# MMODA: Multi-Messenger observatory platform of FACE

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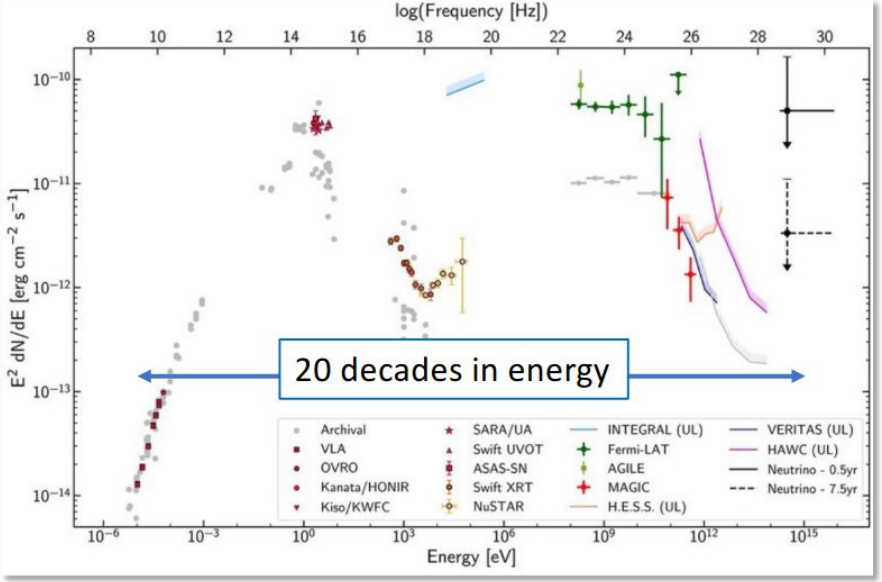
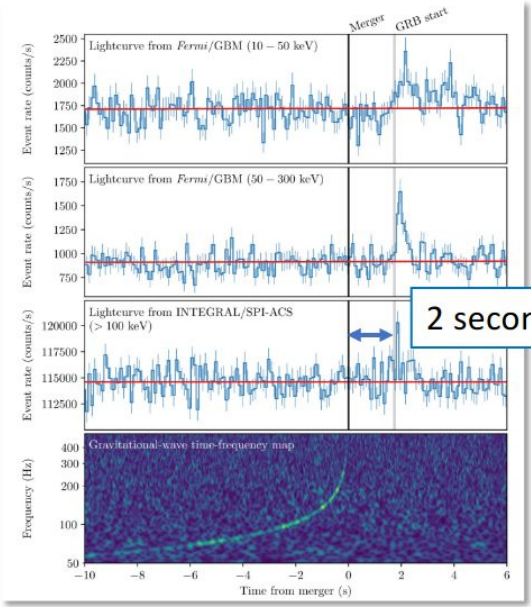
*Astroparticule et Cosmologie*

# Multi-Messenger data analysis




Example: blazar TXS 0506+056 (a supermassive black hole).

A wealth of astronomical sources emit over very broad energy range. Understanding of emission mechanisms requires astronomical data collected with many different types of telescopes.

Individual astronomers cannot master data analysis techniques of all these telescopes at once. A system that helps (guides) them to obtain analysis-ready results for multiple types of astronomical instruments, would be useful.

Example: GW 170817 (a neutron star merger event).

A wealth of astronomical sources appears on the sky for a short period of time (down to milli- and microseconds in the case of “fast radio bursts”). Understanding of emission mechanisms requires ”fast reaction”, to observe the source with multiple telescopes, while it is “in action”.

Individual astronomers cannot master all these telescopes at once. A system that helps coordinated observation campaigns and extracts data analysis results in automatic way would be useful.

# Multi-Messenger data analysis

Only combining data together, it is possible to see a complete picture of physical phenomena in astronomical sources.

