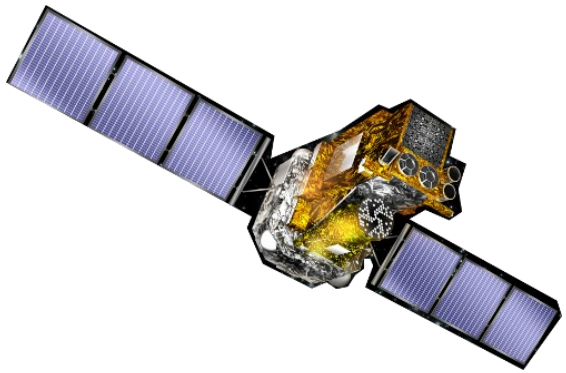
MMODA
Multi-Messenger Online Data Analysis

UNIVERSITÉ DE GENÈVE
FACULTÉ DES SCIENCES
Département d'astronomie

ISDC

AstroORDAS

MultiMessenger Online Data Analysis



Carlo Ferrigno, Volodymyr Savchenko, Gabriele Barni, Mohamed Meharga, Andrii Neronov, Stéphane Paltani

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

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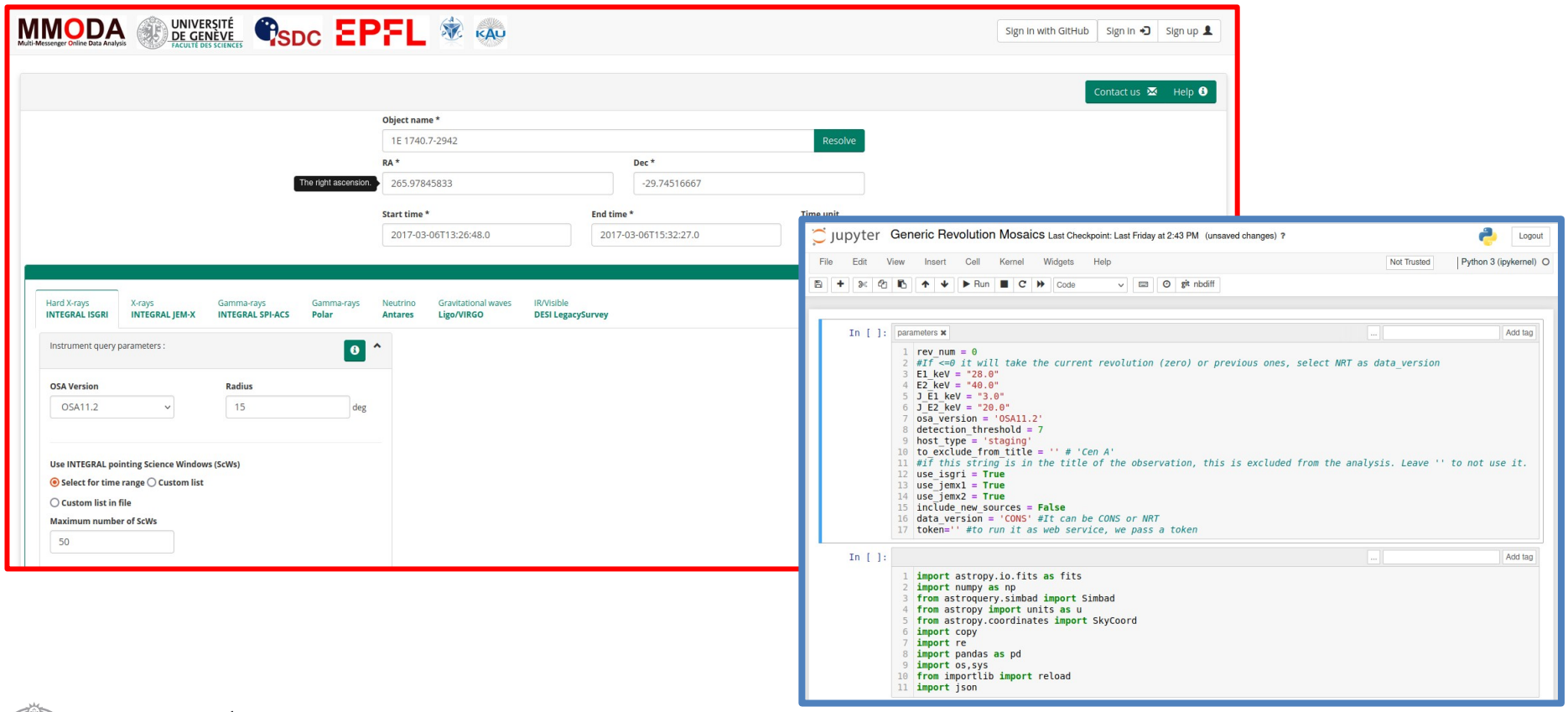
The need of reliable high-level products

