

# A blackbox view of incoherent scatter radar

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# Outline

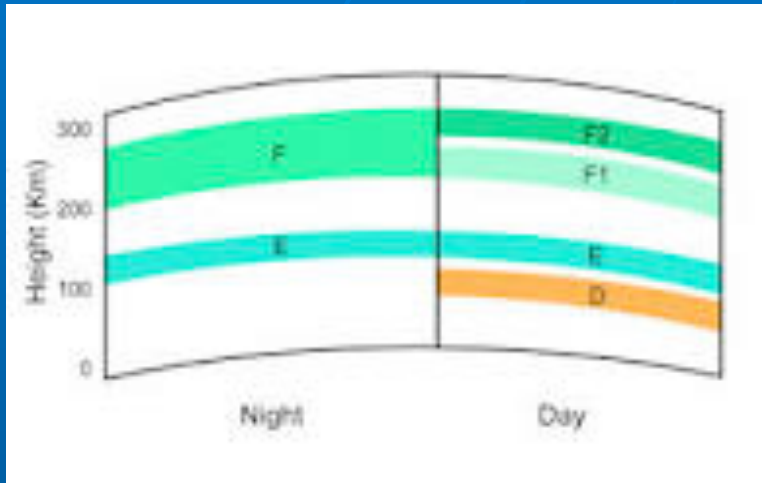
1. Brief discussion of ISR blackbox
2. Group exercises with simulator:
  1. Simulate existing ISR's
  2. Simulate creating a new ISR

# 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

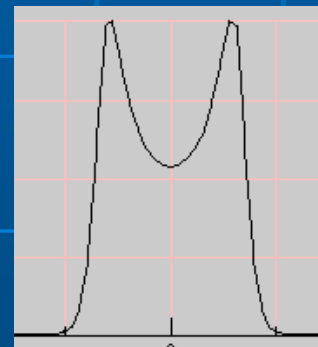
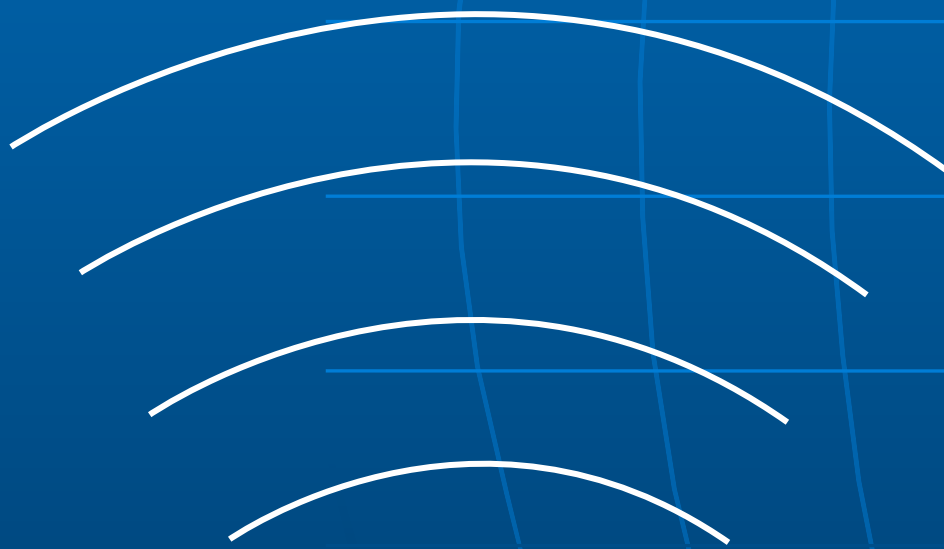


