HamSCI Workshop 2021: Midlatitude Ionospheric Science

Friday, March 19 – Saturday, March 20, 2021

The University of Scranton

Scranton, PA
A Word From Our Provost

Dr. Jeffrey Gingerich, Provost
The University of Scranton
A Word From Our Dean

Dr. Michelle Maldonado, Dean of the College of Arts and Sciences
The University of Scranton
What is Ham Radio?

- **Hobby for Radio Enthusiasts**
  - Communicators
  - Builders
  - Experimenters

- **Wide-reaching Demographic**
  - All ages & walks of life
  - Over 760,000 US hams; ~3 million Worldwide

- **Licensed by the Federal Government**
  - Basic RF Electrical Engineering Knowledge
  - Provides a path to learning
  - Licensing ensures a basic interest and knowledge level from each participant
  - Each ham has a government-issued “call sign”
Examples of Ham Radio Communications

- Emergency & Public Service
- Contesting / Radio Sport
- DXing / Distance Awards

Field Day Emergency Preparedness
K3LR Contest Super Station
CANDAC/PEARL, Eureka, Canada
Photo: Pierre Fogal VE3KTB
K2BSA Scout Jamboree
K3LR Contest Super Station
KL7/KJ4OAP
KL7/W2NAF

Adak Island IOTA NA-039
What is Space Weather & Space Science?

Sun

Solar Wind

Magnetosphere

Geospace System

Atmosphere

Credit: Randy Russell, UCAR
https://scied.ucar.edu/ionosphere
Space Weather Station Goals

In building a Personal SW Station, what do we want to do?

**Operations**

**Hams**

• Know the best frequencies for working DX
• Understand the RFI Environment
• Communicate better during emergencies

**Research**

**Scientists**

◦ Better sample the environment
◦ Better understand near-Earth Space

*Note: We have a good understanding of space climate, but not space weather…*
A collective that allows university researchers to collaborate with the amateur radio community in scientific investigations.

Objectives:

1. **Advance** scientific research and understanding through amateur radio activities.
2. **Encourage** the development of new technologies to support this research.
3. **Provide** educational opportunities for the amateur community and the general public.
<table>
<thead>
<tr>
<th>Frequency</th>
<th>Wavelength</th>
</tr>
</thead>
<tbody>
<tr>
<td>LF 135 kHz</td>
<td>2,200 m</td>
</tr>
<tr>
<td>MF 473 kHz</td>
<td>630 m</td>
</tr>
<tr>
<td>MF 1.8 MHz</td>
<td>160 m</td>
</tr>
<tr>
<td>MF 3.5 MHz</td>
<td>80 m</td>
</tr>
<tr>
<td>MF 7 MHz</td>
<td>40 m</td>
</tr>
<tr>
<td>MF 10 MHz</td>
<td>30 m</td>
</tr>
<tr>
<td>MF 14 MHz</td>
<td>20 m</td>
</tr>
<tr>
<td>MF 18 MHz</td>
<td>17 m</td>
</tr>
<tr>
<td>MF 21 MHz</td>
<td>15 m</td>
</tr>
<tr>
<td>MF 24 MHz</td>
<td>12 m</td>
</tr>
<tr>
<td>MF 28 MHz</td>
<td>10 m</td>
</tr>
<tr>
<td>VHF+ 50 MHz</td>
<td>6 m</td>
</tr>
</tbody>
</table>

- Hams routinely use HF-VHF transionospheric links.
- Often ~100 W into dipole antennas.
- Common HF Modes
  - Digital: FT8, PSK31, WSPRNet, RTTY
  - Morse Code / Continuous Wave (CW)
  - Phone: Single Side Band (SSB)
Invited Speakers

Keynote Address
Dr. Liz Bruton
Science Museum
London
*The History of Radio*

Scientist Tutorial
Dr. Mike Ruohoniemi
Virginia Tech
*Midlatitude Ionospheric Physics*

Amateur Radio Tutorial
Joe Dzekevich
K1YOW
*Amateur Radio Observations of Midlatitude Sporadic E*

nathaniel.frissell@scranton.edu
Online Workshop Schedule

HamSCI 2021 Program

Participation is free thanks to support from The University of Scranton and National Science Foundation

Main workshop page: http://hamsci.org/hamsci2021
Final video production will be done by Jason KC5HWB of Ham Radio 2.0.
Oral Presentation PDF and PowerPoint Files
iFoster Gallery
HamSCI Glossary

Friday, March 19, 2021

Opening Remarks & Oral Session I
Personal Space Weather Station Engineering & Science
Chair: Nathaniel Frissell W2NAF
Zoom Moderators: Gareth Perry KD2SAK & Diego Sanchez KD2RLM

8:30 AM EDT 1230z Opening Remarks / Webinar Opens The University of Scranton

https://hamsci.org/hamsci-2021-program
This Year, We’re Virtual!

- **Session Chair**: Person responsible for introducing talks, controlling flow of questions, and keeping track of time.

- **Zoom Moderator**: Panelists who are assigned to monitor the Zoom Chat window and interact with attendees.

- **Presenter**: The person giving the presentation.

- **Panelist**: Includes presenters and invited participants. Presenters can share video, talk, and ask questions directly.

