



Time Domain Metadata modeling, sharing, exploring

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with material and guidance from Ada Nebot,
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□ Time Domain Astronomy

*The study of **variability** of astronomical objects over different time-scales*

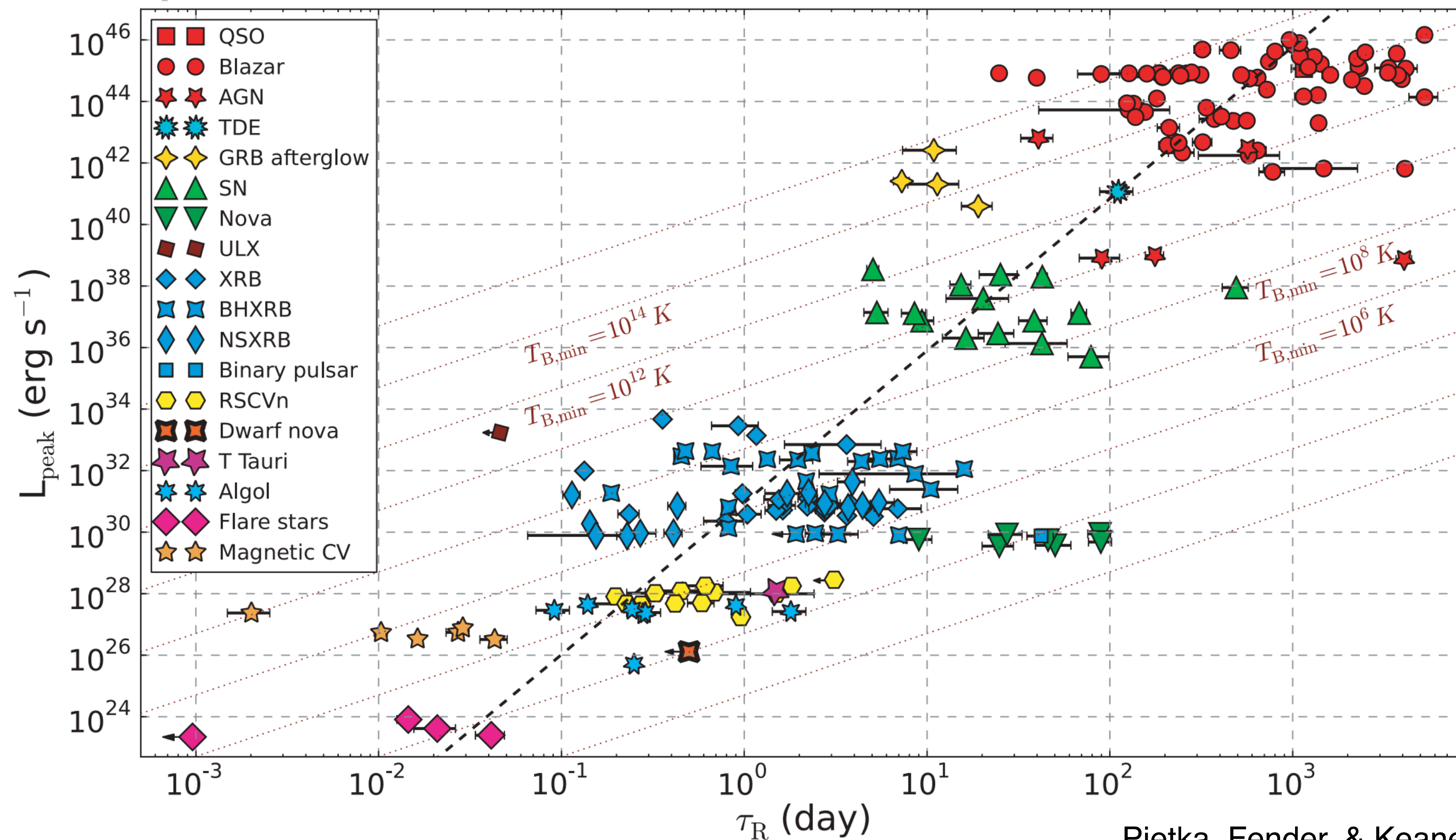
- What type of variable phenomena?
 - **Periodic**: binary orbits of stars/extrasolar planets, stellar rotation, stellar pulsation...
 - **Transient**: supernovae, gamma-ray bursts, novae, X-ray bursts, transits, gravitational microlensing, flares, tidal disruption events...
 - **Stochastic**: accretion in CVs, X-ray binaries,...



