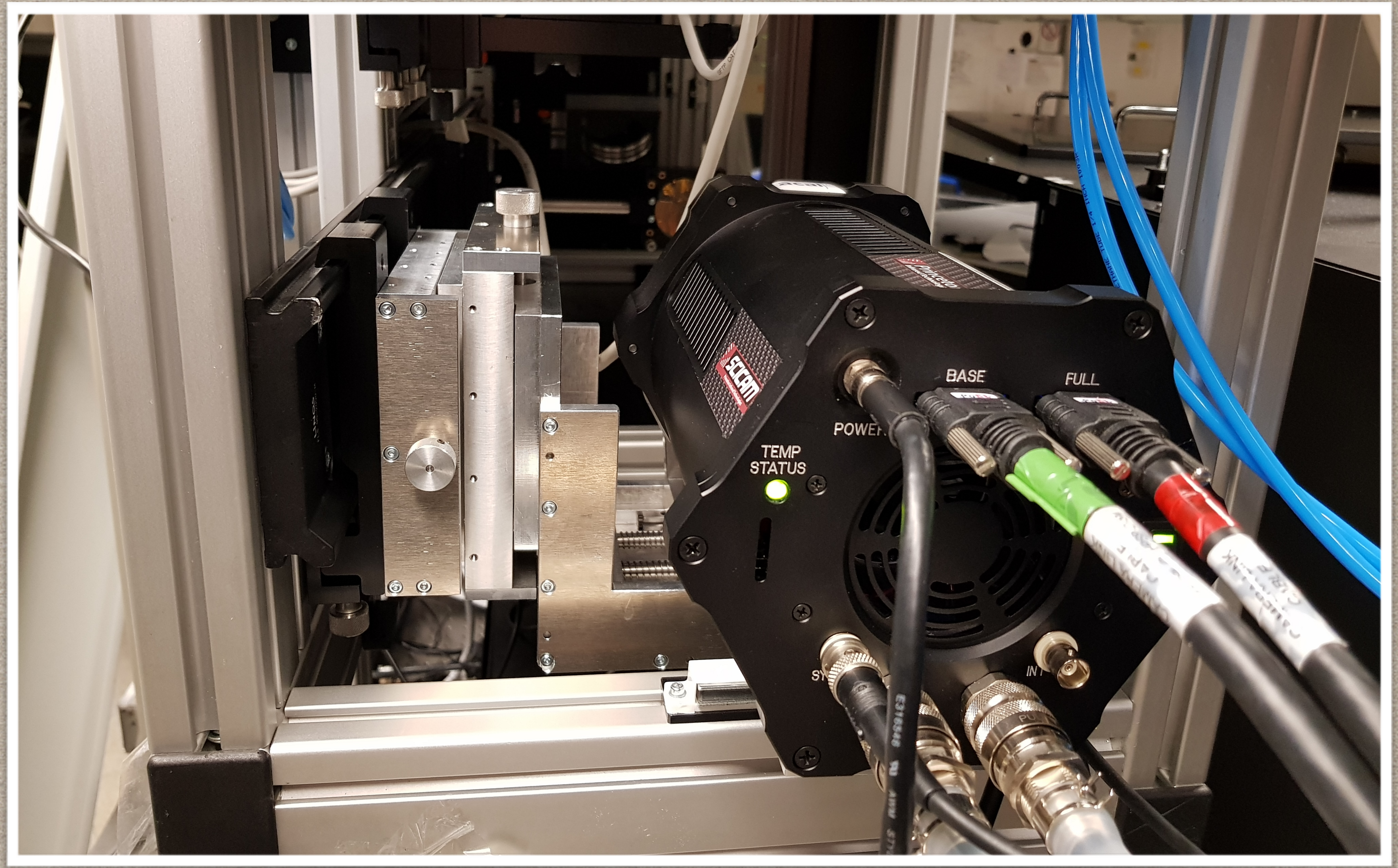


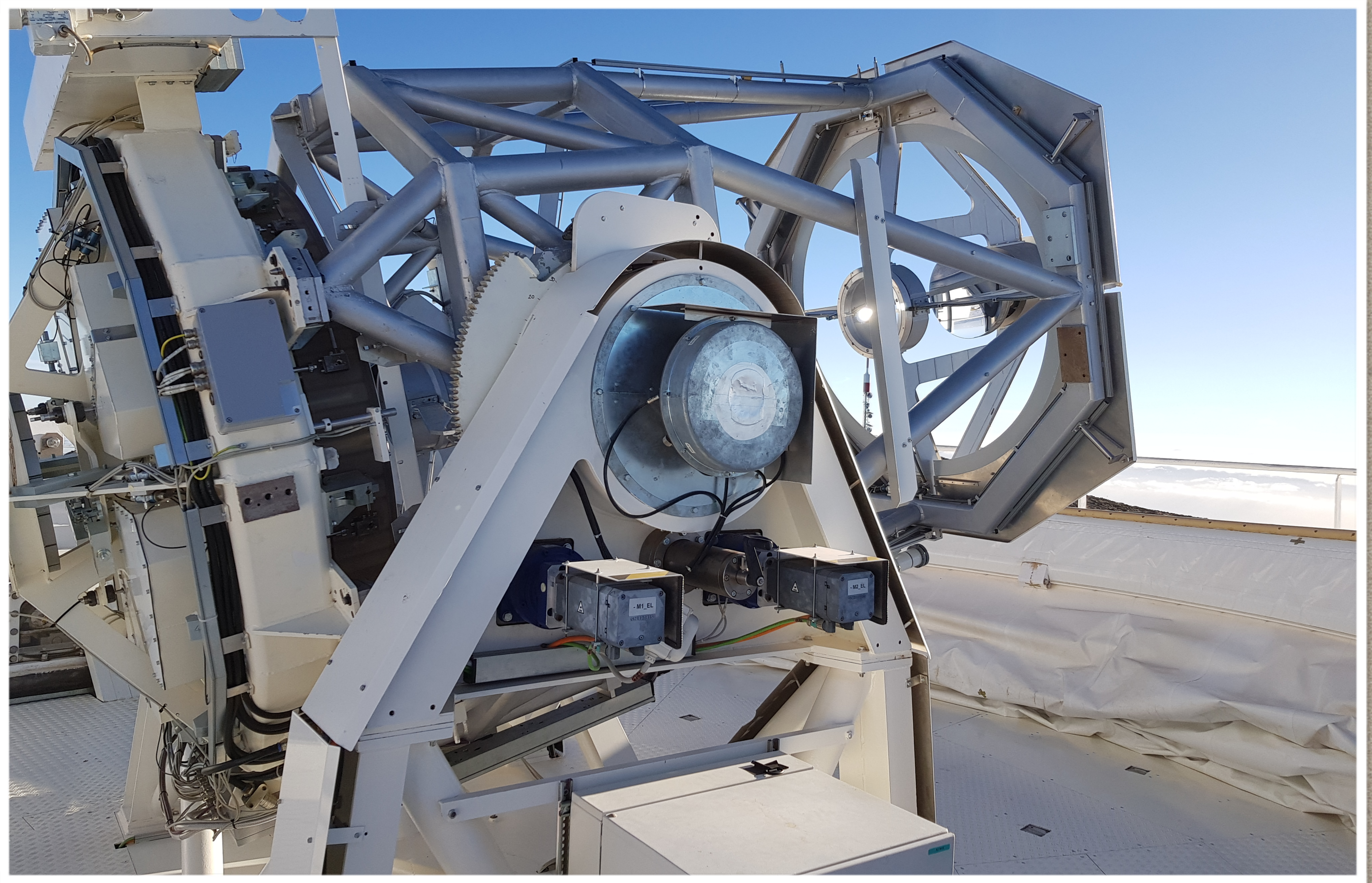
GRIS+ ∘ Why GREGOR Needs New Eyes

Andreas Lagg, H.-P. Doerr, F. Iglesias, M. van Noort and the GRIS+ Team
MPI for Solar System research, Göttingen

