The TRASGO project

Status report 2023

Juan A. Garzón

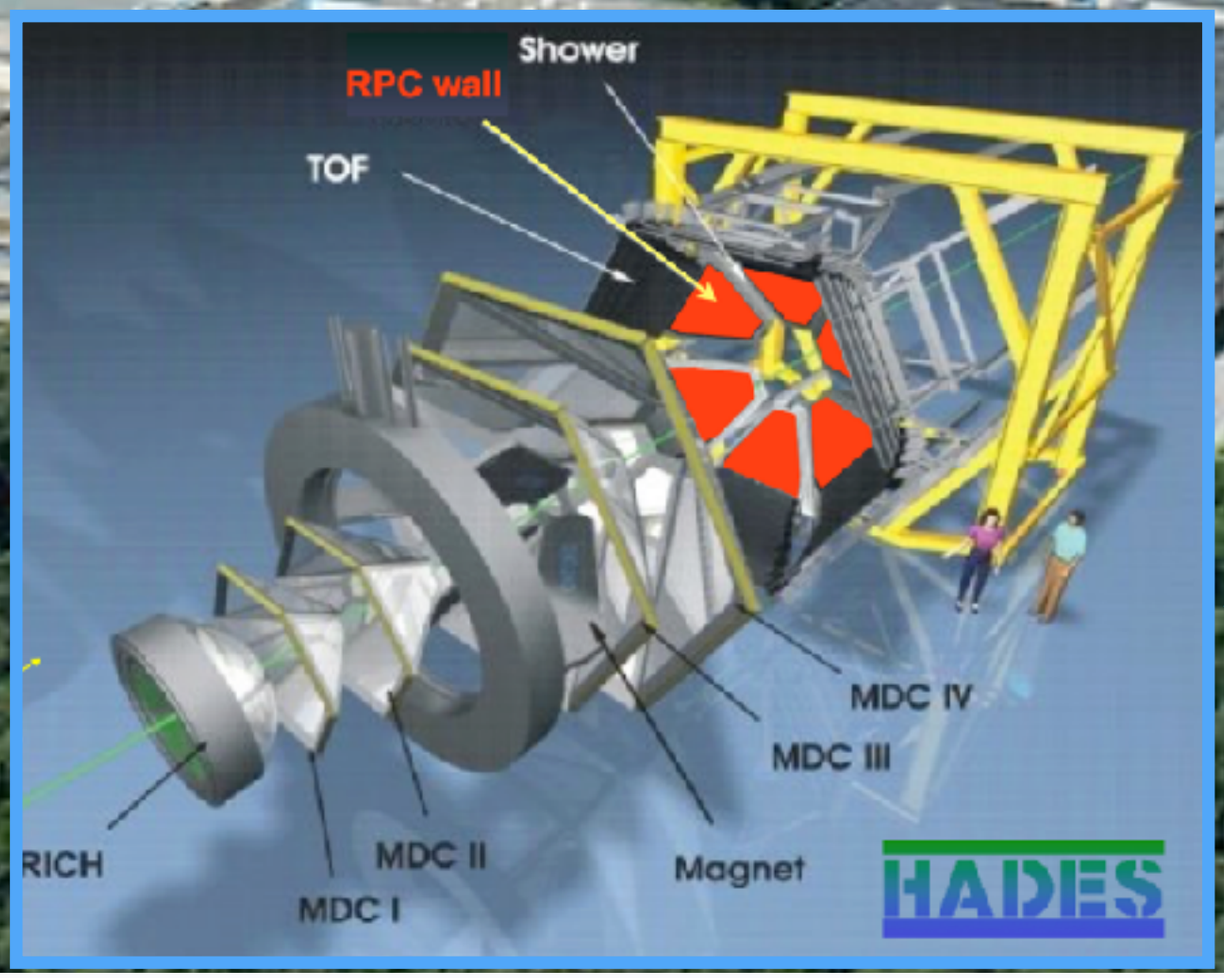
LabCAF - IGFAE / Univ. Santiago de Compostela

The beginning

The beginning

Darmstadt (Germany)

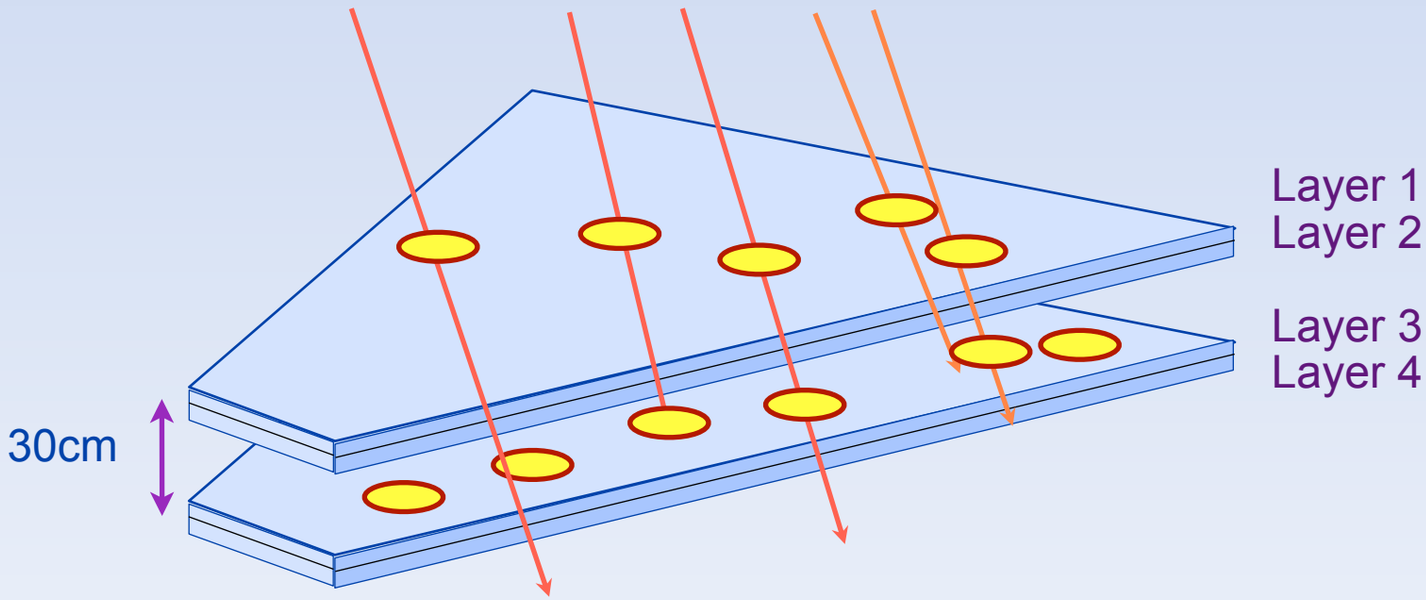
Latitude 49.9° N, Longitude 8.7° E; 100 m above **sea level**,

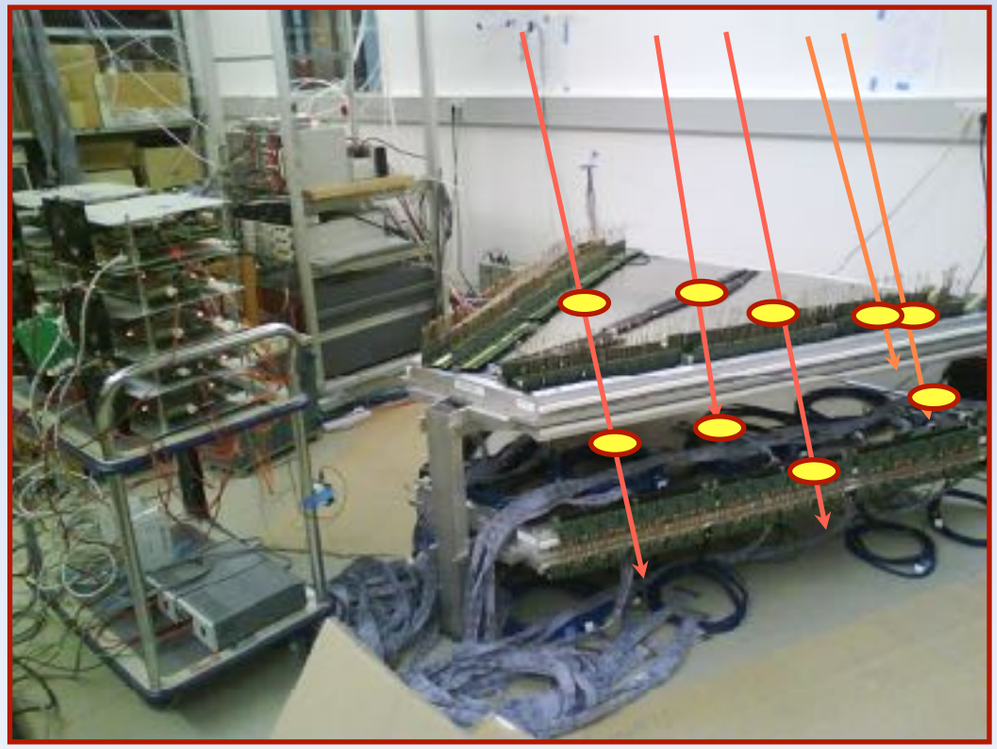


The beginning

The HADES RPC ToF Wall Commissioning

- Surface: ~1.2 m^2
- Mean position resolution: ~ 5 cm^2
- Granularity: up to >100 particles / event
- Time resolution ~ 80ps (hit)

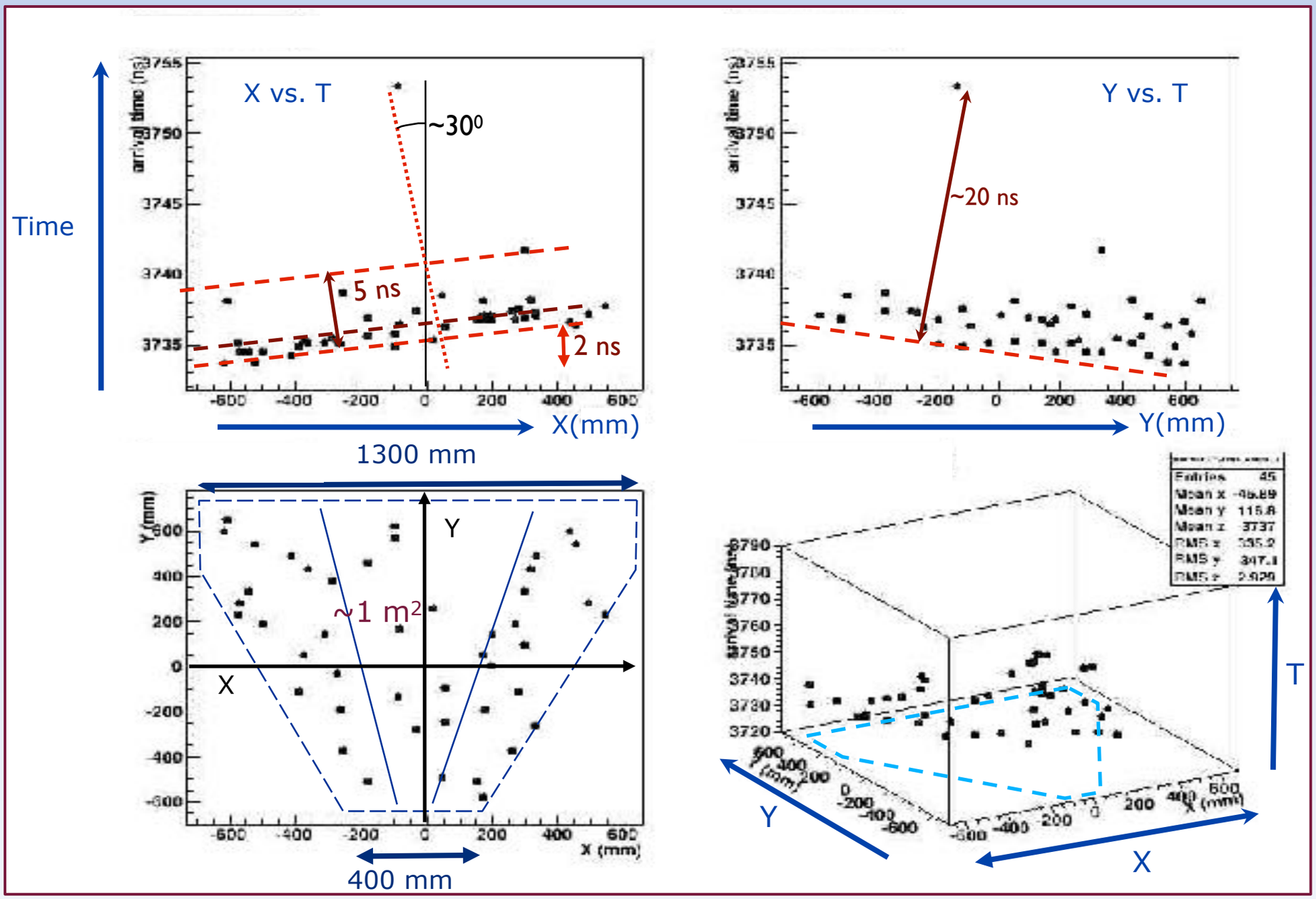




34 millions of events (~5 days) were taken under very stable conditions

The beginning

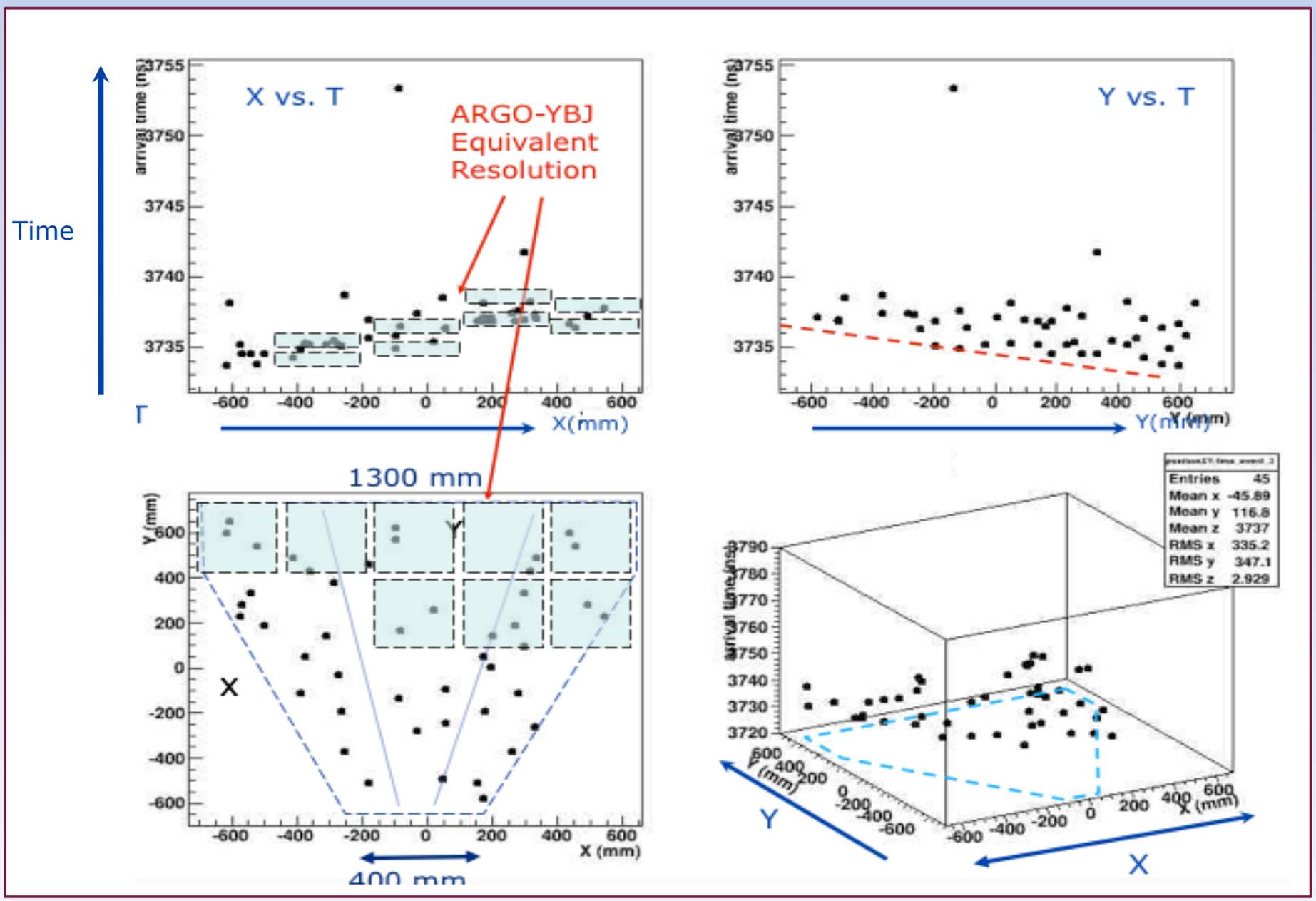
A typical high multiplicity event:



A high-time resolution ~1 m² detector provides a good image of the showers time profile

The beginning

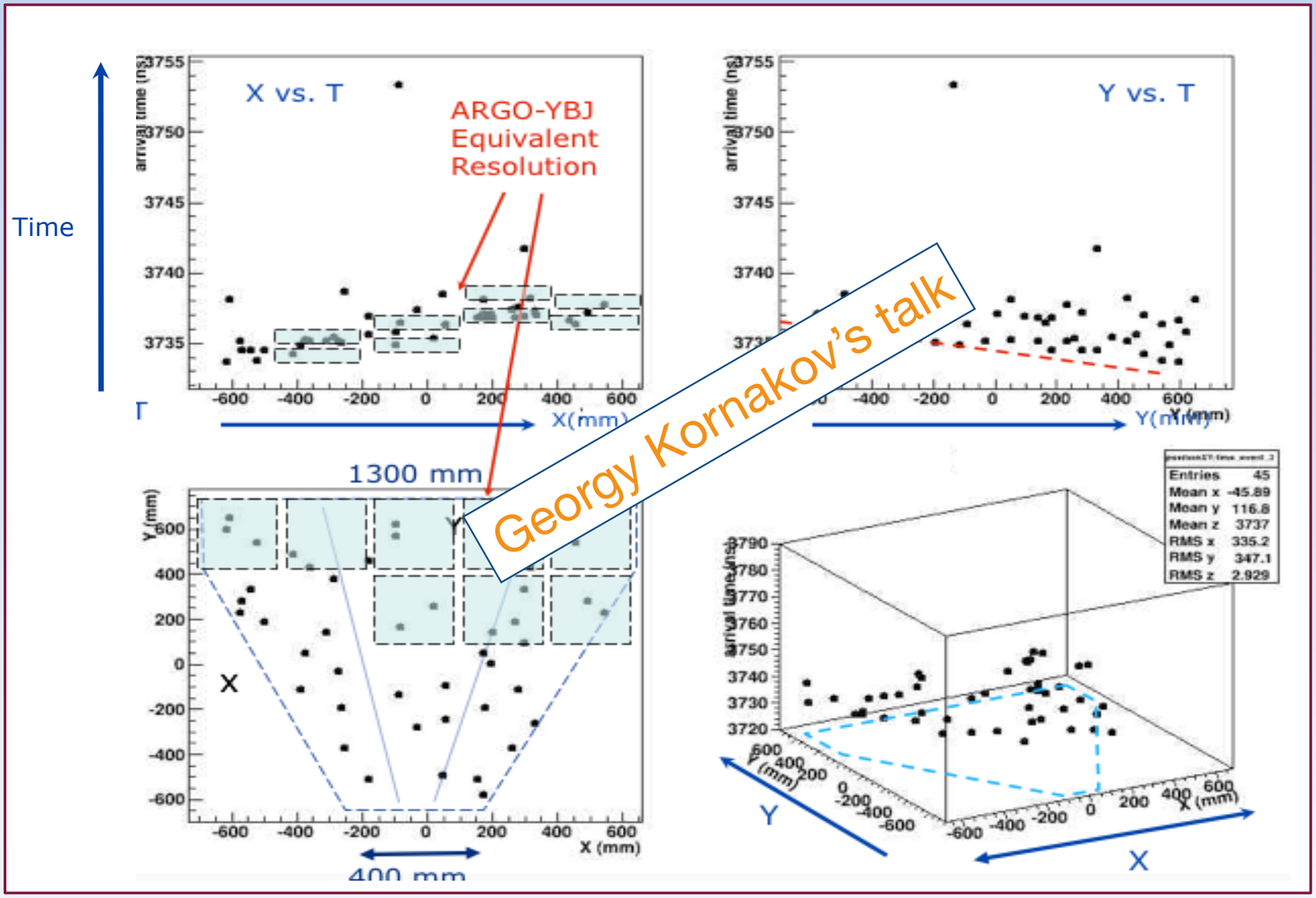
A typical high multiplicity event:



A better resolution than any other observatory in the world! (+ tracking)

The beginning

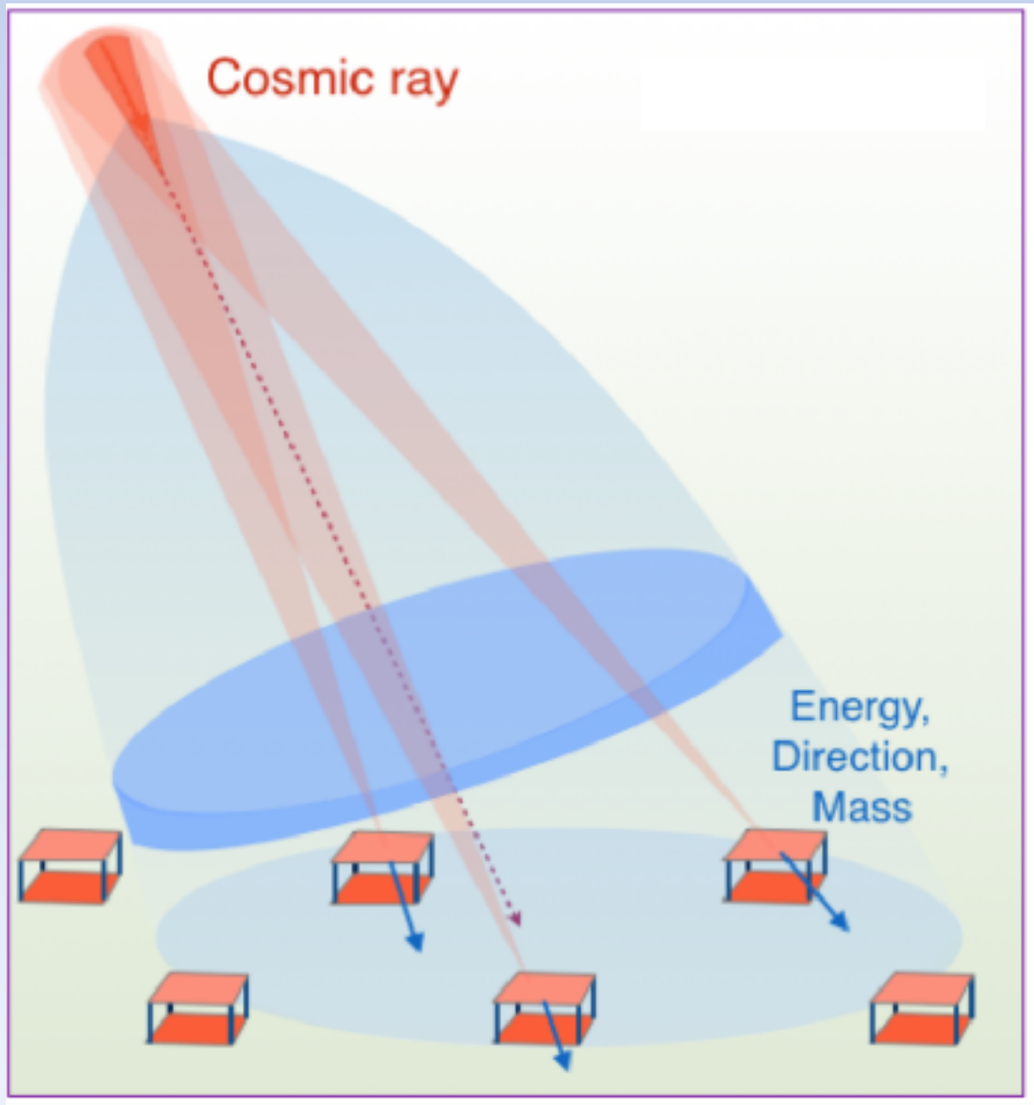
A typical high multiplicity event:

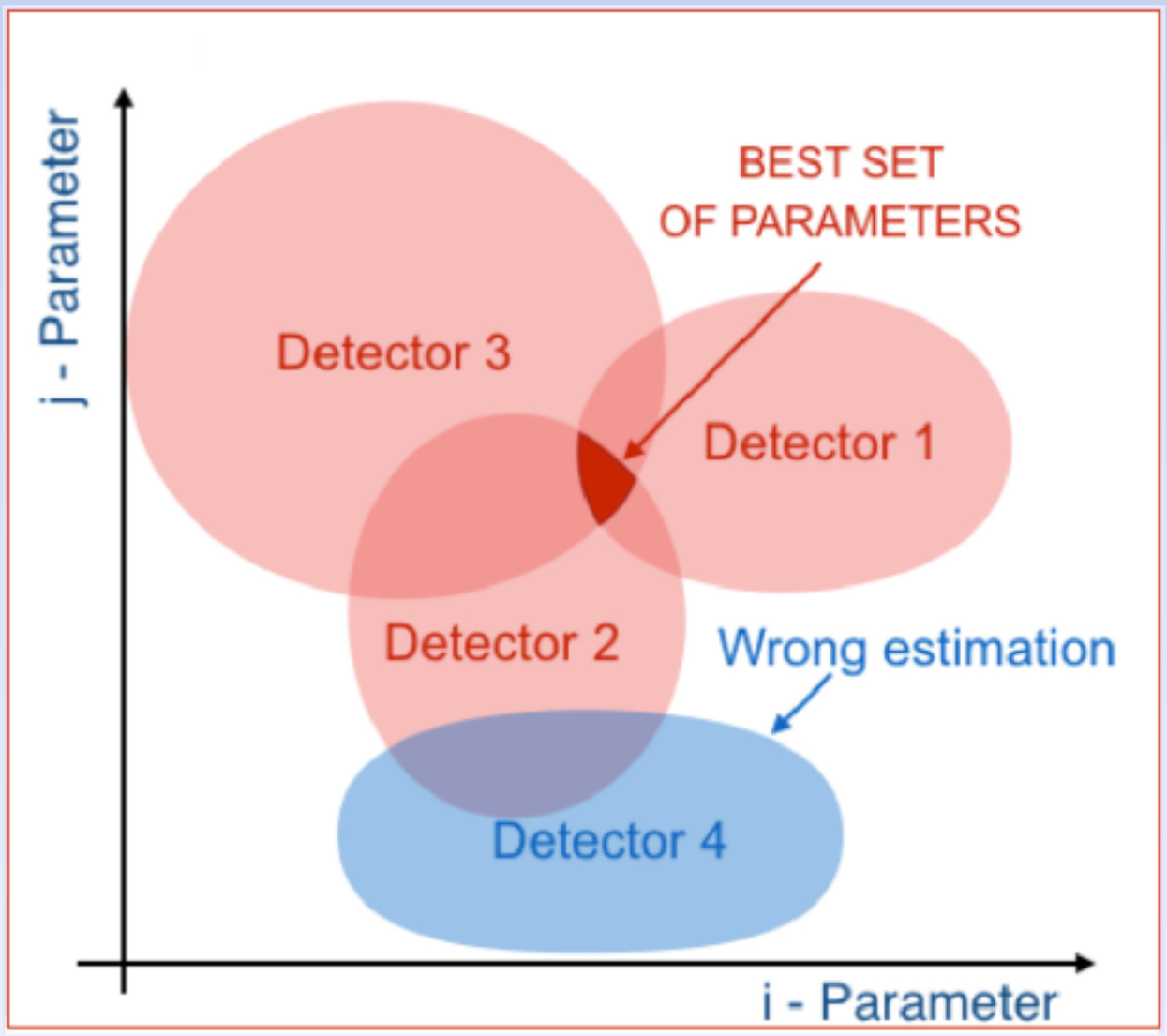


A better resolution than any other observatory in the world! (+ tracking)

The beginning

Do the cosmic ray air shower have fingerprints?





