Ligo Update

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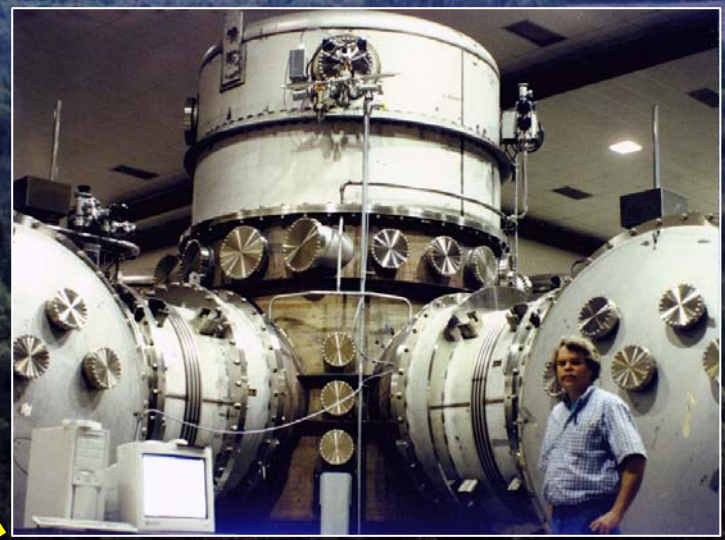
On behalf of the Ligo Collaboration

*Slides Cheerfully stolen from everyone careless enough to make their slides public

