

Multi-Messenger Online Data Analysis

Andrii Neronov
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<https://mmoda.io>

The screenshot shows the MMODA web interface in a browser. The address bar displays <https://mmoda.io>. The page header includes logos for MMODA, Université de Genève, ISDC, EPFL, and KAU. The main content area features a search form with the following fields and values:

- Object name *: 1E 1740.7-2942
- Buttons: Resolve, Explore
- RA: 265.97845833
- Dec: -29.74516667
- Start time *: 2017-03-06T13:26:48.0
- End time *: 2017-03-06T15:32:27.0
- Time unit: ISO/ISOT

Below the search form is a navigation bar with tabs for various astronomical instruments and observatories, including INTEGRAL ISGRI, INTEGRAL JEM-X, INTEGRAL SPI-ACS, Polar, Antares, LIGO VIRGO, DESI LegacySurvey, SGWB, IceCube, HESS, and CTA.

The "Query parameters" section is expanded, showing the following settings:

- OSA Version: OSA11.2
- Radius: 15 deg
- Use INTEGRAL pointing Science Windows (ScWs): Select for time range, Custom list, Custom list in file
- Maximum number of ScWs: 50
- INTEGRAL data access privilege: Public, All Private
- Energy Min *: 28 keV
- Energy Max *: 40 keV

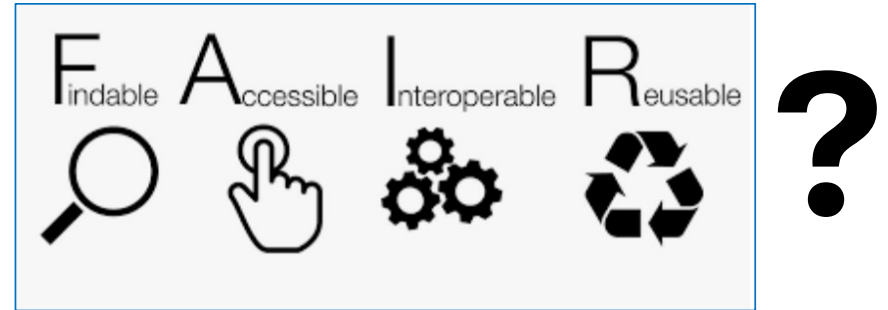
MMODA motivation: open data

It becomes a common practice to make datasets publicly available, to implement “**FAIR** principle” of data management..... “**F**”-Ok, “**A**”-Ok....

How about “**I**”=Interoperable and “**R**”=Reusable?
This requires :

- Data analysis workflow (that needs to be FAIR as well)
- Expertise in manipulating that data analysis workflow

This is not always available “by default”, compromising the “**IR**” part of the FAIR principle.



arXiv > astro-ph > arXiv:2101.09836

Astrophysics > High Energy Astrophysical Phenomena

[Submitted on 25 Jan 2021 (v1), last revised 27 Jan 2021 (this version, v2)]

IceCube Data for Neutrino Point-Source Searches Years 2008-2018

IceCube Collaboration: R. Abbasi, M. Ackermann, J. Adams, J. A. Aguilar, M. Ahlers, M. Ahrens, C. Alispach, N. M. Amin, K. Andeen, J. Anselmo, G. Anton, C. Argüelles, S. Axani, X. Bai, A. Balagopal V., A. Barbano, S. W. Barwick, B. Bastian, H. Becker, J. Becker Tjus, C. Bellenghi, S. BenZvi, D. Berley, E. Bernardini, D. Z. Besson, G. Binder, D. Borner, J. Böttcher, E. Bourbeau, J. Bourbeau, F. Bradascio, J. Braun, S. Bron, J. Brostean-Kaiser, A. Buatois, C. Carver, C. Chen, E. Cheung, D. Chirkin, S. Choi, B. A. Clark, K. Clark, L. Classen, A. Coleman, G. H. C. Cowen, R. Cross, P. Dave, C. De Clercq, J. J. DeLaunay, H. Dembinski, K. Deoskar, S. De Ridder, A. De Simone, S. De Vries, J. De Wit, T. DeYoung, S. Dharani, A. Diaz, J. C. Díaz-Vélez, H. Dujmovic, M. Dunkman, M. A. DuVernois, S. E. Enzenauer, E. Enzenauer, S. Fahy, A. R. Fazely, J. Felde, A. T. Fienberg, K. Filimonov, C. Finley, L. Fischer, D. Fox, A. Franckowiak, et al. (274 additional authors not shown)

