New Physics with Trasgos

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THE COSMIC RAYS

GCR

Galactic

Solar

SEP

THE COSMIC RAYS

Primary and Secondary Cosmic Rays

Primary Cosmic rays

E ~1 erg:
1 / (m². year)

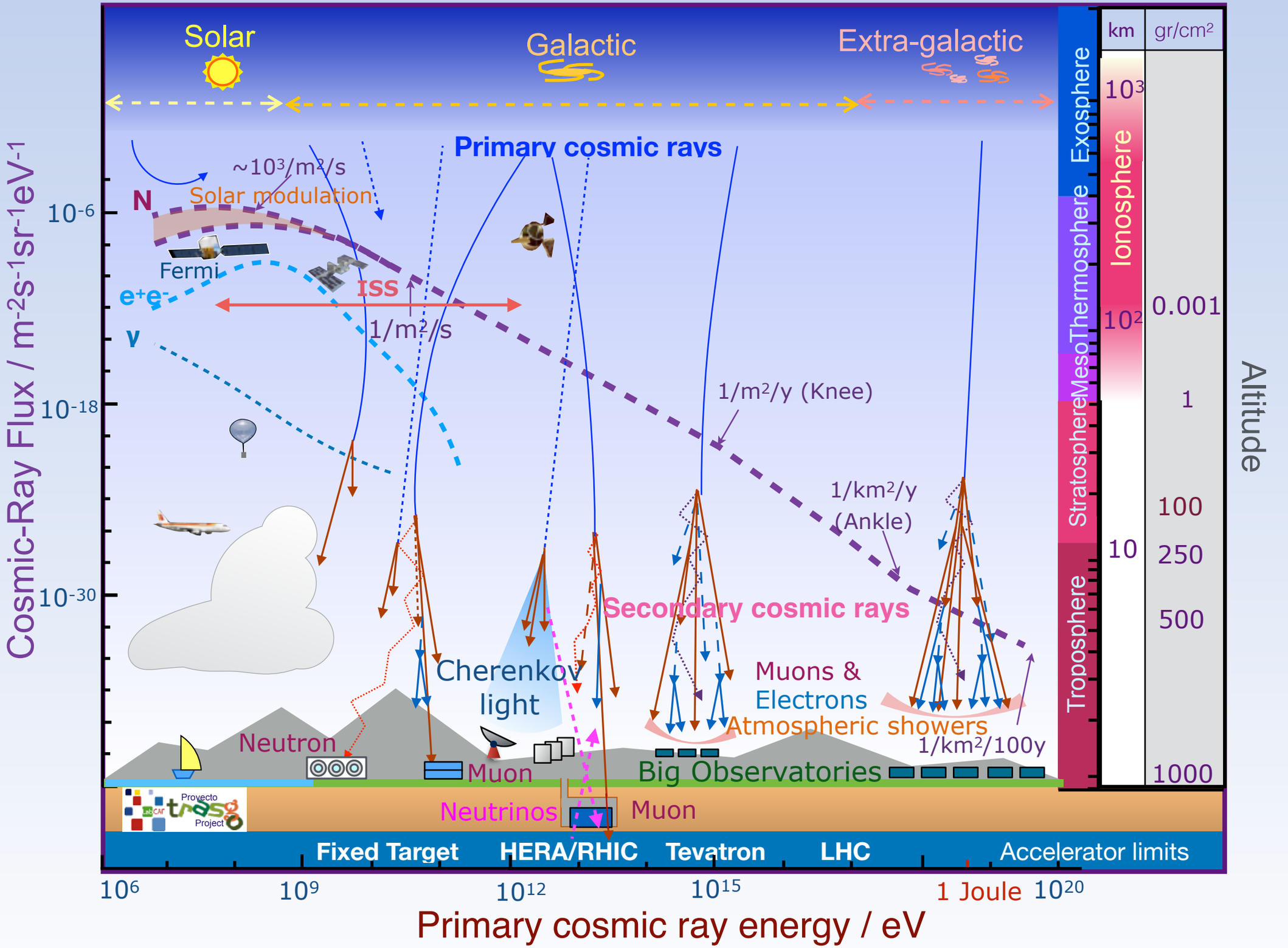
Secondary Cosmic rays

E ~1 Joule
1 / (km². century)

Primary cosmic ray survey

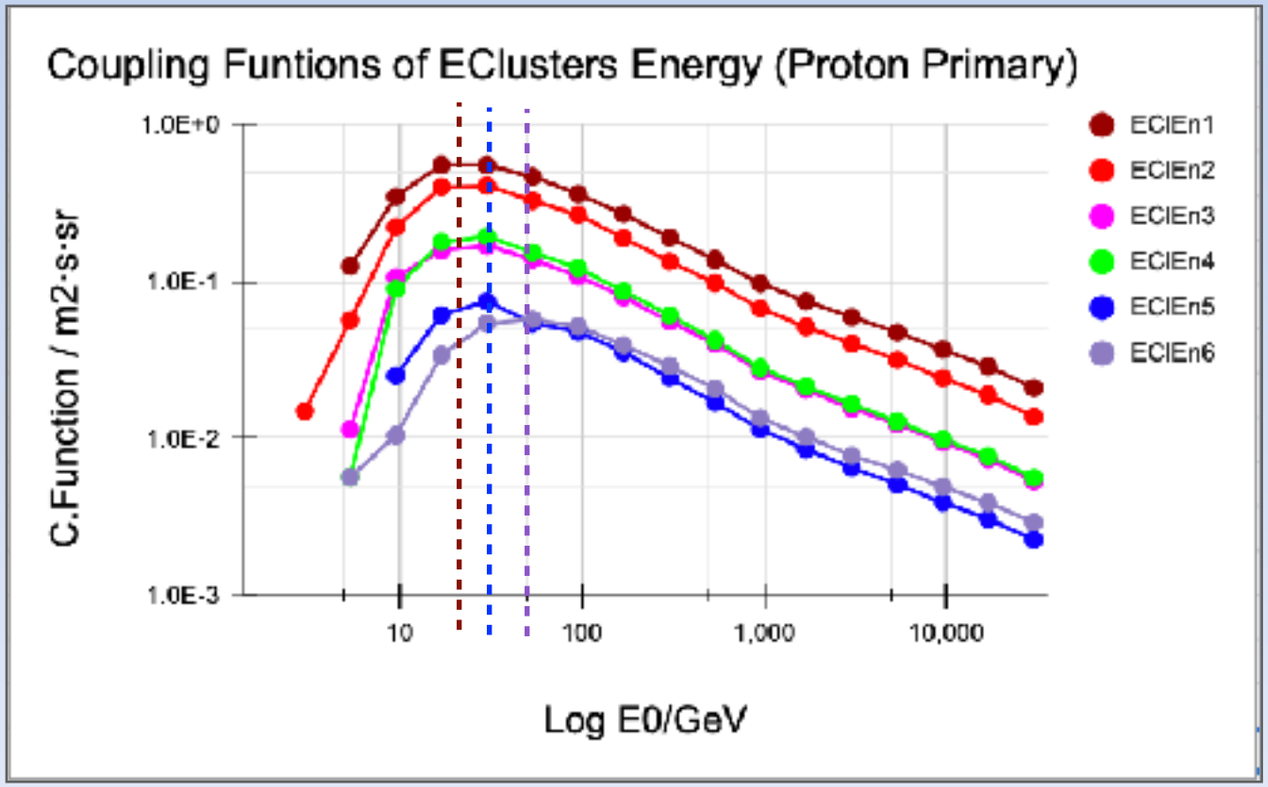
THE COSMIC RAYS

The primary cosmic ray energy spectrum

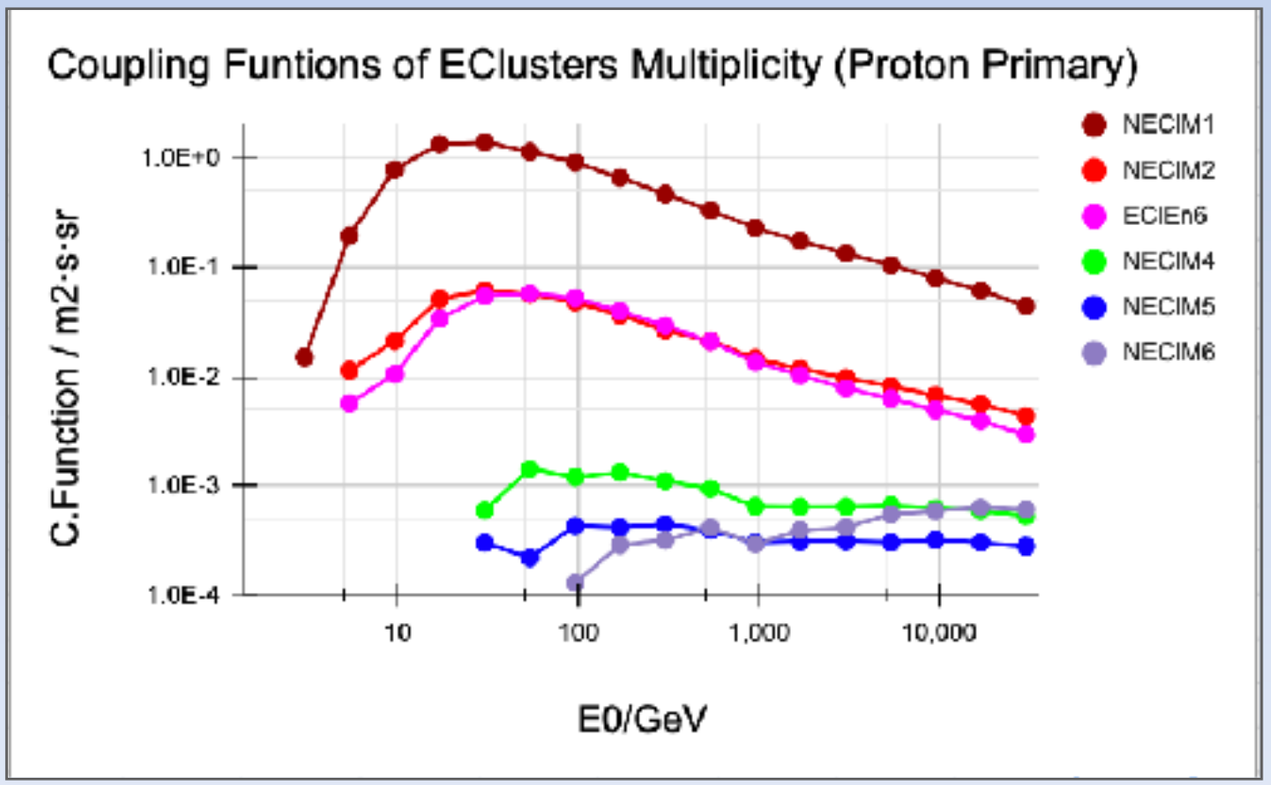


Cluster Analysis

Coupling functions of electron clusters



Cluster energy

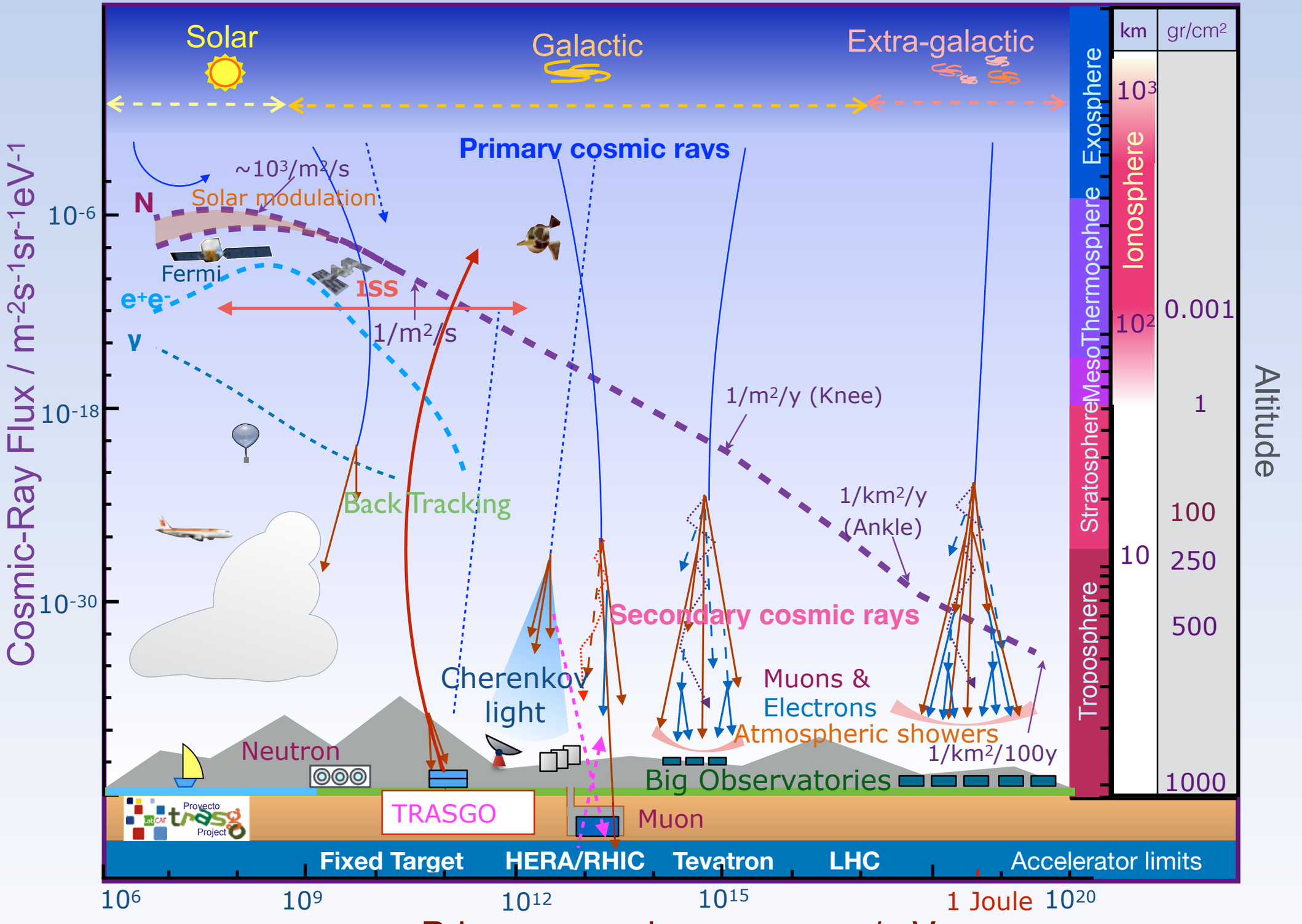


Cluster multiplicity

Electron clusters are sensitive to the energy of the primary cosmic ray

THE COSMIC RAYS

The primary cosmic ray energy spectrum



ISS orbit

MonteCarlo Improvement

MonteCarlo Improvement

KARLSRUHER INSTITUT FÜR TECHNOLOGIE (KIT)

Extensive Air Shower Simulation with CORSIKA: A User's Guide (Version 7.7420 from May 20, 2022)

D. Heck and T. Pierog

Institut für Astroteilchenphysik

AIRES

A system for air shower simulations

User's guide and reference manual

Version 19.04.08

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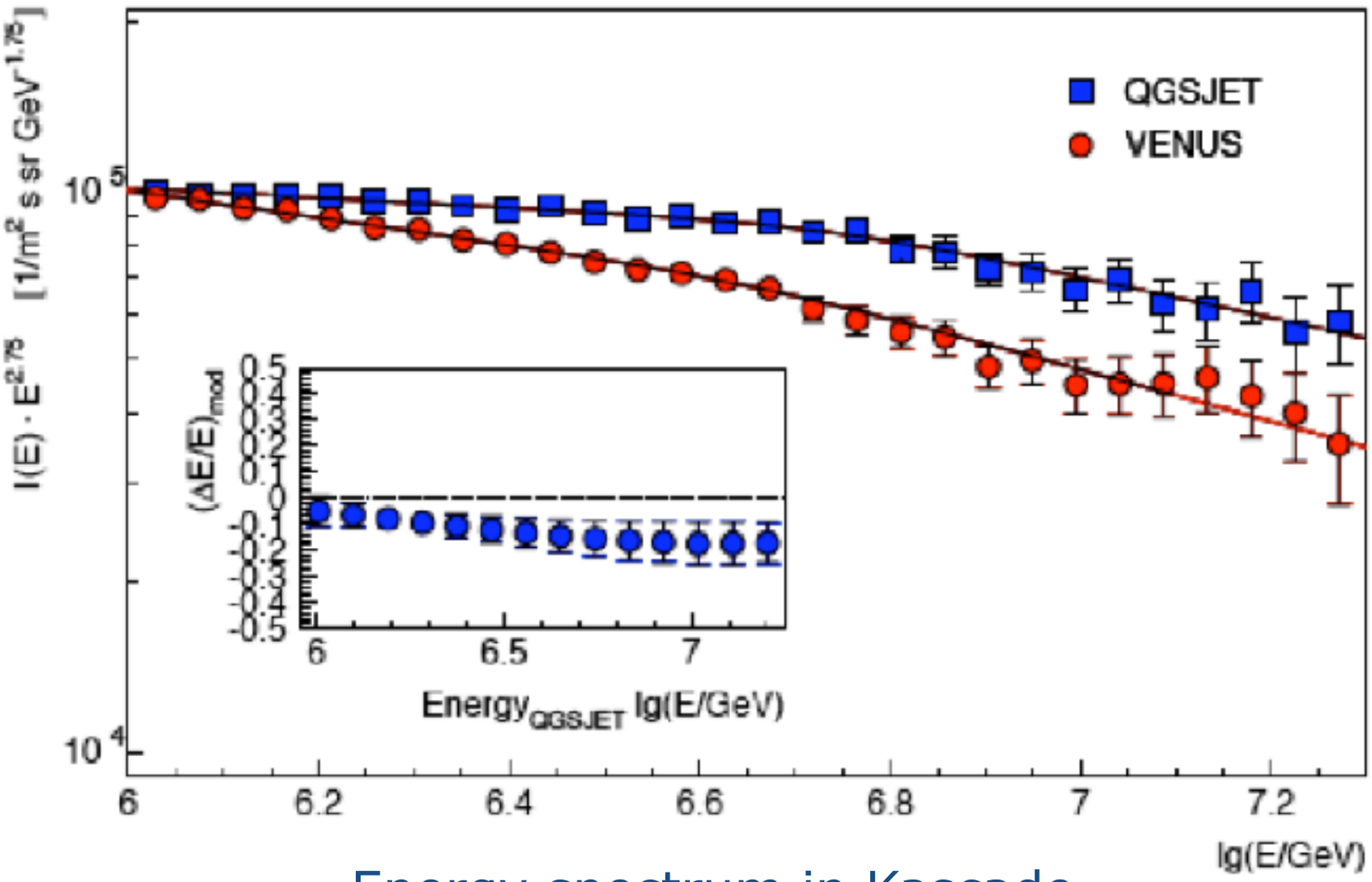
October 22, 2021

