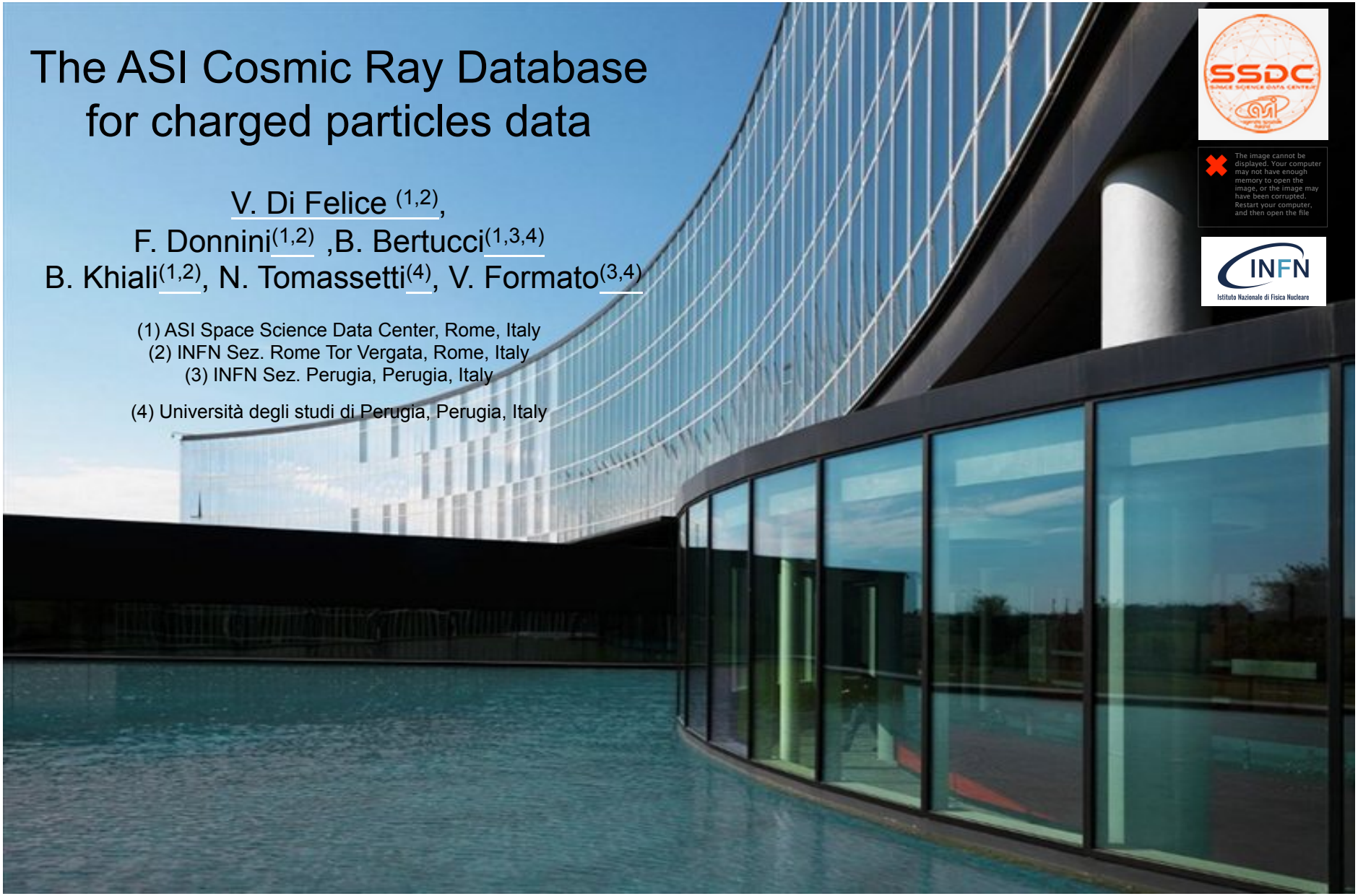
The ASI Cosmic Ray Database for charged particles data

V. Di Felice [1,2],
F. Donnini[1,2] ,B. Bertucci[1,3,4]
B. Khiali[1,2], N. Tomassetti[4], V. Formato[3,4]

(1) ASI Space Science Data Center, Rome, Italy
(2) INFN Sez. Rome Tor Vergata, Rome, Italy
(3) INFN Sez. Perugia, Perugia, Italy
(4) Università degli studi di Perugia, Perugia, Italy



SSDC – Space Science Data Center (http://www.ssdc.asi.it/)

The **Space Science Data Center** (SSDC) is a facility of the Italian Space Agency (ASI)
- It acts as a **multi-mission** science operation, data processing and data archiving center
- It supports several space missions (Astrophysics and Cosmology, Solar System Exploration and Cosmic Rays missions), providing data covering the entire electromagnetic spectrum and other channels.

SSDC – Space Science Data C

Multi-mission archive(Astrophysics and Cosmology, Solar System Exploration and Cosmic Rays missions)

- It is a user-friendly interface that allows users to access this all- encompassing and diverse databases:
- The **Cosmic Ray DataBase** is integrated in such a multi-mission framework.

