Friedrich-Alexander-Universität
Erlangen-Nürnberg

Current status of open data and software in multi-messenger astronomy.

Rodrigo, G. Ruiz

Naples, 10/07/2021

Introduction

Origins of Open Access

- **BUDAPEST OPEN ACCESS INITIATIVE (2002)**
  - First public statement on open access
  - Defines Open Access in the context of scientific literature
  - Signed by early pioneers in Open Access movement
  - Can still be signed: https://www.budapestopenaccessinitiative.org/read/
- **BETHESDA STATEMENT ON OPEN ACCESS PUBLISHING (2003)**
  - Meeting held in Howart Huges Medical Institute (Biomedicine research and education)
  - Builds up on Budapest statement
  - Addresses the right to make derivative works.
- **BERLIN DECLARATION ON OPEN ACCESS KNOWLEDGE IN SCIENCES AND HUMANITIES:** Read it here
  - Builds on Budapest and Bethesda
  - Conference organised by Max Planck Institute and European Cultural Heritage Online
  - Focuses on the Internet as the medium through which knowledge is disseminated
  - Extends the concept of Open Access to Data and Software.

Complexity of Open Access Systems

Quotes from the Berlin Declaration:

1. *Content and **software** tools must be openly **accessible and compatible**.*
2. ***Open access** contributions **include** original scientific research results, **raw data and metadata**, source materials, digital representations of pictorial and graphical materials and scholarly multimedia material.*

The design and implementation of an Open Access system is complex:

- QA/QC in data, software, analysis
- Product versioning
- Documentation
- Follow FAIR principles (see FAIR data principles wikipedia)
- Infrastructures (computing power, and storage)
- Human Resources

Open access data in multi-messenger astronomy

The Virtual Observatory

https://www.ivoa.net/

The Virtual Observatory (VO) is the vision that astronomical datasets and other resources should work as a seamless whole. Many projects and data centres worldwide are working towards this goal. The International Virtual Observatory Alliance (IVOA) is an organisation that debates and agrees the technical standards that are needed to make the VO possible. It also acts as a focus for VO aspirations, a framework for discussing and sharing VO ideas and technology, and body for promoting and publicising the VO.

To learn more about the IVOA as an organisation, read the "About" section.

To learn more about the VO from a user's point of view, including how to find VO tools and services, read the "Astronomers" section. There is also a page about the VO for students and the public.

To learn how to publish VO services, or write VO-compatible software, start by reading the "Deployers/Developers" section.

Internal IVOA discussions are publicly viewable in the "Members" section.

IVOA NEWS

March 2022 Issue of the IVOA Newsletter

UPCOMING MEETINGS

IVOA Northern Fall Interop, 18-20 October 2022 (Virtual)

For Astronomers

Getting Started / Using the VO VO Glossary / VO Applications IVOA newsletter / VO for Students & Public

For Deployers/Developers

Intro to VO Concepts / IVOA Standards / Guide to Publishing in the VO / Technical Glossary

For Members

IVOA Calendar / Working Groups/ Twiki / Documents in Progress / Mailing Lists / IVOA Roadmap

The Virtual Observatory

https://www.ivoa.net/

Virtual Observatory (VO):

- Analogous to WWW but for astronomy
- Allows to interrogate multiple data centers in a transparent way

International Virtual Observatory Alliance (IVOA):

- Formed in 2002
- Focuses on development of standards
- Comprises 22 VO programs from different countries

