Proyecto trasgo Project

# Trasgos

## Toward a new standard of measuring cosmic rays

Juan A. Garzón (LabCAF / IGFAE - Univ. Santiago de Compostela)

# THE TRASGO PROJECT

## Collaborating members

M. Ajoor[12], H. Alvarez-Pol[10], A.Blanco[4], J.J.Blanco[1], P.Cabanelas[10], F.Clemencio[5,6], J.Collazo[13], J.Cuenca[11], J. Flores[9], P.Fonte[4], Y.Fontenla[11], D.García Castro[11], J.A.Garzón[11], A.Gomis[7], G.Kornakov[14], T.Kurtukian[2], L.Lopes[4], C. Loureiro[5], A.Morozova[3], M.A.Pais[3], A.Pazos[10], V.Pérez Muñuzuri[12], P.Rey[8], I.Riádigos[11,12], M.Seco[10], V. Villasante[6], J. Xuna[11].

**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. LIP- Coimbra, Portugal / RPC detectors and instrumentation
5. LIBPhys, Dept. of Physics. U. Coimbra, Portugal / Data Acquisition System
6. E. Superior de Saude, I. Politécnico. Porto, Portugal / Data Acquisition System
7. IGN - Madrid, Spain / Geomagnetic field
8. CESGA Super-computation Center - Santiago de Compostela, Spain / Data storage and distribution
9. CITIUS - Univ. Santiago de Compostela, Spain / Imaging and augmented reality
10. IGFAE - Univ. Santiago de Compostela, Spain / Monitoring and Slow control
11. LabCAF - Univ. Santiago de Compostela, Spain / Cosmic rays physics, software and tracking
12. GFNL - Univ. Santiago de Compostela, Spain / Atmosphere Physics and Climate
13. HIDRONAV. Vigo, Spain / Detector development and Instrumentation
14. Warsaw Univ of Technology. Warsaw, Poland / Software development

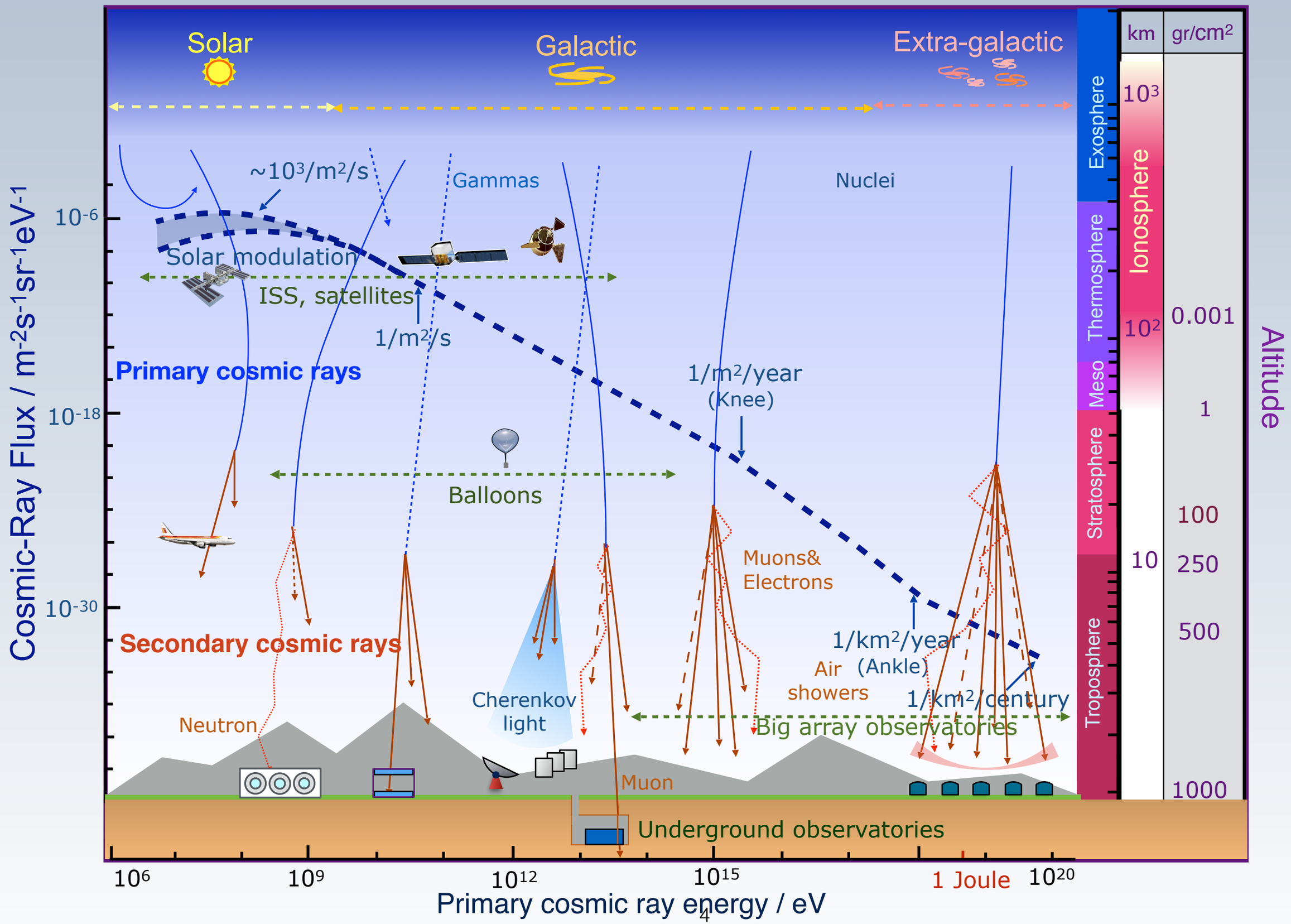
**Other partners:**

Club Desarrollo de las Ciencias, Madrid, Spain

# OUTLOOK

- The cosmic rays
- The TRASGO project
- The TRASGO Fleet
- A few activities and preliminary results
- Summary

# COSMIC RAYS: Summary of detection techniques



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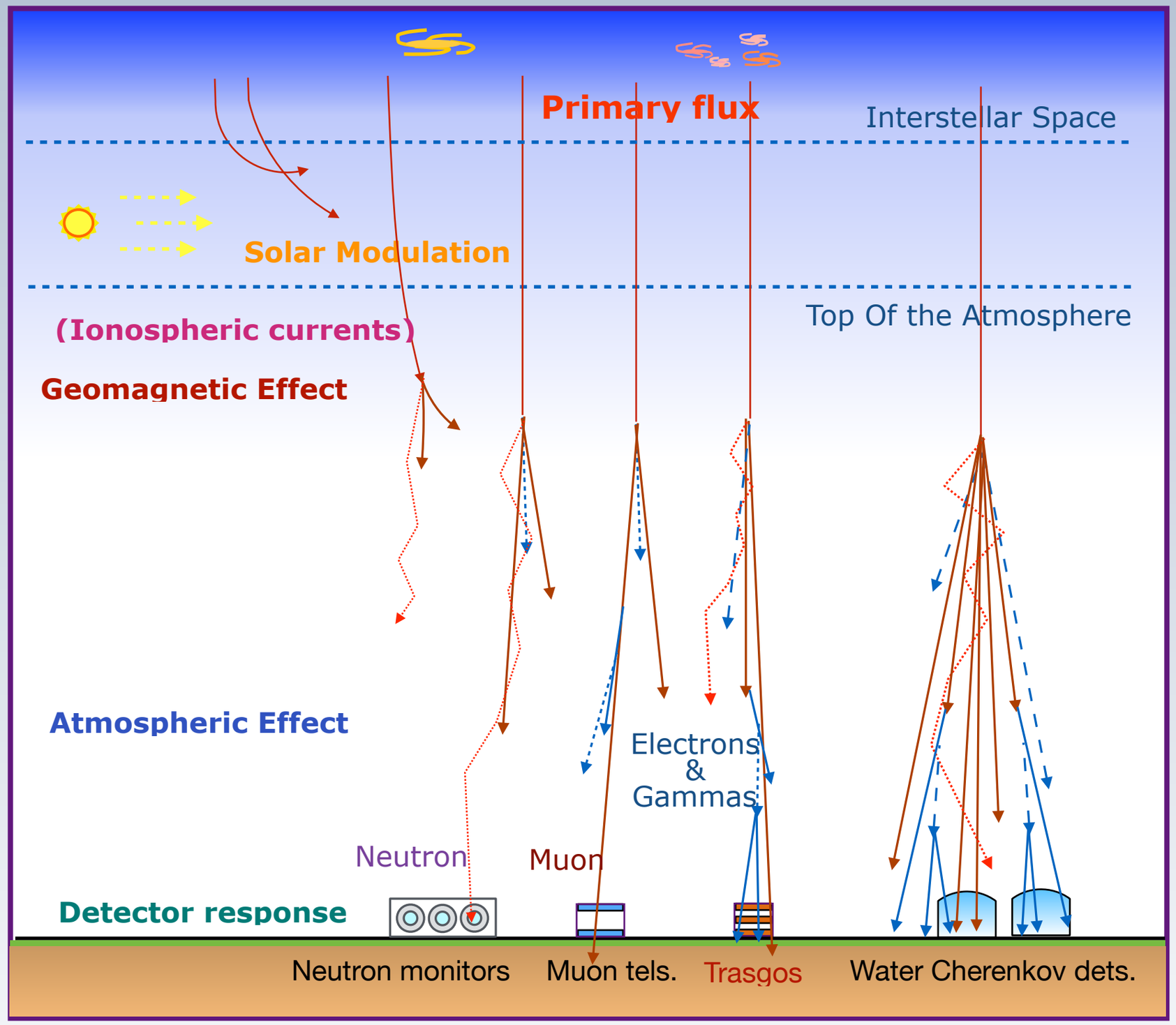
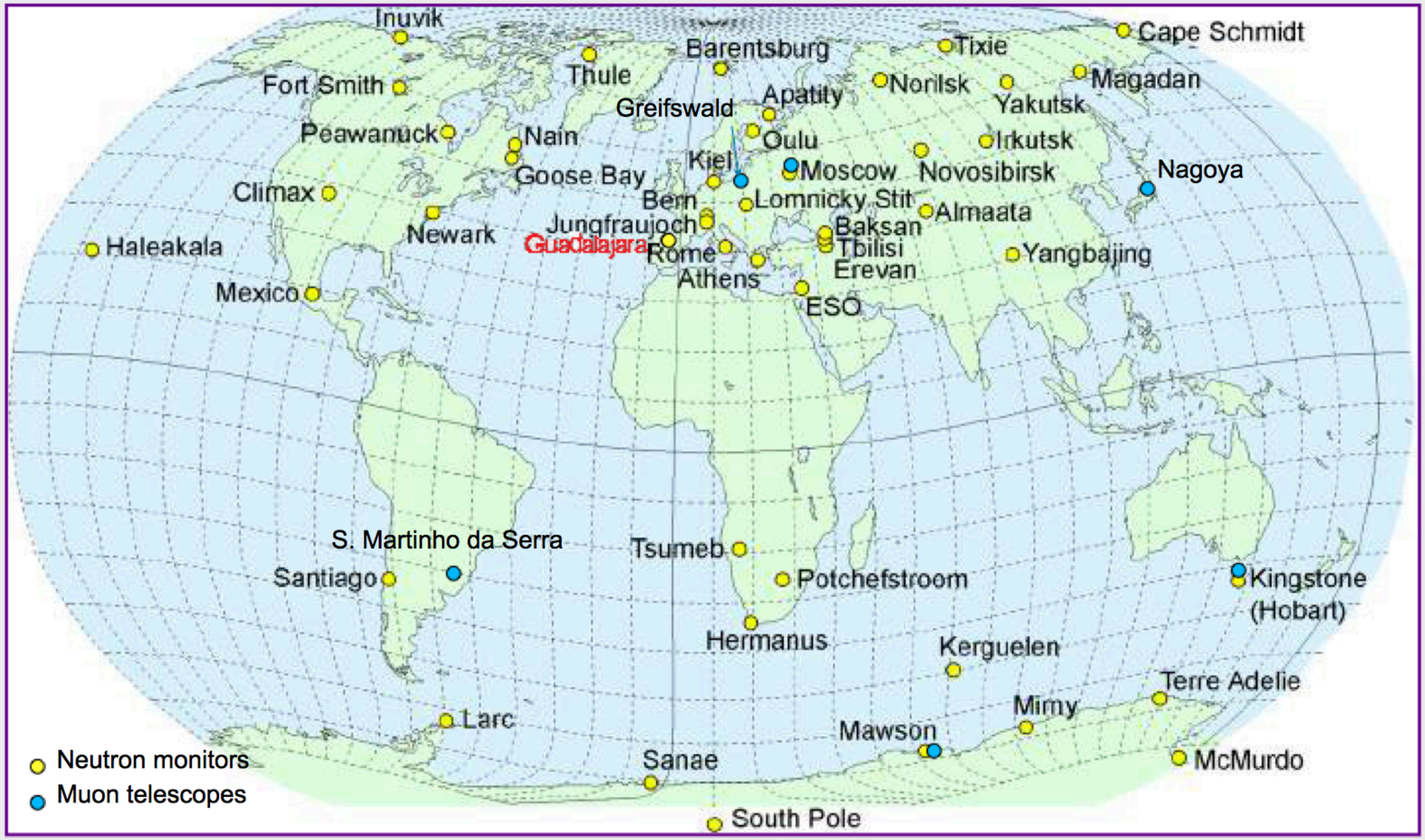
# THE COSMIC RAYS: modulation effects




Primary cosmic ray energy

Can all this effects be disentangled with one or several detectors on Earth?

# COSMIC RAYS




World-Wide network of neutron and muon monitors

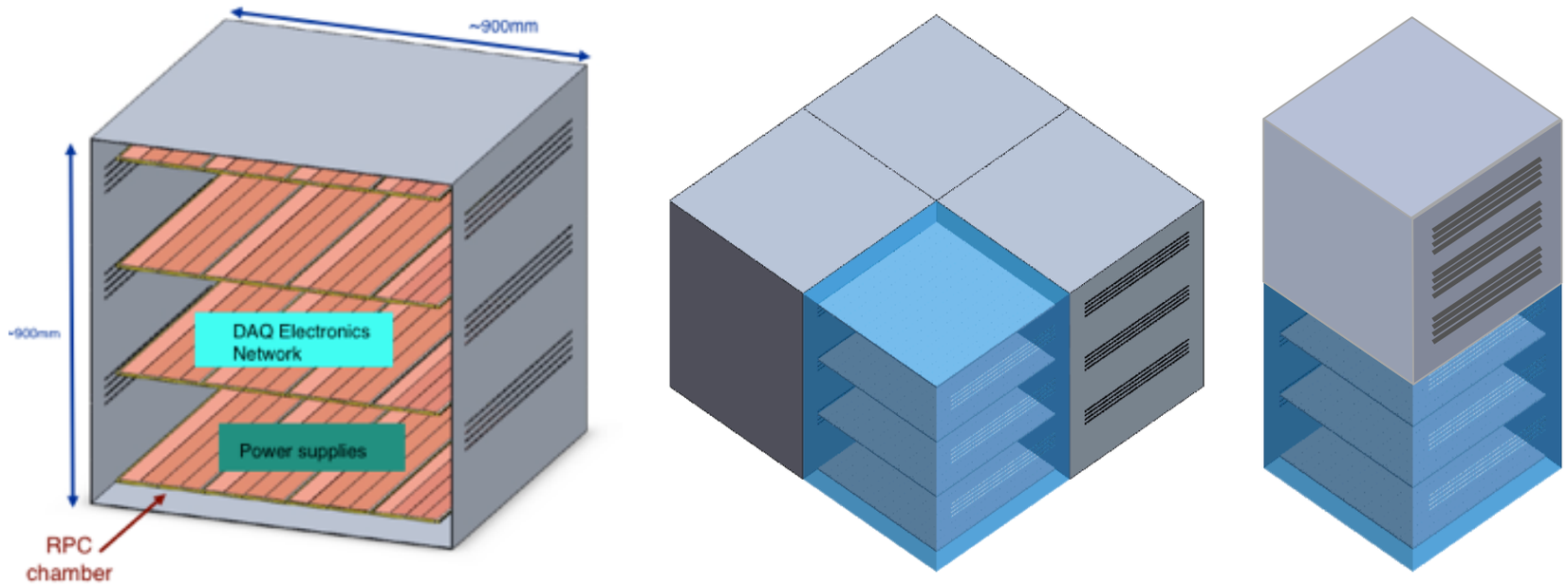
# Cosmic ray survey: summary of main techniques

| Detector type | Sensitivity | Acceptance - Multiplicity | Size Granularity Cell size | Angular resolution | Rate /Hz | Corrections | Special features |
|---|---|---|---|---|---|---|---|
| **Neutron monitors** | Neutrons | Very higth<br>-<br>1 | 20-30 $m^2$<br>10-15<br>~1 $m^2$ | No | 100-250 | Barometric pressure | -Integral flux<br>-1957 GIY design<br>- Energy threshold |
| **Muon directional telescopes** | Muons | Very high<br>-<br>1 | 9-36 $m^2$<br>25 - 289<br>0.3-1 $m^2$ | < 10º | 1K-2K | Barometric pressure<br>Temperature profile | - Flux defined by the acceptance<br>- Different designs<br>- Energy threshold |
| **Trasgos** | Muons, electrons, gammas & protons | Medium<br>-<br>< 100 | 1.8 $m^2$<br>30-120<br>0.02-0.06 $m^2$ | < 3º | 50-60 | Barometric pressure, Temperature profiles for muons & | - Flux defined by the acceptance<br>- Common design/ several layouts |
| **Portable Cosmic Ray Telescope** | Muons<br>Electrons | 1 | 0.06 $m^2$ | - | ~5 | Barometric pressure<br>Temperature profile | . Very affordable<br>. Global network oriented |

Is it room for new families of complementary detectors?

# THE TRASGO CONCEPT
# (A PHILOSOPHY)

## TRASGO (~elf): TRAck reconStructinG bOx




## Main features:

High granularity RPC based tracking detector

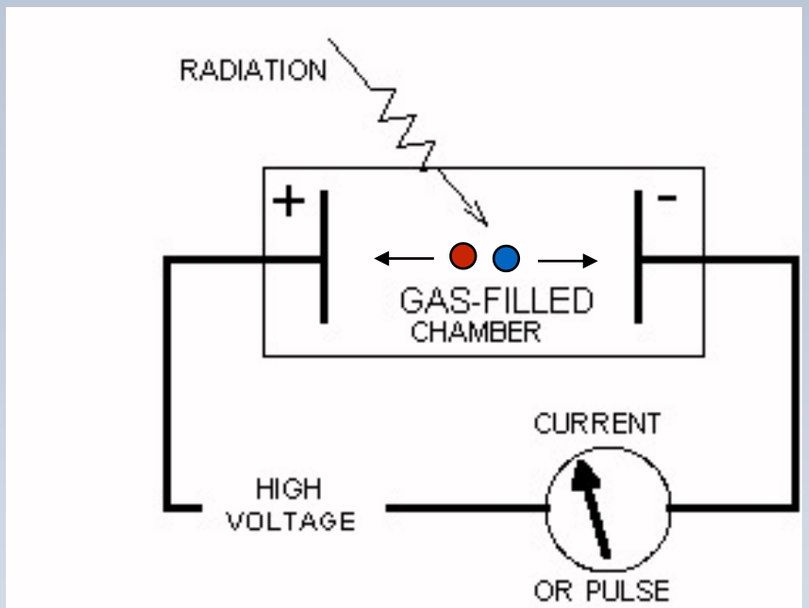
High position-time resolution (~ 10's cm$^2$ - 0.1ns)

Electron-Muon PID

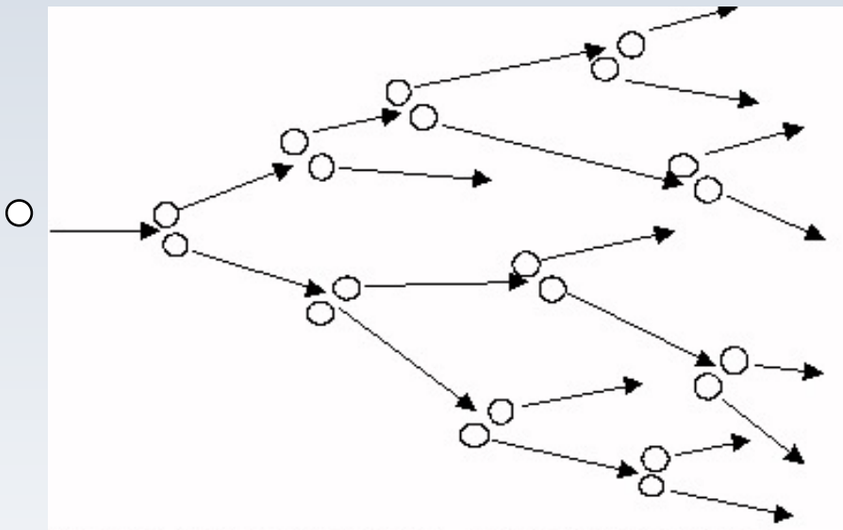
High modularity

with a complete set of tools (monitoring, reconstruction, analysis, visualization…)

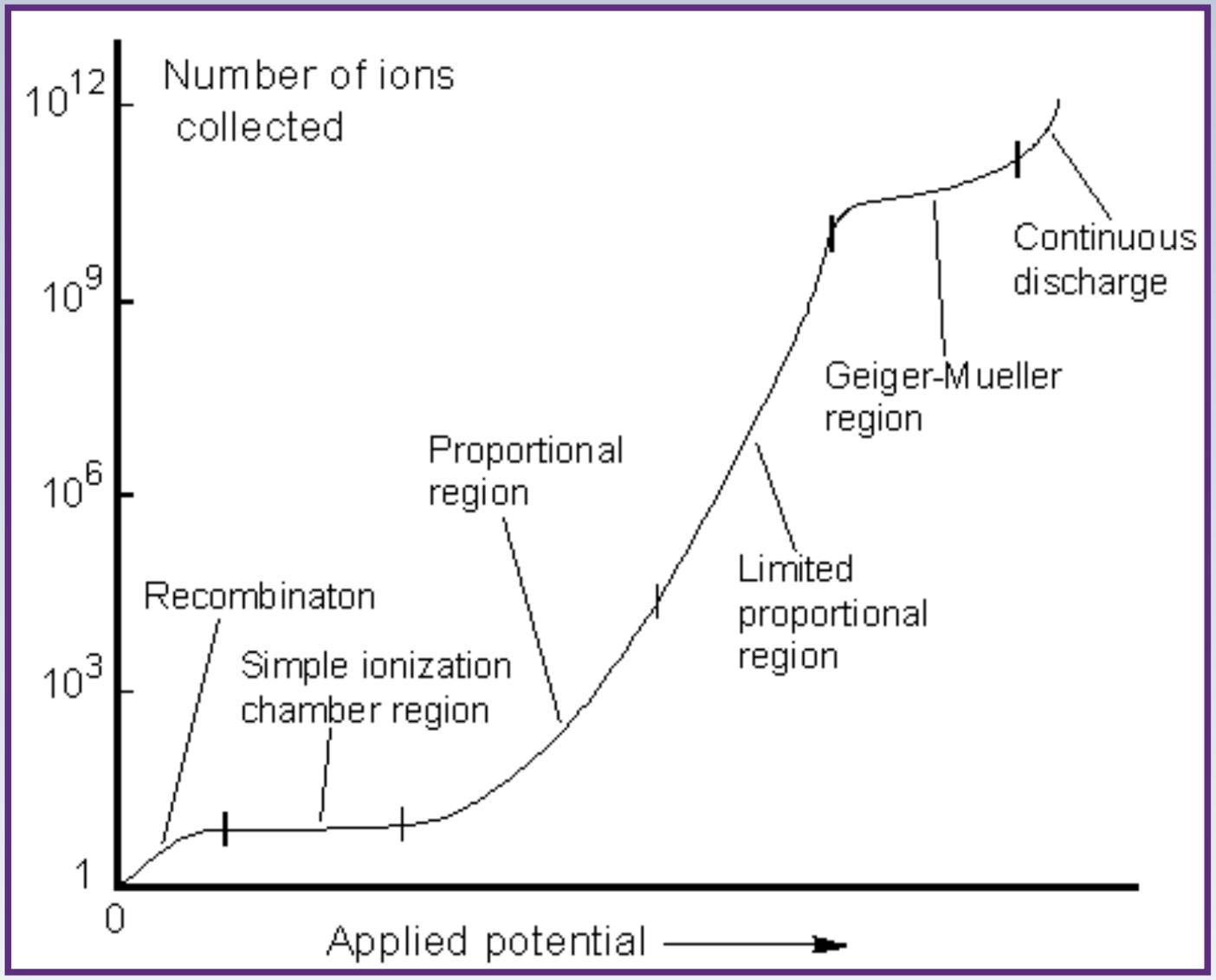
# About gas ionization detectors




Simplest gas detector



Electron avalanche: at each collision the ejected electron is accelerated towards the anode



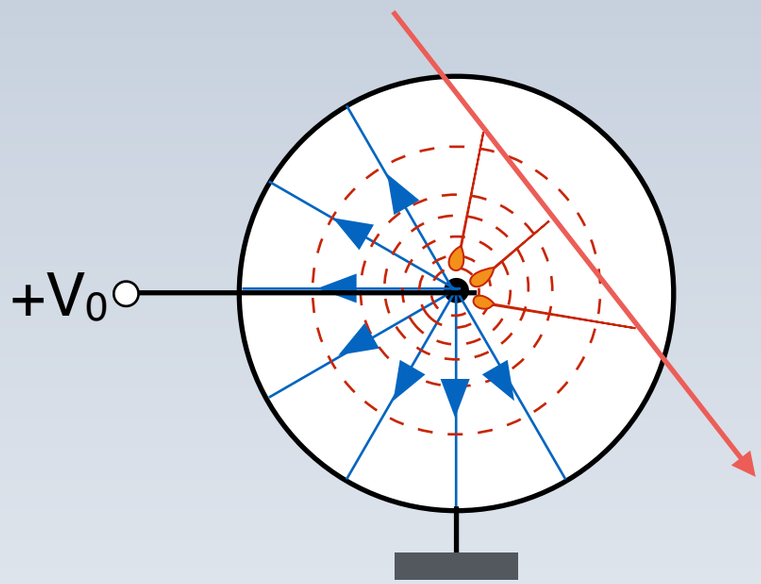

Main detection regions. The external applied potential. provides by the ejected electrons the energy to produce further ionizations.