CRDB Cosmic Ray Data Base - https://tools.asdc.asi.it/CosmicRays/

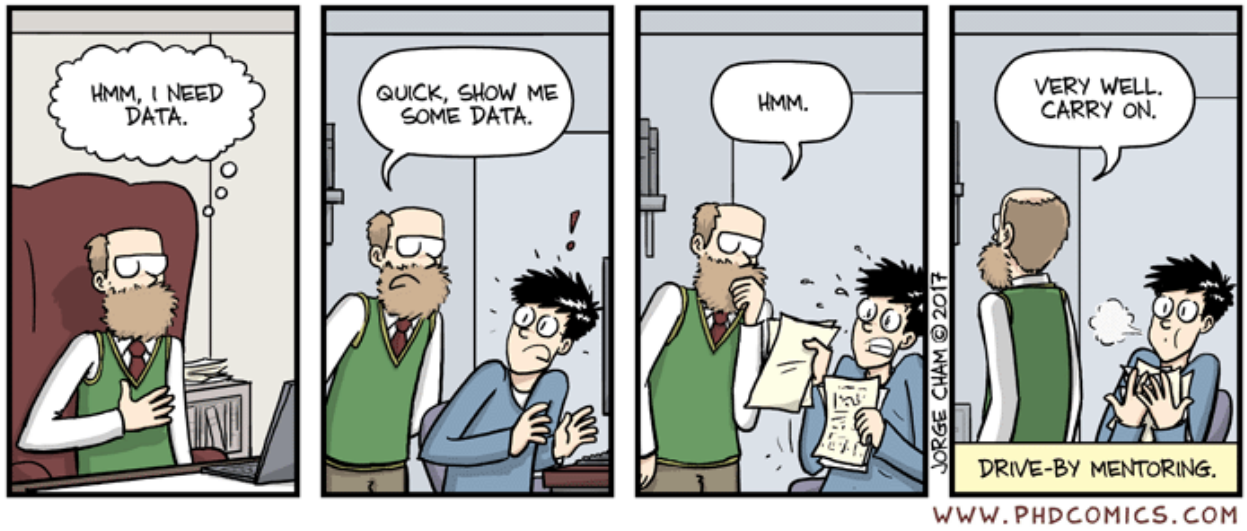
[See also **S6.04 poster** contribution - F. Donnini]

The Cosmic Ray Database (CRDB) aims to provide tools for an easy and efficient access to published data from missions dedicated to charged Cosmic Ray measurements.

- originally developed to support the retrieval of PAMELA and AMS-02 **published data**; it is now expanding to include more data sets from other experiments and evolving to provide new tools for data retrieval, visualization and download;

- The main *query* structure is based on **typical data presentation in scientific papers**: the *physical observable* of interest (such as flux, etc...) as a function of a measured quantity (like rigidity, kinetic energy, etc...);

- **Data** and their connections are organized and stored in a *relational database*, exploiting the *MySQL server* hosted at the Space Science Data Center;
Input data are provided as *xml files*, containing the measurement information as reported in the original publication tables;



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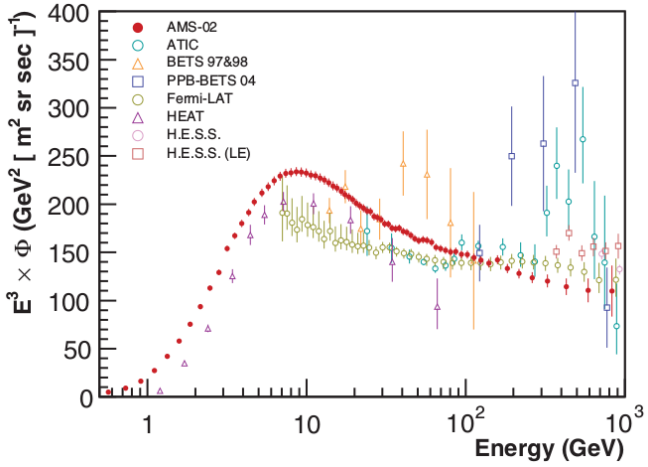


