Equatorial Ionospheric Irregularities and Meteor Studies using Jicamarca

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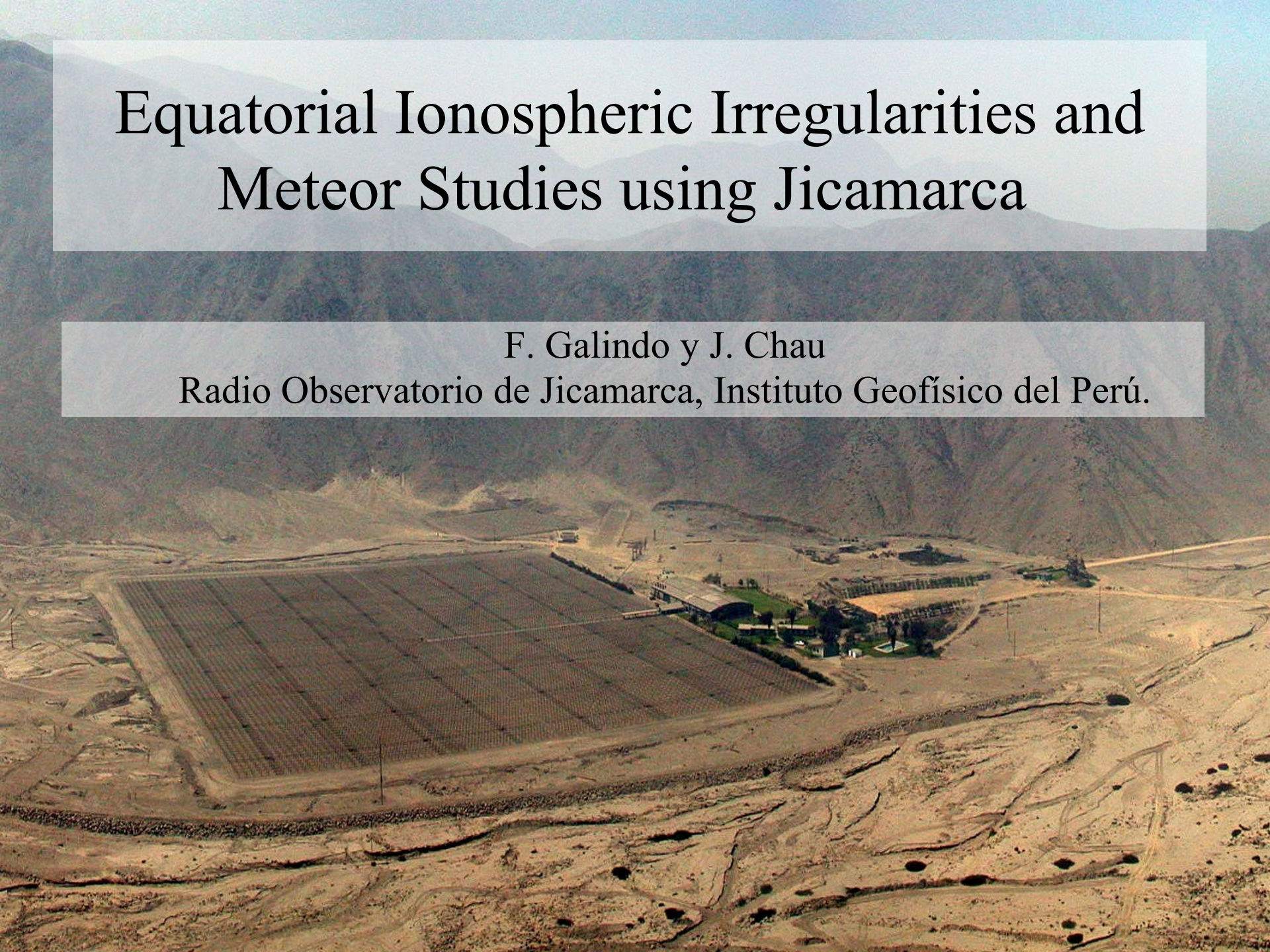

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Jicamarca Radio Observatory

View of Jicamarca

The Observatory was built in **1960-61** by the Central Radio Propagation Laboratory (CRPL) of the National Bureau of Standards (NBS).

Jicamarca Radio Observatory (JRO) is a Incoherent Scatter Radar located ~20km (East) from Lima (Latitude 11.95° South, longitude 76.87° West)

In **1969 JRO was donated to the Instituto Geofísico del Perú (IGP)**. Since then all technical and engineering aspects are in peruvian hands but with international cooperation.

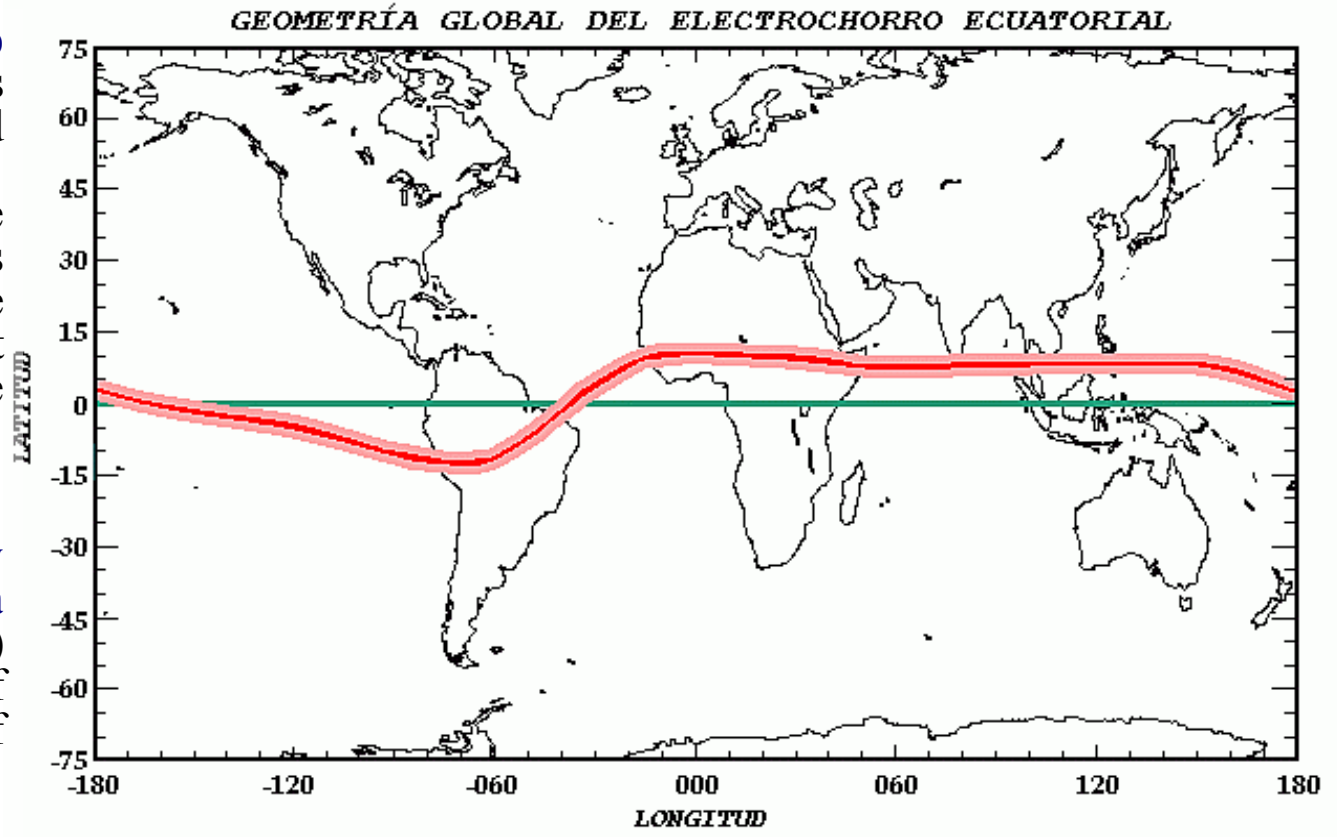
Nowadays, JRO belongs to a chain of incoherent scatter radar (ISR) observatories extending from Lima, Peru to Søndre Strømfjord, Greenland.

Jicamarca Radio Observatory

Radio Observatorio de JICAMARCA Radio Observatory

The magnetic dip angle is about 1°, and varies slightly with altitude and year. The radar can determine accurately the direction of the Earth's magnetic field and can be pointed perpendicular to B at altitudes throughout the ionosphere.

The **phenomena only observed at Jicamarca latitude** (e.g. 150km echoes) shows the importance of Jicamarca in the studies of the Space Weather.



The line in red show the Magnetic Equator geometry.

Antenna Characteristics

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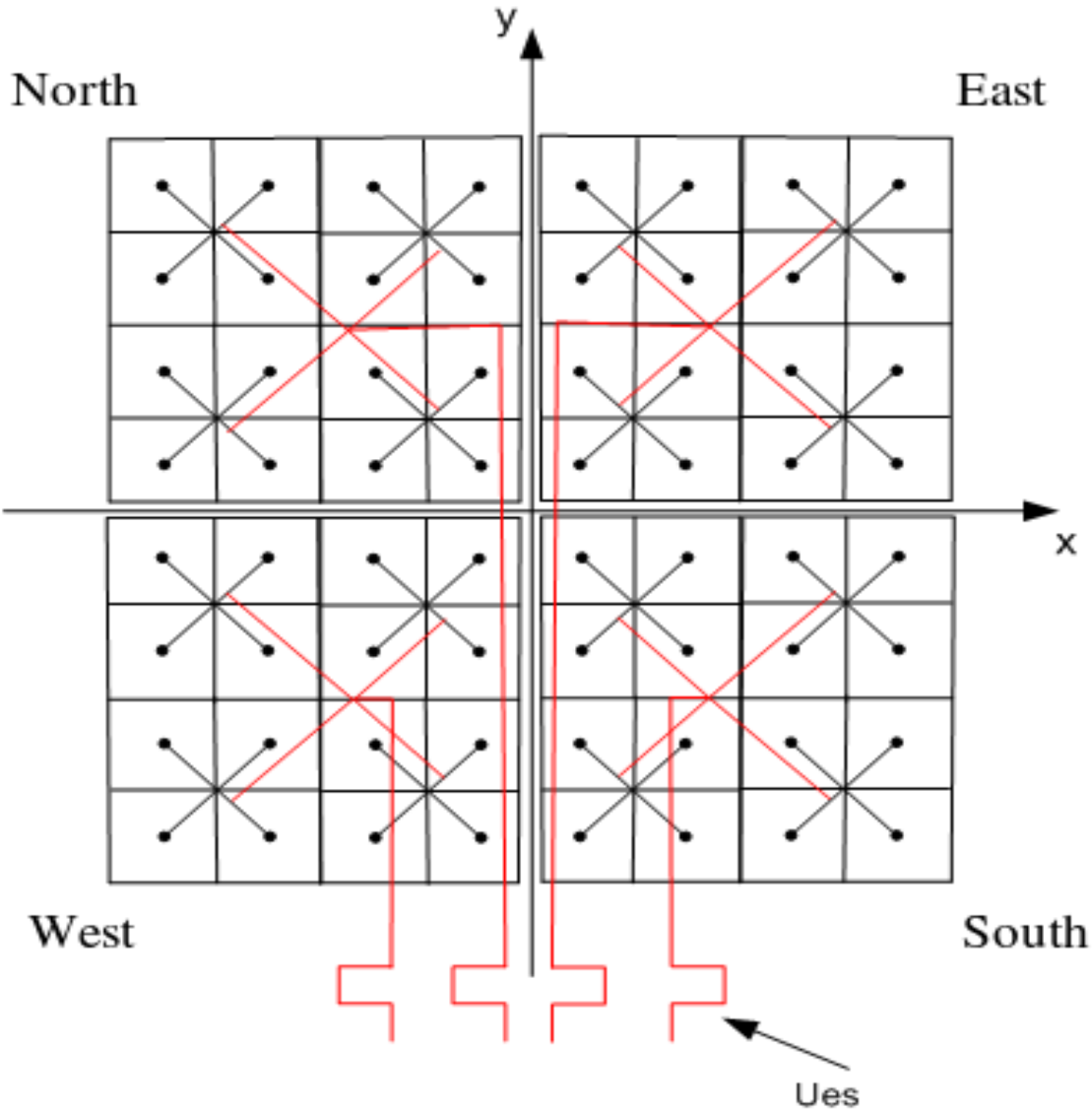
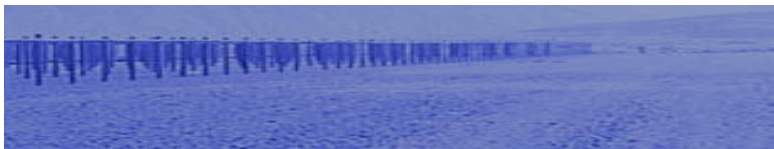


