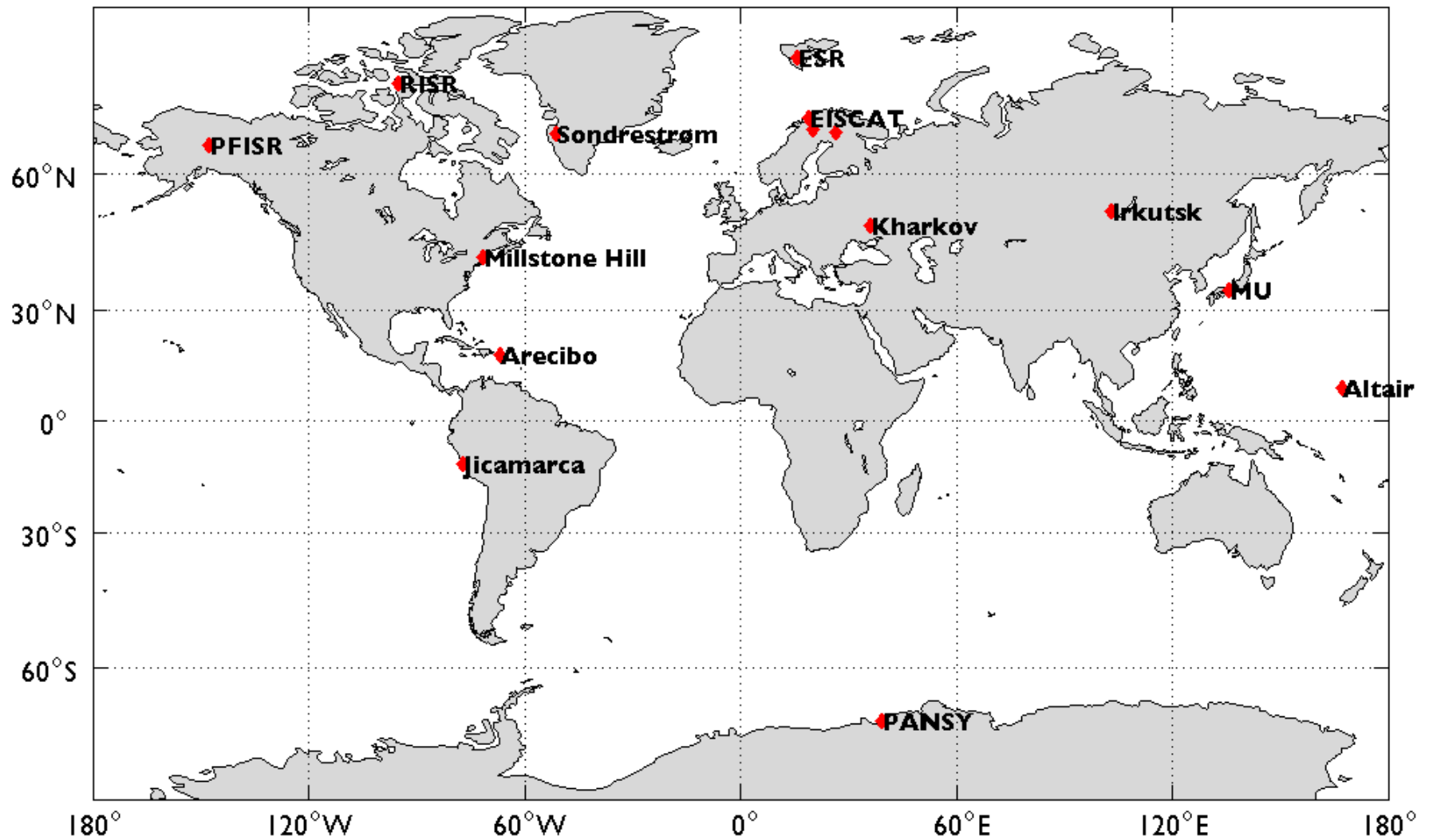


The US Incoherent Scatter Radars

Anja Strømme

National Science Foundation

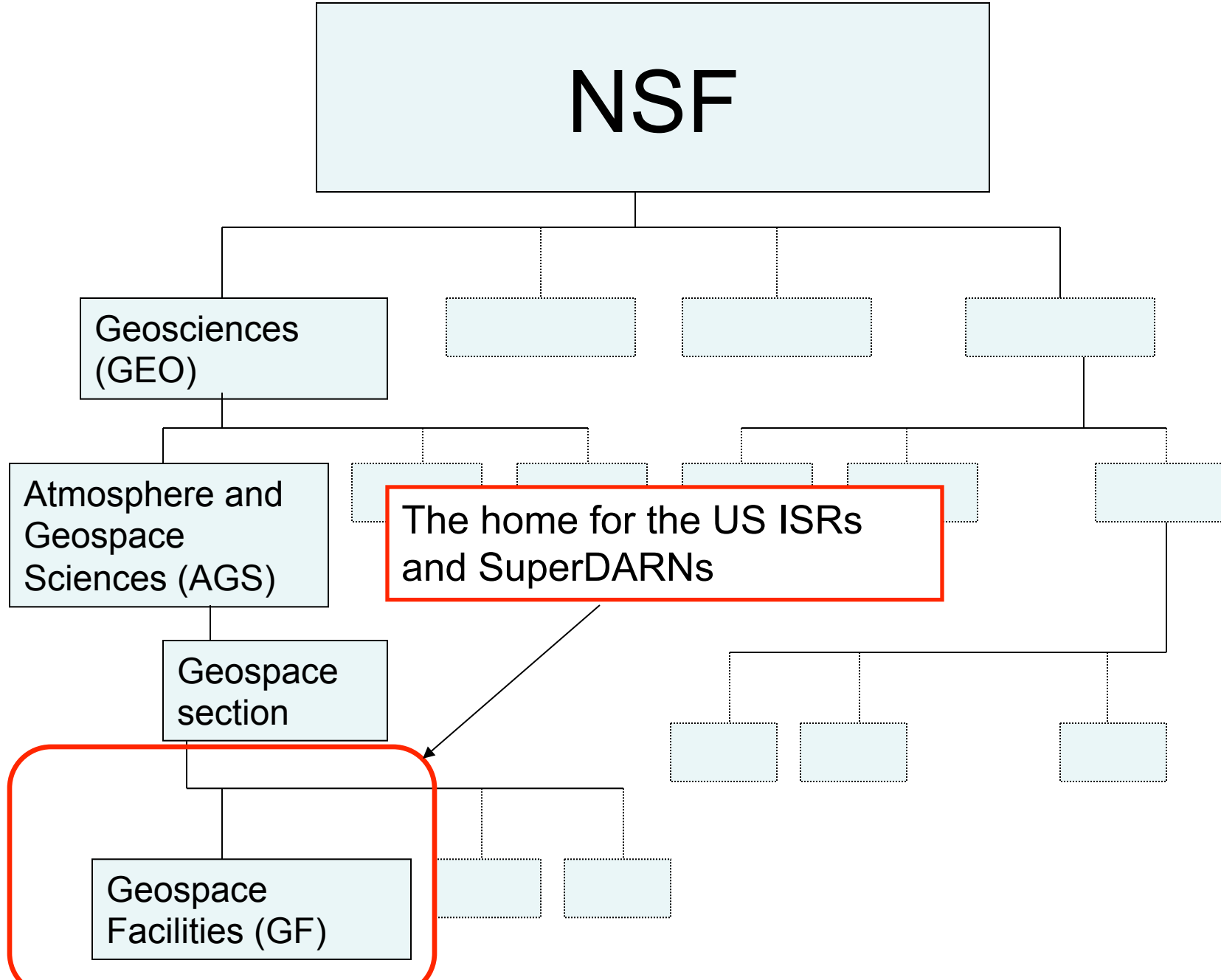
Incoherent Scatter Radars



Map: Thomas Ulich

How it works...

- All the US Incoherent Scatter Radars are funded by the National Science Foundation (NSF) and are governed under the Geospace Facility (GF) program (formerly known as the Upper Atmosphere Facility Program (UAF)).



