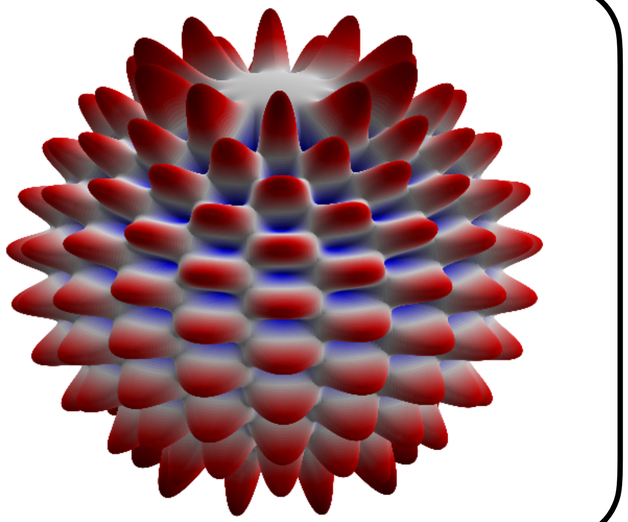
Magnetic activity biases in asteroseismic inferences: challenges for stellar ages in the PLATO era

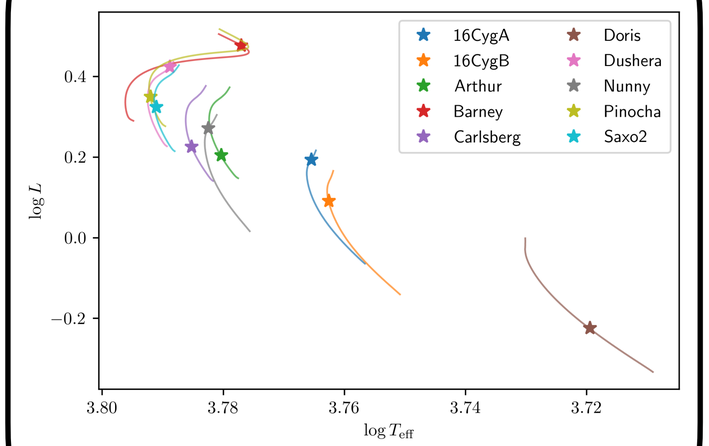
Jérôme Bétrisey
Department of Physics and Astronomy, Uppsala University, Box 516, SE-751 20 Uppsala, Sweden
Email: jerome.betrisey@physics.uu.se
Main collaborators: A.-M. Broomhall, S. N. Breton, R. A. García, E. Panetier, O. Kochukhov, A. M. Amarsi, M. Farnir

UPPSALA UNIVERSITET

FNSNF

General context



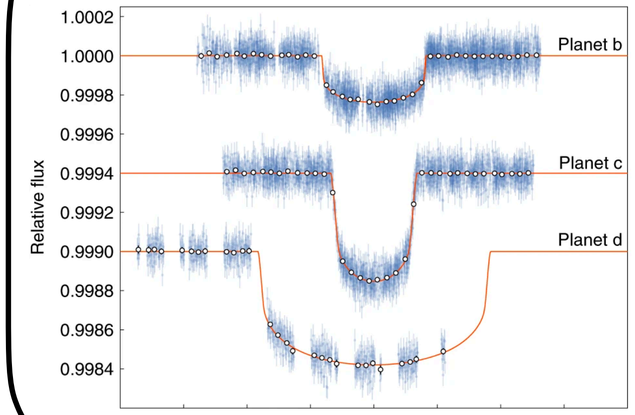


Constrain precisely and accurately the stellar parameters (mass, radius, age, etc.)

Recommended literature: e.g. Chaplin & Miglio 2013; García & Ballot 2019; Aerts 2021

