MOF-based synoptic telescopes for LoS velocity and magnetic fields at different heights in the Sun's atmosphere

SPRING 2019 WORKSHOP

29-30/04/2019

DANIELE CALCHETTI

DEPT. OF PHYSICS – UNIV. OF ROME TOR VERGATA

F. BERRILLI, S. JEFFERIES, M. OLIVIERO, D. DEL MORO, R. FORTE, L. GIOVANNELLI, M. MAGRÌ, N. MURPHY, E. PIETROPAOLO, L. TERRANEGRA, G. VIAVATTENE

Outline

- Magneto Optical Filter working principles
- Magnetic Optical filter at Two Height (MOTH-II)
- Preliminary results from the 2017 Antarctic campaign
- Tor vergata Synoptic Solar Telescope (TSST)
- Outlook

MOF

Magneto Optical Filters (Cimino et al., 1967) provide two very stable and narrow bands (50mÅ at transmission peaks).

They can be used in synoptic telescopes array for long and continuous observations (e.g. MOTH-II + VAMOS + TSST+…).

Study magnetic and velocity field at different heights.

We need details about photospheric magnetic field for SW forecasting.

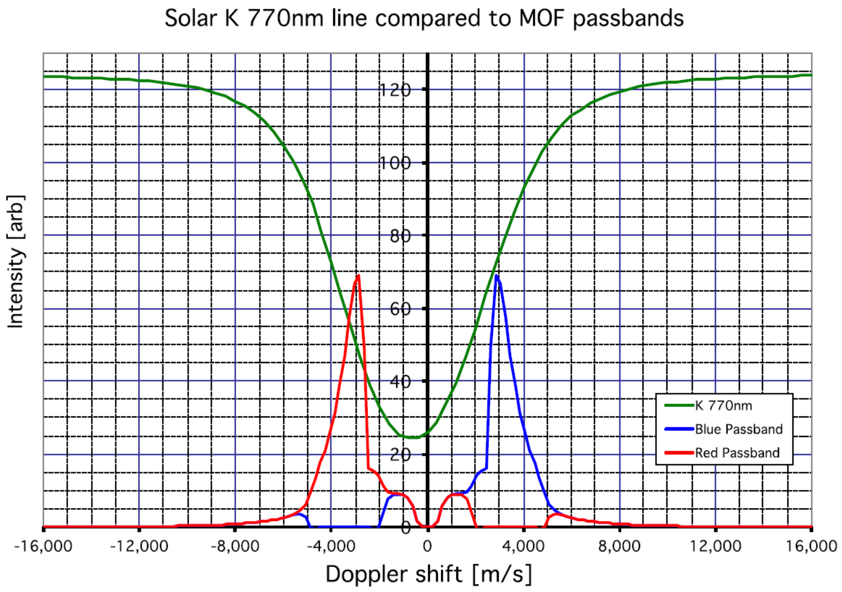
line	**λ (nm)**	**Formation height (km)**
K I	**770**	**300-400**
Na D2	**589**	**600-700**
Ca I	*422*	*1000*
He I	*1083*	*1900*
Fe I (**HMI**)	617	100
Ni I (MDI)	677	125

MOF

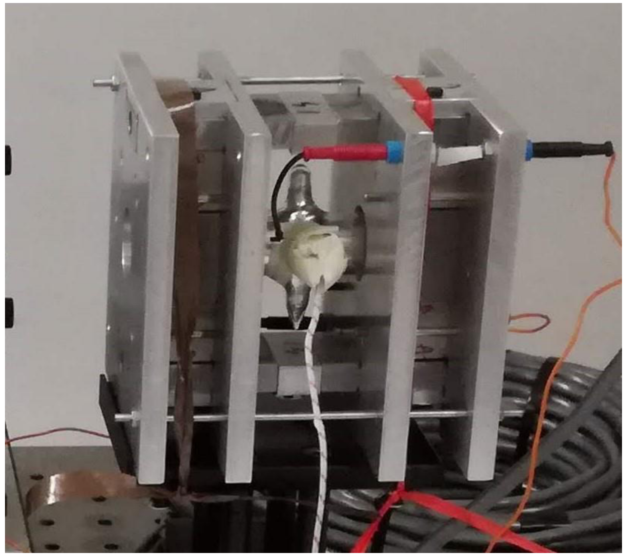
Vapour cell, usually Na or K, with longitudinal magnetic field inside.

The magnetic field induces an inverse Zeeman effect in the vapour and a Macaluso-Corbino effect (magneto-optical Faraday rotation near absorption line) in the polarized light.

Two passabands on the red and blue wing of the absorption line.



MOTH-II K passbands (Forte et al., 2018)



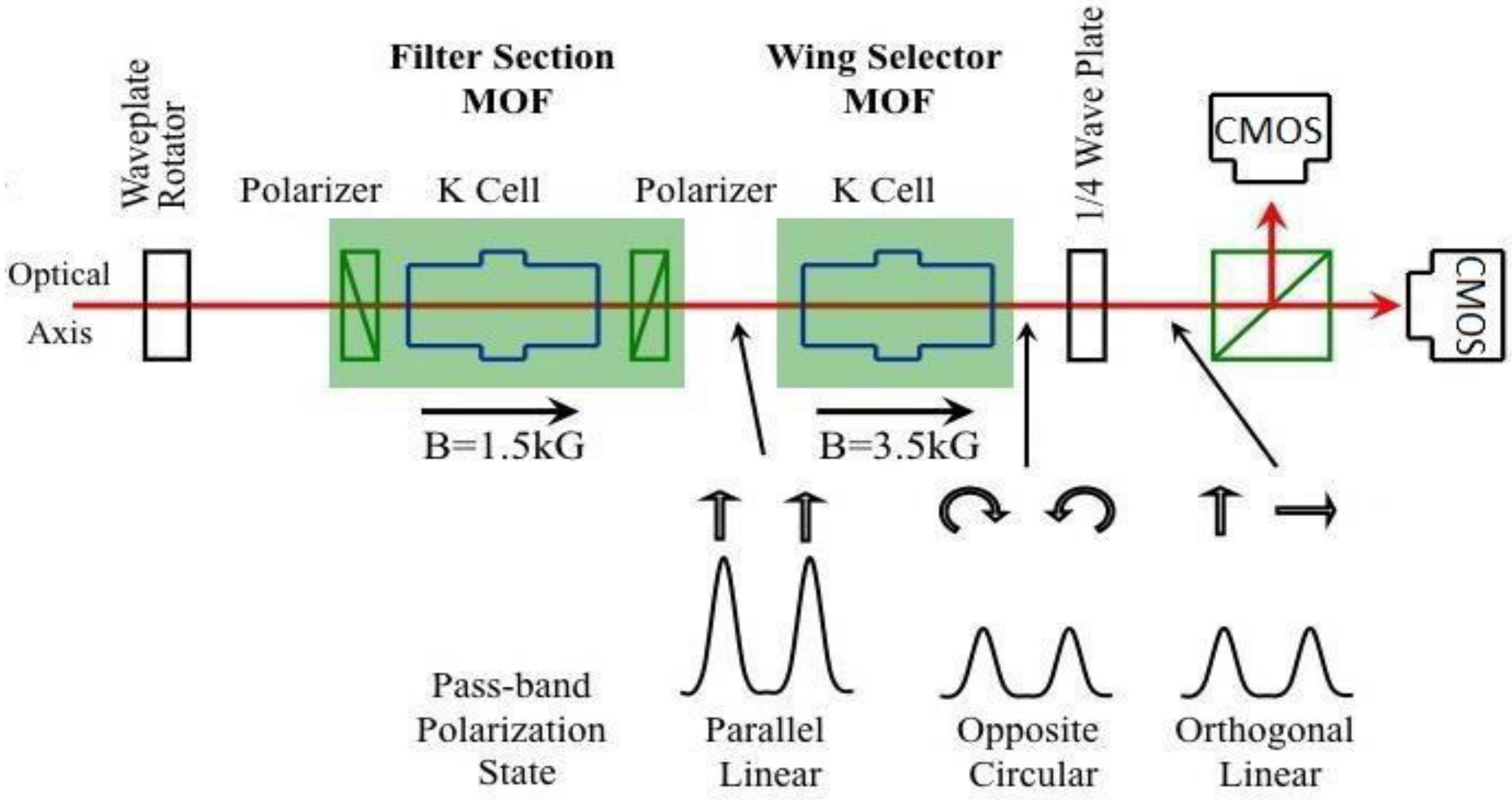
TSST MOF cell and holder during tests at INAF Observatory of Capodimonte

MOF optical line

Magnetic Modulator before the two cells.

