



Leibniz-Institut für  
Astrophysik Potsdam

*Multiwavelength study of penumbral decay using  
GREGOR, VTT, DST, NST, and Hinode.*

*Meetu Verma*

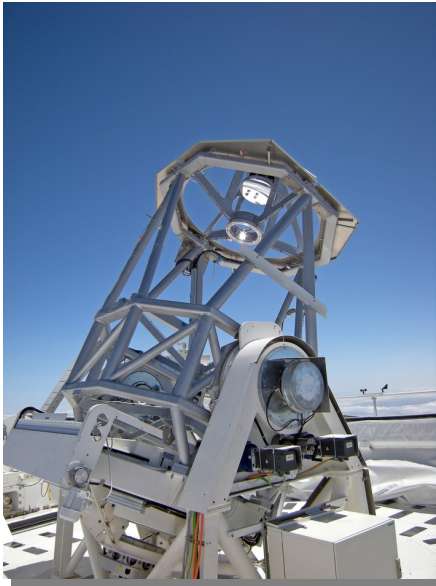
*Leibniz-Institut für Astrophysik Potsdam (AIP), Germany*

*C. Denker, H. Balthasar, C. Kuckein, Reza Rezai, M. Sobotka, N. Deng, H. Wang,  
A. Tritschler, M. Collados, A. Diercke, S.J. González Manrique*

# Motivation

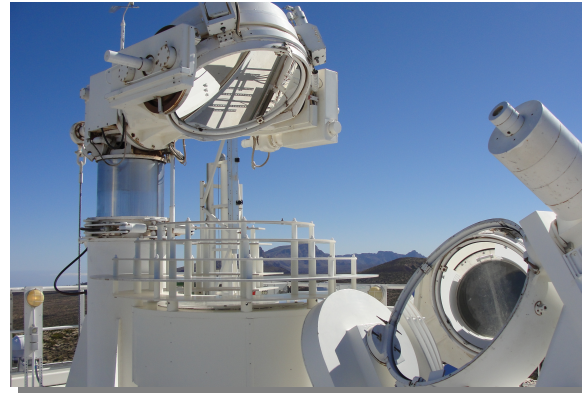
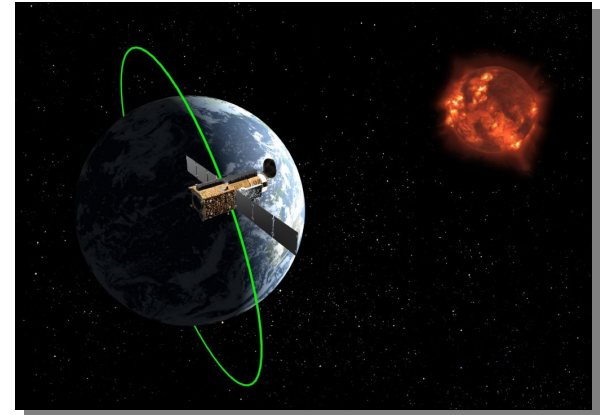
- To exploit the maximum potential of available ground-based as well as space-borne telescopes
- Multi-instrument and multi-wavelength observations
- Various instruments
  - Visible and EUV Imager
  - Fabry-Pérot Interferometer
  - Spectrograph
- Information on the propagation of changes from photosphere to chromosphere and even to transition region

GREGOR



# Motivation

HINODE



VTT

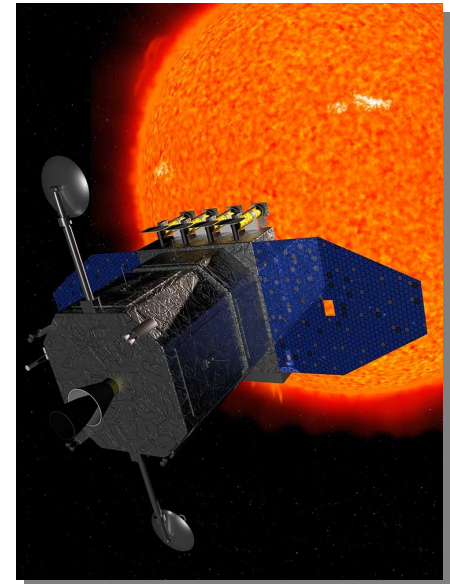


NST



DST

SDO



# Proposed Observations

Active Region Filaments: Observing Shear Flows and the Evolution of Magnetic Shear along Magnetic Neutral Lines with GREGOR, VTT, DST, NST, and Hinode

- GREGOR
  - HiFI: G-band ( $\lambda 430.7\text{nm}$ ), blue continuum ( $\lambda 450.6\text{ nm}$ )
  - GFPI: spectroscopic data - Fe I ( $\lambda 617.34\text{ nm}$ ) and Fe I ( $\lambda 543.4\text{ nm}$ )
  - GRIS: spectropolarimetric data - Si I ( $\lambda 1082.7\text{nm}$ ) He I ( $\lambda 1083.0\text{ nm}$ )
- VTT – Echelle spectrograph - spectral data H $\alpha$  and Na D<sub>2</sub>
- DST
  - IBIS: Ca II ( $\lambda 854.2\text{ nm}$ ), Na ( $\lambda 589.0\text{ nm}$ ), and spectroscopic H $\alpha$
  - ROSA: Images in G-band, Ca IIR, and Hbeta
  - FIRS: Spectropolarimetric data in 1083.0 nm spectral range
- NST
  - BFI: TiO
  - NIRIS: spectroscopic data He I triplet ( $\lambda 1083.0\text{ nm}$ ) range
  - FISS: H $\alpha$  and Ca II H ( $\lambda 854.0\text{ nm}$ )
- Hinode – SP: Fast scans Fe I ( $\lambda 630.15\text{nm}$ ) & ( $\lambda 630.25\text{nm}$ )

Proposal submission time-line VTT (Jan), GREGOR (Jan/Feb), DST (April/May), NST (May), Hinode (May)

