

# **Low latitude ionospheric turbulence observed by Aureol 3 and possible association with seismicity**

Hobara et al., 2005 in Ann. Geophys. (In press)

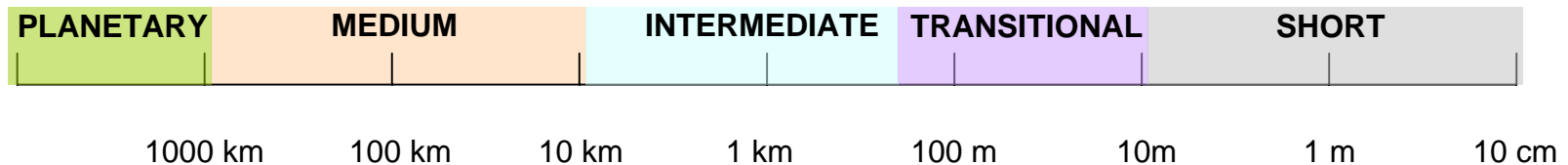
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# Introduction

## Characteristic scale of IT



Kelly et al., 1982

## OBJECTIVES

- IT and electric field turbulence in low ~ middle latitudes.
- Effect to IT from energy sources from the earth (e.g. seismic activities)
- Lithosphere-atmosphere-ionosphere coupling

## PREVIOUS WORKS

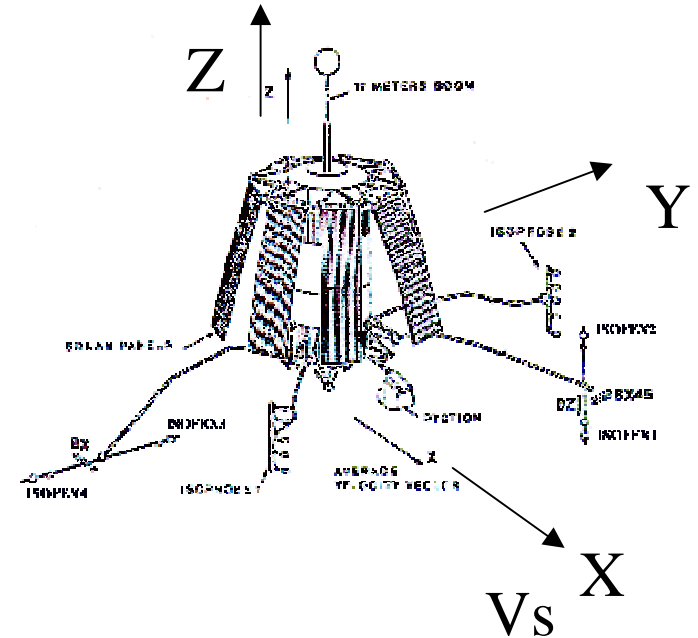
- Molchanov et al., 2002: 2004 IK24, Cosmos-900
- Cerisier et al., 1985. Aureol 3, High lat IT & E.
- Parrot, 1991, Aureol 3, VLF emissions.
- Galperin et al., 1996. Aureol 3, Ground explosion.

# Contents

- Introduction
- Data used
- Results from waveform data (case study)
- Results from filter bank data (statistical study)
- Conclusion

## Data from Aureol-3

- Perigee 400km, Apogee 2000km  
Inclination 82.5deg, Period 109.5min
- Launch: Sep 1981 Termin: Jan 1986



## Data used for current analysis

### Electric Field

- Electric field EH (Y -component)
- Waveform(WF):  $6\text{Hz} < f < 1500\text{Hz}$
- Filter bank (FBE):  $10\text{Hz} < f < 1000\text{ Hz}$
- Time resolution: 0.01 to 2.56 sec (ZAP1 to ZAP4)

### Electron Density

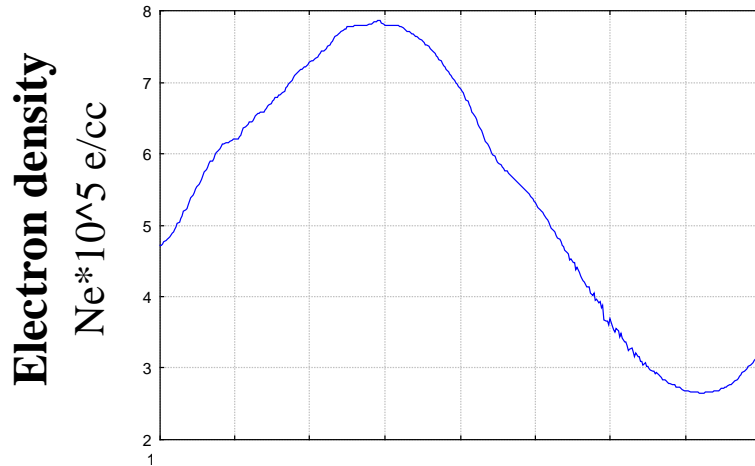
- ISOPROBE (High resolution):  $6\text{Hz} < f < 1\text{kHz}$