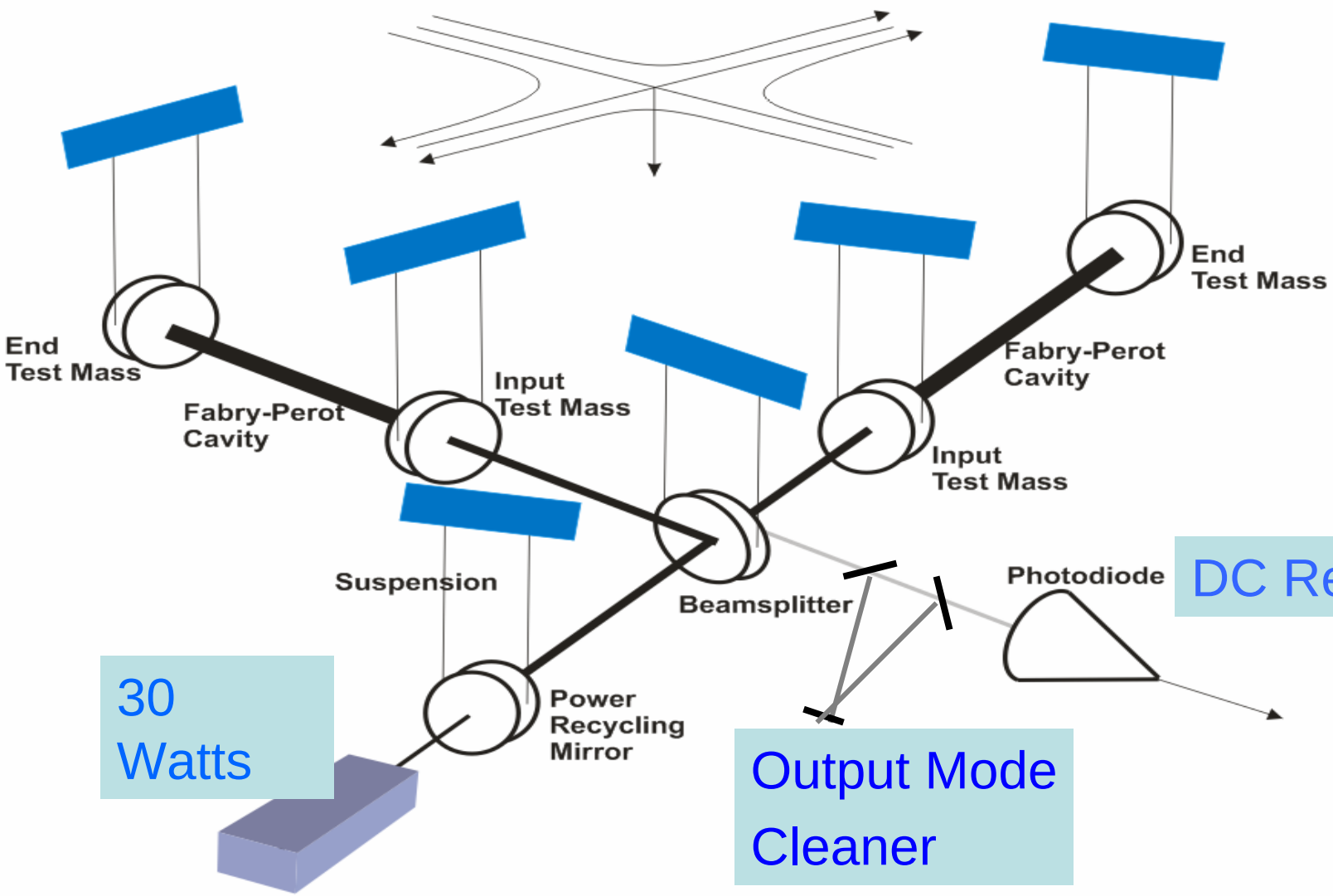
LIGO Livingston



LIGO Hanford

Lots of Institutions

Enhanced Ligo

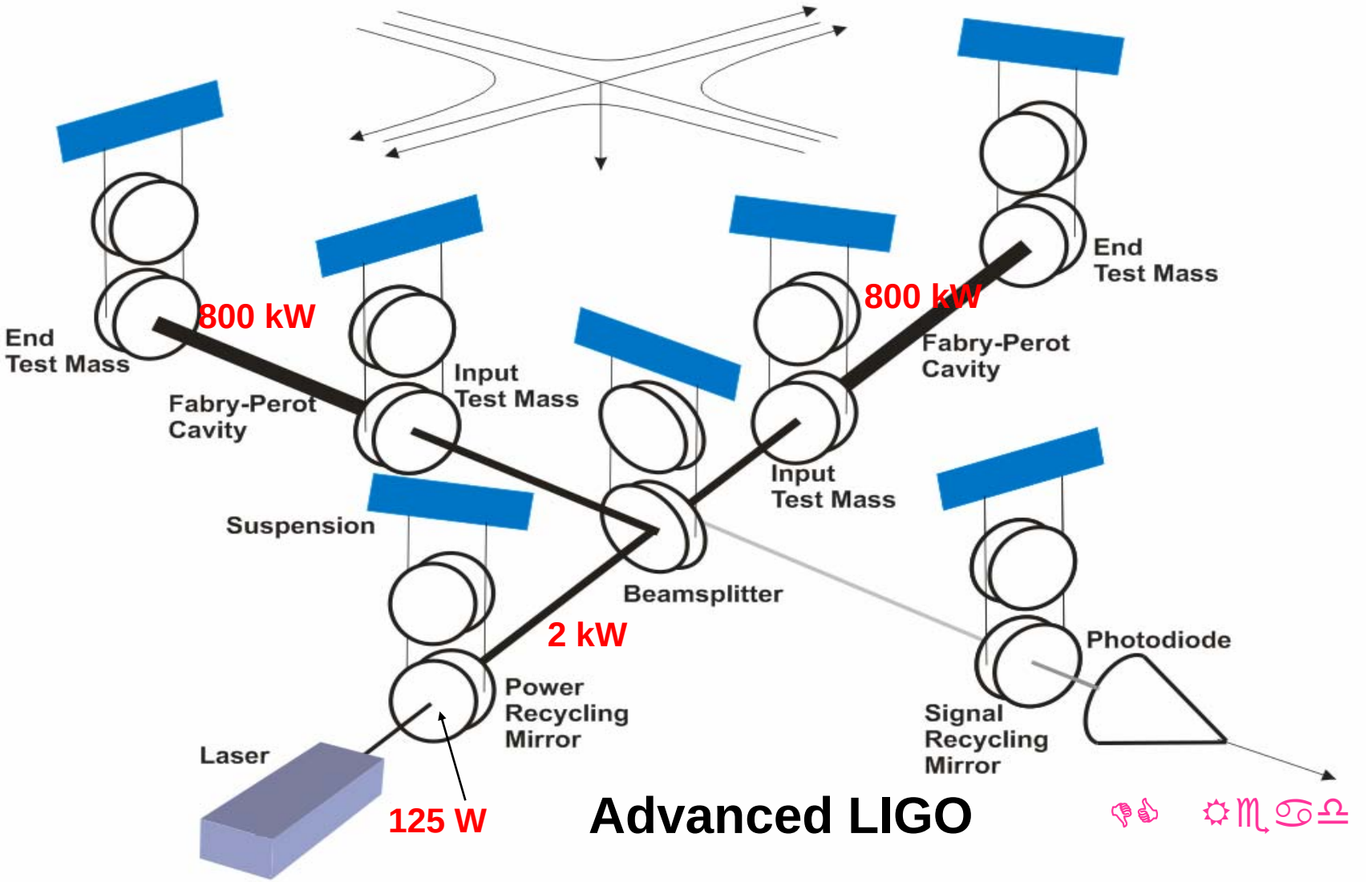


30 Watts

Output Mode Cleaner

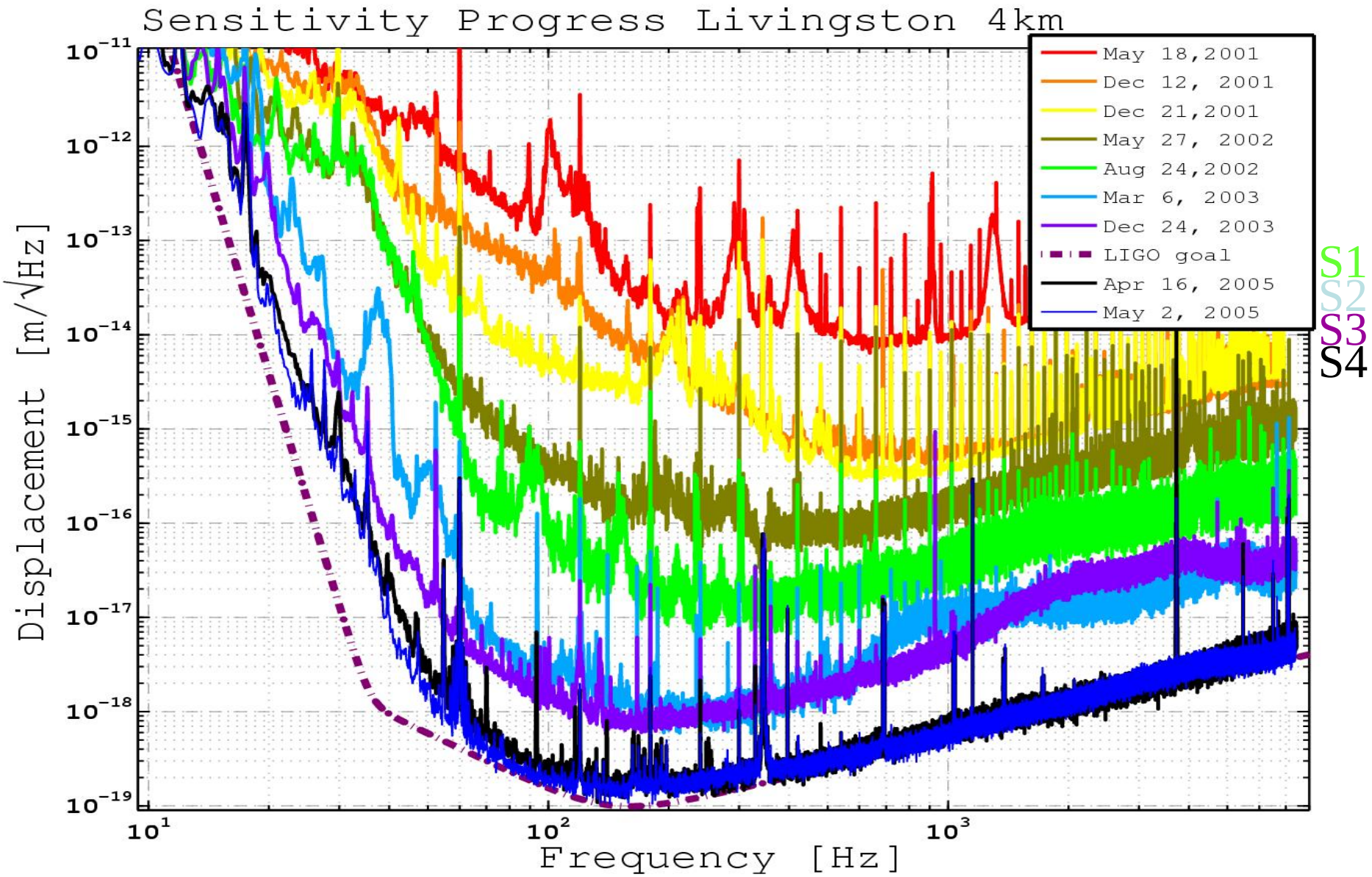
DC Read Out

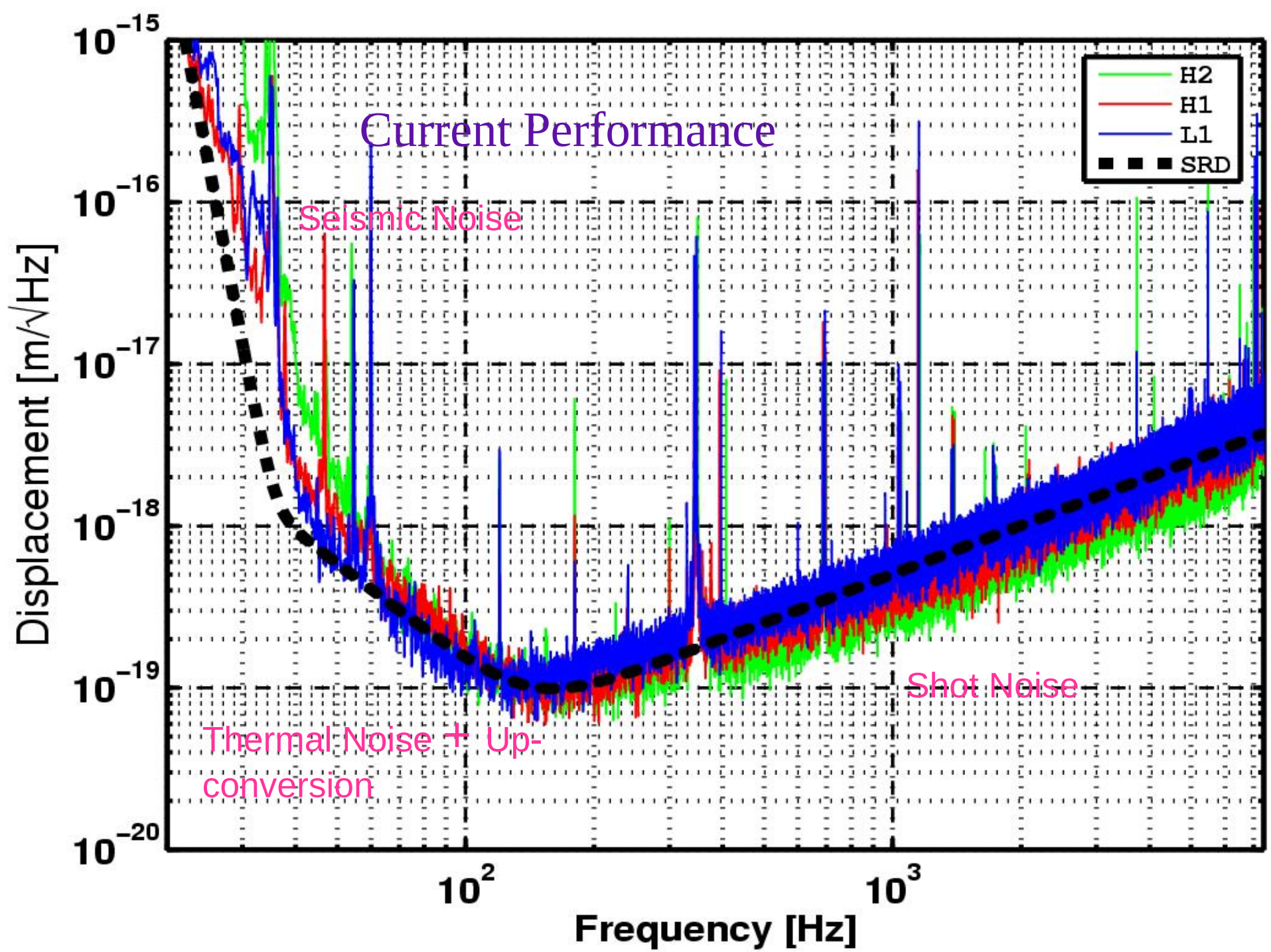
Advanced LIGO

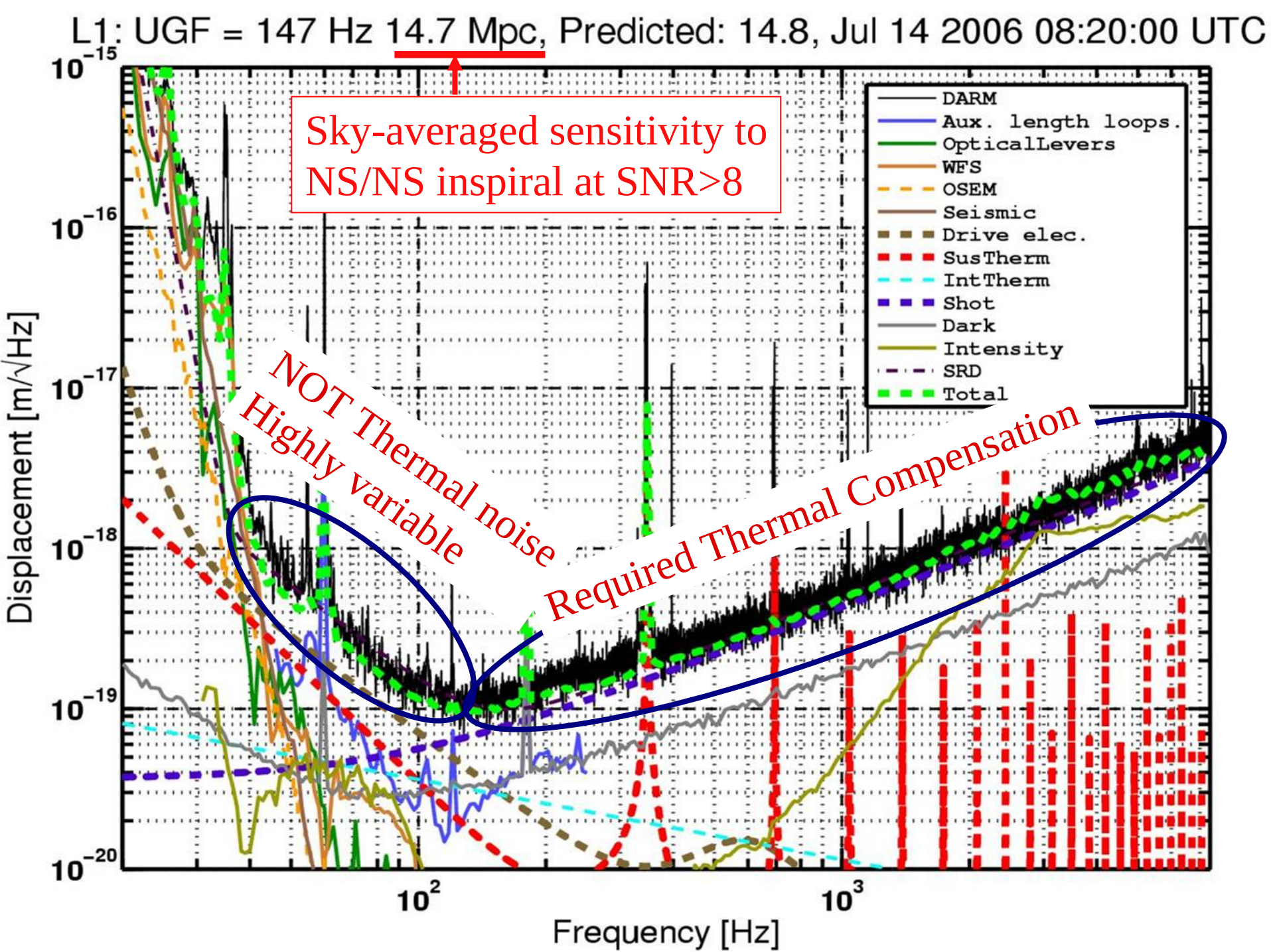


Advanced LIGO

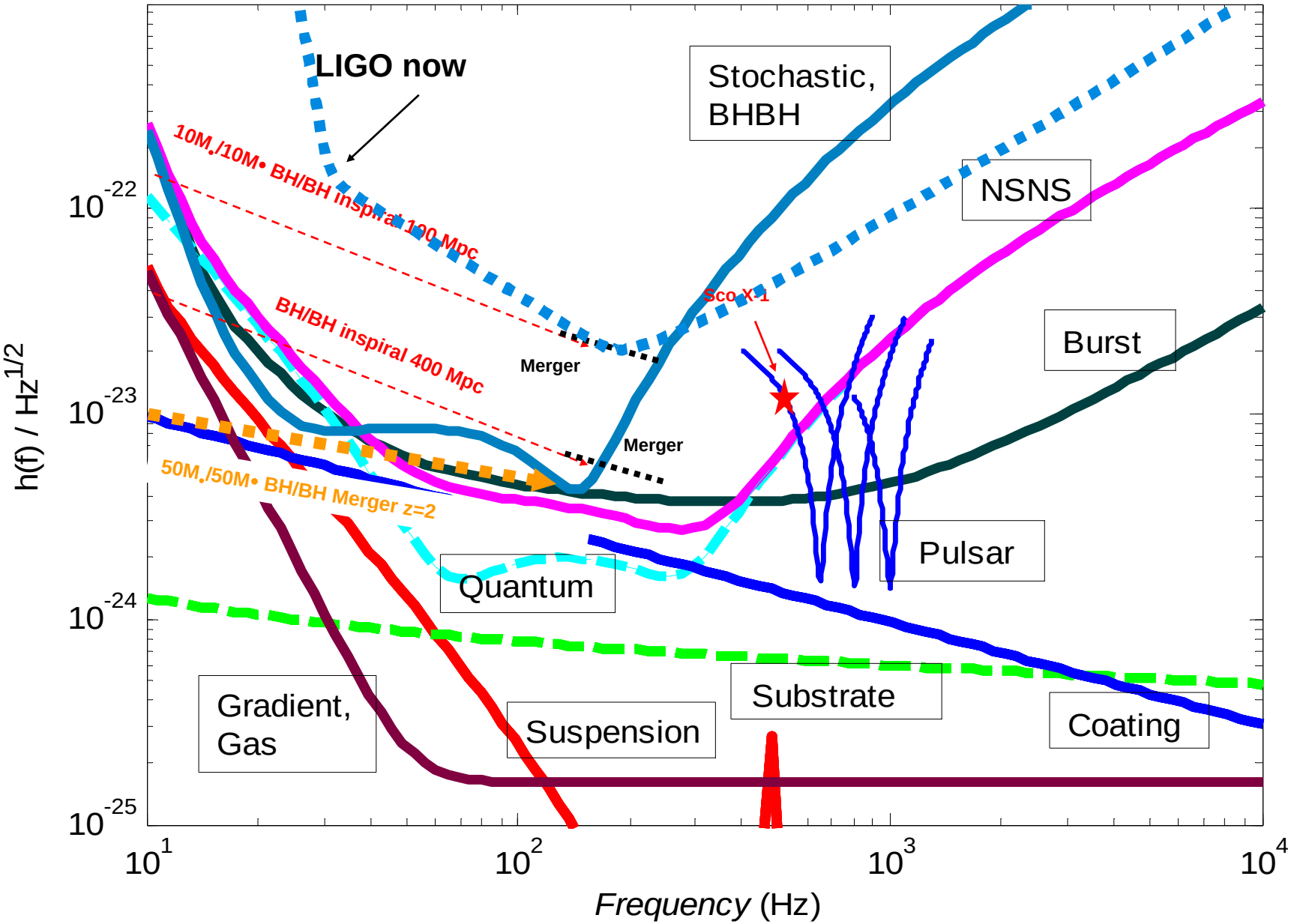
Early Noise Progression Livingston 4km

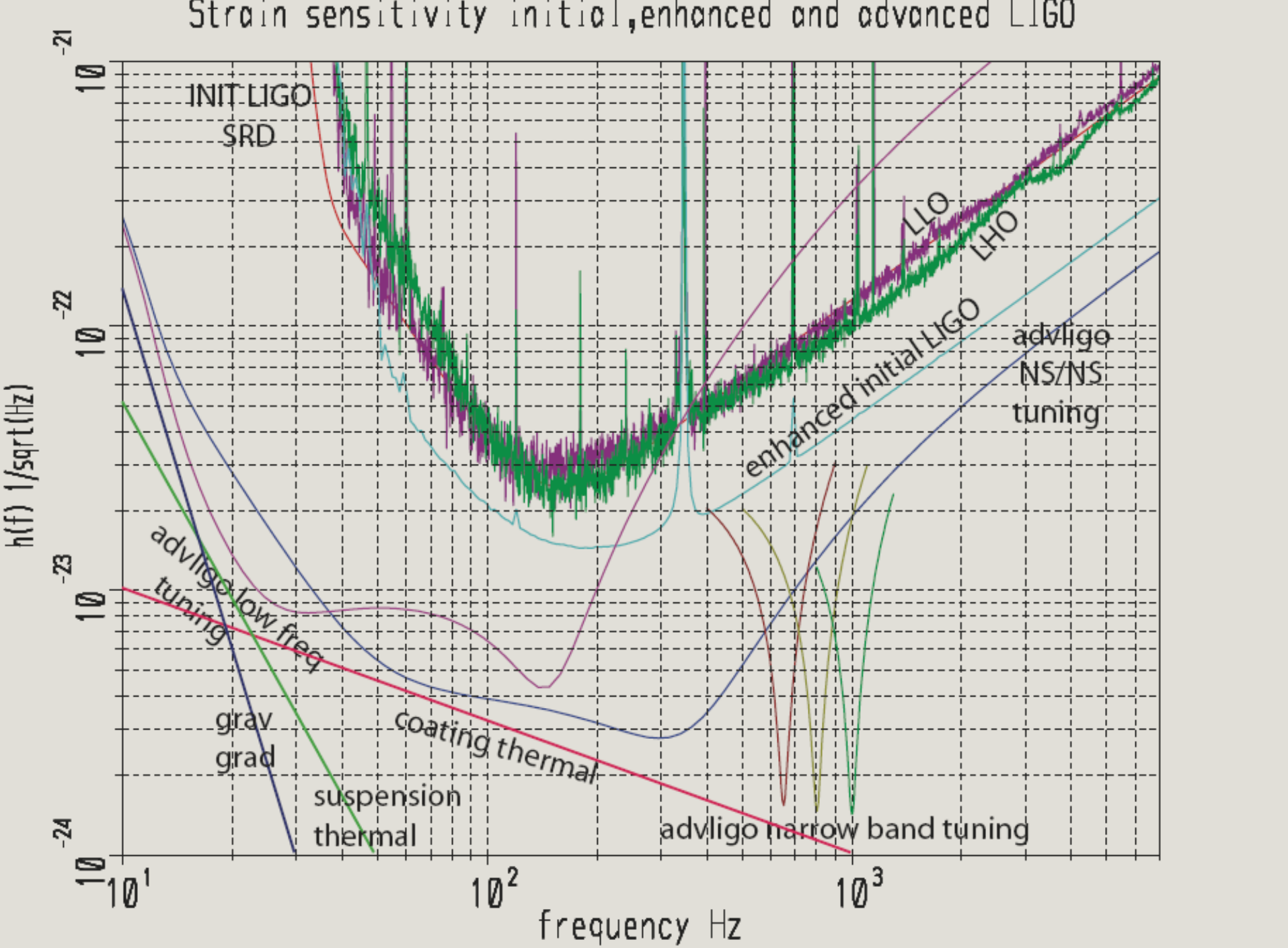



Current Performance
Seismic Noise
Thermal Noise + Up-conversion
