(OH NO) STRAYLIGHT

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KIS
Kiepenheuer-Institut
für Sonnenphysik

Leibniz
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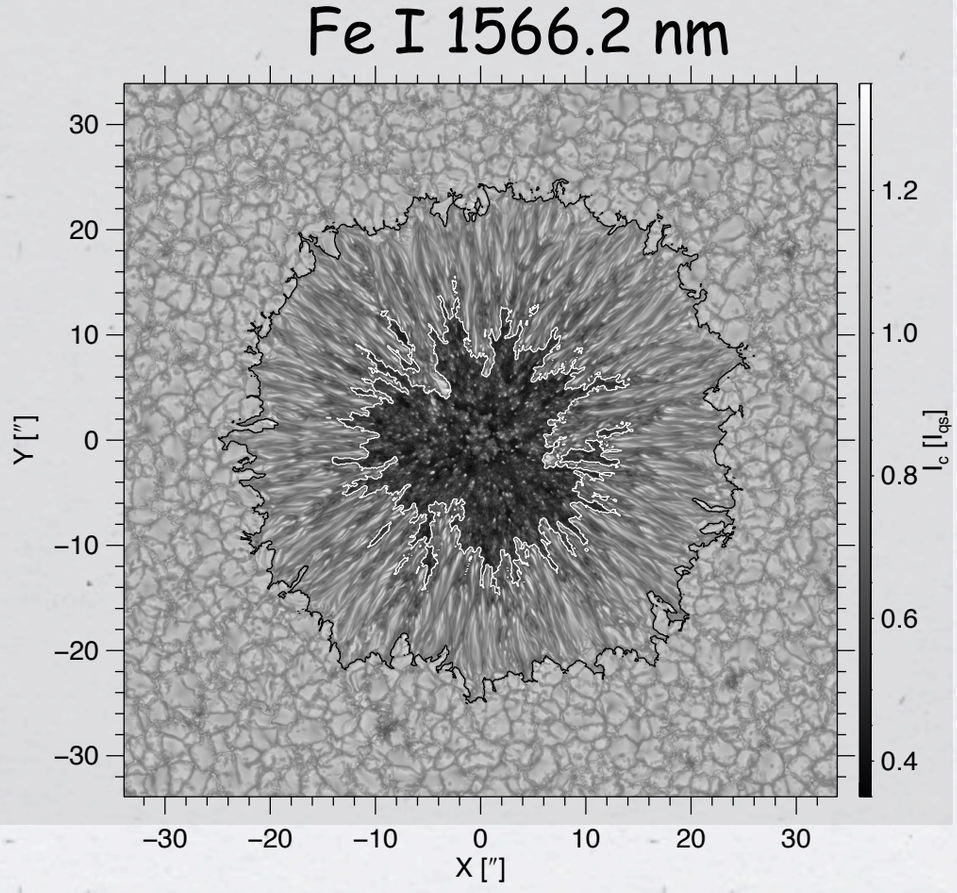
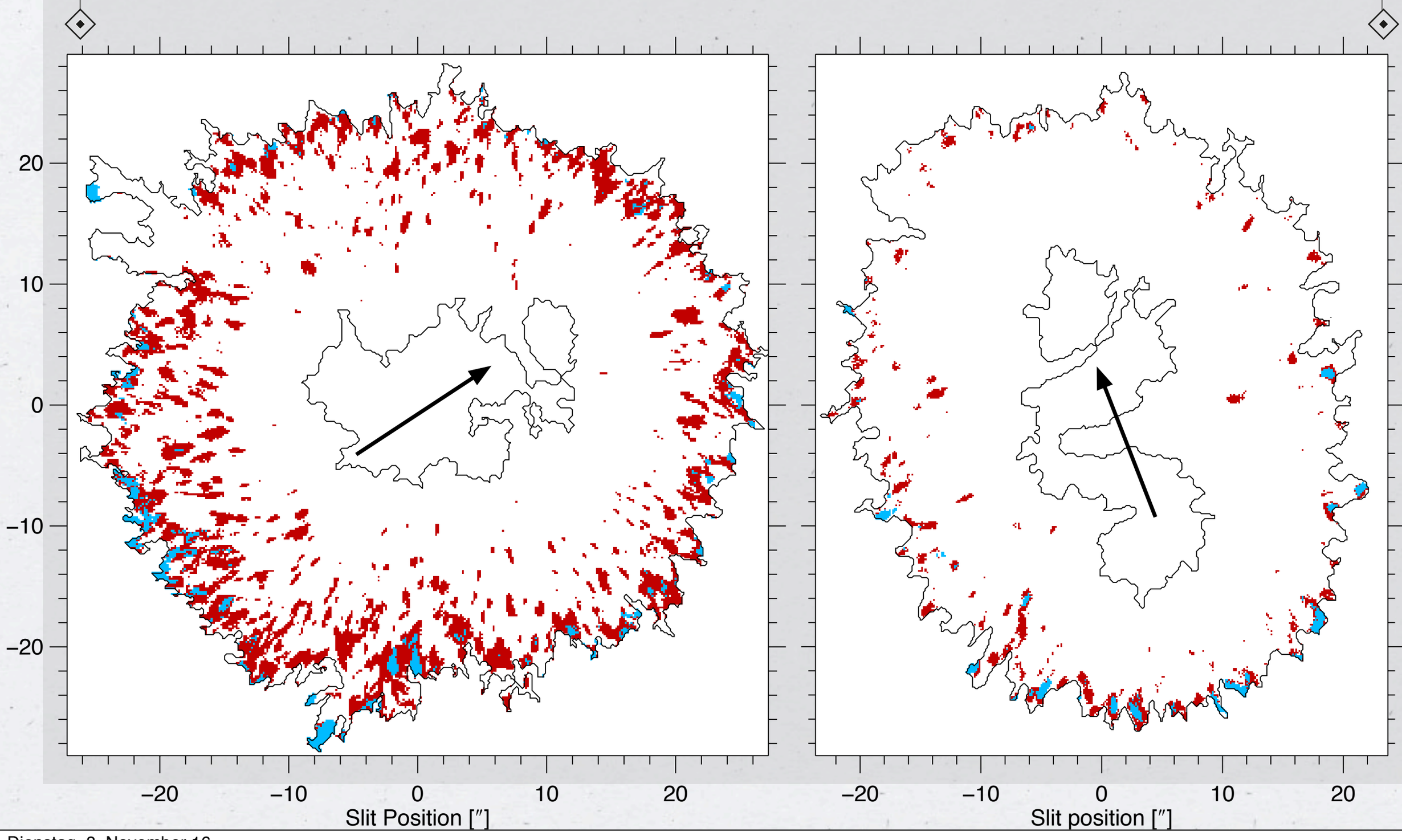


3-lobe & reversed V profiles



Franz et al. 2016 (accepted)

3-lobe & reversed V profiles

Line		Fe 630.15	Fe 630.25	Fe 1564.85	Fe 1565.29	Fe 1566.20
penumbral area with	3-lobe profiles	11.6 %	15.1 %	0.7 %	0.6 %	3.2 %
	reversed polarity profiles	2.4 %	1.9 %	1.1 %	1.1 %	0.9 %

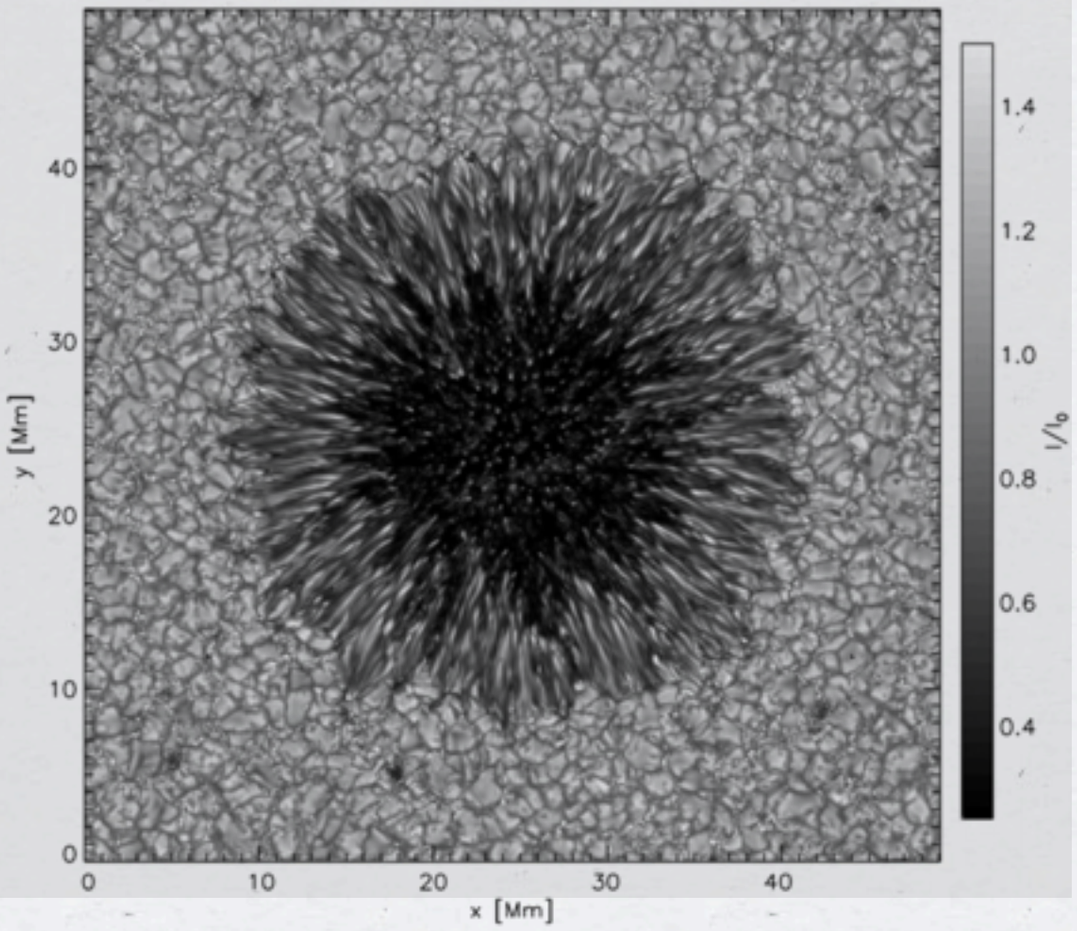
Franz et al. 2016 (accepted)

MHD Simulation

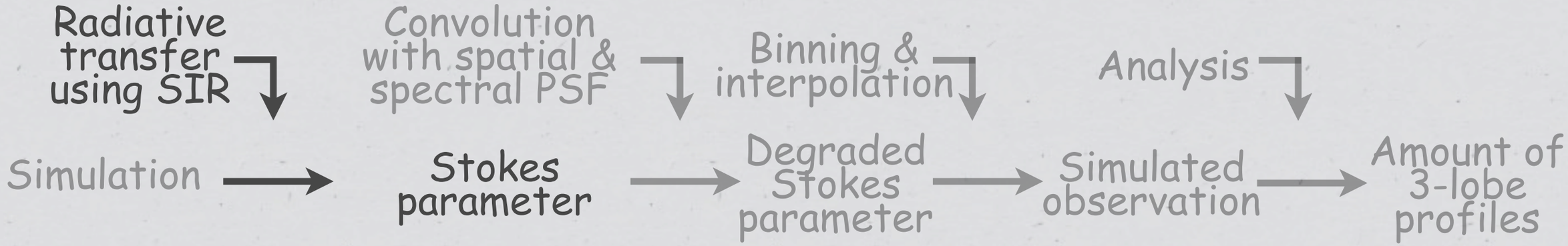
Radiative transfer using SIR → Convolution with spatial & spectral PSF → Binning & interpolation → Analysis

Simulation → Stokes parameter → Degraded Stokes parameter → Simulated observation → Amount of 3-lobe profiles

- Full sunspot simulation using the MURaM code
  Vögler et al. 2005
- Non-grey extension of a grey simulation run
  Rempel 2012
- Grid resolution of 12 km x 12 km x 8 km



MHD Simulation



- Synthesis of several spectral lines using SIR

Borrero et al. 2014

Fe I 630.15	Fe I 1564.74	Fe I 1565.29
Fe I 630.25	Fe I 1564.85	Fe I 1566.20

- 40% of KIS computer resources for 6 Weeks 24/7
- Resulting data cubes 16 x (4096,4096,301) ≈ 0.3TB

