Input optics energy budget for Enhanced LIGO

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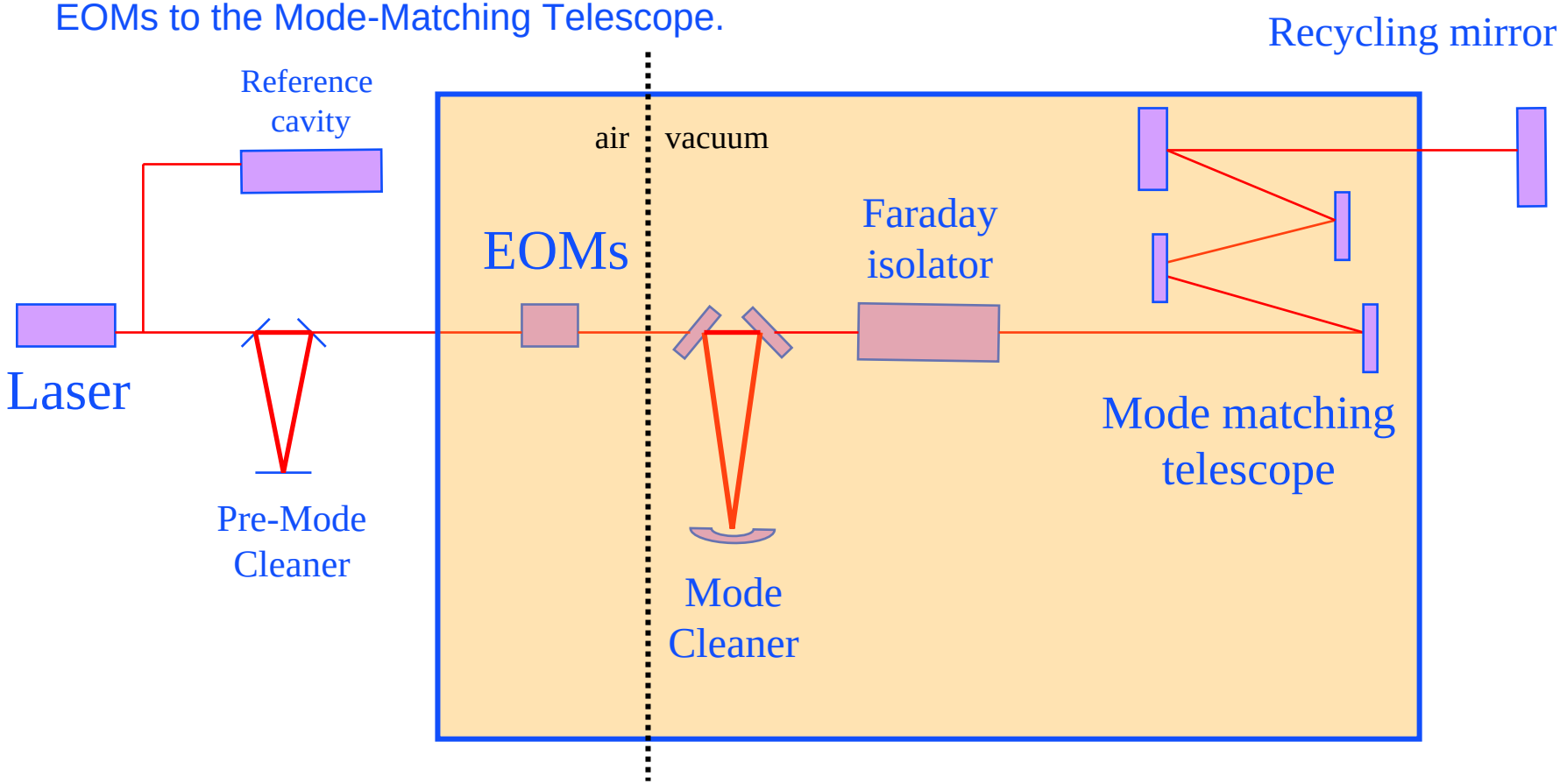
Input Optics

The Input Optics include all the elements from the EOMs to the Mode-Matching Telescope.



