

Gamma Data Astro Format (and beyond)

And

IVOA standards

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The GADF initiative



- Created by a former Lead Developer of Gammapy, C. Deil, in ~2015
- Open initiative to define a common data format between the pointing IACT instruments (≥ 10 GeV)
 - H.E.S.S., MAGIC, VERITAS
 - Format for the Data Level, DL3 → DL6
 - Anyone can contribute and participate to the discussions
- Objectives: interoperability
 - Unique format to facilitate results comparisons
 - Analysis with the same Analysis software
 - Joint analysis of data from different experiments
- No formal organisation of the initiative
 - No formal Lead Editor
 - No coordination committee → no road maps or orientation or objective
- Status
 - A V0.2 has been released, that allows science publications... → DL3 format scientifically functional, and used!
 - Some proposals made for DL5/6, but no international consensus
 - CTAO will probably use its own format, strongly inspired by this V0.2

The GADF format and the FAIR Principles



- **Findable**
 - GADF has created an [obs-table](#) (in FITs) containing all the basic information
 - Metadata needs better descriptions
 - The data description requires more metadata
 - Today, V0.2 is almost compliant with this principle
- **Accessible**
 - Beyond the scope of a format → Data dissemination process
- **Interoperable**
 - Metadata needs better descriptions
 - Today, V0.2 is almost compliant with this principle
- **Reusable**
 - Associated to the Provenance topic...
 - Work on-going and not finished → Today, principle not satisfied
- **P.S.:** here I will not discuss about the DOI issue, which is a problematic that touches in-depth the European strategy of Open Data

GADF & IVOA standards : DL3



- **Obs-table versus Observation Data Model**
 - Review needed to check for compatibility
- **Event list versus Data Model**
 - X-ray photon list enters in this model
 - Review needed! Does our model can enter in this standard?
- **Instrument Response Files versus DataModel**
 - There is a support for ARF/RMF/PSF as axis properties → review needed!
 - No notion of background in this document

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IVOA Documents



Observation Data Model Core Components and
its Implementation in the Table Access Protocol
Version 1.1

IVOA Recommendation 09 May 2017

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IVOA Documents



Data Model for Astronomical DataSet
Characterisation
Version 1.13

IVOA Recommendation 25 March 2008

GADF & IVOA standards : DL4



- Contains data cubes of our IRFs (and events)
 - Review needed with this standards!

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Data Model for Astronomical DataSet
Characterisation
Version 1.13

IVOA Recommendation 25 March 2008

- Minor question:
 - As X-rays are supported, do they use [eV], [m], [s⁻¹]?

GADF & IVOA standards : DL5

- Spectral Energy Distribution versus Spectral Data Model
 - Should be compatible, but support for of a Likelihood Profile per bin? Upper limits?
 - Review needed!
- FluxMap, etc versus Astronomical DataSet
 - Should be compatible, but support for Asymmetric errors maps? Can we have a Map of Likelihood Profile?
 - Review needed!
- Light Curve versus the Time Series
 - It seems that is is compliant, modulo the likelihood profile? Upper limits?
 - Review needed
- Flux/Counts as fct of (orbital) phases
 - Are IVOA Time Series relevant?




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IVOA Spectral Data Model
Version 1.03

IVOA Recommendation 2007-10-29
This version (Recommendation Rev 1)

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Data Model for Astronomical DataSet
Characterisation
Version 1.13

IVOA Recommendation 25 March 2008

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IVOA Documents

Time series: Annotation of light curves in VOTable
Version 0.1

IVOA Note 29 April 2020

GADF & IVOA standards : DL6



- This is no GADF format
- From IVOA, the UCD1+ framework allows to create a VHE format compliant with IVOA
 - And browsable in VO tools, like in Vizier of the CDS
 - E.g., the Fermi-LAT catalogs
- On the ToDo list...

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IVOA Documents



An IVOA Standard for Unified Content
Descriptors
Version 1.10

IVOA Recommendation 19 August 2005

GADF and CEVO



- GADF is organised for and by people from pointing VHE instruments
 - The current format is tested for this type of instruments
- What about Gamma-ray non-pointing instruments?
 - i.e. Water Cherenkov Detectors (WCDs): HAWC/SWGO
 - i.e. Surface Detectors (Sds): LHASSO: Tibet γ -AS
 - The main difference is the axis of the N-dimensional IRFs
 - A format is under test for HAWC using an extension of the GADF one: L. Olivera-Nieto et al., 2021 ([arXiv:2109.04097](https://arxiv.org/abs/2109.04097))
 - If one can have a VO-compliant IRF format for the pointing VHE instrument, it is OK
- What about the Neutrino telescopes?
 - The needed format is similar to the gamma-ray non-pointing instrument
 - If the HAWC experience is positive, then a format will be defined!

Perspectives



- The community is working to extend the GADF format for an interoperability between more instruments types and for multi-messenger analysis!
- The GADF initiative has shown its limit w/o governance
 - Who moderate according to given objectives?
- The community is organising itself to create a “VHE open data format” initiative
 - Still an open community-diven initiative
 - Aiming to define standards and formats to allow multi-wavelength and multi-messenger analysis, as much as possible VO-compliant
 - Coordinated by representatives of the main astroparticles experiments
 - Governance under building with the participation of:

H.E.S.S, Veritas, MAGIC, CTAO, ASTRI, FACT (tbc),
HAWC, SWGO and Fermi-LAT

- The CEVO work can be then a precursor work for the “VHE open data format” initiative