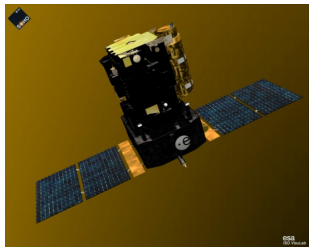
SPACE-INN

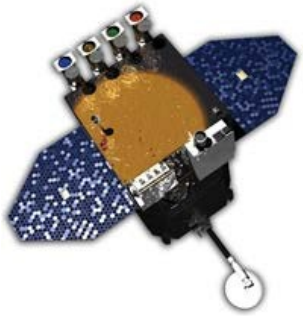
Exploitation of Space Data for Innovative Helio- and Asteroseismology

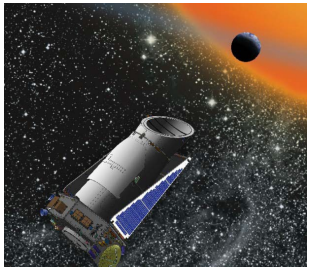
M. Abed, K. Belkacem, R. Michel, R. Peralta, C. Renié, R. Samadi
(LESIA – Observatoire de Paris)
P. Le Sidaner (VO-Paris – Observatoire de Paris)

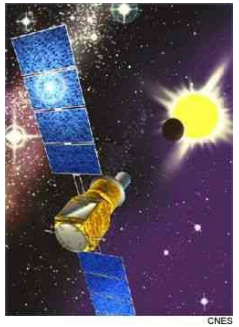
SPACE-INN : Motivations

- SOHO (1996-) ; SDO (2010-), GONG (1995-)
- CoRoT (2006-2012), Kepler (2009-)









Large and increasing volume of space- and ground-based data:

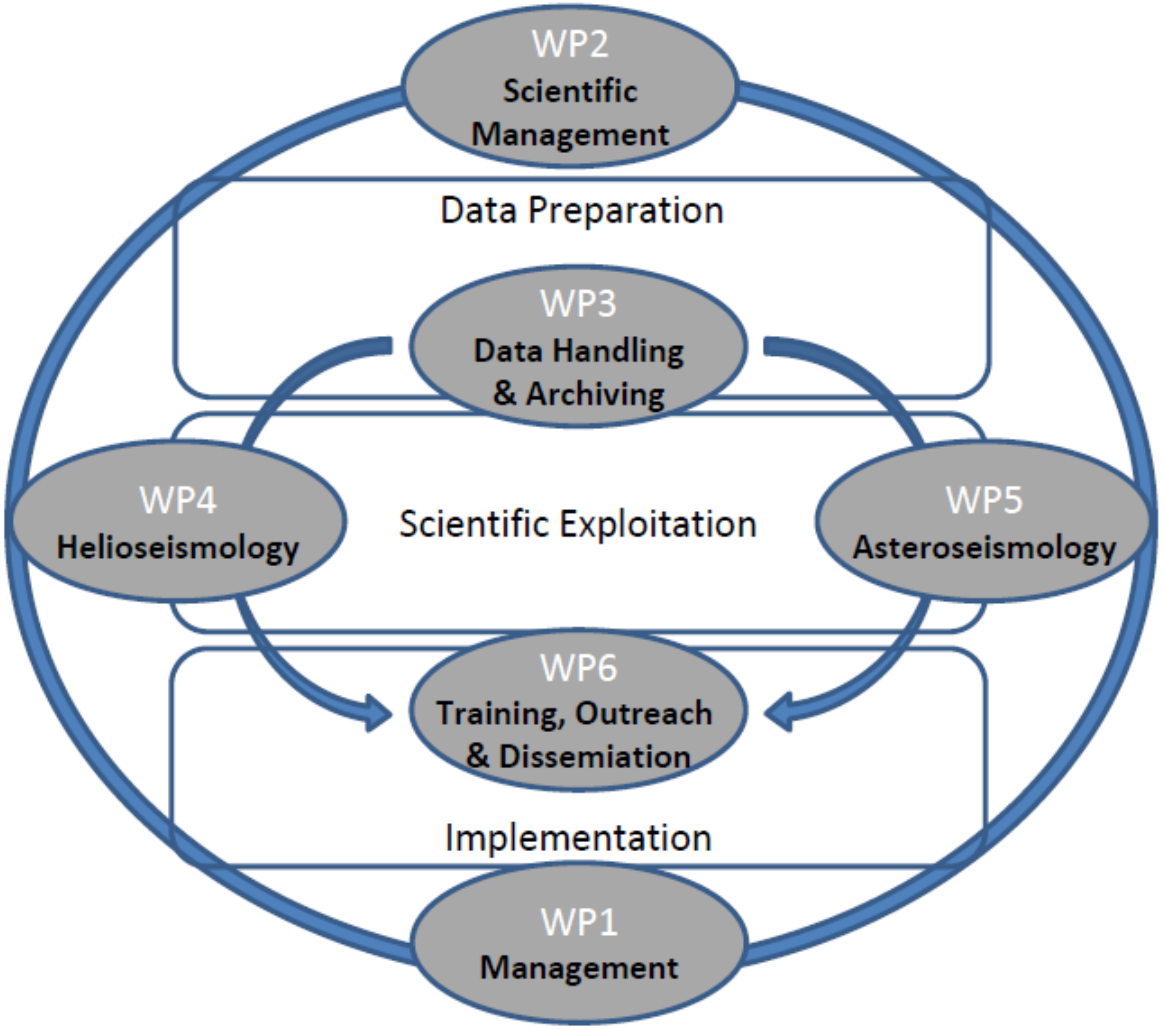
- **In-depth studies** of the interiors of the Sun and the stars
- **Strengthening the cooperation** in a joint research project of the major groups working in this important discipline, where Europe plays a leading role.
- Greatly **improve understanding** of solar and stellar structure, evolution and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

SPACE-INN : 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

Project Duration: January 1, 2013 – December 31, 2016
Funding : EU - FP 7
Seven instituts

Project Overview



WP 3 : Objectives

Overall resp. : Eric Michel (PI) / Christian Renié (Proj. manager)

‘The Seismic Plus’ portal

(WP 3-1)

a global well identified public portal, with standard description of data sources content + tools (VO) to exploit and combine them.

the Stellar Seismic Indices (SSI) data base (WP 3-2)

A data base containing stellar indices extracted from CoRoT and Kepler light-curves.