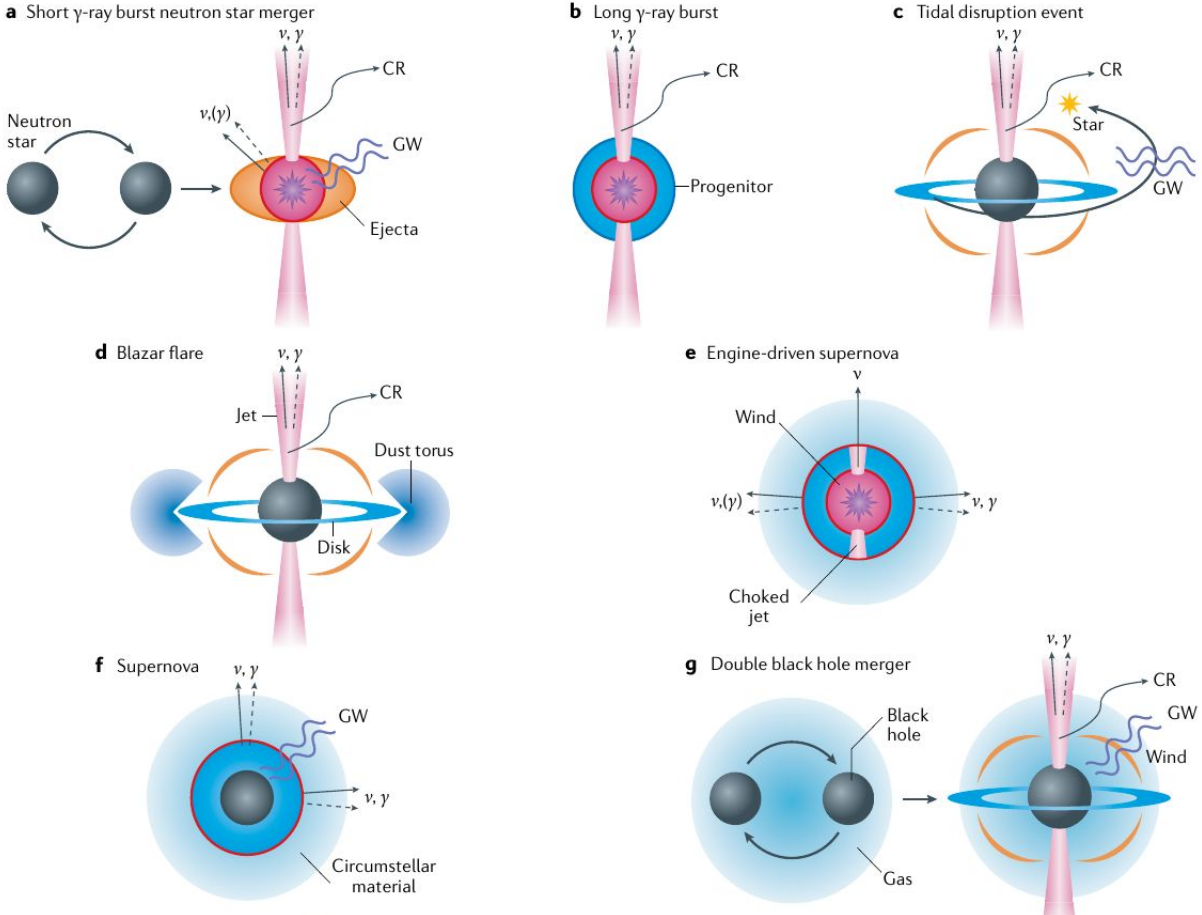


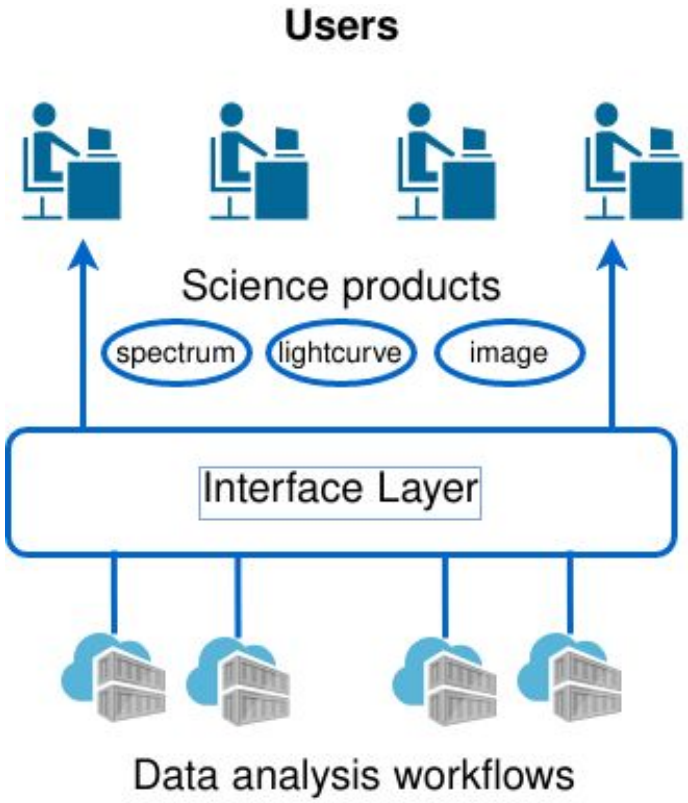

Fig: Meszaros et al. 2019

# MMODA

The MMODA is a data management solution based on cloud computing and virtualization technology to address the challenges of efficient **sharing** and **re-use** of data, their **long-term preservation**, data analysis systems, **reproducibility** of results.

