UNIVERSITÉ DE GENÈVE

FACULTÉ DES SCIENCES
Département d'astronomie

EPFL

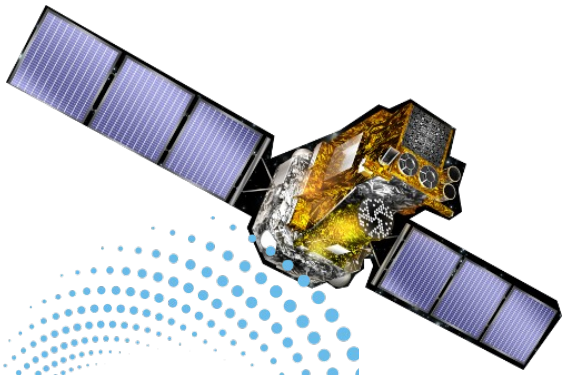
APC

ISDC

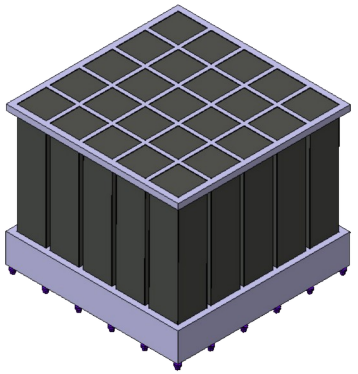
MMODA

Multi-Messenger Online Data Analysis

https://www.astro.unige.ch/mmoda/



Focus on hard X-ray and soft gamma-ray data access.



ACME
Astrophysics Centre for Multimessenger studies in Europe

Carlo Ferrigno
For a larger team

The team

Former

Andrea Tramacere (UniGe)

Mohamed Meharga (UniGe)

Andrei Variu (EPFL)

François Morier-Genoud (EPFL)

Oleg Kalashev (EPFL)

Gabriele Barni (UNIGE)

…

Present

Andrii Neronov (UPCité & EPFL)

Volodymyr Savchenko (EPFL)

Carlo Ferrigno (UniGe)

Denys Savchenko (UPCité)

Bohdan Hnatyk (KNU)

Lidiia Zadorozhna (KNU)

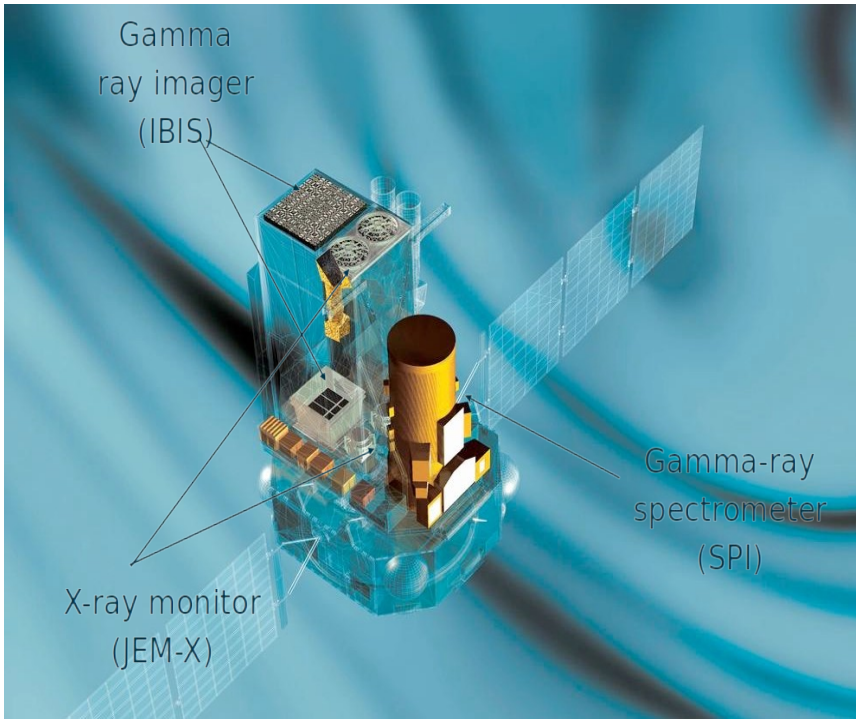
Oleksandr Gugnin (KNU)

