Solar Physics and Space Weather Research Activities at the Helio Geophysical Mountain Laboratory (HML) at CASLEO and OAFA

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Instrumental Facilities at CASLEO and OAFA

- **Solar Submillimeter Telescope (SST; 1999)**

212 and 405 GHz flare observations
Highest energy particles
Dynamics of the low solar atmosphere

- **POEMAS (2012)**

45 and 90 GHz polarimeters
Cm and mm flare emission
Active region

- **CARPET (2006)**

Charged particle detector
Solar modulation of CR flux
FD

- **SAVNET (2007)**

Ionospheric Physics
Response to solar and non-solar bursts
Magnetic Anomaly
Electron density profile
HF absorption

- **Solar Neutron Telescope and Atmospheric Hard X/γ rays (2014)**

Energetic processes in the Earth atmosphere during thunderstorm activity.

MID Infrared active and quiescent solar phenomena

- **Atmospheric Electric Field – AFINSA (2008)**

Study of GAEC
Carnegie Curves
Effects of Geophysical disturbances

INDICATION OF ANOTHER SOLAR BURST CONTINUUM SPECTRUM IN THz

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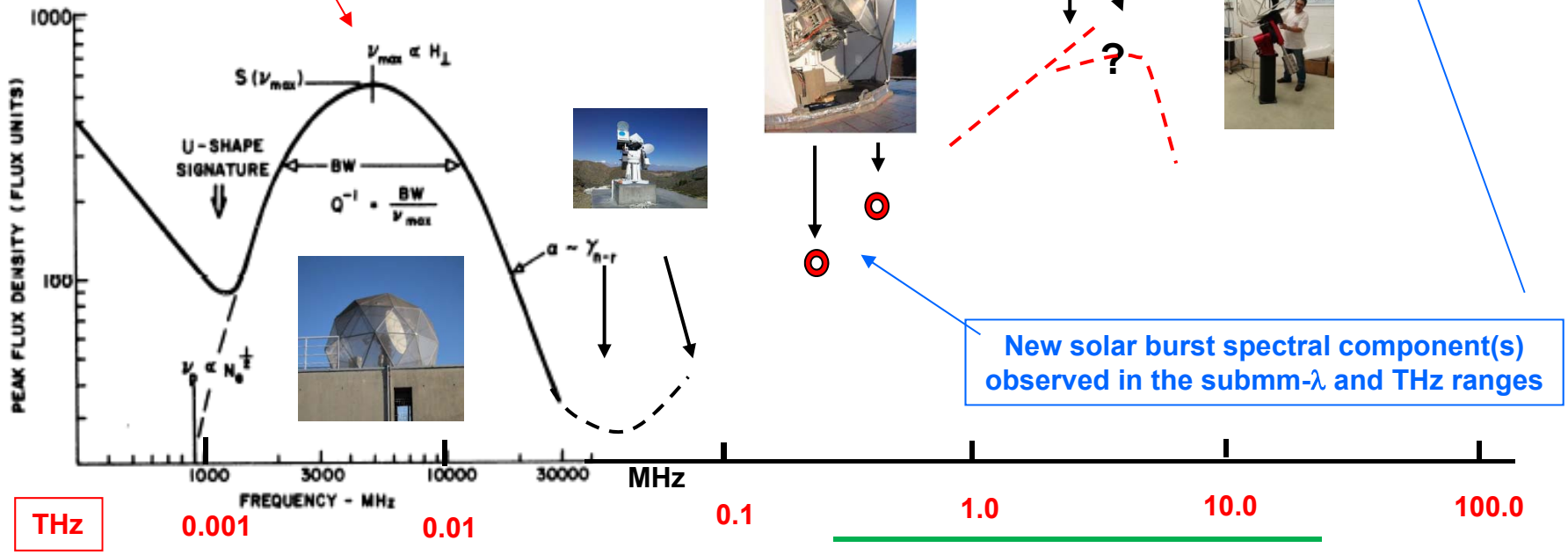
U-shaped spectrum (Castelli 1972)
Assumed as typical and common to all bursts



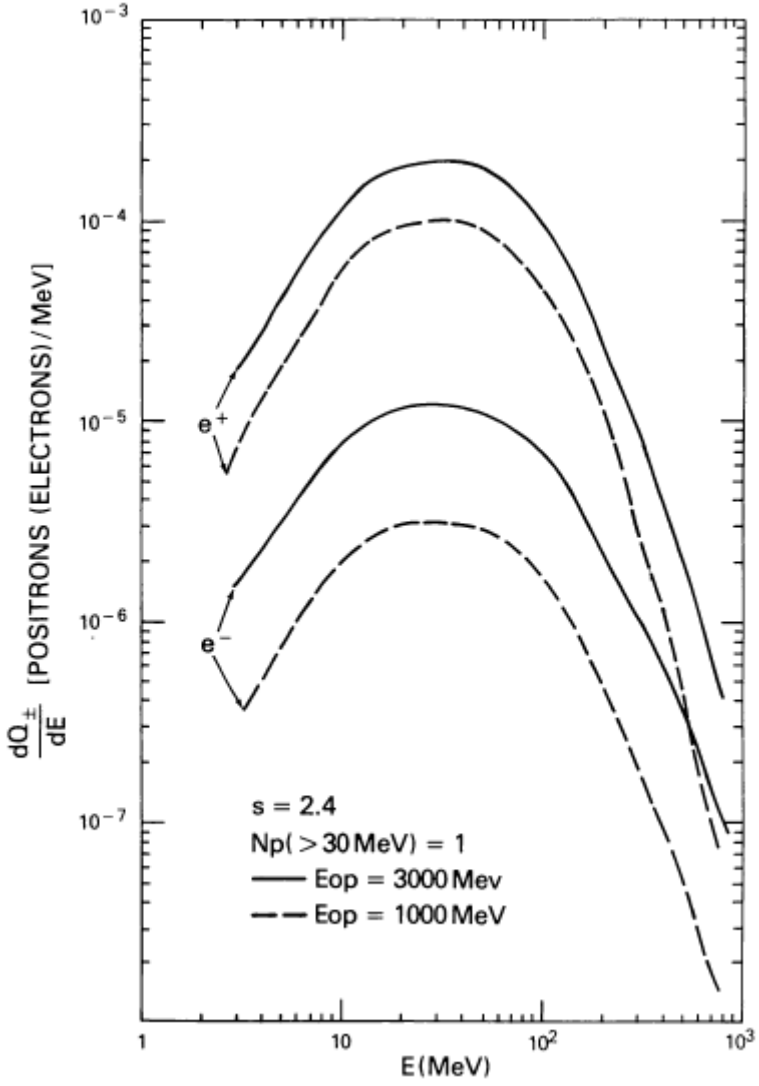
New solar burst spectral component(s) observed in the submm-λ and THz ranges