□ Time Domain Astronomy

The study of variability of astronomical objects over different **time-scales**

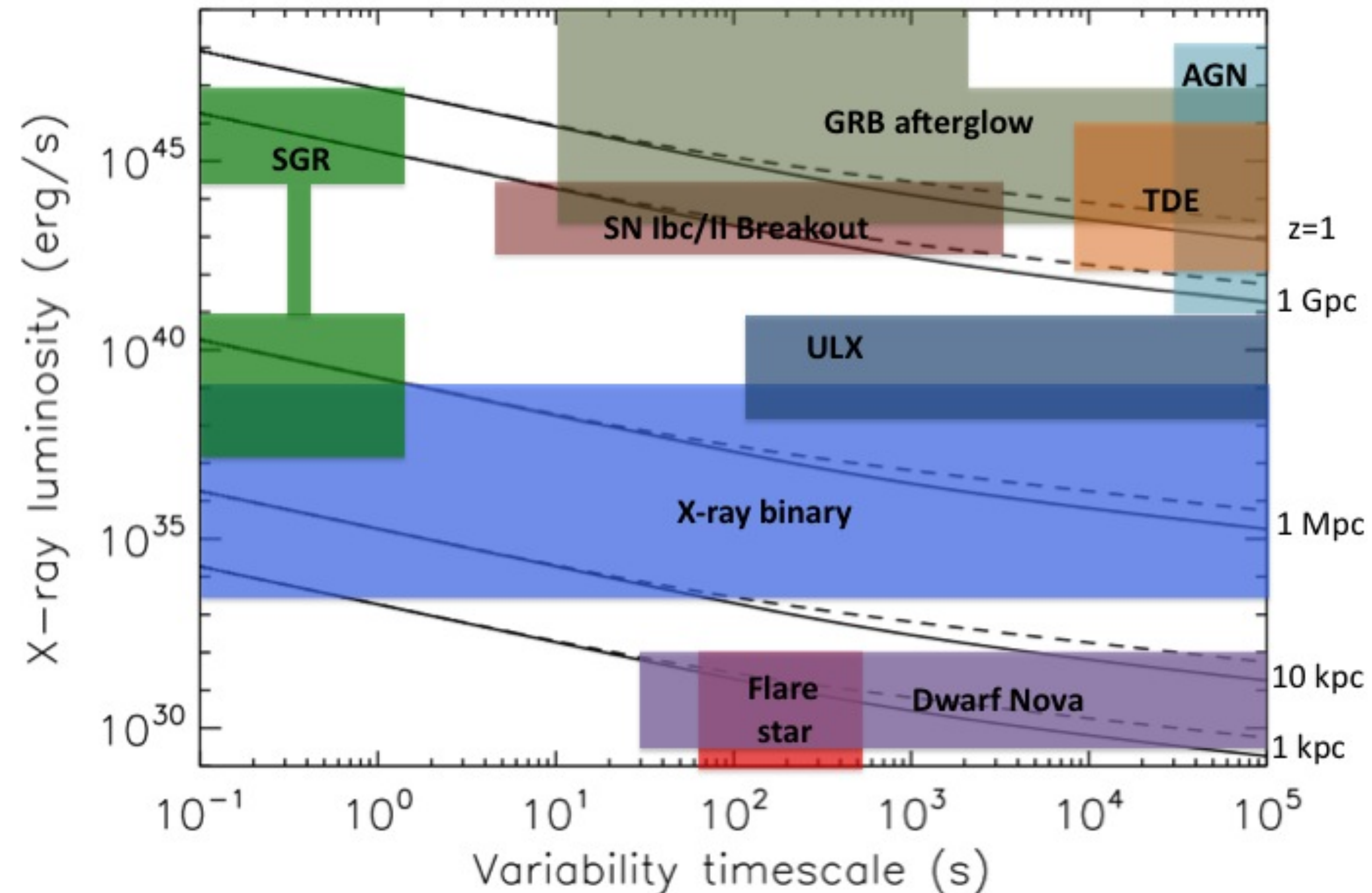
- What time-scales are we talking about?



□ Time Domain Astronomy

*The study of variability of astronomical objects over different **time-scales***

- What time-scales are we talking about?



□ Time Domain Astronomy

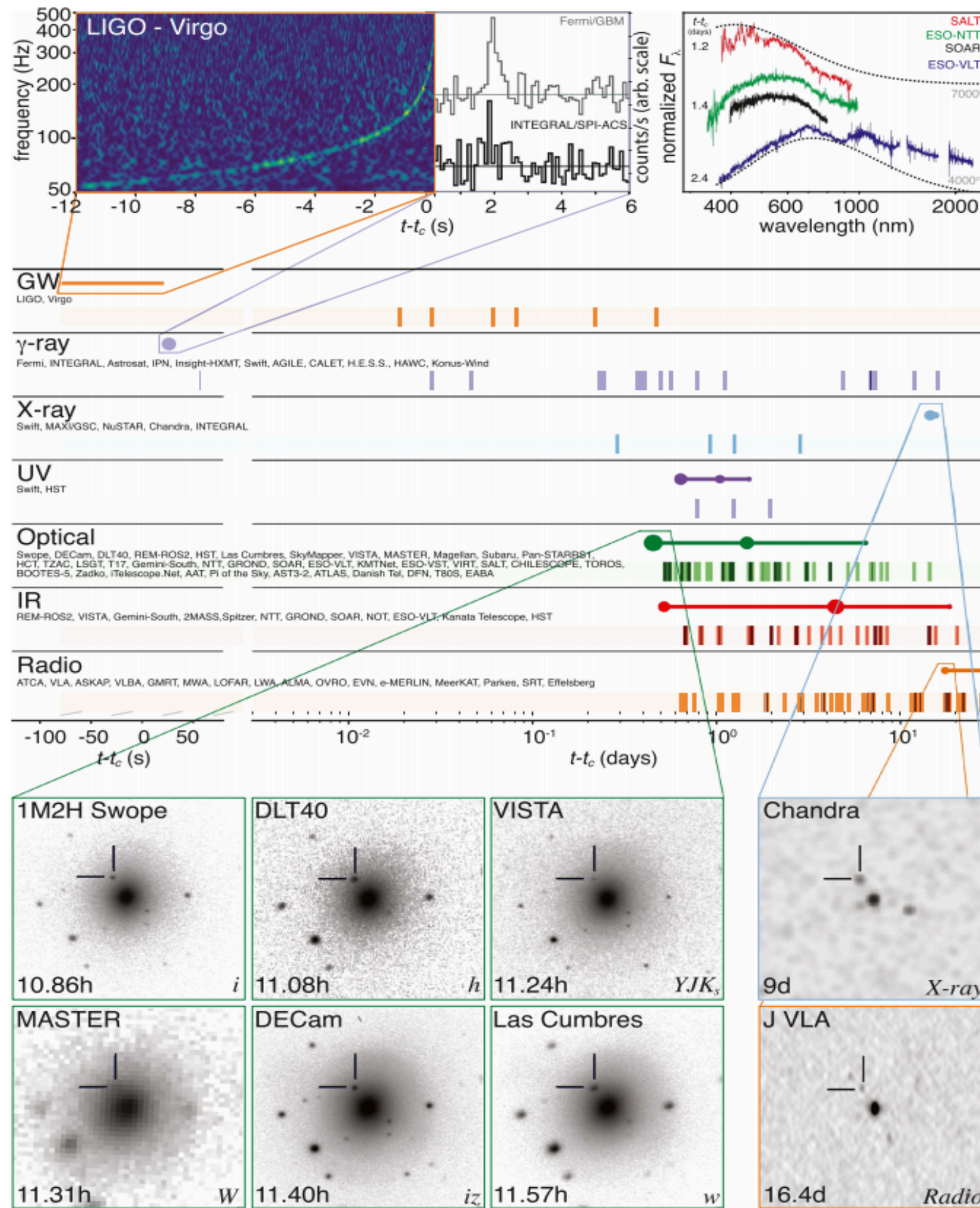
- ➔ Characterisation and classification of sources on the basis of their variability
- ➔ Need to make explicit
 - ➔ Spatial characterisation: position, precision
 - ➔ Spectral coverage for a multi-wavelength approach
 - ➔ Type of Observable : flux, radial velocity, ...