Multidisciplinary applications

Exoplanet science

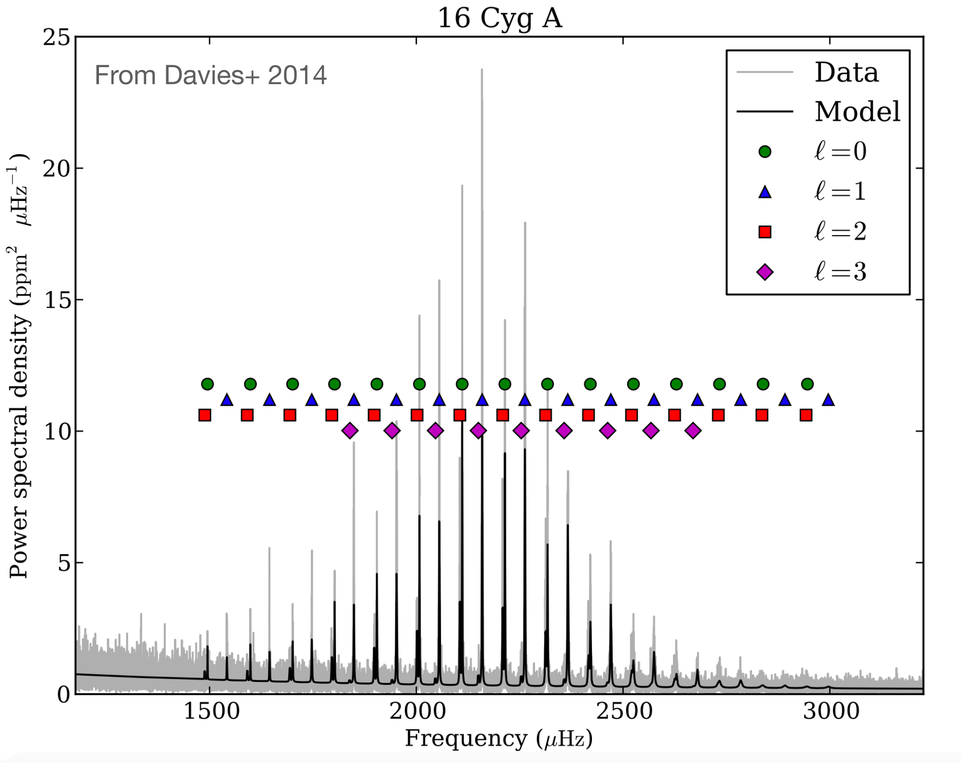


From Delrez+ 2021

Galactic archeology

From eso.org

Seismic inferences



Stellar mass, radius, age, etc.

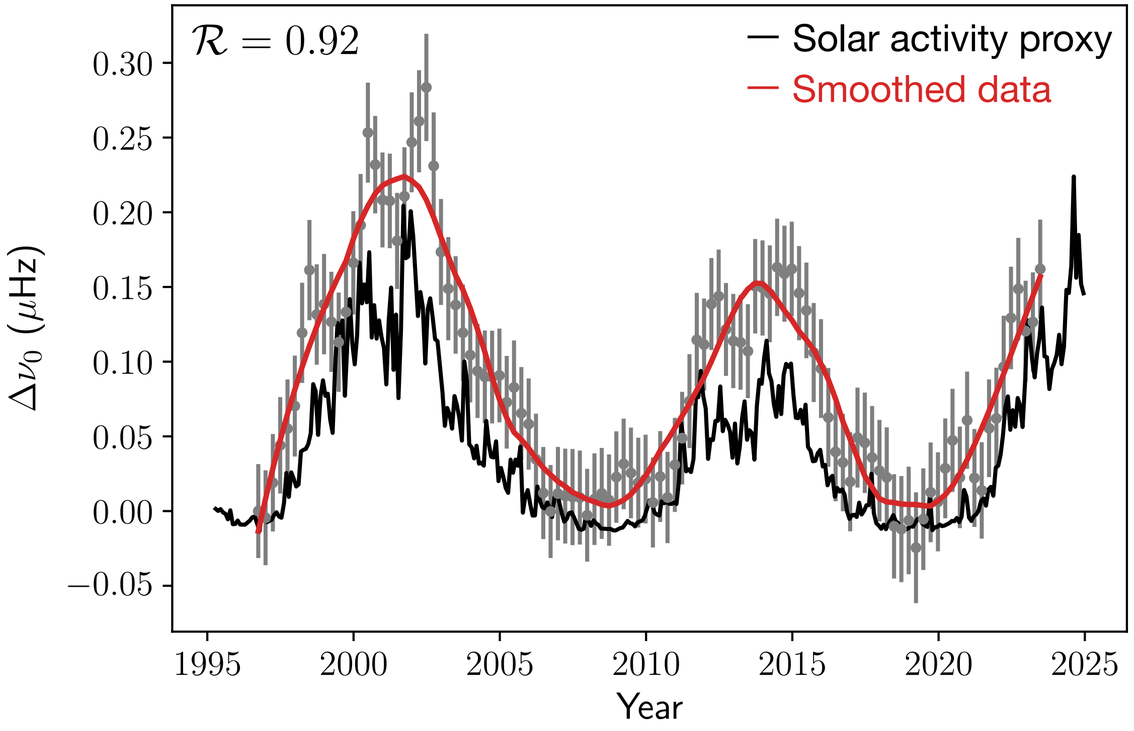
Forward modelling
- Surface-dependent methods
- Surface-independent methods