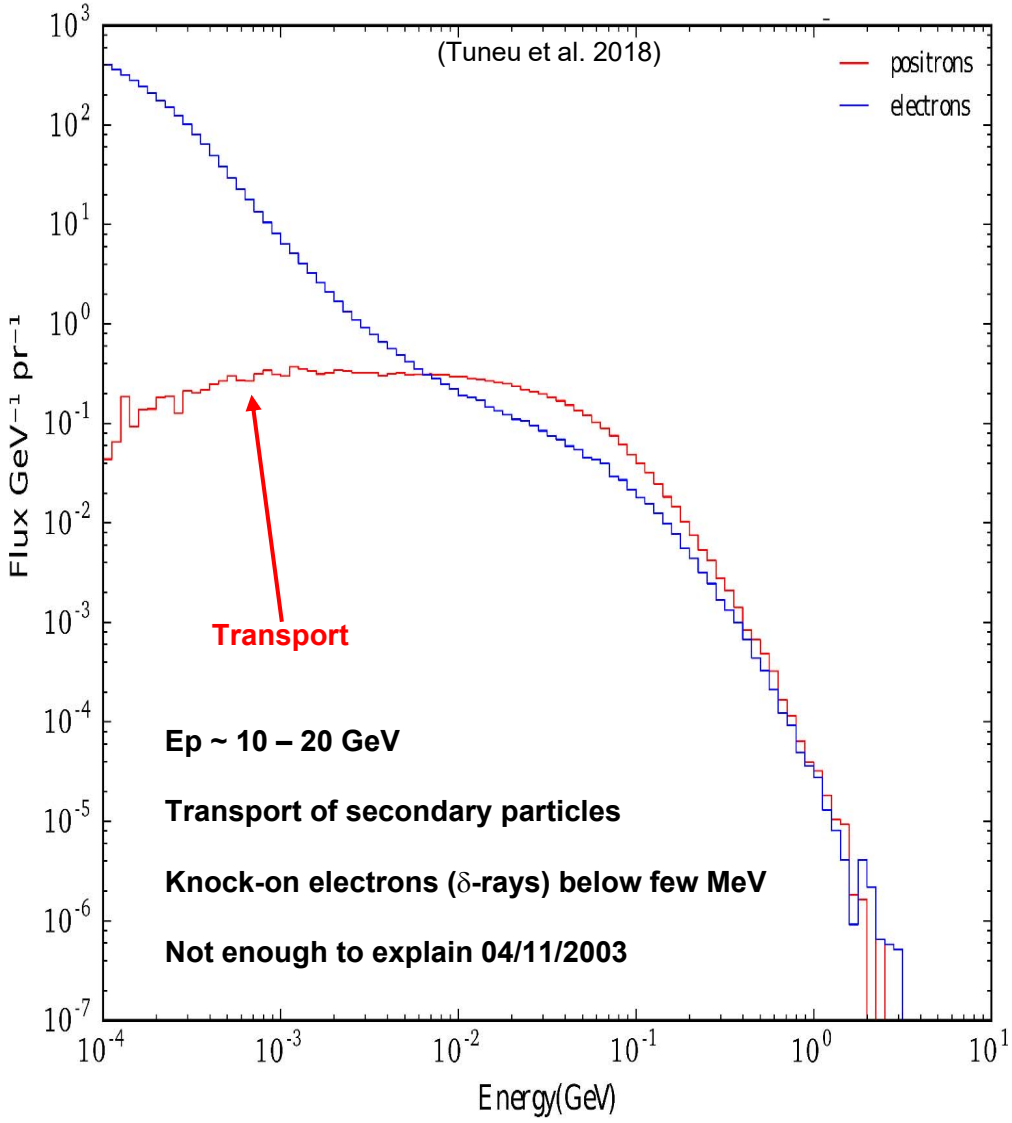
Kaufmann et al. (2004; 2009) Luethi et al. 2004; Trottet et al. 2008; 2011); Silva et al. 2007; Raulin et al. (2003; 2004; 2014)

