SIST 2017: Extension of the image analysis record

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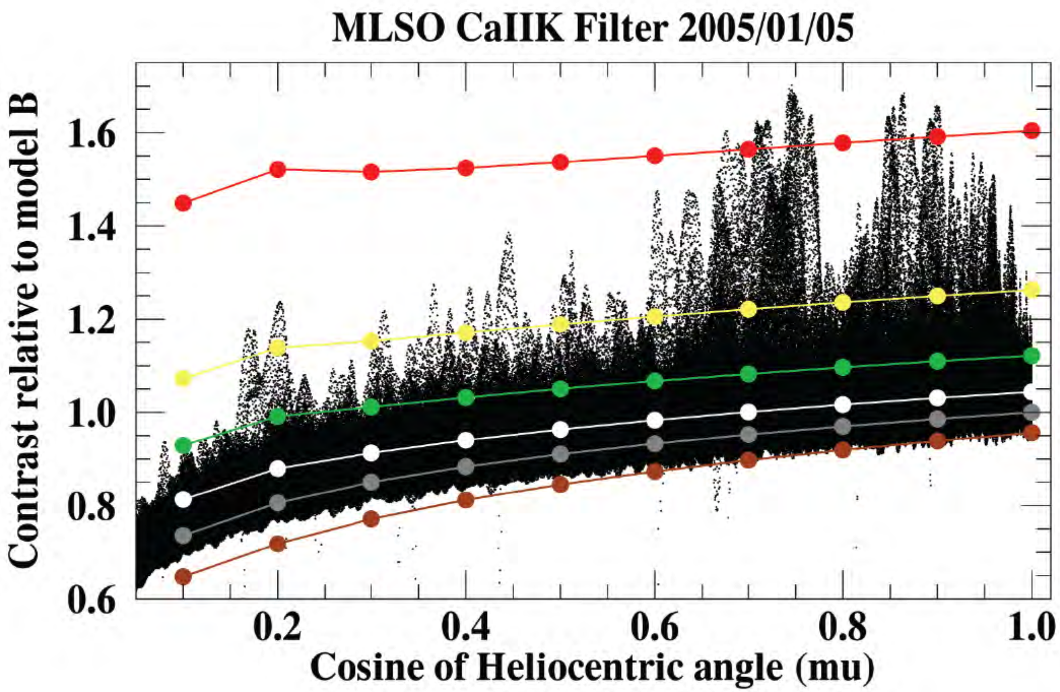
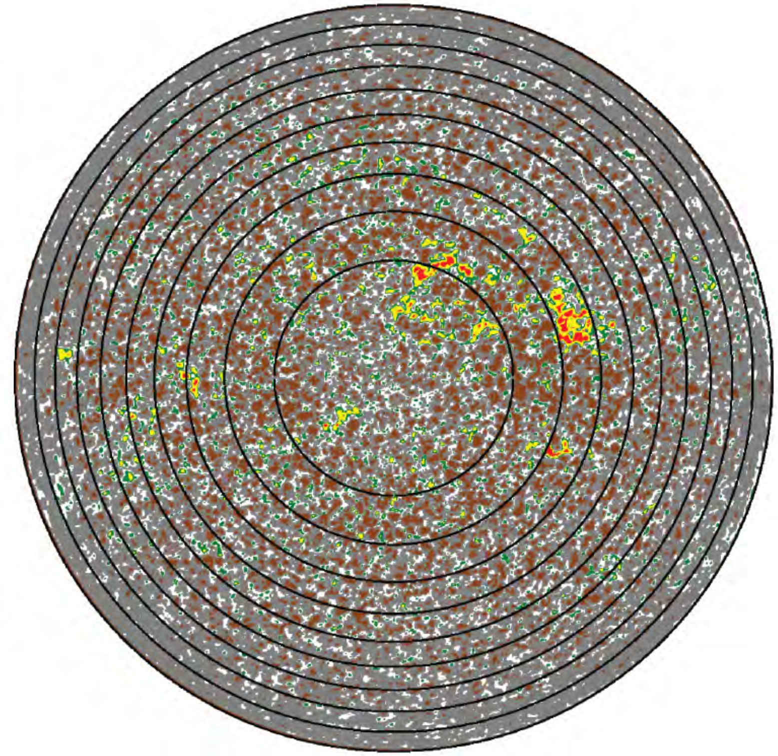
Activity 3: Perform SRPM image processing

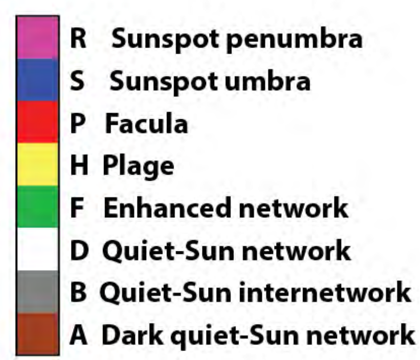




$$\bar{I}_{m,\mu}(\lambda_0) = \int I_{m,\mu}(\lambda_0)\Phi(\lambda-\lambda_0)\,d\lambda \quad \begin{cases} I_{m,\mu} & = \text{The m}^{\text{th}} \text{ model intensity.} \\ \Phi(\lambda) & = \text{Instrument bandpass profile.} \\ \mu & = \cos(\theta),\ \theta\text{=heliocentric angle.} \end{cases}$$