From the end-user perspective it provides the abstraction over the low-level data analysis of different instruments, allowing to operate with the science product, such as spectra, light-curves, sky-images. All difficult data analysis are performed under the hood in the conteinerized environments.

The MMO project is one of the main directions of the **François Arago Centre**



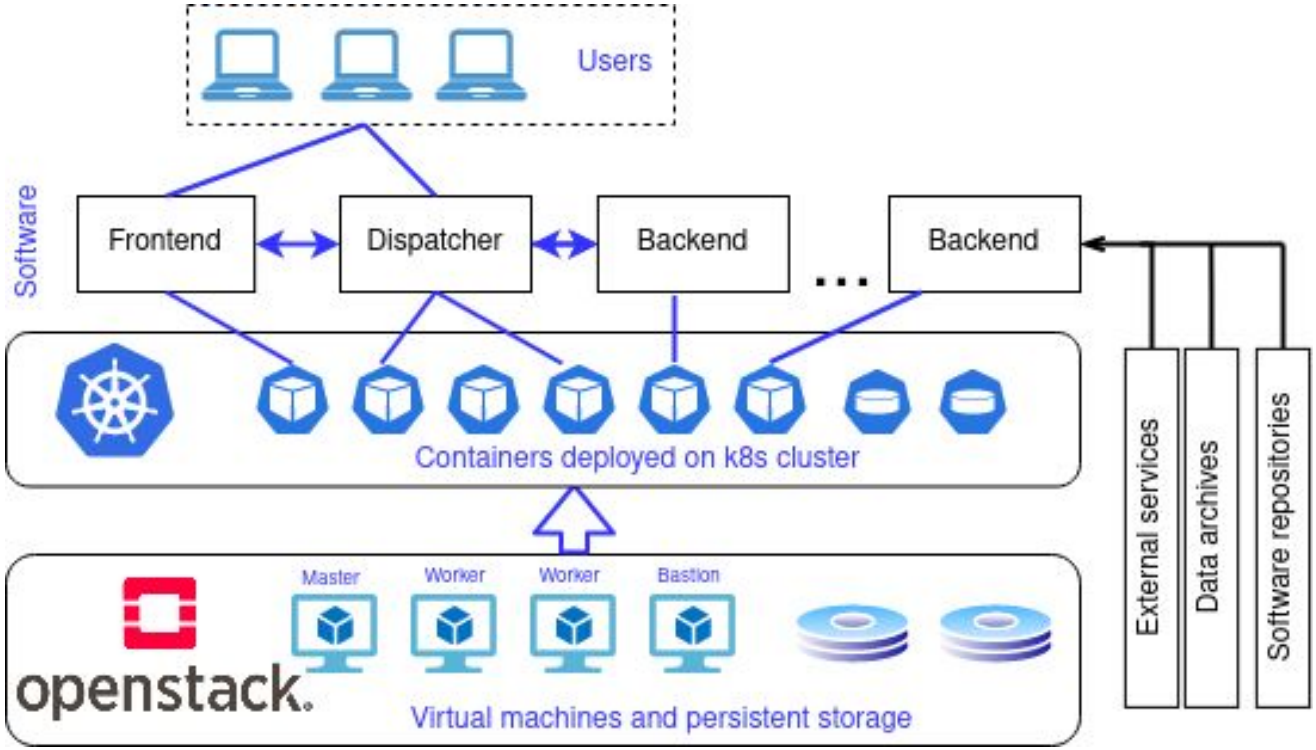
# MMO in the cloud

We provide *charts* for **Kubernetes** orchestrator

two instances:

– UniGE

**– FranceGrilles**



# Software layer

-- **API** access using dedicated python library

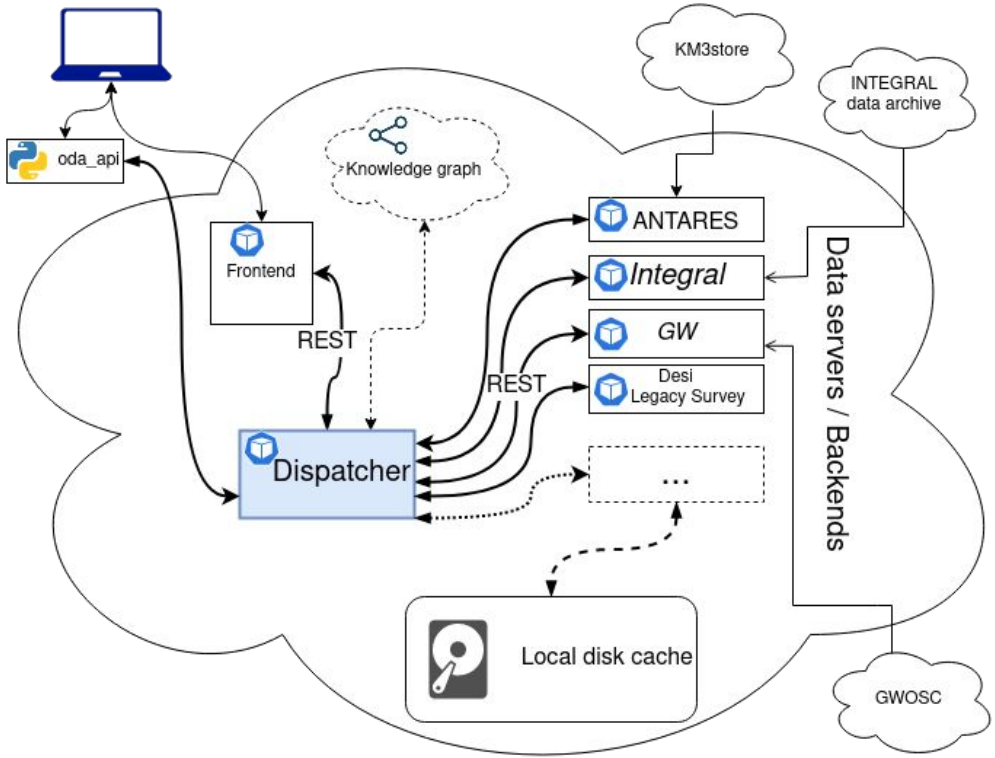
-- WEB-**frontend**

-- **dispatcher** coordinates data flow and job provisioning

-- data products are cached for later use

-- raw data from external services/archives

– provenance metadata in Knowledge Graph




https://github.com/oda-hub

# MMODA service development

François Arago Centre

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**RA ***
257.815417
The right ascension.

**Dec ***
-41.593417
The declination.

**Start time ***
2003-03-15T23:27:40.0

**End time ***
2003-03-16T00:03:15.0

**Time unit**
ISO/ISO

Antares

Instrument query parameters :

