Following Balloons, Questioning Gravitational Waves, and Small Number Statistics

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Remembering Neil – 2018 May 22

Following Balloons

- Compton Spectrometer and Imager (COSI)
- Correspondence with Neil on May 19, 2016

Hi Neil,

COSI successfully launched with the superpressure balloon about 2.5 days ago, and the instrument is working well. Although we've been following the GCN notices and circulars, there has not been a detectable GRB in our field of view yet. SGR 1935+2154 is near the edge of our field of view, and we've also been looking for those flares.

At the Goddard gamma-ray meeting, you and I talked about Swift/BAT following COSI for a few days. If that is a possibility, then we might want to start planning that.

John

Hi John,

Congratulations on having COSI at float and working well! It would be awesome to get a simultaneous GRB with COSI and BAT. If you get a strong burst with a good polarization measurement, it will be one of the hallmark GRB discoveries. We will need to sell this to the Swift ops team (and ourselves) in the face of large TOO oversubscription this week. The way this would work is that we would aim the BAT in the COSI pointing direction during the ~40% of the time that Swift is on the right side of the earth and the pointing direction is above the horizon constraint.

What is the detection rate you expect for GRBs? What fraction will be bright enough for a good polarization measurement? We can certainly do some co-pointing during the flight, recognizing that it is a low-probability but high pay-off observation. How long are you expecting to fly? Are there any particular times during the flight that would be better for Swift co-pointings?

Neil

Photo prior to superpressure balloon flight from New Zealand in 2016

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John

Me: *COSI launched…can Swift/BAT cover our field of view?*

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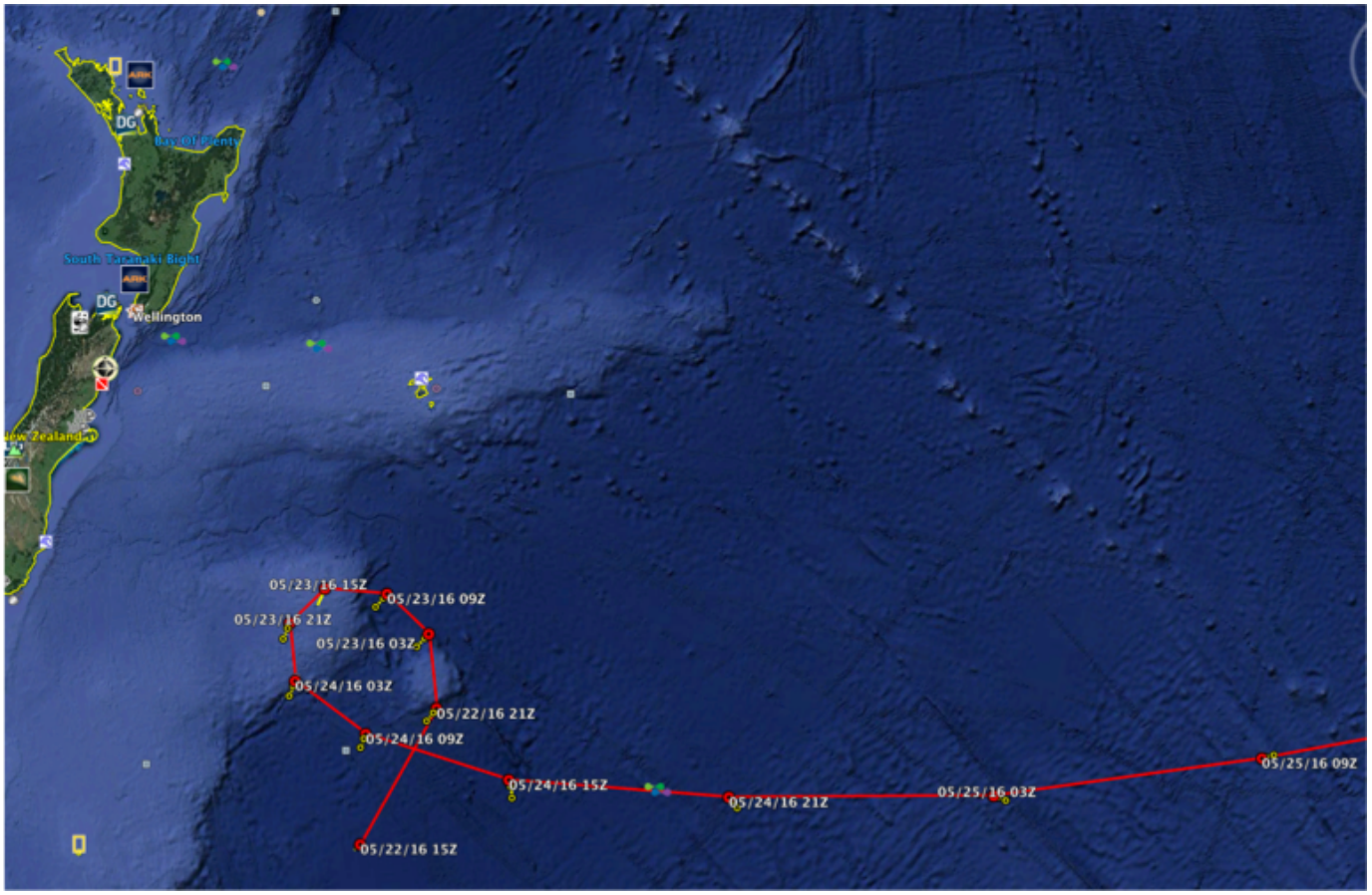
Neil