IceCube has performed several all-sky searches for point-like neutrino sources using track-like events, including the 2014-2015 TXS flare. This paper accompanies the public data release of these neutrino candidates detected by IceCube during the 2008-2018 period. The data includes through-going tracks, primarily due to muon neutrino candidates, that reach the detector from all directions within the instrumented volume. An updated selection and reconstruction for data taken after April 2012 slightly improve the sample overlaps between the old and new versions, differing events can lead to changes relative to the previous releases. The significance of the 2014-2015 TXS flare is reported with an explanation of observed discrepancies with previous years of data and binned detector response functions for muon neutrino signal events, shows improved sensitivity should be preferred over previous releases.

arXiv > astro-ph > arXiv:1810.04516

Astrophysics > High Energy Astrophysical Phenomena

[Submitted on 10 Oct 2018]

H.E.S.S. first public test data release

H.E.S.S. Collaboration

The High Energy Stereoscopic System (H.E.S.S.) is an array of ground-based imaging atmospheric Cherenkov telescopes in Namibia. For the first time, the H.E.S.S. collaboration is releasing a small dataset of event lists and instrument response information. This is a test data release, with the motivation to support the ongoing efforts to define open high-level data models and associated formats, as well as open-source science tools for gamma-ray astronomy. The data are in FITS format. Open-source science tools that support this format exist already. The release data consists of 27.9 hours in total of observations of the Crab nebula, PKS 2155-304, MSH 15-52 and RX J1713.7-3946 taken with the H.E.S.S. 1 array. Most data are from 2004, the PKS 2155-304 data are from 2006 and 2008. In addition, 20.7 hours of off observations of empty fields of view are included. The targets and observations were chosen to be suitable for common analysis use cases, including point-like and extended sources for spectral and morphology measurements, as well as a variable source (PKS 2155-304) and the off dataset for background studies. The total size of the files in this data release is 42.8 MB. This is a very small subset of the thousands of hours of H.E.S.S. 1 observations taken since 2004. The quality of this dataset, and measurements derived from this data, does not reflect the state of the art for H.E.S.S. publications, e.g. the event reconstruction and gamma-hadron separation method used here is a very basic one.

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References & Citations

- INSPIRE HEP
- NASA ADS
- Google Scholar
- Semantic Scholar

arXiv > astro-ph > arXiv:2309.16294

Astrophysics > High Energy Astrophysical Phenomena

[Submitted on 28 Sep 2023 (v1), last revised 26 Jul 2024 (this version, v2)]

The Pierre Auger Observatory Open Data

The Pierre Auger Collaboration: A. Abdul Halim, P. Abreu, M. Aglietta, I. Allekotte, K. Almeida Cheminant, A. Almela, R. Aloisio, J. Alvarez-Muñiz, J. Ammerman Yebra, G.A. Anastasi, L. Anchordoqui, B. Andrada, L. Andrade Dourado, S. Andringa, L. Apollonio, C. Aramo, P.R. Araújo Ferreira, E. Arnone, J.C. Arteaga Velázquez, P. Assis, G. Avila, E. Avocone, A. Bakalova, E. Barbato, A. Bartz Mocellin, J.A. Bellido, C. Berat, M.E. Bertaina, X. Bertou, G. Bhatta, M. Bianciotto, P.L. Biermann, V. Binet, K. Bismark, T. Bister, J. Biteau, J. Blazek, C. Bleve, J. Blümer, M. Boháčová, D. Boncioli, C. Bonifazi, L. Bonneau Arbeletche, N. Borodai, J. Brack, P.G. Bricchetto Orcherá, F.L. Briechele, A. Bueno, S. Buitink, M. Buscemi, M. Búsken, A. Bwembya, K.S. Caballero-Mora, S. Cabana-Freire, L. Caccianiga, F. Campuzano, R. Caruso, A. Castellina, F. Catalani, G. Cataldi, L. Cazon, M. Cerda, B. Čermáková, A. Cermenati, J.A. Chinellato, J. Chudoba, L. Chytka, R.W. Clay, A.C. Cobos Cerutti, R. Colalillo, R. Conceição, A. Condorelli, G. Consolati, M. Conte, F. Convega, D. Correia dos Santos, P.J. Costa, C.E. Covault, M. Cristinziani, C.S. Cruz Sanchez, S. Dasso, K. Daumiller, B.R. Dawson, R.M. de Almeida, B. de Errico, J. de Jesús, S.J. de Jong, J.R.T. de Mello Neto, I. De Mitri, J. de Oliveira, D. de Oliveira Franco, F. de Palma, V. de Souza, E. De Vito, A. Del Popolo, O. Deligny, N. Denner, L. Deval, A. di Matteo et al. (261 additional authors not shown)

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References & Citations

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MMODA motivation: open data analysis software

Analysis frameworks that constitute the basis of data analysis workflows are often publicly available:

- Data analysis workflows can be extracted from open software repositories

These workflows can be made “live” explicitly fostering the **I**nteroperability and **R**euse of data.

arXiv > astro-ph > arXiv:2107.08934

Astrophysics > Instrumentation and Methods for Astrophysics

[Submitted on 19 Jul 2021]

The SkyLLH framework for IceCube point-source search

Tomas Kontrimas, Martin Wolf (for the IceCube Collaboration)

Hypothesis tests based on unbinned log-likelihood (LLH) functions are a common technique used in multi-messenger astronomy searches. We present the general Python-based tool "SkyLLH", which provides a modular framework for implementing data analyses with multi-messenger astronomy data. Specific SkyLLH framework features for a new and improved analysis are highlighted, including the support for kernel density estimation (KDE) based probability density functions. In addition, the support for a variety of point-source analysis types, such as stacked and time-variable searches, will be presented.