Time Domain Multi-messenger Astronomy

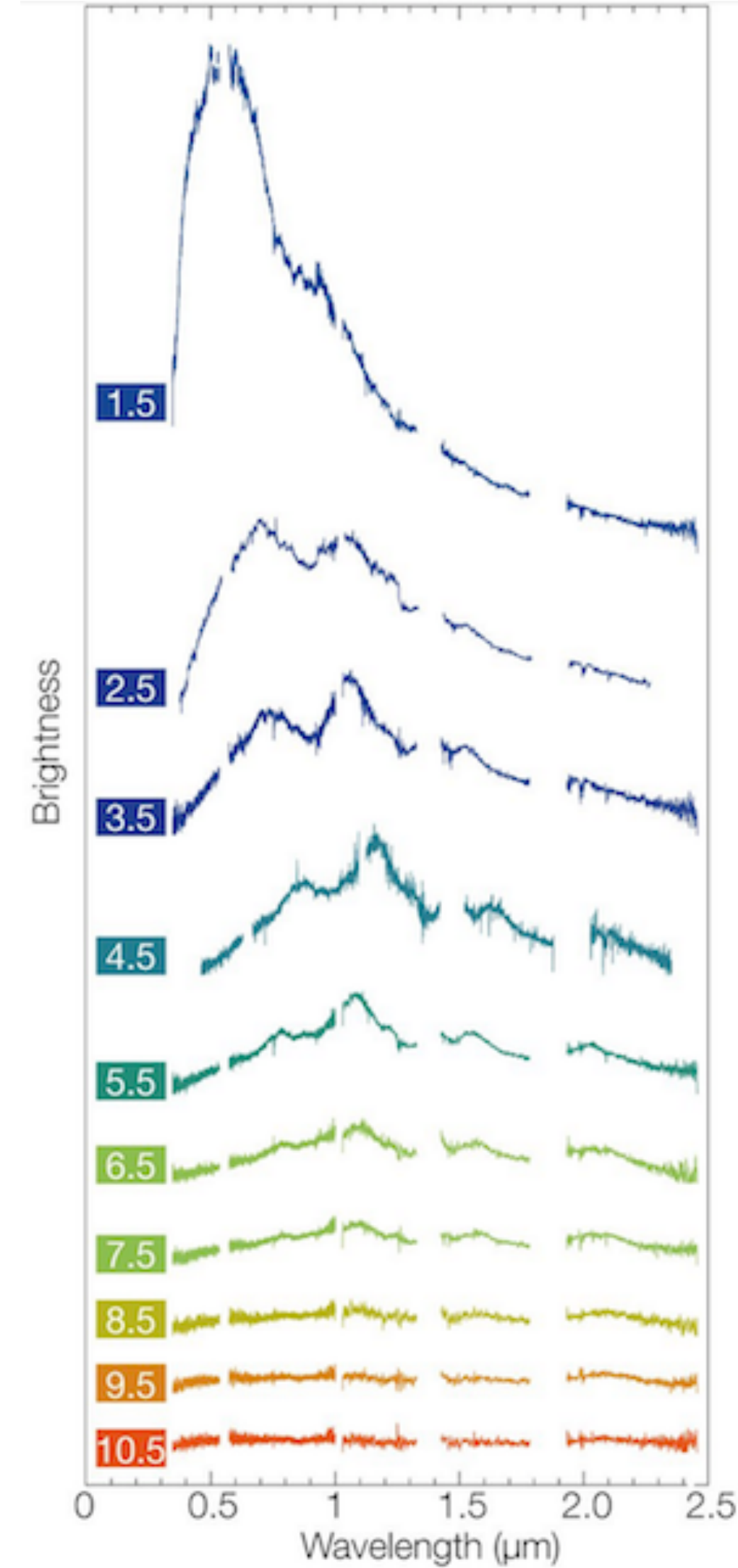
GW170817

THE ASTROPHYSICAL JOURNAL LETTERS, 848:L12 (59pp), 2017 October 20



Abbott et al. 2017

Abbott et al.



X-shooter spectra in the kilonova in NGC 4993 over 12 days. Image credit: ESO/Pian et al./Smartt & ePESSTO.





Visualisation of the sky

- ➔ AladinLite implementation for GW localisation in the sky
- ➔ Background image can be DSS, 2MASS, WISE, XMM, Fermi,...
- ➔ We can overlay catalogues of interest

Interactive Detection Skymap

[Return to the Virgo homepage](#) [Go to the LIGO Open Science Center](#)

The interactive skymap shows the localizations of the various gravitational-wave detections in the sky and helps to understand the importance of multimessenger astronomy.

[Tweet](#) [Share](#)

J2000

Using the skymap

Click on the various options below to display information relating to each detection.

Detection	Sky localisation	Label	Pop-up info
GW170817 - H1 only	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - L1/H1 only	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - L1/H1/V1	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - Refined skymap	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - (GRB170817A) Initial Fermi GBM localization	<input checked="" type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - (GRB170817A) Final Fermi GBM localization	<input type="checkbox"/>	<input checked="" type="checkbox"/>	<input type="checkbox"/>
GW170817 - SSS17a/AT2017gfo Transient sky position	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW170814 - H1/L1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW170814 - H1/L1/V1	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW170814 - Refined skymap	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW170608 - Refined LIGO localization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW170104 - Refined LIGO localization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW151226 - Refined LIGO localization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
GW150914 - Refined LIGO localization	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>