MHD Simulation

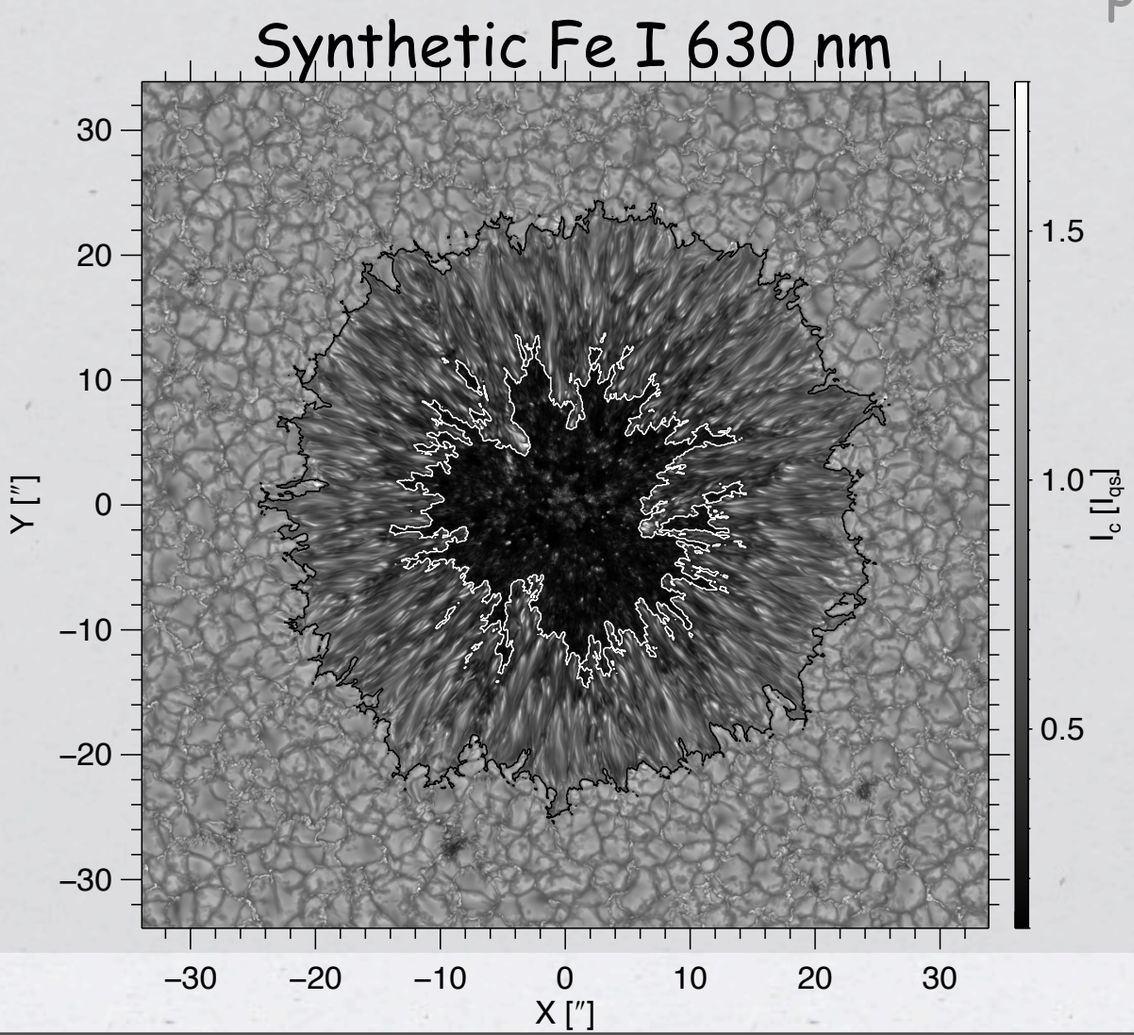
Radiative transfer using SIR

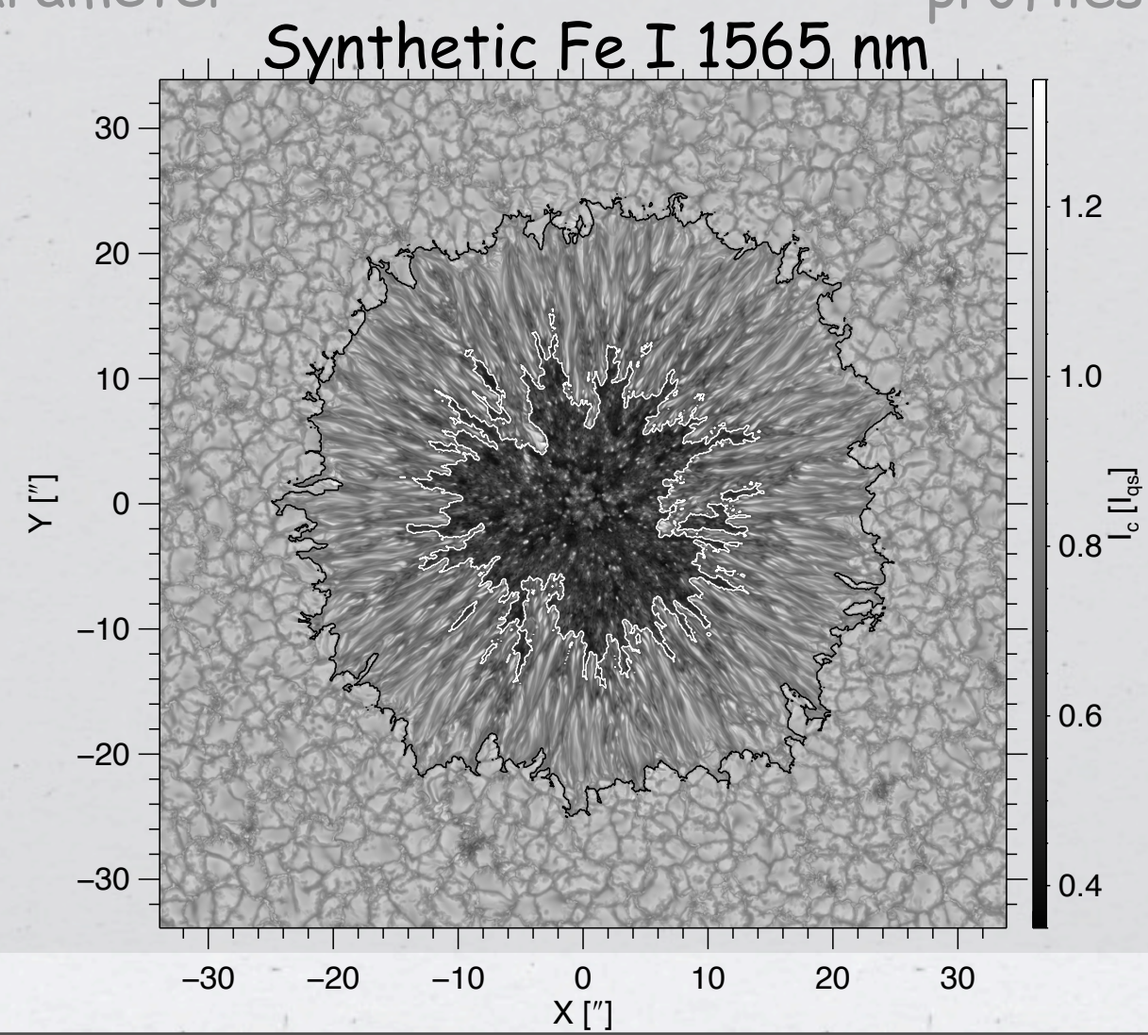
Convolution with spatial & spectral PSF

Binning & interpolation

Analysis

Simulation → Stokes parameter → Degraded Stokes parameter → Simulated observation → Amount of 3-lobe profiles





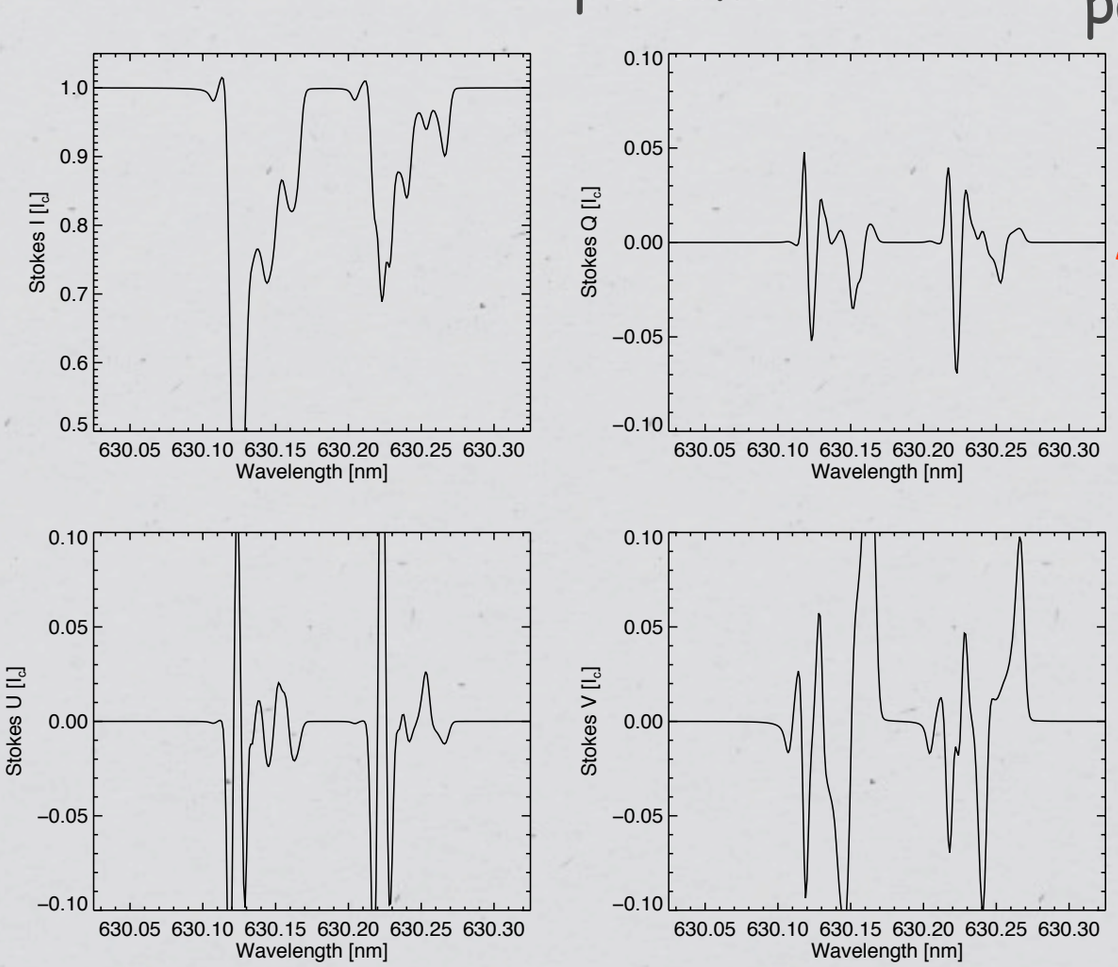
Spectral PSF (vail) of Hinode

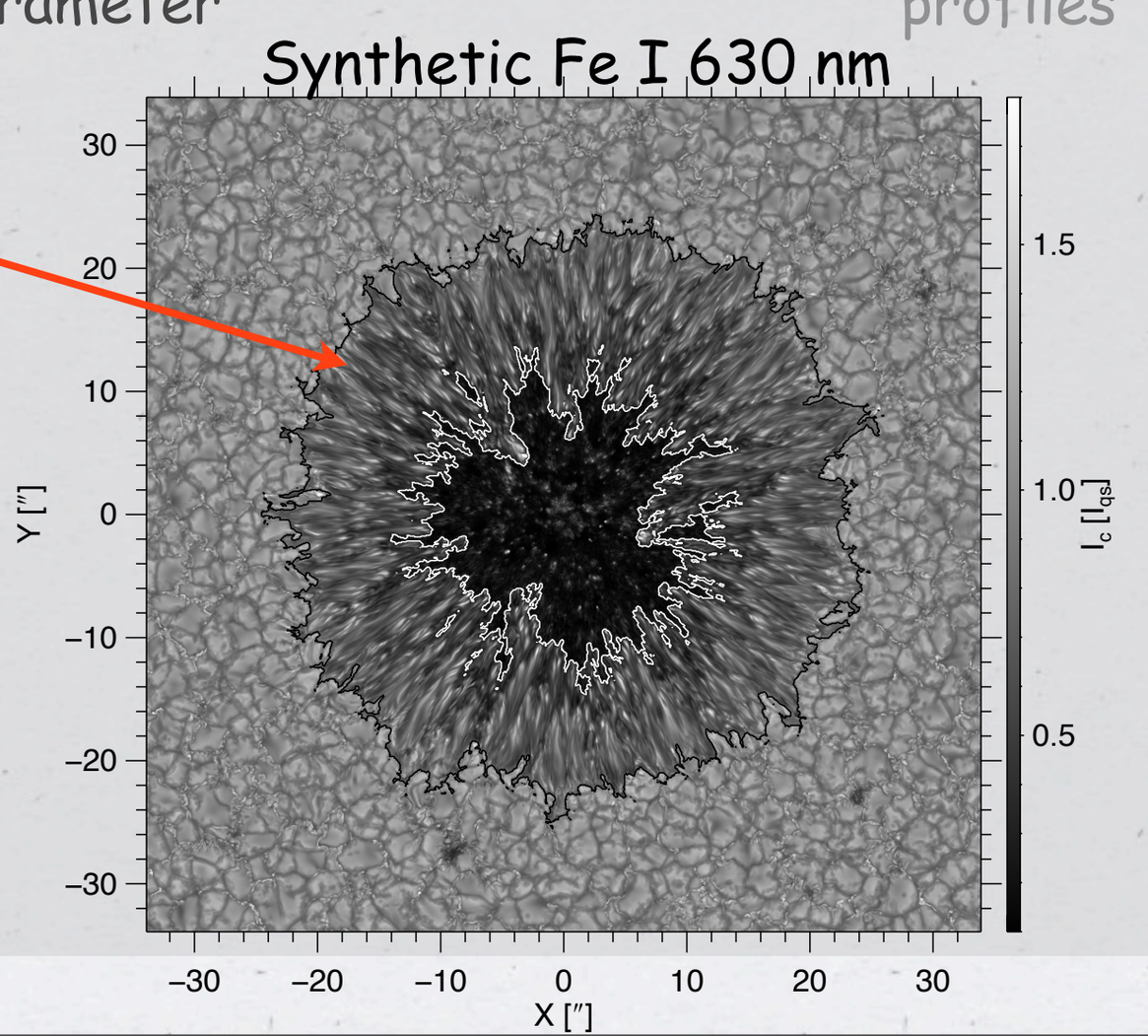
Radiative transfer using SIR → Simulation → Stokes parameter

