAF

Compact Solid-state Meridian Spectrograph



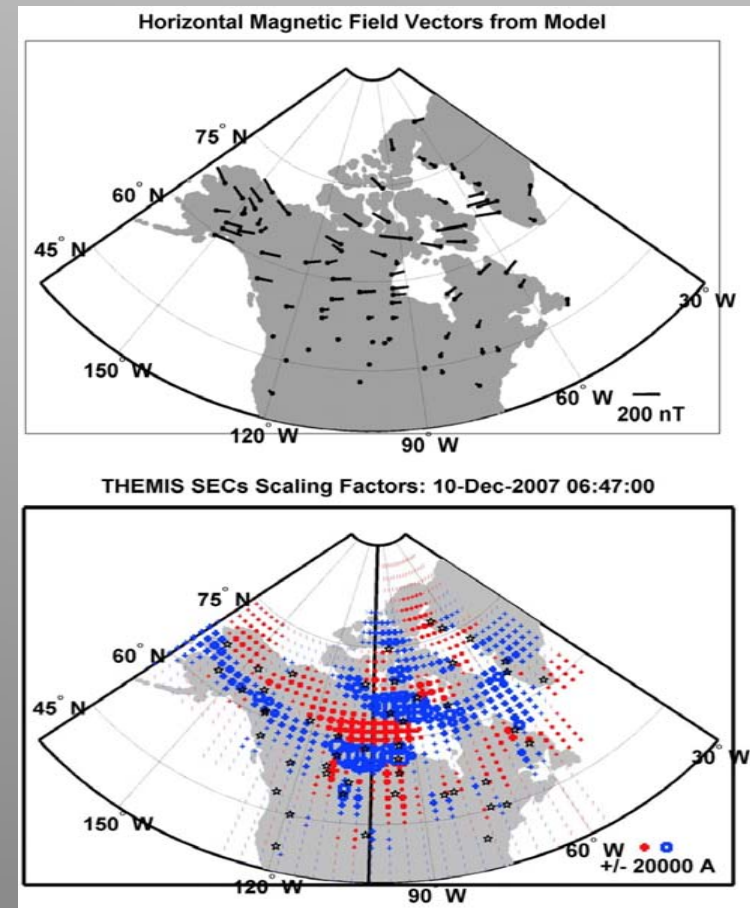
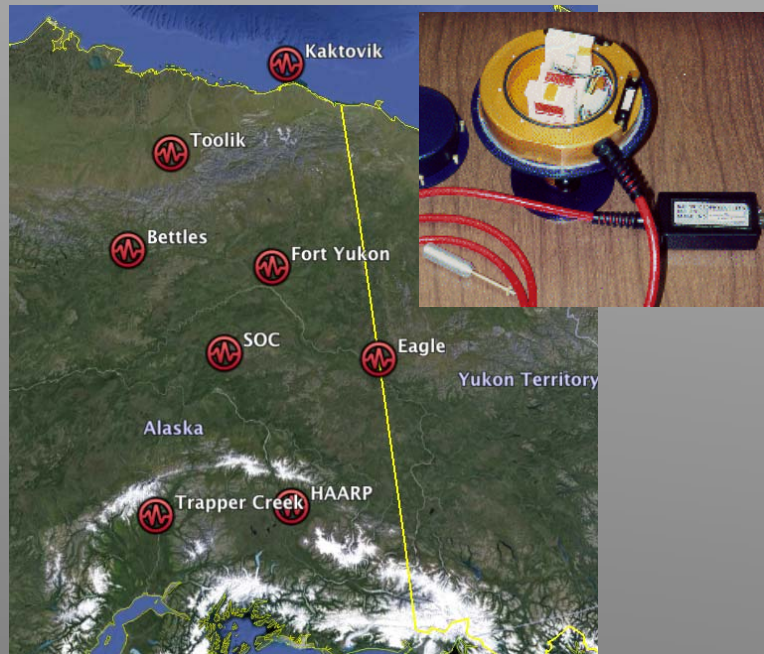
Ratios of
emission lines
tell us about
the energetics
of the
electrons
producing the
aurora



