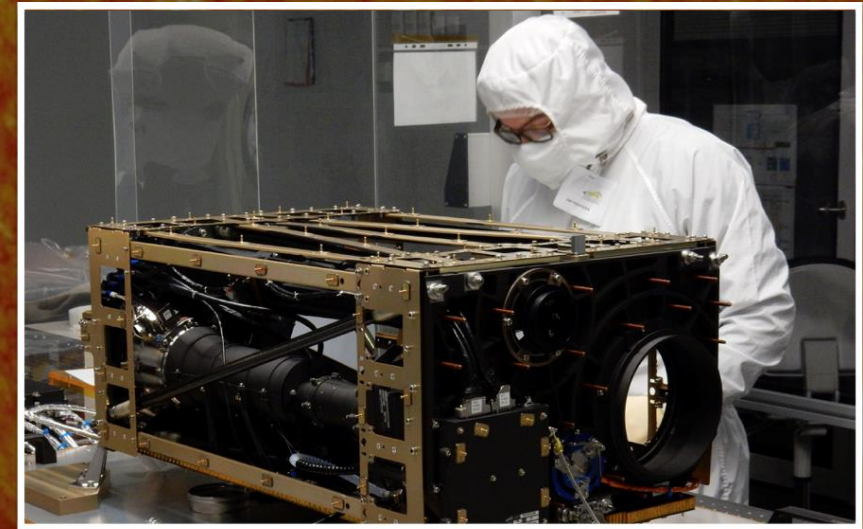


The SO/PHI magnetograph on Solar Orbiter and first preliminary data

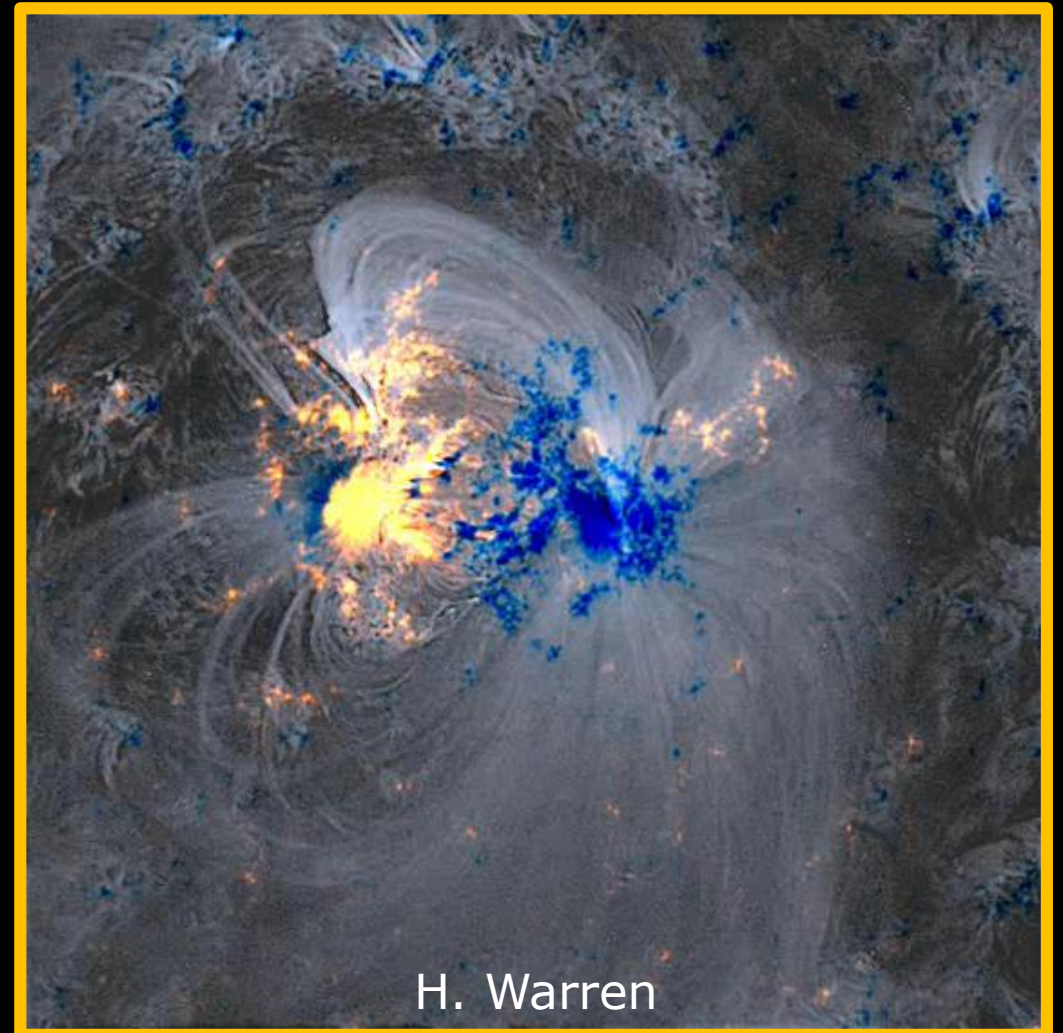


S. K. Solanki, del Toro Iniesta, J.C., Woch, J., Gandorfer, A., Alvarez-Herrero, A., Appourchaux, T., Volkmer, R., Hirzberger, J., Orozco Suárez, D. & SO/PHI team



The Dynamics and activity of the solar atmosphere is determined by its magnetic field

- Magnetic field measurements needed to fully understand results from both remote sensing and in situ instruments
- Solar Orbiter (SO) needs its own magnetograph, as it will observe the Sun from different directions
- SO/PHI provides the magnetic information for the other SO instruments
- SO/PHI is the first magnetograph to leave the Sun-Earth line
- Later it will be the first magnetograph to leave the ecliptic plane

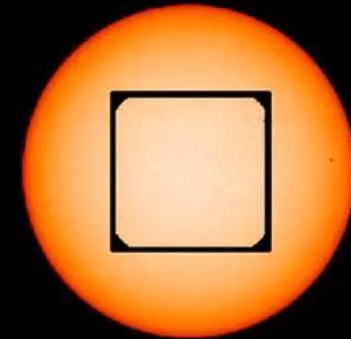


The Polarimetric and Helioseismic Imager (SO/PHI)

- SO/PHI is a tunable, imaging vector spectropolarimeter with two telescopes
- **Full Disk Telescope:**
 - 17.5mm refractor
 - images the entire Sun at all orbital positions (if SO points to Sun-centre)
- **High Resolution Telescope:**
 - 140mm Ritchey-Chrétien
 - maximum resolution (at 0.28 AU): 200km
- Detector: 2k x 2k APS, 11frames p. sec.
- Spectral line is Fe I 6173 Å (same as SDO/HMI)
- Polarimetric sensitivity: $< 10^{-3}$