MonteCarlo Improvement

```
-------------------------------------------------------------------------------
 Which high energy hadronic interaction model do you want to use ?
    1 - DPMJET-III (2017.1) with PHOJET 1.20.0
    2 - EPOS LHC
    3 - NEXUS 3.97
    4 - QGSJET 01C (enlarged commons) [CACHED]
    5 - QGSJETII-04
    6 - SIBYLL 2.3d
    7 - VENUS 4.12

    r - restart (reset all options to cached values)
    x - exit make

    (only one choice possible):
    SELECTED          : QGSJET01


-------------------------------------------------------------------------------
 Which low energy hadronic interaction model do you want to use ?
    1 - GHEISHA 2002d (double precision)
    2 - FLUKA-CERN
    3 - FLUKA-INFN
    4 - URQMD 1.3cr [CACHED]

    r - restart (reset all options to cached values)
    x - exit make
```

MonteCarlo Improvement

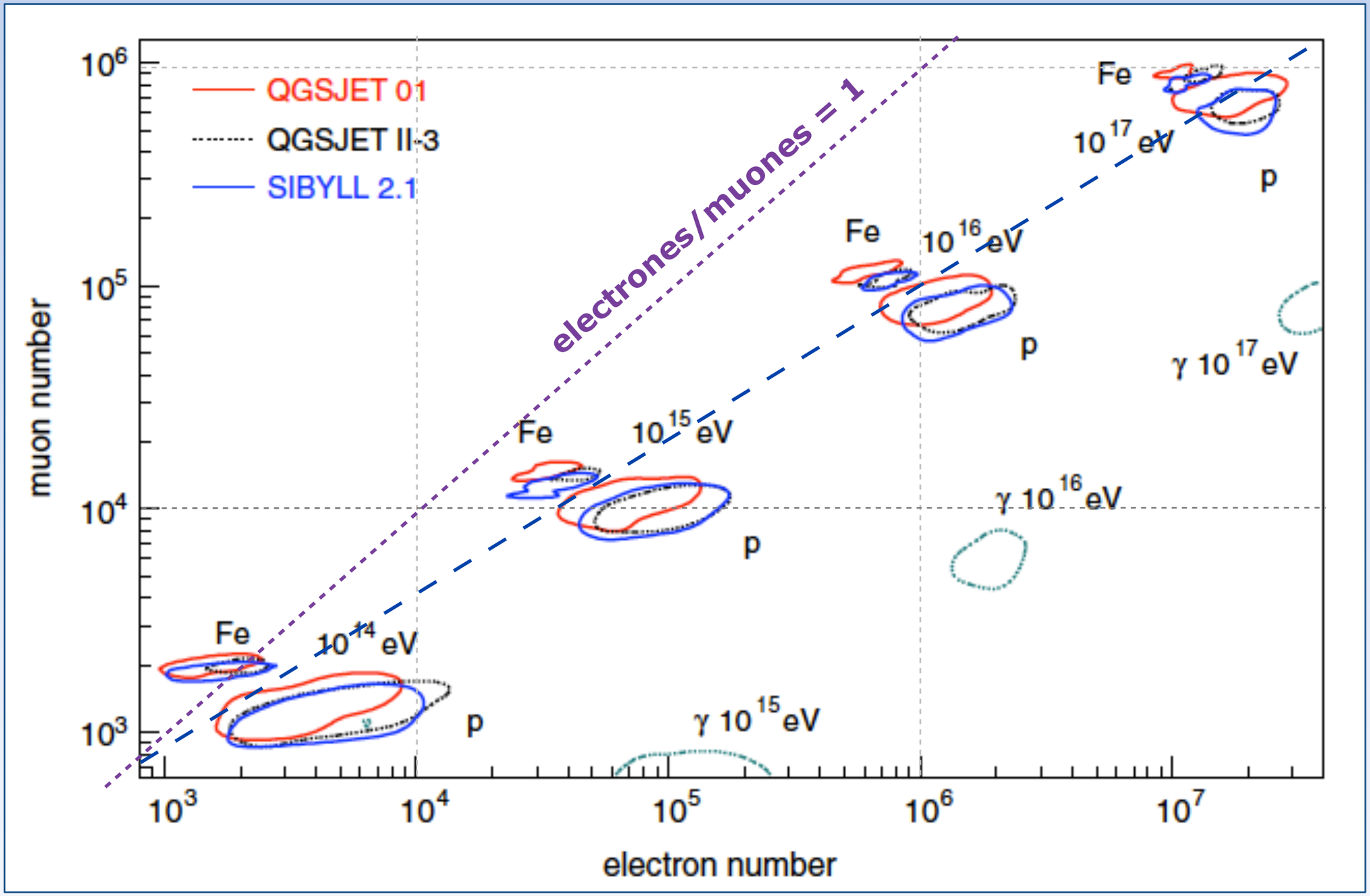


Energy spectrum in Kascade

Figure 10: *All particle spectrum resulting from a non-parametric analysis of KASCADE data [.*

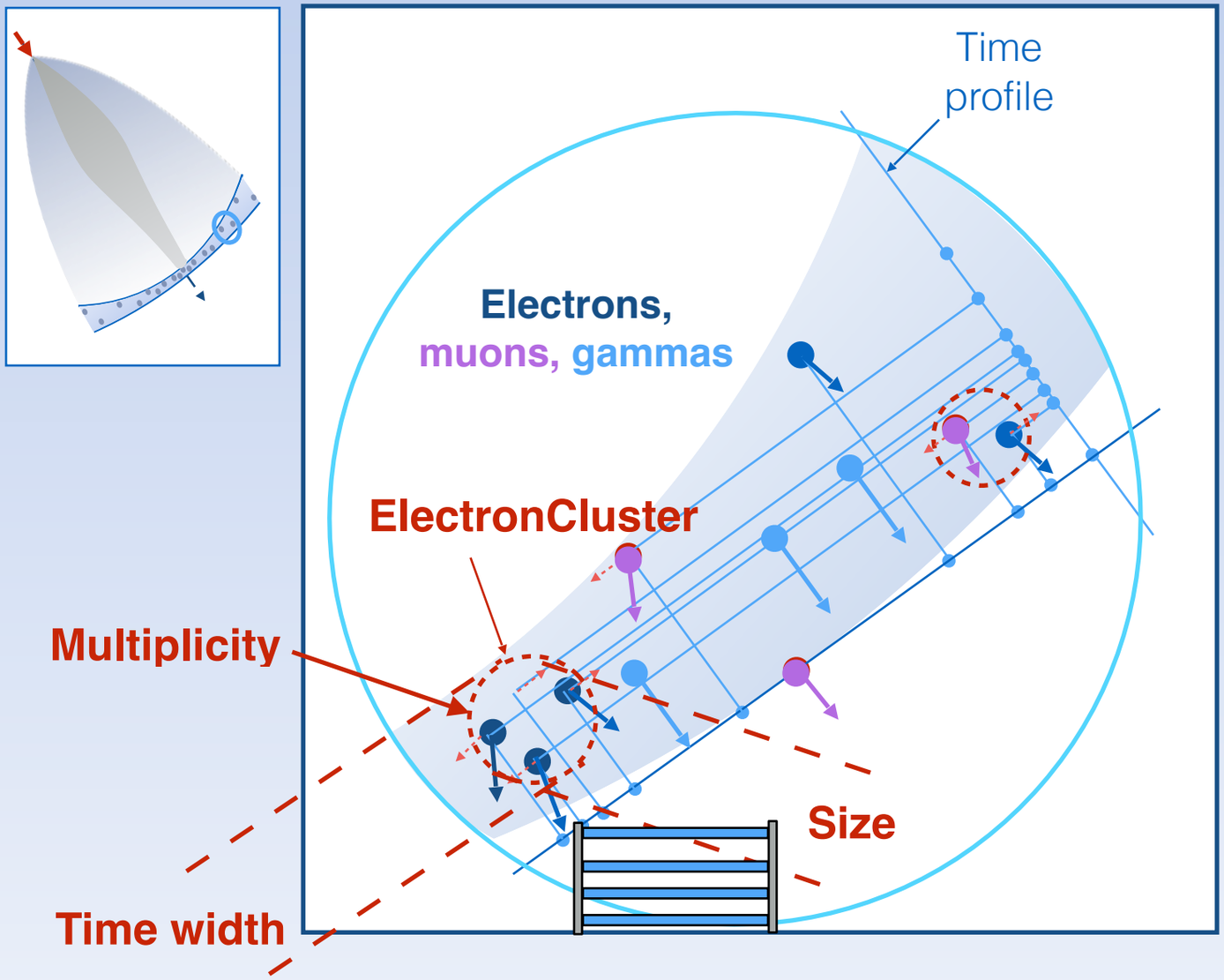
MonteCarlo Improvement

The mass problem



Different interaction models predict different electron/muon ratios

MonteCarlo Improvement



Muon and electron rates, energy and angular distributions and cluster multiplicity rates can be compared with the ones predicted by different MonteCarlo models to test the strength and the weakness of each model

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

Solar Physics and Space Weather

Solar Physics

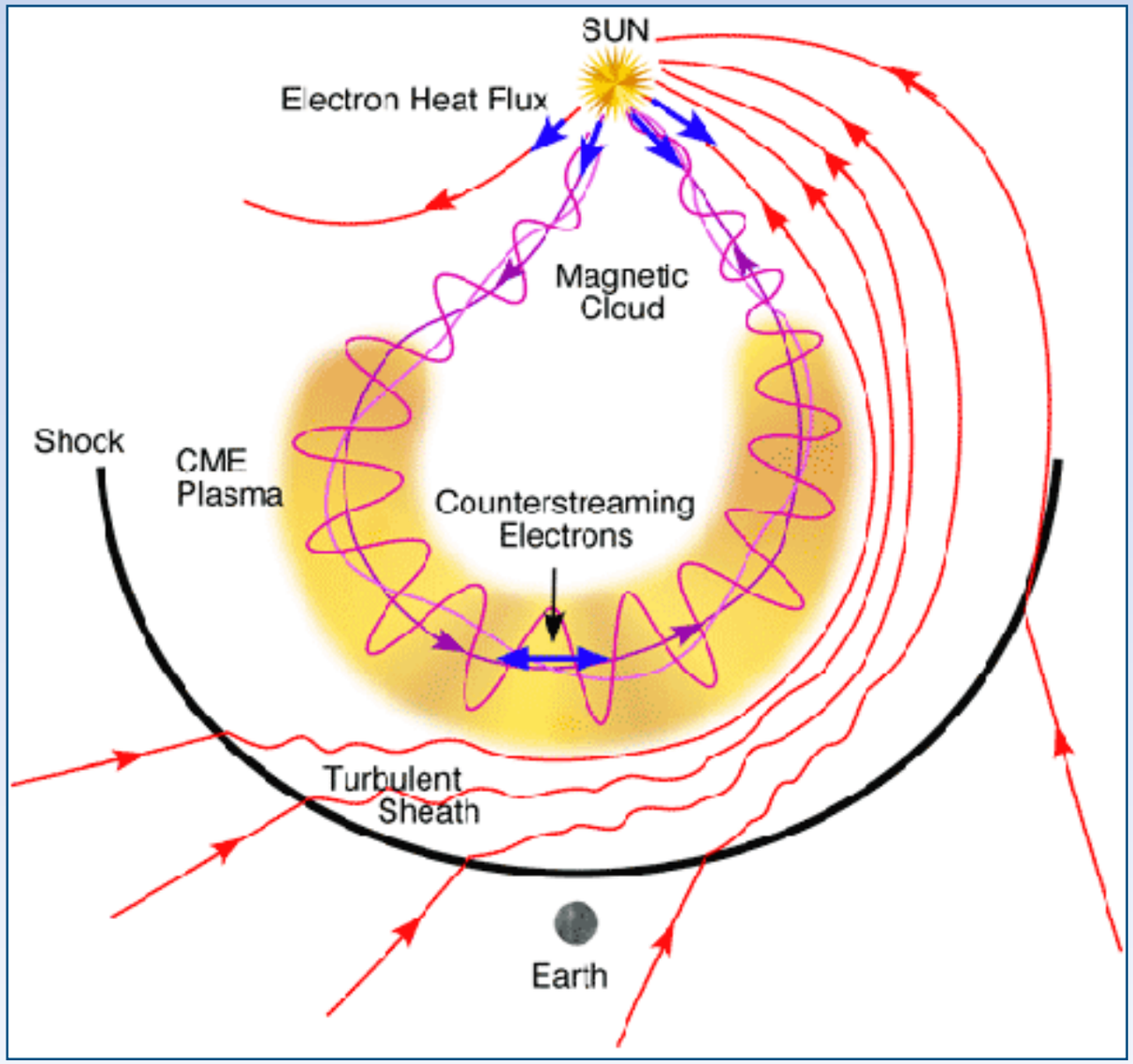
Solar flares

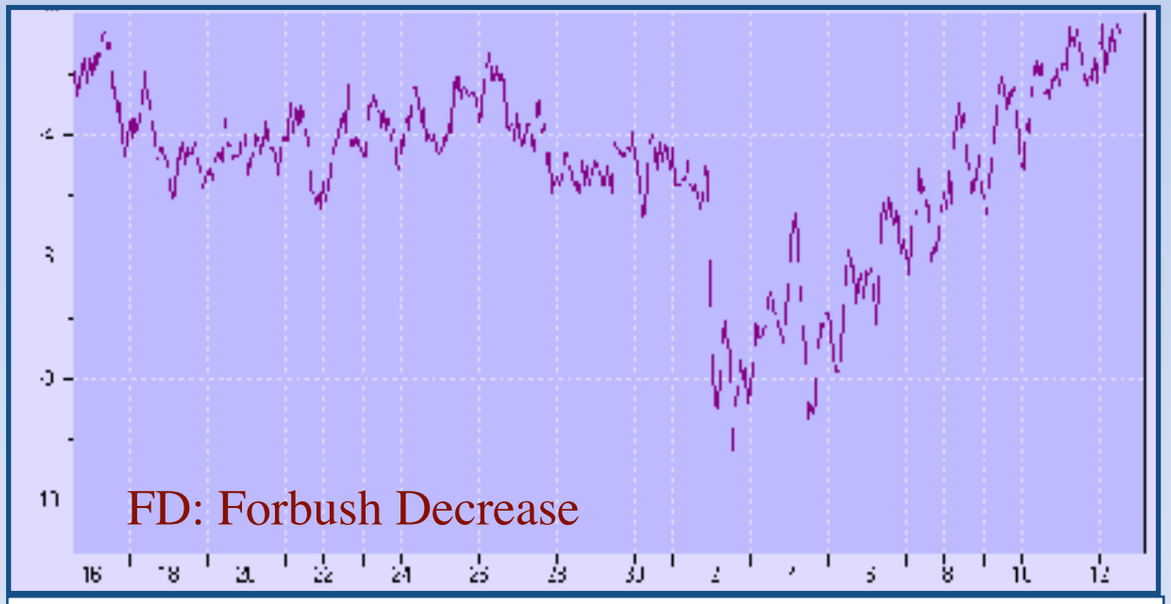
Auroras

Solar wind and solar plasma clouds

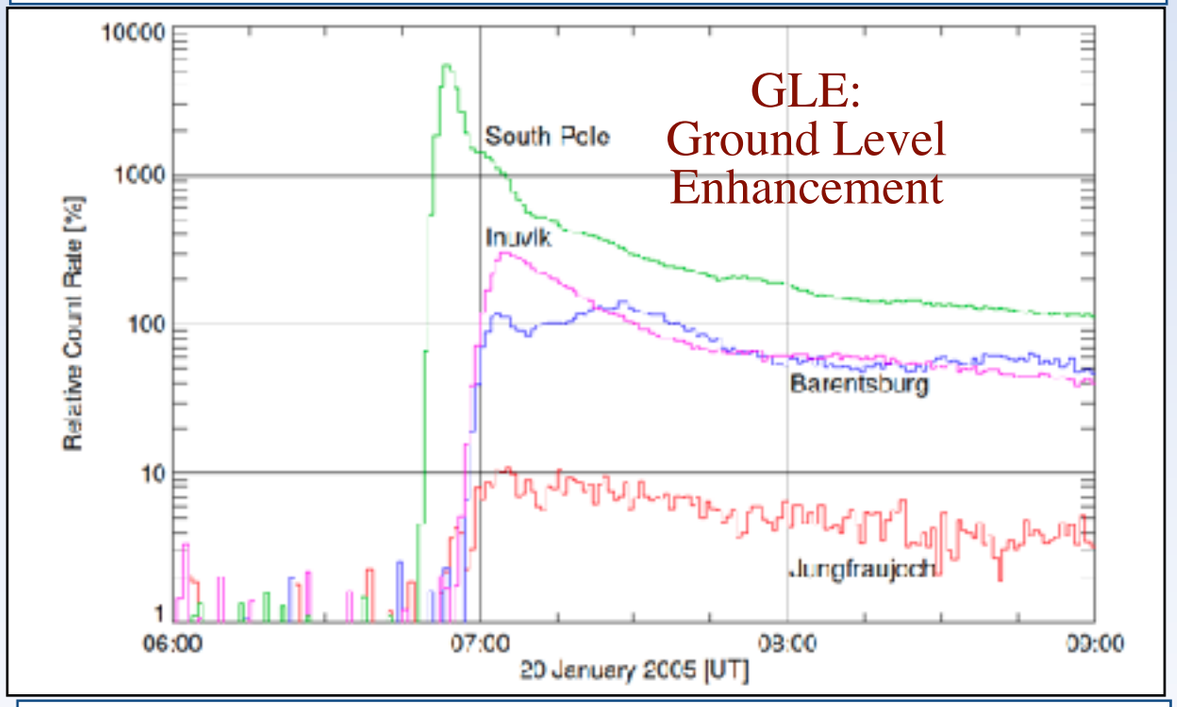
Solar Physics

Sudden Flux variations





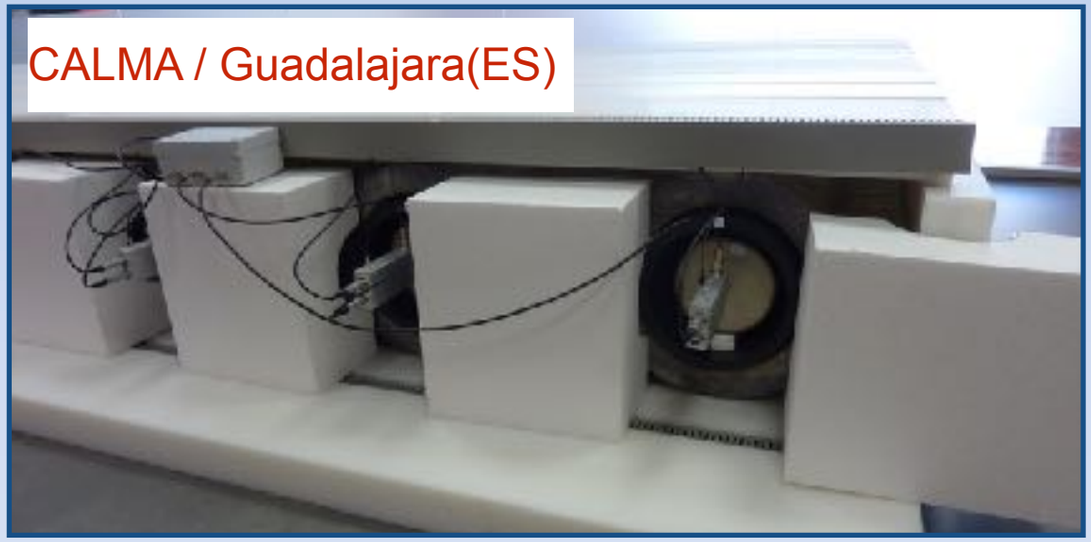
The plasma cloud can screen the cosmic ray background producing a Forbush Decrease

