

TRINITY COLLEGE DUBLIN



δ–formation and it's effects on the solar atmosphere.

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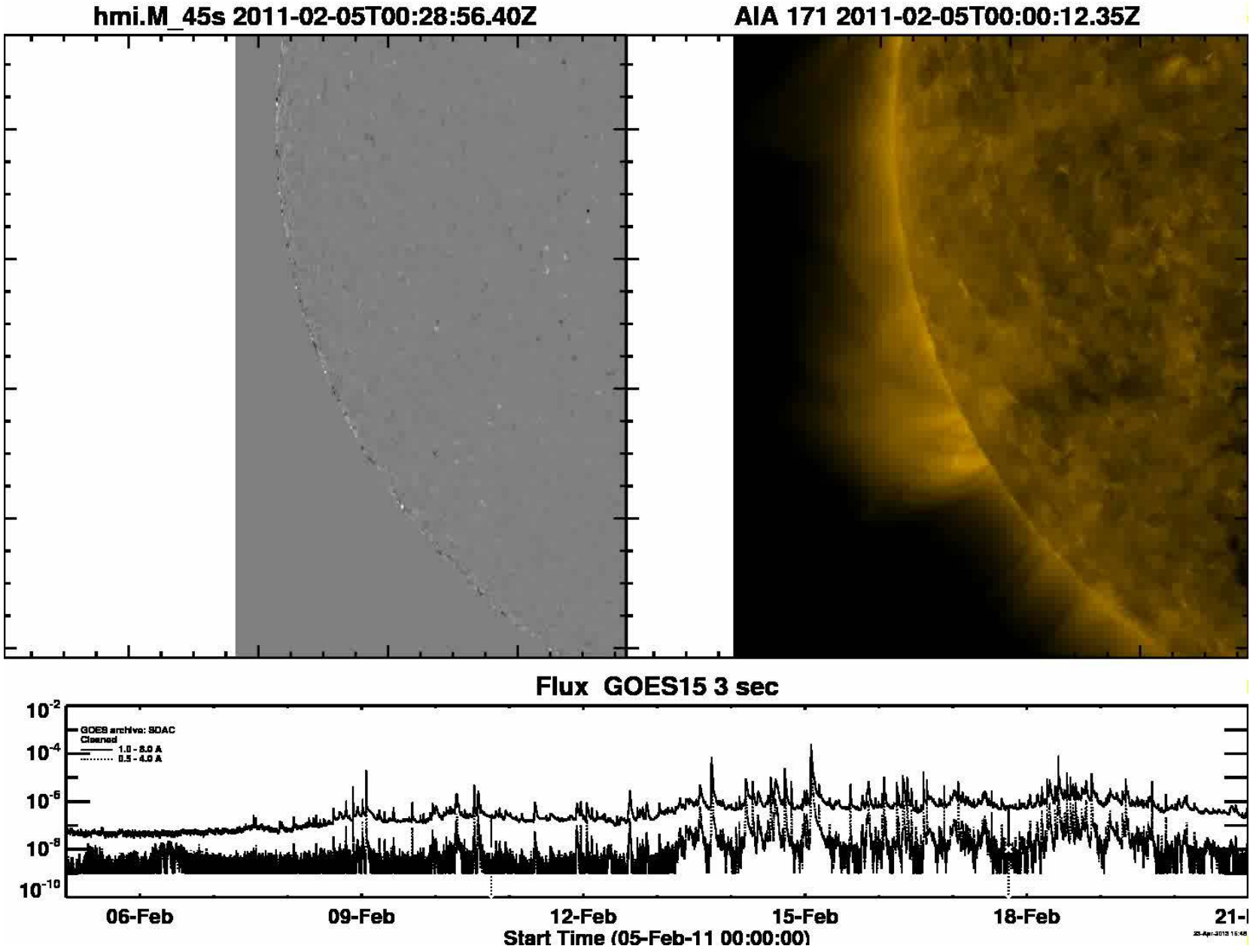
Collaborators: Eamon Scullion, Paul A. Higgins, D. Shaun Bloomfield & Peter T. Gallagher

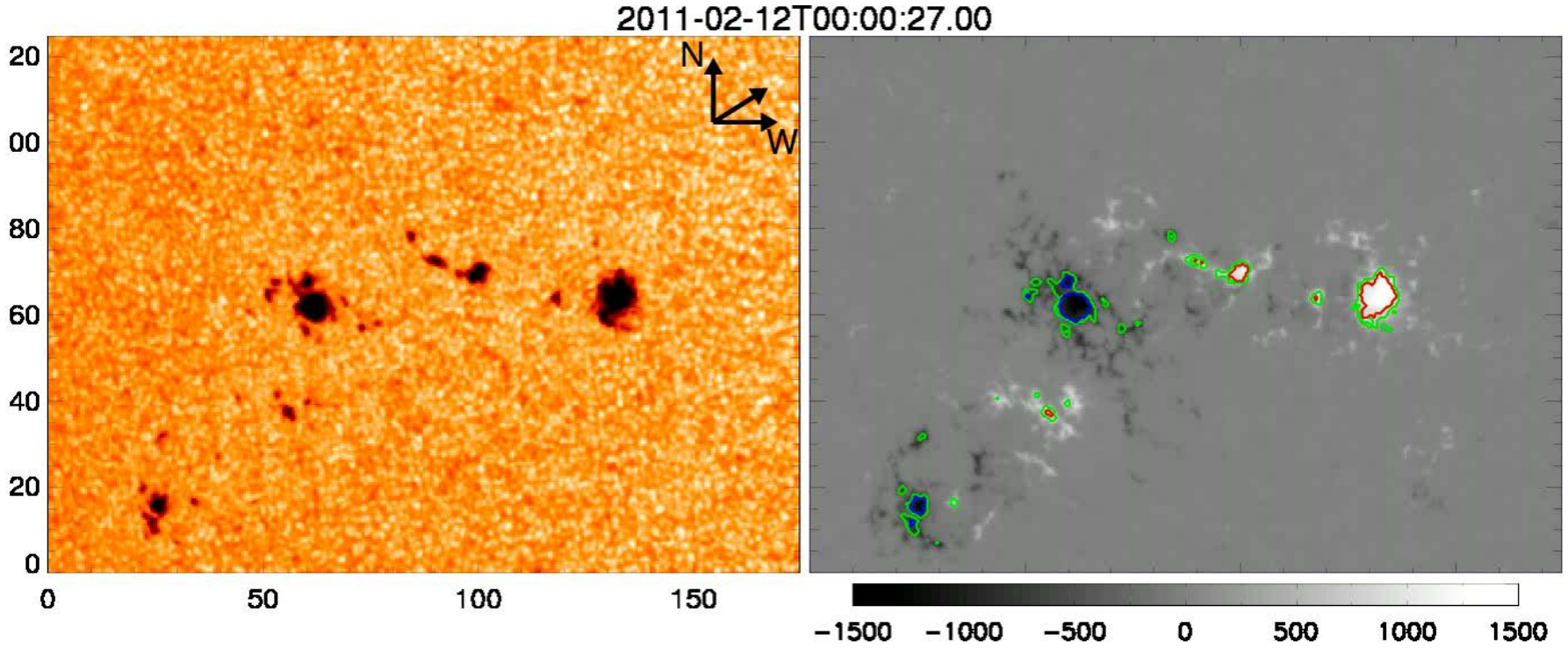
The famous AR-11158



AR-11158

Continuum Intensity

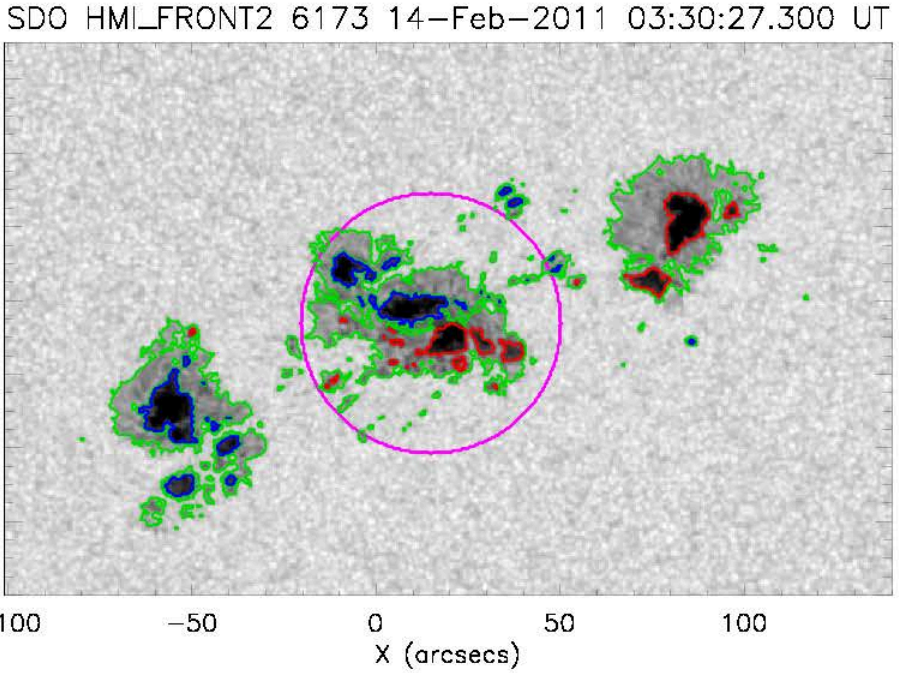
LOS Magnetic Field

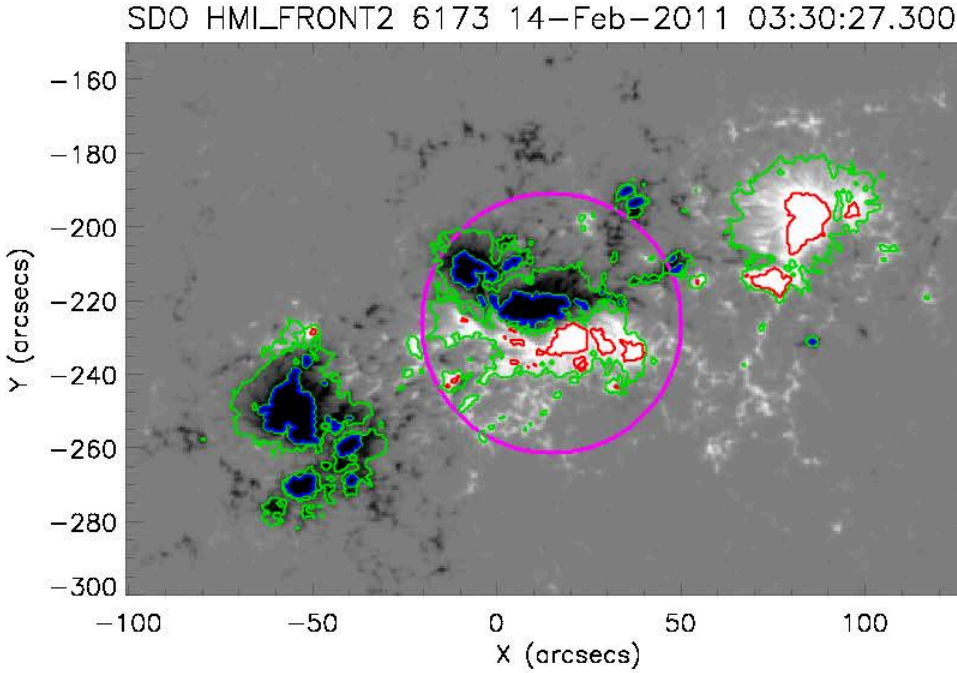


Observed using HMI/SDO

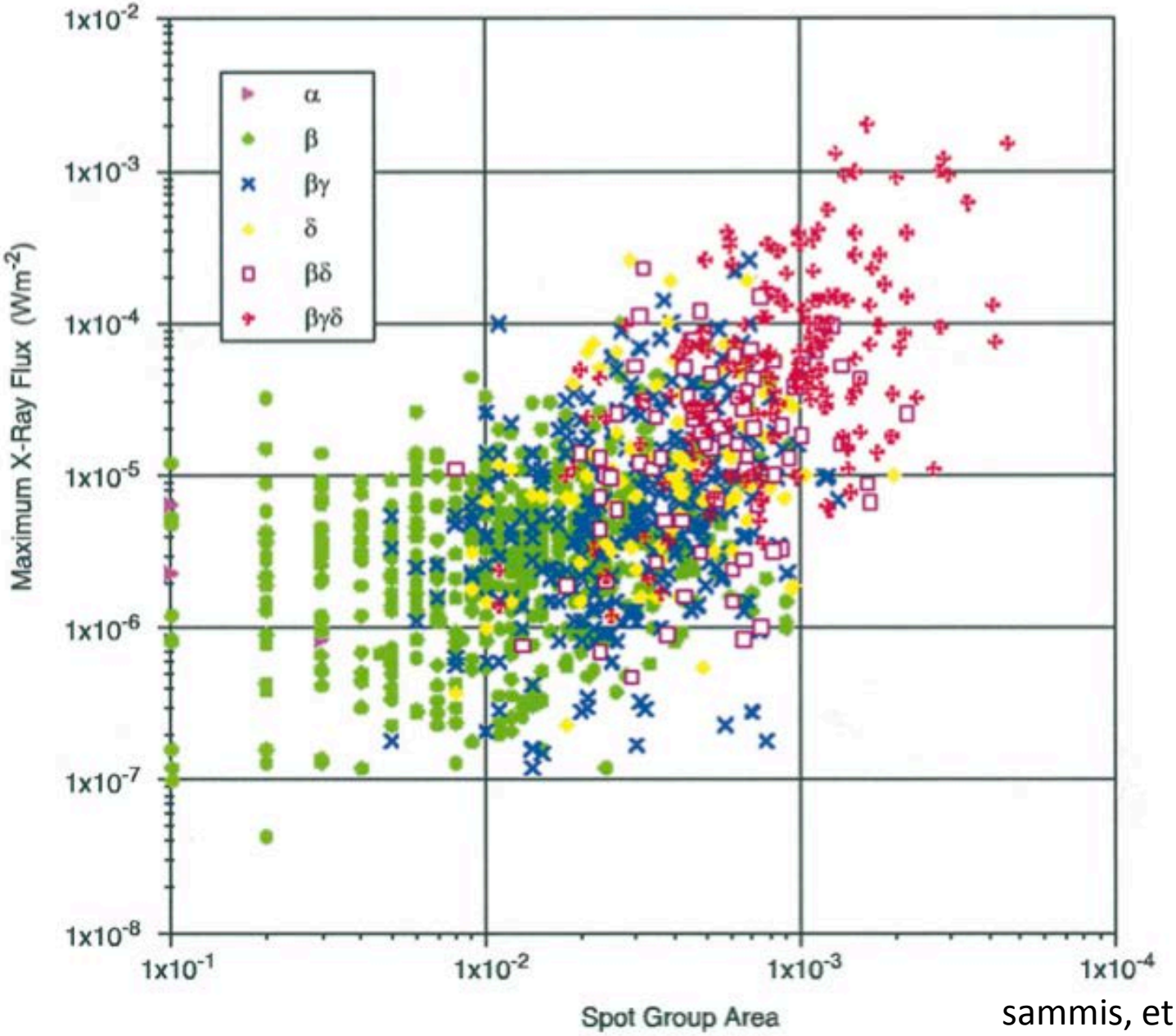
δ–spots

δ-spots are a particular configuration as described by the modified Mount Wilson scheme, where a common penumbra encloses opposite polarity umbrae





δ–spots & Flares

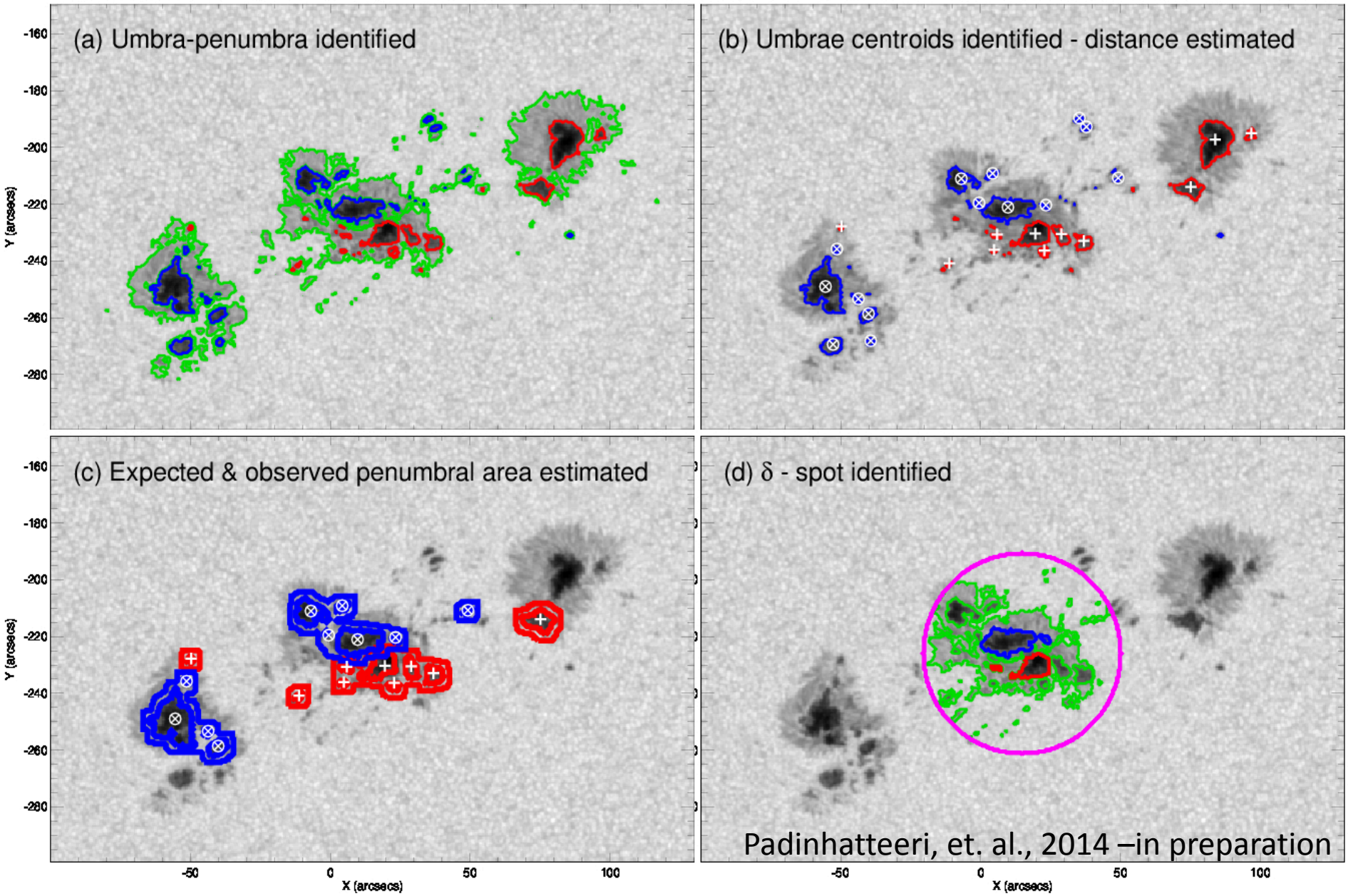


sammis, et. al., 2000

Need for a automated δ–spots detection.

