# Stray Light Control & Viewports

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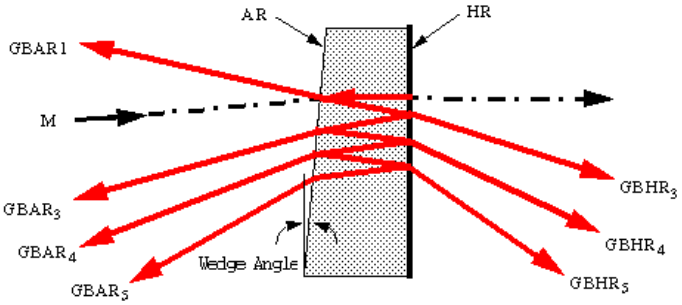
aLIGO NSF Review

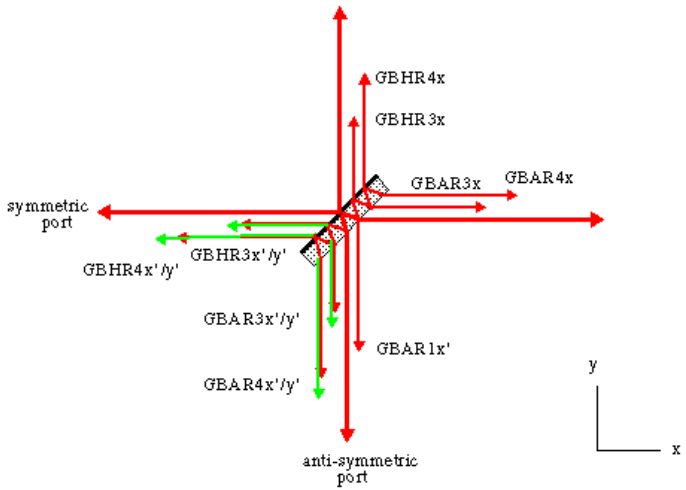
LIGO Livingston Observatory

25-27 April 2011

# Stray Light Control Functions

- Control stray light scatter in the interferometer using baffles, beam dumps, and attenuators
- Reduce scattered light apparent displacement noise