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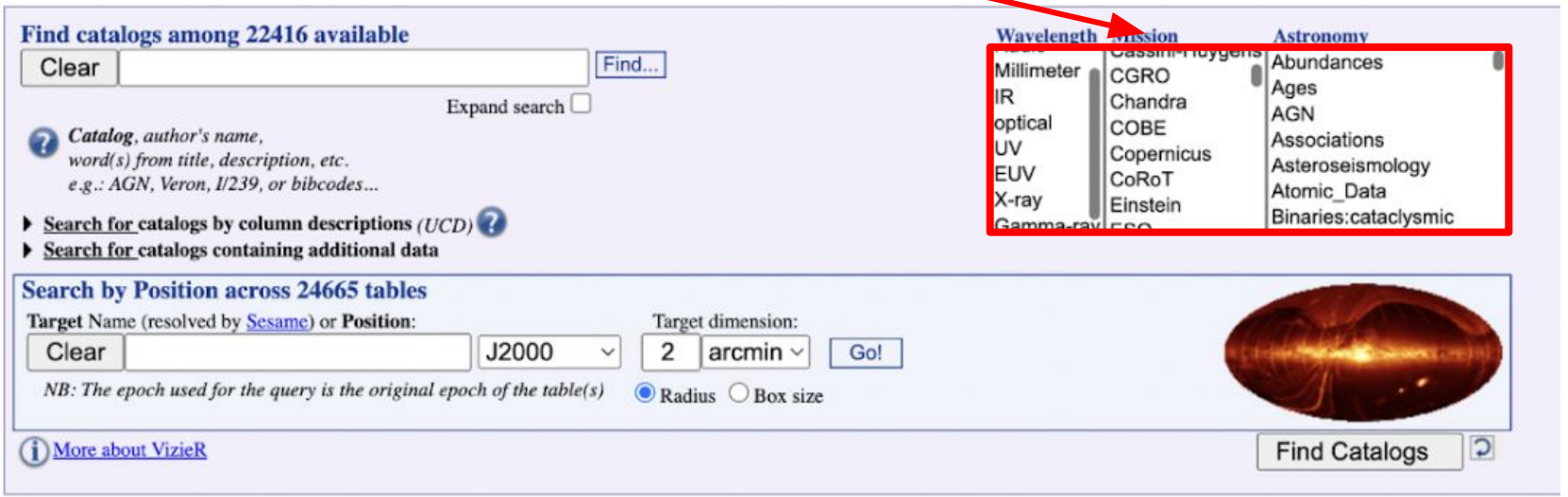
The Virtual Observatory

Example: the vizieR catalog library

Example: vizieR catalog library allows to query multiple catalogs
Many instruments are there already!

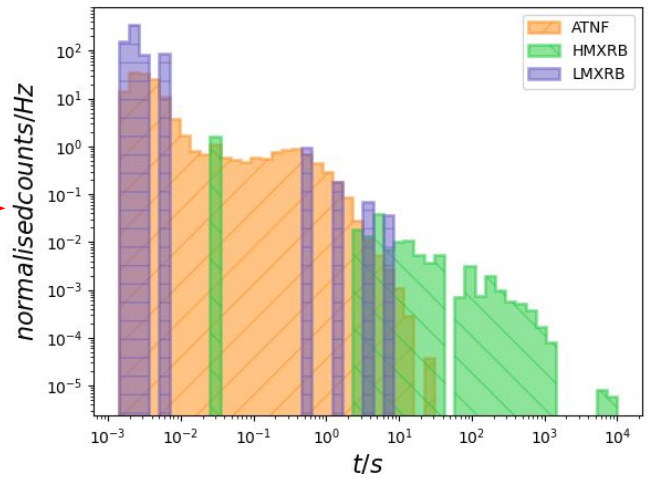


The Virtual Observatory

Examples: the vizieR catalog library

Also easy to use software libraries!

```
1  import pyvo as vo
2  import psrqpy
3  from psrqpy import QueryATNF
4
5  def main():
6      service = vo.dal.TAPService('http://TAPVizieR.u-strasbg.fr/TAPVizieR
           /tap/')
7
8      HMXRB = service.search("SELECT \"J/A+A/455/1165/table1\".Name,  \"J
           /A+A/455/1165/table1\".DEJ2000,  \"J/A+A/455/1165/table1\".GLAT,
            \"J/A+A/455/1165/table1\".GLON,  \"J/A+A/455/1165/table1\"
           .RAJ2000,  \"J/A+A/455/1165/table1\".Type,  \"J/A+A/455/1165
           /table1\".Ppulse FROM \"J/A+A/455/1165/table1\"")
9
10     LMXRB = service.search("SELECT \"J/A+A/469/807/lmxb\".Name,  \"J/A+A
           /469/807/lmxb\".Type,  \"J/A+A/469/807/lmxb\".RAJ2000,  \"J/A+A
           /469/807/lmxb\".DEJ2000,  \"J/A+A/469/807/lmxb\".Ppulse,  \"J/A
           +A/469/807/lmxb\".GLAT,  \"J/A+A/469/807/lmxb\".GLON FROM \"J/A
           +A/469/807/lmxb\"")
11
12     ATNF = QueryATNF().table
13     ...
14     ...
```



