HamSCI Personal Space Weather Station (PSWS): Fall 2021 Update

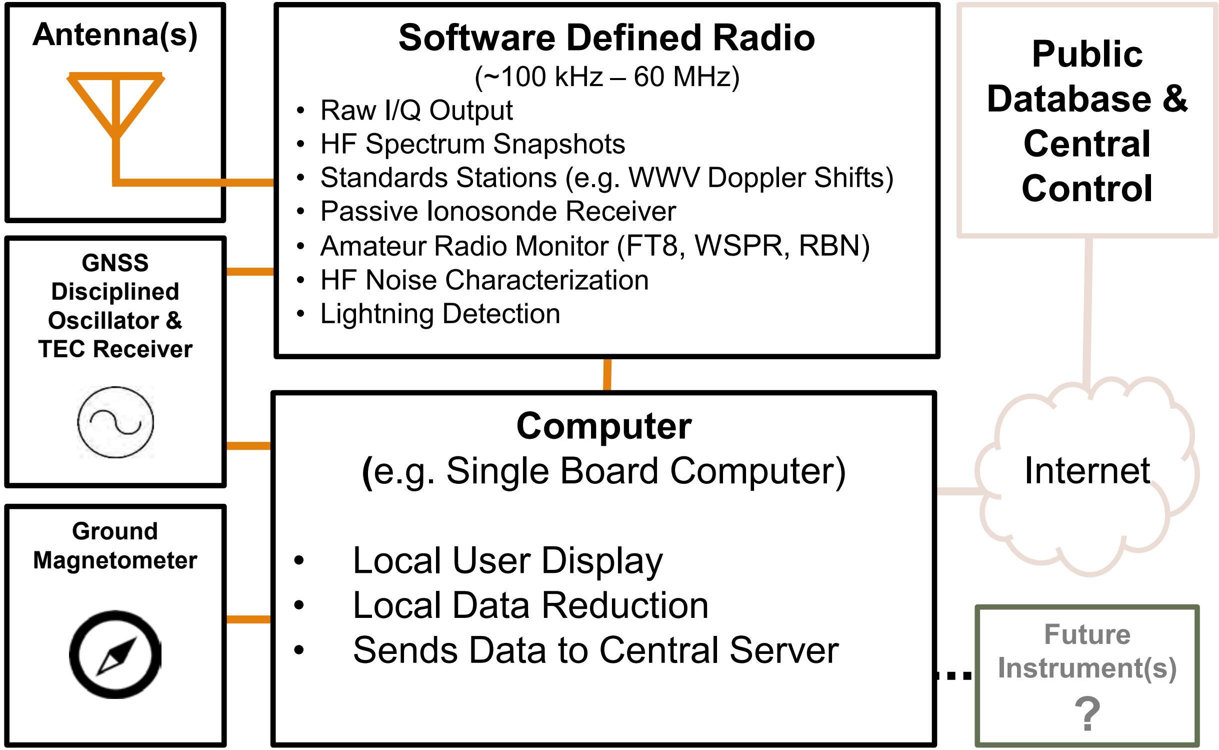
N. A. Frissell[1], D. Joshi[1], V. Romanek[1], K. Collins[2], A. Montare[2], D. Kazdan[2], J. Gibbons[2], W. Engelke[4], T. Atkison[4], H. Kim[5], S. H. Cowling[6], T. C. McDermott[6], J. Ackermann[6], D. Witten[6], J. Madey[6], H. W. Silver[7], W. Liles[7], S. Cerwin[7], P. J. Erickson[8], E. S. Miller[7,9], J. Vierinen[10], and the HamSCI Community

[1]The University of Scranton
[2]Case Western Reserve University
[3]University of Florida
[4]University of Alabama
[5]New Jersey Institute of Technology
[6]TAPR
[7]HamSCI
[8]MIT Haystack Observatory
[9]Systems & Technology Research
[10]University of Tromsø

nathaniel.frissell@scranton.edu

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 works to take into account the needs of both amateur radio operators and professional researchers.



