Magnetic Elements At High Spatial Resolution

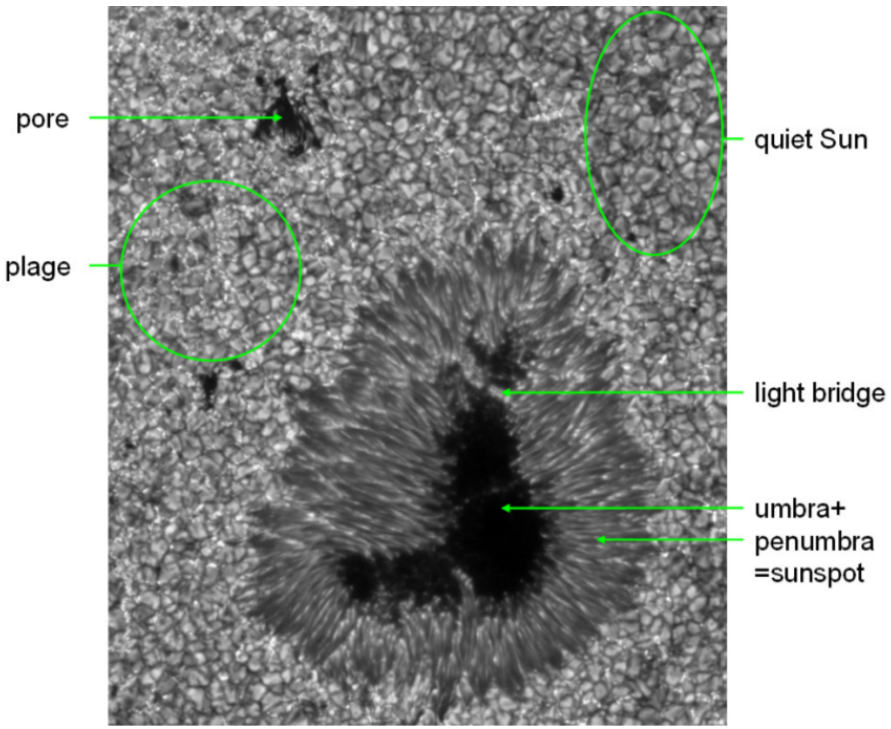
Fatima Kahil

S. Solanki & T. Riethmüller
Max Planck Institute for Solar System Research-Göttingen, Germany

September 20, 2017

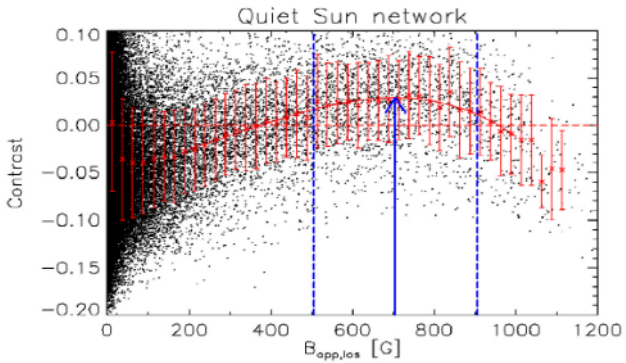
Introduction - Magnetic elements

- Magnetic elements: quiet Sun (QS) network/(AR) plages (Schüssler, 1992)
- kG magnetic fields (1200-2000 G)
- 90 % of magnetic flux outside sunspots
- Bright in continuum and spectral lines (hotter than their surroundings)

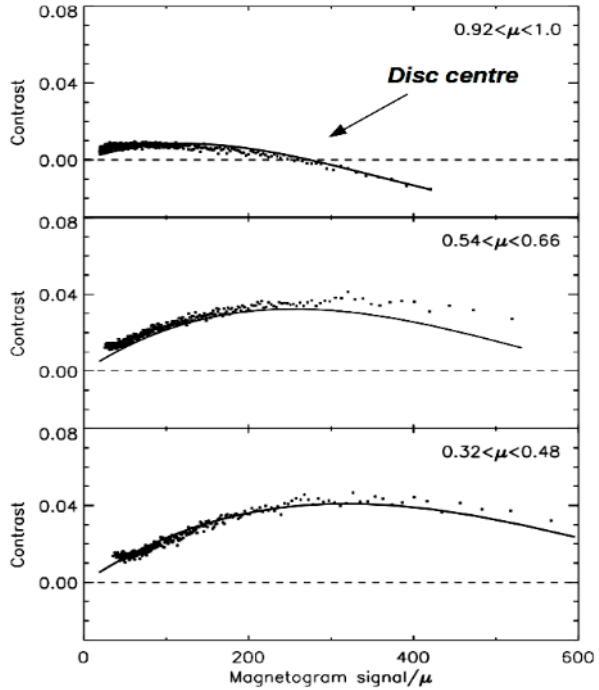


Motivation

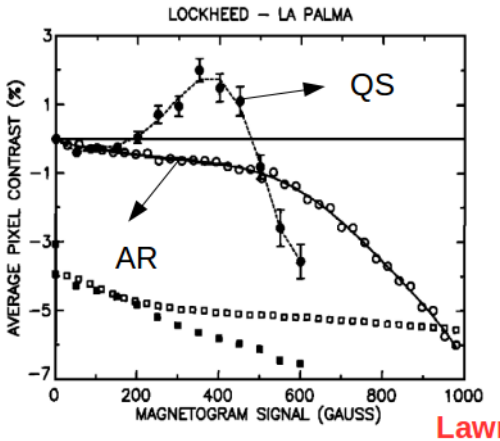
- Brightness-magnetic relationship: input for solar irradiance modelling.
- Different contributions from different magnetic features.



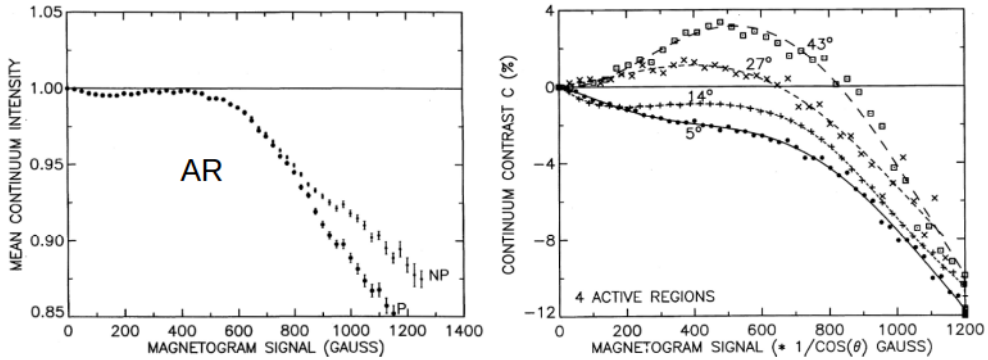
Kobel et al. 2011 (0.3")



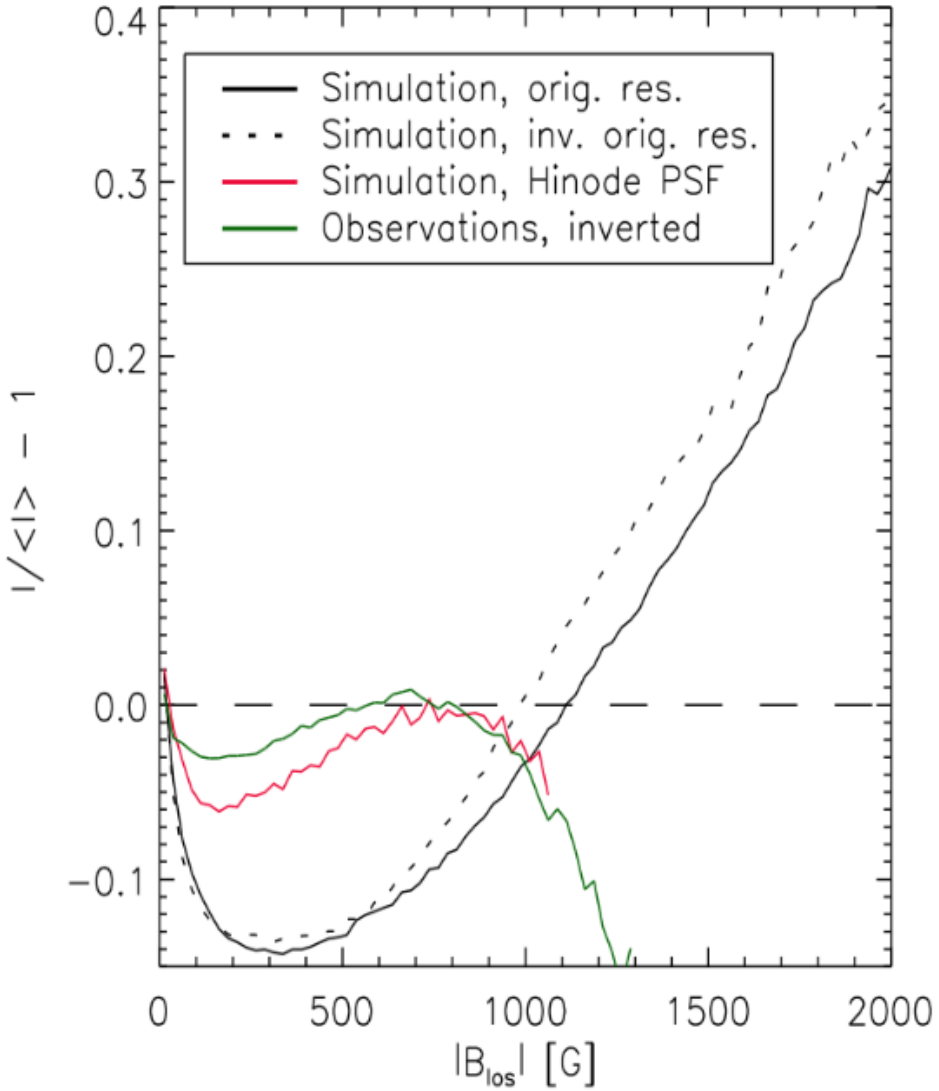
Ortiz et al. 2002 (4")

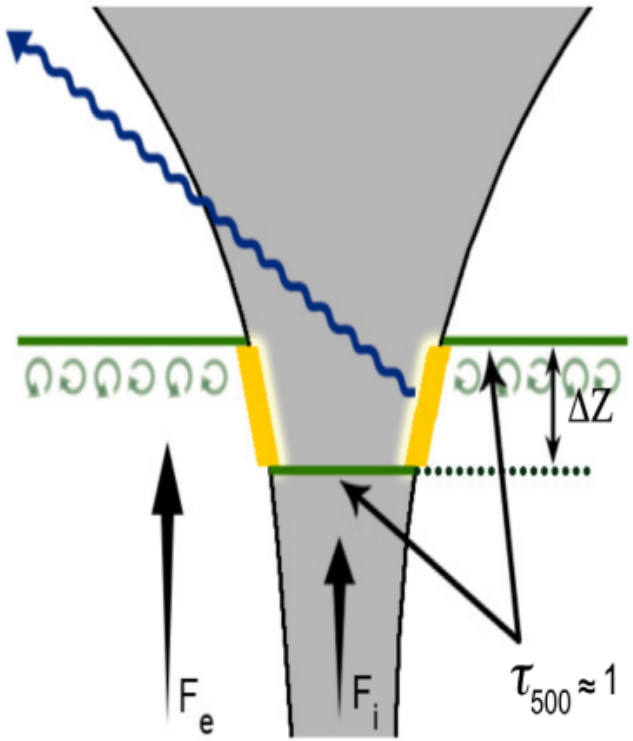


Lawrence et al.1993 (0.45 “)



