

# Seismology with PICARD

## Objectives and results

T. Appourchaux, P. Boumier, T. Corbard,  
P. Journoud, D. Salabert,  
(A. Hauchecorne, S. Turck-Chièze,...)

Many Contributions/inputs from GEVP and PICARD team

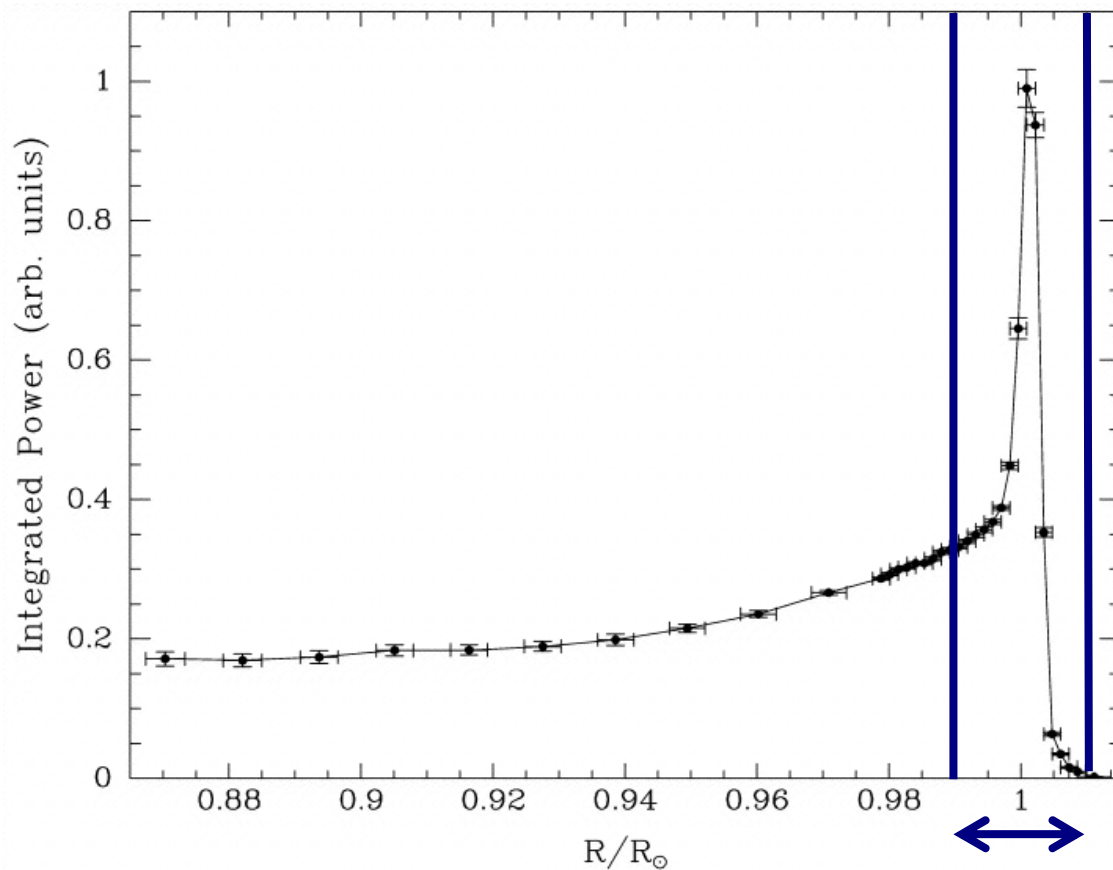
# Helioseismic objectives

1. Structure and dynamics of the nuclear core  
(limb helioseismology or "HL" program and integrated irradiance data ; low frequency domain of the solar oscillation spectra; low and intermediate degree modes). )
2. Nature of the modes, convection, photospheric physics  
(Intensity Medium-I program or "Macro Pixels" program)
3. Fundamental (f) modes and the solar radius ("Macro Pixels" program)

*Corbard, Boumier, Appourchaux et al 2008*

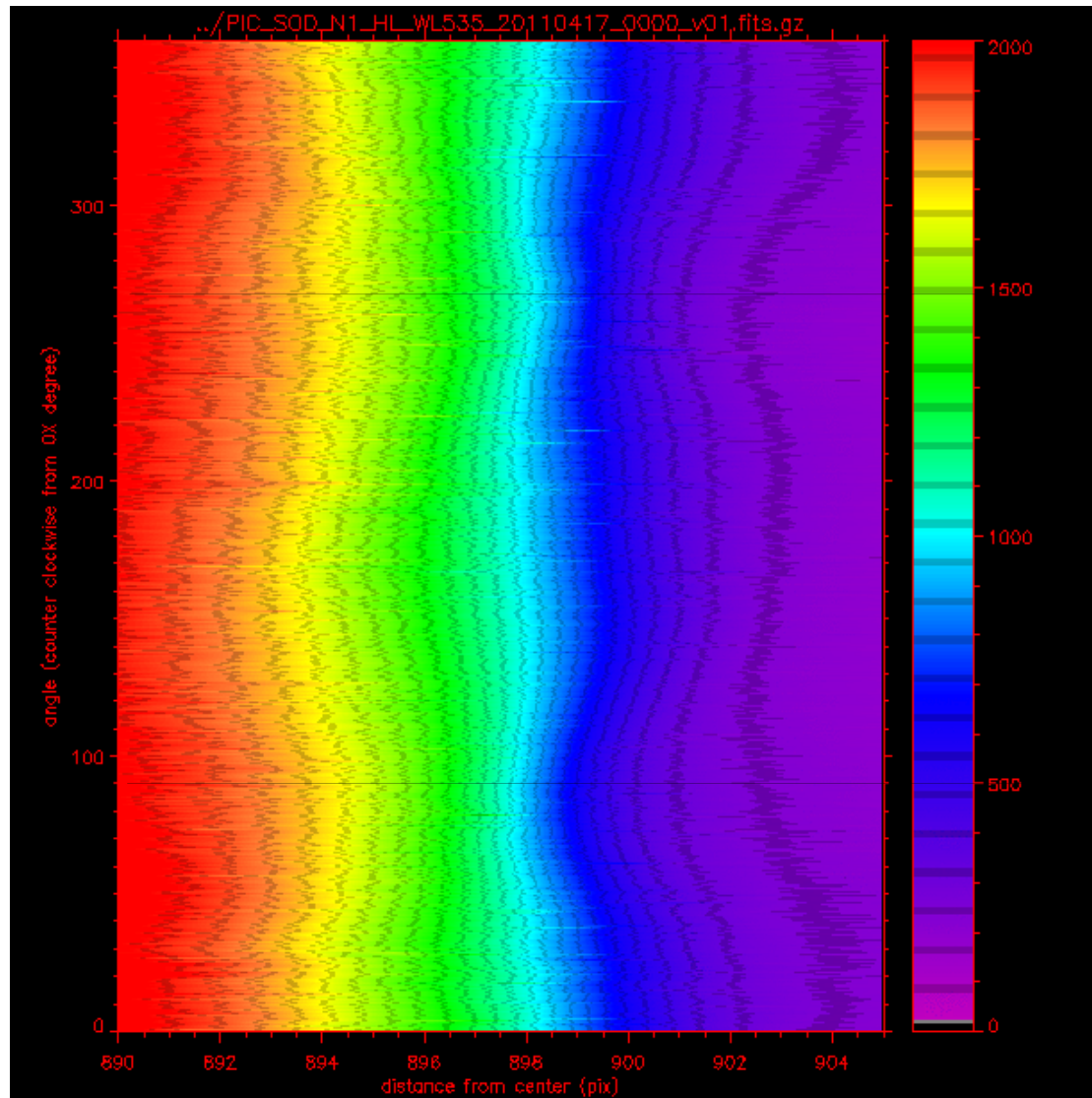
First glance at the observables

## g-modes search with PICARD: take advantage of limb-amplification



- This limb amplification is understood theoretically (Toutain et al., 1999) and it has been observed for p modes using MDI images and LOI guiding pixels. (Appourchaux et al. 1996)
- PICARD: searching low frequency modes.

