A multi-instrument analysis of sunspot umbrae

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National Solar Observatory

Motivation

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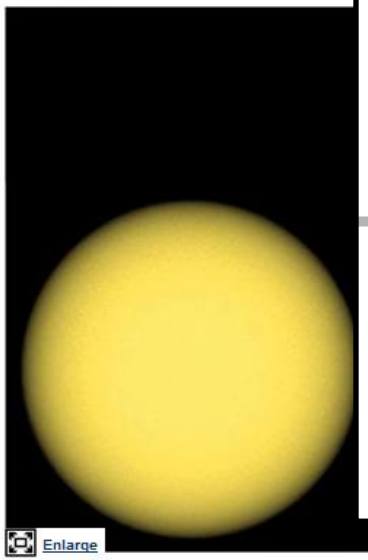
What's down with the Sun? Major dr activity predicted

June 14, 2011



Enlarge

The Sun viewed in visible light, at minim

(PhysOrg.com) -- A missing jet stream poles say that our Sun is heading for the first time in years, according to s

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Next solar cycle could be a no-show

Sun may be entering a long period of reduced activity,

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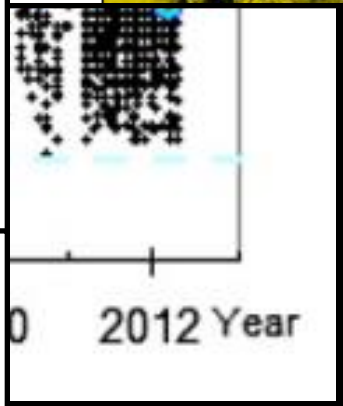

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What's wrong with the sun?

- 14 June 2010 by Stuart Clark
- Magazine issue 2764. Subscribe and save
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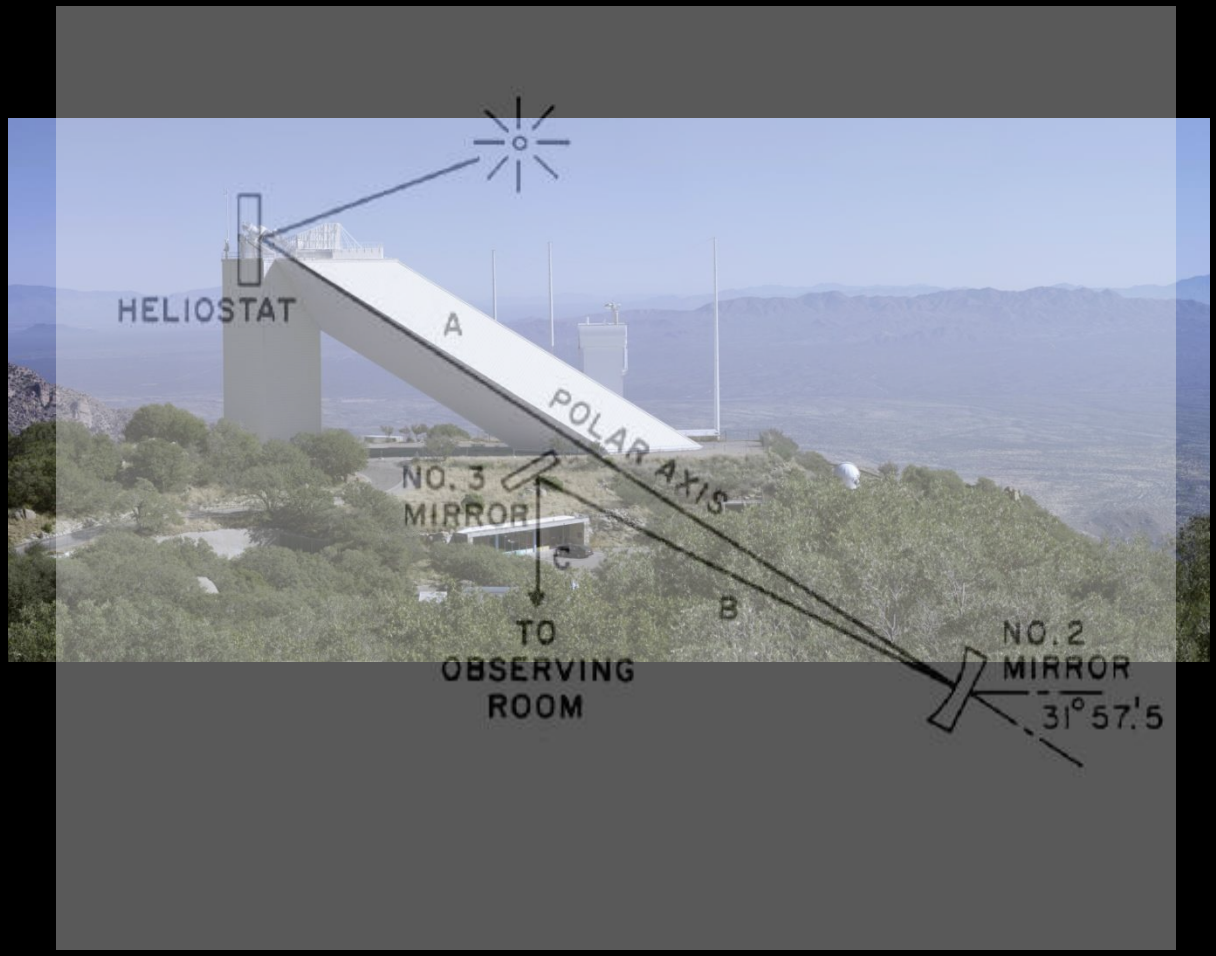
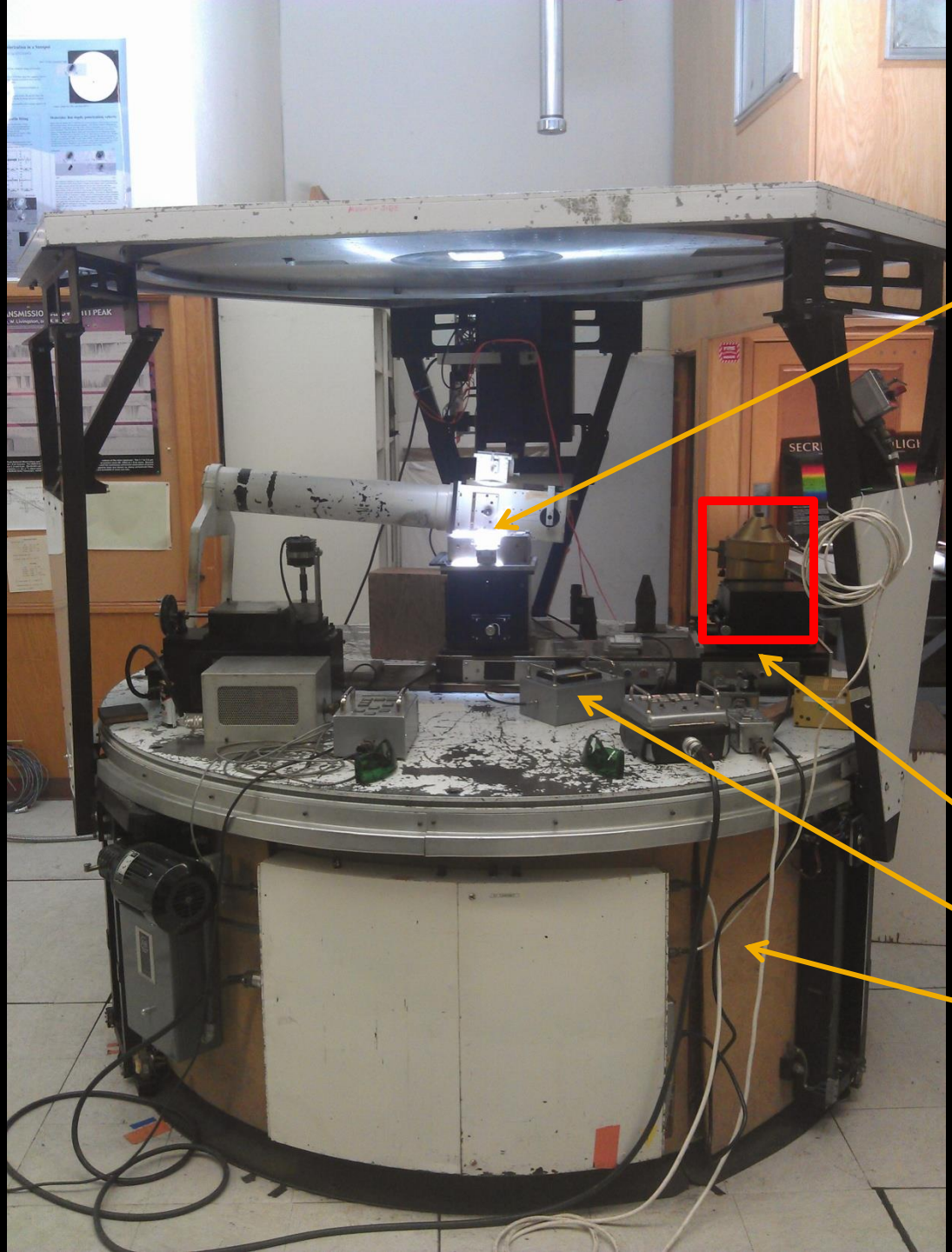
SUNSPOTS come and go, but recently they have mostly gone. For centuries, astronomers have recorded when these dark blemishes on the solar surface emerge, only for them to fade away again after a few days, weeks or months. Thanks to their efforts, we know that sunspot numbers ebb and flow in cycles lasting about 11 years.