The Virtual Observatory

Examples: the vizieR catalog library

BUT: VO is not complete. Some catalogs are published in a standalone way

```
1  import pyvo as vo
2  import psrqpy
3  from psrqpy import QueryATNF
4
5  def main():
6      service = vo.dal.TAPService('http://TAPVizieR.u-strasbg.fr/TAPVizieR
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            \"J/A+A/455/1165/table1\".GLON,  \"J/A+A/455/1165/table1\"
           .RAJ2000,  \"J/A+A/455/1165/table1\".Type,  \"J/A+A/455/1165
           /table1\".Ppulse FROM \"J/A+A/455/1165/table1\"")
9
10     LMXRB = service.search("SELECT \"J/A+A/469/807/lmxb\".Name,  \"J/A+A
           /469/807/lmxb\".Type,  \"J/A+A/469/807/lmxb\".RAJ2000,  \"J/A+A
           /469/807/lmxb\".DEJ2000,  \"J/A+A/469/807/lmxb\".Ppulse,  \"J/A
           +A/469/807/lmxb\".GLAT,  \"J/A+A/469/807/lmxb\".GLON FROM \"J/A
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11
12     ATNF = QueryATNF().table
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```
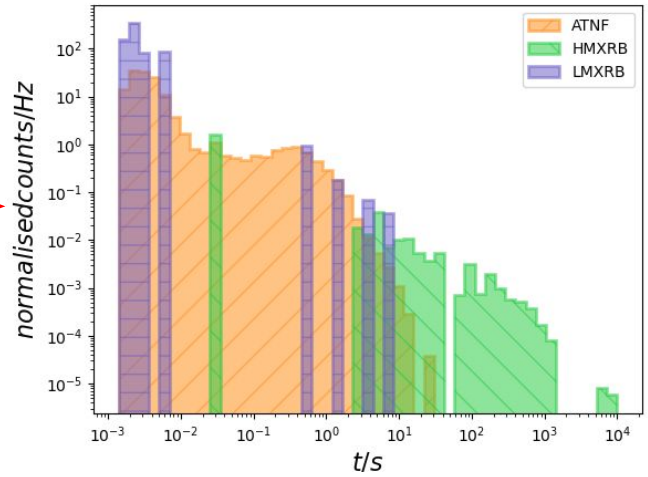
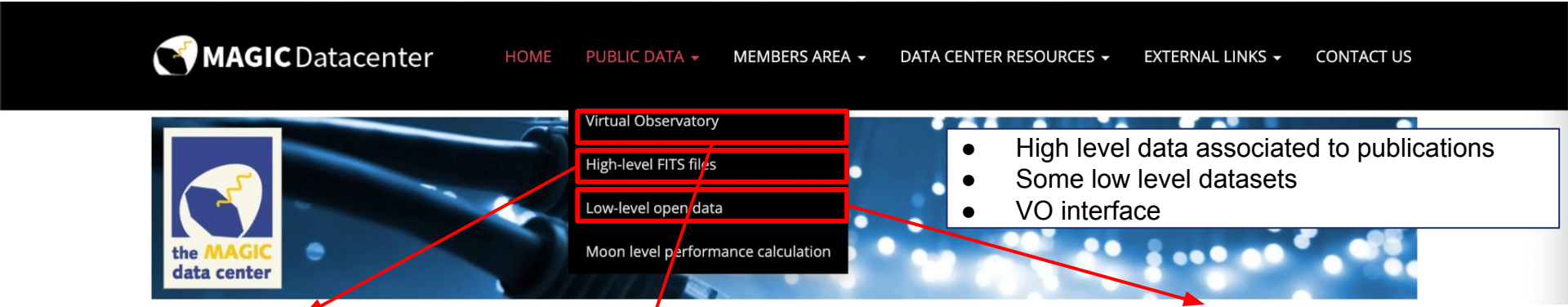



The Virtual Observatory

Example: Magic telescope