Inverse methods
- Seismic inversions

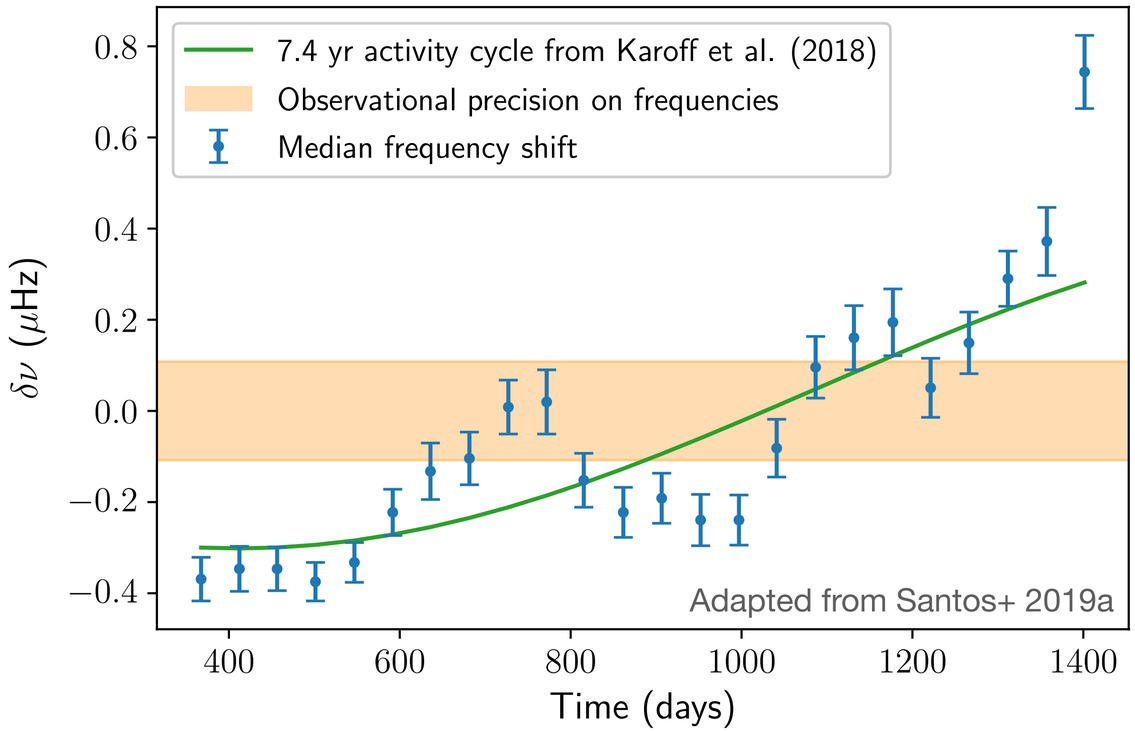
Recommended literature: e.g. Chaplin & Miglio 2013; García & Ballot 2019; Aerts 2021; Buldgen+ 2022