## Waveform and FB

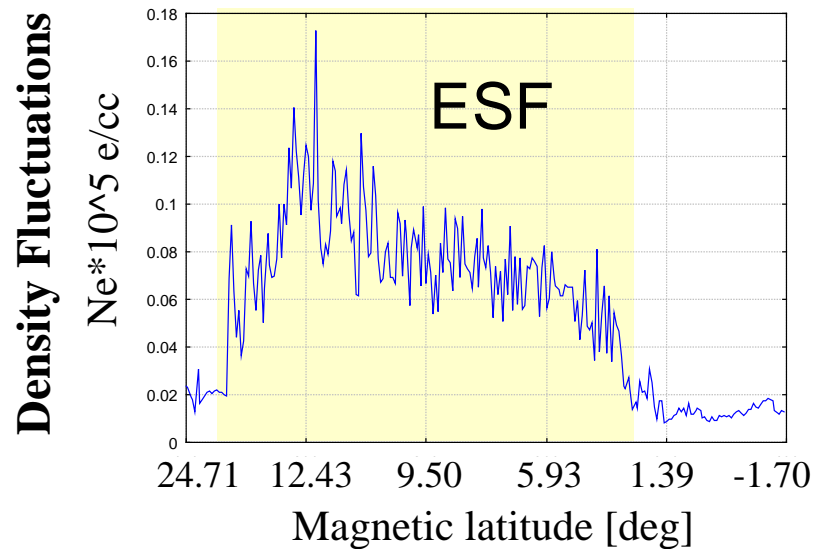
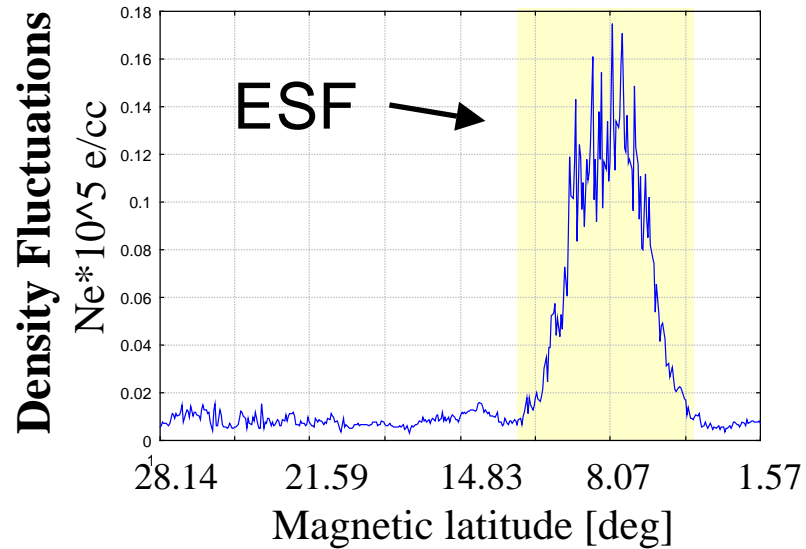
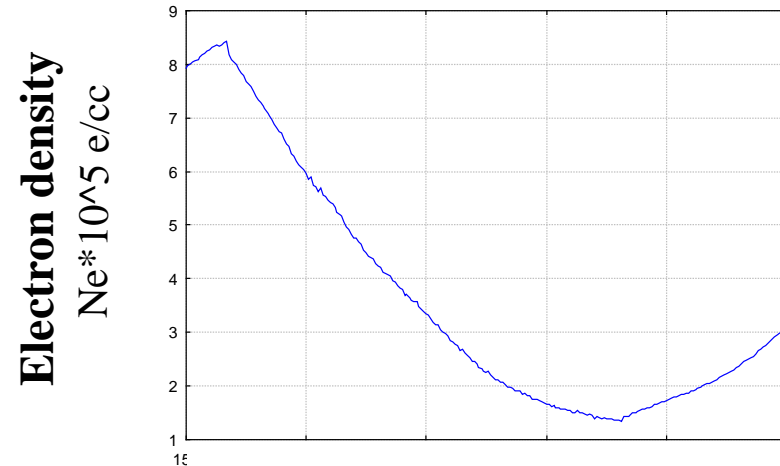
	<b>Waveforms (High time resolution)</b>	<b>Filter banks</b>
<b>Orbit</b>	Near TM station	Entire earth
<b>Component</b>	EH and Ne	EH
<b>Frequency resolution</b>	Arbitrary (fs=5kHz)	6 channels (10Hz < f < 1000Hz)
	Case Study	Statistical Study

