Coronal Holes and Quiet Sun in Mg II observed with IRIS

Durgesh Tripathi[1], Pradeep Kayshap[2]
Sami Solanki[3,4], Hardi Peter[3]

1)IUCAA, Pune, India, 2) UMCS, Poland
3) MPS, Goettingen, Germany
4) Kyung Hee University, Korea

IRIS-9, Göttingen, 25-29 June 2018

Contributed Talk

2. Chromospheric heating and dynamics

Coronal Holes and Quiet Sun in Mg II lines observed by IRIS

Durgesh Tripathi[1], Pradeep Kayshap[2], Sami K. Solanki[3,4], Hardi Peter[3]

[1]*IUCAA, Post Bag 4, Ganeshkhind, Pune 411007, India*
[2]*UMCS, ul. Radziszewskiego 10, 20-031 Lublin, Poland*
[3]*MPI for Solar System Research, Justus-von-Liebig-Weg 3, 37077, Göttingen, Germany*
[4]*School of Space Research, Kyung Hee University, Yongin, Gyeonggi-Do,446-701, Republic of Korea*

Quiet Sun (QS) and coronal hole (CH) regions are very well distinguished in the radiation recorded at coronal temperatures. However, in those recorded at chromospheric (except in He II lines) and transition region temperatures, they appear very similar. In this study, to understand the similarities and differences between QS and CHs at chromospheric heights, we make use of the high-resolution spectroscopic observations recorded by the Interface Region Imaging Spectrograph (IRIS) in Mg II 2796.35 Å spectral line. We find that, in Mg II lines, the QS and CH regions are visually strikingly similar to each other. However, when we compare the radiance in the MgII (k3 and k2v) in areas with similar magnetic field strength, we find that CHs are significantly dimmer than QS. Moreover, the difference in radiance increases with increasing magnetic field. We note that the difference in radiance decreases with decreasing spectral resolution and almost vanishes at a resolution of 11 Å. The region-specific dependence of radiance of Mg II line suggest that the magnetic field plays a vital role in the heating of the quiet chromosphere. Moreover, this study provides essential ingredients for solar spectral irradiance modelling for the better understanding of the Sun-climate relationship.

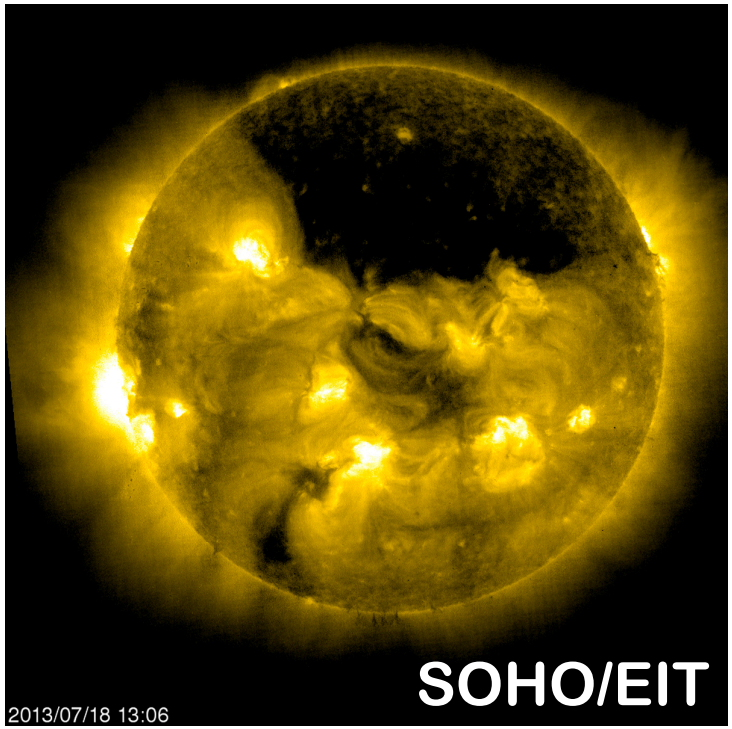
Coronal Holes and Quiet Sun in Mg II observed with IRIS

Durgesh Tripathi[1], Pradeep Kayshap[2]
Sami Solanki[3,4], Hardi Peter[3]

1)IUCAA, Pune, India, 2) UMCS, Poland
3) MPS, Goettingen, Germany
4) Kyung Hee University, Korea

Objective

Coronal holes and quiet sun are distinctly observed in coronal images.



Our aim here is to study and understand the similarities and differences in CH and QS in Mg II lines (i.e. chromosphere)

Objective

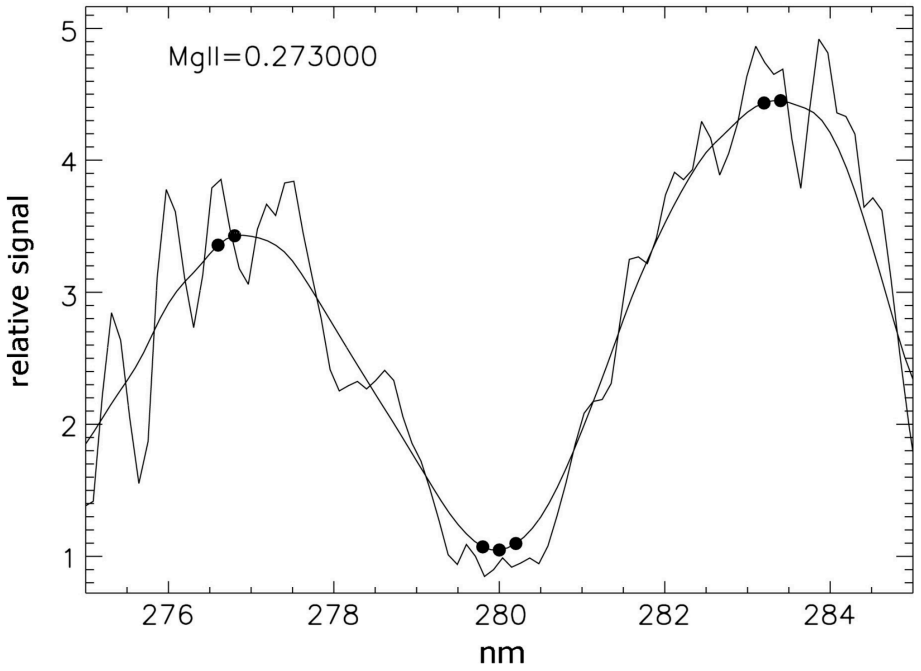
- Any difference may shed light on the way the quiet sun and coronal holes are heated in chromosphere? Population of different kind of loops?
    - Difference in CH and QS in coronal images are explained by loop statistics (Wiegelmann and Solanki 2004)