Backgrounds

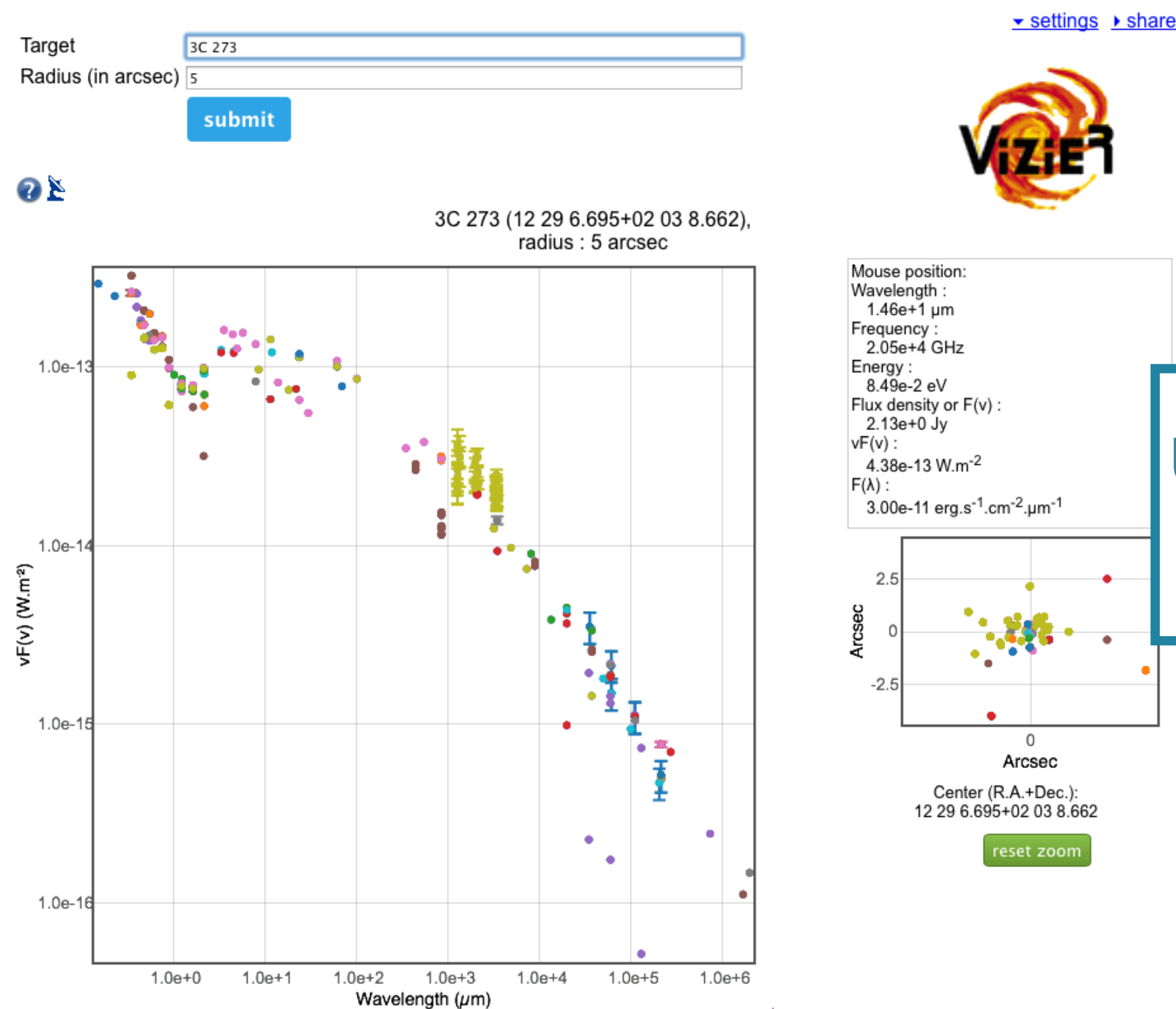
If you want to see the extension of these sky regions through the constellations you can select an artistic background image Constellations.

You can also select various background images at different wavelengths, combining the electromagnetic data with the gravitational-wave information: Mellinger (default) WISE 2MASS DSS color XMM Fermi



Visualisation of photometry

- ➔ Search all the photometry available around a position in the sky
- ➔ Plot photometry against wavelength



Under dev.: A time (series) viewer
➔ Plot photometry against time





Time Series visualisation tools



Select a collection...

MAST Observations by Object Name or RA/Dec

[About Collections...](#)

and enter target:

BD+19 706

Search

[Show Examples...](#) [Random Search](#) [Advanced Search](#)

anonymous

Login...

Account Info...

Upload Target List

My Download Basket: 0 files



[User Manual/Help](#) | [Leave Feedback](#) | [About This Site](#)

Home Page

MAST: BD+19 706

554 Total Rows

NGC 1555, radius: 0.20000°



Footprints: All

AstroView

04:21:59.429 +19:32:06.61
04:21:59.429 +19:32:06.61

RA DEC
hhmmss/deg

Filters

Clear Filters Edit Filters... Help...

List View

Album View

Edit Columns... Table Display: All Show Preview:

Keyword/Text Filter

Filter All Columns

Product Type

Name	Quantity
<input type="checkbox"/> image	(364 of 364)
<input type="checkbox"/> spectrum	(114 of 114)
<input type="checkbox"/> timeseries	(70 of 70)
<input type="checkbox"/> cube	(6 of 6)

Mission

Name	Quantity
<input type="checkbox"/> HST	(232 of 232)
<input type="checkbox"/> HLA	(165 of 165)
<input type="checkbox"/> K2	(71 of 71)
<input type="checkbox"/> IUE	(48 of 48)
<input type="checkbox"/> PS1	(25 of 25)

Show 3 More

	Actions	Mission	Instrument	Project
<input type="checkbox"/>		SWIFT	UVOT	
<input type="checkbox"/>		SWIFT	UVOT	
<input type="checkbox"/>		SWIFT	UVOT	
<input type="checkbox"/>		SWIFT	UVOT	
<input type="checkbox"/>		SWIFT	UVOT	
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1
<input type="checkbox"/>		PS1	GPC1	PS1

