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Fitting Sun-as-a-star GOLF & VIRGO acoustic spectra

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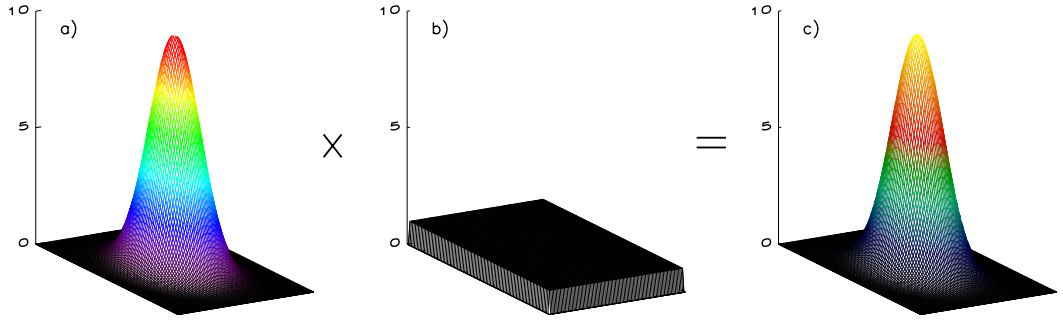
What is DIAMONDS?

high-DImensional And multi-MOdal NesteD Sampling

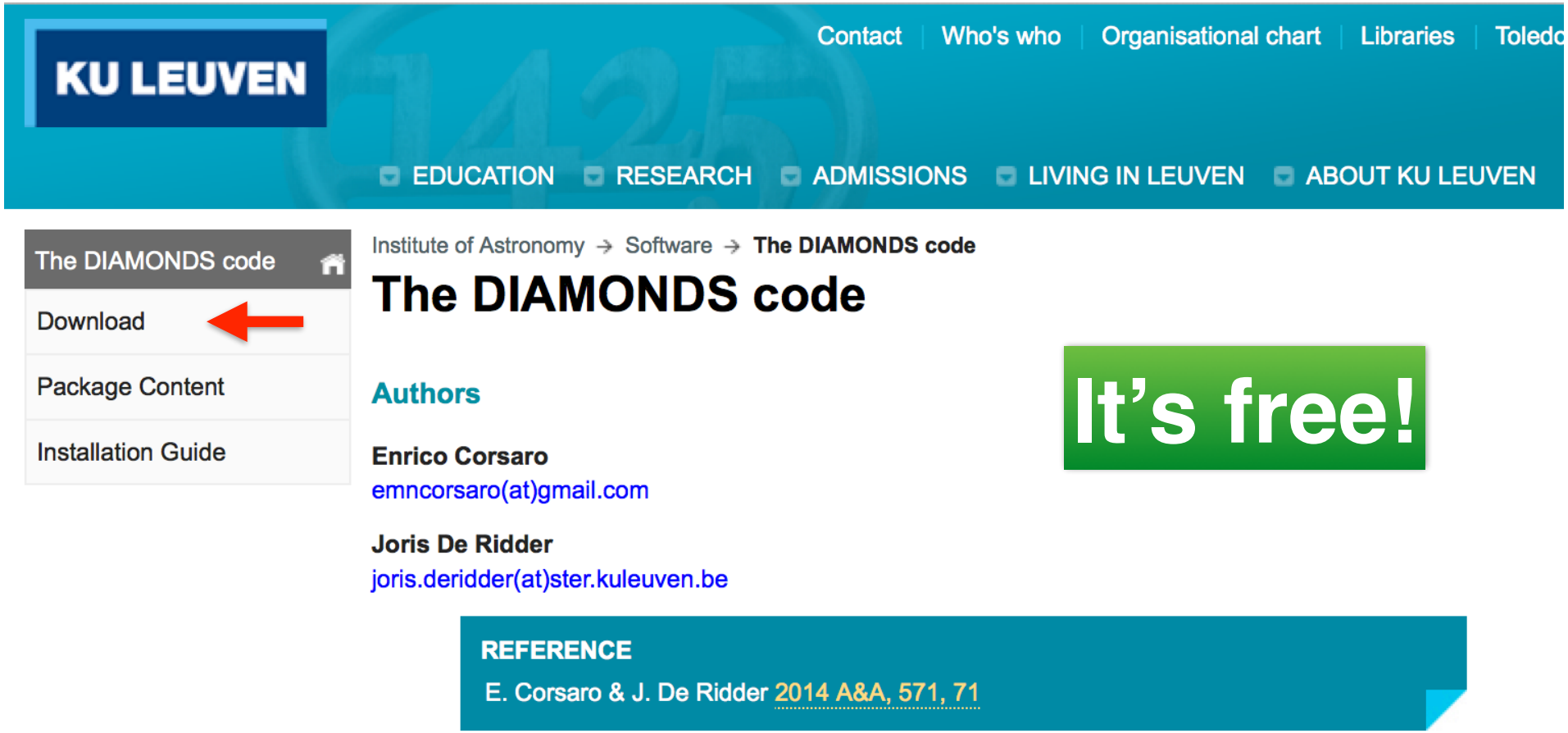
- C++11 code for **Bayesian inference** problems:
  - You have a dataset (-> Likelihood)
  - You have a model you want to test (-> Priors)
  - You want to estimate the free parameters of the model (-> Posterior)

