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Auxiliary Optics System (AOS)

Technical Breakout Presentation

NSF Review of Advanced LIGO Project

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AOS Functions- a Grab Bag of Optics

- **Stray Light Control** (SLC)- baffles and beam dumps to prevent scattered light and ghost beams from interfering with interferometer performance
- **Thermal Compensation System** (TCS)- senses thermal lensing of core optics due to absorbed laser power and compensates using tailored heaters
- **Pickoff Mirrors and Telescopes**- collects a sample of the interferometer beam and reduces its size for transmission out of vacuum to the optical tables
- **Initial Alignment System** (IAS)- surveying and metrology used to install the in-vacuum optics in the correct positions with the correct orientations
- **Optical Lever System** (OpLev)- sensors to monitor the orientation of the optics as they swing in their suspensions
- **Photon Calibrator**- applies a known radiation pressure force to the End Test Masses for interferometer calibration
- **Output Mode-Matching Telescope** (OMMT)- reduces the dark port beam size and couples it into the Output Mode Cleaner
- **Viewports**- gets light into and out of the vacuum

What Ties AOS All Together

- AOS, broadly defined, is concerned with how light is maneuvered around the interferometer and into and out of vacuum:
  - scattered light
  - ghost beams
  - pickoff beams
  - output beams
  - optical levers
  - thermal compensators and compensator probes
  - photon calibrator beams
- The bulk of the optical layout inside the vacuum is defined by AOS

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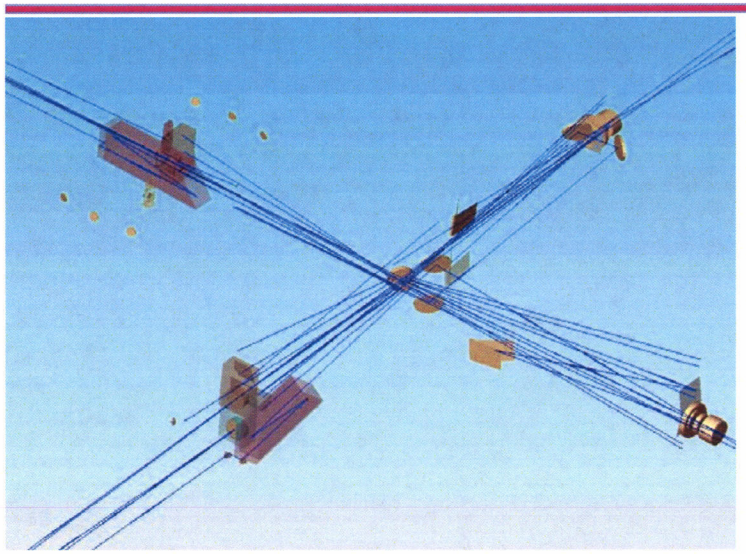
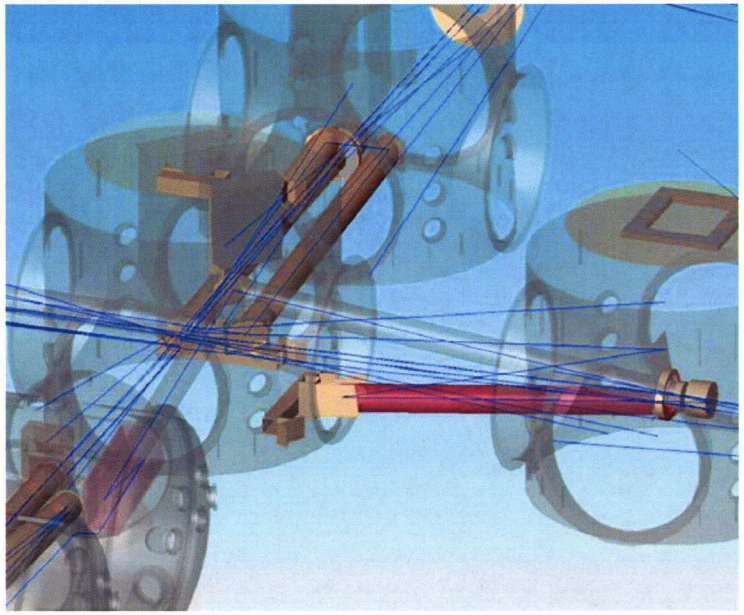
Stray Light Control