Is it possible to measure high energy cosmic rays with only a few detectors?

The next step… the concept

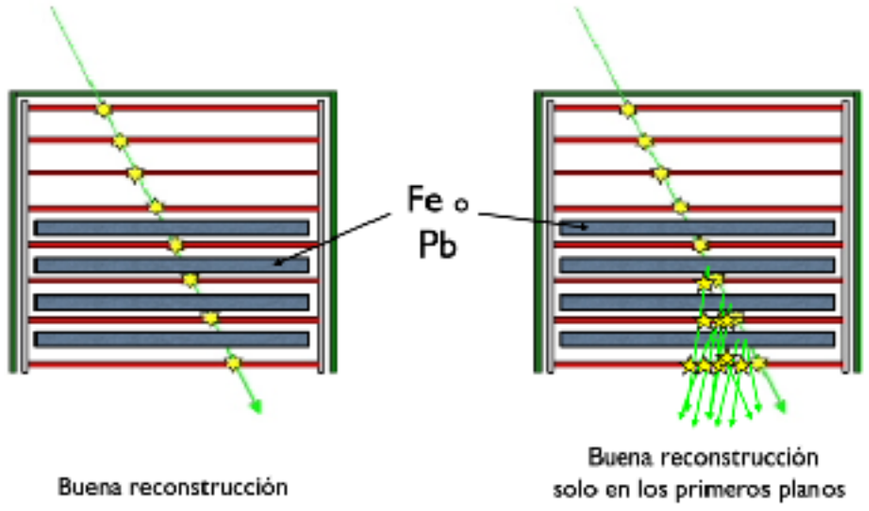
The first Trasgo concept

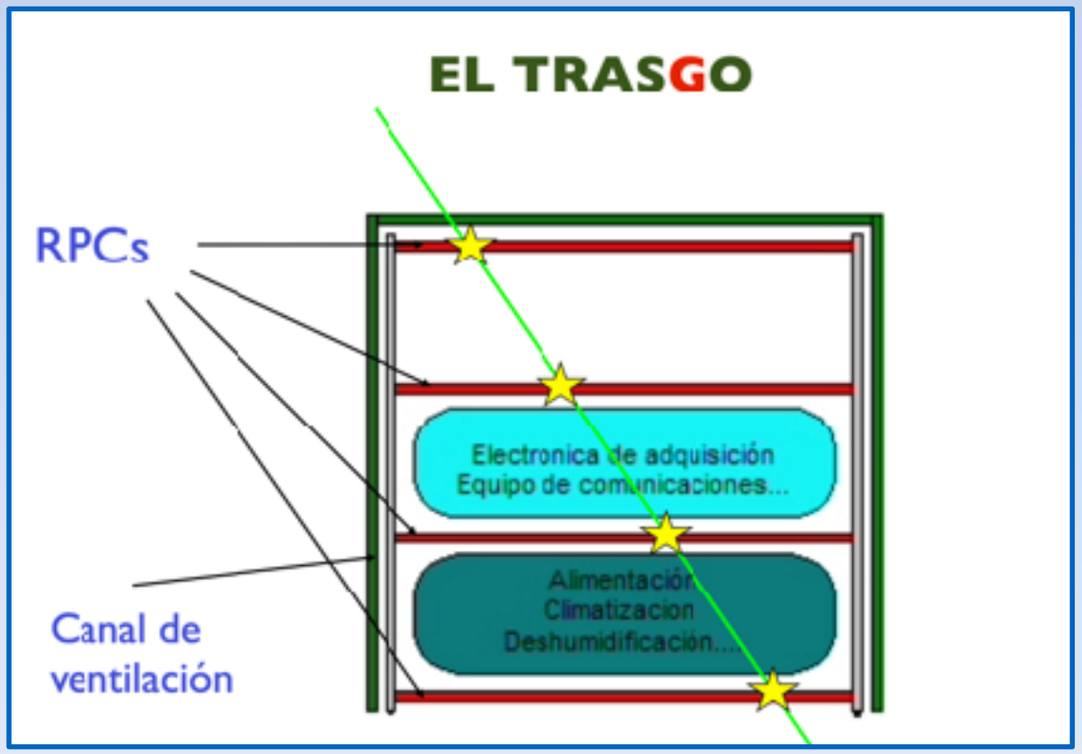
2008: the first slides

TRASGO

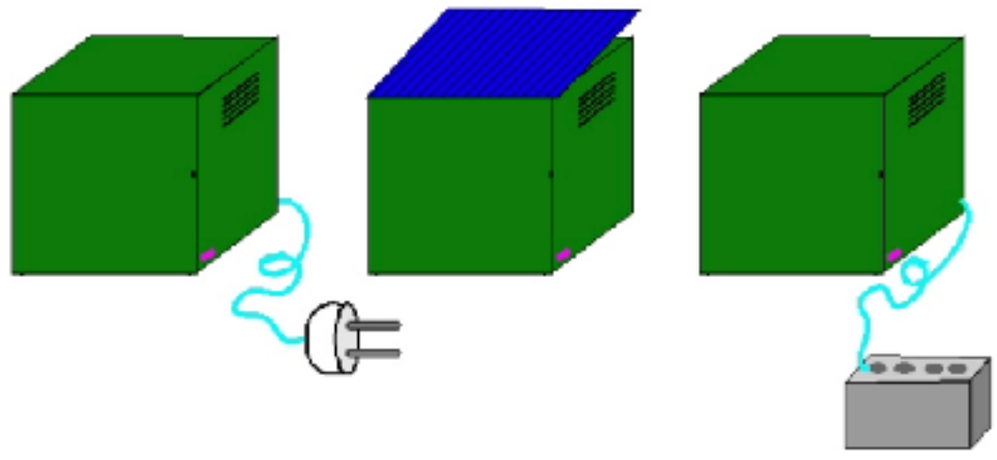
TRAcking Surveyor of Galactic radiatiOn

Posible separación e/μ





Posibles versiones:



…and the Logo

The Logo

TRAck reconStructinG bOx

The first research project

The first Research project

trasgo

An Innovative Detector for the measurement of
High Energy Cosmic Rays

J.A. Garzón Heydt. Univ. Santiago de Compostela
M. A. López Agüera. Univ. Santiago de Compostela

LabCAF

Juan A. Garzón. Univ. Santiago de Compostela. MICINN, May 2009

trasgo

The first Research project

TRASGO Project : The concept

The Trasgo is an innovative detector based on timing RPCs suitable for measuring high energy particles with timing, tracking and some particle identification capabilities.

Main ingredients:

- timing RPCs, affordable to cover big surfaces and with time resolution ~100ps.

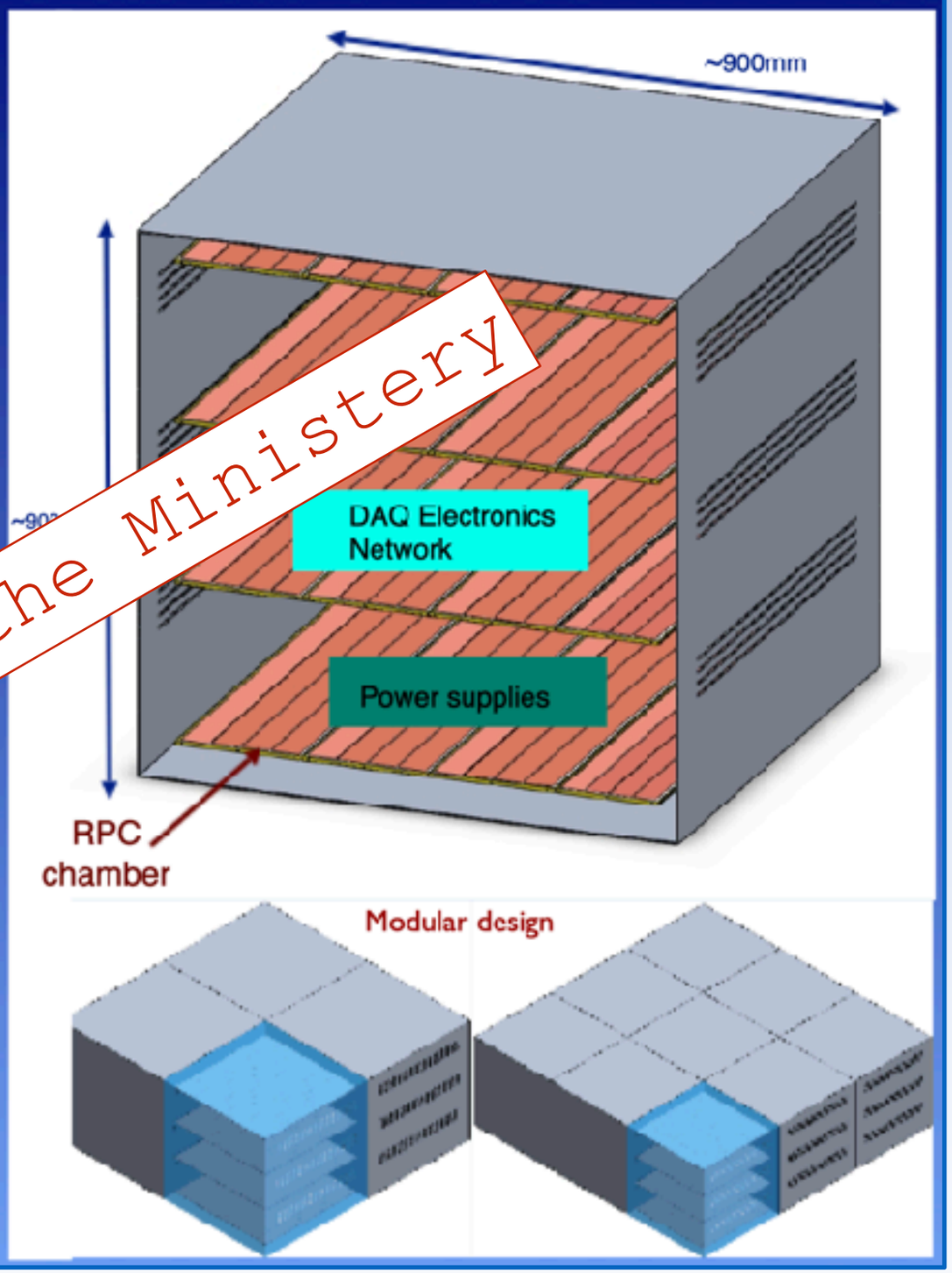
- TimTrack: Fast tracking algorithm with capability of reconstructing the space coordinates and direcions, velocity and time arrival (TimTrack)

- MIDAS: Some capability of separat muons, electrons and protons by a ng method (Midas)

- GSI-TRB The GSI-TRB Data Acquisition board with capability of reading 128 FEE channels

(Aproximate layout)

Refused by the Ministery



Many steps forward…

Many steps forward…

LIP

MADRID

HIDRONAV TECHNOLOGIES

UNIÓN EUROPEA
FONDO EUROPEO DE DESARROLLO REGIONAL
Una manera de hacer Europa

BASE ANTARTICA ESPAÑOLA JUAN CARLOS I

CaLMa

CESGA

meteogalicia

CENBG

Universidad de Alcalá

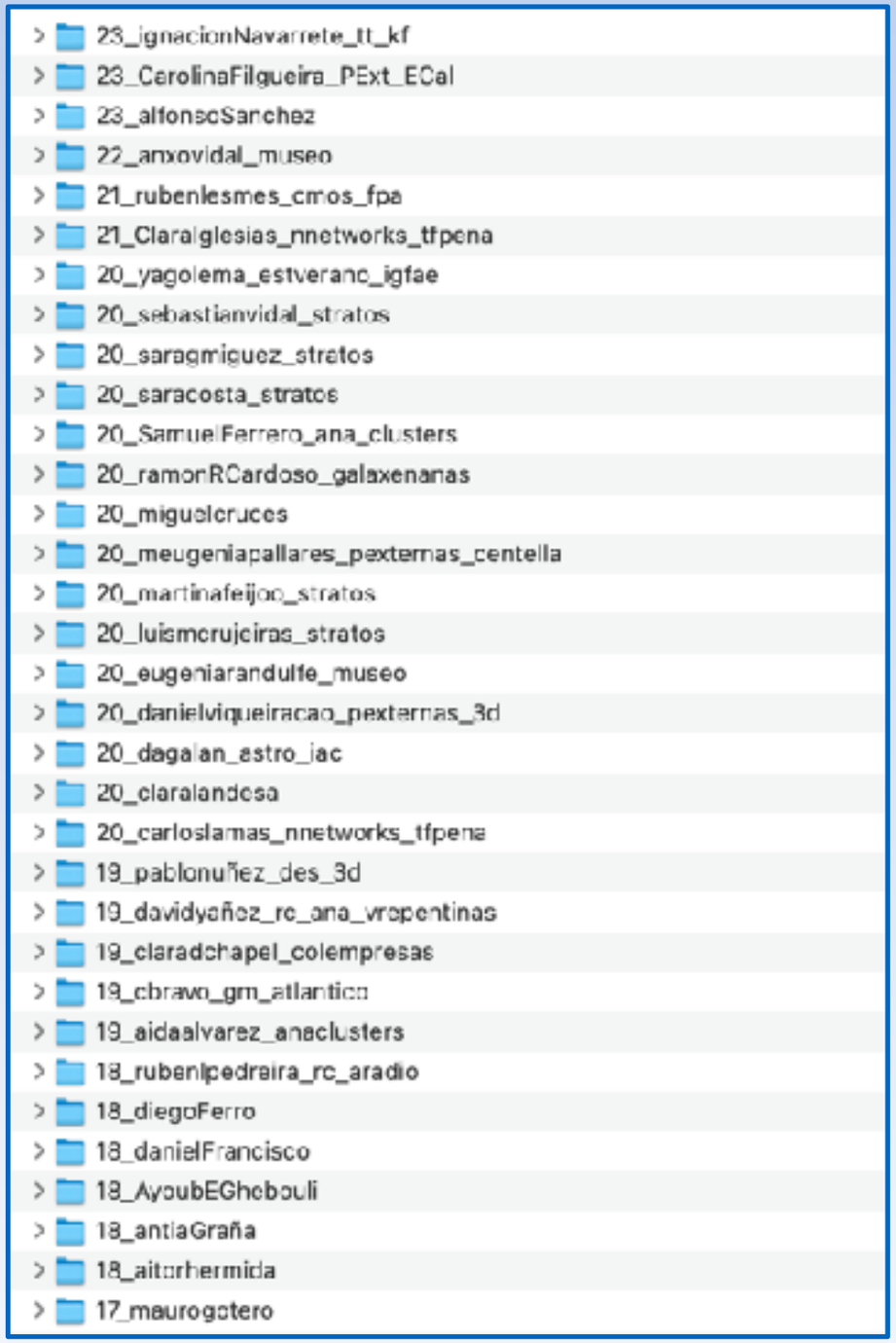
GSI

GOBIERNO DE ESPAÑA
MINISTERIO DE FOMENTO
INSTITUTO GEOGRÁFICO NACIONAL

Tecnociencia

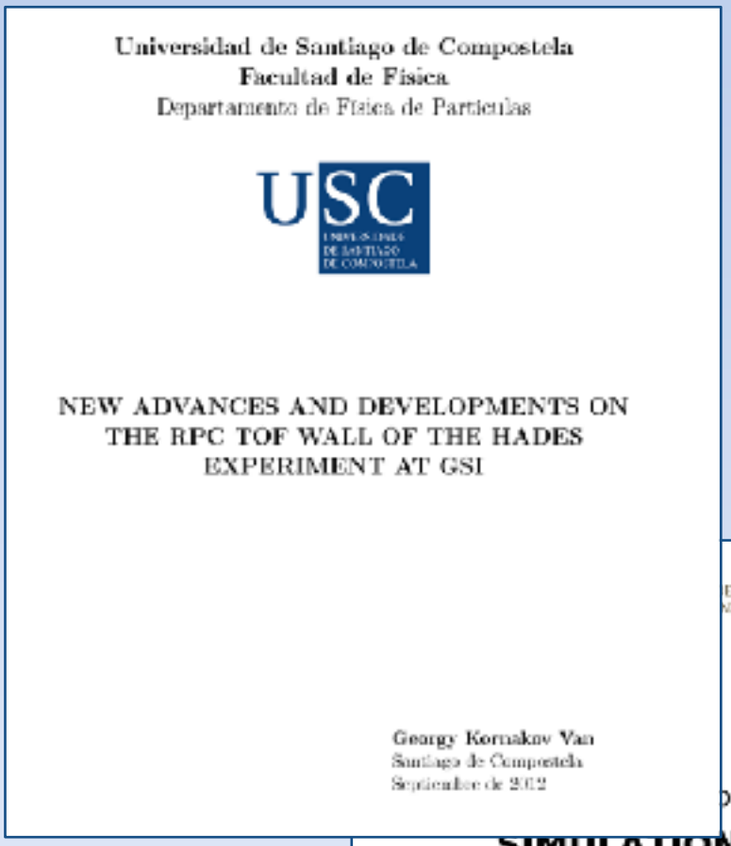
and many partners and a few funding agencies…

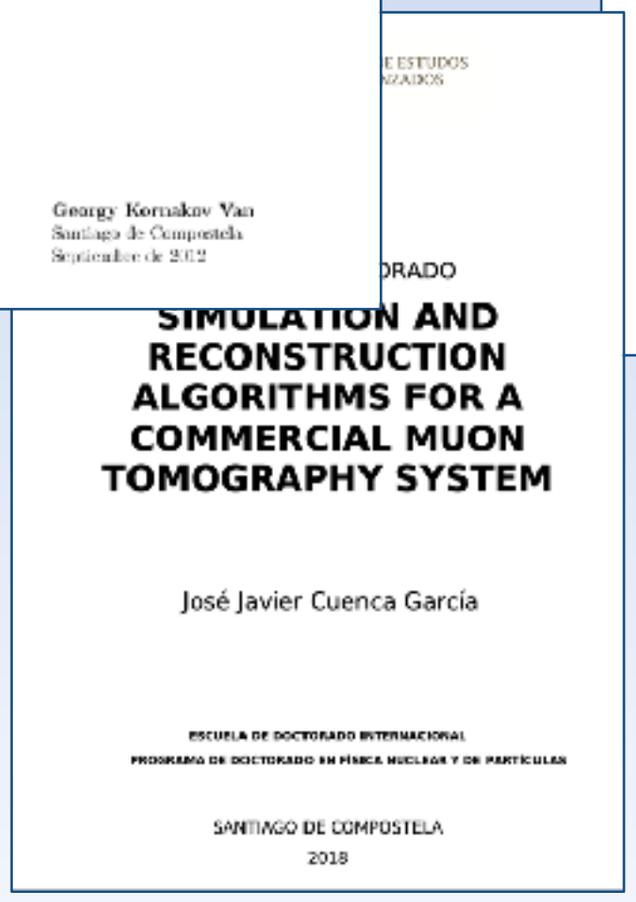
Many steps forward…

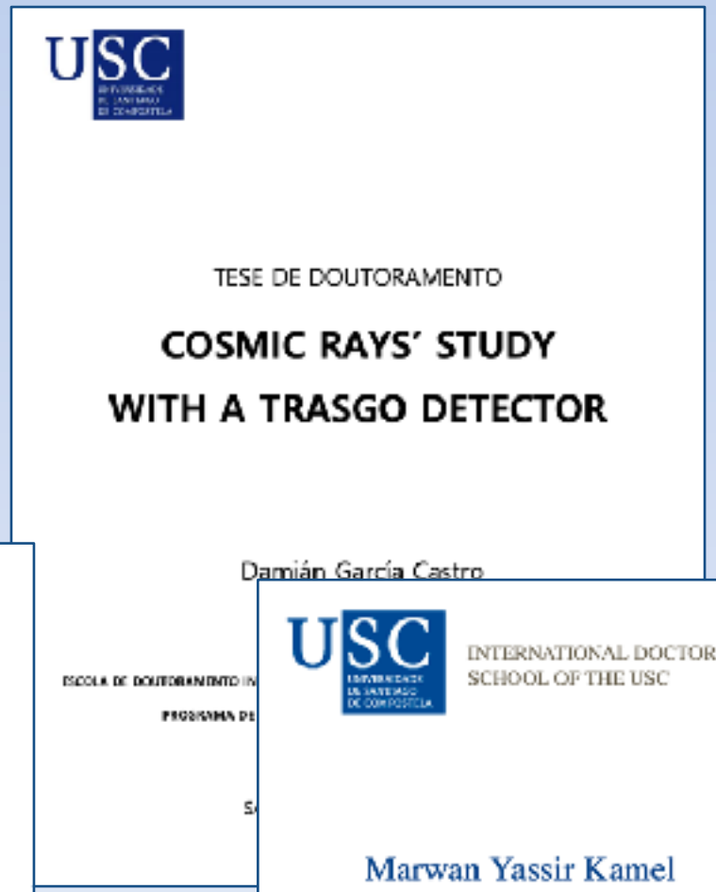


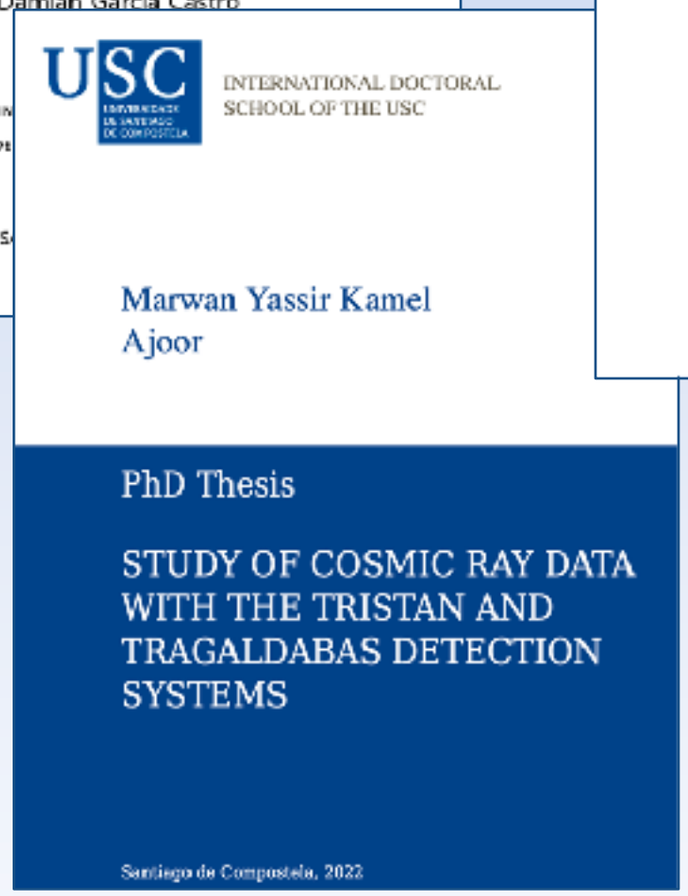
many academic works with graduate and master students…