Likelihood Prior Posterior



Download DIAMONDS

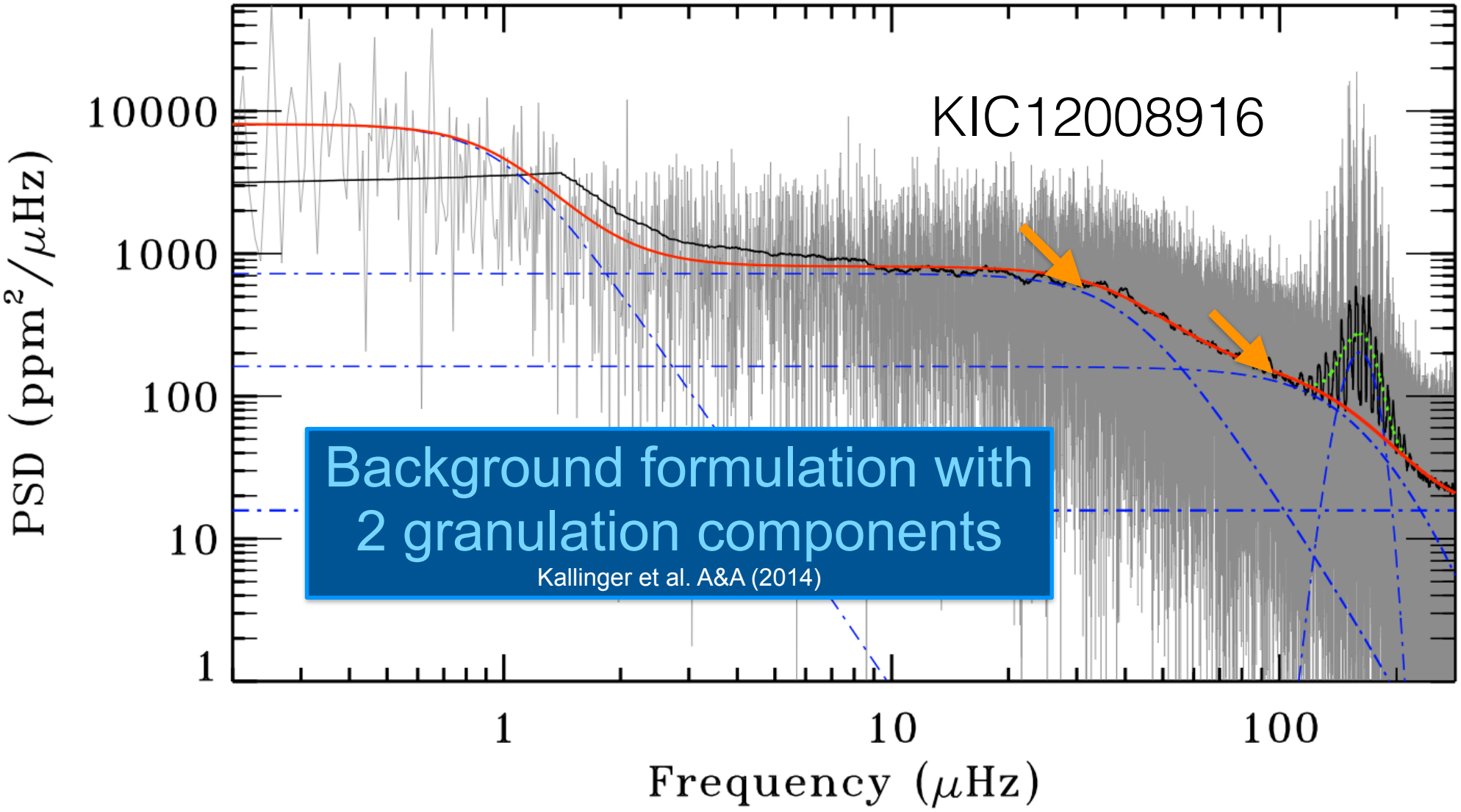
https://fys.kuleuven.be/ster/Software/Diamonds/