Magnetic activity effects

Sun



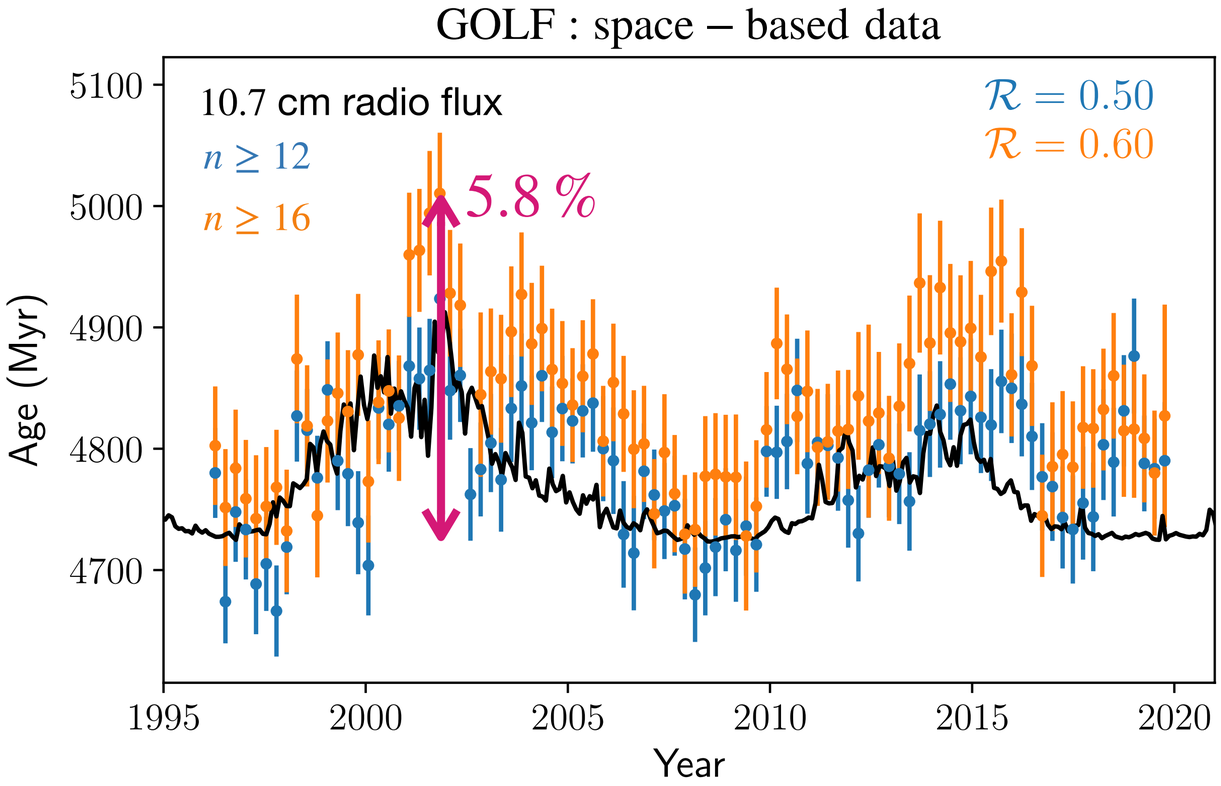
KIC 8006161

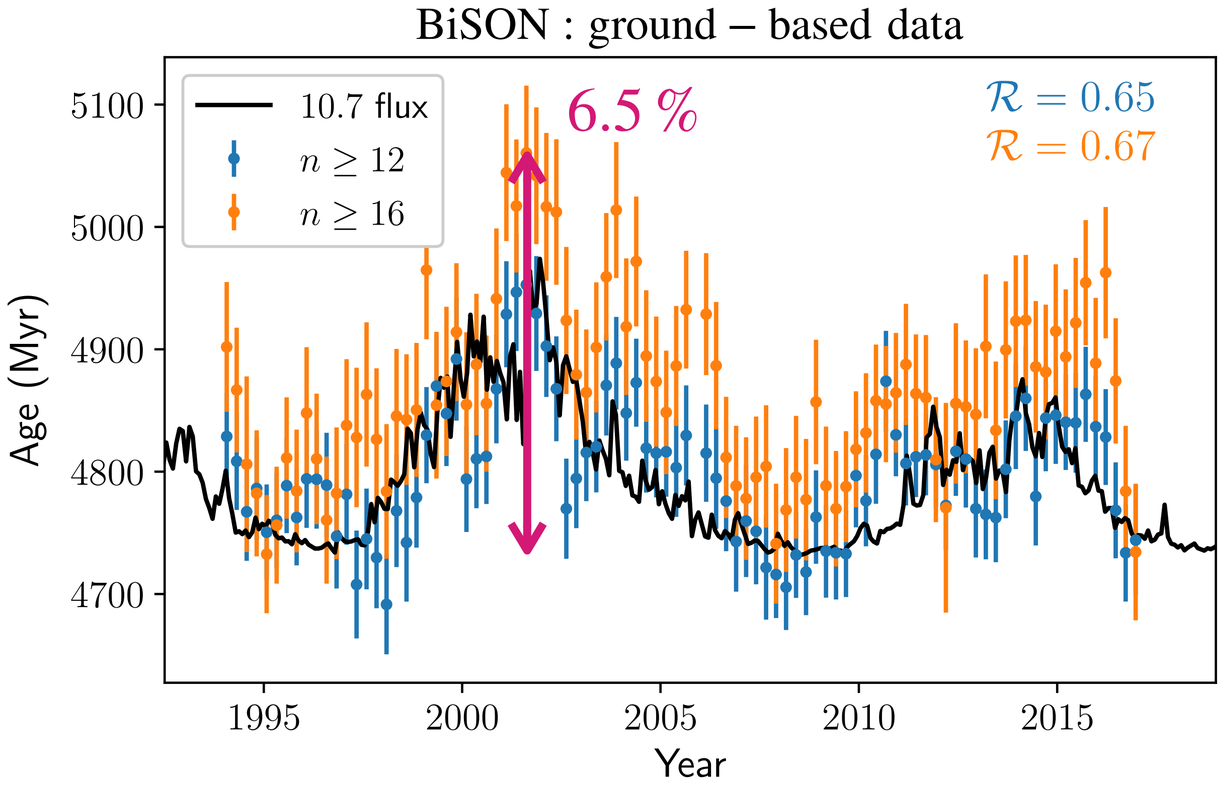


Recommended literature: e.g. Woodard & Noyes 1985; Fossat+ 1987; Kuhn 1998; Libbrecht & Woodard 1990; Howe+ 2002; Dziembowski & Goode 2005; Baldner+ 2009; Basu+ 2012; Broomhall+ 2011, Broomhall & Nakariakov 2015; Howe+ 2017; Perez-Harnandez+ 2019; Santos+ 2019a,b; Howe+ 2020; Thomas+ 2021

