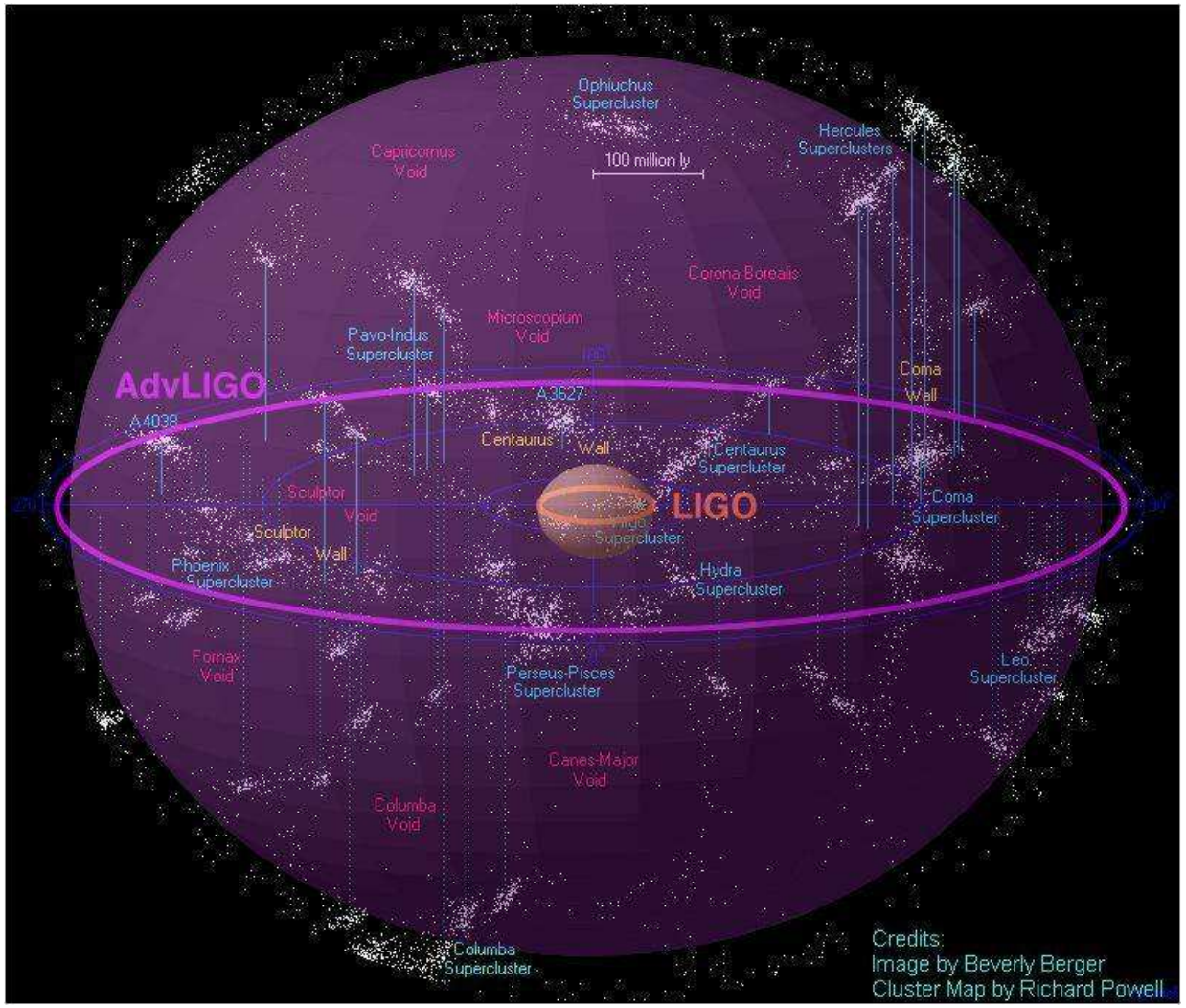
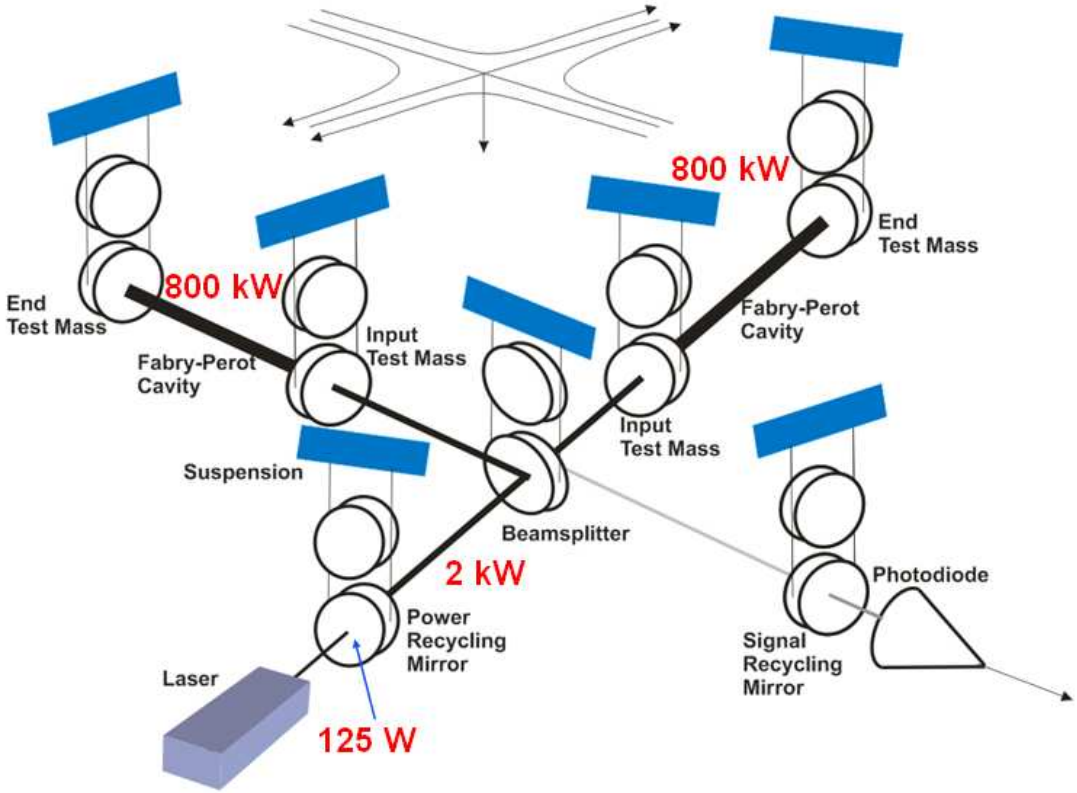
Advanced LIGO

