SODISM RESULTS

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Main goal: to show that SODISM is producing solar oblateness measurements within precision-accuracy compatible with needs to advance solar physics, and able to observe p-mode at the limb and from intensity variation.

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OUTLINE

- Why and how to measure the solar oblateness?
- SODISM measuremente aboard PICARD satellite
- Measurements inter-comparison within a solar cycle
- Helioseismology
- Summary

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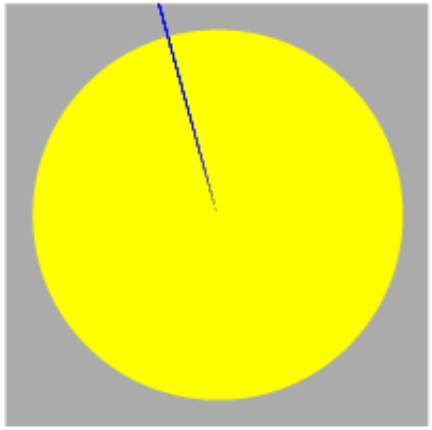
Why and how to measure the solar oblateness?

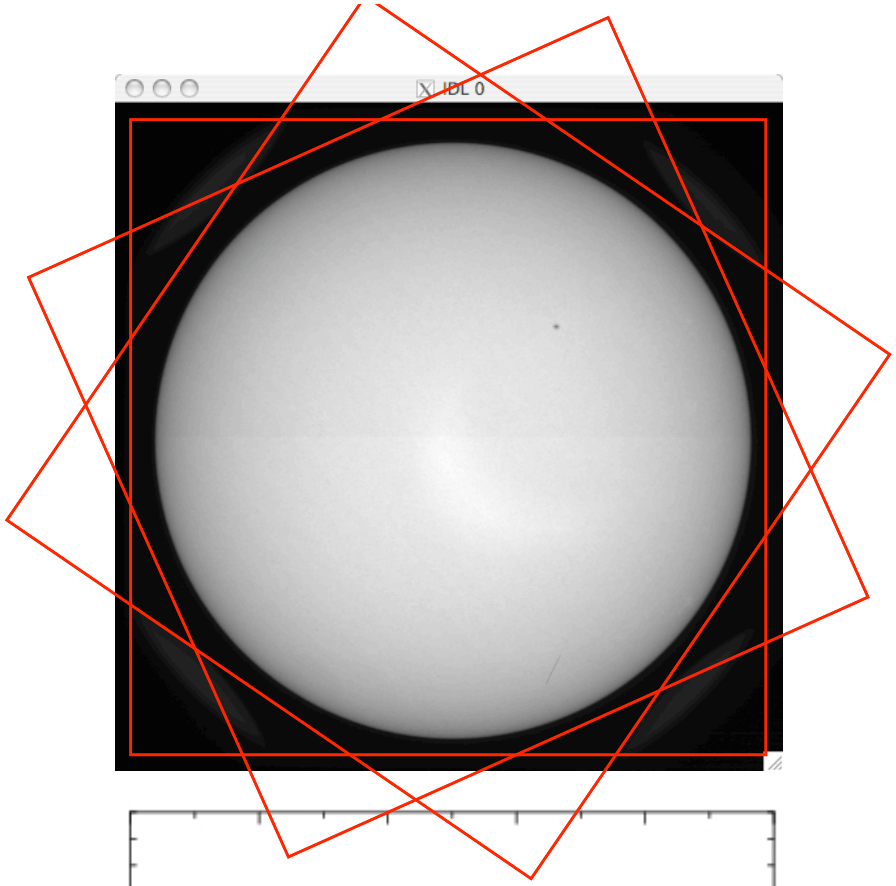
Modeling of the solar interior requires description of a complex interplay of:
- Magnetic field
- Rotation
-Turbulence

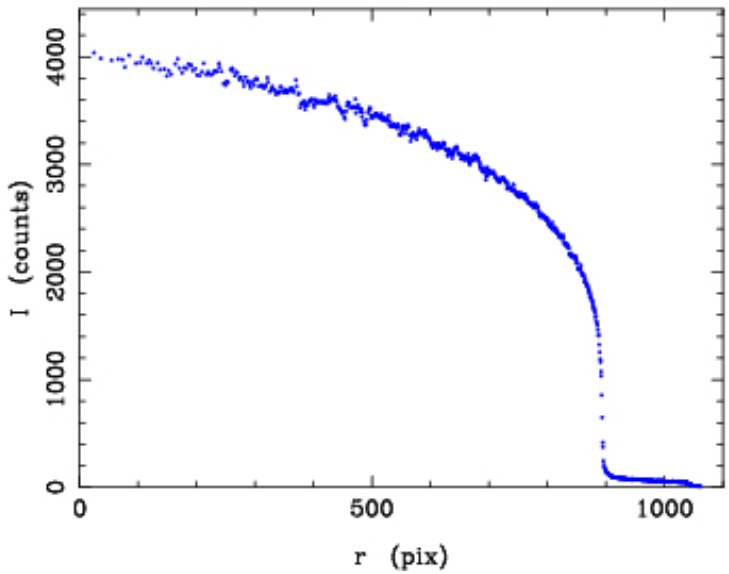
The solar oblatenes is a resulting property of a solar model and therefore
Measurements of solar oblatness provides a mean to validate solar models

