The Poker Flat Instrument Suite

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Measuring the upper atmosphere

The goal of measuring the upper atmosphere is to understand its role in the "geospace" system by determining the composition and dynamics of both neutral and charged constituents as well as their interaction with the lower atmosphere and the magnetosphere.

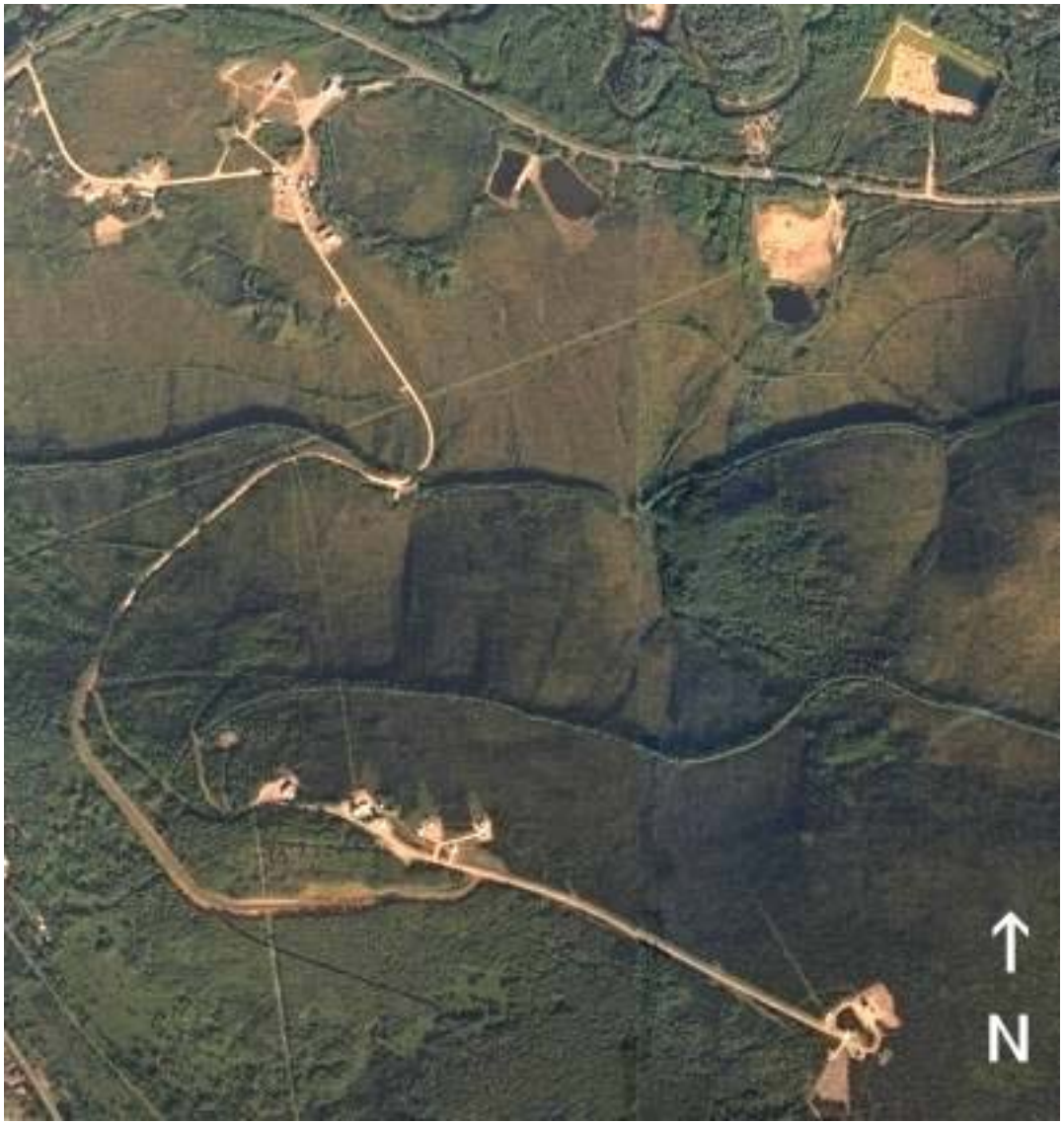
Measuring the upper atmosphere

- Active vs. passive
- *In situ* vs. remote
- Ground-based vs. space-based
- Spatial resolution vs. temporal resolution
- 3D varying volume challenges visualization of data

Measuring the upper atmosphere

- Direct
  - Particle detector
  - Electric field probe
- Radiation
  - Optics
  - ELF/VLF/HF/VHF antenna
  - Magnetometer
  - Fabry-Perot interferometer
  - Spectrograph
- Perturbation
  - Riometer
  - GPS scintillation
  - ELF/VLF stations and receivers
- Reflection
  - Digisonde
  - ISR
  - Coherent scatter radar
  - Lidar

Poker Flat Instrumentation

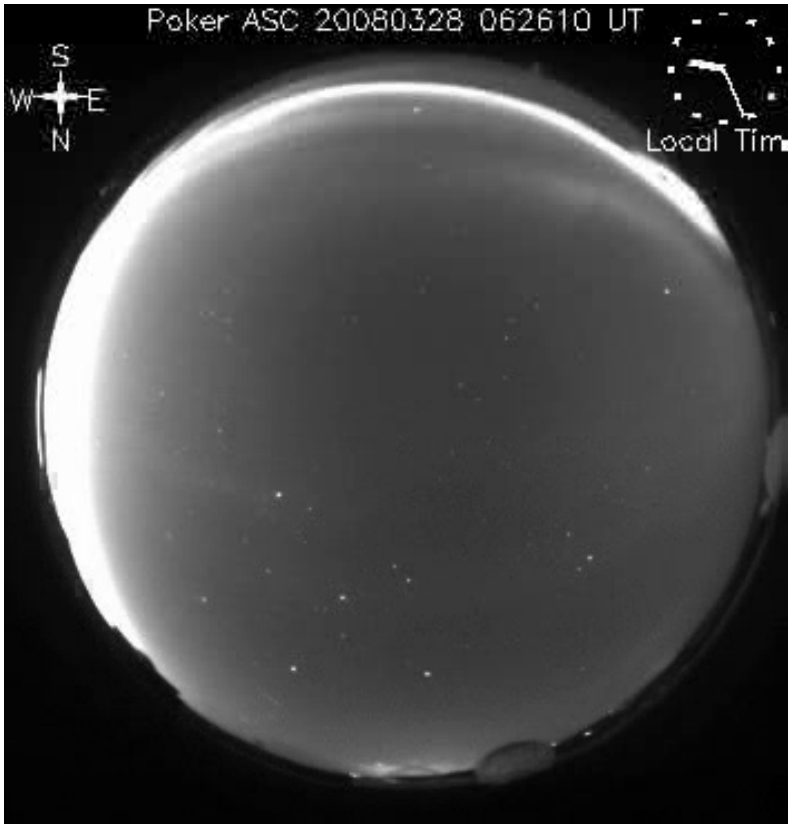


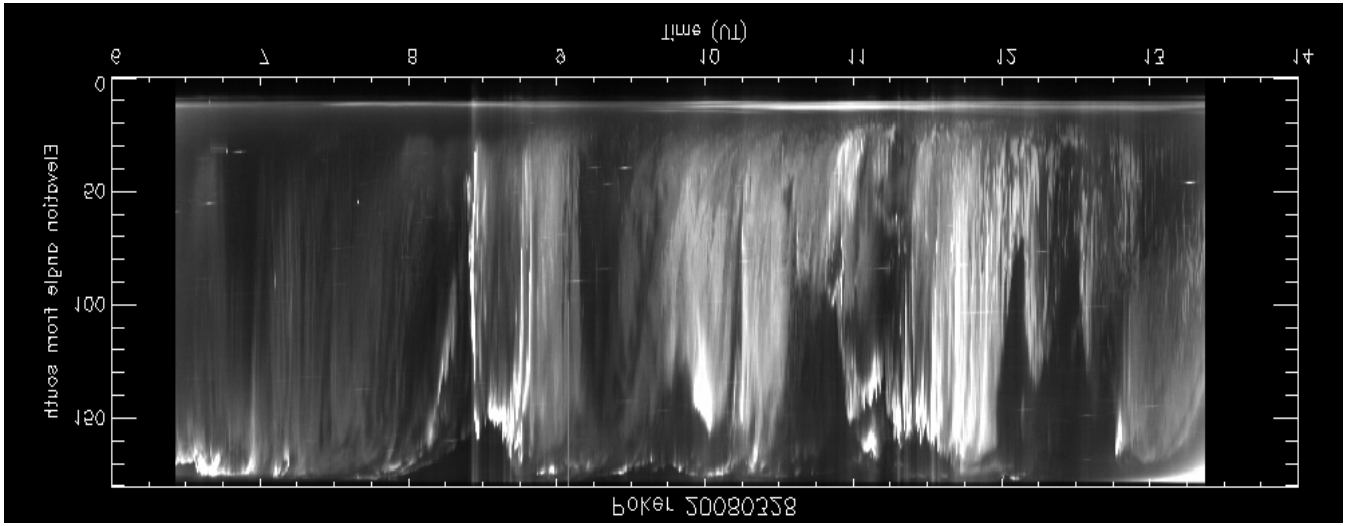
- All-sky cameras
- Spectrographs
- Magnetometers
- Riometers
- Lidar
- Ionosonde
- Meridian Scanning Photometers
- Fabry-Perot interferometers
- PFISR
- VHF radar (off-site)
- SuperDARN
- ELF/VLF receivers
- GPS receivers
- Rocket suites
- Satellite suites

All-sky cameras: PKR DASC

Poker Digital All-sky Camera (PKR DASC)

- Developed by KEO scientific
- Andor IXON+ EMCCD
  - 1k x 1k pixels
  - 16-bit digitization
- Telecentric optical system with filter wheel
- First deployed Sep 2007
  - Unfiltered for 07/08





All-sky cameras: PKR DASC

- For the 2007/2008 season a simple BASIC script was used to determine what parameters are important for operations
  - Not reliable - required nightly monitoring
  - Did not have filter control (no filters, so it didn't matter)
- For 2008 on will have a dedicated standalone application with control over:
  - Image cadence
  - Image exposure time
  - EMCCD operations and gain
  - Image binning
  - Scriptable sequence for filter positions and the parameters above
- Standard operational night will be an image (or a filter set) every N seconds
  - N nominally 15
  - Start and stop times based on sun up/down tables (astronomical twilight)
  - 512 x 512 pixels images (rebinned 2x2 from full frame)
  - Exposure times are 0.25 sec for clear and/or green filter
  - Longer for Red, Blue or H-alpha/beta etc.
- Suggestions for filters are welcome (contact Don Hampton)

All-sky cameras: PKR DASC

- Special modes are available for specific campaigns
  - Can run as short as one image every second if no filter moves required
  - Video modes (up to 33 FPS in 256x256 binned mode) are available in short bursts (>30 seconds, but less than minutes)
- A comprehensive table of modes will be available
  - This will include the radiometric conversions for calibration
  - The standalone application will be able to access all modes

All-sky cameras: PKR DASC

Data products:

- Real time
  - Sub-frame JPEG images ftp'd to PKR/GI
    - Possibly with PFISR beams superimposed
  - Real-time updating keogram
- Next Day
  - B&W keogram
  - MPEG movie
    - Possibly with PFISR beams superimposed
- Long term
  - Raw FITS Images
  - High resolution keograms and MPEGs
  - Az/El images for geographic mapping
  - Radiometric calibration conversion