Timeseries Viewer

Configuration

Range

Time: 0 to 70.878

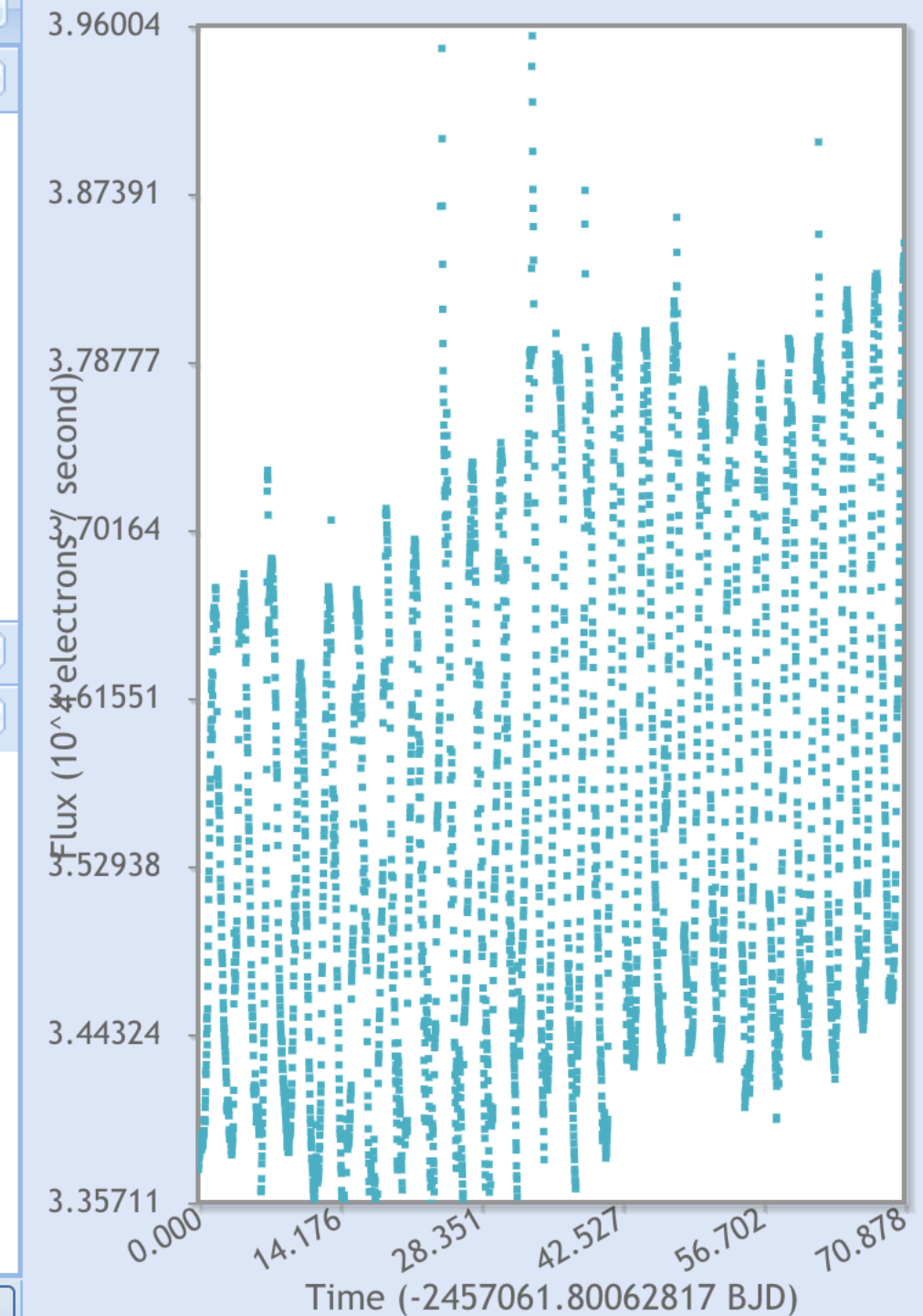
Flux: 3.357111 to 3.96004

Auto Zoom Full Zoom

Options

Phase Folding

Reset All



Legend

Select All S
 EVERE
 EVERE

Time Series view (Aladin beta)

Aladin v10.0 *** BETA VERSION (based on v10.089) ***

Available data → 401 / 22291

Command [] Frame ICRS Projection Aitoff

DSS PanSTARRS SDSS 2MASS WISE GALEX AKARI Gaia Simbad NED YourName +

DSS2 color

5° 23.31° x 8.953°

<Vmag> [mag]: ? Intensity mean V-band magnitude

15

1997-02-20 1998-07-05 1999-11-17 2001-03-31

6 superimposed objects - click Search

recno	n	Star	Field	OGLE	Mode	RAJ2000	DEJ2000	<Imag>	<Vmag>	Per
2670	2670	LMC174.8	25386	10/20	05 37 40.44	-68 50 42.2	17.214	17.949	0.668	
2896	2896	LMC174.4	20390	10	05 40 49.18	-68 23 20.1	17.439	18.005	0.418	
2932	R 2932	LMC182.7	462	10	05 41 24.80	-68 43 05.6	17.212	18.002	0.679	
2973	2973	LMC178.1	39563	10/20	05 42 12.10	-71 12 08.2	17.182	17.964	0.609	
3217	3217	LMC190.8	312	F/10	05 48 44.19	-69 25 40.5	17.098	18.029	1.027	
3356	R 3356	LMC212.3	518	10	06 11 31.81	-69 07 25.6	17.652	18.004	0.306	