Comments: Presented at the 37th International Cosmic Ray Conference (ICRC 2021). See arXiv:2107.06966 for all IceCube contributions

Subjects: **Instrumentation and Methods for Astrophysics (astro-ph.IM)**; High Energy Astrophysical Phenomena (astro-ph.HE)

Report number: PoS-ICRC2021-1073

Cite as: arXiv:2107.08934 [astro-ph] (or arXiv:2107.08934v1 [astro-ph]) <https://doi.org/10.48550/arXiv.2107.08934>

Submission history

From: Tomas Kontrimas [view email]

[v1] Mon, 19 Jul 2021 14:49:16 UTC

arXiv > astro-ph > arXiv:1904.11747

Search... All fields Search

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Astrophysics > Instrumentation and Methods for Astrophysics

[Submitted on 26 Apr 2019]

CASA on the fringe: VLBI data processing in the CASA software package

Ilse van Bemmel, Des Small, Mark Kettenis, Arpad Szomoru, George Moellenbrock, Michael Janssen

In recent years new functionality for VLBI data processing has been added to the CASA package. This paper presents the new CASA tasks 'fringeft' and 'accor', which are closely matched to their AIPS counterparts FRING and ACCOR. Several CASA tasks received upgrades to handle VLBI specific metadata. With the current CASA release VLBI data processing is possible, and functionality will be expanded in the upcoming release. Longer term developments include fringe fitting of broad, non-continuous frequency bands and dispersive delays, which will ensure that the number of use cases for VLBI calibration will increase in future CASA releases.

Comments: 5 pages, 2 figures, EVN 2018 symposium proceedings

Subjects: **Instrumentation and Methods for Astrophysics (astro-ph.IM)**

Cite as: arXiv:1904.11747 [astro-ph.IM] (or arXiv:1904.11747v1 [astro-ph.IM] for this version) <https://doi.org/10.48550/arXiv.1904.11747>

Journal reference: PoS(EVN2018)079

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arXiv > astro-ph > arXiv:2308.13584

Search... All fields Search

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Astrophysics > Instrumentation and Methods for Astrophysics

[Submitted on 25 Aug 2023]

Gammapy: A Python package for gamma-ray astronomy

Axel Donath, Régis Terrier, Quentin Remy, Atréyee Sinha, Cosimo Nigro, Fabio Pintore, Bruno Khélifi, Laura Olivera-Nieto, Jose Enrique Ruiz, Kai Brügge, Maximilian Linhoff, Jose Luis Contreras, Fabio Acero, Arnau Aguasca-Cabot, David Berge, Pooja Bhattacharjee, Johannes Buchner, Catherine Boisson, David Carreto Fidalgo, Andrew Chen, Mathieu de Bony de Lavergne, José Vinícius de Miranda Cardoso, Christoph Deil, Matthias Fülling, Stefan Funk, Luca Giunti, Jim Hinton, Léa Jouvin, Johannes King, Julien Lefaucheur, Marianne Lemoine-Goumard, Jean-Philippe Lenain, Rubén López-Coto, Lars Mohrmann, Daniel Morcuende, Sebastian Panny, Maxime Regeard, Lab Saha, Hubert Siejkowski, Aneta Siemiginowska, Brigitta M. Sipőcz, Tim Unbehaun, Christopher van Eldik, Thomas Vuillaume, Roberta Zanin

In this article, we present Gammapy, an open-source Python package for the analysis of astronomical γ -ray data, and illustrate the functionalities of its first long-term-support release, version 1.0. Built on the modern Python scientific ecosystem, Gammapy provides a uniform platform for reducing and modeling data from different γ -ray instruments for many analysis scenarios. Gammapy complies with several well-established data conventions in high-energy astrophysics, providing serialized data products that are interoperable with other software packages. Starting from event lists and instrument response functions, Gammapy provides functionalities to reduce these data by binning them in energy and sky coordinates. Several techniques for background estimation are implemented in the package to handle the residual

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- NASA ADS
- Google Scholar
- Semantic Scholar

MMODA motivation: open data, open software → web services

arXiv > astro-ph > arXiv:2107.08934

Astrophysics > Instrumentation and Methods for Astrophysics

Submitted on 19 Jul 2021

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Tomas Kontrimas, Martin Wolf (for the IceCube Collaboration)

