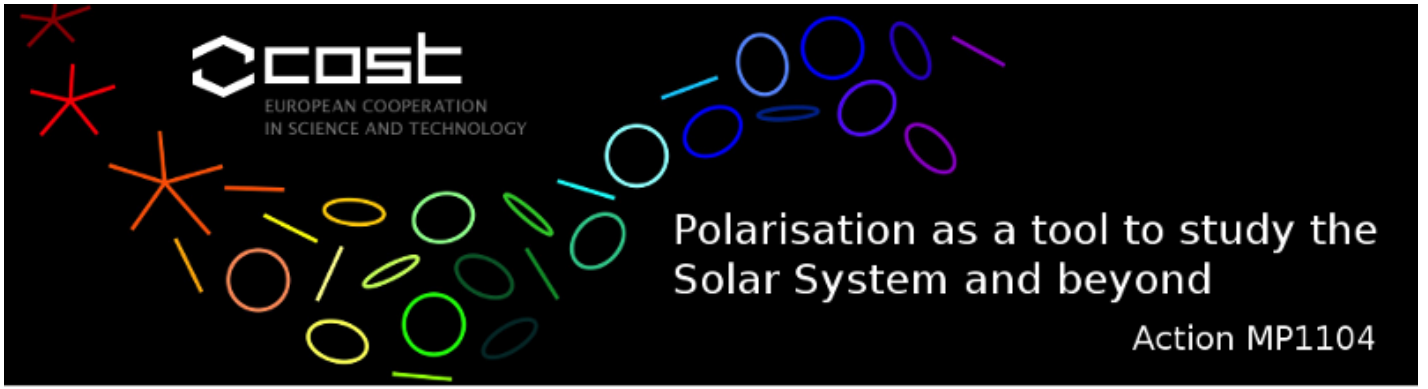
Telescope Bernard Lyot/Narval
In 2012

Rémi CABANAC

TBL Director
Observatoire Midi Pyrénées

COST WORKSHOP
Warsaw
7-9 may 2012



Telescope Bernard Lyot (TBL)

2-m Telescope at Pic du Midi

wwwtbl.bagn.obs-mip.fr

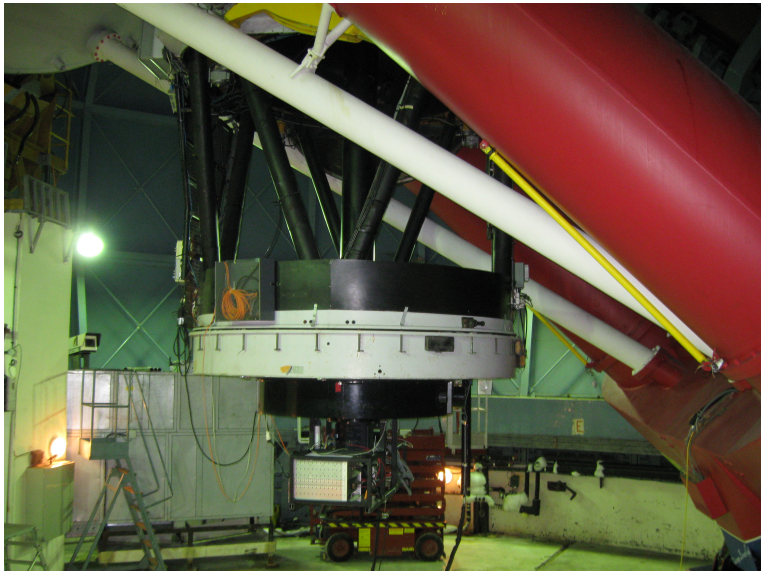
- TBL is dedicated to spectro-polarimetry with Narval since 2007

- TBL completely refurbished with digital control.

- TBL operated in full service mode since 2009

- TBL part of OPTICON transnational access prog.

OPTICON Transnational Access (->2015)
www.astro-opticon.org



- Thinking of the future : 2 options
  - improving Narval
  - Narval → near IR (SPIP = SPIROU @ Pic)

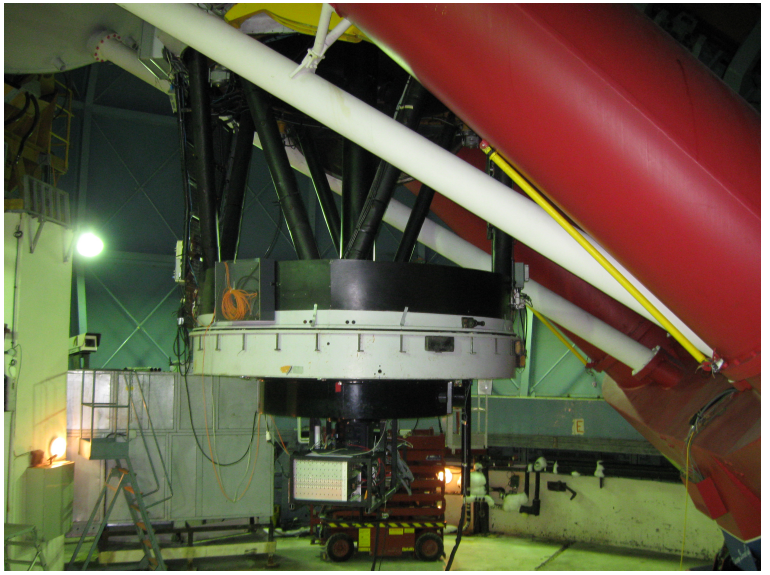
A few stats since 2007

10 semesters with pressure 2-3

Nights offered : 1315

Programmes : 134

Publications : 89 (5 cit>50, 30 cit>10)



Since 2010B :
60% large programmes (2 years)
Next call 2013A (~20 oct 2012)

TBL OPERATION

Operations with TBL/Narval

TBL/Narval is operated in queue service observing.

End-to-end data processing:

- call for proposals (next deadline 2013A → 20 oct 12)
  http://northstar.bagn.obs-mip.fr:8080/

- Service Observers (training of young astronomers)

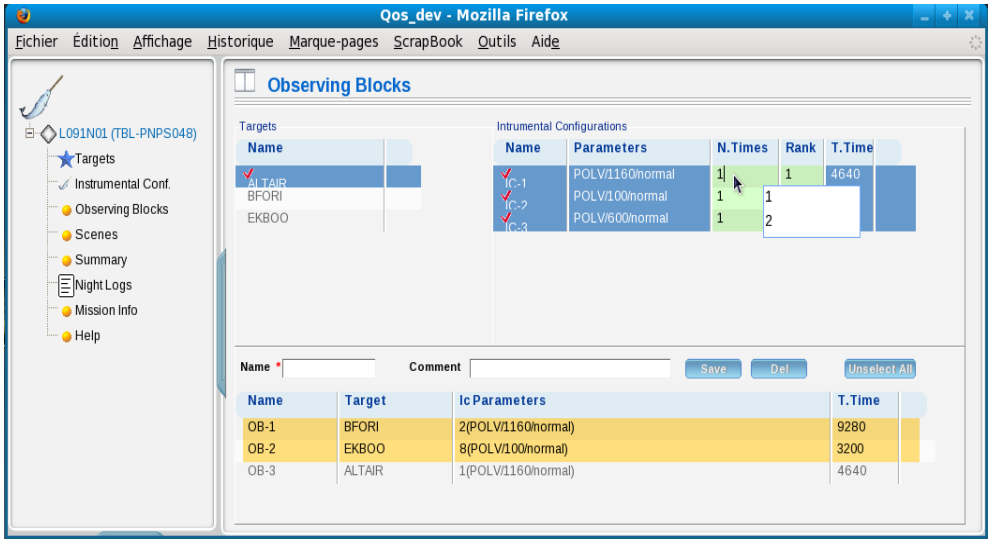
- Complete quality control and data processing: delivers reduced normalized/unormalized 1D spectra + error

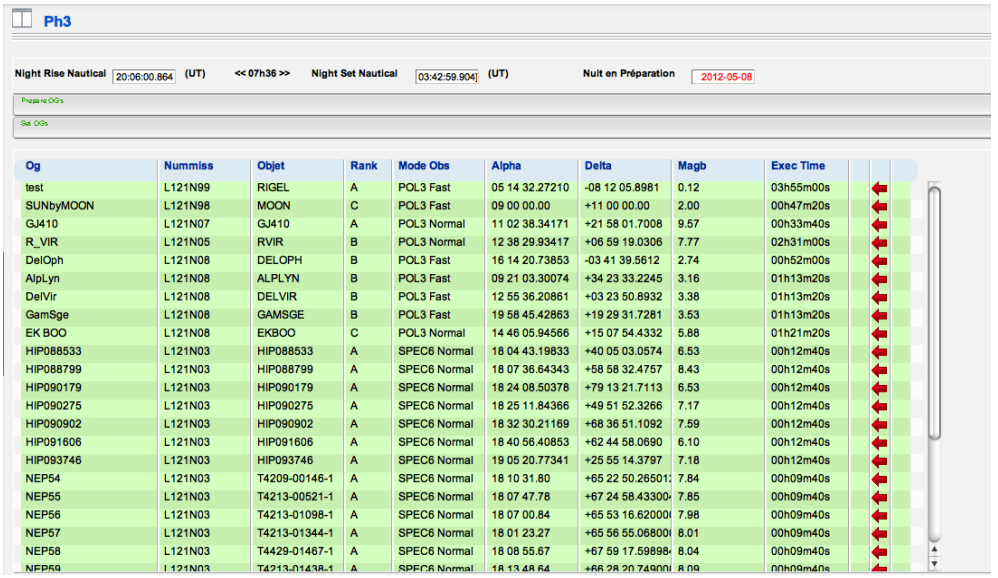
- Higher level tools (Least-Square Deconvolution)