Kinetic Energy (GeV)	Flux $(m^2\ s\ sr\ MeV)^{-1}$			
	2006 Nov 13–2006 Dec 4	2007 Nov 30–2007 Dec 27	2008 Nov 19–2008 Dec 15	2009 Dec 6–2010 Jan 1
0.082–0.095	$(0.721 \pm 0.032^{+0.061}_{-0.100})$	$(1.045 \pm 0.031^{+0.090}_{-0.102})$	$(1.191 \pm 0.035^{+0.105}_{-0.104})$	$(1.730 \pm 0.143^{+0.266}_{-0.163})$
0.095–0.10	$(0.759 \pm 0.036^{+0.063}_{-0.096})$	$(1.111 \pm 0.030^{+0.094}_{-0.098})$	$(1.332 \pm 0.034^{+0.116}_{-0.100})$	$(1.722 \pm 0.156^{+0.263}_{-0.160})$
0.10–0.11	$(0.818 \pm 0.030^{+0.067}_{-0.093})$	$(1.151 \pm 0.027^{+0.097}_{-0.094})$	$(1.401 \pm 0.031^{+0.121}_{-0.097})$	$(2.016 \pm 0.134^{+0.307}_{-0.158})$
0.11–0.12	$(0.893 \pm 0.034^{+0.072}_{-0.089})$	$(1.230 \pm 0.027^{+0.102}_{-0.091})$	$(1.477 \pm 0.031^{+0.126}_{-0.094})$	$(2.210 \pm 0.151^{+0.336}_{-0.157})$
0.12–0.13	$(0.928 \pm 0.030^{+0.074}_{-0.086})$	$(1.334 \pm 0.026^{+0.110}_{-0.088})$	$(1.543 \pm 0.029^{+0.131}_{-0.091})$	$(2.162 \pm 0.129^{+0.327}_{-0.155})$
0.13–0.15	$(0.960 \pm 0.028^{+0.076}_{-0.084})$	$(1.411 \pm 0.025^{+0.115}_{-0.086})$	$(1.607 \pm 0.027^{+0.135}_{-0.089})$	$(2.256 \pm 0.123^{+0.341}_{-0.154})$
0.15–0.16	$(1.030 \pm 0.028^{+0.081}_{-0.083})$	$(1.453 \pm 0.023^{+0.117}_{-0.085})$	$(1.675 \pm 0.026^{+0.139}_{-0.087})$	$(2.447 \pm 0.122^{+0.368}_{-0.153})$
0.16–0.17	$(1.085 \pm 0.027^{+0.084}_{-0.081})$	$(1.477 \pm 0.022^{+0.118}_{-0.083})$	$(1.727 \pm 0.025^{+0.142}_{-0.085})$	$(2.359 \pm 0.112^{+0.354}_{-0.152})$
0.17–0.19	$(1.123 \pm 0.025^{+0.086}_{-0.079})$	$(1.545 \pm 0.021^{+0.122}_{-0.081})$	$(1.805 \pm 0.024^{+0.147}_{-0.084})$	$(2.277 \pm 0.102^{+0.341}_{-0.151})$
0.19–0.21	$(1.164 \pm 0.024^{+0.088}_{-0.078})$	$(1.613 \pm 0.020^{+0.126}_{-0.080})$	$(1.865 \pm 0.023^{+0.150}_{-0.082})$	$(2.423 \pm 0.097^{+0.362}_{-0.150})$
0.21–0.22	$(1.194 \pm 0.022^{+0.090}_{-0.076})$	$(1.634 \pm 0.019^{+0.126}_{-0.081})$	$(1.899 \pm 0.021^{+0.152}_{-0.081})$	$(2.592 \pm 0.093^{+0.386}_{-0.149})$
0.22–0.24	$(1.222 \pm 0.022^{+0.091}_{-0.075})$	$(1.673 \pm 0.018^{+0.128}_{-0.077})$	$(1.968 \pm 0.021^{+0.156}_{-0.080})$	$(2.647 \pm 0.091^{+0.393}_{-0.149})$
0.24–0.26	$(1.278 \pm 0.021^{+0.094}_{-0.074})$	$(1.732 \pm 0.018^{+0.131}_{-0.076})$	$(2.031 \pm 0.020^{+0.159}_{-0.079})$	$(2.682 \pm 0.088^{+0.397}_{-0.148})$
0.26–0.29	$(1.359 \pm 0.020^{+0.098}_{-0.073})$	$(1.775 \pm 0.017^{+0.133}_{-0.075})$	$(2.047 \pm 0.019^{+0.159}_{-0.078})$	$(2.684 \pm 0.082^{+0.396}_{-0.148})$
0.29–0.31	$(1.371 \pm 0.020^{+0.098}_{-0.072})$	$(1.788 \pm 0.016^{+0.132}_{-0.074})$	$(2.025 \pm 0.018^{+0.155}_{-0.077})$	$(2.603 \pm 0.077^{+0.383}_{-0.147})$
0.31–0.34	$(1.380 \pm 0.019^{+0.098}_{-0.071})$	$(1.818 \pm 0.016^{+0.133}_{-0.073})$	$(2.040 \pm 0.017^{+0.155}_{-0.076})$	$(2.656 \pm 0.075^{+0.390}_{-0.147})$
0.34–0.36	$(1.381 \pm 0.018^{+0.097}_{-0.070})$	$(1.822 \pm 0.015^{+0.132}_{-0.072})$	$(2.036 \pm 0.017^{+0.153}_{-0.075})$	$(2.633 \pm 0.072^{+0.385}_{-0.146})$
0.36–0.39	$(1.398 \pm 0.017^{+0.097}_{-0.069})$	$(1.816 \pm 0.014^{+0.130}_{-0.072})$	$(2.019 \pm 0.016^{+0.150}_{-0.074})$	$(2.504 \pm 0.067^{+0.366}_{-0.146})$
0.39–0.43	$(1.410 \pm 0.016^{+0.096}_{-0.068})$	$(1.778 \pm 0.013^{+0.126}_{-0.071})$	$(1.983 \pm 0.015^{+0.146}_{-0.074})$	$(2.415 \pm 0.061^{+0.351}_{-0.146})$
0.43–0.46	$(1.396 \pm 0.016^{+0.094}_{-0.068})$	$(1.754 \pm 0.013^{+0.123}_{-0.070})$	$(1.959 \pm 0.014^{+0.143}_{-0.073})$	$(2.495 \pm 0.060^{+0.362}_{-0.145})$
0.46–0.50	$(1.391 \pm 0.015^{+0.093}_{-0.067})$	$(1.715 \pm 0.012^{+0.119}_{-0.069})$	$(1.941 \pm 0.014^{+0.140}_{-0.072})$	$(2.383 \pm 0.056^{+0.345}_{-0.145})$
0.50–0.54	$(1.349 \pm 0.014^{+0.089}_{-0.066})$	$(1.677 \pm 0.012^{+0.115}_{-0.068})$	$(1.844 \pm 0.013^{+0.132}_{-0.073})$	$(2.200 \pm 0.052^{+0.318}_{-0.144})$

CRDB Cosmic Ray Data Base – present dataset (in expansion)