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Comments: Presented at the 37th International Cosmic Ray Conference (ICRC 2021). See arXiv:2107.06966 for all IceCube contributions

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Report number: PoS(ICRC2021)-1073

Cite as: arXiv:2107.08934 [astro-ph.IM] (or arXiv:2107.08934v1 [astro-ph.IM] for this version) <https://doi.org/10.48550/arXiv.2107.08934>

Submission history

From: Tomas Kontrimas [\[view email\]](#)

[v1] Mon, 19 Jul 2021 14:49:16 UTC (871 KB)

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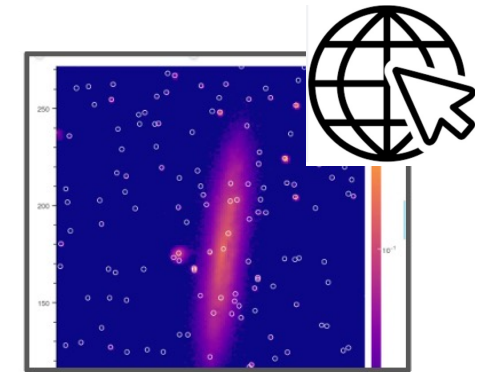
parameters

Data Release: DR0

Product Type: Image & Catalog Phenometry

Image size: 3 arcmin Pixel size: 1 arcmin per pixel

Image Band: g r i



Example: IceCube analysis

arXiv > astro-ph > arXiv:2107.08934

Astrophysics > Instrumentation and Methods for Astrophysics

Submitted on 19 Jul 2021

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https://mmoda.io

UNIVERSITÉ DE GENÈVE | ISDC | EPFL | KAU

Object name *
IE 1740.7-2942

Resolve Explore

RA 265.97845833 Dec -29.74516667

Start time * 2017-03-06T15:32:48.0 End time * 2017-03-06T15:32:27.0 Time unit ISO/ISOT

Hard X-rays INTEGRAL ISGRI X-rays INTEGRAL JEM-X Gamma-rays INTEGRAL SPI-ACS Gamma-rays Polar Neutrino Antares Gravitational waves LIGO/VIRGO IR/Visible DESI LegacySurvey gravitational SGWB

neutrino IceCube Gamma-rays Fermi-LSS GRB detection Gamma-rays CTA

Query parameters:

Radius 15

Energy Max * 40 keV

Example: IceCube analysis

Added value to the data: the original IceCube 10-year analysis publication only reported upper limits on (or measurements of) neutrino flux for a fixed set of sources from a pre-defined catalogue, for two different spectral models (E^{-3} or E^{-2} powerlaws).

Reuse cases: e.g. get an upper limit on neutrino flux for an arbitrary *sky position*, arbitrary assumed *source spectrum*, for a given *time interval*, etc.

Object name *
NGC 1068
Resolve Explore
Name resolved by local resolver.

RA Dec
40.66962125 -0.013294166666666668

Start time * End time * Time unit
2000-03-06T13:26:48.0 2020-03-06T15:32:27.0 ISO