How does it work?





2mm square aperture
(22.5 arcsec^2 total area)

The 'Baboquivari' detector

Box containing 45 degree flat and an IR filter.

Power meter (more later)

Main spectrograph

BABO

Single element diode detector

Held under vacuum

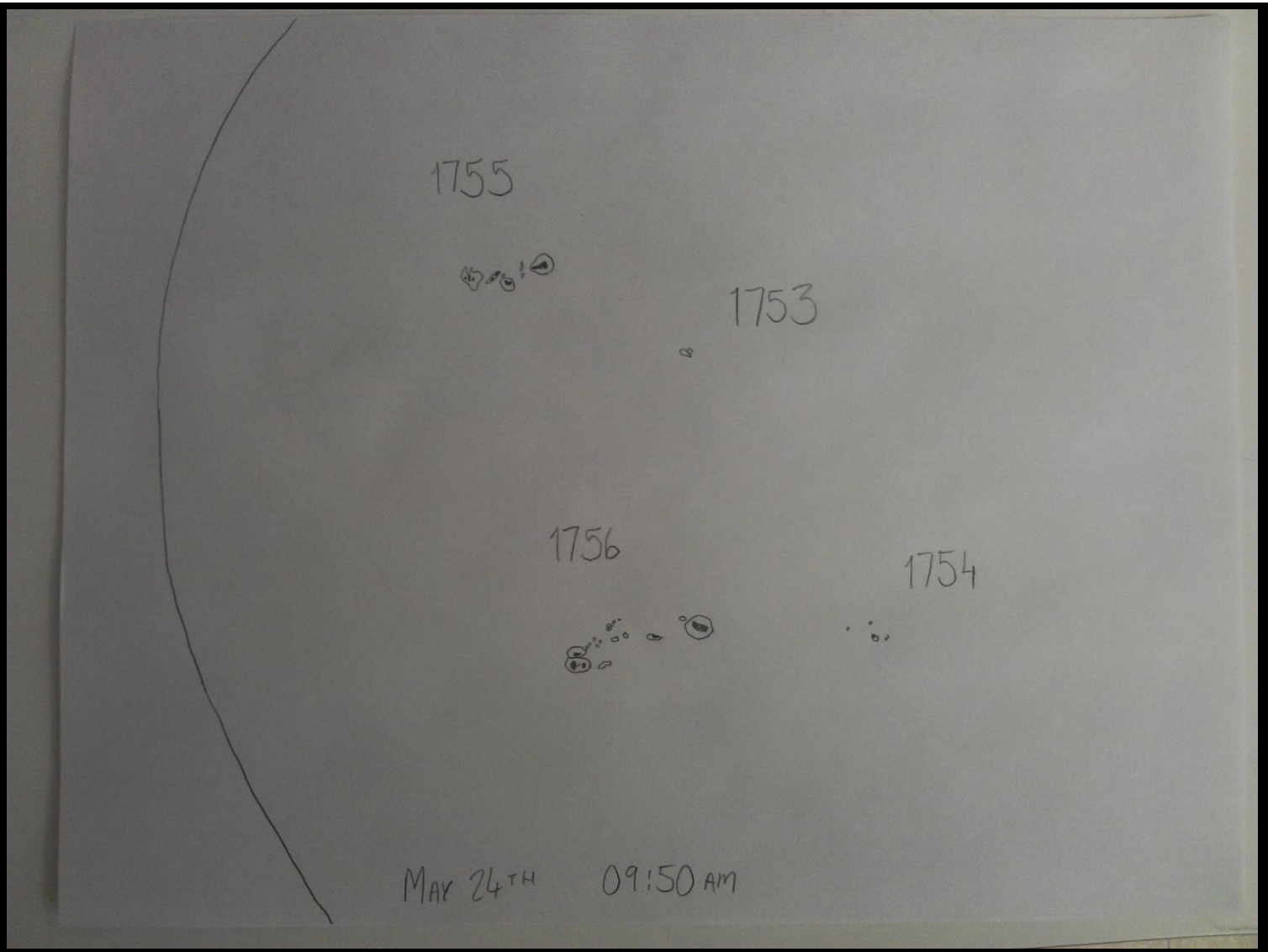
Liquid Nitrogen cooled

No flat field (one pixel)

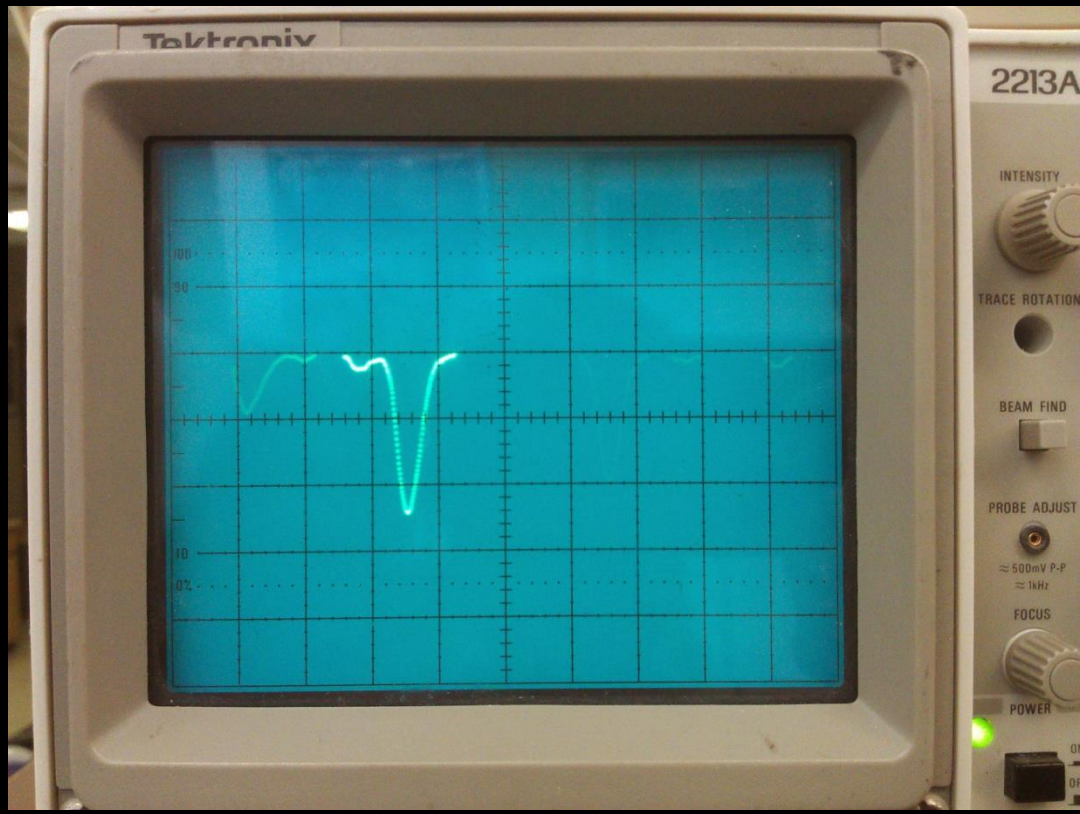
No dark measurements

Step 1 – go to the West aux.

