

# The Arecibo Observatory – HF facility



A modern Ionospheric Modification Facility with the most sensible Incoherent Scatter Radar.

Eliana Nossa



# HF Facility



Frequency	5.1MHz	8.175MHz
Gain	22dB	25.5dB
Beam width	13 deg	8.5 deg

- Maximum transmitted power: 600KW
- Cassegrain telescope =  
Arecibo dish (primary) +  
mesh (secondary) +  
three cross dipole antennas per frequency (feed)

# HF Facility

6 / 100kW



5.1 MHz



8.175 MHz



3 antennas  
per frequency

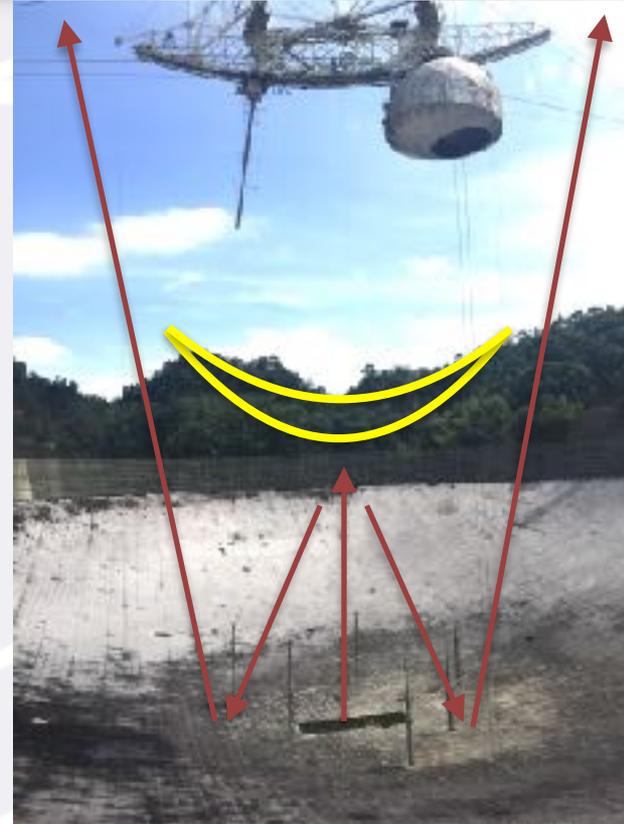
# HF Facility



5.1 MHz



8.175 MHz



# Uniqueness / Advantages

## *We are part of an Observatory*



Picture by Ismael Cabrera

### Radio telescope

- **Flexible configuration**
  - 6 receivers / different frequencies
  - 4 transmitters
    - S-band,
    - 46MHz,
    - two at 430MHz (ISR)
- Other extensive instrumentation is available
  - Optics, RF, ...

# Arecibo Observatory



## Incoherent Scatter Radar (ISR) or 430MHz systems (Tx/Rx)

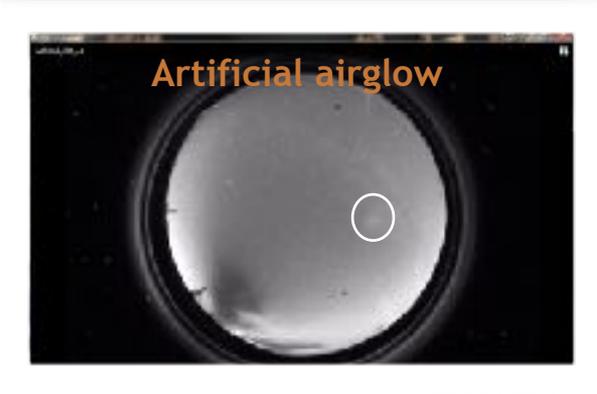
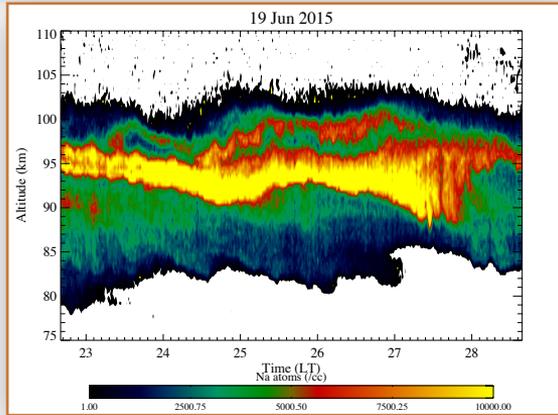
- Dish of 305m diameter
- ISR: plasma density and temperature variations, ion composition, ion drifts, electric fields, neutral winds,...
- HF and ISR run in parallel

