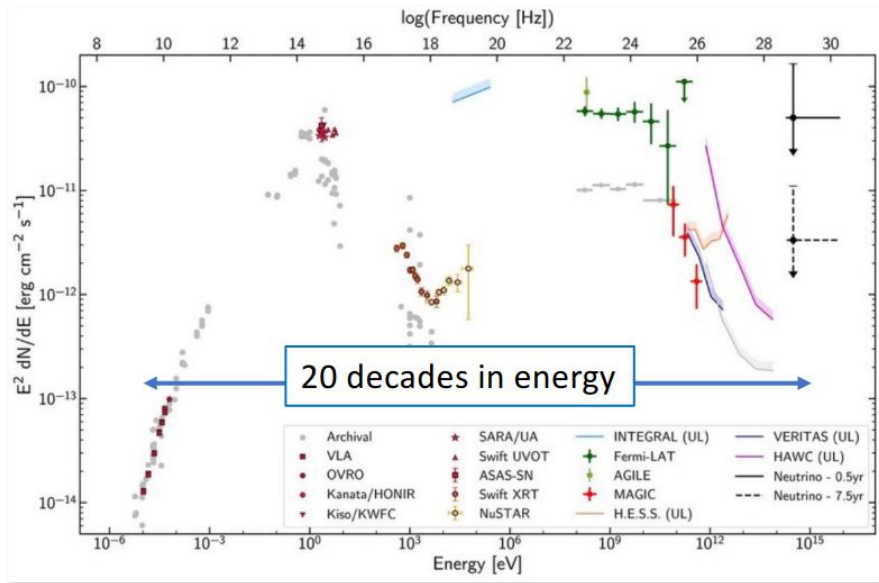


MMODA: Multi-Messenger observatory platform of FACE

Denys Savchenko, Andrii Neronov, Cécile Cavet

Astroparticule et Cosmologie

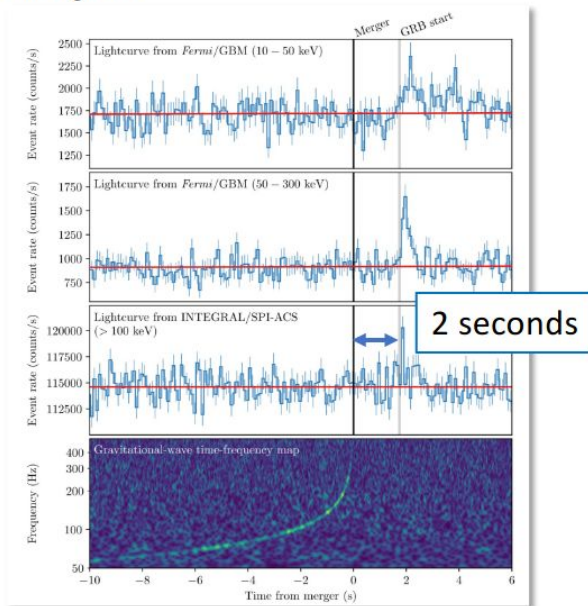
Multi-Messenger data analysis



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.