# GMC vs RPCs

- High electric fields are necessary in order to produce good read-out pulses

## Geiger Counter (GMC)

(Cylindrical capacitor)

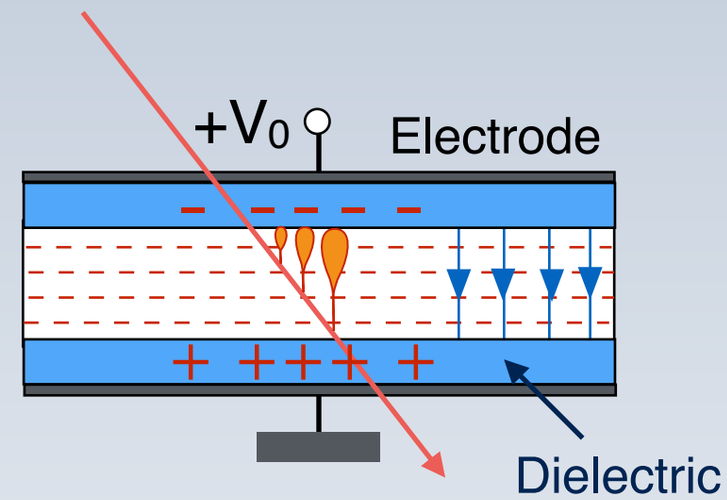



$$E(r) \sim \frac{V_0}{r}$$

- ~ Low $V_0$
- Avalanches start near the anode
- Geiger - Müller mode
- Bad time-resolution
- Bad position-resolution

## Resistive Plate Ch. (RPC)

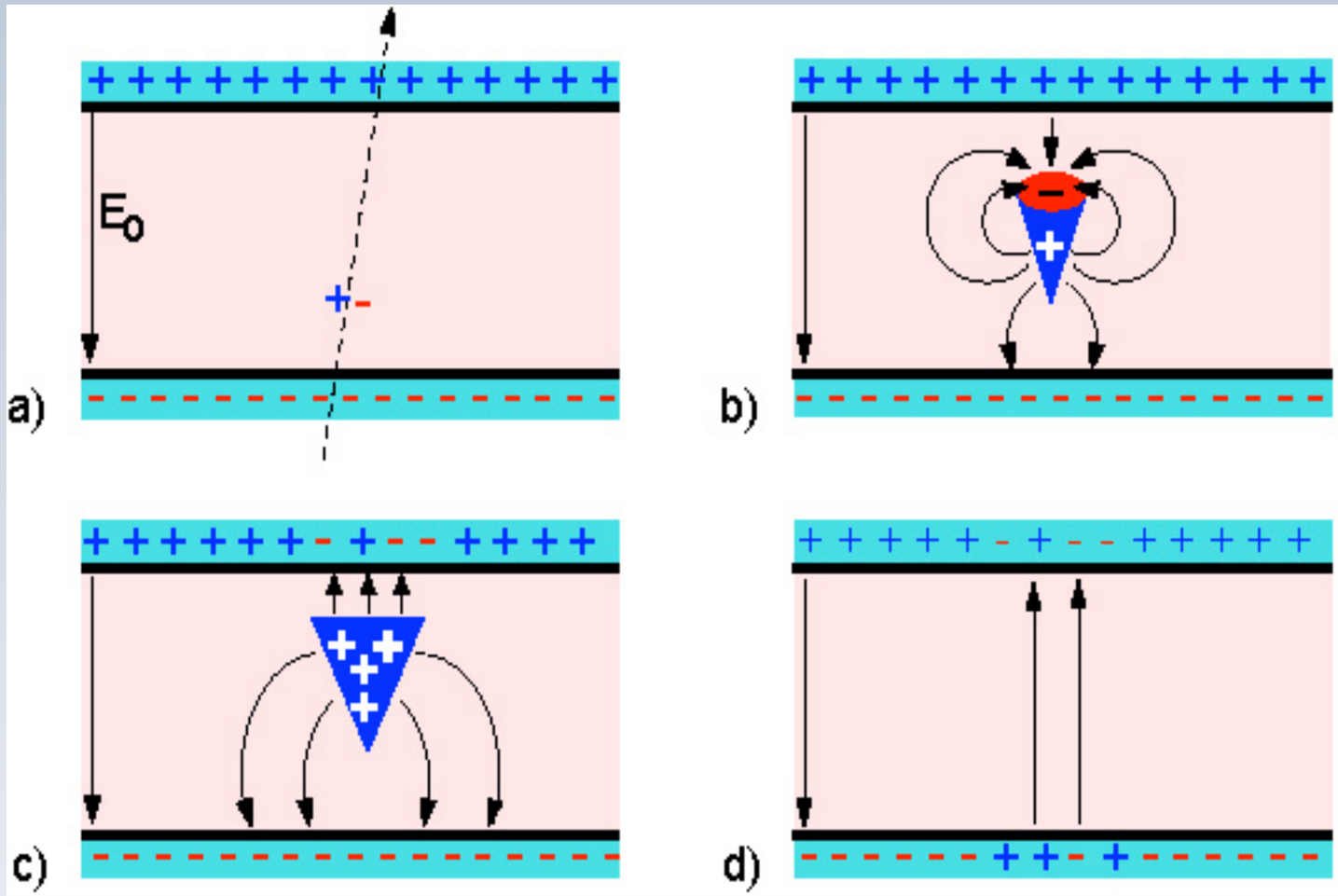
(Parallel capacitor)




- High $V_0$
- Avalanche or Streamer mode
- Outstanding time resolution
- Up to very good position resolution (depends on the read-out method)
- Affordable price for big surfaces

# The RPC (Resistive Plate Chamber)

RPCs belong to the familiy of the gas ionization detectors (as GM counters of MWPCs)




R. Santonico, R. Cardarelli, NIM 187 (1981) 377, NIM A 263 (1988) 20

a) ionisation
b) Avalanche (space charge effects!)
c) Slow ion drift (in RPCs electrons induce the signal!)
d) Charge sticks in resistive plates after avalanche (rate effects!)

time constant: $\tau = \rho\, \varepsilon_0\, \varepsilon_r$

$\rho$ = Volume resistivity
$\varepsilon_0$ = Dielektr. constant
$\varepsilon_r$ = rel. permittivity

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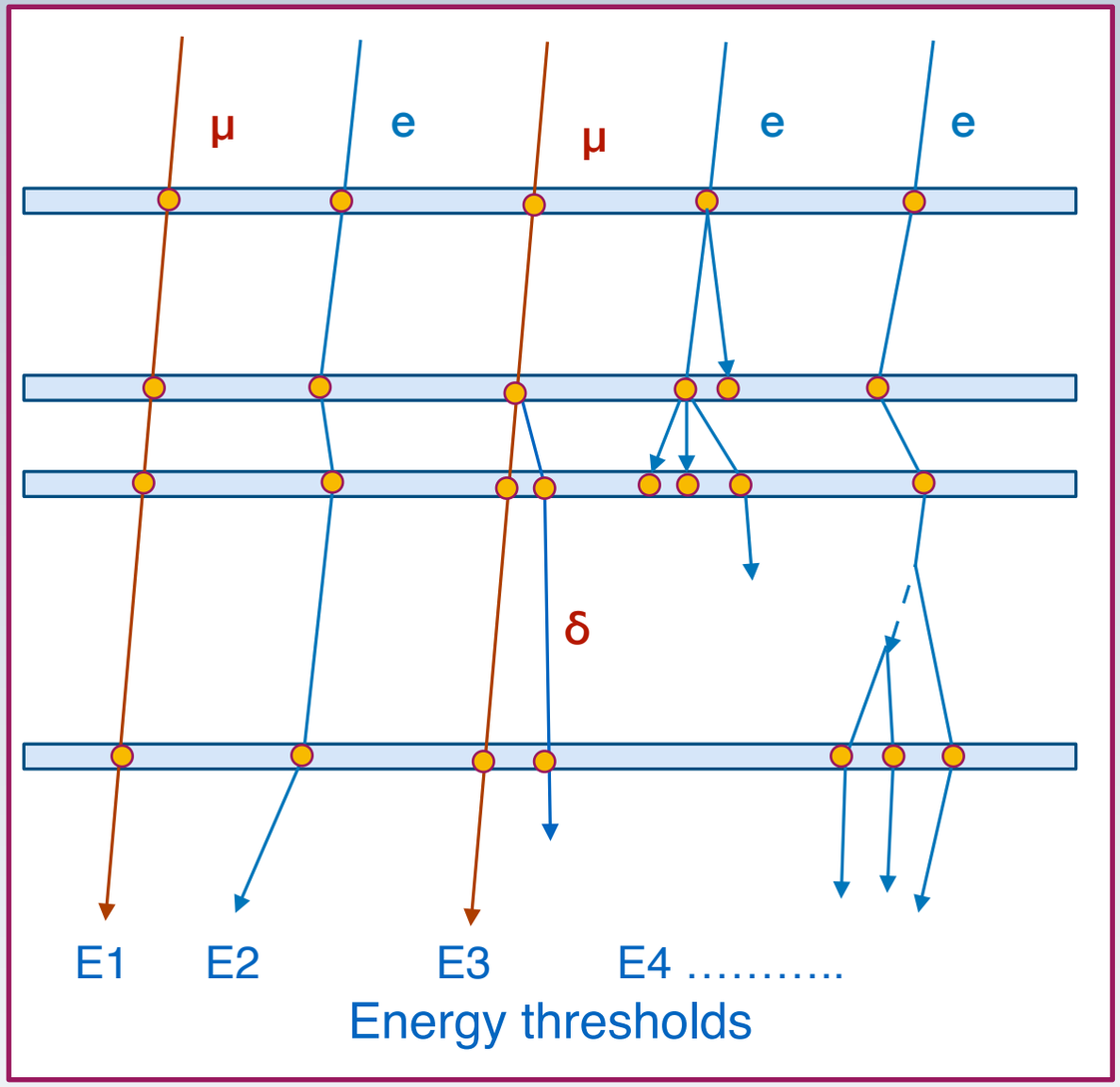


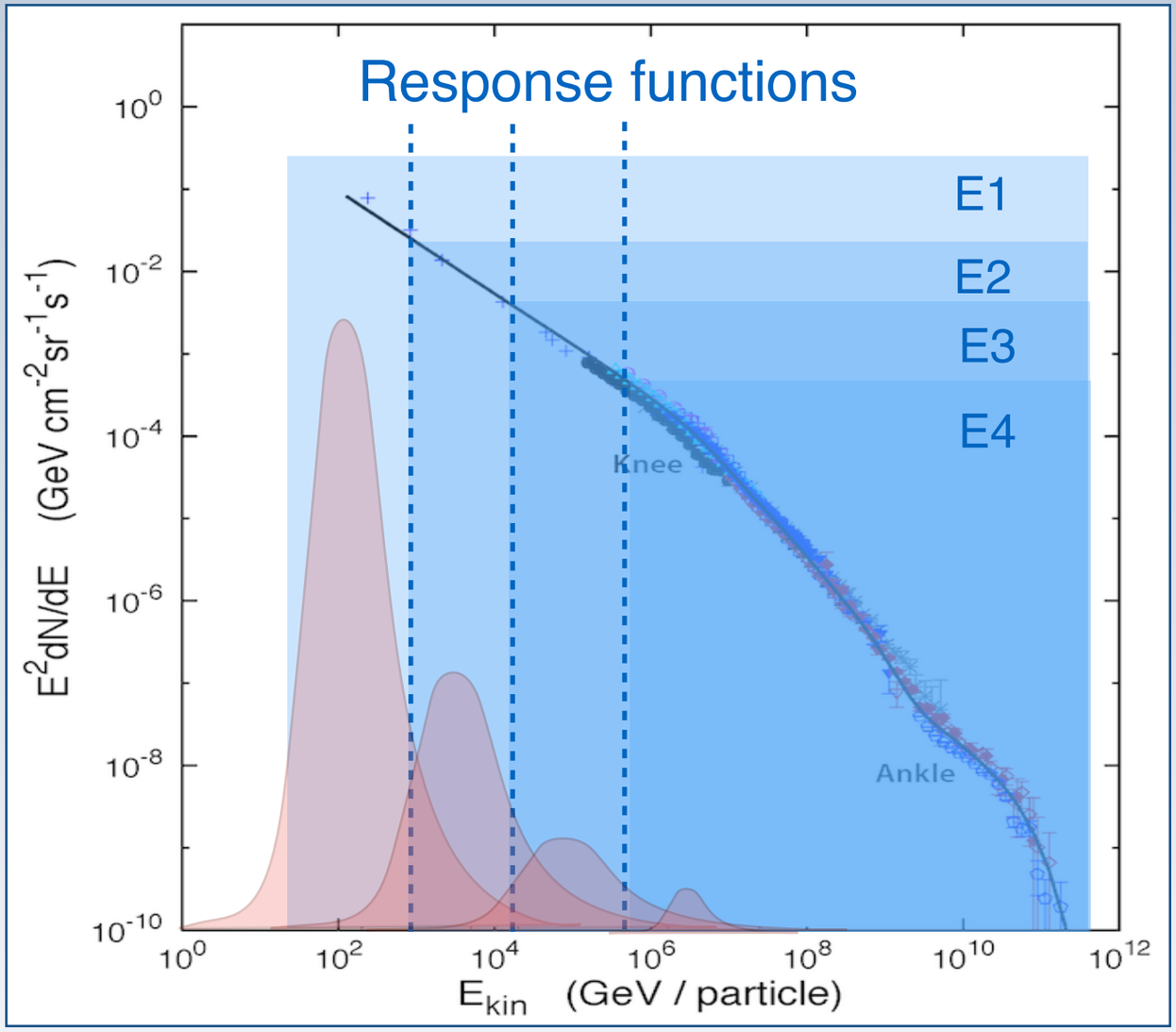


Trasgos could scan the arrival of primary cosmic rays in Energy slices



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# (A PHILOSOPHY)

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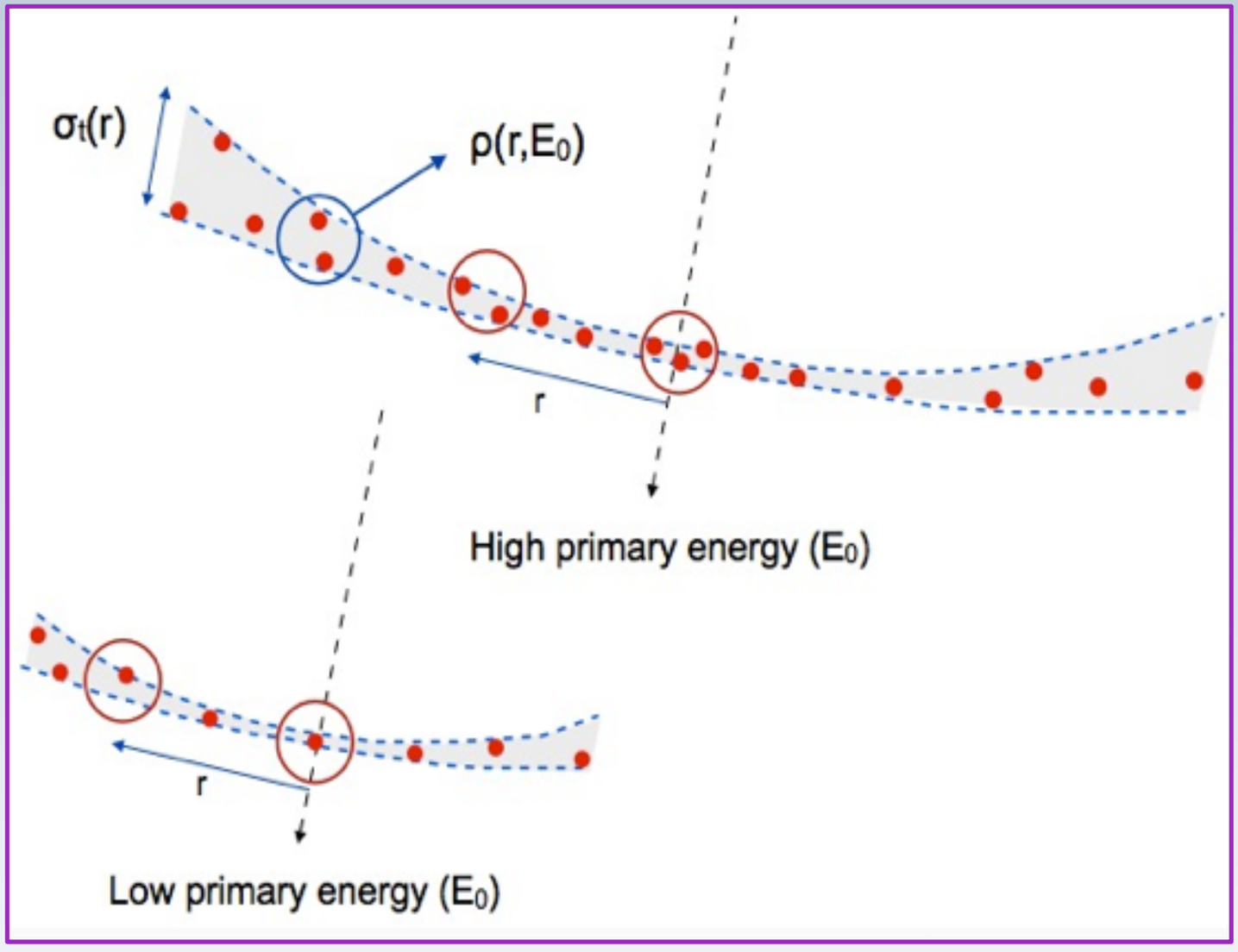


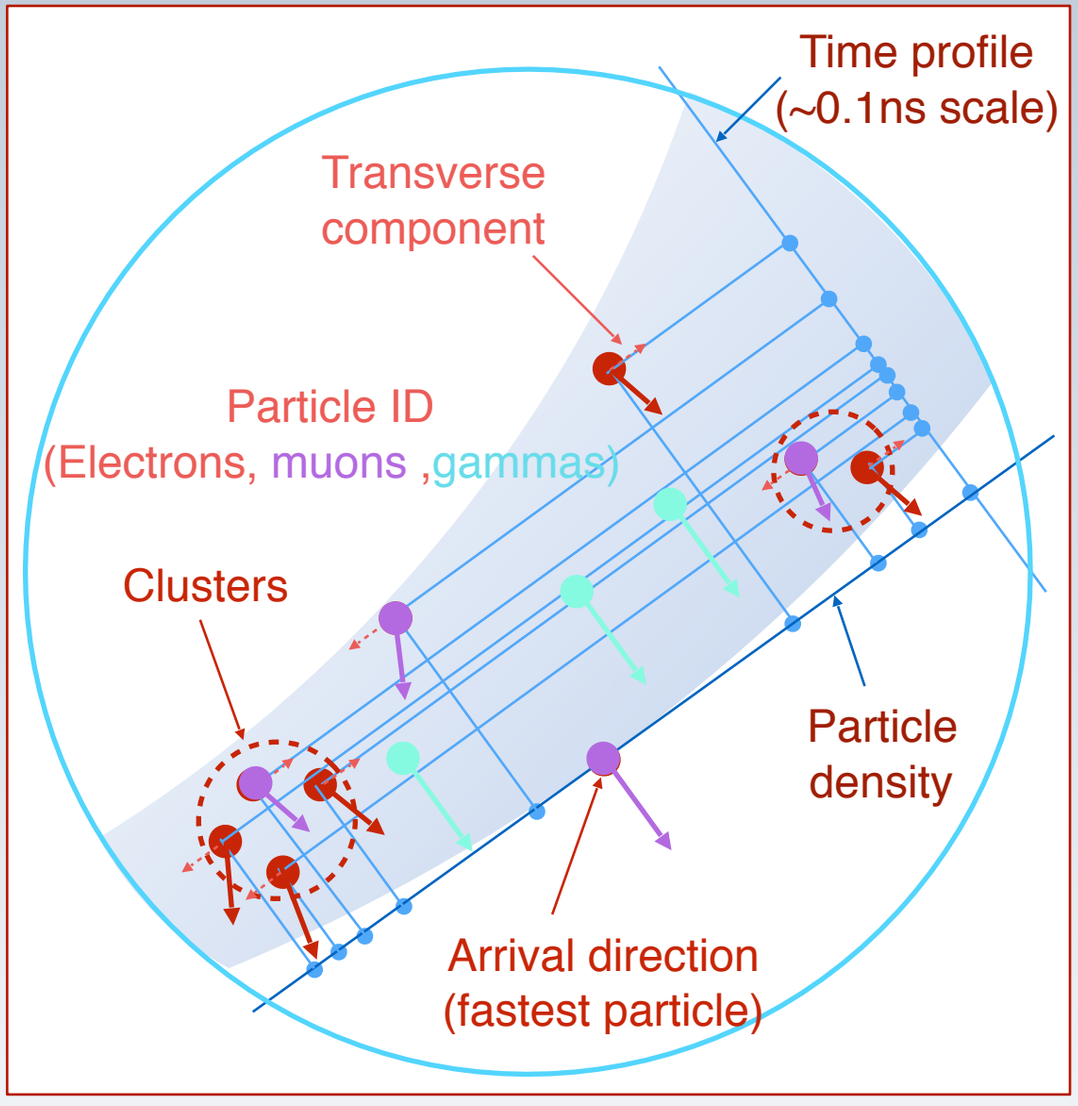


Trasgos could have access to many new observables



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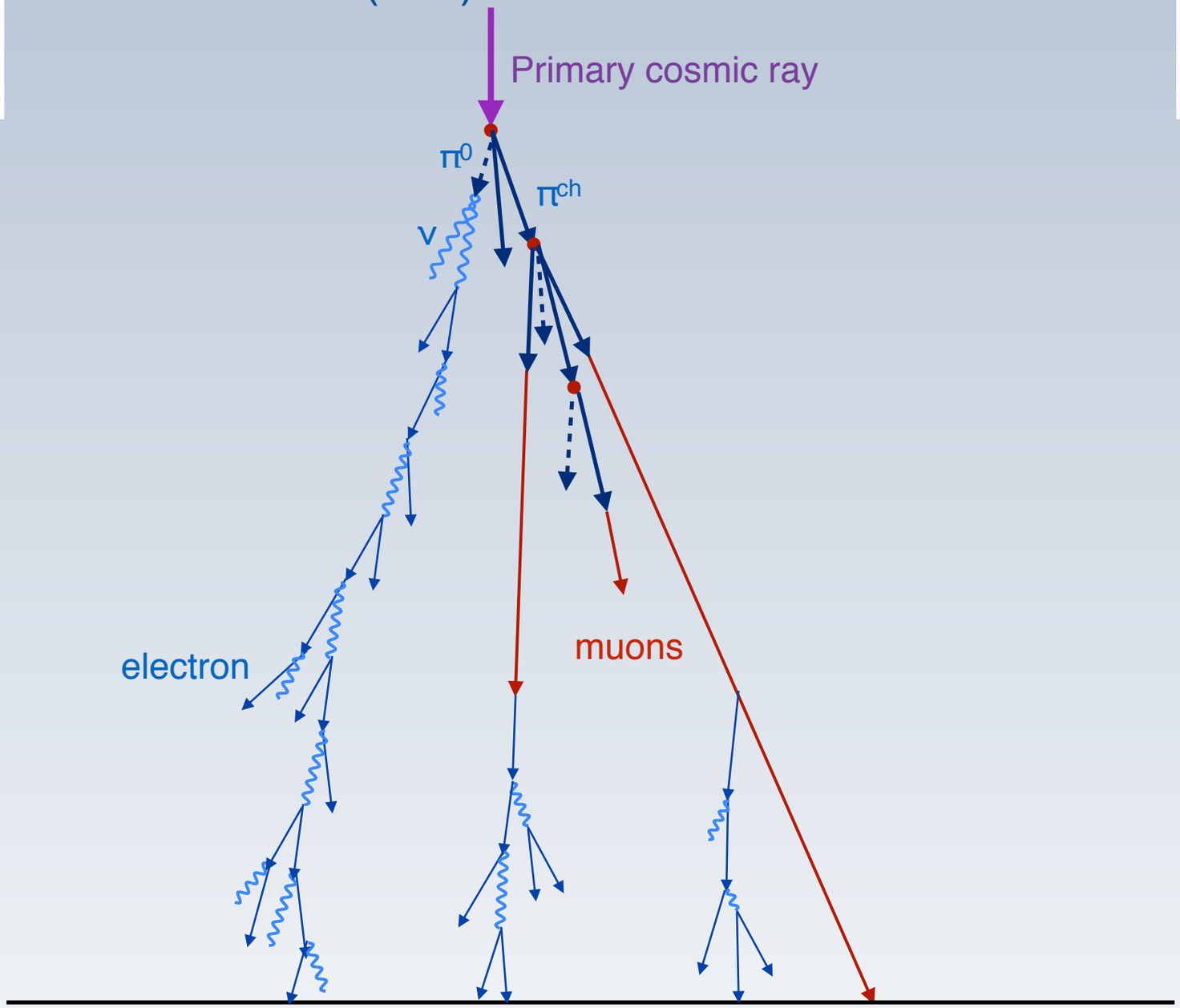


| π0-electron | decay electron | δ-electron | muon |
|---|---|---|---|
| $N_e^{\pi^0} = \gamma N_e$ | $N_e^{dec} = \alpha N_e$ | $N_e^{\delta} = \beta N_e$ | $\alpha + \beta + \gamma = 1$ |