See Solanki et al. (2020) A&A 642, A11

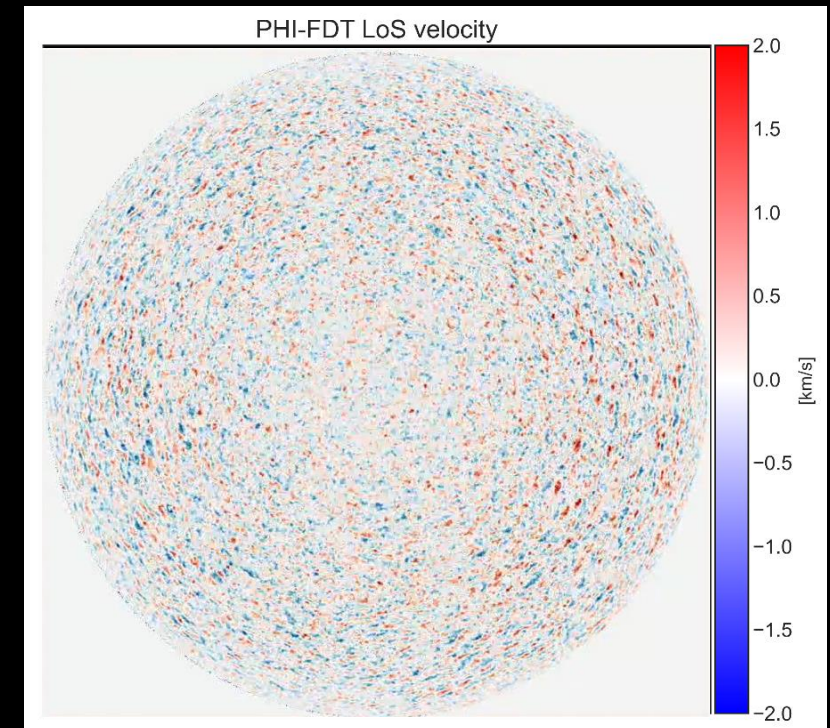
SO/PHI FDT/HRT FOV at DC POINTING



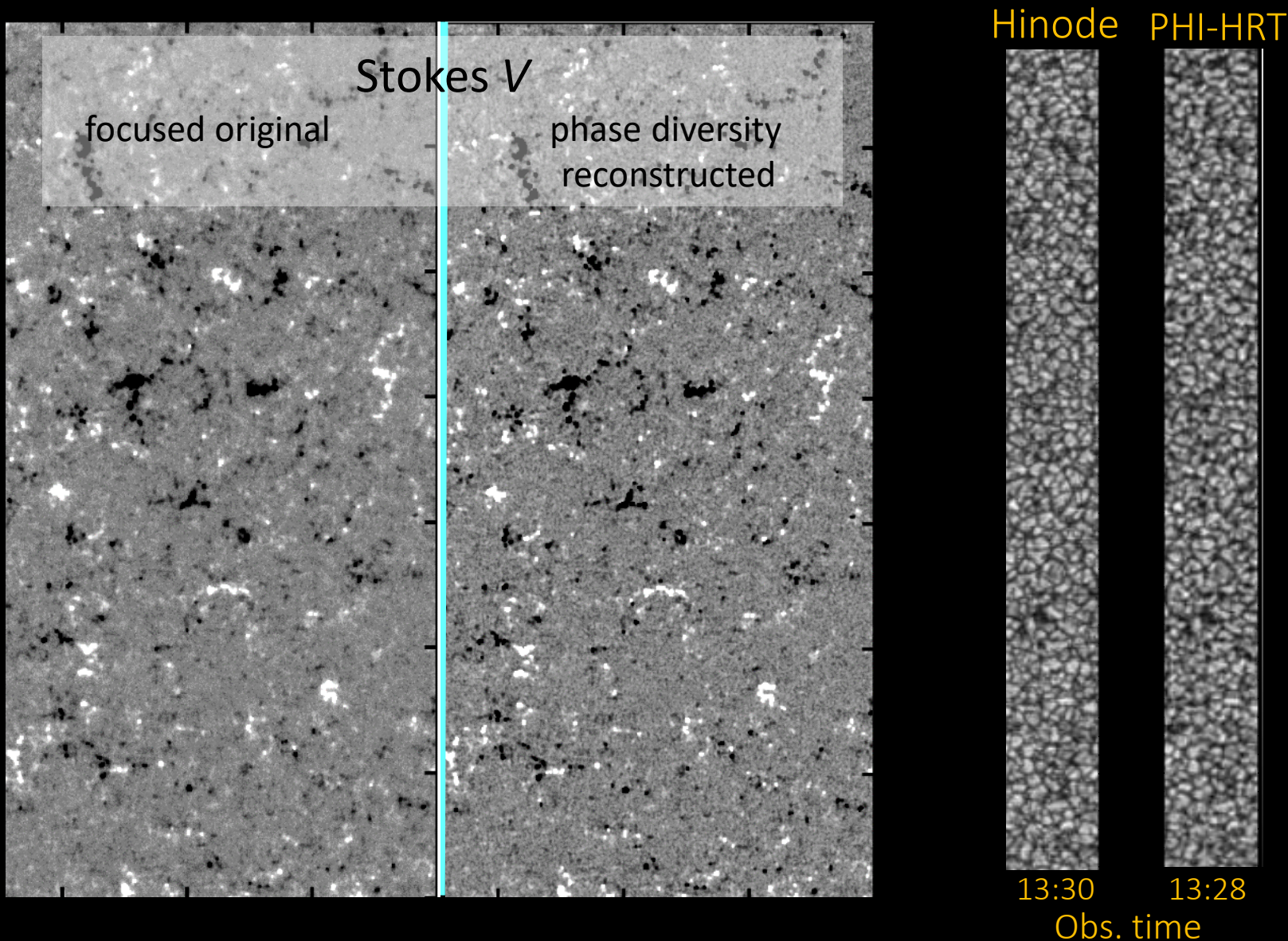
Distance = 0.80 AU

Instrument Status

- SO/PHI is commissioned and calibrated for outer parts of orbit, but further software improvements still ongoing
- Very limited telemetry & other constraints during cruise phase → only a few individual data sets so far, no synoptic science and no high resolution science (still too far from Sun), but first magnetograms of the far side of the Sun.