SUN-TERAHERTZ onboard ISS
0.2 – 15 THz

OBSERVATIONS IN THE THz RANGE ARE NEEDED TO UNDERSTAND THE EMISSION MECHANISMS INVOLVED

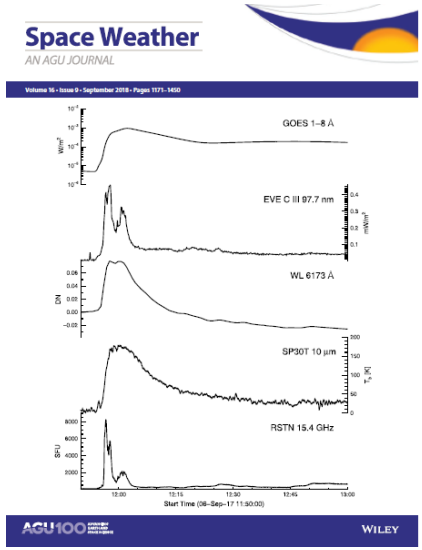
Positron production during flares



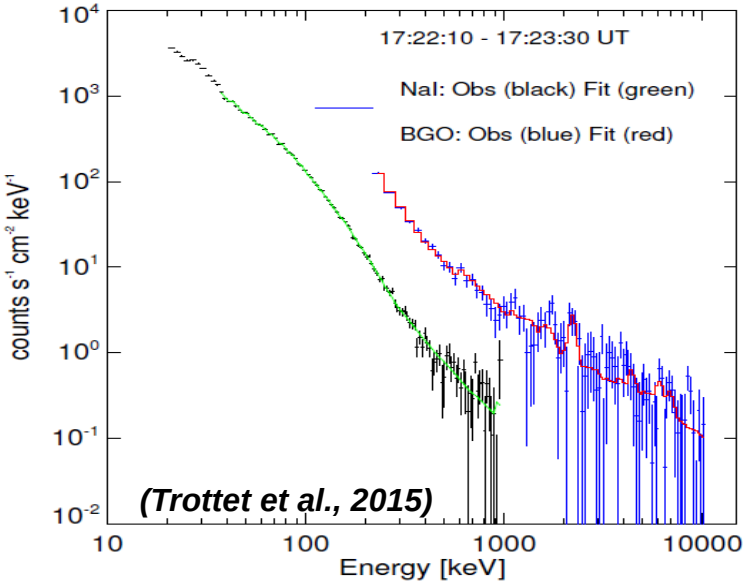


IR Instrumental facilities

10 μ solar observations at OAFA



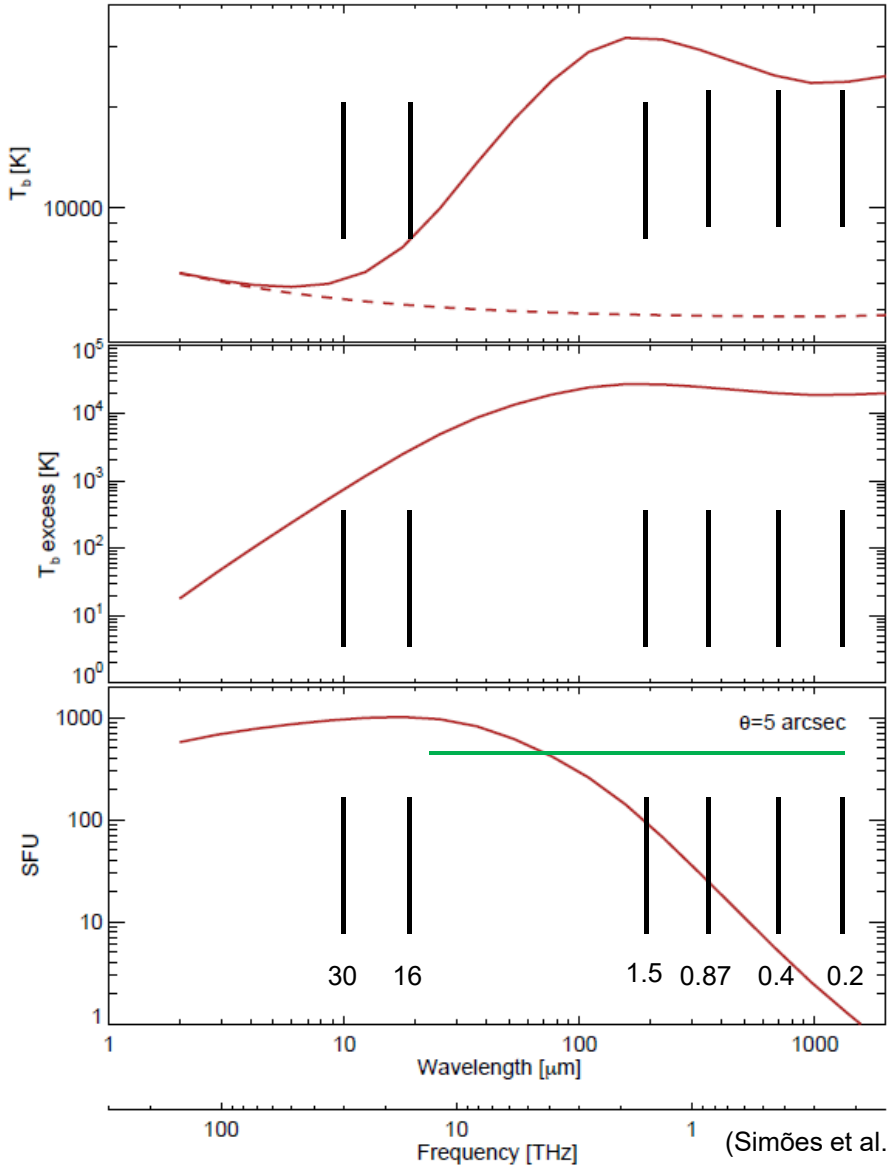
(de Castro et al., 2018)



30 THz quiescent emission → an optically thick layer at ~ 5000 K below the temperature minimum region.

30 THz flare emission is consistent with that expected from the F2 (Machado, Mauas) model: (i) 80% → optically thin source at ~ 8000 K well above the temperature minimum region; (ii) 20% → optically thick source below the temperature minimum region. In agreement with old models (Ohki & Hudson, 1975).

Next



(Simões et al. 2017)

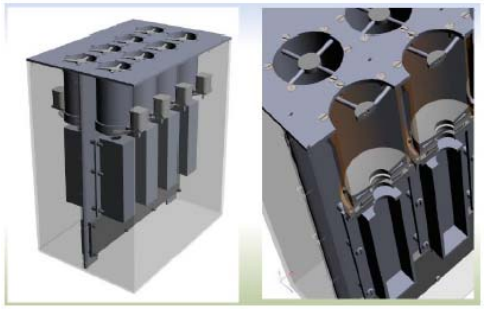
- **Solar Submillimeter Telescope (SST) - Upgrade**

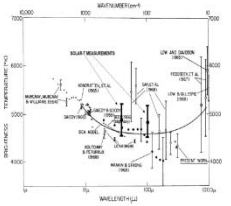
- **HATS: High Altitude Terahertz Solar telescope – 16 THz**

  - Sub-systems integration: mount + optics + Golay
  - Installation at OAFA (2550 masl) end-2019

