TANGERINE SDR PSWS CONTROL SOFTWARE AND DATABASE – DESIGN & STATUS

OBSERVING THE IONOSPHERE FROM YOUR HOME QTH

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OVERVIEW

- What will the PSWS Network be?
- How will the TangerineSDR work within this network?
- What is our progress so far?

GOAL: A CROWD-SOURCED IONOSPHERIC OBSERVATION SYSTEM

- Build a network of receivers that can observe the ionosphere by watching doppler shift in WWV and other stable signals (plus other analysis as well, e.g., SNR) at individual own stations, and uploading to a central host

WHAT WILL PSWS NETWORK BE?

- Organized by a group of Universities and research facilities
- Several hundred (maybe thousands) - Software Defined Radios scattered across the globe – in shacks, schools, universities, etc.
- Each includes a low-cost yet powerful Single Board Computer
  - 2 versions: TangerineSDR and Grape Ultra-Low Cost version
- All tied together into a network
  - Data analysis for science objectives PLUS
  - Each station is a personal propagation monitor

WHAT WILL WE BE ABLE TO DO?

High-resolution observing of geomagnetics, the ionosphere and other near-Earth space environment, in order to…

- Improve our understanding of RF propagation and improve forecasting
- Solar-caused radio blackouts – what to expect and what to do
- Provide hams with their own local propagation info
- Advance scientific understanding of ionosphere & magnetosphere

POSSIBLE SCIENTIFIC DISCOVERIES

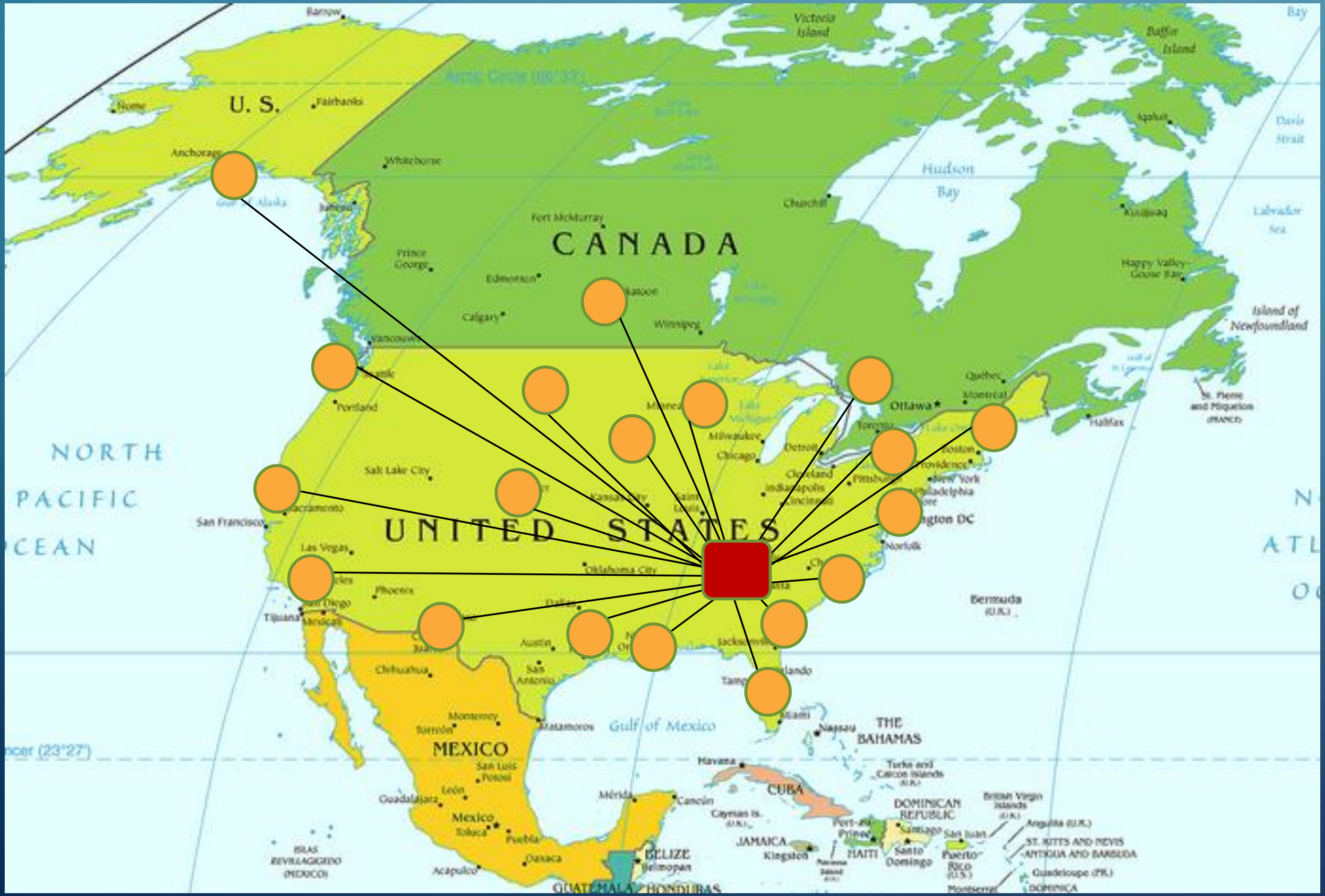
Try to discover more about the causes of a range of (so far) poorly understood phenomena like:

- Traveling ionospheric disturbances (TIDs) – ionospheric waves; gravity (tidal) waves
- Long-delayed echoes
- Sporadic E propagation
- Ionospheric movements linked to tsunamis, upper level lows, volcanic eruptions, polar vortex, etc., etc.; energy transfer between troposphere and ionosphere
- Improved accuracy of ionosphere models

HOW DOES A STATION WORK?