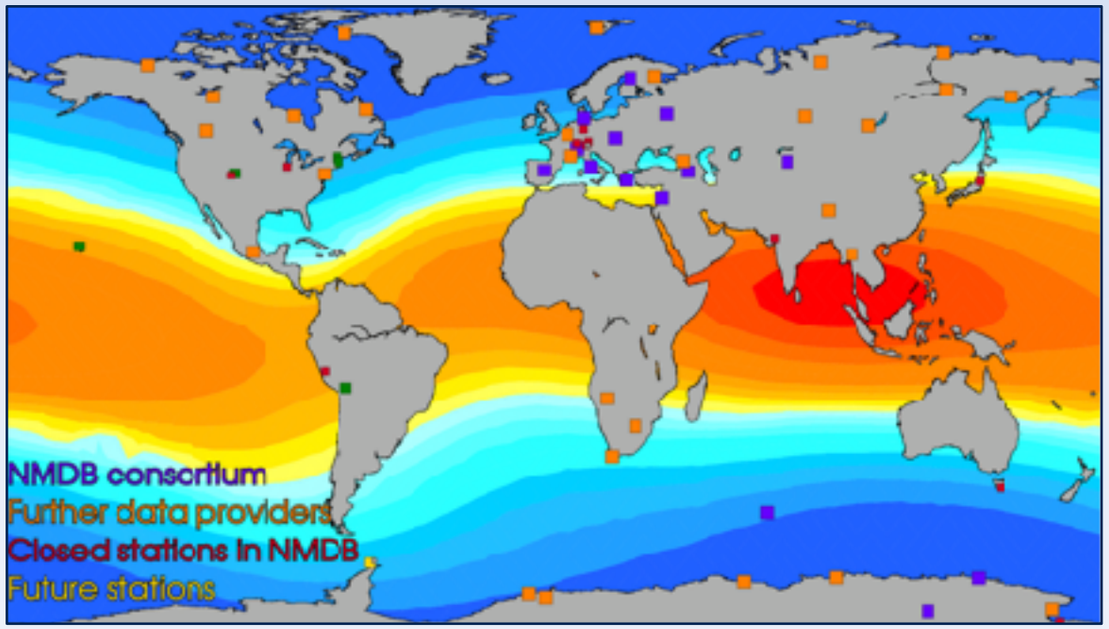


Solar high energetic particles (E >1GeV) break through the Earth magnetic field and be detected on the ground

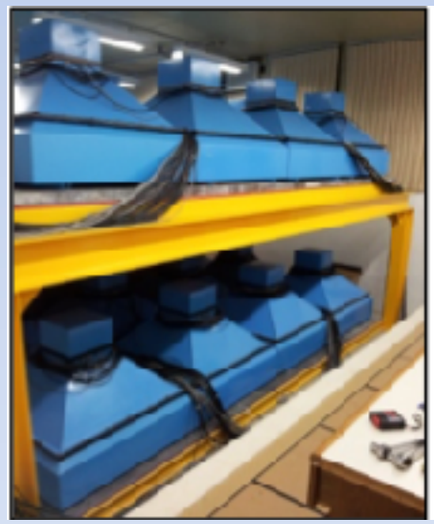
Solar Physics

Neutron monitors



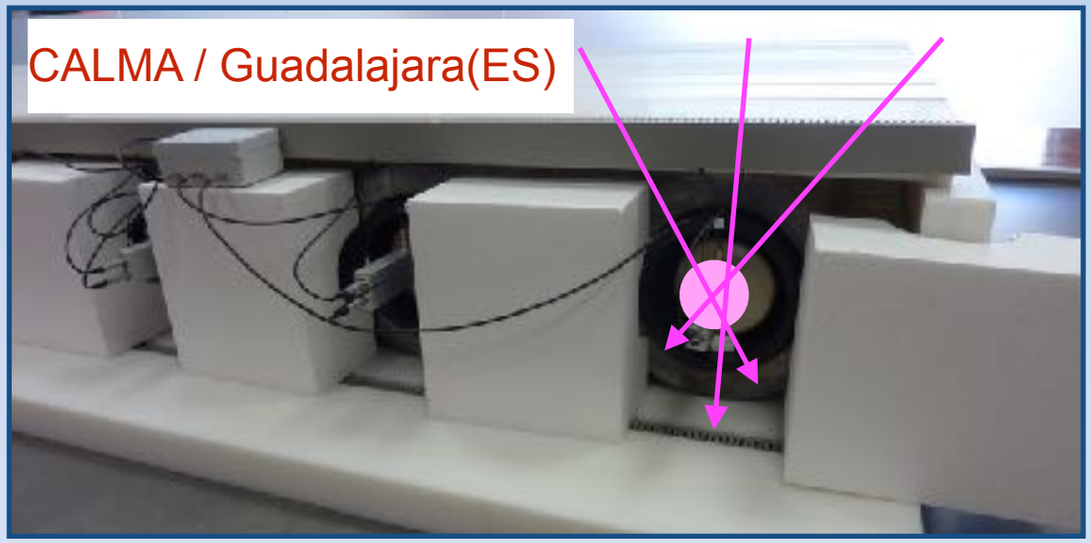


Muon directional telescopes

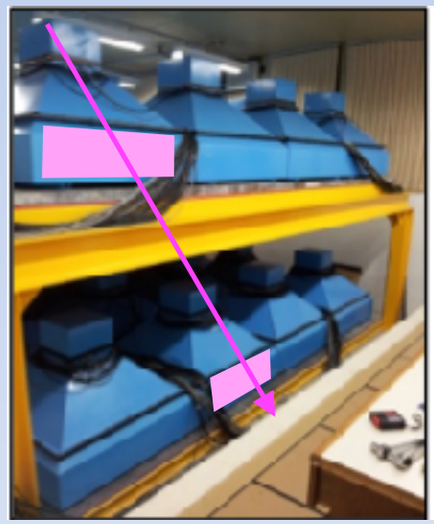


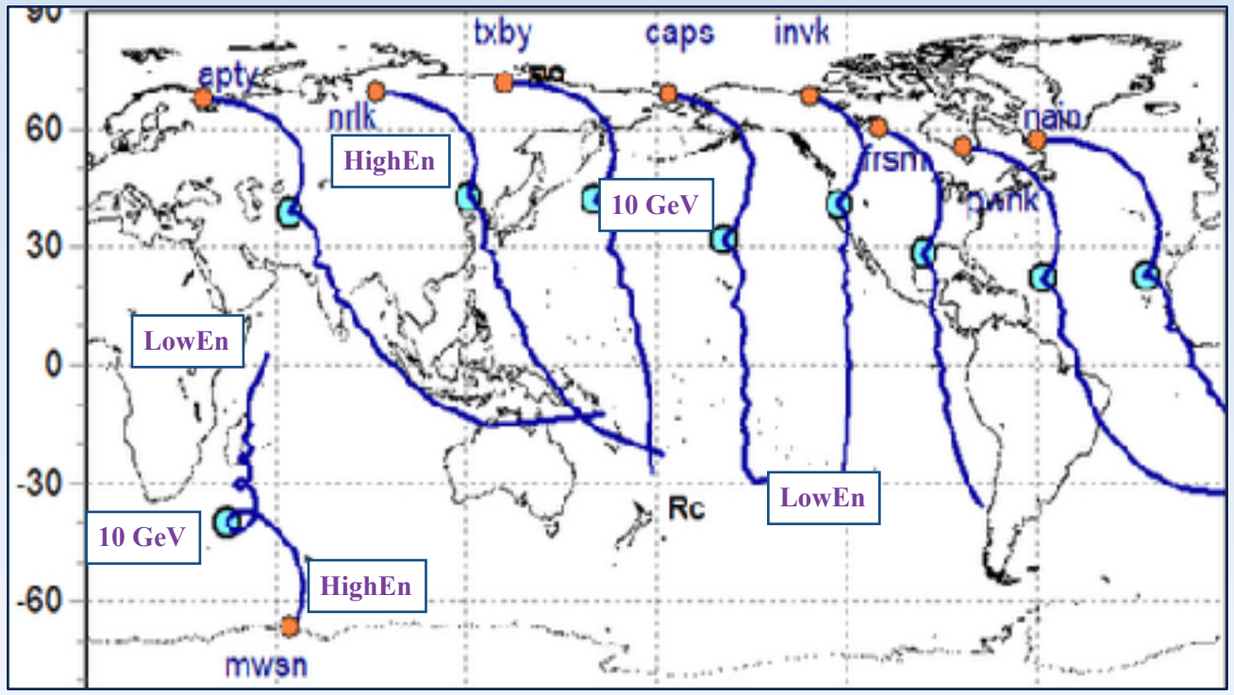
Solar Physics

Neutron monitors

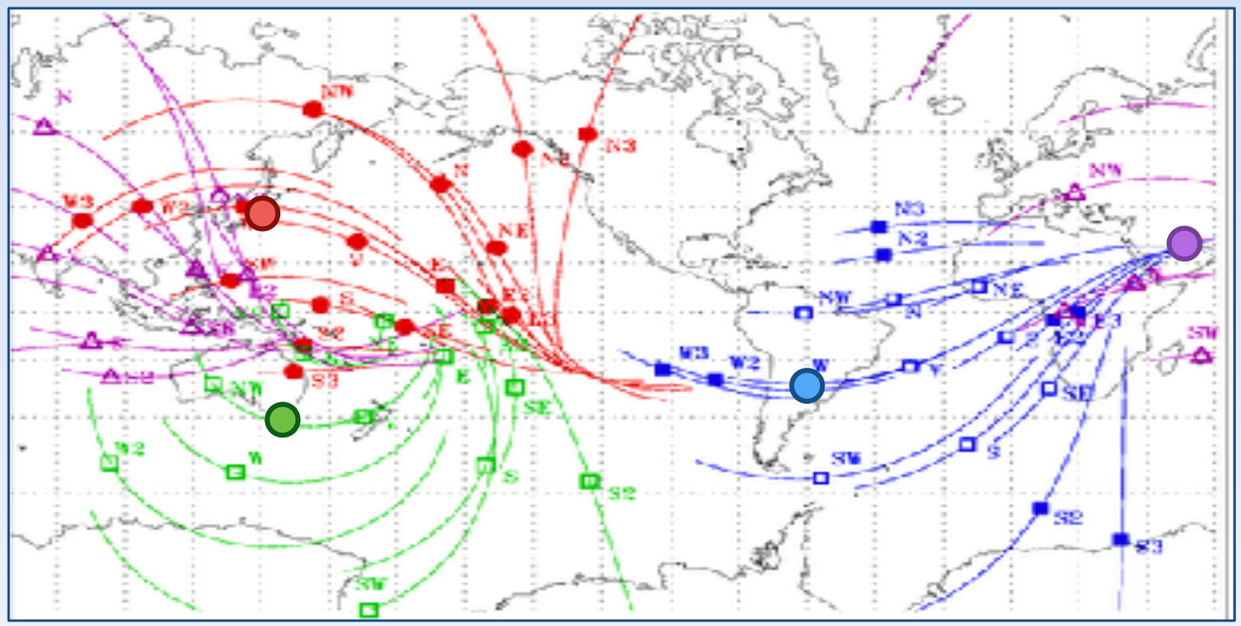


Muon directional telescopes





Asymptotic directions of some detectors for vertically incident particles of different energies.

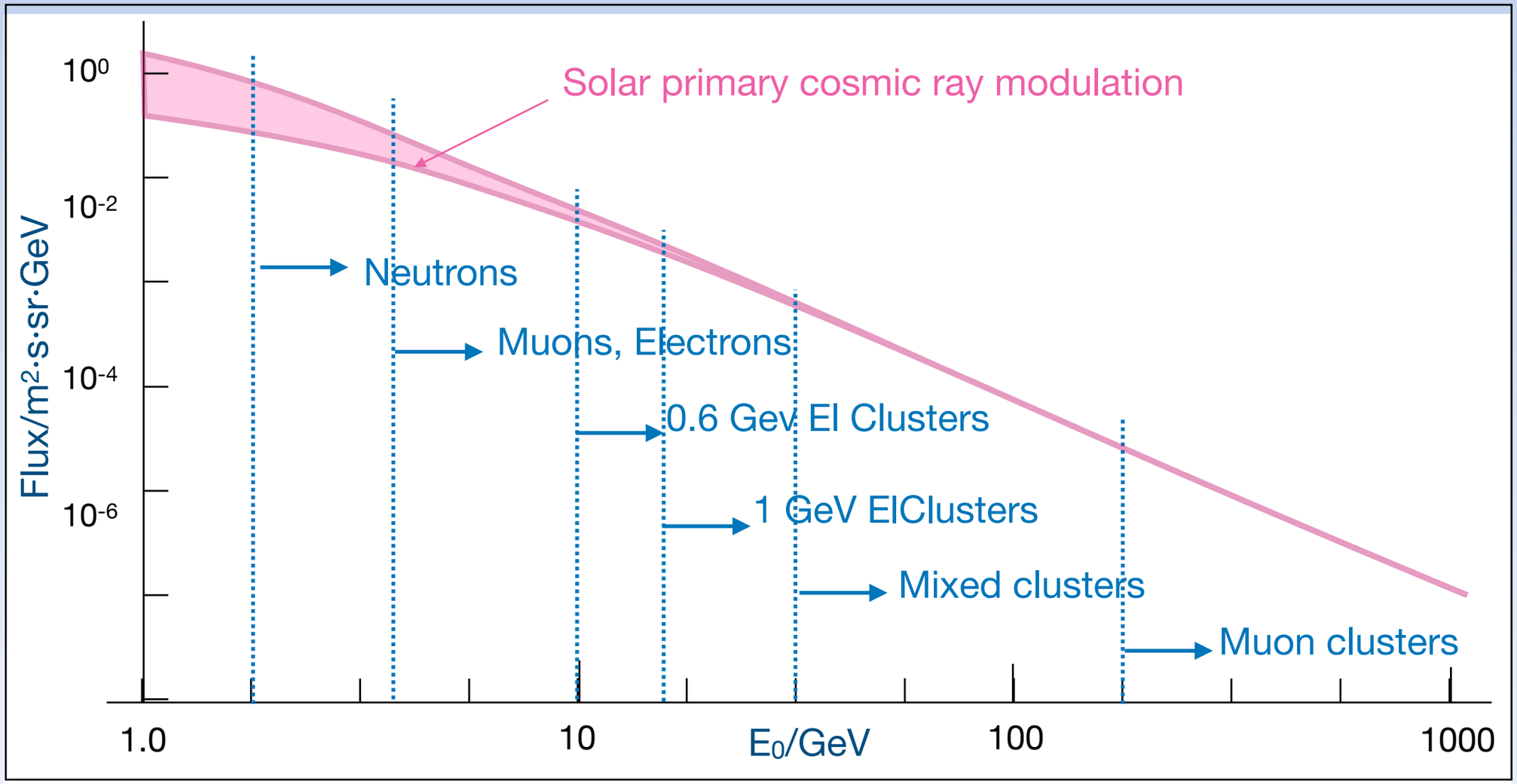


Asymptotic viewing directions available in the current GMDN. Each symbol indicates the asymptotic viewing direction of a particle incident to one of 60 directional channels available from the GMDN.

Both, neutron monitors and muon telescopes are insensitive to the energy of the primary cosmic ray and both are “unfocused”.