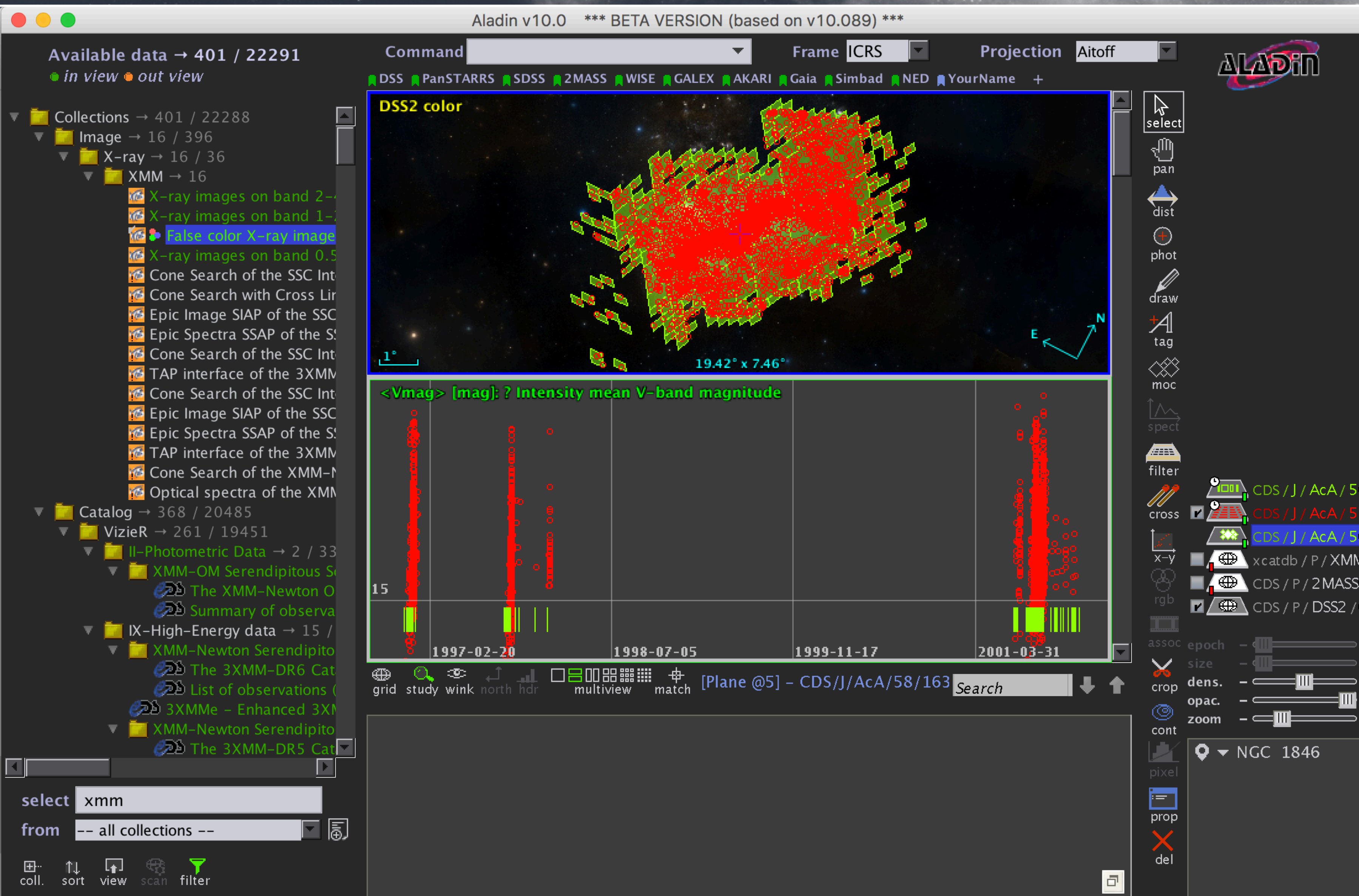
select xmm
from -- all collections --

coll. sort view scan filter

- For all catalogues available through Aladin (VizieR, Simbad,...)+ users
- Plot position in the sky
- Background image can be any available through Aladin + users

- **Under dev.:**
- **Measurements as a function of time**
- **Simultaneously visualise the catalogue positions in the sky**

Time Series view (Aladin beta)



→ Coverage of a survey in space: MOC

Under dev.:

→ Temporal coverage of a survey: TMOG

→ Simple operations such as union, intersections, filter a catalogue by temporal coverage, ...

Under dev.: combine both spatial and temporal coverages

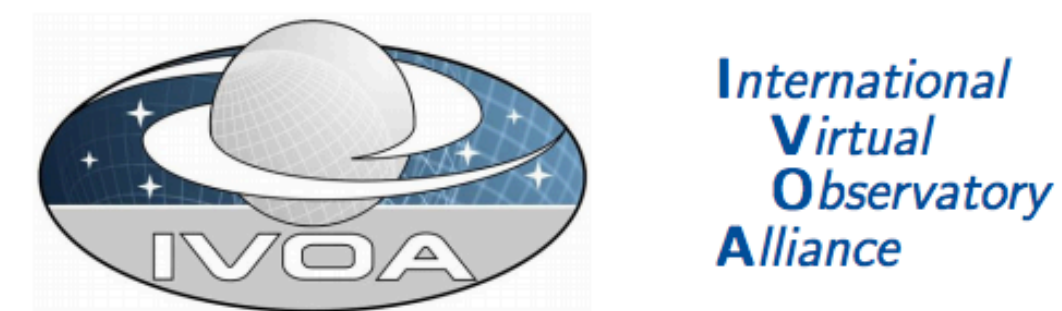
□ Data Access, Discovery and Interoperability for time

- Need of unambiguous declaration of metadata associated to time values
- **Minimum metadata**
 - time scale (TT, TAI, TDB, TCB,...)
 - reference position (topocenter, barycenter,...)
 - offset (random values subtracted to the time values)

Under dev.: A standard way to annotate data to allow for interoperability



A Proposal for a TIMESYS Element in
VOTable
Version 1.1



**VOTable Format Definition
Version 1.4**

IVOA Working Draft 2019-01-31

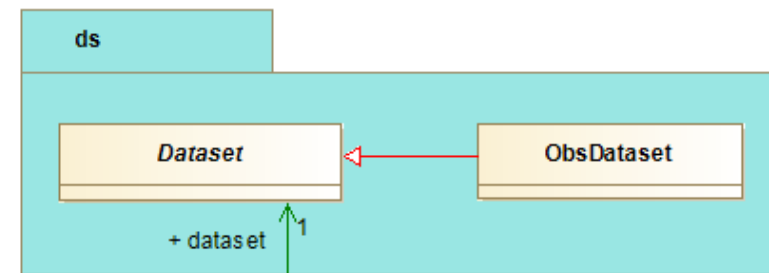
This version:
<http://www.ivoa.net/Documents/VOTable/20190131/>