- If you observe the carrier frequency of WWV, you will see it change due to Doppler shift as ionosphere moves
- As sun goes up and down; also in response to eclipse
- Range is on order of +/- 0.5 to 1.5 Hz, but you can see it clearly with a stable enough receiver and GPS-disciplined oscillator
- By using 2 orthogonal loop antennas, can study polarization
- There are many other things that move the ionosphere around
  - E.g., solar eclipse, solar flares, geomagnetic storms, etc.
  - Want to find and characterize these

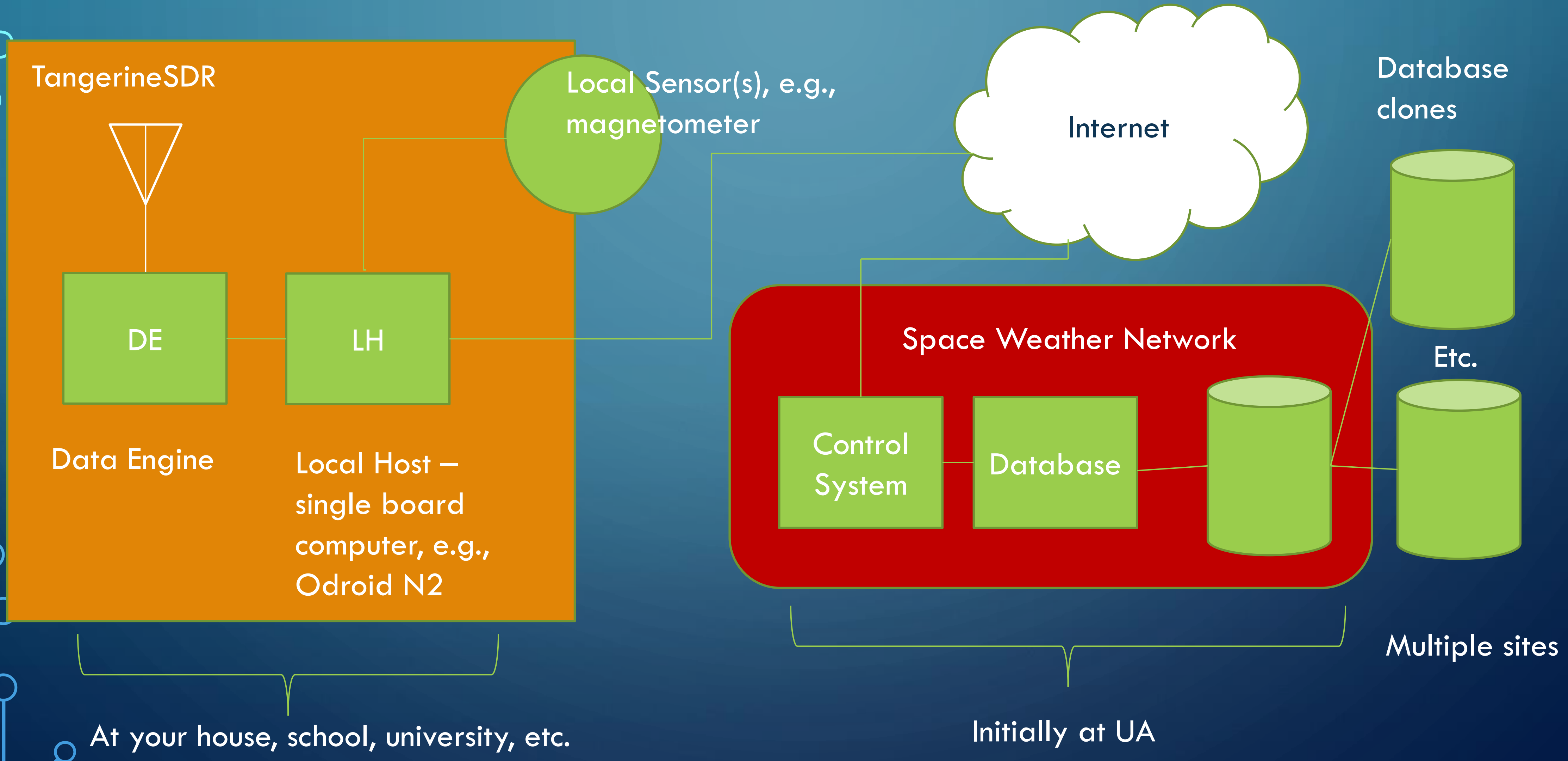
PSWS NETWORK, TOP LEVEL – PHASE 1



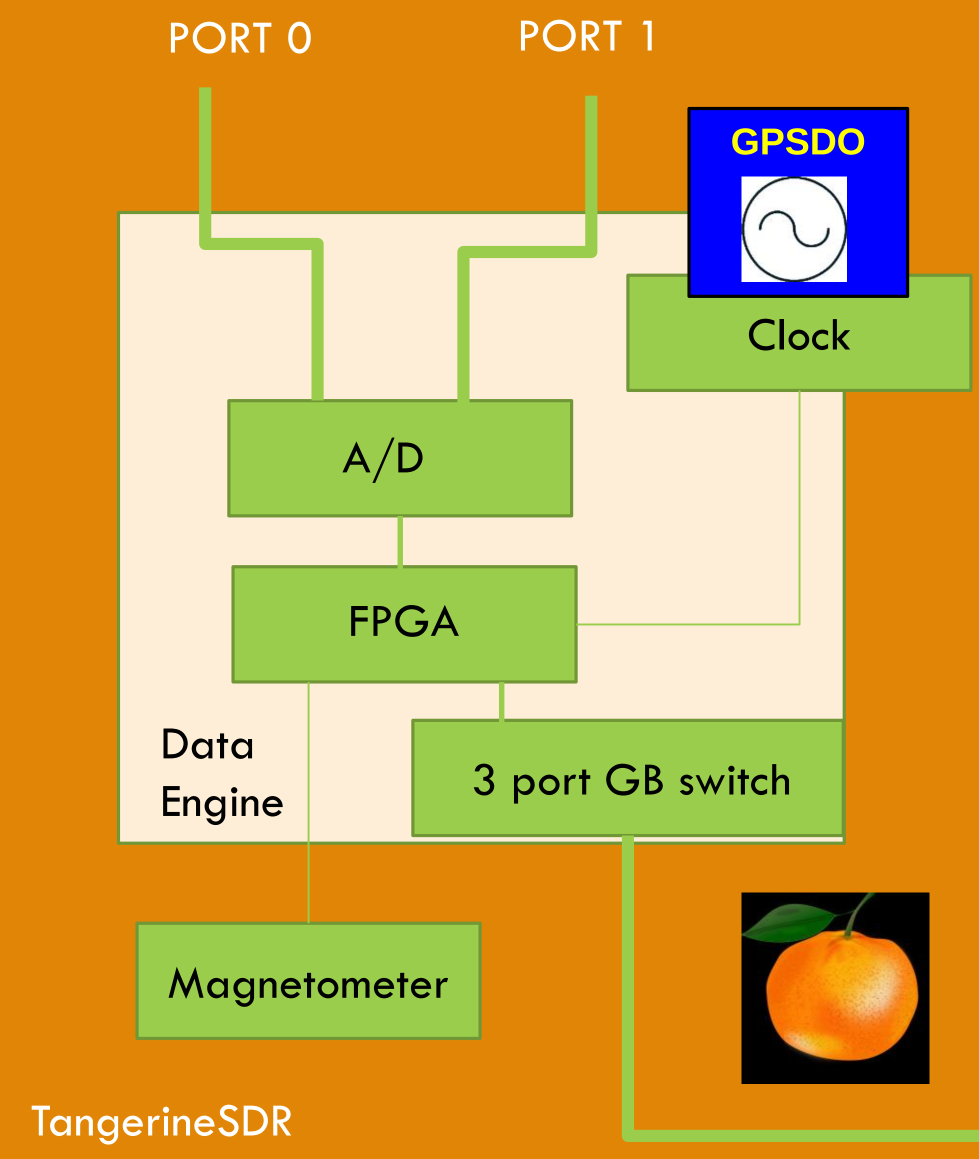
- Station locations are just examples. Emphasis is on North America, but users in other locations are also welcome
- Database will be at University of Alabama for Phase 1

Goal is to have hundreds of these operating

PSWS – LOGICAL ARCHITECTURE

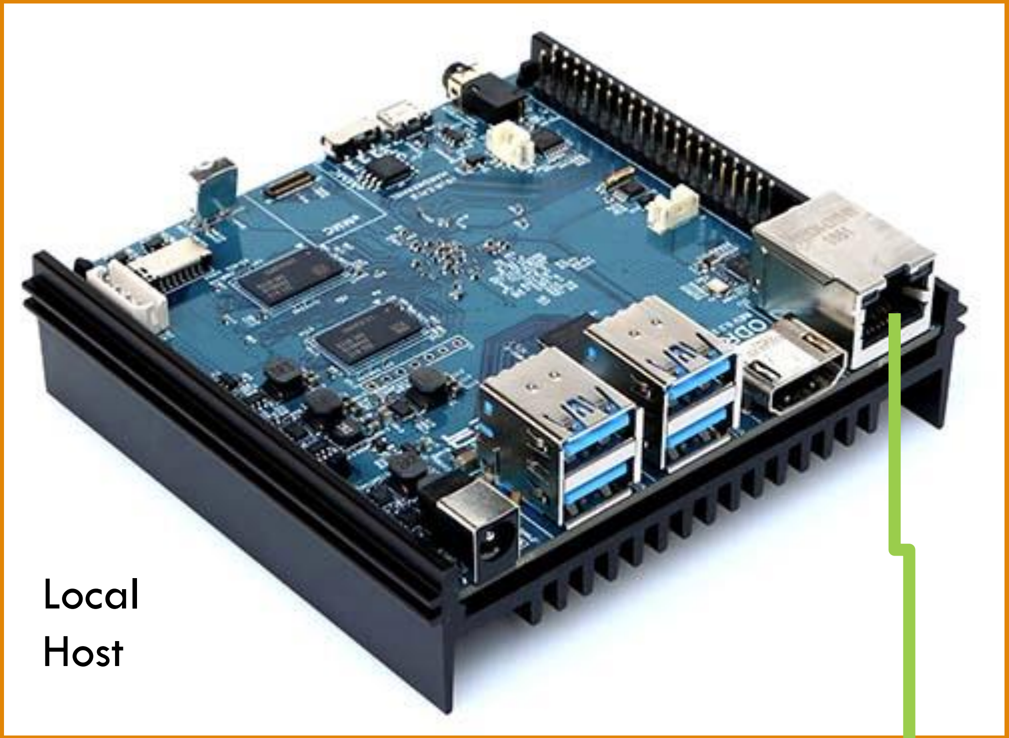


WHAT IS IN THE TANGERINE SDR?



