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C. Reylé, J. Richard, L. Cambrésy, M. Deleuil, E. Pécontal, L. Tresse and I. Vauglin (eds)

TELESCOPE BERNARD LYOT: OPERATION, INSTRUMENTATION, PERSPECTIVES

R. Cabanac[1] and TBL Team[2]

Abstract. This talk is the TBL director report at the 3rd French national telescopes Users Meeting of 2016. Telescope Bernard Lyot, the 2-m at Pic du midi (2870m), is dedicated to spectro-polarimetric studies since 2007 with the instrument Narval. This paper presents TBL operation, science highlights and statistics of the past 10 years of operation. It also opens perspectives for the coming 10 years with the funding of Neo-Narval (Narval stabilized to $v_r < 3$m/s) and SPIrou at Pic du midi (aka SPIP) for the study of the young exoplanetary systems.

Keywords: Telescope operation, instrumentation, spectropolarimetry, stellar magnetism, exoplanets

1 Introduction

Before describing the details of Telescope Bernard Lyot operations, it is important to recall the users that Pic du midi Observatory is still used for science observations today because of the partnership with an independent administration, a public syndicate, funded by Occitanie Region, departmental and local governments. That public administration is responsible for maintaining the buildings, the access to the summit via a cable car, and the hotel and restaurant logistics. The public administration also runs a museum and a planetarium in the historic part of the summit and manage an average of 100,000 public visitors per year. A leasing treaty running until 2029 is regulating the partnership between the Observatory Midi-Pyrenees (University of Toulouse, Paul Sabatier) and the public administration. This partnership is extremely successful and few common projects are on tracks, an international Dark Sky reserves covering 3000 km^2 around Pic du midi, and a World Heritage UNESCO series is on track (High Mountain Observatories, with Spanish, Chilean and US partners).

2 TBL administrative status in 2016

At the beginning of the last contract (2012-2015), CNRS INSU has proposed to delegate the administrative management of the National Telescopes (OHP T2M and TBL) to their local Universities (Aix-Marseille and U Toulouse), which both have an Observatory (OSU Pytheas and OMP). The date of TBL adminitrative transfer to OMP was set to the end of the contract (31 dec 2015). Starting in 2013, A working group have extensively discussed and prepared to fusion of TBL to the OMP staff, and proposed a working solution for TBL to continue its science observations in optimal conditions. Since January 1st, TBL is therefore managed by OMP Executive Science Director at Pic du midi and Tarbes (R. Cabanac until Sept 6, 2016, Eric Josselin from Sept 7, 2016).

2.1 TBL budget in 2016

The University Paul Sabatier funding to TBL is 40 keuros per year, the CNRS contribution is 80 keuros. This budget barely covers costs for operating the telescope in service mode, and TBL still needs project-oriented funding for instrumentation upgrades and dome maintenance. The staff is divided between 11 University staff and 9 CNRS staff for a global budget (including salaries) of ∼1 million euros.

[1] IRAP, University of Toulouse, CNRS, France
[2] OMP-TBL, University of Toulouse, CNRS, France

2.2 TBL staff

TBL staff has gained 2 new telescope operators to increase the number of observable nights to 320, but the electronic TBL specialists are now requested to support all Pic du midi telescope and experiments, the staff is now 8 operators, 5.5 electronicians, and 5.5 support staff (2 software, 1 secretary, 1 instrument specialist, 1 technical director).

3 Science operations

3.1 Service observing

TBL is operated in full service mode since semester 2009B. Philippe Mathias, CNAP AA SO3, is responsible of this service that covers all aspects of observations. A team of 4 CNAP support astronomers (SO3) shares the task of preparing observing queues each night for the service observers. Service observateurs are hired among Masters and PhD students all over France, post-docs who wish to gain experience in telescope observations and among a team of volunteers (TBL associated observers) who are trained for observations at TBL.
Service observing at TBL includes the proposal phase (through Northstar interface), 2 calls for proposals per year in semesters A (March 1-August 31) and semesters B (Sept 1- Feb 28), the Time allocation phase then done by the French national TAC, the observations performed by TBL science team after successful PI have filled their Phase 2 program definition (Protected link to PH2), the release of all observations, which are reduced and released to the PIs after a quality check and validation process is done by the support astronomer, at the end of each night of observations (using automated software). A PH2 night log allows PI to follows the progress of their program during the semester. Finally, TBL /Narval data is kept proprietary for one year is spectroscopic mode and 2 years for polarimetric mode, after which data is released on the Public TBL Legacy database and Polar Base database.