- **SUNTERAHERTZ onboard ISS (ROSCOSMOS)**

  - Phase B approved 03/2019
  - 0.2 – 15 THz

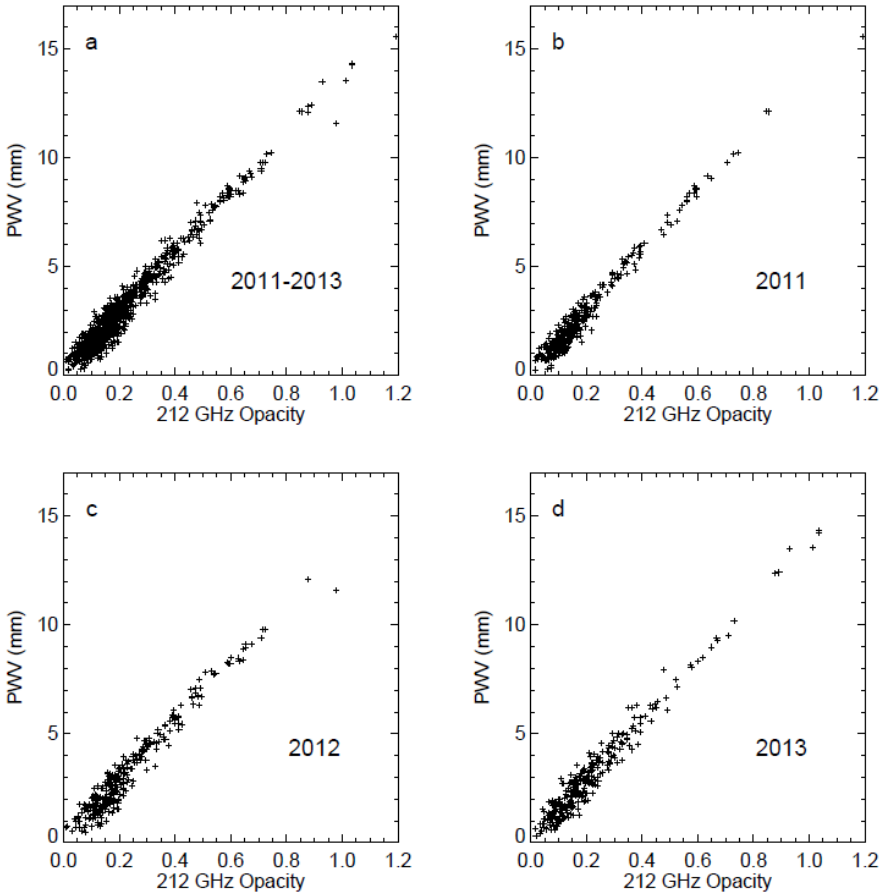


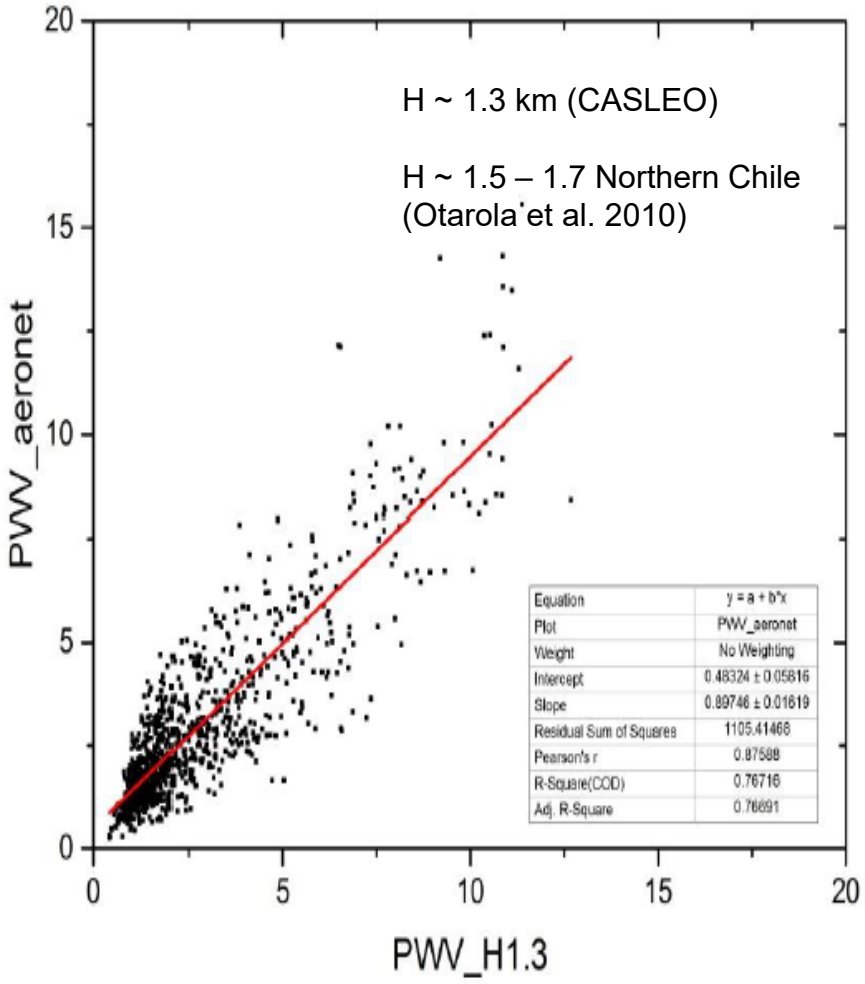


Atmospheric transmission measurements at submm-λ at CASLEO

PWV AERONET versus τ_{212} ; R = 0.98 ; slope ~14 mm/Np

(Cassiano et al. 2018)





Infer PWV when τ_{212} available

TRANSIENT SOLAR FORCING: FLARES

Photons and/or energetic particles → ionization excesses → changes of the electrical conductivity

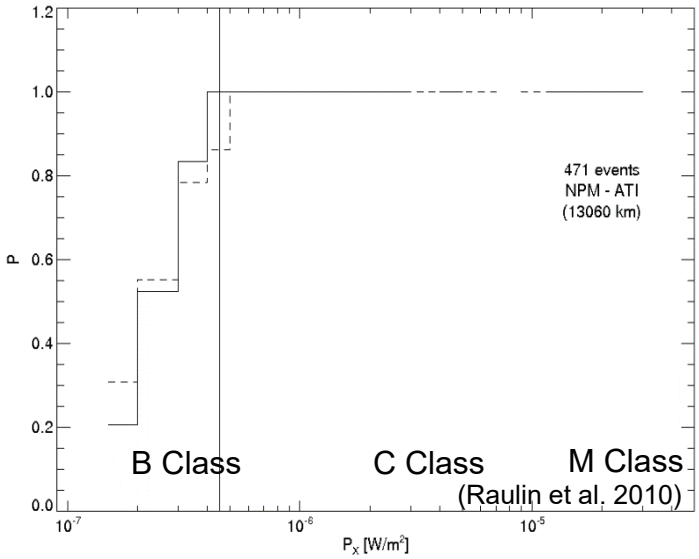
→ VLF propagation anomalies → VLF phase and amplitude changes

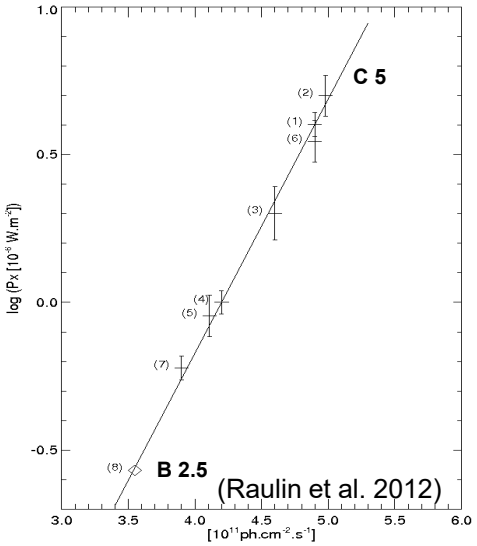
Solar: quiescent, Ly-α, X-rays (flares), particles (SEPs); Non-Solar: X-rays, GRB, flares from SGR