A TangerineSDR consists of:

- Data Engine – A/D converter and FPGA
- Single Board Computer (Odroid N2 4GB RAM)
- Connected together by a gigabit switch
- (optional) – highly accurate clock; magnetometer



HARDWARE DESIGN STATUS

- Magnetometer is designed & built; Version 1 is now being tested by comparison to research grade magnetometers and IAGA data
- Data Engine and Radio modules are in final design
- Includes a high-precision clock (GPSDO)

TANGERINE-SDR SOFTWARE

Internet

To Central Control System

Local Host

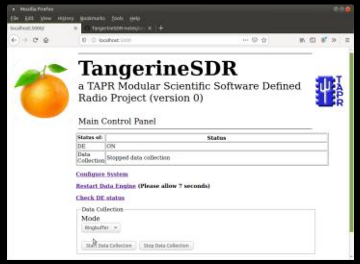
Data Engine

3 port GB switch

Mainctl – written in C

- Handles commands from local web server
- Handles high speed data feed from DE (UDP)
- Saves data in Digital RF format
- Decodes FT8 & WSPR signals
- Manages uploads to Central Control system
- Interfaces to GNURadio
- Spawn subprocesses to run DRF, FFT, FT8, WSPR, data uploading

Monitor



Local Browser-based UI “Web Controller”
(running flask, flask-WTForms)

Local USB HD

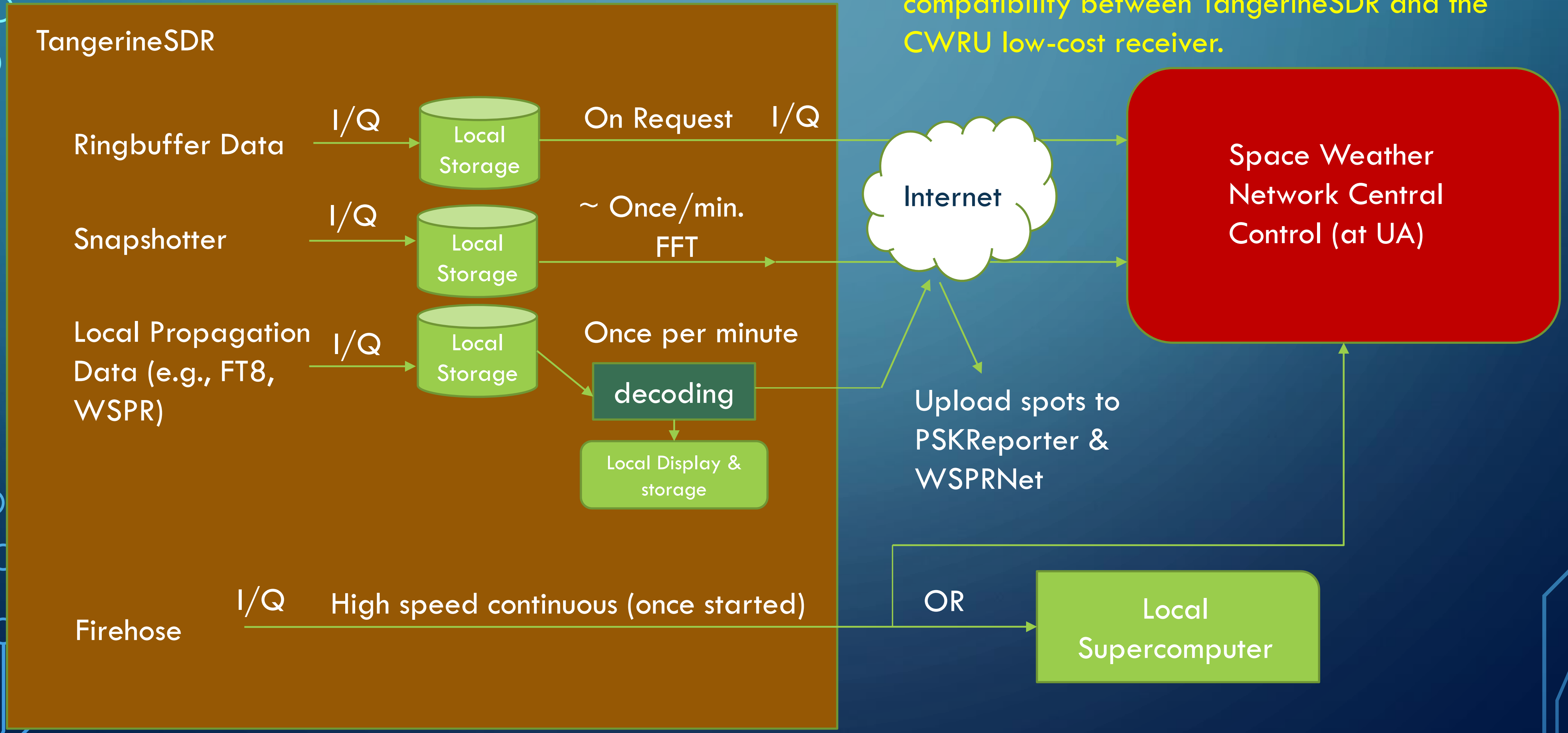
RAMdisk

DATA COLLECTION

- Can monitor up to 16 band segments at a time
- 4 types of data collection
  - SNAPSHOTTER: ~Once-per-minute waterfall snapshot upload
    - (good in cases of low internet bandwidth)
  - RINGBUFFER: Continuous local storage for 24 hours, then upload on request from Central Control (with throttling)
  - FIREHOSE: 2 submodes: Continuous transfer to local supercomputer or remote server(with throttling)
  - Propagation Monitoring: decode of FT8 and WSPR on up to 8 bands each (total capacity is TBD), every 1 to 2 minutes

