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An ASI web portal for the Open Universe Initiative

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Abstract "Open Universe" is an initiative under the auspices of the Committee on the Peaceful Uses of Outer Space (COPUOS) that aims at stimulating a dramatic increase in the availability and usability of space science data, extending the potential of scientific discovery to new participants in all parts of the world, especially for developing and underdeveloped Countries. Originally proposed by Italy, the initiative is carried out in cooperation with the United Nations Office of Outer Space affairs (UNOOSA) as part of the activities in preparation for UNISPACE+50, the conference that in 2018 will define a comprehensive United Nations Space2030 agenda for the contribution of space to the achievement of the UN Sustainable Development Goals. Open Universe seeks to trigger a major evolution of current space science data availability fostering the publication of all existing open space science data in a way that is easily discoverable and immediately usable, thus responding to the global demand for transparency that is growing in all sectors of public administrations. As a first contribution to the initiative the Italian Space Agency (ASI) is developing a prototype Open Universe portal, that is a multi-discipline (astrophysics, planetary sciences, cosmic-ray and atmospheric physics) web site where a large number of space science data sets, analysis tools, bibliography and general information services, provided by many on-line space science data archives, can be found next to each other.
The ASI Open Universe portal can be thought of a sort of virtual "shopping mall" dedicated to space science data, where professional scientists and common citizens alike can go, call on the many "shops" (data archive sites, each identified by its own brand) offering different services and data products, use the results to learn about space science or perform scientific analyses, while the software running behind the portal communicates with all components, in an attempt to adapt to the user's needs. This paper briefly illustrates the principles behind the Open Universe initiative and

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provides a description of the main features of the first version (V1.0) of the Open Universe portal.

1 Introduction: transparency and space science data

The almost universal availability of electronic connectivity, web software and screen touch technologies is bringing about a number of revolutions: information of all kinds is rapidly becoming accessible to an ever-larger number of users. Constant on-line reporting, organisations accountability and performance evaluation, interaction between Public Administrations (PA) and citizens, and open disclosure of scientific data are all examples of what is now becoming a common reality.

Internet technologies represent an unprecedented and extraordinary two-way channel of communication between producers and users of data. For this reason the web is widely recognised as a great asset to achieve the fundamental goal of transparency of information and data products, in line with the growing global demand for transparency of all goods that are produced with public money.

All space science data that have been generated through public funding should eventually become openly available to all tax payers, according to clear rules that take into account the investment in terms of intellectual property and efforts of the teams that generate the data, and the more general interest of the society that payed for it. In particular high level calibrated data products, like images, spectra etc., should become available in a transparent form, that is usable by all.

The benefits of openness and transparency are so large and evident both for the users and the data providers that even scientific data generated through private funds should aim at transparency. Implementing open policies in forms that ensure a fair scientific reward for the provider increases the overall return for the investment by expanding the impact of the scientific products that are generated, and by reinforcing the importance of the facilities as the data is used more extensively producing more knowledge.

A number of measurable indicators of data transparency need to be identified so that the transparency level of space science data can be quantitatively evaluated. For the purpose of this paper we assume that space science data can be considered ***transparent*** if it is:

- **Discoverable**. Space science data must be easily discoverable by means of free software services on the web.
- **Open**. Data products must be accessible from the web, free of any legal restrictions and bureaucratic barriers.
  In space astronomy scientific data access is often restricted to the projects teams for a limited amount of time, (usually one year), according to rules agreed during the definition phase of each scientific satellite. After this initial ”proprietary period” access to the data becomes unrestricted. This is however not common practice in all areas of space science.
- **Accessible**. Data access must be simple. Data services should be easy to use and intuitive so that users do not have to go through complex and discouraging learning curves.

- **Understandable**. High level space science data products (e.g. calibrated images, spectra etc). should be understandable without specialised knowledge about the instrumentation that produced the data or calibration details. Systems and data set description must be clear, effective and must avoid documentation overload.
- **Web-ready** High level data products must be "web-ready", that is no further processing of the data is necessary before it can be used. Data products of this type should be downloadable with one simple man-machine interaction, e.g. one click, one screen touch, or equivalent future way of accessing data.
- **Timely**. Data should be publicly available in a timely fashion, so that it can be reused by anyone before it becomes obsolete.