Images courtesy of Don Hampton, UAF

GI Magnetometer Array

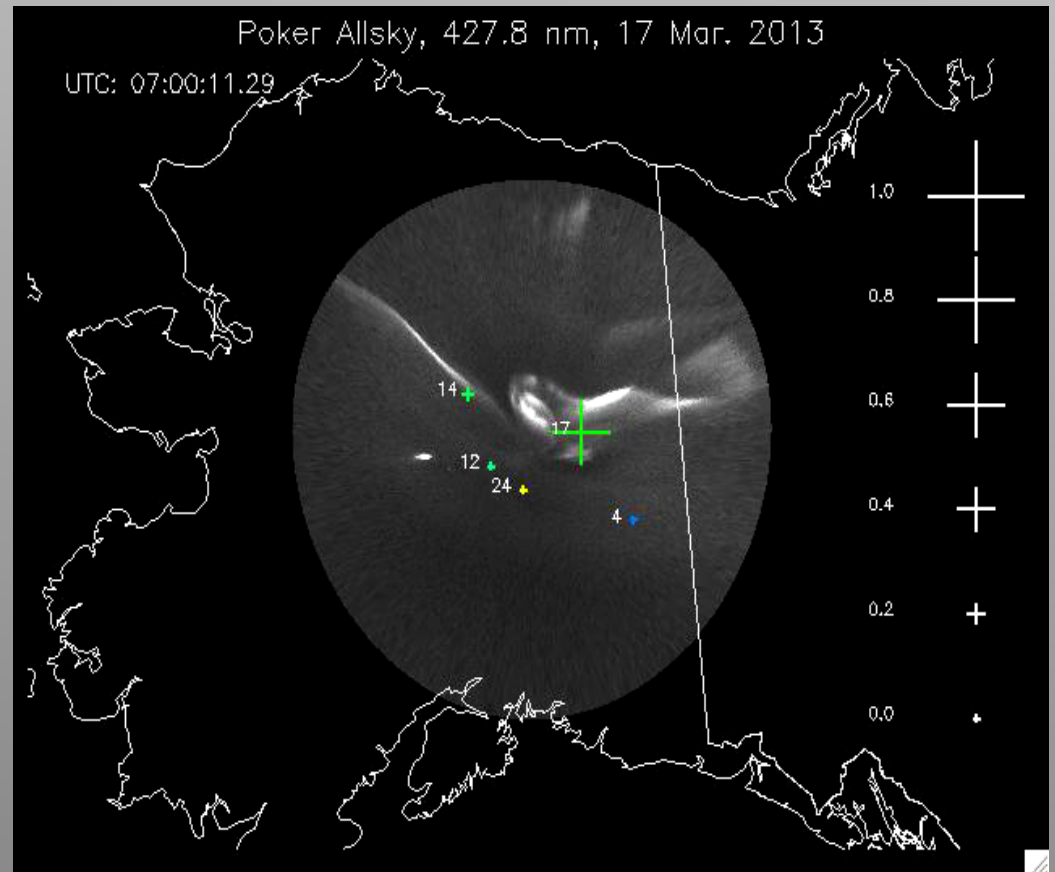
Toolik mag is part of an array of magnetometers used to determine ionospheric and magnetospheric currents



