

Onwards to a N-Dimensional Cube model

Science Priority

Long standing Science Priority

Current scientific priorities at IVOA



- **Time-domain astronomy:** TIMESYS (light curves) and ST-MOC (discovery). -> Handling of alerts? GW triggers?
- **Multi-dimensional data:** spectral or time cubes (sky + wavelength/frequency or sky + time)

Upcoming priorities: Example case for the Multi-Dimensional use-

- Python reference major services
- Ways for access surveys?
- Other growing

User requirements defined in 2013:

Data Discovery (Query) as a function of

- RA, Dec
- Frequency/wavelength
- Polarization states
- Spatial scale
- Angular resolution
- Integration time
- Time of observations

• Data Access

- Download complete science data
- Download simple cutouts

Simple cut-outs

- Spatial : a circle (a coordinate + radius)
- Energy : one interval (energy1 – energy2)
- Time : one interval (time1 – time2)
- Polarization : a list

Additional requirements for cut-outs:

- Sum along any one or more axes
- Re-bin in one or more axes
- Multiply by a function
- Other action on the data

Extract from CSP presentation
Nov 2019

CSP outlook

- Next generation missions coming up
- Which are needed upgrades to protocols to keep up with the needs?
 - Different formats from different communities FORNITS, GADE...
 - Different data types >> **Data cubes & >> Spectra** - Are we ready for the exploration, visualisation and analysis?
 - Transient phenomena alert distribution is evolving, implications?
 - Extend protocols from discovery & access to data manipulation?
 - Can VO protocols & formats help ML and AI algorithms?
 - What is the role of the VO in the Cloud & Science Platforms?
 - Interoperability of science platforms?
 - Reproducibility & reusability? What is the role of the provenance data model in this context?
- Can only be achieved with community engagement -> We need you

CSP Status

8

Extract from CSP presentation
Oct 2022

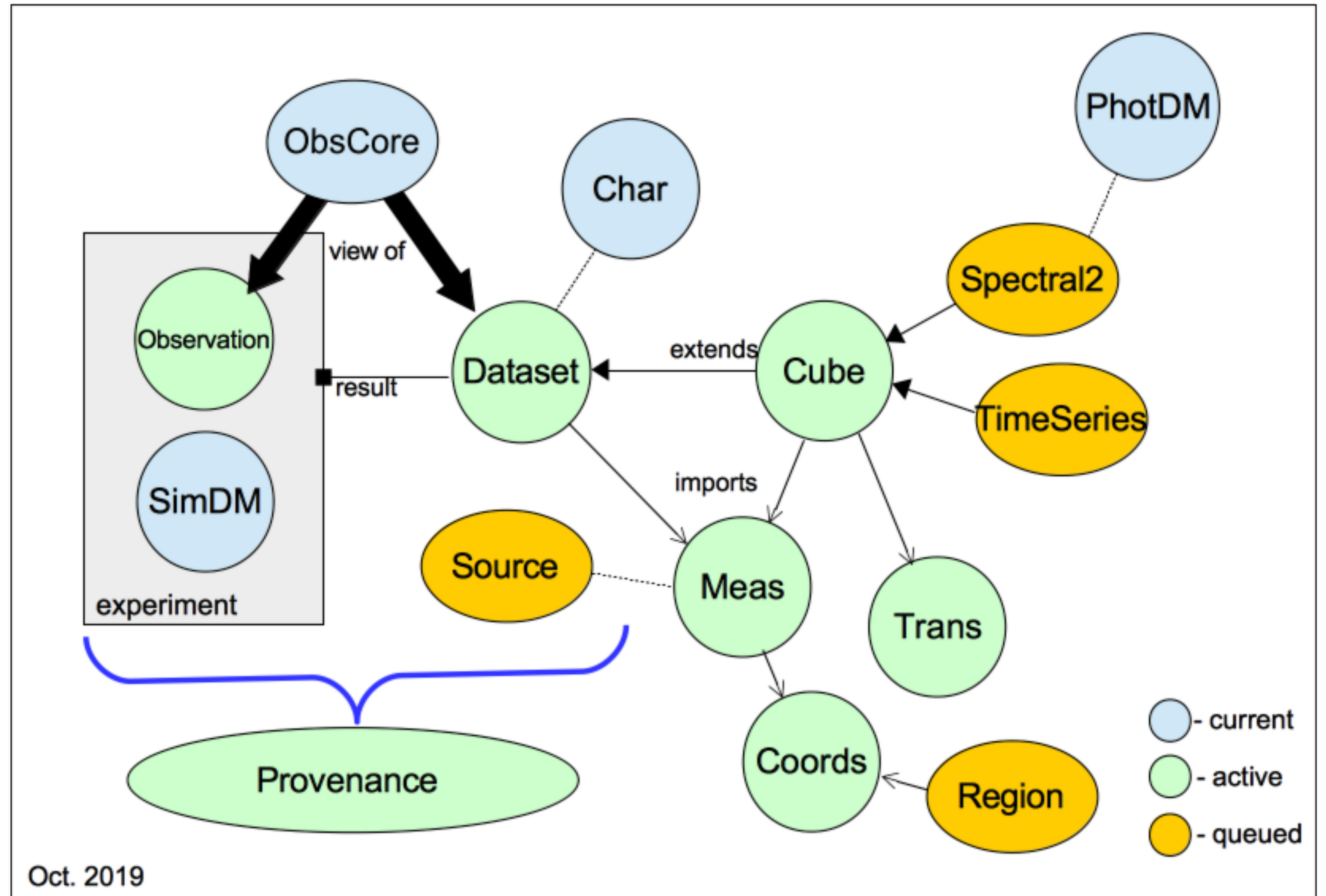
Cube model

Goals

- Primary goal
 - To facilitate the representation of multi-dimensional cube data products.
 - Event Lists: contain various properties of single photon events
 - Pixelated Images: N-dimensional axes + physical property value
 - Requirements
 - Enhance interoperability: provides a common picture \longrightarrow VODML, Annotation syntax
 - Easily identify physical property: e.g. time, position, magnitude, etc \longrightarrow Meas. and Coords models
 - with associated errors, if any.
 - Support functional axes/properties: e.g. $eqpos(ra, dec) = T(sky(x,y))$ \longrightarrow Transform model
 - Access to metadata related to the dataset and its origins \longrightarrow Dataset Metadata model
 - Flexible container for organizing content: \longrightarrow Cube model

