



# SPACEINN

## Exploitation of Space Data for Innovative Helio- and Astero-seismology

COSADIE Forum

Heidelberg, 10/06/13

E. Michel, Observatoire de Paris-LESIA



# SPACEINN and VO

- What is SPACEINN?
- What kind of science at stake?
- What is the community possibly interested?
- What kind of data and data sources are we talking about?
- Where does the VO come in?

# What is SPACEINN?

**Collaborative Project EU FP7 / Cooperation Theme 9: Space** of the European research groups active in helio- & asteroseismology

to make full use of data collected in space and complementary on ground for the physics of solar and stellar interiors.

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Kiepenheuer-Institut für Sonnenphysik, Freiburg

**Scientist in Charge:**

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Kiepenheuer-Institut für Sonnenphysik, Freiburg

**Project Duration:** January 1, 2013 – December 31, 2016

# What is SPACEINN?

## The Consortium

- 1 Kiepenheuer-Institut für Sonnenphysik, Freiburg, Germany KIS
- 2 Instituto de Astrofísica de Canarias, La Laguna, Spain IAC
- 3 Commissariat à l'Énergie Atomique et aux Énergies Alternatives, Saclay, France CEA
- 4 Max-Planck Institute for Solar System Research, K.- Lindau, Germany MPG
- 5 Istituto Nazionale di Astrofisica, Rome, Italy INAF
- 6 Katholieke Universiteit Leuven, Instituut voor Sterrenkunde, Belgium KUL
- 7 Observatoire de Paris, Meudon, France OPM
- 8 Universidade do Porto, Centro de Astrofísica, Porto, Portugal CAUP
- 9 University of Birmingham, United Kingdom UOB
- 10 Aarhus Universitet, Institut for Fysik og Astronomi, Århus, Denmark AU
- 11 Institut Astrophysique Spatial, Orsay, France IAS
- 12 Université Paul Sabatier (Toulouse III), France UPS
- 13 Instituto de Astrofísica de Andalucía, Granada, Spain IAA
- 14 Royal Library Copenhagen, Denmark KB-DK
- 15 National Solar Observatory, Tucson, USA NSO
- 16 High Altitude Observatory, Boulder, USA HAO
- 17 Konkoly Observatory of the Hungarian Academy of Sciences, Hungary KO



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Who is Who



Calendar



Science Products



Outreach

**Welcome to HELAS**

It is a great pleasure to introduce a new European initiative: "HELAS", the European Helio- and Asteroseismology Network . This initiative is funded by the European Commission since April 1st, 2006, as a "Co-ordination Action" under its Sixth Framework Programme (FP6).

**HELAS (2006-2010):** Co-ordinated Action funded under EU FP6

**Objectives:** Coordinate European research groups active in Helio- and Asteroseismology

prepare: SDO, CoRoT, PICARD, GOLF-NG, Solar Orbiter,...

**Statistics**

Visits	By country
Visits today:	0
Visits yesterday:	0
Visits month:	0
Visits total:	0

**Warning:**  
 mysql\_fetch\_array(): supplied argument is not a valid MySQL result resource in

As a central node making all this coordination possible, the HELAS IT platform was born as the reference site in the domain of Helio- and Asteroseismology. The common information on these research fields shall be available here. Moreover the HELAS IT will ensure coordination between groups by offering a forum for discussion and exchange of knowledge.

All European researchers interested in Helio- and Asteroseismology are invited to participate in this activity and to benefit from the information, tools and products offered here. We would like to strongly encourage you and your colleagues to participate actively in the HELAS activities and the further development of the HELAS website.

HELAS Consortium.

Last Updated ( Tuesday, 03 July 2007 )

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**Warning:**  
 mysql\_fetch\_array(): supplied argument is not a valid MySQL result resource in /datos/ext/proyecto/helas/modules/mod\_jstats\_counters.php on line 183

**Warning:**  
 mysql\_free\_result(): supplied argument is not a valid MySQL result resource in /datos/ext/proyecto/helas/modules/mod\_jstats\_counters.php on line 208

**Warning:**  
 mysql\_fetch\_array(): supplied argument is not a valid MySQL result resource in /datos/ext/proyecto/helas/components/com\_joomlastats/joomlastats.inc.php on line 685

## Who is Who

How to Navigate:

1. **Arrows:** Click the appropriate arrow buttons to move the view north, south, east or west. Click Center button to return to your original view.
2. **Zoom:** Click + to zoom in on the center of the map. Click - to zoom out.
3. **Zoom slider:** Drag the zoom slider up or down to zoom in or out incrementally.