Two beams:

The line feed and the Gregorian

It is the most sensitive ISR in the world

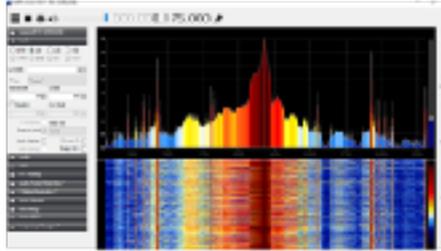
# Arecibo Observatory



## Additional diagnostics:

- Active optics:  
K, Na, Ca and Rayleigh lidars
- Passive optics:  
imagers, spectrometers, FP

# Arecibo Observatory



## Additional diagnostics:

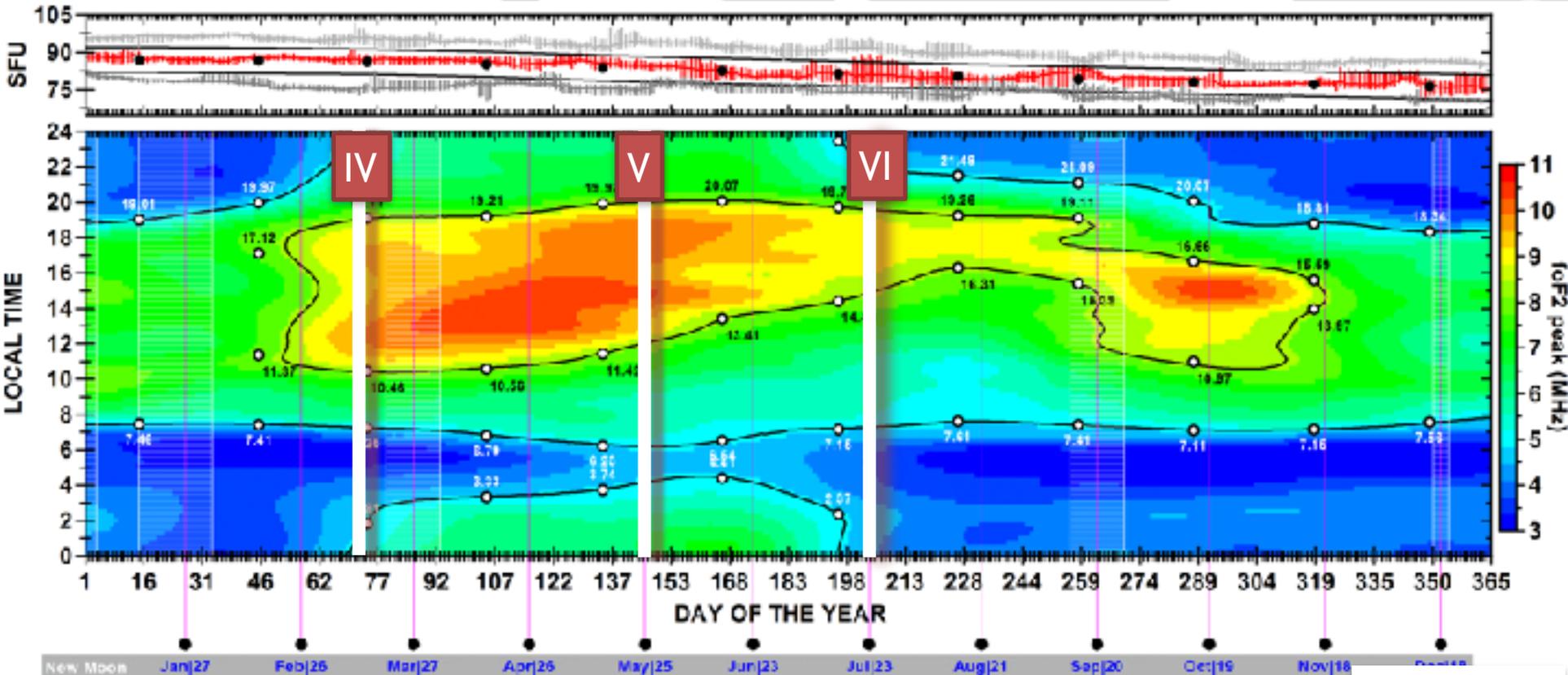
- Other RF instrumentation: ionosondes, SDR
- Unique user's equipment: HF receivers, lightning sensors, dedicated satellites, GPS networks, SEEs, OHRs