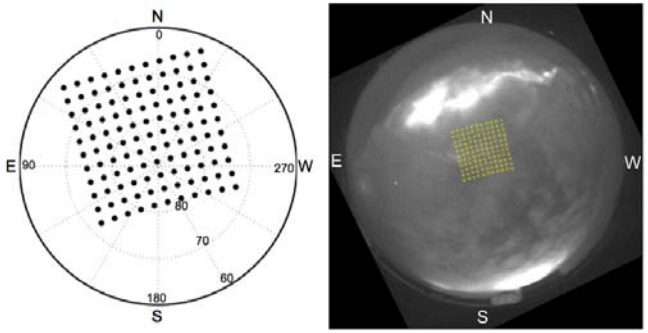
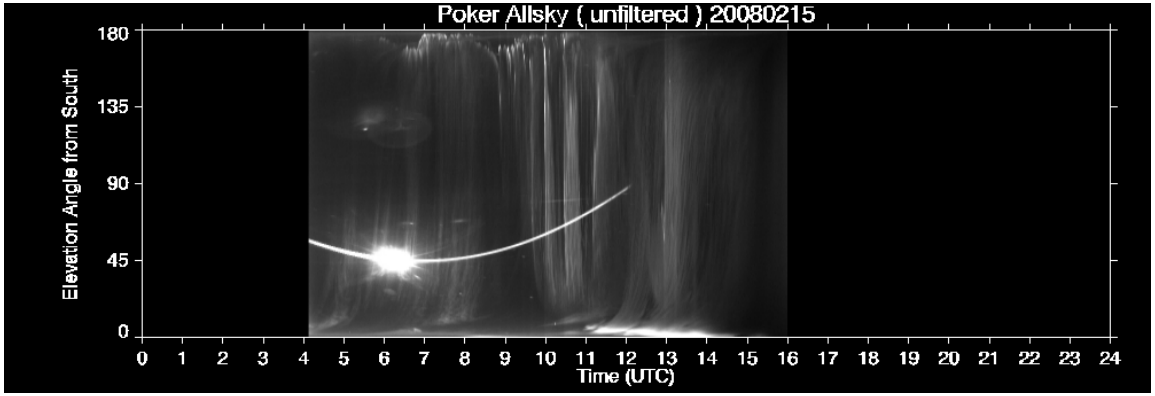


Fig. 1. a) PFISR beam positions used in this experiment, depicted in horizontal polar coordinates. b) Beam positions superimposed on an unfiltered image from collocated all-sky camera.

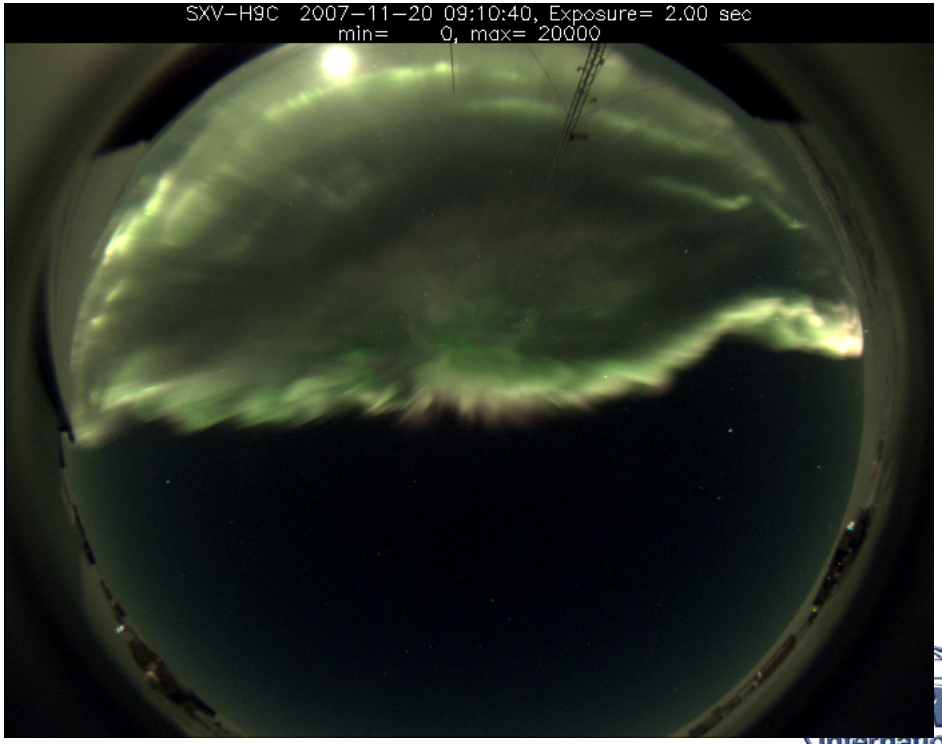
From Semeter et al., JASTP 2008



All-sky Cameras: CASC

Single Shot Color All-sky Imager (CASC):

- Starlight Xpress SXV-H9C CCD
  - Sony ICX285AL 2/3” (11 mm) CCD
  - Bayer encoded color pixels
  - 1392 x 1040 pixels
- OIC f/1.9 190º c-mount lens
- Mechanical sun shade
  - Camera does not have integral shutter
- Image time synched to GPS clock time
- Deployed at Toolik Field Station and Eagle

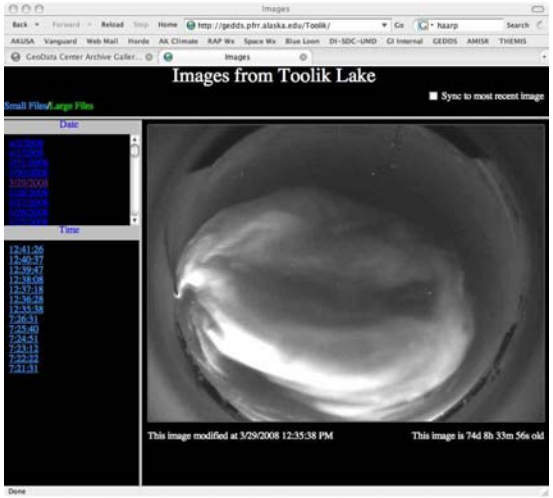


All-sky cameras: CASC

CASC operations:

- Start and stop times based on sun up/down tables (astronomical twilight)
  - Sun shade power is controlled by photo sensor to preclude CCD damage in the event of clock error
- Image taken every N seconds - N ranges from 5 to 2^{16} seconds
  - N is normally 20 or 30 seconds
  - Full-frame images stored locally in FITS format
- Exposure times can be from to 10 ms to 2^{16} seconds
  - Normally 2 sec
- Parameters can be updated on a nightly basis
- Every n^{th} image is converted into a jpeg and ftp'd to a GI and PFRR computer for "real time" display and to be converted into keograms and MPEG movies at the end of the night
  - Generally one per minute - every 2nd or 3rd

All-sky cameras: CASC



CASC products

Real Time

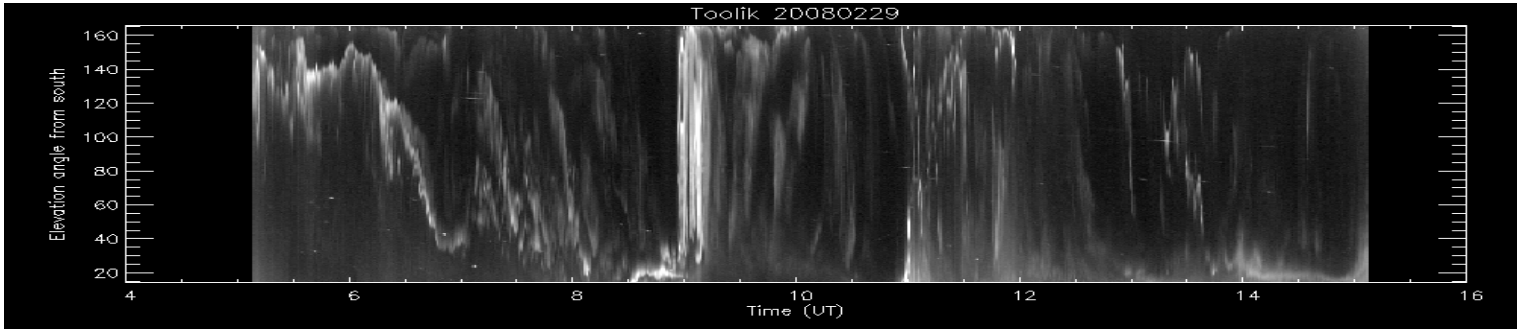
- Sub-frame B&W images ftp'd to PKR/GI
- Possibly real-time updating keograms

Next Day

- B&W Keogram and MPG sub-frame movie - 1 image every minute
  - Note that pixels saturated in the MPEG movies are due to 8-bit scaling of 16-bit images. The 16-bit images are not saturated.

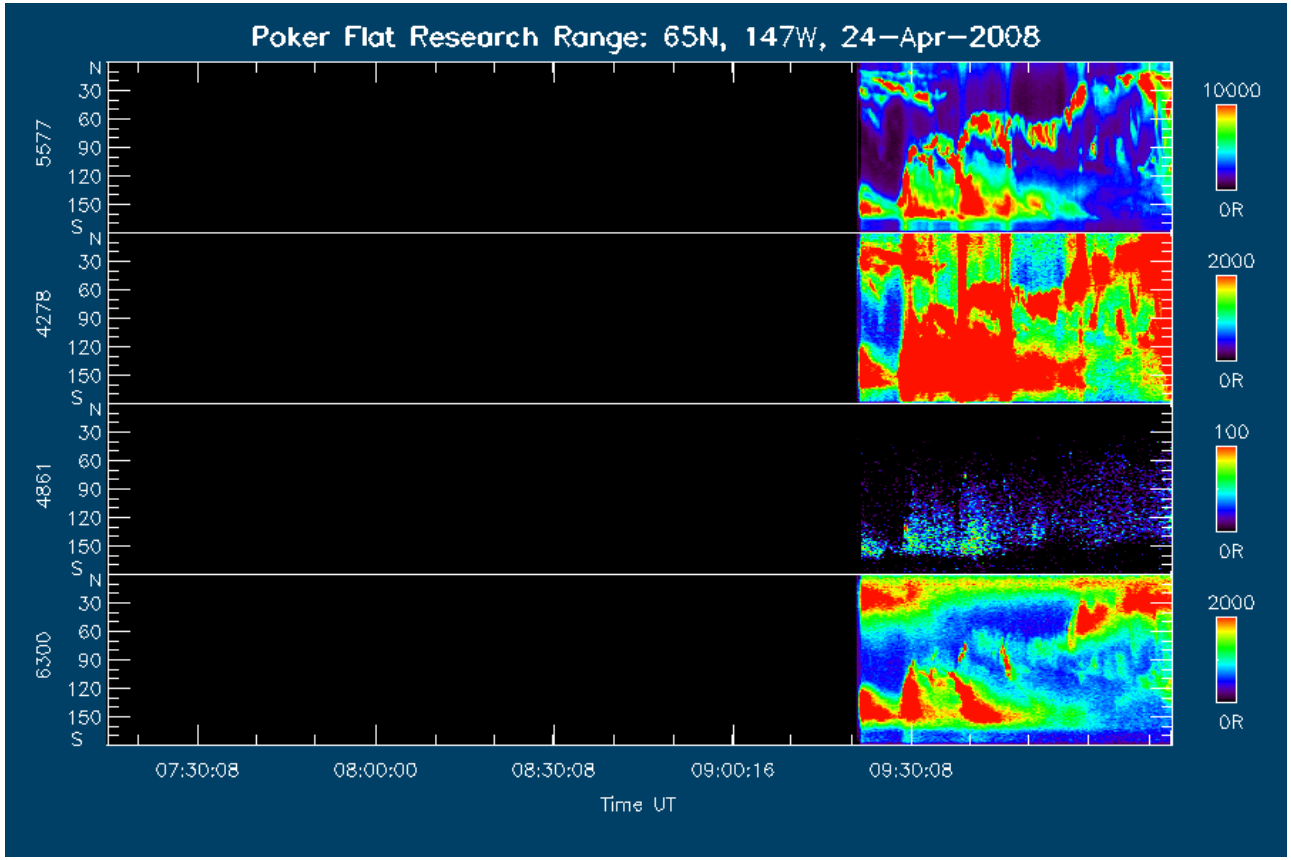
Long Term

- Stored full frame FITS images, raw and color balanced
- Color Keograms
- Az/El images for for geographic mapping
- Radiometric calibration conversion (e.g. Rayleighs / DN for each color)