Input Optics Upgrade

Why?

- 3x increase in laser power
- Test advLIGO IO technology
- Fix problems found during iLIGO

Tasks:

- New Faraday Isolator
- Clean mode cleaner
- Adjust mode matching telescope
- New electro-optic modulators

HAM 1 – MC1&3, MMT1&3, Faraday

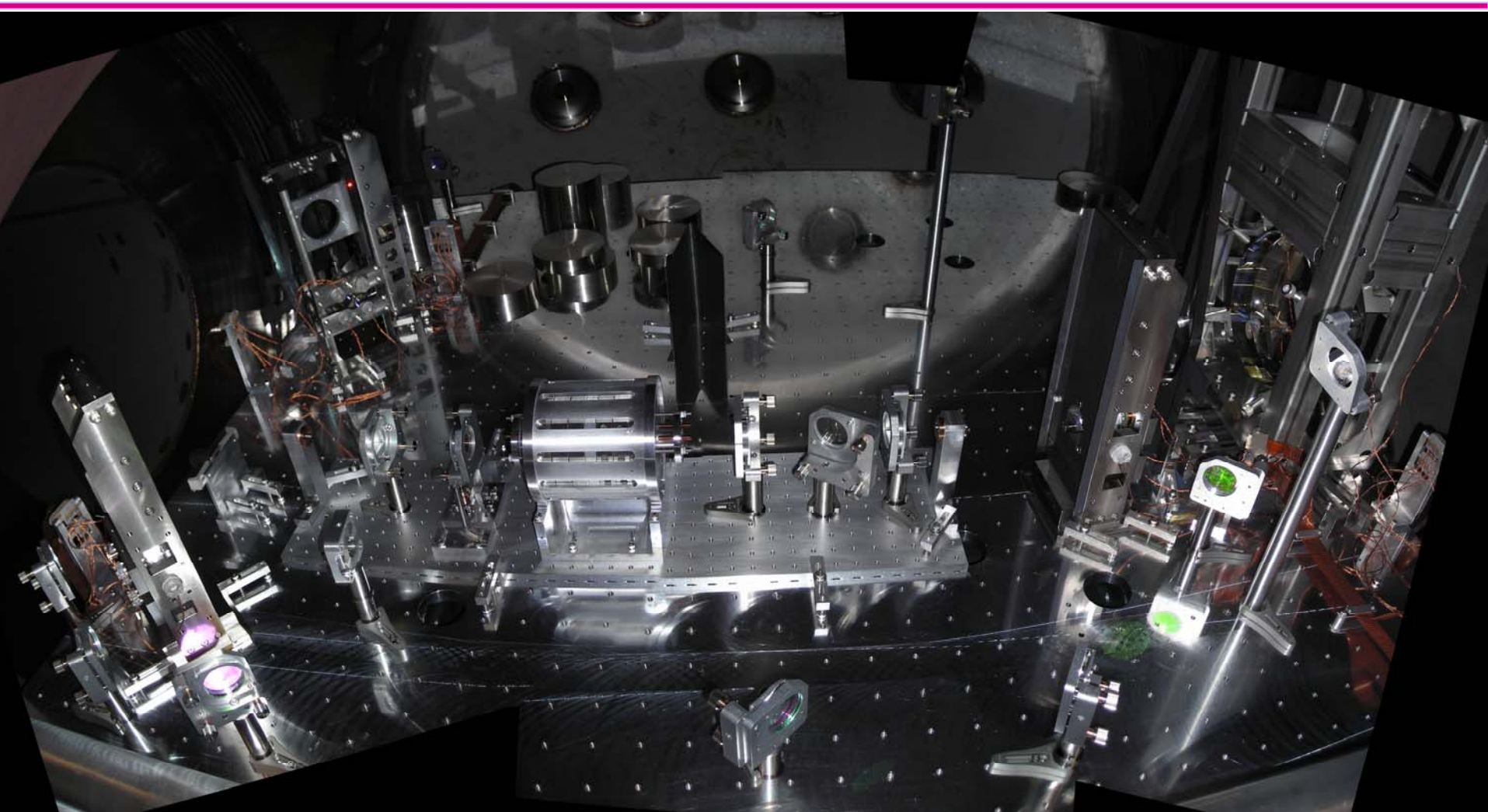
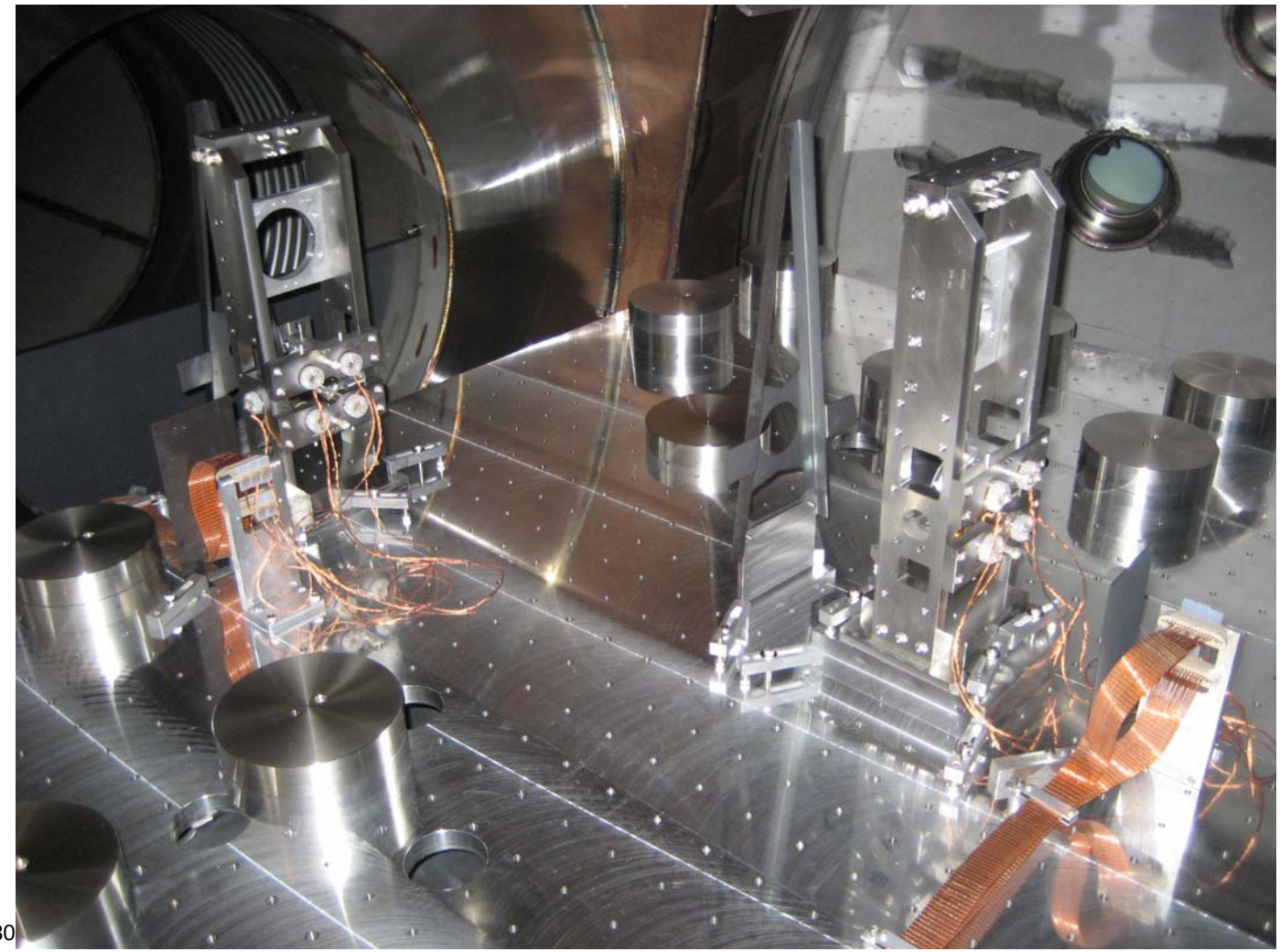
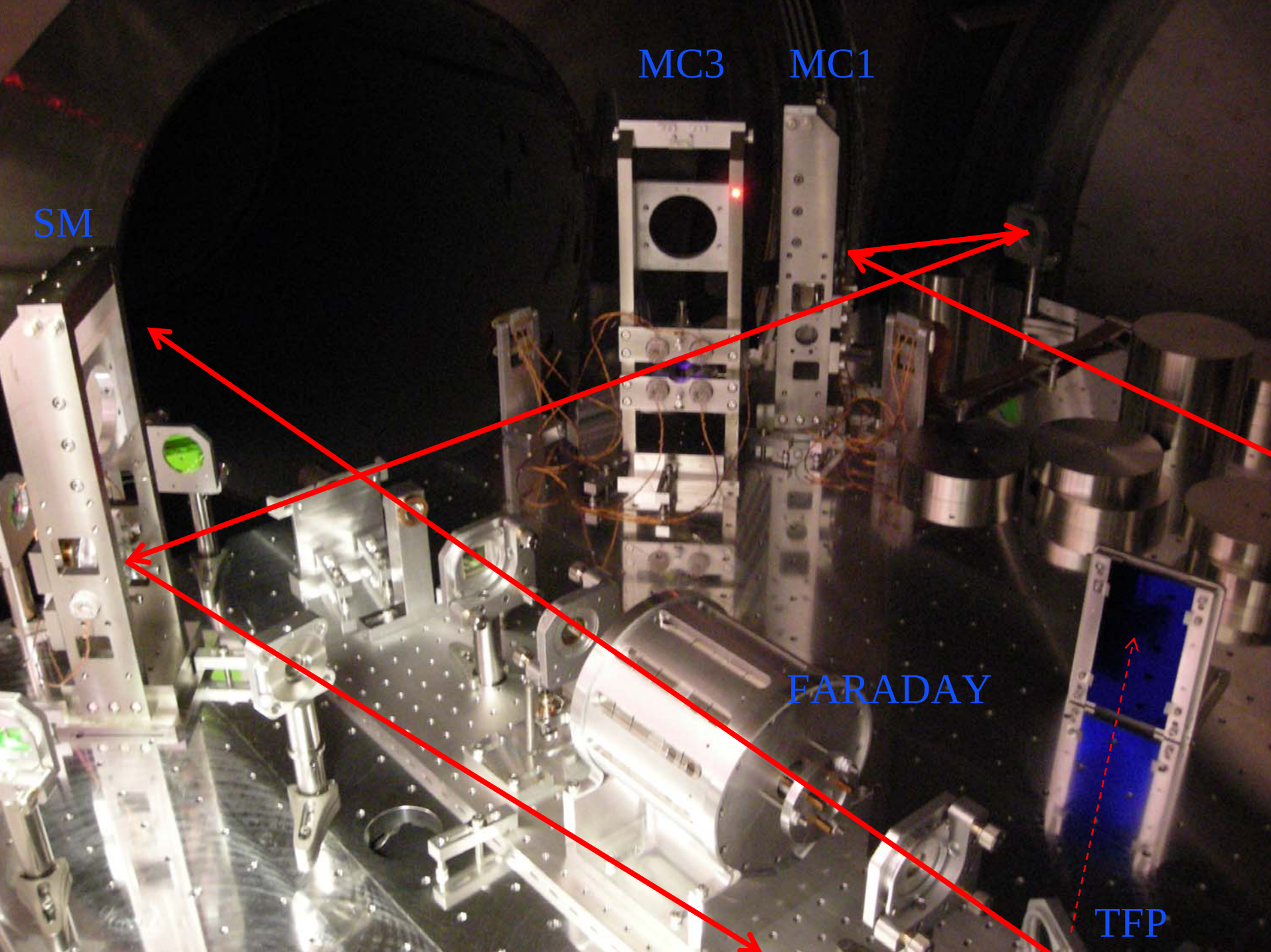


