GAPS

S. Desidera & GAPS Team

Meeting Title
Place

Global Architecture of Planetary Systems

- Collaboration among many Italian scientists working in the exo-planetary field
- Supported by Premiale WOW
- Asked and obtained a long-term multi-purpose observing program
- Method: Radial Velocities
- Instrument: HARPS-N@TNG
- Aims: Characterization of the architectural properties of planetary systems

More than 60 people from INAF Observatories & Universities

+

GAPS facts

Objectives:

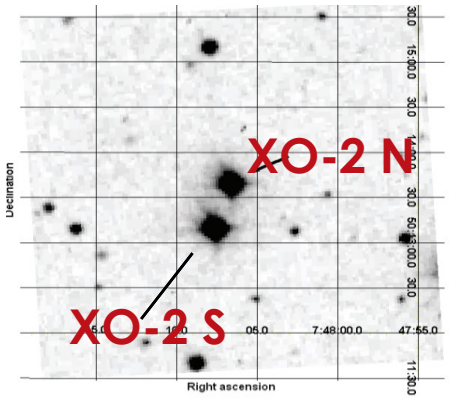
- **Frequency** of exoplanets around M stars, metal poor stars, stars in open clusters
- Search for **additional low mass companions** in stars with known planets
- **Characterization** through Rossiter-McLaughlin effect and Asteroseismology/SPI (star-planet interaction) and orbital refinement of known systems

- ~2500 allocated hours
- > 6500 spectra
- ~ 250 targets
- 13 accepted papers, 1submitted, many others in preparation or close to the submission

lected and retrieved 13 abstracts.

