# A blackbox view of incoherent scatter radar
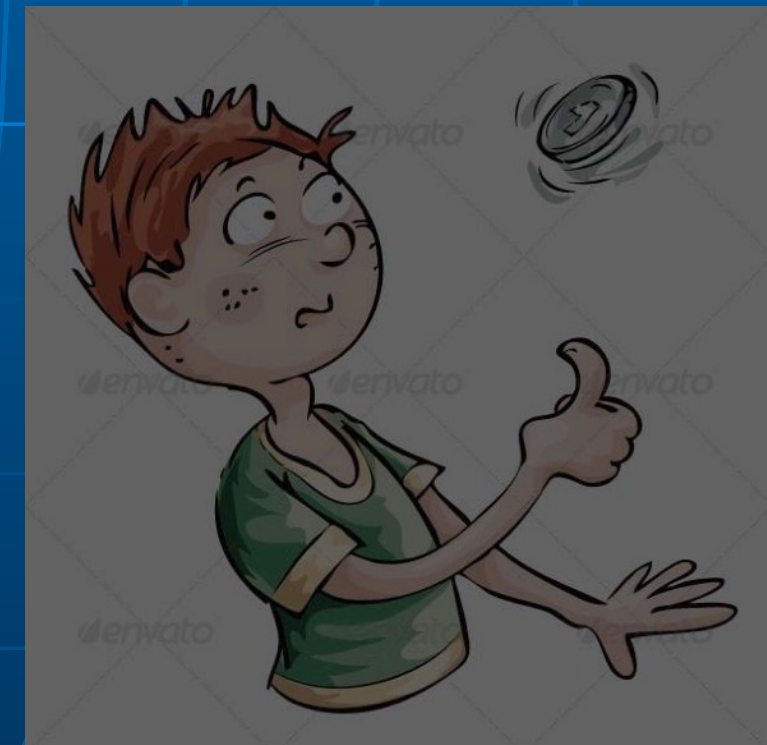
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2020 ISR Summer School

# Outline

## Blackbox ISR Video 1

- Brief discussion of ISR blackbox

- Existing ISRs treated as blackbox
  - Exercise with simulator - existing ISRs

## Blackbox ISR Video 2

- New ISRs treated as a black box
  - Exercise with simulator - new ISRs Simulate creating a new ISR

# Treat ISR as a blackbox

- What are the science outputs?
- What knobs can you turn at the input?
  - For an existing ISR
  - If you got to build a new ISR
- Try it yourself with two on-line tools
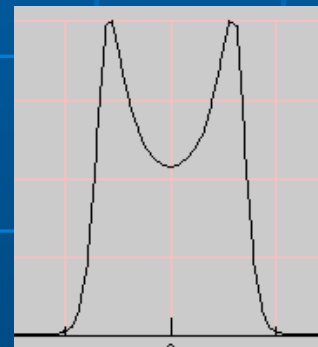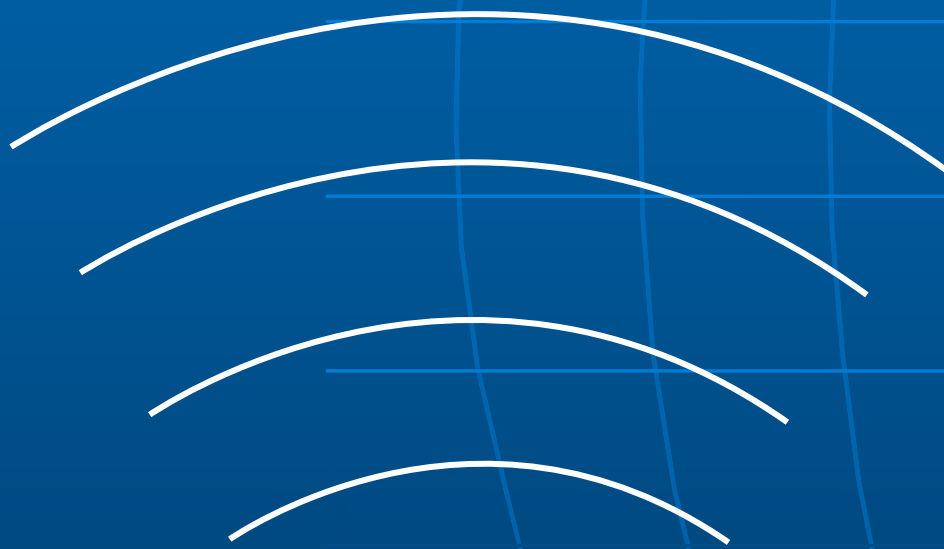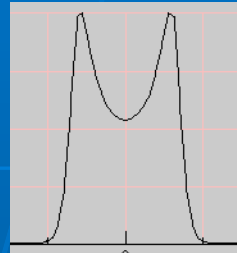  - Existing and new ISR simulators