In the field of scientific research most of the data are generated through projects financed with public money. An approximate estimate of the current level of investment is of the order of 15 Billion Euros per year for the sector of space science only (**?**). Applying the transparency criteria listed above to space science data will ensure that the benefits of the large investments made have the potential to reach all citizens, from professional scientists working in other sectors, to school educators and to the common citizen, increasing the amount of knowledge obtained from existing data and democratizing access to information.

Much has been done in recent years to offer open access to valuable scientific data, however, there is still a considerable degree of unevenness in the services currently offered by providers of data from outer space. Further efforts are necessary to consolidate, standardise and expand services, promoting a significant inspirational data-driven surge in training, education and discovery. Such a process, leading to a larger level of transparency of space science data, should be open to people worldwide and supported by a wide initiative of international cooperation among space science data providers.

This paper briefly describes the main features of the prototype of a web-based software tool that is being developed at the Italian Space Agency (ASI) within "Open Universe", an initiative under the auspices of the Committee on the Peaceful Uses of Outer Space (COPUOS) of the United Nations.

2 The United Nations Open Universe Initiative

"Open Universe" is an initiative proposed by Italy in 2016 to the UN-COPUOS with the objective of stimulating a dramatic increase in the availability and usability of space science data, extending the potential of scientific discovery to new participants in all parts of the world and empowering global educational services.

The goals of "Open Universe" will be pursued with the coordination of the Office for Outer Space Affairs (UNOOSA) of the United Nations, as part of the activities in preparation of the fiftieth anniversary of the first United Nation Conference on the Exploration and Peaceful Uses of Outer Space (UNISPACE+50). Open Universe will ensure that space science data will become gradually more openly available, easily discoverable, free of bureaucratic or administrative barriers, and usable by the widest possible community, from professional space scientists (several thousands of

individuals) to citizen scientists (potentially of the order of millions) to the common citizens generally interested in space science (likely hundreds of millions).

The services delivered by existing space science data archives are very heterogeneous, ranging from basic support reserved to a restricted number of scientists, to open access digital archives offering "science-ready" data products, that is high-level calibrated space science data that can be published without further analysis by professionals with suitable knowledge.

"Open Universe" will implement a method of measuring the transparency (based on the indicators listed above) of the data stored in current space science data archives, and urge the data producers to increase their present efforts so as to extend the usability of space science data to the non-professional community.

The extra cost of reaching the level of adequate transparency (or "web-readiness") is a very small fraction (certainly less than 1%) of the funding level that is invested every year to produce and archive space science data. The benefits of such a cultural step are potentially enormous.

3 The ASI "Open Universe" portal prototype

In an effort to make a step towards the implementation of the principles put forward by "Open Universe", the Italian Space Agency (ASI) has developed a prototype web portal for the initiative that aims at becoming a multi-discipline, multi-provider open space data service. The first version (V1.0) of the ASI "Open Universe" portal (openuniverse.asi.it) has been released on the occasion of the United Nations/Italy workshop on Open Universe held in Vienna in November 2017.

The main aims of the portal are:

1. develop the first prototype of a multi-discipline multi-provider space science web site that aims at data transparency
2. concentrate in a single web page the potential of accessing space science data and information from several data archives and related information systems (e.g. catalogs, bibliographic services etc.)
3. facilitate new types of scientific research based on data intensive/ data fusion analysis
4. stimulate discussion among experts and users so as to collect suggestions on how to reach the goals of the "Open Universe" initiative.
5. help defining the requirements for a new generation of "user-centred" integrated space science data archives that could be used in principle by anyone having access to touch-screen or equivalent technology of the future.
6. explain and demonstrate the potential of "Open Universe" to the non-space science professionals (e.g. museums, education sector, common citizens).
7. provide links to a large number of services that give access to space science data services that could be used to evaluate the level of transparency provided.

The space disciplines supported are:

- **astrophysics and cosmology**,
- **planetary science**,

Fig. 1 The Open Universe front page provides general information about the Open Universe initiative, documentation for the user, several links to space science related sites, and an input area (marked as "User input") where the user can specify his/her requests about astronomical sources, planets, cosmic ray particles etc. The response of the portal following a request is directed to the area marked as "info and output area".

- **cosmic rays physics**
- **atmospheric physics** (limited to Terrestrial Gamma Ray Flashes).

