Time Series: the GAPS Experience

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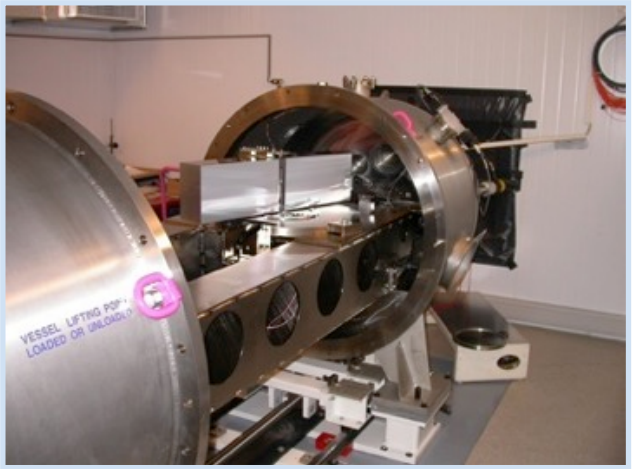
Exo-Planetary Systems Data Model Meeting
Padova, 20-21/09/2018

GAPS = Global Architecture of Planetary Systems

- Italian collaboration among ~80 scientists working in the exoplanets field
- Long-term multi-purpose observing program since 2012
- Radial velocities with HARPS-N@TNG & GIARPS@TNG ➔ **TIME SERIES**
- Characterization of the architectural properties of planetary systems and study of the origin of their diversity