Neil: *Great! I'd love to have Jamie do that… and, by the way, can you tell him where BAT should point?*

Balloon path predictions



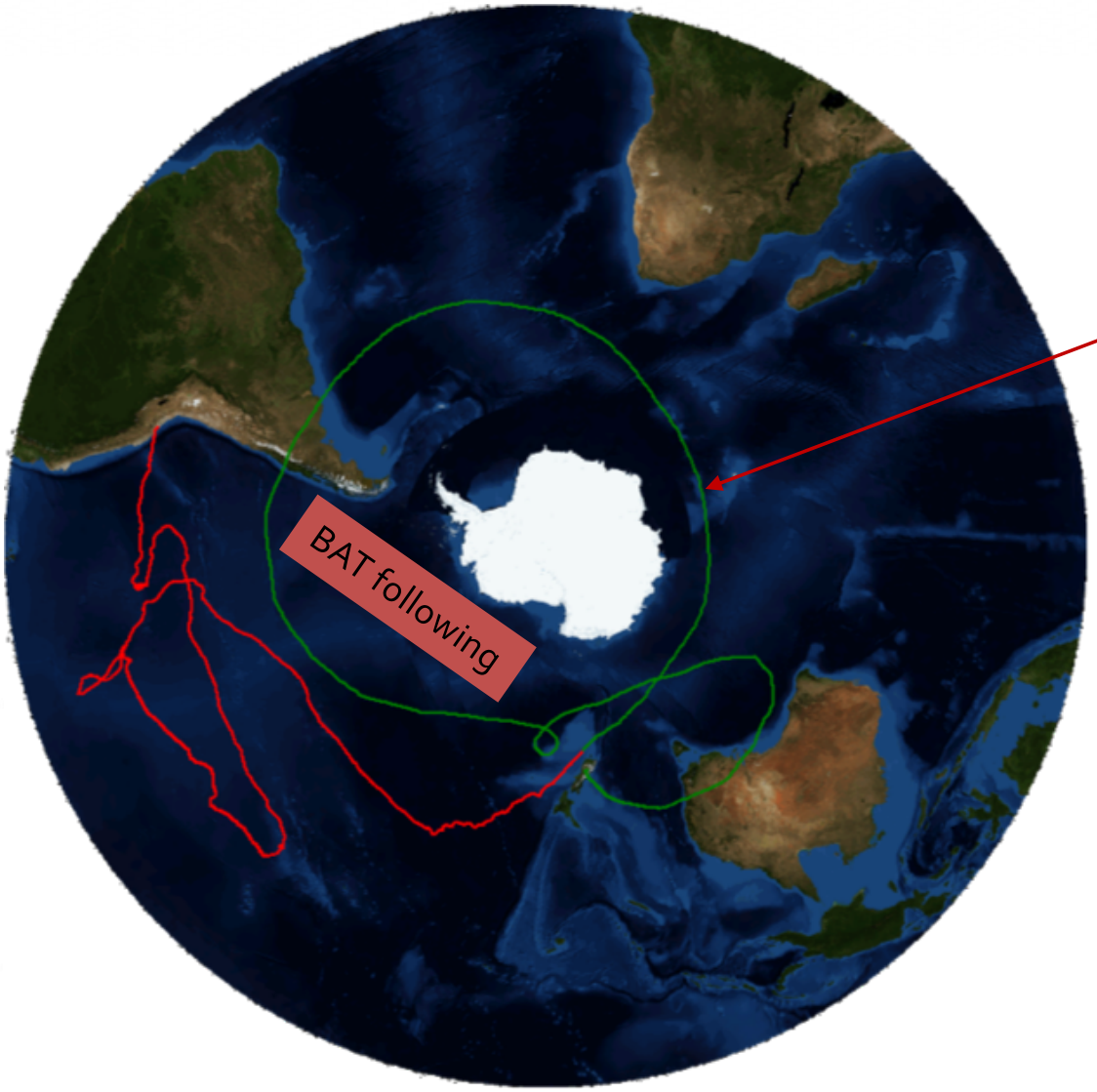
Column#1 = hour on May 24 UT
Column#2 = RA (J2000) in degrees
Column#3 = Dec (J2000) in degrees
Column#4 = Earth Longitude (East, deg)