Convolution with spatial & spectral PSF → Stokes parameter

Binning & interpolation → Degraded Stokes parameter

Analysis → Simulated observation → Amount of 3-lobe profiles





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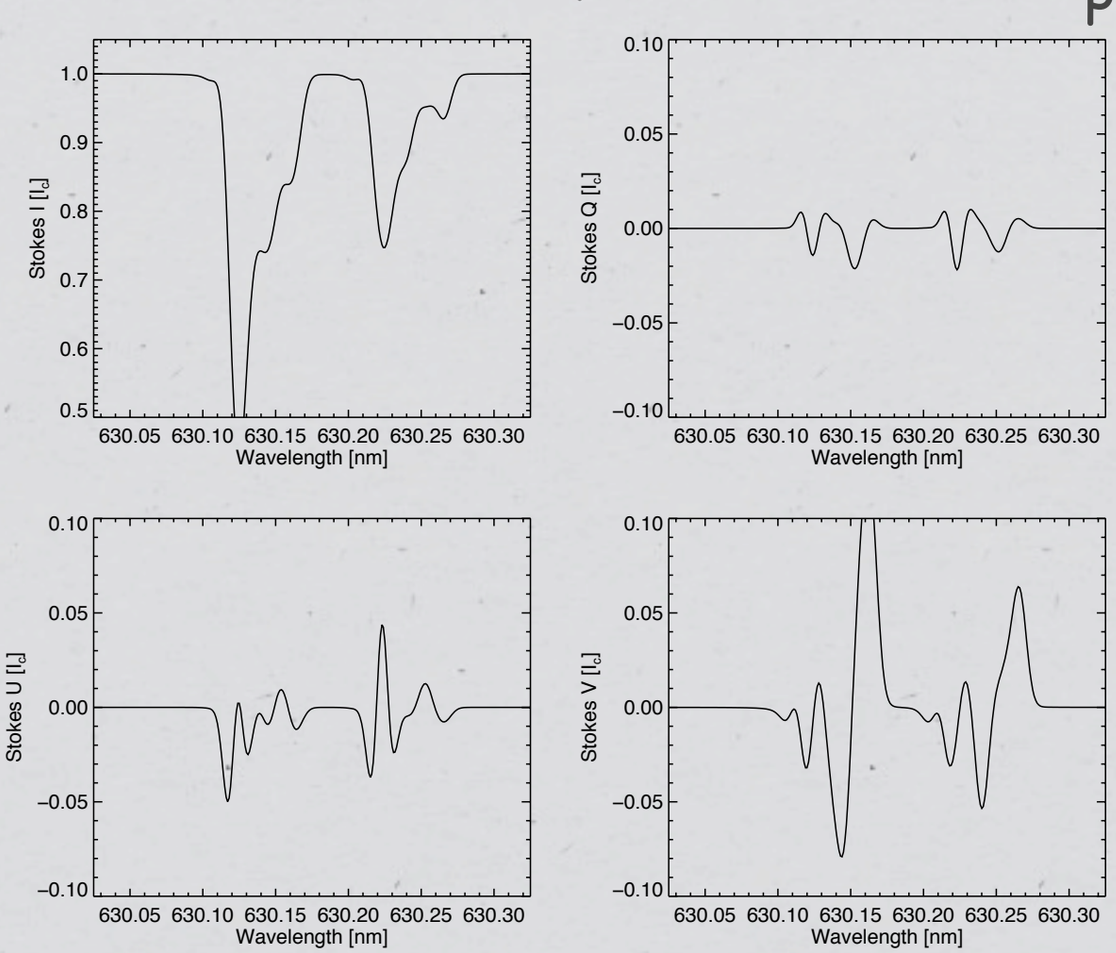
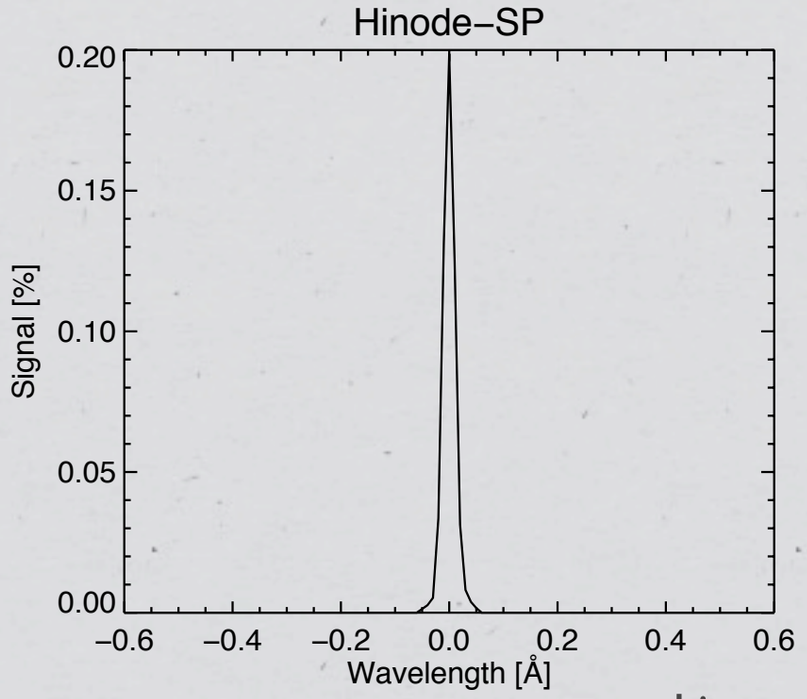
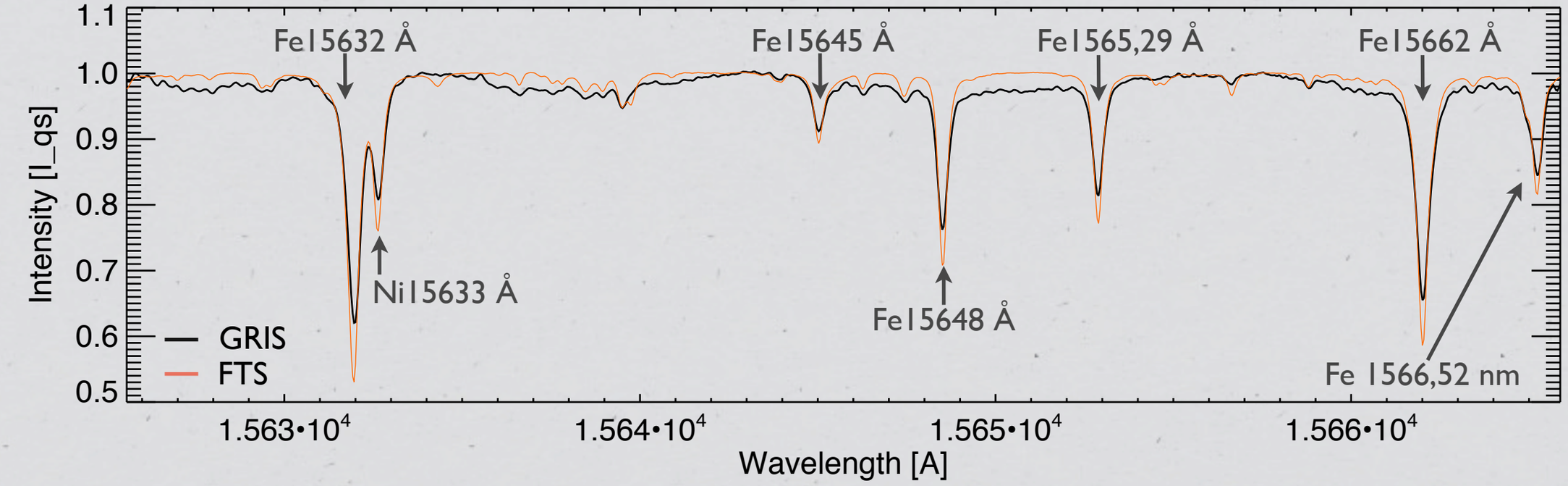
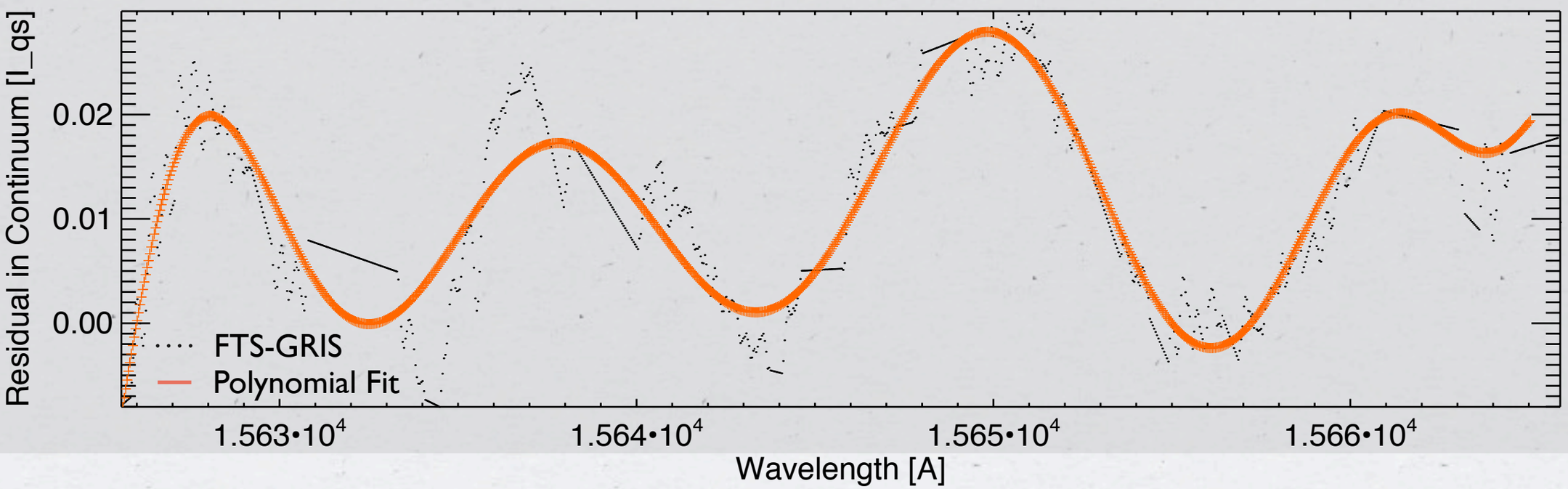