…

INTEGRAL

INTErnational Gamma-Ray Astrophysics Laboratory: INTEGRAL

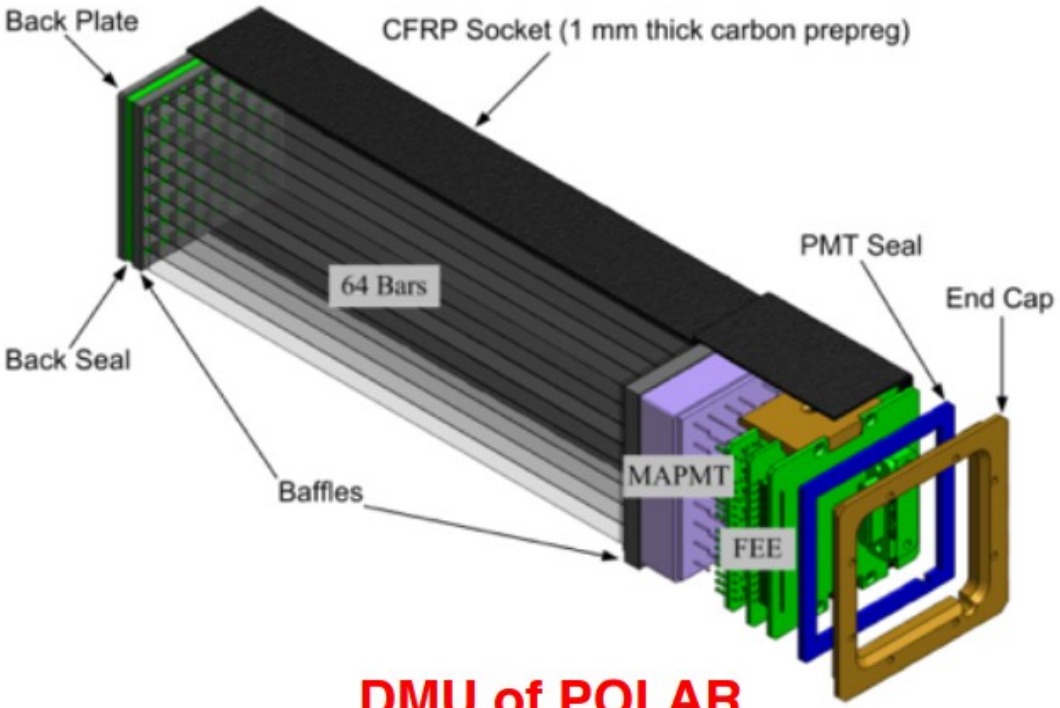
5 meters high
More than 4 tons in weight.
Launched on October 17, 2002
Optimal orbit for long observations
Operations ended in Feb 2025



Unique coverage from 3 keV to 30 MeV

POLAR

- POLAR OBOX is composed of 25 independent detector modular unit (DMU)



DMU of POLAR

- It lived for 6 months on the Tiangong-2 space mission (October 2016- March 2017)
- It detected 55 GRBs measuring polarization in 14 of them
- Data are preserved at UNIGE and made available through MMODA and on the web

https://www.astro.unige.ch/polar/polar-mission

POLAR2

- We are mandated to provide data from Polar-2 foreseen to be launched in early 2028
- Polar-2 is a collaborative effort by University of Geneva, NCBJ, Poland, MPE in Germany and IHEP in China.
- It is an upgrade by one order of magnitude in size of Polar

Data analysis in the multi-messenger astronomy era

- Multi-messenger approach requires efficient combination of data from different telescopes and astronomical messenger detectors.
- Long-term preservation of data analysis capability is essential
- This combination could be facilitated by availability of open access telescope data .....

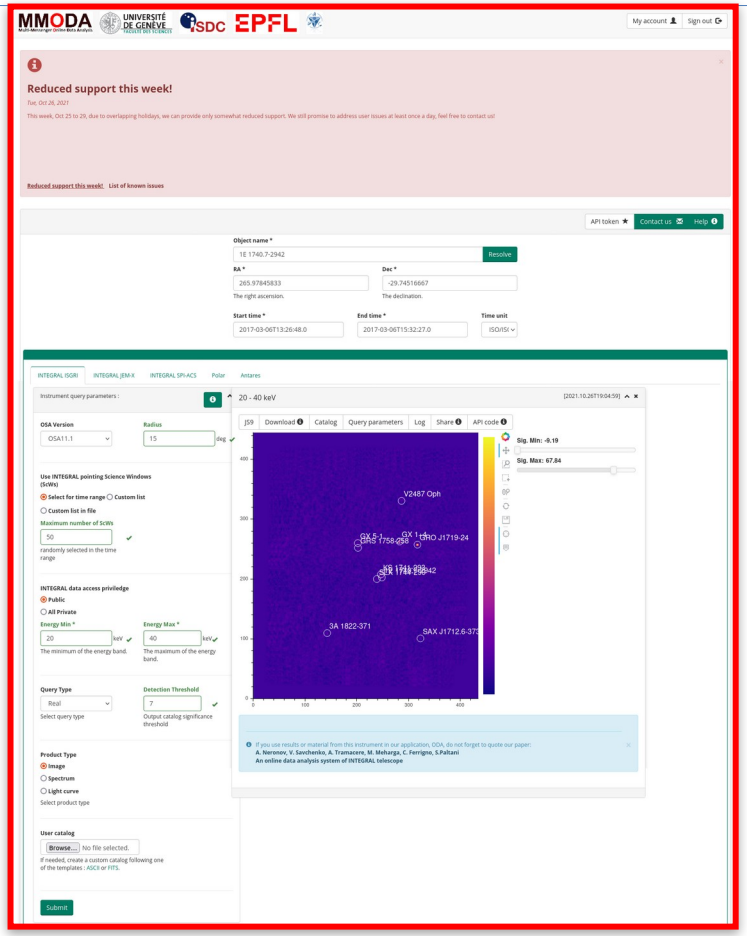
  ..... **and data analysis tools**
- We published a paper on A&A: Online data analysis system of the INTEGRAL telescope by A. Neronov et al.