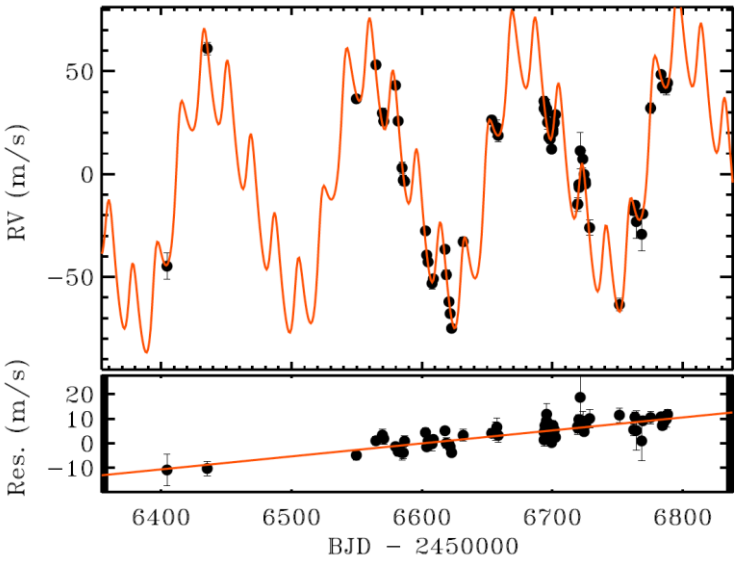
Bibcode Authors	Score Title	Date	List of Links Access Control Help
2016A&A...588A.118M Malavolta, L.; Nascimbeni, V.; Piotto, G.; Qian, S. N.; Borsato, L.; Granata, V.; Bonomo, A. S.; Marzari, F.; Bedin, L. R.; Rainer, M.; and 38 coauthors	1.000 The GAPS programme with HARPS-N at TNG. XI. Pr 0211 in M 44: the first multi-planet system in an open cluster	04/2016	A E F X D R U
2015A&A...583A.135B Biazzo, K.; Gratton, R.; Desidera, S.; Lacatello, S.; Sozzetti, A.; Bonomo, A. S.; Damasso, M.; Gandolfi, D.; Affer, L.; Boccato, C.; and 19 coauthors	1.000 The GAPS programme with HARPS-N at TNG. X. Differential abundances in the XO-2 planet-hosting binary	11/2015	A E F X D R C S O U
2015ApJ...811L..2M Maggio, A.; Pillitteri, I.; Scandariato, G.; Lanza, A. F.; Sciortino, S.; Borsa, F.; Bonomo, A. S.; Claudi, R.; Covino, E.; Desidera, S.; and 7 coauthors	1.000 Coordinated X-Ray and Optical Observations of Star-Planet Interaction in HD 17156	09/2015	A E F X D R C S U
2015A&A...583L...6D Damasso, M.; Esposito, M.; Nascimbeni, V.; Desidera, S.; Bonomo, A. S.; Bieryla, A.; Malavolta, L.; Biazzo, K.; Sozzetti, A.; Covino, E.; and 32 coauthors	1.000 The GAPS programme with HARPS-N at TNG. IX. The multi-planet system KELT-6: Detection of the planet KELT-6 c and measurement of the Rossiter-McLaughlin effect for KELT-6 b	09/2015	R C S U
2015A&A...579A.136M Mancini, L.; Esposito, M.; Covino, E.; Raia, G.; Southworth, J.; Tregloan-Reed, J.; Biazzo, K.; Bonomo, A. S.; Desidera, S.; Lanza, A. F.; and 29 coauthors	1.000 The GAPS Programme with HARPS-N at TNG. VIII. Observations of the Rossiter-McLaughlin effect and characterisation of the transiting planetary systems HAT-P-36 and WASP-11/HAT-P-10	07/2015	A E F X D R C S O U
2015A&A...578A..64B Borsa, F.; Scandariato, G.; Rainer, M.; Bignamini, A.; Maggio, A.; Poretti, E.; Lanza, A. F.; Di Mauro, M. P.; Benatti, S.; Biazzo, K.; and 27 coauthors	1.000 The GAPS programme with HARPS-N at TNG. VII. Putting exoplanets in the stellar context: magnetic activity and asteroseismology of τ Bootis A	06/2015	A E F X D R C S O U
2015A&A...577A.132M Maldonado, J.; Affer, L.; Micela, G.; Scandariato, G.; Damasso, M.; Stelzer, B.; Barbieri, M.; Bedin, L. R.; Biazzo, K.; Bignamini, A.; and 22 coauthors	1.000 Stellar parameters of early-M dwarfs from ratios of spectral features at optical wavelengths	05/2015	A E F X D R C S O U
2015A&A...575L..15S Sozzetti, A.; Bonomo, A. S.; Biazzo, K.; Mancini, L.; Damasso, M.; Desidera, S.; Gratton, R.; Lanza, A. F.; Poretti, E.; Rainer, M.; and 31 coauthors	1.000 The GAPS programme with HARPS-N at TNG. VI. The curious case of TrES-4b	03/2015	A E F X D R C S O U
2015A&A...575A.111D Damasso, M.; Biazzo, K.; Bonomo, A. S.; Desidera, S.; Lanza, A. F.; Nascimbeni, V.; Esposito, M.; Scandariato, G.; Sozzetti, A.; Cosentino, R.; and 49 coauthors	1.000 The GAPS programme with HARPS-N at TNG. V. A comprehensive analysis of the XO-2 stellar and planetary systems	03/2015	A E F X D R C S O U
2014A&A...567L...6D Desidera, S.; Bonomo, A. S.; Claudi, R. U.; Damasso, M.; Biazzo, K.; Sozzetti, A.; Marzari, F.; Benatti, S.; Gandolfi, D.; Gratton, R.; and 41 coauthors	1.000 The GAPS programme with HARPS-N at TNG. IV. A planetary system around XO-2S	07/2014	A E F X D R C S O U
2014A&A...564L..13E Esposito, M.; Covino, E.; Mancini, L.; Hartytyan, A.; Southworth, J.; Biazzo, K.; Gandolfi, D.; Lanza, A. F.; Barbieri, M.; Bonomo, A. S.; and 15 coauthors	1.000 The GAPS Programme with HARPS-N at TNG. III. The retrograde orbit of HAT-P-16b	04/2014	A E F X D R C S O U
2013A&A...551A..79D Desidera, S.; Sozzetti, A.; Bonomo, A. S.; Gratton, R.; Poretti, E.; Claudi, R.; Latham, D. W.; Affer, L.; Cosentino, R.; Damasso, M.; and 30 coauthors	1.000 The GAPS programme with HARPS-N at TNG. II. No giant planets around the metal poor star HIP 11952	06/2013	A E F X D R C S O U
2013A&A...551A..29C Covino, E.; Esposito, M.; Barbieri, M.; Mancini, L.; Nascimbeni, V.; Claudi, R.; Desidera, S.; Gratton, R.; Lanza, A. F.; Sozzetti, A.; and 60 coauthors	1.000 The GAPS programme with HARPS-N at TNG. I. Observations of the Rossiter-McLaughlin effect and characterisation of the transiting system Qatar-1	06/2013	A E F X D R C S O U

