Results & Analysis of the measurements with the **HELLRIDE Instrument @ Vacuum Tower Telescope**

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Motivation

We investigate the propagation of high frequency waves in the solar atmosphere under the magnetic and non-magnetic environmental conditions. Based on the acoustic waves we want to better understand :

- Structure of the magnetized atmosphere
- Energy transport through the solar atmospheric layers
- Chromospheric temperature jump

We carry out the observation with the newly developed instrument HELLRIDE at the Vacuum Tower, Tenerife.

INSTRUMENTS : Vacuum Tower Telescope & HELLRIDE Instrument

Vacumm Tower Telescope, @ Teide Observatory in Tenerife

Cross section through the VTT. Photo: KIS

Filter matrix with 13 interfernce filters. Part of the Hellride Instrument.

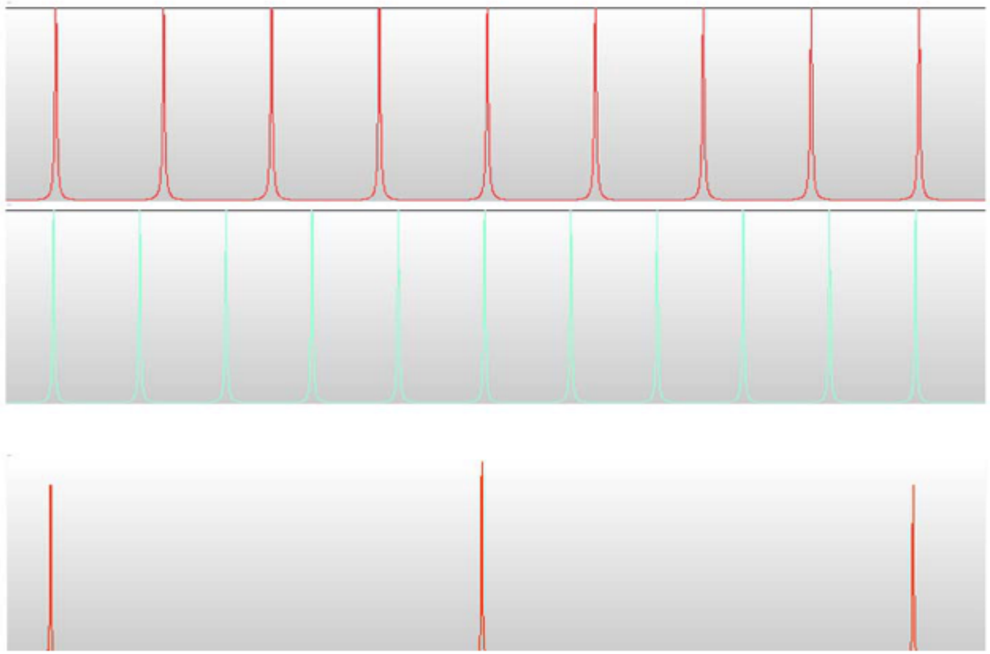
HELLRIDE : Helioseismologic Large Regions Interferometric Device

The new Fabry-Pérot spectrometer HELLRIDE was specifically developed at KIS to record the Doppler shifts of a large number of solar spectral lines with many different interferometric filters. Thanks to this device with a double etalon system and the filter matrix, we can measure in the **future up to 21 spectral lines.**

The instrument is currently unique in its ability to measure

quasi-simultaneously a large number of spectral lines over extended times.

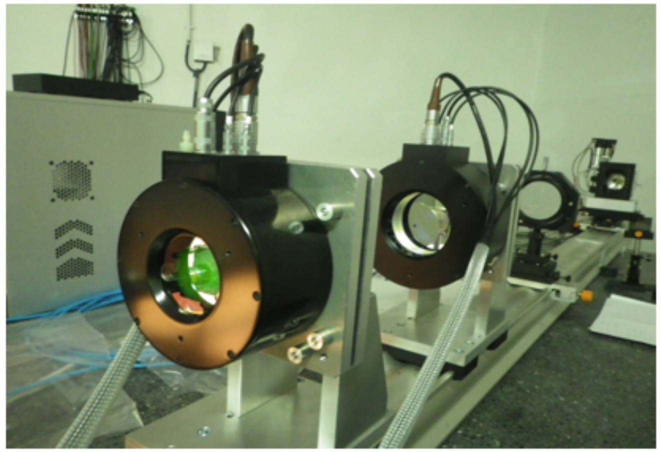
INSTRUMENT, Helioseismologic Large Regions Interferometric Device