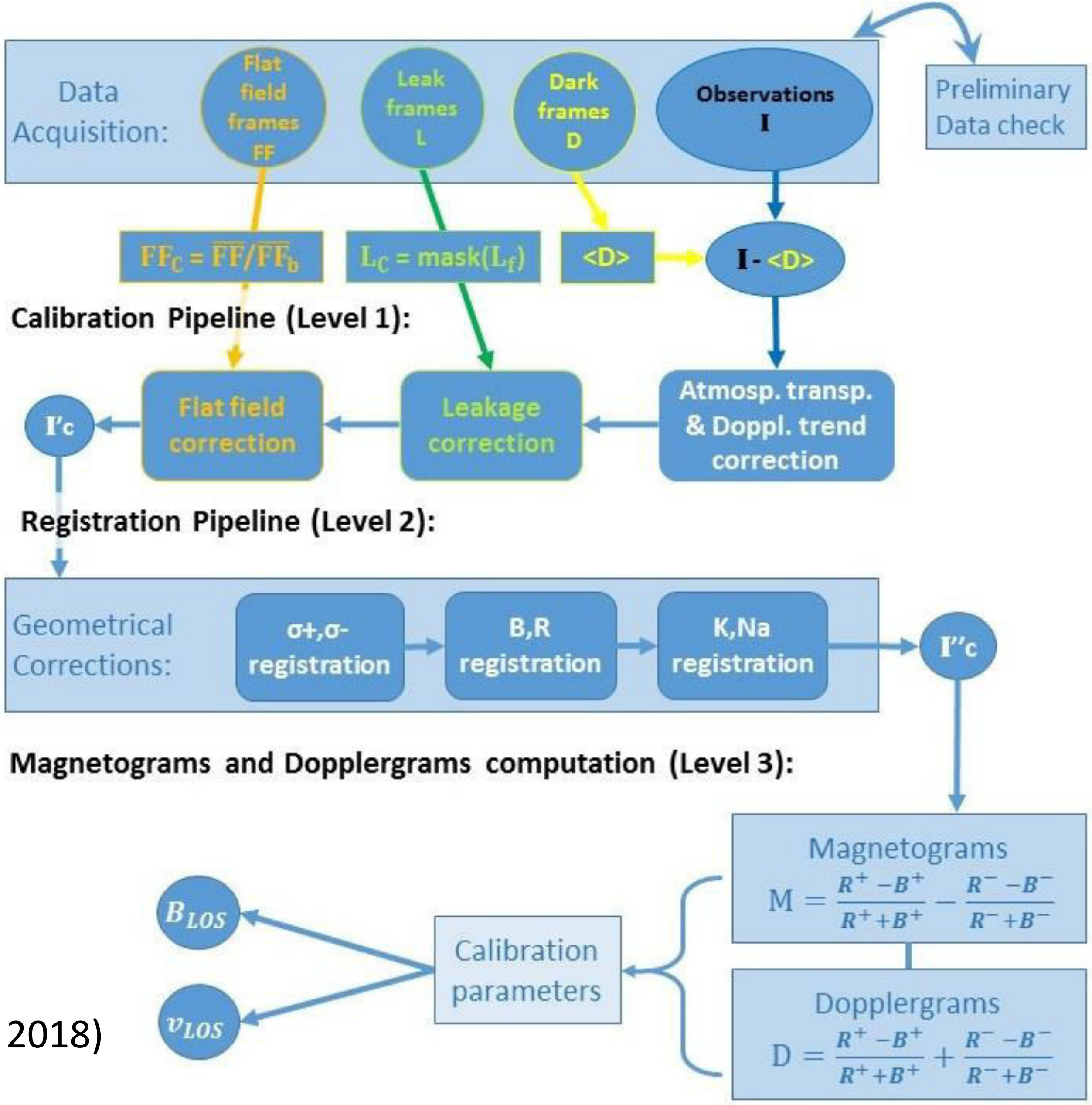
Incoming light in the first cell is a σ^+or σ^- absorption line linearly polarized.

The two cells can separate blue and red wings.



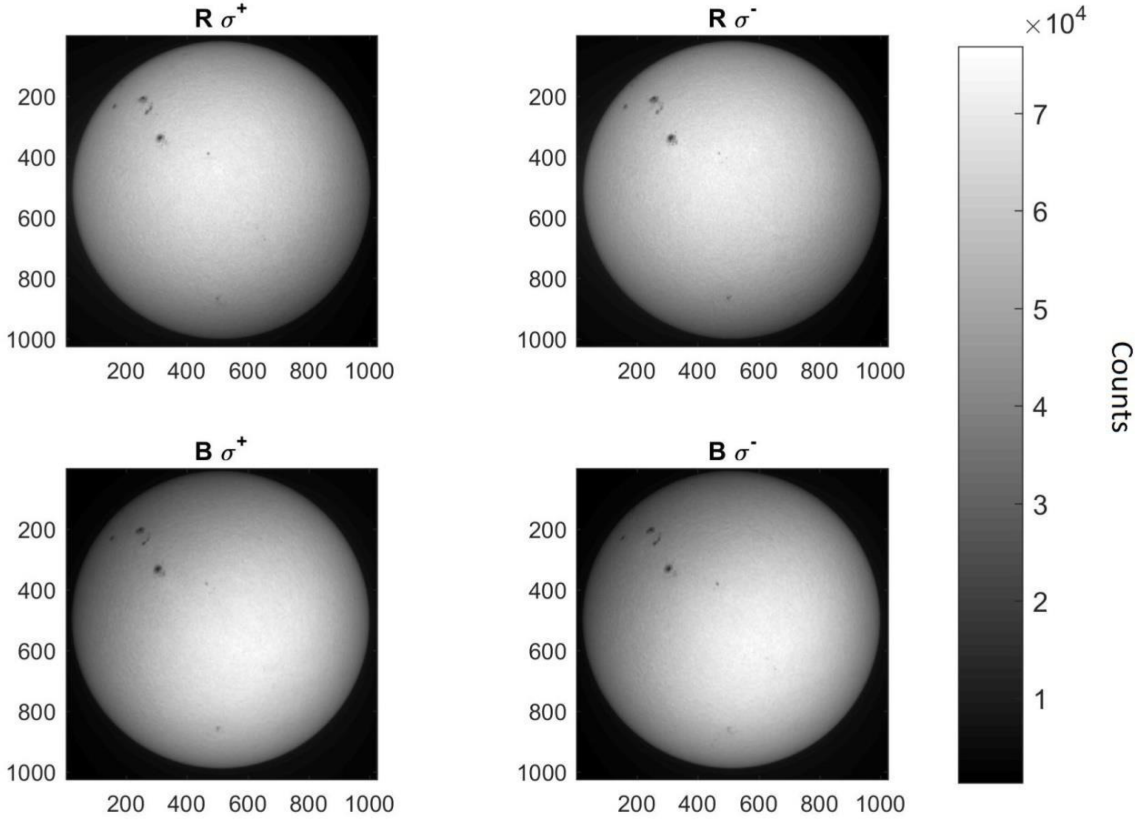
MOF pipeline

- Standard Dark subtraction and Flat Field correction
- Sky transparency and orbital trend correction
- Leakage correction
- Rotate, Resize and Align the images