Planet detections: XO-2 S b & c

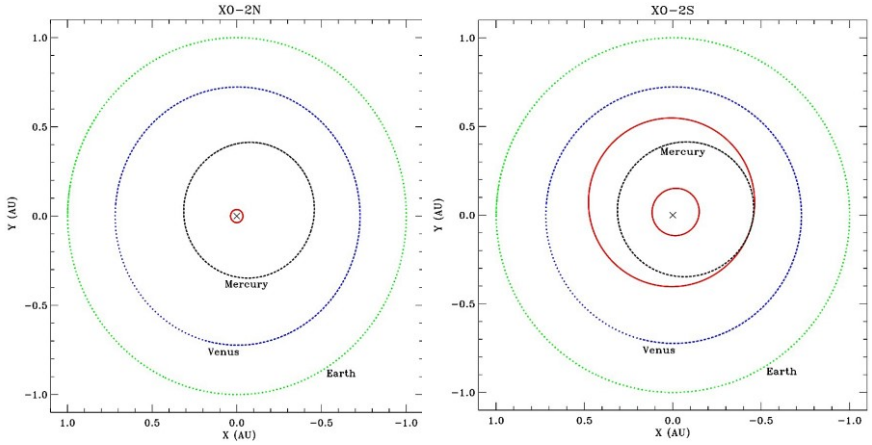


Burke et al. 2007: Hot Jupiter transiting XO-2 N
Desidera et al. 2014: 2 planets around XO-2S
First case of binary system on which both components host planets

