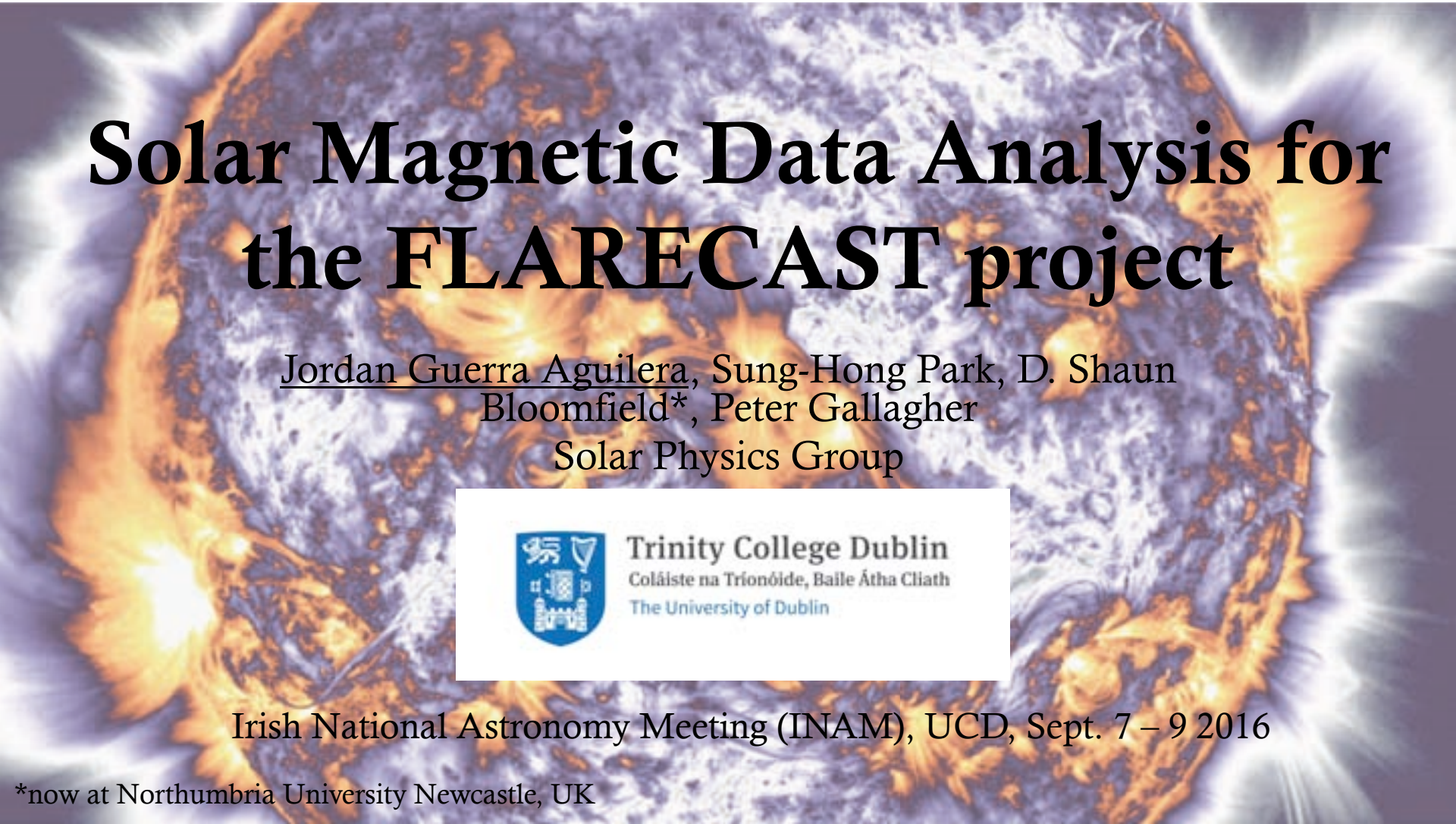


Solar Magnetic Data Analysis for the FLARECAST project

Jordan Guerra Aguilera, Sung-Hong Park, D. Shaun Bloomfield*, Peter Gallagher
Solar Physics Group

Trinity College Dublin
Coláiste na Tríonóide, Baile Átha Cliath
The University of Dublin

Irish National Astronomy Meeting (INAM), UCD, Sept. 7 – 9 2016

*now at Northumbria University Newcastle, UK

The FLARECAST Project

- Flare Likelihood And Region Eruption foreCASTing: EC H2020 consortium project.