Keys:

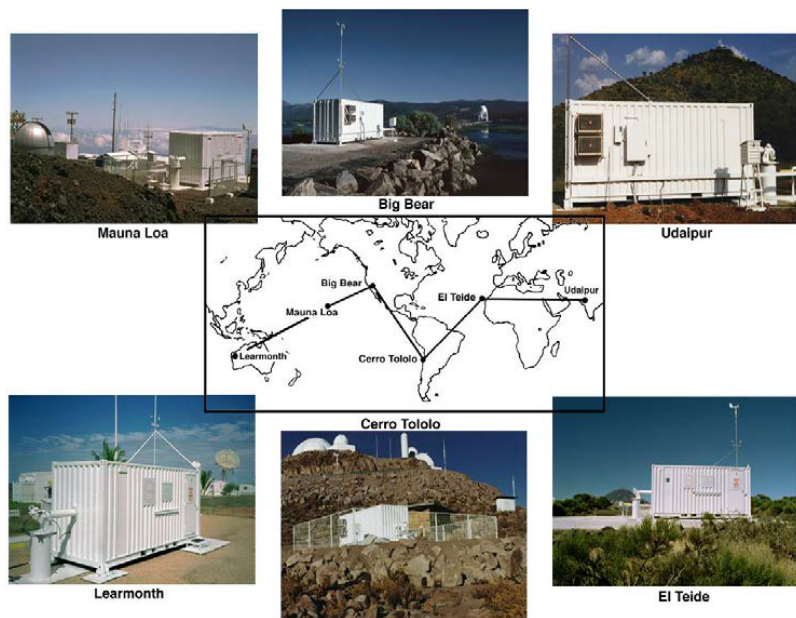
- HELAS Nodes
- University
- Research Center



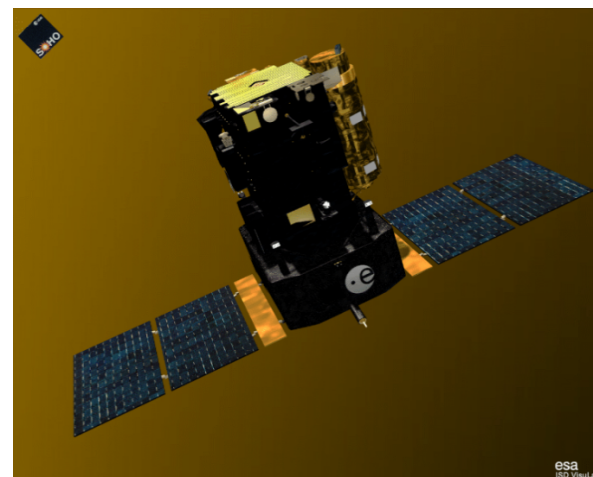
Research Institutions hosting Helio- and Asteroseismology Groups worldwide

# Instruments for Helioseismology

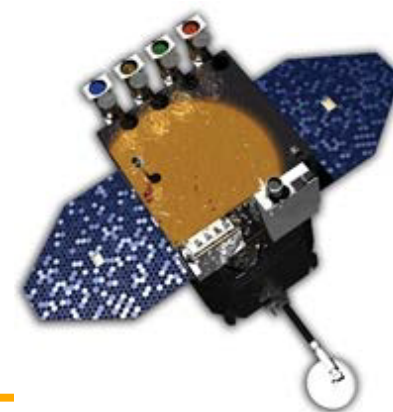
**GONG (Global Oscillation Network Group, 1995)**



**SOHO (Solar Heliospheric Observatory, 1996)**



**SDO (Solar Dynamics Observatory, 2010)**

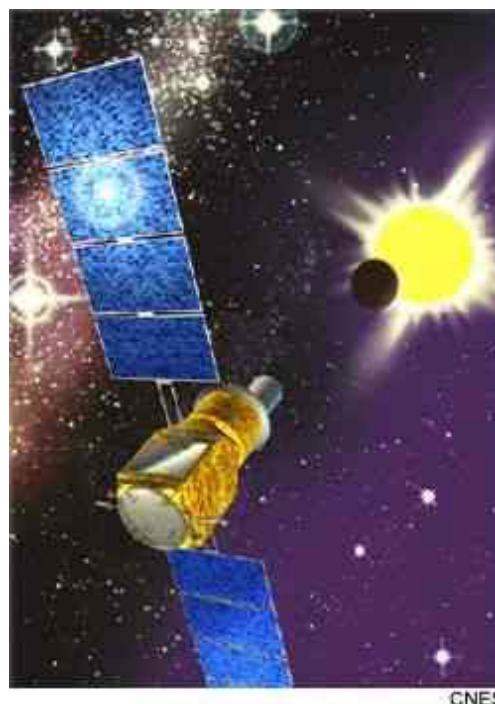


## **Data rates:**

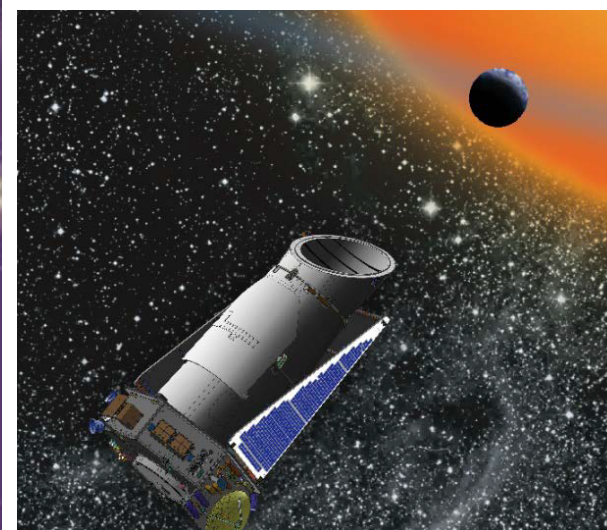
GONG & SOHO: each 1 MP image per minute + magnetograms  
 SDO: 16 MP image per 45 s + magnetograms; 2 TB per month