- **Attendees**: People who can watch and listen to the workshop, but cannot directly talk or share video.
  - Attendees can ask questions and make comments through the Zoom Chat window.
  - Moderators will be watching the chat window and can ask questions on your behalf.
  - You can “raise your hand” to get the attention of a moderator.
Saturday iPosters

See Gallery Link at the top of
https://hamsci.org/hamsci-2021-program
Saturday iPosters

- **Saturday morning** will use this webinar link.
- **Saturday afternoon** iPoster session will be on a different Zoom link.
- Link will be posted at the top of the schedule page on Saturday.
- The goal of the iPoster session is to make the meeting more interactive.
- We will use breakout rooms and you will have a chance to socialize more casually with other people in the meeting.
- Make sure you are using the latest Zoom client.
- This is experimental! Please be patient and help to make this a good experience for everyone!
Live Streaming and Video Recording

• We have live YouTube Stream!
  • Address is posted on hamsci.org/hamsci2020
  • No live chat in YouTube stream... you need to log into Zoom for that!

• Meeting is being recorded and will be post-processed by Jason Johnston KC5HWB of Ham Radio 2.0
Questions?
HamSCI Personal Space Weather Station: Overview and Project Update

Nathaniel A. Frissell W2NAF¹

¹The University of Scranton
HamSCI Personal Space Weather Station

- The PSWS is a multi-instrument, ground-based device designed to observe space weather effects both as a single-point measurement and as part of a larger, distributed network.

- It is “Personal” because it is being designed such that an individual should be able to purchase one and operate it in their own backyard.

- The PSWS design also works to take into account the needs of both amateur radio operators and professional researchers.

For more information, visit http://hamsci.org/psws
### Low-Cost “Grape” PSWS

- HF “Doppler Shift” Monitoring
- Main components: Raspberry PI, GPSDO, Custom Direct-conversion receiver board
- Cost: ~$100 to $200
- Developed by Case Western

### SDR-Based “Tangerine”

- HF FPGA-based Software Defined Radio
- Precision timing and frequency measurement
- 2 to 4 coherent, phase-locked receive channels
- Cost ~$500 to $1000
- Developed by Amateur Radio Group TAPR

#### 10 MHz Doppler During 2017 Eclipse

**TX:** WWV  
**RX:** WA9VNJ (Milwaukee)

![Doppler Graph](image)

[Collins et al., 2021]

#### Oblique Ionograms

(Currently on Ettus N200 but will be ported to Tangerine)

![Ionogram Image](image)

Movie by Dev Joshi
GNUChirpsounder2 by Juha Vierinen
## PSWS Teams

### University of Scranton
- Nathaniel Frissell W2NAF (PI)
- Dev Joshi KC3PVE (Post-Doc)
- Jonathan Rizzo KC3EEY
- Veronica Romanek KD2UHN

**Responsibilities**
- Lead Institution
- HamSCI Lead
- Radio Science Lead

### University of Alabama
- Bill Engelke AB4EJ (Chief Architect)
- Travis Atkison (PI)

**Responsibilities**
- Central Database
- Central Control Software
- Local Control Software

### TAPR & Zephyr Engineering Inc.
- Scotty Cowling WA2DFI (Chief Architect)
- Tom McDermott (RF Board)
- John Ackerman N8UR (Clock Module)
- David Witten KD0EAG (Magnetometer)
- Jules Madey K2KGJ (Magnetometer)
- David Larsen KV0S (Website)

**Responsibilities**
- TangerineSDR (High Performance)
- Data Engine
- Ground Magnetometer

### Case Western Reserve University
- David Kazdan AD8Y (Lead)
- Kristina Collins KD8OXT
- John Gibbons N8OBJ
- Rob Wiesler AC8YV
- Chris Zorman (PI)
- Matt McConnell KC8AWM
- Skylar Dannhoff KD9JFJ
- Aidan Montare KB3UMD

**Responsibilities**
- Low Cost PSWS System

### New Jersey Institute of Technology
- Hyomin Kim KD2MCR (PI)
- Gareth Perry KD2SAK
- Andy Gerrard KD2MCQ
- Diego Sanchez KD2RLM

**Responsibilities**
- Ground Mag Oversight & Testing
- Science Collaborators

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**MIT Haystack Observatory**
- Phil Erickson W1PJE

**Responsibilities**
- Science Collaborator
PSWS Current Engineering Status

- **Tangerine Data Engine (MAX10)**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - Component placement: 100% complete
  - Next step: routing & pin swap

- **Tangerine RF Module (dual-channel 0.1-54MHz)**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - Component placement and routing: 100% complete
  - Update will be required for DE compatibility

- **Tangerine Clock Module (ZED-F9T SynthDO)**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - Component Placement: 100% complete
  - Routing and pin swap: 50% complete

- **MagnetoPi Hat**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - PC Board placement and layout: 100% complete
  - Compatibility review with LC-PSWS: 100% complete
  - Prototype build of 50 units: 100% complete

- **Low Cost PSWS (Grape)**
  - Grape Generation 1 consists of a Leo Bodnar GPSDO frequency standard, a low IF receiver and a USB based A/D converter running a modified version of FLDIGI executing on a Raspberry Pi.
  - ~15 Grape Generation 1 stations operational
  - Grape v2 Design in Progress

- **Control Software and Database**
  - Prototype of local control software exists
  - Runs on Odroid N2 Single Board Computer
  - Uses data from a TangerineSDR Simulator (FlexRadio with GPSDO + DAX IQ output)
  - Can monitor up to 16 band segments at a time
  - 4 types of data collection: Snapshotter, Ring Buffer, Firehose(L+R), and FT8/WSPR
  - Propagation Monitoring
  - Proof of concept code working for all modes except WSPR and Firehose L (supercomputer interface)
Thank You!

This project is supported by NSF Grants AGS-2002278, AGS-1932997, and AGS-1932972, and many volunteers in the amateur radio community. We also thank the ARDC for their support of the TangerineSDR prototype build.