- High level data associated to publications
- Some low level datasets
- VO interface

LS I +61 303	Variable Very High Energy Gamma-ray Emission from the Microquasar LSI +61 303	2006	(J. Albe
1ES1218+30.4	Discovery of VHE gamma-ray emission from 1ES1218+30.4	2006	(J. Albe
HESS J1834-087/W41	Observation of VHE gamma radiation from HESS J1834-087/W41 with the MAGIC telescope	2006	(J. Albe
HESS J1813-178	MAGIC Observations of very high energy gamma-rays from HESS J1813-178	2006	(J. Albe
GRB050713a	Flux upper limit of gamma-ray emission by GRB050713a from MAGIC Telescope obervations	2006	(J. Albe
Galactic Center	Observation of Gamma Rays from the Galactic Center with the MAGIC telescope	2006	(J.Albe
1ES1959+650	Observation of VHE gamma-ray emission from the Active Galactic Nucleus 1ES1959+650 using the MAGIC telecope	2006	(J. Albe

* The .fits file is not complete. If the data you need is missing, please contact the corresponding authors.

MAGIC VIRTUAL OBSERVATORY INTERFACE

For MAGIC public results in a VO-compatible form, please send query or fill the search form at vobs.magic.pic.es.

DOCUMENTATION

FITS format for MAGIC data

MAGIC Open Data Repository

