LEDA status update

Gianni Bernardi

INAF-IRA & Rhodes University

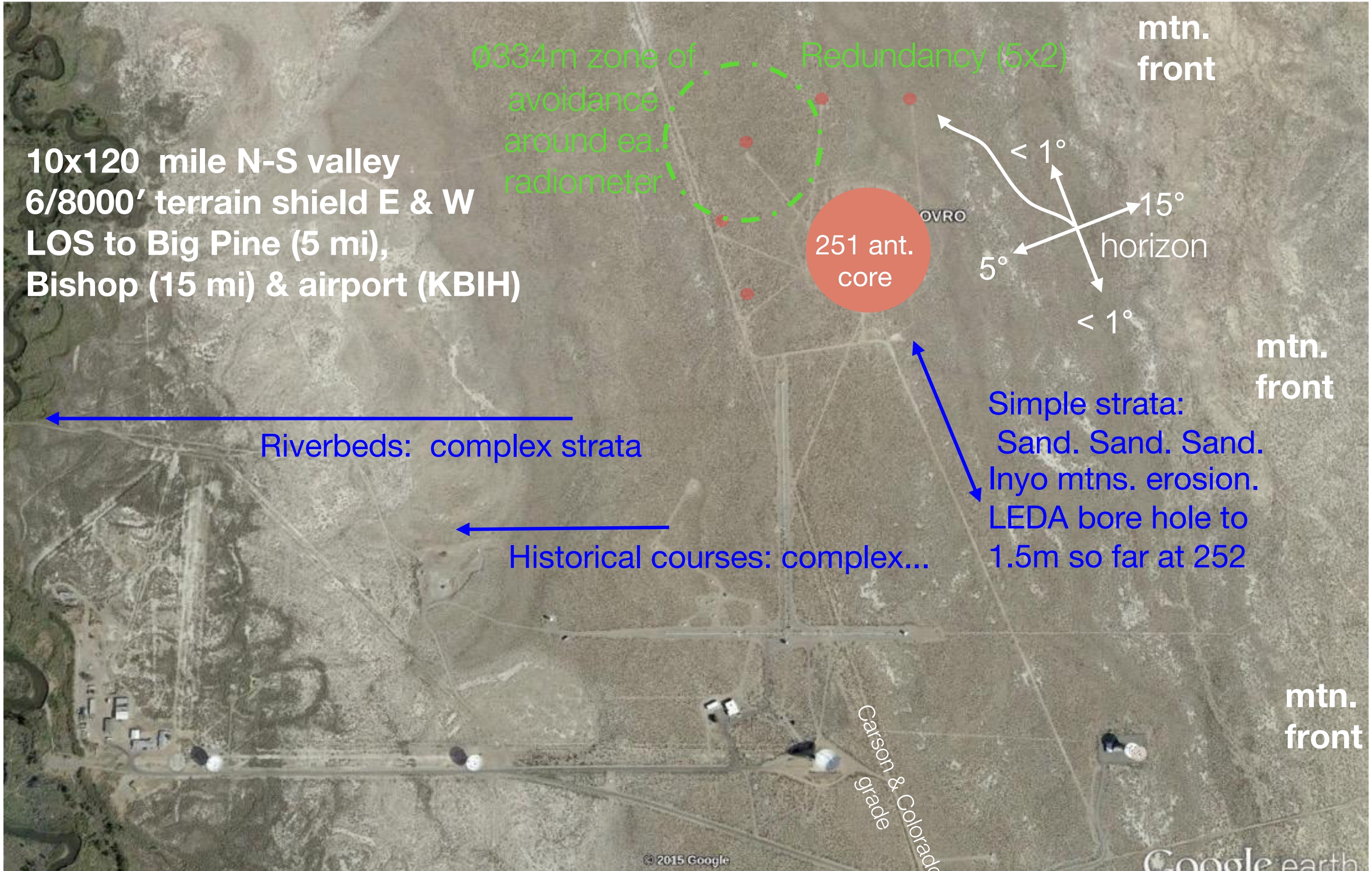
for/with/on behalf of L. Greenhill, A. Fialkov, H. Garsden, D. Price & M. Spinelli

“Always be the best version of yourself”

Patrizio Paoletti

“Many unexpected learning opportunities”

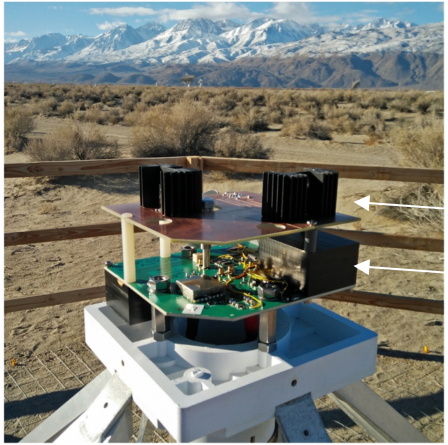
Boyan Slat



LEDA @ OV-LWA (LOL)