Geospace section

```
graph TD; A[Geospace section] --> B[Geospace facilities]; A --> C[Aeronomy]; A --> D[Magnetosphere]; A --> E[Solar]; A --> F[Space Weather]
```

Geospace
facilities

Aeronomy

Magnetosphere

Solar

Space
Weather

How it works

- All the US Incoherent Scatter Radars are funded by the National Science Foundation (NSF) and are governed under the Geospace Facility (GF) program.
- The Operation and Maintenance (O&M) is done by a host institution through a cooperative agreement renewed every 5 years.

From South to North...

- Jicamarca - Cornell University (in collaboration with Instituto Geofísico del Perú)
- Arecibo - SRI International in collaboration with USRA and UMET
- Millstone Hill - MIT
- PFISR - SRI International
- Sondrestrom - SRI International
- RISR-N - SRI International
- RISR-C - Calgary University

Contact information Principal Investigator

- Jicamarca: Jorge L. (Koki) Chau
jorge.chau@jro.igp.gob.pe
- Arecibo: Bob Kerr
Bob.kerr@sri.com
- Millstone Hill: Phil Erickson
pje@haystack.mit.edu
- PFISR: Mike Nicolls michael.nicolls@sri.com
- RISR (+AMISR): Craig Heinzelman/Mike Nicolls
craig.heinzelman@sri.com/
michael.nicolls@sri.com
- Sondrestrom: Mary McCready
mary.mccready@sri.com

How it works - practically (1)

- The radars are available to all US users, and **in reality to all users.**
- Analyzed data is available in the madrigal database
 - <http://jro.igp.gob.pe/madrigal/> (Jicamarca)
 - <http://madrigal.naic.edu/> (Arecibo)
 - <http://madrigal.haystack.mit.edu/madrigal/> (Millstone Hill)
 - <http://isr.sri.com/madrigal/> (SRI International)
 - <http://www.eiscat.se/madrigal/> (EISCAT)

How it works - practically (2)

- There are annual “world days” coordinated between all the radars (515 hours in 2011).
- Otherwise scheduling is done individually for each radar (the SRI radars - Sondrestrom, PFISR and RISR - are scheduled together).
- We are working toward more coordinated scheduling and operation of all the GF radars.

- One slide history of ISRs (by Bob Robinson)



B Millstone
 cc by MIT
 ii Lab
 scatter
 DNA built
 NSF takes
 Stanford
 over
 Arecibo
 Chatanika

NSF takes
 over
 Jicamarca
 from NOAA
 Chatanika
 radar moved
 to Canada
 EISCAT
 built

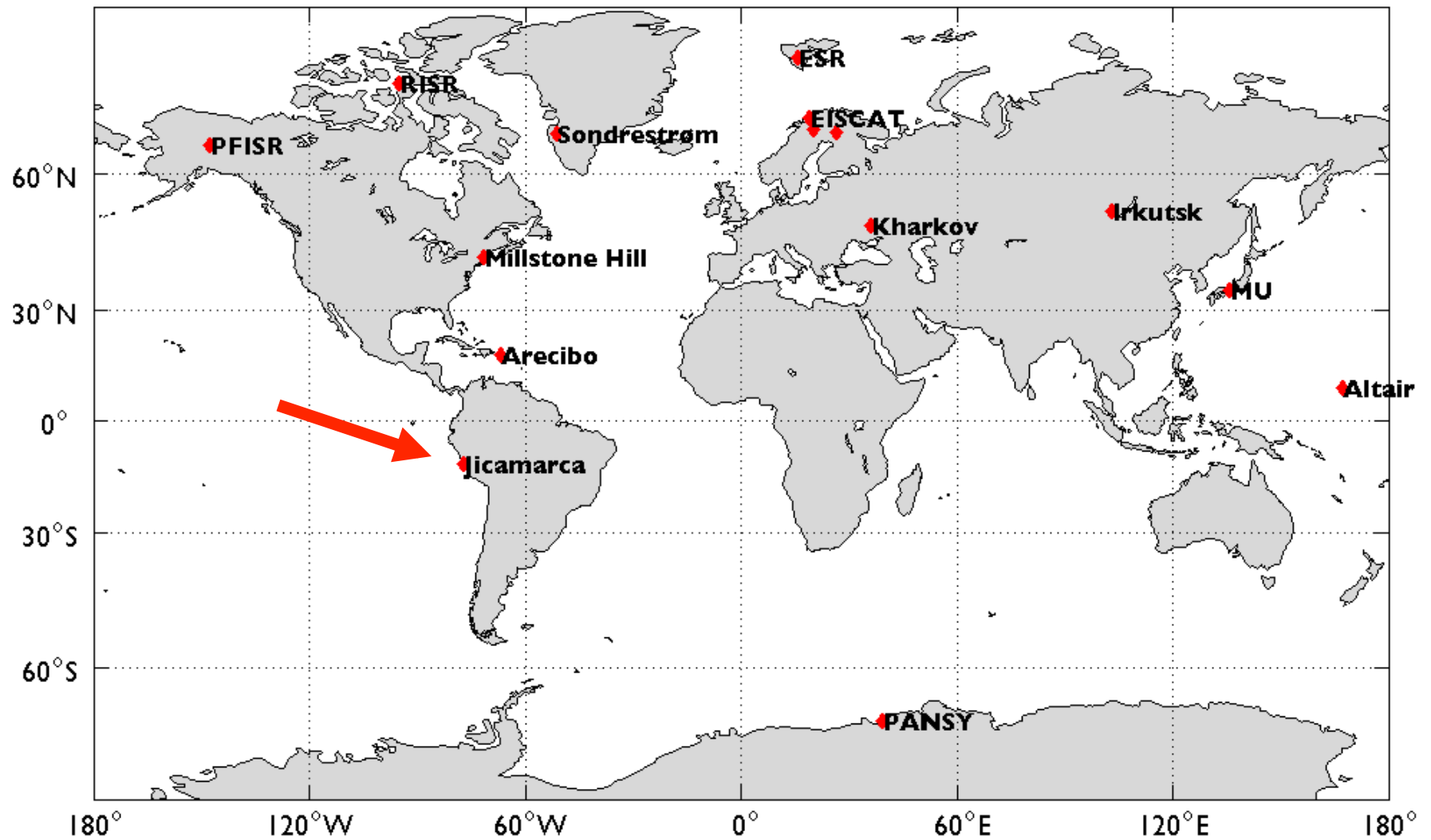
EISCAT
 Svalbard
 Radar built

AMISR is
 built in
 Canada

1955 1960 1965 1970 1975 1980 1985 1990 1995 2000 2005 2010

The radars:

Incoherent Scatter Radars

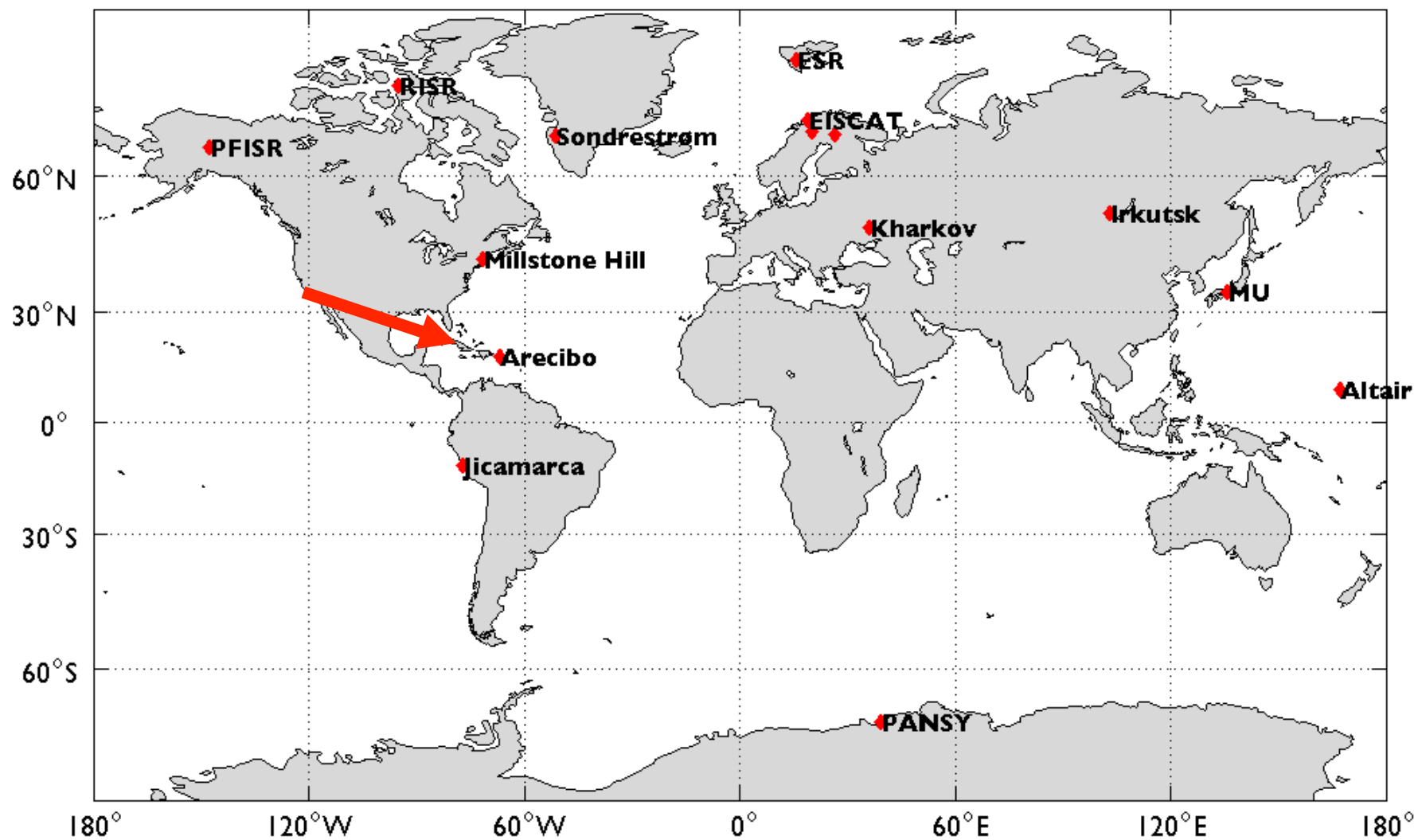


Map: Thomas Ulich

Low-Latitude Incoherent Scatter Radar - Jicamarca

- latitude 11.95° South, longitude 76.87° West
- 50 MHz
- 3 x 1.5 MW transmitters
- 18,432 dipole elements (64 sections of 12×12)
- 300 x 300 m main array (with a 12×12 array offset to the west for longer baseline interferometry)
- Close to magnetic equator (about 1° dip angle)
- Unique imaging/interferometric capabilities

Incoherent Scatter Radars



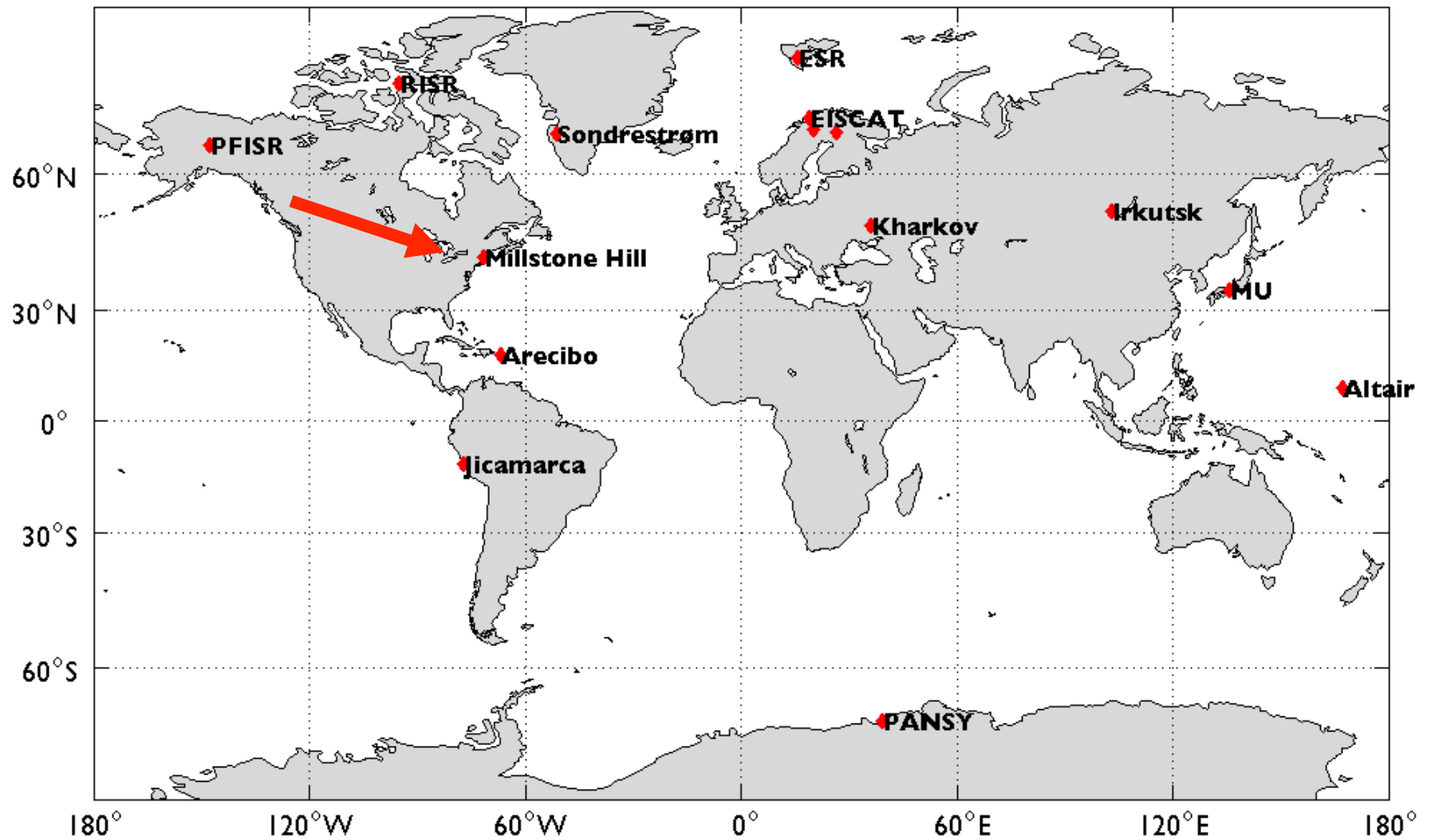
Map: Thomas Ulich

... Photo courtesy of the NAIC - Arecibo Observatory, a facility of the NSF
... Photo by David Parker / Science Photo Library

