Radio Time Series discovery and access use cases

- In alphabetic order : François Bonnarel, Mireille Louys, Laurent Michel, Marco Molinaro, Ada Nebot

- Acknowledge : Radio IG, TD IG, DM WG, DAL WG discussions

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ESCAPE
European Science Cluster of Astronomy & Particle physics ESFRI research Infrastructures

IVOA

What is a time series for us ?

- « some astronomical data » varying with time
- Time is independant variable
  - Light curve, Velocity curve
  - Multi-band light curve
  - Sequence of images (« movie »???)
  - Dynamic spectrum
- Let’s restrict to radio light curves

Use cases (1)

J/other/PASA/27.64/pulsars — Parkes Radio Telescope pulsar timing (Weltevrede+, 2010)
Post annotation
Parameters and post-fit RMS *(tables 1 and 2 of paper) (168 rows)*

start AladinLite | plot the output | query using TAP/SQL

Full	RAJ2000 "h:m:s"	DEJ2000 "d:m:s"	n	PSR	M	Per ms	DM pc/cm3	log(dE/dt) [10-7W]	rms	S08	Simbad	RA deg	DE deg
1	05 43 09.6500	+23 29 06.100		J0543+2329		246.0	78	34.6	1.1	S08	Simbad	085.79021	+23.48503
2	06 14 17.2500	+22 30 37.400		J0614+2229		335.0	97	34.8	3.3	S08	Simbad	093.57187	+22.51039
3	06 27 44.0000	+07 06 00.000		J0627+0705		475.9	138	34.0	0.4	S08	Simbad	096.93333	+07.10000
4	06 59 48.1340	+14 14 21.500		J0659+1414	M	384.9	14	34.6	3.2	S08	Simbad	104.95056	+14.23931
5	07 29 16.4500	-14 48 36.800		J0729-1448	M	251.7	92	35.4	5.3	S08	Simbad	112.31854	-14.81022
6	07 42 49.0580	-28 22 43.760		J0742-2822	M	166.8	74	35.1	0.9	S08	Simbad	115.70441	-28.37882
7	07 45 02.3000	-53 51 22.000		J0745-5353		214.8	122	34.0	4.2	S08	Simbad	116.25958	-53.85611
8	08 21 00.0000	-38 24 00.000		J0821-3824		124.8	196	34.7	1.9	S08	Simbad	125.25000	-38.40000
9	08 34 16.3000	-41 59 51.000		J0834-4159		121.1	240	35.0	3.9	S08	Simbad	128.56792	-41.99750
10	08 35 20.6553	-45 10 35.155		J0835-4510	M	89.4	68	36.8	2.3	S08	Simbad	128.83606	-45.17643
11	08 55 36.1800	-46 44 13.400		J0855-4644		64.7	238	36.0	12.0	S08	Simbad	133.90075	-46.73706
12	08 57 55.1590	-44 24 10.320		J0857-4424		326.8	184	34.4	1.4	S08	Simbad	134.47983	-44.40287
13	09 01 40.1200	-46 24 48.500		J0901-4624		442.0	199	34.6	0.6	S08	Simbad	135.41717	-46.41347
14	09 05 51.9220	-51 27 48.710		J0905-5127		346.3	196	34.4	0.4	S08	Simbad	136.46634	-51.46353
15	09 08 35.5300	-49 13 06.500		J0908-4913		106.8	180	35.7	0.5	S08	Simbad	137.14804	-49.21847
16	09 40 58.2200	-54 28 40.600		J0940-5428		87.5	134	36.3	4.5	S08	Simbad	145.24258	-54.47794
17	09 54 06.0400	-54 30 53.500		J0954-5430		472.8	200	34.2	0.7	S08	Simbad	148.52517	-54.51486
18	10 03 21.5800	-47 47 02.000		J1003-4747		307.1	98	34.5	0.5	S08	Simbad	150.83992	-47.78389
19	10 15 37.9600	-57 19 12.800		J1015-5719		139.9	279	35.9	4.8	S08	Simbad	153.90817	-57.32022
20	10 16 12.1000	-58 19 01.150		J1016-5819		87.8	252	34.6	2.0	S08	Simbad	154.05042	-58.31699
21	10 16 21.1600	-58 57 12.100		J1016-5857		107.4	394	36.4	3.2	S08	Simbad	154.08817	-58.95336