Step 2 - Draw



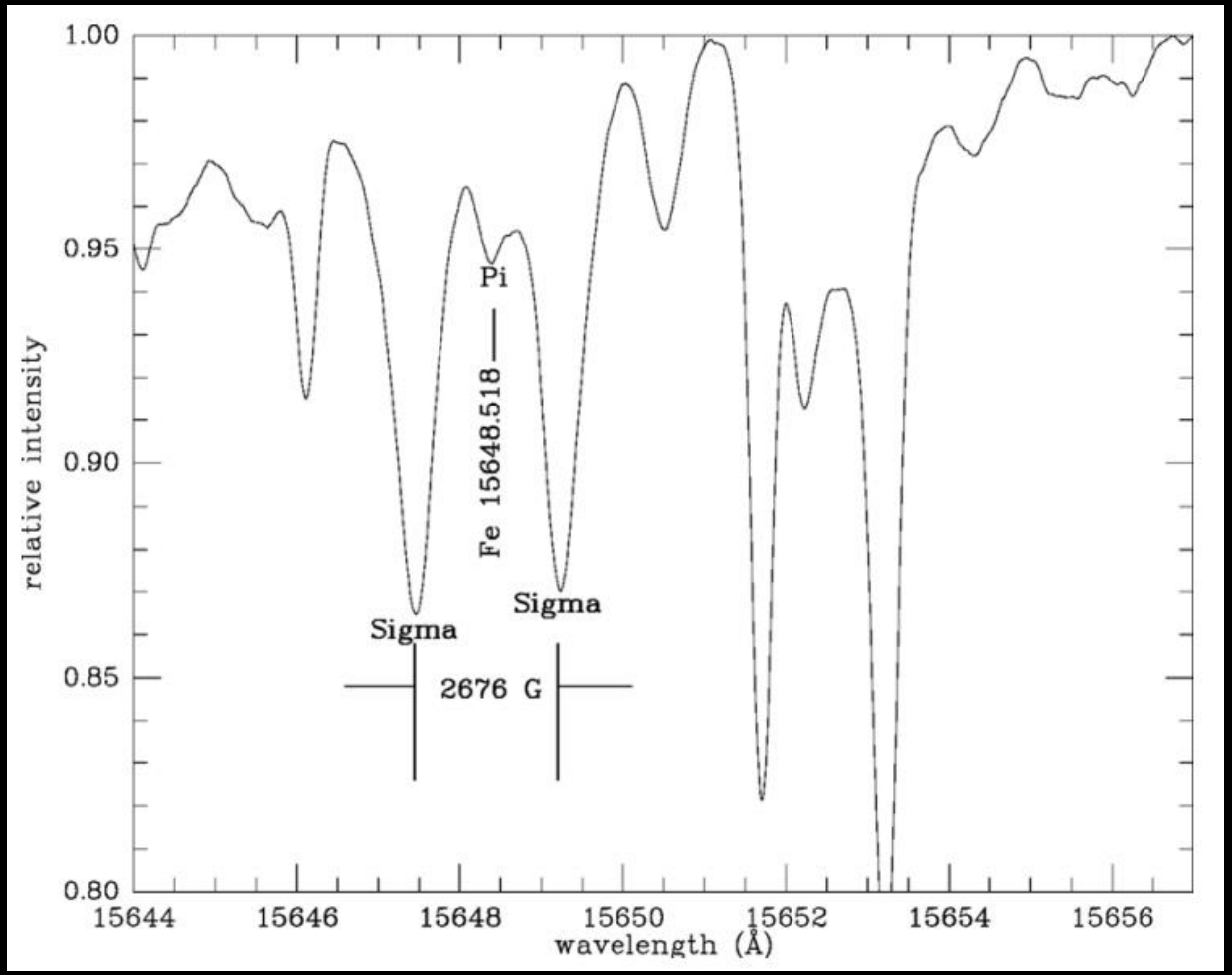
Step 3 – Take quiet Sun spectrum



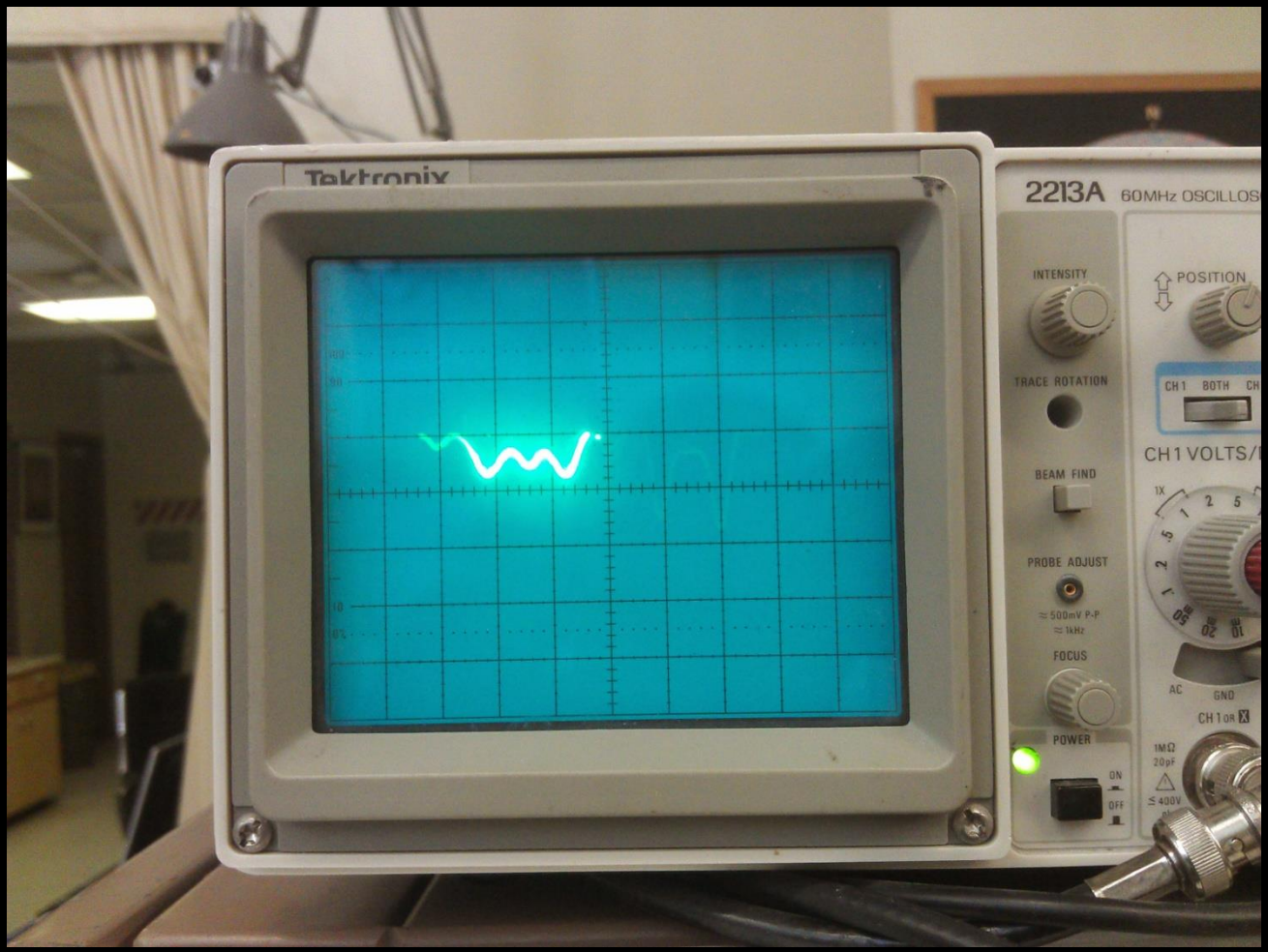
Step 4 – Find a sunspot umbra

- Slew the telescope until an umbra is near the aperture.
- Move around until the minimum power is seen on the meter.

