



Cosmic ray physics with the TRAGALDABAS detector

Juan A. Garzón

LabCAF, IGFAE. Univ. Santiago de Compostela
on behalf of the

TRAGALDABAS Collaboration

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IS CRA. Moscow, June 22nd. 2017



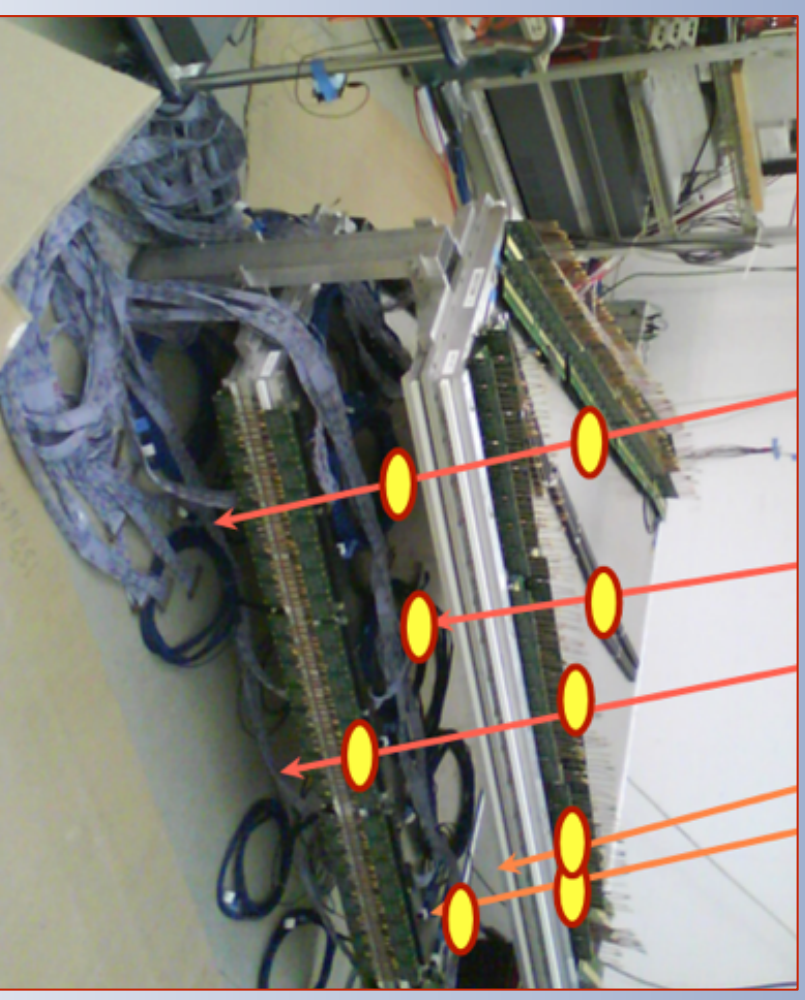
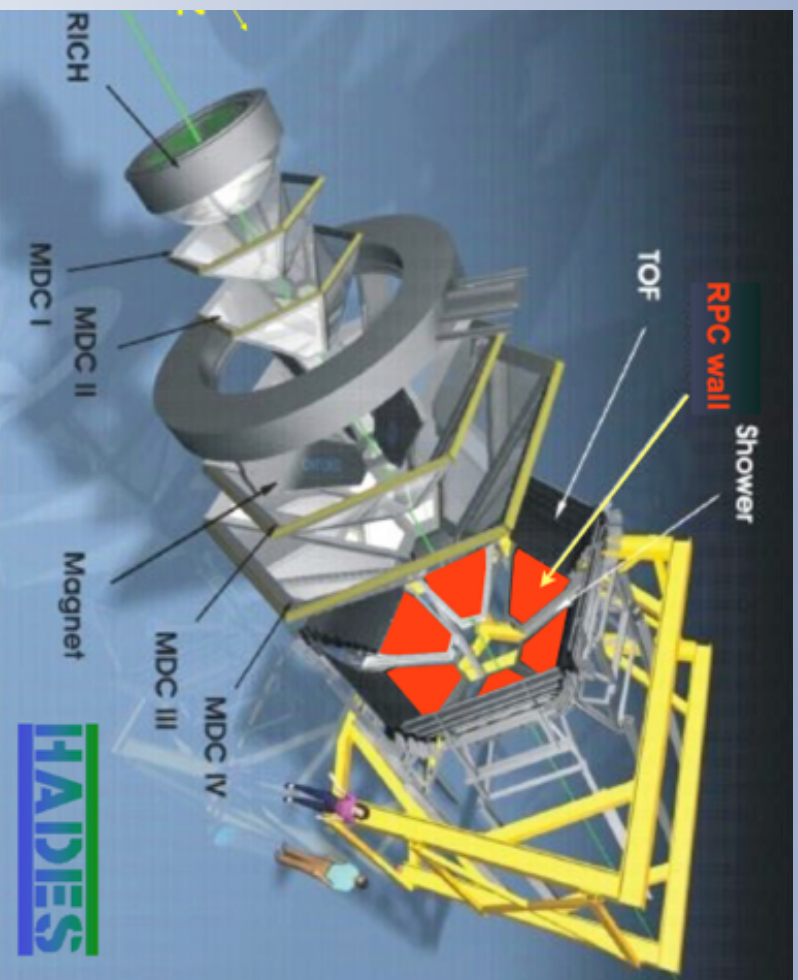
Outlook:

1. The beginning
2. The TRASGO Project
3. The first TRASGO: TRAGALDABAS
4. TRAGALDABAS: preliminary results
 - FD June 2015
 - Atmosphere analysis
5. The TRASGO Project: Next steps & Summary

The beginning

The Nuclear Physics HADES experiment

The RPC wall commissioning

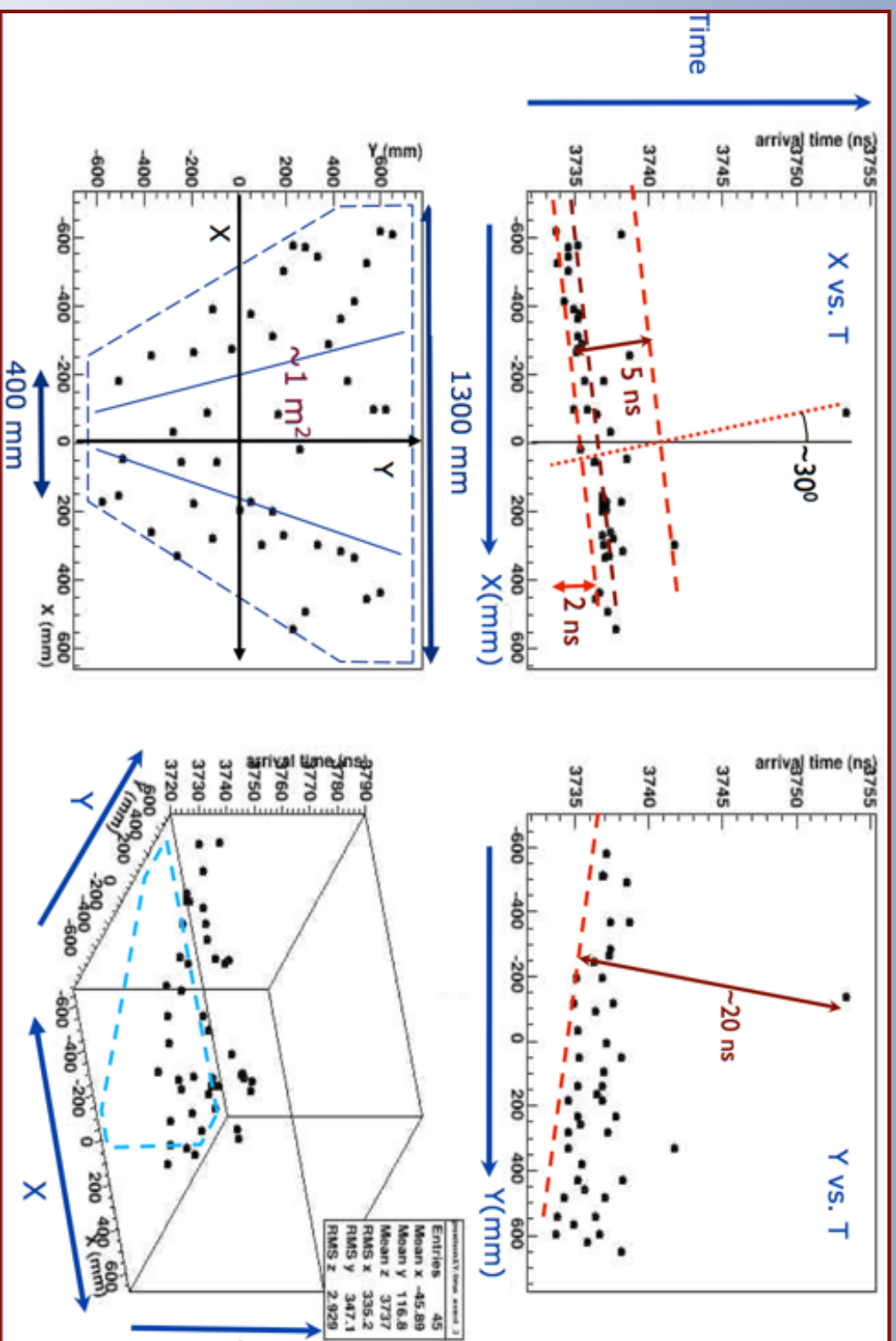


The HADES spectrometer at GSI-Darmstadt

RPC commissioning with cosmic rays

The beginning

A cosmic ray shower picture using the HADES RPC detectors

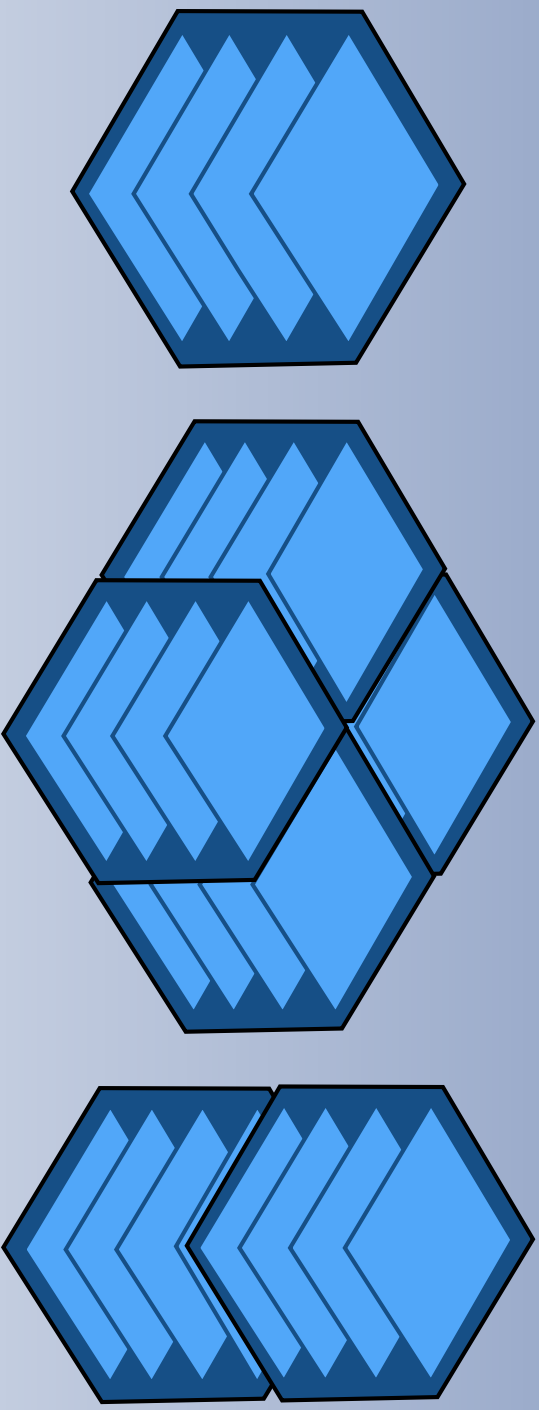


$\delta T \sim 150$ ps, $\delta S \sim 5$ cm², $\delta \theta \sim 5^\circ$

Never cosmic rays were observed at the Earth's surface with such accuracy!

The TRASGO project

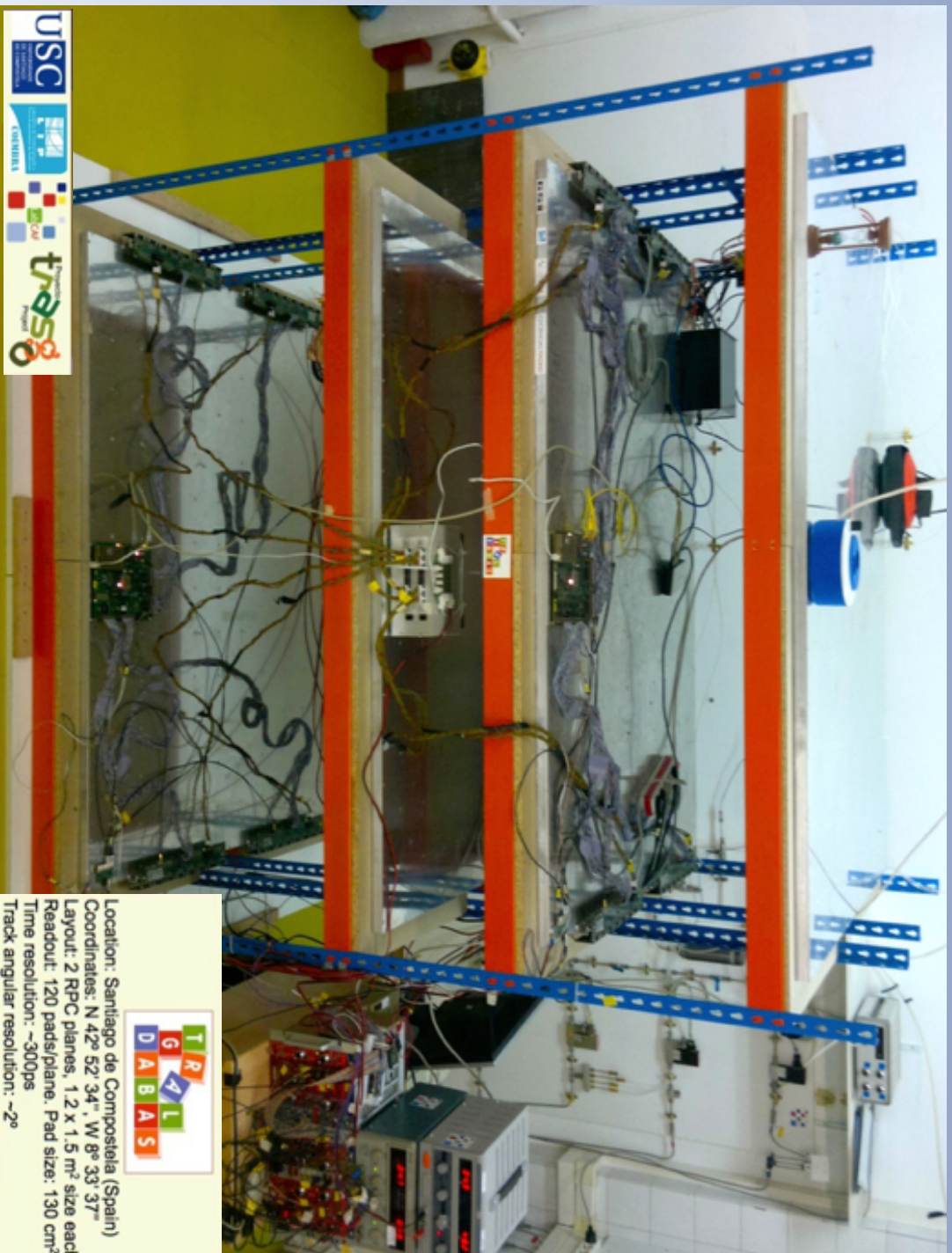
The idea: why not developing modular cosmic ray tracking detectors?