Product Type
 Image
 Lightcurve
 Spectrum

IC40
 True
 False

IC59
 True
 False

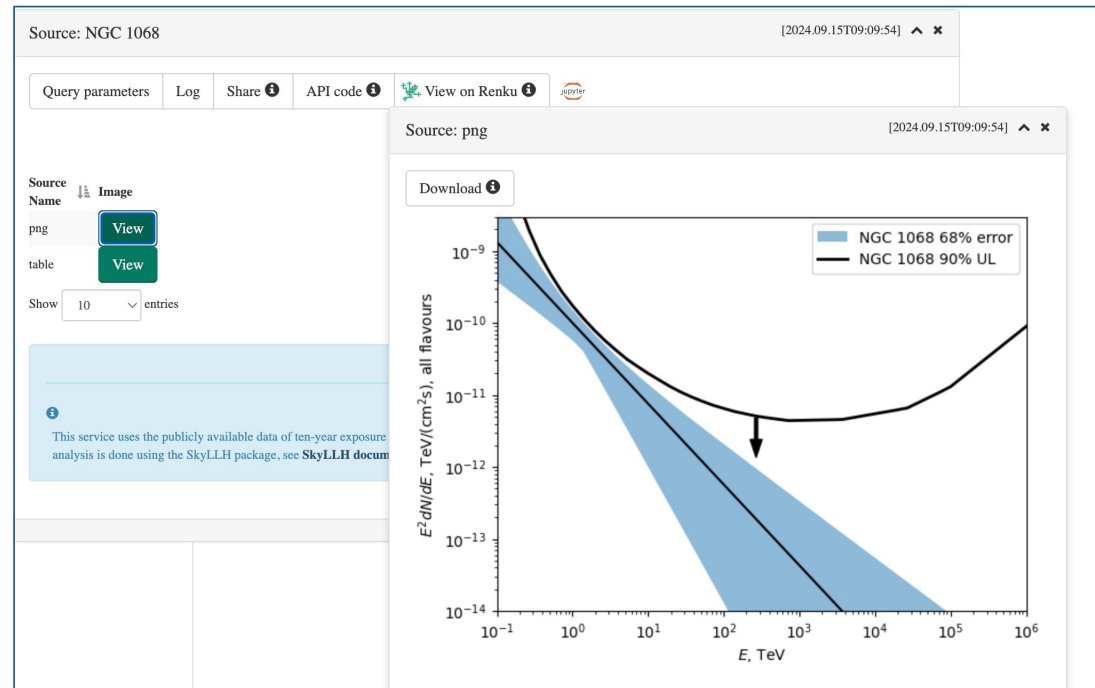
IC79
 True
 False

IC86_I
 True
 False

IC86_II_VII
 True
 False

Slope
3

Spectrum_type
Free_slope



Example: IceCube analysis

Object name *

[Resolve](#) [Explore](#)

Name resolved by local resolver.

RA Dec

Start time * End time * Time unit

There are two ways to get the data product:

- through MMODA web front-end
- through Python API

`pip install --upgrade oda_api`

e.g. from a Python notebook locally on user laptop

Product Type

Image

Lightcurve

Spectrum

IC40

True

False

IC59

True

False

IC79

True

False

IC86_I

False

True

IC86_II_VII

False

True

Slope

Spectrum_type

Source: NGC 1068 [2024.09.15T09:09:54] ^ x

Query parameters Log Share API code View on Renku

Source: png [2024.09.15T09:09:54] ^ x

Download

NGC 1068 68% error
NGC 1068 90% UL

Source : NGC 1068 - API code ^ x

```

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

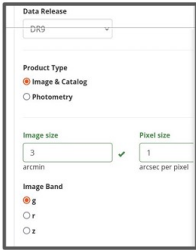
par_dict={
    "DEC": -0.013294166666666668,
    "IC40": False,
    "IC49": False,
    "IC59": False,
    "IC79": False,
    "IC86_I": True,
