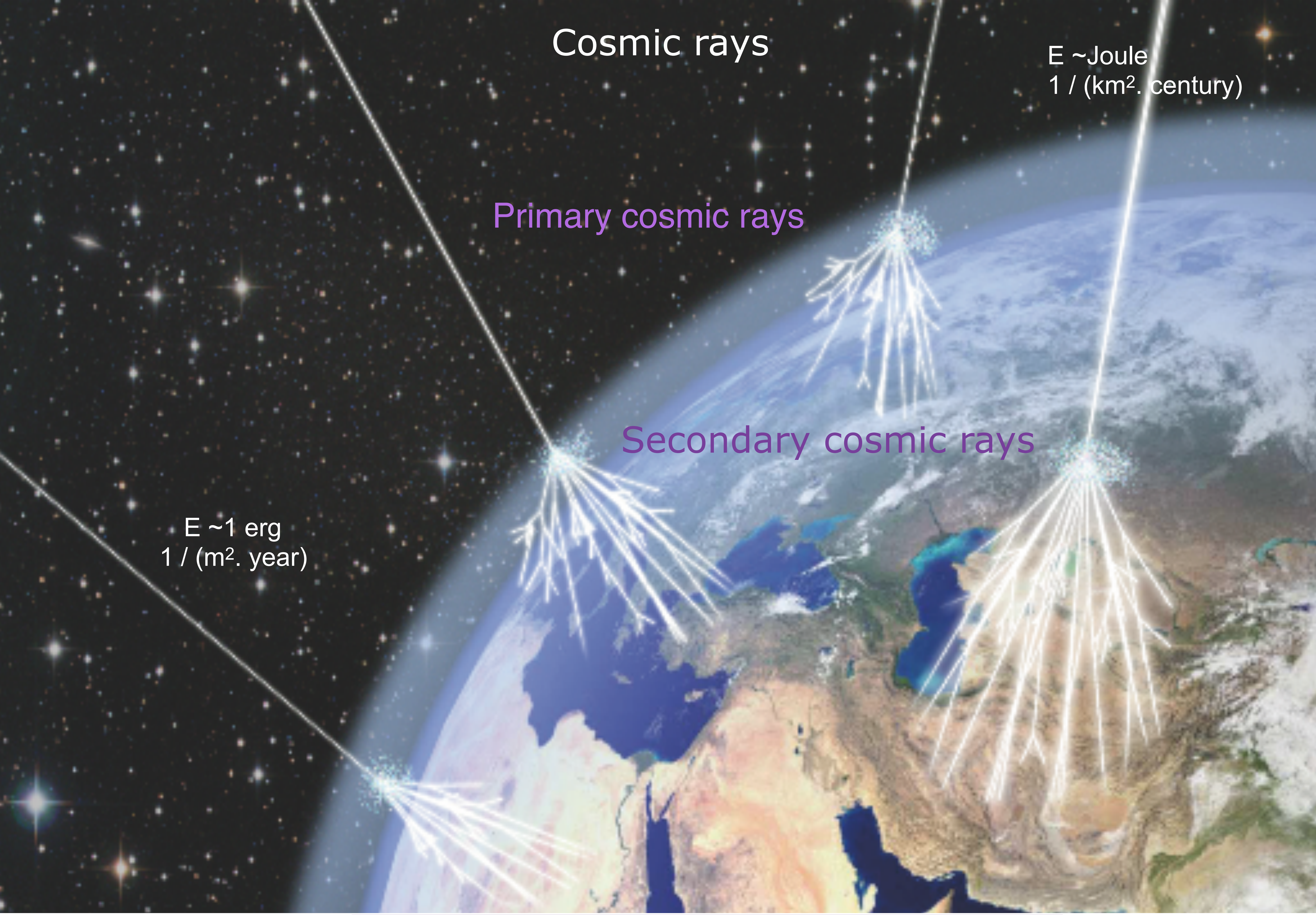
Trasgos

Towards a new standard of measuring cosmic rays

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

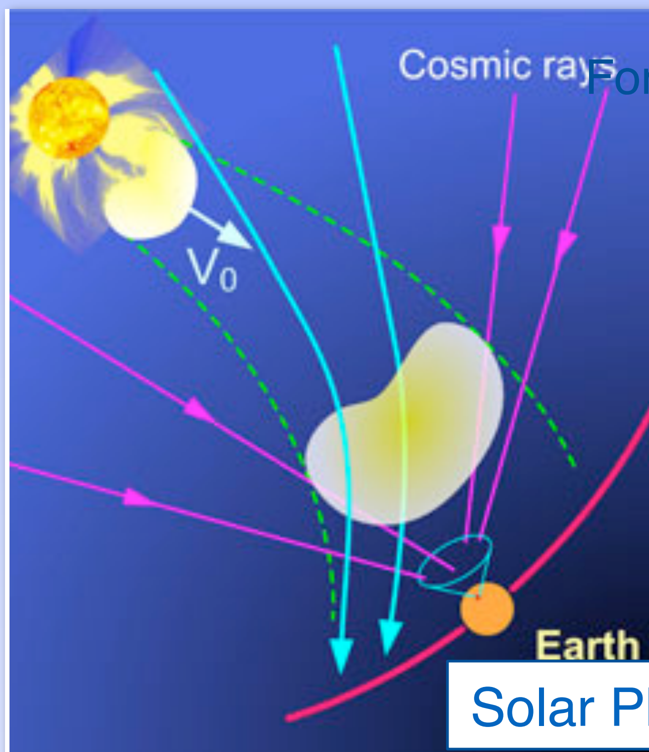
(on behalf of TRAGALDABAS, MuTT, TRISTAN and Stratos Collaborations)

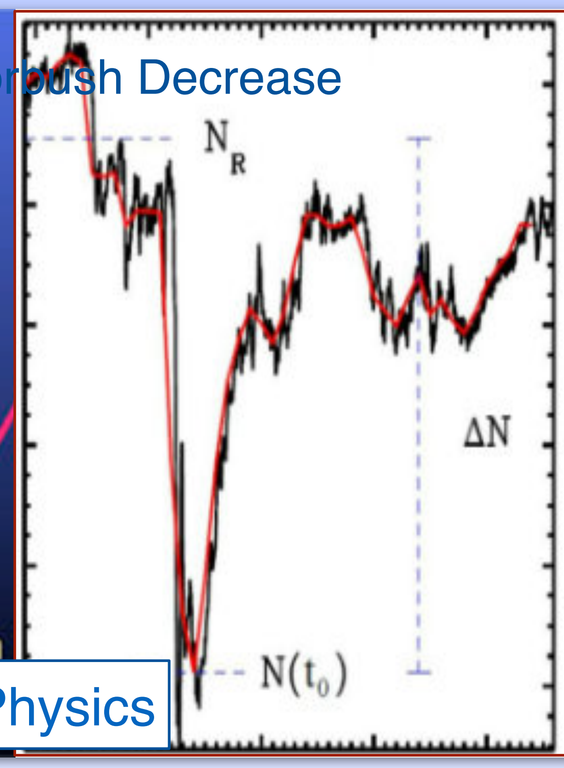
Cosmic rays


E ~Joule
1 / (km^2. century)
Primary cosmic rays
Secondary cosmic rays
E ~1 erg
1 / (m^2. year)