Shot Noise
H2
H1
L1
SRD
Displacement [m/√Hz]
Frequency [Hz]
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^2
10^3

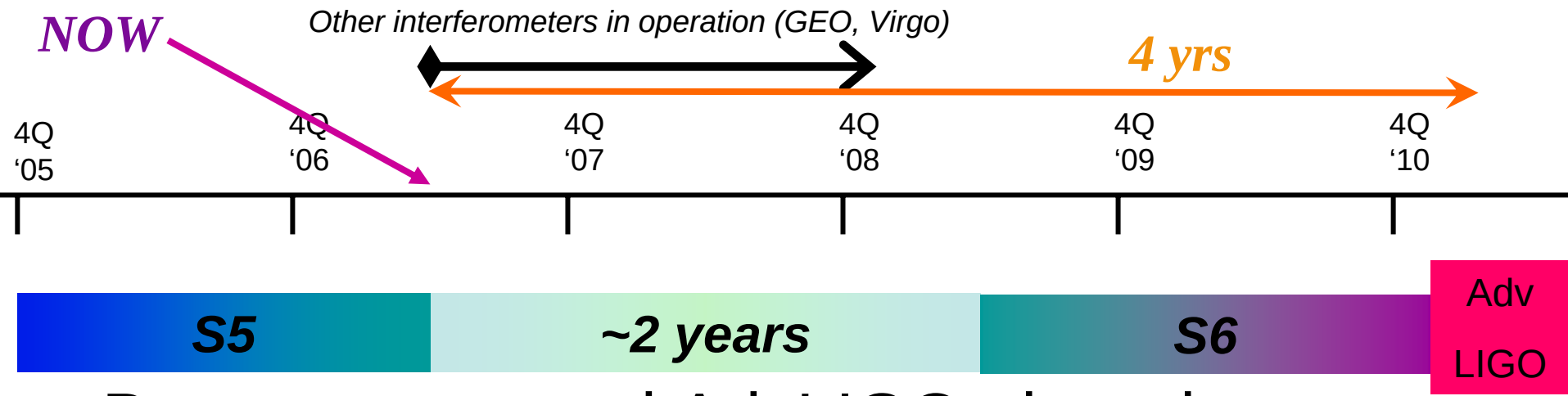

L1: UGF = 147 Hz 14.7 Mpc, Predicted: 14.8, Jul 14 2006 08:20:00 UTC
Sky-averaged sensitivity to
NS/NS inspiral at SNR>8
NOT Thermal noise
Highly variable
Required Thermal Compensation
DARM
Aux. length loops.
OpticalLevers
WFS
OSEM
Seismic
Drive elec.
SusTherm
IntTherm
Shot
Dark
Intensity
SRD
Total
Displacement [m/√Hz]
Frequency [Hz]
10^-15
10^-16
10^-17
10^-18
10^-19
10^-20
10^2
10^3

