Time in Aladin

Pierre Fernique[1], Daniel Durand[2], and Ada Nebot[1]
[1]*Observatoire astronomique de Strasbourg, Université de Strasbourg, CNRS, UMR 7550, 11 rue de l'Université, F-67000 Strasbourg, France*

[2]*National Research Council Canada - Herzberg Astronomy and Astrophysics, Canadian Astronomy Data Centre, Victoria, B.C., Canada*

Abstract.
This paper is presenting a few recent Aladin's developments which are designed to handle and display the astronomical time dimension. Aladin (Bonnarel et al. 2000) was originally designed to visualise astronomical data using their spatial coordinates. Using the same basic technology, we have incorporated the time dimension in Aladin.

1. Introduction

Aladin was originally designed to visualise astronomical data based on their spatial coordinates. Using the same technology, we have incorporated a new dimension in Aladin: the time. A new Aladin prototype, based on the core of Version 10, incorporates two new components: a **Time view** window and a **Time coverage** capability. This new Aladin prototype incorporates two new components: a time visualisation window and a time coverage capability. The time view window is a light Aladin modification of its regular graphic window originally designed to handle longitude VS latitude plots. This new graphic capability is dedicated to draw scatter plots where the primary axis is time and the secondary axis can be any of the other catalogue quantity (i.e. magnitude, flux, radial velocity, etc.). The original spatial view and the new time view are fully interoperable allowing the users to select objects in either views to see them selected in the alternate view. The time coverage capability is based on the technology developed for the Multi-Ordered Coverage (MOCs) (Fernique et al. 2015), replacing the HEALPix space with a time scale instead. Thus the way the user manipulates time coverage is similar to space coverage manipulation, like performing fast coverage intersection or union, generating a time coverage from a list of sources, etc. These new capabilities are already available in the Aladin Beta version available on the Aladin CDS Web site. `http://aladin.u-strasbg.fr`

2. The Time View

The **Time View** window is a simple extension to Aladin's graphic window originally designed to handle longitude VS latitude plots. This new graphic mode is now capable of drawing scatter plots where the primary axis is time and the secondary axis is selected by the user and could use any of the accessible quantities like magnitude, flux, radial

velocity, etc. This new graphic mode is fully interoperable with Aladin's spatial window so selected objects markers are visible on both windows simultaneously. It is thus possible to explore the time variation of any quantities and identify any interesting measurements and see their localisation on the Aladin main image window. Please look at Figure 1

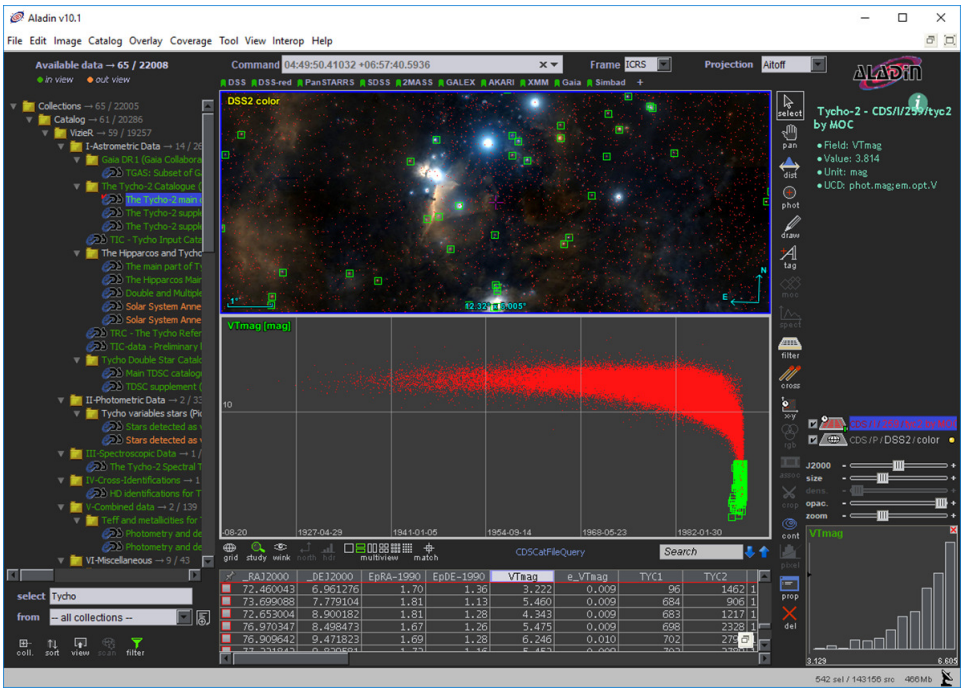

Figure 1. Aladin showing the time view graphic window

3. The Time Coverage

The **Time coverage** capability is based on the technology we used to support the Multi-Ordered Coverage (MOCs). To support the time axis, we simply replaced the HEALPix space discretisation with a time scale using the same properties as the MOC but covering only one axis. (Fernique et al. 2015). With the **Time coverage** support, the user is able to manipulate the time coverage the same way he/she was able to manipulate the space coverage using Aladin. Thus one can perform time coverage manipulation like intersections or unions of different time coverages, generate new time coverage from catalog. For this to be possible, Aladin prototype is introducing a new version of MOC files dedicated for the time axis called T-MOC. Creating T-MOCs was made possible with a very simple modification of the basic MOC java library since it is based on the same algorithm. The T-MOC cell definition are exposed in Table 1.

Visually, Aladin is presenting the T-MOCs like a code bar representing the time coverage of a given collection at a given resolution. It is possible to zoom in and out the T-MOC to explore the time coverage. Please see Figure 2 and Figure 3 which is showing a T-MOC window over Aladin.