Solar Physics

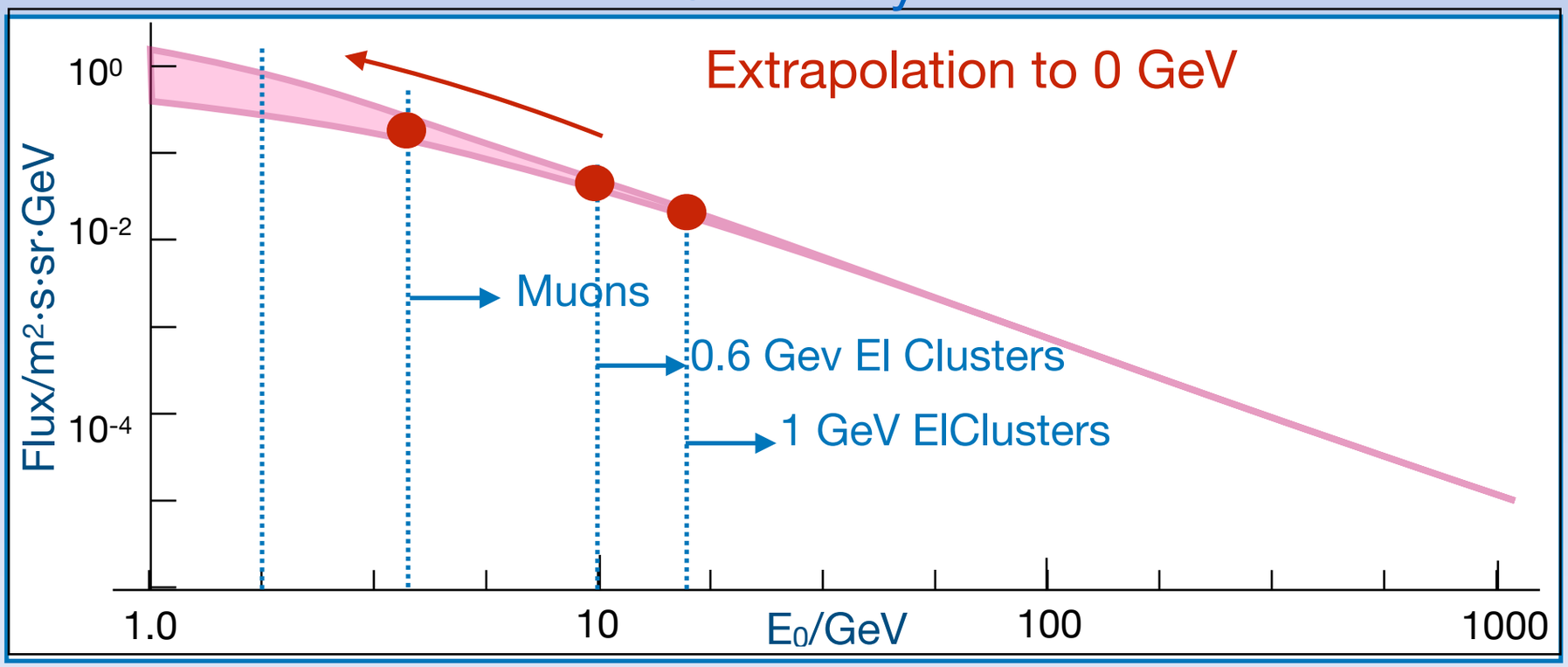
Summary

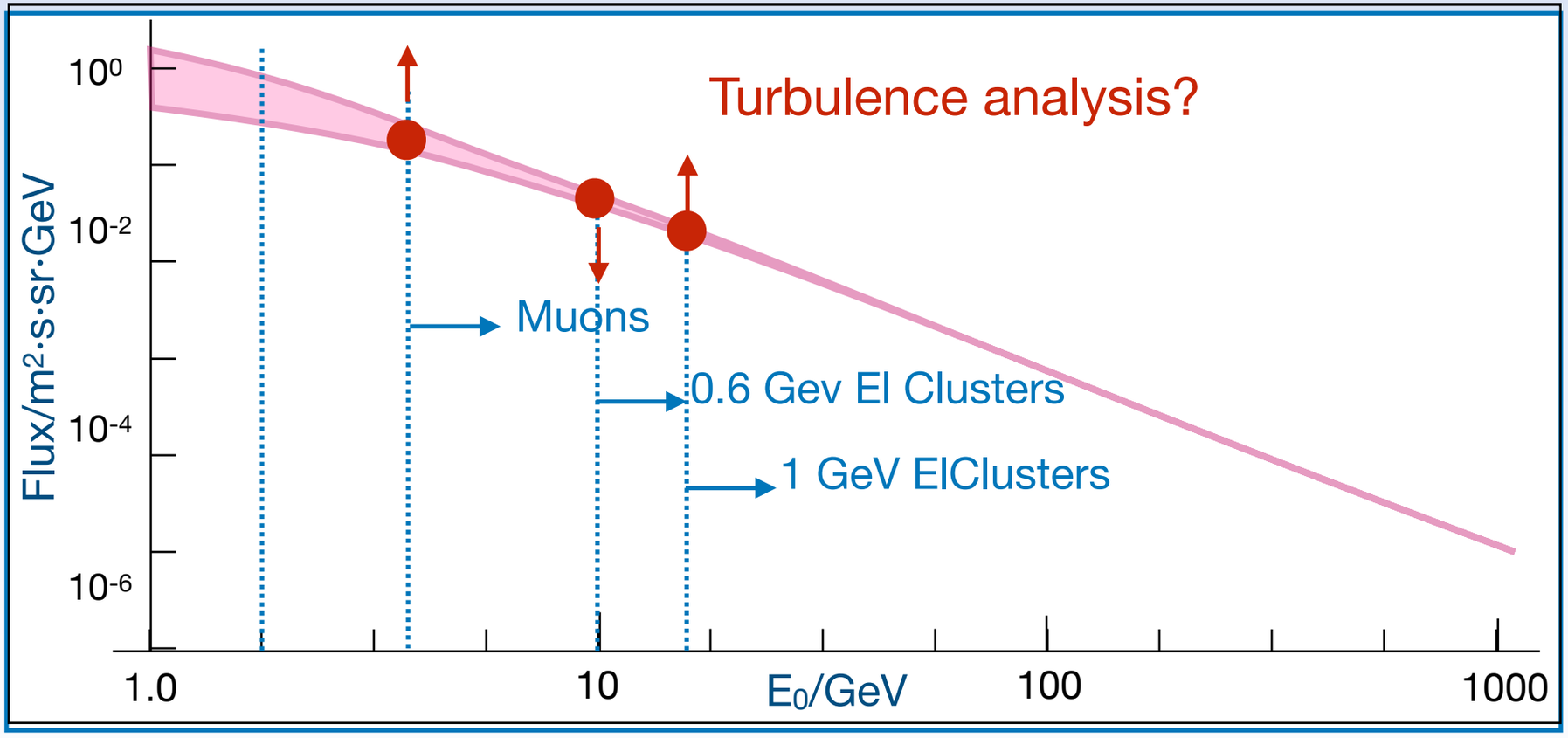


Threshold energies for different particles and clusters (S~1.8 m²)

Solar Physics

Summary





Atmosphere Physics

Atmosphere Physics

THE EARTH ATMOSPHERE

Stratosphere (15% of the mass of the atmosphere)

- Low dynamic region
- Low density
- Very slow dynamics: ~weeks (sometimes, ~ days, with $\Delta T > 20^{o}C$)

Tropopause ($T = T_{min}$)

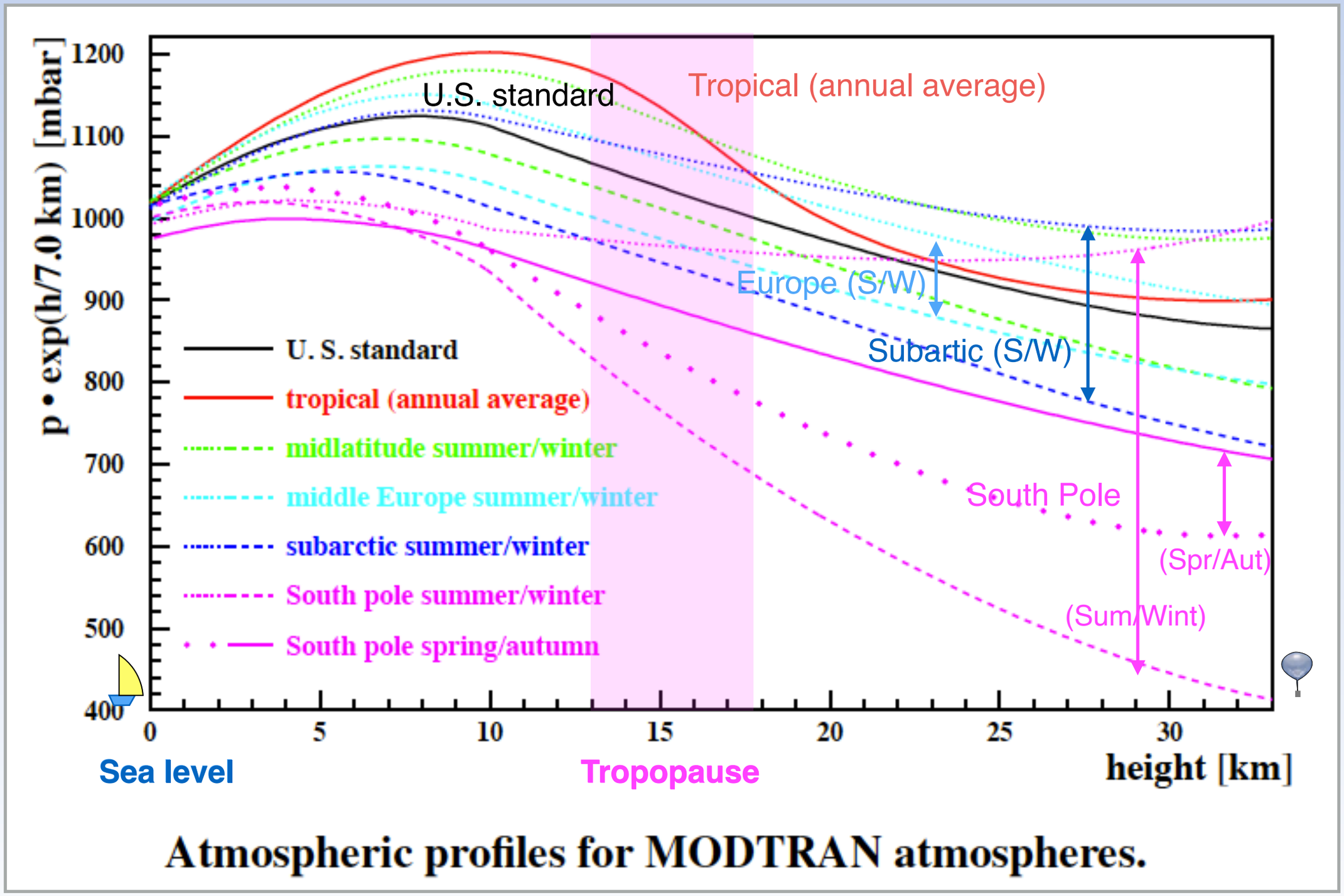
Troposphere (85% of the mass of the atmosphere)

- Very dynamic region
- Rich in water vapor: cloudy
- Very fast dynamics: ~days (sometimes, ~hours)
- Very complex dynamics: clouds, wind, storms, electric discharges…

Atmosphere Physics

THE EARTH ATMOSPHERE

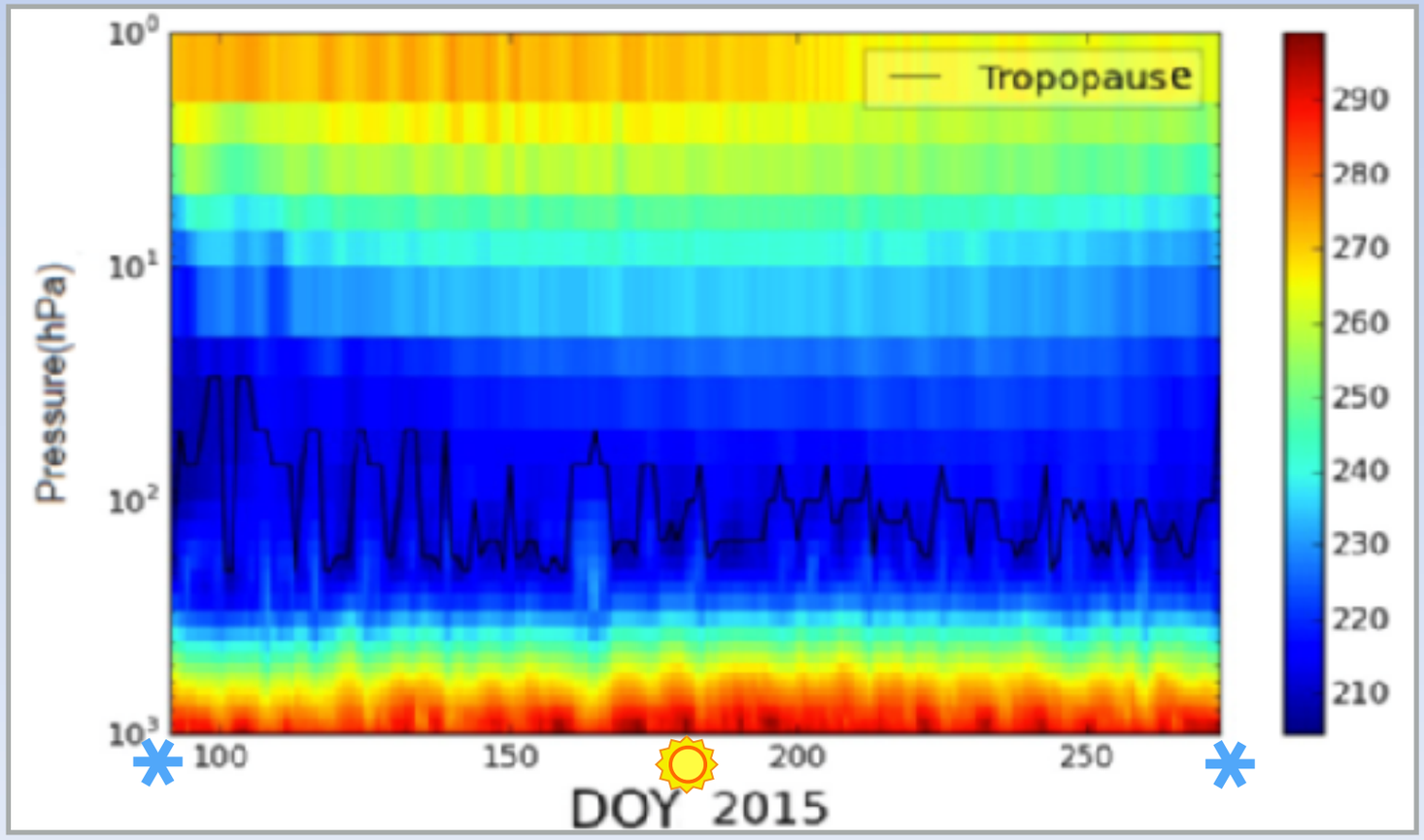
The atmosphere: pressure profiles at different latitudes and regions



Atmospheric profiles for MODTRAN atmospheres.

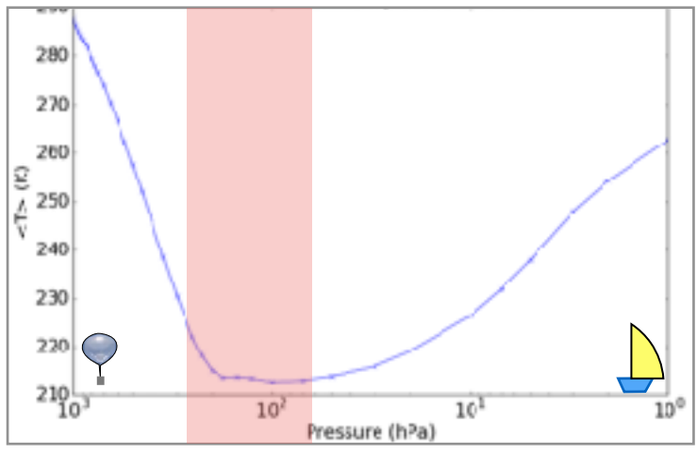
Atmosphere Physics

The atmosphere over Santiago de Compostela. Temperature behavior at 37 pressure levels