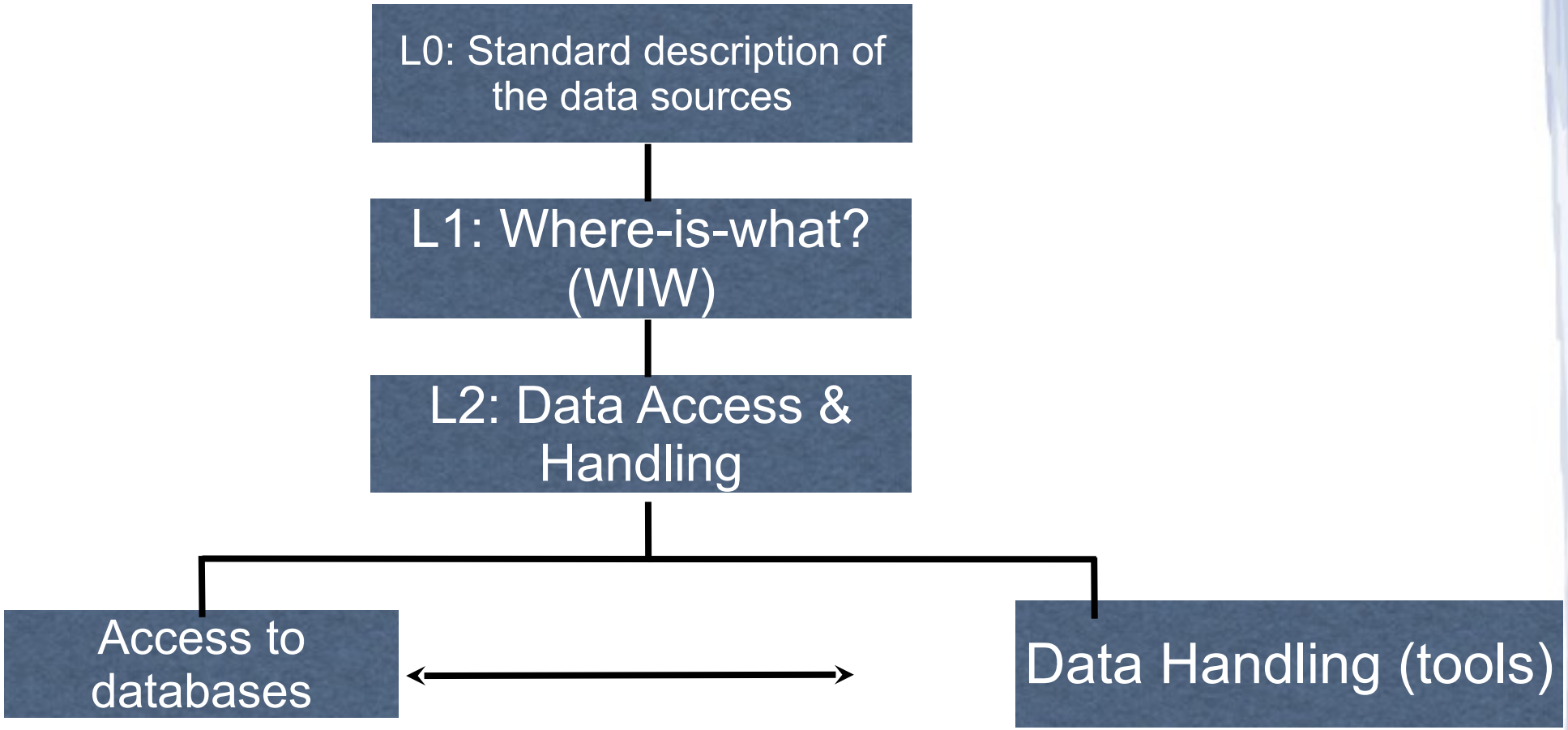
The Seismic Plus portal : objectives

- **Coordinated access** to the large variety of data sources available
- **Homogeneous description** of the data available from various source
- **Provide tools** to **handle** and **combine** data for a broad scientific community

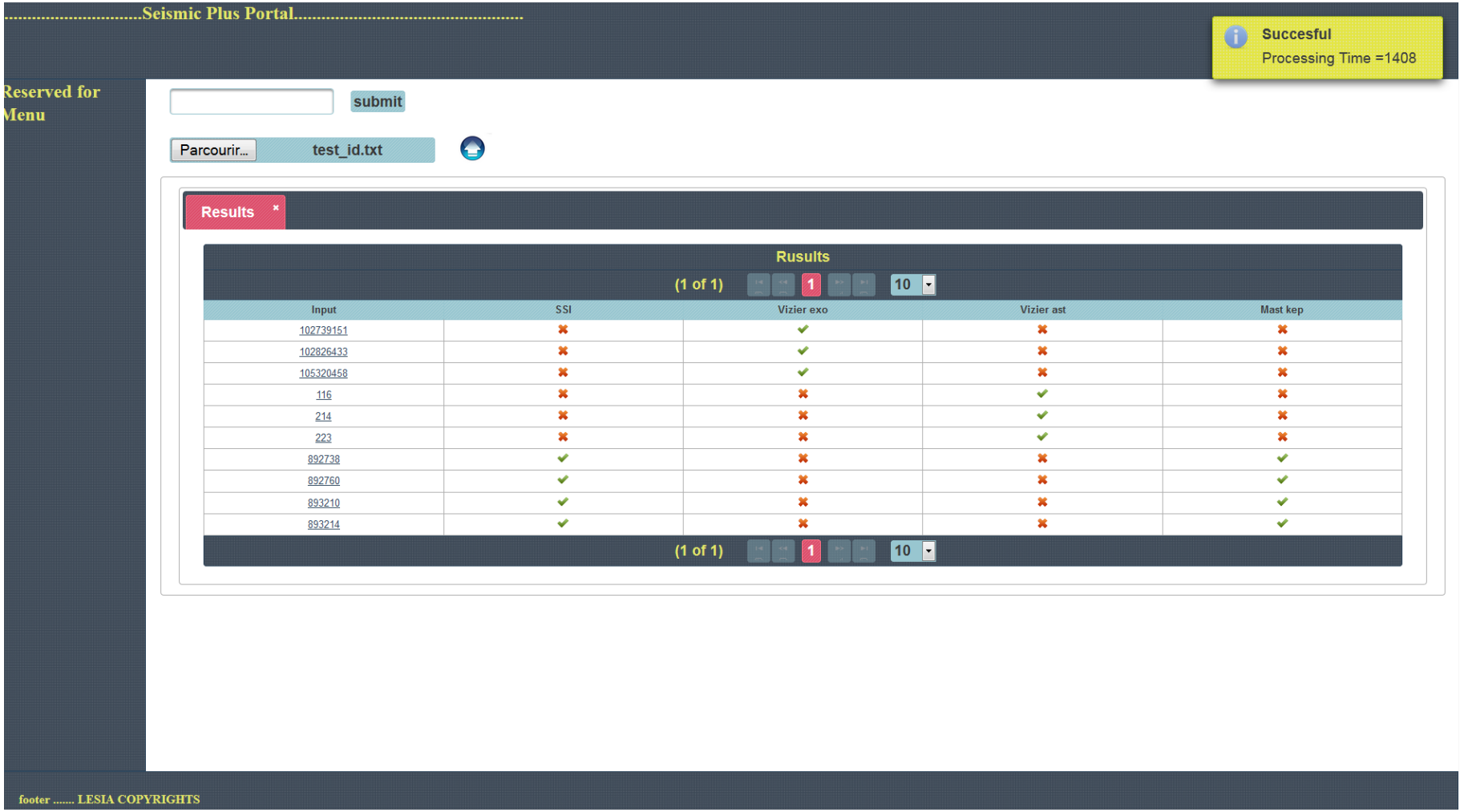
- Chef de projet : Christian Renié
- Resp. scientifique : Kévin Belkacem
- Ingénieur : Mahfoudh Abed