- Detector upgrade is planned for 2011-2014
  - » Factor of 10 increase in distance probed ('reach')
  - » Factor of 1000 increase in event rate
- Fabrication began in 2009
  - » Long lead time parts
  - » Mirror blanks, polishing, coating



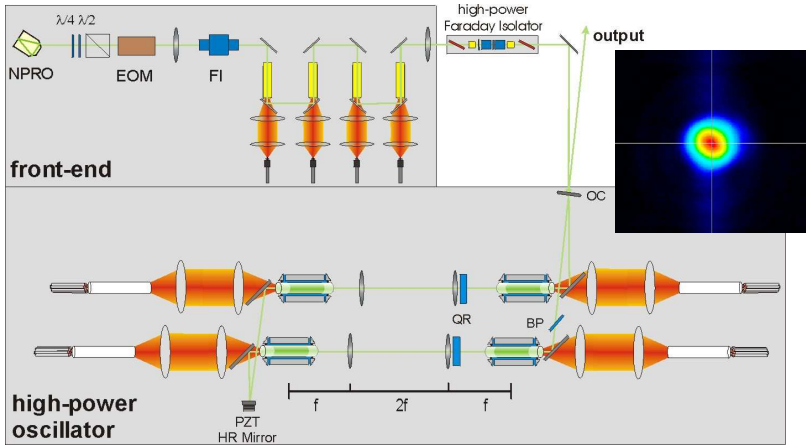
Advanced LIGO

- 125 W laser
- Quadruple pendulum suspensions
- Improved seismic isolation
- Signal recycling
- Stable recycling cavities
- DC readout