- The success of a mission as INTEGRAL relies (among other assets) on the availability of easily accessible products for both Near Real Time and archive data.
- In the mission maturity, it is becoming rarer to be able to perform dedicated INTEGRAL analysis.
- The emerging paradigm for data centers is bringing the analysis to the data (NASA Hera, Science Case, ESA DataLabs, etc.)
- We have developed MMODA for this purpose exploiting various funding lines (including Open research Data) https://www.astro.unige.ch/mmoda

Multi-Messenger Online Data Analysis

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

- Interactive: From a browser web interface
- Coded: Python API (e.g. Jupyter notebooks)



Accessing online services

- The web interface for MMODA is meant to be intuitive and easy to use, with emails notifications functionalities for submission and completion
- The python api can be used to build and perform more complex calls analysis

- A Third possibility is to make custom workflows based on an accessible development guide: https://odahub.io/docs/guide-development/
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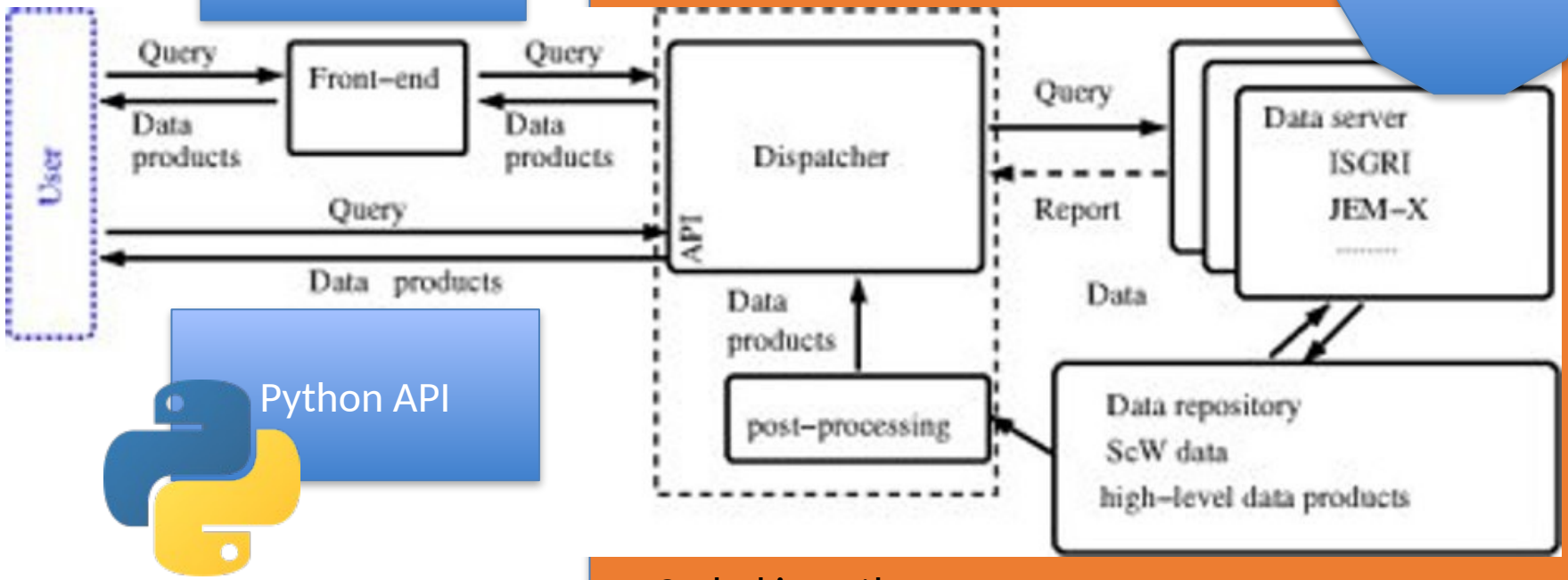
The general architecture

S/W runs in Docker containers on K8s

Backend

Web interface



Python API

- Coded in python
- Plugins for instruments
- Plugins for data products
- Asynchronous requests

- A daemon listens to requests from the dispatcher
- Deployed also on HPC cluster.