Forward modelling

Significant imprint of the magnetic activity cycle on the estimated solar age

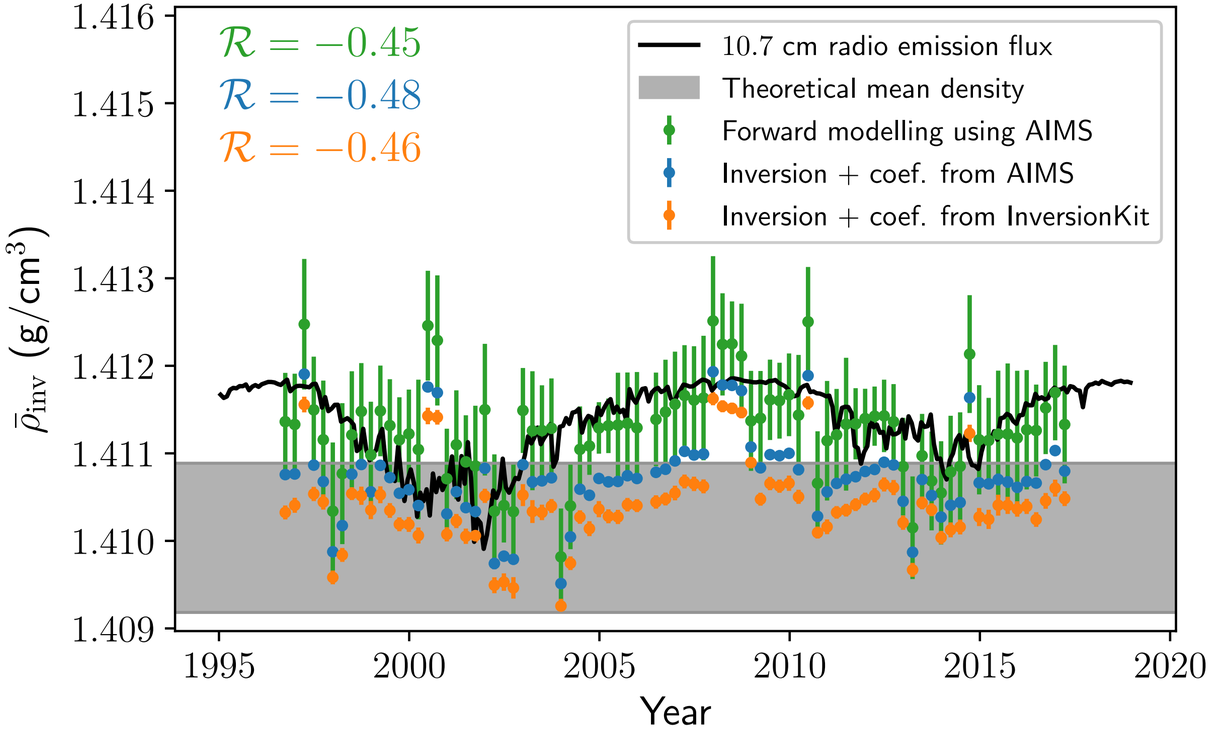




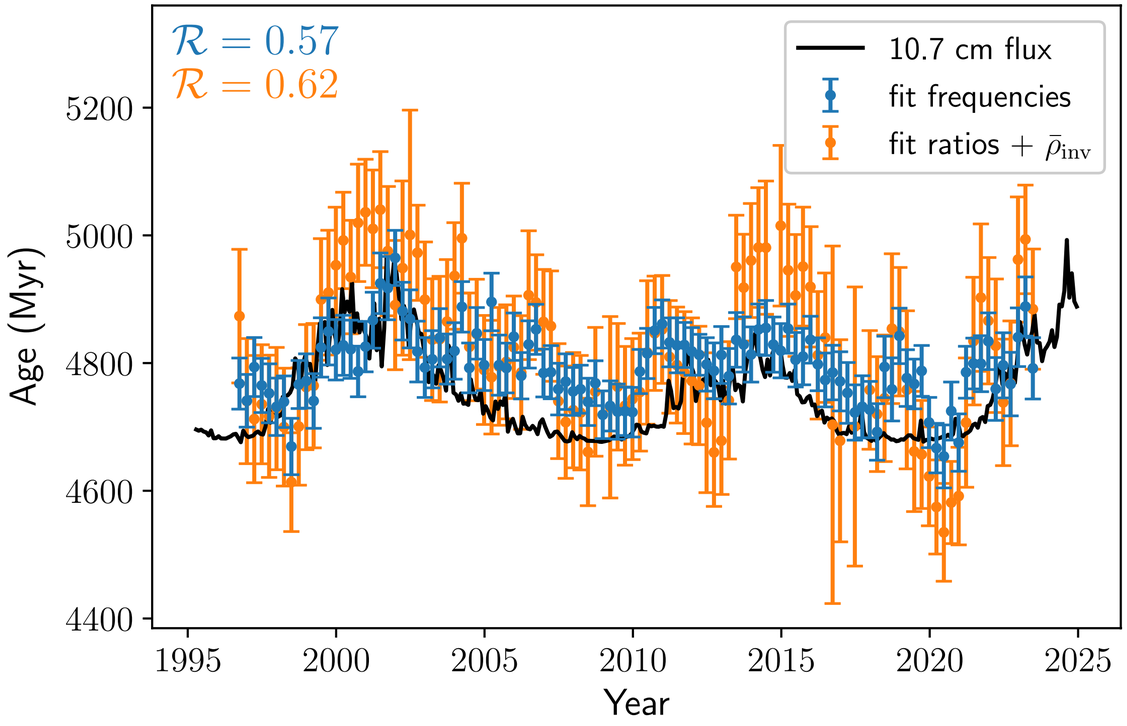
Note: PLATO requires 10% precision in stellar age for a Sun-like star