Topka et al. 1992

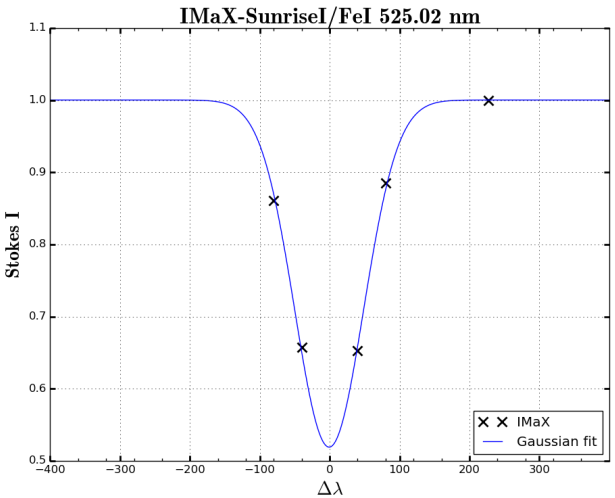


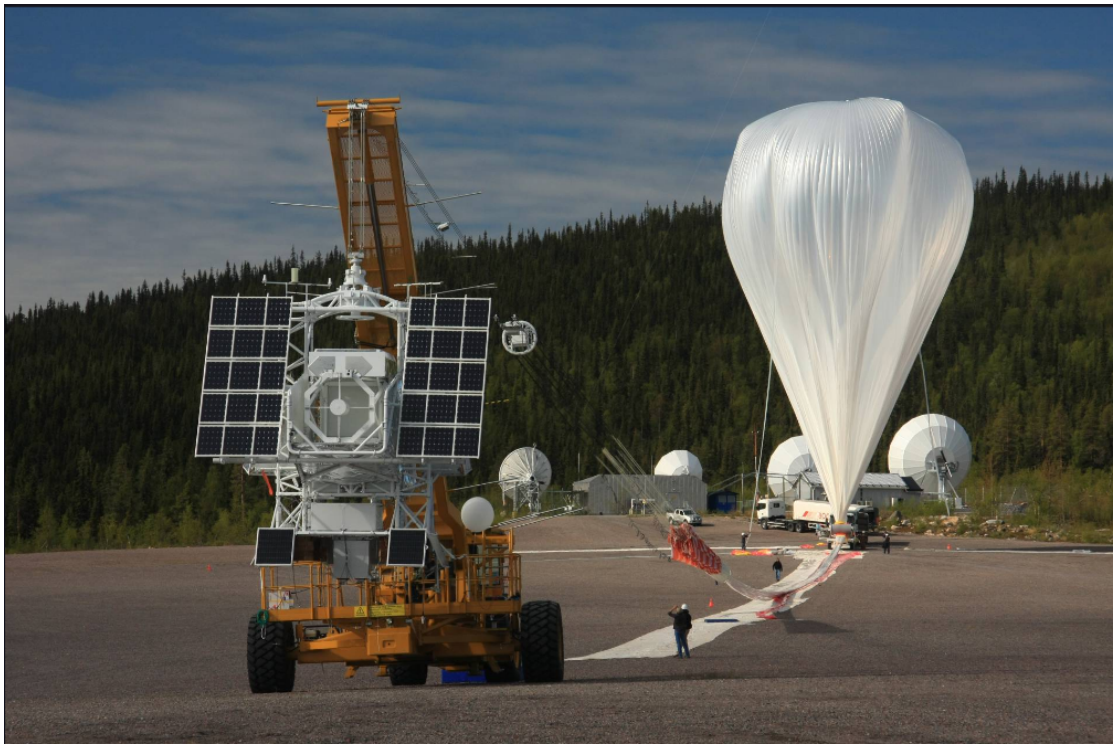


Danilovic et al. 2012

Sunrise I

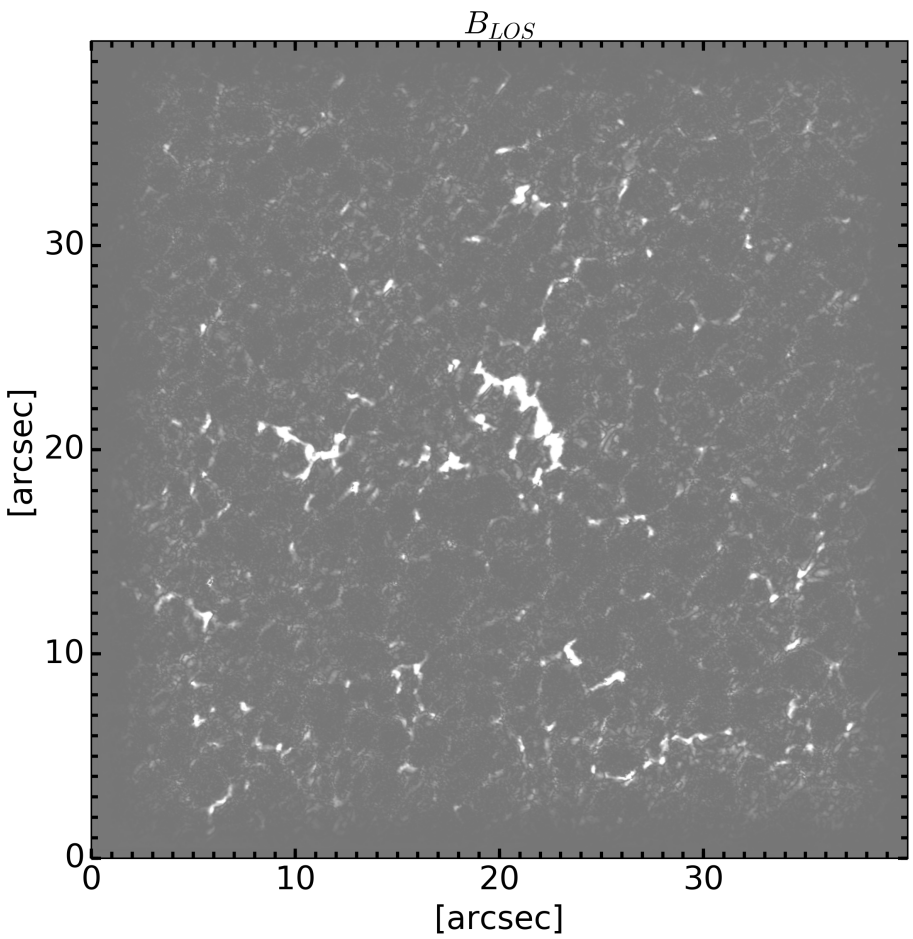
- Balloon-borne solar observatory:
  - 1 m telescope
  - Near-diffraction limit observations
  - UV filter imager (SuFI)
  - imaging vector polarimeter (IMaX) (0.15″-0.18″)

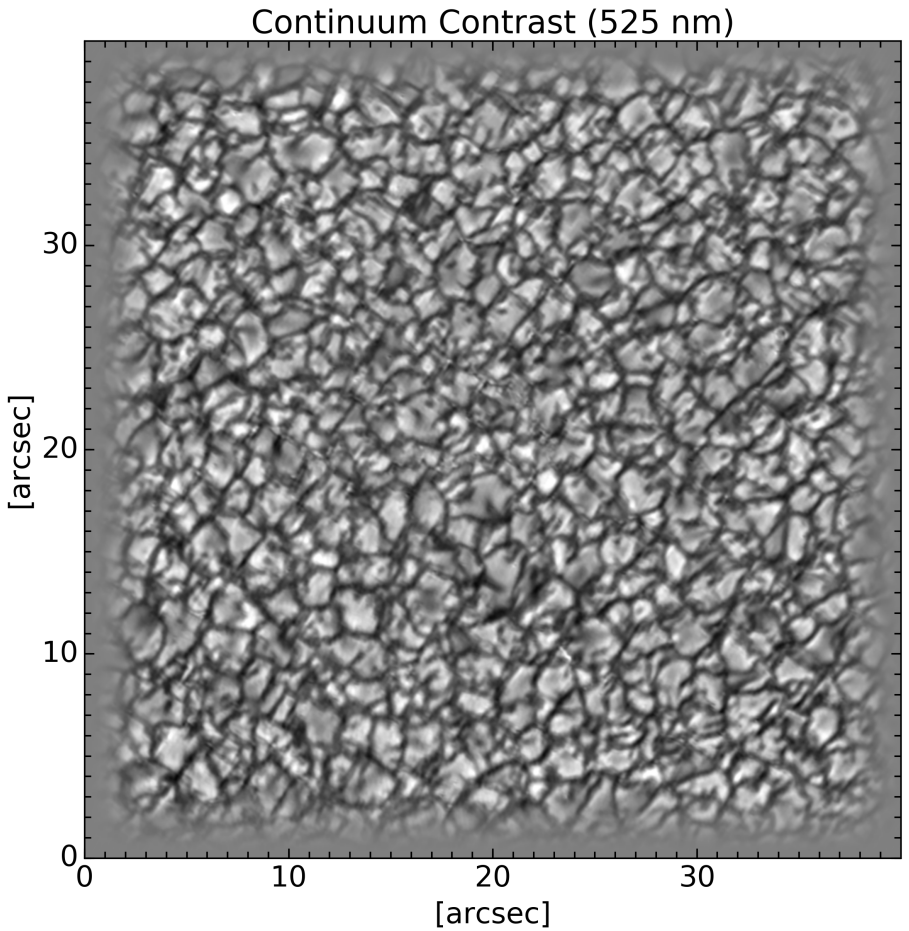




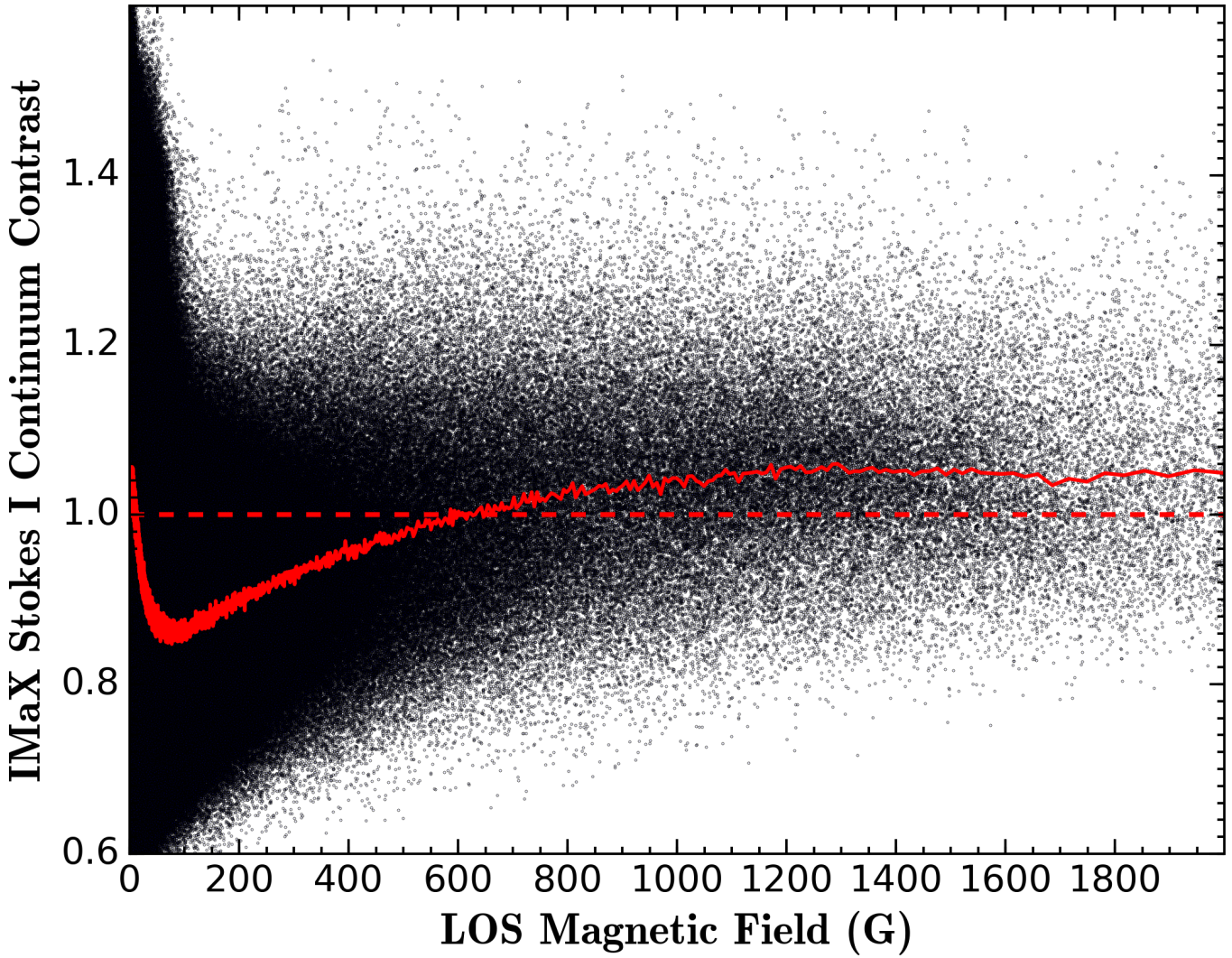
What new insights could high resolution observations provide about these structures?