# HL limb shape analysis



2011/04/17

Cadence: 1 image/2 mn

Angular resolution: 0.02 deg

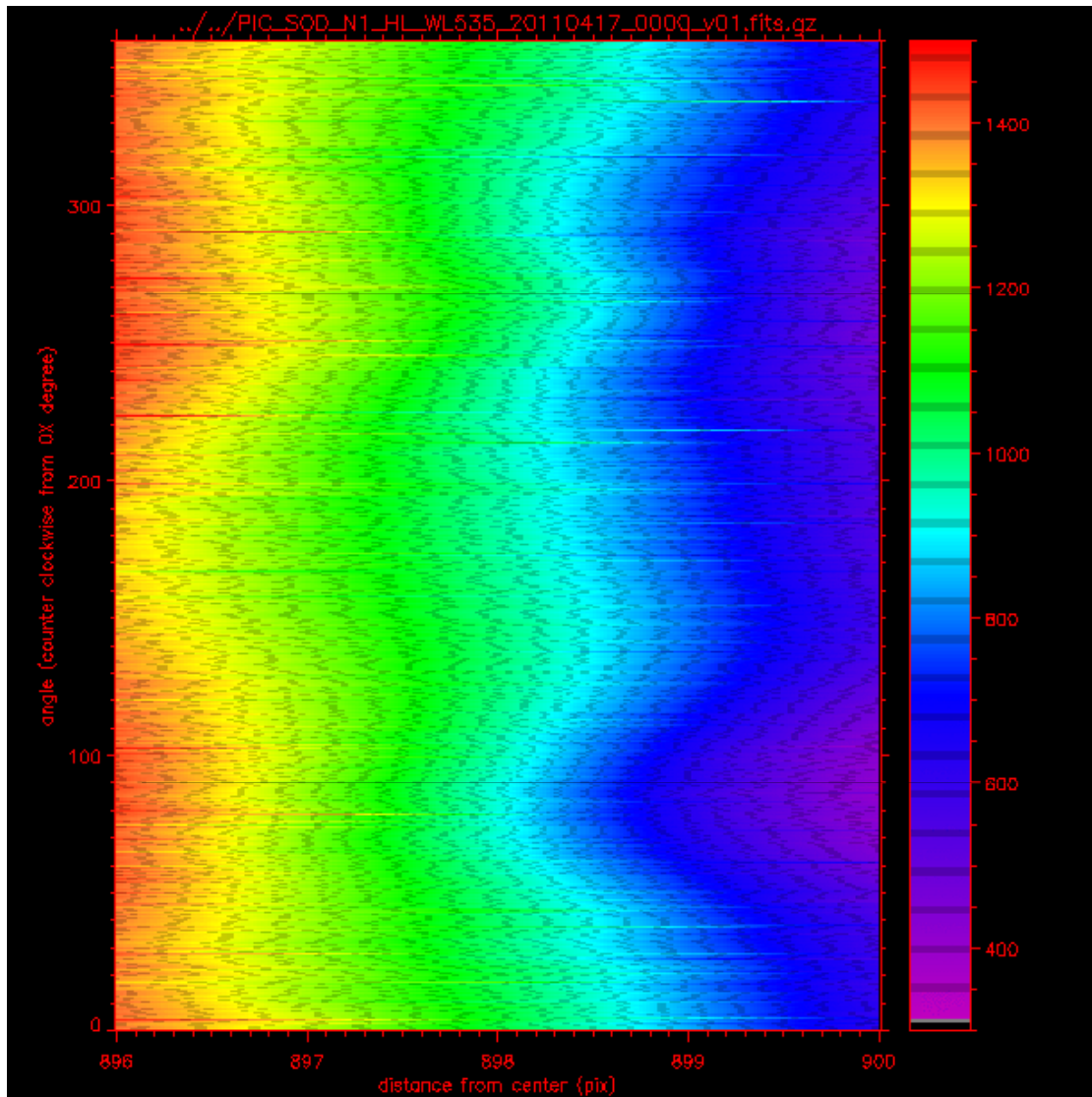
Radial resolution: 0.02 pixels

→ South Pole

Radial extent : 15 pixels

→ North Pole

# HL limb shape analysis



2011/04/17

Cadence: 1 image/20 mn

Angular resolution: 0.02 deg

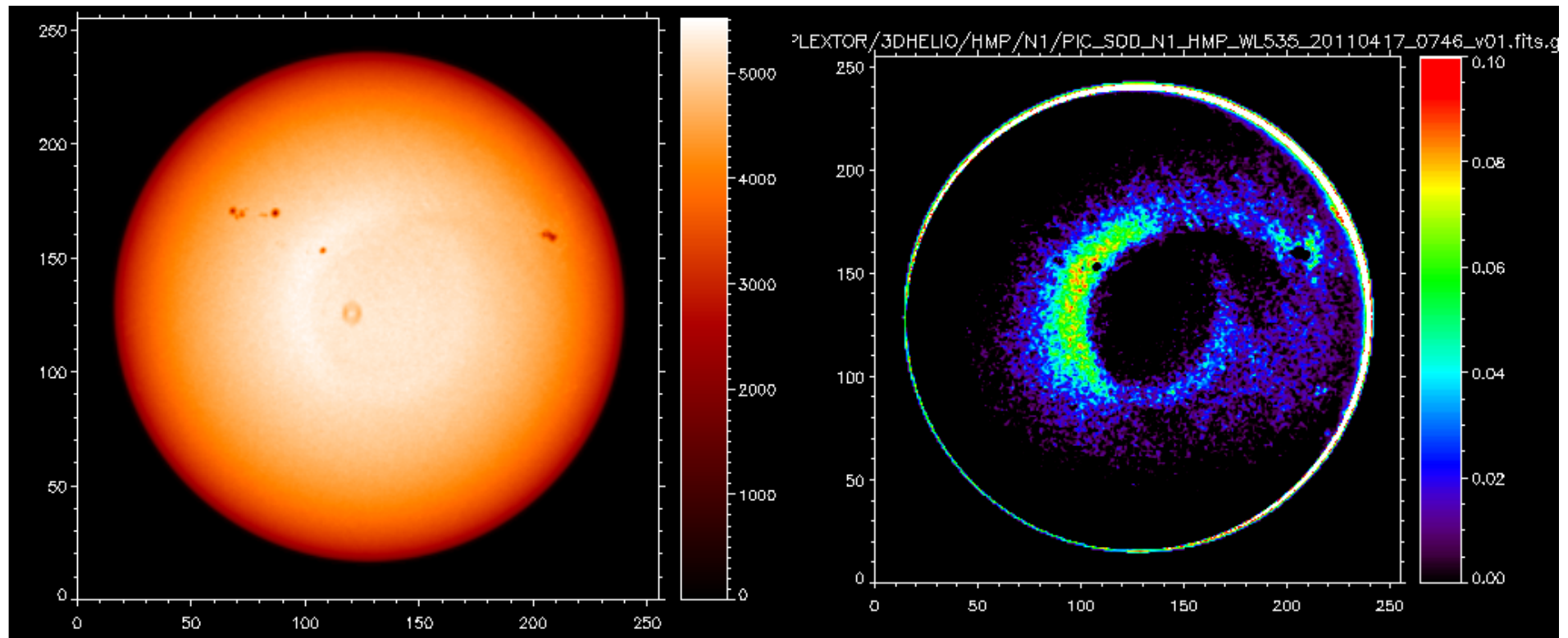
Radial resolution: 0.02 pixels

→ South Pole

Radial extent : 4 pixels

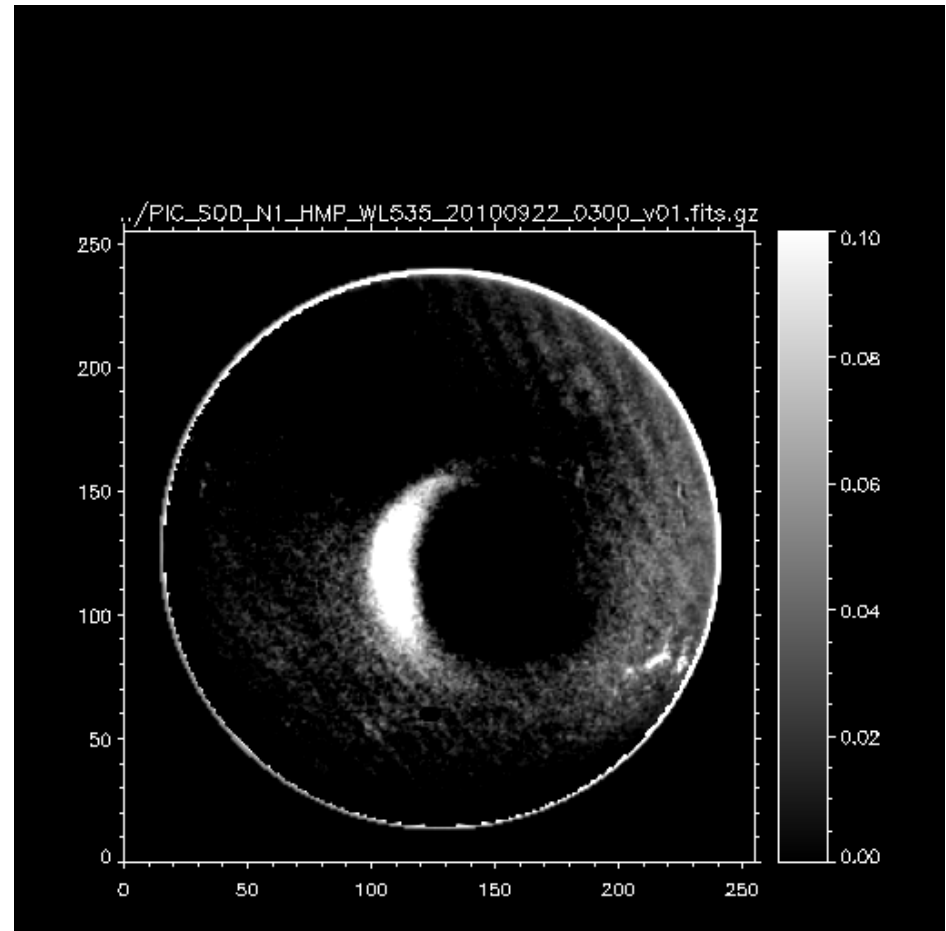
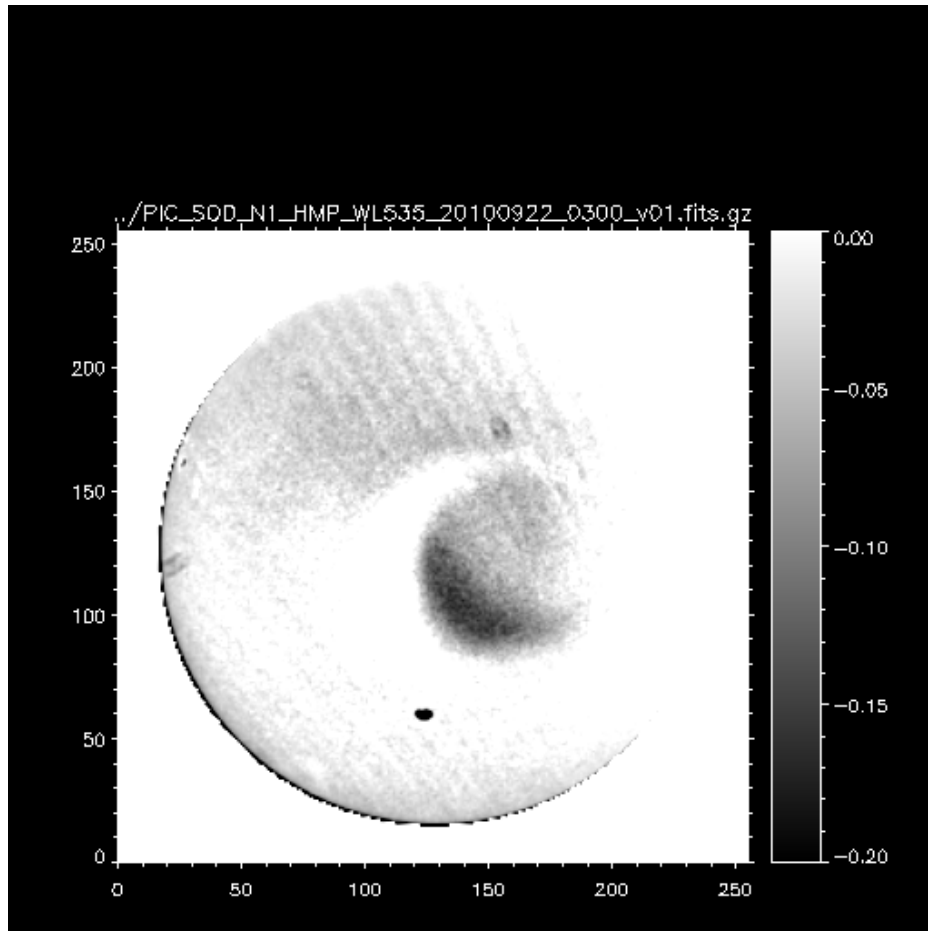
→ North Pole