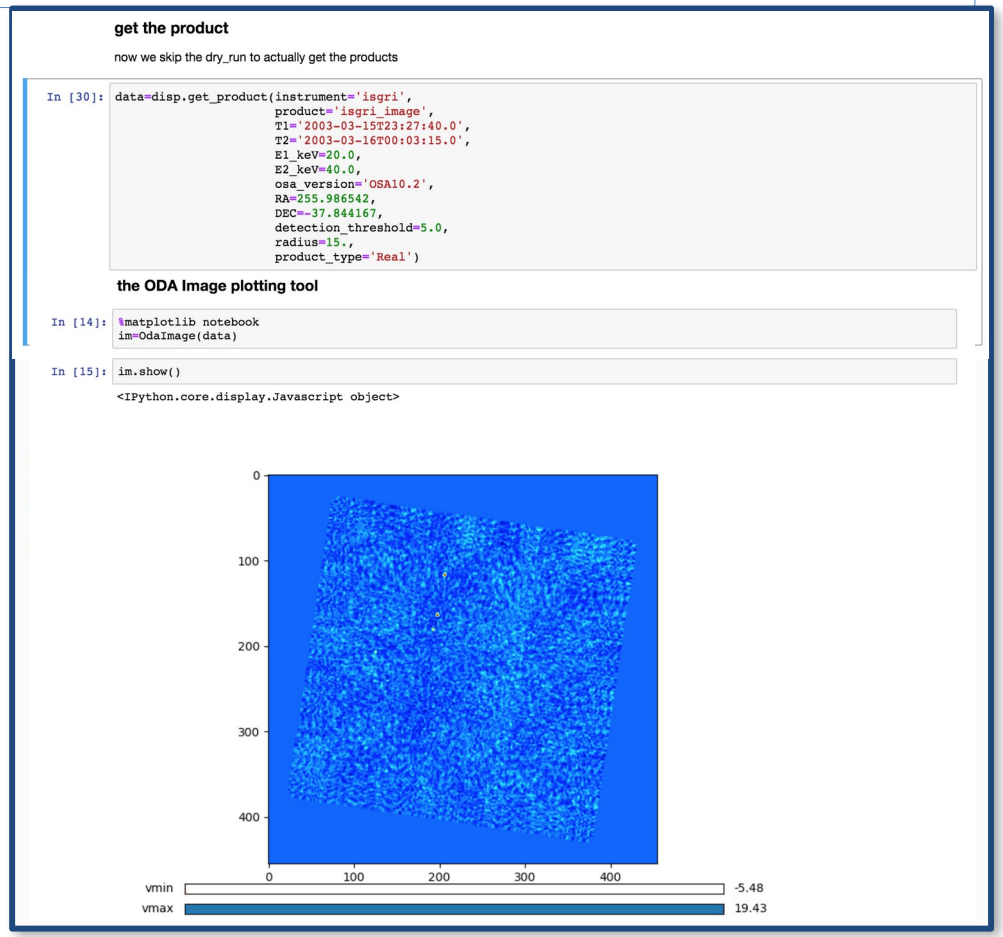
https://www.aanda.org/articles/aa/abs/2021/07/aa37850-20/aa37850-20.html

Data analysis services

Data analysis of telescopes and astronomical messenger detectors could now be done on remotely via dedicated services accessible via

- Web interface (in a browser)
- Application Programming interface (API) from e.g. Jupyter notebooks