The solution: **TRASGO** (= pixie, goblin) : **TRAcK** reconStructing box

- Multi-channel Tracking detector
- Modular concept
- Sensitive to both muon and electromagnetic showers (software PID)
- Stand-alone Plug&Play very affordable detector (RPC-based)

The first Trasgo: TRAGALDABAS (Pronuntiation: *truɡuldubus*)



TRASGo for the Analysis of the nuclear matter Decay, the Atmosphere, the earth B-field And the Solar activity

The first Trasgo: TRAGALDABAS

The TRAGALDABAS Collaboration

H. Alvarez-Pol, A.Blanco, J.J.Blanco, P.Cabanelas, J.Collazo, J.Cuenca, P.Fonte, Y.Fontenla, D.García Castro, J.A.Garzón, A.Gómez-Tato, D.González-Díaz, G.Kornakov, T.Kurtukian, L.Lopes, A.Morozova, J.C.Mouriño, M.A.Pais, A.Pazos, V.Pérez Muñuzuri, P.Rey, I.Riádigos, M.Seco, V. Villasante

Laboratory / Task

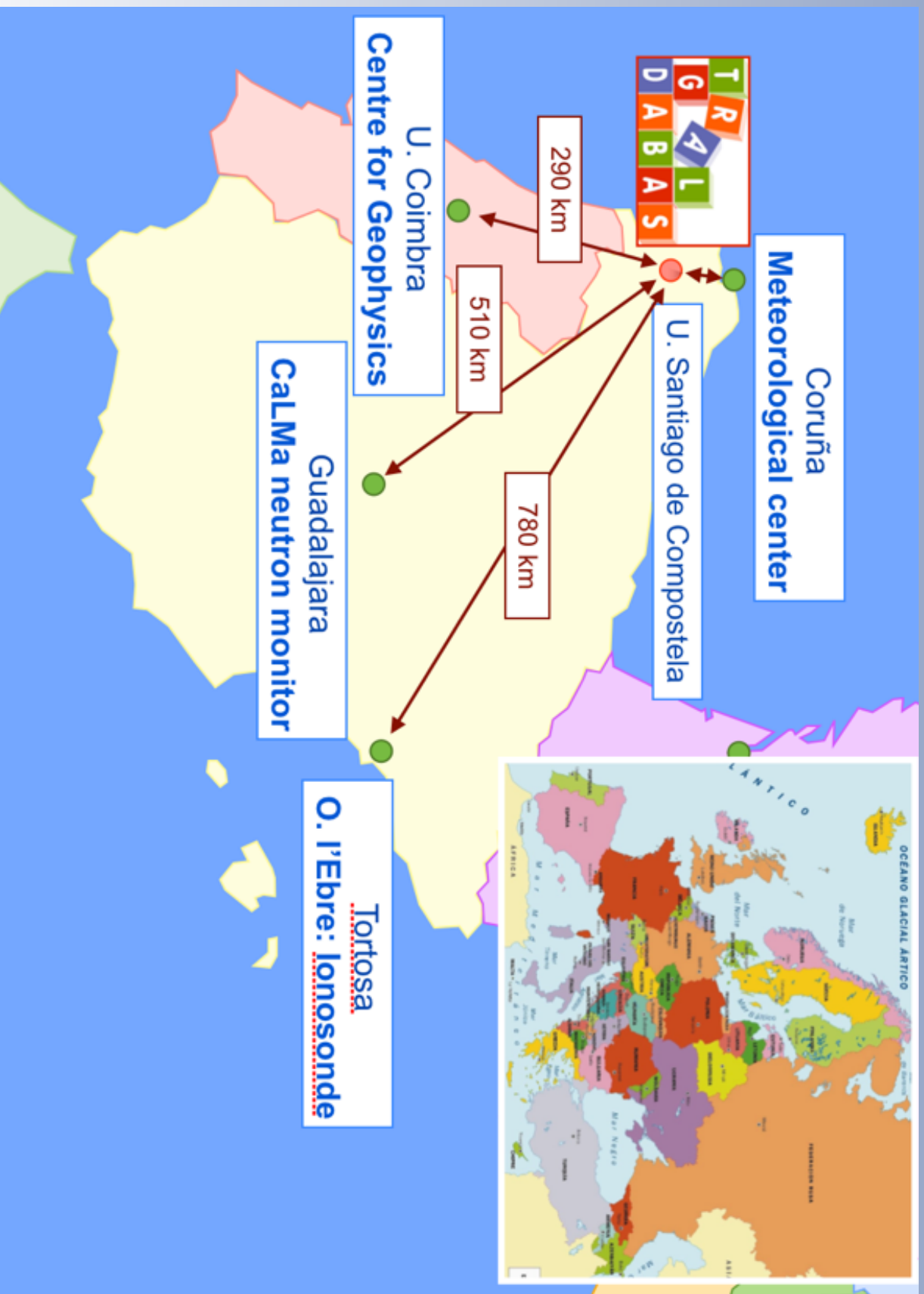
1. Univ. Alcalá de Henares, Spain / **Solar Physics**
2. CEN - Bordeaux, France / **Nuclear and Solar Physics**
3. CITEUC - U. Coimbra, Portugal / **Geomagnetic field and Space Weather**
4. CESGA Supercomputation Center - Santiago de Compostela, Spain / **Data storage and distribution**
5. GENP - Univ. Santiago de Compostela, Spain / **Software development and simulation**
6. IGFAE - Univ. Santiago de Compostela, Spain / **Monitoring and Slow control**
7. LabCAF - Univ. Santiago de Compostela, Spain / **Track reconstruction and data analysis**
8. NILFG - Univ. Santiago de Compostela, Spain / **Atmosphere and Climate studies**

Other partners:

ATI Sistemas. La Coruña, Spain
Hydra Technologies Spain S.L. Vigo, Spain
Club Desarrollo de las Ciencias, Madrid, Spain

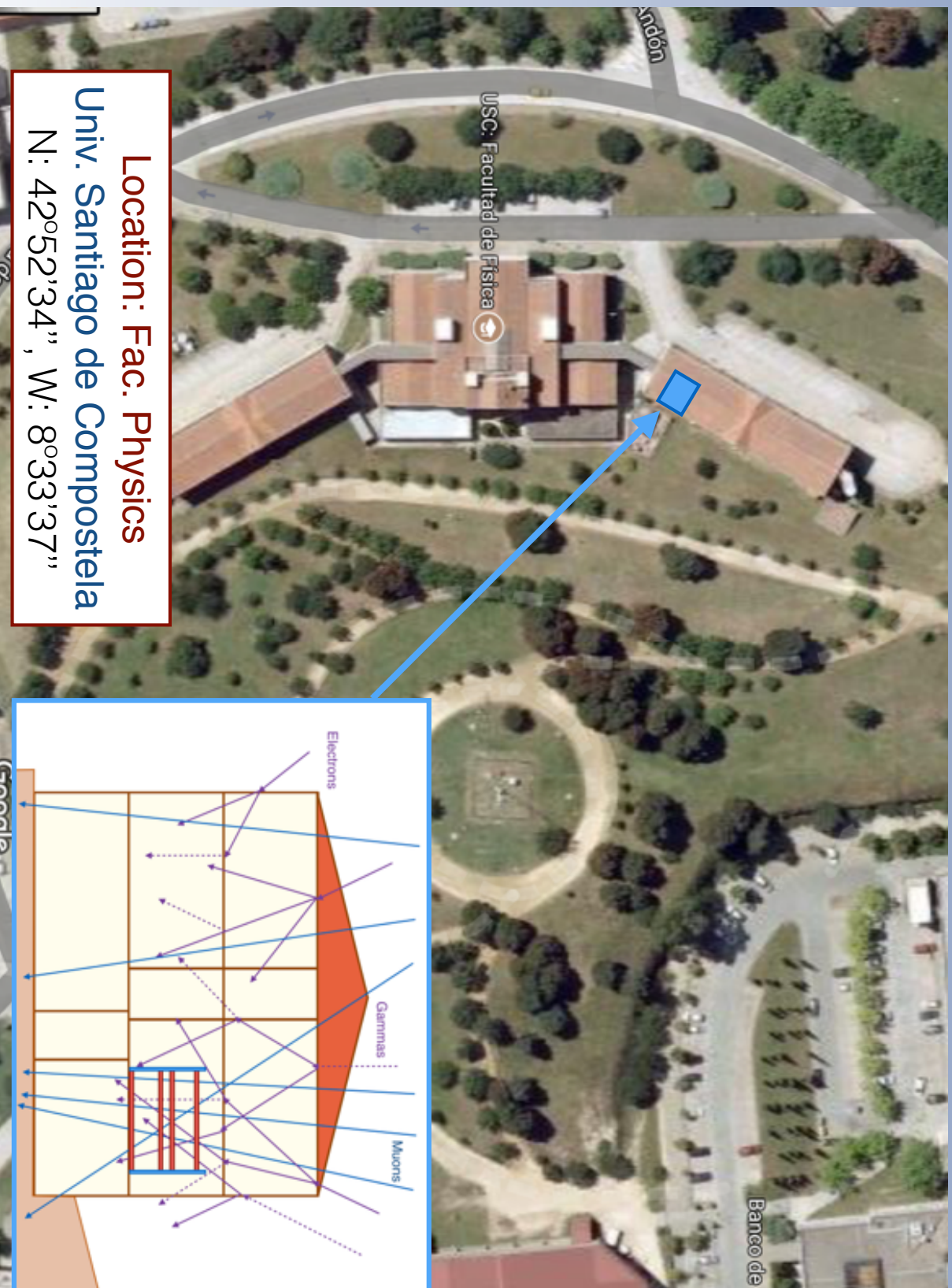
The first Trasgo: TRAGALDABAS

Location



The first Trasgo: TRAGALDABAS

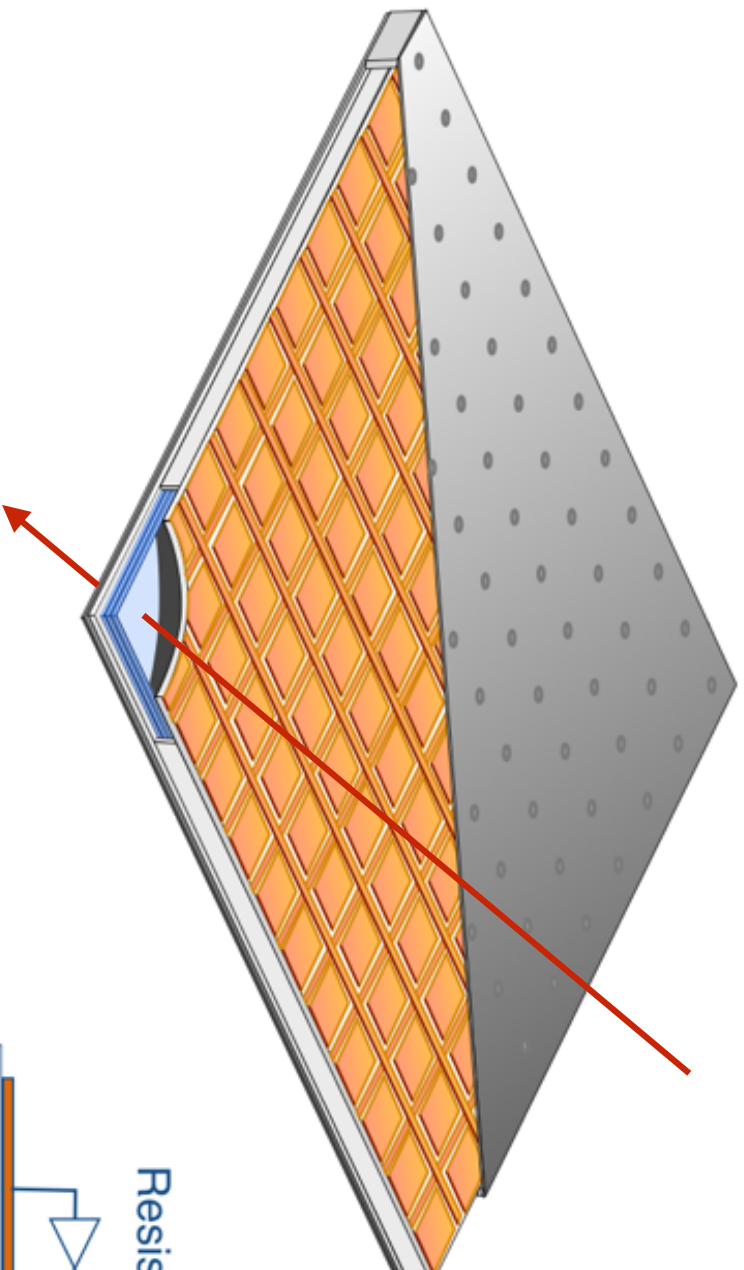
The site



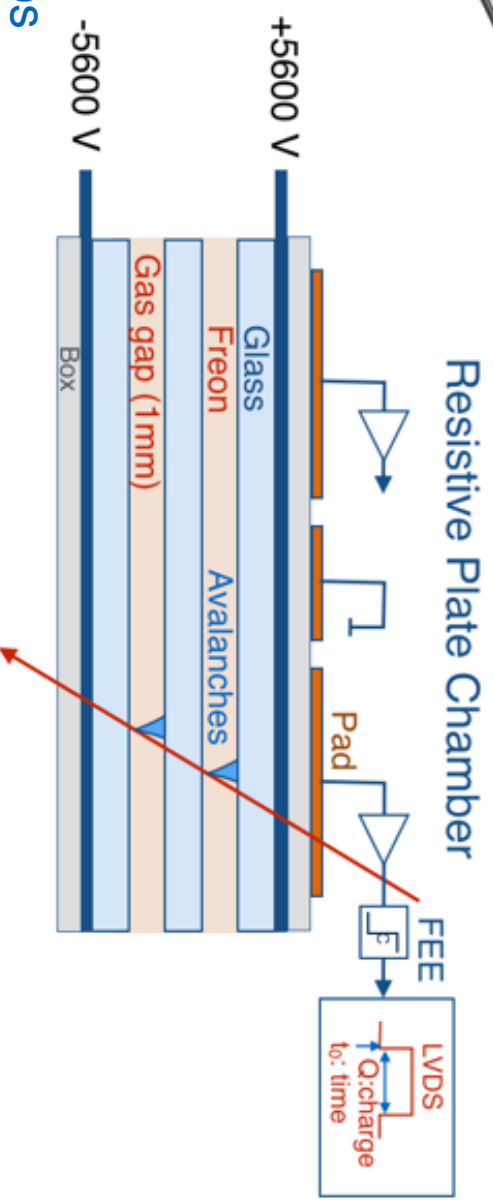
Location: Fac. Physics
Univ. Santiago de Compostela
N: 42°52'34", W: 8°33'37"