EM showers is an indirect way to measure high energy muons



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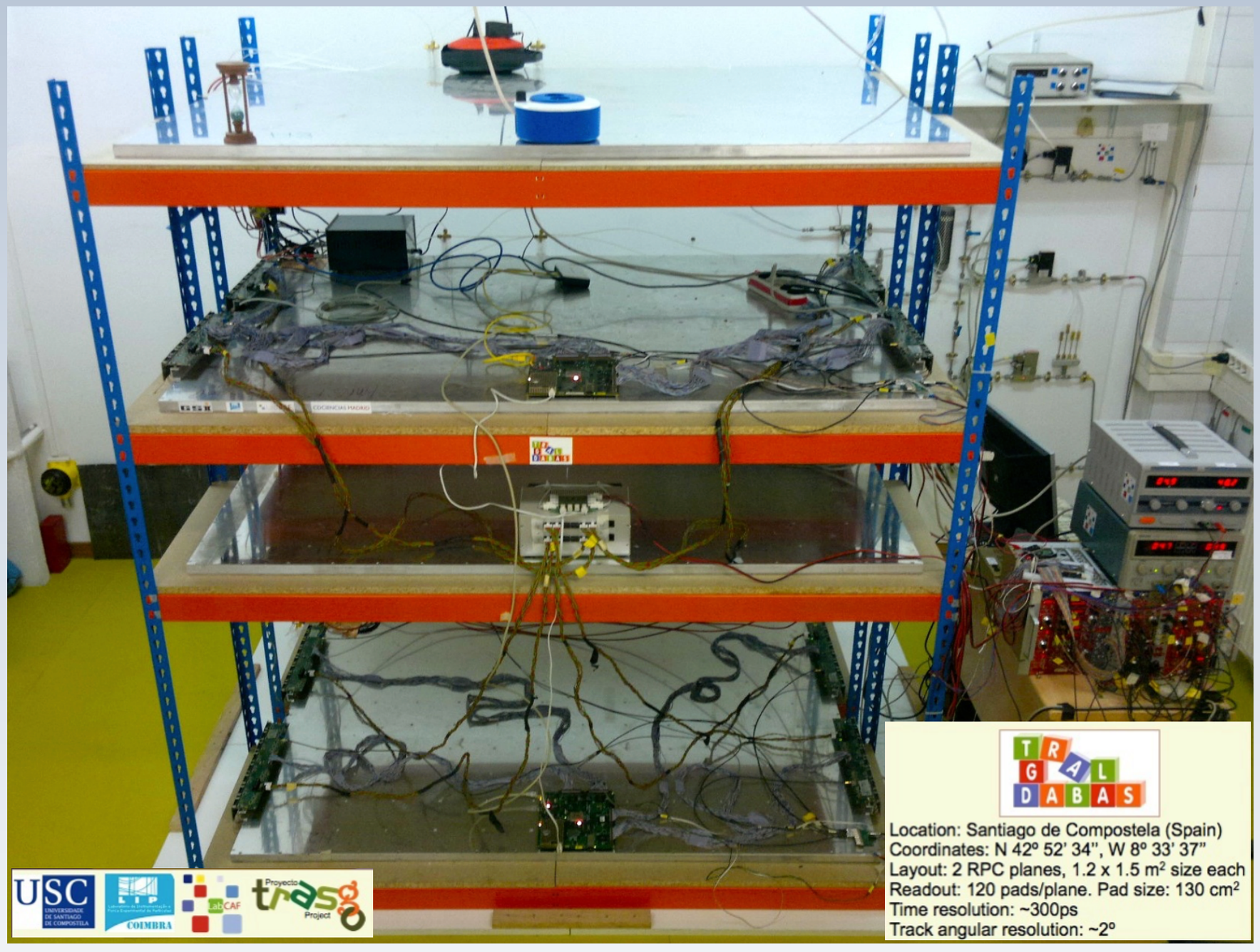
# The first Trasgo: TRAGALDABAS

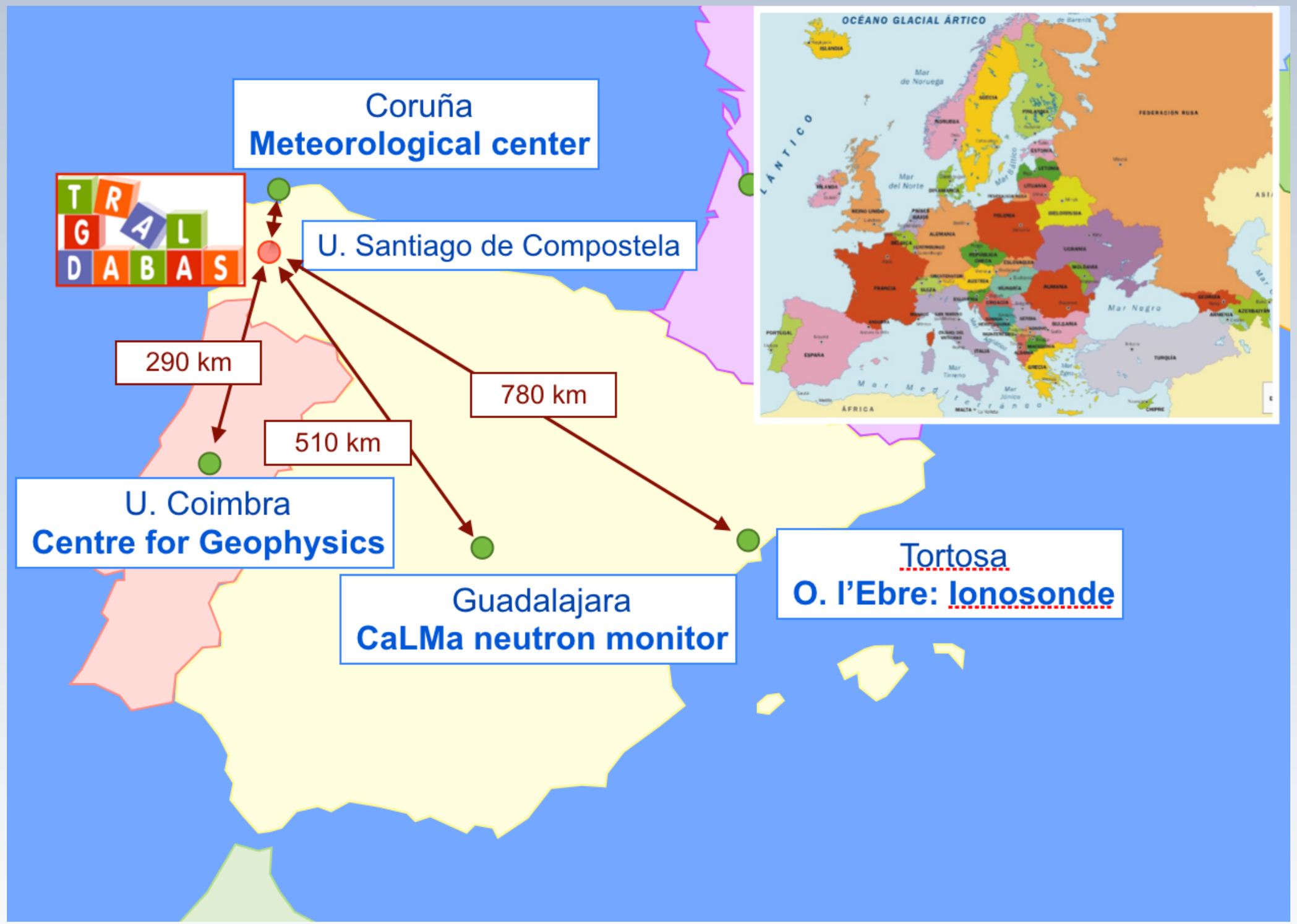
(Pronuntiation: *truguldubus*)



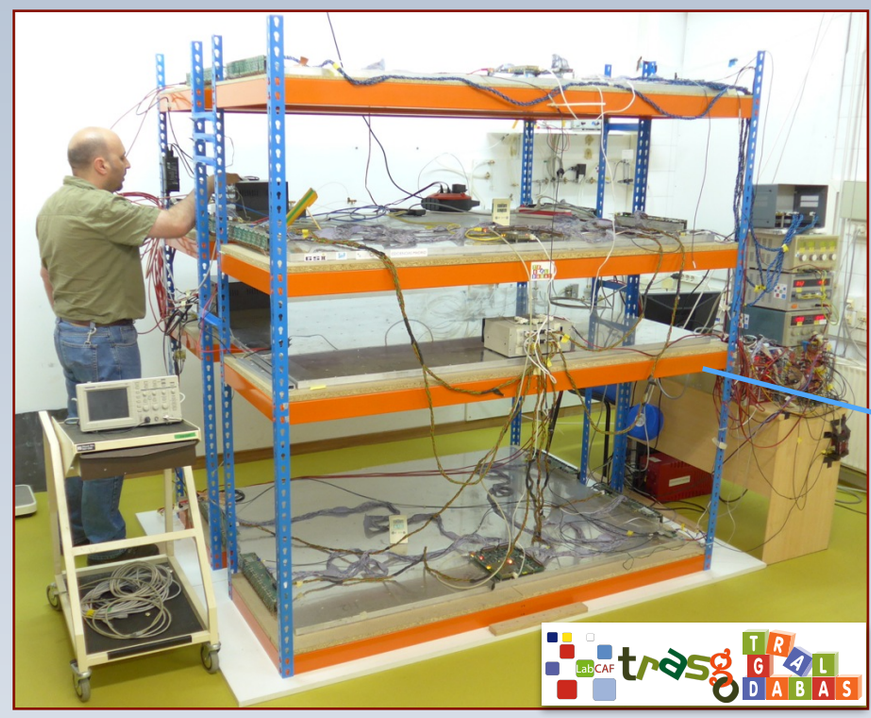

TRAsGo for the AnaLysis of the nuclear matter Decay, the Atmosphere, the earth B-field And the Solar activity

# The first Trasgo: TRAGALDABAS

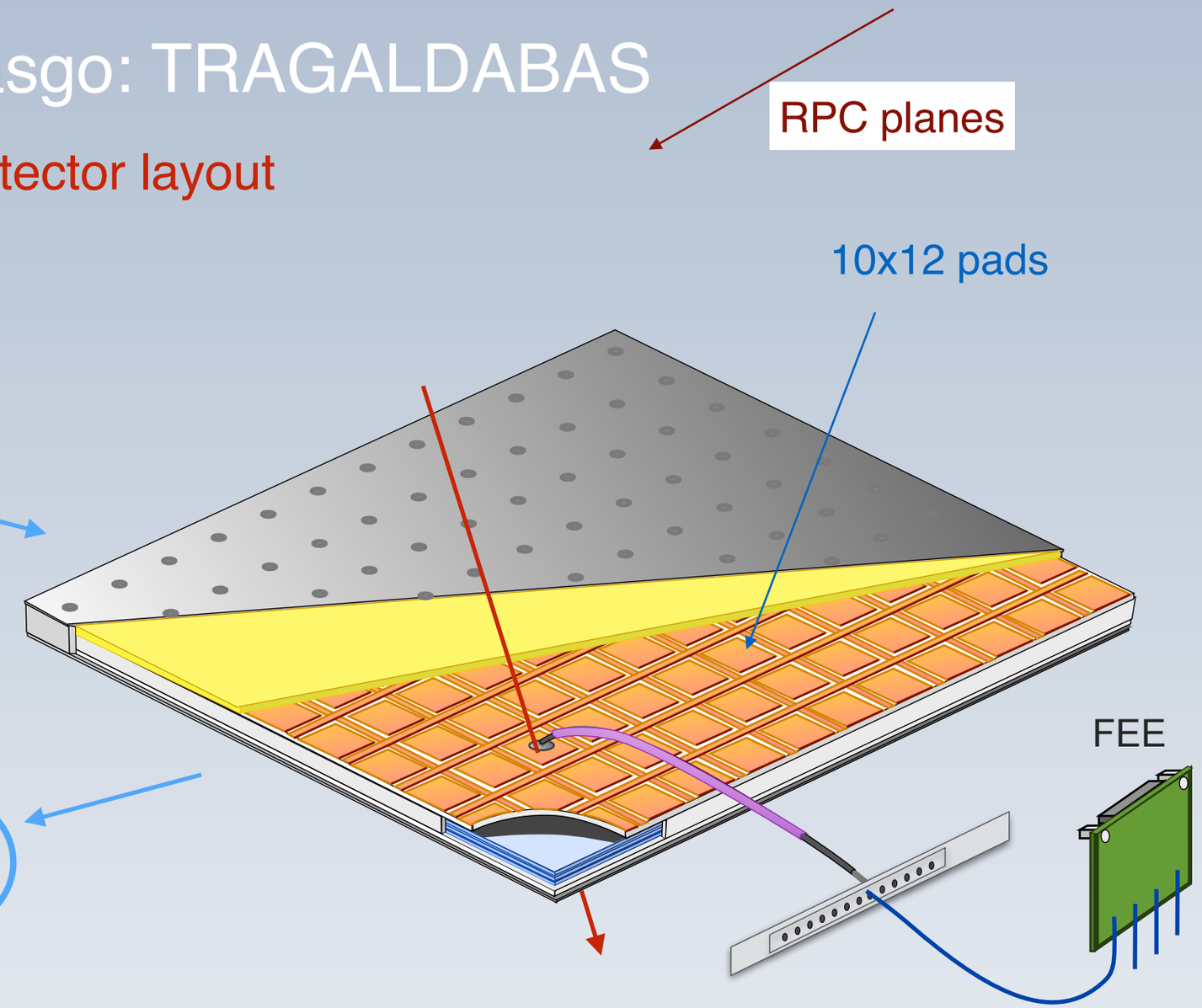
## Location

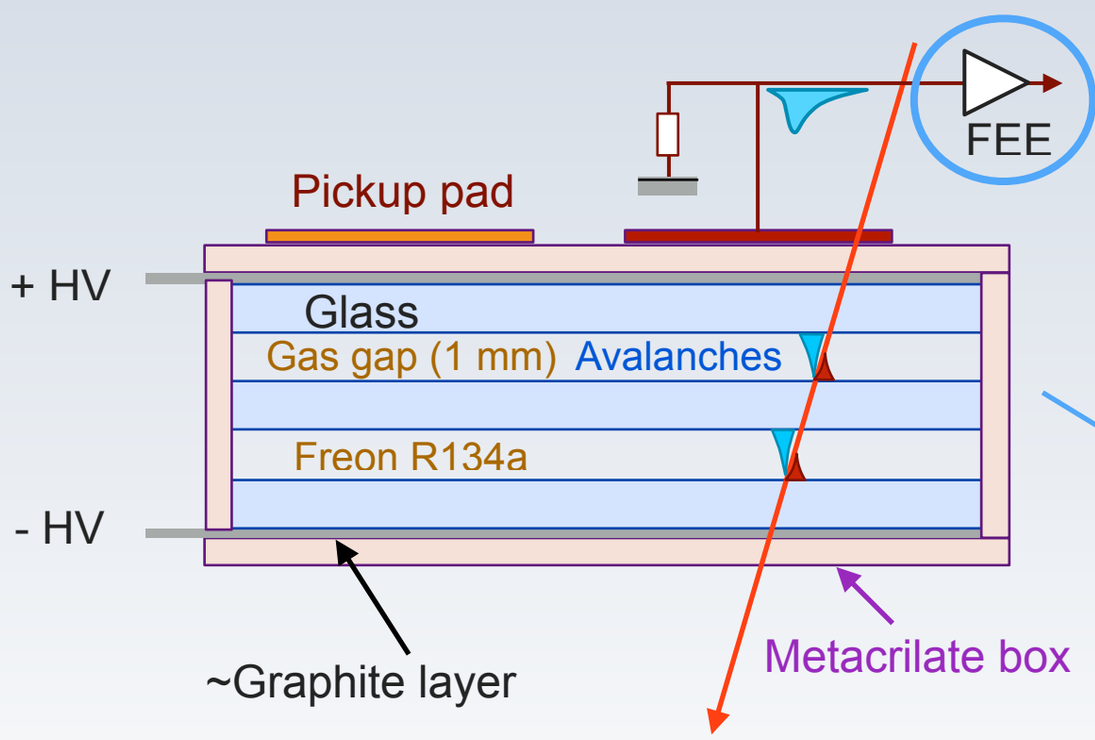


# The first Trasgo: TRAGALDABAS

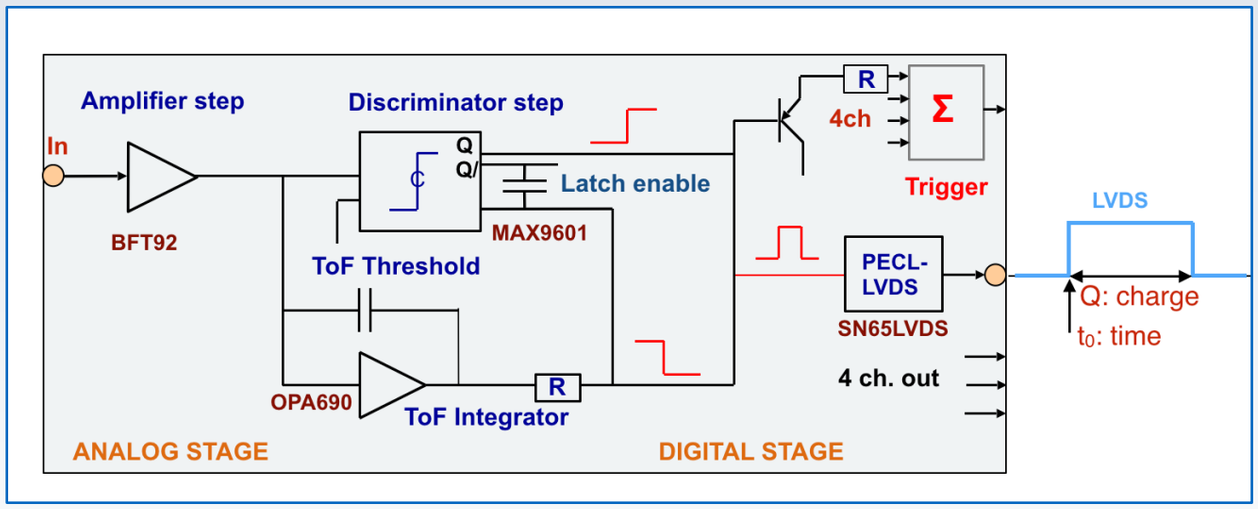


## Detector layout




RPC: Resistive Plate Chamber cut




FEE (HADES-GSI)



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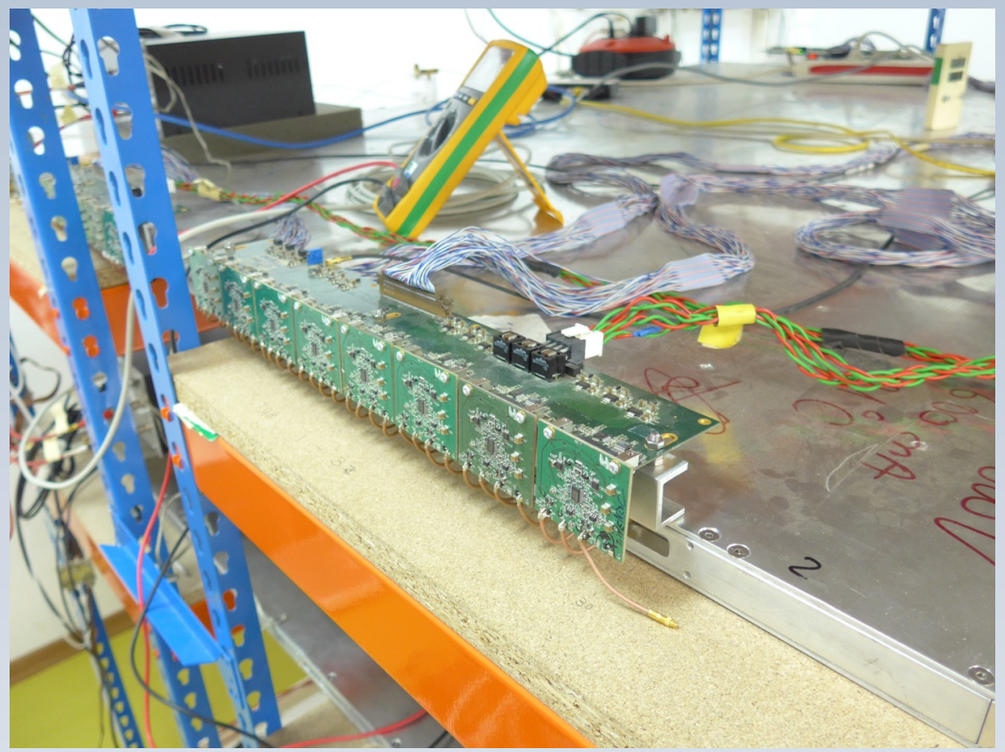
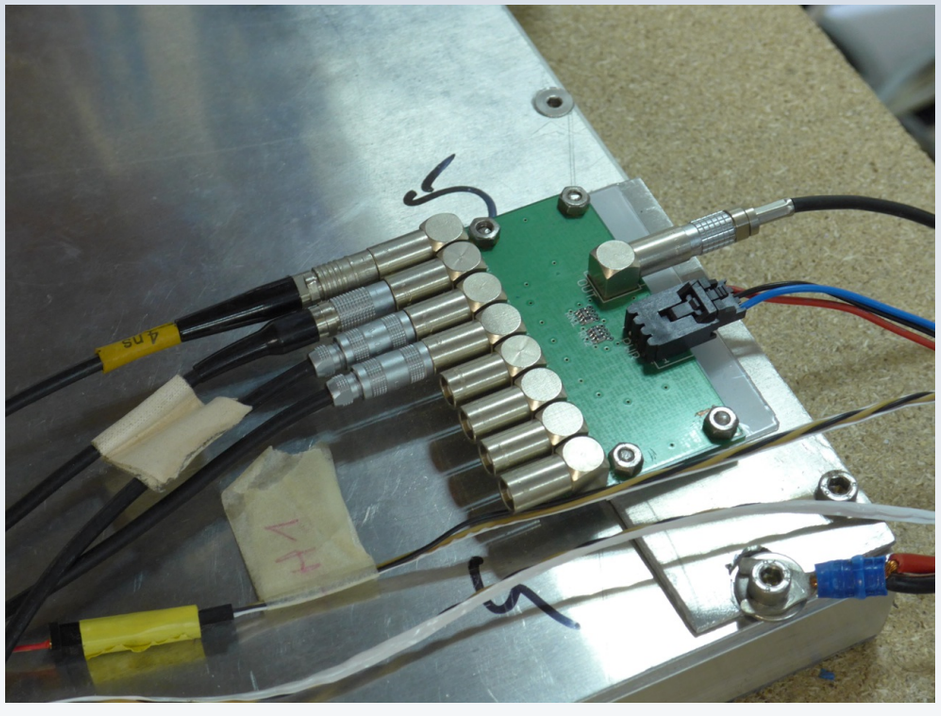
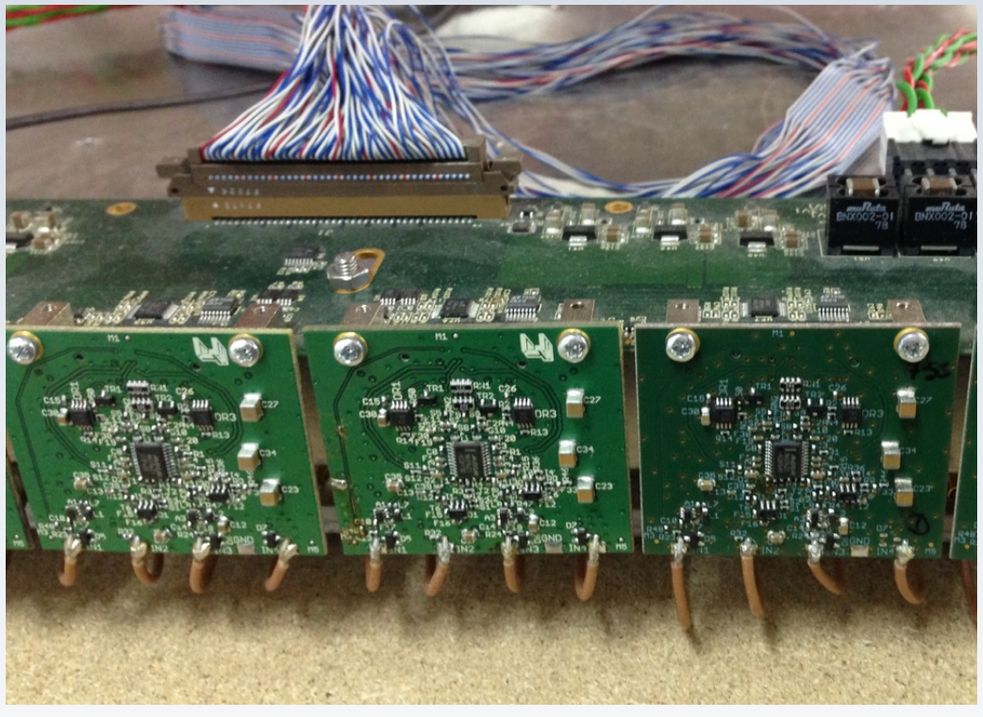
# The first Trasgo: TRAGALDABAS