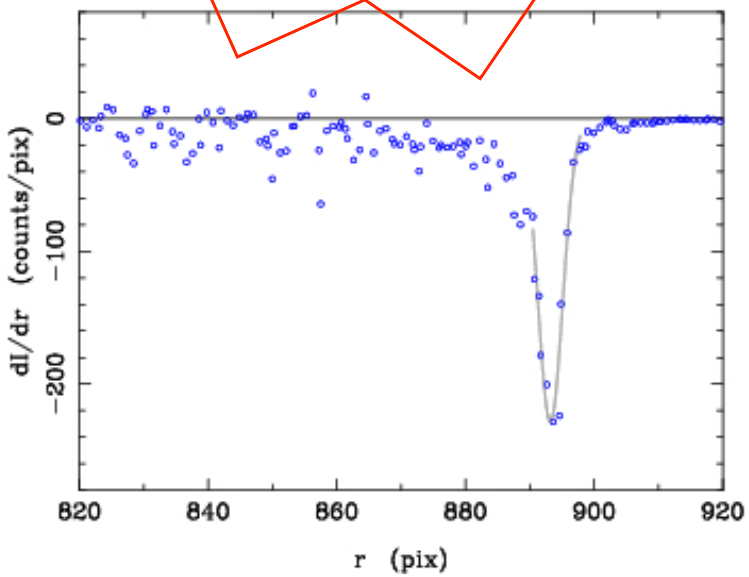
Measurement method:
-The telescope is turned around the Sun's central axis.
-The rotation, made by 30° angular steps, allows us to determine the instrument optical distortion and extract the solar oblateness from the images.
- the region of the CCD where the psf is the narrowest is used.
-Two orbits of data per spacecraft position are registered to detrend the temperature effect.

PICARD/SODISM









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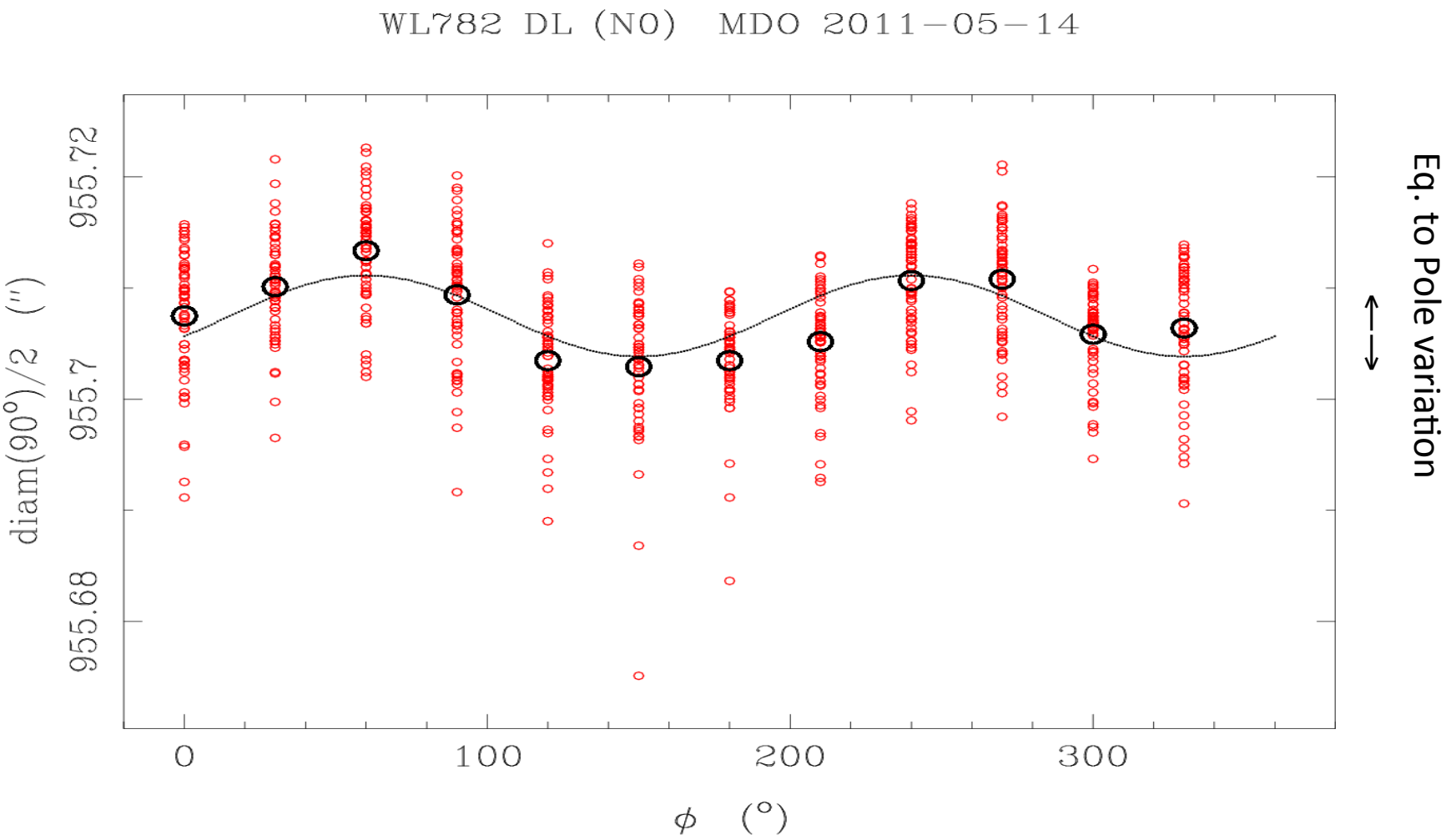
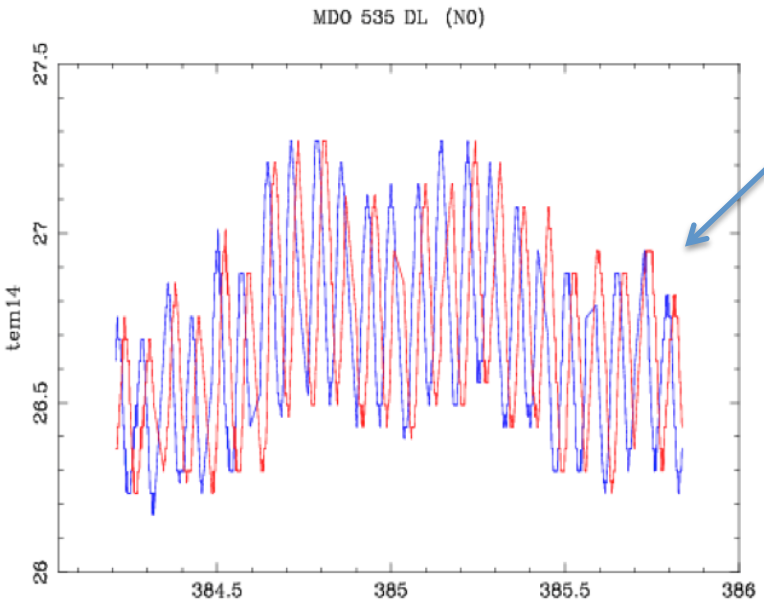