Advanced Ligo




Strain sensitivity initial,enhanced and advanced LIGO
INIT LIGO
SRD
LLO
LHO
enhanced initial LIGO
advligo
NS/NS
tuning
advligo low freq
tuning
grav
grad
coating thermal
suspension
thermal
advligo narrow band tuning
h(f) 1/sqrt(Hz)
frequency Hz
10^-21
10^-22
10^-23
10^-24
10^1
10^2
10^3

The next several years



- Between now and AdvLIGO, there is some time to improve…

1) ~Few years of hardware improvements +

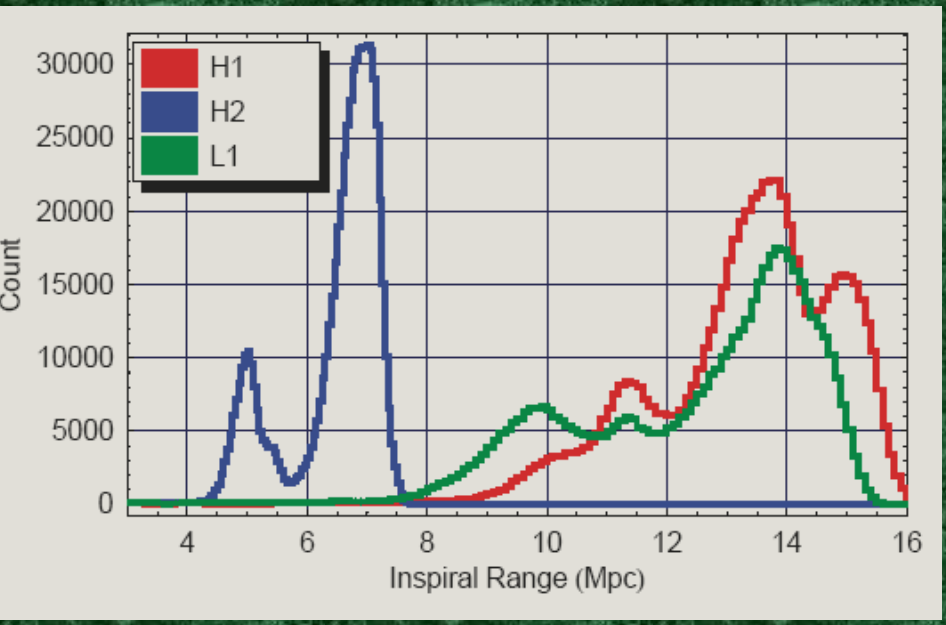
1 ½ year of observations.

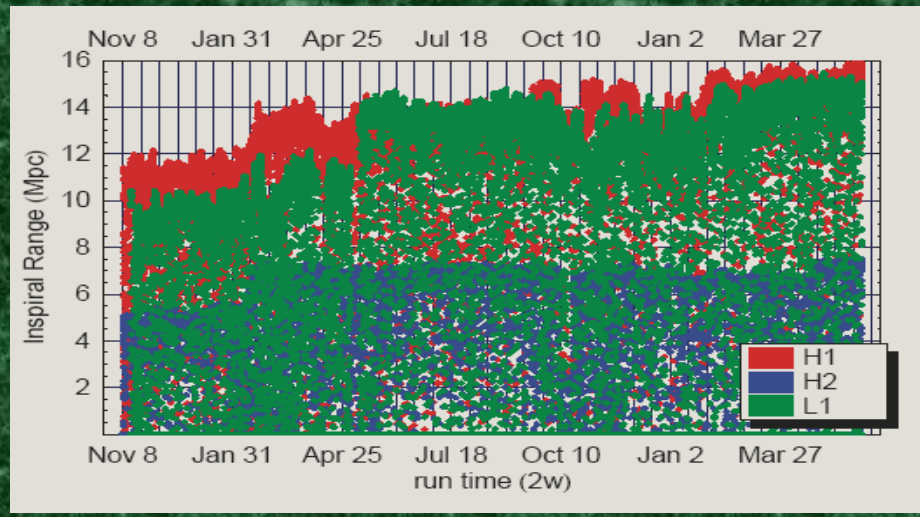
1) Factor of ~2.5 in noise, factor of ~10 in event rate.

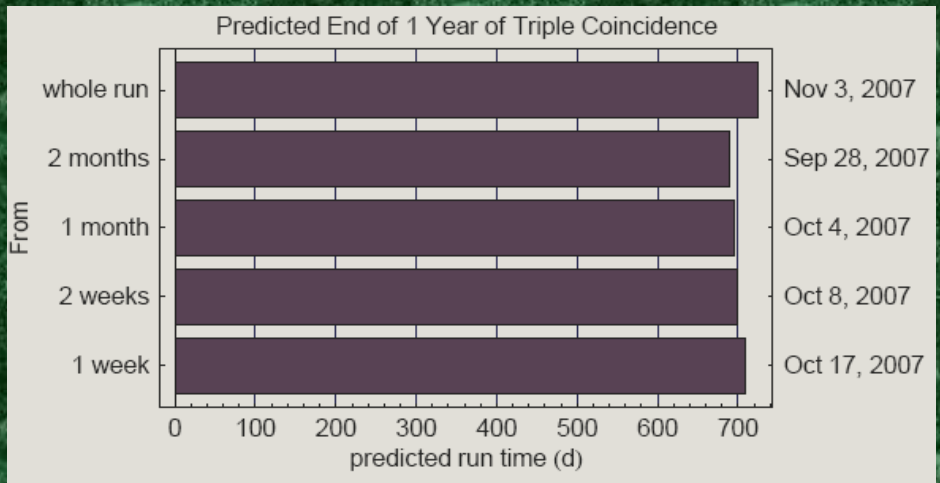
2) 3-6 interferometers running in coincidence !