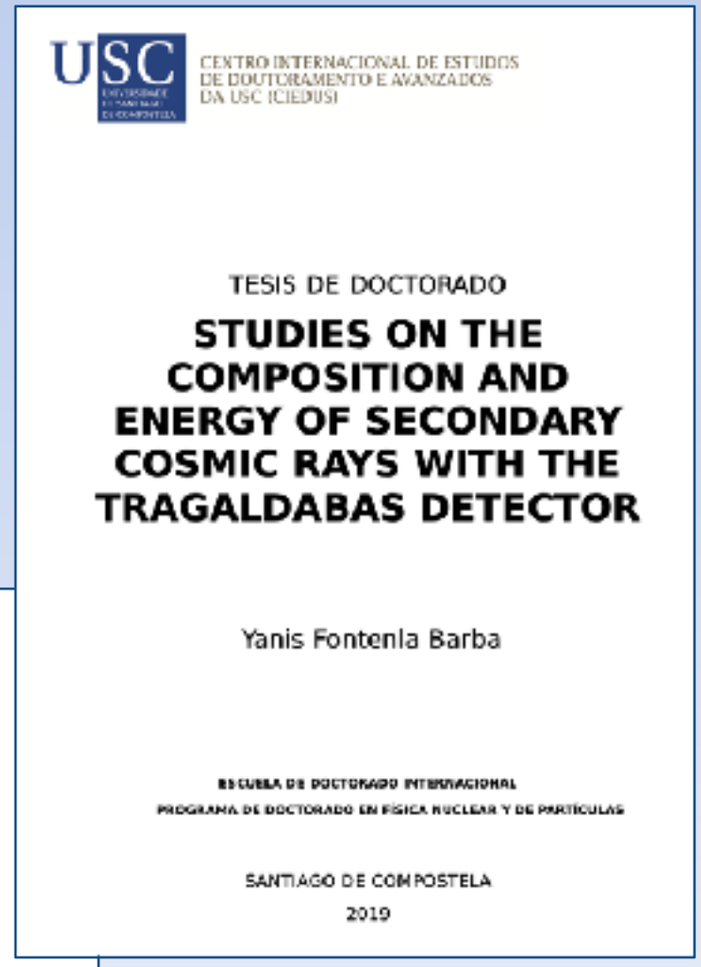
Many steps forward…











+ 5 Ph.D. Thesis…

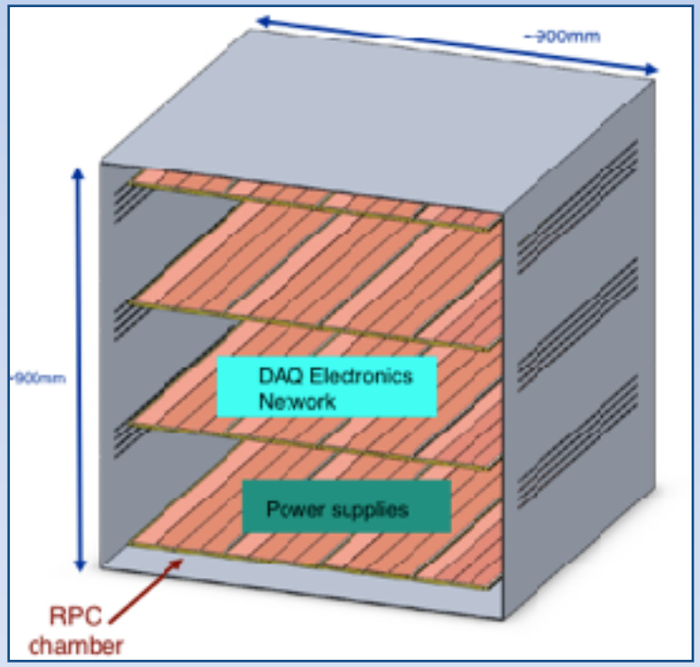
Many steps forward…

+ many people contributions + 2 Trasgo + 2 Tragaldabas research meetings

… here we are

The TRASGO project today

The Trasgo Project

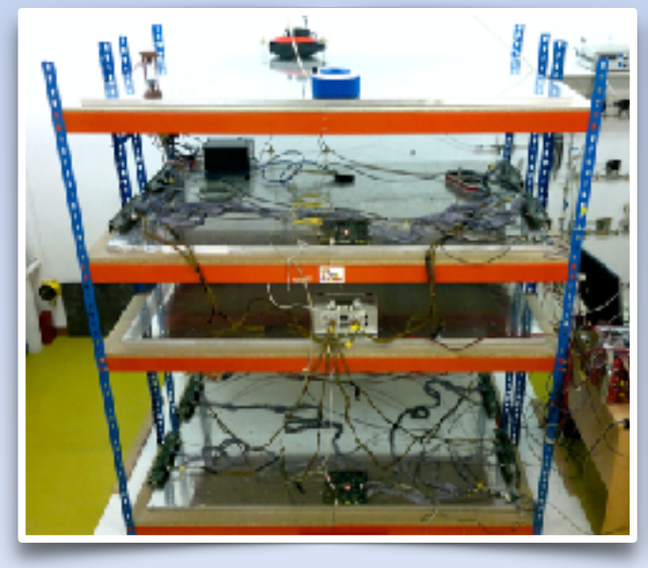


Main features (strengths):

- High granularity tracking detector
- Sensitive to bundles of particles
- Muon / Electron software PID
- Rough estimation of the electron energy distribution

The Trasgo Project

10 year after… The TRASGO family

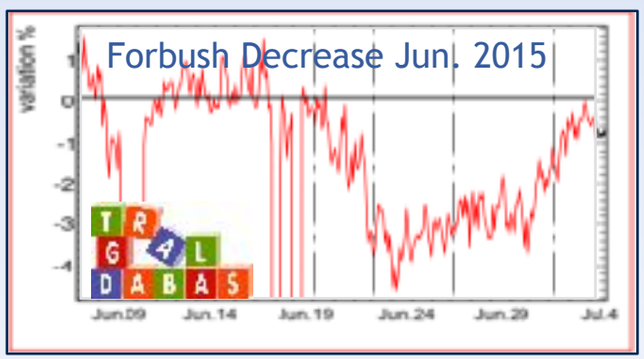


TRAGALDABAS
(Univ. S. Compostela)

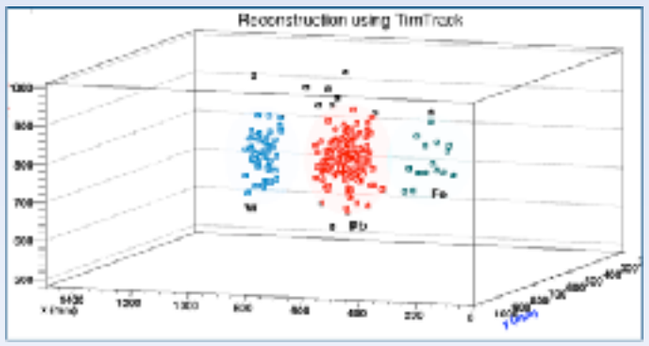
MuTT
(Porriño)

TRISTAN
(Antarctica, Alcalá U.)

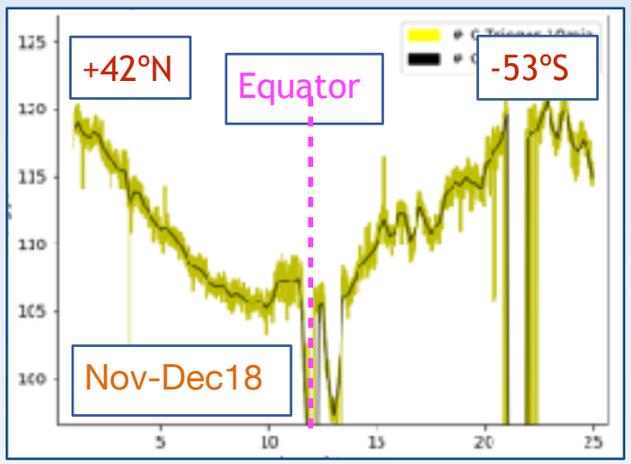
STRATOS
(Hidronav-Vigo)



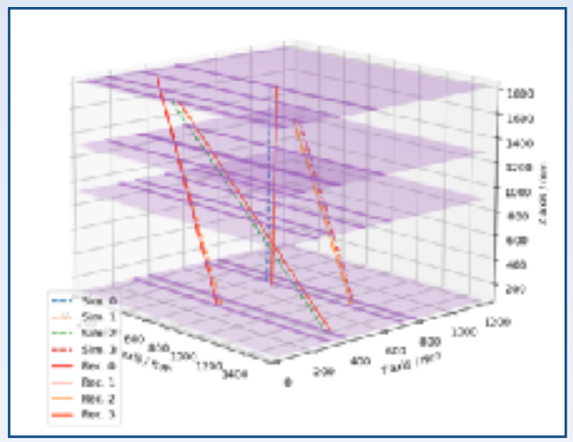
June 2015
Forbush Decrease



Cosmic Ray Muography
(W-Pb-Fe identification)



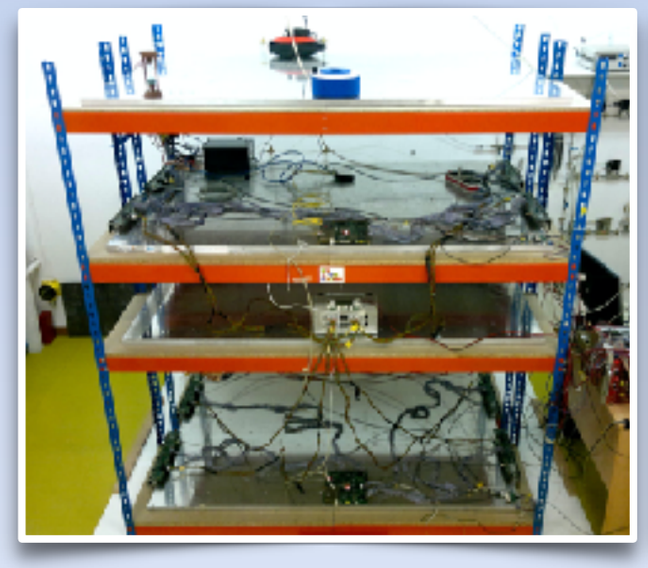
Geomagnetic Survey



Atmospheric studies

The Trasgo Project

10 year after… The TRASGO family



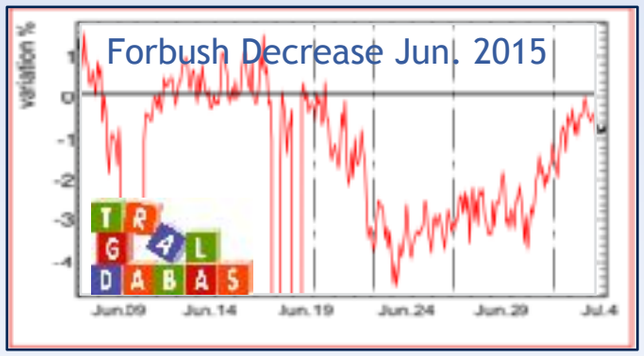
TRAGALDABAS
(Univ. S. Compostela)

TT
rriño)

TRISTAN
(Antarctica, Alcalá U.)

STRATOS
(Hidronav-Vigo)

José Cuenca's talk



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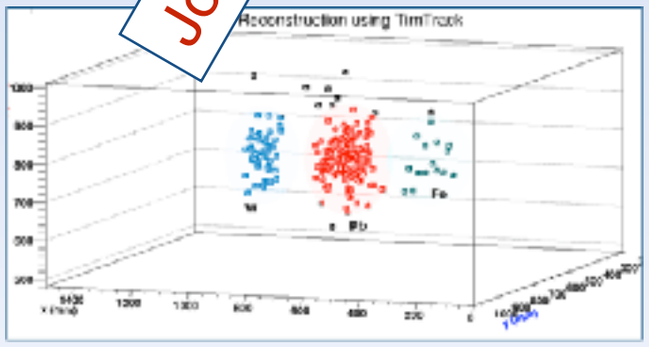

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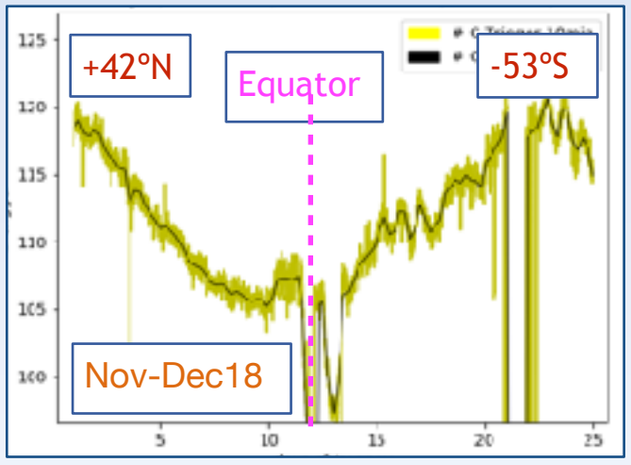
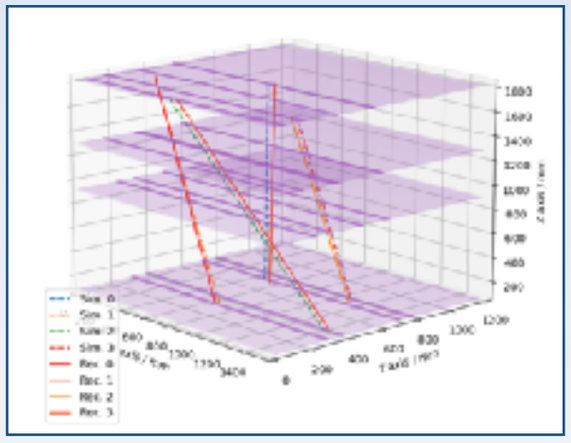


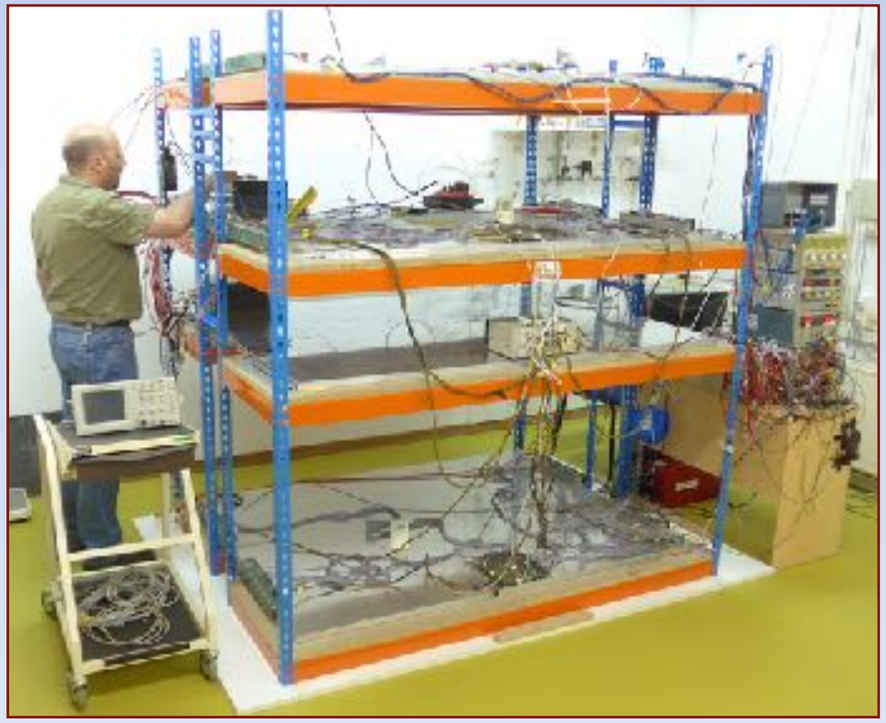
Geomagnetic Survey

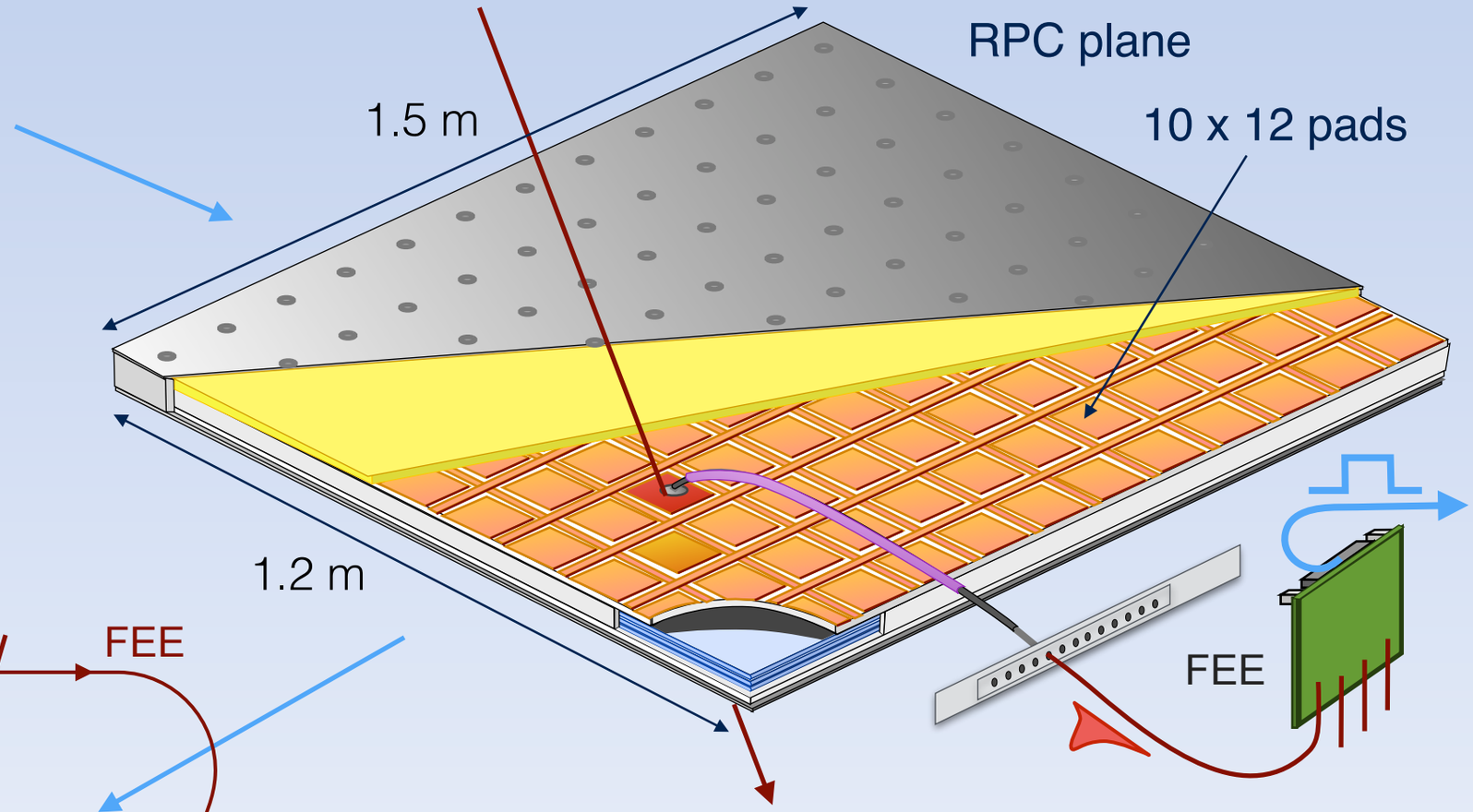


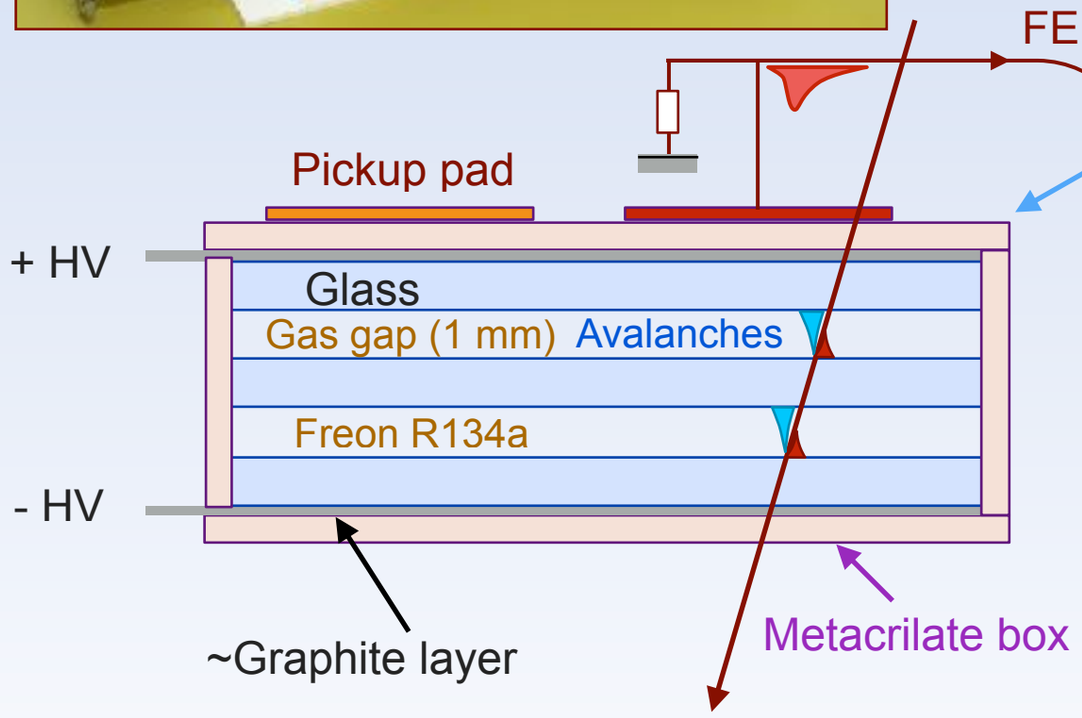
Atmospheric studies

The Trasgo Project

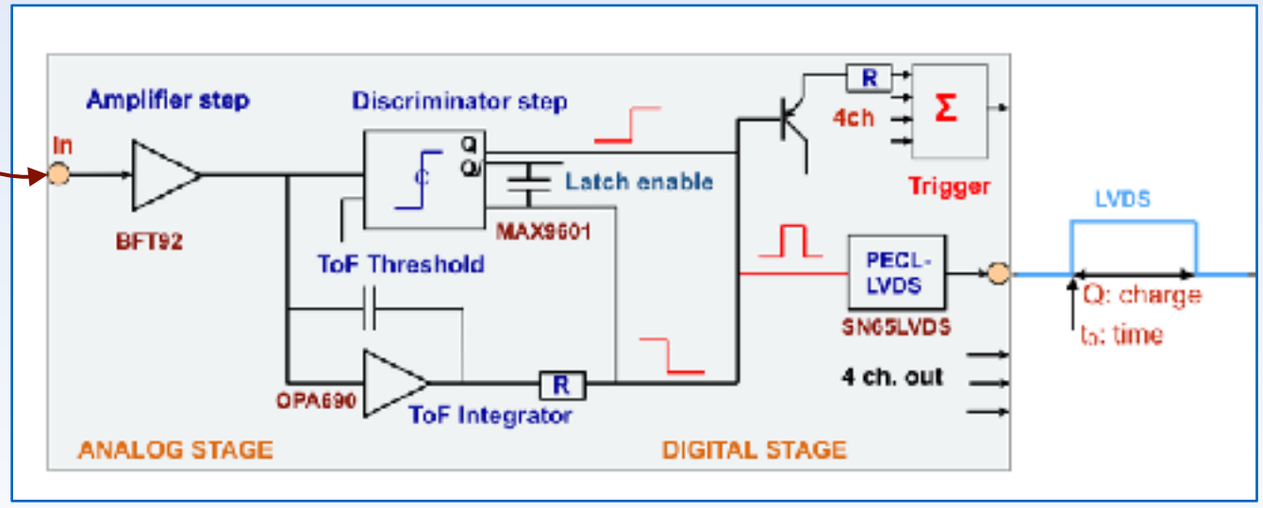
The first TRASGO: TRAGALDABAS







RPC: Resistive Plate Chamber



FEE (HADES-GSI)