This web site it is not initially meant to be a software system where all space science data can be accessed, viewed and fully analysed in a homogeneous and integrated way. It is rather a web site where a wide range of services developed independently by different space data providers and archive sites can be found in the same place. It is a sort of space science data "shopping mall" where professional scientists and common citizens alike can go, visit and use (shop) the many web services (each clearly identified by its "brand" or developers logos) available next to each other, with the peculiarity that all the services (shops) know what the user is looking for as soon as he/she enters the mall.

In the following we give a preview description of some of the features of the prototype that have been completed at the time of writing.

The entry point for the user is the input area at the top right part of the front page of the system, as shown in Fig.**??**. Depending on the input provided, the system attempts to recognise the science discipline that is of interest to the user, and reacts accordingly. For example if a user enters the name of an astronomical object (e.g. Andromeda, M101 or Pleiades) the software will start the astronomy section (Fig.**??**)

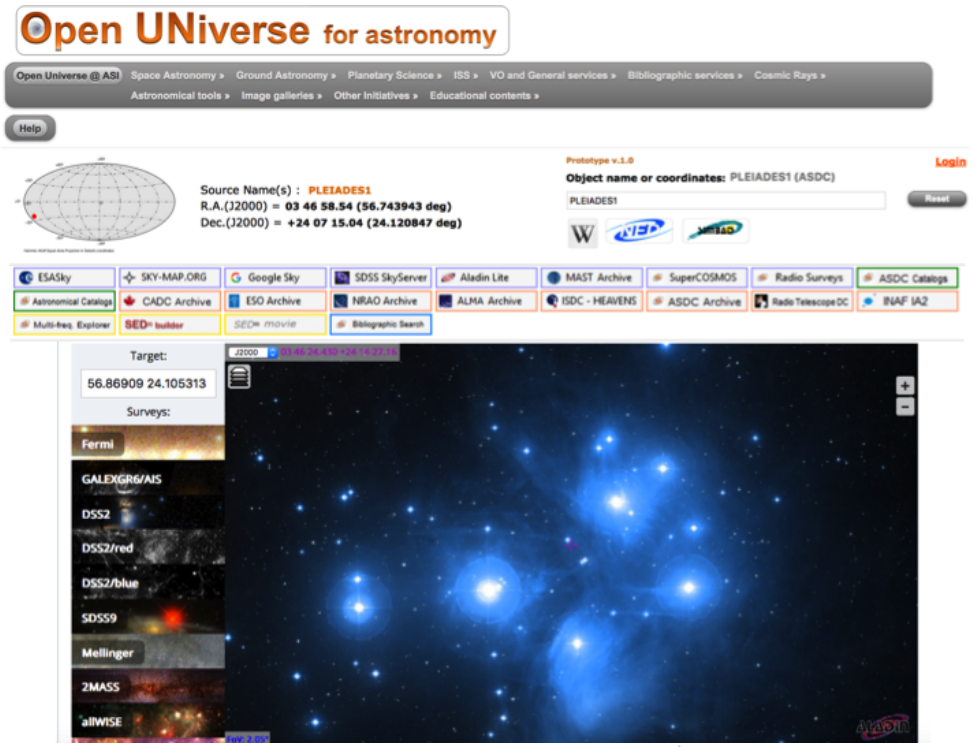

Fig. 2 The appearance of Open Universe prototype following a request for data about the Pleiades open star cluster, and selecting "Aladin light" among the several astronomical services providing access to survey images, archival data, catalogs, multifrequency information, and bibliographic services (see text for detail).

providing access to several astronomical services; if instead the user types e.g. moon, proton, or atmosphere the system will start the planetary science (Fig.**??**), cosmic rays (Fig.**??**) or atmospheric science (Fig.**??**) section, respectively.