Meridian Scanning Photometer

- 4-channel MSP at Poker Flat
- Data archived on GEDDS
- May be replaced by solid-state meridian spectrographs (demo shown later in this presentation)



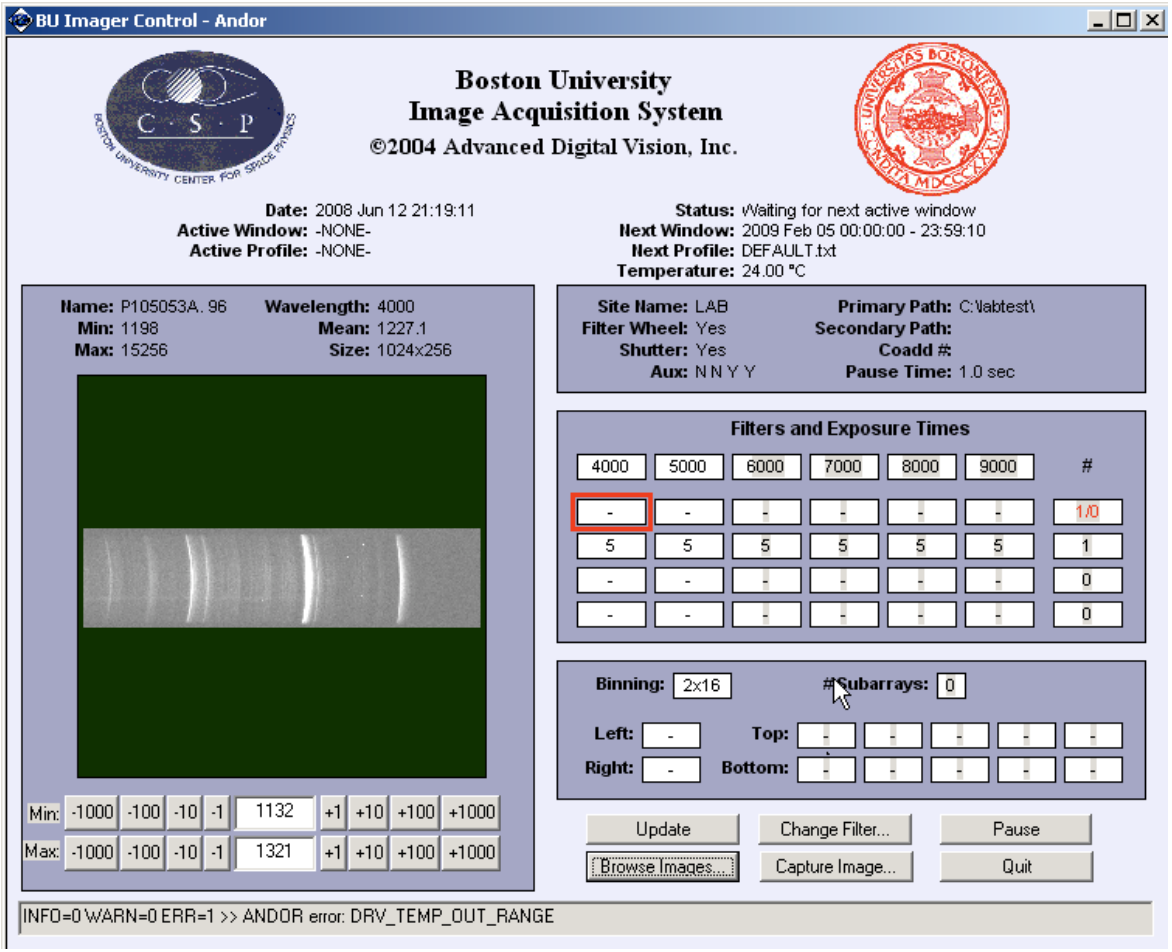
Spectrographs: BUNS

Boston University Narrowfield imaging Spectrometer

- High resolution narrowfield grating imaging spectrometer
- Covers visible/NIR spectrum in 6 steps
  - Each position covers ~ 120 nm
  - Resolving power from 2000 to 5000
  - Along-slit field of view ~8 degrees
  - Choice of 4 slit widths
    - 50,100,200 500 microns
- Images collect by 2k x 2k Andor Ikon CCD
- Mounted on Az-El mount
  - Controlled at Poker
  - Typically pointed at Mag Zenith, but can be oriented any direction
  - Generally use co-aligned CCD to get orientation of mount

Spectrographs: BUNS

- Images collected based on configurable sequences
  - For each spectral position the sequence defines: binning, integration time, type of exposure (light/dark)
  - Each sequence file can define up to four sequences, each of which can be repeated N times
- The particular sequence file is defined by an overall schedule file which defines date start/stop times and sequence file
- Sequences do NOT control the slit position - this has to be set manually
- Please note that Jan '08 data are missing due to operator error

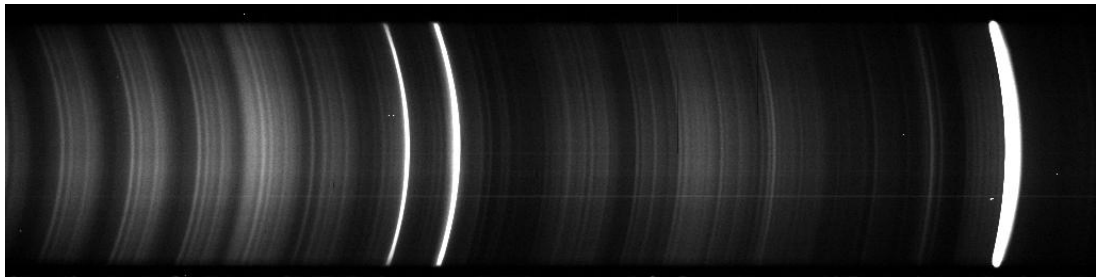


Spectrographs: BUNS

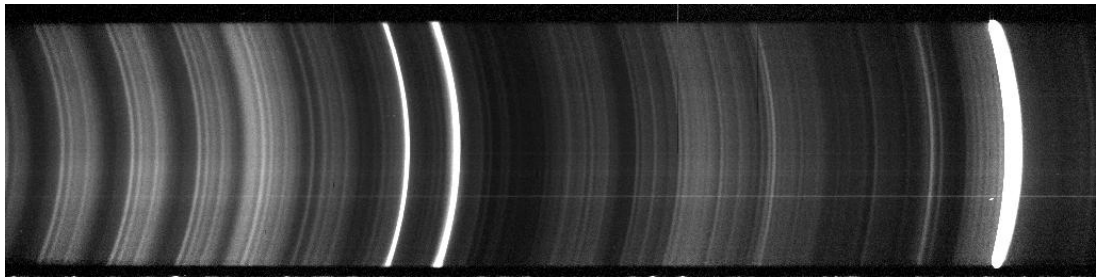
- The raw images will be stored, but are not particularly useful until they have been through a set of pipeline steps
  - Converted images will be stored as FITS files
- Products will be look-angle and wavelength specific
  - Will provide calibration resources (e.g. wavelength maps, radiometric conversion) and some basic IDL tools

increasing λ

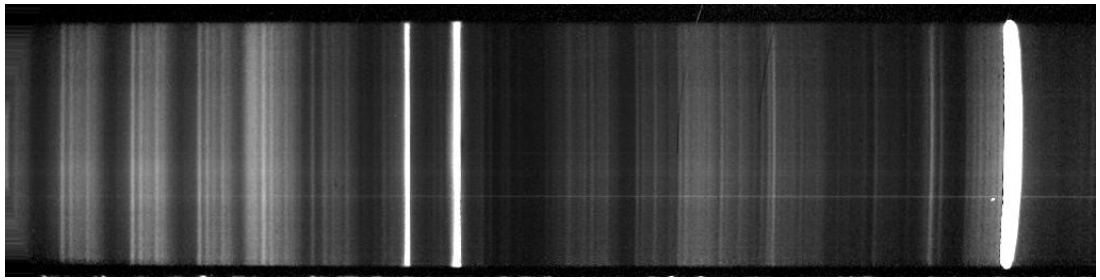
Raw Image



Cosmic rays removed and intensity is normalized

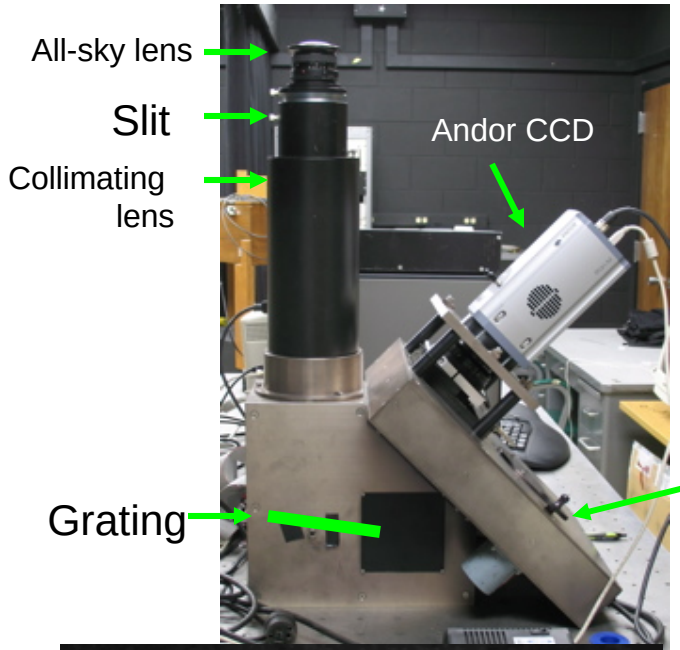


Spectral dispersion is straightened



Spectrographs: BUIS II

- Previously run at PKR with ICCD and video digitizer
  - Formerly known as COTIF spectrometer and BUIS
- Covers Vis/NIR range in 6 steps each ~ 100 nm
- Horizon to horizon spatial coverage
- Refurbishment is part of AMISR optical support
  - Images to be collected on Andor Ikon 1k x 1k backside thinned CCD
  - Determined in Fall '07 that internal optics were mismatched, so deployment was delayed
  - Expected 2008/2009 season