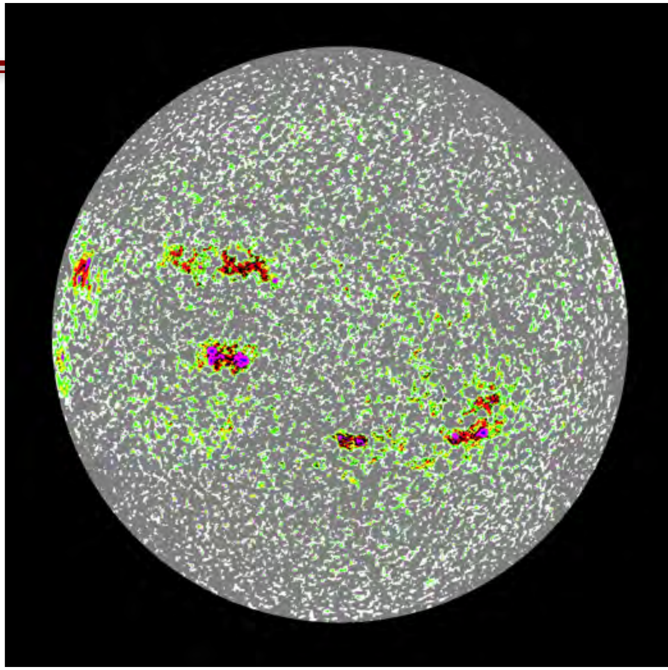
$$I_a = \frac{\sum_{n=1}^{All\ Pixels} I_{m_n,\mu_n}}{Number\ of\ Pixels} \quad \begin{cases} I_a & = \text{Average disk intensity found from spline interpolation to account for CLV and normalized to total number of pixels.} \end{cases}$$

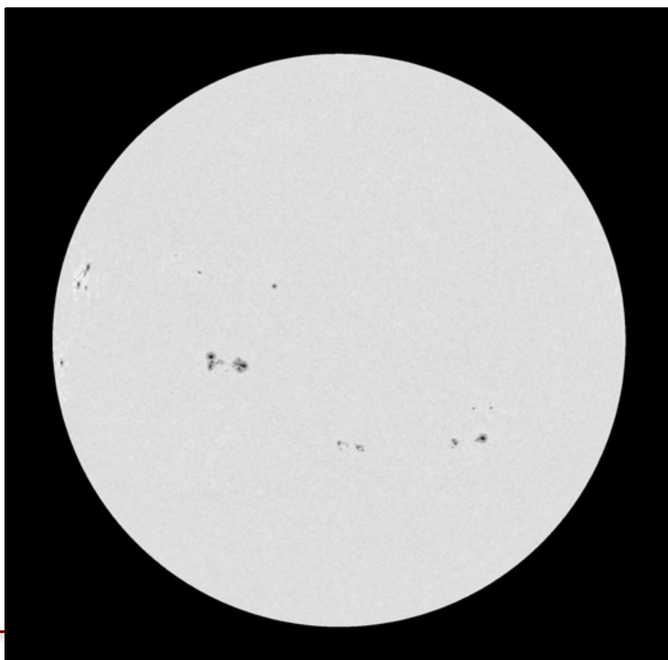
$$R = \Omega_{Sun} I_a \quad \begin{cases} R & = \text{Irradiance calculated at 1 AU.} \\ \Omega_{\text{Sun}} & = \text{Solid angle subtended by solar disk.} \end{cases}$$