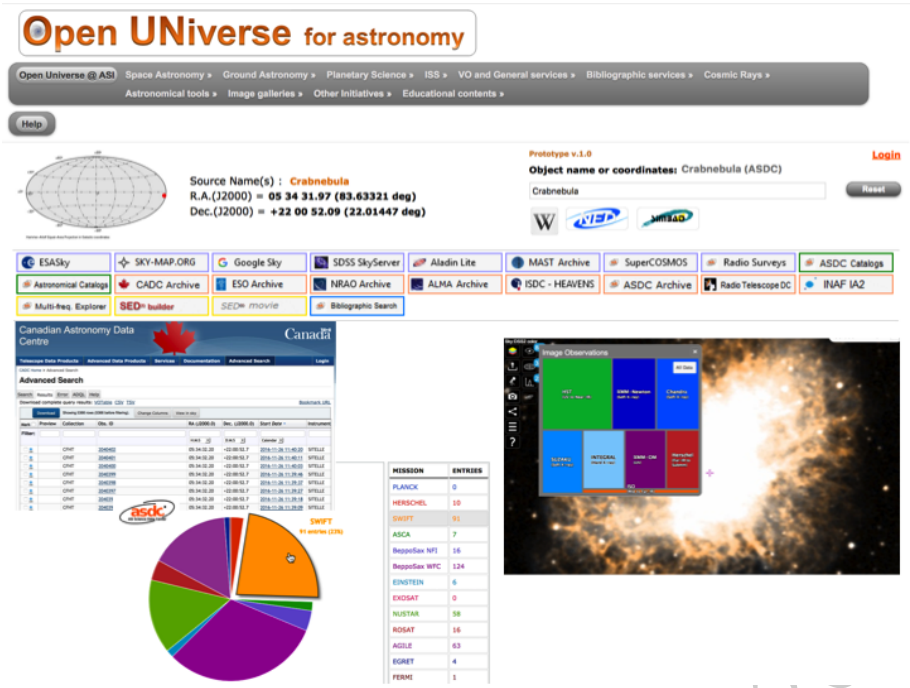

Fig. 3 This figure combines in a single picture the results of a query to three space science data archive services (CADC, left; ESASky, right, and the ASDC bottom) requesting the available observations of the astronomical source "Crab Nebula". The results are presented in very different ways: tabular form for CADC, a combination of an image and graphics for ESASky and pie chart for ASDC.

3.1 Links to space science related sites

The grey area in the top part of the portal above the *user input* and highlighted by a red rectangle marked as "links to web sites" in Fig. **??** is gives links to the major existing web pages providing data, services or information about space science. Sites are grouped in different categories, as follows:

- Space astronomy, pointing to links providing data services for satellite astronomical data
- Ground astronomy, pointing to links providing data from ground based telescopes
- Planetary science
- ISS (International Space Station
- Virtual Observatory (VO) and General services
- Bibliography services
- Cosmic Rays
- Astr onomical web tools
- Astronomical image galleries
- Educational contents

– Other initiatives

This part of the ASI Open Universe portal does not add value to the linked sites but, by placing the information in a single place, it contributes to increase discoverability, the first indicator of transparency (see Par **??**).

3.2 Open Universe for Astronomy

By entering the name of a known astronomical source (e.g. Crab Nebula, Andromeda, 3C273 etc.) the system activates the astronomy part of the "Open Universe" portal giving access to services offering astronomical data from many archives, catalogs of astronomical objects, data intensive/fusion tools, and bibliographic information (see Fig.**??**).

A series of icons appearing in the mid part of the page (see Figs. **??**,**??**,**??**,**??**) allow the users to activate services of different types (each identified by a specific colour), as provided by several existing major web sites. The list of the services included in the current version V0.8 is the following:

1. Icons with border in light blue colour - Sky survey services
   – ESA Sky (European Space Agency)
   – SKY-MAP
   – Google sky (Google)
   – Sloan Digital Sky Survey (SDSS) sky server
   – Aladin lite (CDS)
   – MAST archive (STSci)
   – Super COSMOS Sky Surveys (SSS, via ASDC)
   – Radio Surveys (NRAO, SIFA, ASTRON.via ASDC)
2. Icons with border in red colour - Data archive services
   – ESA Sky (European Space Agency)
   – ALMA archive (ALMA)
   – CADC (Canadian Astronomy Data Centre)
   – ESO archive (ESO)
   – ISDC - HEAVENS
   – NRAO archive (NRAO)
   – Radio Telescope data Center (SAO)
   – ASDC multi-mission archive for astronomy
3. Icons with border in green colour - Astronomical catalogs
   – Catalogs generated with the contribution of ASDC
   – Catalogs grouped by energy band from ASDC, VIZIER, HEASARC, NVO
4. Icons with border in yellow colour - Data fusion
   – Multi frequency explorer (ASDC)
   – SED builder (ASDC)
   – SED movies (ASDC)
5. Icons with border in dark blue colour - Bibliography services
   – NED via source name(s)
   – ADS via source coordinates

More general information is also available through services like Wikipedia, NED, and SIMBAD located just under the entry area on the top right part of the portal (see Fig.**??**).

