



AstroWatch Update

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LIGO PAC Meeting
LIGO Hanford Observatory
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What is AstroWatch?

LIGO 4-km IFO's and Virgo undergoing major upgrades for Enhanced LIGO / Virgo+

→ Hanford 2-km IFO (H2) is world's most sensitive operational GW detector during 2008

→ Operate it!

GEO 600 also operational with good duty factor

→ Try to maintain good coverage with one or both IFOs

Why maintain coverage?

“Because we ought to”

Counterarguments:

- Operating H2 is not free – would be unreasonable to use operators needed for ELIGO (and AdLIGO) work
- Once ELIGO begins, will rapidly make up for lost time
→ 1 month of ELIGO \geq 64 months of H2 AstroWatch
(event rate scales like inverse cube of sensitivity)

So why bother with AstroWatch?

Why maintain coverage?

**Inverse cube relation applies to extragalactic sources
(e.g., inspiraling compact binaries)**

Relation does not apply to galactic sources

- **Depending on supernova model, H2 already covers much or all of galactic disk**
- **Galactic supernovae occur ~ 1 / per 30 years**
- **No assurance that even AdLIGO will see one**

Would hate to lose once-per-generation scientific opportunity

Stan Whitcomb's Nightmare...

The New York Times



\$500M Gravity Network Blows Discovery – Tinkering Scientists Miss the Big One

Congressman calls for funding halt

Congressman John Dingell wants to know why a half-billion-dollar astronomical network funded by the National Science Foundation was turned off when a giant star exploded in the Milky Way last week.

The influential Democrat from Michigan has called for a freeze on additional funding for the network until the NSF explains why scientists didn't bother to keep one of three instruments running while working on improvements to the other two.

"Taxpayers have spent more than \$500M to fund these instruments. It is outrageous that these scientists didn't trouble themselves to operate

...

Who is doing AstroWatch?

Volunteer graduate students from the LSC

AstroWatch is good training ground for students who might otherwise not touch an interferometer

- Builds for LSC future**
- Instrumental experience informs analysis work**

Students devote ~50% effort to AstroWatch and ~50% to dissertation work or H1/H2 commissioning

Housing & transportation subsidized by Observatory

Who is doing AstroWatch?

First set of students arrived in January 2008 for training by LHO operator / trainer (Anamaria Effler)

Many other LHO staff have helped in training too, especially in addressing problems after run began on February 18

Student leadership:

- Evan Goetz (Michigan) led initial team (end of 2-year LHO residence)
- Leadership now rotates ~monthly among experienced students:

June – Philip Roberts (Andrews)

July – Jake Slutsky (LSU)

August – Pinkesh Patel (Caltech)

Who is doing AstroWatch?

Berit Behnke (AEI)	Philip Roberts (Andrews)
Evan Goetz (Michigan)	Jacob Slutsky (LSU)
Pinkesh Patel (Caltech)	Junyi Zhang (Michigan)
Szymon Steplewski (WSU)	Matt West (Syracuse)
Adam Mullavey (ANU)	Satya Mohapatra (U. Mass. Amherst)
Llucia Sancho de la Jordana (U. de les Illes Balears)	Miquel Trias (U. de les Illes Balears)
Jericho Cain (U. Miss)	

13 students volunteered to date:

9 from U.S. institutions, 4 from Europe or Australia

Month by month schedule for student presence

	Feb-08	Mar-08	Apr-08	May-08	Jun-08	Jul-08	Aug-08	Sep-08	Oct-08	Nov-08	Dec-08
Adam					1.00	0.67	1.00	1.00	1.00	1.00	
Berit	1.00	1.00							1.00	1.00	1.00
Evan	1.00	1.00	1.00	1.00							
Jacob	1.00	1.00	1.00	1.00	1.00	1.00					
Jericho									0.00	0.00	0.00
Junyi	1.00	1.00	0.00								
Lucia								1.00	1.00	1.00	
Matt				0.50	1.00			1.00	1.00	1.00	1.00
Miquel								1.00	1.00	1.00	
Philip	1.00	1.00	1.00	1.00	1.00	1.00	0.50				
Pinkesh	1.00	0.50	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Satya						1.00	1.00	1.00			
Szymon				0.50	0.50	1.00	1.00	1.00	1.00	1.00	1.00
Totals	6.00	5.50	4.00	5.00	5.50	5.67	4.50	7.00	7.00	7.00	4.00

Rough month!

