



Time Series and the VO.

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IVOA Interoperability Meeting 2017
18/05/2017

Time Series at SVO



- SVO was the first time series provider in the VO.
- Two services registered as SSAP:
 - **CoRoT** published in September 2009
 - **OMC** published in August 2010

Time Series at SVO

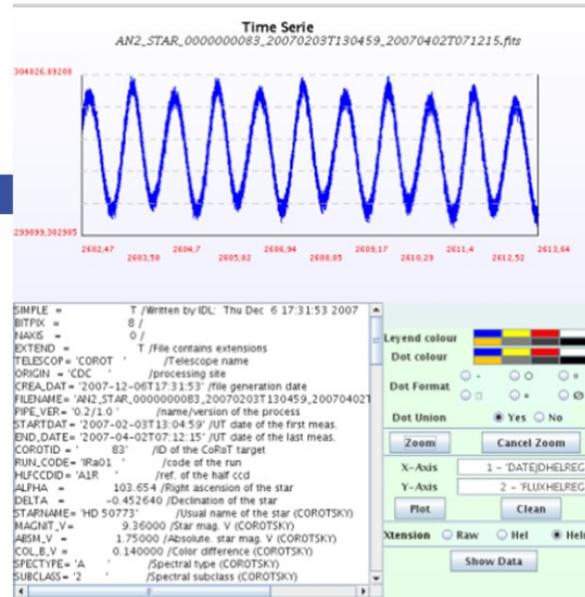


THE COROT PUBLIC ARCHIVE AT LAEFF

This data server provides access to the COROT Archive at LAEFF.

Resources

- ▶ Archive search and data retrieval
- ▶ News
- ▶ System Overview
- ▶ Help Desk
- ▶ Usage Statistics (private)
- ▶ Outreach/Divulgación
 - ▶ Transiting Exoplanets/ Planetas extrasolares detectados utilizando el método de tránsitos.



The COROT Public Archive has been developed in the framework of the Spanish Virtual Observatory project (AYA 2008-02156). The system is maintained by the Data Archive Unit of the CAB (CSIC -INTA).

If you use COROT data in your research, please include the following acknowledgement in any resulting publications: **"Based on data from the COROT Archive at LAEFF"**.

- Available at: <http://sdc.cab.inta-csic.es/corotfa/> since February 2009.
- More than 150.000 light curves.

Time Series at SVO

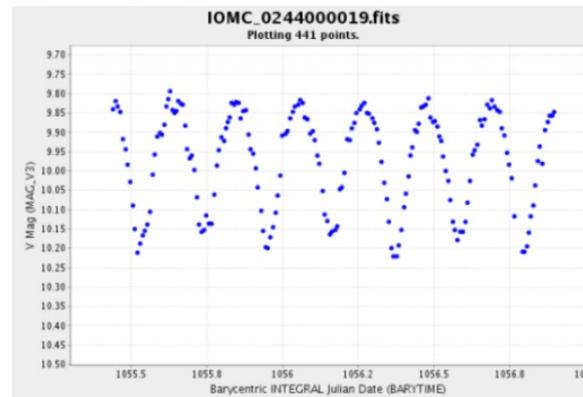


The OMC Archive

This data server provides access to the INTEGRAL Optical Monitoring Camera (OMC) Archive.

Resources

- ▶ Archive search and data retrieval
- ▶ News
- ▶ System Overview
- ▶ Help Desk
- ▶ Project Documentation
- ▶ Change your password



The system is developed and maintained by LAEFF, based on data pre-processed by ISDC. LAEFF is part of the Space Science Division of INTA.

If you use OMC data in your research, please include the following acknowledgement in any resulting publications:
"Based on data from the OMC Archive at LAEFF, pre-processed by ISDC".

- **OMC:** Available at <http://sdc.cab.inta-csic.es/omc/> since 2003.
- More than 86.000 light curves with more than 50 photometric points.