# HMP



**max scattered light ~ 10% of mean image intensity**

# HMP

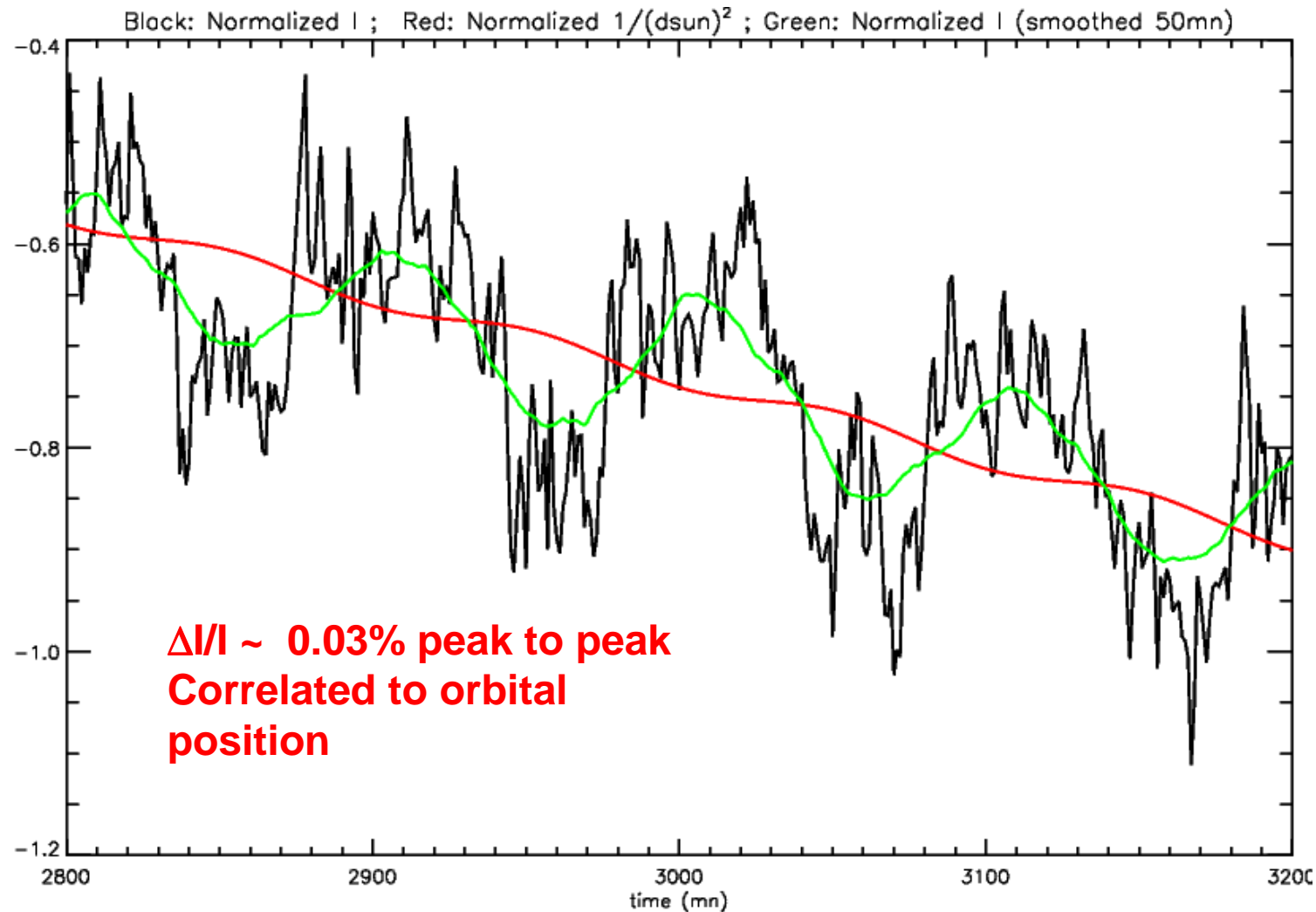


**Central spot appears on 2010/11/21**

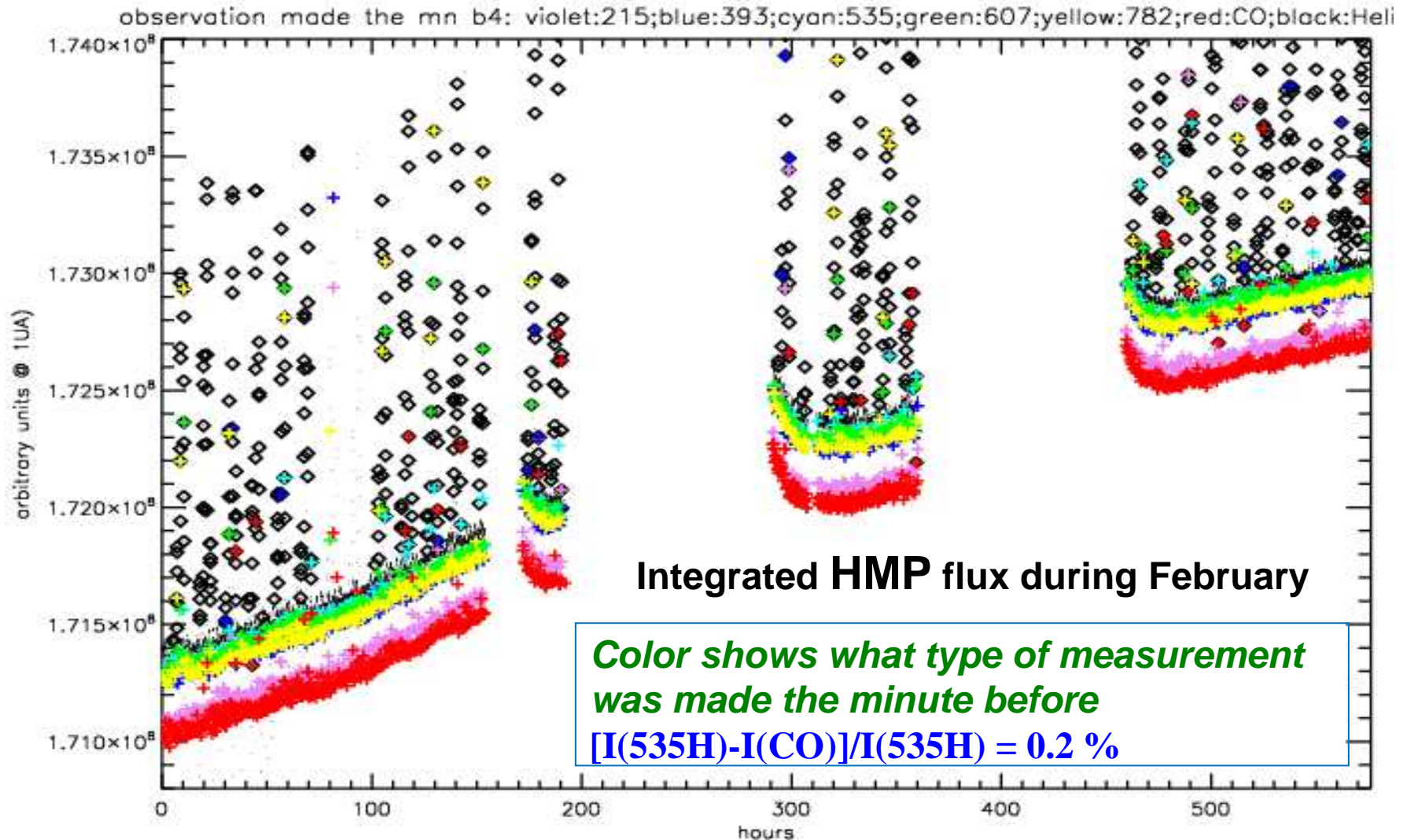
**Important change in scattered light shape and intensity starting 2011/03/31**



