

Contribución española a la red global de monitores de neutrones

3rd. Workshop on Trasgo detectors. The New Generation

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27/06/2023



Proyecto: PID2019-107806GB-100

≈ 30 investigadores (Ingenieros, Físicos y Estudiantes) 6 en CaLMa
Lineas de investigación del Grupo

- Arquitectura y modelado de procesadores optimizados para aplicaciones espaciales
- Control óptimo
- Desarrollo de instrumentación científica embarcable en misiones espaciales
- Diseño de software basado en componentes
- Hardware en Ingeniería Espacial
- Ingeniería de software dirigida por modelos
- Modelado orbital y de radiocomunicaciones
- Software de Control en tiempo real para Sistemas Espaciales
- Sistemas de adquisición de datos para instrumentación nuclear
- Física del Sol y de la Heliosfera
- Interacción Sol-Tierra
- Rayos cósmicos

<https://www.uah.es/es/investigacion/unidades-de-investigacion/grupos-de-investigacion/Grupo-de-Investigacion-Espacial-Space-Research-Group/>

CaLMa hace referencia a un conjunto de detectores distribuidos en diferentes localizaciones geomagnéticas cuyo objetivo principal es la observación de la actividad solar a través de la medida de rayos cósmicos de energías por debajo de 100 GeV/nucleon.

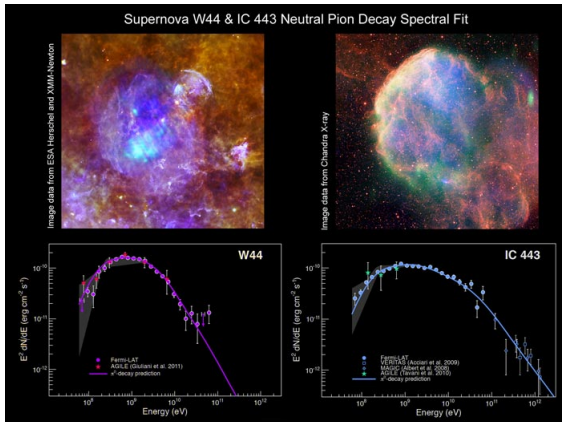
web: <https://neutronmonitors-srg-uah.web.uah.es/>

- CaLMa: Castilla-La Mancha Neutron Monitor
- ORCA: Observatorio de Rayos Cósmicos Antártico
- MiniCaLMa
- ICaRO: Izaña Cosmic Ray Observatory

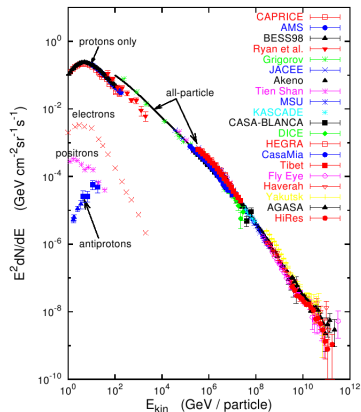


Rayos cósmicos galácticos

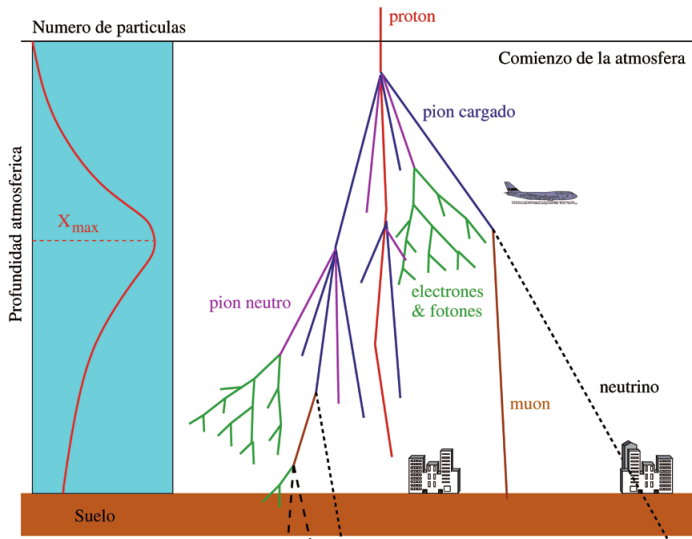
Supernova W44 & IC 443 Neutral Pion Decay Spectral Fit