System overview: 2013-2016

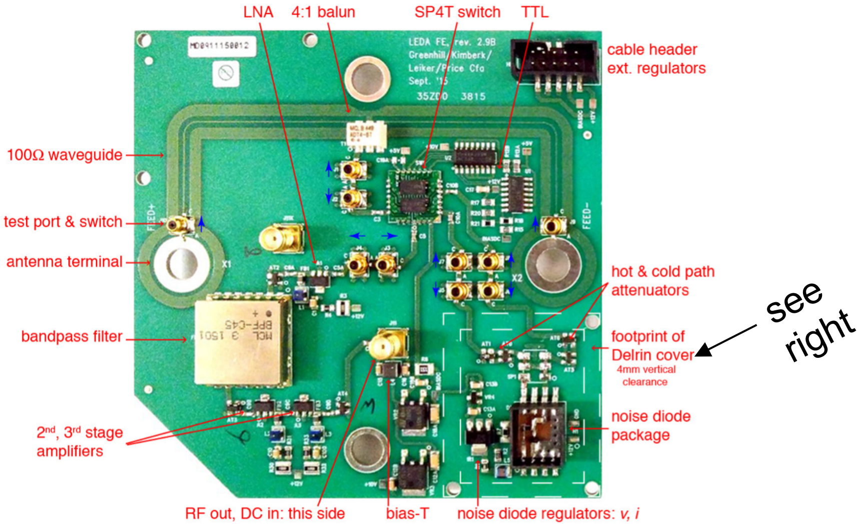
Wed to LWA mast antenna design: + /- ves



Short signal paths from antenna and w/in RX

regulators

noise source

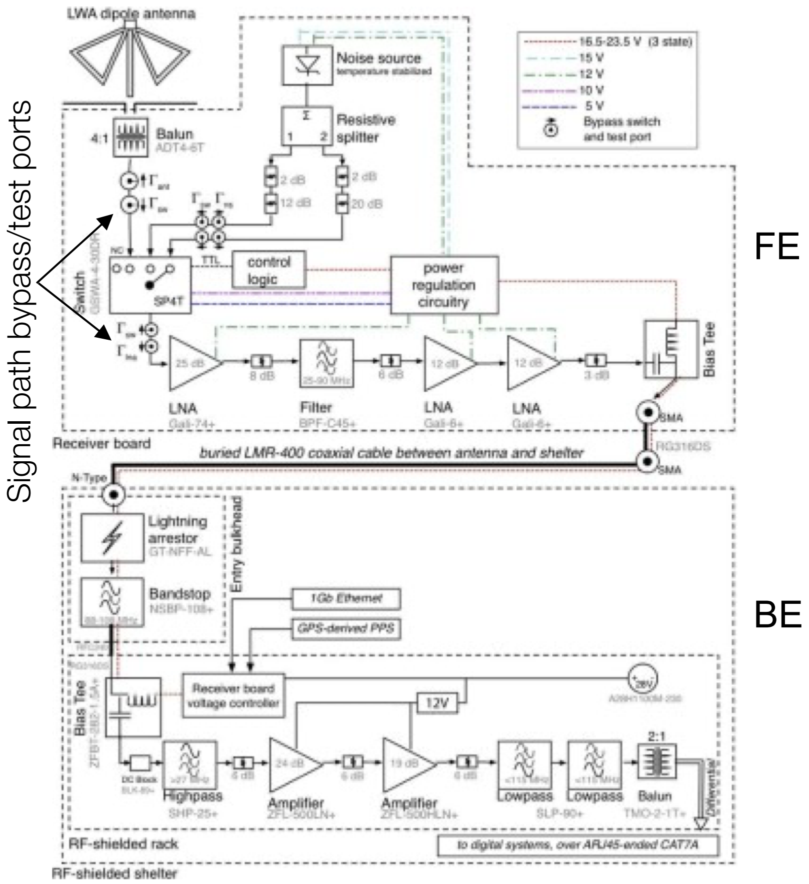


Flash fwd.: h/w improvements 2017+

- noise source stability & match
- signal path reflections
- bandpass filter roll-off & respective S_{11}
- ground screen, soil monitoring
- …

Price, Greenhill, Fialkov, GB et al. (2018), GB et al. (2016)

System overview: 2013-2016



Price et al. (2018)

- Calibration through a 3-position solid-state switch;
    - $T_{hot} \sim T_{sky}$(40 MHz)
    - $T_{cold} \sim T_{sky}$(80 MHz)
- Correction for reflection coefficients (measured on site);
- Receiver stability characterized in lab (σ^2_{Allan} after switching) ;
- Joint fit: foreground polynomial + 21cm signal