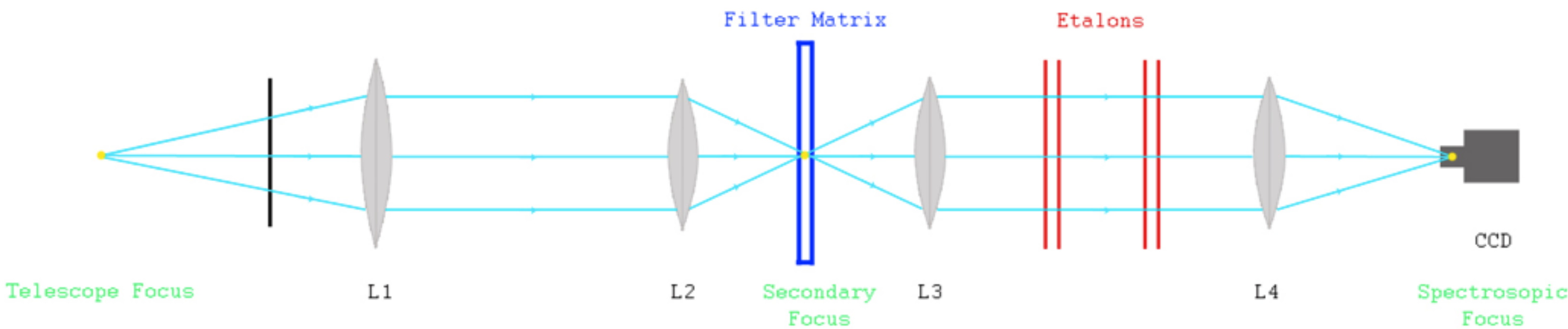


<u>Etalons:</u> IC Optical,

Spectral range: 530 – 860 nm

plates interval 1.4 and 1.1 mm





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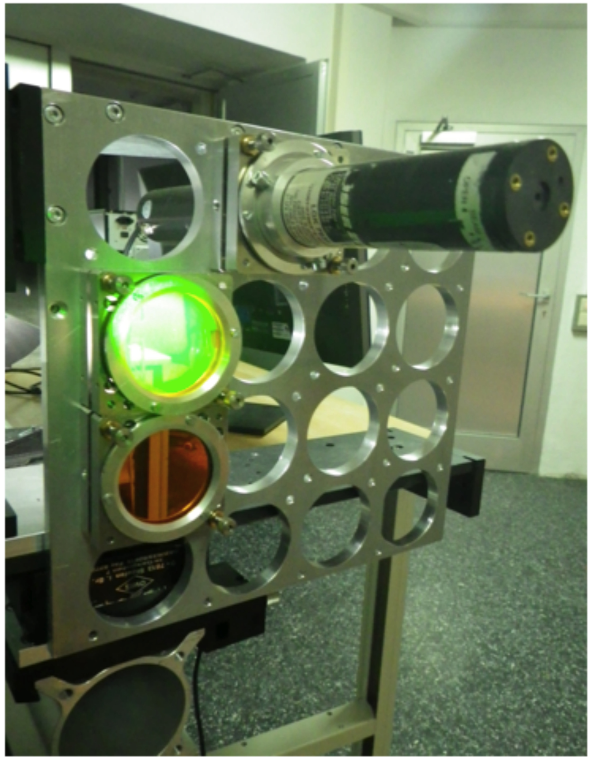
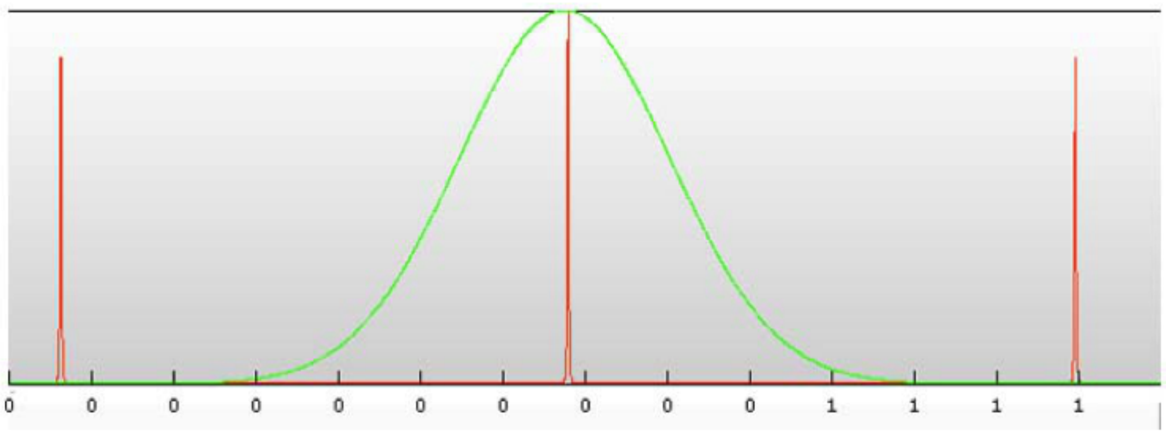
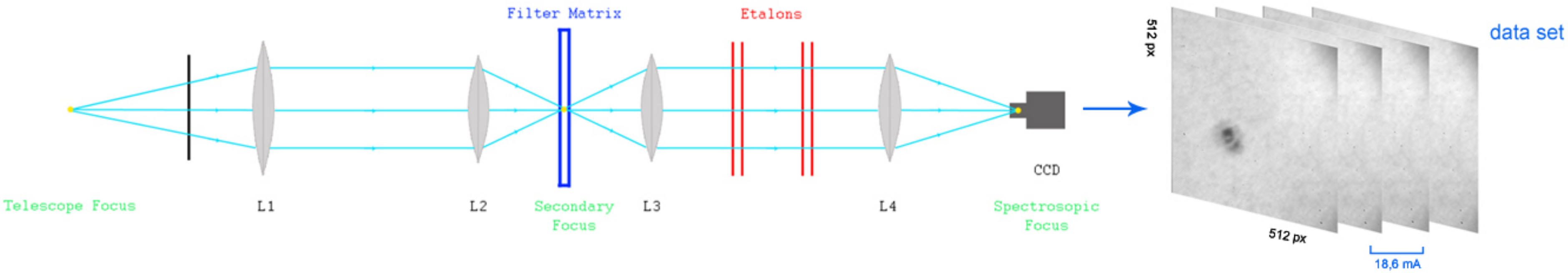