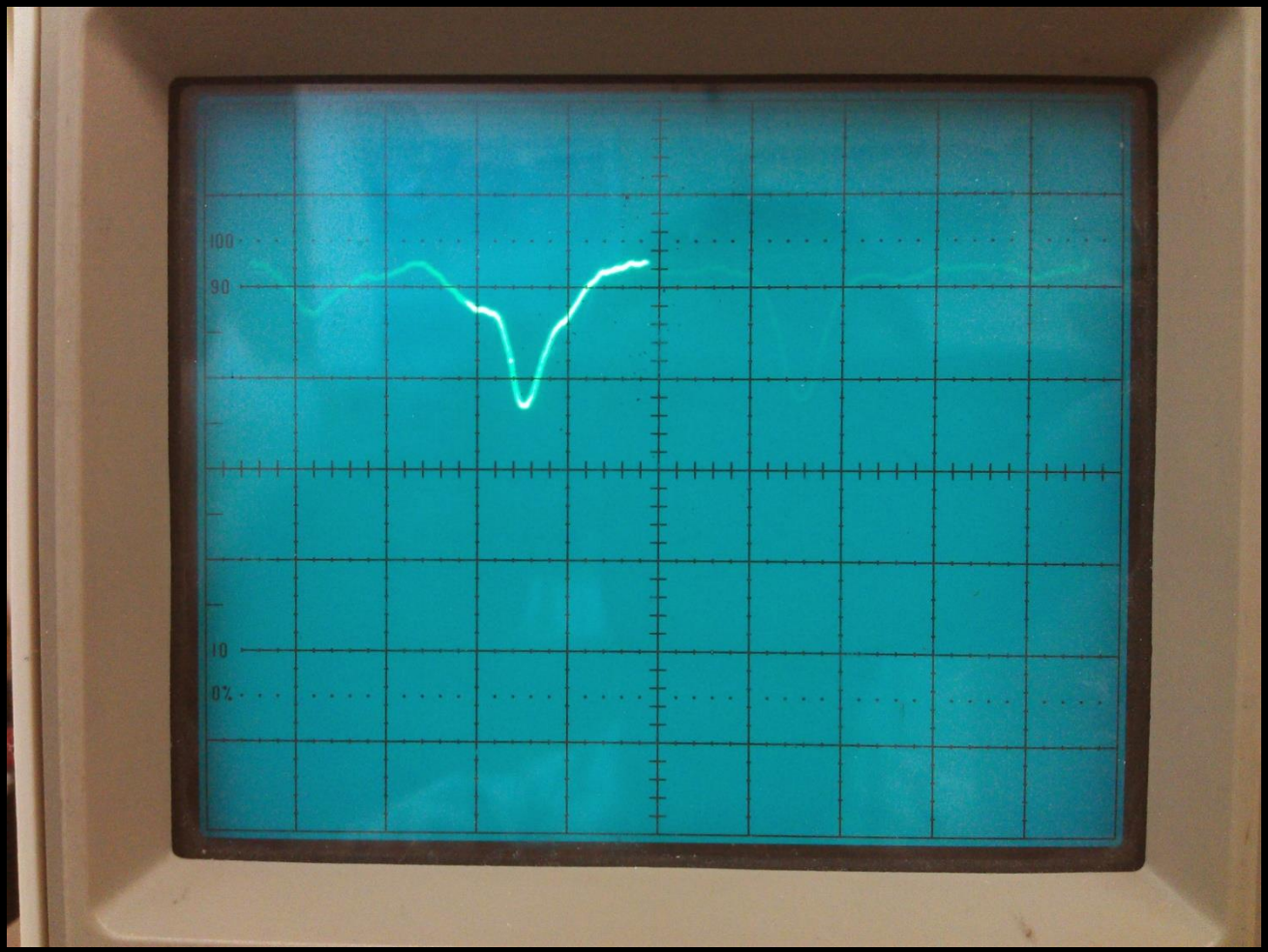
Step 5 – Take sunspot spectrum



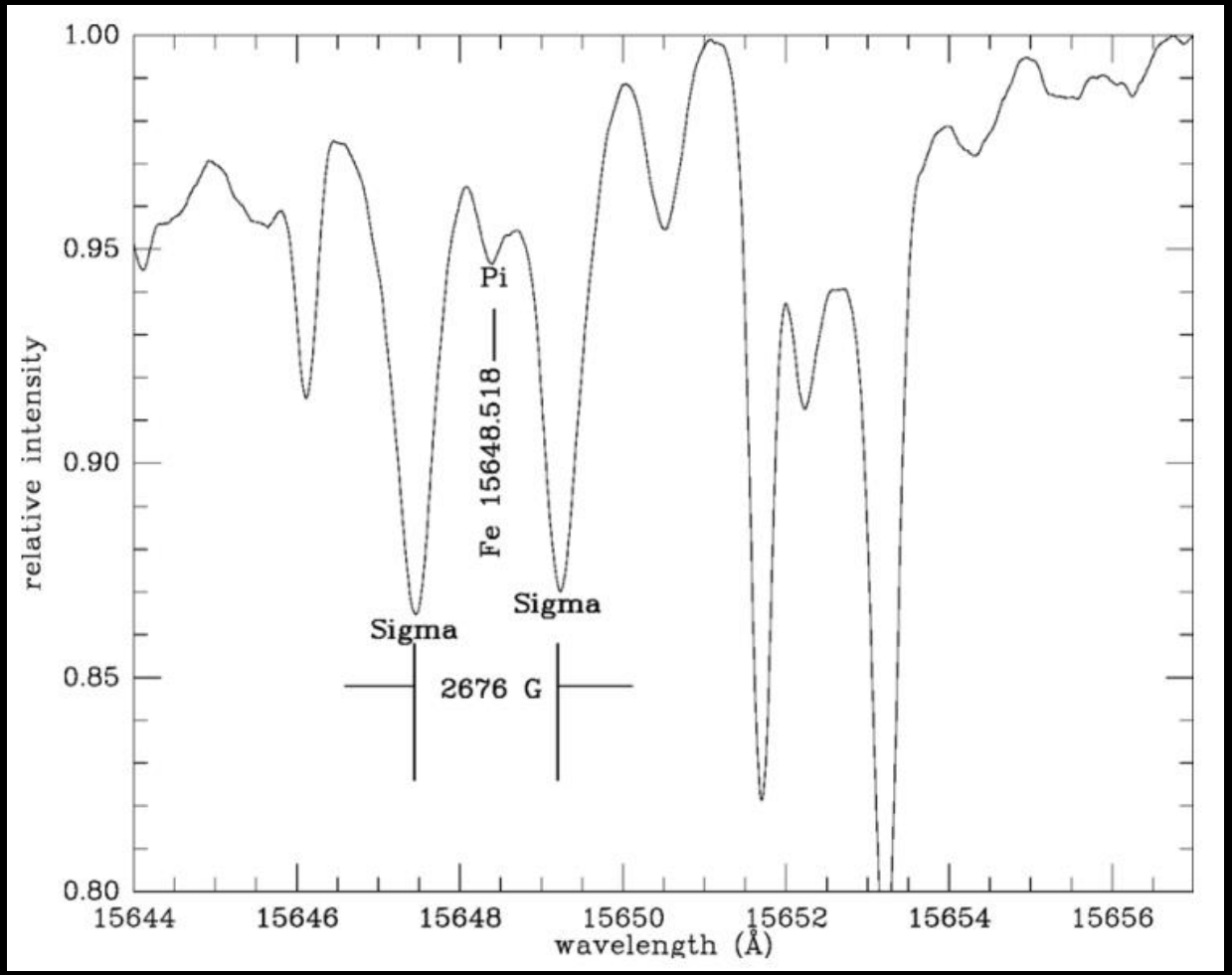
Step 5 – Take sunspot spectrum



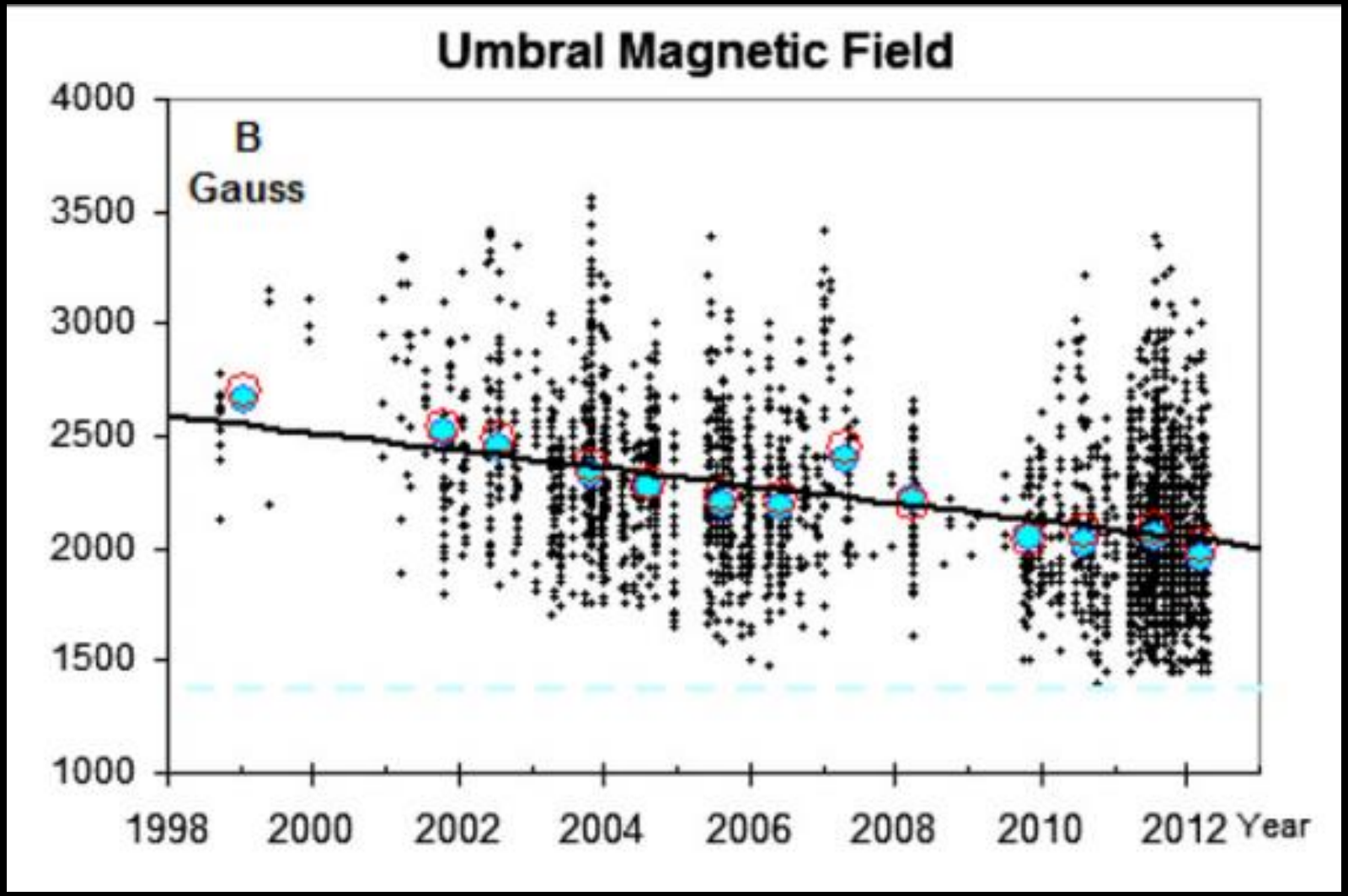
Step 5 – Take sunspot spectrum



Step 5 – Take sunspot spectrum



Step 6 - Repeat



What does it mean?