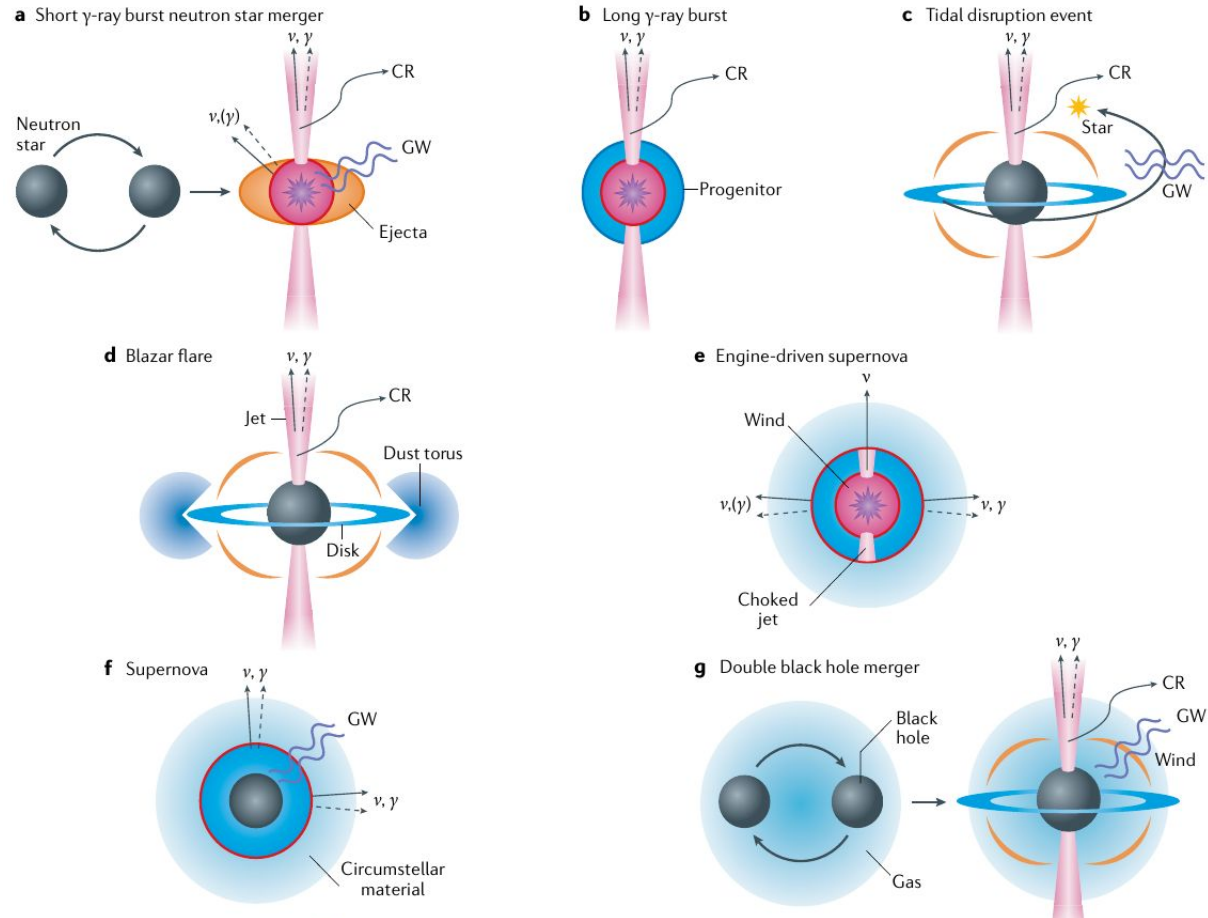


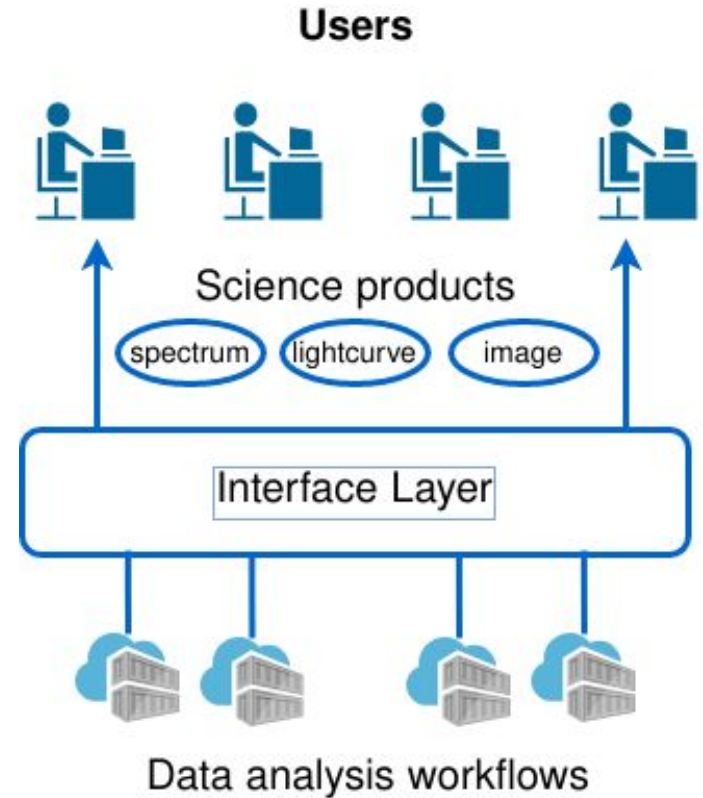
Fig: Meszaros et al. 2019

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 containerized environments.