Filter matrix, possible to mount 16 filters

Used Filters: **5434.5 Å, Fe I &**

5890 Å, Na D II





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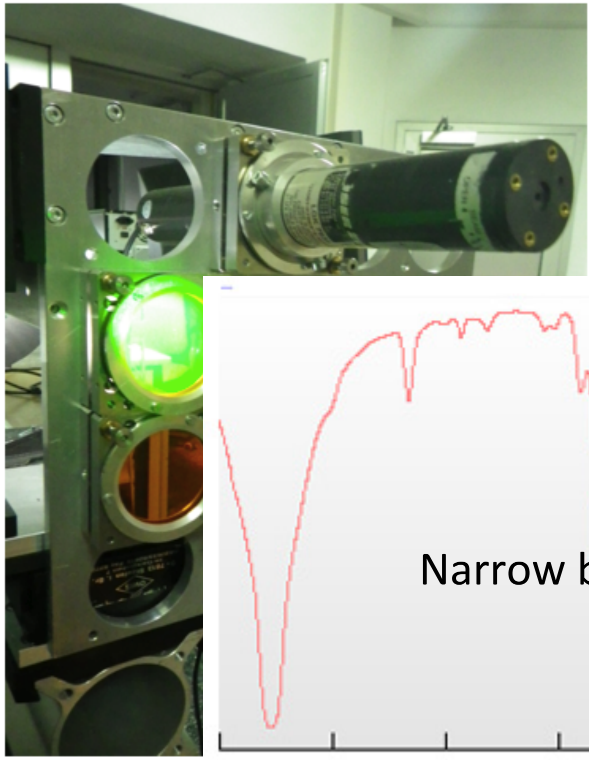
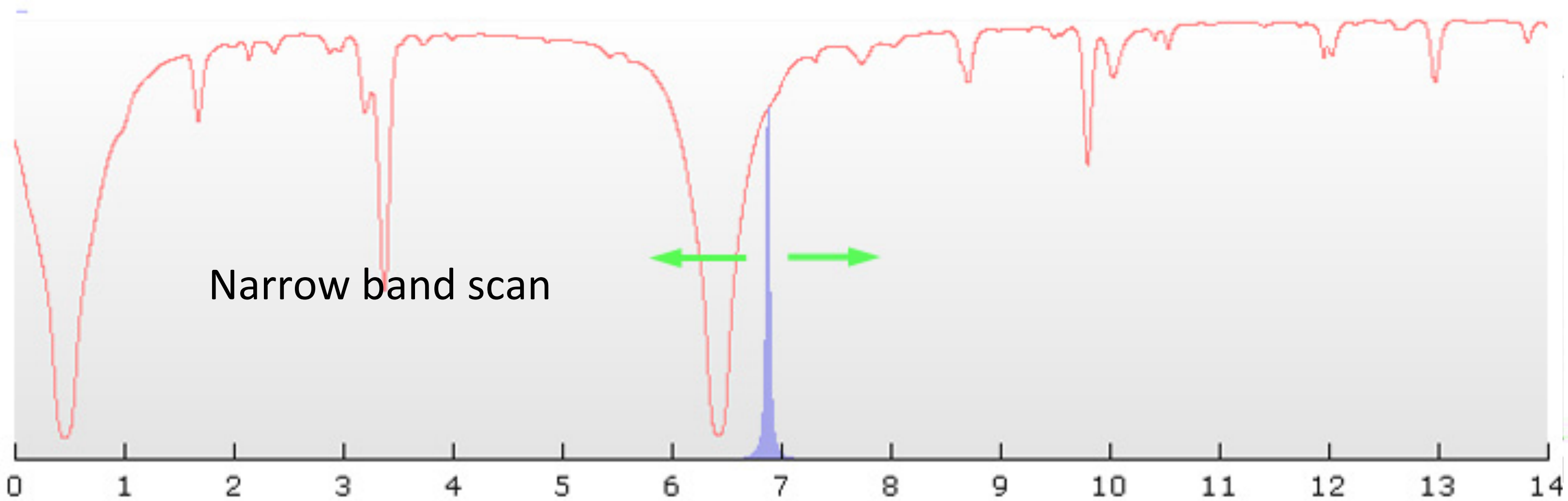
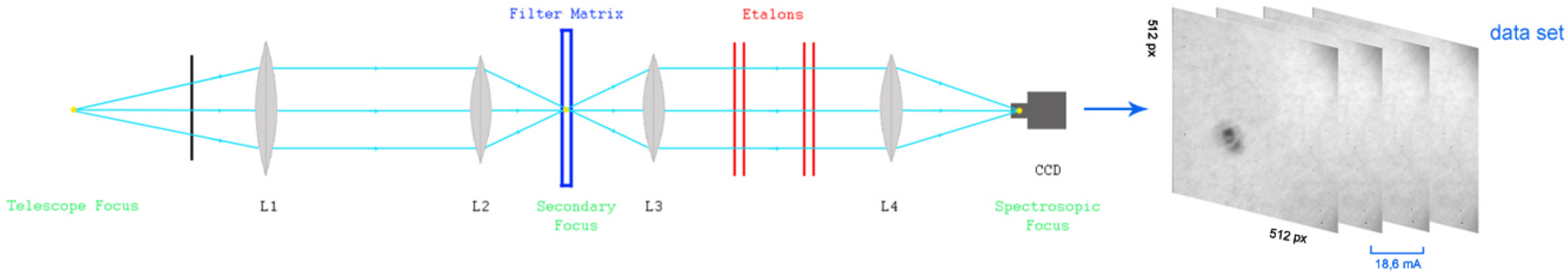