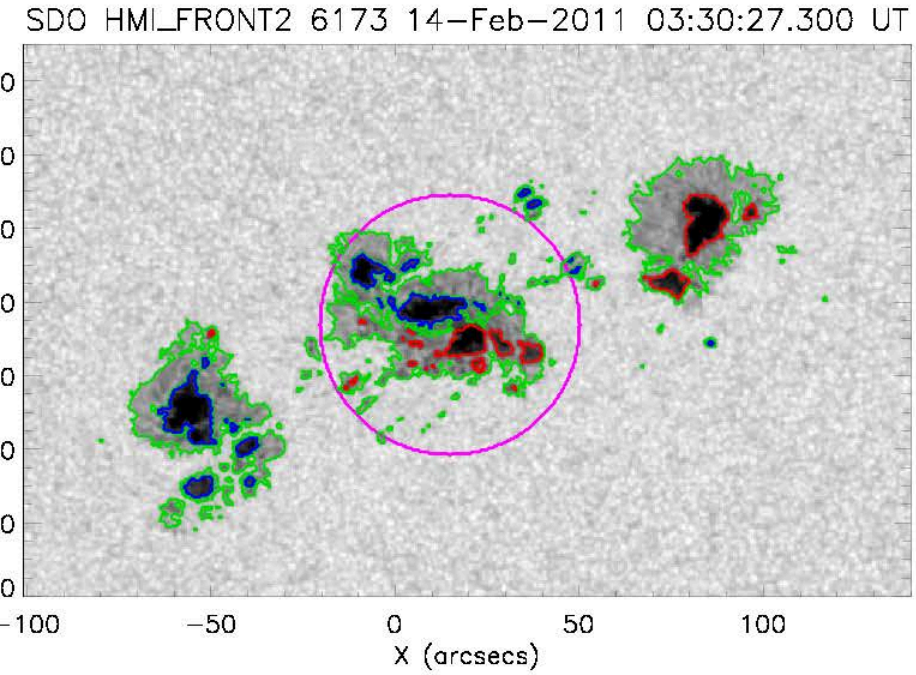
- NOAA – Solar Region Summary (SRS) is released only once per day at 00.30 UT
- NOAA-SRS is based on the previous whole day's observation data
- Near Real Time (NRT) detection of δ–spots can be useful in flare-forecasting.

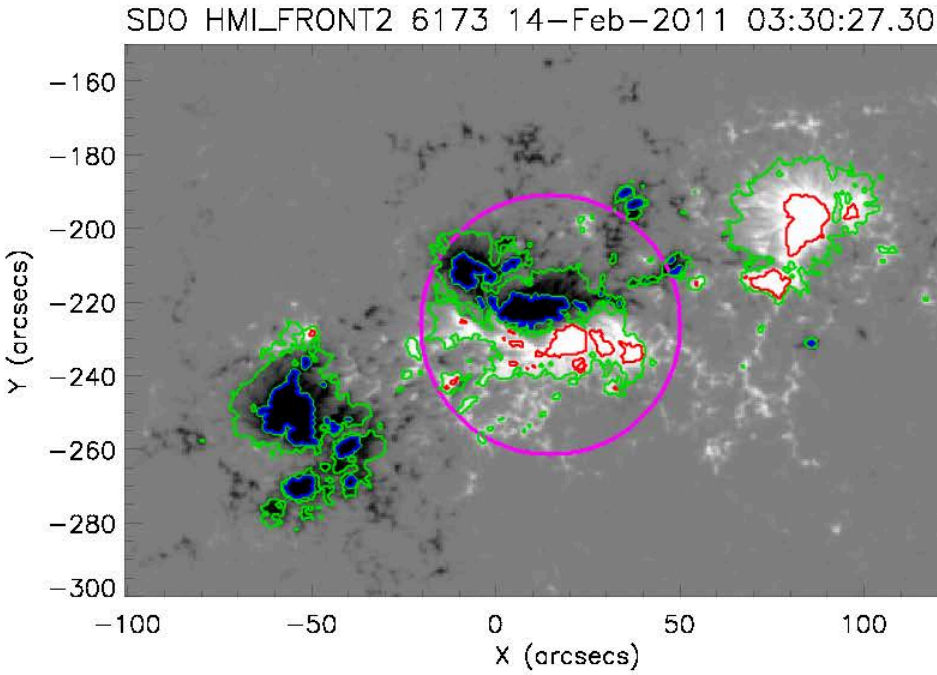
SMART-Delta Finder (SMART-DF)