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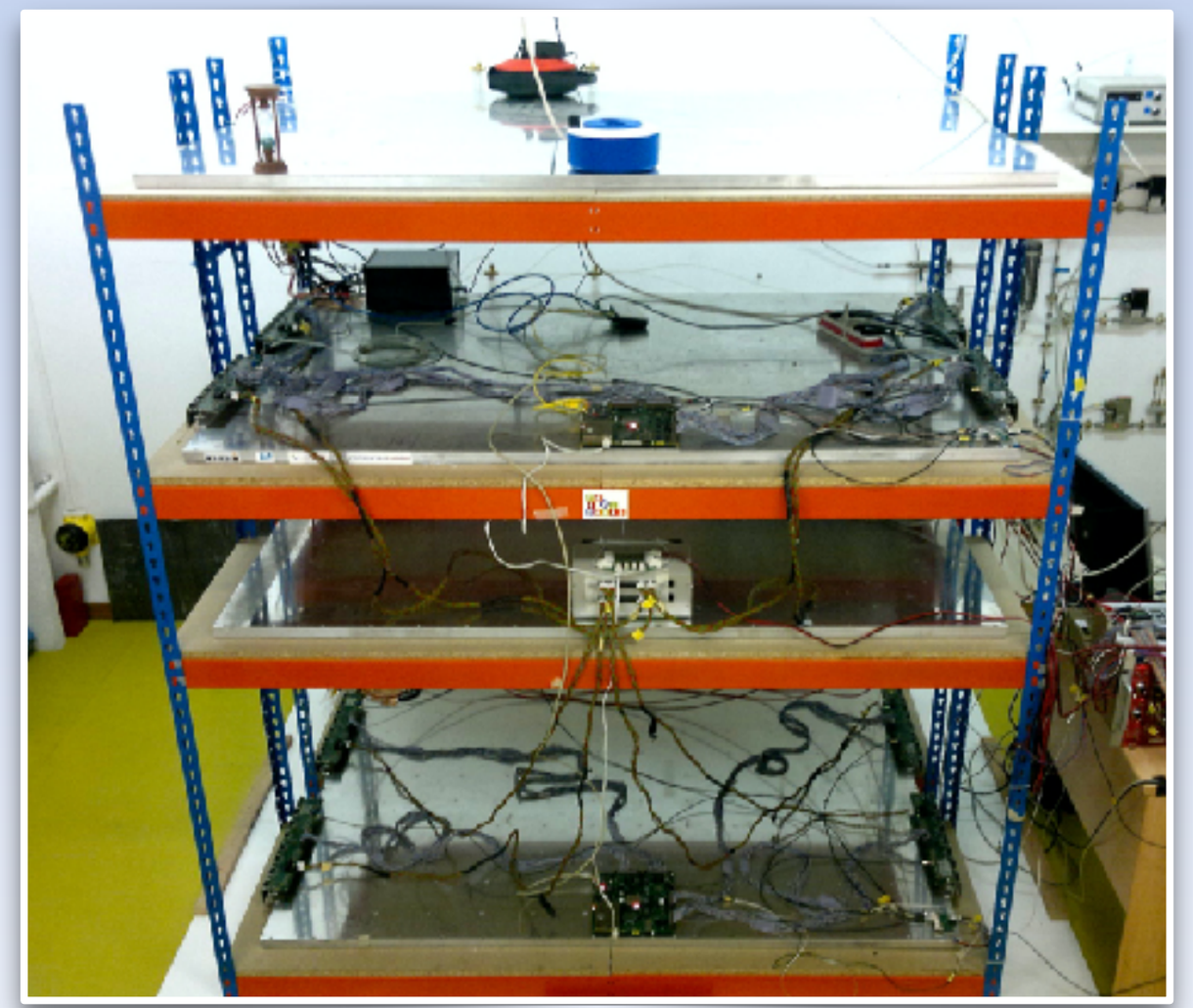
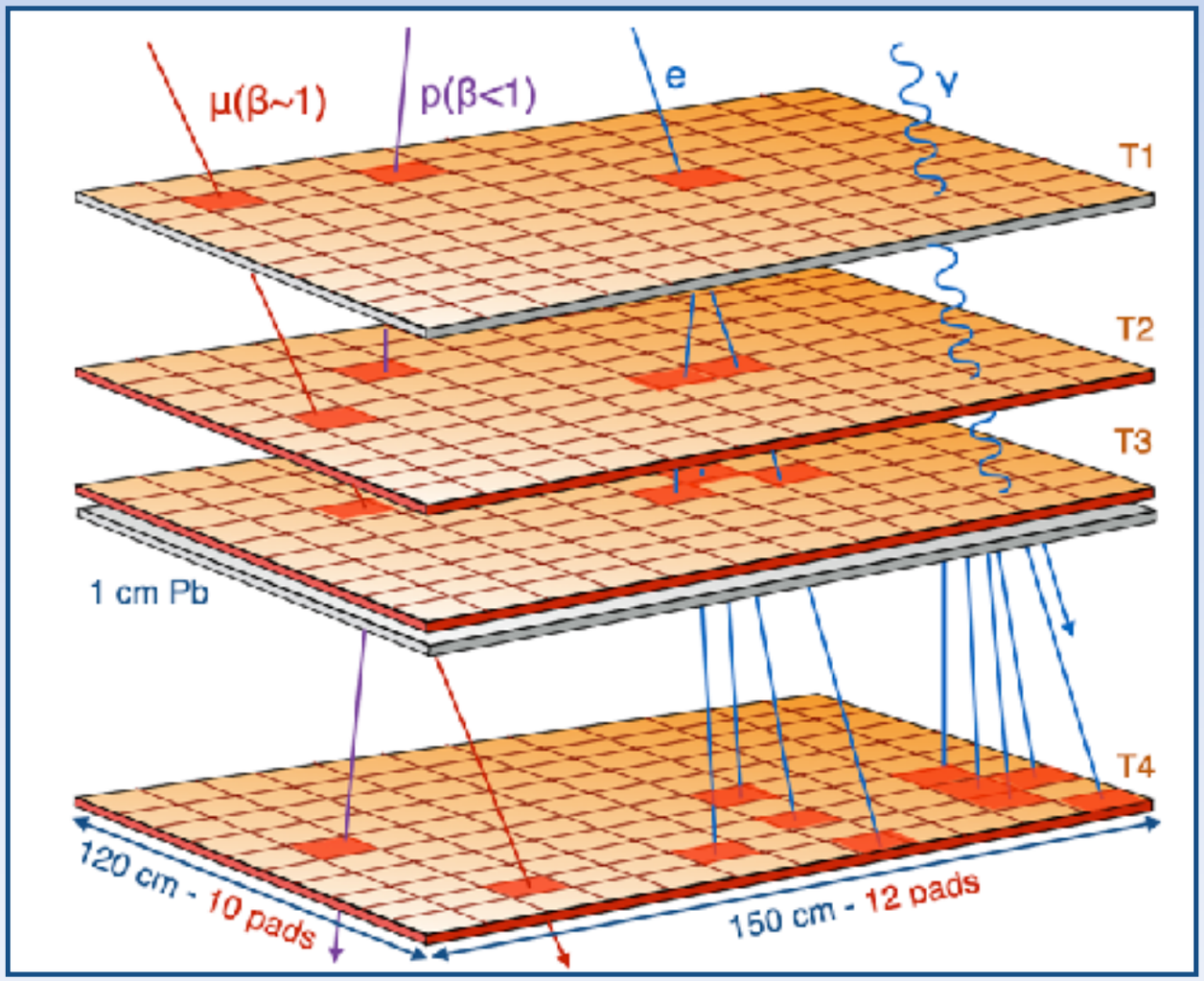
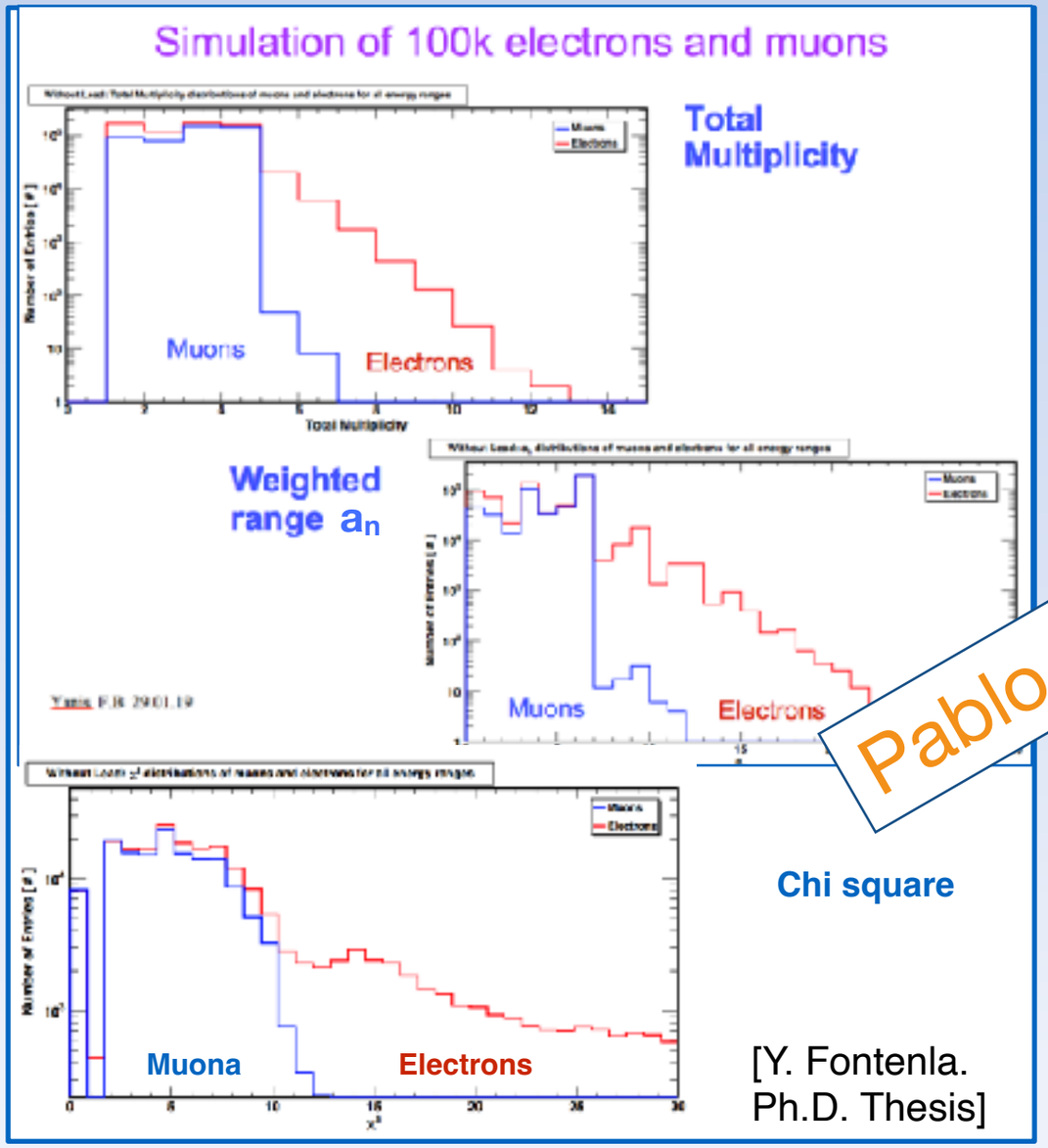
Tragaldabas. PID capability



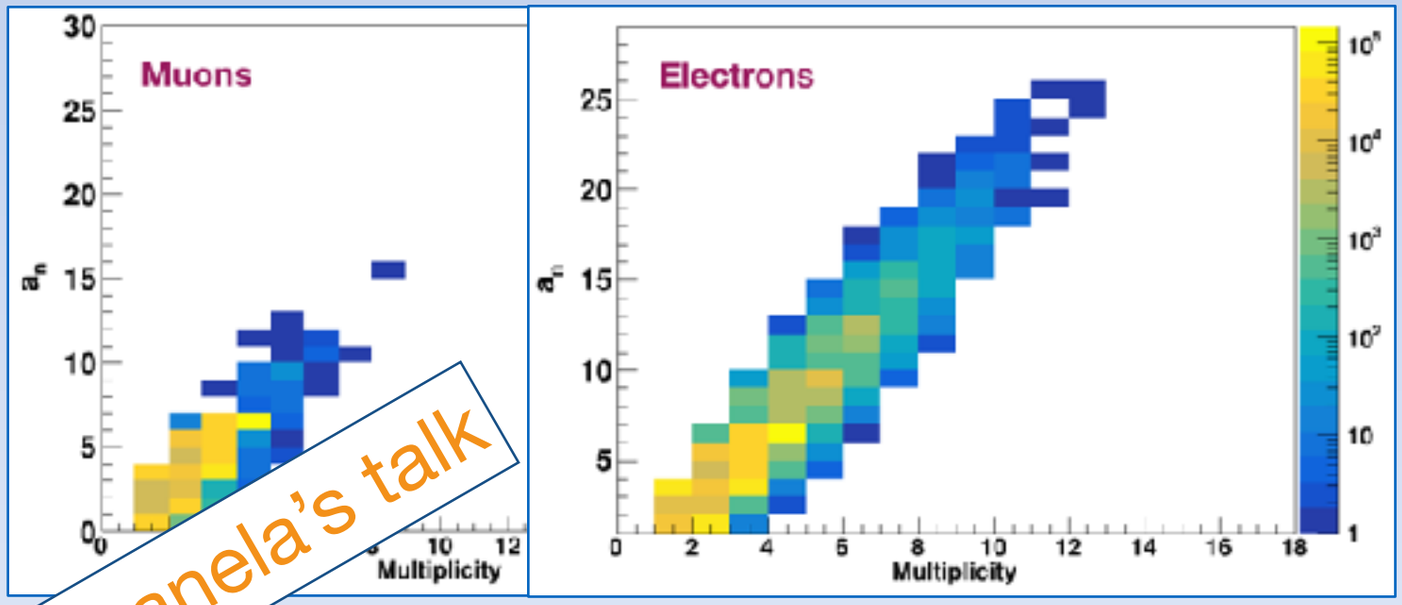


The Trasgo Project

Tragaldabas. PID capability

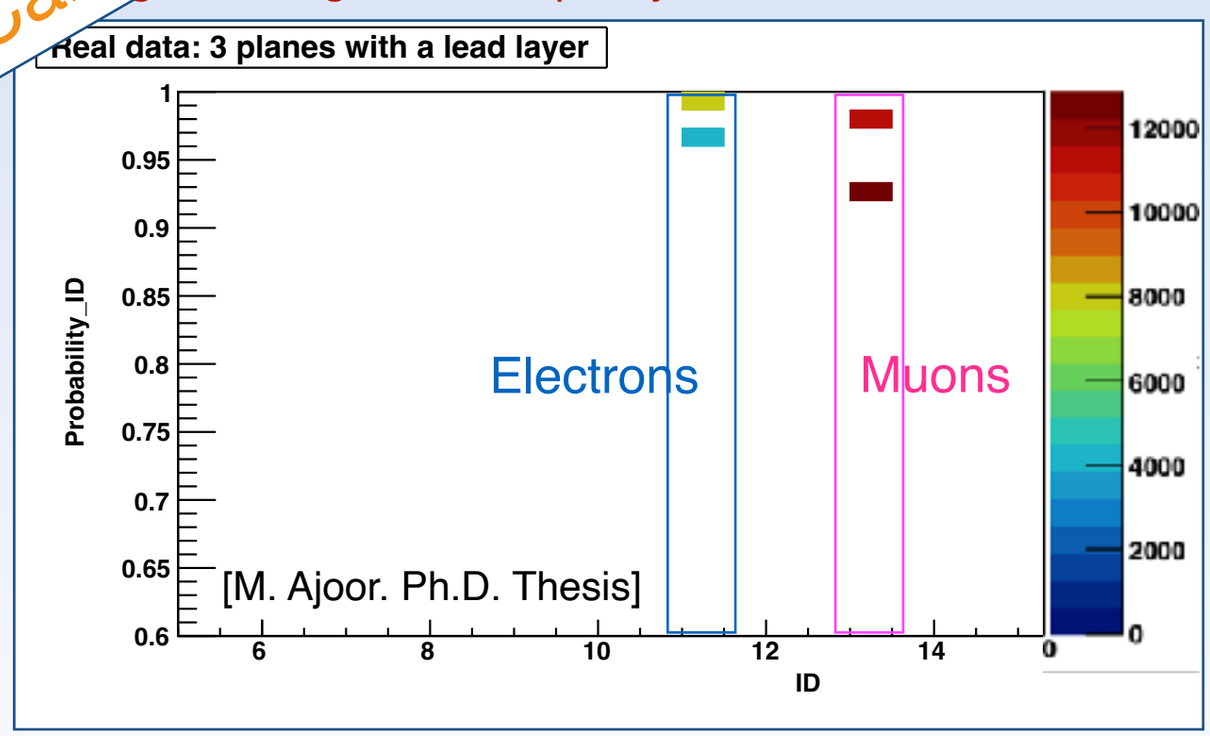


Multiplicity, Weighted range and χ^2 dist. for muons and electrons



Pablo Cabanela's talk

ighted range vs. Multiplicity for electrons and muons



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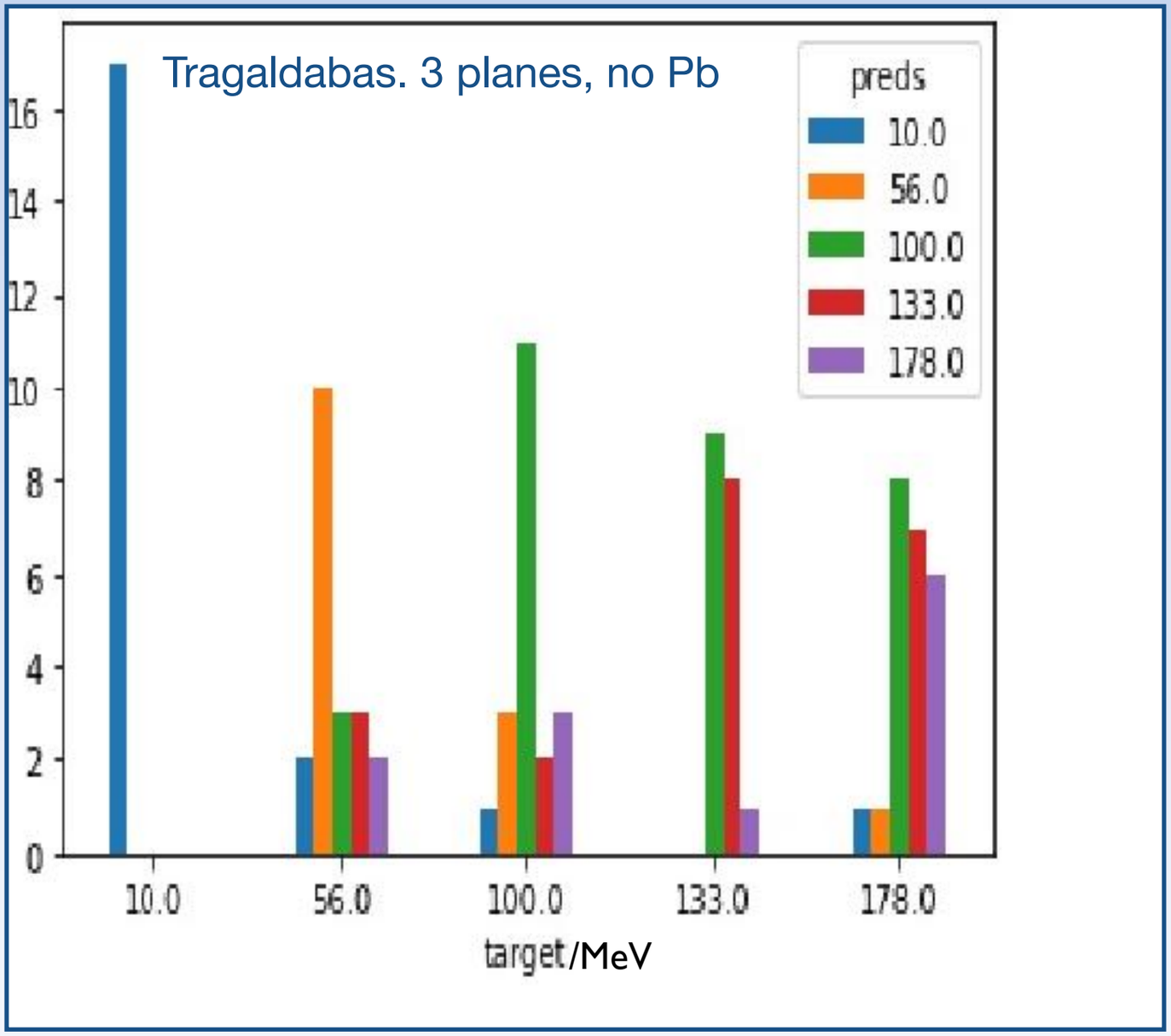
Tragaldabas. EM Calorimetry

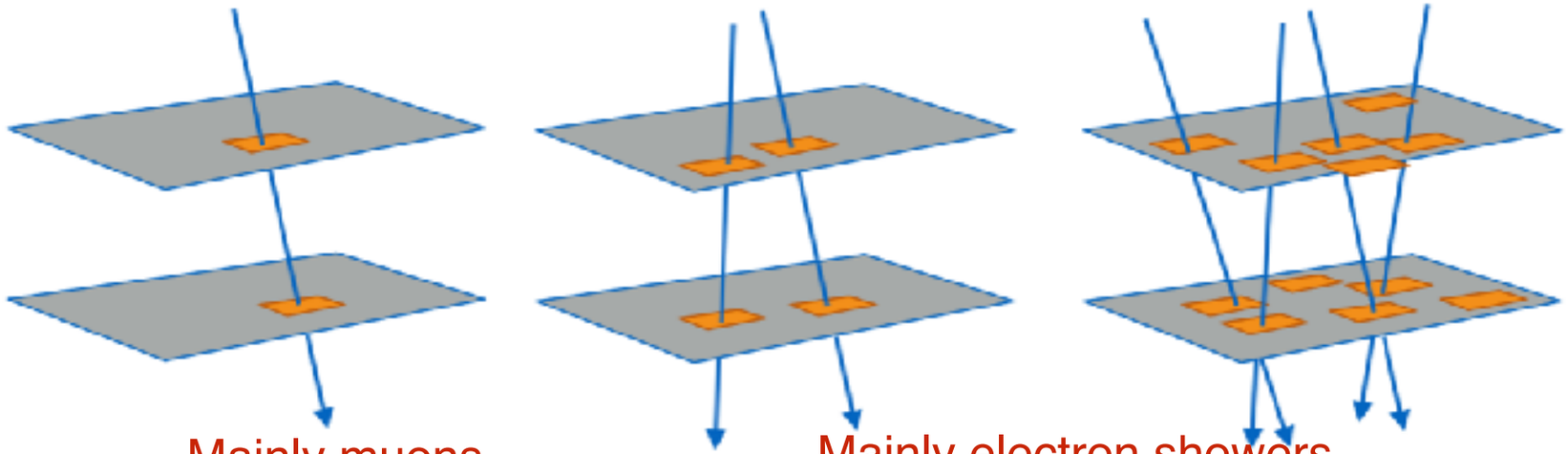
Using neural networks (J. Flores / CITIUS-USC).

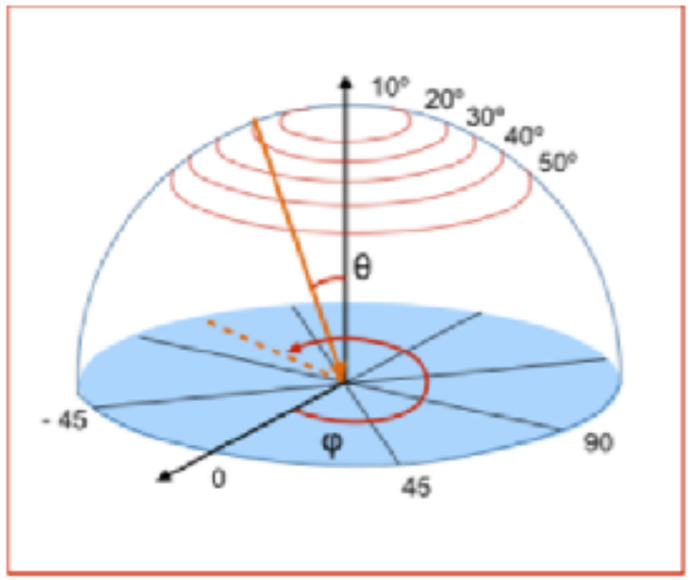


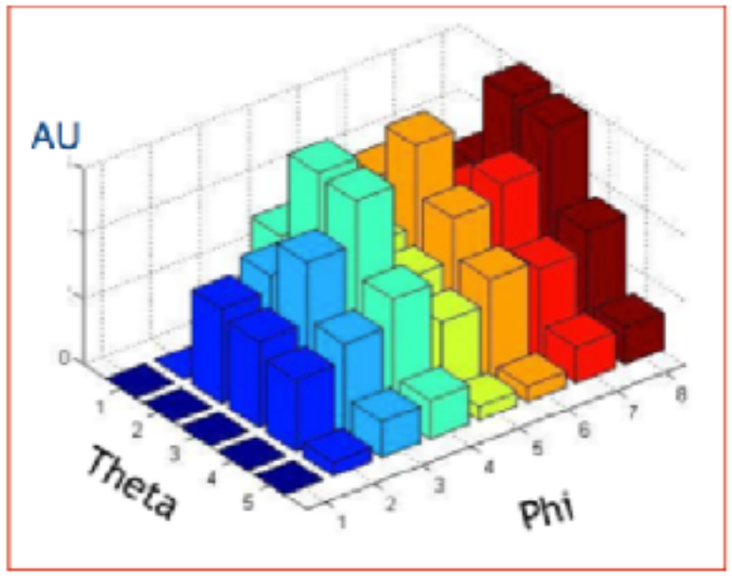
Good results only for low energy electrons (< 100 MeV)