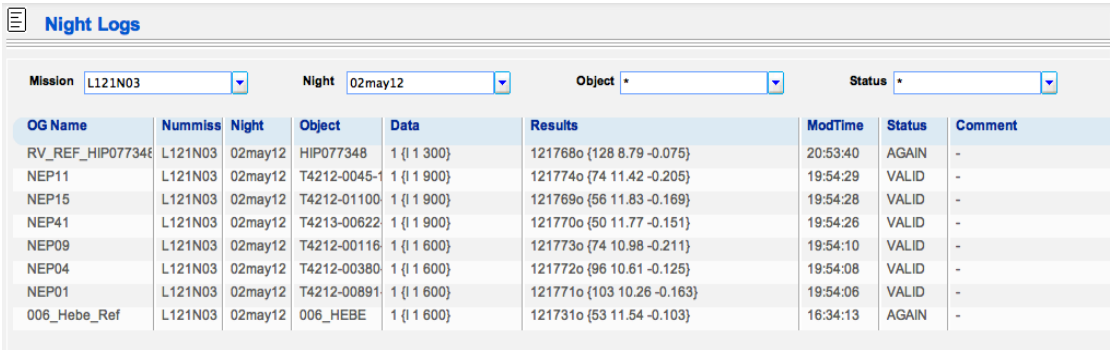
- TBL/Narval reduced data are released 1yr after PI release (for Intensity spectra, 2 yr for polar data), fully compliant with VO spec tblegacy.bagn.obs-mip.fr