Jicamarca is the biggest antenna of the world. The area of the antenna is **90000 meter square** (300m x 300m) and this **size is equivalent to 10 football fields** approximately.

The operating frequency is **50Mhz**.

Jicamarca is an array of **18432 dipoles,** organized in 8x8 **cross-polarized** (“ x” or down, and “y” or up) modules.

Transmitters: **3x1.5MW** of peak-power with 5% duty cycle.



Antenna Characteristics

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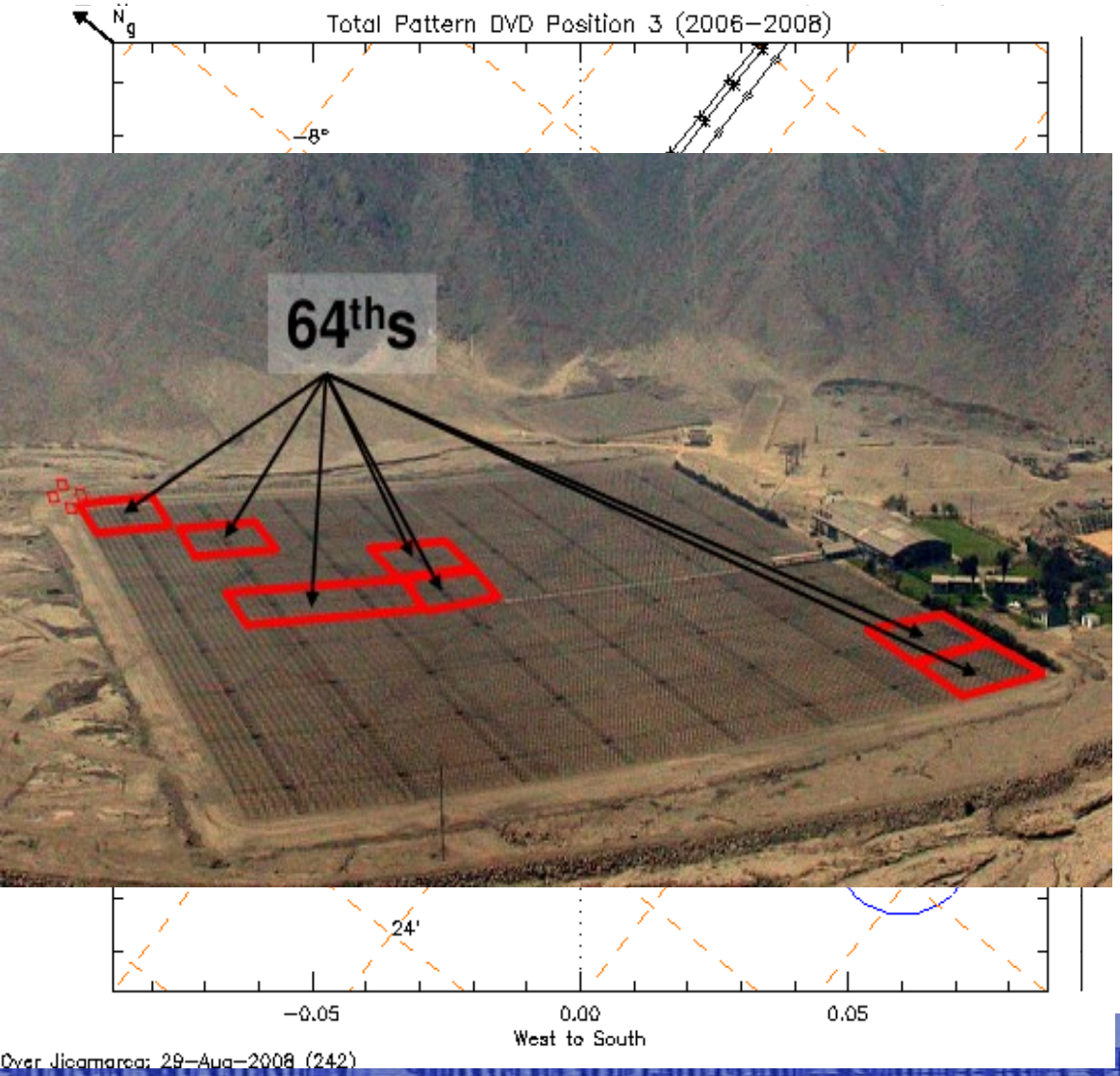

The **modular characteristic** allows different transmission and reception configurations.

Tx: The **direction of the transmission beam can be modified** changing the input phase in the modules or/and in the Ues. The phase changes are currently done manually.

Rx: The different sections of the antenna (e.g. Modules or quarters) can be used as a receivers. (**Interferometry**)

Antenna Characteristics

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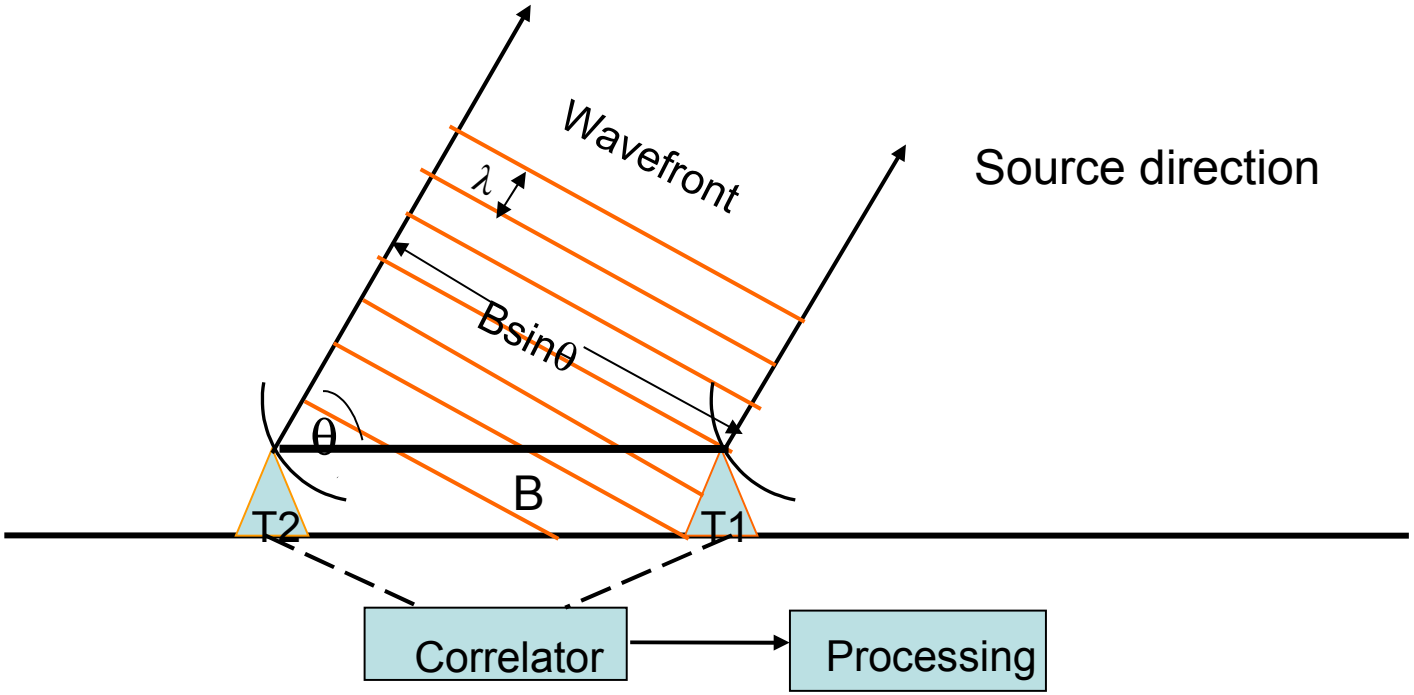
Interferometry:



The antenna T2 will see the echo with a delay respect to T1.

The angle of arrival of the signal can be computed!

What do we study at Jicamarca?