The Trasgo Project

Tragaldabas. Main data samples



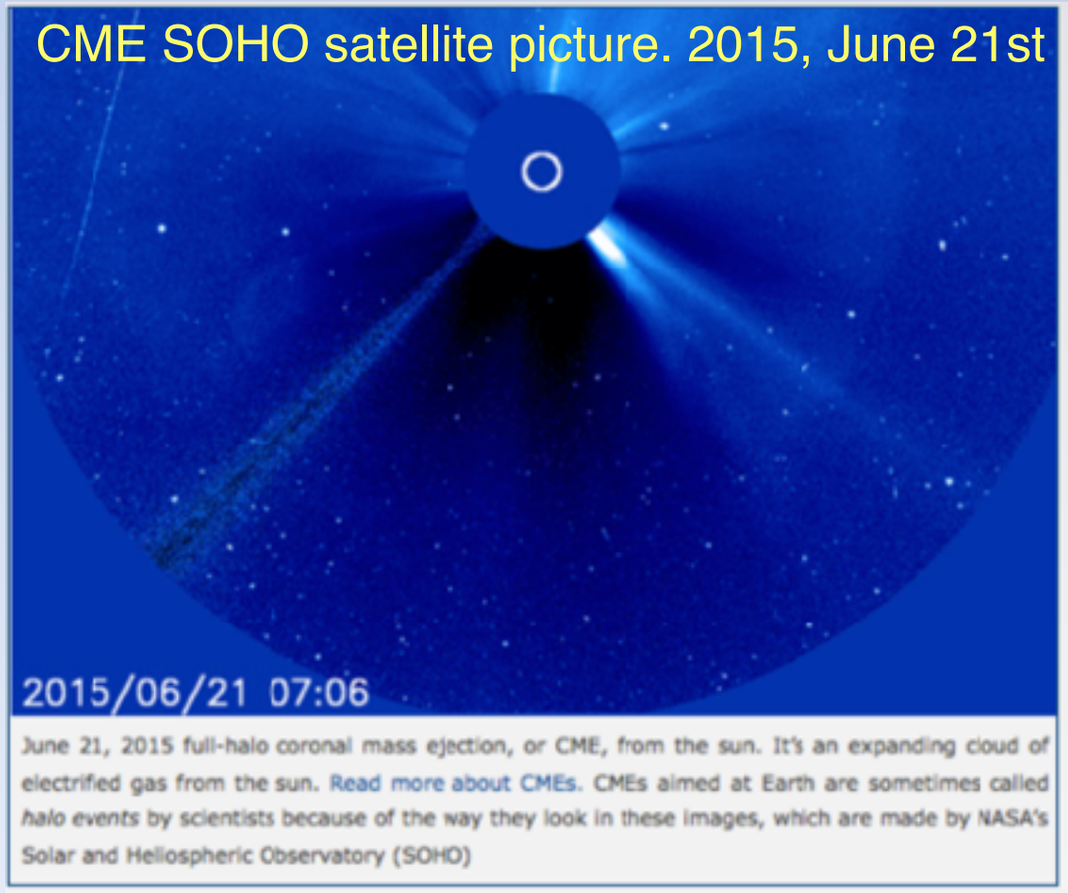




Data stored in 5x8 (theta x phi) matrices in 10-min time intervals

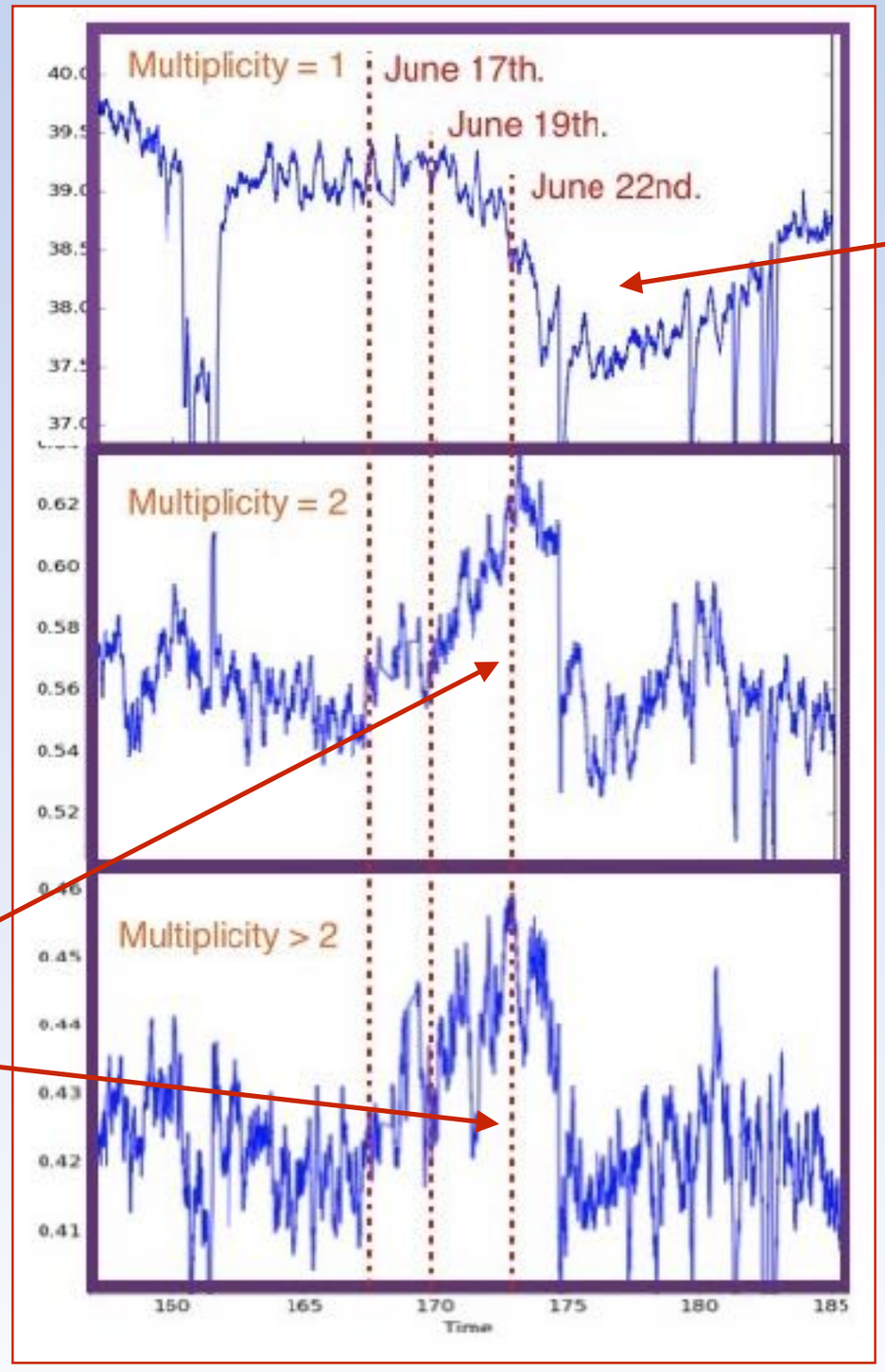
The Trasgo Project

Tragaldabas. Analysis of the Forbush Decrease on June 2015



June 21, 2015 full-halo coronal mass ejection, or CME, from the sun. It's an expanding cloud of electrified gas from the sun. Read more about CMEs. CMEs aimed at Earth are sometimes called *halo events* by scientists because of the way they look in these images, which are made by NASA's Solar and Heliospheric Observatory (SOHO)

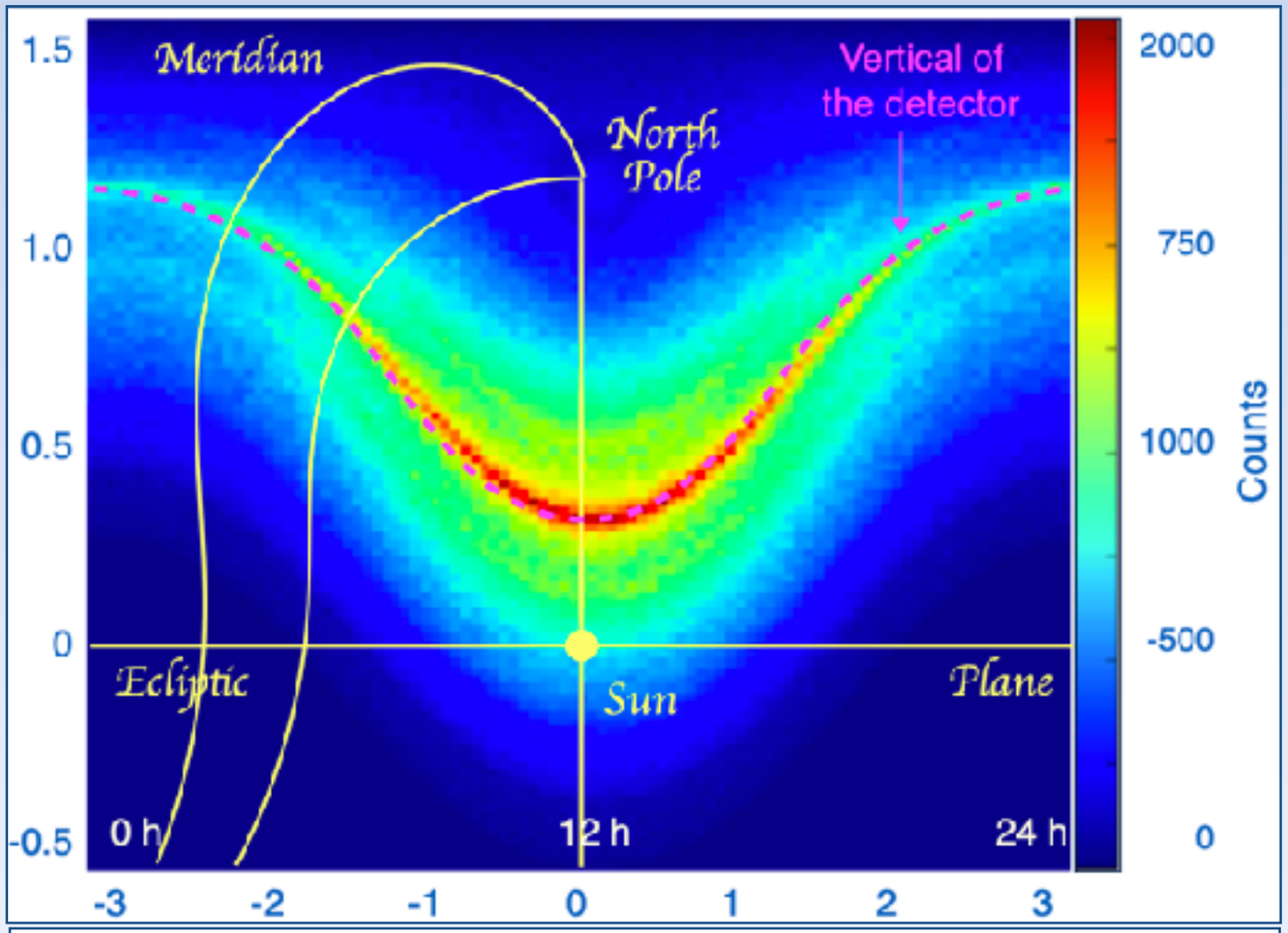
Not yet understood unexpected electron excesses!



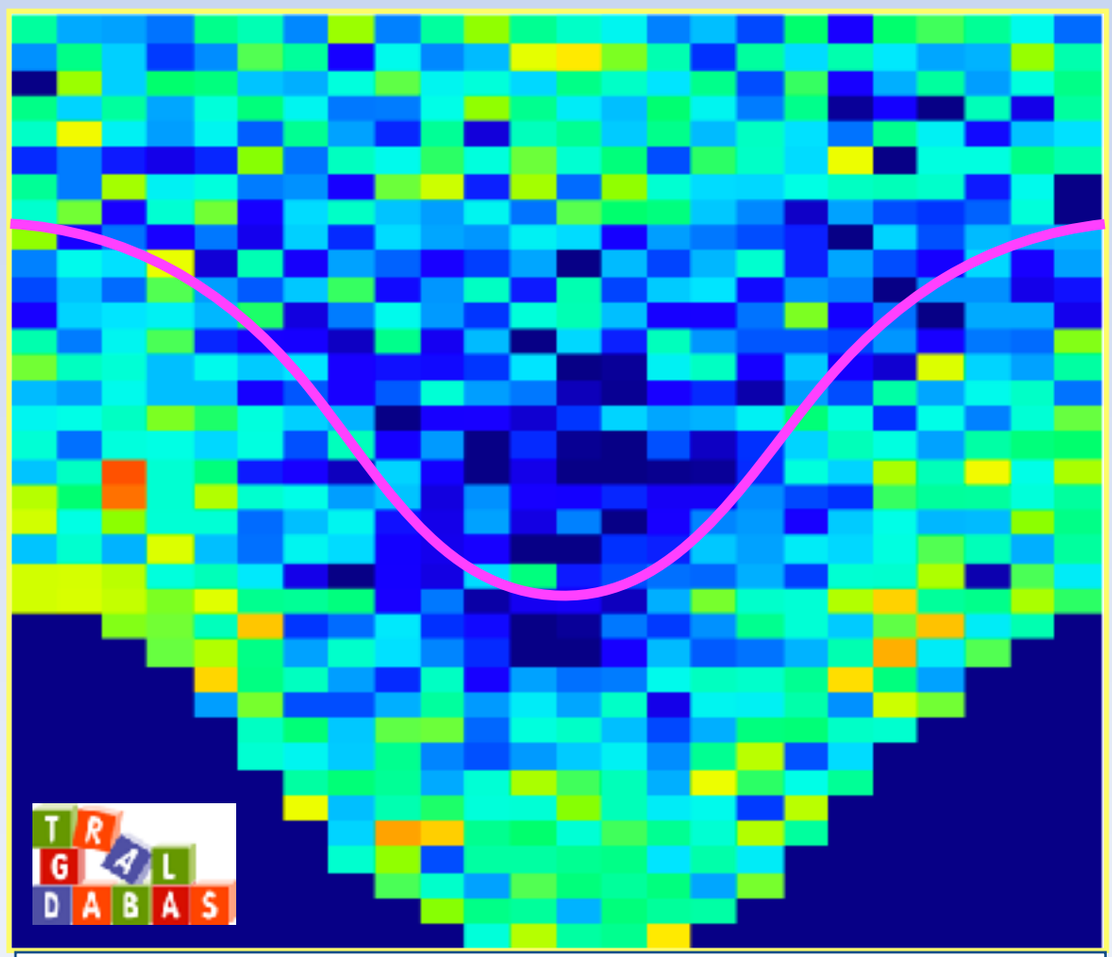
The Trasgo Project

Tragaldabas. Analysis of the Forbush Decrease on June 2015

The Tragaldabas data in ecliptic coordinates



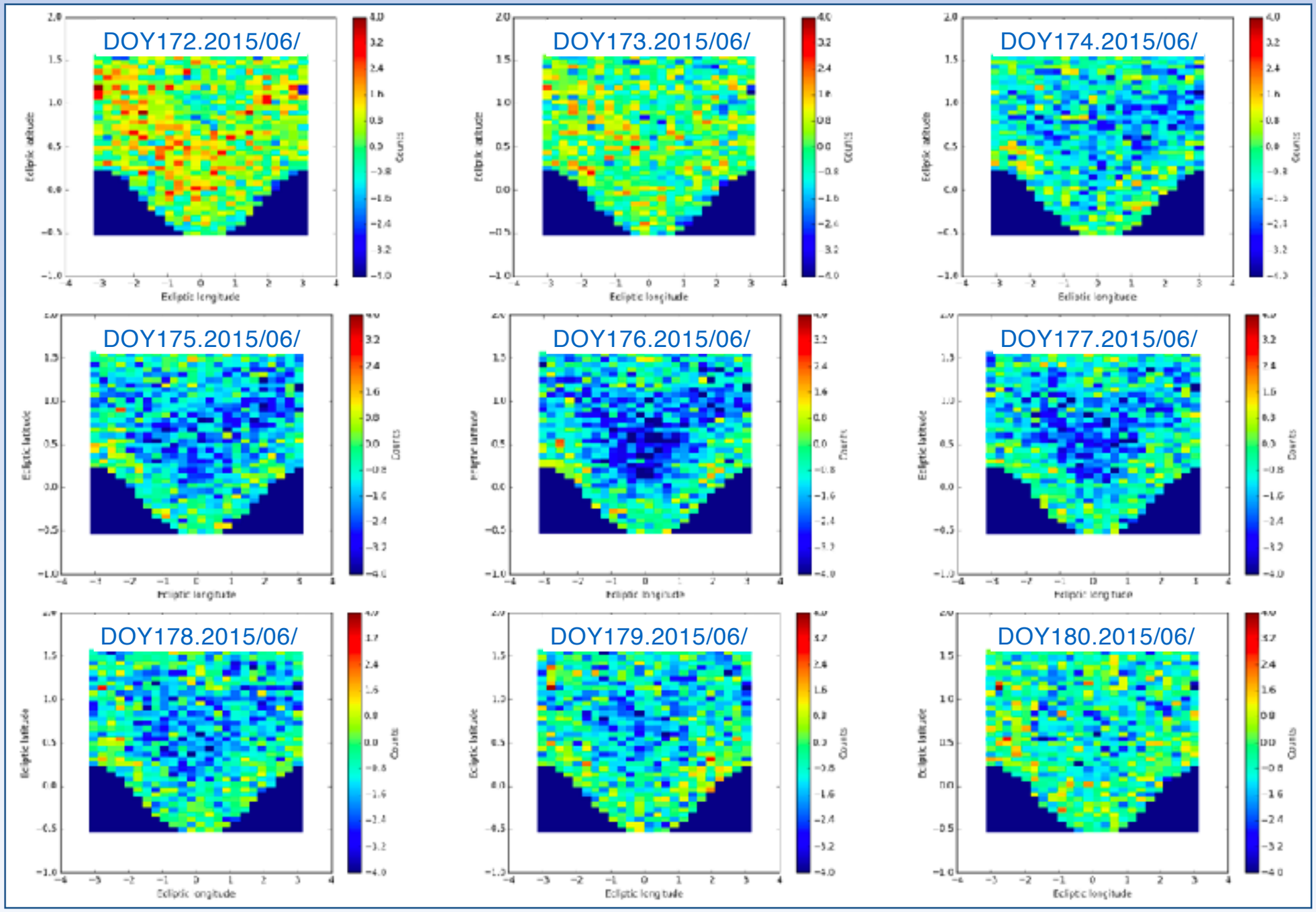
Tragaldabas. Daily acceptance in ecliptic coordinates



1 day differential picture

The Trasgo Project

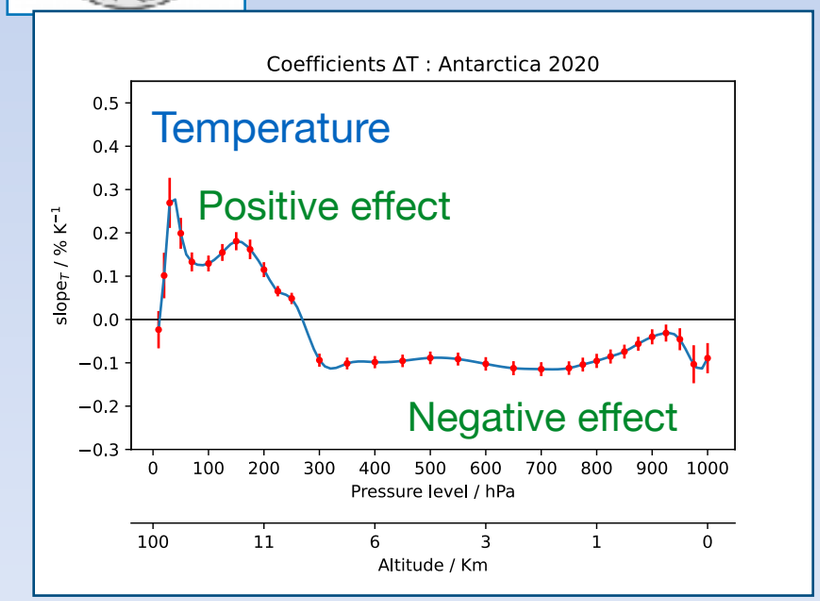
Tragaldabas. 2D June 2015 Forbush Decrease evolution



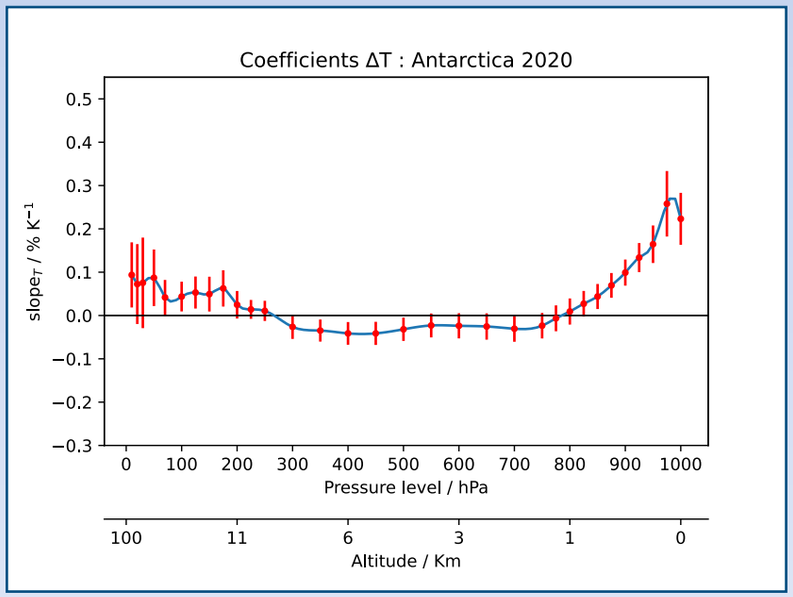
The Trasgo Project

TRISTAN: Regression slopes between measured rates and pressure levels

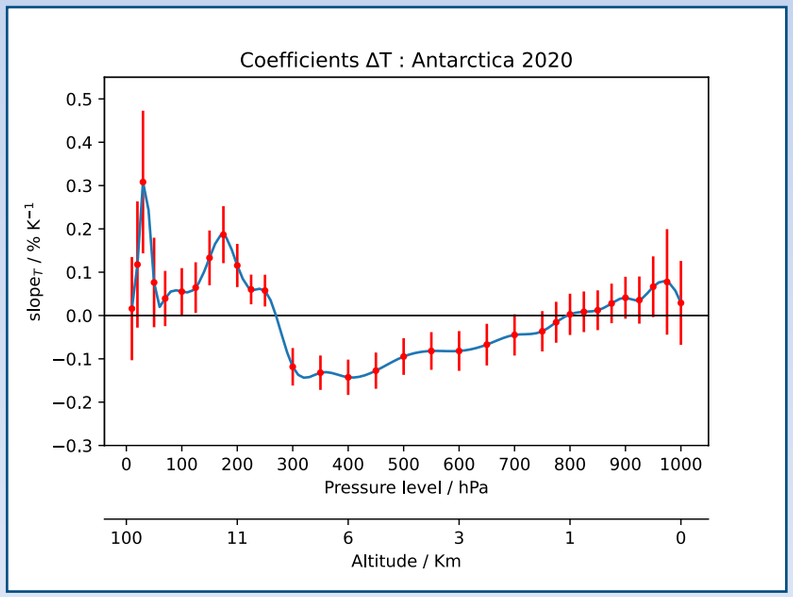
M1



M2



Mn

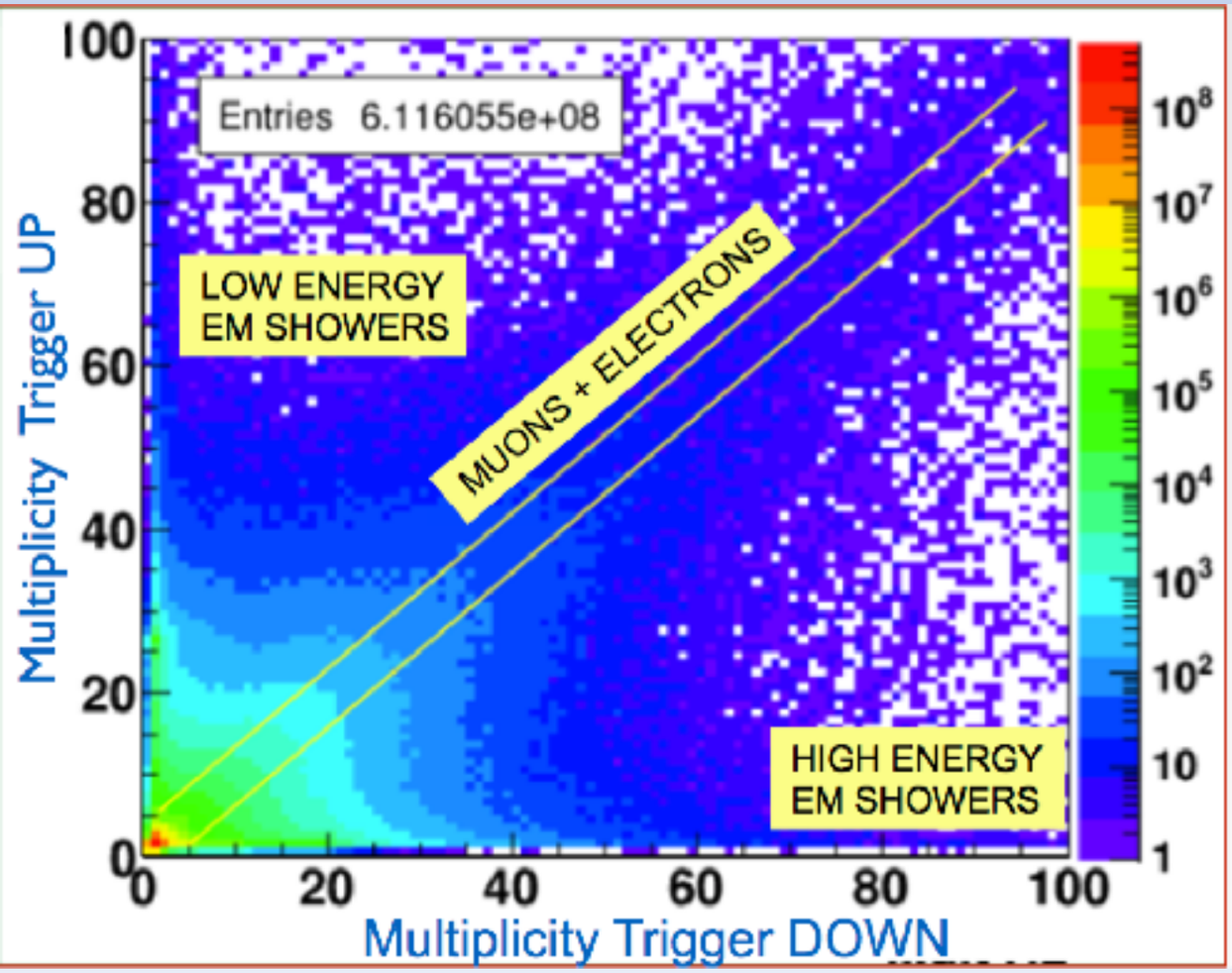


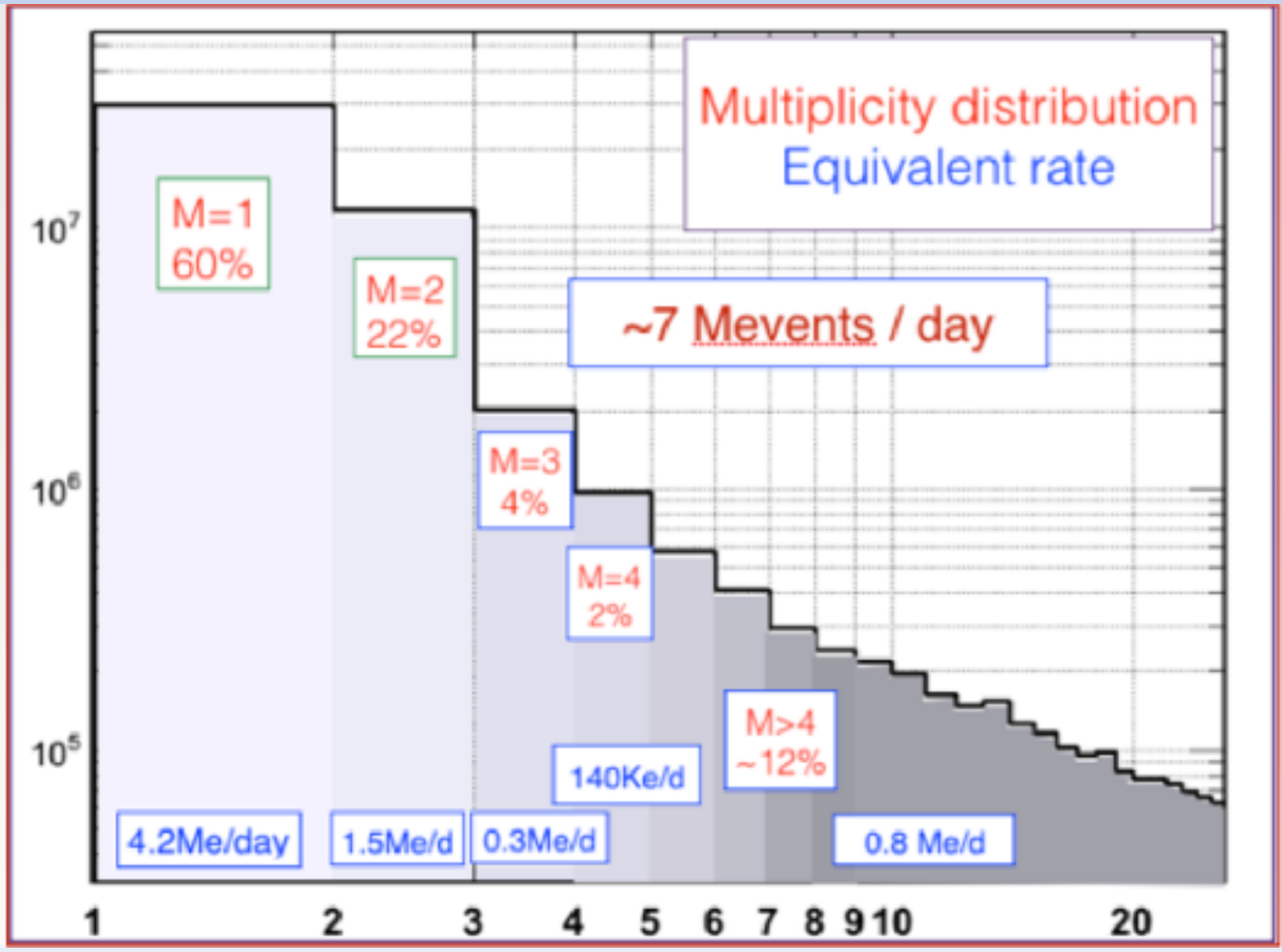
Different multiplicities keep memory of the atmosphere at different pressure levels