Background fitting

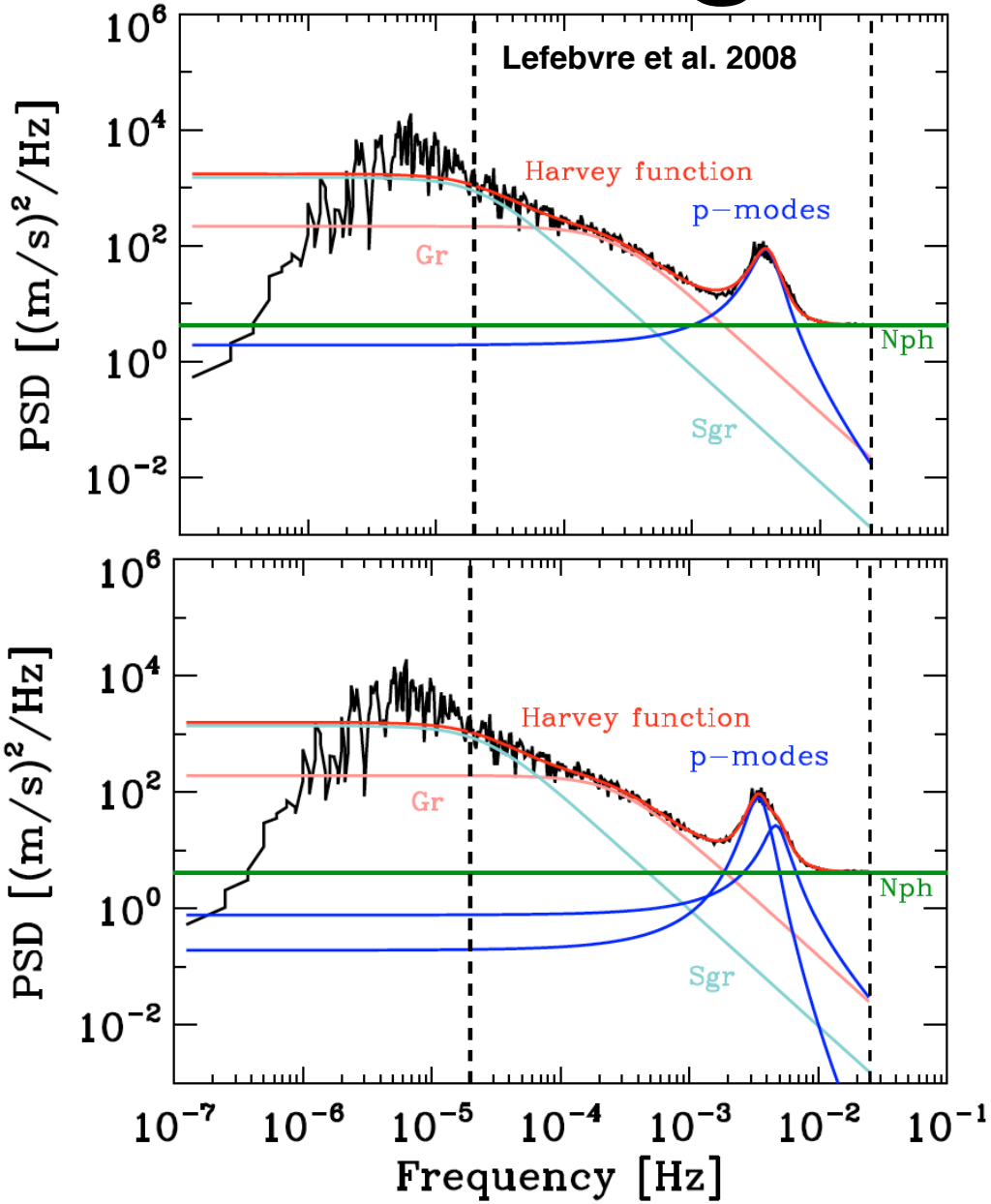
- Which model?
- Use findings on large number of Kepler targets?
- 2 different granulation components + 1 long trend variation due to activity
- What to fit for the power excess?
  Asymmetric hump (long-tail toward higher freq.)
- 1 or 2 Lorentzian profiles? GOLF especially, with second hump on the high-frequency side