The first Trasgo: TRAGALDABAS

The timing RPC technology

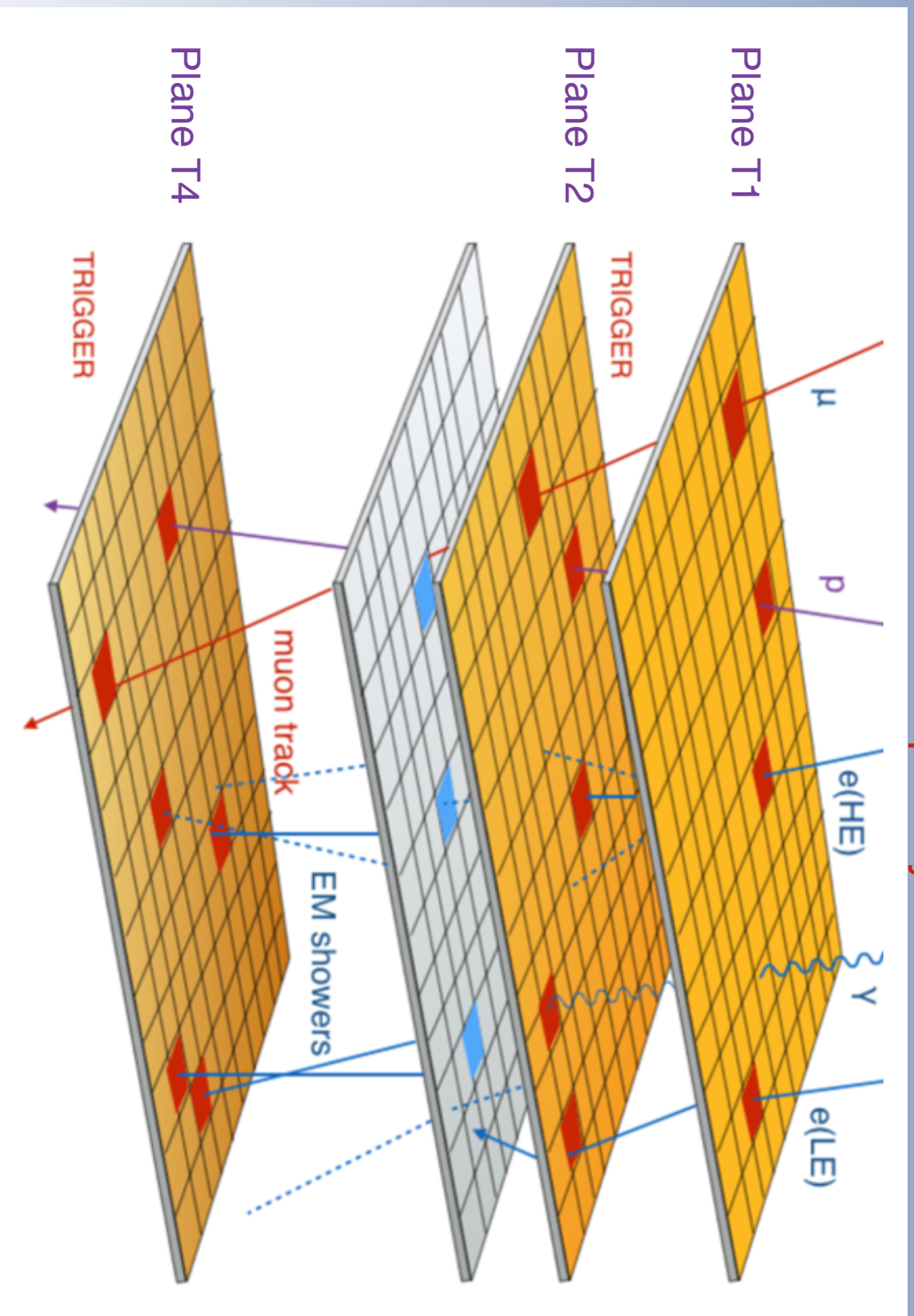


- Main features:
- Very affordable technology
 - Very good time resolution: ~ 0.5 ps
 - 120 (10x12) channels ($\sim 11 \times 11$ cm²)
 - 1.8 m² (1.2 x 1.5 m²) planes



The first Trasgo: TRAGALDABAS

PID capability

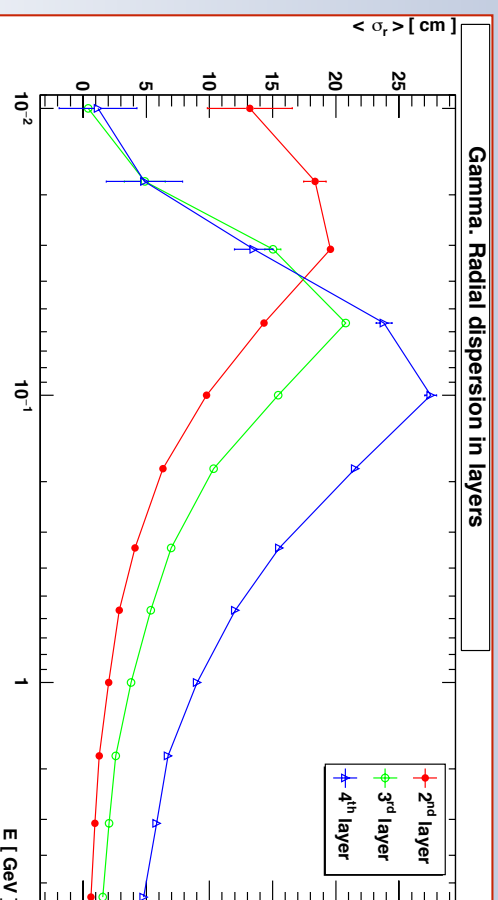
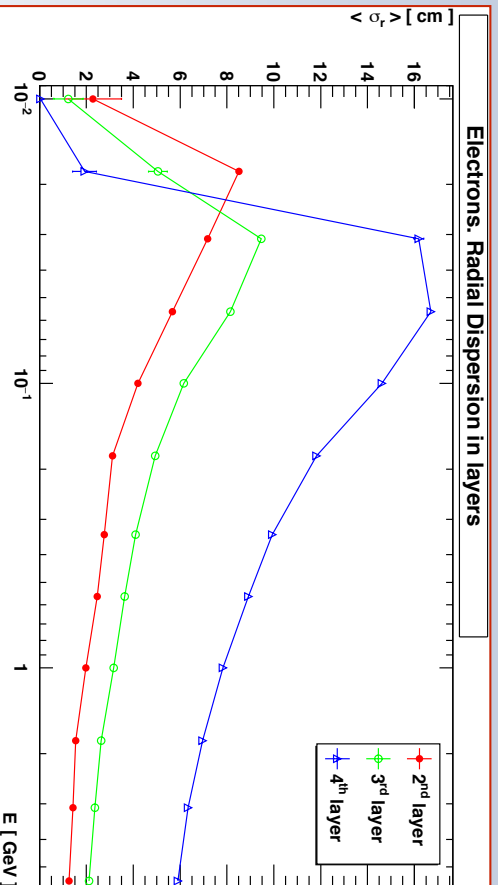
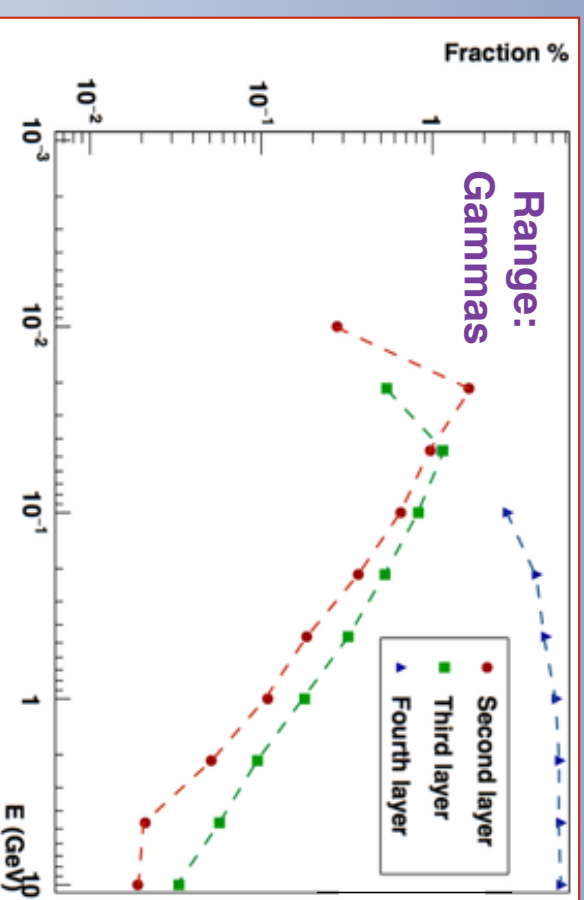
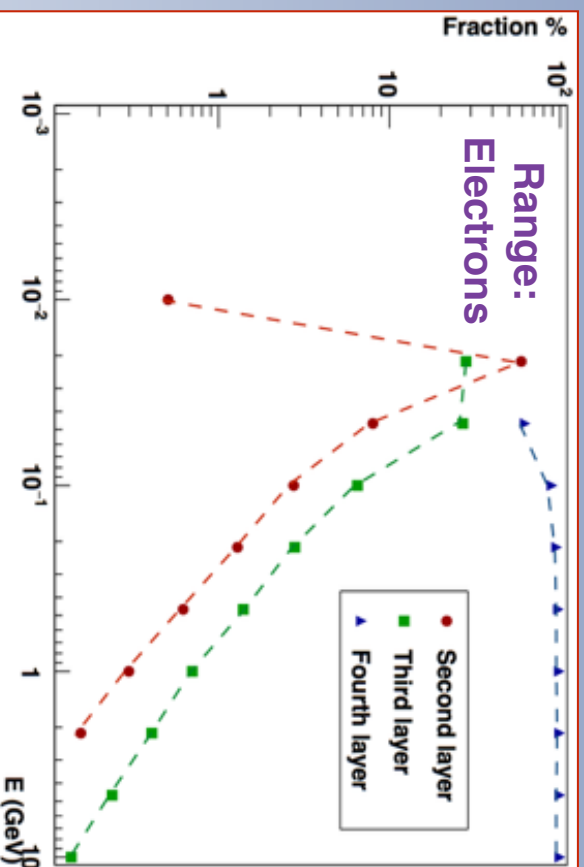


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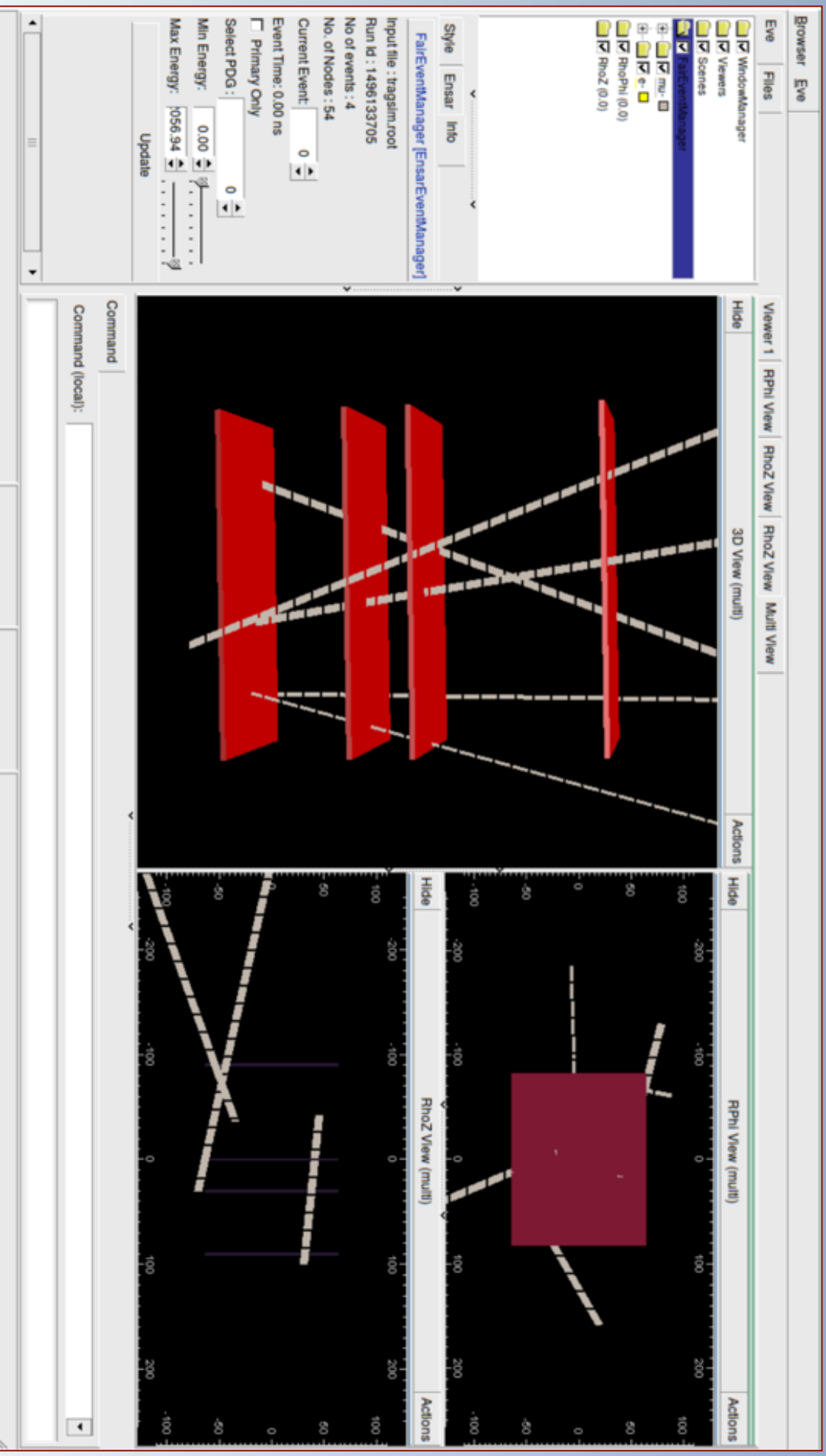
The first Trasgo: TRAGALDABAS