Solar oblateness obtained using data at 90 and 270° in the photosphere continuum at 782 nm. The spread around the mean is due to change of the thermal equilibrium during the rotation. The Equator-Pole difference is 8. mas.

Thuillier et al., 2011, AGU

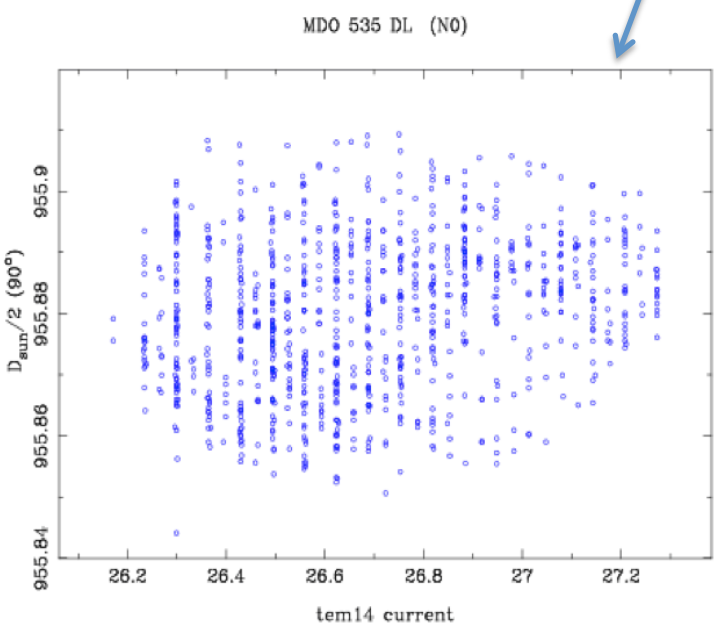
DIAMETER DEPENDENCE WITH TEMPERATURE

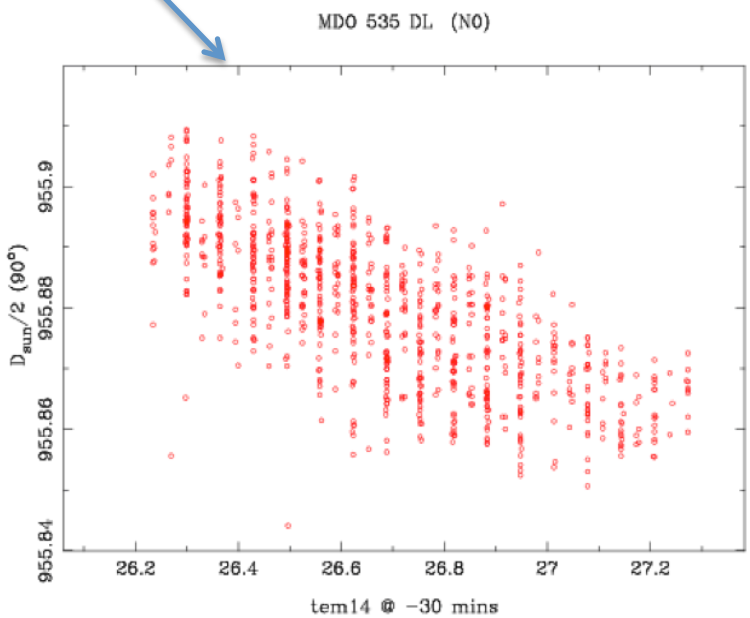


Temperature* variation during the spacecraft rotation

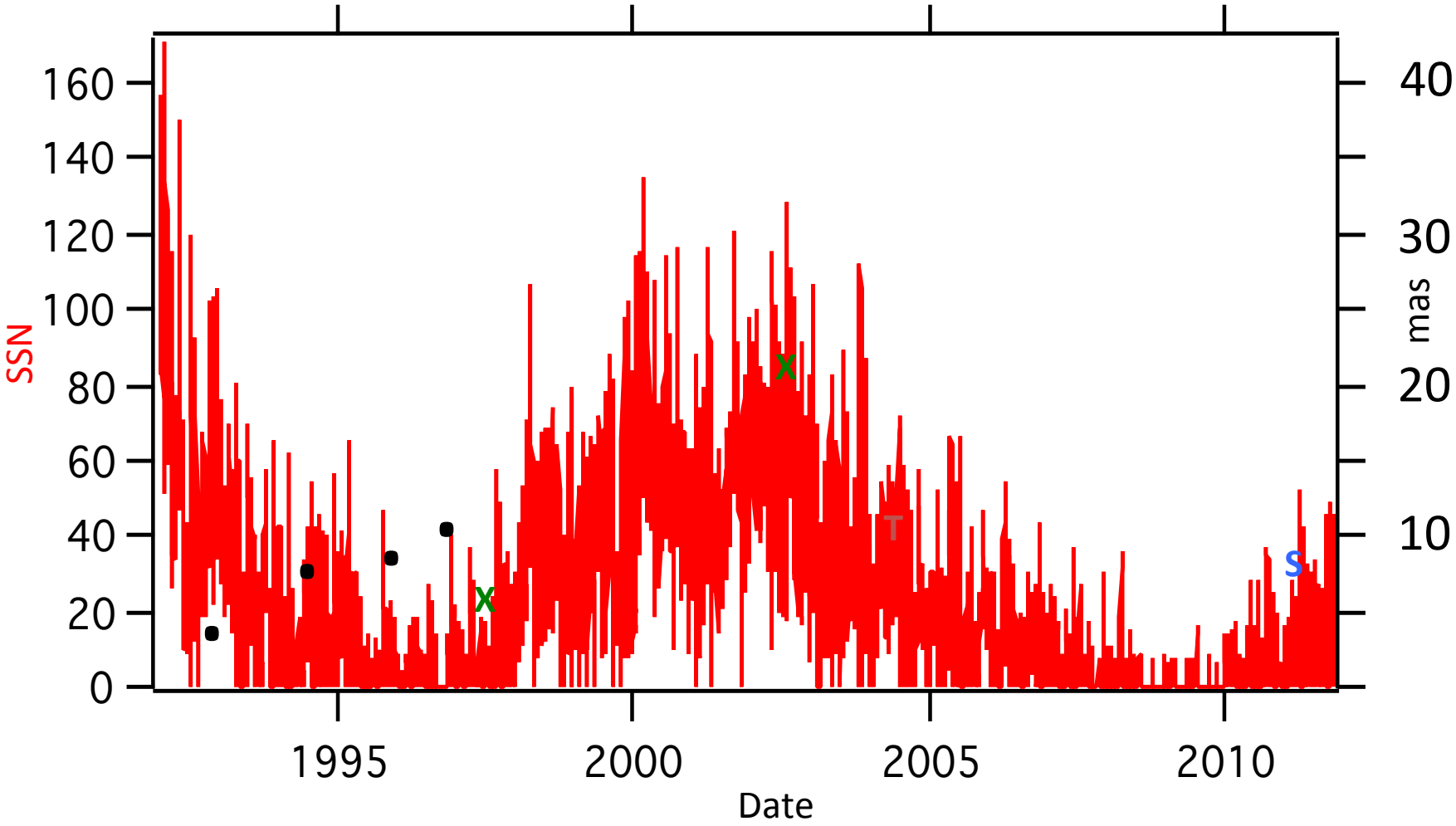
Radius versus temperature

Radius versus shifted temperature by 30 minutes





*Temperature measured behind the entrance window



SDS: • ; MDI: X; Rhessi: T; Sodism: S

1 Solar oblateness relationship with solar cycle:

- A strong positive correlation between solar activity and oblateness, first reported Dicke in the 60’s, has been widely attributed to light contamination by active regions at the limb of the Sun, especially at low latitude at high solar activity. The shown correlation is based on a single point.