Kubernetes cluster

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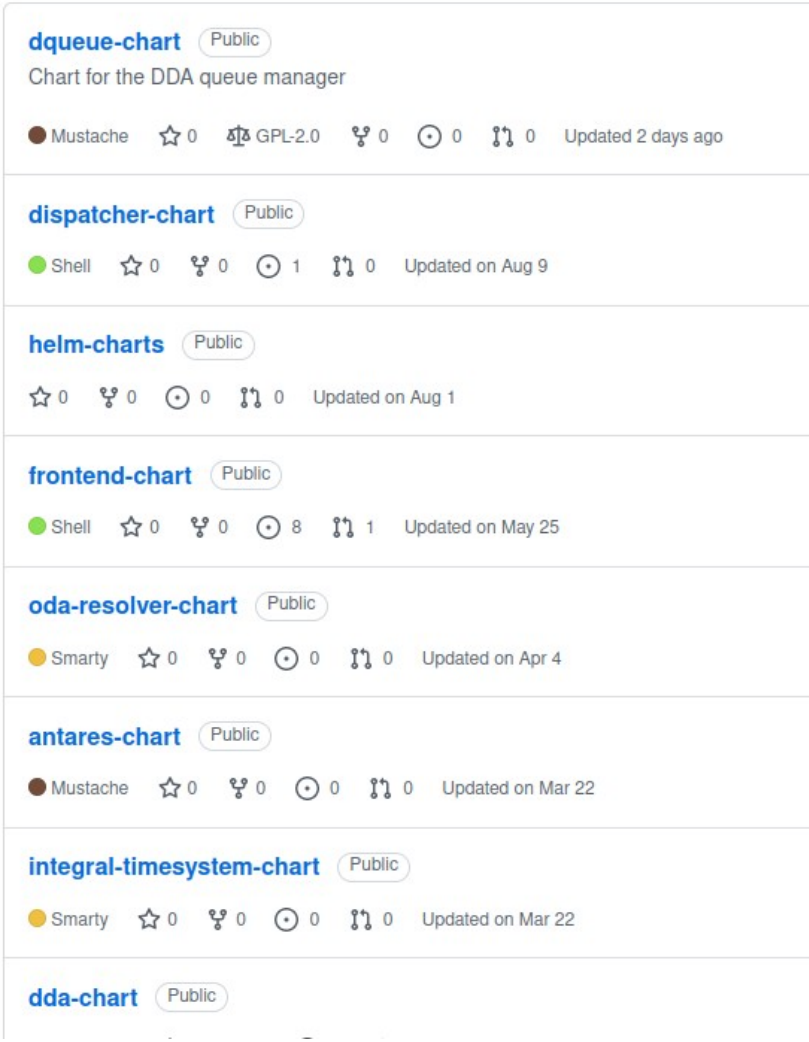
Open source and portable

- All the infratructure is publicly available
- It can be run on any Kubernetes cluster (something that is common use nowadays)
- Public on github -> **oda-hub** https://github.com/oda-hub
- Available from ESA Datalabs !



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Flexible and extensible implementation of workflows

- Public Workflows are available for:
  - INTEGRAL IBIS/ISGRI (images, spectra, lightcurves)
  - INTEGRAL SPI-ACS (lightcurves)
  - INTEGRAL JEM-X (images, spectra, lightcurves)
  - Polar (light curves)
  - LIGO-Virgo (spectrograms, localizations)
  - Desi Legacy Survey (images, photometry)
  - GRB analysis
- We provide workflows in python for many other analysis (e.g. Euclid, Gaia, SKA prototype, CTA are in development)

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The MMODA product gallery

- An explorable collection of high-level products from the IBIS/ISGRI, and JEM-X instruments (for now)
- Hosted on a Drupal-powered website with full REST-API access for content creation, editing, and exploration.