PID capability



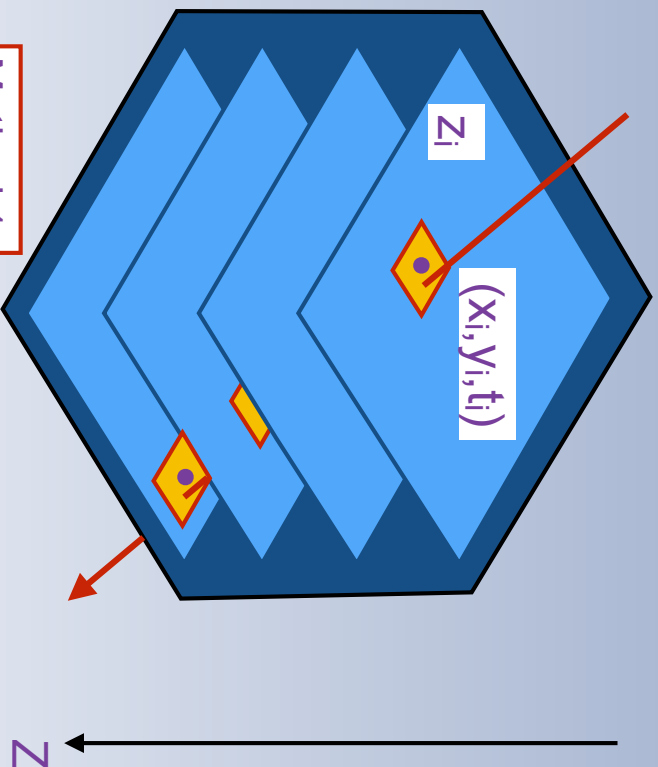
Gamma showers are broader than electron showers

The first Trasgo: TRAGALDABAS EnsarRoot based detector simulation



The first Trasgo: TRAGALDABAS

Tracking strategies based on TimTrack



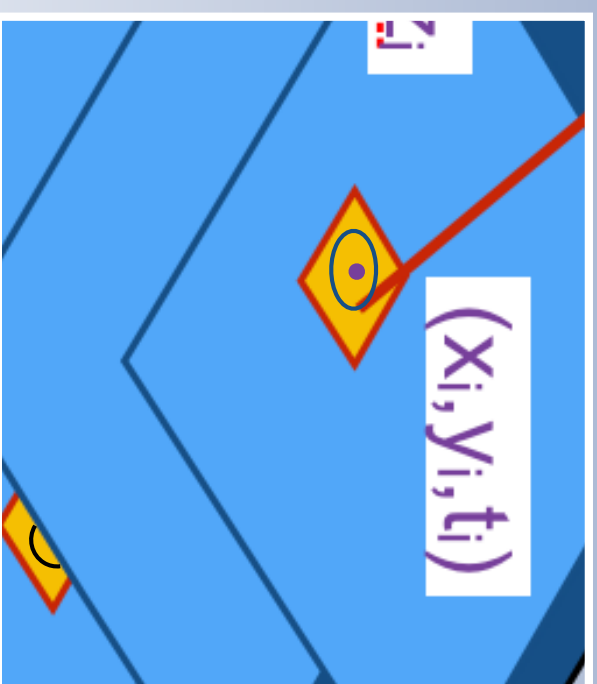
Method 1.

$$X_i = X_0 + X' \cdot Z_i$$

$$Y_i = Y_0 + Y' \cdot Z_i$$

$$t_i = T_0 + \sqrt{1 + X'^2 + Y'^2} \cdot Z_i / V$$

Direct fit to 6 parameters!



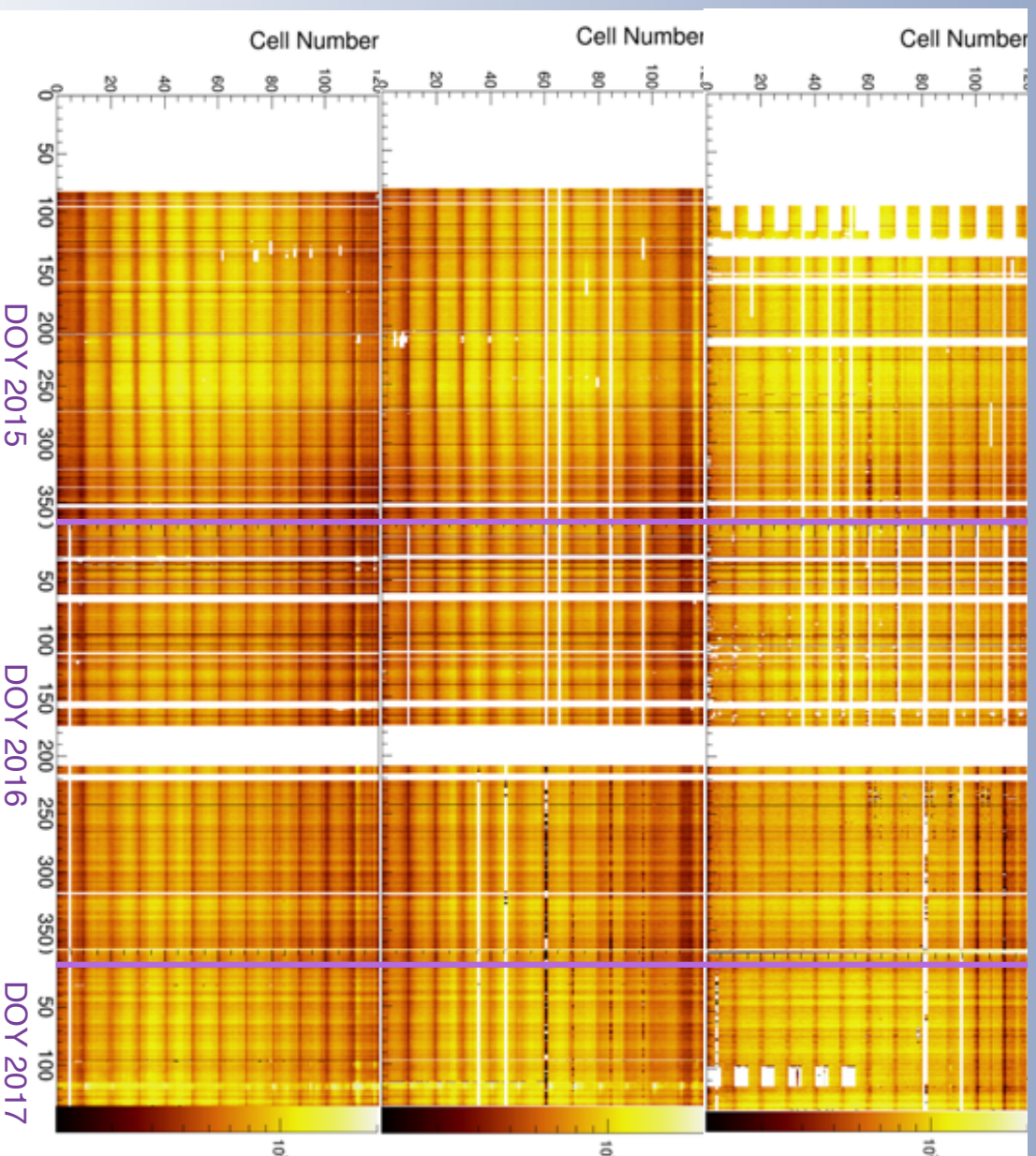
Method 2.

We are trying to implement a new method including the drift time of electrons in the electrodes.

Still, convergence problems! :(

TRAGALDABAS: preliminary results

Data sample: fired cells map



Plane T1

Plane T2

Plane T4

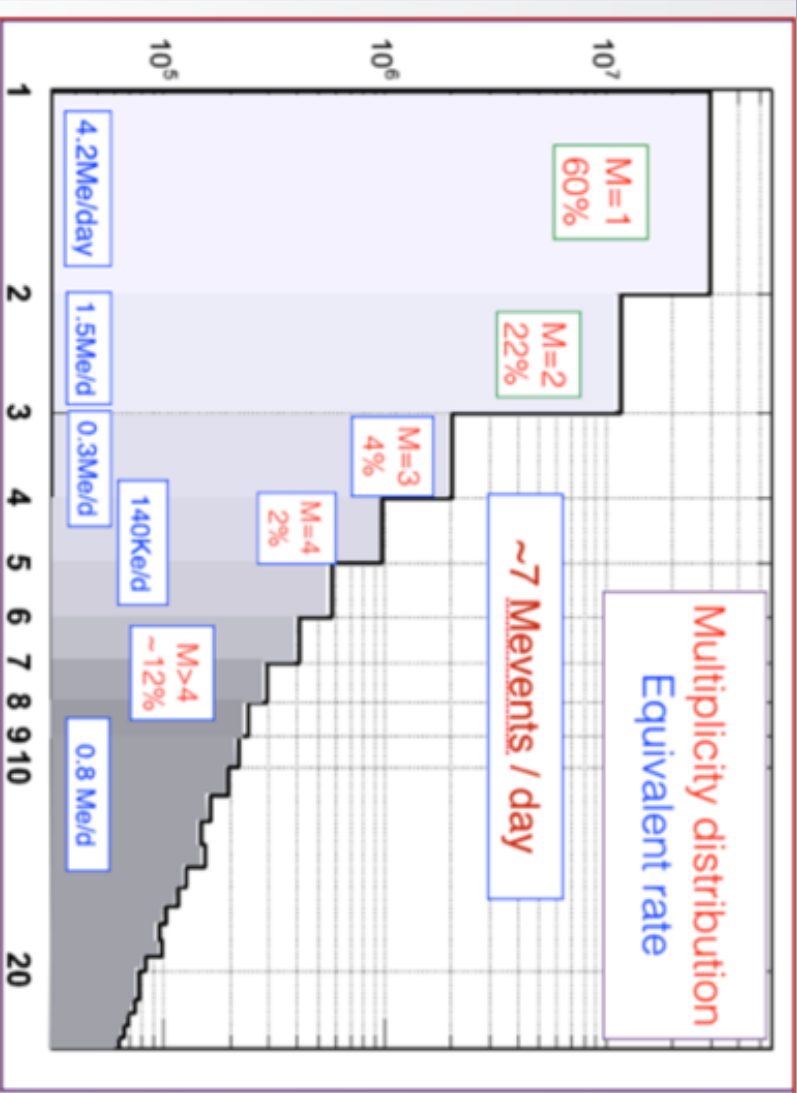
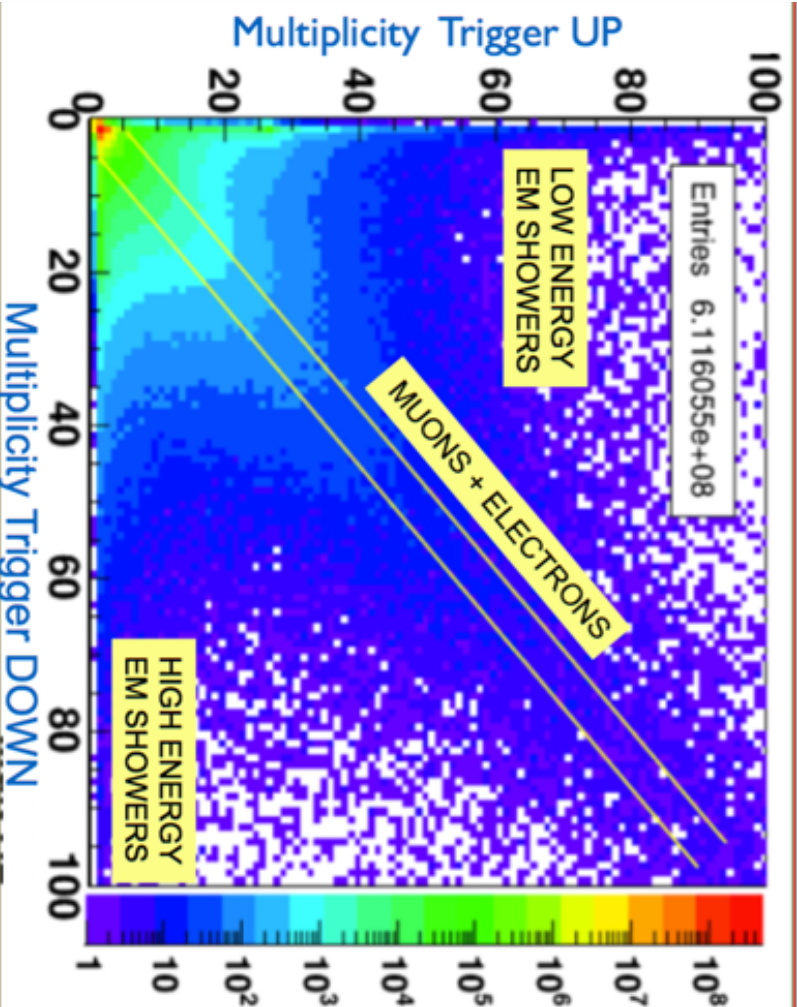
2 years of data collected: ~ $5 \cdot 10^9$ events!