# Blackbox ISR Outputs



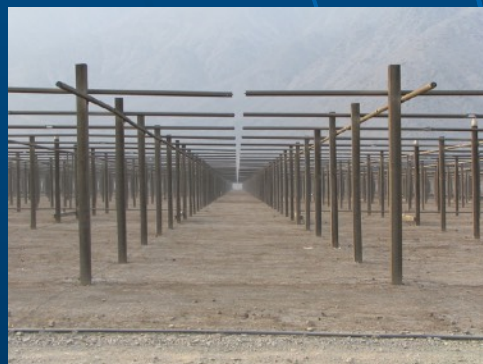
## Parameters

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



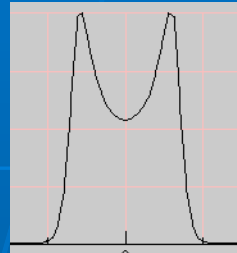
## Quality of measurement

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



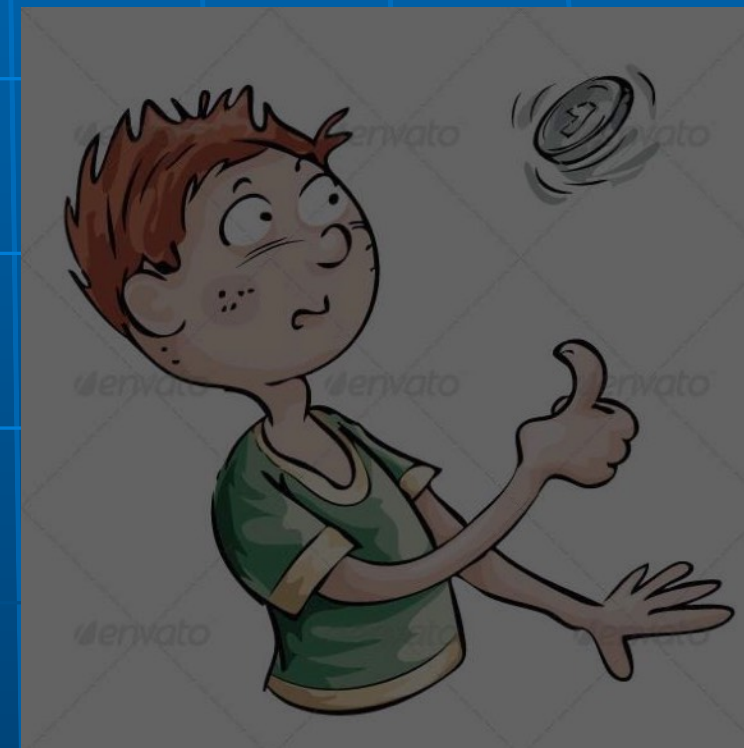


# Nature of ISR measurements



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

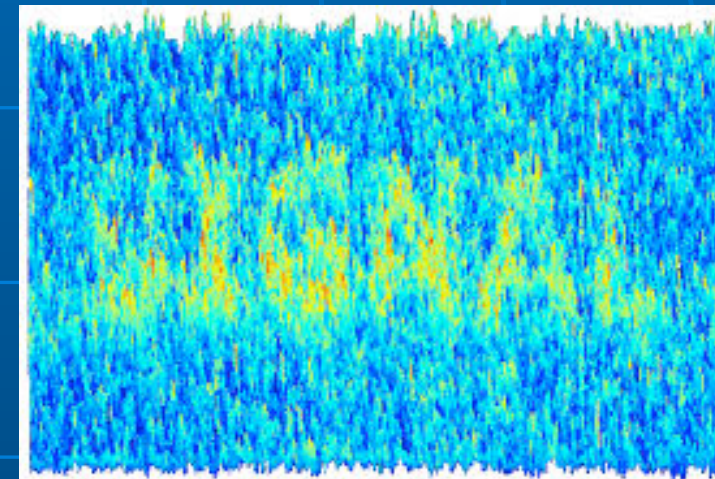
What determines the error bar on a measurement?

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?



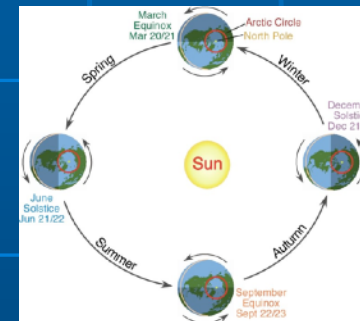
Pointing direction  
pattern



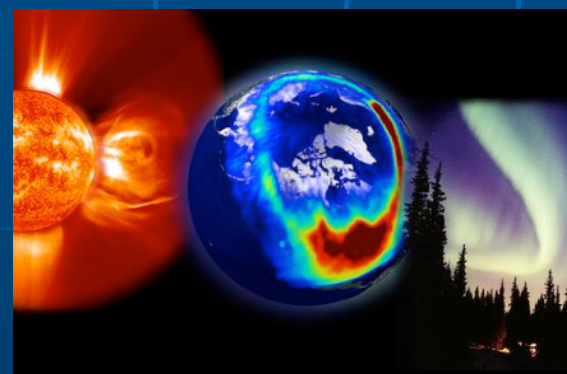
Integration period (sets  
count statistics)



Radar mode (pulse length  
and coding, interpulse  
period)