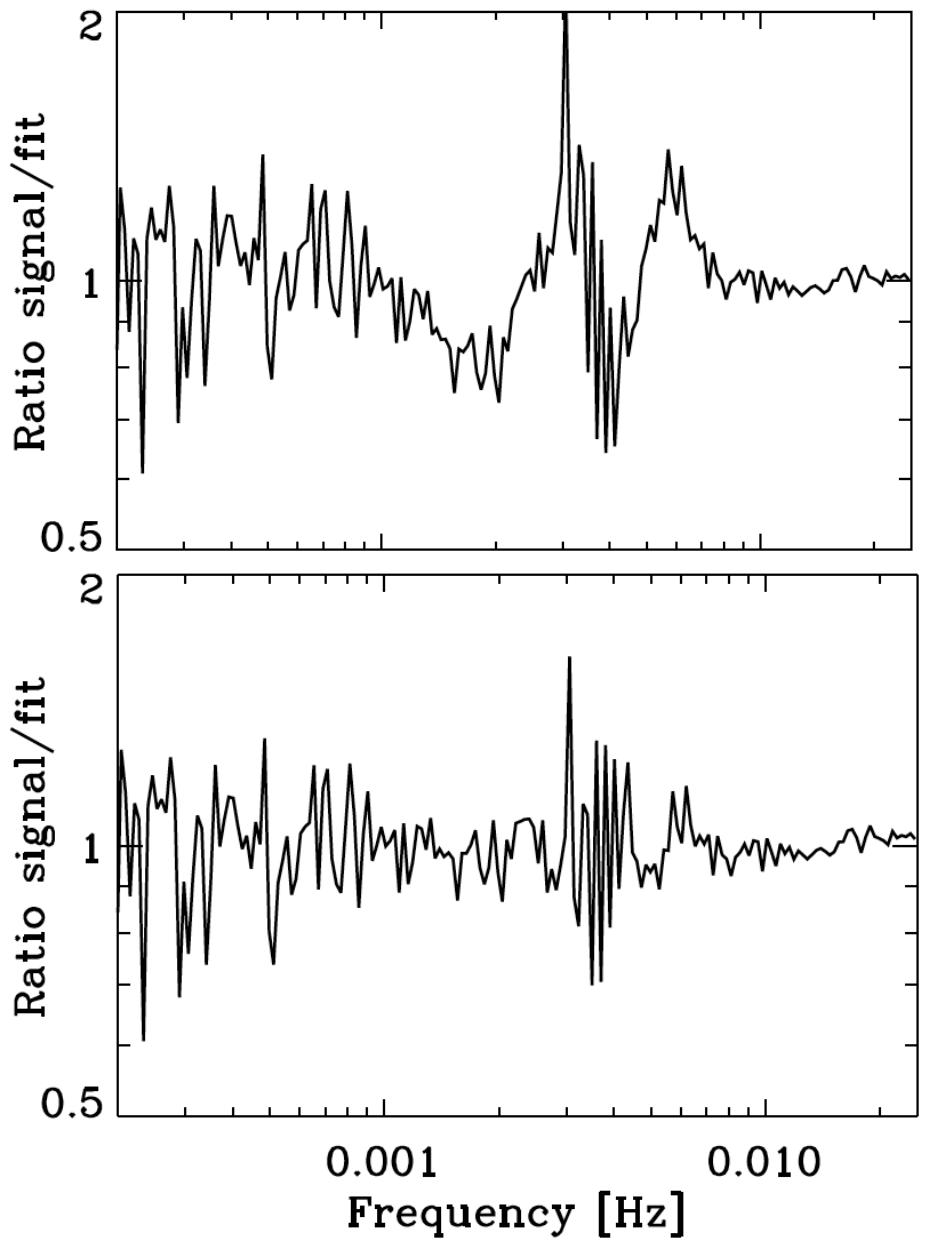
Background model



Corsaro, De Ridder, García (a, submitted)

Background model



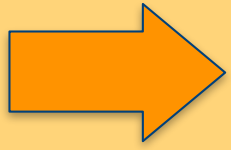


Bayesian Model Comparison

Bayesian Evidence

WEIGHT: simple models are preferred

In DIAMONDS (and NS codes) $\mathcal{E}$ is direct output!

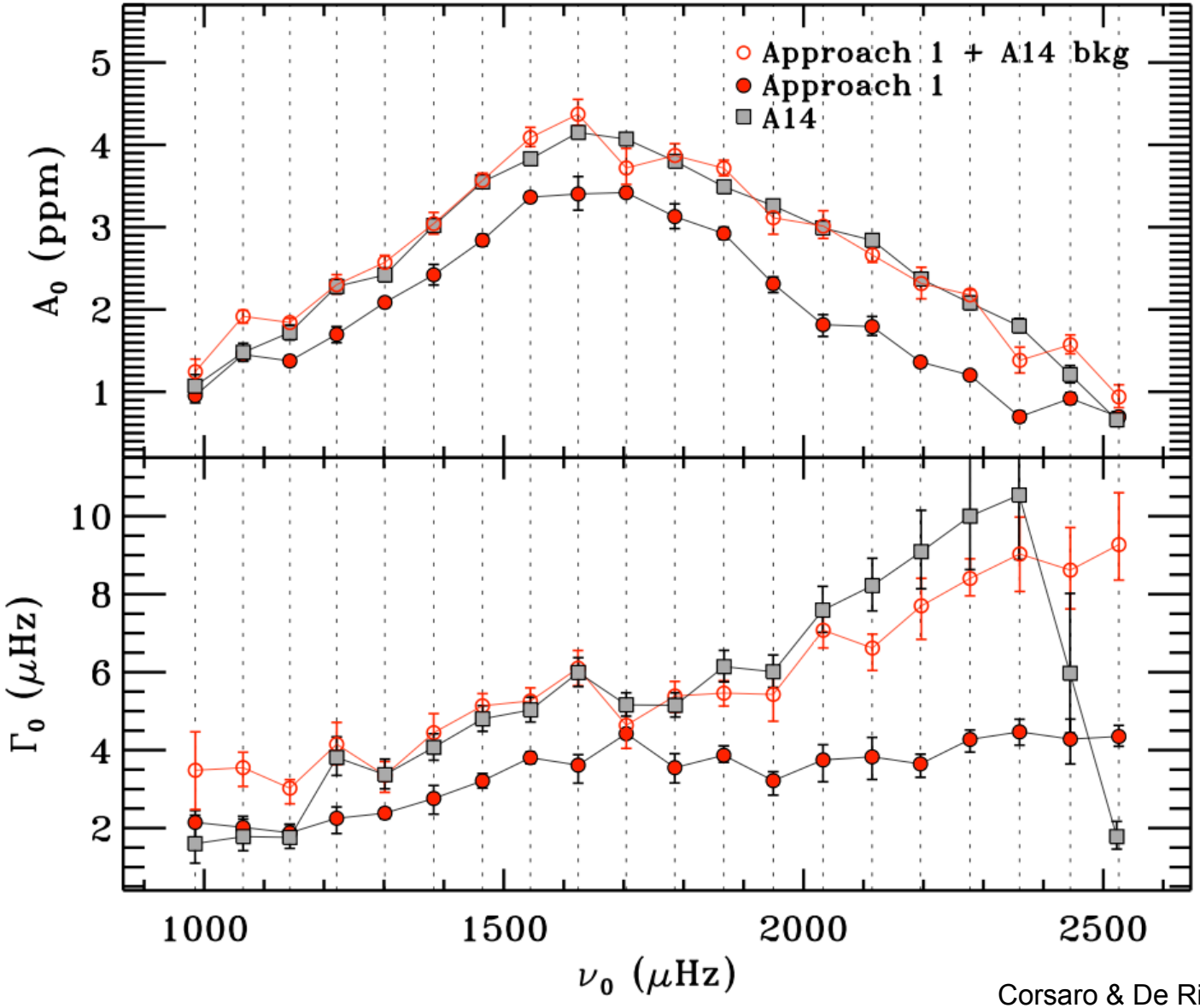


Model comparison is immediate

Oscillations fitting

- Which approach? PPM, PGM, etc.
- DIAMONDS can fit many oscillation modes at the same time (can handle ~50 free parameters easily)
- Possibility to increase windowing size in PPM or PGM-like approaches
- Overlapping windowing and fitting works very well for F-type stars with Kepler