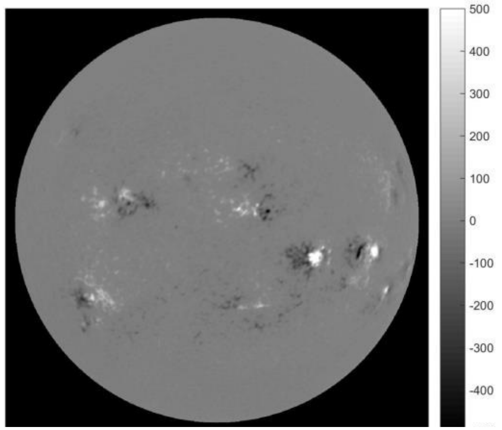


(Forte et al., 2018)

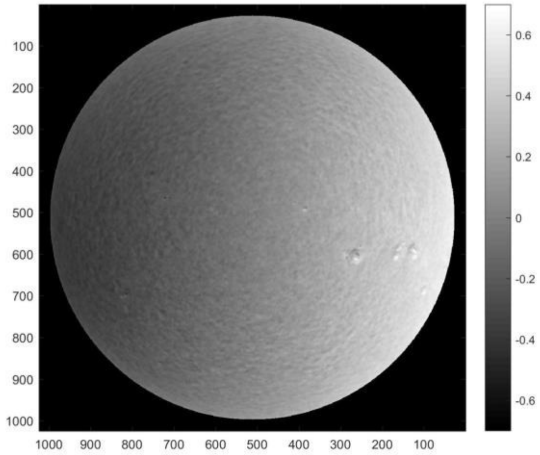
Observations with MOFs



Magnetogram acquired by MOTH



Dopplergram acquired by MOTH



$$B_{LOS} \propto \frac{R^{+} - B^{+}}{R^{+} + B^{+}} - \frac{R^{-} - B^{-}}{R^{-} + B^{-}}$$

$$v_{LOS} \propto \frac{R^{+} - B^{+}}{R^{+} + B^{+}} + \frac{R^{-} - B^{-}}{R^{-} + B^{-}}$$

Mees Solar Observatory, Maui, Hawaii
(Courtesy of S. Jefferies)

MOTH-II

Magneto Optical filter at Two Height

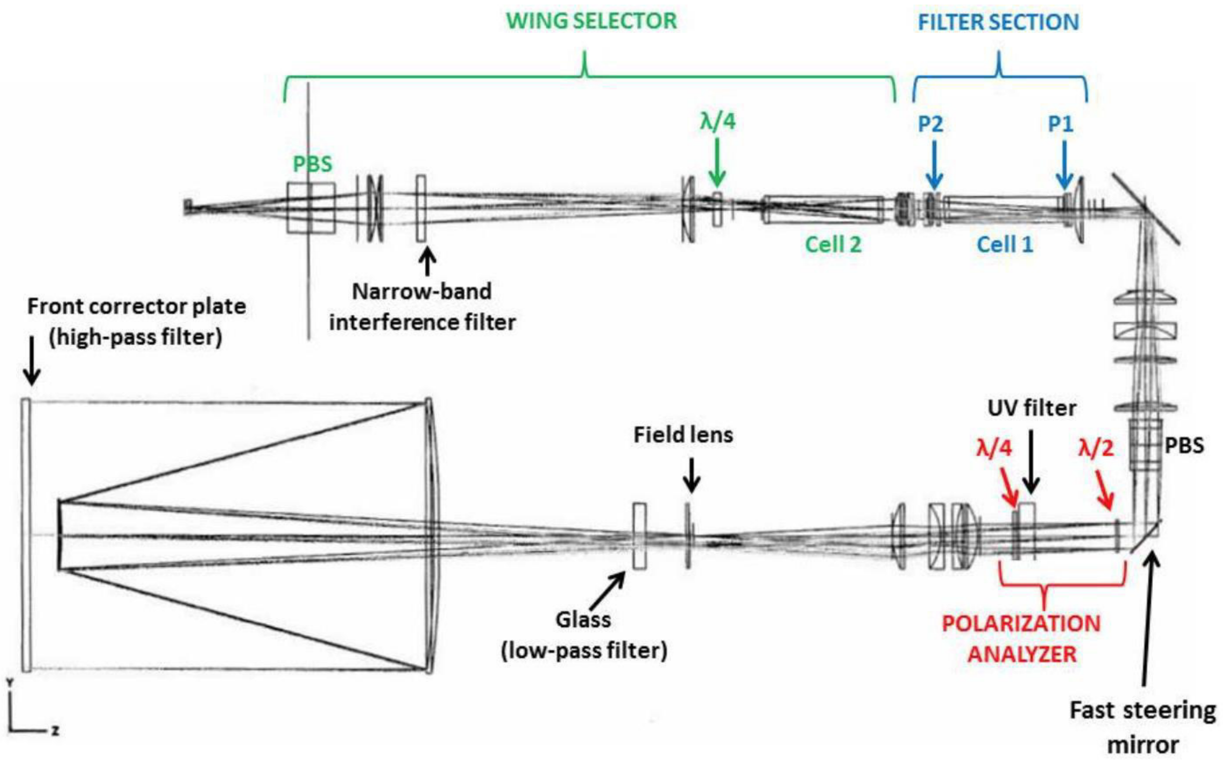
Full-disk Dopplergram and Magnetograms

KI D1 (770nm) and NaI D2 (589nm) lines

High cadence (5s)

High resolution (3k x 3k)

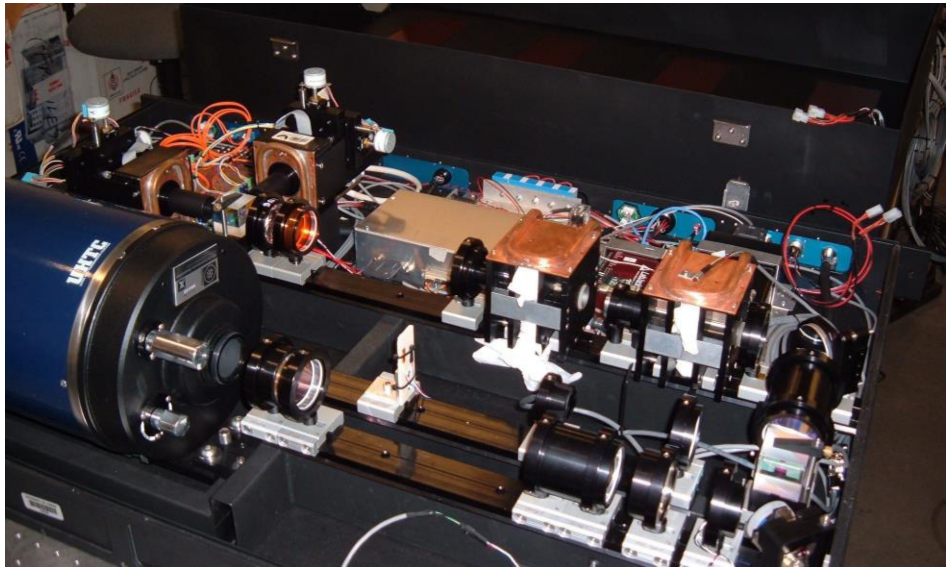
Simultaneous measurements in blue and red wings of the σ^+ and σ^- polarization states



MOTH-II 2016-17 and 2017-18 Antarctic Campaigns at South Pole Solar Observatory

Scientific goals require extended continuous observation (e. g. long-period gravity waves or magnetic/dynamic flare precursors)