# Challenges

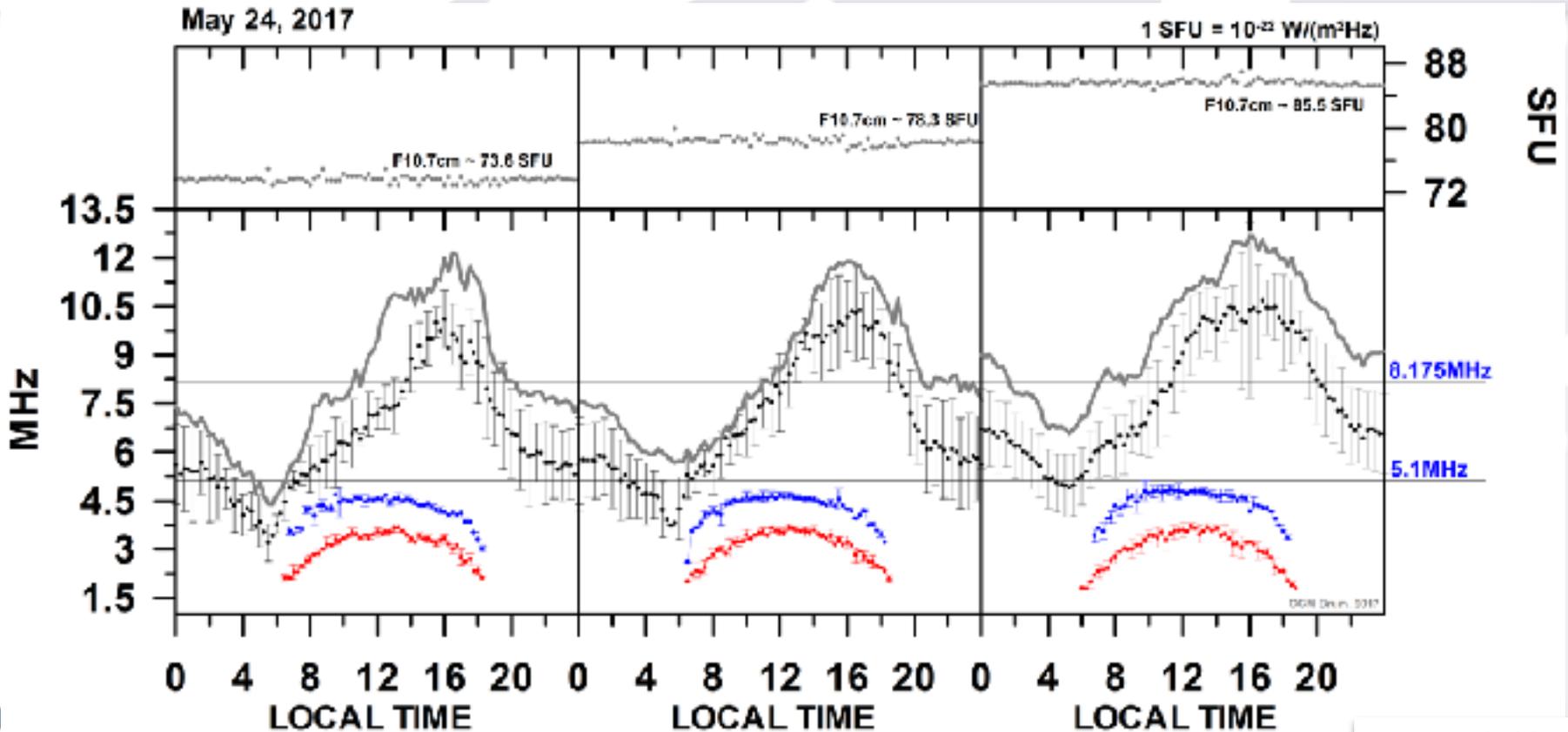


- Coordination with different instruments
  - Sharing the same dish
  - Protection of other sensible instruments (like S-band)