- Mg II index - used in modelling of solar spectral irradiance - Sun-as-a-star

Mg II index

- Mg II core-to-wing ratio
- Indicator of chromospheric activity
- Strongly correlated with the most strongly varying Ly-alpha (Krivova et al. 2006)
- Insensitive to instrumental degradation (to first order (Heath and Schlesinger 1986)
- Used for UV solar spectral reconstruction and degradation correction

Snow et al. 2014



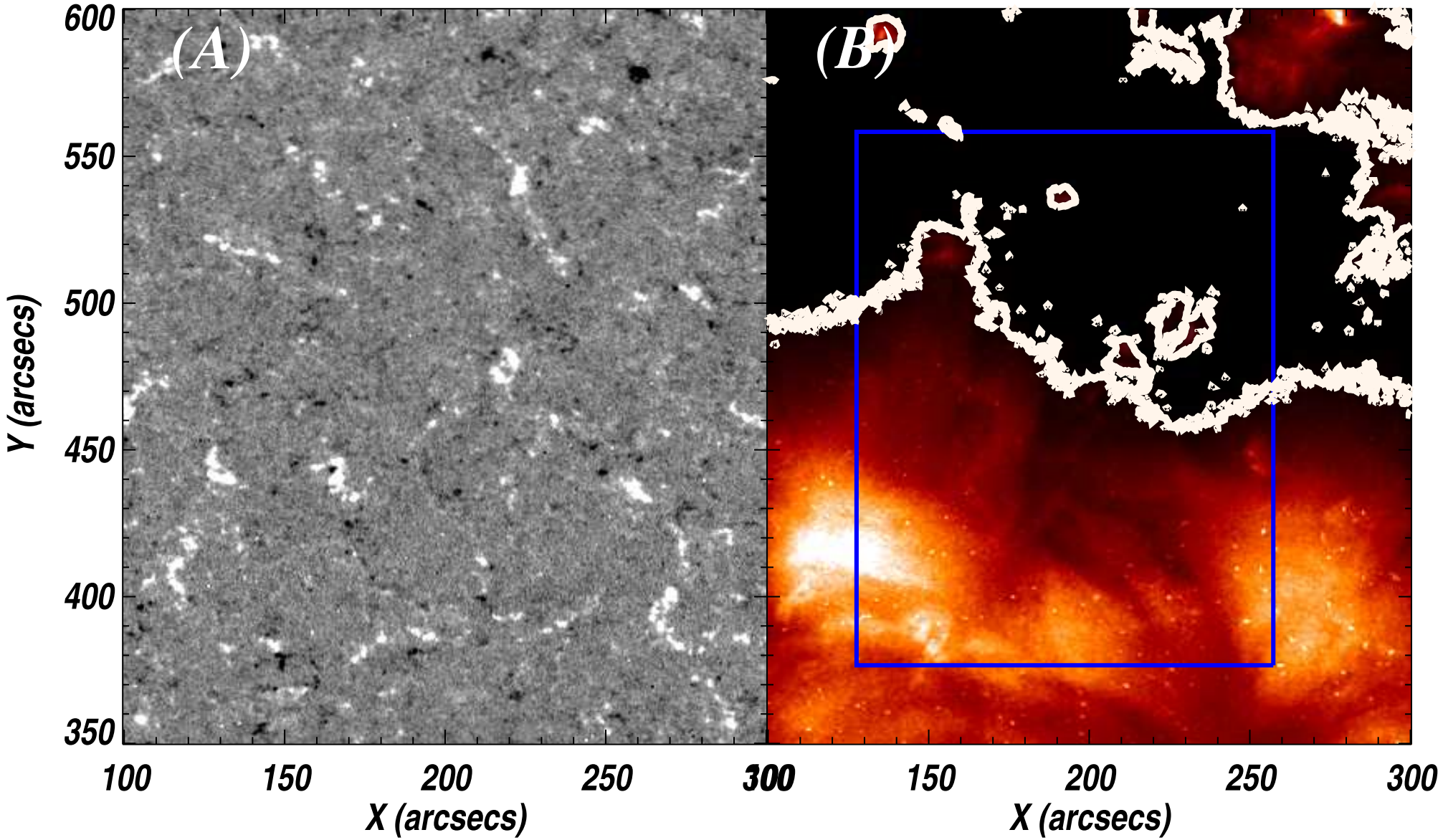
Any difference in Mg II in QS and CH, will give difference in Mg II index and therefore needs to be incorporated into Sun-climate models.