3.2 TBL users

TBL observing time is mostly reserved to the French astronomical community that have performed 208 science programs between 2007A and 2015B, 10 Large programs running for 4 consecutive semesters and covering 50% of the observing time, and 188 PI programs of one semester. The science themes of the programs are mostly stellar physics (188), interstellar medium (4), and planetology (16).
TBL also participates to European Transnational access program OPTICON that buys nights at consolidated cost to 22 european-managed 2 to 4-m telescopes. Between 2007A and 2015B, 19 programs where selected and funded by OPTICON.
Finally, TBL can sell nights (at consolidated costs) to foreign PIs or Agencies, 3 such foreign programs were 'allocated' since 2007A (for Bulgarian Academy of Science, and Netherland).
The following table summarizes the statistics of proposals and pressure on the offered clear times.

Source des demandes TBL/NARVAL depuis 2007:

Mode service

	2006B	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
PNPS	173	407	386	282	200.5	145.5	156	138.5	138	168	167
PNP	0	0	41	55	37	12	0	10.5	14.5	15	3
PCMI	0	32	0	1	5	0	0	0	1	5	4
OPTICON	0	33	48	25	7.5	21	28	5.5	13.5	23	14.5
AUTRE								4			3.5
	173	472	475	363	250	178.5	184	158.5	167	211	192
PRESSION	-	2.0	2.0	4.8	3.3	2.4	2.5	2.1	2.2	2.8	**2.6 (PI<2)**

3.3 Science highlights in 2016

Any non-exhaustive science highlight is necessarily biased by an arbitrary selection function, the one chosen here is to mention works that underline the notable quality of Narval used in synergy with other instruments. In this respect, two papers are worth mentioning, the first one is a work of Hébrard et al. (2016), that made a detailled analysis of the correlation observed in magnetic M dwarf stars between their phometric jitter and magnetic fields, five stars were followed (GJ 205, GJ 358, GJ 410, GJ 479, GJ 846) with HARPS-Pol and NARVAL (see Figure 1).

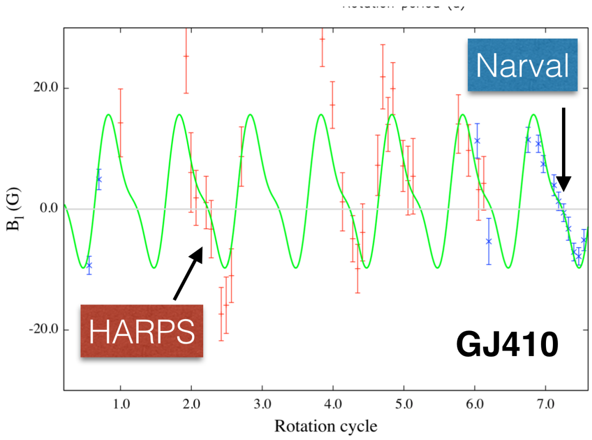

Fig. 1. Periodogram of M dwarf GJ410, observed with both HARPS-Pol and Narval Hébrard et al. (2016). Note that despite being mounted on a 2-m telescope, Narval data are significantly more accurate than HARPS-Pol data (@ ESO 3.6m). This underlines the importance of designing dedicated spectro-polarimeters, instead of adding polarimetric module to an existing spectrograph.

Aurière et al. (2016) have been studying the supergiant Betelgeuse for many years. The most recent paper of the team shows a remarkable detection of a linearly polarized spectrum for Betelgeuse. This linear polarization signature is interpreted as a depolarization of the continuum by the absorption lines. The linear polarization of the Betelgeuse continuum is due to the anisotropy of the radiation field induced by brightness spots at the surface and Rayleigh scattering in the atmosphere. Aurière et al. (2016) have developed a geometrical model to interpret the observed polarization, from which they infer the presence of two brightness spots and their positions on the surface of Betelgeuse. Their study of the linearly polarized spectrum of Betelgeuse provides a novel method for studying the evolution of brightness spots at its surface and complements quasi-simultaneous observations obtained with PIONIER at the VLTI, cf Figure 2.