+ I have a standard catalogue of pulsars

+ I want to attach radio TimeSeries of these pulsars to catalogue records

+ we could use LINK or DataLink to do that

+ → source driven discovery

Use cases (2)

+ I have an FRB VoEvent or SCS (from a database)

+ I look for counterparts around the same position and time

    + we can use STMOC features to discover data in these ranges

    + we can use SCS (with TIME) to discover data in these ranges

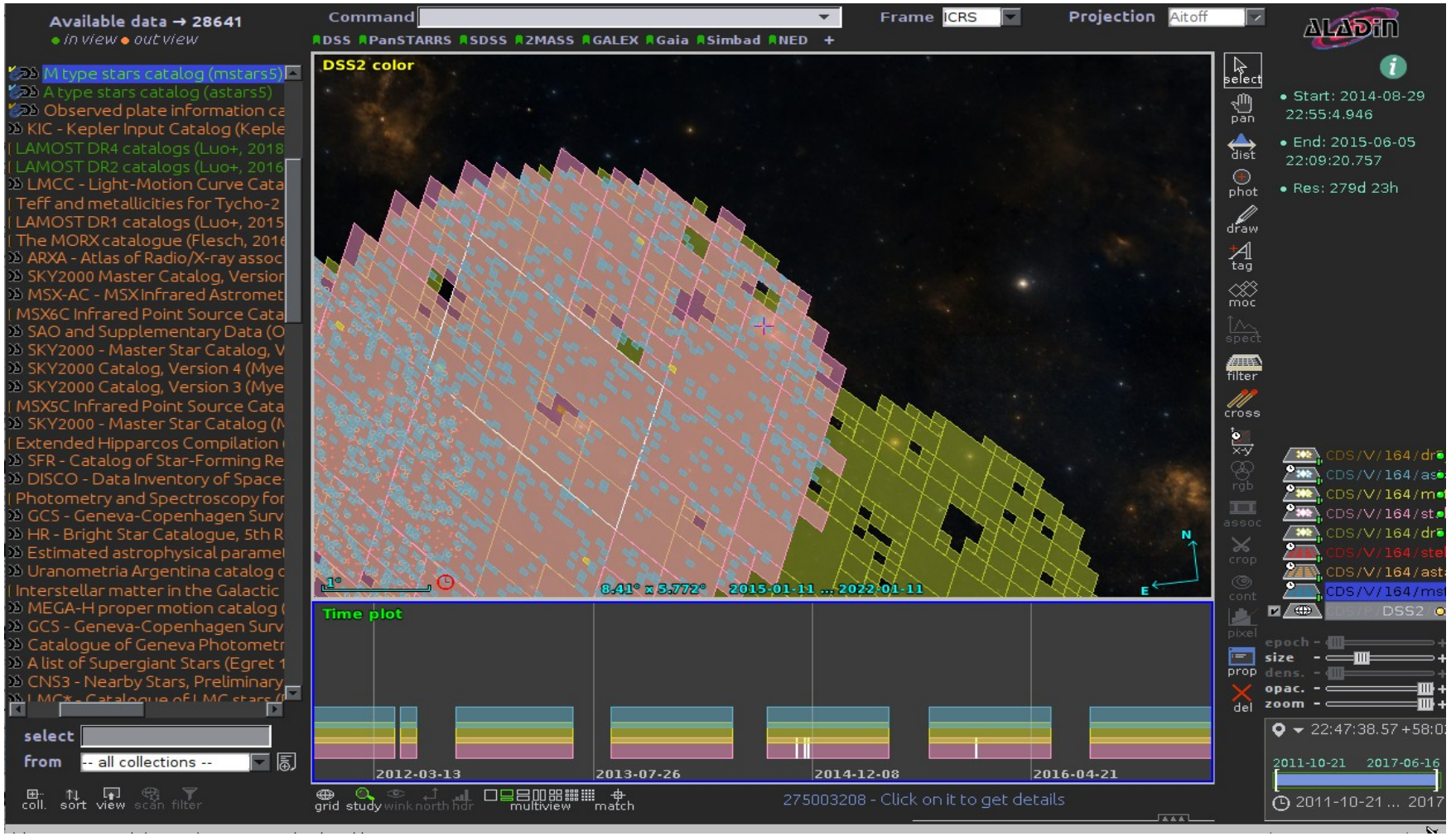
    + we can query ObsTAP to discover datasets covering these constraints