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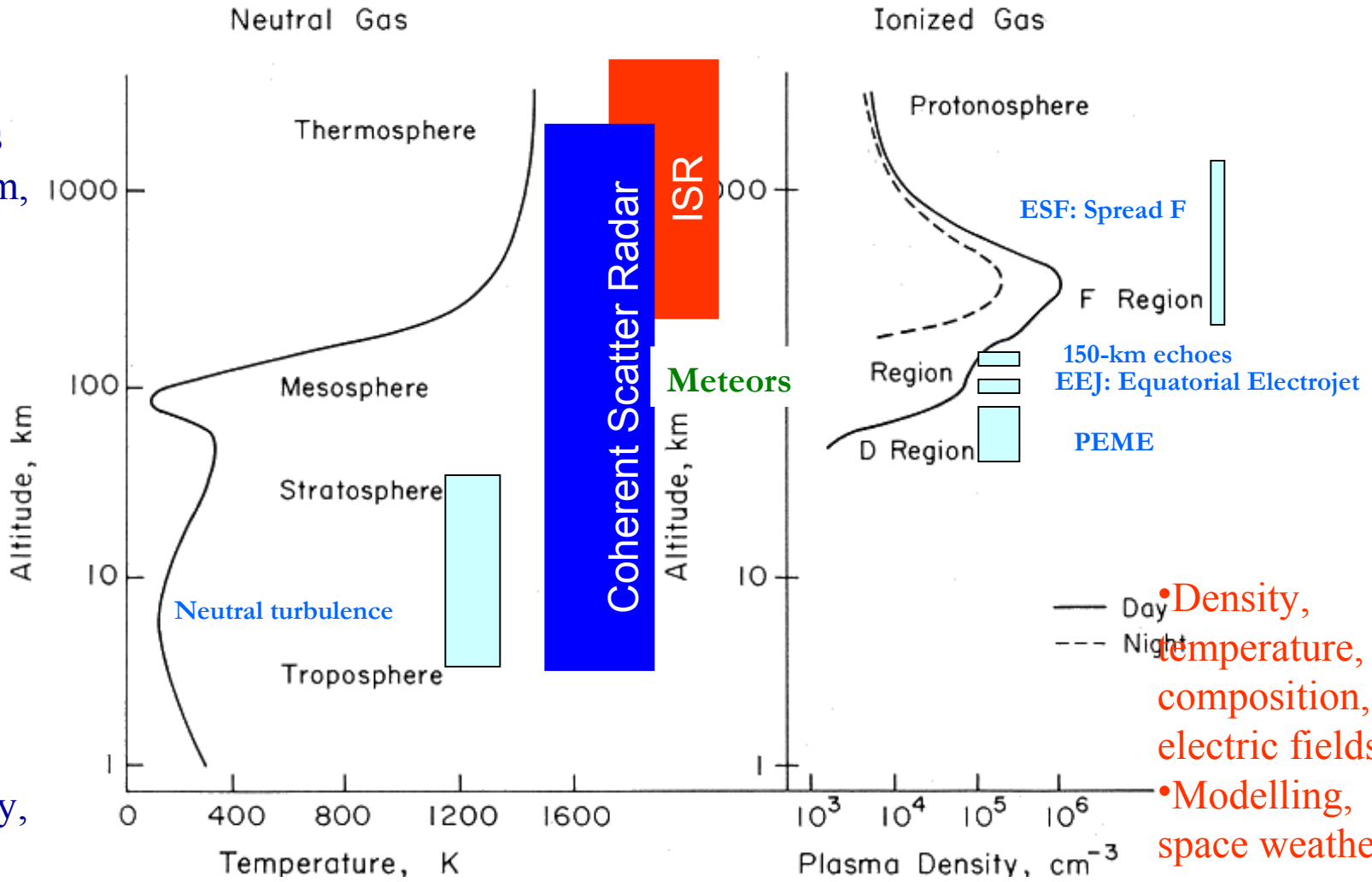
- Ionospheric Irregularities (EEJ, 150-km, ESF).
- SAR, GPS

- Neutral atmosphere dynamics (winds, turbulence, vertical velocities)
- Meteorology, aviation.



- Density, temperature, composition, electric fields
- Modelling, space weather

What do we study at Jicamarca?

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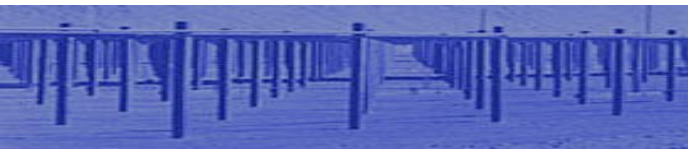
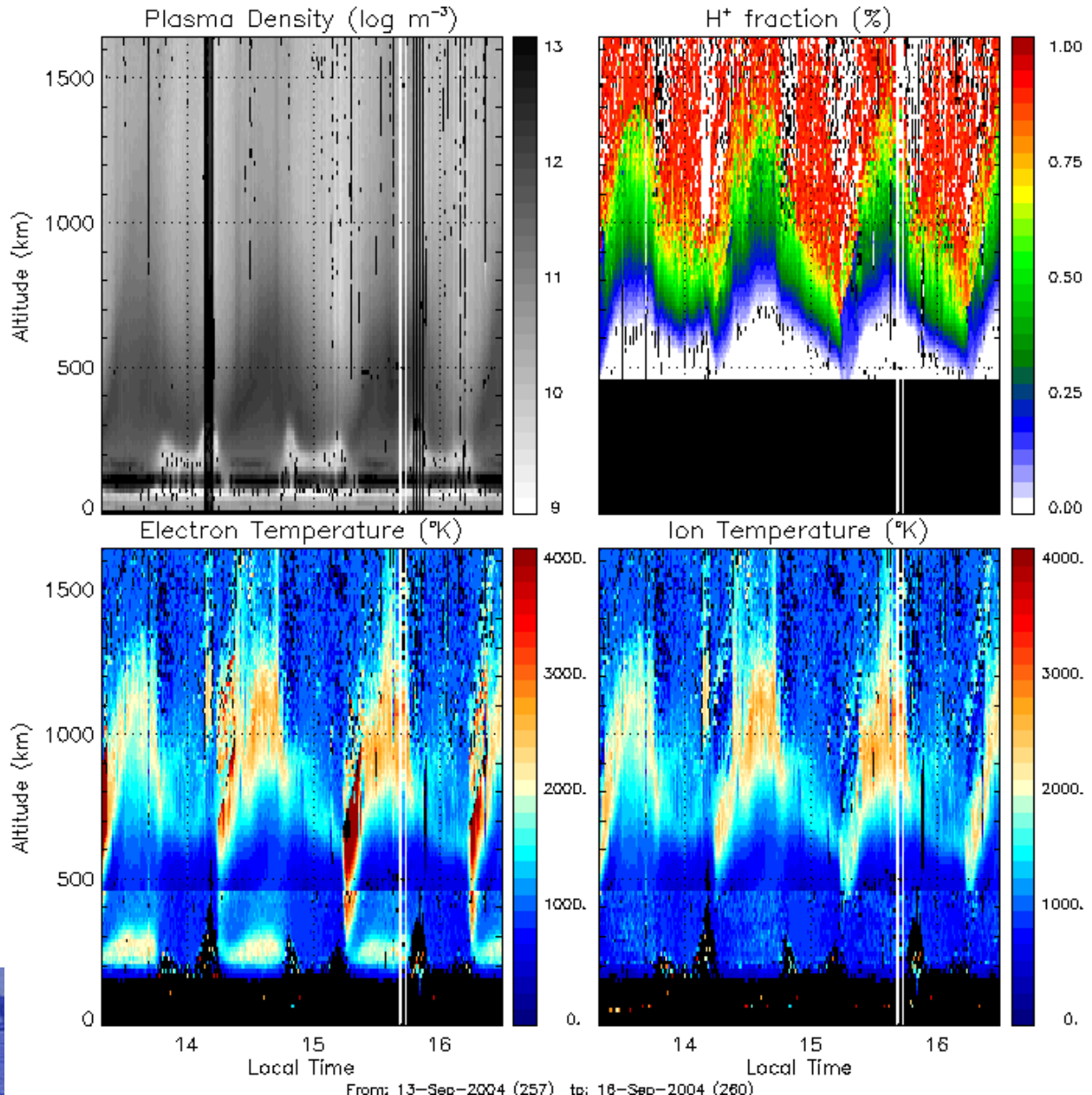
Oblique ISR Examples

This mode of operation provides:

- **Absolute electron density** (From Faraday rotation) and **temperatures below 500km**.
- Density, temperatures and **composition above 500km**.





What do we study at Jicamarca?

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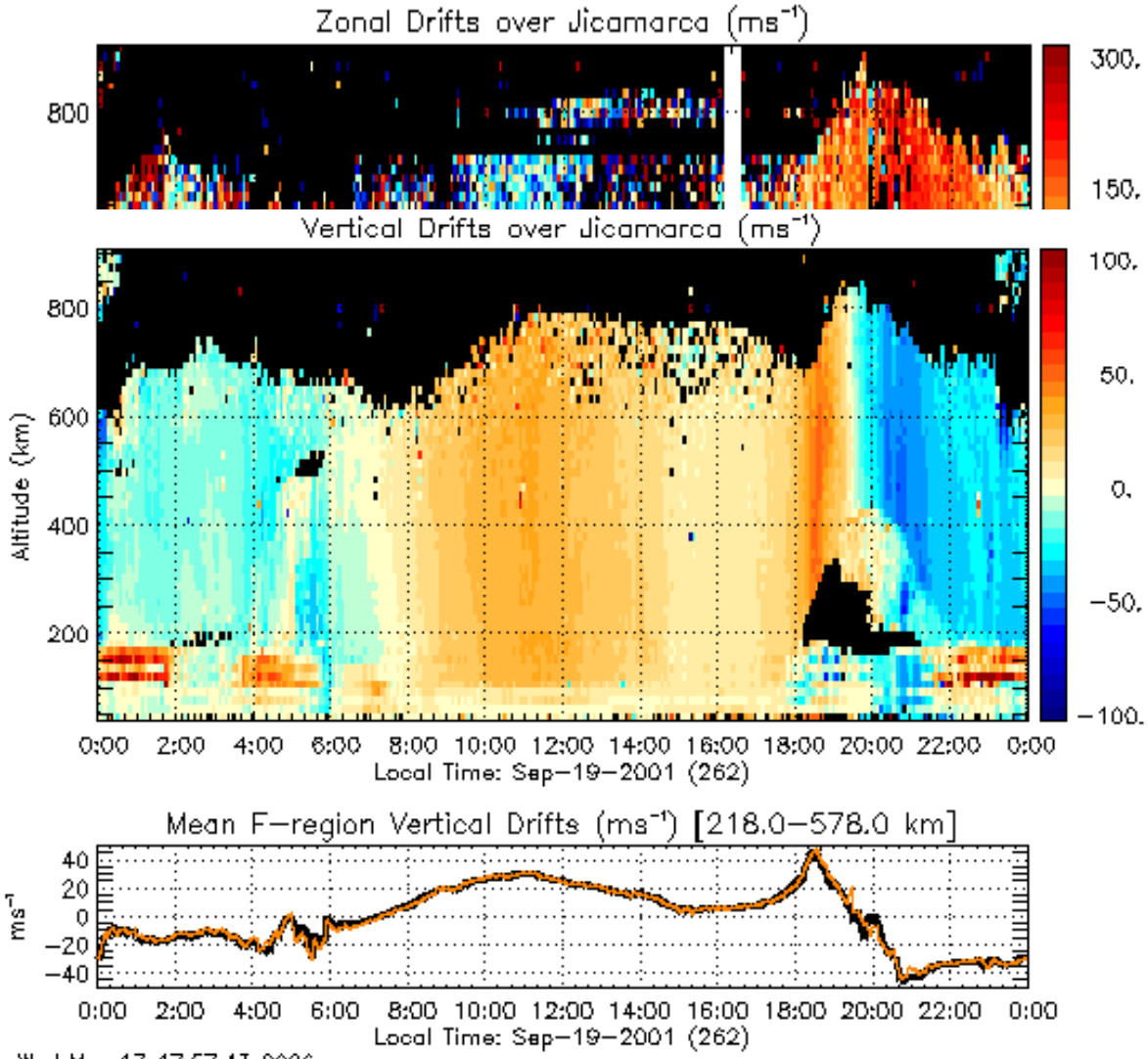
Perpendicular ISR Examples

