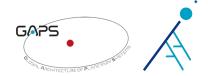# GAPS Time Series

Resource and Service Implementation

Andrea Bignamini[1]

Serena Benatti[2] – Riccardo Claudi[2] – Marco Molinaro[1]
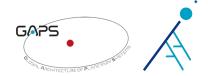
[1] INAF – OATs

[2] INAF – OAPd

Outline

- GAPS Time Series

- GAPS Time Series in Virtual Observatory (VO)

- ObsTAP Service

- Next steps

The GAPS Project

GAPS (Global Architecture of Planetary Systems) is a long-term program for the comprehensive characterization of the architectural properties of planetary systems as a function of the hosts' characteristics (mass, metallicity, environment):
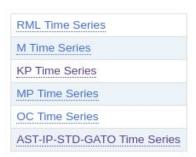
- more than 50 INAF and associated scientists in Italy, and from foreign institutes
- more than 15.000 spectra at TNG (HARPS-N and GIANO-B) since August 2012

GAPS required a strong interaction with TNG private data

- Customizable re-process of GAPS data with appropriate spectral line mask and options;
- Perform queries on additional metadata content;
- A flexible and collaborative tool to manage additional info about the project and the observations;
- A repository where to access, synchronize, share and search for interesting data.

GAPS Time Series

RML Time Series
M Time Series
KP Time Series
MP Time Series
OC Time Series
AST-IP-STD-GATO Time Series

- Product of the GAPS project
- Internally stored and built
- RV temporal series

GAPS KP Targets

GAPS Name	α	δ	μα	μδ	Mv	(B-V)	Spectral Type	Radial Velocity	Number of Data	Discarded Data	Time Series	Pdf Report	Status	Update On
KP1	03:48:00.370	+40:31:50.30	0.054000	0.021100	7.24	0.634	G2	-10.100	93	0	KP1.dat	KP1.pdf	active	2017-10-05 at 03:50
KP2	05:23:21.570	-02:16:39.40	0.034400	-0.096900	8.94	0.761	G5	29.590	51	0	KP2.dat	KP2.pdf	active	2017-10-05 at 04:50
KP3	08:53:50.810	+33:03:24.50	-0.095400	-0.028400	8.03	0.626	G0	21.300	96	0	KP3.dat	KP3.pdf	active	2019-01-23 at 01:25
KP4	10:18:21.290	+12:37:16.00	-0.272300	-0.039900	7.03	0.594	G0	22.600	63	0	KP4.dat	KP4.pdf	active	2017-05-21 at 21:18
KP5	12:15:06.570	-07:15:26.40	-0.249700	-0.052300	7.96	0.815	G5	20.660	47	0	KP5.dat	KP5.pdf	active	2017-06-23 at 21:14
KP6	02:34:11.046	-12:23:03.47	0.057300	-0.187700	9.85	0.000	F2	24.250	27	0	KP6.dat	KP6.pdf	rejected	2013-01-30 at 20:38
KP7	12:30:26.900	+22:52:47.30	0.127100	-0.089400	8.76	0.738	G9	-29.600	97	0	KP7.dat	KP7.pdf	active	2017-02-06 at 06:06
KP8	00:15:50.850	+01:12:00.75	0.002600	0.012500	11.30	0.476	F8	18.280	12	0	KP8.dat KP8_F.dat	KP8.pdf KP8_F.pdf	active	2016-10-07 at 02:53
KP9	00:18:24.700	-15:16:02.30	0.025500	-0.026500	11.30	0.576	G0	8.460	12	0	KP9.dat	KP9.pdf	active	2016-10-07 at 00:36
KP10	00:20:40.080	+31:59:23.79	-0.004800	-0.005600	11.79	0.538	F7	-13.500	13	0	KP10.dat KP10_F.dat	KP10.pdf KP10_F.pdf	active	2016-07-25 at 03:03