Images courtesy of Don Hampton, UAF

GPS Scintillation and Total Electron Content

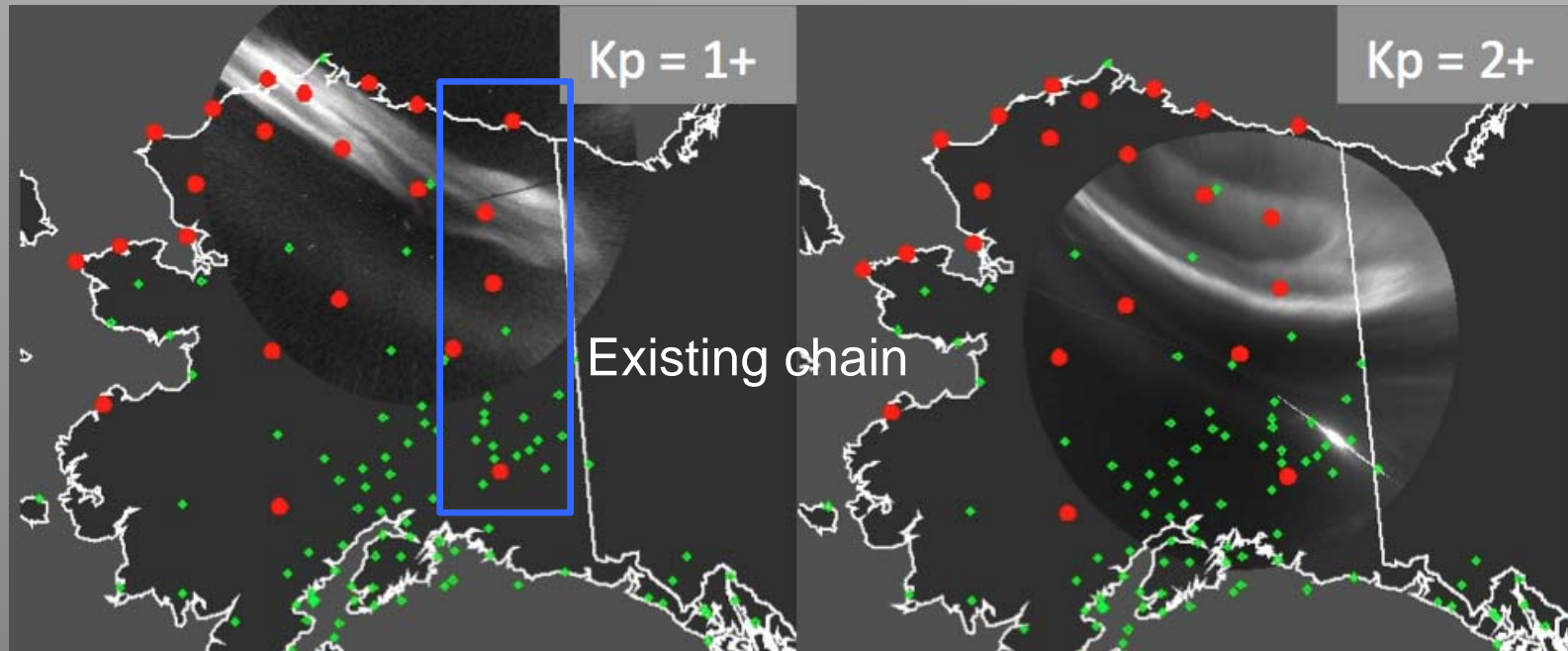
- Uses dual frequency GPS signal to measure index of refraction in atmosphere
- Can infer total electron content between receiver and GPS Sat.
- Correlates highly with auroral activity (new physics)
- Toolik is part of a larger network of



Video courtesy of Don Hampton, UAF

GPS Array Expansion

Proposed to add ~20 new dual-frequency GPS receivers sites.



Images courtesy of Don Hampton, UAF

Dartmouth Group: RF antennas and receivers

The aurora emits radio waves in addition to visible light. These radio emissions are significant for at least three reasons:

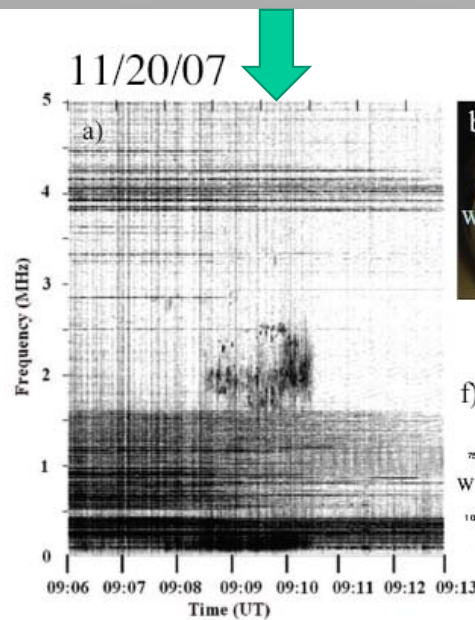
- they play a role in the dynamics of aurora and other phenomena
- they bring us information about conditions and processes in the ionosphere at several hundred kilometers altitude
- They are similar to radio emissions at other planets and stars which are much more difficult to study directly