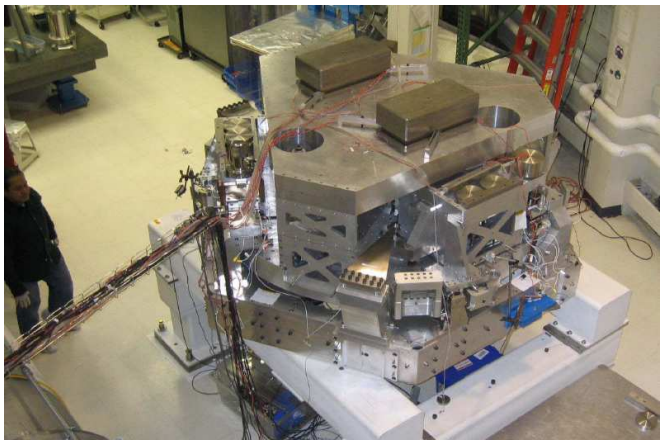
Advanced LIGO

180 W laser

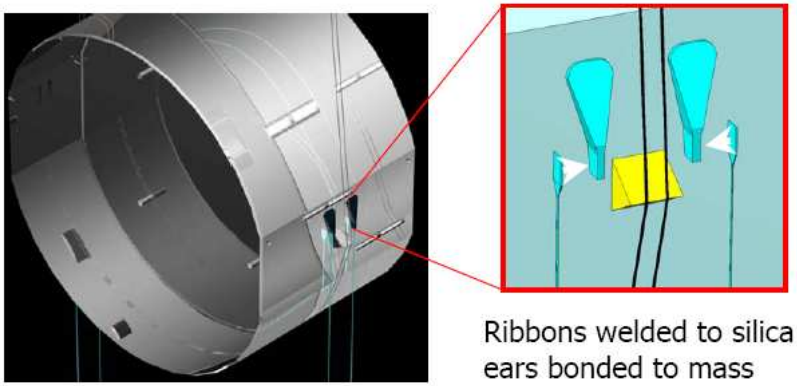


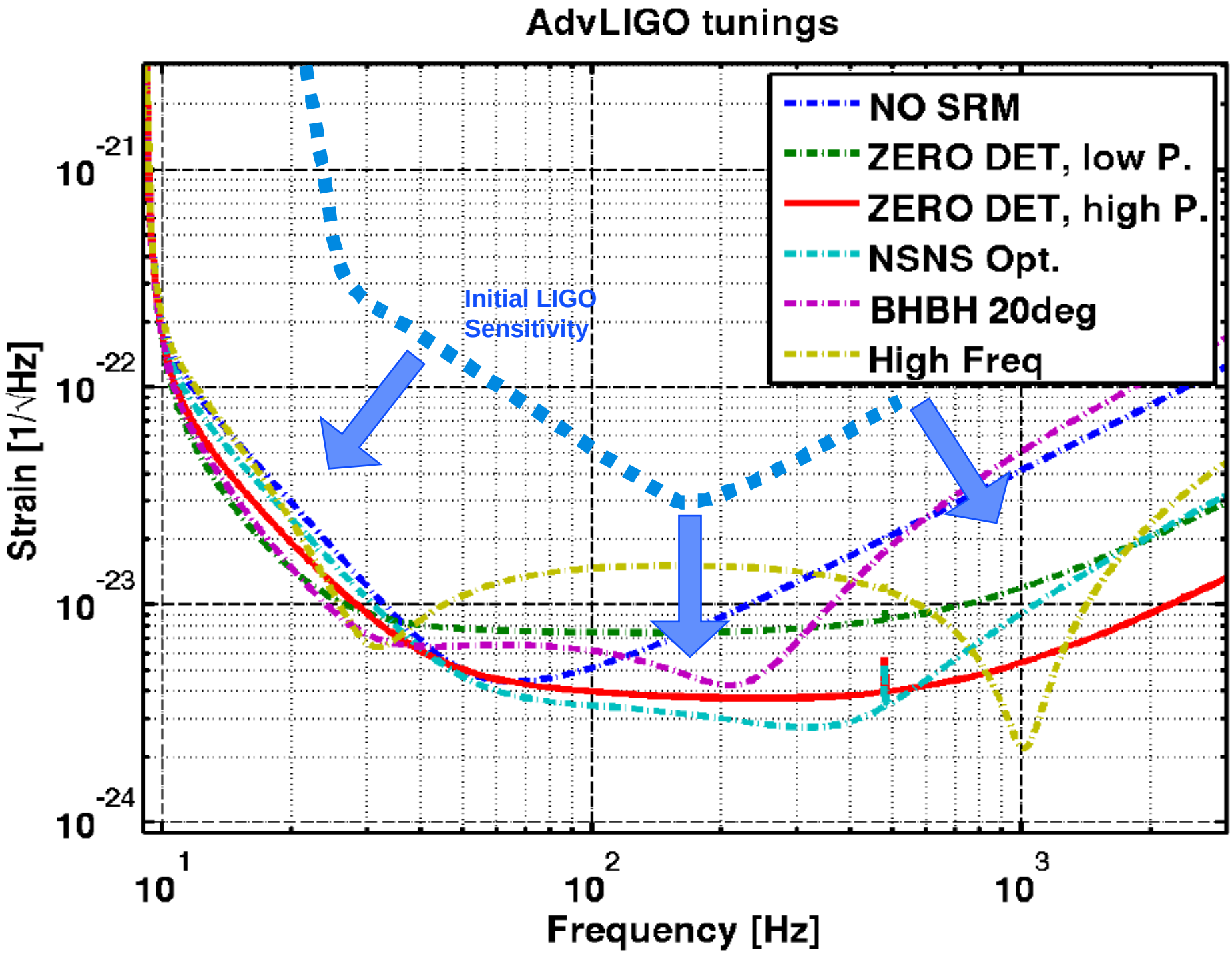
Mirror Suspensions

Seismic isolation



Mirrors




AdvLIGO tunings
NO SRM
ZERO DET, low P.
ZERO DET, high P.
NSNS Opt.
BHBH 20deg
High Freq
Initial LIGO
Sensitivity
Strain [1/√Hz]
10^-21
10^-22
10^-23
10^-24
10^1
10^2
10^3
Frequency [Hz]

Schedule (approximate) (at LLO)