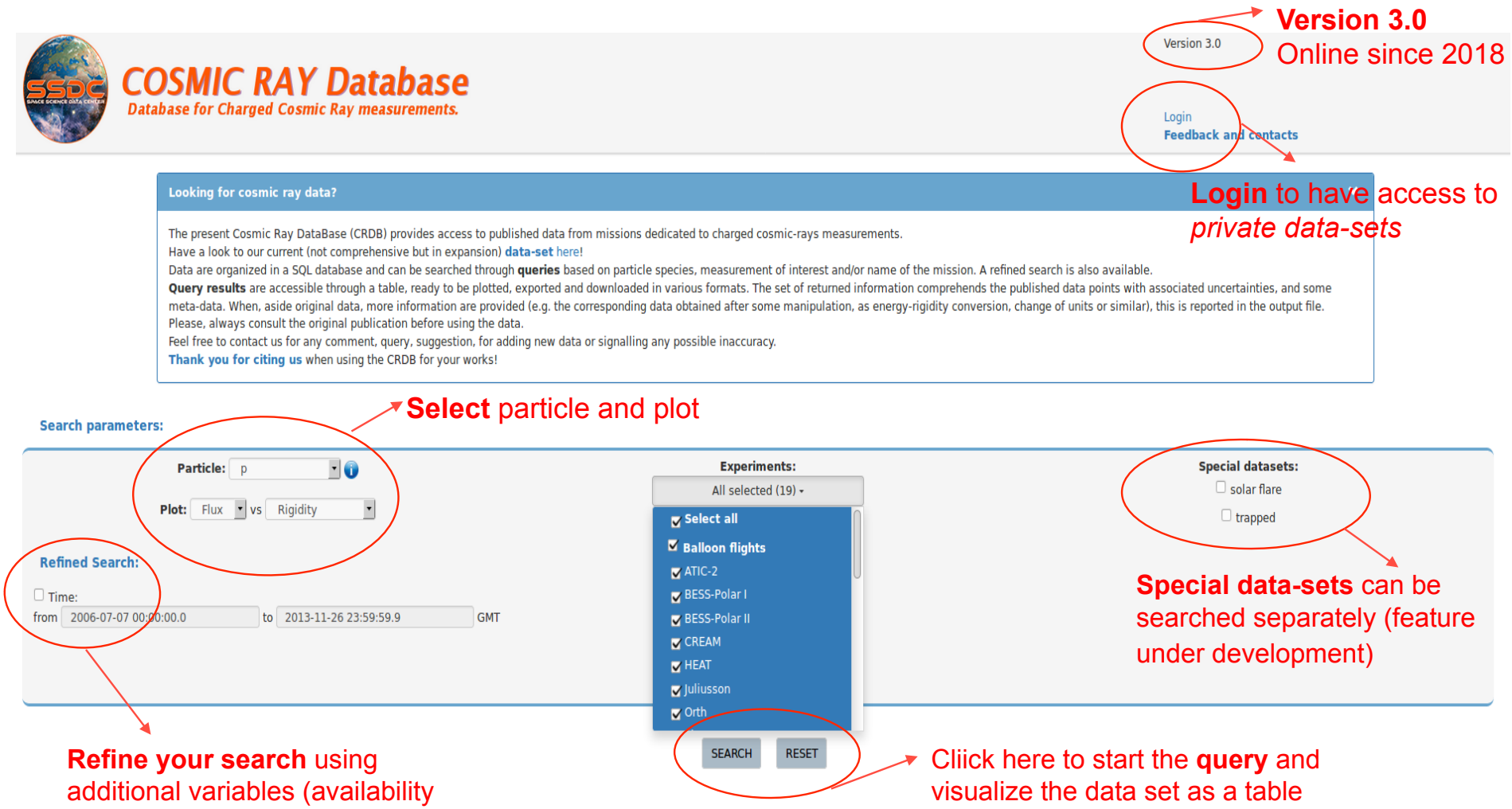
The Cosmic Ray DataBase currently contains ~100 data-sets from 15 different **missions**, in space (ISS, satellite, balloon and space shuttle flights) and ground-based, since the 70's to now.

Energy range: ~MeV to ~250 TeV

Particles: Electrons, Protons, H isotopes, He isotopes, Antiprotons, Positrons, Nuclei and flux ratios

Experiment	Particle	Publication	Publication Title	Publication Year
AMS-01	Li/C	ApJ 724 (2010) 329	Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays: Results from AMS-01	2010
AMS-01	Li/B	ApJ 724 (2010) 329	Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays: Results from AMS-01	2010
AMS-01	3He/4He	JHEP 11 (2003) 048X	Measurement of 3He/4He ratio in cosmic rays with the AMS experiment	2003
AMS-01	Be/C	ApJ 724 (2010) 329	Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays: Results from AMS-01	2010
AMS-01	Be/B	ApJ 724 (2010) 329	Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays: Results from AMS-01	2010
AMS-01	2H	Phys. Rep. 366 (2002) 331	The Alpha Magnetic Spectrometer (AMS) on the International Space Station: Part I – results from the test fight on the space shuttle	2002
AMS-01	B/C	ApJ 724 (2010) 329	Relative Composition and Energy Spectra of Light Nuclei in Cosmic Rays: Results from AMS-01	2010
AMS-02	He/O	PRL 119 (2017) 251101	Observation of the Identical Rigidity Dependence of He, C, and O Cosmic Rays at High Rigidities by the Alpha Magnetic Spectrometer on the International Space Station	2017
AMS-02	Be	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	He	PRL 119 (2017) 251101	Observation of the Identical Rigidity Dependence of He, C, and O Cosmic Rays at High Rigidities by the Alpha Magnetic Spectrometer on the International Space Station	2017
AMS-02	e+/[(e-)+(e+)]	PRL 110 (2013) 141102	First Result from the Alpha Magnetic Spectrometer on the International Space Station: Precision Measurement of the Positron Fraction in Primary Cosmic Rays of 0.5–350 GeV	2013
AMS-02	Be/C	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	e+	PRL 113 (2014) 121102	The Electron and Positron Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station	2014
AMS-02	Li/C	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	He	PRL 115 (2015) 211101	Precision Measurement of the Helium Flux in Primary Cosmic Rays of Rigidities 1.9 GV to 3 TV with the Alpha Magnetic Spectrometer on the International Space Station	2015
AMS-02	pbar/e-	Phys. Rev. Lett. 117 (2016) 091103	Antiproton Flux, Antiproton-to-Proton Flux Ratio, and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station	2016
AMS-02	B	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	pbar/e+	Phys. Rev. Lett. 117 (2016) 091103	Antiproton Flux, Antiproton-to-Proton Flux Ratio, and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station	2016
AMS-02	B/C	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	e+/[(e-)+(e+)]	PRL 113 (2014) 121101	High Statistics Measurement of the Positron Fraction in Primary Cosmic Rays of 0.5?500 GeV with the Alpha Magnetic Spectrometer on the International Space Station	2014
AMS-02	p/e-	Phys. Rev. Lett. 117 (2016) 091103	Antiproton Flux, Antiproton-to-Proton Flux Ratio, and Properties of Elementary Particle Fluxes in Primary Cosmic Rays Measured with the Alpha Magnetic Spectrometer on the International Space Station	2016
AMS-02	C/O	PRL 119 (2017) 251101	Observation of the Identical Rigidity Dependence of He, C, and O Cosmic Rays at High Rigidities by the Alpha Magnetic Spectrometer on the International Space Station	2017
AMS-02	B/C	Phys. Rev. Lett. 117 (2016) 231102	Precision Measurement of the Boron to Carbon Flux Ratio in Cosmic Rays from 1.9 GV to 2.6 TV with the Alpha Magnetic Spectrometer on the International Space Station	2016
AMS-02	Li	PRL 120 (2018) 021101	Observation of New Properties of Secondary Cosmic Rays Lithium, Beryllium, and Boron by the Alpha Magnetic Spectrometer on the International Space Station	2018
AMS-02	O	PRL 119 (2017) 251101	Observation of the Identical Rigidity Dependence of He, C, and O Cosmic Rays at High Rigidities by the Alpha Magnetic Spectrometer on the International Space Station	2017