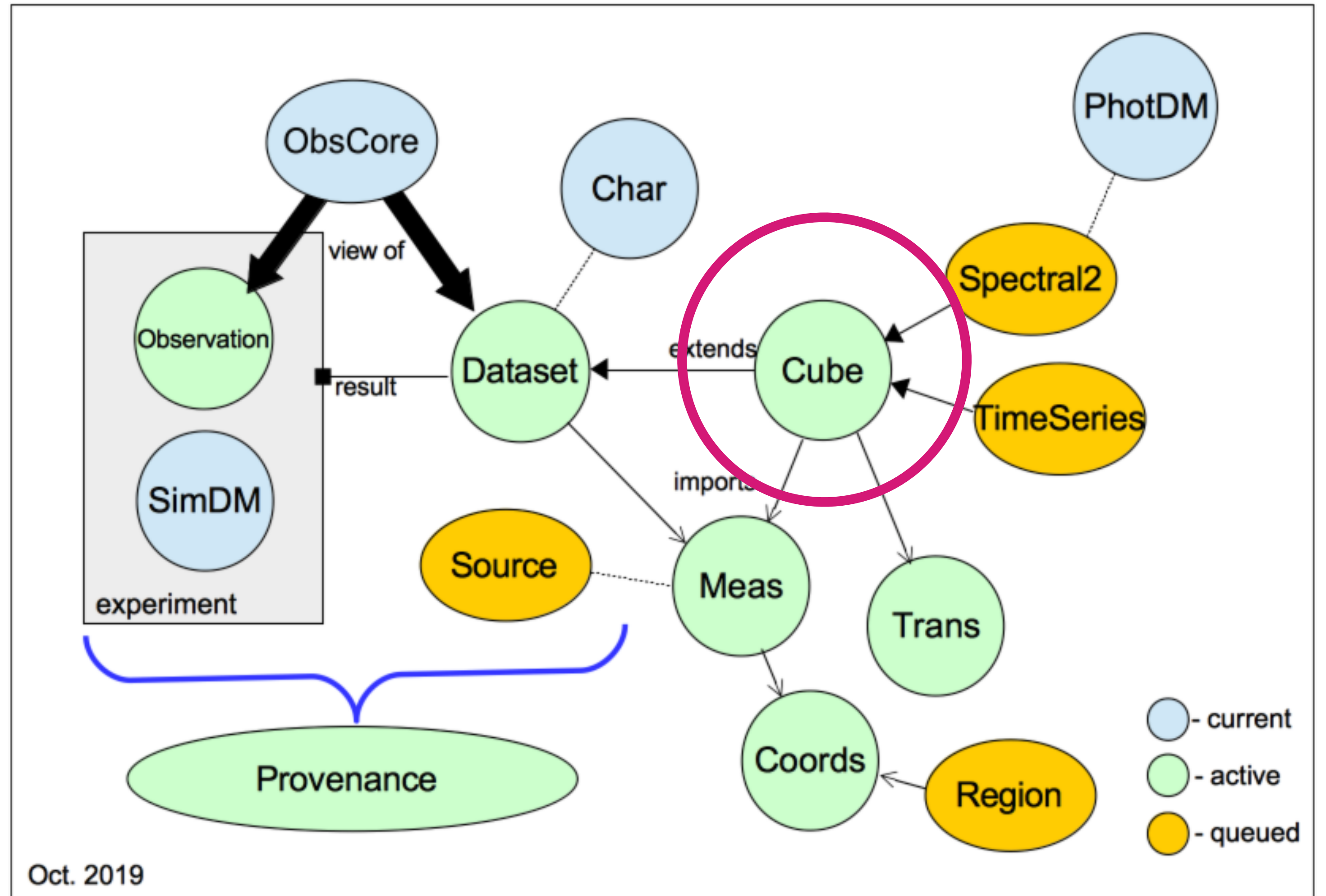
Data Model Ecosystem

- Set of small, building block models used to construct complex data structures.