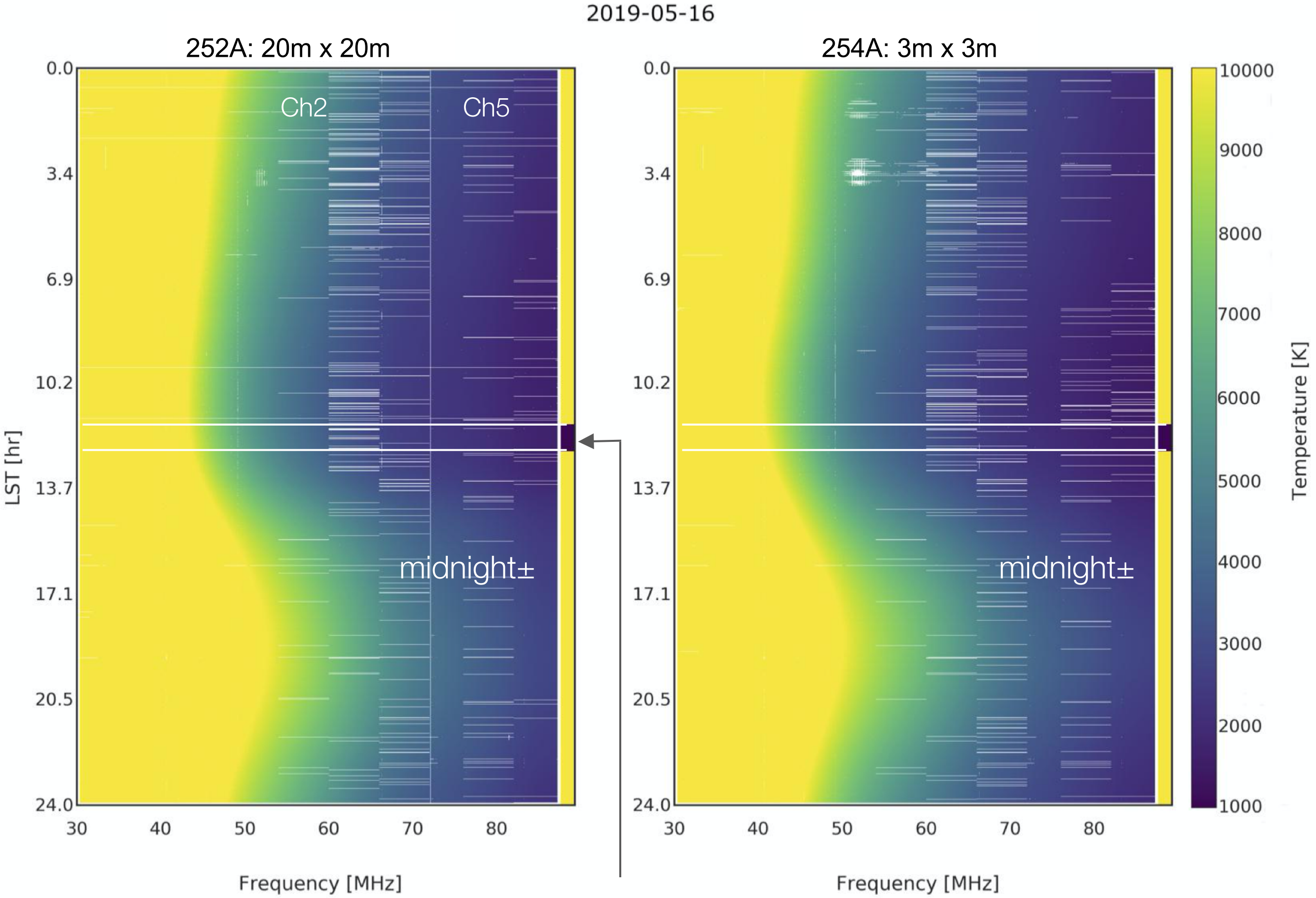
System upgrades: 2017 + ...

Driver	Time	Activity	
noise source regulation (*T, i, v*)	Q1CY17	Deploy RX v2.99a	Refine circuitry on RX PCB & heater contact w/ diode; mitigate RF reflections @ diode. Achieve 0.04% C^{-1} output (installed) w/r to $T_{ambient}$. Allan var. ↓ 10x.
receiver $T_{physical}$ not completely regulated			Grid of digital thermometers on RX PCB. Implement real-time monitoring.
est. systematics in calib.	Q4CY17-Q2CY18	field-calibration campaigns	Repetitive measurement of all calibration parameters, for all antennas, *in situ.* Quantify repeatability @ 0.03 dB
bandpass roll-off	Q2CY18		Restore 82-88.0 MHz performance (gain, Γ): new FM bandstop filter chain replaces 2013 scheme.
1% ripple post-cal high noise floor	Q1CY19	Δ ant.-ground interaction	20x20m serrated screen @ ant. 252; flatten area: ±½ " .
	Q3-4CY19	RFI excision	Add layer of RFI detection: Fourier filters, unbiased threshold clipping and tests for Gaussian statistics
	Q4CY19	Deploy RX v2.99b	Reduce "noise wave" magnitude > 82 MHz. Boost thermal isolation of solid-state noise switch, etc.

System upgrades: 2017 + ...