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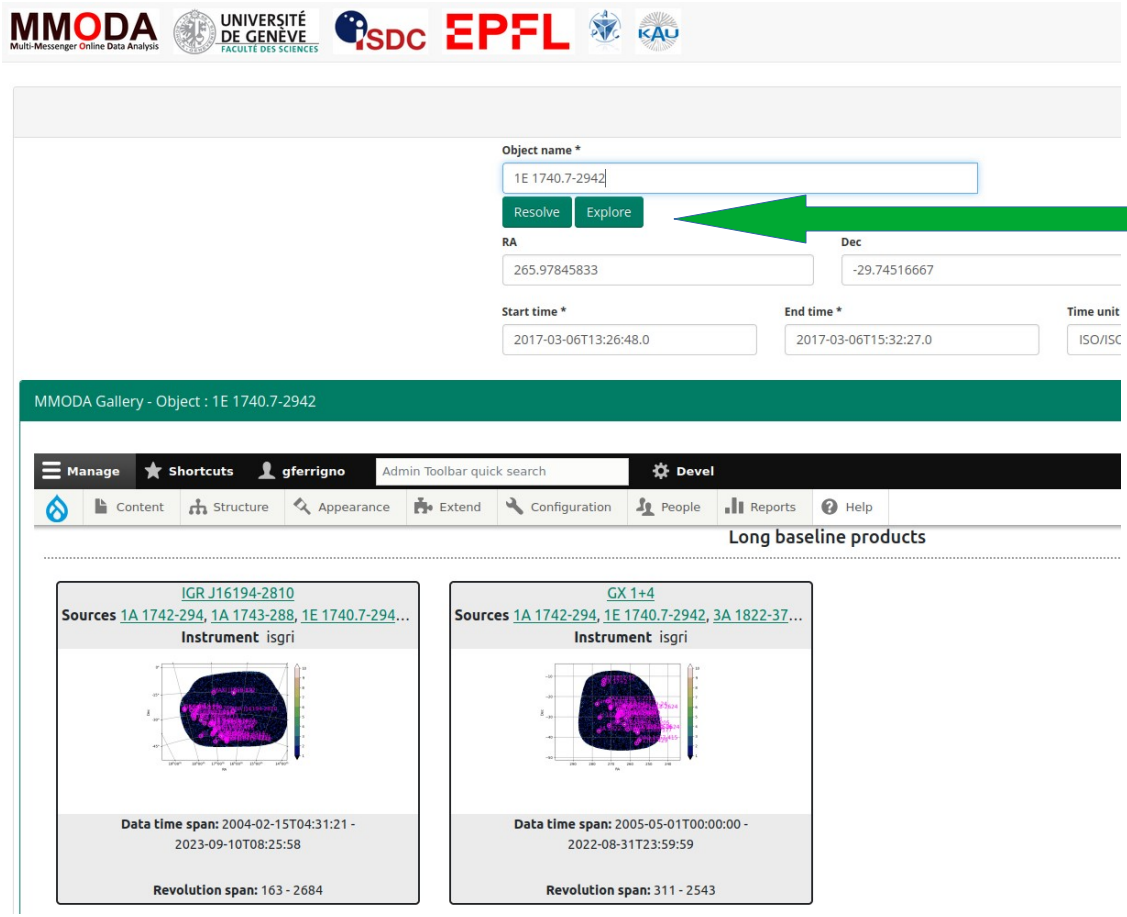
Exploring the Gallery from MMODA



By Clicking on “Explore” button, it is possible to have a snapshot of what is available in the gallery for a specific source.

Legacy products as a gallery

- Based on a study for legacy products triggered by ESA, we produce:
  - Standard products per each observation in each satellite revolution for Consolidated data: images for IBIS/ISGRI and JEM-X with source fluxes, spectra and light curves for each detected source.
  - Long-term light curve of each significantly bright source
  - Special products for sources: e.g. outburst light curve, spectra over longer campaigns will be provided (*we need your inputs* !)
  - Other …