Overlapping windowing

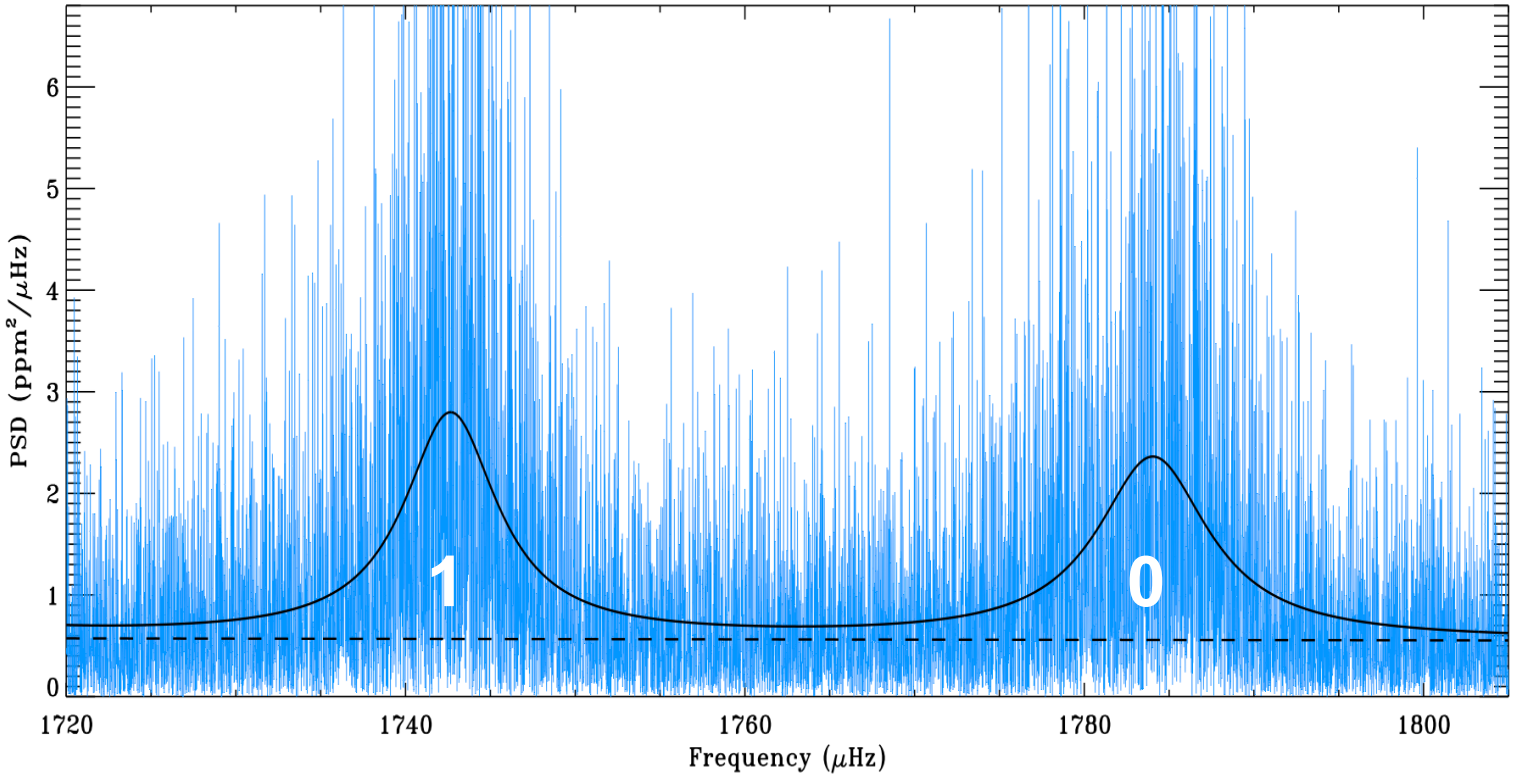


Corsaro & De Ridder, A&A, 2014, 571, 71

Low-frequency modes

- Low-frequency modes are difficult to detect (higher noise, low amplitude, low linewidth)
- How to deem a peak significant? Is it a real mode or just noise?
- With Bayesian approach possibility to compute detection probability
- Method based on Bayesian evidence and model comparison