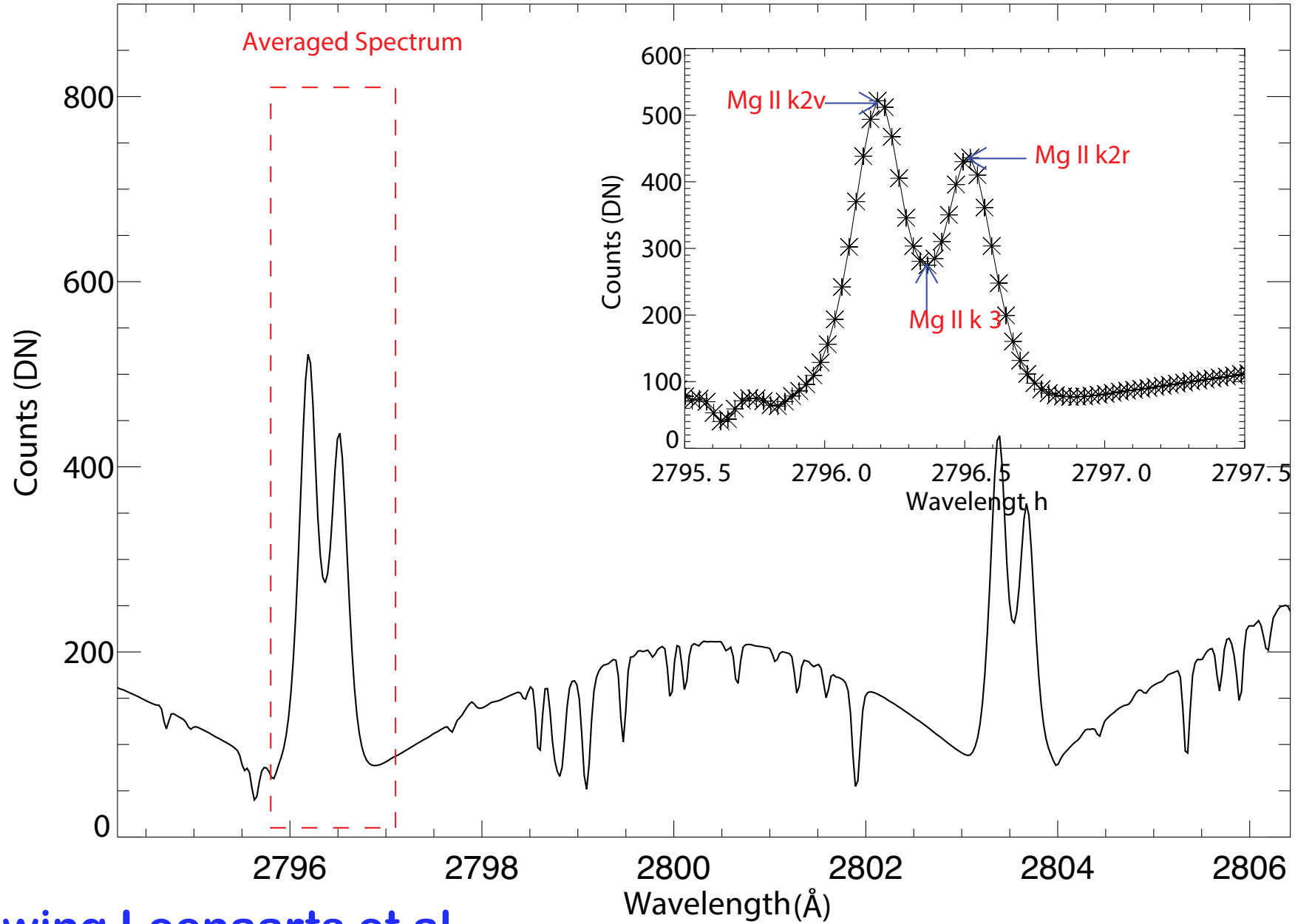
Observations

- Mg II spectral line is optically thick (show centre-to-limb variation)
  - CH and QS observations should be taken at the same heliographic location
  - Either at the same time (in the same raster) OR sufficiently close in time to avoid any bias due instrumentation degradation

Data	Date(Time)		Field of View		τ [s]		μ	
	QS	CH	QS	CH	QS	CH	QS	CH
Set 1	10.11.15(13:30:04)		$129'' \times 170''$		15		0.81	0.88
Set 2	04.01.16 (04:54:38)	05.01.16 (14:50:33)	$126'' \times 130''$	$129'' \times 173''$	15	15	0.90	0.90
Set 3	18.12.14 (05:47:42)	29.11.14 (23:02:45)	$34'' \times 181.0''$	$126'' \times 129.0''$	30	30	0.88	0.81