# Ne near the Equator (WF)

6/8/1982 Orb 3420

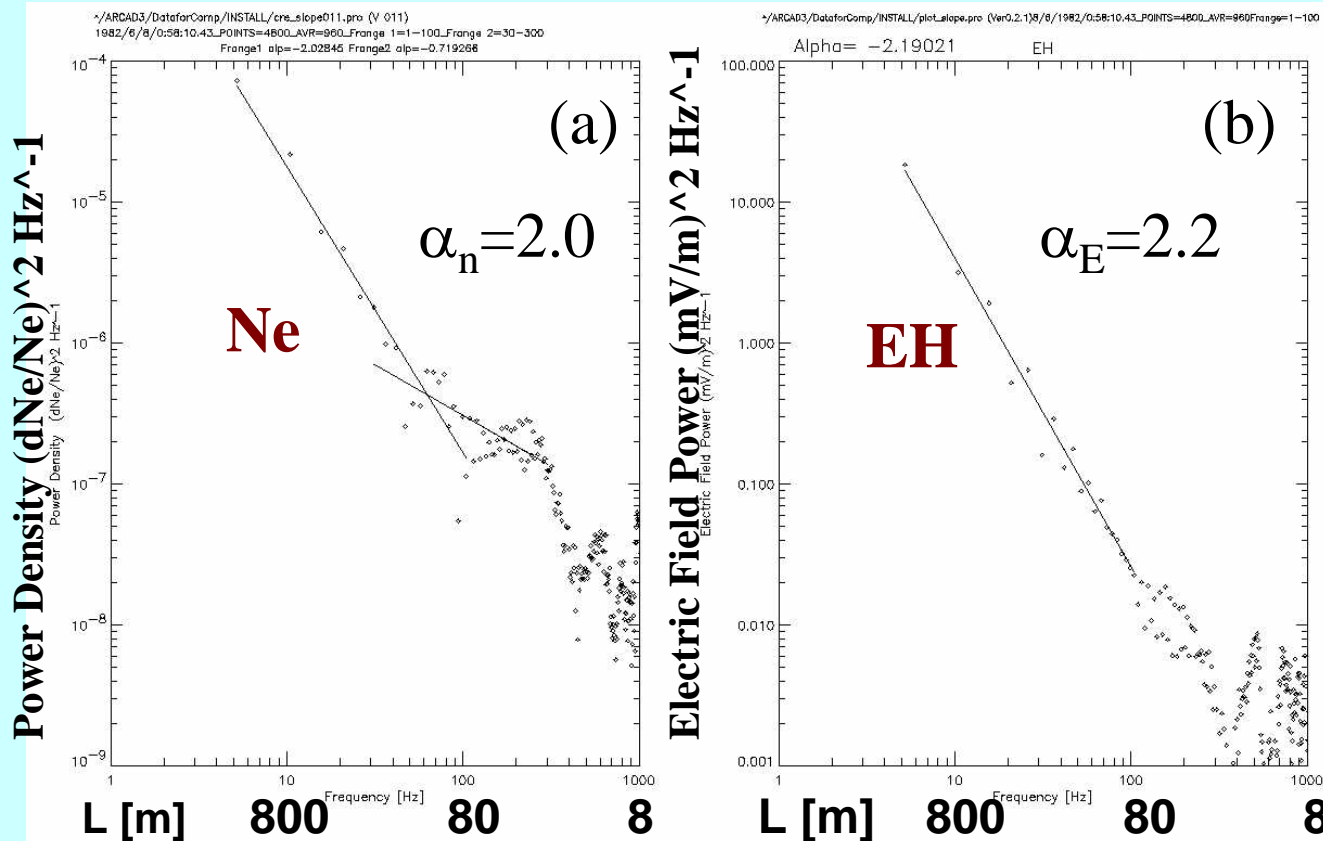


6/9/1982 Orb 3433



# PSD (WF)

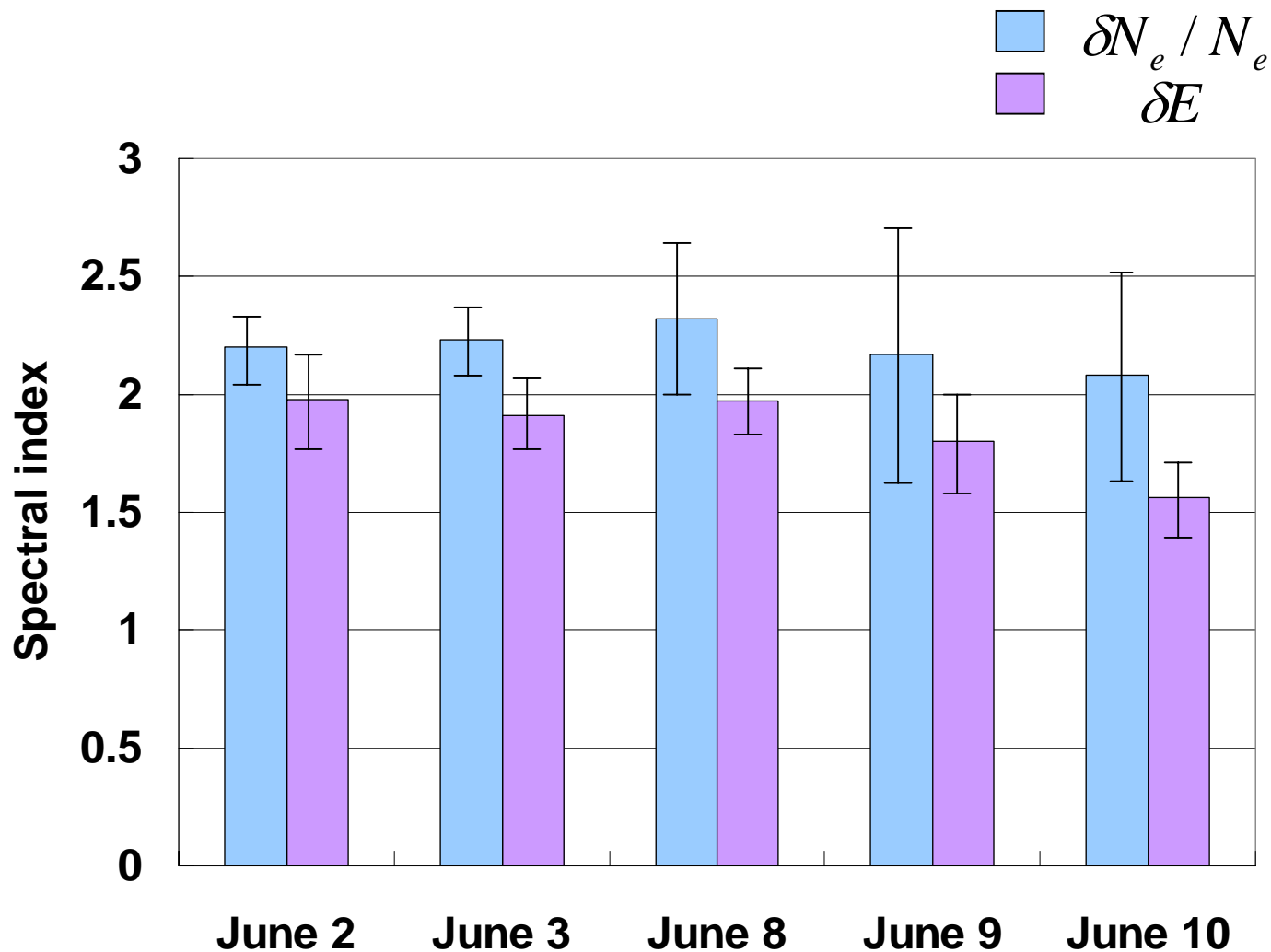
1982/6/8/0:58:10.043 (UT) Mlat=7.81 deg, Alt=437.0 km



Power spectra of (a) electron density and (b) electric field turbulence inside equatorial spread F (ESF)