$$Contrast = I / < I >_{QS}$$





Results - Continuum contrast vs. B_{LOS}

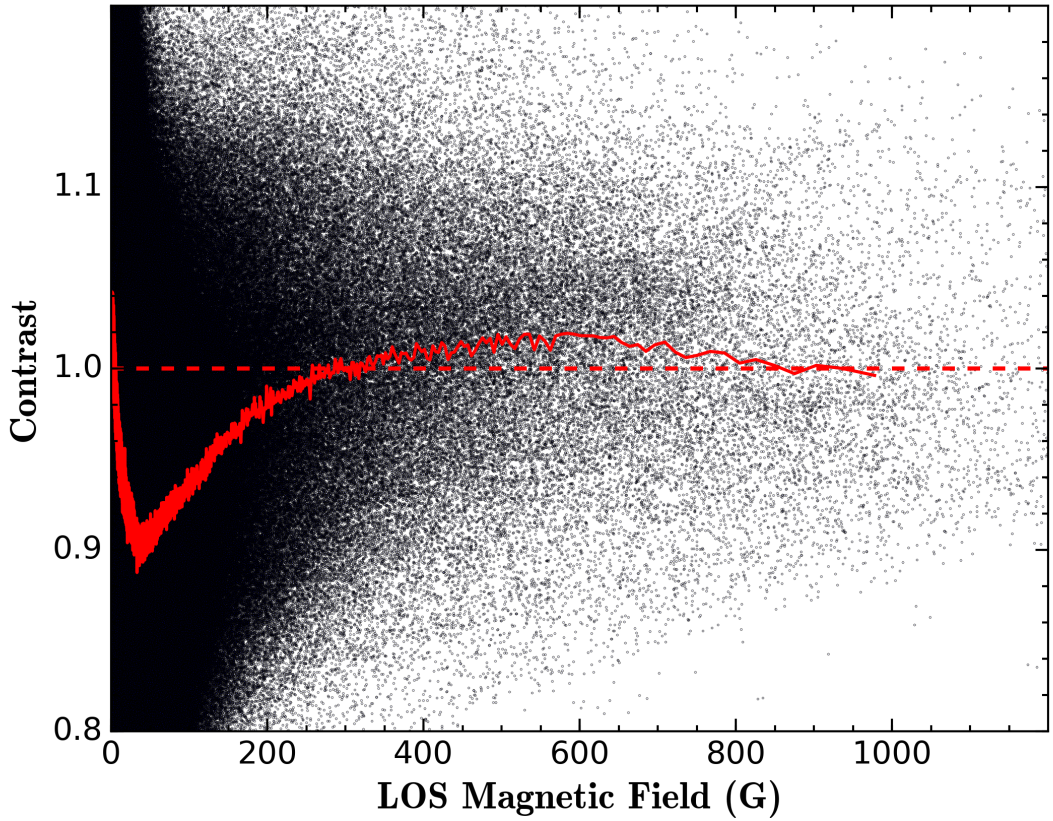


Results - Continuum contrast vs. B_{LOS}

- Stokes I and V degraded to Hinode's spatial resolution
- Convolution with a Gaussian of FWHM $= 0.32''$
- Centre of gravity method (C-O-G) to derive B_{LOS}

Results - Continuum contrast vs. $B_{\rm LOS}$

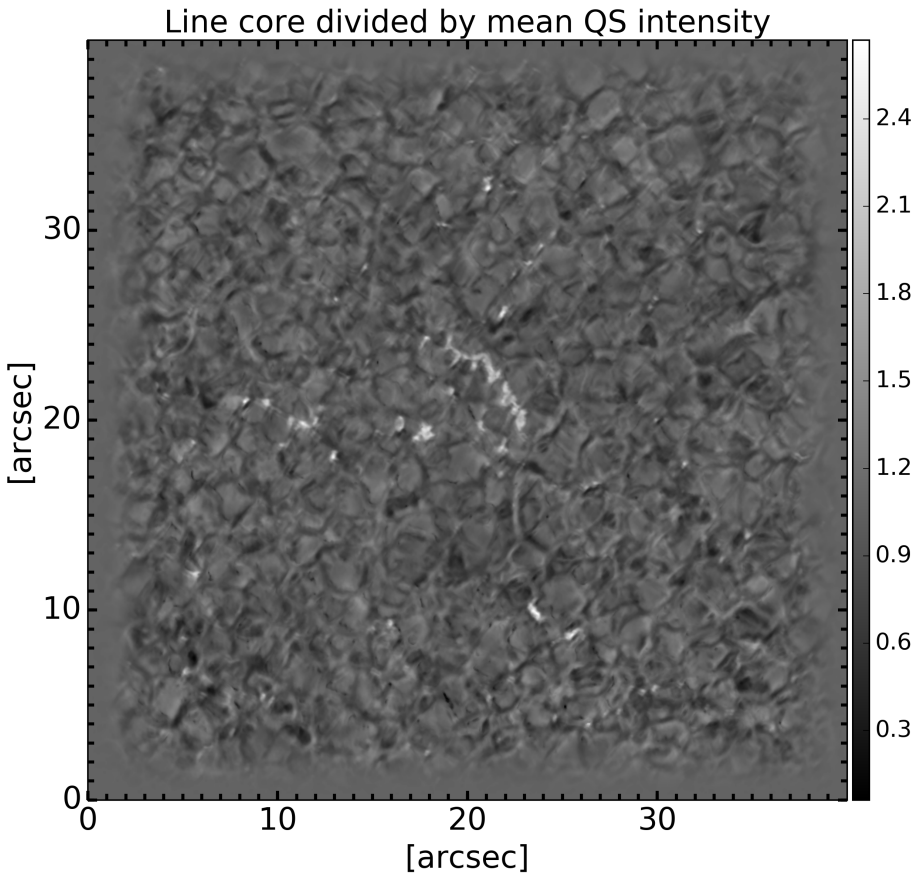
- Stokes I and V degraded to Hinode's spatial resolution
- Convolution with a Gaussian of FWHM $= 0.32''$
- Centre of gravity method (C-O-G) to derive $B_{\rm LOS}$