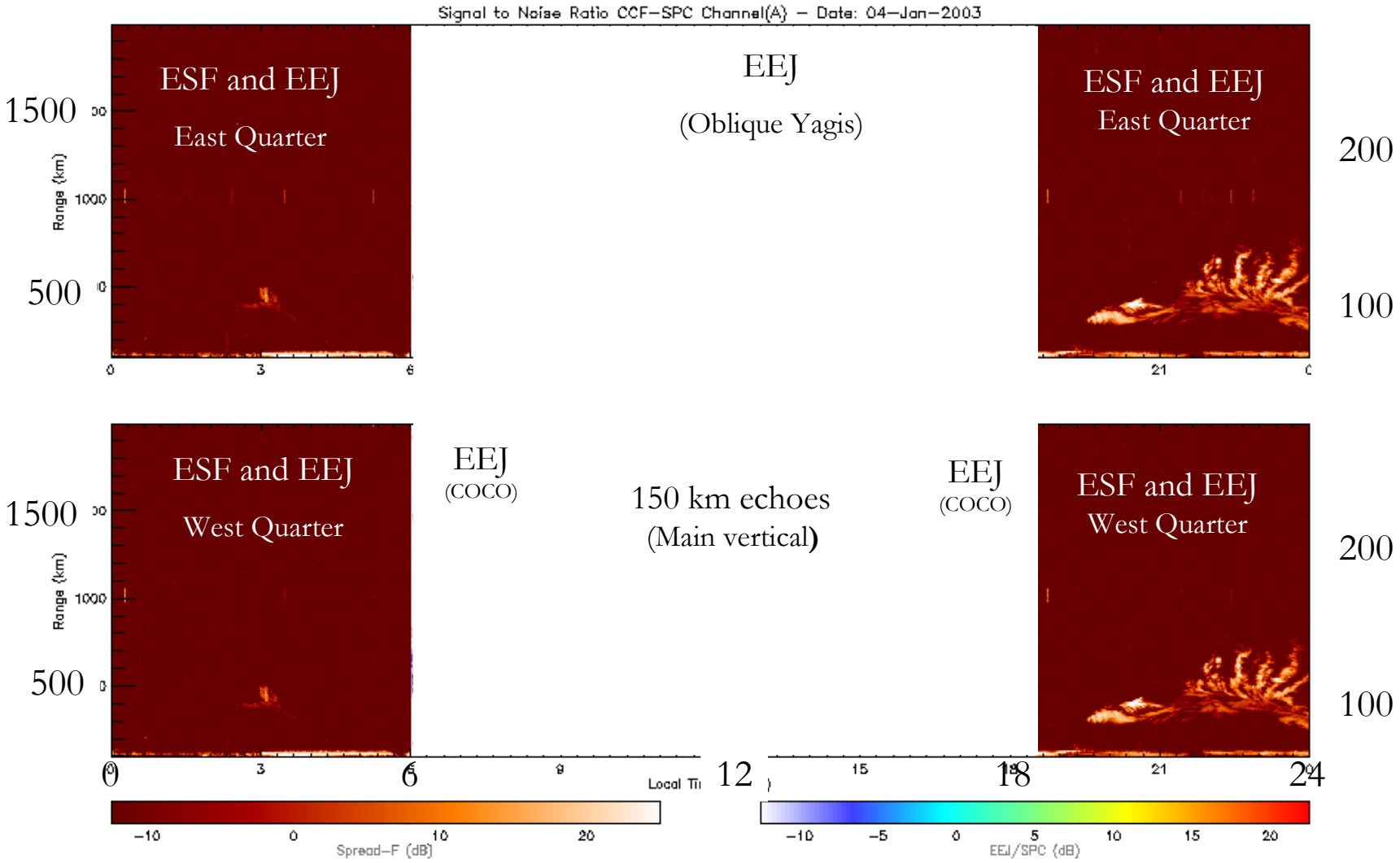


Simultaneous measurements of **vertical and zonal drifts**, with 15km and 5min resolutions.

What do we study at Jicamarca?

Radio Observatorio de JICAMARCA Radio Observatory

Coherent echoes over Jicamarca: RTIs above 100 km



ESF: Equatorial Spread F (nightime)

150-km echoes: Daytime

EEJ: Equatorial Electrojet (all day)

What do we study in JRO?

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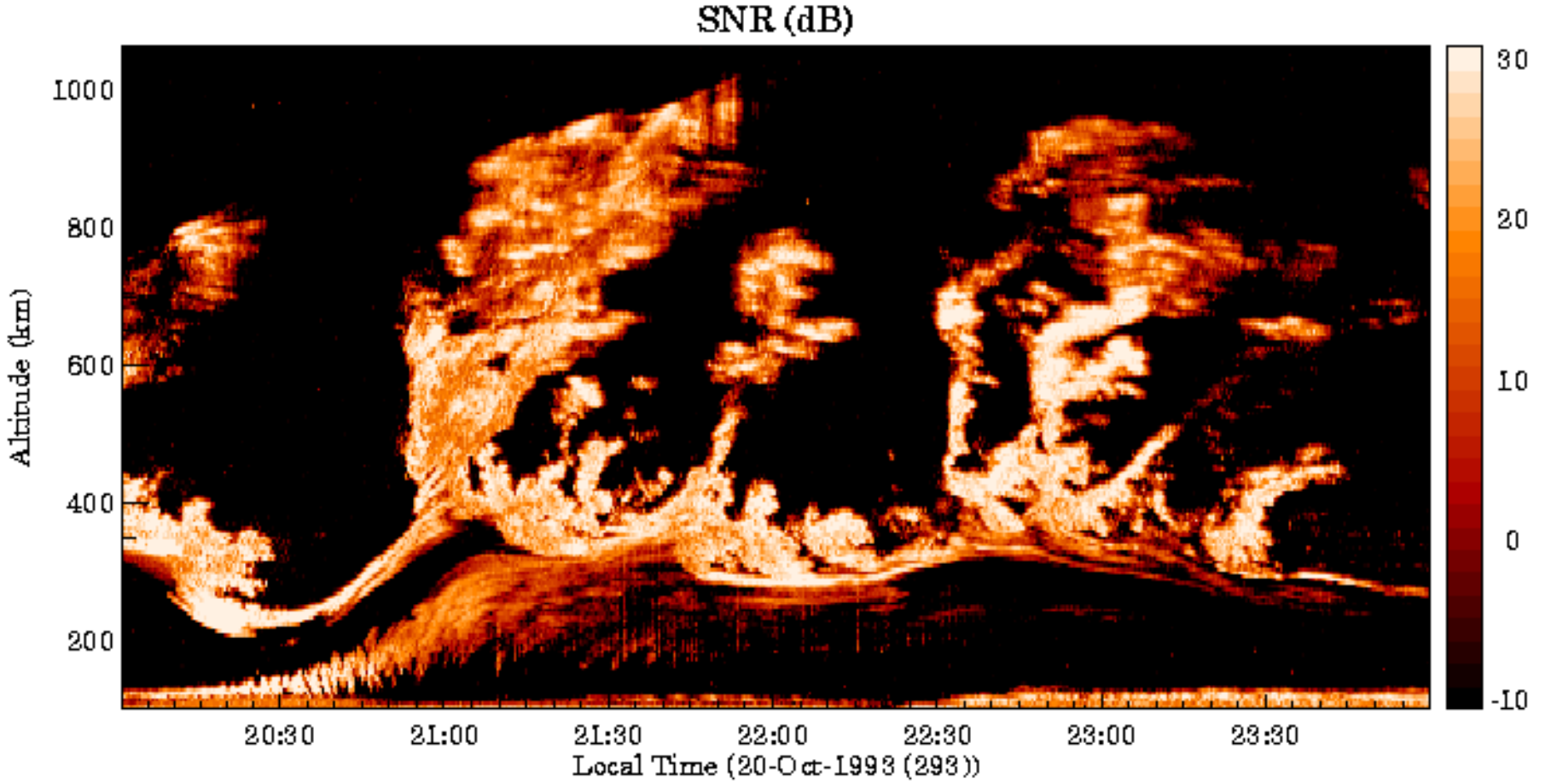
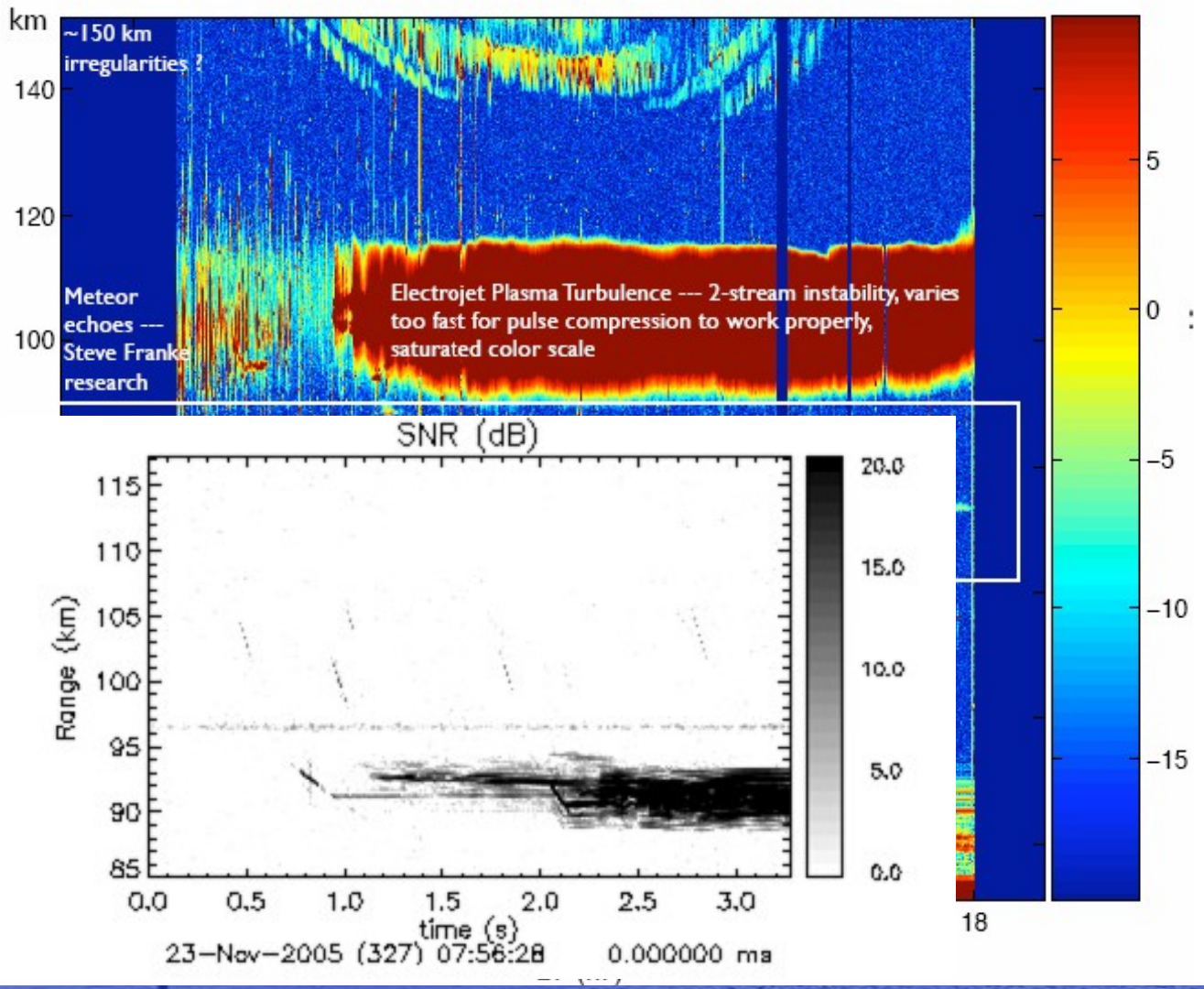
Coherent echoes over Jicamarca: RTIs above 100km