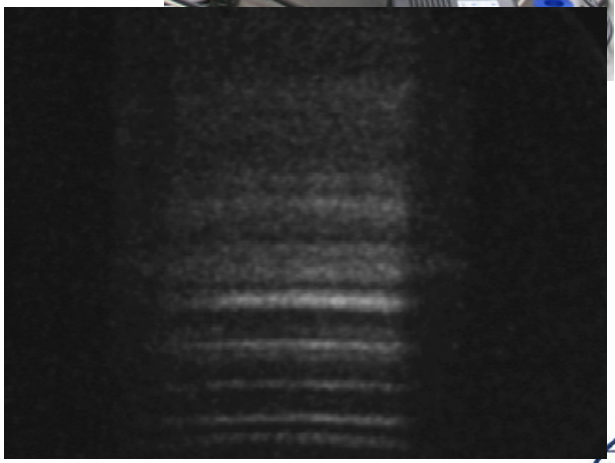


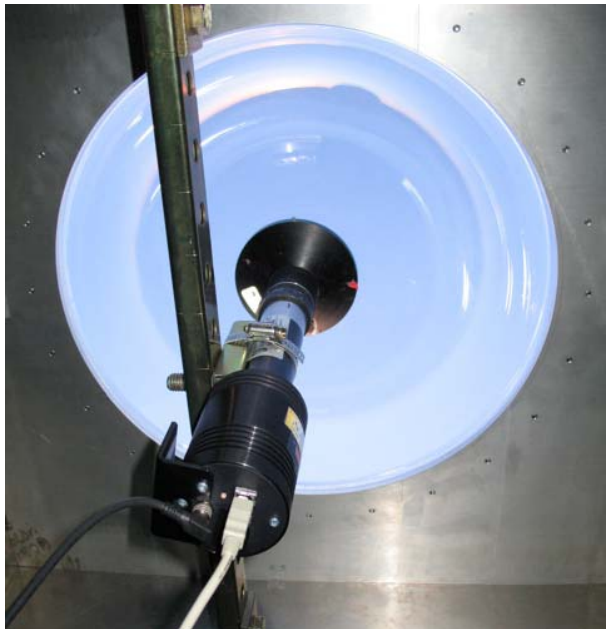
Image from BUIS I (ICCD)

Spectrographs: BUIS II

- See BUNS for operation

- Real-time updating keograms
- Will develop routines to produce meridian Keograms of any spectral line

Spectrographs: CSMS

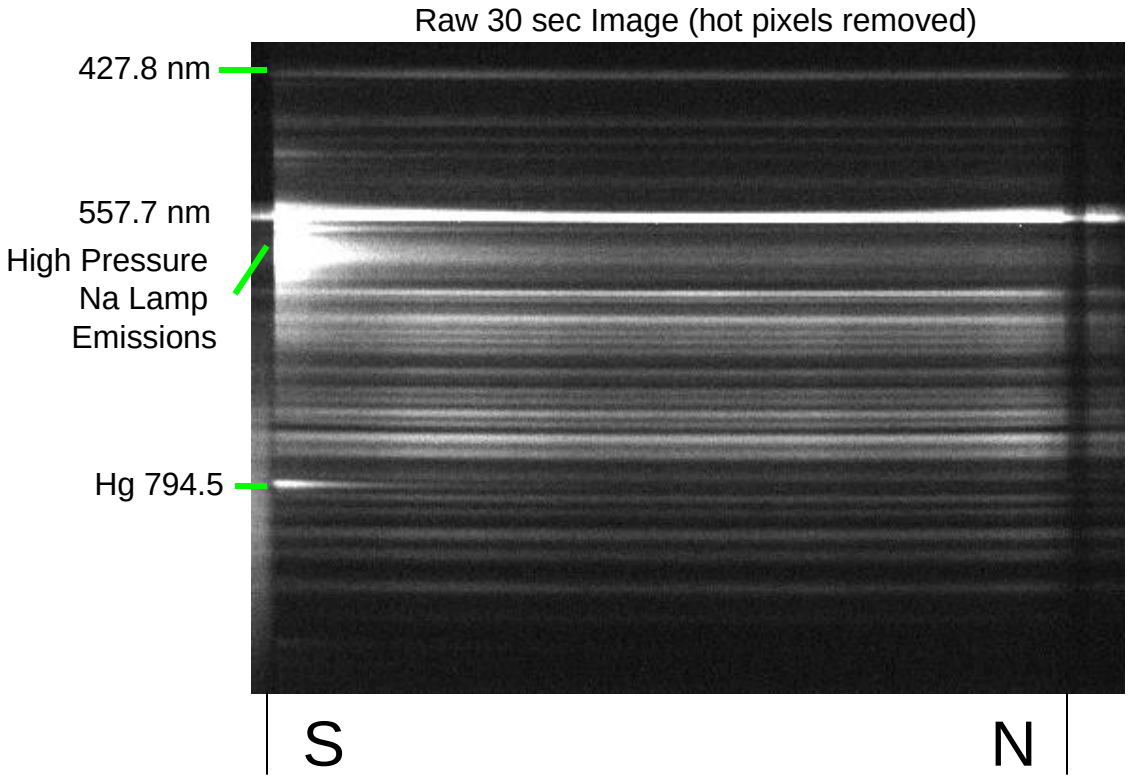


Compact Solid-state Meridian Spectrograph

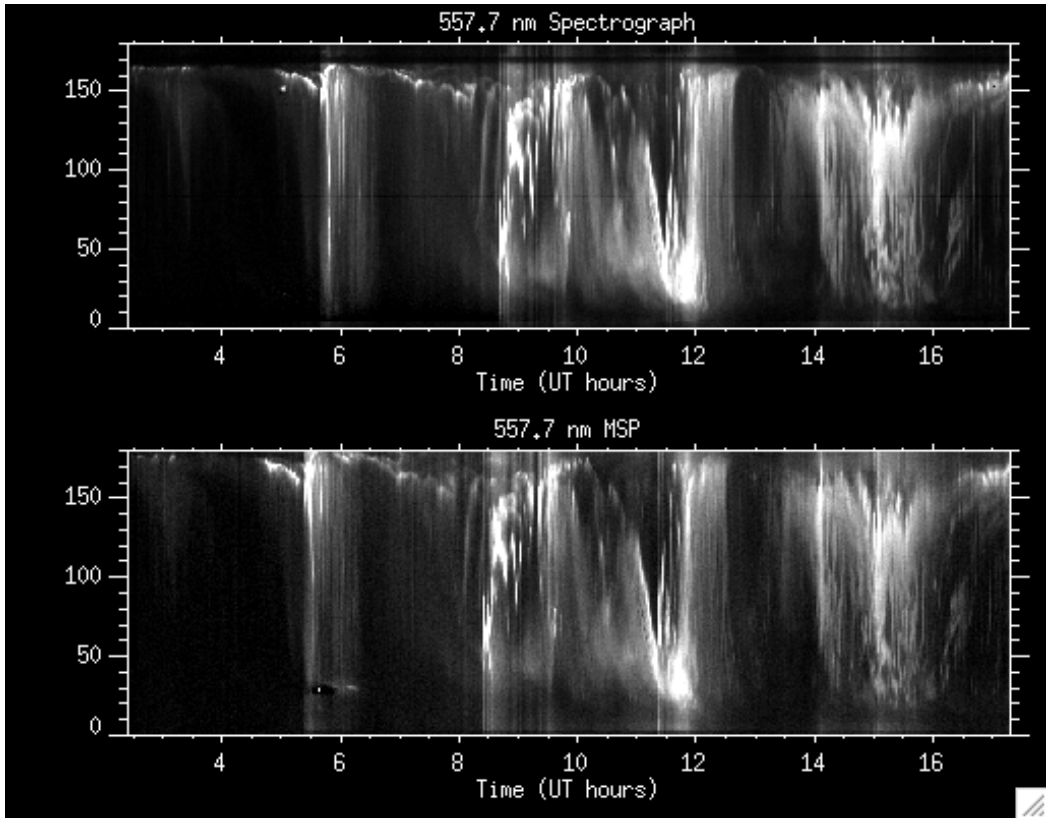
- As part of another project the GI purchased a SPECIM V10 hyperspectral core
- Attached a c-mount all-sky lens and a Starlight Xpress SXV-H9 camera and ran in a simple survey mode to compare the performance to the MSP
  - Typically a spectral image every 15 or 30 seconds
  - Compare to MSP data with double correlated samples at 16 second cadence (see next slide)
- Systems like this could be a low-cost replacement for the troublesome remote MSPs
  - Local processing would produce blue, green and red line traces every 15 to 30 seconds to be ftp'd back to Poker in real time
  - Images with more spectral information stored locally

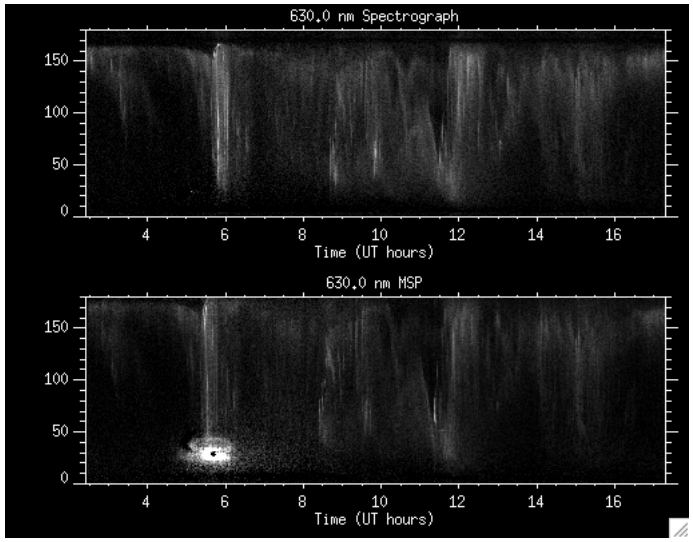
Spectrographs: CSMS

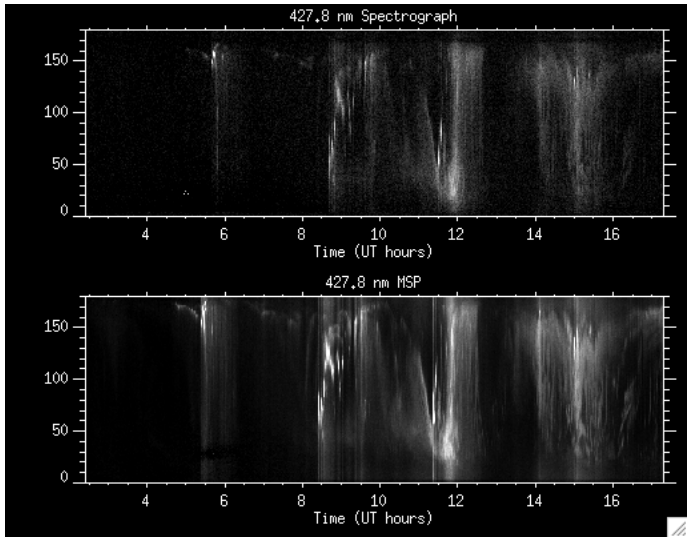
- For 2007/2008 season images were collected during the evening and keograms were produced later
- For an operational instrument an application is required to pull out emission line traces, and background level traces to be converted to intensity vs. angle profiles
- Expose for N seconds, with a cadence of N+Dt seconds, where Dt is the detector readout time
  - Images are rebinned 3x3