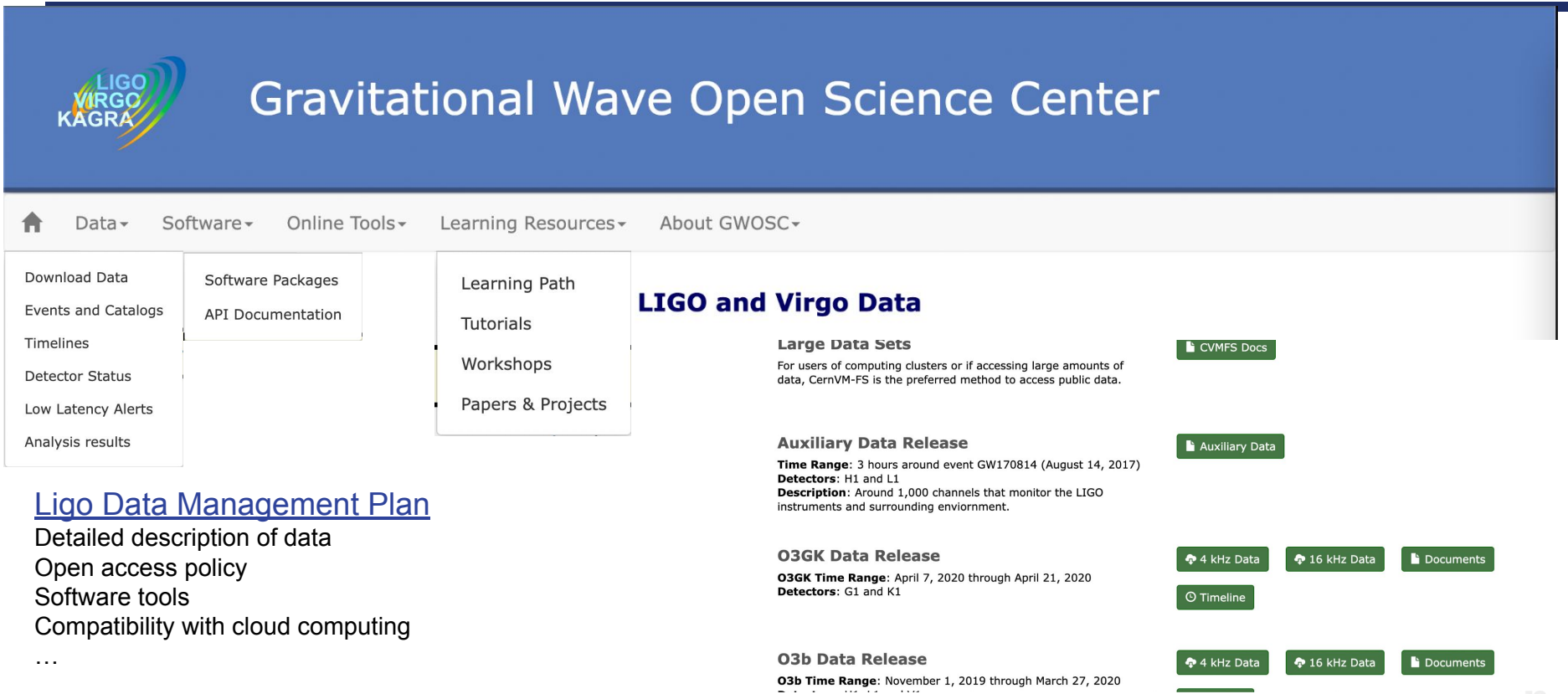
This is the repository for MAGIC low level (event lists and corresponding IRFs) data. Find below links to access data relative to different observational projects, identified by the respective observed source(s). Each dataset is accompanied by a description of the data format.

Publication	Description	Release date
MAGIC_2021RSOph	Proton acceleration in thermonuclear nova explosions revealed by gamma rays	2022-02-17
MAGIC_JointCrab	Two Crab Nebula observations included in the sample used for the stereo upgrade performance evaluation, publicly released for the joint-crab project. [Astronomy & Astrophysics, Volume 625, id.A10, 8 pp, doi:10.1051/0004-6361/201834938]	2019-05-02
MAGIC_TXS0506+056	Data from the observations of the blazar TXS 0506+056 carried out by the MAGIC telescopes between September 24 and October 04, 2017, and reported by the IceCube Collaboration et al. [Science 361, eaat1378 (2018). DOI: 10.1126/science.aat1378].	2018-07-12

PIC port d'Informació Científica IFAE

Gravitational Waves

https://www.gw-openscience.org/



[Ligo Data Management Plan]

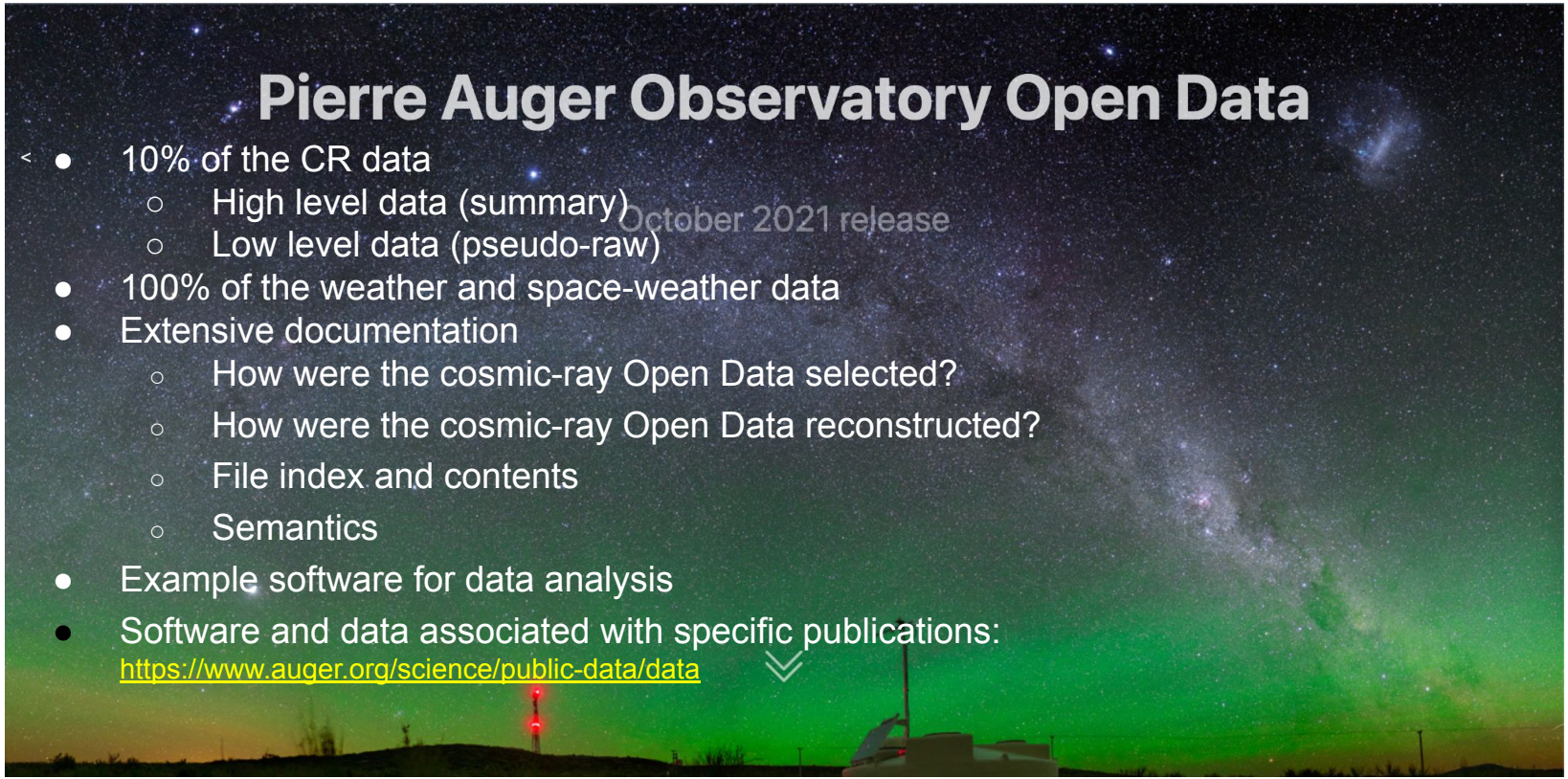
Detailed description of data