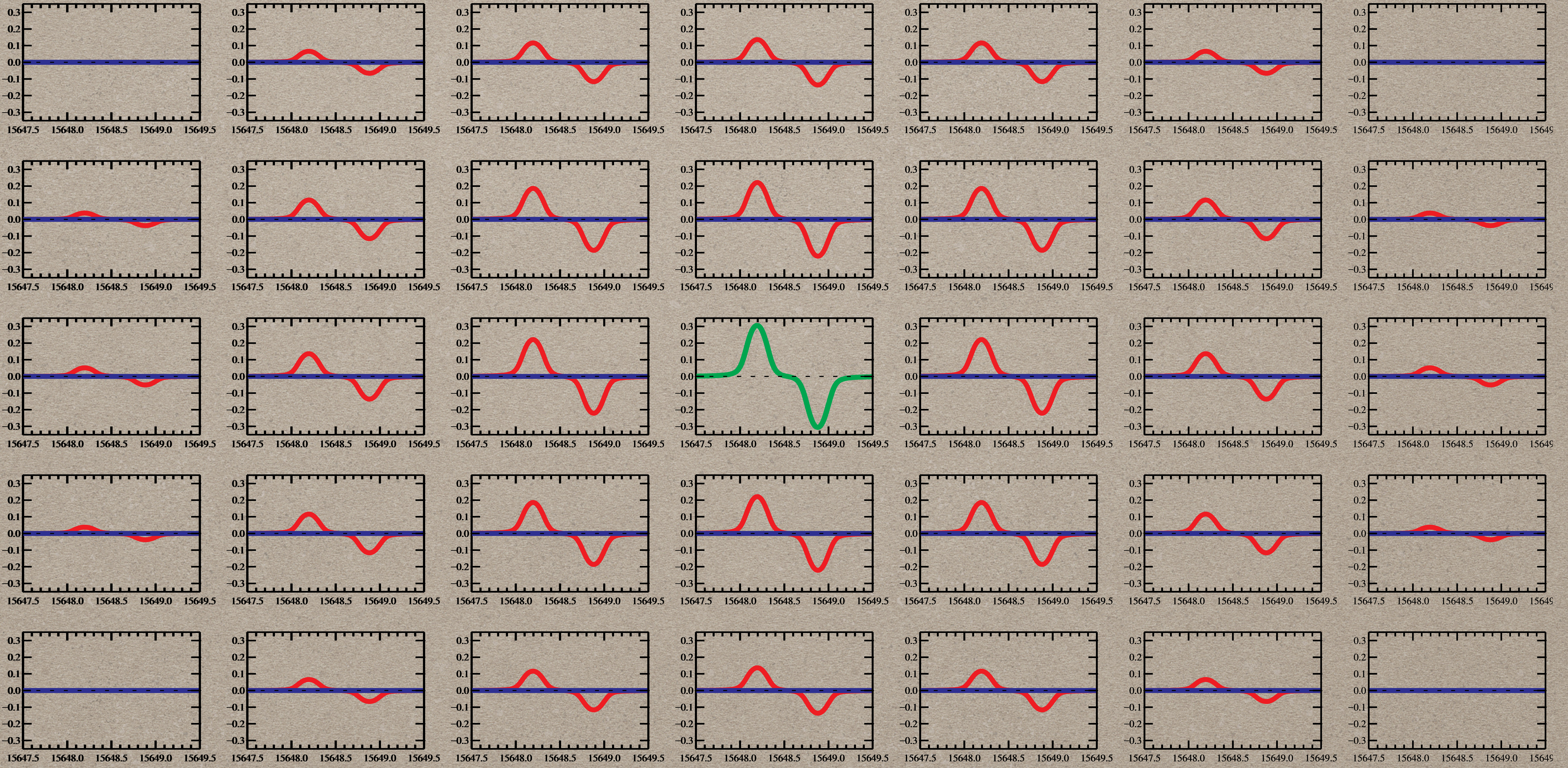
Motivation for GRIS+

- GRIS is scientifically successful
- GREGOR performs well in the IR
- IR highest magnetic sensitivity
- Interesting lines for photosphere & chromosphere:
  - He 10830 (incl. Si 10827, Ca 10834, Ca 10838)
  - Fe 15650 (g=3, 50–100 km deeper than 630 nm), (Fe 15550 –> Smitha)

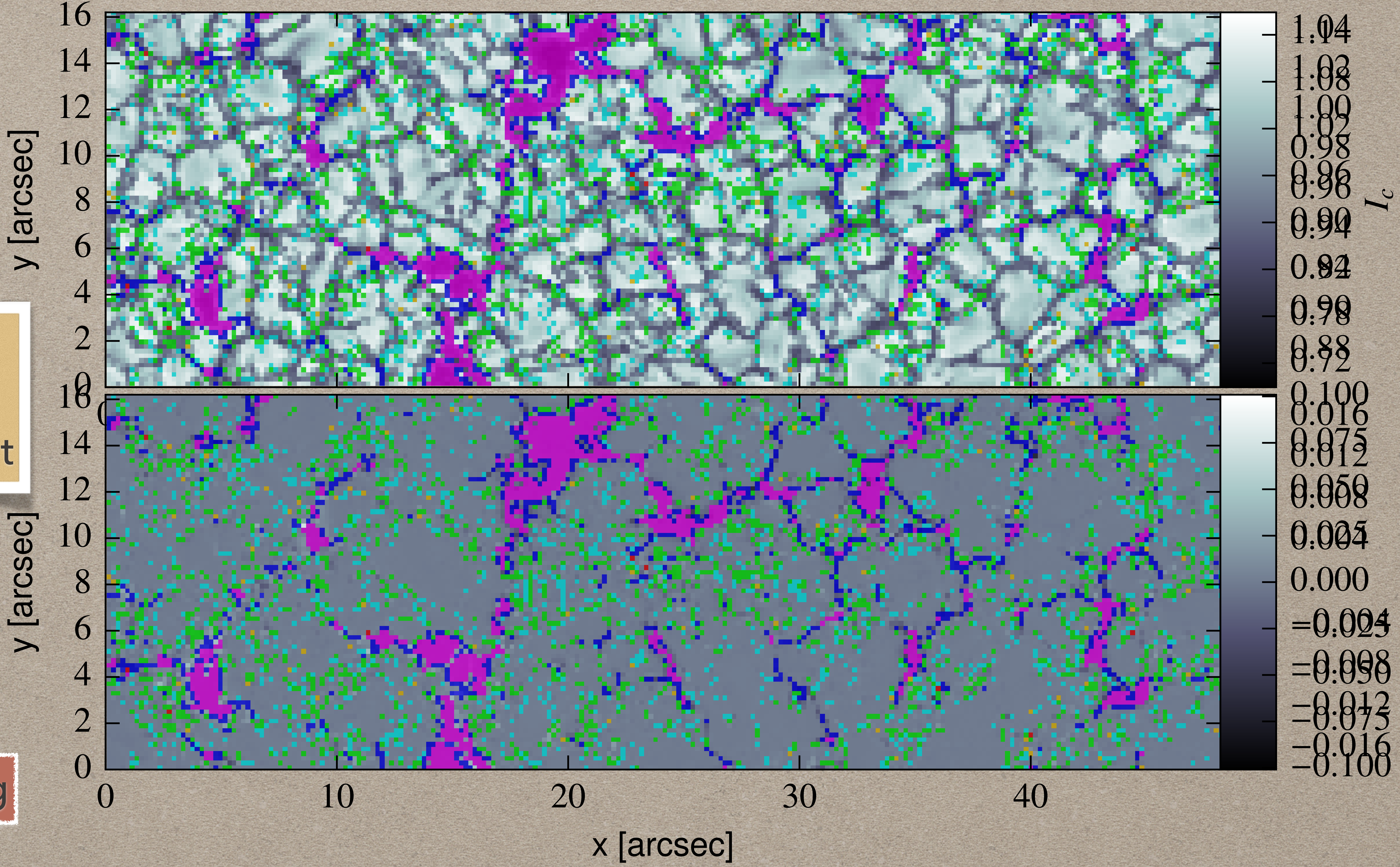
- Spatial resolution not at diffraction limit
- Photon efficiency too low