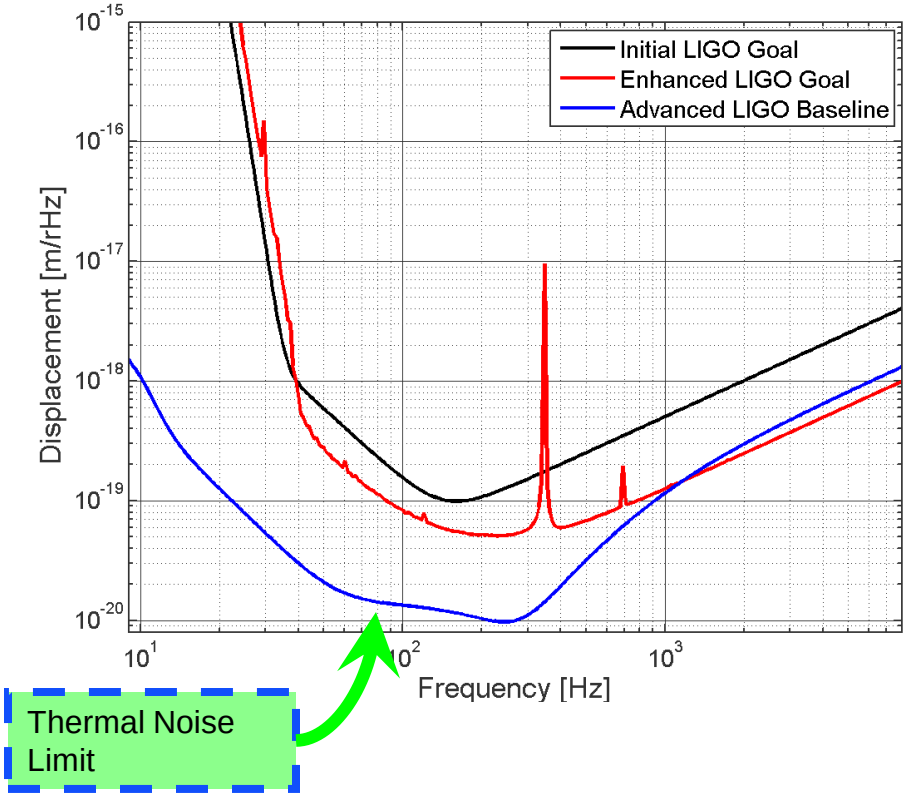



Ghost beams

# Stray Light Control Requirements

- Total apparent stray light displacement noise <1/10 thermal noise limit



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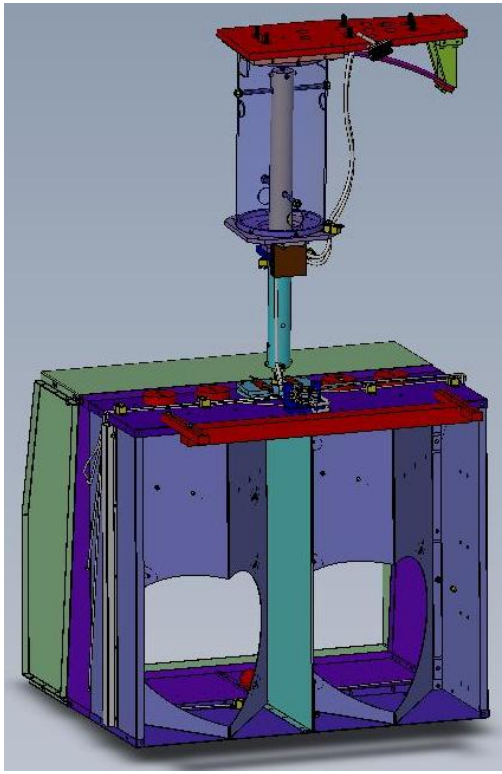
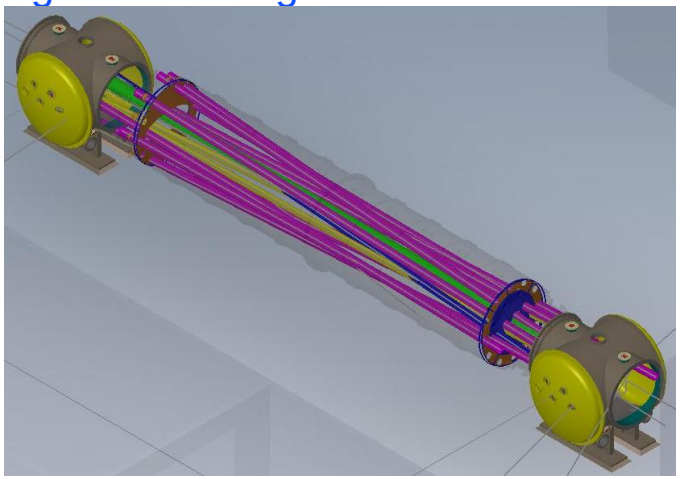
# Stray Light Control Design Concept

- Porcelainized enamel coatings to reduce scattered light power
- Small, Core Optic wedge angles simplify/consolidate many baffles and beam dumps in the recycling cavities
  - » Cavity Mirror Wedge angles
    - – ITM, 0.07 deg vertical wedge angle causes ghost beams to separate from the main beam in the vicinity of PR2 and SR2 for interception with beam dumps
    - – BS, 0.07 deg horizontal wedge angle provides the ITM pickoff beam in vicinity of SR2
- Variety of suspended baffle surfaces reduce apparent scattered light displacement noise
  - » Arm Cavity Baffle (ACB), ITM Elliptical Baffle, Manifold/Cryopump Baffle
  - » Output Faraday Isolator
- New ACB catches narrow and wide-angle scatter from ITM and ETM
- New ACB photodetectors aid initial alignment; measure scattered light
- New Mode Cleaner Tube Baffle mitigates recycling cavity scatter and errant beams