…. and more …



DB characteristics:

Flexibility (multi-parameter search allowed)
Scalability (new variables and plots easily handled - input xml files)
Simple web interface for the user

[See also **S6.04 poster** contribution - F. Donnini]

SSDC Cosmic Ray Data Base – query output table

Search the table by **keyword** (e.g. publication journal)

Search:

Showing 1 to 12 of 12 entries 6 rows selected

Sort the table output according to additional **parameters**

Plot Selected | Select all items | Select none | Show/Hide Columns

Select	Particle	Mission	Time (GMT)	Time Min (GMT)	Time Max (GMT)	Reference Link	Link	Notes	Ouput File
☑	(e+)+(e-)	AMS-02		2011-05-19 00:00:00.0	2013-11-26 23:59:59.9	PRL 113 (2014) 221102			allele_AMS_PRL2014_000.xml
☑	(e+)+(e-)	CALET		2015-10-13 00:00:00.0	2017-06-30 00:00:00.0	PRL 119 (2017) 181101			e+e-_CALET_PRL2017_000.xml
☑	(e+)+(e-)	DAMPE		2015-12-27 00:00:00.0	2017-06-08 00:00:00.0	Nature 552 (2017) 63			e+e-_DAMPE_NATURE2017_000.xml
☐	(e+)+(e-)	Fermi-LAT		2008-08-04 00:00:00.0	2009-08-04 00:00:00.0	Phys. Rev. D 82 (2010) 092004		Fermi Pass 8 - HE selection	e+e-_FERMI_PRD2010_HE_000.xml
☐	(e+)+(e-)	Fermi-LAT		2008-08-04 00:00:00.0	2009-08-04 00:00:00.0	Phys. Rev. D 82 (2010) 092004		Fermi Pass 8 - LE selection	e+e-_FERMI_PRD2010_LE_000.xml
☑	(e+)+(e-)	Fermi-LAT		2008-08-04 00:00:00.0	2015-06-24 00:00:00.0	Phys. Rev. D 95 (2017) 082007		Fermi Pass 8 - HE selection	e+e-_FERMI_PRD2017_HE_000.xml
☐	(e+)+(e-)	Fermi-LAT		2008-08-04 00:00:00.0	2015-06-24 00:00:00.0	Phys. Rev. D 95 (2017) 082007		Fermi Pass 8 - LE selection	e+e-_FERMI_PRD2017_LE_000.xml
☑	(e+)+(e-)	H.E.S.S.		2004-01-01 00:00:00.0	2006-01-01 00:00:39.9	Astron.Astrophys 508 (2009) 561		LE analysis	e+e-_HESS_AA2009_LE_000.xml
☑	(e+)+(e-)	H.E.S.S.		2004-01-01 00:00:00.0	2008-01-01 00:00:39.9	PRL 101 (2008) 261104		HE analysis	e+e-_HESS_PRL2008_HE_000.xml
☐	(e+)+(e-)	HEAT		1994-05-03 00:00:00.0	1994-05-05 00:00:00.0	ApJ 559 (2001) 296		Data from flight 1 (3-5 May,1994)	e+e-_HEAT_ApJ2001_flight1_000.xml
☐	(e+)+(e-)	HEAT		1995-08-23 00:00:00.0	1995-08-24 00:00:00.0	ApJ 559 (2001) 296		Data from flight 2 (23-24 August,1995)	e+e-_HEAT_ApJ2001_flight2_000.xml
☐	(e+)+(e-)	HEAT		1994-05-03 00:00:00.0	1995-08-24 00:00:00.0	ApJ 559 (2001) 296		Combined data from flights 1994-1995	e+e-_HEAT_ApJ2001_flight_combined_000.xml