History - Diffraction Limited Spectro-Polarimetry



The problem: Unknown PSF influences Interpretation

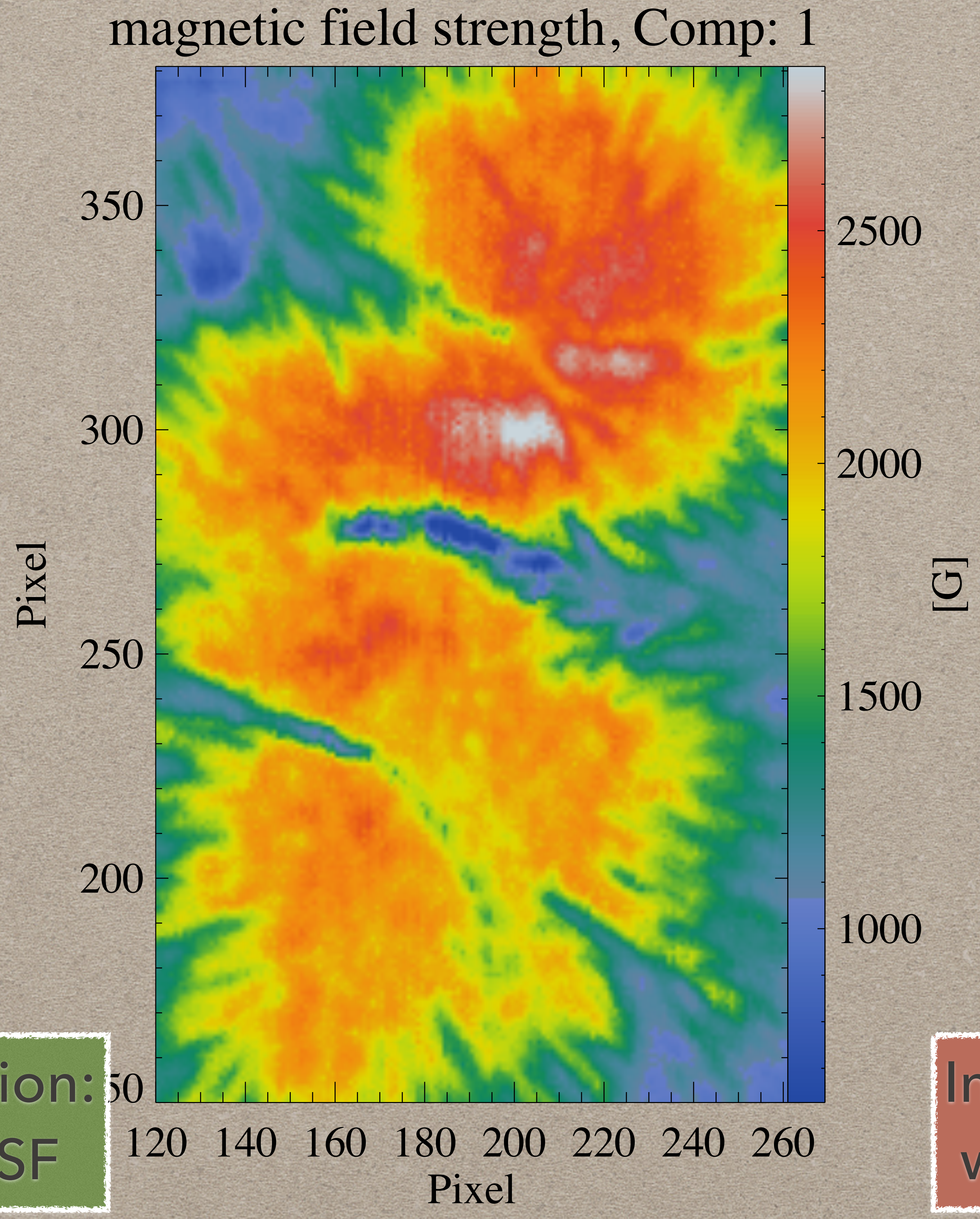


Example 1:
Strong fields in a quiet environment

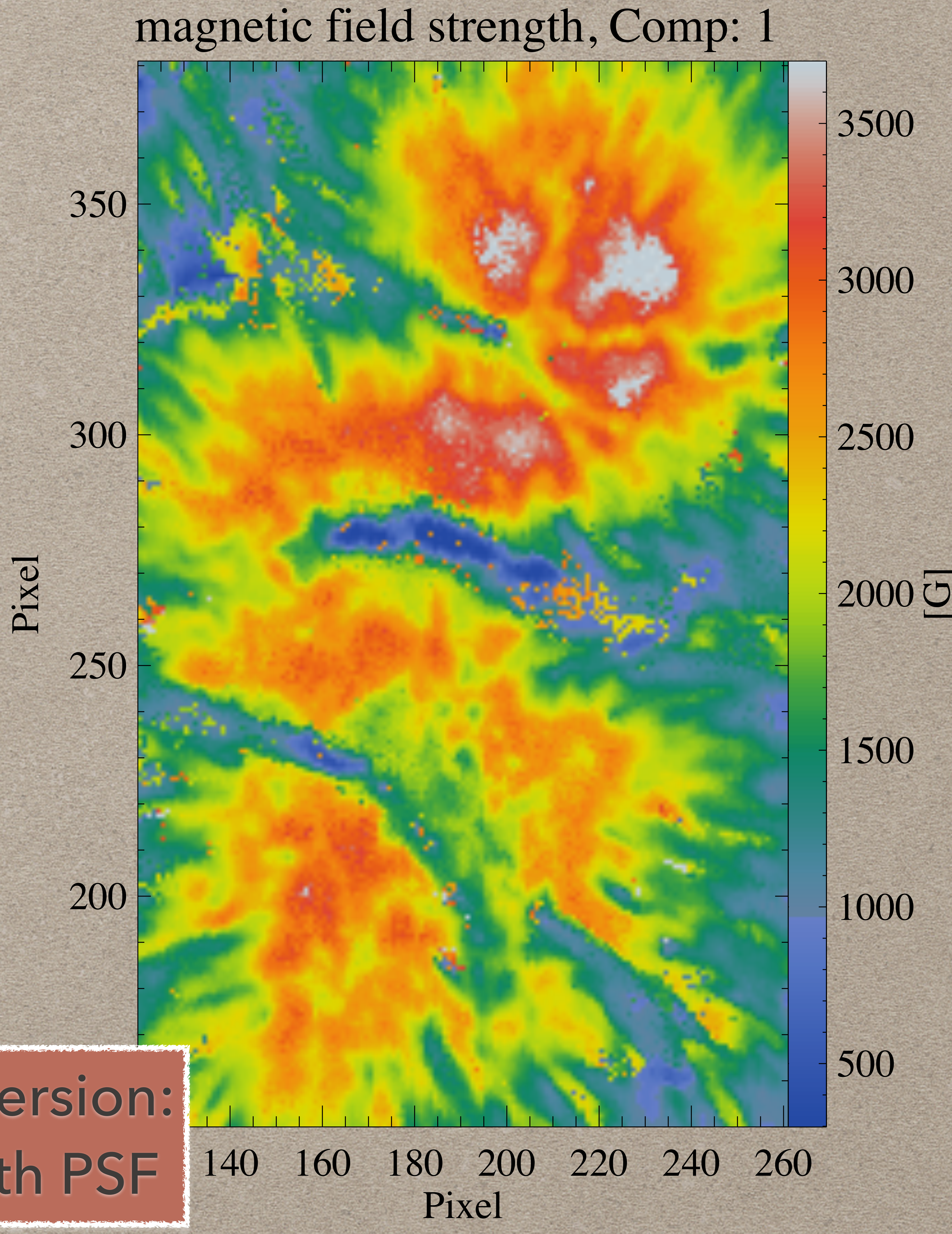
PS No PSF ng

The problem: Unknown PSF influences Interpretation

Example 2: Weak fields in a strong B regions

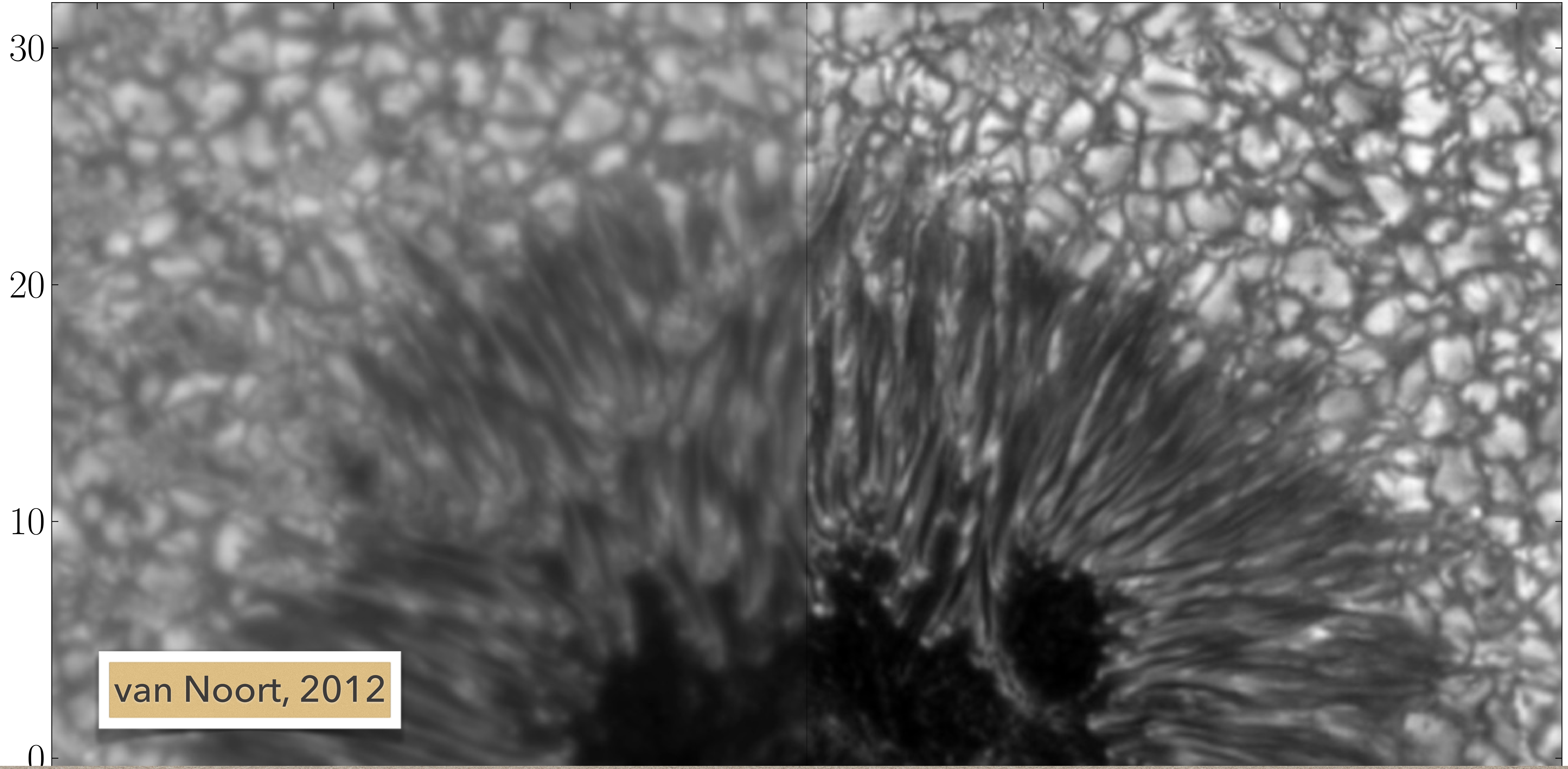


Inversion: no PSF



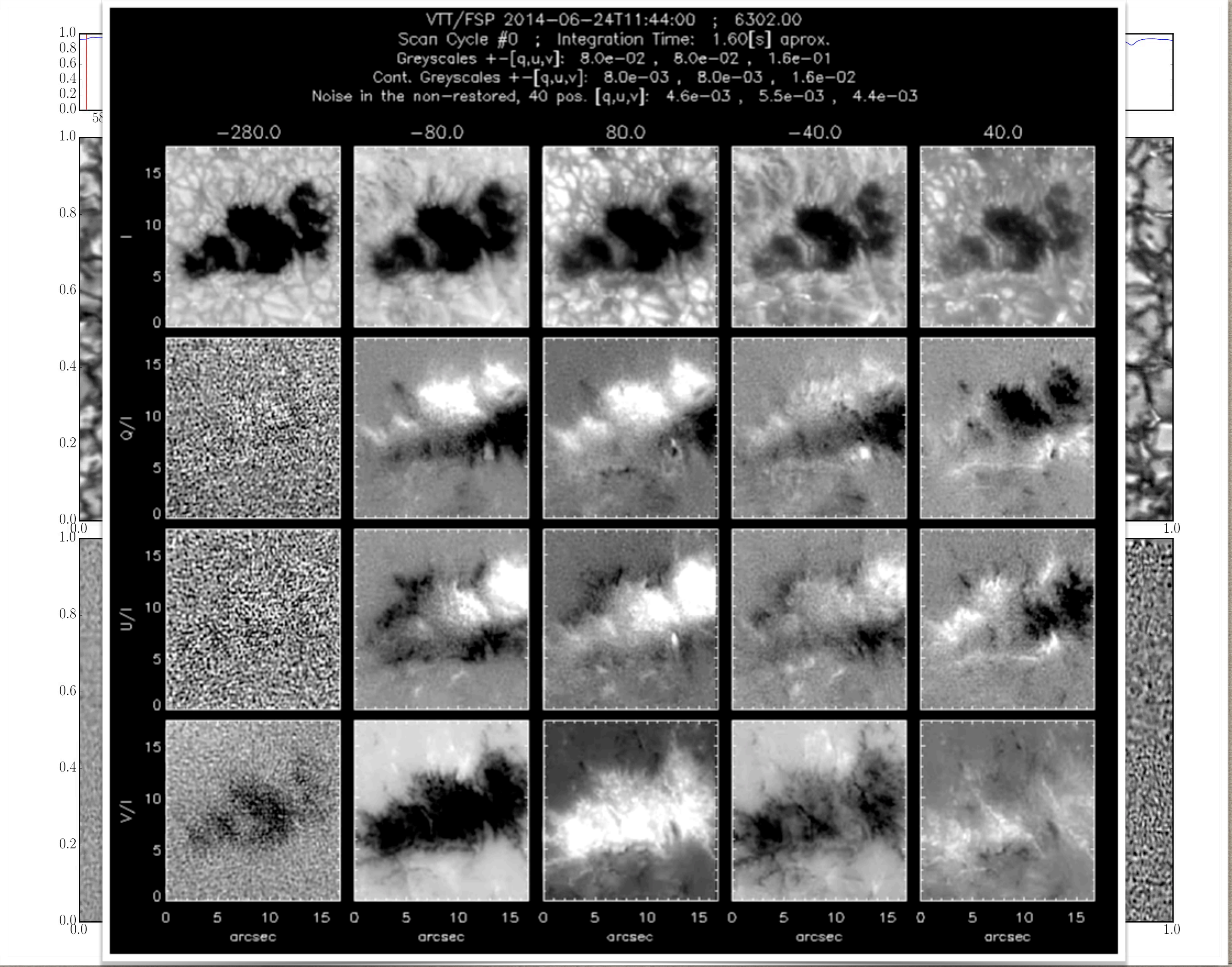
Inversion: with PSF

The Solution: Know your PSF



MPS Instrument Development Followed…

1. Fast Solar Polarimeter (FSP + FSP2, Alex Feller)
2. Microlens Hyper Imager (MiHI, Michiel van Noort)
3. Reconstruction of slit spectra (with TRIPPEL@SST, Michiel van Noort)
4. GRIS+ (Hans-Peter Doerr, Francisco Iglesias)



MvN: It occurred to me…

Astronomy & Astrophysics manuscript no. ms
November 23, 2017

Image restoration of solar spectra

M. van Noort

Max-Planck Institute for Solar System Research, Justus-von-Liebig-Weg 3, D-37077 Göttingen, Germany