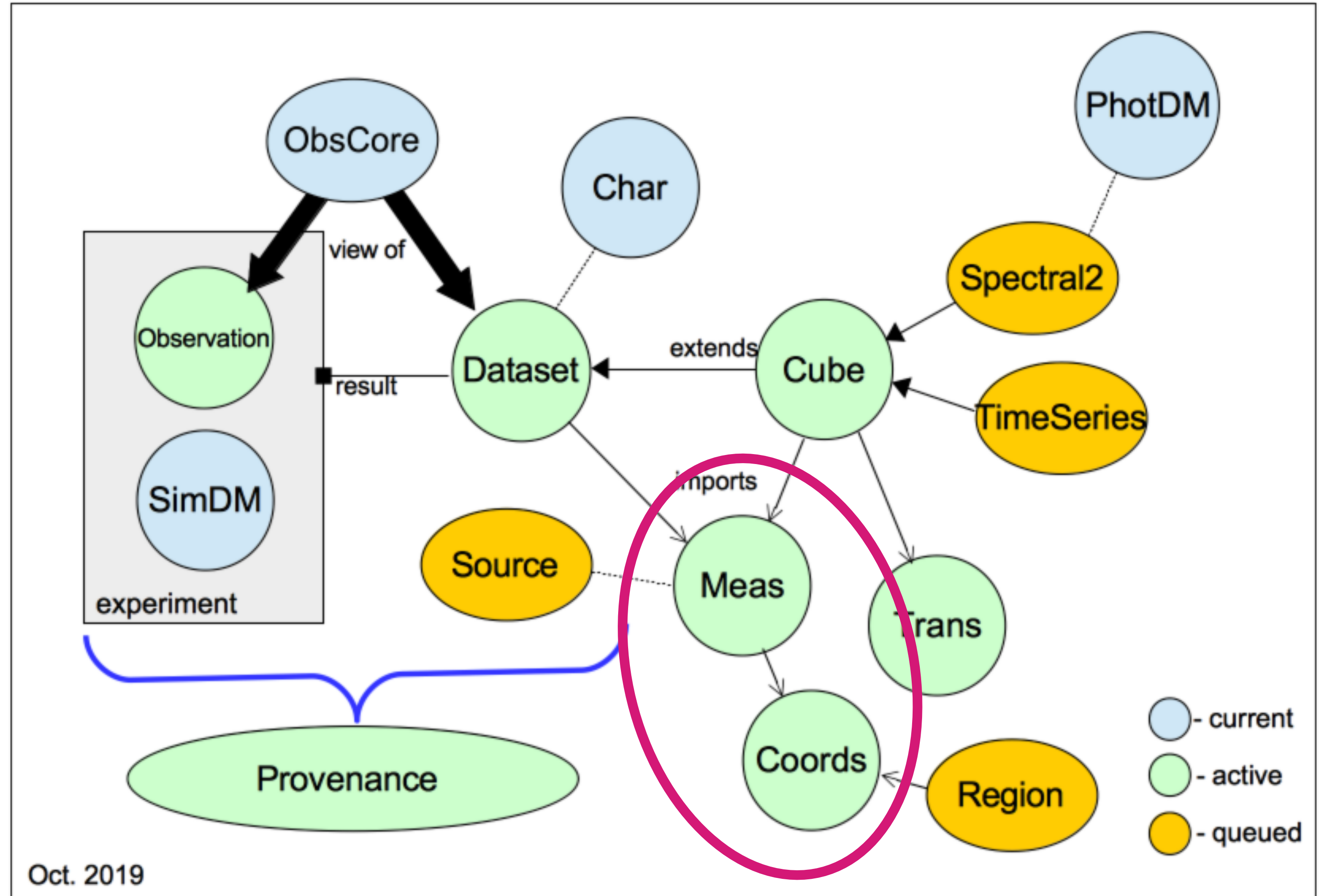
Data Model Ecosystem

- Goal: NDCube model




Data Model Ecosystem

- Focus has been on the STC replacement models.




Data Model Ecosystem

- Which are now REC!!!



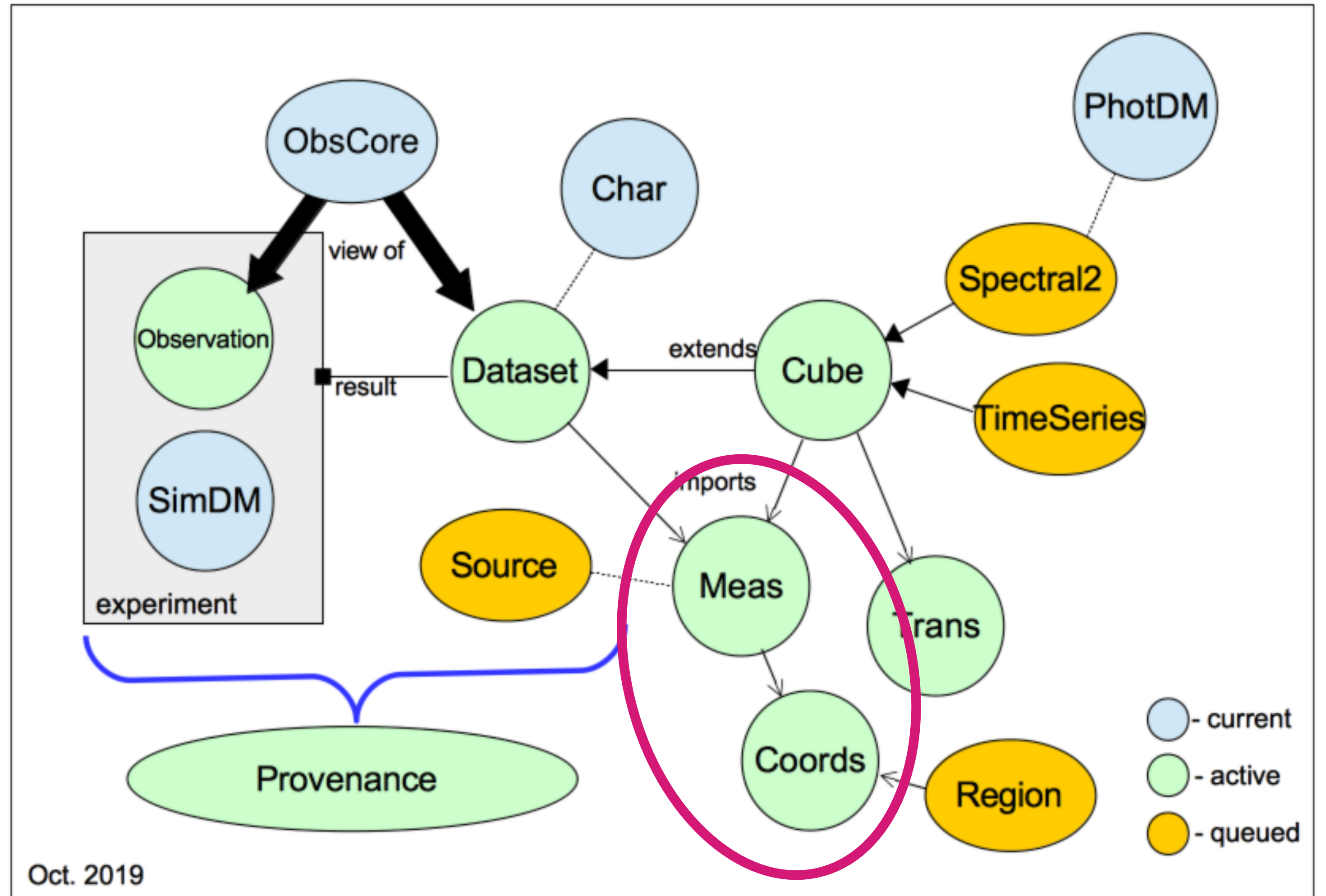
Astronomical Coordinates and Coordinate Systems
Version 1.0
IVOA Recommendation 2022-10-04
Working group: Data Model Working Group
This version: <https://www.ivoa.net/documents/Coordinates/20221004>
Latest version: <https://www.ivoa.net/documents/Coordinates>
Previous versions: This is the first public release
Author(s): Arnold Rots, Mark Crestello-Dittmar, Omar Laurino
Editor(s): Arnold Rots, Mark Crestello-Dittmar