# Instruments for stellar seismology

CoRoT (2006)



Kepler (2009)



NASA

## **Data rates:**

CoRoT: ~150000 stars observed up to 5 months, one photometric measurement every 8.5 minute  
Kepler: ~150000 stars observed up to 4 years, one photometric measurement every 30 minutes



# SPACEINN: Objectives

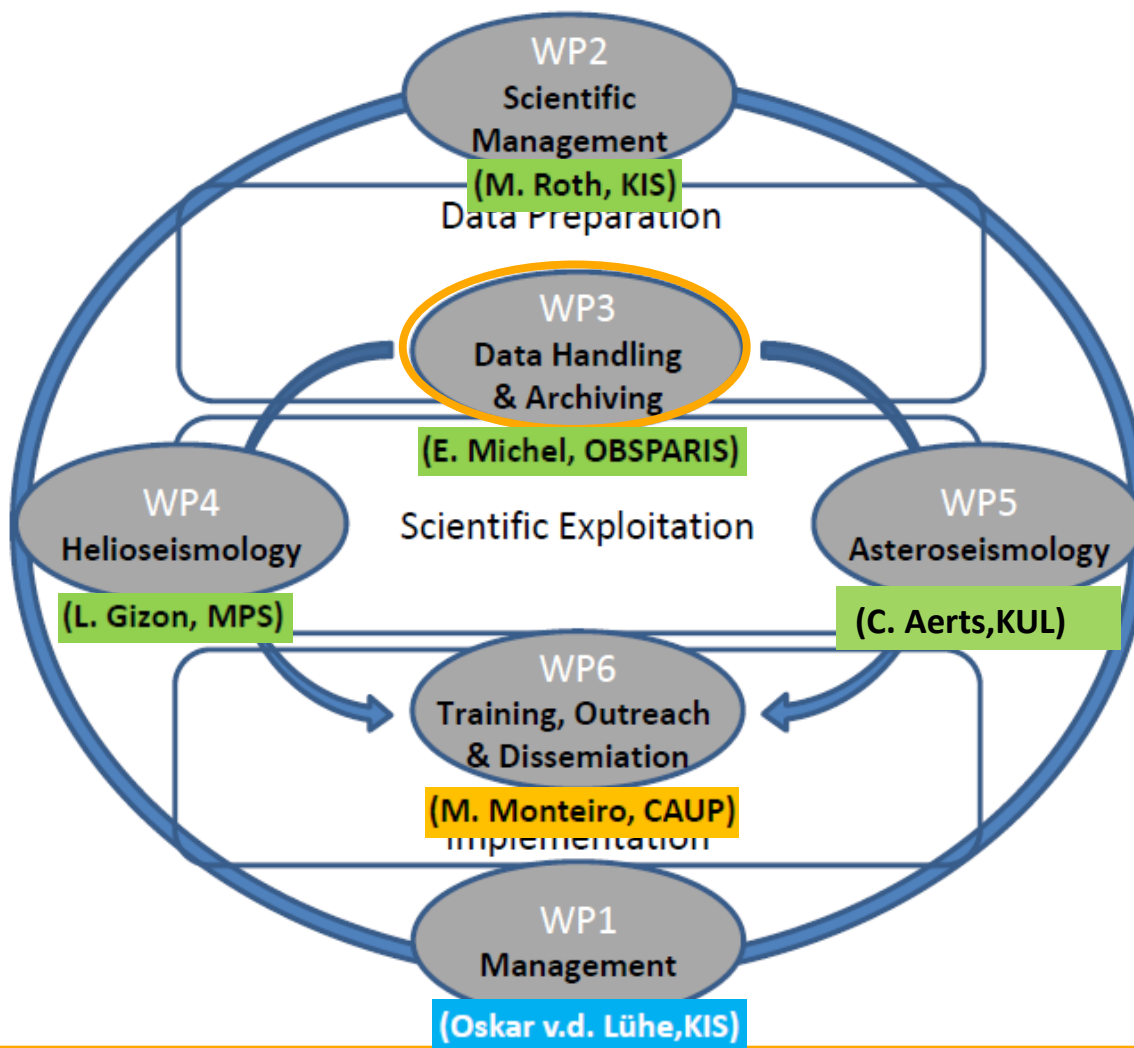
The organization of this large and increasing volume of space- and ground-based data will result in

- In-depth studies of the interiors of the Sun and the stars
- Strengthening the cooperation in a joint research project of the major groups working in this important discipline, where Europe plays a leading role.
- Greatly improve understanding of solar and stellar structure, evolution and activity
  - including also those aspects of the solar activity of potentially societal effects.