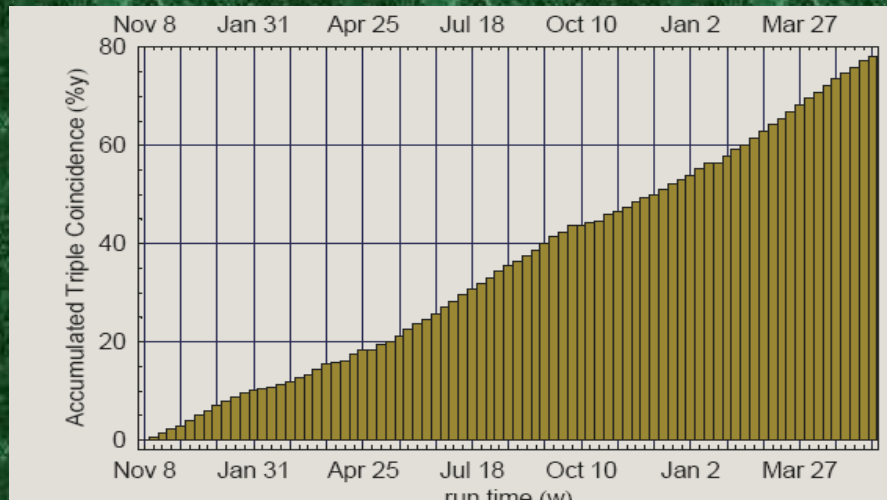
S5 Progress So Far

As of May 29, 2007

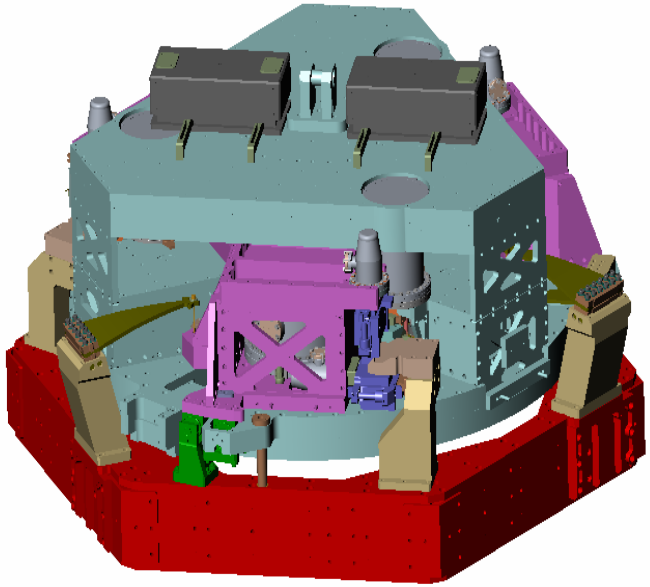


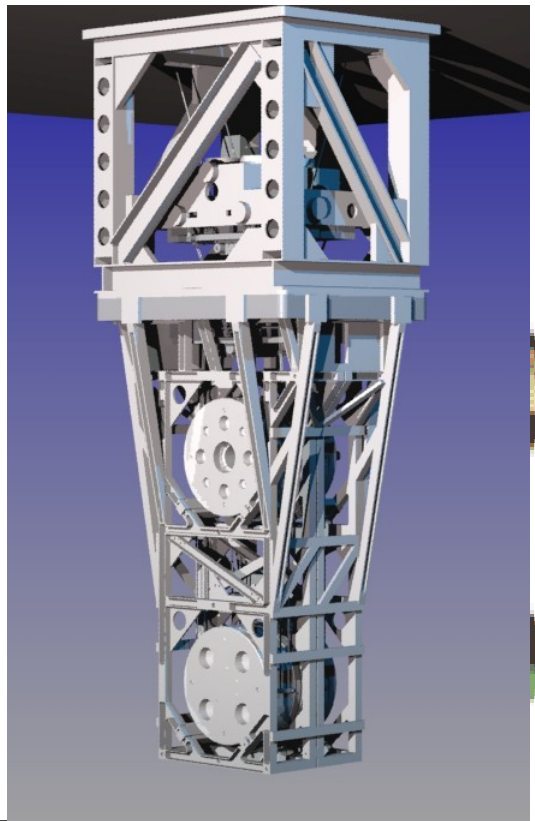


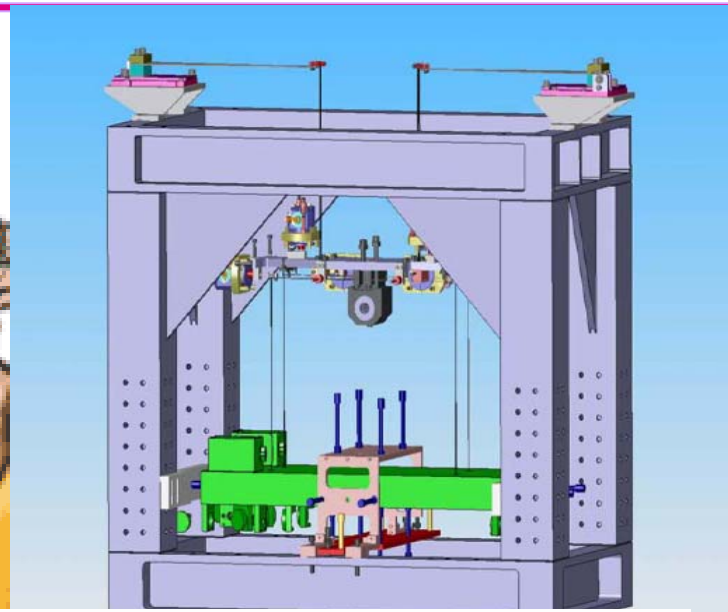


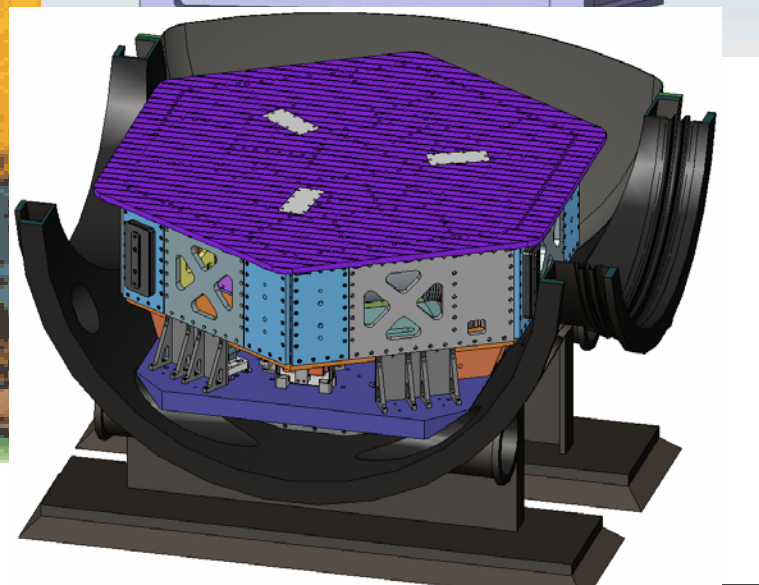


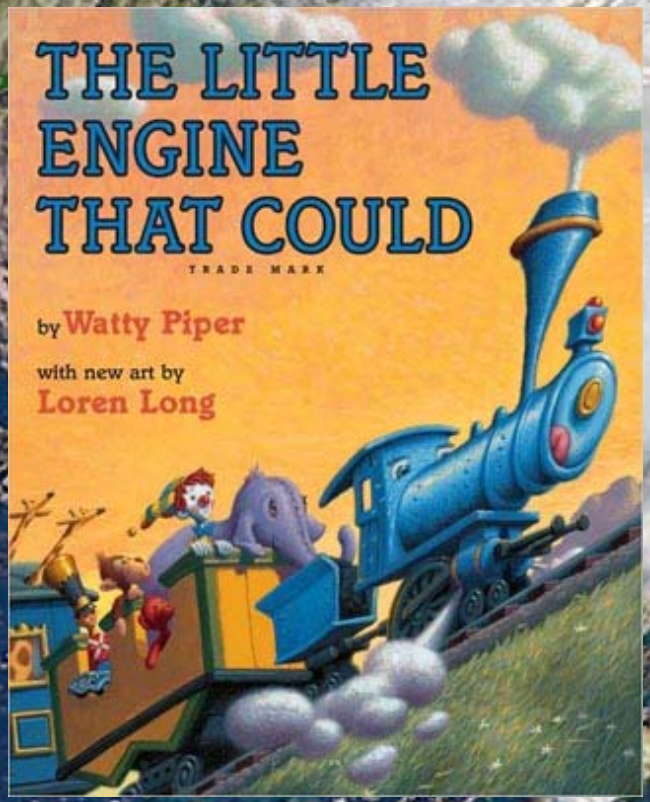