The Seismic Plus portal

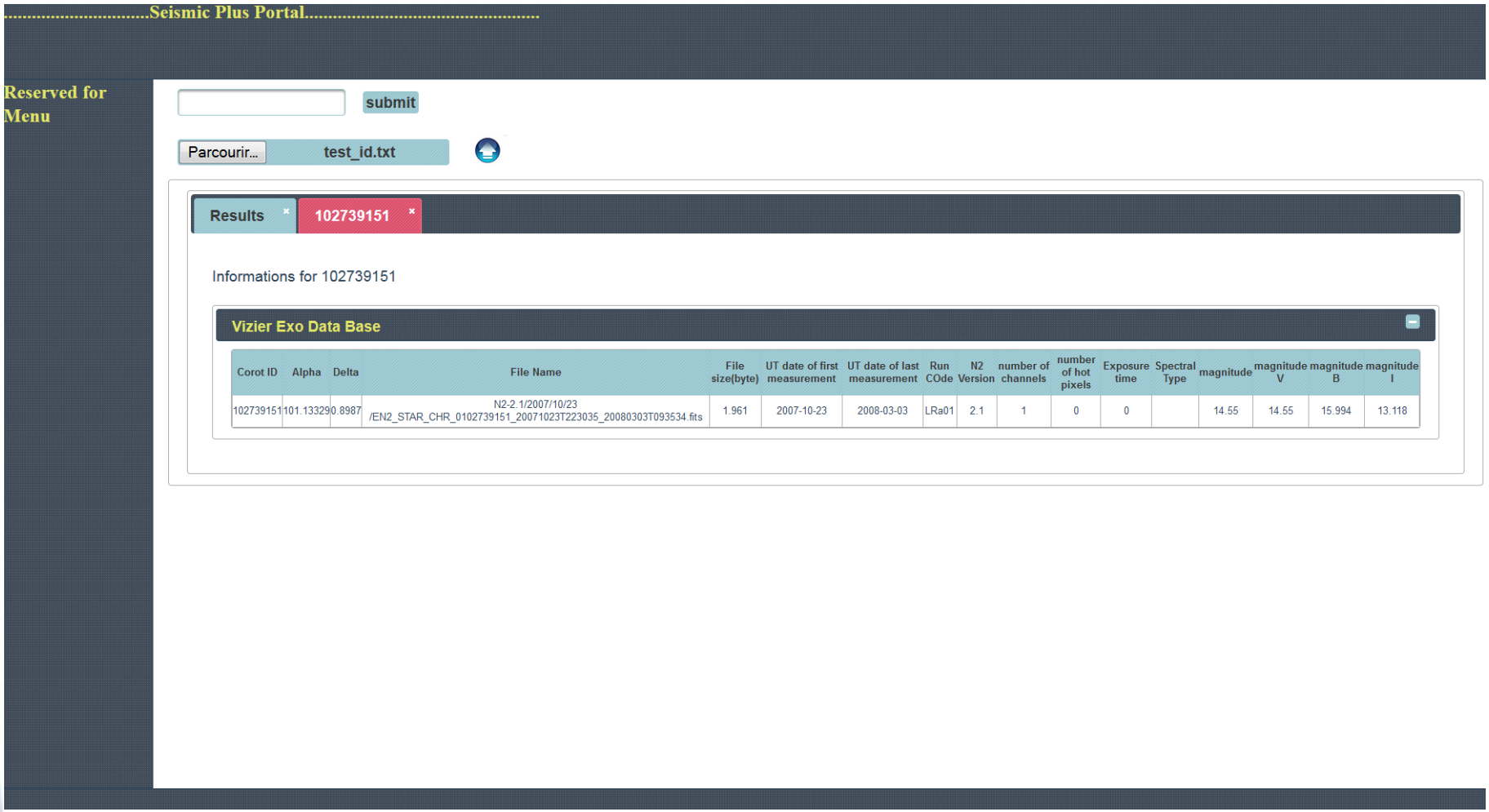
Three different levels (L0,L1,L2)