GAPS Time Series

Text File Format

- Custom ASCII format

  - Used in internally developed libraries

- Datasets and metadata stored in RDB

```
# GAPS_NAME:   KP7
# ALPHA:    12:30:26.900
# DELTA:    +22:52:47.30
# PROPER MOTION (ALPHA):   0.127100
# PROPER MOTION (DELTA):  -0.089400
# MAGNITUDE:   8.76
# (B-V):   0.738
# SPECTRAL TYPE:   G9
# SPECTRAL TYPE OF THE MASK:   G2
# SYSTEMIC RV:   -29.600 [km/s]
# TIME SERIES UPDATED ON:   2017-02-06 at 06:06
# -------------------------------------------------------------------
#ID           H_BJD               C_BJD          RVC[km/s]          dRVC[m/s]           BIS_SPAN
1       2456266.7756144     2456266.7768700   -30.000592793654    0.438641811740    -0.033687885349
2       2456288.7600700     2456288.7592600   -30.002592926899    0.652667304176    -0.035340040928
3       2456297.7797343     2456297.7778000   -30.017483243655    1.021413642952    -0.038451460912
4       2456298.7464164     2456298.7447100   -30.013971322659    0.401420395594    -0.033602684455
5       2456299.6857577     2456299.6840800   -30.017148485730    0.342304763703    -0.036787794336
6       2456305.7751079     2456305.7729100   -30.019509192761    0.414129371691    -0.034515653547
7       2456324.7450514     2456324.7415500   -30.025061639205    0.904676089902    -0.038409472716
8       2456324.8134471     2456324.8099100   -30.024866267906    0.610715811992    -0.031641312430
9       2456344.6559588     2456344.6513500   -30.041959907801    0.344306618194    -0.035302283354
10      2456345.5576606     2456345.5529300   -30.045054078932    0.483426241143    -0.032098020289
11      2456362.6409069     2456362.6358500   -30.045100931374    0.363052628555    -0.037400048651
12      2456363.6494948     2456363.6445000   -30.044223978297    0.421959466464    -0.036265889749
13      2456364.6765535     2456364.6715900   -30.045960349050    0.431904482152    -0.038855300832
14      2456365.6796057     2456365.6743900   -30.047683570576    0.404503349773    -0.035468293995
15      2456366.5462550     2456366.5393300   -30.050098153026    0.809221945047    -0.032358314979
16      2456375.5578538     2456375.5522500   -30.053986167976    0.656030366888    -0.038302196119
17      2456376.5564906     2456376.5511800   -30.052118020609    0.381495874323    -0.034762268290
18      2456379.6199837     2456379.6147900   -30.055001407306    0.463575651085    -0.034606213278
19      2456380.6110450     2456380.6058800   -30.055845494098    0.663712314063    -0.036645746079
20      2456382.6569003     2456382.6517400   -30.054586051565    0.365017000690    -0.036948848003
21      2456398.5531917              NaN       -30.053622043262    0.569969166224    -0.034282347747
22      2456399.5046787     2456399.5000600   -30.049408795551    1.275193650360    -0.036938724265
23      2456404.5386094     2456404.5339500   -30.050609779089    0.567713324318    -0.033962760561
```

GAPS Time Series

Pdf File Format

GAPS Target: KP7

Last update: 2017-02-06 at UT 06:06:11

Star	Value
α	12:30:26.900
δ	+22:52:47.30
μ_α	0.1271 arcsec/yr
μ_δ	-0.089 arcsec/yr
M_v	8.8
$(B-V)$	0.7
Spectral Type	G9
Radial Velocity	-29.60 km/s
Known planets	2

Table 1: Stellar parameters from GAPS Master Catalog.

Time series	Value
Data points	97
Acquisition	HARPN_ech_acq_wavesimult
Mean RV	-30.053 km/s
Median RV	-30.054 km/s
σ_{RV}	0.155 km/s
Mean Err_{RV}	0.66 m/s
Median Err_{RV}	0.53 m/s
$\sigma_{Err_{RV}}$	0.15 m/s
Independent frequencies[1]	118
Total SNR	10703

Table 2: Time series information. [1]From Horne & Baliunas, 1986, ApJ, 302, 757.