Draft: 4:12pm November 23, 2017 (*CVS version 1.2, checked in by noort on 2015-01-14, 09:29:41 UT*)

ABSTRACT

Context. When recording spectra from the ground, atmospheric turbulence causes degradation of the spatial resolution.
Aims. We present a data reduction method that restores the spatial resolution of the spectra to their undegraded state.
Methods. By assuming that the point spread function (PSF) estimated from a strictly synchronized, broadband slit-jaw camera is the same as the PSF that spatially degraded the spectra, we can quantify what linear combination of undegraded spectra is present in each degraded data point.
Results. The set of equations obtained in this way is found to be generally well-conditioned and sufficiently diagonal to be solved using an iterative linear solver. The resulting solution has regained a spatial resolution comparable to that of the restored slit-jaw images.
Conclusions. We have developed a new image restoration method for the restoration of ground-based spectral data over a large field of view. The method builds on the PSF information recovered by the MOMFBD code and typically reaches a spatial resolution comparable to that of the broadband slit-jaw images used to recover the PSF.

Key words. Techniques: imaging spectroscopy, methods: data analysis, numerical

SPECTRAL RECONSTRUCTION: THE METHOD

Image data (SJC):

- based on Multi-Frame Blind Deconvolution (MFBD, Löfdahl, 2002; van Noort, 2005)
- assumption of spatially independent transfer function over 5″x5″ (1-m class telescope)
- image recording must be significantly faster than timescales of wavefront changes (seeing-freezing, typically 10 ms for 1m)

➟ obtain SJC PSF

Spectroscopic data:

- required: low readout noise, high duty-cycle, fast detectors
- slit transmits only 1 spatial dimension, low photon flux
- seeing / jitter + scanning adds 2nd spatial dimension (note: discrete scanning is disadvantageous!!)