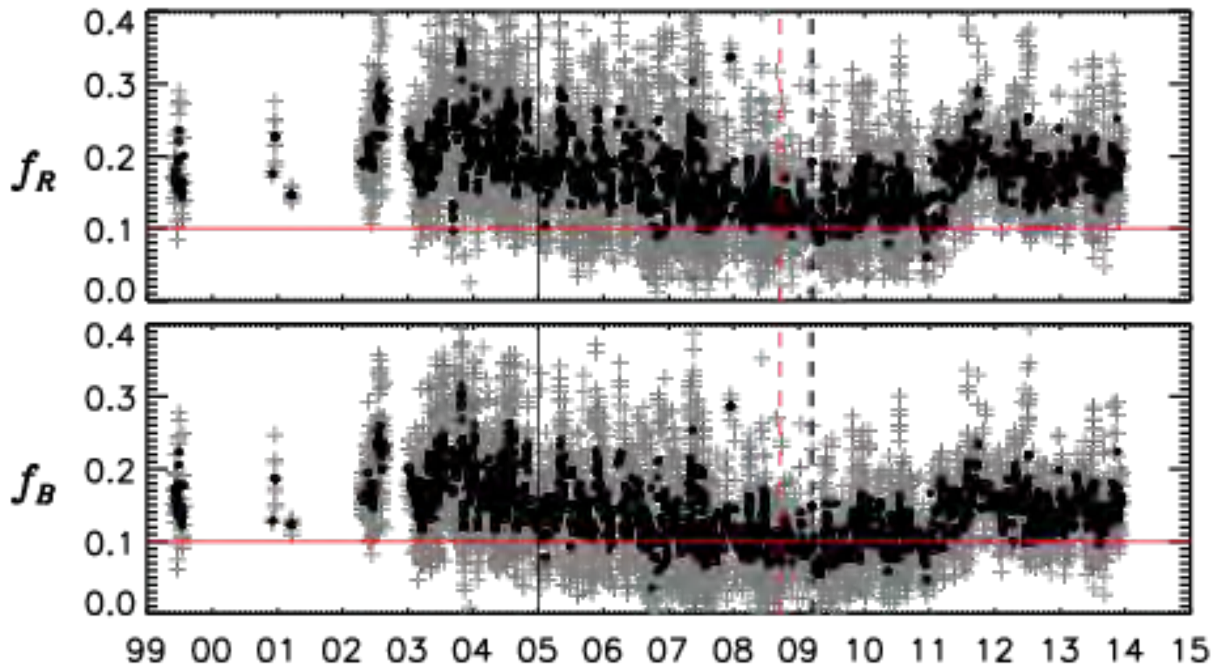


../2015/SIST_2015/presentations/SIST_meetingJuly2016/Illustrator/allimg_vs_mu.ai

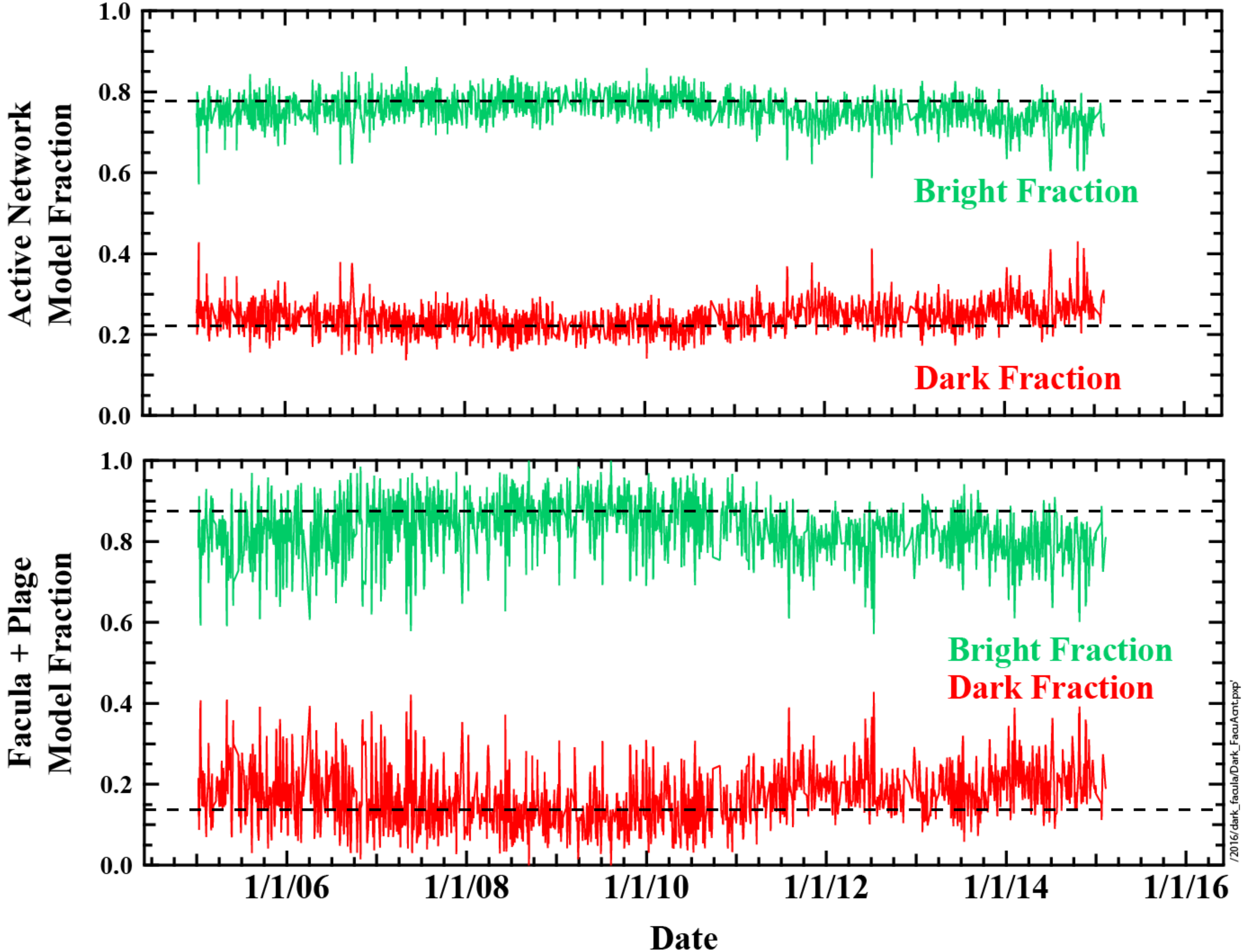
PSPT observations of Facula







- Some Facula and plage have negative contrast at red continuum wavelengths
- The fraction of dark Facula decreases into SC23 minimum and increases into rising phase of SC24