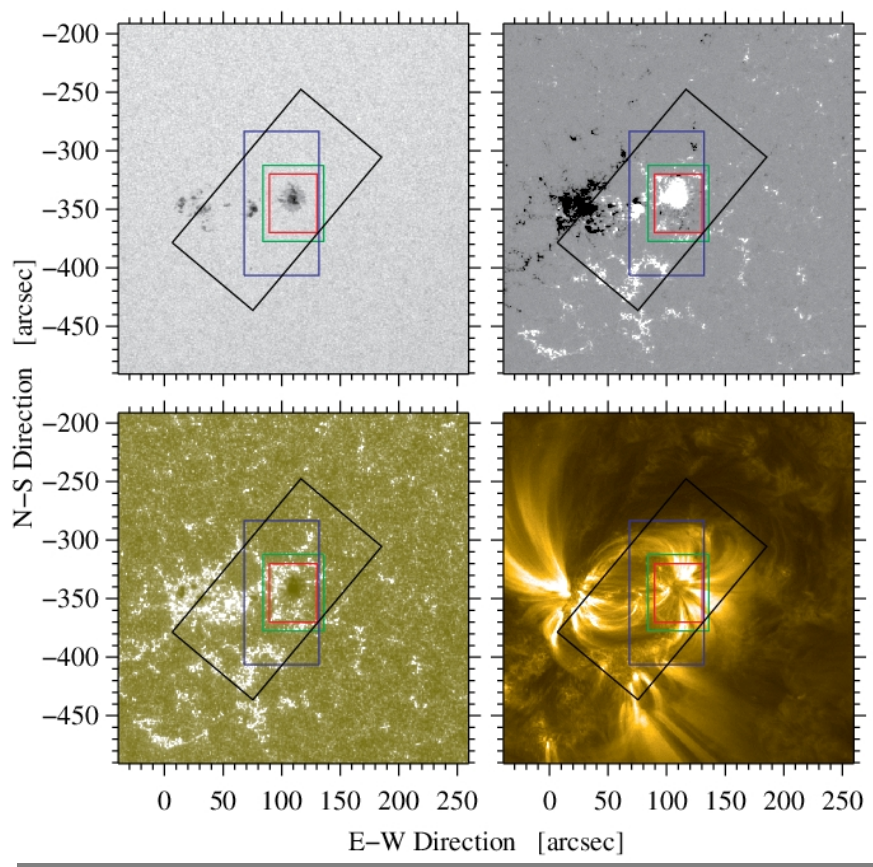
# Actual Observations

DATE	TELESCOPES	REGION
16/09/2016 – 19/09/2016	VTT, Hinode	AR12592, AR12593
20/09/2016	VTT, DST*, Hinode	AR12594
21/09/2016 – 23/09/2016	VTT, GREGOR, DST*, NST** Hinode***	AR12593
24/09/2016	VTT, GREGOR, NST, Hinode	AR12597
25/09/2016	NST, Hinode	AR12597
26/09/2016	VTT, GREGOR, Hinode	AR12597
27/09/2016	VTT, Hinode	AR12597
28/09/2016	VTT, GREGOR, DST, Hinode	AR12597
29/09/2016	VTT, GREGOR, Hinode	AR12597, Filament in NE

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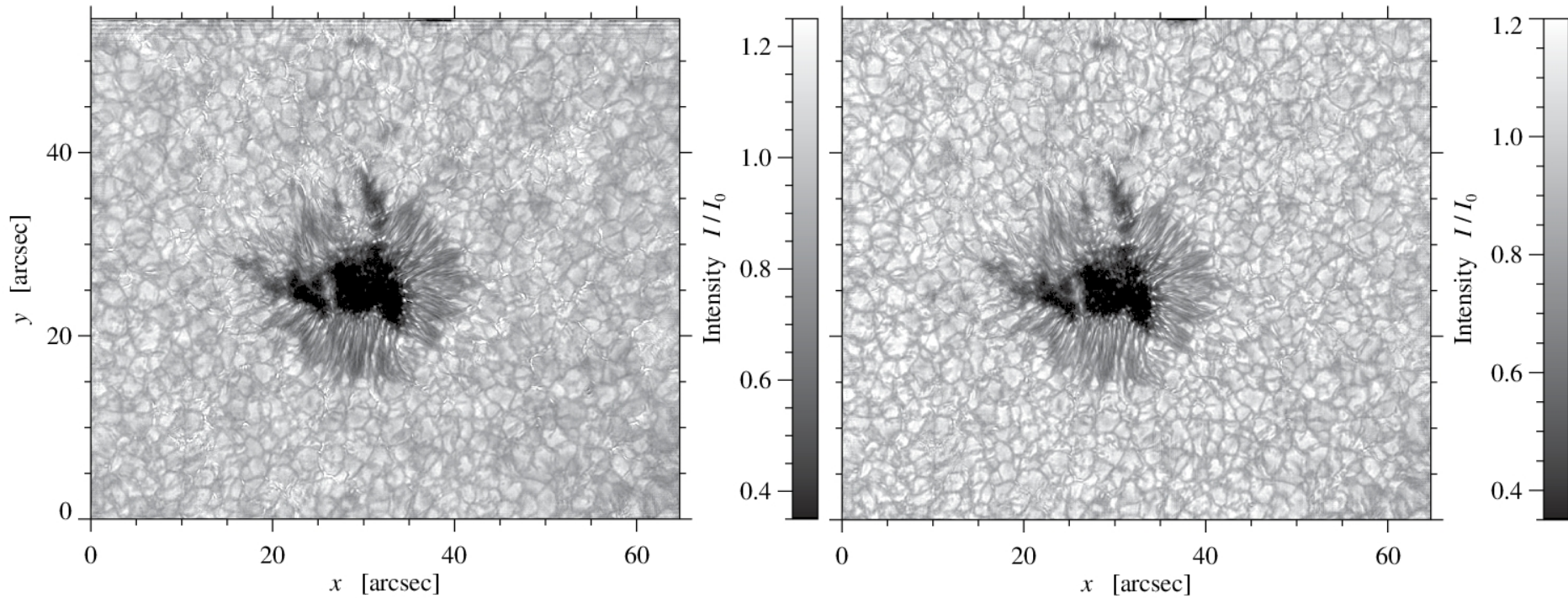
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# Leading sunspot in NOAA 12597



- Glimpse of data and very preliminary results
- 24 September 2016 08:52 UT
- Appeared on south east near disk center on 22 September
- Position on 24 September (110", -350") and classified as  $\beta/-$
- Focused on the leading spot
- Mature sunspot with decaying penumbra
- SDO – continuum, LOS magnetogram, 1600nm, and 171nm
- Boxes are FOV covered by GFPI, GRIS, Hinode, and VTT