Cluster Analysis

Cluster Analysis

TRAGALDABAS: Trigger summary

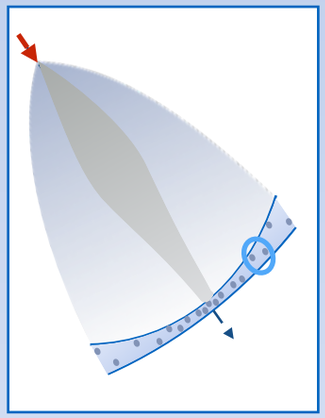


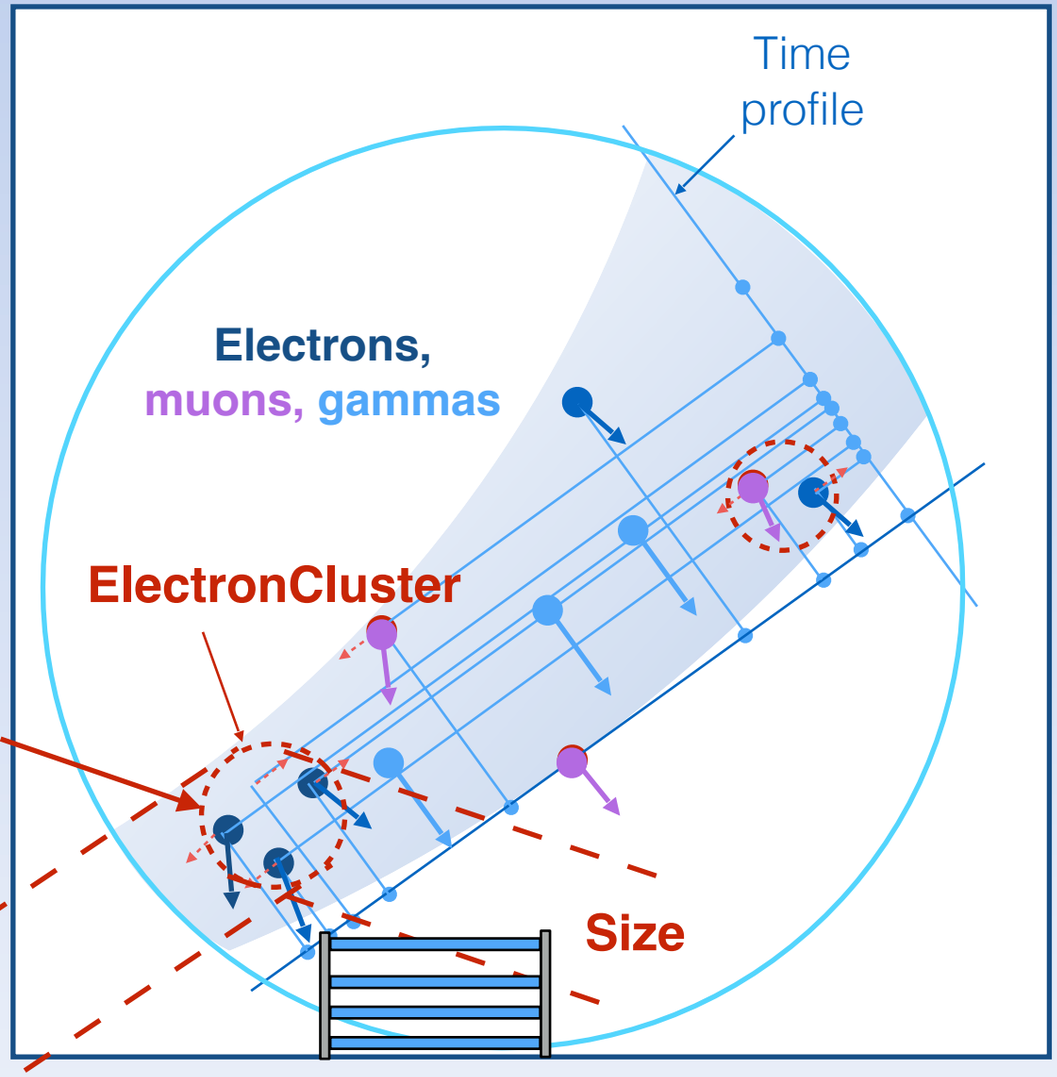


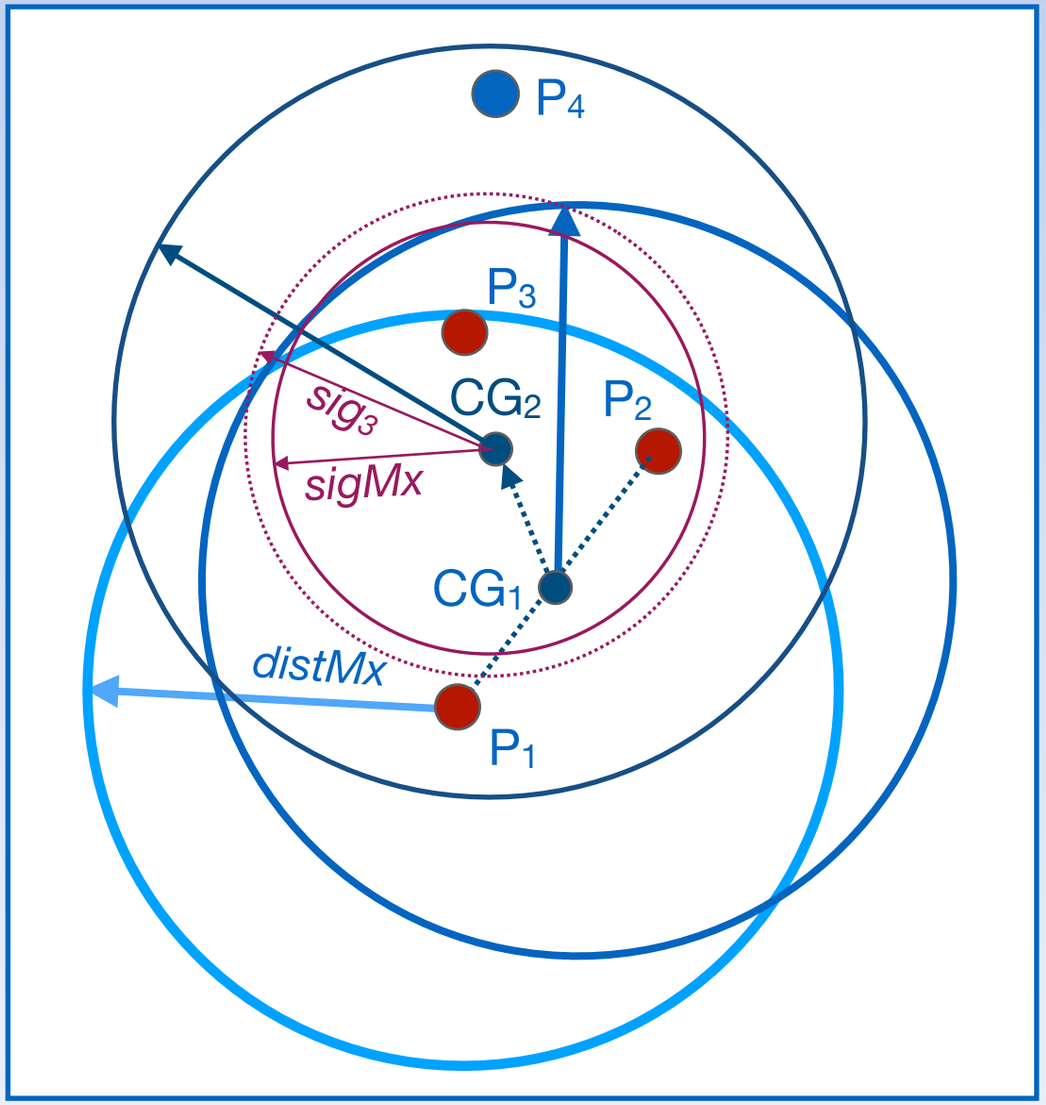
Trigger rate: ~ 70 Hz.
Event rate: ~ 7Mevents /day
Storage rate: ~ 0.7 Tb / year (1.9 Gb /day)
Mean duty time: > 90%

Cluster Analysis

Cluster search strategy







Clusters: Electron (> 1 electrons)
Muon (> 1 muons)
Mixed (1 muon + electrons)
1 Electron + Gammas (1 electron + gammas)
Gammas (only gammas)

*TRASGO for the Analysis of the Nuclear Matter Decay, the Atmosphere, the Earth B-field And the Solar activity

Cluster Analysis

The sample

Number of simulated events					
$LogE_0/n/GeV$	$E_0/n/GeV$	H	He	C	Fe
0.25	1.8	>	-	-	-
0.50	3.2	100K	-	-	-
0.75	5.6	100K	100K	-	-
1.0	10	100K	100K	-	-
1.25	18	100K	100K	100K	-
1.50	32	100K	100K	100K	-
1.75	56	100K	100K	100K	-
2.00	100	100K	75K	75K	75K
2.25	180	75K	75K	75K	75K
2.50	320	50K	50K	50K	50K
2.75	560	25K	25K	25K	25K
3.00	1000	40K	10K	10K	10K
3.25	1800	30K	10K	10K	10K
3.50	3200	25K	8K	8K	8K
3.75	5600	20K	6K	6K	6K
4.00	10000	15K	4K	4K	4K
4.25	32000	10K	6K	6K	6K
4.50	56000	6K	4K	4K	4K

Cluster Analysis

Output files

```
# Clusters Summary: DetMxD, DetMSg, PCRZhMin, PCRZhMx:  1.51388 1.51388 0       0.25     HMin, HMax:    0       32
#PrCR   LPCREn  HghPCR  IShow   IClust  CltIC   sClIC   NparCt  NGamC   NEleC   NMuCl   XmClst  YmClst  RmClst  RSigCl  TmClst
       sTClst  PICFtP  XFPClt  YFPClt  TFPClt  ZhFstP  AzFstP  PmFstP  PICLtP  XLPClt  YLPClt  TLPClt  ZhLstP  AzLstP  PmLstP
       ECldt   ECltEn  ECltTh  ClAng/º
#-------------------------------------------------------------------------------------------------------------------
--------------------------------
56     2.923   31.96   906     1       1001    0       2       1       1       0       251     -1876   1893    1.492   2920
       2.625   1000    251.3   -1875   2920    0.7267  -2.542  0.06358 1       250.7   -1877   2923    0.7147  -2.536  0.1813
       0       0.06358 0       0.716
56
```

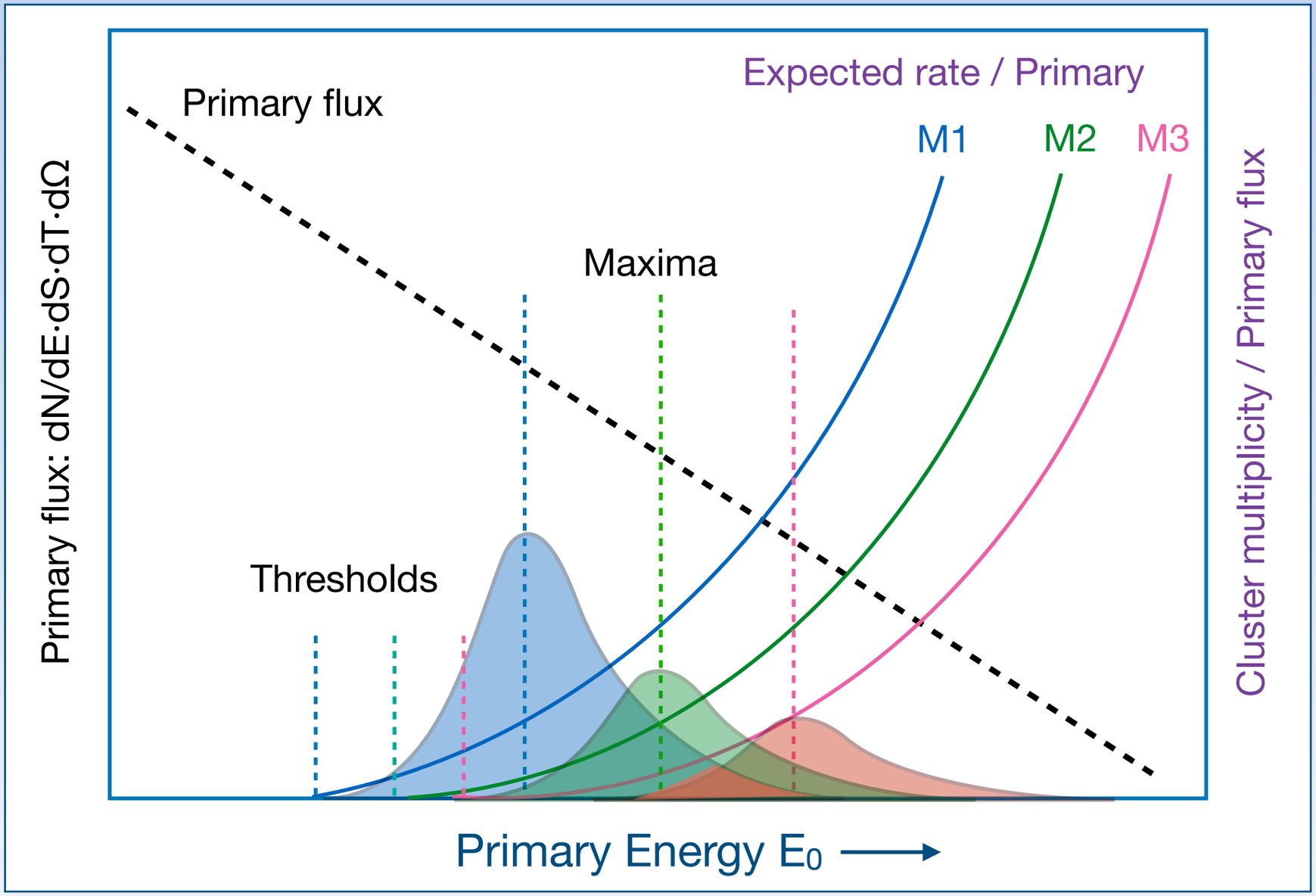
```
# Showers Summary: DetMxD, DetMSg, PCRZhMin, PCRZhMx:  1.51388 1.51388 0       0.25     HMin, HMax:    0       32
#PrimCR LPCREn  HghPCR  FlinSh  IShow   ClICS   NSecP   NClst   NGamS   NEleS   ElMnR   NMuS    MuMnR   NNeutS  NProtS  NOthrS
        MElEnS  MMuEnS  NClEl   NClMu   NClMx   NClOt   NEClM1  NEClM2  NEClM3  NEClM4  NEClM5  NEClM6  NEClE0  NECE01  NECE02
        NECE03  NECE06  NCE1.2  NCldT0  NCdT04  NCdT08  NCldT2  NCdT10  NCdT20  NECTh0  NECTh5  NECT10  NECT15  NECT20  NECT30
        NECSz1  NECSz2  NECSz3  NECSz4  NECSz5  NECSz6  NEClR1  NEClR2  NEClR3  NEClR4  NEClR5  NEClR6  NEltR1  NEltR2  NEltR3
        NEltR4  NEltR5  NEltR6  NMuEn0  NMuEn2  NMuEn3  NMuEn4  NMuEn8  NMuE16  NMuR1   NMuR2   NMuR3   NMuR4   NMuR5   NMuR6
        ElMER1  ElMER2  ElMER3  ElMER4  ElMER5  ElMER6  ElMTR1  ElMTR2  ElMTR3  ElMTR4  ElMTR5  ElMTR6  MuMER1  MuMER2  MuMER3
        MuMER4  MuMER5  MuMER6  MuMTR1  MuMTR2  MuMTR3  MuMTR4  MuMTR5  MuMTR6  EMdTR1  EMdTR2  EMdTR3  EMdTR4  EMdTR5  EMdTR6
        EMERR1  EMERR2  EMERR3  EMERR4  EMERR5  EMERR6
```

```
# Particles Summary: DetMxD, DetMSg, PCRZhMin, PCRZhMx:  1.51388 1.51388 0       0.25     HMin, HMax:    0       32
#PrimCR LPCREn  MnHPCR  FlxInt  NShAna  NtSePs  NtClts  NtGam   NtEle   NtMu    NNeut   NProt   NOthr   MElEne  MMuEne  NClEl
        NClMu   NClMx   NElR1   NElR2   NElR3   NElR4   NElR5   NElR6   NEClM1  NEClM2  NEClM3  NEClM4  NECl56  NEClMM  NEClE0
        NECE01  NECE02  NECE05  NEClE1  NEClE2  NCldT0  NCdT04  NCdT08  NCldT2  NCdT10  NCdT20  NECTh0  NECTh5  NECT10  NECT15
        NECT20  NECT30  NECSz1  NECSz2  NECSz3  NECSz4  NECSz5  NECSz6  NEClR1  NEClR2  NEClR3  NEClR4  NEClR5  NEClR6  NMuEn0
        NMuEn1  NMu
        ElMER5  ElM
        MuMTR2  MuM
        EMERR5  EME
#-------------------
-------------------
56      2.979   31.
        0       0
        6       4
        0       0
        77      28
        0.189   0.1
        2.44    1.7
        -1.52   -2.
56      1.49    31.
        0       0
        8       2
        0       0
        78      27      1       0       0       1       3       23      59      158     25      0       0.187   0.104   0.201
        0.19    0.299   0       1.37e+03        716     772     1.63e+03        4.38e+03        4.18    1.36    2.64    2.18
```

```
# Radial Summary: DetMxD, DetMSg, PCRZhMin, PCRZhMx:  1.51388 1.51388 0       0.25     HMin, HMax:    0       32
#PrimCR LEnPCR  MnHPCR  FlxInt  NShAna  NtSePs  NtClts  ElMER1  ElMER2  ElMER3  ElMER4  ElMER5  ElMER6  ElMTR1  ElMTR2
        ElMTR3  ElMTR4  ElMTR5  ElMTR6  MuMER1  MuMER2  MuMER3  MuMER4  MuMER5  MuMER6  MuMTR1  MuMTR2  MuMTR3  MuMTR4
        MuMTR5  MuMTR6  NCElR1  NCElR2  NCElR3  NCElR4  NCElR5  NCElR6  NCMuR1  NCMuR2  NCMuR3  NCMuR4  NCMuR5  NCMuR6
        NCMxR1  NCMxR2  NCMxR3  NCMxR4  NCMxR5  NCMxR6
#-------------------------------------------------------------------------------------------------------------------
----------------------------------------
56      2.979   31.17   5.3e-06 30      422     4       0.19117 0       0.14626 0.18262 0.1891  0.12764 860.42  0
        1737    3752.9  2440    3960.8  4.1972  1.5214  2.2536  2.4433  1.7647  1.4191  2847.9  2421.3  2255.9  1994.2
        2389.9  3298.8  0       0       0       1       1       0       0       0       0       0       0       0
        0       0       0       0       0       0
56      1.49    31.05   5e-06   28      381     5       0       0.18701 0.10376 0.20088 0.19007 0.29877 0       1373.3
        715.71  771.91  1630    4375.3  4.1814  1.3563  2.6387  2.1836  1.8765  1.3742  388.5   1770.3  1083.6  1628.7
        1722.4  3696.6  0       0       0       0       2       0       0       0       0       0       0       0
        0       0       0       0       0       0
56      2.979   37.54   0.00039 2183    29749   276     0.2182  0.23927 0.23267 0.2092  0.20477 0.19481 2111.8  1627.2
        1801.4  1750.2  2183.4  4696.7  3.5084  2.4753  2.4672  2.3035  1.8162  1.3671  1486    1674.1  1696.3  1745.3
```

Cluster Analysis

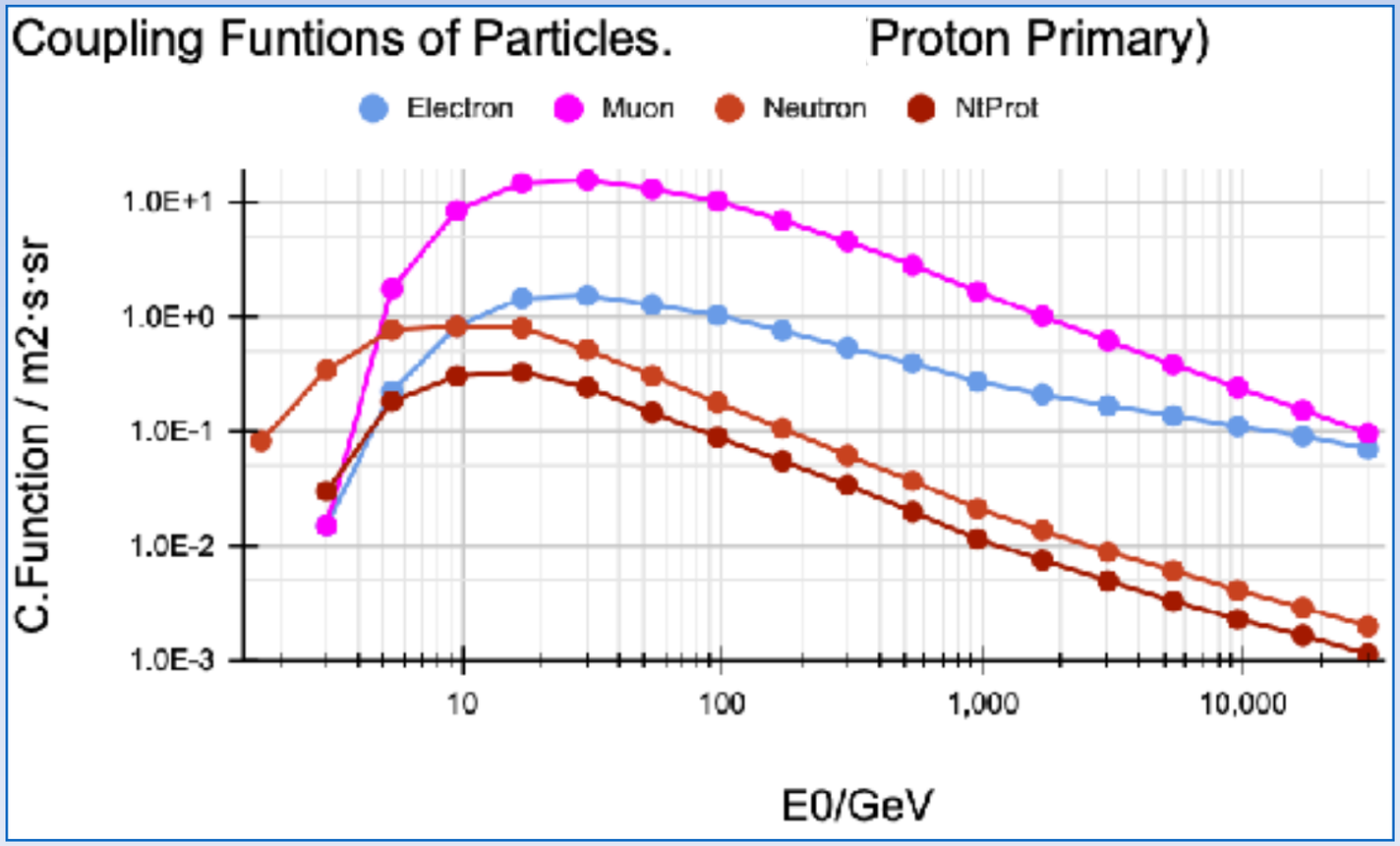
The Coupling Function



The coupling function provides de probability that a given bundle of particles is produced by a primary of a certain mass or energy