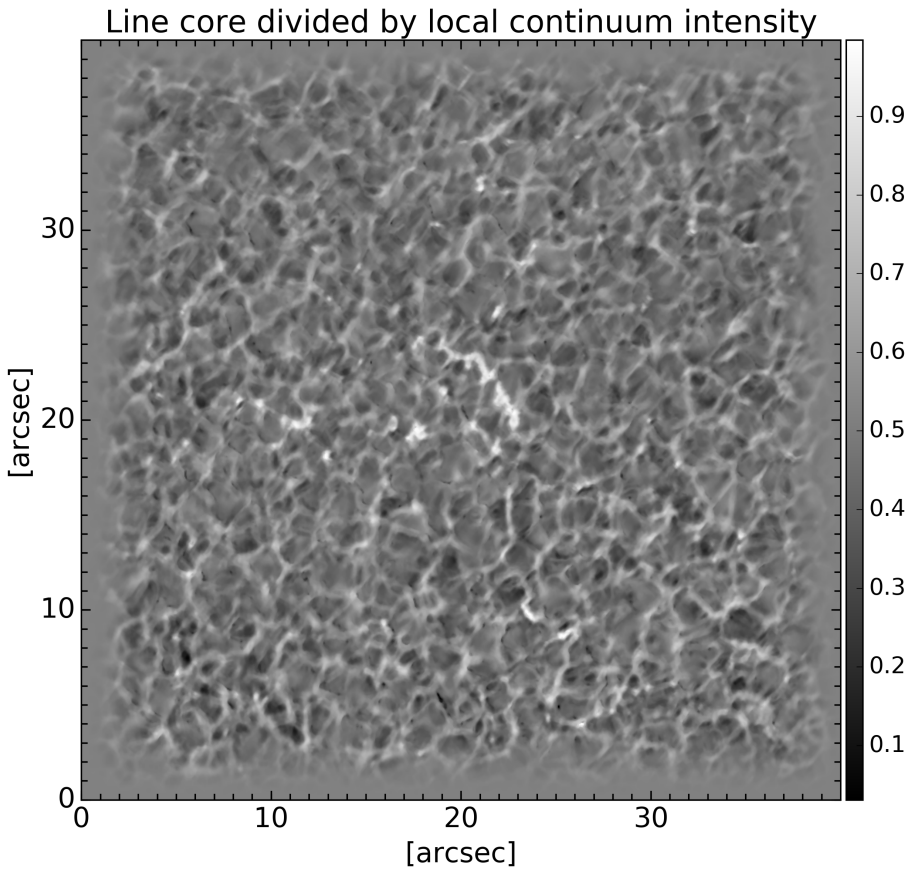


Results - Line core contrast vs. B_{LOS}

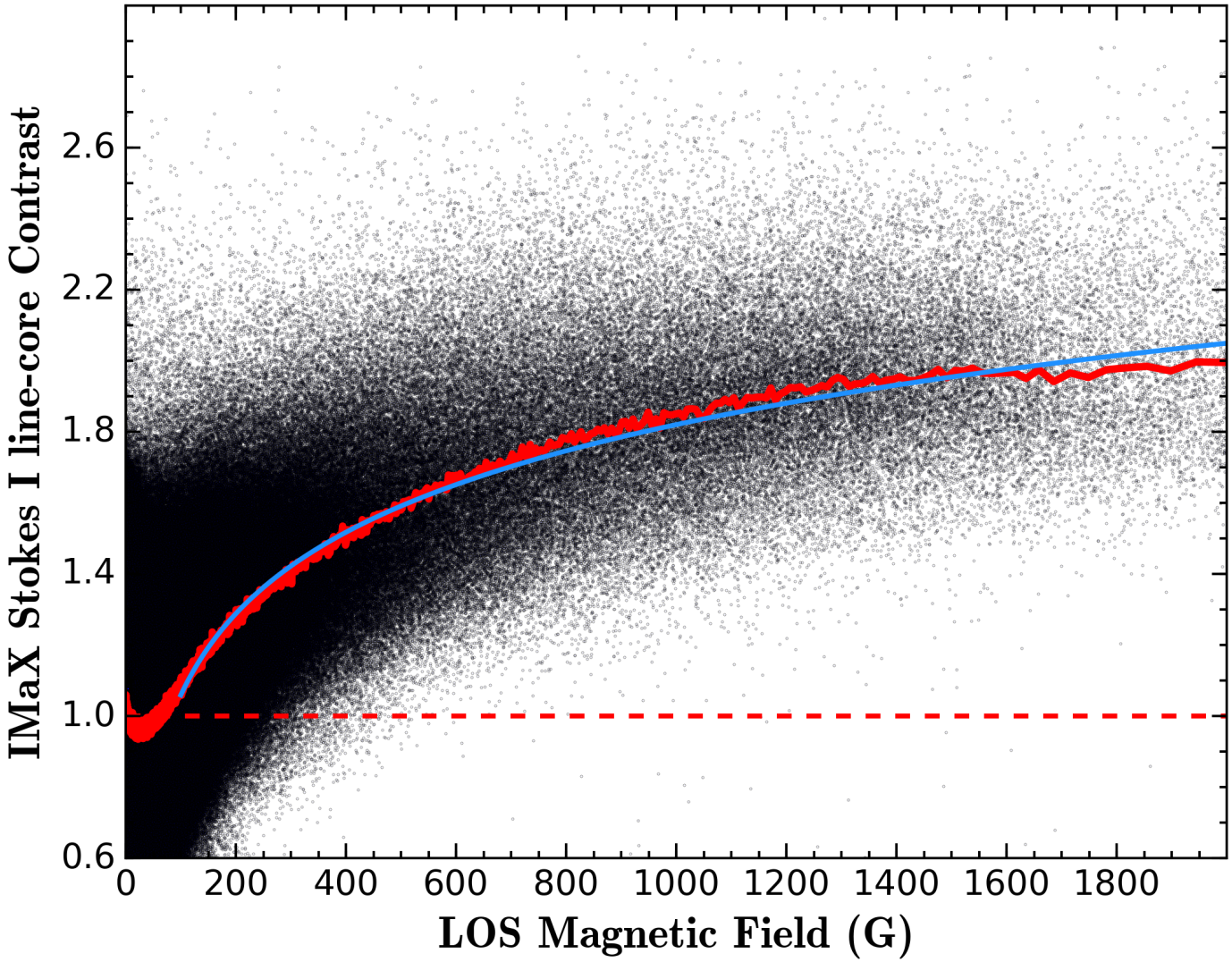
Line core computation

- Gaussian fits to Stokes I profiles



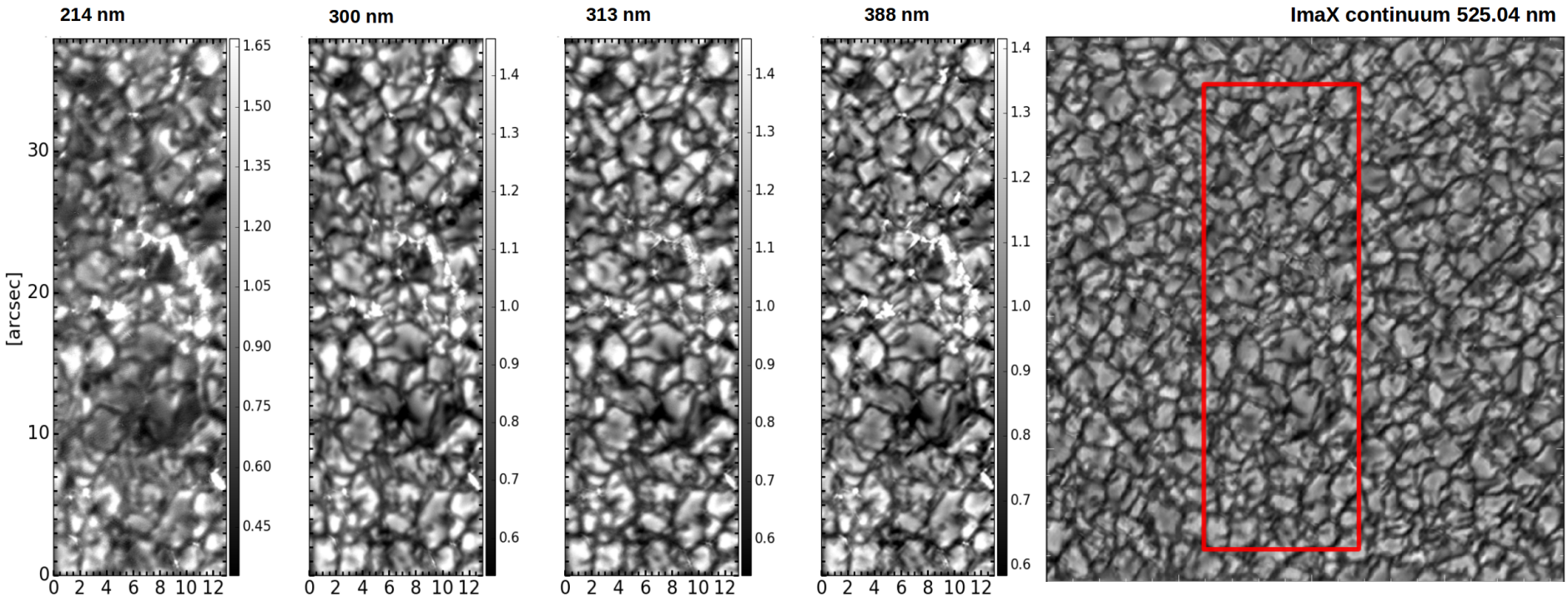


Results - Line core contrast vs. B_{LOS}

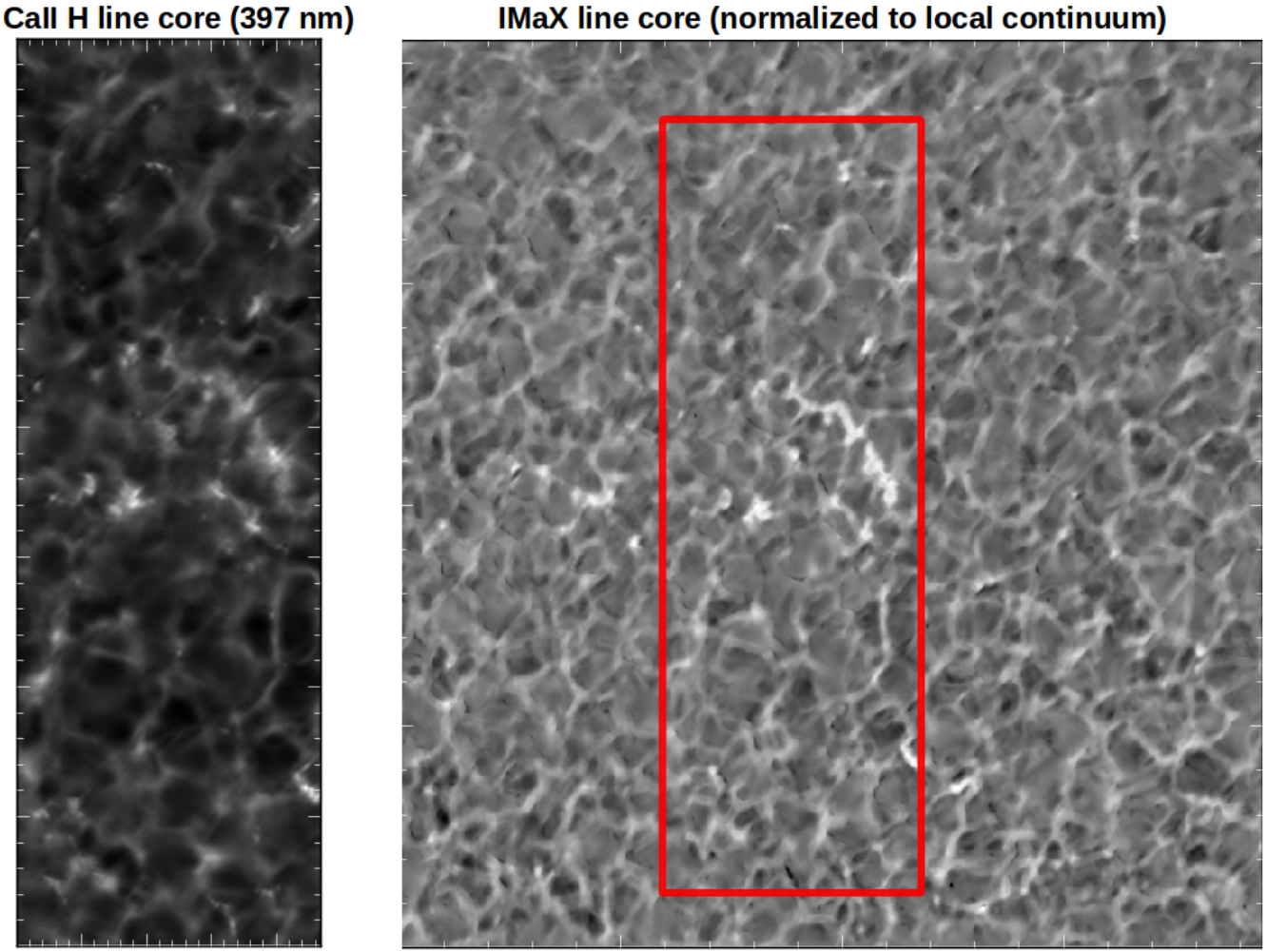


SuFI data

- Resample SuFI data (0.02”/pixel) to IMaX pixel size (0.05”/pixel) via bi-linear interpolation
- Cross-correlation technique to find x and y offsets to sub-pixel accuracy