Energies and rates of the cosmic-ray particles



Rayos cósmicos galácticos



Rayos cósmicos galácticos

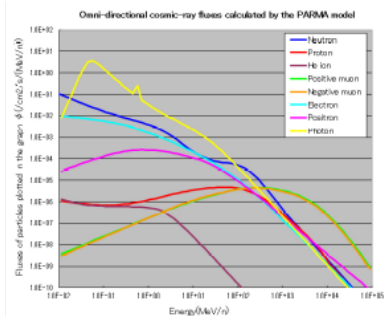
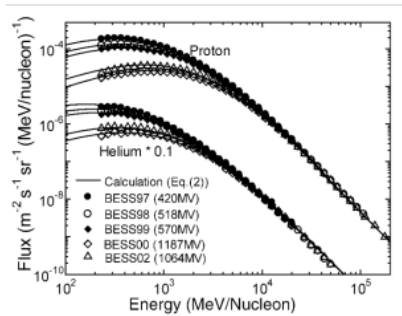


Figure: Sato et al., 2008

Rayos cósmicos galácticos

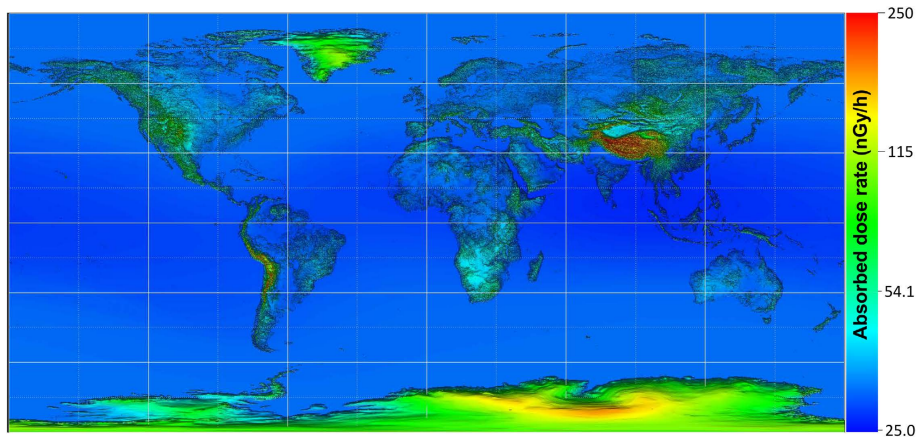


Figure: Sato et al., 2016

NMDB: the Neutron Monitor Database

Real-Time Database for high-resolution Neutron Monitor measurements



one stop shop for cosmic ray data

NMDB provides access to Neutron Monitor measurements from stations around the world. The goal of NMDB is to provide easy access to all Neutron Monitor measurements through an easy to use interface. NMDB provides access to real-time as well as historical data.

An interdisciplinary session on Cosmic Rays will take place at the [EGU 2023 in Vienna](#). Please submit your abstracts now!

NMDB distributes official data provided by the PIs of the neutron monitor stations. Data of different origin may not have been validated or authorised by the respective PI, and any deviation with respect to the authorised data is not his/her responsibility.

Data retrieved via NMDB are the property of the individual data providers. These data are free for non commercial use within the restrictions imposed by the providers. If you use such data for your research or applications, please acknowledge the origin by a sentence like "We acknowledge the NMDB database www.nmdb.eu, founded under the European Union's FP7 programme (contract no. 213007) for providing data.", and acknowledge individual monitors following the information given on the respective station information page (see sub-pages under www.nmdb.eu).

Figure: <https://www.nmdb.eu/>

Neutron Monitor Data Base

3 ways 2 use NEST

NEST
MICRO-EVENT SEARCH TOOL

Quick Plots
New / Last Data GLE 73 GLE 72

conditions & information
to use data

top
the last 7 days, including integral flux for
protons > 500MeV.
[mar 2020] As SWPC GOES data format

Stations
(When selecting multiple stations, note that only one variable can be plotted)

<input type="checkbox"/> AATA	<input type="checkbox"/> AATB	<input type="checkbox"/> APTY	<input type="checkbox"/> ARNM	<input type="checkbox"/> ATHN
<input type="checkbox"/> BKSJ	<input type="checkbox"/> CALG	<input type="checkbox"/> CALM	<input type="checkbox"/> DJON	<input type="checkbox"/> DOMB
<input type="checkbox"/> DOMC	<input type="checkbox"/> DRBS	<input type="checkbox"/> ESOK	<input type="checkbox"/> FSMT	<input type="checkbox"/> HRMS
<input type="checkbox"/> INVK	<input type="checkbox"/> IRK2	<input type="checkbox"/> IRK3	<input type="checkbox"/> IRKT	<input type="checkbox"/> JBGO
<input type="checkbox"/> JUNG	<input type="checkbox"/> JUNG1	<input type="checkbox"/> KERG	<input type="checkbox"/> KIEL	<input type="checkbox"/> KIEL2
<input type="checkbox"/> LMK5	<input type="checkbox"/> MCRL	<input type="checkbox"/> MGDN	<input type="checkbox"/> MOSC	<input type="checkbox"/> MPRNY
<input type="checkbox"/> MWSN	<input type="checkbox"/> MXCO	<input type="checkbox"/> NAIN	<input type="checkbox"/> NANM	<input type="checkbox"/> NEUS
<input type="checkbox"/> NEWK	<input type="checkbox"/> NRLK	<input type="checkbox"/> NVBK	<input type="checkbox"/> OULL	<input type="checkbox"/> PSNM
<input type="checkbox"/> PTFM	<input type="checkbox"/> PWNK	<input type="checkbox"/> ROME	<input type="checkbox"/> SANB	<input type="checkbox"/> SNAE
<input type="checkbox"/> SOPB	<input type="checkbox"/> SOPO	<input type="checkbox"/> TERA	<input type="checkbox"/> THUL	<input type="checkbox"/> TSMB
<input type="checkbox"/> TXEY	<input type="checkbox"/> YKTK			