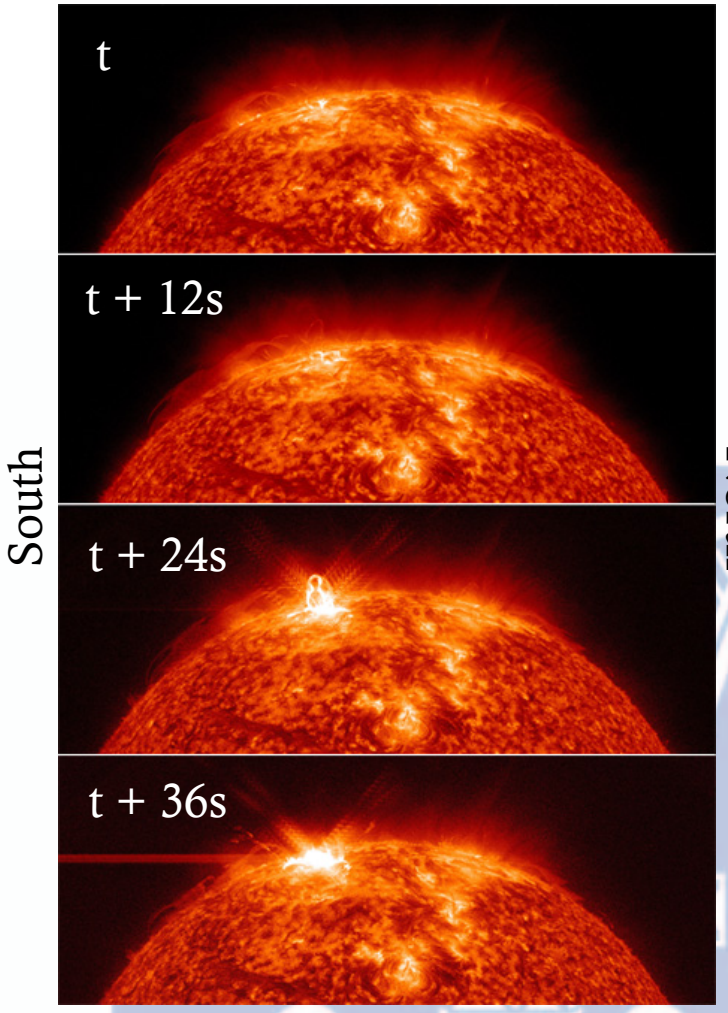
FLARECAST

Goals:

- Understanding properties and evolution that leads to flares.
- Enhance quality of flare predictions by using a great number of predictors and state-of-the-art prediction algorithms.
- Allow end-users access to past and future data for scientific and operational purposes.

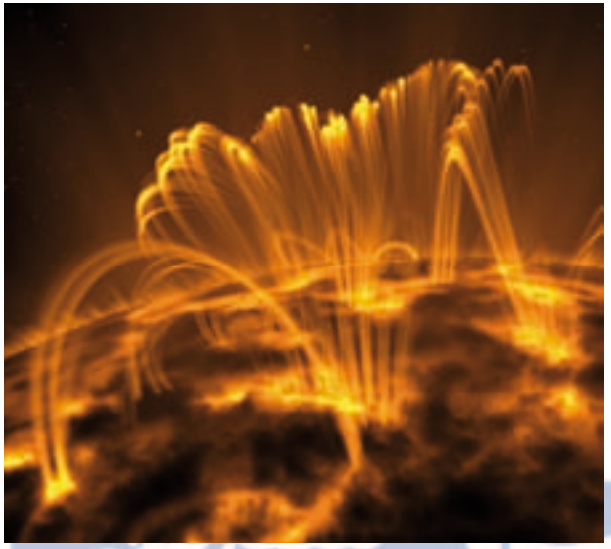
Solar Flares

- Rapid enhancement of emission.