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TRAGALDABAS: preliminary results

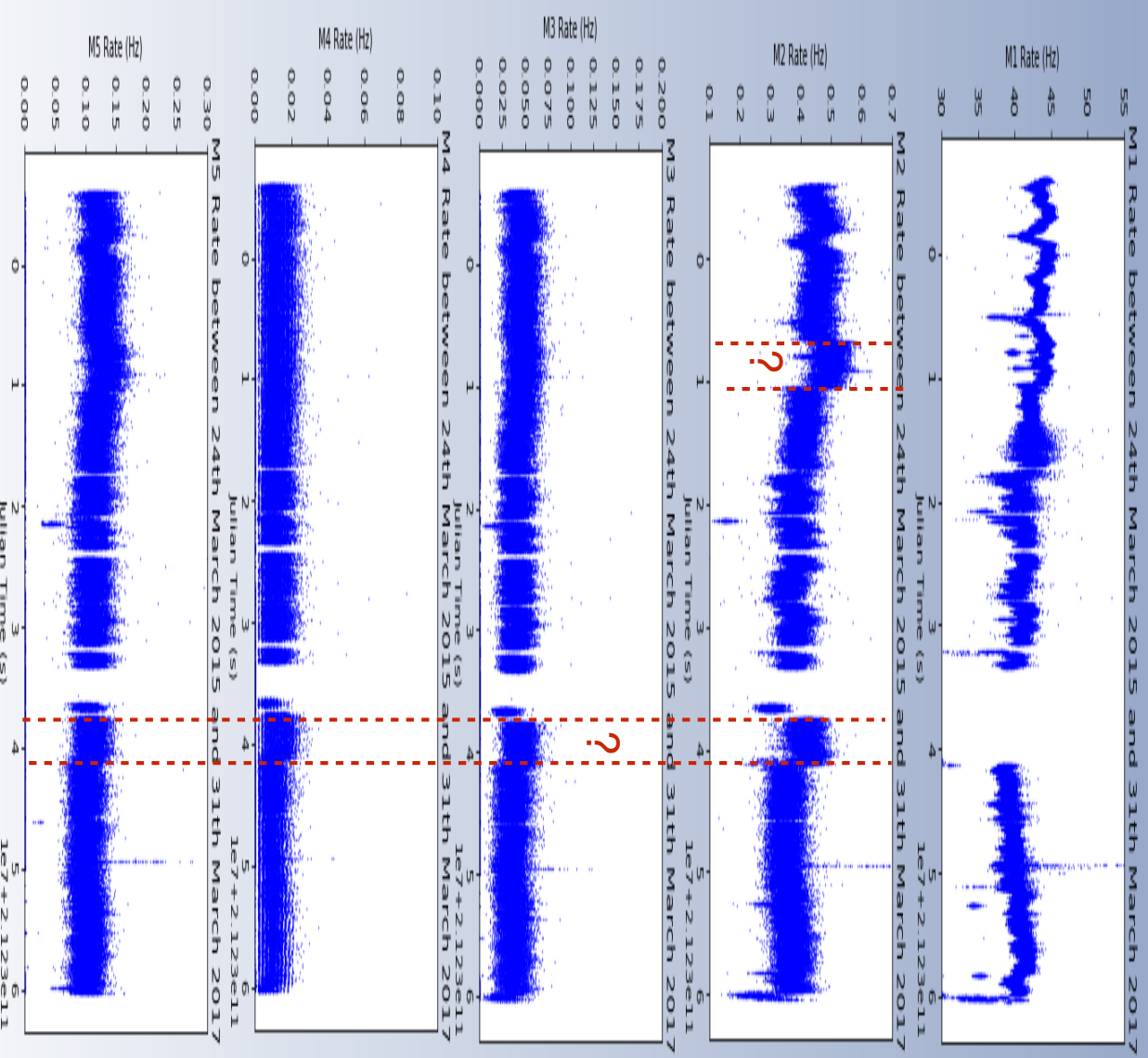
Trigger summary



- Trigger rate: ~ 70 Hz.
- Event rate: ~ 7 Mevents /day
- Storage rate: ~ 0.7 Tb / year (1.9 Gb /day)
- Mean duty time: $> 90\%$

TRAGALDABAS: preliminary results

2 year rate behaviour (pressure corrected)



Multiplicity $M=1$

Multiplicity $M=2$

Multiplicity $M=3$

Multiplicity $M=4$

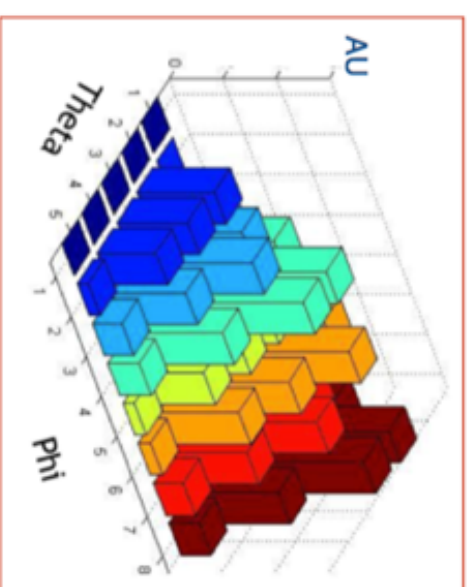
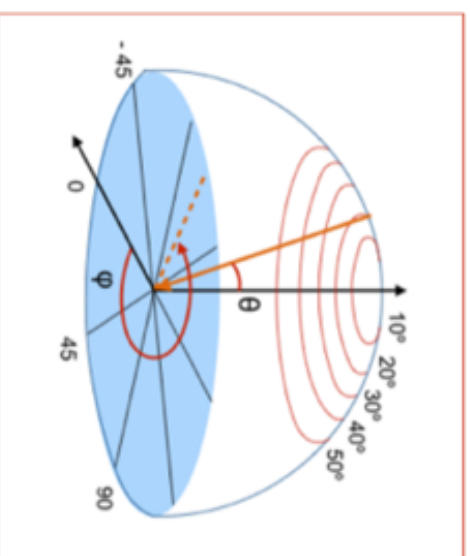
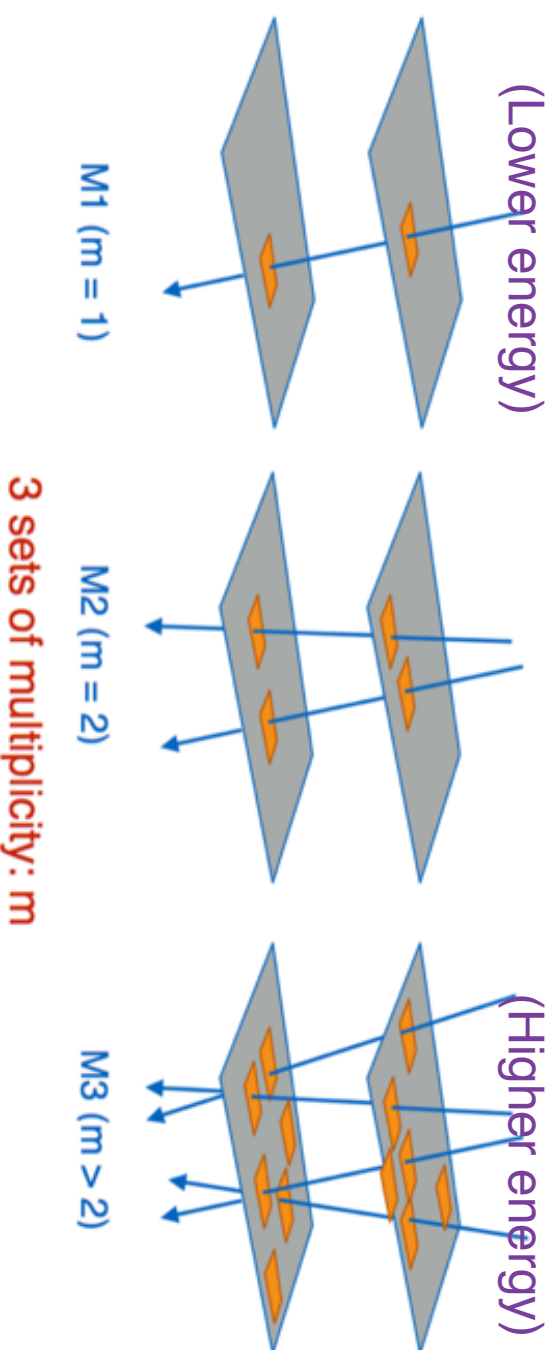
Multiplicity $M>4$

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TRAGALDABAS: preliminary results

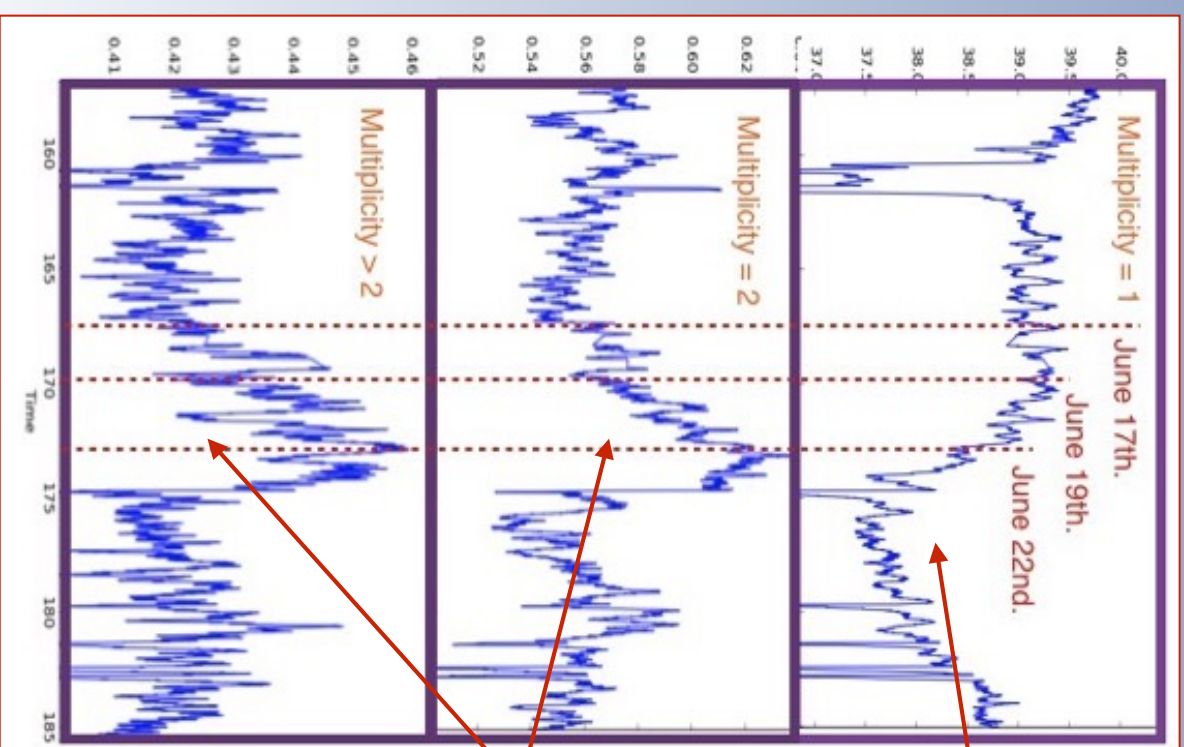
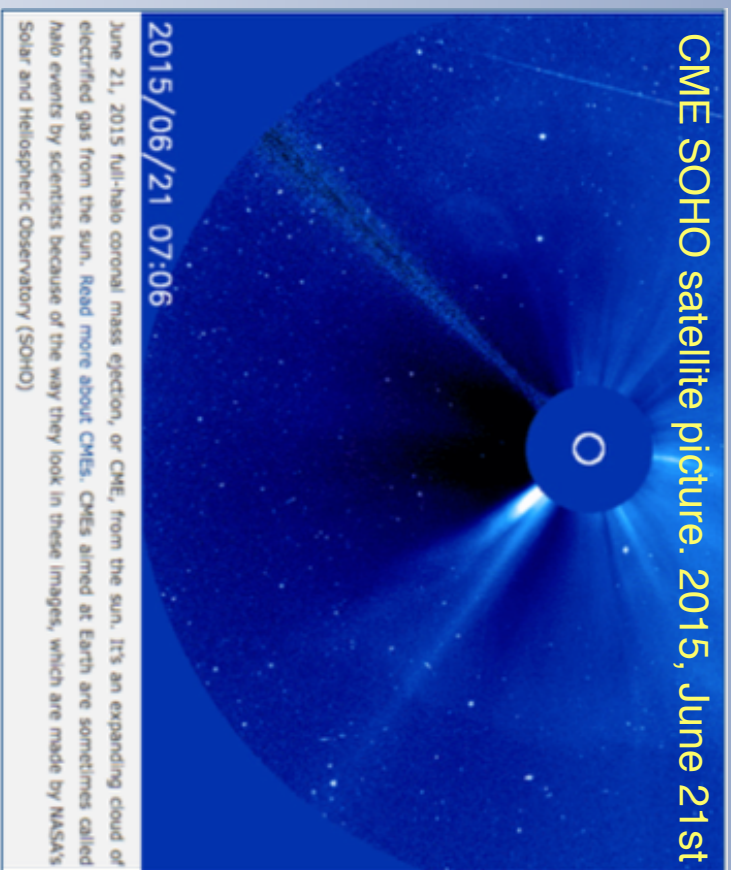
Preliminary reconstructed data sample