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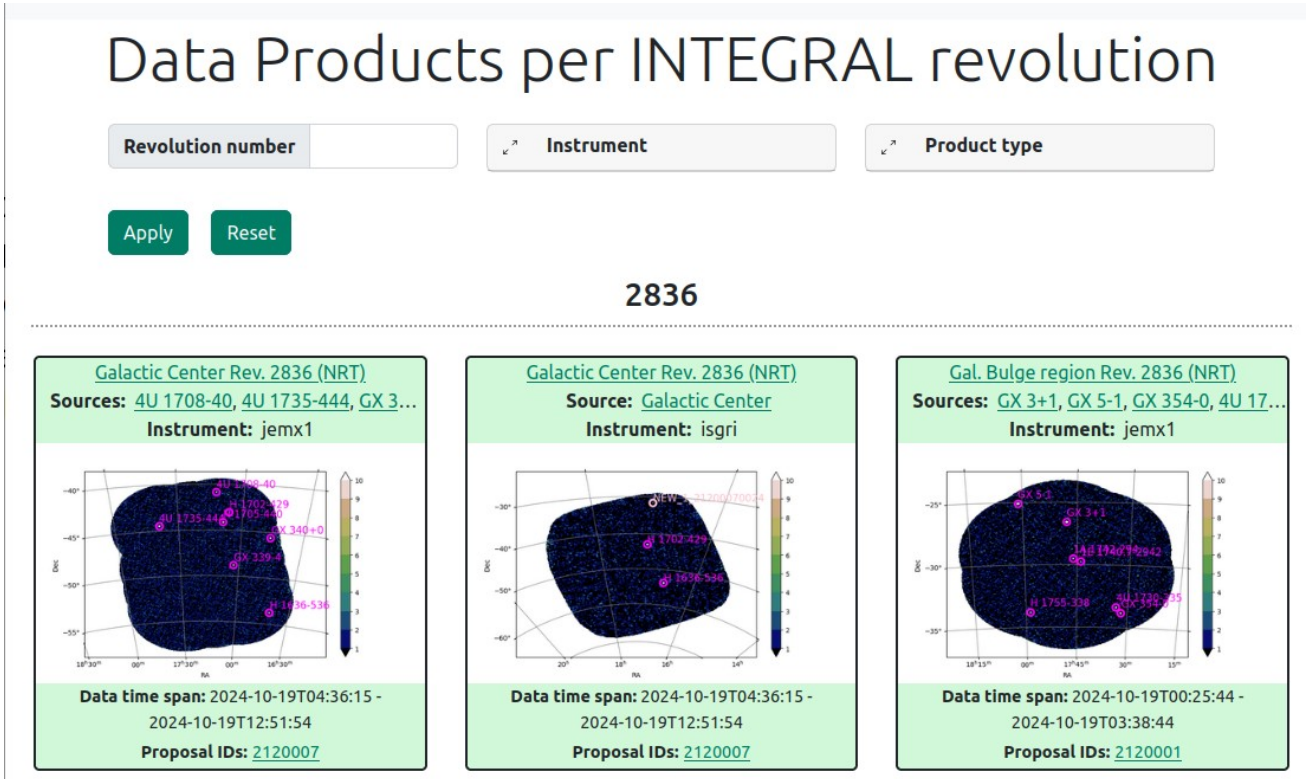
Near Real Time Data

- We expose the standard operations we do for quick look:
  - We process **daily** data to produce images and detect possible sources with their flux
  - We extract light curves and spectra for each detected source
  - This is done per observation within the satellite revolution
  - Conveniently highlighted in green



