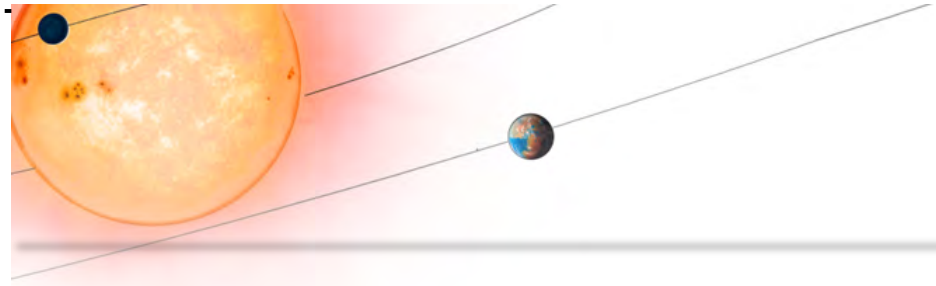


STELLAR ANALYSIS SYSTEM (SAS)

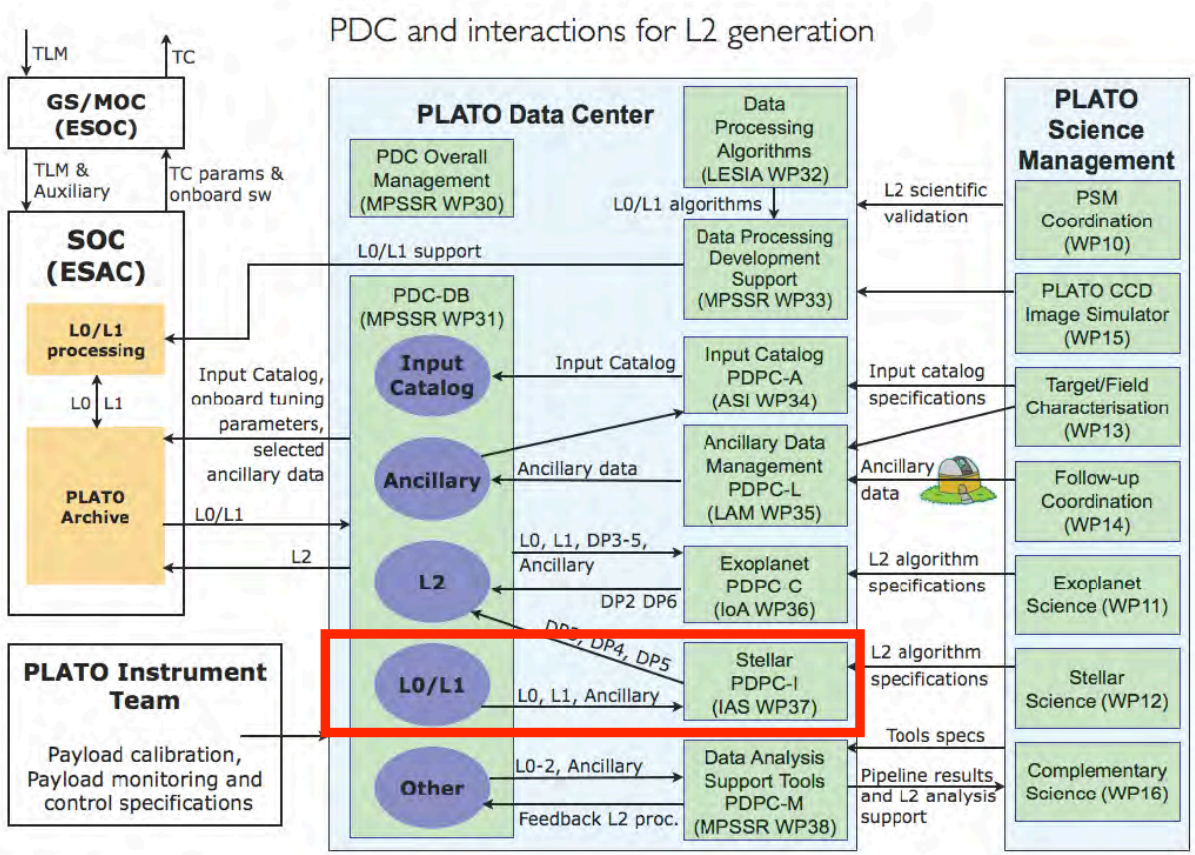
T.Appourchaux

Institut d'Astrophysique Spatiale

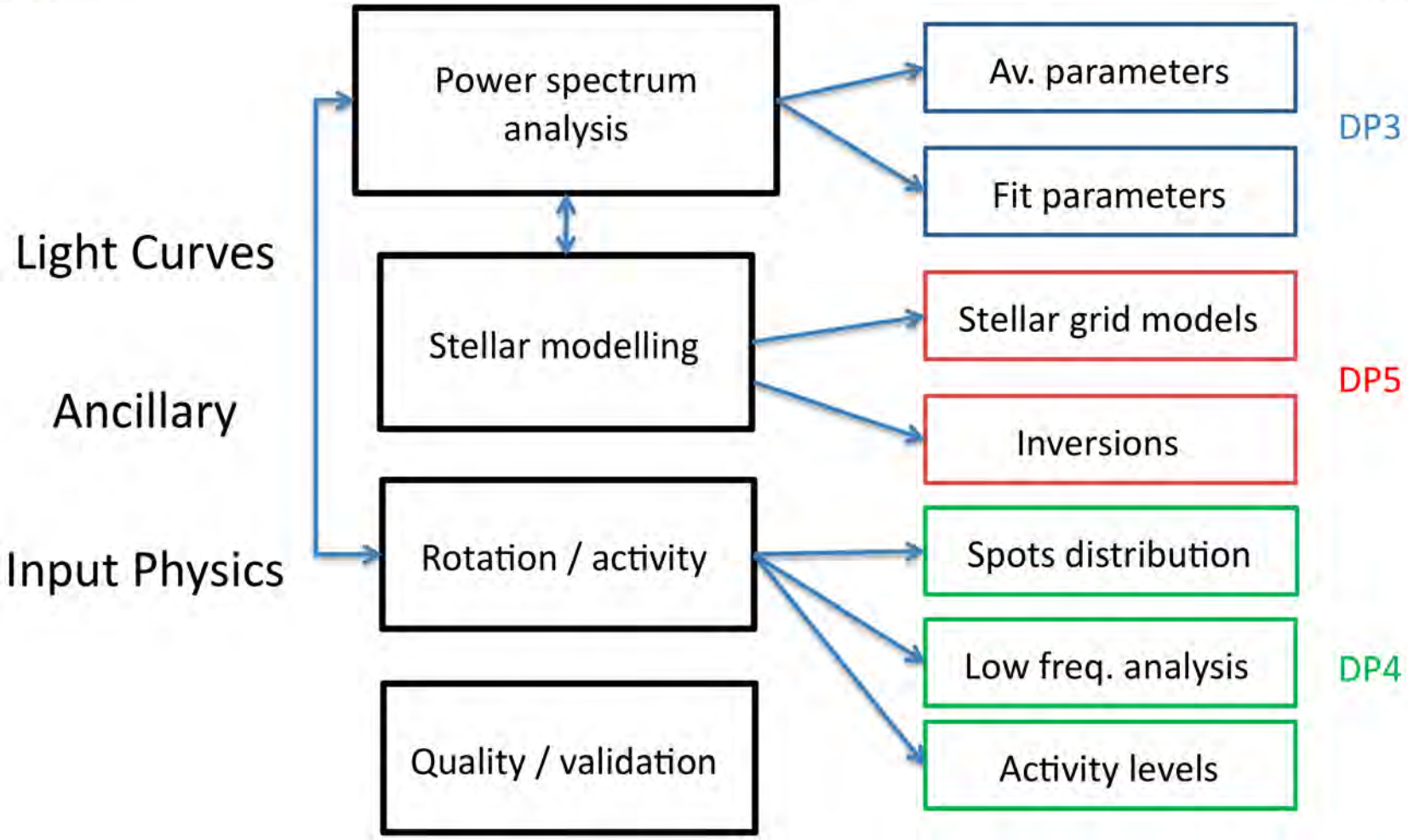
