Staged approach to Advanced LIGO implementation

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Staged vs full upgrade

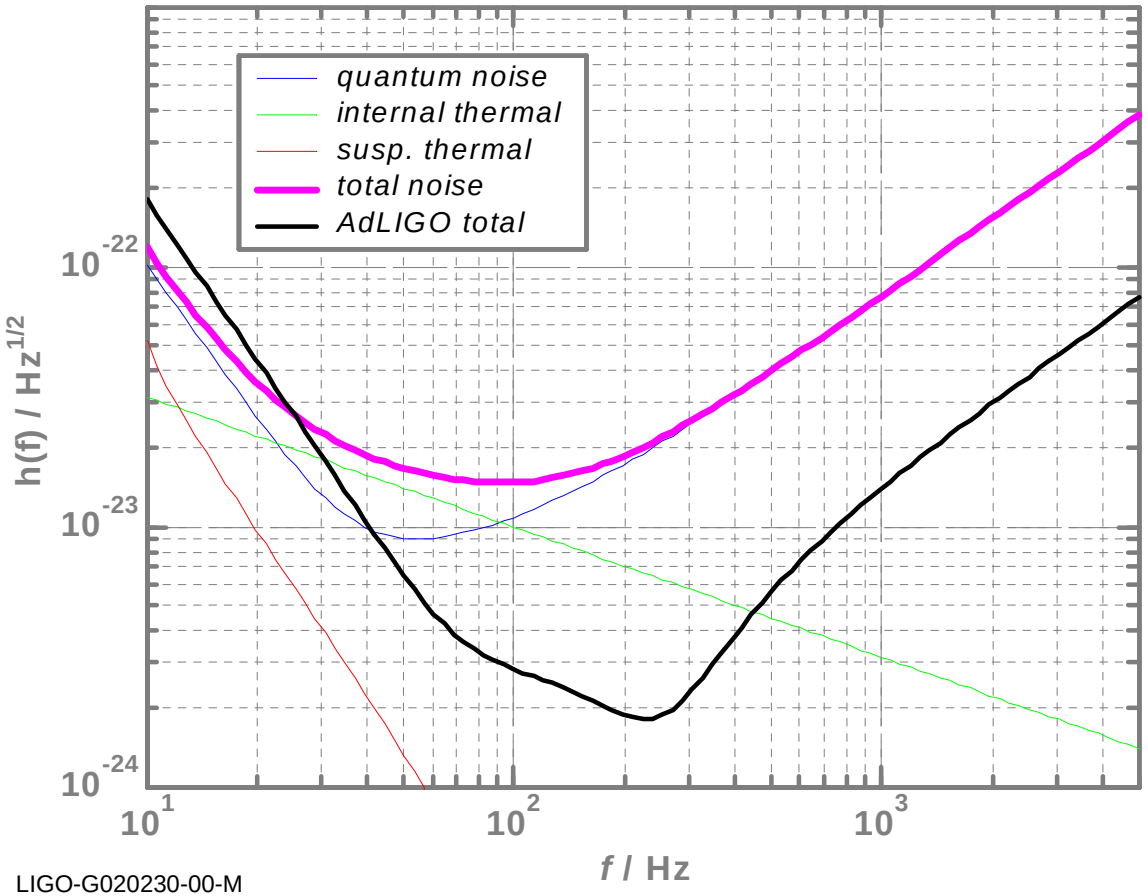
- Advanced LIGO interferometers were originally thought of as a series of upgrade steps
- This concept overtaken by the ‘full-upgrade’ approach, mostly to limit excursions into the vacuum
- Given the long time frame of the scenarios presented at the LSC meeting, we should revisit our strategy for implementing the full upgrade
- Is there a subset of the full upgrade that could be installed, giving an interesting sensitivity increase, without moving too far from the full path ?