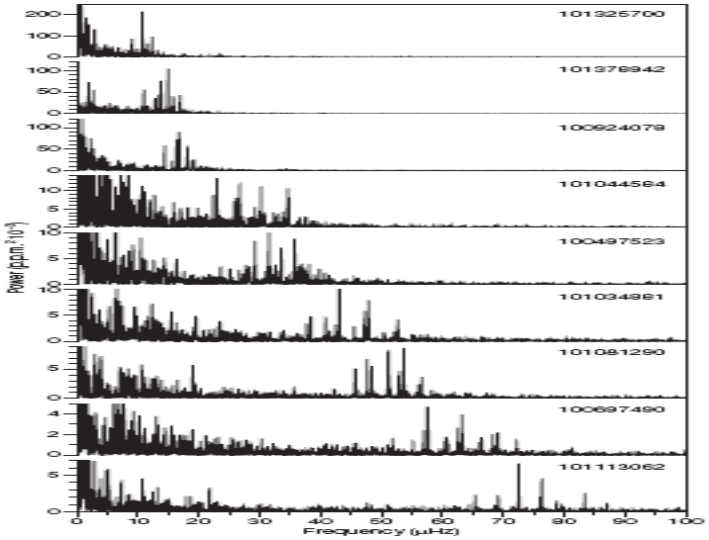
The Seismic Plus portal



The Seismic Plus portal



Stellar Seismic Indices



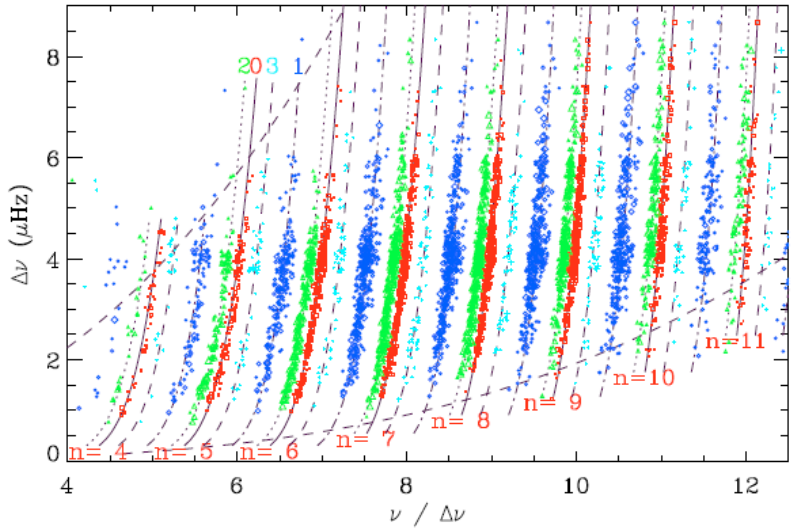
(De Ridder et al. 2009 Nature)

Oscillations measured in several hundreds red giant by CoRoT and Kepler (NASA) :

- Nonradial modes with long lifetimes
- Regular frequency spacing ($\Delta\nu$)

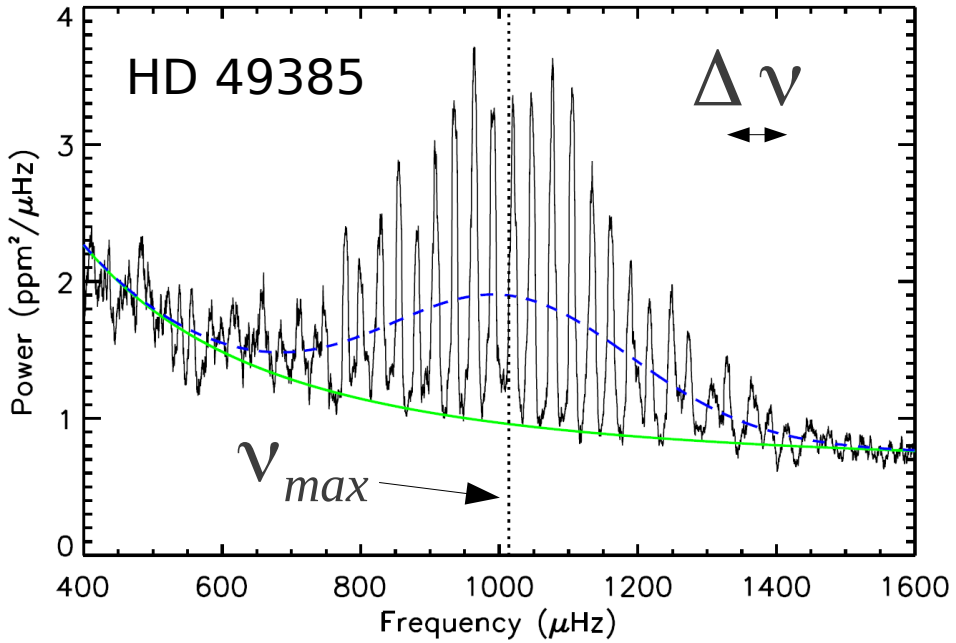
Existence and understanding of an (« universal ») pattern :

$$\nu\ n,l\ /\ \Delta\nu = n + l/2 + \varepsilon\ (\Delta\nu) - d\ 0,l\ (\Delta\nu)$$



(Mosser et al. 2011 A&A 525)

Stellar Seismic Indices



(Deheuvels et al 2009)

ν_{max} Peak frequency

$\Delta\nu$ Mean large separation

Scaling relations

From **Δν, ν_{max}** and a given effective temperature one can deduce an estimation of **mass and radius**

$$\frac{M}{M_\odot} \simeq \left(\frac{\nu_{max}}{\nu_{max,\odot}}\right)^{3} \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-4} \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{3/2}$$

$$\frac{R}{R_\odot} \simeq \left(\frac{\nu_{max}}{\nu_{max,\odot}}\right) \left(\frac{\Delta\nu}{\Delta\nu_\odot}\right)^{-2} \left(\frac{T_{eff}}{T_{eff,\odot}}\right)^{1/2}$$

➔ Many applications : stellar structure and evolution, stellar population ;
➔ Opened the way to « Ensemble asteroseismology » ;
➔ See recent reviews : Chaplin & Miglio (2012, ARAA), Mosser (2012, EPJWC), Mosser et al (2013, SF2A), ….

Applications

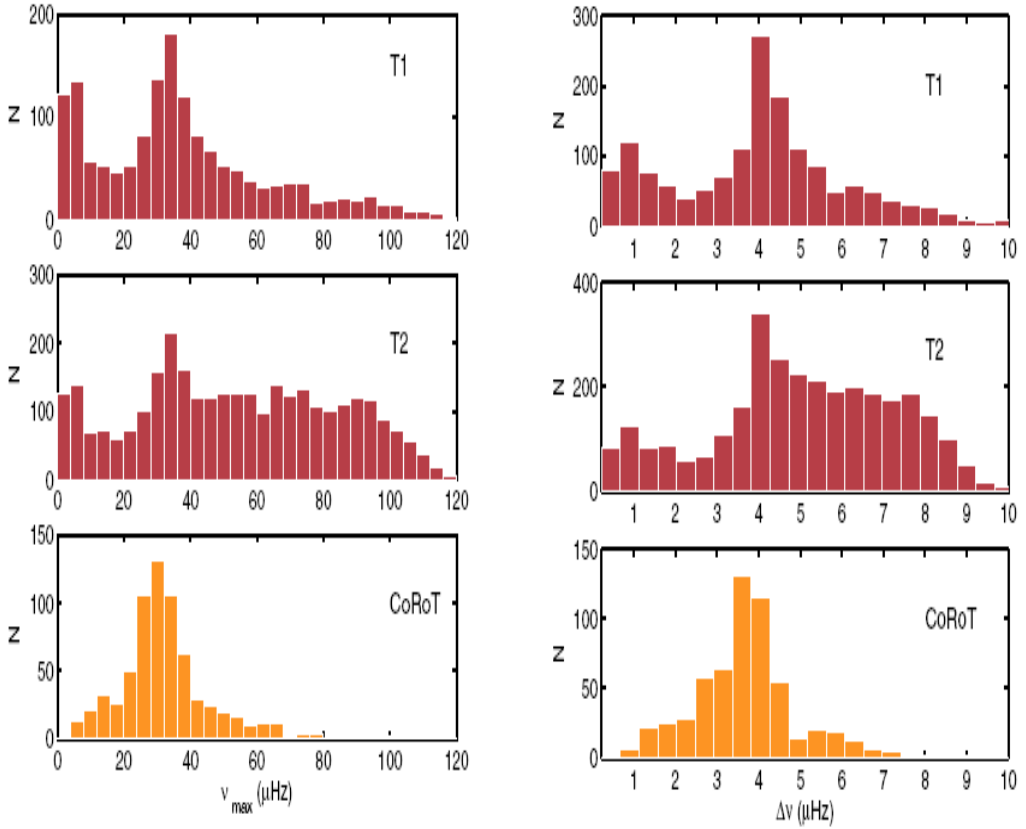
Seismic indices can be used to characterize red giant stars