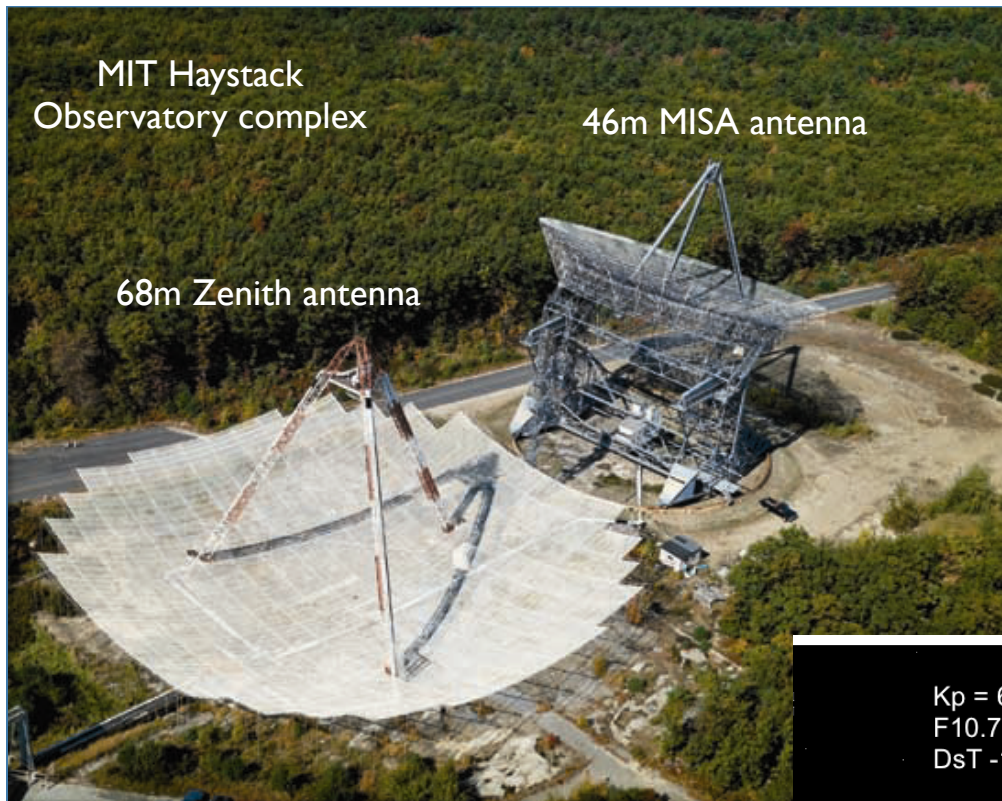
Arecibo ISR

- latitude $18^{\circ} 20' 36.6''$ North
- longitude $66^{\circ} 45' 11.1''$ W West
- 430 Mhz
- 2.5 MW transmitters
- 305m diameter fixed dish
- Two feeds - line feed and Gregorian feed
- Also used as 2.4 GHz planetary radar
- Also used as (the worlds largest single dish) radio telescope
- New heater any day now