Technical and environmental challenges



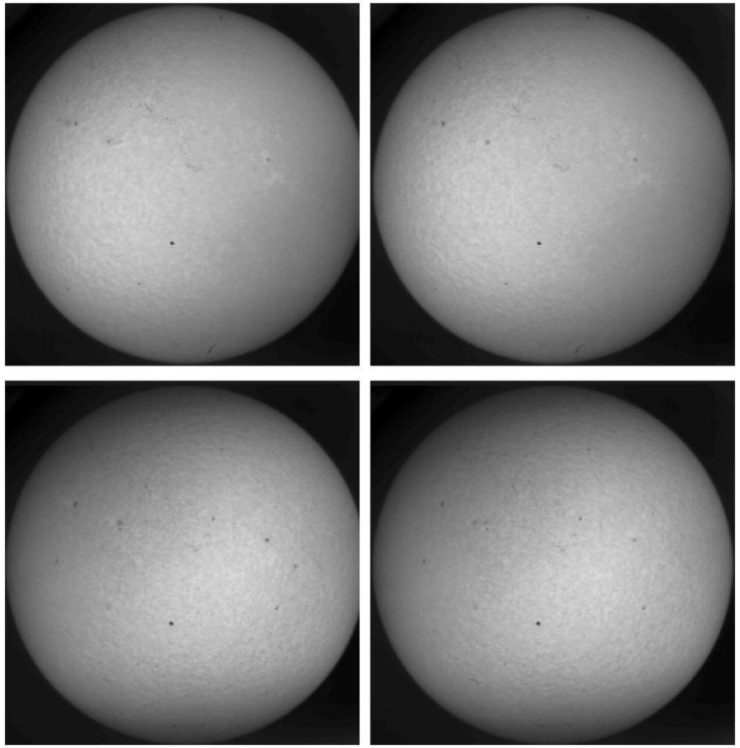
MOTH-II 2016-17 Antarctic Campaign

Analyzed Dataset:

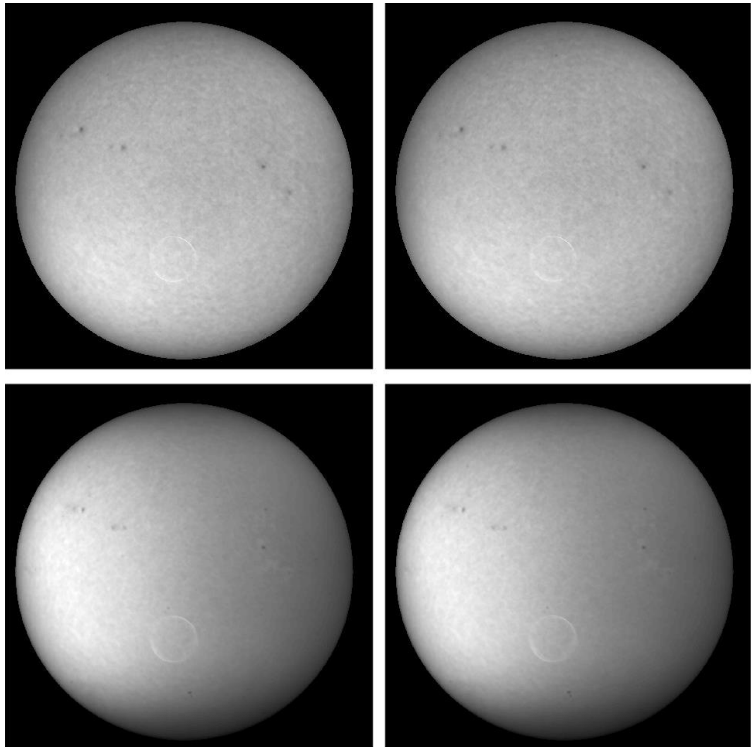
6 consecutive hours in Potassium (21 Jan 2017 7:00 – 13:00)