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

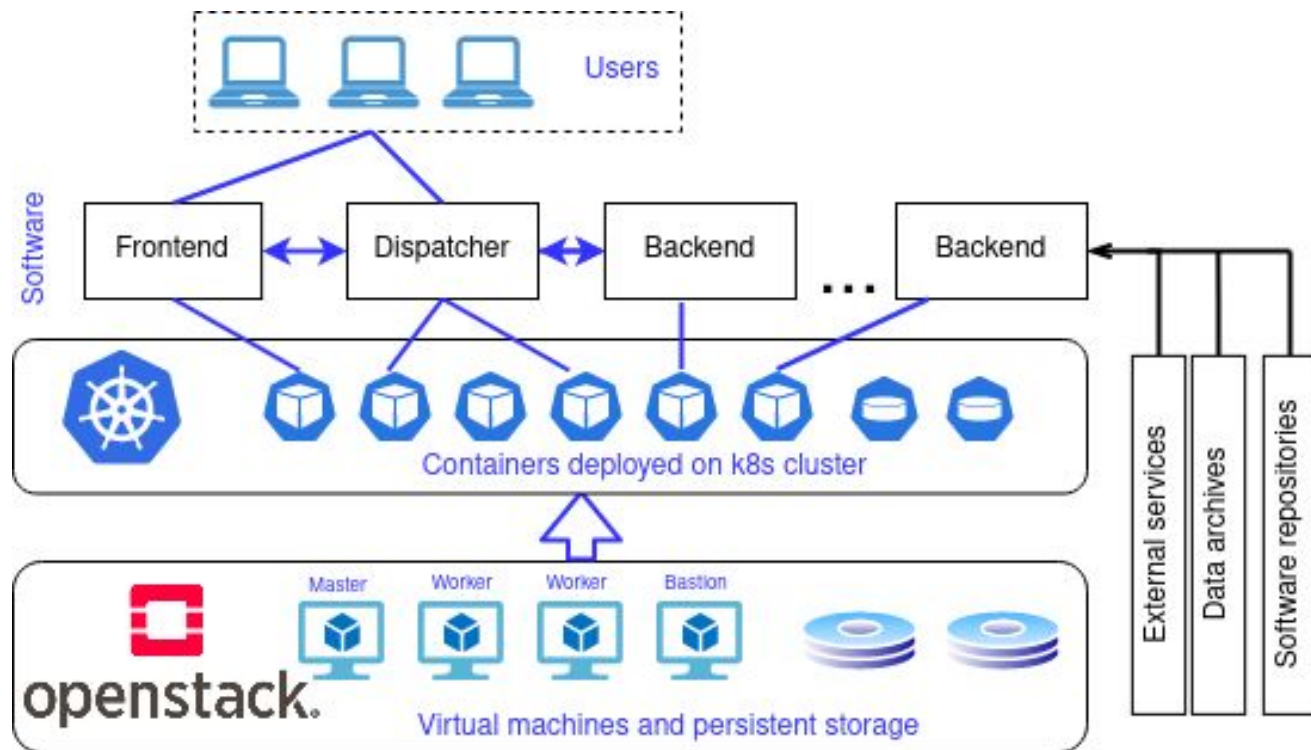


MMO in the cloud

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

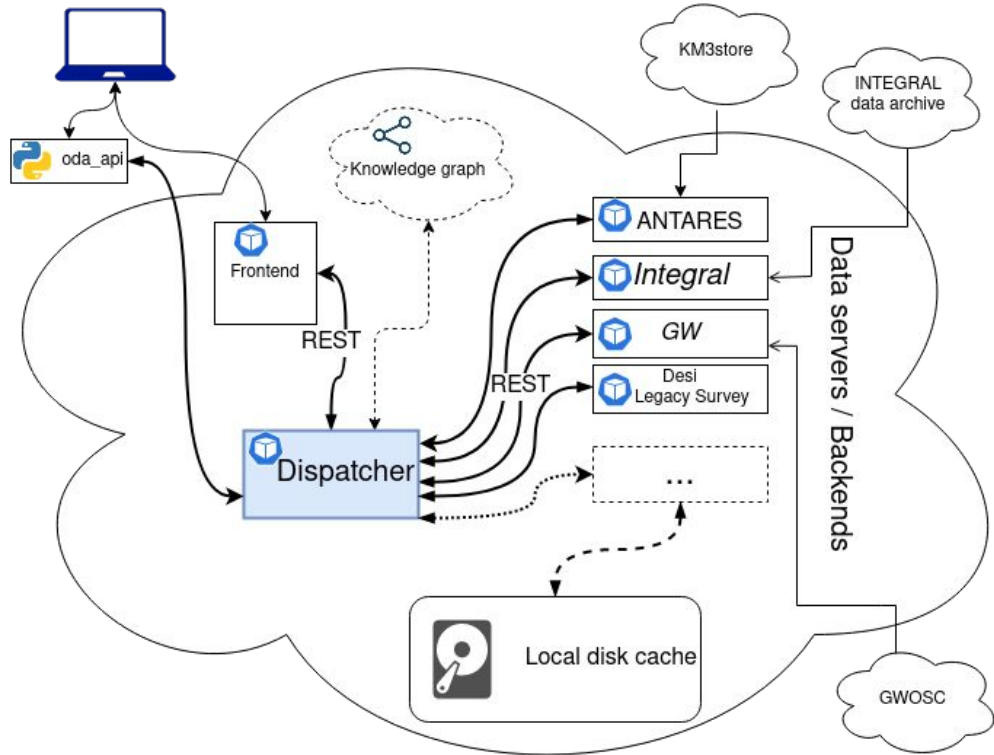
two instances:

- 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



MMODA service development



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RA *

The right ascension.