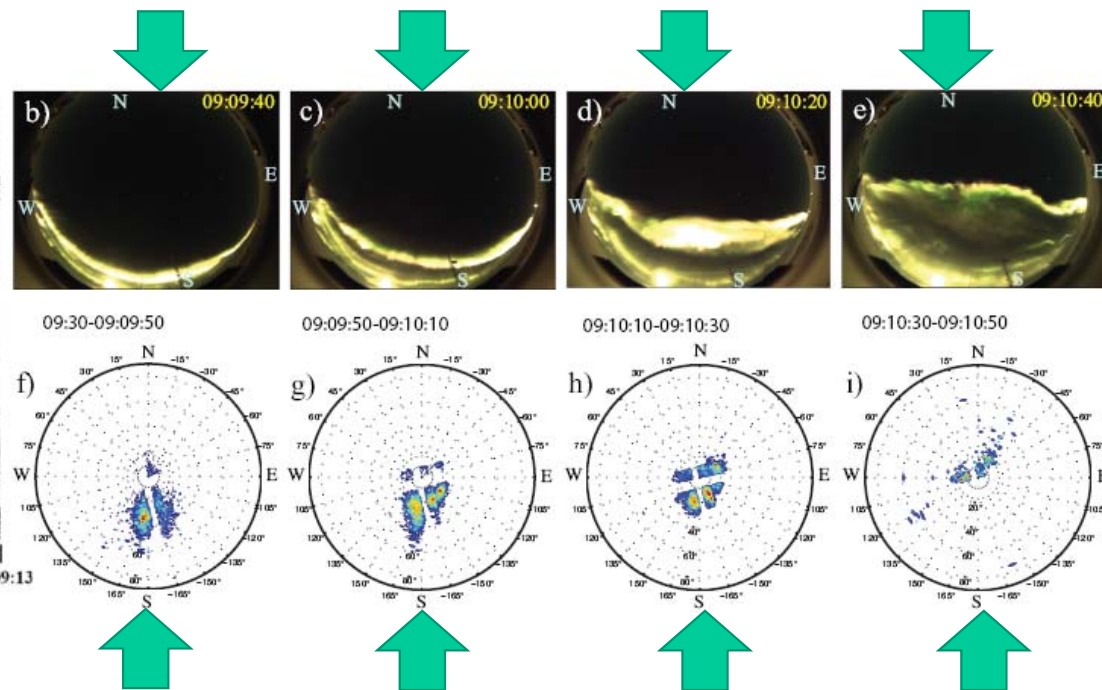
Image courtesy of Don Hampton, UAF

Example results from Dartmouth radio receivers at Toolik Lake (published in Journal of Geophysical Research):

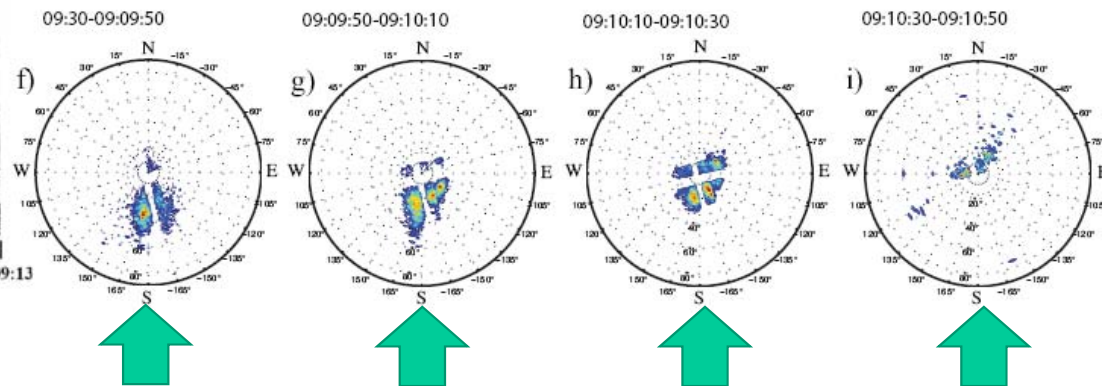
1. “frequency-time” diagram of
auroral radio emissions