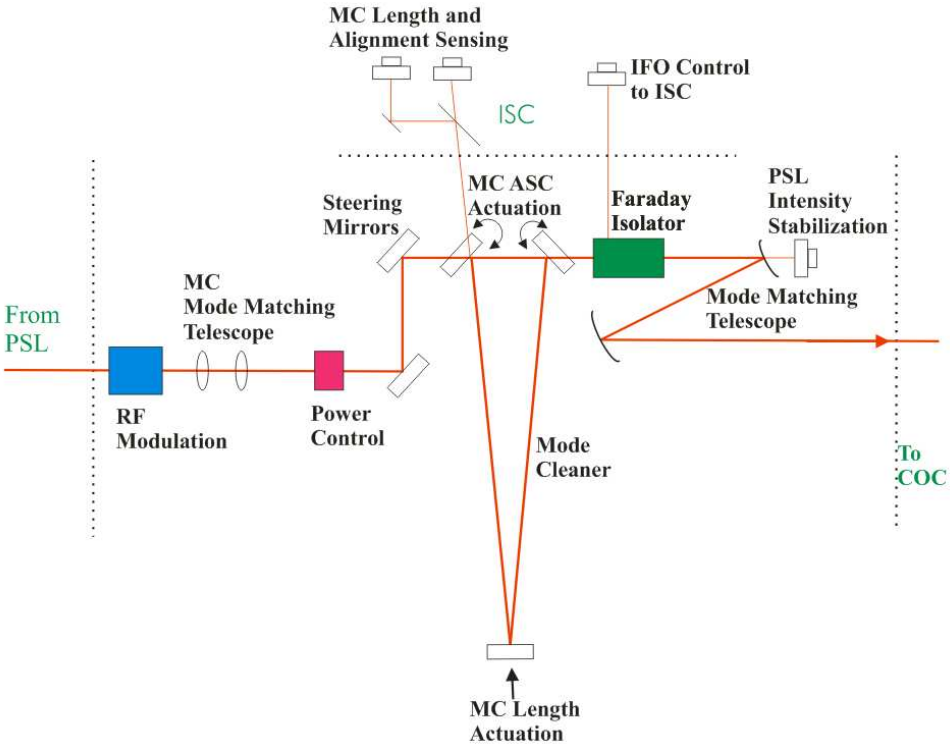
- S6 (Science run 6) will end in Oct 2010
- Initial LIGO parts to be removed from chambers Nov 2010
- Install hutch/cleanroom for laser, move HAM 1 for in-vacuum signals detection, new larger tube to connect HAM 2/3, clean chambers and lab. Nov 2010–Jan 2011
- Install new seismic isolation Jan–Feb 2012 (staggered)
- Install PSL and IO components Feb–July 2011
- Install vertex core optics, quad suspensions Oct 2011–Mar 2012
- Test PSL/IO/Power recycled short Michelson Mar 2012
- Install seismic isolation and quad suspensions Oct 2011–July 2012
- Commissioning July 2012–June 2013
- LHO (H1+H2) in 2014

The input optics (IO)

The input optics (IO) conditions the PSL laser light and delivers it to the interferometer.

It provides:

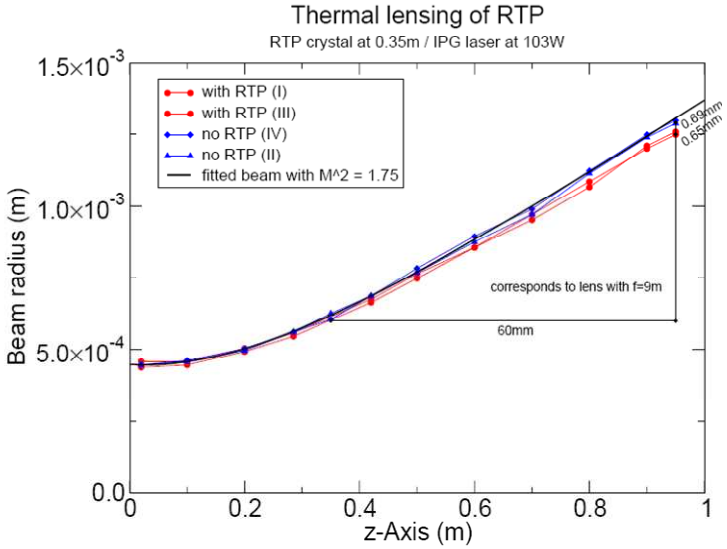
- RF modulation for length and alignment control functions
- Power control
- Laser mode cleaning and frequency stabilization
- Isolation of laser from interferometer reflected light
- Optical signal distribution to length and alignment control
- Mode matching to recycling and arm cavities
- Design and fabrication of small PRMs and SRMs