www.sciops.esa.int/index.php?project=ESAVO&page=vospec

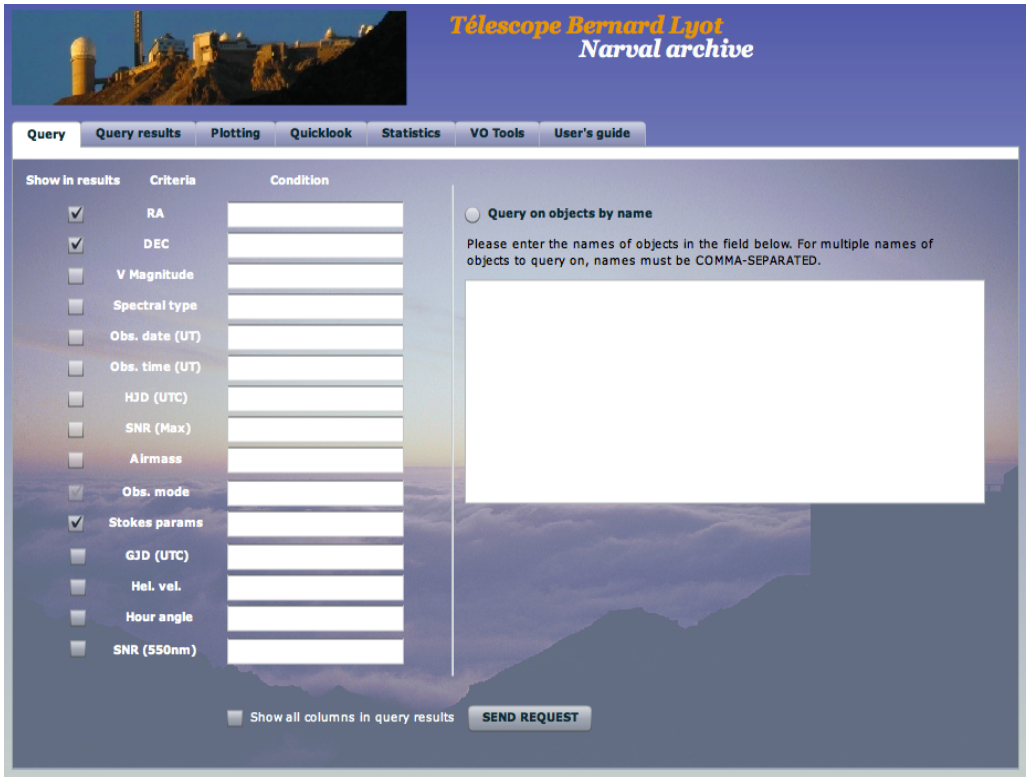
Operations with TBL/Narval

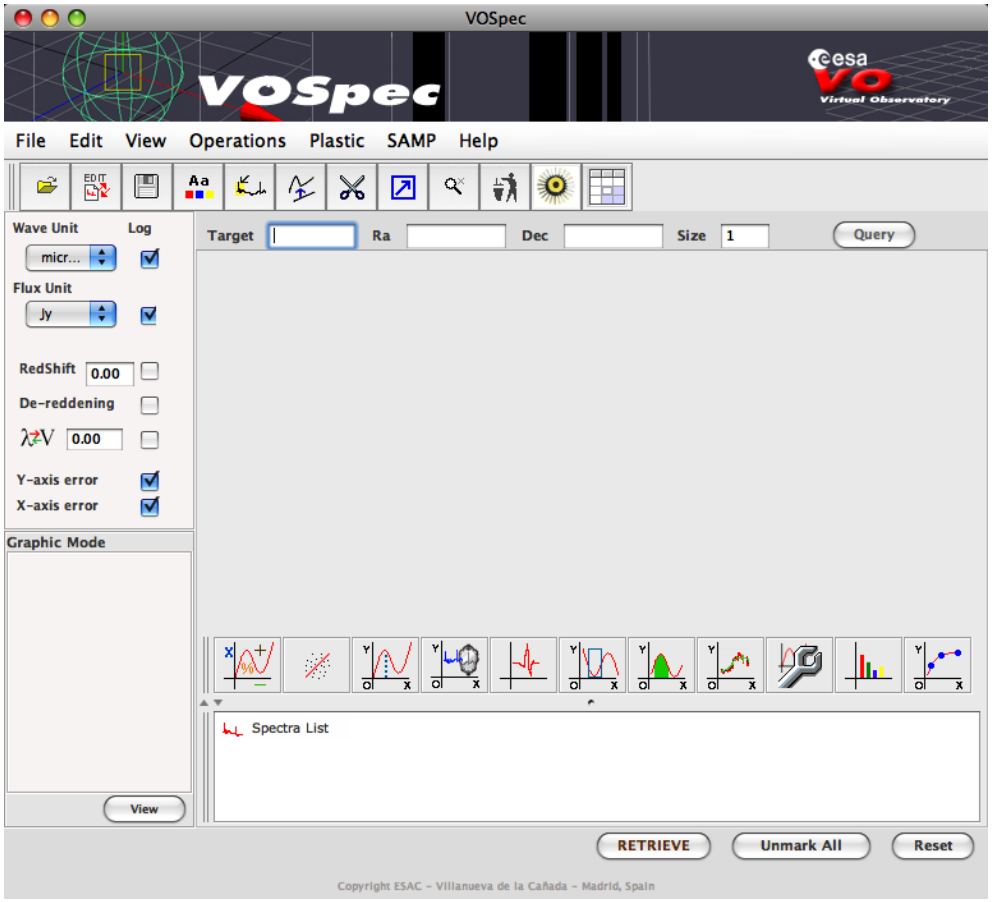






Operations with TBL/Narval

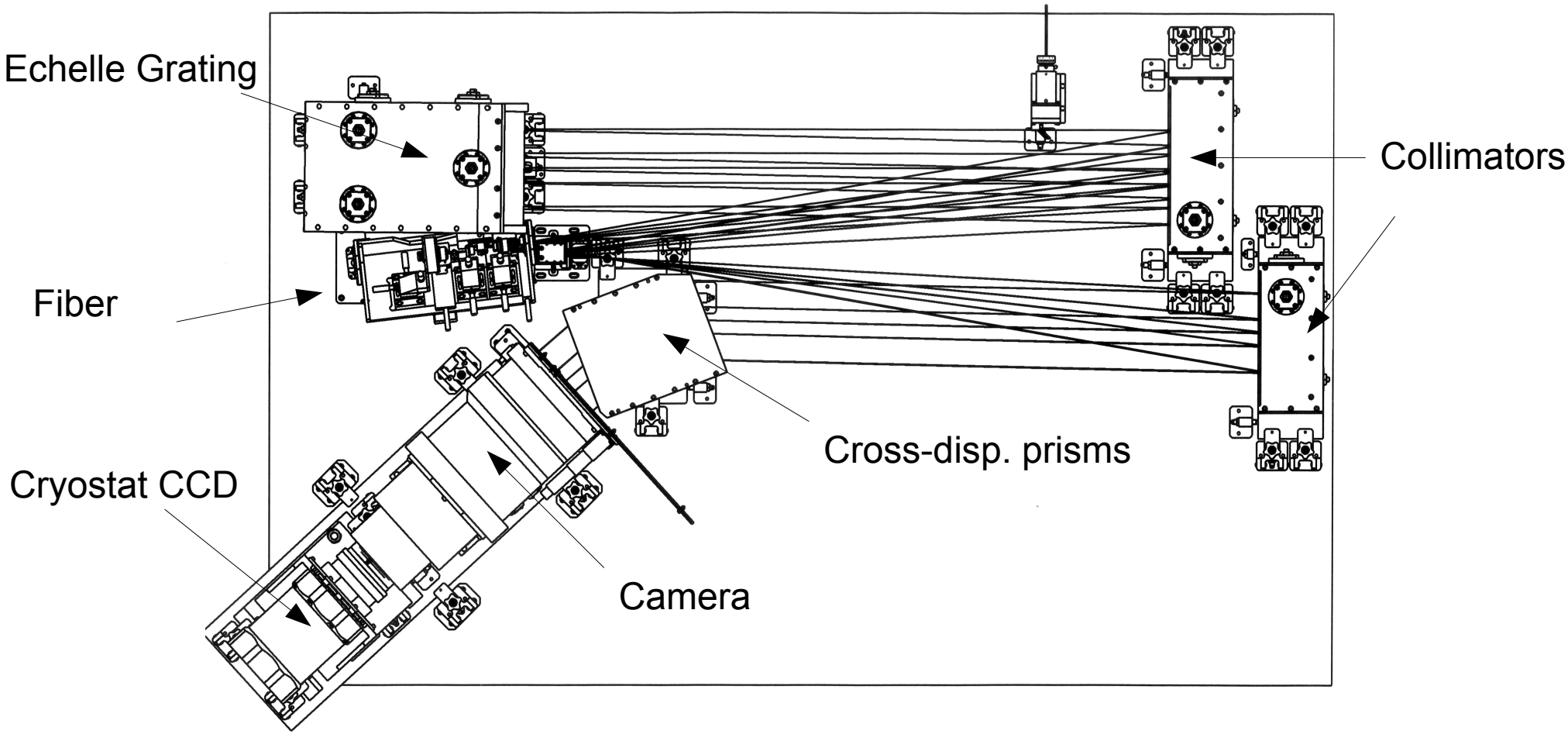




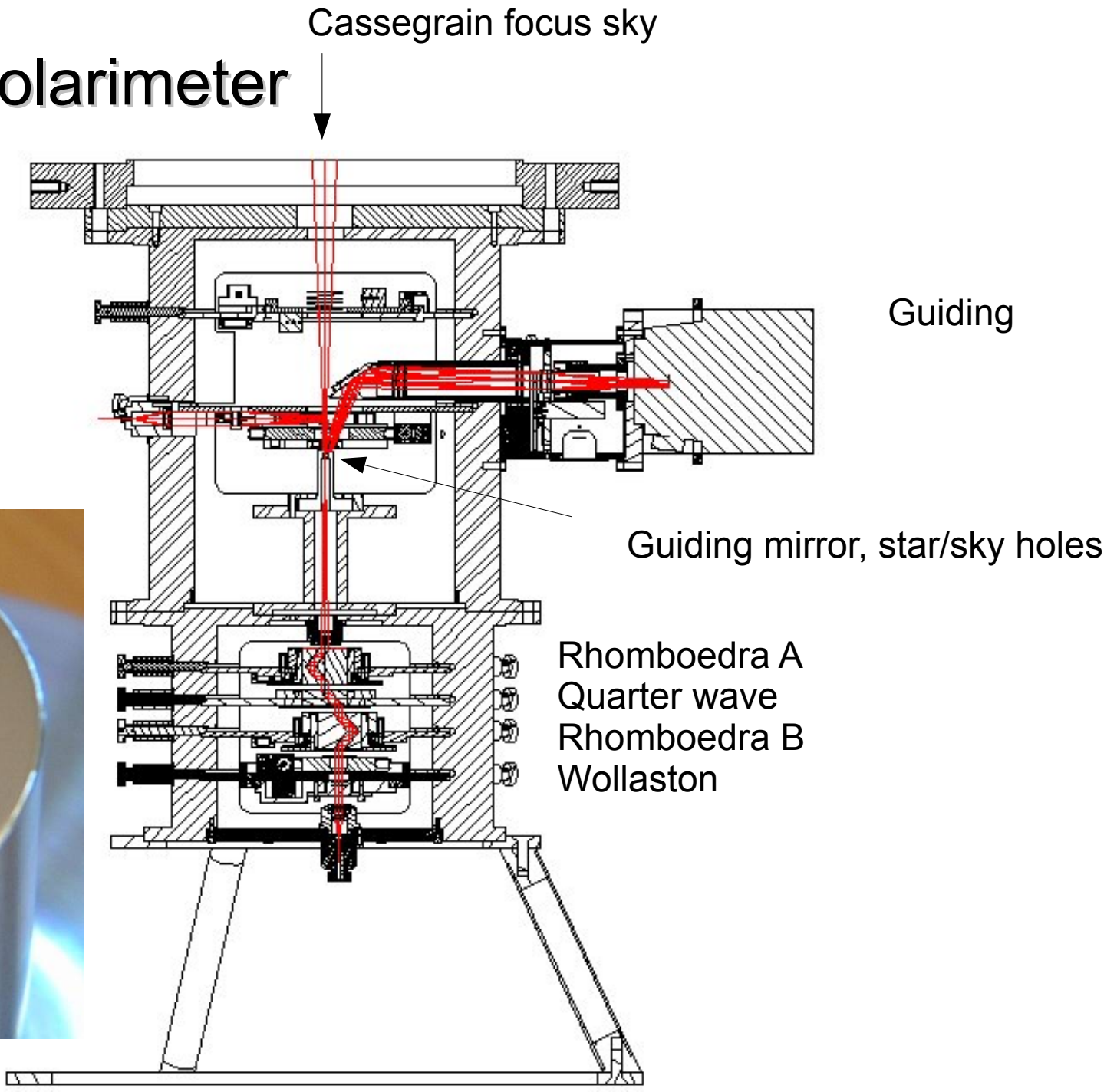
NARVAL

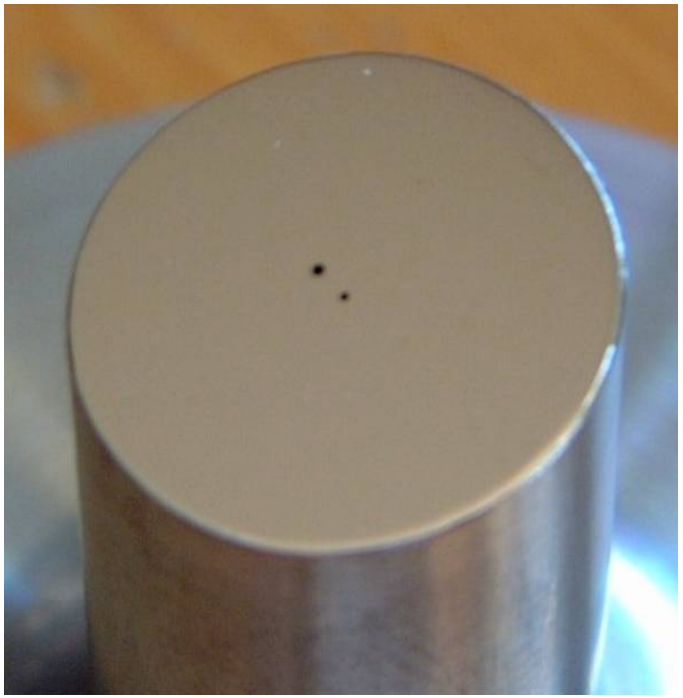
Narval is a spectrograph...

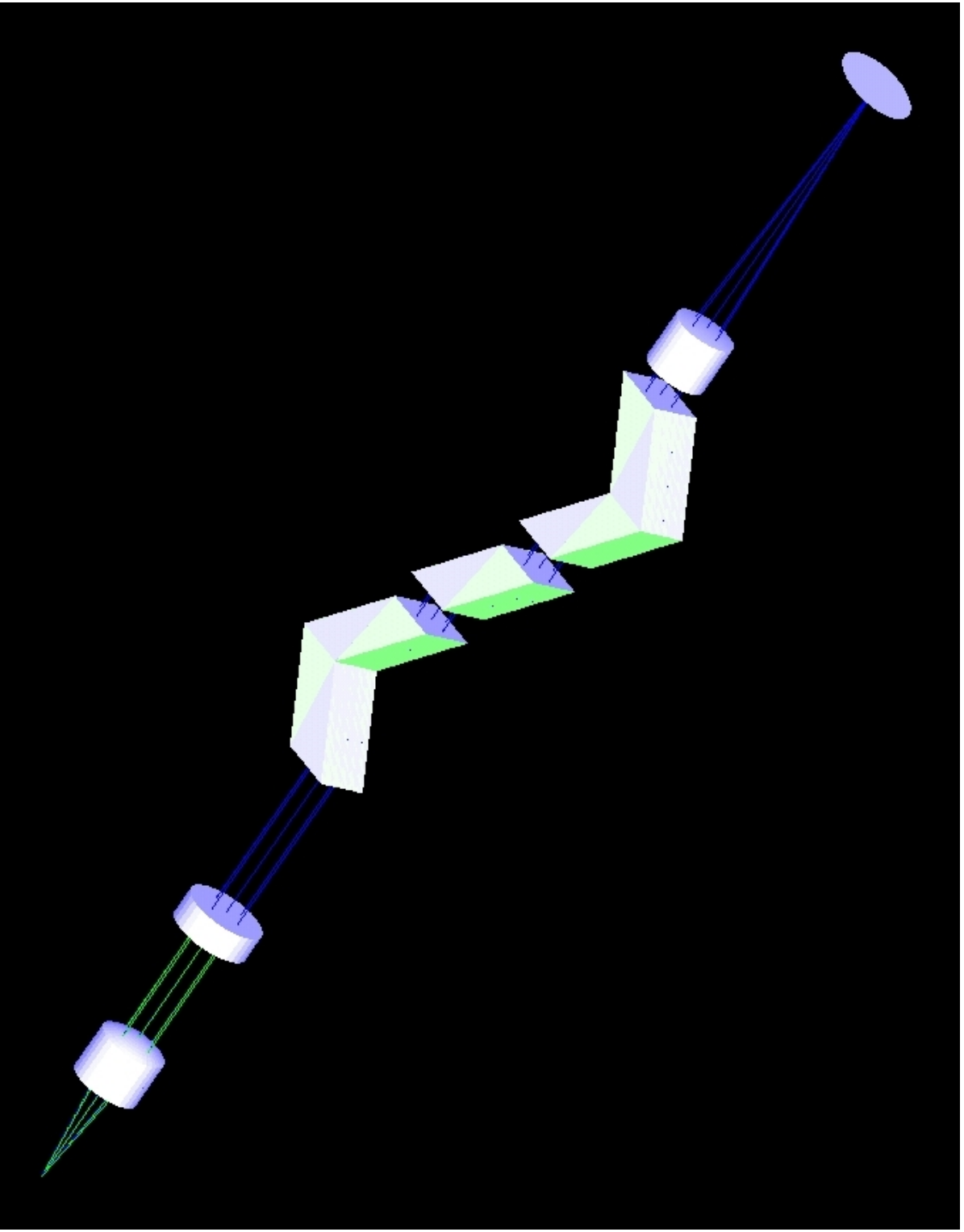
Temperature controled enclosure, optical bench, stable (~10 m/s in a night), range 370-1000nm