For more information, visit http://hamsci.org/psws

nathaniel.frissell@scranton.edu

What is the purpose of the PSWS?

The **PSWS aims to support two primary groups of users, space scientists and amateur radio operators**. Each of these groups have different but related needs:

- **Space Science Researchers**
  - Observe, characterize, and understand ionospheric variability on small temporal and spatial scales
  - Understand coupling between the neutral atmosphere, ionosphere, and magnetosphere
  - Validate and improve models with the goals of prediction and understanding
- **Amateur Radio Operators**
  - Understand and predict radio propagation to support amateur radio communications, including public/emergency service operations, contesting, and DX (long distance) communications.
  - Study space weather and propagation for personal edification and to contribute back to science and the radio art.

nathaniel.frissell@scranton.edu

PSWS Teams

University of Scranton
- **Nathaniel Frissell W2NAF (PI)**
- Dev Joshi KC3PVE (Post-Doc)
- Veronica Romanek KC2UHN (Undergrad)
- Cuong Nguyen (Undergrad)

Responsibilities
- Lead Institution
- HamSCI Lead
- Radio Science Lead

TAPR & Zephyr Engineering
- **Scotty Cowling WA2DFI (Chief Architect)**
- Tom McDermott N5EG (RF Board)
- John Ackerman N8UR (Clock Module)
- David Witten KD0EAG (Magnetometer)
- Jules Madey K2KGJ (Magnetometer)
- David Larsen KV0S (FPGA Code/Website)

Responsibilities
- TangerineSDR (High Performance)
- Ground Magnetometer

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

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

Case Western Reserve University
Case Amateur Radio Club W8EDU
- **Kristina Collins KD8OXT**
- **David Kazdan AD8Y**
- **John Gibbons N8OBJ**
- Christian Zorman (PI)
- Skylar Dannhoff KD9JPX
- Aidan Montare KB3UMD

Responsibilities
- Low Cost PSWS System

MIT Haystack Observatory
- **Phil Erickson W1PJE**

Responsibilities
- Science Collaborator

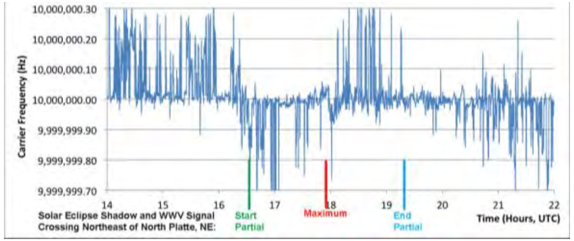
New Jersey Institute of Technology
- **Hyomin Kim KD2MCR (PI)**
- Gareth Perry KD2SAK
- Andy Gerrard KD2MCQ

Responsibilities
- Ground Mag Oversight & Testing
- Science Collaborators

Low-Cost "Grape" PSWS

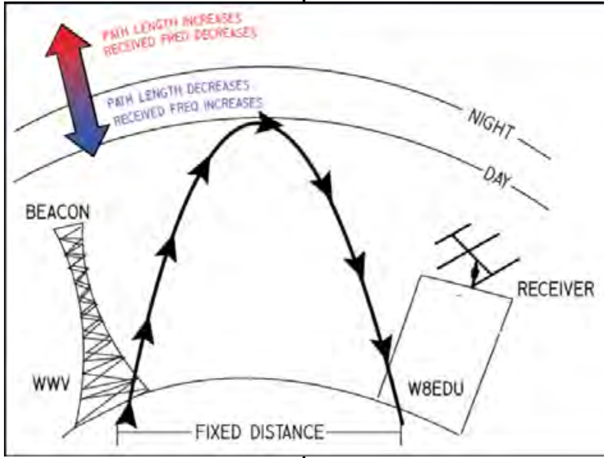
- HF "Doppler Shift" Monitoring
- Main components: Raspberry PI, GPSDO, Custom Low-IF receiver board
- Cost: ~$300
- Developed by Case Western