# Blackbox ISR Outputs
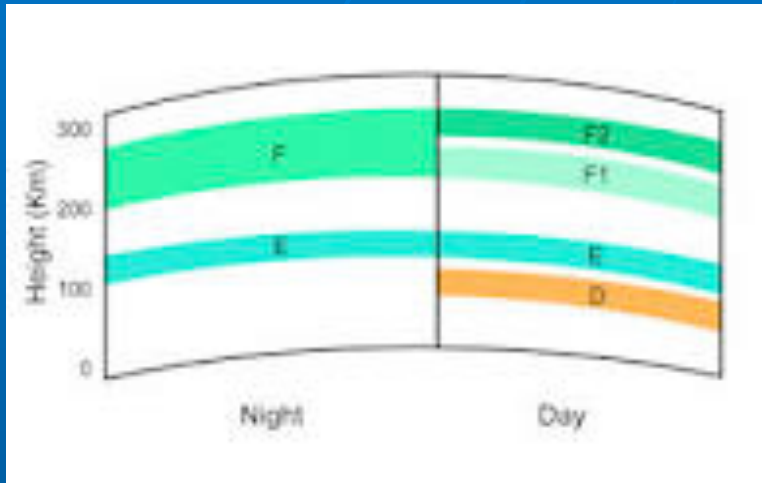


Parameters

- Electron density
- Electron temperature
- One (or more) ion temperatures
- One (or more) ion velocities
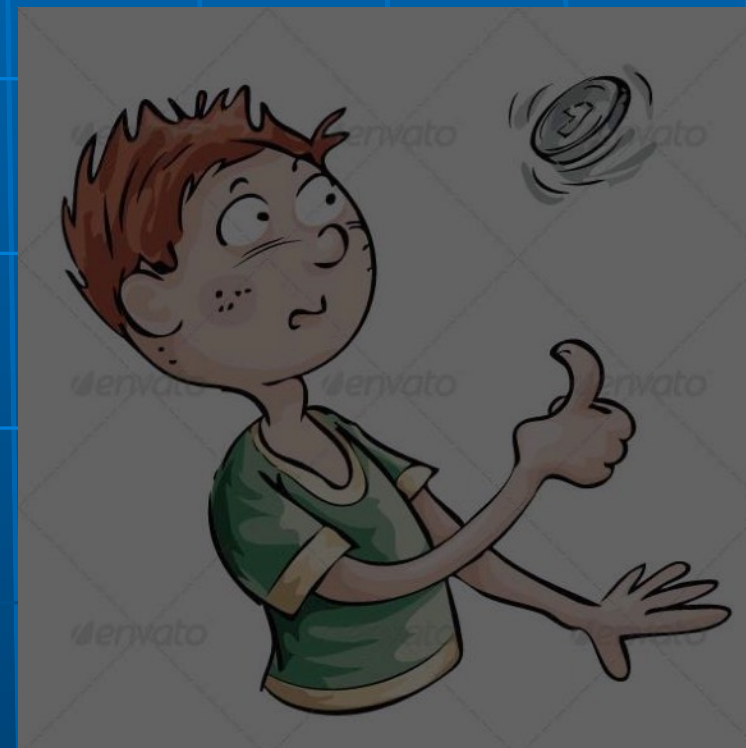
Quality of measurement

- Error bar on each parameter
- Spatial resolution
- Time resolution
- Spatial coverage

# Nature of ISR measurements

 is a probability distribution, not a signal...

Imaging trying to determine if a coin is fair in a dark room...



Both the number of tries and the chance of mistaking head and tails needs to be taken into account...
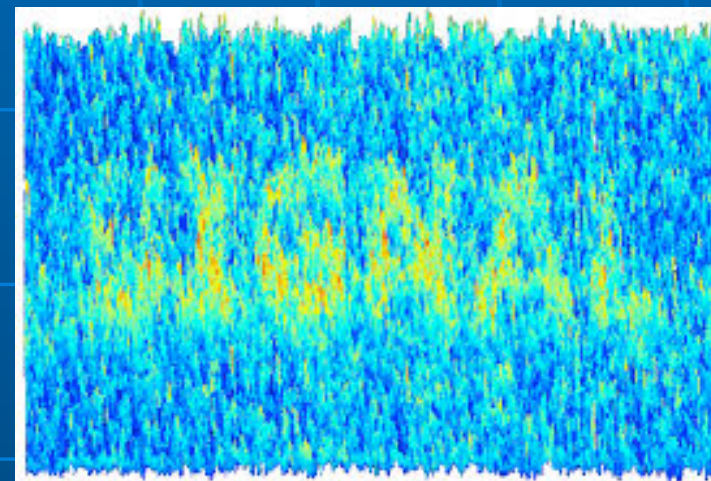
# Nature of ISR measurements

What determines the error bar on a measurement?