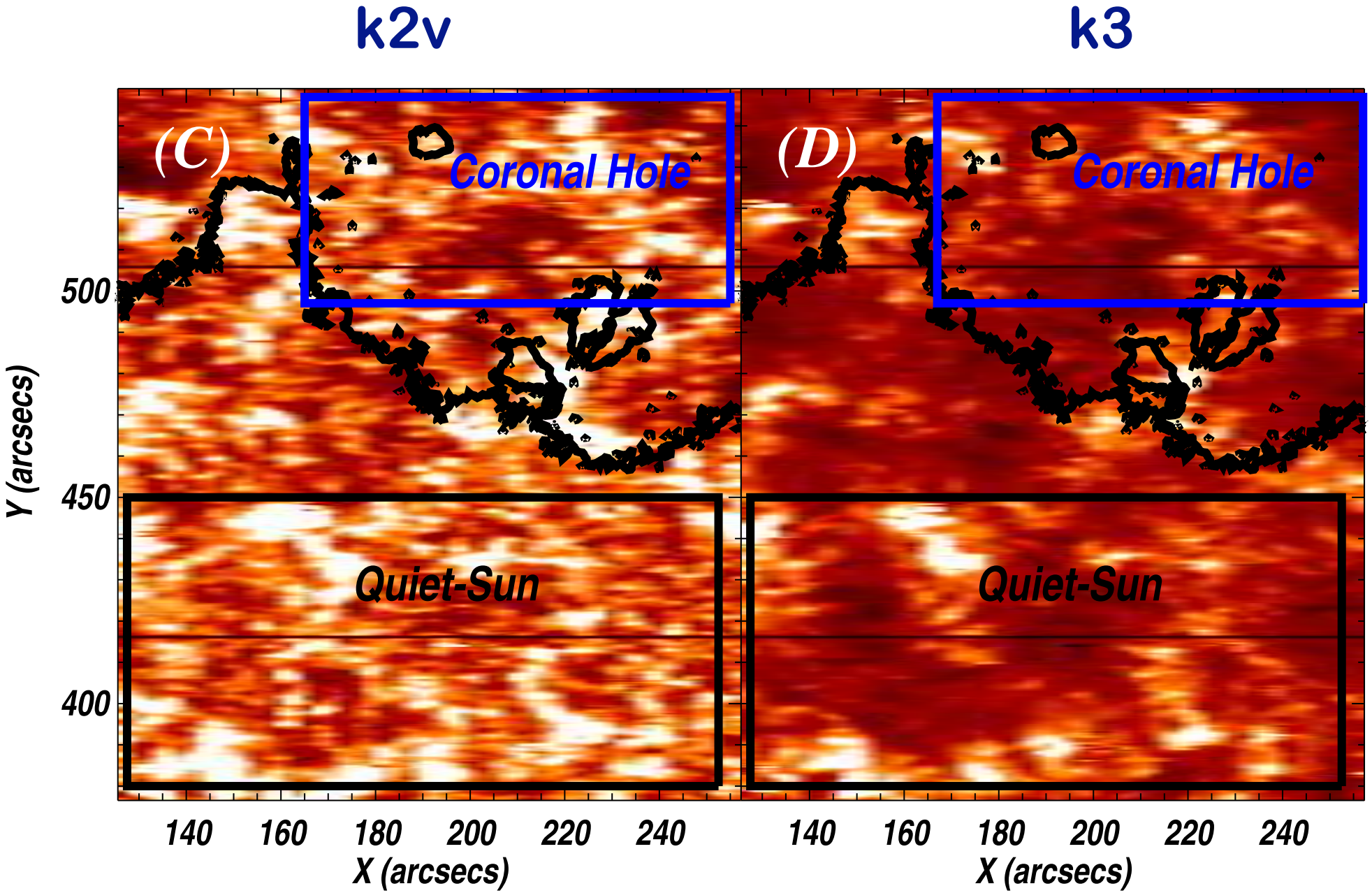
Observation Set 1 - HMI and AIA

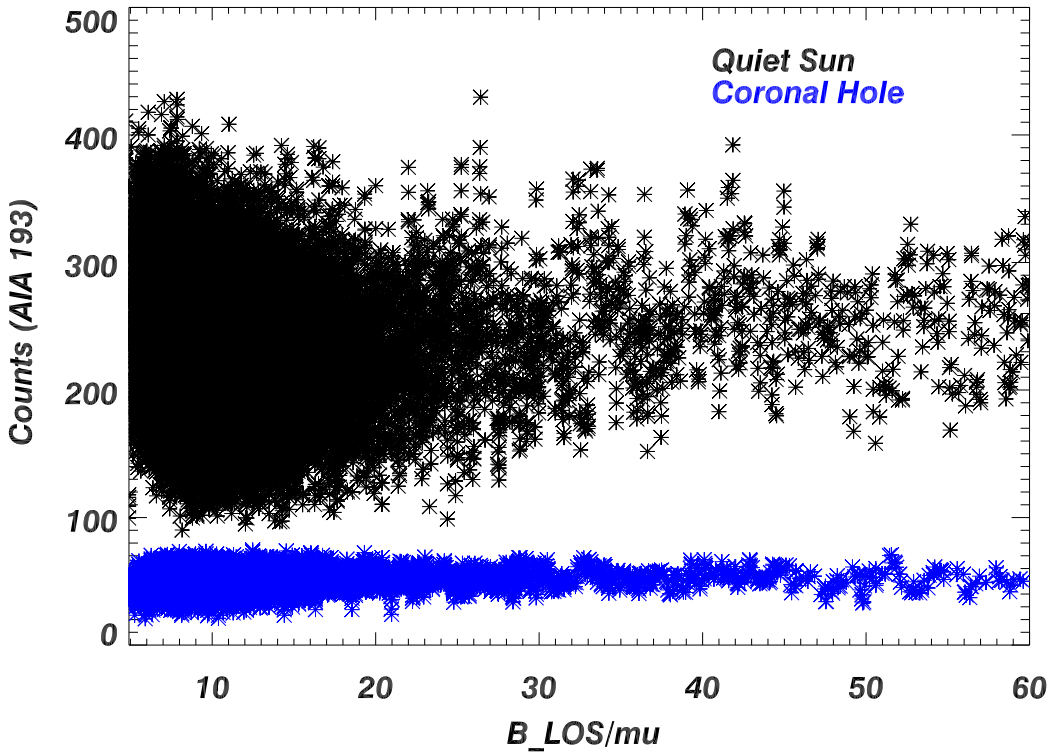


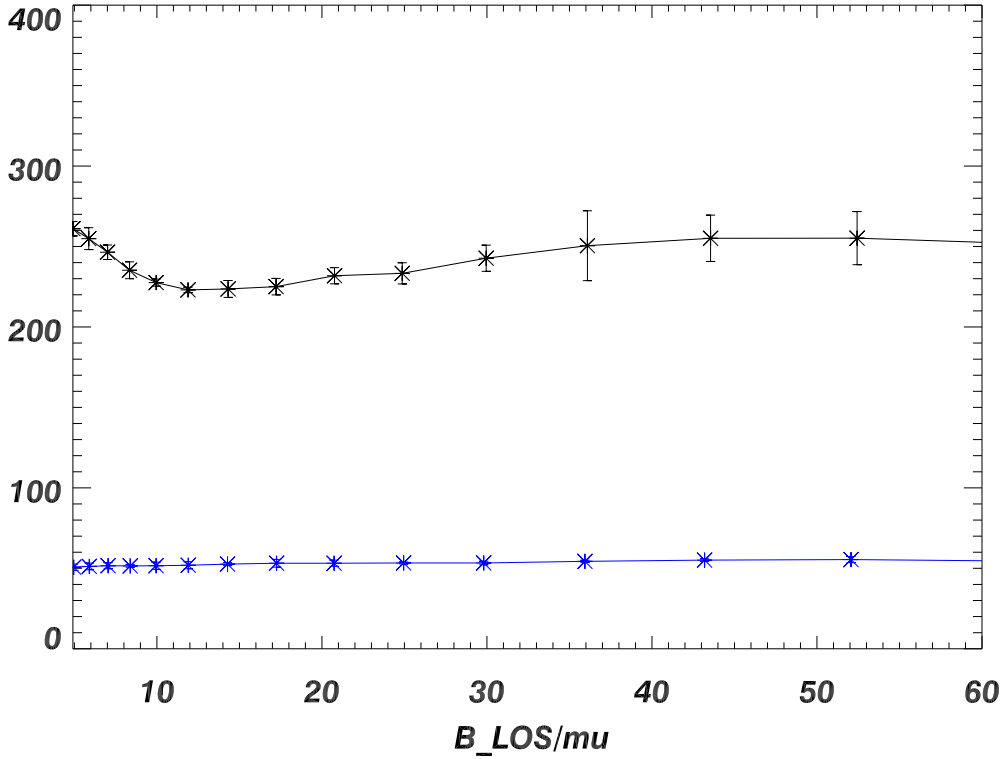


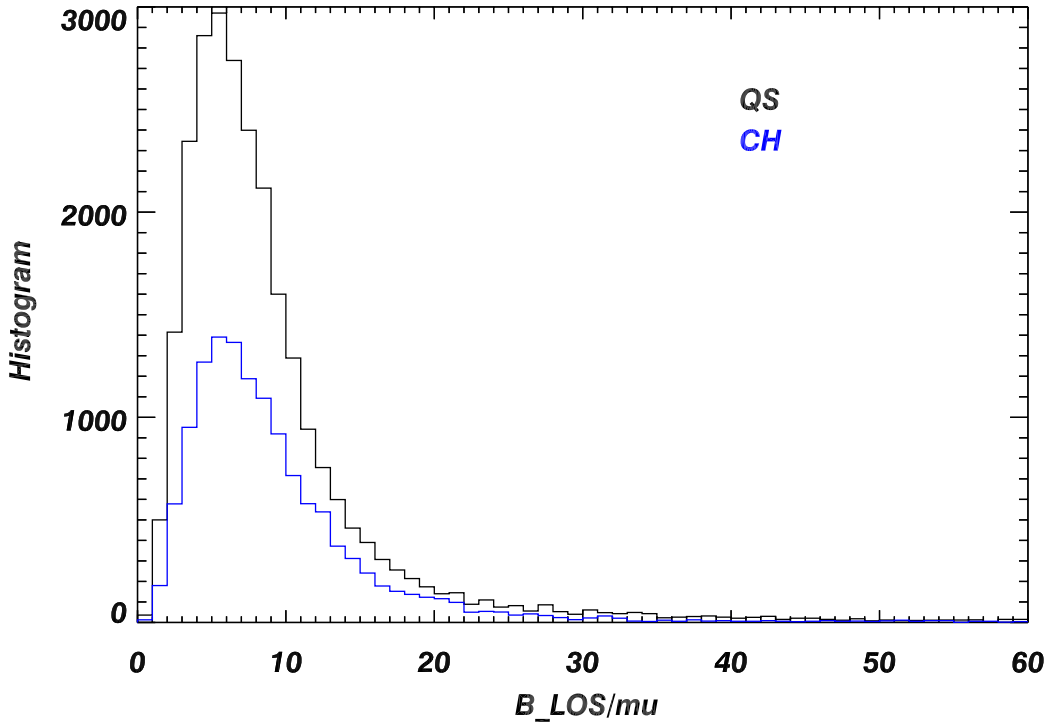
Following Leenaarts et al