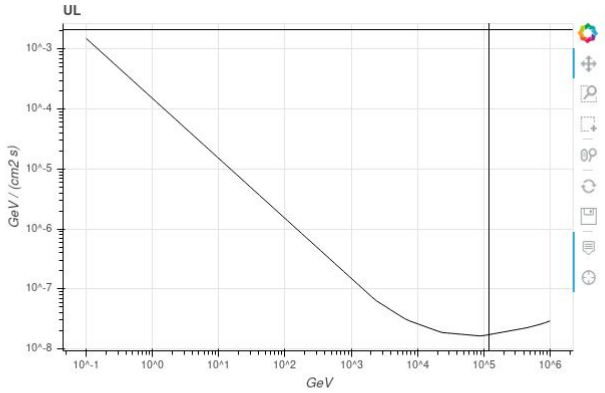
**Query Type**
Real
Select query type

**Radius**
2 deg

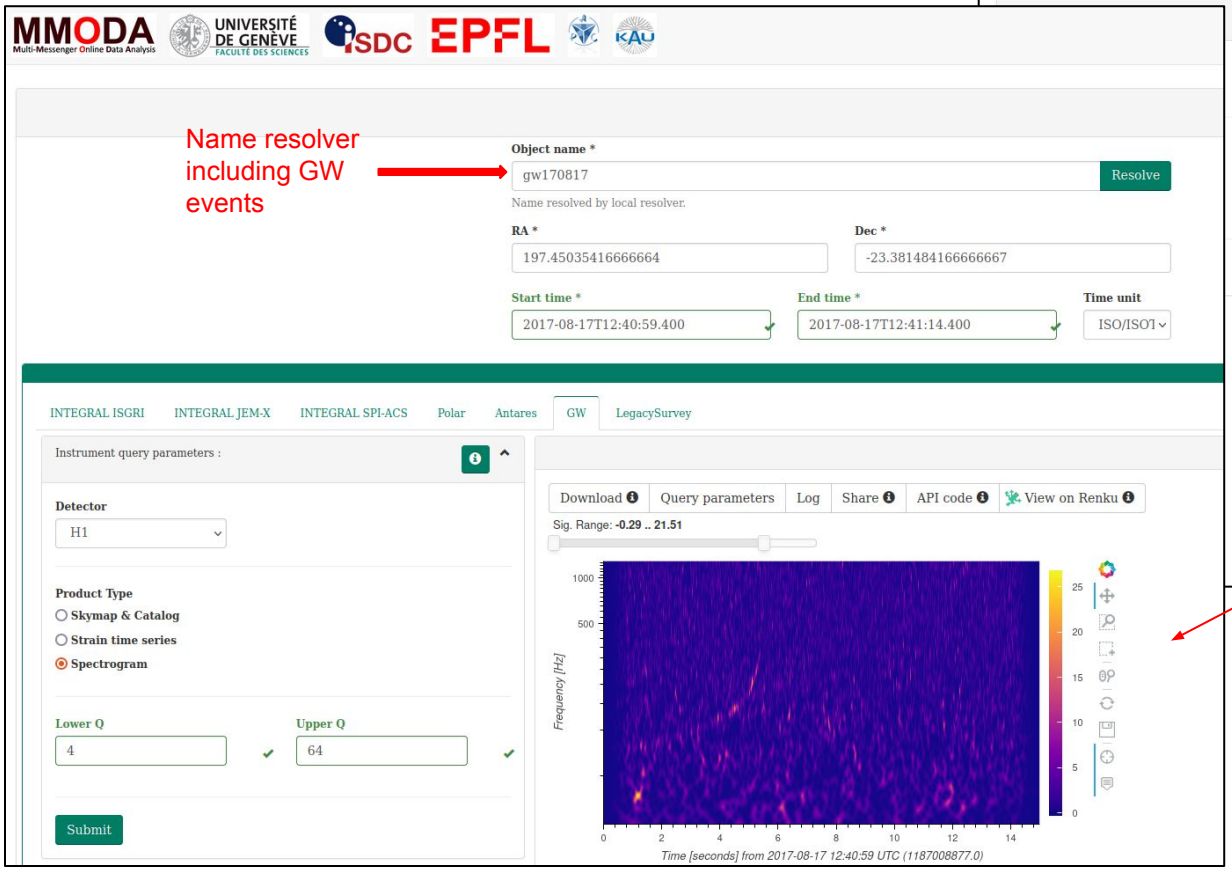
**Product Type**
**Spectrum**
Select product type
Submit