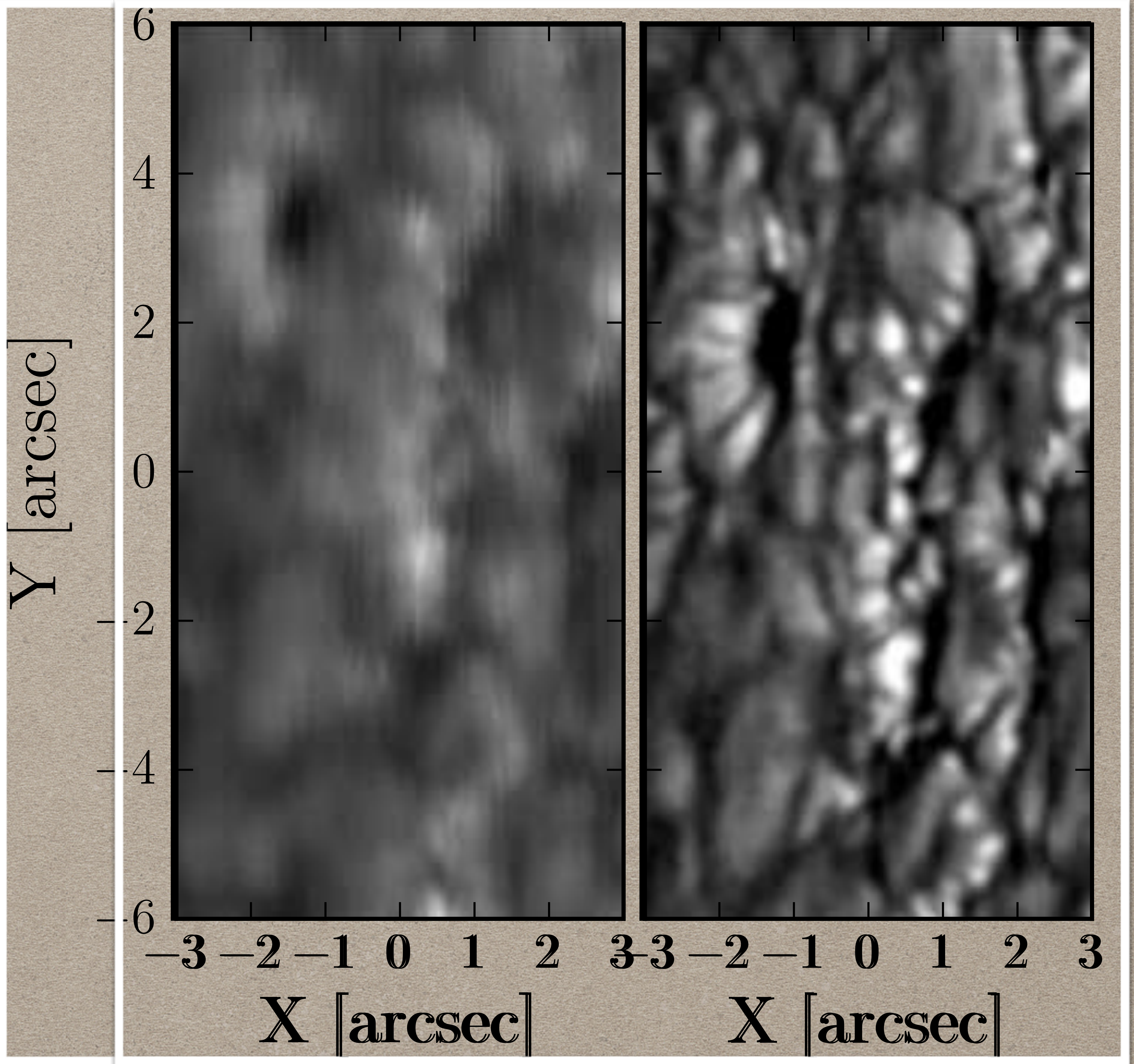
➟ apply SJC PSF

- typically 10^7 variables, solved in segments of 10^4

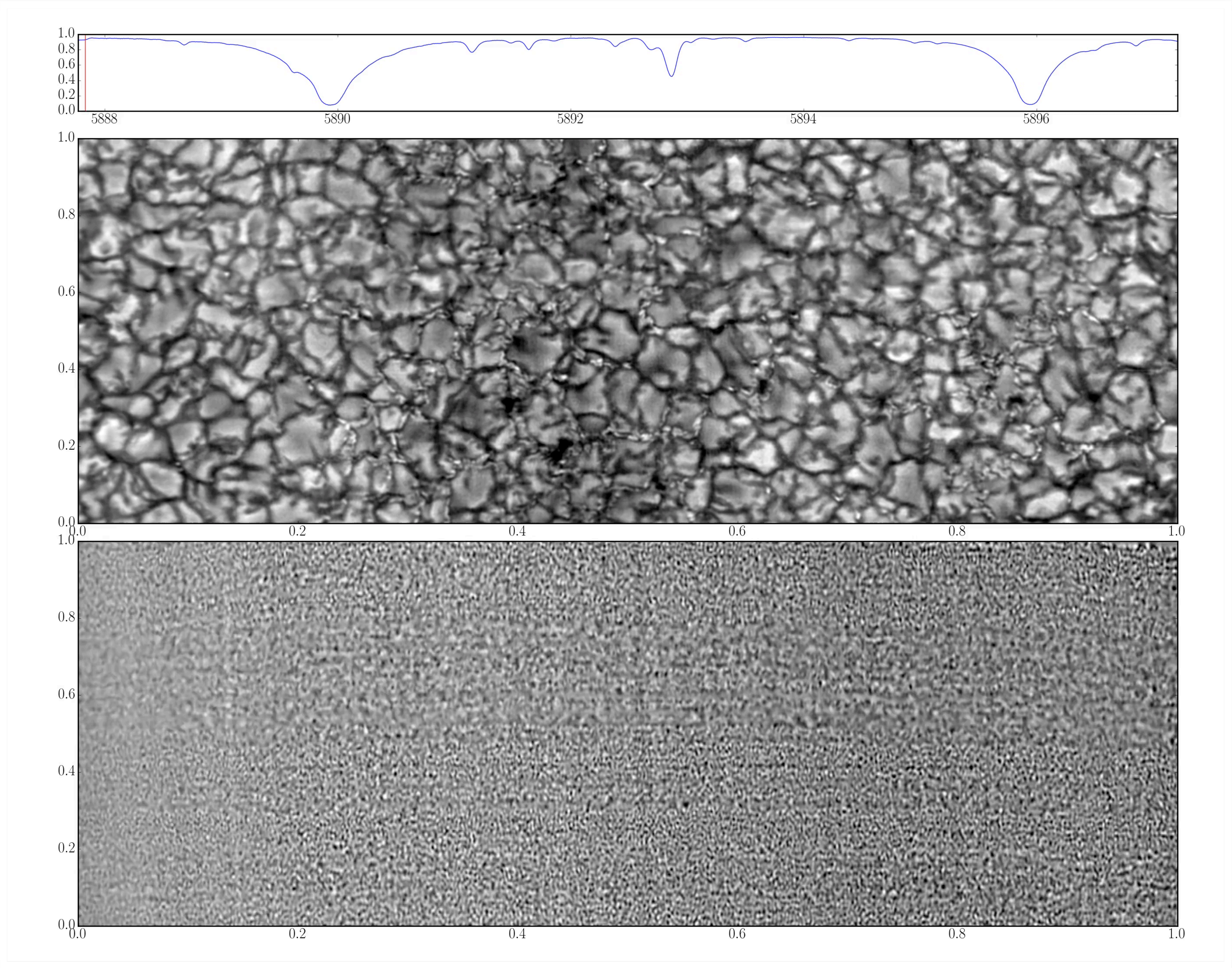
Original idea: C. Keller et al., 1995

Spectral Reconstruction

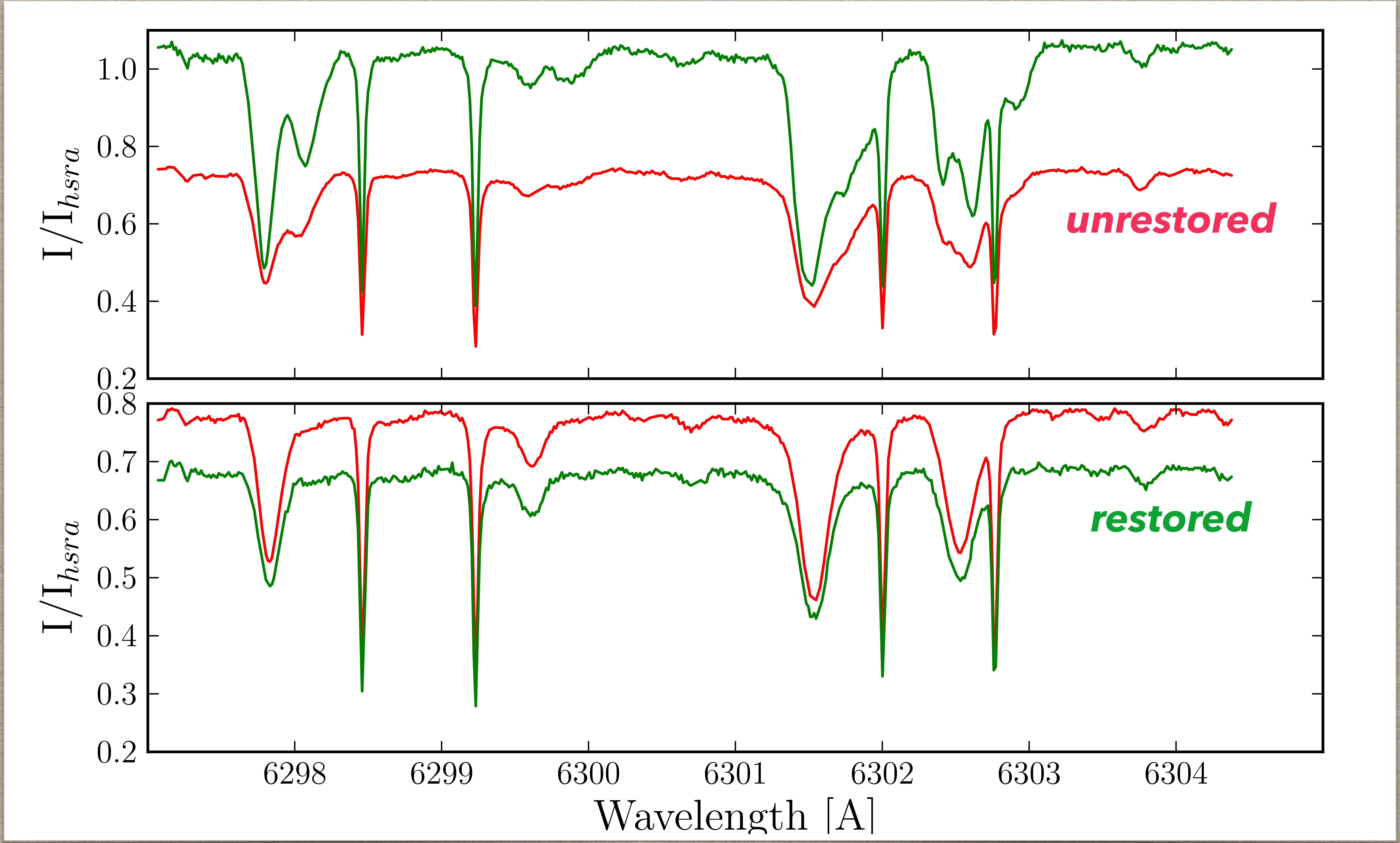
- Diffraction limit can be reached even for spectropolarimetric data
- Constant quality during whole scan (seeing fluctuations enter mainly into the noise level)