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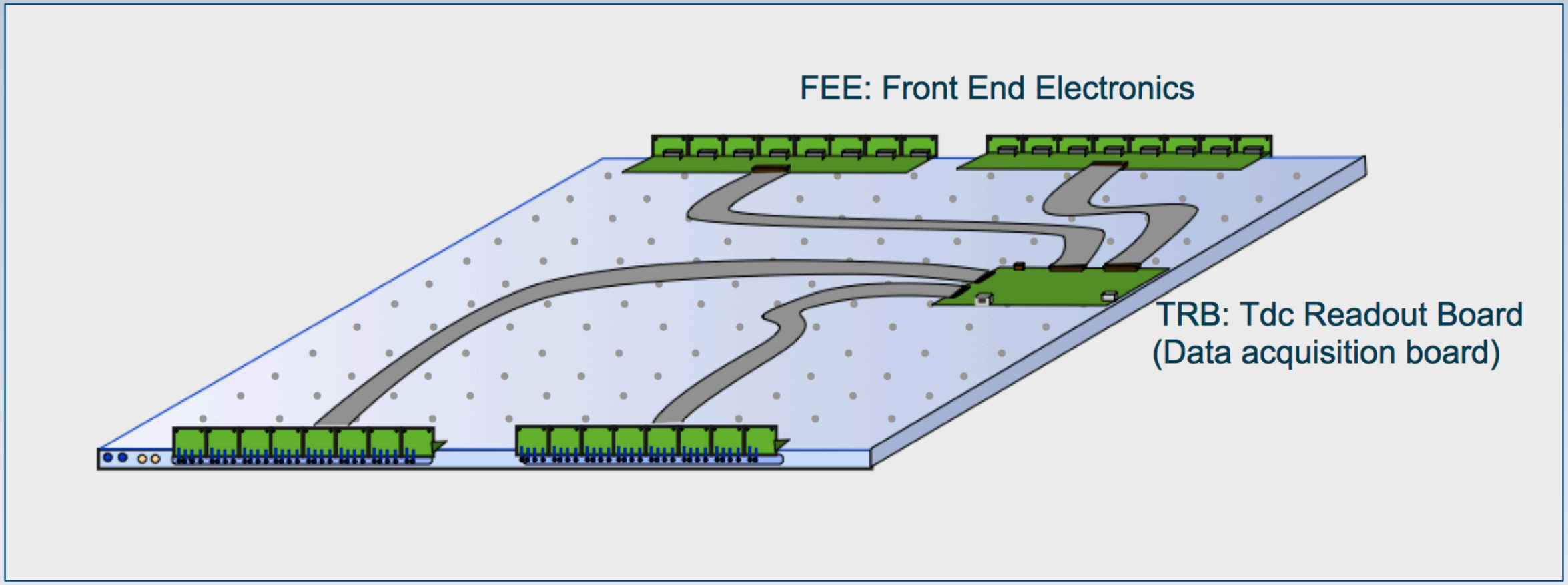
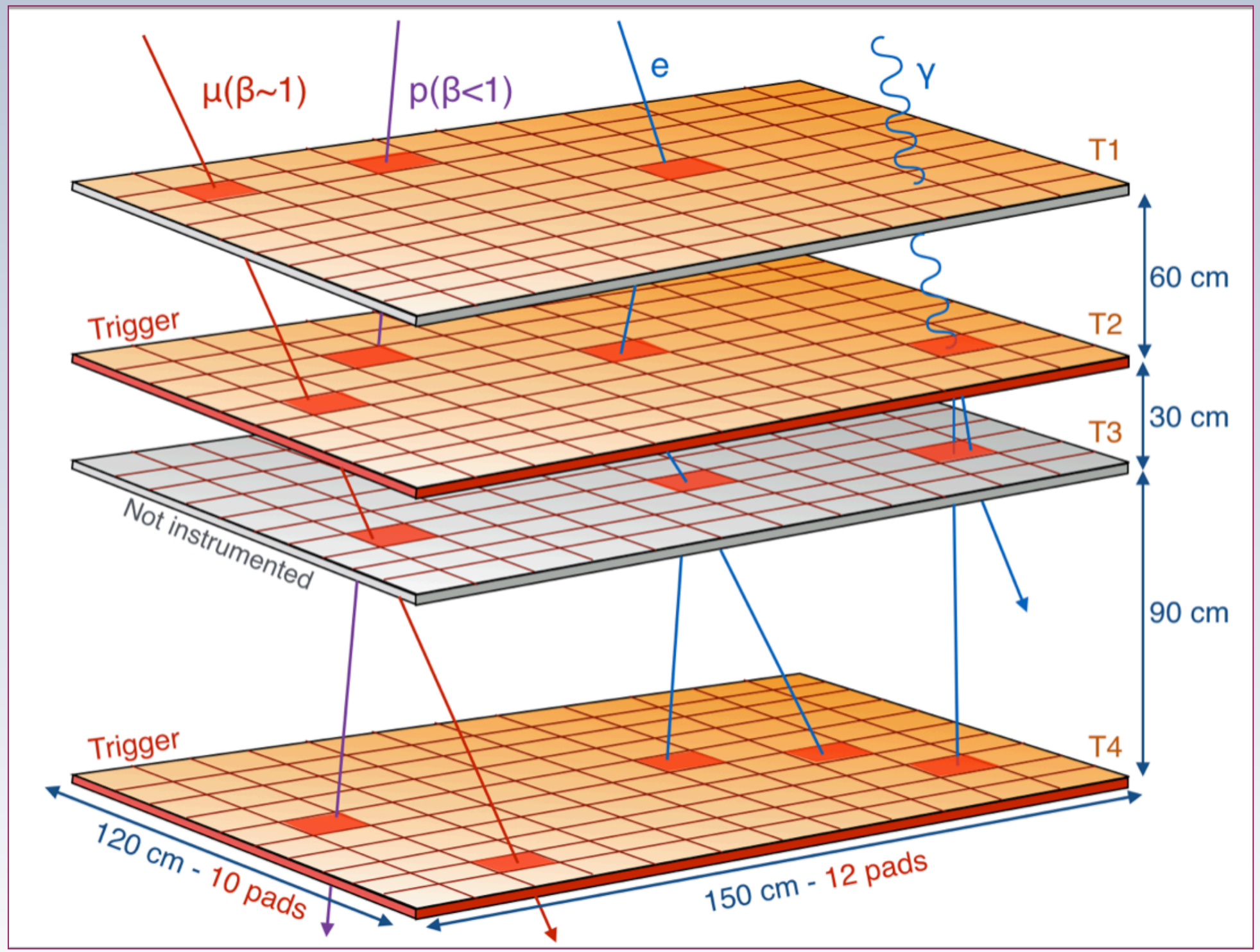



Front End Electronics and Read-Out system

# THE TRASGO FLEET

## 1.TRAGALDABAS: PID strategy



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# THE TRASGO FLEET

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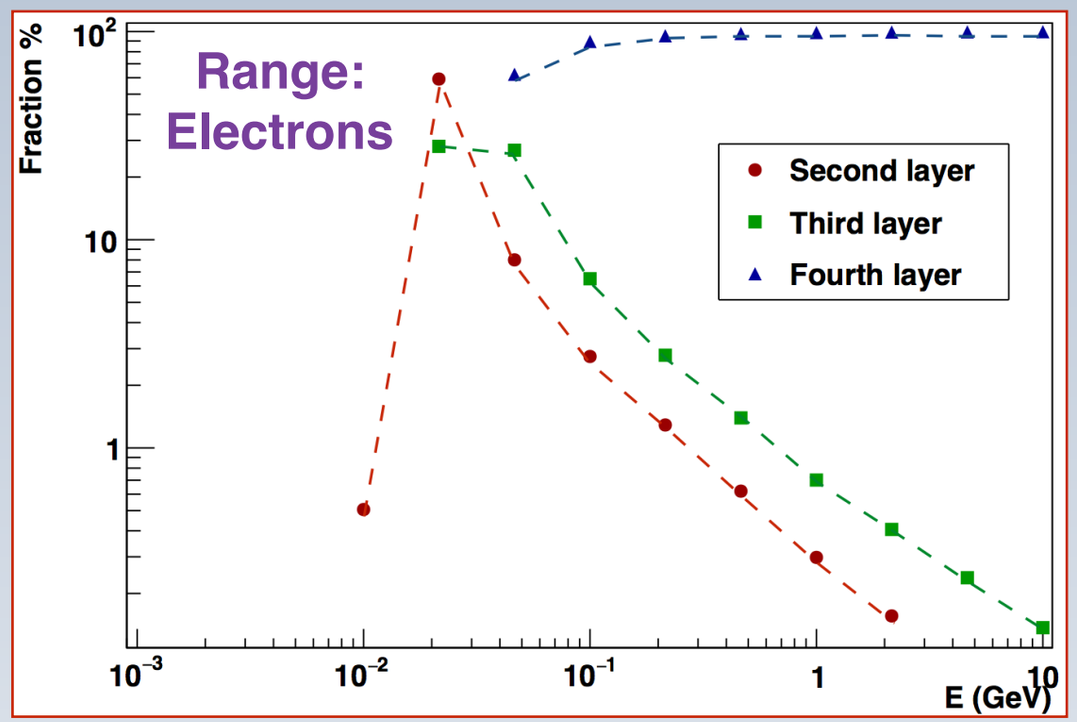


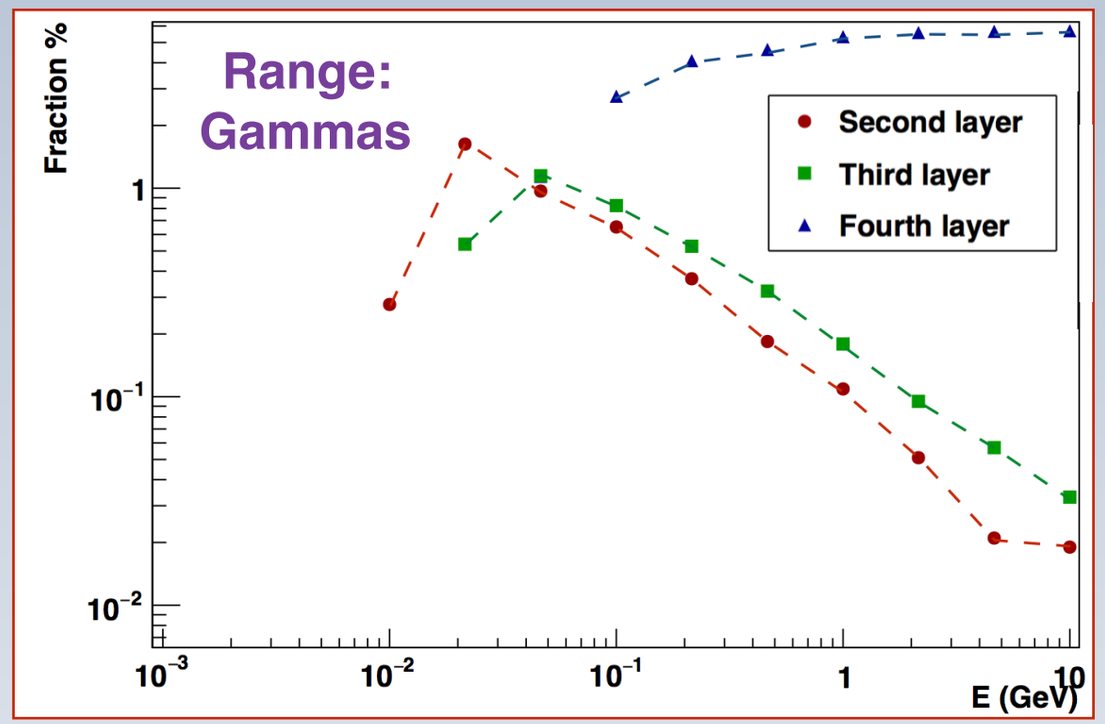


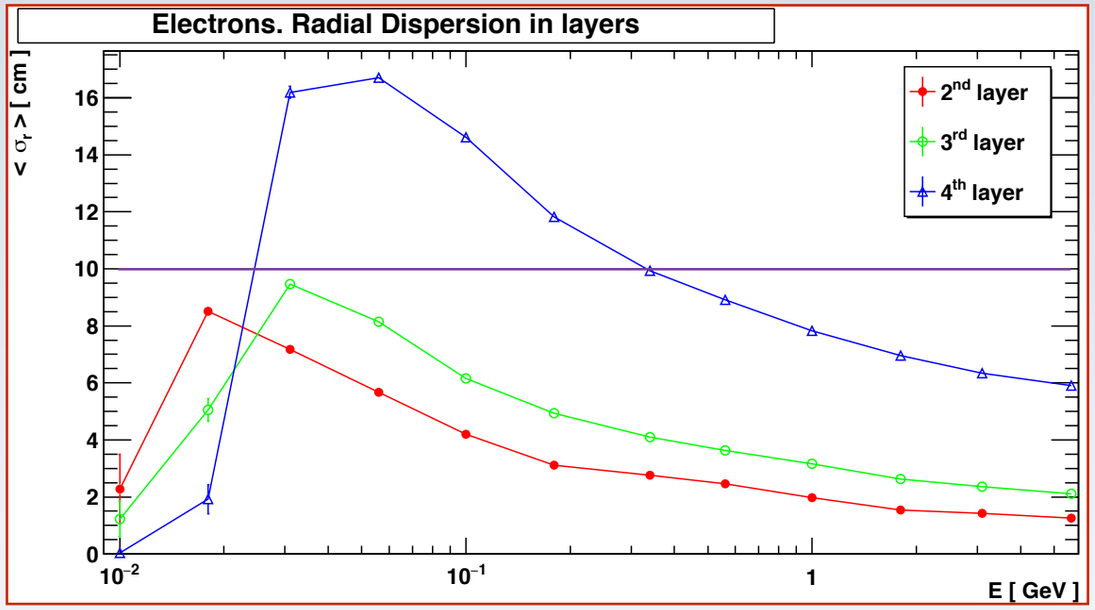


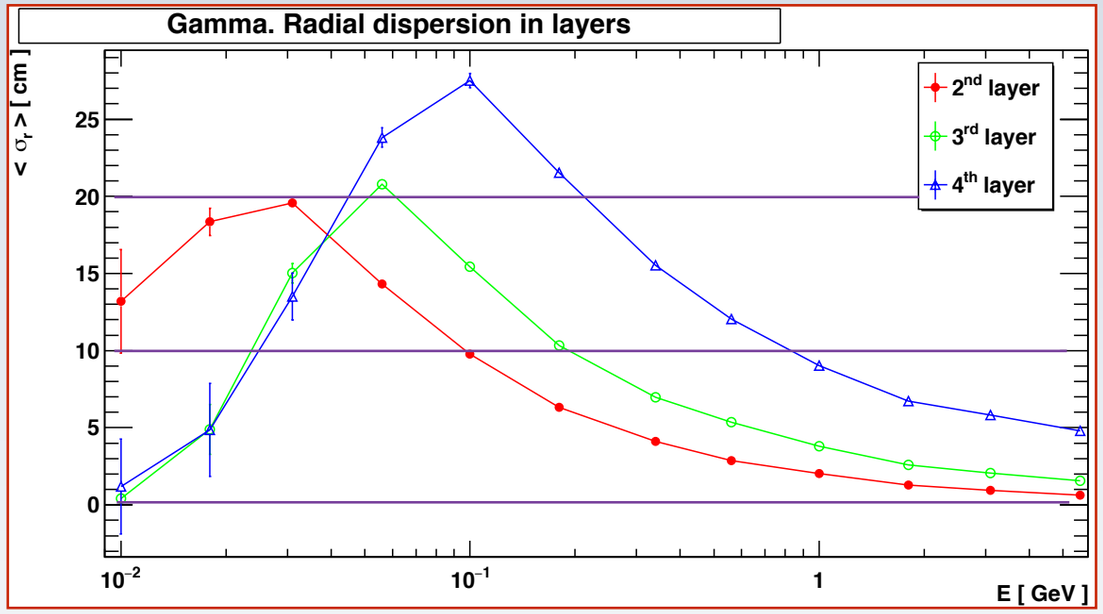


Gamma showers are typically broader than electron showers!



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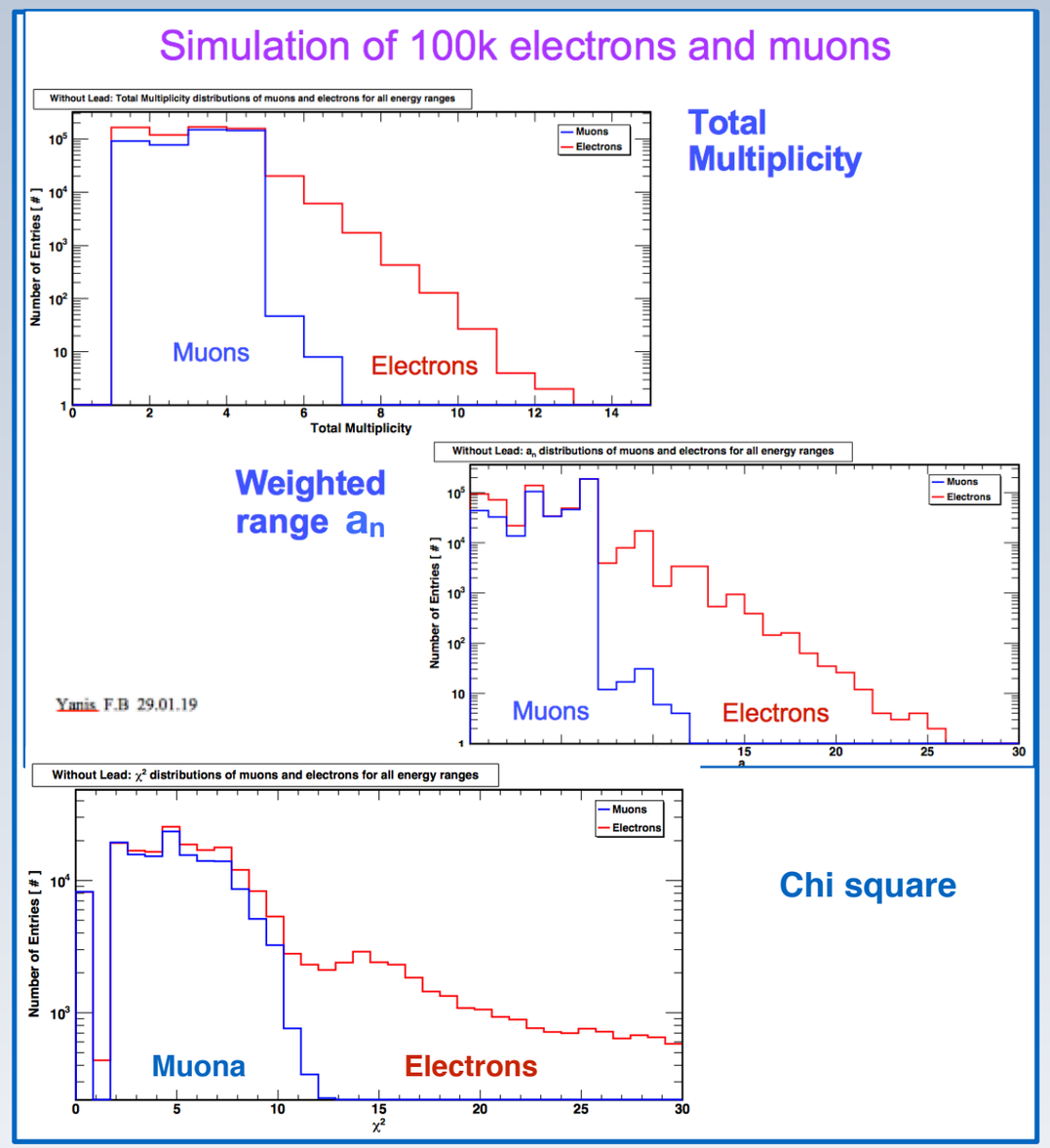
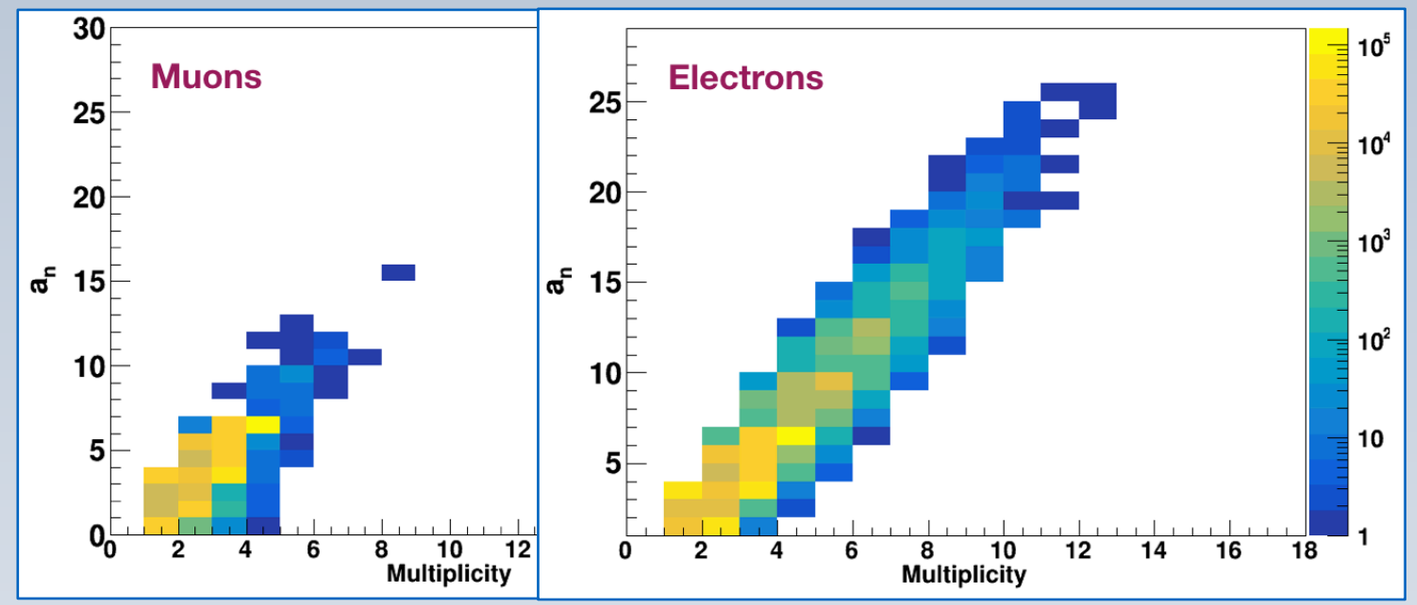
# THE TRASGO PROJECT: a small scope of activities