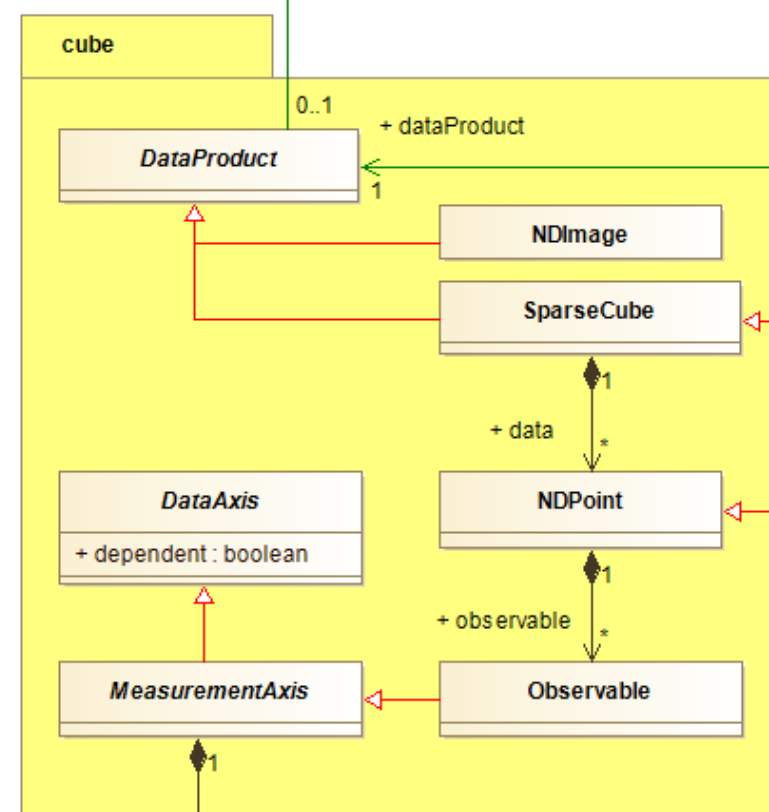


Time domain model

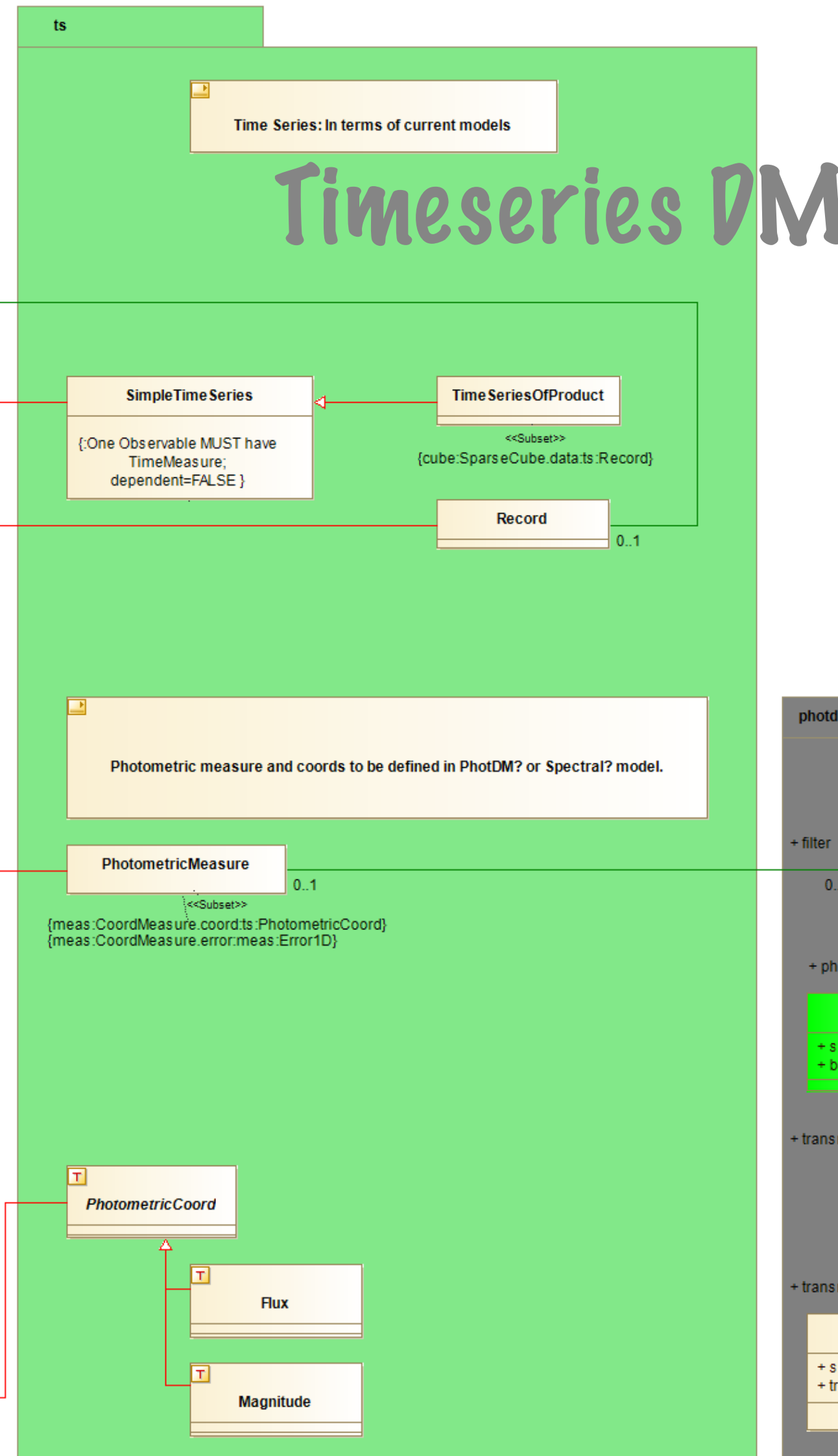
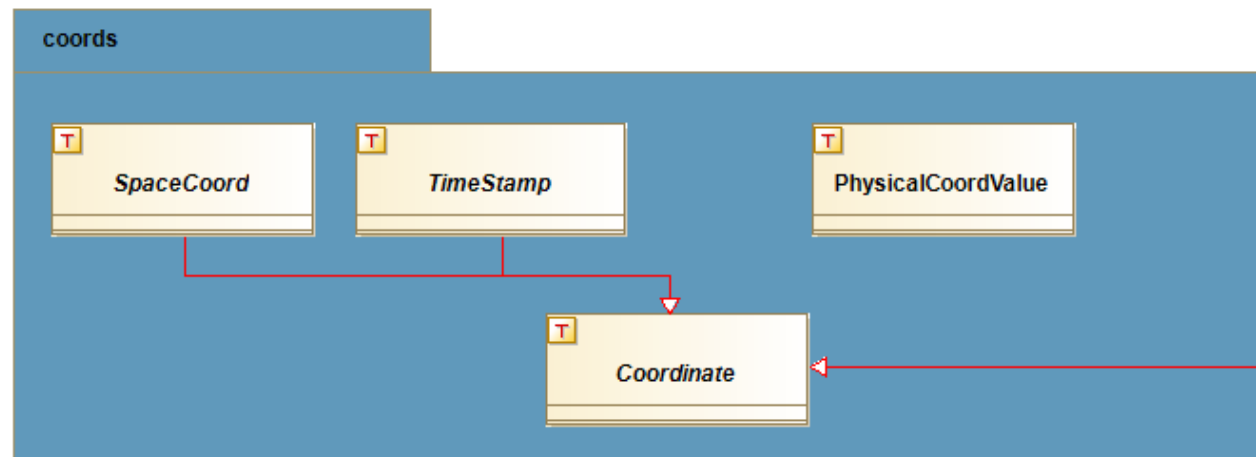
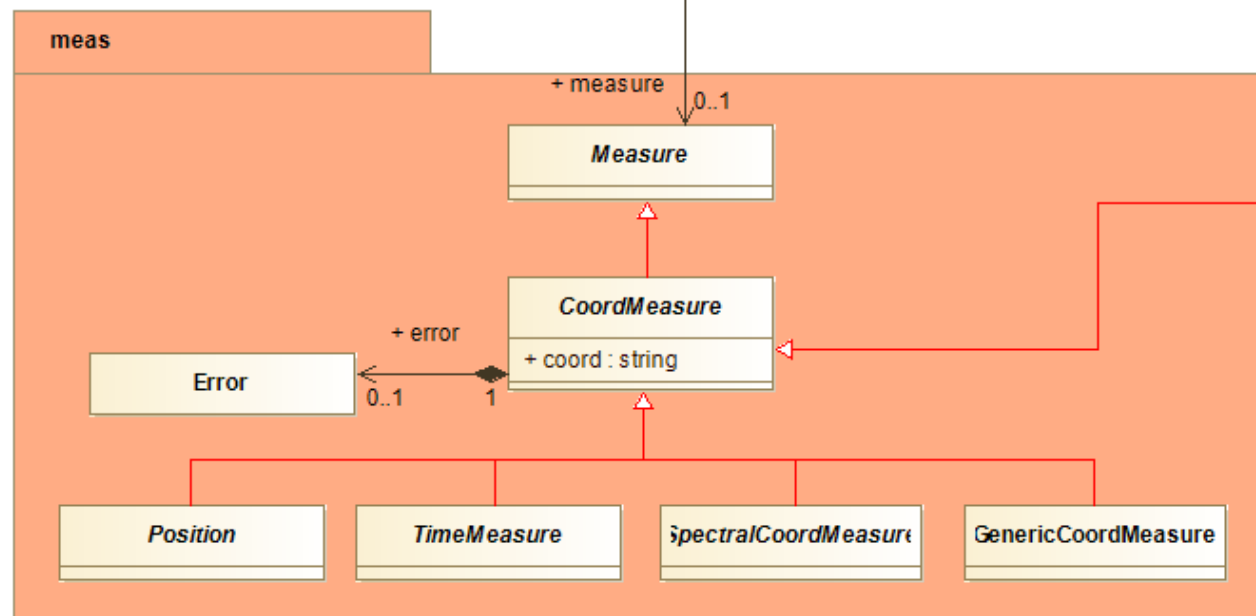
Dataset Metadata DM