Cluster Analysis

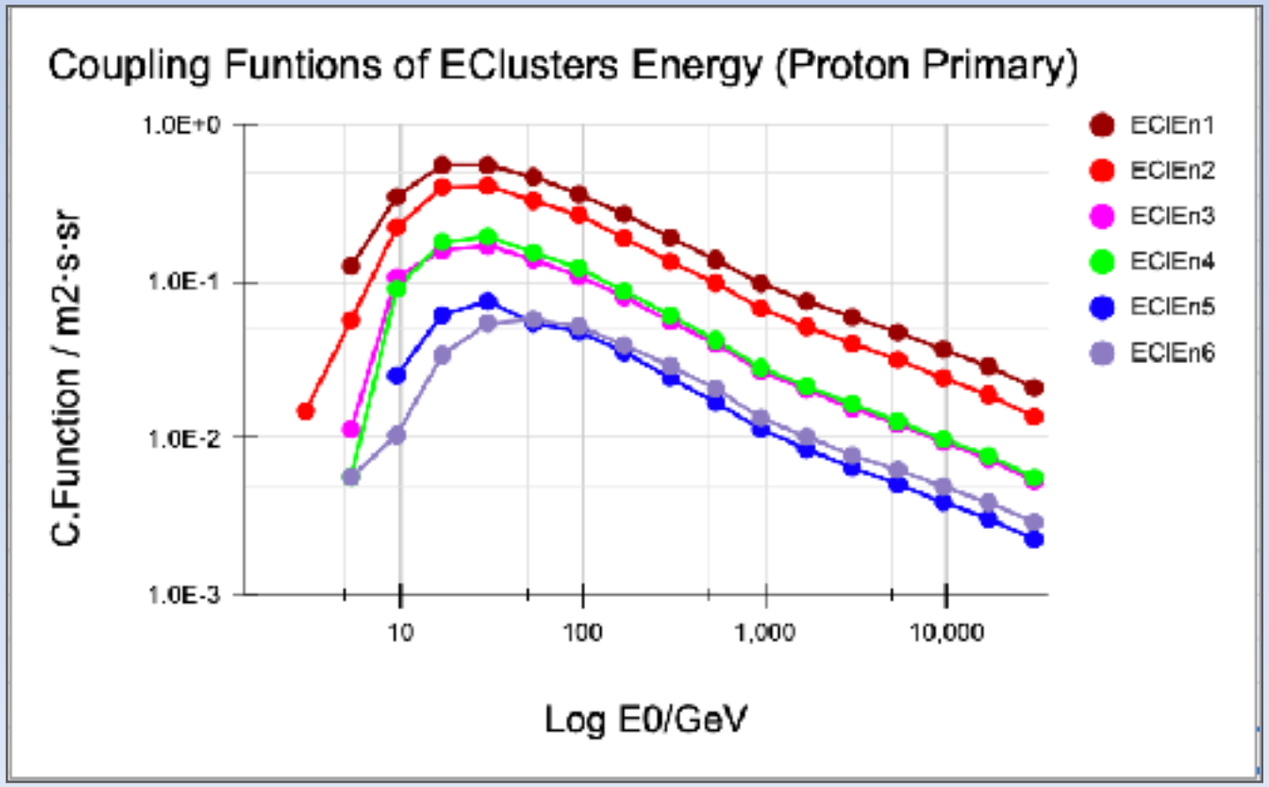
Coupling functions of different particles (S~1.8 m²)



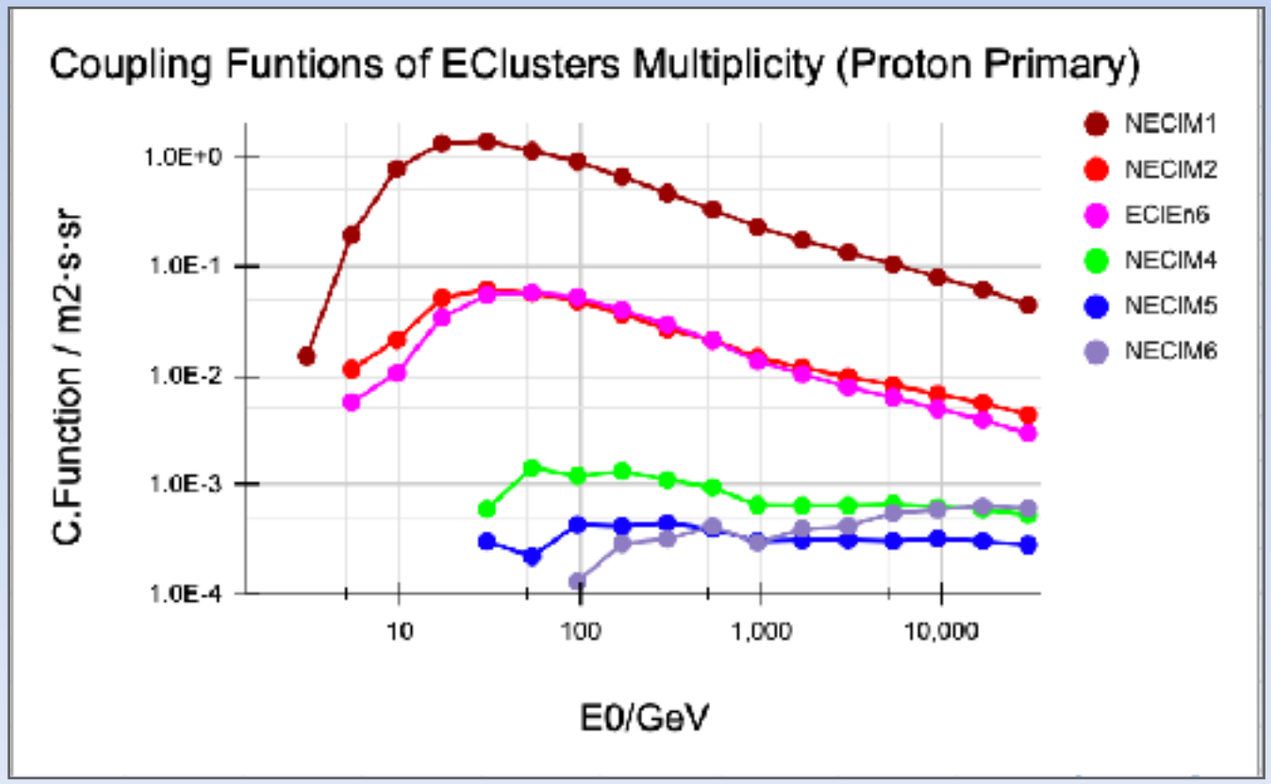
Coupling functions					
Particle	**Rate / m²·s·sr**	**Threshold / GeV**	**Maximum / GeV**	**10% Max / GeV**	**90% Max/ GeV**
Neutron	4	~ 2	9	2	160
Muon	80	~ 4	30	5	1000
Electron	9	~ 5	30	5	6000

Cluster Analysis

Coupling functions of electron clusters



Cluster energy

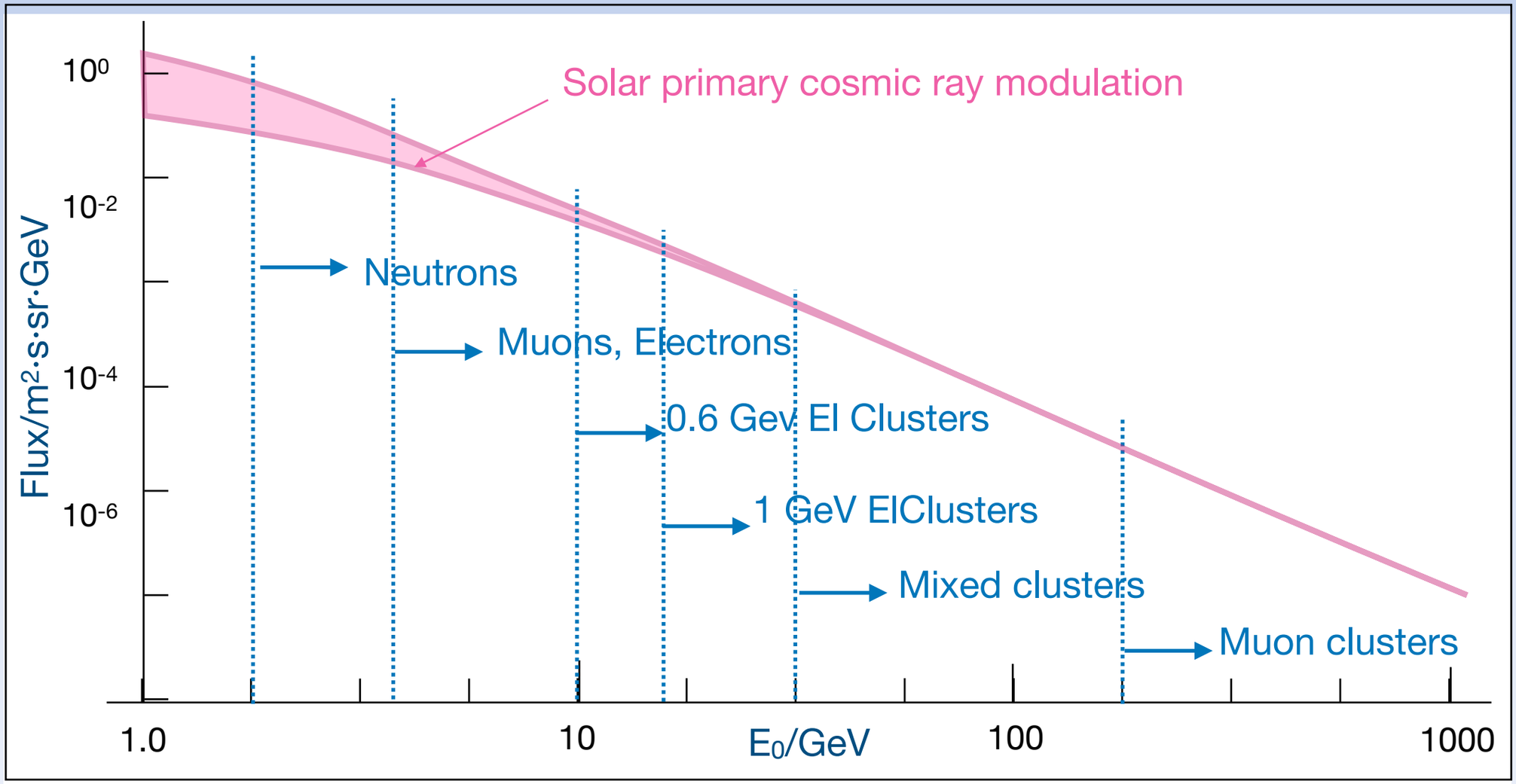


Cluster multiplicity

Electron Clusters Coupling functions		
Cluster E_Threshold / GeV	**Primary E_Threshold / GeV**	**Primary E_Max / GeV**
0.1	~ 5	20
0.6	~ 10	30
1	~ 15	40

Cluster Analysis

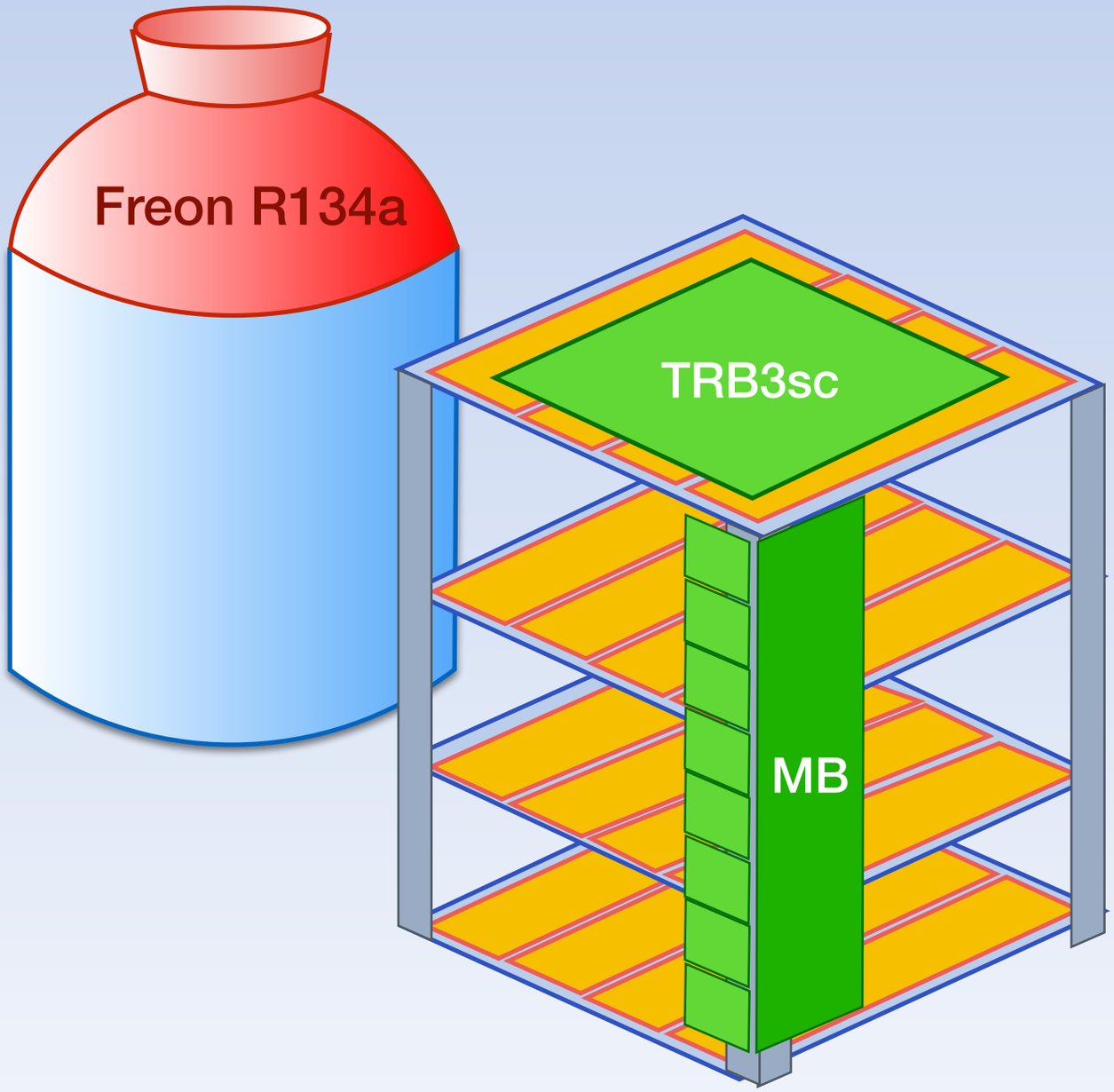
Summary

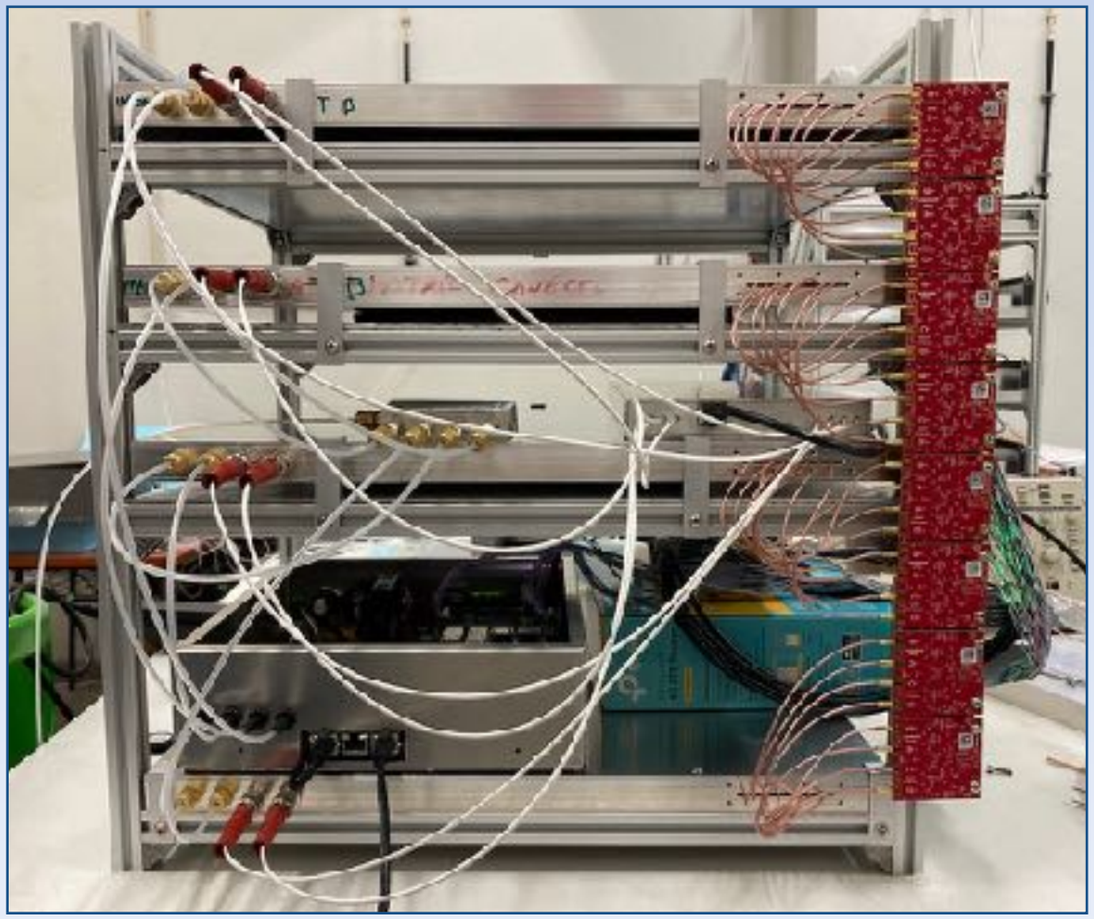


Threshold energies for different particles and clusters (S~1.8 m²)

Next future…miniTrasgos

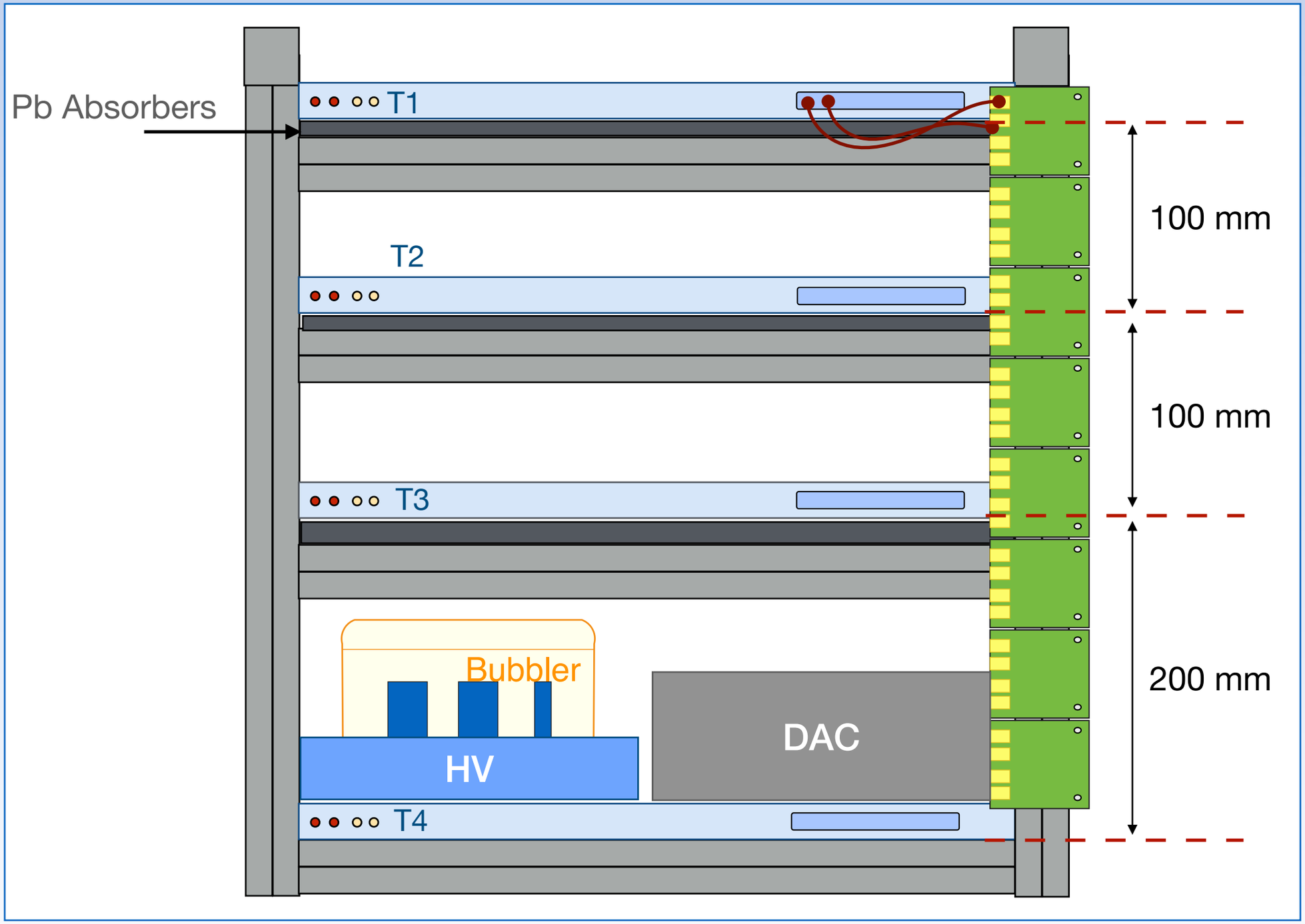
miniTrasgos





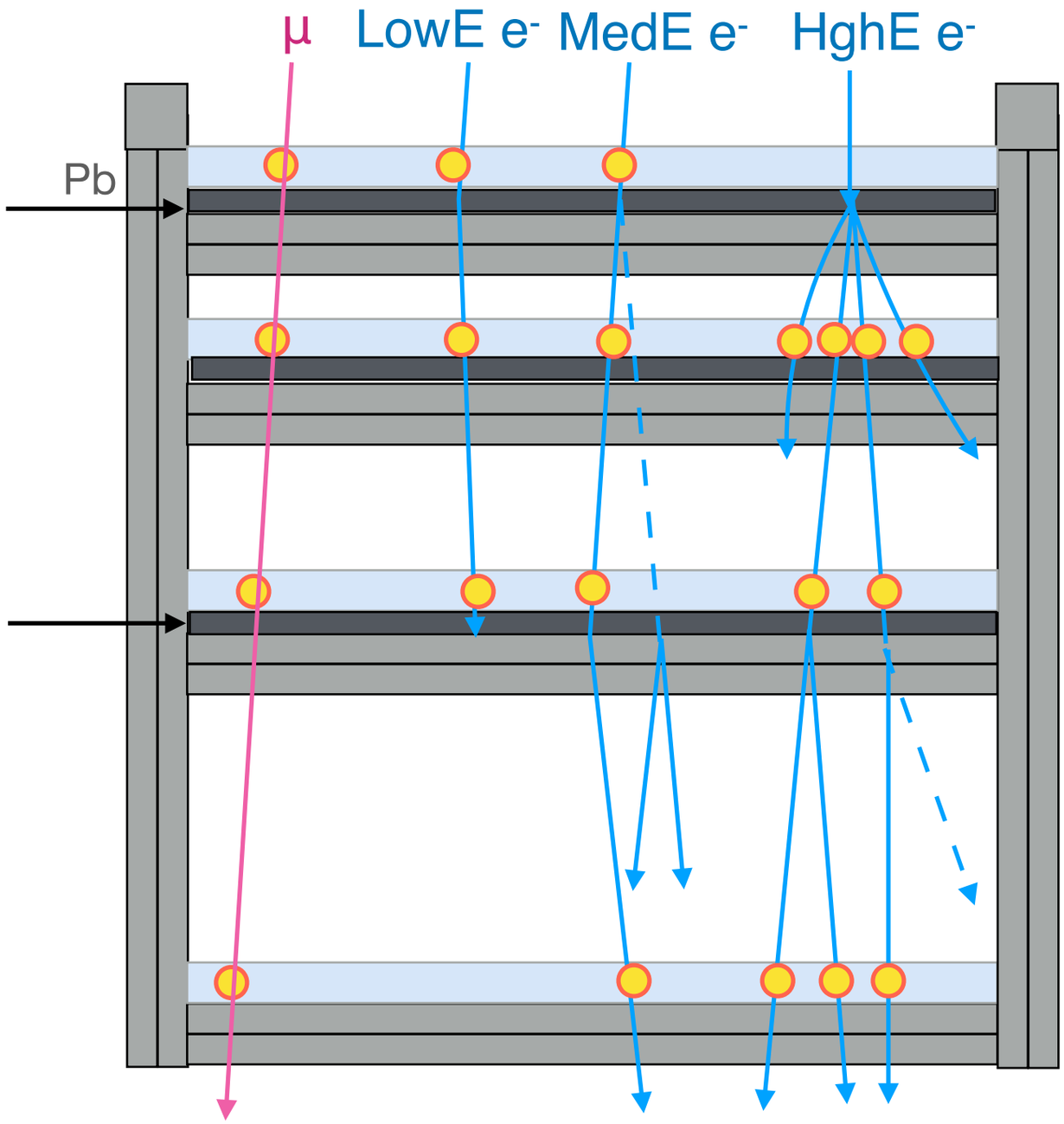
miniTrasgos

Approximate layout



miniTrasgos

PID capability and Electron pre-Calorimetry



miniTrasgos

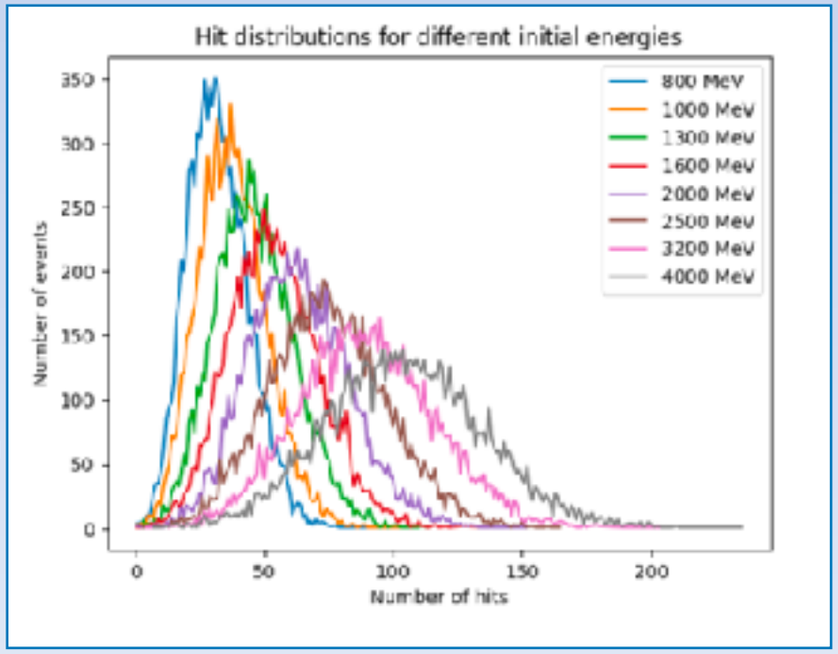
PID capability and Electron pre-Calorimetry