Data stored in 5x8 (theta x phi) matrices in 10-min time intervals

TRAGALDABAS: preliminary results

Analysis of the FD of June 2015

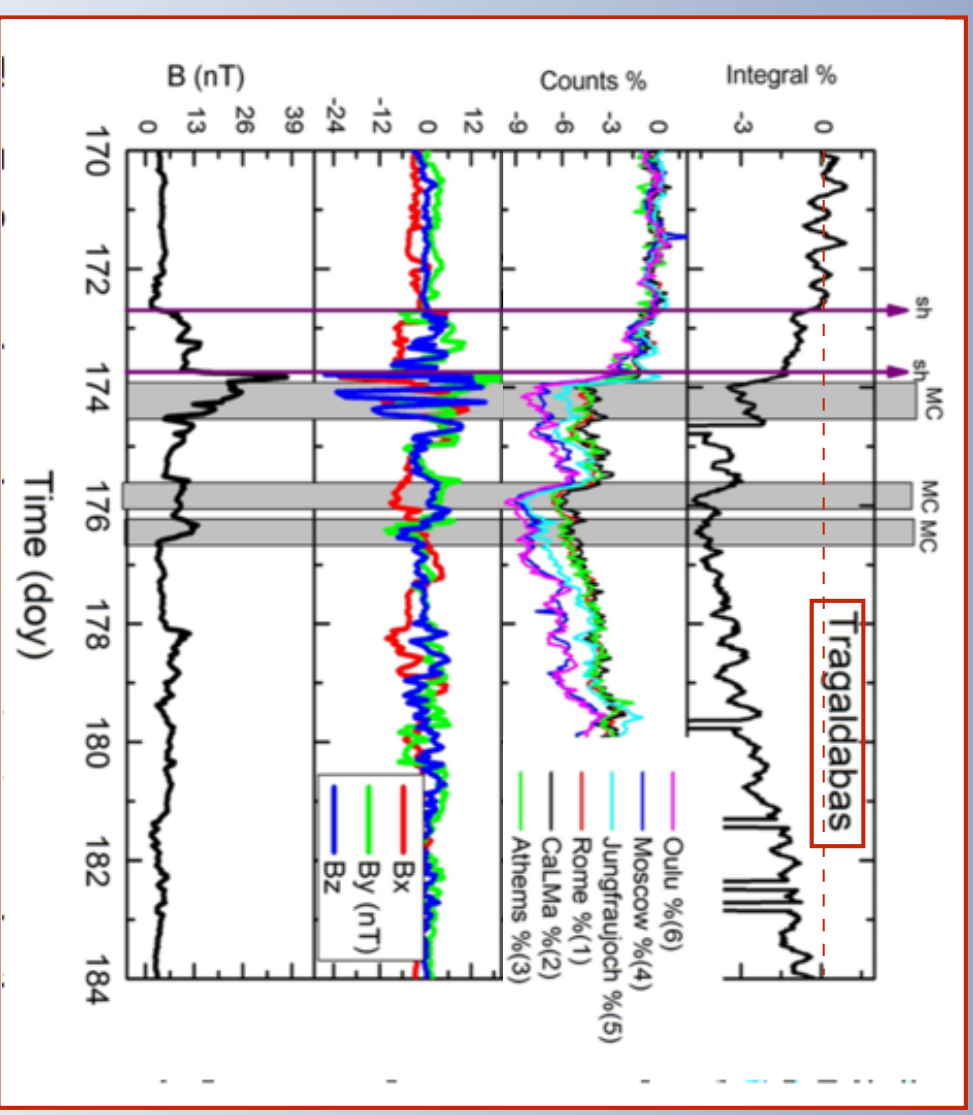
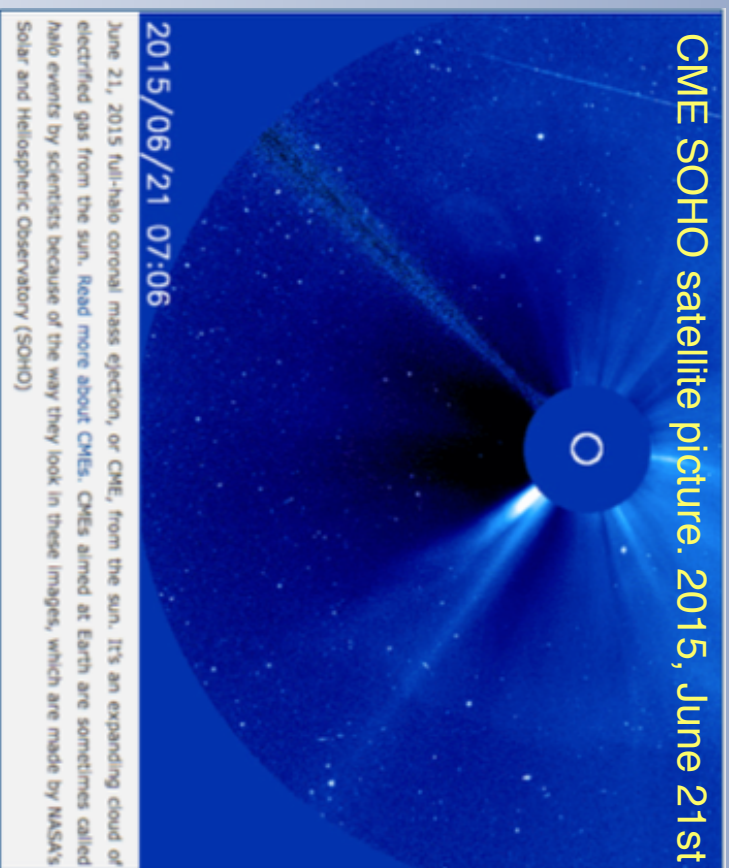


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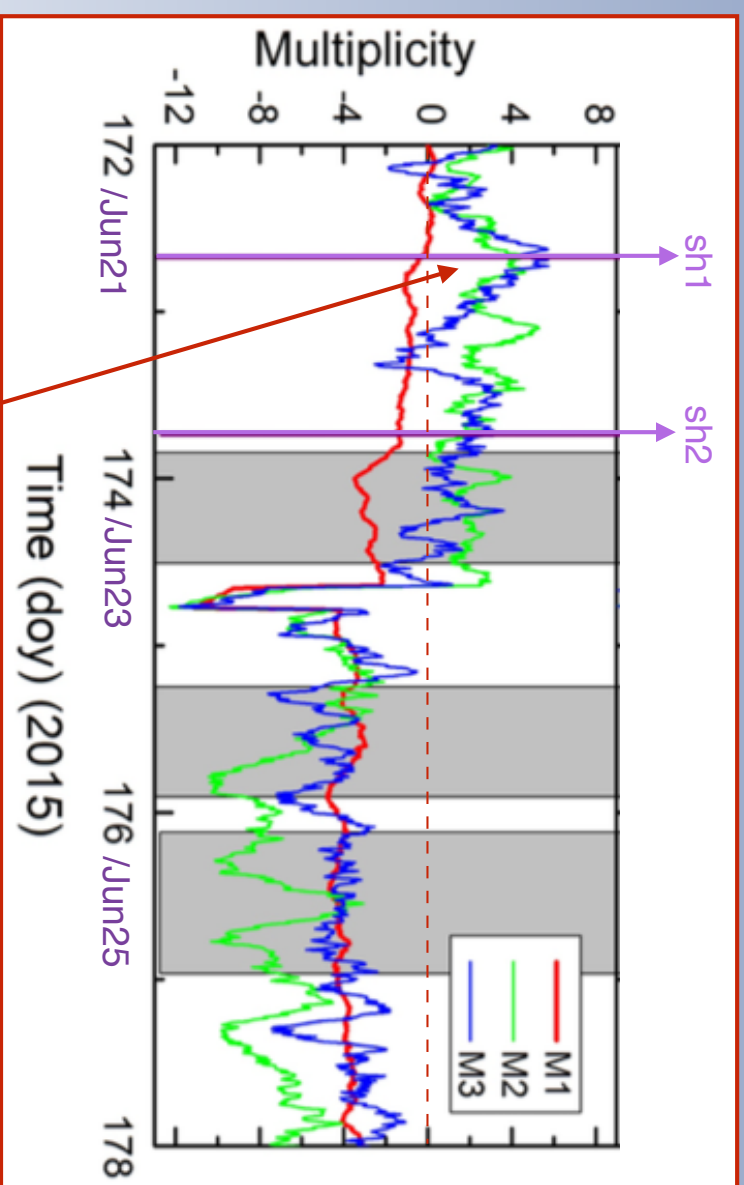
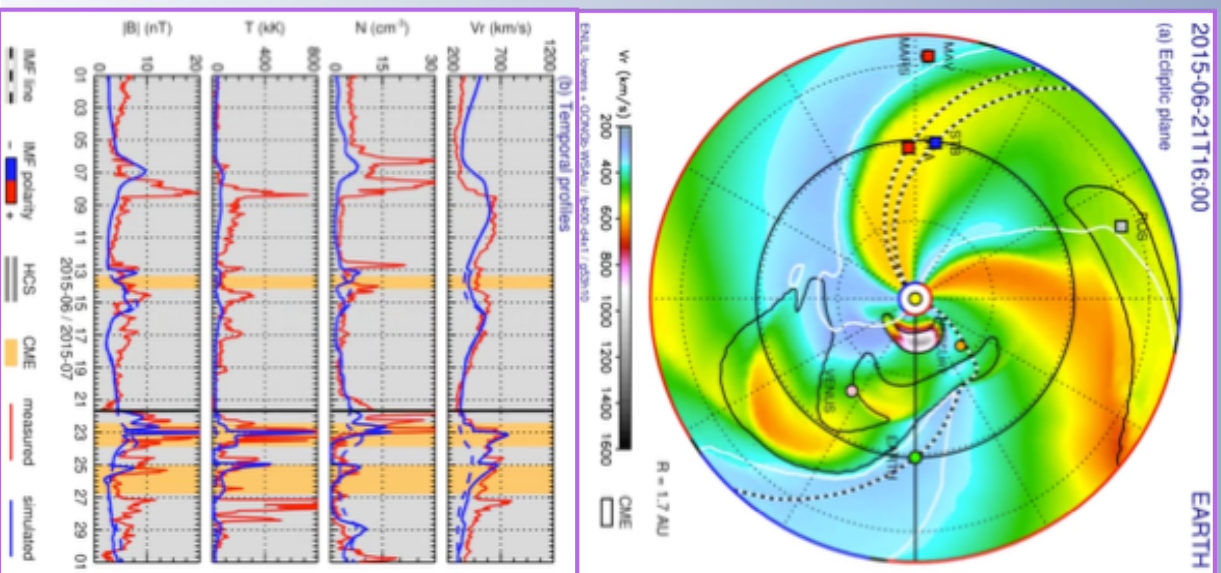
FD is observed very well with a roughly 2 m² detector !

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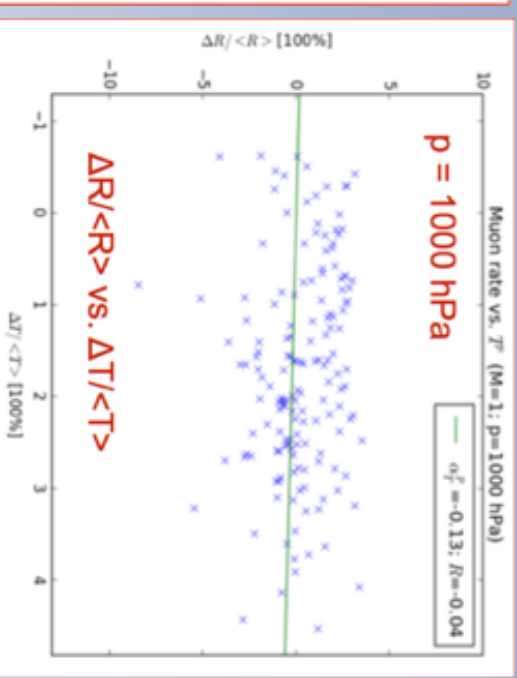
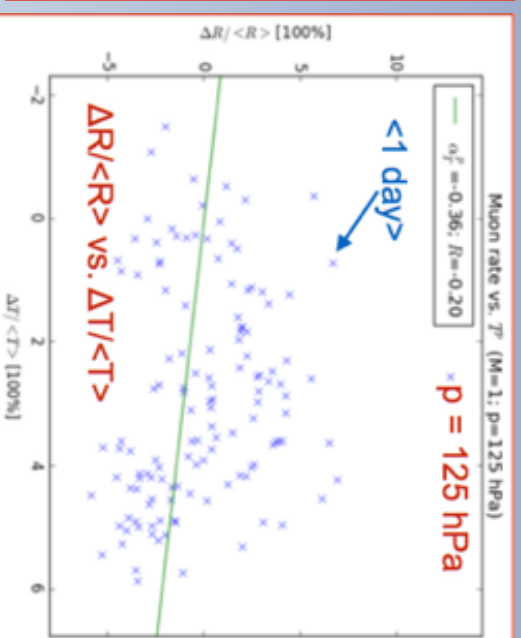
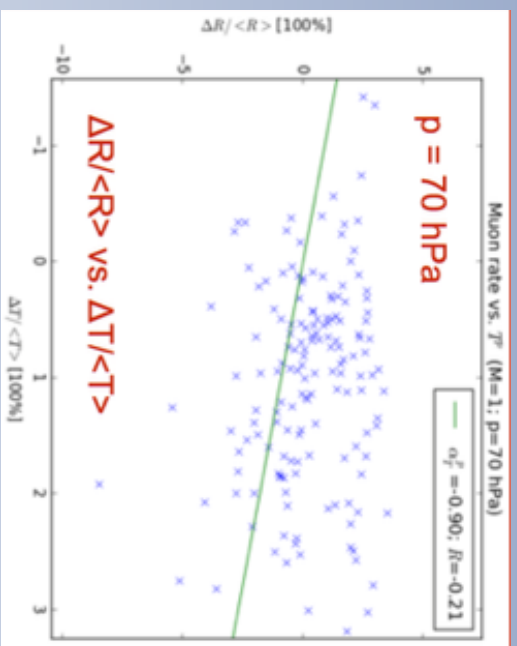
Interesting feature: high multiplicity excesses seem to be associated with the first magnetic shock!

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TRAGALDABAS: preliminary results

Atmosphere slope analysis



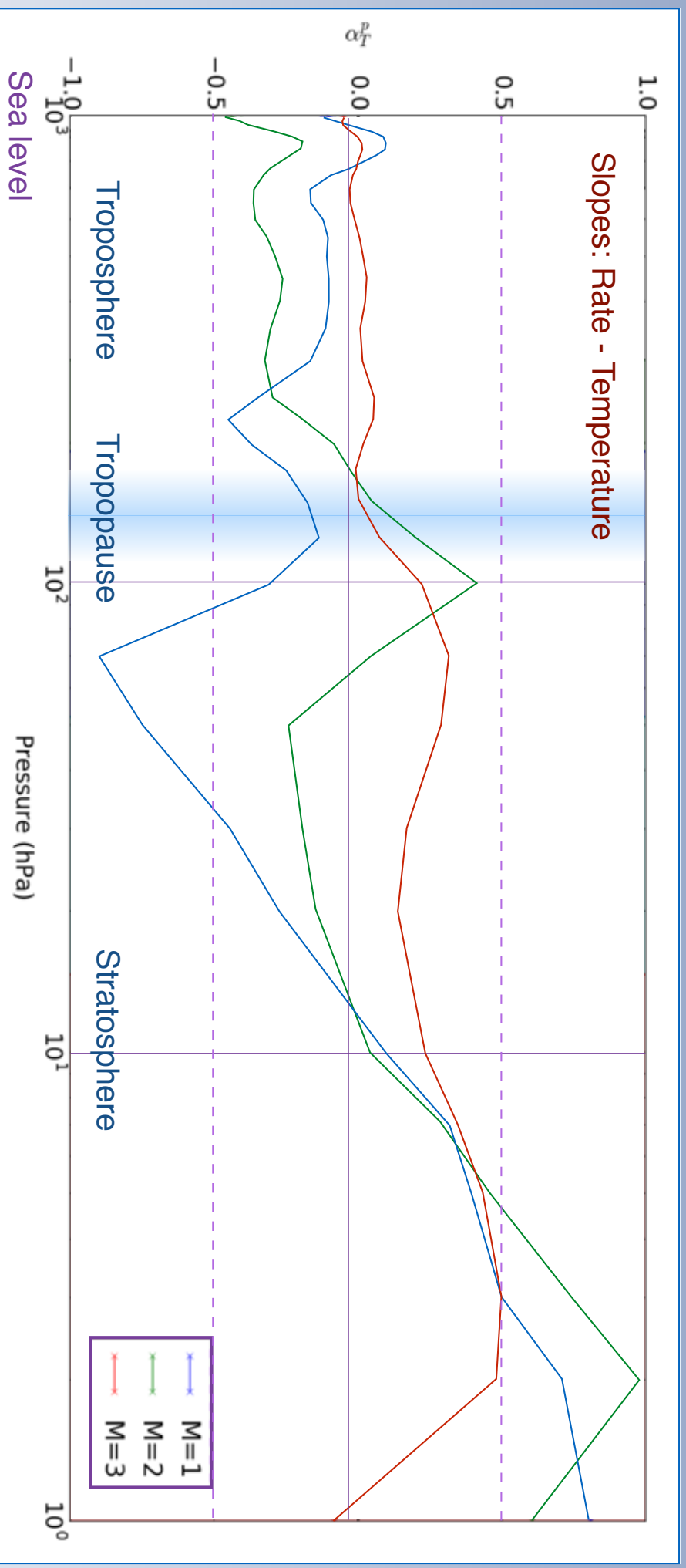
Slopes of linear fits of the relative rate changes (dR/R) as a function of the relative temperature changes (dT/T) at different pressure levels