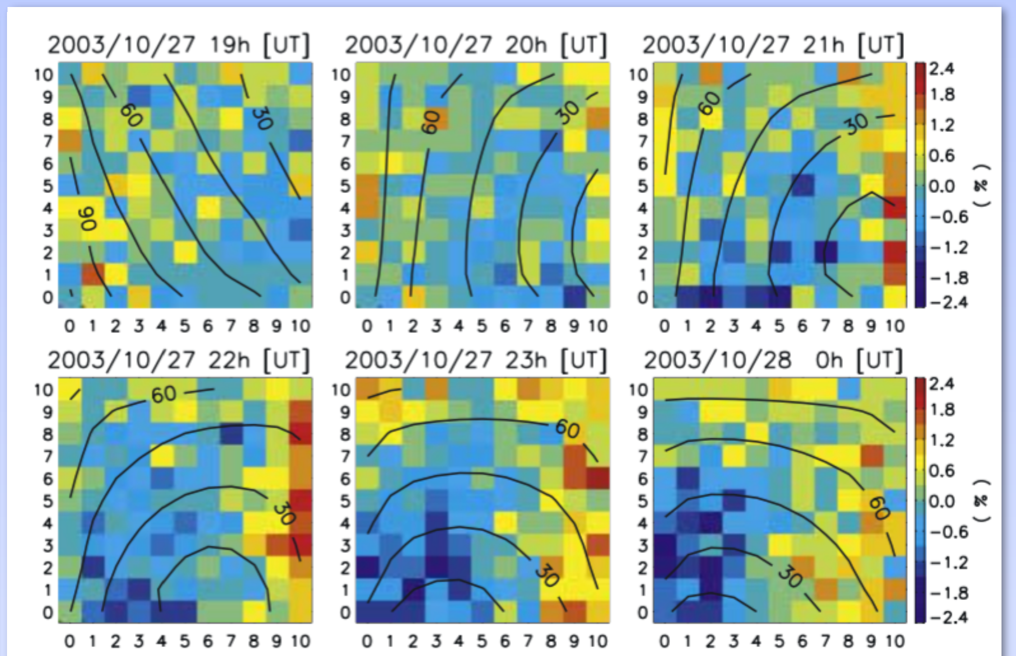
COSMIC RAYS

A few research fields

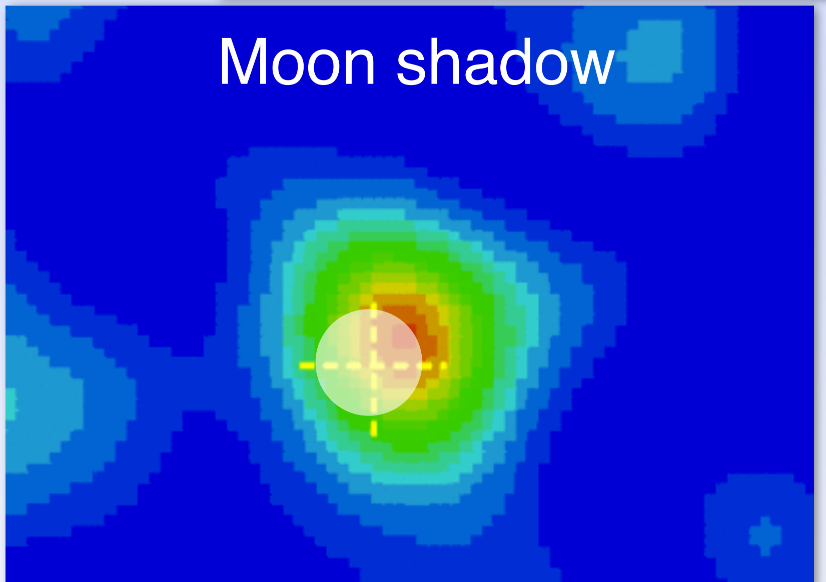




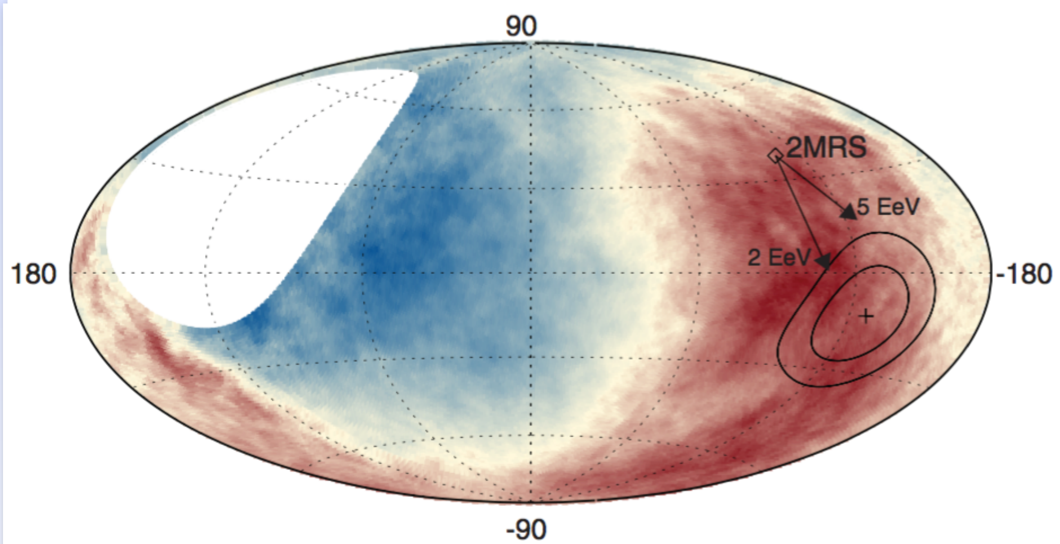
Solar Physics



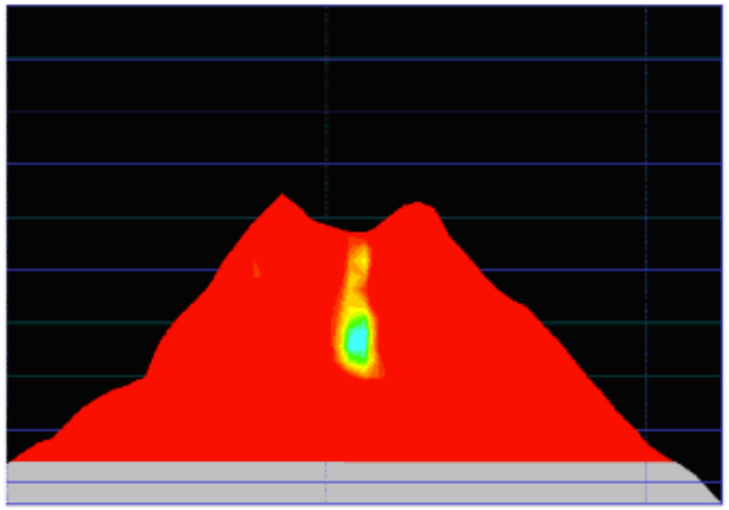
Magnetic storm forecasting



Interplanetary magnetic field

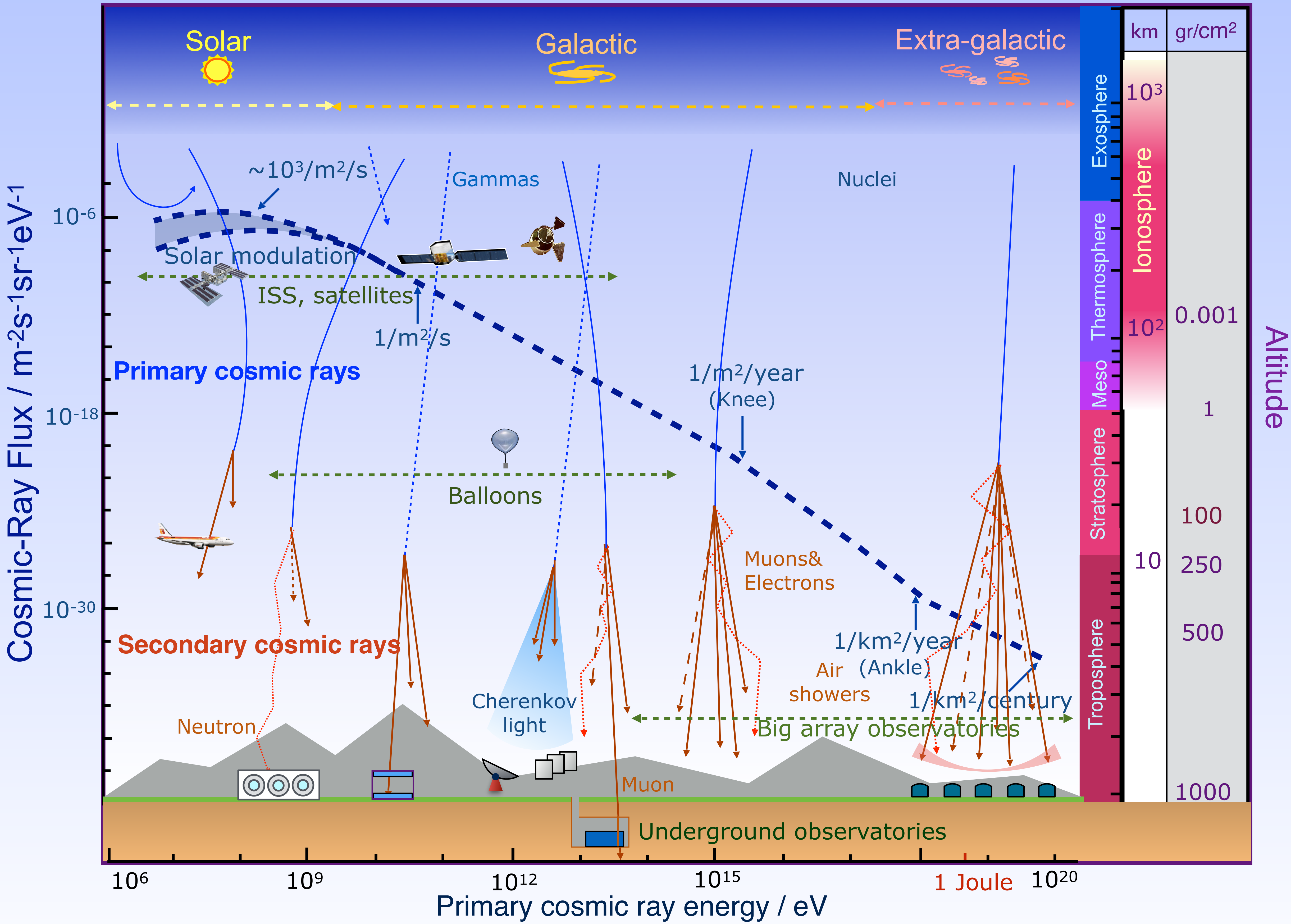


Cosmic Ray Astronomy



Muon tomography

THE COSMIC RAYS: Typical detectors



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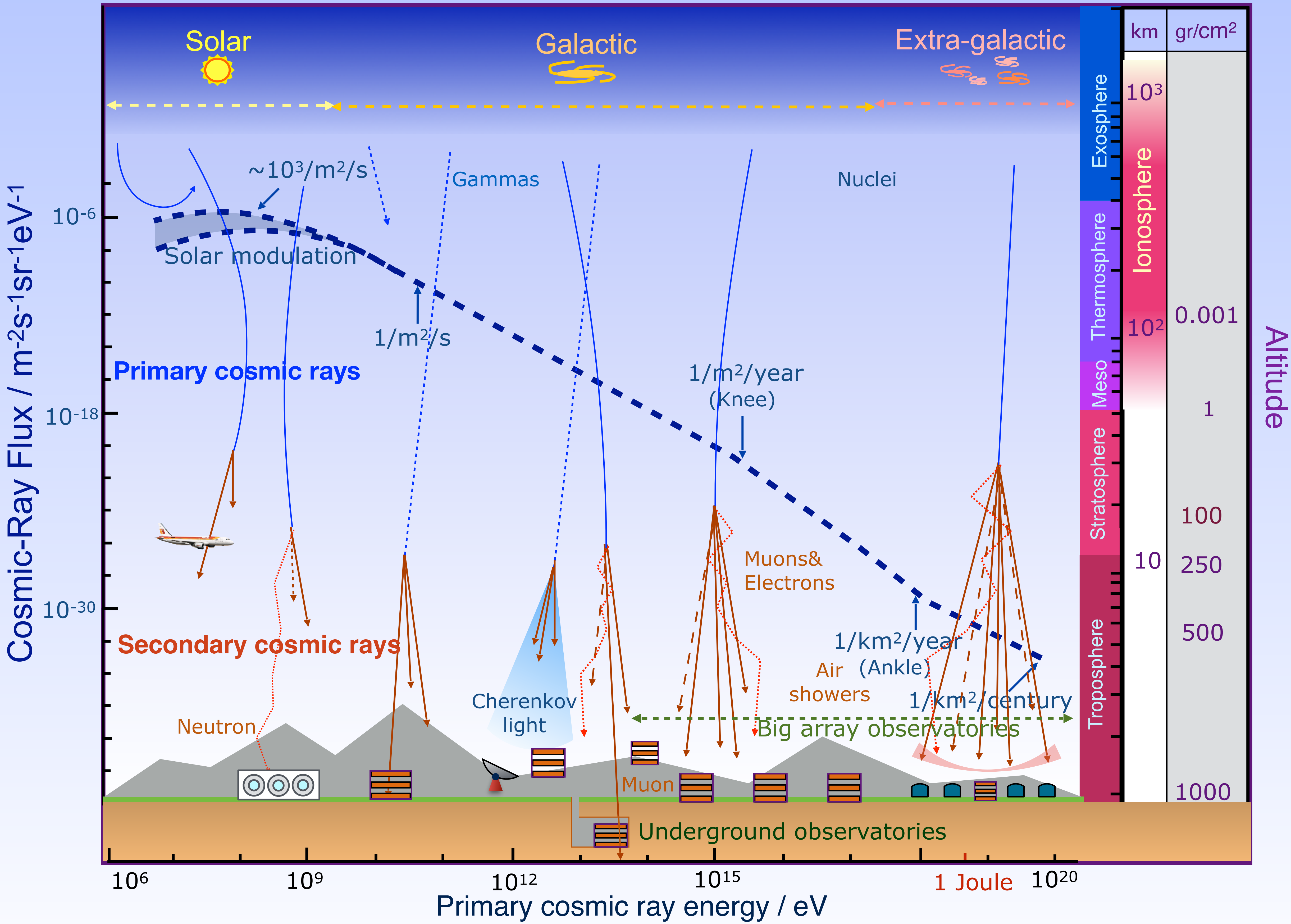
2nd. Joint IGFAE-LIP Workshop, S. Compostela April, 26th. 2019
LabCAF
Proyecto trasgo Project