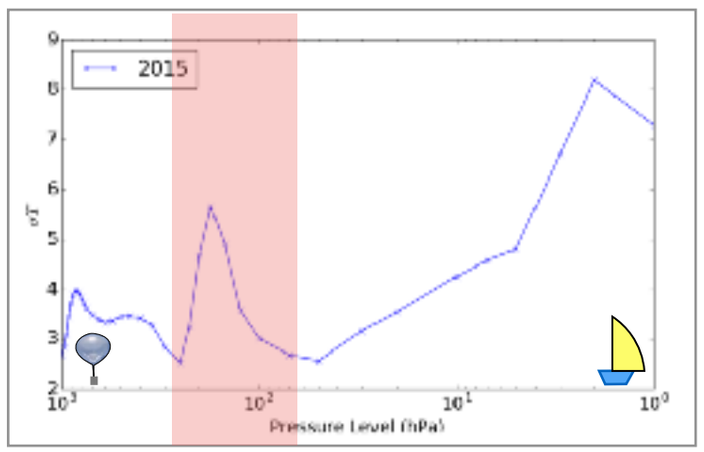


2015 Mean temperature behavior

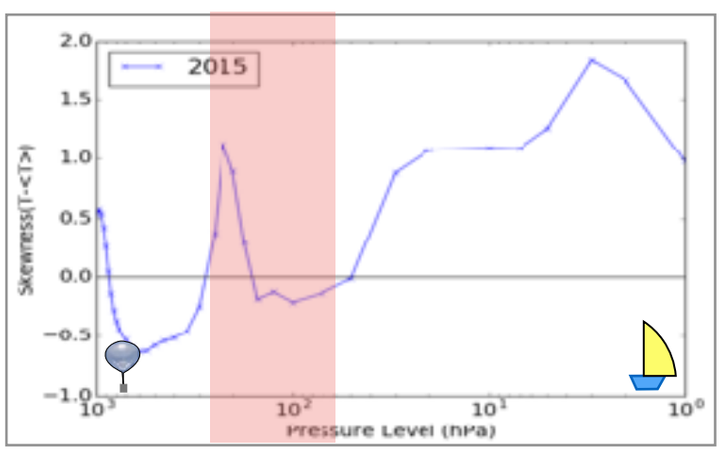
Mean temperature



Standard deviation

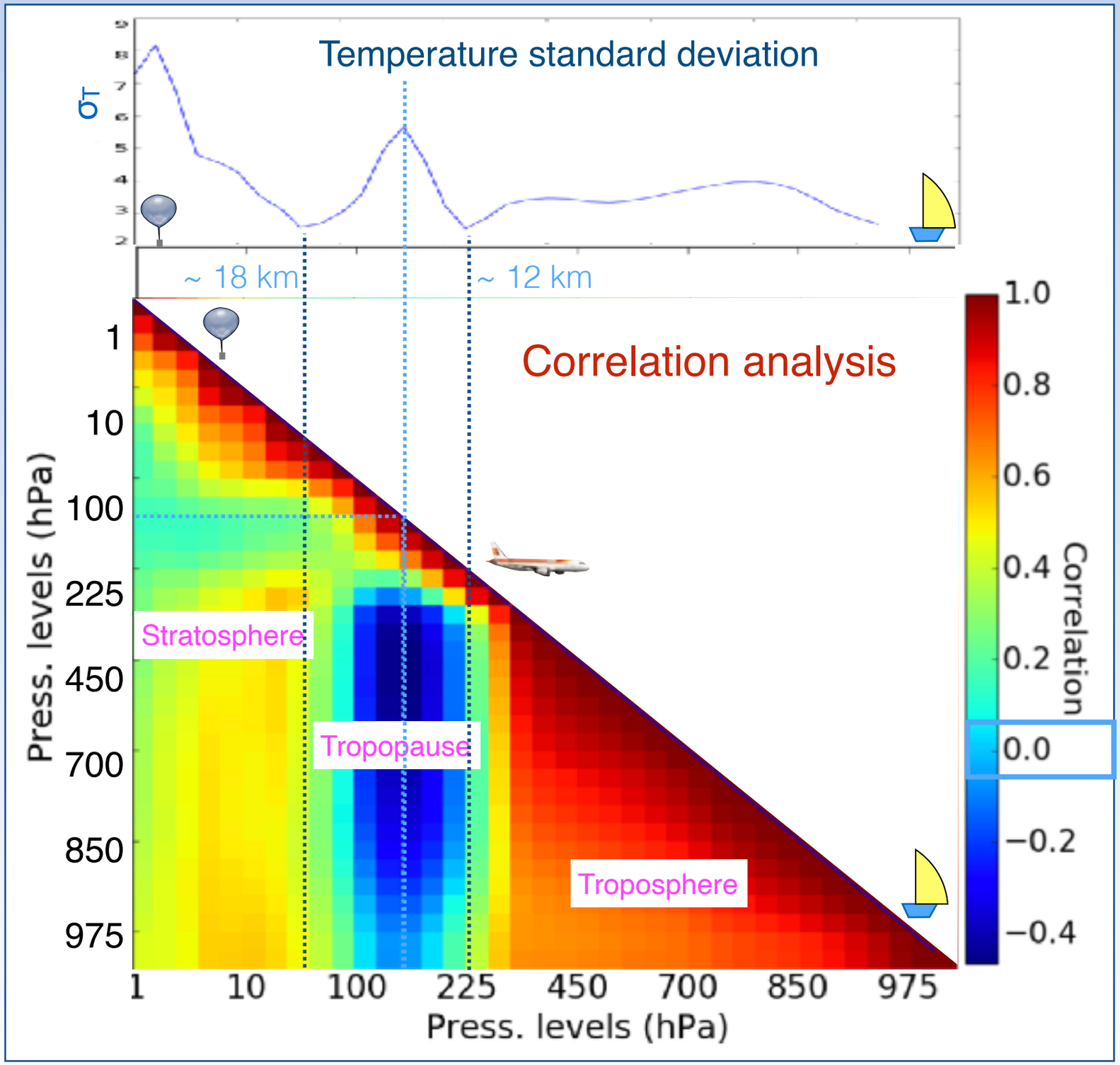


Skewness



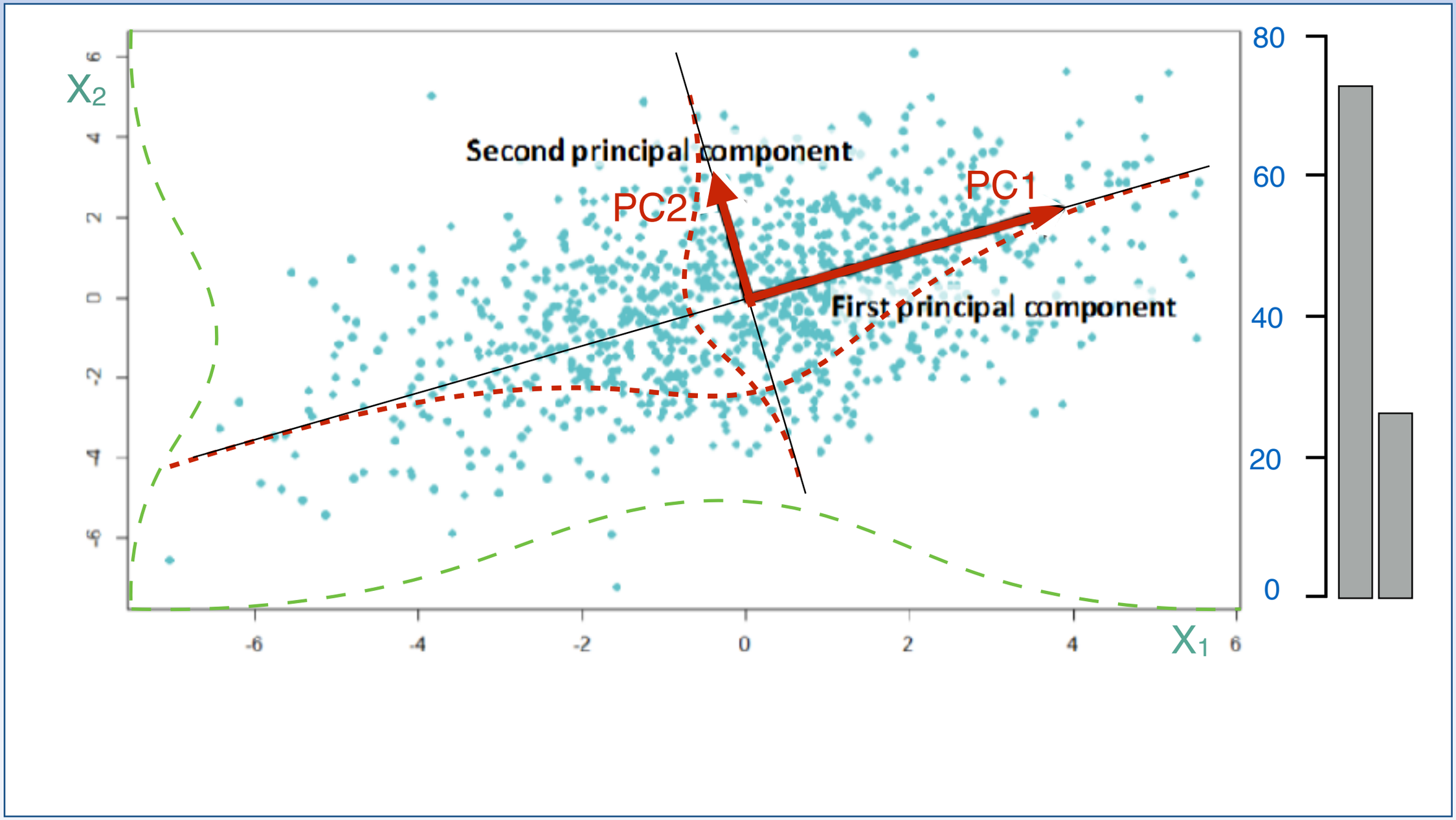
Atmosphere Physics

The atmosphere over Santiago de Compostela. Temperature behavior at 37 pressure levels



Atmosphere Physics

PCA: Principal Component Analysis

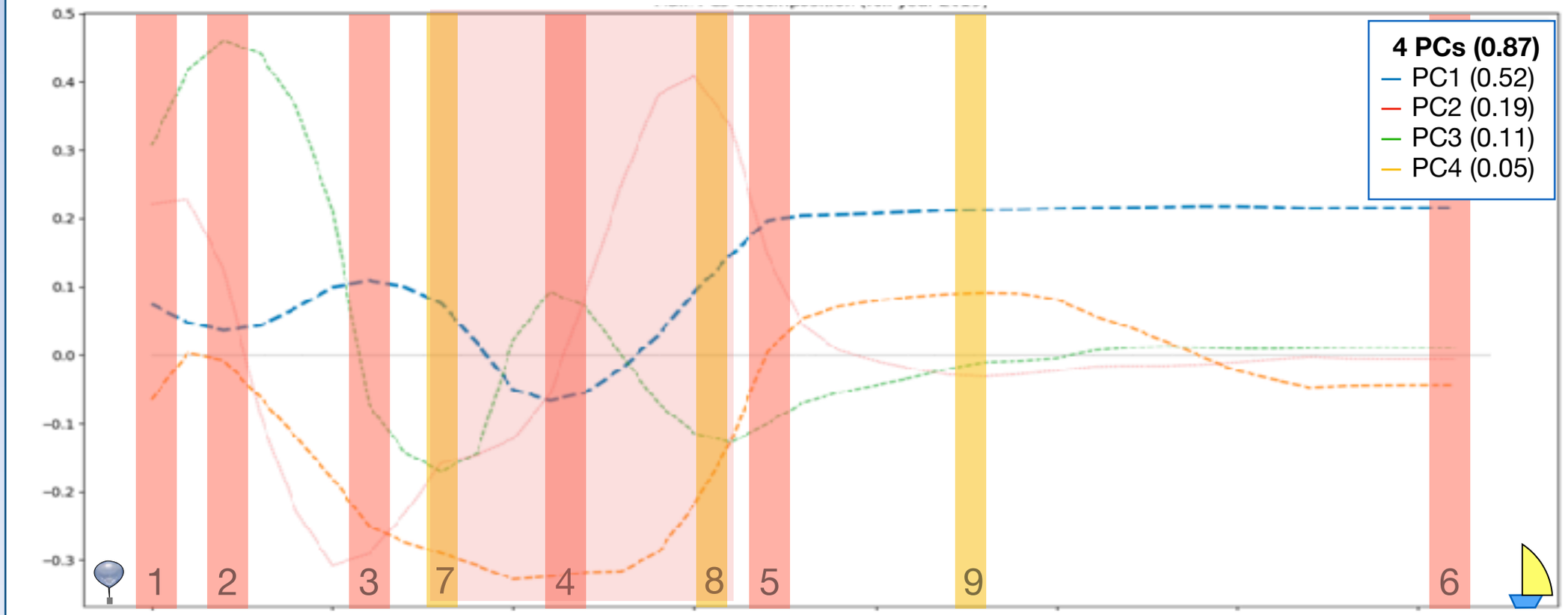


Given a sample of correlated data, the PCA provide new non-correlated variables and ordered in inverse order of their variance

Atmosphere Physics

PCA: Principal Component Analysis of the atmosphere over Santiago de Compostela

Atmosphere over Santiago de Compostela. PCA main levels

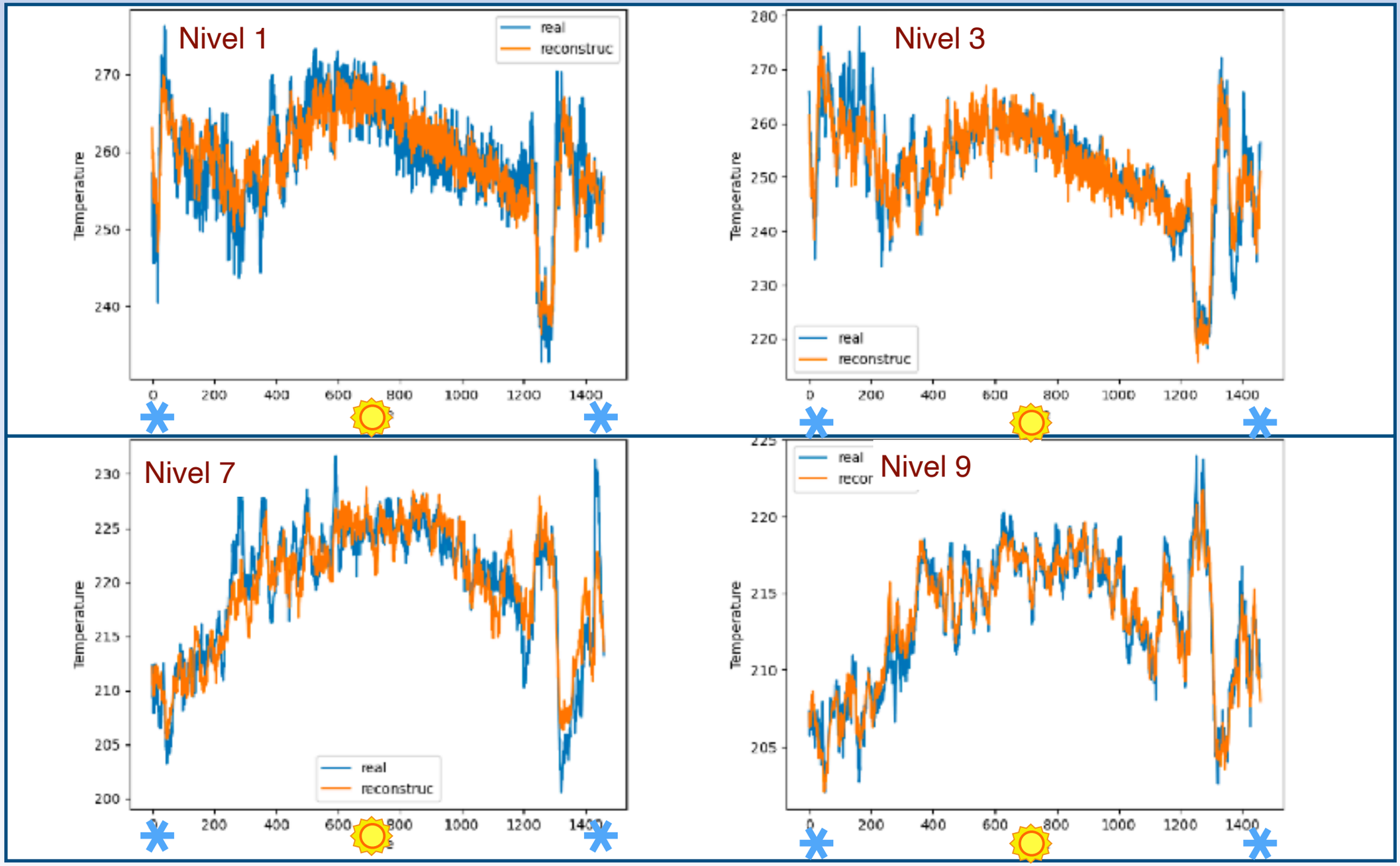


Order	Pres. Level	Altitude/hPa	PC1 (52%)	PC2 (19%)	PC3 (11%)	PC4 (5%)
1	1	1	Extreme	Extreme	Extreme	Extreme
2	3	3	Rel. minimum	Rel. maximum	Maximum	-
3	7	20	Rel. maximum	-	0 (Null)	Minimum
4	12	125	Minimum	Minimum	Rel. maximum	0 (Null)
5	18	300	Inflection P. -	0 (Null)	~ Rel. minimum	-
6	37	1000	Extreme - Maximum	Extreme - Rel.	Extreme - 0 (Null)	Extreme - 0 (Null)
7	9	50	-	-	Rel. minimum	-
8	16	225	-	~Rel. minimum	Rel. minimum	Maximum
9	24	600	Maximum	Maximum	Inflection P. - 0 (Null)	Rel. minimum

Atmosphere Physics

PCA: Principal Component Analysis of the atmosphere over Santiago de Compostela

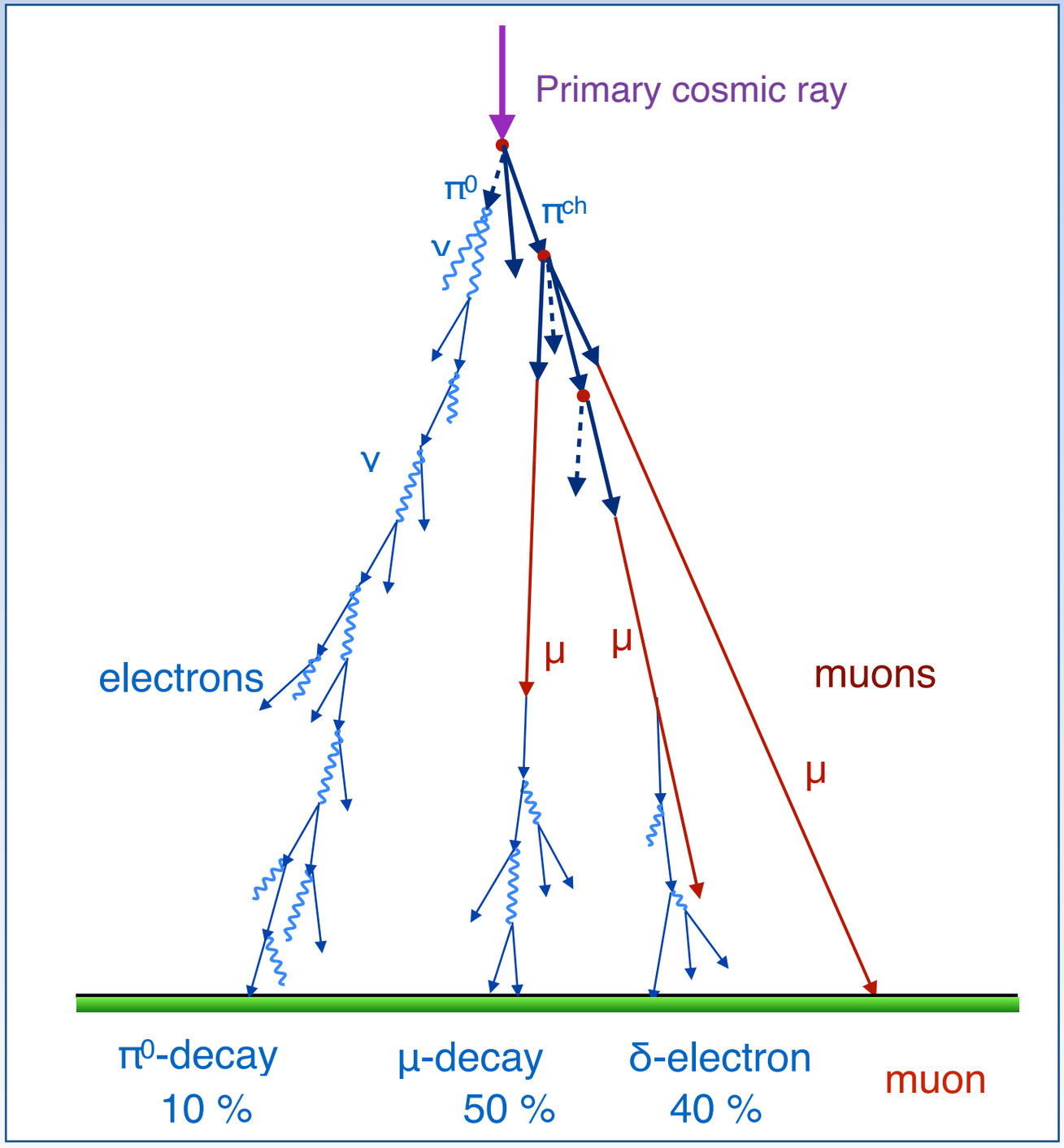
Difference between the real temperature and the one estimated from the temperature at 9 pressure levels