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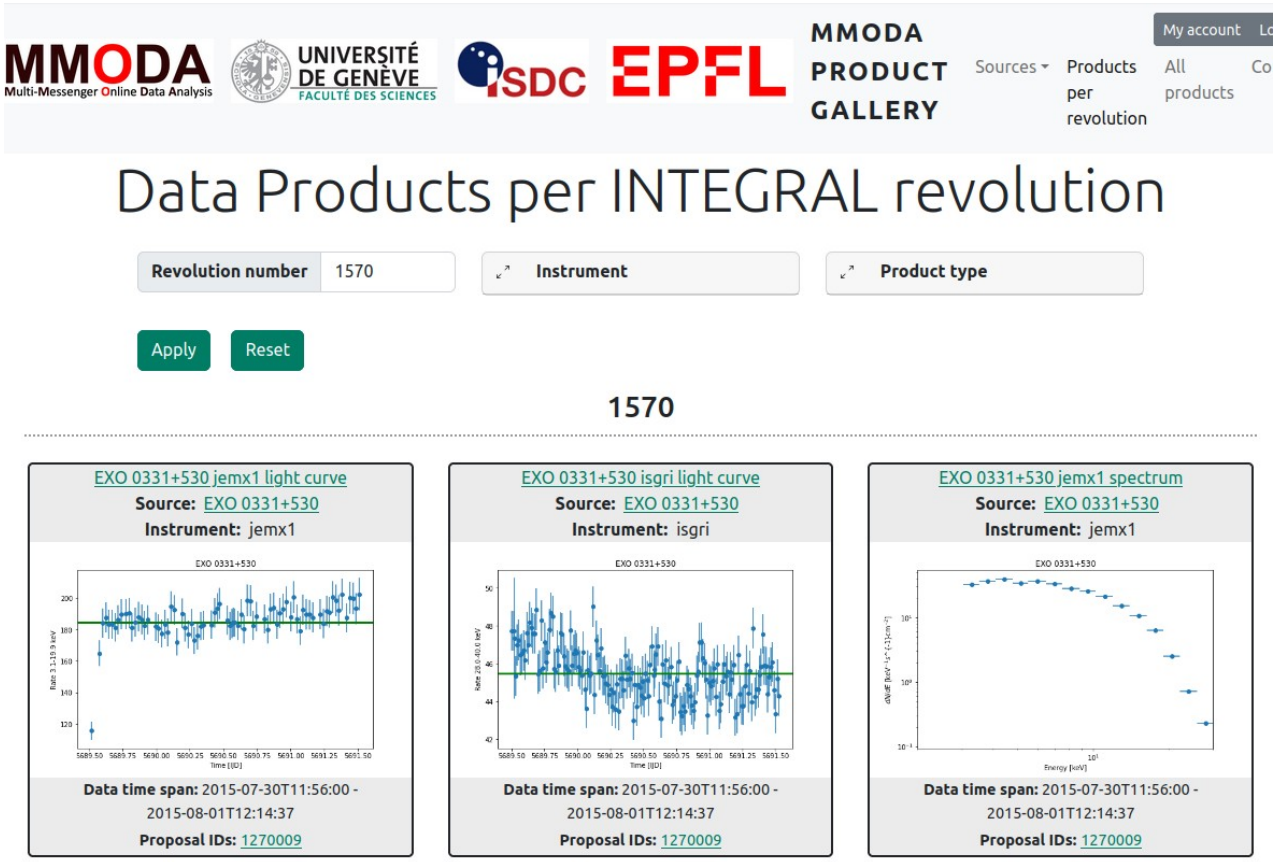
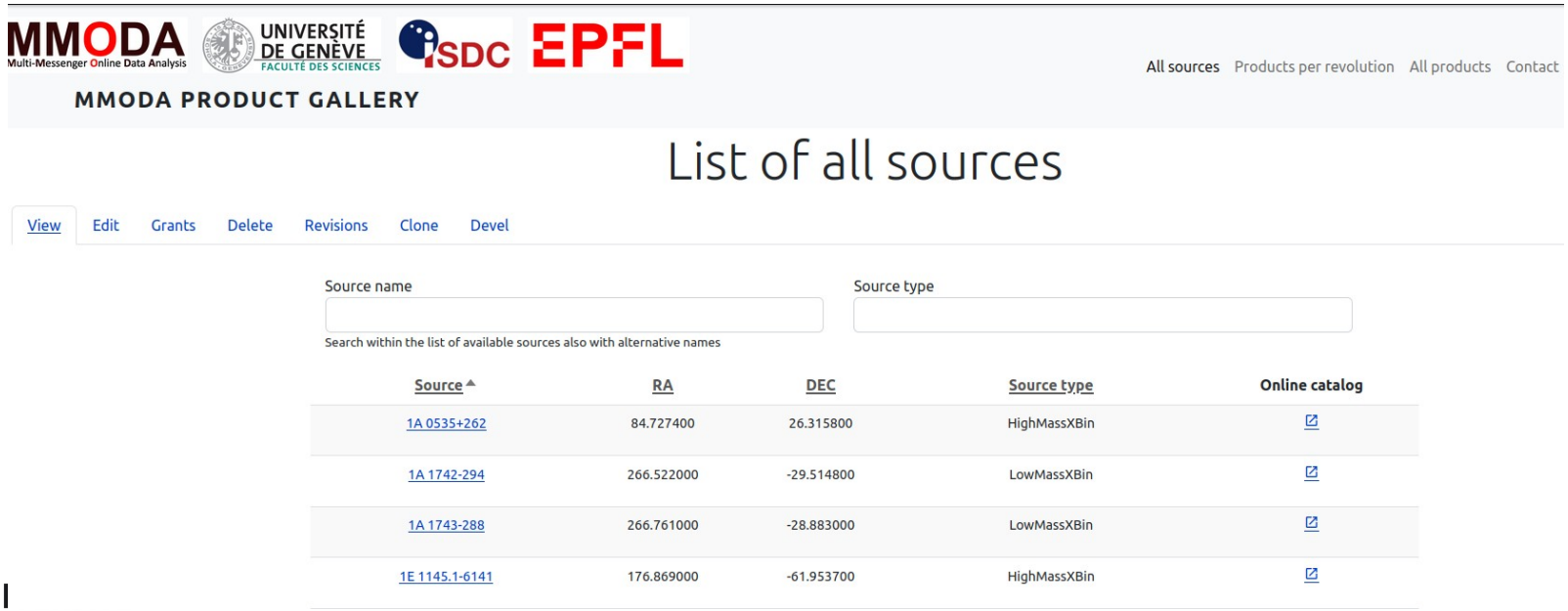
Products per revolution

- After data consolidation, we replace NRT with CONS products
- Products are easily searchable per satellite revolutions



INTEGRAL Sources

- Every source that is detected by ISGRI or JEM-X during at least in single observations appears in the Gallery.
- Search can be done also on source class: e.g. all blazars
- We (will) produce long-term light curves for most of them for reference and spectra on certain targeted intervals using a single catalog to optimize resources.