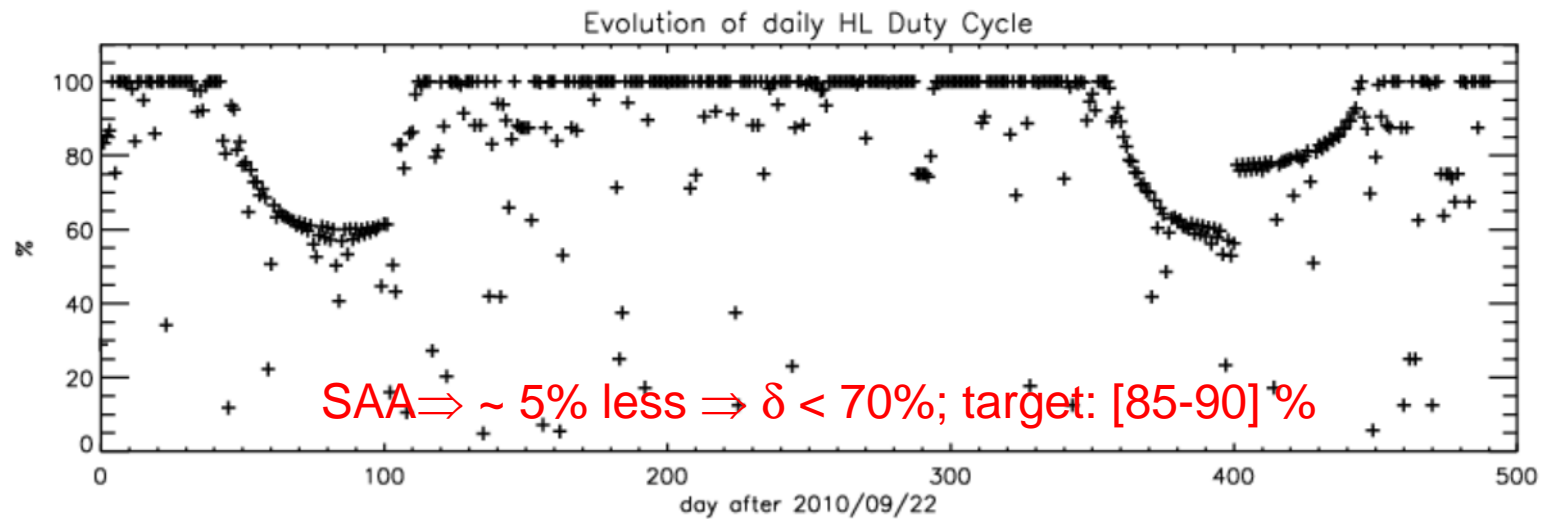
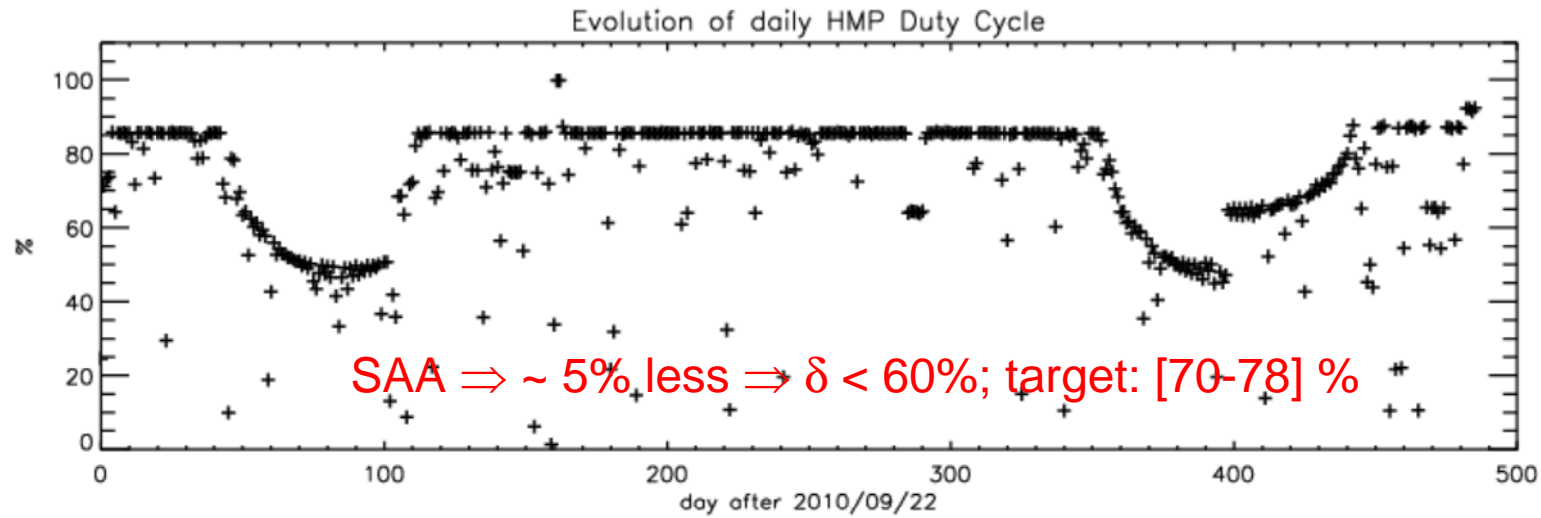
# HMP integrated photometry