# GREGOR High-resolution Fast Imager (HiFI)



G-band and Blue continuum images



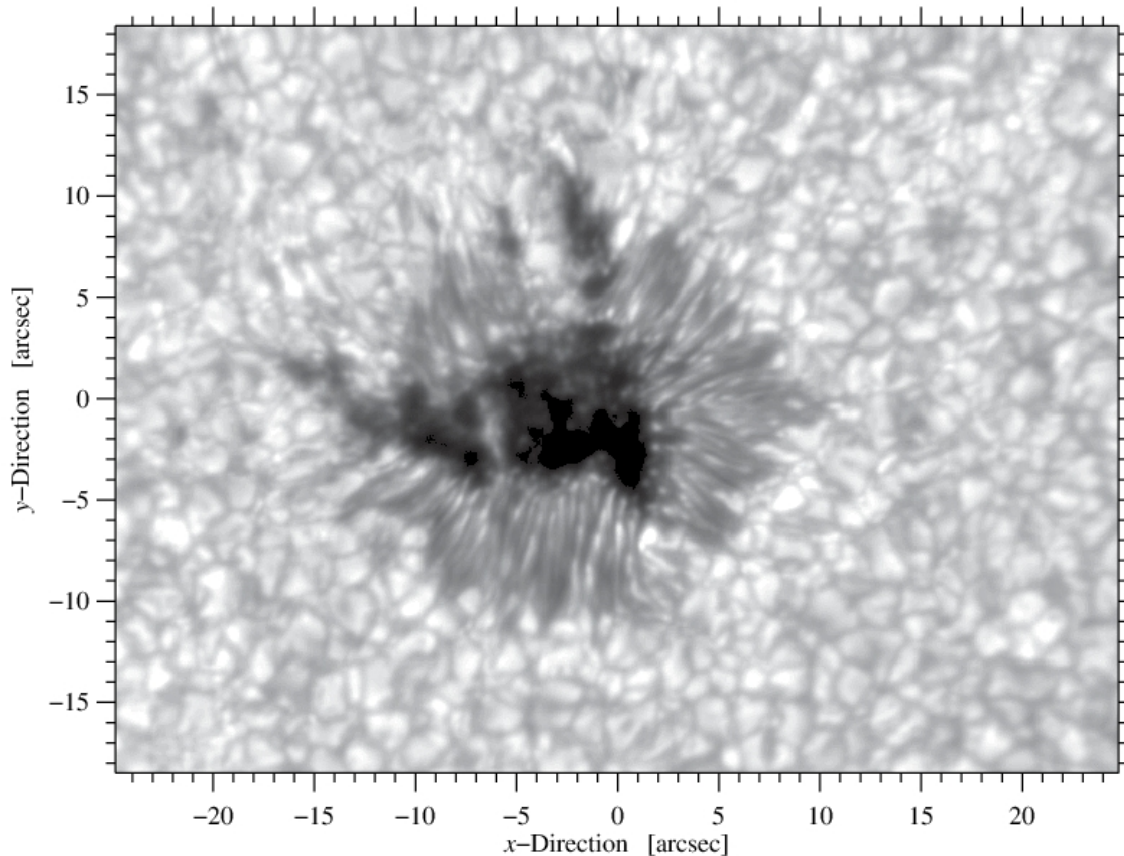
# GREOR Fabry-Pérot Interferometer (GFPI)



- Spectroscopic data in 617.3 nm Fe I line
- Exposure time 10~ms
- One line scan ~ 21 s
- ~ 170 scans
- Level1 & Level2 MOMFBD data
- Example of line scan

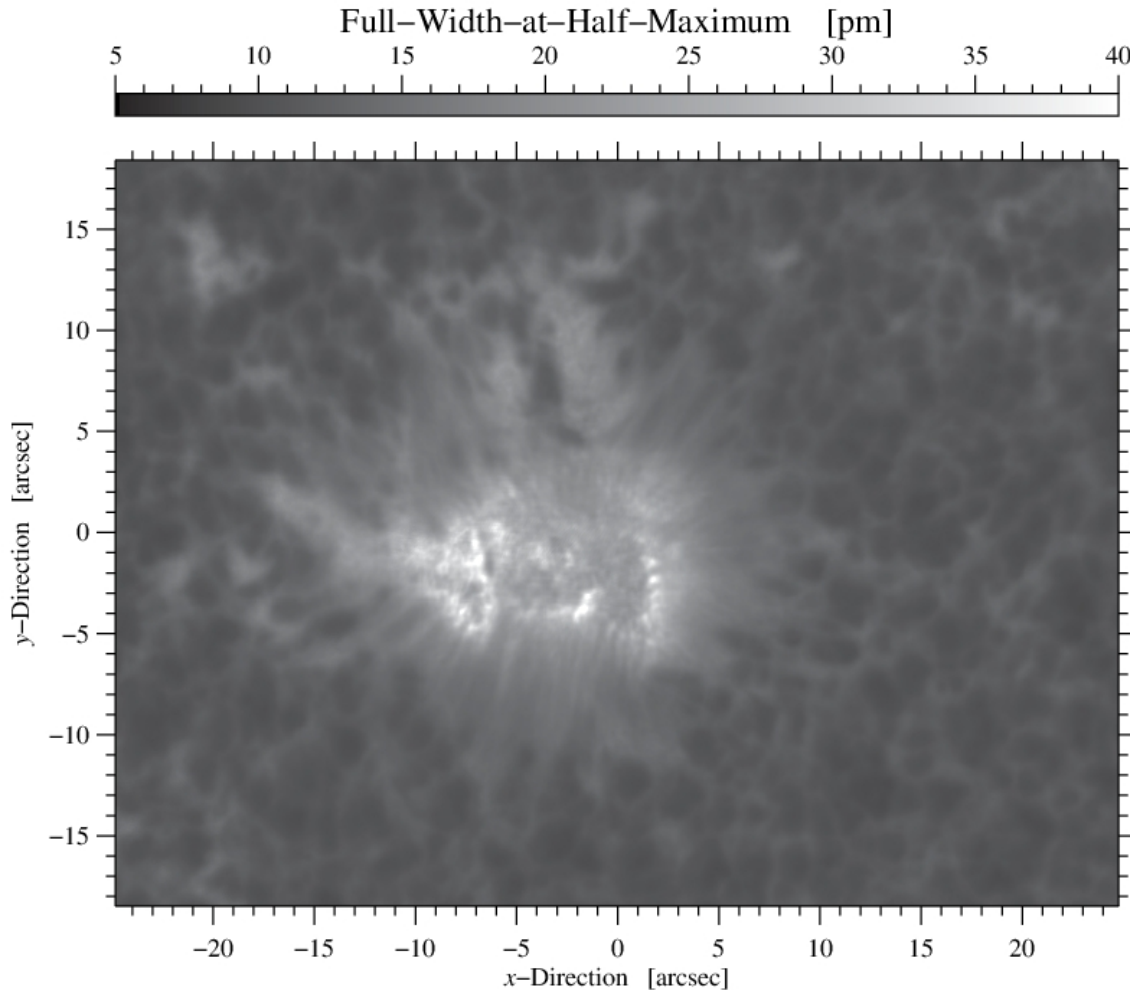
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Broad-Band Image