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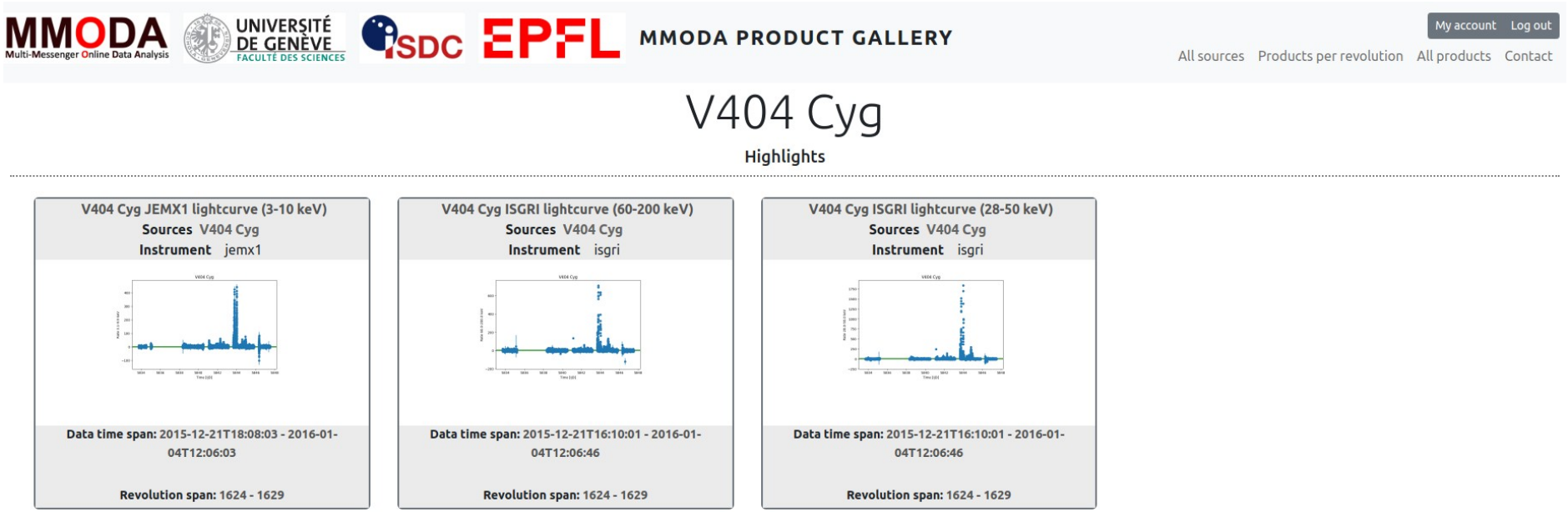
Distribution of relevant products

- V404 Cyg data products were distributed and led to tens of publications
- They are straightforwardly produced and shared (about 1 hour per product)



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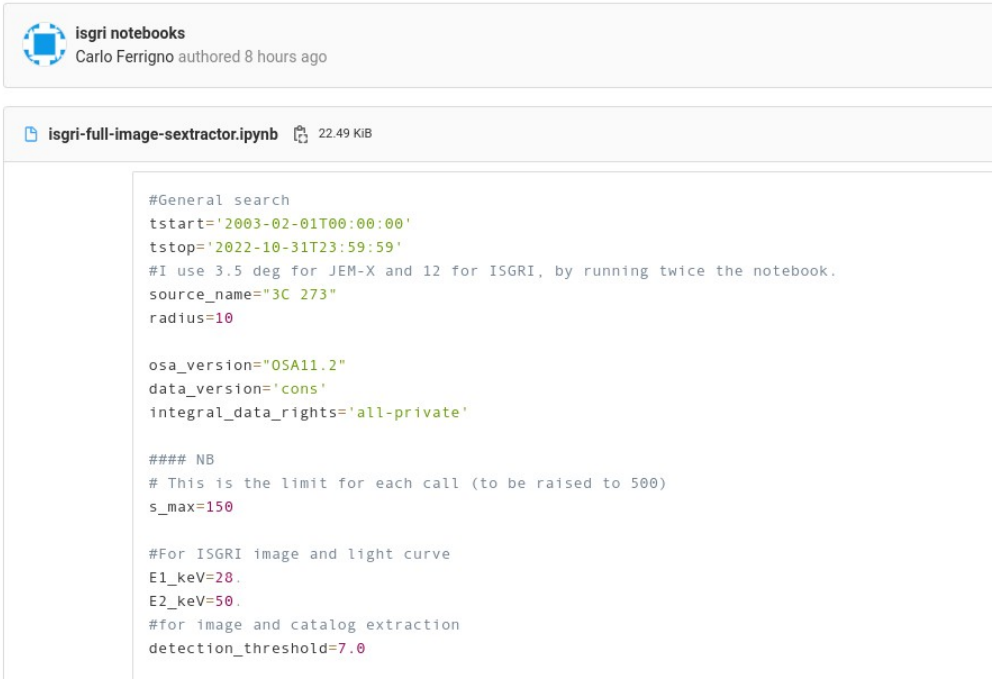
Provenance

- The python notebooks used to create these products have been developed by us and are linked at the page of the product together with the input parameters.
- The analysis is fully reproducible -> FAIR and open data !