Peak significance

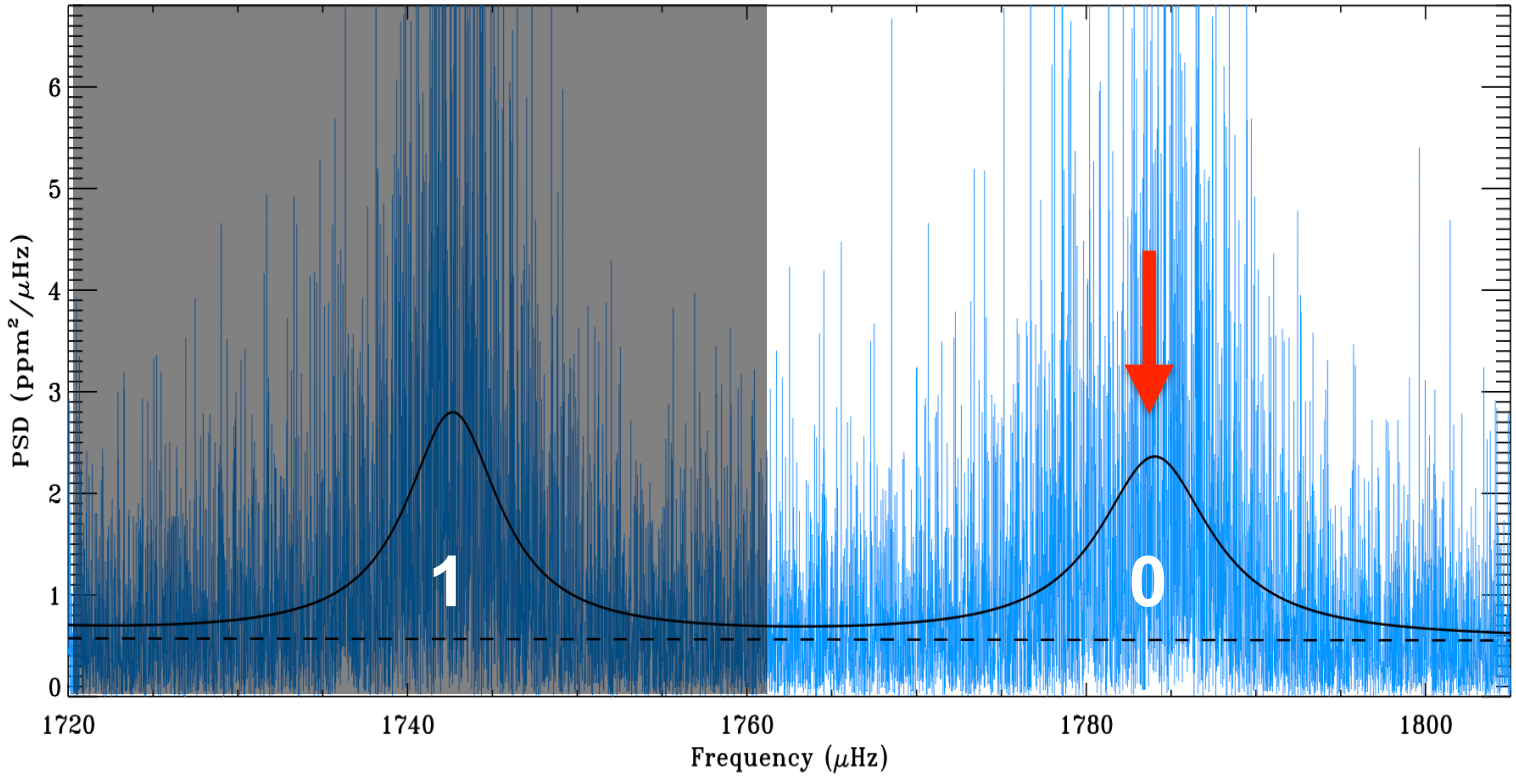


Corsaro & De Ridder, A&A, 2014, 571, 71

Peak significance

$\mathcal{M}_{\ell=0}$ **Only ℓ = 0**

$\mathcal{E}_{\ell=0}$ **Bayesian Evidence**

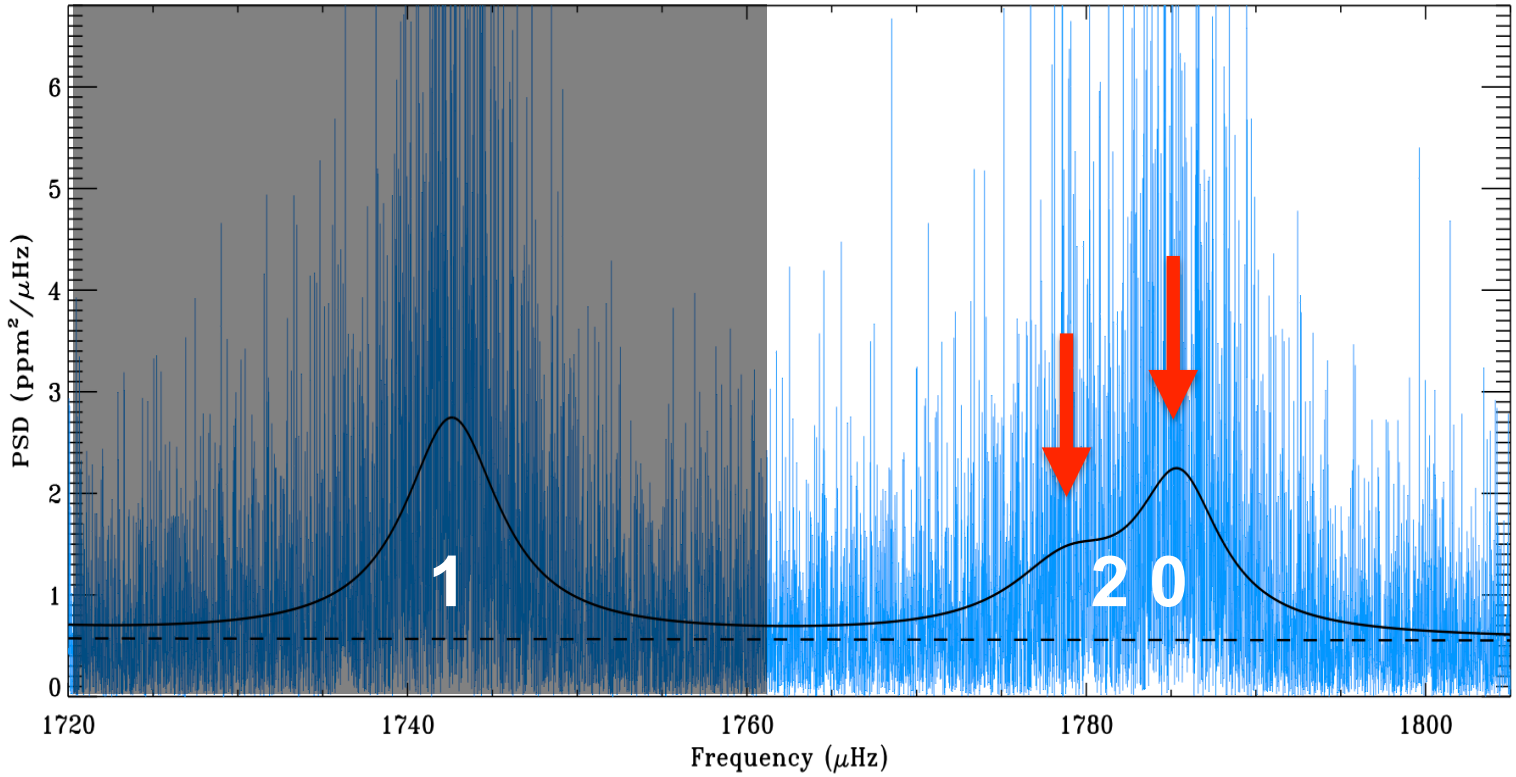


Corsaro & De Ridder, A&A, 2014, 571, 71