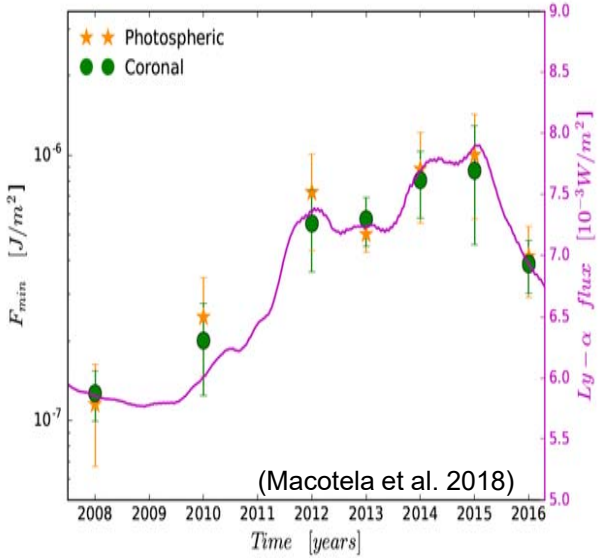
≥ B4 Class events are detected with 100 % probability

the higher the solar activity the higher Px

F_{min} is well correlated with reproduces the solar Lyman-α photon flux





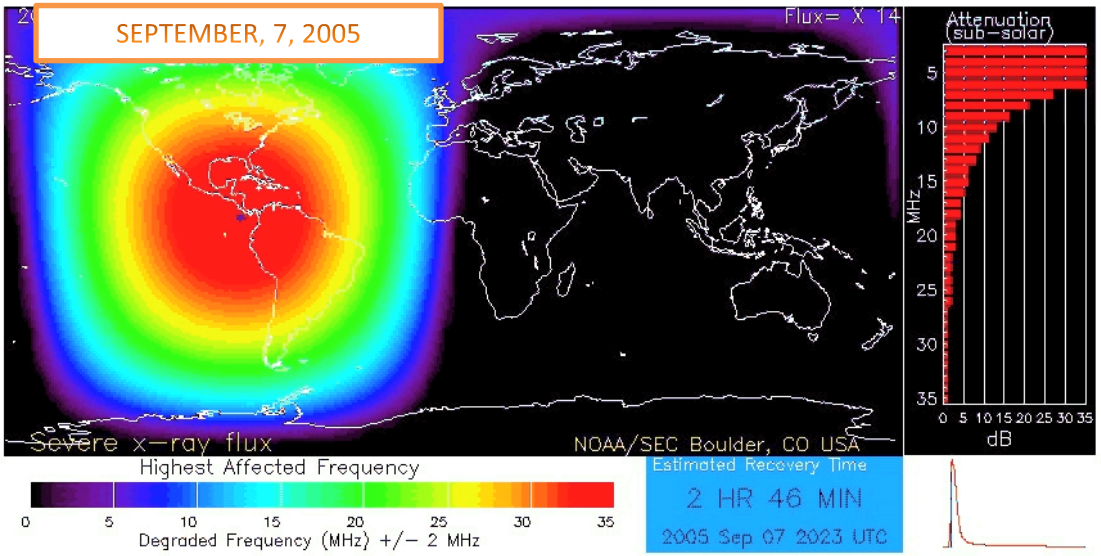


Lyman-α solar radiation maintains the quiet (non-disturbed) ionospheric D-region (Nicolet & Aikin 1960)

Ionospheric índice for the solar Ly-α radiation

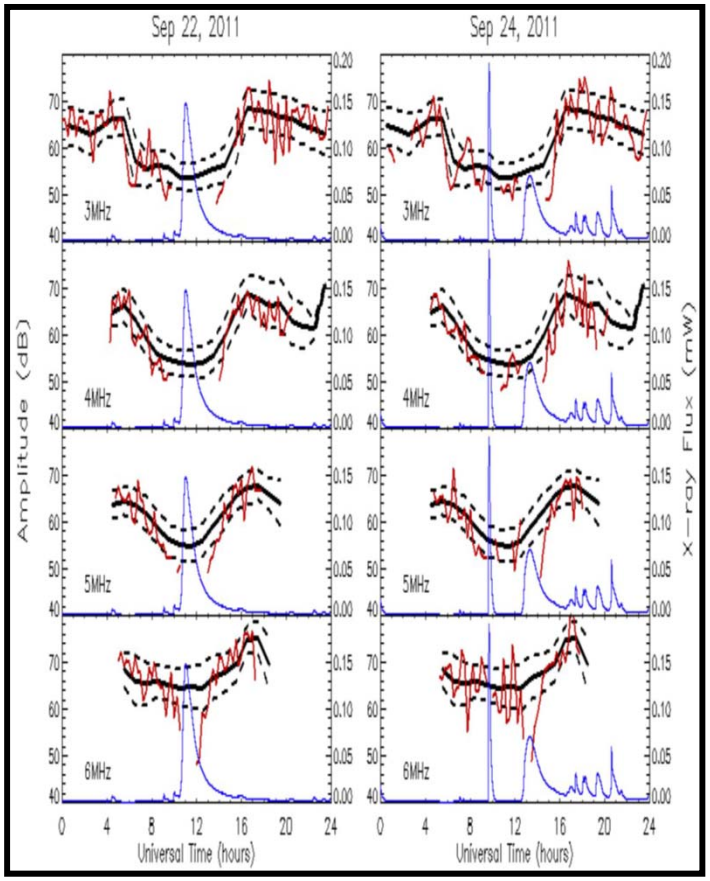
Ionospheric HF absorption

D-RAP at peak time of M3.7 solar flare.



$$HAF\ [MHz] = 10.\ \log[flux\_1\_8\ (W/m^2)] + 65$$

- Photons versus particles
- Riometers of high latitude
- Photon energies
- ionosondes