- From various articles, if this continues sunspot fields will get so weak that sunspots cannot form.
- There will be no sunspots.

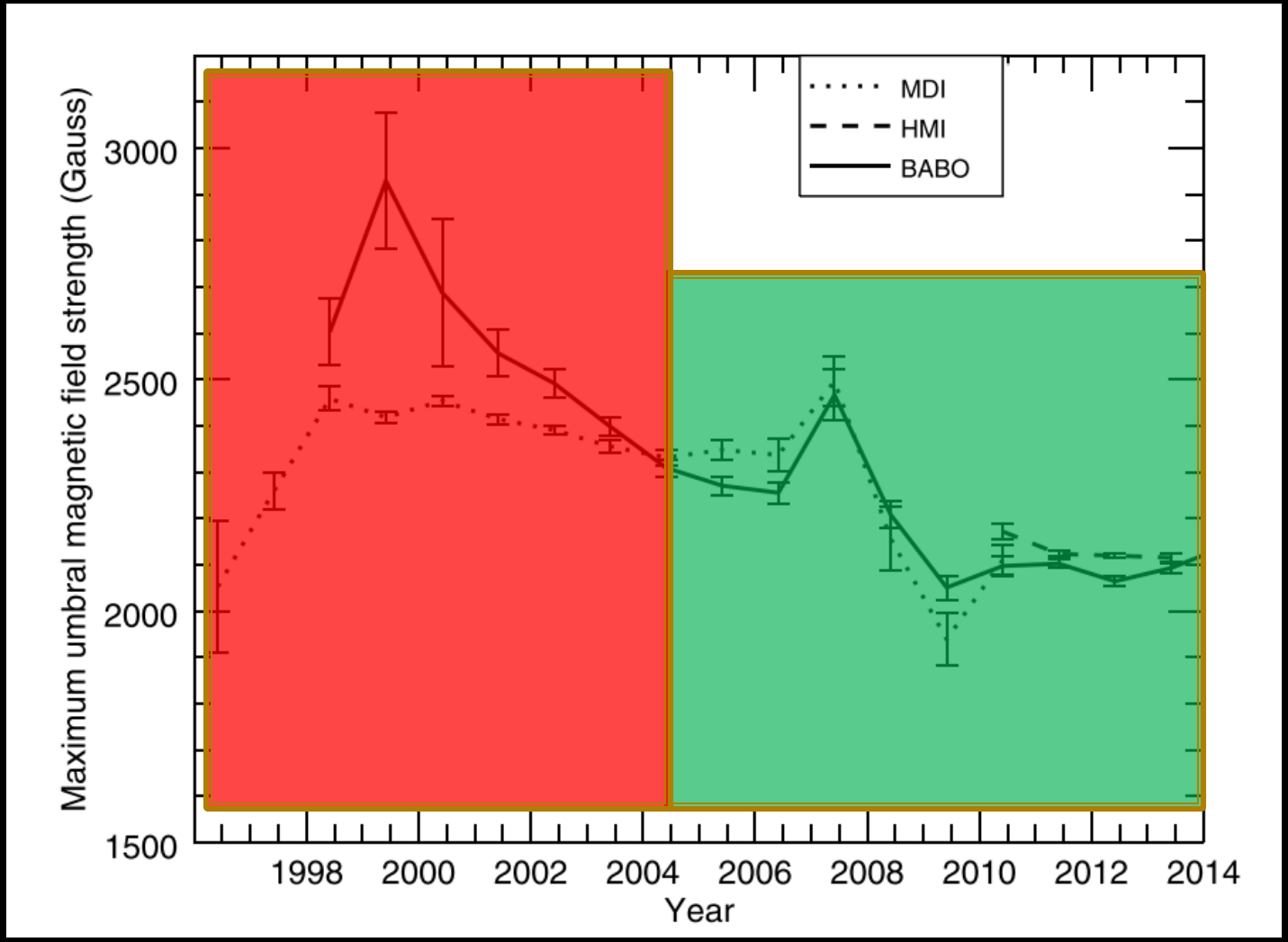
What now…

- Test with another dataset.
- In this case, MDI and HMI as we have synoptic white light data and magnetograms from 1996 – present.
- Still, there are issues with human observation.