- Reconstruction
  - increases noise level
  - increases signal



Scan with TRIPPEL @ SST: Stokes I & V



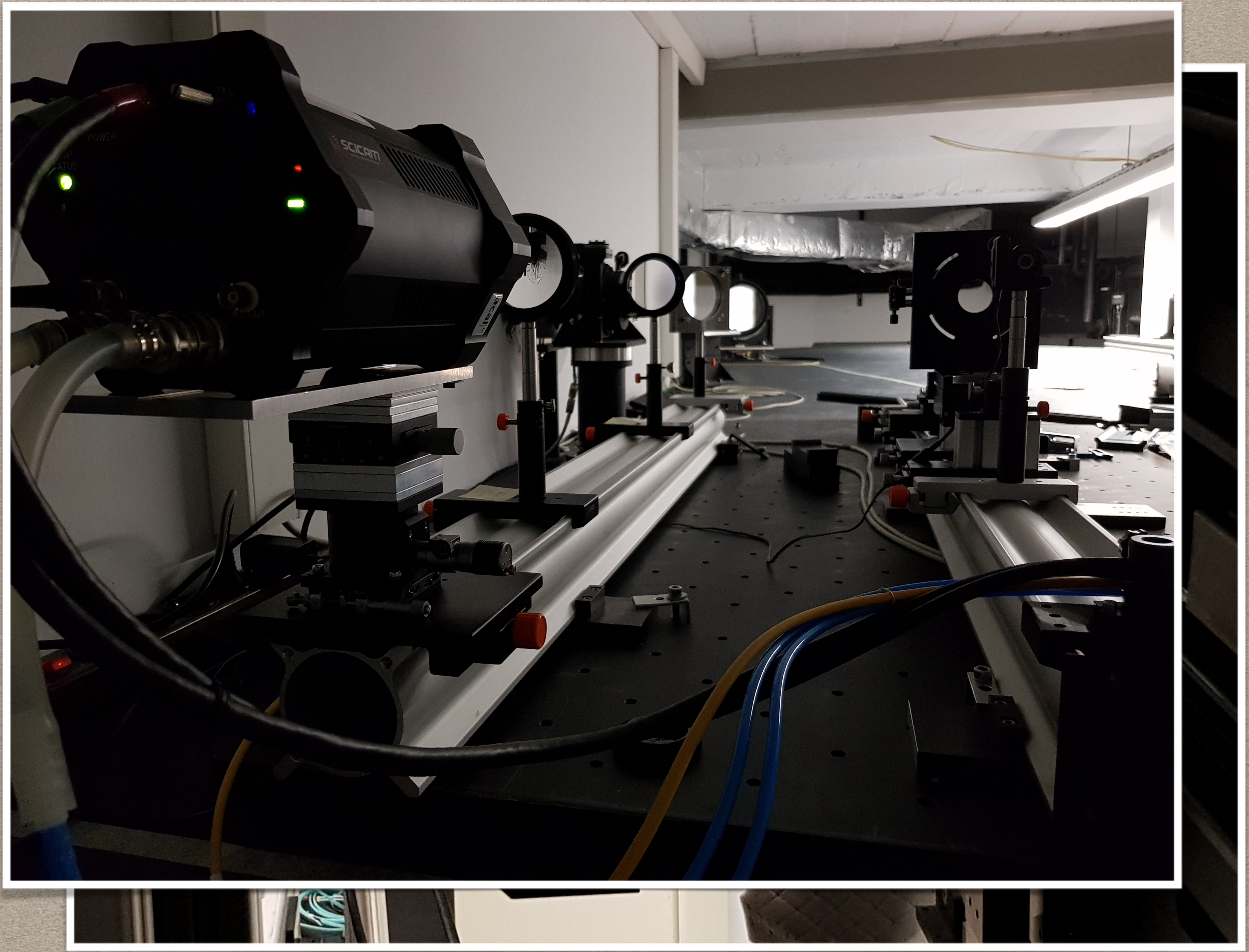
Scan with TRIPPEL @ SST: Restored Spectra



GRIS+ - Status

- spectrograph camera: mounted October 2017
- slit-jaw camera: mounted November 2017
- temporary setup

- only single-beam (dual beam 2018)
- no large scans possible
- spectrograph (grating) jitter