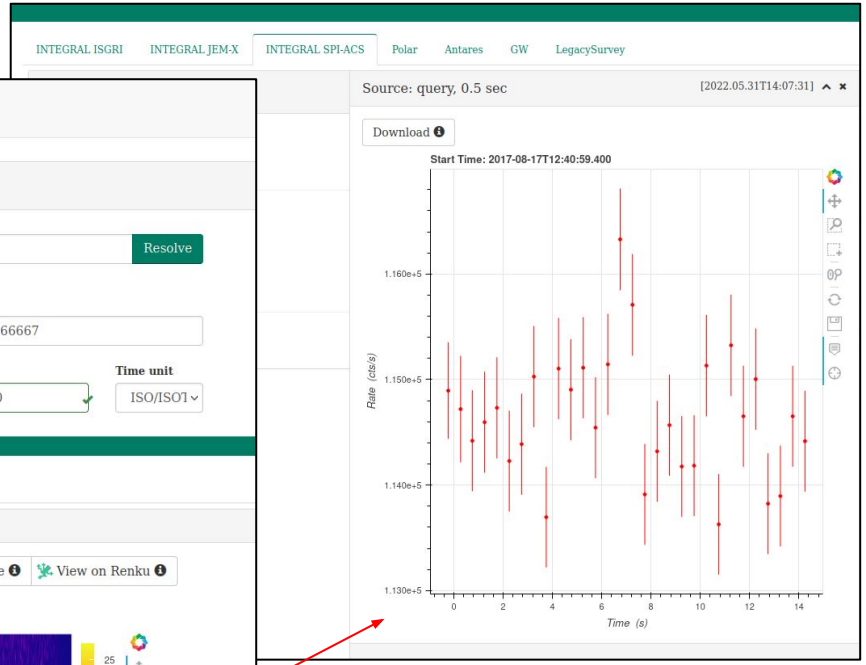
[2021.06.16T15:03:33]

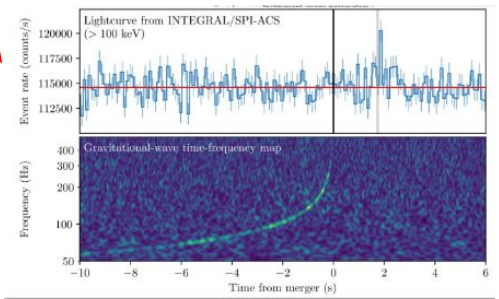
JS9 | Download | Query parameters | Log | Share | API code