The temperature of only 9 levels seems to be enough for estimating the temperature of the whole atmosphere

Atmosphere Physics

Cluster Analysis



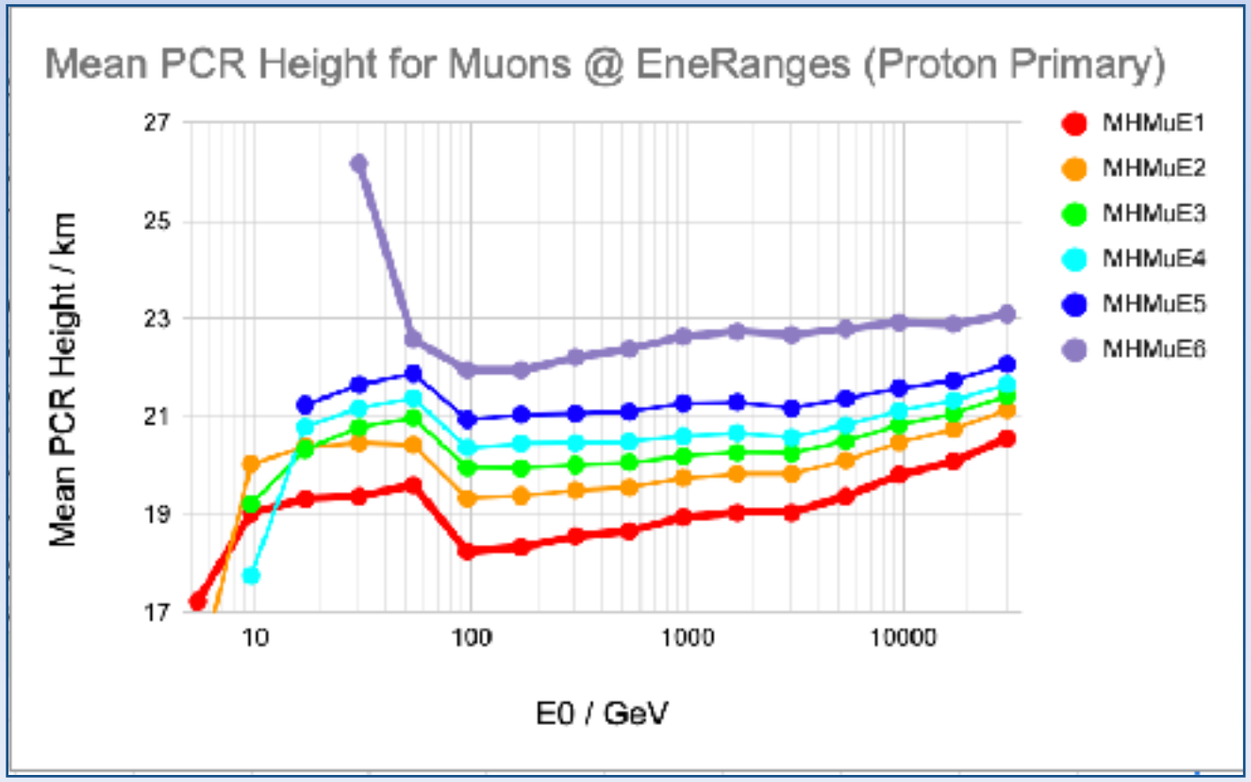
Most of the electron clusters on the ground come from the decay of muons

Atmosphere Physics

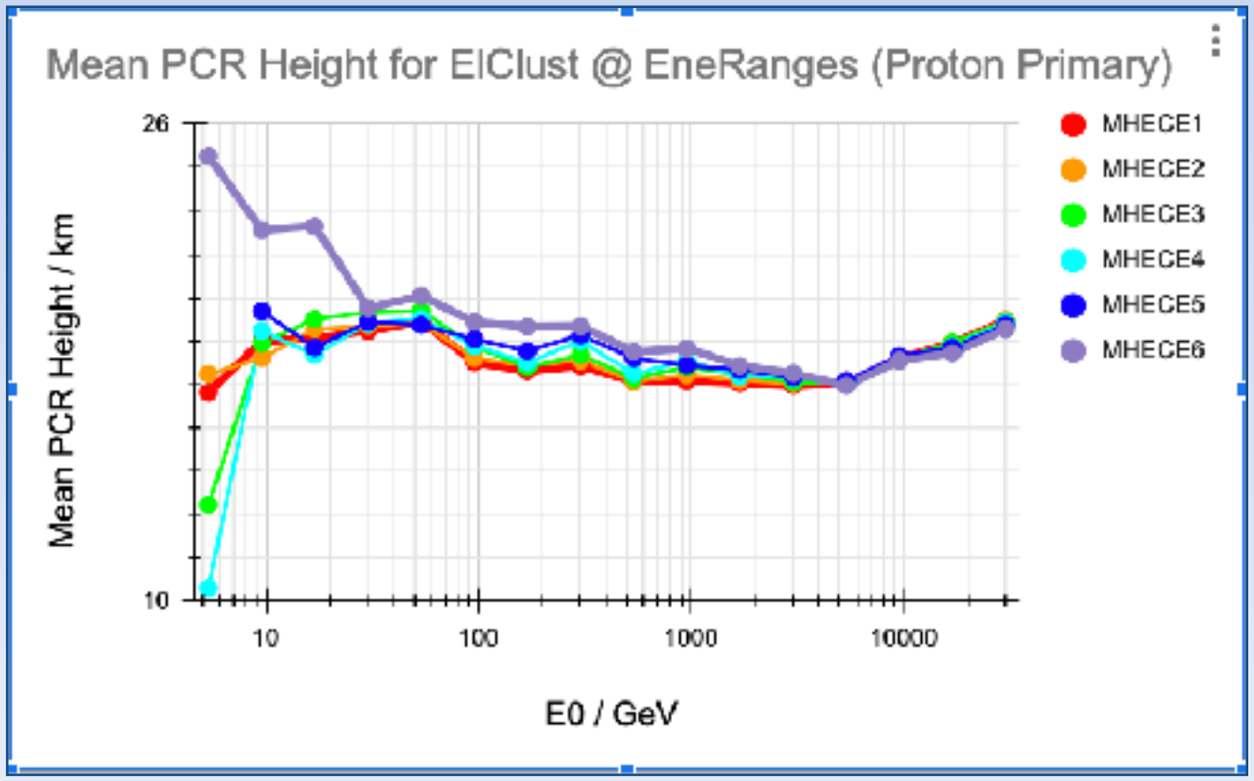
Cluster Analysis

Mean Height of the Primary Cosmic Ray first interaction

Muons of different energies



Clusters of electrons of different energies

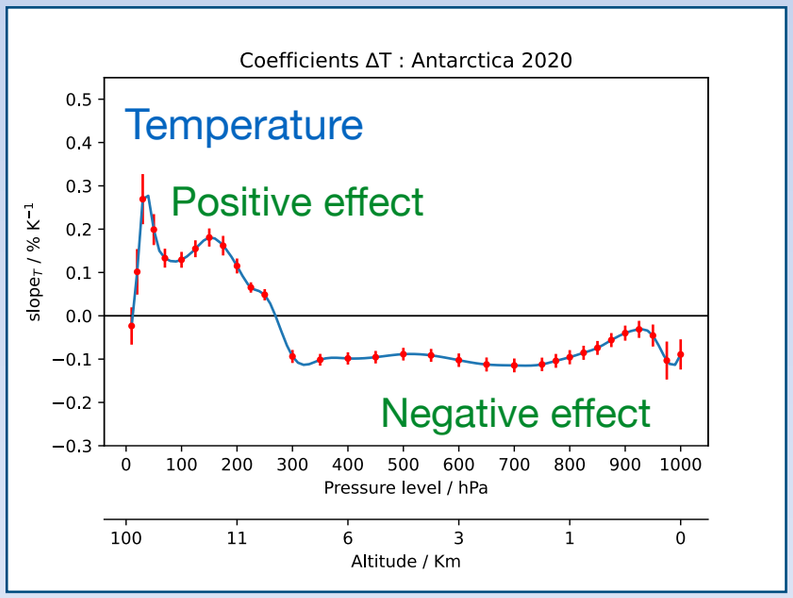


Muons and electrons of different energies show some similarities. High energy electron clusters are an indirect way of measuring changes in the arrival of high energy muons

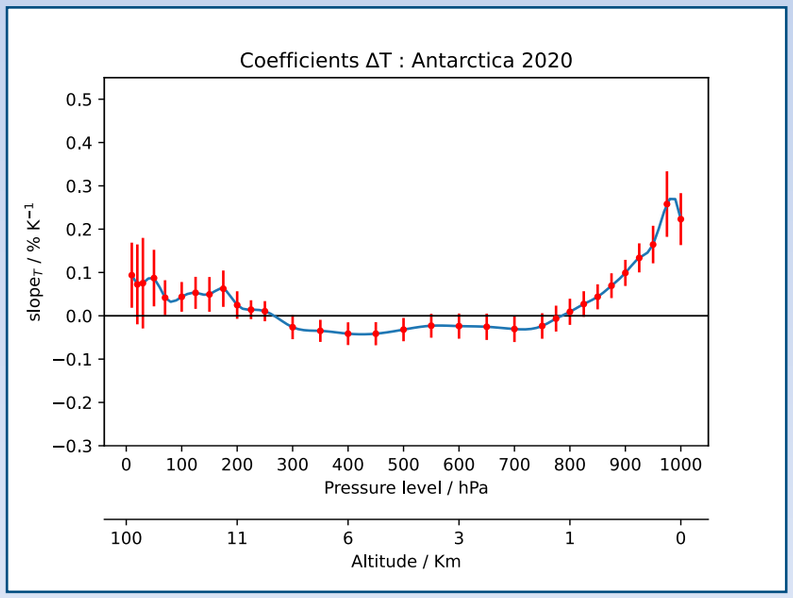
Atmosphere Physics

TRISTAN: Regression slopes between measured rates and pressure levels

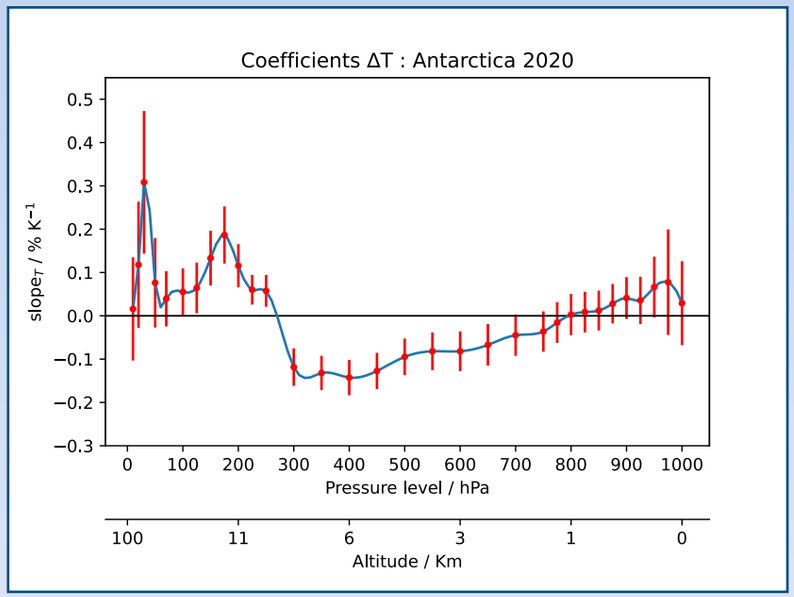
M1



M2



Mn



Different multiplicities keep memory of the atmosphere at different pressure levels

… and in the next future…

Trasgo network at end 2024

TRASGO

miniTRASGO

?

?

?

Warsaw

Ferrol

Madrid

S. COMPOSTELA

ALCALA

Puebla

GeV

18.0
17.0
16.0
15.0
14.0
13.0
12.0
11.0
10.0
9.0
8.0
7.0
6.0
5.0
4.0
3.0
2.0
1.0
0.8
0.6
0.4
0.2

Thanks :)

RESUMEN

Los electrones de alta energía y los clusters de electrones ofrecen unas propiedades únicas para el estudio de la actividad solar

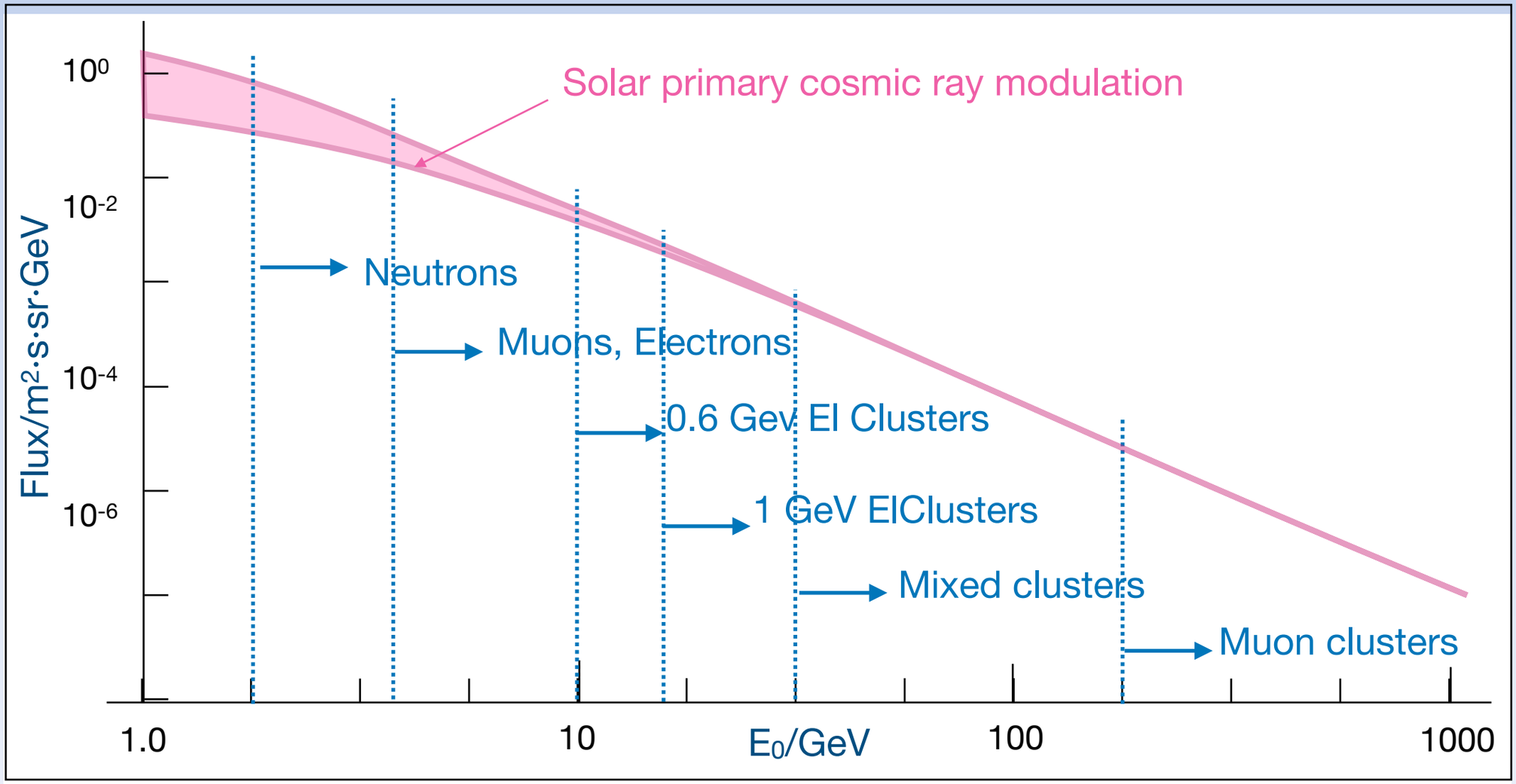
- Son direccionales
- Es posible estimar su energía y establecer bandas de energía en la medida de los rayos cósmicos primarios
- En función de la energía del primario, es posible “reenfocar” su llegada y obtener mejores imágenes de la modulación solar
- Su mayor nitidez permite usar detectores de menor superficie

Los detectores tipo Trasgo ofrecen un gran numero de variables: tasas direccionales de muones y electrones, medida de clusters y sus propiedades (multiplicidad, tamaño, anchura temporal, estimación de su energía, etc.) abriendo un nuevo abanico de posibilidades aun inexploradas para el estudio en tiempo real de la actividad solar y, en particular, para la detección temprana de tormentas magnéticas

