The Jicamarca Radio Observatory: Instrumentation, Experiments, and Database

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Jicamarca Radio Observatory - Introduction

- A research facility dedicated to study and monitor the Equatorial ionosphere and upper atmosphere.
- It is located at ~20 km east of Lima, Peru. (11.95°S, 76.87°W).
- Operates a variety of instruments: radars, ionosondes, magnetometers, GPS receivers, Fabry Perot interferometers, etc.

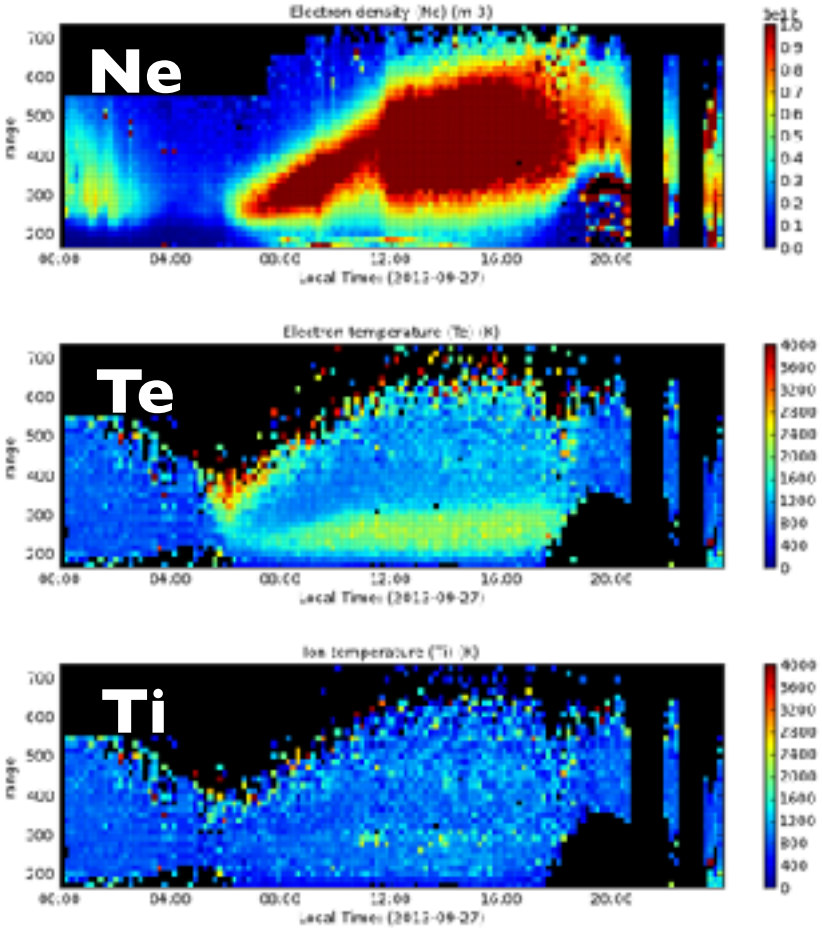
Its main instrument is one of the largest incoherent scatter radars in the World.

Outline

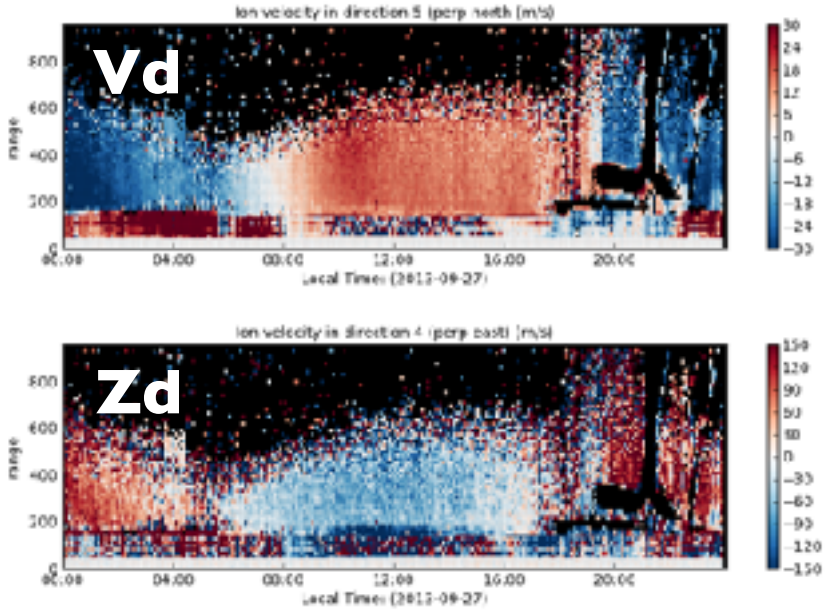
- Status of standard radar modes
- New modes of radar observation
- Cluster of instruments

Status of standard radar modes

Combo mode for simultaneous measurements of Ne, Te, Ti, Vd, and Zd



Simultaneous measurements of F-region densities, temperatures and drifts are conducted routinely at Jicamarca applying a multi-beam radar technique that interleaves perpendicular-to-B and off-perpendicular observations.