- Measurements during solar maximun activity will be performed to clarify this point.

2 Solar models predict a very small dependence on activity cycle

3 Thermal equilibrium
During the rotation of the spacecraft around the Earth, the different satellite parts are successively exposed to the radiating Earth surface, which have furthermore changing albedo propeties (ocean, continents, polar ices, …). As the thermal equilibrium is never reached, several orbits are used to calculate the mean oblateness. The absence of thermal equilibrium is reflected in the RMS of measured oblateness.

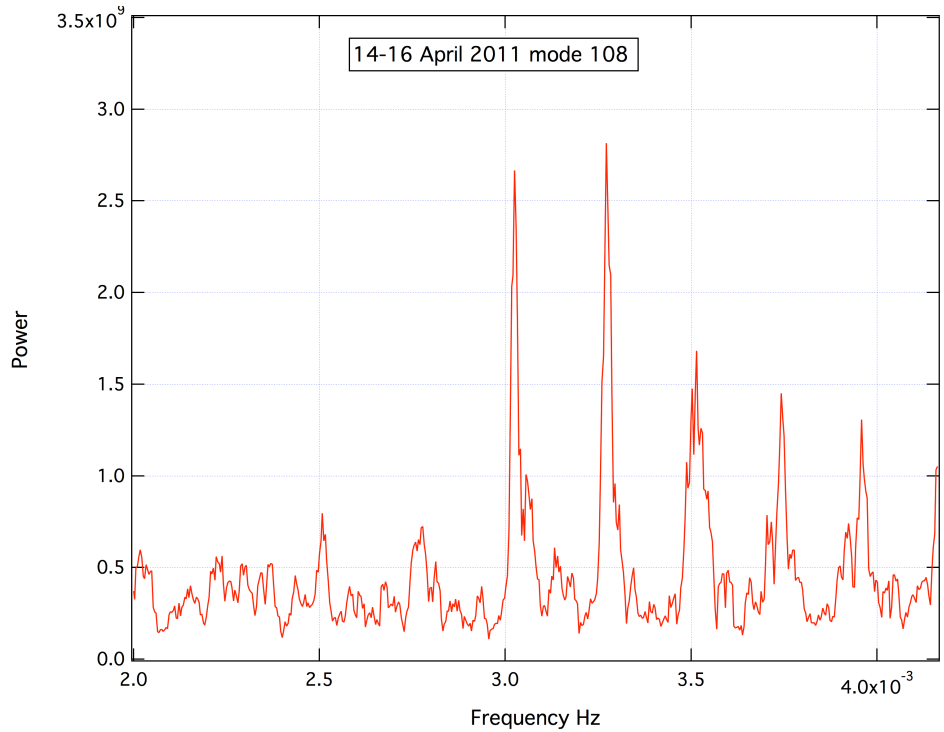
Note: the absence of thermal equilibrium is also experienced during all routine measurements. A change of satellite attitude would allow to partially moderate these effects.