	XO-2 Sb	XO-2 Sc
P [d]	18.157	120.80
m sini [M_J]	0.259	1.370
e	0.180	0.153



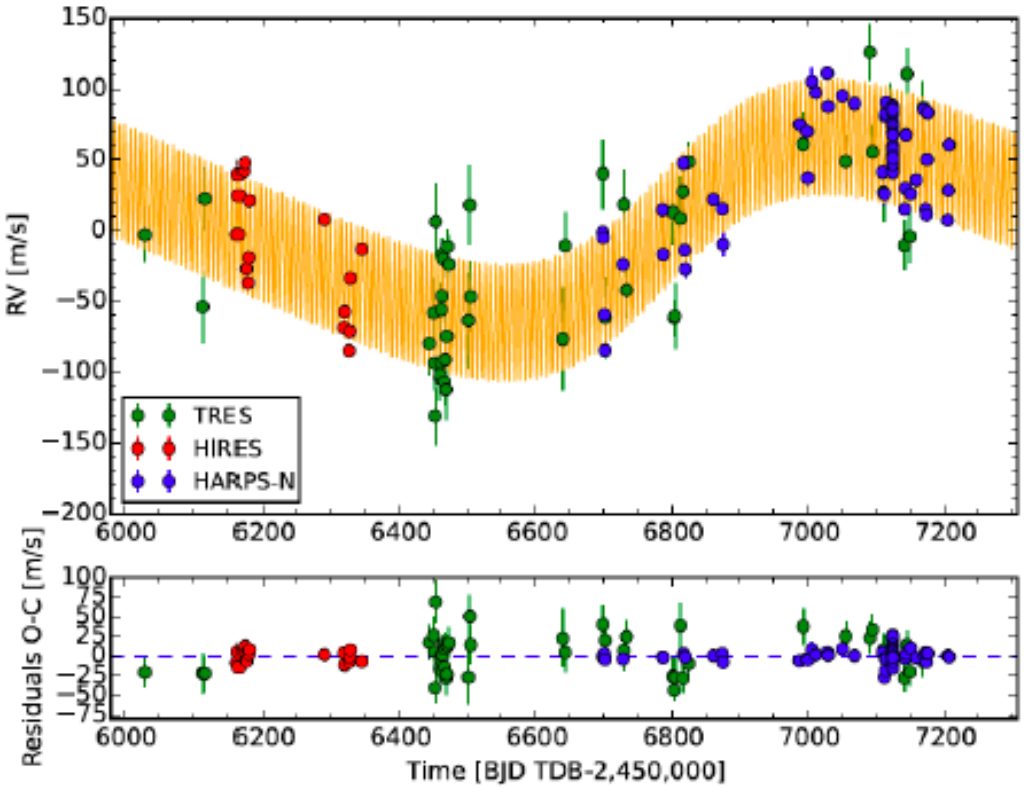
Laboratory for planet formation process:

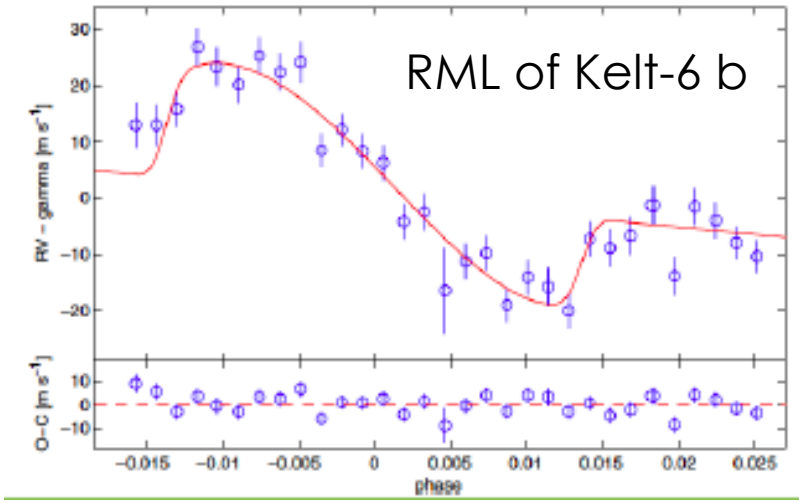


Abundance difference between the components
Damasso et al 2015, Biazzo et al. 2015

Planet detections: Kelt-6 c

Kelt-6 b, Saturn-mass planet orbiting a late-F star (Collins et al. 2014)