- The instrument appears to be of very high quality, better than we had hoped for → remarkable given the very difficult environment it is flying in



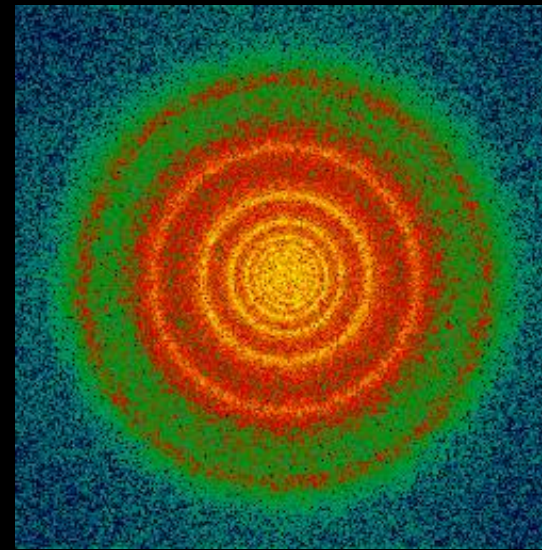
SO/PHI-HRT: phase diversity reconstruction



- ✓ Comparison with data taken with Hinode/SOT/SP
- ✓ Quality of SO/PHI data taken at 0.82 AU is surprisingly similar to that of Hinode data
- ✓ → at perihelion, 0.28 AU, SO/PHI will in theory have same resolution as Hinode, but with PD will obtain superior images