# SPACEINN: Objectives

- **Coordinated archives** of space- and ground-based data & results of the analyses. –Tools for efficient data access –Organization in a Virtual Observatory environment
- Secured **long-term preservation** of these often unique data – Expertise by the National Library of Denmark in Copenhagen
- **Coordinated utilization** of the data –Improved understanding of solar structure, dynamics and activity, as well as of stellar structure and evolution
- An **increased awareness** of the field –Amongst the general public – At all levels of the educational system, throughout Europe

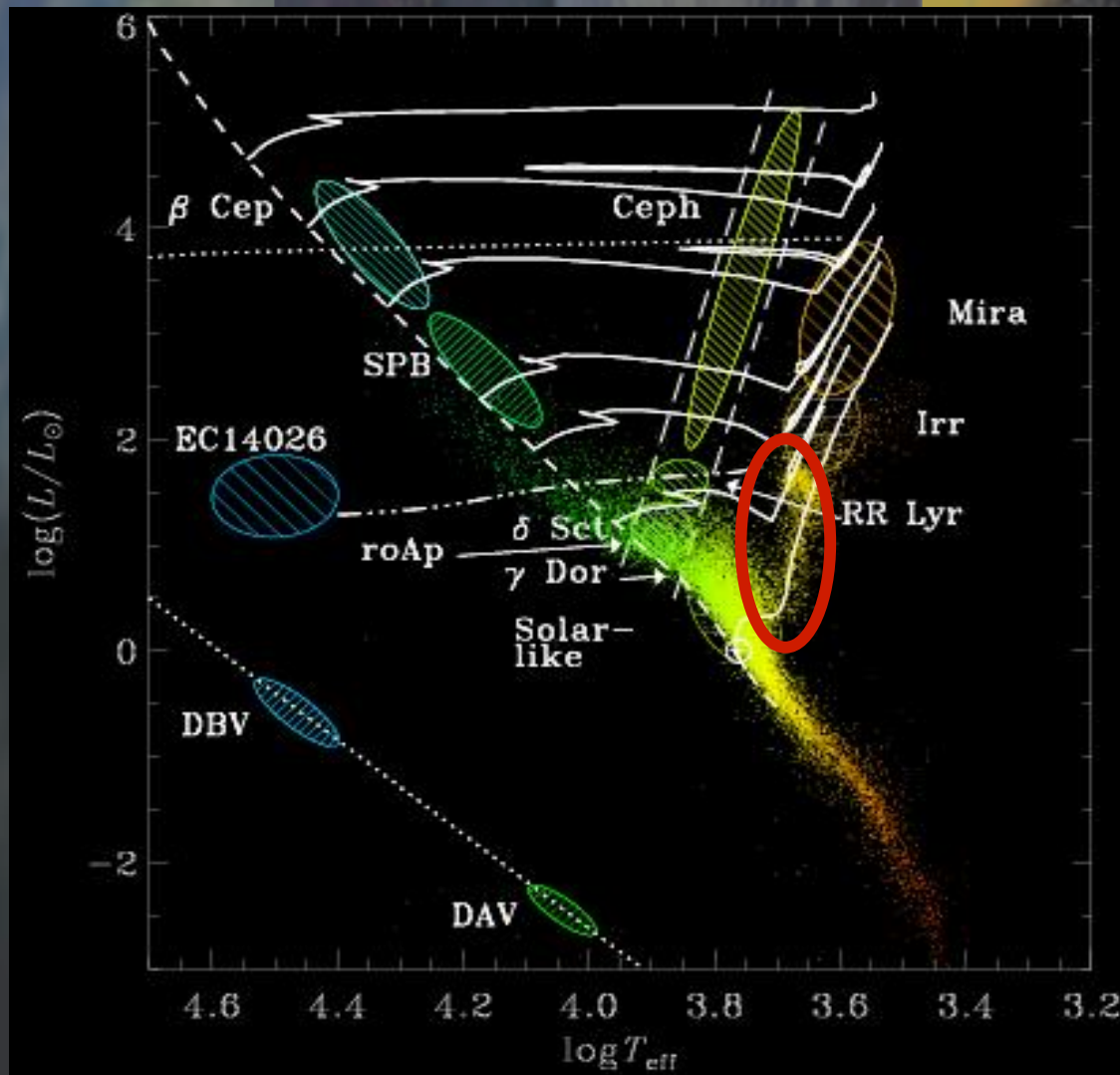
# Project overview



# The scientific community interested

- Helio- and Asteroseismology ->Solar and stellar physics:  
large number of seismic data AND complementary data (global parameters:  $T_{\text{eff}}$ ,  $M_V$ ,  $[\text{Fe}/\text{H}]$ ,  $\pi$ , ..., spectropolarimetric, interferometric,...)
- Exoplanets : observational and theoretical synergies (CoRoT, *Kepler*,..., PLATO)
- Galactic: Population studies, the 'Red Giant revolution'...
- ...