Spectrographs: CSMS



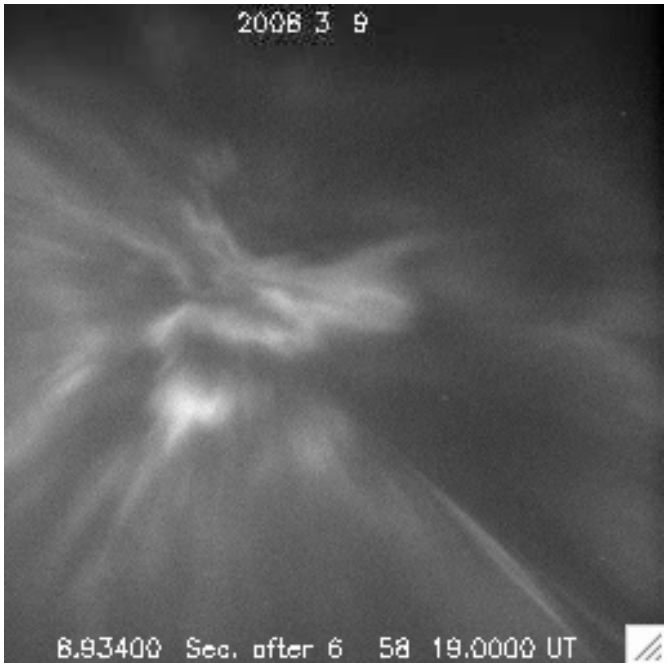




Narrowfield cameras

Utah State Narrowfield Imager

- The final award for the AMISR optics support contract included a narrowfield imaging system
  - The detector - an Andor Ixon+ EMCCD - was purchased in 2006
  - 1k x 1k backside thinned CCD with electron multiplying ouput circuitry
  - Gain, binning and readout speed are all configurable
- The detector was sent to PKR to support NEIALS campaign (R. Michelle and M. Samara) in Feb, 2008
  - Data were collected with a 50 mm lens & Kodak No. 32 Wratten filter (to suppress green and red-line emissions)
  - Data stored in proprietary Andor format (*.sif)
  - We now have an IDL routine to read *.sif files



Narrowfield cameras

UNAR products:

- Real time
  - Sub-frame JPEG images ftp'd to PKR/GI
  - Running keogram
- Next Day
  - B&W keogram
  - MPEG movie
    - Possibly with PFISR beams superimposed
- Long term
  - Raw FITS Images
  - Raw FITS multi-frame images (converted *.sif files)
  - High resolution keograms and MPEGs

Magnetometers

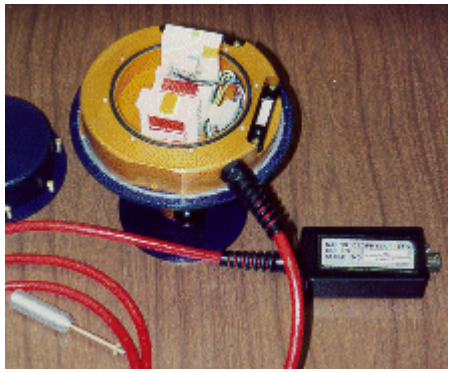
Key

Optics Only

Optics and Mag

Mag Only

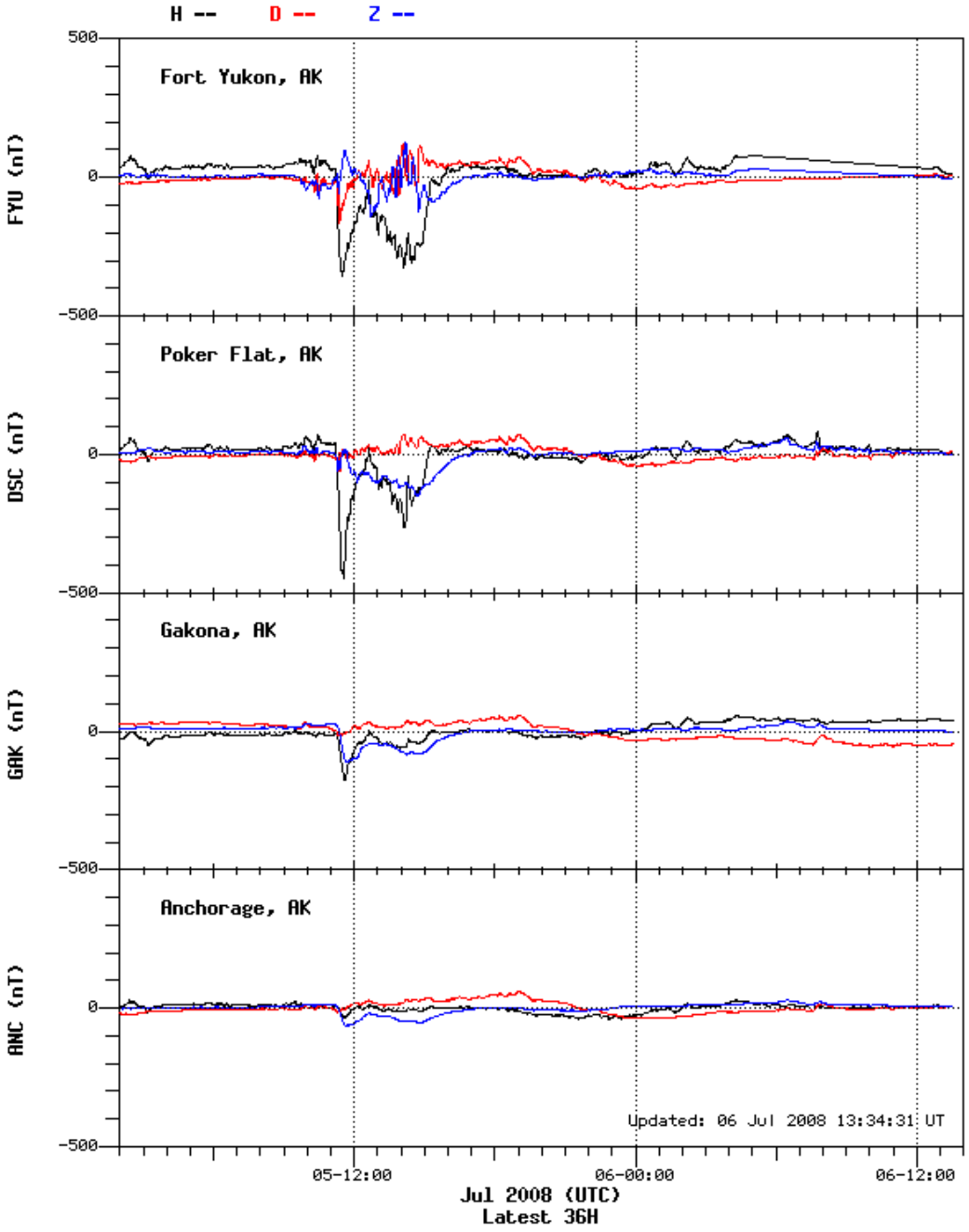
Magnetometers



The Narod ring-core fluxgate system:

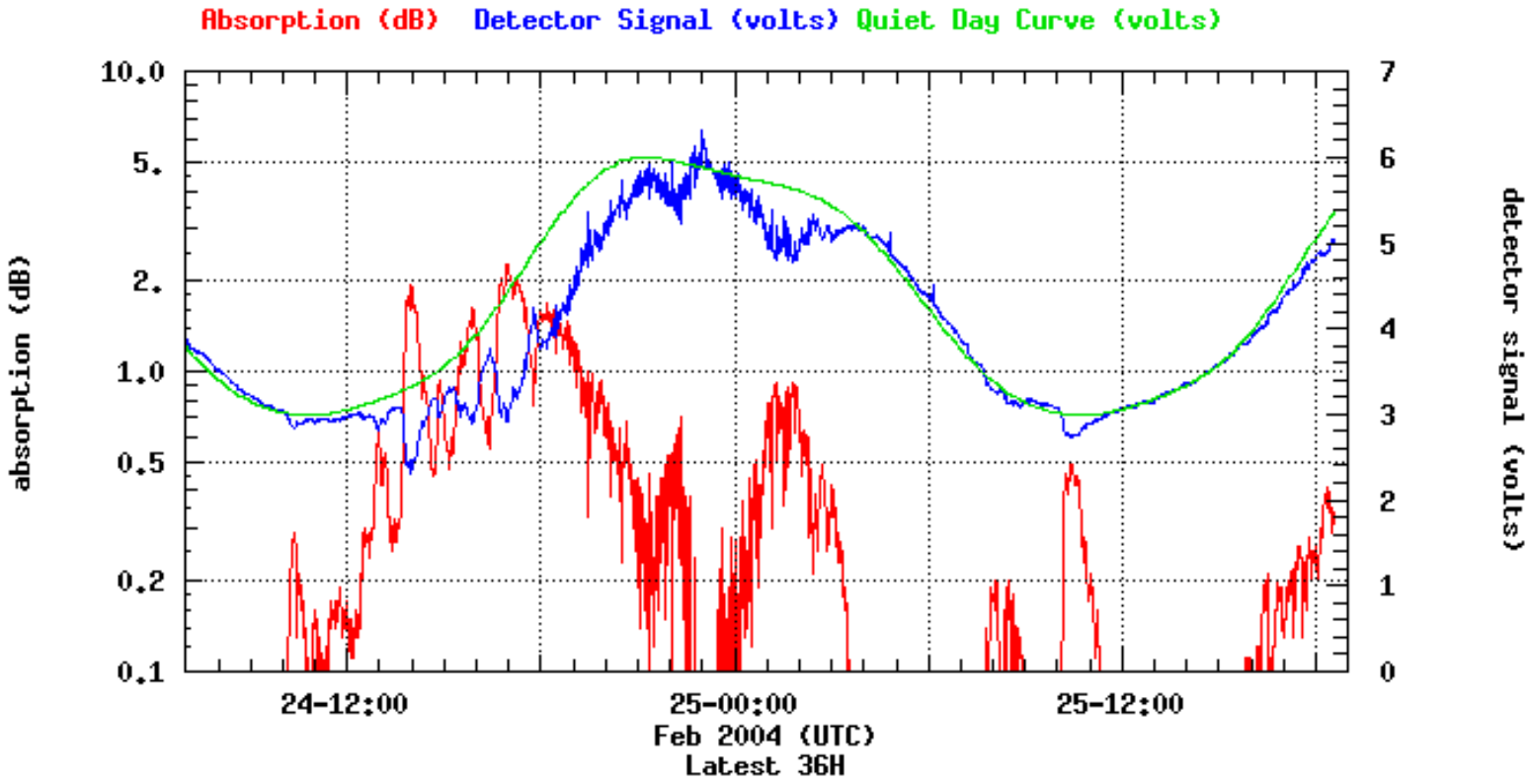
- Temperature stability: < 0.1 nT/degree (sensor);
- Long term drift: < 10 pT/day;
- Noise: 7 pT/root Hz @ 1Hz;
- Orthogonality error: <0.1 degree;
- Digitization: 16 bits;
- IEEE-696/S-100 Bus.