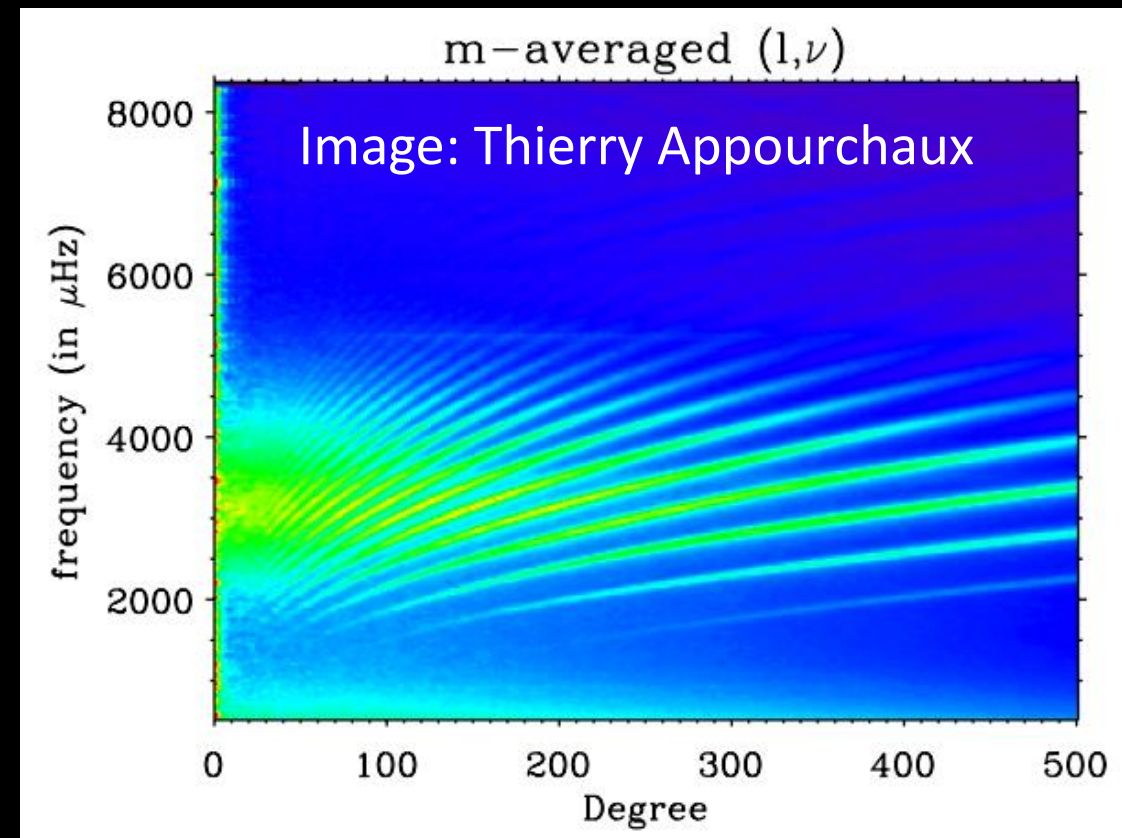
PHI as a helioseismology instrument

- SO/PHI is designed to measure velocity timeseries in a stable manner, as needed for helioseismology (in spite of the variable surroundings)
 - First test with an 8 hour long timeseries has been very positive. See l, ν diagram at right
 - Positive surprise: even $l = 1$ mode clearly detected, although instrument is not designed to detect modes below $l = 10$
- Instrument is better than the requirements also in this respect