# The red giants saga – the worst is not always sure...



# The red giants saga – the worst is not always sure...

➤ oscillations measured in several hundreds RG

over 700 spectra among ~11000 from LRc01 !!

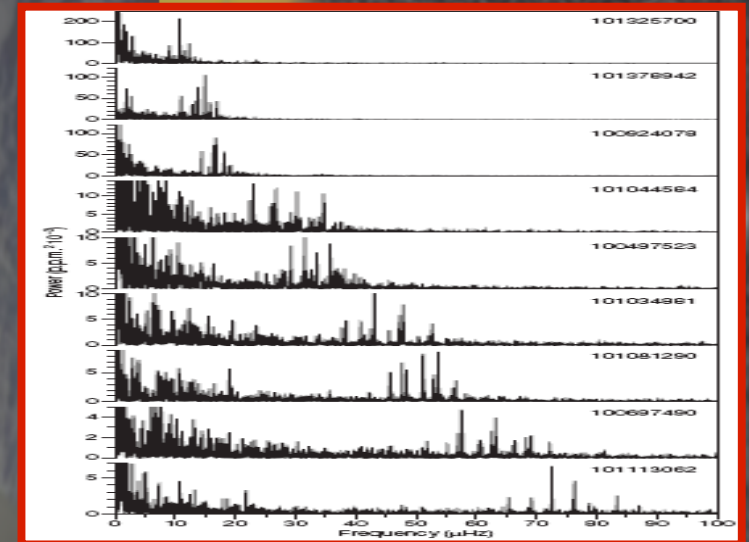
➤ Showing

➤ Nonradial modes with long lifetimes

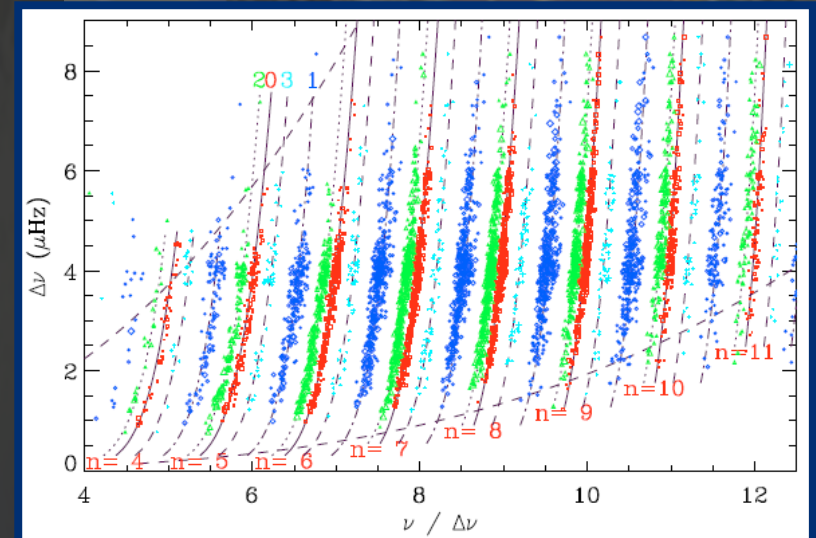
➤ regular spacing ( $\Delta\nu$ )

➤ Reasonable understanding of the general pattern

$$\nu_{n,l} / \Delta\nu = n + l/2 + \varepsilon(\Delta\nu) - d_{0,l}(\Delta\nu)$$



(De Ridder et al. 2009 Nature)



(Mosser et al. 2011 A&A 525)