Astronomical Measurements Model
Version 1.0
IVOA Recommendation 2022-10-04
Working Group: Data Model Working Group
This version: <https://www.ivoa.net/documents/Measurements/20221004>
Latest version: <https://www.ivoa.net/documents/Measurements>
Previous versions: This is the first public release
Author(s): Arnold Rots, Mark Crestello-Dittmar
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Abstract
In creating version 2 of "Space-Time Coordinate Metadata for the Virtual Observatory" (STC) (Rots, 2007) Data Model, it was decided to split the content into various component models which focus on particular aspects of the previous model scope.
This model covers the description of measured or determined astronomical data, and includes the following concepts:

- The association of the determined 'value' with corresponding errors. In this model, the 'value' is given by the various Coordinate types of the Coordinates data model (Rots and Crestello-Dittmar et al., 2019).
- A description of the Error model.

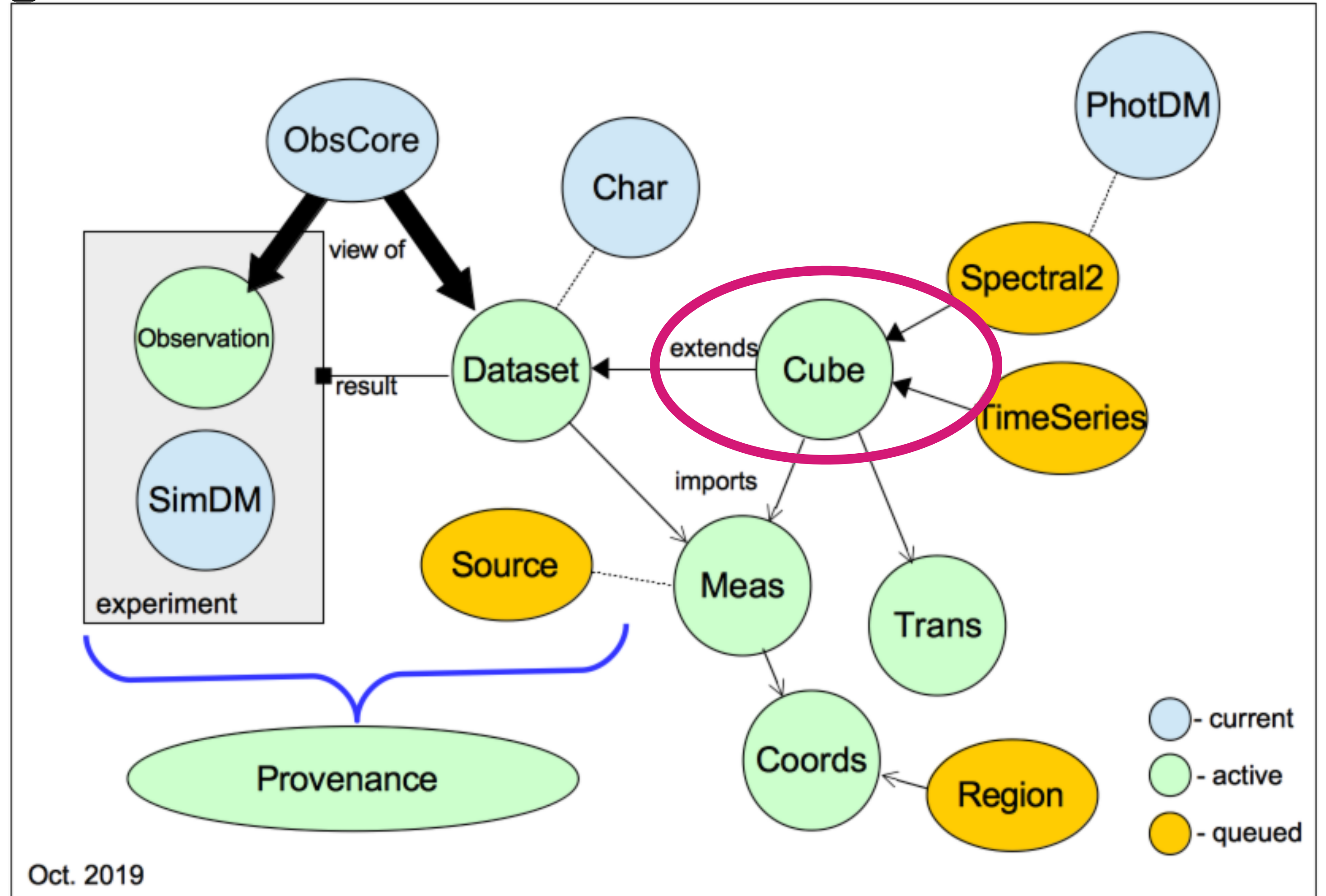


So, where do we go from here?