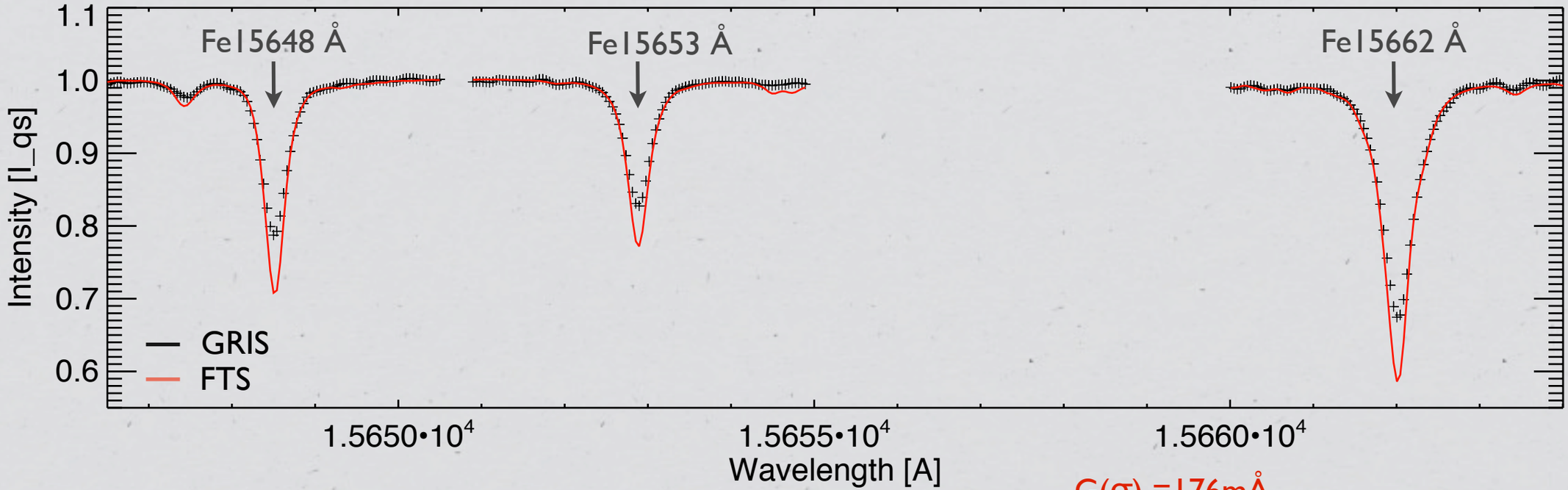
Lites et al. 2013

Spectral PSF (vail) of GRIS





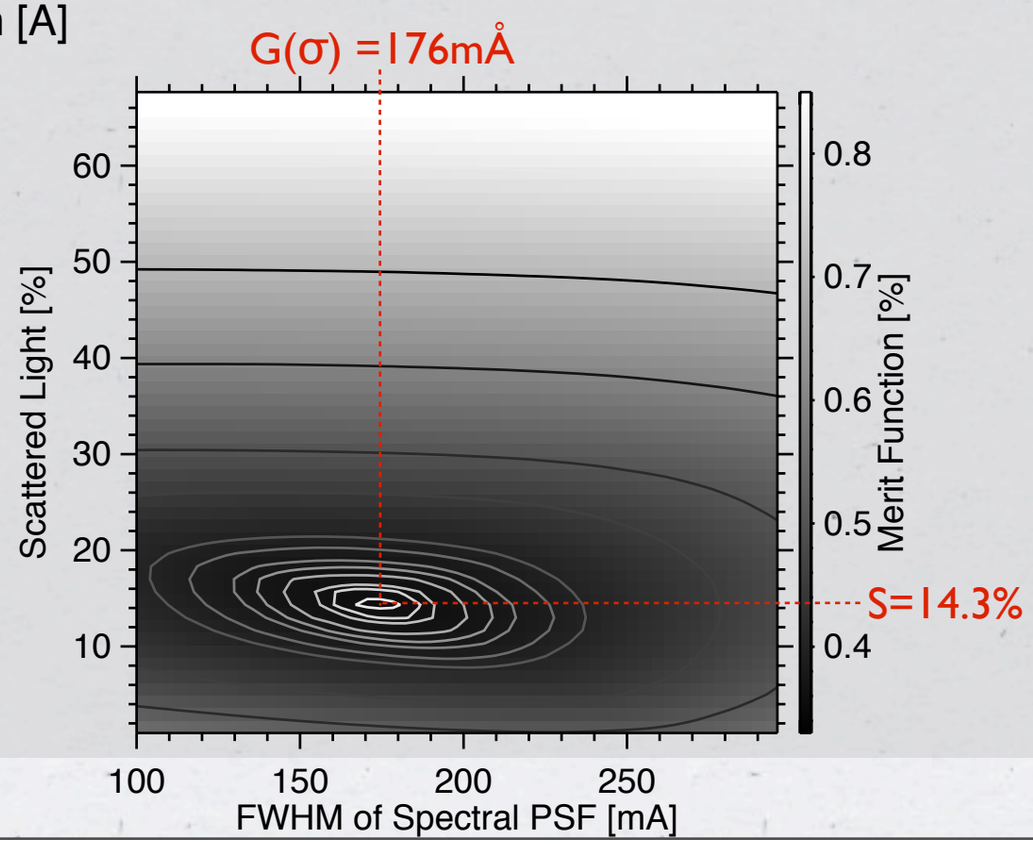
Spectral PSF (vail) of GRIS



$$I = \frac{I_{FTS} + S}{1 + S} \otimes G(\sigma)$$

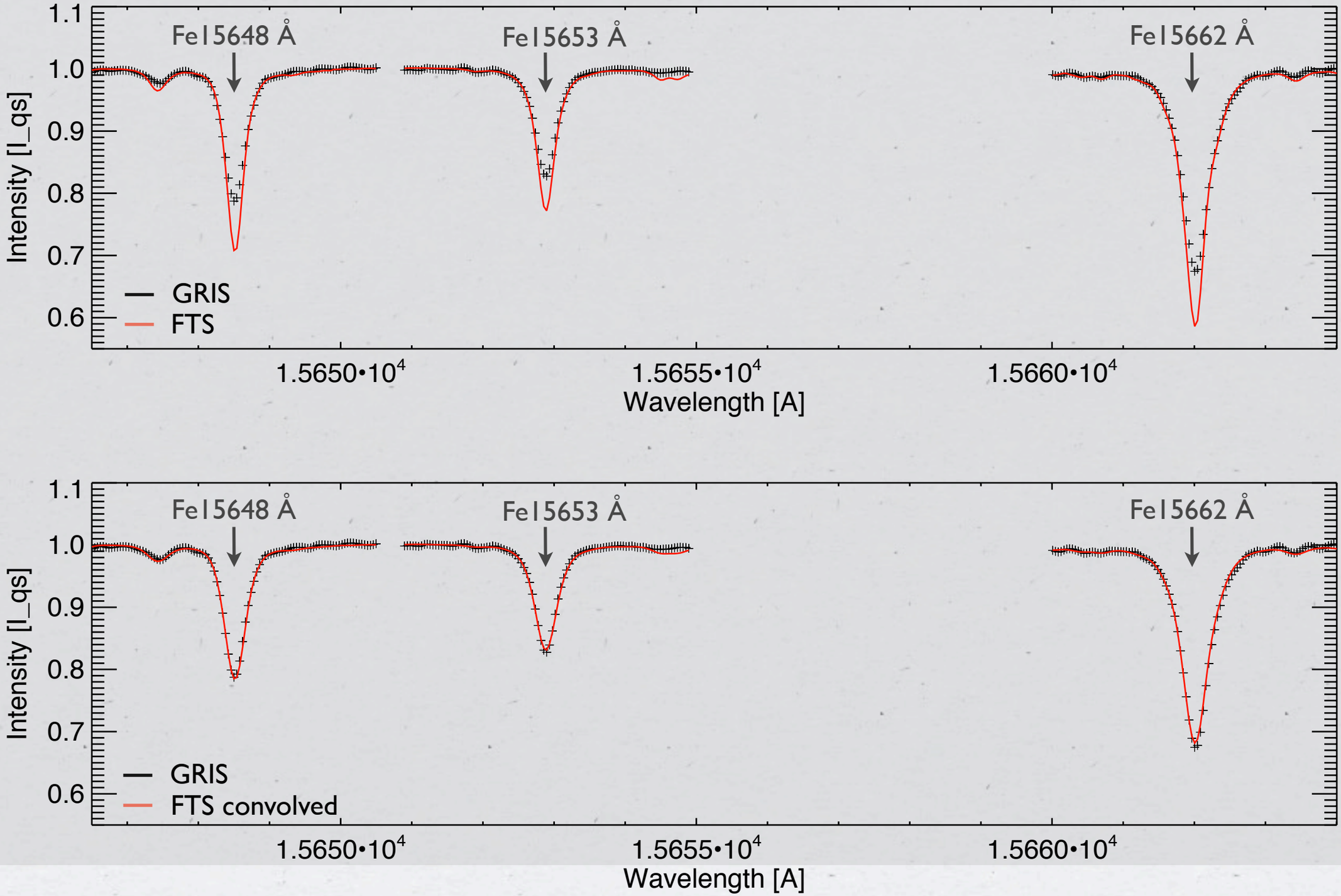
- I: GRIS profile
- I_{FTS}: FTS profile
- S: Fraction of spectrally scattered light
- $G(\sigma)$: PSF (Gaussian with FWHM σ)

Cabrera Solana et al. 2007



Allende Prieto et al. 2004

Spectral PSF (vail) of GRIS



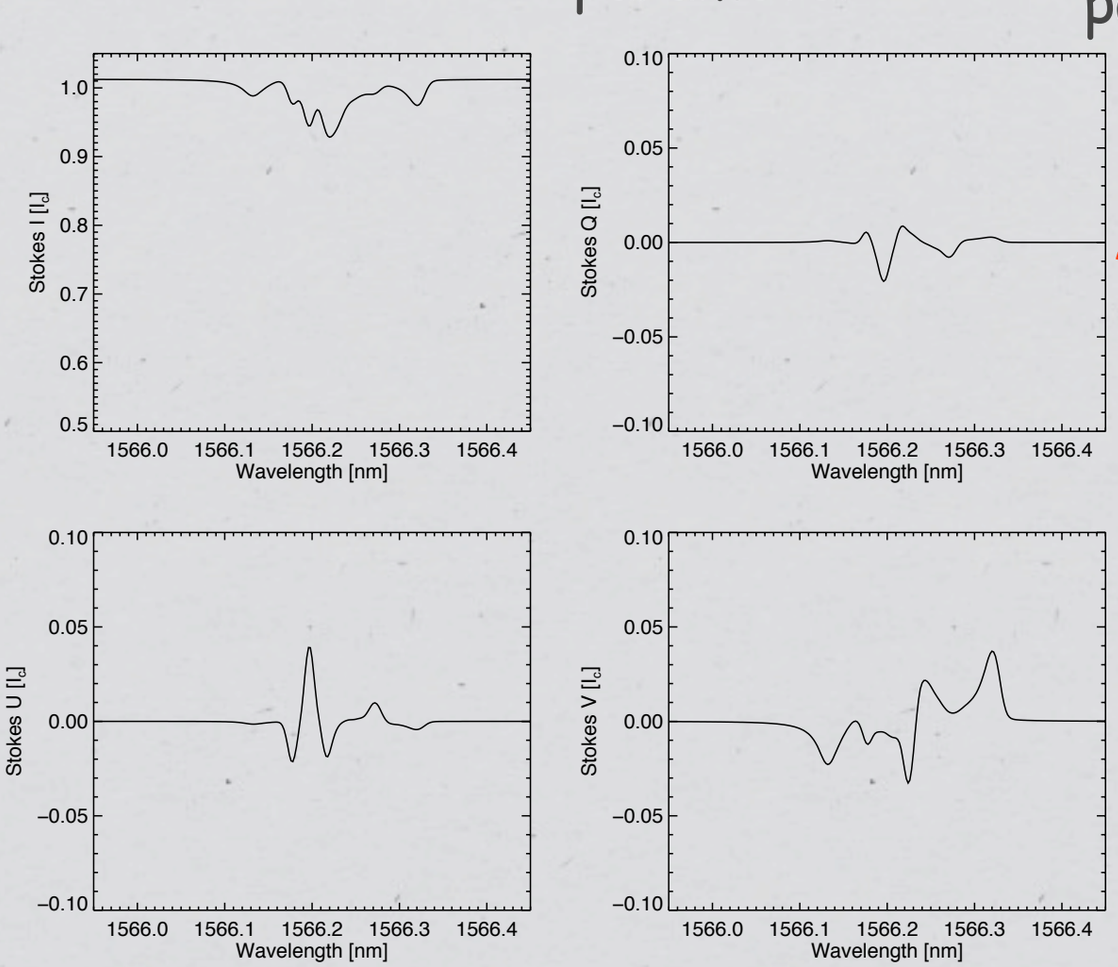
Spectral PSF (vail) of GRIS

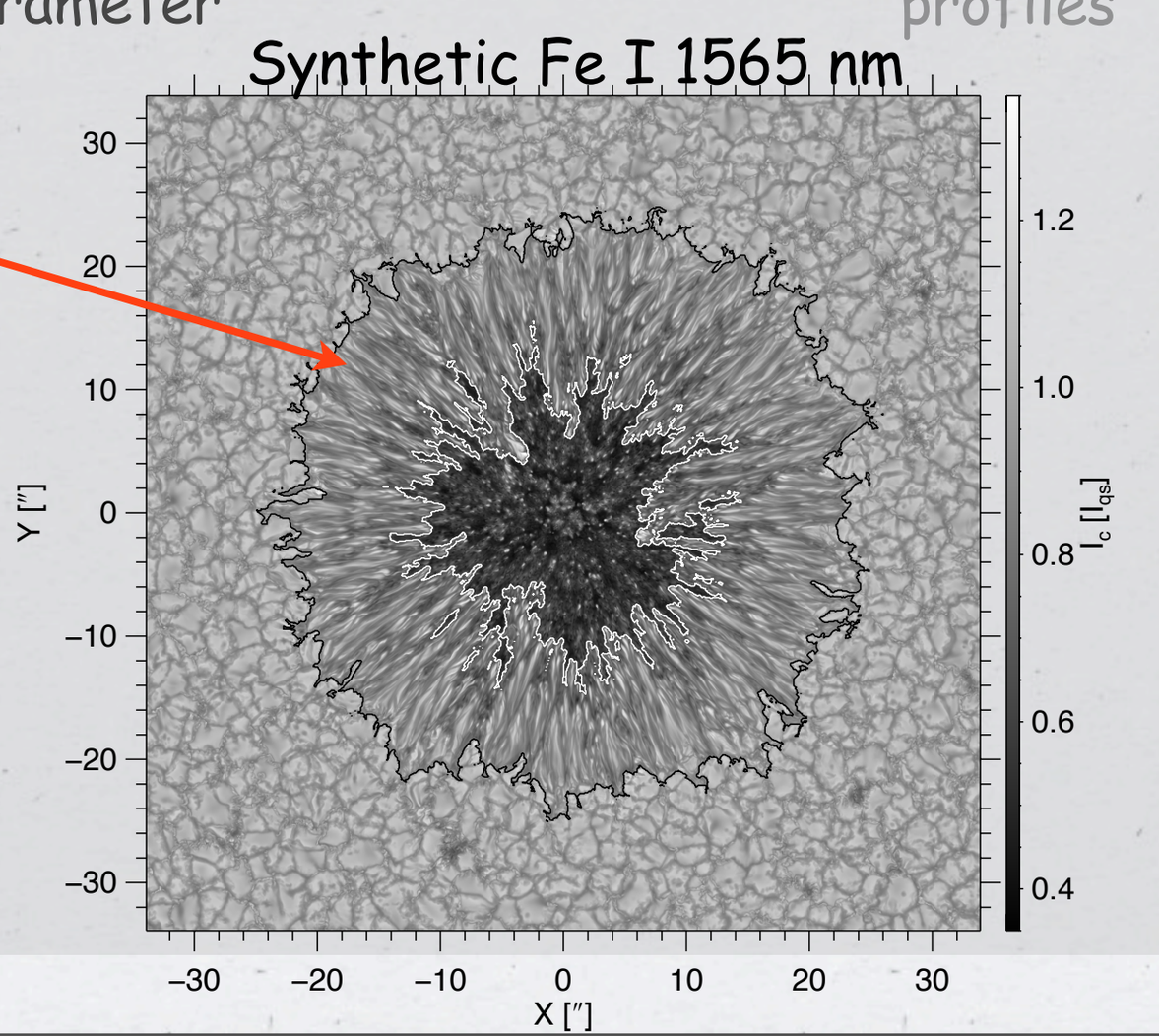
Radiative transfer using SIR → Simulation → Stokes parameter

Convolution with spatial & spectral PSF → Stokes parameter → Degraded Stokes parameter