Time of year and solar  
activity during  
measurement





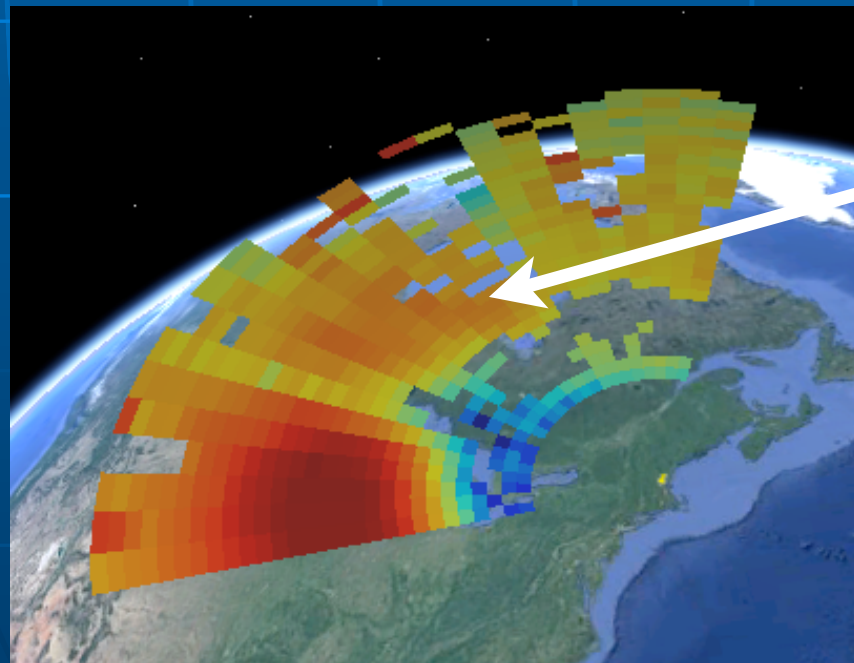
# Pointing direction (monostatic)



Single  
direction gives  
best time  
resolution



Multiple  
directions in  
local area  
gives  
vector  
velocities



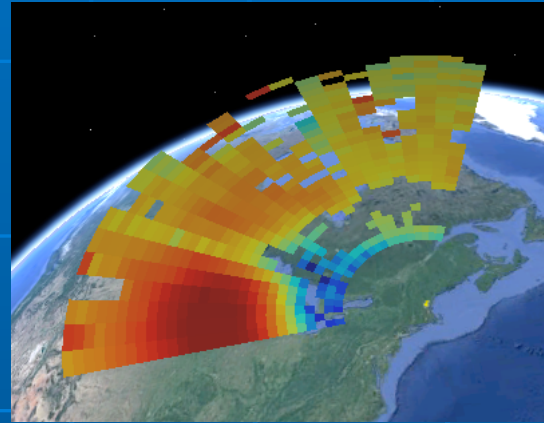
Measurements can be combined  
into scans

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.