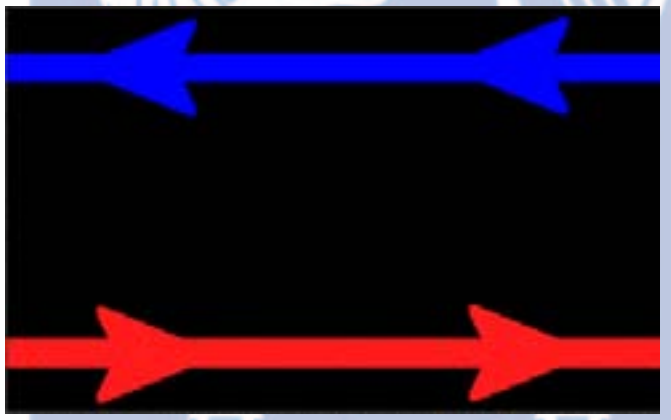


Solar Flares

- Rapid enhancement of emission.
- EM nature: energy released via magnetic reconnection of **B** lines.



Coronal loops



Reconnection of field lines

Solar Flares

- Rapid enhancement of emission.
- EM nature: energy released via magnetic reconnection of **B** lines.
- Origin in strong-**B** areas in the Sun's surface (active regions)

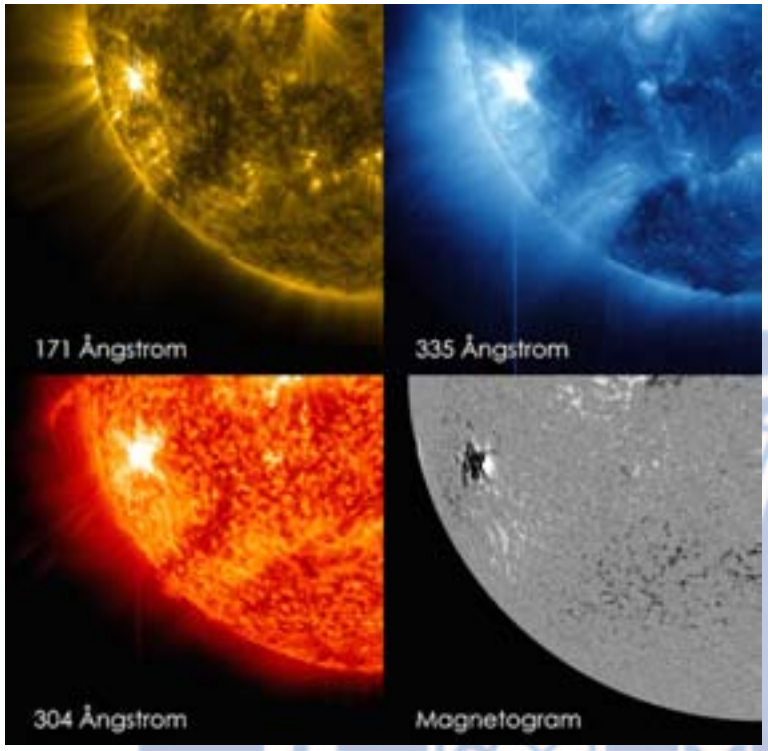
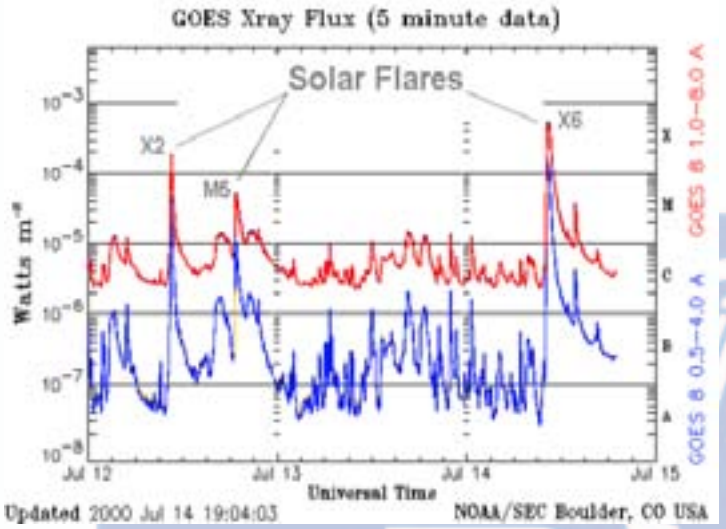


Image: SDO HMI (surf. magnetic) and AIA (EUV coronal)

Solar Flares

- Rapid enhancement of emission.
- EM nature: energy released via magnetic reconnection of **B** lines.
- Origin in strong-**B** areas in the Sun's surface (active regions)
- Classified according to peak in X-rays near Earth.