… and a Polarimeter







Polarisation parametrized through the Stokes parameters (E Field pola.):

100% Q	100% U	100% V
+Q Q > 0; U = 0; V = 0 (a)	+U Q = 0; U > 0; V = 0 (c)	+V Q = 0; U = 0; V > 0 (e)
-Q Q < 0; U = 0; V = 0 (b)	-U Q = 0, U < 0, V = 0 (d)	-V Q = 0; U = 0; V < 0 (f)

4 rel. pos. of Rhomb A, B and $\lambda/4$ plate leads to 4 pairs of orthogonally polarized spectra

$$\frac{P}{I} = \frac{R-1}{R+1},$$

where

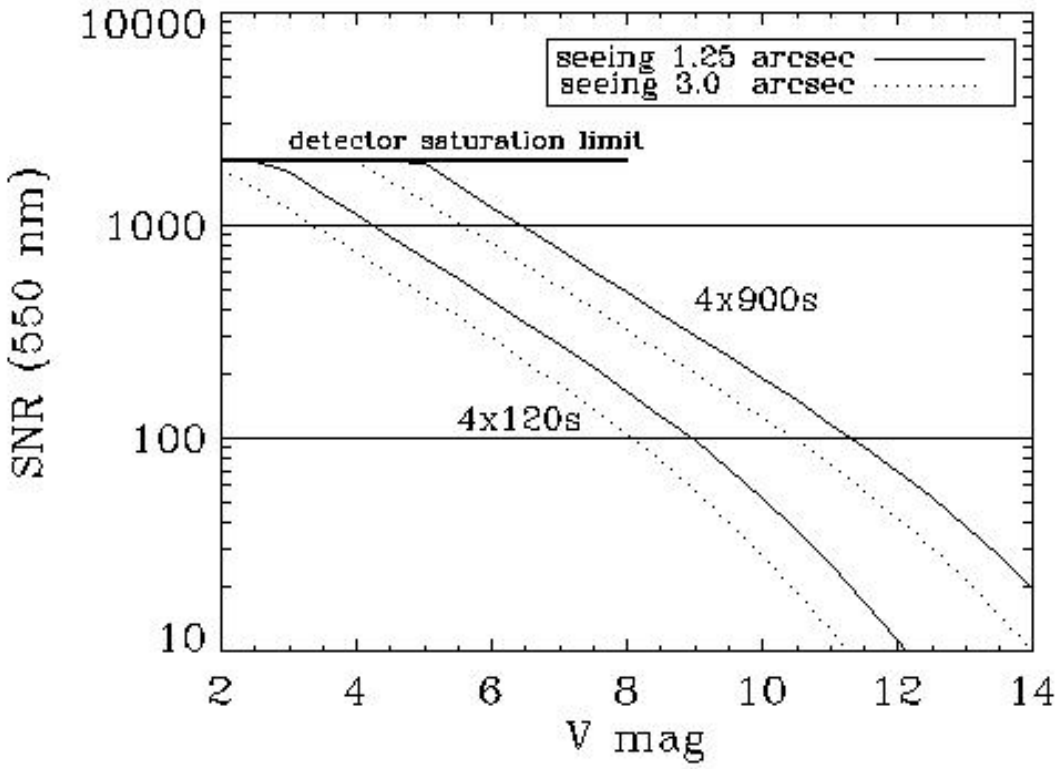
$$R^4 = \frac{i_{1,\perp}/i_{1,\parallel}}{i_{2,\perp}/i_{2,\parallel}} \frac{i_{4,\perp}/i_{4,\parallel}}{i_{3,\perp}/i_{3,\parallel}} \qquad R^4 = \frac{i_{1,\perp}/i_{1,\parallel}}{i_{4,\perp}/i_{4,\parallel}} \frac{i_{2,\perp}/i_{2,\parallel}}{i_{3,\perp}/i_{3,\parallel}}.$$

Operations with TBL/Narval

Offers 3 modes of operations:

- Spectroscopic mode star only, resolution ~ 77000
- Spectroscopic mode star+sky, resolution ~ 65000
- Polarimetric mode: Q U or V, resolution ~ 65000

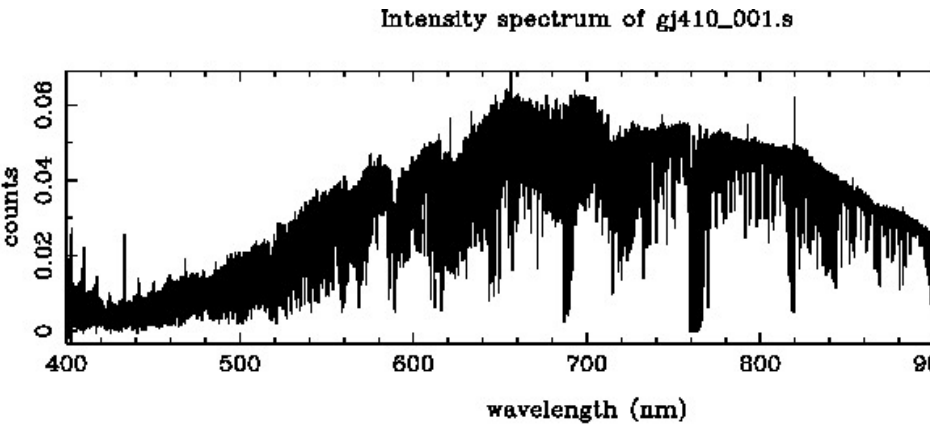
Sensitivity of TBL/Narval: S/N = 100 in 1h V=12