Binning & interpolation → Degraded Stokes parameter → Simulated observation

Analysis → Simulated observation → Amount of 3-lobe profiles





Spectral PSF (vail) of GRIS

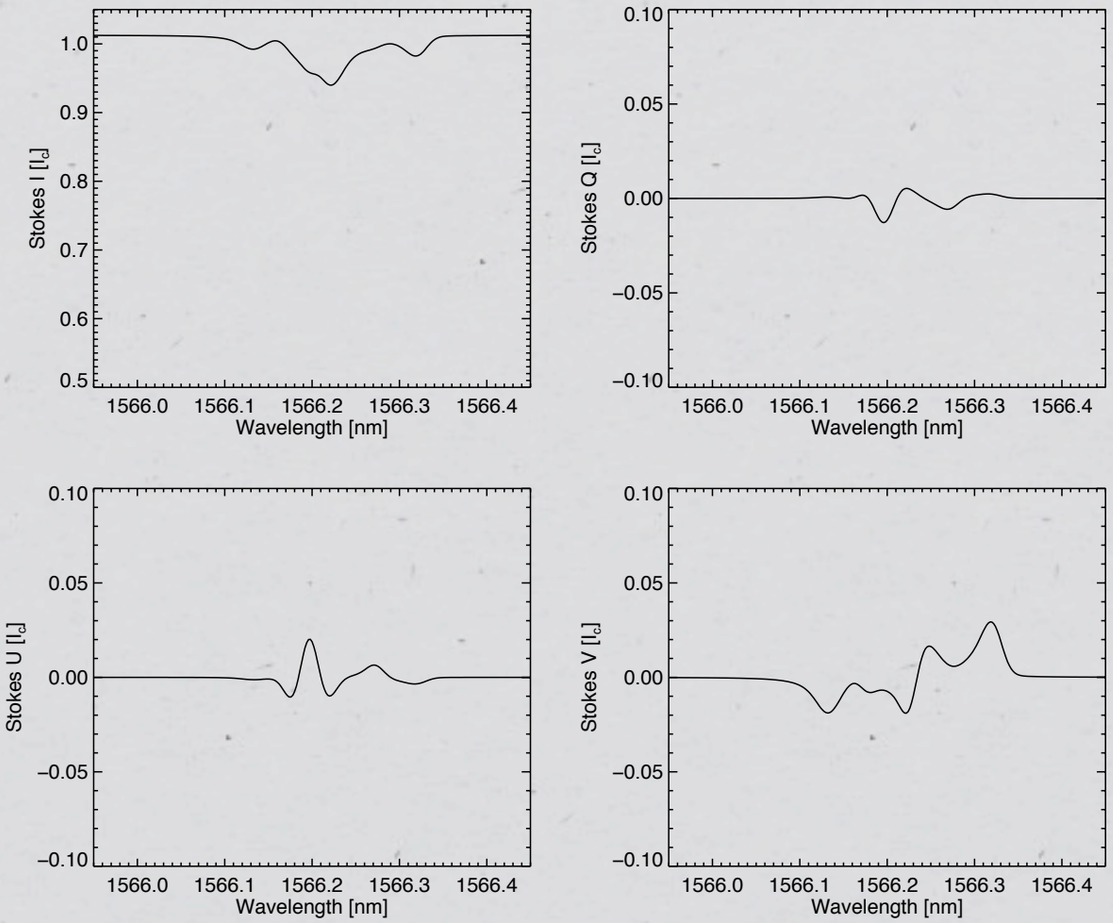
Radiative transfer using SIR

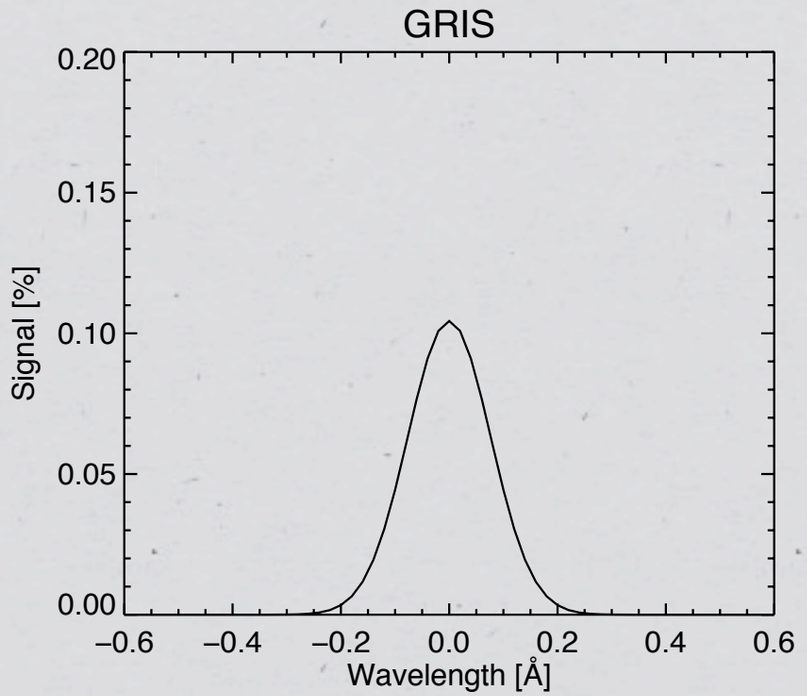
Convolution with spatial & spectral PSF

Binning & interpolation

Analysis

Simulation → Stokes parameter → Degraded Stokes parameter → Simulated observation → Amount of 3-lobe profiles





Spatial PSF

* Spatial PSF
  - Function that projects a 0 - dimensional point onto the 2 - dimensional detector plane under the influence of optical elements, atmosphere, etc.
* Strehl
  - Ratio of encircled energy of the central peak (or maximal amplitude) of the actual PSF and the theoretical PSF
* GREGOR
  - For the theoretical PSF (in F3) the encircled energy of the core is 63%
  - Strehl is 30% at 1.5µm => the encircled energy in the core is only 20%
  - PSF varies across the FOV because of GREGOR beam path and ‘limited‘ AO correction
  - Best AO correction is close to the lock-point

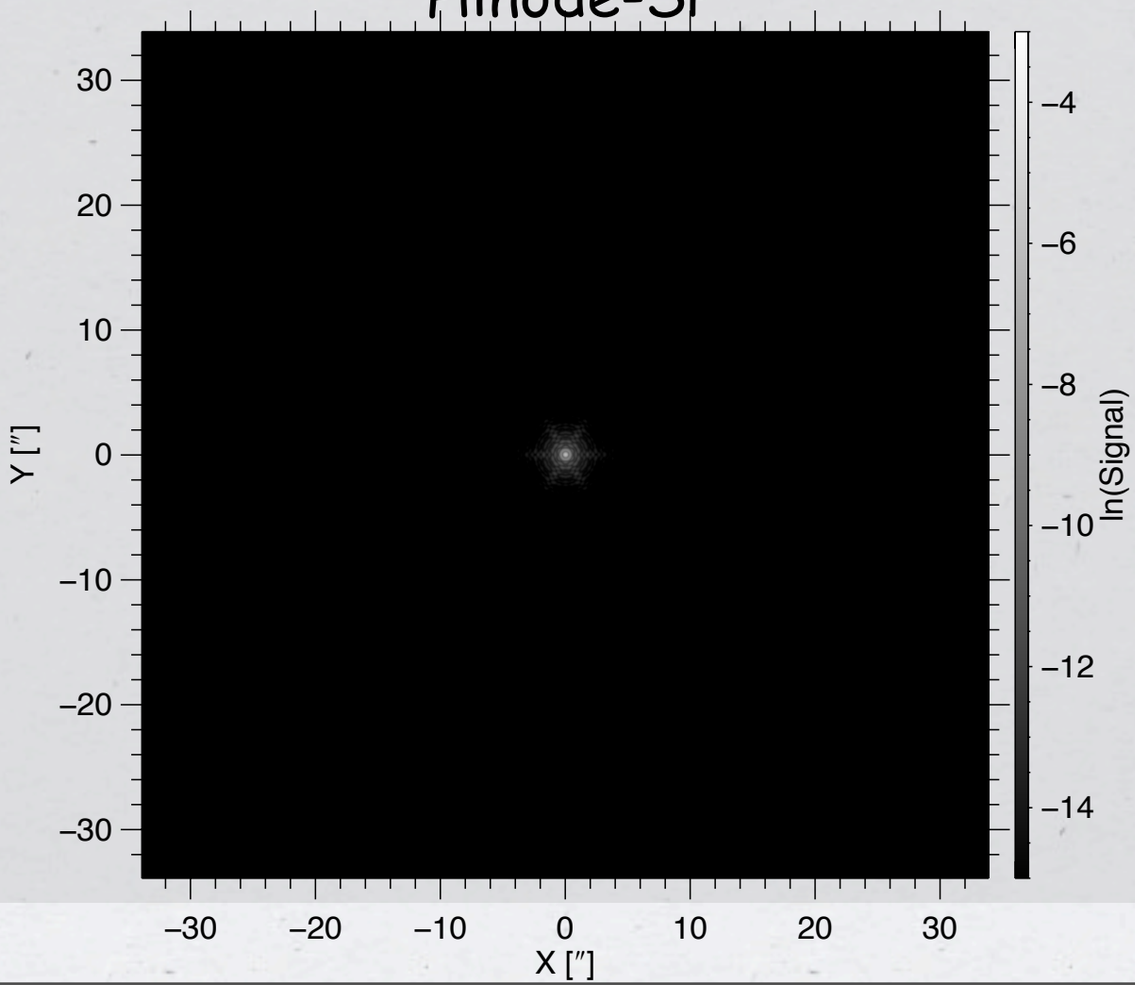
Spatial PSF of Hinode-SP

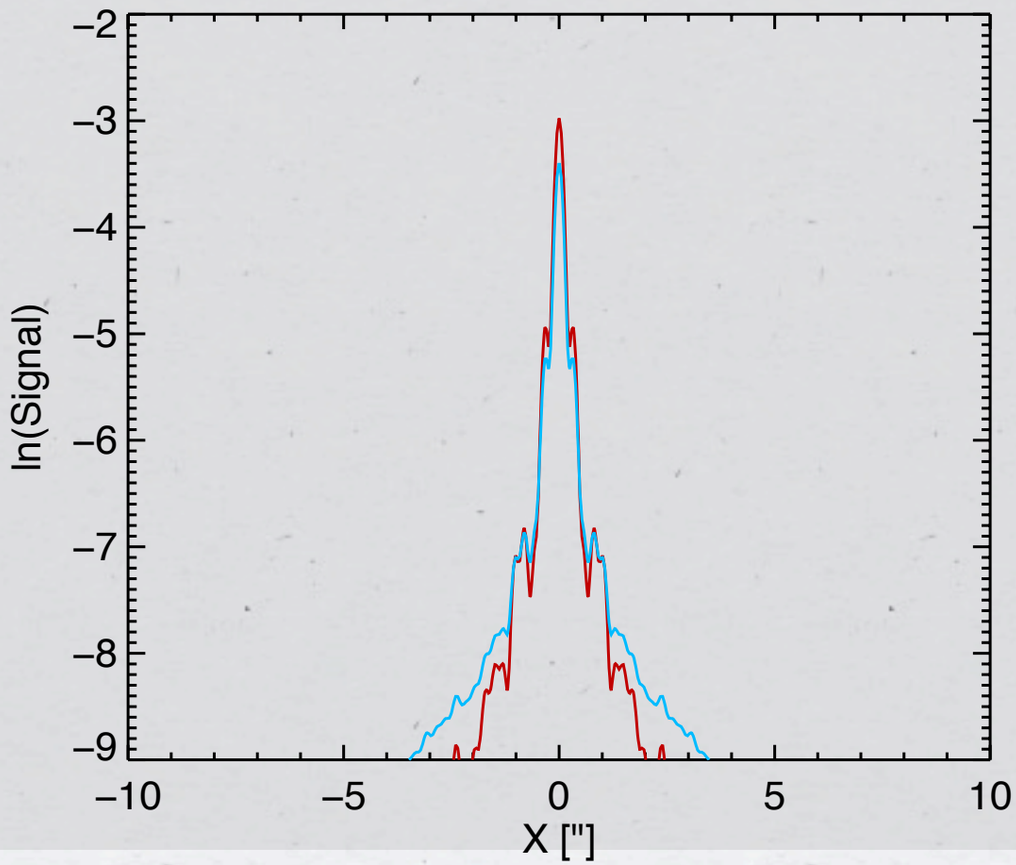
Radiative transfer using SIR → Simulation → Stokes parameter