Incoherent Scatter Radars



Map: Thomas Ulich



Millstone Hill UHF Incoherent Scatter Radar Westford, MA USA

440.2 MHz frequency

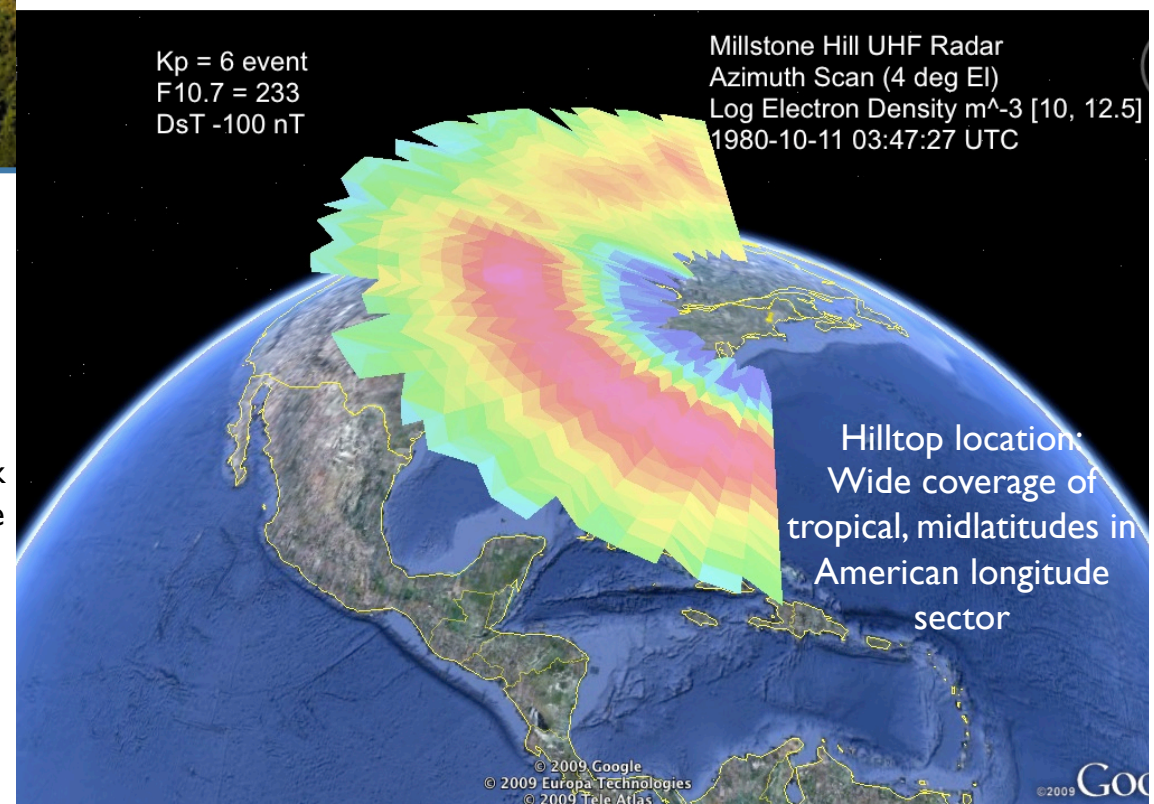
2.5 MW peak TX

System temperature ~ 150 -200 K overall

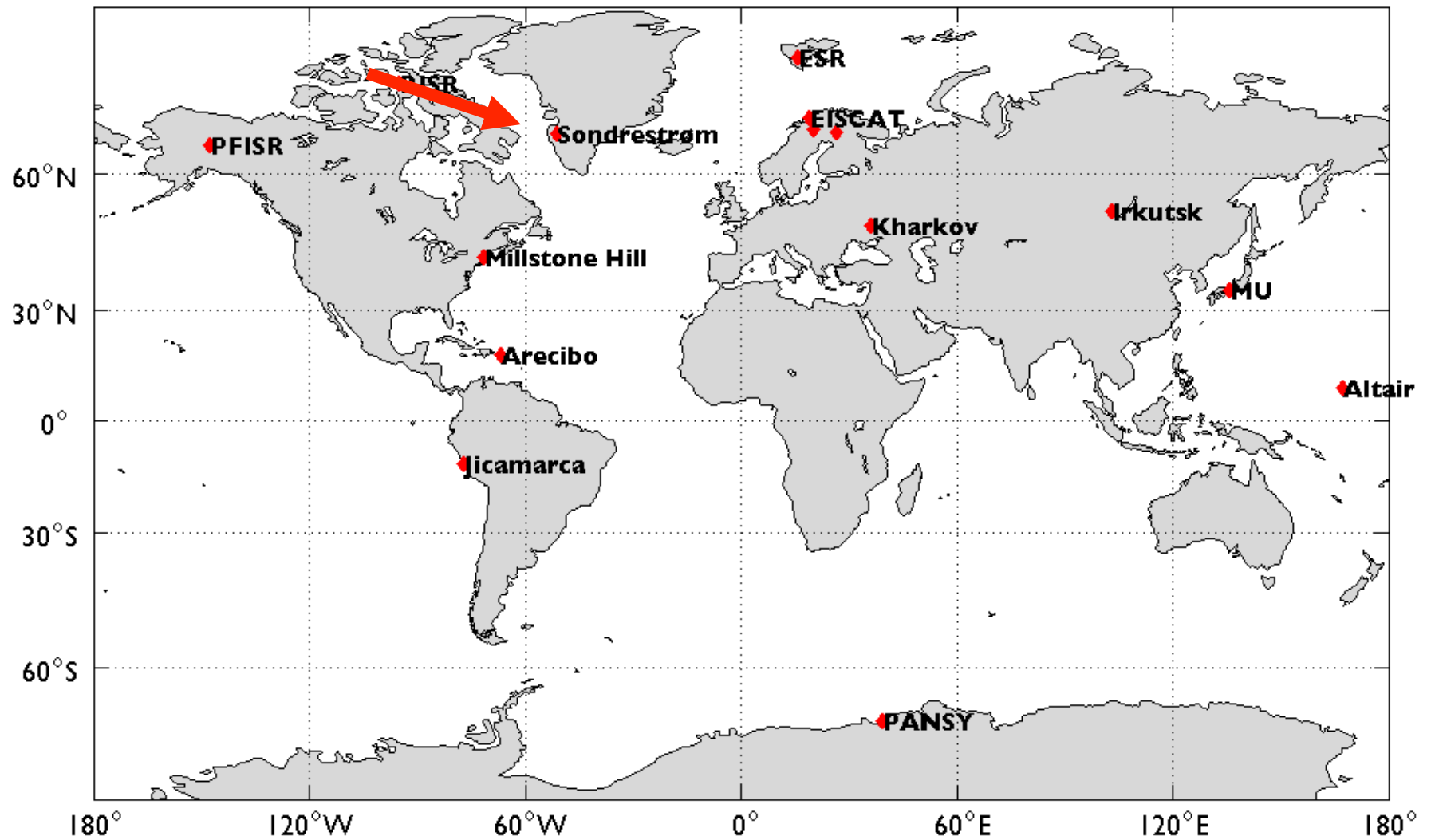
Fully steerable 46m antenna

68m zenith antenna

In operation since 1960



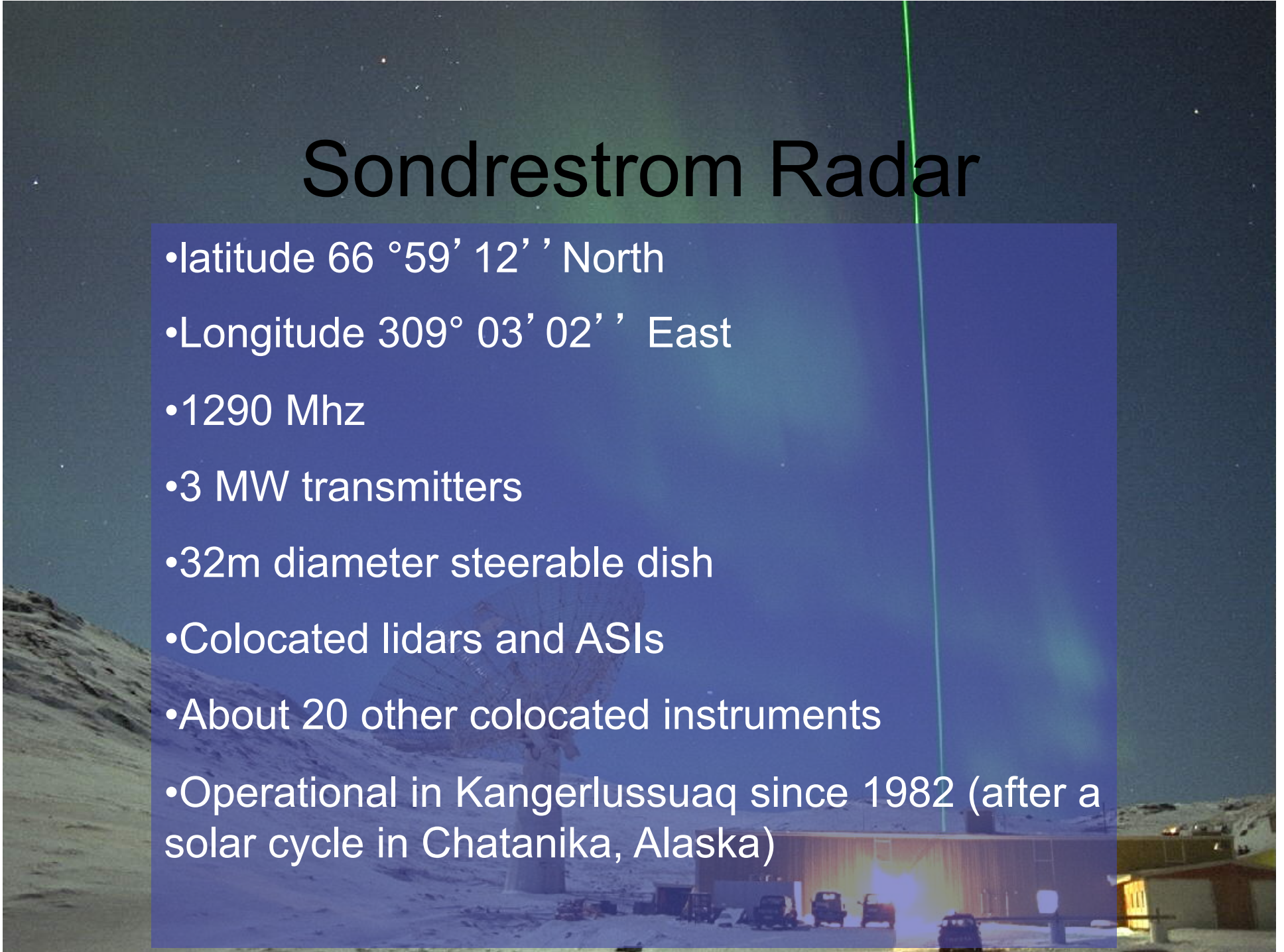
Incoherent Scatter Radars



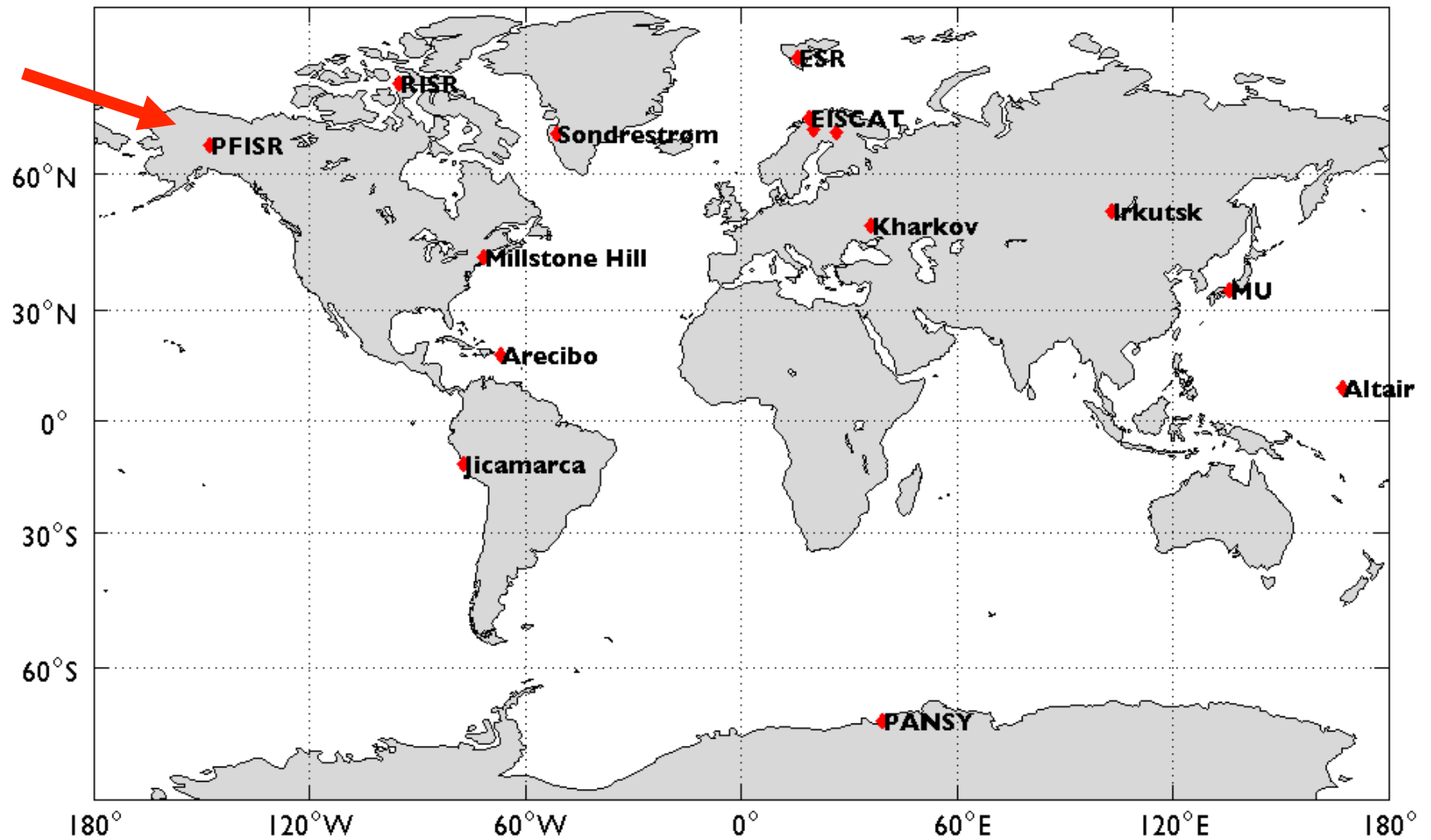
Map: Thomas Ulich

Sondrestrom Radar

- latitude $66^{\circ}59'12''$ North
- Longitude $309^{\circ}03'02''$ East
- 1290 Mhz
- 3 MW transmitters
- 32m diameter steerable dish
- Colocated lidars and ASIs
- About 20 other colocated instruments
- Operational in Kangerlussuaq since 1982 (after a solar cycle in Chatanika, Alaska)



Incoherent Scatter Radars



Map: Thomas Ulich

...but first some general words
about AMISR...