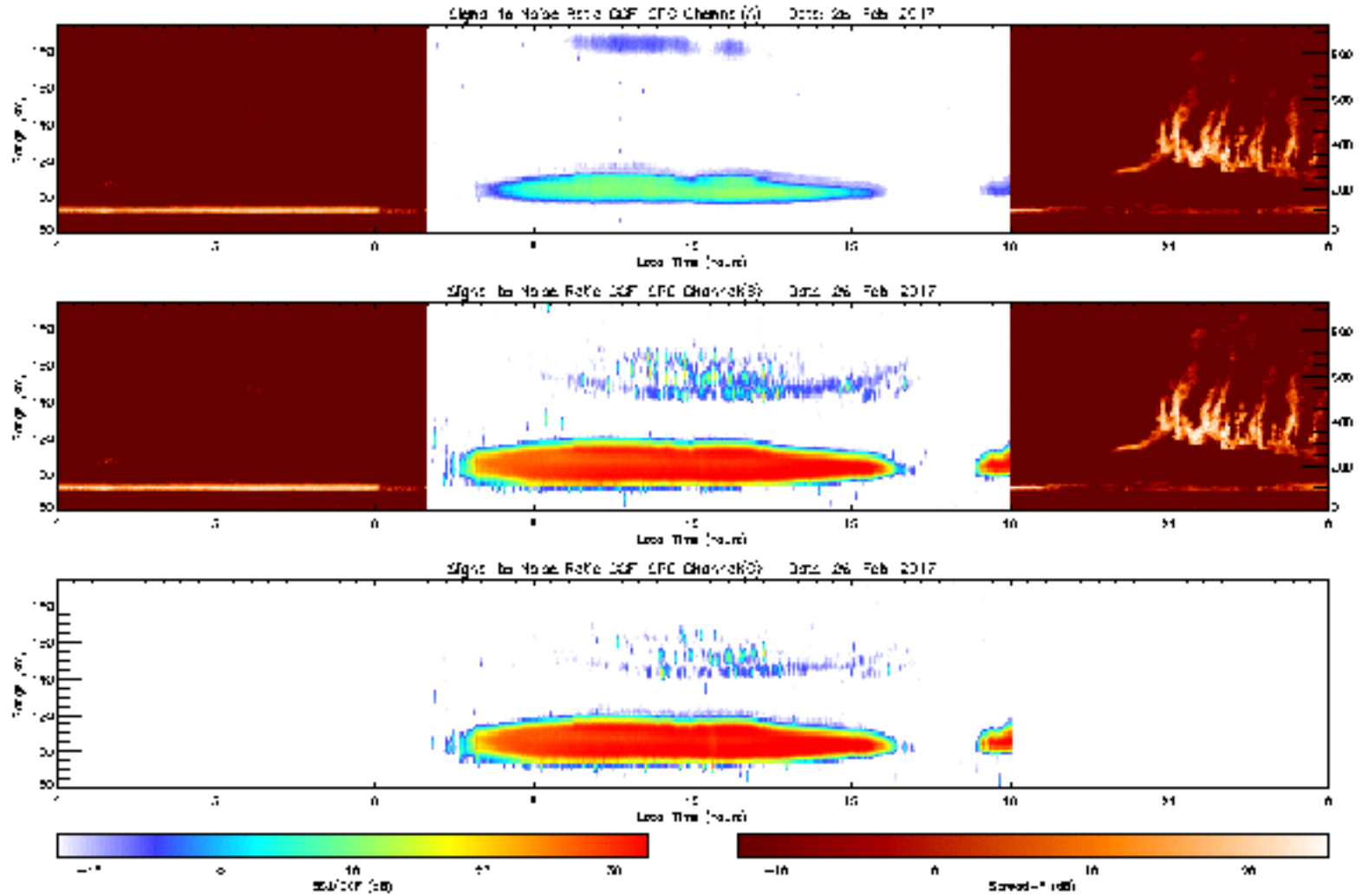
This mode is used in most of the ISR coordinated campaigns since 2011.

Statistics of Combo mode in Madrigal

	2011	2012	2013	2014	2015	2016	2017
EW-Drift (Vx, Vz)	29	35	36	49	43	32	19
Faraday (Ne, Te, Ti)	29	22	15	45	33	0	19
Combo mode	23	22	10	45	28	0	19

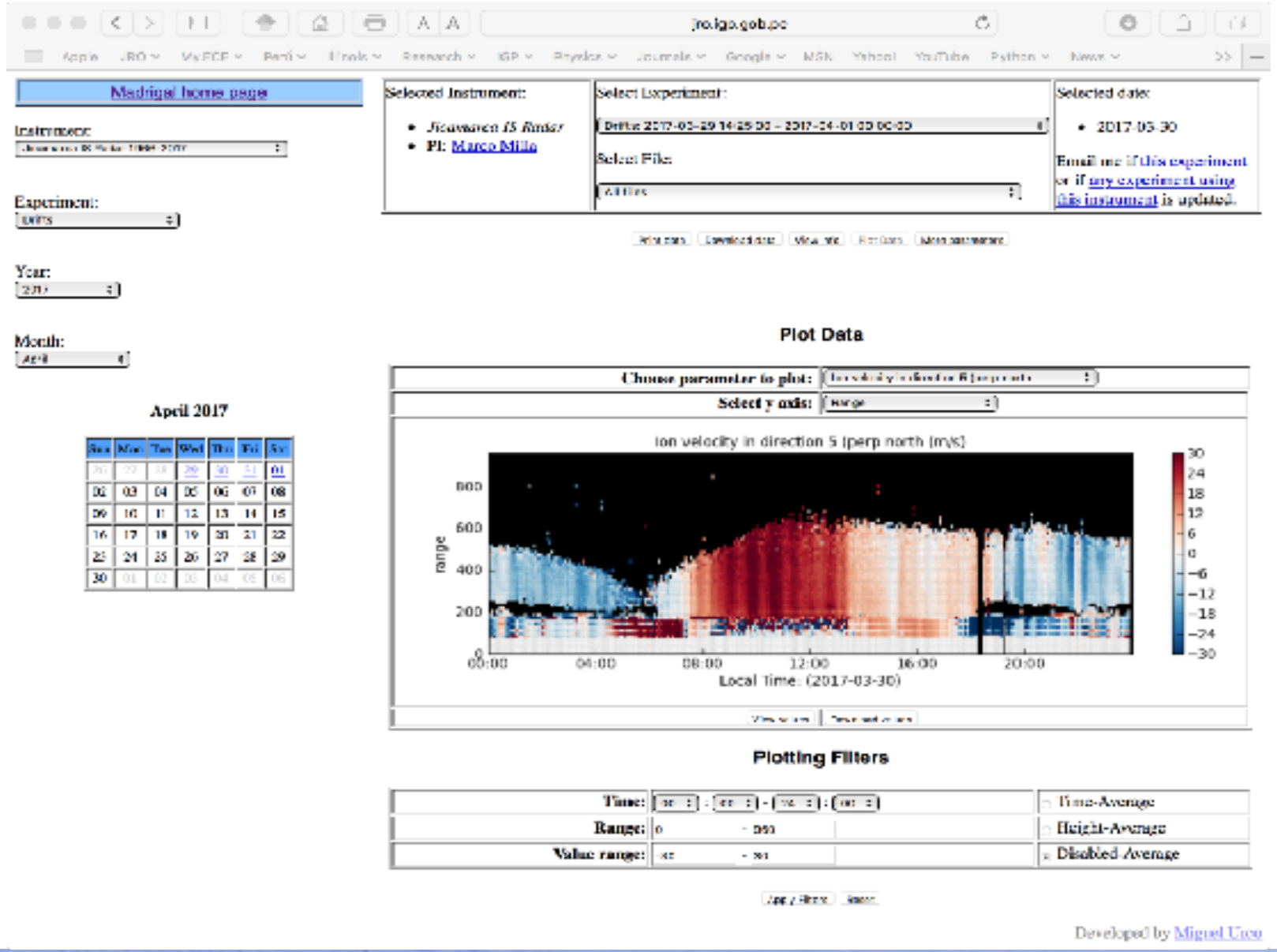
Number of days per year in which the radar has operated in the EW-Drift & Faraday modes. More than 147 days since 2011.