Seismic Noise

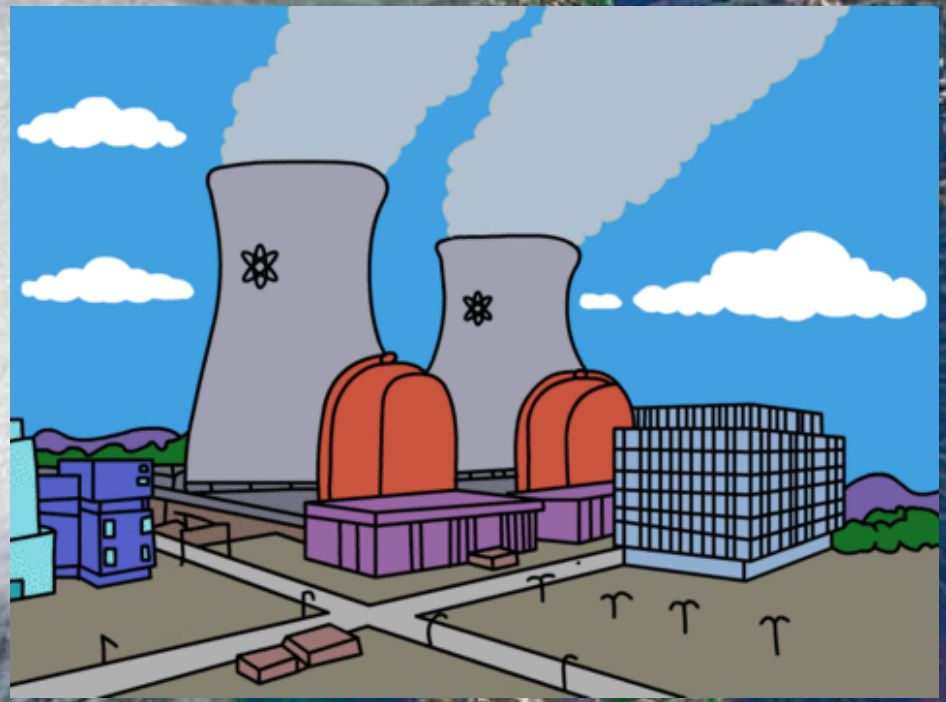




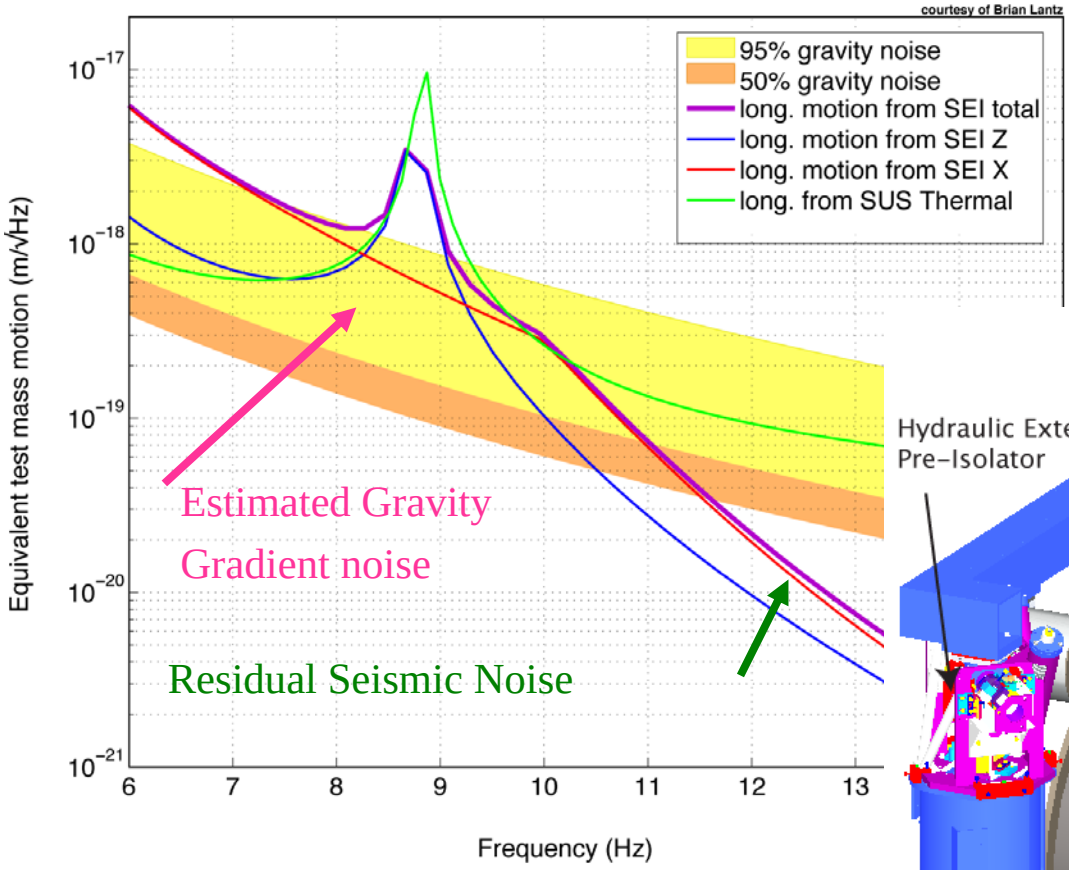


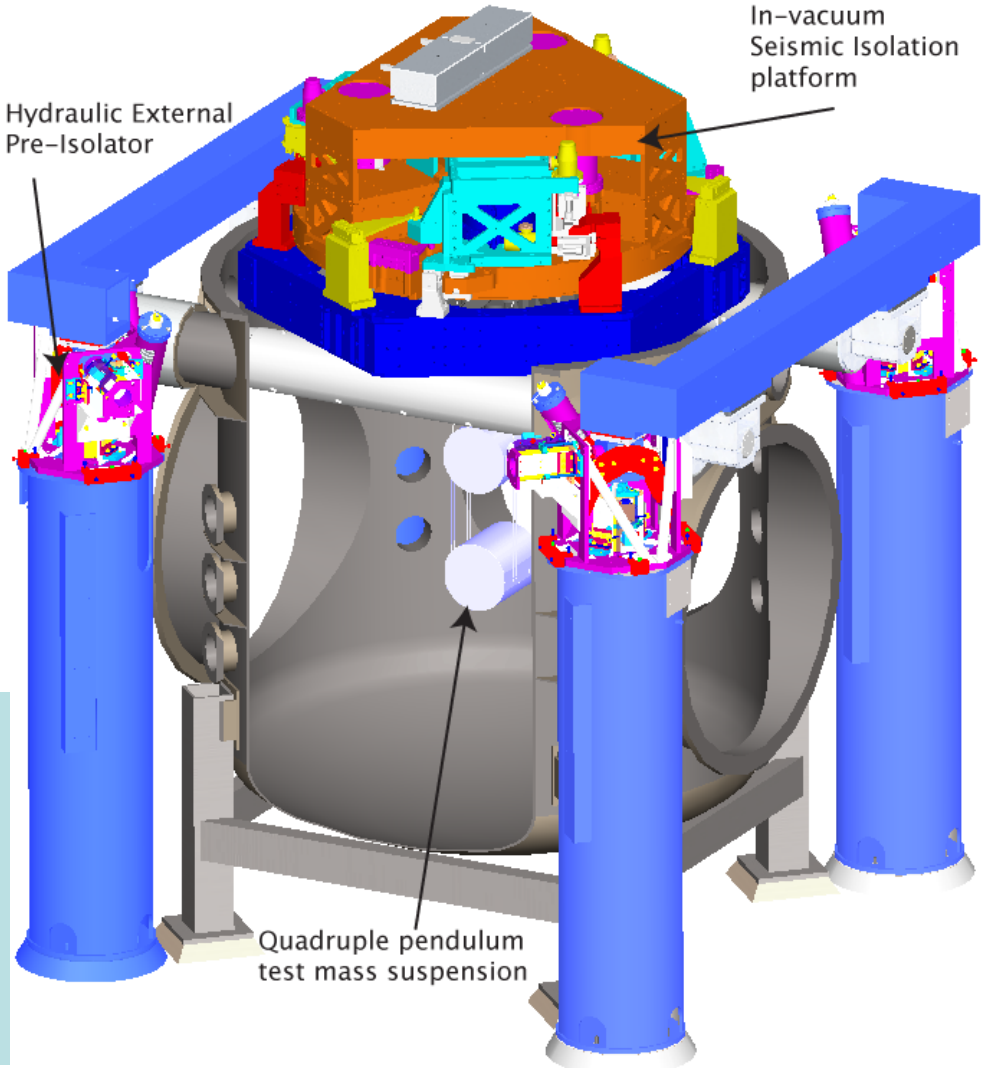






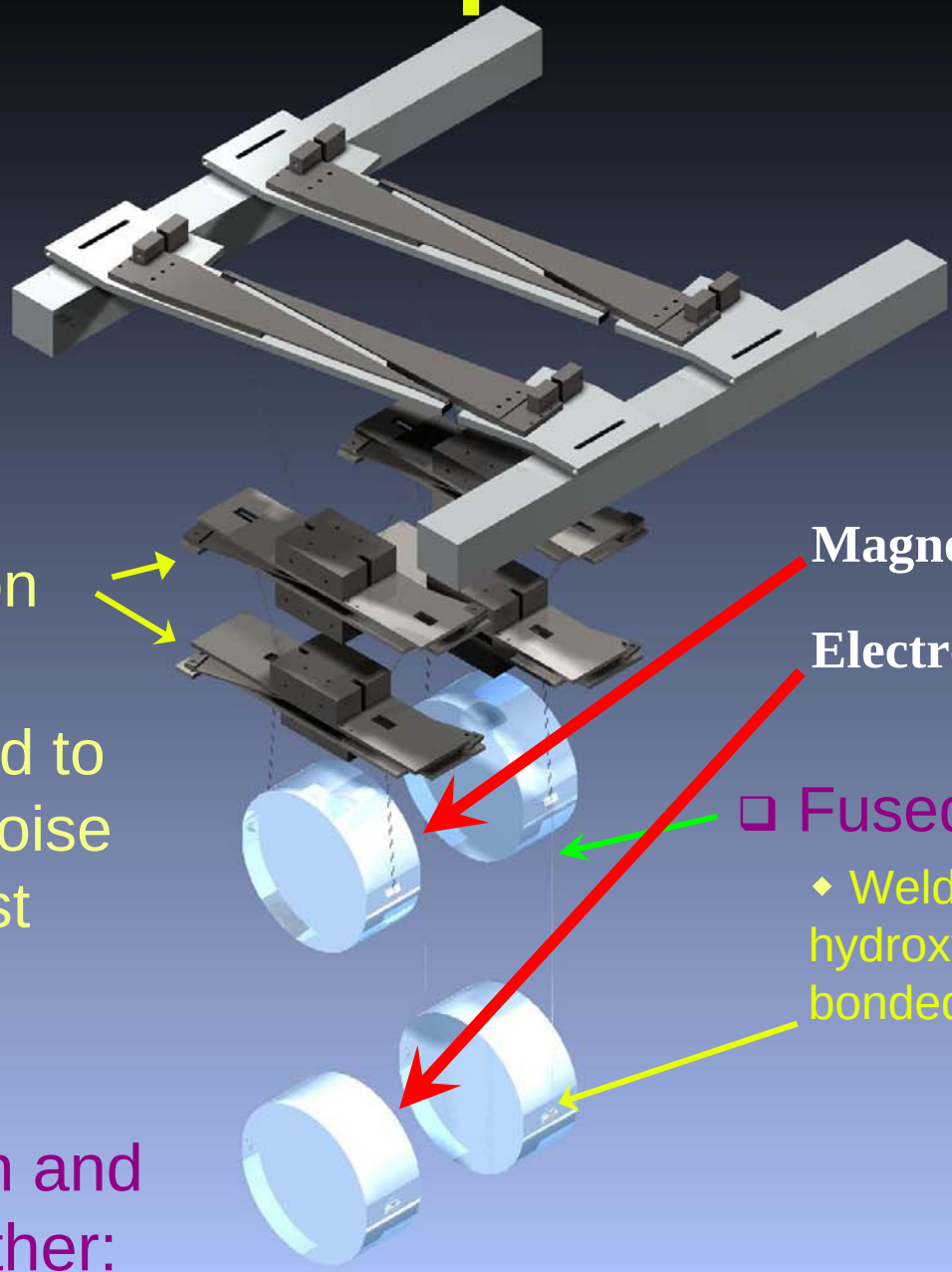
Hurric
27 Sep
GOES p





Advance Ligo Seismic Isolation is designed so as not to be a limiting noise source