Time Series at IVOA



- Time Series identified by IVOA as a *Science Priority*.
- SVO, in its double role of data provider and IVOA member, made in 2012 an assessment on the existing limitations to discover, access and describe time series in the VO:

TimeSeries in VO
Use Case Assessment

Raúl Gutiérrez Sánchez
Spanish Virtual Observatory
Centro de Astrobiología (INTA-CSIC)
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IVOA Interoperability Meeting.
São Paulo, 21-26 October 2012



Raúl Gutiérrez-Sánchez Time Series in VO_1

Data discovery	•Registry
Data access	•SSAP •IVOA note on 'Time Series Data' (Dec 2010) •ConeSearch •TAP
Data model	•SDM 1.1 •SDM 2.0 •IVOA note on 'Time Series Data' (Dec 2010) •DotAstro SimpleTimeseries

CoRoT Time Series



Committee on Science Priorities

3 groups of scientific use cases identified by IVOA:

- **Group A:** Combine phot. and LCs in the same band.
• Cases: #1, #2, #3, #4
- **Group B:** Combine phot. and LCs in different bands.
• Cases: #5
- **Group C:** Time series other than light curves.
• Cases: #6, #7, #8

CoRoT: simple Light Curves in the same band.

CoRoT Time Series: Data Access



-SSAP:

SSA is capable of describing most tabular spectrophotometric data, including **time series** and spectral energy distributions (SEDs) as well as 1-D spectra.

Dataset.Type:

```
-<PARAM ID="Type" name="Type" utype="ssa:Dataset.Type" value="TimeSeries" datatype="char" arraysize="*">  
  <DESCRIPTION>Dataset or segment type.</DESCRIPTION>  
</PARAM>
```

According to the SSAP Protocol, the Dataset.Type value must be “Spectrum”

CoRoT Time Series: Data Model



Based in the Spectral DM.

Metadata information:

Position



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IVOA Spectral Data Model
Version 2.0
IVOA Proposed Recommendation 20160928

This version:
[PR-SpectralDM-2.0-20160928](#)

Previous version(s):
[PR-SpectralDM-2.0-20150528](#)
[PR-SpectralDM-2.0-20150206](#)
[PR-SpectralDM-2.0-20140730](#)
[PR-SpectralDM-2.0-20140309](#)
[PR-SpectralDM-2.0-20130425](#)
[WD-SpectralDM-2.0-20130308](#)
[WD-SpectralDM-2.0-20120907](#)
[SpectrumDM-2011020](#)

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```

- <GROUP ID="Char.SpatialAxis" name="Char.SpatialAxis" utype="ssa:Char.SpatialAxis">
  <DESCRIPTION>Spatial Axis Characterization</DESCRIPTION>
  <FIELDref ref="Location"/>
  - <FIELDref ref="Coverage.Bounds.Extent" utype="ssa:Char.SpatialAxis.Coverage.Bounds.Extent" ucd="instr.fov" datatype="double">
    <DESCRIPTION>Aperture angular size.</DESCRIPTION>
  </FIELDref>
</GROUP>

```

CoRoT Time Series: Data Model



Metadata information:

Time frame

```
-<GROUP ID="Char.TimeAxis" name="Char.TimeAxis" utype="ssa:Char.TimeAxis">
  <DESCRIPTION>Time Axis Characterization</DESCRIPTION>
  -<FIELDref ref="Coverage.Location.Value" name="Coverage.Location.Value" utype="ssa:Char.TimeAxis" ucd="time.epoch" datatype="double">
    <DESCRIPTION>Midpoint of exposure on MJD scale.</DESCRIPTION>
  </FIELDref>
  <FIELDref ref="StartDate"/>
  <FIELDref ref="EndDate"/>
  -<PARAM ID="Calibration" name="Calibration" utype="ssa:Char.TimeAxis.Calibration" value="CALIBRATED" datatype="char" arraysize="*">
    <DESCRIPTION>Type of coord calibration.</DESCRIPTION>
  </PARAM>
</GROUP>
```

Flux

```
-<GROUP ID="Char.FluxAxis" name="Char.FluxAxis" utype="ssa:Char.FluxAxis">
  <DESCRIPTION>Flux Axis Characterization</DESCRIPTION>
  -<PARAM ID="FluxAxisUnit" name="FluxAxisUnit" utype="ssa:Char.FluxAxis.Unit" value="electrons/s" datatype="char" arraysize="*">
    <DESCRIPTION>Unit for flux</DESCRIPTION>
  </PARAM>
  -<PARAM ID="FluxCalibration" name="FluxCalibration" utype="ssa:Char.FluxAxis.Calibration" value="RELATIVE" datatype="char" arraysize="*">
    <DESCRIPTION>Type of flux calibration</DESCRIPTION>
  </PARAM>
</GROUP>
```

CoRoT Time Series: Data Model



Metadata information:

Spectral frame