Constraints on population synthesis studies:

800 red giants (exo LRc01)
Using $\Delta\nu$, νmax seismic indices

Comparison with population synthesis :

- seismic indices are discriminant
- suggest absence of recent stellar burst



(Miglio et al. 2009 A&A 503)

the Stellar Seismic Indices data base

Objectives : provided seismic v_{max}, $\Delta\nu$ and $\Delta\pi$ for scientific community within and beyond stellar physic community

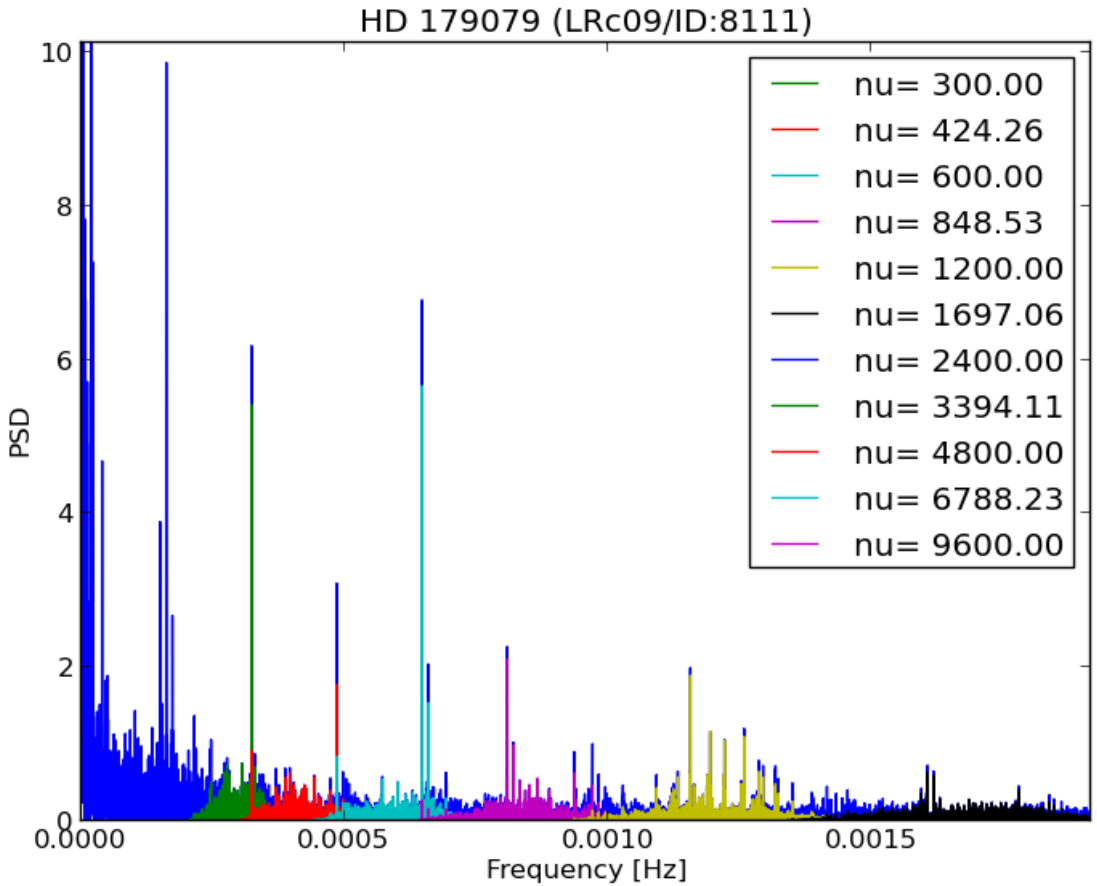
Input data:

- CoRoT and Kepler ligth-curves (20 000 - 30 000 red giants)
- OGLE ligth-curves ligth-curves (20 000 red giants)

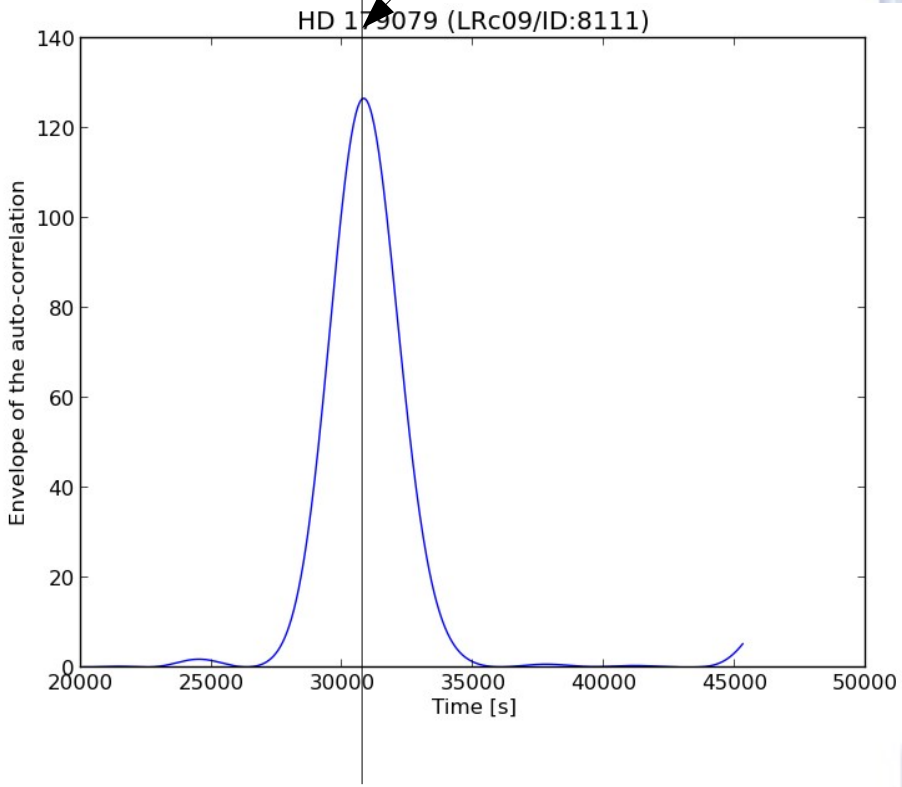
Chef de projet : Christian Renié
Resp. scientifique : Réza Samadi / Doctorant : Raphaël Peralta
Ingénieur : Mahfoudh Abed