Results of the observational campaign

Observations cover a large field-of-view of 100 x 100 arcsec and a high spatial and spectral resolution. During the observations at VTT, taken in April 2013 & September 2013, we used only 3 of narrow band filters in the spectral lines

Fe I, 5434 Å (formation height appr 500 km)

Fe I, 6302 Å (formation height appr 600 km)

Na I D2, 5890 Å (formation height appr 800 km).

SPECYFICATION OF THE RECORDED DATA

- Field of view : 100'' by 100''
- Pixel distance : 0,2 arc sec
- Exposure time : 10 – 15 ms
- Image spacing: 18,6 mA
- Scan cadence : 15 sec

The results of the last campaign are **36 hours long** good quality time series of the Sun surface in intensity.

The observed areas were a quiet Sun region at solar disk center and an active region with a sunspot (AR 11727) in April & (AR 11836) in September.

Scanning lines

Wavelength [nm]	Element	Scan steps
517.2	Mg I	20
538.0	C I	15
538.1	Fe I	15
538.2	Ti I	15
543.4	Fe I	10
557.6	Fe I	20
589.0	Na D2	30
589.6	Na D1	30
630.1	Fe I	20
630.15	Telluric	15
630.2	Fe I	15
632.8	He-Ne Laser	15
656.3	Hα	50
709.1	Fe I	20
777.1	Fe I	20
777.2	Fe I	10