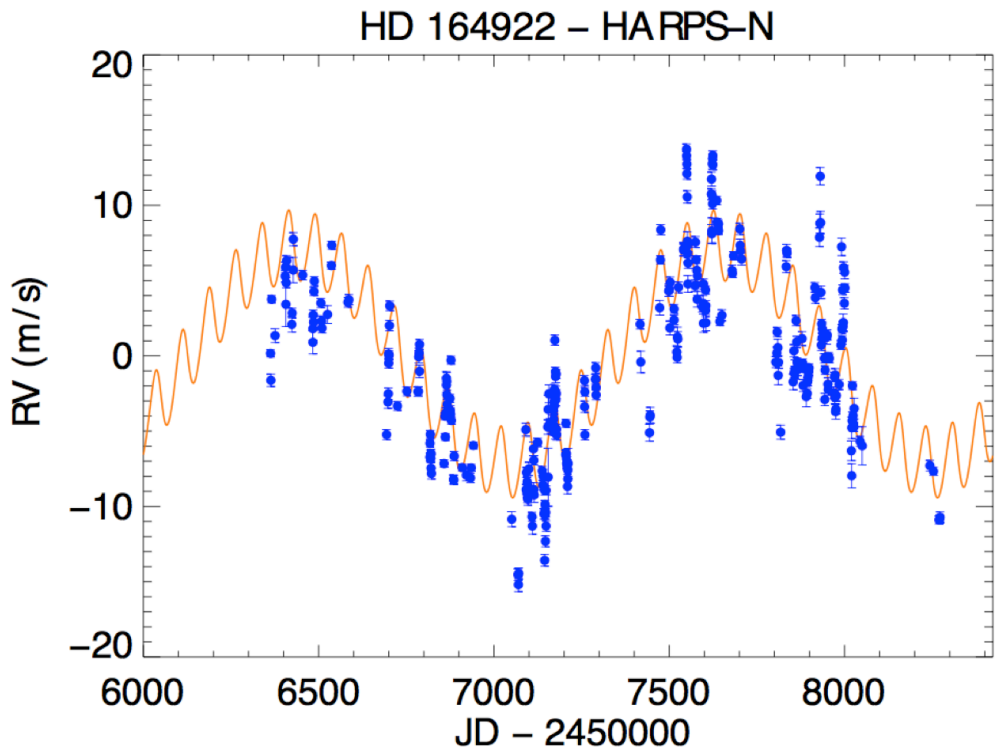


From spectra to time series

1 Spectrum → 1 Radial Velocity

From spectra to time series

More Spectra → RV Time Series



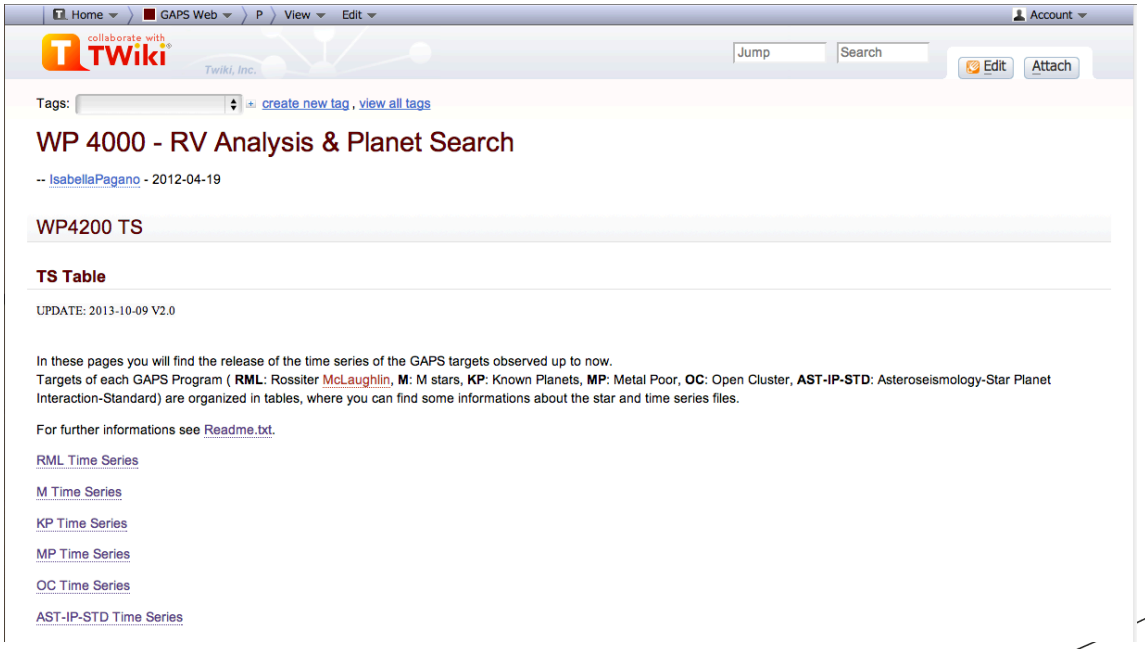
More than 300 RVs

Publication of Time Series on GAPS Twiki web page

http://twiki.oats.inaf.it/twiki/bin/view/GAPS/WP4000

Purpose:

- Collect the output of data reduction and other information
- **~300 targets**: Organize the data into sub-programs (RML, KP,…) through tables for an easy consultation
- Sharing the data to the whole community



Time Series tables

RML Targets

GAPS Name	multiple code	α	δ	μα	μδ	Mv	(B-V)	Spectral Type	Radial Velocity	Number of data	Time_series.dat	Report.pdf	Status	Updated on
RML1	-	19:07:53.11	46:52:05.95	0.0006	-0.0174	9.95	0.21	A0	-99999	23	RML1.dat	RML1.pdf	-	2012-08-08
RML2	KP33	20:13:31.62	65:09:43.48	0.0071	0.058	12.84	1.06	K3V	-38	13	RML2.dat	RML2.pdf	-	2012-09-04
RML3	-	23:15:58.30	31:27:46.28	0.0214	-0.0289	12.7	0.57	K5	-99999	13	RML3.dat	RML3.pdf	-	2012-11-13
RML4	KP13	02:49:44.49	71:45:11.63	0.09114	-0.03314	8.2	0.62	G0	-99999	0	-	-	-	2013Sep19
RML5	KP22	07:48:06.47	50:13:32.96	-0.0347	-0.1536	11.2	0.7	K0V	-99999	18	RML5.dat	RML5.pdf	-	2012-12-05