Dec *

The declination.

Start time *

End time *

Time unit

Antares

Instrument query parameters :



Query Type

Real

Select query type

Radius

2 deg

Product Type

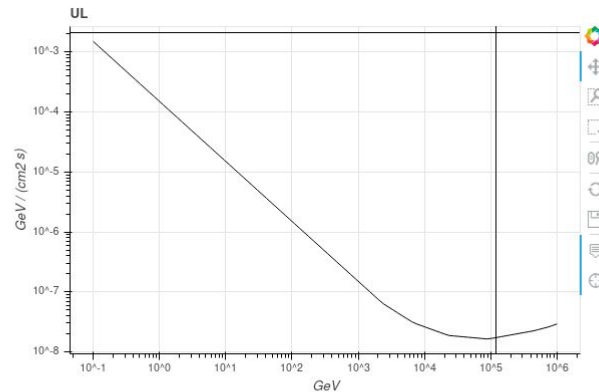
Spectrum

Select product type

Submit

[2021.06.16T15:03:33] ^ x

JS9 Download Query parameters Log Share API code



MMODA service development

Name resolver including GW events

Object name *
gw170817 Resolve

Name resolved by local resolver:

RA * 197.45035416666664 Dec * -23.381484166666667

Start time * 2017-08-17T12:40:59.400 End time * 2017-08-17T12:41:14.400 Time unit ISO/ISO1

Instrument query parameters :

Detector

H1

Product Type

- Skymap & Catalog
- Strain time series
- Spectrogram

Lower Q

4

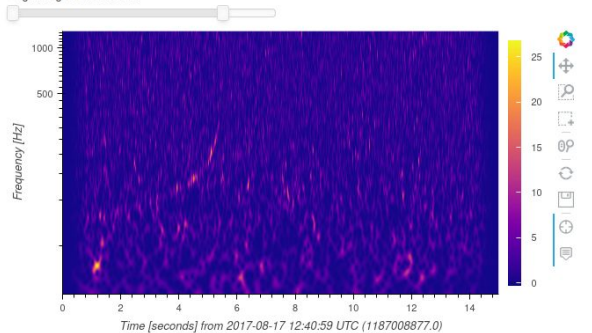
Upper Q

64

Submit

Download Query parameters Log Share API code View on Renku

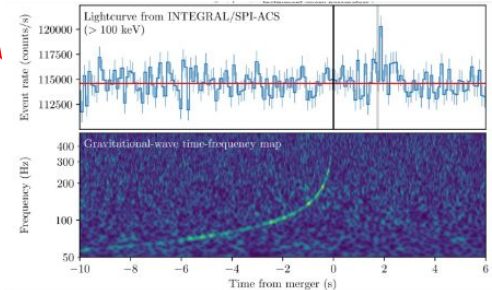
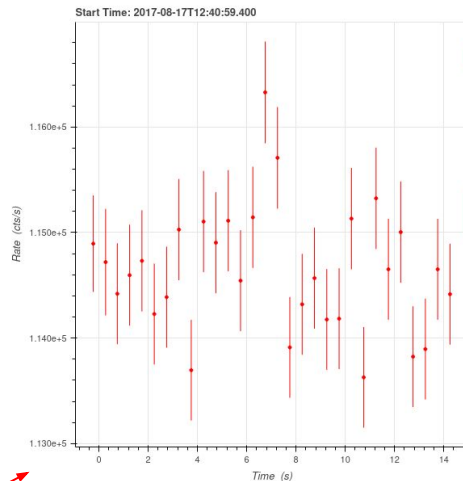
Sig. Range: -0.29 .. 21.51



Source: query, 0.5 sec

[2022.05.31T14:07:31]

Download



MMODA service development

Object name *
gw170817
Name resolved by local resolver.