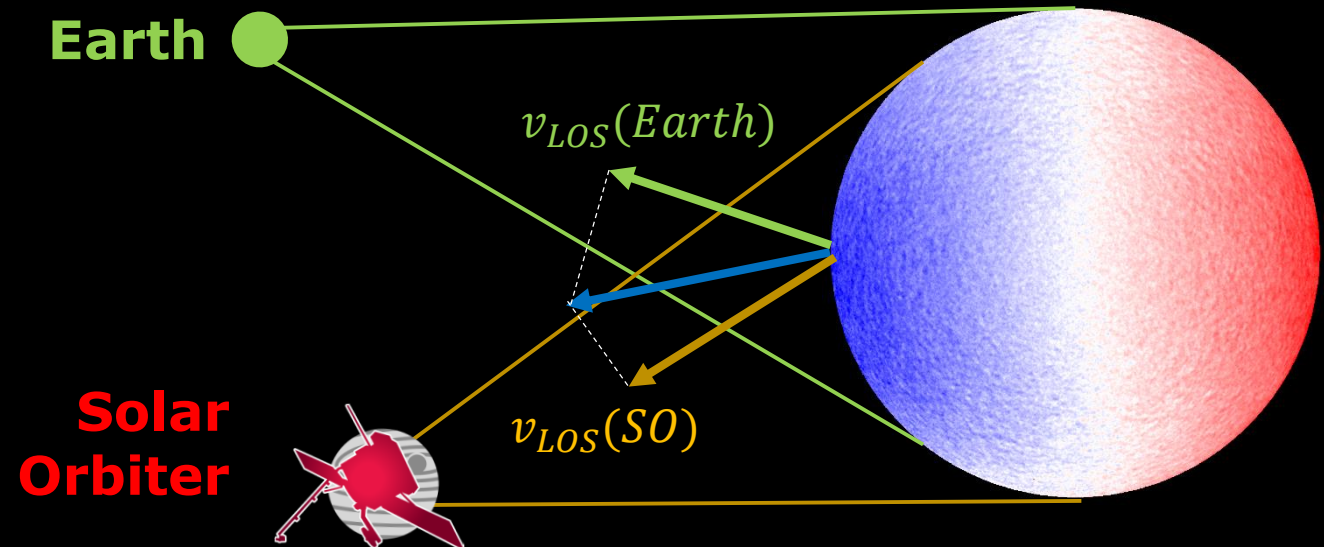
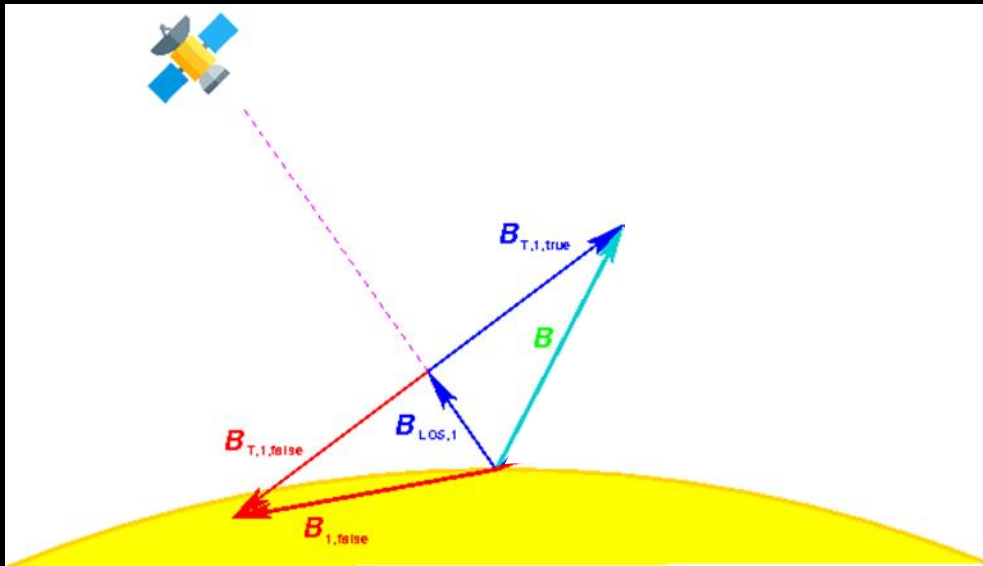
Ring diagram: cut at fixed ν vs. k_x and k_y

Image: Jesper Schou



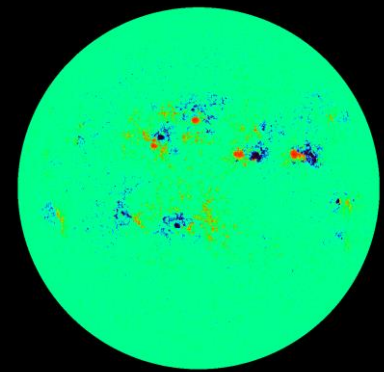
Advantages of multi-point observations

- Combination with Earth-orbiting and ground-based resources provides additional novel insights:
 - Resolve the 180° ambiguity without further assumptions \rightarrow more accurate magnetic vector
 - Determine two components of the velocity vector directly from the Doppler effect
 - Test tracking methods (e.g. correlation tracking, etc.)
 - Stereoscopy of photospheric structures
 - Obtain true CLV of brightness contrast of magnetic features, etc. etc.