Table 1. TMOC cell definition covering 9133y 171d 11h 22m 31.711744s

order	Cell Resolution
0	9133y 171d 11h 22m 31.711744s
1	570y 307d 11h 35m 9.481984s
2	570y 307d 11h 35m 9.481984s
...	...
6	2y 83d 22h 52m 24.177664s
...	...
12	4h 46m 19.869184s
...	...
22	16.384ms
...	...
27	16 μs
28	4 μs
29	1 μs

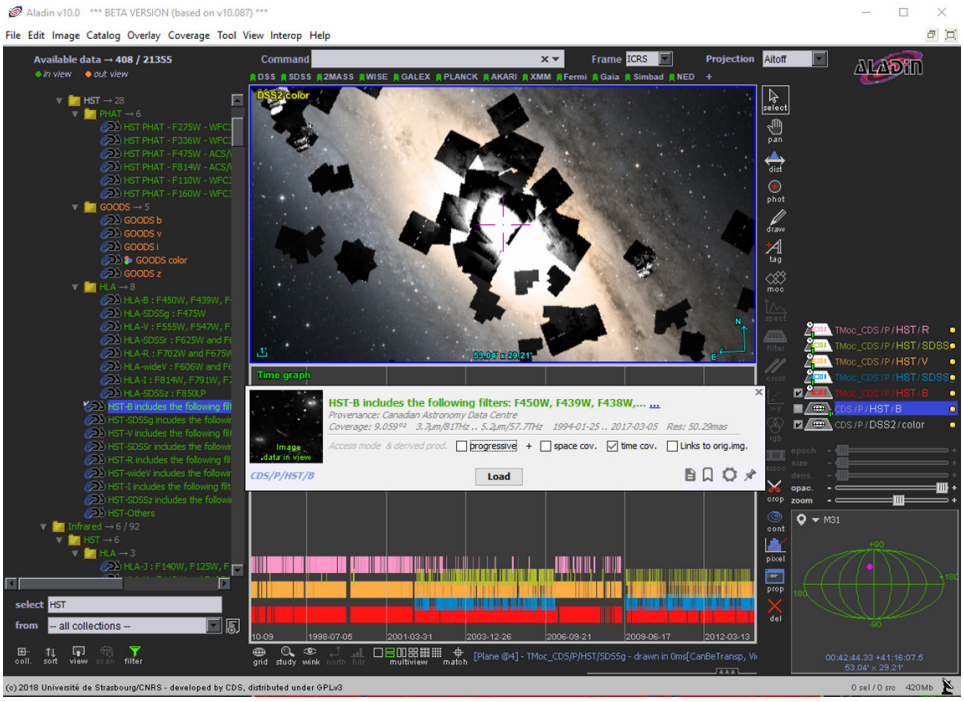

Figure 2. Aladin showing the time view graphic window

4. Requirements

4.1. Requirements for the Time View

In order to be able to display the time values in Aladin, one needs to setup the catalogue with its time value or Aladin needs to discover any existing time information. Since at the moment of writing there is no standard way of describing metadata related to time, Aladin is using an heuristic approach to derived the required information for

each catalogue. In order to succeed Aladin is using an heuristic approach and try to derive these quantities. As there is multiple parameters like format, scale, offset even the observer location which need to be known, essentially Aladin is executing a best guess approach by scanning all parameters from VOTables (Ochsenbein et al. 2004) or FITS files loaded. When a *discovery* occurs, a little clock symbol is displayed close to the name of the loaded file informing the user of such a discovery. Although this heuristic approach works, it is prompt to errors and it would be much better if a formal description for describing time metadata would exist, e.g. using the *TIMESYS* tag element in VOTable (Please see (Demleitner et al. 2018)).

4.2. Requirements for the T-MOCs

What are the standards we should use to produce T-MOC which are interoperable?

- Using JD(TCB,Barycentric,no offset) requires a Time conversion library.
- Using 1μs for order 29 T-MOC resolution covers a period of 9133 years if we use JD=0 (Monday, 4713 B.C. Jan 1, 12:00:00.0) as the zero point.

Please note that for unknown system, the T-MOC will be created at a lower resolution for covering the system imprecision (typically 16minutes).

5. Conclusions

We present two new features of Aladin, both related to Time Domain Astronomy. The first new enhancement of Aladin is the *Time View*, which allows users to visualise light curves, radial velocity plots as well as any other variable of time, while keeping interoperability with the sky position of the objects. The second enhancement of Aladin is the *T-MOC* which allows the users to know the coverage of a catalogue in time. These two new features are only possible if the time is well described in terms of its metadata. At the moment Aladin uses a heuristic approach for deriving the needed metadata. But a proper description of metadata in a well defined standard would be very helpful for such a purpose.

6. References

References

Bonnarel, F., Fernique, P., Bienaymé, O., Egret, D., Genova, F., Louys, M., Ochsenbein, F., Wenger, M., & Bartlett, J. G. 2000, A&AS, 143, 33

Demleitner, A., M.and Nebot, Bonnarel, F., Michel, L., Fernique, P., & Boch, T. 2018, A Proposal for a TIMESYS Element in VOTable, IVOA Note 29 October 2018

Fernique, P., Boch, T., Donaldson, T., Durand, D., O'Mullane, W., Reinecke, M., & Taylor, M. 2015, ArXiv e-prints. 1505.02937

Ochsenbein, F., Williams, R., Davenhall, C., Durand, D., Fernique, P., Giaretta, D., Hanisch, R., McGlynn, T., Szalay, A., Taylor, M. B., & Wicenec, A. 2004, VOTable Format Definition Version 1.1, IVOA Recommendation 11 August 2004