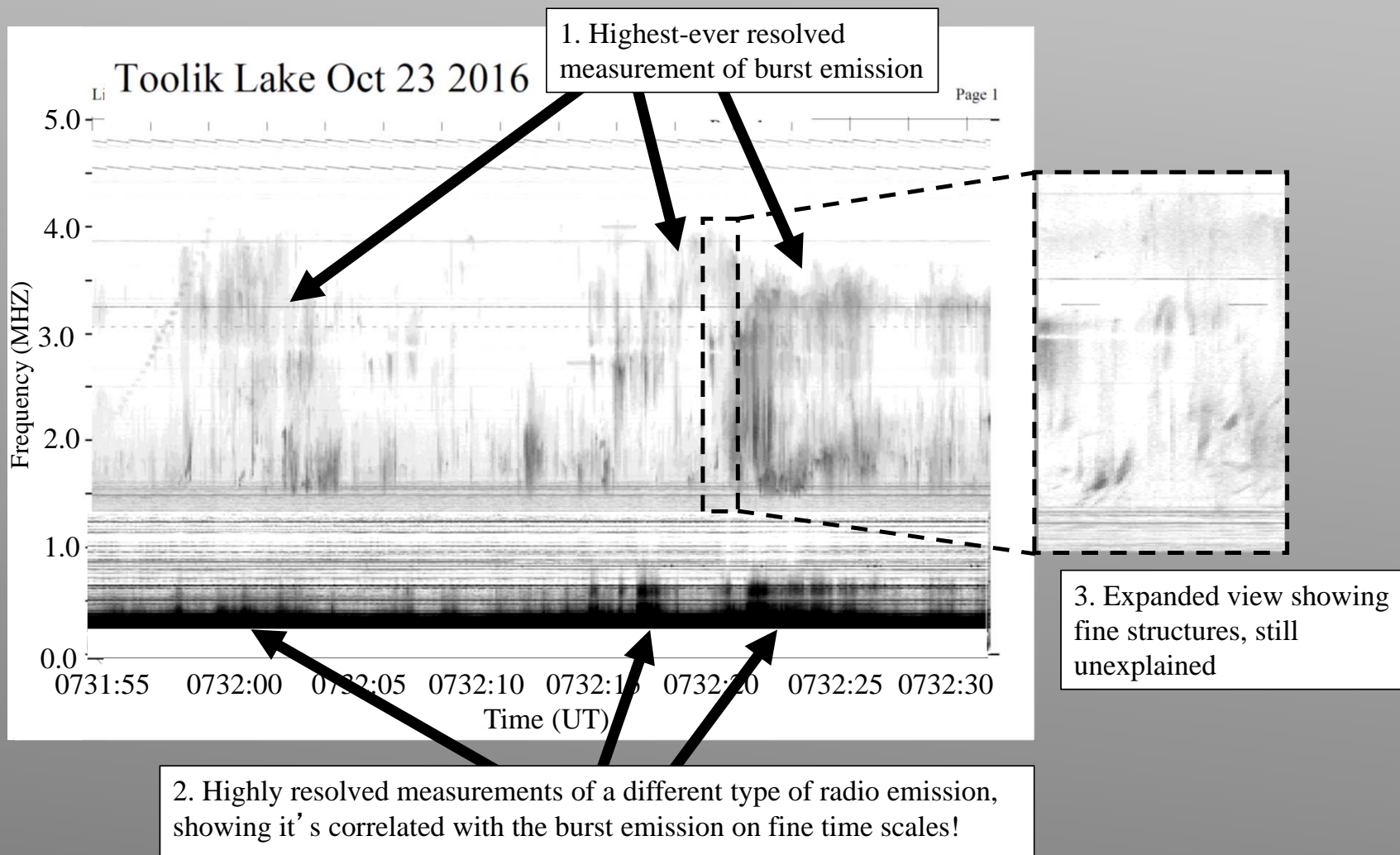
2. camera images of the aurora at the same time,
showing it moving northward



3. radio images of the aurora showing that the radio emissions
move northward also!



Frequency-time diagram of auroral radio emissions:



What's next for Space Physics at TFS?

- We have several projects that we would like to implement at TFS.
 - Optical bandpass imagers
 - Hyperspectral analysis instrumentation
 - Narrow-field imagers in support of rocket missions
 - Broadband EM receivers to investigate fundamental auroral physics
- However we are running out of the Smurf hut currently which presents a few solvable problems.
 - Small space, nearly full
 - Leaks in roof, walls
 - Close to pollution, affects some instrumentation (current/future)



Summary and Conclusion

- Space physics is active at TFS
- We're working on new physics research as well as remote sensing techniques
- Having a location like TFS available enables us to perform unique and otherwise difficult primary physics research.
- Given the site's availability, we have continual interest in TFS in a variety of space physics applications.



Photo Credit : John Elliott University of Alaska Fairbanks