THE COSMIC RAYS: TRASGOS, a versatile complement



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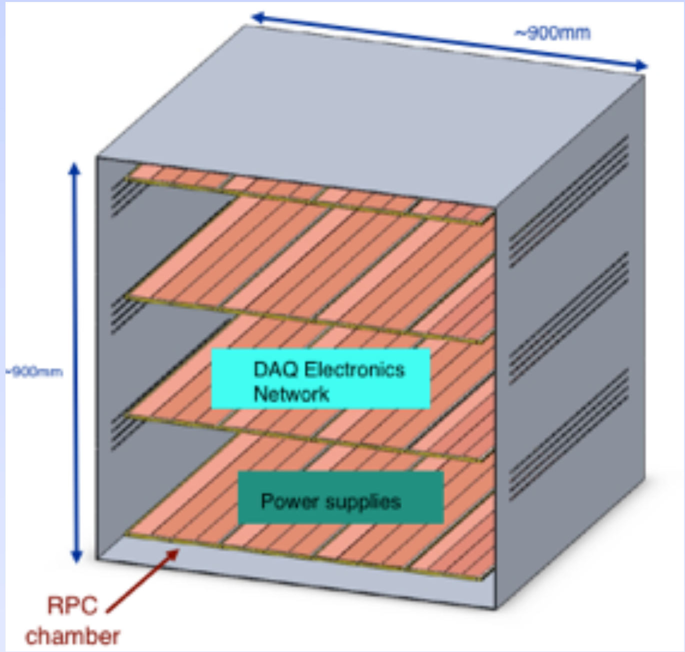
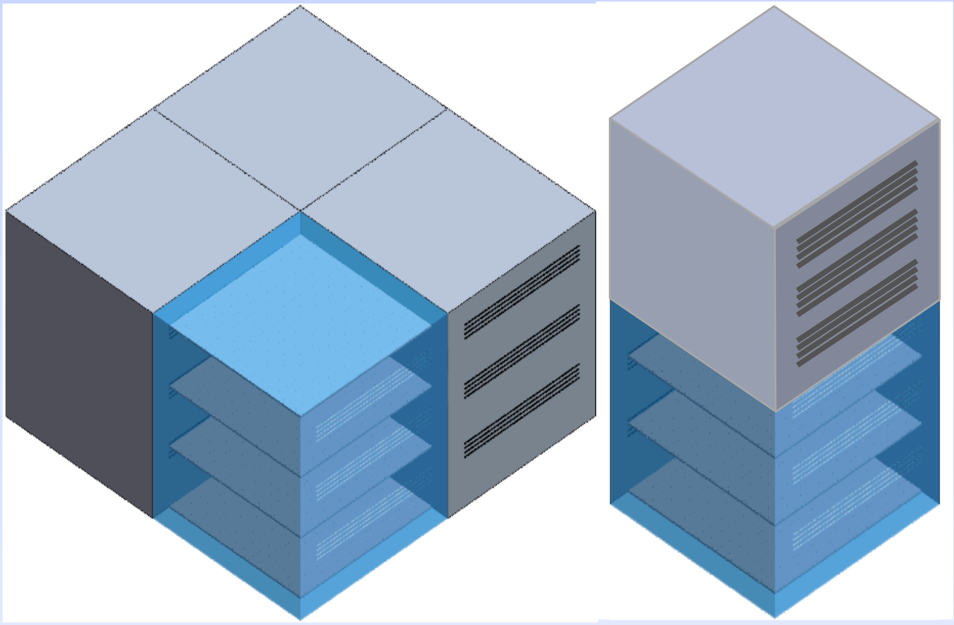
THE TRASGO CONCEPT
(A PHILOSOPHY)

TRASGO: TRAck reconStructinG bOx (Fradinho de mão furada)





Main features:

High granularity tracking detector

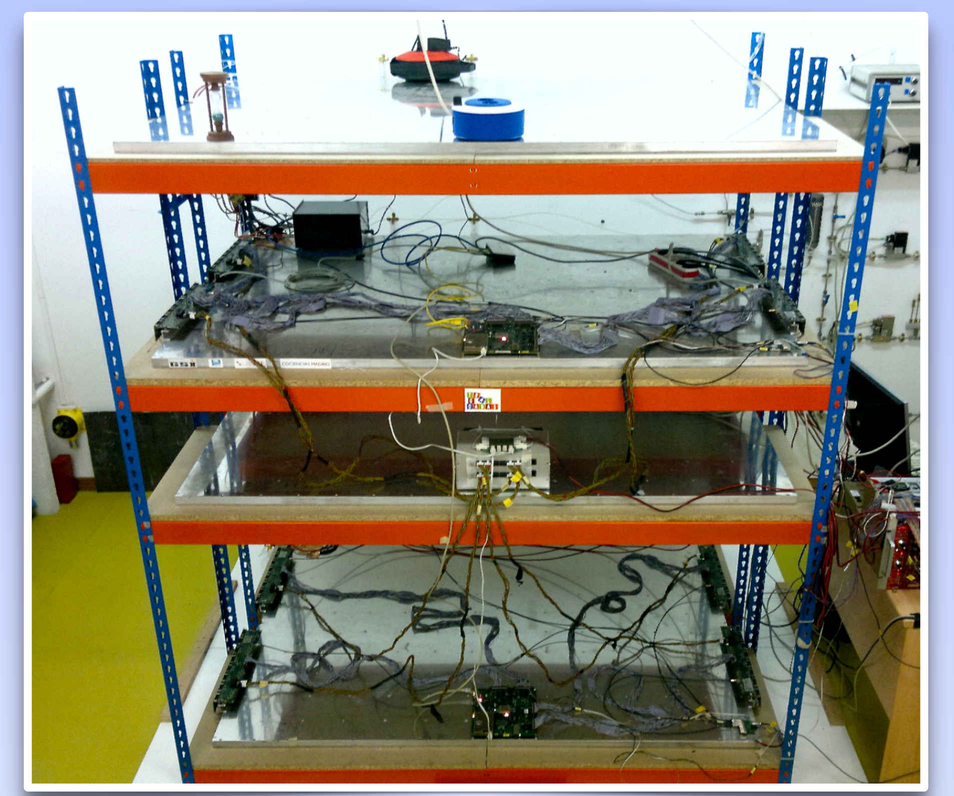
Electron-Muon PID

Affordable RPC-based detectors

High modularity

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

THE PRESENT FLEET OF TRASGOS

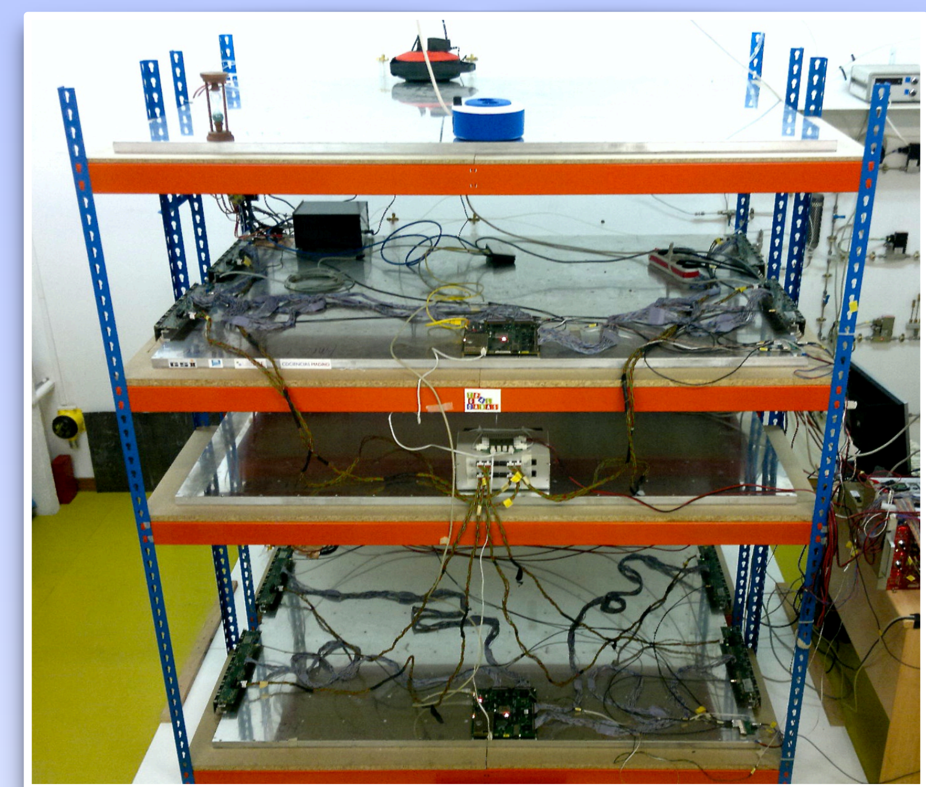


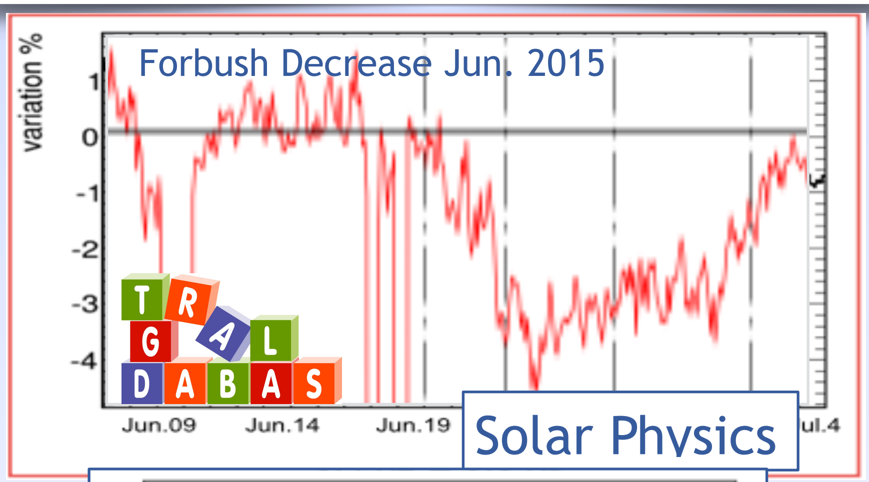
TRAGALDABAS
(Univ. S. Compostela)
Multipurpose detector

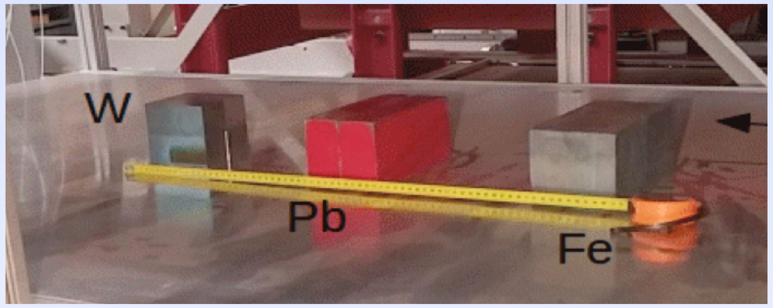
MuTT
(Porriño, Vigo)
Tomography studies
HIDRONAV Initiative

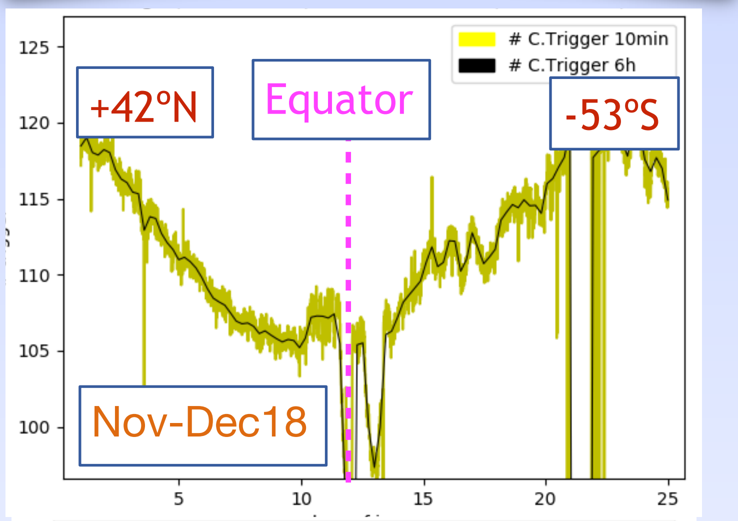
TRISTAN
(Antarctica, End 2019)
Multipurpose detector