JULIA mode: EEJ + 150km + Spread-F



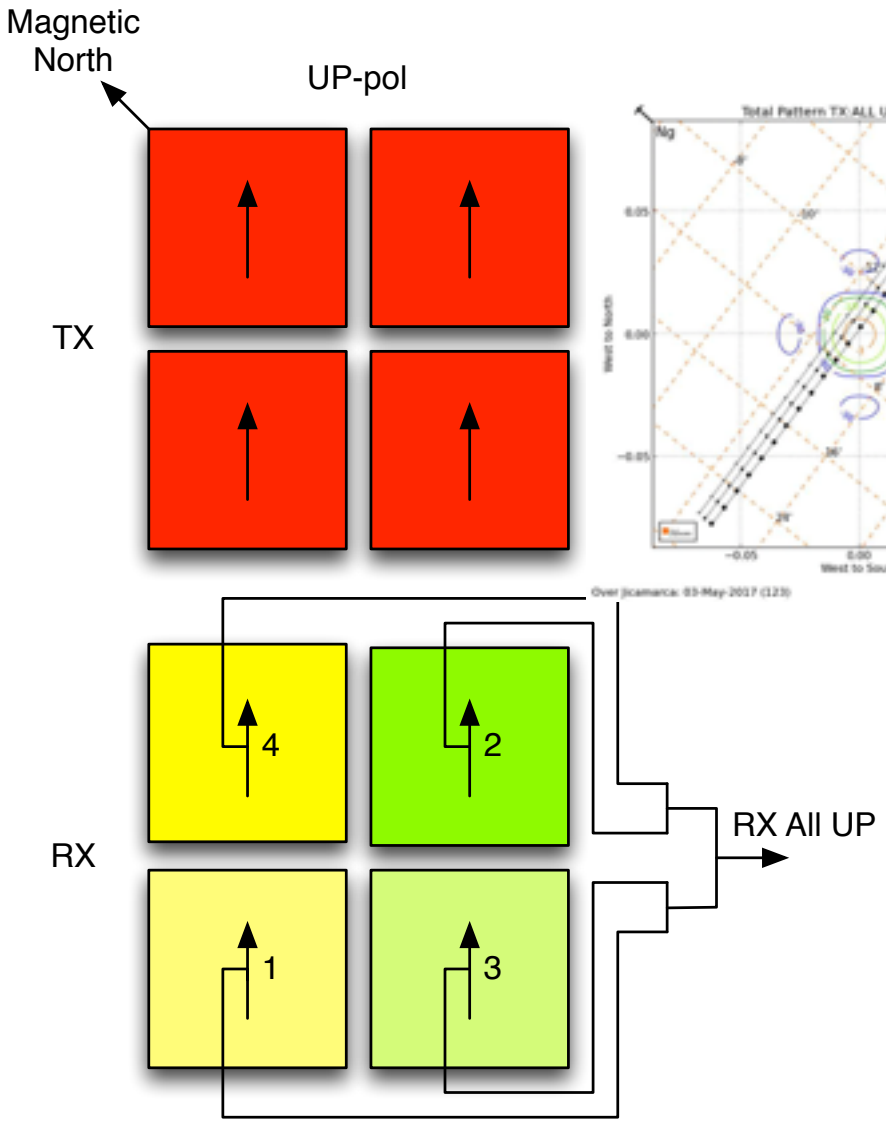
More than 4000 hours per year of plasma irregularities observations: EEJ, 150km echoes and Spread-F. Data available in Madrigal.