Acoustic p modes detection on the limb

Helioseismology allows to study the internal structure of the Sun for validation of solar models
Acoustic p modes are in general detected in Doppler velocity and in intensity on the solar disk

An amplification of p modes is expected at the limb inducing a displacement of the inflection point position

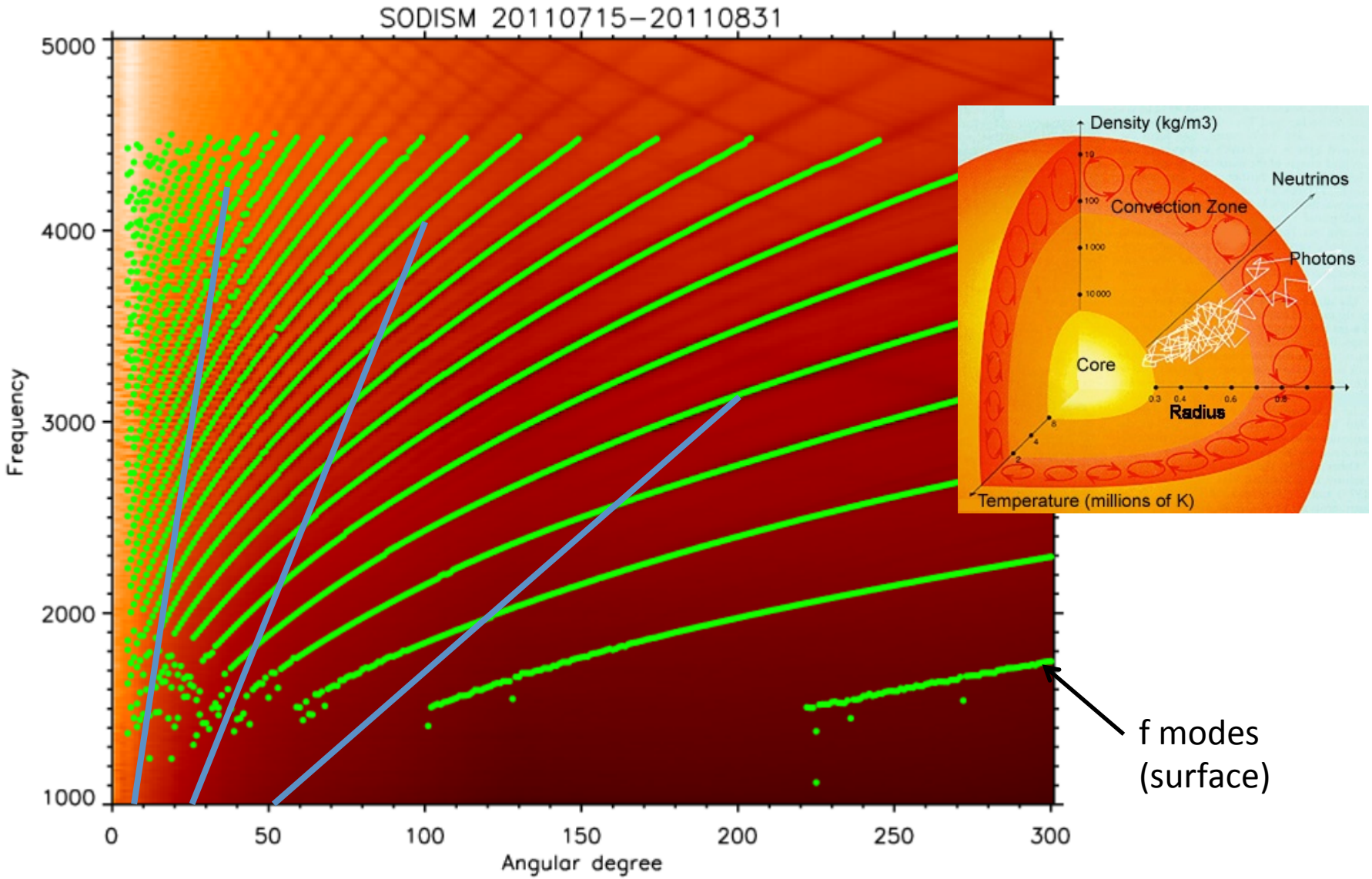
- These results will be studied as a function of solar activity
- Furthermore, these measurements will be be carried out at other wavelengths, in particular to look for chromospheric modes (393 nm).



First p mode detection by SODISM at limb from a 3-day dedicated helioseismology sequence 16-18 April 2011