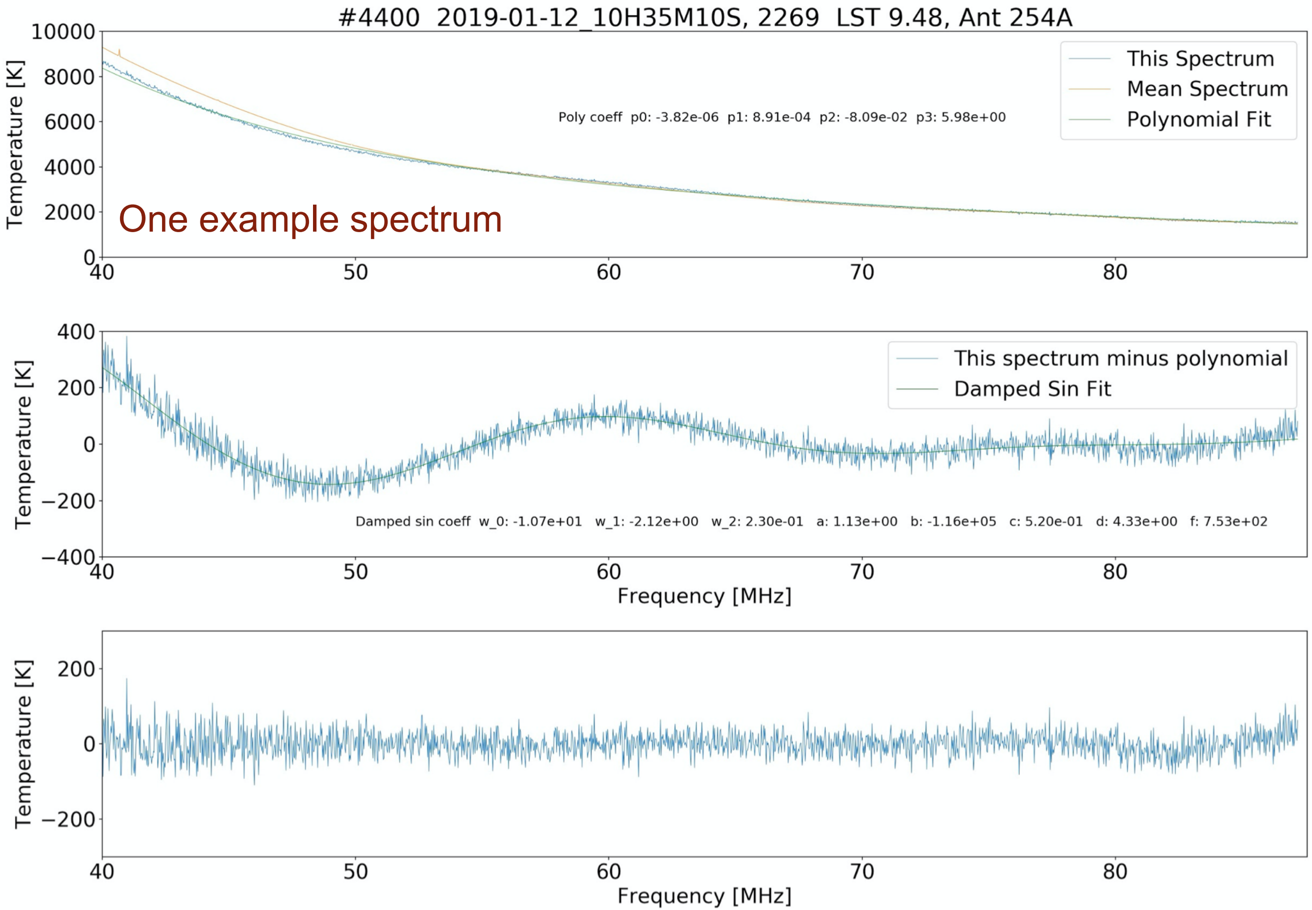
New ground screen is 200 m^2 (from 9 m^2), stiff and flat up to 0.013 m. It is made of 72 mesh panels, weighing 554 kg and required by-hand swaging along 523 meters of wire. We could not make it larger without substantive disruption of brush in an environmentally sensitive area.