Data available at http://jro.igp.gob.pe/madrigal



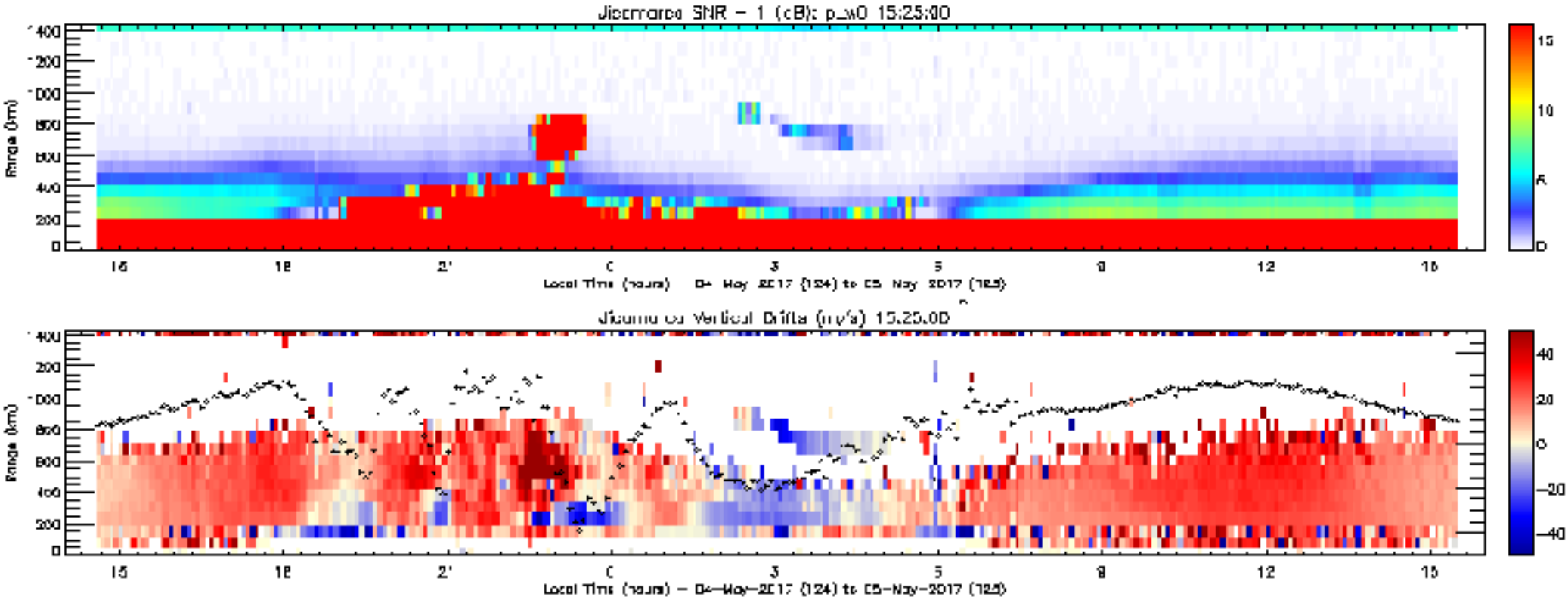
New modes of radar observation

Medium power ISR mode for drifts



- Goal: To implement a mode to measure plasma drifts without using the high-power transmitters for routine operation (JULIA).
- Antenna position - On Axis (Perpendicular to B)
- TX parameters
  - Full antenna (UP polarization)
  - IPP: 1500 km
  - PW: 75 km (no code)
  - 120 KW peak power (2 drivers)
- RX parameters
  - Full antenna and quarters (UP)

Medium power ISR mode for drifts - Results

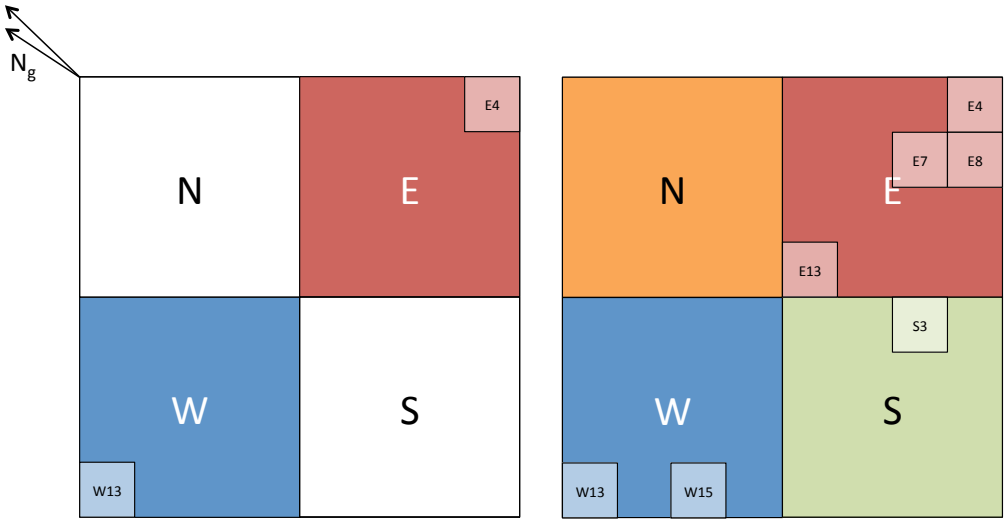


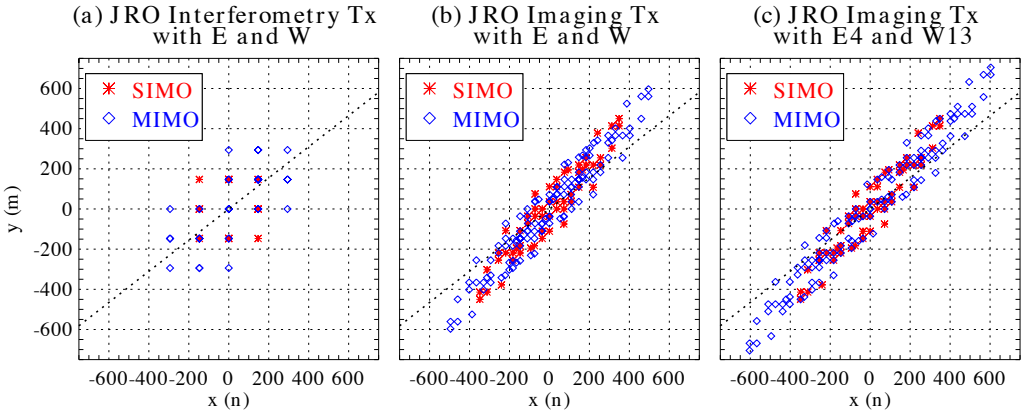
Tests were conducted in May 2017.