Open access policy
Software tools
Compatibility with cloud computing
…

Pierre Auger

https://opendata.auger.org/

Pierre Auger

https://opendata.auger.org/

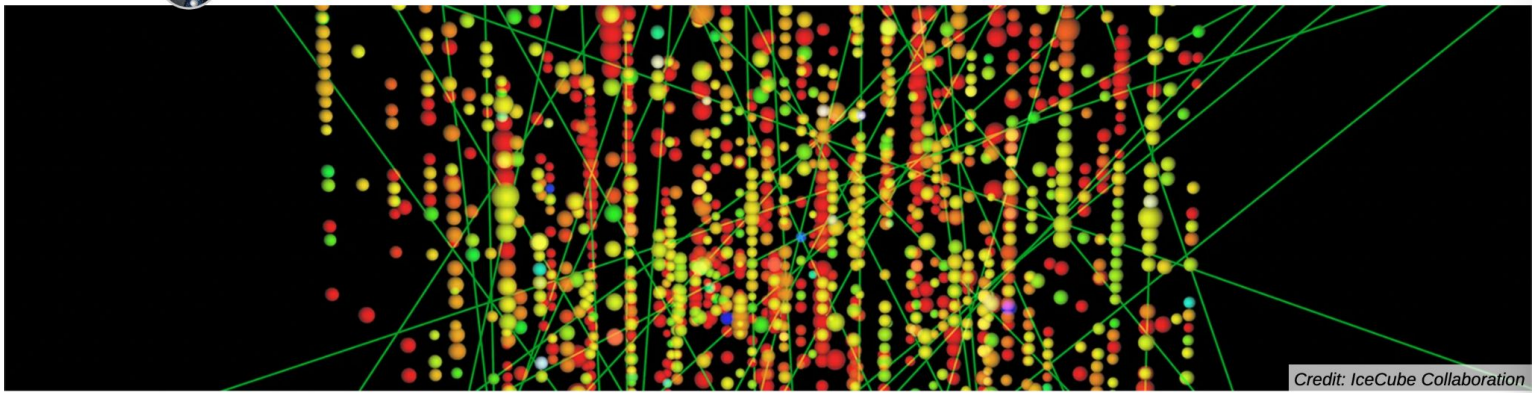


IceCube

https://icecube.wisc.edu/science/data-releases/

ICECUBE NEUTRINO OBSERVATORY

About Us Science Collaboration Outreach Life @ Pole Galleries News



Credit: IceCube Collaboration

Data Releases

Featured Releases

On July 12, 2018, the IceCube Collaboration together with partner telescopes and observatories announced the first evidence of a source of high-energy cosmic neutrinos. The results were presented in two papers published in Science. The first paper provided an analysis of the neutrino alert event IceCube-170922A in coincidence with electromagnetic observations of the blazar TXS 0506+056. The second paper presented an analysis of IceCube neutrino point source data in the direction of TXS 0506+056 prior to the alert event. Together these results allowed the identification of this blazar as the first likely source of high-energy neutrinos and cosmic rays.

RESEARCH NEWS

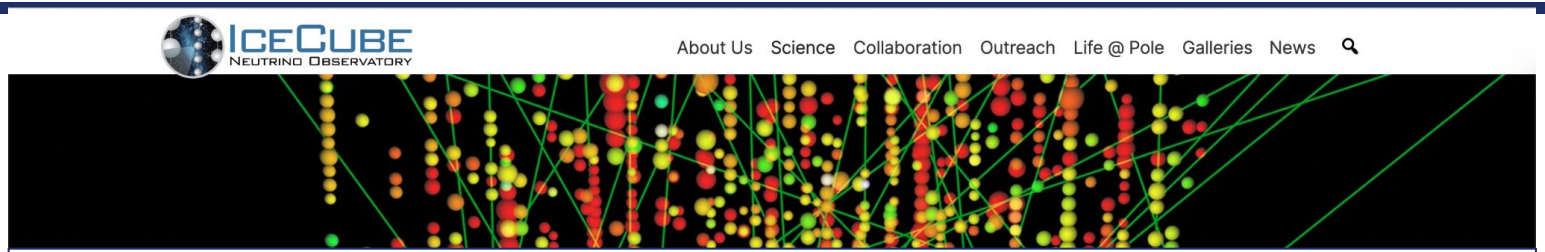