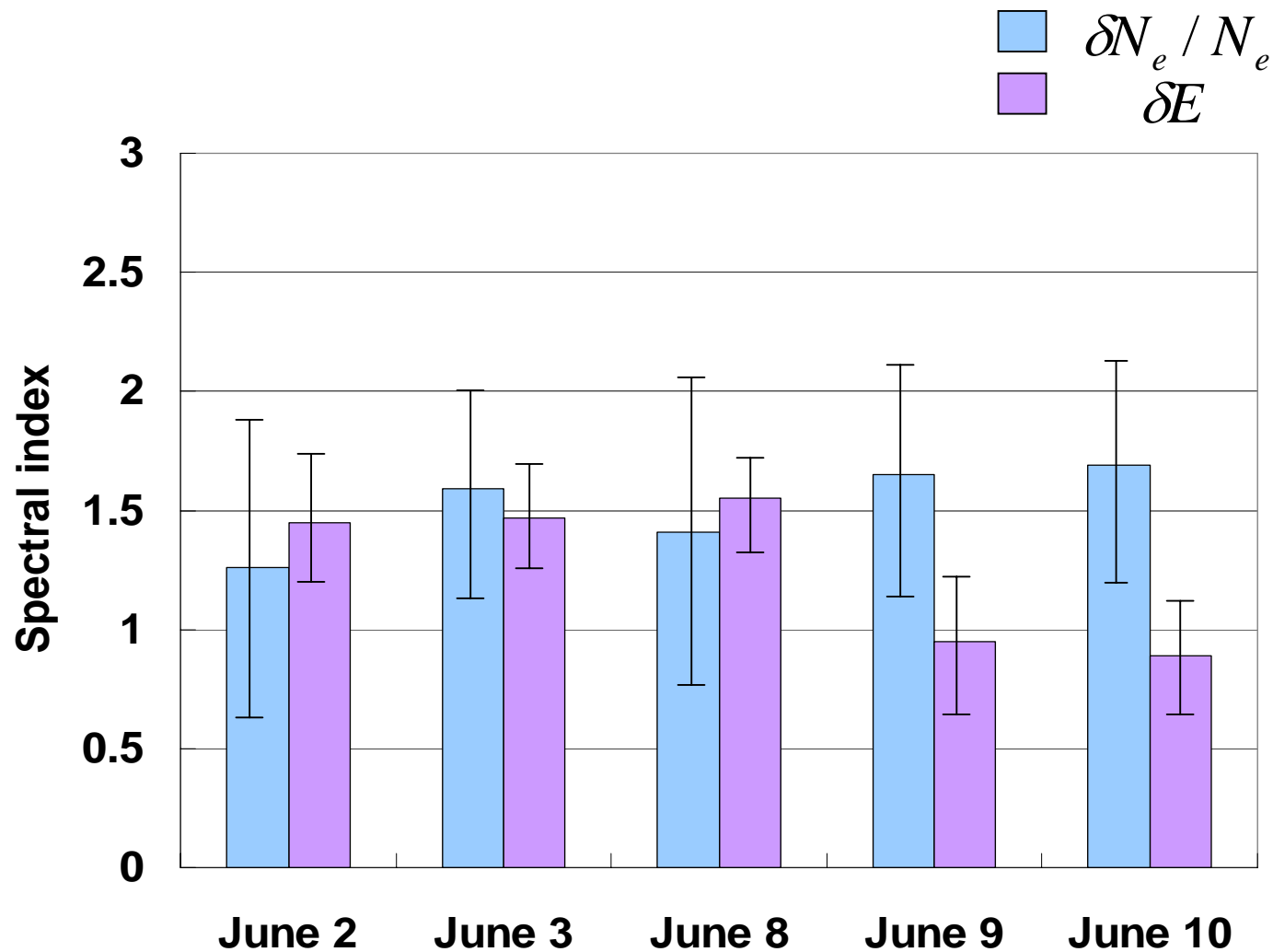
$\alpha_n \sim \alpha_E$ : RT instability regime,  $P \propto f^{-\alpha}$  ( $6\text{Hz} < f < 100\text{Hz}$ )

## Spectral index (6Hz<f<100Hz)





# Spectral index (30Hz<f<300Hz)



# Statistical study (FB)

Advantage: Global orbital coverage

## Data selection

### Orbit

- Altitude  $< 900$  km
- $-45^\circ < \text{Magnetic latitude} < 45^\circ$

### Electric Field Power ( $10 \text{ Hz} < f < 100 \text{ Hz}$ )

- **Burst event** (significant local enhancement of E-power)
- **Burst intensity** and corresponding **spectral index**

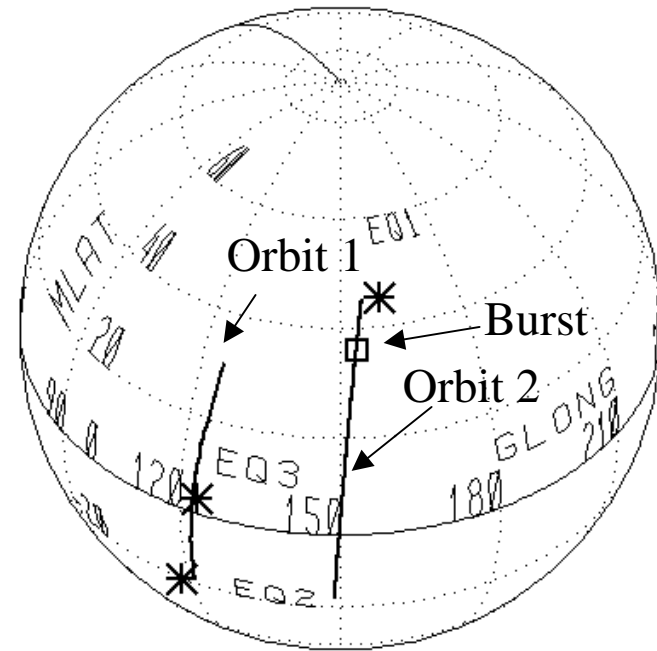
### Seismic events

- NGDC seismic catalogue (1964-1995)
- Extract events :  $M_s > 5.5$ , Depth  $< 100$  km