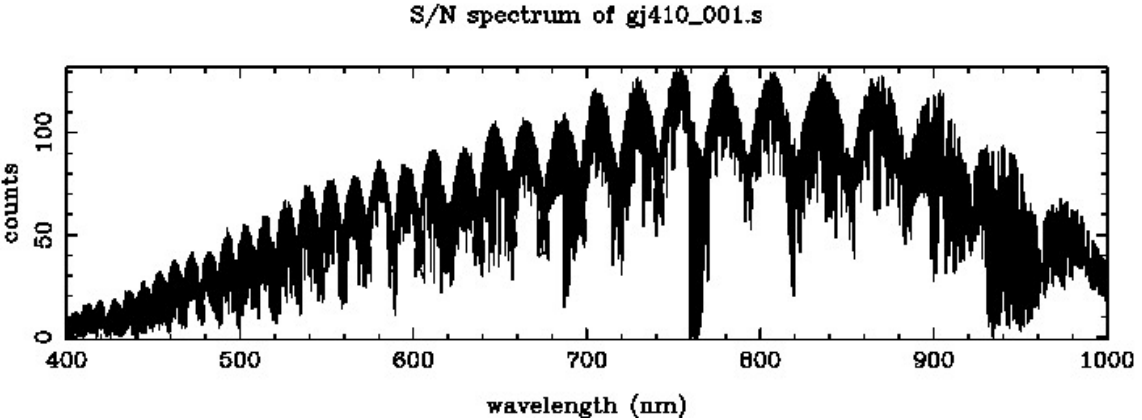


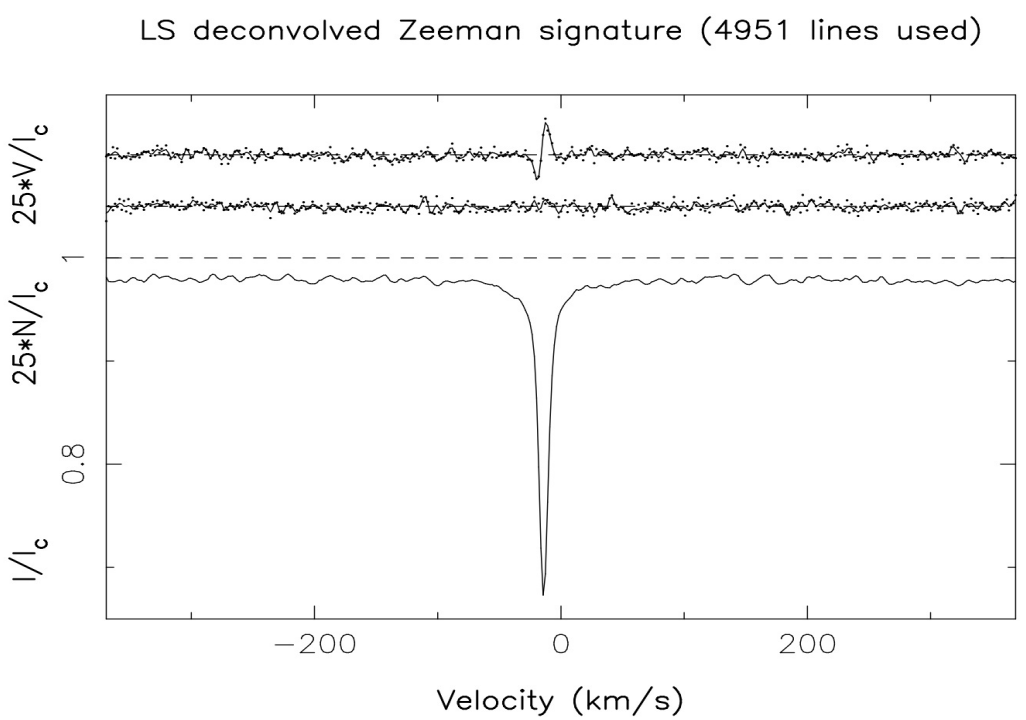
Operations with TBL/Narval

Example **V* DS Leo** -- Variable of BY Dra type Vmag = 9.5

Exp. Time 4 x 400 sec







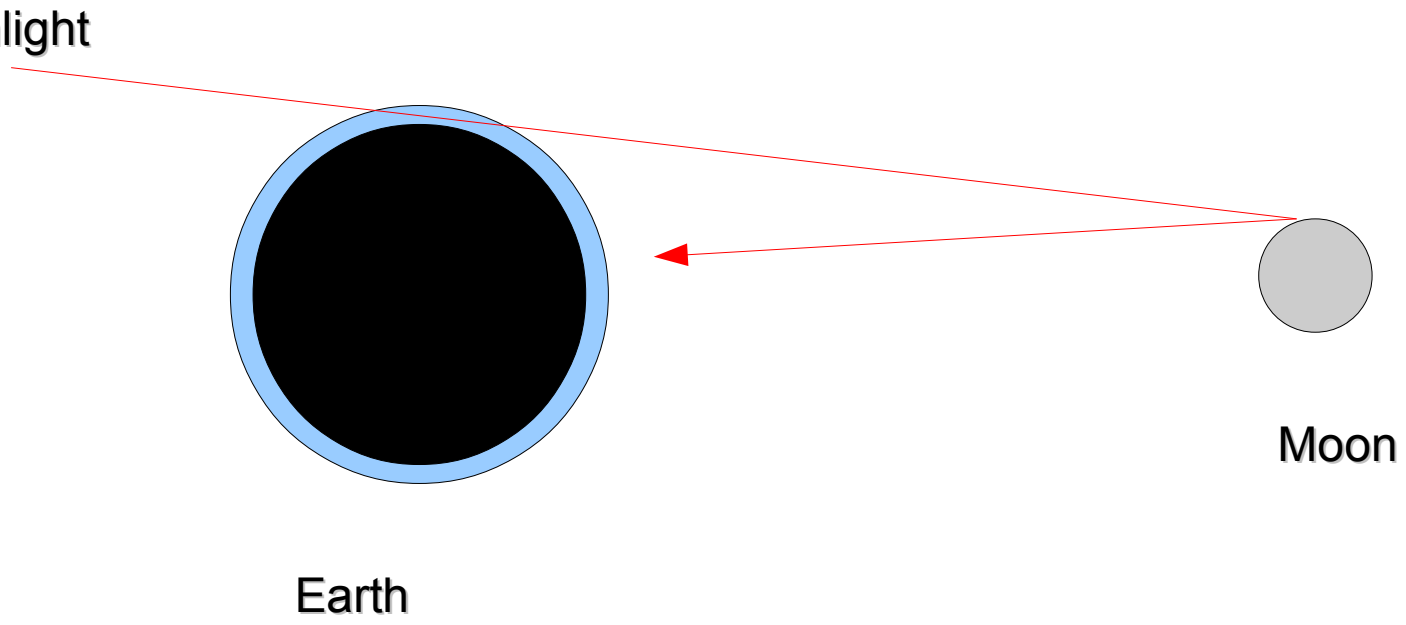
SCIENCE EXAMPLES

Science with TBL/Narval

In Spectroscopy:

- Planet studies: Moon eclipses (Ferlet et al.)
- Spectro follow-up exoplanet transits (Miller et al.)

Each Moon eclipse: test of observability exoplanet atmospheres thru transit,
Next visible eclipse from Pic du Midi 2015 !



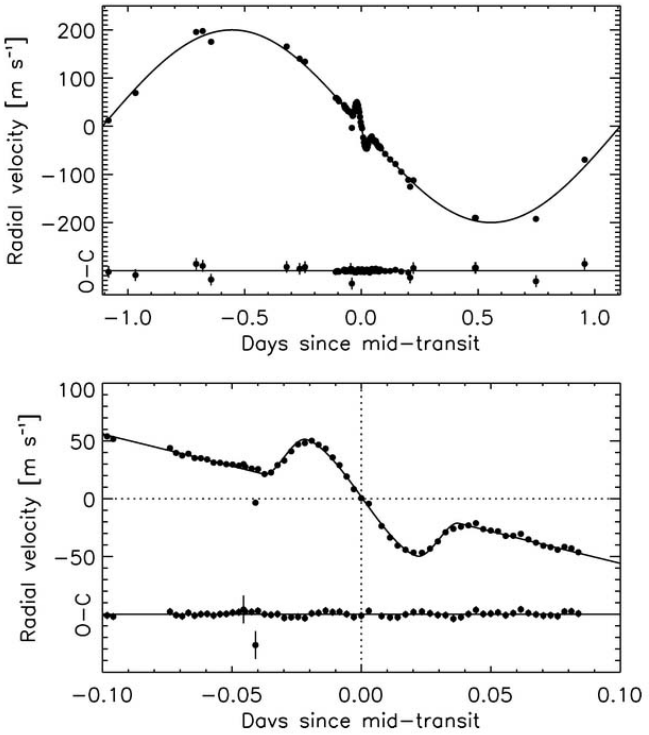
Detect water, methane, carbon dioxide, etc...

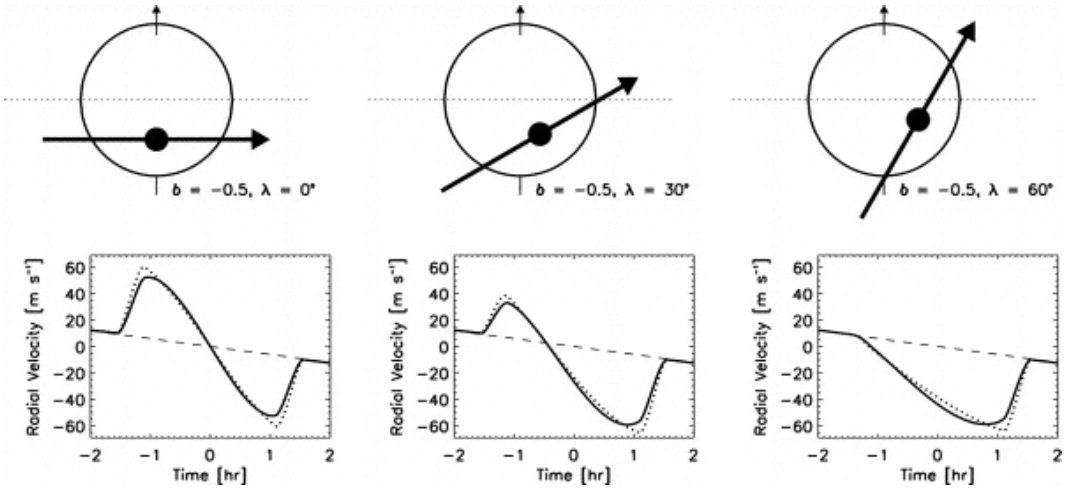
Science with TBL/Narval

In Spectroscopy:

- Planet studies: Moon eclipses (Ferlet et al.)
- Spectro follow-up exoplanet transits (Miller et al.)