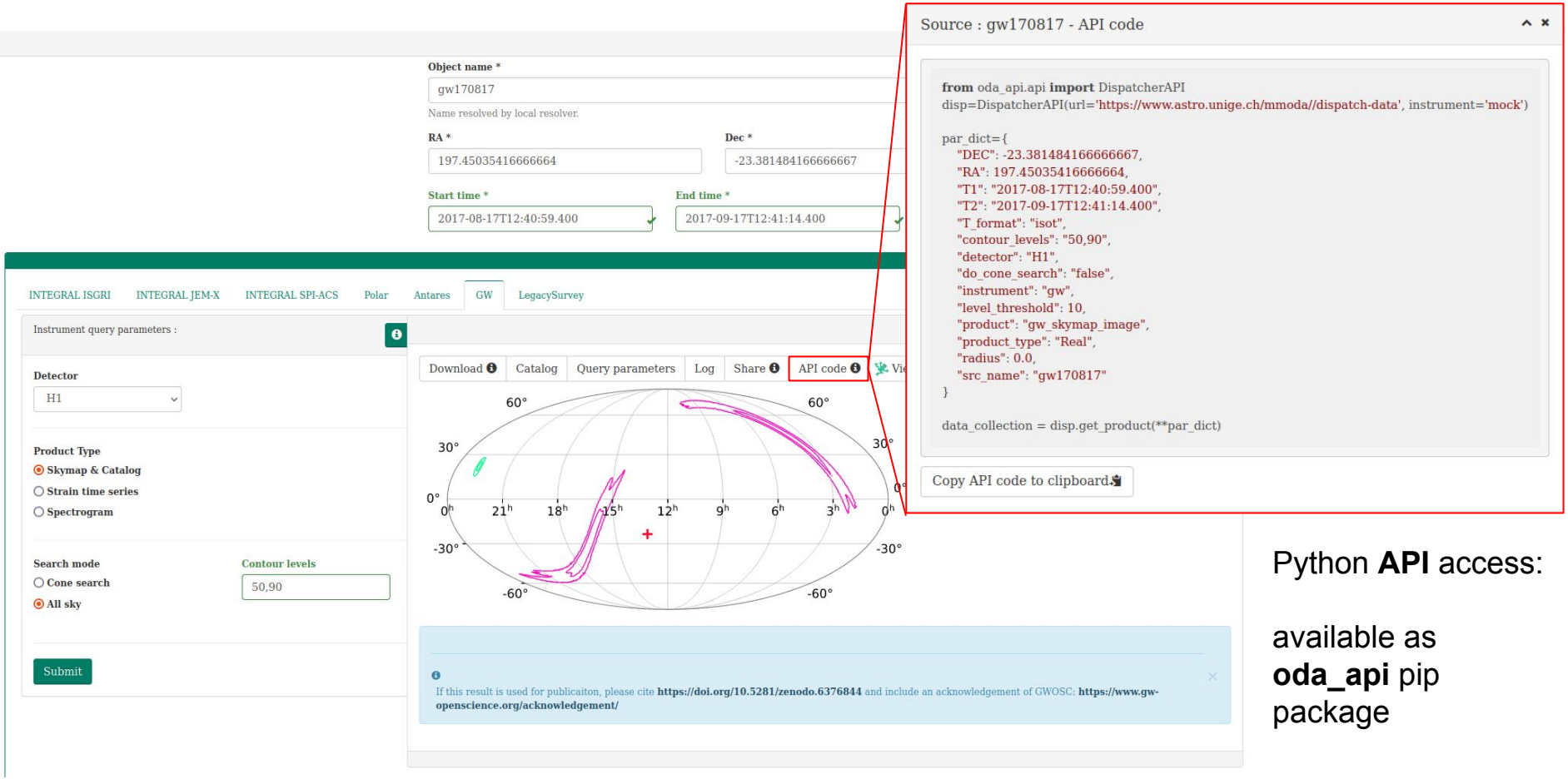
# MMODA service development



# MMODA service development




Python **API** access:

available as **oda_api** pip package

# Jupyter notebook to MMODA service

*Current development*

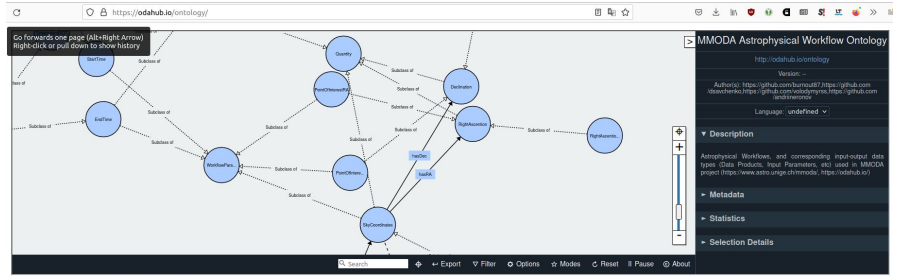
Workflow notebook on Renku
(SDSC data science platform)