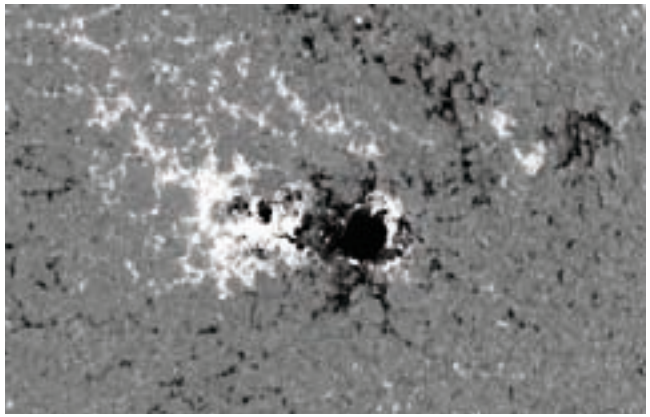
Data: GOES X-rays

Photospheric predictors of Solar Flares

- Search for patterns in the Sun's photosphere and empirical relations.

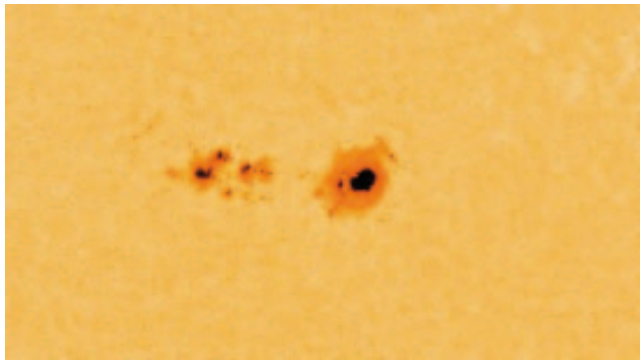
?

Magnetic Field or Magnetogram



- Magnetic class (Bornmann & Shaw, 1994)
- Length of Polarity Inversion Line (PIL, Falconer 2003)
- Total magnetic flux

Visible surface



- McIntosh class (1990)
- Sunspot group area (Qahwaji & Colak, 2008)

Work Package 2: Active regions properties

- TCD focuses on the satellite data analysis for extracting AR properties (WP2).
- These properties will be used by the prediction algorithms.
- Calculate as many as possible (relevant) parameters.

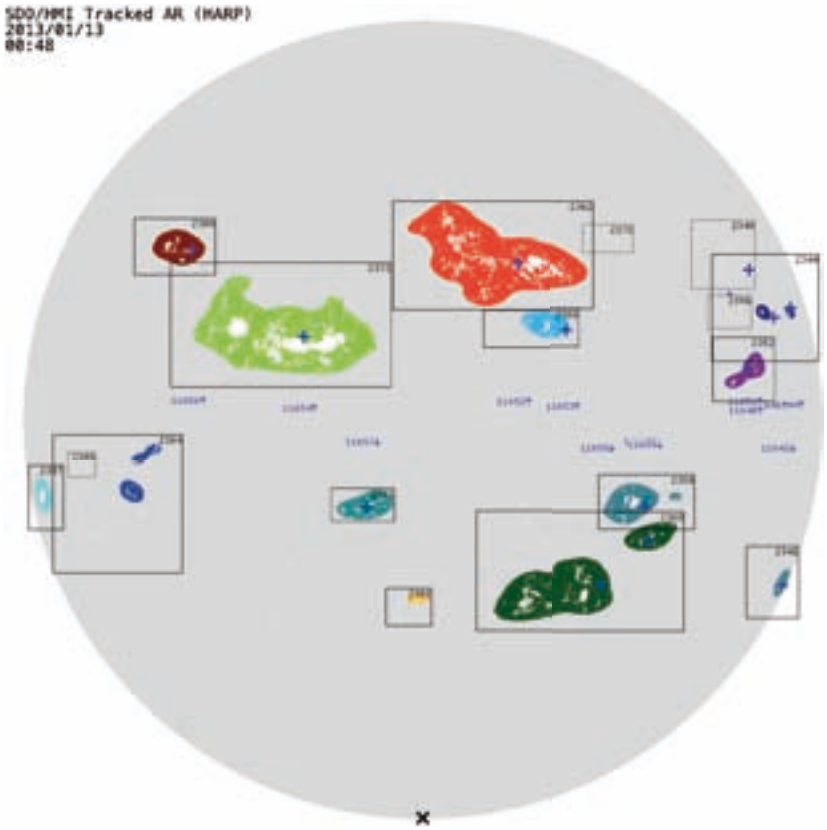
?