STELLAR ANALYSIS SYSTEM

- **PLATO Official Products**

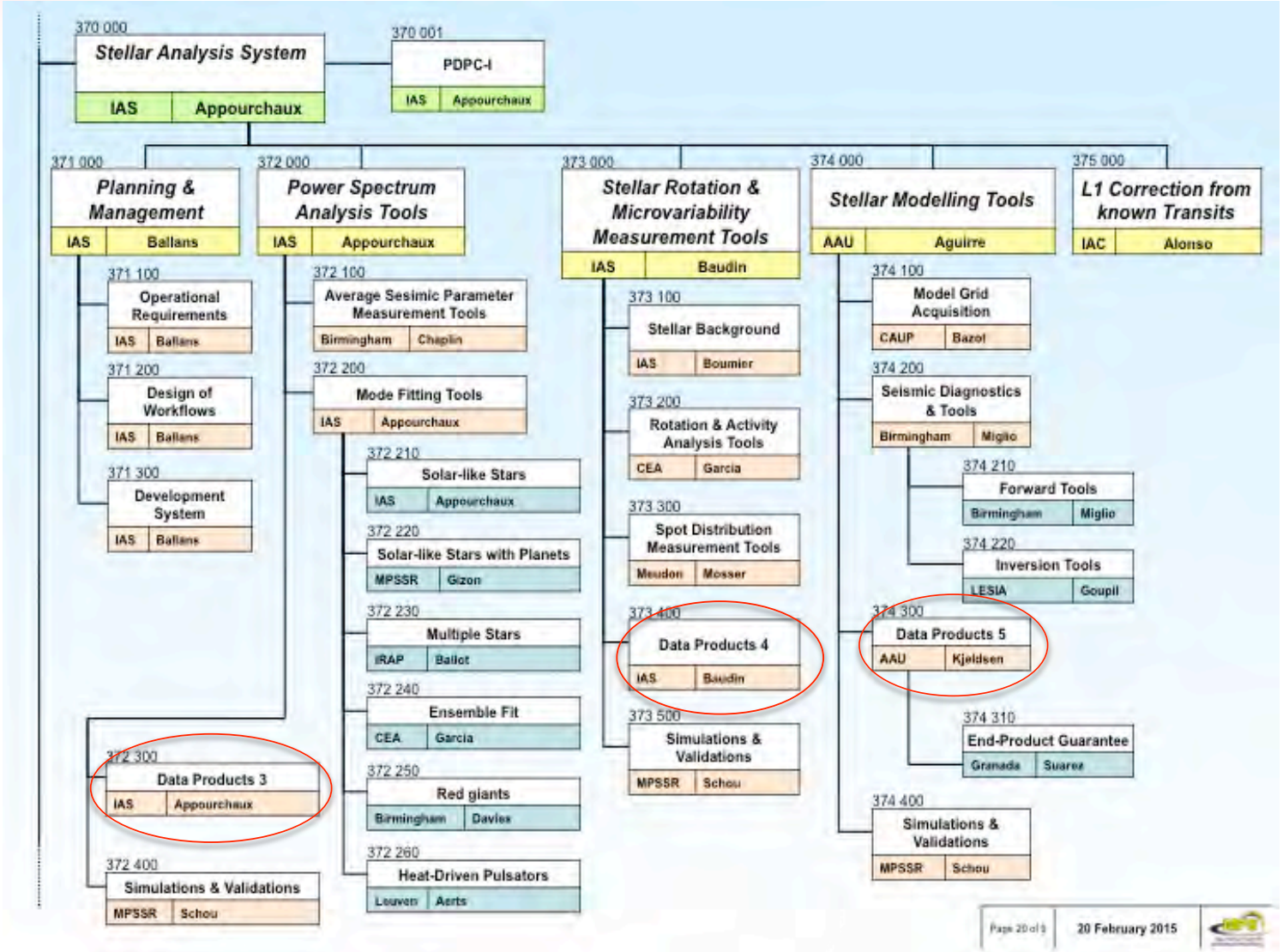
- DP3: stellar mode parameters
- DP4: rotation and activity
- DP5: Radius, mass and age of stars