Padinhatteeri, et. al., 2014 –in preparation

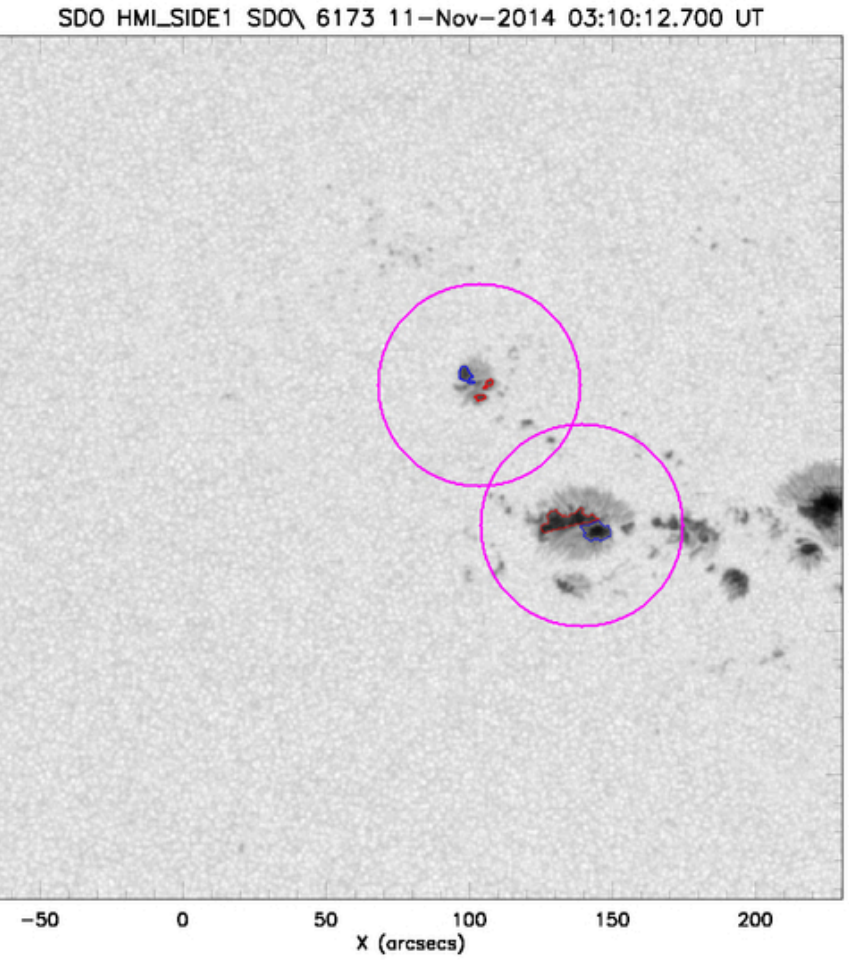
Results – NOAA AR 11158

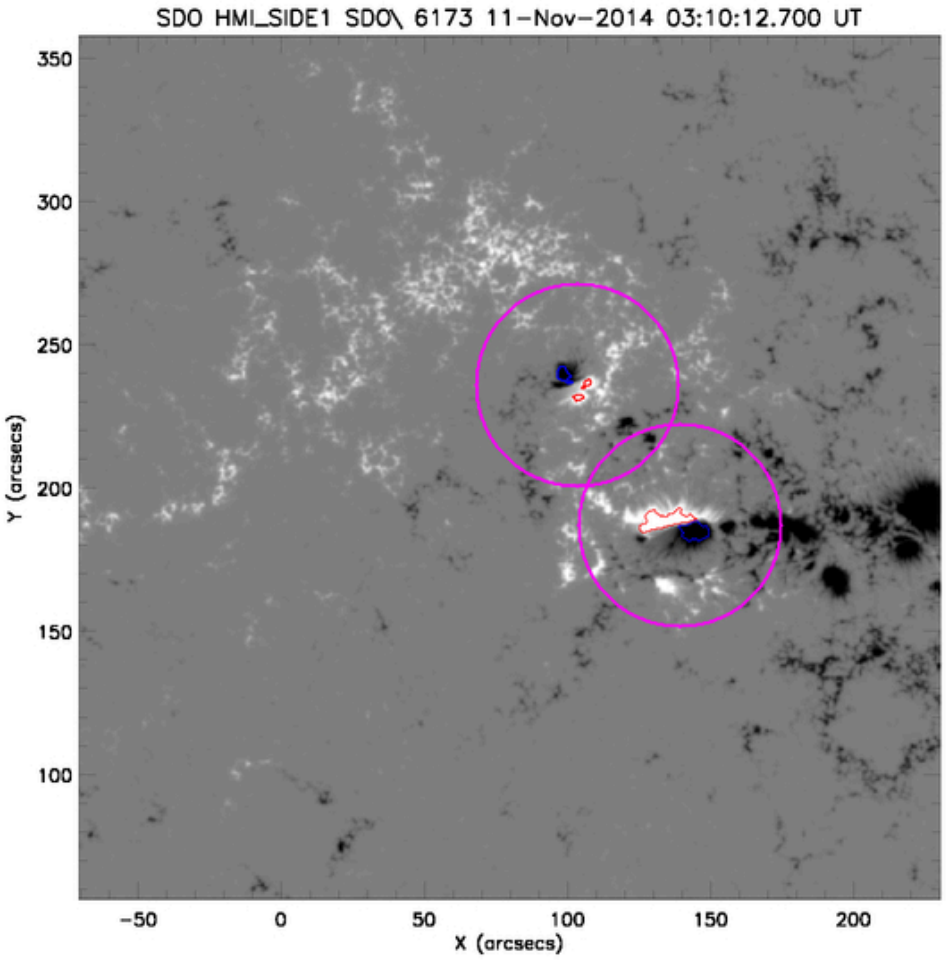




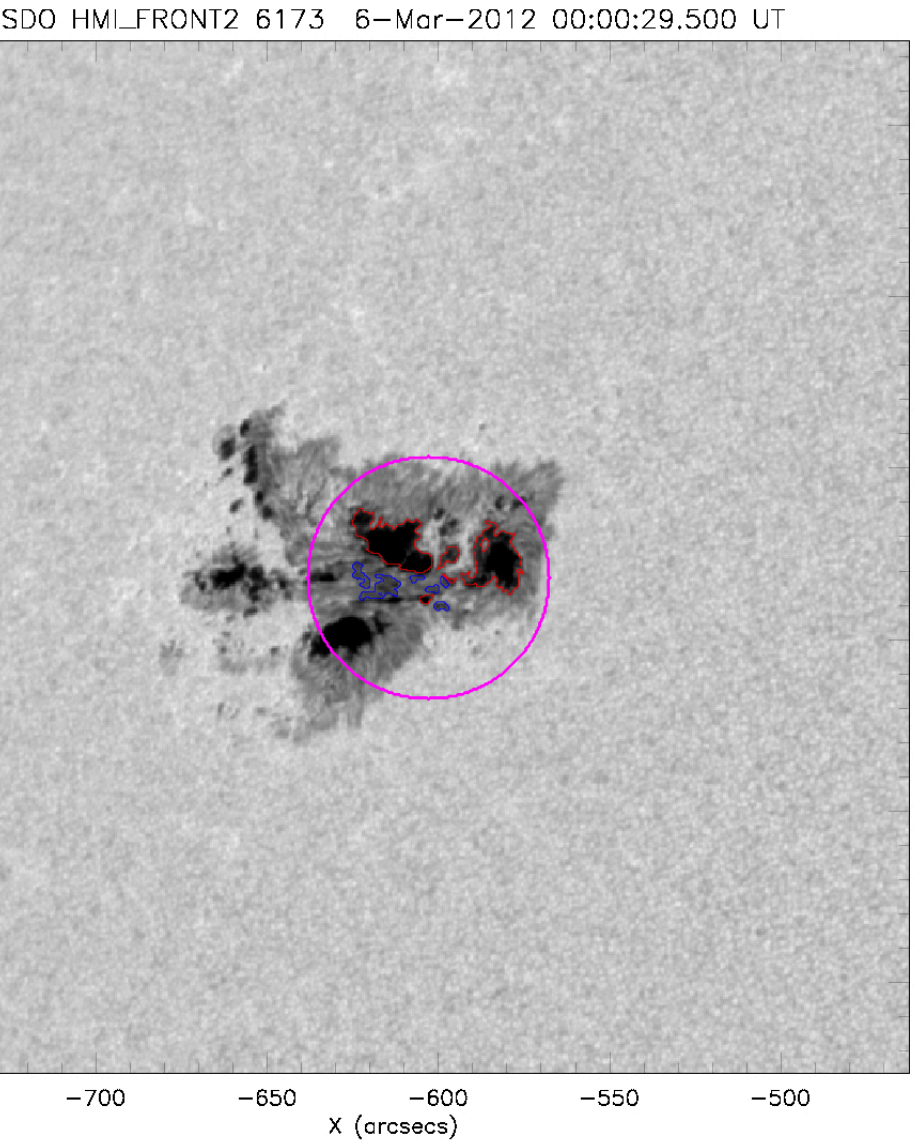
Padinhatteeri, et. al., 2014

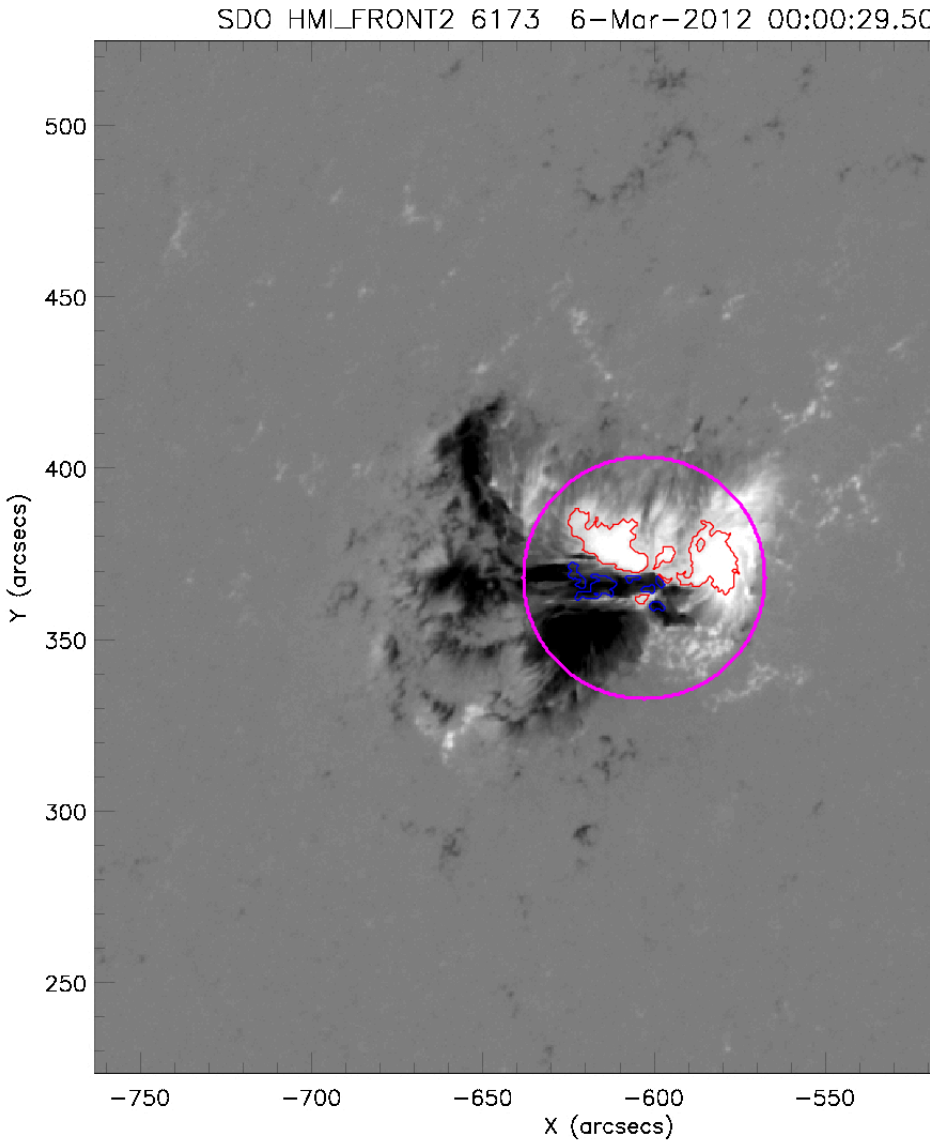
AR12205 – This Morning



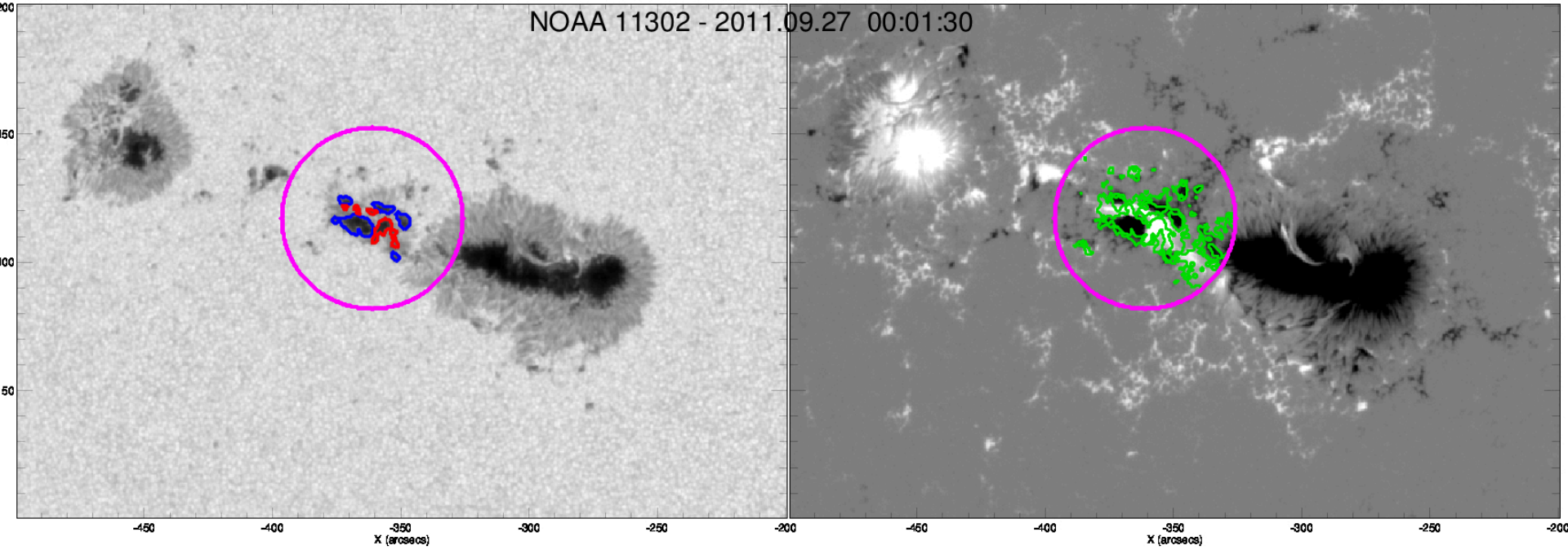


NOAA AR 11429



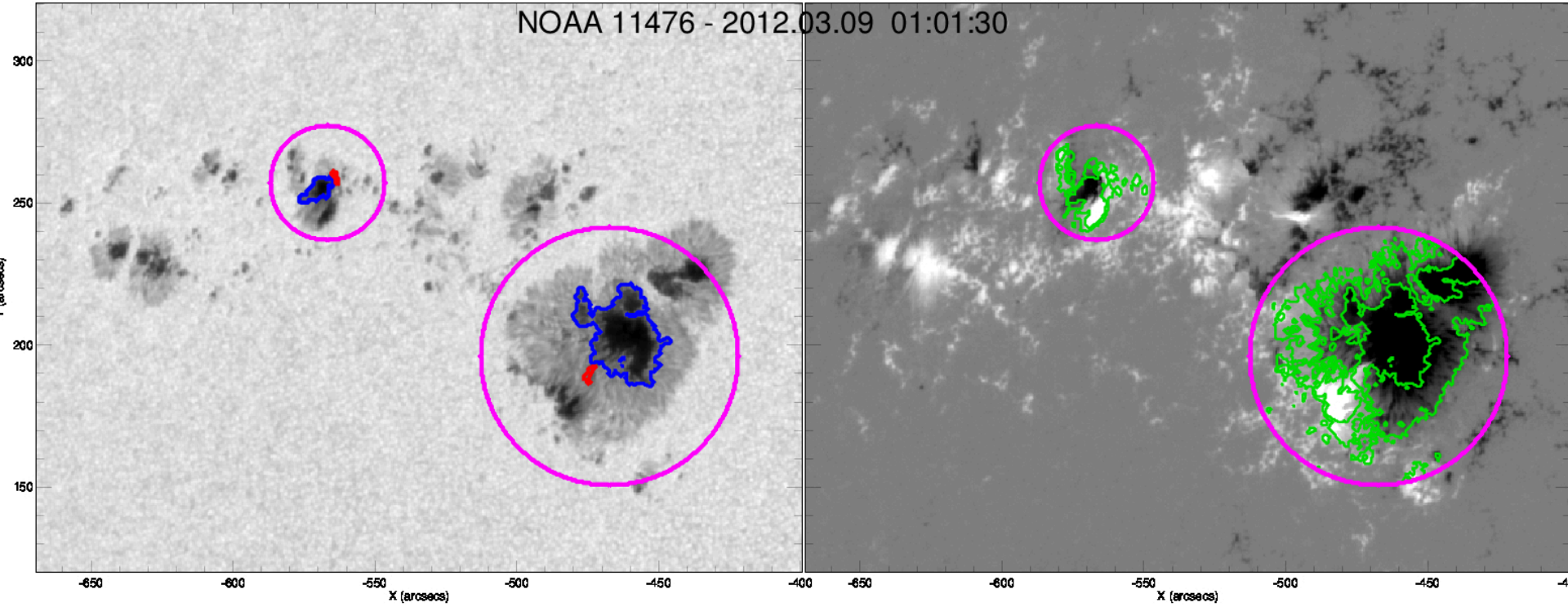


NOAA AR 11302

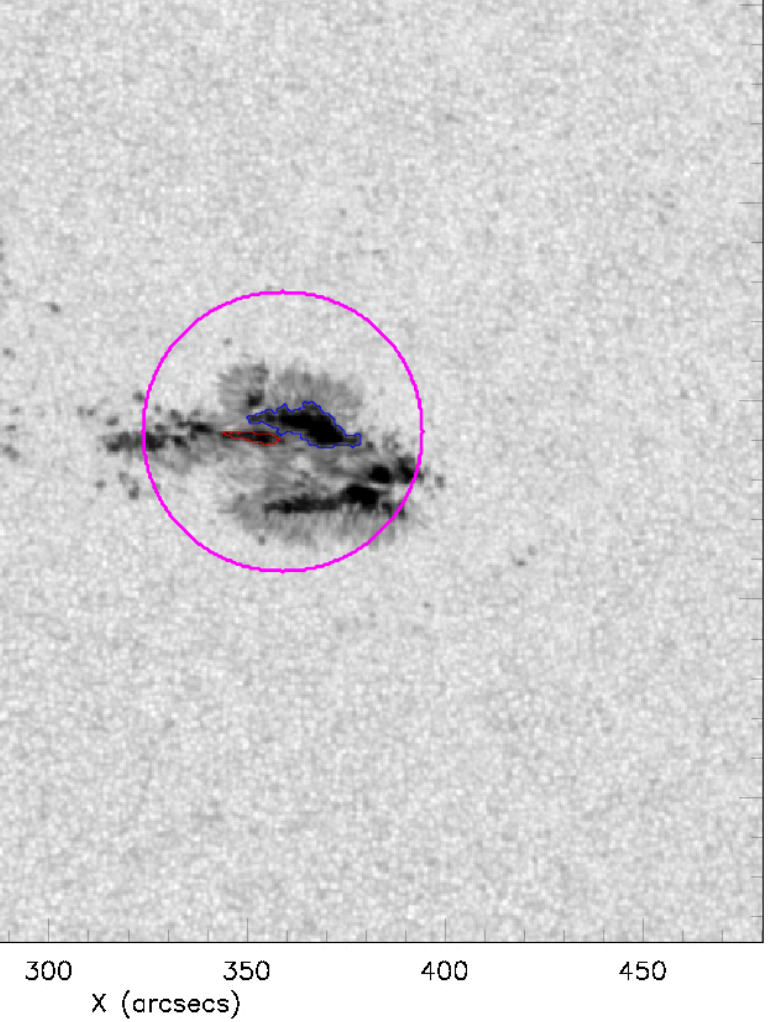


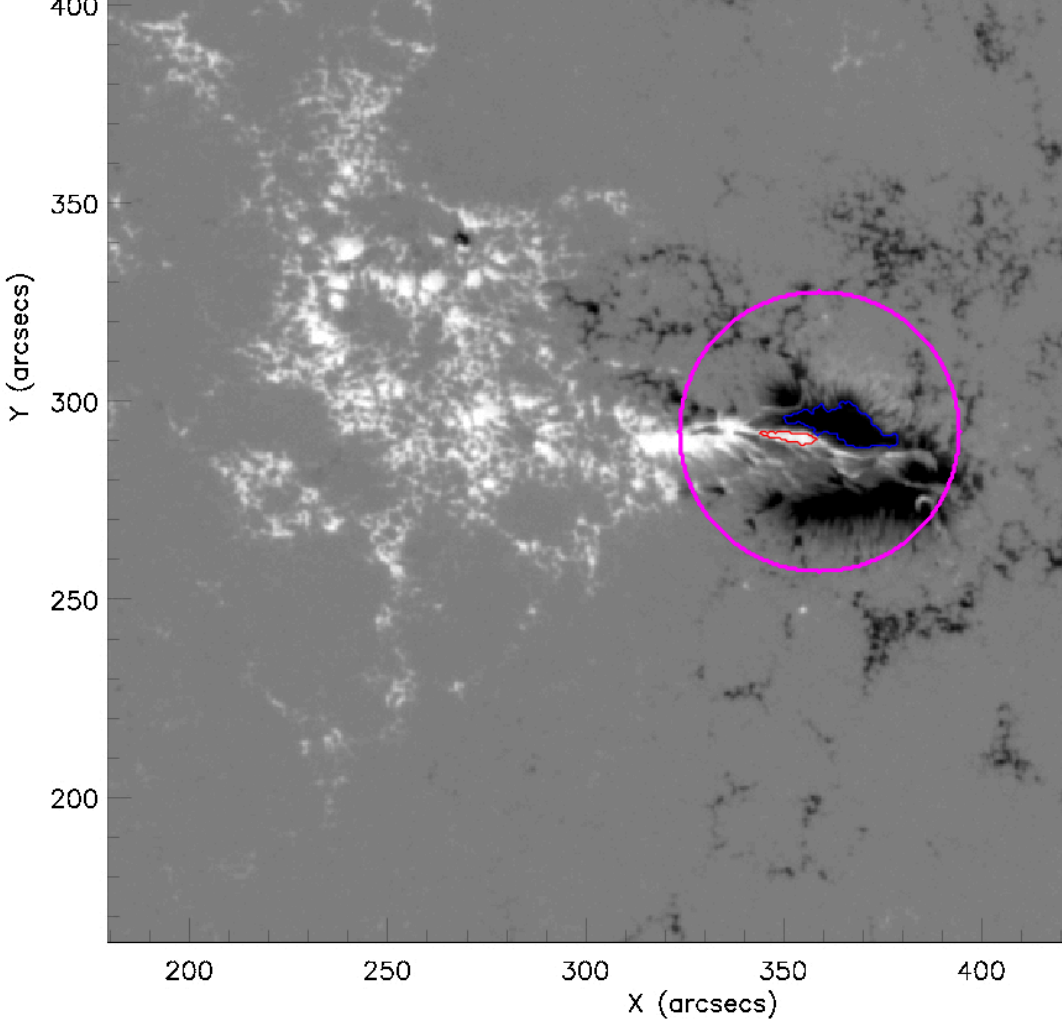
Padinhatteeri, et. al., 2014 –in preparation

NOAA AR 11476



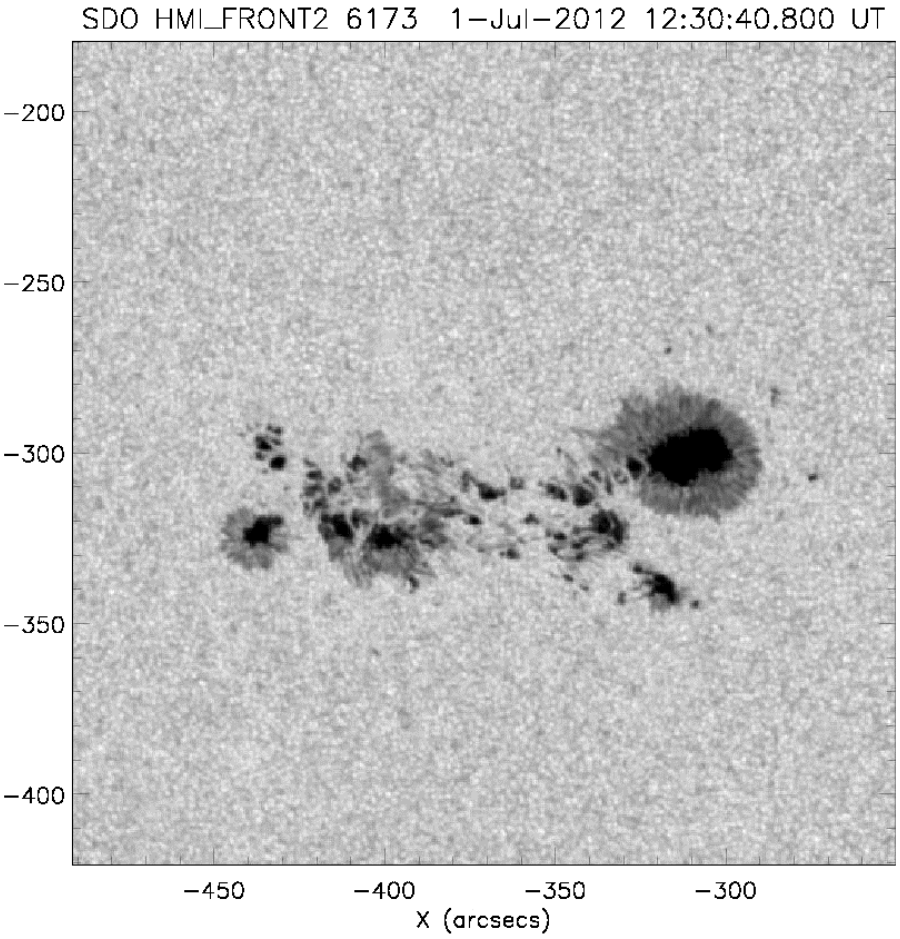
Padinhatteeri, et. al., 2014 - –in preparation

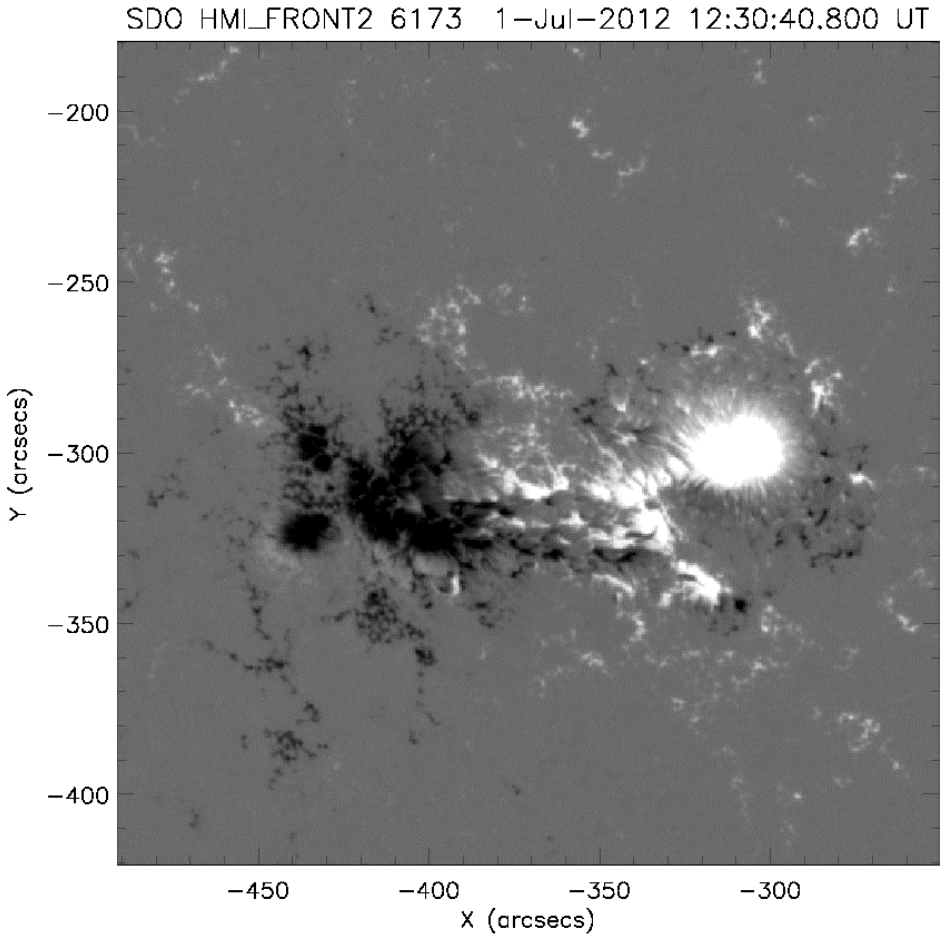




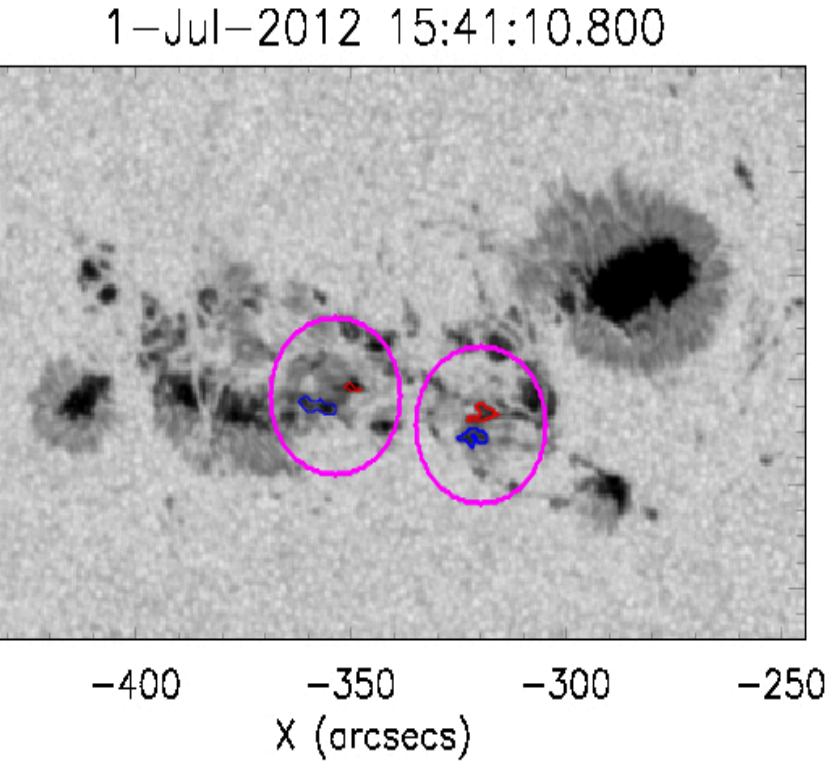
- First M-class flare from AR 11190 a day after marked as δ by SMART-DF. Where as NOAA never marked AR 11190 as δ!