0.00000	58.6742	-50.5000	176.650
1.00000	73.7986	-50.7333	176.733
2.00000	88.9230	-50.9667	176.817
3.00000	104.047	-51.2000	176.900
4.00000	119.672	-51.4500	177.483
5.00000	135.296	-51.7000	178.067
6.00000	150.921	-51.9500	178.650
7.00000	166.545	-52.2000	179.233
8.00000	182.169	-52.4500	179.817
9.00000	197.794	-52.7000	180.400
10.0000	213.985	-52.8833	181.550
11.0000	230.176	-53.0667	182.700
12.0000	246.367	-53.2500	183.850
13.0000	262.558	-53.4333	185.000
14.0000	278.749	-53.6167	186.150
15.0000	294.940	-53.8000	187.300
16.0000	311.748	-53.8000	189.067
17.0000	328.556	-53.8000	190.833
18.0000	345.363	-53.8000	192.600
19.0000	2.17118	-53.8000	194.367
20.0000	18.9790	-53.8000	196.133
21.0000	35.7867	-53.8000	197.900
22.0000	52.6110	-53.5667	199.683
23.0000	69.4355	-53.3333	201.467

- Succeeded in having BAT follow COSI from May 23-27

2016 Flight Path

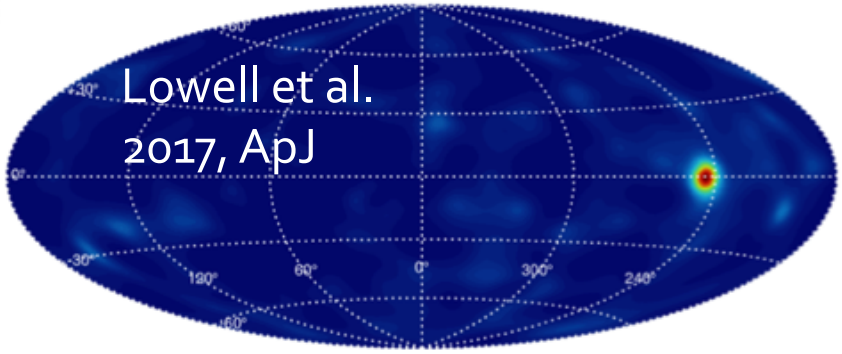
Landed in Peru
(46 day flight)