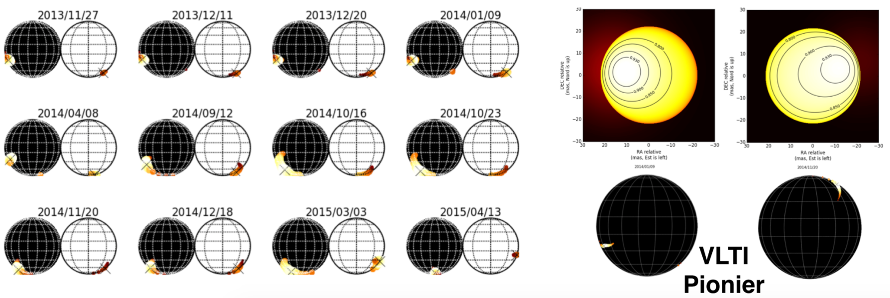

Fig. 2. Comparison between the models of spot evolution on Betelgeuse based on Narval data (**left**), and VLTI/PIONIER data (**right**). The two models are remarkably concordant.

3.4 *TBL publication record*

A more quantitave account of TBL/Narval impact in the field of stellar magnetism over the years (2007-2015) is its publication record based on the new ADS interface ui.adsabs.harvard.edu shown in the following table that summarizes the record as of June 2016.

Papers	Total	Refereed
Number of papers	441	275
Normalized paper count	111.9	54.1
Total number of reads	121446	105687
Average number of reads	275.4	384.3
Median number of reads	172	312
Total number of downloads	66400	58644
Average number of downloads	150.6	213.3
Median number of downloads	94	166
Citations	**Total**	**Refereed**
Number of citing papers	3212	3158
Total citations	7118	6835
self-citations	1585	1478
Average citations	16.1	24.9
Median citations	4	12
Normalized citations	1155.1	1082.9
Refereed citations	5089	4913
Average refereed citations	11.5	17.9
Median refereed citations	3	8
Normalized refereed citations	821.8	778.7
Indicators	**Total**	**Refereed**
h index	46	46

3.5 More decenal statistics

A detailled set of observing statistics computed over the period 2007-2015 have been published on TBL web site: http://spiptbl.bagn.obs-mip.fr/observation/statistiquesobservations. The salient results per semester are shown in the table below.

total numbers a dark time per semester (Nautical twilight): from **~74000 science fits**.
semester A: 1391.36097228 h semester B: 2067.81753856

Name	**Science** h (% SROP)	**Readout** h (% SROP)	**Overhead** h (% SROP)	**Pointing** h (% SROP)	**S+R+O+P** h (% SROP)	**Close** h	**Total** h
2007A	281.0 (74)	25.7 (6.8)	17.0 (4.5)	54.5 (14.4)	378.0 (41)	475.1	1391.4
2008A	268.5 (70)	37.3 (9.8)	16.4 (4.3)	60.0 (15.7)	382.2 (46)	564.2	1391.4
2009A	310.2 (72)	28.9 (6.7)	13.3 (3.1)	76.2 (17.8)	428.5 (49)	511.0	1391.4
2010A	272.0 (64)	49.3 (11.7)	34.5 (8.2)	67.2 (15.9)	423.0 (46)	479.2	1391.4
2011A	245.9 (63)	29.4 (7.6)	22.6 (5.8)	89.9 (23.2)	387.7 (41)	448.7	1391.4
2012A	283.6 (65)	39.9 (9.2)	38.3 (8.8)	71.8 (16.6)	433.7 (45)	431.4	1391.4
2013A	208.2 (67)	29.0 (9.4)	27.9 (9.0)	45.1 (14.5)	310.2 (36)	535.9	1391.4
2014A	205.7 (61)	38.1 (11.3)	37.6 (11.2)	54.5 (16.2)	335.9 (37)	480.9	1391.4
2015A	219.8 (62)	41.3 (11.6)	42.6 (11.9)	53.6 (15.0)	357.4 (36)	399.3	1391.4
2006B	283.7 (66)	26.6 (6.2)	13.3 (3.1)	105.6 (24.6)	429.2 (21)	0.0	2067.8
2007B	646.8 (75)	65.7 (7.6)	48.5 (5.6)	99.3 (11.5)	860.3 (53)	449.7	2067.8
2008B	289.1 (71)	39.2 (9.7)	18.4 (4.5)	59.3 (14.6)	405.9 (30)	694.1	2067.8
2009B	299.9 (70)	33.0 (7.7)	19.7 (4.6)	78.3 (18.2)	431.0 (31)	674.6	2067.8
2010B	387.8 (71)	45.5 (8.3)	34.2 (6.3)	78.0 (14.3)	545.4 (39)	654.7	2067.8
2011B	410.2 (68)	61.0 (10.2)	49.8 (8.3)	78.7 (13.1)	599.7 (45)	725.3	2067.8
2012B	196.4 (65)	20.1 (6.7)	18.8 (6.2)	65.4 (21.7)	300.7 (22)	700.0	2067.8
2013B	325.5 (71)	37.2 (8.1)	40.6 (8.8)	56.2 (12.2)	459.5 (32)	631.6	2067.8
2014B	265.9 (62)	42.4 (9.9)	49.9 (11.6)	72.1 (16.8)	430.3 (29)	597.1	2067.8
2015B	326.9 (59)	48.4 (8.7)	74.8 (13.5)	104.6 (18.9)	554.7 (35)	496.9	2067.8