# Scattered Light Control Development Accomplishments - I

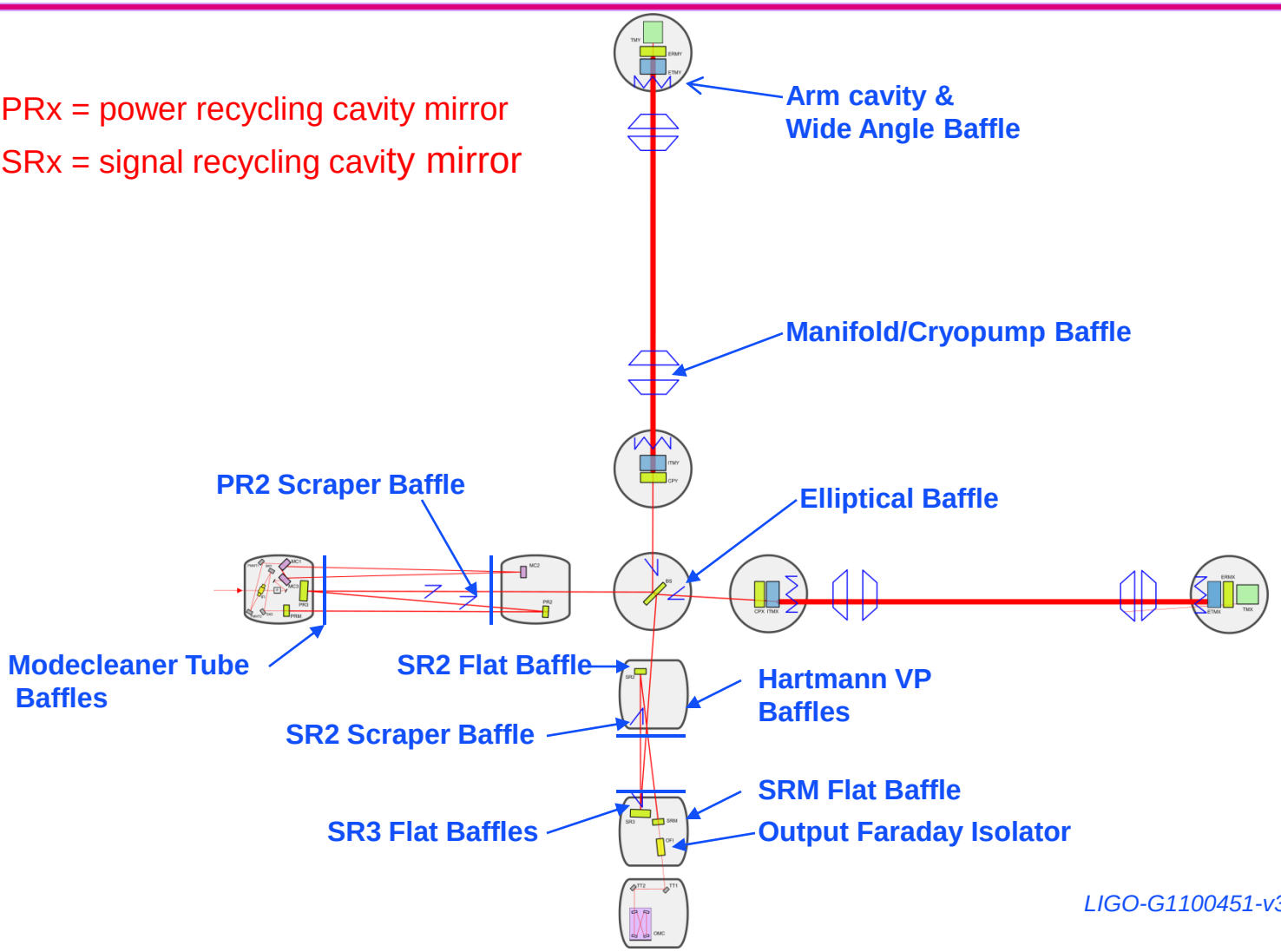
- Scattered light displacement noise models with real suspensions meet SLC requirement
- Developed porcelainized coating for baffles and beam dumps
- Tested Output Faraday Isolator (OFI) and Arm Cavity Baffle (ACB) suspension designs with eddy current-damping at Caltech and LASTI
  - » Suspension model matches experimental data
- Shipped OFI 1st Article to LHO for squeezer test
- Completed vibration test --Manifold/Cryopump Baffle 1st Article
  - » Ready for one-arm integration at LHO
- Developed new ACB design to mitigate wide-angle scatter from Test Mass
- Created new Mode Cleaner Tube baffles for recycling cavity, based on eLIGO experience





# Stray Light Control (SLC)

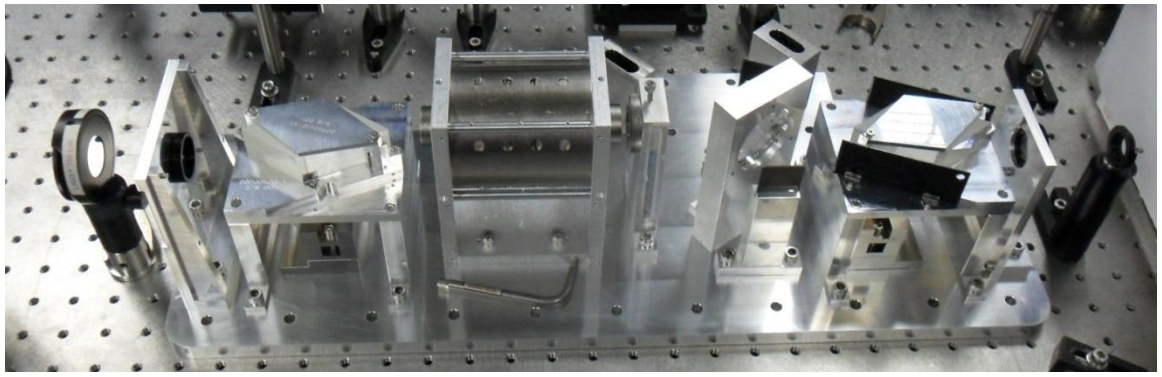
- PRx = power recycling cavity mirror
- SRx = signal recycling cavity mirror