Target low frequency noise

- Initial LIGO limited by suspension thermal noise + seismic noise
- What if we installed only active seismic isolation + quad/triple suspensions ?
  - » Use initial LIGO core optics (spares)
    - – Must interface to quad suspension design
  - » Use initial LIGO pre-stabilized laser
  - » Initial LIGO sensing/controls system
    - – With modifications to actuation interfaces
  - » Mode cleaner? Probably upgrade as well

Sensitivity: 100x in R^3

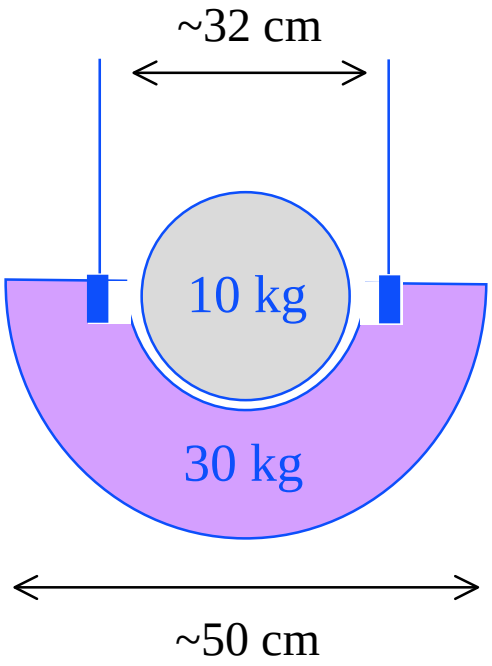
initial		*intermediate*		*advanced*
Inspiral Range: 13 Mpc	⇒	60 Mpc	⇒	210 Mpc



- Internal thermal:
  - phi = 10^{-7}
- 6 W input power
  - shot noise doesn't include any detection inefficiency
- Suspension thermal noise as in AdLIGO
- Radiation pressure overestimated
  - 10 kg instead of 40 kg

Use of initial LIGO core optics

- Avoids long lead time of sapphire optic fabrication
- Interface to quad suspension:
  - » Still want a 40 kg final mass
  - » Need a way to attach fused silica fibers
  - » Some sort of cradle for the 10 kg mirror:
- Cradle-to-mirror interface
  - » Don't know best design
  - » Clearly carries some risk of noise generation
  - » Can be tested in LASTI



Detection Rate Impact

- Interpolating from K Thorne's Feb 2001 NSF presentation:

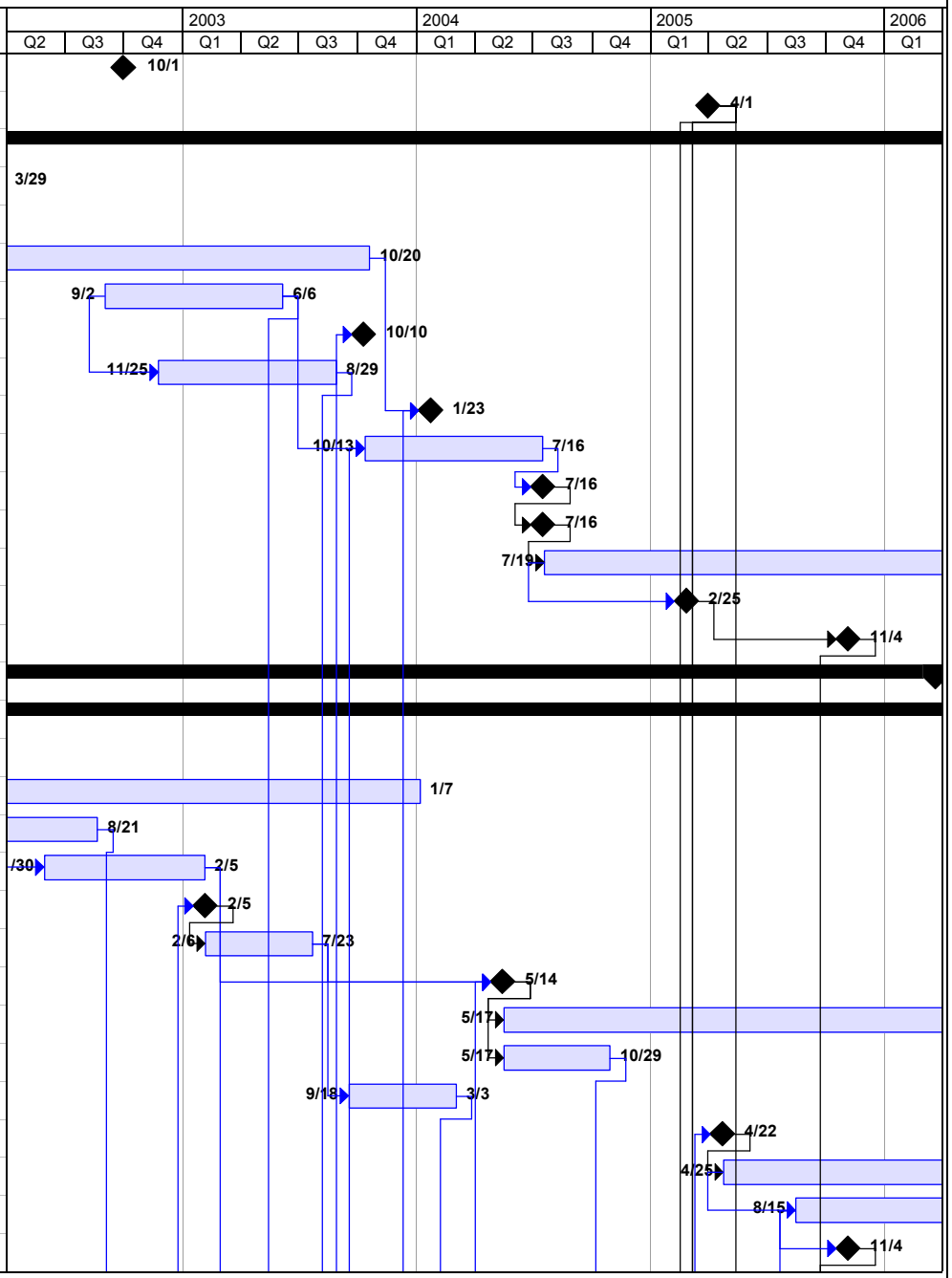
Source	Initial LIGO	Intermediate	Advanced
NS-NS	1 / 3000 yrs to **1 / 3yrs**	1 / 30 yrs to **1 / 10 days**	**1 / yr to 2 / day**
NS-BH	< 1 / 2500 yrs to **1 / 2yrs**	< 1 / 25 yrs to **1 / wk**	**< 1 / yr to 4 / day**
BH-BH	< 1 / 300 yrs to **~1 / yr**	< 1 / 3 yrs to **~2 / wk**	**< 2 / month to ~10 / day**
Stochastic BG	**$\Omega > 10^{-5}$**	**$\Omega > 5\times10^{-9}$**	**$\Omega > 5\times10^{-9}$**