Select a subset of data

Showing 1 to 12 of 12 entries 6 rows selected

Plot Selected | Select all items | Select none | Show/Hide Columns

Change selection and **Plot**

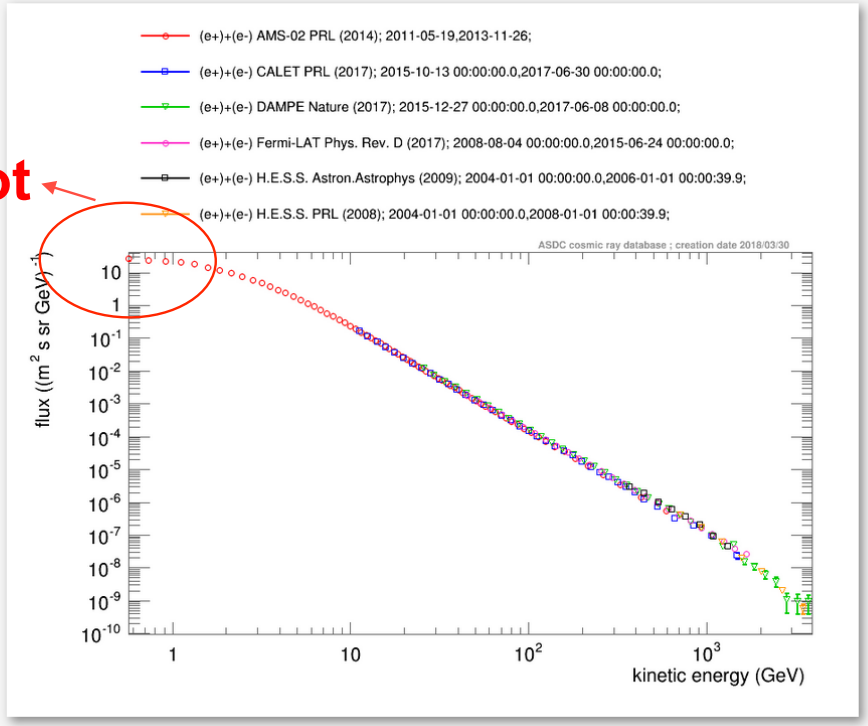
Link to **reference** paper

Previous 1 Next

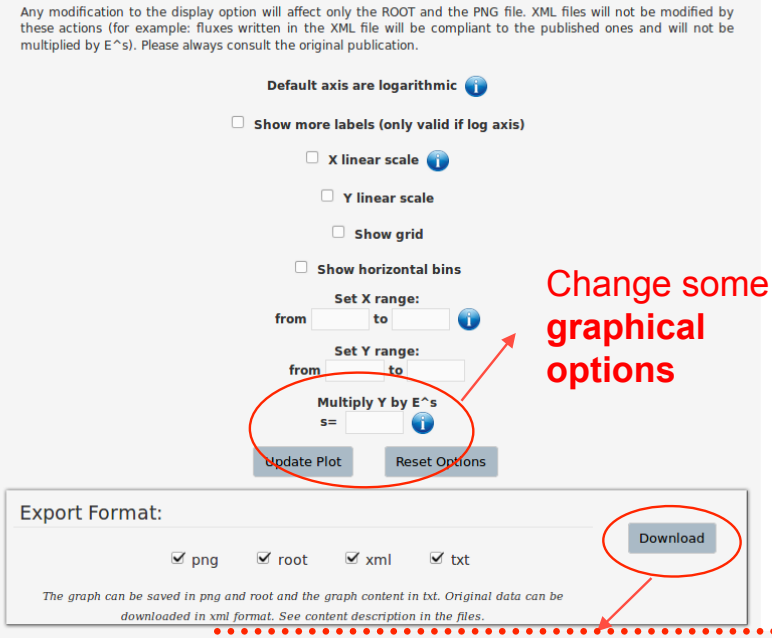
[See also **S6.04 poster** contribution - F. Donnini]

SSDC Cosmic Ray Data Base – output plot examples

Plot Graph:

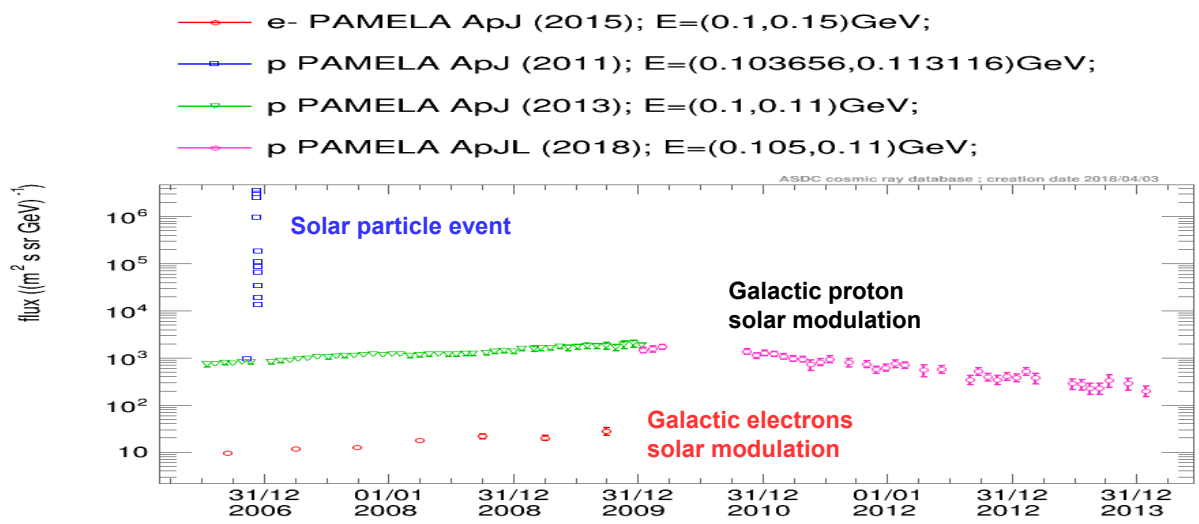


Plot



Change some **graphical options**

- Different export options available for the data to **download** (xml, root, text, png)
- Clearly indicated in the output files whether data are **original** or somehow manipulated beore the download



One more example:

PAMELA flux measurement during quiet time and solar flare, for protons and electrons

SSDC Cosmic Ray Data Base – ongoing and future developments

- Expand our **current dataset** to better join other existing cosmic ray databases