Online* stations in green

Closed Stations*

Bonner Spheres*

Smart Selection

Date Selection (UTC)
Last 1 days hours mins
From 26 Jun 2023 0h 0m
To 26 Jun 2023 23h 59m
GLE number/date 73 (2021-10-28) detailed list
FD number/date 53 (2011-02-18)

Resolution
Time resolution: best
Force**
Smooth window: 0

Data variables
Pressure & efficiency corr.
Pressure corrected
Uncorrected
Pressure

Scale
Relative scale
Counts/s*
Log scale
(* nbar for pressure)

Output
Plot
Ascii
Plot & ascii

Contact: questions@nmdb.eu

NMDB tables

Overplot main

Overplot RI

Proton / Kp plots

Env. & meta data

Scaling Options

Event Options

Ascii Options

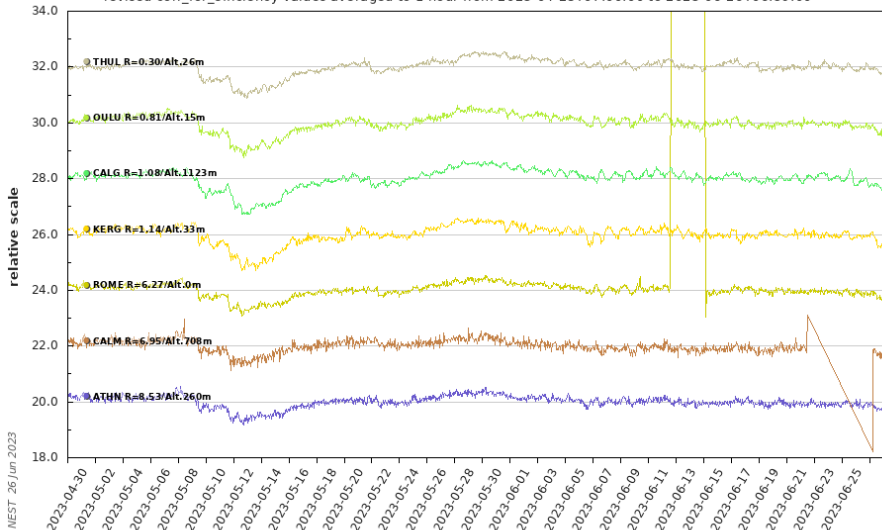
Style Options

NEST is provided by
DISPATCHER | PSL*

Figure: <http://www01.nmdb.eu/nest/>

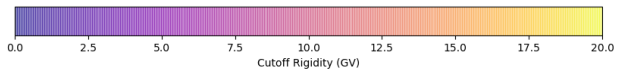
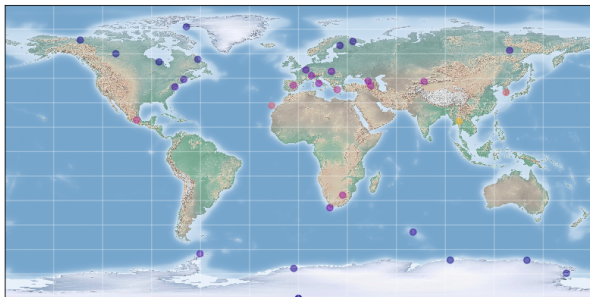
Neutron Monitor Data Base

revised corr_for_efficiency values averaged to 1 hour from 2023-04-28T07:00:00 to 2023-06-26T06:59:00