Schedule implications

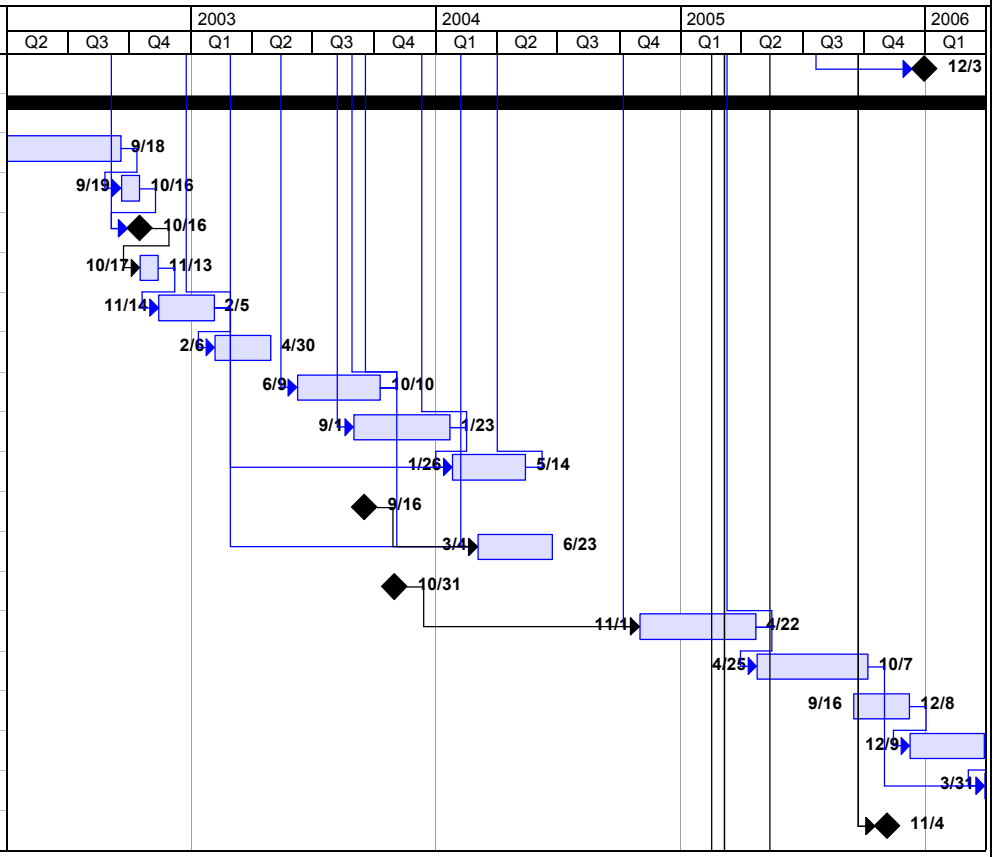
- Schedule options discusssed on the last day of the last LSC meeting are not driven by advanced LIGO COC schedule
  - » Proposed use of LIGO-1 COC does not enable an earlier start compared to these options – it is an alternative
- If we take more risk, we can bring the installation start back to Nov05
- Reduction in the initial commissioning length has not been estimated as yet
  - » Might expect 18 months to reduce to 12 months (in a paper exercise at least)

	Options	proposal submission	MRE $ available	start install	1st Obs on-line	2nd Obs on-line
-1	Aug/2001 LSC	4Q2001	4Q2003	Jan-06	Dec-08	Dec-08 (Jun-10)
0	Mar/2002 LSC	4Q2002	1Q2005	Jun-07	Apr-09	Feb-11
1	both oservatories in parallel			Jun-07	Apr-09	Apr-09
2	+ purchase core optics early			Mar-07	Jan-09	Jan-09
3	+ parallel (or no) first article test at LASTI			Nov-06	Sep-08	Sep-08
4a	+ production SEI < (MRE, LASTI cavity test)			Sep-06	Jul-08	Jul-08
4b	+ production SUS < (LASTI cavity test)			Jan-06	Nov-07	Nov-07
5	{1,3,4a} + Upgrade SEI & SUS only; Plan to use LIGO-1 COC			Sep-06	?	?
6	{5} + SUS production start < LASTI cavity test			Jan-06	?	?
7	{6} + no delay between stand-alone noise SUS test & production (was 3 mo) + 1st IFO SEI set ready in 16 mo (not 17)			Nov-05	?	?

