NJIT New Jersey Institute of Technology

HamSCI

HamSCI and the 2017 Total Solar Eclipse

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[3]Virginia Tech, [4]MIT Haystack, [5]SciVision, Inc., [6]SRI International, [7]JHU/APL,[8]Univ. Of Calgary, [9]Afreet Software, Inc., [10]ARRL

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Outline

I. Introduction
II. Data Sources
III. Amateur Radio Doppler Measurements
IV. Solar Eclipse QSO Party
V. SEQP PHaRLAP Simulation
VI. Summary

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Solar Eclipse Ionospheric Effects?

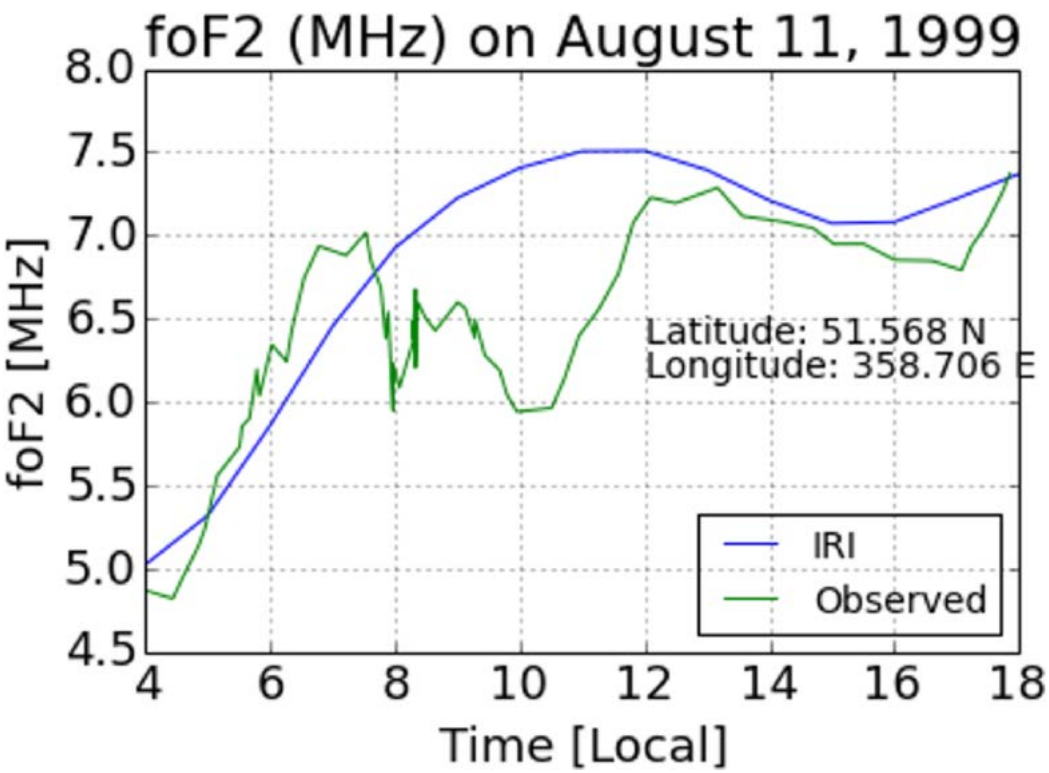
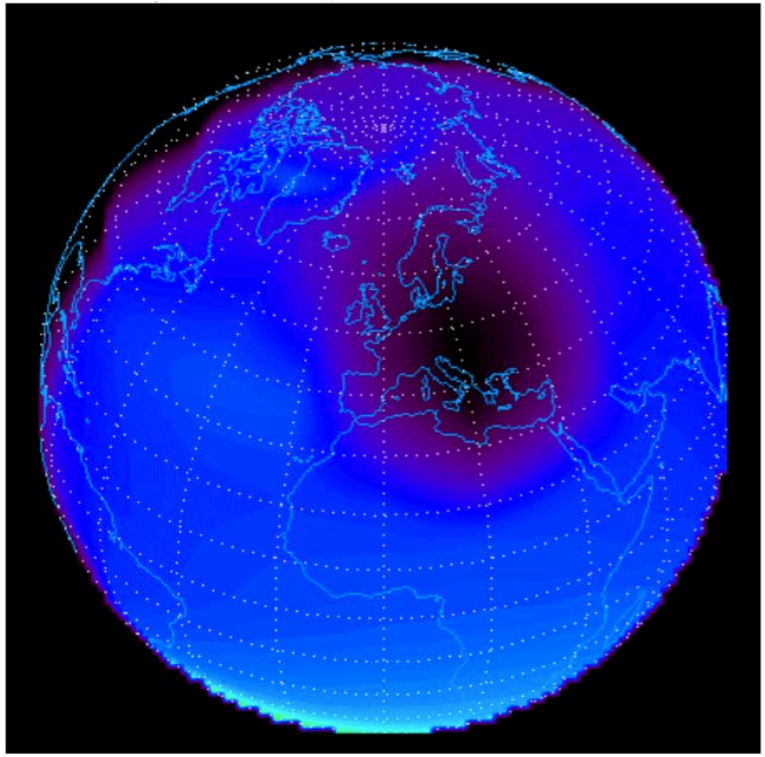


Figure: M. Moses after *Afraimovich et al.*, 2002



Model Electron Density at ~280 km alt. during 1999 Eclipse
M. Harris from *Bamford* 2000.

Solar Eclipse research is in collaboration with Virginia Tech. [Earle et al.]