Good quality of vertical drifts (altitude coverage: above 600 km).

Note: A100kW solid-state TX is needed to implement an unattended mode (the new JULIA).

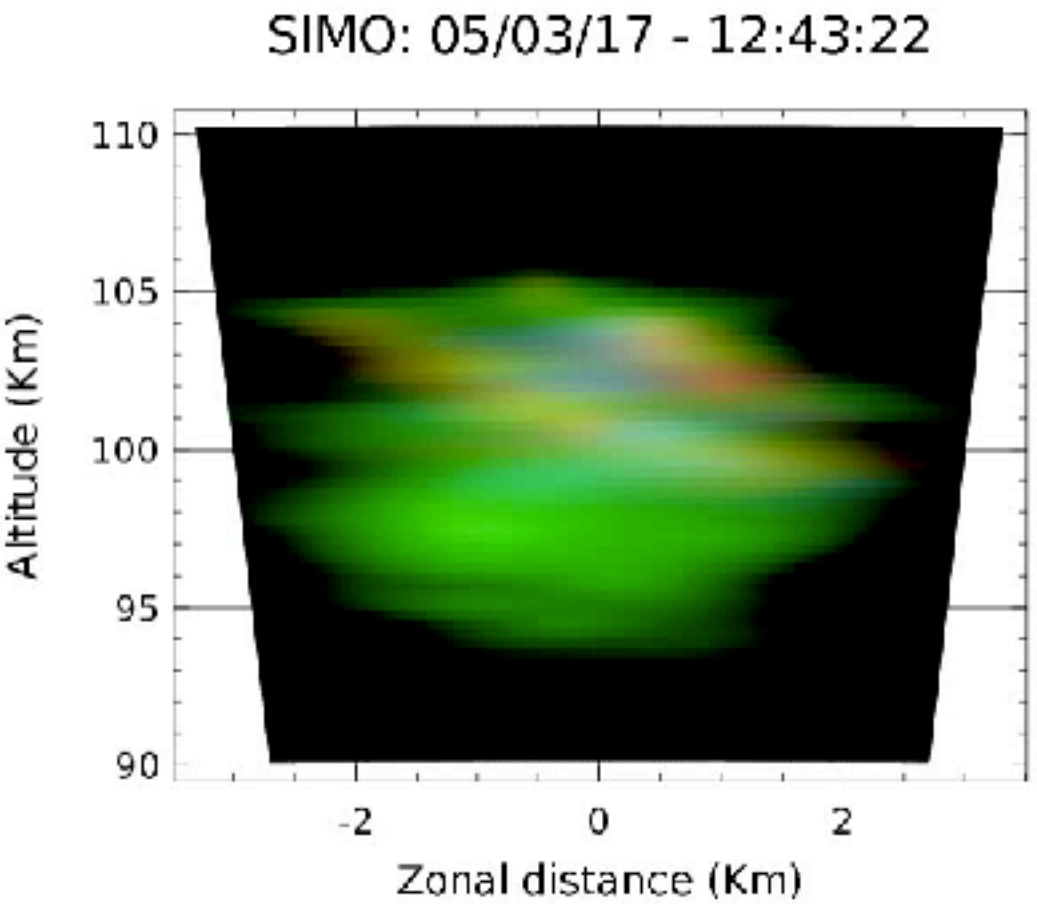
MIMO radar imaging technique

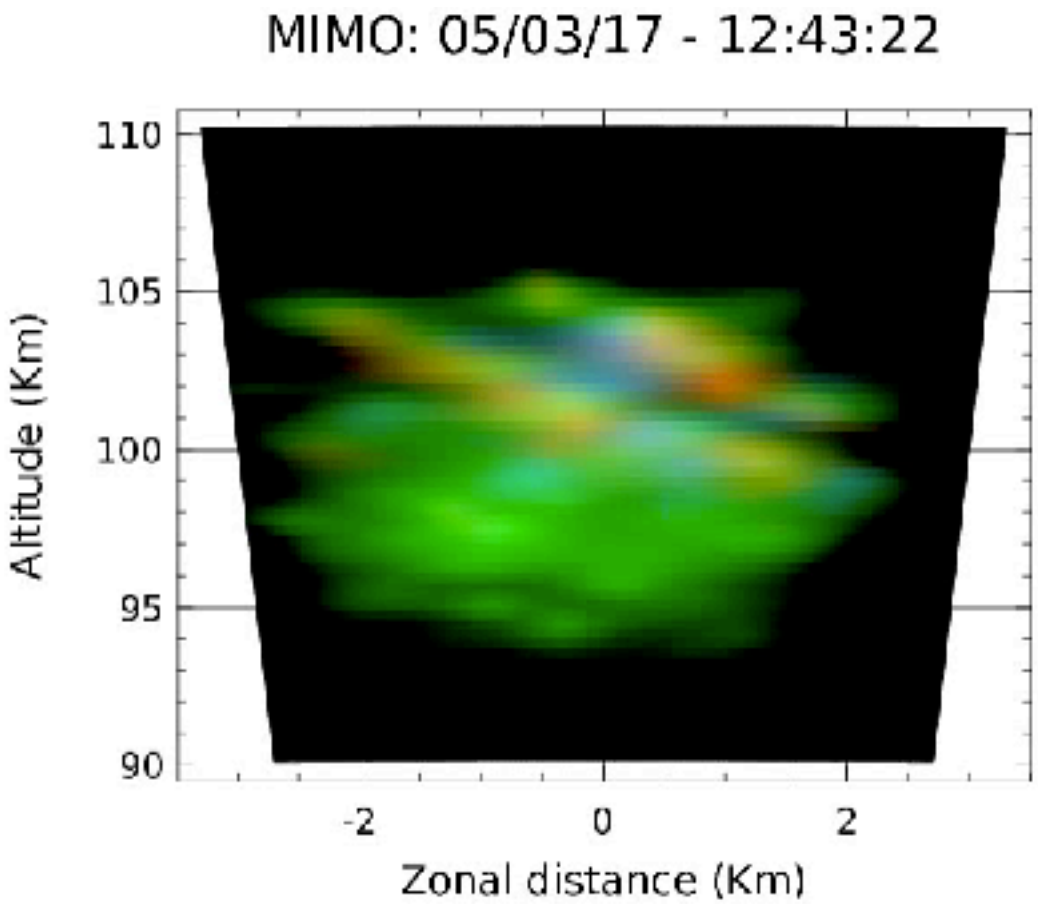




- Idea: To apply spatial-diversity in transmission and reception in order to improve the quality of the radar images.
- Two different quarters were configured in TX.
- More and longer baselines can be implemented using MIMO rather than SIMO.
- Time, Polarization and Code diversity were tested.
- Pulses were transmitted in parallel using orthogonal codes to isolate radar responses.

MIMO radar imaging technique - Results





Tests were also conducted in May 2017. MIMO images provide higher quality images (sharper features and details can be observed).

Cluster of instruments for ionospheric and upper-atmospheric observations

Cluster of Instruments for Equatorial and Low-latitude Observations (CIELO)

- LISN (C. Valladares, UTDallas)
- Magnetometers (IGP, MAGDAS)
- Digisonde (B. Reinish, U. Mass. Lowell)
- VIPIR (E. Kudeki, J. Makela, Illinois)
- Beacon RXs (P. Bernhardt, NRL, Tsunoda, SRI)
- GNSS RXs (J. Morton, MU)
- CIRI Huancayo (J. Urbina, PSU)
- AMISR14 (J. Arratia, UMET)
- FPI chain (A. Gerrard, NJIT, Clemson)
- Airglow camera (C. Martinis, BU, G. Swenson,, Illinois)