Convolution with spatial & spectral PSF → Hinode-SP → Degraded Stokes parameter

Binning & interpolation → Degraded Stokes parameter → Simulated observation

Analysis → Simulated observation → Amount of 3-lobe profiles





Wedemeyer-Böhm 2008

Spatial PSF of Hinode-SP

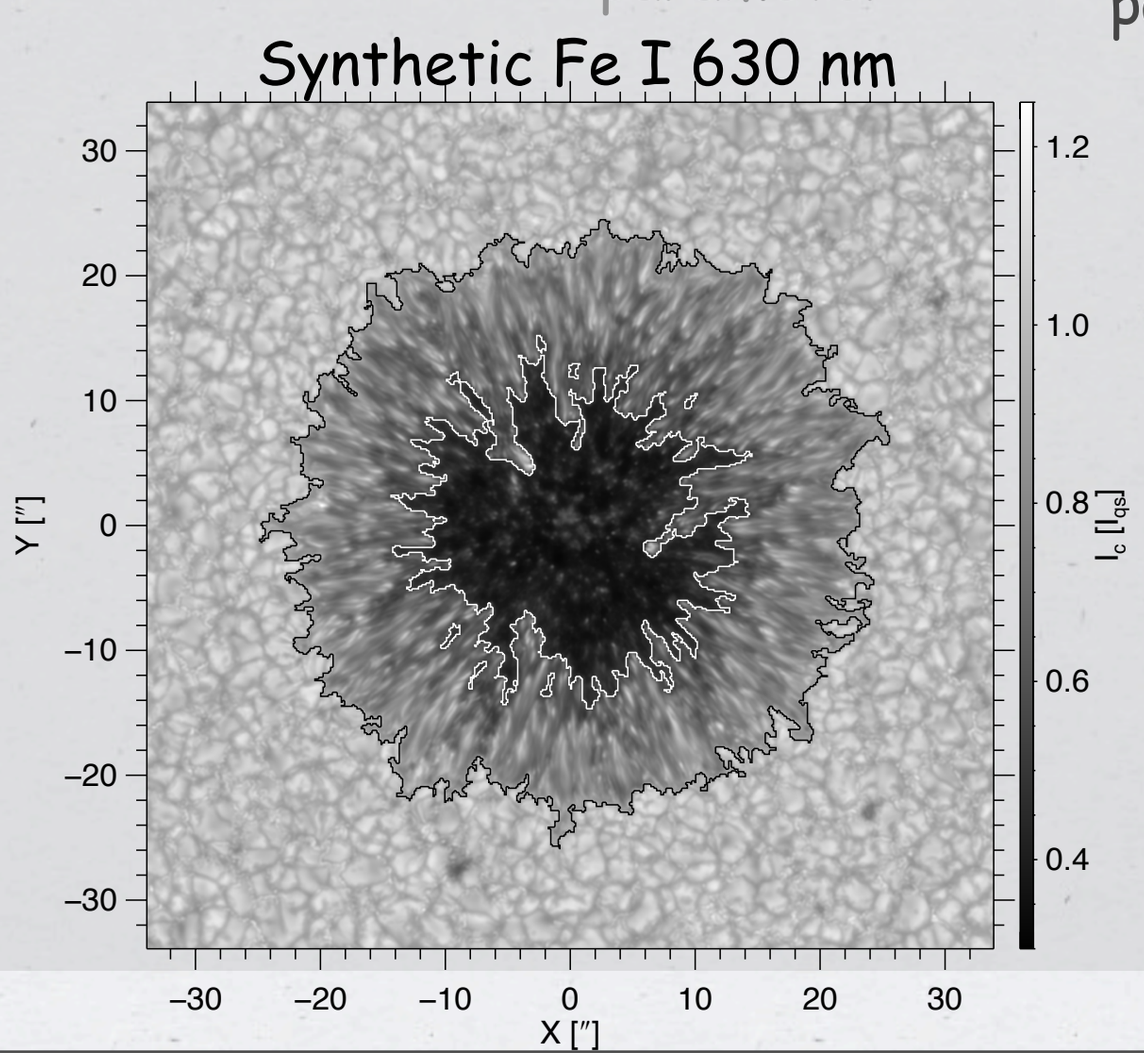
Radiative transfer using SIR

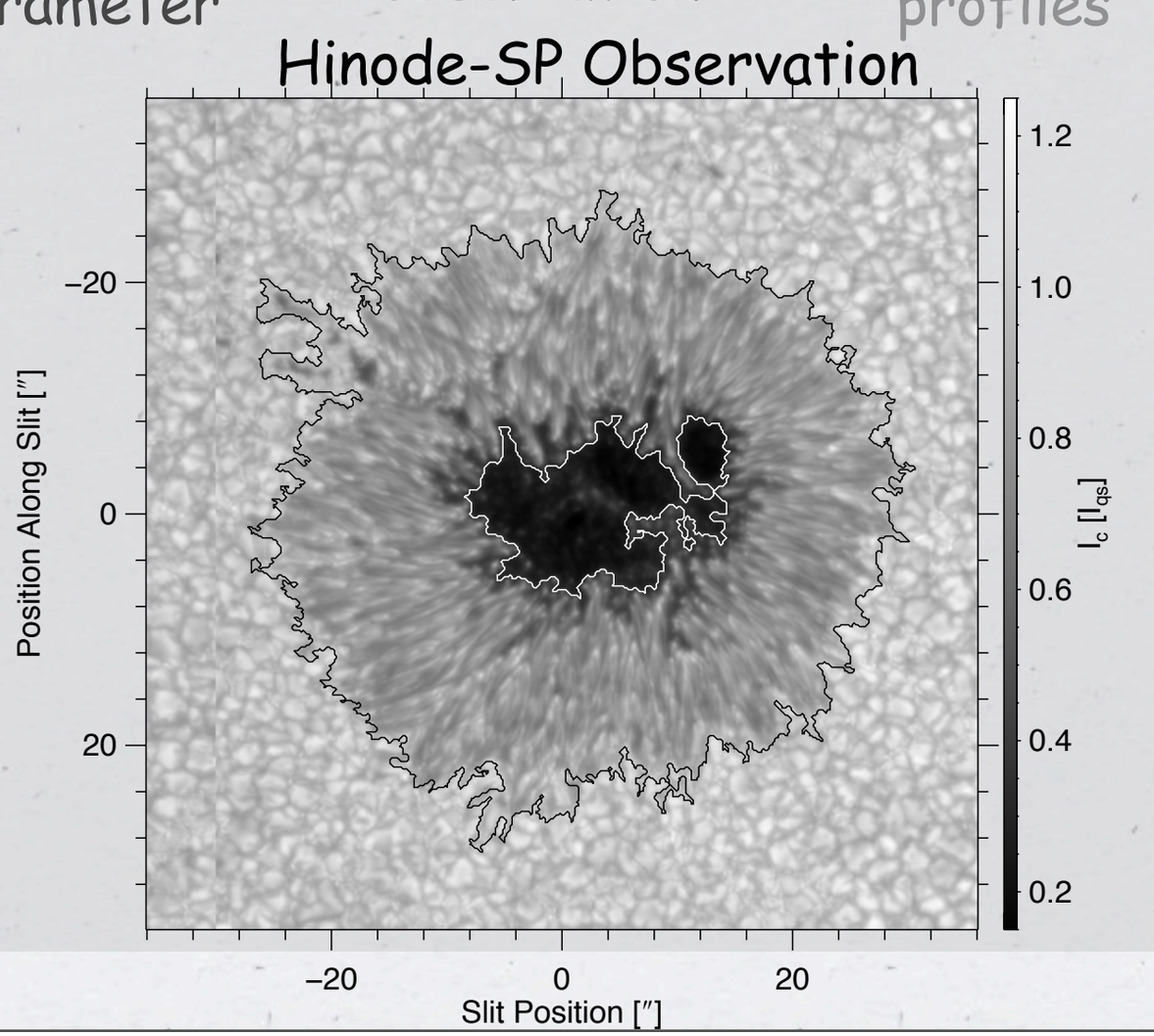
Convolution with spatial & spectral PSF

Binning & interpolation

Analysis

Simulation → Stokes parameter → Degraded Stokes parameter → Simulated observation → Amount of 3-lobe profiles





Spatial PSF of Hinode-SP

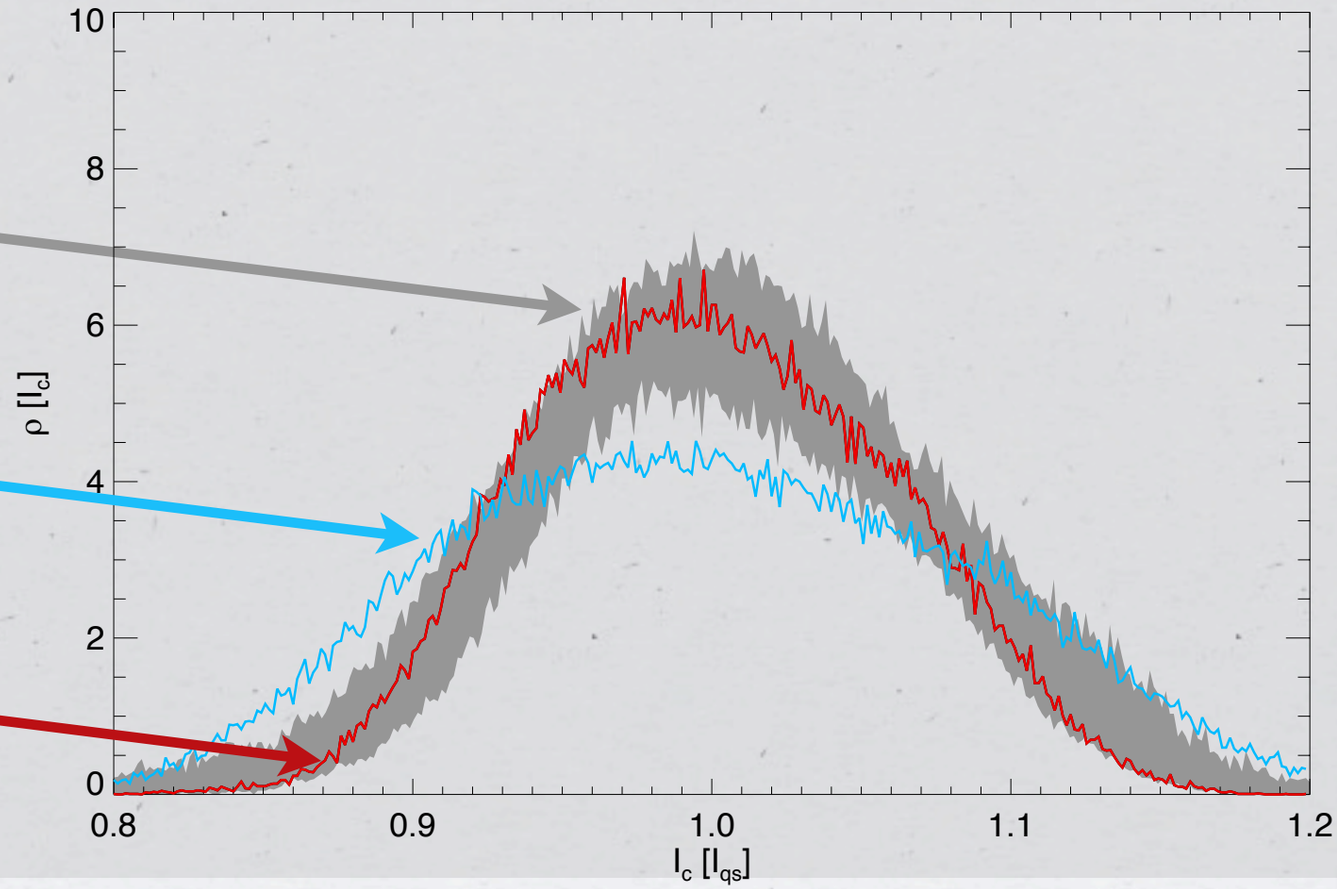
Radiative transfer using SIR → Simulation → Convolution with spatial & spectral PSF → Stokes parameter → Binning & interpolation → Degraded Stokes parameter → Analysis → Simulated observation → Amount of 3-lobe profiles

RMS contrast (σ of histogram)

Hinode SP Observation
5.9 % - 7.8 %

Simulation ⊗ DF-PSF
8.5 %

Simulation ⊗ DF-PSF &Voigt
5.9 %



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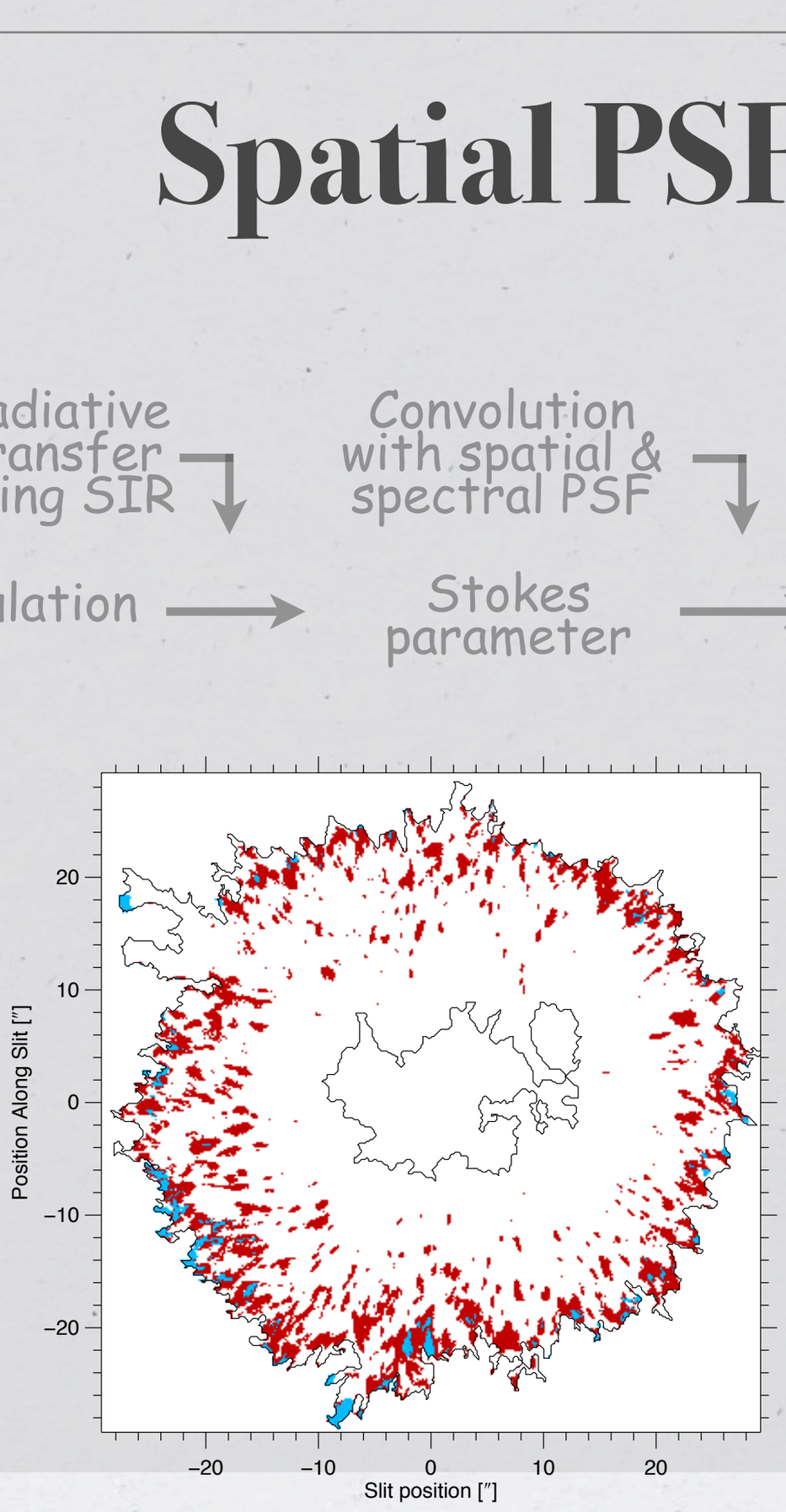
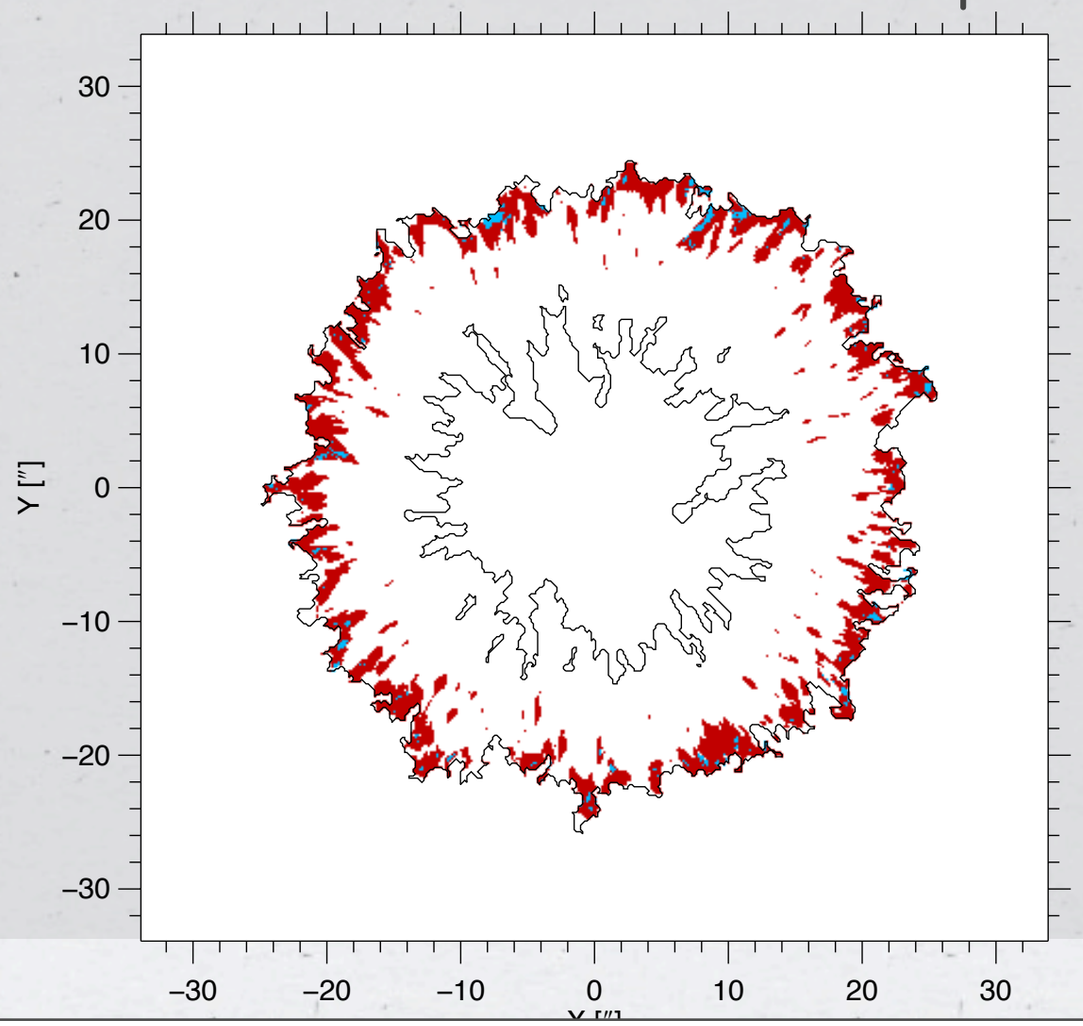