Magnetometers

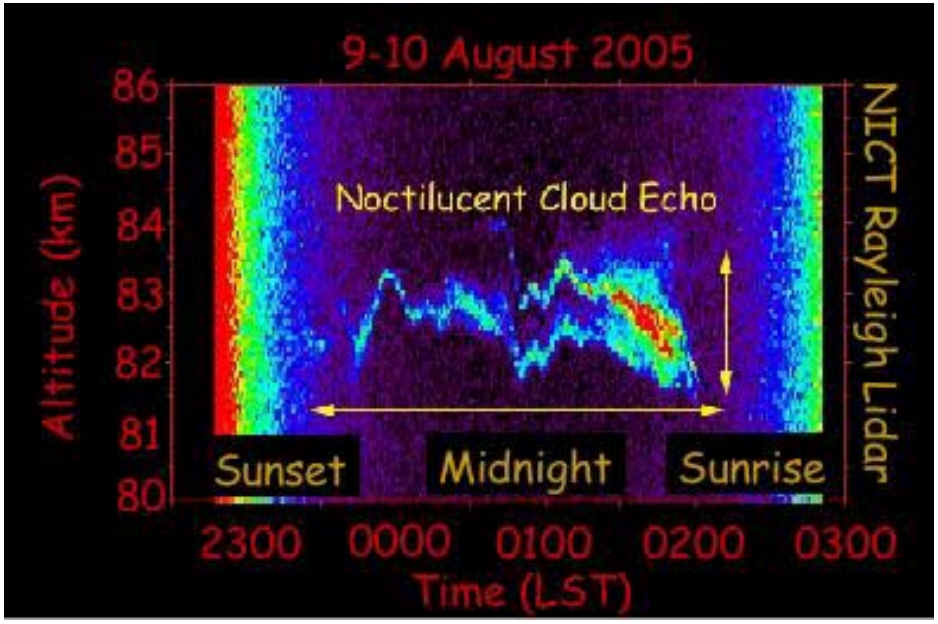


Riometers

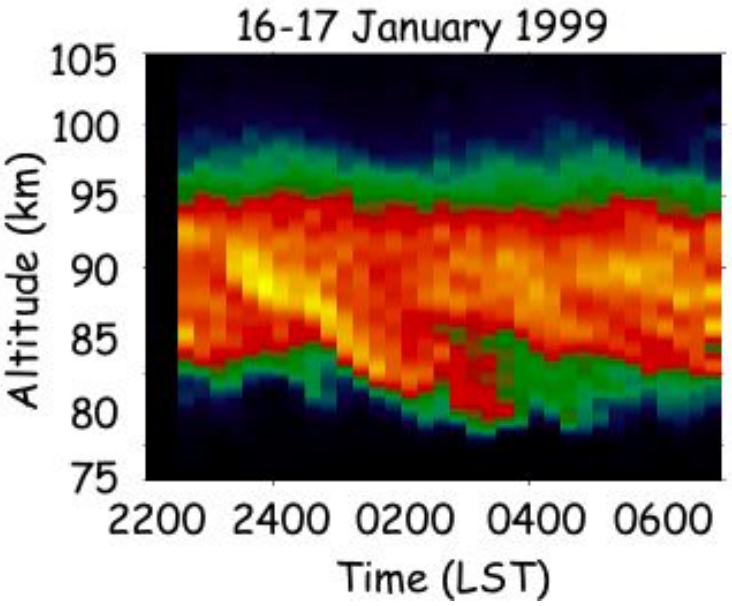
- Measures the natural background radio radiation at ~30 Mhz
- A “quiet day curve” is assumed and the measurements are compared to this curve to determine how much absorption is present at this frequency.

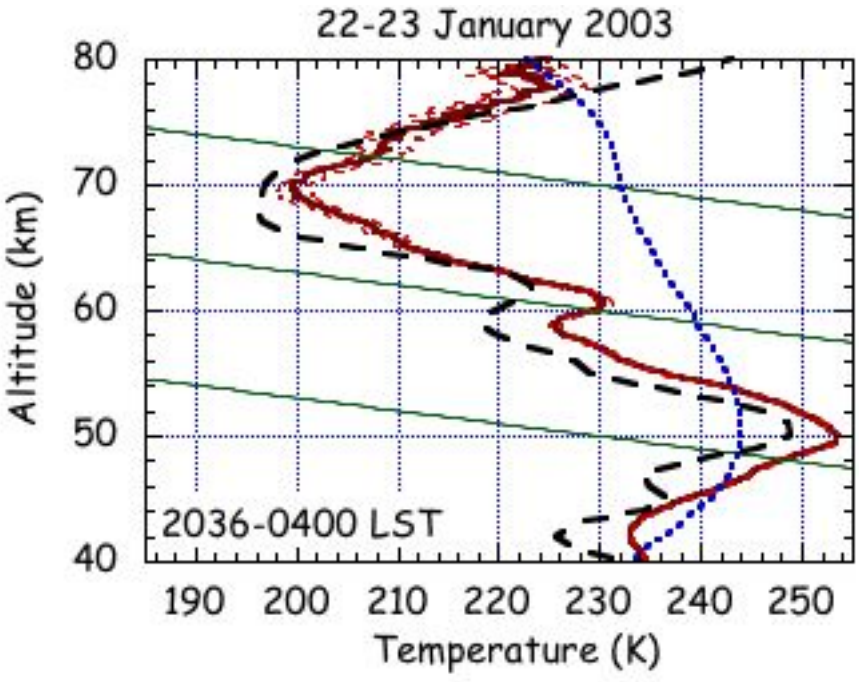


LIDAR



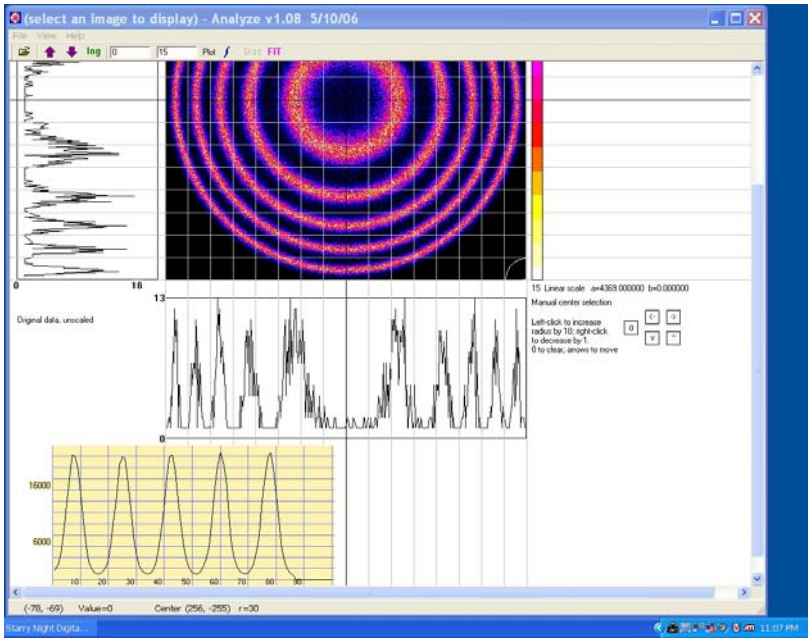
For further information contact:
Dr. Richard Collins
E-mail: rlc@gi.alaska.edu.

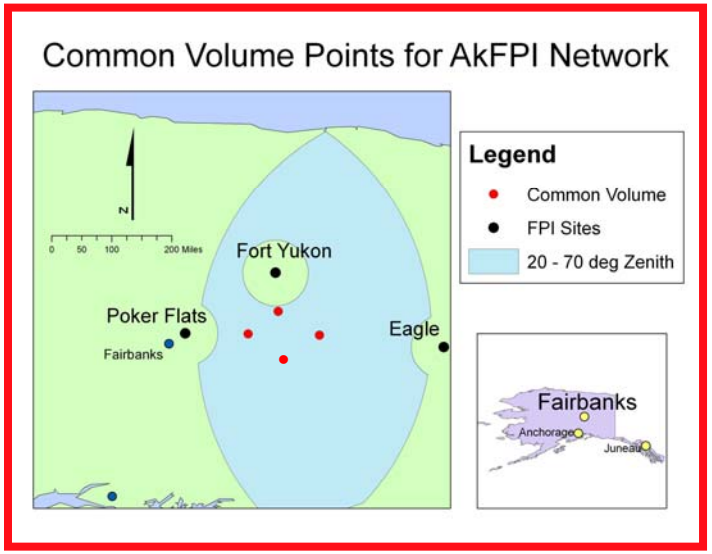




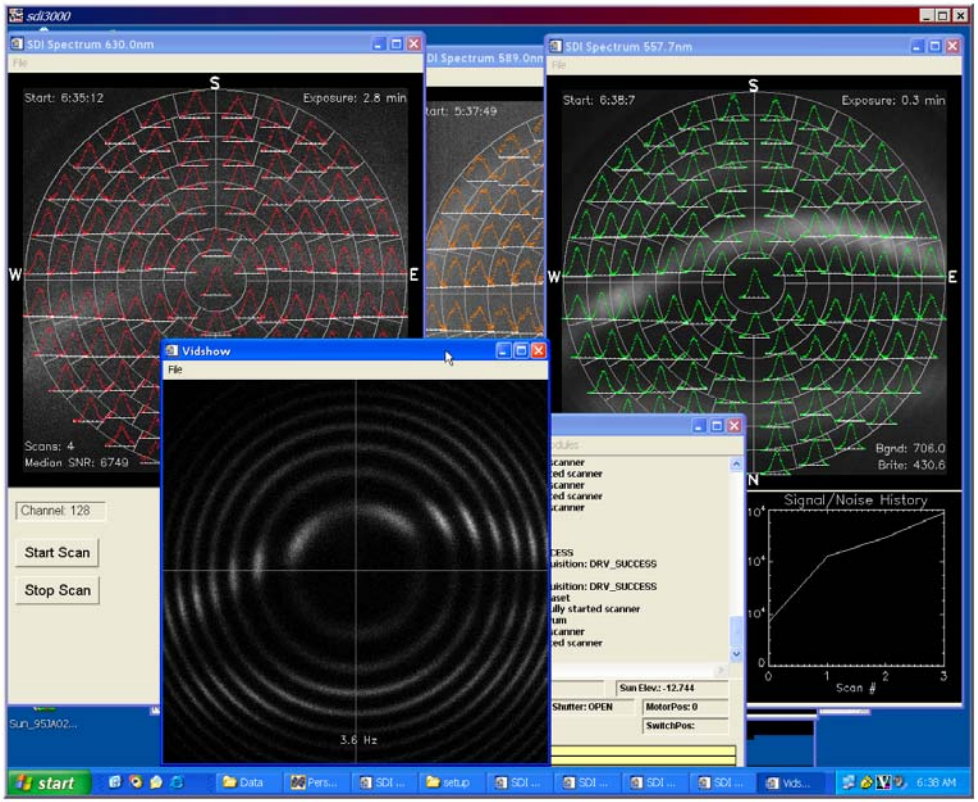
Fabry-Perot interferometers

- Three imaging Fabry-Perot spectrometers developed by John Meriwether (Clemson U.)
  - Measure O I 630.0 nm emission for temperature and line of sight velocity
  - Using three stations to make tri-static measurements at four common volumes to resolve zonal, meridional and vertical winds
- AkFPI Details
  - Real-time - quick-look line of sight velocity data
  - Next day - higher fidelity analysis of PKR data
  - Long term - raw images and tri-static resolved wind fields