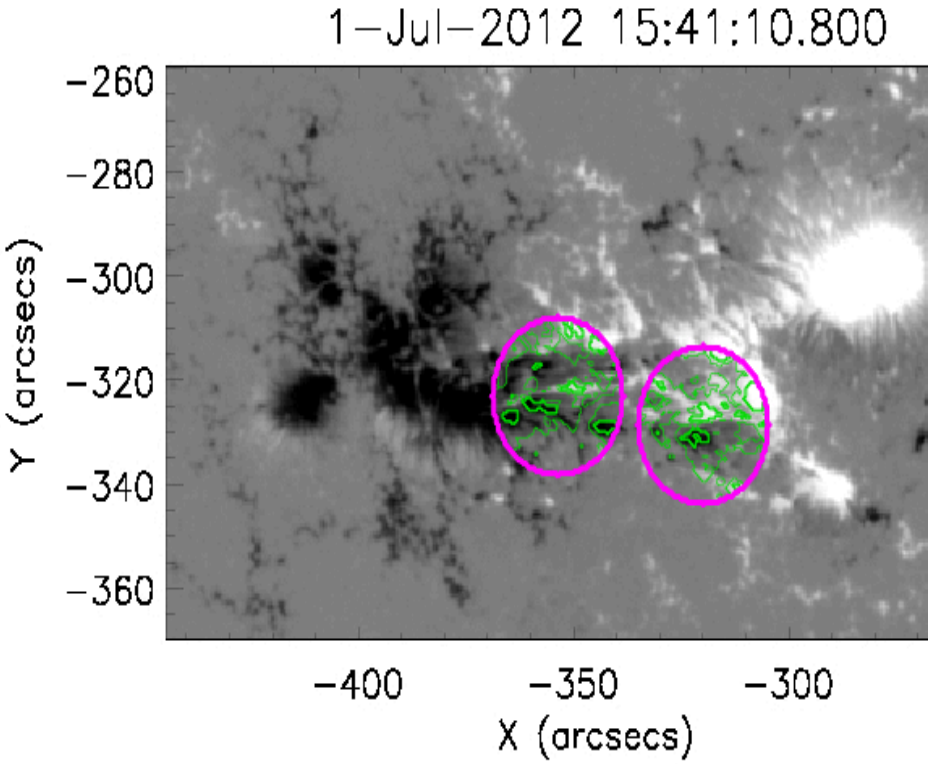
AR 11515


SDO HMI_FRONT2 6173 1-Jul-2012 12:30:40.800 UT
-200
-250
-300
-350
-400
-450
-400
-350
-300
X (arcsecs)


SDO HMI_FRONT2 6173 1-Jul-2012 12:30:40.800 UT
-200
-250
-300
-350
-400
Y (arcsecs)
-450
-400
-350
-300
X (arcsecs)

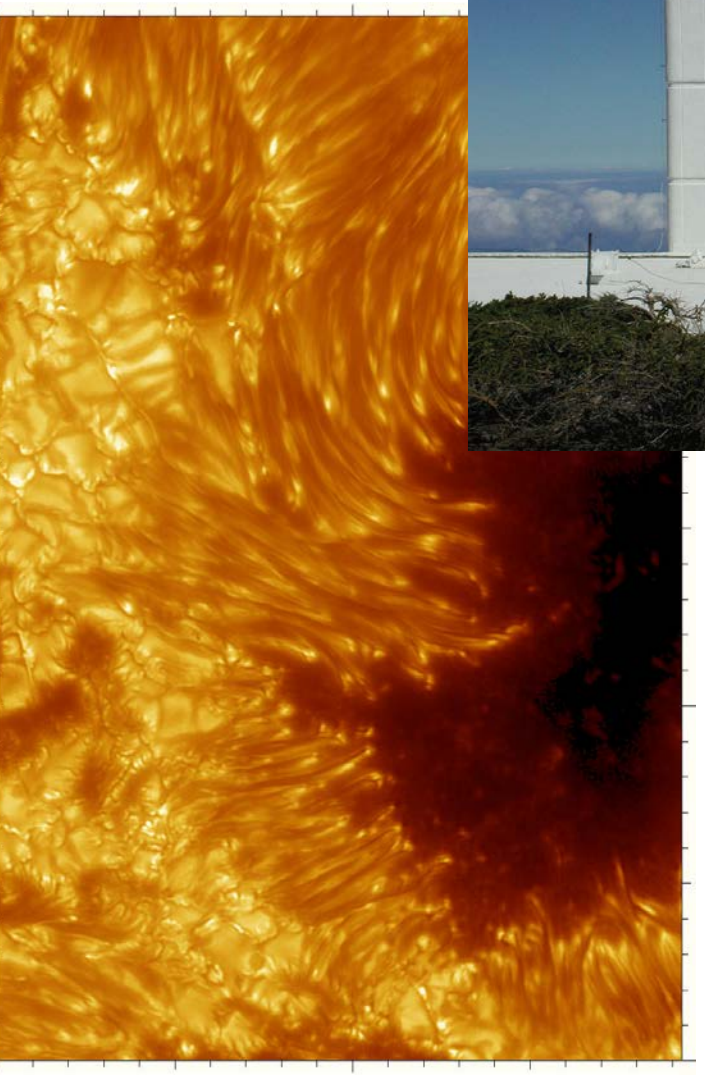
δ–spots??


1–Jul–2012 15:41:10.800
−400
−350
−300
−250
X (arcsecs)


1–Jul–2012 15:41:10.800
−260
−280
−300
−320
−340
−360
Y (arcsecs)
−400
−350
−300
X (arcsecs)

SST/CRISP data





Scharmer et al., 2003a; 2006, 2008

SST/CRISP

- **Advance**
  - CRisp Imaging Spectro-Polarimeter (2008)
- Dual Fabry-Pérot interferometer (FPI)
- Line sampling between 510 - 860 nm: 36 fps
- Chromosphere and Photosphere analysis in:

Red Beam (nb + wb)	**Blue Beam**
Ca II 8542 Å (Infra-red triplet)	G-Band
H-alpha 6563 Å	Ca II H
Na D 5896 Å	
Mg b 5172 Å	
Fe I 6301 & 6302 Å	