Tshisaphungo and Danskin, 2016

The AFINSA network https://theafinsa.wordpress.com/

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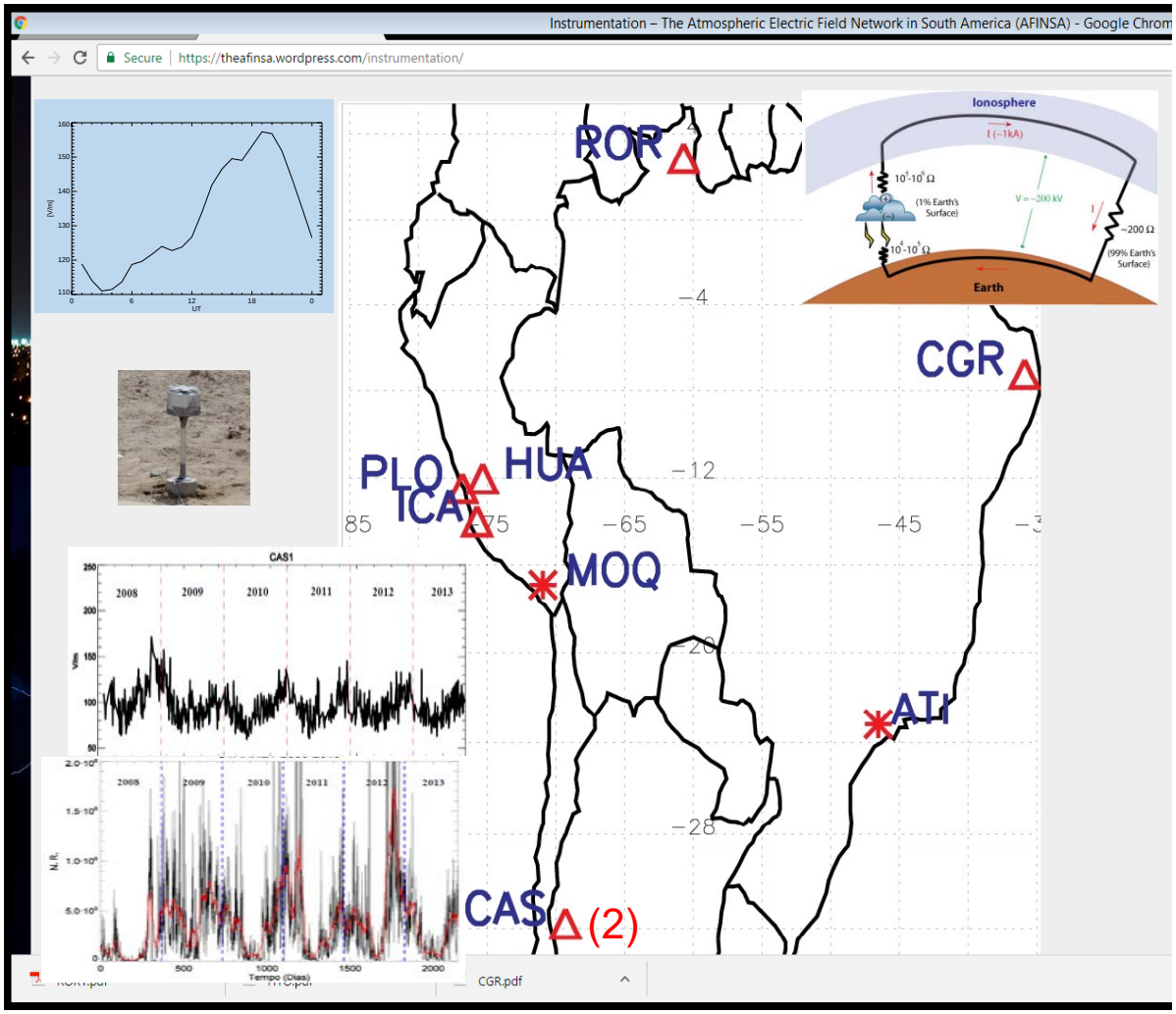
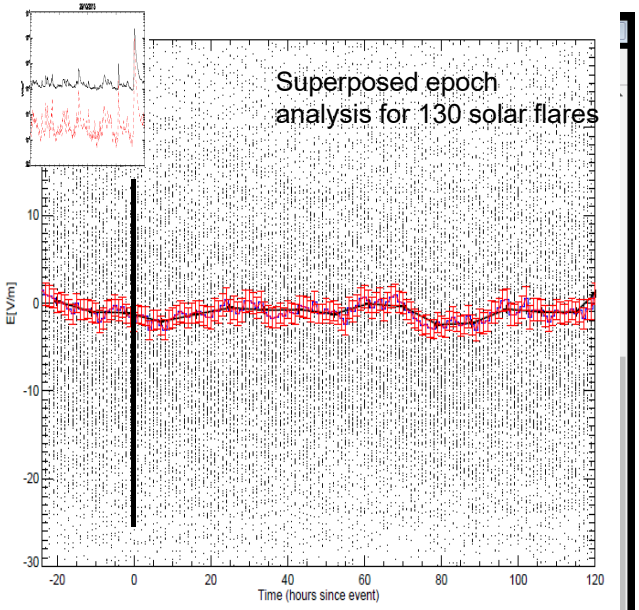
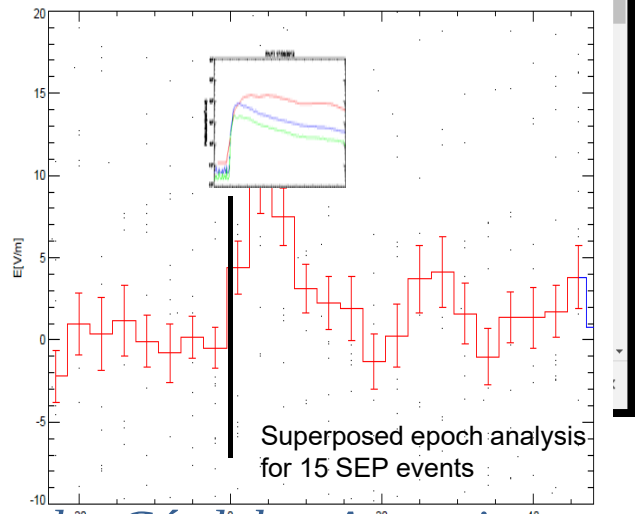
Atmospheric Electric Field - GAEC