2.5 consecutive hours in Sodium (21 Jan 7:00 – 9:30) due to cell failure

Dark, Flat Field and Leakage available in both channels



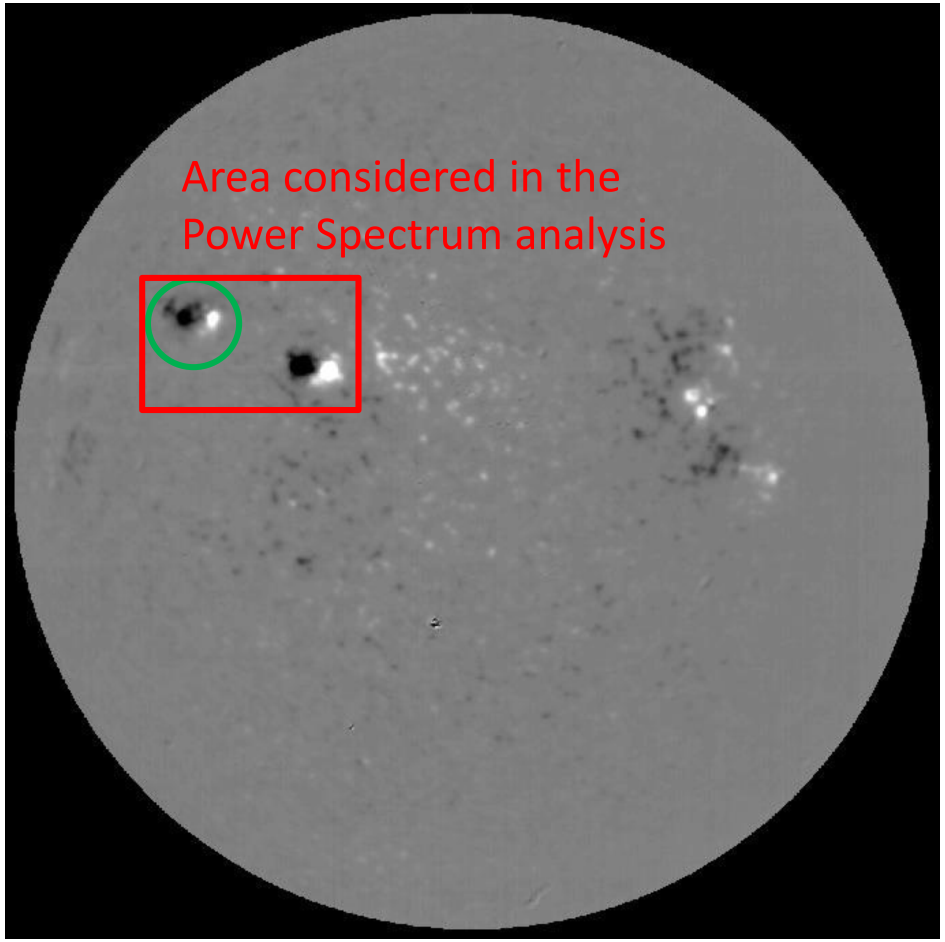
Example of K corrected data



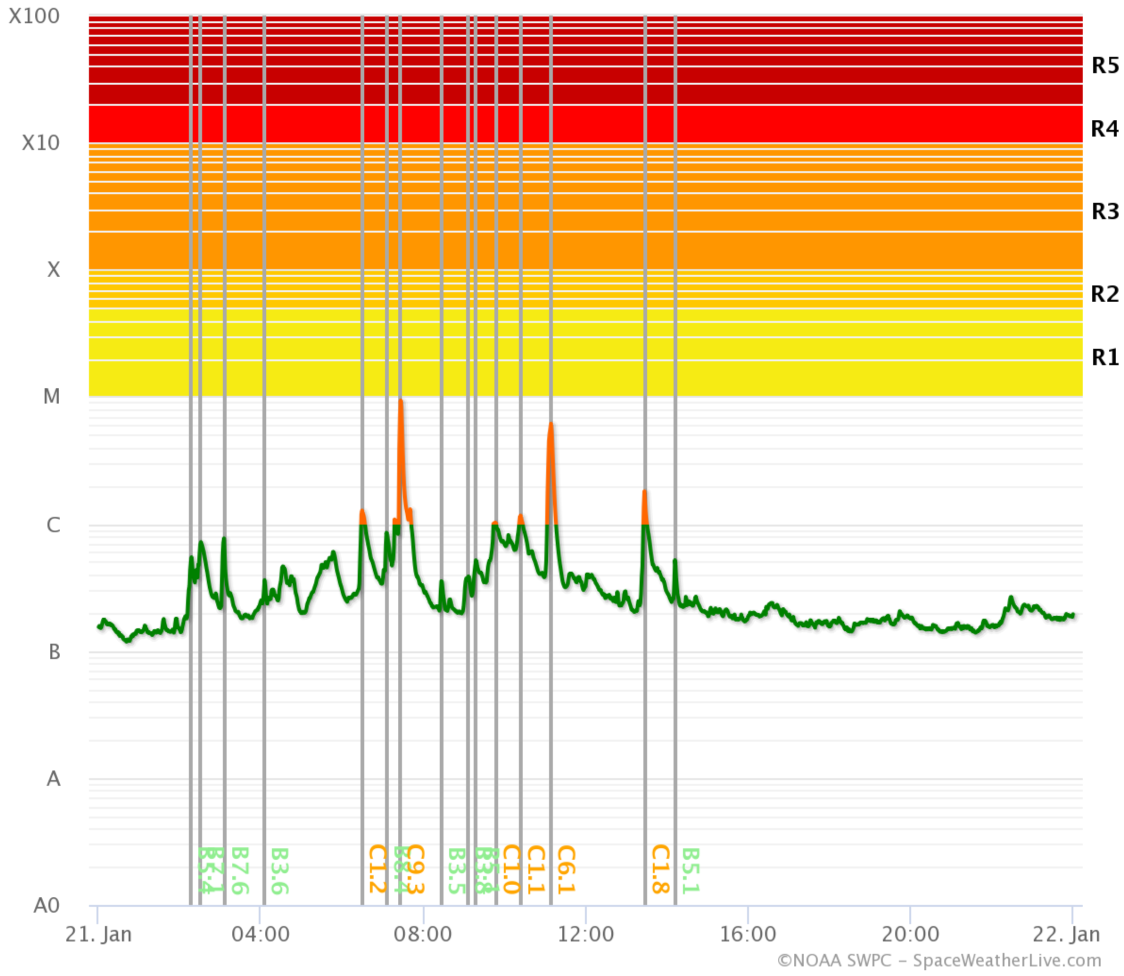
Example of Na corrected data

MOTH-II 2016-17 Antarctic Campaign

Flares from AR12628

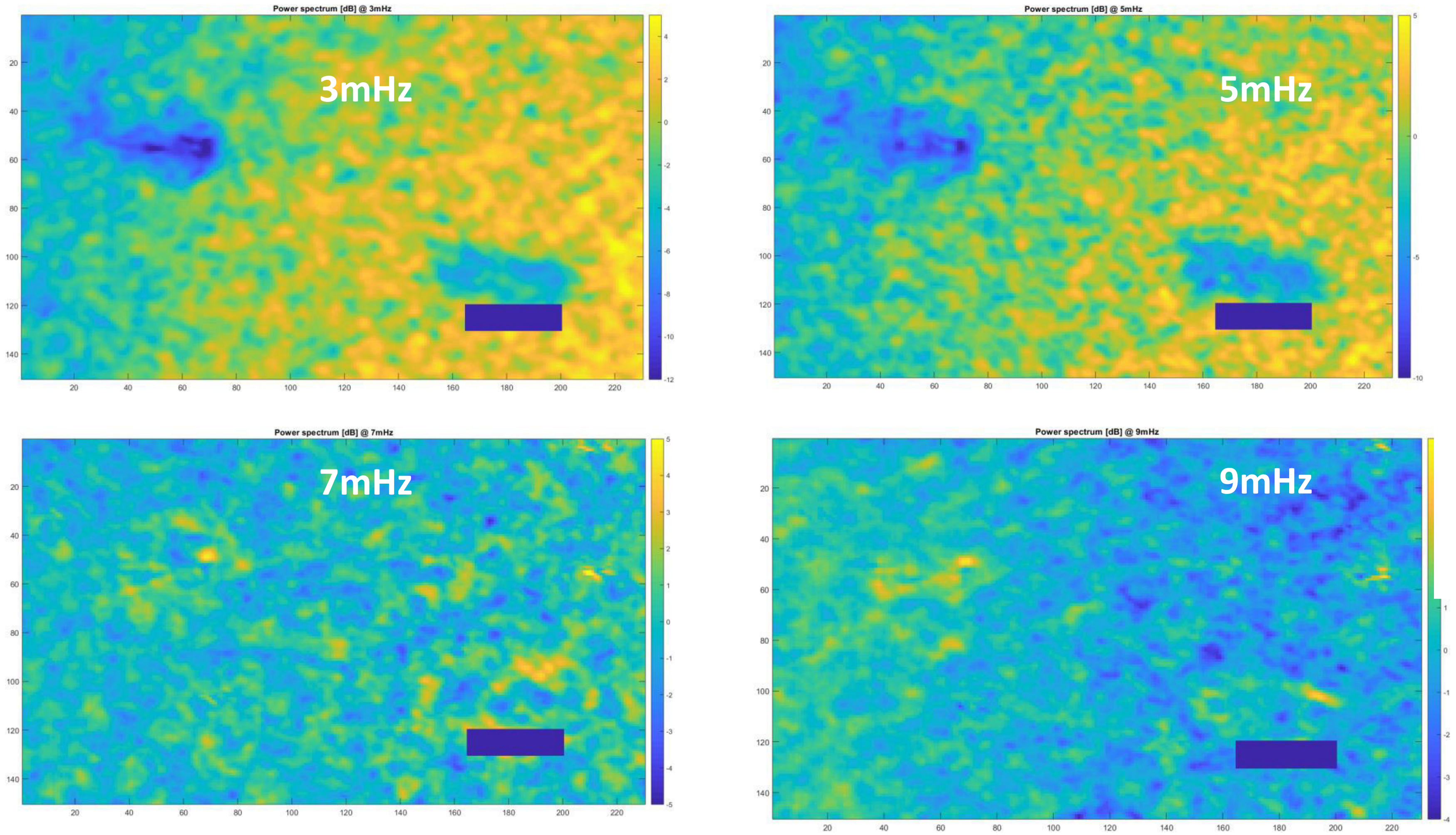


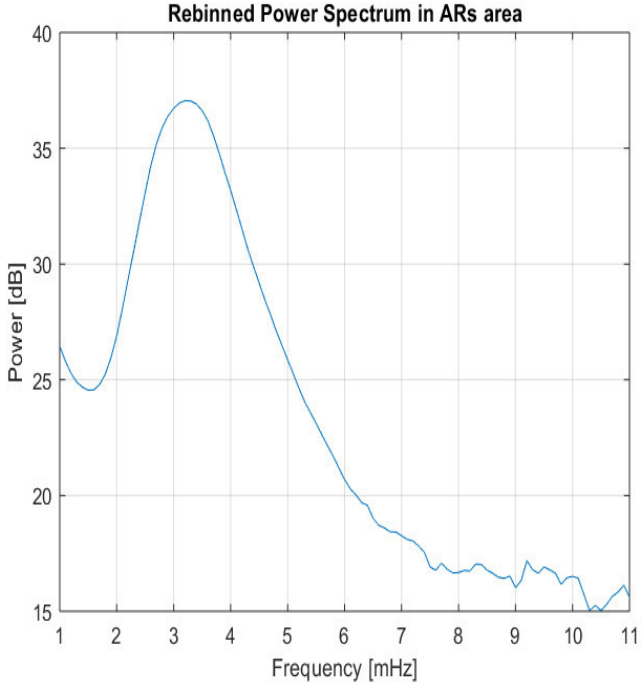
Solar activity of Saturday, 21 January 2017