AMISR

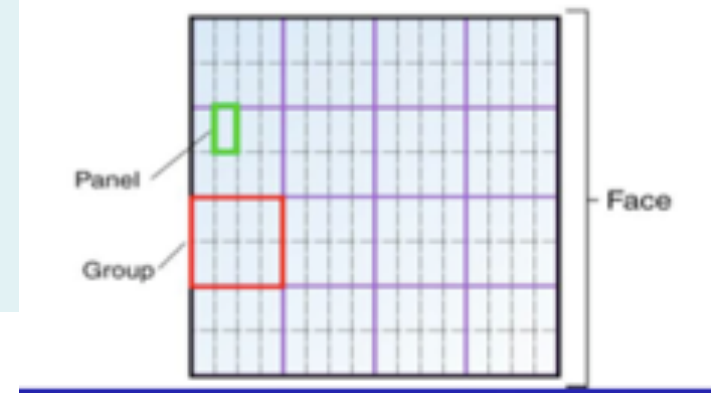
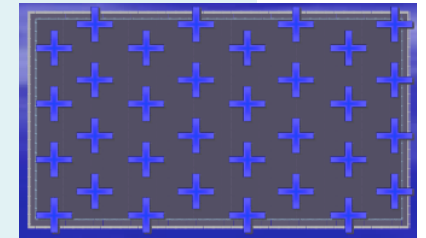
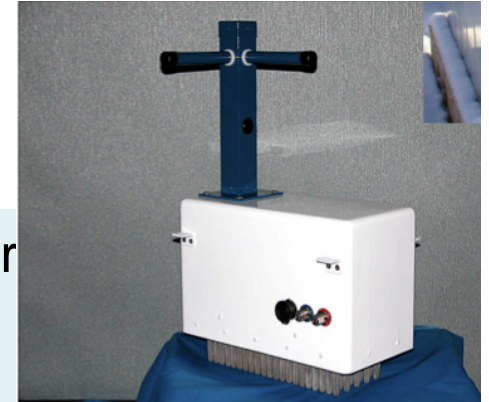
- First US ISR designed under NSF funding for pure scientific research
- First modular pulse-to-pulse steerable Incoherent scatter radar

Abbreviations!!!!

- **AMISR** - Advanced Modular Incoherent Scatter Radar
 - Refers to the technology and the overall kind of radar
- **PFISR** - Poker Flat Incoherent Scatter Radar
 - An AMISR radar located in Poker Flat, Alaska
- **RISR-N** - Resolute Bay Incoherent Scatter Radar – North
 - An AMISR Radar in Resolute Bay, Canada. Pointing north
- **RISR-C** - Resolute Bay Incoherent Scatter Radar – Canada
 - An AMISR radar under construction in Resolute Bay, Canada. Pointing South. Funded (and owned) by Canada. Official name RISR-C

The lego set

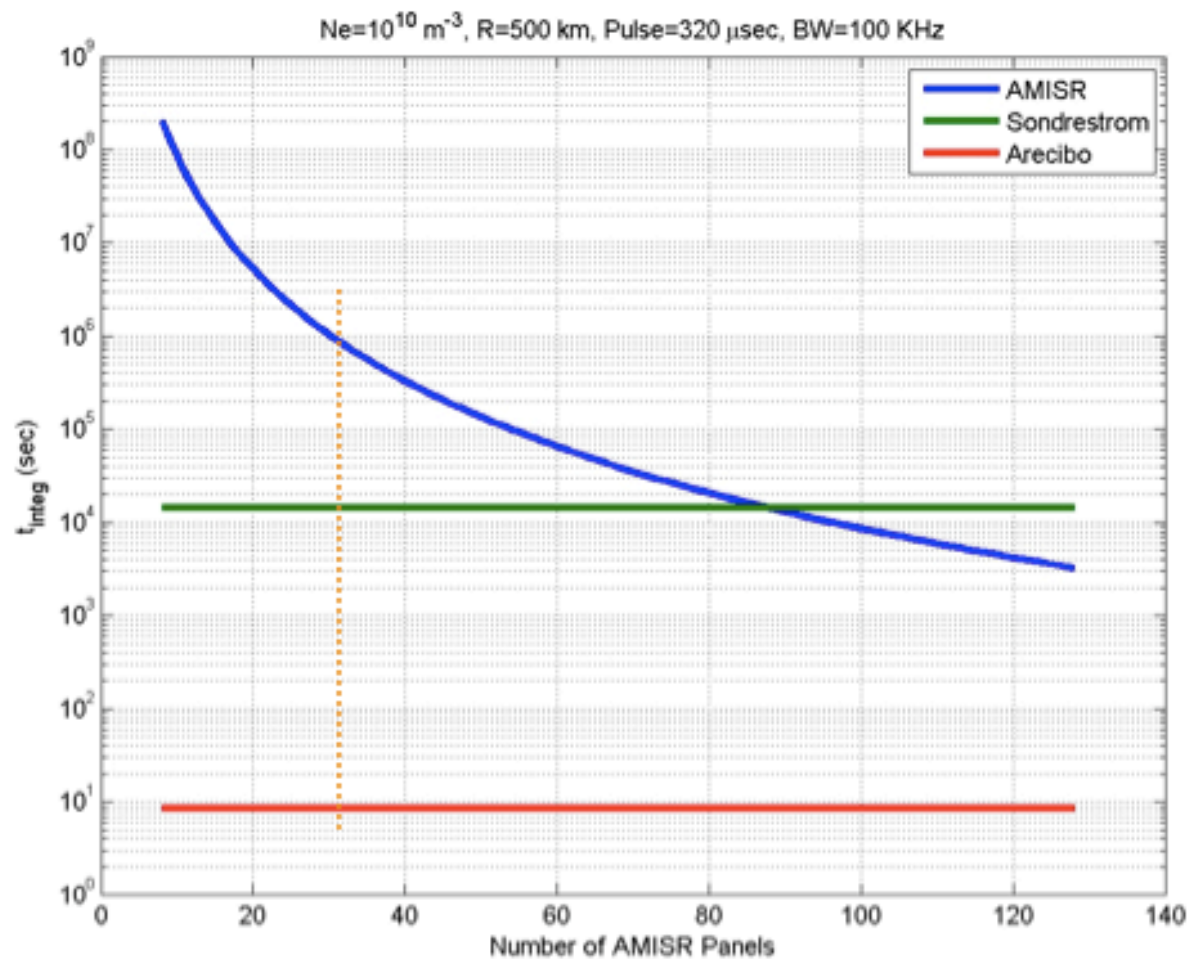
- AMISR: Advanced Modular Incoherent Scatter Radar
- AEU: Antenna element unit (4096 per radar)
- Panel: smallest “lego” piece (consist of 32 AEU)
- Group: Set of Panels (consist of 8 panels)
- Face: Set of groups (one complete radar (“Face”) consist of 16 groups, 128 panels, 4096 AEU...)