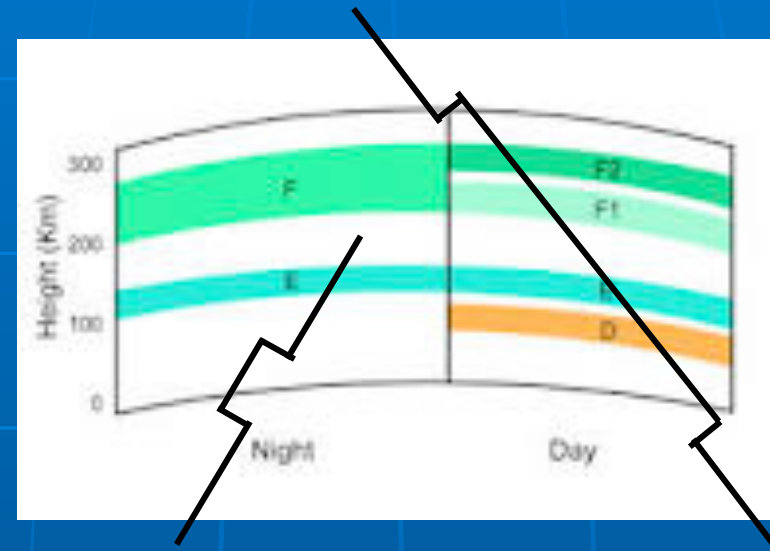


# ISR modes - single pulse

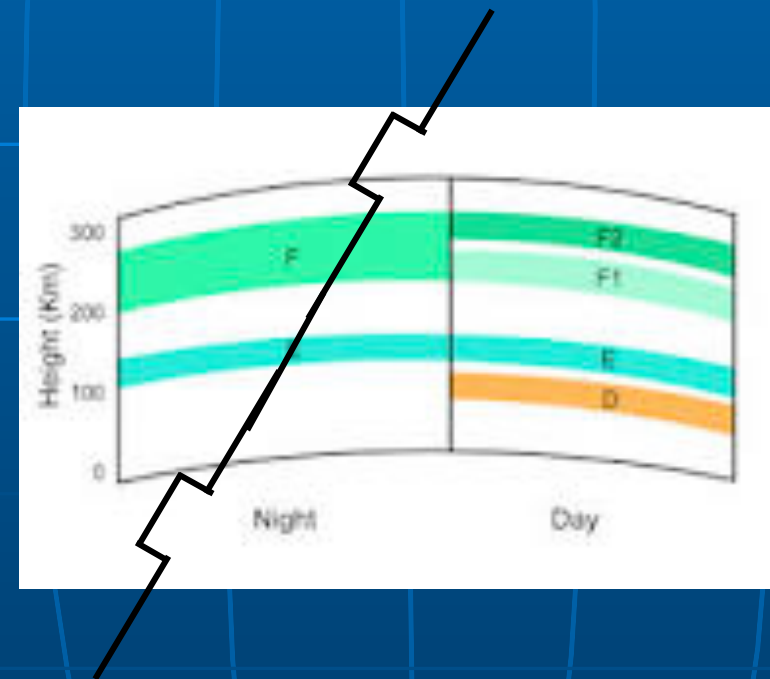
Parameters to set:

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

# Coded pulses - alternating code and barker code

**Alternating code** - a combined series of phase coded pulses

Spatial resolution set by baud length, not pulse length

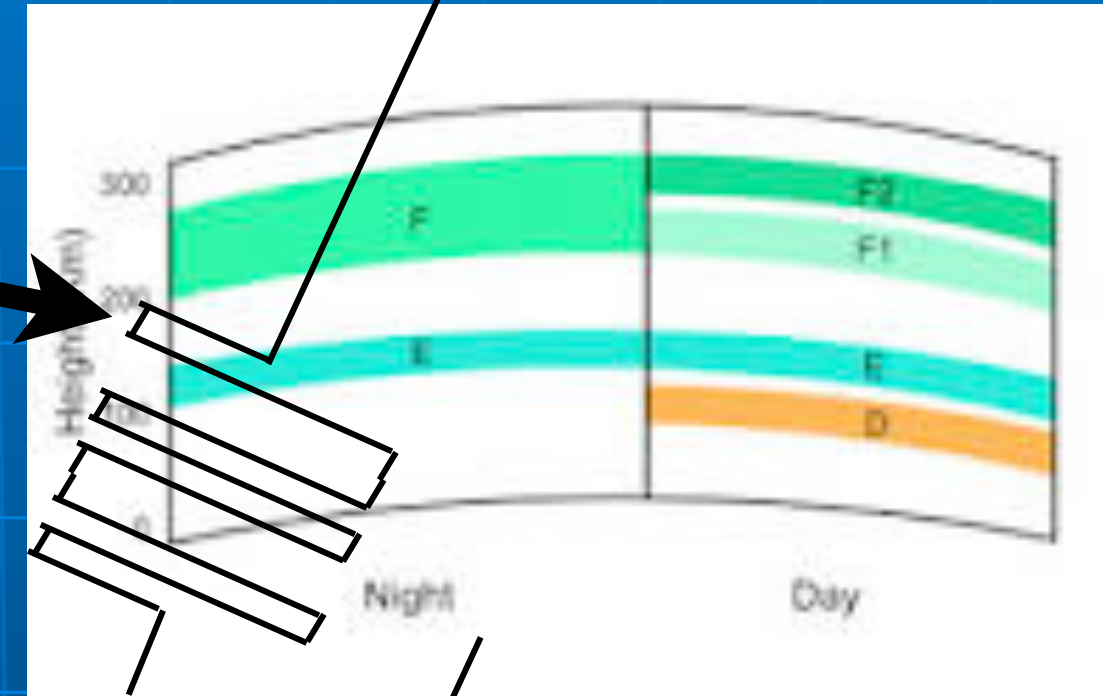
S/N set by pulse length (but not quite as good as single-pulse)