```
-<GROUP ID="Char.SpectralAxis" name="Char.SpectralAxis" utype="ssa:Char.SpectralAxis">
-<FIELDref ref="Coverage.Location.Value" name="Coverage.Location.Value" utype="ssa:Char.SpectralAxis.Coverage.Location.Value" ucd="instr.bandpass" datatype="double">
  <DESCRIPTION>Spectral coord value</DESCRIPTION>
</FIELDref>
-<FIELDref ref="Coverage.Bounds.Extent" name="Coverage.Bounds.Extent" utype="ssa:Char.SpectralAxis.Coverage.Bounds.Extent" ucd="instr.bandwidth" datatype="double">
  <DESCRIPTION>Width of spectrum</DESCRIPTION>
</FIELDref>
</GROUP>
```

DataID and Curation

```
-<GROUP ID="DataID" name="DataID" utype="ssa:DataID">
  <DESCRIPTION>Dataset Identification Metadata</DESCRIPTION>
  <FIELDref ref="Title"/>
  <PARAM ID="Creator" name="Creator" utype="ssa:DataID.Creator" value="IAS CoRoT Data Center" datatype="char" arraysize="*">
    <DESCRIPTION> Dataset creator. </DESCRIPTION>
  </PARAM>
</GROUP>
-<GROUP ID="Curation" name="Curation" utype="ssa:Curation">
  <DESCRIPTION>Curation Metadata</DESCRIPTION>
  <PARAM ID="Publisher" name="Publisher" datatype="char" utype="ssa:Curation.Publisher" value="CAB(INTA-CSIC)/SVO(Spanish Virtual Observatory)" arraysize="*">
    <DESCRIPTION>Publisher</DESCRIPTION>
  </PARAM>
  <PARAM ID="Reference" name="Reference" datatype="char" utype="ssa:Curation.Reference" value="http://sdc.cab.inta-csic.es" arraysize="*">
    <DESCRIPTION>URL or Bibcode for documentation.</DESCRIPTION>
  </PARAM>
  <PARAM ID="Rights" name="Rights" datatype="char" utype="ssa:Curation.Rights" value="Public Data" arraysize="*">
    <DESCRIPTION>Restrictions on data access.</DESCRIPTION>
  </PARAM>
</GROUP>
```

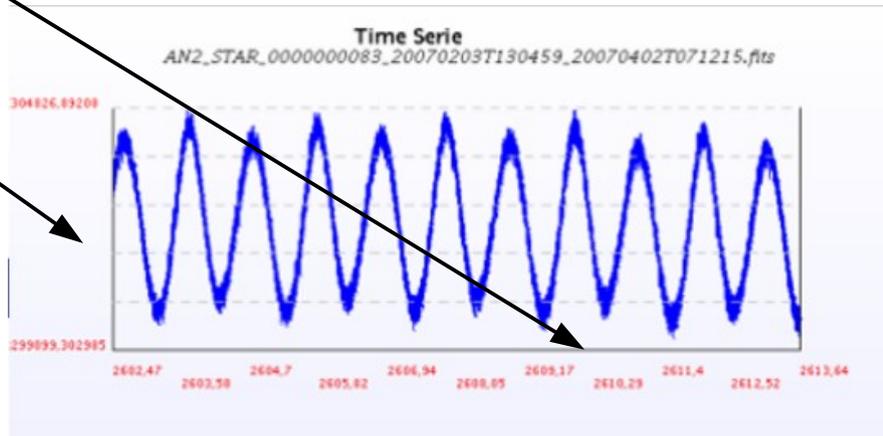
CoRoT Time Series: Data Model



Data serialization:

FITS format