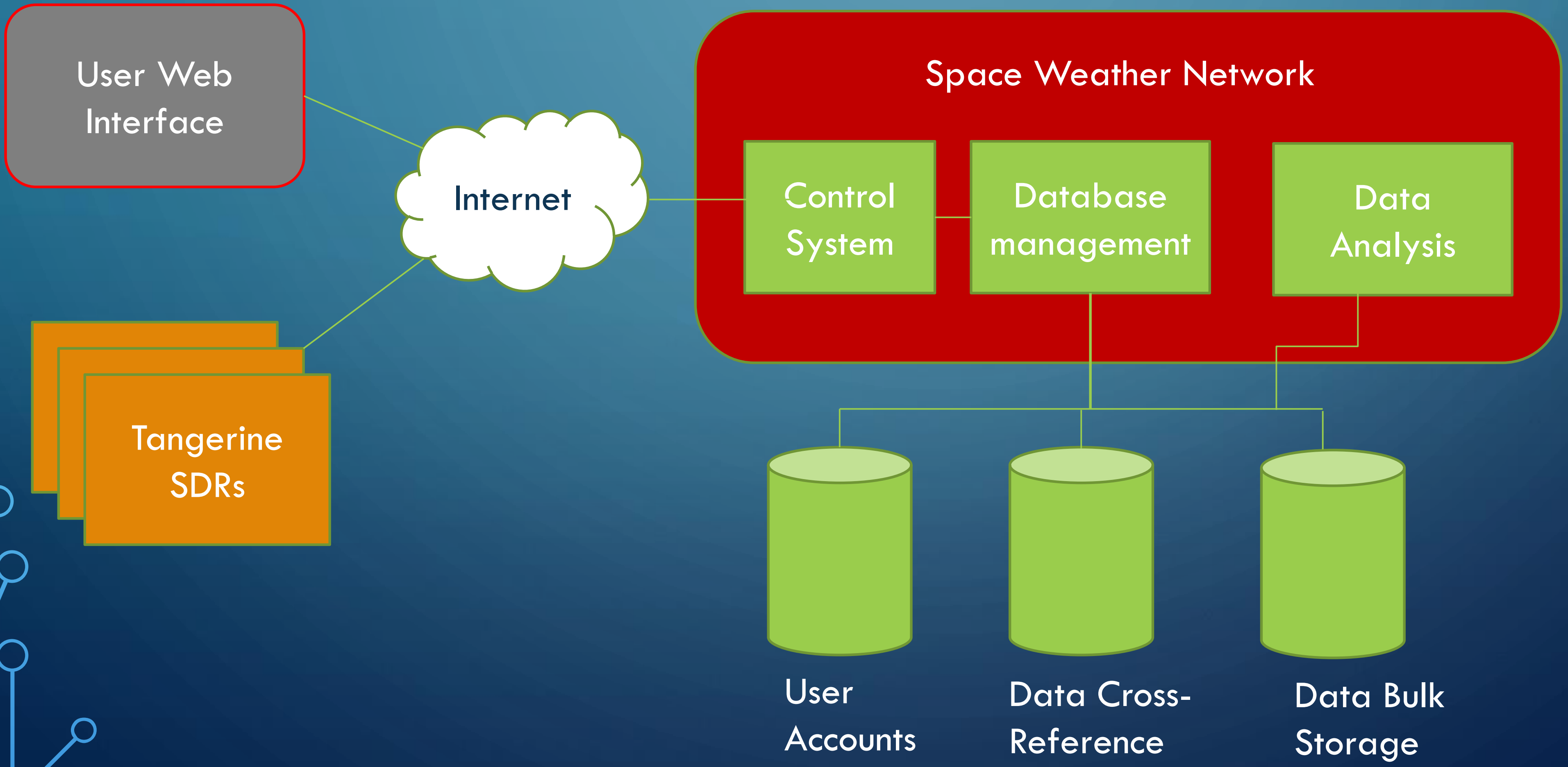
HANDLING COLLECTED DATA

UA and CWRU are working together towards compatibility between TangerineSDR and the CWRU low-cost receiver.



CENTRAL CONTROL SYSTEM

- Similar to SATNOGS network



Planned software includes:

- Django
- Celery
- RabbitMQ
- MariaDB

HOW YOU WILL USE THE NETWORK

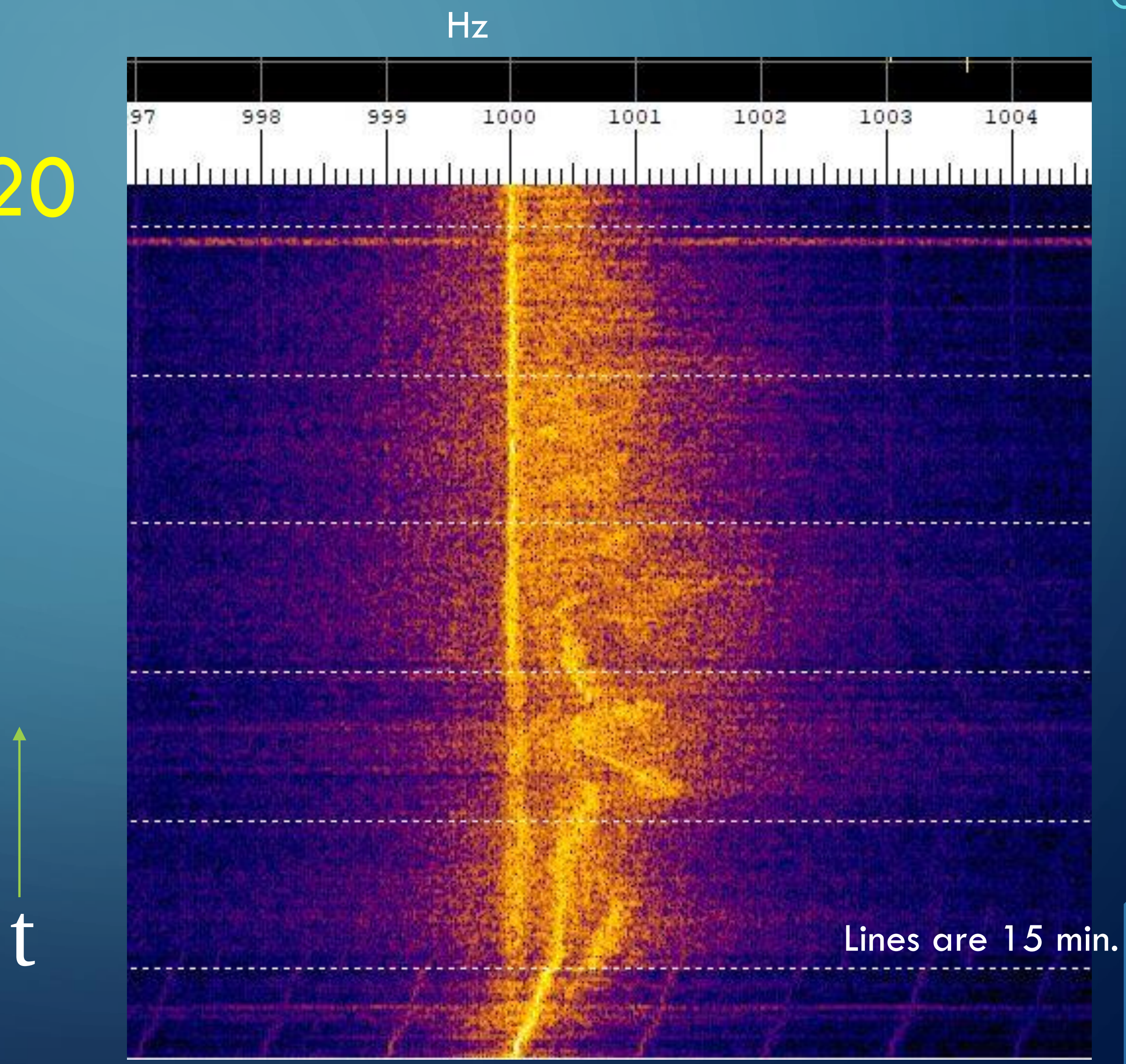
- Build your TangerineSDR & get it working locally
- Browse to the Central Control System & sign up for account
- Get security token from Central & paste into Tangerine web interface: this identifies your Tangerine to Central
- Start collecting data!
- You can also do Local Propagation Analysis at the same time if you wish

DATA ANALYSIS

- TangerineSDRs collecting data using Snapshotter, Ringbuffer, or Firehose-R mode
- Central system will request data, which then get uploaded; or upload continuously if you have "enuff" internet bandwidth
- Data saved in database for analysis
  - Spectrum data to be stored in Digital RF (HDF5) format
  - Science users can run analyses; anyone can download data
- Local propagation reports via FT8, WSPR

EXAMPLE 1, TAKEN JUL. 31, 2020

This is the sun coming up, observing WWV at 5 MHz, with rig tuned to 4.999 MHz. In USB, we have a 1 KHz tone which shifts up more than 1 Hz as sun pushes ionosphere down. There seem to be multiple layers involved, with varying levels of opacity; also some discontinuities which have yet to be explained; sometimes they can be correlated with solar flares (even minor flares).



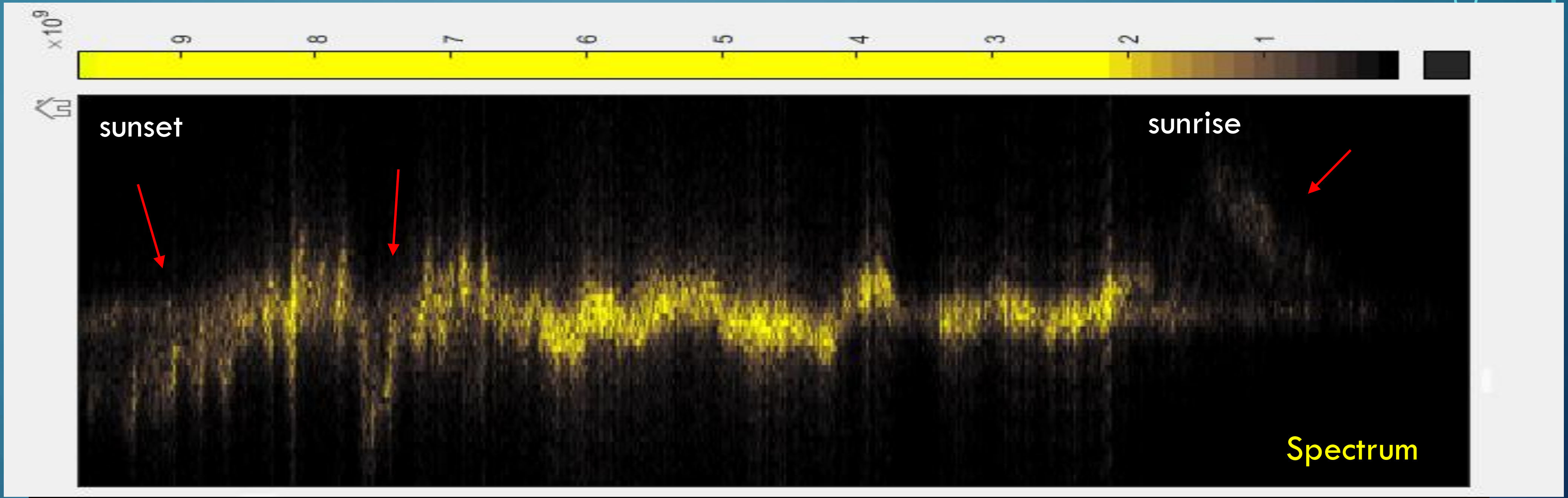
This example uses FlexRadio with GPSDO & SpectrumLab