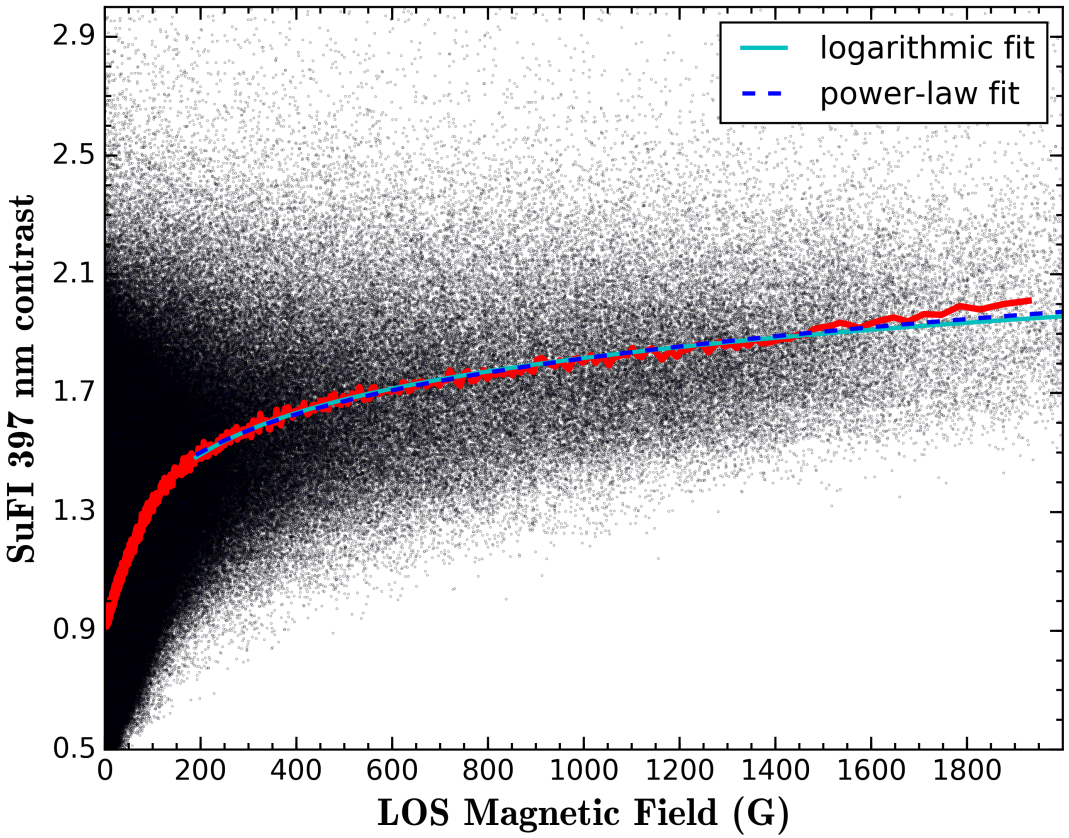


SuFI data



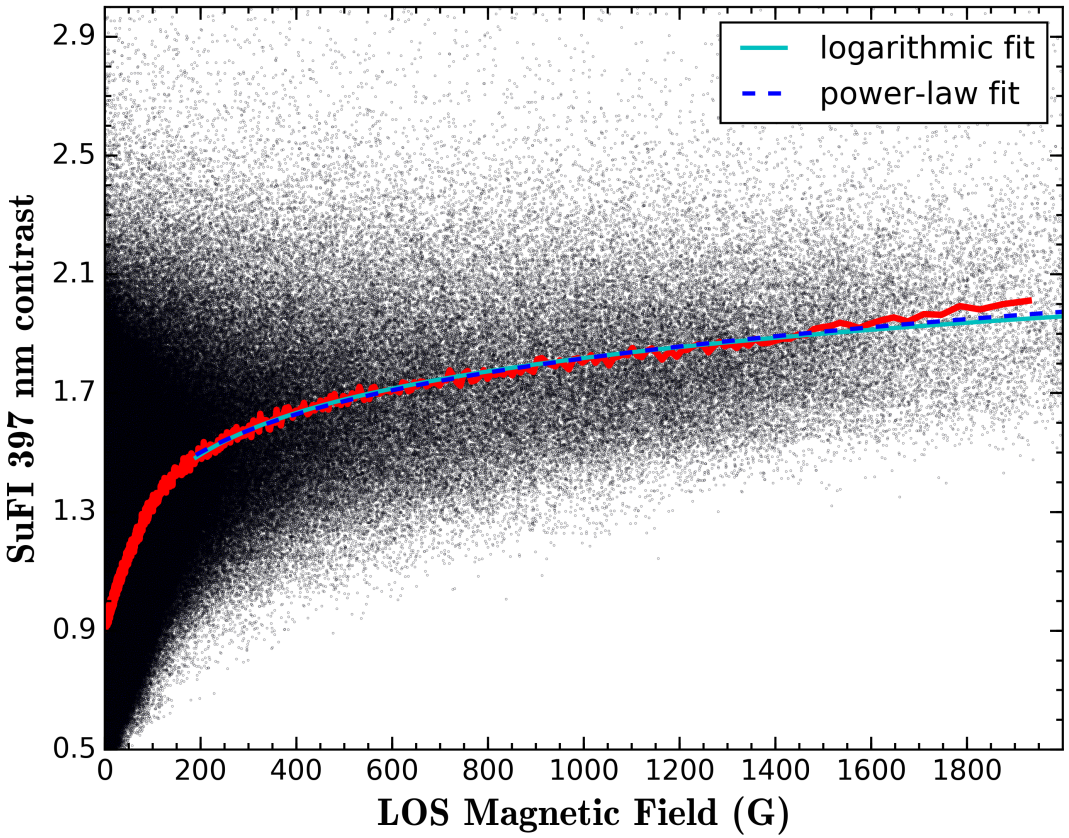
CFOV $= 13'' \times 38''$

Results - NUV contrast vs. B_{LOS}



$$I = a.B_{\mathrm{LOS}}^{b} + I_0$$

Results - NUV contrast vs. B_{LOS}



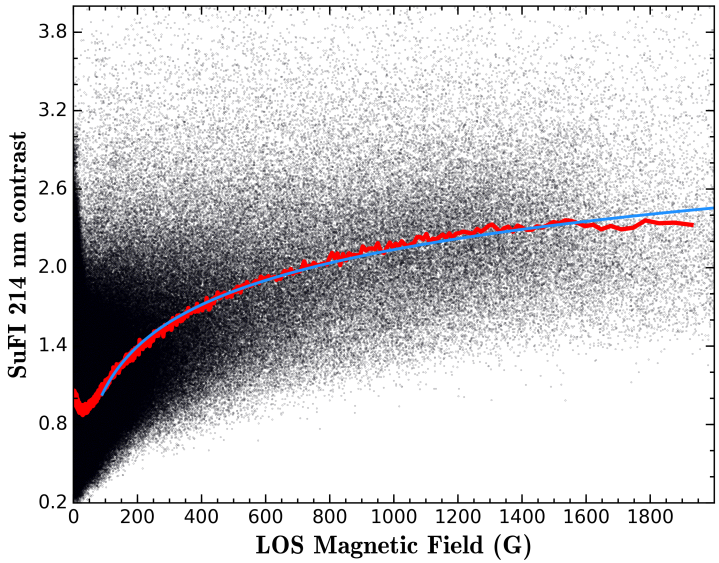
$$I = a.B_{\mathrm{LOS}}^{b} + I_0$$

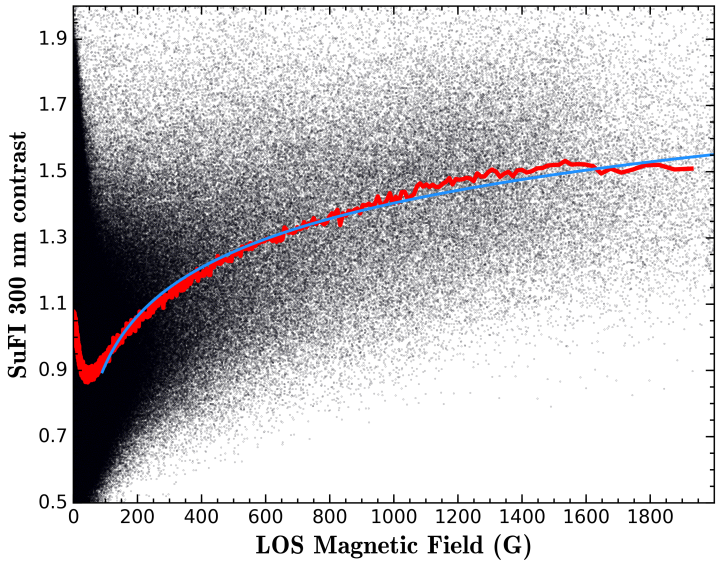
Threshold (G)	b
190	0.14±0.02
210	0.16±0.03
230	0.21±0.03
250	0.28±0.04

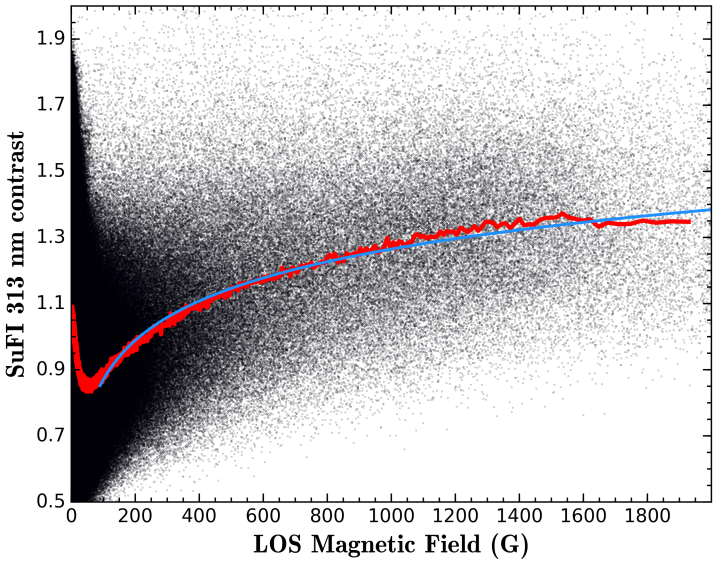
Table : Power-law fit

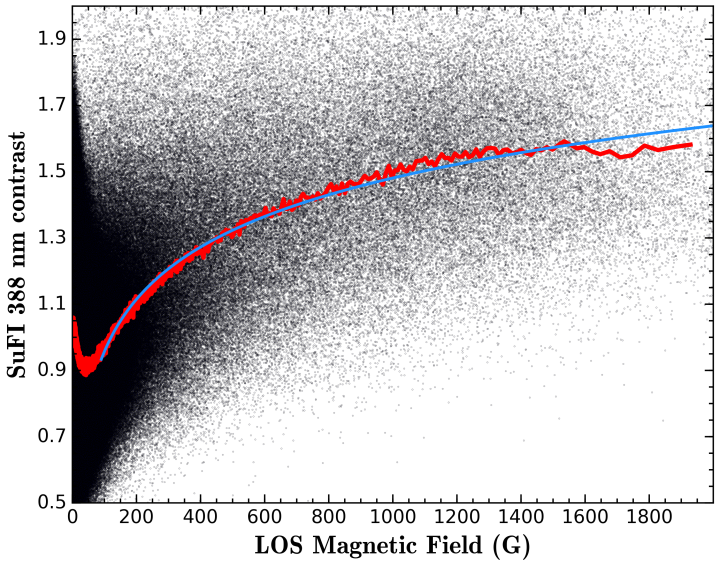
$$I = \alpha.\log_{10}(B_{\mathrm{LOS}}) + \beta$$