- Multi-static HF radar (D. Hysell, Cornell)
- TIDDBIT (G. Crowley, ASTRA)

JRO & Cluster of instruments

Instrument	Parameter	Region	Time Coverage	Annual Coverage	Regional Coverage
ISR	Ne, Te, Ti, Vz, Vx, %	Ionosphere	24h	1000 hours	JRO
MST	U,V,W	Troposphere, Stratosphere, Mesosphere	24h (T,S) Daytime (M)	> 10 days	JRO
JULIA	Irregularity intensity, Vz, Vx	Ionosphere	24h	4000 hours	JRO
JULIA-150	Vz	Ionosphere	Daytime	150 days	JRO
FPI (AQP, SOFDI, MRH)	U,V, Tn	Bottom *F* region	Nighttime Daytime (SOFDI)	> 100 days	Peru
Magnetometers (JRO, LISN)	Vz	Ionosphere	Daytime	365 days	Peru
LISN GPS	TEC, scintillations	Ionosphere	24h	365 days	South America
Ionosondes (JRO, LISN)	Ne	Ionosphere	24h	365 days	Peru
JASMET-Meteors	U, V	Mesosphere	24h	Campaigns	JRO, HYO (*)

Note: Results are available in Madrigal, LISN, and other databases.

LISN database at http://lisn.igp.gob.pe

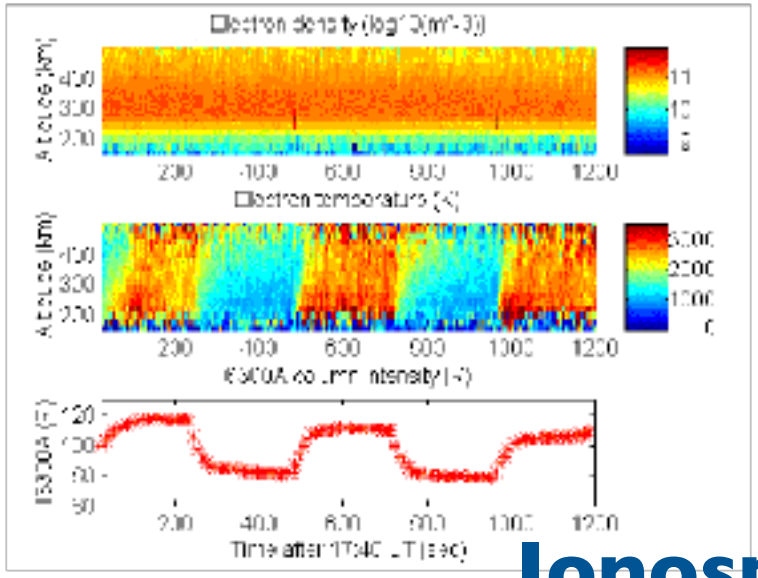
Conclusion:

The Jicamarca radio observatory operates and maintains a variety of instruments for ionospheric and upper-atmospheric observations. The incoherent scatter radar at Jicamarca is a robust and flexible system that facilitates the implementation of new modes of radar observation. Most of the measurements conducted at Jicamarca can be found available in Madrigal and other databases of public access.


Thanks for your attention!