# CCD Remanence/Persistence

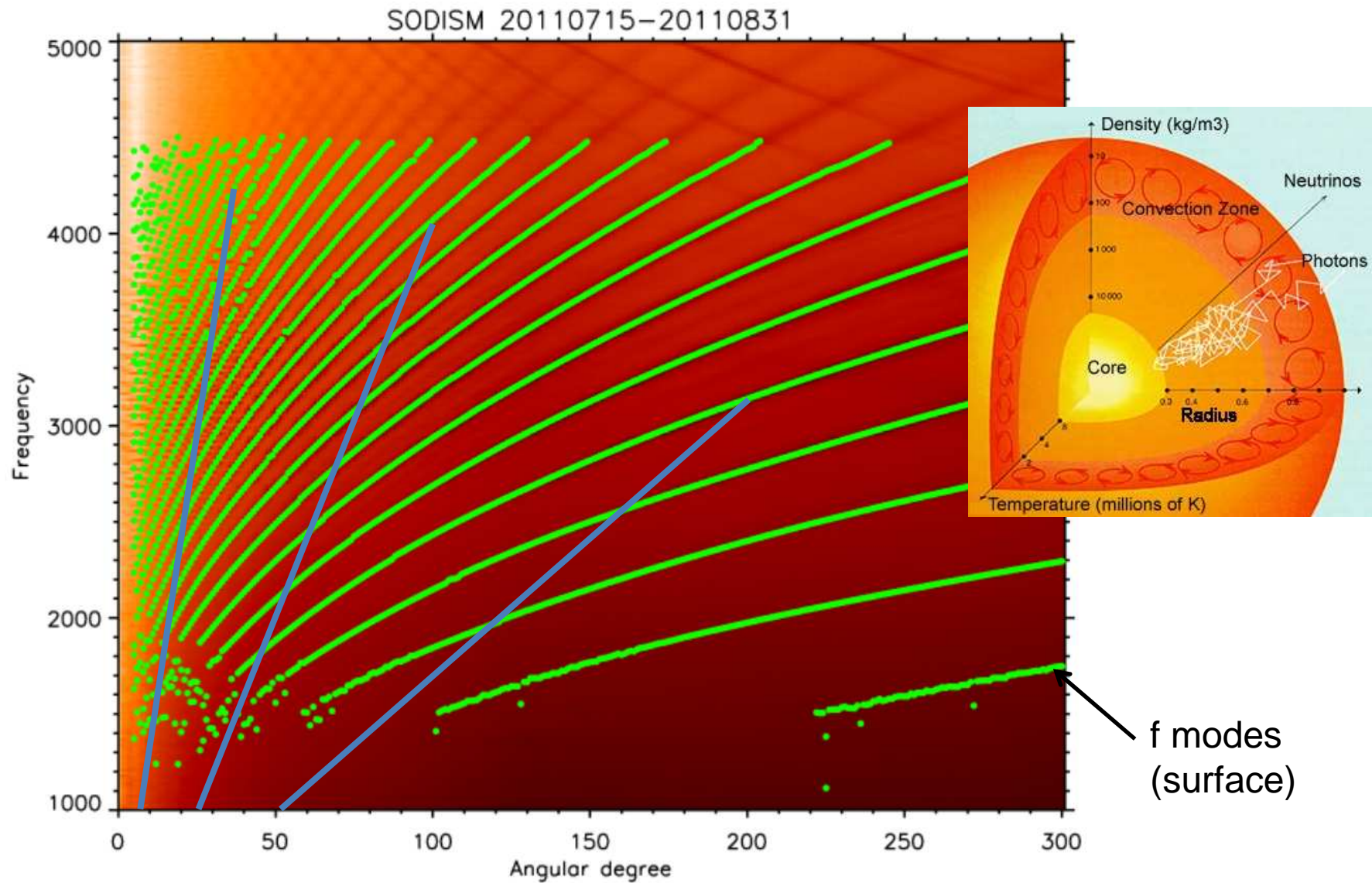


# Operational duty cycle



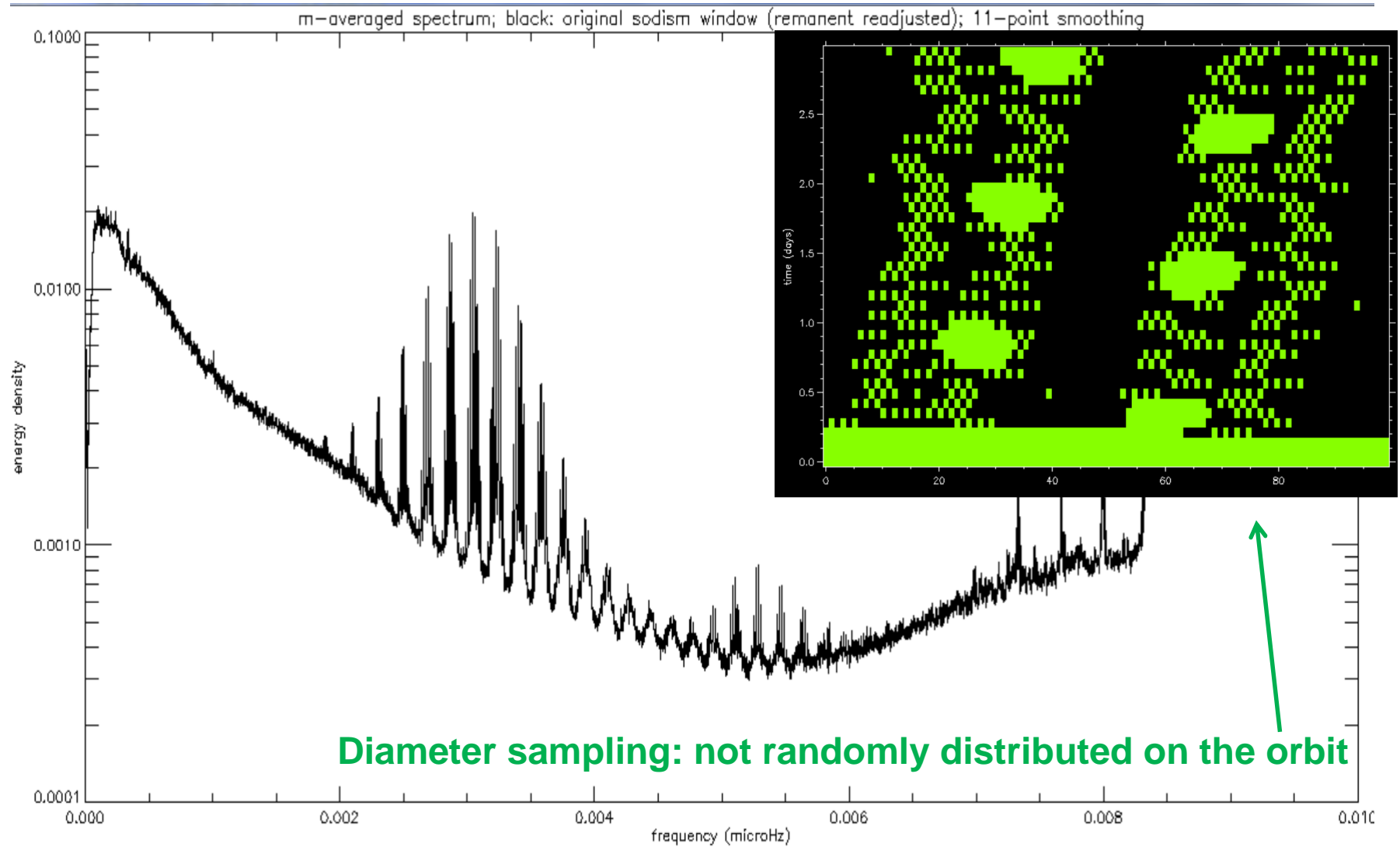
# HMP RESULTS

# I-nu diagram (macropixels)



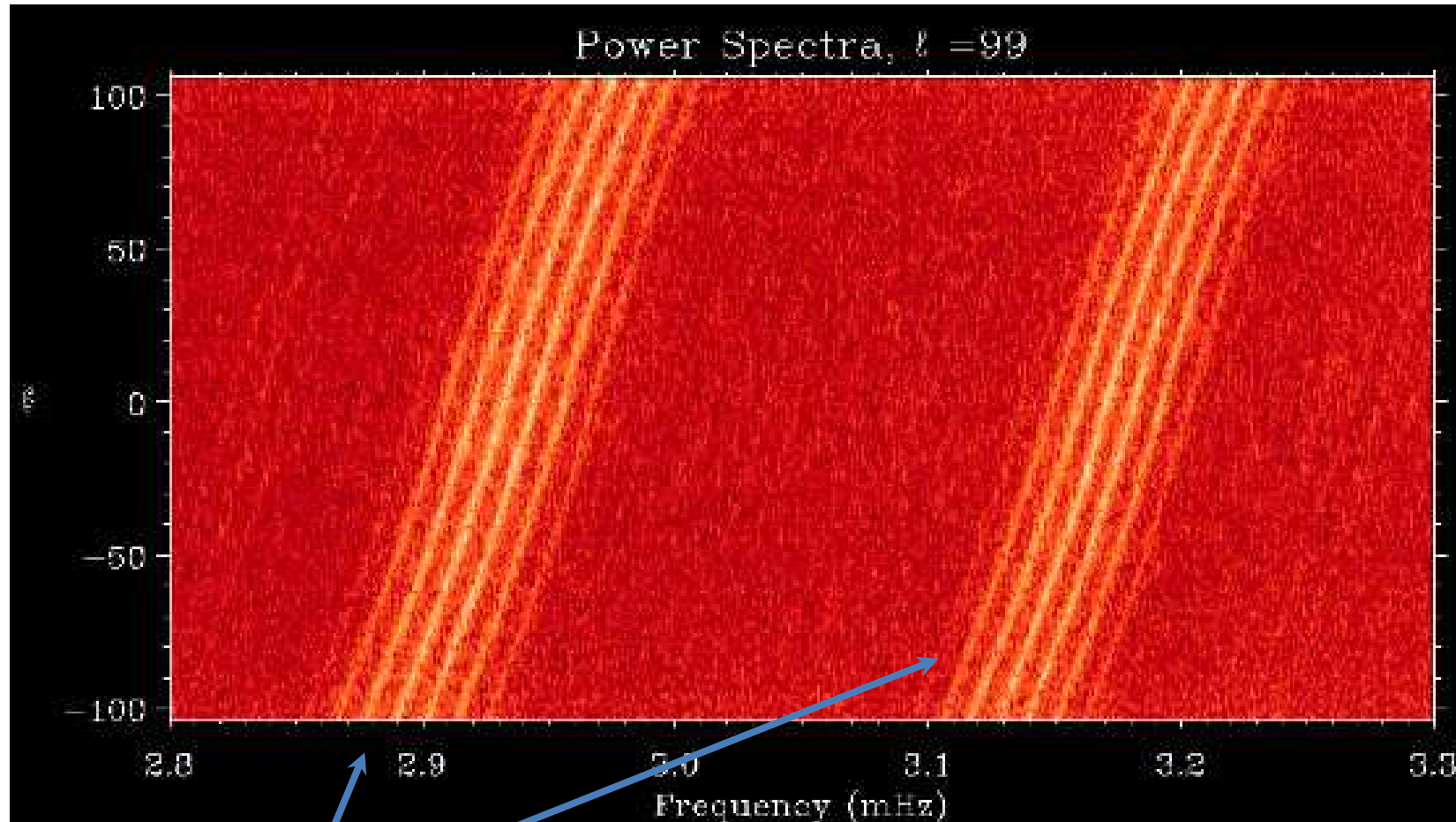
Blue lines: modes with turning points at 0.4, 0.85 and 0.95  $R_{\odot}$  from the left to the right

# $l=50$ spectrum





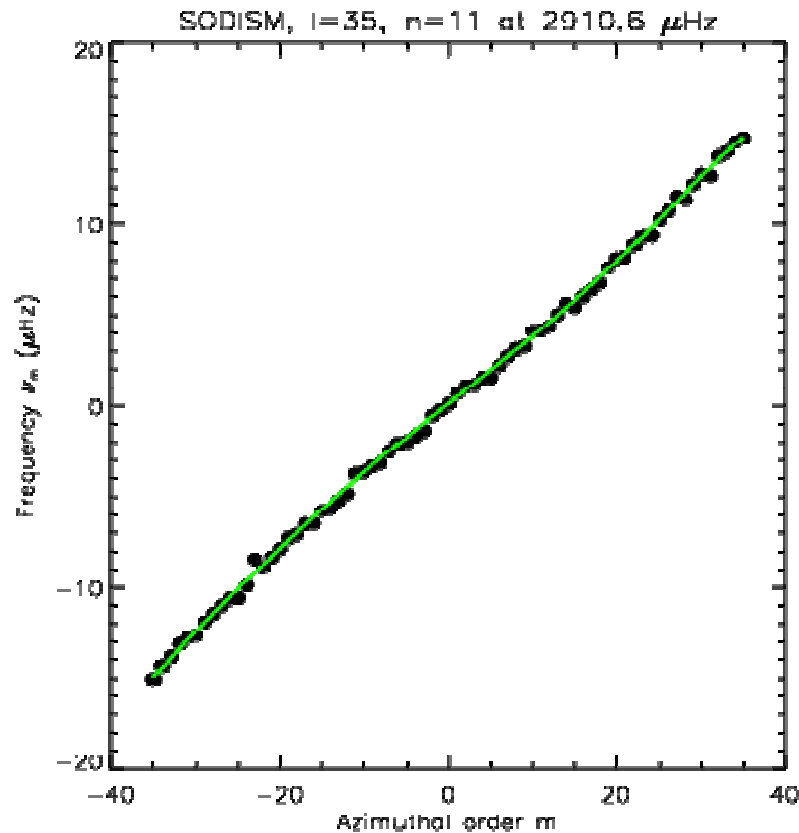
# Solar rotation



2 consecutive radial harmonics of  $l=99$  mode (with leakage from other degrees).

Straight line  $\Rightarrow$  uniform rotation ; S-like lines  $\Rightarrow$  differential rotation