```
--<FIELD ID="TimeAxis" name="TimeAxis" utype="ssa:Dataset.TimeAxis" datatype="char" arraysize="*">  
  <DESCRIPTION> Table column containing time values </DESCRIPTION>  
</FIELD>  
--<FIELD ID="FluxAxis" name="FluxAxis" utype="ssa:Dataset.FluxAxis" datatype="char" arraysize="*">  
  <DESCRIPTION> Table column containing flux values </DESCRIPTION>  
</FIELD>
```



CoRoT Time Series: Data Model



CoRoT light curves described with the Spectral Data Model can be managed with VO tools like SPLAT.



CoRoT Time Series: Data Model



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**Time Series Cube Data Model
Version 1.1**

IVOA Note 2017-02-05

Working group
Time domain interest group

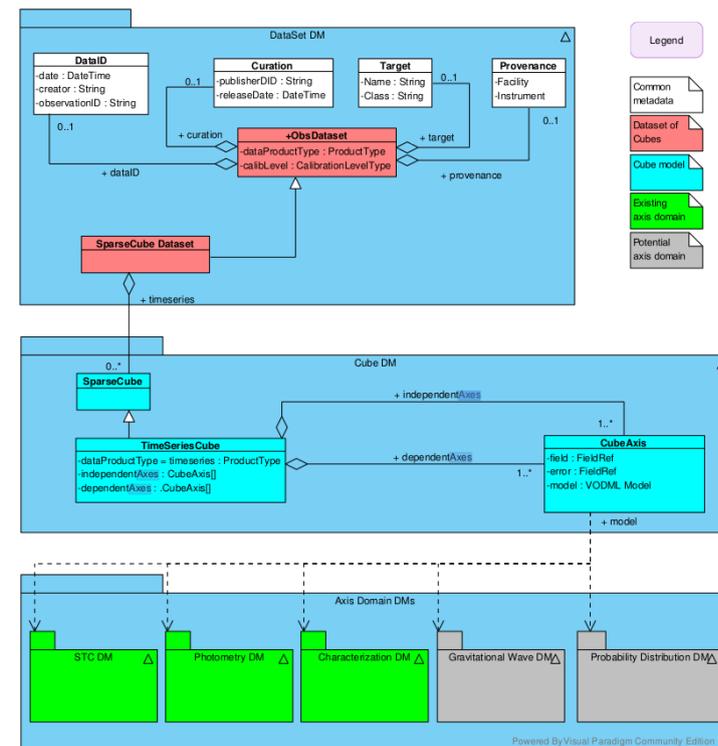
This version
<http://www.ivoa.net/documents/cubeDM/20170205>

Latest version
<http://www.ivoa.net/documents/cubeDM>

Previous versions

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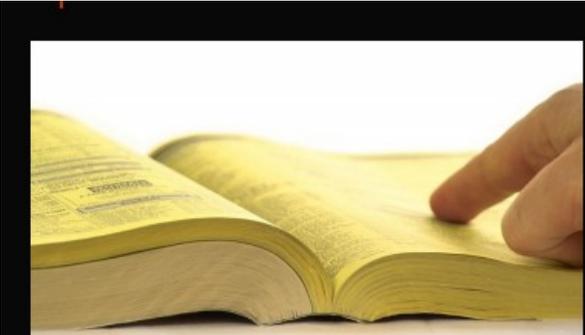


For our case (simple LCs) this new data model does not bring any improvement.

CoRoT Time Series: Data Discovery



- Time Series cannot be discovered at Registry level.



And light curves?

And light curves?

Catalog servers	
1)	<input checked="" type="checkbox"/> CDS VizieR catalog service (>5000 astronomical cat...
2)	<input checked="" type="checkbox"/> CDS SIMBAD astronomical database (>3,000,000 obj...
3)	<input checked="" type="checkbox"/> NASA/IPAC Extragalactic Database (Caltech/Pasad...
4)	<input checked="" type="checkbox"/> SuperCOSMOS catalog server - Edinburgh (UK)
5)	<input checked="" type="checkbox"/> LEDA Hypercat (Lyon-Meudon Extragalactic Databa...
6)	<input checked="" type="checkbox"/> Generic ConeSearch query
7)	<input checked="" type="checkbox"/> Galaxy Evolution Explorer Catalog (STScI)
8)	<input checked="" type="checkbox"/> San Pedro Martin Open Cluster Survey
9)	<input checked="" type="checkbox"/> Starlight: Synthesis parameters

Image servers	
1)	<input checked="" type="checkbox"/> The Aladin image server (CDS/Strasbourg)
2)	<input checked="" type="checkbox"/> The UKIRT DR7 Infrared Deep Sky Survey
3)	<input checked="" type="checkbox"/> SDSS DR7 images
4)	<input checked="" type="checkbox"/> Multimission Archive of TPT (MAST)
5)	<input checked="" type="checkbox"/> Hubble Legacy Archive Footprint Data (HLA)