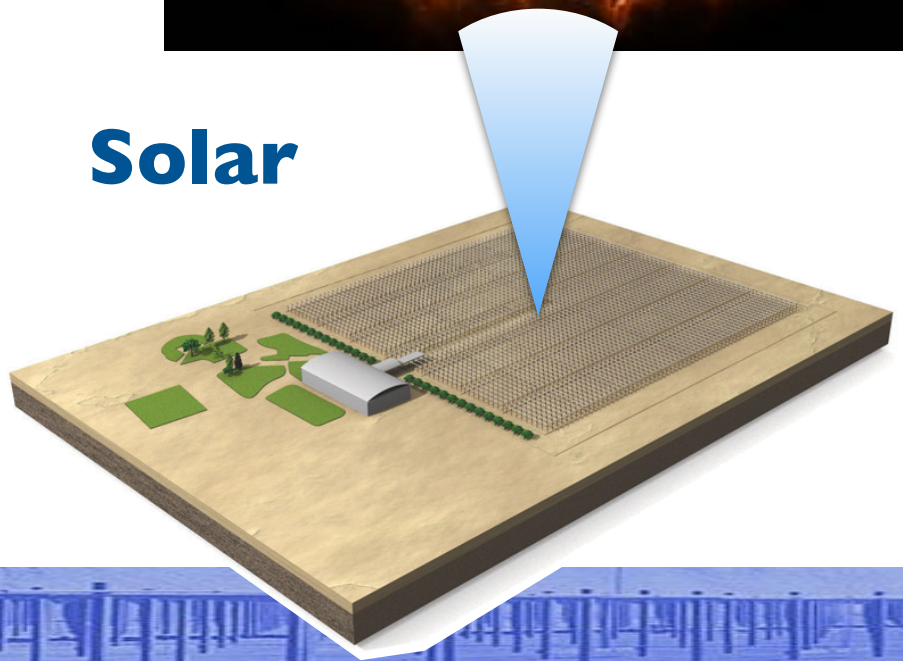
Ideas for the future:
More new experiments and upgrades

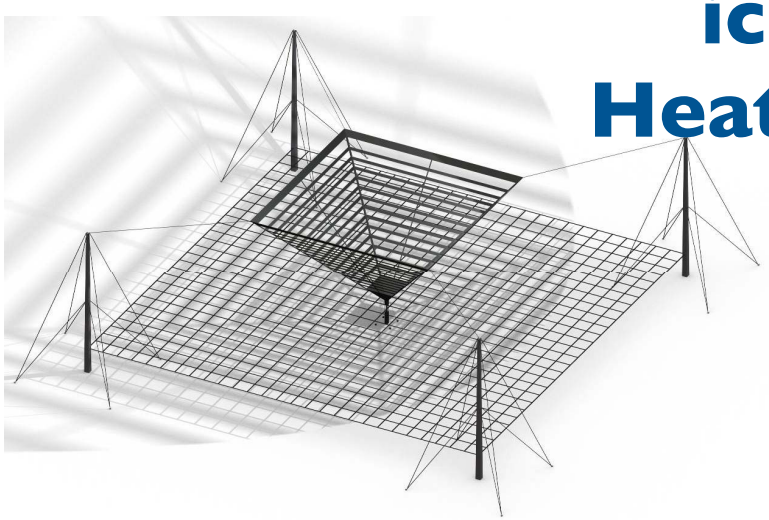
Ideas for new experiments at Jicamarca



Ionospheric Heater

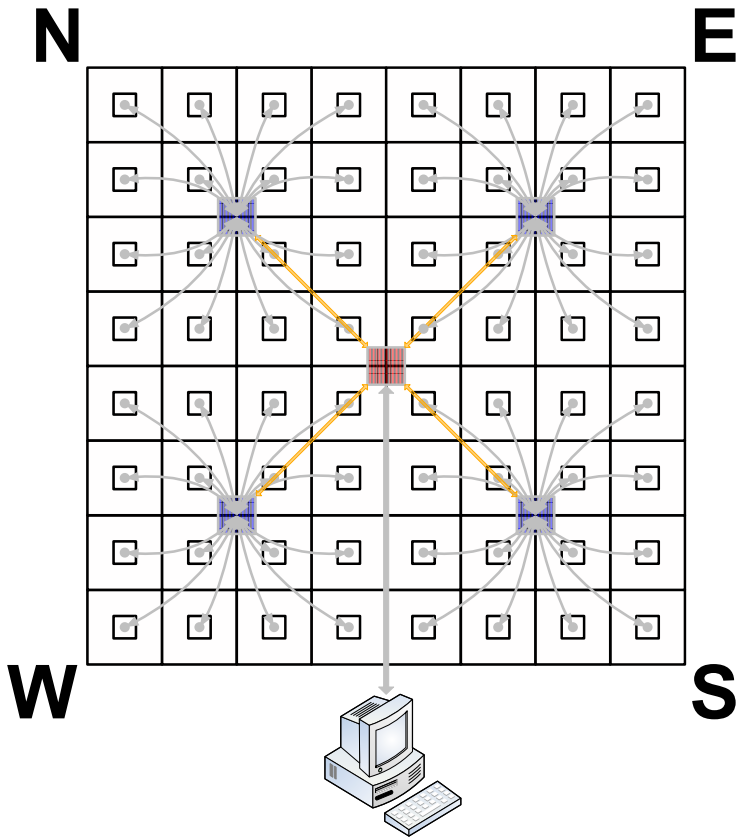
Solar





Short-term upgrades

- Complete the electronic beam steering system.
- Replace the antenna ground plane.



- Put fully operational the four high-power transmitters.
- Minimize cross-talk and local interference in the reception lines.

What is needed in the long-term?