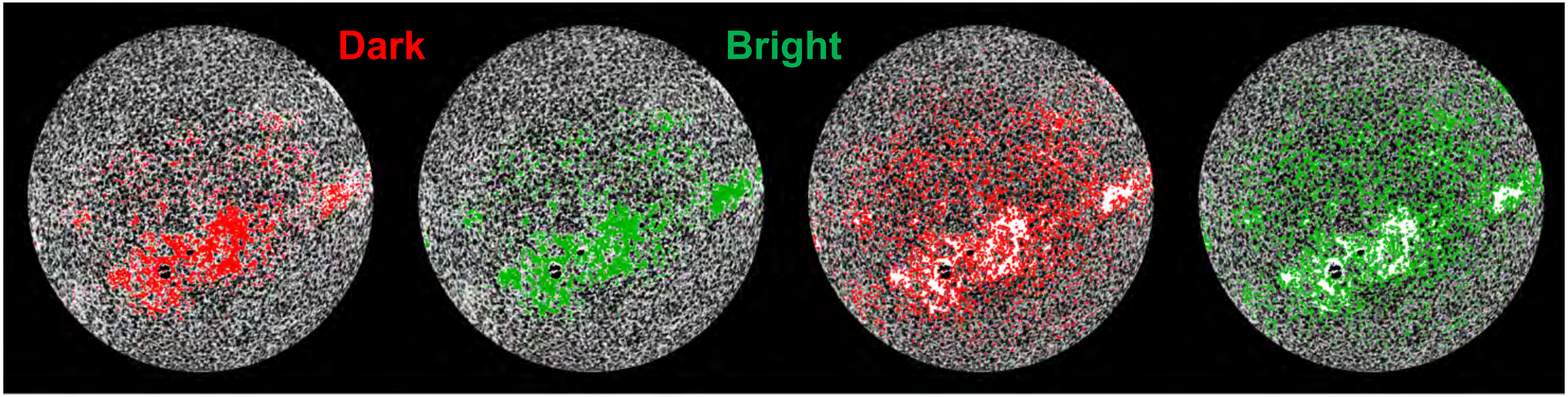


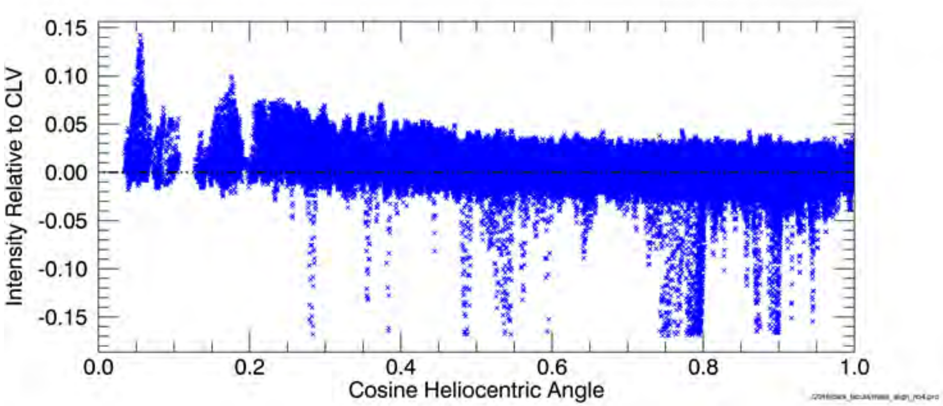
Active Network Model Fraction
Bright Fraction
Dark Fraction
Facula + Plage Model Fraction
Bright Fraction
Dark Fraction
1.0
0.8
0.6
0.4
0.2
0.0
1/1/06
1/1/08
1/1/10
1/1/12
1/1/14
1/1/16
Date