6)	<input checked="" type="checkbox"/> Canadian Astronomical Data Center (CADC)
7)	<input checked="" type="checkbox"/> Hubble press release images
8)	<input checked="" type="checkbox"/> VO-Paris Southern Atlas (VOPSAT)
9)	<input checked="" type="checkbox"/> Generic SIA query
10)	<input checked="" type="checkbox"/> The XMM-Newton Science Archive InterOperability System
11)	<input checked="" type="checkbox"/> The ISO Data Archive InterOperability System
12)	<input checked="" type="checkbox"/> The Integral Science Data Archive InterOperability System
13)	<input checked="" type="checkbox"/> SkyView Virtual Observatory
14)	<input checked="" type="checkbox"/> SuperCOSMOS Sky Surveys SSS SIAP Cutout Service
15)	<input checked="" type="checkbox"/> UKIDSS DR1 SIAP Service

Spectra servers	
1)	<input checked="" type="checkbox"/> AXIS-XMS Optical Spectra
2)	<input checked="" type="checkbox"/> Be Star Spectra SSAP
3)	<input checked="" type="checkbox"/> HEROS archive of Ondrejov observations
4)	<input checked="" type="checkbox"/> SSA Service for Optical Spectroscopy in the CDF-5
5)	<input checked="" type="checkbox"/> cutout server of HEROS archive of Ondrejov observati...
6)	<input checked="" type="checkbox"/> SSA Service for Synthetical Spectra (TMAP)
7)	<input checked="" type="checkbox"/> Espadons/Narval legacy database (Castor)
8)	<input checked="" type="checkbox"/> HiG - Simple Spectral Access to HI (21cm) Spectra of Ga...
9)	<input checked="" type="checkbox"/> International Ultraviolet Explorer
10)	<input checked="" type="checkbox"/> International Ultraviolet Explorer
11)	<input checked="" type="checkbox"/> Wisconsin Halfwave Spectropolarimeter
12)	<input checked="" type="checkbox"/> Wisconsin Halfwave Spectropolarimeter
13)	<input checked="" type="checkbox"/> HyperLeda FITS Archive Simple Spectrum Data Access(...)
14)	<input checked="" type="checkbox"/> ELODIE archive

CoRoT Time Series: Data Discovery



- Time Series could be discovered using ObsCore / TAP .



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

Most of the data providers (at least the VO newcomers) tend to use simple protocols (like SSAP). Therefore, the discover of SSAP Time Series services has to be a must.

A.4. Discovering time series

A.4.1. Use case 4.1