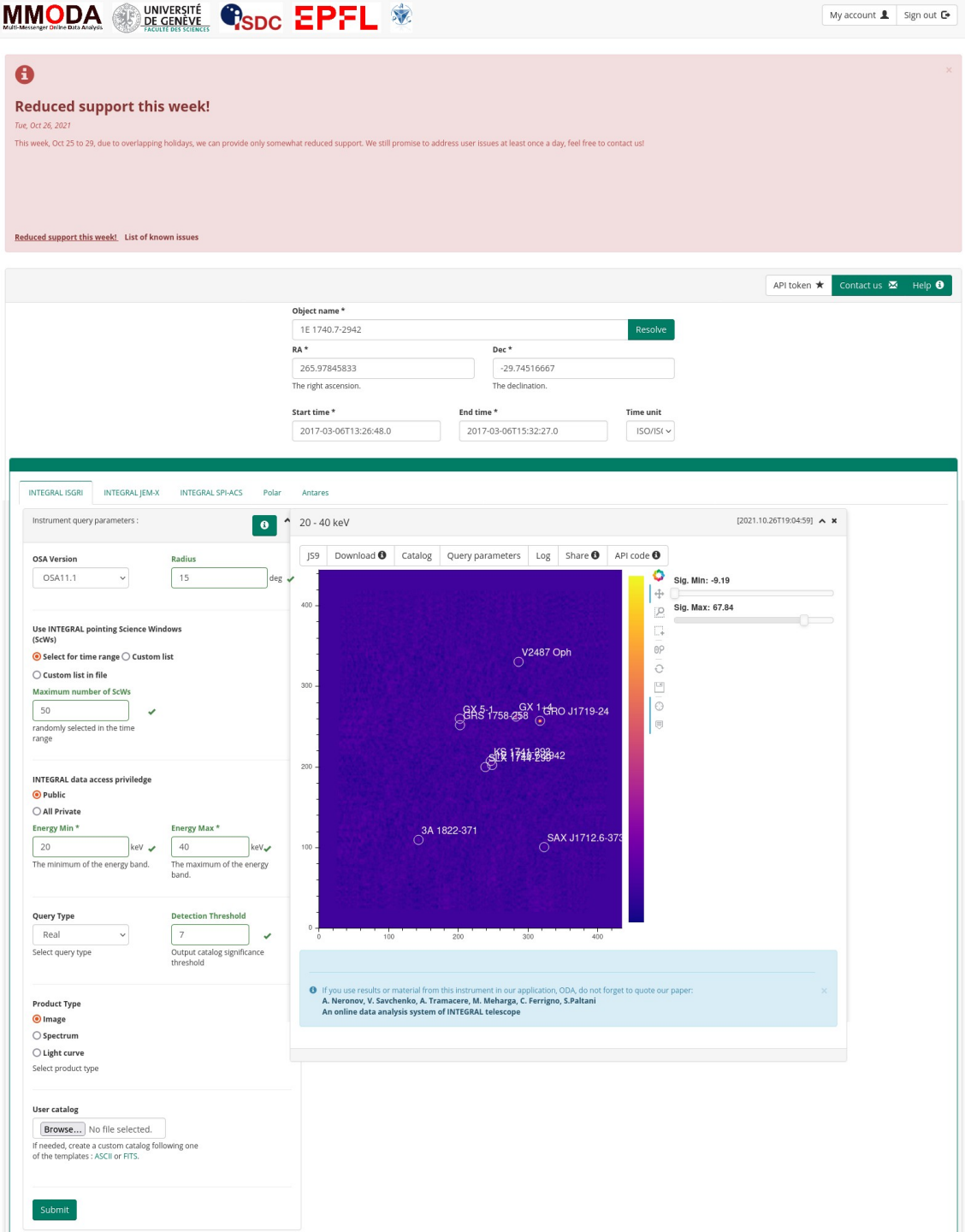


Multi-messenger Online Data Analysis (MMODA) interface

It provides high-level science products for:

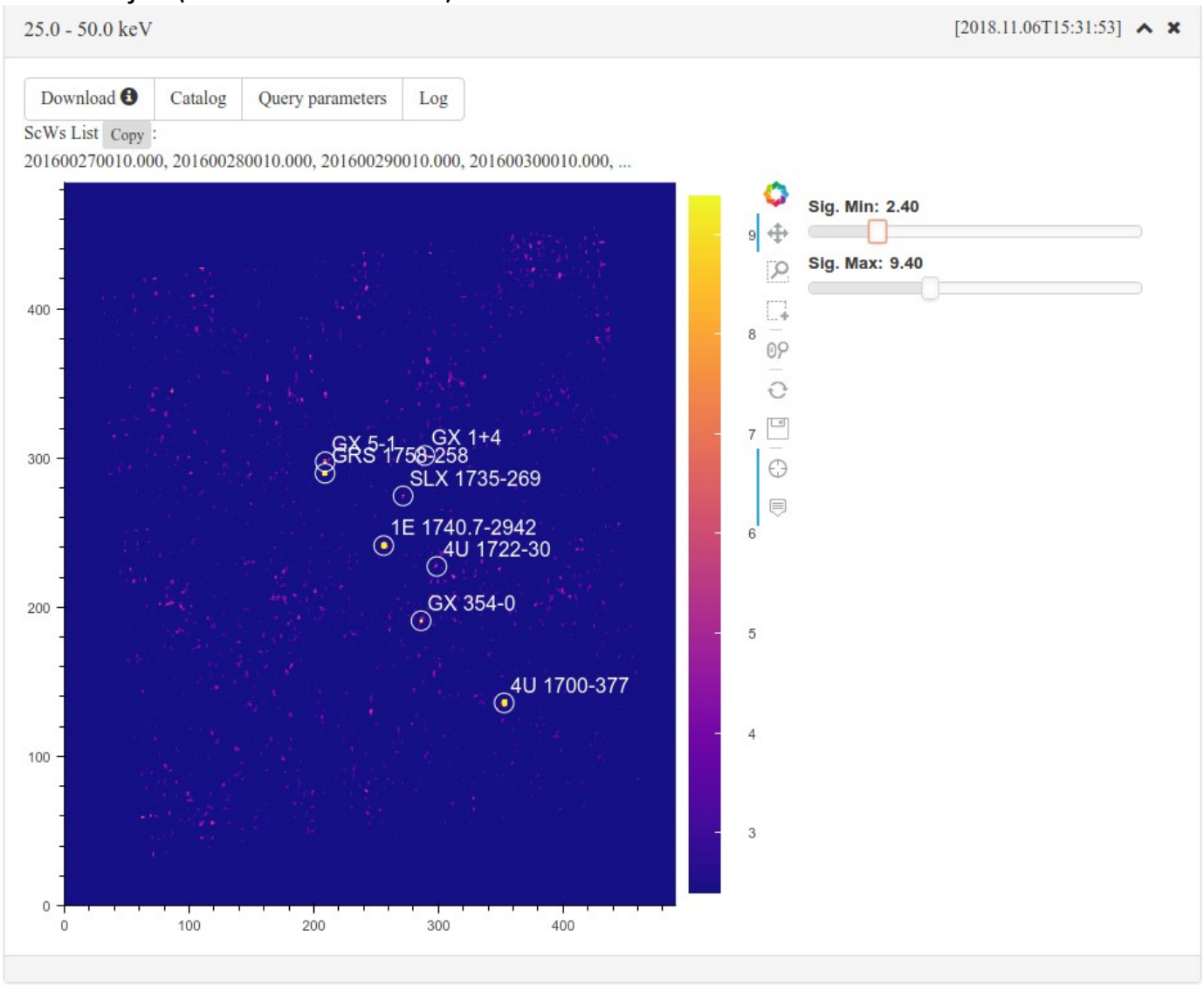
+ IBIS/ISGRI
+INTEGRAL / JEM-X
+ INTEGRAL / SPI-ACS
+ Polar
…

Using standard software in the backend



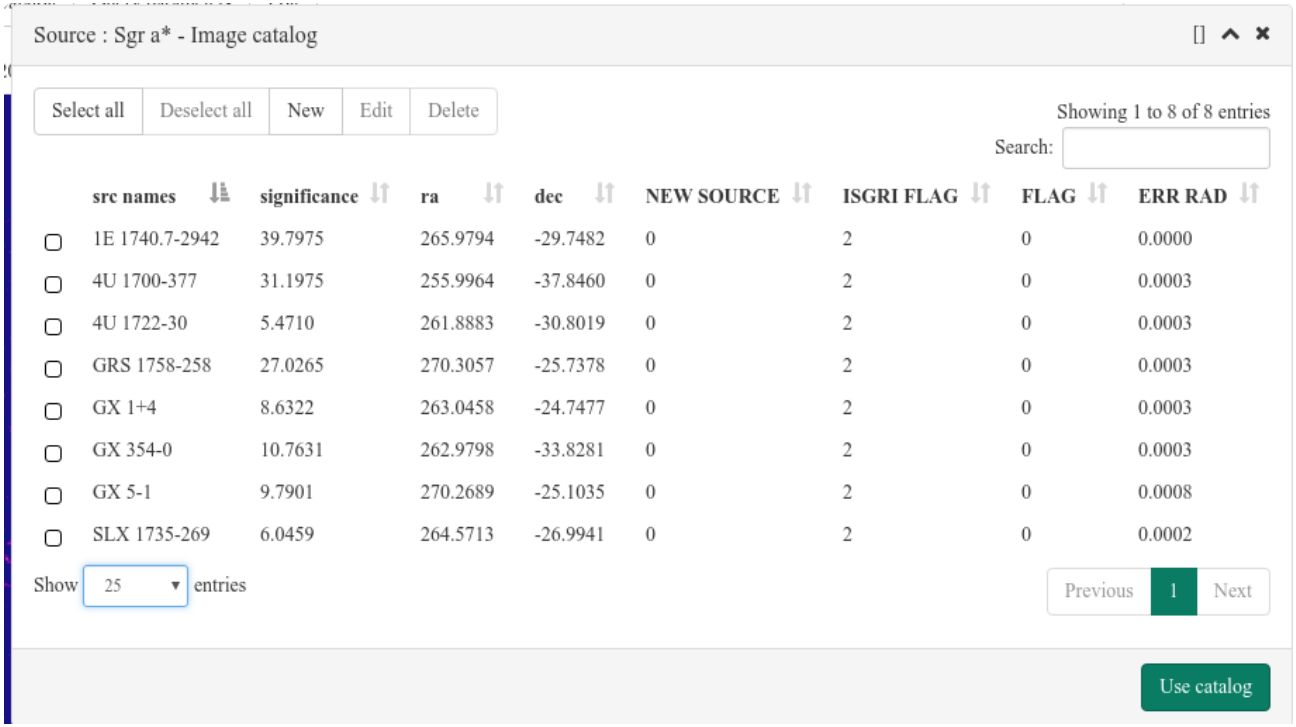
Imaging (ISGRI and JEM-X)