Eclipse HF Doppler Measurements

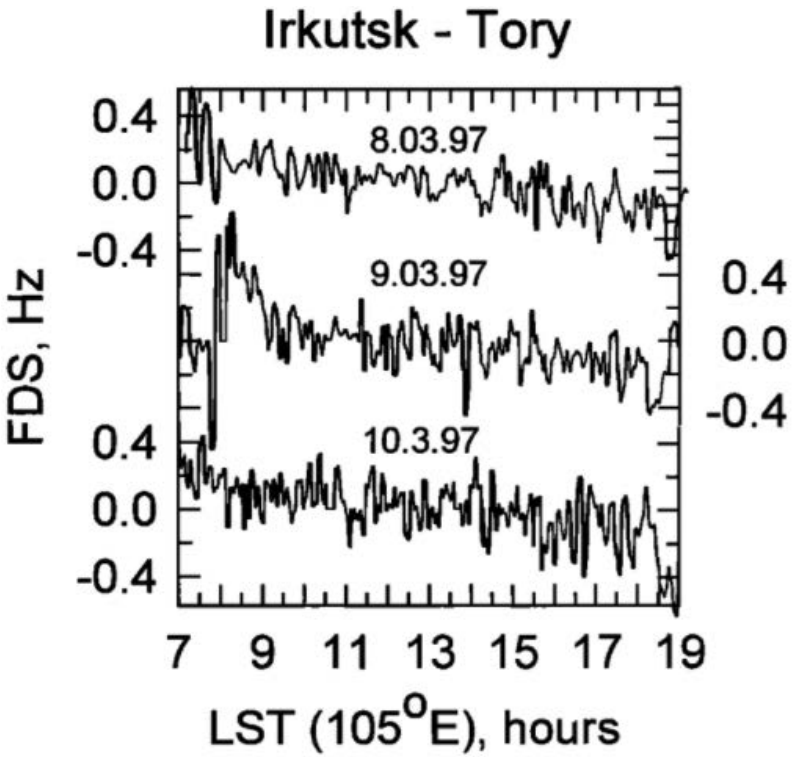


Figure 6. Temporary variations of frequency Doppler shift (FDS) recorded on the HF ray path Irkutsk – Tory during the daytime for March 8, 9, and 10, 1997.

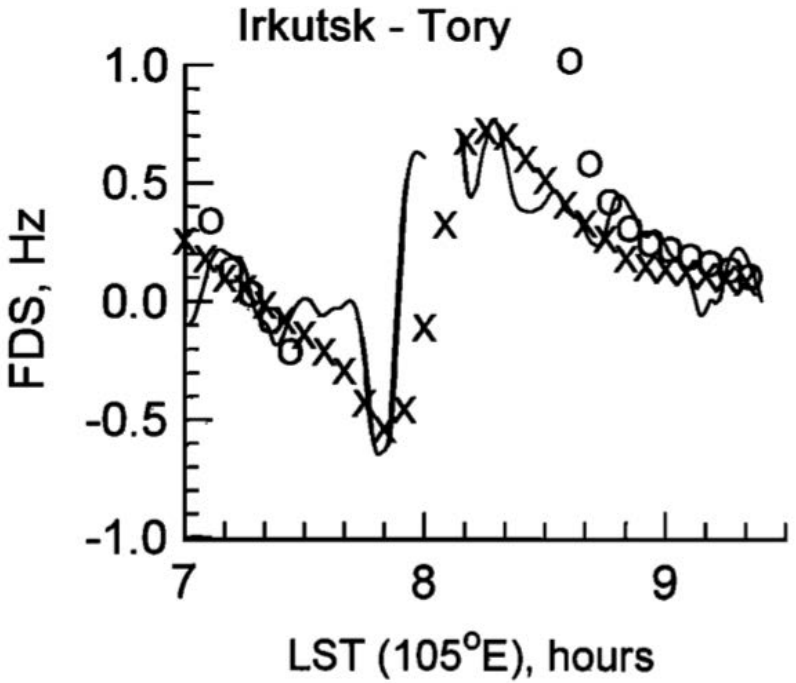


Figure 7. Comparison of measured (solid lines) and calculated temporary variations of frequency Doppler shift (FDS) during the eclipse on the HF ray path Irkutsk – Tory. Circles, calculation for the ordinary mode; crosses, calculation for the extraordinary mode.

[*Boitman et al.,* 1999]

Amateur/Ham Radio

- Hobby for Radio Enthusiasts
  - Communicators • Builders • Experimenters
- Wide-reaching Demographic
  - All ages & walks of life
  - Over 730,000 US hams; ~3 million World Wide

[http://www.arrl.org/arrl-fact-sheet]

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HamSCI Eclipse Research Questions

- What are the temporal and spatial scales of eclipse-induced ionospheric effects?
- Can we observe TIDs in the ionosphere caused by the eclipse?
- How does the eclipse affect HF propagation?

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Data Sources

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Amateur Radio and the HF Bands

Frequency	Wavelength
1.8 MHz	160 m
3.5 MHz	80 m
7 MHz	40 m
10 MHz	30 m
14 MHz	20 m
18 MHz	17 m
21 MHz	15 m
24 MHz	12 m
28 MHz	10 m
50 MHz	6 m

K2MFF, The NJIT Ham Radio Station

- Hobbyists routinely use HF-VHF transionospheric links.
- Often ~100 W into dipole antennas.

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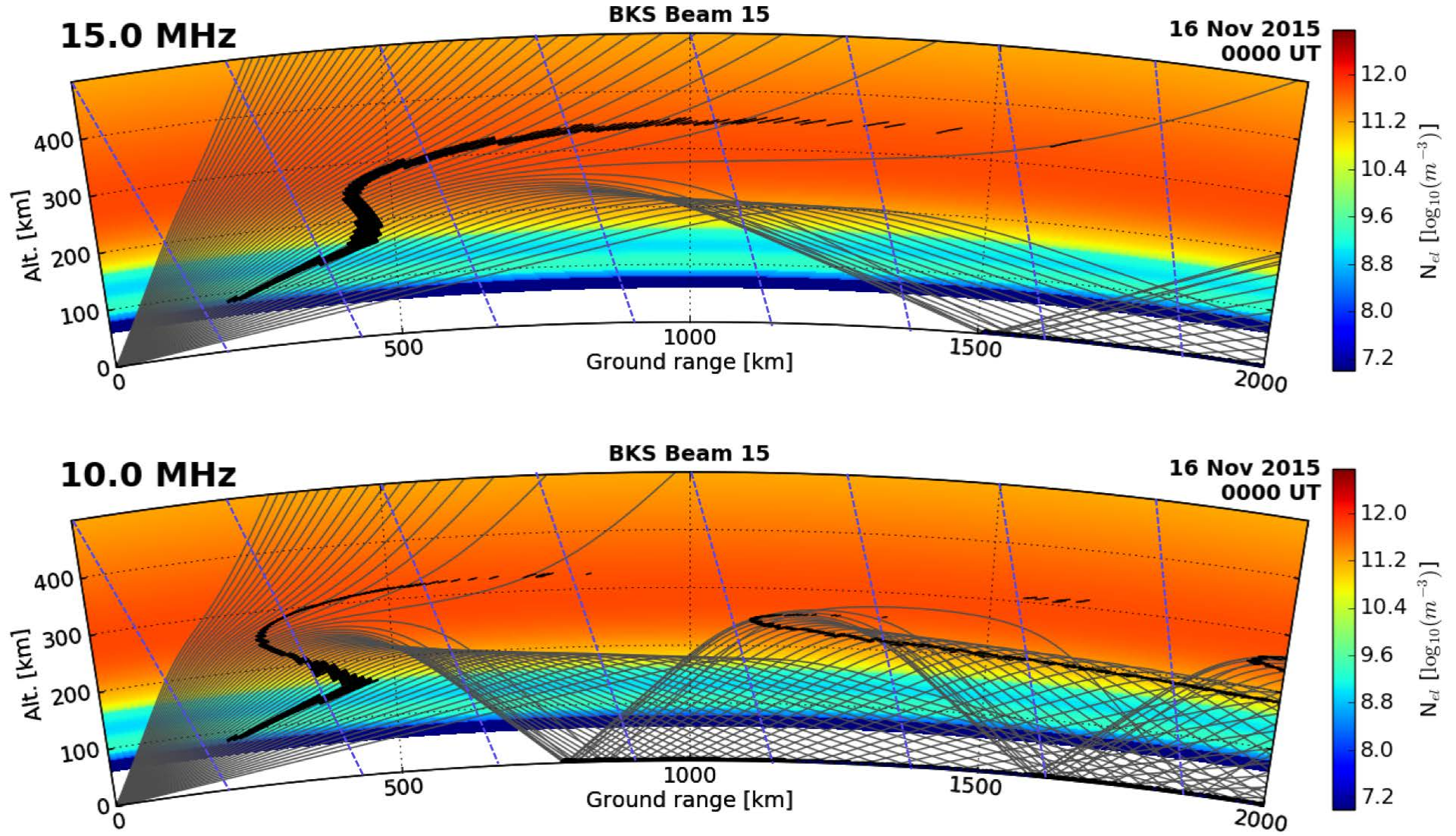
HF Propagation & The Ionosphere