The Rossiter-McLaughlin Effect





Science with TBL/Narval

In Polarimetry: Stellar Magnetism

Method: observing Zeeman splitting in absorption lines

HR + Least-Square Deconvolution → multiplexing effect , combination of many lines

Hot stars/fast rotators → more difficult to measure

Cool giant/MS → extreme sensitivities ±0.2 Gauss (Stokes V)

POLLUX K0III (34 ly) ~ 0.7±0.2 G

VEGA A0V (25 ly) ~0.6±0.3 G

Science with TBL/Narval

Pollux, averaged LSD profile

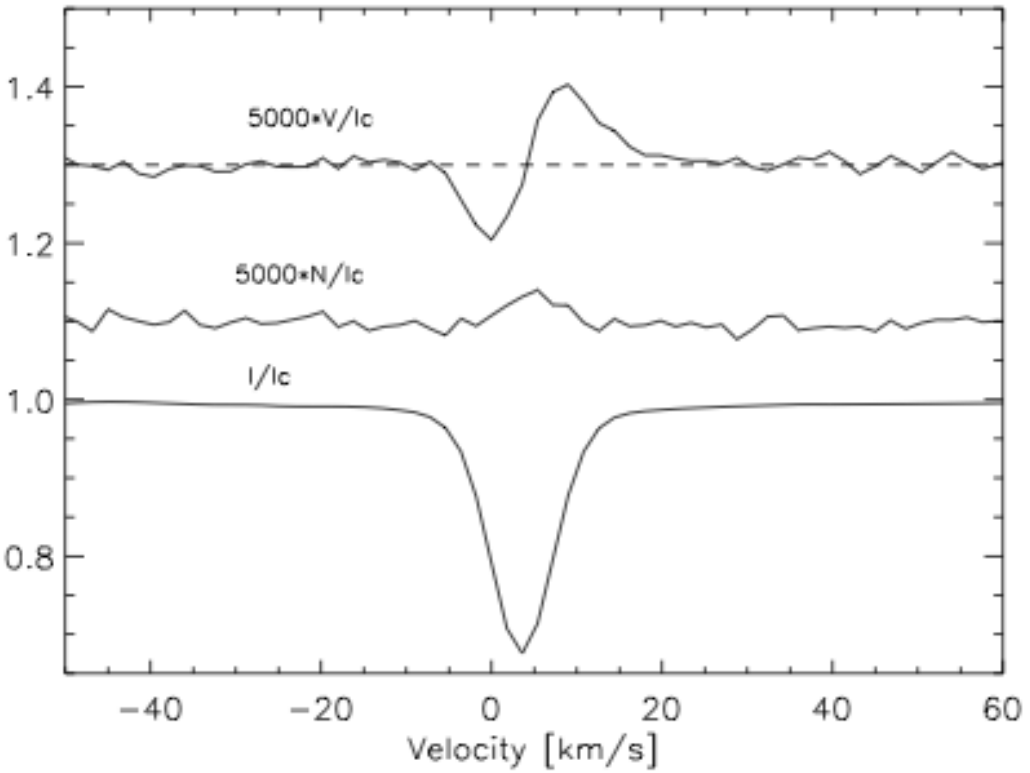


Fig. 1. Mean LSD profiles of Pollux from all 91 spectra acquired with ESPaDOnS and NARVAL in the September 2007–March 2009 period. From top to bottom are Stokes V, null polarisation N, and Stokes I profiles. For display purposes, the profiles are shifted vertically, and the Stokes V and diagnostic N profiles are expanded by a factor of 5000. The dashed line illustrates the zero level for the Stokes V profile.

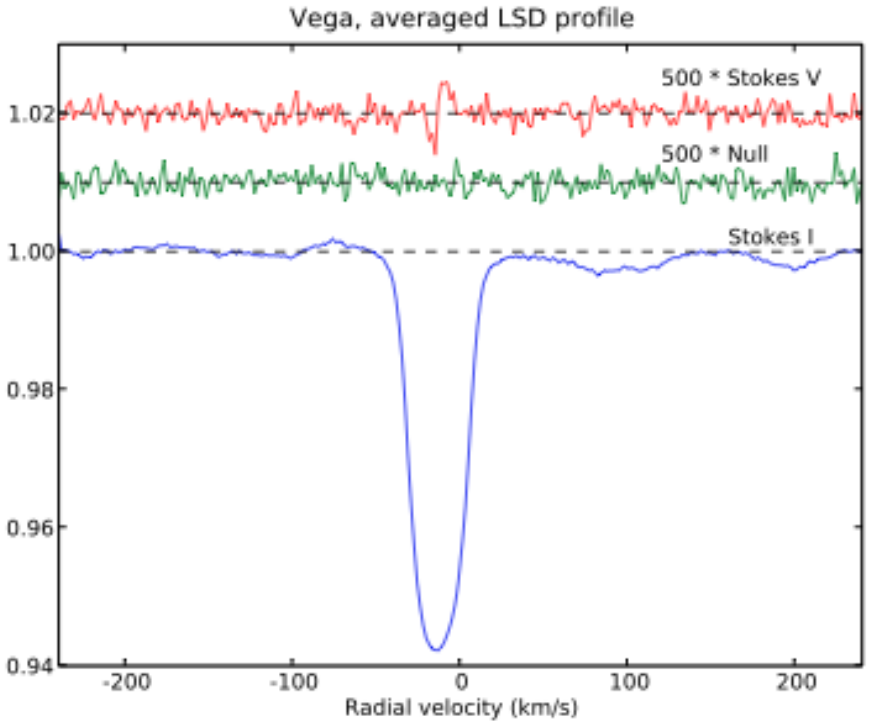


Fig. 1. Average of the 257 normalized Stokes I (blue/bottom) and Stokes V (red/upper) LSD profiles of Vega, as a function of the radial velocity. The green/middle curve is the "null" profile. The Stokes V and null curves are shifted vertically and expanded by a factor of 500. Dashed lines indicate the continuum level for Stokes I, and the zero level for the circular and null polarization.

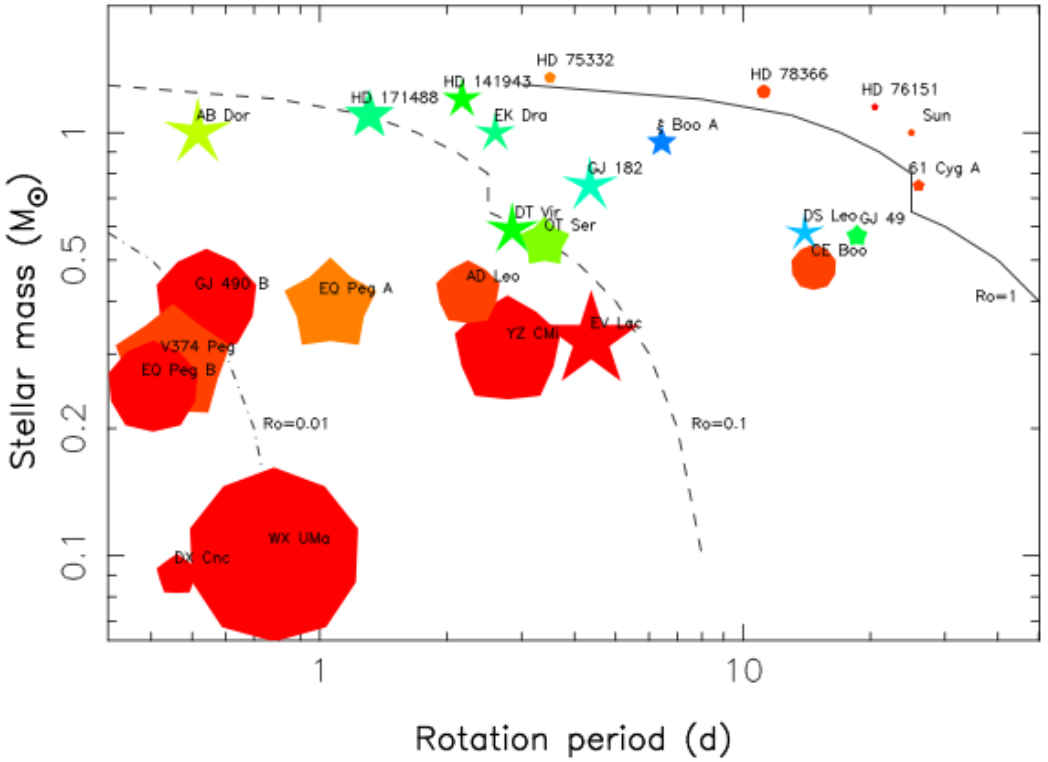
Science with TBL/Narval

A short summary on theory:

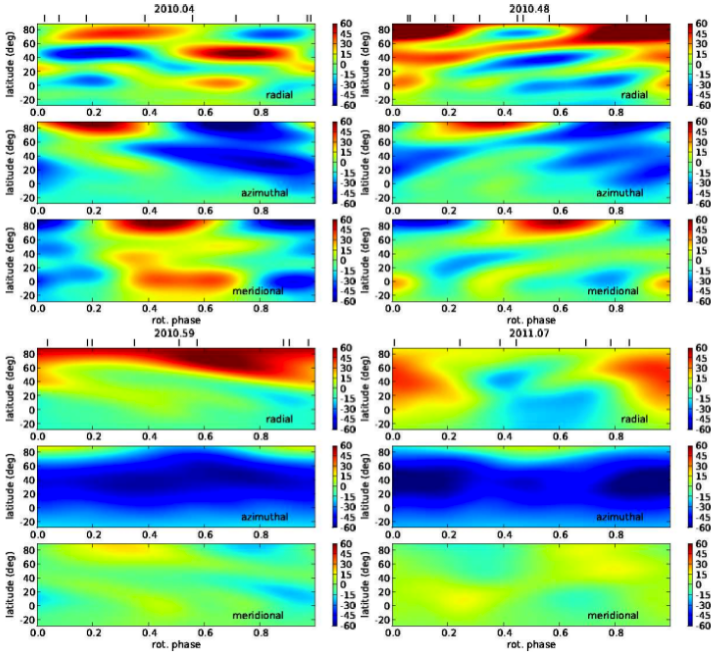
2 contenders for the origin of stellar magnetic fields