Property Extraction Algorithms

LOS magnetograms	
	SMART-derived properties (Ahmed et al., 2013)
	SMART delta finder (Padinhatteeri et al., 2015)
→	Effective connected magnetic field strength (B_{eff}) (Georgoulis & Rust, 2007)
	Fractal dimension (Georgoulis, 2012)
	Multi-fractal structure function s(q) inertial range index k (Georgoulis, 2012)
→	Fourier power spectral index (Guerra et. al., 2015)
	CWT power spectral index (Hewett et. al., 2008)
	Generalised correlation dimension (Georgoulis, 2012)
	Holder exponent h (Conlon et al., 2010)
	Hausdorff dimension D(h) (Conlon et al., 2010)
	WTMM (Conlon et al., 2010)
→	Decay index (Zuccarello et al. 2014)
→	Magnetic polarity inversion line characteristics (Mason & Hoeksema 2010)
	3D magnetic null point (Reid et al. 2012)
→	R (Schrijver 2007) *
	$^{L}WL_{SG}$ (Falconer et al. 2008) *
→	Ising energy (Ahmed et al. 2010)
	WG_M and $S_{I,t}$ (Korsos et al. 2015)
	Magnetic helicity injection rate proxy (Park et al. 2010)

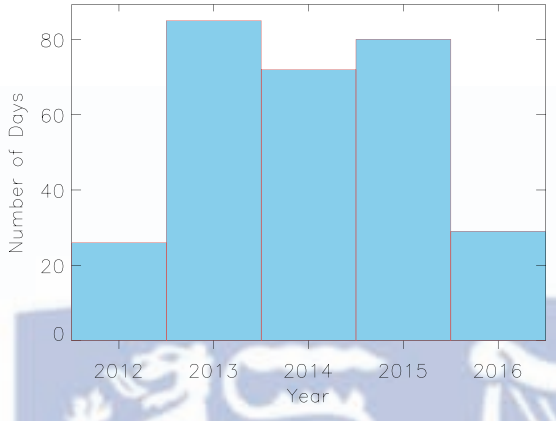
Spaceweather HMI Active Region Patches

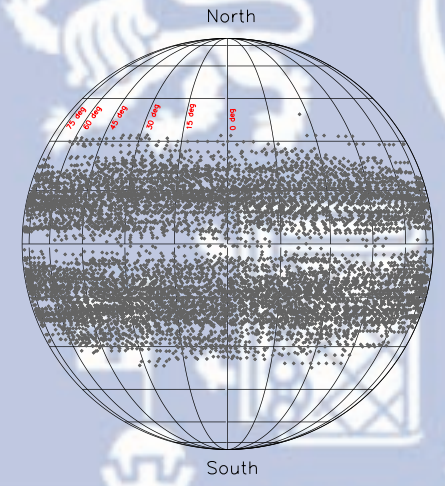
- From HMI full-disk Vector Magnetogram (12 min)



SHARP vector components, LOS, continuum available at: http://jsoc.stanford.edu/ajax/lookdata.html

- For this study: random selection of 25% of days.