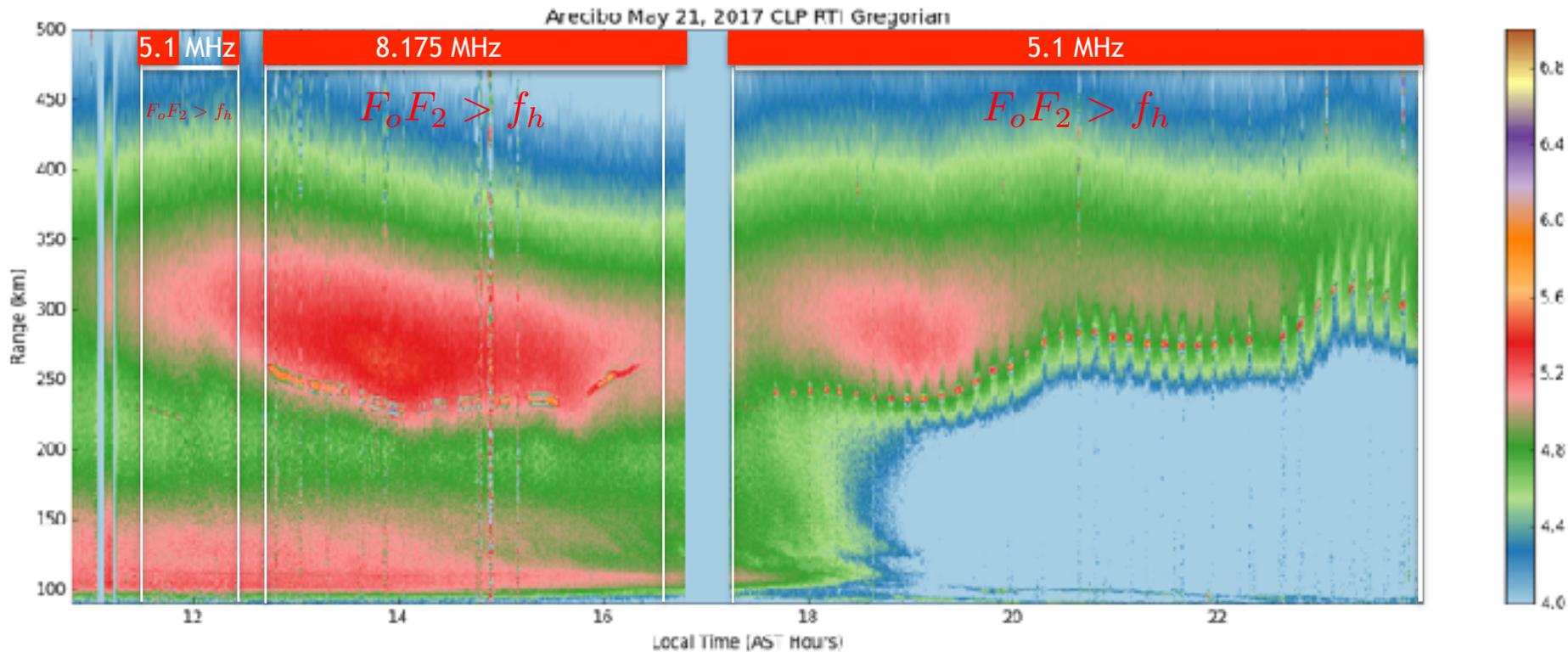
# HF Campaigns - Ionospheric Forecast



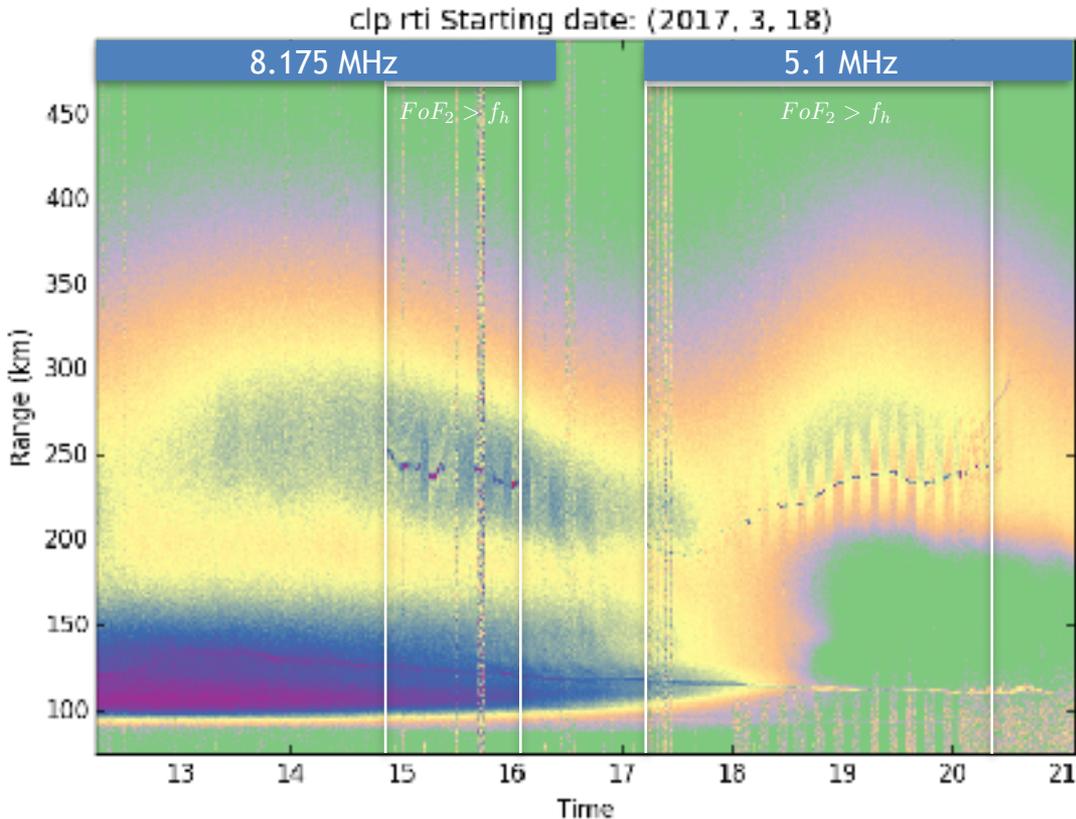
# HF Campaigns - Ionospheric Forecast



# Results



# Results



## Results

HF-enhanced plasma and ion lines

Artificial and excitation of strong natural plasma density irregularities (layers and holes)