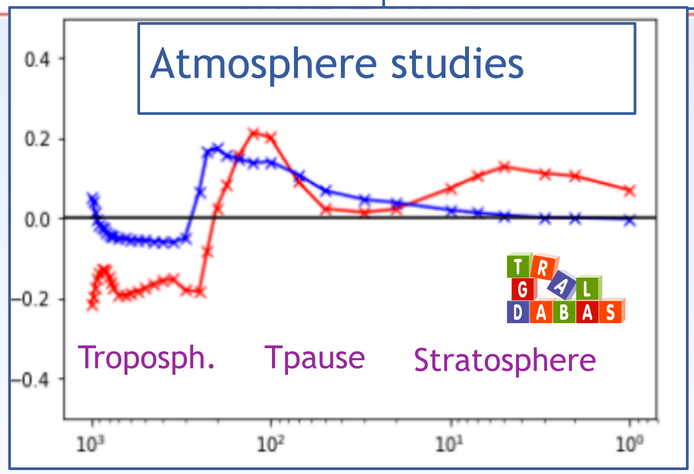
THE PRESENT FLEET OF TRASGOS

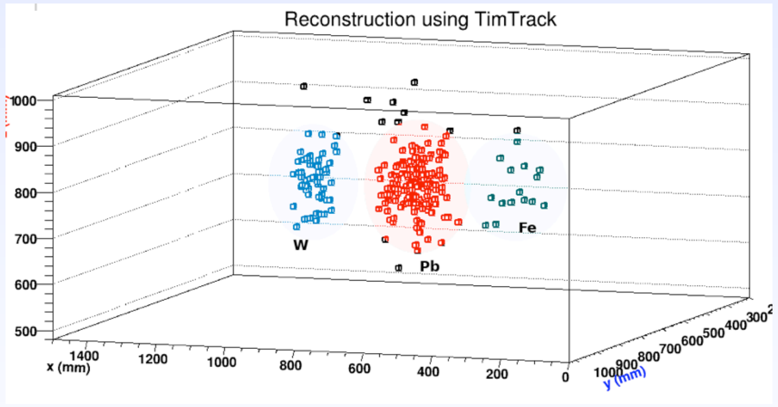


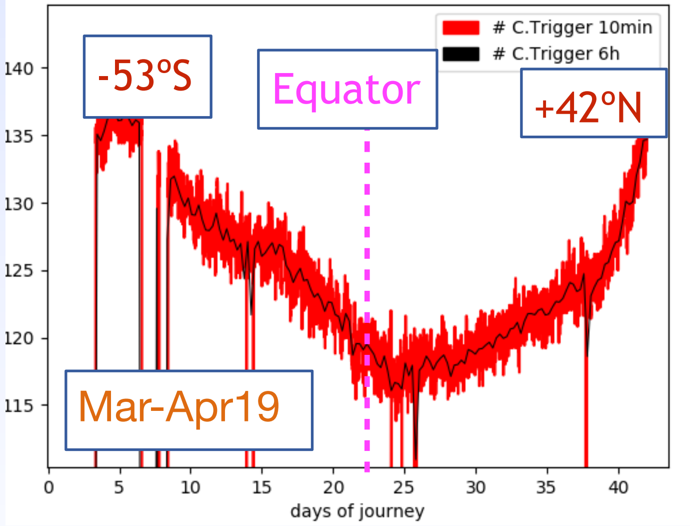












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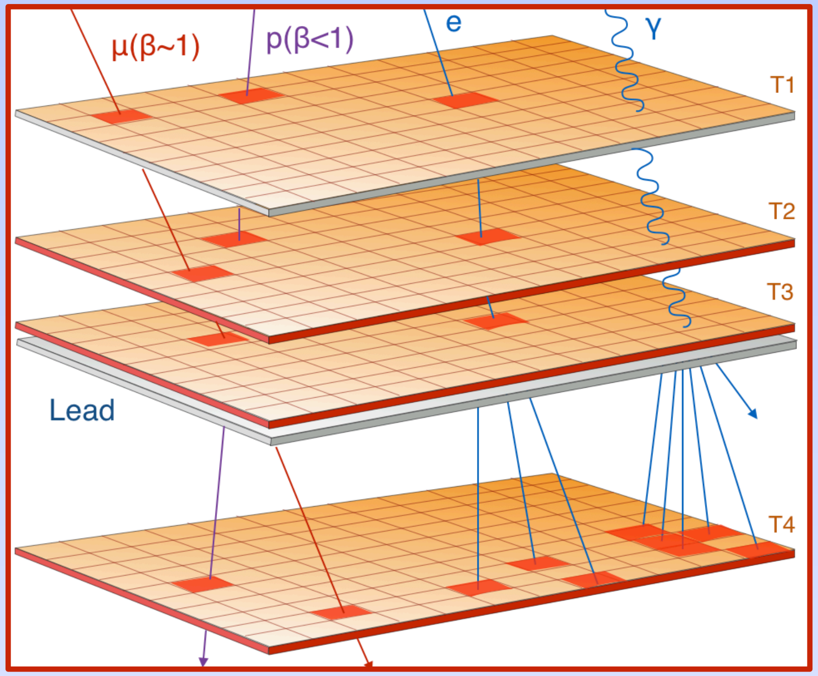
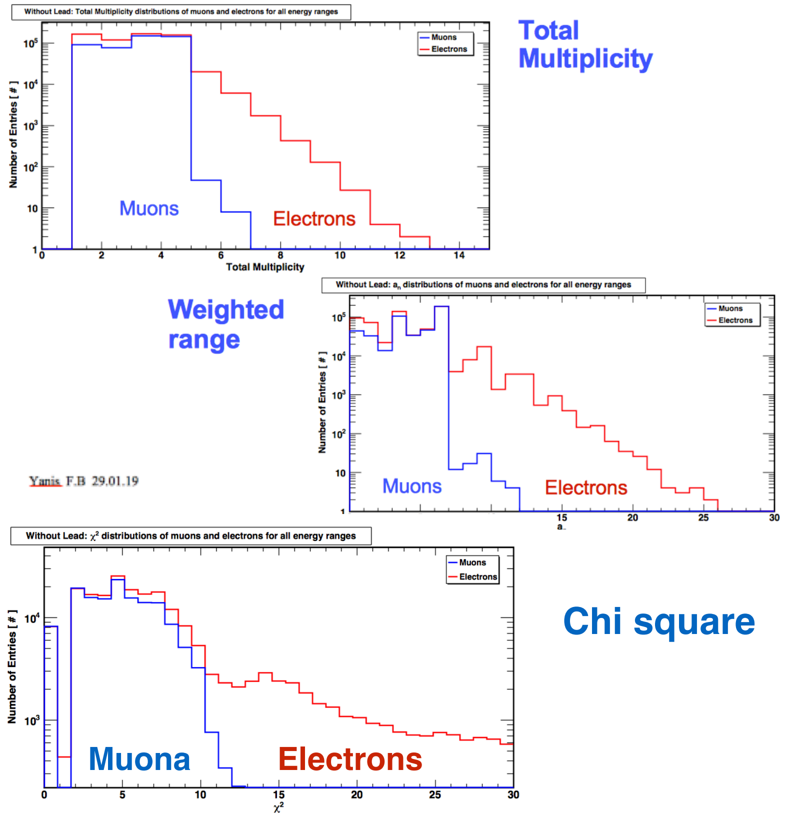
THE PRESENT FLEET OF TRASGOS