# M-nu spectra : rotation coefficients measurements



---

Central frequency=  $2906.920 \pm 0.002$

$a(1) = 409.463 \pm 0.100$

$a(2) = -0.725 \pm 0.121$

$a(3) = 19.877 \pm 0.141$

$a(4) = -0.163 \pm 0.146$

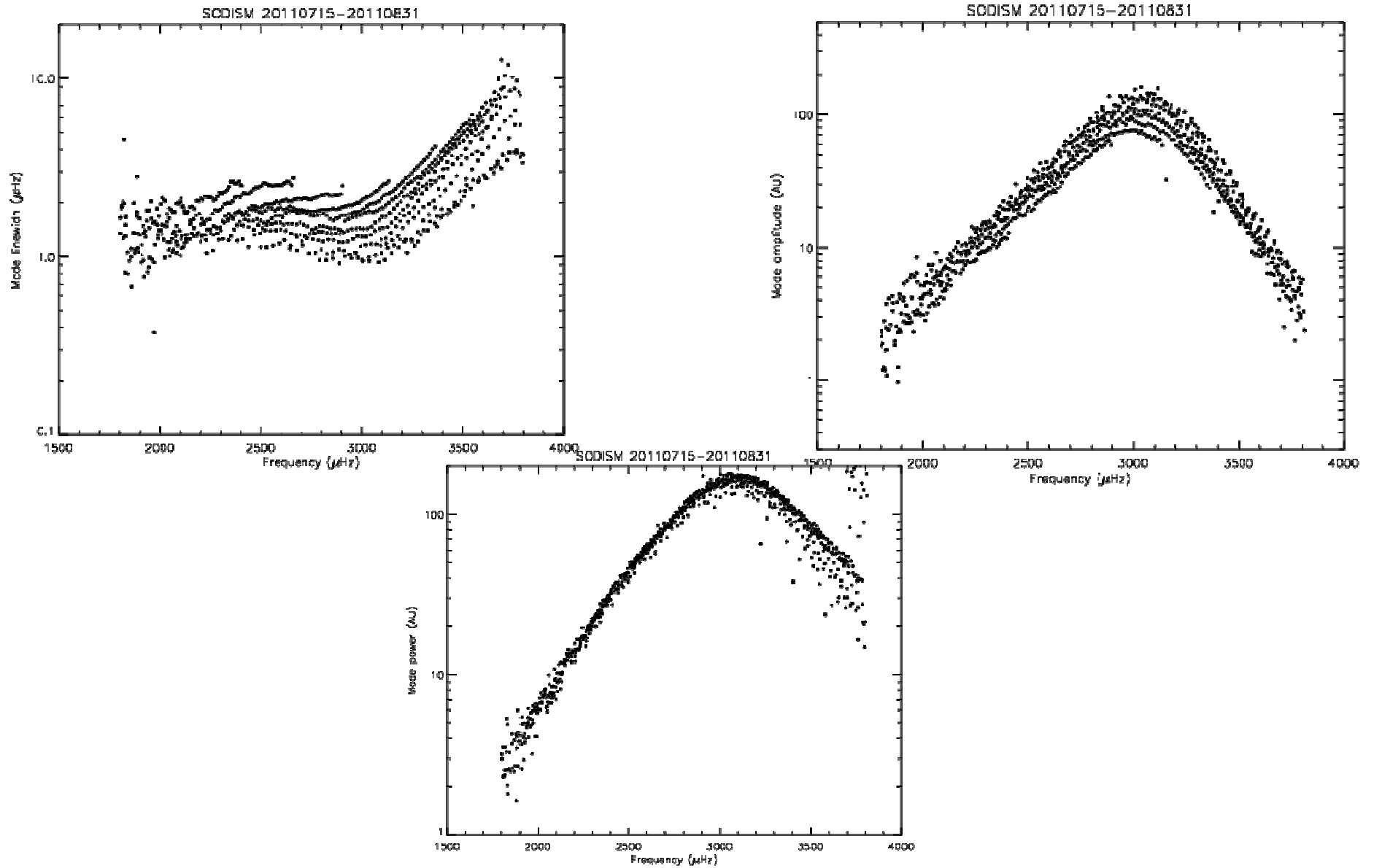
$a(5) = -4.508 \pm 0.144$

$a(6) = -3.905 \pm 0.150$

---

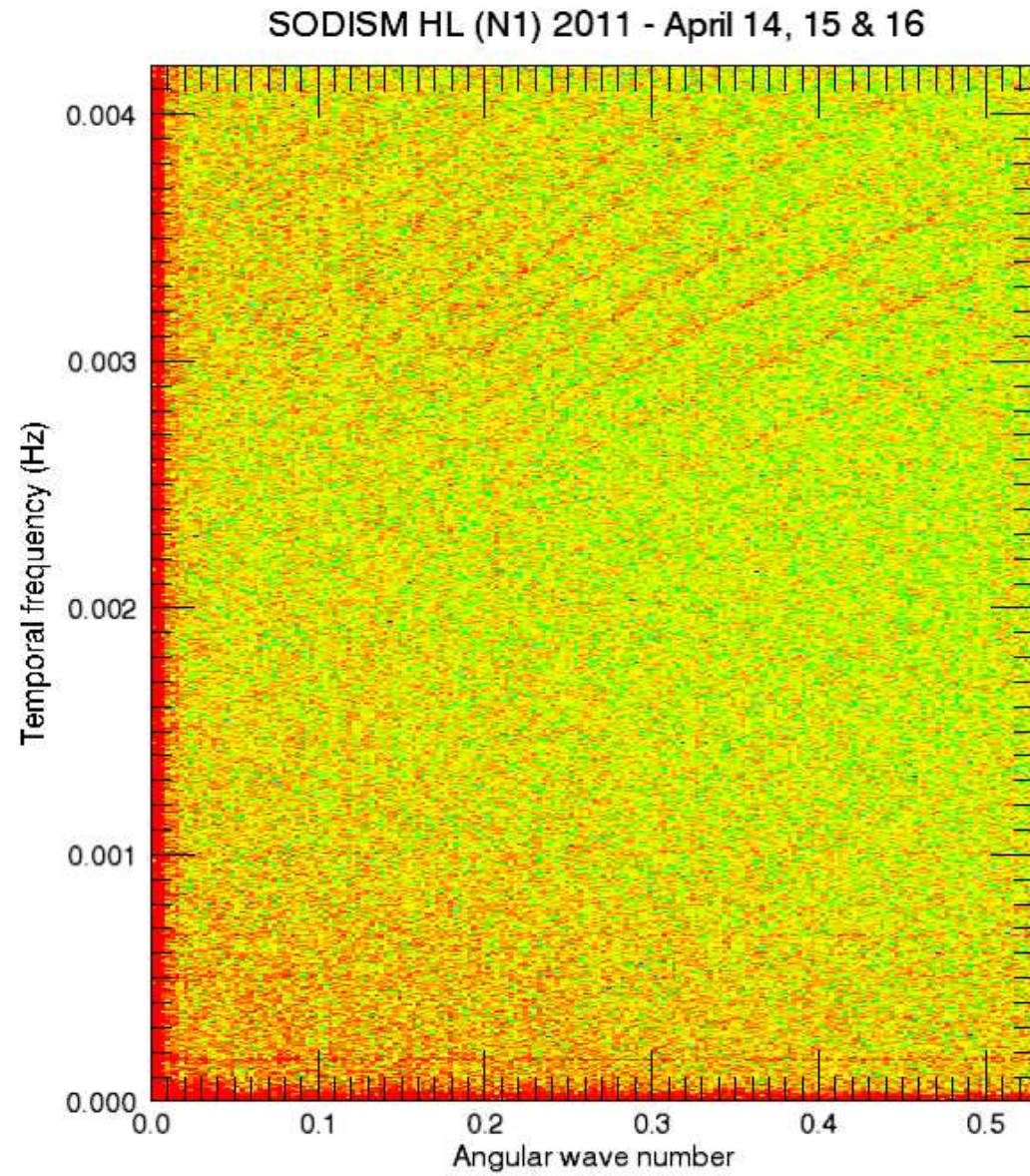


# Mode parameters : First results from PICARD

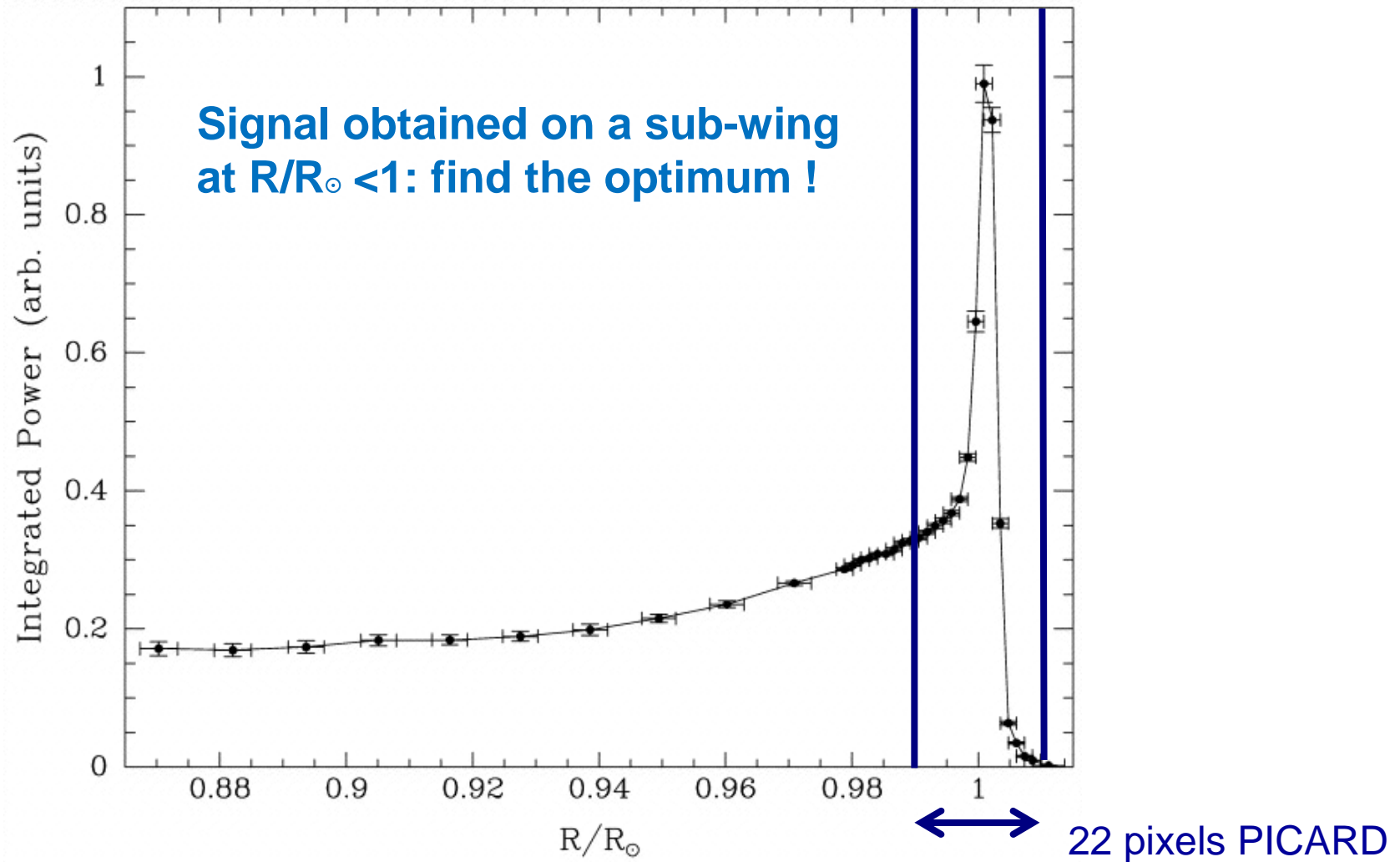


# Limb RESULTS

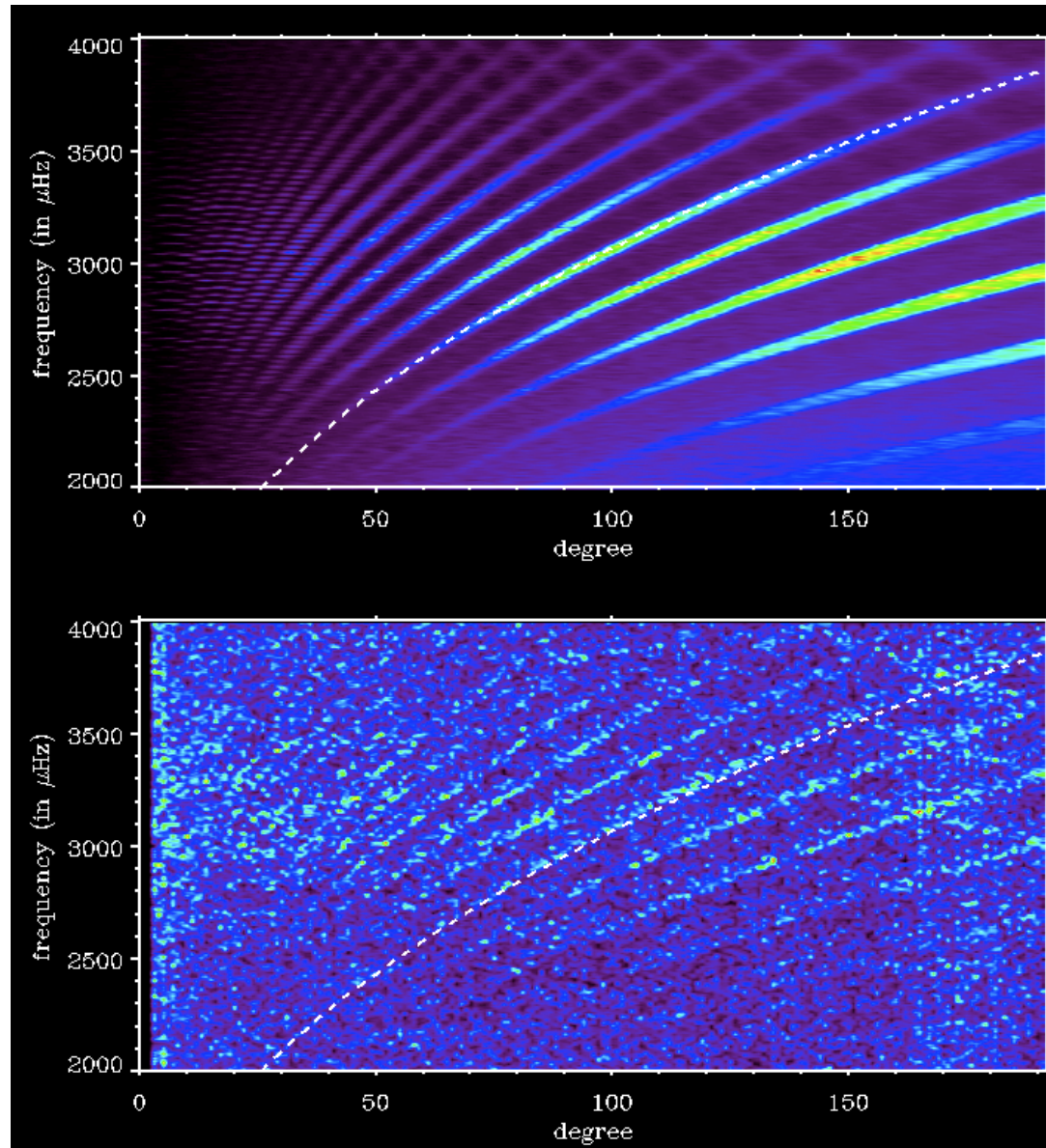