NEST 26 Jun 2023

The Earth as a global detector



The Earth as a global detector

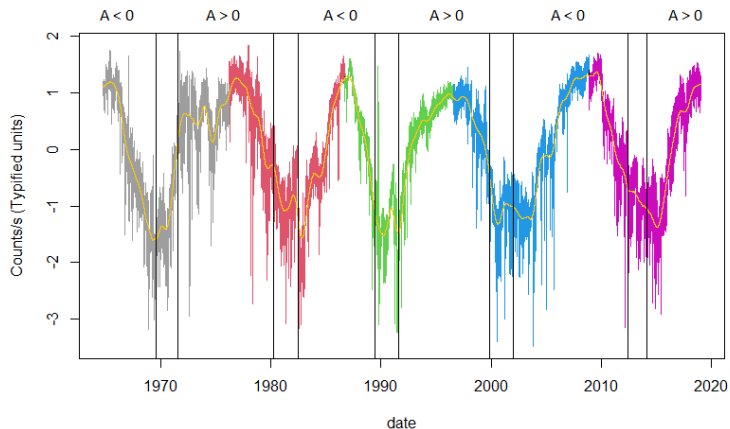
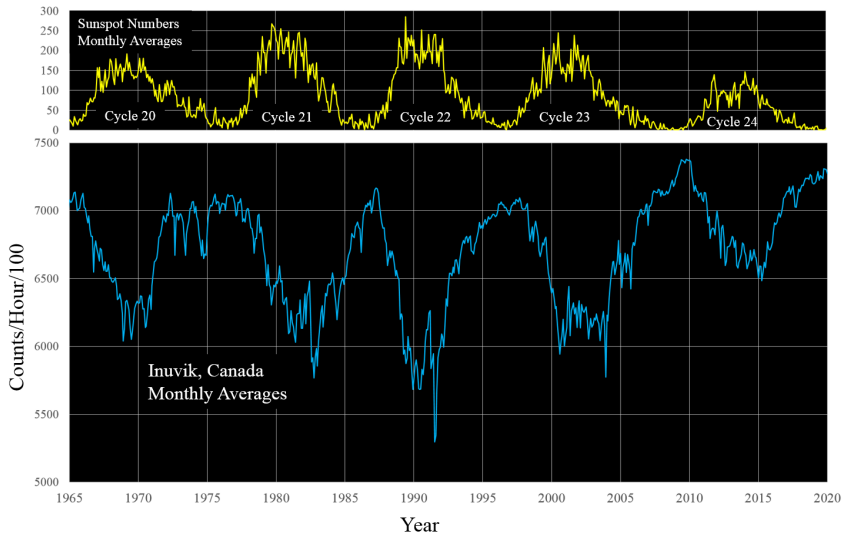
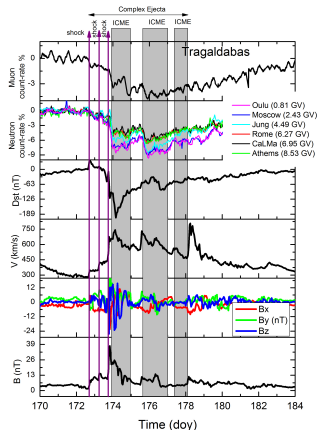
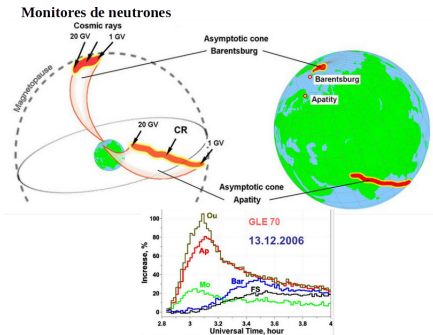


Figure: López-Comazzi and Blanco, ApJ 2022

The Earth as a global detector



The Earth as a global detector



CaLMa ($R_{eff} = 6.95 \text{ GV}$)

Flujos de neutrones ($5.3 / \text{s} / \text{counter}$)

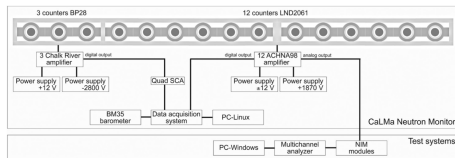


12 NM64

Guadalajara, Spain

($40^{\circ}38'N$, $3^{\circ}19'W$ at 708 m above sea level)

CaLMa	
Counter Type	LND2061
Effective diameter (mm)	149.1
Effective length (mm)	1956.3
Cathode material	Stainless steel
Gas filling	$BF_3(96\%^{10}B)$
Gas pressure (mmHg)	200
Operational voltage (V)	1800
Number of counters	12
Moderator (g/cm^2)	Polyethylene (1.84)
Producer (g/cm^2)	Lead (156)
Reflector (g/cm^2)	Polyethylene (7.0)