- Possible to make images in one energy range
- Interactive imaging display
- Use of js9 (web version of ds9)



Standard workflow: use a catalog

- Easy handling of source catalog.
- You can delete, add sources found from imaging
- You can load a catalog from a file.



Spectra and online fitting

- From the catalog, you get all spectra simultaneously at full 256 channel resolution
- Fit individual spectra using Xspec and/or download files in fits format

Processing ...
Session : 2a10871c8d4db1429e62d218acd7b2d1 | Job Id : -7594506992834016721

2018.11.06T15:48:58 Status : ready

	Data unit	ISGRISpectraSum	il_spectra_extract	il_skyimage	ibis_gti	ibis_dead	ISGRIEvents
001	201600270010.000						
002	201600280010.000						
003	201600290010.000						
004	201600300010.000						
005	201600310010.000						
006	201600320010.000						

2018.11.06T15:49:56 done

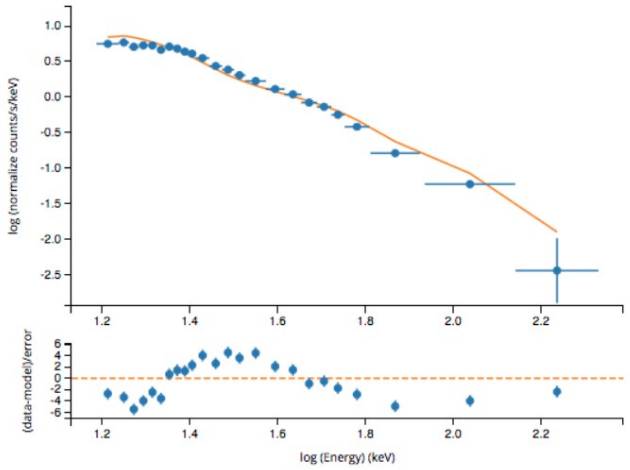
More details >

Source : 4U 1700-377 - Spectra table @ 03.10.2017T13:54:07

Source name	Spectrum
IGR J17252-3616	Show
4U 1700-377	Show
H 1705-440	Show
4U 1722-30	Show
1E 1740.7-2942	Show
GX 1+4	Show
GX 349+2	Show
OAO 1657-415	Show
Background	Show
GX 354-0	Show
4U 1735-444	Show

Source : 4U 1700-377 - Spectrum @ 03.10.2017T13:54:07

Download



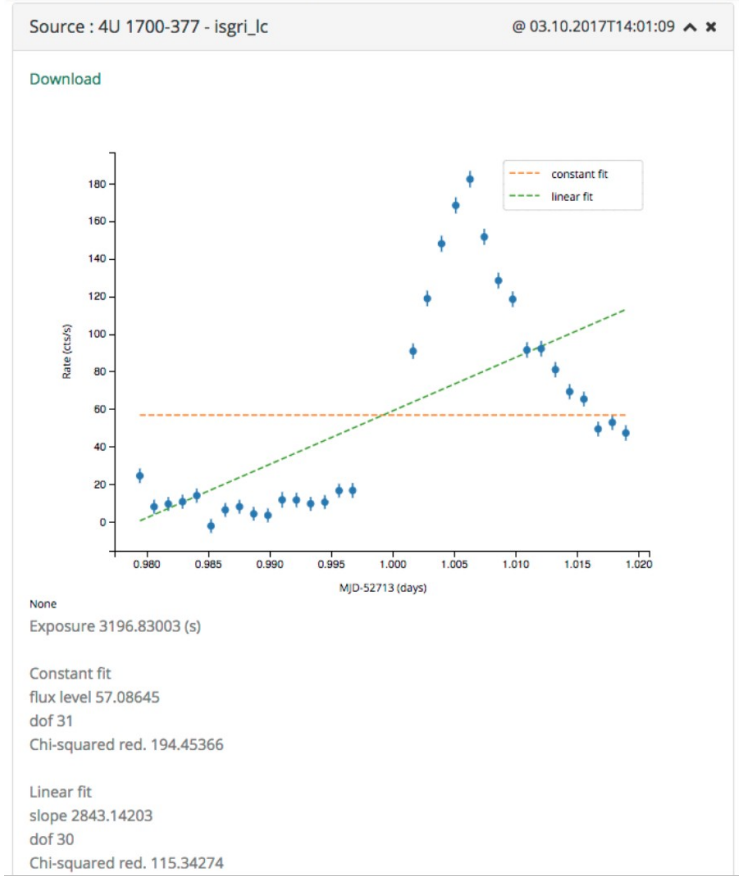
Exposure 2399.275146 (s)
Fit report for model powerlaw