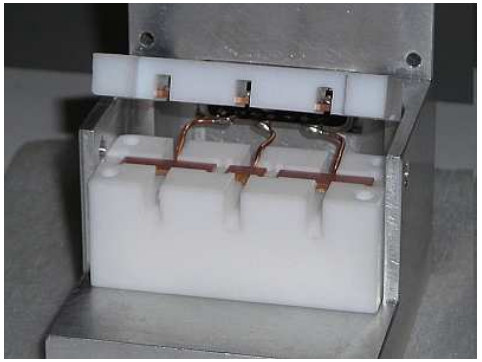


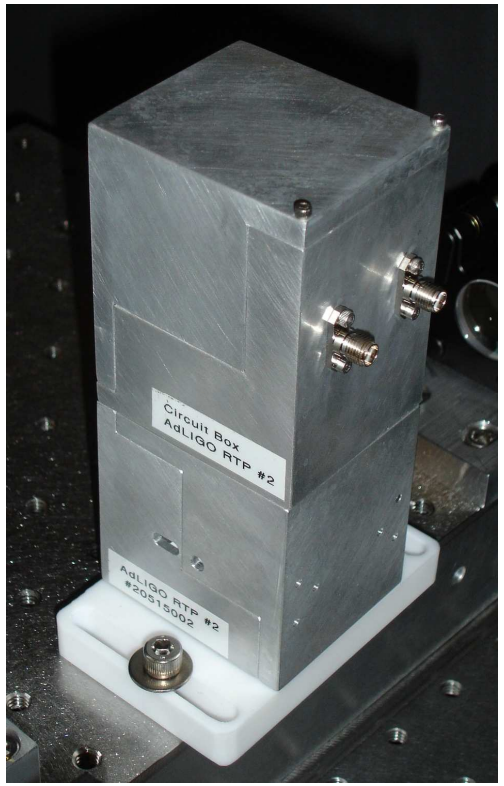
PSL = pre-stabilized laser
COC = core optical components
IMC = input mode cleaner
ISC = interferometer sensing and control
PRM = power recycling mirror
SRM = signal recycling mirror

Electro-optic modulator

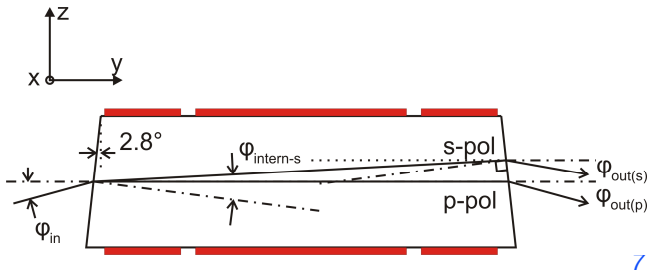
- Modulators use rubidium titanyl phosphate (RTP)
  - » Electro-optic response similar to $LiNbO_3$
  - » low absorption → low thermal lensing





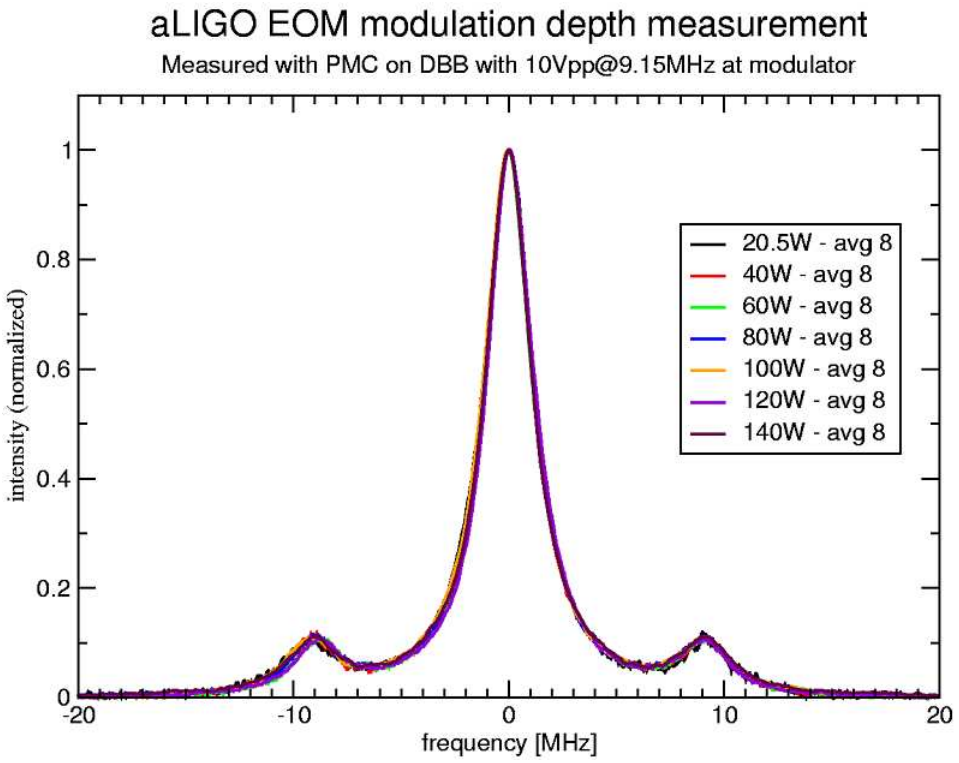


- Multiple electrode configuration
- Wedge, to reduce RFAM from polarization impurity
- RF matching circuit in separate housing
- Installed in enhanced LIGO at both sites