A completely rebuilt antenna array

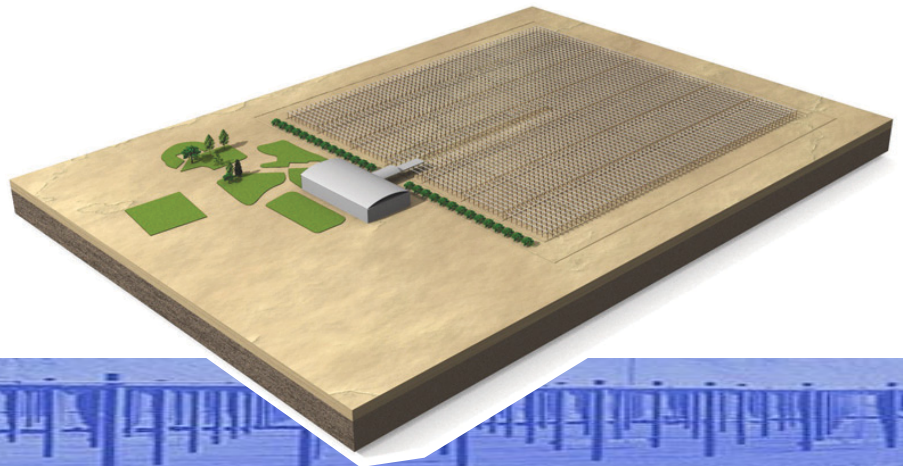
Some considerations for the new array

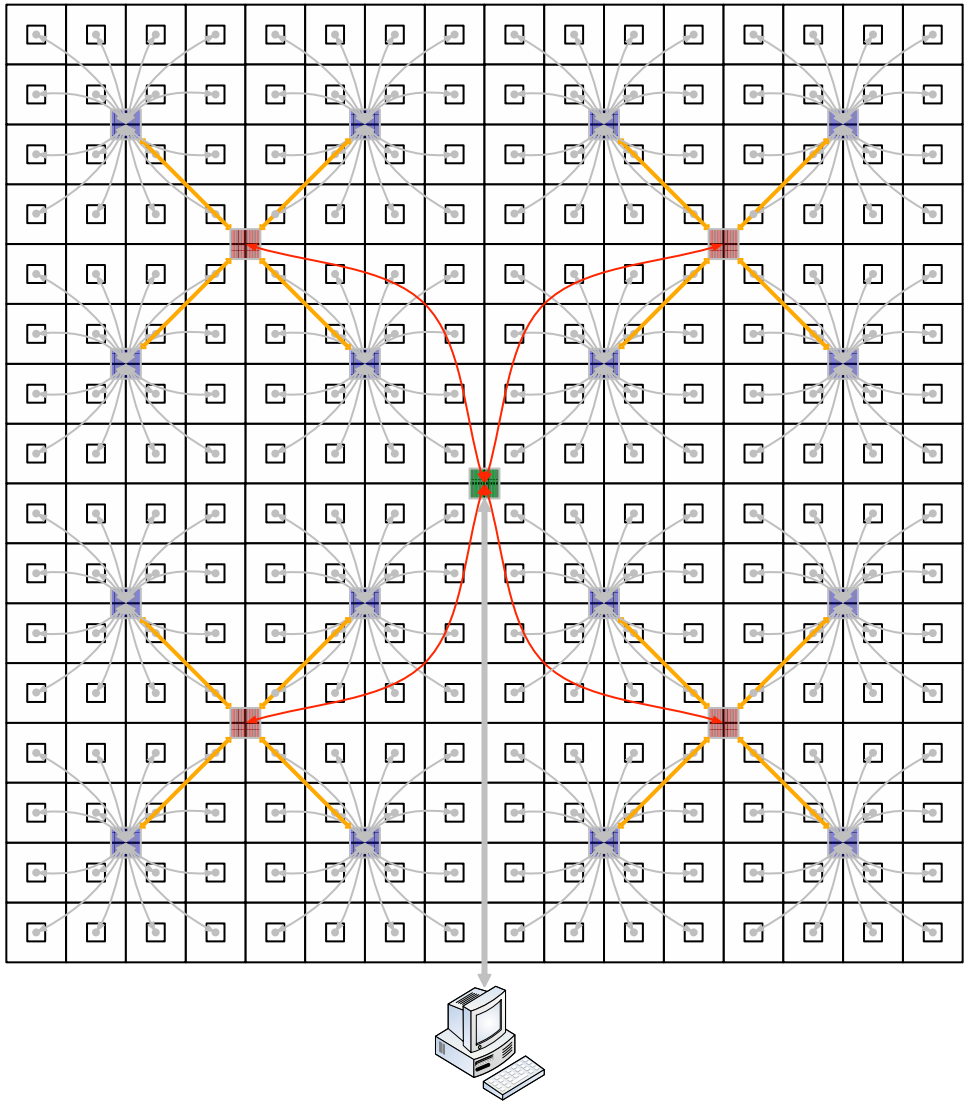
- To keep pointing perp-to-B, we need to increase angular coverage from +/-3 deg to +/-10 deg.
- To improve the quality of estimated physical parameters or to increase altitude coverage, we need to deliver more power and use narrower beams.
- To track the Sun or any other object, we need to change the beam position from pulse to pulse.
- To improve our observational capabilities, we need to transmit different waveforms and antenna patterns.

Antenna upgrades I

To increase angular coverage and be able to keep pointing perp-to-B,

- We need to increase the number of antenna modules from 64 to at least 256.
- We also need to reduce the size of an antenna module from 12x12 elements to 8x8 or even better to 6x6 elements.





Antenna upgrades 2

To improve the quality of our drift estimates, or to increase altitude coverage.

- A larger antenna array (from 300x300m2 to 400x400m2)

To track the sun or any other object.

- A new ABS system that changes beam position from pulse to pulse.

To transmit different waveforms and antenna patterns.

- A distributed power transmission system (i.e., one solid state 20 KW TX per module per polarization).
- Digital receivers in each antenna module.