Observation Set 1 - IRIS k2v & k3



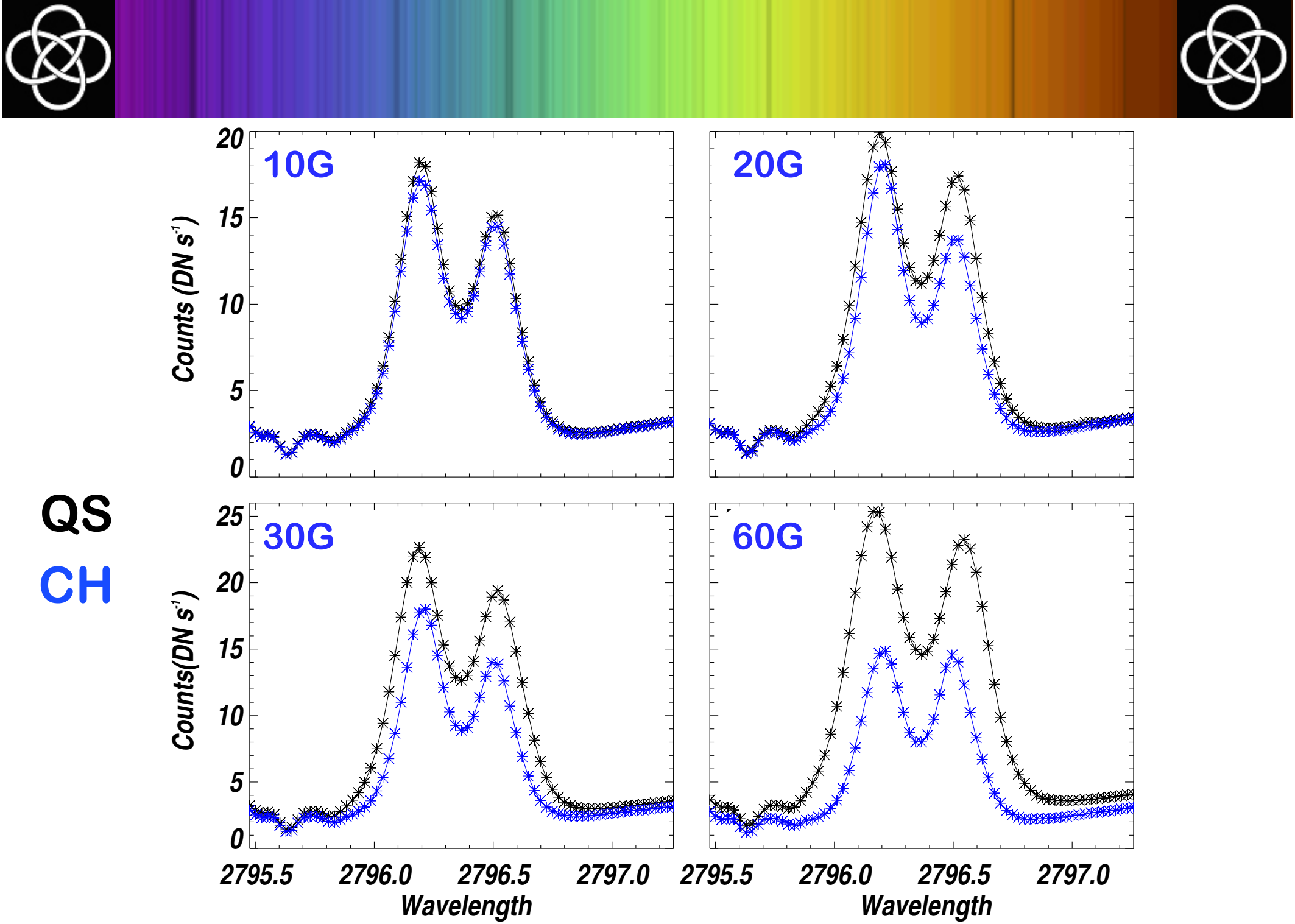


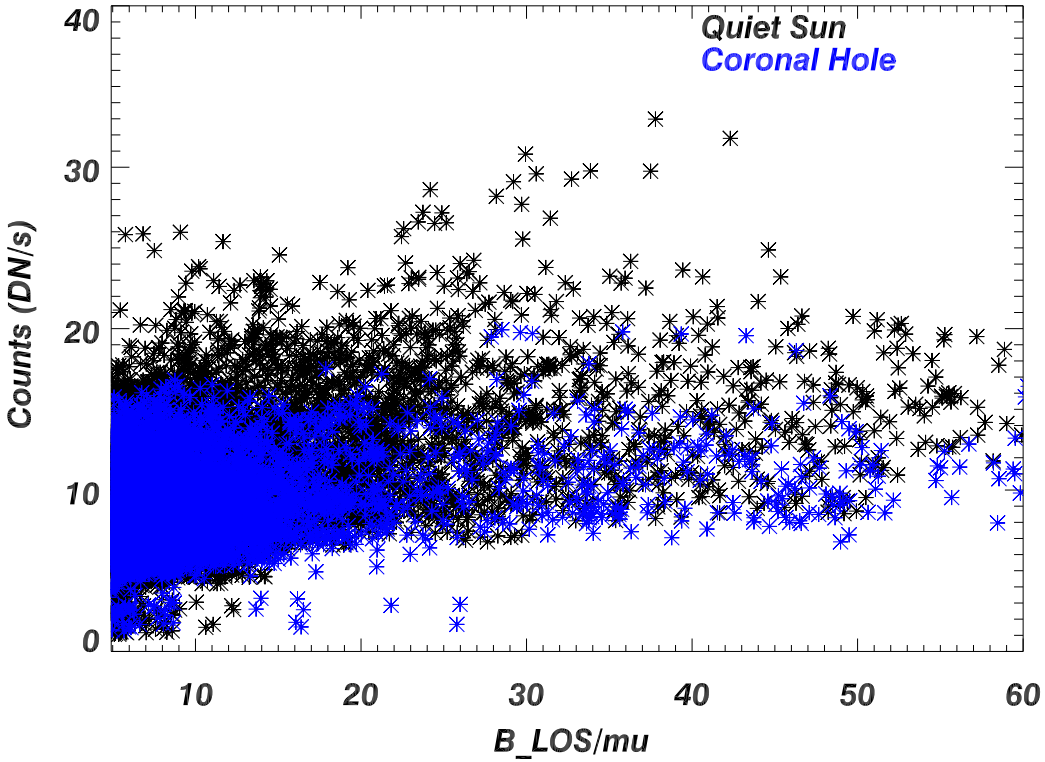


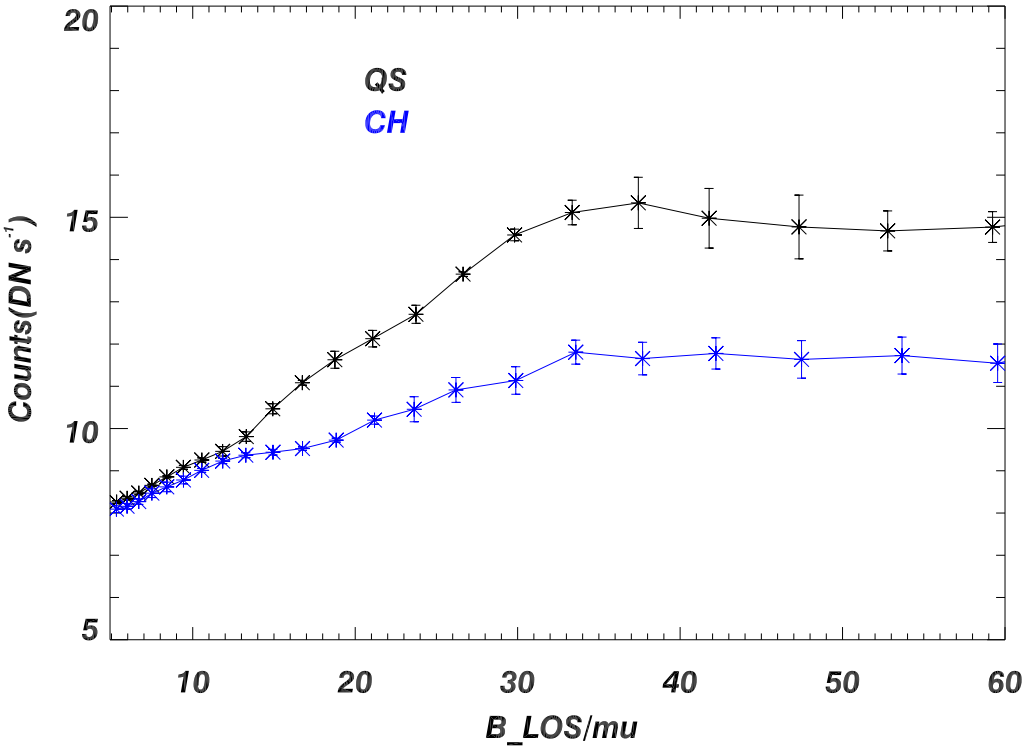


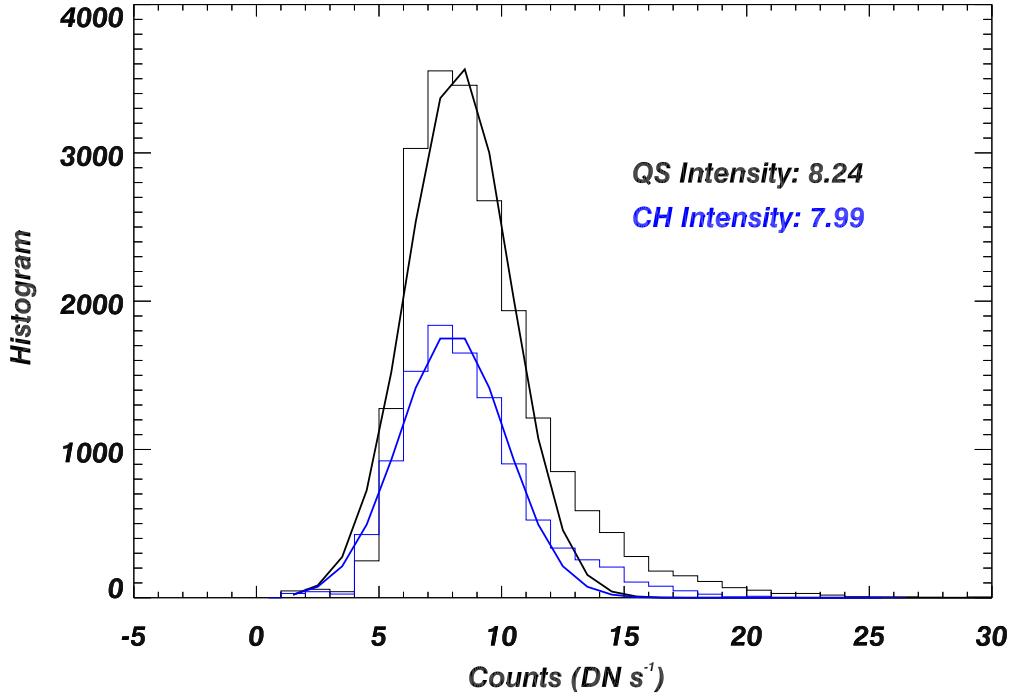
Factor of ~5 difference in the CH and QS intensities in Corona

Distribution of B-field in CH and QS is very similar


10G
20G
30G
60G
QS
CH
Counts (DN s-1)
Counts(DN s-1)
0
5
10
15
20
25
2795.5
2796.0
2796.5
2797.0
Wavelength