## RAGALDABAS: electron/ muon PID simulation




Multiplicity, Weighted range and $\chi^2$ dist. for muons and electrons

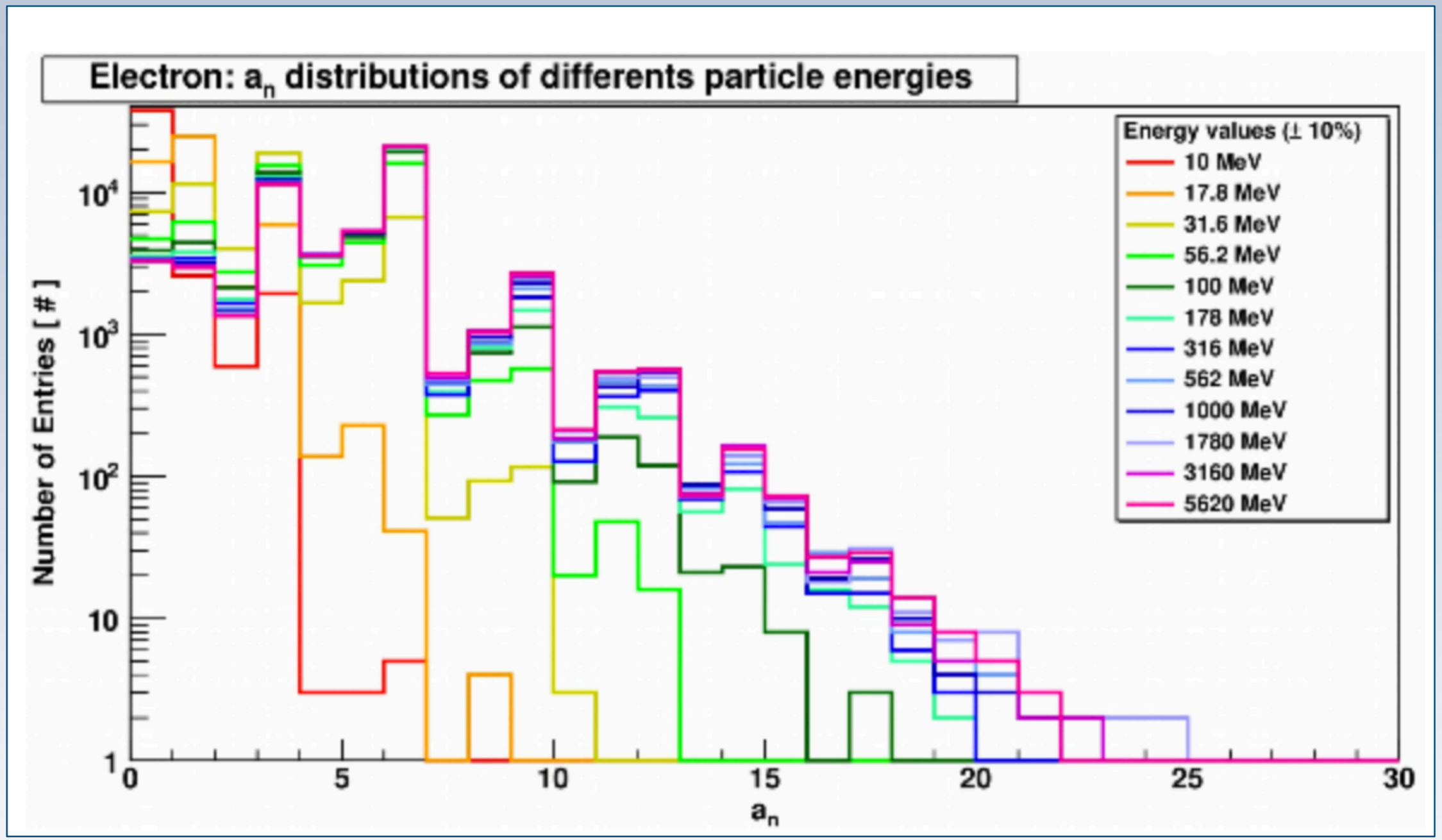



Weighted range vs. multiplicity for muons and electrons

| Nplanes | Success Probability (%) | |
|---|---|---|
| | Indoors | Outdoors |
| 3 | 90.2 +/- 1.4 | 99.3 +/- 0.2 |
| 4 | 87.9 +/- 1.5 | 99.3 +/- 0.2 |
| 4 +1 cm Pb | 91.9 +/- 1.6 | 99.2 +/- 0.2 |
| 4 +1.5 cm Pb | 90.3 +/- 1.6 | 98.8 +/- 0.2 |

# THE TRASGO PROJECT: a small scope of activities

Electron “calorimetry” simulation

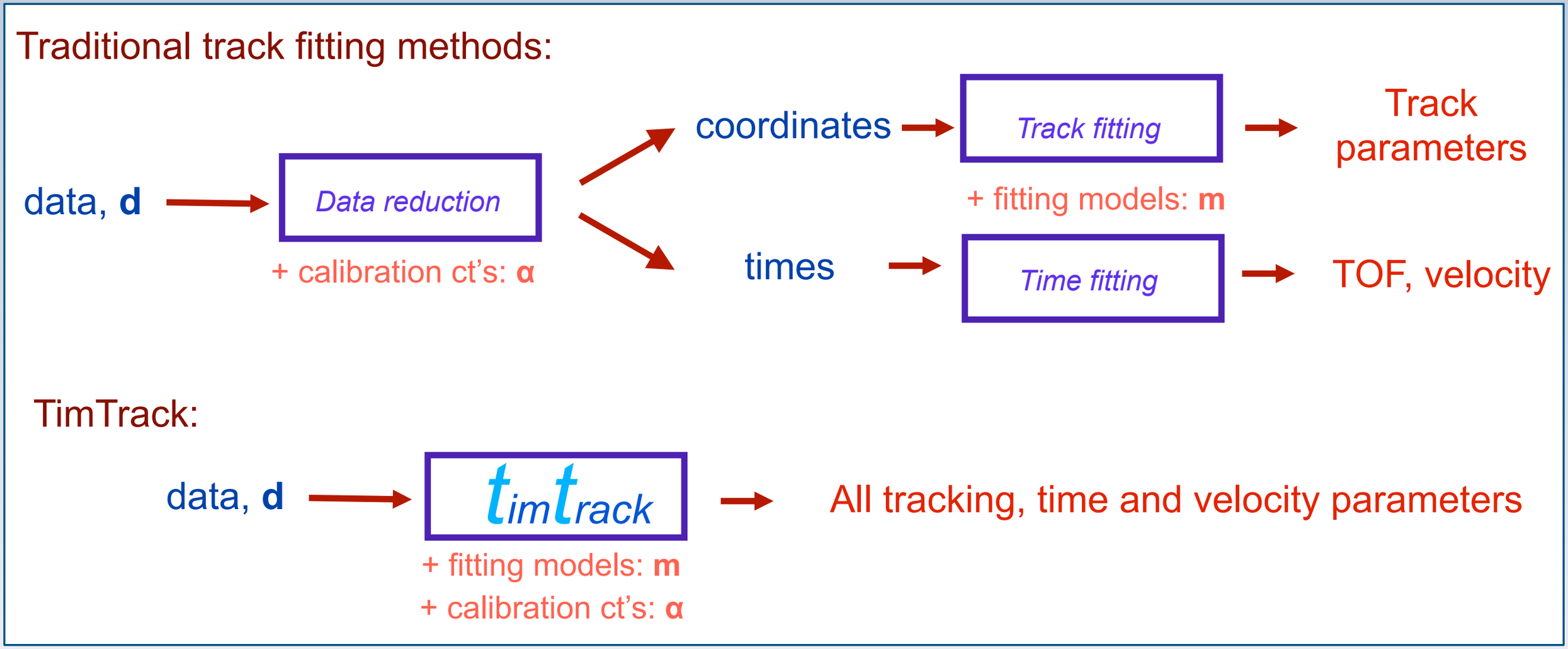



Weighted range distributions for different electron energies

# THE TRASGO PROJECT: a small scope of activities

## TimTrack fitting method

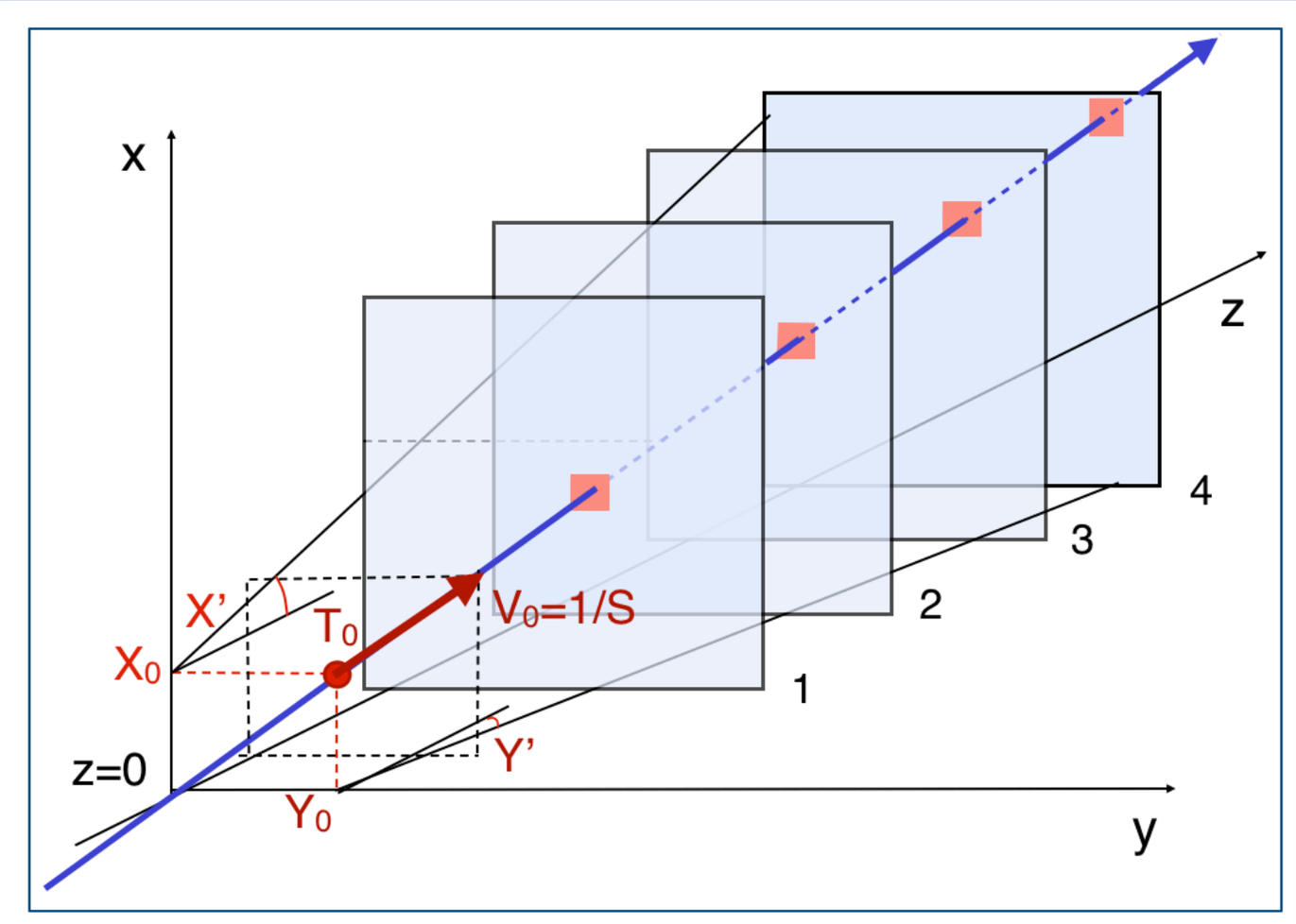
### TimTrack vs. traditional fitting methods:



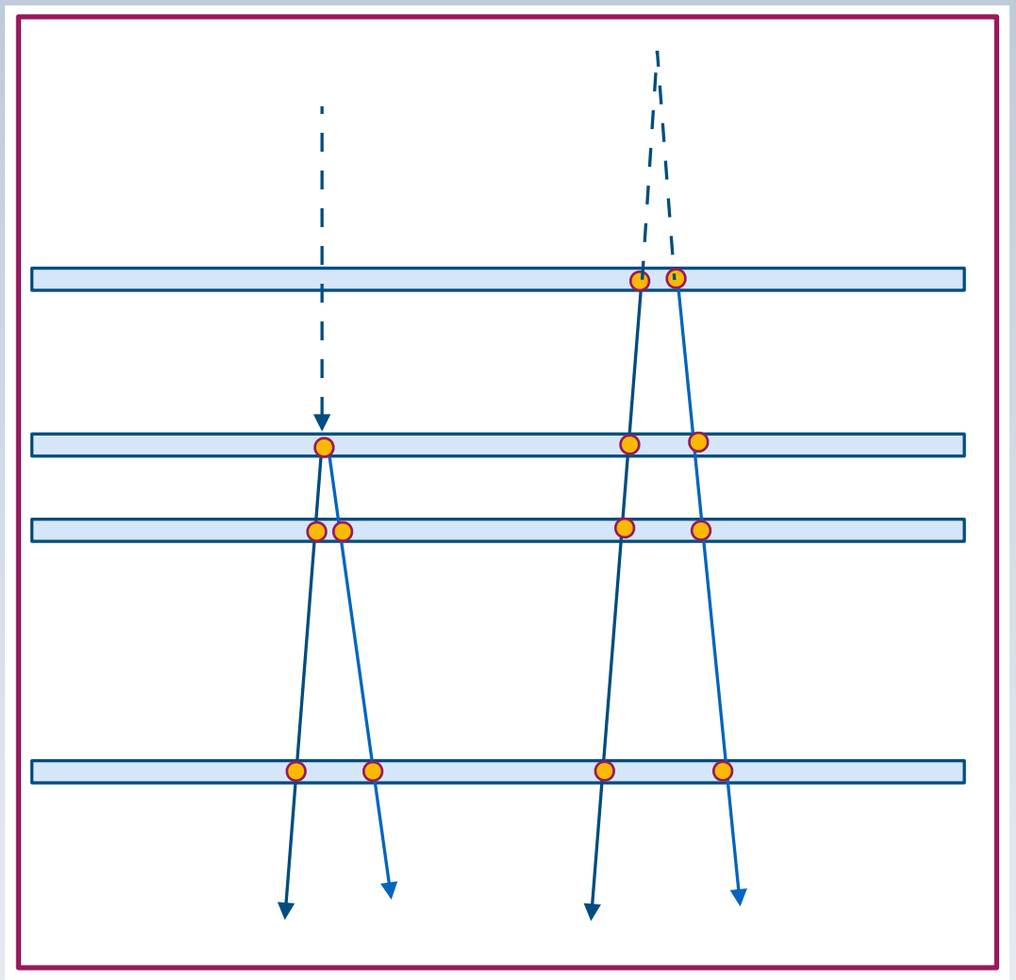

Comparison between the TimTrack formalism and the typical reconstructing methods

# THE TRASGO PROJECT: a small scope of activities

## TimTrack fitting method




Definition of saeta, **s** = {$X_0$, X', $Y_0$, Y', $T_0$, $S_0$=1/V}, parameters



Joint reconstruction of tracks



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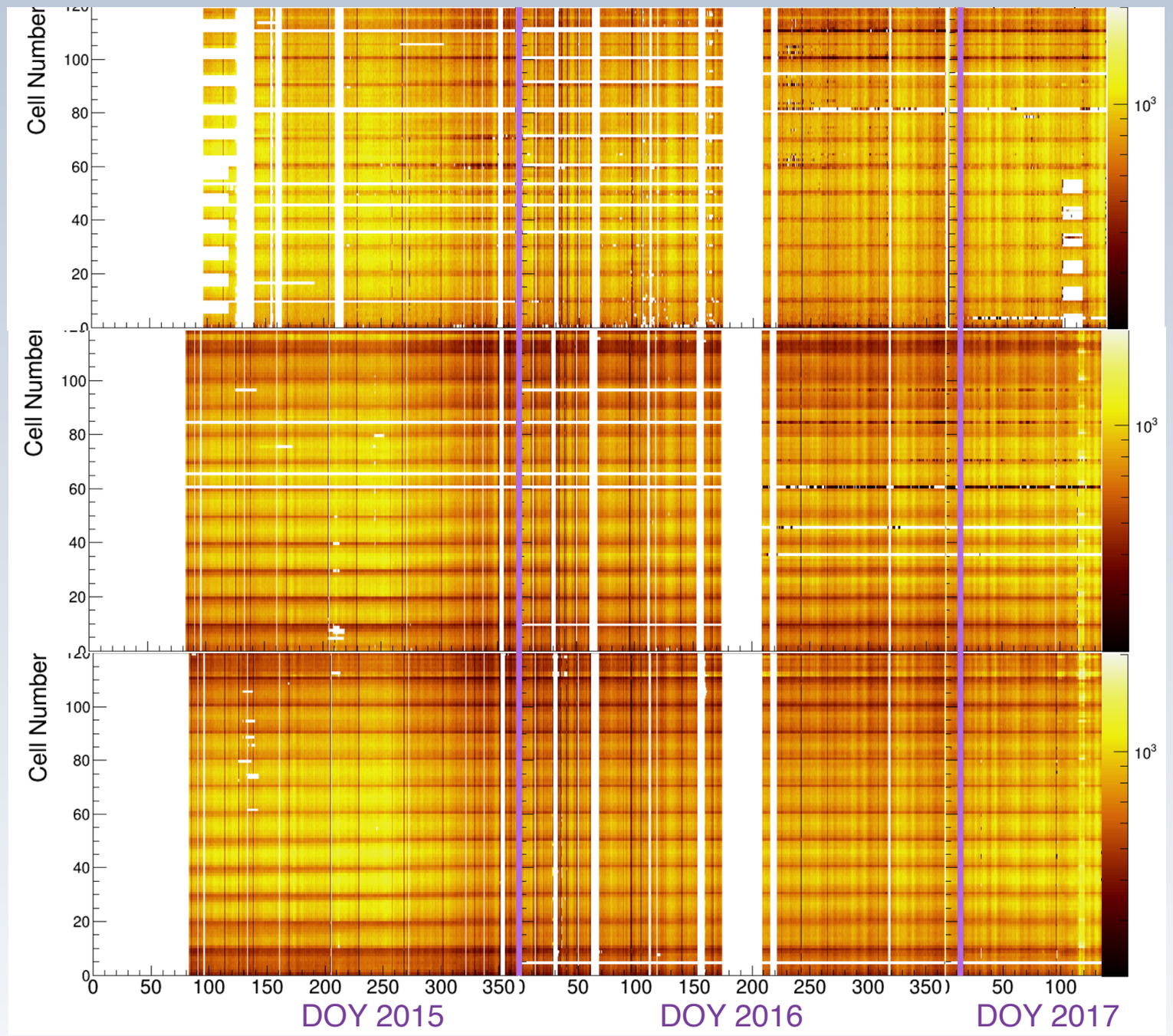
# TRAGALDABAS: preliminary results

## 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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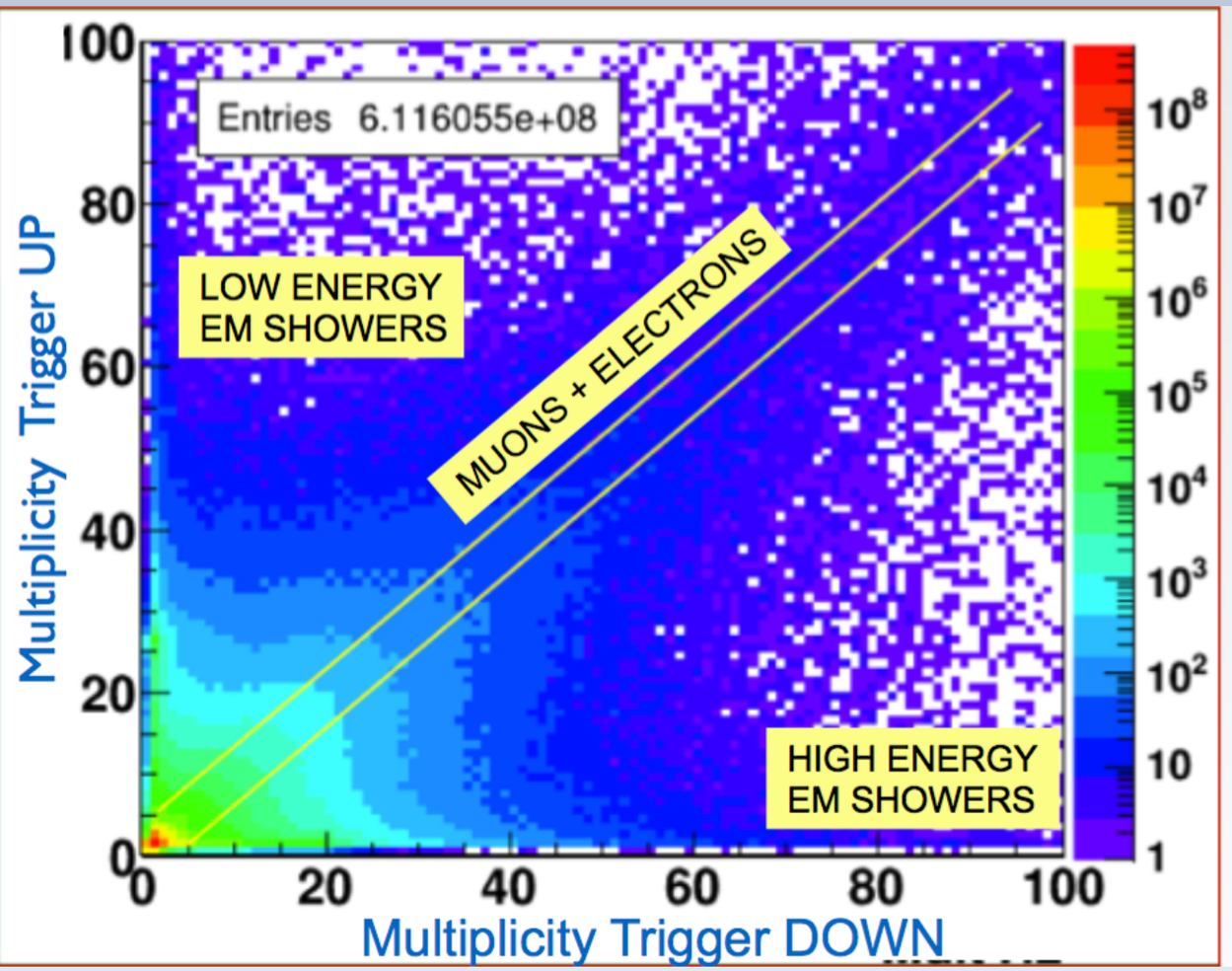
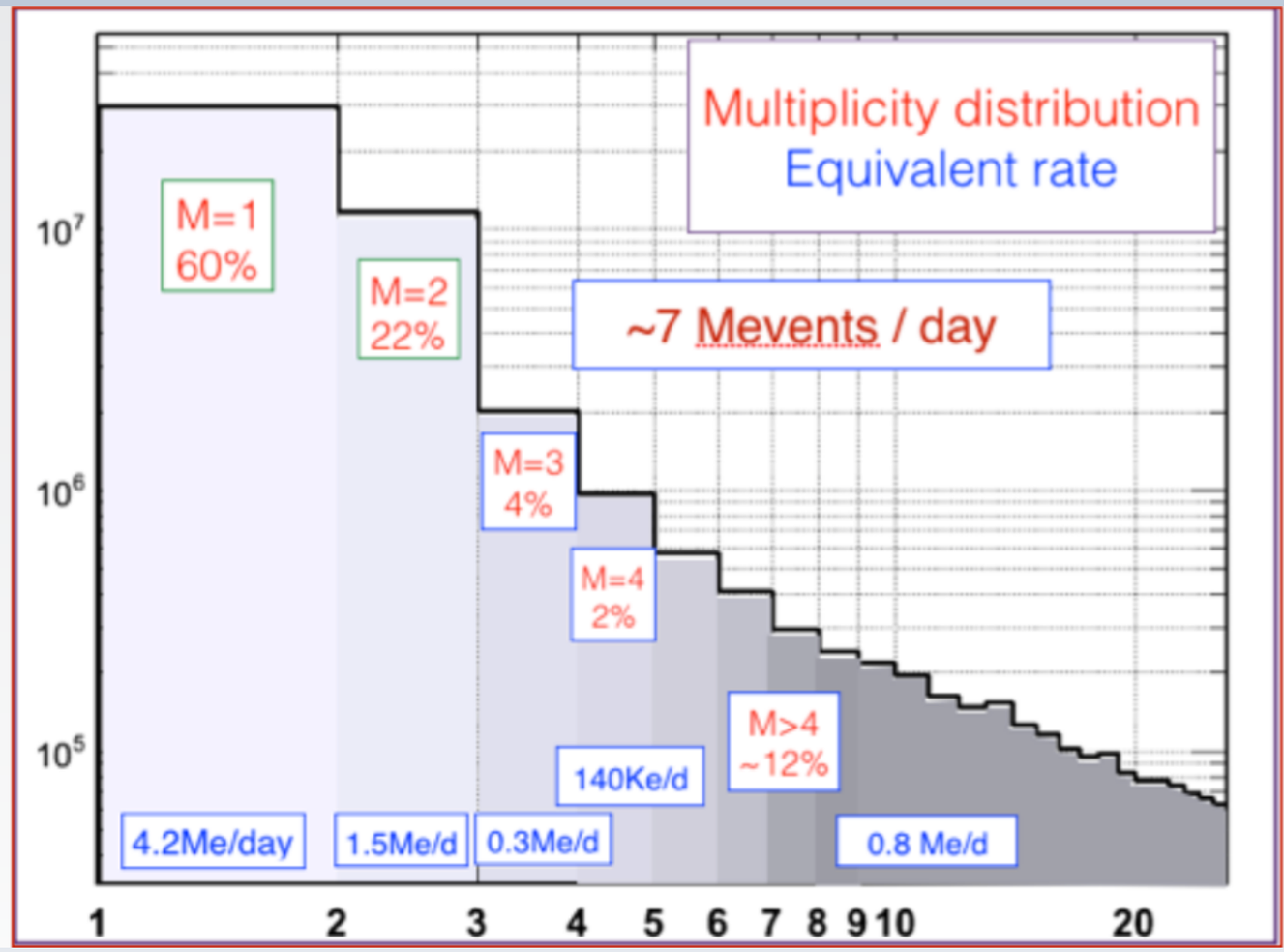
# TRAGALDABAS: preliminary results