Star rotation + convection (Dynamo)	Fossil remnants (Ap-Bp, few %)
Low mass stars (mostly)	Large scale
Complex toroidal structure	Simple polloidal structure
Variable	No variability

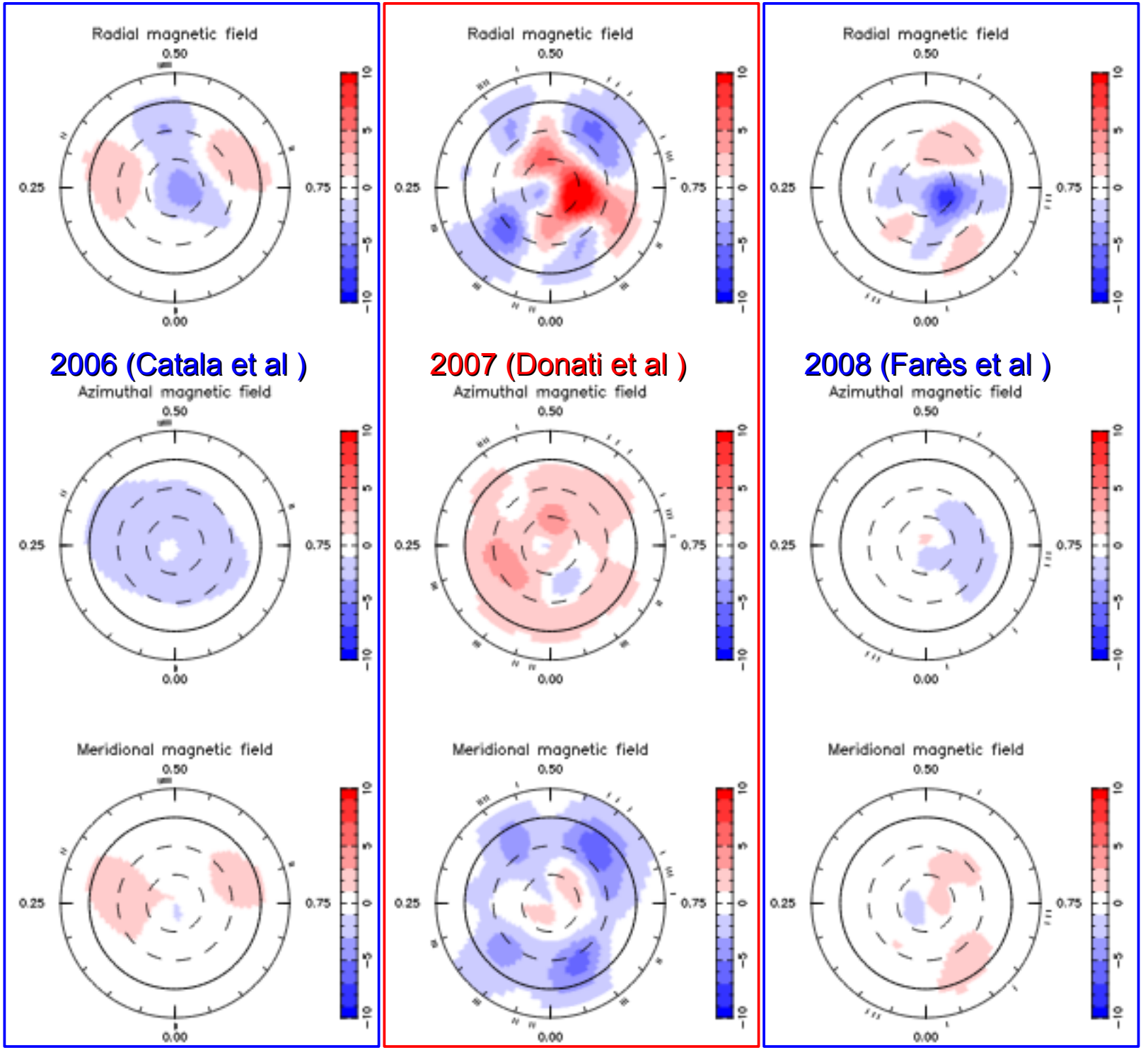
Science with TBL/Narval



bootis A Zeeman Doppler Imaging
(76 spectra 2007-2011, Morgenthaler et al.)



Donati & Landstreet (ARAA 47, 2009), Morin et al., Petit et al.



Planet hosting τ Boo magnetic polarity flip

Science with TBL/Narval

Giant stars. (Auriere, Konstantinova, Charbonnel et al. in prep)
Mira (cf N. Fabas talk)

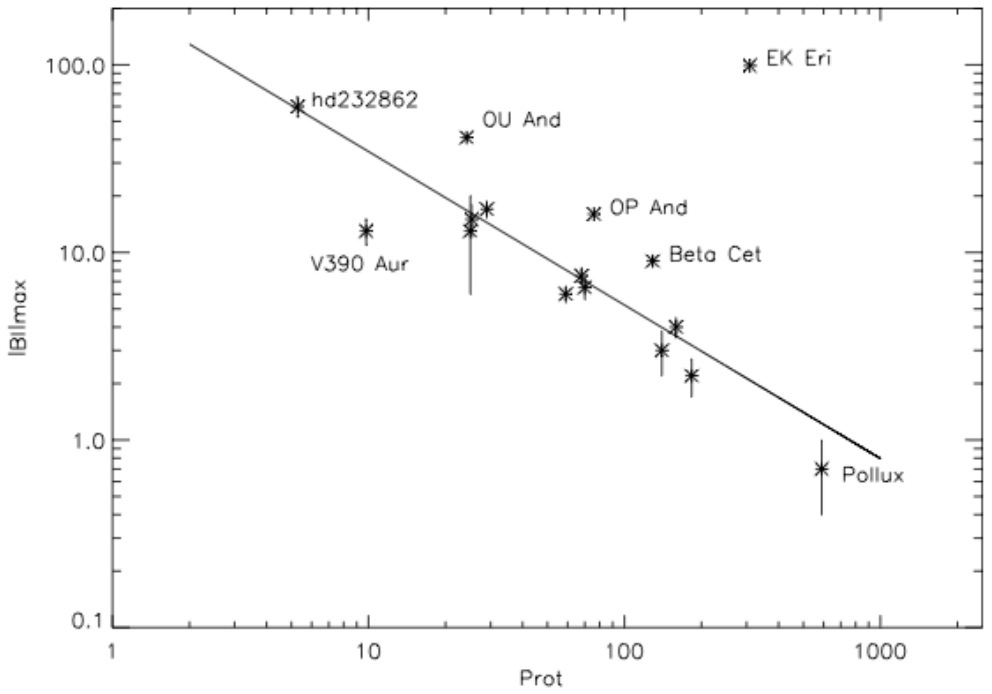


Fig. 8. Variations of the strength of the magnetic field ($|B_\ell|_{max}$) with the rotational period.