Algorithms

The autocorrelation method :
Roxburgh & Vorontsov (2006) ; Mosser & Appourchaux 2009

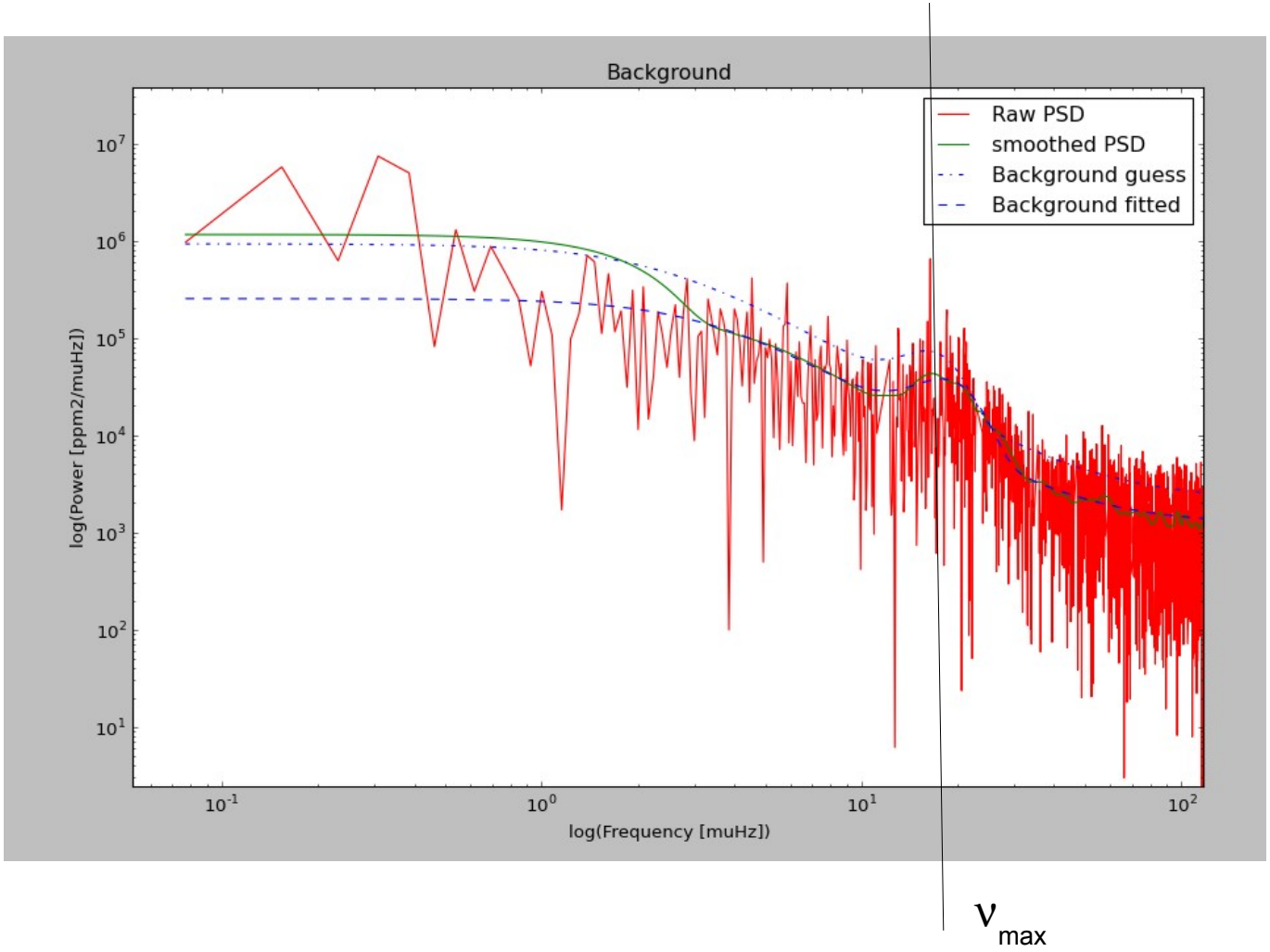


$$\frac{2}{\Delta \nu}$$



Algorithms

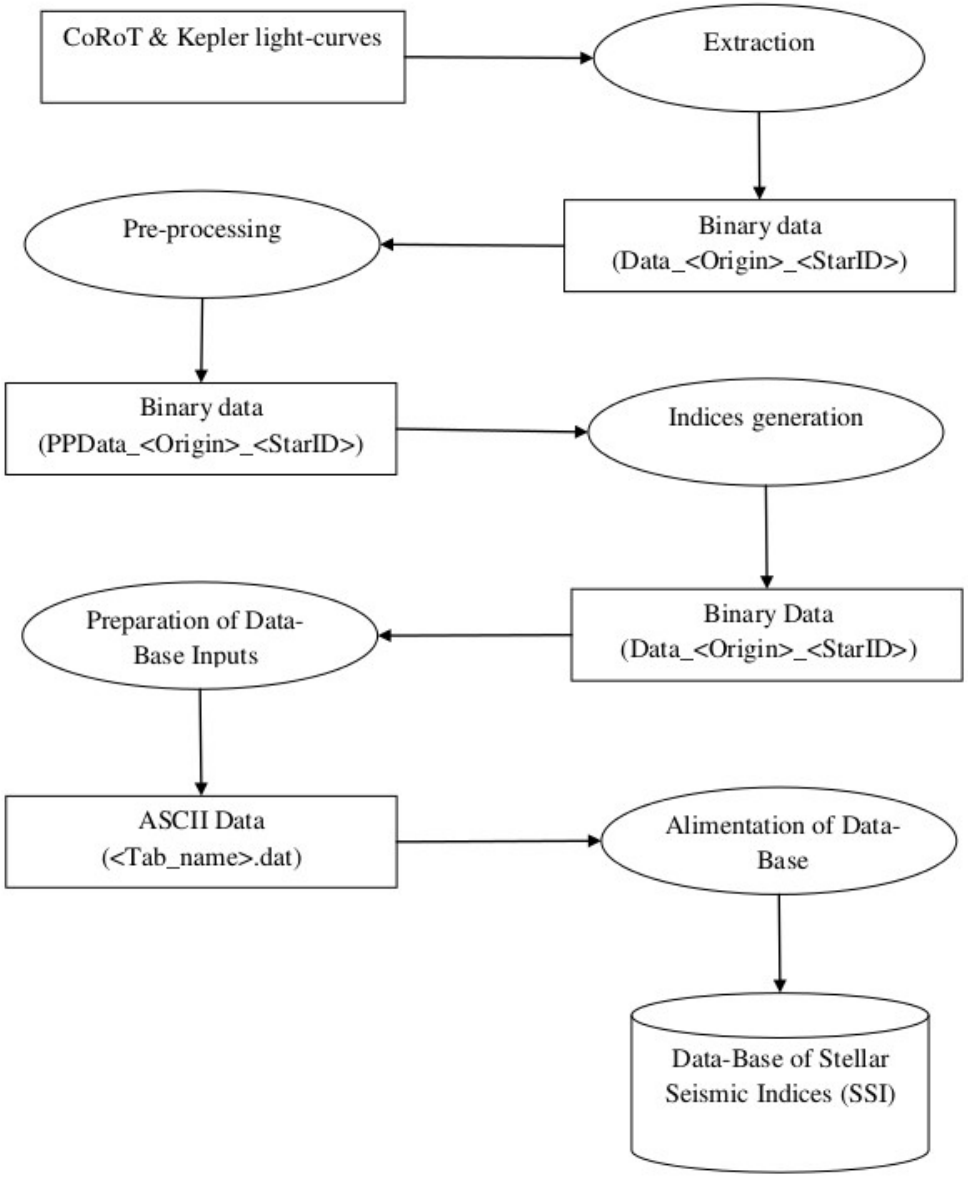
Stellar background + oscillation envelopes



Pipeline architecture

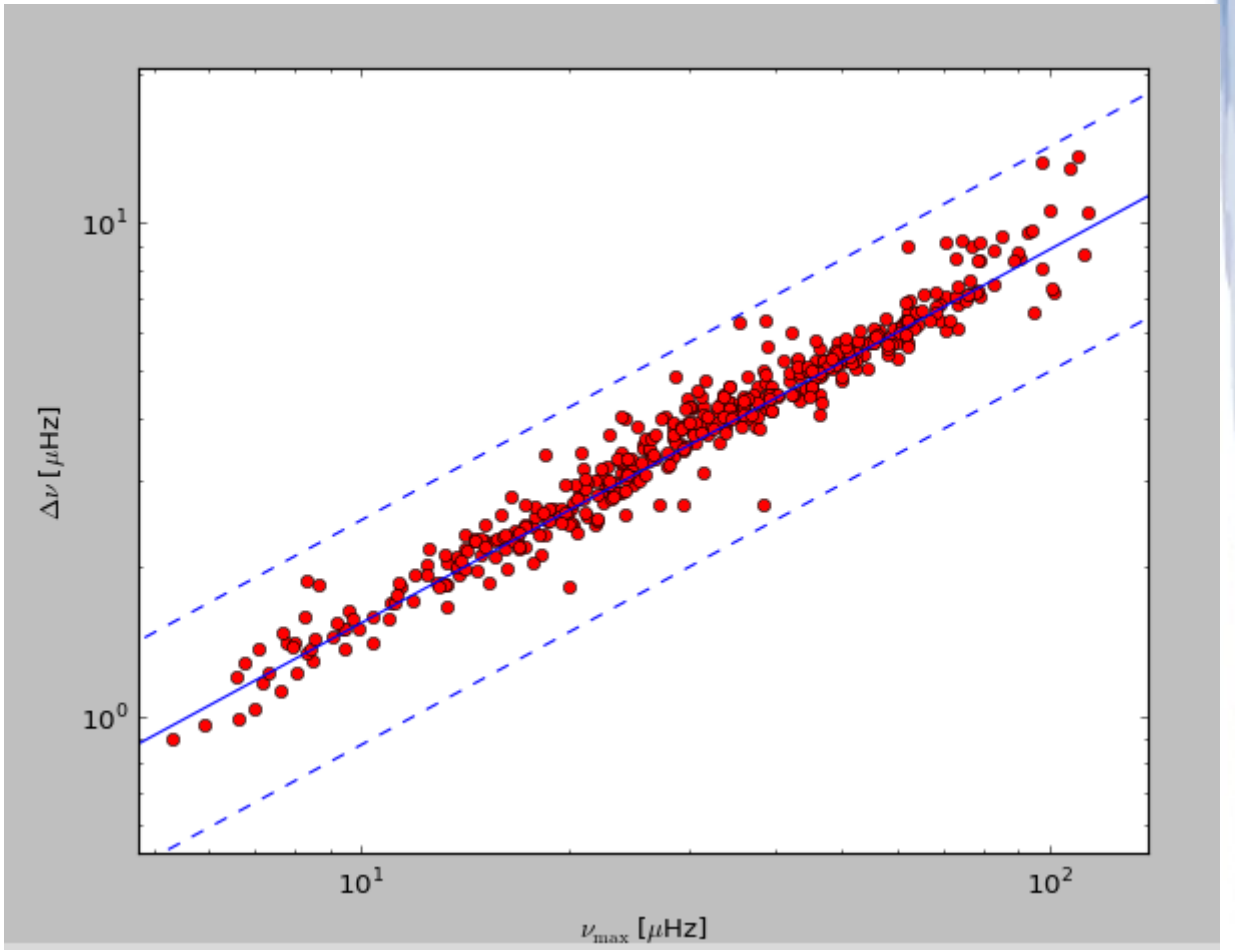
- Data extraction
- Pre-processing : jump correction, trend correction, calculation of the PDS
- Processing : the generation of the seismic indices
- Insertion into the SSI DB

✗ Coded in python (≥ 2.7)
✗ Multiprocessing capability



Some results

- ~ 1500 CoRoT targets
- « N2 » data from the Exo-Channel (with jumps correction ...)
- Seismic indices obtained for ~ 500 targets (~ 1/3)
- Performance (24 CPU-cores):
  - Pre-processing time: 10'
  - Processing time : 15'