## Trigger summary

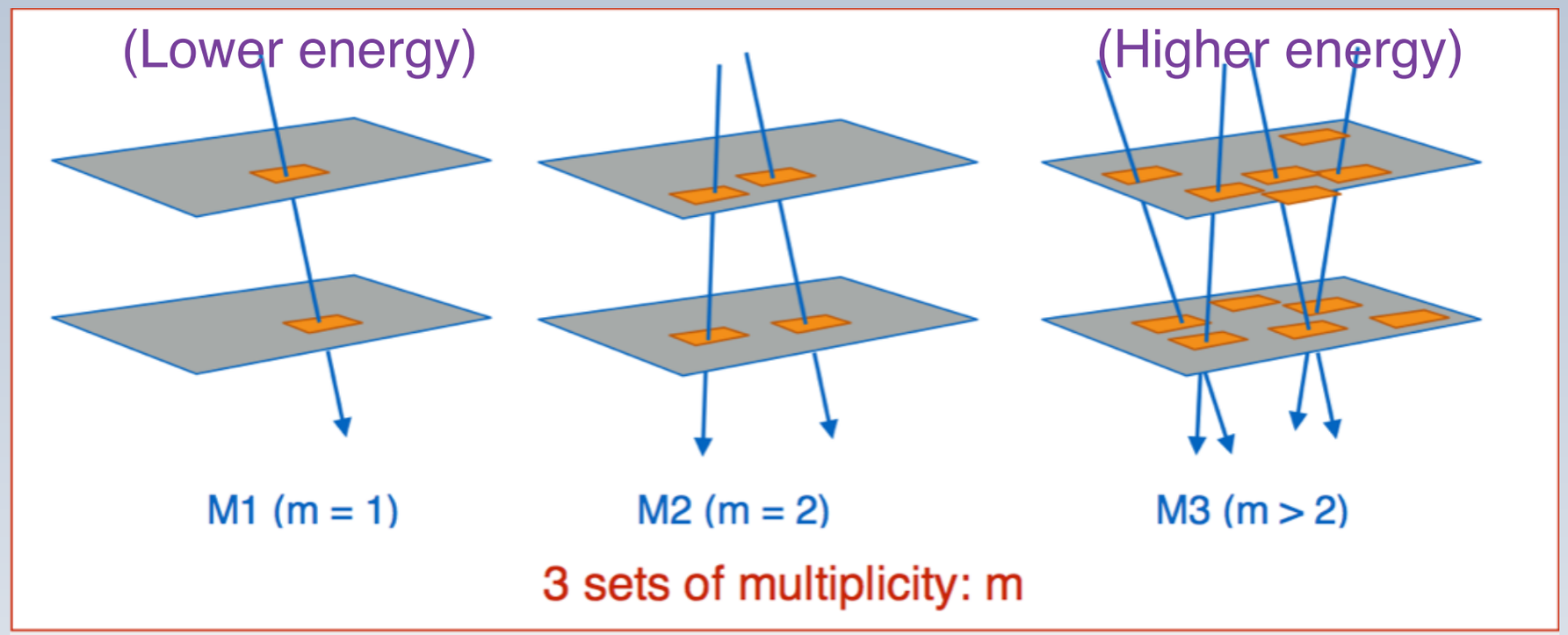


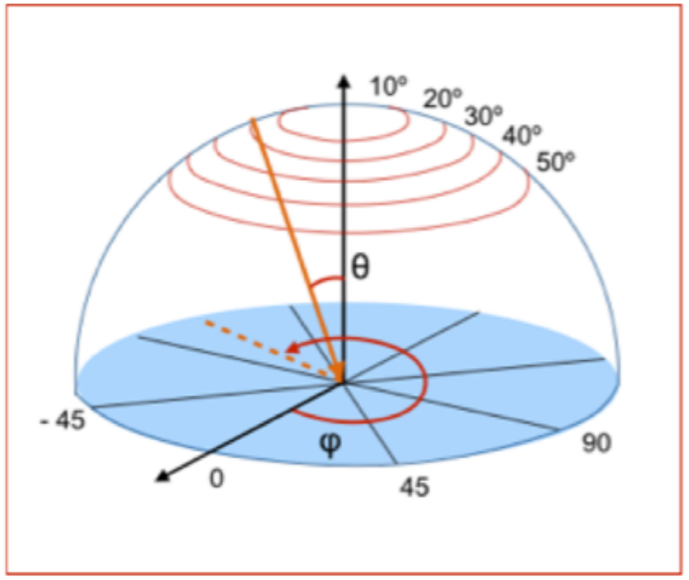



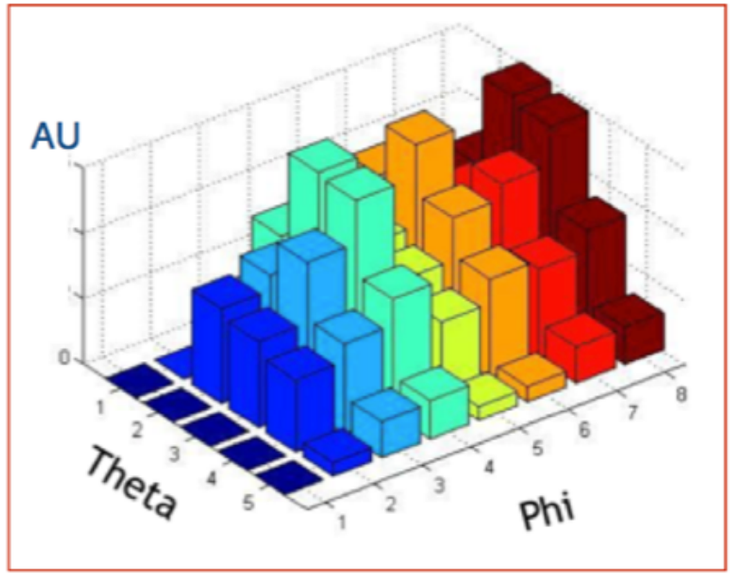

Trigger rate: ~ 70 Hz.
Event rate: ~ 7Mevents /day
Storage rate: ~ 0.7 Tb / year (1.9 Gb /day)
Mean duty time: > 90%

# TRAGALDABAS: preliminary results

## Preliminary reconstructed data sample




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



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# TRAGALDABAS: preliminary results

## 2 year rate behaviour (pressure corrected)

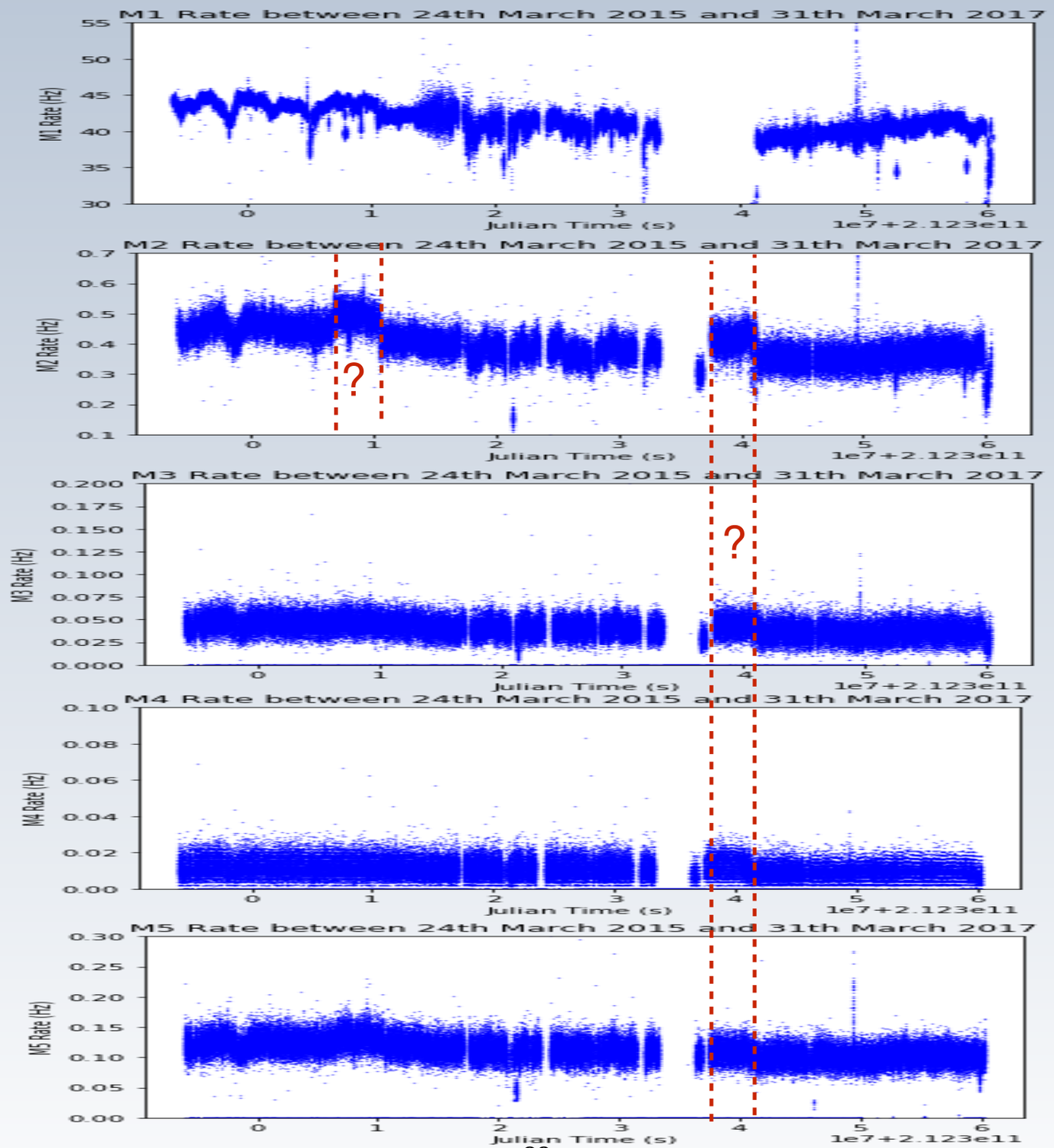
Multiplicity M=1

Multiplicity M=2

Multiplicity M=3

Multiplicity M=4

Multiplicity M>4



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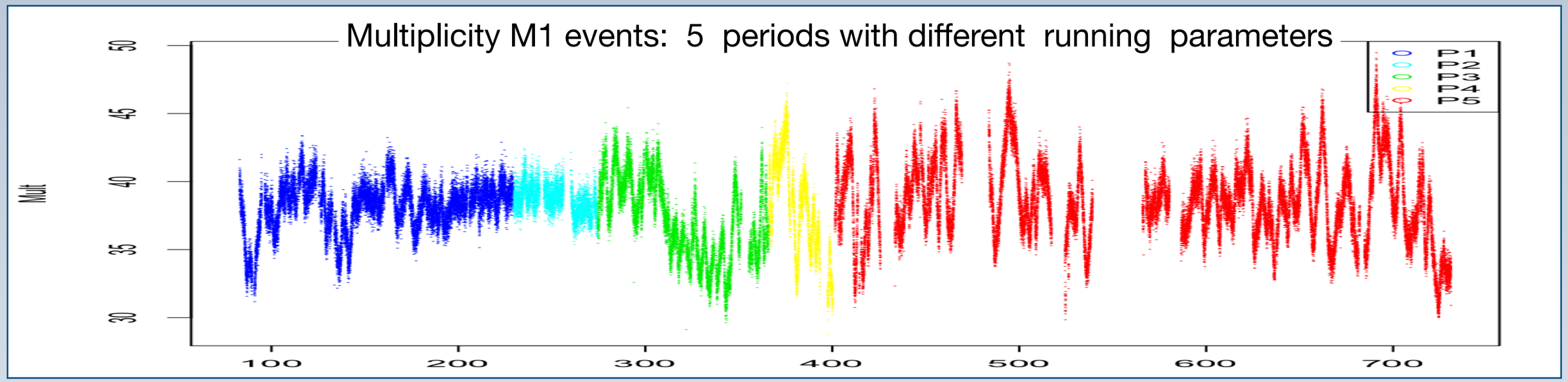
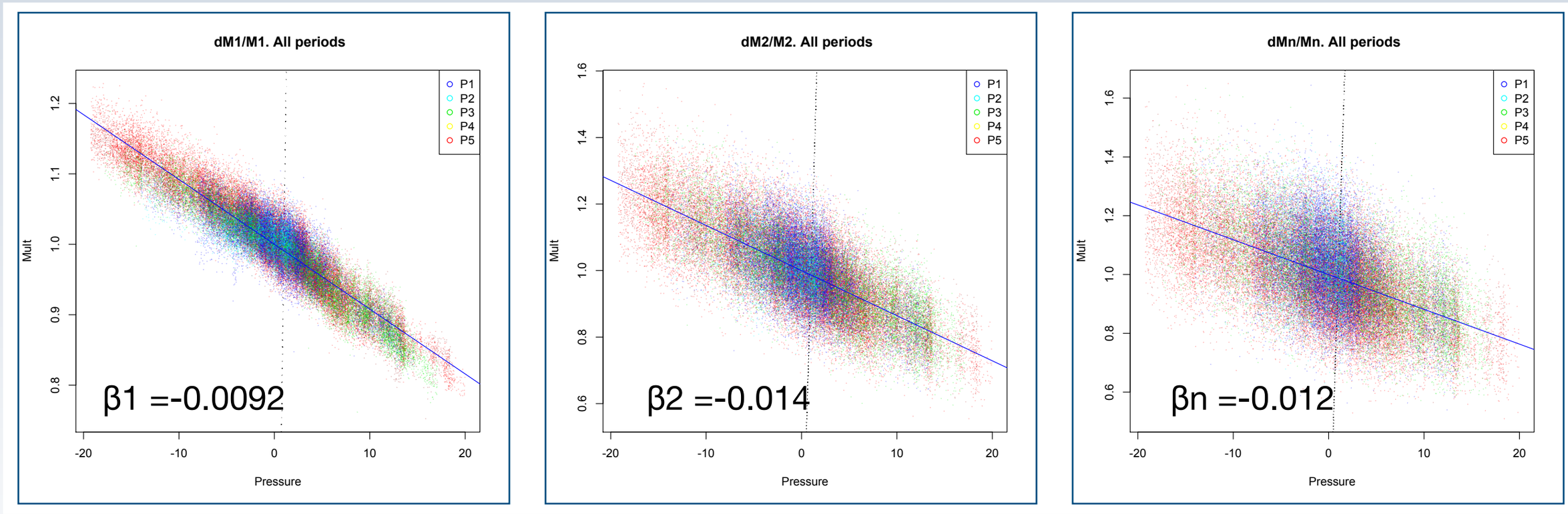
# THE TRASGO PROJECT: a small scope of activities

## TRAGALDABAS: Data sample pressure correction (Mar. 2015- Dec.2016)




Pressure correction fits



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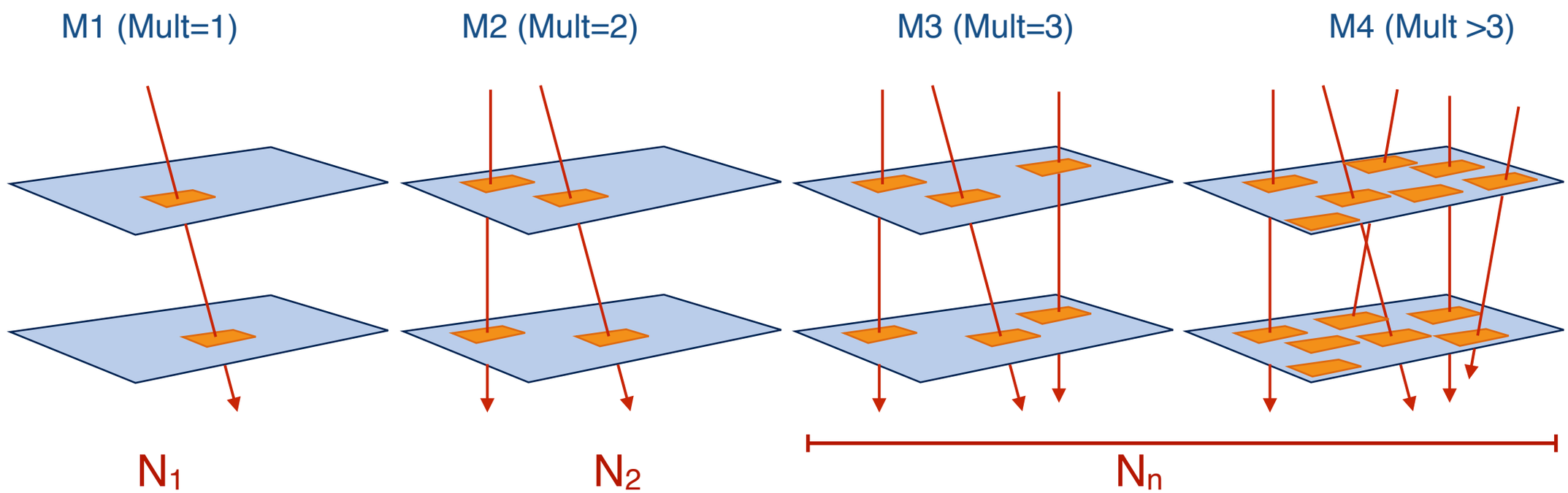
# THE TRASGO PROJECT: a small scope of activities

## TRAGALDABAS: Data sample




A few definitions:

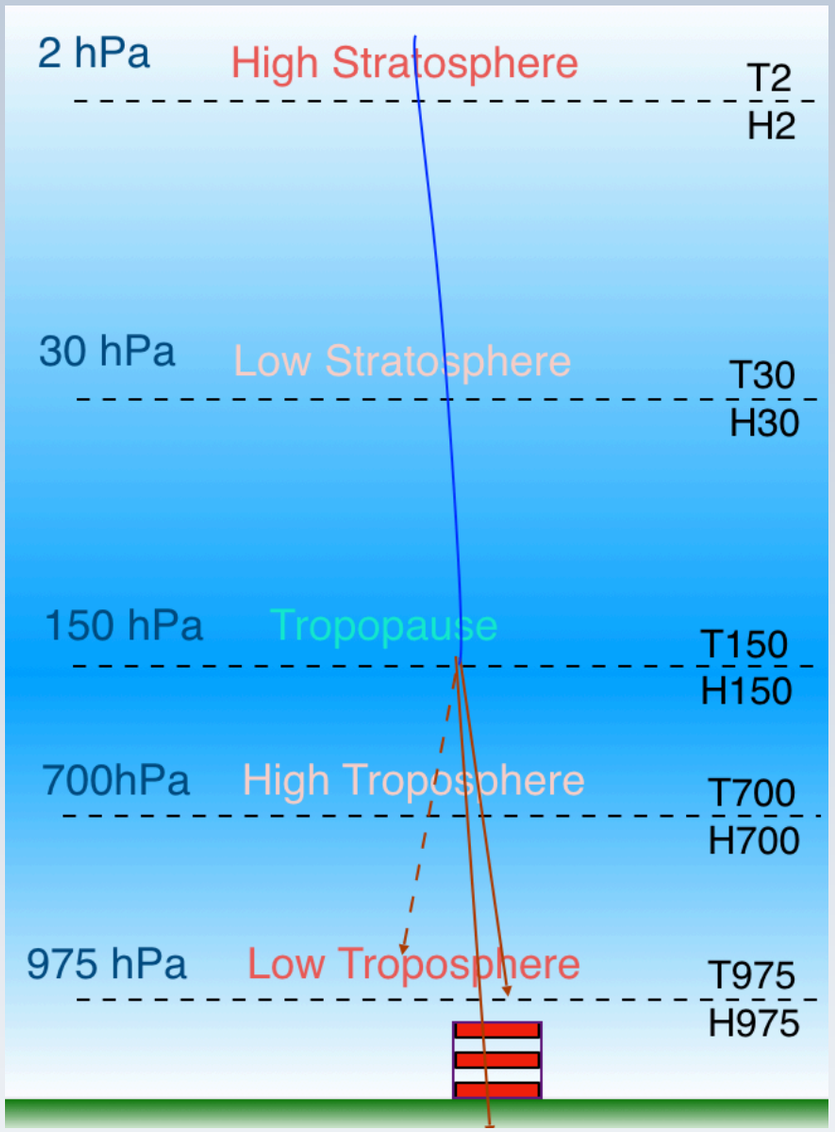
Total: $N_t = \Sigma N_i$

Fractions: $F_1 = N_1/N_t$, $F_2 = N_2/N_t$, $F_n = N_n/N_t$

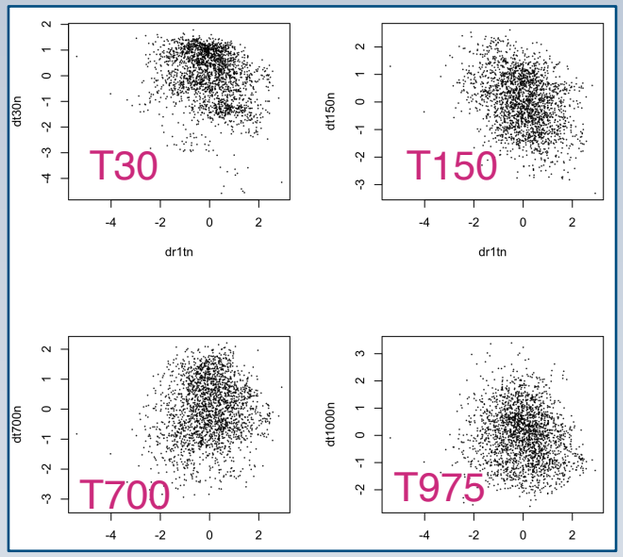
Ratios: $R_{21} = N_2/N_1$, $R_{n1} = N_n/N_1$, $R_{n2} = N_n/N_2$

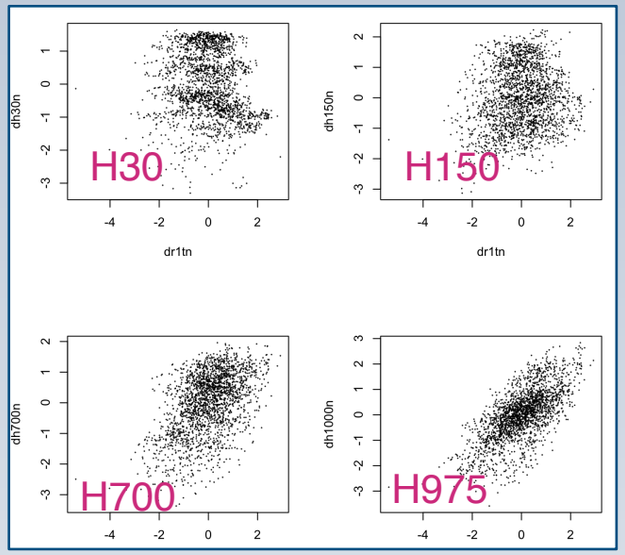
# THE TRASGO PROJECT: a small scope of activities

## TRAGALDABAS: Atmosphere studies

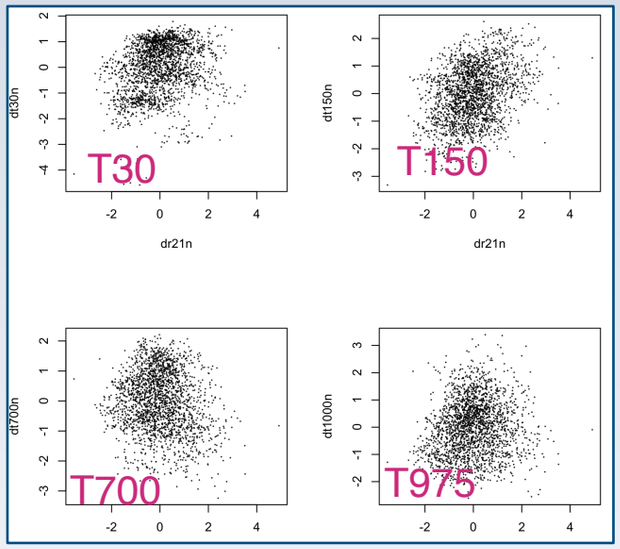


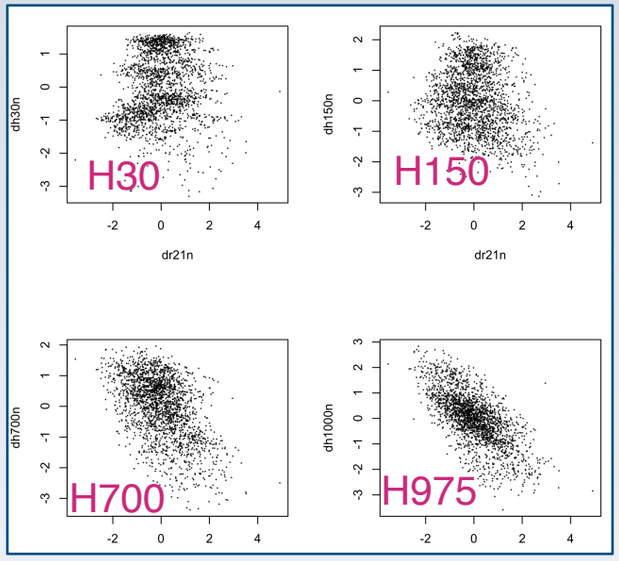

A few examples:




$F_1$




$R_{21}$

Correlations of all the ratios with the temperatures are negligible

There are significative correlations with the expansion of the troposphere

Without separating electrons and muons Trasgos are very insensitive to T



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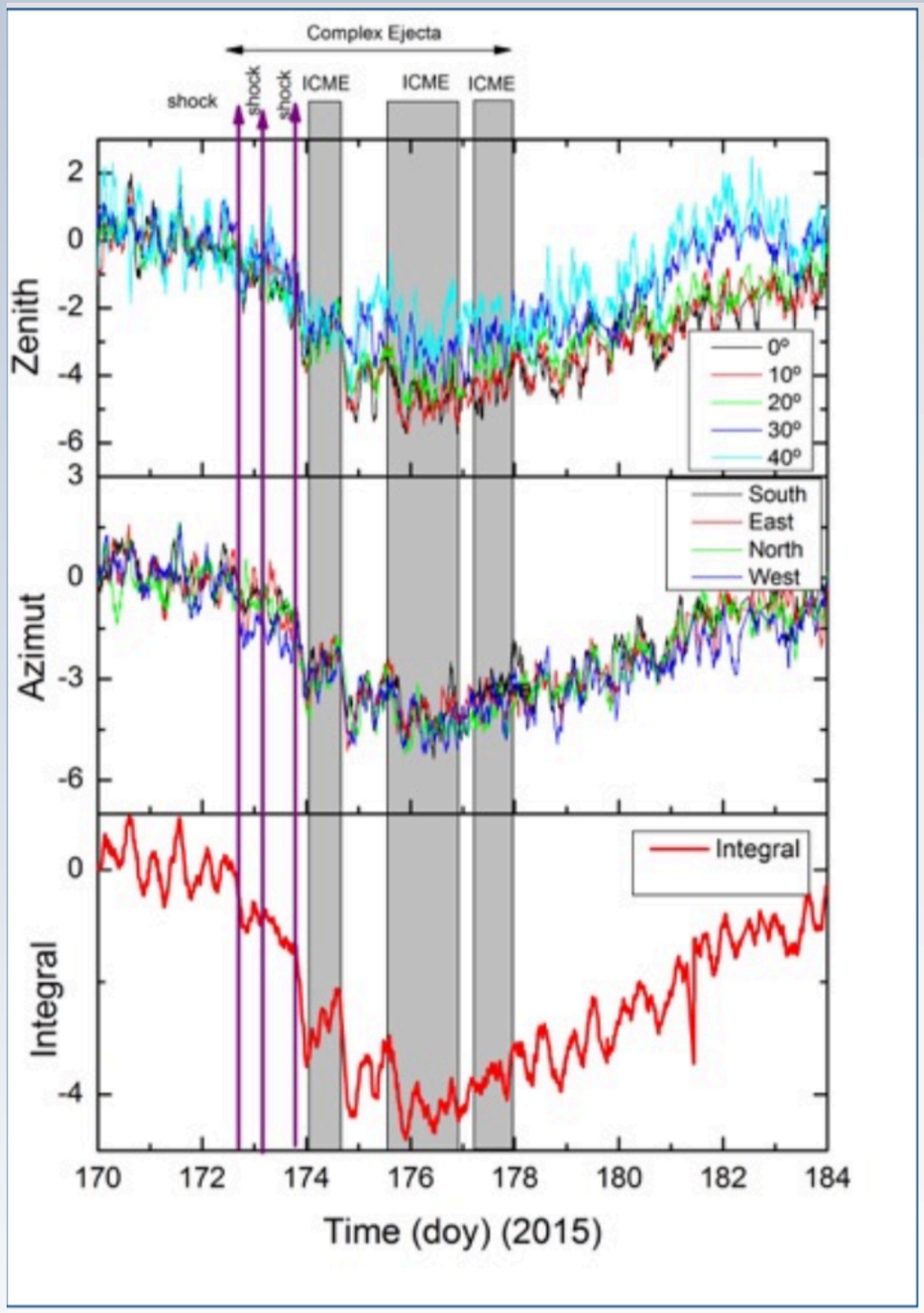
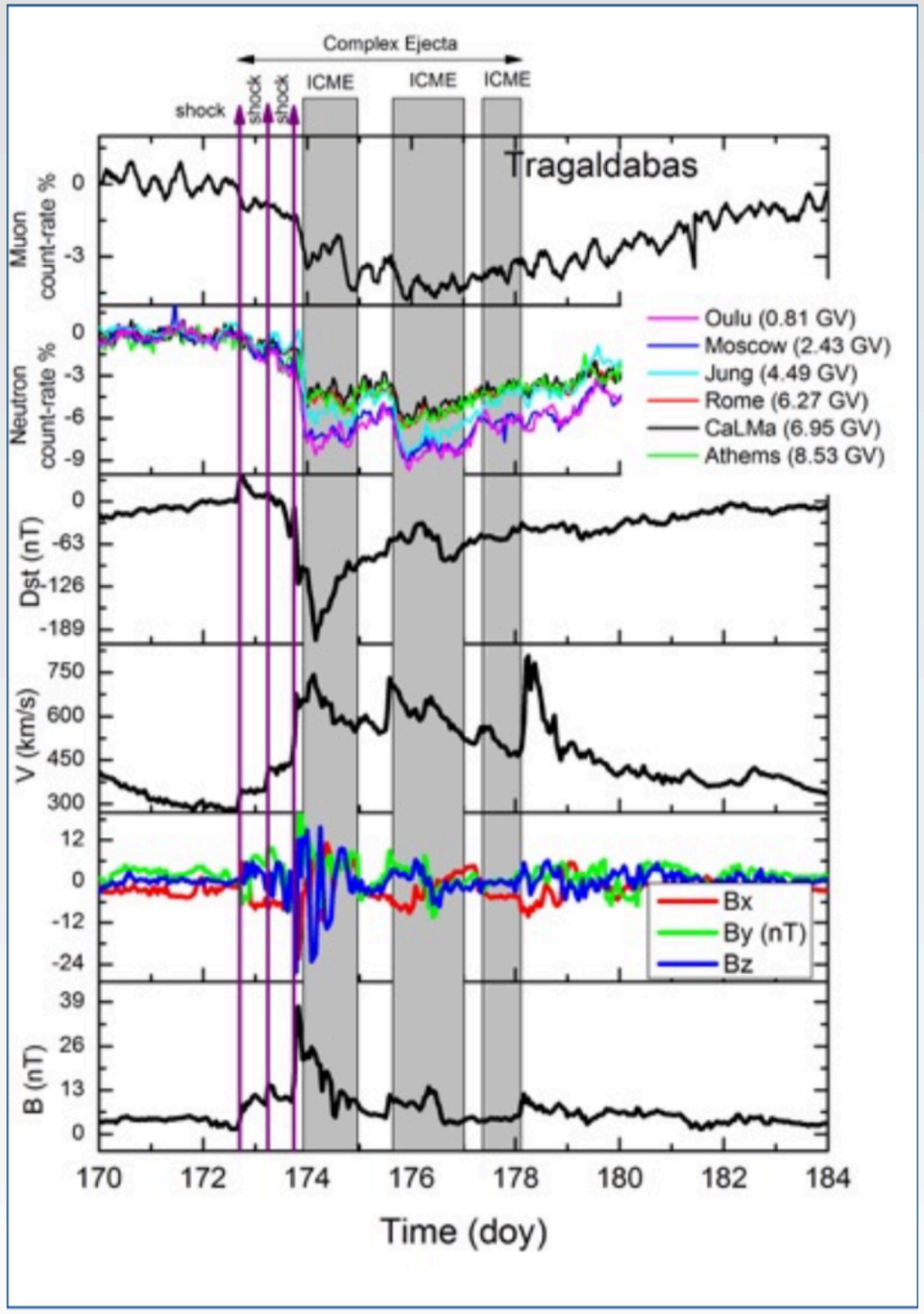
# THE TRASGO PROJECT: a small scope of activities

## TRAGALDABAS: Solar Physics




## TRAGALDABAS: Analysis of the Forbursh Decrease on June 2015



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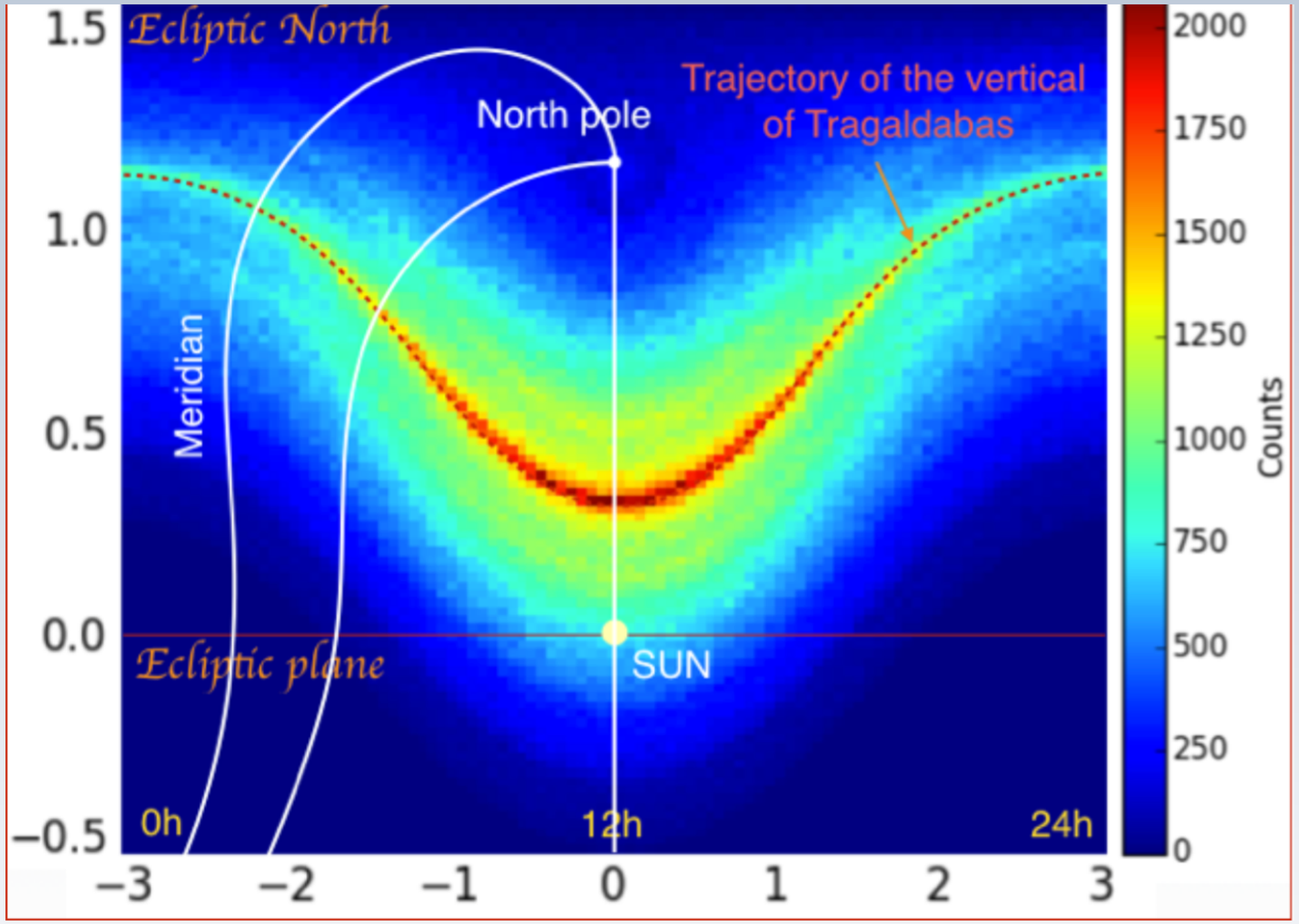
# TRAGALDABAS @ USC

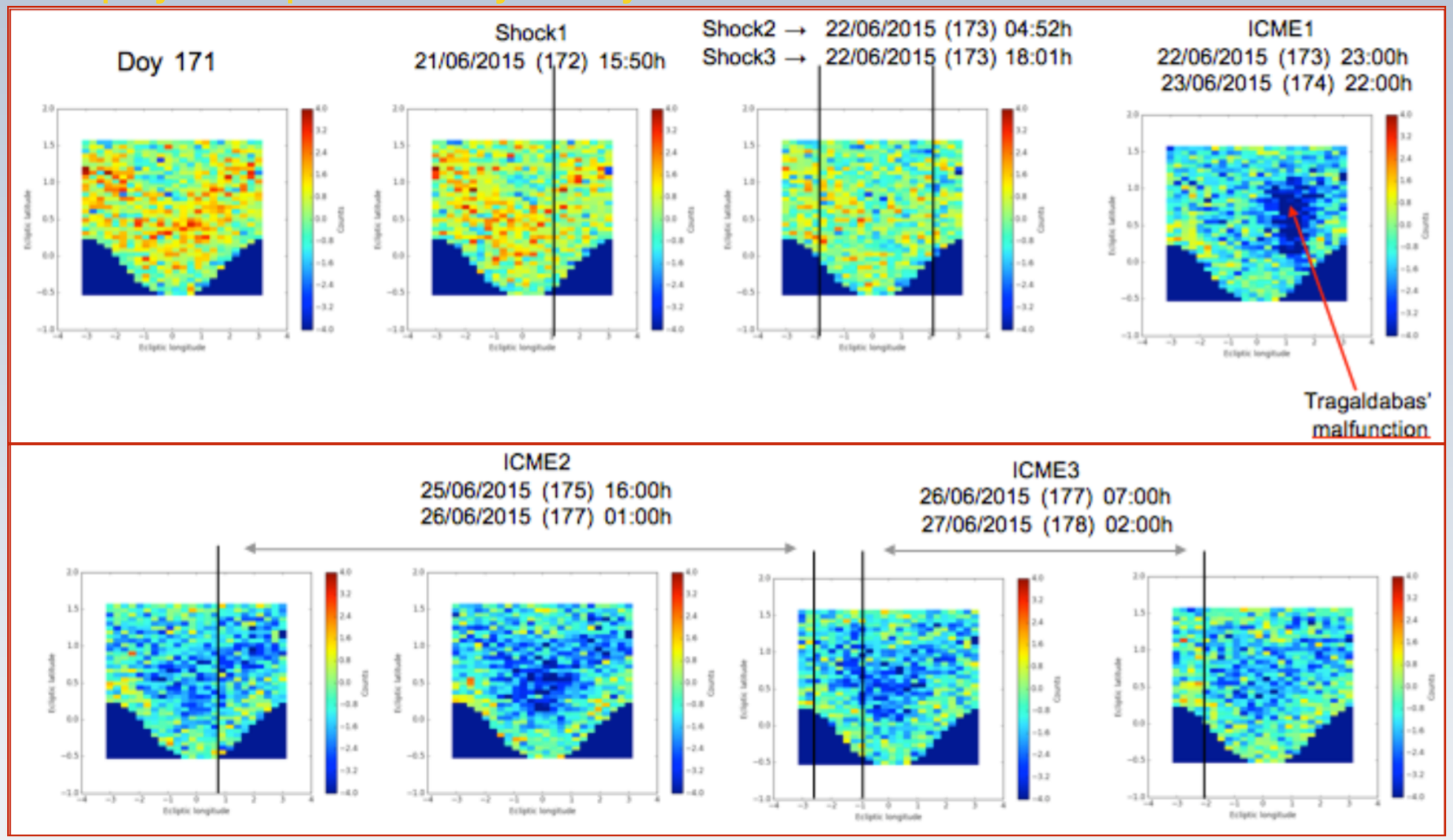
## Solar physics: preliminary analysis of the FD held at June 22nd. 2015




Example: one-day picture of the sky in Ecliptic Coordinates

# TRAGALDABAS @ USC

## Solar physics: preliminary analysis of the FD held at June 22nd. 2015




Daily pictures of the excess/defect of cosmic rays sky before and after the FD arrival date

Even, in its low resolution mode the detector is working properly :) !!!



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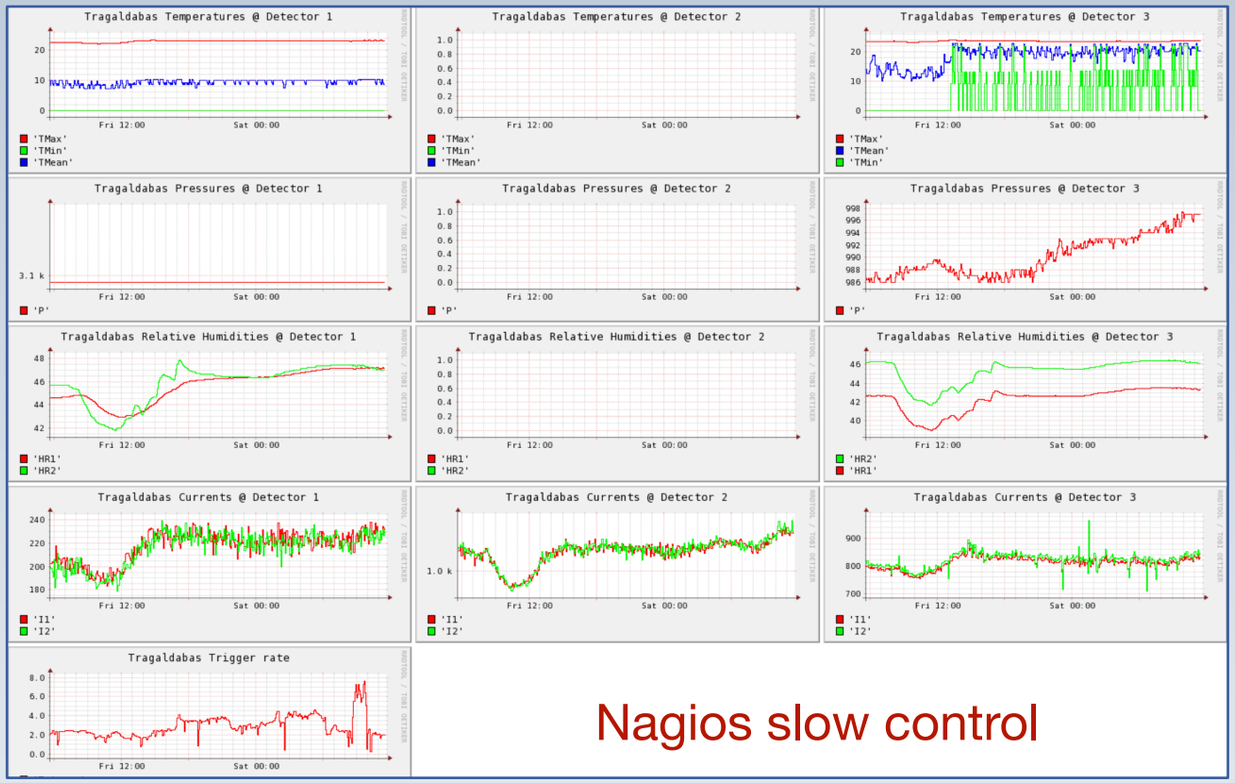
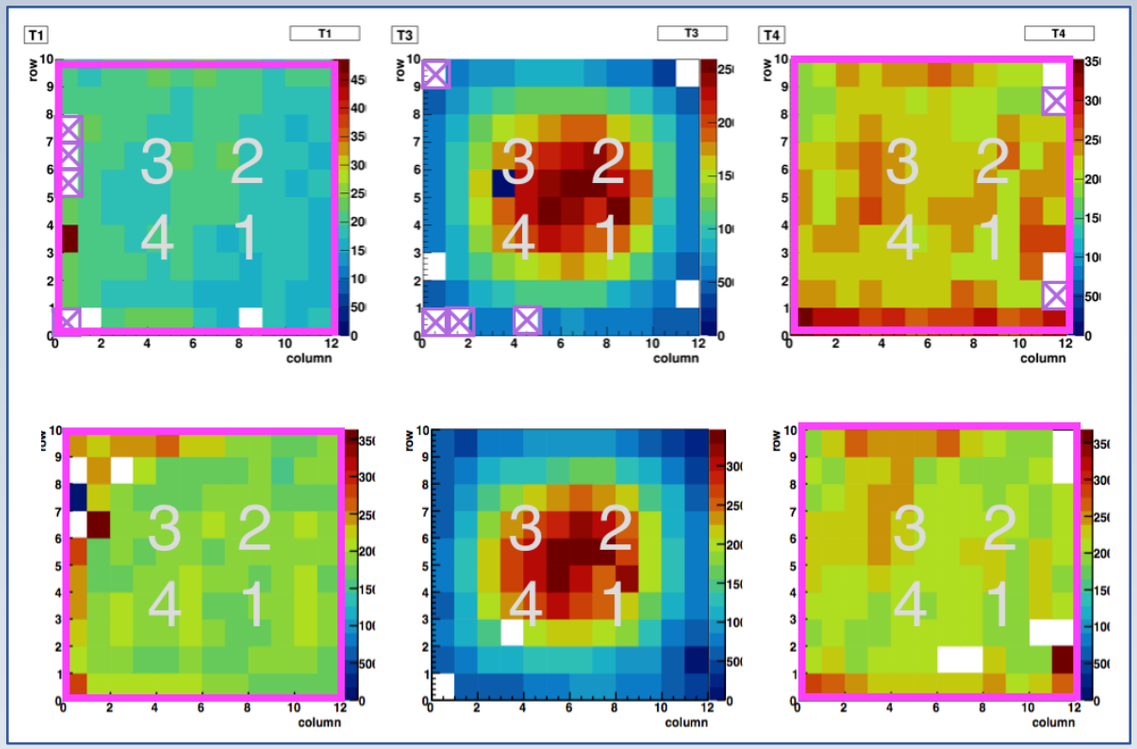
# THE TRASGO PROJECT: a small scope of activities