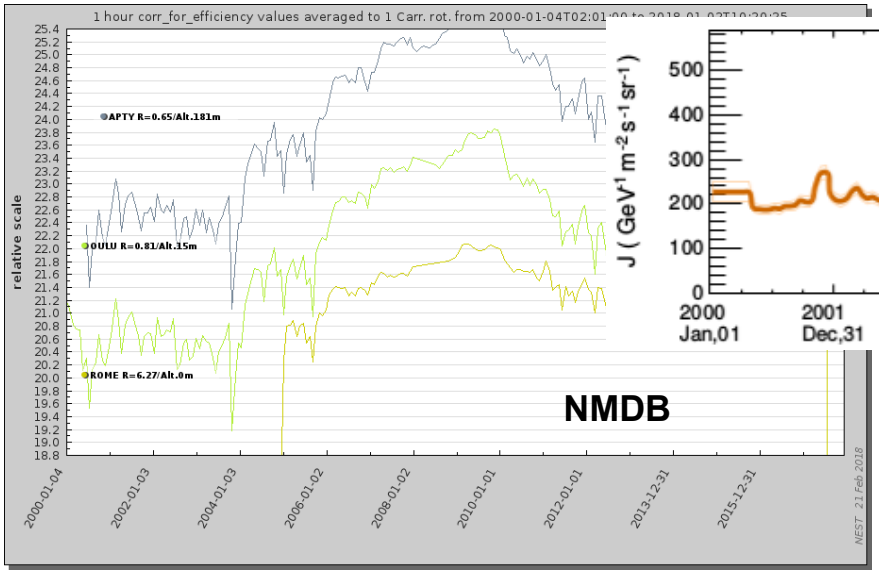
- **Interactive plot** using **JSROOT** (https://root.cern.ch/js/) → change plot options panel, graphical options not any more needed

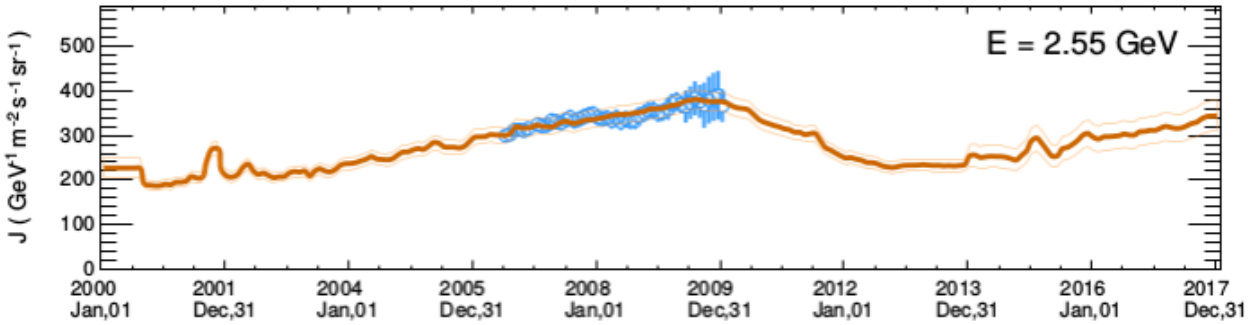
- **Additional plot options** such as:
  Conversion of measurement units (R <-> Ekin)
  Normalization (e.g. to better compare flux evolution in time)
  Add **modeling** results

- Interfacing **other existig databases** for correlated measures (e.g. neutron monitor network **NMDB** or WSO – Wilcox solar observatory) – useful for *low energy studies*

- Additional variables to plot (e.g. measurement uncertainties)

- Bug fixes





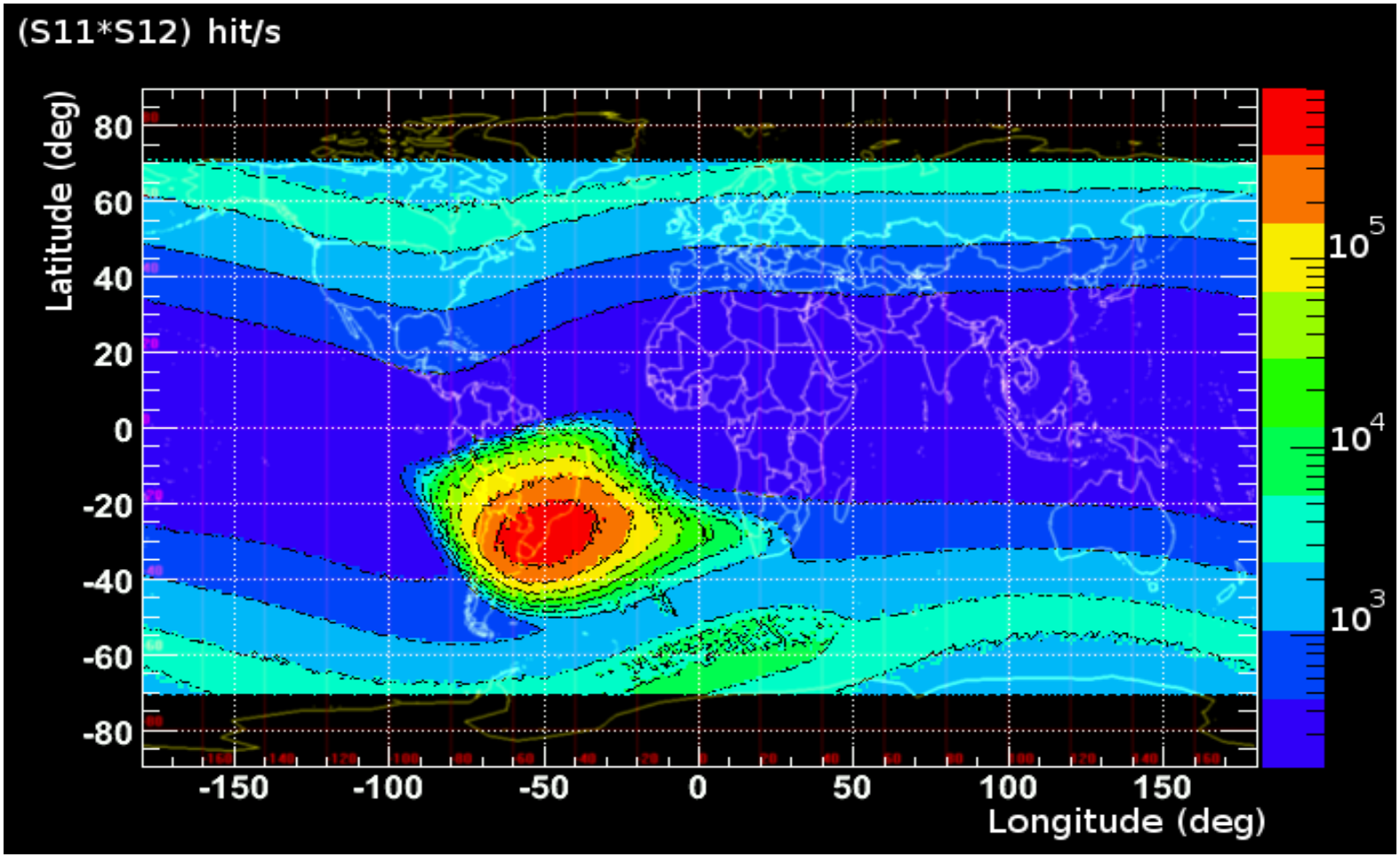
Data + model + more data!
Easily retrievable and in a single output format