Peak significance

$\mathcal{M}_{\ell=2}$ **Both ℓ = 2 and ℓ = 0**

$\mathcal{E}_{\ell=2}$ **Bayesian Evidence**



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Peak significance

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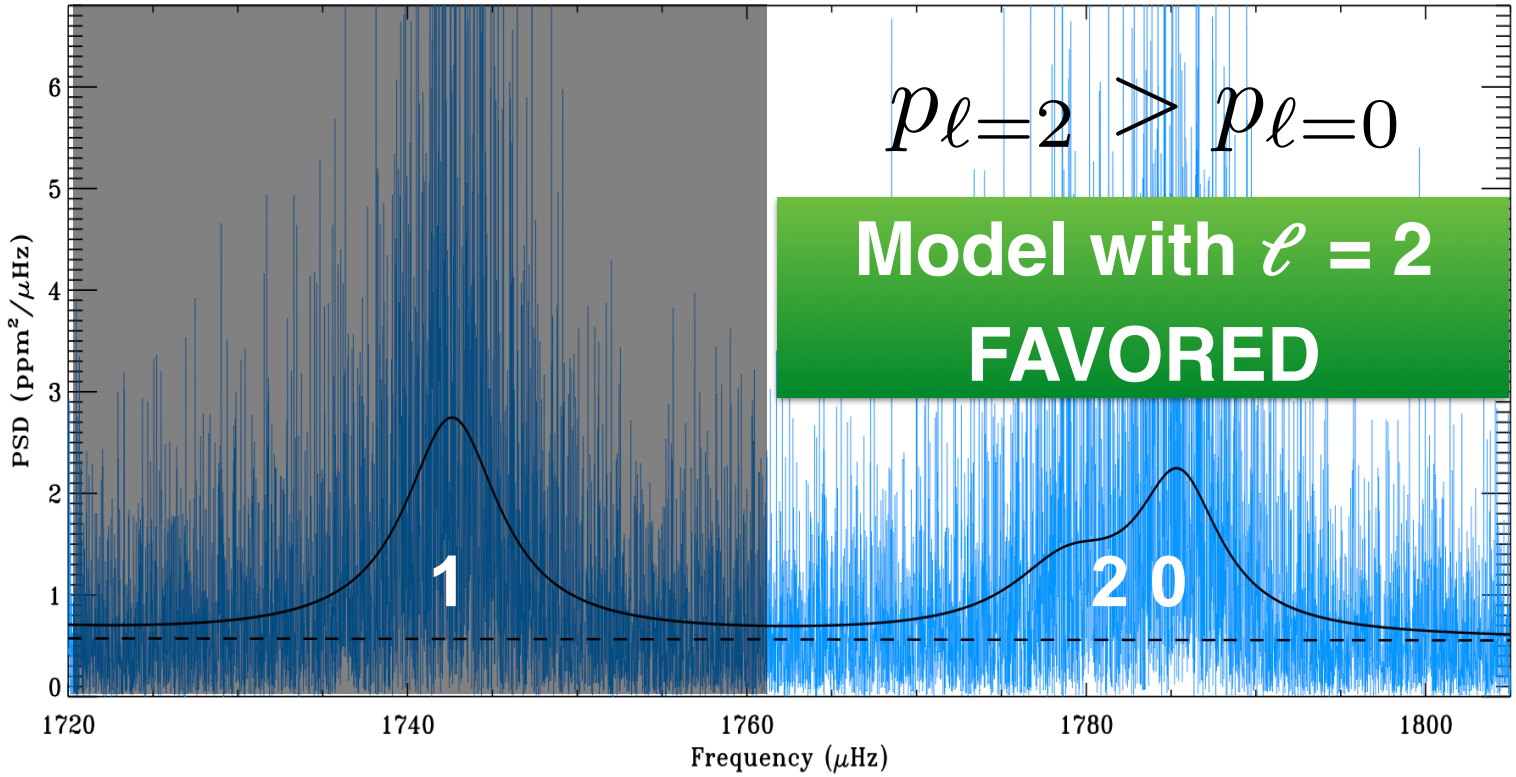
Detection Probability