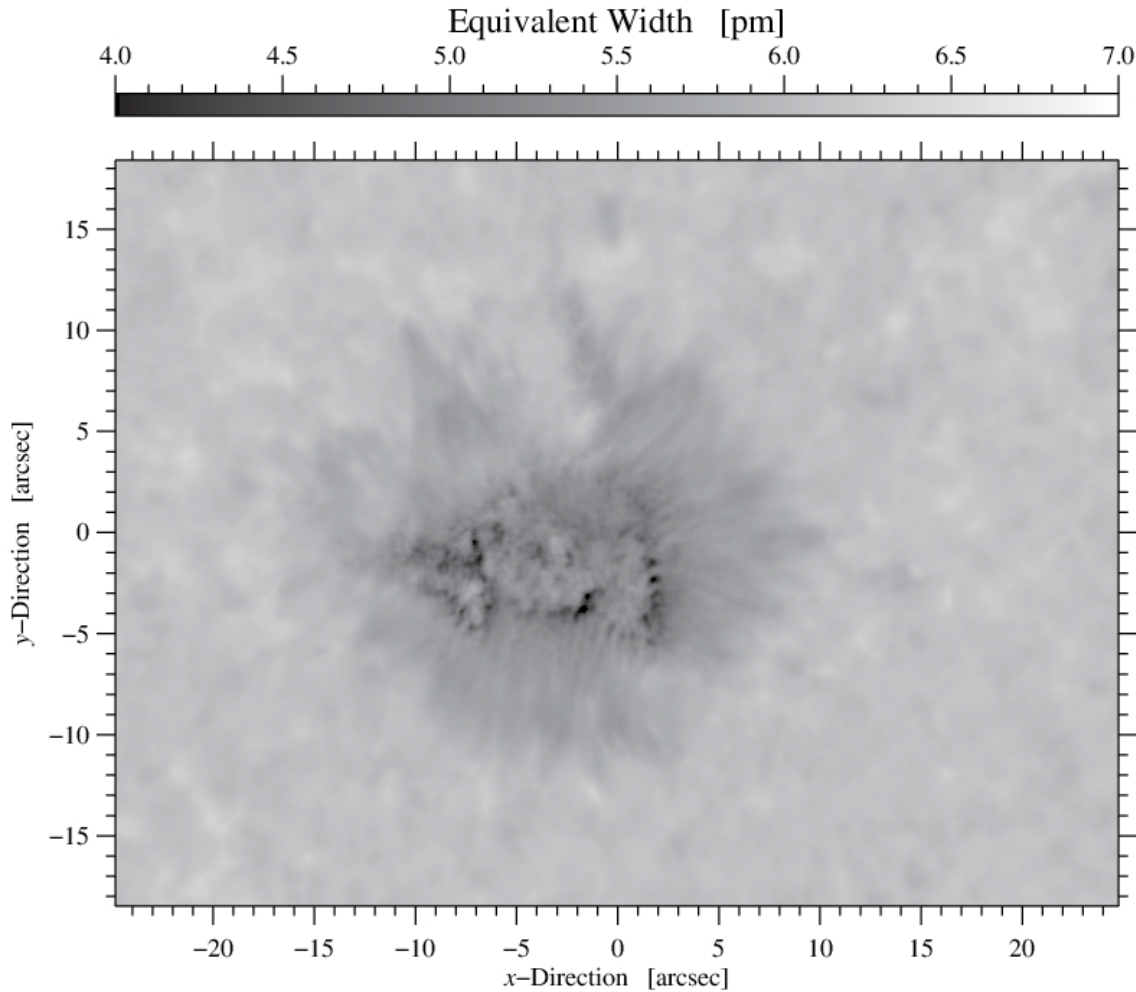
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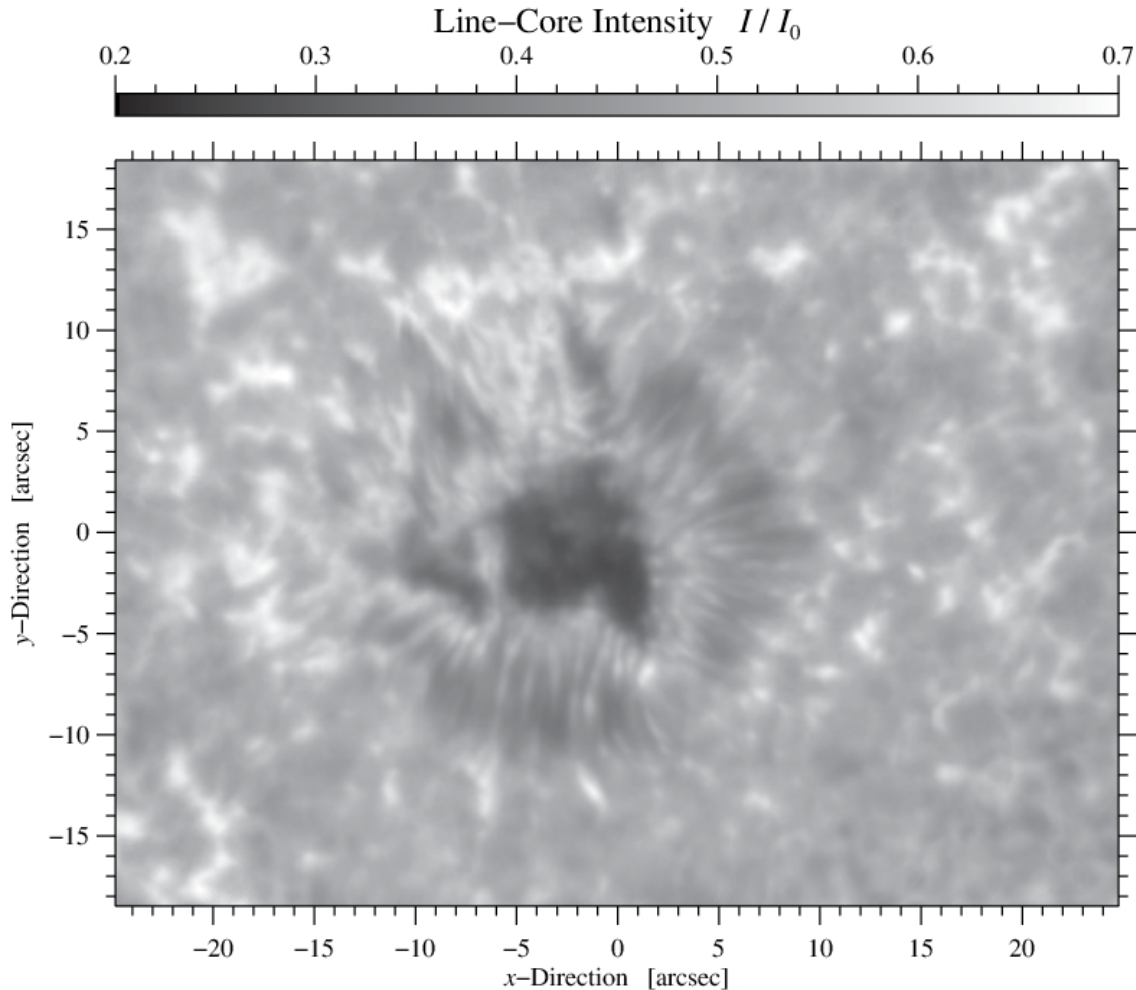
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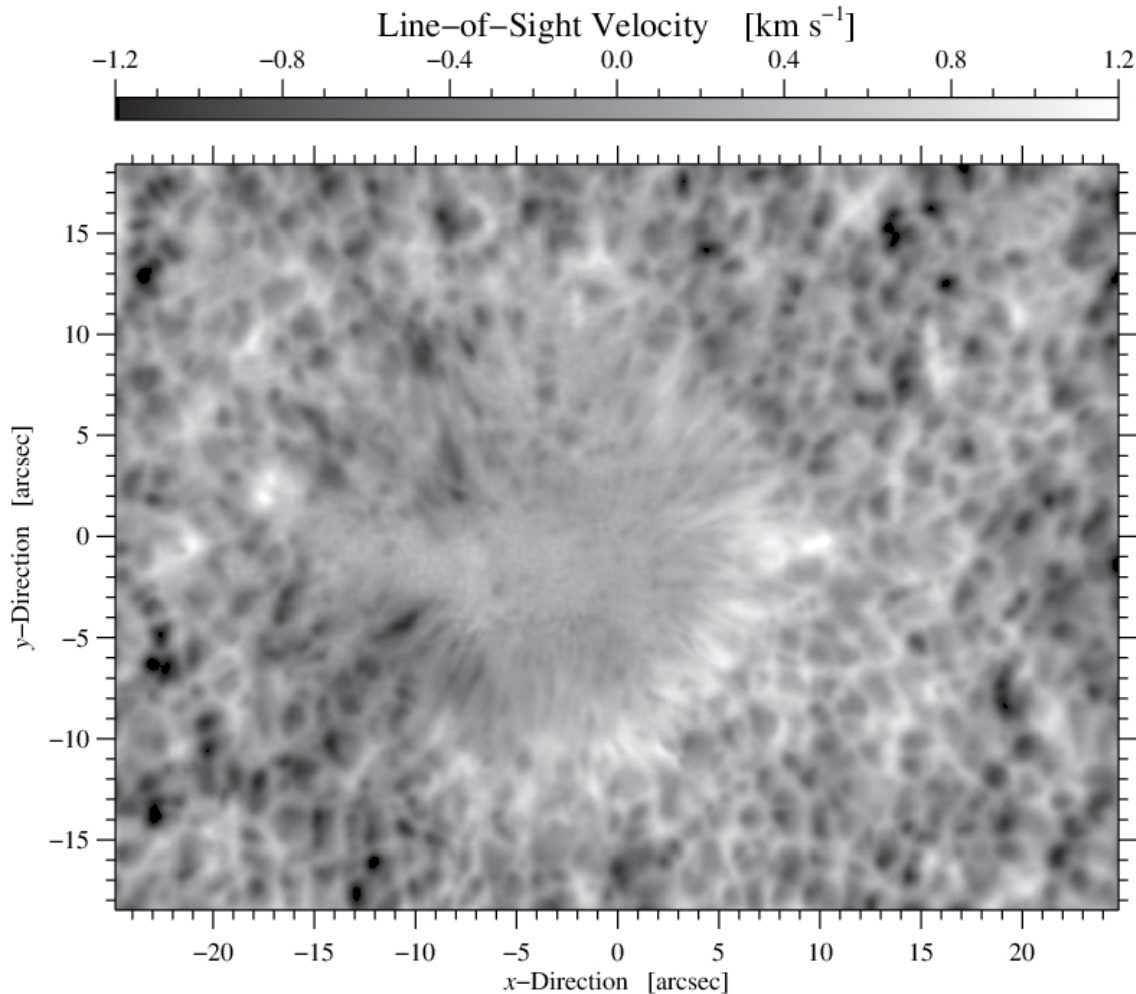