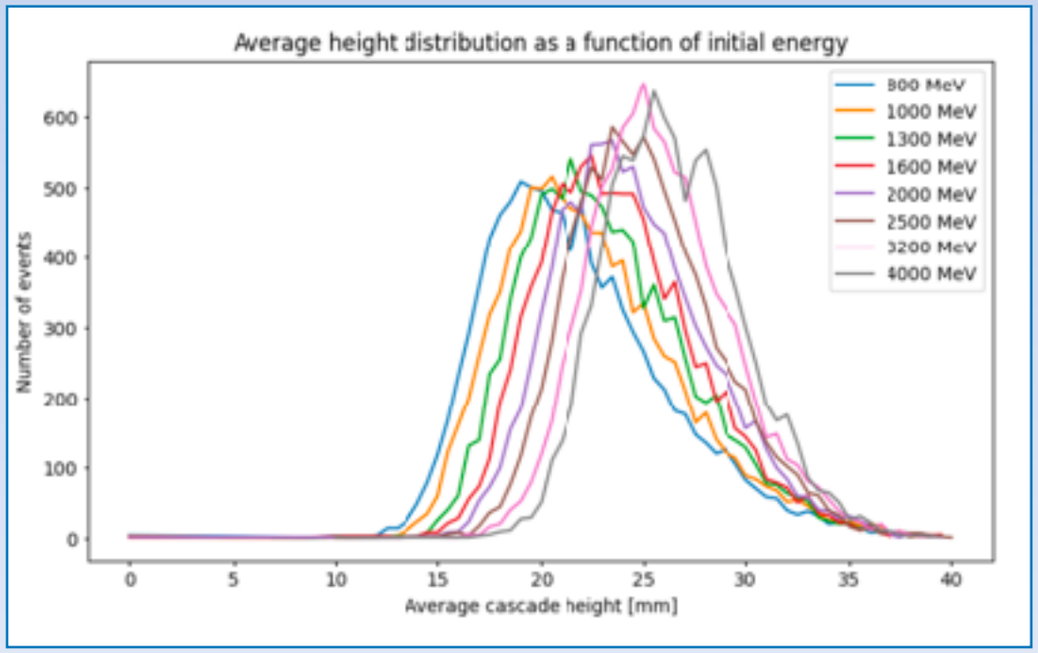
New simulations with Pb (Jose L. Rodríguez & Alfonso Sánchez)

Conf1

Pb 16.2 mm

Pb 10.4 mm

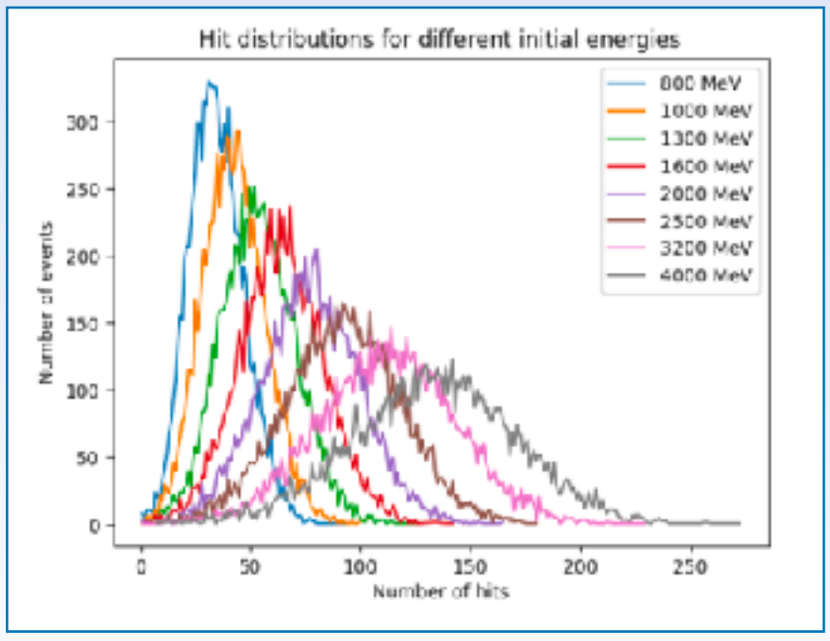


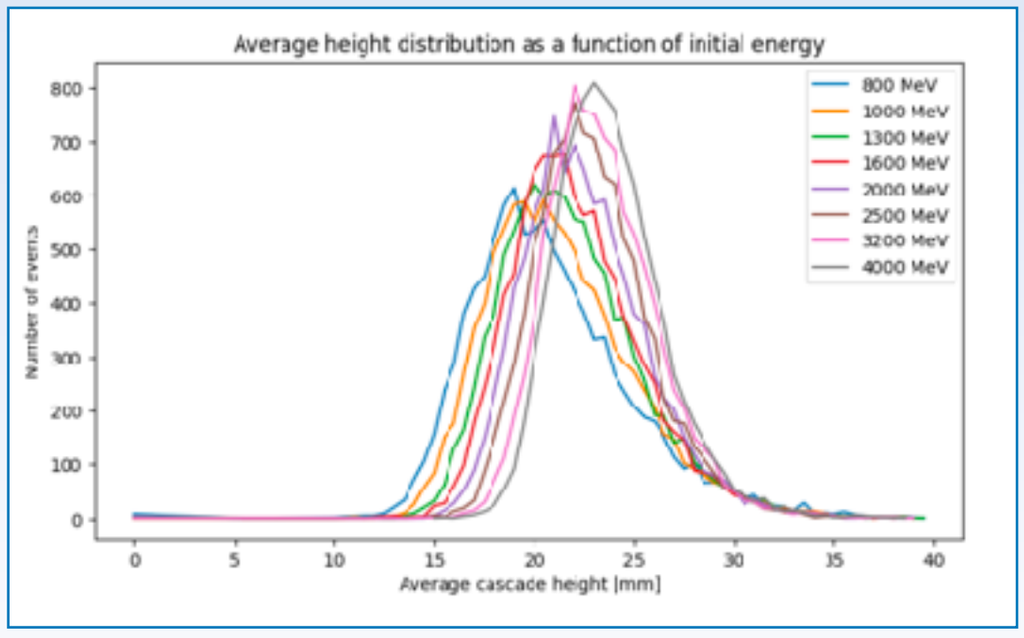


Conf2

Pb 10.4 mm

Pb 16.2 mm





Hit N.

Mean depth / mm

miniTrasgo. Expected count rates

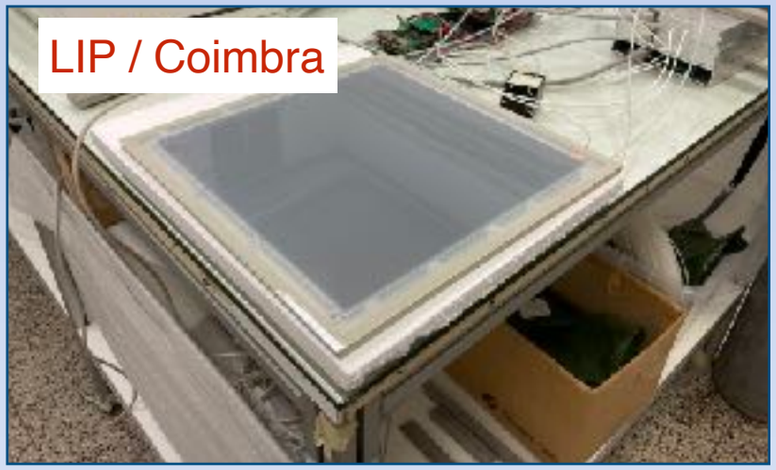
(Expected rate of a 0.1 m^2 detector: 5 particles/s)

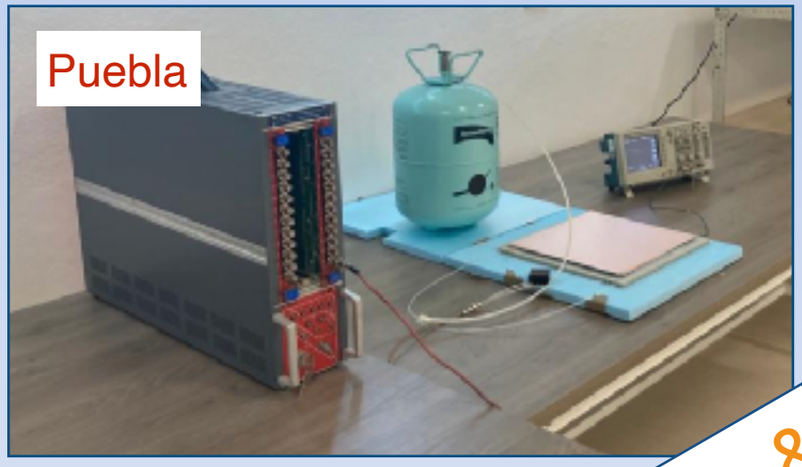
Expected resolutions for effects of different intensity: 100/sqrt(N)										
Time interval	Total rate		Effect: 5%		Effect: 2%		Effect: 1%		Effect: 0.5%	
	Count N.	100/ sqrt(N)	Count N.	100/ sqrt(N)	Count N.	100/ sqrt(N)	Count N.	100/ sqrt(N)	Count N.	100/ sqrt(N)
10 min	**3000**	2	**150**	8	**60**	13	**30**	18	**-**	**-**
1 h **1/24 Accep.**	**18000**	0.7	**900**	3.3	**360**	5	**180**	7.5	**90**	11
1 día	**430 000**	0.2	**2200**	0.7	**8600**	1	**4300**	1.5	**1200**	3

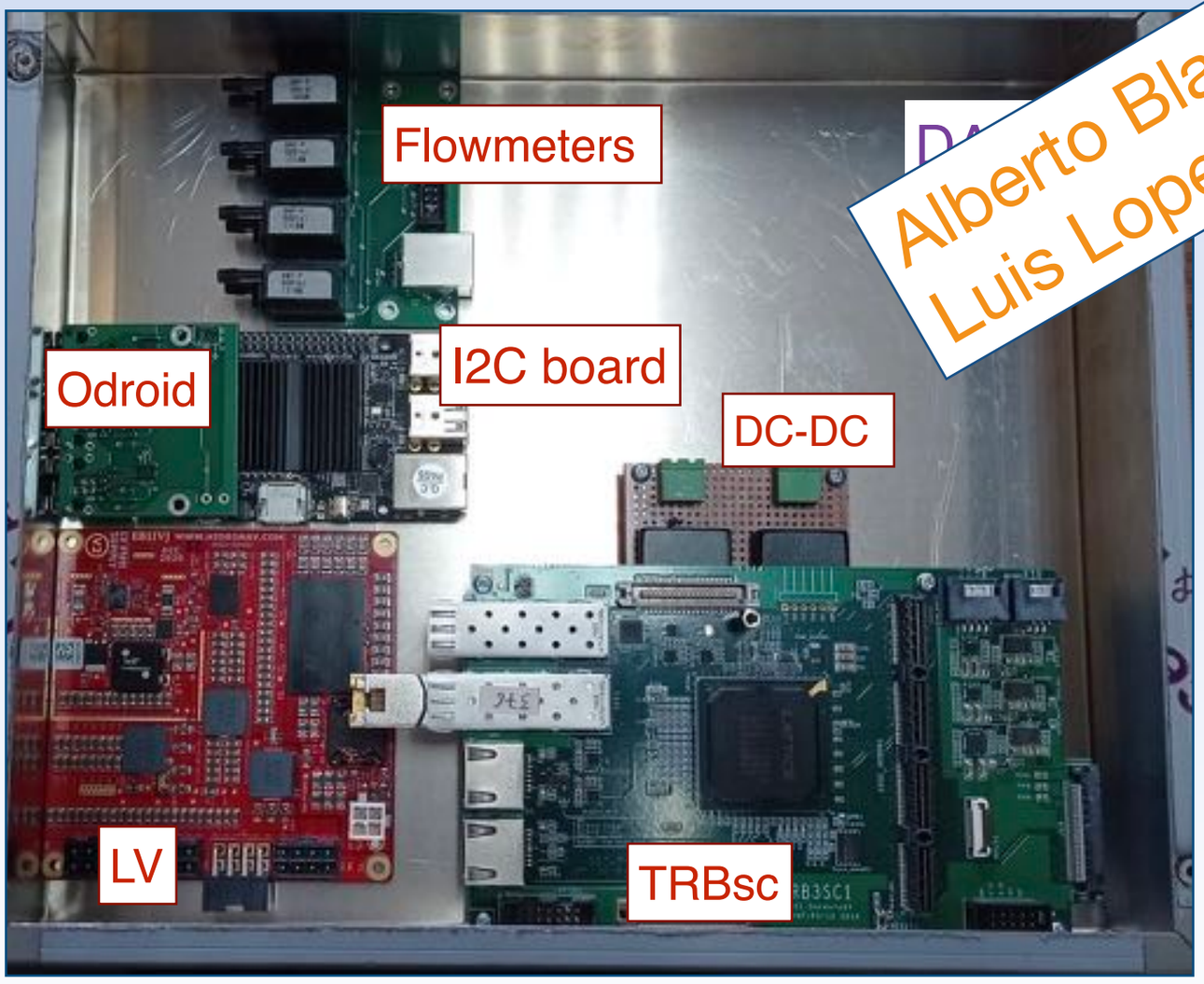
Summary: sensitive with a resolution better than 1% to hourly changes in the total rate or for daily effects higher than 2%.

miniTrasgos

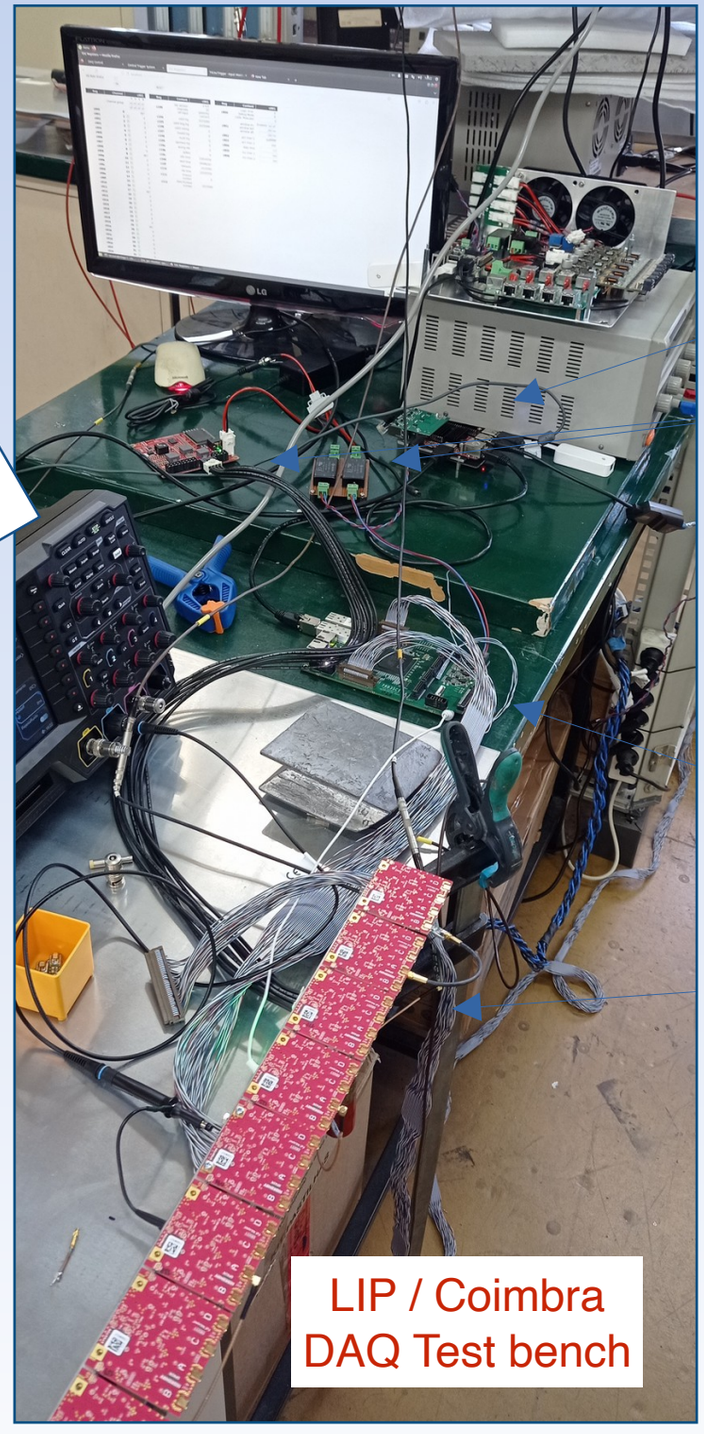
Status report



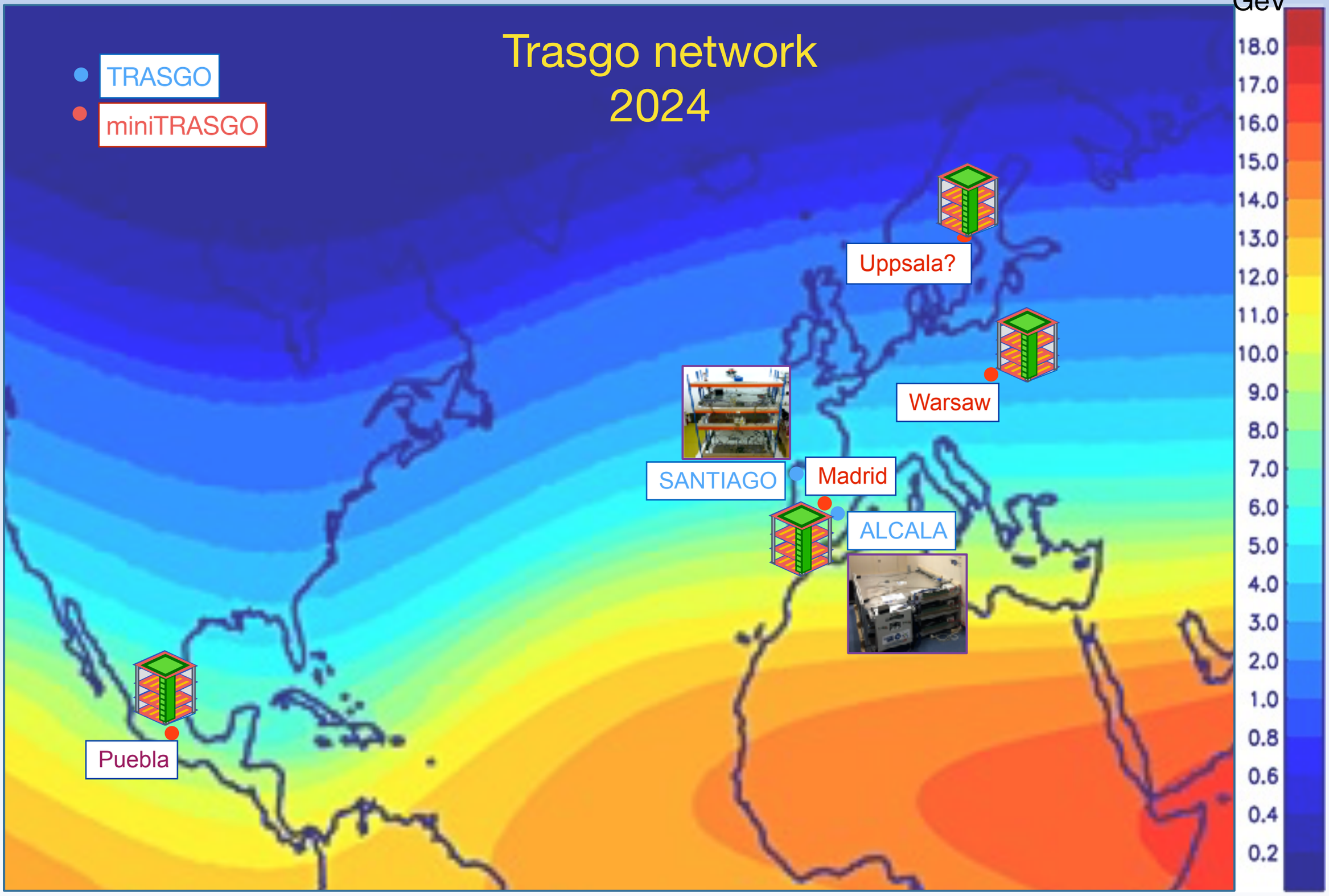


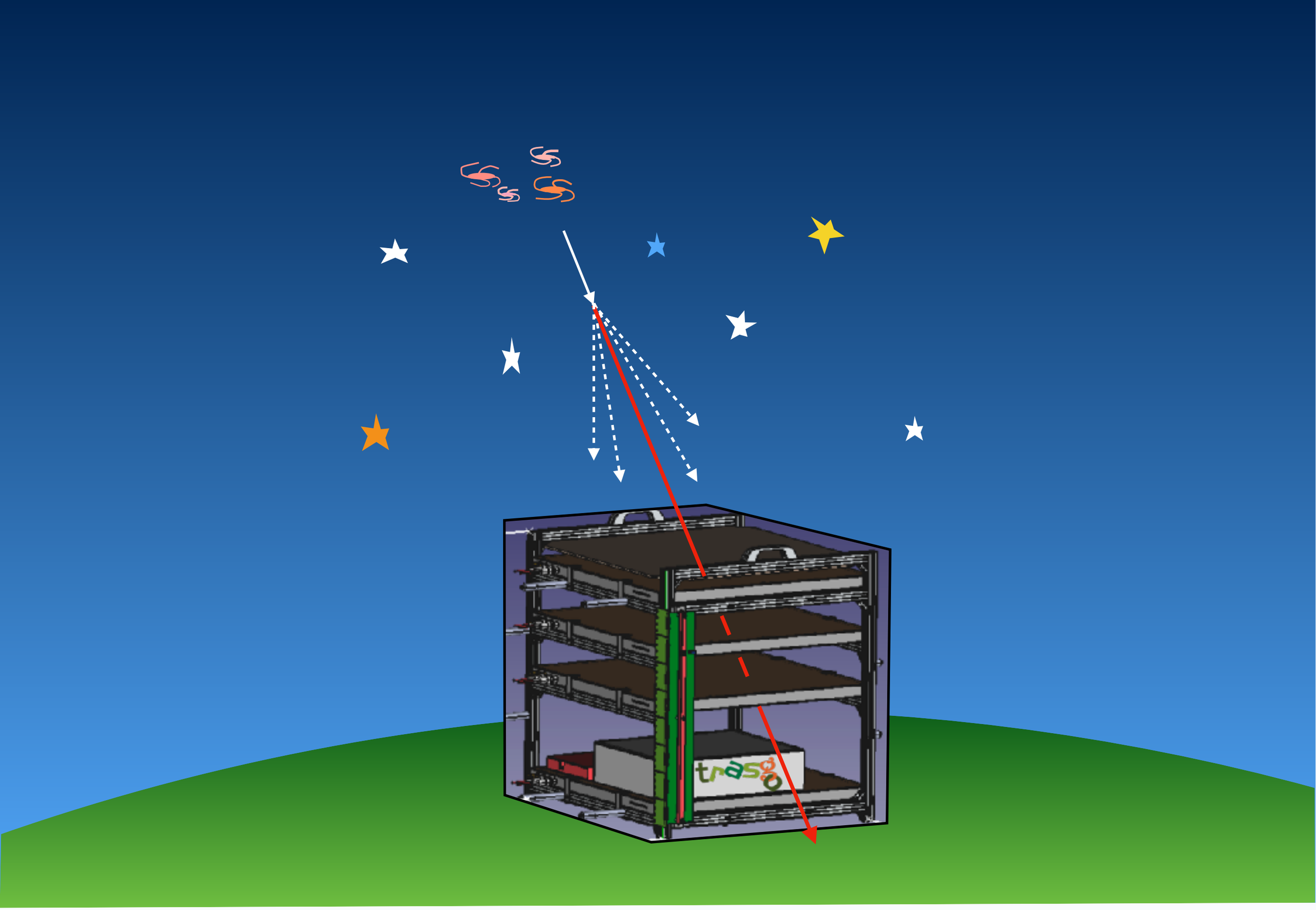


Alberto Blanco & Luis Lopes talk



miniTrasgos




trasgo

Thanks :)