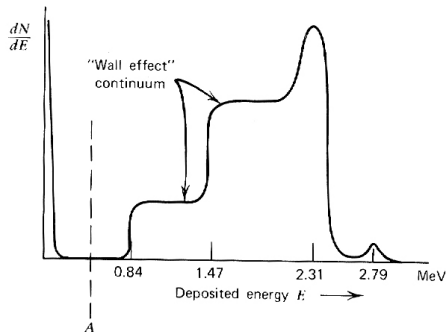
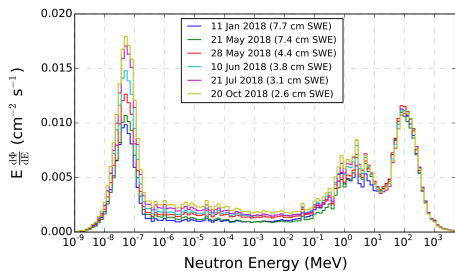
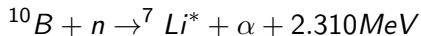
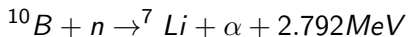


Figure: Brall et al, The Cryosphere, 15, 4769–4780, 2021.

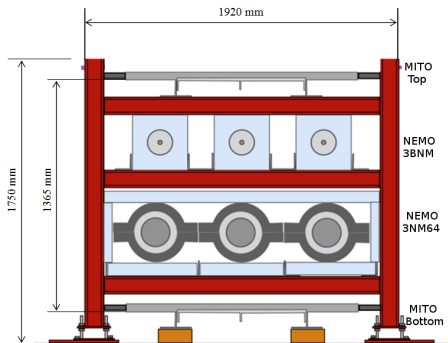


ORCA ($R_{eff} = 2.487GV$)

Penumbra for the Juan Carlos I Spanish Antarctic Base at ($S62.65^\circ$, $W60.38^\circ$), 12m asl at a date 2019-01-02 12:00:00 UT according to the results of the calculator at <http://crsv.izmiran.ru/cutoff> using the IGRF model. $R_d = 2,221GV$ and $R_u = 2,673GV$



ORCA & ICarO



ORCA: 12 /s /c, ORCB: 2 /s /c
 Top: 190 /s , Bottom: 130 /s and Coin8: 30 /s

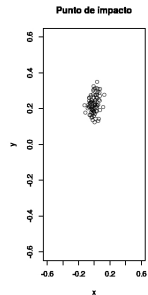
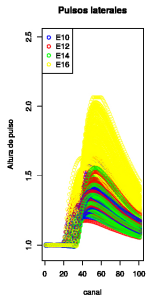
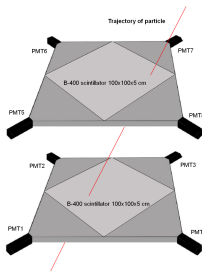
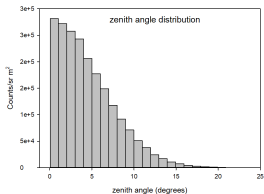
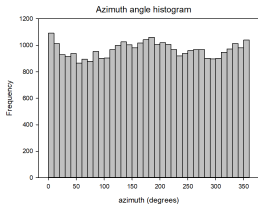
135W

	NEMO 3NM64(ORCA)	NEMO 3BNM(ORCB)
Counter Type	BP28	LND2061
Effective diameter (mm)	148.5	149.1
Effective length (mm)	1908.0	1956.3
Cathode material	Stainless steel	Stainless steel
Gas filling	$BF_3(96\%^{10}B)$	$BF_3(96\%^{10}B)$
Gas pressure (mmHg)	200	200
Operational voltage (V)	-2700	1800
	MITO Top	MITO Bottom
Scintillator	BC400	BC400
Dimension (cm)	100x100x5	100x100x5
Operational voltage (V)	1000	1000
PMT	4 R2154	4 R2154
	Vaisala Meteorologic station	
PTU 301	500-1100 hPa	$\pm 0.05 hPa$
Pt100	-40 to 60°C	$\pm 0.2^\circ C$
HUMICAP 180C	0-100%	$\pm 1\%$