Fabry-Perot interferometers



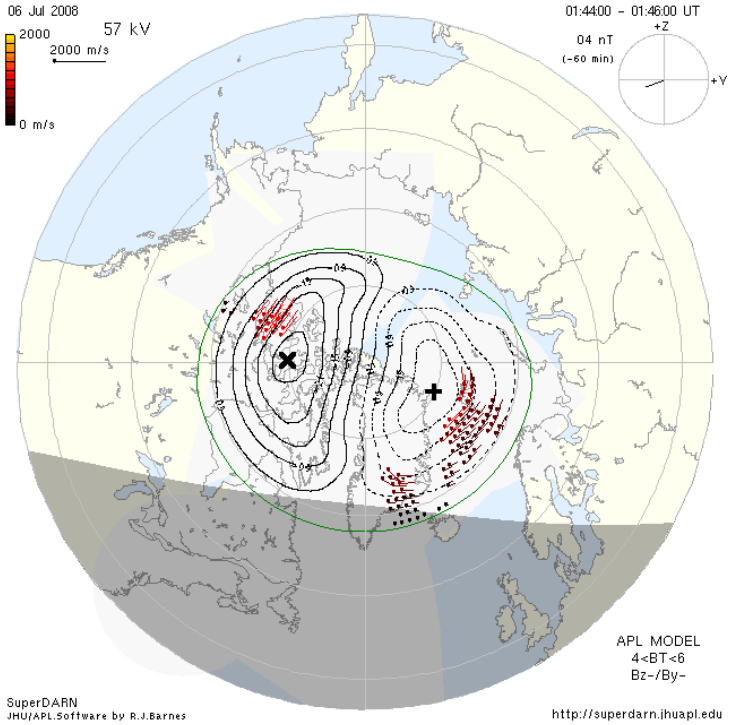
Poker Flat All-sky Wind Imager:

- An all-sky imaging Fabry-Perot spectrometer has been operating at Poker Flat since the mid 1990's
- It was recently upgraded
  - Replaced its old intensified CCD detector with an electron-multiplying CCD camera.
    - This has yielded a sensitivity gain of several times relative to the previous system
  - The instrument control software was also upgraded to a new version, produced by La Trobe University in Australia.
    - Several new observing modes and capabilities are now available

PFISR

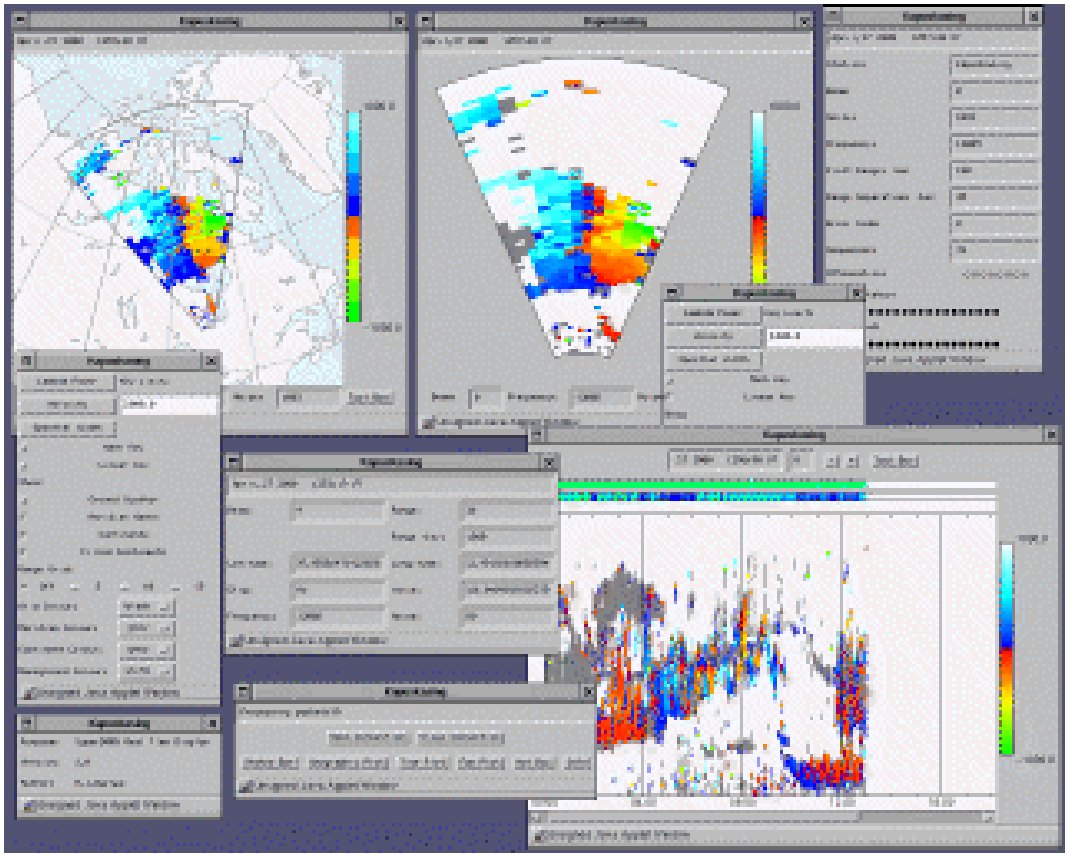
SuperDARN

- Network of radars circling both poles (9 in the north, 6 in the south)
- Data merged to generate convection maps
- The Kodiak radar beam covers Poker Flat
- The data can be used to detect ionospheric electron density irregularities above PFISR



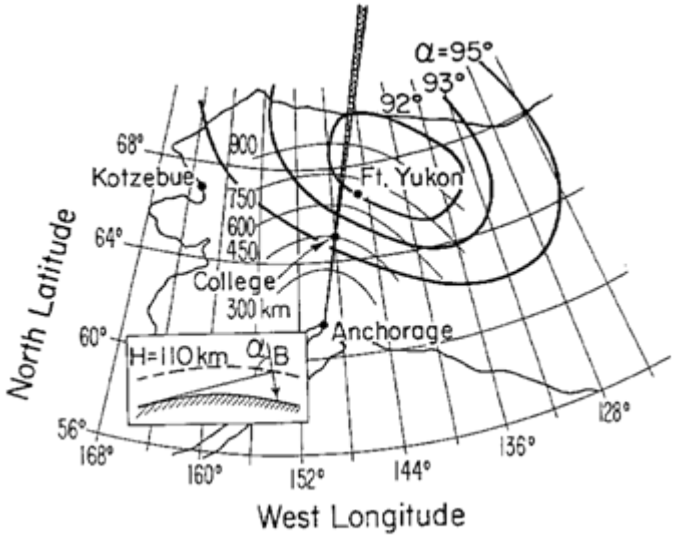
SuperDARN

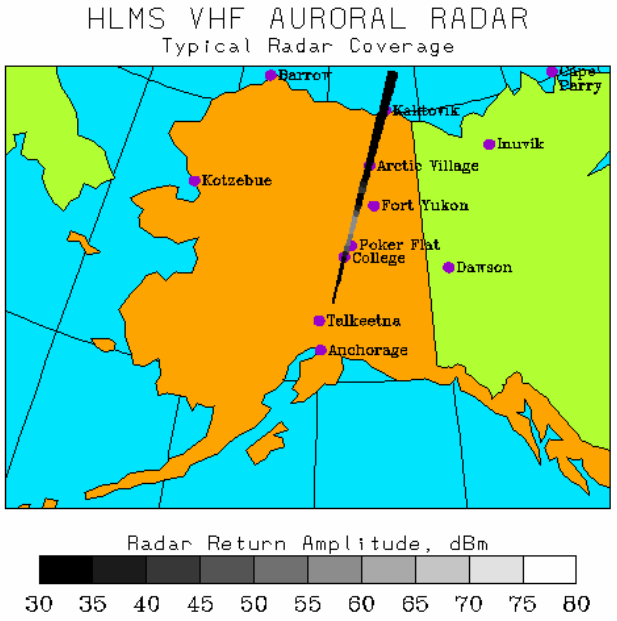
- The SuperDARN website holds a wealth of information on the radar network
- Applications can be launched to plot the data in a variety of ways



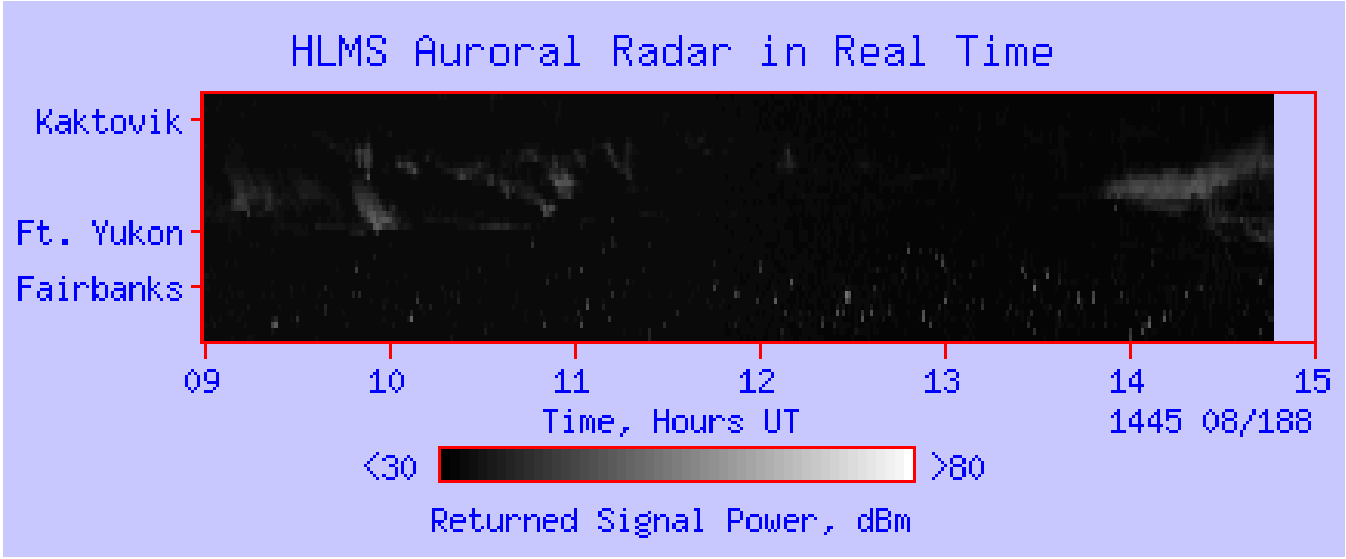
VHF radar

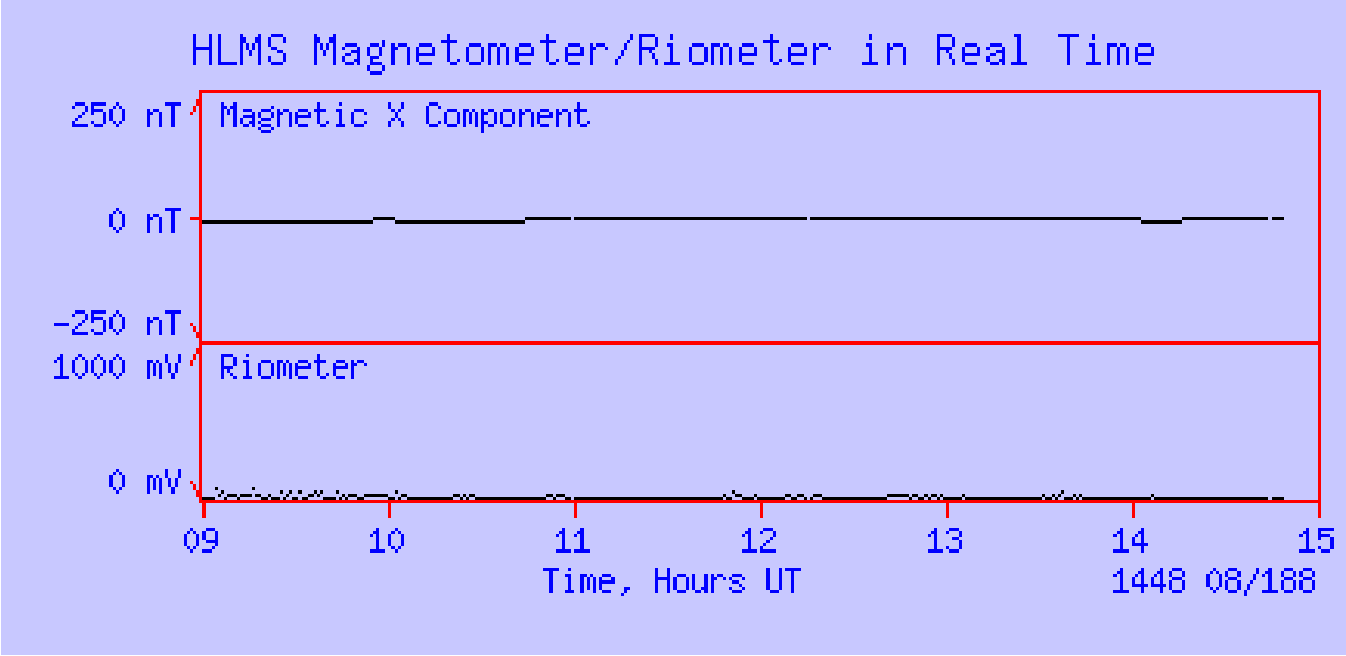
- 50 Mhz radar operated at the High Latitude Monitoring Station (HLMS) on Elmendorf AFB
- Single beam aimed over Poker Flat, Fairbanks, Fort Yukon
- Relies on perpendicularity to magnetic field for a reflection
- 200-1200 km range, 40 range gates @ 25 km each
- Real-time and archived data available on GEDDS site