RML6	-	10:19:38.01	-09:48:22.50	-0.0432	-0.0432	12.4	1	K7V	-99999	49	RML6.dat	RML6.pdf	-	2013-03-31
RML7	KP25	10:22:43.60	50:07:42.03	-0.0266	0.0831	9.76	0.86	G5	12.49	0	-	-	-	2013Sep19
RML8	-	12:33:03.90	44:54:55.18	-0.0127	0.007	12.15	0.82	G0	-16.29	10	RML8.dat	RML8.pdf	-	2013-02-22
RML9	-	11:42:10.50	26:42:30.46	0.89607	-0.81354	10.59	1.47	M3.5	-99999	0	-	-	-	2013Sep19
RML10	KP36	13:44:22.60	48:01:43.18	-0.0233	-0.024	11.86	0.67	K0	-99999	23	RML10.dat	RML10.pdf	-	2013-06-11
RML11	KP75	17:05:23.20	33:00:44.97	-0.0213	-0.0442	12.76	-99999	K2	-11.92	20	RML11.dat	RML11.pdf	-	2013-06-12
RML12	-	19:50:22.47	40:58:38.20	0	0	14.5	0.45	F6	-1	1	RML12.dat	RML12.pdf	-	2013-07-13
RML13	KP35	21:38:08.73	+30:29:19.42	-0.0768	-0.1248	10.54	0	G0	20.13	0	-	-	-	2013Sep19
RML14	KP12	02:12:31.49	+51:46:43.57	-0.0107	0.0049	11.83	0	G0	-21.67	0	-	-	-	2013Sep19
RML15	-	23:46:39.98	+31:09:21.4	0.0246	-0.0093	12.18	0.68	G1	-26.5	0	-	-	-	2013Sep19
RML16	-	04:24:59.53	+39:27:38.29	0.0056	-0.0102	12.41	0.61	G5	31.67	0	-	-	-	2013Sep19
RML17	KP21	07:27:39.95	+24:20:11.37	0	0	11.34	0	K3	-18.81	0	-	-	-	2013Sep19
RML18	-	13:57:33.47	+43:29:36.8	-0.132	-0.038	12.84	0	K5	-40.64	0	-	-	-	2013Sep19
RML19	KP27	11:25:05.99	+41:01:40.65	-0.0007	0.0119	11.69	0	G3	-53.19	0	-	-	-	2013Sep19