- **55 x 55 arcsec FOV**
- **0.059 arcsec / pixel**

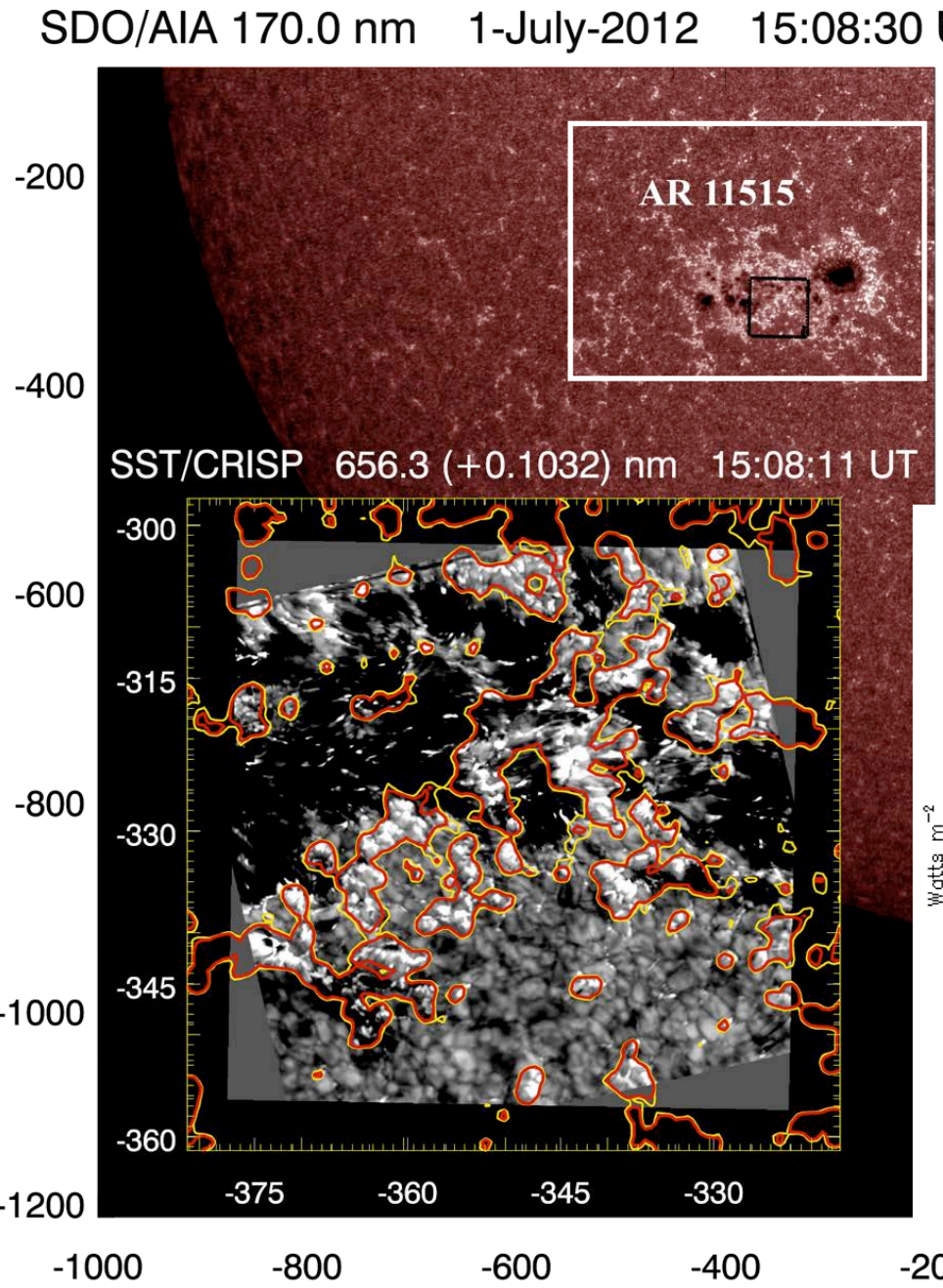
Observation

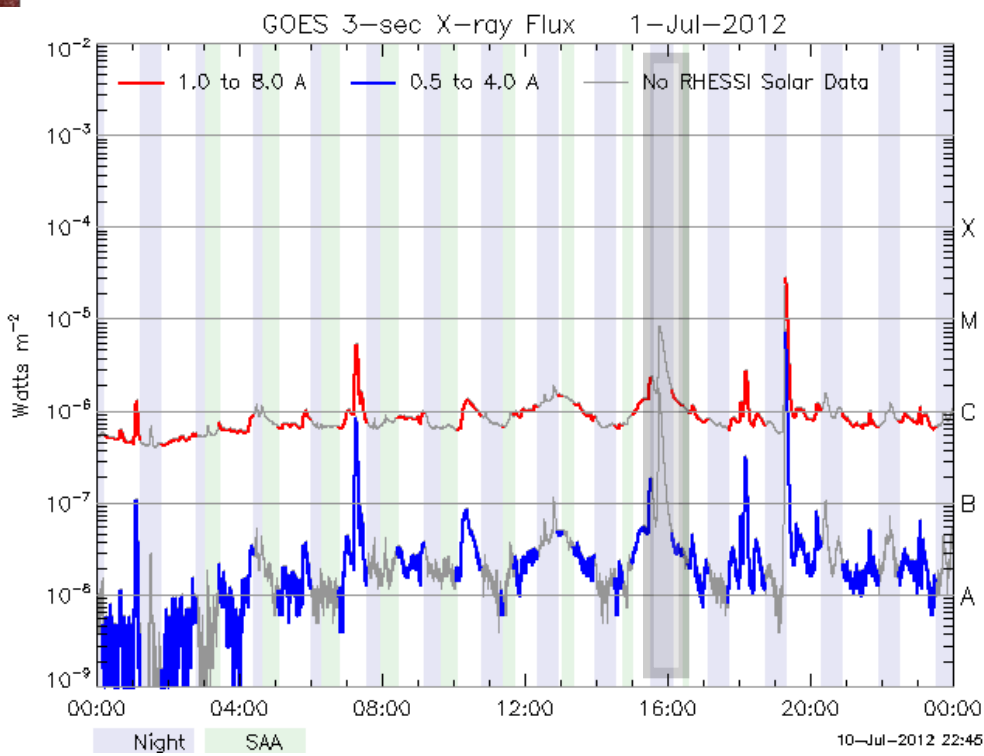
15:08.11 - 16:31.23 UT

C9.0 – class Flare

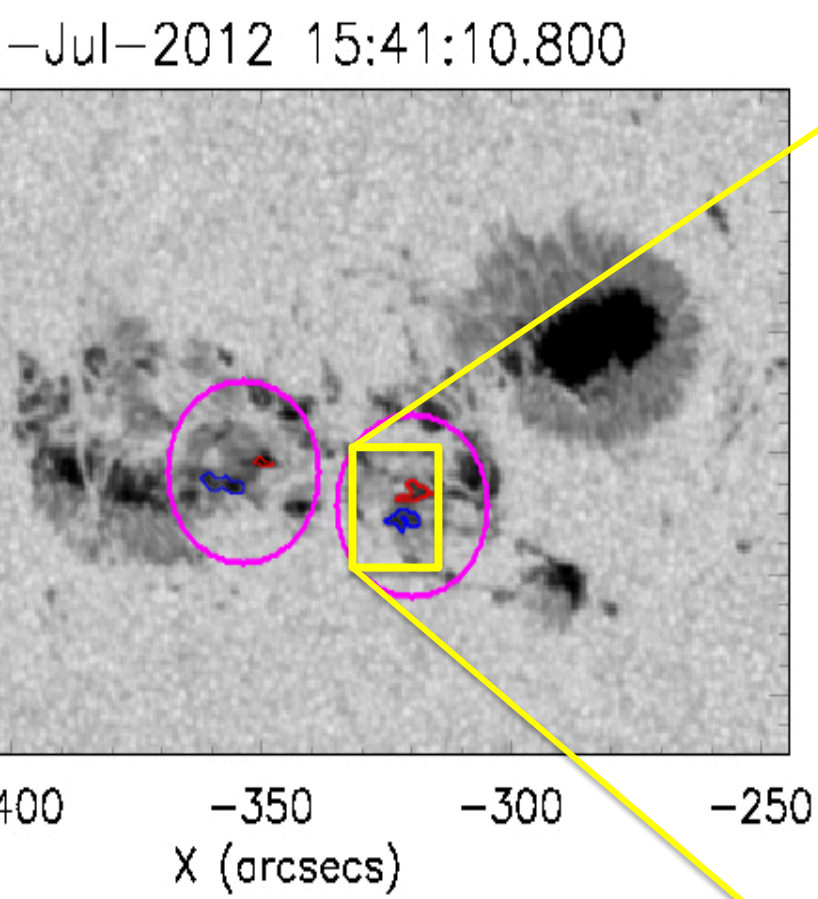
15:43 UT = peak

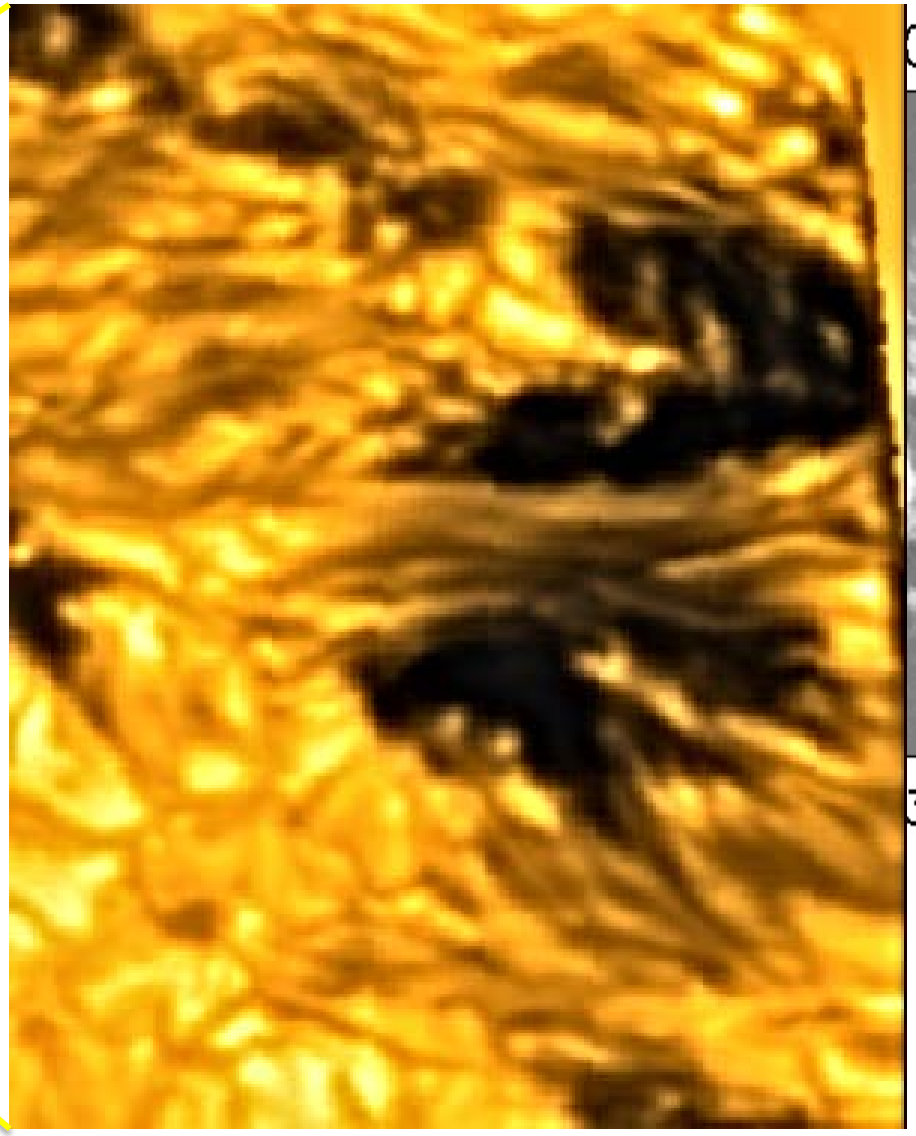
PRE - PEAK - POST flare chromosphere



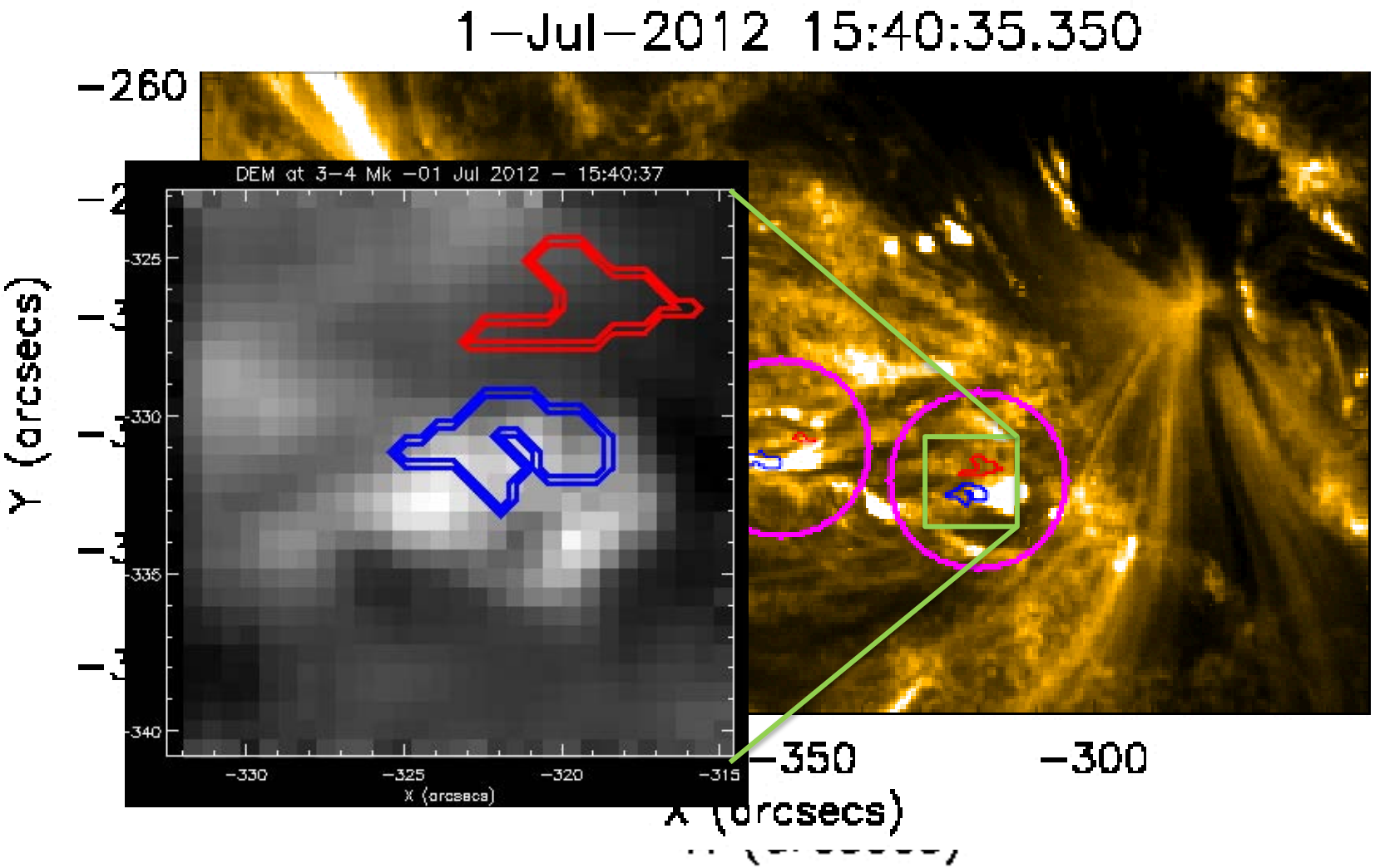


δ–spot??

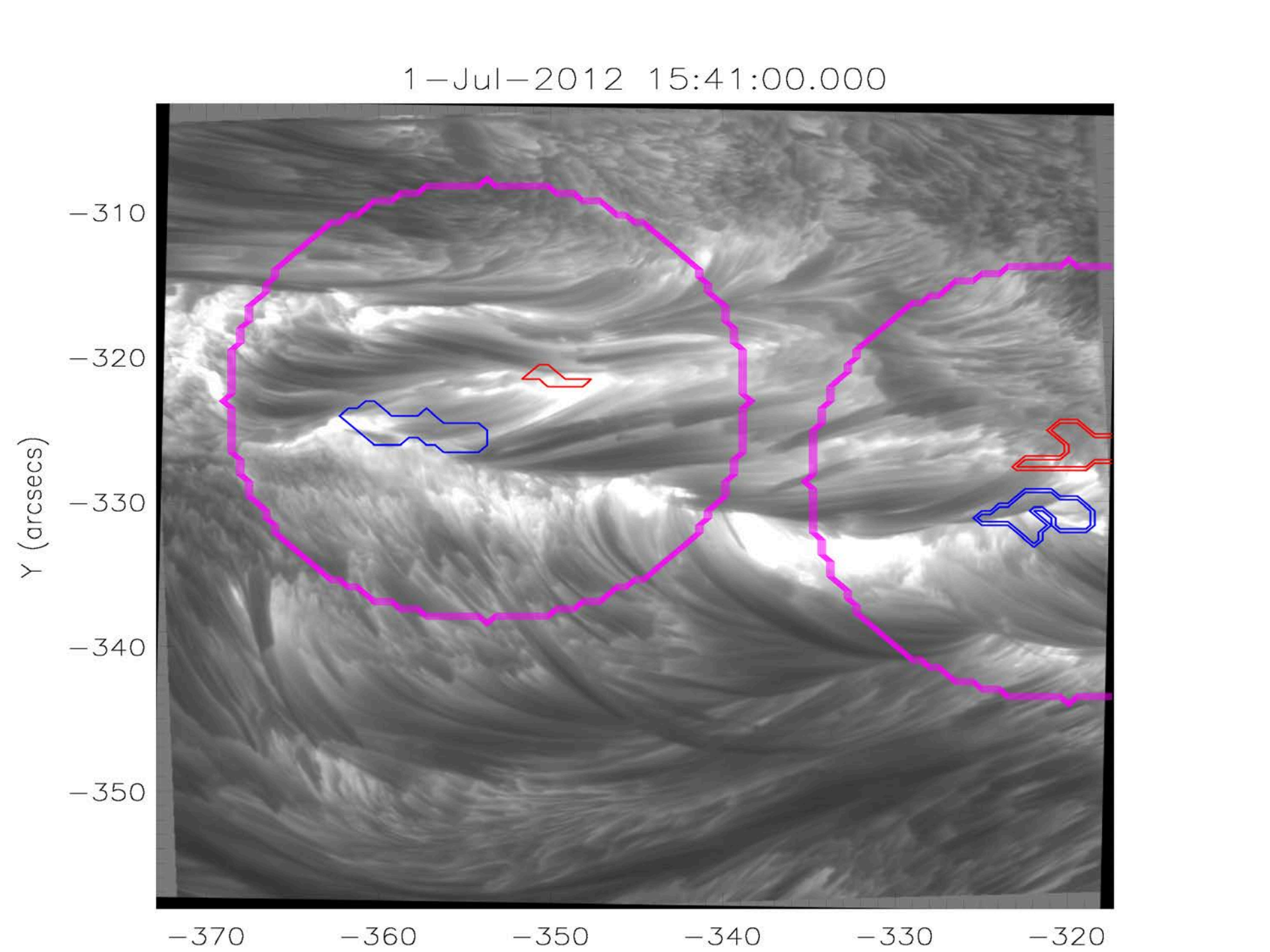




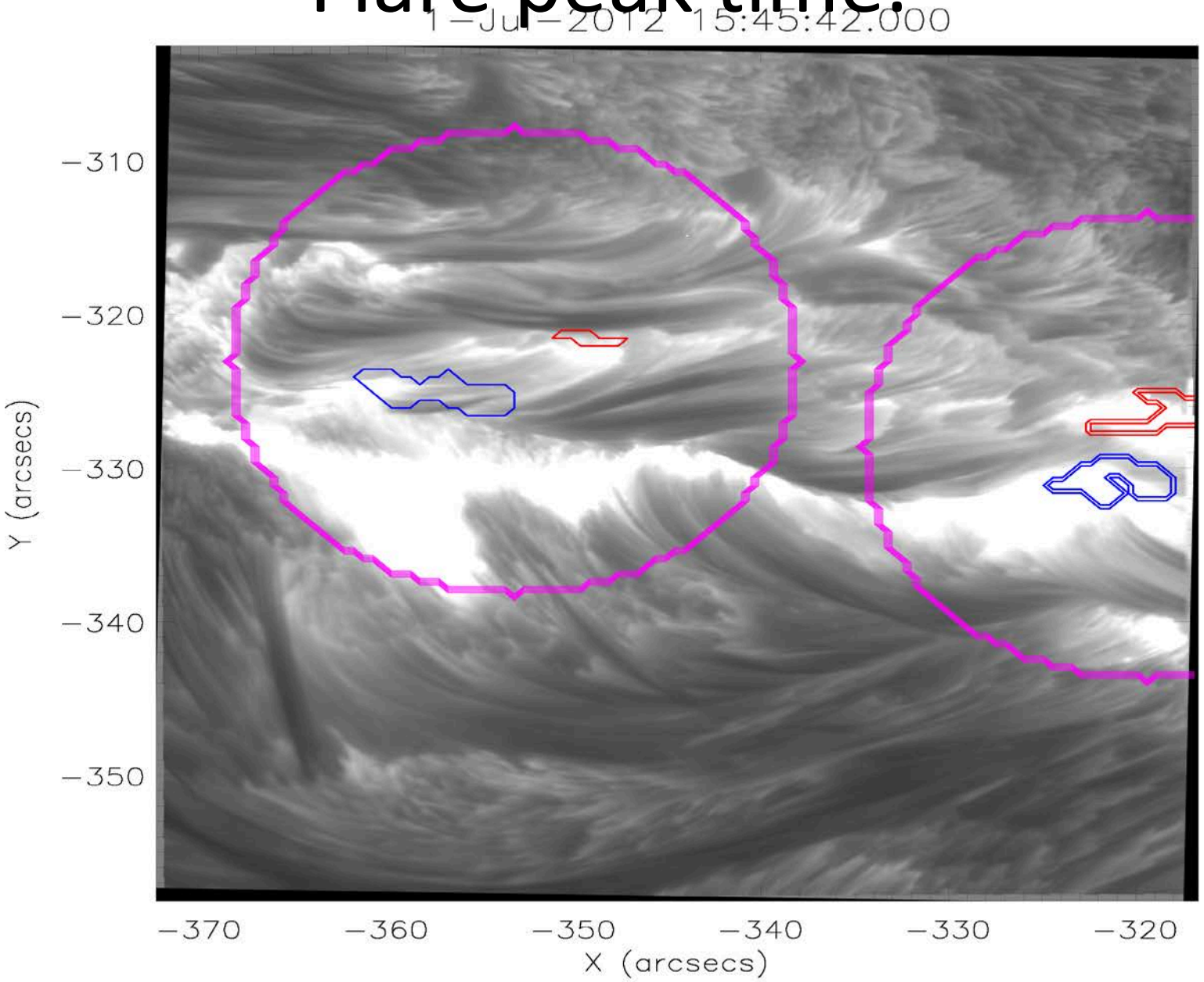
Effects on atmosphere



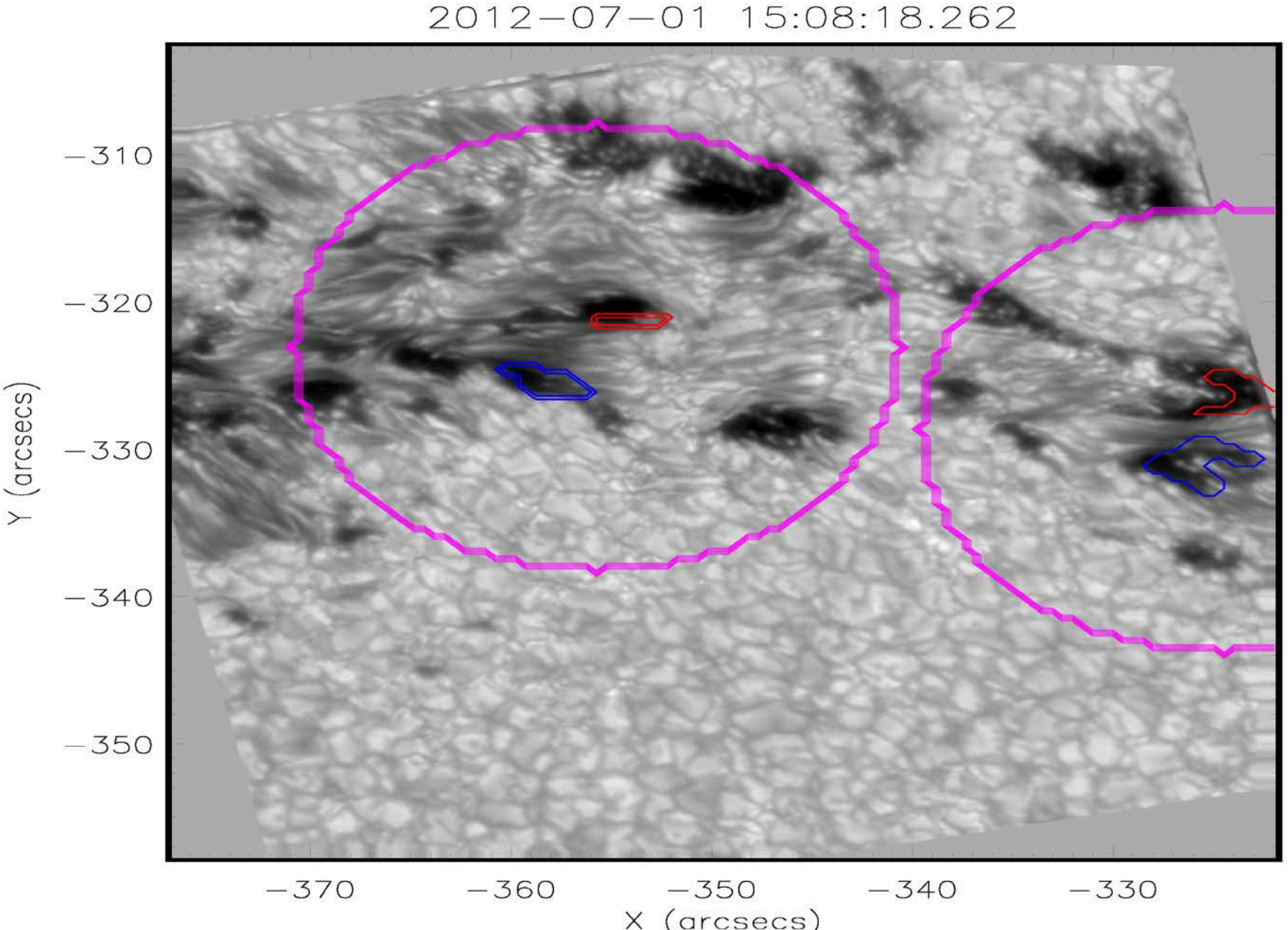
DEM calculation using


1−Jul−2012 15:41:00.000
−310
−320
−330
−340
−350
Y (arcsecs)
−370
−360
−350
−340
−330
−320

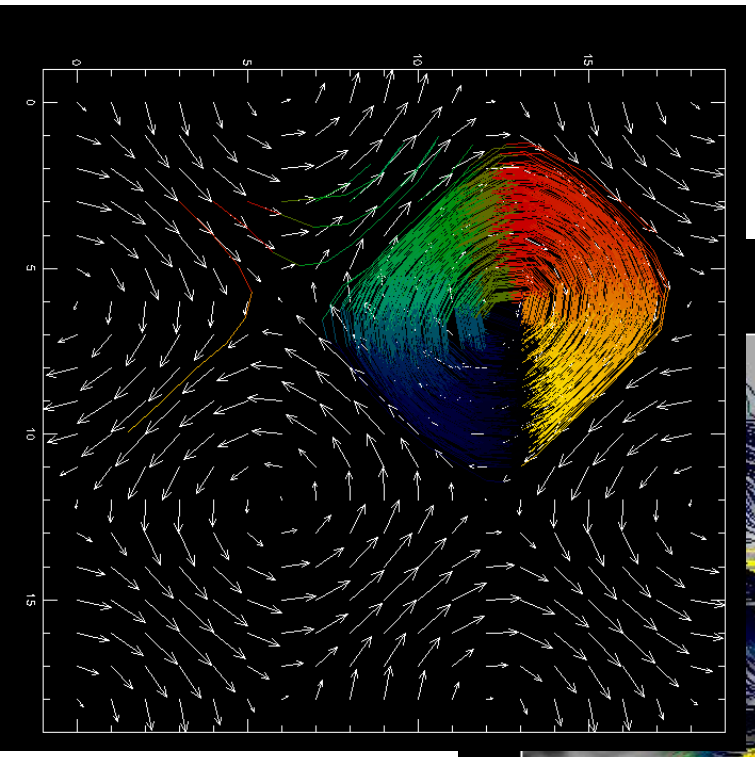
Flare peak time.