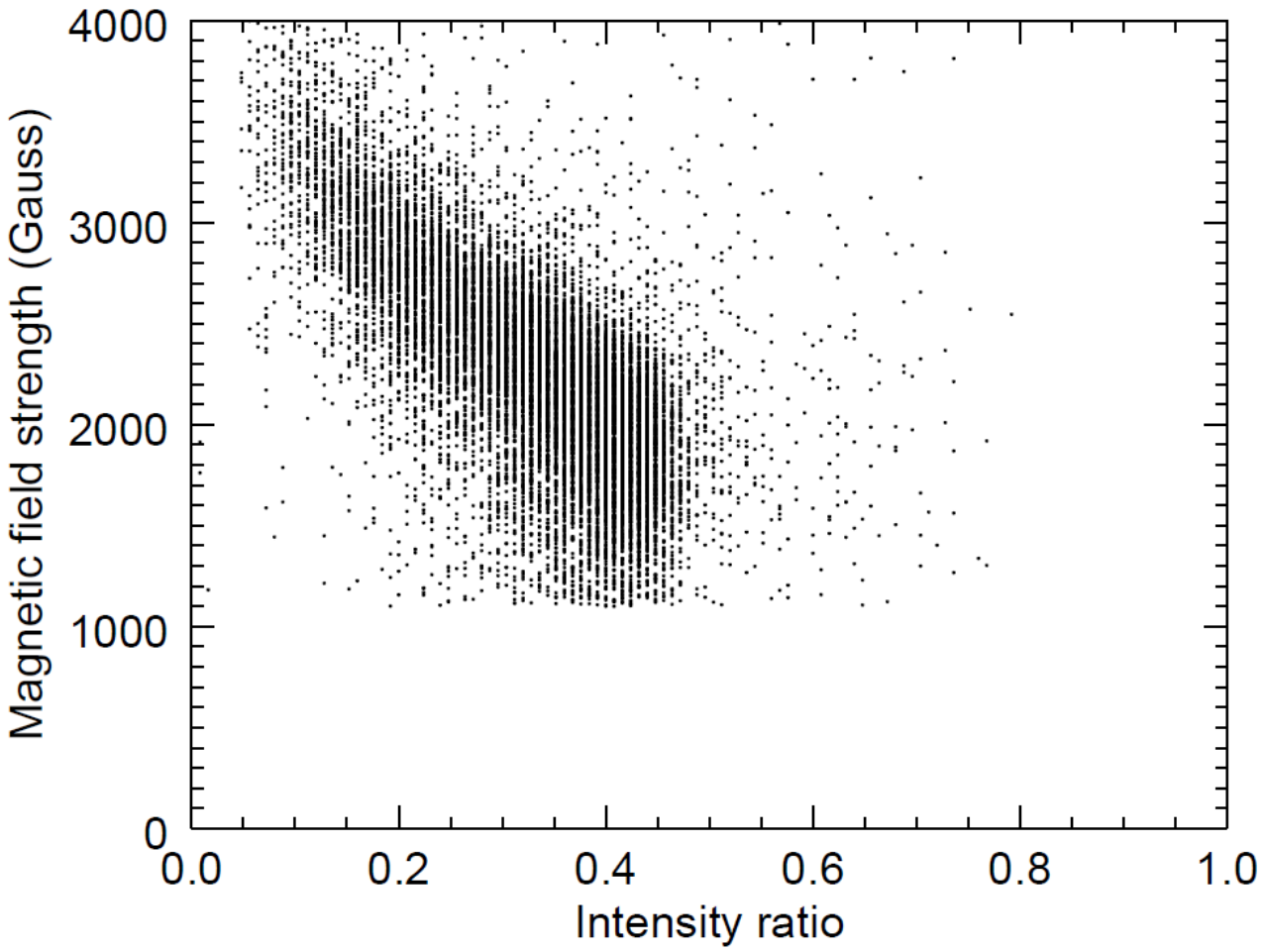
STARA

- Automated sunspot detection algorithm applied to entire MDI and HMI dataset.
- Livingston catalogue has around 2700 detections.
- STARA catalogue has around 27000 detections.

The comparison

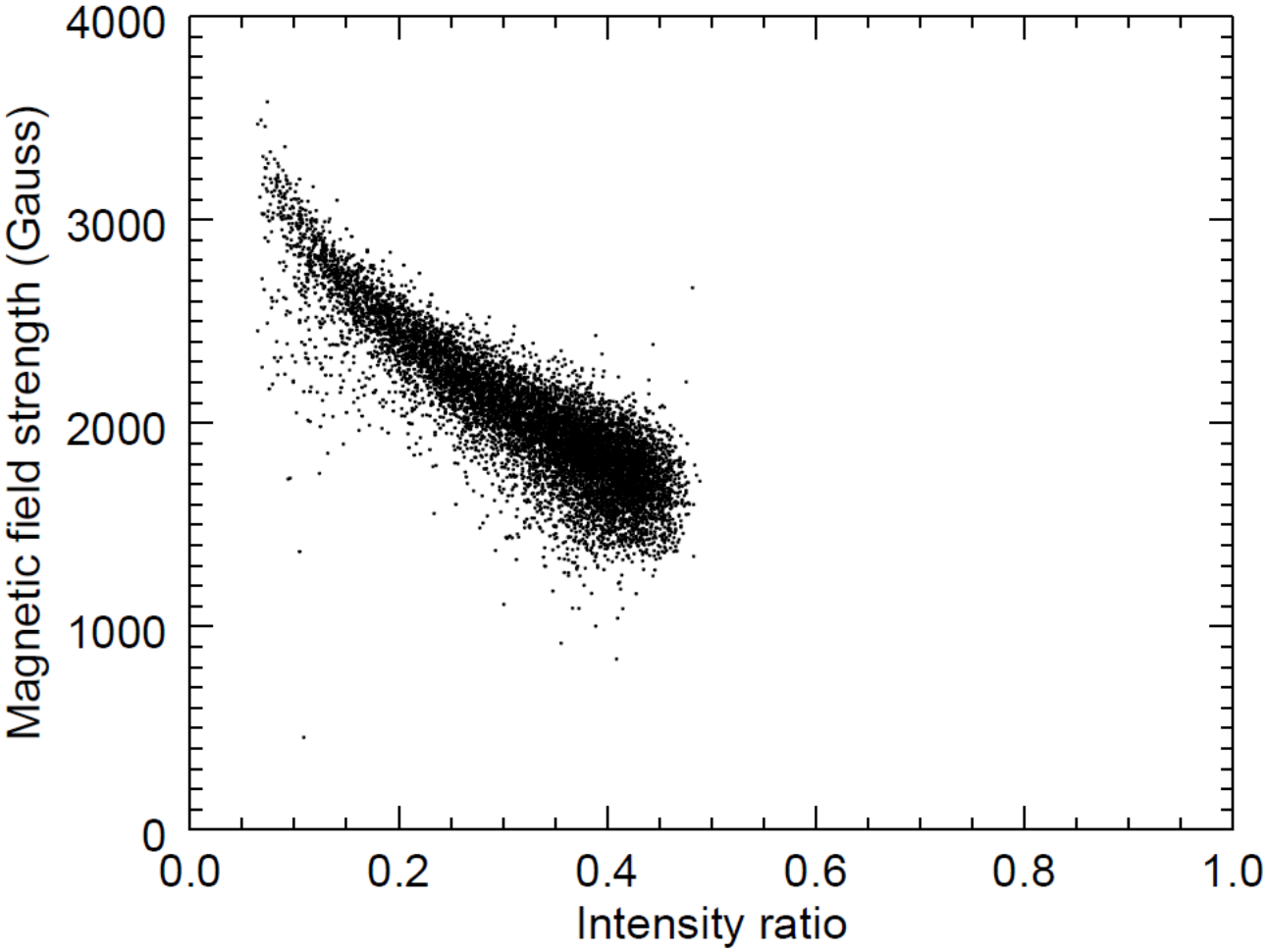


Maybe there is a problem with the data?