ID	Task Name	Duration	Start	Finish
1	MRE Proposal submitted	0 d	10/1/2002	10/1/2002
2	MRE funding available	0 d	4/1/2005	4/1/2005
3	**Seismic Isolation (SEI)**	**1640 d**	**5/29/2000**	**9/8/2006**
4	prototype	24 mons	5/29/2000	3/29/2002
5	DRR	0 d	1/16/2001	1/16/2001
6	Prelim Design	36 mons	1/16/2001	10/20/2003
7	pathfinder fab (HAM)	10 mons	9/2/2002	6/6/2003
8	PDR (HAM)	0 d	10/10/2003	10/10/2003
9	pathfinder fab (BSC)	10 mons	11/25/2002	8/29/2003
10	PDR (BSC)	0 d	1/23/2004	1/23/2004
11	Final Design	10 mons	10/13/2003	7/16/2004
12	FDR	0 d	7/16/2004	7/16/2004
13	Fab Readiness Rev	0 d	7/16/2004	7/16/2004
14	production	28 mons	7/19/2004	9/8/2006
15	first article avail	0 d	2/25/2005	2/25/2005
16	sufficient qty to start install	0 d	11/4/2005	11/4/2005
17	**Core Optics Components (COC)**	**1382 d**	**12/4/2000**	**3/21/2006**
31	**Suspension (SUS)**	**1377 d**	**9/20/2001**	**12/29/2006**
32	DRR	0 d	9/20/2001	9/20/2001
33	Preliminary Design	30 mons	9/20/2001	1/7/2004
34	non-TM Controls Prototypes Fab	6 mons	3/7/2002	8/21/2002
35	TM Controls Prototypes Fab	9 mons	5/30/2002	2/5/2003
36	non-TM PDR	0 d	2/5/2003	2/5/2003
37	non-TM Final Design	6 mons	2/6/2003	7/23/2003
38	TM PDR	0 d	5/14/2004	5/14/2004
39	TM Final Design	26 mons	5/17/2004	5/12/2006
40	TM 'noise' prototype fab	6 mons	5/17/2004	10/29/2004
41	non-TM 'noise' prototype fab	6 mons	9/18/2003	3/3/2004
42	FDR	0 d	4/22/2005	4/22/2005
43	production	22 mons	4/25/2005	12/29/2006
44	Assembly	10 mons	8/15/2005	5/19/2006
45	first article completed	0 d	11/4/2005	11/4/2005



ID	Task Name	Duration	Start	Finish
46	IFO1 Assy completed	0 d	12/30/2005	12/30/2005
47	**LASTI Experiments/Tests**	**1176 d**	**2/7/2002**	**8/10/2006**
48	seismic pre-isolator tests	8 mons	2/7/2002	9/18/2002
49	set HAM table height to match adv LIGO	1 mon	9/19/2002	10/16/2002
50	receive HAM SUS: fit-test suspensions	0 d	10/16/2002	10/16/2002
51	install HAM suspensions	1 mon	10/17/2002	11/13/2002
52	HAM SUS Controls stand-alone testing	3 mons	11/14/2002	2/5/2003
53	laser intensity stabilization testing	3 mons	2/6/2003	4/30/2003
54	HAM SEI stand-alone testing	18 w	6/9/2003	10/10/2003
55	BSC SEI stand-alone tests	21 w	9/1/2003	1/23/2004
56	BSC SUS Controls stand alone tests	4 mons	1/26/2004	5/14/2004
57	HAM SUS 'noise' optics ready	0 d	9/16/2003	9/16/2003
58	HAM SUS assy/instal/test 'noise' SUS proto.	4 mons	3/4/2004	6/23/2004
59	TM 'noise' optics ready	0 d	10/31/2003	10/31/2003
60	TM assy/instal/test 'noise' SUS proto.	25 w	11/1/2004	4/22/2005
61	cavity tests	6 mons	4/25/2005	10/7/2005
62	install PSL, IO	3 mons	9/16/2005	12/8/2005
63	commission PSL	4 mons	12/9/2005	3/30/2006
64	PSL-MC Integ Test	19 w	3/31/2006	8/10/2006
65	**Installation Start**	**0 d**	**11/4/2005**	**11/4/2005**



Summary of pros & cons

- Pros
  - » Earlier installation of an upgrade with a significant performance improvement
  - » Shorter commissioning time
  - » Experience with the *'intermediate interferometer'* could make a valuable impact on the remaining *'advanced interferometer'* design
- Cons
  - » Requires a second excursion into the vacuum system to get to the full upgrade
  - » All (or most) suspended optics would need to be replaced for the full upgrade