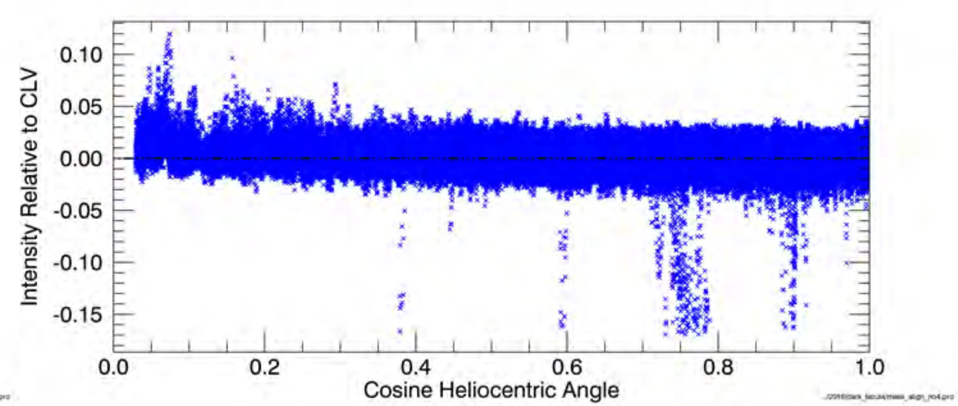
Cycle 24 2014/11/18

Facula and Plage

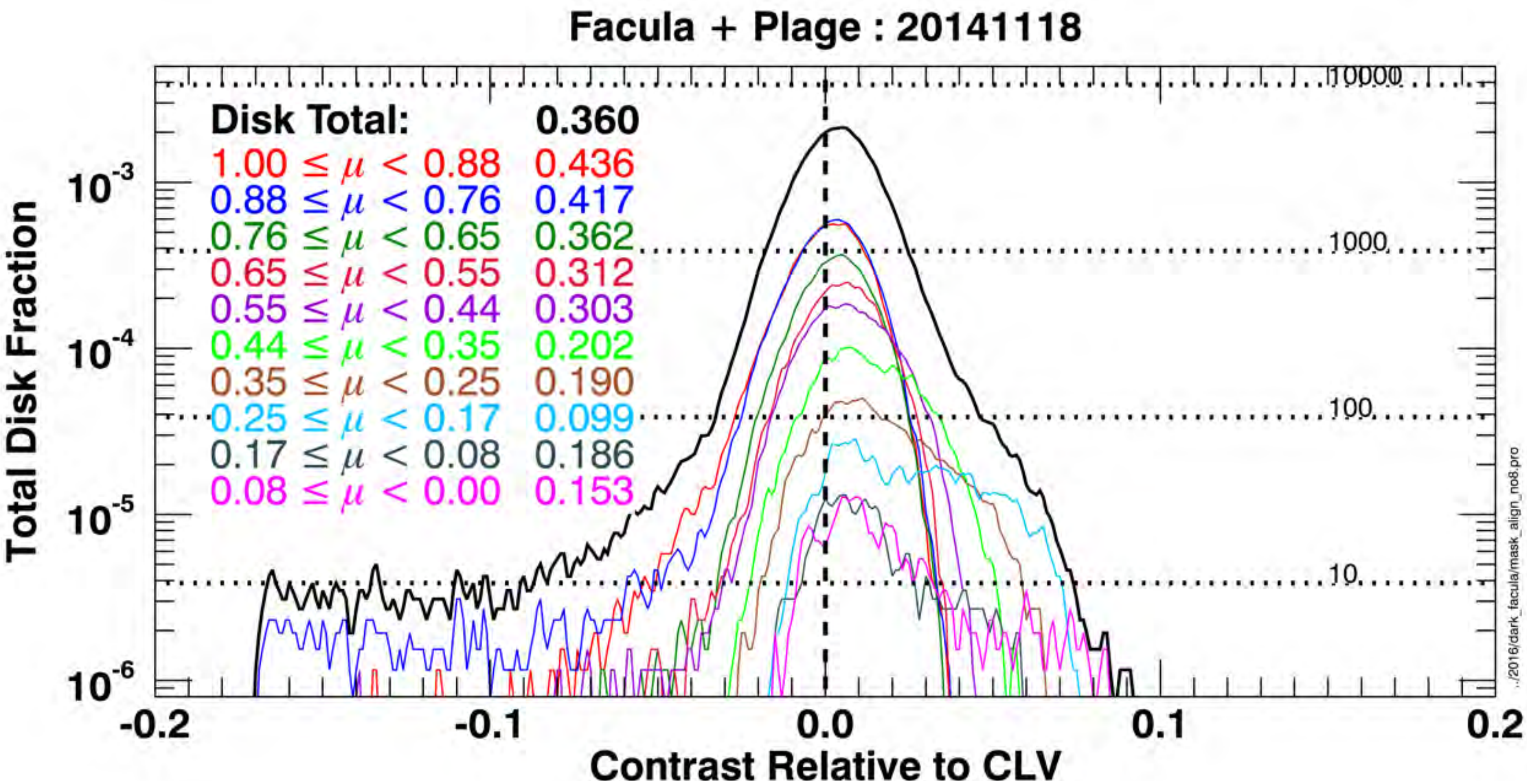
Active Network



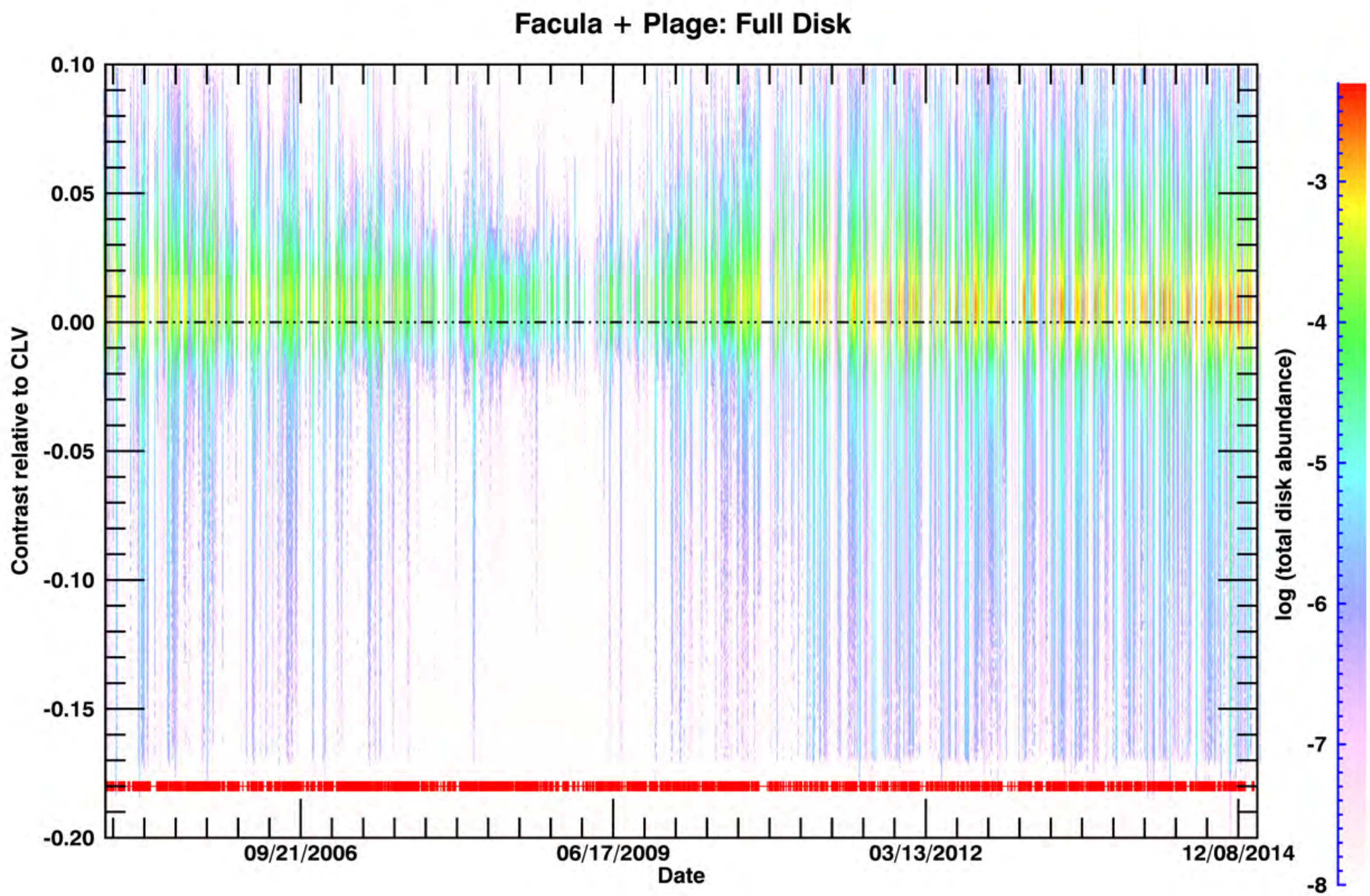




Brightness Histograms from PSPT Analysis



- Brightness histograms of individual pixels relative to CLV
- Second column in legend gives the fraction of pixels that are darker than the CLV pixels become progressively brighter near the solar limb
- Dark pixels appear in each SRPM feature type, but the broadest distribution appears for faculae and plage.
- Highest population of dark facular regions appears near disk center, in this example about 44%