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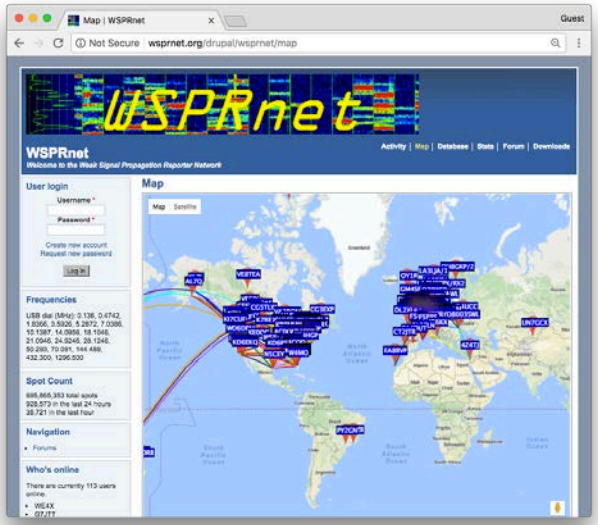
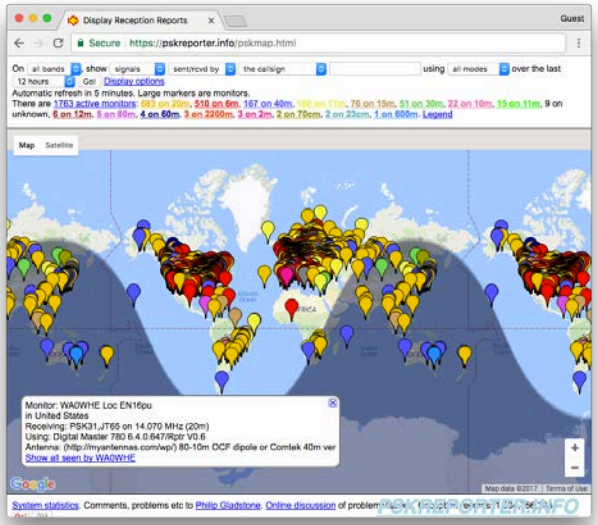
Big Data – Ham Radio Observatories

RBN
reversebeacon.net



WSPRNet
wsprnet.org



PSKReporter
pskreporter.info

Network	Start Year	# Spots	DB Size
RBN	2009	578,000,000	36 GB
WSPRNet	2008	535,000,000	44 GB
PSKReporter	2013	1,000,000,000	100 GB

There is A LOT of data!

Amateur Radio Doppler Measurements

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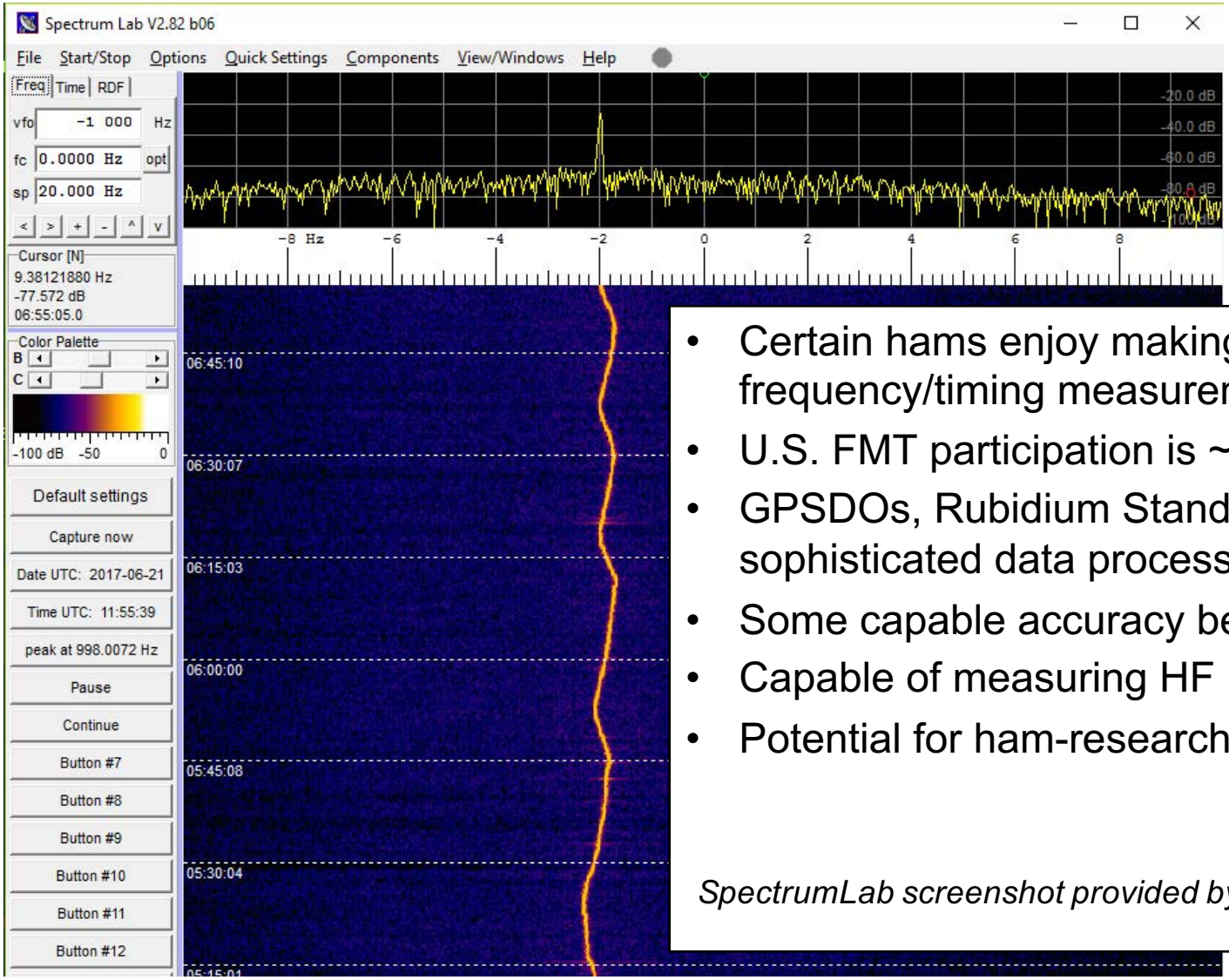
Frequency Measurement Community