Current state of remaining models

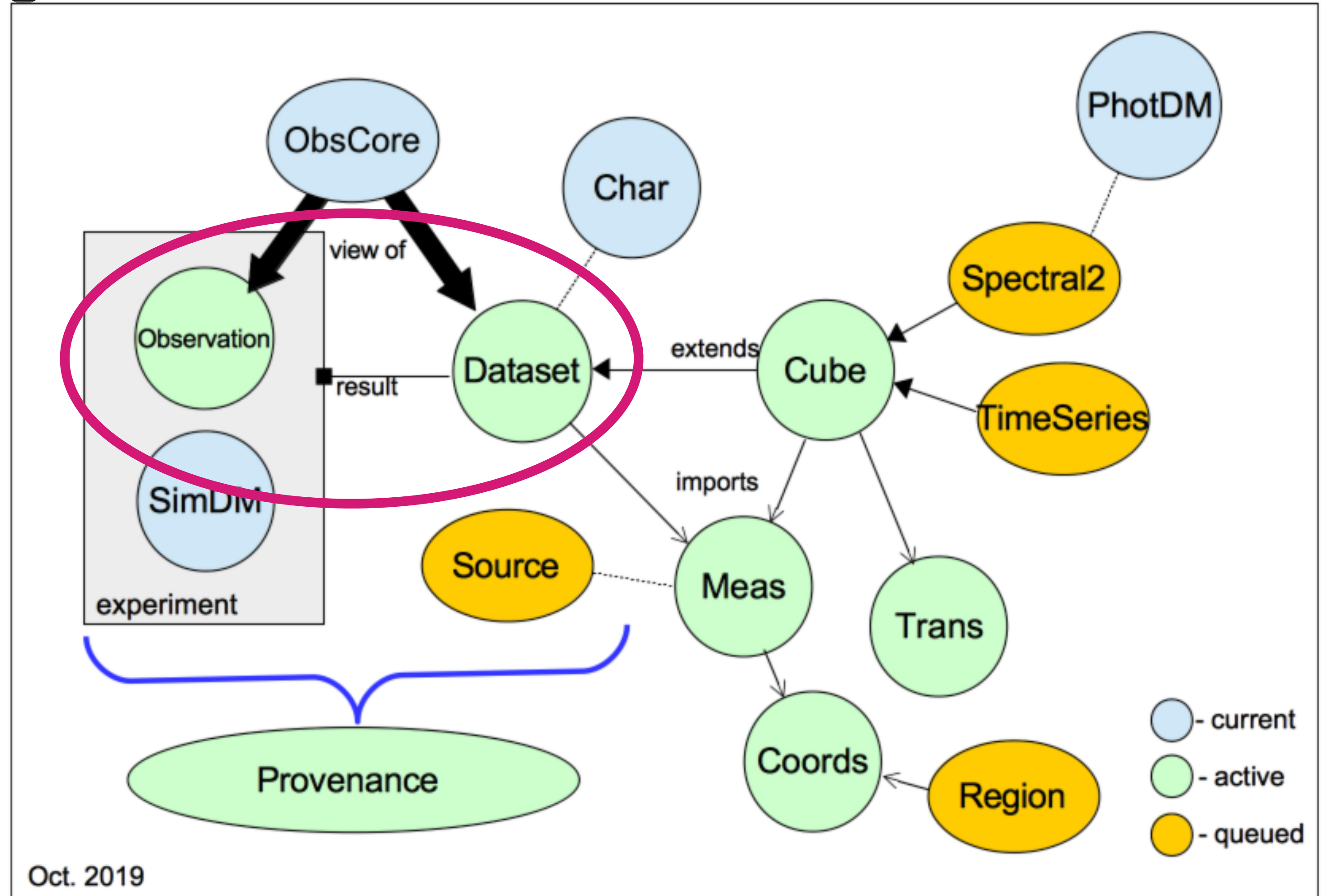
- N-Dimensional Cube
 - WD last revision: 2019
 - WD location: Volute
 - WD status: Complete
 - Serializations: Yes
 - Usage
 - Good usage in workshop (data seg.)

DM Working Group Twiki



Current state of remaining models

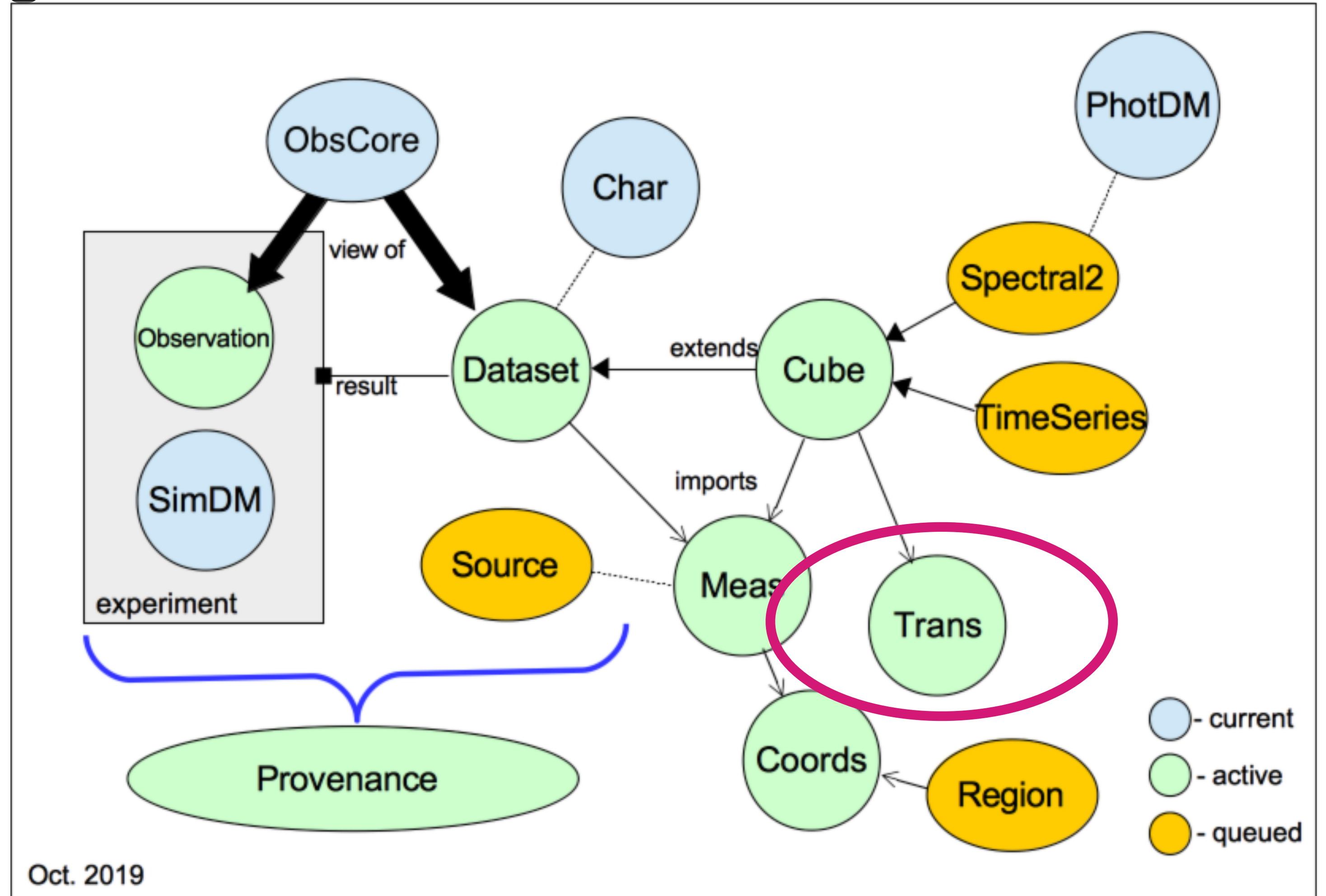
- Dataset Metadata
 - WD last revision: 2019
 - WD location: Volute
 - WD status: Complete
- Serializations: Yes
- Usage
 - Light usage in workshop