AstroWatch Operations

Shift scheduling depends on number of students present:

- $\geq 6 \rightarrow$ At least 1 shift per night (2 students on duty)
- $< 6 \rightarrow$ Mixture of shifts and visits to site to restore lock

LHO staff & visitors chip in occasionally

Two modes of operation:

- “**Science mode**” (students present to sign off on data quality)
- “**Power-up mode**” (IFO at high power, but unattended or with known data quality issues, e.g., human activity near optical table)

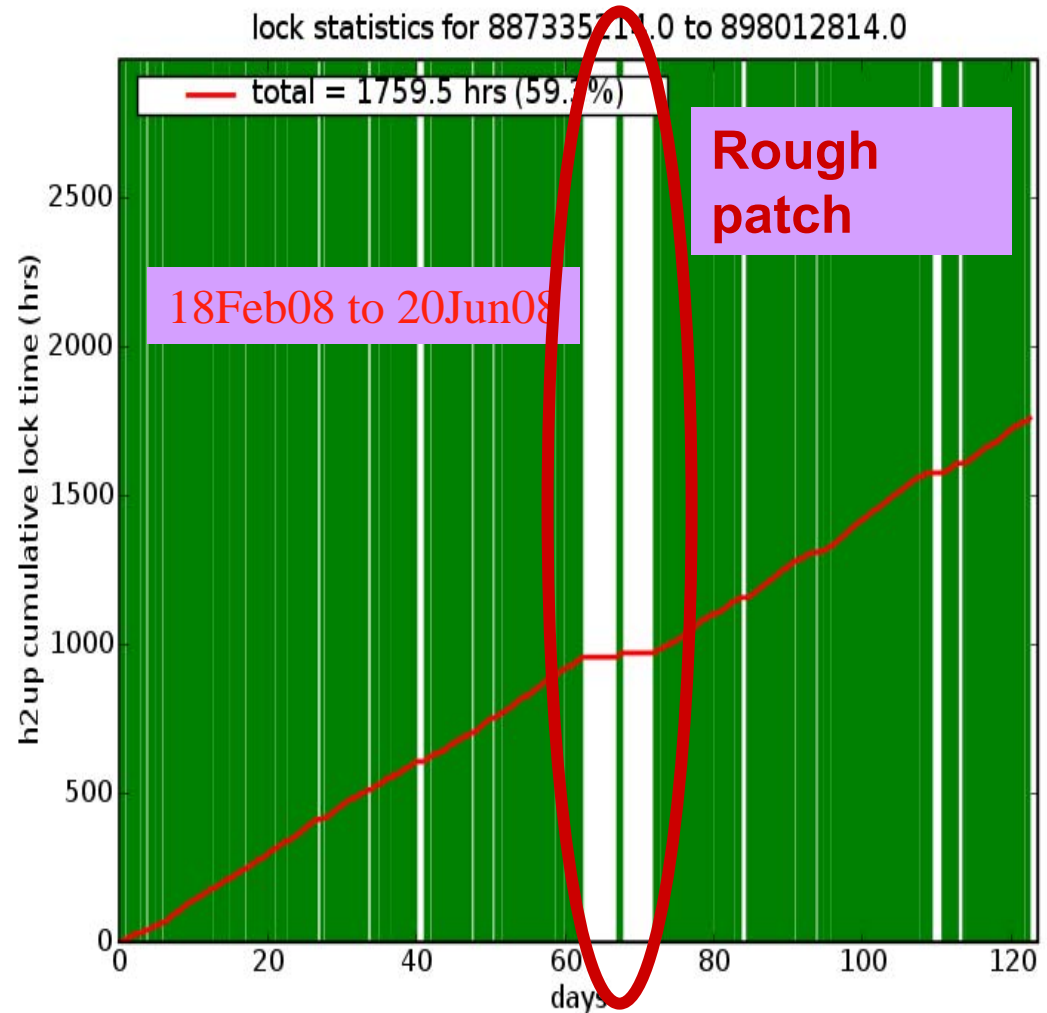
AstroWatch Operations

Duty factors:

Science mode – 33%

Power-up or science mode – 59%

Archiving 12-20 hours of data per day



AstroWatch Operations

Rough patch:

Students attacked problem doggedly

Chased many red herrings



**But “good exercise” in troubleshooting
(eliminating explanations)**

**Problem turned out to be obscure feature of EPICS
controls system screens!
(operator “lore” came to the rescue)**

Tough lesson at the school of hard locks

AstroWatch Operations

Why is “Power-up mode” legitimate to count in livetime?