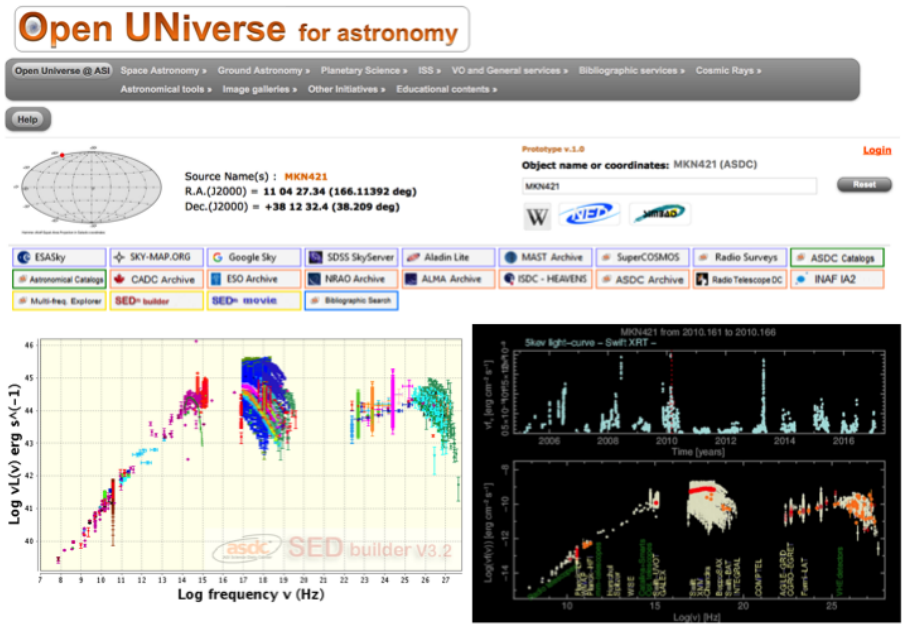

Fig. 4 Examples of data intensive tools combining thousands of flux density measurements of the active galaxy MKN421 across the electromagnetic spectrum in a single Spectral Energy Distribution (SED) plot (left) or even shown as an SED movie (right). This is only available for a few selected bright objects, e.g. 3C273, MKN421, WR140 etc.

Fig. **??** gives an example of a query regarding the well known astronomical source ”Crab Nebula”, showing on the left side the result of a request for image products available within the ESASky service and to the right side the result of a query to the ASDC multi-mission archive. The two outputs are complementary providing information and data from many space telescopes operating in different parts of the electromagnetic spectrum, operated by a number of international space agencies, including ESA, ASI, NASA and JAXA.

3.3 Open Universe for planetary science

By entering the name of a planet or of other objects in the solar system, (e.g. Moon, Mars or Lutetia) the ASI prototype activates the planetary science section, which gives access to the popular web service ”Google moon” and to MATISSE (Refer-