Charged particle observations at CASLEO

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Физический институт имени П.Н.Лебедева
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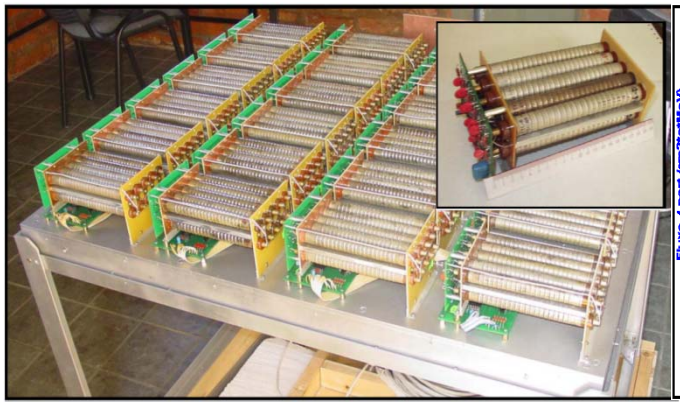
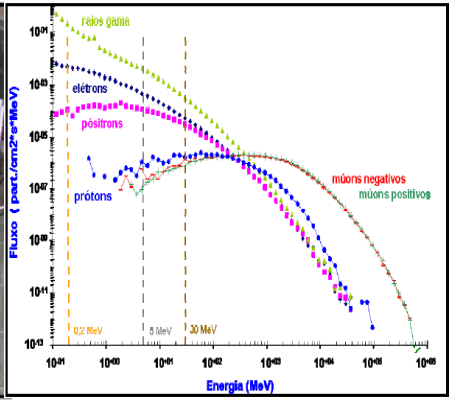
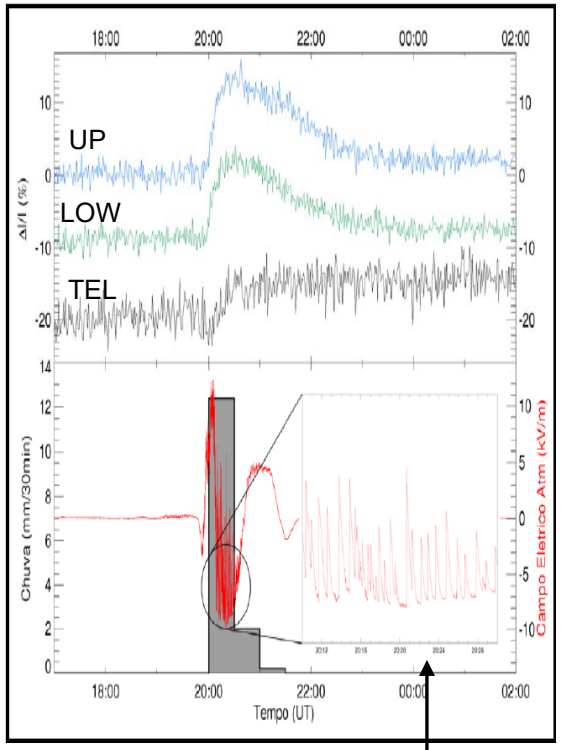
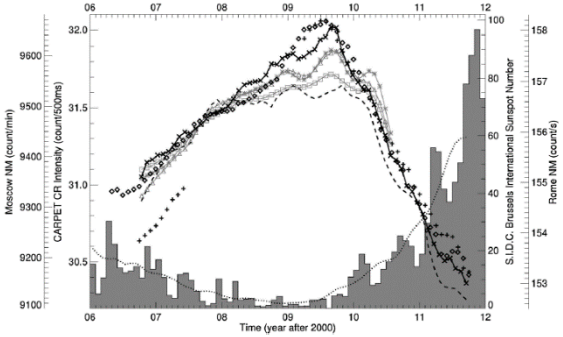


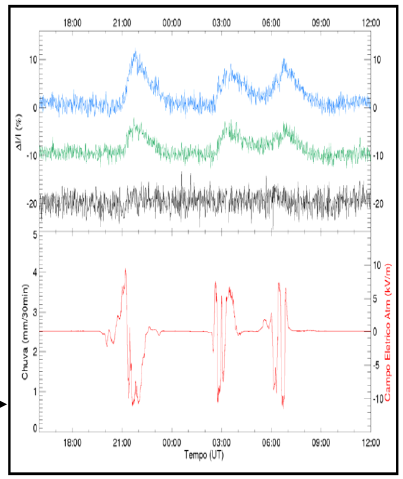


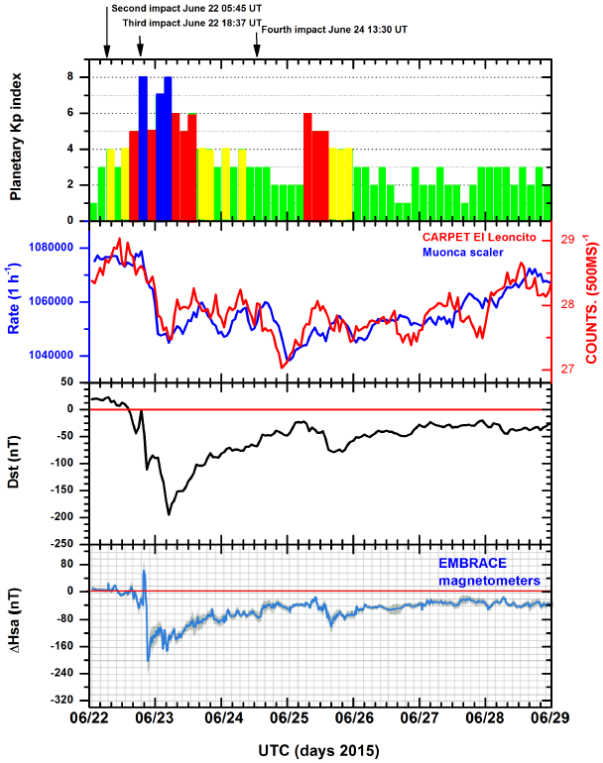


Charged particle acceleration due to few 10s kV/m AEF (Alexeenko, Toropov, Muraki papers).