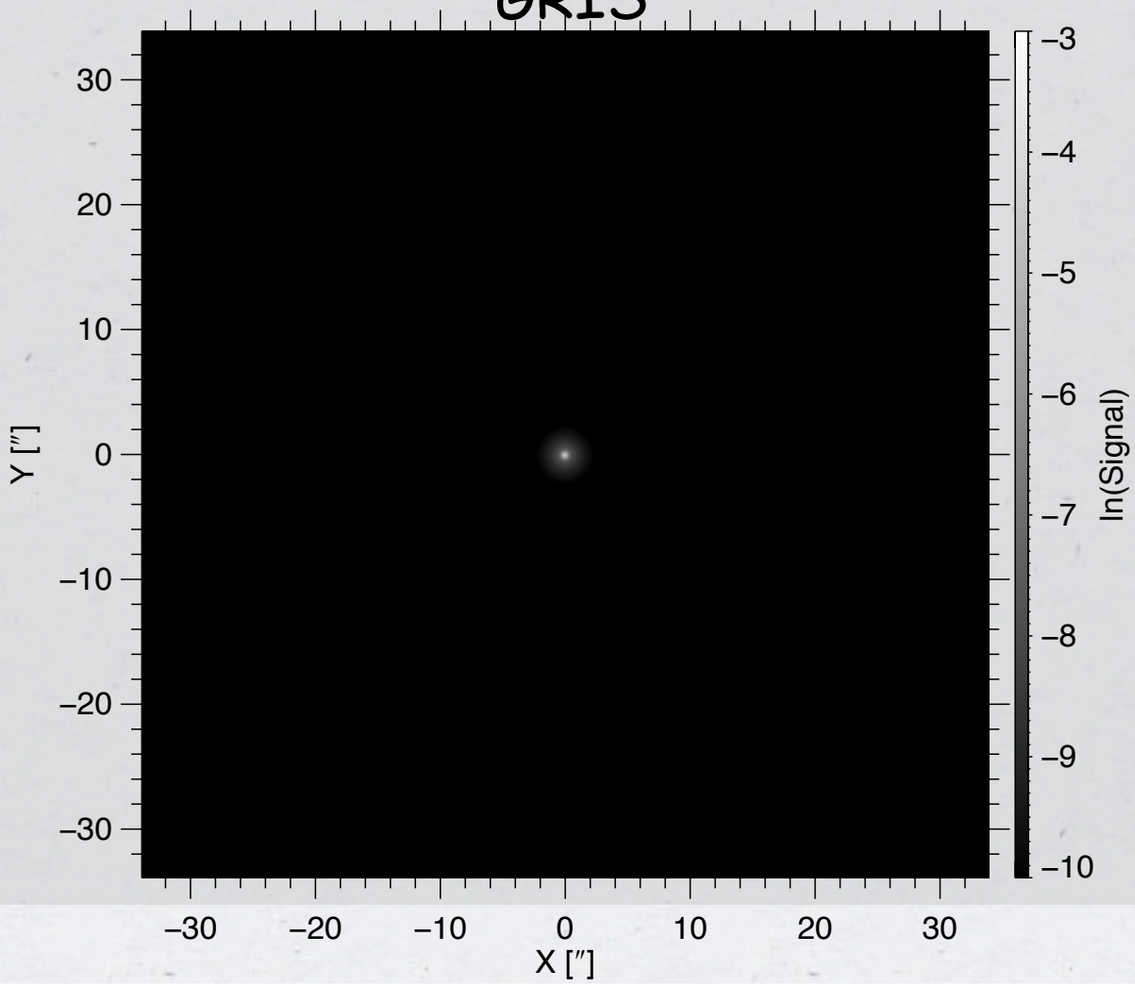
Spatial PSF of GRIS

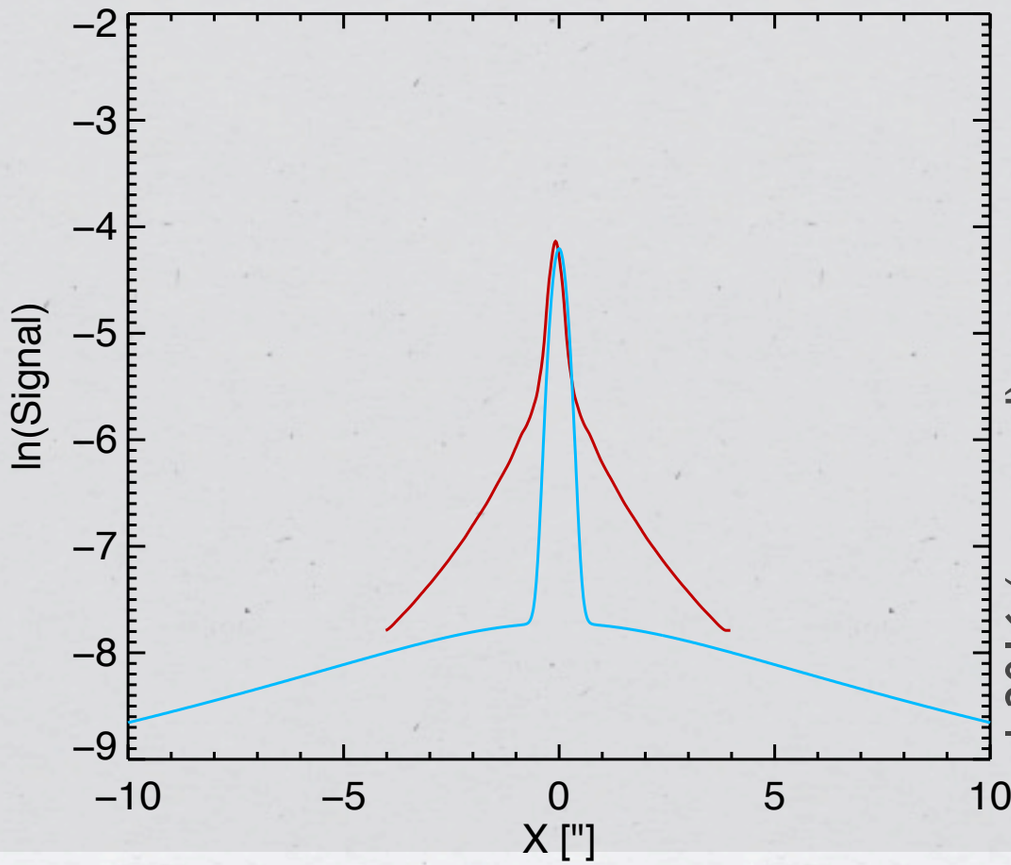
Radiative transfer using SIR → Simulation → Stokes parameter

Convolution with spatial & spectral PSF → GRIS → Degraded Stokes parameter

Binning & interpolation → Degraded Stokes parameter → Simulated observation

Analysis → Simulated observation → Amount of 3-lobe profiles





Lagg et al. 2016 (accepted)
Borrero et al. 2016 (accepted)
Collados et al. 2016 (private communication)

Spatial PSF of GRIS

Radiative transfer using SIR → Convolution with spatial & spectral PSF → Binning & interpolation → Analysis

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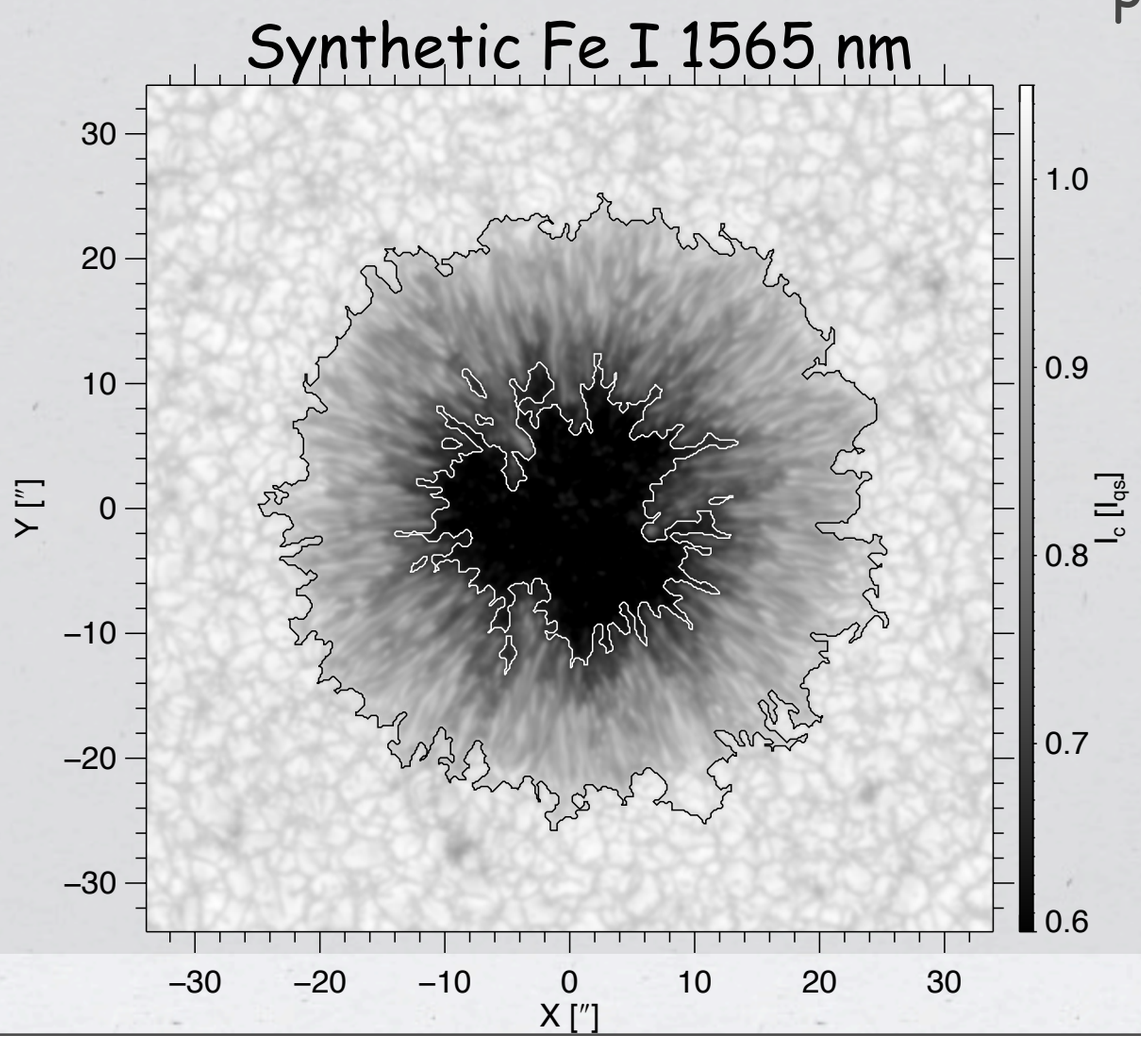
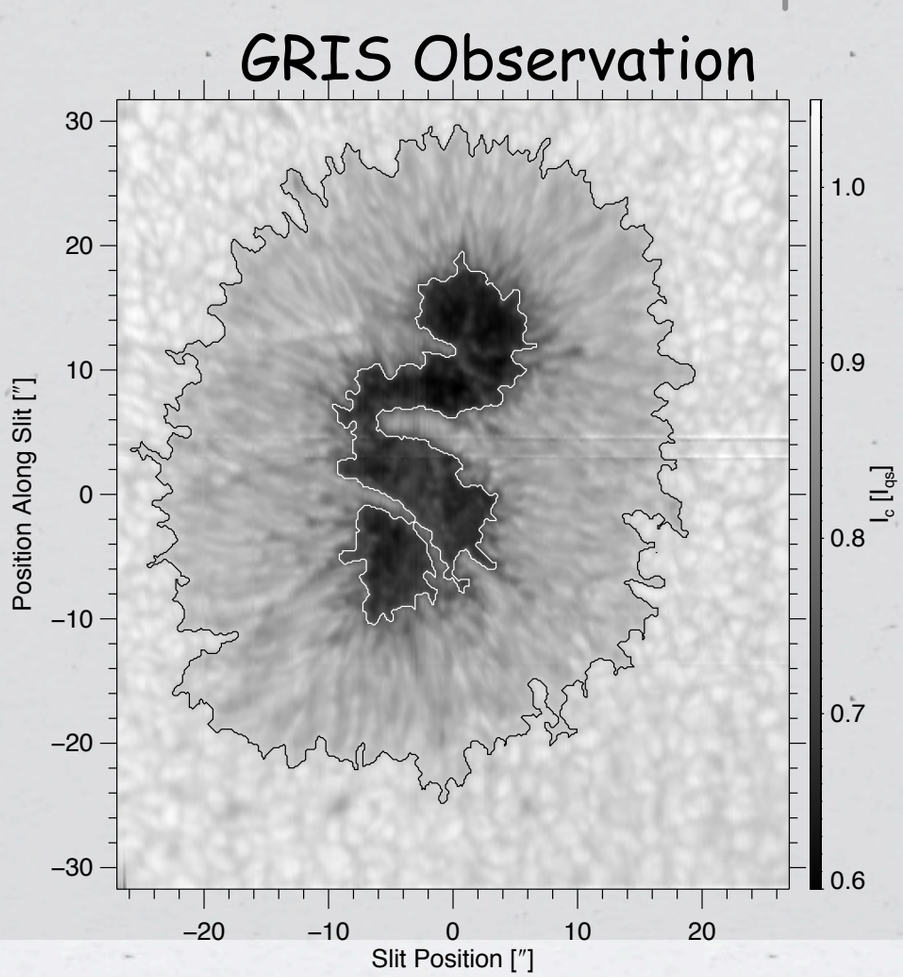