The number of measurements

*and*

The measurement S/N



- Flipping a coin in a bright room only one time tells you little (good S/N - small count)
- Flipping a coin a million times in a completely dark room tells you little (poor S/N, large count)

# ISR blackbox inputs

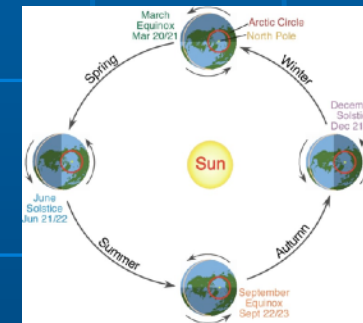What can an ISR user typically control with an existing ISR?
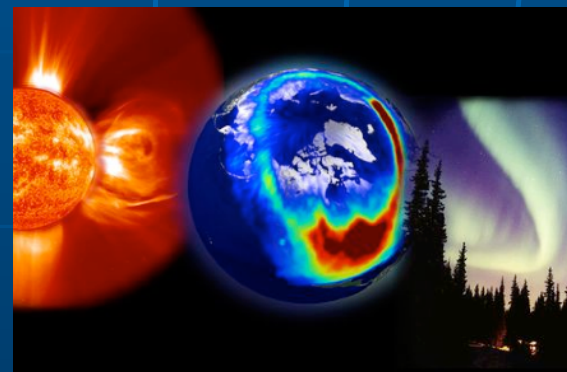

Pointing direction pattern


Integration period (sets count statistics)


Radar mode (pulse length and coding, interpulse period)


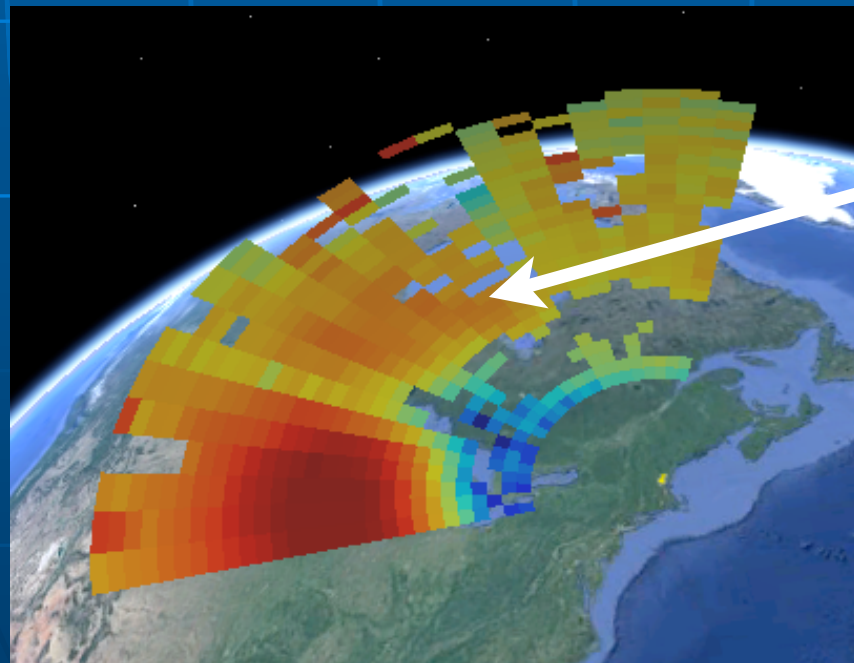Time of year and solar activity during measurement

# Pointing direction (monostatic)



Single direction gives best time resolution

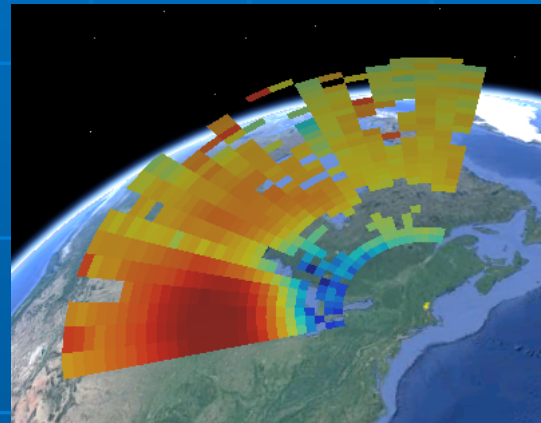Multiple directions in local area gives vector velocities

Measurements can be combined into scans

Tradeoff: number of pointing directions versus time resolution

# Integration period

For dish antenna with multiple positions, integration periods must be selected beforehand.