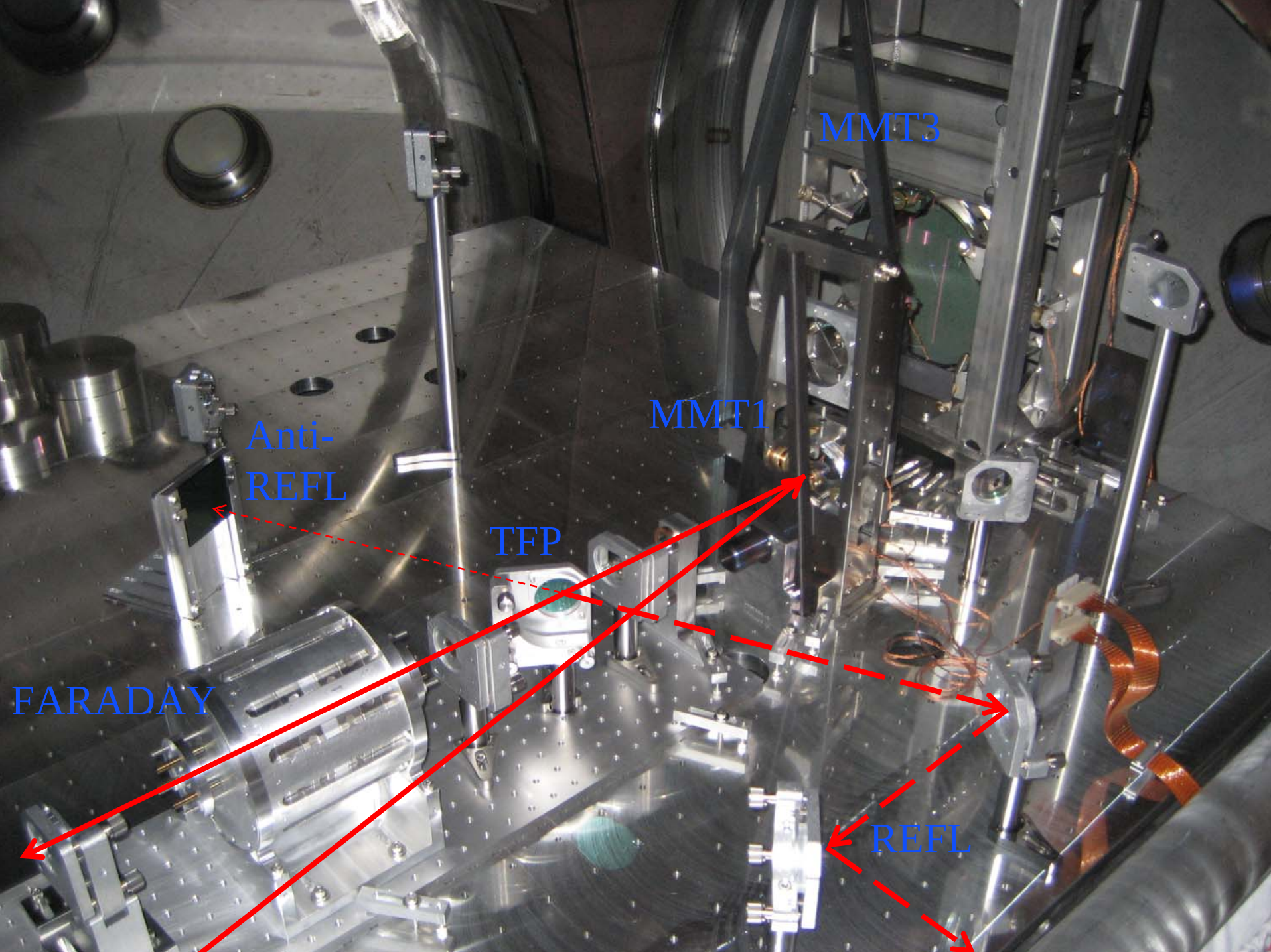
Photo courtesy of Volker

LIGO