What do we study in JRO?

Radio Observatorio de JICAMARCA Radio Observatory

Coherent echoes over Jicamarca: RTIs below 100km



150-km echoes Daytime

EEJ echoes all Day (Daytime stronger)

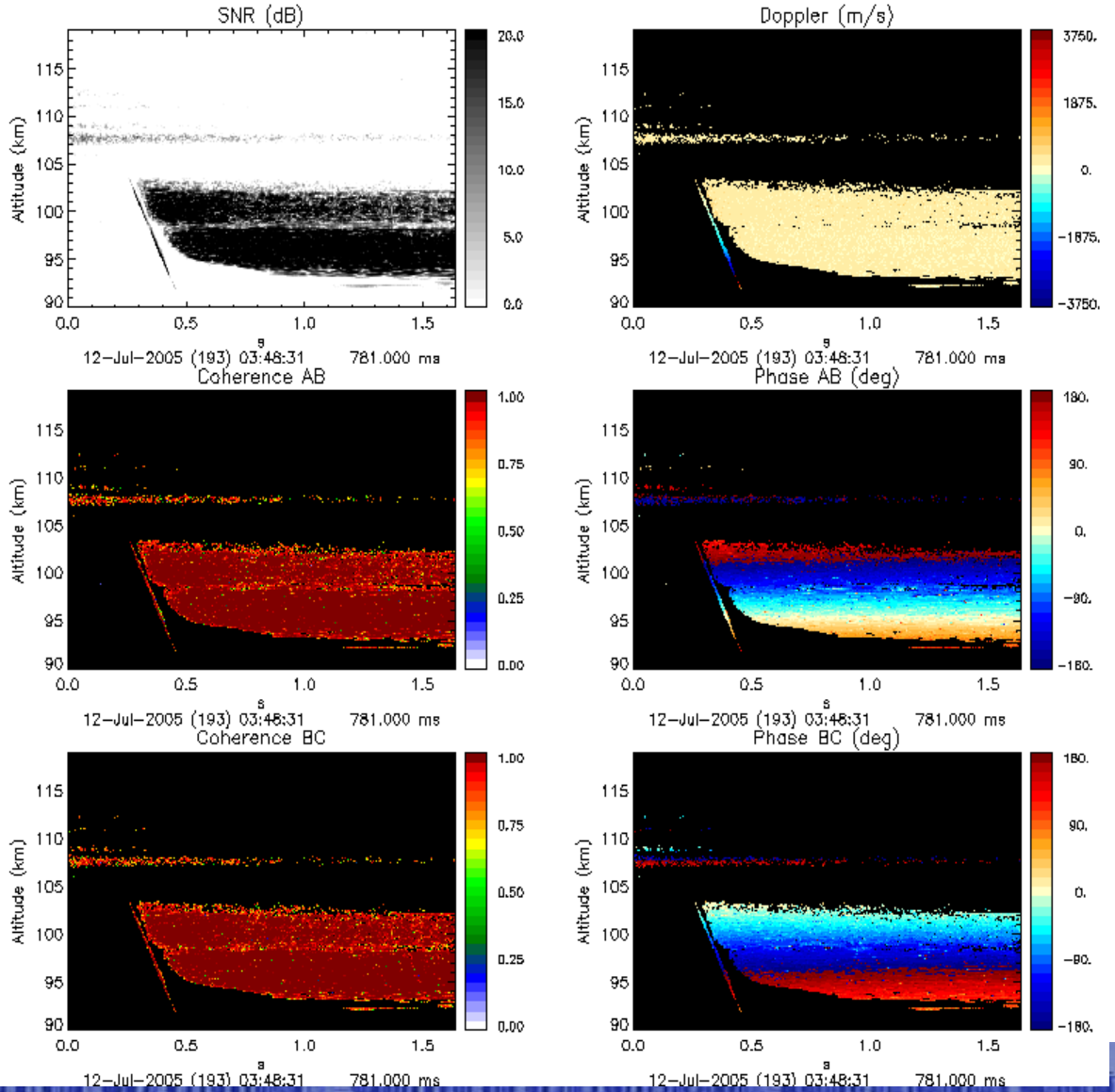
Mesospheric echoes Daytime

Stratospheric and Tropospheric echoes all all Day

Meteor echoes all Day (head, non-specular and specular trails)

Meteor studies at Jicamarca

Radio Observatorio de JICAMARCA Radio Observatory



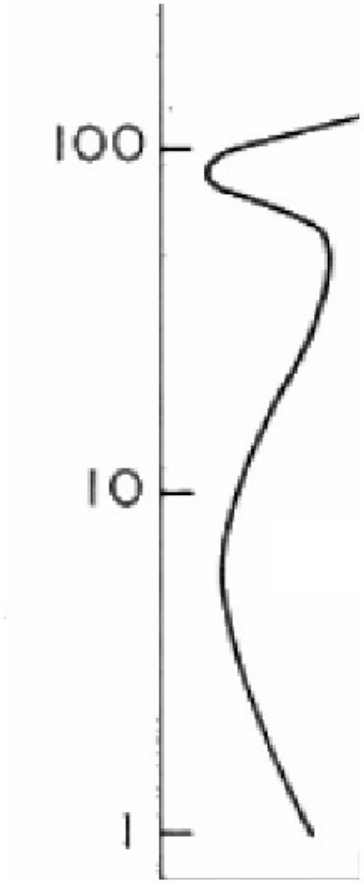
- The meteor studies at Jicamarca started in 90's to research the meteor Shower knowing as Leonids.

- Chau & Woodman [2004] defined a simplified geometry of a meteor trajectory with respect to the illuminated beam and then computed the meteor parameters.

- The results from those experiment showed that radars like JRO were not sensible to Meteor Showers, but they are good tools to study Sporadic sources of Meteors.

Meteor studies at Jicamarca

Radio Observatorio de JICAMARCA Radio Observatory



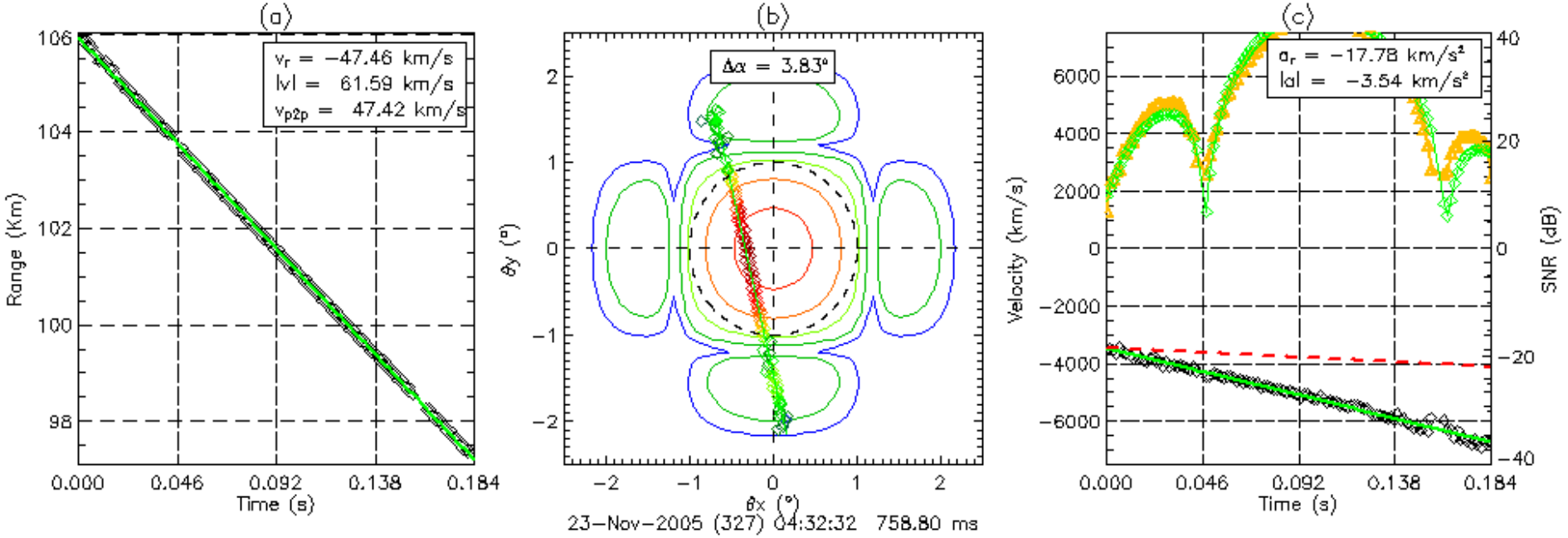
Antenna: 300m x300m
Peak Power: 2MW
Frequency: 50 MHZ
HPBW: ~1 degree

Not a scale

Meteor studies at Jicamarca

Radio Observatorio de JICAMARCA Radio Observatory

Measured and Derived Parameters



Measured Parameters

- Initial range
- Range and time coverage
- Radial velocity (coarse and fine)
- Radial deceleration
- Azimuth (from direction cosines)