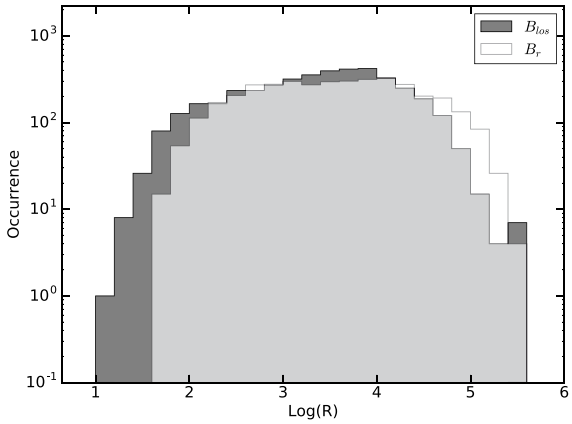
Active region properties

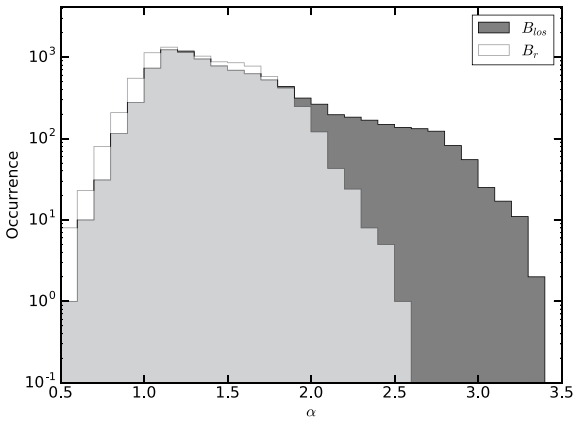
- Active region properties considered:
  - Schrijver's R value (Flux PILs)
  - Fourier spectral index, α (Scaling of spectral power)
  - MPIL-related properties (Total length of PILs)
  - Decay index (Vert. variation of potential field)
  - Effective connected Field strength (coronal connectivity)
  - Ising energy (coronal connectivity)
- Special emphasis on differences when using B_{los} and B_r.

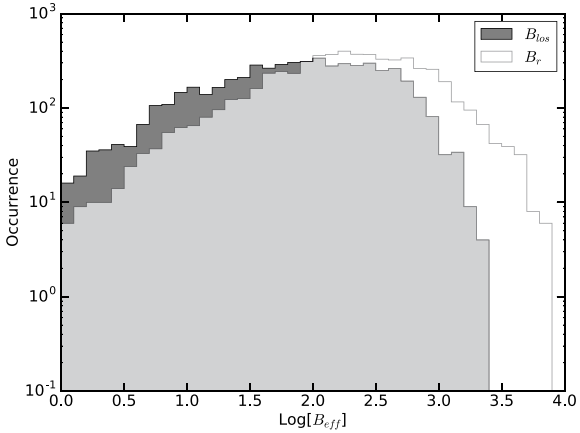
?

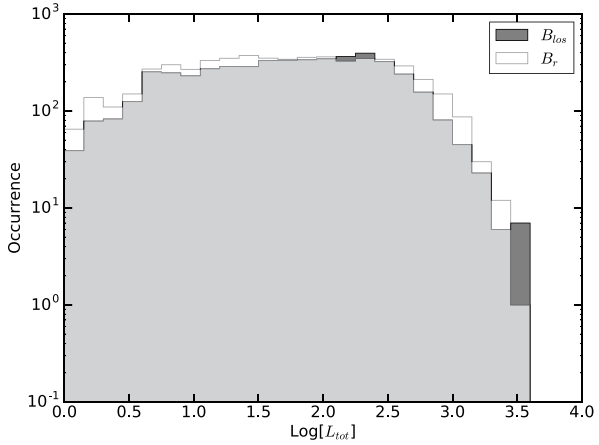
Preliminary results

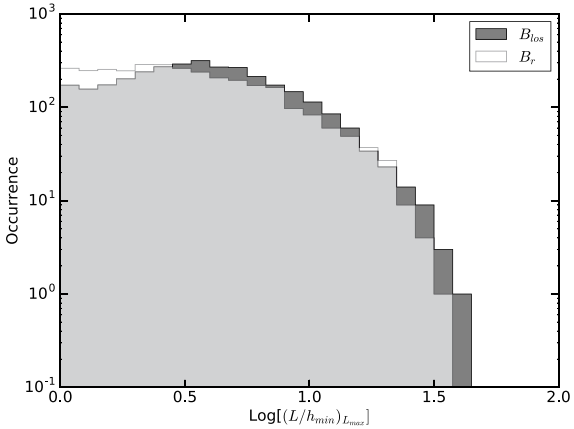
At 6 h cadence: 12733 regions. Valid points: 9454