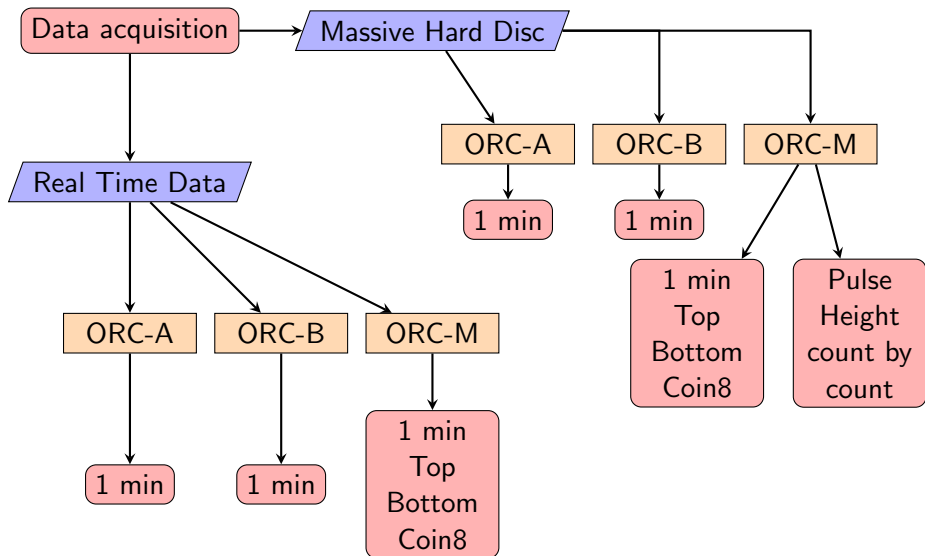
ORCB: neutrones $< 10eV$

ORCA: neutrones $> 100MeV$

Coin8: muones $> 350MeV$, protones $> 290MeV$, electrones No



ORCA/ICaRO data



- Hermano gemelo de ORCA
- $28^{\circ}18'N$, $16^{\circ}29'W$, 2373 m a.s.l., $R = 11.5$ GV.
- Cubre un hueco en la NMDB [Artamonov et al.,2016.]
- Su altura y corte en rigidez magnética podría permitir la observación de neutrones solares
- Izaña Atmospheric Research Center (IARC)
- Güimar Geomagnetic Observatory (GGO)
- Observación de RC, condiciones atmosféricas y estado de la magnetosfera

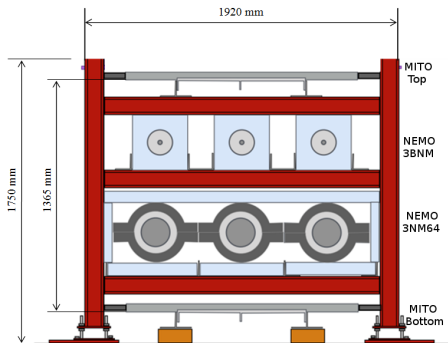


Proyecto

PID2019-107806GB-100,
financiado por Ministerio de
Ciencia e Innovación.



ORCA & ICaRO



ICRO: 13 /s /c, ICRB: 3 /s /c
 Top: 300 /s , Bottom: 180 /s and Coin8: 30 /s

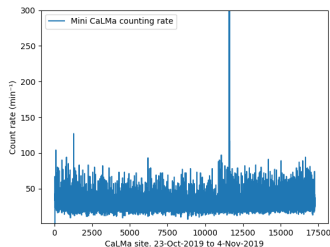
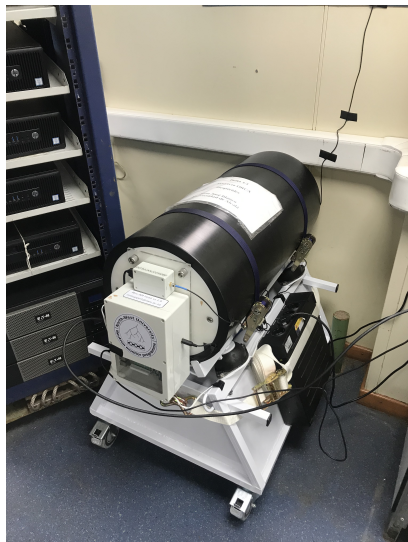
135W

	NEMO 3NM64(ICRO)	NEMO 3BNM(ICRB)
Counter Type	BP28	LND2061
Effective diameter (mm)	148.5	149.1
Effective length (mm)	1908.0	1956.3
Cathode material	Stainless steel	Stainless steel
Gas filling	$BF_3(96\%^{10}B)$	$BF_3(96\%^{10}B)$
Gas pressure (mmHg)	200	200
Operational voltage (V)	-2700	1800
	MITO Top	MITO Bottom
Scintillator	BC400	BC400
Dimension (cm)	100x100x5	100x100x5
Operational voltage (V)	1000	1000
PMT	4 R2154	4 R2154
	Vaisala Meteorologic station	
PTU 301	500-1100 hPa	$\pm 0.05 hPa$
Pt100	-40 to 60°C	$\pm 0.2^\circ C$
HUMICAP 180C	0-100%	$\pm 1\%$