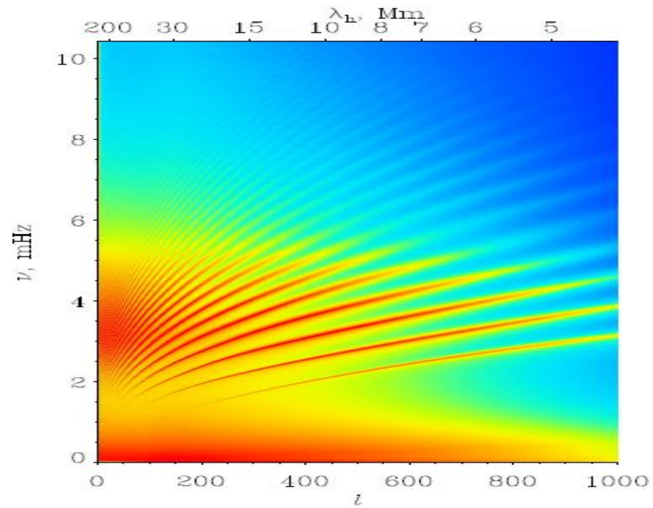
Staiger, 2011

Local Helioseismology

Analysis of the measured Doppler velocities for active regions and the quiet Sun area in the **Fourier space**, gives us the **power spectrum of oscillations** for chosen region and at the respective height in the solar atmosphere. The diagnostic diagram displays the spectral power density as function of frequency ν and harmonic degree l.

The narrowband ridges in the diagnostic diagram connect oscillations with identical radial order. The f-mode are on the lowest ridge. It becomes clear, that the spectral power density is not uniformly distributed, but it is concentrated on certain ridges.

This allows tracing acoustic waves and studying their phase shifts and couplings to magneto-acoustic waves above active regions.

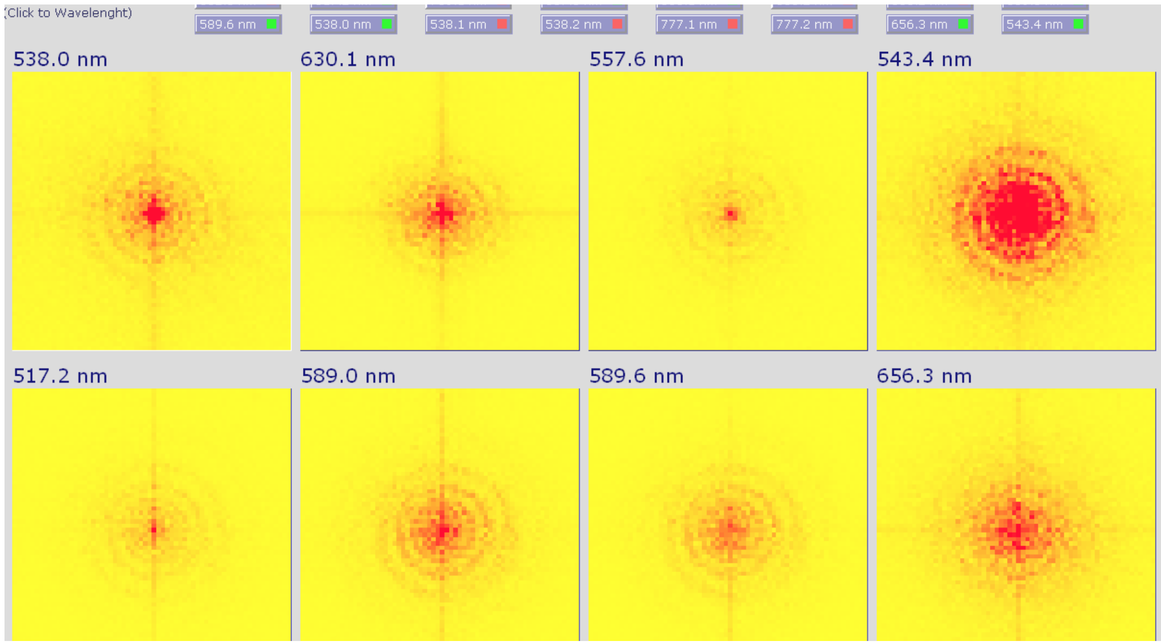


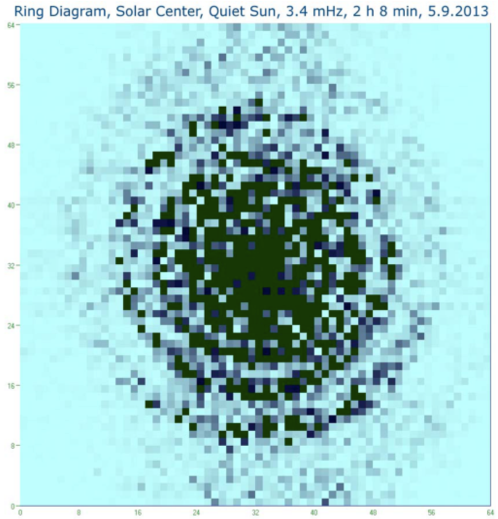
Helioseismological diagram, k-omega or l-nu diagram, HMI Instrument