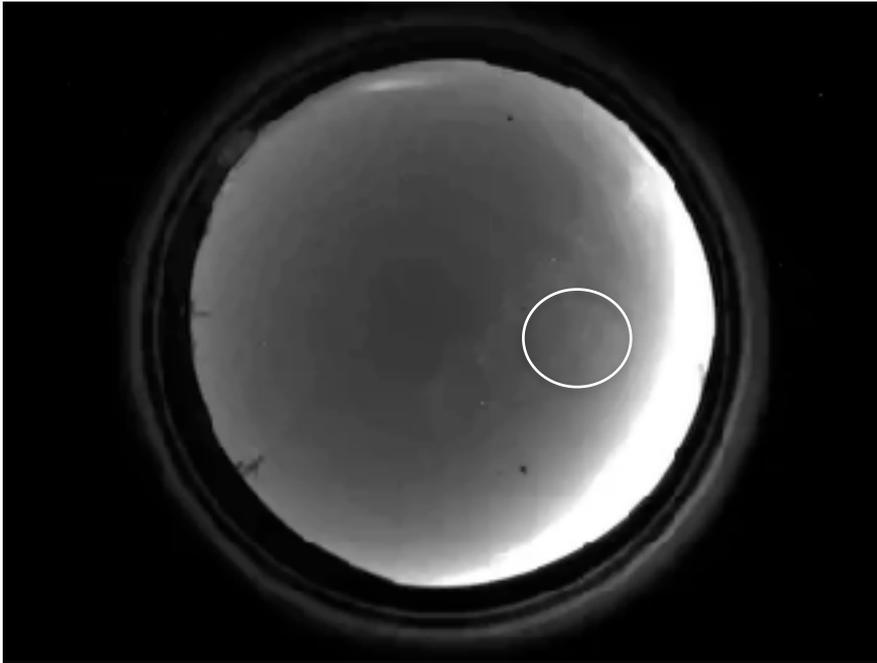
Artificial optical airglow and Stimulated electromagnetic emissions (SEE)

## Effects (among others)

Radio scintillations

Disrupted radio propagation

# Results



Nov, 2015, Heating band: 5MHz  
Ethan Miller's all-sky imager at Culebra Island, red line emission

## Results

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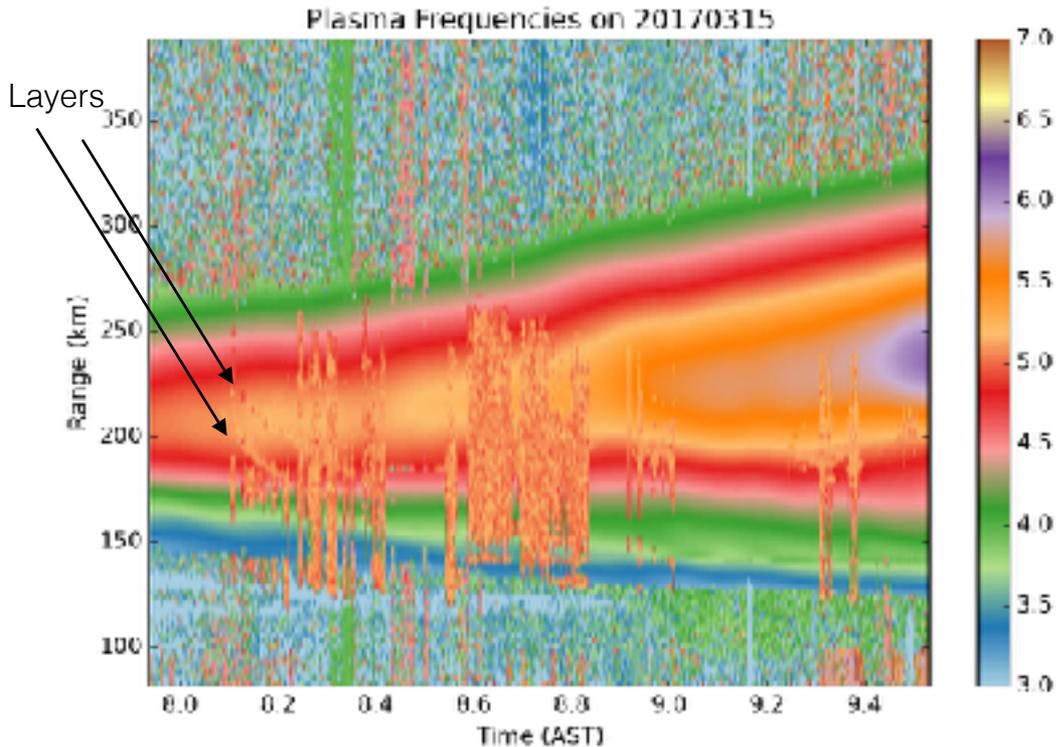
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# Results



Although the enhanced plasma line might conceivably contribute to this, it only comes from one at a time, and so actual enhancement exists.