Solar Activity and Space Weather

Cluster Analysis

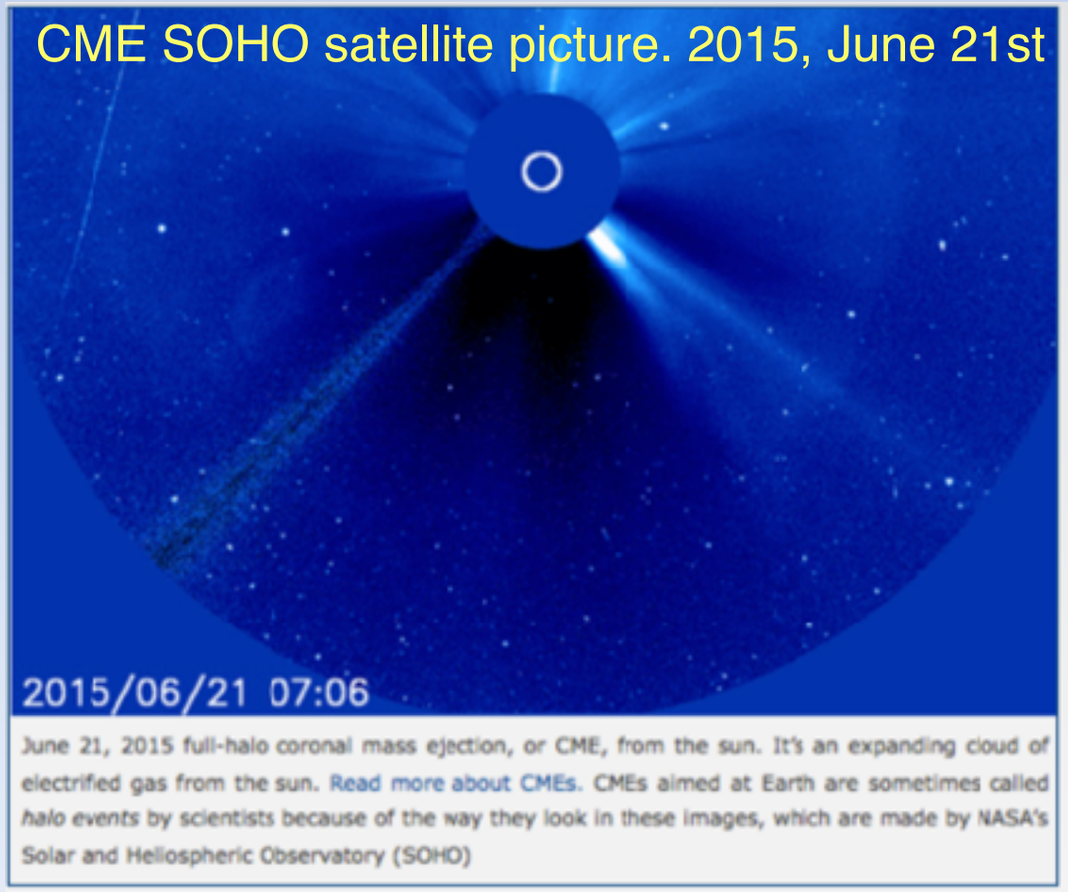
Threshold energies for different particles and clusters (S~1.8 m²)

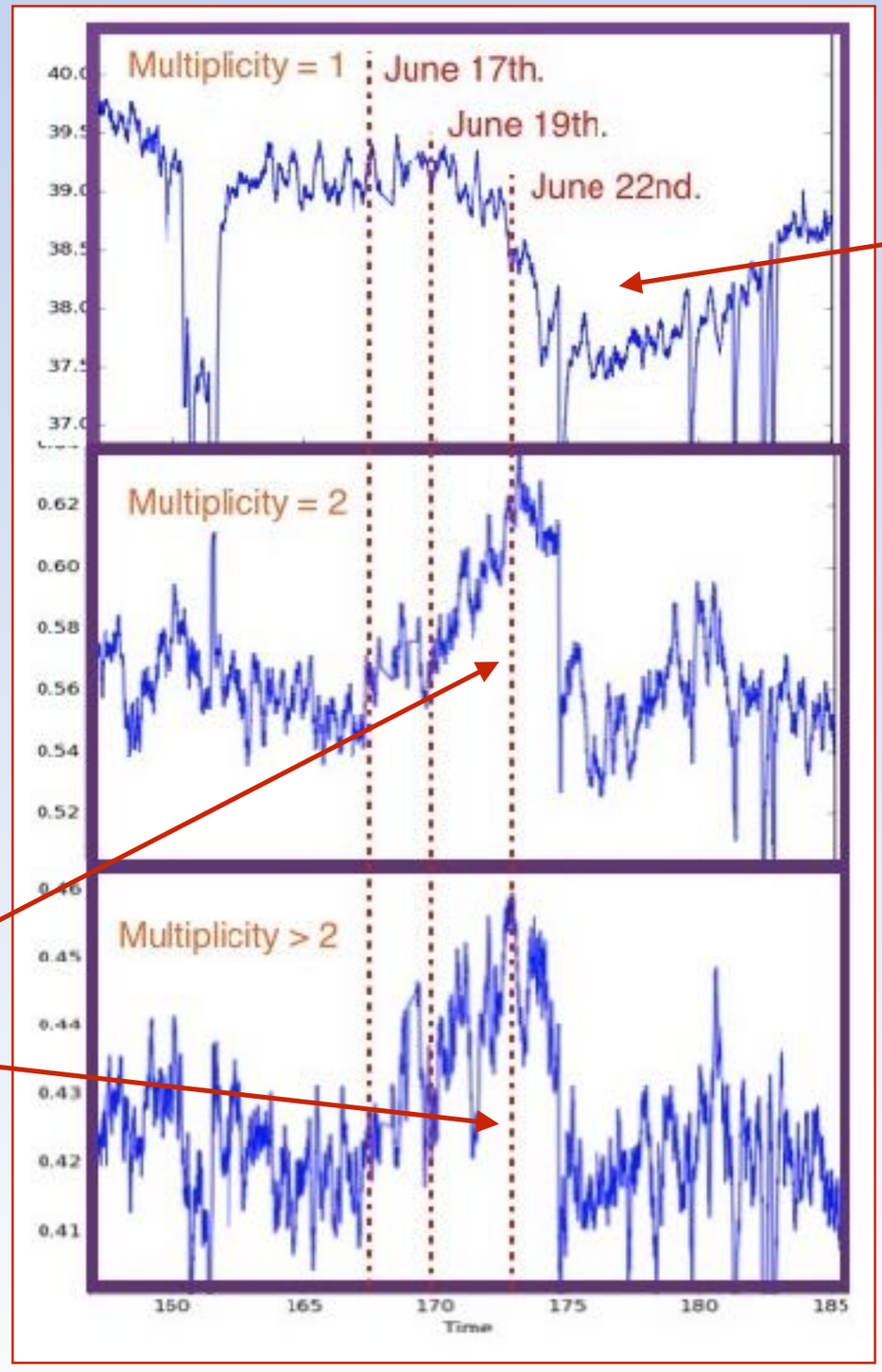


Ground based Trasgo detector allows estimating the rate of primary cosmic rays of different energies

The Trasgo Project

Tragaldabas. Analysis of the Forbush Decrease on June 2015

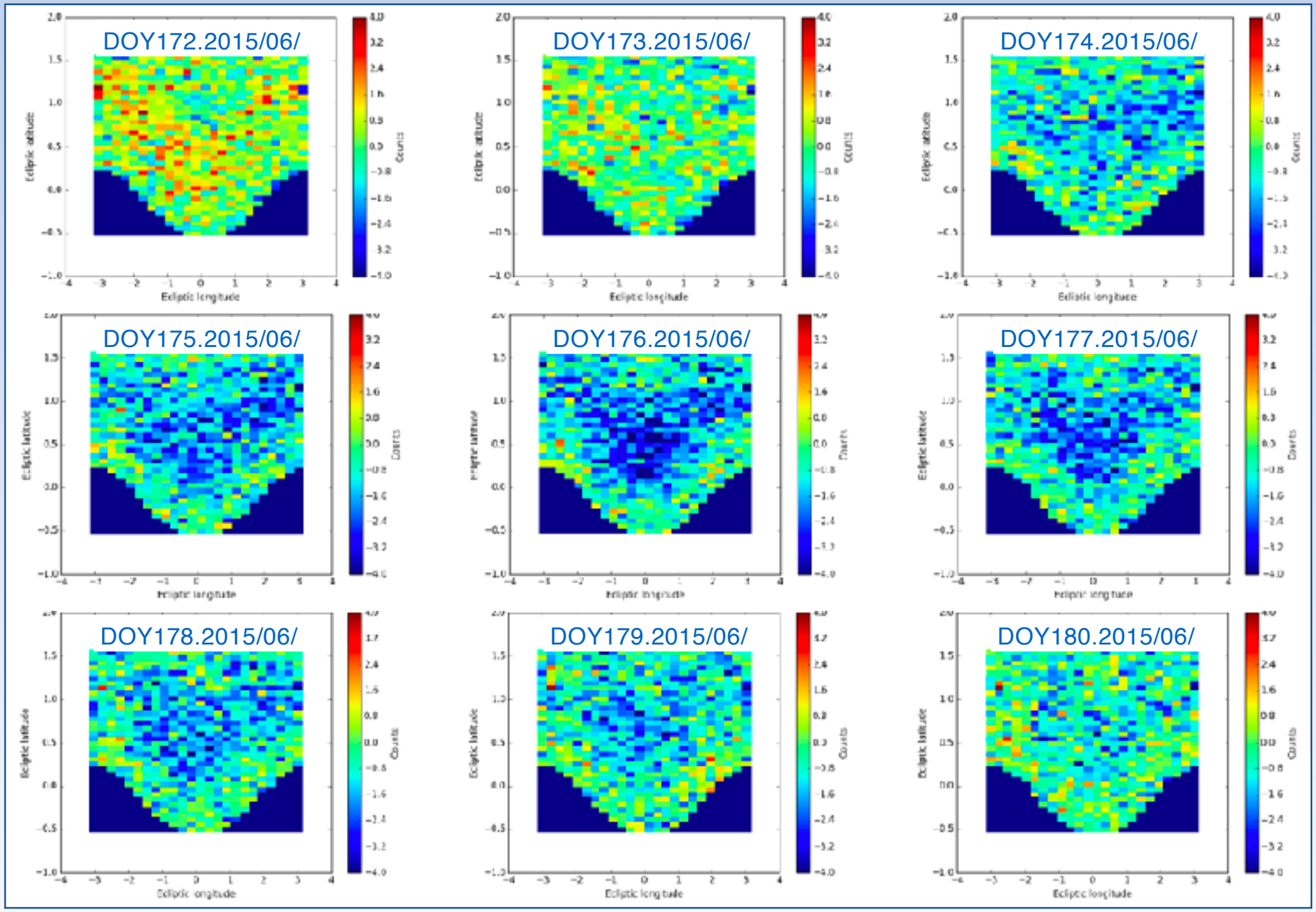




Not yet understood unexpected electron excesses!

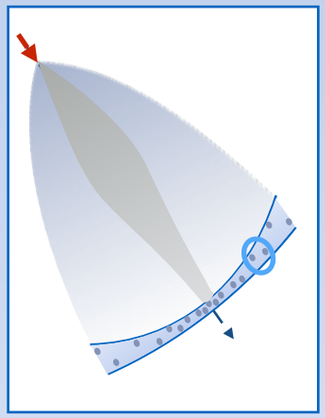
The Trasgo Project

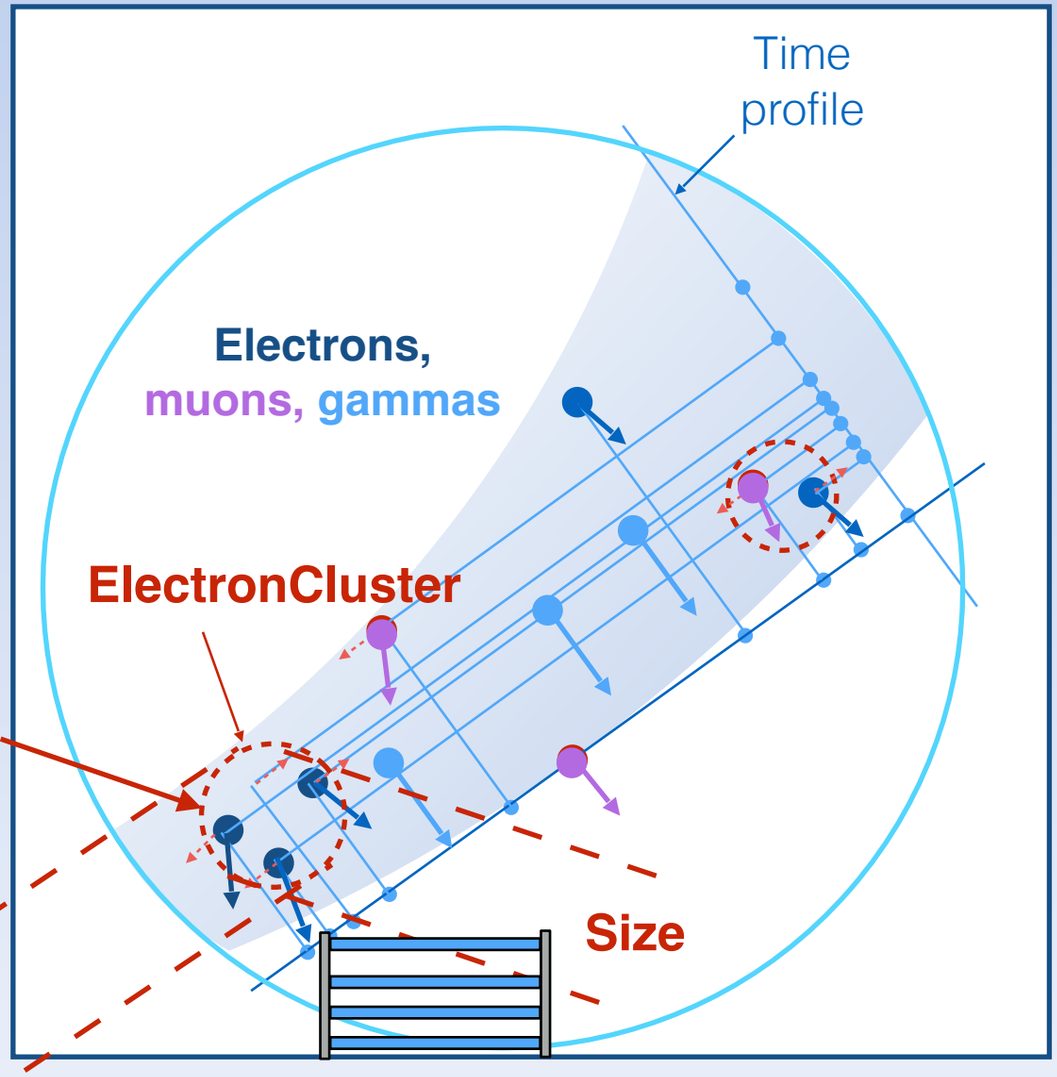
Tragaldabas. 2D June 2015 Forbush Decrease evolution