 + I look for counterparts around the same position and time (+ specific time frame + period)

    + ObsTAP with TimeDomain ObsCore extension to discover TimeDomain datasets

+ ObsCore based discovery

Use cases (2)


Available data → 28641
in view out view
Command
Frame ICRS
Projection Aitoff
DSS PanSTARRS SDSS 2MASS GALEX Gaia Simbad NED +
DSS2 color
M type stars catalog (mstars5)
A type stars catalog (astars5)
Observed plate information ca
KIC - Kepler Input Catalog (Keple
LAMOST DR4 catalogs (Luo+, 2018
LAMOST DR2 catalogs (Luo+, 2016
LMCC - Light-Motion Curve Cata
Teff and metallicities for Tycho-2
LAMOST DR1 catalogs (Luo+, 2015
The MORX catalogue (Flesch, 2016
ARXA - Atlas of Radio/X-ray assoc
SKY2000 Master Catalog, Versior
MSX-AC - MSX Infrared Astromet
MSX6C Infrared Point Source Cata
SAO and Supplementary Data (O
SKY2000 - Master Star Catalog, V
SKY2000 Catalog, Version 4 (Mye
SKY2000 Catalog, Version 3 (Mye
MSX5C Infrared Point Source Cata
SKY2000 - Master Star Catalog (M
Extended Hipparcos Compilation
SFR - Catalog of Star-Forming Re
DISCO - Data Inventory of Space
Photometry and Spectroscopy for
GCS - Geneva-Copenhagen Surv
HR - Bright Star Catalogue, 5th R
Estimated astrophysical paramet
Uranometria Argentina catalog c
Interstellar matter in the Galactic
MEGA-H proper motion catalog
GCS - Geneva-Copenhagen Surv
Catalogue of Geneva Photometr
A list of Supergiant Stars (Egret 1
CNS3 - Nearby Stars, Preliminary
select
from -- all collections --
coll. sort view scan filter
8.41° x 5.772°
2015-01-11 ... 2022-01-11
Time plot
2012-03-13
2013-07-26
2014-12-08
2016-04-21
grid study wink north hdr multiview match
275003208 - Click on it to get details
select pan dist phot draw tag moc spect filter cross x-y rgb assoc crop cont pixel prop del
ALADIN
Start: 2014-08-29 22:55:4.946
End: 2015-06-05 22:09:20.757
Res: 279d 23h
CDS/V/164/dr
CDS/V/164/as
CDS/V/164/m
CDS/V/164/st
CDS/V/164/dr
CDS/V/164/ast
CDS/V/164/ms
DSS2
epoch
size
dens.
opac.
zoom
22:47:38.57 +58:0
2011-10-21
2017-06-16
2011-10-21 ... 2017

Use cases (3)

+ I want to discover all TimeSeries available for some spectral domain and some position

    + I send the same query to all DataSetSAP services

    + DataSetSAP is similar to SIA2.0 but not restricted to images

    + HAS parameter DPTYPE=TimeSeries settled

    + May have specific TimeSeries Parameters allowed (constraining TimeSeries ObsCore extension … eg cadence, period, etc.)