Derived Parameters

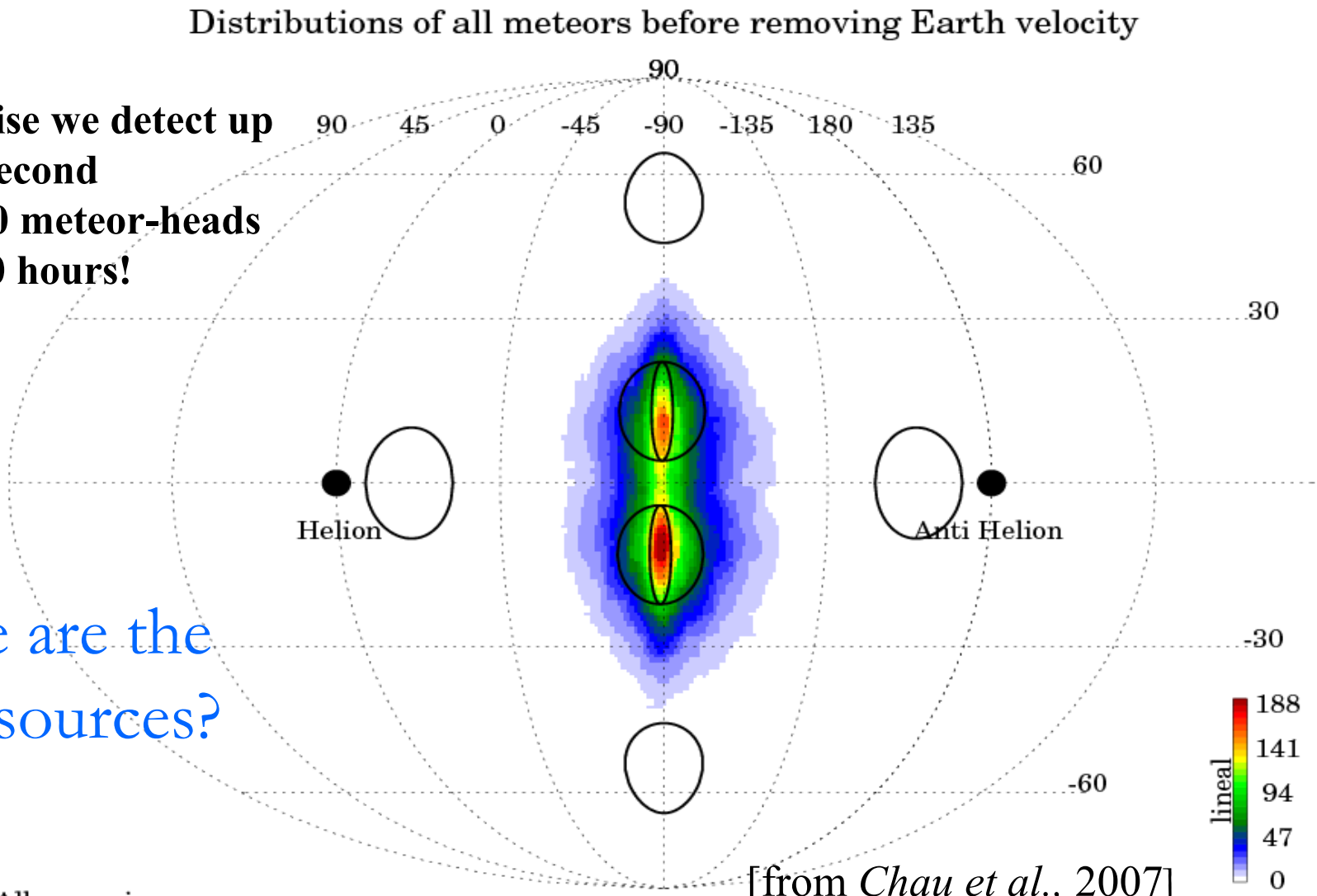
- Zenith angle
- Absolute geocentric velocity
- Absolute deceleration
- Orbital parameters (inclination, eccentricity, axis length, origin)
- Other (e.g., mass)

Meteor studies at Jicamarca

Radio Observatorio de JICAMARCA Radio Observatory

Raw meteor distributions from Jicamarca observations

- **Around sunrise we detect up to 4 meteors/second**
- **From 180,000 meteor-heads observed in 90 hours!**



Where are the other sources?

[from *Chau et al.*, 2007]

Meteor studies at Jicamarca

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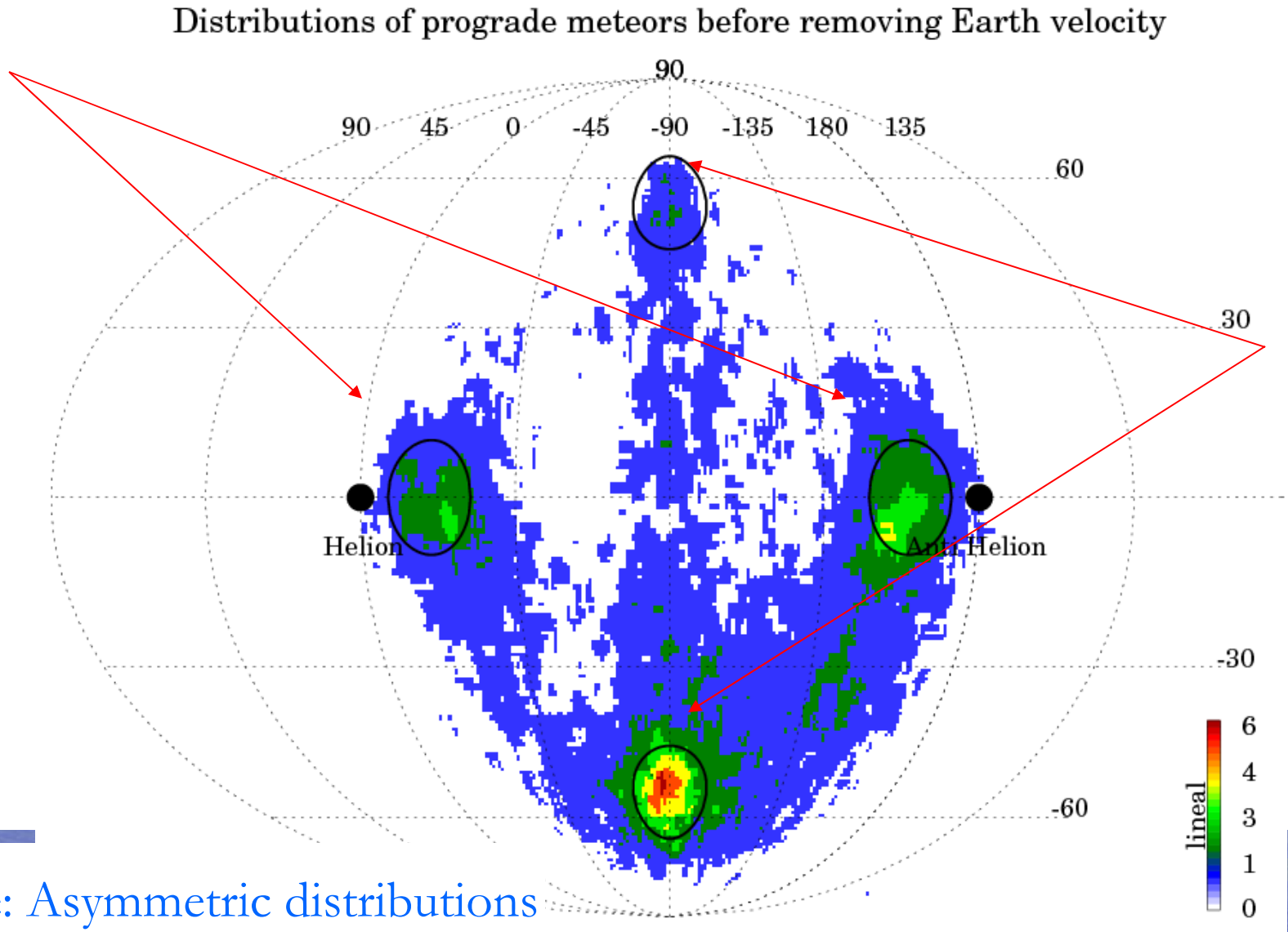
Meteor distributions: Prograde only



Note: Asymmetric distributions

Meteor studies at Jicamarca

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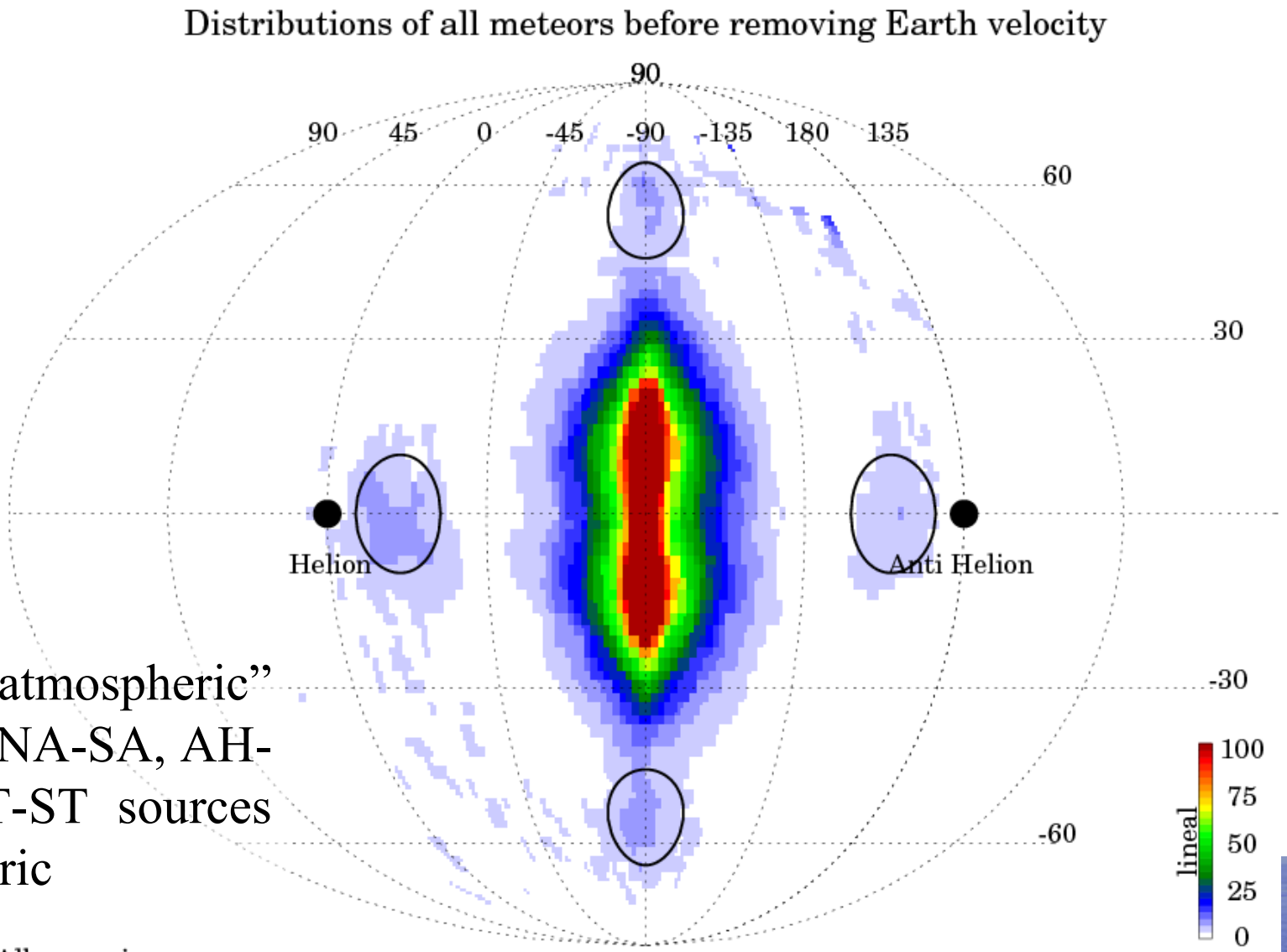
Meteor distributions: Corrected by angular function