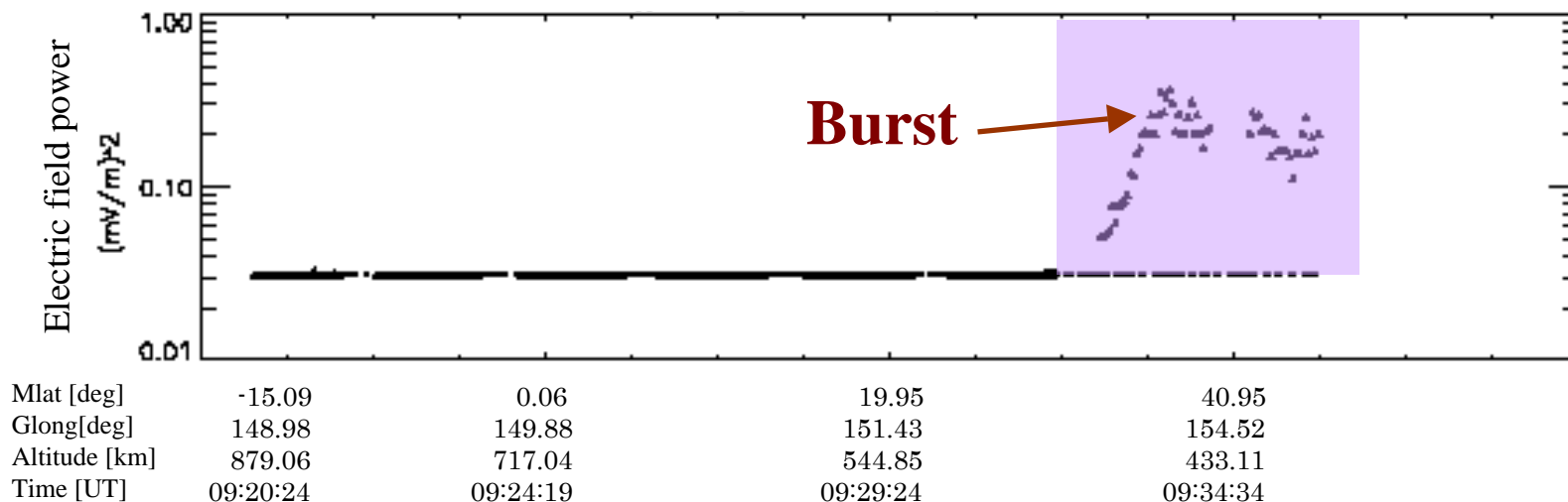
# Burst event (FB) -1

## Seismic events:

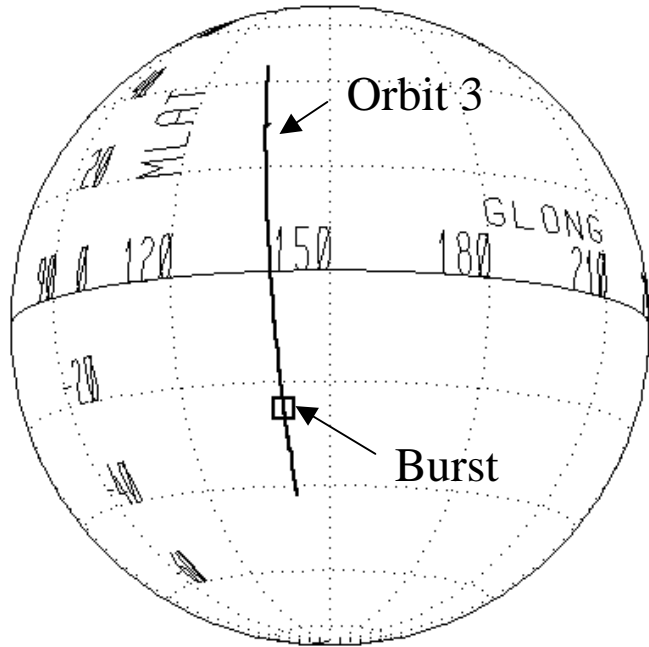
- $M > 5.5$
- $\Delta \text{Magnetic long} < 15^\circ$
- $\Delta \text{Day} < 5 \text{ days}$