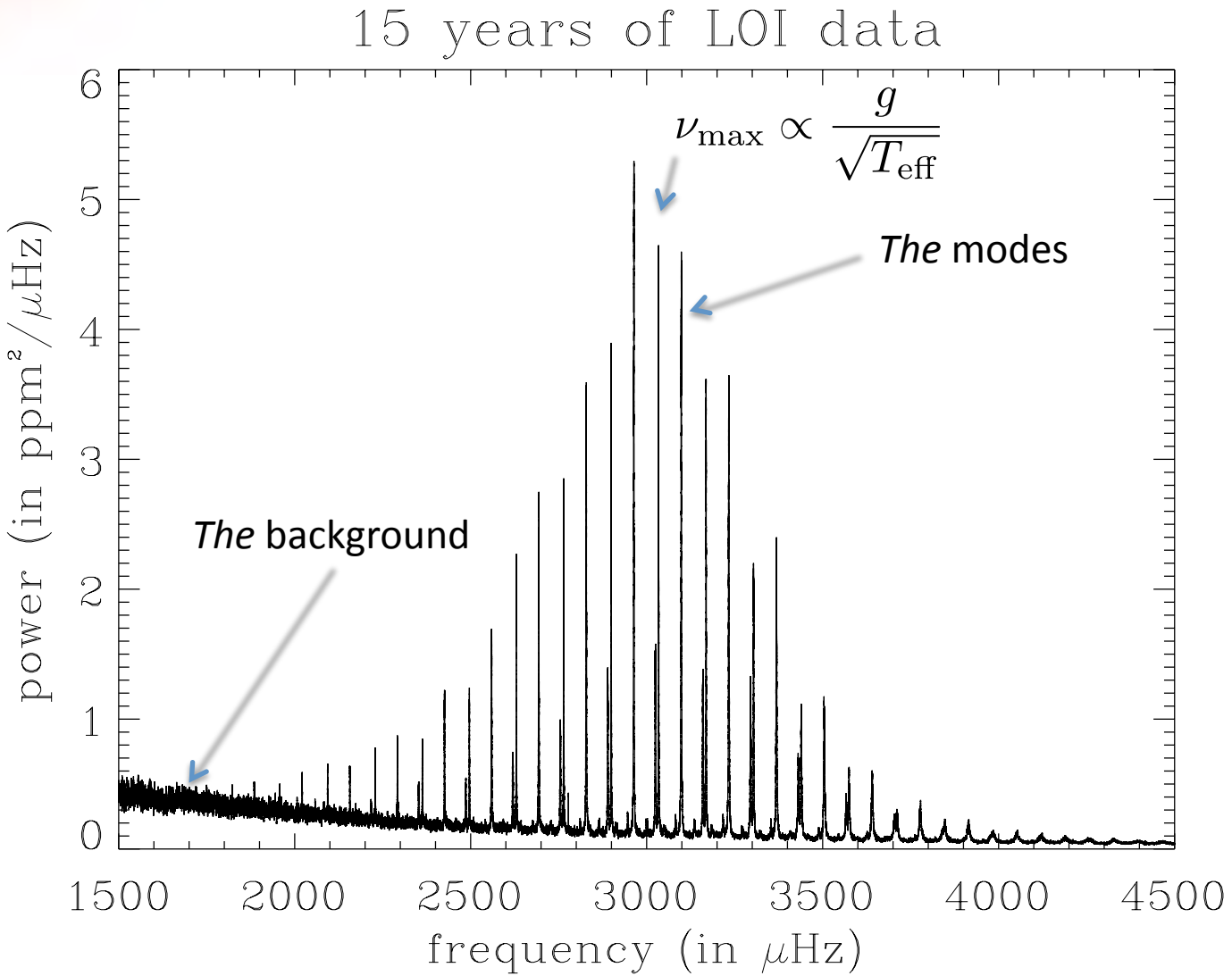
SAS PRODUCTS



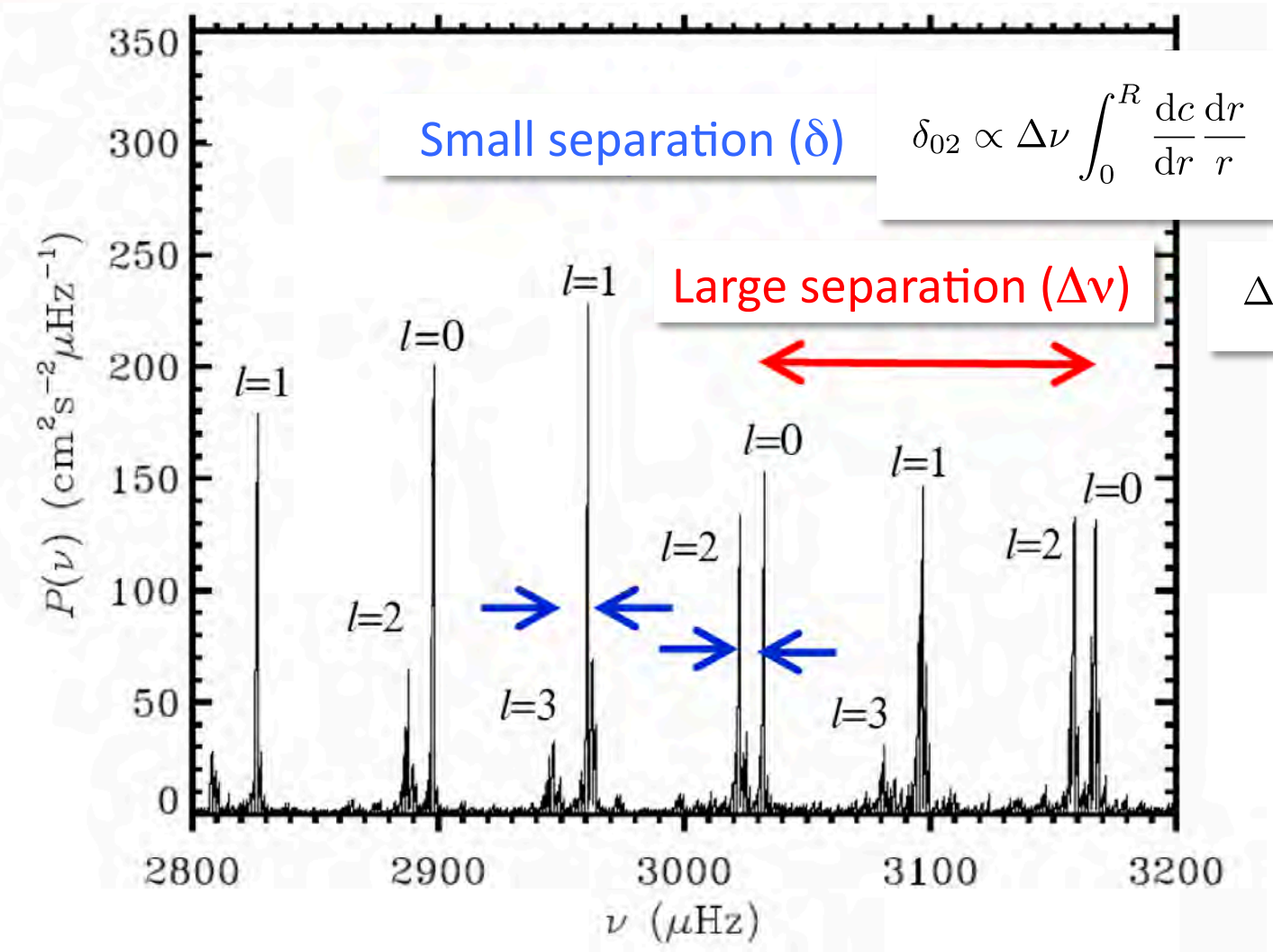
SAS IN DETAILS



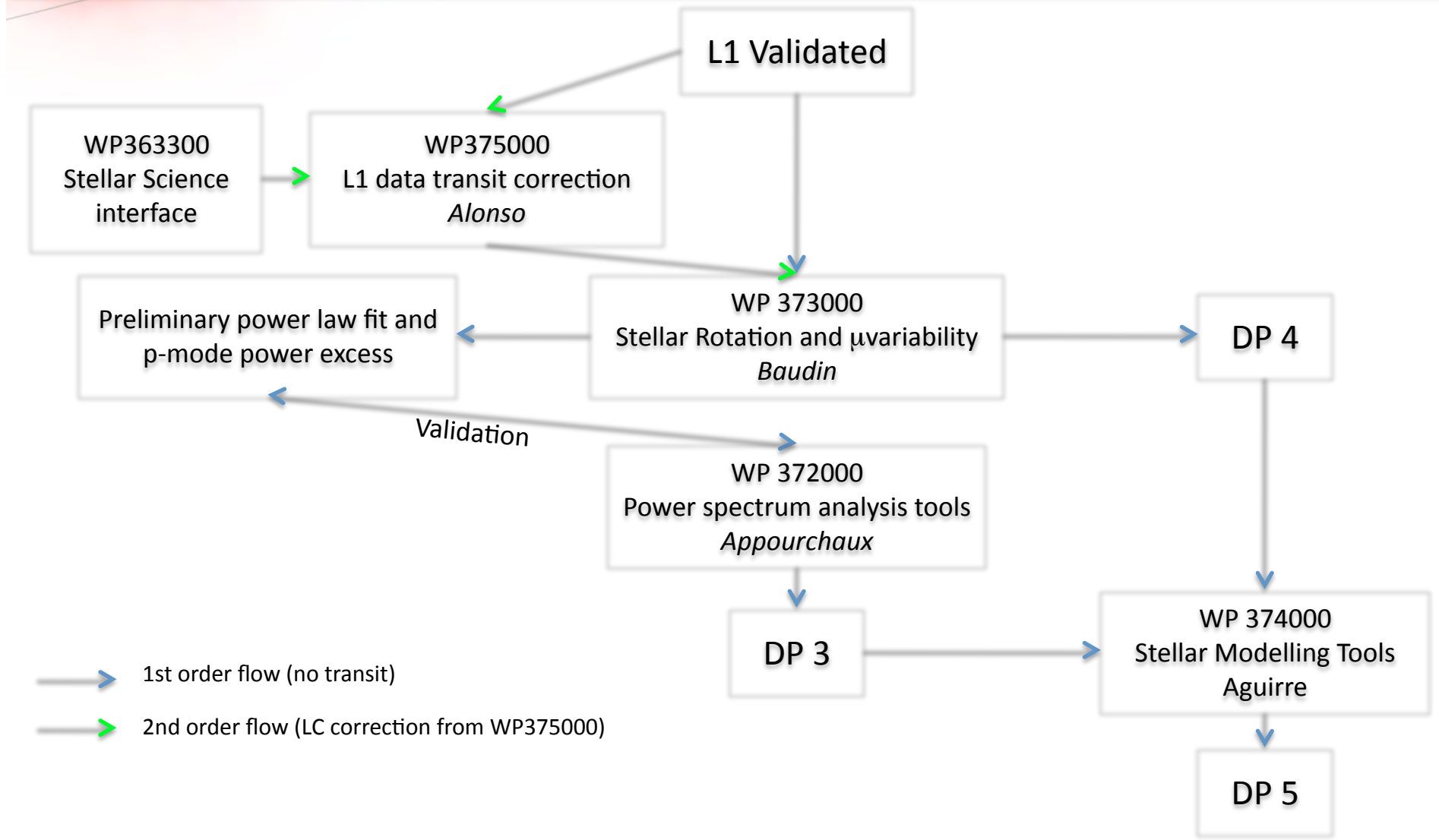
POWER SPECTRUM

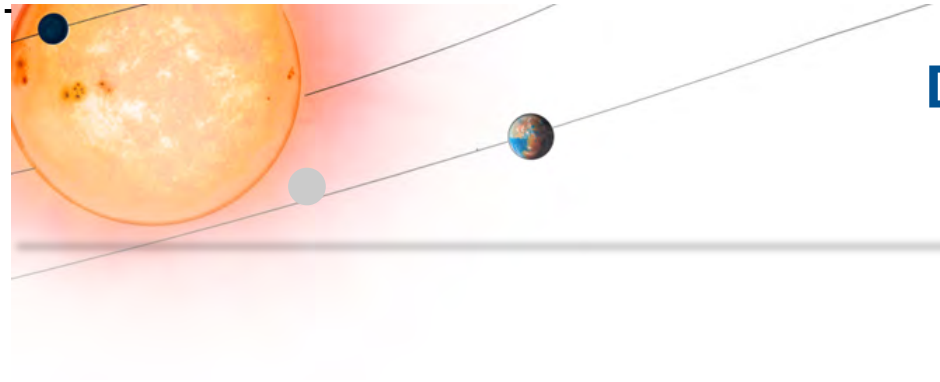


A ZOOM IN


Small separation (δ)
$\delta_{02} \propto \Delta\nu \int_0^R \frac{\mathrm{d}c}{\mathrm{d}r}\frac{\mathrm{d}r}{r}$
Large separation (Δν)
$\Delta\nu \propto \sqrt{\rho}$
l=1
l=0
l=2
l=3
l=1
l=0
l=2
l=3
l=1
l=0
l=2
350
300
250
200
150
100
50
0
2800
2900
3000
3100
3200
$P(\nu)$ $(\mathrm{cm^2 s^{-2} \mu Hz^{-1}})$
ν $(\mu\mathrm{Hz})$

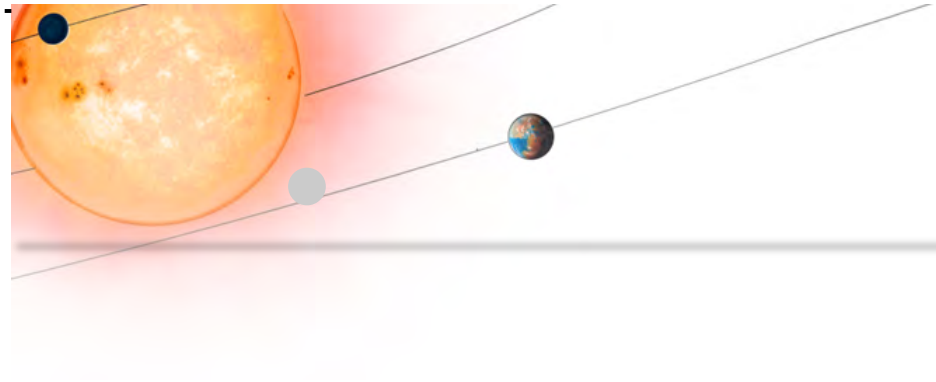
DATA FLOW IN THE SAS





DP4: STELLAR ROTATION AND MICROVARIABILITY TOOLS

- Inputs:
  - L1 transit removed, Harvey-like guess, ancillary data