Current state of remaining models

- Transform
 - WD last revision: 2020
 - WD location: Git
 - WD status: Complete
 - Serializations: Yes
- Usage:
 - AST implementation
 - GWCS implementation
 - No usage in workshop

[DM Working Group Twiki](#)



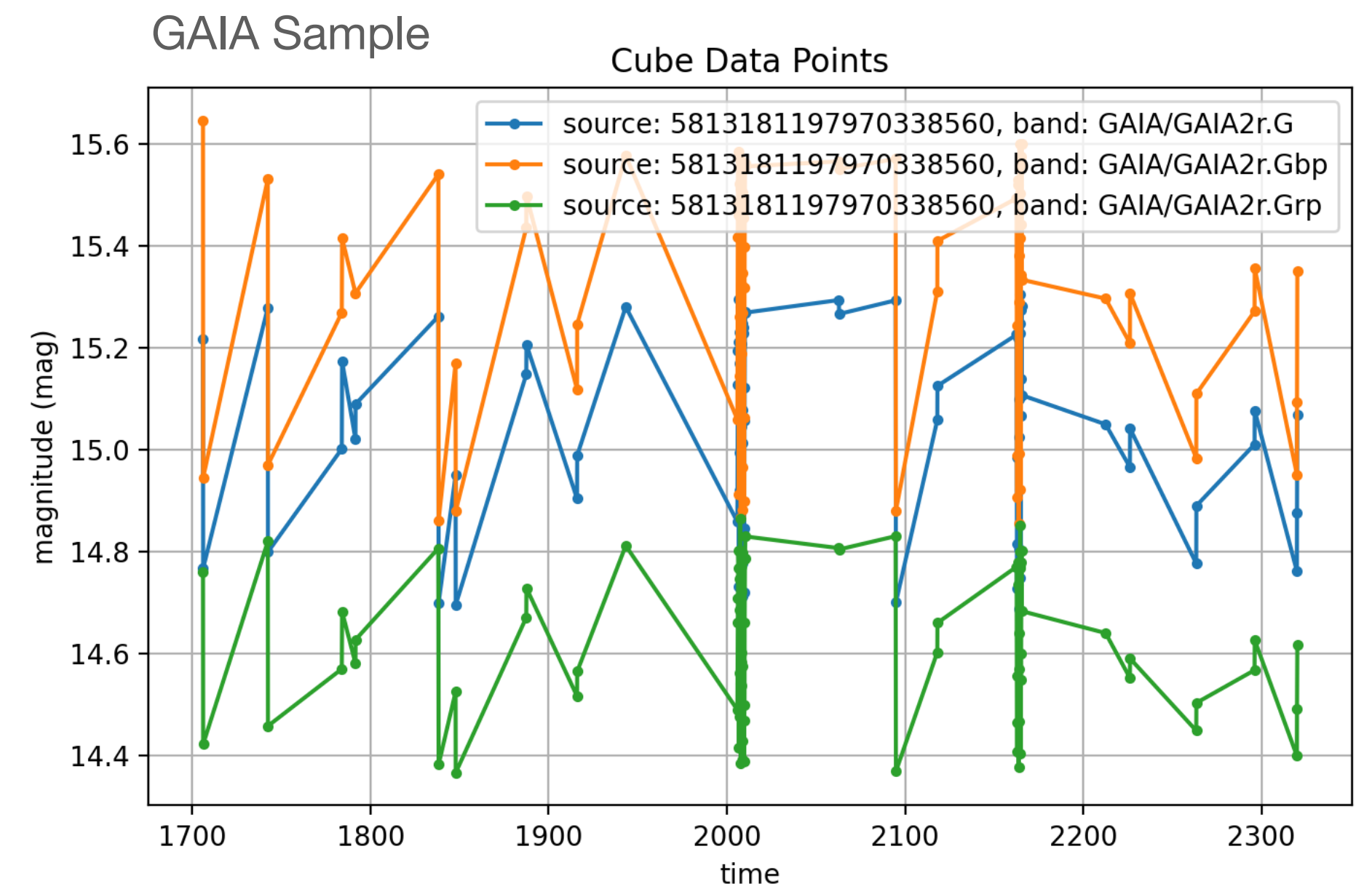
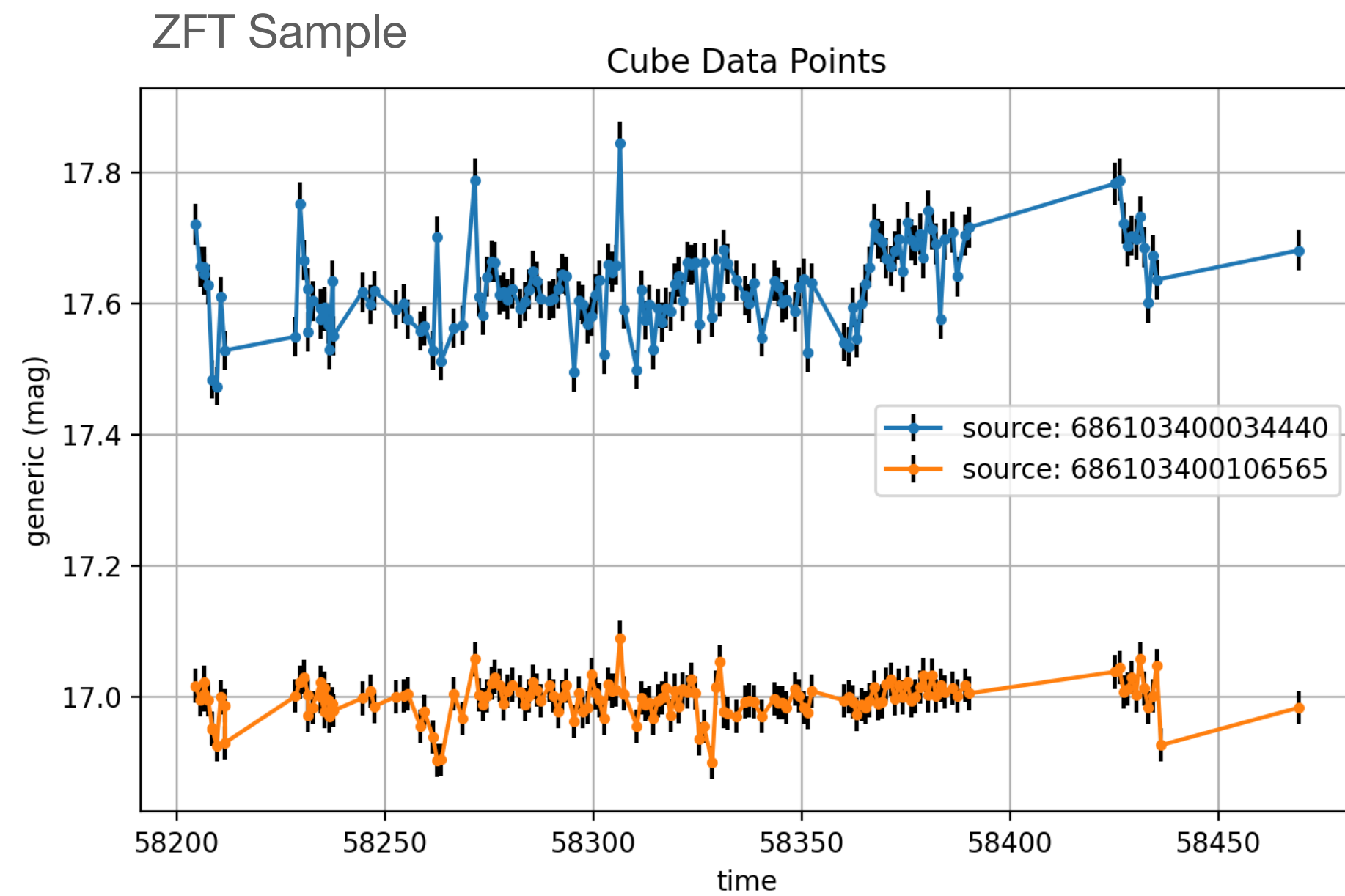
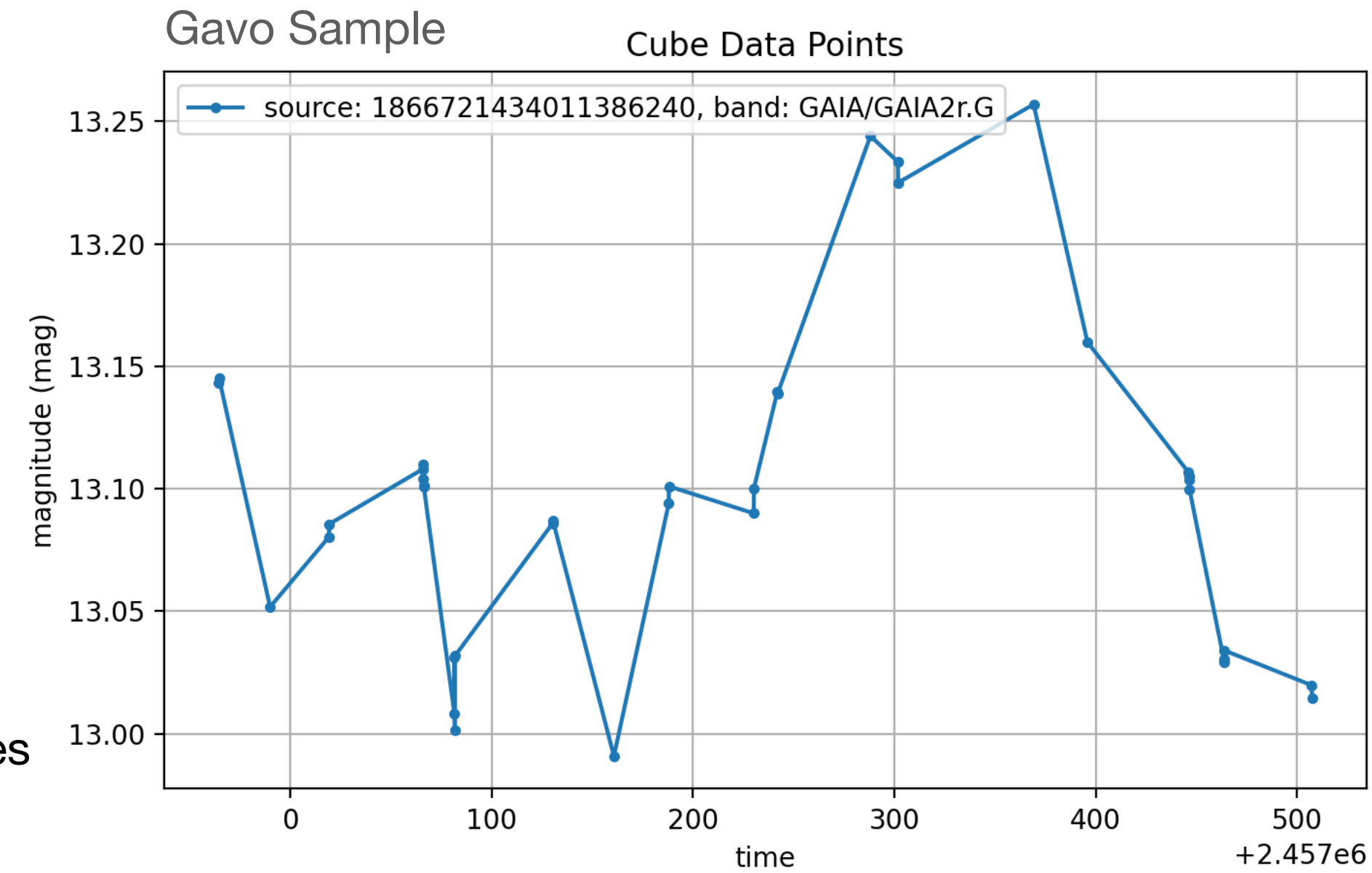
Usage