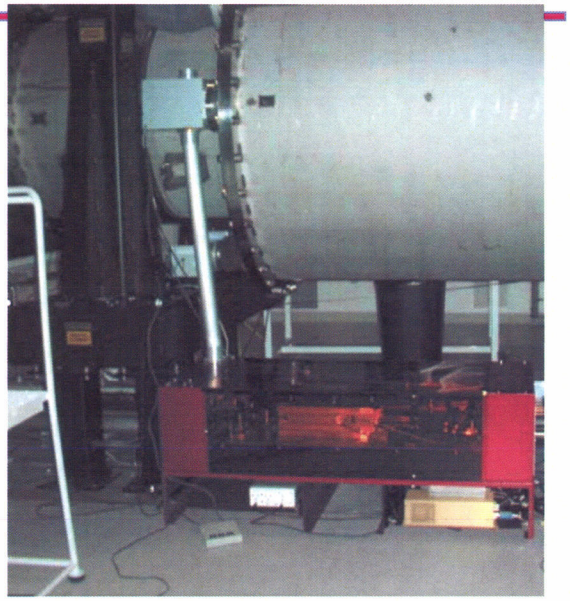


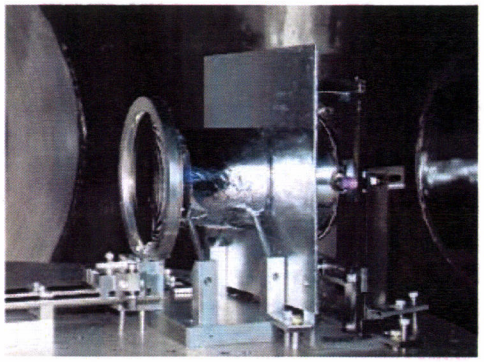
- Stray Light Control uses baffles and beam dumps to safely discard scattered light and ghost beams before they can interfere with IFO operation.
- *Requirement: the phase noise resulting from stray light scattered back into the IFO from moving surfaces must not exceed 1/10th the Advanced LIGO sensitivity.*
- Estimates of the coupling paths and sensitivity of the interferometer to scattered light are underway.
- Technical challenges under control.

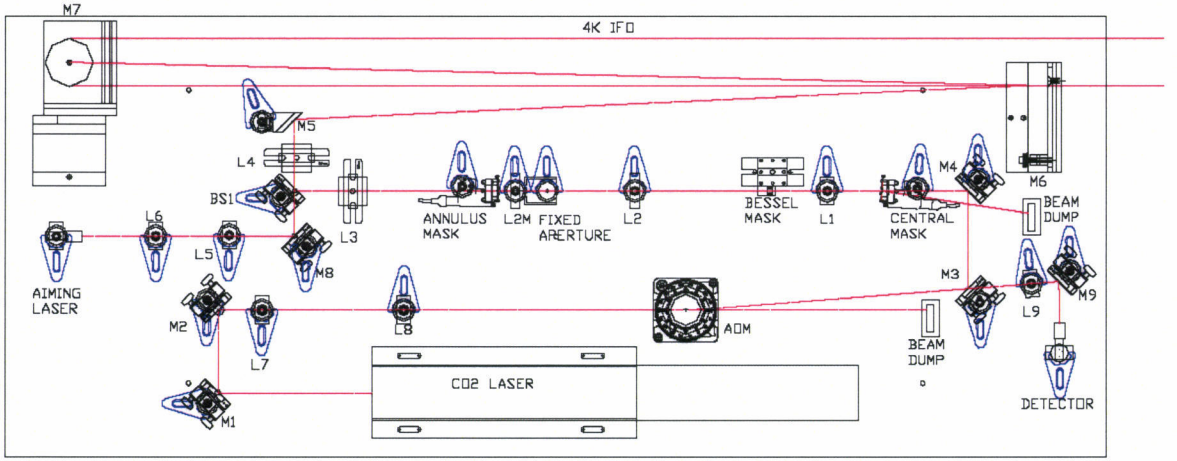
cost: $661k

Thermal Compensation System (TCS)