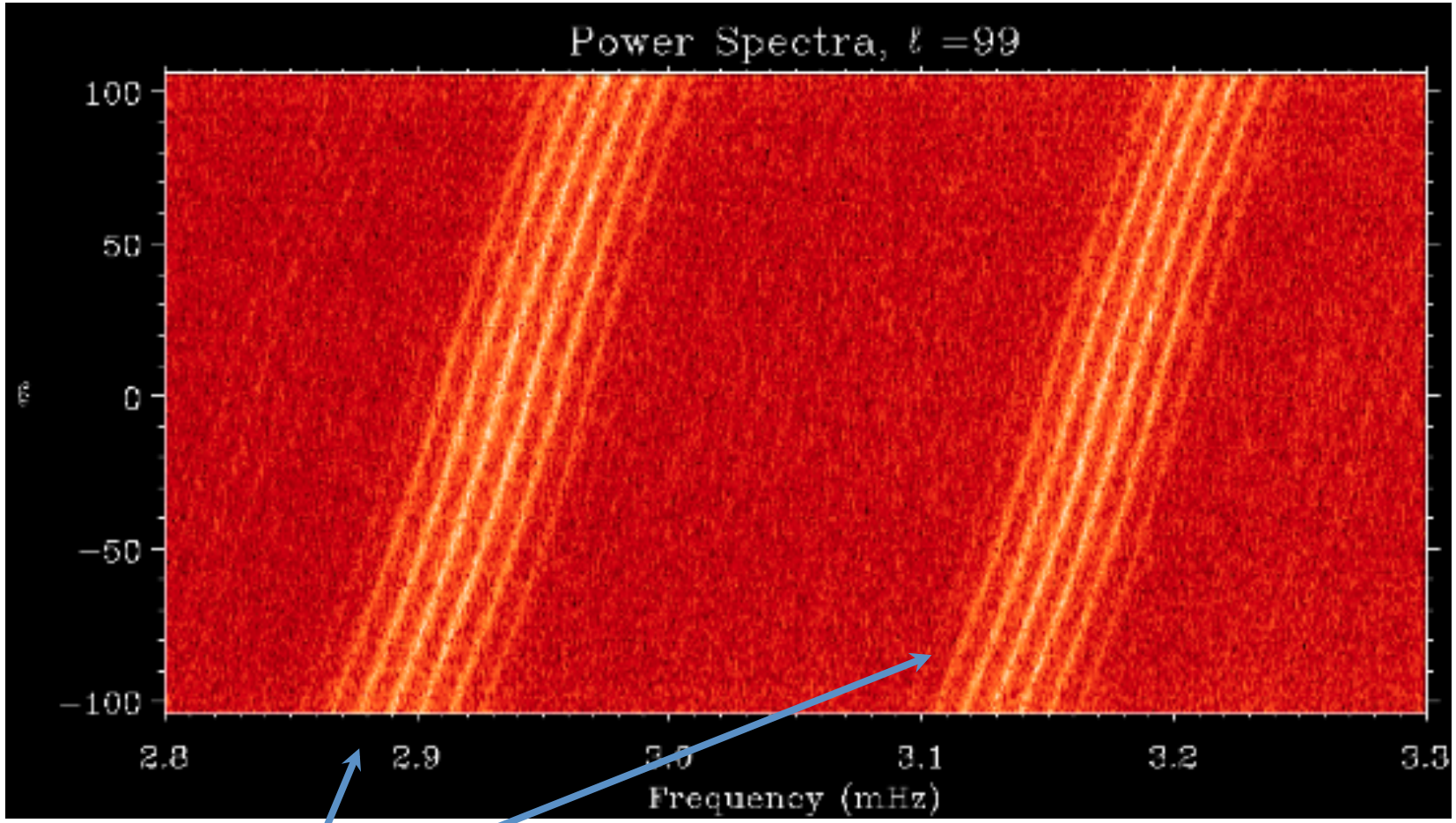
Hauchecorne et al., 2012, work in progress

l-nu diagram (macropixels)



Blue lines: modes with turning points at 0.4, 0.85 and 0.95 R⊙ from the left to the right

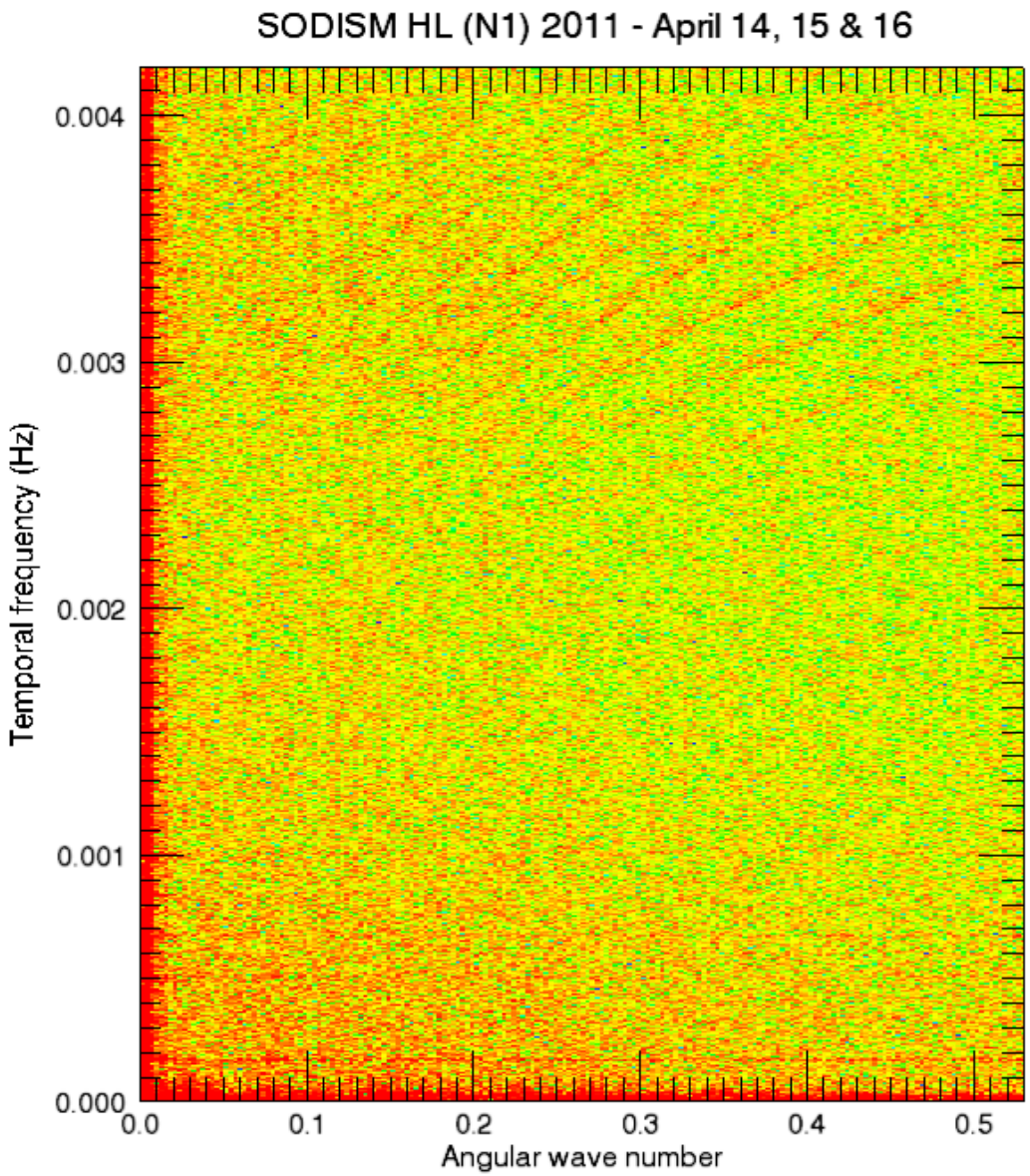
Solar rotation



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

Straight line ⇒ uniform rotation ; S-like lines ⇒ differential rotation

Limb signal


SODISM HL (N1) 2011 - April 14, 15 & 16
Temporal frequency (Hz)
0.004
0.003
0.002
0.001
0.000
0.0
0.1
0.2
0.3
0.4
0.5
Angular wave number