# The red giants saga – the worst is not always sure...

➤ these seismic indexes can be used to characterize RG

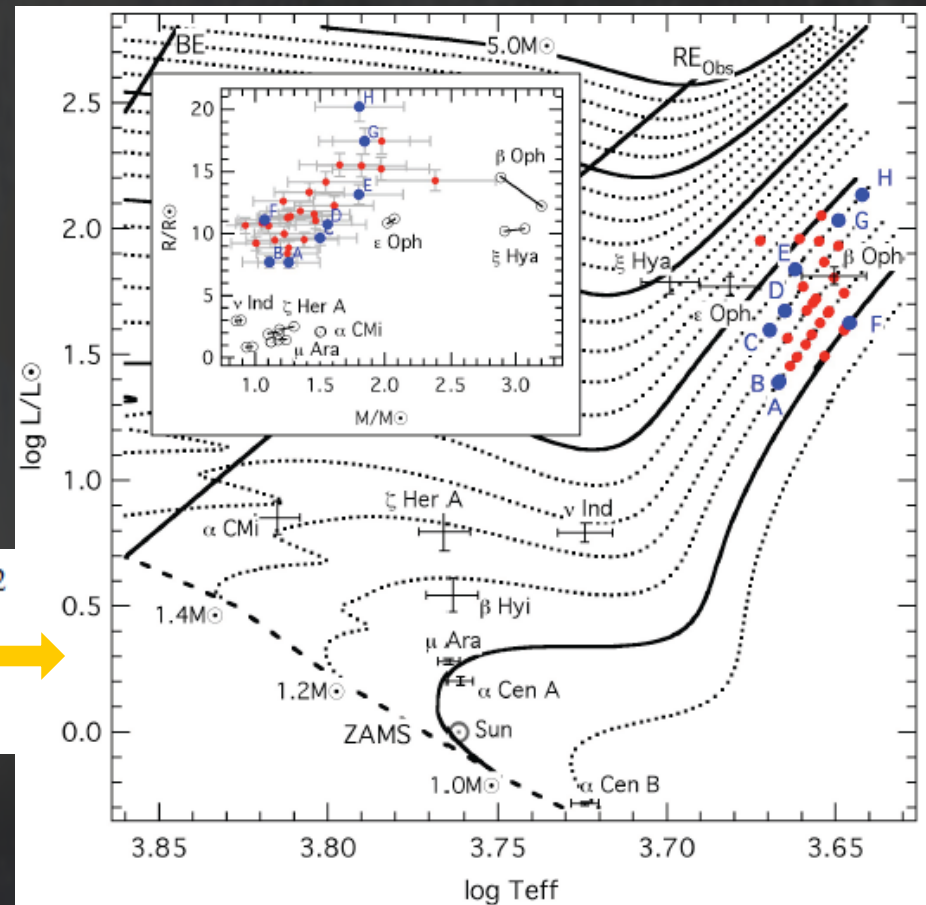
$$v_{\max} = \frac{M/M_{\odot}}{(R/R_{\odot})^2 \sqrt{T_{\text{eff}}/5777 \text{ K}}} 3050 \mu\text{Hz}.$$

$$\Delta\nu = \sqrt{\frac{M/M_{\odot}}{(R/R_{\odot})^3}} 134.9 \mu\text{Hz}.$$

$$R/R_{\odot} = (v_{\max}/v_{\max,\odot}) \cdot (\Delta\nu/\Delta\nu_{\odot})^{-2} \cdot (T_{\text{eff}}/5777 \text{ K})^{1/2}$$

$$M/M_{\odot} = (R/R_{\odot})^3 \cdot (\Delta\nu/\Delta\nu_{\odot})^2.$$

(Kallinger 2010 A&A 509)



# The red giants saga – the worst is not always sure...

➤ these seismic indexes can be used to characterize RG

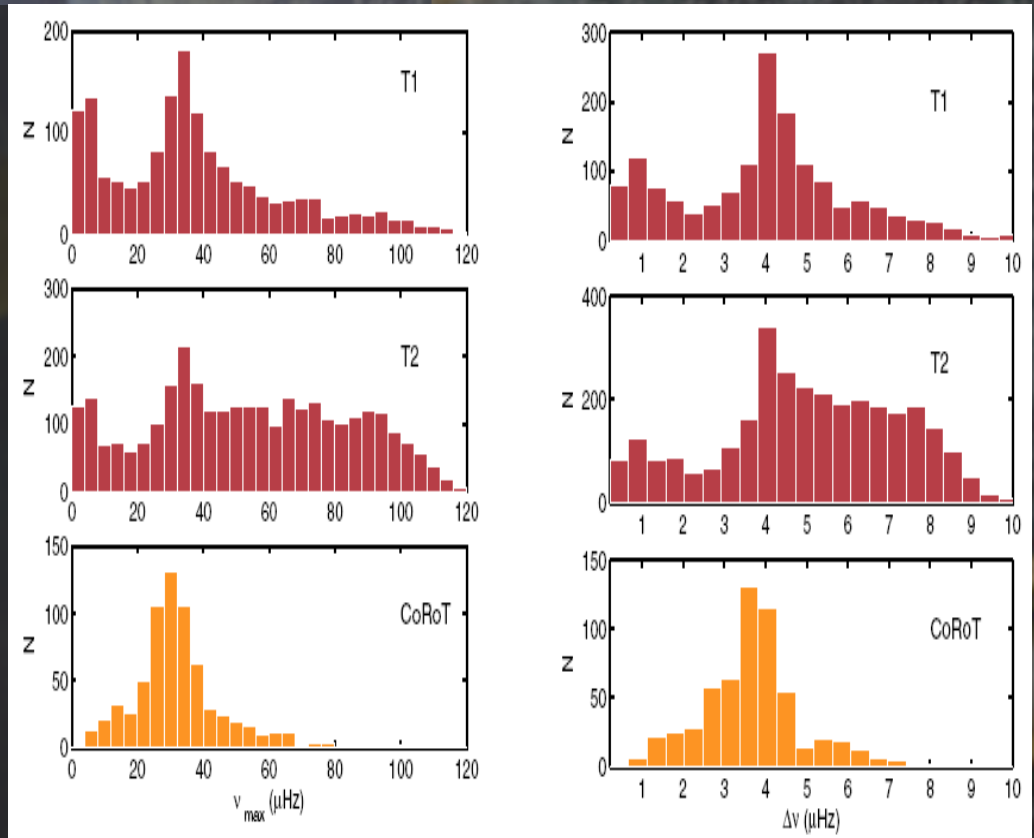
➤ ...to constraint population synthesis studies:

800 red giants (exo LRc01)  
Using  $\Delta\nu$ ,  $\nu_{\max}$  seismic indexes  
as fundamental parameters

Comparison with population synthesis

-> indexes are discriminant

-> suggest absence of recent stellar burst



(Miglio et al. 2009 A&A 503)



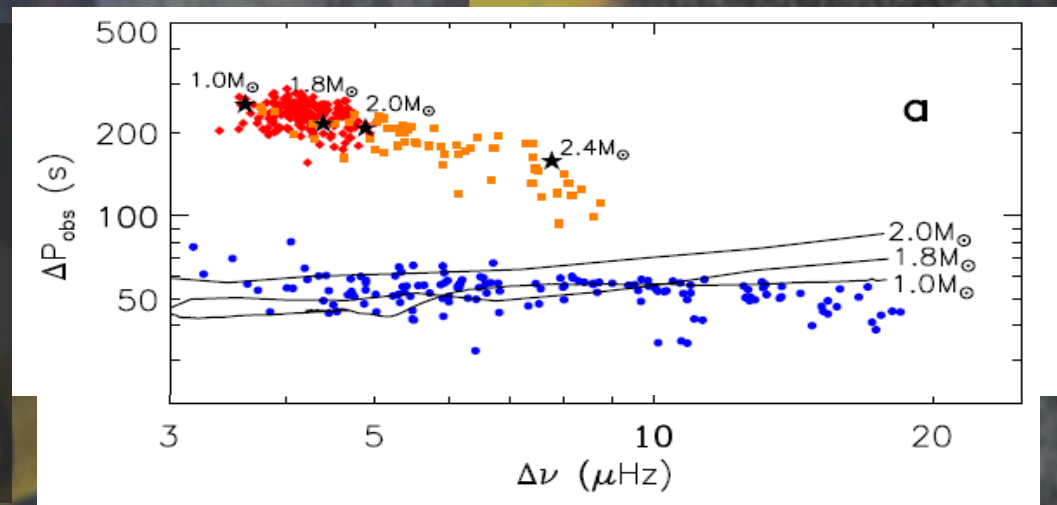
# The red giants saga – the worst is not always sure...

## ➤ application:

> Distinguish evolutionary states

Red Clump / Red giant branch

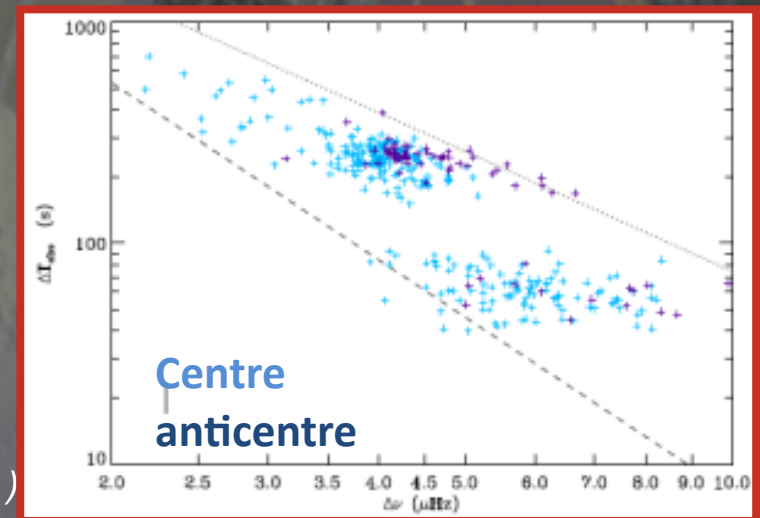
> Mass loss ?



(Bedding et al. 2011 Nature 471)

## ➤ application:

➤ Compare distributions in two opposite directions in the Galaxy



(Mosser et al. 2011 A&A)

# SPACEINN/WP3: Objectives

- Coordinated access to the large variety of data sources available (Space, Ground, Stellar, Solar, photometry, velocimetry,...)
- Provide tools to handle and combine data for a broad scientific community (Seismo community and beyond,... exoplanets, galactic populations,...)