Component	Par name	Value	Units	Error
powerlaw	PhoIndex	2.43386		0.02466
powerlaw	norm	8.96472		0.75978

dof 52
Chi-squared 269.91328
Chi-squared red. 5.19064

Light curves

- From the catalog, you can create light curves with time bins longer than 10 seconds (4 for JEM-X) and display them individually
- Download light curves in OGIP format



Reproducible and storable

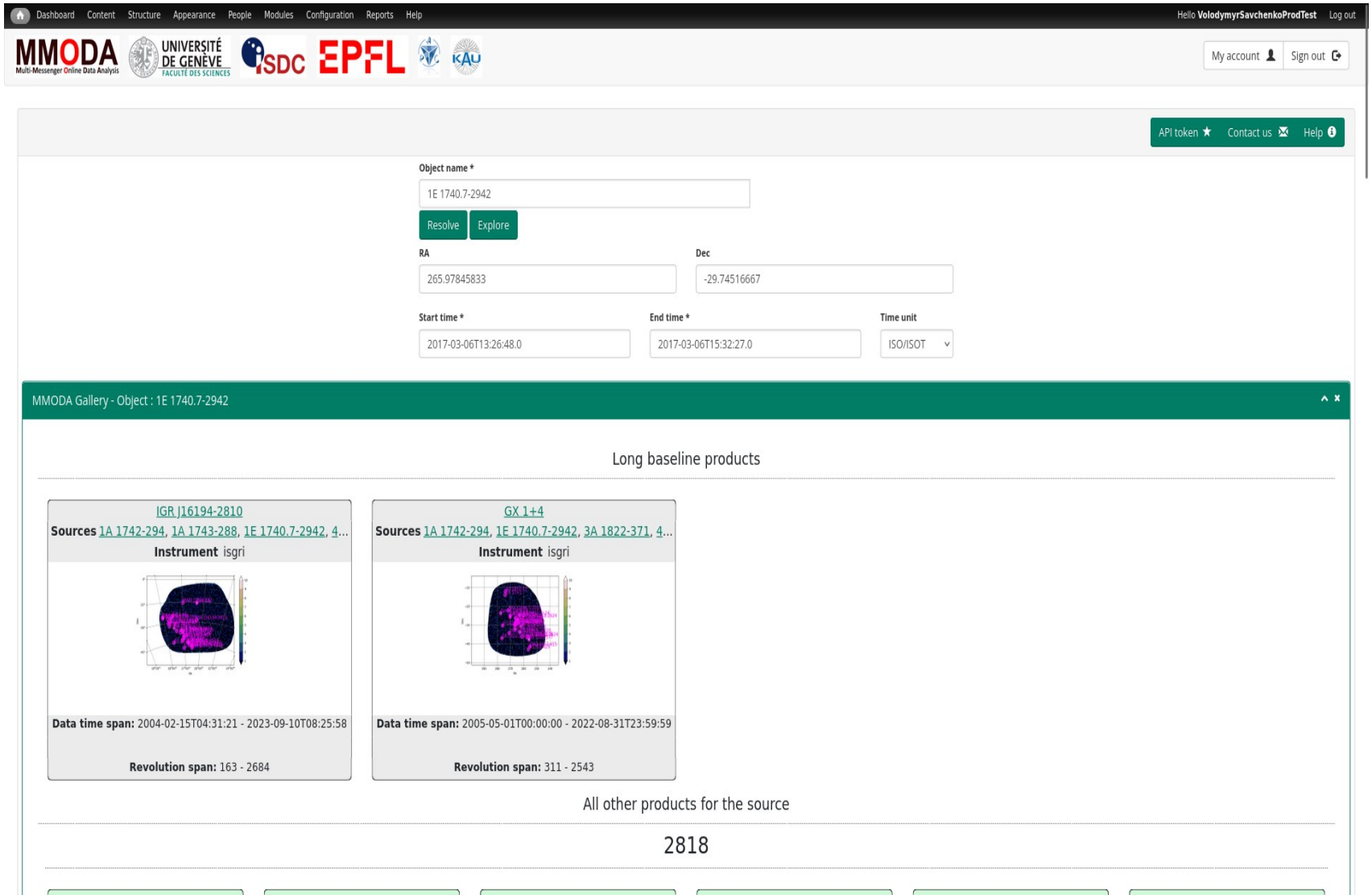
- The system is built with internal cache to save intermediate products.
- The second time you make the same query, results are almost instantaneous.
- It optimizes resources for frequent calls
- Backend can be deployed virtually anywhere, because it is based on a scalable virtual cluster, which runs individual pointings in parallel (deployed at ESA).
- We exploit in-kind contribution of the Department of astronomy to elaborate data in the local HPC cluster.

