RedGreenBlue
Discussion topics

Benno Willke, David Shoemaker

LIGO-G1200581-v1

Some numbers
(all these slides LIGO-centric, mea culpa)

- aLIGO timeline
  - 1999 aLIGO White Paper
  - 2005 Proposal to NSF
  - 2008 Project start – was made conditional on reaching the initial LIGO sensitivity curve and completing one year of observation
  - 2015 Project complete
- And then….
  - ~2016 AdVirgo-aLIGO first detections (need this to expect a sizable Proposal to the NSF to be taken seriously)
  - ~2018 KAGRA on line
  - ~2020 LIGO-India on line
- aLIGO Costs
  - ~$220M USD for entire project, $205M from NSF
  - Includes all labor
  - Includes 3 instruments, data analysis computers, vacuum changes

How did aLIGO go from ideas to execution?

- Some key ideas had some prototype/parameter experimental verification:
  - Low-loss monolithic fused silica suspensions
  - Signal-recycled interferometer topologies
- This allowed several basic noise sources to be established, and top-level requirements written down – 1999 White Paper (LIGO-T990080)
- Several basic design questions remained:
  - Fused silica or sapphire optics
  - Approach to the high-power laser source
  - Approach to seismic isolation
- For each, work continued on several approaches in parallel for some years
  - Downselects mostly required more than friendly discussion
  - Transition from a research plan to a detector design
- So…a key question for this new endeavor: when to start to narrow choices?
  - …but first a few more general comments and questions

Prototypes

- Prototypes are very important:
  - Convincing oneself that ideas are sensible
  - Convincing colleagues that an approach is basically successful and can be engineered into a 90% instrument availability
  - Convincing one's sponsor that the proposal is sensible
- 1) Tabletop proof-of-principle
- 2) Demonstrating a key parameter at the level required in the final implementation
- 3) Establishing interfaces, installation procedure, reliability

- Clearly, modeling must track – the objective is to have a set of reduced-scale measurements, plus a model, that makes a projected instrument performance credible
- So….

- What prototyping for each new aspect of the proposed interferometers is needed?

Some general questions

- What top-level physical constraints are sensible?
  - Re-use of km vacuum envelope
  - Re-use of instrument vacuum chambers
  - Re-use of seismic isolation
- Target an upgrade of Advanced LIGO (Virgo, etc.), or form the basis for a truly new generation?
- Should we plan on complementing aLIGO with second detectors – Xylophone?
- How to arrive at a reasonable cost envelope?
- How can the project be re-scoped at a later point to …
  - adapt to available funds and observational criteria?
  - respond to successes and failures of development of elements of the design?
- How long will the instruments be unavailable due to the upgrades? (shut down one LIGO instrument for a year or two, then the other? Network matters!)
- Incremental vs. wholesale changes?
  - …but next, narrowing choices

When to start to narrow choices?

- A $50-100M proposal will require that detections have been made
- Earliest is 2015, could be 2016, or 17…
- A goal to have a proposal ready in ~2016 means..
  - 2015 engineering study, cost and schedule baseline starting
  - 2014 all design choices made
  - 2012 Project identified – White paper exists, a few choices remaining
- When would this instrument start operating? Some optimistic guesses
  - 2016 proposal
  - 2017 approval (aLIGO etc. full sensitivity, having made many detections)
  - 2019 engineering done
  - 2021 hardware available, ready for shutdown of one or more Observatories
  - 2023 installation complete, start of integrated testing, then tuning
  - 2025 observation…
- ….an argument to create even a grander vision, and propose ET?
- ….or, the smaller/simpler the upgrade, the shorter the process…

Incremental upgrades?

- Implementation strategy
  - Small cost: faster proposal/funding cycle (to the point of being covered by Operating budgets of observatories)
  - Smaller technical scope: quicker R&D/engineering cycle
  - Short interruption of observation: slips in when ready, between runs
- Obvious disadvantages: smaller steps forward, probably poorer end sensitivity
- A number of technical candidates at hand
  - Improved coatings on existing substrates
  - Squeezing with no filter cavity
  - …..add in the filter cavity…
  - NN sensing array
  - Extend suspensions, larger masses (starting to be ambitious!)

    - **As Ron Drever often said: there are lots of possibilities.**