- Data Products 4:
  - Background: three Harvey-like components + white noise
  - Rotation estimate from low freq. (differential)
  - Spot distribution (rotation, active longitudes, lifetime)
- Current procedure derived from *Kepler* and CoRoT



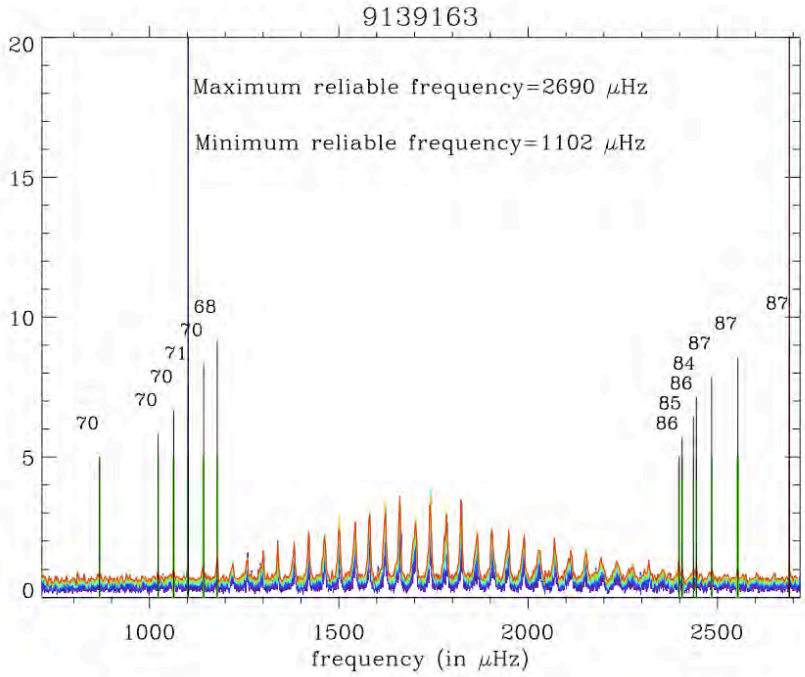
DP3: POWER SPECTRUM ANALYSIS TOOLS

- Inputs:
  - L1 transit removed or not, fitted Harvey-like guess, ancillary data
- Data Products 3:
  - Modes: mean mode separation, mean linewidth, maximum amplitude, mean splitting; frequencies, linewidths, heights, amplitudes, splitting, stellar incliantion angle
  - Background: three Harvey-like components + white noise
  - Power spectrum
- Current procedure derived from *Kepler*