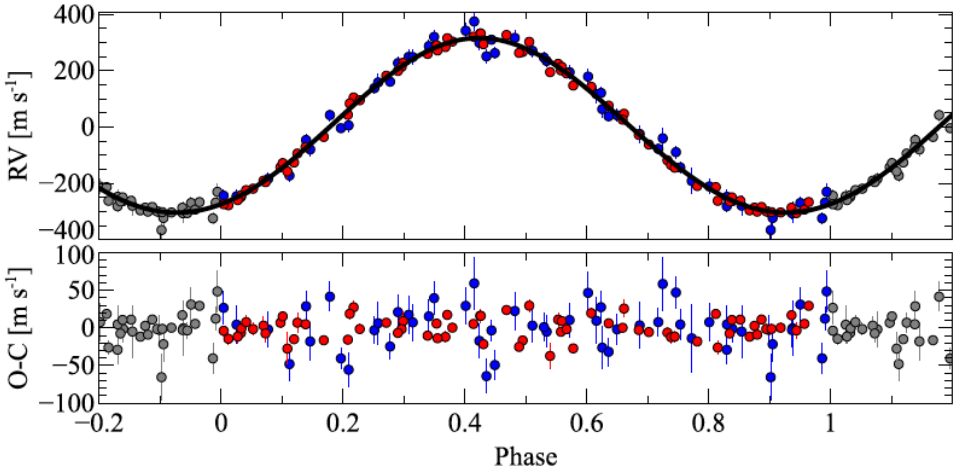


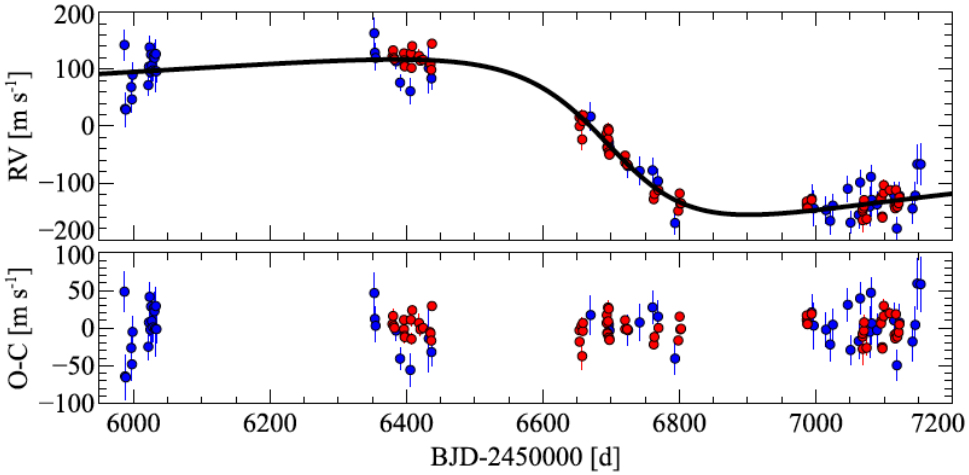
	Kelt-6 b	Kelt-6 c
Period	7.8 d	1276 ± 74 d
Mass	0.44 M_J	3.7 M_J
e	0.03	0.2
λ	-36 ± 11	-

Damasso et al. 2015

First planetary system in OC (Malavolta et al. 2016)

70 HARPS-N + 36 TRES observations of the known Hot Jupiter around Pr 0211 (Quinn et al. 2012), additional photometric observations (STELLA)