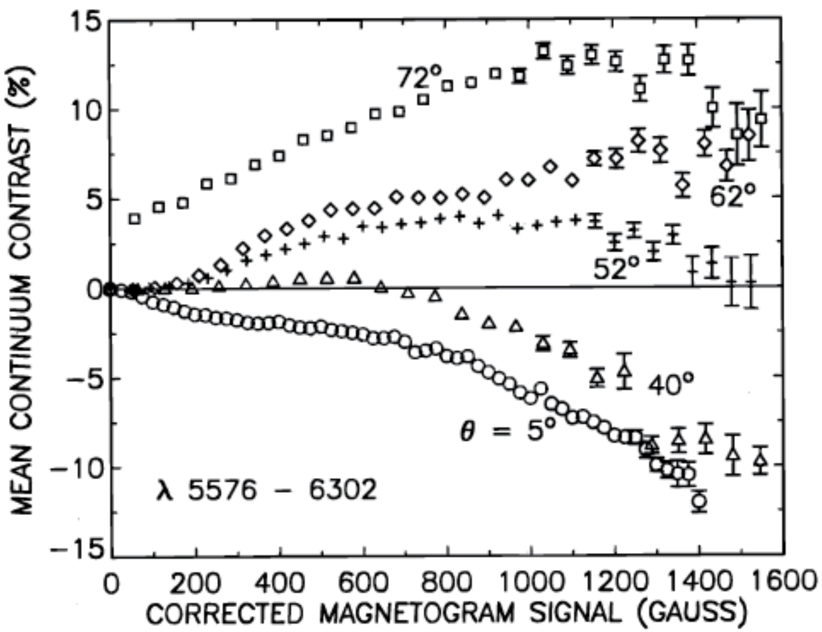


Facula + Plage: Full Disk
0.10
0.05
0.00
-0.05
-0.10
-0.15
-0.20
Contrast relative to CLV
09/21/2006
06/17/2009
03/13/2012
12/08/2014
Date
log (total disk abundance)
-3
-4
-5
-6
-7
-8

Summary & Conclusions from PSPT Analysis

- Ca II images from PSPT are used to identify 7 distinct solar surface features. Masks of these features are used to identify the corresponding regions in the PSPT red filter that has been flattened to contrast image.
- Analysis is performed on each image to determine the feature brightness relative to disk position.
- The time series of dark features show a distinct increase in area that is in-phase with proxies of solar activity –i.e. magnetic field strength.
- These dark features appear in every feature type but the broadest distribution in brightness and number density of dark regions appears in the facula + plage, and active network components.
- As expected large numbers of relatively weak bright pixels are responsible for the brightening seen nearing the solar limb.
- Smaller numbers of significantly darker pixels are seen throughout the solar disk but produce the largest contribution near disk center.