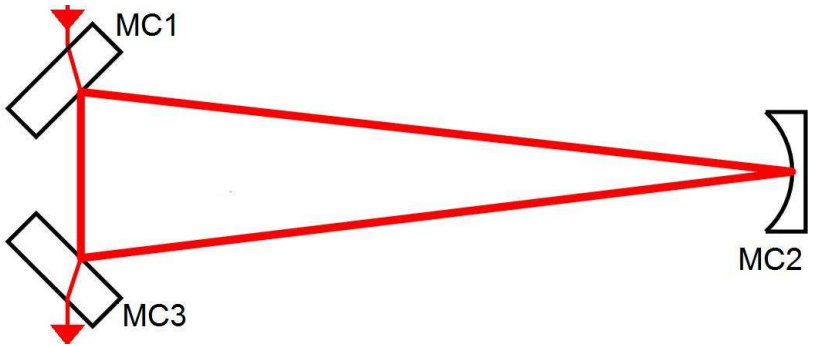
EOM performance

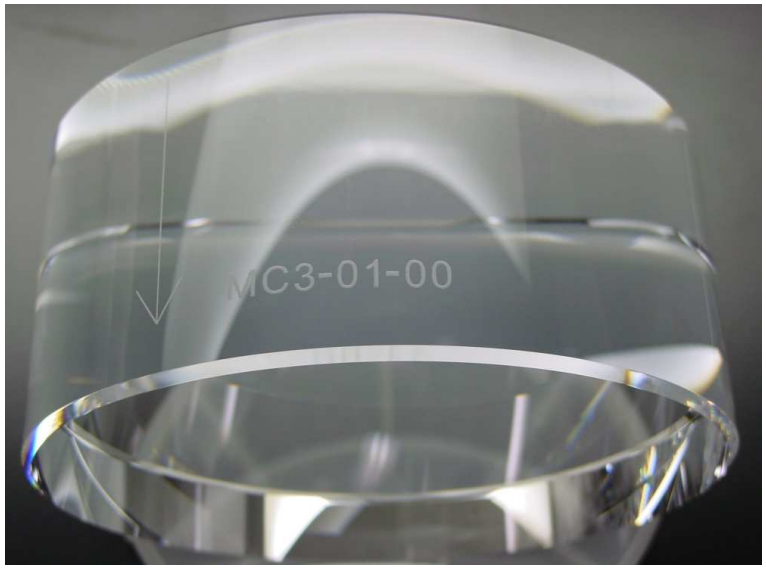
- Modulator tested to 140 W
- 300 hours sustained exposure of 100 W; >1 year at 30 W
- Modulation indices up to 0.8



Input Mode Cleaner

- Triangular ring cavity
- Length, *L/2* = 16.5 m
- FSR = 9.1 MHz
- Finesse = 520
- P_{store} = 23,200 W (@ 165 W input)
- All three mirrors on SUS-supplied "mode-cleaner triple suspensions"
- Occupies HAM2 and HAM3 in straight interferometers (L1, H1)
- HAM8 and HAM9 in folded interferometer (H2)