Modulation of CR during cycle 23

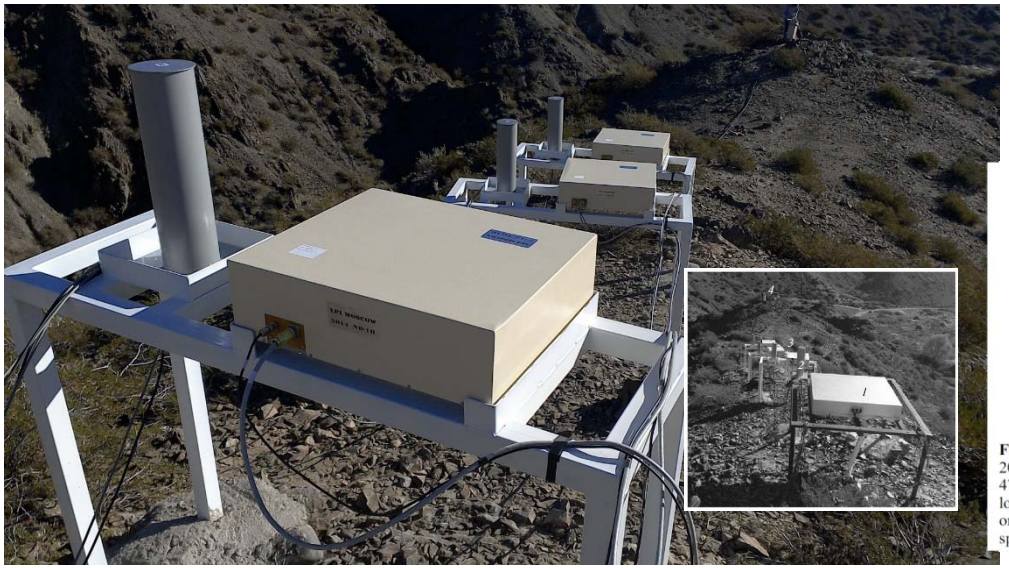




Forbush decrease

WIAA May 8-10 2019, Observatorio Astronómico Córboda, Córdoba, Argentina

Neutrons and X/γ-rays observations at CASLEO



Energetic processes in the Earth atmosphere during thunderstorm activity.

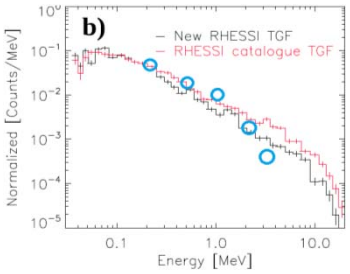
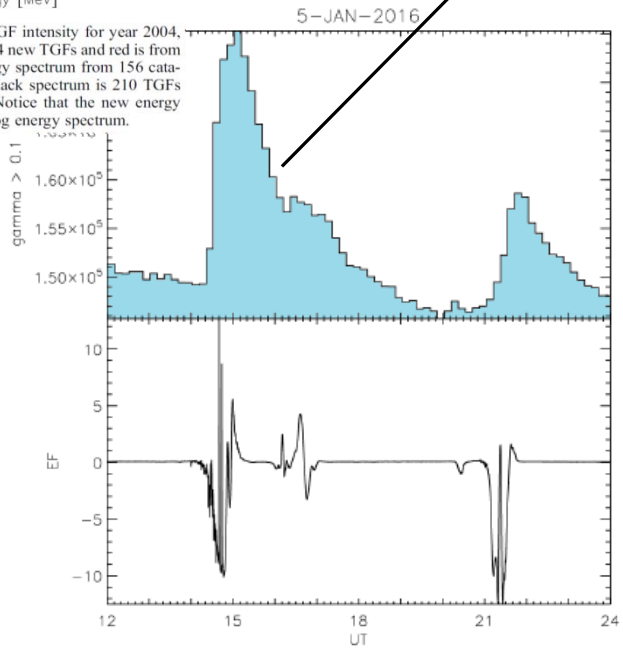
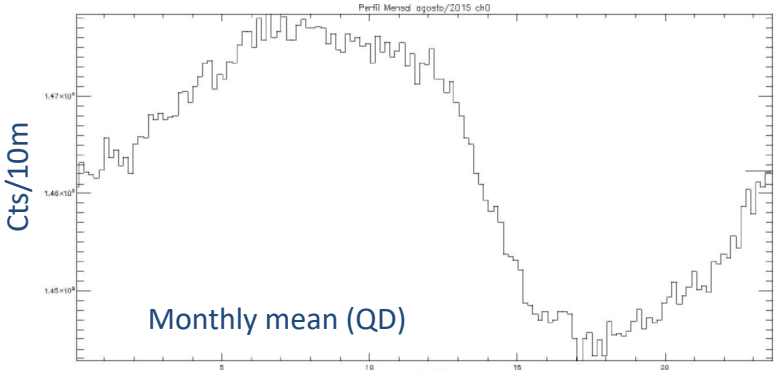
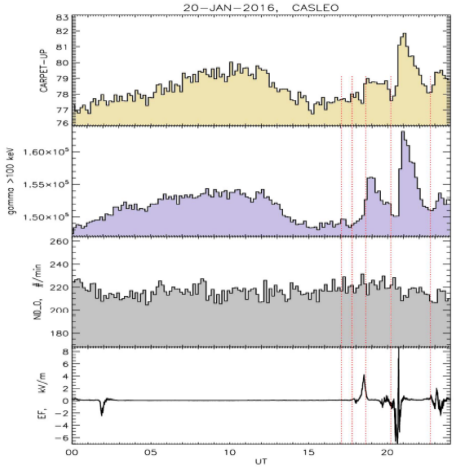


Figure 2. (a) Distribution of TGF intensity for year 2004, 2005 and 2006. Black is from 554 new TGFs and red is from 474 catalog TGFs. (b) The energy spectrum from 156 catalog TGFs in 2004 in red. The black spectrum is 210 TGFs only found in the new search. Notice that the new energy spectrum is softer than the catalog energy spectrum.

Detected > 3 MeV







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Conclusions

Instrumental facilities at Complejo Astronómico El Leoncito (CASLEO) and at Observatorio Astronómico Felix Aguilar (OAFA) allow to study solar flare continuum emission from the mid-infrared domain (a few tens of THz) to the millimeter-sub-millimeter radio domain. Such observations provide in principle unique diagnostics of energy transport processes from the flare energy release region to the chromosphere and of the most energetic flare accelerated particles.

High frequency radio emissions in the mm-λ to submm-λ are produced by the highest energy particles accelerated during solar flares: radiation processes, acceleration mechanisms

High frequency radio emissions in the mm-λ to submm-λ inform on the properties and the dynamics of the cool and dense plasma in the chromosphere

OThinTB and OThickTB candidates to explain IR observations; chromospheric/photospheric plasma heated by accelerated particles

The VLF technique provides a powerful diagnostic of the long-term and short-term solar activity, including disturbances from cosmic bursts

New diagnostics of energetic phenomena in the atmosphere of the Earth

Tables of instrumental characteristics and time periods of operation are available for the use of the whole community