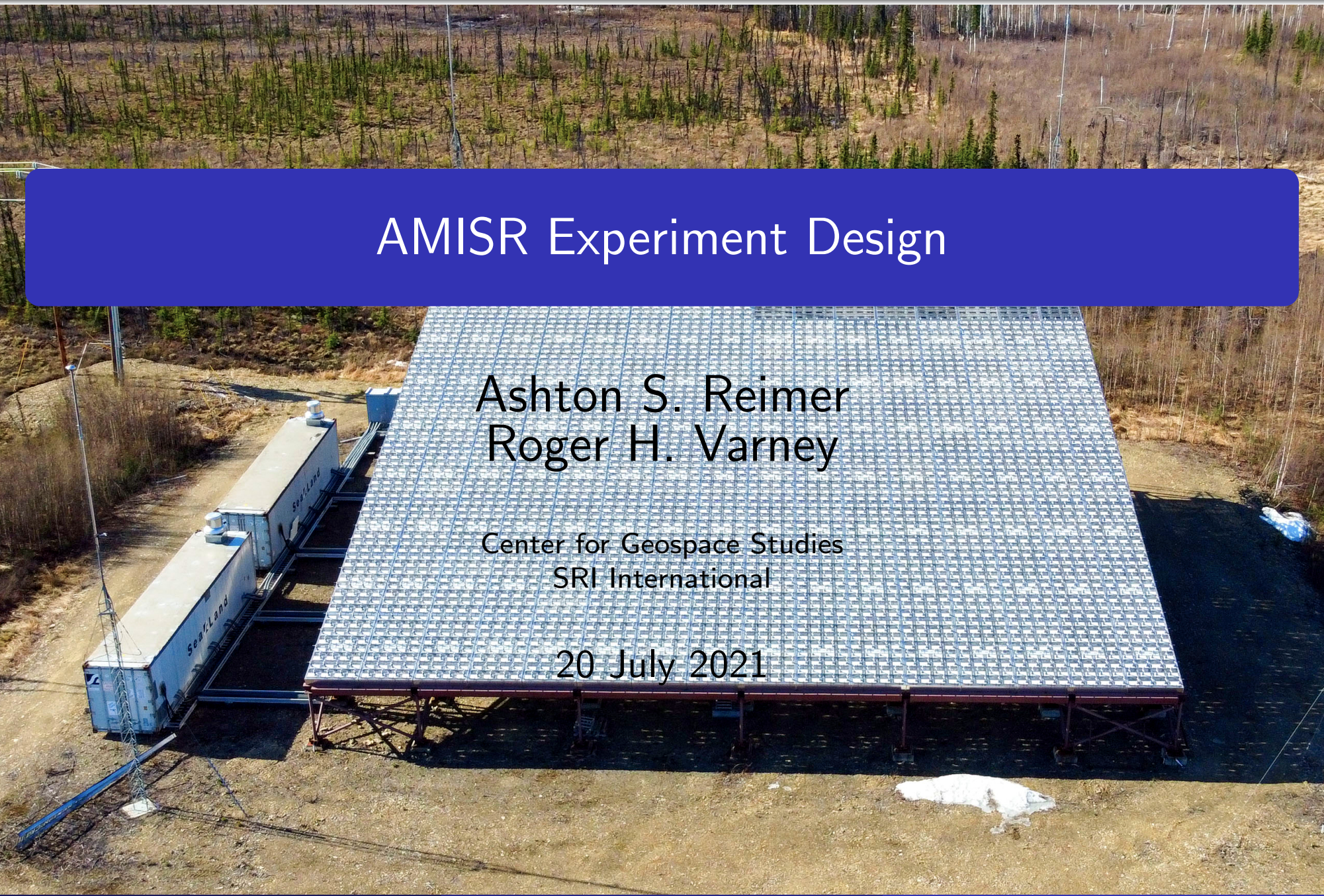

AMISR Experiment Design

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20 July 2021

Experiment Design

Science objectives and radar operations are a coupled system. Designing a radar experiment is an optimization problem.