After "atmospheric" correction, NA-SA, AH-H, and NT-ST sources are symmetric

All campaigns

Meteor studies at Jicamarca

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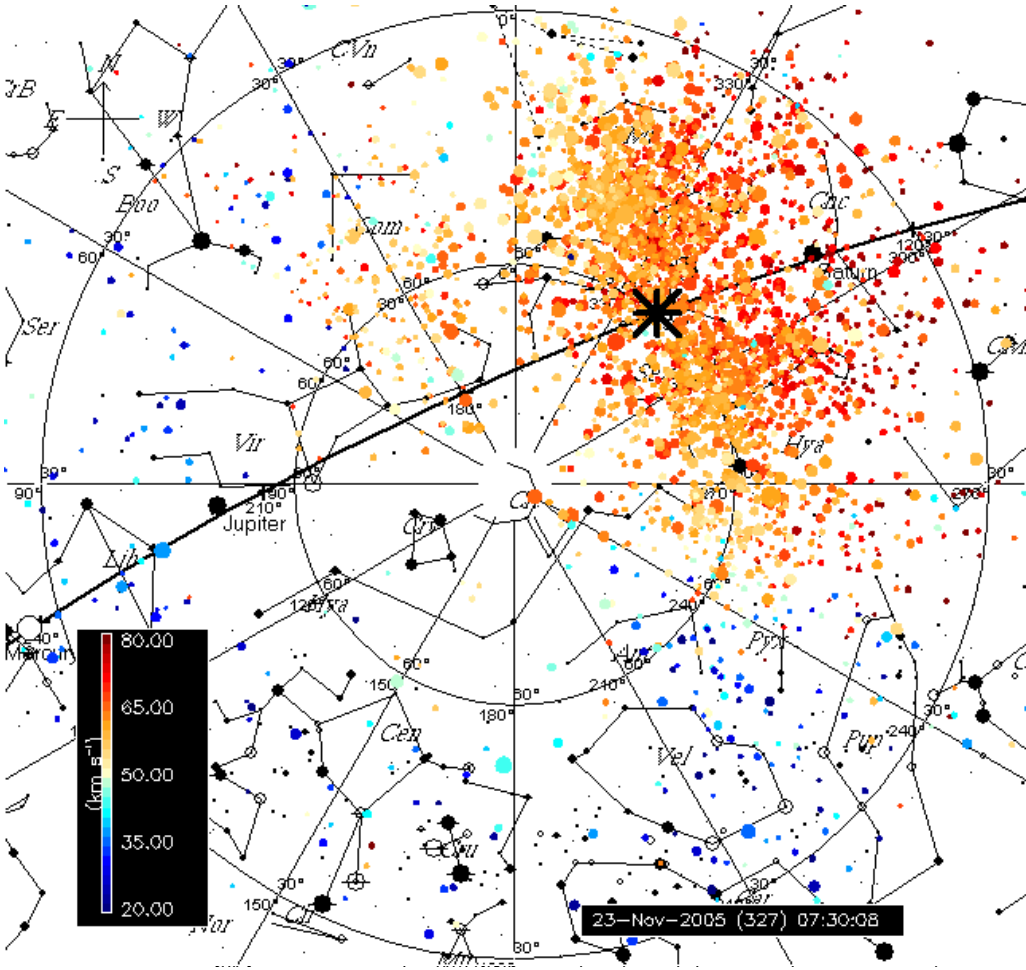
Can HPLARs detect meteor showers?

- So far HPLARs have not been able to detect meteor shower activity.
- Recall that HPLAR observe a very small volume as compared to optical instruments or SMRs, therefore the probability of being observe is much less.
- It is difficult to discriminate meteor shower signature from its velocity distribution. Sporadic population it is much larger and cover almost all velocities.
- In the case of Jicamarca, the Leonids radiant almost coincide with the Apex, making its discrimination from the sporadic population harder.
- What about other showers?



Meteor studies at Jicamarca

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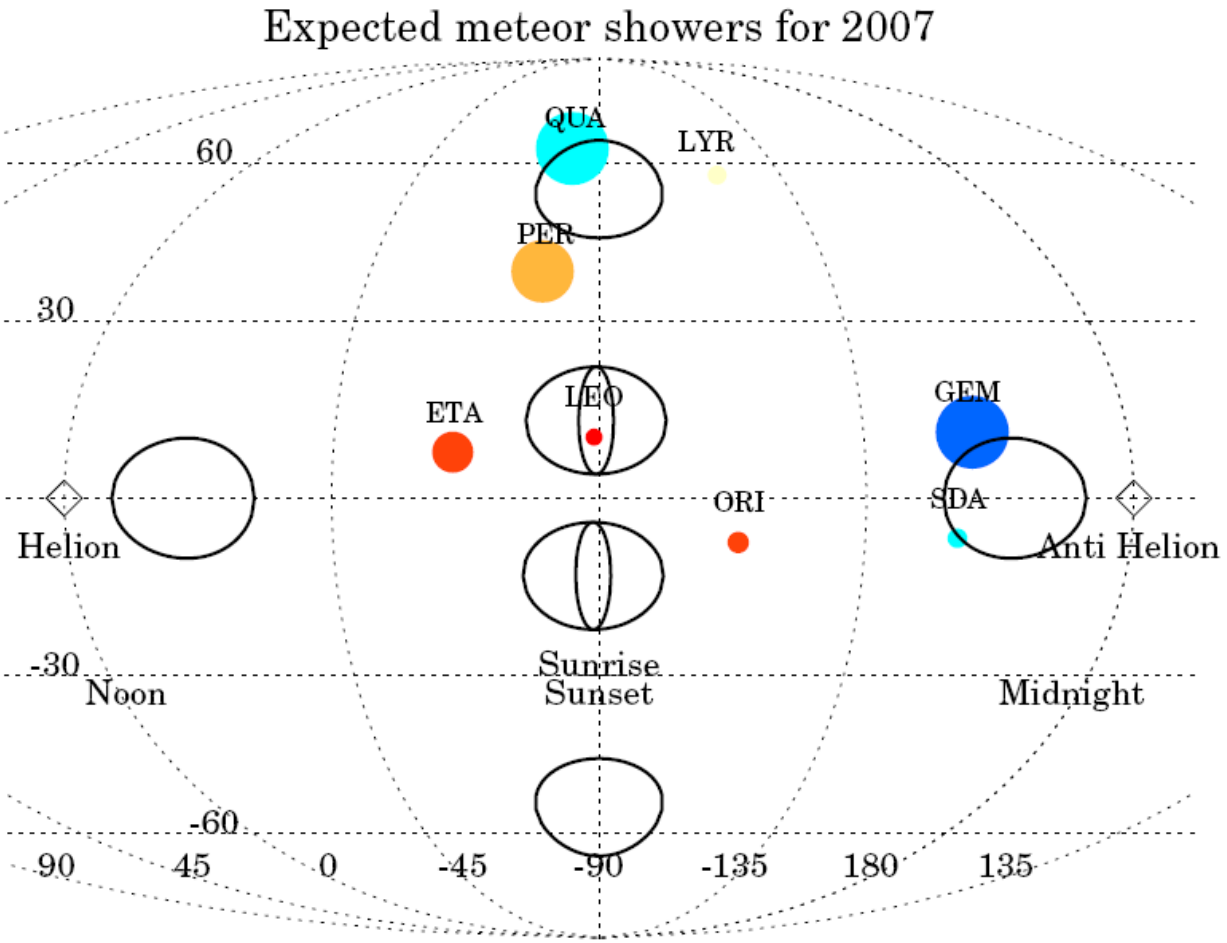
What about other meteor showers?

First attempts

- Are limited to nighttime to avoid the strong Electrojet echoes during the day
- Should avoid radiants that coincide with known sporadic populations.