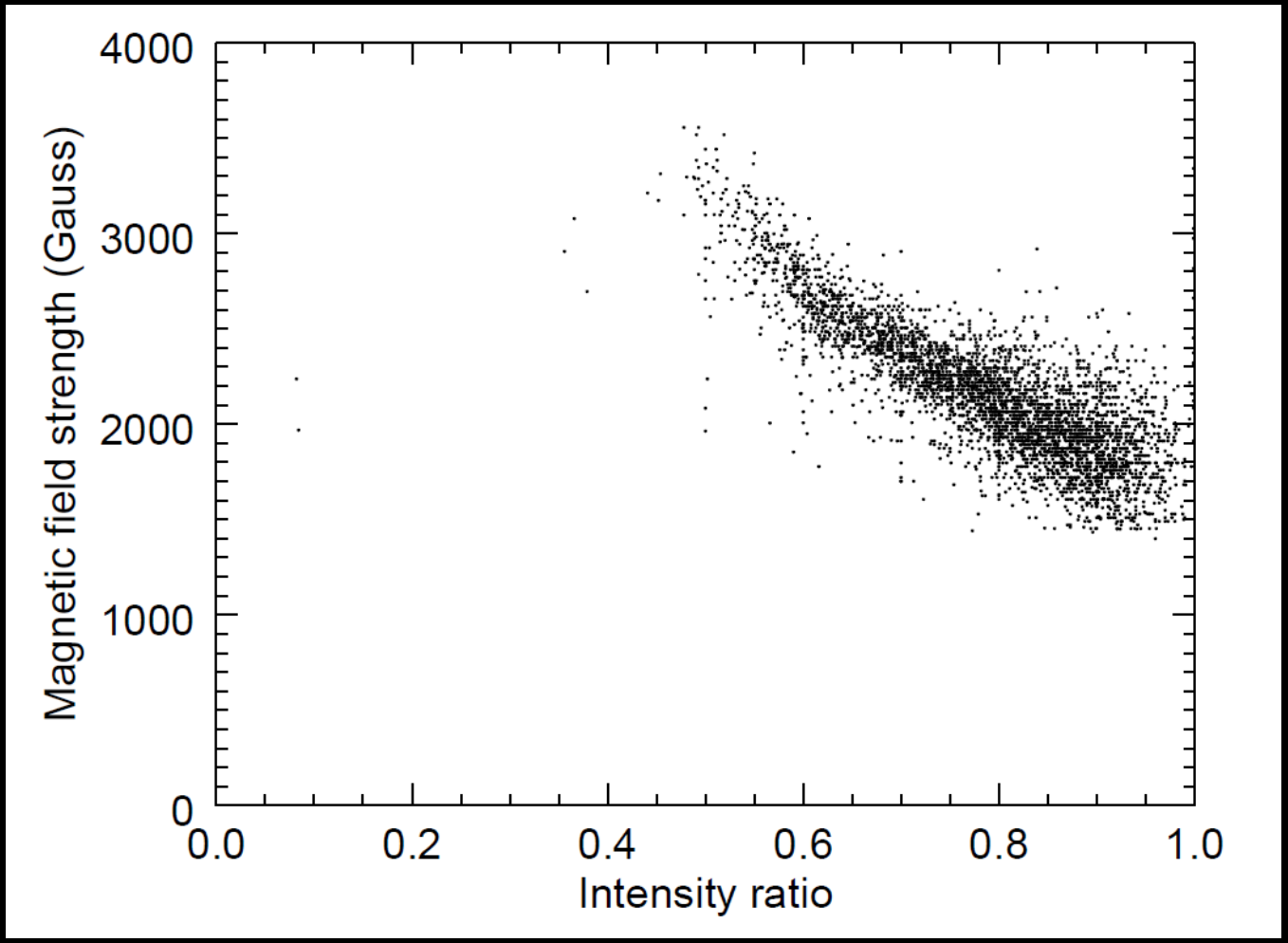
MDI

Maybe there is a problem with the data?



HMI

Maybe there is a problem with the data?



BABO

Maybe there is a problem with the data?

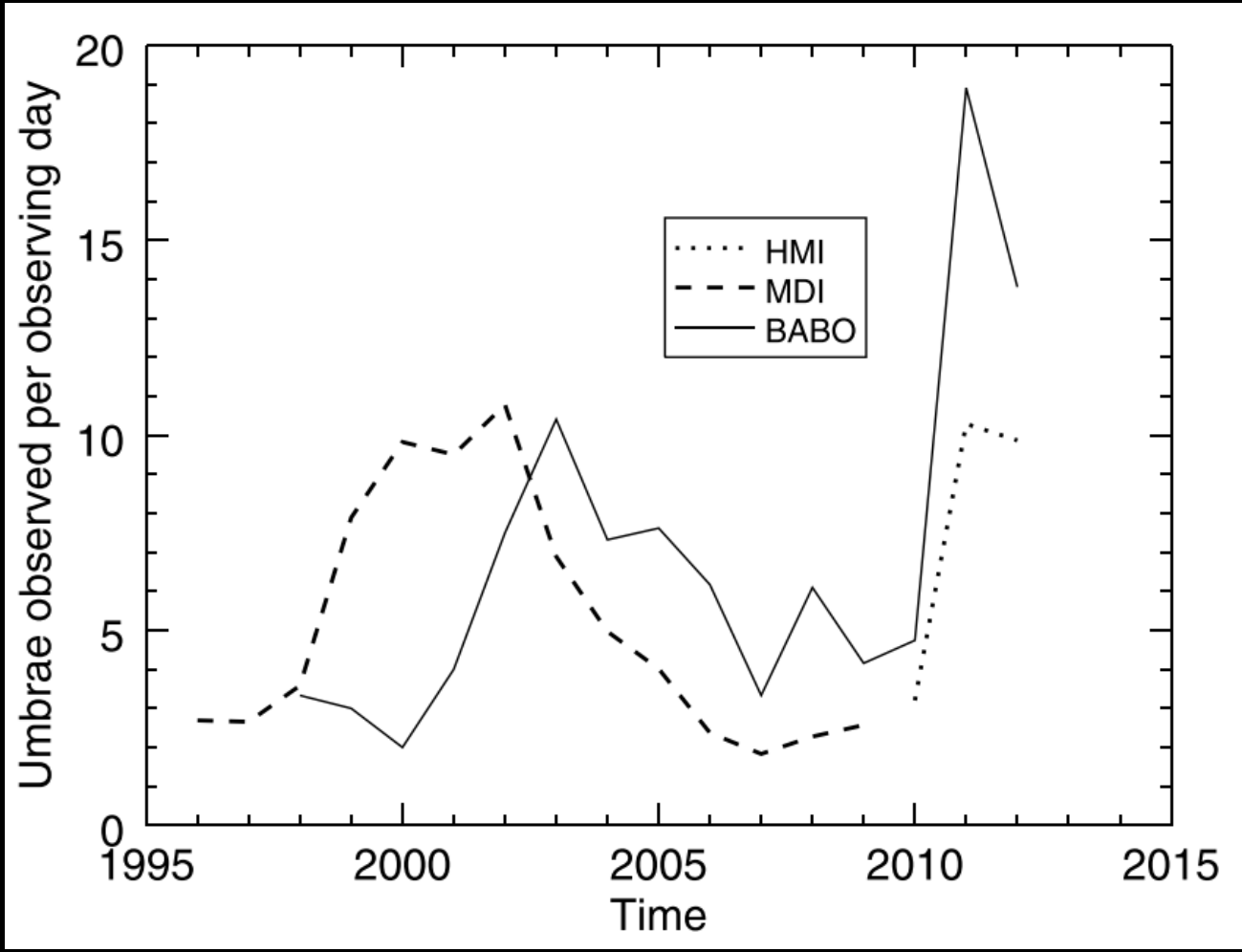
- The BABO data is potentially more accurate than the MDI data.
- MDI magnetic measurements are just line of sight fields corrected for viewing angle.
- HMI magnetic measurements are Milne-Eddington inversions recently made available by the HMI team.
- Perhaps something changed?

What changed?

- MDI and HMI are fully synoptic. The number of detected umbrae rises and falls with the cycle.
- BABO data is taken when telescope time is available. The number of umbrae detected does NOT rise and fall with the cycle.