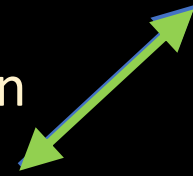


SO/PHI higher level data products

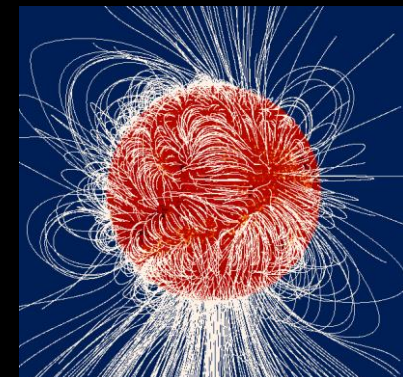
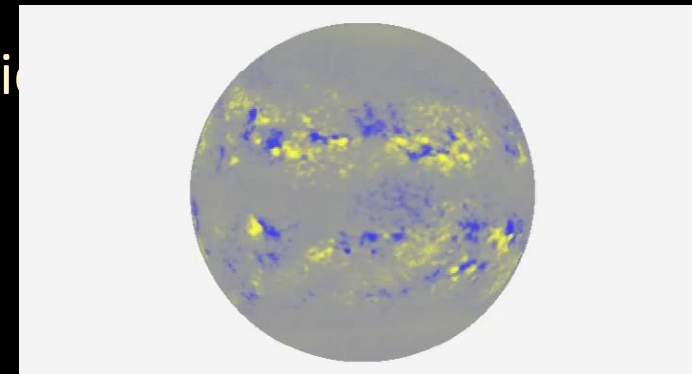
- Normal data products: $B, \gamma, \chi, I_c, v_{LOS}$ (magnetic vector, continuum intensity, line-of-sight velocity)
- LOS Magnetograms will be created from field strength and inclination (most reliable magnetic data product)
- Zeeman effect: azimuthal angle of field is only modulo 180° . Provides disambiguated azimuthal data in many cases
- Synoptic charts: needed for global magnetic field extrapolations & for other studies
- Magnetic field extrapolations, both global and local
- Phase Diversity reconstructed images, if telemetry allows
- Higher level data products will be added with time