- Report in PDF format

  - Includes global metadata and data

  - Provides data overview

  - Linked in the relational DB

Target: KP7, 97 data point/s

KP7, n.pts: 97

Time Series in VO

VO & GAPS
June 2017

ASTERICS Wiki pages

Trace: · wp4exodm · wp4 · **wp4gapsinaf**

open:wp4:wp4gapsinaf

GAPS Time Series face-to-face Meeting

Edit

INAF-OAPd, Padova, 22/06/2017

[back to ASTERICS DADI WP4 main wiki page]

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Participants

Name	Affiliation
Marco Molinaro	INAF-OATs
Andrea Bignamini	INAF-OATs
Serena Benatti	INAF-OAPd
Riccardo Claudi	INAF-OAPd

- Time Series is one of the GAPS products

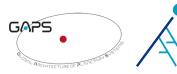- Time Domain is an IVOA priority

- Let's bring GAPS Time Series in the VO

Edit

Meeting Report

A face-to-face meeting has been held at INAF-OAPd (Padova, Italy) on Thursday the 22th of June 2017 to discuss the use cases and possible prototyping of a service to deploy dataset consisting of time series of radial velocity produced by the ⊕ GAPS project when studying stellar systems for discovery of exoplanets.

Time Series in VO

ADASS &
IVOA
Reports
October 2017

Our approach:
- Use Case (UC) driven
- DataSet discovery
- ObsCore based

Time Series in VO

Time Axis Characterisation

May 2018

ObsCore

Time Axis description

is not enough

ObsTAP Service

...or use whatever programmatic access based on the TAP protocol

ObsTAP Service

Use Case Fulfill

```
SELECT
        obs_collection, dataproduct_type, obs_id, target_name, access_url, access_format
FROM
        obscore
WHERE
        s_ra > 187.6 AND s_ra < 187.7 AND
        s_dec > 22.8 AND s_dec < 22.9 AND
        dataproduct_type = 'timeseries' AND
        o_ucd = 'spect.dopplerVeloc.opt'
```
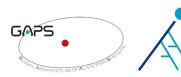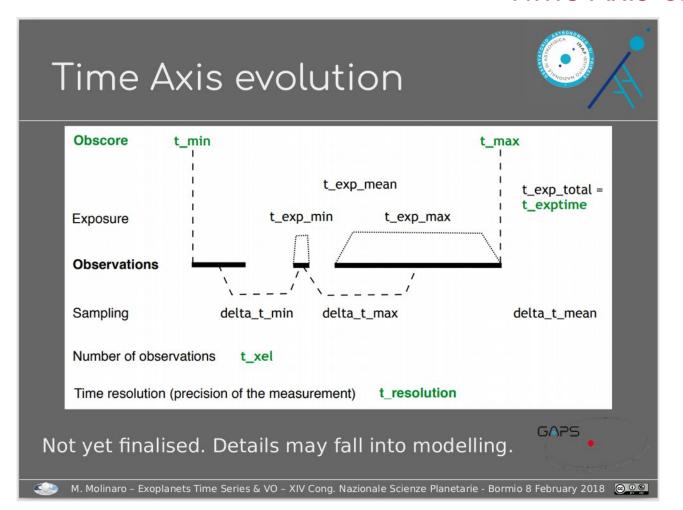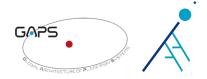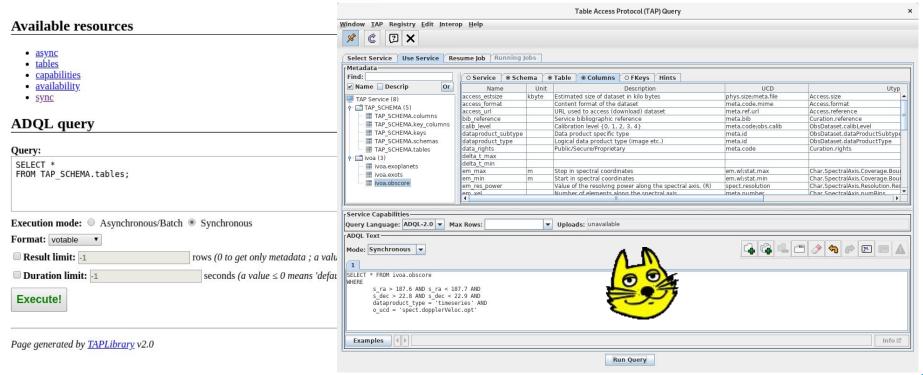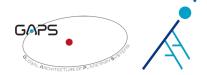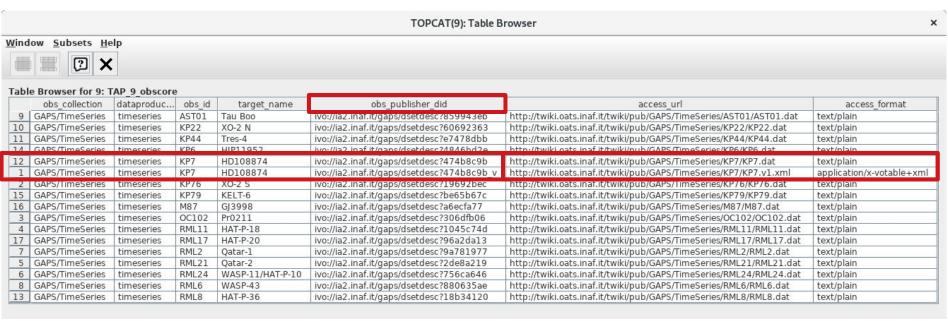
Table Browser for 14: TAP_14_obscore