+ ObsCore based discovery

Mixed use case

- The TimeSeries is attached to the source
- and both the source parameters and (let’s say) the lightcurve obscore description are in a database
- (case of an exoplanet and companion star for example)
- → We may want to discover by constraints on both timeseries characterization and « spectral type » or « proper motion »
- → Store two tables in the TAP service and make joins or add star parameters to basic ObsCore

Access the data

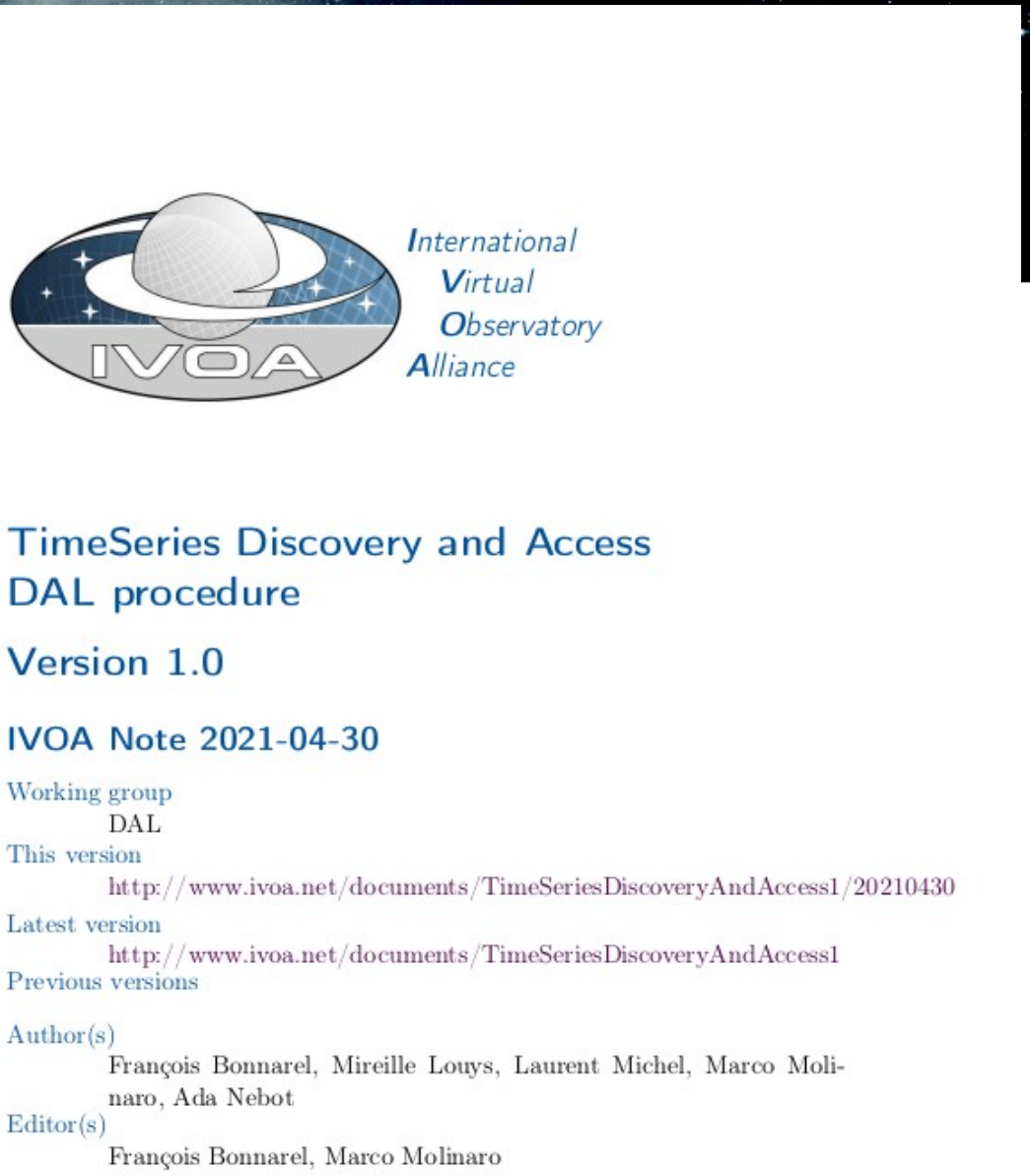
- Full retrieval from DataLink or main source/Obscore table
- Excerpt/transform of the data via SODA-next
  - Selection of data points in a given time range
  - Extraction of one single scalar curve from a multi-scalar one
  - Reduction of dimensionality (cube with time axis → TimeSeries)
  - Changing TimeScale or Time representation