2019 run: RFI

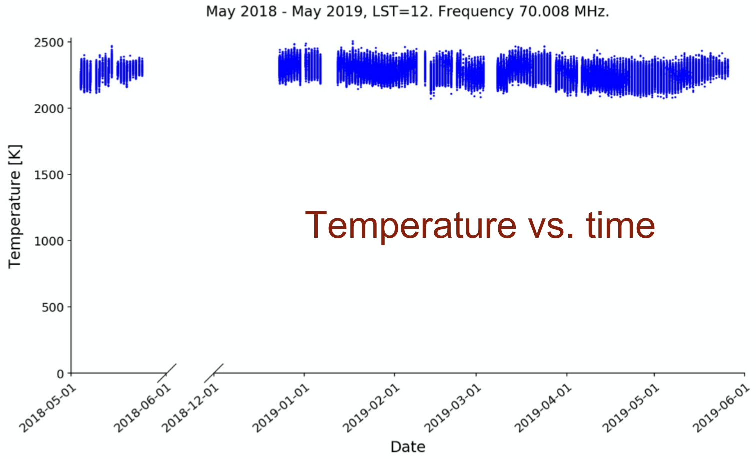


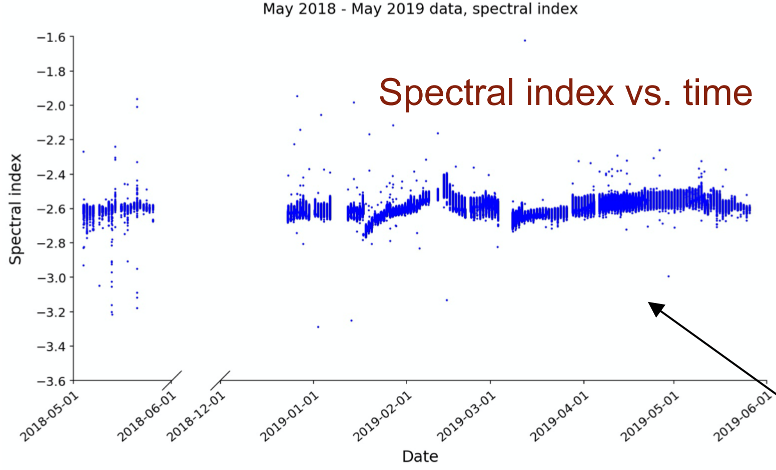
"Night": sunset + $1^h \rightarrow$ GC elv. = 0

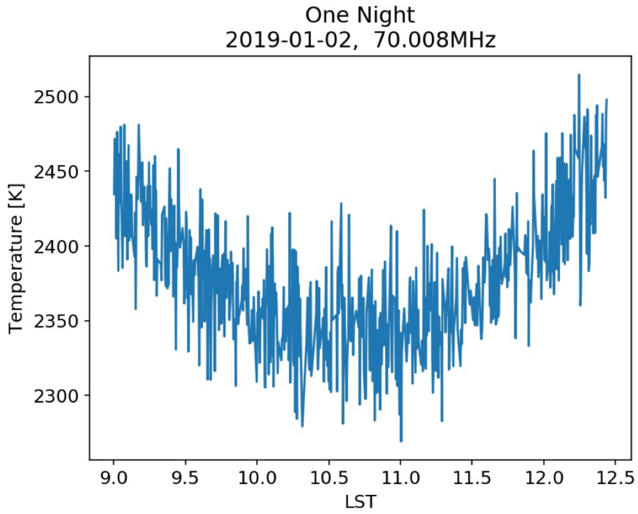
2019 run: systematic ripple



2019 run:stability tests







Temperature, one night

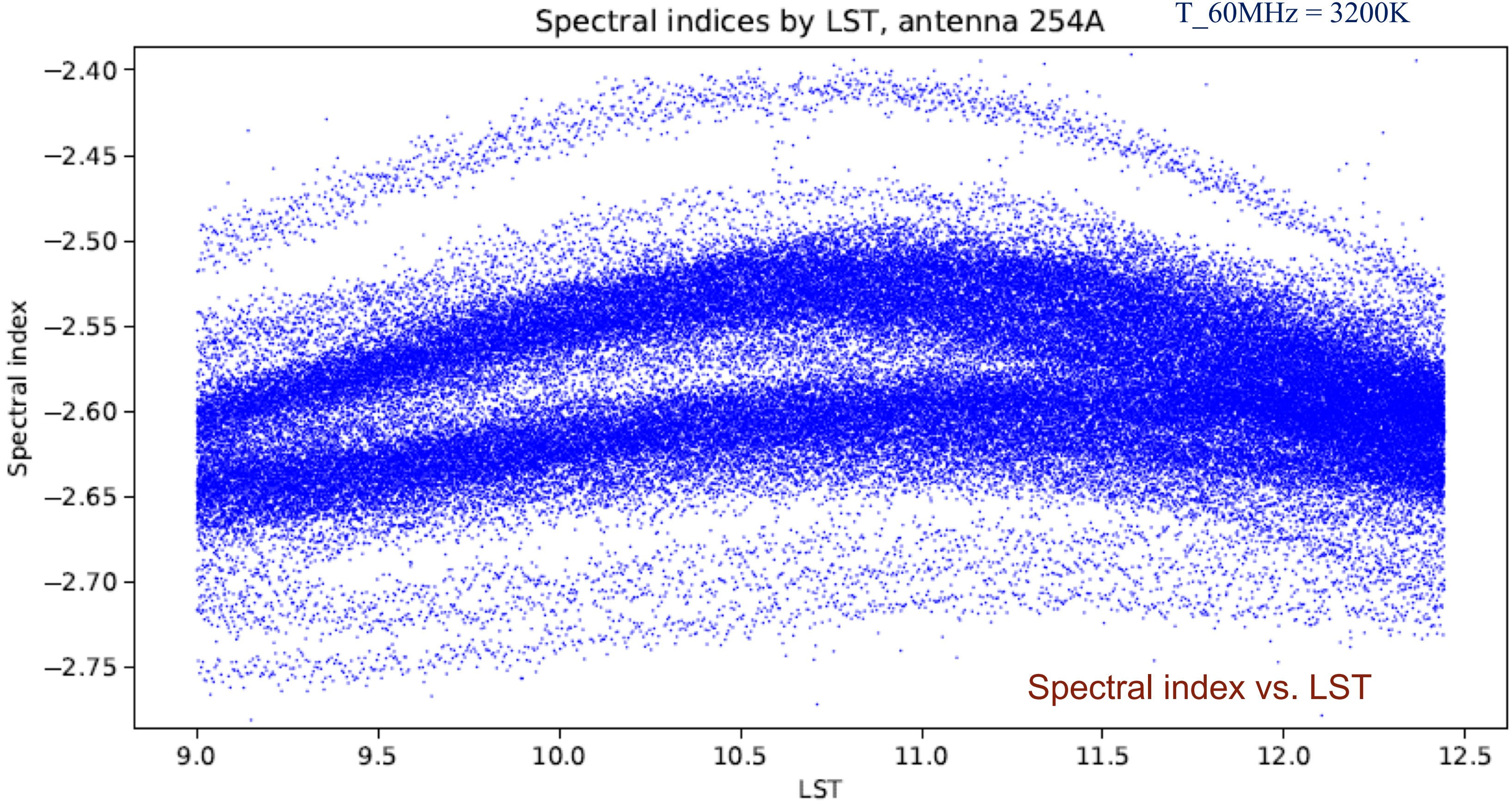
90428 spectra
T_rx = 420K
T_60MHz = 3200K