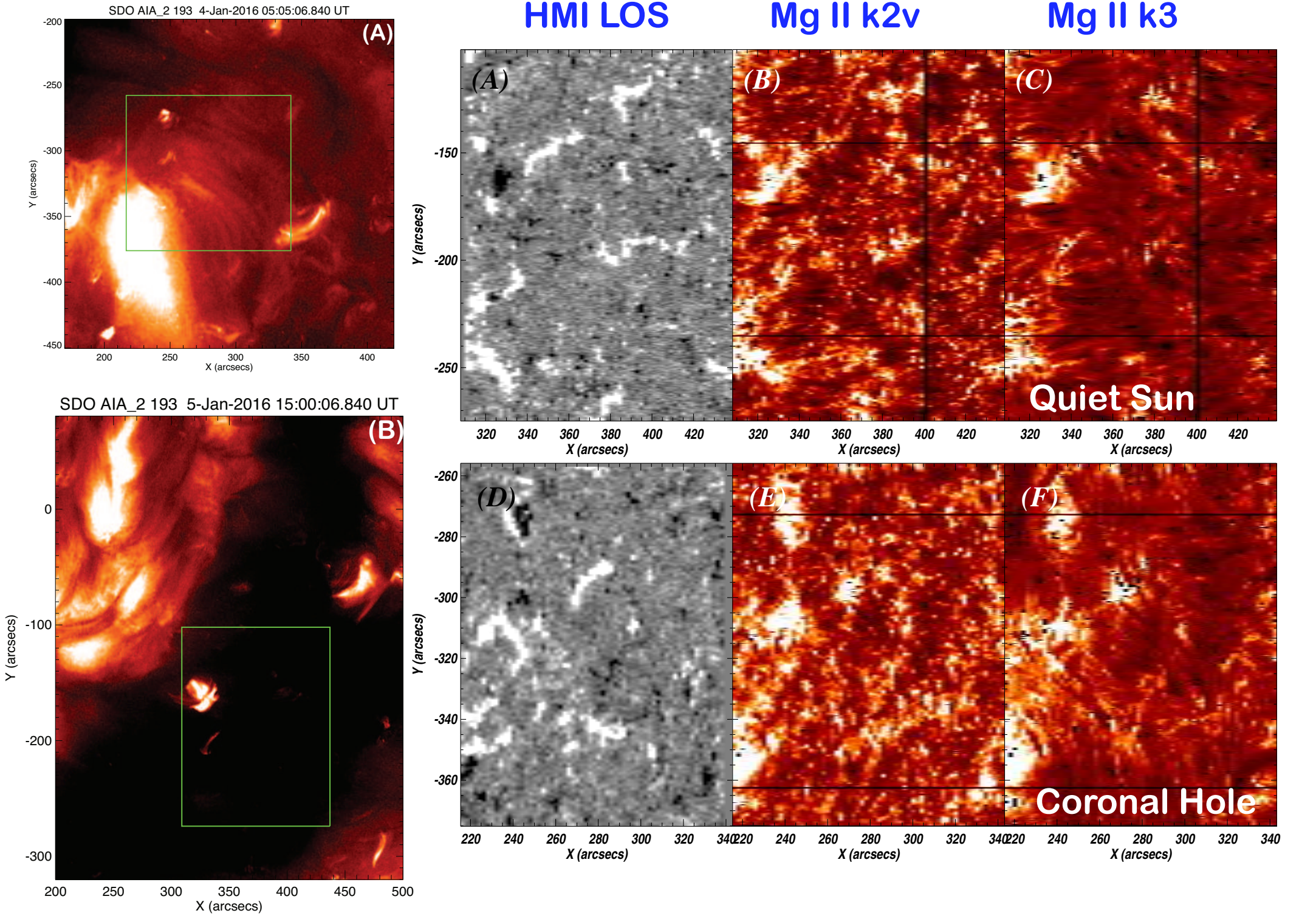


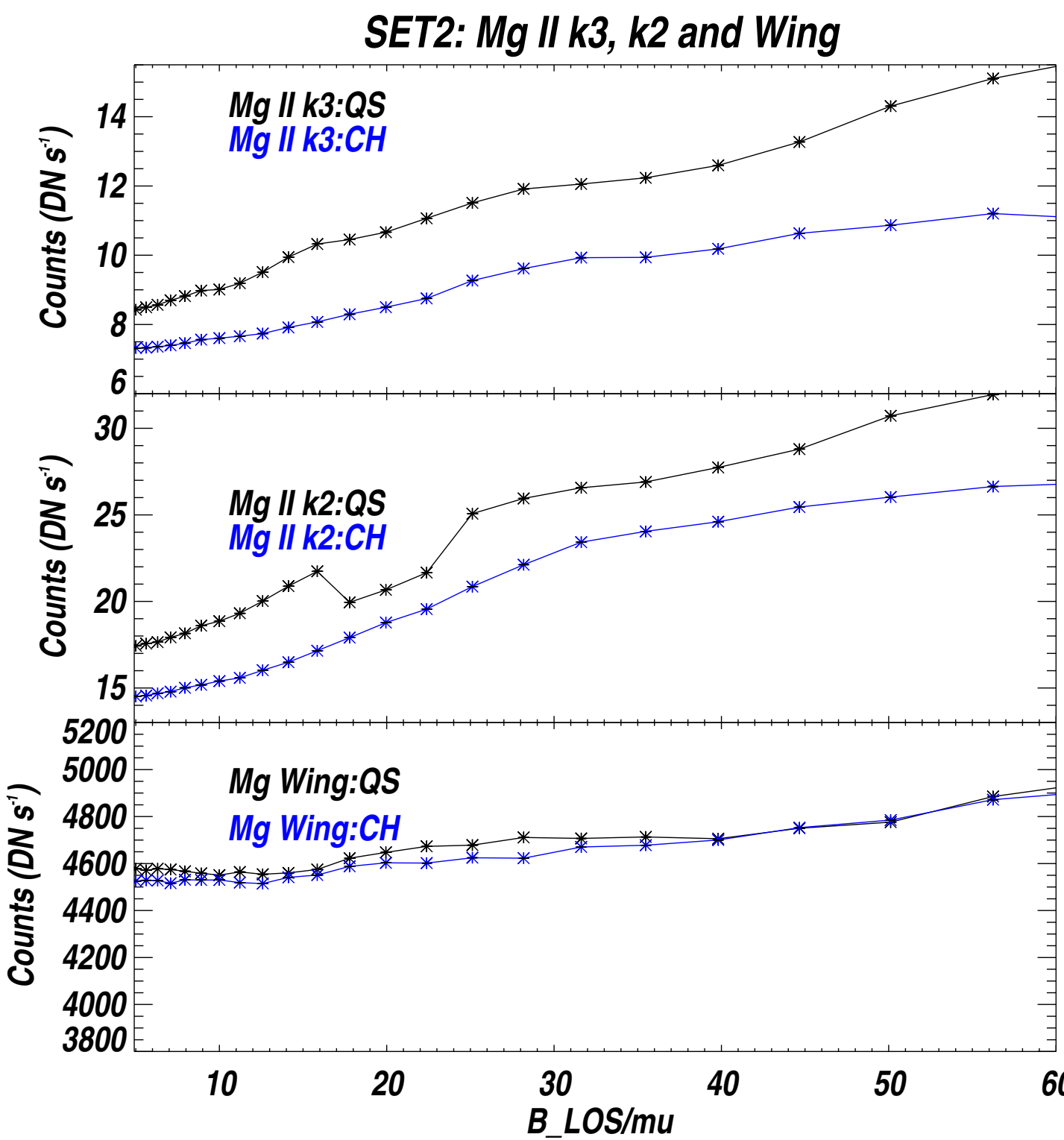


Significant differences between QS and CH intensities for identical field

The difference increases with magnetic field, saturates later on.