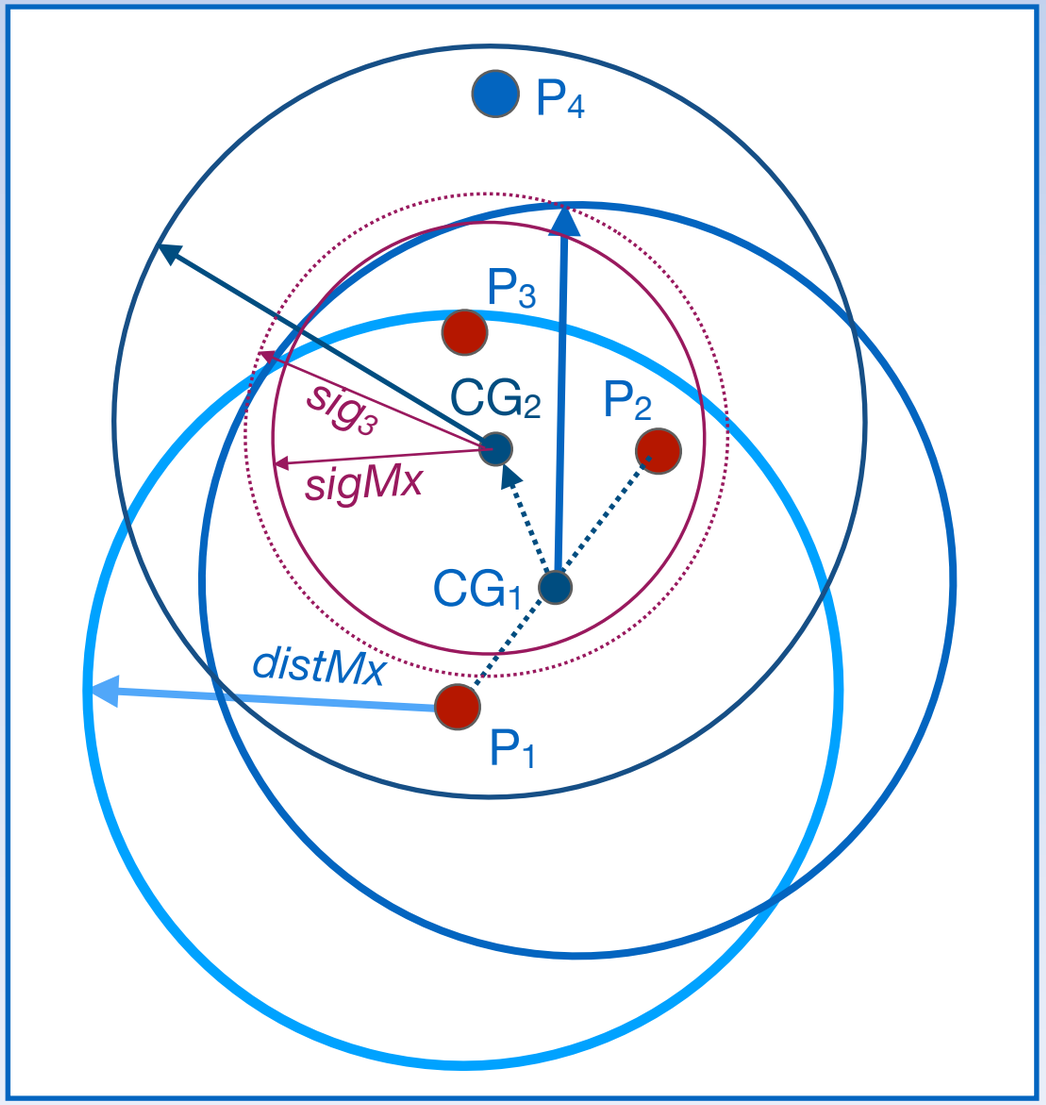


Cluster Analysis

Cluster search strategy





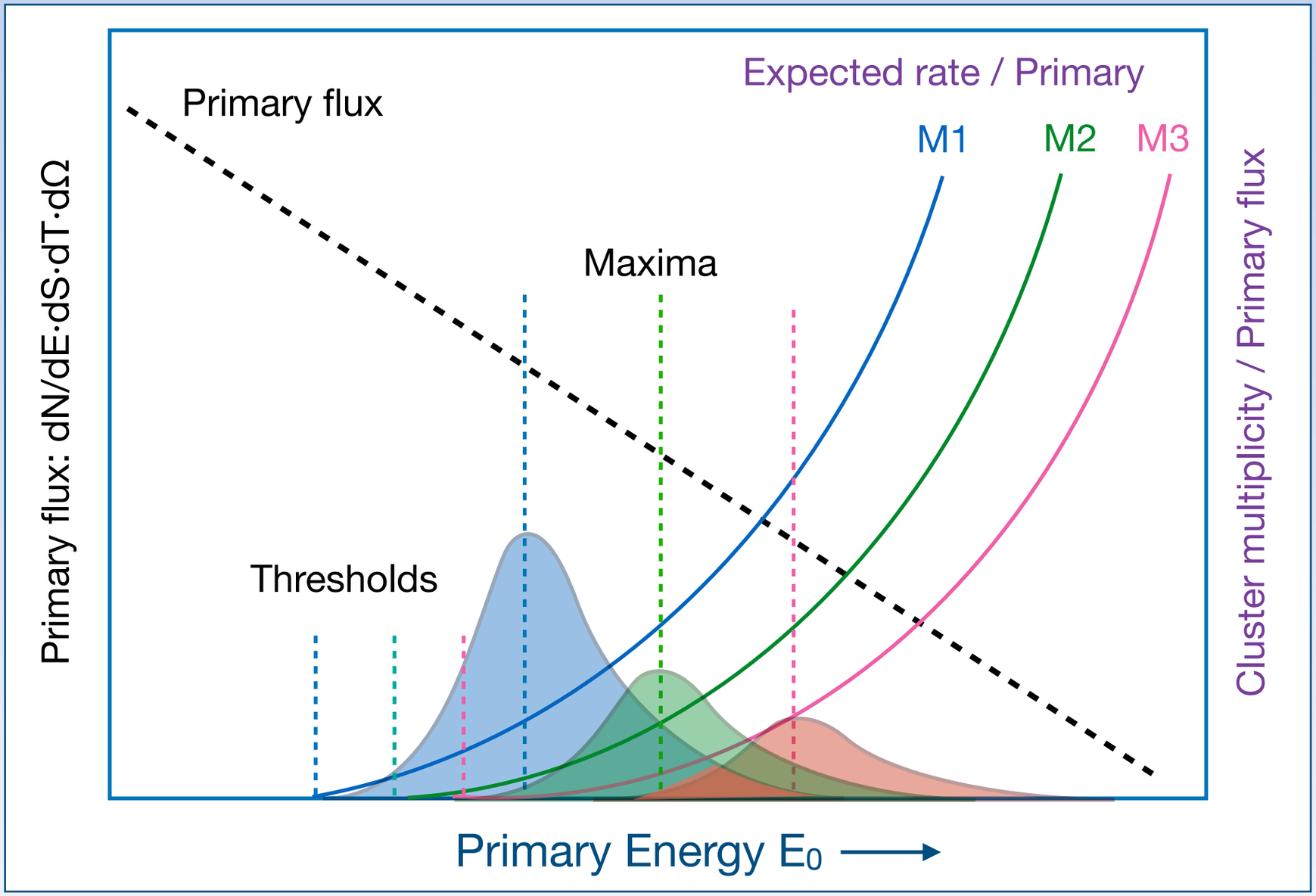


Clusters: Electron (> 1 electrons)
Muon (> 1 muons)
Mixed (1 muon + electrons)
1 Electron + Gammas (1 electron + gammas)
Gammas (only gammas)

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

Cluster Analysis

The 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

Algunos observables directos accesibles a un detector tipo MINGO:

- Tasa de rayos cósmicos aislados
- Tasas de distintas multiplicidades de rayos cósmicos
- Tasa de muones
- Tasa de electrones
- Espectro de energía de electrones
- Distribución angular de incidencia de muones
- Distribución angular de incidencia de electrones
- Distribución del tiempo de llegada entre rayos cósmicos
- Distribución de tiempos entre eventos
- Distribución de tiempos en grupos de partículas

Observables indirectos:

- Variaciones en la actividad solar y clima espacial
- Variaciones atmosféricas
- Variaciones en el campo magnético terrestre
- Variaciones en la tasa total del fondo de rayos cósmicos

Otras posibilidades:

- Los detectores pueden disponerse fácilmente en red, sincronizados, para cubrir mayores superficies

The Trasgo Project

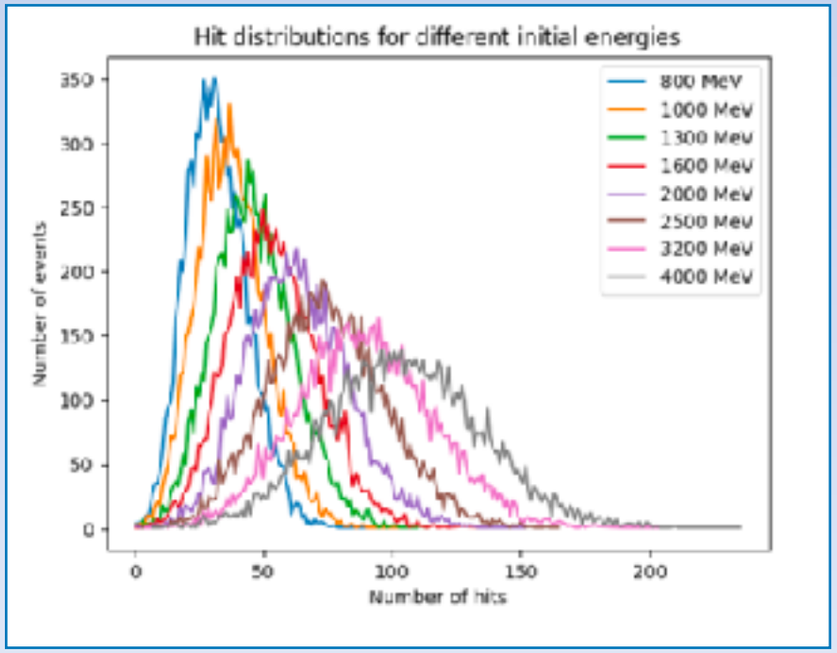
miniTrasgos. ECalorimetry

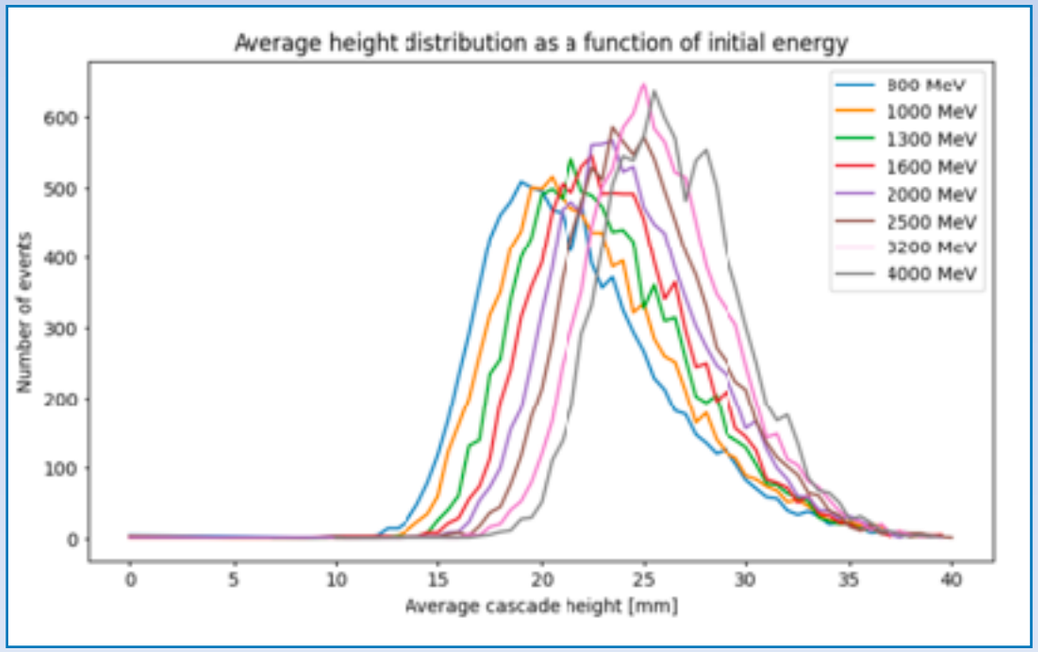
New simulations with Pb (Jose L. Rodríguez & Alfonso Sánchez)

Conf1

Pb 16.2 mm

Pb 10.4 mm

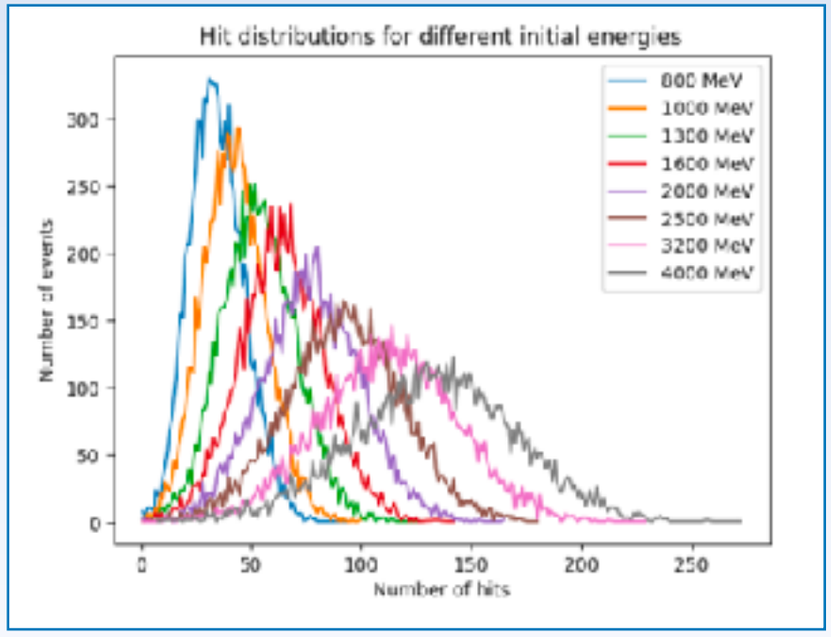




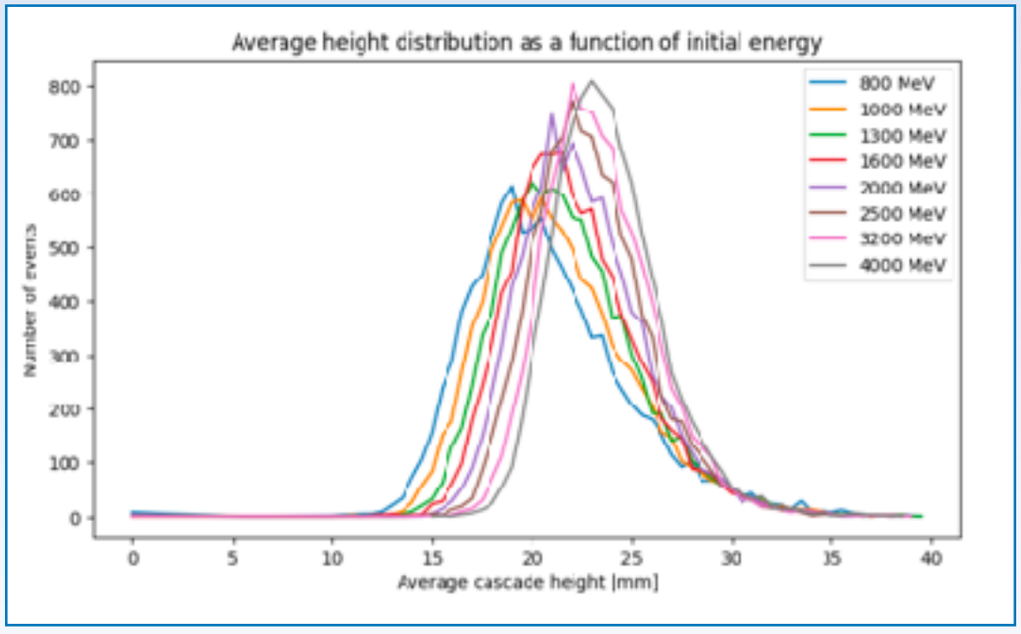
Conf2

Pb 10.4 mm

Pb 16.2 mm



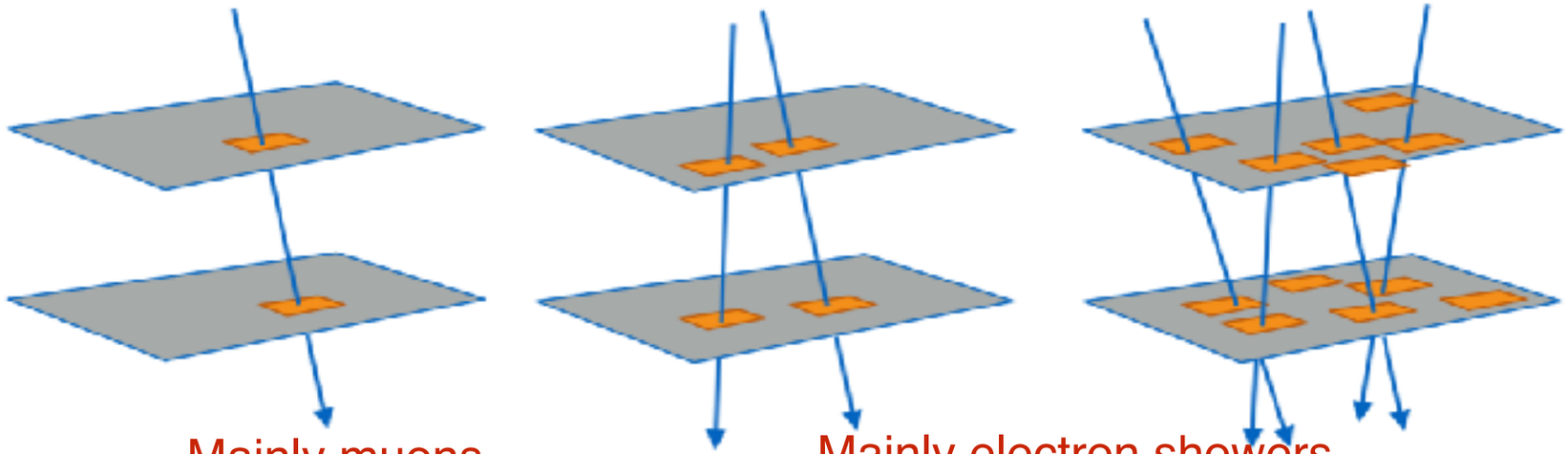
Hit N.



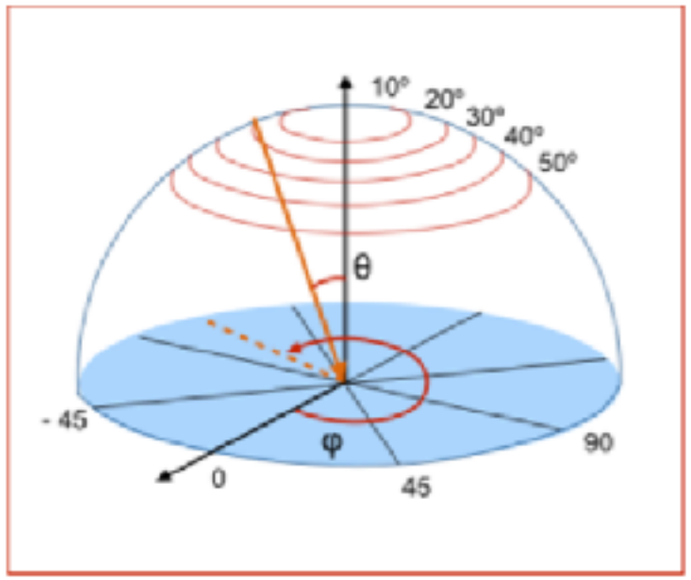
Mean depth / mm

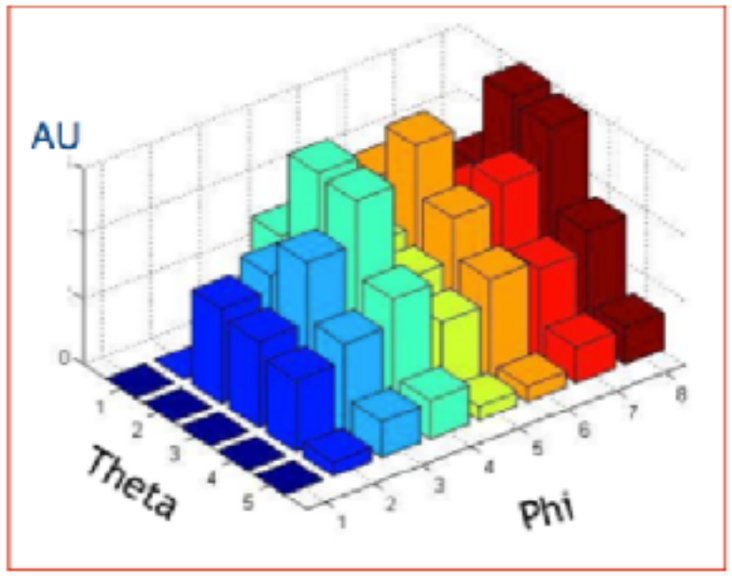
The Trasgo Project

Tragaldabas. Main data samples



3 sets of multiplicity: m





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