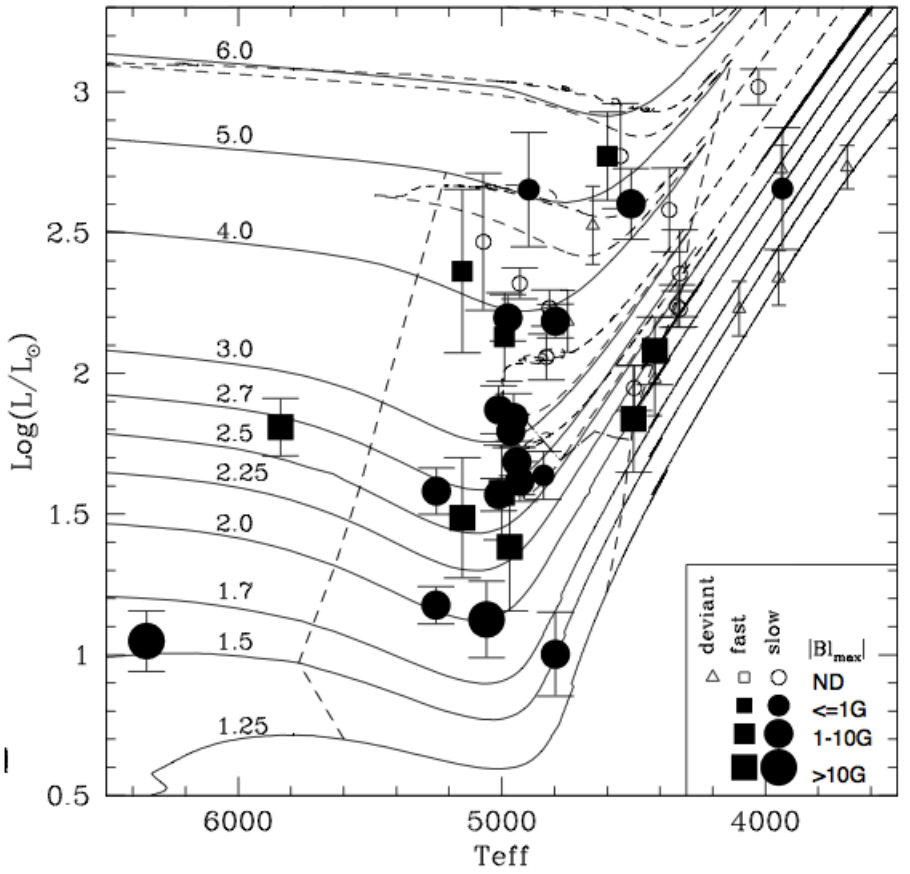


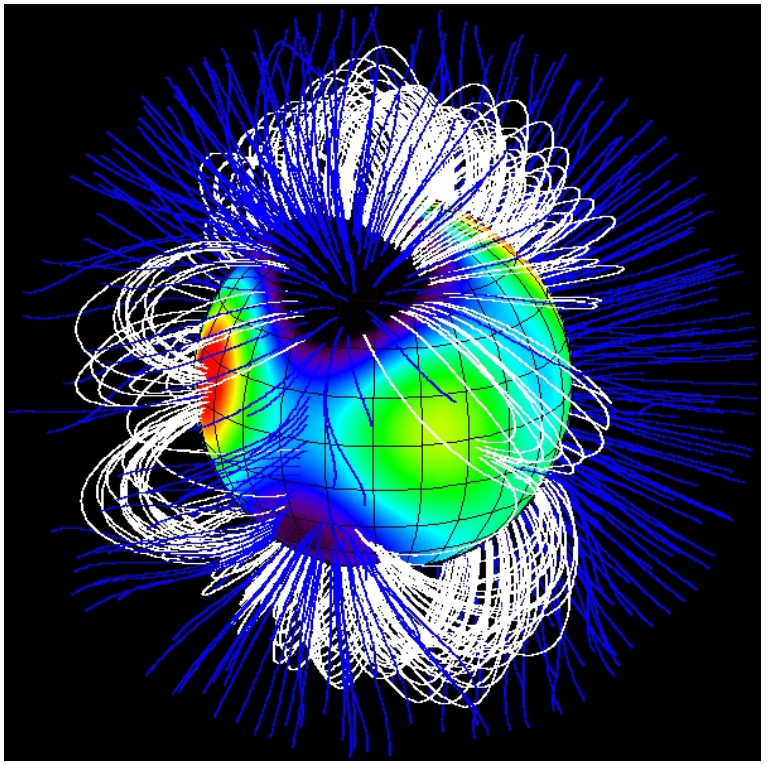
Fig. 3. Position of the Red Giants of our sample in the Hertzprung-Russel Diagram. Tracks of the standard evolutionnary models of Charbonnel and Lagarde (2010) are shown.

Science with TBL/Narval

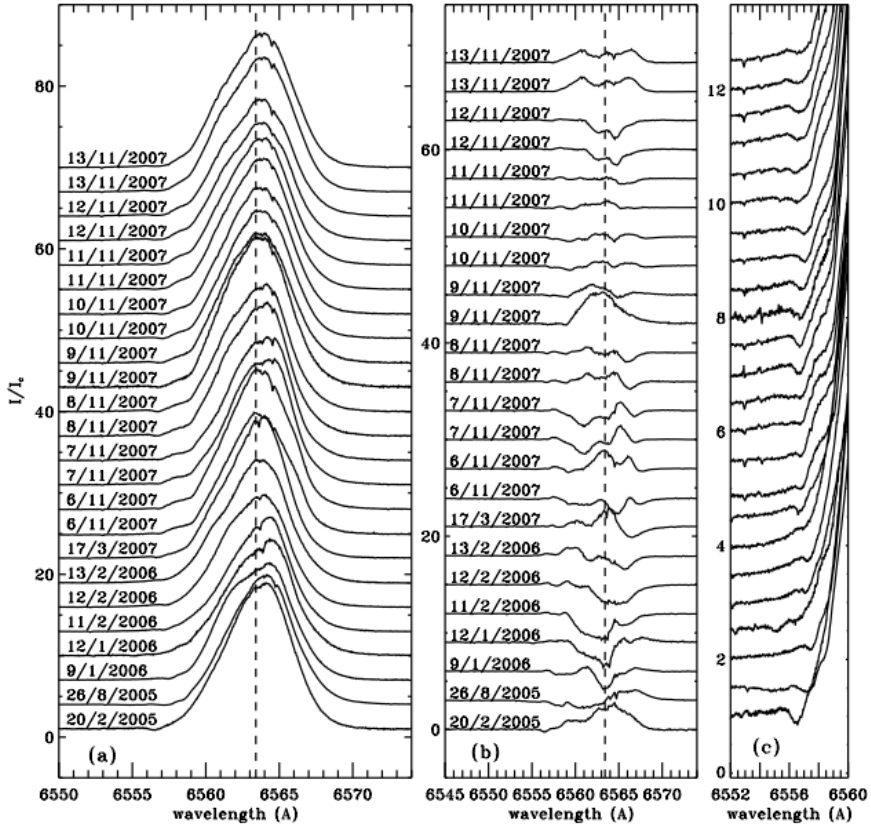
The case of OB stars (Bourret, Neiner, Alecian, Wade et al.)

Program Magnetism in Massive Stars (MiMeS): origins and evolution of magnetic fields in hot stars, Herbig, OB

Complex field on Tau Sco (Jardine et al.)



Herbig V380 Ori (Alecian et al)



Also work on ζ Ori O9 (Bouret et al., 2009)

Science with TBL/Narval

Proto-stars and accretion disks: FU Ori & TTauri stars (large program MAPP; Bouvier & Donati)

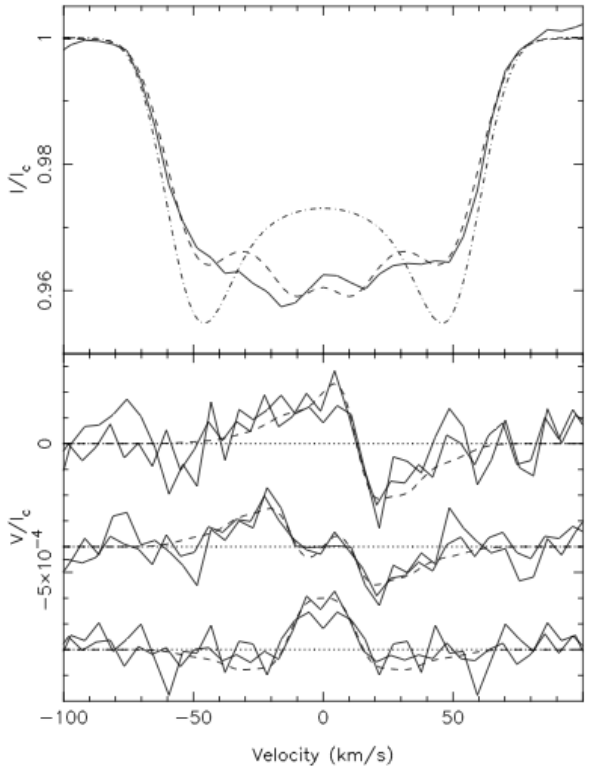


Fig. 6. Unpolarised and circularly polarised profiles of the protostellar accretion disc FU Ori. **Top panel**: observed Stokes *I* profile (solid line) and model profiles assuming either a Keplerian disc (dash-dot line) or a non-Keplerian disc (with 20% of the plasma rotating at strongly sub-Keplerian velocities, dashed line). **Bottom panel**: observed Zeeman signature (top curve) split into its anti-symmetric and symmetric components (middle and bottom curves, shifted by −4 and -8×10^{-4}) respectively characterising the vertical and azimuthal axisymmetric magnetic fields. The model (dashed line) requires the slowly rotating disc plasma to host a 1 kG vertical field plus a 0.5 kG azimuthal field (from Donati et al. 2005).

- SPIROU precursors
- GAIA preparation
- Corot follow-ups

FUTURE

Future

TBL/Narval, (CFHT/ESPADONS) are still very unique instruments for the study of polarisation in high-res spectra.

A lot of interesting science besides stellar magnetism

Up to 20% of TBL can be used by European astronomers
(OPTICON Access program FP7)

Narval is on TBL until 2015+

TBL Science council has started the process of new instrumentation

Call for proposal spring 2012. Two possibilities are explored.

Option 1 : improve Narval

Option 2 : SPIP → SPIrou @ Pic du midi : Narval in range 1-2.4μm

Future

Option 1 : continue the studies on stellar magnetism -> improve Narval

- better stability RV (10m/s long range)
- improve dome seeing (bad)
- guiding tip/tilt (gain 1-2 mag depth)
- decrease cross-talk (now ~1-3% ADC/Triplet)
- add continuum polar module

Option 2 : study young stellar system and planet formation

SPIP → SPIrou @ Pic du midi : Narval in range 1-2.4µm

lamwws.oamp.fr/magics/spirou

Specifications from main science drivers

- spectral domain: 0.98-2.4µm (w/ full coverage up to at least 2.3µm)
- spectral resolution >70,000 (goal 75,000) w/ 2 km/s sampling
- radial velocity precision < 1m/s
- S/N=110 per 2 km/s pixel in 1hr @ J=12 & K=11
- thermal background from instrument smaller than telescope emission @ 2.4µm
- all polarisation states accessible with <1% crosstalk over full spectral domain

Future

All that will be discussed at

TBL Users Meeting, June 4, 2012 Nice (France)

Thank you !