    "IC86_II_VII": True,
    "RA": 40.66962125,
    "Slope": 3.0,
    "Spectrum_type": "Free_slope",
    "instrument": "icecube",
    "product": "Spectrum",
    "product_type": "Real",
    "src_name": "NGC 1068"
}

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

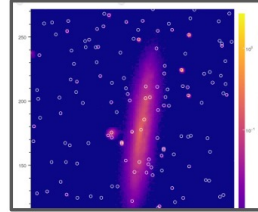
Copy API code to clipboard

open data, open software → web services (how to)

parameters



results



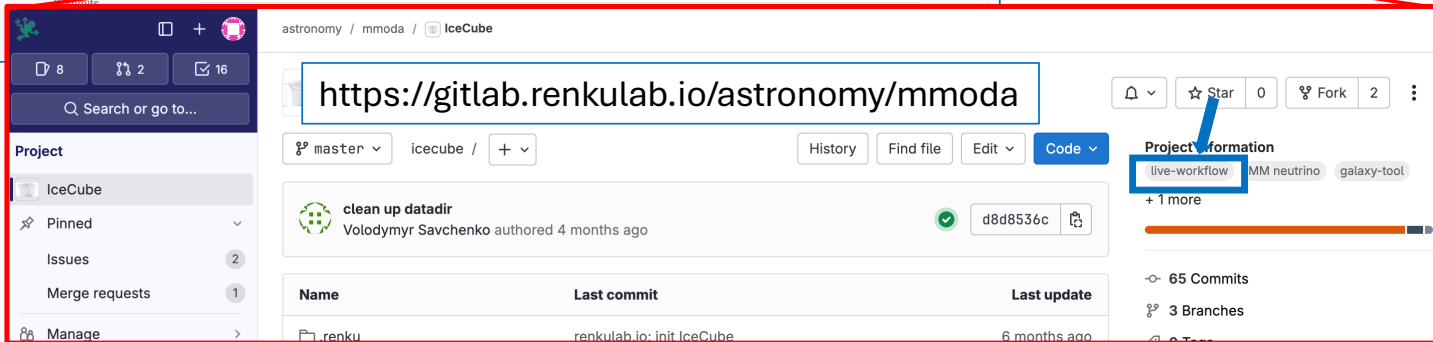
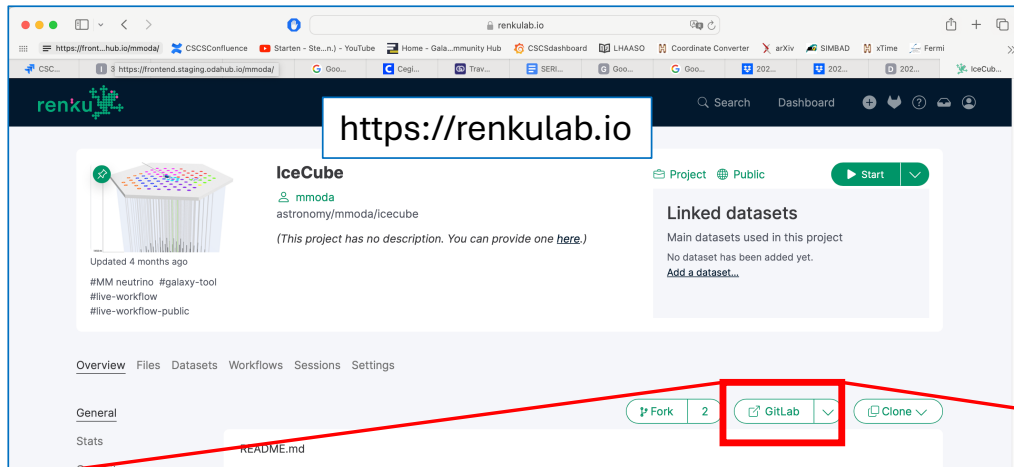
MMODA services can be created starting from e.g. a Python notebook, deposited to a dedicated Gitlab domain:

<https://gitlab.renku.io/astronomy/mmoda>

by users known to the MMODA team (you are welcome to give it a try!)

MMODA currently uses **Renkulab** collaborative data science platform (Jupyter lab + Gitlab) as a convenient environment for new service development.

To promote a notebook to a service, it is enough to tag the Gitlab repository in “astronomy/mmoda” domain with a “**live workflow**” tag. As soon as it is the case a “bot” scanning the domain will pick up the notebook and convert it to a service of MMODA.



open data, open software → web services (how to)

<https://renkulab.io>