All antenna 254A

2019: heavy precipitation events penetrate the rain shadow surrounding OVRO. Large ground-loss variations→varying index.

2019 run

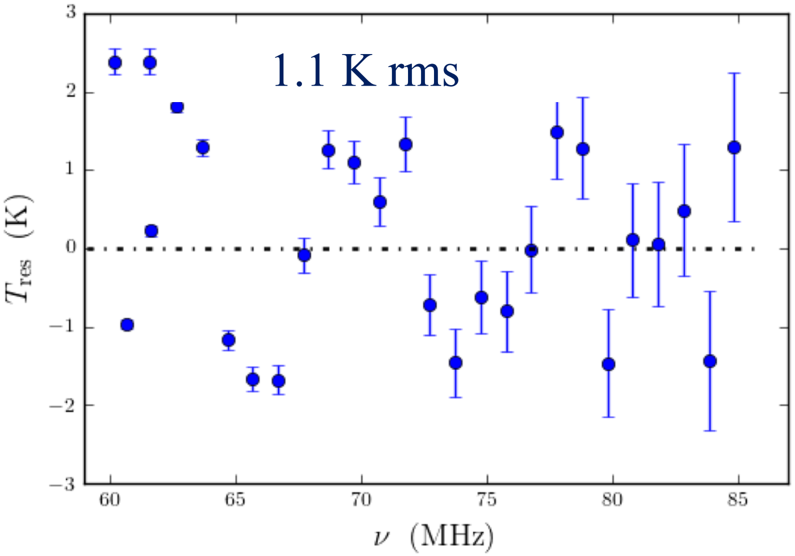
90428 spectra
T_rx = 420K
Reference frequency = 60MHz
T_60MHz = 3200K

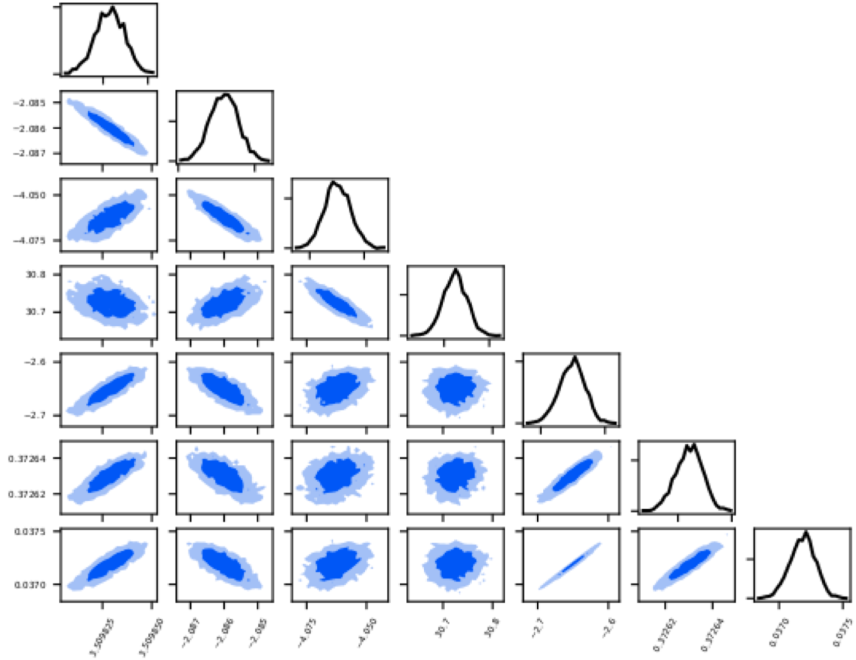


The moment of truth...