10 MHz Doppler During 2017 Eclipse
TX: WWV RX: WA9VNJ (Milwaukee)



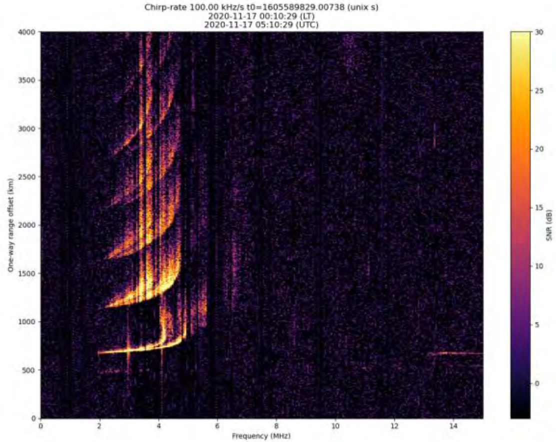
SDR-Based "Tangerine"

- 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



[Collins et al., 2021]

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



Movie by Dev Joshi
GNUChirpsounder2 by Juha Vierinen

Ground Magnetometer

Developed by TAPR and NJIT

Purpose
- To establish a densely-spaced magnetic field sensor network to observe Earth's magnetic field variations in three vector components.

Target performance level
- ~10 nT field resolution
- 1-sec sample rate (note: Earth's magnetic field ranges from 25,000 to 65,000 nT)
- Total cost ~$100-$150

Sensors
- PNI RM3100 magnetometer module
  - 3 axis magneto-inductive measurement module
  - Very small (25.4 x 25.4 x 8 mm)
- MCP9808 temperature sensor

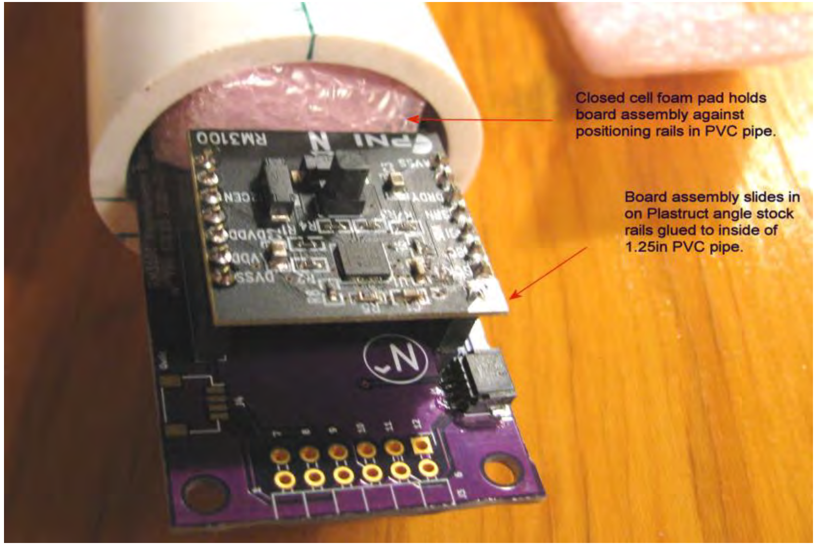


Photo by Jules Madey, K2KGJ

PSWS Current Engineering Status

- **Tangerine Data Engine (MAX10)**
  - Schematic capture: 100% complete
  - BOM: 100% complete
  - Component placement: 100% complete
  - Almost all parts delivered
  - Next steps: **Designing an adapter board to continue development with dev board while waiting for FPGA chip delivery**
- **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
- **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
  - **Preparing to put Revision E into production.**

- **Low Cost PSWS (Grape)**
  - Grape Generation 1 consists of
    - Leo Bodnar GPSDO frequency standard
    - low IF receiver
    - USB based A/D converter
    - RaspberryPi running a modified version of FLDIGI
  - Several Grape V1 stations operational, and build instructions available at hamsci.org/grape1.
  - Grape v2 Design in Progress, will be capable of receiving 4 HF channels simultaneously.

- **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)

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nathaniel.frissell@scranton.edu

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