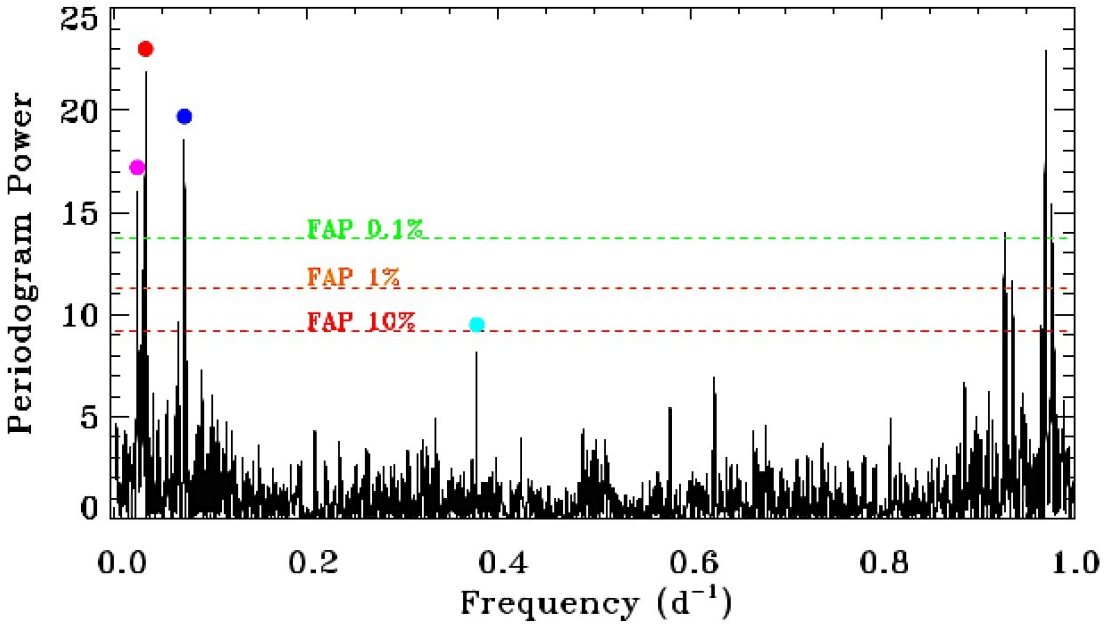




Parameter	Pr0211b	Pr0211c	unit
P	$2.14609 \pm 2 \cdot 10^{-5}$	4364^{+3237}_{-1327}	days
K	309.7 ± 2.5	136 ± 4	m s^{-1}
ϕ	153.0 ± 0.4	259 ± 4	deg
$\sqrt{e}\sin\omega$	-0.03 ± 0.06	0.79 ± 0.07	
$\sqrt{e}\cos\omega$	$0.12^{+0.04}_{-0.06}$	-0.17 ± 0.08	
e	0.019 ± 0.009	0.65 ± 0.11	
ω	344 ± 28	103 ± 6	deg
$M_p \sin i$	1.91 ± 0.02	8.1 ± 0.2	M_{jup}
a	0.03210 ± 0.00009	$5.2^{+2.3}_{-1.1}$	AU

- HJ in nearly circular orbit
- Long period Jupiter in high eccentricity orbit
- Activity in this target stronger with respect to other M44 targets
- Other 4 planet candidates in M44 (Malavolta et al. in preparation)

Planet detections: GJ 3998 b & c



Super Earths system around an M dwarf

Affer et al. submitted

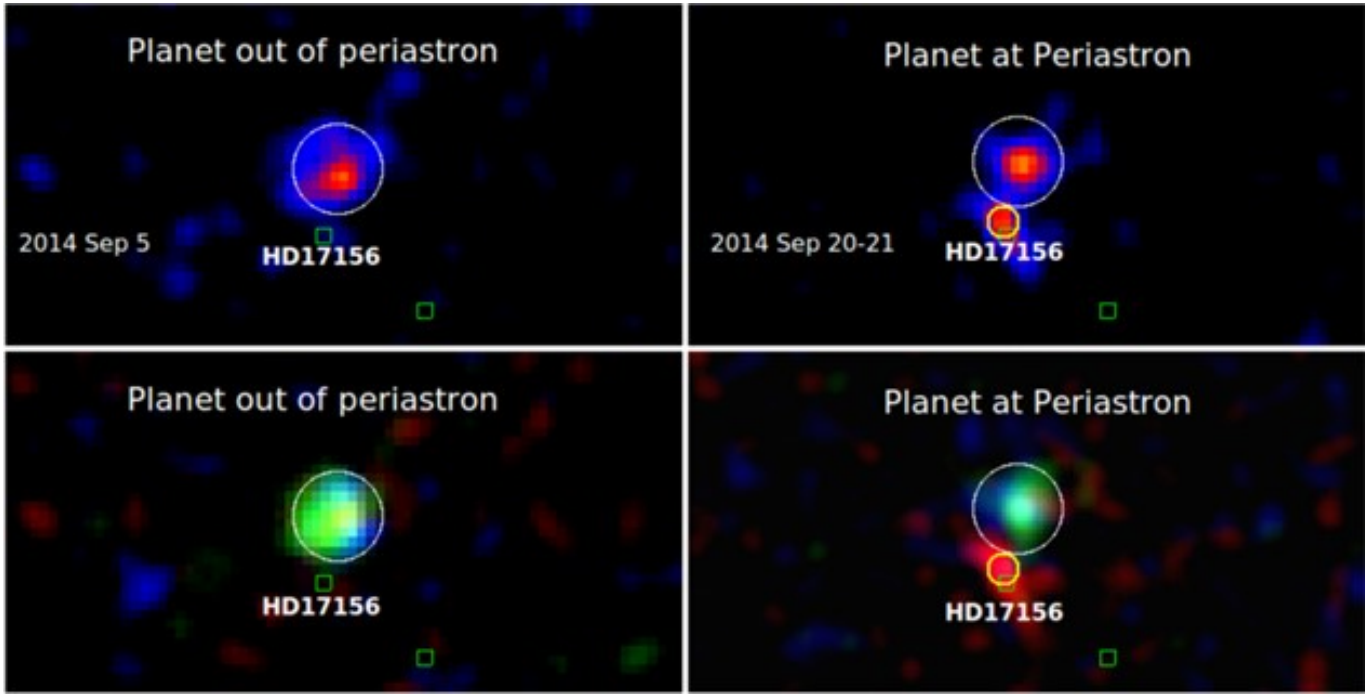
HADES *(HArps-n red Dwarf Exoplanet Survey):*
GAPS + ICE + IAC