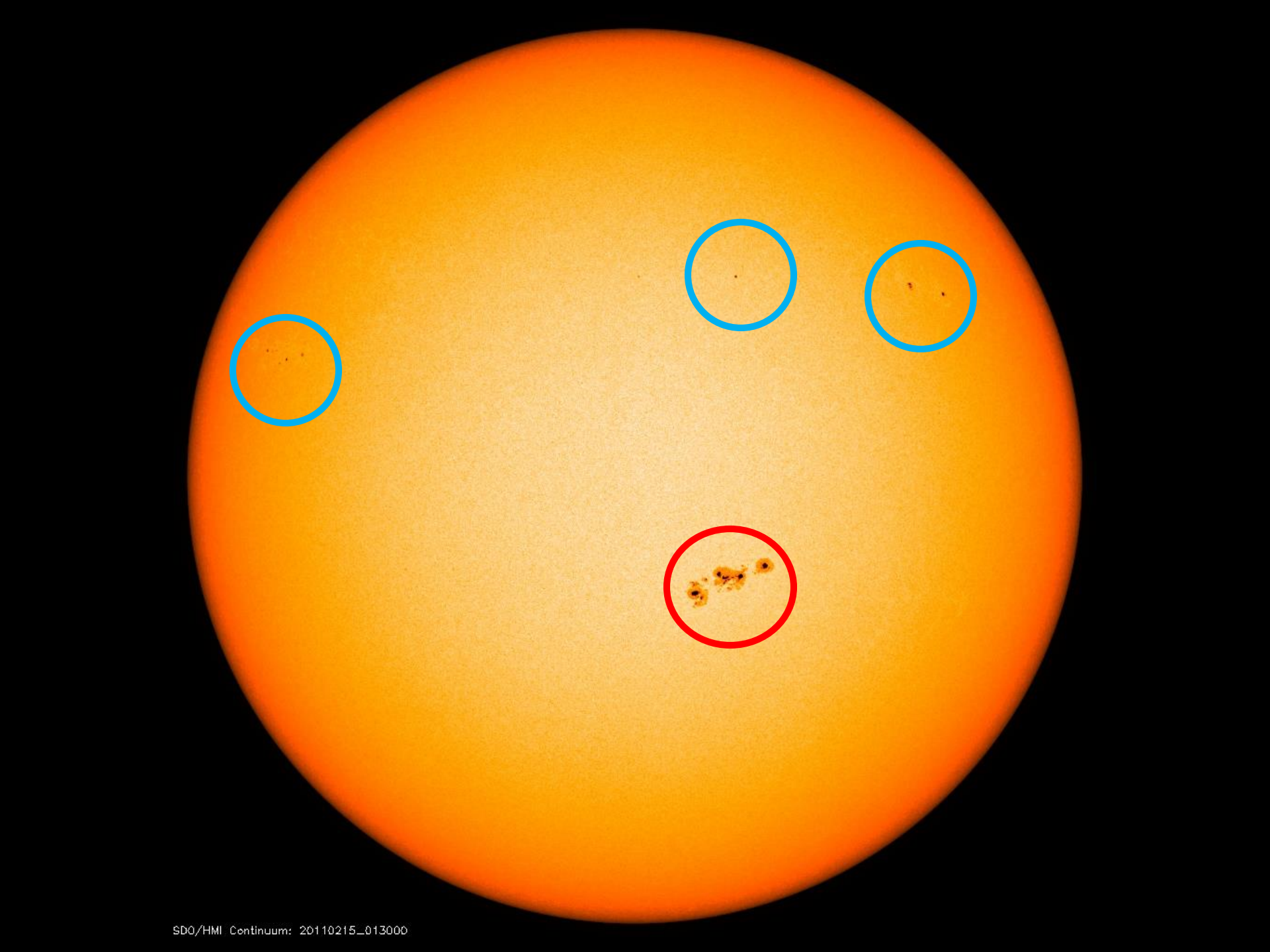
Year	MDI / HMI			BABO		
	#	Days	# per day	#	Days	# per day
1996	35	13	2.69	-	-	-
1997	178	67	2.66	-	-	-
1998	570	159	3.58	10	3	3.33
1999	2265	287	7.89	6	2	3.00
2000	3018	307	9.83	4	2	2.00
2001	3071	323	9.51	56	14	4.00
2002	3419	317	10.79	105	14	7.50
2003	1896	275	6.89	302	29	10.41
2004	1143	230	4.97	249	34	7.32
2005	819	282	4.01	282	37	7.62
2006	356	150	2.37	179	29	6.17
2007	154	84	1.83	60	18	3.33
2008	41	18	2.28	61	10	6.10
2009	54	21	2.57	79	19	4.16
2010	564	176	3.20	223	47	4.74
2011	3500	340	10.29	1059	56	18.91
2012	3554	360	9.87	911	66	13.80

What changed?



What changed?

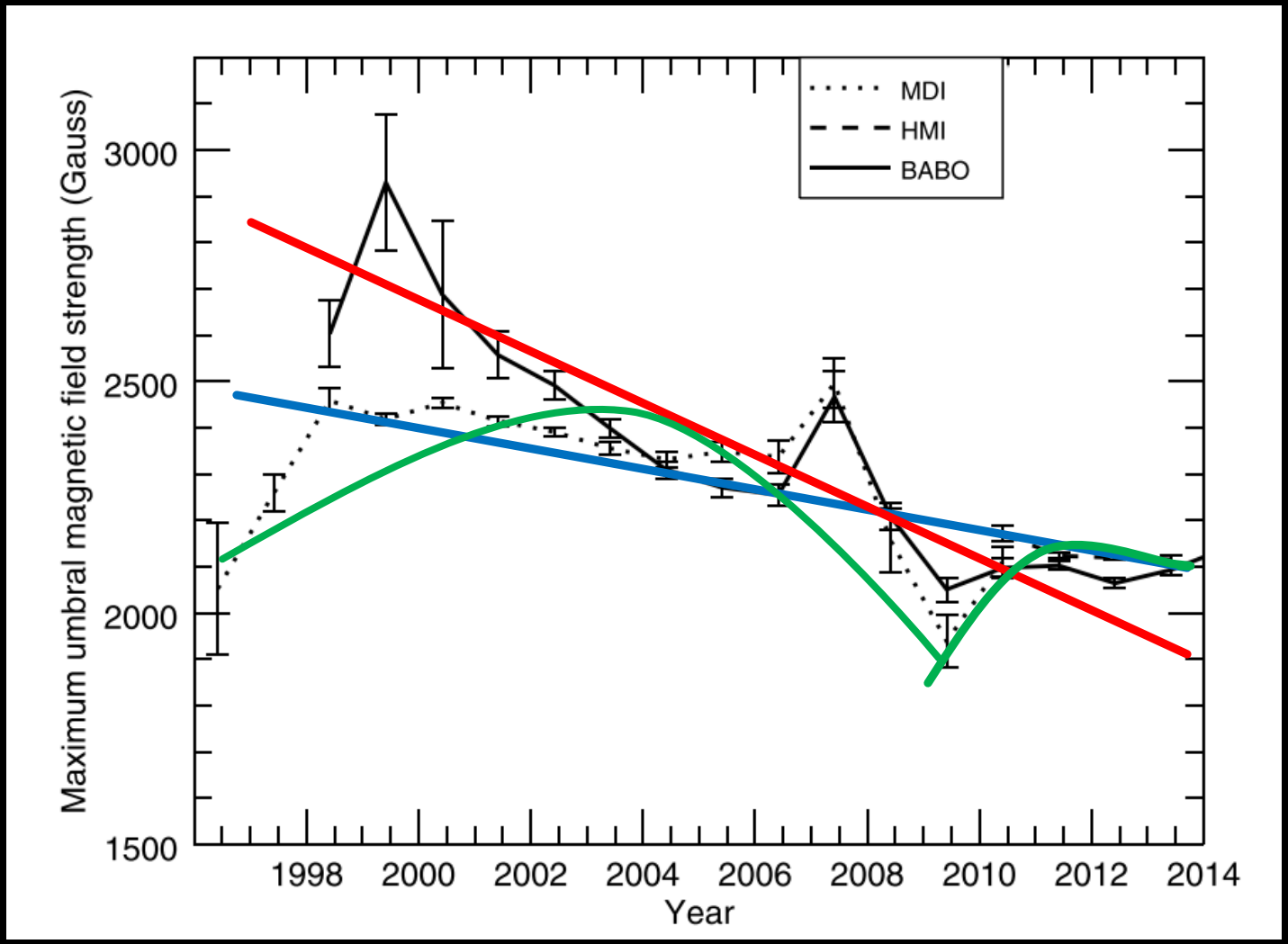
- The BABO measurements are undersampling the sunspot population in early years.
- This changes between 2003 and 2005.
- If the sunspot population was undersampled early on, which sunspots were chosen?


SDO/HMI Continuum: 20110215_013000

What changed?

- The most likely explanation is that the measurements were not initially planned as a full synoptic program and so only the most interesting (biggest, strongest) sunspots were measured.
- Once the large decrease in fields was observed, the program became more synoptic and care was taken to measure everything visible on the disk.

The comparison



Conclusions

- The Livingston dataset is fundamentally flawed until around 2006.
- After this time, the data trends seems more reasonable, but the actual individual measurements are good over the entire range of the data set.