IVOA Note

(Bonnarel, Louys, Michel, Molinaro, Nebot)

- IVOA note : what standards to implement, what changes to make in the standards
- first published in 2018
- New version in 2021
- Implementation note + Decisions about the changes to make in DAL standards in the next months
- Github :

https://github.com/ivoa/TimeSeriesDiscoveryAndAccess



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TimeSeries Discovery and Access
DAL procedure

Version 1.0

IVOA Note 2021-04-30

Working group
DAL

This version
http://www.ivoa.net/documents/TimeSeriesDiscoveryAndAccess1/20210430

Latest version
http://www.ivoa.net/documents/TimeSeriesDiscoveryAndAccess1

Previous versions

Author(s)
François Bonnarel, Mireille Louys, Laurent Michel, Marco Molinaro, Ada Nebot

Editor(s)
François Bonnarel, Marco Molinaro

ObsCore based discovery

ObsCore DM Proposed Extension for time series and radio visibilities

Mireille Louys,
F. Bonnarel, Ada Nebot, L.Michel
following discussions with Time domain IG and Radio

CDS and Observatoire de Strasbourg
ICube Laboratory, Strasbourg University

Louys et al , 2020 November interop

→ what do you need for discovery of radio TimeSeries ?

Time description in ObsCore

Obscore + TObs	Definition	Utype/datamodel path	UCD	Units	Mandatory/ optional
t_min	Time start of the sequence	Char.TimeAxis.Coverage.Bounds.Limits.LoLim	time.start;obs.sequence	s	man
t_max	Time end of the sequence	Char.TimeAxis.Coverage.Bounds.Limits.HiLim	time.end;obs.sequence	s	man
t_exptime	Exposure time (sum of multiple exposures)	Char.TimeAxis.Support.Extent	time.duration;obs.exposure	s	man
t_exp_min	minimal length of time sample (min integration time)	Char.TimeAxis.Sampling.Extent.loLim	time.duration;obs.sequence;stat.min.	s	opt
t_exp_max	maximal length of time sample (max integration time)	Char.TimeAxis.Sampling.Extent.hiLim	time.duration;obs.sequence;stat.max	s	opt
%time space between 2 time samples / cadence					
t_delta_min	minimal length of time interval between 2 observations / cadence (min)	Char.TimeAxis.Sampling.Period.loLim	time.interval;obs.sequence;stat.min.	s	opt
t_delta_max	maximal length of time interval between 2 observations / cadence (max)	Char.TimeAxis.Sampling.Period.hiLim	time.interval;obs.sequence;stat.max	s	opt
t_resolution	minimal interpretable time difference	Char.TimeAxis.Resolution.Refval			
t_xel	nb of time stamps in the series	Char.TimeAxis.numBins	meta.number	null	man

grey cell = current Obscore keywords

add every parameter in blue cells to *ivoa.t_obs* table

Representation : next step to discuss

- Simple Light curve serialisation :