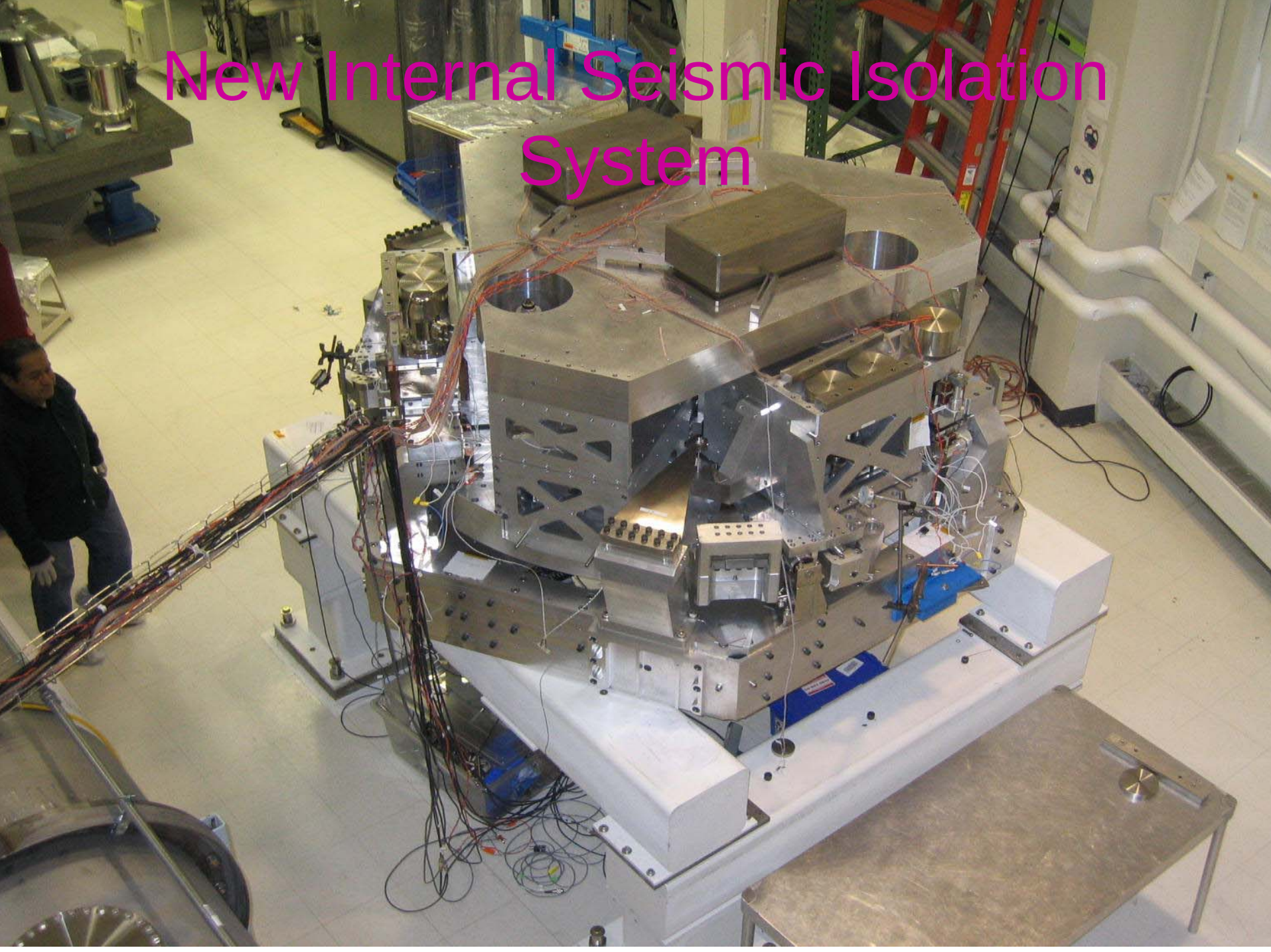
Quad Suspensions



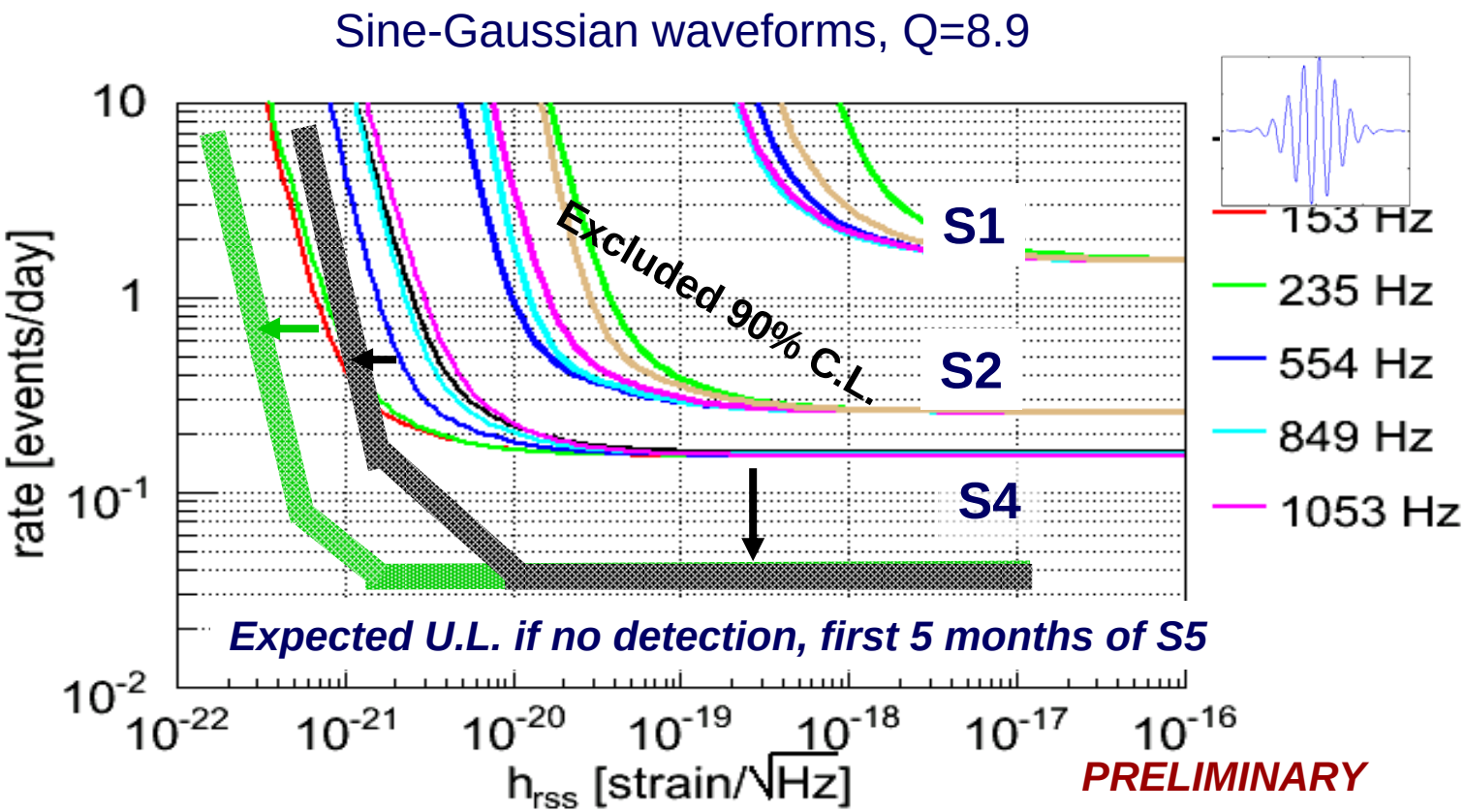
- Quadruple pendulum:
  - ~10^7 attenuation @10 Hz
  - Controls applied to upper layers; noise filtered from test masses
- Seismic isolation and suspension together:

- Fused silica fiber
  - Welded to 'ears', hydroxy-catalysis bonded to optic

New Internal Seismic Isolation System



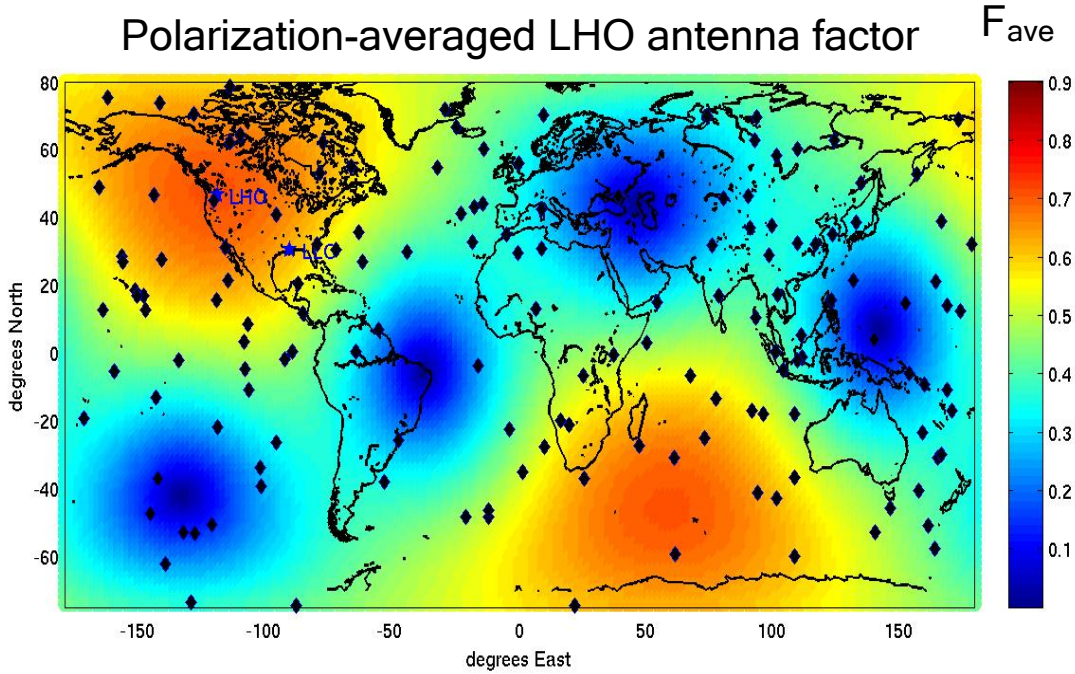
LSC Burst Search from S1 to S5



$$h_{\mathrm{rss}} \equiv \sqrt{\int \left(|h_+(t)|^2 + |h_\times(t)|^2\right) dt}$$

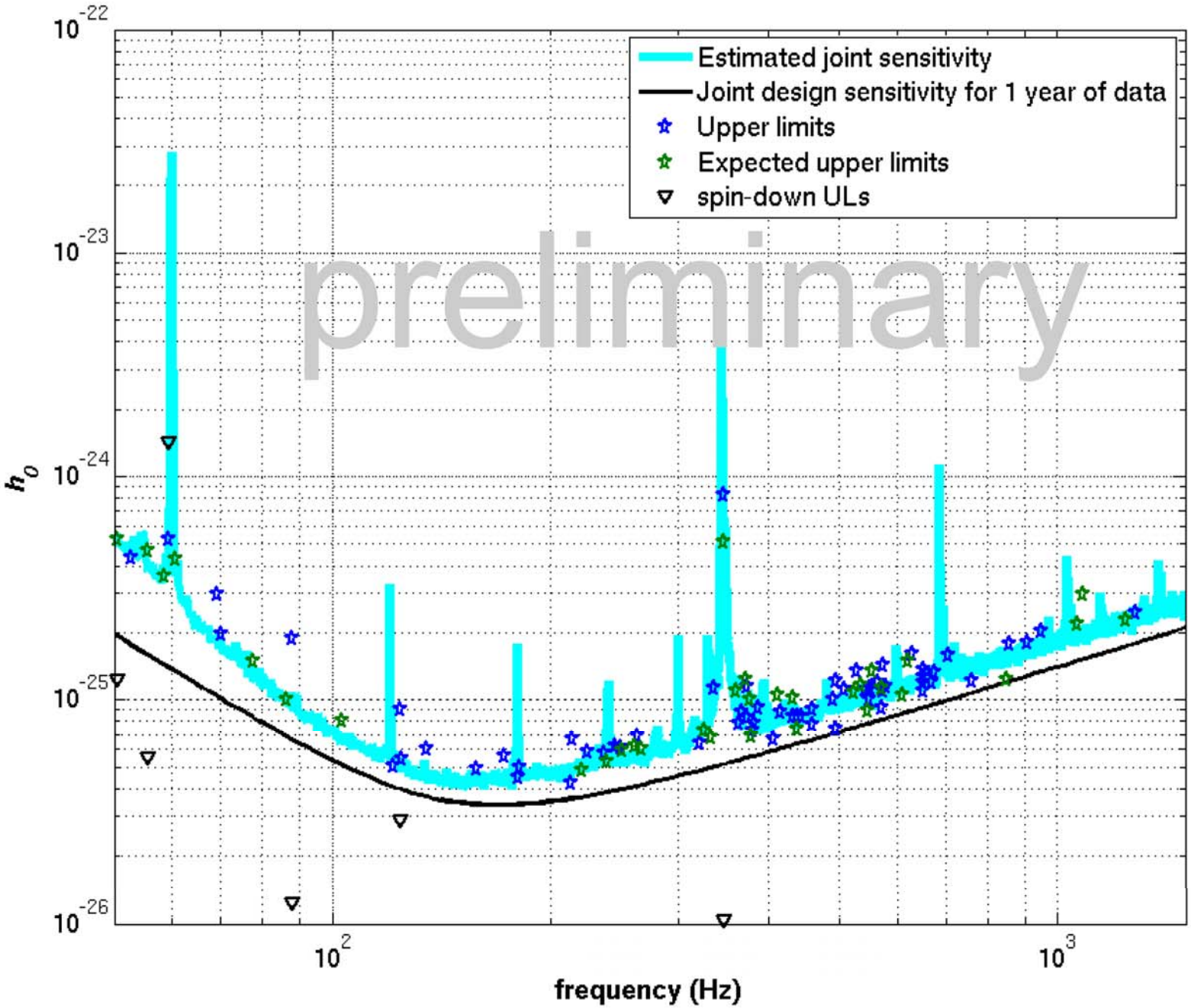
The current GRB sample for the LIGO S5 run