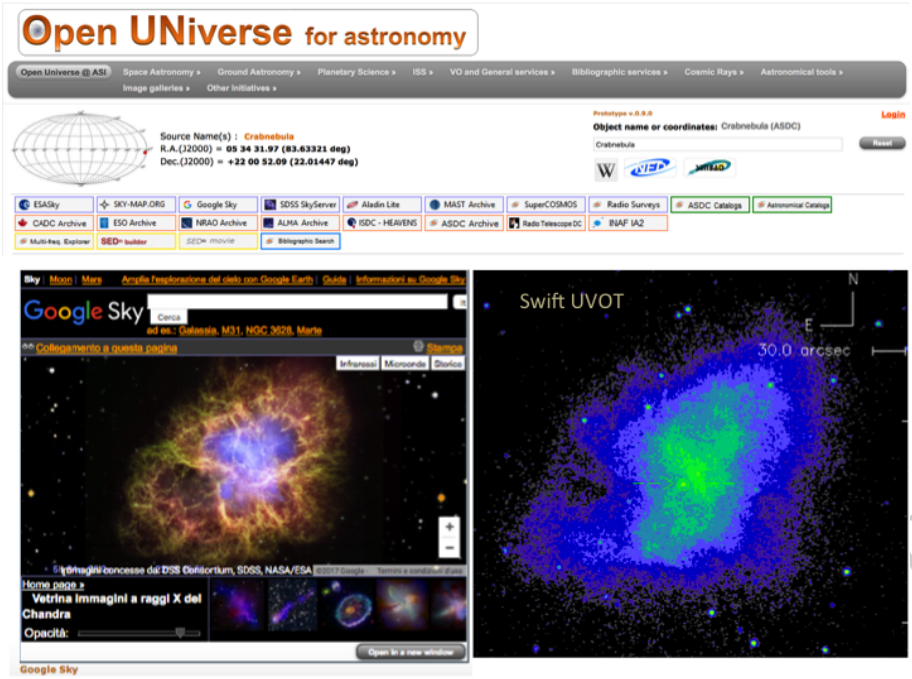

Fig. 5 Optical (orange) and X-ray (blue) images of the Crab Nebula are shown overlaid in the left panel produced with Google-Sky. A UV image of the same source from the Swift UVOT archive is shown on the right side.

ence), the ASDC archive interface dedicated to planetary science, which serves data from several planetary space missions like Rosetta, Dawn, Chang'e1-2 etc.

Fig.**??** shows an example of what can be done in the planetary science part of the Open Universe prototype. On the left side we have a view of the Moon obtained with "Google Moon", while the right side shows an image of the Moon surface obtained from the data of the Chinese mission Chang'e-2. The green path highlights a probable lunar lava tube. Lava tubes are tunnels that formed billions of years ago when basaltic lava was flowing on the moon. These natural structures could be exploited in the future to build human habitats.

To support users interested in specific craters or on the location of a lander of a exploration mission on the Moon or on Mars the system provides the names and geographical coordinates of all major catalogued craters and landing sites by typing e.g. "mooncrater" or "moonlander".

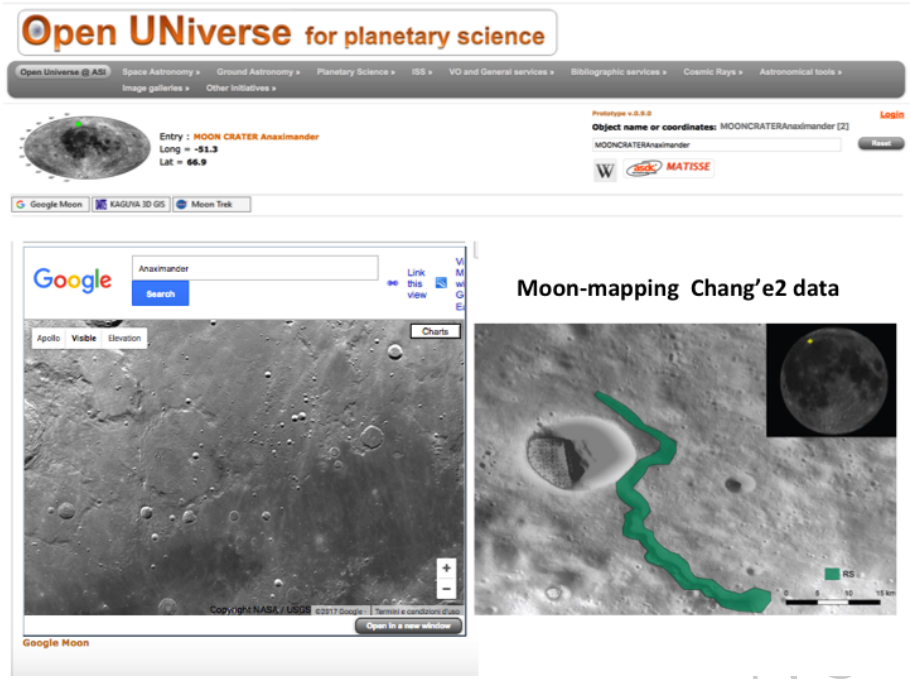

Fig. 6 Views of the surface of the Moon obtained with "google moon" and from the MATISSE ASDC system. The picture on the right is from the Chinese Chang'e mission. The green path highlights a lunar lava tube, see text for details.