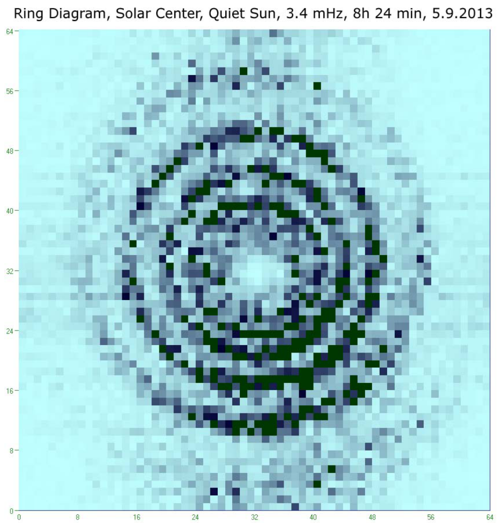
Frequency of oscillations

Harmonic degree l

First Results from 2009 and from observational campaigns in April & September 2013







Helioseimological diagrams from Data sets:
above testing set from 2009 *(Staiger 2011) for 8 lines (4h)*
left from April 2013, for 543,4 nm Fe I
bottom right September 2013, for 543,4 nm Fe I.

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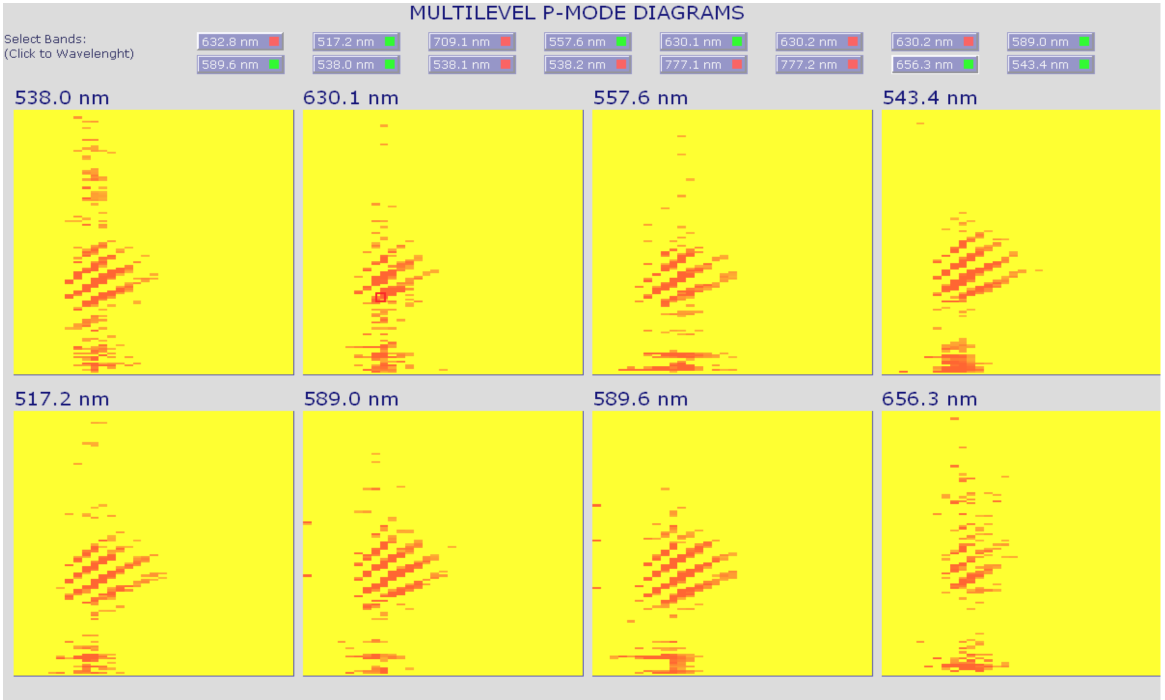