Results - NUV contrast vs. B_{LOS}







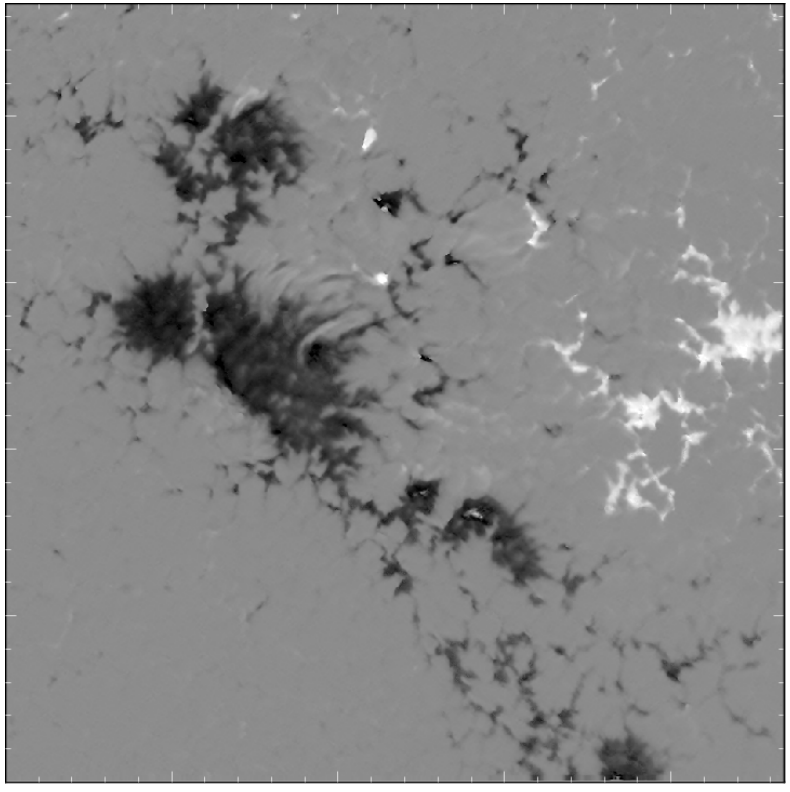


Sunrise II

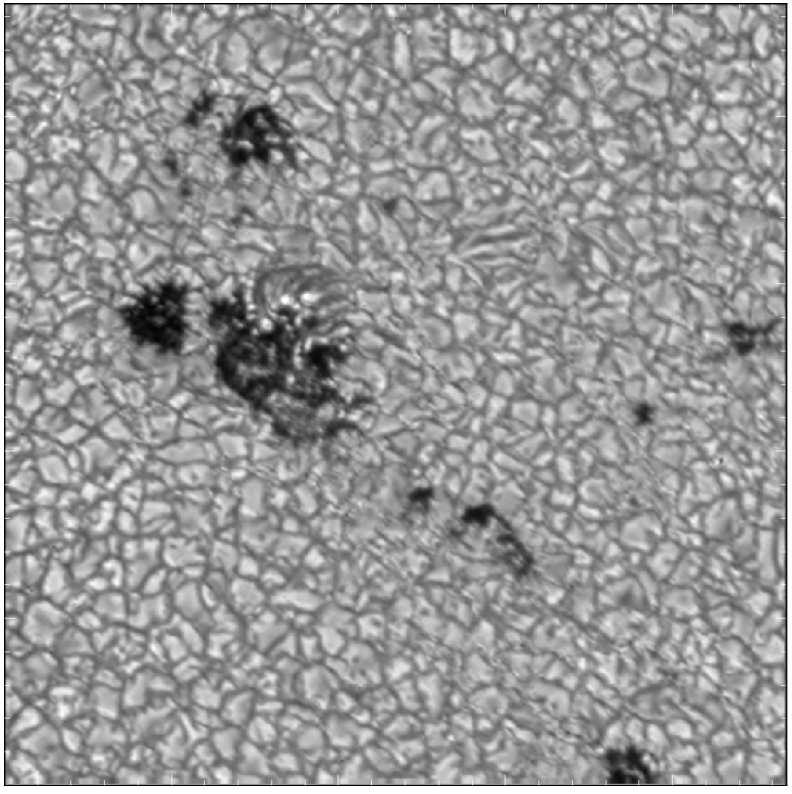
Active Regions: Plage

$\mu = 0.93$

Spinor inversion $\rightarrow B_{LOS}$



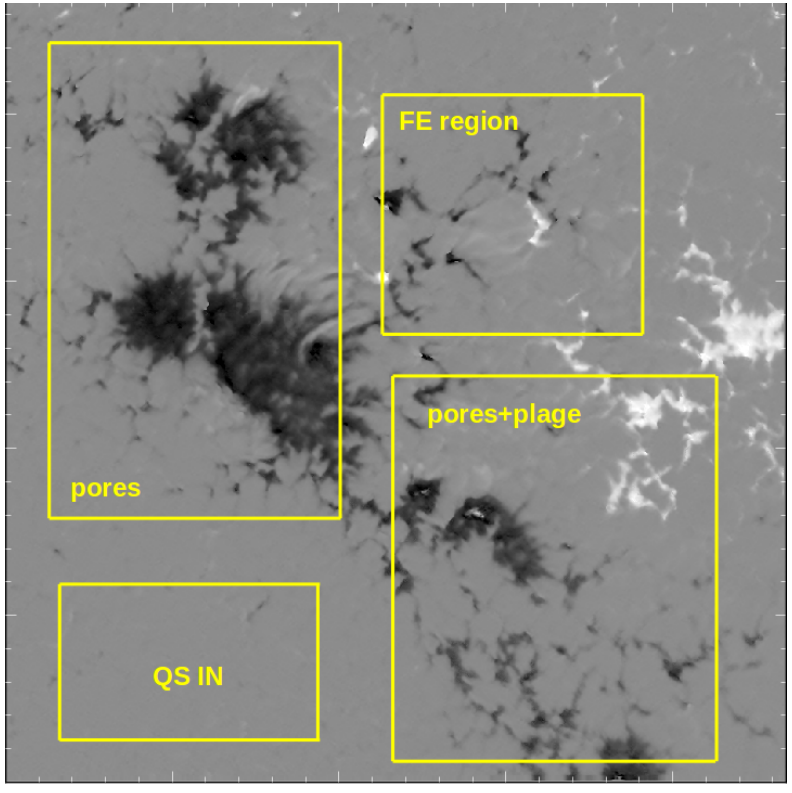
Cotninuum contrast



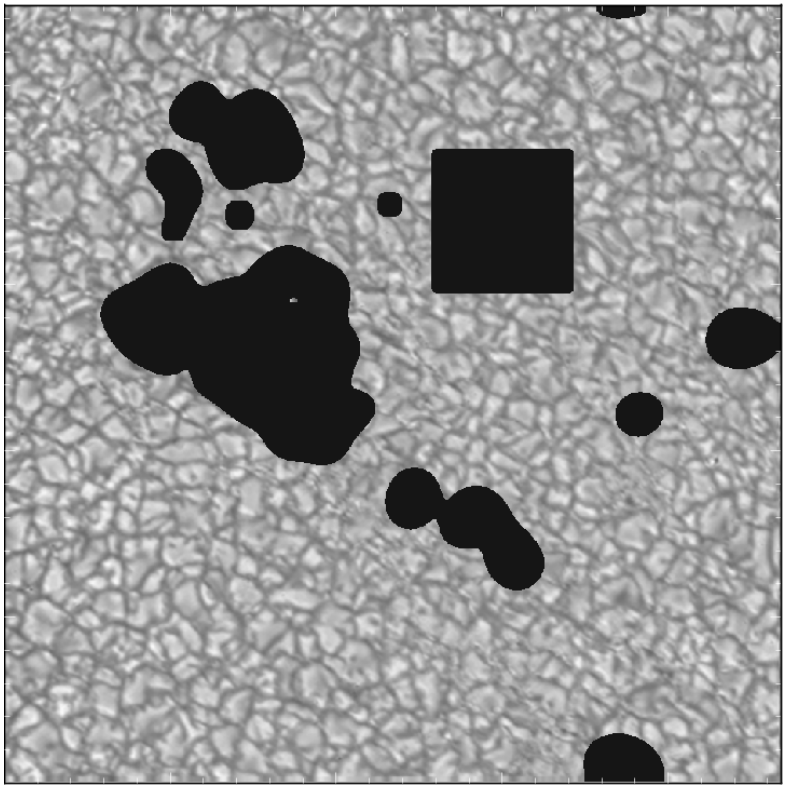
Active Regions: Plage

$\mu = 0.93$

Spinor inversion $\rightarrow B_{LOS}$



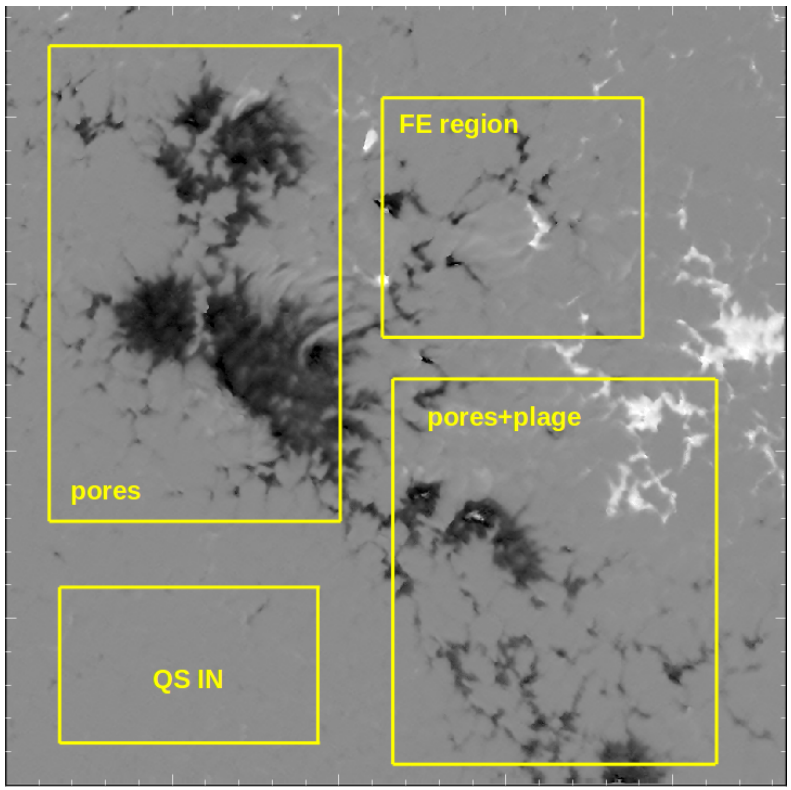
Cotninuum contrast



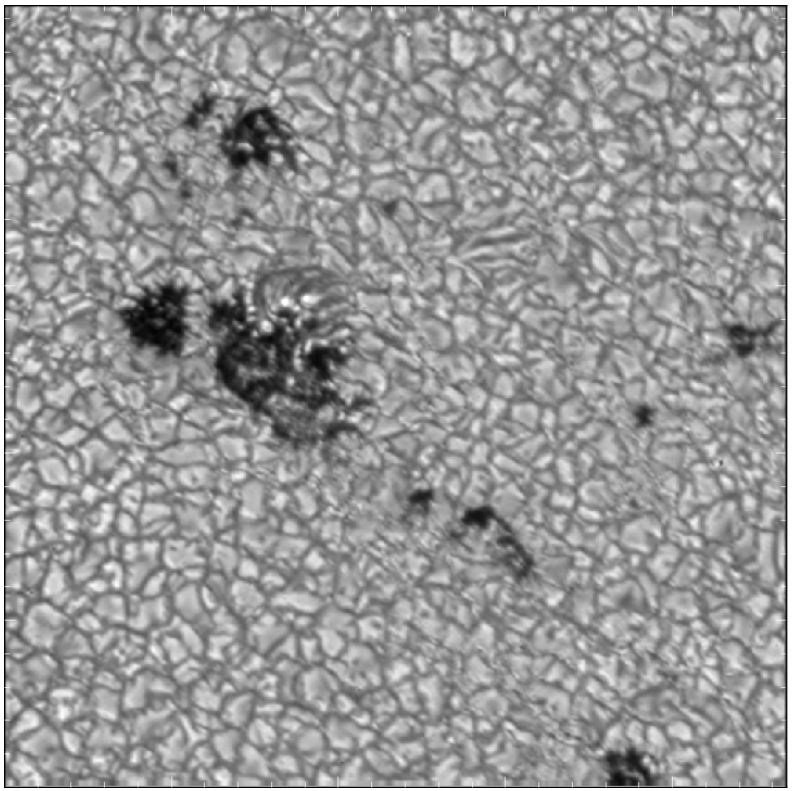
Active Regions: Plage

$\mu = 0.93$

Spinor inversion $\rightarrow B_{LOS}$

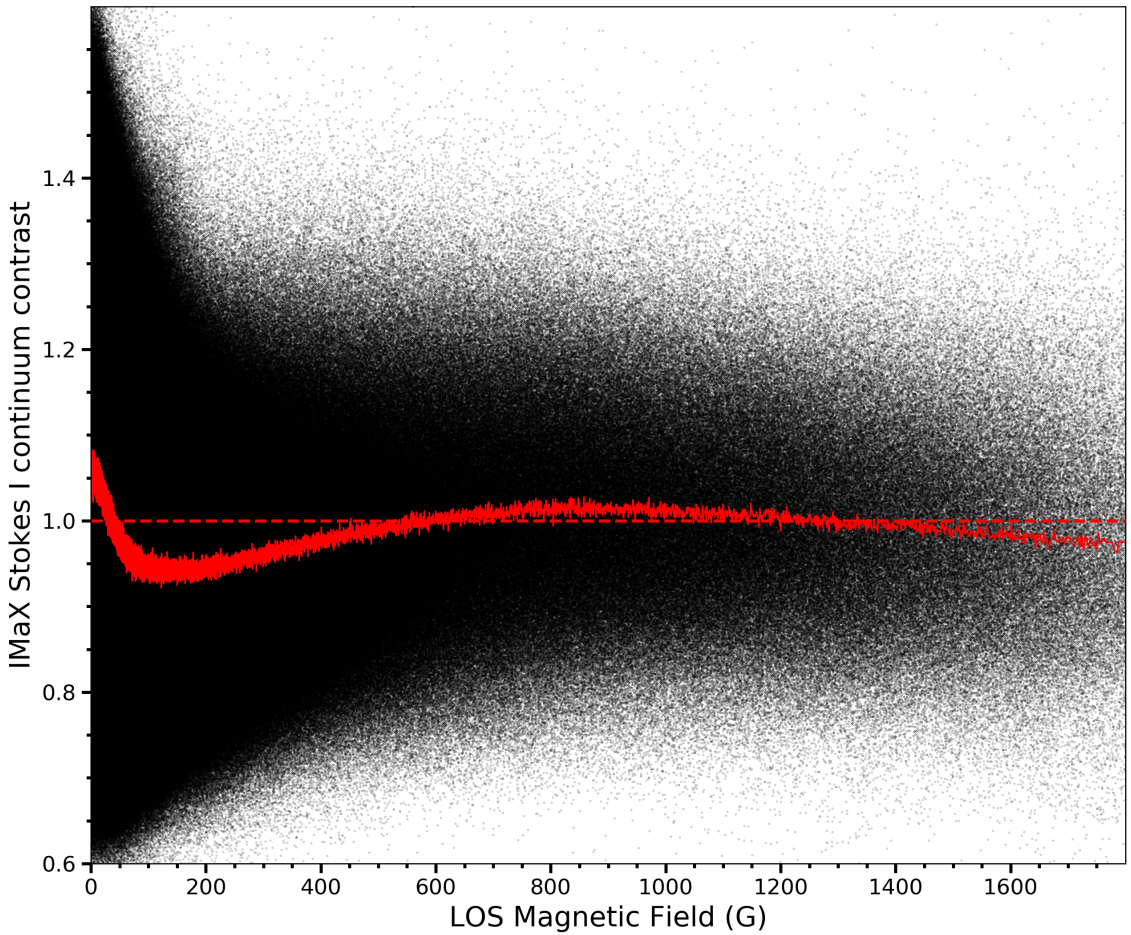


Cotninuum contrast



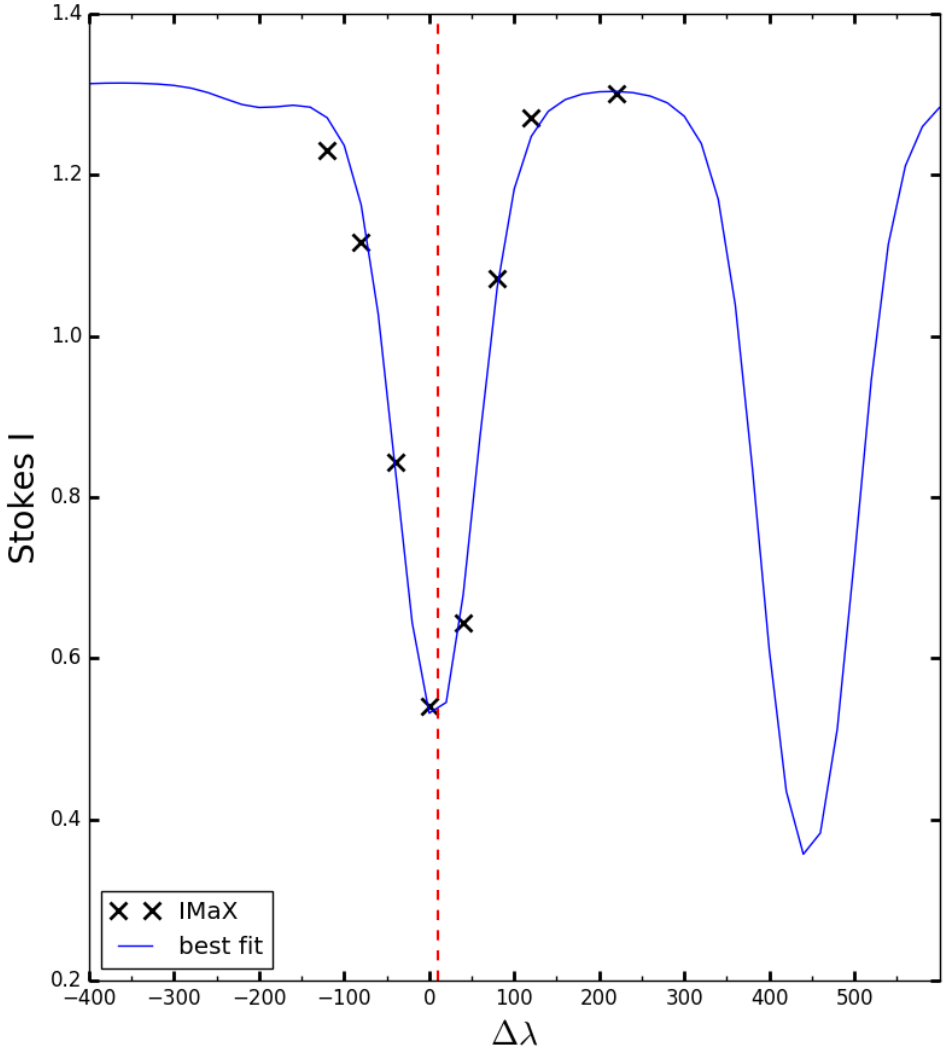
Results - Continuum contrast vs. B_{LOS}