The hunt for neutrinos from gamma-ray bursts
July 1, 2022

Are extragalactic sources of ultra-high-energy cosmic rays efficient emitters of neutrinos?
March 17, 2022

Improved reconstruction of low-energy events in IceCube

IceCube

https://icecube.wisc.edu/science/data-releases/



From: https://res.cloudinary.com/icecube/image/upload/governance_document.pdf

In order to be responsive to both the scientific communities' need for usable scientific data and to the NSF requirement for public access to unselected data, **IceCube plans to release data in two ways**.

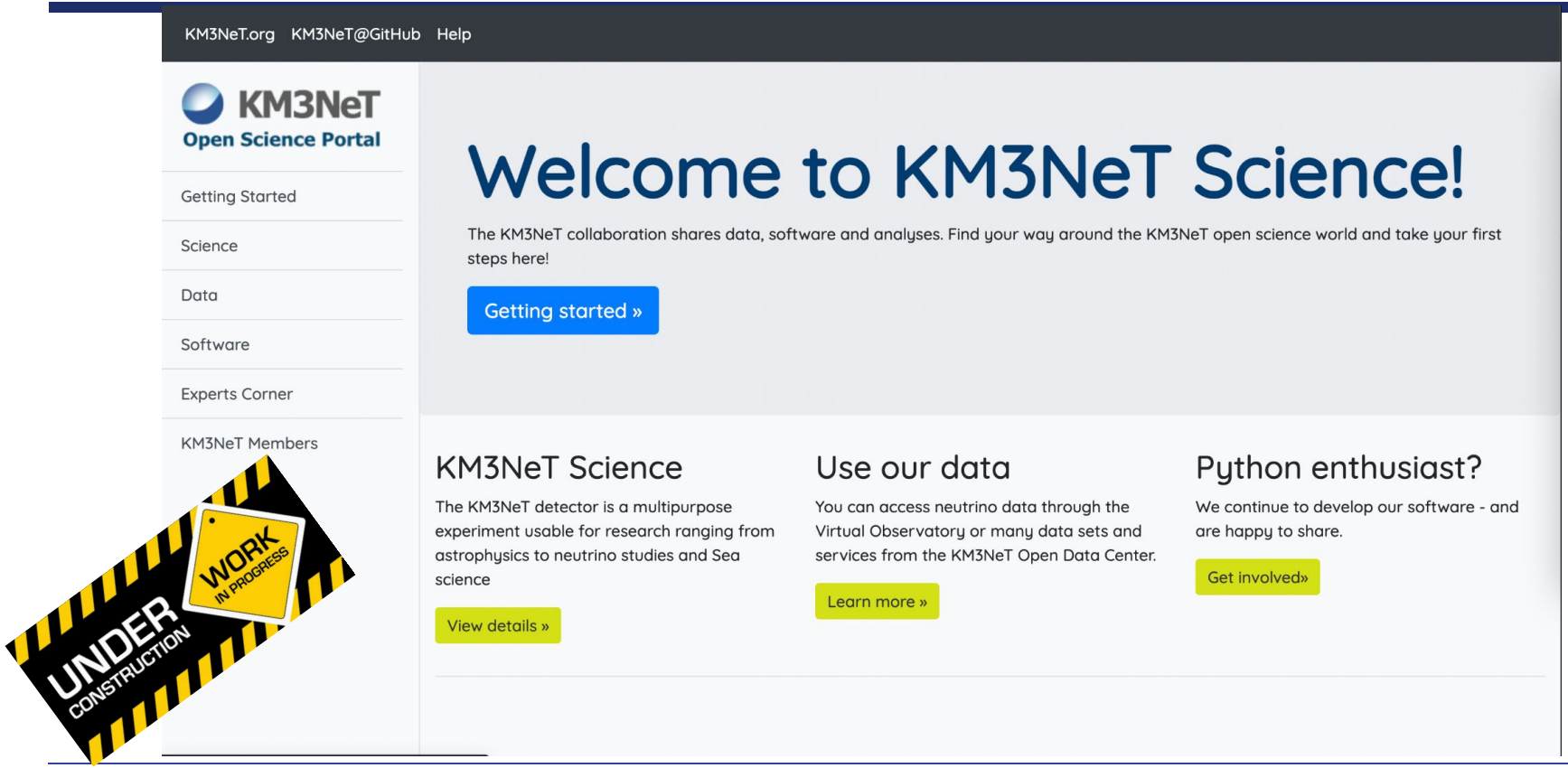
1. Release of event **reconstruction information for events selected as neutrinos** from the overwhelming background of cosmic ray muons.

2. Release of **primary event data on all events** transferred north over the satellite and used as the basis for analyses.

in IceCube

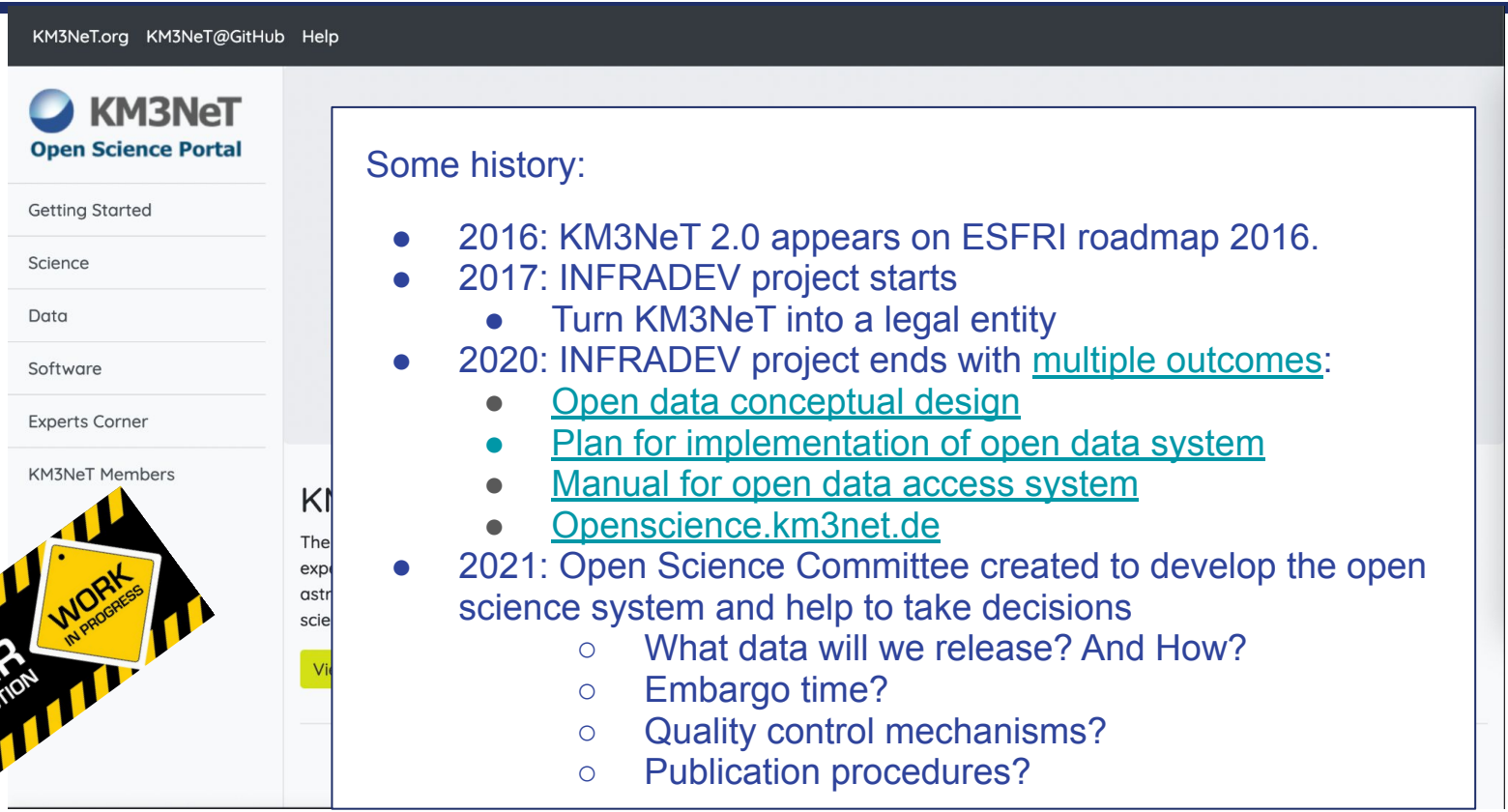
KM3NeT

https://open-data.pages.km3net.de/openscienceportal/



KM3NeT

https://open-data.pages.km3net.de/openscienceportal/



Some history:

- 2016: KM3NeT 2.0 appears on ESFRI roadmap 2016.
- 2017: INFRADEV project starts
  - Turn KM3NeT into a legal entity
- 2020: INFRADEV project ends with multiple outcomes:
  - Open data conceptual design
  - Plan for implementation of open data system
  - Manual for open data access system
  - Openscience.km3net.de
- 2021: Open Science Committee created to develop the open science system and help to take decisions
  - What data will we release? And How?
  - Embargo time?
  - Quality control mechanisms?
  - Publication procedures?

Outlook

- Situation of open access in multi-messenger astronomy far from ideal
  - Many biased datasets (high level, with selections, cuts..etc)
  - Incomplete datasets
  - Procedures not yet standardised

- But it is getting better
  - Almost every experiment shares some data
  - Awareness about open science increasing in the experimental community
  - Funding agencies require public distribution of data and software
  - Increase of funds for infrastructures and HHRR dedicated to open science.

- What you can do to contribute: lobbying
  - Make a public statement about needs (ie white paper)
  - Ideally, you should be able to do the same as any member of an experiment could do.
  - Teachers: use public data in your courses!