DP3 IMPLEMENTATION IN KEPLER

Oscillation mode frequencies of 61 main sequence and subgiant stars observed by *Kepler*

T. Appourchaux[1,2], W. J. Chaplin[3], R. A. García[4], M. Gruberbauer[5], G. A. Verner[3], H. M. Antia[6], O. Benomar[7], T. L. Campante[8,9], G. R. Davies[4], S. Deheuvels[10], R. Handberg[8], S. Hekker[11,3], R. Howe[3], C. Régulo[12,13], D. Salabert[14], T. R. Bedding[7], T. R. White[7], J. Ballot[15,16], S. Mathur[17], V. Silva Aguirre[18], Y. P. Elsworth[3], S. Basu[10], R.L Gilliland[19], J. Christensen-Dalsgaard[8], H. Kjeldsen[8], K. Uddin[20], M. C. Stumpe[21], and T. Barclay[22]



Degree	Frequency (μHz)	1-σ error (μHz)	Comment
0	986.105	1.130	Not detected
0	1064.982	0.690	0.703
0	1142.941	0.230	OK
0	1221.476	0.544	OK
0	1301.395	0.332	OK
0	1383.093	0.366	OK
0	1464.189	0.381	OK
0	1544.456	0.317	OK
0	1623.952	0.380	OK
0	1703.1000	0.340	OK
0	1785.675	0.330	OK
0	1866.729	0.420	OK
0	1949.424	0.391	OK
0	2031.407	0.706	OK
0	2114.451	0.607	OK
0	2195.335	1.219	OK
0	2276.836	0.928	OK
0	2359.243	1.229	OK
0	2444.022	1.734	OK
0	2689.590	Not fitted	0.873

DP3 IMPLEMENTATION IN KEPLER

Oscillation mode linewidths and heights of 23 main-sequence stars observed by *Kepler*⋆

T. Appourchaux[1], H. M. Antia[2], O. Benomar[3,4], T. L. Campante[5,9], G. R. Davies[5,10], R. Handberg[5,9], R. Howe[5], C. Régulo[6,7], K. Belkacem[8], G. Houdek[9], R. A. García[10], and W. J. Chaplin[5]

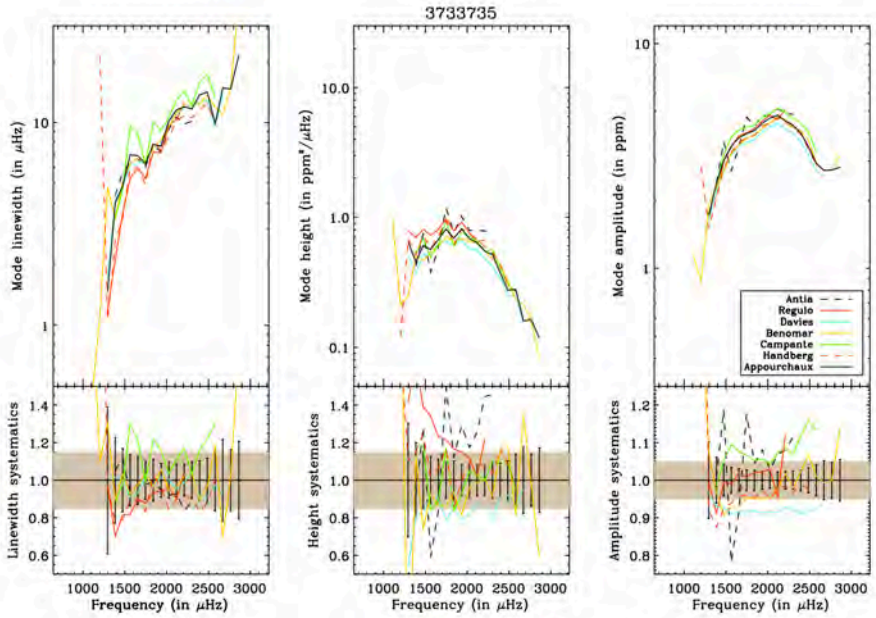


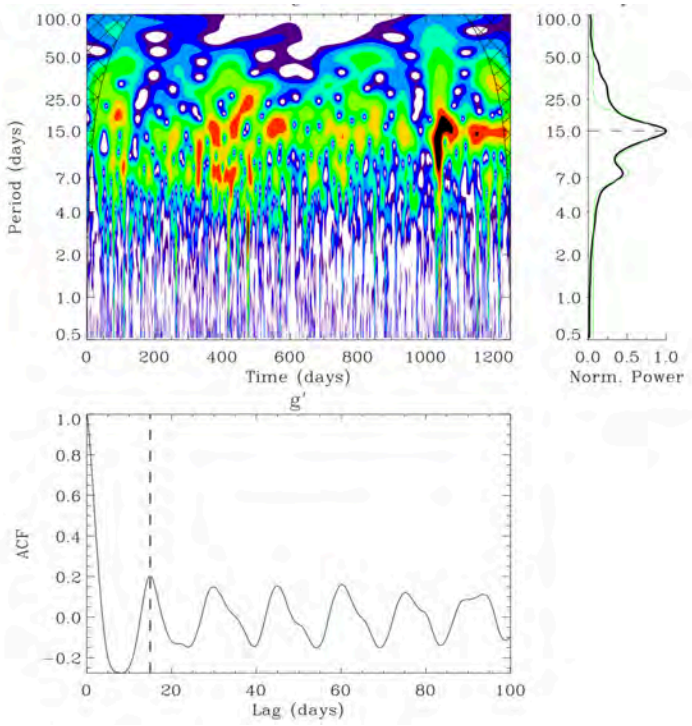
Table 7. Mode heights, mode linewidths and mode amplitude for KIC 3733735.