For phased array antenna or single position dish antenna, can be chosen after the experiment is run.
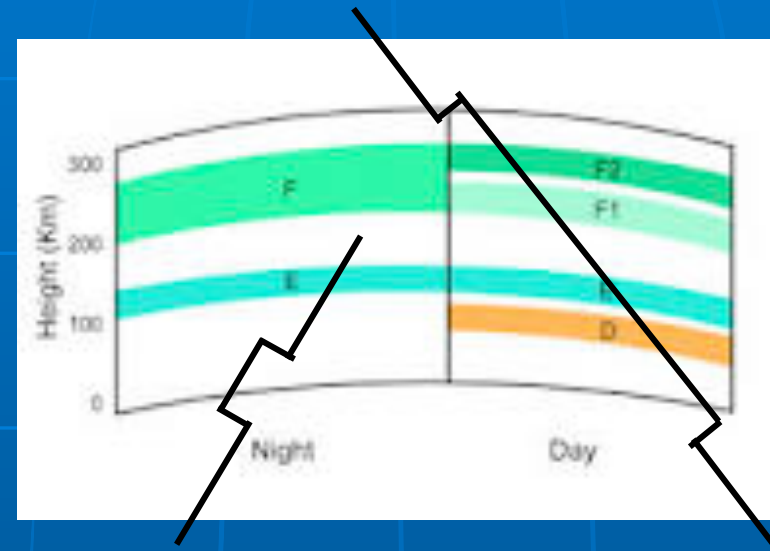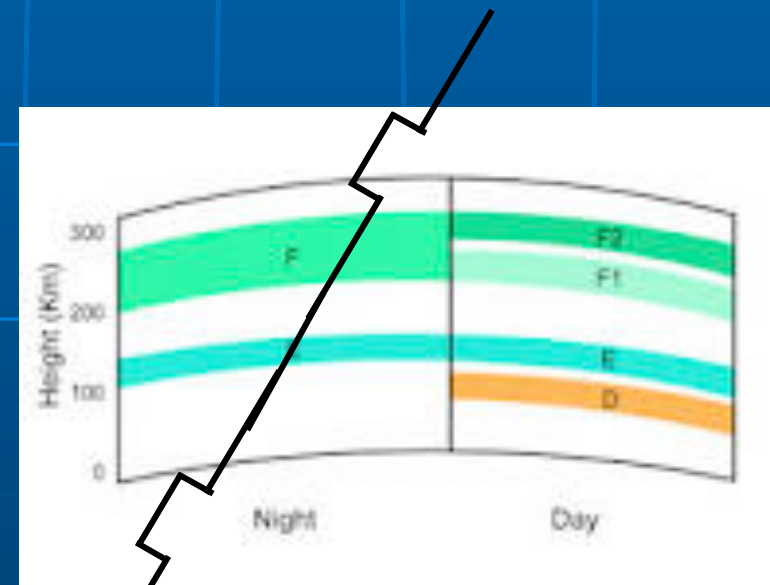
# ISR modes - single pulse

Parameters to set:

Pulse length

Shorter uncoded pulses:
Better spatial resolution,
worse S/N

Longer uncoded pulses:
Worse spatial resolution,
better S/N

Interpulse period

Shorter time increases counts/sec, limited by duty cycle of transmitter
and need to have previous pulse not returning signal

# Existing ISR simulator exercise

Additional inputs

[https://tinyurl.com/2020ISR](https://tinyurl.com/2020ISR)

Blackbox ISR exercises

# ISR blackbox inputs for a new radar

What design decisions affect a new monostatic ISR?

- Radar frequency
- Aperture (m^2)
- Peak power
- Location
- Steering method and range

# New ISR simulator exercise

Ionosphere generated by
IRI model (quiet day)

Full code available
(~650 lines of python)

All equations to be covered in
rest of this course

## https://tinyurl.com/2020ISR

Blackbox ISR exercises