MOTH-II 2016-17 Antarctic Campaign

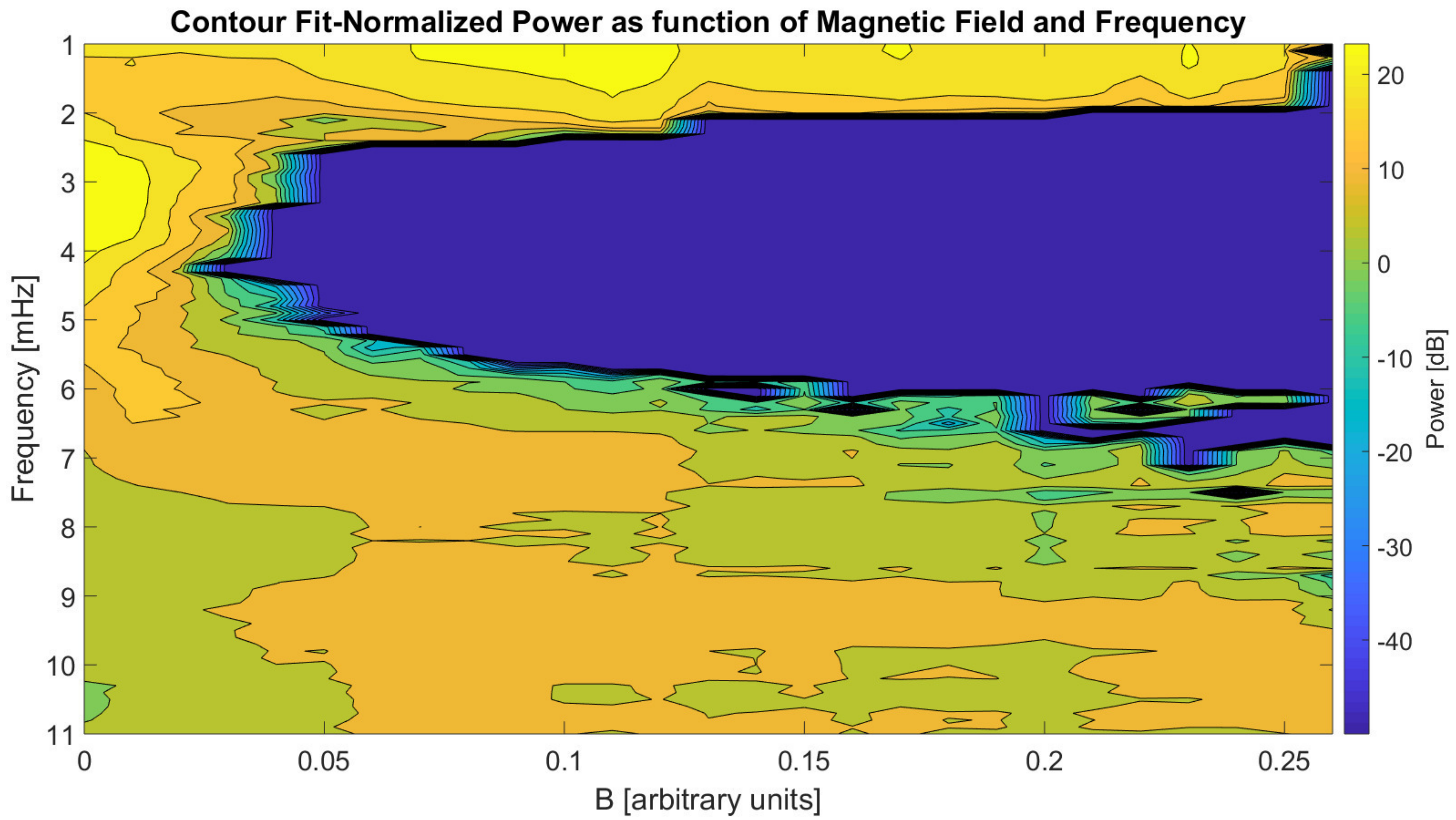
Potassium power spectrum in the AR12627 and AR12628 area





Frequency bins width 0.1mHz

MOTH-II 2016-17 Antarctic Campaign



Power as function of Frequency and Magnetic Field in the AR12627 and AR12628 area

TSST

Tor Vergata Synoptic Solar Telescope

2 channels: Hα and K MOF

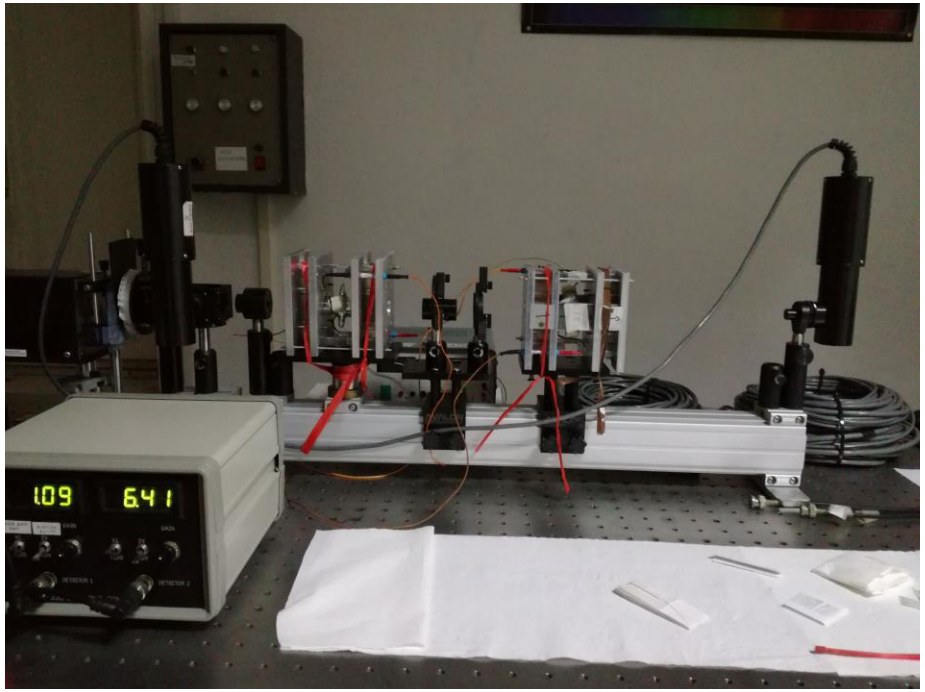
Daystar SR-127 0.4Å

Real time flare region detection

Hα filter compatible with INAF Observatory of Catania and Capodimonte

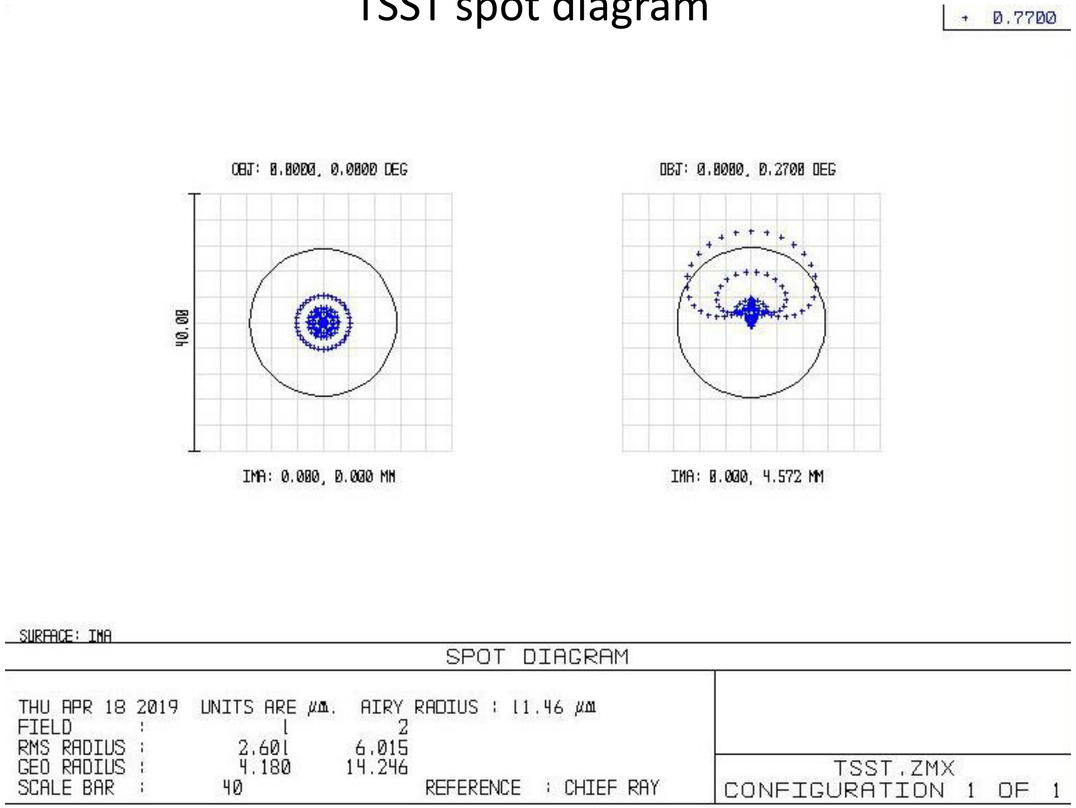
MOF-based telescope with 80mm aperture f/12.5