Spatial PSF of GRIS

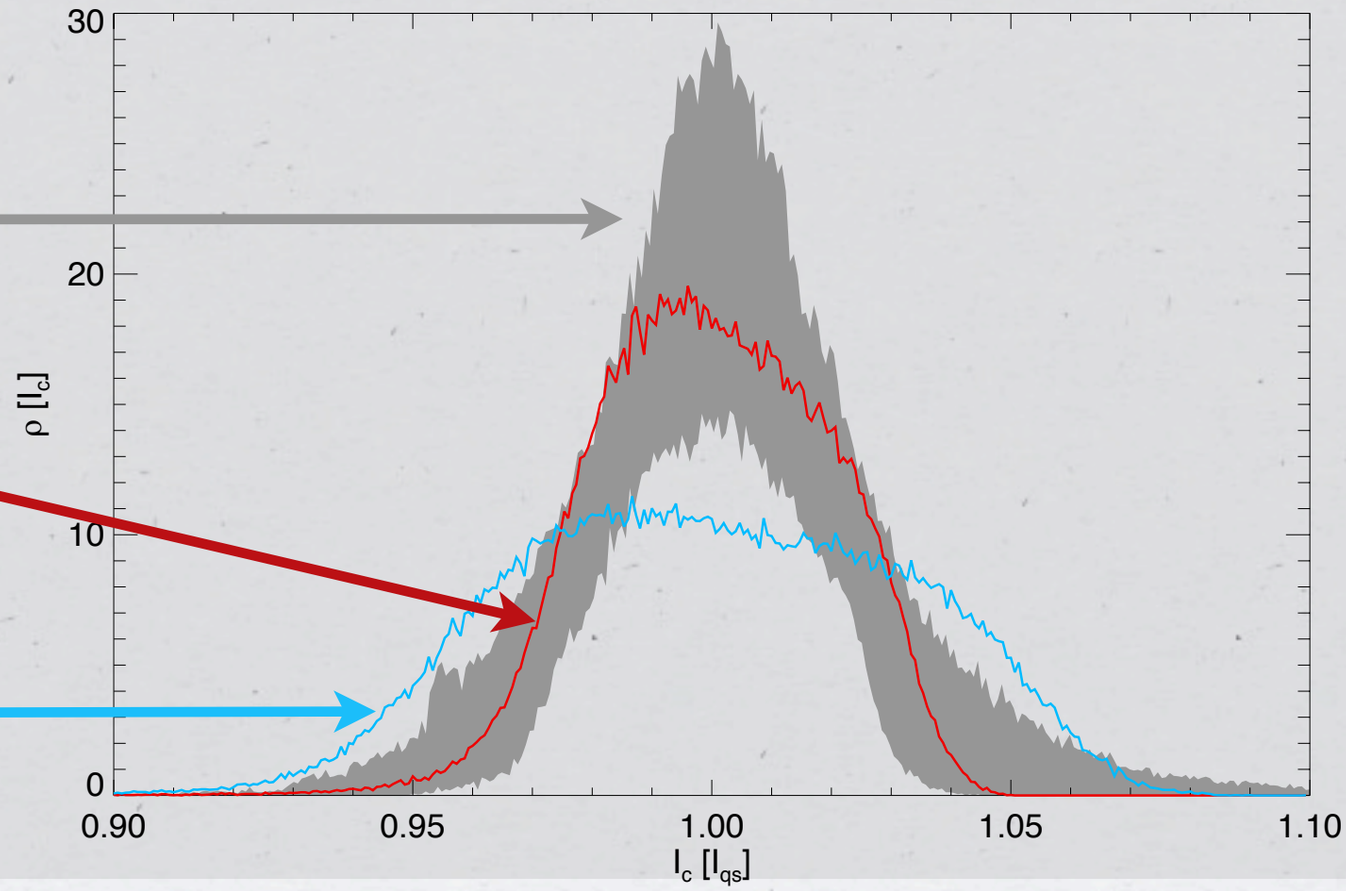
Radiative transfer using SIR → Simulation → Convolution with spatial & spectral PSF → Stokes parameter → Binning & interpolation → Degraded Stokes parameter → Analysis → Simulated observation → Amount of 3-lobe profiles

RMS contrast (σ of histogram)

GRIS Observation
1.6 % - 2.6 %

Simulation ⊗ Lagg-PSF
2.0 %

Simulation ⊗ Mercury-PSF
3.2 %

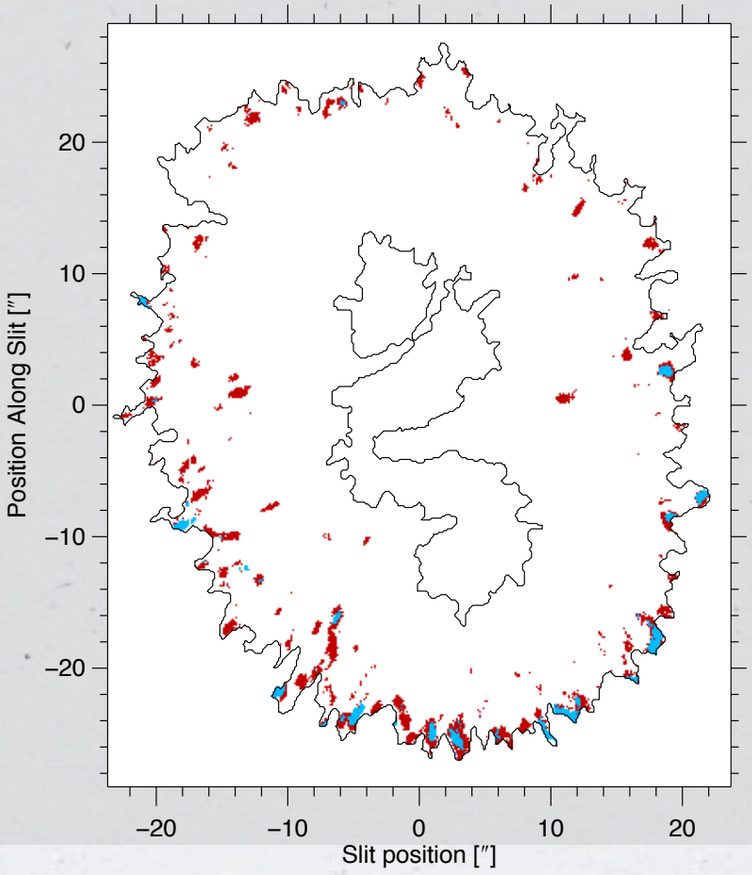


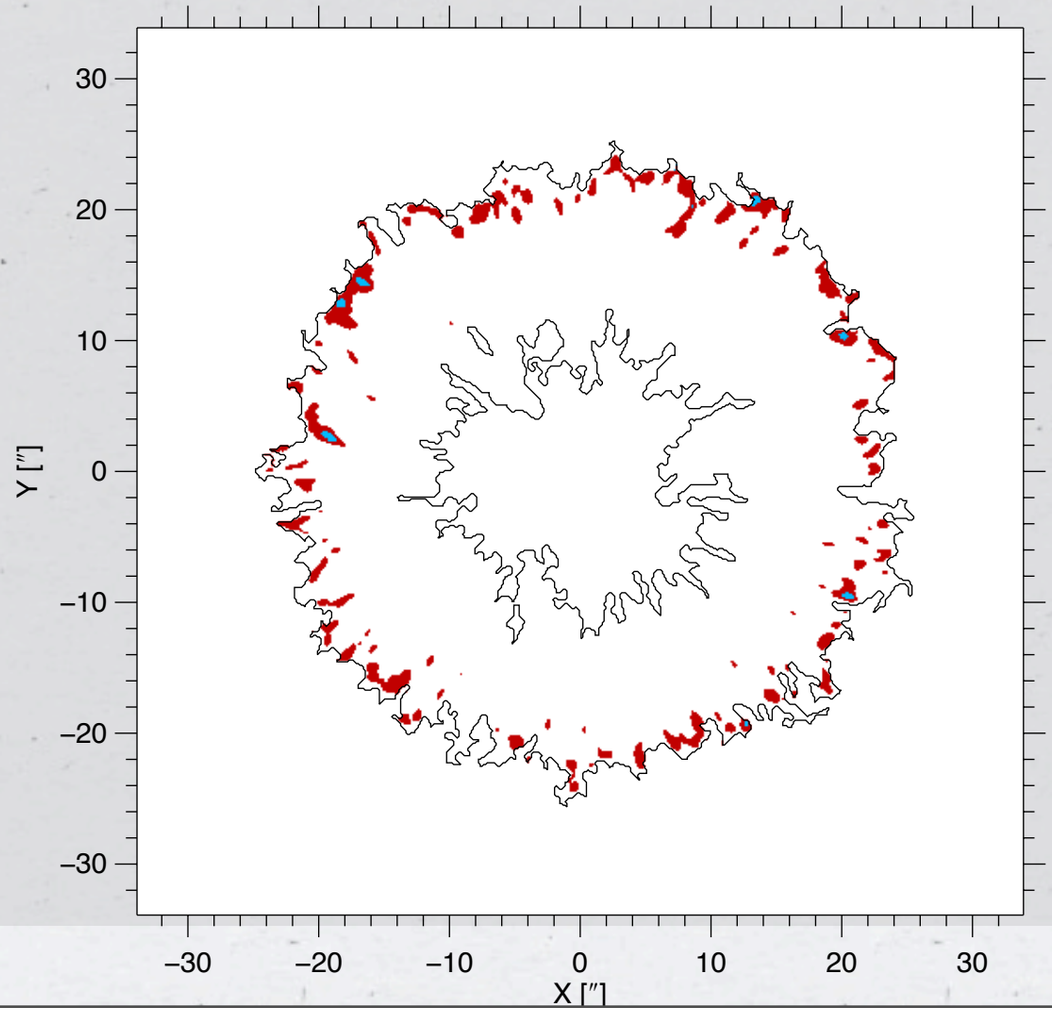
Spatial PSF of GRIS

Radiative transfer using SIR → Simulation → Stokes parameter

Convolution with spatial & spectral PSF → Binning & interpolation → Degraded Stokes parameter

Analysis → Simulated observation → Amount of 3-lobe profiles





3-lobe & reversed V profiles

- Hinode Observation
- Degraded Simulation (Hinode PSF & Voigt)
- Degraded Simulation (Hinode PSF)

- GRIS Observation
- Degraded Simulation (PSF from Lagg et al. 2016)
- Degraded Simulation (σ_n=0.“18 / p_w=0.4 / σ_w=5“)

	Line	Fe 630.15	Fe 630.25	Fe 1564.85	Fe 1565.29	Fe 1566.20
penumbral area with	3-lobe profiles	11.4 % 11.9 % 8.7 %	15.1* % 16.5* % 10.5* %	0.7 %	0.6 % 6.3 % 14.9 %	3.2 % 5.8 % 12.5 %
	reversed polarity profiles	2.4 % 3.1 % 0.7 %	1.9 % 1.0 % 0.2 %	1.1 %	1.1 % 0.2 % 0.6 %	0.9 % 0.2 % 0.6 %

* Removing profiles from the inner penumbra that show magneto optical effects

Summary

- Synthetic data from MHD simulation are degraded using various PSF‘s to study the influence of spectral and spatial straylight
- PSF is selected such that it reproduces the RMS contrast and distribution of quiet Sun intensities or obtained from measurements during Mercury transit
- Especially in the IR, the amount of reversed polarity and 3-lobe Stokes V profiles could not be reproduced reasonably.
- It could provide an additional measure to constrain the PSF

References

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Acknowledgements

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The **M**PS **U**ofC **Ra**diation **M**agneto-hydrodynamics code resulted from a cooperation of the solar MHD groups at the Max-Planck-Institut für Sonnensystemforschung and the University of Chicago.