DM Workshop 2021

Code: [GitHub Implementation Page](#)

- * Any data annotated to Cube model (TimeSeries)
- * Regardless of native data structure, the client sees a homogeneous view of contents: Set of TimeSeries
- * Same code can handle all samples.

Time Series

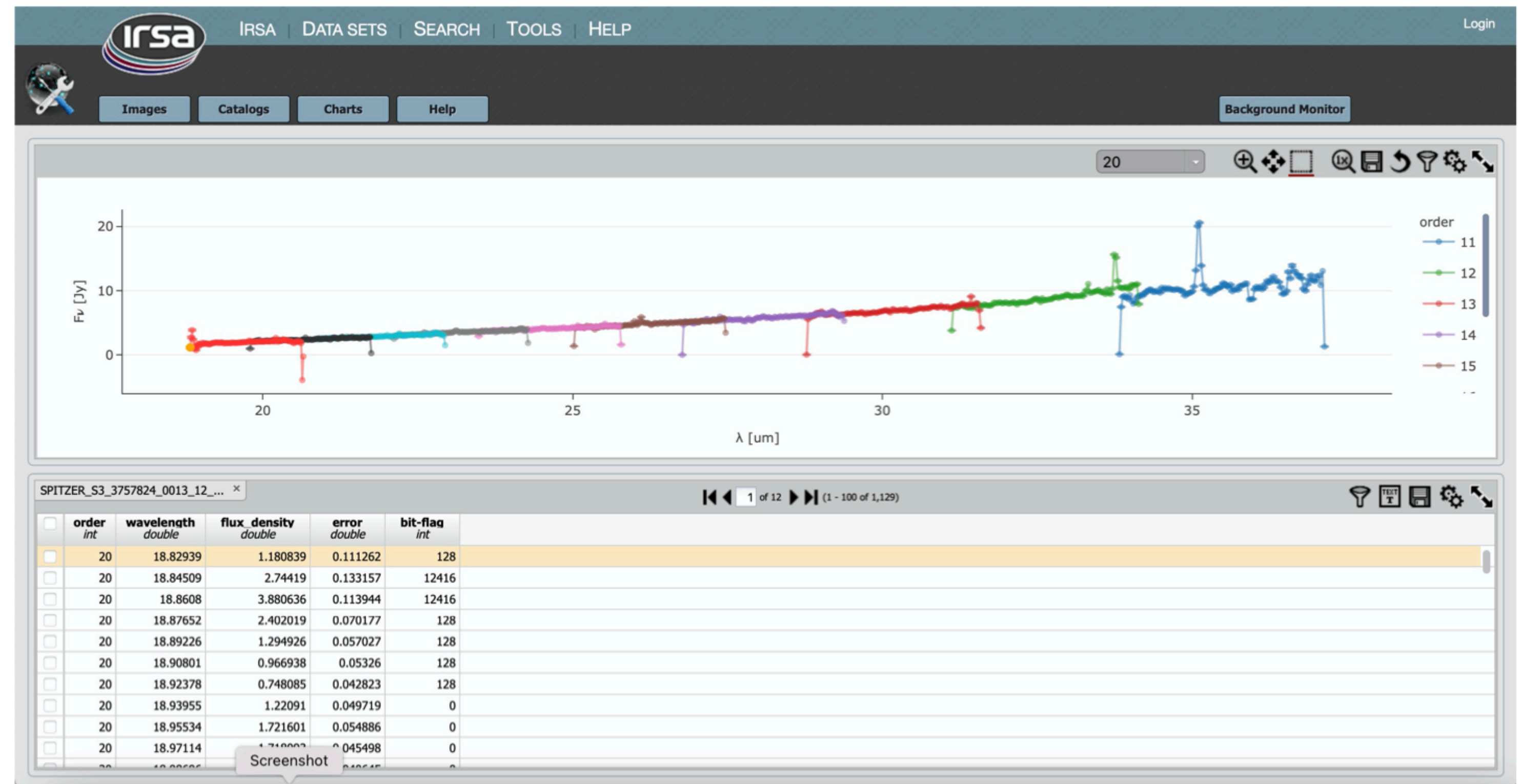


Usage

Spectral Analysis

- * Discover data via modeled content
- * Obtain model annotated data products
- * With model-aware software, an application can easily extract and combine data from various facilities.
- * Lets the application focus on the Science!!

“IVOA Spectral Models and Access in the Era of Big Data”, Vandana Desai: May 2021



Firefly-based IRSA Viewer tool shows multi-order Spitzer spectrum as a chart (top) and a table (bottom). Both are interactive.

Next Steps

- Migrate Dataset and Cube documents to Git
- Review of each document for open issues
- Confirm implementation level/documentation is sufficient
- Identify order of migration forward

Look for updates on DM mail list and/or discussion in DM Running meetings