Topka, Tarbell, and Title (1997), ApJ, 484, pp479



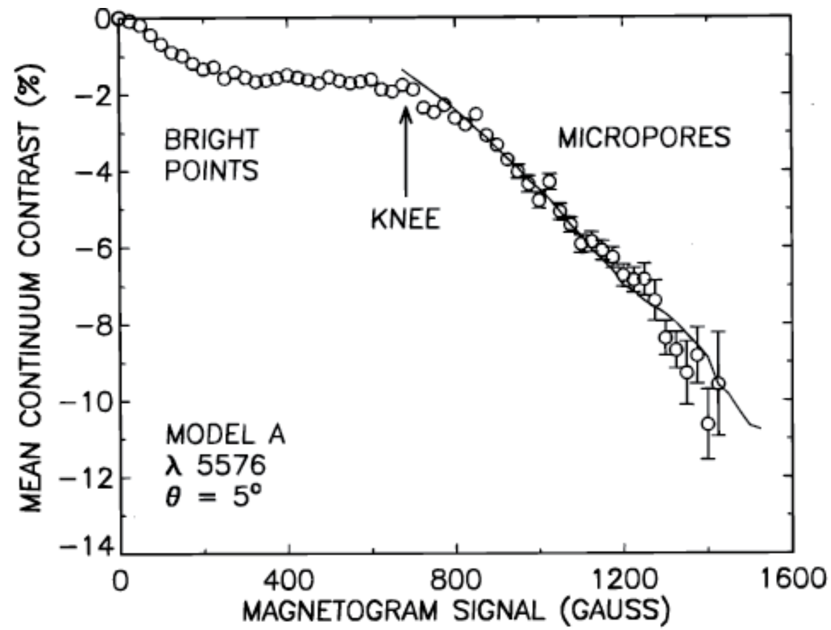
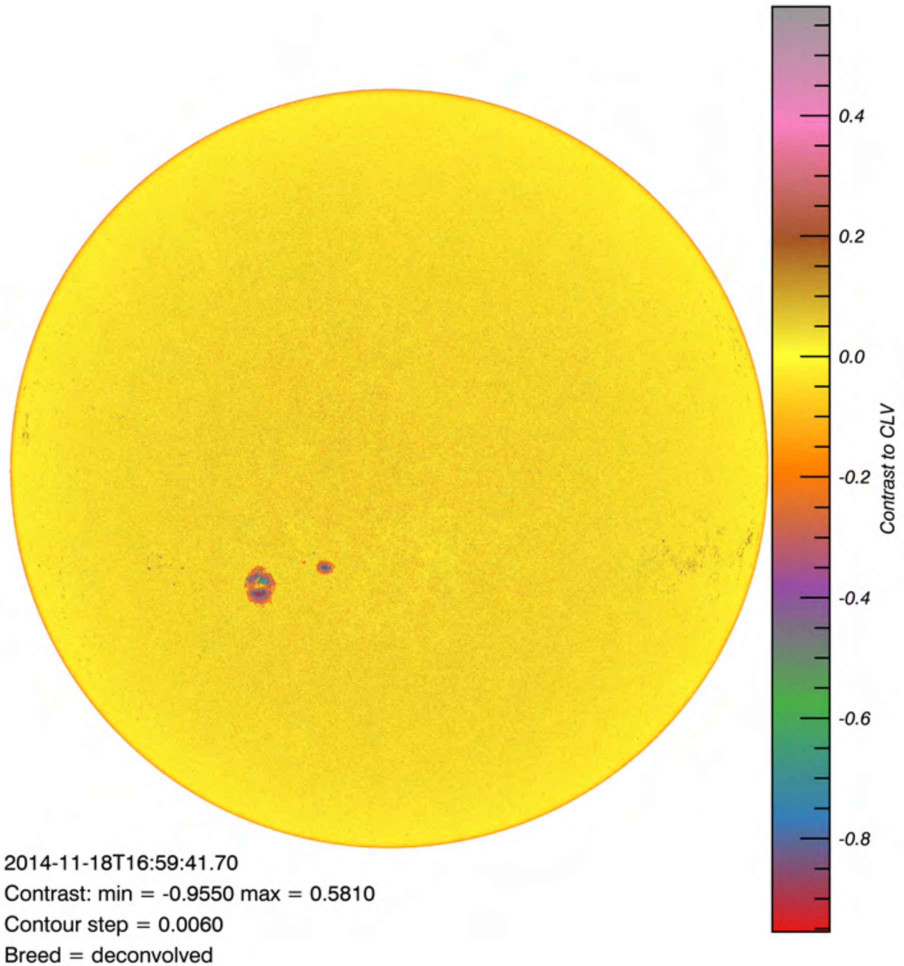
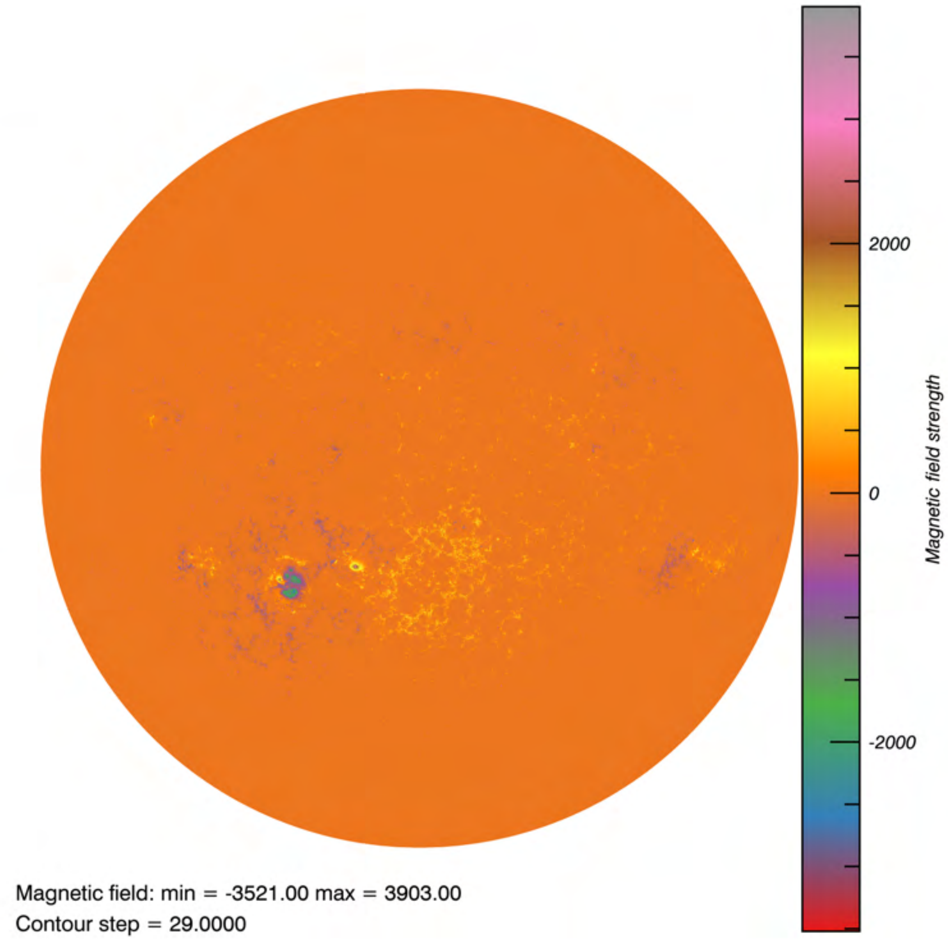


Fig. 1.-Observed bin-averaged contrast vs. magnetogram signal (absolute value, corrected for line-of-sight component) for active region faculae located at five different heliocentric angles. Included are +/- 1sigma error bars when they are larger than the plot symbols

Fig. 3.- Comparison of model A prediction (solid line) and observation (open circles) obtained near disk center (theta =5 degrees). The hot wall model is designed to predict the behavior of pixels with magnetograms signal greater than 600 G (micropore region). Included are the +/- 1 sigma error bars.