Many parameters need to be determined:

- pulse length $\longleftrightarrow$ range resolution
- pulse type/code $\longleftrightarrow$ range resolution
- Rx sampling rate $\longleftrightarrow$ range resolution
- interpulse period $\longleftrightarrow$ maximum range
- Tx/Rx frequencies $\longleftrightarrow$ increasing duty cycle/sampling statistics
- antenna pointing, "look directions" or "line-of-sight" $\longleftrightarrow$ capturing dynamics, time resolution
- measurement uncertainty $\longleftrightarrow$ duty cycle, total number of pulses, time resolution
- etc.

Parameters are radar dependent. Each ISR is different.

Relative Error

Most of the experiment design choices are trying to balance:

$$\%\mathtt{error} \approx \frac{1}{\sqrt{K}}\left(1+\frac{1}{\mathtt{SNR}}\right)$$

K is affected by:

- interpulse period $\longleftrightarrow$ maximum range
- Tx/Rx frequencies $\longleftrightarrow$ increasing duty cycle/sampling statistics
- antenna pointing, "look directions" or "line-of-sight" $\longleftrightarrow$ capturing dynamics, time resolution

SNR is affected by:

- pulse length $\longleftrightarrow$ range resolution
- pulse type/code $\longleftrightarrow$ range resolution
- Rx sampling rate $\longleftrightarrow$ range resolution

Example: Different ISR Antennas

Dish antenna:

- Single pointing direction
- Moving the dish requires time, usually minutes
- Spatial-temporal ambiguities: is the plasma moving or evolving in time?

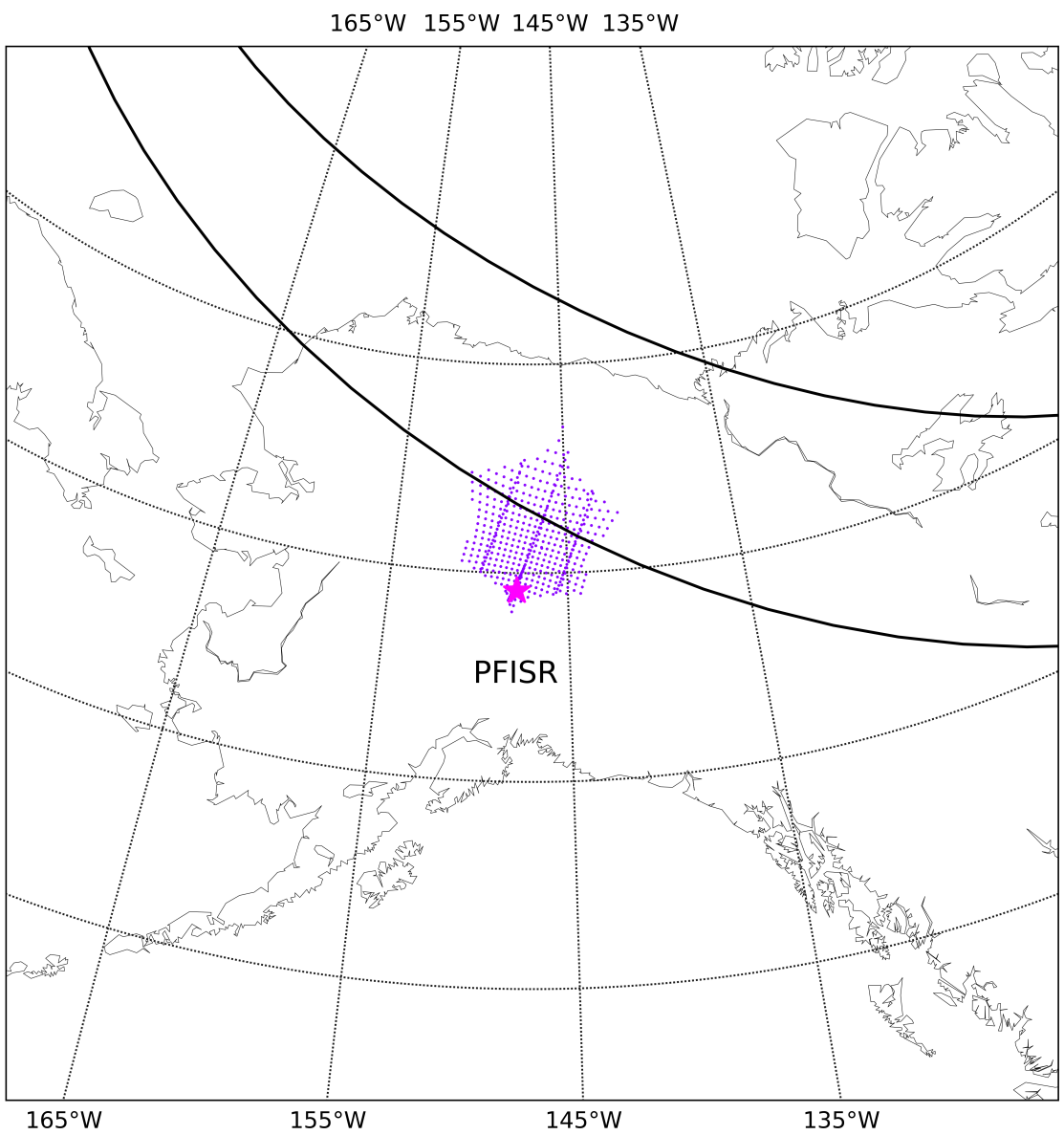
Phased array antenna:

- Multiple pointing directions, change on a "pulse-to-pulse" basis
- Volumetric determination of scalar parameters: density and temperature
- Measurements can be post-integrated; flexible integration time

PFISR: Poker Flat Incoherent Scatter Radar

(May 2021)

PFISR Location



Pulse Types

AMISR pulse types, a qualitative summary:

- Uncoded Long Pulse
  - Low range resolution, high sensitivity
  - Best suited for F-region measurements above peak ($\gtrsim$ 250km)
- Alternating Code
  - High range resolution, medium sensitivity
  - Best suited for E- and lower F-region measurements ($\lesssim$ 250km)
- Barker Code
  - Highest range resolution, high sensitivity
  - Best suited for D- and lower E-region measurements ($\lesssim$ 120km)

Note: There are many other radar pulse types, including: psuedo-random phase codes, poly-phase codes, amplitude modulated, frequency modulated, etc.

3 Flavors

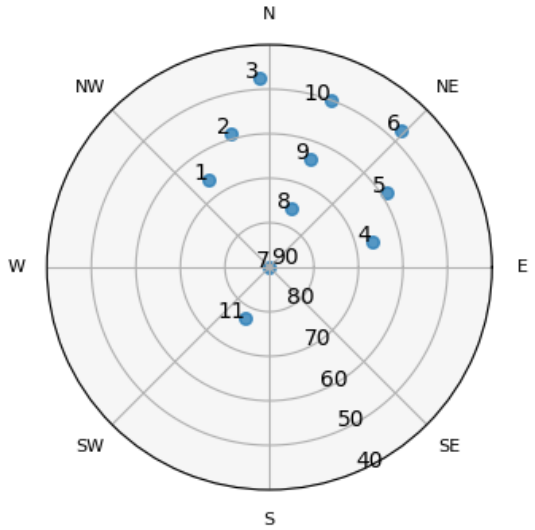
Can propose one of 3 "flavors" of experiments:

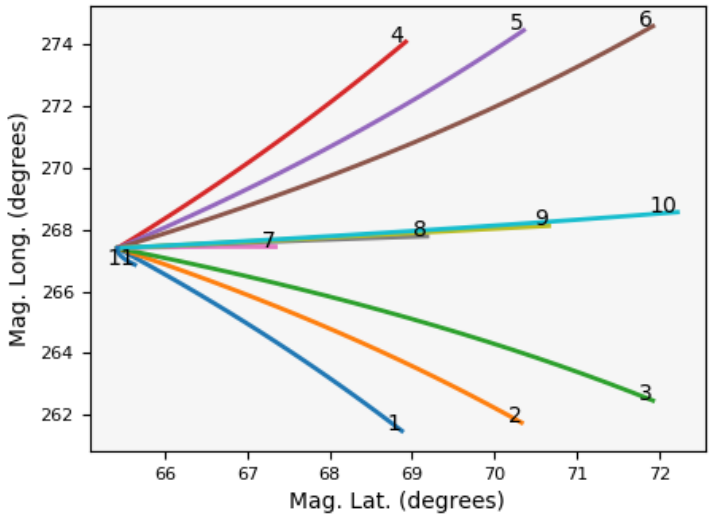
- **E- and F-region:**
  - alternating code
  - long pulse
- **D-region focus, E- and F-region context:**
  - barker code
  - alternating code
  - long pulse
- **F-region only:**
  - long pulse only

E- and F-region

Example Mode, WorldDay35:

- 480 us pulse, alternating code, 30 us bauds, 10 us samples
- 330 us uncoded long pulse, 20 us samples
- Both upshifted and downshifted plasma line channels
- 11 Beams
- 1/1 pulses split between long pulse/alternating code
- F-region ion velocity field reconstruction and E-region neutral winds

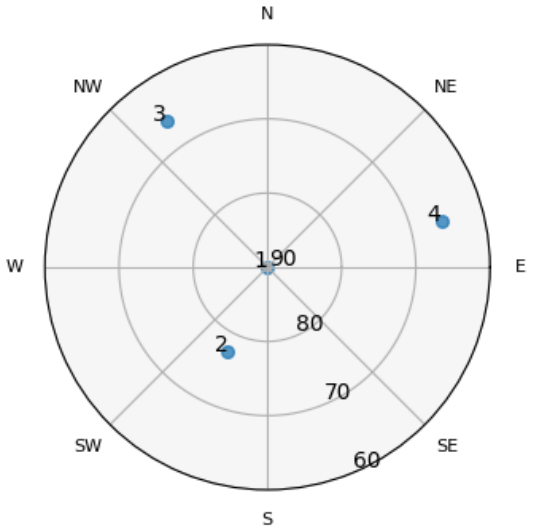


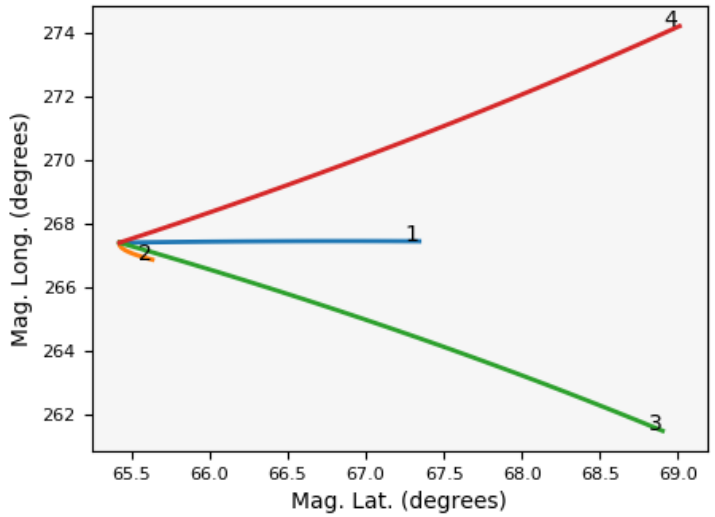


D-region focus, E- and F-region context

Example Mode, MSWinds26.v03:

- 130 us, 13 baud barker code, 10 us bauds, 5 us samples
- 480 us pulse, alternating code, 30 us bauds, 10 us samples
- 480 us uncoded long pulse, 30 us samples
- 4 Beams
- 8/1/1 pulse split between barker code/long pulse/alternating code
- F-region ion velocity field reconstruction and both D- and E-region neutral winds

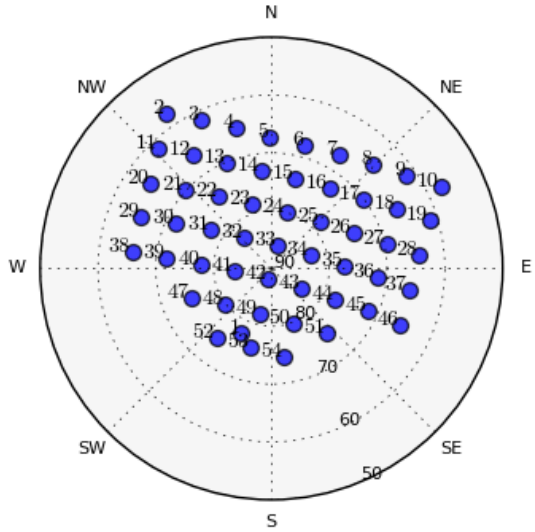


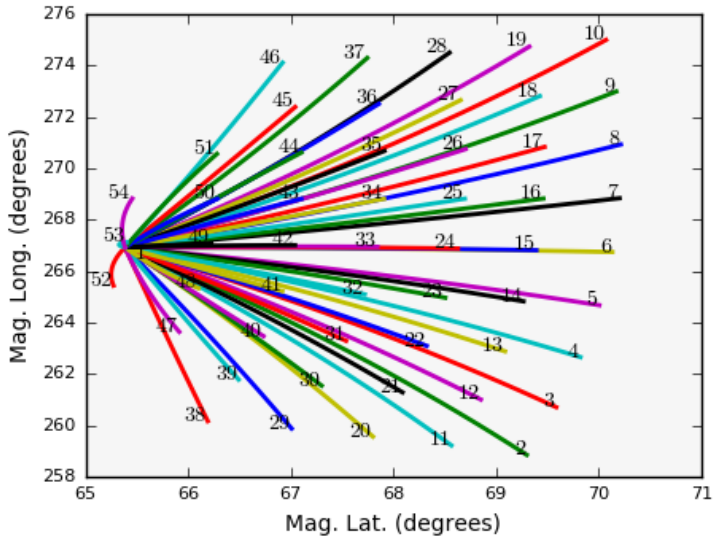


F-region only

Example Mode, ZenithImaging:

- Tri-frequency uncoded long pulse
- 330 us uncoded long pulse, 20 us samples
- 54 Beams
- F-region ion velocity field reconstruction





Experiment Design Choices

Limited Design Choices

- Propose an experiment for PFISR
- Pick a flavor: D-, E- and F-region, E- and F-region, or F-region only
- Specify a beam pattern (elevation/azimuth pairs)
- Specify a beam revisit pattern (e.g. evenly spread pulses? revisit 1 beam?)

PFISR Beams:

- PFISR beamcodes: `https://amisr.com/amisr/about/about_pfisr/pfisr-specs/`

PFISR Schedule:

- `https://amisr.com/database/61/sched/2019/08`

Operations

PFISR Realtime Displays:

- `https://amisr.com/realtime/viewer`

Global Context:

- Realtime Alaska magnetometer data: `https://www.gi.alaska.edu/monitors/magnetometer`
- Realtime SuperDARN data: `https://superdarn.ca/real-time`
- Realtime solar wind data:

`https://www.swpc.noaa.gov/products/real-time-solar-wind`

AMISR Questions

If you have any questions or would like feedback on experiment proposals, please speak to Roger Varney or Ashton Reimer.
Email: `roger.varney@sri.com` and `ashton.reimer@sri.com`