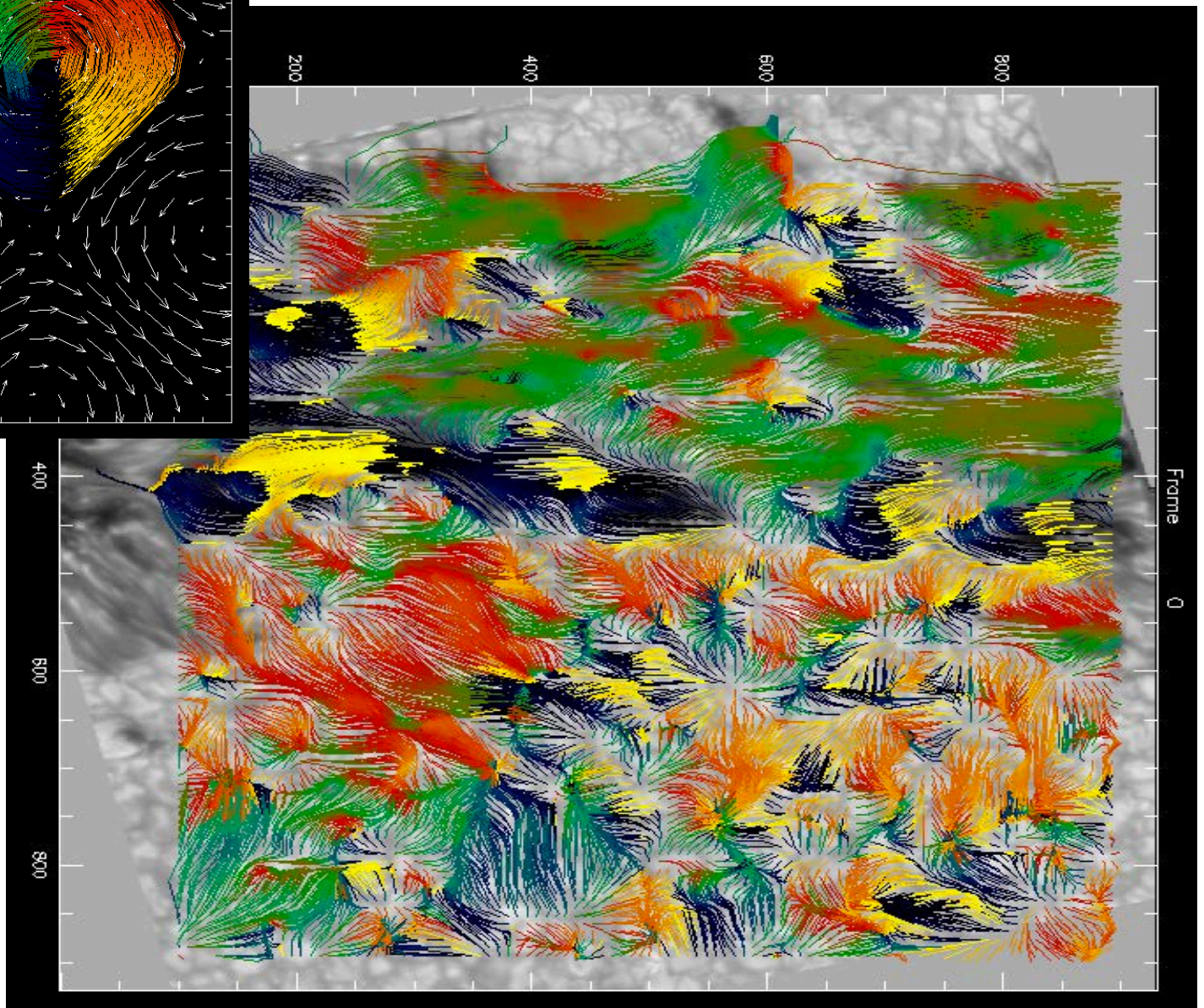


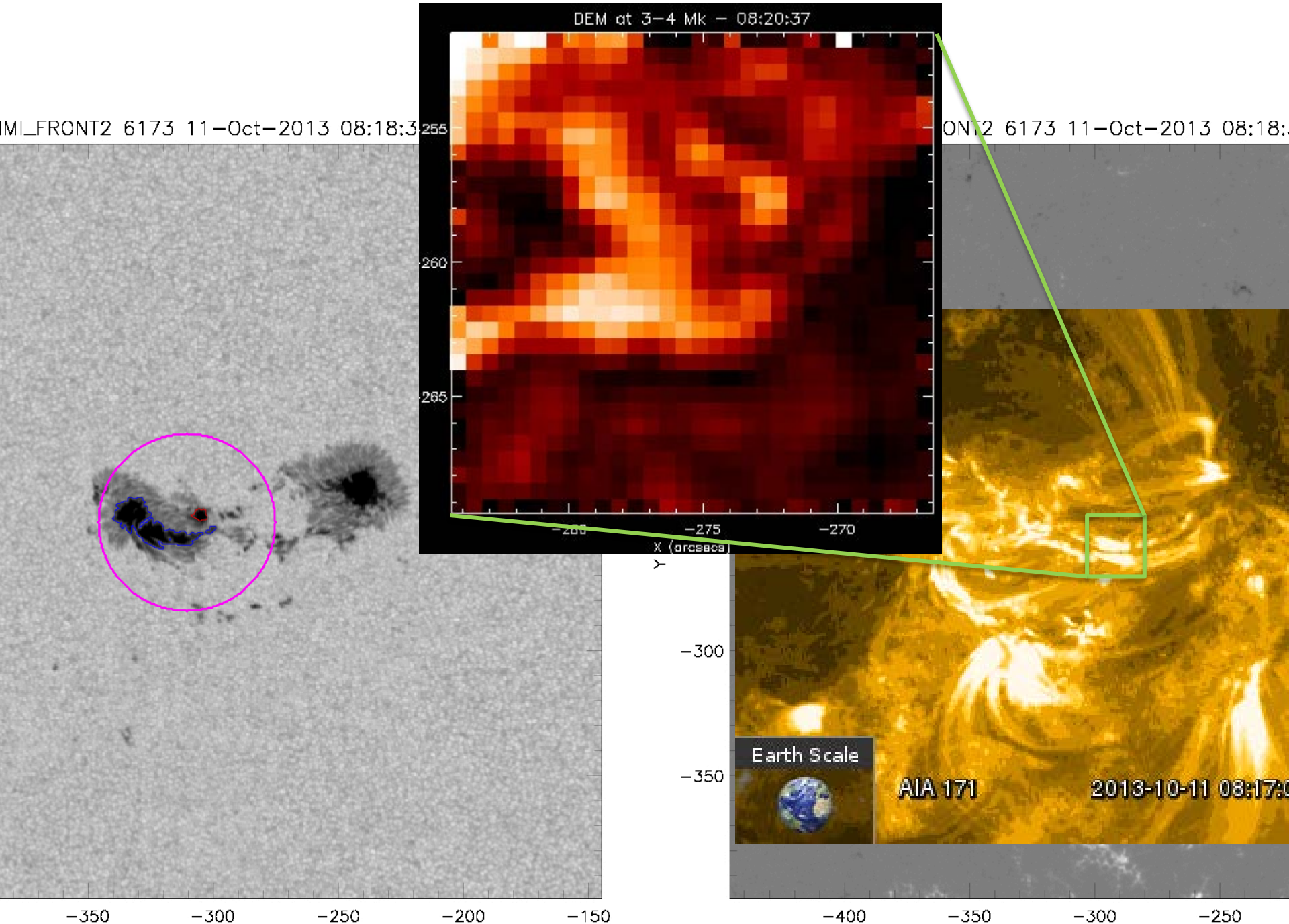
SST- White light

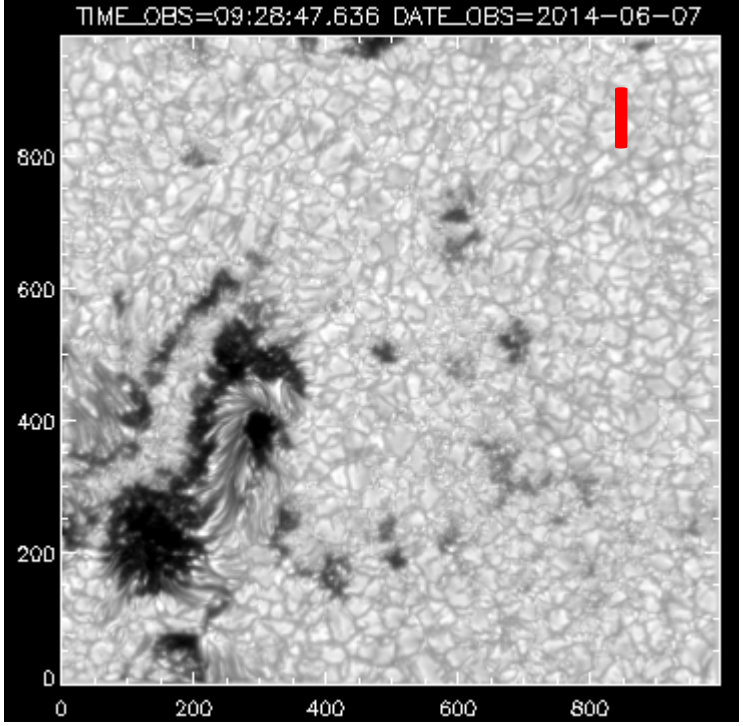


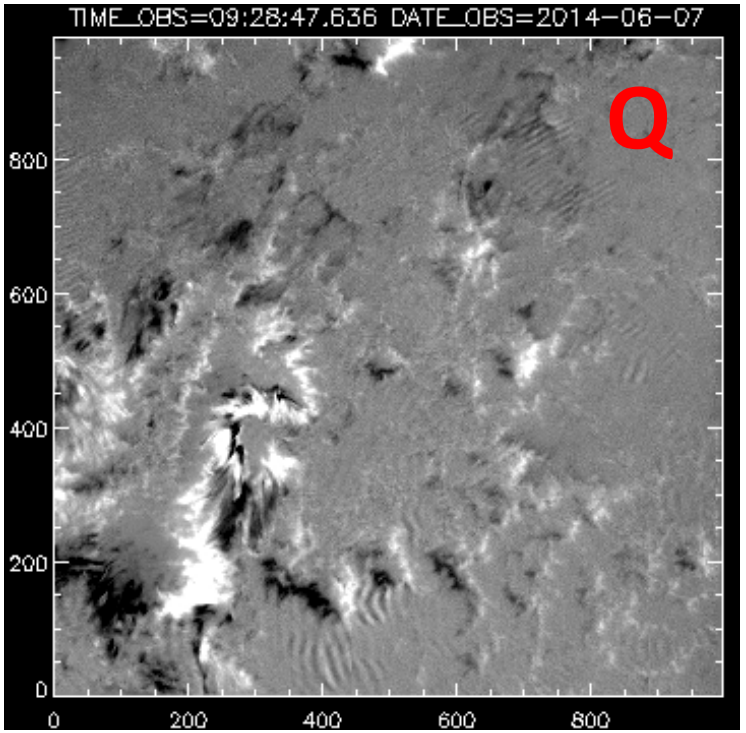
Horizontal flow

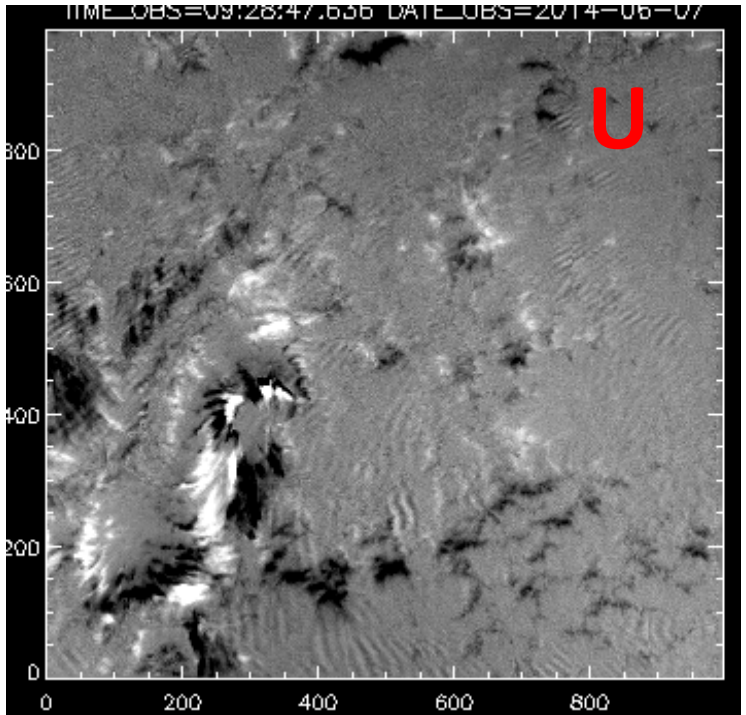


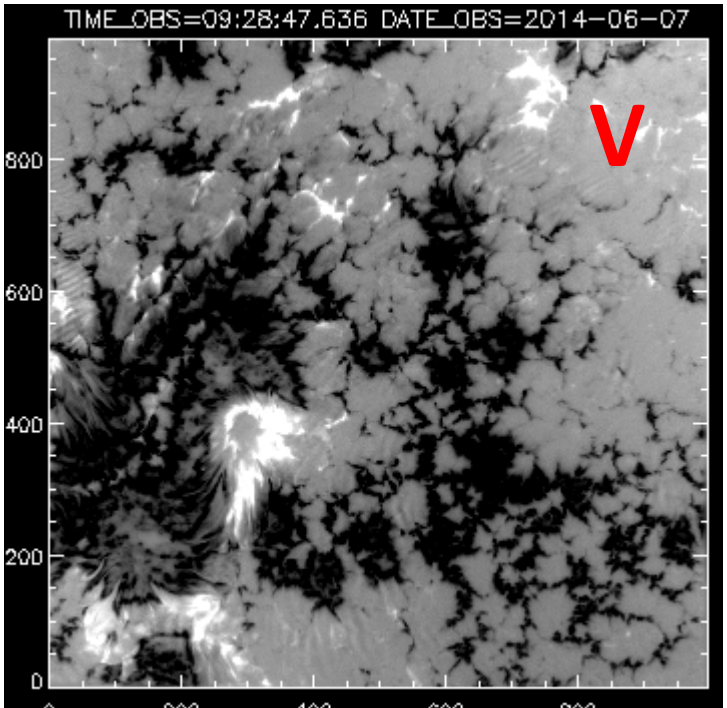



DEM at 3–4 Mk – 08:20:37
X (arcsecs)
Earth Scale
AIA 171
2013-10-11 08:17:
−350
−300
−250
−200
−150
−400
−350
−300
−250









Future work..

AR 12080

6-June-2014

CRISP/SST

Conclusion

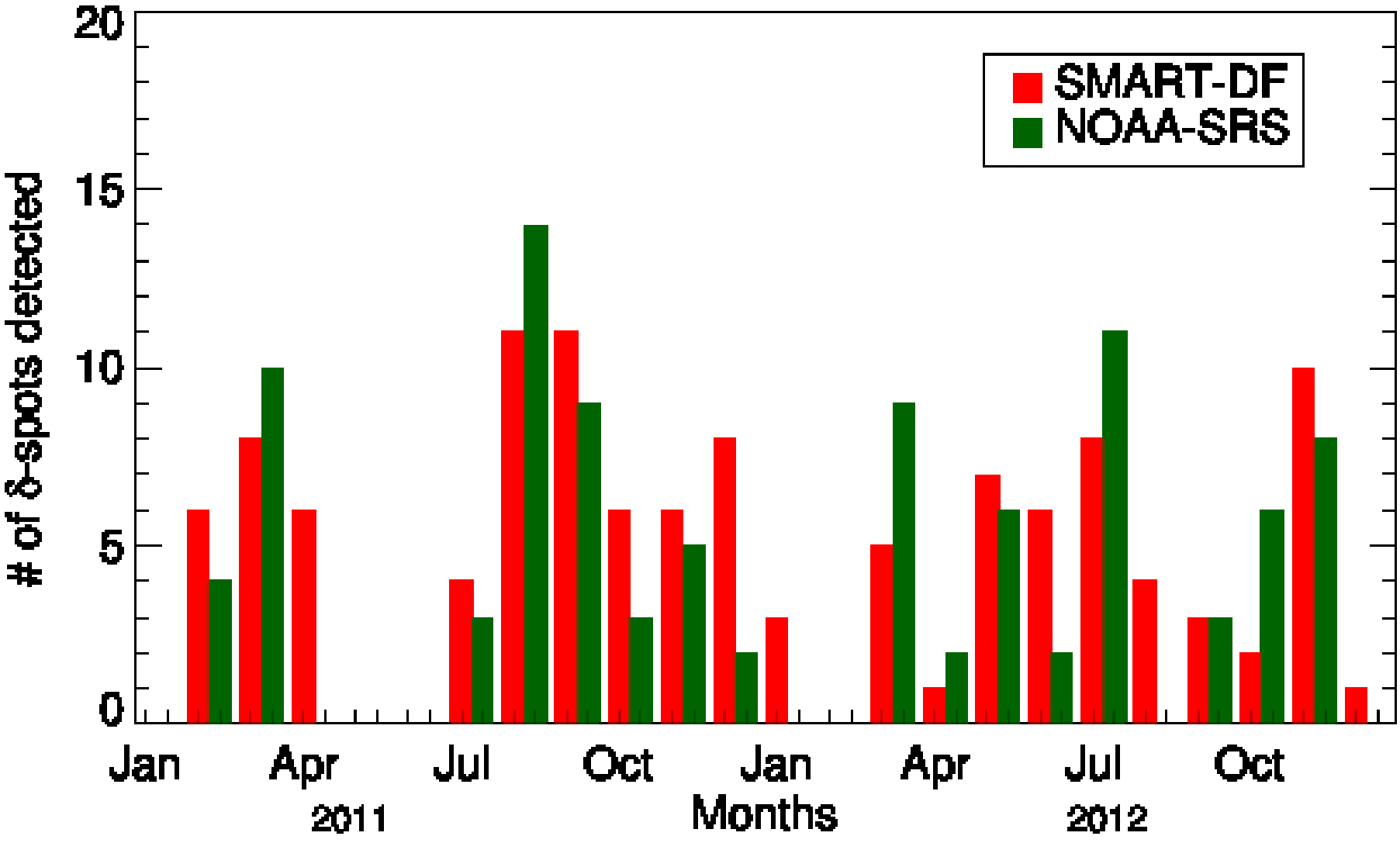
- A new automated δ-spots detection code named SMART-DF is developed and tested.
- Small scale, transient δ-spots are important in pre-flare studies. Many such configurations are observed in the heart of major flares.
- strong shear is observed between these small opposite polarity umbrae - they heat up the atmosphere.
- SMART-DF will be soon integrated to www.solarmonitor.org, and will be made available to public.

Thanks.