- Certain hams enjoy making high precision frequency/timing measurements.
- U.S. FMT participation is ~100 RX stations
- GPSDOs, Rubidium Standards, and sophisticated data processing.
- Some capable accuracy better than 0.001 Hz.
- Capable of measuring HF path Doppler shift.
- Potential for ham-researcher collaboration.

SpectrumLab screenshot provided by Steve Reyer, WA9VNJ.

Tentative FMT Plans

- Highly stable HF ham beacon in middle US.
- Ham radio receivers spread across US.
- ePOP RRI observes from the sky.

- Engineering test in mid-to late July.
- Control Day:
  - August 20, 2017 1400 – 2200 UTC
- Eclipse Day:
  - August 21, 2017 1400 – 2200 UTC

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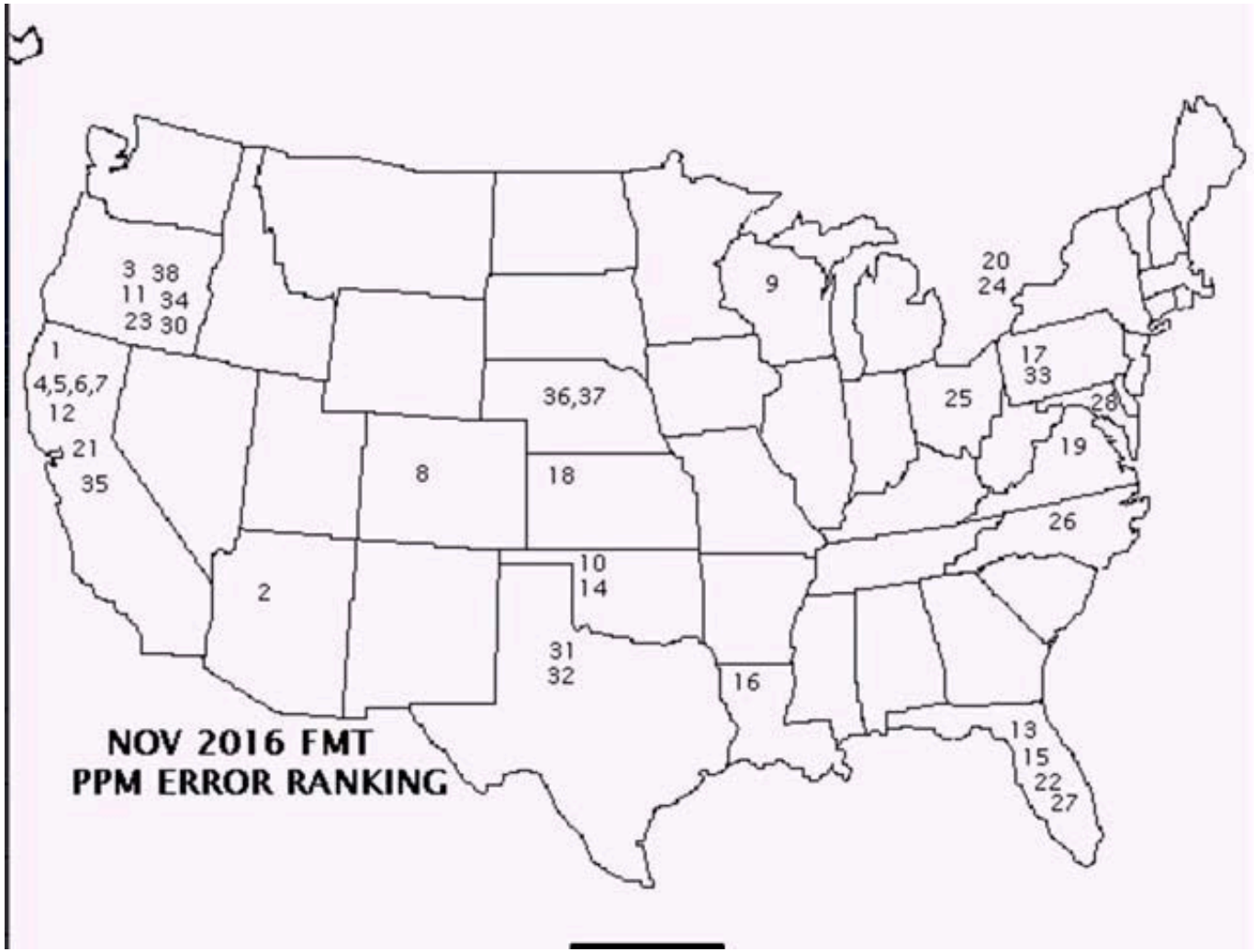
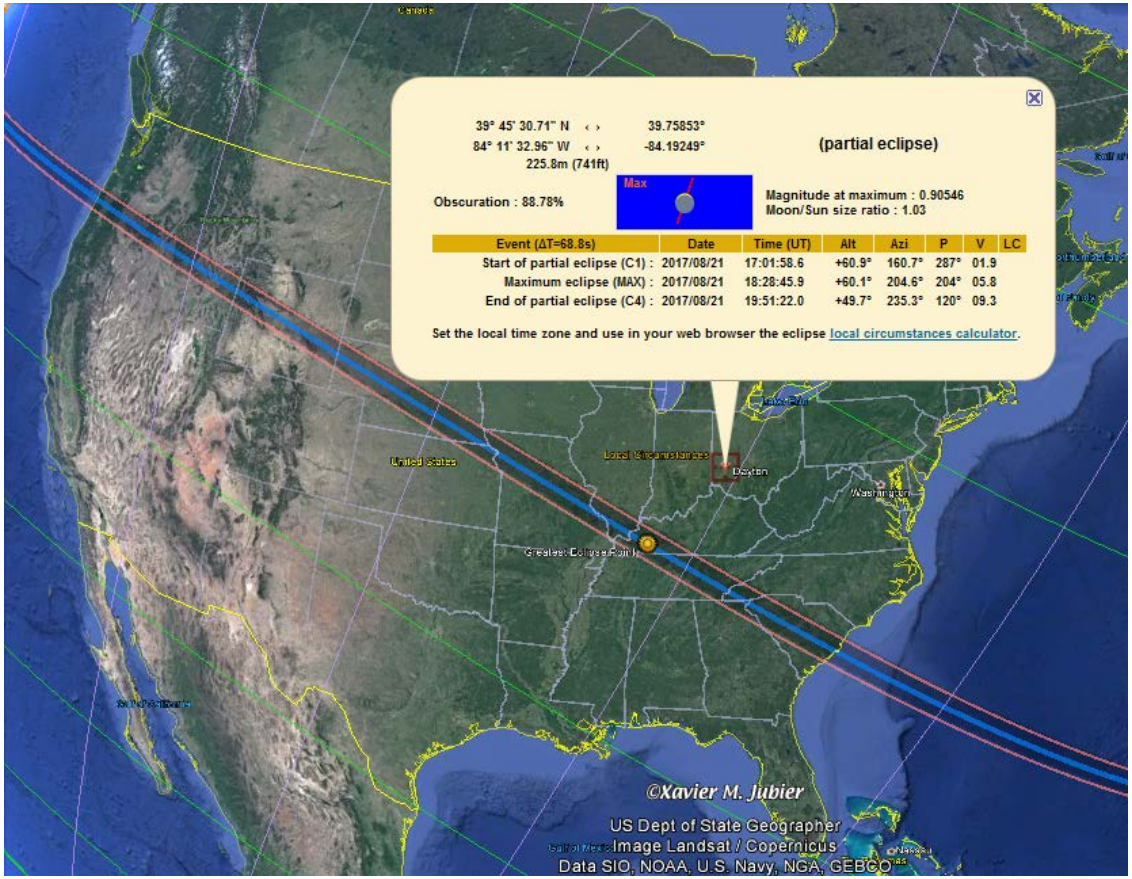
FMT Receiver Distribution