Publication of Time Series : text file

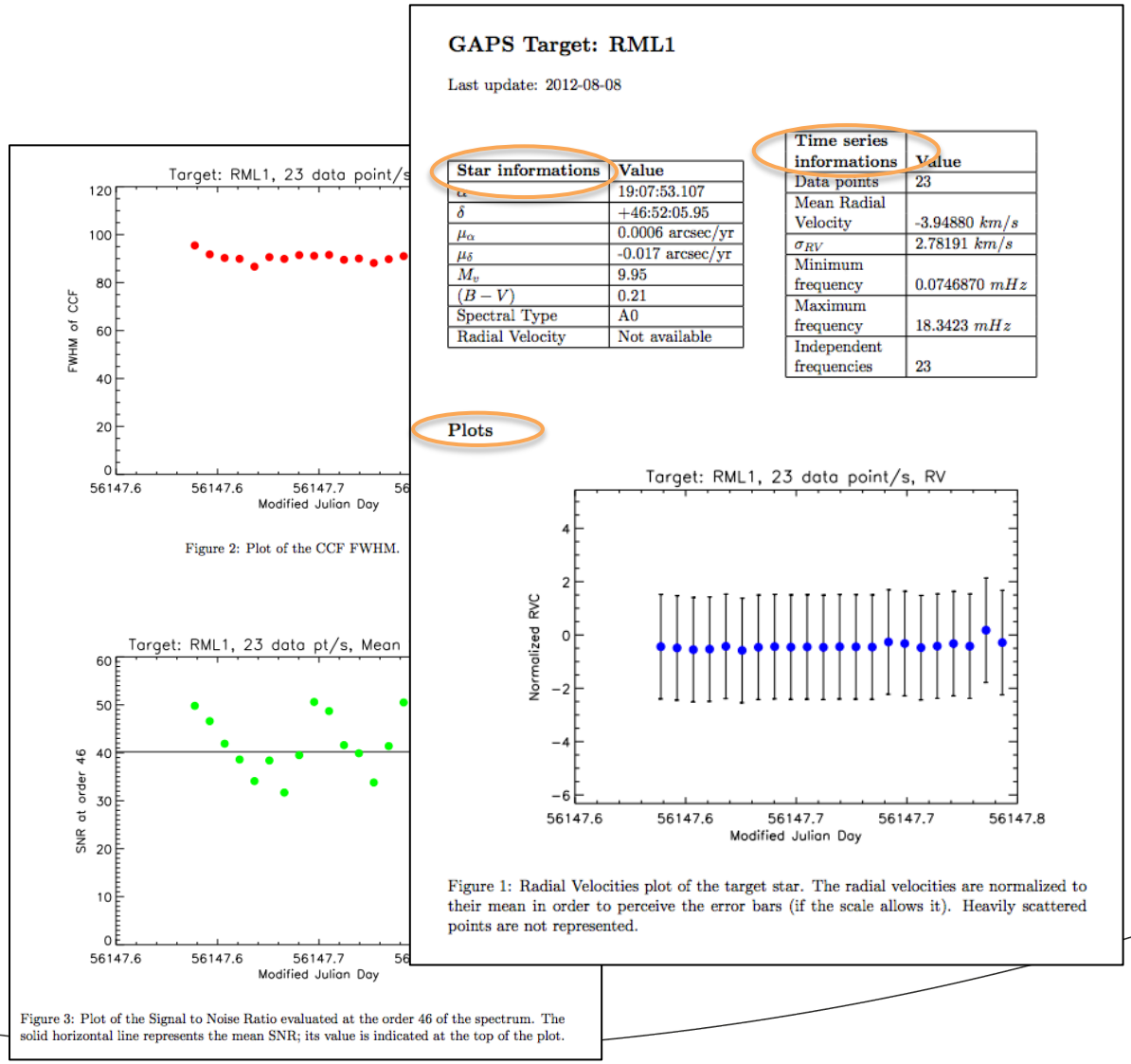
header

Date of the last observation

```
# GAPS_NAME:   RML1
# ALPHA:   19:07:53.107
# DELTA:   +46:52:05.95
# PROPER MOTION (ALPHA):   0.0006
# PROPER MOTION (DELTA):   -0.0174
# MAGNITUDE:   9.95
# (B-V):   0.21
# SPECTRAL TYPE:   A0
# SPECTRAL TYPE OF THE MASK:   A0
# SYSTEMIC RV:    Not available
# TIME SERIES UPDATED ON 2012-08-08
# ------------------------------------------------------------------------
   #            H_BJD            C_BJD       RVC [km/s]            dRVC         BIS SPAN          H alpha
RHK      CCF MAX CCP     CCF CONTRAST         CCF FWHM         CCF MASK        CCF NOISE      EXPTIME [s]
AIRMASS       H_CENTROID       C_CENTROID             SN46             BERV   DRIFT RV
            FLAG         FILENAME
   1  2456147.4394900  2456148.0887500       -2.2152331        2.5392145        0.6113757              NaN
NaN   1315       1.7068602       95.4835623              G2        0.0367460    600.000      1.060
NaN        0.4942426       49.7999992       -2.4385915        0.6950000              NaN
HARPN.2012-08-07T22-24-50.996
   2  2456147.4468400  2456148.0960700       -2.0294742        2.6923962        1.8425852              NaN
NaN   1177       1.8747494       91.7724104              G2        0.0372578    600.000      1.050
NaN        0.4895548       46.5999985       -2.4526570        0.3080000              NaN
HARPN.2012-08-07T22-35-25.848
   3  2456147.4541900  2456148.1034100       -1.7705271        2.9598276        1.8715971              NaN
NaN    986       1.9254806       90.2834709              G2        0.0353451    600.000      1.050
NaN        0.4893011       41.9000015       -2.4667856        0.3590000              NaN
HARPN.2012-08-07T22-46-00.316
   4  2456147.4615400  2456148.1107300       -1.8492645        3.1696269     -314.8375736              NaN
NaN    867       1.9322889       89.9215217              G2        0.0379059    600.000      1.050
NaN        0.4853115       38.5999985       -2.4809900        0.2580000              NaN
HARPN.2012-08-07T22-56-35.552
   5  2456147.4688900  2456148.1181600       -2.2600599        3.5460577     -162.5939615              NaN
NaN    727       1.9529274       86.6519246              G2        0.0344856    600.000      1.050
NaN        0.4959139       34.0999985       -2.4952226        0.2720000              NaN
HARPN.2012-08-07T23-07-10.408
   6  2456147.4762400  2456148.1254400       -1.6532845        3.2091325        1.1853325              NaN
NaN    860       1.9355438       90.6254397              G2        0.0387134    600.000      1.050
NaN        0.4870075       38.4000015       -2.5094555        0.2080000              NaN
HARPN.2012-08-07T23-17-45.260
   7  2456147.4835900  2456148.1328000       -2.1273322        3.7237463        1.4421552              NaN
NaN    604       1.9449996       89.8856131              G2        0.0374488    600.000      1.050
NaN        0.4878989       31.7000008       -2.5236409        0.3860000              NaN
HARPN.2012-08-07T23-28-20.497
   8  2456147.4909400  2456148.1410400       -2.2215189        3.0869397        0.1929622              NaN
NaN    846       1.9047241       91.4682999              G2        0.0384484    600.000      1.060
NaN        0.6156220       39.5000000       -2.5377917        0.3450000              NaN
HARPN.2012-08-07T23-38-55.349
```

```
#
H_BJD, C_BJD
RVC + dRVC
BIS VEL SPAN
H alpha, RHK
CCF MAX CCP
CCF CONTRAST
CCF FWHM
CCF MASK
CCF NOISE
EXPTIME
AIRMASS
H_CENTROID, C_CENTROID
SN46
BERV
DRIFT RV USED
FLAG
FILENAME
```