- We have a public github project open to contributions

https://github.com/oda-hub/

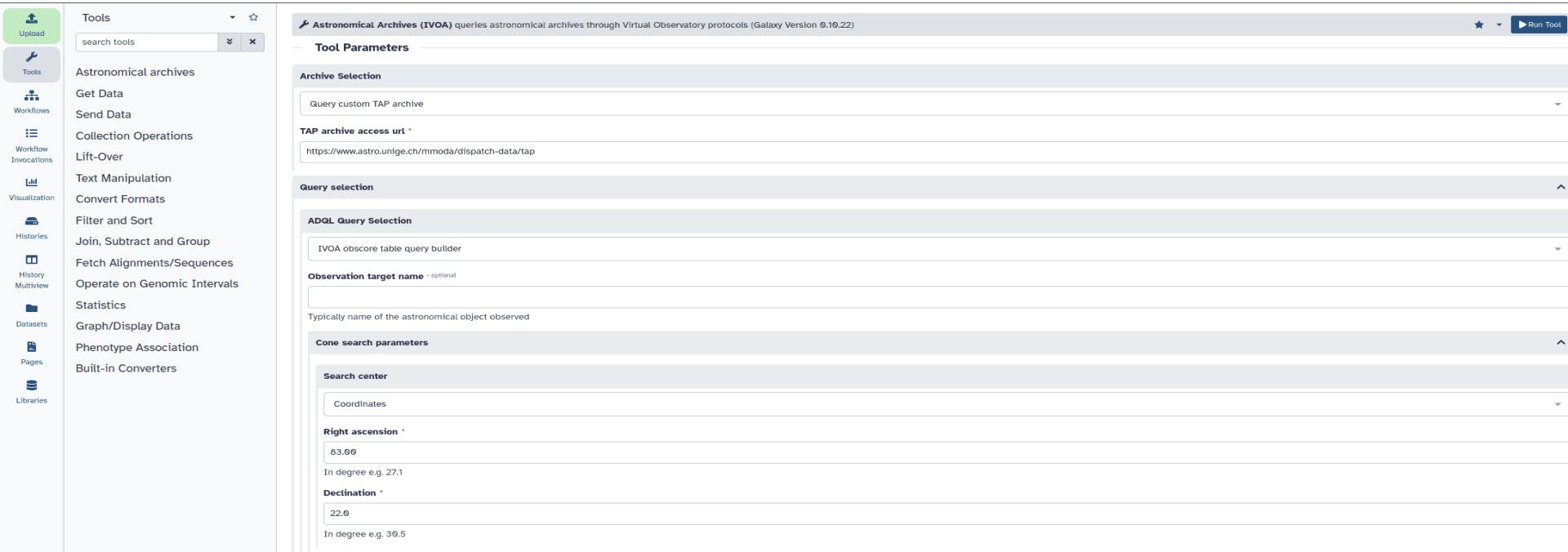
Gallery: reproducible data products
https://www.astro.unige.ch/mmoda/gallery

MMODA Gallery keeps track of user-selected computations done by MMODA services. These data products can be referenced as-is or recomputed with some changes, reproducing the results in new conditions.



TAP server

- We have a TAP server endpoint compatible with VO standard to expose all the available products in the gallery
- https://www.astro.unige.ch/mmoda/dispatch-data/tap/
- It was announced as part of MMODA collaboration with Galaxy : https://galaxyproject.org/news/2025-08-15-mmoda-tap-server/
- You can access it using the Galaxy astronomical archives https://usegalaxy.eu/root?tool_id=astronomical_archives



Conclusions

- https://www.astro.unige.ch/mmoda/
- Provides access to ISGRI and JEM-X high-level products: images, spectra, light curves
- Allows the user to extract light curves from Polar and SPI-ACS
- More experiments are available
- It brings the user close to data without the steep learning curve of scientific S/W
- Gallery of products with provenance
- Getting closer to FAIR principles