4 What's next for TBL?

4.1 New instruments

Narval has been the dedicated instrument of TBL for almost ten years, it is now approaching the end of its scheduled scientific life. Although the pressure on the instrument is still high for a 2-m telescope, The TBL science committee (CS TBL, chair D Mouillet) was mandated to explore future instrumentation for TBL and actual interest of the community to continue using TBL beyond Narval. A call for idea was published in 2012 by the CS TBL. Letters of intent were received for two instruments. One was Neo-Narval (PI T Boehm), an upgraded version of Narval providing a stabilized spectrograph ($\sim$2m/s) for velocimetry and polarimetric studies in the visible range, and SPIP (PI Hebrard/Donati), a copy of SPIRou, a velocimetry-stabilized spectropolarimeter ($\sim$1m/s) in the near infrared to be installed at CFHT in the coming years. The two projects were presented in 2013-2014 at the Prospective exercise of INSU-AA Hyres. The stellar physics community expressed a strong support and interest for both instruments, stating the complementary of the two projects, although no funding was available at the time. In 2015, the two projects were funded on CPER with 500 keuros Neo-Narval and 4 Meuros SPIP (cf talk of T. Boehn on Neo-Narval).
The science cases and technical documents of the two instruments are available online, at spiptbl.bagn.obs-mip.fr/INSTRUMENTATION2/neonarval for Neo-Narval, and http://spirou.irap.omp.eu/ for SPIRou.
Neo-narval is scheduled to be commissioned in 2018 and SPIP by 2021.

4.2 TBL operation with Neo-Narval and SPIP

Assuming one can disregard decommissioning of Neo-Narval because the stellar community has expressed a concern that Neo-Narval will be the only spectropolarimeter in operation in the northern hemisphere when SPIROU replace Espadons at CFHT, diverse operation modes can be proposed when Neo-Narval and SPIP are both available at TBL.
A first mode would be to mount one instrument on the telescope based on a fixed calendar. This mode is the most straightforward, but is arguably not very efficient. A second mode could be to have both polarimeters mounted on the telescope with a system switching the beam from one instrument to the other in a timely fashion. This would require the TBL to redesign the bonnette. A third solution would be to used both instruments at the same time, while one would be used in full spectropolarimetry mode, and the other in spectroscopic mode. Finally, a fourth solution would be to use both spectropolarimeters in full mode simultaneously. Mode 2, 3 and 4 would require more and more complex redesign of the bonnette and some R&D for the fourth one, none of those implementations being funded, yet.

5 Conclusion

Thanks to its existing and future instrumentation Telescope Bernard Lyot is still a competitive internationally acclaimed telescope in 2016, and promise to be very successful in the coming years. This was possible because of the dedication of a very competent and enthusiastic technical team working without counting hours, days and nights, for maintaining both the telescope and its instrumentation. This was also possible thanks to the dynamic scientific community pushing for the best performing instruments and asking for challenging programs, and finally this was possible because of the financial support of local and regional governments, which year after year support science at the summit of Pic du midi. Would any of those three legs disappear, TBL would be doomed. As a leaving director I express my gratitude to all those people and wish you clear skies!

References

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