- TCS was developed for Advanced LIGO, but retrofit to initial LIGO and has proven itself essential.
- *Requirements: TCS must…*
  - » *prevent RF sideband power buildup in the recycling cavities from saturating due to aberration losses*
  - » *keep GW sideband amplitude loss through the signal cavity below 5%*
  - » *keep dark port contrast defect light below 1 mW level*
- TCS could also adjust static curvature errors and control acoustic parametric instability by tuning the arm cavity mode spectrum.
- TCS will employ two types of actuator:
  - » Incandescent ring heaters for homogeneous absorption
  - » Carbon dioxide laser heaters for inhomogeneous absorption
- TCS will employ two types of sensor:
  - » Dedicated probes for individual optic phase profiles
  - » Phase cameras for IFO beam structure



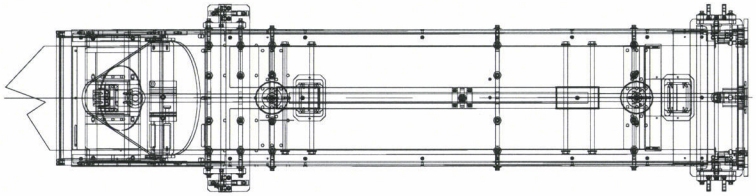


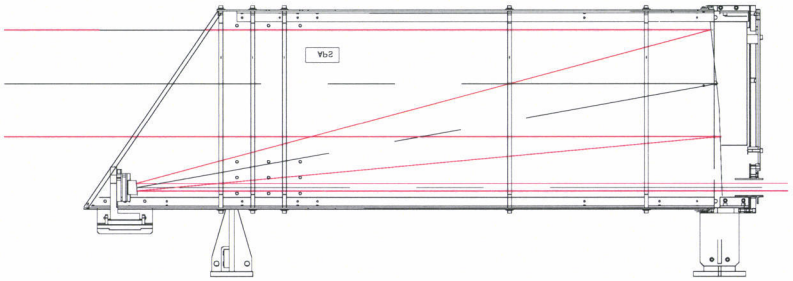


$1,959k

Pickoff Mirrors and Telescopes

- Pickoff mirrors reflect a small fraction of IFO beam out of the main beam to be sensed for IFO control; telescopes reduce the beam size to fit through viewports to sensing tables.
- *Requirements: TBD, but conservative estimate is to scale up proportional to the increase in beam size from LIGO to Advanced LIGO.*
- All basic optics and not technically demanding.

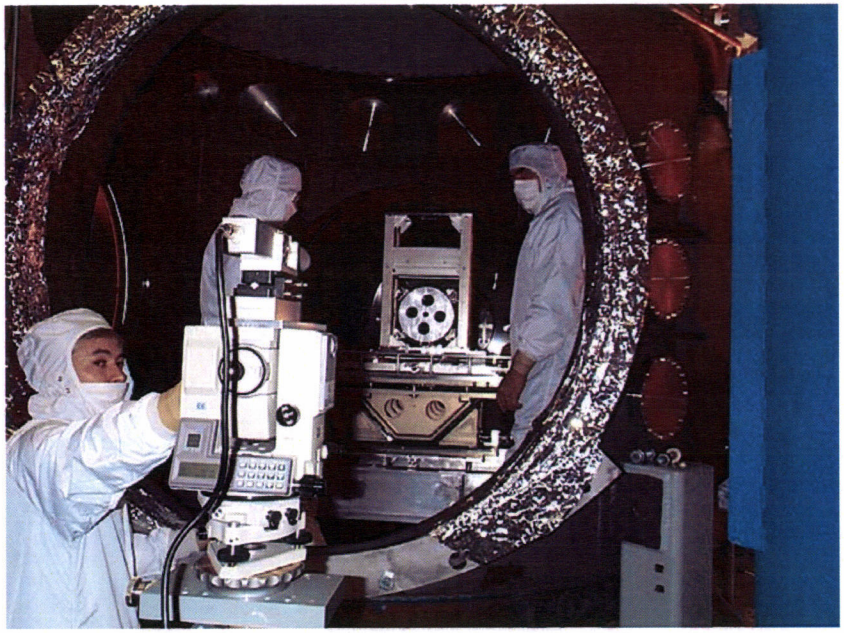




$2,757k

Initial Alignment System

- Surveying and metrological equipment for positioning and orienting core optics during initial installation.
- *Requirements: same as those for initial LIGO-*
  - » *+-0.1 mrad pitch and yaw*
  - » *+- 1mm transverse positioning*
- Essentially no difference from initial LIGO.



$136k