Magnetic activity effects are always present

Inverse methods

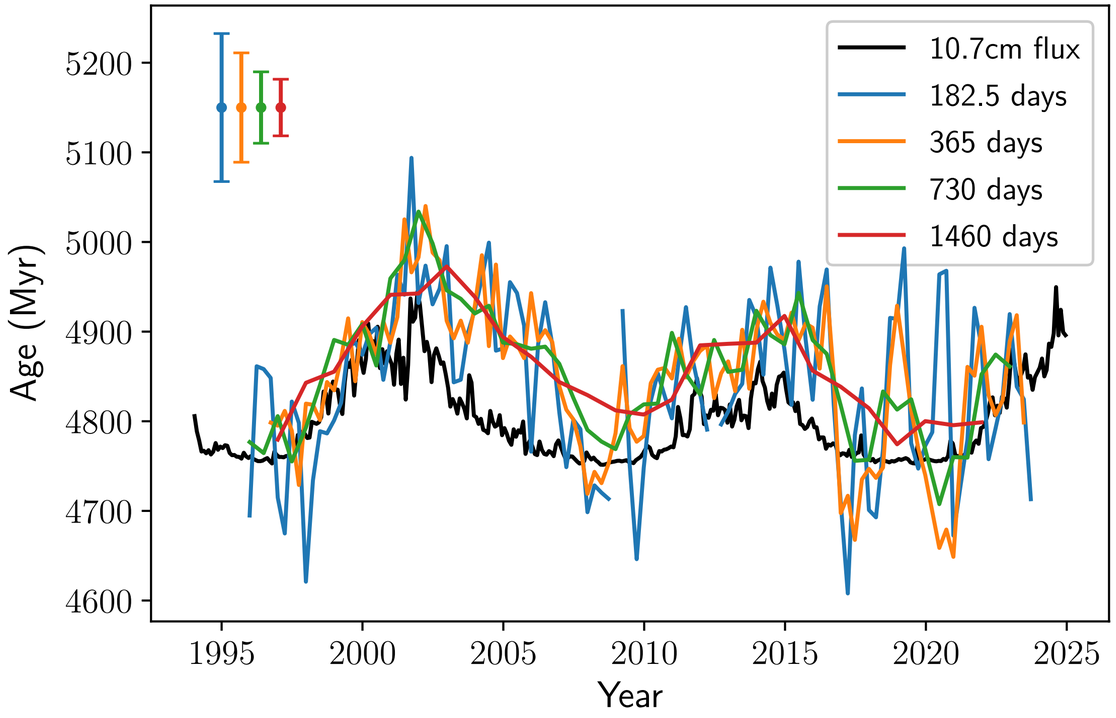


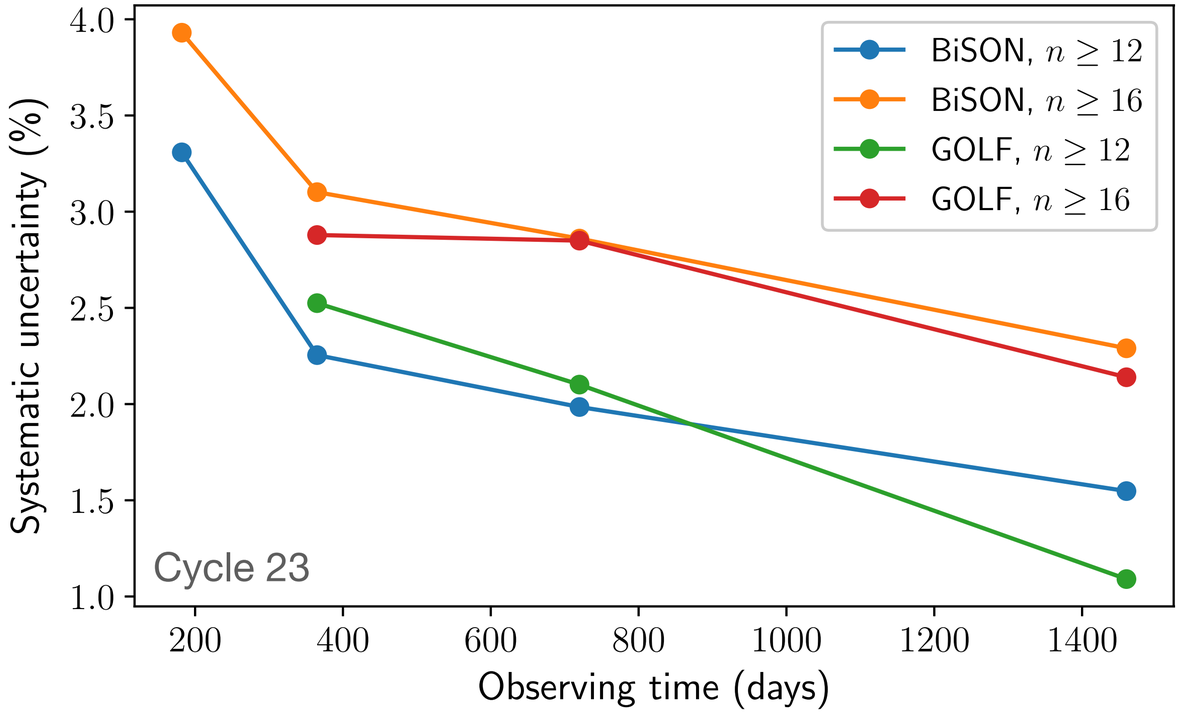
Surface-independent methods



Averaging of magnetic activity effects

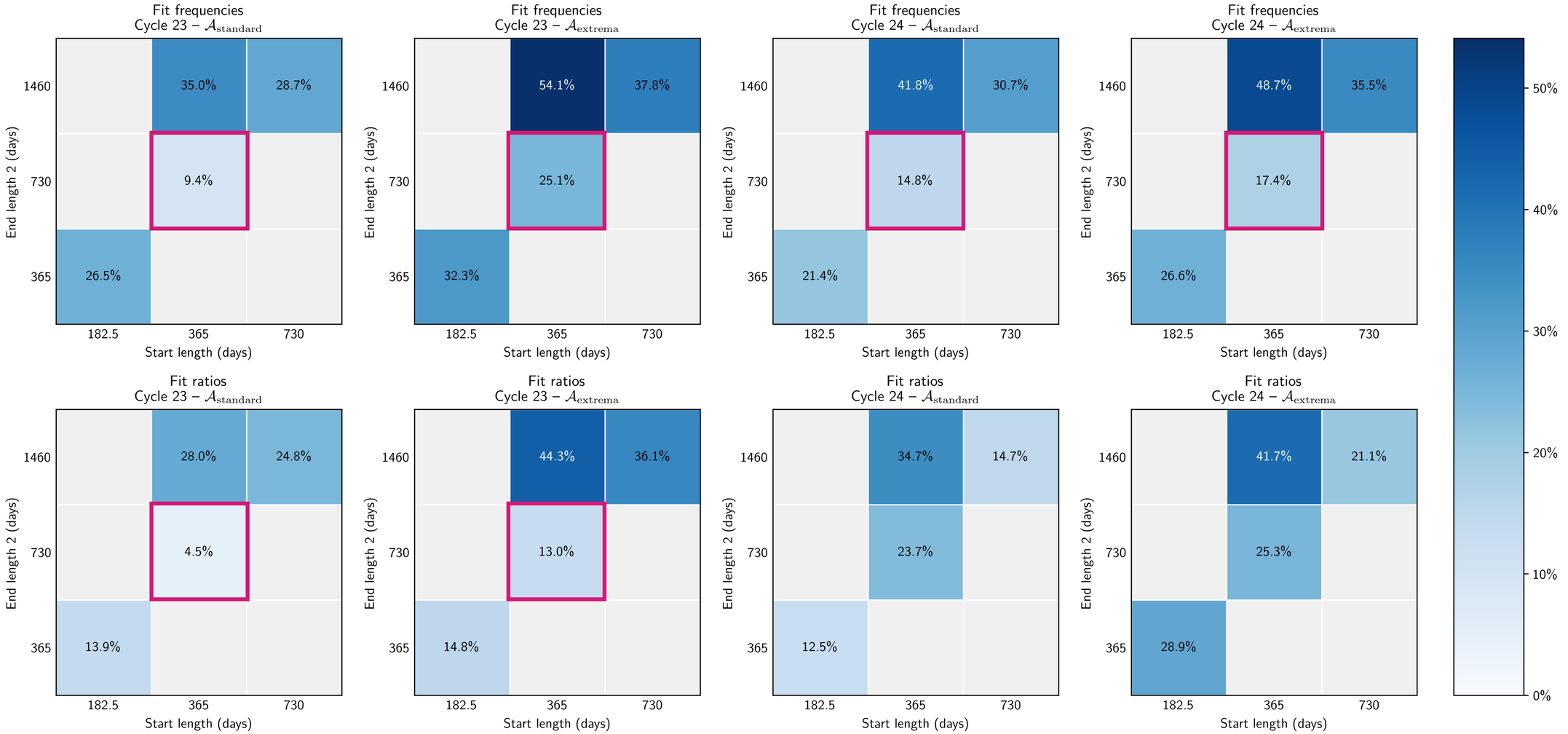
Still not negligible with 4yr observing baselines !





Impact for PLATO observing strategy

PLATO single-field 4yr much better than 2+2-yr in two distinct fields



Conclusions and perspectives

Results for the Sun as a star

- **Stellar parameters are sensitive to the activity cycle, especially the seismic solar age**, up to 6.5% for a star which is not particularly active (e.g. Reinhold+ 2020, Santos+ 2023)
- **Imprint is present regardless of whether forward and inverse methods are used**
- **Very inefficient damping with surface-independent methods**
- **We might expect strong variations in active asteroseismic targets:** larger age variation for the more active cycle 23
- **Magnetic biases can be averaged out, but underperformance of 2yr baseline**

Results in the context of space-based missions (e.g. *Kepler*, PLATO)

- **Stellar characterisations may be influenced by the phase of the activity cycle**, leading to potential biases if observations coincide with cycle extrema
- **PLATO is expected to observe many more active stars, but with lower data quality,** resulting in fewer detectable acoustic oscillations: further investigations are required
- **PLATO observing strategy: 4yr** (or more) **in a single field much better than 2+2yr in two fields**