More about the “current” AMISR

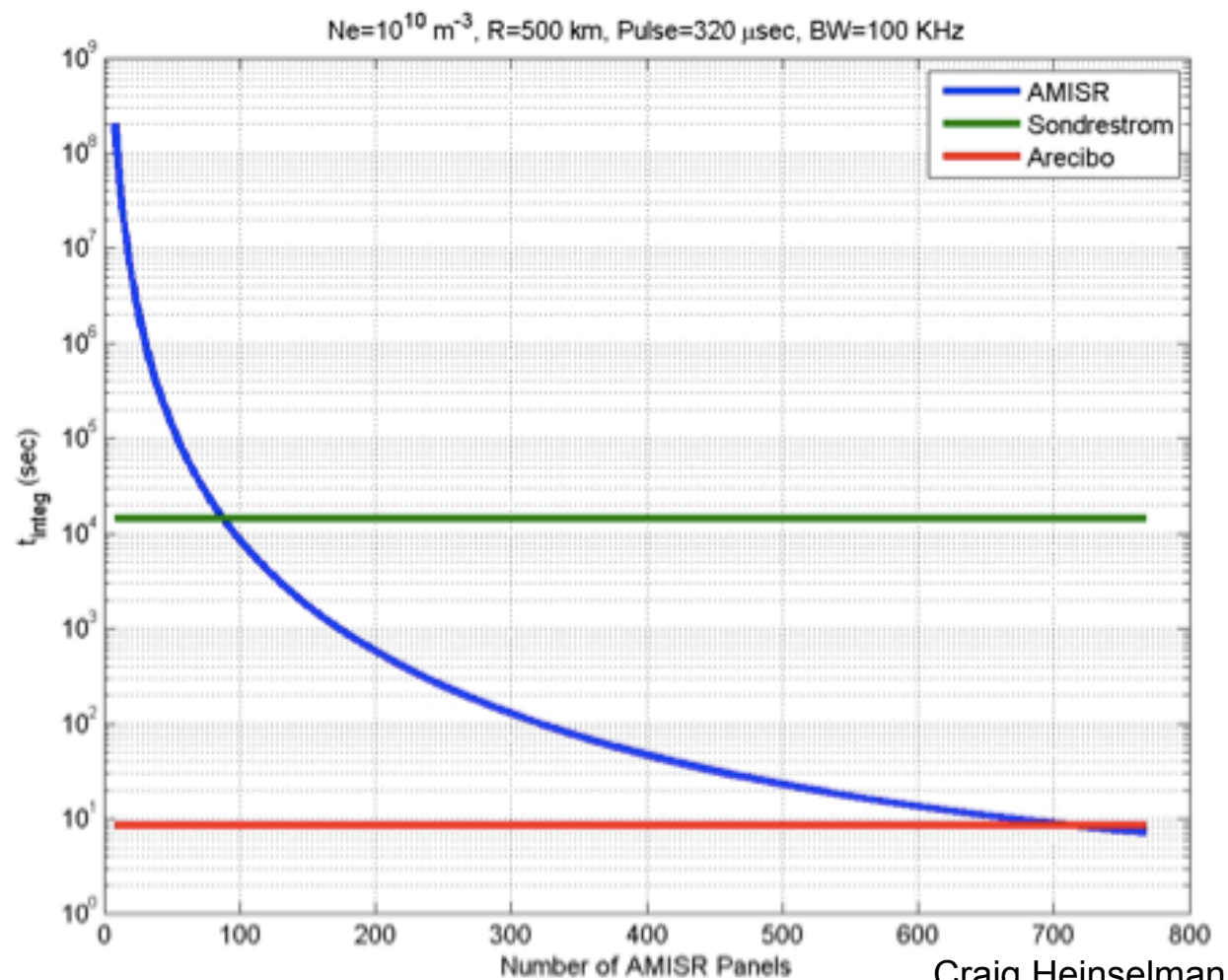
- NSF originally funded 3 full faces. Funding was sufficient to two (and a bit)
 - One operational since January 2007 in Poker Flat, Alaska (PFISR)
 - Second operational since Dec 2009 in Resolute Bay, Canada (RISR-N)
 - A collaboration with Canada will lead to the completion of the third face of the original AMISR plan (RISR-S now RISR-C).
- Modular/Transportable/Reconfigurable
- Phased array - pulse-to-pulse steering
- Solid state
 - No moving parts, can hence be remotely controlled
- Gentle degrade
- 430-450 MHz TX frequency
- ~2 MW peak power per radar (10% duty cycle)
- 1 μ s to 2 ms pulses