	obs_collection	dataproduc...	obs_id	target_name	access_url	access_format
1	GAPS/TimeSeries	timeseries	KP7	HD108874	http://twiki.oats.inaf.it/twiki/pub/GAPS/TimeSeries/KP7/KP7.v1.xml	application/x-votable+xml
2	GAPS/TimeSeries	timeseries	KP7	HD108874	http://twiki.oats.inaf.it/twiki/pub/GAPS/TimeSeries/KP7/KP7.dat	text/plain

```
SELECT
        target_name, systemic_RV, access_url , planet_id, period, eccentricity
FROM
        obscore AS o
        JOIN
                exots AS s
                ON s.obs_publisher_did = o.obs_publisher_did
        JOIN
                exoplanets AS p
                ON p.obs_publisher_did = s.obs_publisher_did
WHERE
        confirmed IS NOT NULL
```

Table Browser for 12: TAP_12_obscore,exots,exoplanets

	target_name	systemic_RV	access_url	planet_id	period	eccentricity
1	HD108874	-29.6	http://twiki.oats.inaf.it/twiki/pub/GAPS/TimeSeries/KP7/KP7.dat	b	395.34	0.142
2	HD108874	-29.6	http://twiki.oats.inaf.it/twiki/pub/GAPS/TimeSeries/KP7/KP7.dat	c	1732.2	0.229

ObsTAP Service

Discovery Response

- Query response allows

  - Direct access (single format currently)

  - Dataset unique identification (see next steps…)