SEVENTH FRAMEWORK PROGRAMME

SpaceInn.eu

Stellar Seismic Indices database

SSI Data-Base

Request Interface

Home

Admin

Stars Identification Submit

Data's resources: Corot Exo Corot Ast Kepler

Star ID (enter values or upload star ID's file): Parcourir... stars_list.txt add delete

757231
757218
757137
757099
757076
49933
12557548
1495211
102794085
20

Stars Properties Submit

Alpha [deg] :	min		max	
Delta [deg]:	min		max	
Teff [K]:	min		max	
Log g [cm^2/s^2]:	min		max	
V magnitude :	min		max	
R magnitude :	min		max	
Color (B-R for kepler, V-R for corot) :	min		max	

Spectral class: O B A F G K M

Luminosity class: I II III IV V

Seismic indices Submit

Delta nu [µHz] :	min		max		prec	
nu_max [µHz] :	min		max		prec	
Amax :	min		max		prec	
A_env [ppm^2/µHz] :	min		max		prec	
P_gran [ppm^2/µHz] :	min		max		prec	
tau_gran [s] :	min		max		prec	
alpha :	min		max		prec	

Reset Submit

R. Samadi (LESIA)

SSI data base

Request Interface

Home

Admin

Download as csv file

Show 10 entries Search:

Origin	SrarID	alpha	delta	teff	grav	mag_v	mag_r	specType	lumClass	Delta nu [µHz]		nu_max [µHz]		Amax		A_env [ppm²/µHz]		
										value	prec	value	prec	value	prec	value	prec	value
1	100486326	290.69441	1.40077	3120		13.465	12.785	K	III	1.71	0.05	9.77	0.00	7.84	0.00	193628.12	10.12	2836107.
1	100486393	290.694538	1.576191	4460		-99	14.94	K	V	1.68	0.36	8.68	0.00	0.96	0.00	61533.63	4.36	2629975
1	100527321	290.75516	1.39221	5000		13.461	13.103	G	IV	1.23	0.13	8.70	0.00	1.58	0.00	1304.56	0.34	97405.22
1	100553631	290.794645	1.273513	4519		-99	12.98	K	III	1.76	0.04	9.19	0.00	9.98	0.00	258338.18	11.58	2826650.
1	100557143	290.800096	1.672989	4491		-99	14.41	K	III	1.35	0.06	9.08	0.00	3.65	0.00	7607.05	0.66	573474.8
1	100576701	290.829606	1.787653	4575		-99	12.72	K	III	1.56	0.05	8.80	0.00	8.07	0.00	204354.36	10.74	2674145.
1	100580176	290.83481	1.27742	3040		13.109	12.399	K	III	1.22	0.02	8.03	0.00	15.18	0.00	463166.36	24.38	630897.7
1	100585212	290.842391	1.834353	4636		-99	13.92	G	V	1.88	0.11	8.64	0.00	4.04	0.00	13936.39	2.32	1279702
1	100586342	290.844064	1.226402	4523		-99	14.99	G	IV	1.68	0.03	8.36	0.00	17.60	0.00	288555.54	19.94	1002377
1	100660190	290.9499	1.53317	4960		14.358	13.913	G	II	2.14	0.01	8.73	0.00	40.91	0.00	2424042.03	38.89	4017041

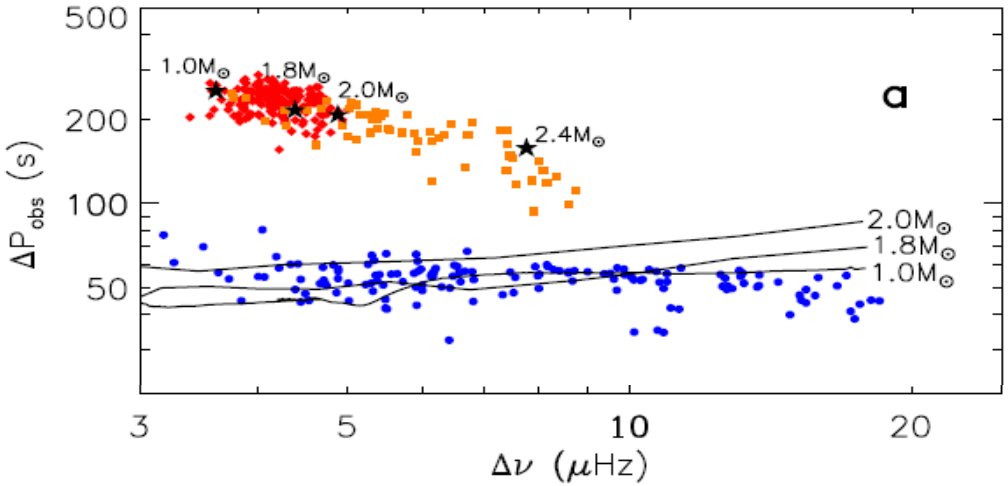
Showing 1 to 10 of 649 entries First Previous 1 2 3 4 5 Next Last

Thank you !

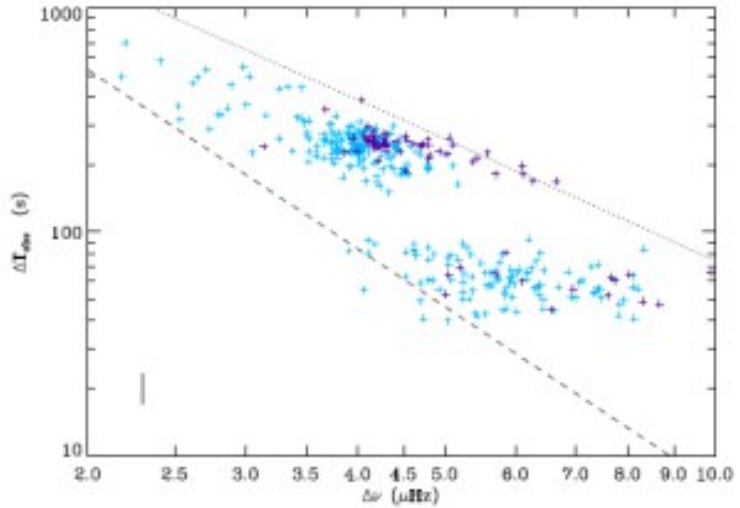
Applications

Use of the period spacing $\Delta\Pi$:

- Distinguish evolutionary states
- Red Clump / Red giant branch



(*Bedding et al. 2011 Nature 471*)



(Mosser et al. 2011 A&A)

Compare distributions in two opposite directions in the Galaxy (Center versus Anti-Center)