CONCLUSION

- PICARD is producing reliable solar oblateness measurements
- Comparison with other measurements shows consistency for similar solar magnetic activity levels
- Our plans are to continue the measurements towards the rising phase of the solar cycle to further explore the possible effect of magnetic activity on the oblateness. However, special caution will be taken into account concerning the active region effect on the inflection point determination.
-The presented measurements were obtained in the solar photospheric continnum at 782 nm. The observations at other wavelengths are needed.

- The detection of p-modes usually made by Doppler and intensity measurement. It can be now performed at the limb. The advantage of this new method has to be studied in details.

References:

Sofia, S., Spada, F., Li, L., and Ventura,P., Proceedings of conference on Advances In computational modeling Astrophysics, Cefalù(Sicily), June 2011.
Thuillier, G., et al. Advances in Space Research 38, 1792 (2006)
Emilio, M. et al., Astrophys.J. 660, L161 (2007).
Egidi, A. et al., Sol. Phys. 235, 407 (2006).
Fivian, M. D., et al., Science, 232, 560 (2008).

THANK YOU FOR YOUR ATTENTION

THE YALE MODEL OF THE SOLAR INTERIOR

1. TWO-DIMENSIONAL STRUCTURE AND EVOLUTION

2. EMPHASIS ON CONVECTION ZONE

3. INCLUDES MAGNETIC FIELDS, DIFFUSION, ROTATION, AND TURBULENCE

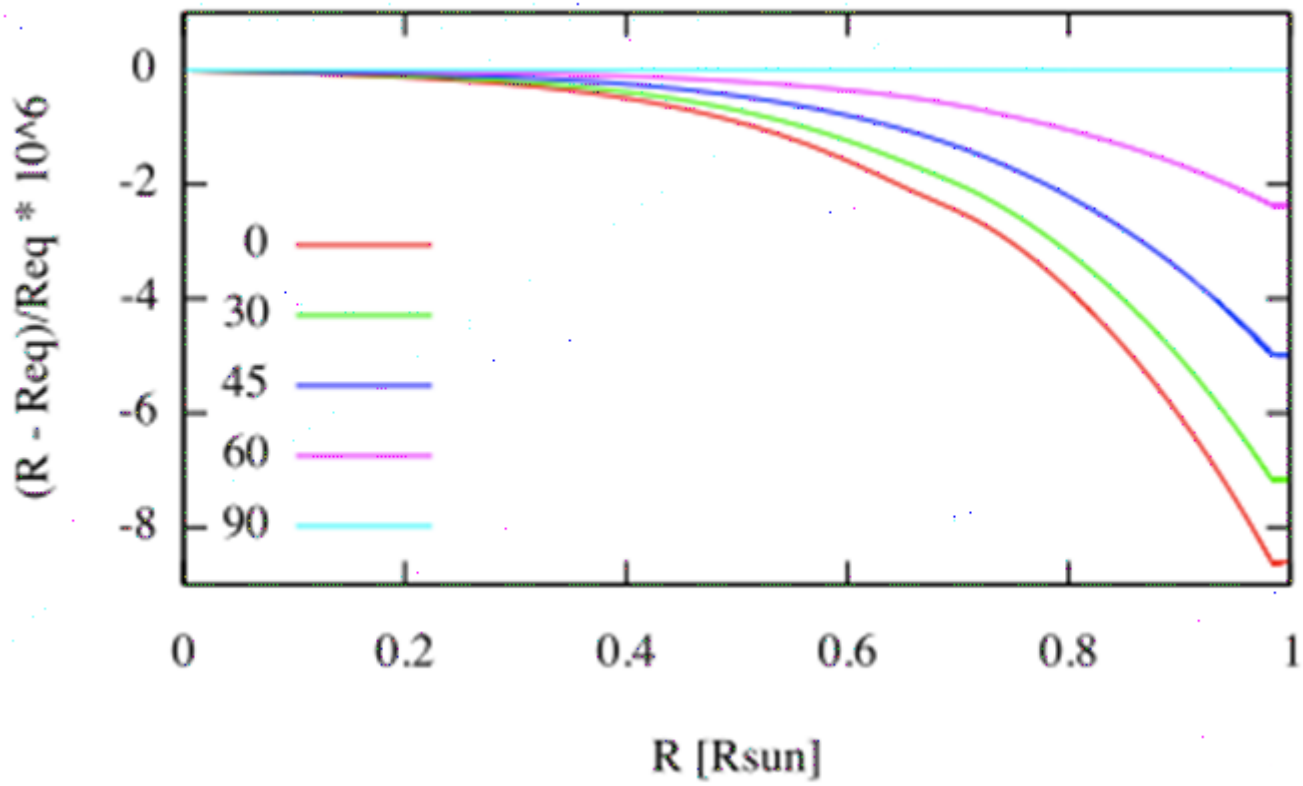
PROPERTIES:

- It is able to simulate the 11-year solar cycle

- It is able to represent some p-mode properties as the frequency shift as a function of solar activity.