Some tools

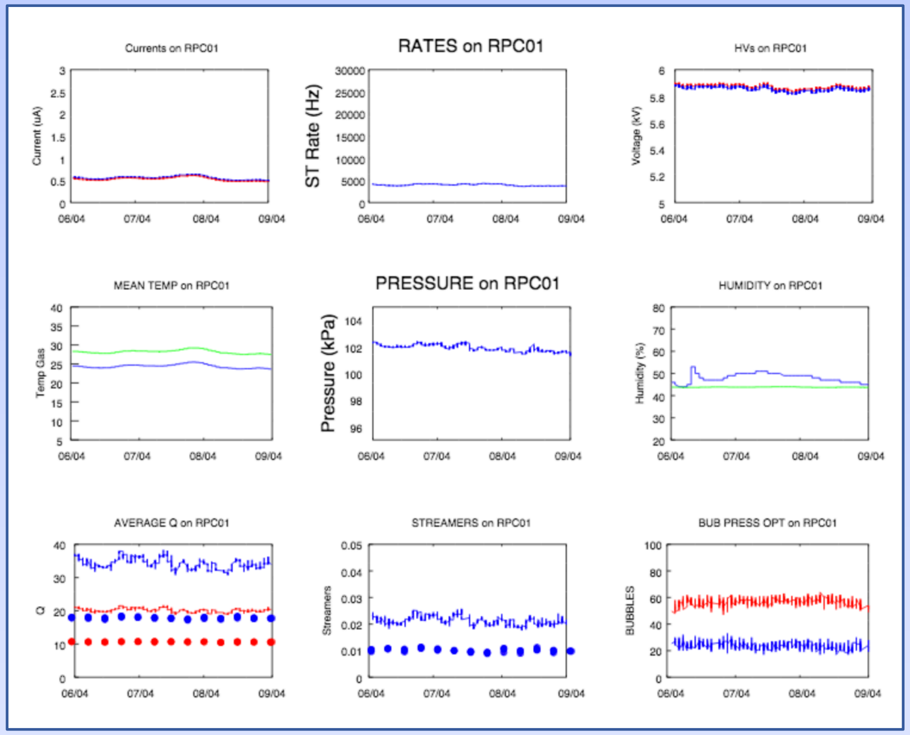
Particle identification

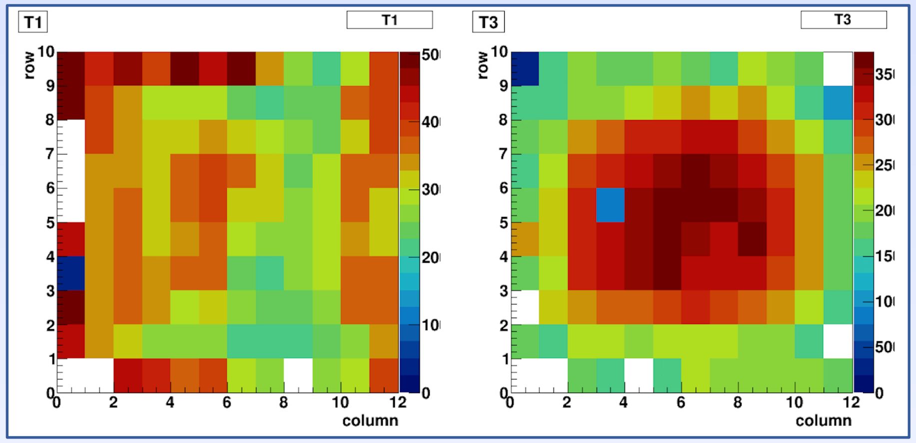


Simulation of 100k electrons and muons

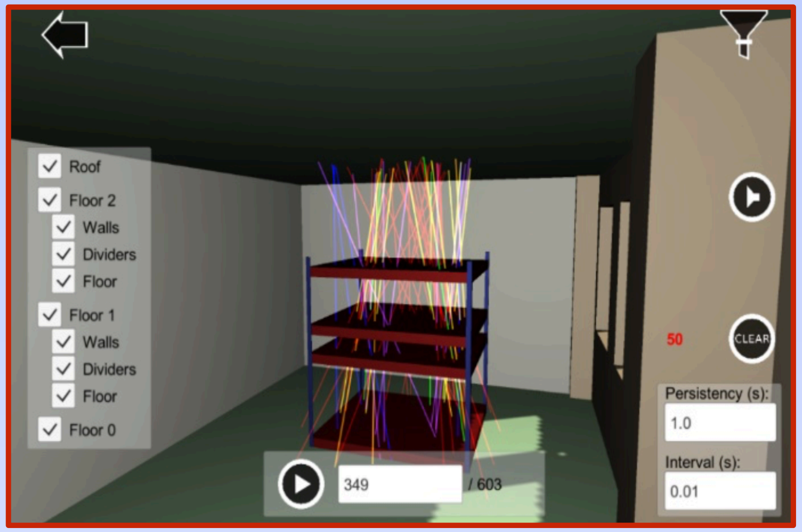


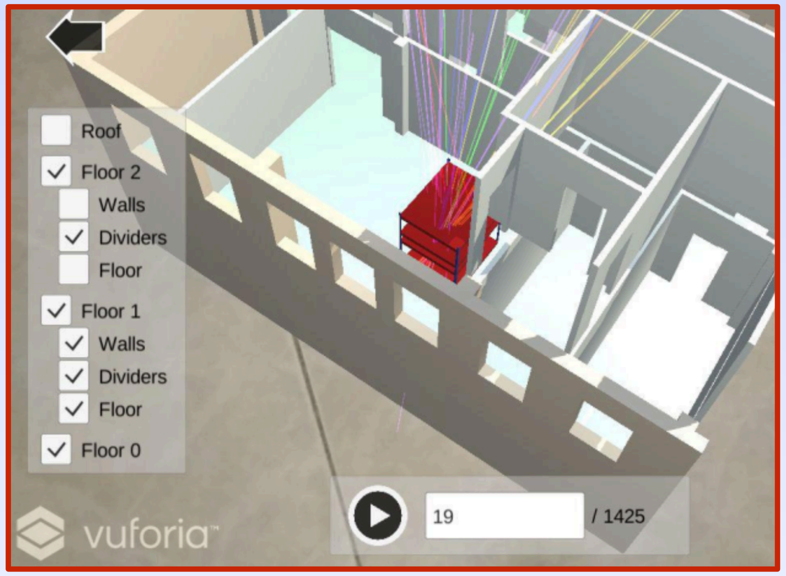
Monitoring





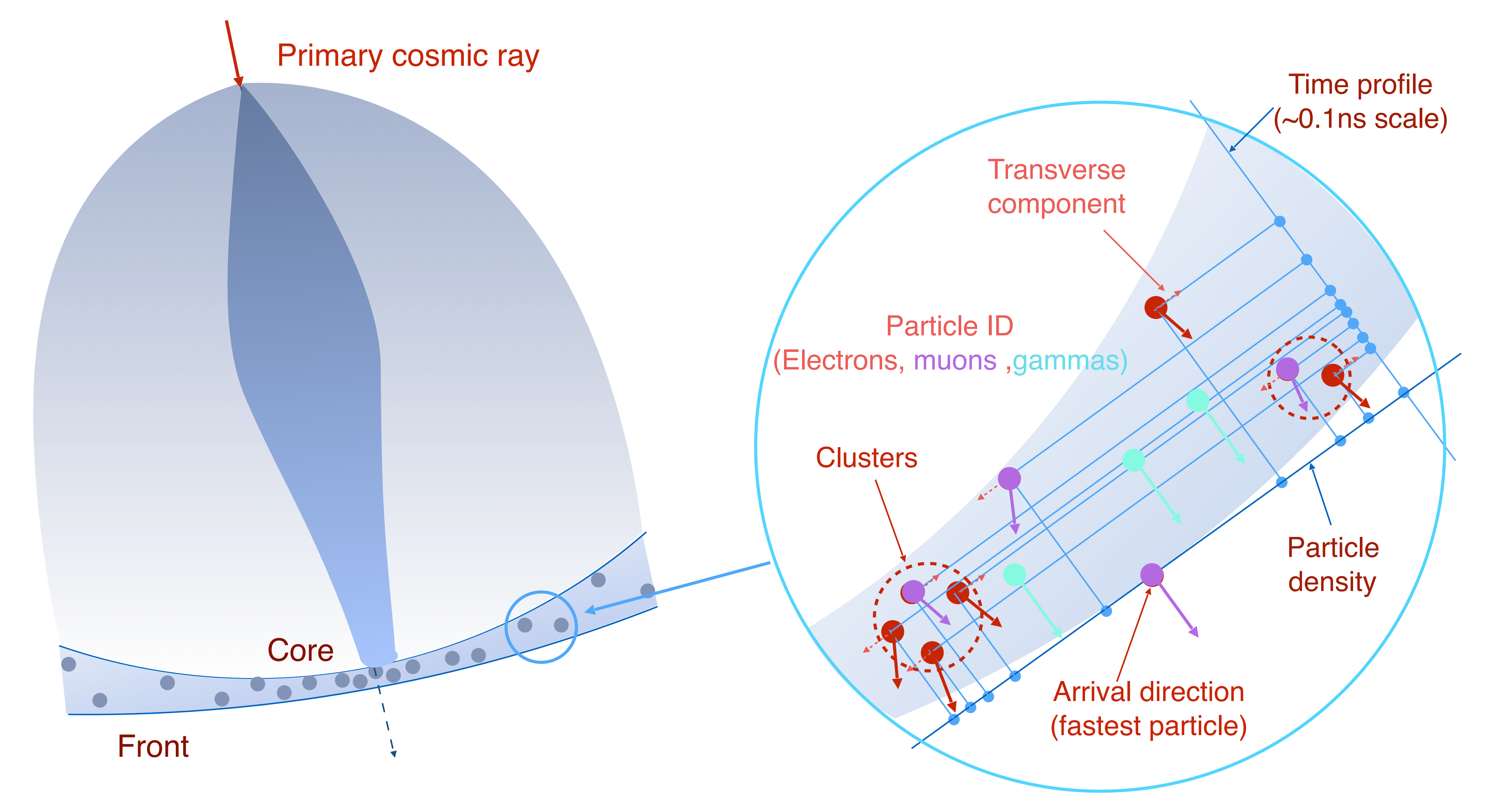
3D-Visualization





THE TRASGO PROJECT: Other initiatives

1. Analysis of the microstructure of cosmic ray air showers

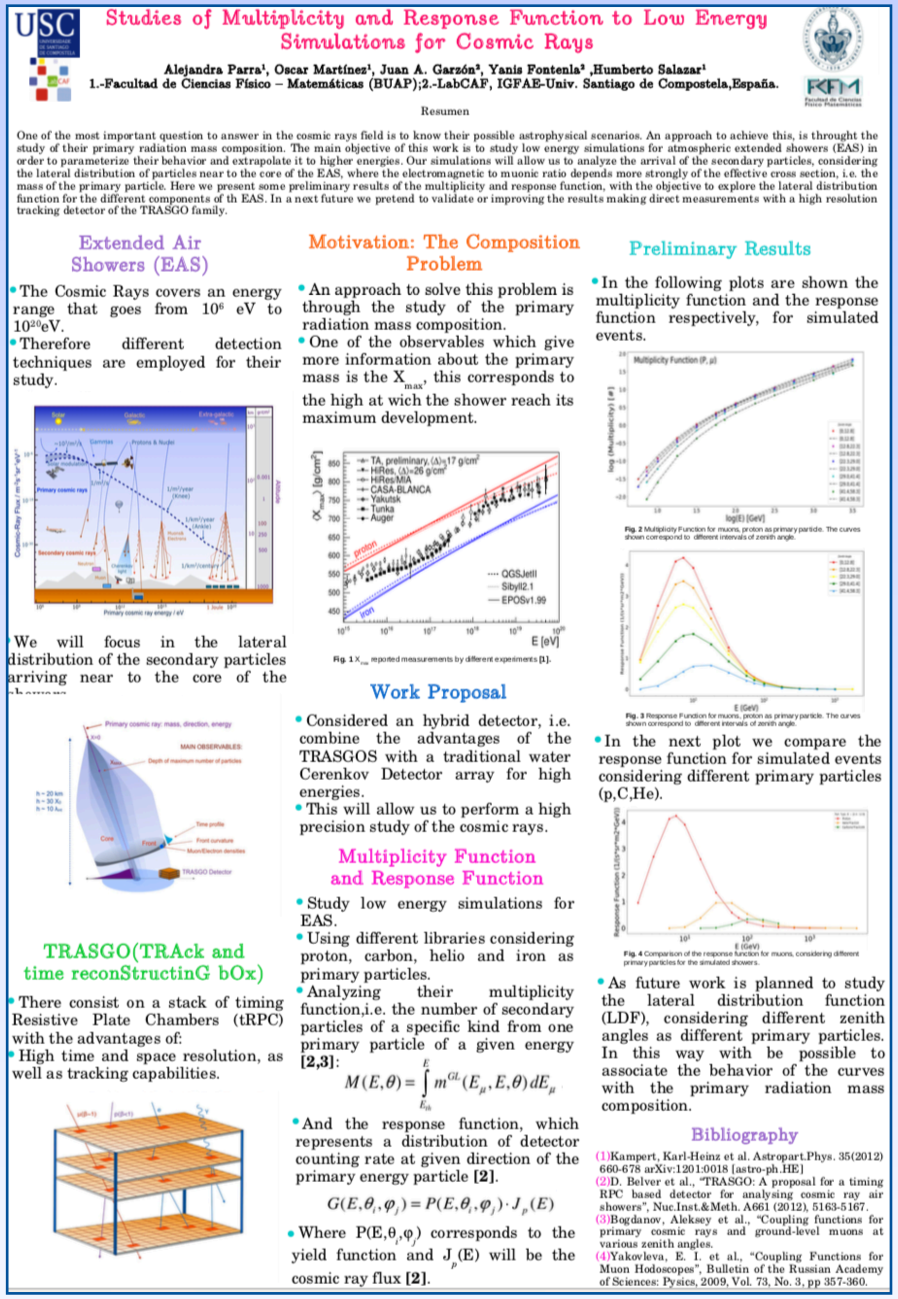


Correlations between primary cosmic ray parameters and air shower properties

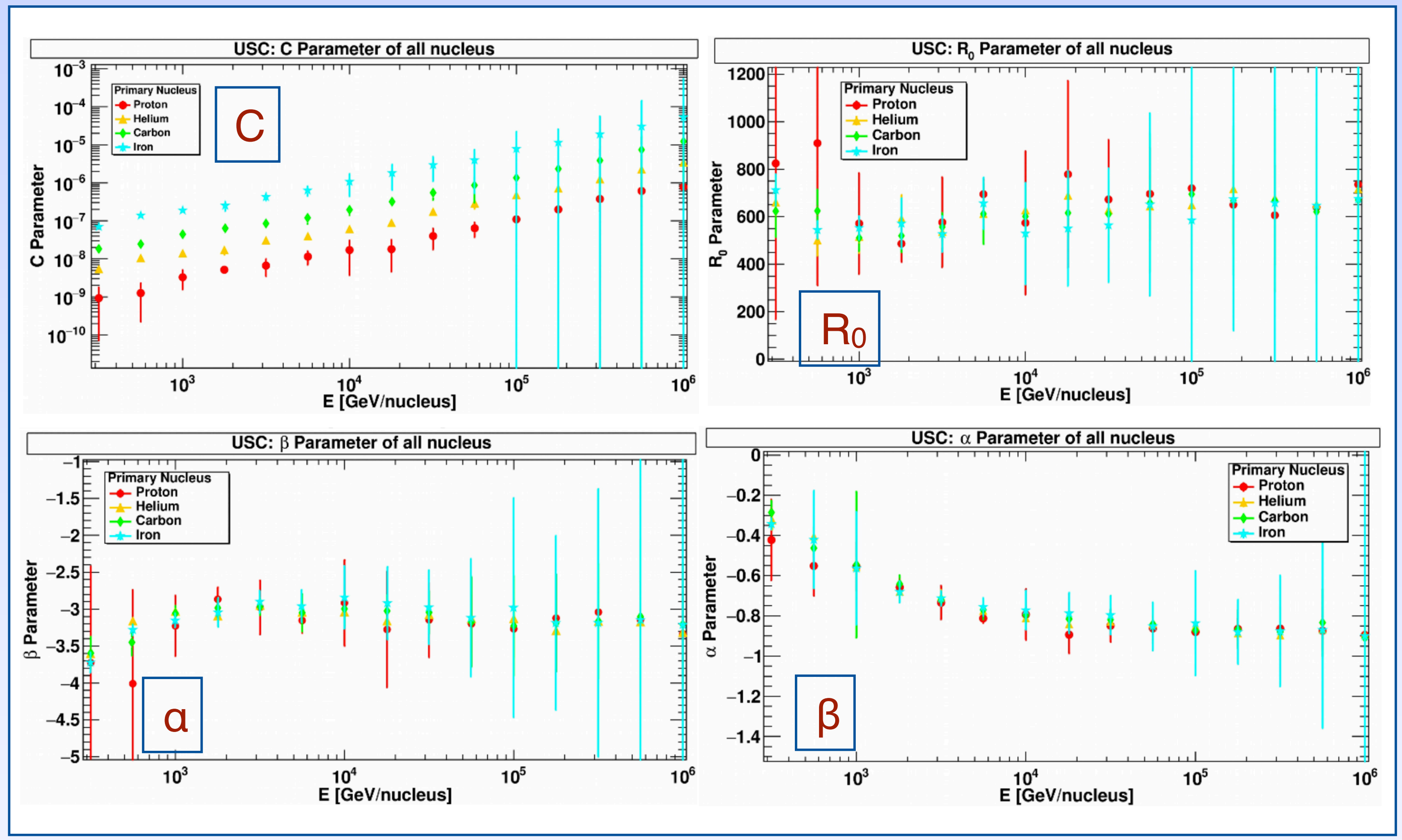
THE TRASGO PROJECT: Other initiatives