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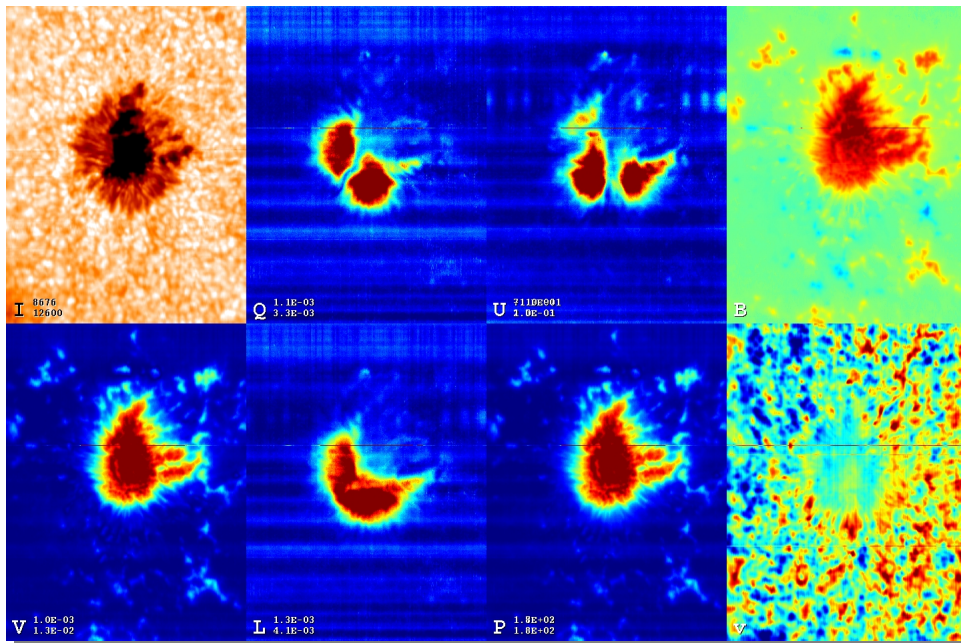
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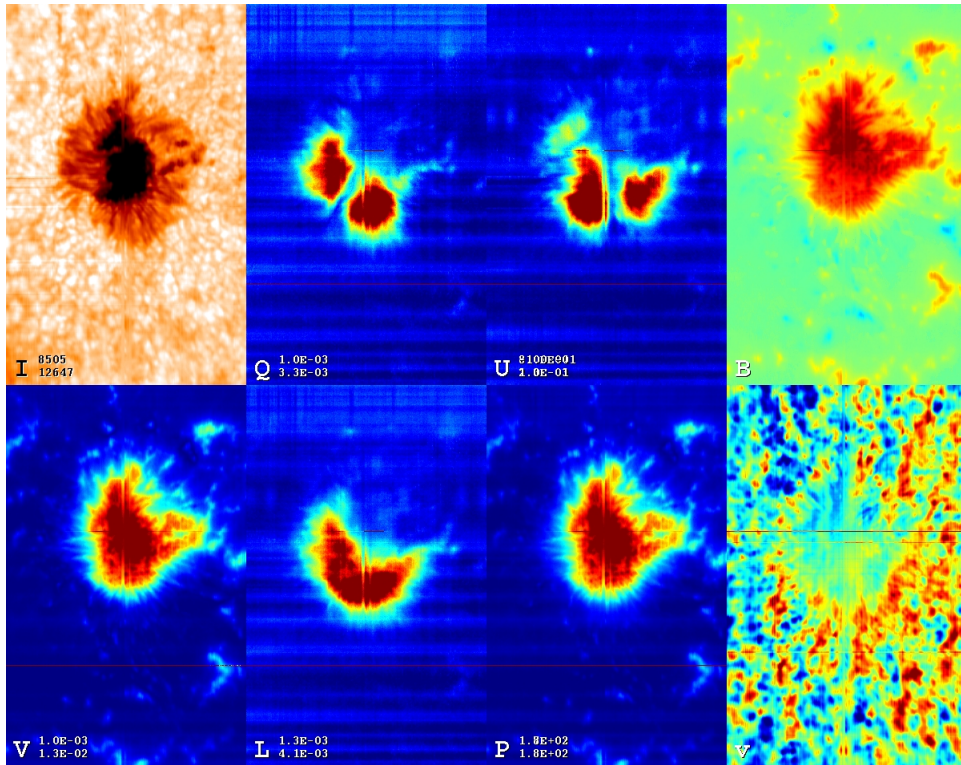
# GREGOR Infrared Spectrograph (GRIS)