AMISR Sensitivity vs. Size



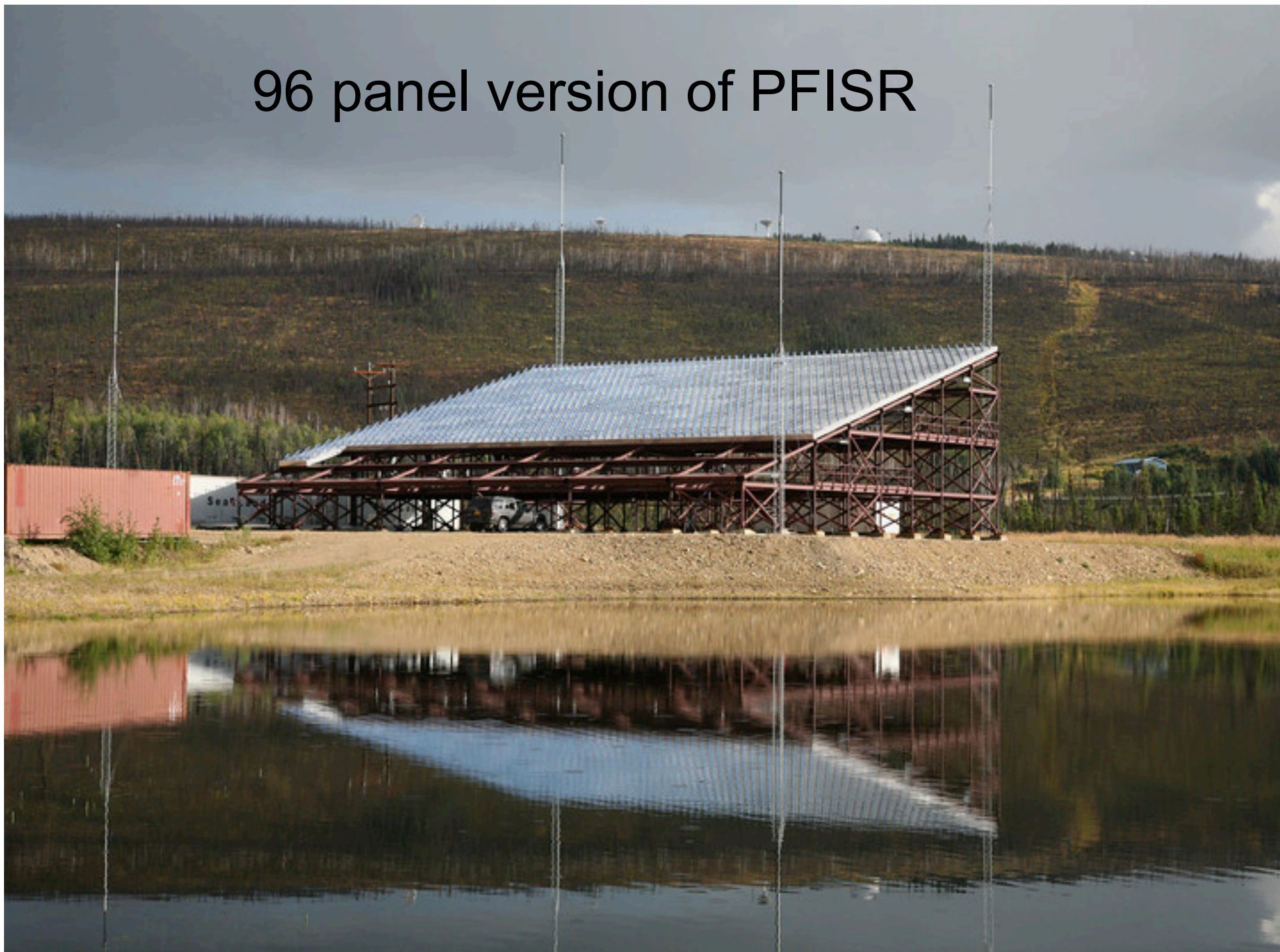
Craig Heinselman

AMISR Sensitivity vs. Size



Craig Heinselman

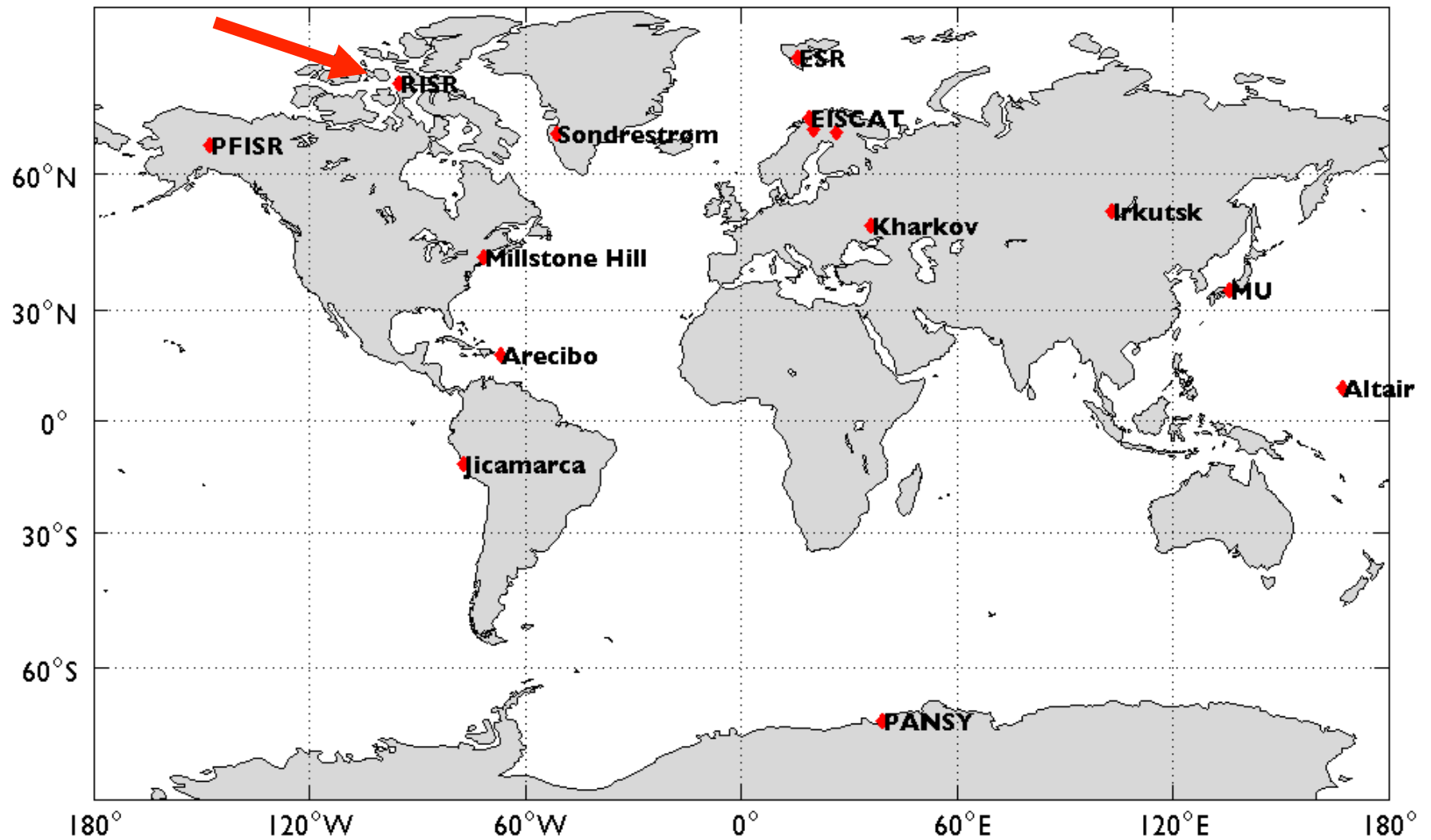
96 panel version of PFISR



PFISR



Incoherent Scatter Radars



Map: Thomas Ulich



Photo: John Kelly

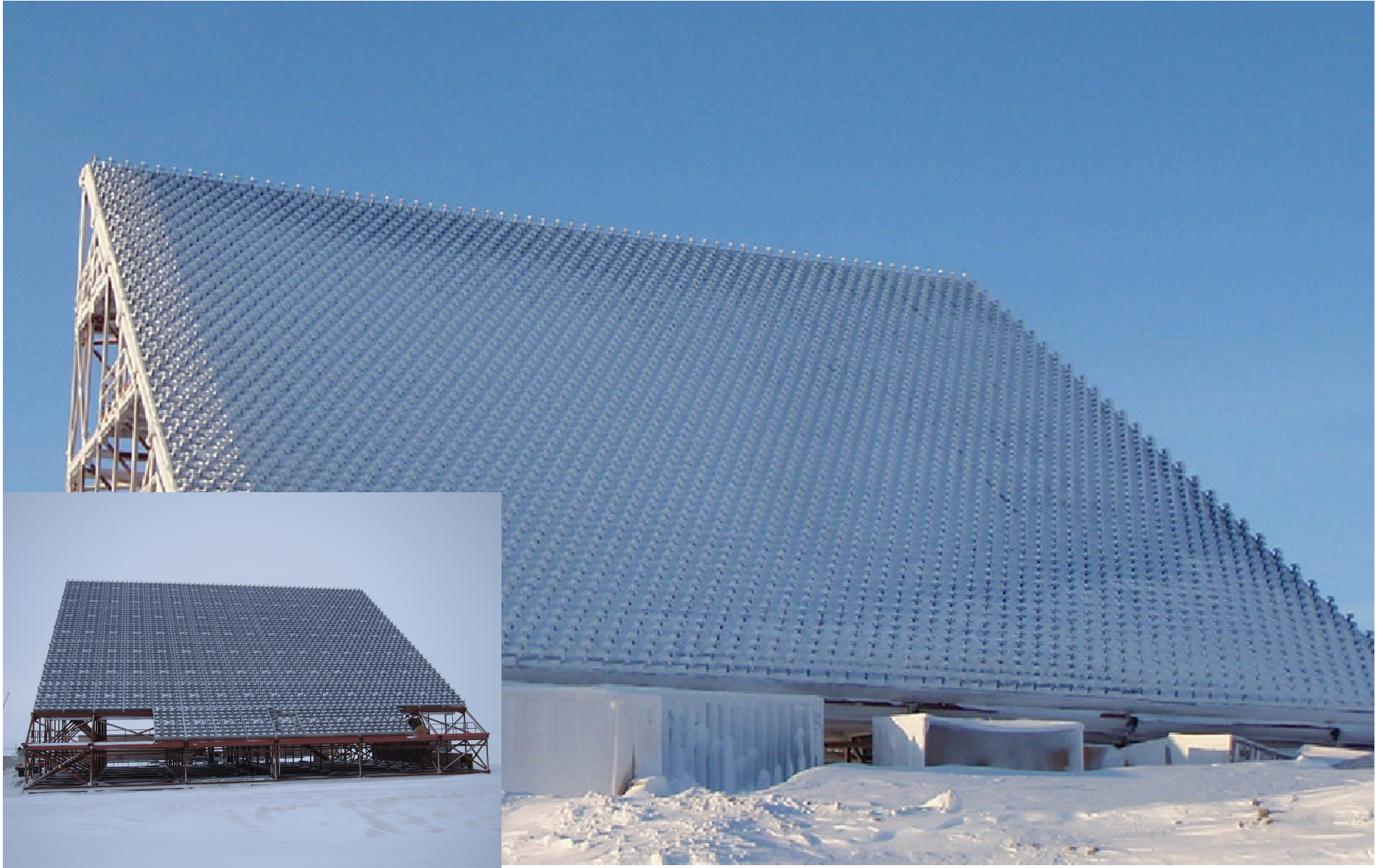


Photo: Craig Heinselman

Question

- **What is the most important aspect of incoherent scatter radars that have kept them at the forefront of ionospheric and atmospheric research?**