ICRB: neutrones $< 10eV$

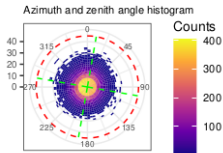
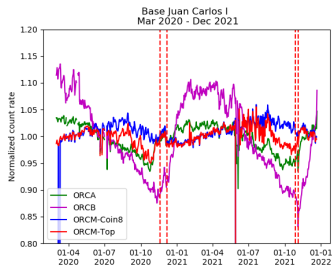
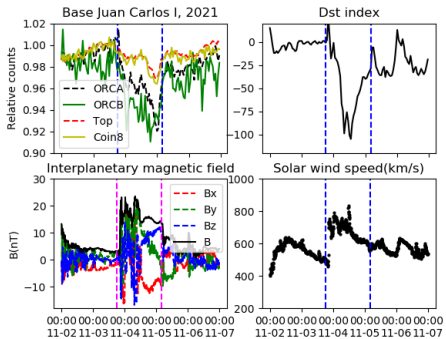
ICRO: neutrones $> 100MeV$

Coin8: muones $> 350MeV$, protones $> 290MeV$, electrones No

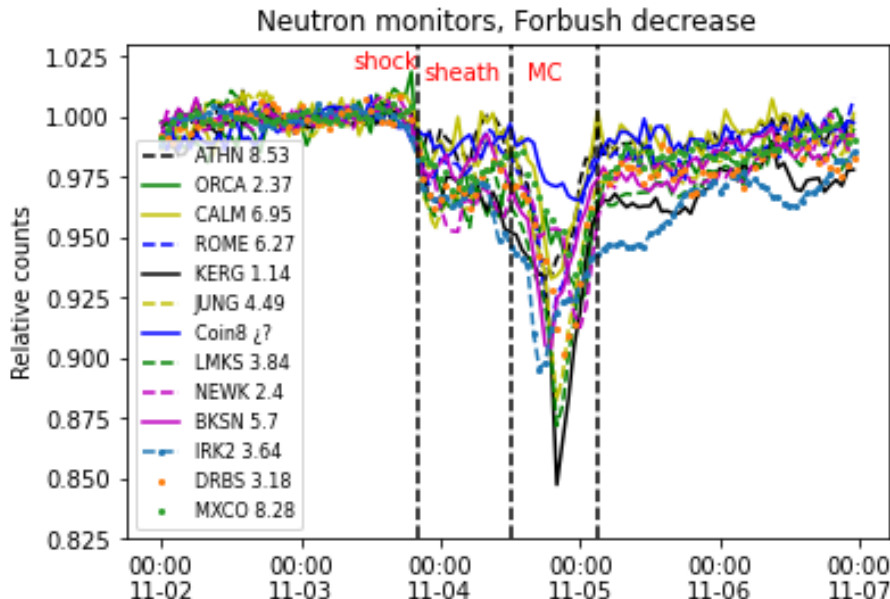


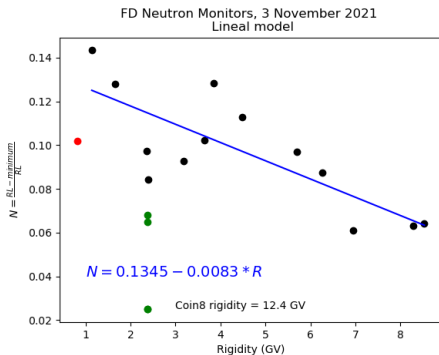
MiniCaLMa	
Counter Type	LND2043
Effective diameter (mm)	89
Effective length (mm)	697
Cathode material	Stainless steel
Gas filling	BF_3 (96% ^{10}B)
Gas pressure (mmHg)	700
Operational voltage (V)	2120–2370