- 157 GRB triggers from November 4, 2005 to March 31, 2007
  - ~70% with double-IFO coincidence LIGO data
  - ~40% with triple-IFO coincidence LIGO data
  - ~25% with redshift
  - ~10% short-duration GRBs
  - all but two have have position information



LIGO sensitivity depends on GRB position

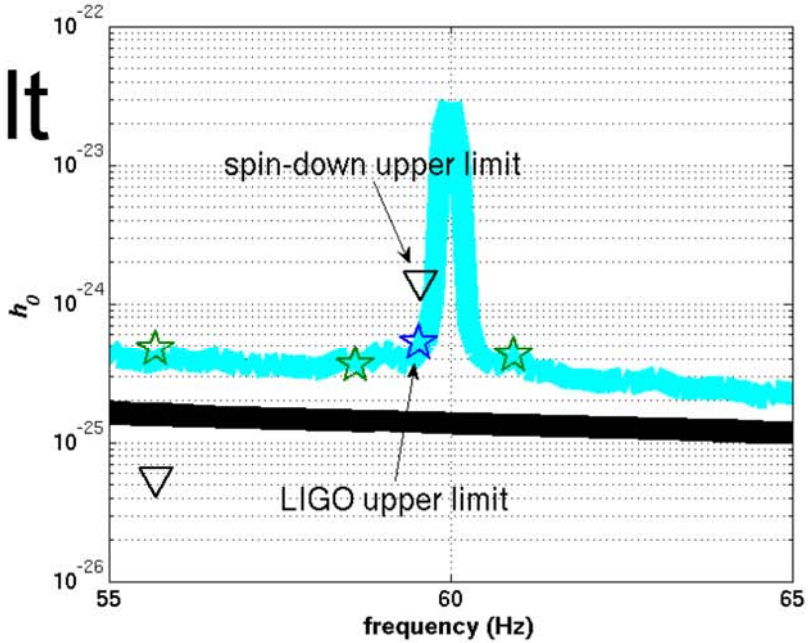
- analysis is ongoing

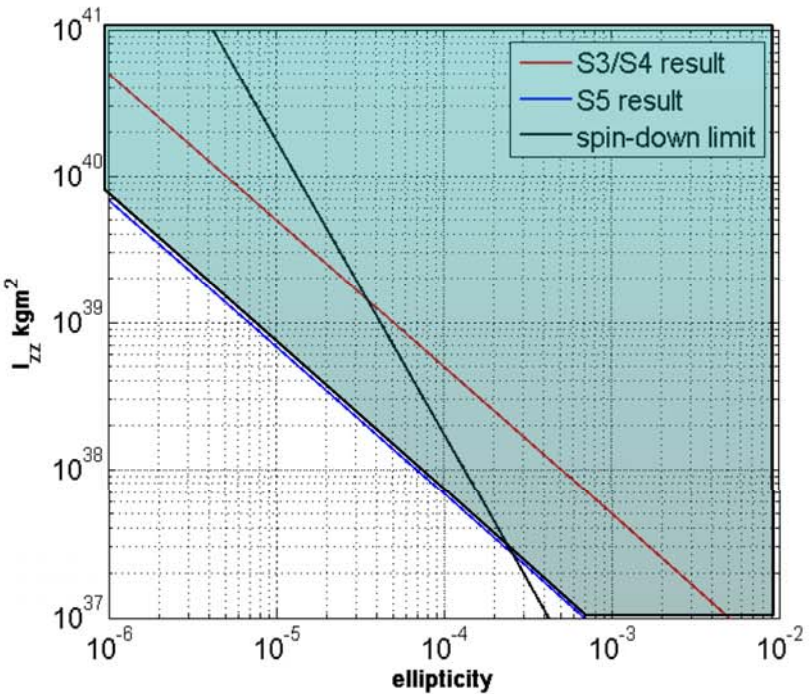


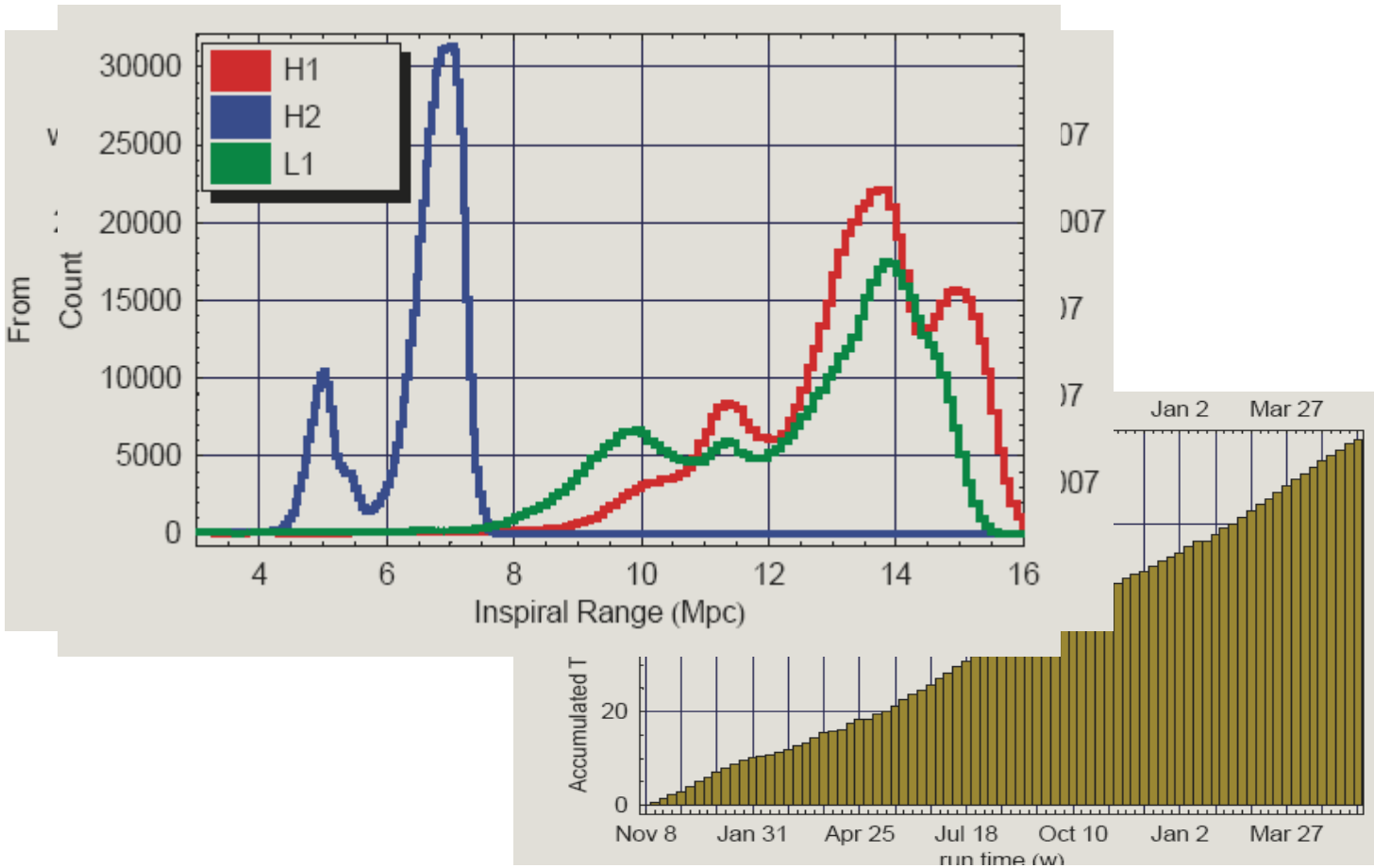
- **Black** curve represents one full year of data for all three interferometers running at design sensitivity
- **Blue** stars represent pulsars for which we are reasonably confident of having phase coherence with the signal model
- **Green** stars represent pulsars for which there is uncertainty about phase coherence

Crab pulsar - result

- These results give upper limits for the Crab pulsar of $\varepsilon < 2.8 \times 10^{-4}$, $h_0 < 5.2 \times 10^{-25}$
  - » this value of the ellipticity is now in the range of some of the more speculative equations of state (Owen, 2005)
- These beat the spin-down limit of $h_0 < 1.4 \times 10^{-24}$ by a factor of 2.7 – for canonical moment of inertia $I = 10^{38}$ kgm^2 - we even beat Palomba's limit
- Start to constrain the amount of spin-down energy in GWs to less than 10% of overall emitted and known spin-down (Palomba, 2000, Santostasi).
  - » This is significant: the ***uncertainties*** on all non-GW contributions add up to 80% of the total!
- Moment of inertia is uncertain by about a factor of three, but we can plot the result on the moment of inertia – ellipticity plane to give exclusion regions (Pitkin for the LSC, 2005)






H1
H2
L1
30000
25000
20000
15000
10000
5000
0
Count
From
4
6
8
10
12
14
16
Inspiral Range (Mpc)
Jan 2
Mar 27
Accumulated T
20
0
Nov 8
Jan 31
Apr 25
Jul 18
Oct 10
Jan 2
Mar 27
run time (w)