1982/03/12 Orbit 2



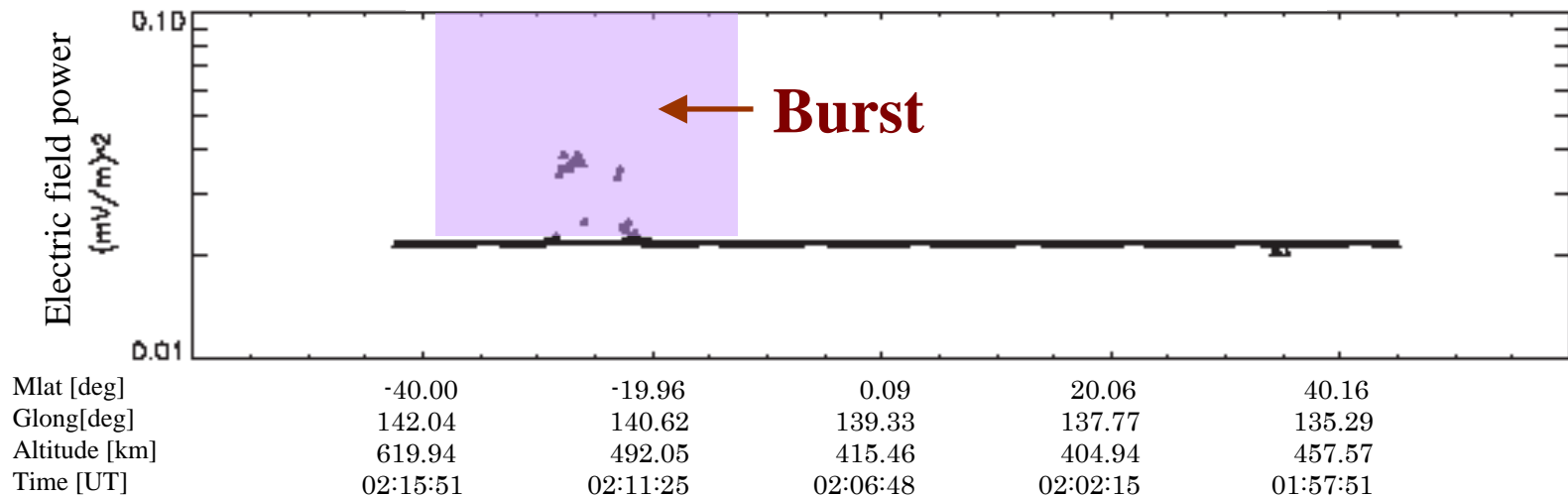
## Burst event (FB) -2



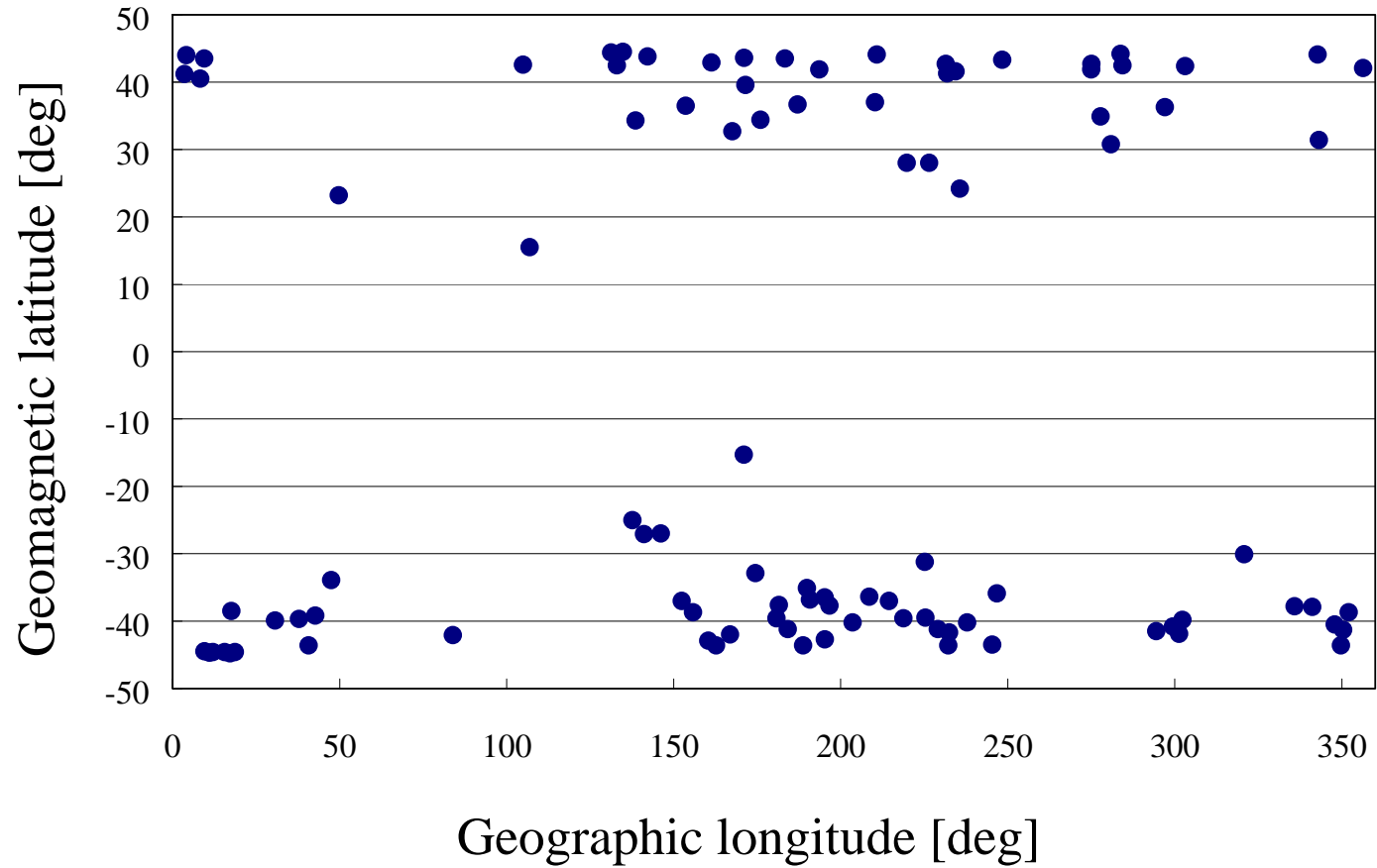
### Number of H-orbits:

- Total : 864
- Low alt bursts : 96
- Bursts with EQ: 32

1982/02/04 Orbit 3



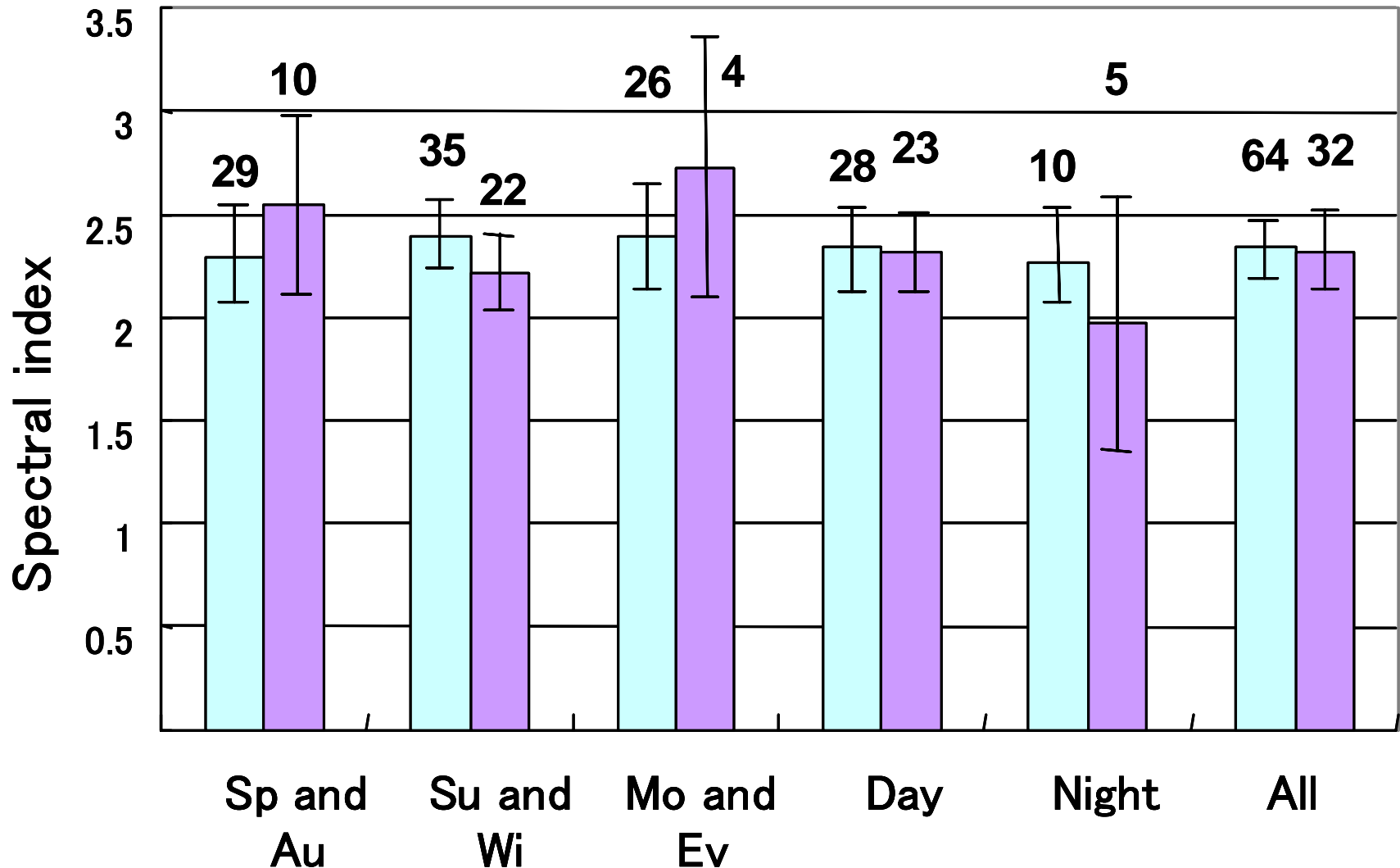
# Lat-long distribution of the burst



# Spectral index (FB)

\*Error bars: 95 % confidence interval (Gaussian distribution)

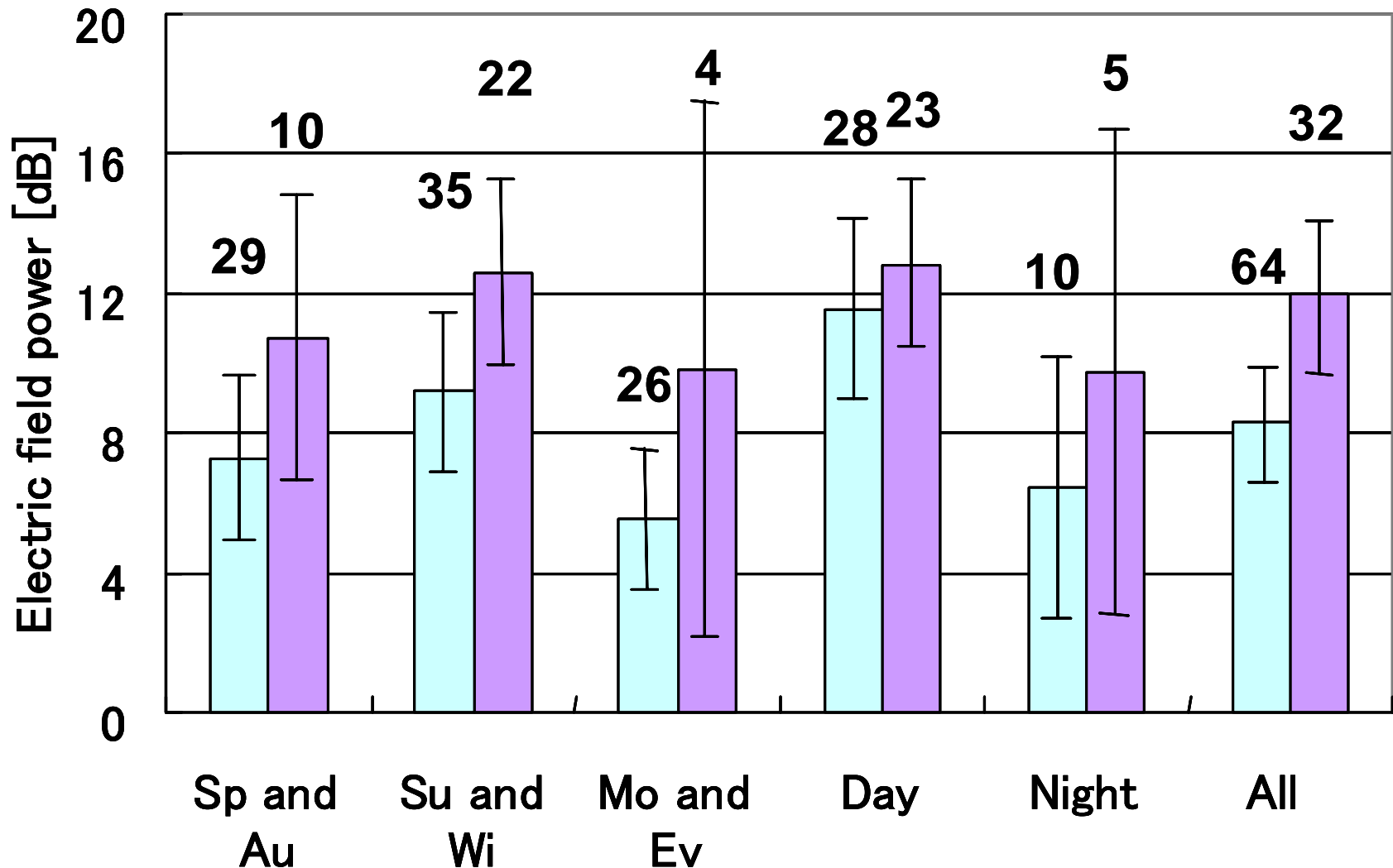
□ No EQs  
■ With EQs



# Electric Field Power (FB)

\*Error bars: 95 % confidence interval (Gaussian distribution)

□ No EQs  
■ With EQs



## The statistical test

The probability to have different parent distributions between seismic and non seismic periods. (Gaussian distribution assumed)