3.4 Open Universe for cosmic ray physics

If the user enters the name of a Cosmic Ray particle (e.g. proton, e+, e- etc.), or simply "cosmic rays", the "Open Universe" prototype activates the part of the system dedicated t o cosmic ray physics. This component which gives access to several published results from the AMS-02 and PAMELA experiments via the ASDC cosmic Ray database, the database of charged cosmic rays maintained at LPSC, as well as tables of Ultra High Energy cosmic rays.

Fig.**??** gives an example of a query to the PAMELA results showing a plot of the flux ratio between Hydrogen and Helium particles as a function of kinetic energy.

3.5 Open Universe for Atmospheric Physics

In case the user is interested in Terrestrial Gamma-ray Flashes or TGF[1] he/she can type "TGF" and the software will activates the part of the system dedicated to atmospheric physics (at the moment limited to TGF events detected by the AGILE satellite).

[1] Terrestrial Gamma-Ray Flashes, or TGFs, are bursts of gamma-ray that are generated in the earth atmosphere during strong storms, that can be detected by satellites from space.

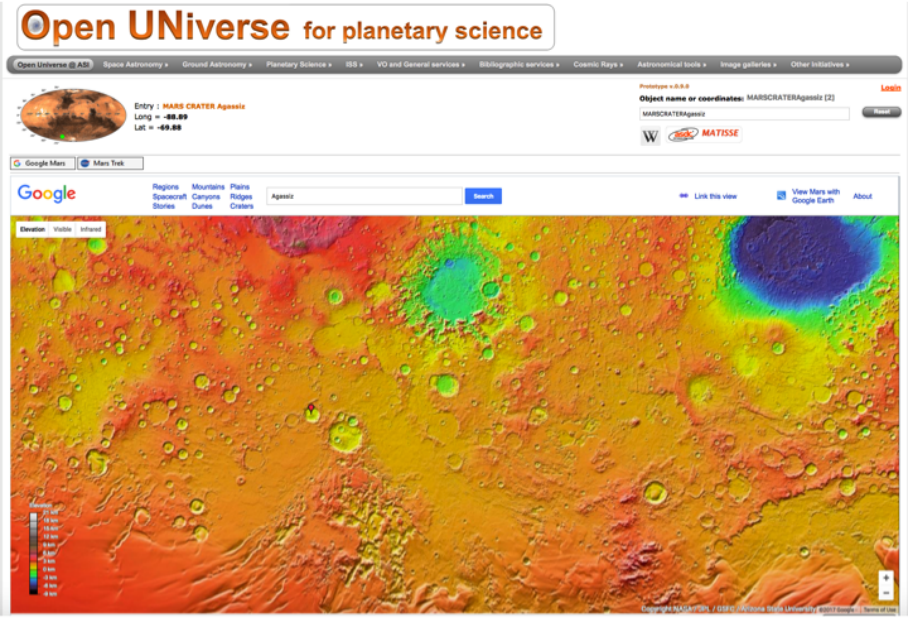

Fig. 7 Views of the surface of the planet Mars obtained with "google mars" ....

Fig.**??** shows an example of a request to visualize data from a TGF. On the top left part of the page the prototype shows the location of the event giving both its geographical coordinates and a plot where the TGF is represented by a red point on the image of the Earth plotted in Hammer-Aitoff coordinates. The bottom part of the image shows the temporal evolution and the energy spectrum of the flash.