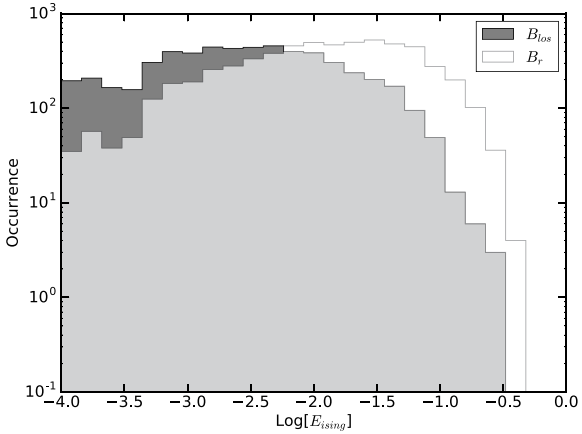






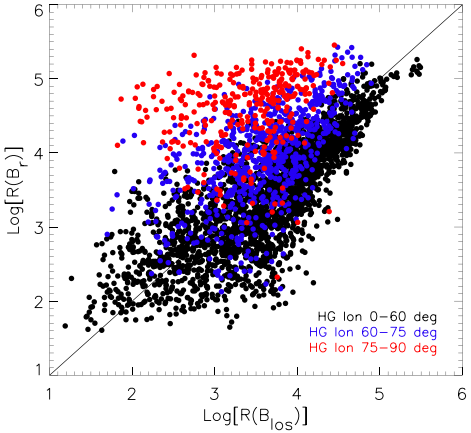


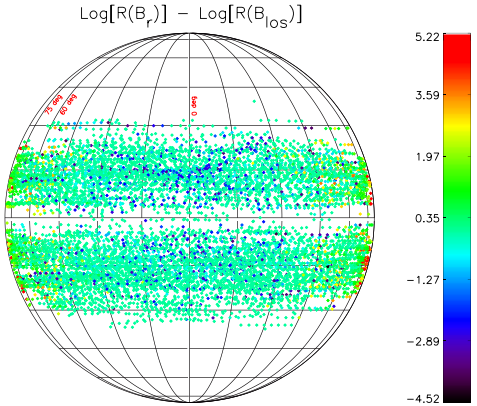




Preliminary results

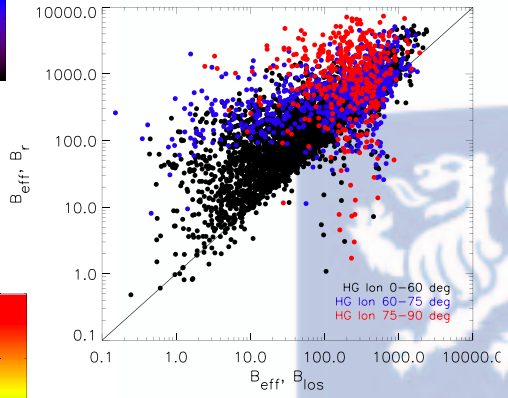
- Log(R)