# Limb signal



# Optimisation of the signal/noise

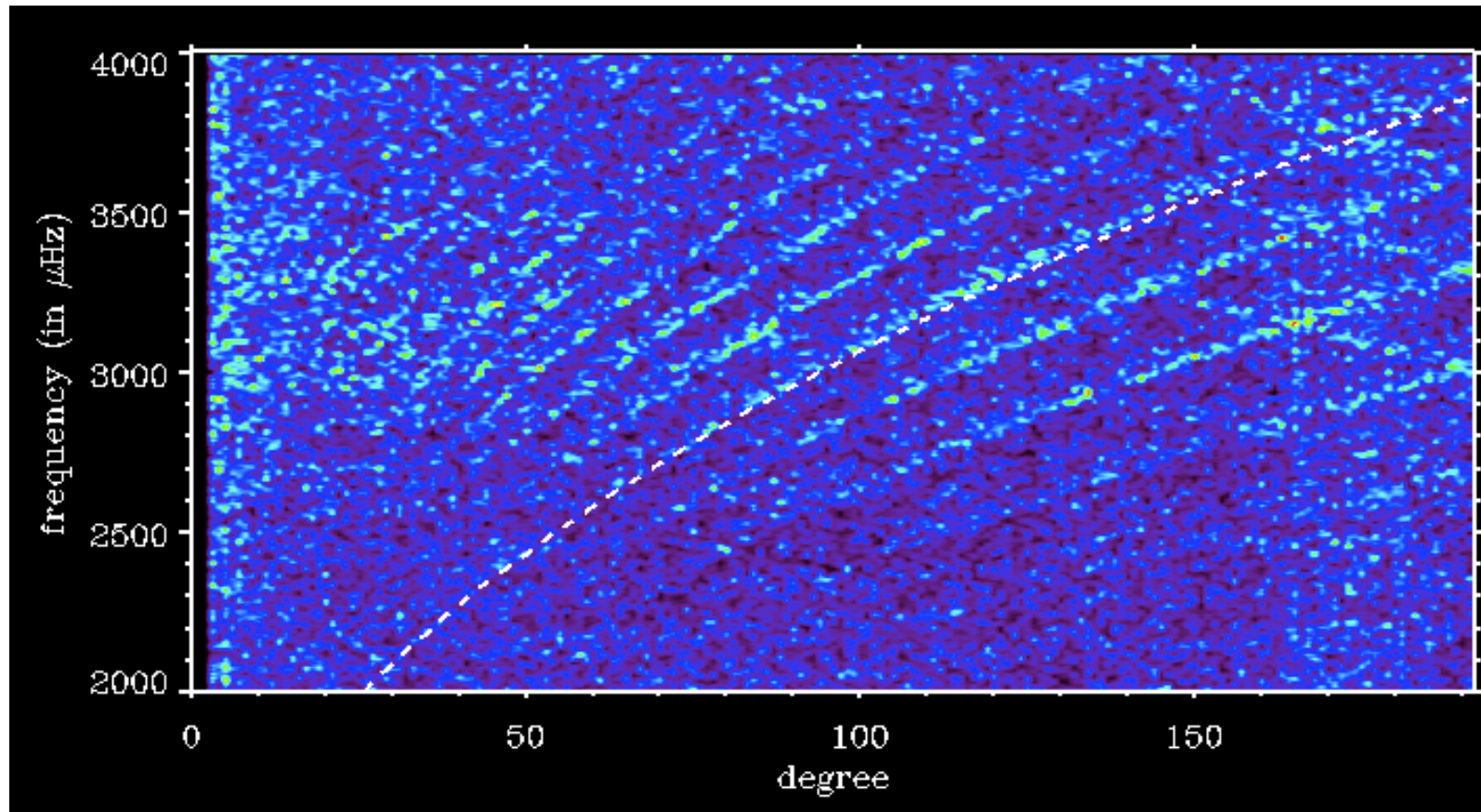


# Understand the link between HL and HMP

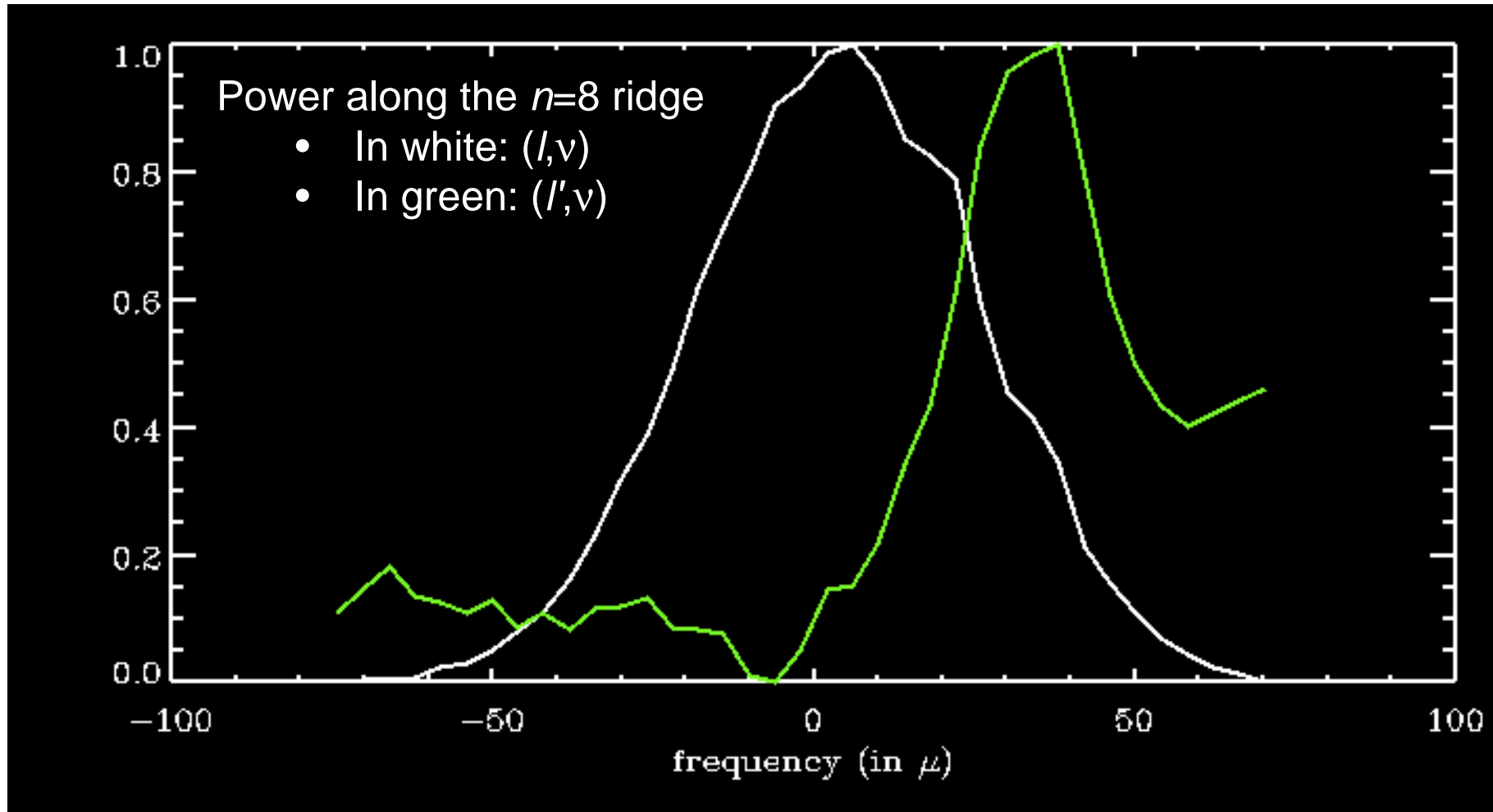




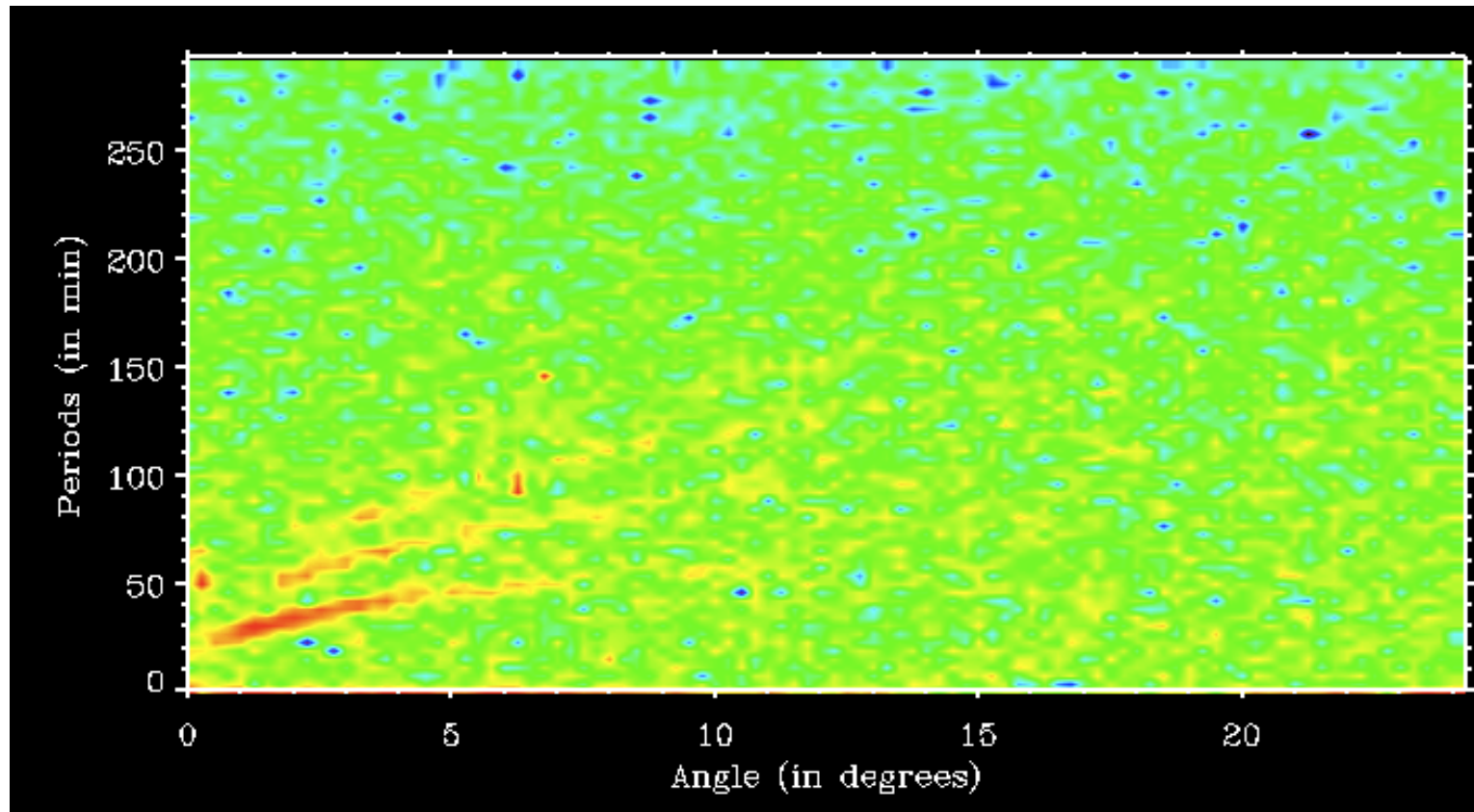
# $(l', \nu)$ diagram of the HLs



# Shift between ridges



# Time-distance with the LPs





# Organisation / future

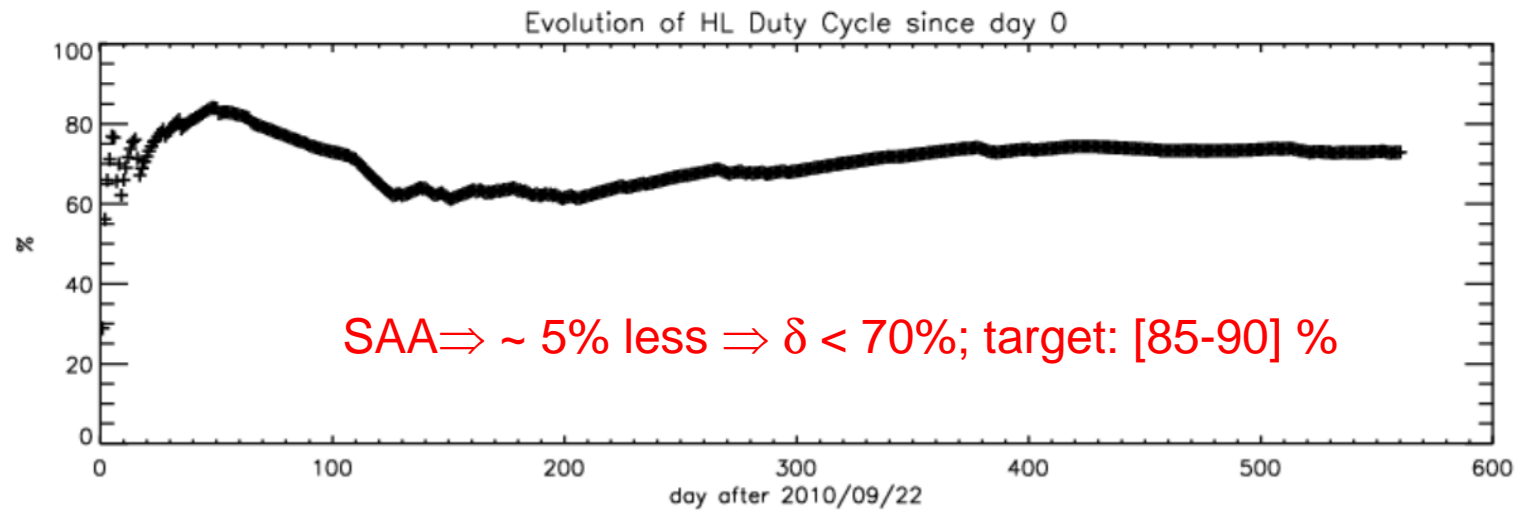
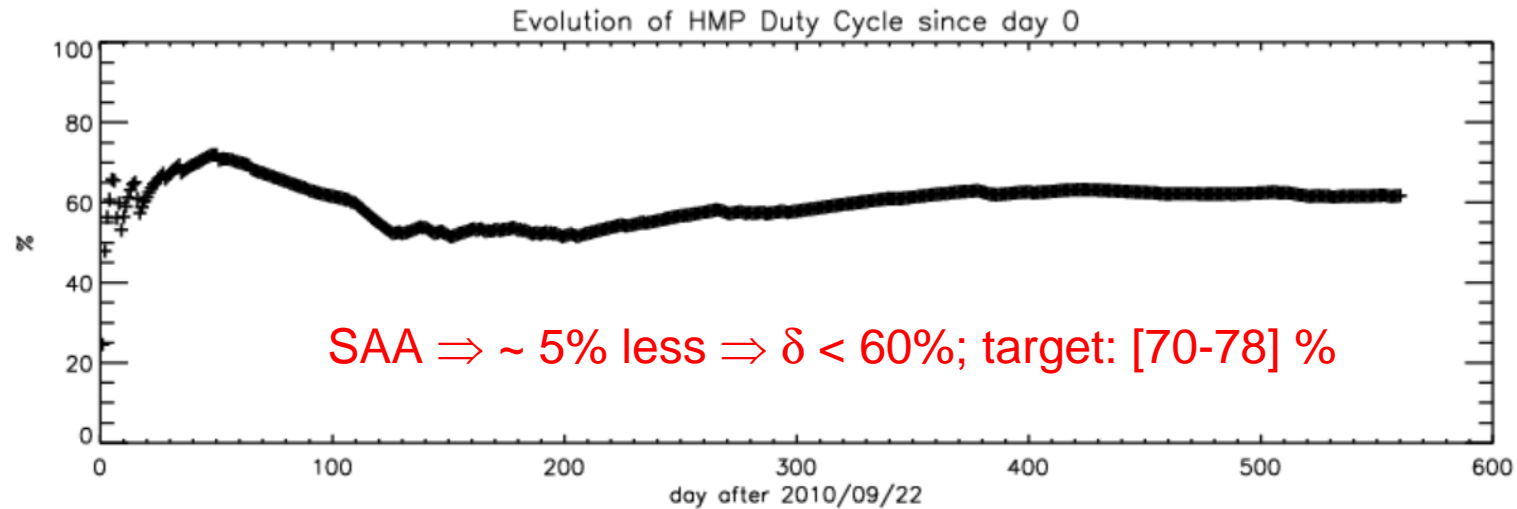
- 12/2008 : Helas workshop; Nice; « getting ready for PICARD Helioseismology program ».
- Letter of Interest: 4 answers; presented to the Scientific Committee in May 2009.
- 2010-2012: data reduction and analysis; « revisite of the scientific objectives ». Define a program with other filters like 393 nm ?
- 2012: call for « guest investigators ».



# Mode parameters : results from GONG



# global duty cycle (from the beginning)



# Diameter sampling: not randomly distributed on the orbit