http://www.arrl.org/frequency-measuring-test

Doppler Shift Experiments

These plans are tentative… watch hamsci.org for final experiment protocol!



Transmission Beacon:

- W8RKO in Dayton, Ohio
- 50-100 W
- HP 5065A Rubidium Standard
  - Stable to parts in 10e-14 from about 80 to several thousand seconds averaging times

- CW signals
  - 3.598 MHz (80 m)
  - 7.064 MHz (40 m)
  - 14.121 MHz (20 m)

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Solar Eclipse QSO Party (SEQP)

- **August 21, 2017 from 1400 – 2200 UT**
- **Contest-like**
  - 2 Points CW or Digital
  - 1 Point for Phone
  - Multiply Score by # of Grids
- **Exchange**
  - RST + 6 Character Grid Square
- **Data sources**
  - Reverse Beacon Network
  - PSKReporter
  - WSPRNet
  - Participant-submitted logs

http://hamsci.org/seqp

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Bonus Points

- **Operate during totality** – 100 pts
- **Operate outdoors** (so you can see the eclipse) –100 pts
- **Operate at a public venue** –100 pts
- **Provide detailed station operation info** – 50 pts each:
  - Antenna design characteristics
  - HFTA terrain profile.
  - Estimated Ground conductivity
  - Station Effective Radiated Power relative to a Dipole (ERPD) on each band.
- **Operate a wideband RBN, PSKReporter, or WSPRNet node during the contest** – Varying Pt Values
- **Bonus points for being spotted by RBN, PSKReporter, and Spotting Network.**

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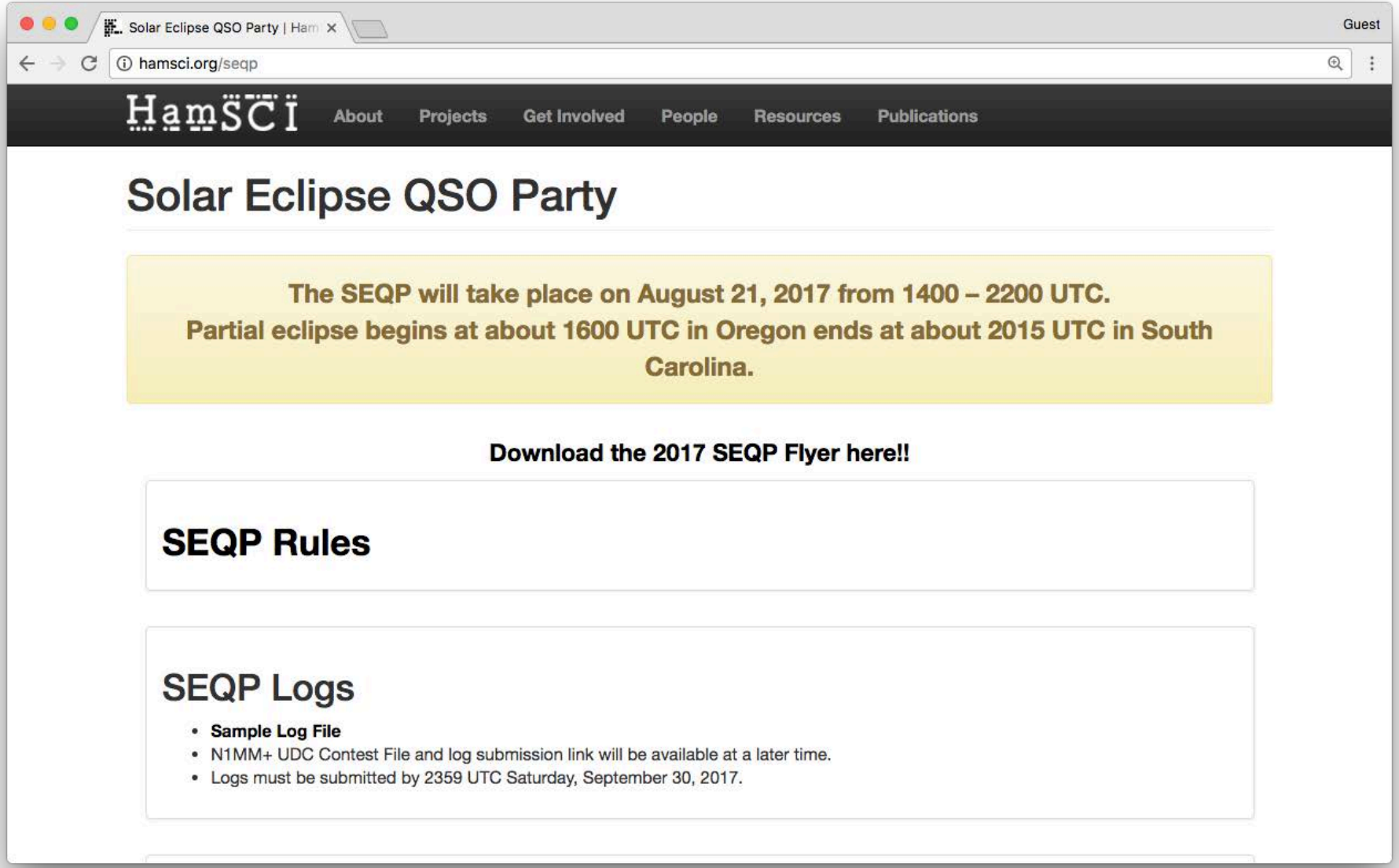
Logging & Certificates