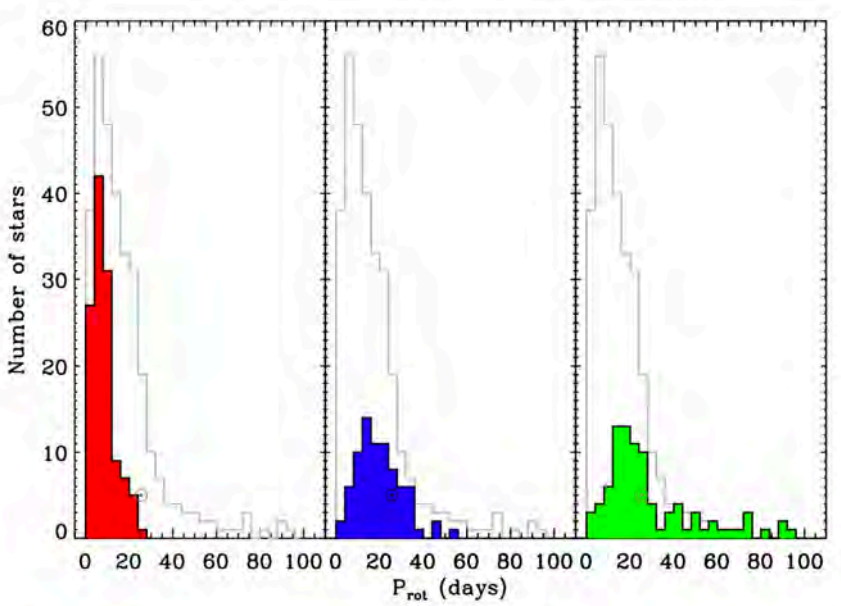
Frequency (in μHz)	Mode height (in ppm^2 μHz^{-1})	1-σ uncertainty (in ppm^2 μHz^{-1})	Linewidth (in μHz)	1-σ uncertainty (in μHz)	Amplitude (in ppm)	1-σ uncertainty (in ppm)
1293.12	0.65	+0.23/–0.17	1.45	+0.69/–0.47	1.21	+0.13/–0.12
1385.60	0.45	+0.10/–0.08	4.01	+1.02/–0.82	1.68	+0.11/–0.10
1473.54	0.60	+0.10/–0.08	4.83	+0.88/–0.75	2.14	+0.09/–0.09
1562.96	0.56	+0.07/–0.07	6.91	+1.00/–0.87	2.47	+0.09/–0.08
1653.77	0.67	+0.08/–0.07	6.85	+0.94/–0.82	2.69	+0.08/–0.08
1747.04	0.81	+0.08/–0.07	6.22	+0.66/–0.59	2.81	+0.08/–0.08
1840.35	0.69	+0.07/–0.07	7.79	+0.91/–0.81	2.90	+0.08/–0.08
1933.52	0.81	+0.07/–0.06	7.63	+0.72/–0.65	3.12	+0.07/–0.07
2026.36	0.68	+0.06/–0.06	10.18	+1.02/–0.92	3.30	+0.07/–0.07
2117.55	0.64	+0.05/–0.05	11.53	+1.05/–0.97	3.39	+0.07/–0.07
2209.06	0.55	+0.04/–0.04	11.94	+1.07/–0.98	3.20	+0.08/–0.07
2301.84	0.51	+0.05/–0.05	11.65	+1.20/–1.09	3.07	+0.07/–0.07
2393.06	0.37	+0.04/–0.03	13.67	+1.48/–1.34	2.83	+0.08/–0.08
2483.81	0.27	+0.03/–0.03	14.13	+1.76/–1.56	2.46	+0.08/–0.08
2581.11	0.28	+0.04/–0.04	9.82	+1.73/–1.47	2.07	+0.09/–0.08
2669.78	0.16	+0.03/–0.03	14.81	+3.57/–2.88	1.93	+0.10/–0.10
2765.25	0.16	+0.02/–0.02	14.61	+2.58/–2.20	1.93	+0.10/–0.09
2863.16	0.12	+0.02/–0.02	21.47	+4.92/–4.01	1.99	+0.11/–0.11

DP4 IMPLEMENTATION IN KEPLER

Towards asteroseismically calibrated age-rotation-activity relations for *Kepler* solar-like stars

R. A. García[1], T. Ceillier[1], D. Salabert[1], S. Mathur[2], J. L. van Saders[3], M. Pinsonneault[3], J. Ballot[4,5], P. G. Beck[1,6], S. Bloemen[7], T. L. Campante[8], G. R. Davies[1,8], J.-D. do Nascimento Jr.[9,10], S. Mathis[1], T. S. Metcalfe[2,11], M. B. Nielsen[12,13], J. C. Suárez[14], W. J. Chaplin[8] A. Jiménez[15,16], and C. Karoff[11]





DP5: STELLAR PARAMETER TOOLS

- Inputs:
  - DP3 and DP4 (mode parameters, etc..),
  - rotation, stellar characteristics ($T_{\rm eff}$, log g, v sin i, etc...),
  - model grid, ancillary data
- Data Products 5:
  - Stellar mass, radius, age, Inversions (structure, rotation)
- Current procedure yet to be derived !
  - At least Radius and Mass proxies from scaling laws

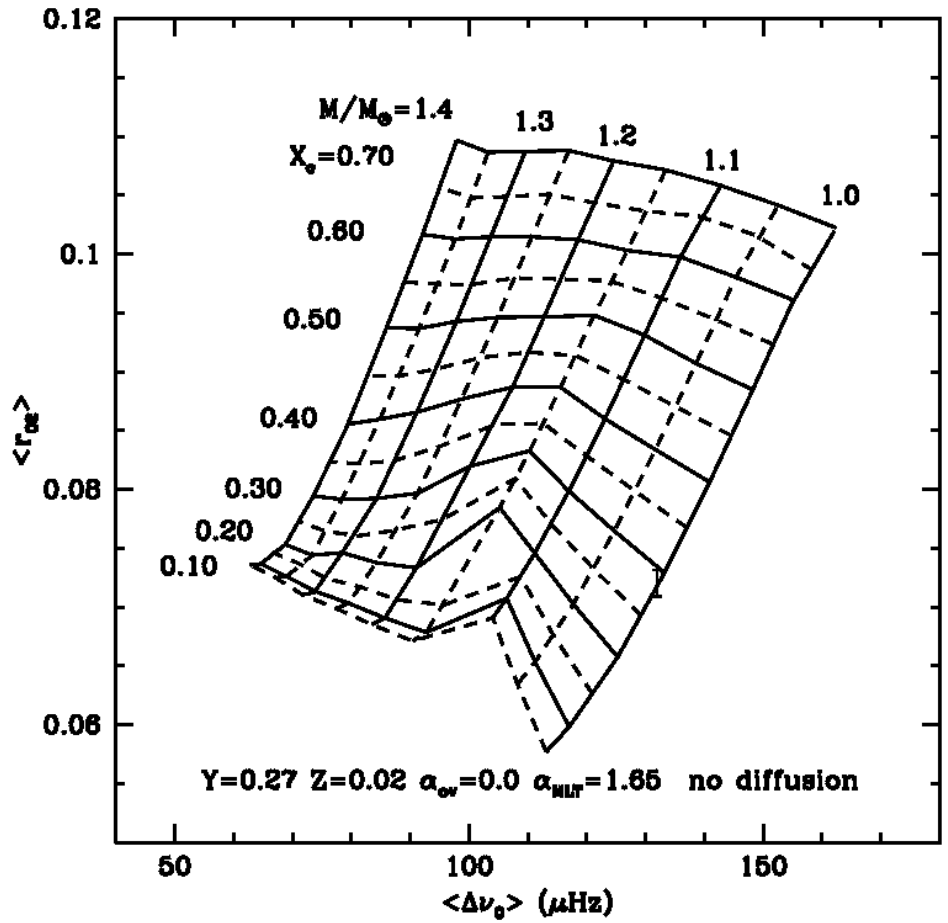
$$\left(\frac{R}{\mathrm{R}_\odot}\right) \simeq \left(\frac{\nu_{\rm max}}{\nu_{\rm max,\odot}}\right)\left(\frac{\langle\Delta\nu_{nl}\rangle}{\langle\Delta\nu_{nl}\rangle_\odot}\right)^{-2}\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\odot}}\right)^{0.5},$$

$$\left(\frac{M}{\mathrm{M}_\odot}\right) \simeq \left(\frac{\nu_{\rm max}}{\nu_{\rm max,\odot}}\right)^{3}\left(\frac{\langle\Delta\nu_{nl}\rangle}{\langle\Delta\nu_{nl}\rangle_\odot}\right)^{-4}\left(\frac{T_{\rm eff}}{\mathrm{T}_{\rm eff,\odot}}\right)^{1.5},$$

  - Better Radius, Mass and Age from detailled stellar modelling (Systematics!)