$$p_{\ell=2} \equiv \frac{\mathcal{E}_{\ell=2}}{\mathcal{E}_{\ell=2} + \mathcal{E}_{\ell=0}}$$



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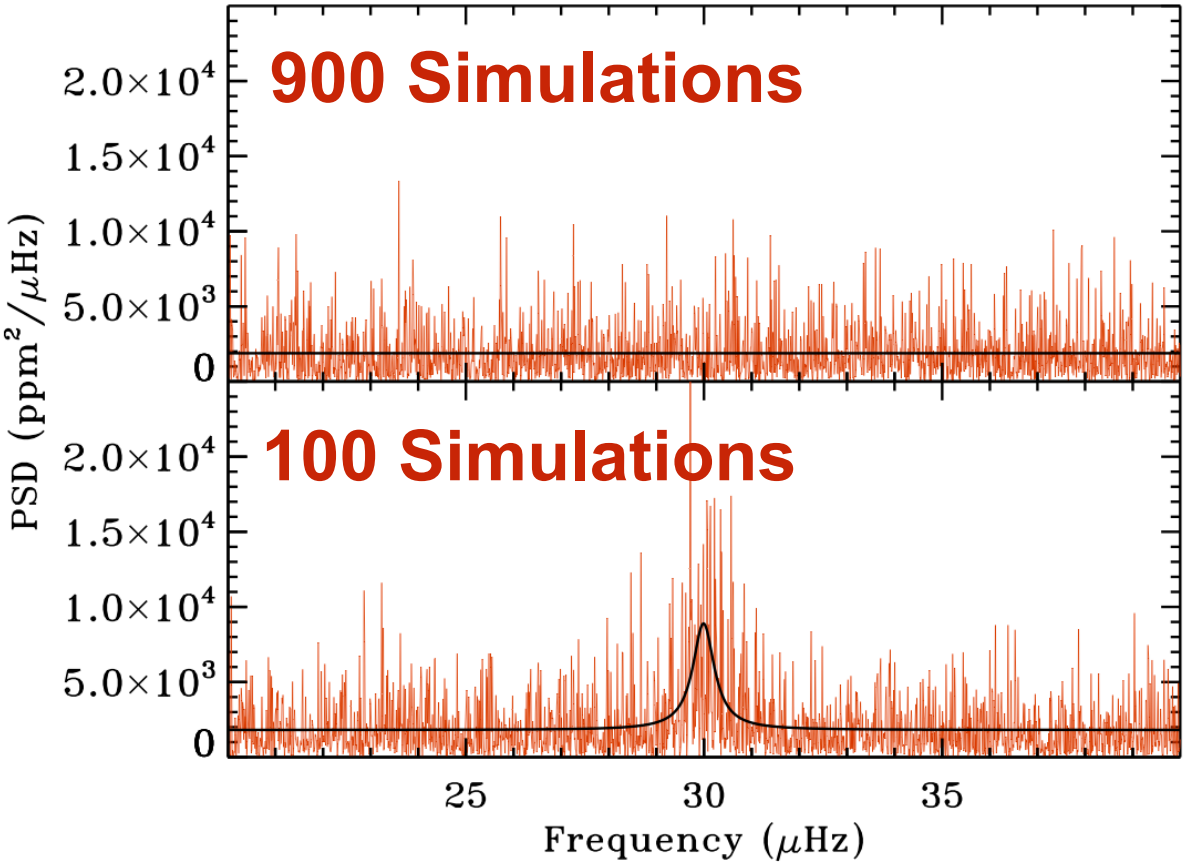
Peak Significance Criterion

- Simulation test
- 1000 artificial chunks of PSD
  De Ridder et al. 2006 MNRAS
- Blind search for those with a peak

$$p_{\mathrm{peak}} \gtrsim 99\,\%$$

All peaks found!



Height and amplitude ratios

- DIAMONDS approach is not using mode visibilities. All mode amplitudes are fit independently from one another.
- m-height ratio can be an issue but calibration from previous dataset exist (e.g. Salabert et al. 2011)
- m-components are fit by rescaling height according to m-height ratios

Deliverable

- A code package with the following features:
  - A full background model implemented
  - An oscillation model implemented
  - One-time compilation. Fit peaks can be included or excluded and tested by input file only

Evidence 1

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Evidence 2

Thank you!