Cube DM

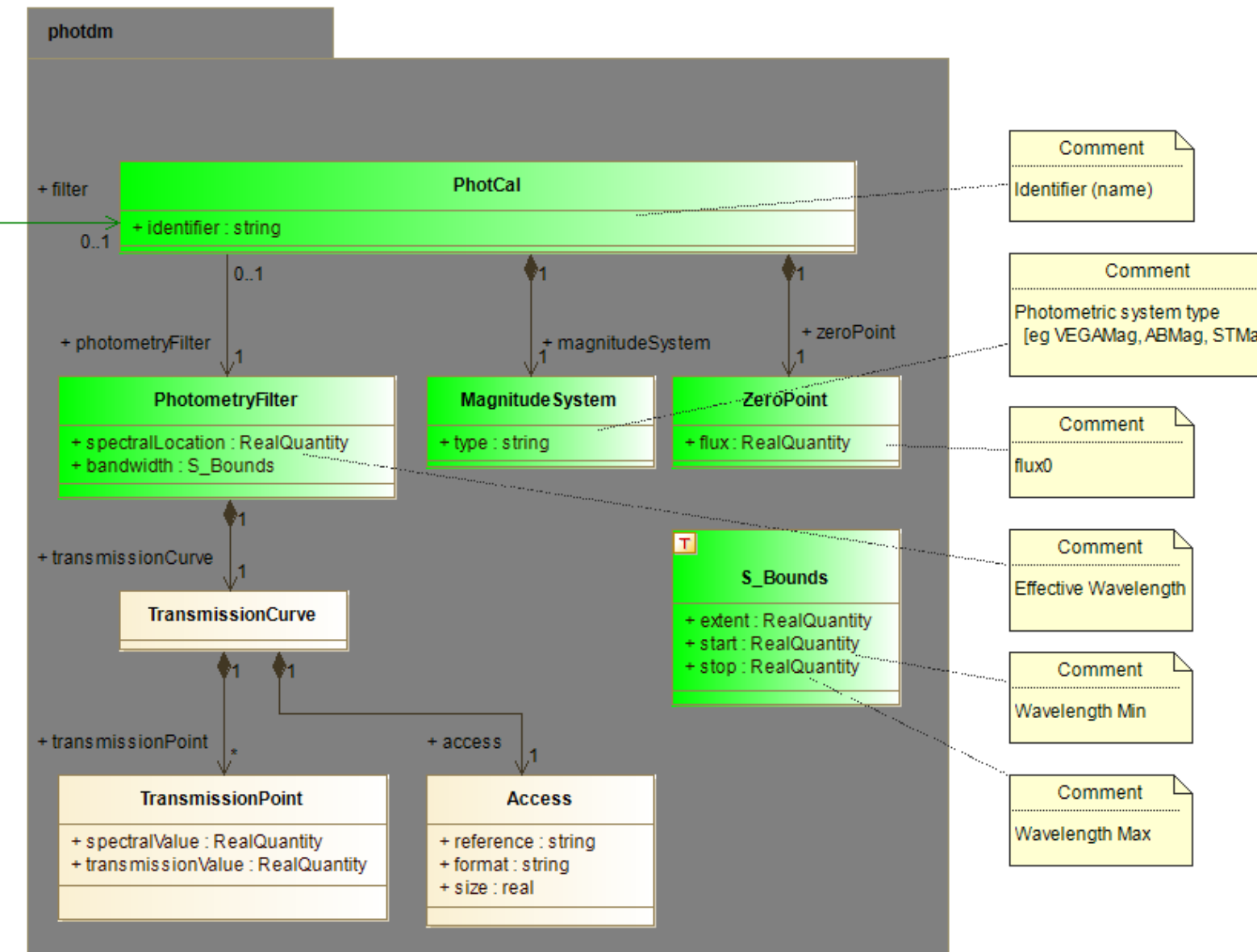


STC DM



- M. Cresitello, L.Michel, A.Nebot, F. Bonnarel, M.Louys
- A comprehensive description of Multi-D datasets

PhotDM



□ TAP metadata profile for Time series

- A suggestion to access time series of any kind (spectra, images, cubes, etc.)
- Based on the principles of ObsCore and EPN Core
 - data product type and curation
 - List metadata characterising all axes : Time, Space, Spectral, Polarimetry, Observable
- Current proposal discussed <https://wiki.ivoa.net/internal/IVOA/TimeSeries/>
 - compare with EPN -TAP description
 - validate on other projects (eg. GASP, exoplanets data sets , etc)





Thanks 🙏 Merci