Scenario:

Students go home at 4:00 a.m.

H2 falls out of lock at 4:30 a.m., automatically reacquires lock and returns to full power by 5:00 a.m.

Gravitational wave burst arrives at 5:30 a.m.

Data could easily be just as good as that collected at 3:00 a.m.
when scientists on duty to confirm quality

But would we dare publish?

AstroWatch Operations

Yes! (maybe)

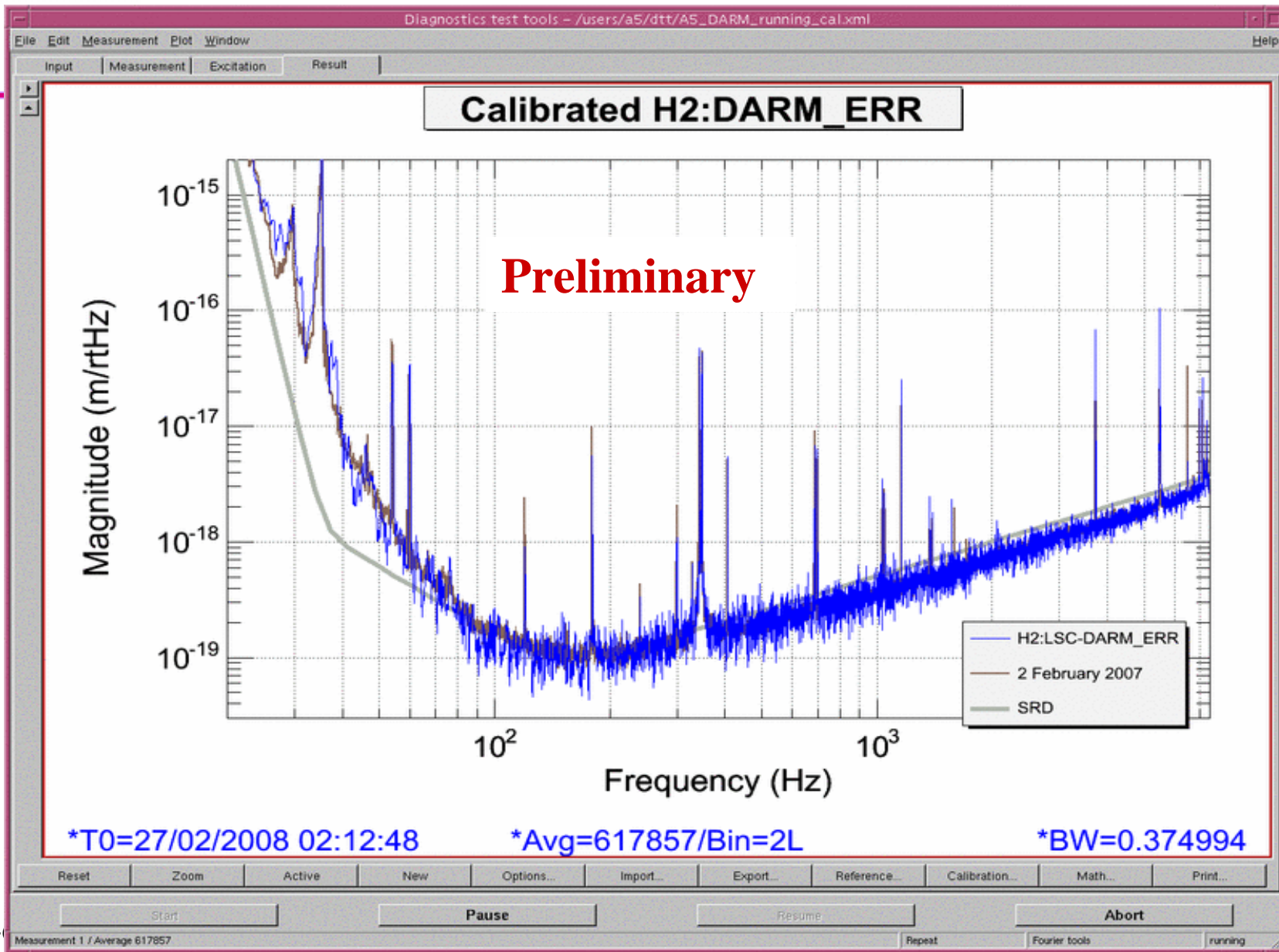
Precedent:

First AstroWatch run (much less formal) coincided with giant flare from **SGR 1806-20** (magnetar) on December 27, 2004

No declaration of science mode, but data turned out to be clean

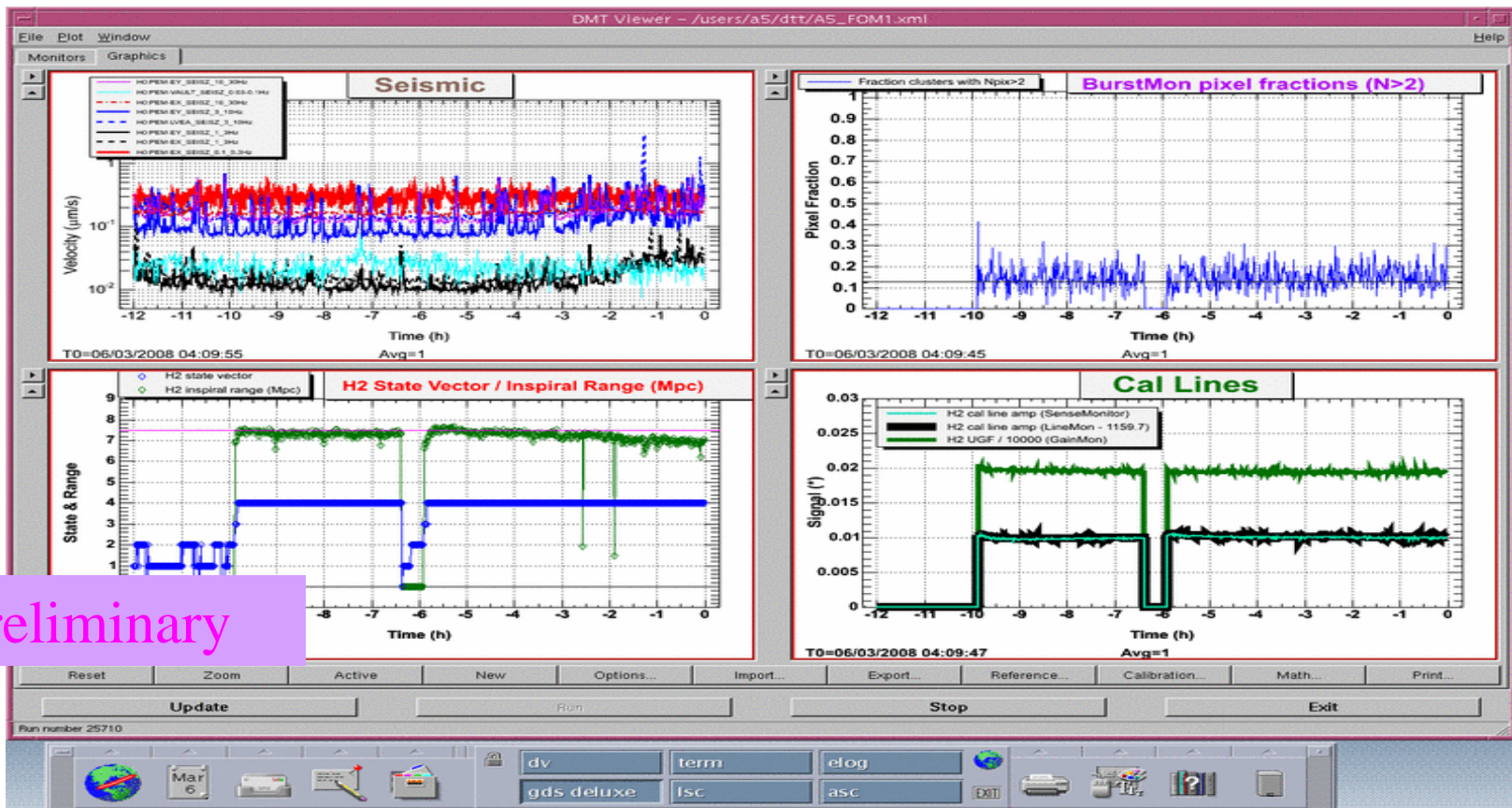
Led to *Physical Review D* article limiting GW emission from flare
– PRD 76 (2007) 062003

H2 running well, considering...