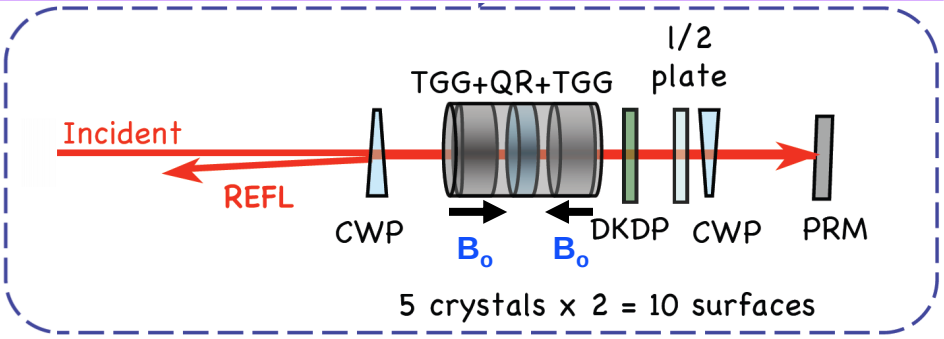


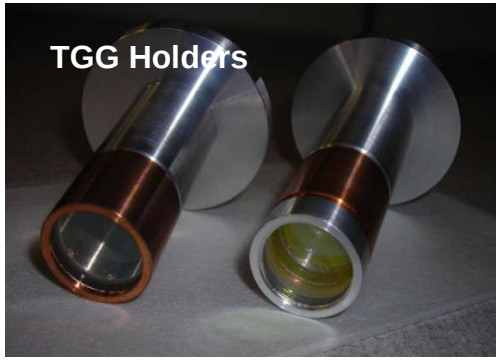


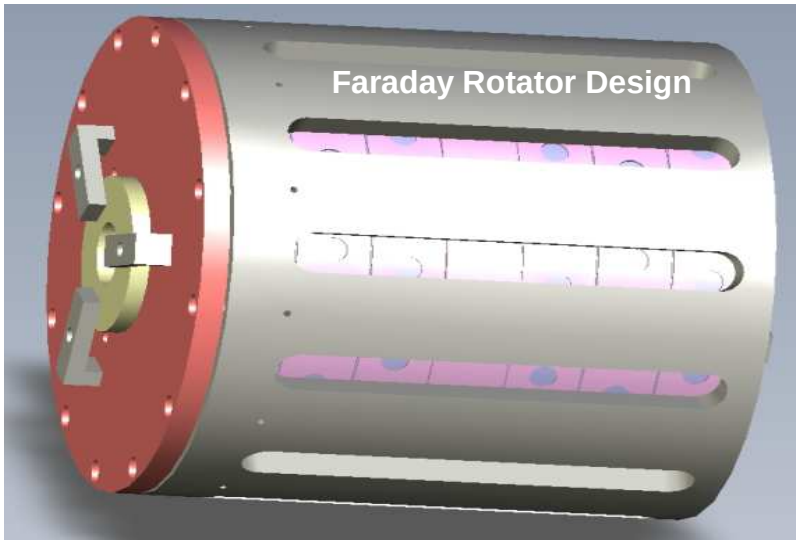
FSR = free spectral range
SUS = suspensions subsystem
HAM = horizontal access module chamber

Faraday Isolator

- IAP/UF design and construction
- Passively compensated (for depolarization and thermal lensing)
- Consists of 2x calcite polarizers, 2x TGG crystals, quartz rotator, λ/2 plate and *–dn/dT* DKDP thermal compensator
- Observed >50 dB isolation (in lab)



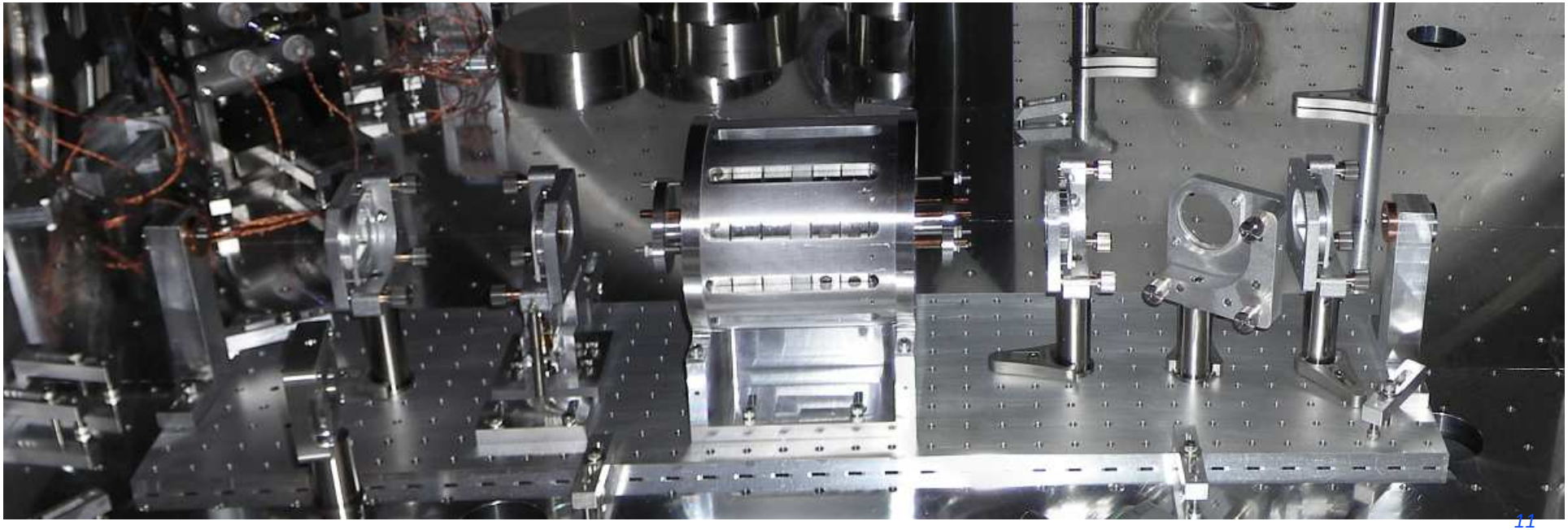




IAP = Institute of Applied Physics, Nizhny Novgorod
TGG = terbium-gallium garnet
DKDP = deuterated potassium dihydrogen phosphate, KD_2PO_4