Sampling the Low Earth Orbit radiation environment – ideas for a new future tool at SSDC

- Several instruments designed for cosmic ray measurements are actually sampling the low Earth radiation environment.

- They can provide information about the charged particle distribution along a given orbit.(**low-level data**) being of interest for the scientific community, e.g. during mission design phases, data analysis and/or for their connection with space weather

- Such data are not currently publicly available



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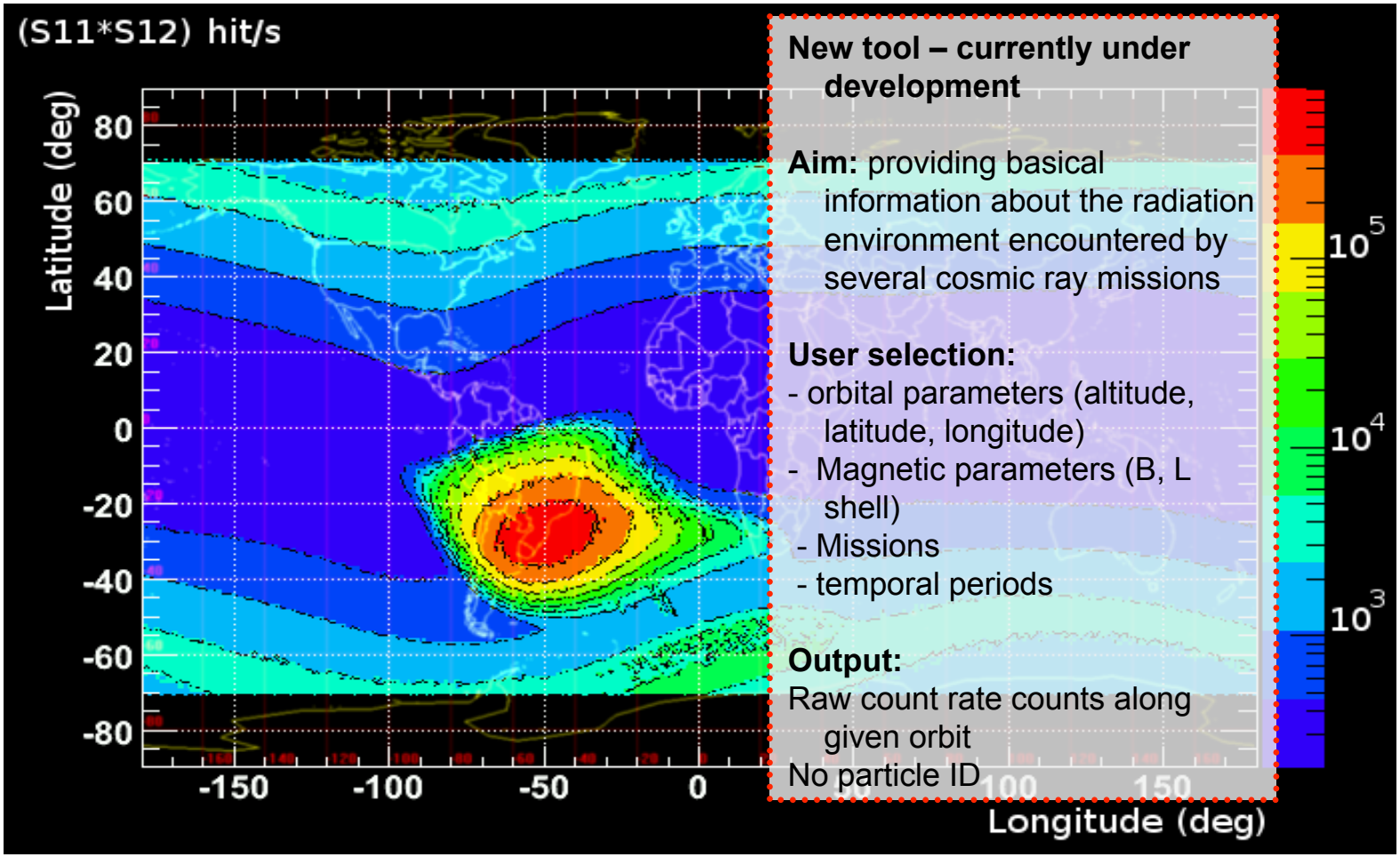

Cosmic Ray data at SSDC – Conclusions and Perspectives

– ASI SSDC provides a framework for preserving and accessing scientific data from space missions, in a ***multi-messenger*** environment;

– *Charged cosmic ray data* constitute an important and growing part of it;

– The **Cosmic Ray DataBase** aims to provide easy access to *published data* and it is developing to connect them to different data-sets and *modelling* results;

Data are welcome!

– New tools exploiting the availability of an organized set of ***lower level data*** could provide additional and useful information to the scientific community.