- We expect an N1MM+ module to be available for the SEQP.
- Any logging software that supports the ARRL VHF contest exchange format can also be used.
- Follow instructions at hamsci.org/seqp for uploading logs.
- Downloadable participation certificate will be available.
- Final scores (with bonuses) will be posted on hamsci.org.

Log Submission and Rules



Participation Certificates

Collaboration with the ARRL

August 2017 *QST*

American Radio Relay League

- National Organization for Ham Radio
- Over 170,000 members (Jan. 2016)
- Monthly magazine
- Publishes over 160 books
- Strong web/social media presence
- Education/Outreach Program

- **Promoting HamSCI and the Solar Eclipse QSO Party**

SEQP Simulation

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HF Raytracing of SEQP

- To predict SEQP results and aid in the interpretation of collected data, we ran the PHaRLAP HF Raytracing toolbox [*Cervera and Harris,* 2014] on the NJIT Kong computer cluster.
- The PHaRLAP HF propagation toolbox created by Dr. Manuel Cervera, Defence Science and Technology Group, Australia is available on request by contacting manuel.cervera@dsto.defence.gov.au.

Simulation Parameters

- **TX/RX Pairs**
  - RBN-Identified TX-RX Pairs
  - 1–3 November 2014
  - CW Sweepstakes is similar to SEQP
- **Frequencies:** 1.83, 3.53, 7.03, 14.03, and 21.03 MHz.
- **Times:**
  - 1400 – 2145 UT
  - 21 August 2017
  - 15 min cadence
- **Ionospheres:**
  - Unmodified IRI-2016 [*Bilitza*, 2011]
  - IRI-2016 modified with *Moses et al.* [2017] eclipse attenuation function.

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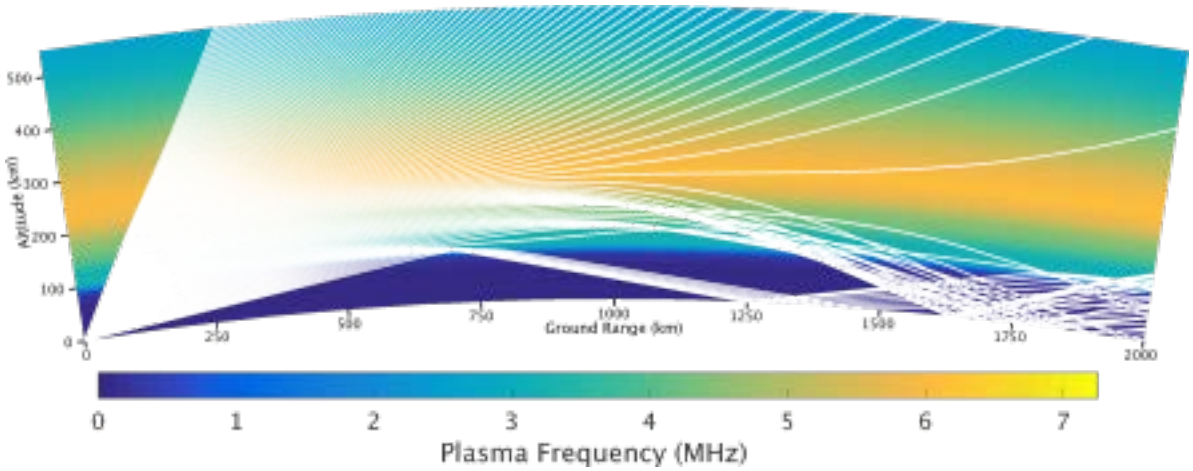
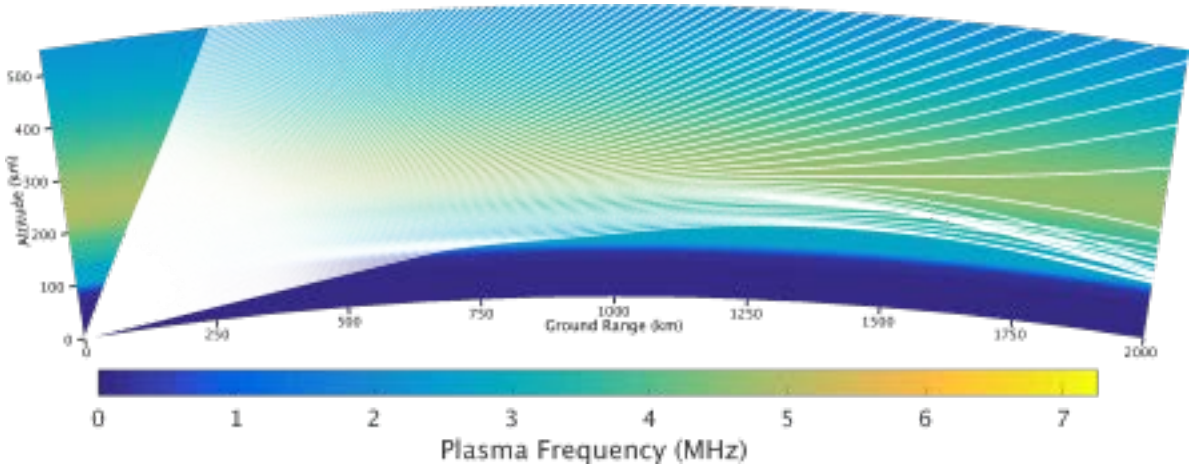
Example Raytraces