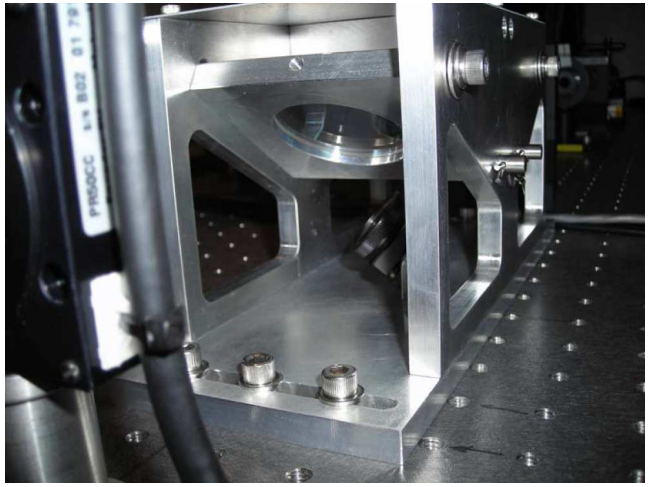
Faraday for enhanced LIGO

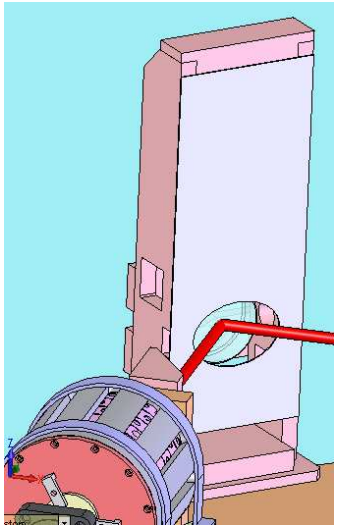
- Faraday installed in enhanced LIGO, both sites
- FI giving 25 dB isolation, 1-18 W; 20 μrad REFL drift (L1 data)



Other items

- Power control: motorized waveplate and 2x thin-film polarizers on PSL table, behind EOMs. *T* ~ 98%. Extinction ratio 140,000:1
- Mode-matching to IMC: 2 lens telescope on PSL table
- Periscope: Oil derrick
- Injection into vacuum: viewport on HAM1, sealed beam pipe to HAM2
- Errant beam baffles: silicon carbide for places where high-intensity beams could go

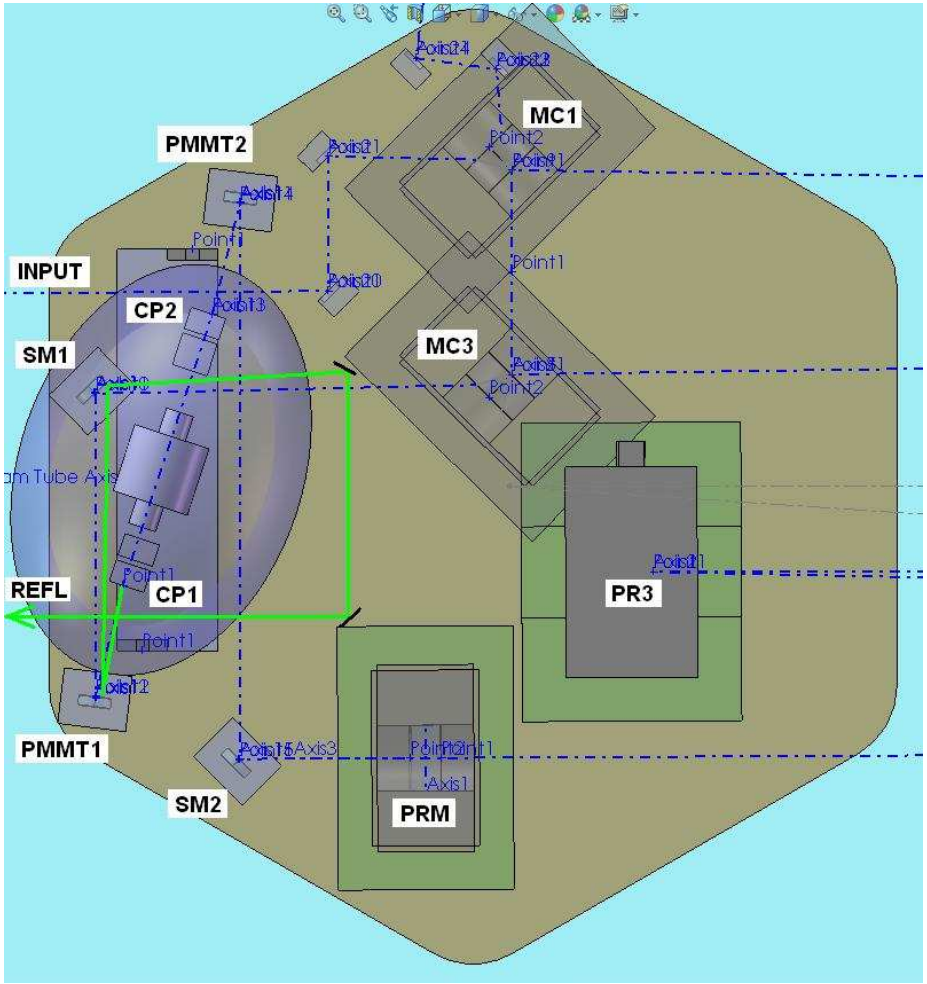




PSL = pre-stabilized laser;
EOM = electro-optic modulator
IMC = input mode cleaner
HAM = vacuum chamber

Other items 2

- Mode-matching to PRC: PMMT mirrors on SOS
- IO carries PRC and SRC layout, radii for mode-matching to arms
- Active control of mode matching with 4-heater thermal lens on SF57 glass plate
- Diagnostics: RFAM monitor, cameras, optical spectrum analyzer



PRC = power recycling cavity
PMMT = pre-mode-matching telescope
SOS = small optic suspension
IO = input optics
SRC = signal recycling cvity

Project Status: parts fabrication