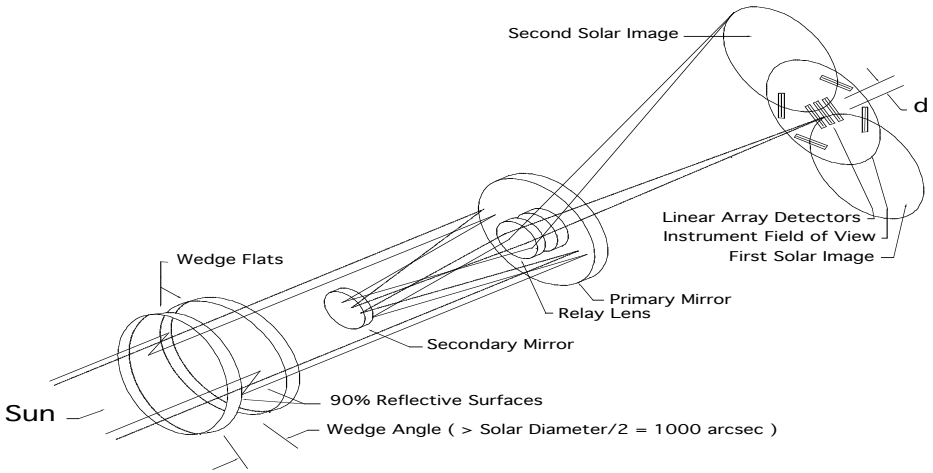
Modeled solar center to limb variation (CLV) as a function of co-latitude

- A prediction for a certain solar level. It allows to investigate the solar activity influence by changing the amplitude of the magnetic field in the model.

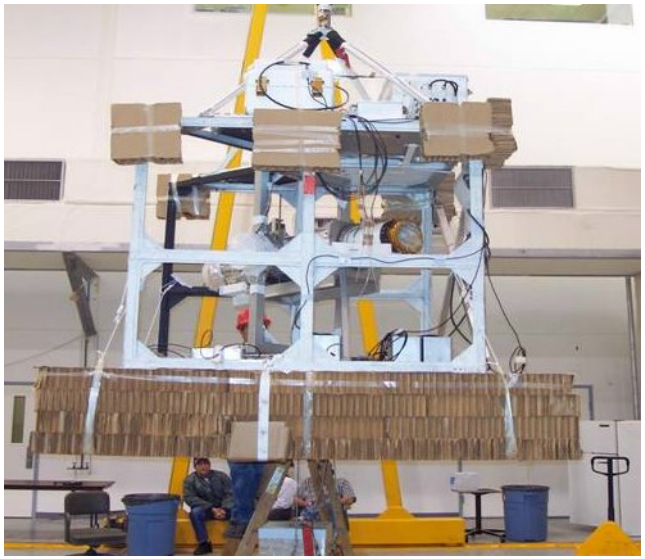


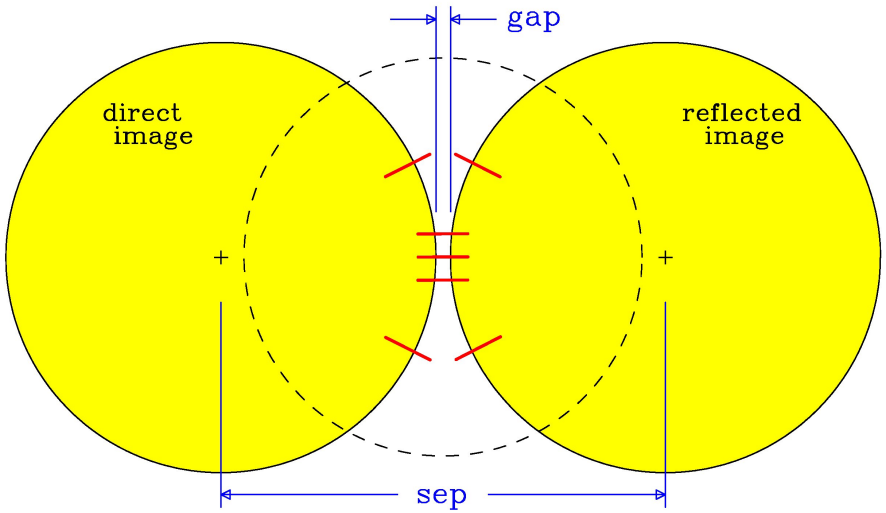
For example for $\Delta R/R = 8\ 10^{-6}$, the model value for oblateness is 7.6 mas.

Solar Disk Sextant (SDS)



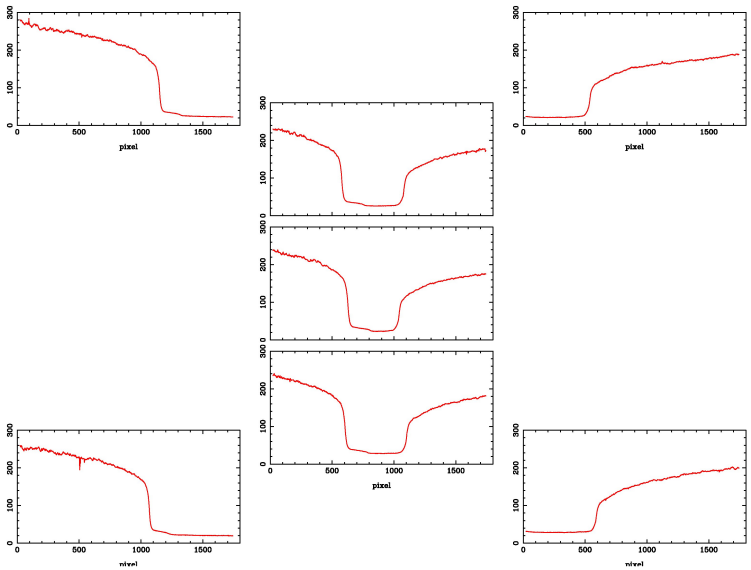
SDS layout





$$D_{\odot} = 2W(1-gap/sep)$$

where W = wedge angle (″)



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