2. Systematic analysis of the properties of low energy cosmic ray extensive air showers (in S. Compostela- Spain, Sierra Negra- Mexico, Livingston I.-Antarctica)

1. Lateral distribution analysis [+ O. Martinez, A. Parra (Puebla, Mexico)]



$$\rho(R) = C\,(R/R_0)^{\alpha}\,(1+R/R_0)^{\beta}$$



2018: Mexican meeting on particles&fields

Lateral distribution analysis for P, He, C & Fe, under the knee at SCQ

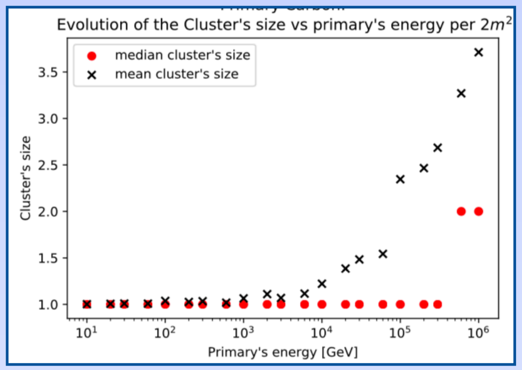
THE TRASGO PROJECT: Other initiatives

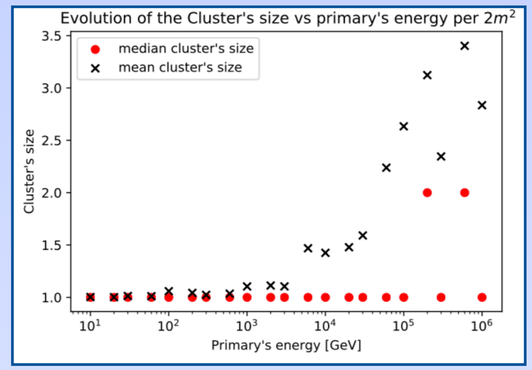
2. Systematic analysis of the properties of low energy cosmic ray extensive air showers (in S. Compostela- Spain, Sierra Negra- Mexico, Livingston I.-Antarctica)

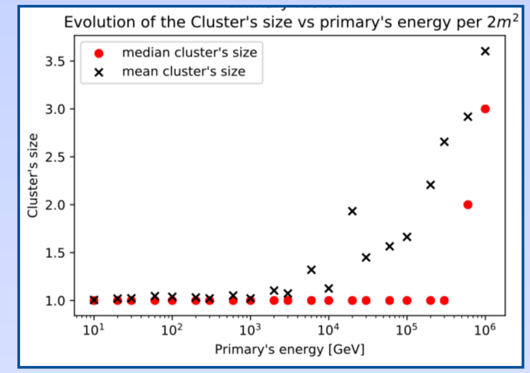
2. Muon cluster analysis analysis [+ A. Diaz]