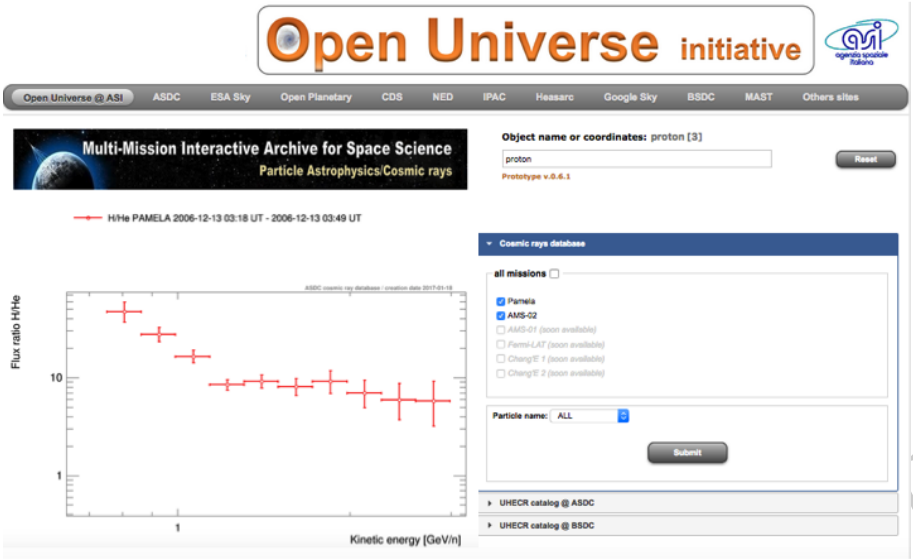

Fig. 8 The Open Universe page dedicated to cosmic ray physics

4 Conclusions

Since the advent of the first web-based digital archives offering on-line open astronomical data services in the early nineties, much has been done in the direction of offering space science data to an ever increasing number of users, from the small community of scientists involved in the experiments that produced the data to several thousands of non-specialists researchers. This progress, however, has been strongly discipline dependent, with the astronomy sector leading the way, while other space science disciplines moving much less rapidly and in many cases still restricting the use of the expensive data they produce to the scientists belonging to the projects teams.

Much work is still ahead of us to meet the goals of the ”Open Universe” initiative, which are in line with the increasing demand for transparency of all that is produced with public money. The ASI prototype that has been described in this paper represents a first step along this way.

Even in the astronomy sector, today’s best digital archives provide in most cases calibrated data and the associated software suitable for higher level scientific analysis that must be carried out by expert users. The rest of the world is still largely precluded from the utilisation of the data.

It is too early to predict what is the detailed work that is necessary to achieve all goals of ”Open Universe”. It is however easy to predict that the associated extra cost is only

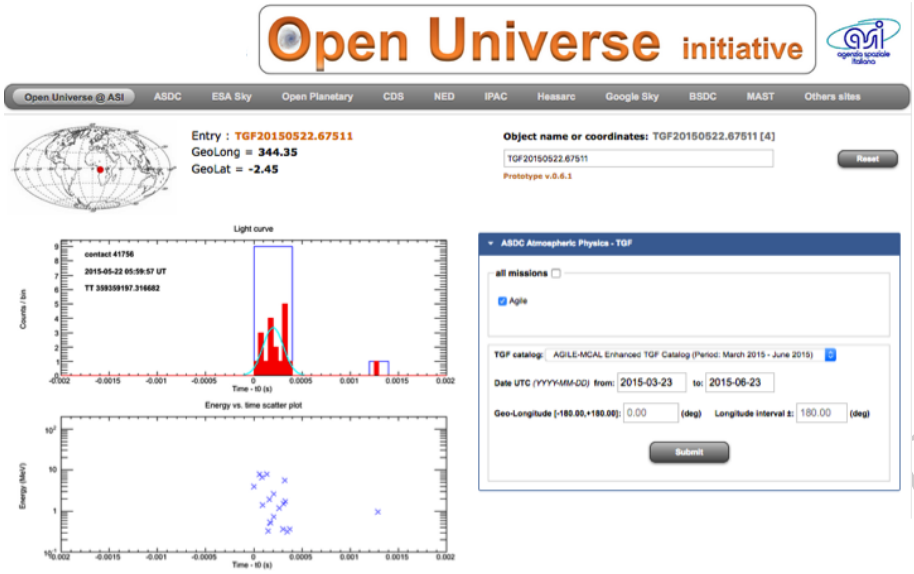

Fig. 9 The Open Universe prototype showing an example of Terrestrial Gamma-ray Flash (TGF) detected by the AGILE satellite

a tiny fraction of the amount of ≈15 Billion Euros (**?**) that is spent every year in the world to generate scientific space data.
To define the elements that are needed to meet the goals of Open Universe a series of events have been scheduled. The first one is an "expert meeting", that took place at the ASI headquarters in Rome, Italy, on 11-12 April 2017, bringing together representatives of the major space science data producers and world experts in different sectors. The next step is an open workshop hosted by the UN Office for Outer Space Affairs (UNOOSA), in Vienna, Austria on November 20-22, 2017. The ASI Open Universe prototype portal will be demonstrated on this occasion, alongside with other software tools and web services.

The ASI developers welcome contributions of other space science data archives at any level, from the inclusion of a simple link to a full integration to the system.

Acknowledgements Thanks to ... TBD

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