- IQUV Stokes Spectra
- Si I ( $\lambda 1082.7\text{nm}$ , photosphere)
- He I ( $\lambda 1083.0\text{ nm}$ , chromosphere)
- Two scans
  - 09:02 UT
  - 10:30 UT
- 360/300 steps covering FOV of  $62'' \times 52'' / 62'' \times 42''$
- Infer magnetic field information

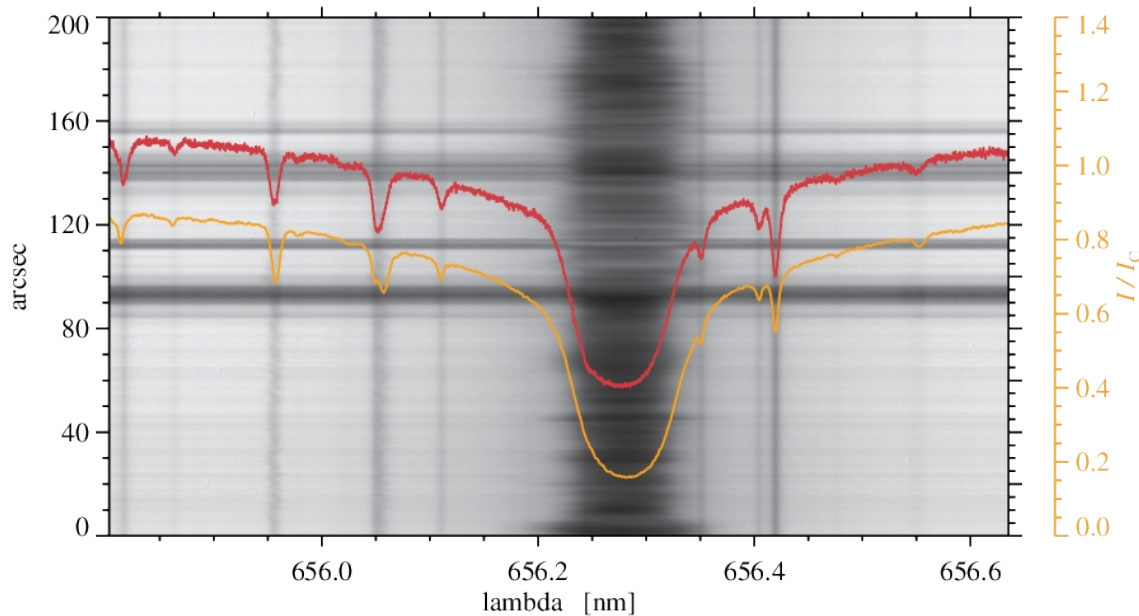


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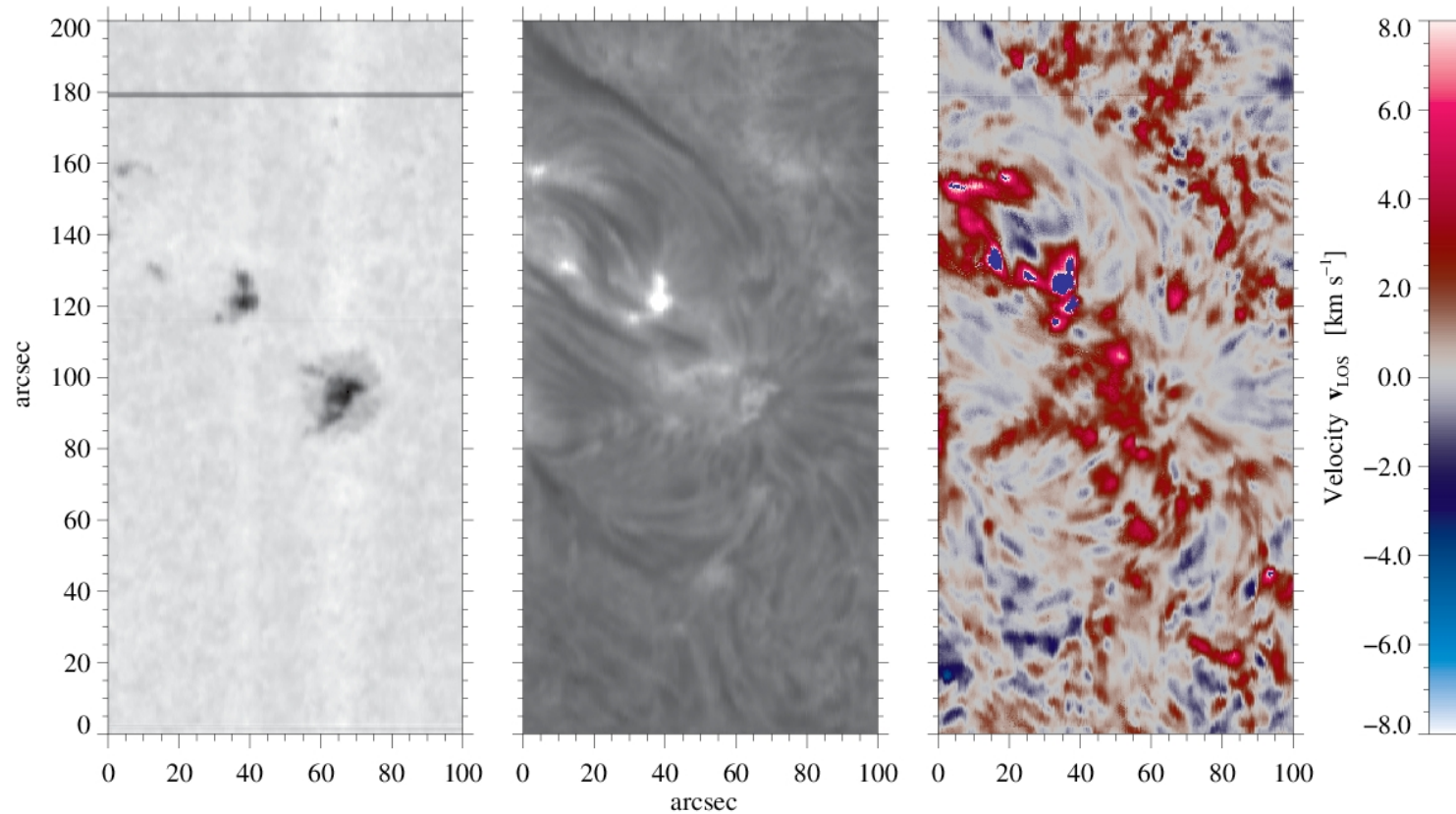
# H $\alpha$ and NaD<sub>2</sub> Spectra (VTT)



Red → observed spectra  