"Brute force" analysis

$$T_f(\nu) = 10^{\sum_{n=0}^{2} a_n \log\left(\frac{\nu}{\nu_0}\right)^n} + a_3 \cos(a_4 \nu) e^{a_5 \nu}$$





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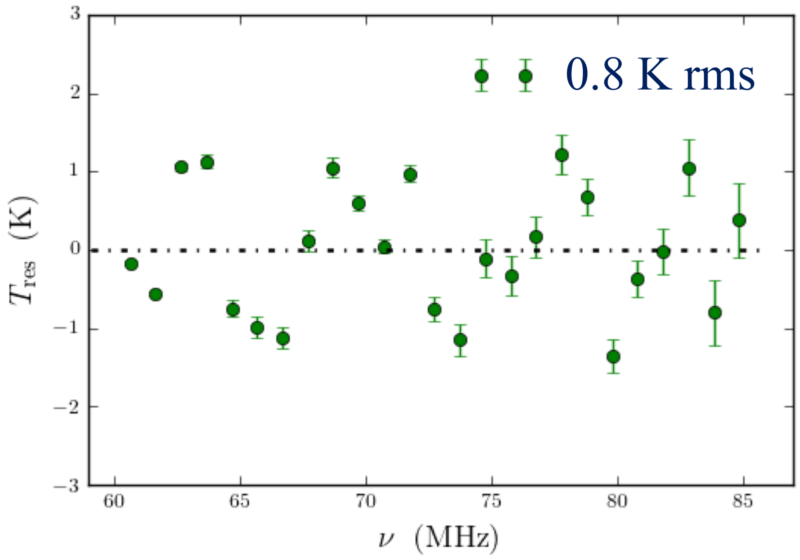
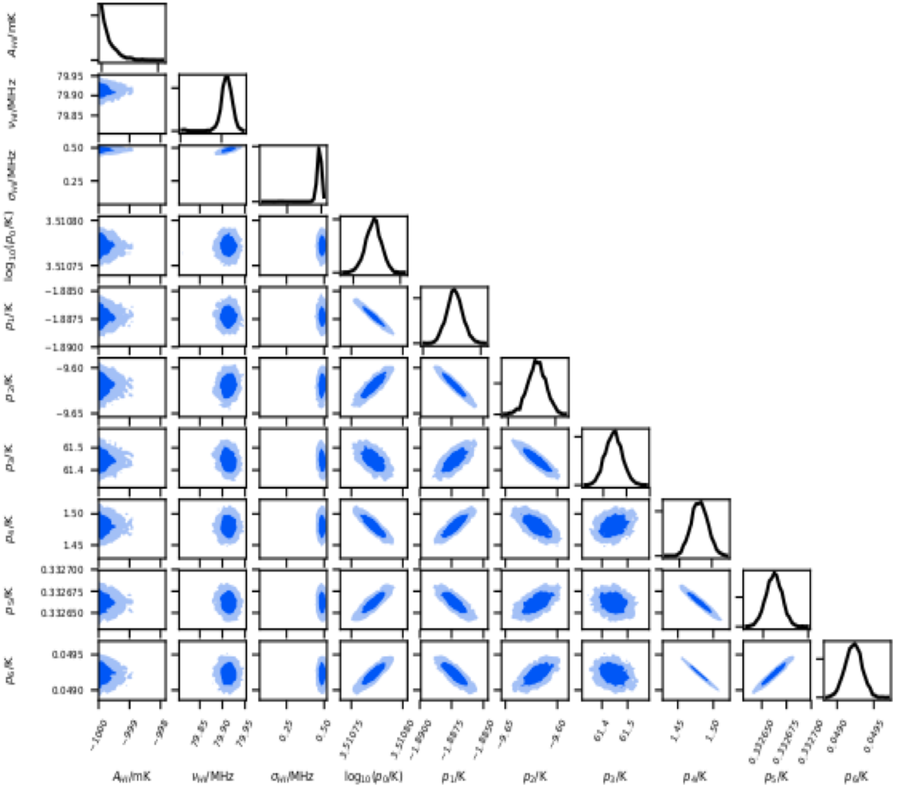