Times series for a sky position, with date, length and exposure constraints

Show me a list of all data which satisfies:

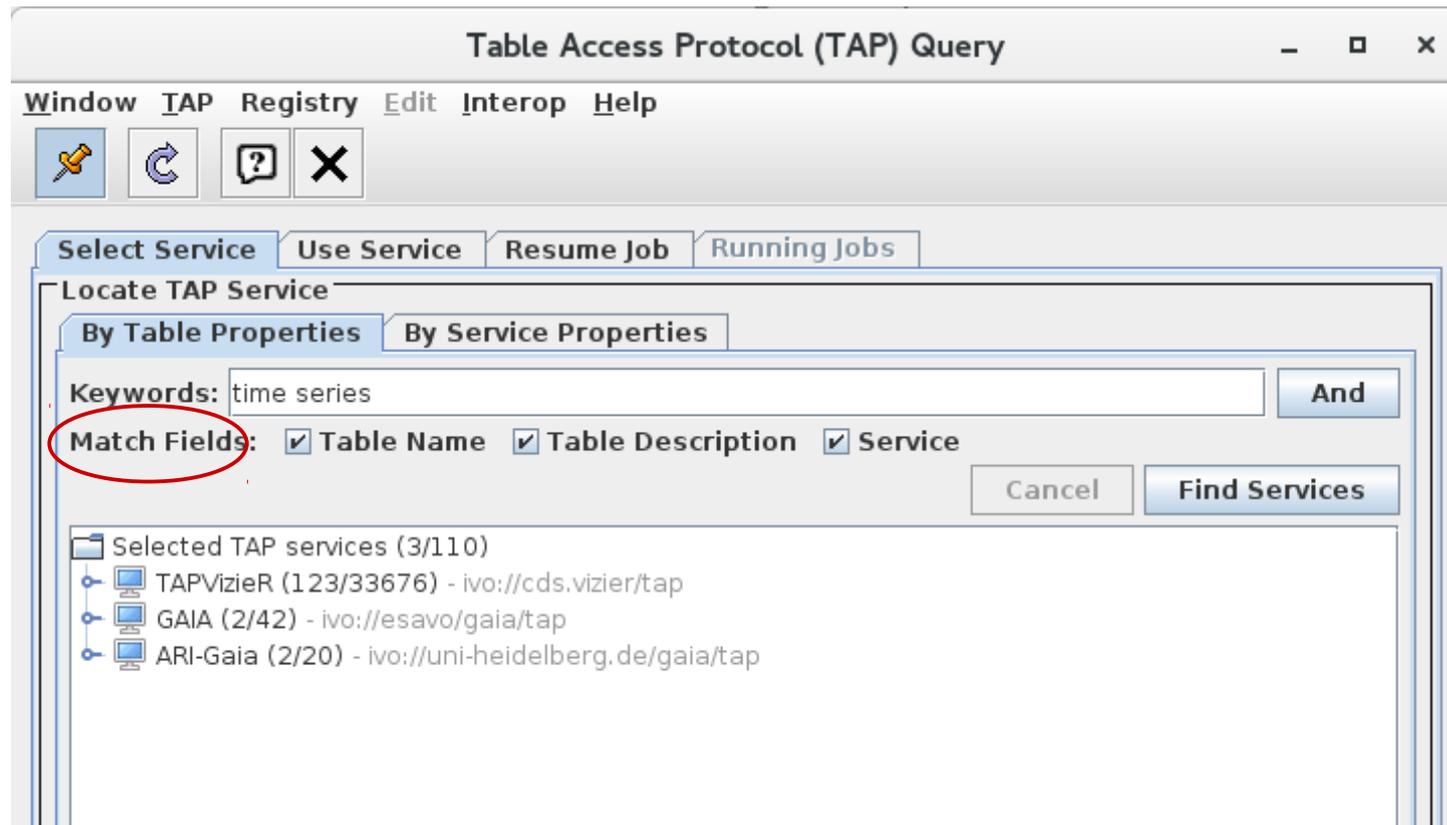
- I. **DataType=TimeSeries**
- II. RA includes 16.00 hours
- III. DEC includes +41.00
- IV. Time resolution better than 1 minute
- V. Time interval (start of series to end of series) > 1 week
- VI. Observation data before June 10, 2008
- VII. Observation data after June 10, 2007

CoRoT Time Series: Data Discovery



The scientific community uses VO-Tools to discover data

But Datatype is not included in the Match Fields options of TOPCAT.



CoRoT Time Series: Data Discovery



Splat-VO does not have Time Series option

Starlink SPLAT-VO: Query VO for Spectra

Search parameters:
Object: HD49933
RA: 06:50:49.831 Dec: -00:32:27.18
Radius: 10.0
Band: MAXREC
Time: /
Query Format: None
Wavelength calibration: None
Flux calibration: None

Optional Parameters

U...	Name	Value	UCD
<input type="checkbox"/>	SPECPR		
<input type="checkbox"/>	SPECRES		
<input type="checkbox"/>	TARGETSPECTYPE		
<input type="checkbox"/>	VERSION	1.02	
<input type="checkbox"/>	teff		phys.temperature.effective
<input type="checkbox"/>	logq	4.4	phys.gravity
<input type="checkbox"/>	feh	0	phys.abund.Fe
<input type="checkbox"/>	OBJECT		
<input type="checkbox"/>	SamplingTime	6.30	

Query: <SERVER>?REQUEST=queryData&POS=102.70762916666666,-0.540883333333334&SIZE=0.16666666666666666

Query results:

Title	Corot Id	AcRef	Format	TimeAxis	FluxAxis	Run	Location	StartDate	EndDate	SPECTYPE	LUM	VMAG	B-V
1 CoRoT light curve_COROT...	20	http://sdc.cab.inta-csic.es/8...	timeseries/frts	DATE_IDHELREG	FLUXHELREG	LRa01	(102.708, -0.54088)	(2846.8733)	(2983.9094)	F	V	5.77	0.39
2 CoRoT light curve_COROT...	20	http://sdc.cab.inta-csic.es/8...	timeseries/frts	DATE_IDHELREG	FLUXHELREG	LRa01	(102.708, -0.54088)	(2586.963)	(2647.8003)	F	V	5.77	0.39

Time Series and the VO



Conclusions:

To repeat the VO success stories achieved with other datasets (tables/TOPCAT; images/Aladin, SEDs/VOSA, spectra/SPLAT...) it is compulsory to provide the scientific community with an easy and transparent access to Time Series through VO tools.

For this, it is absolutely necessary to fix the problems related to data discovery (registry) and data representation (data model).