Orange → Atlas spectra

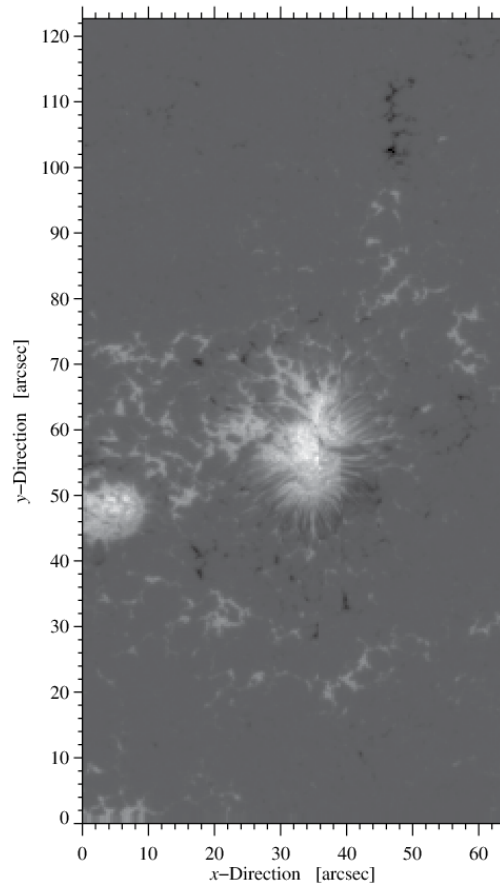
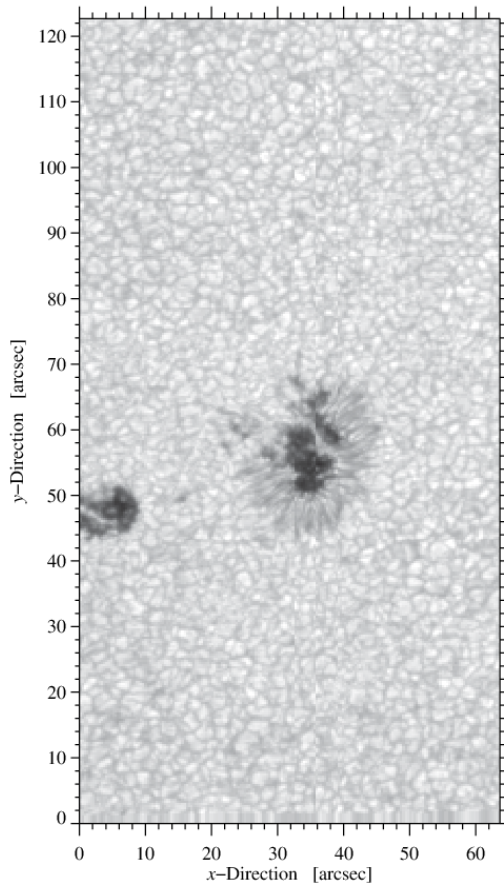
- Observations in H $\alpha$  ( $\lambda$ 656.3nm) and Na D<sub>2</sub> ( $\lambda$ 589.0nm)
- The two-dimensional FOV was scanned with a spatial step of 0.32'' and 312 spectra were recorded in a sequence.
- A sequence takes about 15 minutes and covered a FOV of  $\sim 200'' \times 100''$
- Chromospheric evolution of active region NOAA 12597