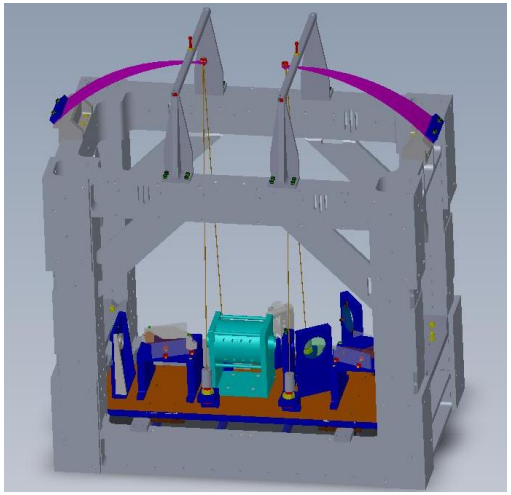
# Scattered Light Control Development Accomplishments – II

- 1st Articles Complete
  - » Manifold/Cryopump Baffle
  - » Output Faraday Isolator
- Suspensions Tested
  - » Arm Cavity Baffle
  - » Manifold/Cryopump Baffle
  - » Output Faraday Isolator

**Manifold/Cryopump Baffle 1st Article suspended inside manifold tube mock-up**



**Optical test of OFI at Caltech**

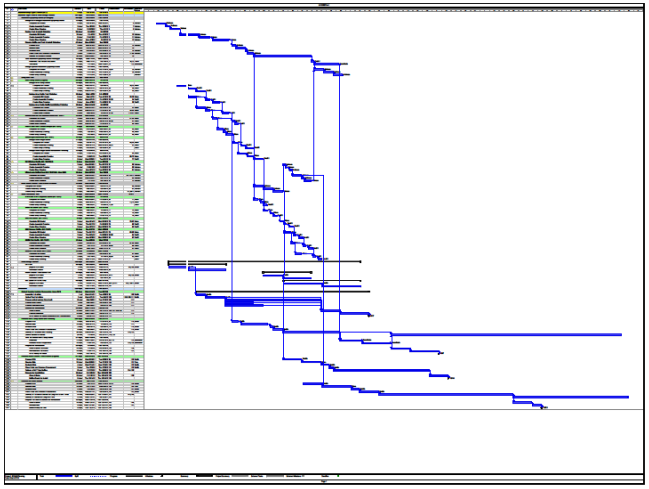


# Stray Light Control Development Status

- Completed Output Faraday Isolator Final Design Review – Oct 2010
- Completed Arm Cavity Baffle Final Design Review – April 2011
- Most designs and drawings are complete
- All other SLC baffles and beam dumps Final Design Review – June 2011

# Stray Light Control
# Project Plans and Reorganization

- Project Plans
  - » Output Faraday Isolator 1st Article at LHO– April 2011
  - » Baffles and Beam Dumps for One-arm Integration ready – July 2011
  - » Baffles and Beam Dumps for Michelson Integration ready – August 2011
  - » All other baffles and beam Dumps for aLIGO Installation – Nov. 2011
- Project Organization - Caltech
  - » Team Leader/Optical Engineer – Michael Smith
  - » Coordinator – Lisa Austin
  - » Suspensions Testing - Virginio Sannibale
  - » Mechanical Designer - Heidy Kelman
  - » Mechanical Designer - Niem Nguyen
  - » Mechanical Designer – Manuel Ruiz
  - » Draftspersons - Pool



# Scattered Light Control Challenges, Risks, and Mitigations

- Delivering SLC in time for the One-arm & Michelson Integration?
  - » On track to meet Installation Schedule
- Adequate seismic attenuation achieved?
  - » All suspended baffles and attenuators tested at CIT and LASTI, and meet SLC requirements
  - » Porcelainization of baffles is now a standard process
- On-time delivery of procurements?
  - » Continuous monitoring of manufacturing progress
- No remaining risks!!