## Results

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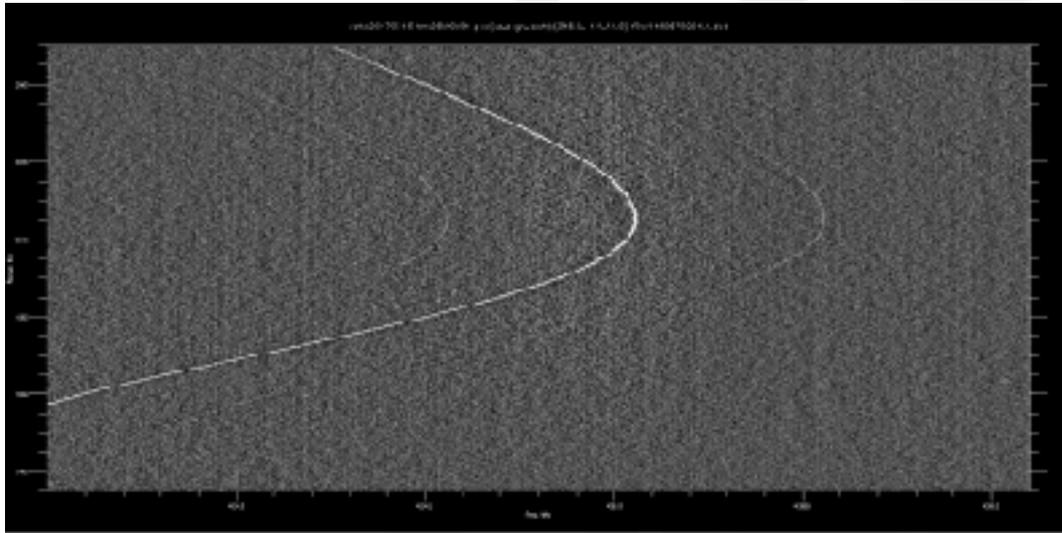
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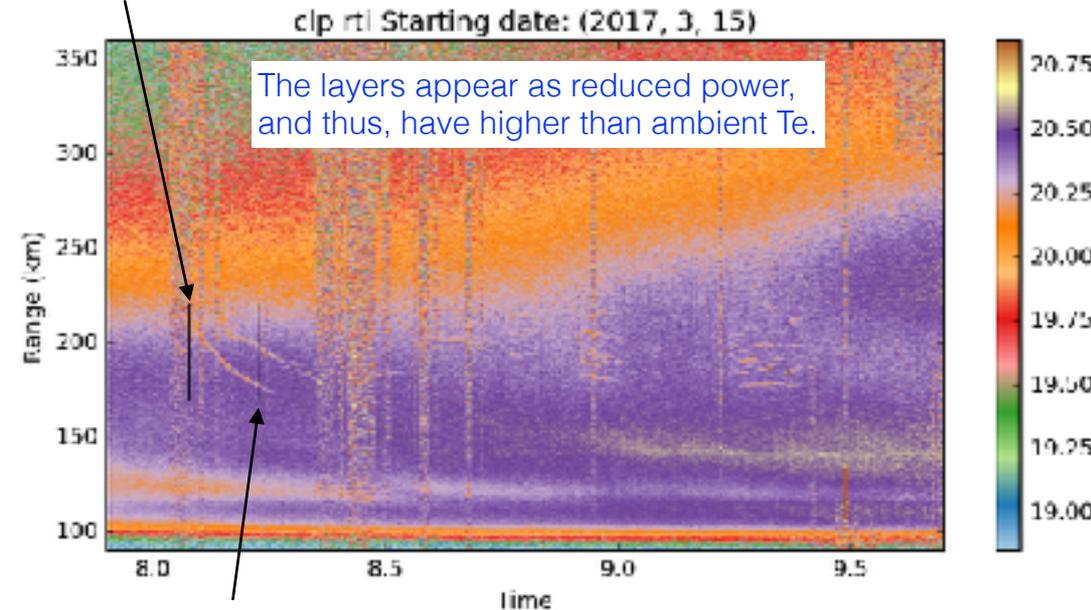
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# Results