# H $\alpha$ – Maps



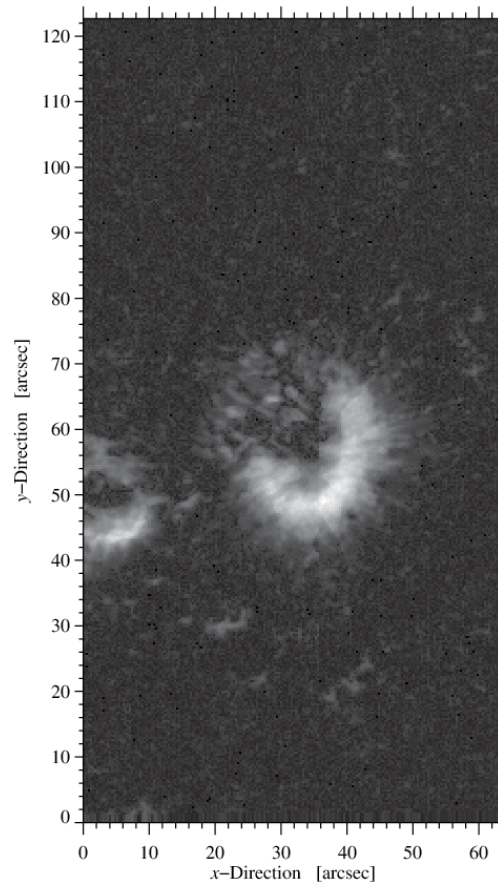
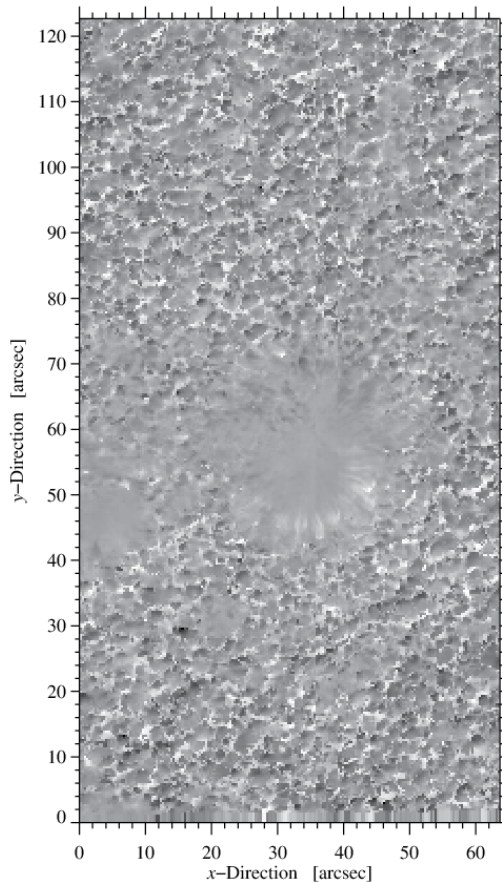
The chromospheric fibril structure can be traced

# Hinode Spectro-Polarimeter (SP)



- Coordinated with US observatories
- Measures four stokes parameter in 630.1 – 630.2 nm line pair
- SP fast maps
- Cover FOV 64'' x 123''
- Quick look data available
- Level 1 and Level 2 with MERLIN code
- Continuum, B-longitudinal, Doppler velocity, B transverse at 14:30 UT

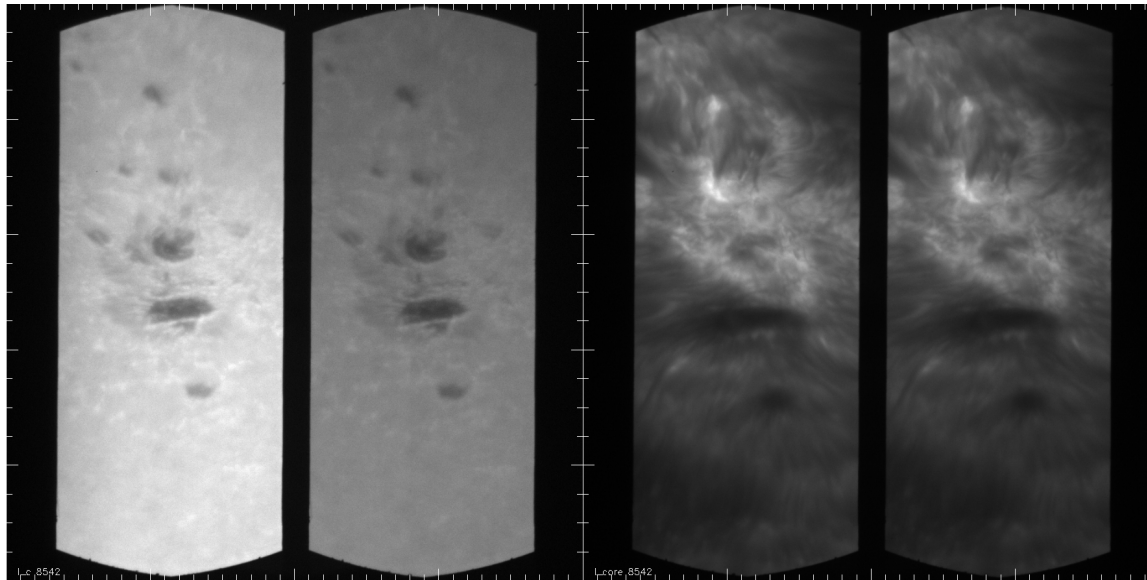
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# There is more data!!

- NST – On 24 September 17:00 UT : PCO TiO, FISS – H $\alpha$  and Ca II 854.2 nm, NIRIS – 1083.0 nm
- DST - Followed same region on 27/28 September
- IRIS – Spectra as well as Slit-jaw images



# Future Work

- Glimpse of the potential of coordinated observing campaign
- Preliminary results of multi-wavelength study
- Further steps include
  - Magnetic field and area evolution (SDO)
  - Inversion of GRIS data → Si I, He I
  - Inversion of Hinode data
  - LCT on GFPI and HiFI data
  - Cloud Model inversion of H $\alpha$  spectra
  - Analysis of NST data

*Thank you!*