# Stray Light Control
# Near Term Activities

- Shipped 1st Article OFI to LHO for Squeezer Test
- Shipped 1st Article Manifold/Cryopump Baffle to LHO for One-arm Integration
- Completing procurement of Arm Cavity Baffle 1st Article
- Completing Final Design Review
  - » Manifold/Cryopump Baffle and Mode Cleaner Tube Baffle – May, 2011
  - » All Other SLC baffles and beam dumps – June, 2011
- Procuring all remaining baffles and beam dumps
- Developing installation procedures and tooling

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# Viewport Functions

- Provide optical viewports for the passage of optical beams in and out of the vacuum region(s) of the Interferometer.
  - » optical lever beams
  - » chamber illumination beams
  - » video camera beams
  - » optical beams for interferometer sensing and control
  - » Hartmann Sensor beams
  - » Photon Calibrator beams
- Provide safety covers for all installed viewports

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# Viewport Requirements

- Video camera  Viewport (VP)—transmit visible light spectrum
- Chamber illumination VP—uncoated viewports
- OpLev VP—similar to iLIGO
- Septum Plate (to isolate input and output HAM chambers) VP—similar to eLIGO
- ISC and Hartmann VP—super-polished, low scattering, < 1/10 wave , special AR coatings
  - » Hartmann AR coating:  800nm – 1080nm
  - » ISC AR coating:  532nm and 1064nm
- Safety covers to protect viewports during installation and commissioning

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# Viewport Design Concept

- Reuse iLIGO VP wherever possible
- New O-ring-sealed 6.0 inch VP for Interferometer Sensing and Control, and Hartmann beams
- Septum VP similar to eLIGO design
- Additional iLIGO style VPs needed for new Mode Cleaner Tube VPs

# Viewport Development Accomplishments

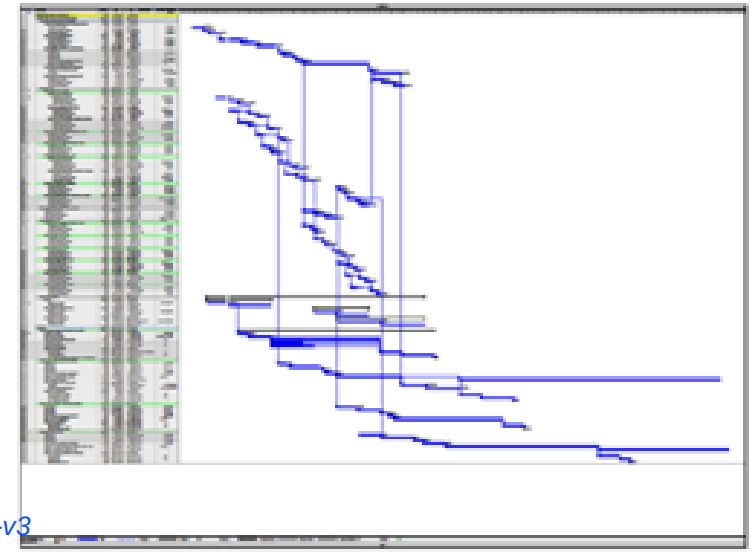
- Analyzed VP scattered light
- Determined viewport locations using ZEMAX beam layout
- Established proper names for all viewports according to LIGO naming convention
- Created a catalog of VP requirements and part numbers for all subsystems
- Completed VP Final Design Review
- Developed new specification for 6.0 inch ISC/Hartmann VP

# Viewport Development Status

- Drawings for 6.0 inch VP and Septum VPs are in progress
- Final Design Review Complete April 2011

# Viewport Project Plans and Reorganization

- Project Plans
  - » On schedule for installation One-arm Integration– June 2011
  - » On schedule for deployment for Michelson Integration– July 2011
  - » On schedule for deployment of three aLIGO IFOs – August 2011
- Project Organization
  - » Cognizant Engineer and Leader – Michael Smith – Caltech
  - » Coordinator – Lisa Austin – Caltech
  - » Installation Leads –
    - Gerardo Moreno – Hanford
    - Chris Guido– Livingston



# Viewport
# Challenges, Risks, and Mitigations

- On-time procurement of 6.0 inch VP and Septum VP?
  - » Monitoring of procurement and manufacturing progress
- Other VPs mostly catalog items
  - » No known technical or schedule risks