GRIS+ - FUTURE PLANS

1st half 2018

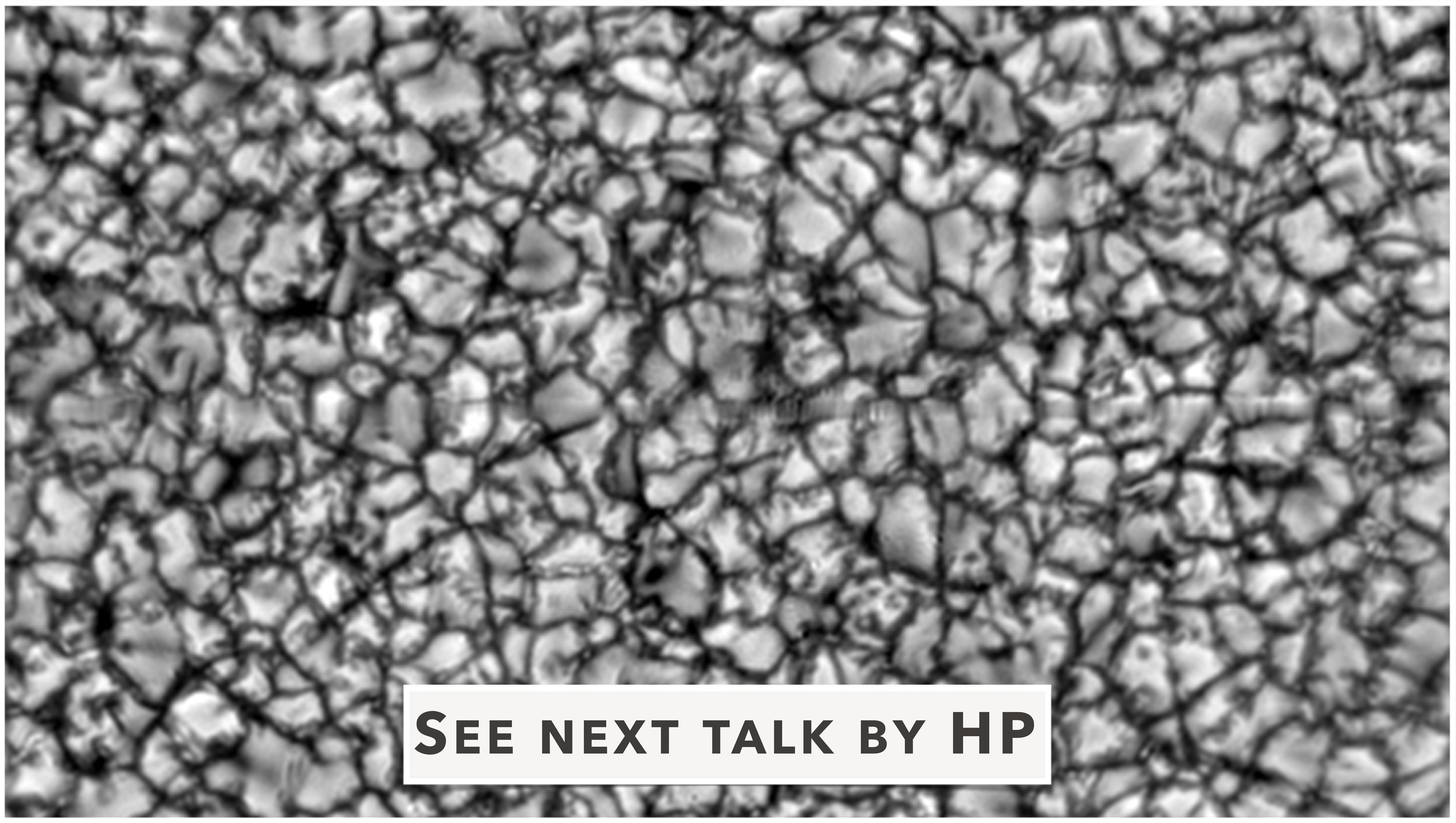
- solidify setup
  - improve AO scanner
  - improve SJ-unit
  - new slit (avoid 4 mirrors) + dust prevention / cleaning plan
  - cabling, location, ...
- software development
  - operation GUI
  - data reduction software & quick look tools
  - communication with GREGOR
- scientific test campaigns

2nd half 2018

- scientific campaigns:
  with MPS participation only!
- continuation of software development
- completely new setup in 5th floor?

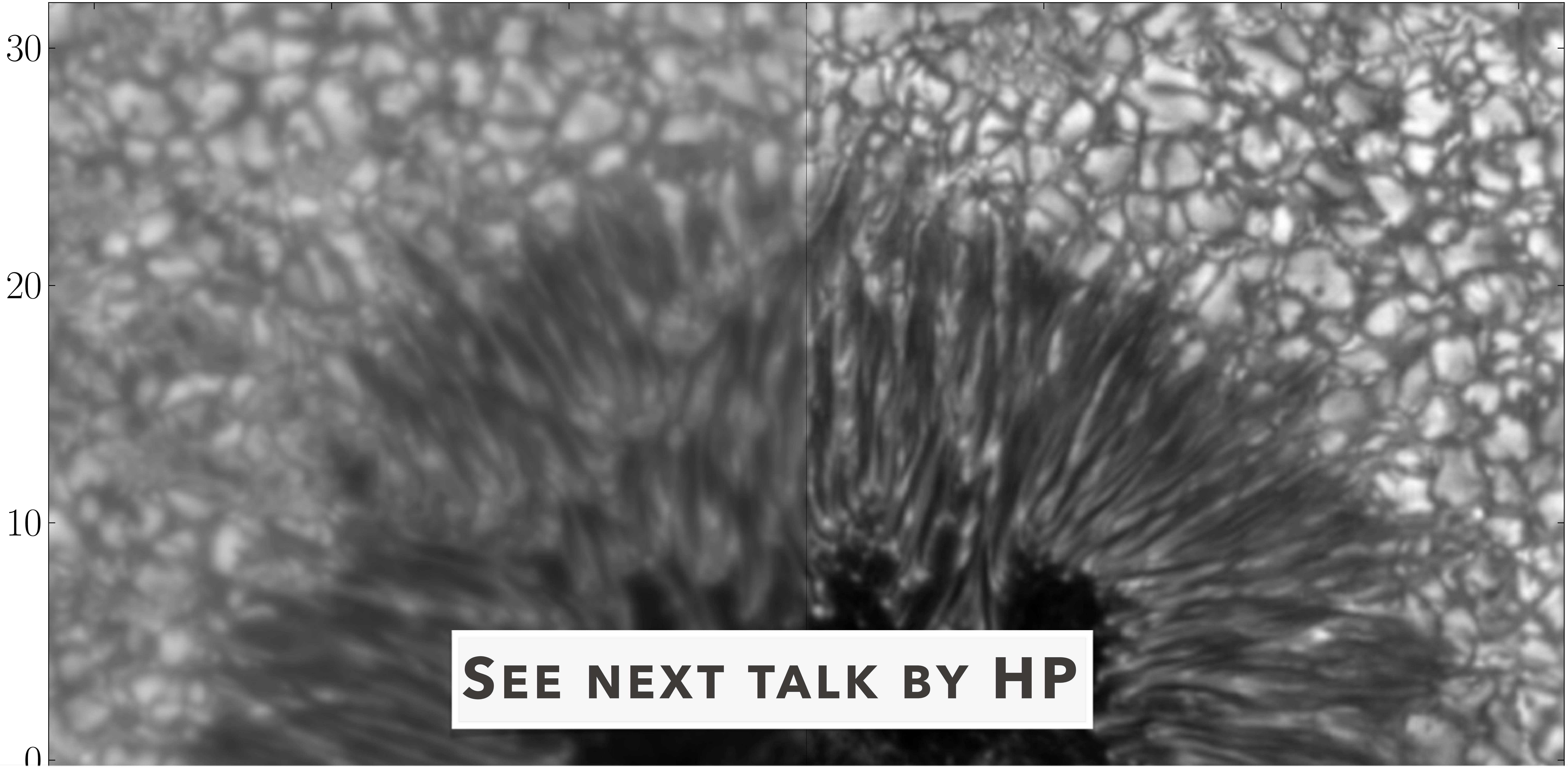
User instrument not before it's good! (2019??)

GRIS+ - First Data



See next talk by HP

HINODE –> GRIS+



SEE NEXT TALK BY HP