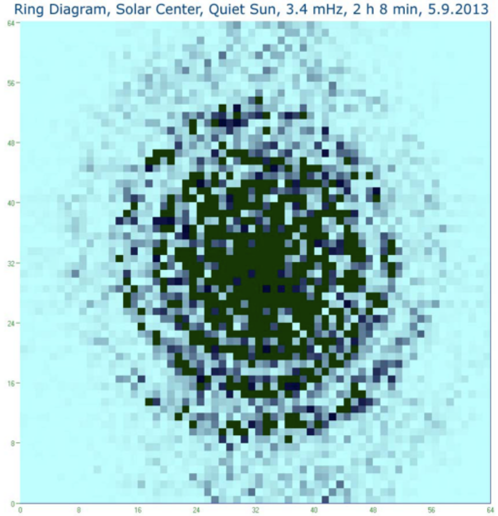

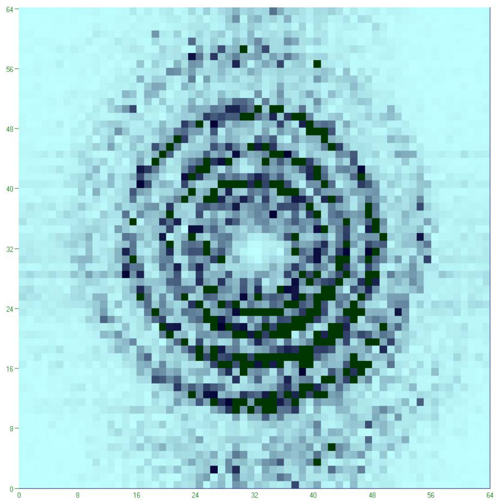

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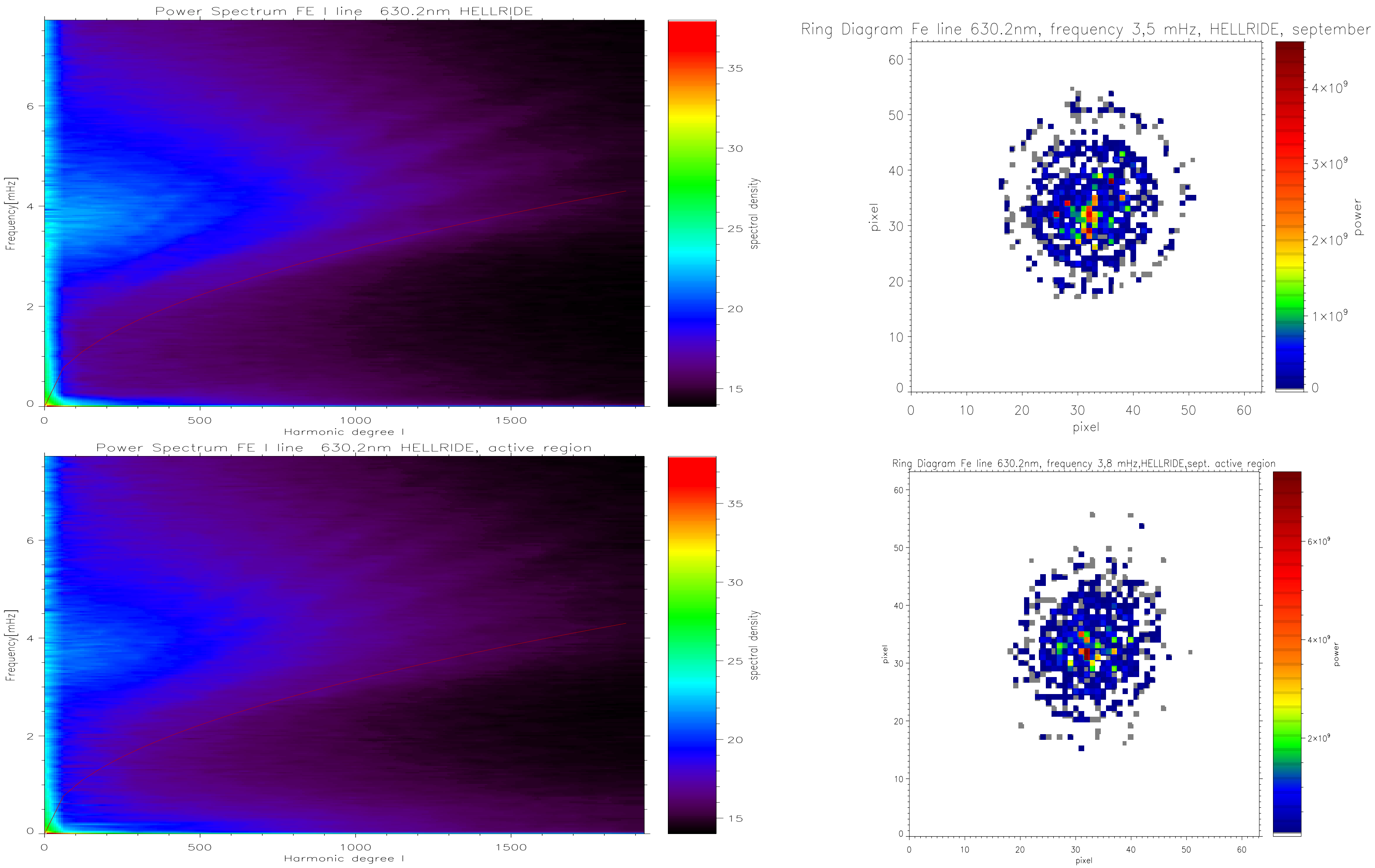
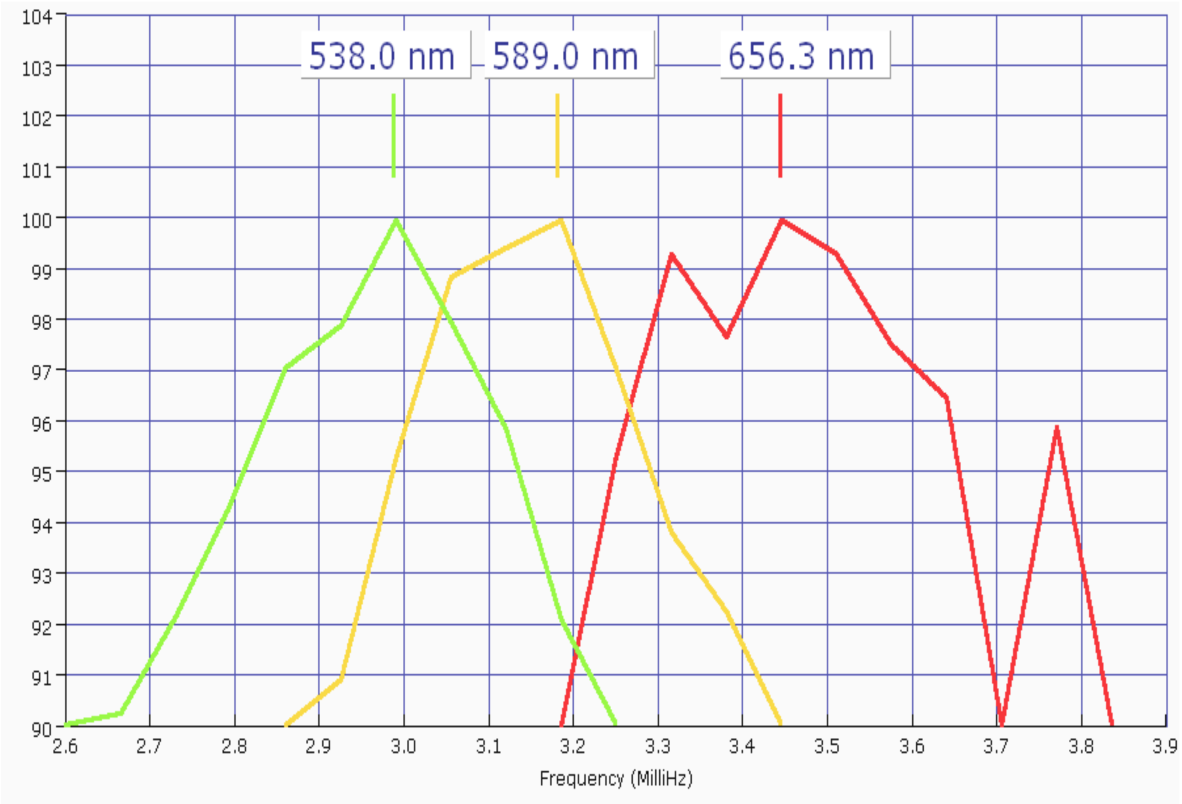
Power distribution Diagrams from HELLRIDE measurement taken on 5.09.2013