Non-parametric regression: peak at 850 G

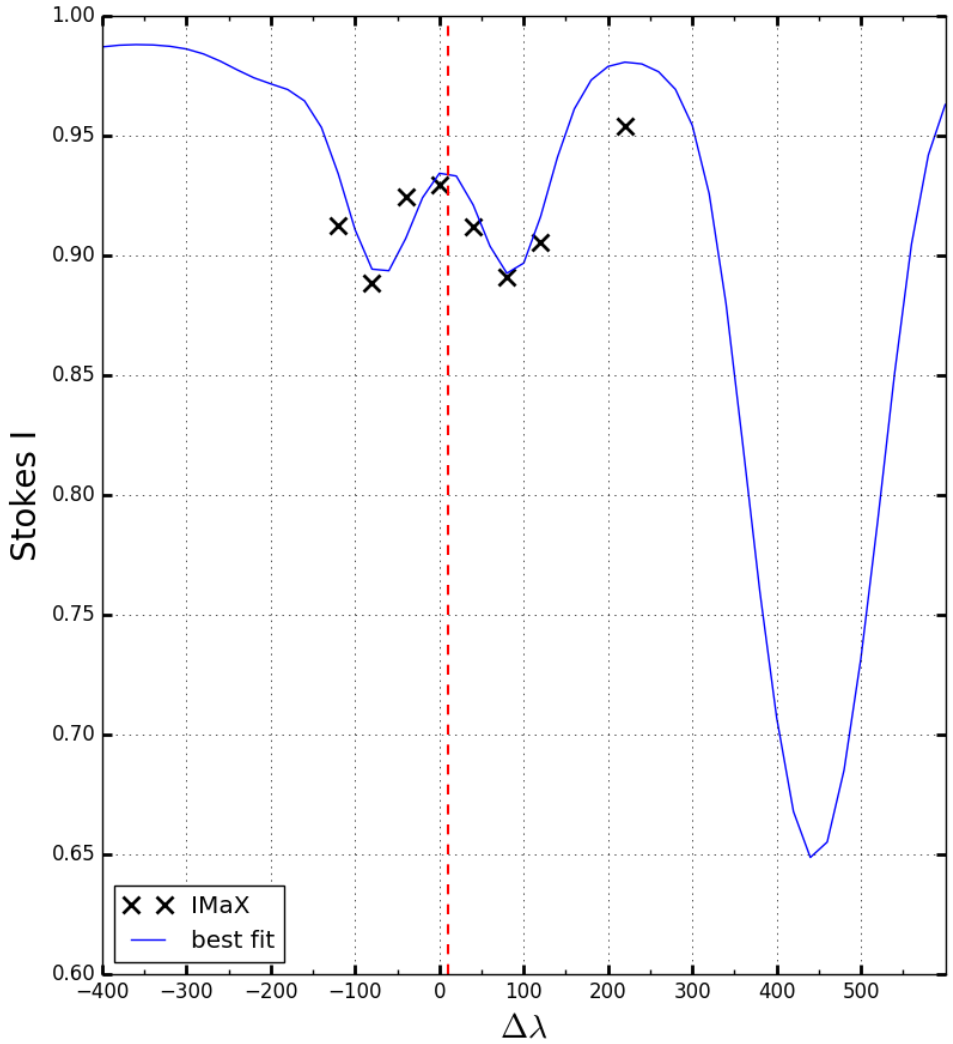


Reference	θ	**Peak**
Ortiz et al. 2002	4"	100 G
Yeo et al. 2013	1"	200 G
Kobel et al. 2011	0.3"	700 G
Berger et al. 2007	0.15"	700 G

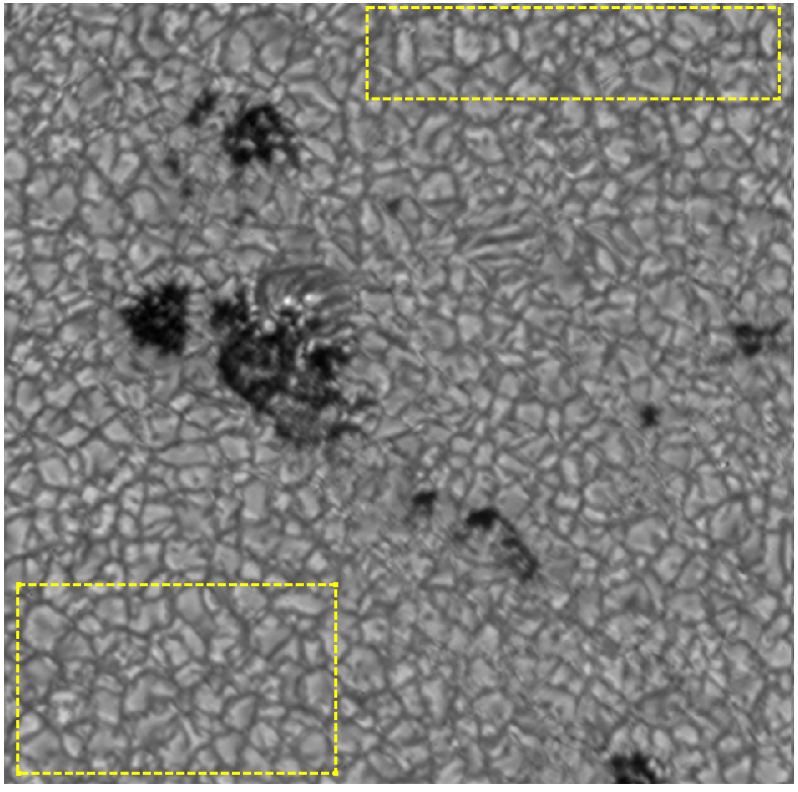
Results - Line core contrast vs. B_{LOS}