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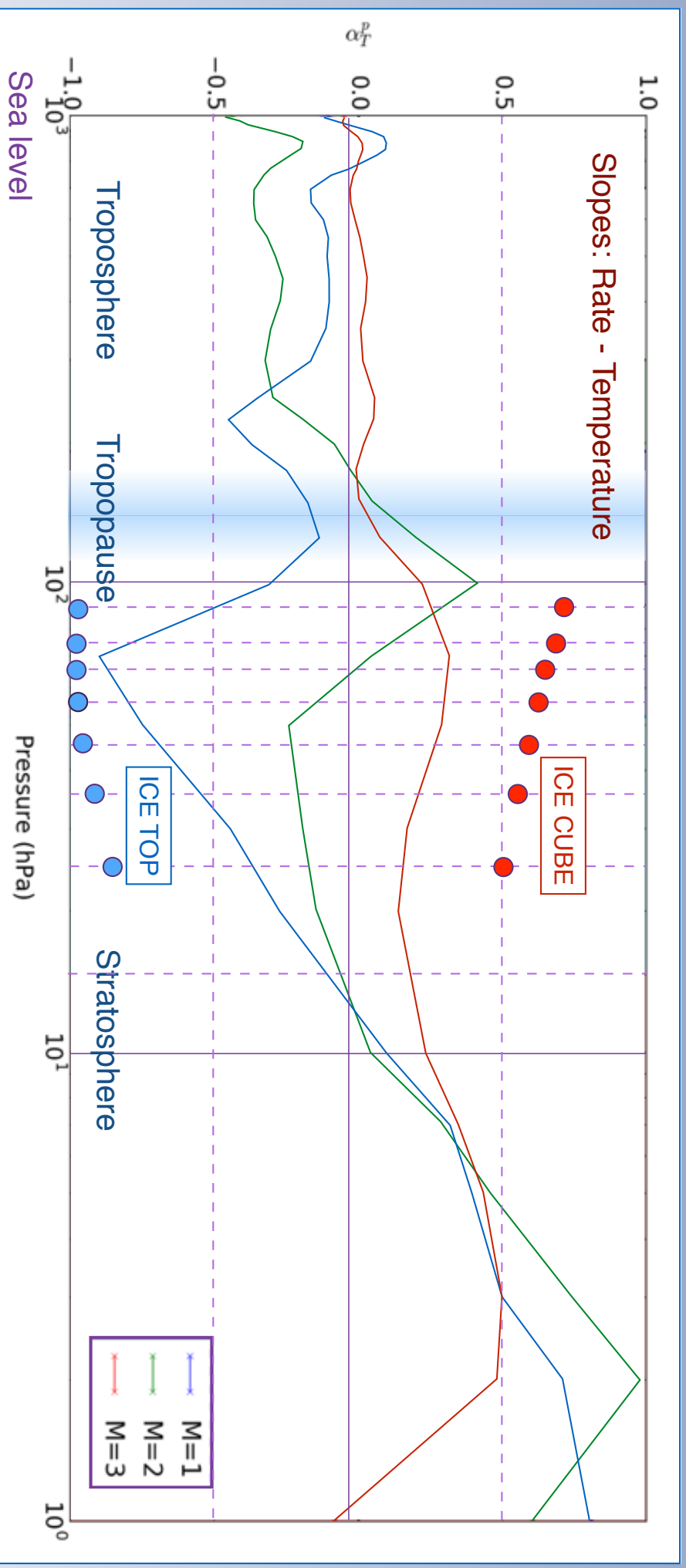
Atmosphere slope analysis



Different multiplicity (energy) events show a different behaviour respect temperatures at the different heights of the atmosphere

TRAGALDABAS: preliminary results

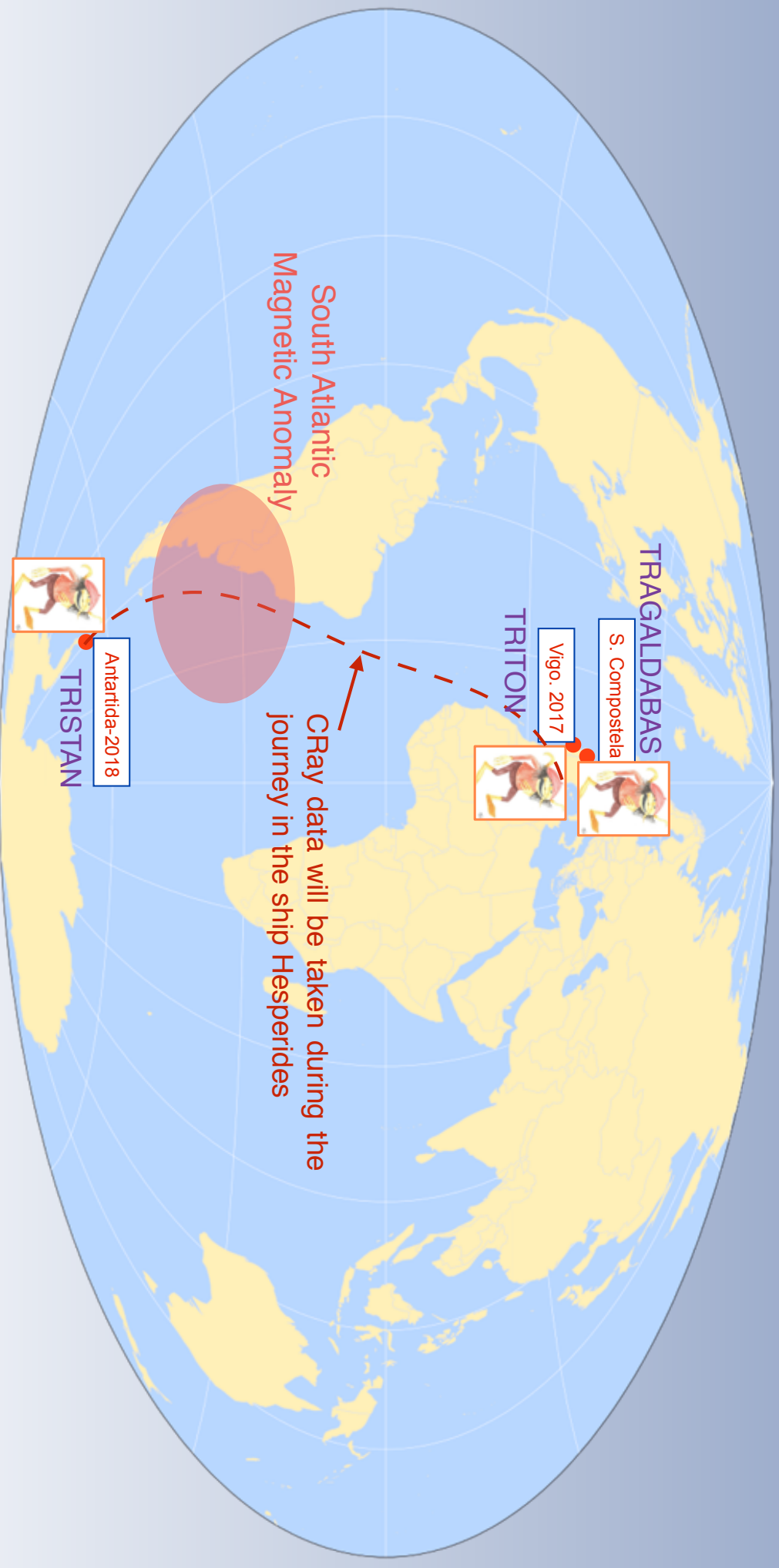
Atmosphere slope analysis



We observe similar trends that the ones observed in the IceTop - IceCube observatory for low and high energy muons

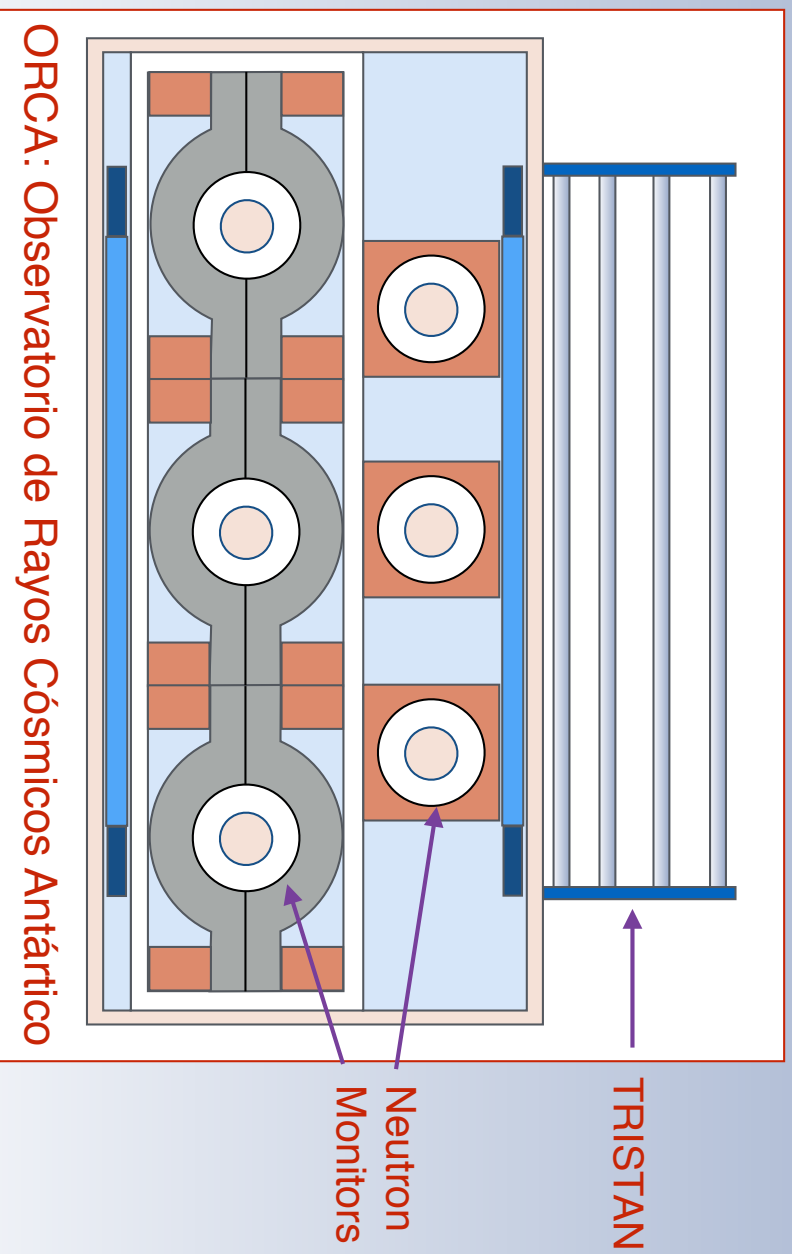
The TRASGO project: next steps

- Install new Trasgos in other places: Vigo & Spanish Antarctic Base



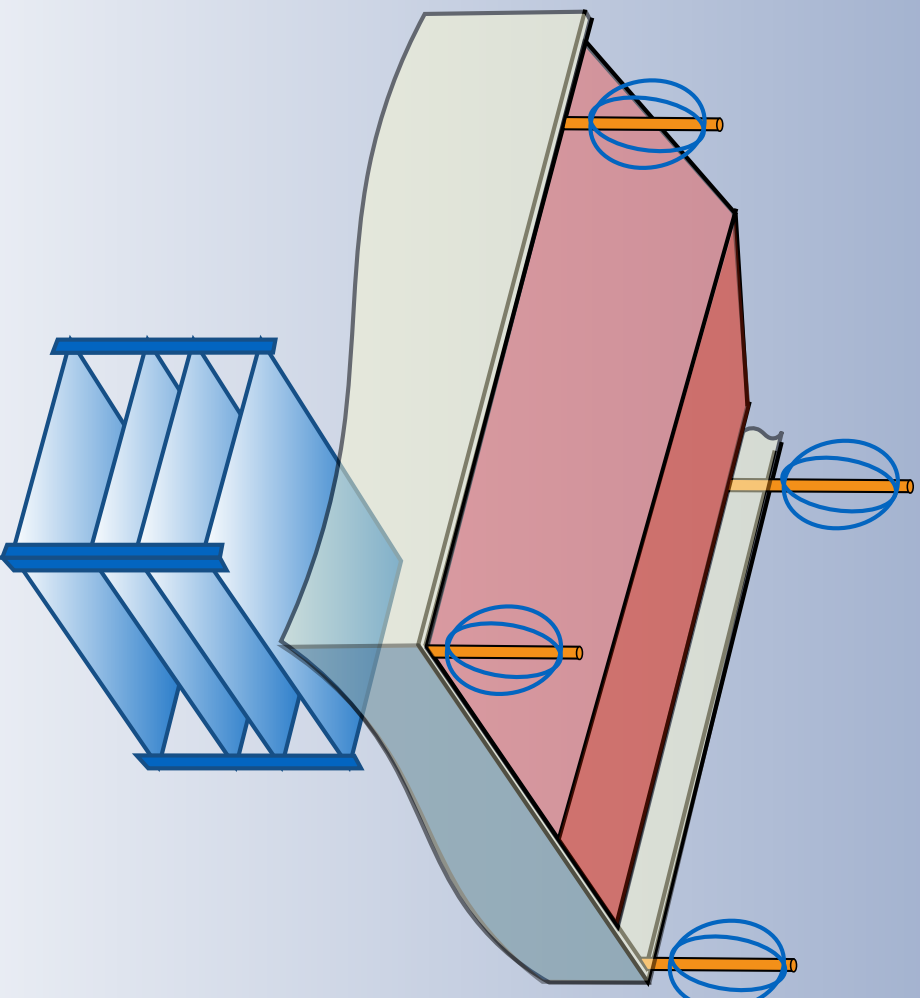
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- Install new **Trasgos** in other places: **Vigo & Spanish Antarctic Base**