RA *
197.45035416666664

Dec *
-23.381484166666667

Start time *
2017-08-17T12:40:59.400

End time *
2017-09-17T12:41:14.400

INTEGRAL ISGRI INTEGRAL JEM-X INTEGRAL SPI-ACS Polar Antares GW LegacySurvey

Instrument query parameters :

Detector
H1

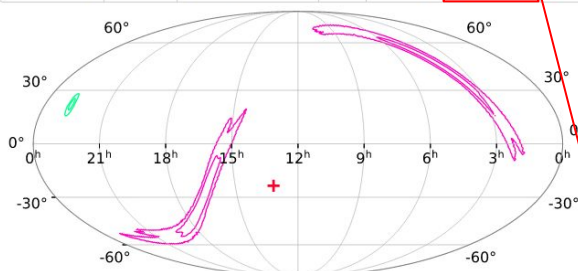
Product Type
 Skymap & Catalog
 Strain time series
 Spectrogram

Search mode
 Cone search
 All sky

Contour levels
50,90

Submit

Download Catalog Query parameters Log Share API code View



```
Source : gw170817 - API code

from oda_api import DispatcherAPI
disp=DispatcherAPI(url='https://www.astro.unige.ch/mmoda/dispatch-data', instrument='mock')

par_dict={
  "DEC": -23.381484166666667,
  "RA": 197.45035416666664,
  "T1": "2017-08-17T12:40:59.400",
  "T2": "2017-09-17T12:41:14.400",
  "T_format": "isot",
  "contour_levels": "50,90",
  "detector": "H1",
  "do_cone_search": "false",
  "instrument": "gw",
  "level_threshold": 10,
  "product": "gw_skymap_image",
  "product_type": "Real",
  "radius": 0.0,
  "src_name": "gw170817"
}

data_collection = disp.get_product(**par_dict)
```

Copy API code to clipboard

If this result is used for publication, please cite <https://doi.org/10.5281/zenodo.6376844> and include an acknowledgement of GWOSC: <https://www.gwoscience.org/acknowledgement/>

Python **API** access:

available as
oda_api pip
package

Jupyter notebook to MMODA service

Current development

Workflow notebook on Renku
(SDSC data science platform)

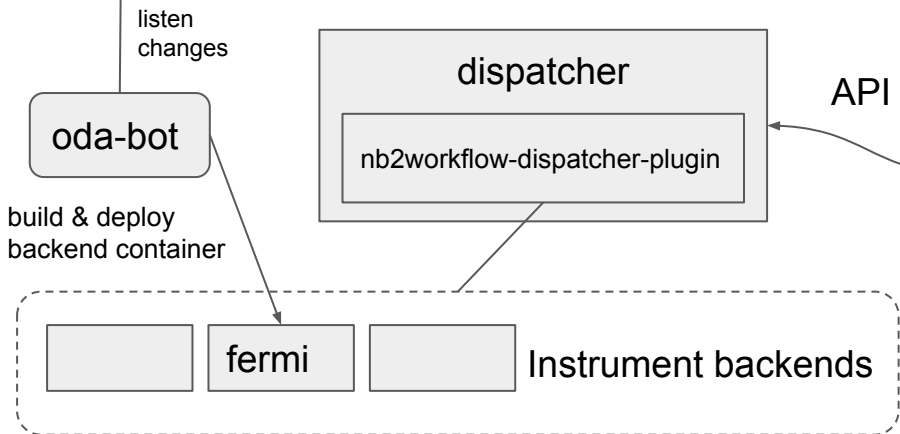
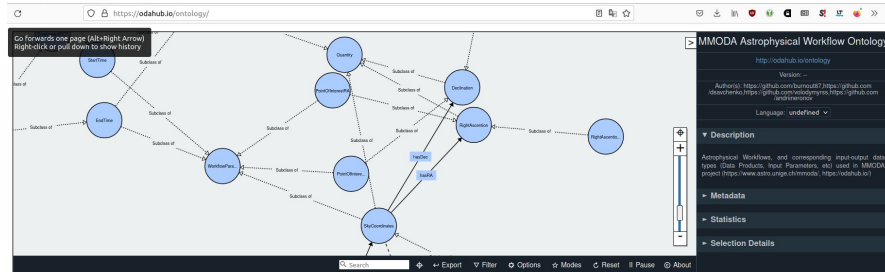


```
[12] src_name='Mrk 421' #http://odahub.io/ontology#AstrophysicalObject
RA = 165.113808 # http://odahub.io/ontology#PointOfInterestRA
DEC = 38.208833 # http://odahub.io/ontology#PointOfInterestDEC
T1='2010-03-06T13:26:48.0' #http://odahub.io/ontology#StartTime
T2='2020-03-06T13:26:48.0' #http://odahub.io/ontology#EndTime
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:query_name: instr_query
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: [{"instrument": "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.)