EXAMPLE 2 - DATA TAKEN USING TANGERINE SDR PROTOTYPE (DE is a FlexRadio with GPSDO) - 9/1/2020

Observing WWV at 4.999 MHz

Freq.

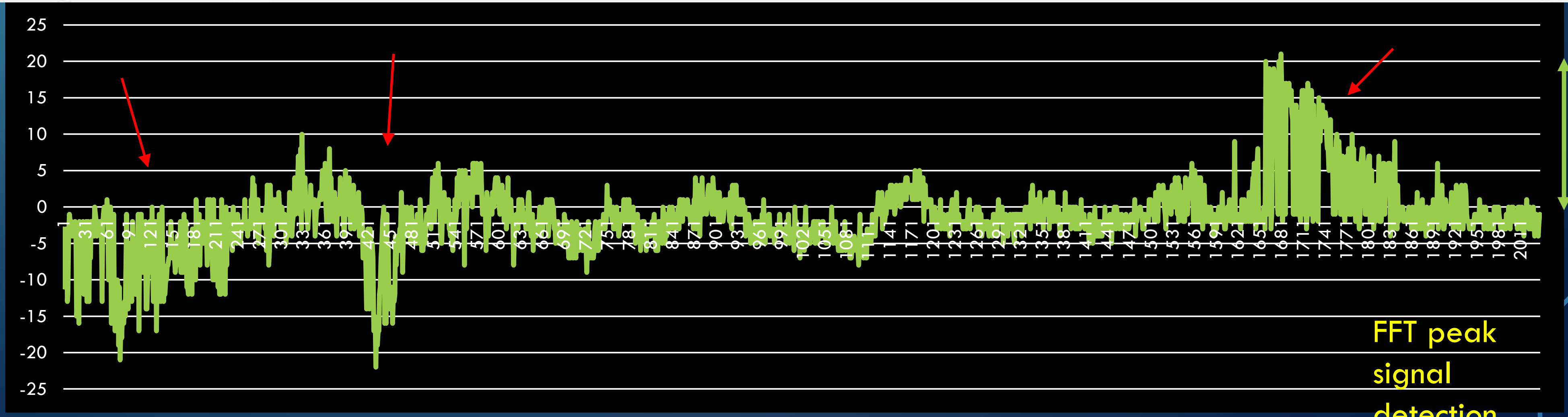
Matlab heatmap



Excel line plot

Freq.