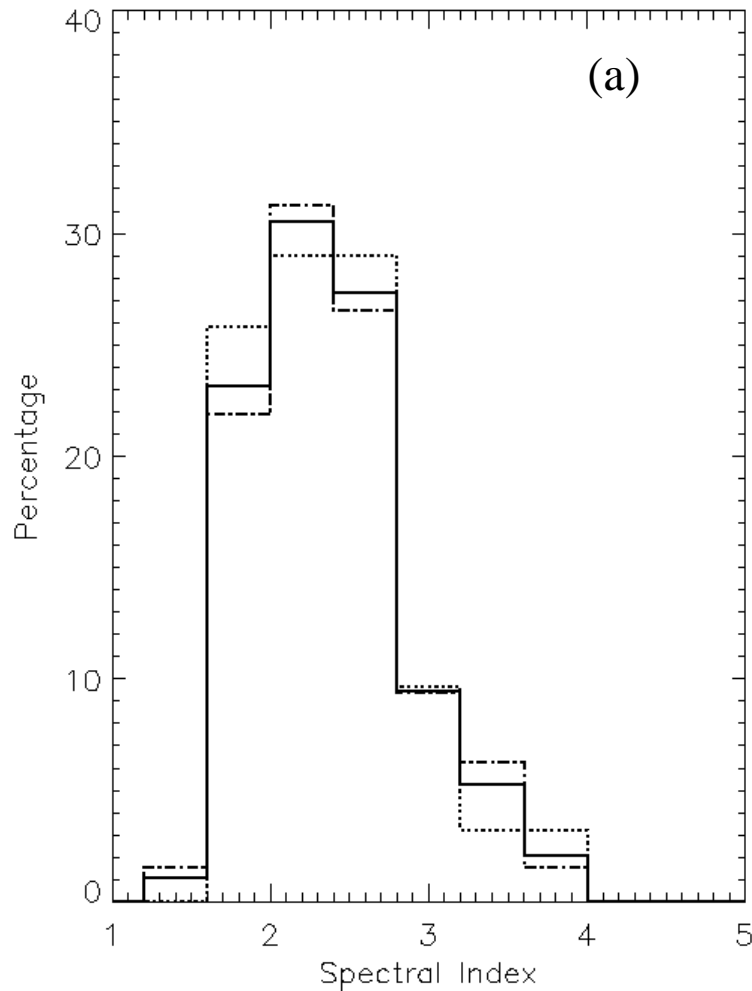
	Sp. and Au.	Su. and Wi.	Mo. and Ev.	Day	Night	All
Spectral index	0.55	0.67	0.55	0.05	0.5	0.094
Electric field power	0.7	0.82	0.61	0.38	0.45	0.93



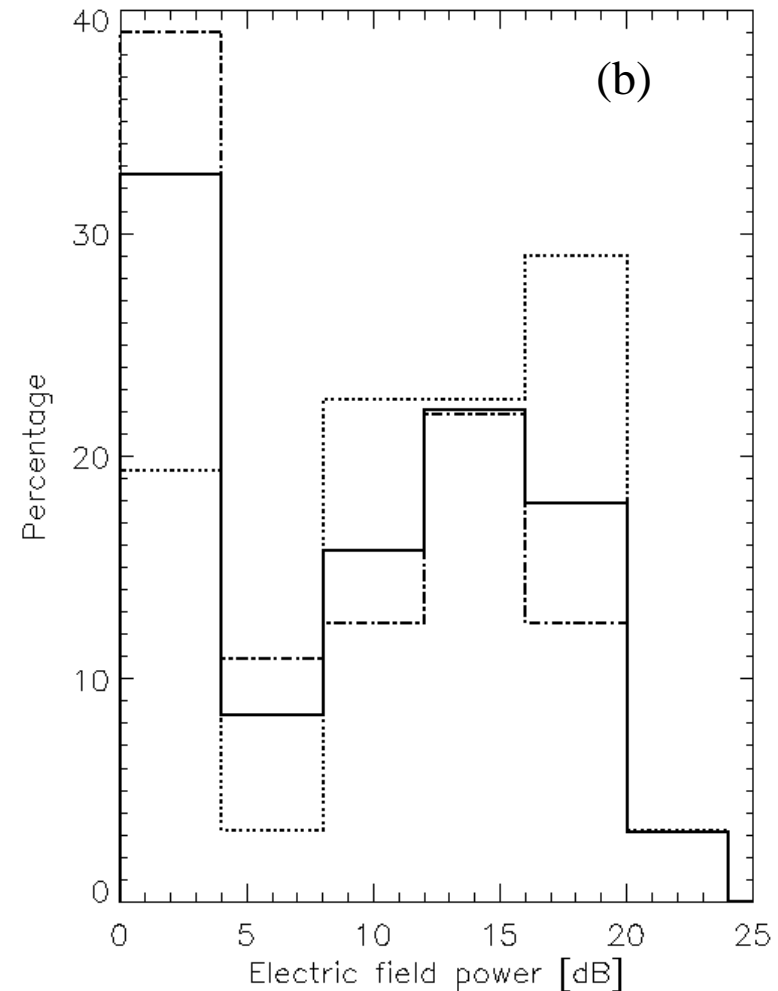
# Probability Distributions

Solid: ALL  
Dotted: EQ  
Dash dotted: NO EQ

\*/ARCAD3/BURST/INSTALL/plot\_allhist.pro: V00, MIN=0, MA=5,BINSIZE=0.4  
Distribution of spectral index of the burst



\*/ARCAD3/BURST/DEVELOP/cal\_alpha.pro: V09, MIN=-8, MA=40,BINSIZE=4  
Distribution of E-field power of the burst



## Conclusion

- Spectral indices for density and electric field turbulence in the IT (ESF) show similar value around 2 for different days (case study)
- 96 events of electric field enhancement (burst events) connected to the IT in low-mid latitudes are analyzed.
- Spectral indices for seismic and non-seismic events have no remarkable statistical difference.
- Mean E-field burst power between seismic and non-seismic burst events has a statistical difference with 93 % confidence.
- AGW and/or atmospheric turbulence due to the seismic activity may intensify the IT.