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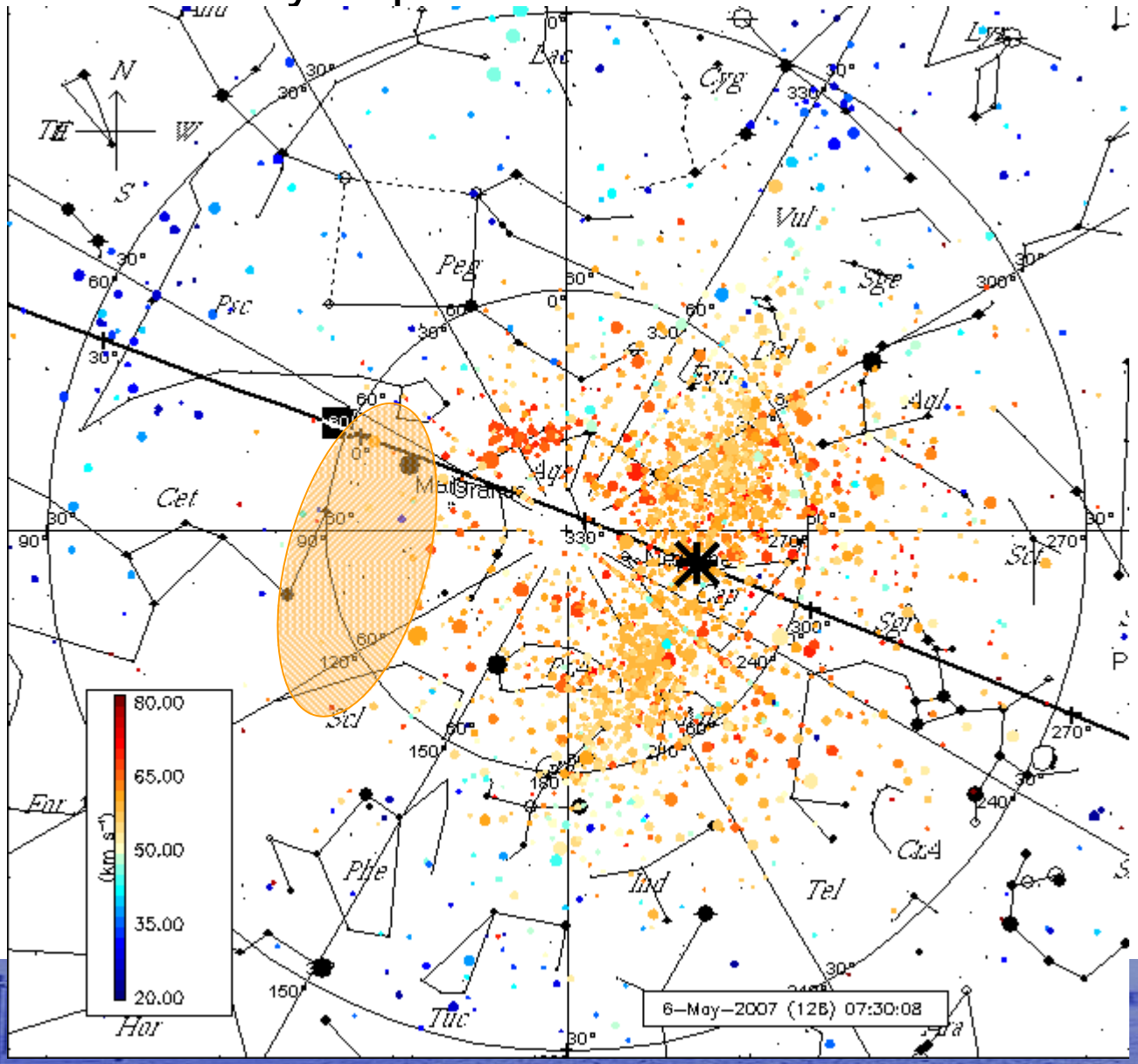
ETA Observations: Skymap



Meteor studies at Jicamarca

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Eta-Aquarids (May 5-6, 2007)

η-Aquarids (Visual)

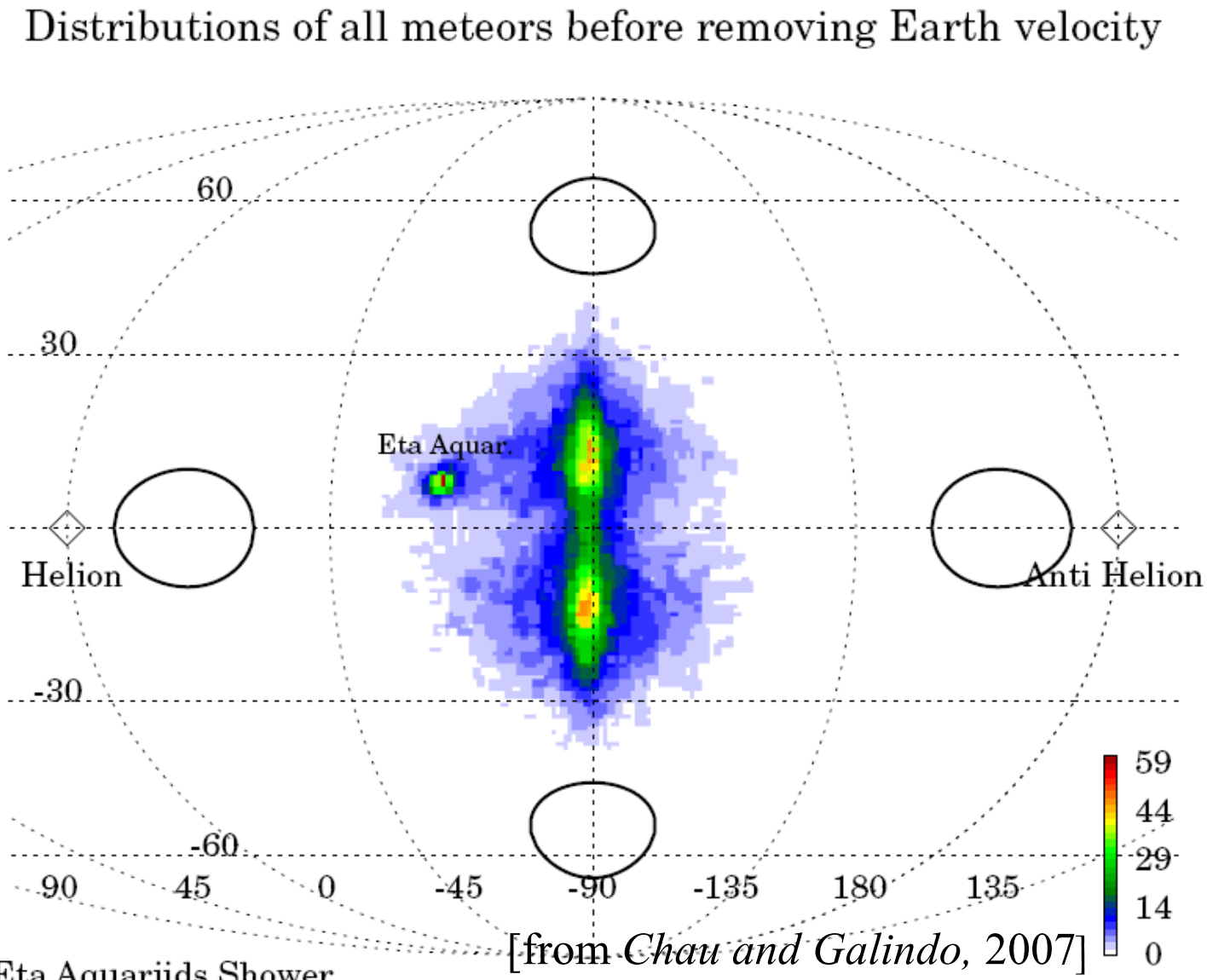
Max. Date = May 06

RA = ~338°

Dec = -01°

V_{inf} = 66 km/s

ZHR = 60



[from *Chau and Galindo*, 2007]

ETA parameters from Jicamarca

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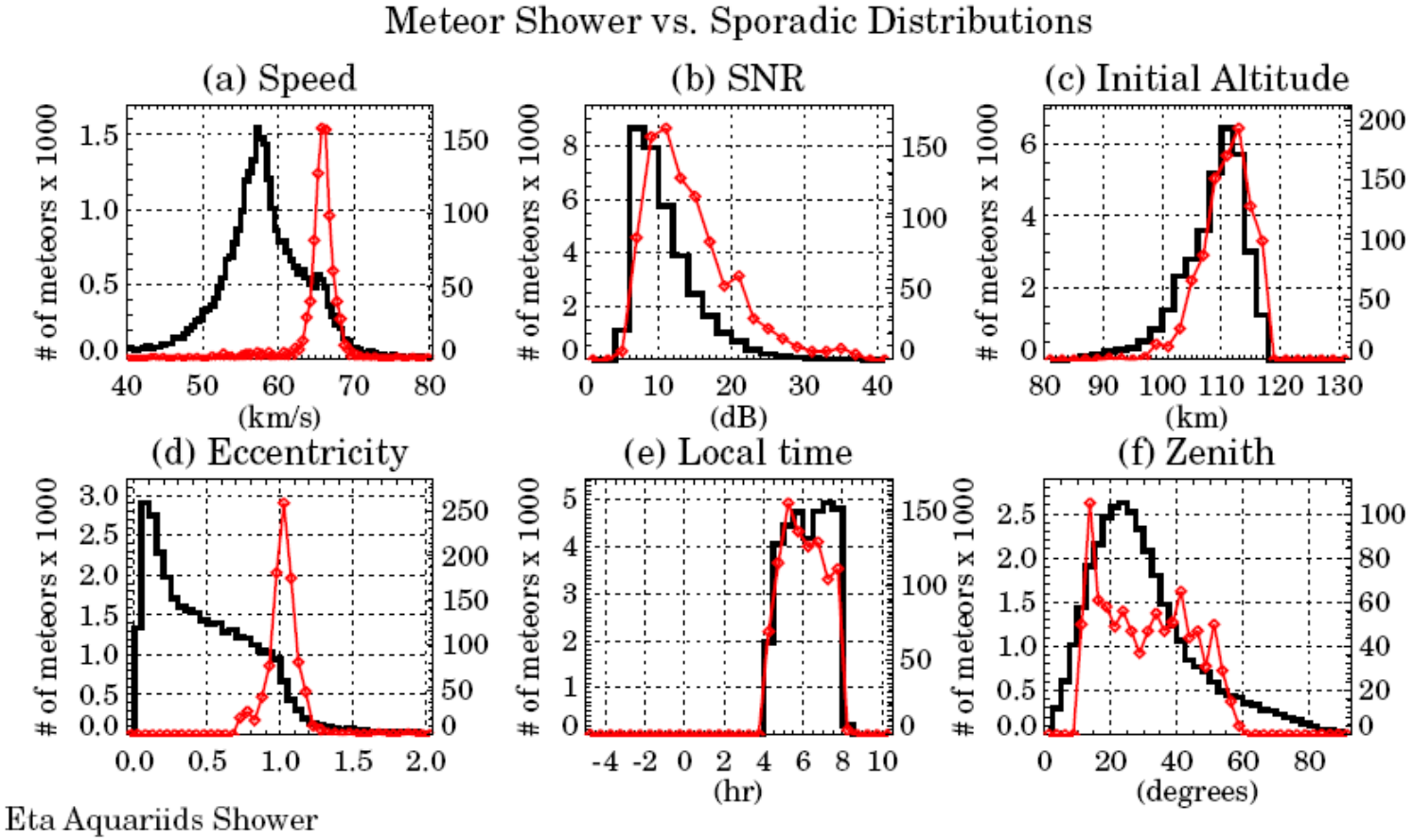
Apex
ETA



- There is an excellent agreement in the mean speed (65.90 vs 66 km/s) and location (fraction of a degree in both long and lat).
- Spread in velocity (1 km/s) and location (1°) within expected intrinsic results

- ETA: Mean orbits are parabolic, Halley-type orbits.
- Proportionally, there are “larger” ETA meteors than sporadic.
- ~120 ETA meteors/hour (1000 more meteors that one could observe optically in the same volume).

Meteor studies at Jicamarca

Radio Observatorio de JICAMARCA Radio Observatory

Conclusions for interferometry observations of meteor-head echoes

- HPLARs are sensitive to meteor showers.
  - Some showers could be detected from velocity distributions (e.g., ETA).
  - Other shower need the combination of velocity and location distributions (e.g., PER).
  - Some of them might need besides velocity and location, size distributions (e.g., Leonids).
- The shower parameters are obtained from meteor sizes previously not observed with any other meteor technique.

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Thanks!

jro.igp.gob.pe