Simultaneous dopplergram and magnetogram every 25s (TBC)

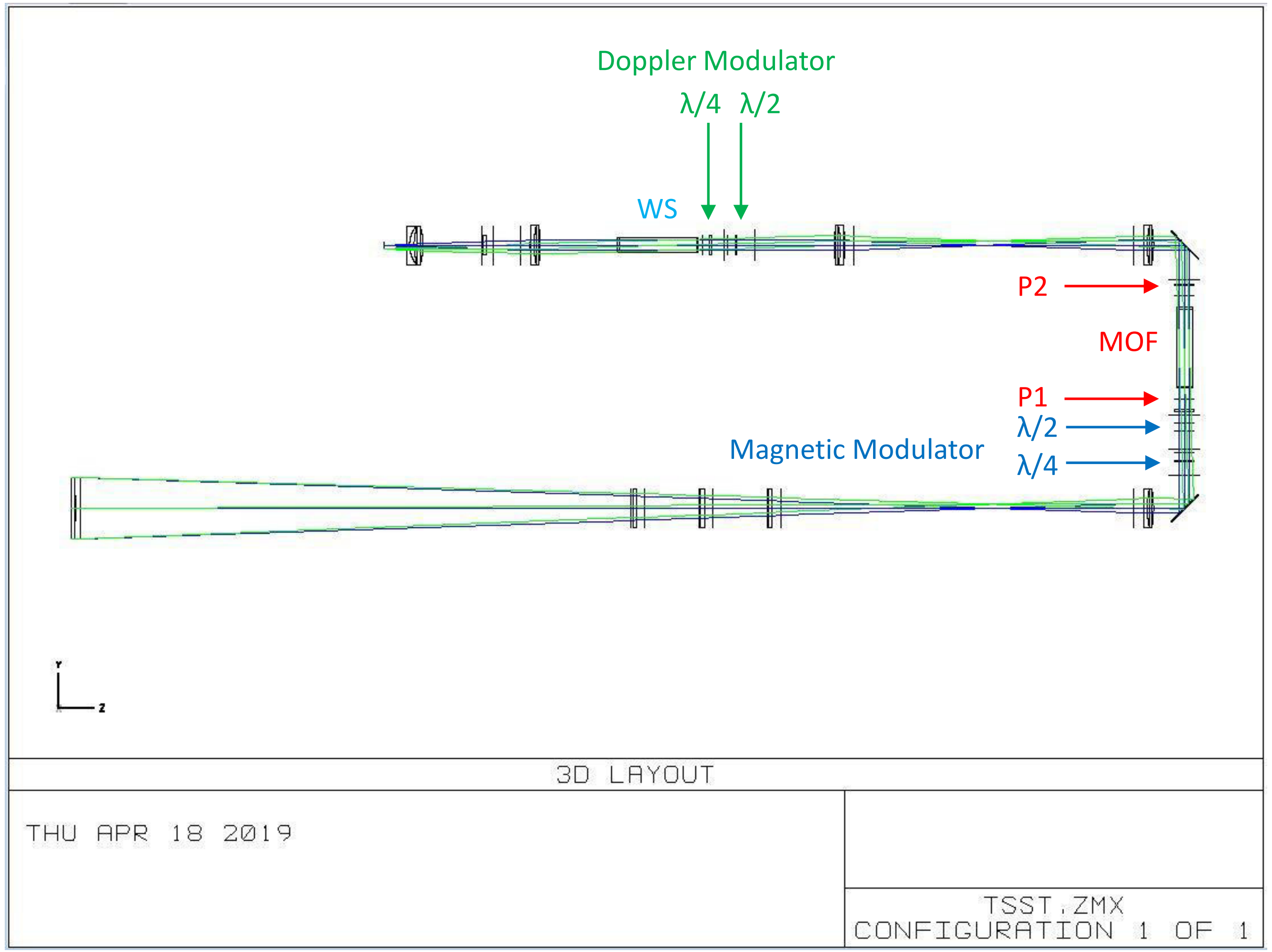


TSST

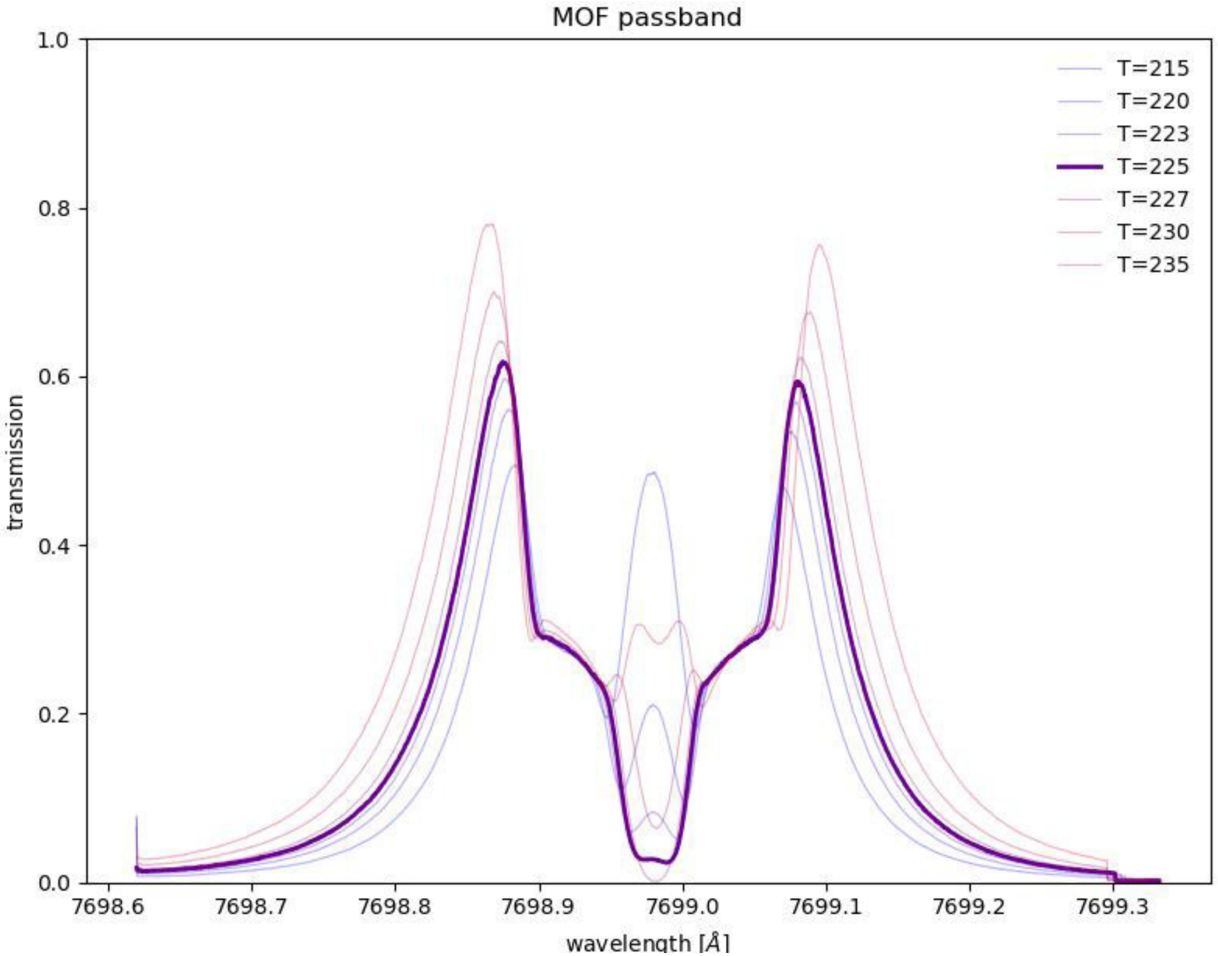
TSST spot diagram

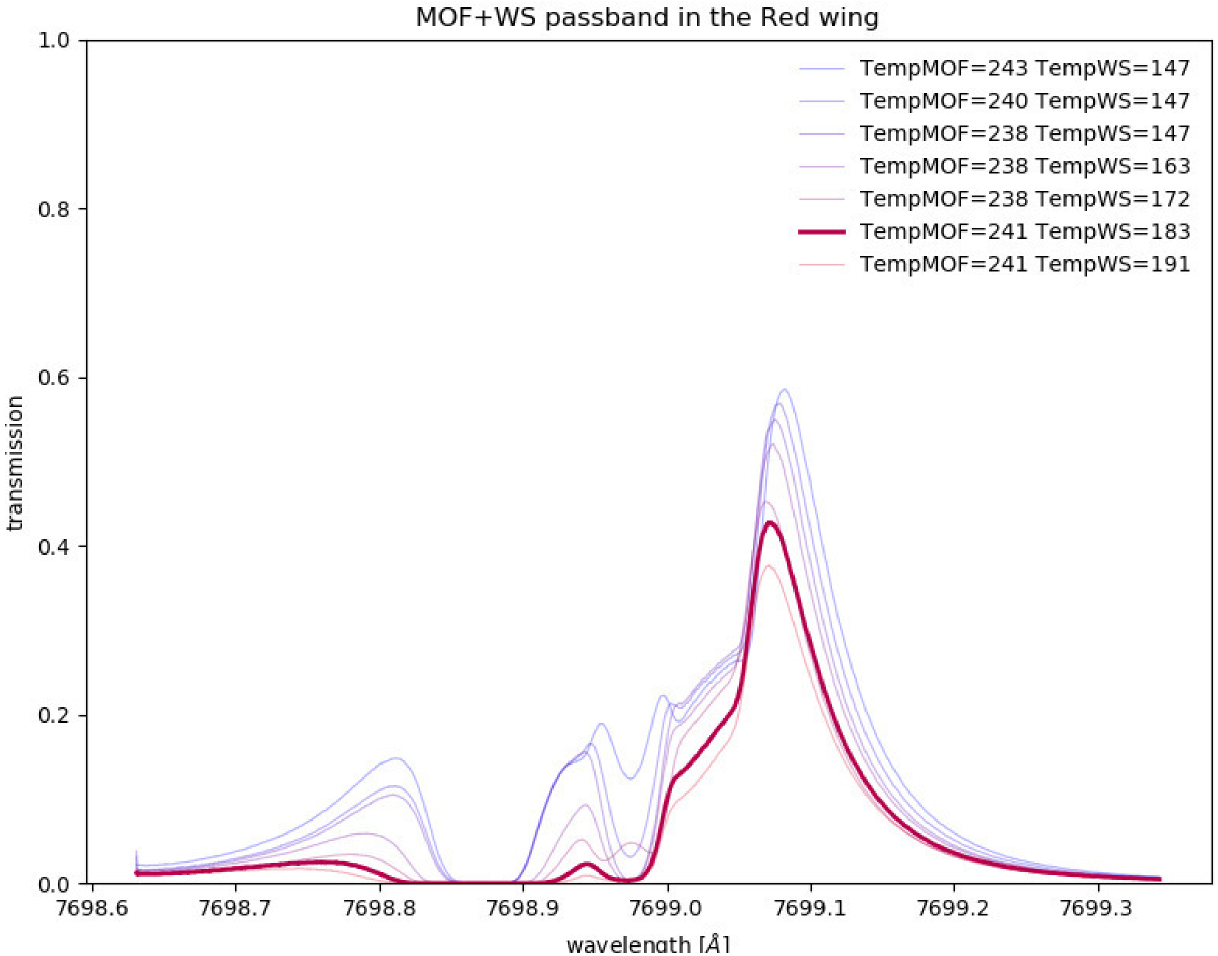


TSST preliminary optical design

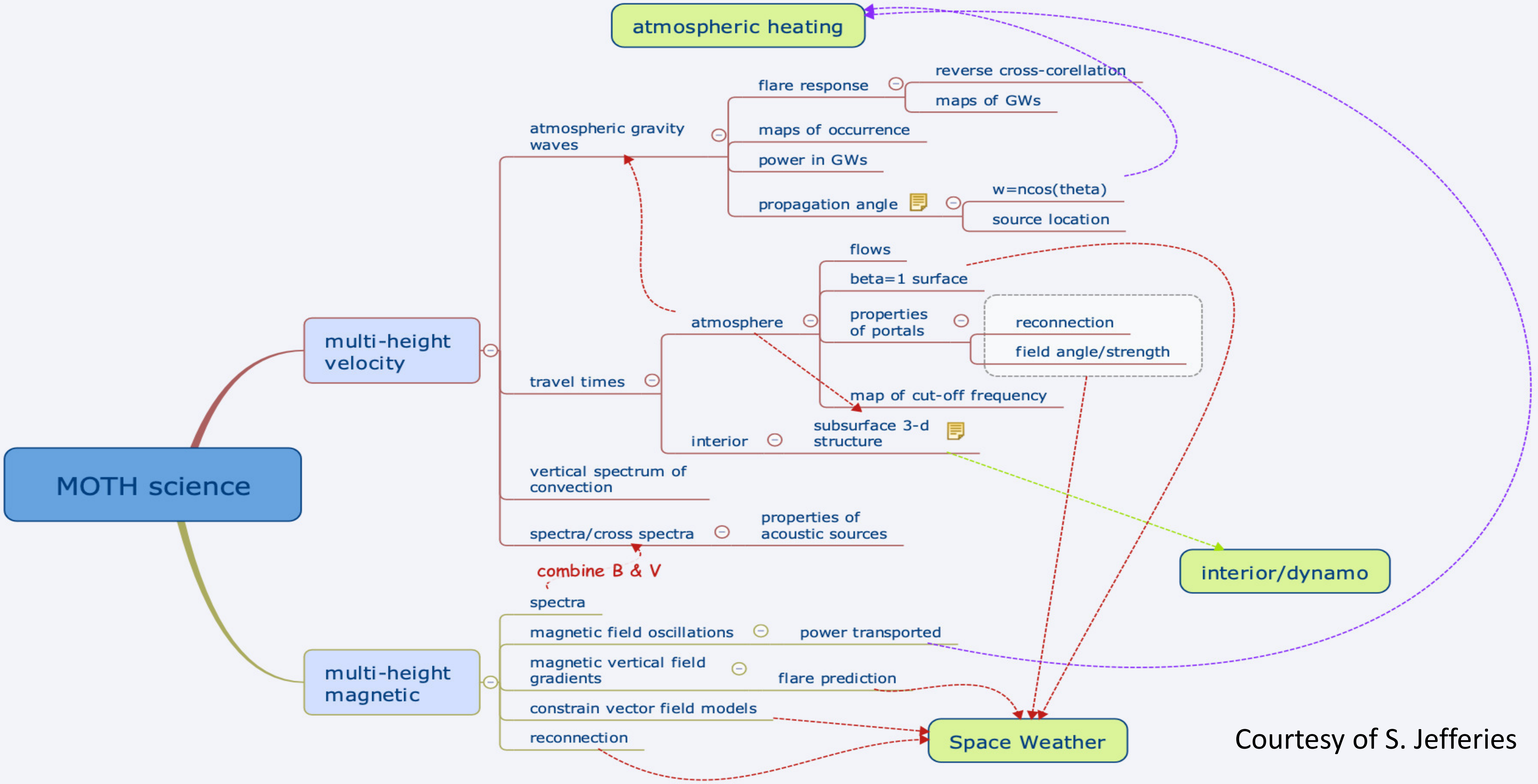


TSST





Test at INAF Observatory of Capodimonte



Courtesy of S. Jefferies

References

[1] Cimino M., Cacciani A., Sopranzi N., An instrument to measure solar magnetic fields by an atomic-beam method, 1967

[2] Forte R., Jefferies S. M., Berrilli F., Del Moro D., Fleck B., Giovannelli L., Murphy N., Pietropaolo E., Rodgers W., The MOTH II Doppler-Magnetographs and Data Calibration Pipeline, 2018