Units are ~ 45 millihertz



0.9 Hz

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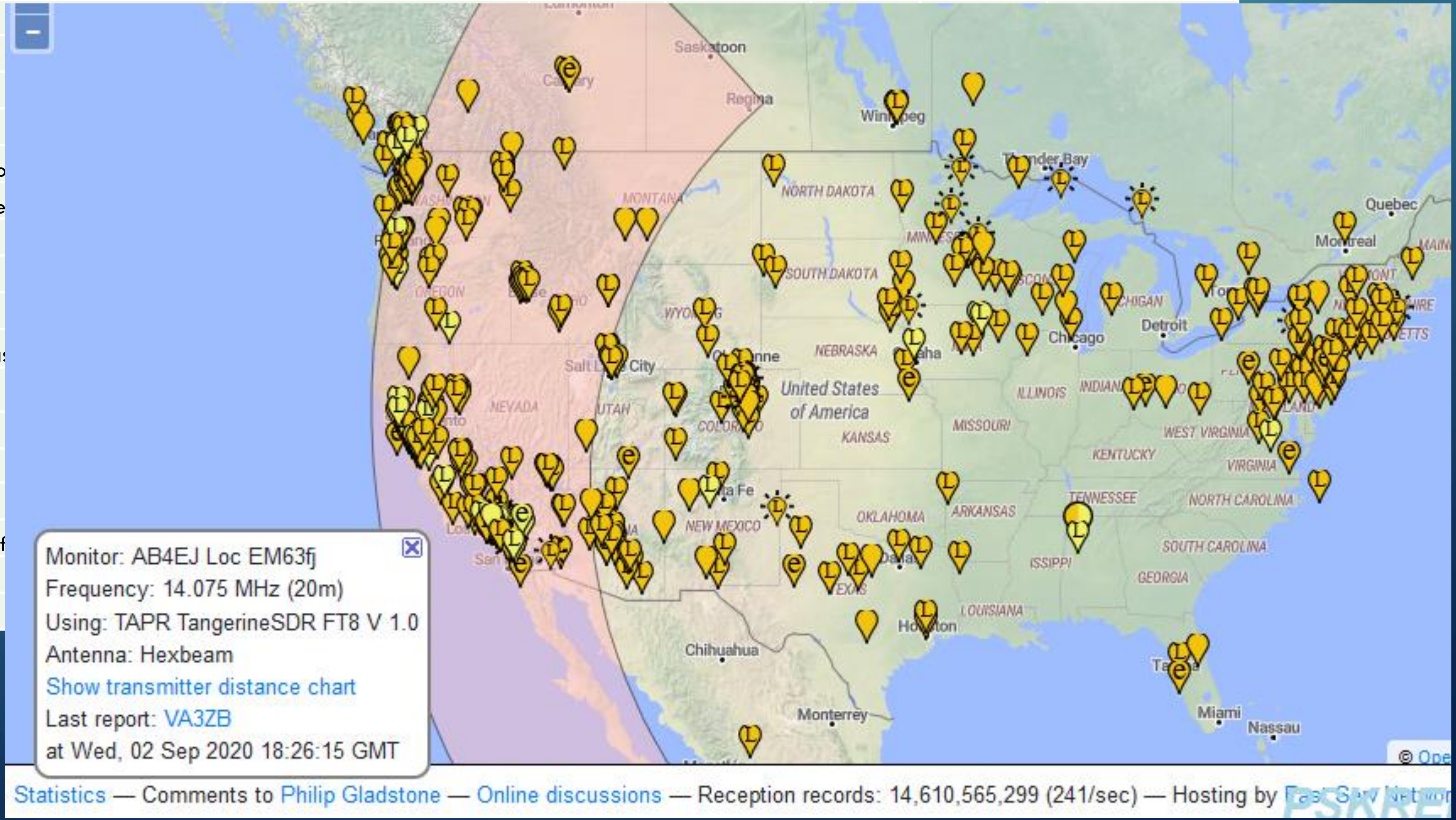
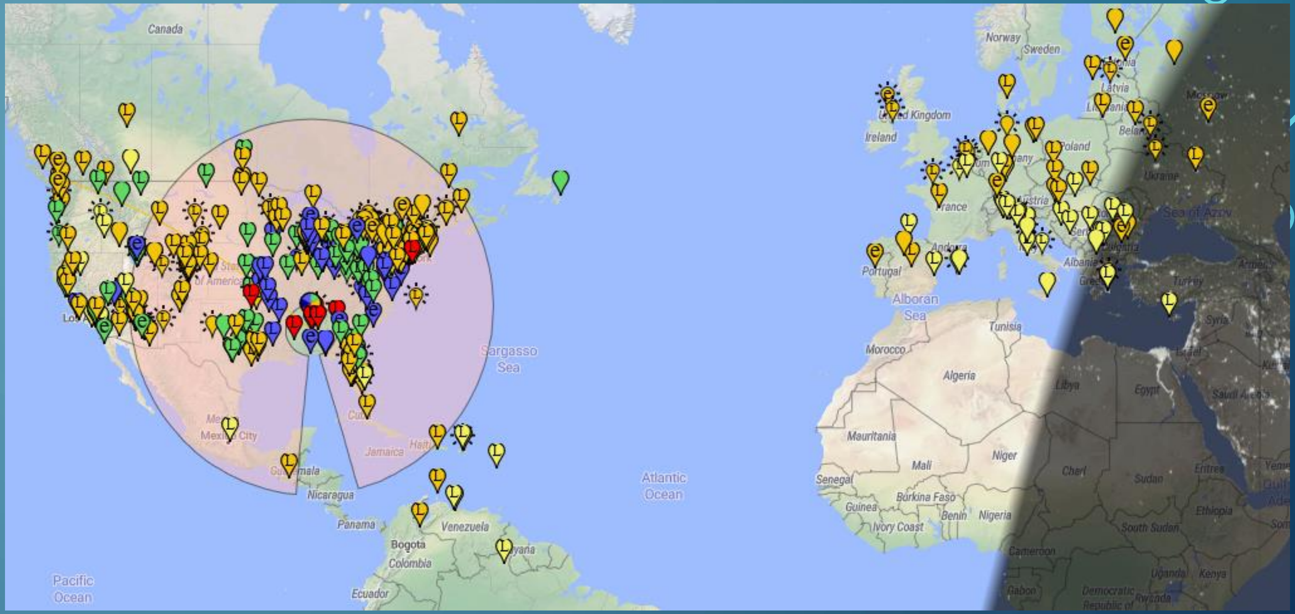
STATUS – 9/2/2020

Major Software sub-modules for PSWS	designed	concept coded	initial unit test	build-out	full unit test	integration test	user acceptance test
Tangerine Local Host (LH)							
User Interface							
'mainctl' interface to DE							
Ringbuffer data storage subsystem							
Snapshotter FFT							
Continuous Upload ('Firehose-R') mo							
Firehose-L (supercomputer interface							
FT8 decode/upload							
WSPR decode/upload							
Heartbeat & on-demand uploader							
Central Control System/Databa							
Tool/web framework selection							
User Interface							
Account Management							
User Profile Management							
Data Inbounding/Storage/cross-ref							
Superuser Controls							
Data Analysis							



WHY PARTICIPATE?



- Be part of new science
- Compete for wallpaper
- PSWS is planned to provide ongoing propagation monitoring at your location with multiband FT8, WSPR, etc., etc.

Q & A

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