Similar results were obtained for k2v.

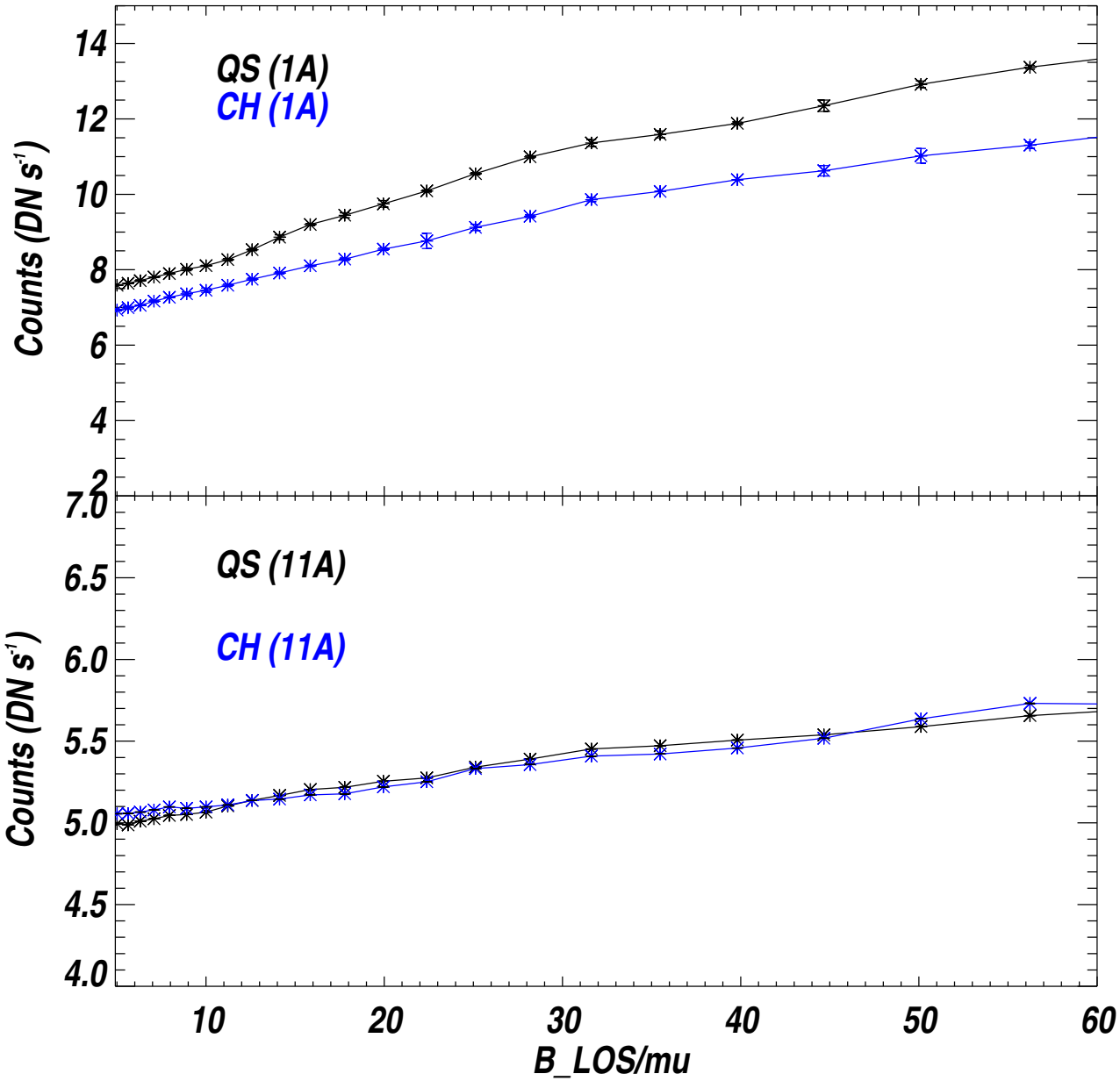

SDO AIA_2 193 4-Jan-2016 05:05:06.840 UT
(A)
Y (arcsecs)
X (arcsecs)
SDO AIA_2 193 5-Jan-2016 15:00:06.840 UT
(B)
Y (arcsecs)
X (arcsecs)
HMI LOS
Mg II k2v
Mg II k3
(A)
(B)
(C)
(D)
(E)
(F)
Y (arcsecs)
X (arcsecs)
Quiet Sun
Coronal Hole



As in the case 1, significant differences are observed

Just to make sure that these differences are not instrumental e.g., stray light

Effects of the Spectral Resolution



Mg II indices are measured using 11A and 1A sun-as-a-star spectra

Differences are seen even at 1 A resolution, that disappear for the 11 A resolution data

Mg II index derived using 1 A data being used for modelling of SSI needs to take this into account.

Summary and Conclusions

- No visual differences in QS and CH in Mg II line
- Emission from Mg II k3 & k2v, originating in the chromosphere, is significantly lower in CH than in QS for the regions with similar magnetic field strength.
- Wing Emission, originating in photosphere, do not show any difference (as it should be), ruling out instrumental effects such as stray light.
- The difference in Mg II (k3 and k2) intensities between QS and CH increases with increasing magnetic field strength.
- The differences in the intensities decrease with decreasing spectral resolution, and disappear for 11 A resolution.

- Loops in coronal holes are on average flatter than in QS

- High and long closed loops are extremely rare in coronal holes

- Short and low-lying loops are almost as abundant in coronal holes as in the quiet Sun.
    - Many low lying short loops —
        - strong chromospheric and TR emission
    - Very few high and long closed loops
        - very weak coronal emission

(Wiegelmann and Solanki 2004)

B distribution