Publication of Time Series : Report



GAPS Target: RML1

Last update: 2012-08-08

Star informations	Value
α	19:07:53.107
δ	+46:52:05.95
μ_α	0.0006 arcsec/yr
μ_δ	-0.017 arcsec/yr
M_v	9.95
$(B-V)$	0.21
Spectral Type	A0
Radial Velocity	Not available

Time series informations	Value
Data points	23
Mean Radial Velocity	-3.94880 km/s
σ_{RV}	2.78191 km/s
Minimum frequency	0.0746870 mHz
Maximum frequency	18.3423 mHz
Independent frequencies	23

Plots

Figure 1: Radial Velocities plot of the target star. The radial velocities are normalized to their mean in order to perceive the error bars (if the scale allows it). Heavily scattered points are not represented.

Figure 2: Plot of the CCF FWHM.

Figure 3: Plot of the Signal to Noise Ratio evaluated at the order 46 of the spectrum. The solid horizontal line represents the mean SNR; its value is indicated at the top of the plot.

GAPS

FLAGS:

BS: Bad Seeing
NSA: No Seeing Available
NCE: Not Complete Exposure
NGA: No Guide Available
BG: Bad Guide
NWE: Not Working Exposure-meter
HC: Half Chip

```
# GAPS_NAME:   KP3
# ALPHA:   08:53:50.810
# DELTA:   +33:03:24.50
# PROPER MOTION (ALPHA):   -0.0954
# PROPER MOTION (DELTA):   -0.0284
# MAGNITUDE:   8.03
# (B-V):   0.00
# SPECTRAL TYPE:   G0
# SPECTRAL TYPE OF THE MASK:   G2
# SYSTEMIC RV:   +21.30 [km/s]
# TIME SERIES UPDATED ON 2014-02-10 at UT: 23:03
# ------------------------------------------------------------------------
          H_BJD            C_BJD        RVC[km/s]        dRVC[m/s]        BIS_SPAN
 2456200.7557668  2456200.7588300      21.8023656        0.8123805        0.0529019
 2456201.7554000  2456201.7582500      21.7956787        0.7163032        0.0519882
 2456202.7486562  2456202.7510800      21.7952829        0.6576859        0.0558640
 2456208.7552608  2456208.7576300      21.7957564        0.9855250        0.0638696
 2456211.7534035  2456211.7560300      21.8718552        0.0614172        0.1237391
 2456226.7223306             NaN      21.7984521        1.7967061        0.0622531
 2456244.7469618  2456244.7455600      21.8057955        0.5025945        0.0381191
 2456288.5732555  2456288.5682700      21.8453824        0.7686659        0.0346025
 2456295.5821588  2456295.5776400      21.8535595        0.6039189        0.0398504
10  24
11  24
```

BERV	DRIFT_RV	FLAG	FILENAME
25.5215625	0.3450000	NGA-NWE-HC-	HARPN.2012-09-30T06-07-15.768
25.7554460	0.4410000	NGA-NWE-HC-	HARPN.2012-10-01T06-04-06.212
25.9901392	0.4170000	NGA-NWE-HC-	HARPN.2012-10-02T05-54-16.667
27.1920155	0.5730000	NGA-NWE-HC-	HARPN.2012-10-08T06-03-01.817
27.6977589	-0.2920000	NGA-NWE-HC-	HARPN.2012-10-11T05-59-57.914
29.0989499	0.8990000	NGA-NWE-HC-	HARPN.2012-10-26T05-14-50.038
28.1263962	1.8040000	NGA-NWE-	HARPN.2012-11-13T05-46-09.953
15.2249617	-0.5010000	NGA-NWE-	HARPN.2012-12-27T01-31-14.694
12.0085557	-0.8990000	NGA-NWE-	HARPN.2013-01-03T01-43-36.868
11.4624986	0.2310000	NGA-NWE-	HARPN.2013-01-04T02-24-41.442
10.8799222	0.8080000	NGA-NWE-	HARPN.2013-01-05T03-22-15.822

IDL command (readcol.pro) to read the .dat files

Improvement: GAPS Database

collaborate with TWiki

Twiki, Inc.