## Monitoring tools

### TRAGALDABAS



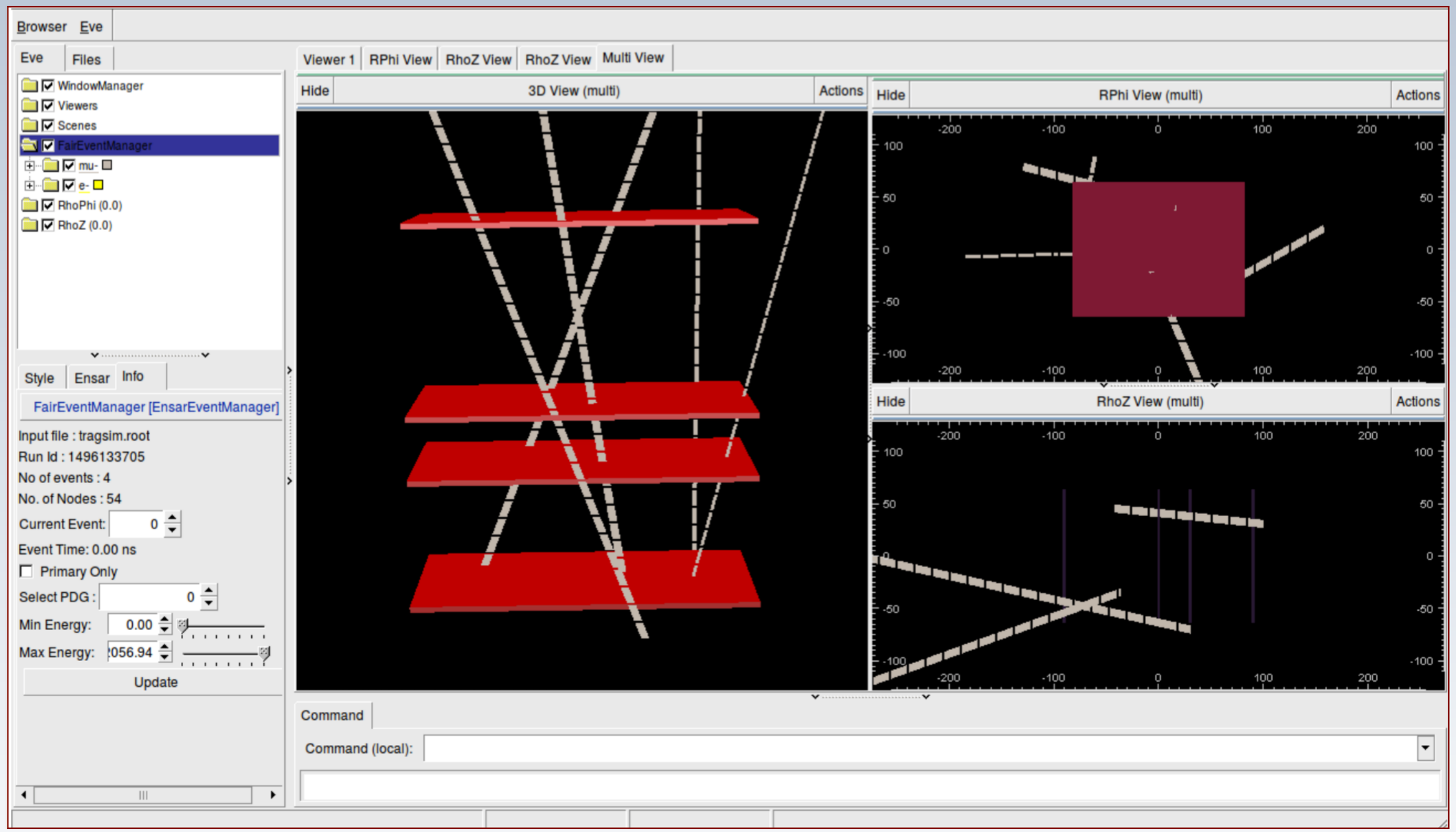

Nagios slow control




Cell map

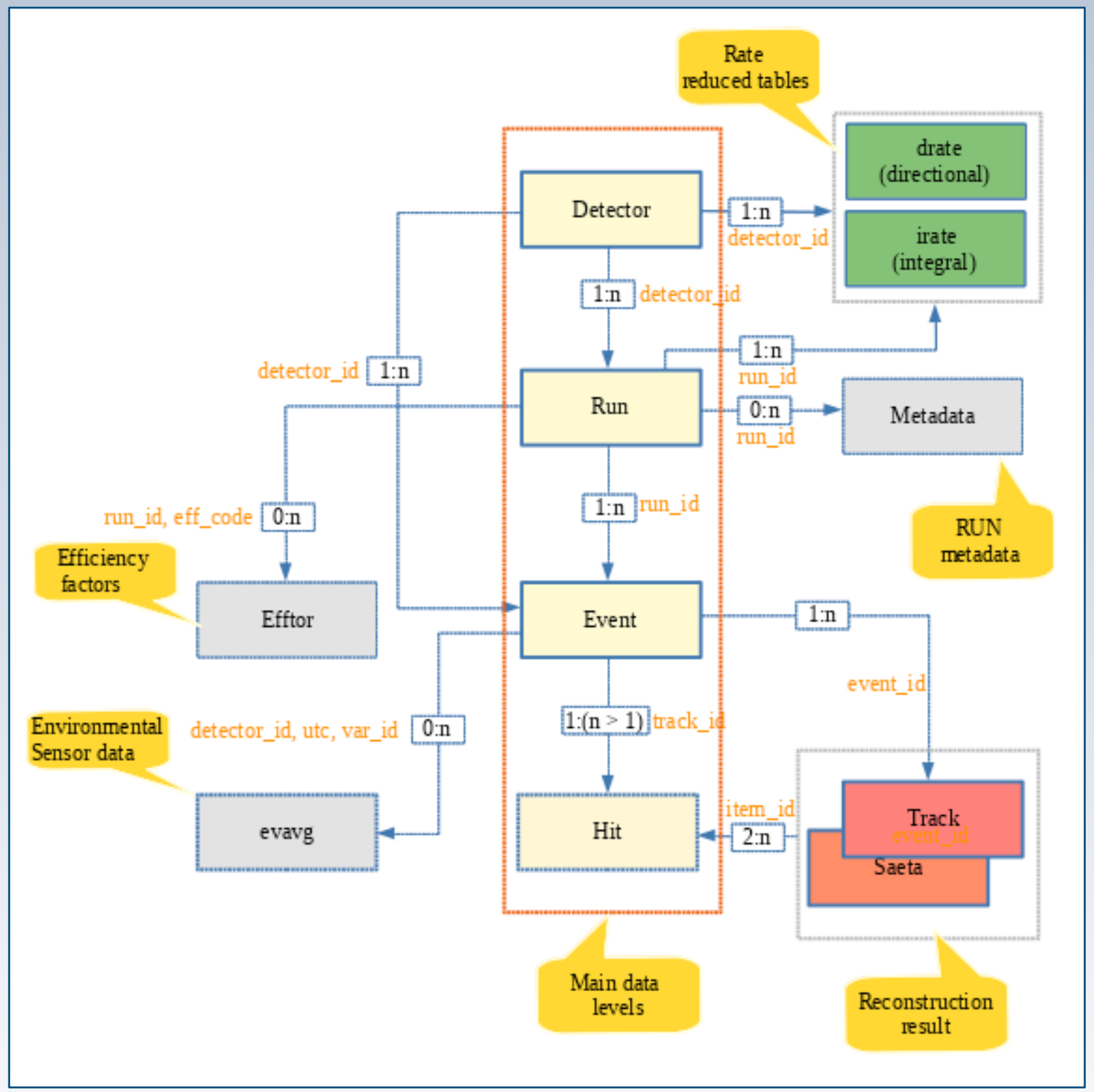
# The first Trasgo: TRAGALDABAS

## EnsarRoot based detector simulation



# THE TRASGO PROJECT: a small scope of activities

## Data level structure (facing future implementation of Big Data techniques)




ERD data level diagram



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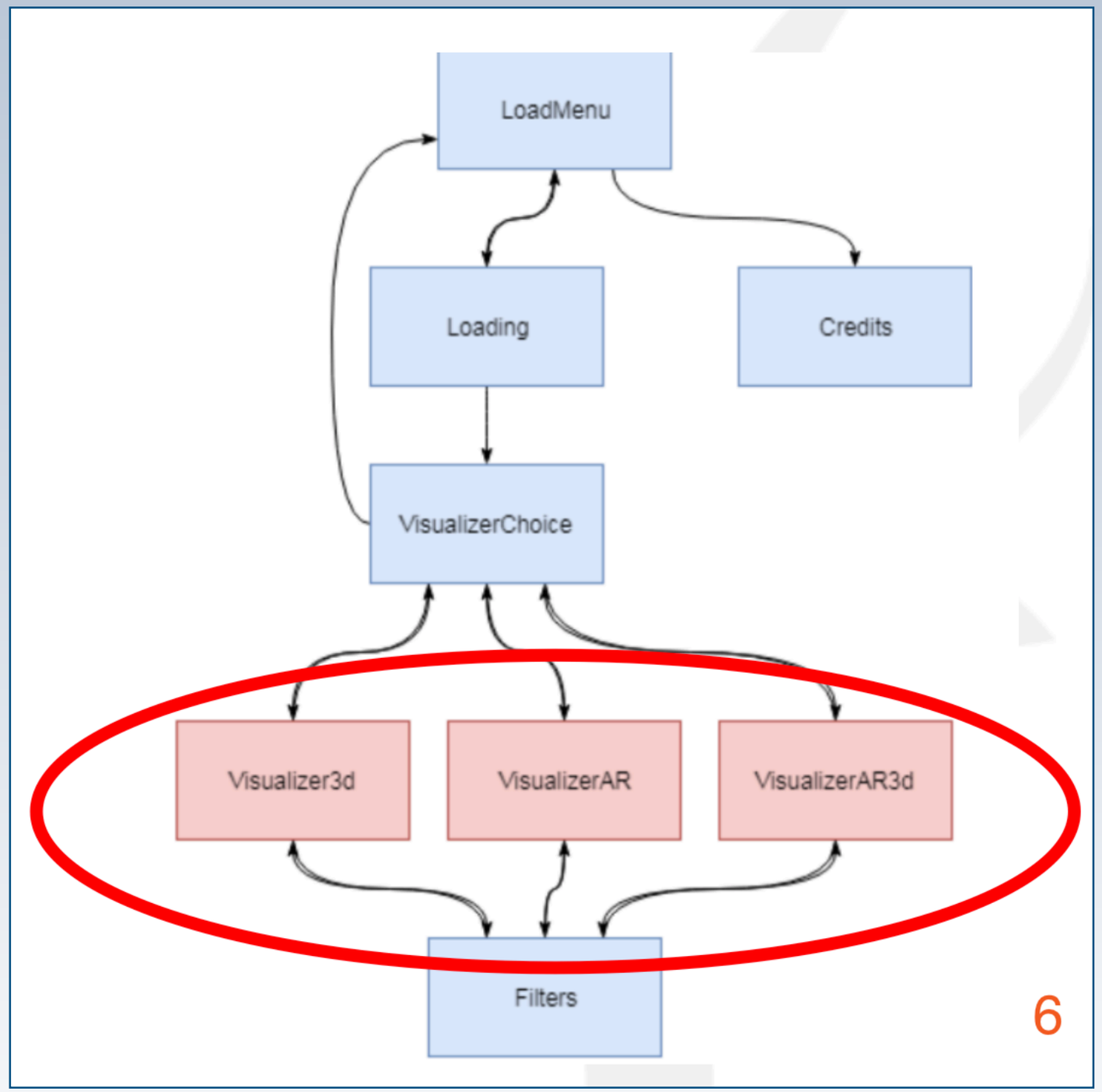
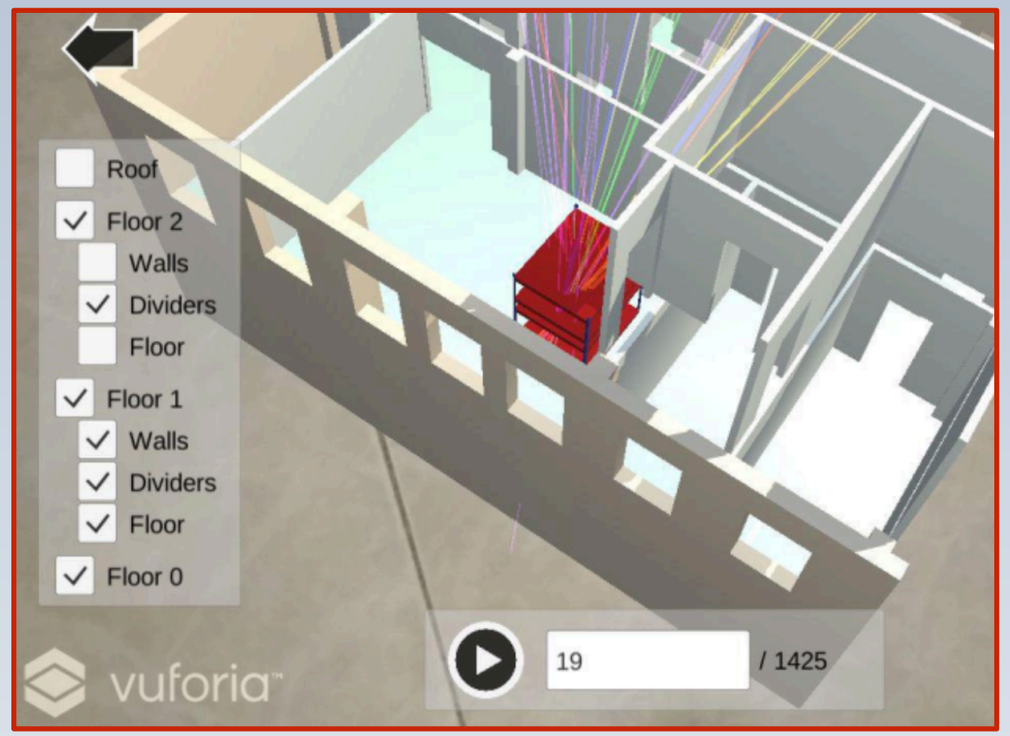
# THE TRASGO PROJECT: a small scope of activities

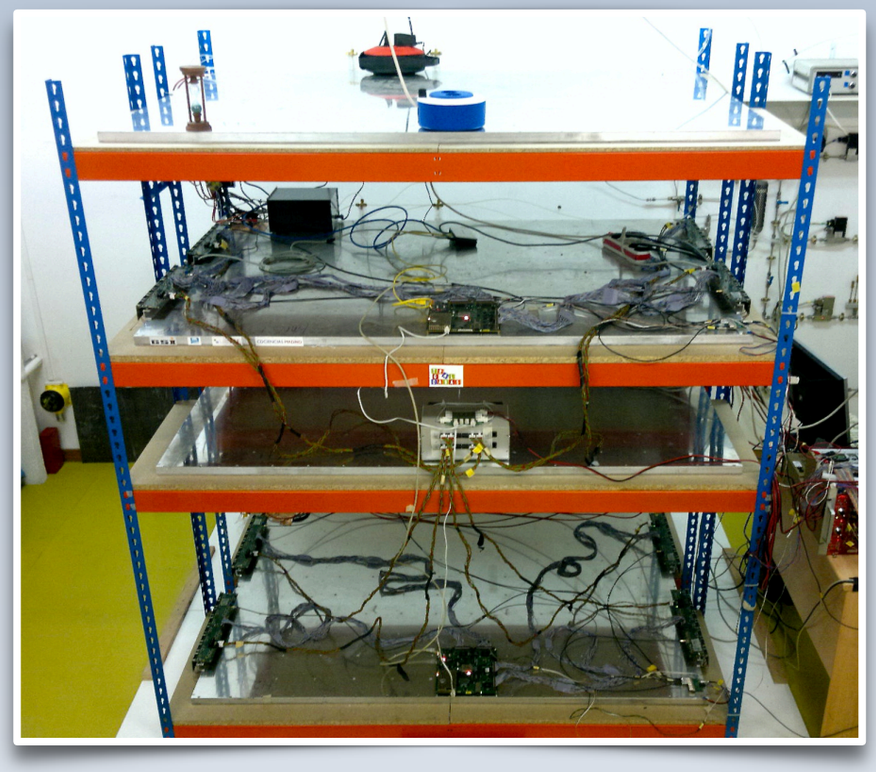
## 3D visualization tools



We are developing virtual reality and augmented reality tools

# THE TRASGO ARMADA

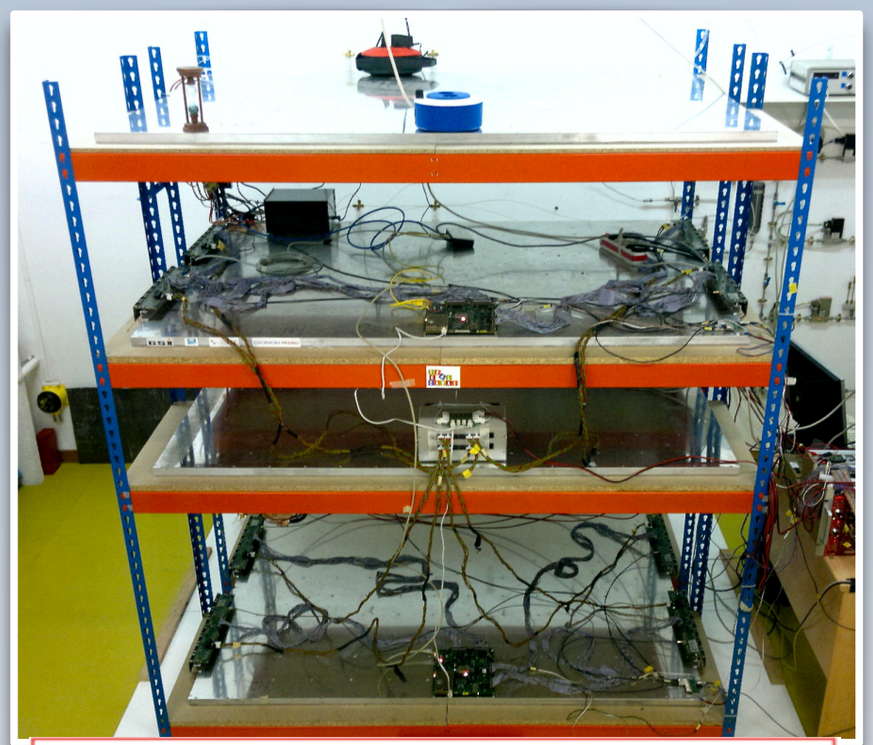


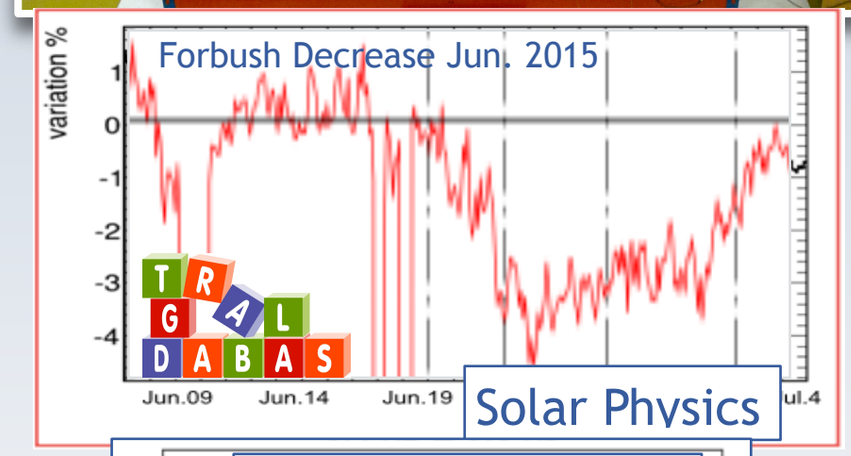
**TRAGALDABAS**
(Univ. S. Compostela)
Multipurpose detector

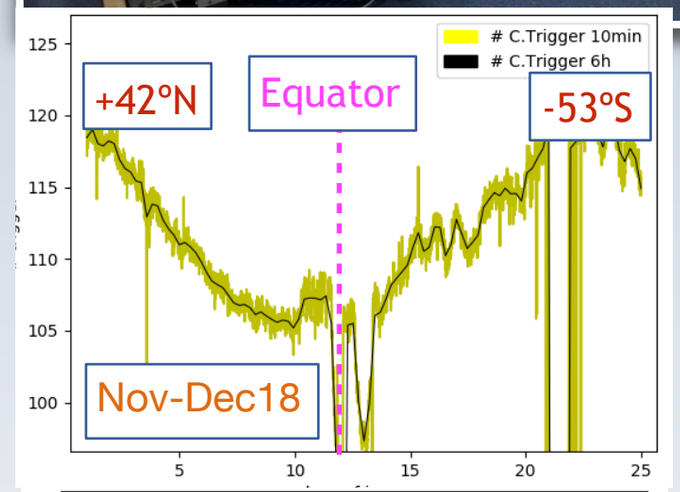
**MuTT**
(Porriño, Vigo)
Tomography studies
**HIDRONAV Initiative**

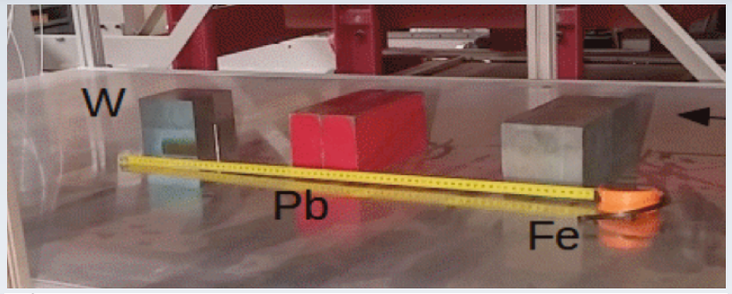
**TRISTAN**
(Antarctica, End 2019)
Multipurpose detector

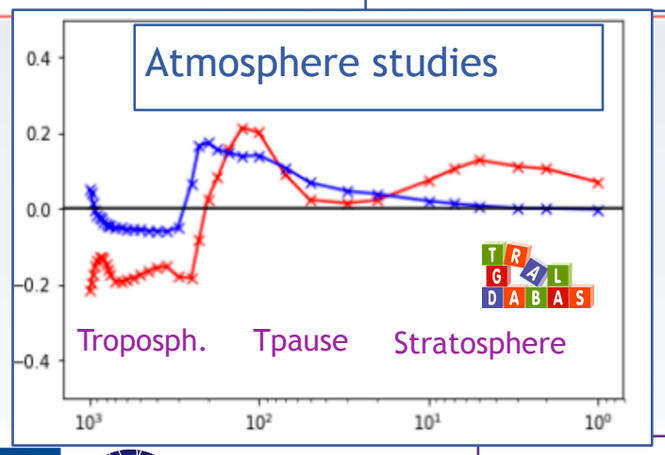
# THE TRASGO ARMADA

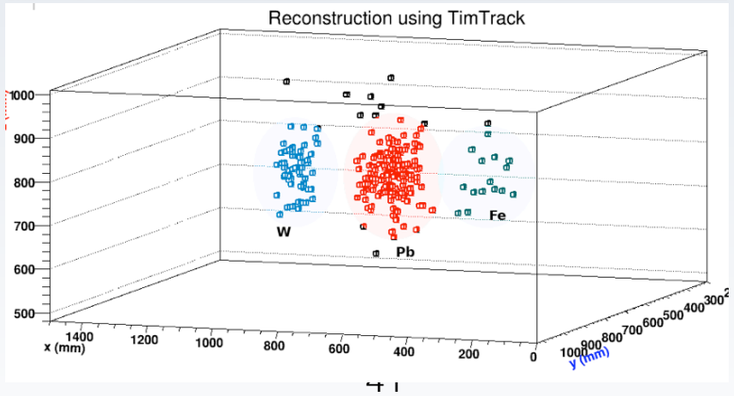


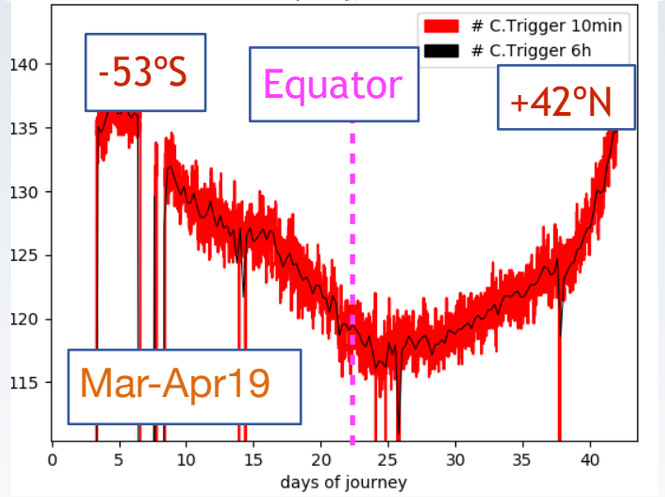
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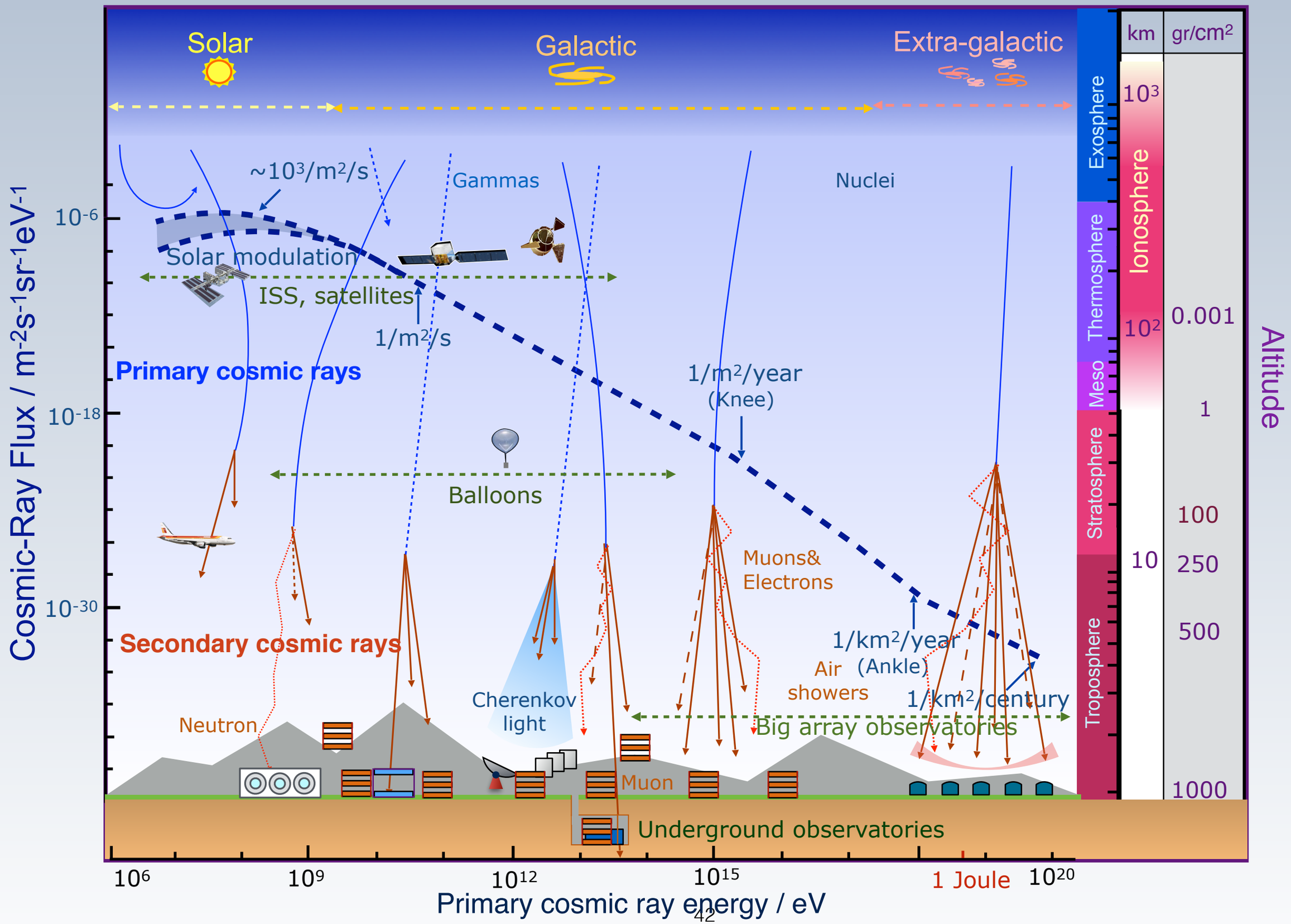
# COSMIC RAYS: Trasgos as a complementary multipurpose detector



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# THE TRASGO PROJECT: summary

- A new family of detectors, Trasgos, for the regular study of cosmic rays has been proposed by the LIP-Coimbra & LabCAF-IGFAE teams.
- 3 Trasgos are now operative and soon other two detectors will be built for atmospheric studies in Galicia.
- A big team (> 30) of experts is collaborating developing new tools and analysis programs in a wide field of activities
- Trasgos may became a NEW STANDARD for the study of cosmic rays all around the world: they are small and affordable and do offer high performances. All the main tools (acquisition, monitoring, reconstruction, analysis, display, etc. are under development) and the main standard levels are being defined.
- The main goal is to offer Plug&Play detectors + their main operative tools, that can be easily adapted to many research areas either to substitute or to complement the existing devices.

The END

THANKS!

MACROESCANER project