Ejemplos de medidas



Solar events: November 2021 FD



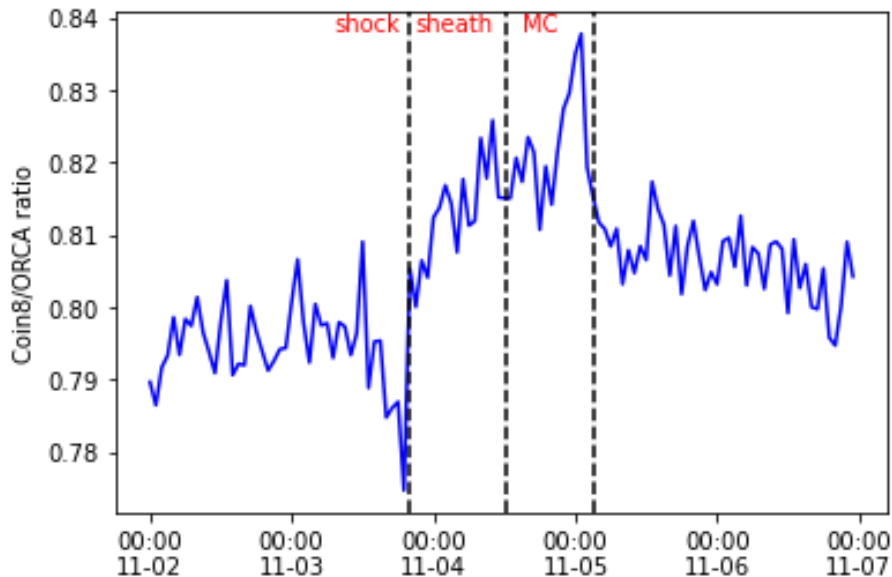


Coin8: Rigidity threshold estimation \rightarrow 12.4GV

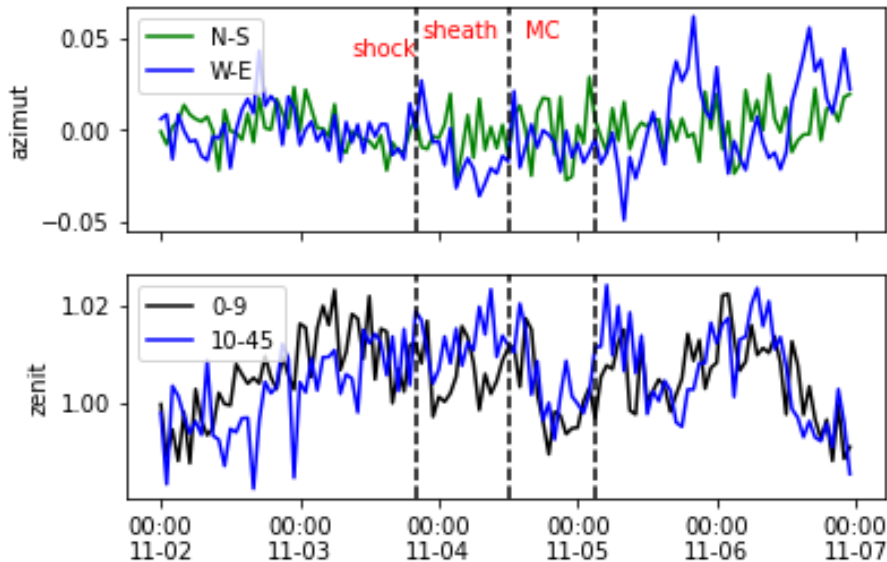
Neutron monitors

Name	Rigidity (GV)	$N = \frac{RL - \text{minimum}}{RL}$
ATHN	8.53	0.0640
MXCO	8.28	0.0631
CALM	6.95	0.0610
ROME	6.27	0.0874
BKSN	5.7	0.0968
JUNG	4.49	0.1128
LMKS	3.84	0.1284
IRK2	3.64	0.1023
DRBS	3.18	0.0927
NEWK	2.4	0.0843
KIEL2	2.36	0.0972
IKTK	1.65	0.1281
KERG	1.14	0.1433
OULU	0.81	0.1020
ORCA	2.37	0.0680
Top	$i?$	0.0249
coin8	$i?$	0.0251
ORCB	2.37	0.0649

Solar events: November 2021 FD

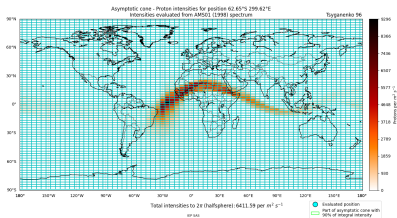
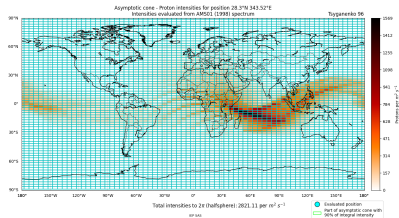
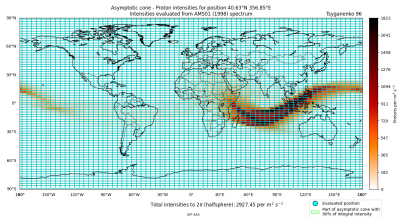


Solar events: November 2021 FD



- Castilla-La Mancha neutron monitor, Medina et al., Nuclear Instruments and Methods in Physics Research A 727 (2013) 97–103
- The mini-neutron monitor: a new approach in neutron monitor design, Du Toit et al., J. Space Weather Space Clim. 2020, 10, 39.
- MITO: a new directional muon telescope, Ayuso et al., J. Space Weather Space Clim. 2021, 11, 13S.
- Cosmic ray observations from Livingston Island, Blanco et al., Advances in Space Research 69 (2022) 3514–3524

Conclusions



<https://cor.crmodels.org/>