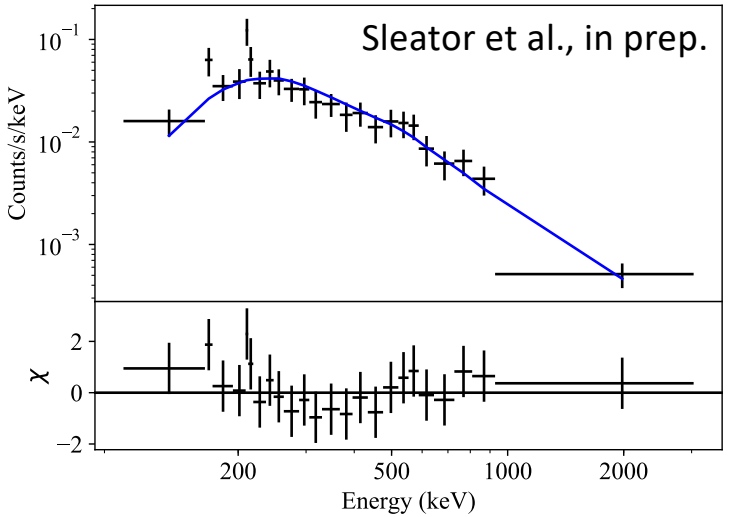


Launch from
New Zealand
on May 17th

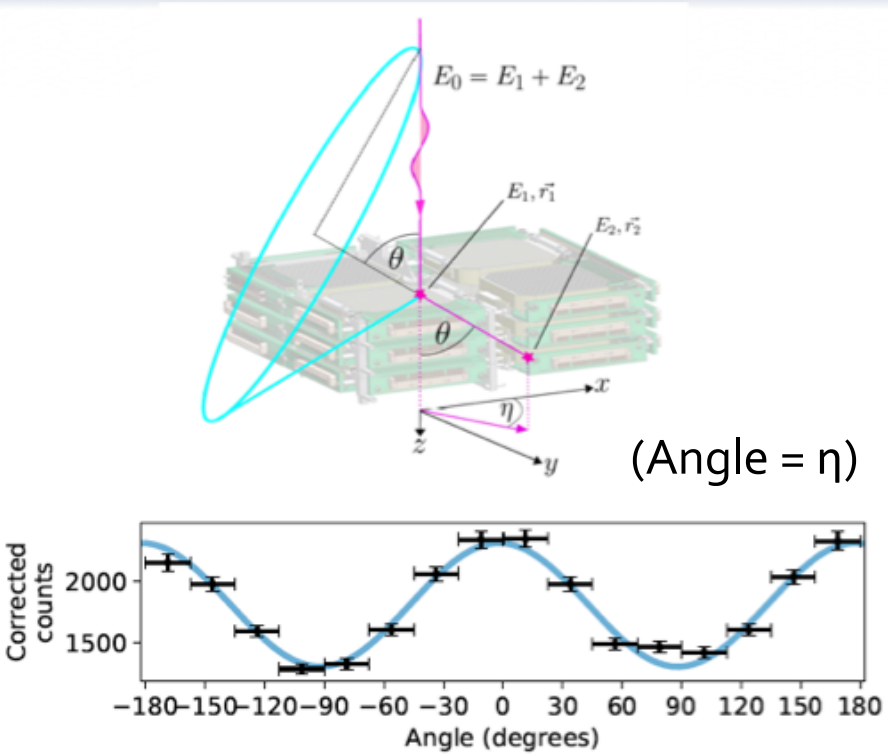
GRB 160530A

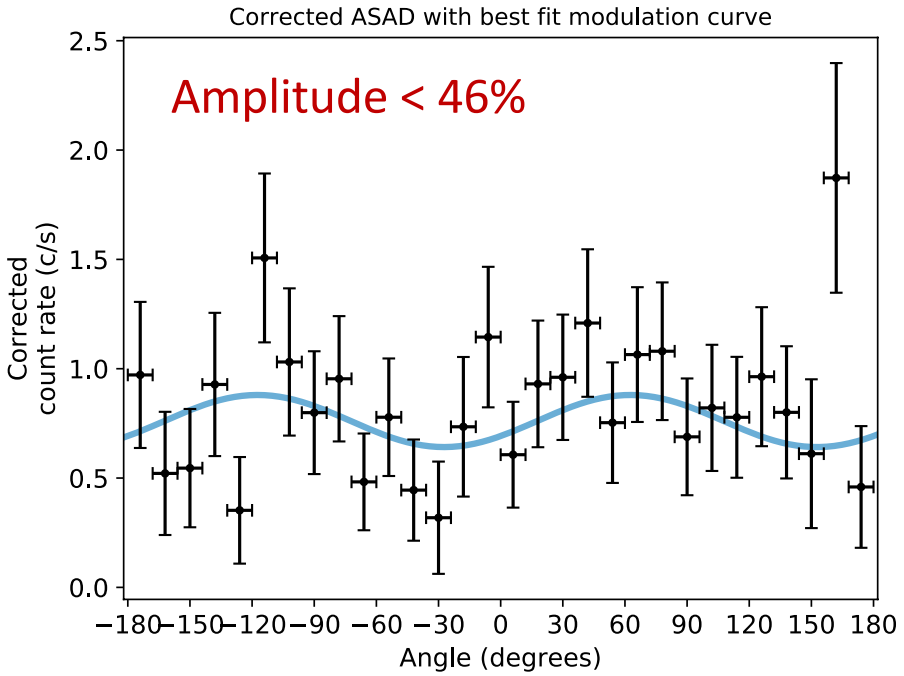
- Found in real time
  - reported in GCN#19473
- Also detected by AstroSat, INTEGRAL, and Konus-Wind
  - Absolute timing
  - Localization capabilities
  - Energy spectrum
- COSI spectral parameters and fluence agree with Konus-Wind (Svinkin et al. 2016, GCN#19477)