Results – Comparison with NOAA-SRS

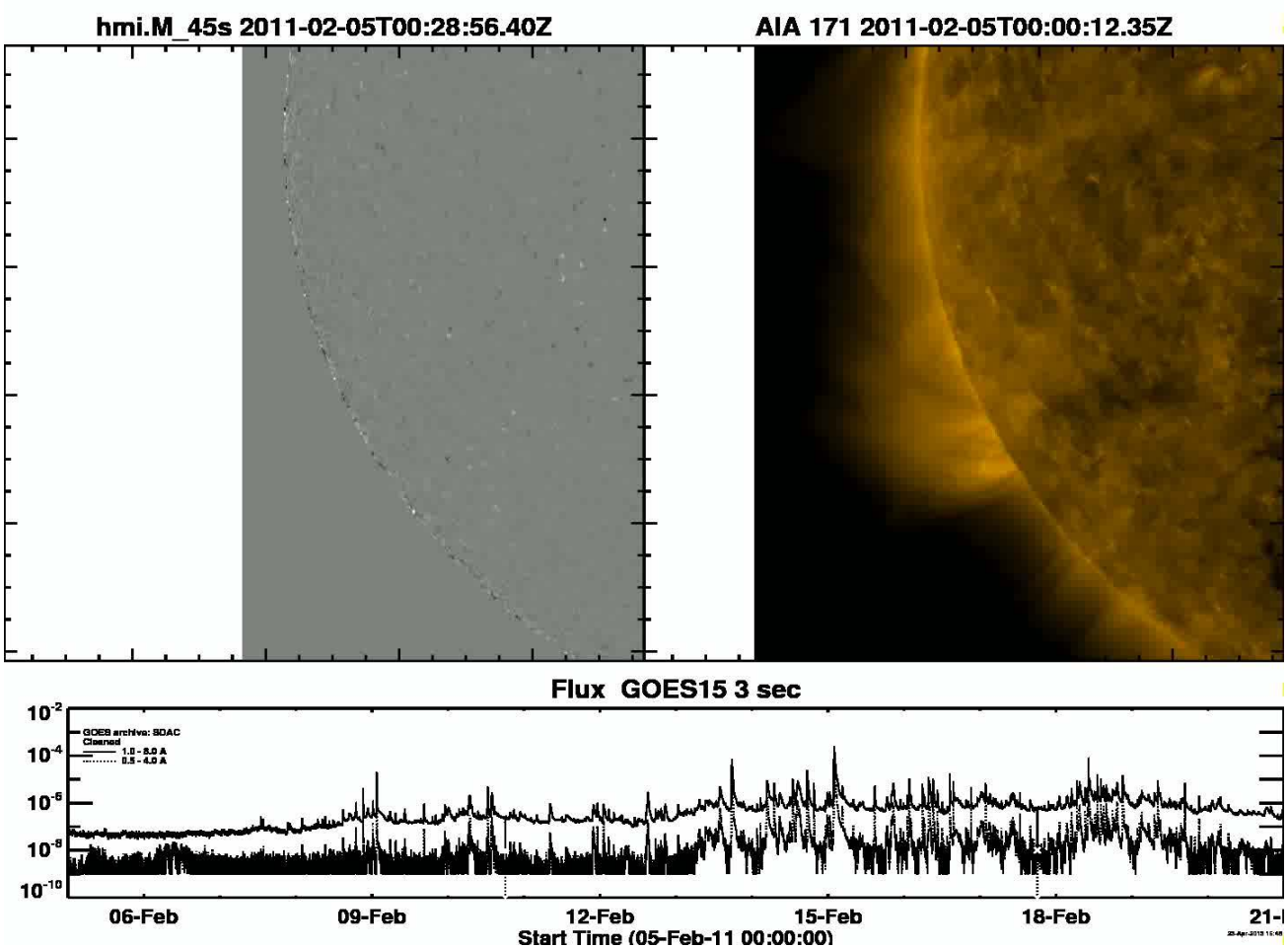
- Observation period: 1 Jan 2011- 31 Dec 2012
- Instrument (SMART-DF) : HMI/SDO, 12 hour cadence.
- NOAA-SRS : One SRS per day (at 00.30 UT)
- NOAA : 33 ARs marked as δ-spots
- NOAA: 23 ARs were first marked as δ in the region between +/- 60 degrees longitude
- SMART-DF : 21 out of 23 were detected before SRS release.
- with a cadence of 1/day, NOAA detected 97 instances of δ-spots formation, SMART-DF recorded 116 instances

NOAA-SRS Vs SMART-DF



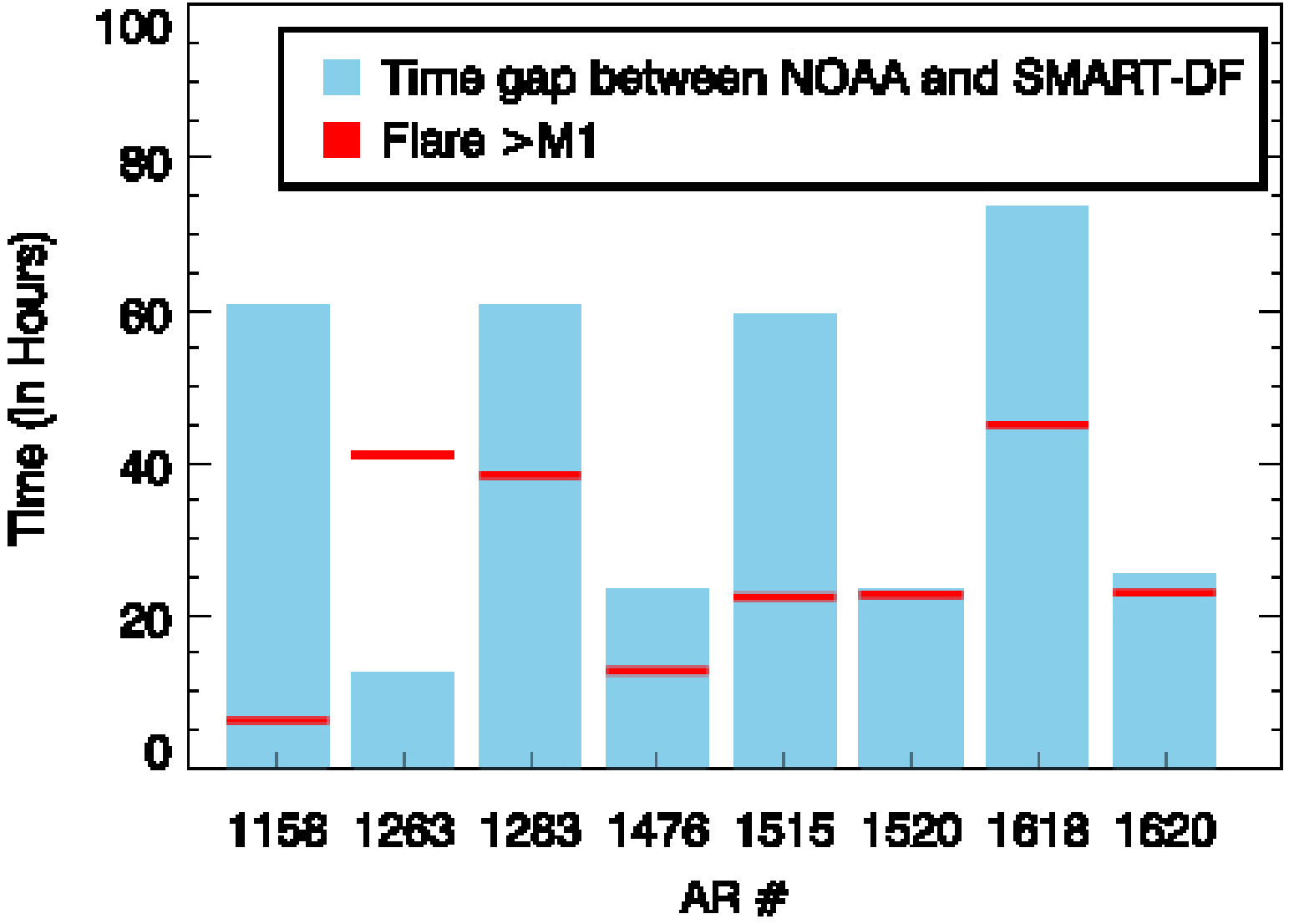
Padinhatteeri, et. al., 2014 –in preparation

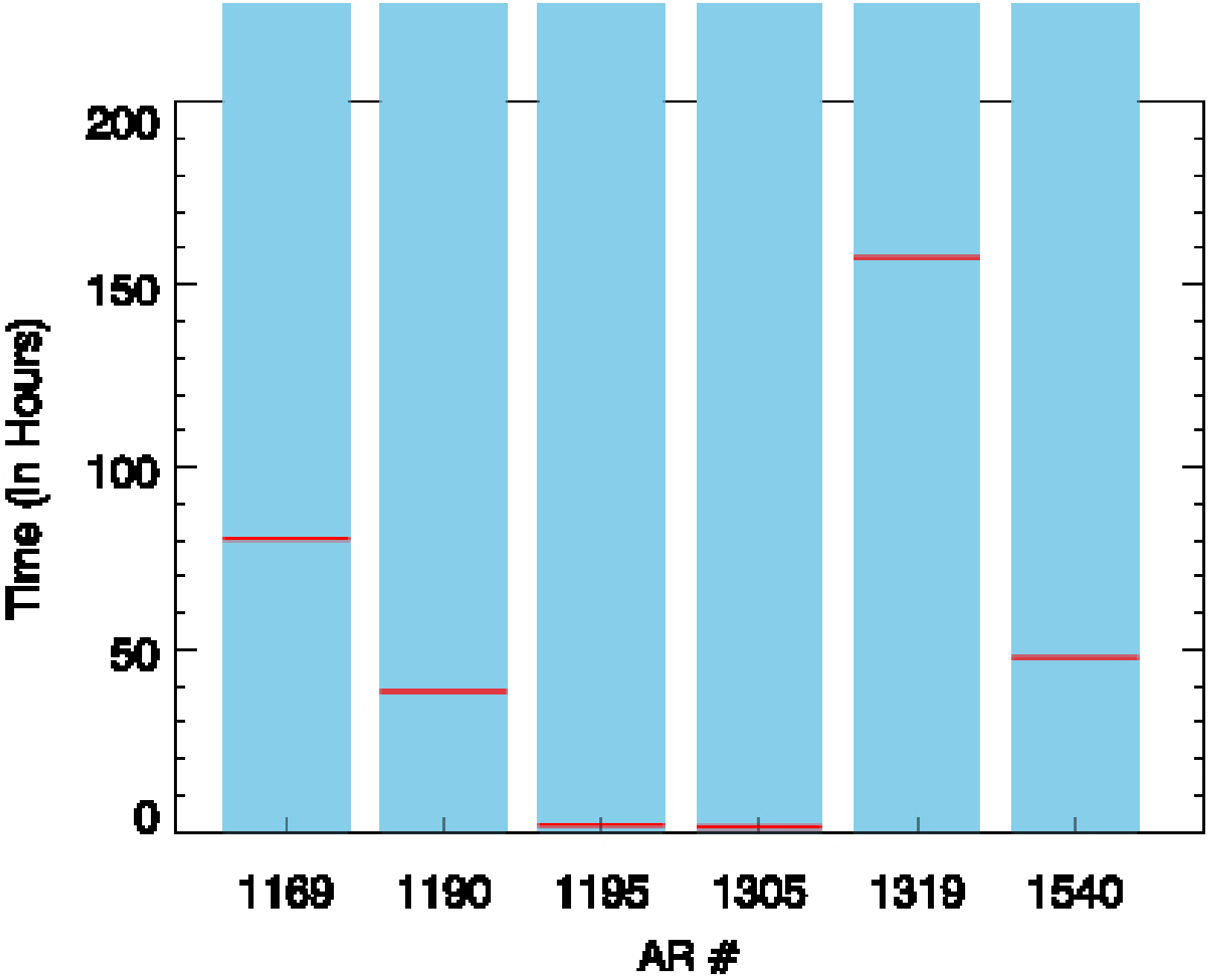
SMART-DF and Flares

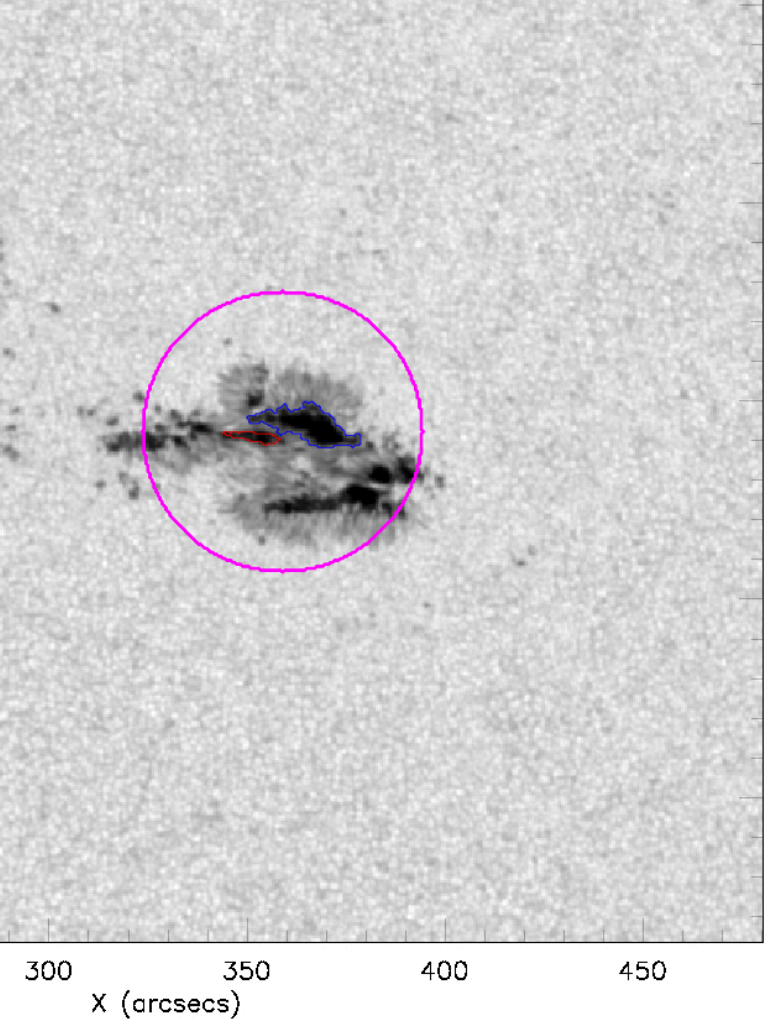


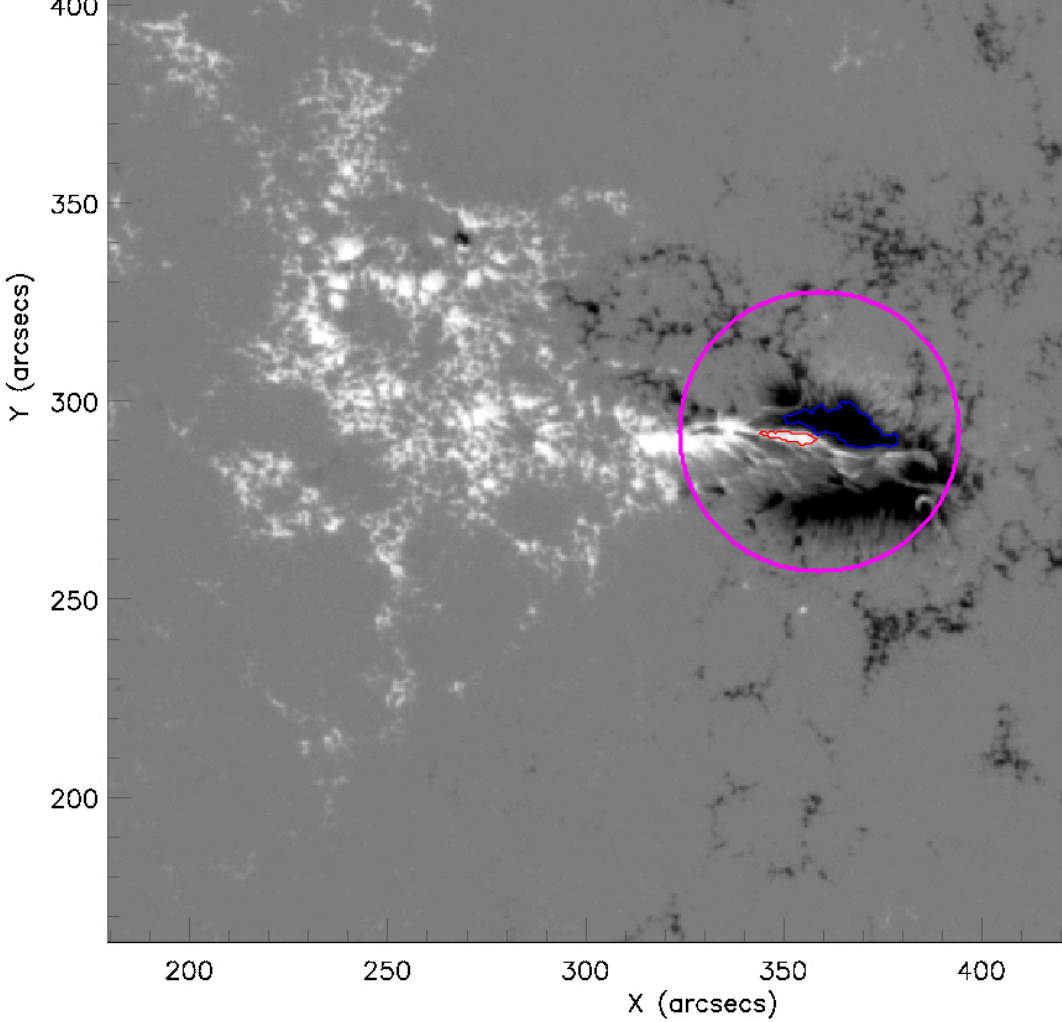
- δ-Region on AR11158 was detected by SMART-DF at least 5 Hours before the first M-class Flare.