```
[ ]: import numpy as np
from matplotlib import pyplot as plt
import scipy.stats
import os

from oda_api.data_products import PictureProduct
from oda_api.data_products import ODAAstropyTable

import sys

from astropy.time import Time

from numpy import pi
from oda_api.api import ProgressReporter

[ ]: rc_name='NGC 1068' # http://odahub.io/ontology#AstrophysicalObject
A = 40.669622 # http://odahub.io/ontology#PointOfInterestRA
EC = 0.013294 # http://odahub.io/ontology#PointOfInterestDEC
C40 = False # http://odahub.io/ontology#Boolean
C59 = False # http://odahub.io/ontology#Boolean
C79 = False # http://odahub.io/ontology#Boolean
C86_I = True # http://odahub.io/ontology#Boolean
C86_II_VII = True # http://odahub.io/ontology#Boolean
spectrum_type='Free_slope' # http://odahub.io/ontology#String ; oda:allow_value "Fixed_slope"
slope=3.0 # http://odahub.io/ontology#Float

[ ]: from skypy.cosm import Conf
from skypy import Cosm
from skypy import Galaxies
from skypy import Galaxies

[ ]: pe_modes=
if IC40
per=
+//
```

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The **bot** identifies specific cells of the notebook that provide **input parameters** and **output data products** of the workflow. It also can interpret the parameters and outputs if they are annotated following certain “**astrophysical workflow ontology**”.

<https://odahub.io/ontology/>

MMODA Astrophysical Workflow Ontology

Authors:

- <https://github.com/andriineronov>
- <https://github.com/burnout87>
- <https://github.com/dsavchenko>
- <https://github.com/volodymyras>

Download serialization:

License:

Visualization:

Cite as:

Provenance of this page:

Abstract

VOA kindly provides various data and object types, but very little is available about workflow types. It is possible to contribute and define supporting types, our own versions of some of the generic types, and anything else needed. Please refer to <https://odahub.io/docs/guide-ontology/> for instructions on how to contribute.

Table of contents

- 1. Introduction
 - 1.1. Namespace declarations
- 2. MMODA Astrophysical Workflow Ontology: Overview
- 3. MMODA Astrophysical Workflow Ontology: Description

Reference for MMODA Astrophysical Workflow Ontology classes, object properties and data properties classes:

- Object Properties
- Data Properties
- Instance Properties
- Named Individuals

- 5. References
- 6. Acknowledgments

open data, open software → web services (how to)

The screenshot shows a web browser at odahub.io/docs/guide-development/. The page title is "MMODA workflow development". The left sidebar contains a navigation menu with items: About ODA, Search, Guide Development (highlighted), Guide Discovery, Guide Ontology, Issues, Reasoning Engine, Workflow Development, and Progression. The main content area includes a search bar, a list of bullet points about MMODA services, and a list of links for workflow development. A small box at the bottom left of the screenshot contains the URL <https://odahub.io/guide-development/>.

MMODA workflow development

The **MMODA** platform provides access to the Astronomical Open Data Service (ORDAS). Good fraction of these services follow a common pattern:

- access publicly available external astronomical source or source catalog,
- transform the fetched data using a workflow based on the MMODA interface to produce a data product.
- display a preview of the data product on the MMODA interface to the user via Python **API**

The users of **MMODA** are encouraged to become its contributors. This page provides a step-by-step instructions on how to develop a new service.

Workflows are all things that can be computed, but they should be designed to be repeatable: producing the same output given the same input. They should be as easy enough in first approximation, but might be hard to use if the workflow relies on external data and compute resources. The MMODA team is working on ORDAS in an ever-evolving compute environment. The MMODA team is working on ensuring reproducibility and reusability of workflows.