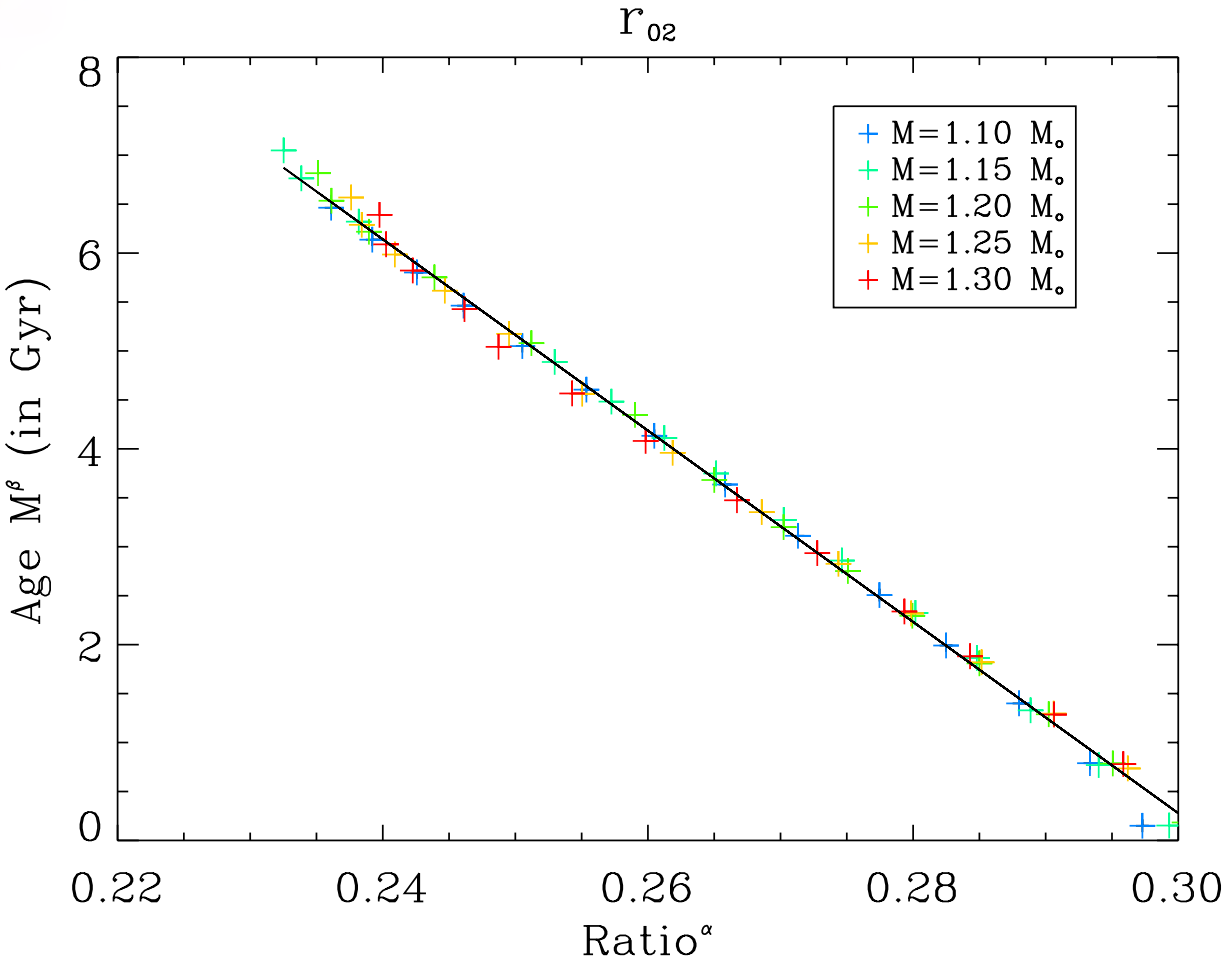
AGE PROXY:
RATIO VS LARGE SEPARATION

$$r_{02} = \frac{\delta_{02}}{\Delta\nu}$$



Lebreton and Montalban (2009)

AGE PROXY: A GOOD BASE



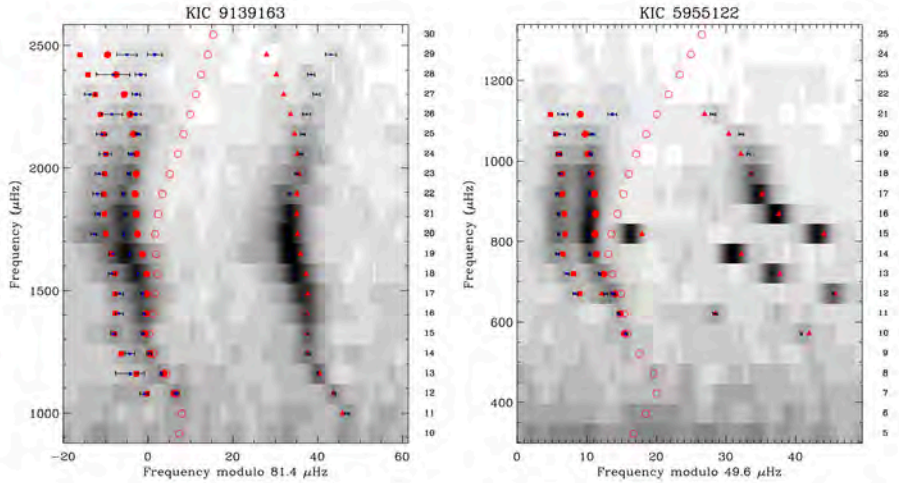
Appourchaux et al (2015)

DP5 IMPLEMENTATION IN KEPLER

PROPERTIES OF 42 SOLAR-TYPE *KEPLER* TARGETS FROM THE ASTEROSEISMIC MODELING PORTAL

T. S. METCALFE[1,2], O. L. CREEVEY[3], G. DOĞAN[2,4], S. MATHUR[1,4], H. XU[5], T. R. BEDDING[6], W. J. CHAPLIN[7], J. CHRISTENSEN-DALSGAARD[2], C. KAROFF[2], R. TRAMPEDACH[2,8], O. BENOMAR[9], B. P. BROWN[10,11], D. L. BUZASI[12], T. L. CAMPANTE[7], Z. ÇELIK[13], M. S. CUNHA[14], G. R. DAVIES[7], S. DEHEUVELS[15,16], A. DEREKAS[17,18], M. P. DI MAURO[19], R. A. GARCÍA[20], J. A. GUZIK[21], R. HOWE[7], K. B. MACGREGOR[4], A. MAZUMDAR[22], J. MONTALBÁN[23], M. J. P. F. G. MONTEIRO[14], D. SALABERT[20], A. SERENELLI[24], D. STELLO[6], M. STĘŚLICKI[25], M. D. SURAN[26], M. YILDIZ[13], C. AKSOY[13], Y. ELSWORTH[7], M. GRUBERBAUER[27], D. B. GUENTHER[27], Y. LEBRETON[28,29], K. MOLAVERDIKHANI[30], D. PRICOPI[26], R. SIMONIELLO[31], T. R. WHITE[6,32]