- P = 30.7 d: rotational period of the star
- P = 42.5 d: modulation of the stellar variability due to differential rotation
- P = 2.6 d: orbital period of GJ 3998b
- P = 13.7 d: orbital period of GJ 3998c

Msini ~ 2.5 M_{Earth}
P = 2.6 d
e = 0
K = 1.8 m/s

Msini ~ 6 M_{Earth}
P = 13.7d
e = 0.06
K = 2.7 m/s

Star-planet interaction in a highly eccentric planetary system



Strong increase in X-ray luminosity and chromospheric emission close to periastron passage of the planet around HD 17156 in a highly eccentric orbit

Maggio et al. 2015

System characterization and other results

- Rossiter-McLaughlin effect: ***Covino et al. 2013***, ***Esposito et al. 2014***, ***Damasso et al. 2015***, ***Mancini et al. 2015***, ***Damasso et al. 2015***, ***Esposito et al. in prep.***
- Planet rejection: ***Desidera et al. 2013***
- Major refinements for Tres-4: ***Sozzetti et al. 2015***
- Stellar parameters of early-M dwarfs ***Maldondo et al. 2015***
- Asteroseismology of τ Boo: ***Borsa et al. 2015***
- Characterization of HD 108874: ***Benatti et al. in prep***
- Structure and evolution of transiting giant planets: ***Bonomo et al. in prep.***

Lessons learned

- Coordinated work in a national community worked fine
- RV planet searches need a lot of time especially when looking to low-mass planets (about 100 obs/star needed)
- The role of stellar activity in hiding or mimiking planets: rely on specific expertise in Italian community (“traditional” stellar science work)

Perspectives

- Relevance of experiments tailored to test key aspects of planet formation and evolution
- Increasing role of planet characterization
- Lessons from previous planet discovery efforts:

  many, many, surprises and unexpected discoveries
- Exoplanet science well-placed in MA2 but synergies with Solar System community to be exploited (in progress within WOW framework) (and of course with MA5 for technological projects)

Perspectives for GAPS

- Exploit instrumentation uniquely available:
  GIARPS unique tool for planet detection (for specific type of stars) and characterization
- Exploit synergies with other projects on which we have significant participation (SPHERE, GAIA, CHEOPS, on longer term PLATO, ARIEL, etc)
- Increase synergies with HARPS-N Consortium (currently two high-merit targets monitored jointly + time exchanges when needed for optimal scheduling of planet candidates)
- Agreement INAF-HARPS-N Consortium ending May 2017; of course interest of GAPS team in keeping HARPS-N at TNG