AstroWatch Operations

H2 range varies 6-7.5 Mpc, depending on eLIGO activity/hardware.
 Compares well to H1 range during SGR1806-20 of ~5.7 Mpc.



Preliminary

AstroWatch Operations

AstroWatch's primary scientific goal (long shot):

Galactic supernova watch

Secondary goal (set limits on – or detect – faint but common sources):

Gamma Ray Bursts (GRBs) – 51 so far since Feb 18

11 in G1-H2 coincidence (science mode)

28 in G1-only time

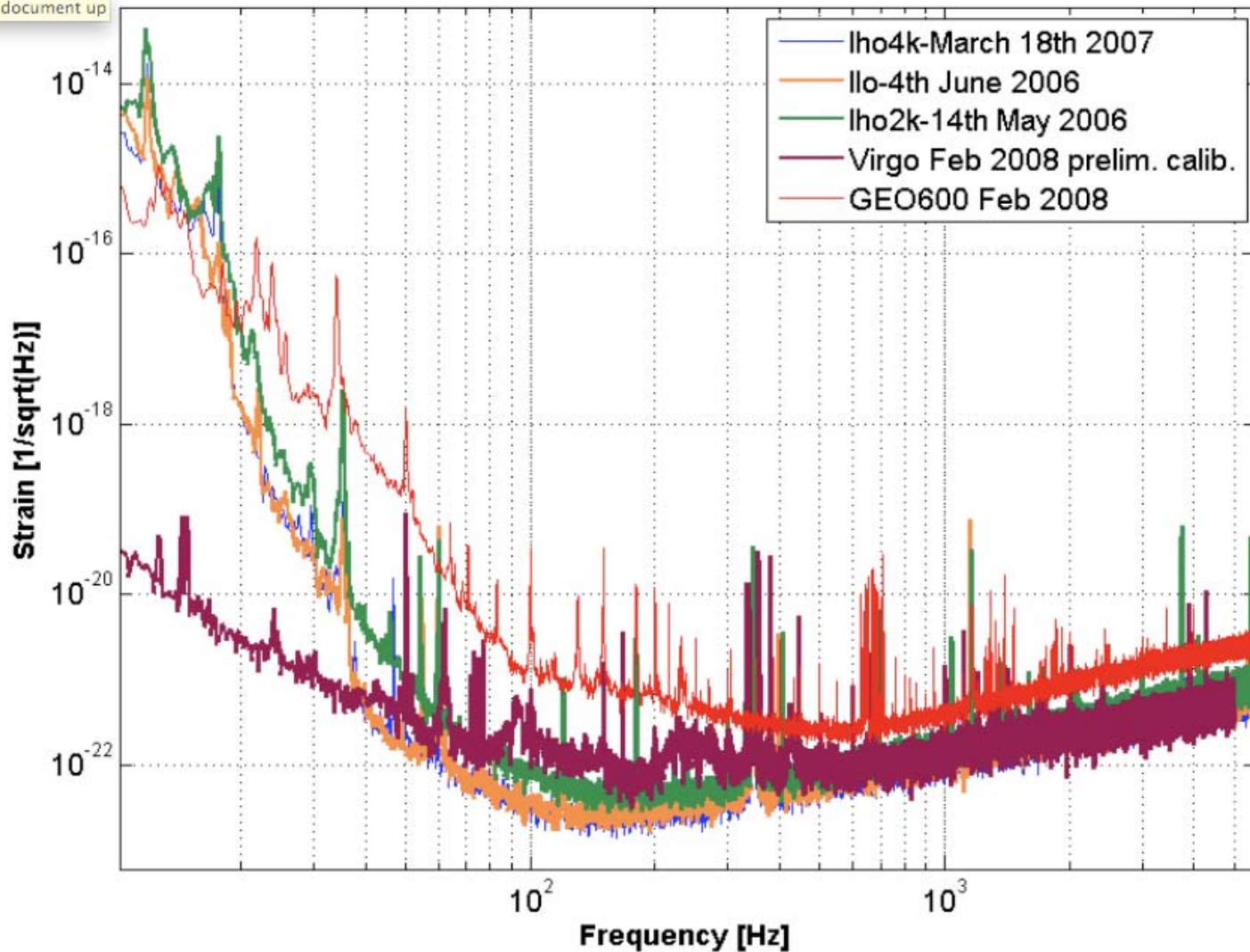
4 in H2-only time

8 when neither detector in science mode

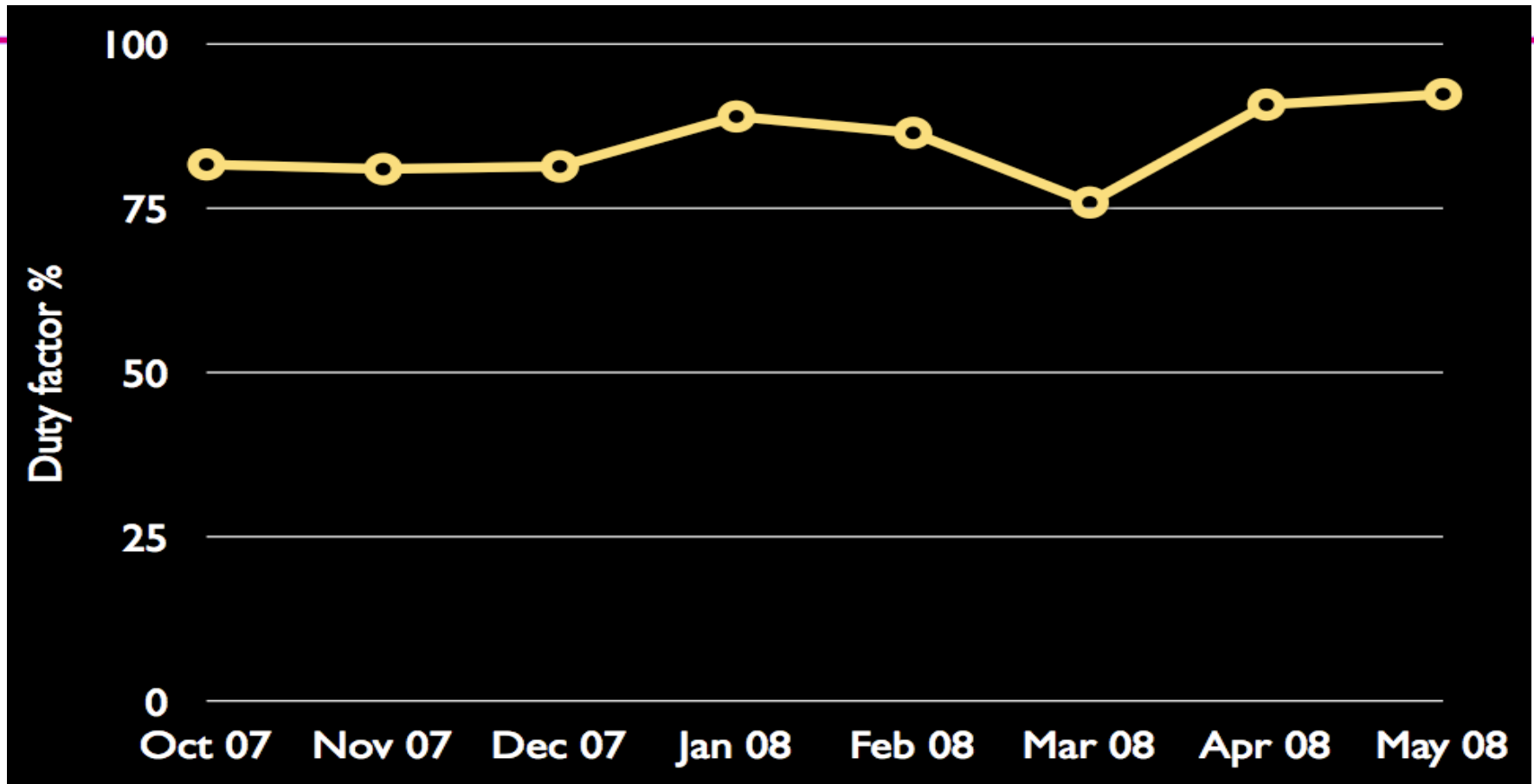
**Will likely publish only unusually energetic events (incl. SGRs)
(precedent: GRB070201 in S5 – ruled out inspiral in Andromeda
– article to appear in *Astrophysics Journal*)**

How is GEO doing?