P | He | C | Fe

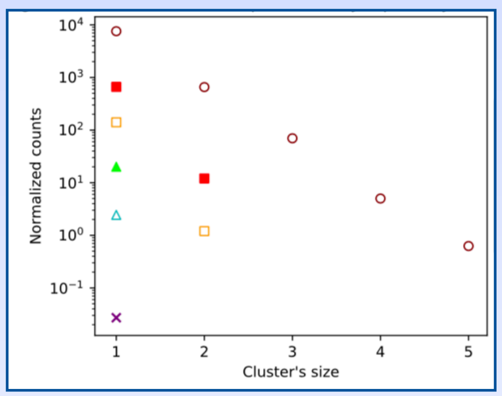
cluster size vs. energy

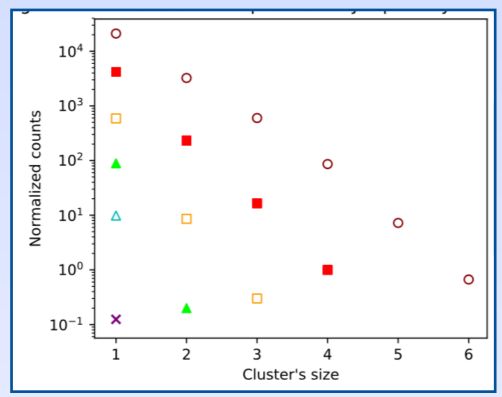


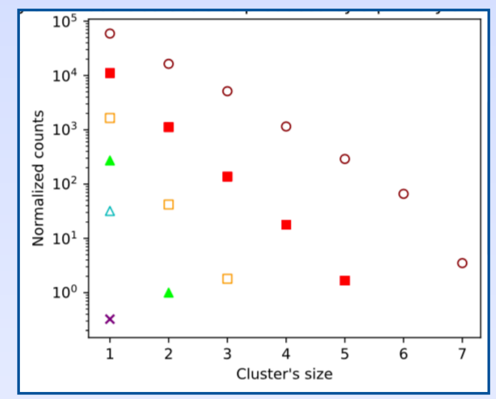




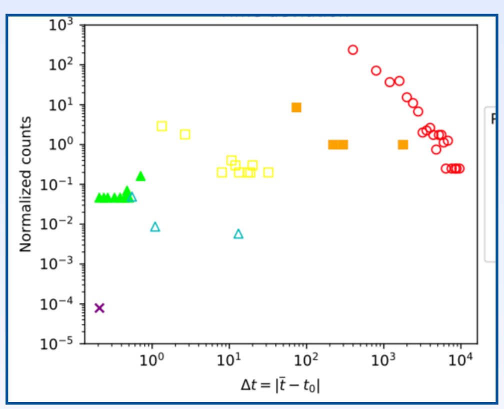
μ clusters

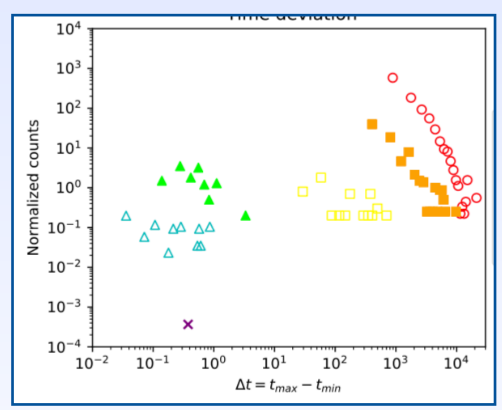


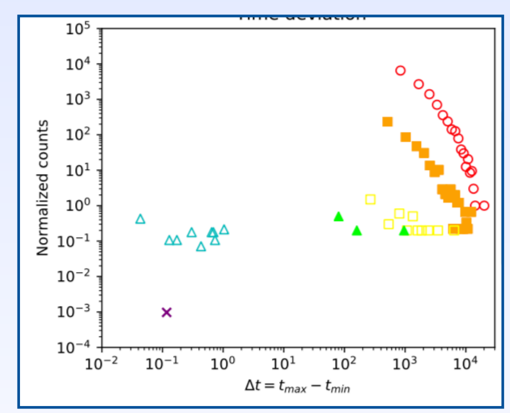


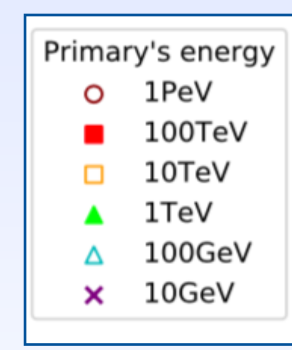


cluster time width







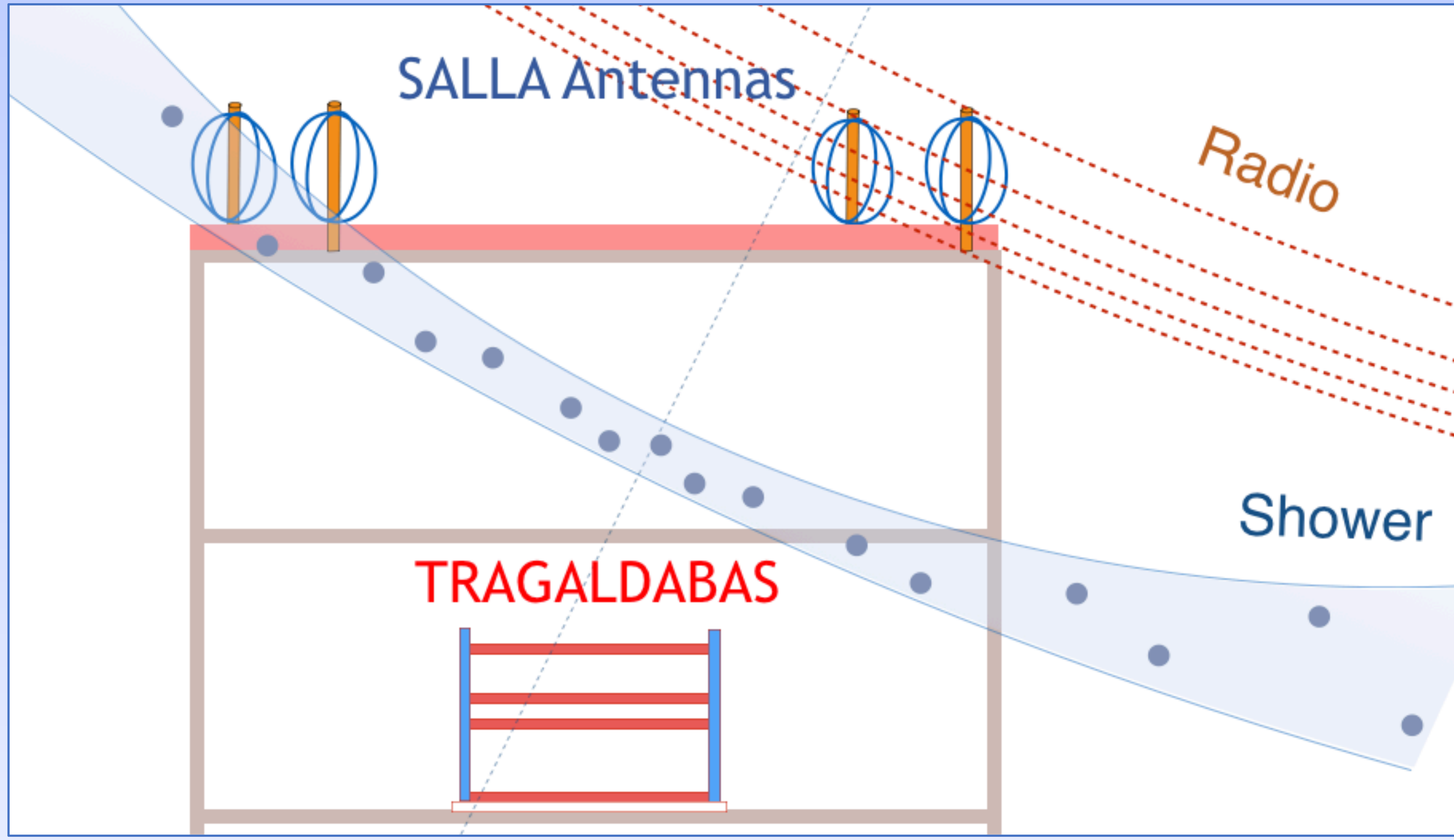


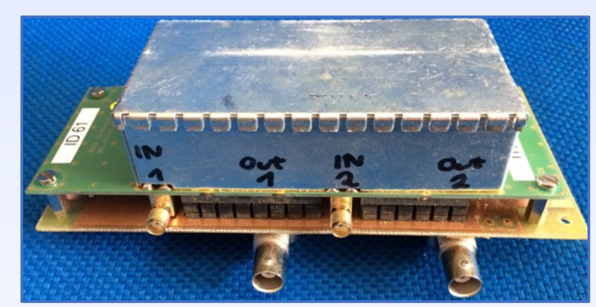
Correlations between primary cosmic ray parameters and cluster of particles properties

THE TRASGO PROJECT: Other initiatives

3. MICROSCOPE: MIni Cosmic Ray Observatory of Santiago de COmPostEla

Four SALLA antennas have been installed at the roof on top of the TRAGALDABAS detector





👁 Correlation between Tragaldabas measurements with an external energy estimation

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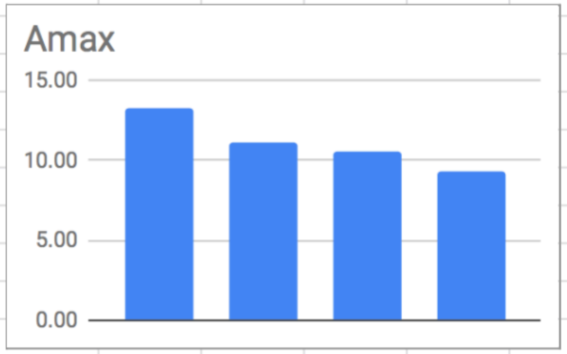
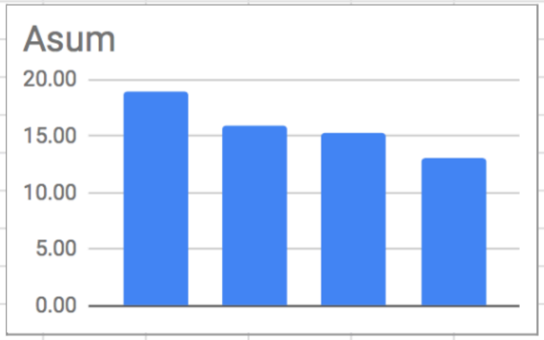
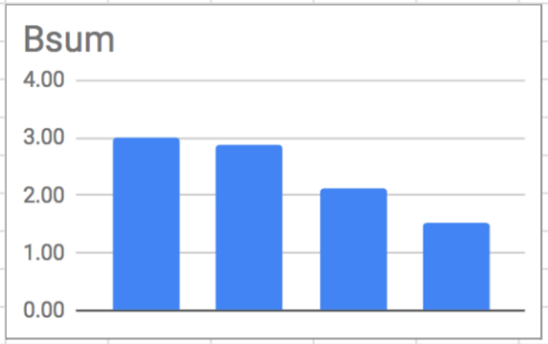
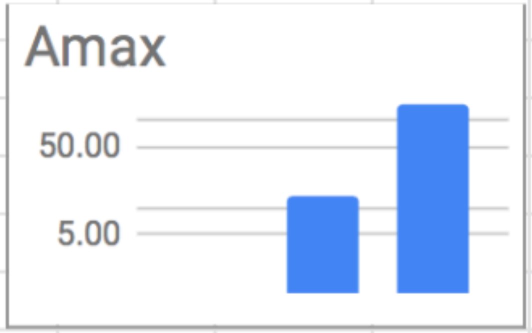
Z	A	Xa	Ya	Seed	1stH	MxPH	NMxP	Amax	AL	AR	BL	BR	BLL	BRR	tMax	tAL	tAR	tBL	tBR	tBLL	tBRR	Asum
1	1						mean	13.29	2.86	2.84	0.55	0.87	0.30	1.30	2.75	-26.00	30.88	-17.50	22.75	-37.28	39.25	18.99
2	4						mean	11.09	2.41	2.37	0.50	0.92	0.27	1.18	2.88	-25.63	31.13	-17.13	23.00	-37.13	39.38	15.87
6	12						mean	10.58	2.27	2.49	0.51	0.92	0.28	0.43	3.00	-25.63	31.38	-17.00	22.75	-36.88	43.25	15.34
26	56						mean	9.28	1.97	1.85	0.46	0.78	0.24	0.05	3.25	-25.63	31.75	-16.88	24.00	-36.75	32.44	13.09

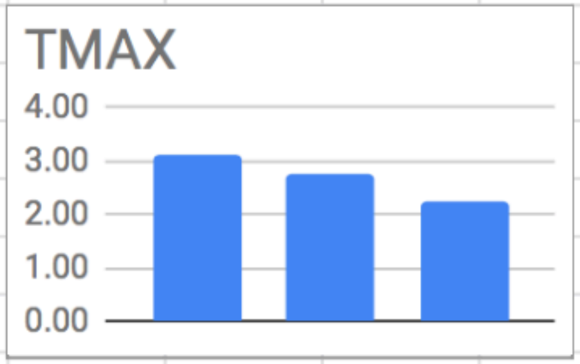


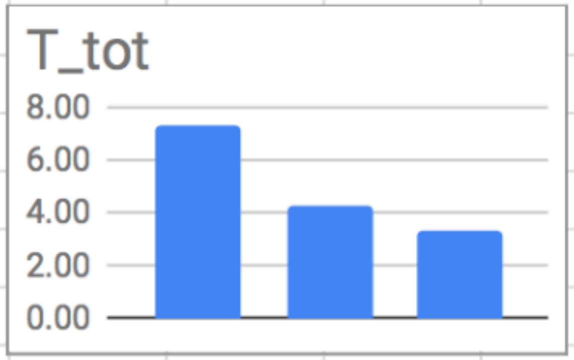




Energy	Xa	Ya	Seed	1stH	MxPH	NMxP	Amax	AL	AR	BL	BR	BLL	BRR	tMax
1.0E+05						mean	1.12	0.24	0.25	0.05	0.09	0.03	-0.22	3.13
1.0E+06						mean	13.29	2.86	2.84	0.55	0.87	0.30	0.21	2.75
1.0E+07						mean	153.93	33.48	33.70	7.27	10.90	3.96	4.47	2.25







- A big simulation program (energy, angle, position, etc.) is going on

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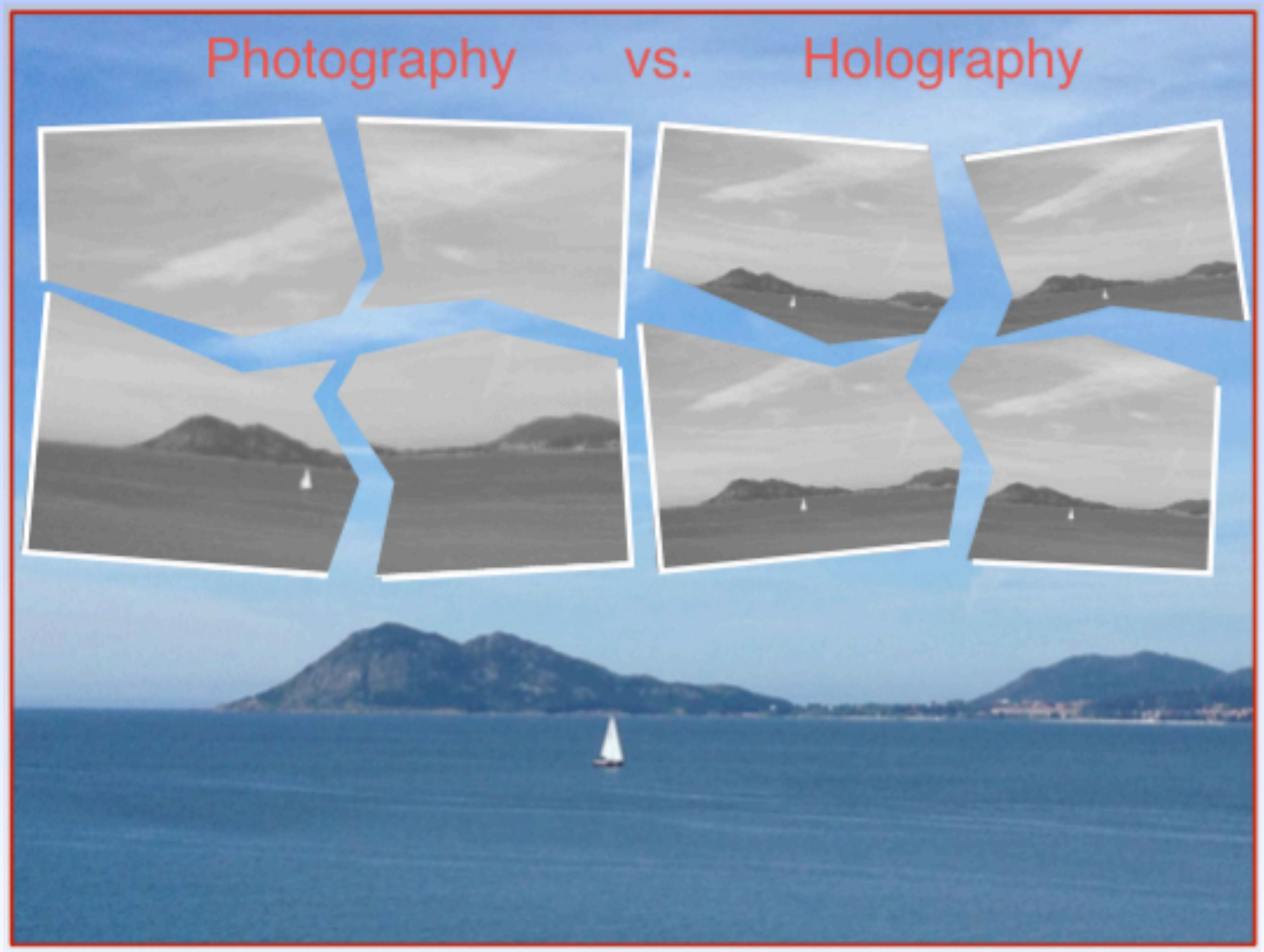
Daily rate of clusters of secondaries at sea level for different primary energies (NKG parametrization)										
Energy	Flux of primary cosmic rays			Daily rate of clusters/m^2.sr, for different multipiplicies M						Energy
E/GeV	F/GeV.m^2.sr.s	IF/m^2.sr.s	IF/m^2.sr.day	M=3-5	M=5-10	M=10-20	M=20-30	M=30-40	M > 40	E/eV
1.00E+06	1.1E-12	6.8E-07	5.9E-02	296	166	60	15			1.00E+15
1.78E+06	2.4E-13	2.6E-07	2.2E-02	222	130	54	17			1.76E+15
3.16E+06	5.1E-14	9.0E-08	7.8E-03	156	95	46	18			3.16E+15
5.62E+06	3.5E-14	5.6E-08	4.8E-03	193	122	69	32			5.62E+15
1.00E+07	6.3E-15	3.8E-08	3.3E-03	264	174	114	66	51	31	1.00E+16
1.78E+07	1.1E-15	1.2E-08	1.0E-03	127	86	59	34	27	17	1.76E+16
3.16E+07	2.0E-16	3.8E-09	3.3E-04	61	43	30	17	14	10	3.16E+16
5.62E+07	3.5E-17	1.2E-09	1.0E-04	29	21	16	9	8	5	5.62E+16
1.00E+08	6.3E-18	3.8E-10	3.3E-05	14	11	8	5	4	3	1.00E+17
1.78E+08	1.1E-18	1.2E-10	1.0E-05	6	5	4	2	2	1	1.78E+17
3.16E+08	2.0E-19	3.8E-11	3.3E-06	3	2	2	1	1	1	3.16E+17
5.62E+08	3.5E-20	1.2E-11	1.0E-06	1	1	1	0	0	0	5.62E+17
1.00E+09	6.3E-21	3.8E-12	3.3E-07	1	0	0	0	0	0	1.00E+18
1.78E+09	1.1E-21	1.2E-12	1.0E-07	0	0	0	0	0	0	1.78E+18
3.16E+09	2.0E-22	4.6E-13	3.9E-08	0	0	0	0	0	0	3.16E+18
TOTAL		1.1E-07	9.8E-02	1,373	858	462	216	107	69	TOTAL
E/A.GeV	Flux	FluxIAS	IF/m^2.s	M=3-5	M=5-10	M=10-20	M=20-30	M=30-40	M > 40	E/A.GeV