- Example provided of "annotated" table

ObsTAP Service

```
<VOTABLE version="1.3" xmlns="http://www.ivoa.net/xml/VOTable/v1.3">
  <!--
  !  VOTable written by STIL version 3.2-1 (uk.ac.starlink.votable.VOTableWriter)
  !  at 2018-03-29T12:21:35
  !-->
  <RESOURCE>
    <!-- Source parameters -->
    <PARAM arraysize="3" datatype="char" name="GAPS name" value="KP7">
      <DESCRIPTION>internal project target identifier</DESCRIPTION>
    </PARAM>
    <PARAM arraysize="12" datatype="char" name="alpha" ucd="pos.eq.ra;meta.main" value="12:30:26.900">
      <DESCRIPTION>Right Ascension of target</DESCRIPTION>
    </PARAM>
    <PARAM arraysize="12" datatype="char" name="delta" ucd="pos.eq.dec;meta.main" value="+22:52:47.30">
      <DESCRIPTION>Declination of target</DESCRIPTION>
    </PARAM>
    <PARAM datatype="float" name="PM alpha" ucd="pos.pm;pos.eq.ra" value="0.1271">
      <DESCRIPTION>Proper motion, alpha component</DESCRIPTION>
    </PARAM>
    <PARAM datatype="float" name="PM delta" ucd="pos.pm;pos.eq.dec" value="-0.0894">
      <DESCRIPTION>Proper motion, delta component</DESCRIPTION>
    </PARAM>
    <PARAM datatype="float" name="Magnitude" ucd="phot.mag;em.opt" unit="mag" value="8.76">
      <DESCRIPTION>Photometric magnitude (optical)</DESCRIPTION>
    </PARAM>
    <PARAM datatype="float" name="B-V" ucd="phot.color;em.opt.b;em.opt.V" unit="mag" value="0.738">
      <DESCRIPTION>B-V color</DESCRIPTION>
    </PARAM>
    <PARAM array
    <DESCRIPTI
    </PARAM>
    <PARAM array
    <DESCRIPTI
    </PARAM>
    <PARAM dat
    <DESCRIPTI
    </PARAM>
    <PARAM array
    <DESCRIPTI
    </PARAM>
```

```
<GROUP ID="char" name="characterisation" utype="ts:Char">
  <!-- This is the characterisation of the whole TimeSeries. It replaces Jiri's quantity and gavers "statistics"  -->
  <PARAM name="SpatLocationRA" ucd="pos.eq.ra" unit="deg" utype="ts:Char.SpatialAxis.Coverage.Location.Coord.SpatialValue2D[0]" datatype="float" value="187.651"/>
  <PARAM name="SpatLocationDEC" ucd="pos.eq.dec" unit="deg" utype="ts:Char.SpatialAxis.Coverage.Location.Coord.SpatialValue2D[1]" datatype="float" value="+22.88643"/>
  <PARAM name="SpatBoundsSizeRA" ucd="pos.eq.ra;stat.length" unit="deg" utype="ts:Char.Coverage.SpatialAxis.Bounds.CharBox.Size2[0]" datatype="float" value="0.0001"/>
  <PARAM name="SpatBoundsSizeDEC" ucd="pos.eq.dec;stat.length" unit="deg" utype="ts:Char.Coverage.SpatialAxis.Bounds.CharBox.Size2[1]" datatype="float" value="0.0001"/>
  <PARAM name="t_min" ucd="time.start" unit="d" utype="ts:Char.TimeAxis.Coverage.bounds.StartTime" datatype="float" value="2456266.77166"/>
  <PARAM name="t_max" ucd="time.stop" unit="d" utype="ts:Char.TimeAxis.Coverage.bounds.StopTime" datatype="float" value="2457790.764710648"/>
  <PARAM name="t_mean" ucd="time" unit="d" utype="ts:Char.TimeAxis.Coverage.location.TimeInstant" datatype="float" value="2456270"/>
  <PARAM name="t_exptime" ucd="time.duration" unit="d" utype="ts:Char.TimeAxis.Coverage.support.Extent" datatype="float" value="84008.801"/>
  <PARAM name="t_resolution" ucd="time.resolution" unit="d" utype="ts:Char.TimeAxis.resolution.RefVal" datatype="float" value="NaN"/>
  <PARAM name="delta_t_min" ucd="time" unit="d" utype="ts:Char.TimeAxis.sampling.bounds.SamplingPrecision.TimeStart" datatype="float" value="0.0002893517"/>
  <PARAM name="delta_t_max" ucd="time" unit="d" utype="ts:Char.TimeAxis.sampling.bounds.SamplingPrecision.TimeStop" datatype="float" value="298.2966319453"/>
  <PARAM name="em_min" ucd="em.wl;sta.min" unit="m" utype="ts:Char.SpectralAxis.Coverage.Bounds.Limits.LoLimit" datatype="float" value="0.000000383"/>
  <PARAM name="em_min" ucd="em.wl;sta.min" unit="m" utype="ts:Char.SpectralAxis.Coverage.Bounds.Limits.HiLimit" datatype="float" value="0.000000690"/>
</GROUP>
```

Annotated Serialisation

- Improve interoperability

- Share with colleagues

- Preserve metadata information

- Still in progress...

Next Steps

- ## Finalise serialisation

  - Requires model annotations

- ## DataLink solution

  - Complete time series dataset description

  - Allow multi-format dataset access

- ## Register the resource and service(s)

  - Simple positional search can be done through a Cone Search

  - Easier client approach

Thank You for Your Attention