**Barker code** - a coded pulse that typically *only returns electron density*

Spatial resolution set by baud length, not pulse length

Traditionally shorter baud

Fewer pulses than AC, but no spectrum





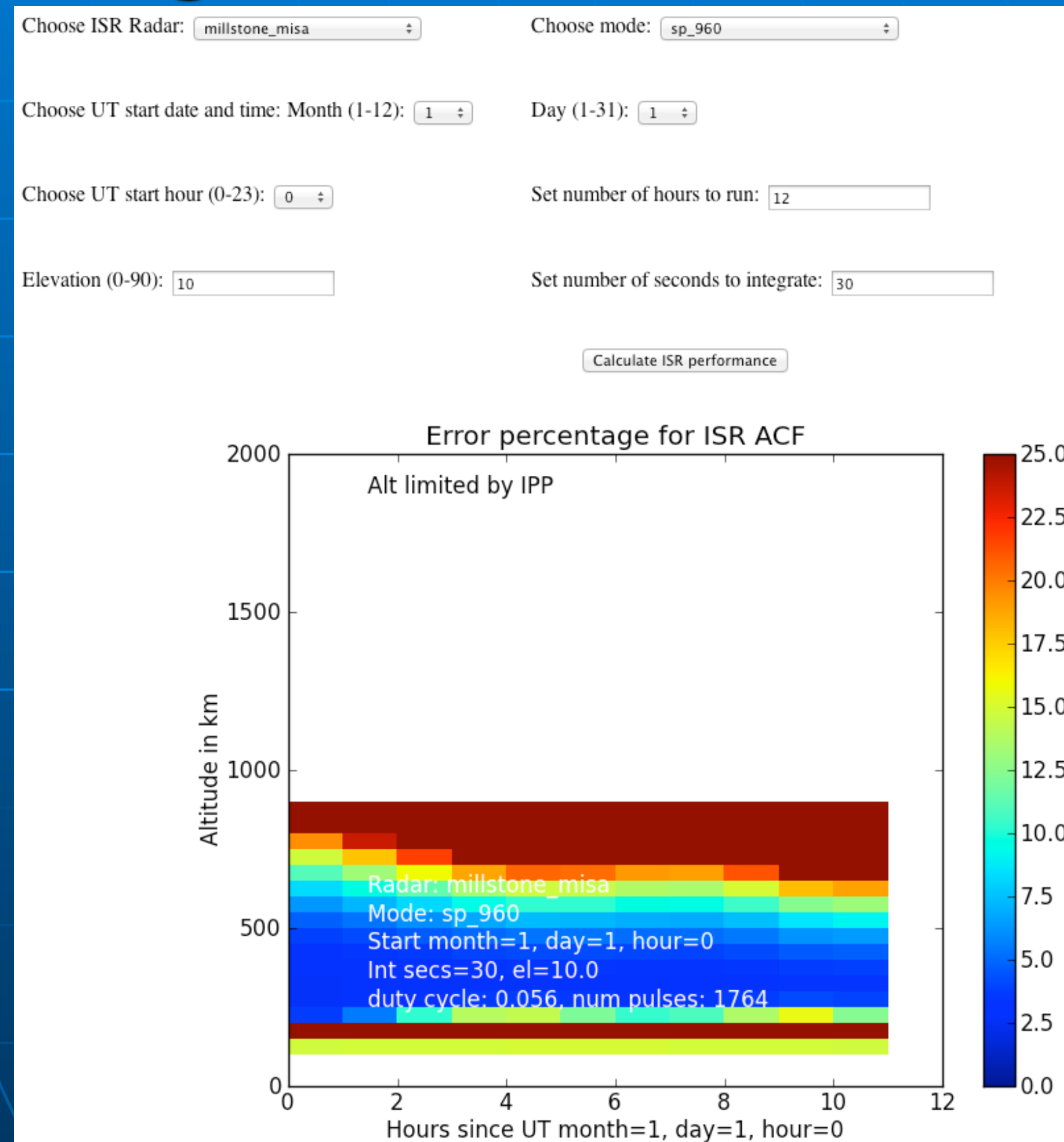
# Existing ISR simulator

<http://tinyurl/2016ISR> ->  
ISR simulator link

Ionosphere generated by  
IRI model (quiet day)

Full code available  
(~650 lines of python)

All equations to be covered in  
rest of this course



# 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

# ISR blackbox - group exercise

Break into groups - Do exercises

<http://tinyurl.com/2019Finland> -  
> See links under Bill Rideout's  
ISR blackbox talk