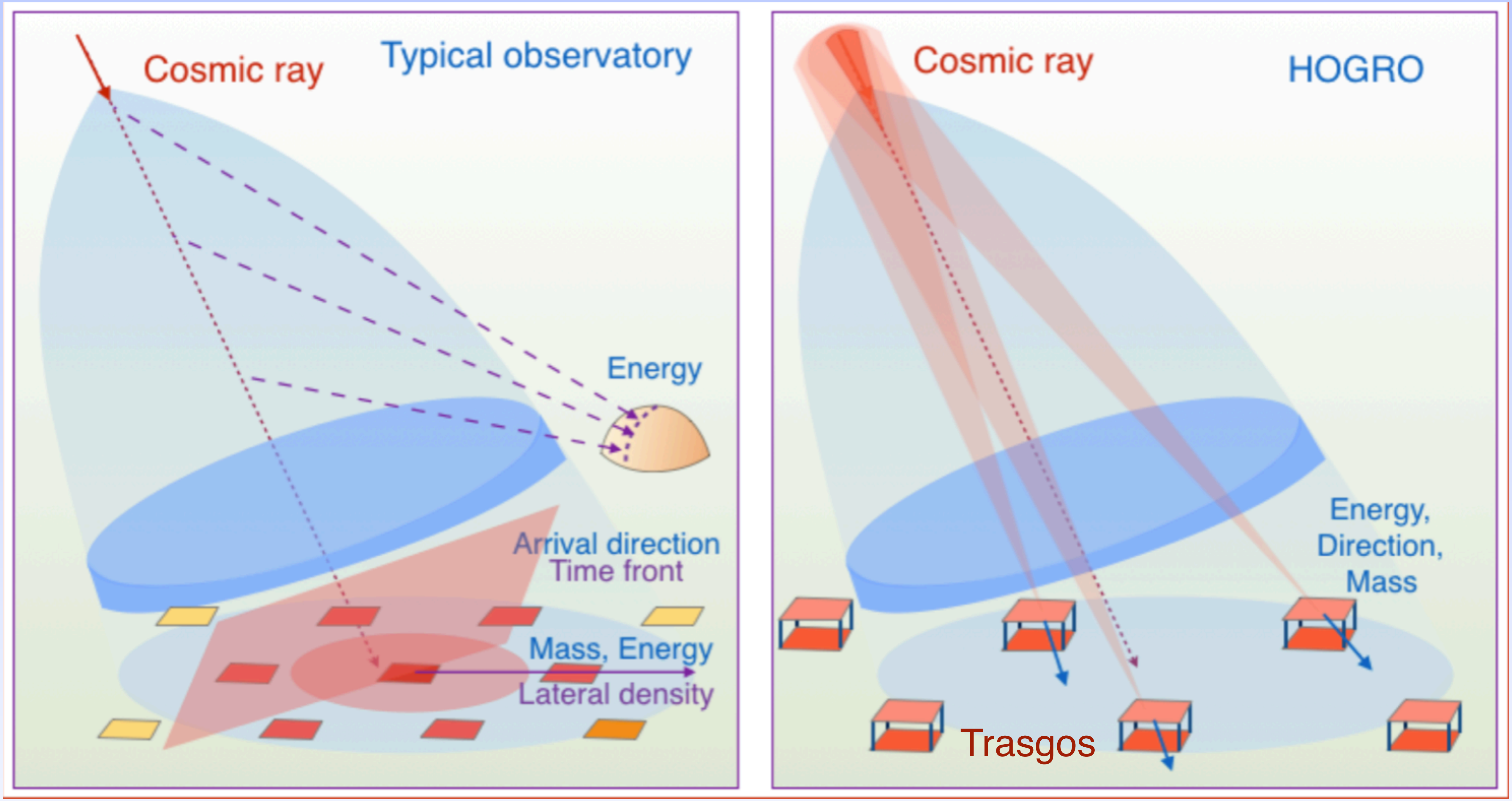
Expected rates of showers of different multiplicities and at different energies.

Around 500 daily triggers of showers with E> 10^{16} eV!!

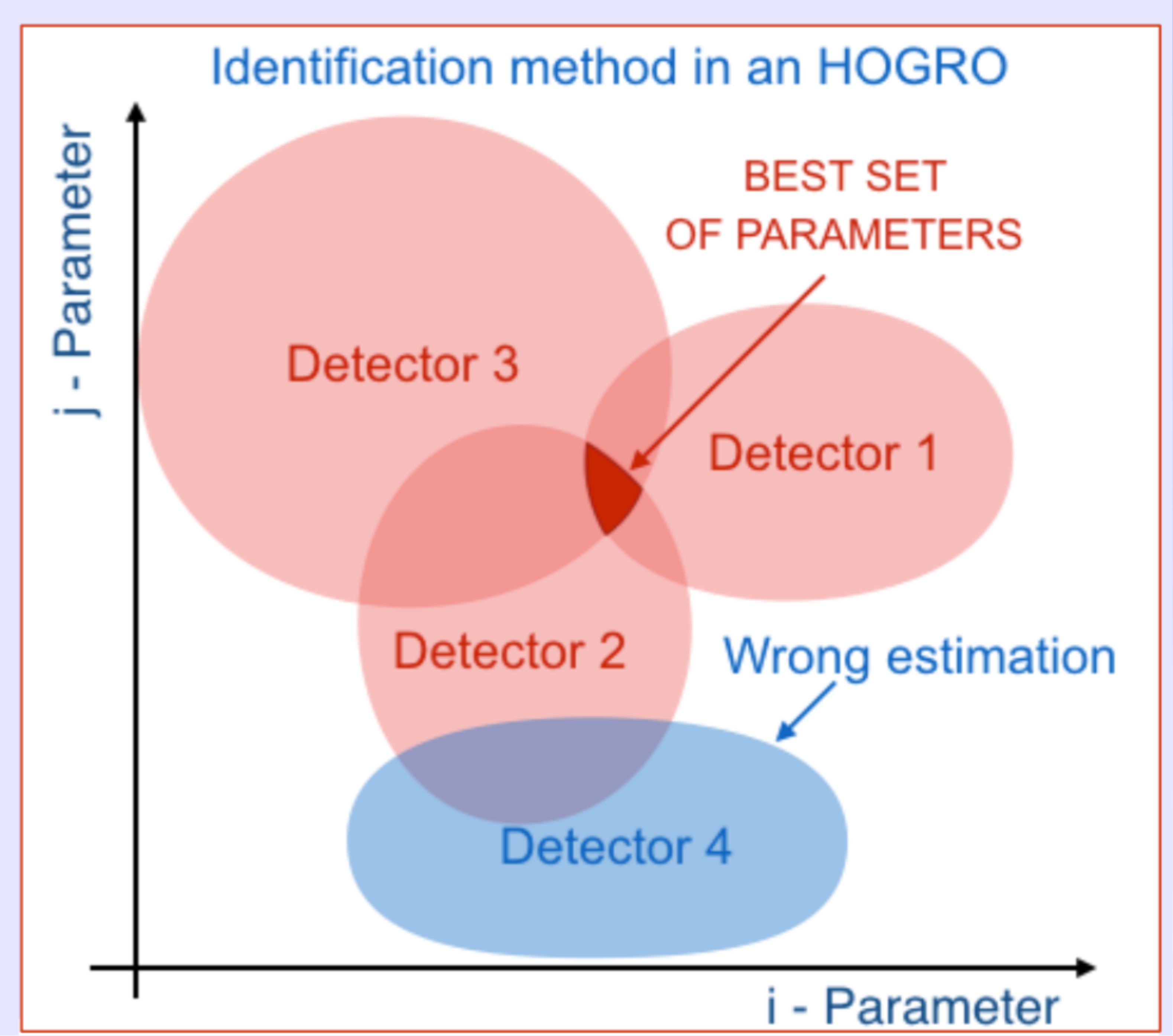
4. Main. HOGRO: HOloGRaphic Observatories?



4. Final goal. HOGRO: HOloGRaphic Observatories?



4. Final goal. HOGRO: HOloGRaphic Observatories?



- The best set of parameters is obtained from the independent estimations done by all the TRASGO stations

SUMMARY and CONCLUSIONS

- 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.
- 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 TRAGALDABAS Collaboration

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

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. Tecknische Univ. Darmstadt, Germany / Software development
6. IGN - Madrid, Spain / **Geomagnetic field**
7. CESGA Super-computation Center - Santiago de Compostela, Spain / Data storage and distribution
8. GENP - Univ. Santiago de Compostela, Spain / Software development and simulation
9. IGFAE - Univ. Santiago de Compostela, Spain / Monitoring and Slow control
10. LabCAF - Univ. Santiago de Compostela, Spain / **Cosmic rays physics**, software and tracking
11. GFNL - Univ. Santiago de Compostela, Spain / **Atmosphere Physics and Climate**

Other partners:

ATI Sistemas. La Coruña, Spain
Club Desarrollo de las Ciencias, Madrid, Spain
HIDRONAV. Vigo, Spain

+C. Alemparte (Hidronav), A. Iglesias (Hidronav), J. Saraiva (LIP-Coimbra), M. Valladares (Hidronav)
+ a few others :(:(:(

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

The end

Thanks!