Scale document up



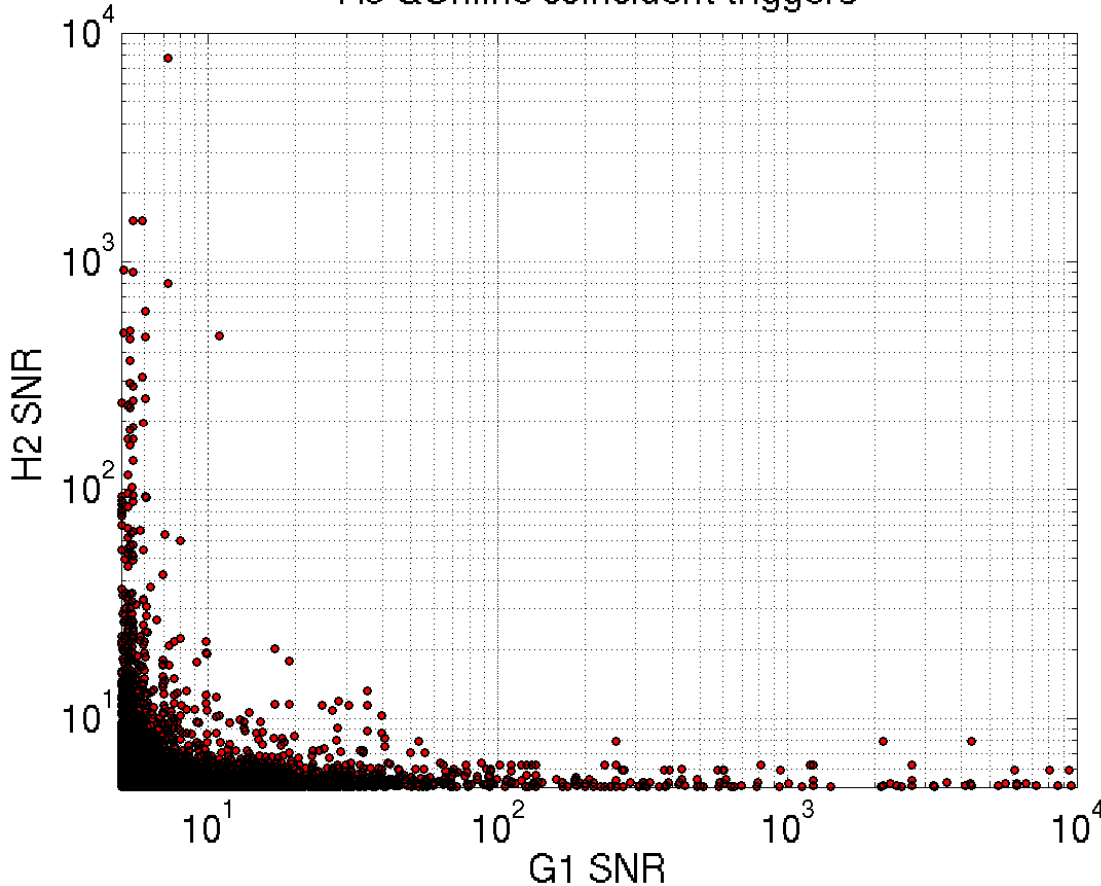
How is GEO doing?



Typically exceeds goal of 80% duty factor

Prototype Online Analysis

A5 QOnline coincident triggers



Sample output from “Q online” search pipeline looking at coincident H2-GEO triggers

Good preparation for S6

Search groups, detector characterization, and software working groups ramping up to do ELIGO analysis in near real-time

AstroWatch will serve as proving ground

Summary

AstroWatch succeeding – maintaining decent duty factors for H2 and GEO, all things considered

- **Hoping for discovery**
- **Addressing obligation to astronomy community (& taxpayers!) to maintain reasonable coverage**

But more student manpower could raise duty factor further in coming months (especially some months!)

Enlarging community of IFO-savvy LSC scientists – good for GW field's future

**Serving as testbed for ambitious online analysis in ELIGO
LSC aspires to issue astronomical alerts to SWIFT, ROTSE, etc.**