Uneclipsed



Eclipsed

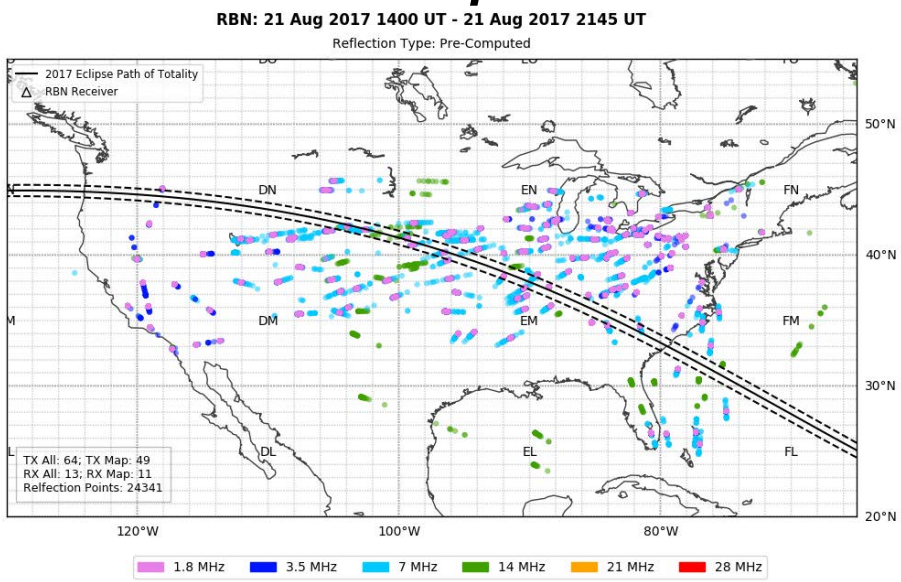


PHaRLAP Raytraces from transmitter Platteville, CO (AA0RS) to Pipersville, PA (WZ7I) at 1815 UT 21 Aug 2017 on 14.030 MHz.