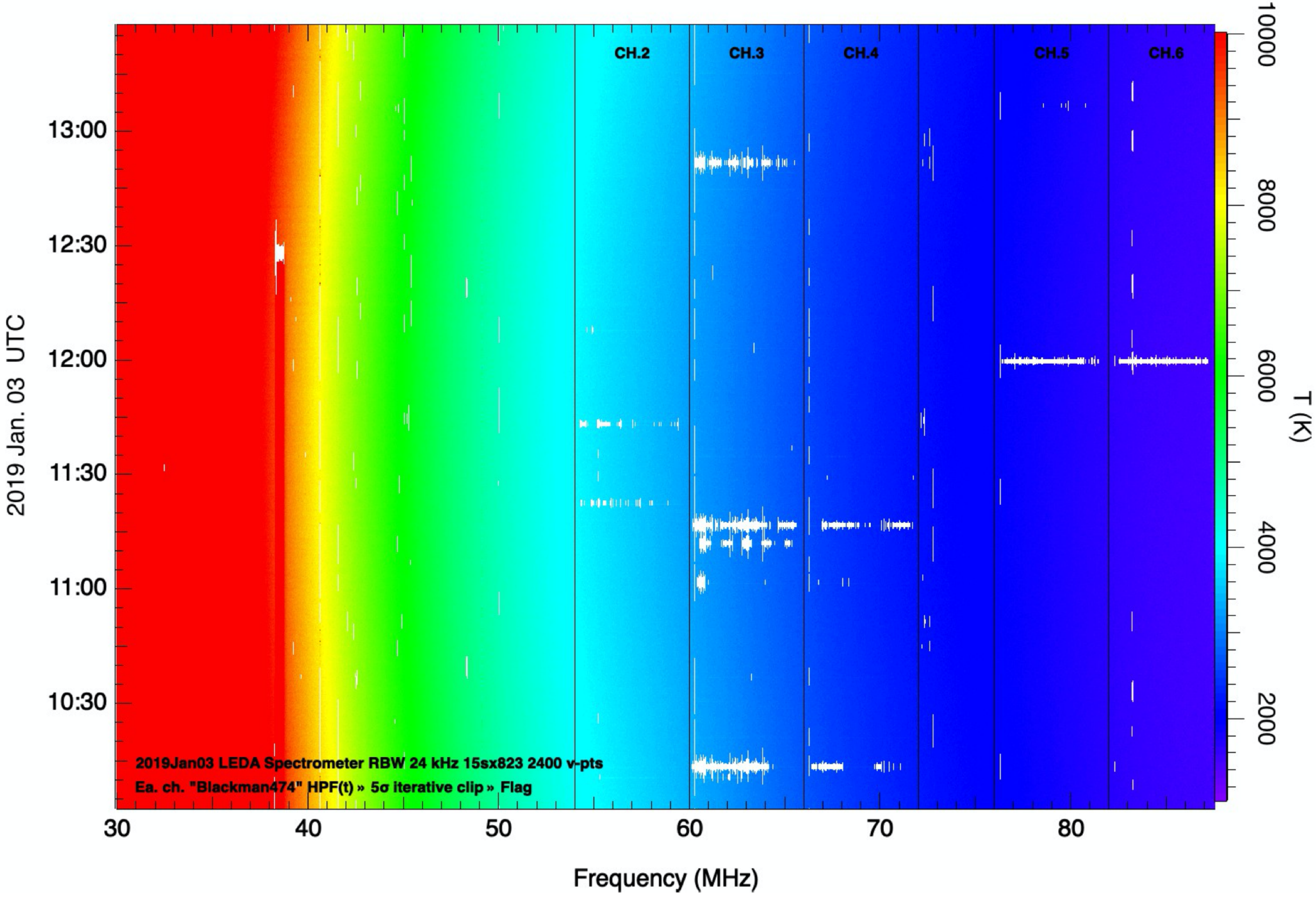
Further developments: archeology….

Artisanally dug & filled pit for real-time measurement of soil complex permittivity. Integration into E&M models.

Summer 2019 used to establish a consistent “dry baseline” for strata complex permittivity.

Data from Jan. to May 2019 damaged by highly variable soil moisture content, arriving before monitor was operational.

Further development: further flagging...



- Flagging algo. till now
  - AOFlagr-class
  - Nσ clipping
  - DTV (flag entirety)
    - pilot ?
    - guard-band dip?
- RFI “leaks” through (DTV)
- Add two tiers
  - Fourier filter time-series for each chan.
  - Nix secular trends
    - Iterative clipping at Nσ
    - Shapiro-Wilk test for “Gaussianity”
  - Clipping weak narrow ban

LEDA Conclusions and future outlook

1) Noise floor persists despite notable instrumentation & technique improvements
2) Final dataset from OVRO: Q4CY19 (3 mo.)
3) Notables coming together:
   - starting line – baked-dry ground strata→repeatability tests
   - coincidence testing of glitches: 3x3 vs. 20x20m; X vs. Y
   - modified screen | RX thermal management | reduced noise-wave > 82 MHz | FEKO model | refined RFI excision | AND HiBayes analysis.
4) Activity at quieter US site with fast ramp-up in planning

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THANK YOU