COSI polarization capabilities and GRB result





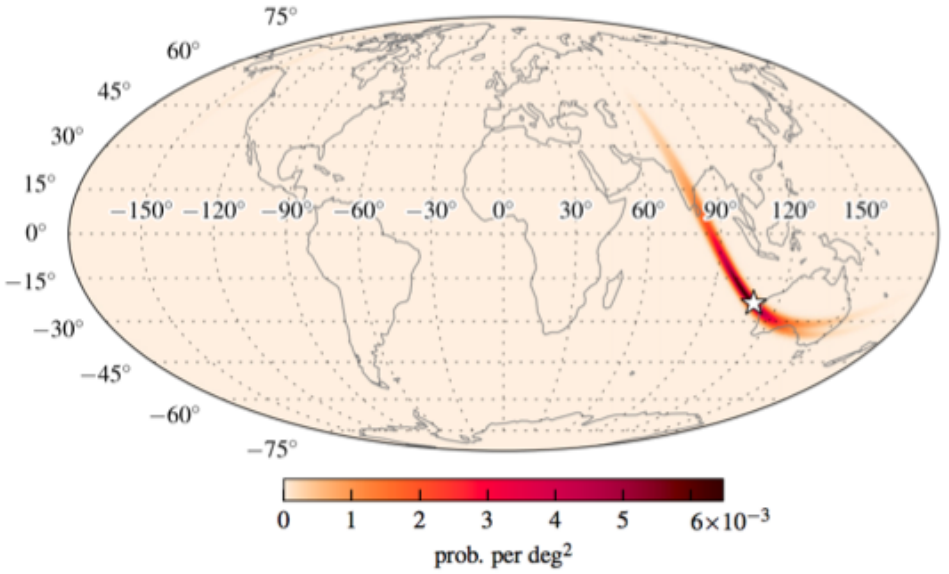
- Calibration with a partially polarized source (Lowell, PhD thesis)

Azimuthal Scattering Angle Distribution for Compton events from GRB 160530A (Lowell et al. 2017ab)

Questioning Gravitational Waves

- Clemson meeting in October 2015 to get ready for the 2016 Senior Review
- My naïve question: why would following up GWs be the top priority for Swift when we have never detected one?

Simulated LIGO localization (Singer et al. 2014)



"Only 300 XRT pointings to cover this region"

Questioning Gravitational Waves

- GW 150914: Merger of 36 and 29 solar mass BHs
  - First GW event was detected about a month before the Clemson meeting
- Secret until February 2016

Questioning Gravitational Waves

2016 NASA Astrophysics Senior Review

22-25 February, 2016

Table 3: Programmatic and scientific ranking of all missions ranked 1-6.

Mission	Ranking
Swift	1
K2	2
NuSTAR	3
XMM	4
Fermi	5
Spitzer	6

Quiz

- What is Neil's 2nd most cited paper?

Small Number Statistics

CONFIDENCE LIMITS FOR SMALL NUMBERS OF EVENTS IN ASTROPHYSICAL DATA

NEIL GEHRELS
Laboratory for High Energy Astrophysics, NASA/Goddard Space Flight Center
Received 1985 August 5; accepted 1985 September 30

1450 citations!

TABLE 1

POISSON SINGLE-SIDED UPPER LIMITS

	CONFIDENCE LEVEL									
n	0.8413[a]	0.90	0.95	0.975	0.9772[a]	0.99	0.995	0.9987[a]	0.999	0.9995
0.....	1.841	2.303	2.996	3.689	3.783	4.605	5.298	6.608	6.908	7.601
1.....	3.300	3.890	4.744	5.572	5.683	6.638	7.430	8.900	9.233	9.999
2.....	4.638	5.322	6.296	7.225	7.348	8.406	9.274	10.87	11.23	12.05
3.....	5.918	6.681	7.754	8.767	8.902	10.05	10.98	12.68	13.06	13.93
4.....	7.163	7.994	9.154	10.24	10.39	11.60	12.59	14.39	14.79	15.71
5.....	8.382	9.275	10.51	11.67	11.82	13.11	14.15	16.03	16.45	17.41

- An early example of Neil's service to the community that continued throughout his career