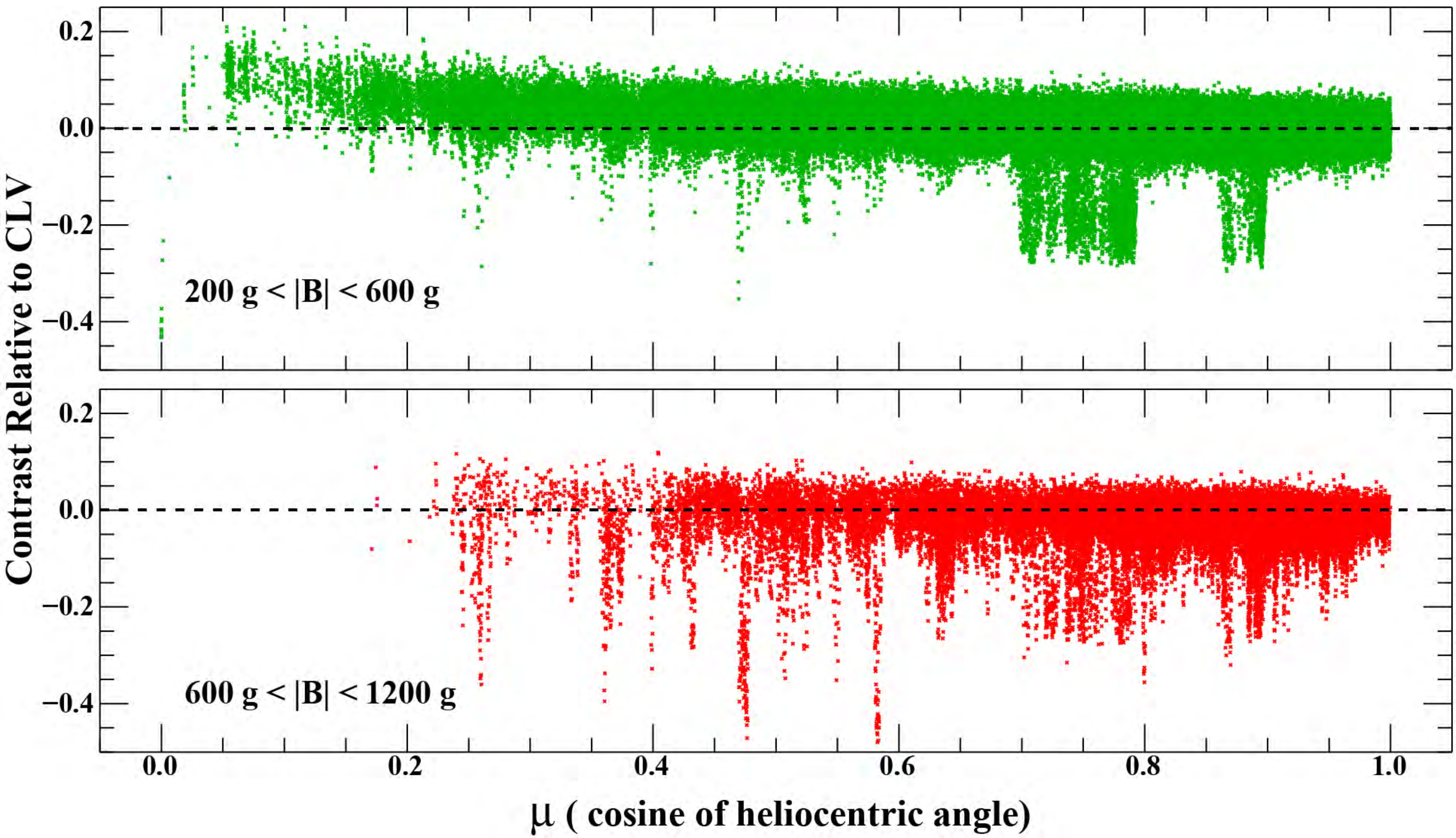
De-convolved HMI images & co-registered magnetic field maps





- Lucy-Richardson deconvolution method corrects a full-disk intensity image
- Very useful, very valuable, very computationally expensive
- Can only conduct analysis on a limited number of images at the present time
- (rotated 180 degrees to match PSPT)

HMI contrast relative to CLV vs heliocentric angle



Summary & Conclusions from HMI Analysis, Page 1

- **Deconvolution of HMI images provides a very valuable data set to study the evolution of dark solar regions. This process tends to broaden the distribution functions for both darker and brighter regions on the solar disk, i.e. enhances contrast.**
- **HMI data interpretation would benefit from the Legendre-Fourier CLV calculation applied to PSPT data to ensure proper CLV interpretation.**
- **Magnetic field strength alone cannot uniquely assign the brightness of a given HMI pixel. In particular, magnetic field strength of penumbra and facular regions are very difficult to separate.**
- **Bright and dark pixels are highly interleaved in solar regions that can be identified as facular structures.**

- **Pixels that are in the 200<|B|<600 Gauss range show a distinct brightening near the limb resembling the structure seen in facula identified in PSPT. This field range is predominately bright relative to the CLV. For 600<|B|<1200 Gauss , it is predominately dark.**
- **Pixels that are in the 600<|B|<1200 Gauss range have a substantial dark population and are significantly darker at disk center. Having a series of daily images could show an indication of how bright they become as they move to the solar limb.**
- **Images that have significant active regions show dark regions even in the the weakest fields. There is no such thing as quiet Sun.**