Time when enhanced plasma line first seen (above the peak)



Time when enhanced plasma line jumps up to next layer

The first layer exists before critical is reached. (See movie.) The second layer exists with high  $T_e$  before high power appears to reach it.

## Results

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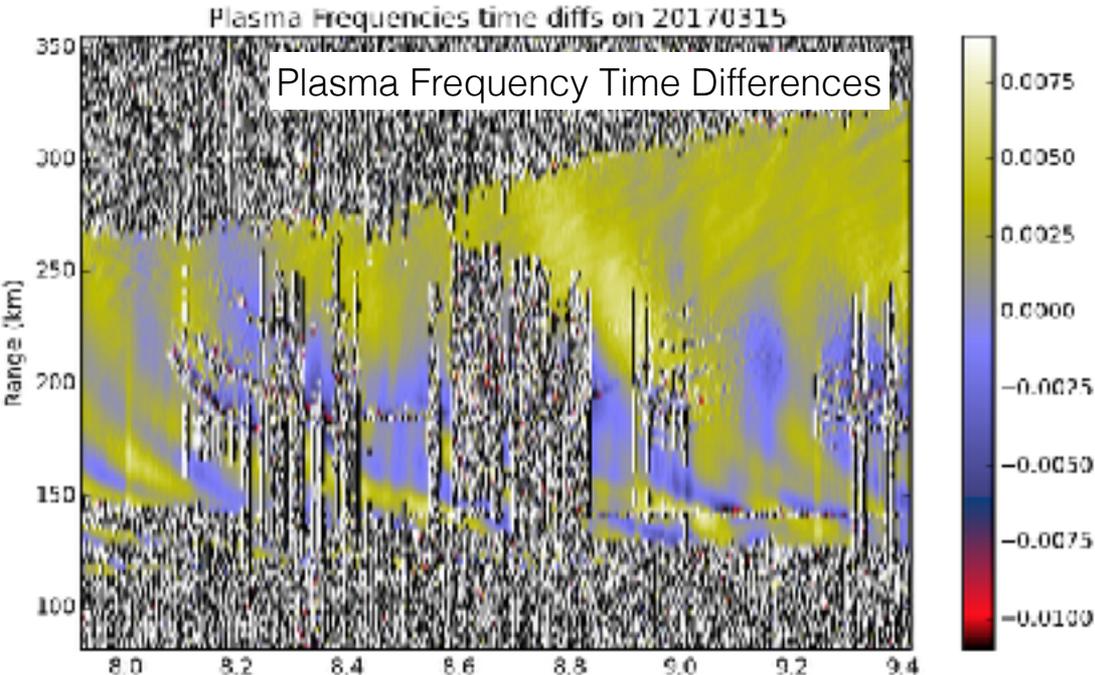
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# Results



The image of plasma frequency differences shows the perturbations resulting from gravity waves. The layers (also visible here) descend at the same rate as the gravity wave perturbations. This suggests that gravity waves can control the downward motion, although other cases appear more complicated.

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# Remarks

- **Arecibo - HF Facility is working!**
- Multiple diagnostics, including ISR
- Unique conditions to perform active experiments and to study the natural ionosphere.

# The Arecibo Observatory – HF facility

Invitation to submit proposals for next campaigns  
Students and Researchers



<http://www.naic.edu/~astro/proposals/hfprop.php>

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