Magnetogram



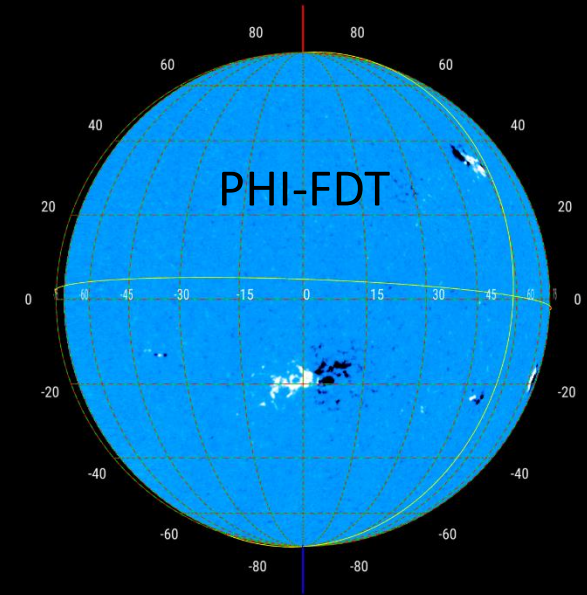
D. Hathaway



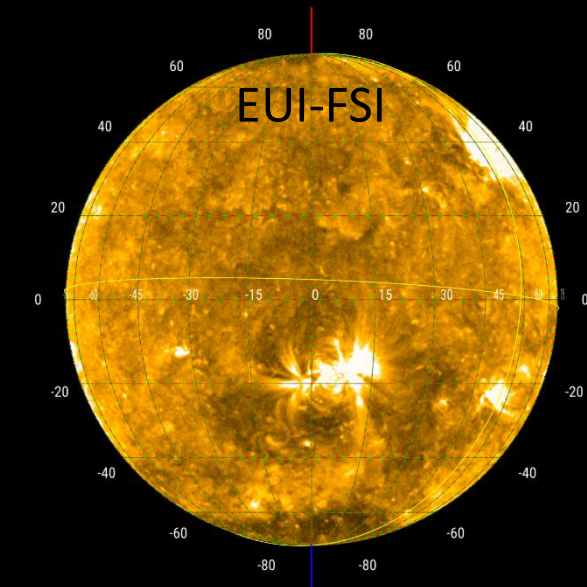
T. Wiegmann

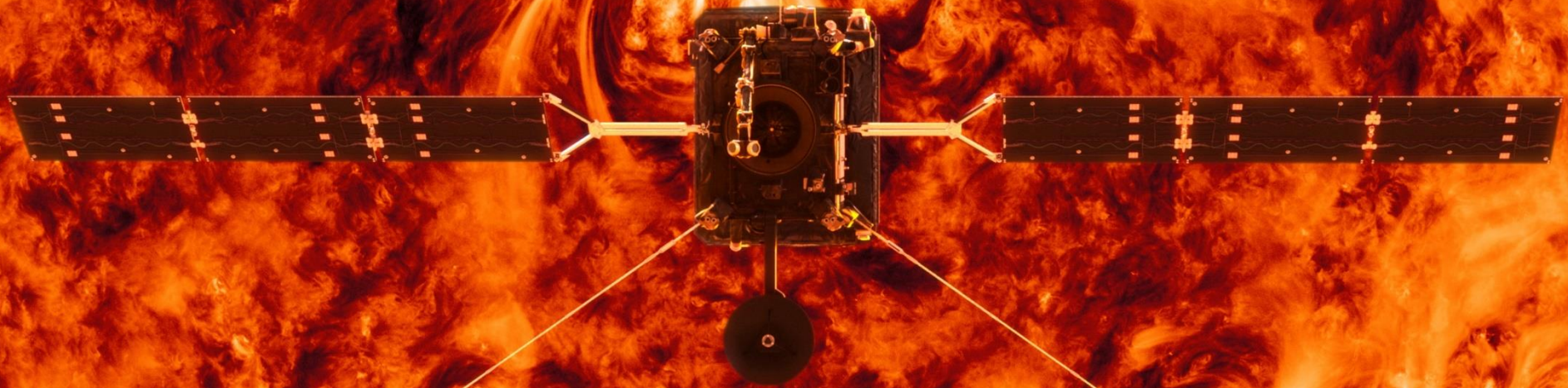
Conclusions

- Solar Orbiter with SO/PHI is in cruise phase till end 2021
- SO/PHI provides the first magnetograms from outside the Sun-Earth line and of the solar poles
- The instrument performs better than expected
- The SO/PHI team is very open to joint observations with space- and Earth-based assets
- The community is invited to participate in SO/PHI data analysis from an early stage. Data will initially be distributed in a controlled manner.
- SO/PHI meeting open to community planned, possibly in week of 29th November in Granada + online



S.O. at 0.8 AU & 122°
from Sun-Earth line





Thank you for your attention!

SO/PHI data policy

- Everyone is welcome to work with data, as long as they adhere to the SO/PHI data and publication policy
- Initially data will be distributed in a controlled manner, i.e through contact with SO/PHI team
- To get involved contact SO/PHI team
- Also, join Remote Sensing Science Working Groups (RSSWGs), e.g.:
 - Magneto-convection. Chairs: Luis Bellot Rubio & Shahin Jafarzadeh (PHI)
 - Dynamo & solar cycle. Chairs: Zhi-Chao Liang & Jie Jiang (PHI, EUI, Metis)
 - Atmospheric heating. Chairs: Pradeep Chitta & Hui Tian (EUI, SPICE, PHI, Metis)
- Plan of SO/PHI team: organize an open, community-wide workshop, possibly in week of 29th November:
 - explain instrument, status, data and plans
 - provide you with a chance to air your ideas and obtain data for your project