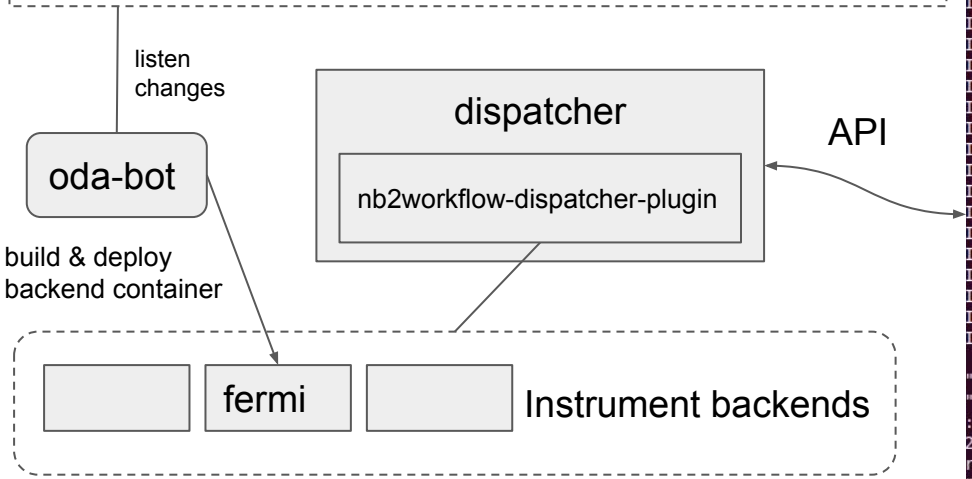
```
[12] src_name='Mrk 421' #http://odahub.io/ontology#AstrophysicalObject
     RA = 165.113808  # http://odahub.io/ontology#PointOfInterestRA
     DEC = 38.208833 # http://odahub.io/ontology#PointOfInterestDEC
     T1='2010-03-06T13:26:48.0'#http://odahub.io/ontology#StartTime
     T2='2020-03-06T13:26:48.0'#http://odahub.io/ontology#EndTime
     dT=2 # integrer in months
```

workflow parameters annotations

```
[20] result=lc.encode() # http://odahub.io/ontology#LightCurve
```

outputs annotations




```
(e) oda api ~ oda-api -u https://dispatcher-staging.odahub.io get -i fermi
INFO:oda_api:created dispatcher: [ DispatcherAPI: https://dispatcher-staging.odahub.io ]
INFO:oda_api.api.dispatcherapi:
INFO:oda_api.api.dispatcherapi:--------------
INFO:oda_api.api.dispatcherapi:query_name: src_query
INFO:oda_api.api.dispatcherapi: name: src_name,  value: 1E 1740.7-2942,  units: str,
INFO:oda_api.api.dispatcherapi: name: RA,  value: 265.97845833,  units: deg,
INFO:oda_api.api.dispatcherapi: name: DEC,  value: -29.74516667,  units: deg,
INFO:oda_api.api.dispatcherapi: name: T1,  value: 2017-03-06T13:26:48.000,  units: isot,
INFO:oda_api.api.dispatcherapi: name: T2,  value: 2017-03-06T15:32:27.000,  units: isot,
INFO:oda_api.api.dispatcherapi: name: token,  value: None,  units: str,
INFO:oda_api.api.dispatcherapi:
INFO:oda_api.api.dispatcherapi:--------------
INFO:oda_api.api.dispatcherapi:query_name: instr_query
INFO:oda_api.api.dispatcherapi:
INFO:oda_api.api.dispatcherapi:--------------
INFO:oda_api.api.dispatcherapi:query_name: fermi_lc_query
INFO:oda_api.api.dispatcherapi: product_name: fermi_lc
INFO:oda_api.api.dispatcherapi: name: dT,  value: 2,  units: None,
INFO:oda_api:instrument description: [[{'instrumet': 'fermi'}, {'prod_dict': {'fermi_lc':
 'fermi_lc_query'}}, '[{"query_name": "src_query"}, {"name": "src_name", "units": "str",
"value": "1E 1740.7-2942"}, {"name": "RA", "units": "deg", "value": 265.97845833}, {"name
": "DEC", "units": "deg", "value": -29.74516667}, {"name": "T1", "units": "isot", "value
": "2017-03-06T13:26:48.000"}, {"name": "T2", "units": "isot", "value": "2017-03-06T15:32:
27.000"}, {"name": "token", "units": "str", "value": None}]', '[{"query_name": "instr_que
ry"}]', '[{"query_name": "fermi_lc_query"}, {"product_name": "fermi_lc"}, {"name": "dT",
"units": None, "value": 2}]']]
```

# Summary

- MMODA cloud platform for astronomical multi-messenger data analysis
- we are developing specific instrument services for MMODA multi-messenger platform
- main instance in UniGE, second instance using France Grilles resources
- current direction: facilitate MMODA services creation from workflow in .ipynb form

Future developments

- further services in collaboration with teams @APC
- “smart” multi-messenger & multi-product data combination service
- multi-site integration & resource federation
- integration with EOSC (SSO, workflow discovery etc.)