Source Name	object	Data type	www.address
		<b>Time series</b>	
CoRoT archive	stars	Photometry series(1D)+...	<a href="http://idoc-corot.ias.u-psud.fr/">http://idoc-corot.ias.u-psud.fr/</a>
Kasoc archive	stars	Photometry series(1D)+	<a href="http://kasoc.phys.au.dk/">http://kasoc.phys.au.dk/</a>
Kepler archive	stars	Photometry series(1D)+	<a href="http://kepler.nasa.gov/Science/ForScientists/dataarchive/">http://kepler.nasa.gov/Science/ForScientists/dataarchive/</a>
Ground-based CoRoT complementary archive	Stars (CoRoT)	Spectra series (2D)	
SOHO	Sun		<a href="http://idc-medoc.ias.u-psud.fr/">http://idc-medoc.ias.u-psud.fr/</a> <a href="http://sohowww.nascom.nasa.gov/data/data.html">http://sohowww.nascom.nasa.gov/data/data.html</a>
SOHO/VIRGO/PMO 6V	Sun	Bolometric series (1D)	
SOHO/VIRGO/DIAR AD	Sun	Bolometric series (1D)	
SOHO/VIRGOS/SPM	Sun	Photometry series (1D)	
SOHO/MDI	Sun	Magnetograms series (3D)	
SOHO/...LASCO_CEL AS/MTOF/PM/CTOF/STOF/HSTOF/SEM...?			
SDO	Sun		<a href="http://jsoc.stanford.edu/ajax/look_data.html">http://jsoc.stanford.edu/ajax/look_data.html</a>
SDO/HMI	Sun	Dopplergrams+Magnetograms+Broad band images series (3D)	
SDO/AIA?	Sun		
SDO/...			
GONG	Sun	Dopplergrams+Magnetograms series (3D)+radial velocity+intensity series (1D)	<a href="http://gong2.nso.edu/archive/patch.pl?menutype=s">http://gong2.nso.edu/archive/patch.pl?menutype=s</a>
Bison	Sun	Radial velocity series (1D)	<a href="http://bison.ph.bham.ac.uk/index.php?page=data_timeseries">http://bison.ph.bham.ac.uk/index.php?page=data_timeseries</a>
MARK-I	Sun	Radial velocity series (1D)	



		Sources of fundamental parameters: $T_{\text{eff}}$ , Fe/H, L, $\rho_i$ , ...	
PASTEL	<a href="#">Stars/biblio</a>	<a href="#">Teff</a> , <a href="#">log_g</a> , Fe/H	
APOGEE	<a href="#">Stars/spectr</a> <a href="#">Q</a>	<a href="#">Teff</a> , <a href="#">log_g</a> , Fe/H	
P2F	<a href="#">Stars/multi color photometry +calibration</a>	<a href="#">Teff</a> , <a href="#">log_g</a> , Fe/H	<a href="http://www.univie.ac.at/p2f/cgi-bin/P2F.cgi">www.univie.ac.at/p2f/cgi-bin/P2F.cgi</a>
<a href="#">Hipparcos&amp;Tycho catalogue</a>	<a href="#">stars</a>	Position astrometry	<a href="http://www.rssd.esa.int/index.php?project=HIPPARCOS&amp;page=Research_tools">http://www.rssd.esa.int/index.php?project=HIPPARCOS&amp;page=Research_tools</a>
SSI Stellar Seismic Indices	<a href="#">Stars+Sun</a>	Seismic indices	
		<a href="#">Spectra/observed/theo</a>	
APOGEE (Sloan Digital Survey)	<a href="#">Stars (Kepler)</a>	spectra	<a href="http://www.sdss3.org">www.sdss3.org</a>
GAUDI	<a href="#">Stars (CoRoT)</a>	spectra	
Gaia ESO Survey (GES)	<a href="#">stars</a>	spectra	
TBL Legacy	<a href="#">Stars</a>	spectra	<a href="http://tblegacy.bagn.obs-mip.fr/">http://tblegacy.bagn.obs-mip.fr/</a>
POLLUX	<a href="#">Theo.</a>	Stellar spectra	<a href="http://pollux.graal.univ-montp2.fr/">http://pollux.graal.univ-montp2.fr/</a>
		<a href="#">Stellar models</a>	
Stellar and solar models and oscillation parameters	<a href="#">Theo.</a>	<a href="#">Solar&amp;stellar models</a>	

# WP3: Objectives

- Coordinated access through:
  - **‘The Seismic Plus’**: a global well identified public portal, with standard description of data sources content + tools (VO) to exploit and combine them (**WP3-1**, OBSPARIS, France).  
(Eric Michel & Christian Renié, Observatoire de Paris-LESIA)  
([Eric.Michel@obspm.fr](mailto:Eric.Michel@obspm.fr) & [Christian.Renie@obspm.fr](mailto:Christian.Renie@obspm.fr))

# SPACEINN/VO: needs

- For the data sources, existing or to be developed within SPACEINN:
    - > VO expertise to help VO compatibility
  - For the Portal 'THE SEISMIC PLUS':
    - > VO expertise to gather/produce tools to explore various data sources and to handle and 'combine' data and produce new scientific outputs
- > Support by and via VO-PARIS