- Needed an account with specific priviledges in MMODA to upload the analysis in the gallery

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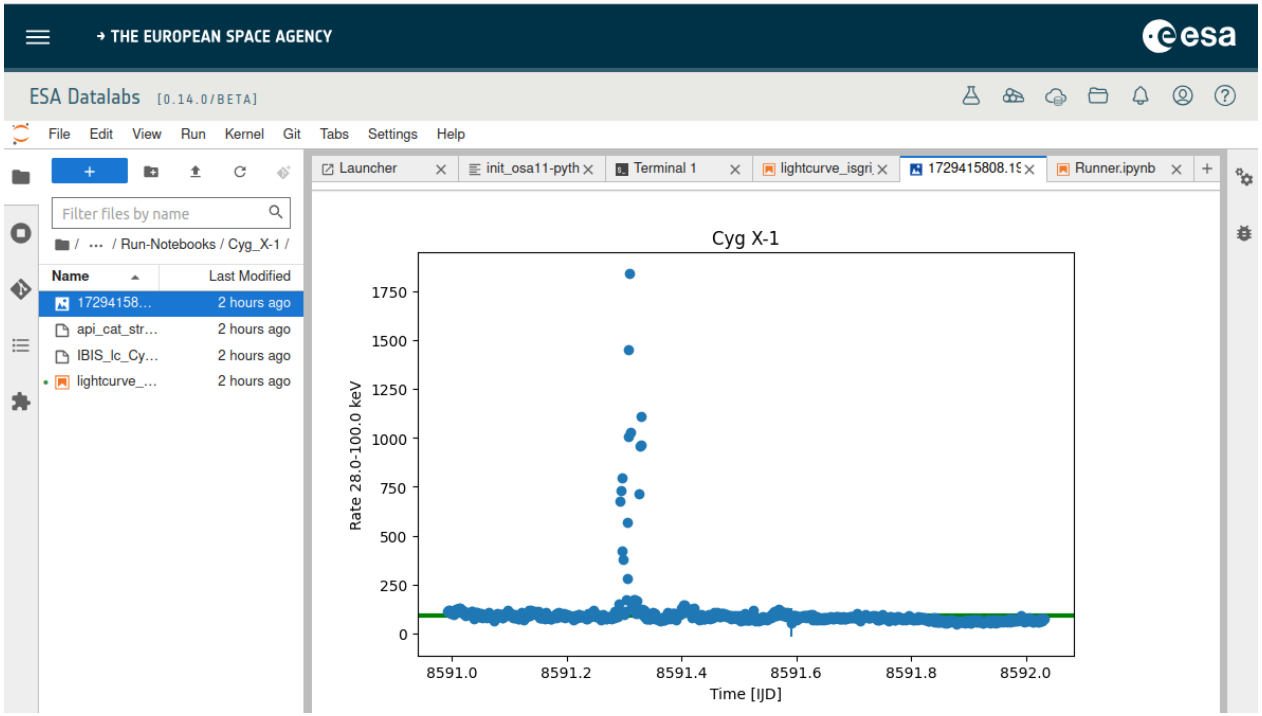
Portable and extensible

- It is now possible to run product extraction also from ESA Datalabs for everybody (instructions to be shared)



Status and Future perspectives

- We have extracted images, spectra and light curve for each observation in each satellite revolution (waiting for ISGRI calibration after 2020)
- We will collect a catalog of noticeable sources to extract mission-long light curves, using available products and specific runs
- For some sources, we plan to extract "highlights"
- We provide workflows to easily process any custom data set both at UNIGE and at ESA

Conclusions

- We have both a the multi-messenger online analysis framework to reproduce data and a gallery to present easily and quickly accessible INTEGRAL products.
- Gallery products are used for Legacy Archive at ESA
- The backend (including dispatcher) is available on the ESA cluster internally from Datalabs
- Extending functionalities can be done with relative ease e.g. for GRBs