Tags: create new tag , view all tags

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	93	0	KP3.dat	KP3.pdf	active	2018-01-05 at 05:13
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
KP11	00:38:17.560	+42:27:47.08	-0.020300	-0.005600	10.81	0.542	F8	-16.830	21	0	KP11.dat KP11_F.dat	KP11.pdf KP11_F.pdf	active	2017-09-15 at 03:41
KP12	02:12:31.494	+51:46:43.57	-0.010700	0.004900	11.83	0.553	G0	-21.650	28	0	KP12.dat	KP12.pdf	active	2017-08-31 at 05:15
KP13	02:49:44.488	+71:45:11.63	0.091100	-0.033100	8.17	0.000	G0	-3.300	26	0	KP13.dat	KP13.pdf	active	2016-10-22 at 01:11
KP14	02:54:45.140	-10:53:53.00	0.004100	0.007500	11.60	0.742	G9	25.400	12	0	KP14.dat	KP14.pdf	active	2016-01-03 at 20:13
KP15	03:09:28.550	+30:40:24.90	-0.004000	-0.049100	11.89	0.989	K3	4.910	21	0	KP15.dat	KP15.pdf	active	2017-09-23 at 03:51
KP16	04:21:52.700	+57:49:01.89	-0.004800	0.002300	9.91	0.372	F5	-12.050	21	0	KP16.dat KP16_F.dat	KP16.pdf KP16_F.pdf	active	2016-10-19 at 03:39
KP17	05:04:19.630	-06:13:47.30	0.019100	0.010900	10.95	0.548	F9	17.720	13	0	KP17.dat KP17_F.dat	KP17.pdf KP17_F.pdf	active	2016-10-18 at 05:03
KP18	06:30:32.790	+29:40:20.29	-0.000700	-0.007800	11.69	0.544	G0	19.060	23	0	KP18.dat	KP18.pdf	active	2017-09-26 at 05:47
KP19	07:15:18.020	+14:15:45.39	0.009800	-0.003500	11.76	0.467	F8	-2.090	17	0	KP19.dat	KP19.pdf	active	2016-05-04 at 20:58

GAPS

Time Series & Observing Reports

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collaborate with TWiki

Tags: create new tag , view all tags

Target Summary of KP1

GAPS Target: KP1

Data Points: 93
Last Update: 2017-10-05 at 03:50
Status: active

Star Informations

α: 03:48:00.370
δ: +40:31:50.30
μα: 0.054000 arcsec/yr
μδ: 0.021100 arcsec/yr
Mv: 7.24
(B-V): 0.634
Spectral Type: G2
Radial Velocity: -10.100 km/s

Available Observation Reports

2017-01-02
2016-10-21
2016-09-18
2016-08-23
2016-08-03
2016-08-02
2016-03-27
2016-03-26
2016-03-24
2016-02-24
2016-01-31

GAPS2: more time series…

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collaborate with TWiki

Tags: create new tag , view all tags

-- SerenaBenatti - 2018-01-24

YO17

Name	VIS	NIR	Photometry	Notes
YO01	CaHK_TERRA.dat harpsn_DRS.rv [BJD_TDB] harpsn_TERRA.rv [BJD_TDB]	gianob.txt [MJD]		CaHK di TERRA non è aggiornato agli ultimi spettri
YO13	harpsn_TERRA.dat [BJD_TDB] harpsn_DRS.rv [BJD_TDB]	gianob.txt [MJD]		
YO14	harpsn_DRS.rv [BJD_TDB] harpsn_TERRA.dat [BJD_TDB]	RV_wei_mask_mean.txt [MJD]	Fotometria STELLA : I_band.dat V_band.dat	RV NIR poco affidabili causa scarsità di righe
YO16	YO16_harpsn_DRS.dat[BJD_TDB YO16_harpn_S.rdb YO16_asy.dat	RV_wei_mask_mean.txt [BJD]	Fotometria STELLA: I_band.dat V_band.dat	RV GIANO non aggiornate
YO17	haprsn_TERRA.txt [BJD_TDB] harpsn_DRS.rv [BJD_TDB]	YO17_gianob.txt [MJD]	Fotometria STELLA : I_band.dat V_band.dat	
YO21	YO21_harpsn_DRS.dat[BJD_TDB YO21_harpn_S.rdb		Fotometria STELLA : I_band.dat	

Two instruments:

- RV VIS
- RV NIR

+ photometry

RV program
ATM program

Lesson learned

- Useful to get the TS ready for the analysis
- The side report is useful to get information on the targets
- Useful as a quick look on the observations
- Missing: orbital elements of known planets