Power Spectra of oscillations for line 630,2 nm Fe I in quiet Sun- and active- region

Linear power diagrams



The upper sections of three five-minute power peaks representing the deep photosphere (538.0 nm, C I), the transition region from photosphere to chromosphere (589.0 nm, Na I) and the chromosphere (656.3 nm, Hα) are shown reveals a change in peak frequency from 2.95 mHz (538.0 nm) towards 3.45 mHz (656.3 nm). This shift may be related to frequency-dependent wave damping with an estimated shift rate of appr. 0.04 mHz per 100 km height increase in line formation.

Linear powerspectra 538.0 nm C I (green), 589.0 nm Na D II (yellow), and 656.3 nm Hα (red).

Conclusions Future goals with HELLRIDE

Our first results with HELLRIDE from last year's campaign taken for the wavelengths 6302 Å and 5890 Å, showed that is possible to observe the **shifts of the frequencies** in the power distribution diagrams. With the new measurements that we want to take, we can describe this effect in detail by the **analysis of the properties of acoustic waves** in relation to the oscillation frequency, modal characteristics and the atmospheric level and the additional information from the high-frequency waves.

The ring-diagrams can be good tool for checking the quality of the measurements. Based on the fine structure and the symmetry of the rings, we can estimated the seeing strength and image drift during the measurement.

THANK YOU!