  Nebot et al, 2020

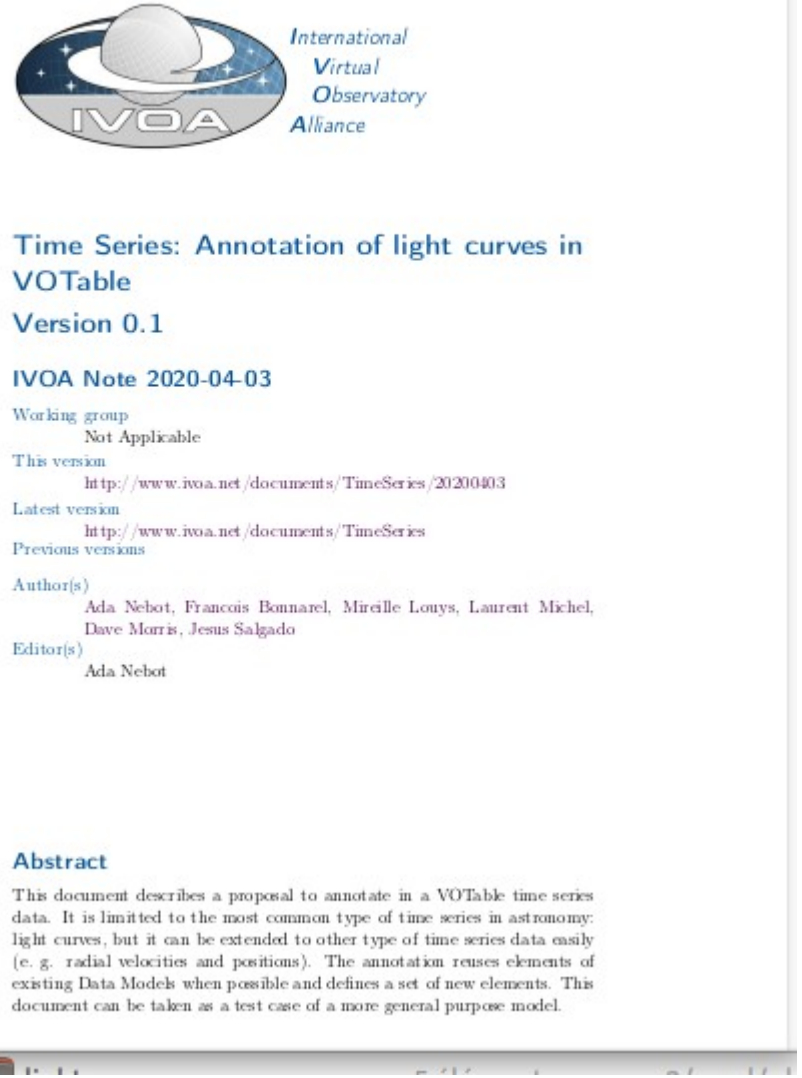
- DAL or DM task to push it ?
- Alternatively, for more complex

  TimeSeries : **Cube DM/Mango**

- + DM annotation/serialisation

  → see last DM Workshop and prototype it !

- → Output format for TimeSeries VO services



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Time Series: Annotation of light curves in VOTable

Version 0.1

IVOA Note 2020-04-03

Working group
Not Applicable

This version
http://www.ivoa.net/documents/TimeSeries/20200403

Latest version
http://www.ivoa.net/documents/TimeSeries

Previous versions

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Ada Nebot

Abstract

This document describes a proposal to annotate in a VOTable time series data. It is limitted to the most common type of time series in astronomy: light curves, but it can be extended to other type of time series data easily (e. g. radial velocities and positions). The annotation reuses elements of existing Data Models when possible and defines a set of new elements. This document can be taken as a test case of a more general purpose model.

Eg : Can we « build » standardized TimeSeries in tools from catalog data ?

- SCS or TAP services response may contain raws of catalogs with timestamps
- SCS-next has now a TIME attribute to select in ranges
- Catalogs in VOTable now provide TIMESYS element for the time frame
- Photometric calibration and system may also be provided in a standard way.
- → A client may provide a functionality to treat such service responses as if they were timeseries
- → moreover these « on the fly timeseries » may be exchanged with other tools (SAMP, Notebooks) or stored for the future