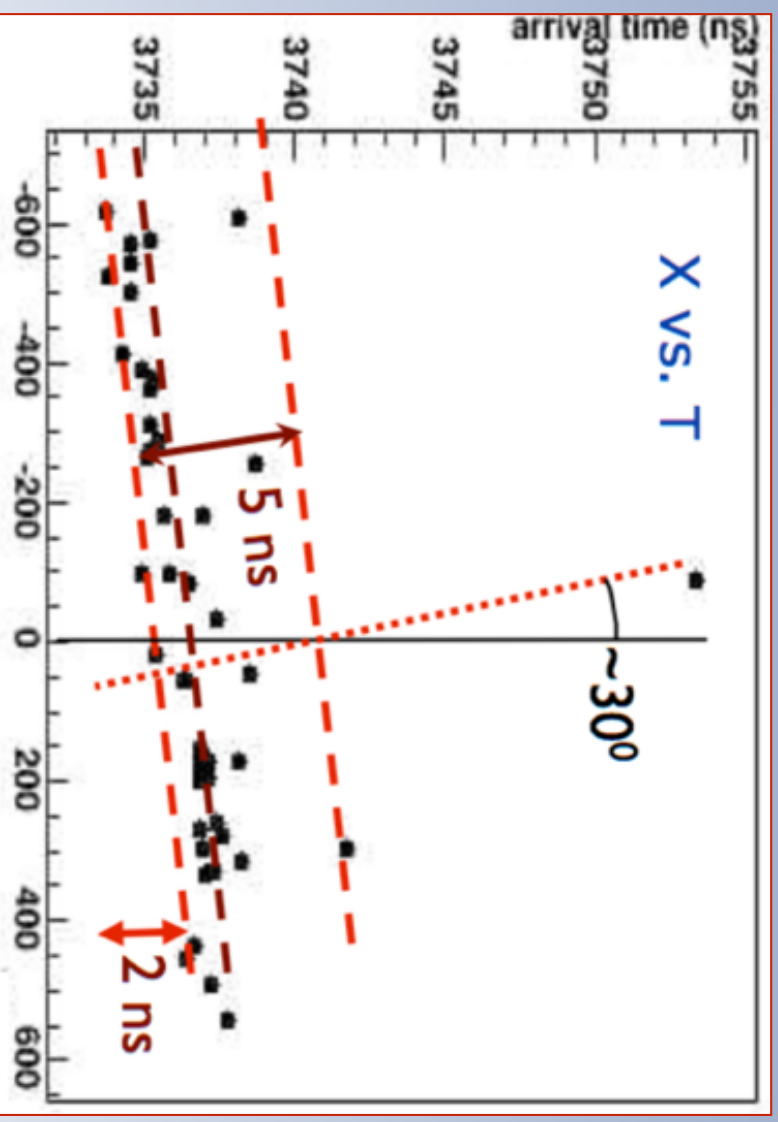
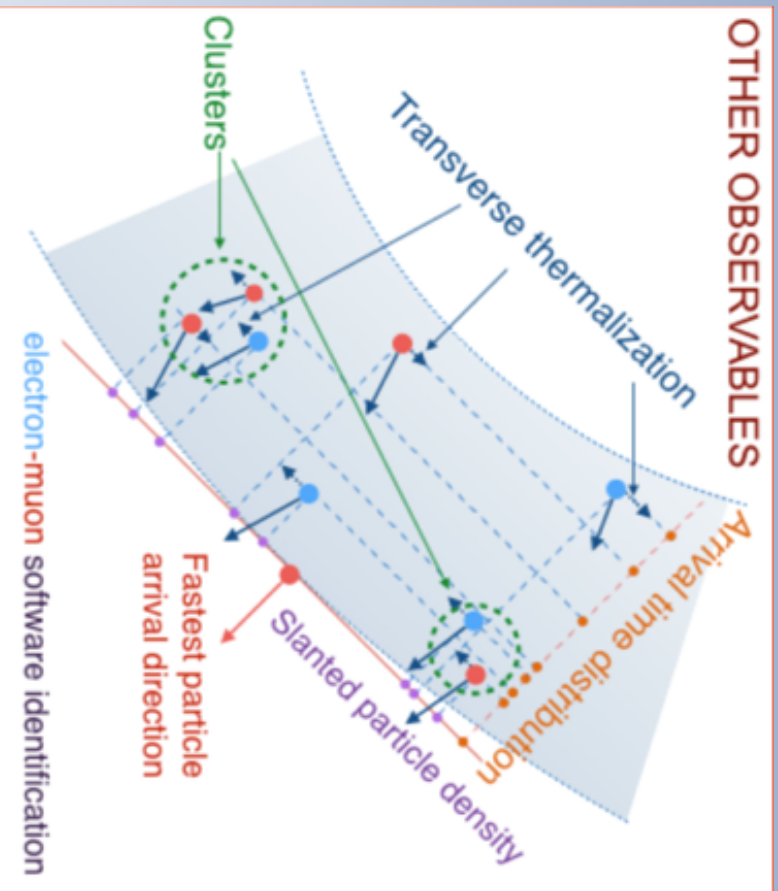
The TRASGO project: next steps

- Install four SALLA radio-antennas provided by KIT (Karlsruhe), on the roof for identifying high energy air showers.



The TRASGO project: next steps

- Look for new signatures allowing a better measurement of primary cosmic rays



Summary

- TRASGOS are very interesting devices that may allow us to improve significantly our knowledge on many cosmic rays aspects.
- Preliminary results are very encouraging
- TRASGOS are complicated devices and still several problems should be fixed
- A first detector is operative and taking data regularly at the Univ. of Santiago de Compostela. Soon other TRASGOS will be operative in other places providing new data

the end
Thanks!

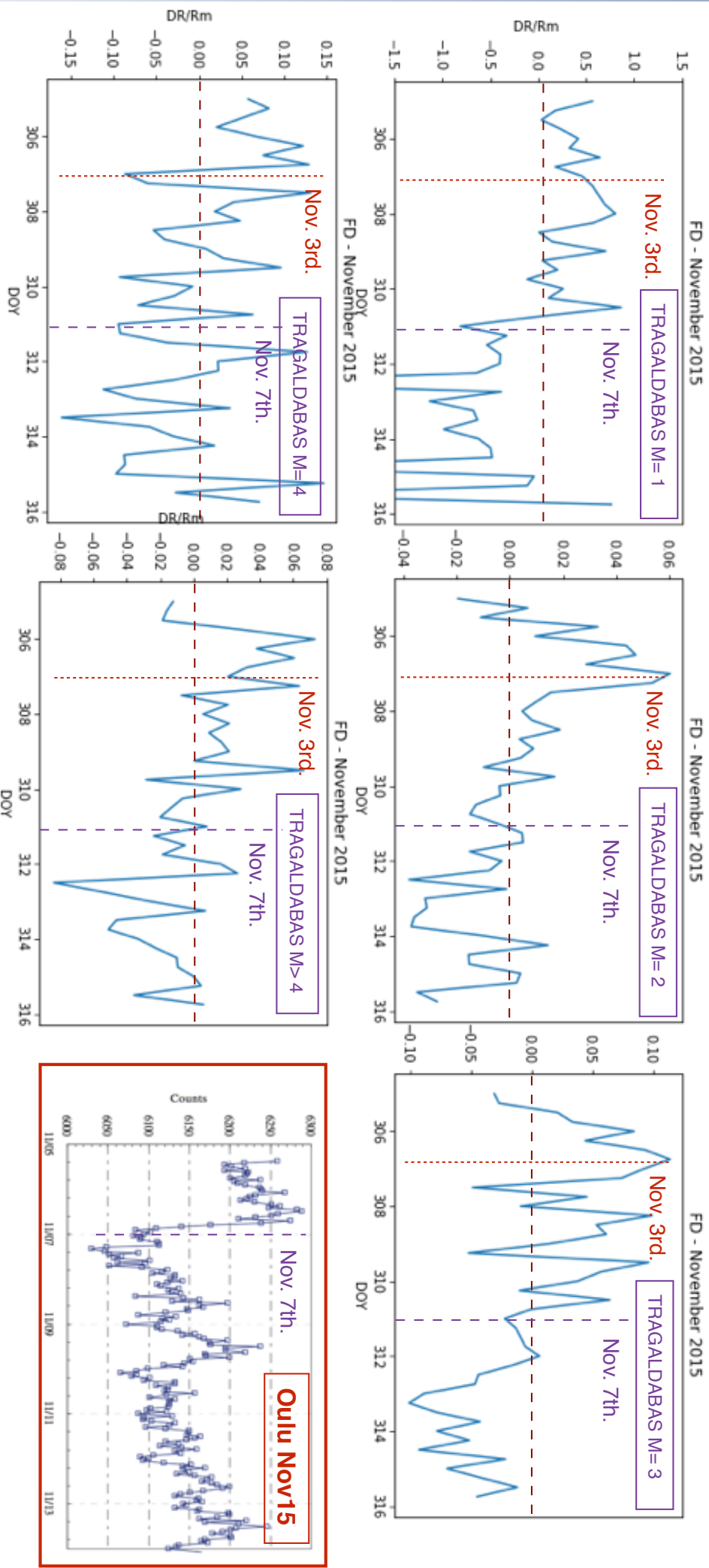
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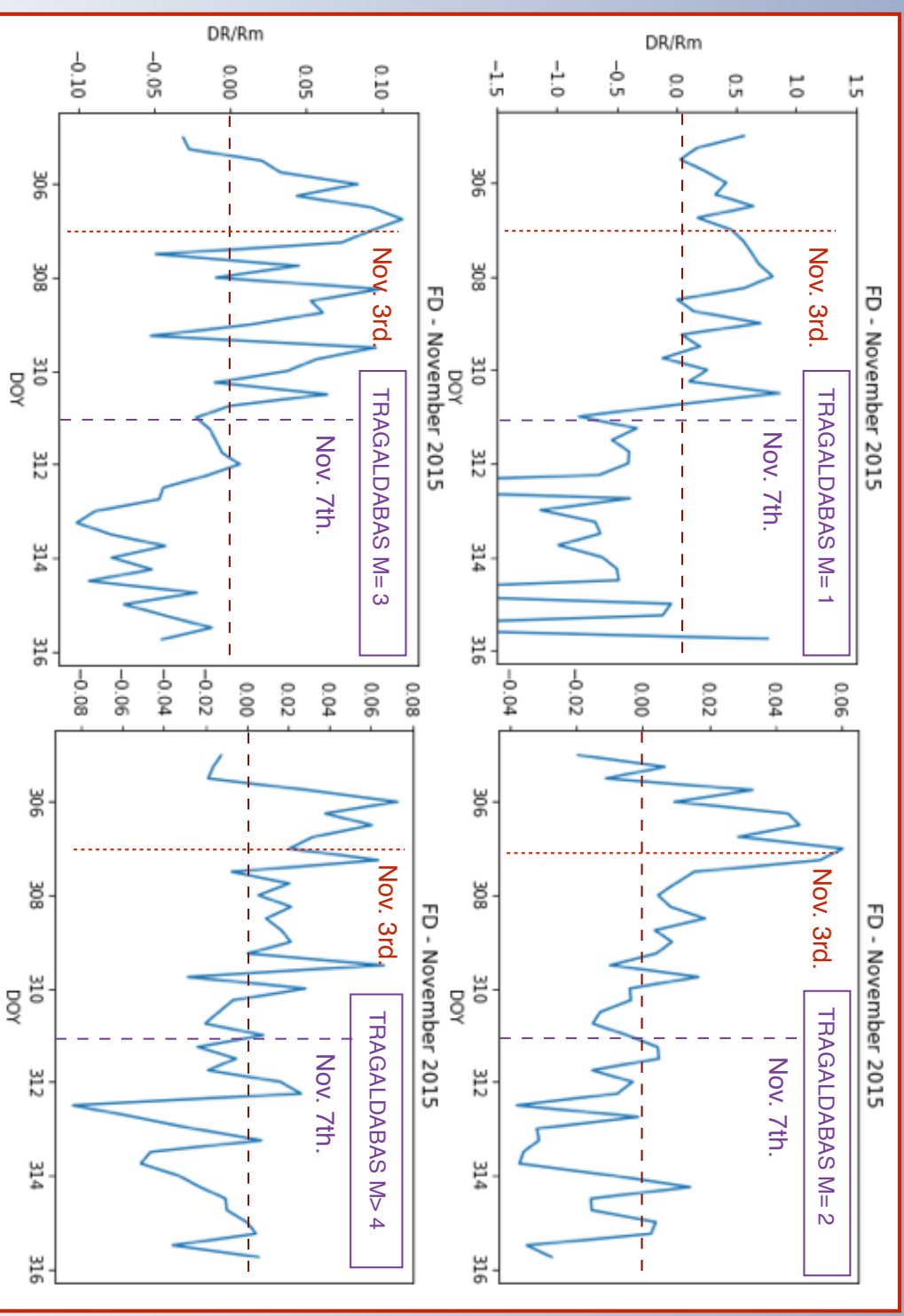
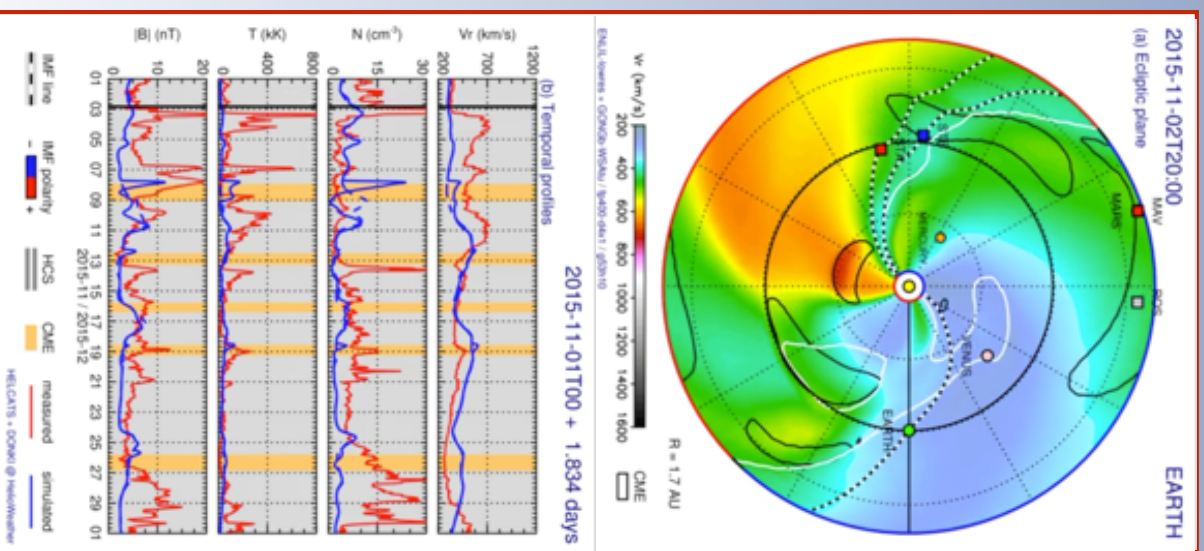


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