Reflection Points

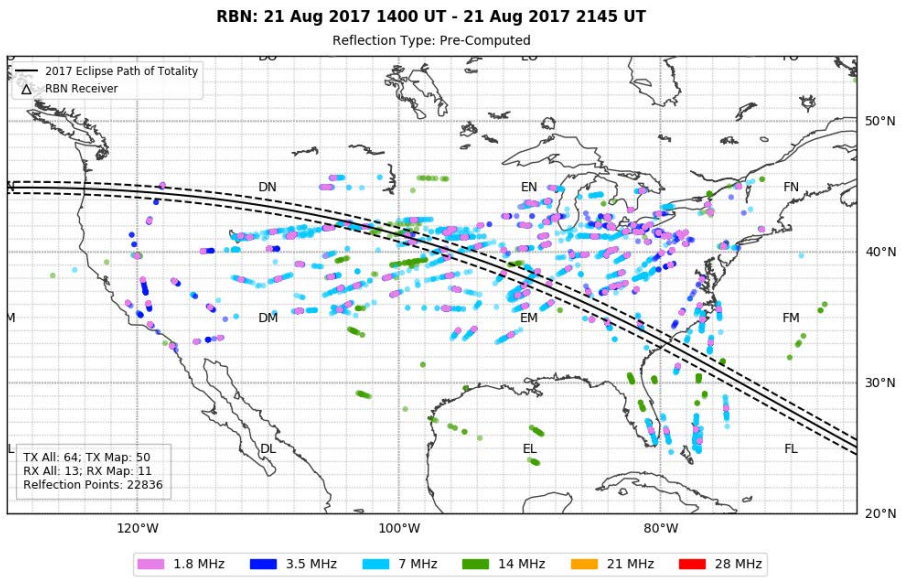
Reflection Points

Uneclipsed



24341 Reflection Points

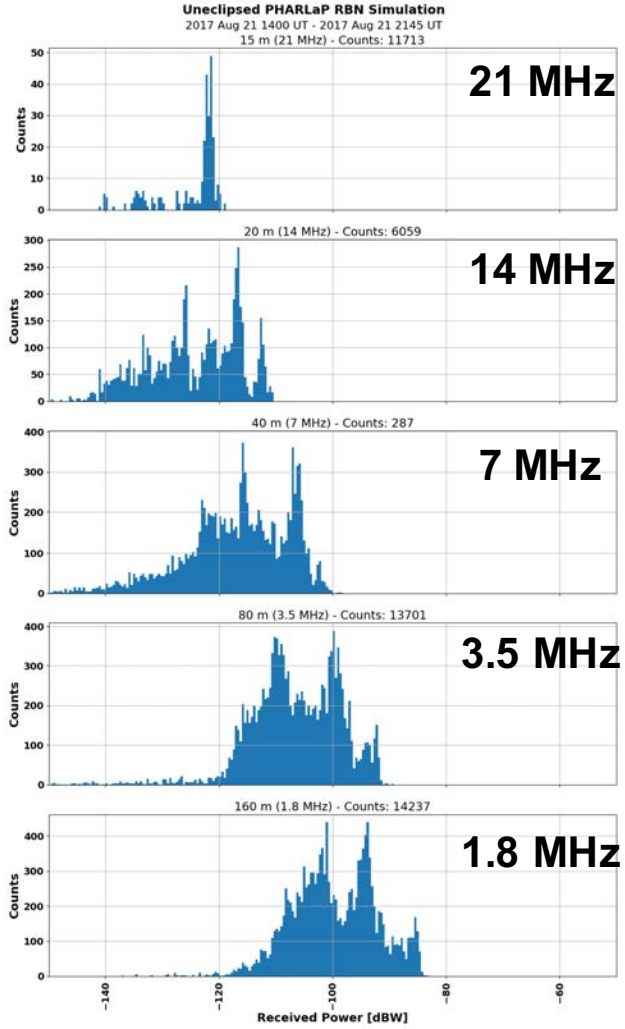
Eclipsed



22836 Reflection Points

Received Power

Uneclipsed



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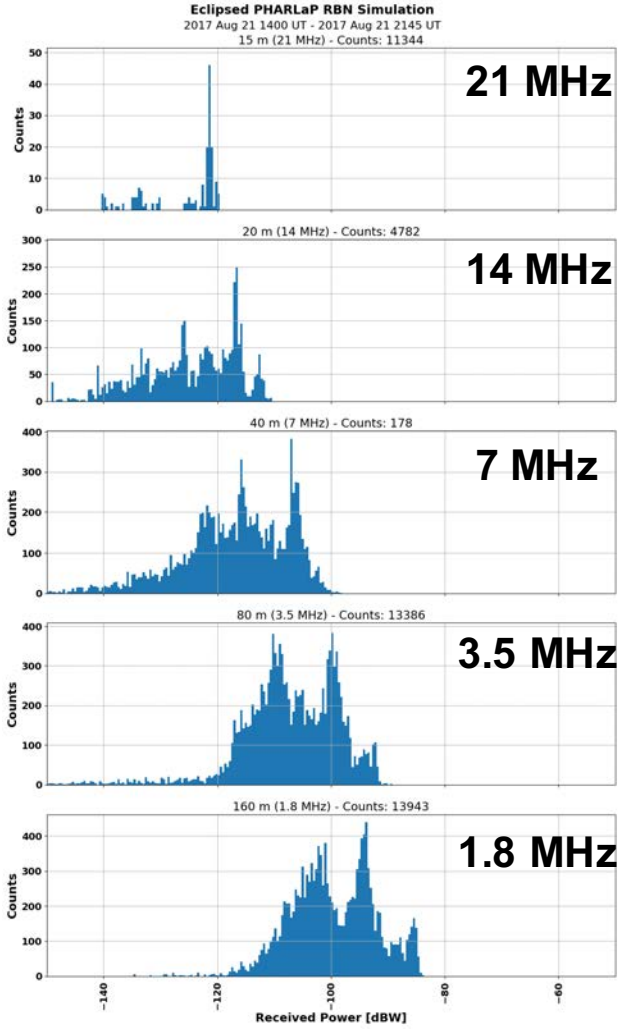

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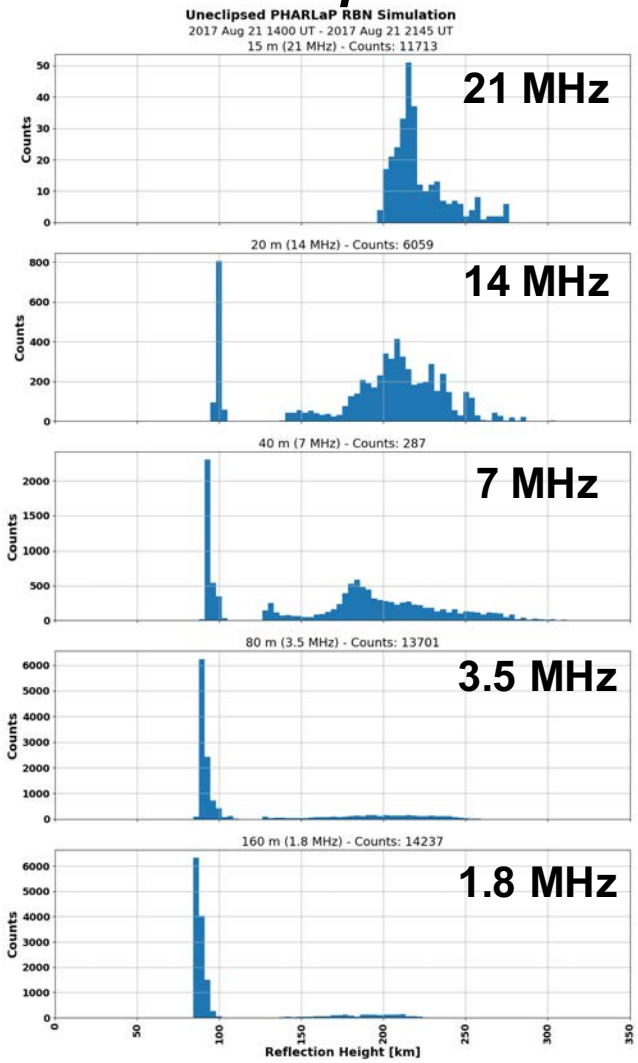
Reflection Height

Uneclipsed



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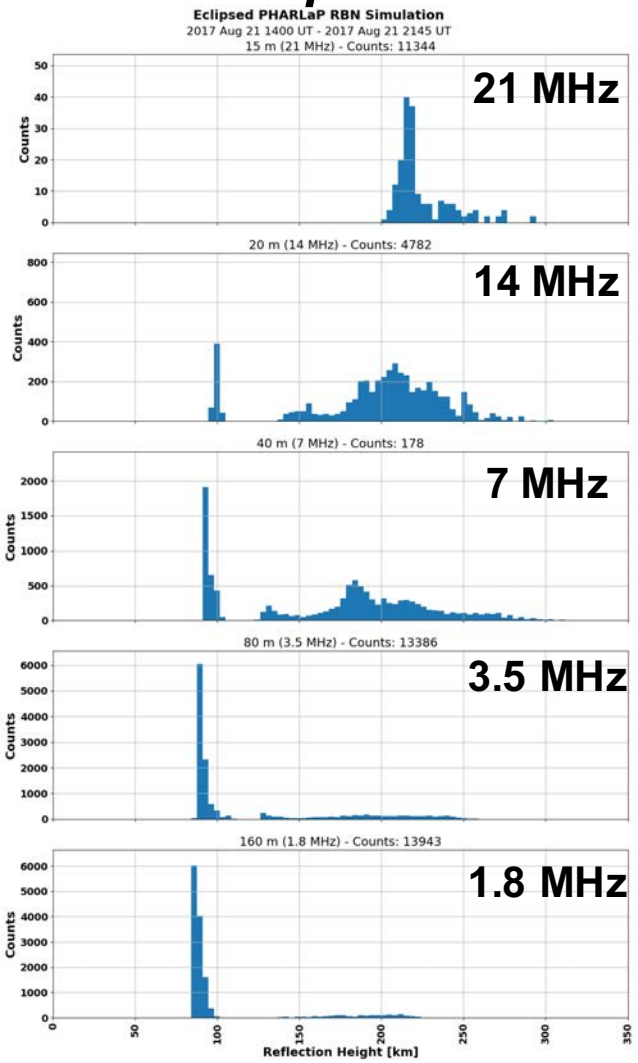

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Summary

- HamSCI is supporting the Virginia Tech effort.
- Amateur Frequency Measurement Community will be looking for HF Doppler shifts.
- Solar Eclipse QSO Party is looking for temporal and spatial eclipse ionospheric effects.
- HF raytracing has been implemented for the purpose of interpreting future SEQP observations.
- We will work with ionospheric modelers to:
  - Interpret ham radio observations
  - Test models
  - Study Eclipse Ionospheric Effects

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References

E.L Afraimovich, E.A Kosogorov, O.S Lesyuta (2002), Effects of the August 11, 1999 total solar eclipse as deduced from total electron content measurements at the GPS network, Journal of Atmospheric and Solar-Terrestrial Physics, Volume 64, Issue 18, Pages 1933-1941, ISSN 1364-6826, http://dx.doi.org/10.1016/S1364-6826(02)00221-3.

Bamford, R. (2000), Radio and the 1999 UK Total Solar Eclipse, Rutherford Appleton Laboratory, Chilton, Didcot, UK

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Thank you!

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