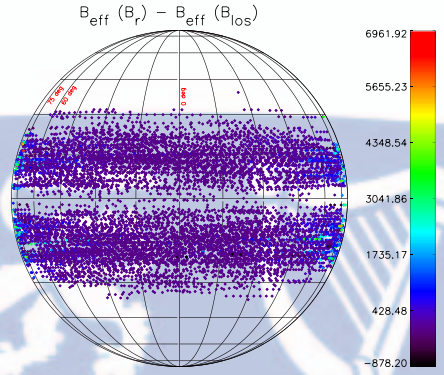




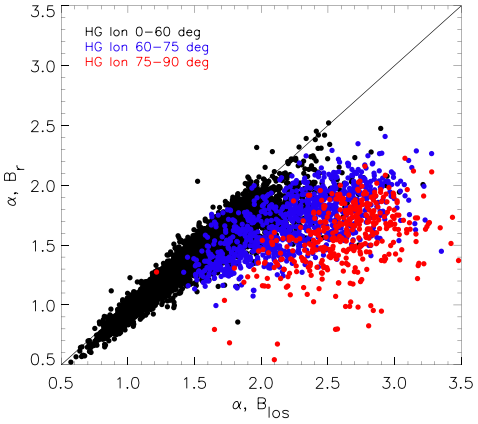
Variation with AR longitudinal position

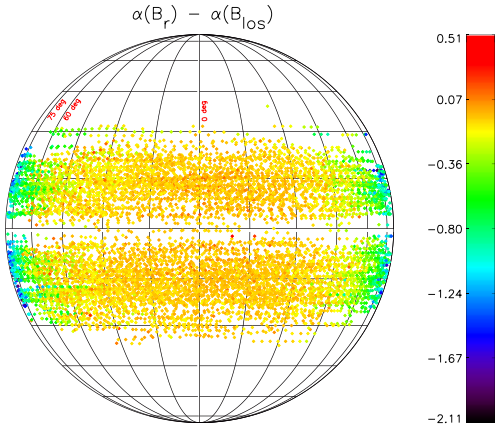
- Beff





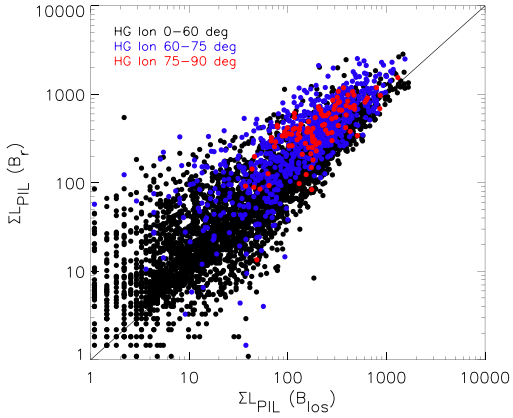
- Alpha

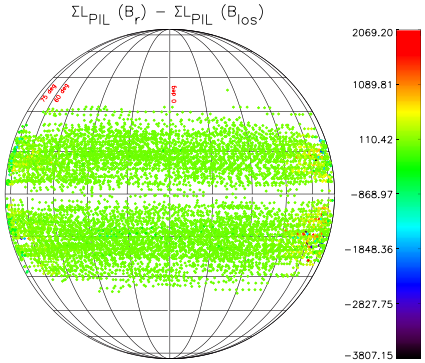




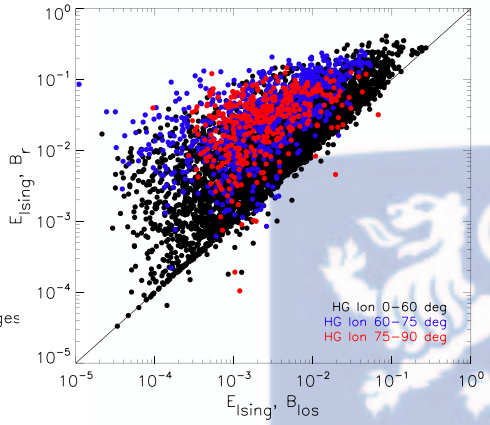
Preliminary results

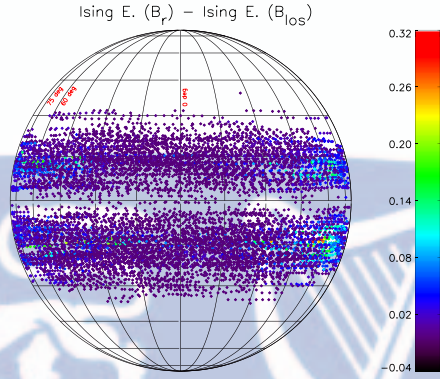
- Total length of MPIL



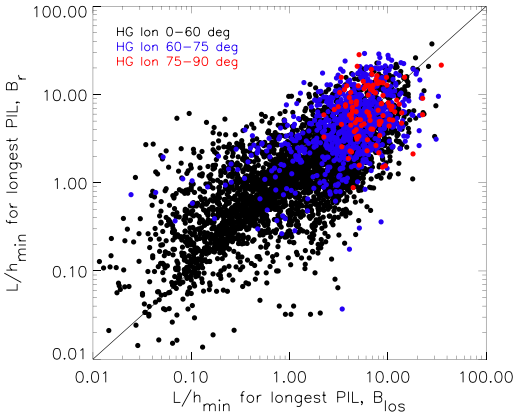


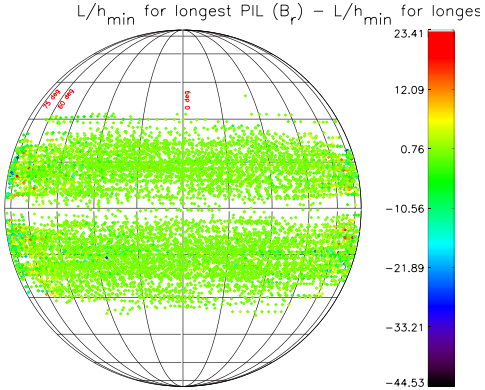
- Ising Energy





- Decay Index





Summary

- FLARECAST is half way through and expecting to start producing forecasts by early 2017.
- About 70% of PE codes have been developed and tested. Processing of the SHARP DB will start soon.
- Coronal connectivity and fractal properties seem to be varies more with the B_z choice. MPIL-related properties are less sensitive.
- Four out six properties do not show strong dependence with AR longitude.
- Usefulness of properties will be determined by their flaring association.