The Astrophysical Journal, SUBMITTED



Properties of the optimal models and surface correction from AMP

KIC	$R/R_\odot$[a]	$M/M_\odot$[a]	t/Gyr[a]
Simple stars			
3427720[c]	1.125 ± 0.014	1.13 ± 0.04	2.24 ± 0.17
6116048[c]	1.219 ± 0.009	1.01 ± 0.03	6.23 ± 0.37
6603624[c]	1.185 ± 0.015	1.10 ± 0.03	7.96 ± 0.45
6933899	1.599 ± 0.018	1.14 ± 0.03	6.87 ± 0.34
7871531	0.874 ± 0.008	0.84 ± 0.02	9.15 ± 0.47
8006161	0.947 ± 0.007	1.04 ± 0.02	5.04 ± 0.17
8394589	1.116 ± 0.019	0.94 ± 0.04	2.92 ± 0.18
8694723	1.436 ± 0.024	0.96 ± 0.03	4.90 ± 0.54
8760414[c]	1.006 ± 0.004	0.77 ± 0.01	13.65 ± 0.74
9098294	1.154 ± 0.009	1.00 ± 0.03	7.28 ± 0.51
9139151	1.146 ± 0.011	1.14 ± 0.03	1.71 ± 0.19
9955598	0.883 ± 0.008	0.89 ± 0.02	6.72 ± 0.20
10454113[c]	1.229 ± 0.015	1.14 ± 0.04	2.00 ± 0.29
10644253	1.108 ± 0.016	1.13 ± 0.05	1.07 ± 0.25
10963065	1.213 ± 0.008	1.05 ± 0.02	4.30 ± 0.23
11244118	1.589 ± 0.026	1.10 ± 0.05	6.43 ± 0.58
12009504	1.375 ± 0.015	1.12 ± 0.03	3.64 ± 0.26
12258514	1.573 ± 0.010	1.19 ± 0.03	4.03 ± 0.32

STELLAR ANALYSIS SYSTEM

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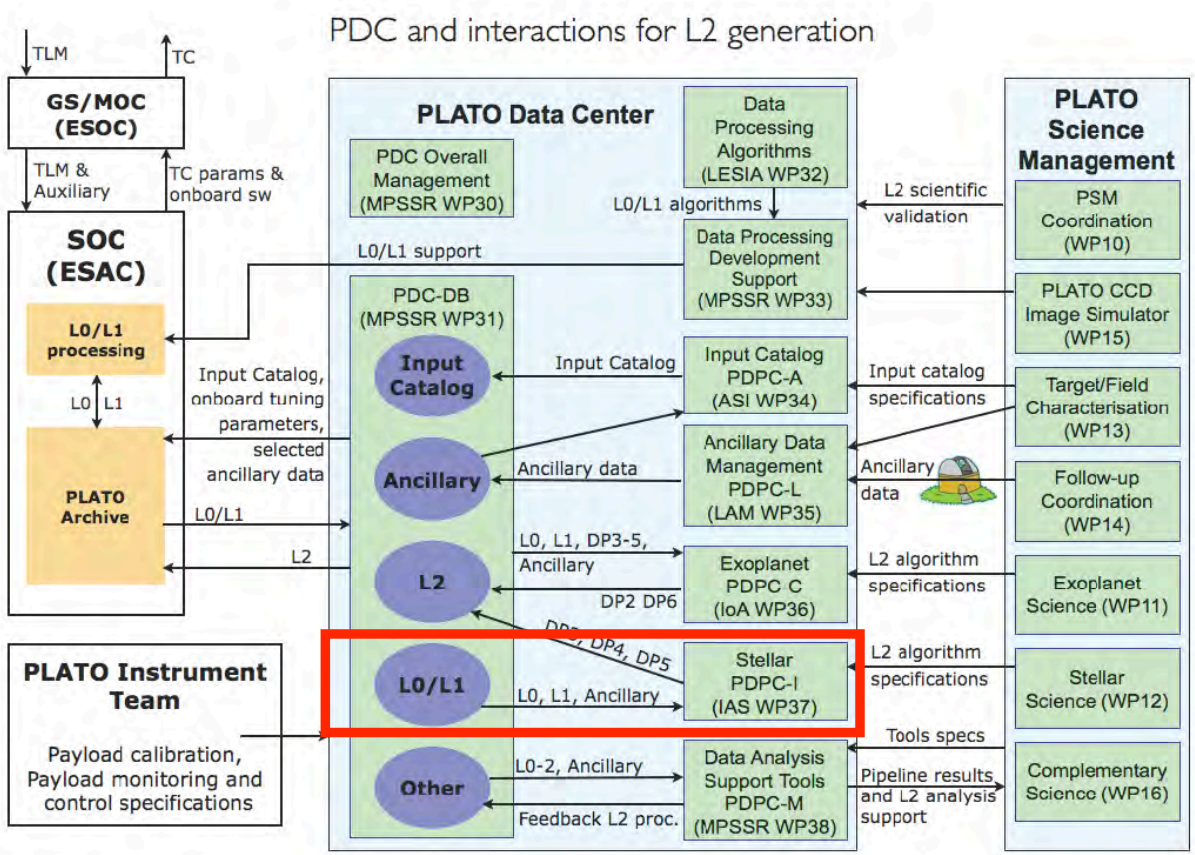

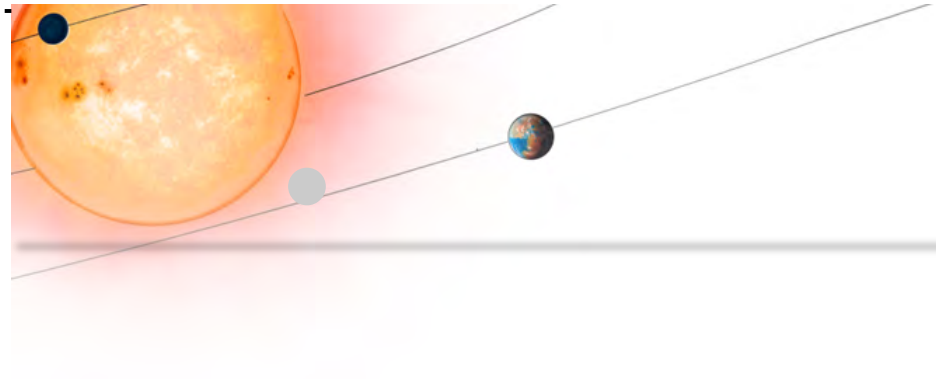

SUMMARY

- All procedures for production of DP3 and DP4 under control
- Proxy for Radius and Mass available for DP5
- Proxy for Age in progress for DP5
- Procedures for getting DP5 from stellar models in progress
- Anything else?