Build a repeatable parameterized workflow

- How to designate input parameters and output cells of the notebook
- How to define input parameters in the dedicated parameters cell
- Default parameters
- Adding annotations the entire notebook
- Adding external resource annotations
- Annotations for the visualization over the Mmoda interface
- How to upload a file to be used for the notebook execution
- Adding token annotations
- How to annotate the notebook outputs
- Querying external astronomical data archives from a notebook
- Handling exceptions
- Using renku secret storage
- How to add a test to the notebook
- Reporting progress for long running tasks
- Make the notebook available for deployment on MMODA via renkulab.io
- Publish your workflow as an **MMODA** service
- Support the workflow development via renku plugin

MMODA team and suggest automatic test cases to ensure the stability

MMODA services can be created starting from e.g. a Python notebook, deposited to a dedicated Gitlab domain:

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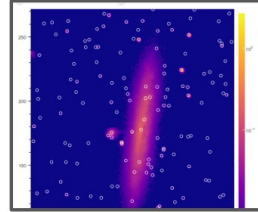
... MMODA team supports a “step-by-step” guide for adding new workflows. Give it a try adding a service for a telescope in which you have expertise in data analysis!

web service “flavours”

parameters



results



MMODA services can be created starting from e.g. a Python notebook, deposited to a dedicated Gitlab domain:

<https://gitlab.renkulab.io/astronomy/mmoda>

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To promote a notebook to a service, it is enough to tag the Gitlab repository in “astronomy/mmoda” domain with a “**live workflow**” tag. As soon as it is the case a “bot” scanning the domain will pick up the notebook and convert it to a service of MMODA... or a “**galaxy-tool**” tag to convert it to a service **Galaxy** platform!

web service “flavours”



https://usegalaxy.eu

Galaxy Europe

Workflow Visualize Data Help Log in or Register

Using 0%

Tools

HESS

HESS (Galaxy Version 0.0.2+galaxy0)

Run Tool

Tool Parameters

Data Product

Image

src_name - optional

Crab

RA (unit: deg) *

83.6287

History

search datasets

Unnamed history

119 kB

7: HESS -> Image fits

6: HESS -> Image png

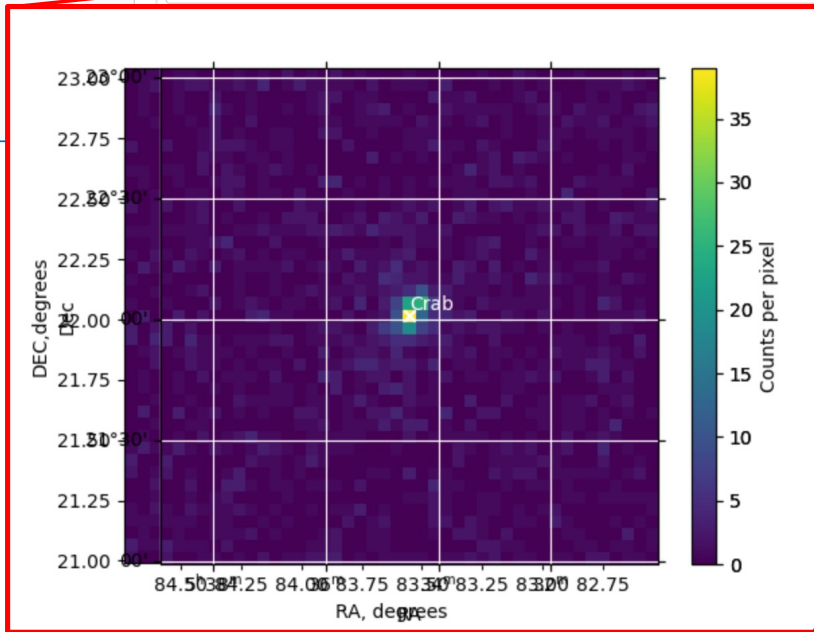
Add Tags

36.7 KB

format png, database ?

/

hdu-index.fits.gz

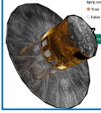
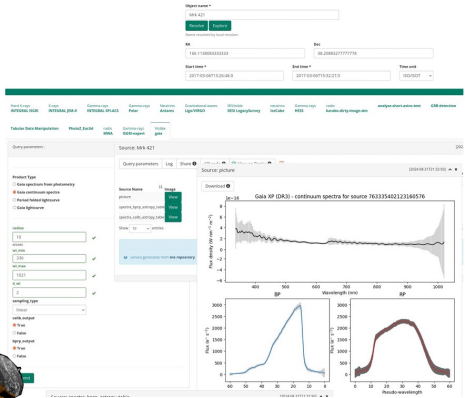


Similar “live-workflow” approach is developed by Euro-Science-Gateway project of the European Open Science Cloud (EOSC). It is implemented within **Galaxy** platform (originally developed by the bio-informatics community). MMODA *bot* can also interpret the workflows in the dedicated astronomy/mmoda Gitlab domain.

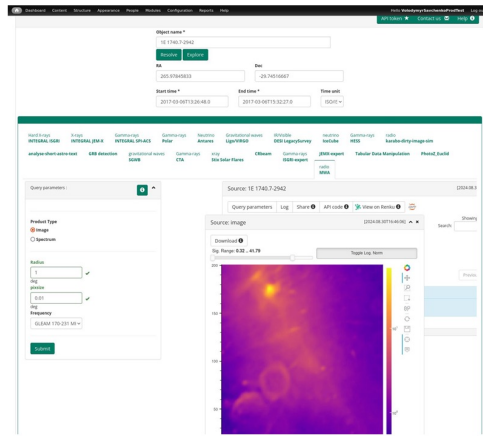
Summary

Gaia

Milestone astrometric mission, we include tools for accessing is

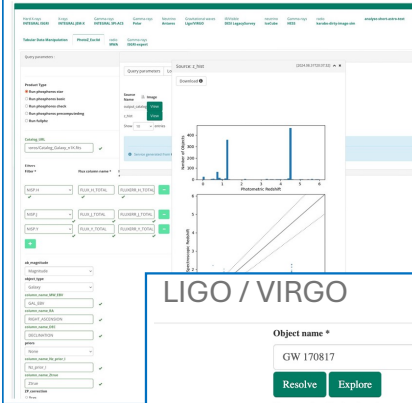


MWA GLEAM: an interface to SkyView incorporating it in AstroORDAS/MMODA and Galaxy



Euclid

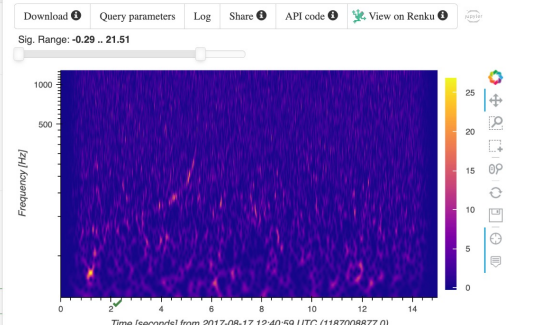
Recently launched cosmology mission, we include tool computing Photometric Redshift.



LIGO / VIRGO

Object name *
GW 170817
Resolve Explore
Name resolved by local resolver.
RA
197.4503541666664
Start time * 2017-08-17T12:40:59.400 End time * 2017-08-17T12:40:59.400

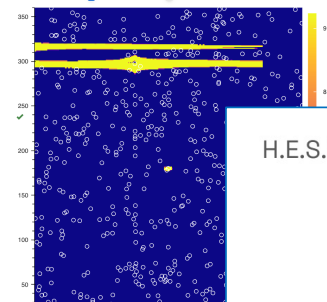
SPI-AACS Gamma-rays Polar Neutrino Antares Gravitational waves LIGO/VIRGO IR/Visible DESI LegacySurvey



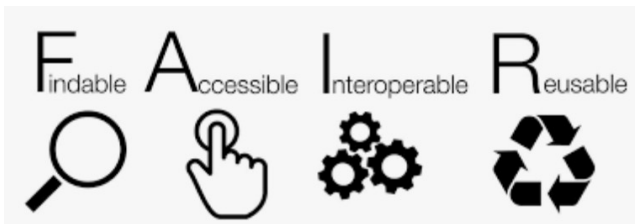
DESI Legacy Survey

Msk 421
Resolve Explore
Name resolved by local resolver.
RA 166.1138083333333 Dec 38.2088327777778
Start time * 2017-03-08T13:26:48.0 End time * 2017-03-08T13:32:27.0

Neutrino Antares Gravitational waves LIGO/VIRGO IR/Visible DESI LegacySurvey Gamma-rays CTA GRB detection



MMODA / Galaxy provide promising approach for making telescope data analysis workflow “live”, a way to boost the Interoperability / Reusability of data



H.E.S.S.: older telescope, public data.