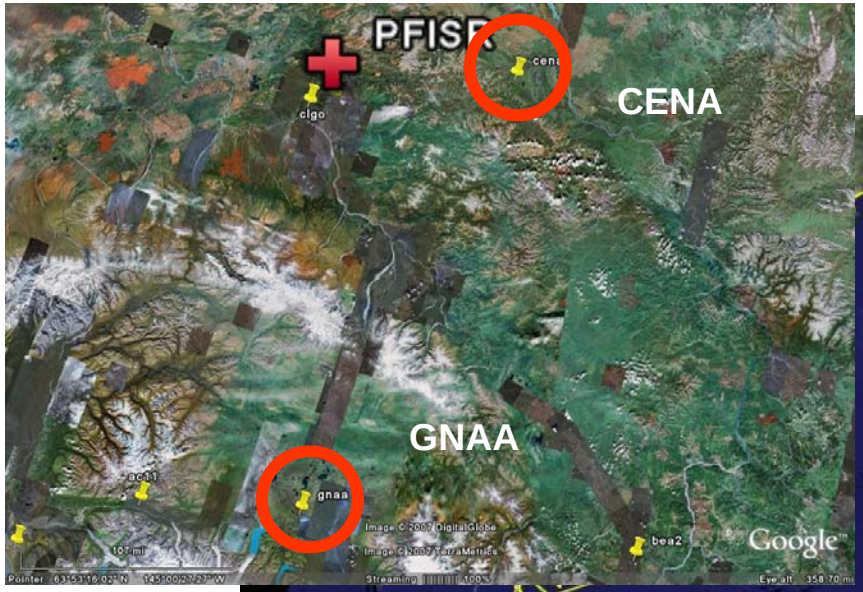


VHF radar

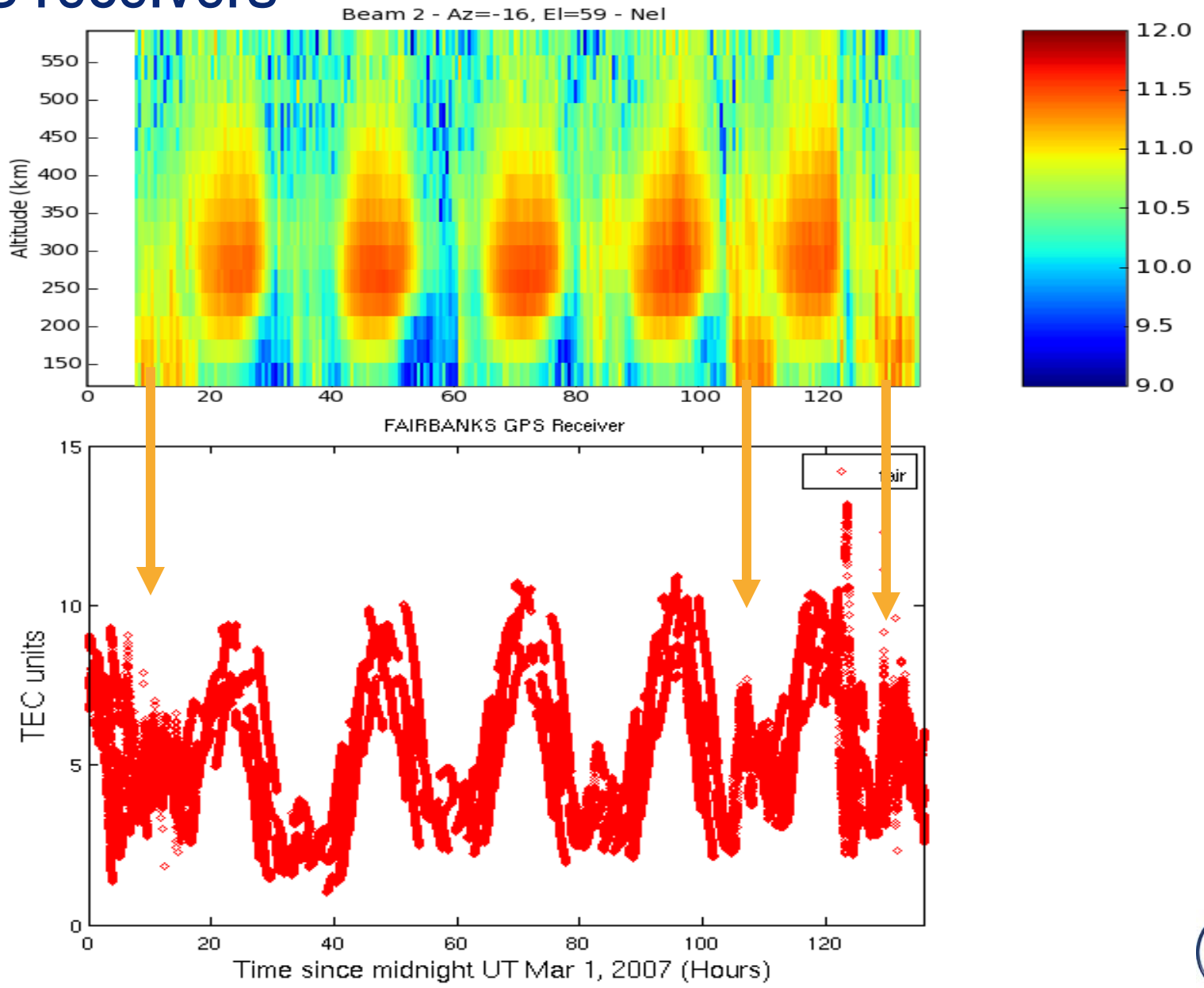




GPS receivers



GPS receivers

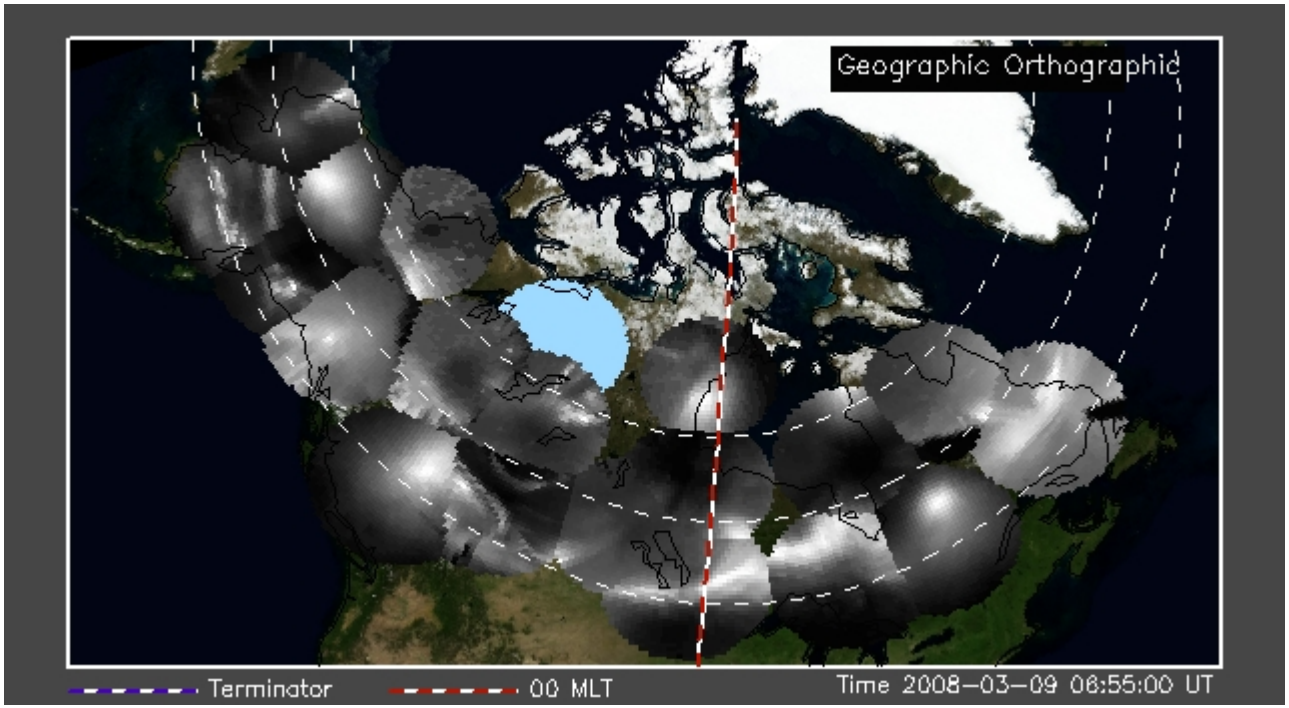


Rockets

- JOULE II, HEX, ROPA rockets launched last year with PFISR ground support
- Many instruments on each rocket to make the in situ measurements

Satellites

- Many satellites pass over the PFISR site
- The data can be used both for validation purposes and for new science
- TIMED, CLUSTER, THEMIS, DEMETER, REIMEI, CHAMP…
- THEMIS mission has also installed a network of ground-based all-sky imagers, some of which are located in Alaska. The auroral mosaics can be accessed on the web



Data access

- MADRIGAL
- GEDDS
- HAARP
- Optical data from the 2007/2008 season is currently available at http://odin.gi.alaska.edu/lumm/Poker
- Raw and digital product images will be available for FTP (contact Don Hampton)
- Future plans for coordinated instrument web site with links to instrument details and data archives

Developers of PFISR instruments

- John Meriwether - Clemson U.
- Trond Trondsen - KEO Scientific
- Jeff Baumgardner - Boston U.
- Mike Taylor - Utah State U.
- Dirk Lummerzheim - GI, UAF
- Roger Smith - GI, UAF
- Brian Lawson - PFRR, UAF
- Ed Hoch - GI, UAF
- Don Hampton – GI, UAF

Contact

For more information on the Poker Flat instruments and to request data, contact:

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