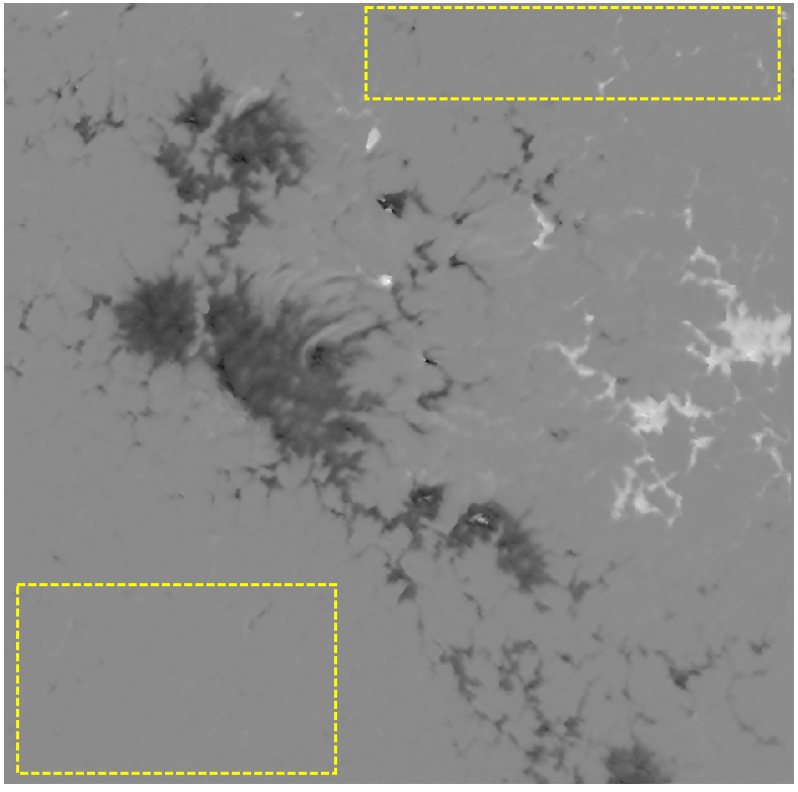


Results - Line core contrast vs. B_{LOS}

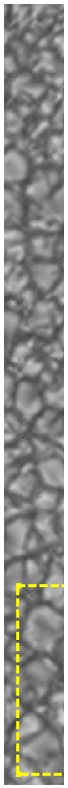


QS regions from Sunrise II

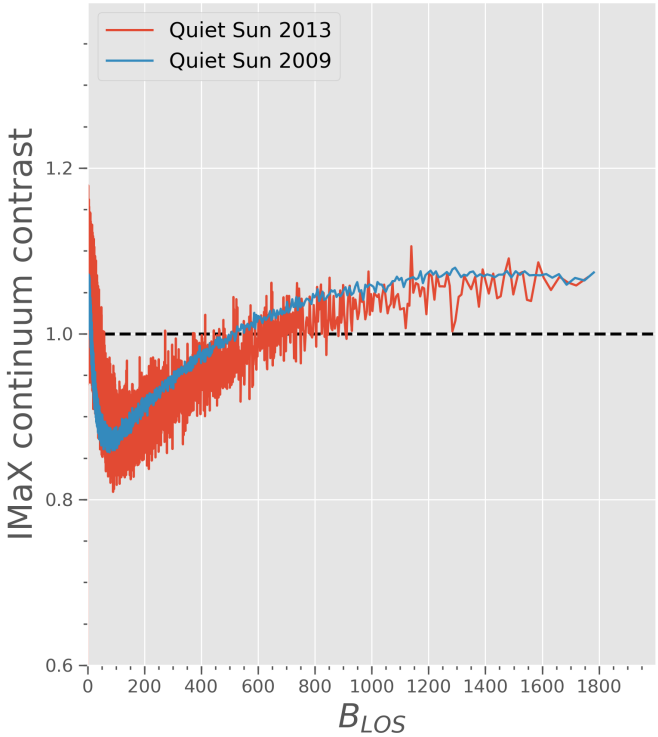


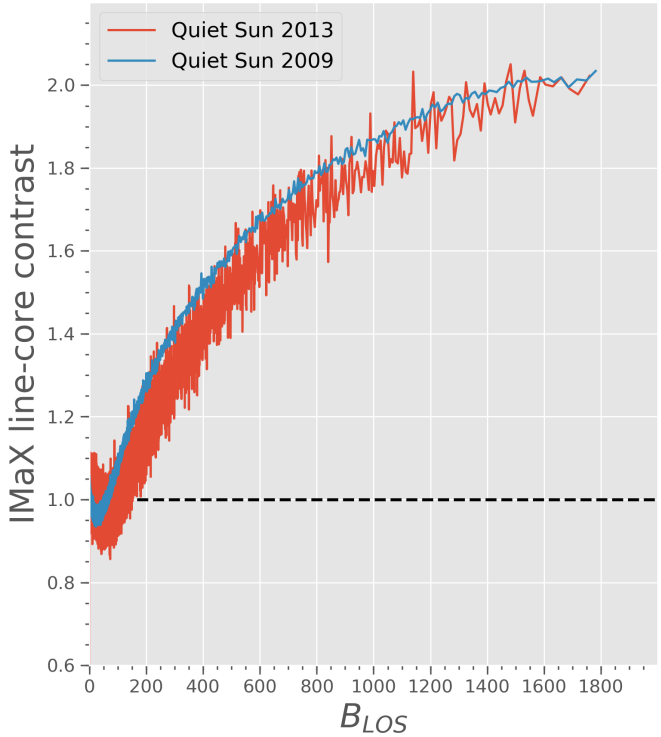


QS regions from Sunrise II

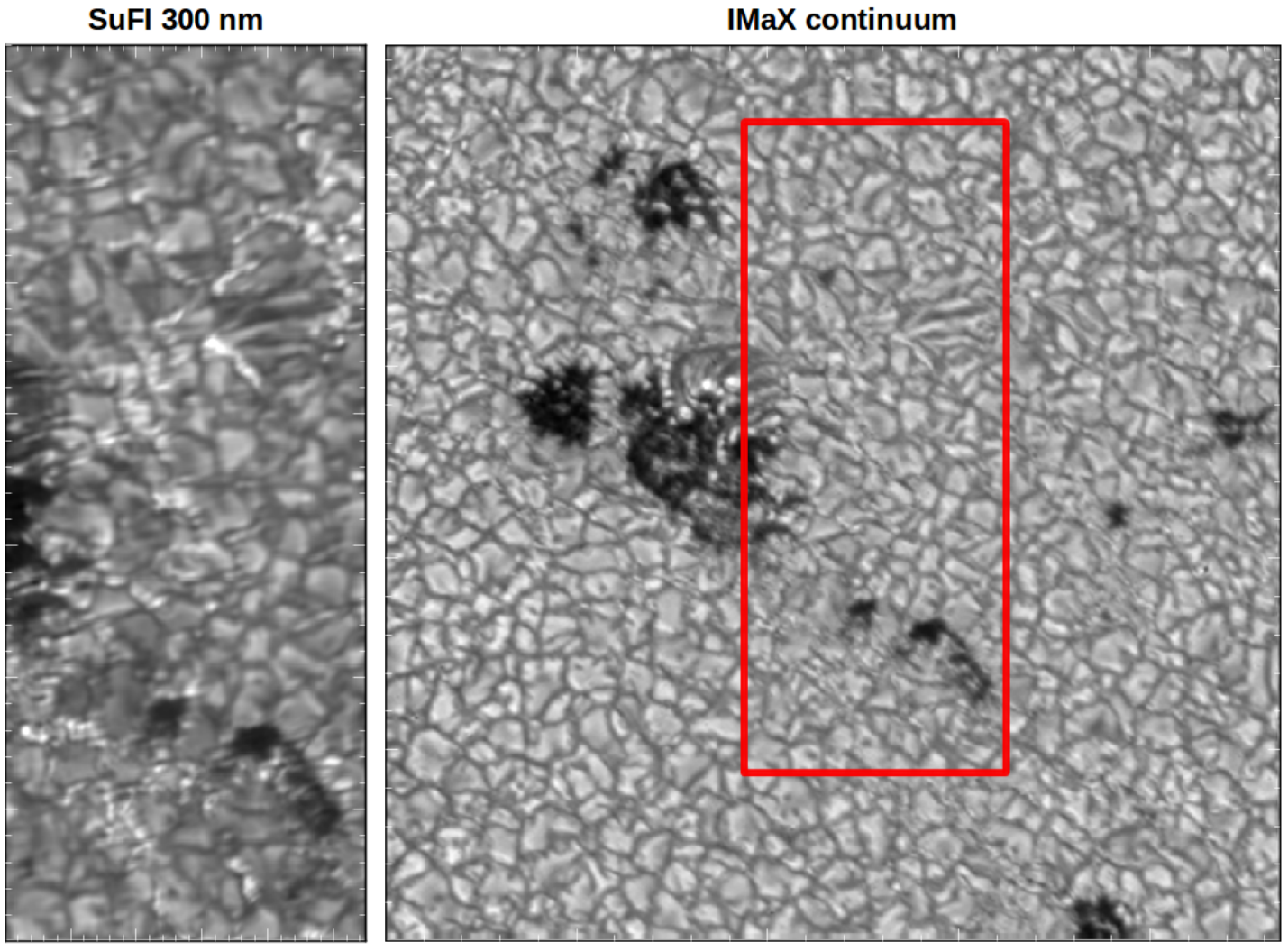


Quiet Sun (2013) vs. Quiet Sun (2009)

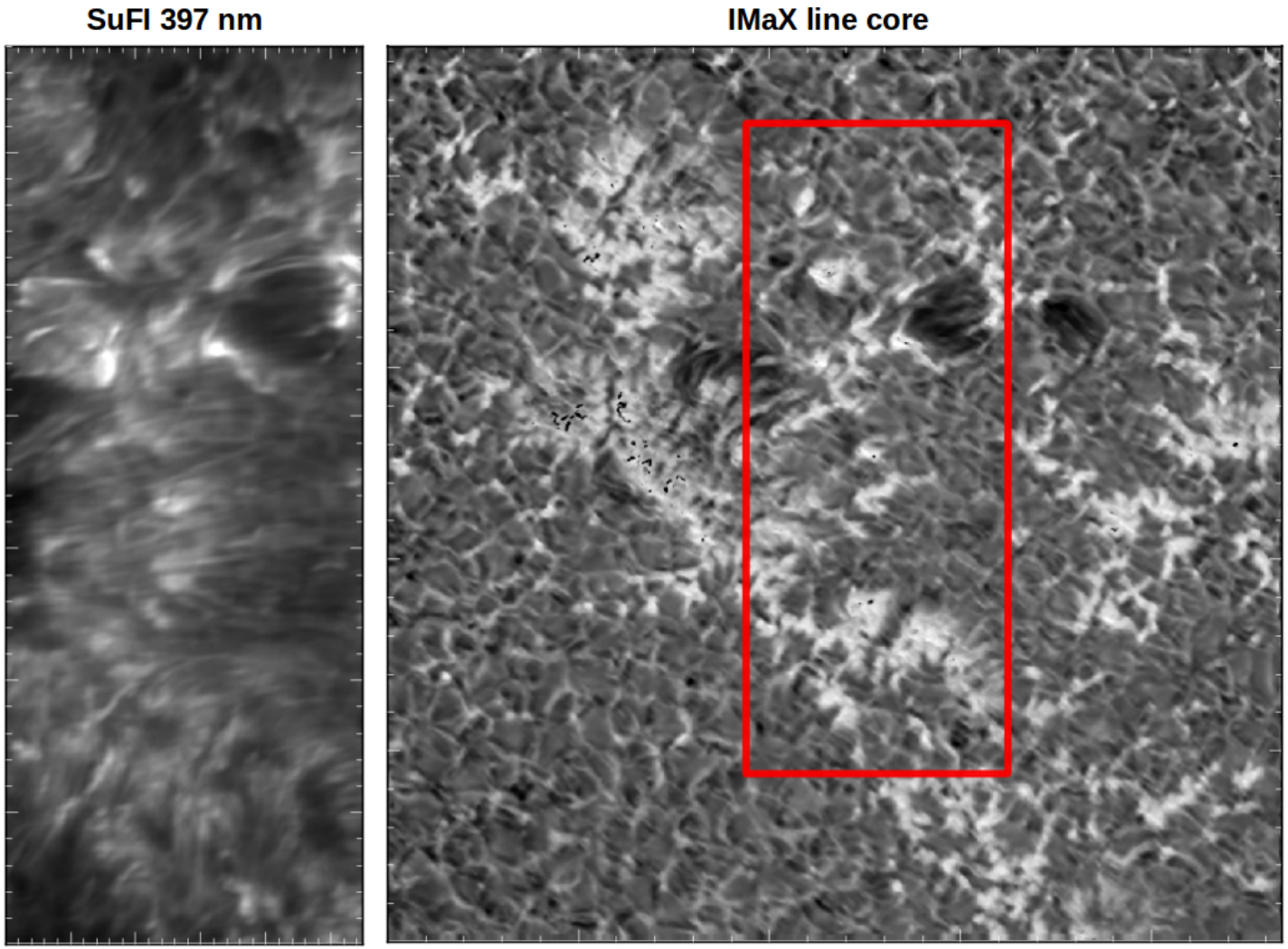




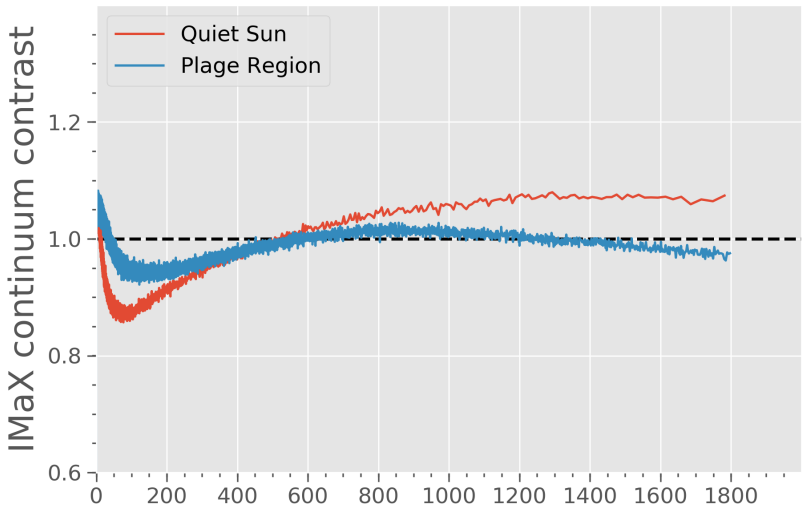
SuFI

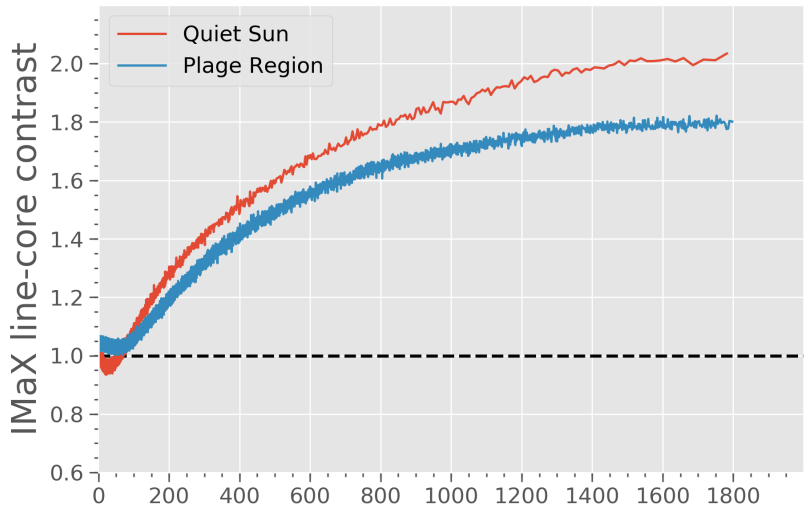


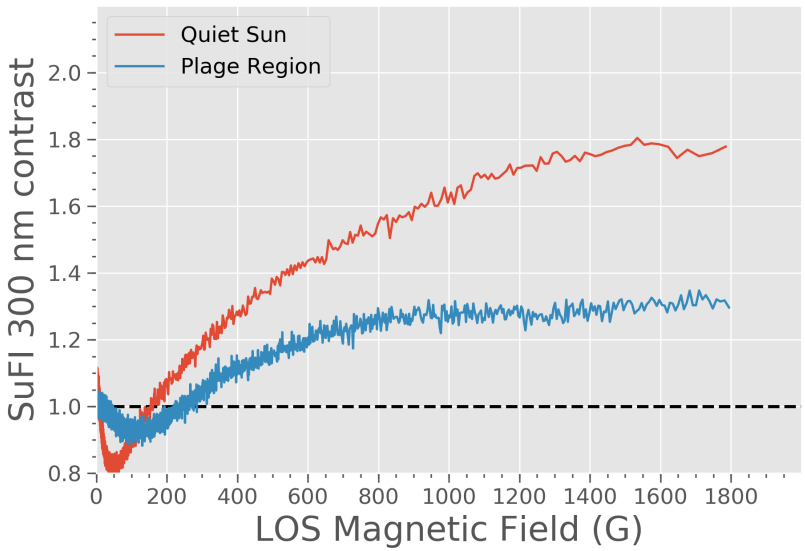
SuFI

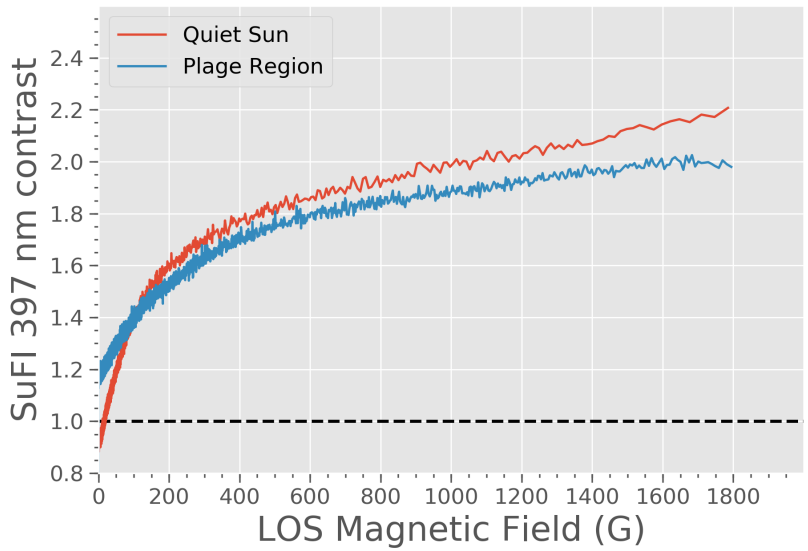


Quiet Sun vs. AR Plage









Conclusions

- Magnetic elements in the QS are starting to be resolved with IMaX (0.15″): (constant contrast at 525.02 nm in strong magnetic features in QS)
- Relationship between contrast in UV and B_{LOS} in QS at disc centre (Spectral irradiance models)
- Contrast-B_{LOS} relationship (QS) best described by a logarithmic function, at all wavelengths.
- Next steps:
  - MHD simulations (with larger mean magnetic flux) vs. observations
  - Optimizing Stray-light correction

Thank you!