SMART-DF vs NOAA-SRS

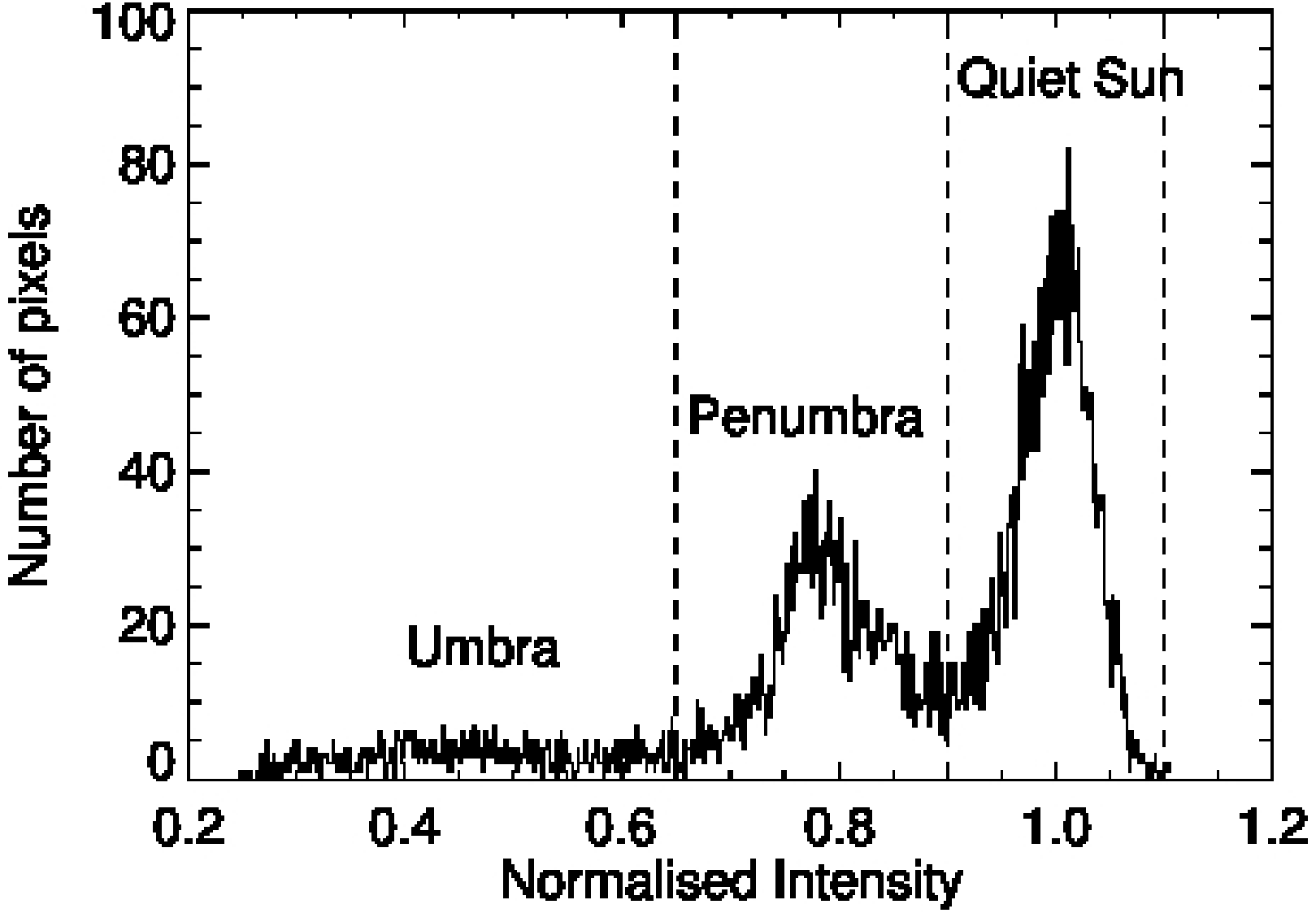


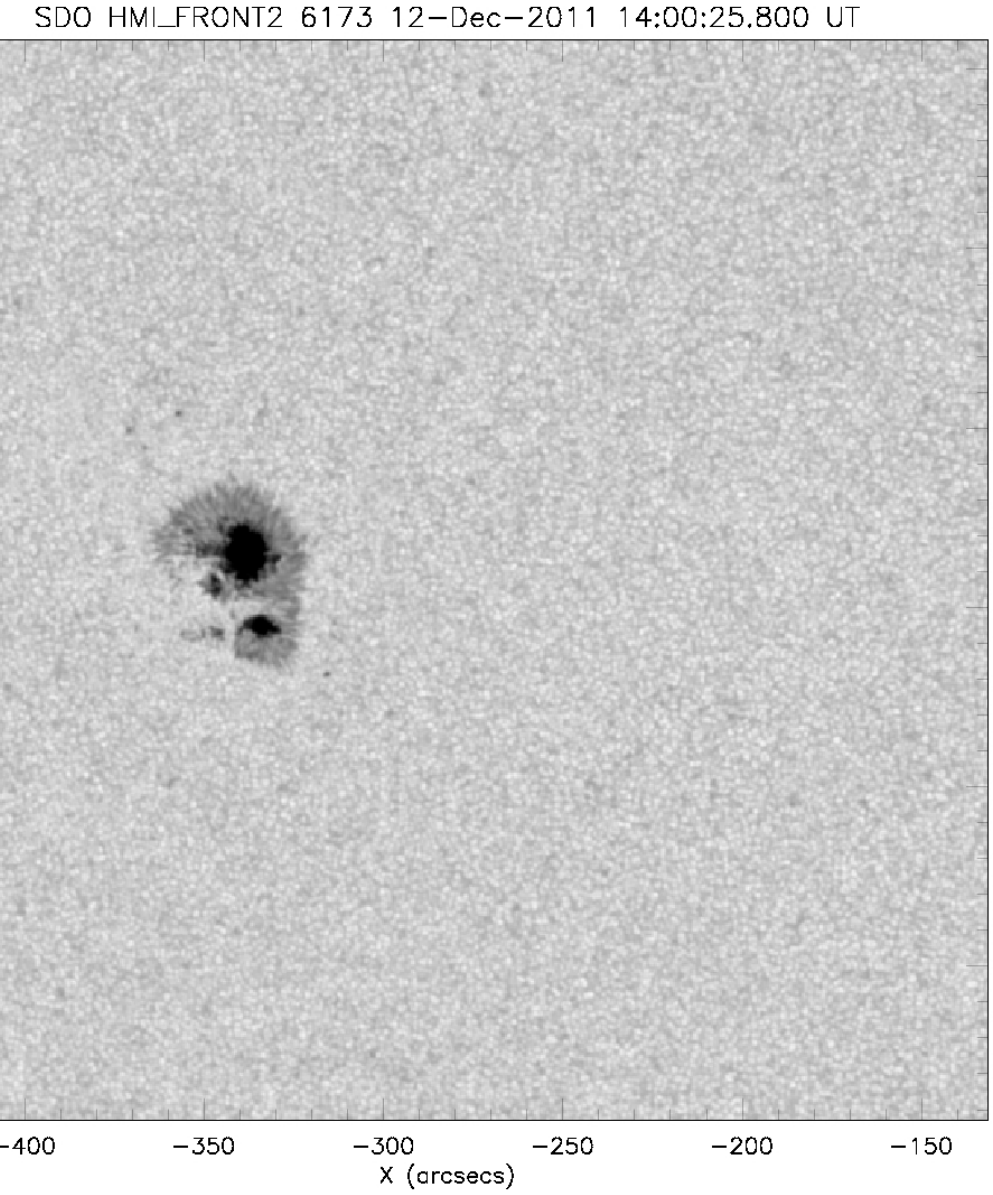

200
150
100
50
0
Time (In Hours)
1169
1190
1195
1305
1319
1540
AR #

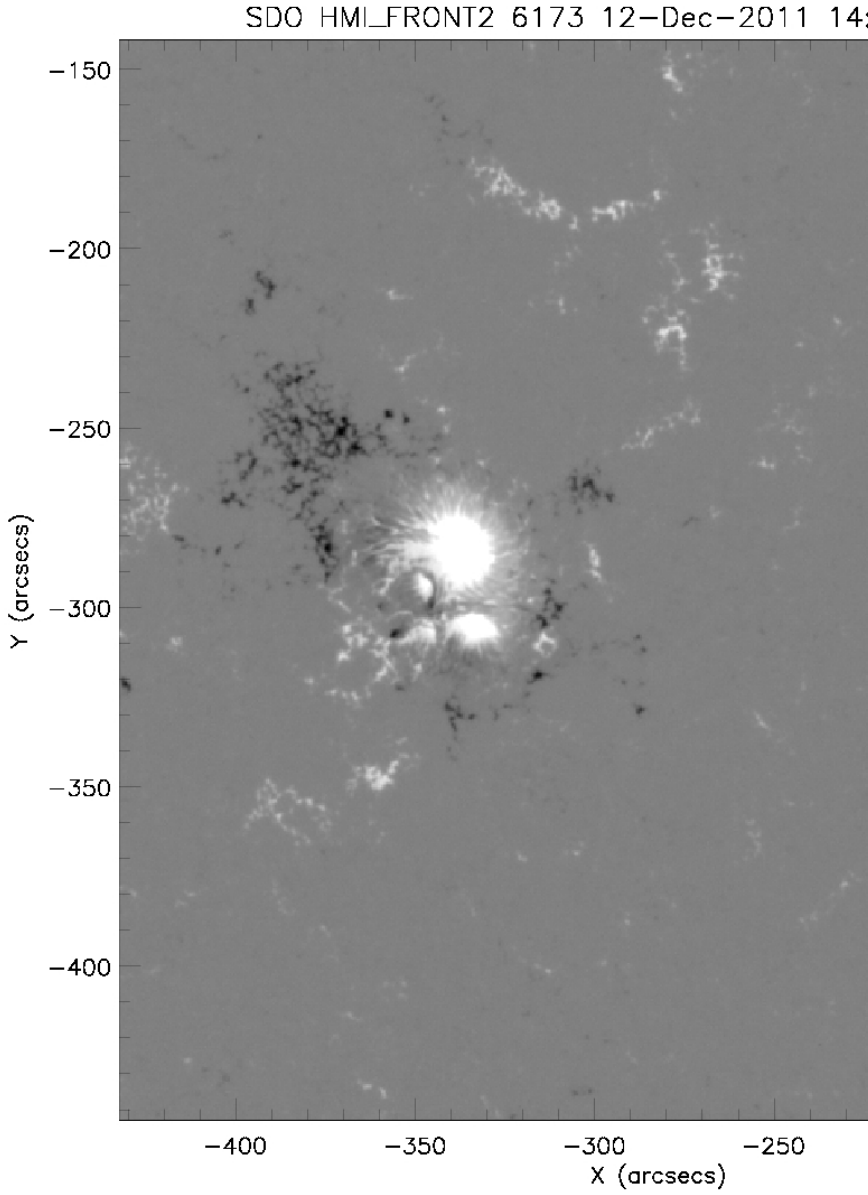


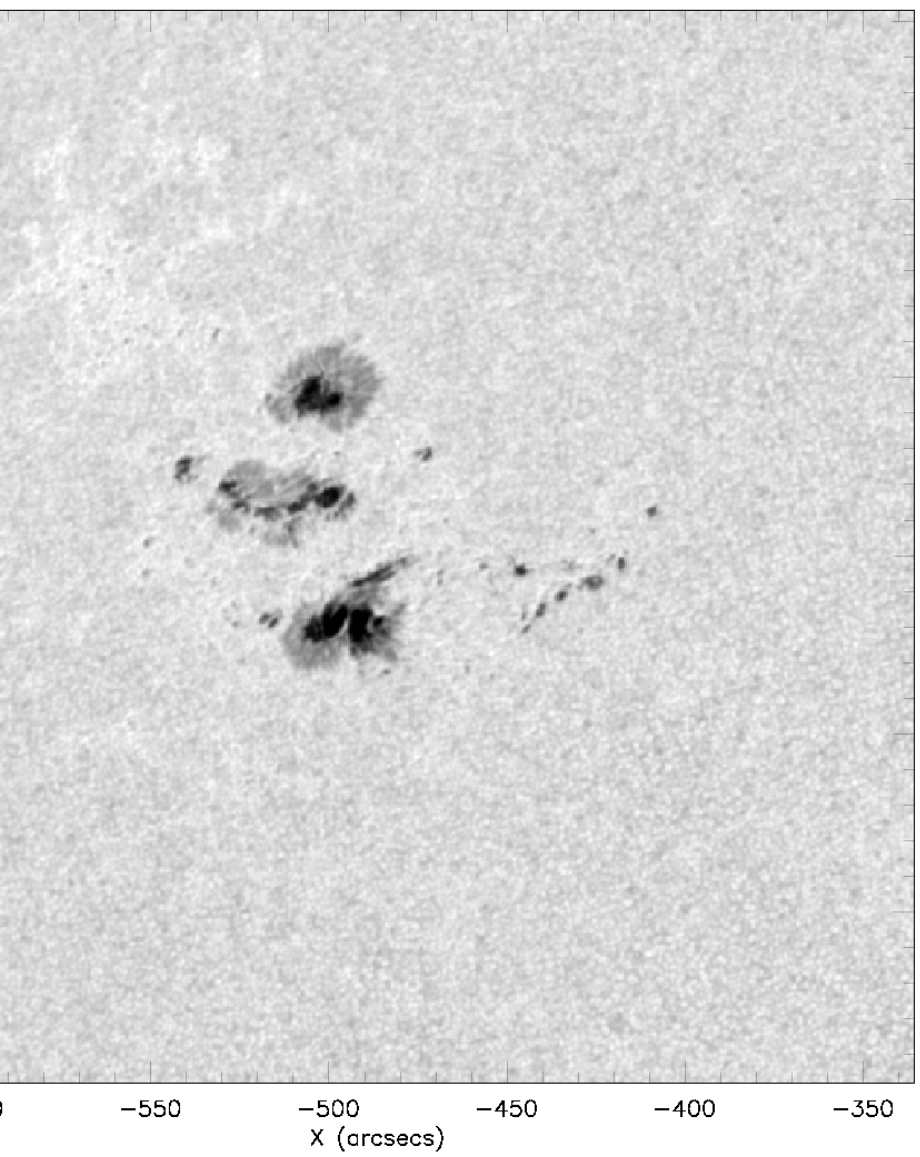


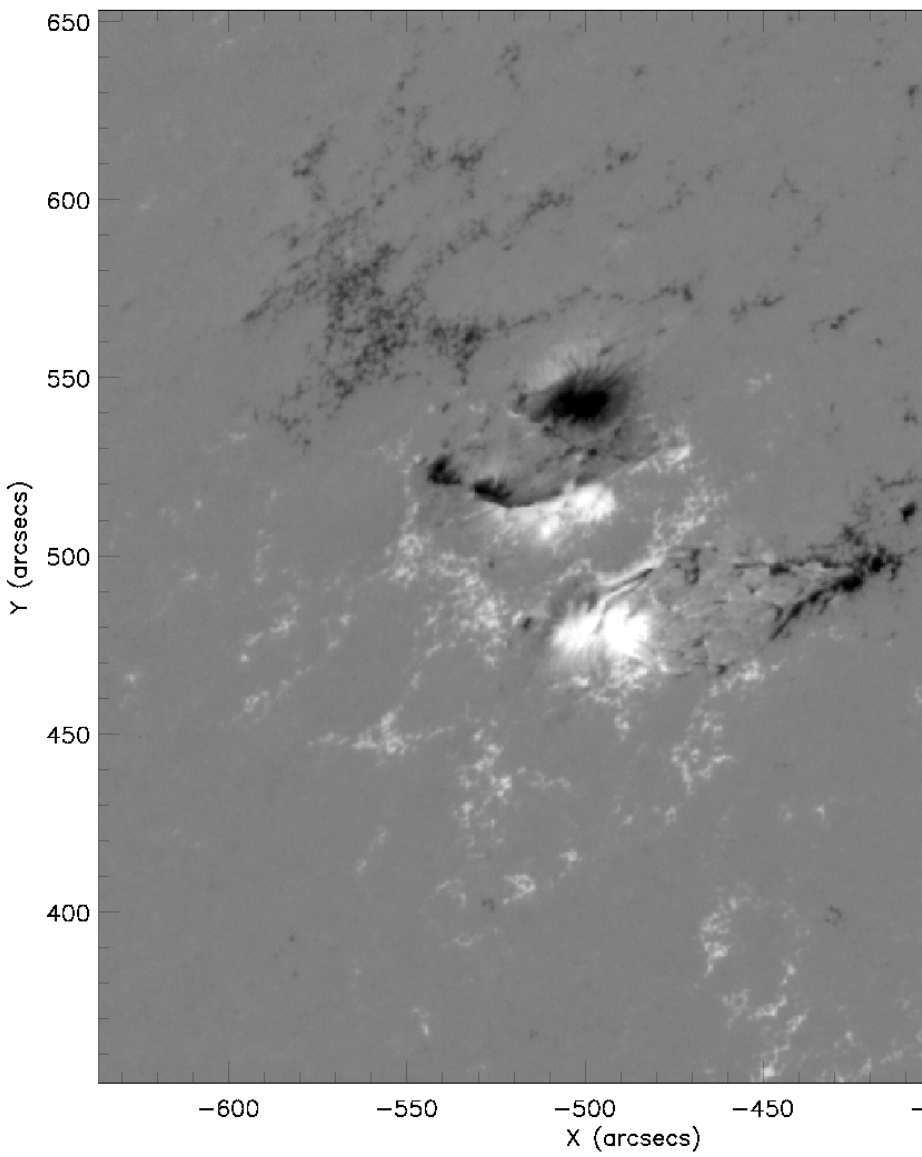
- First M-class flare from AR 11190 a day after marked as δ by SMART-DF. Where as NOAA never marked AR 11190 as δ!


100
80
60
40
20
0
Number of pixels
Quiet Sun
Penumbra
Umbra
0.2
0.4
0.6
0.8
1.0
1.2
Normalised Intensity


SDO HMI_FRONT2 6173 12−Dec−2011 14:00:25.800 UT
−400
−350
−300
−250
−200
−150
X (arcsecs)


SDO HMI_FRONT2 6173 12−Dec−2011 14:
−150
−200
−250
−300
−350
−400
Y (arcsecs)
−400
−350
−300
−250
X (arcsecs)


OO HMI_FRONT2 6173 1-Mar-2011 02:00:28.900 UT
-550
-500
-450
-400
-350
X (arcsecs)


SDO HMI_FRONT2 6173 1-Mar-2011 02:00:28
650
600
550
500
450
400
Y (arcsecs)
-600
-550
-500
-450
X (arcsecs)