HAM 2 – MC2, MMT2

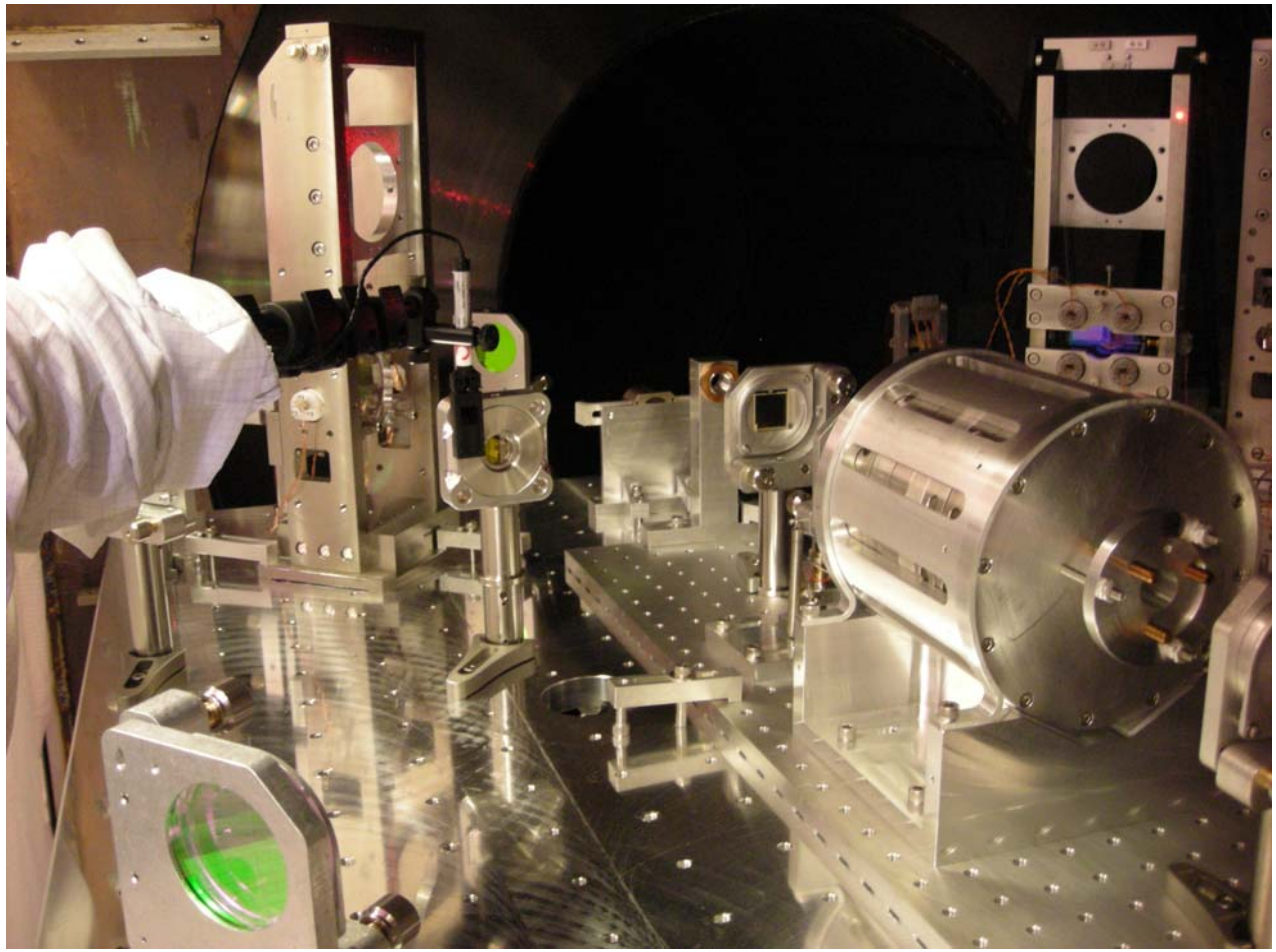



MC3
MC1
SM
FARADAY
TFP

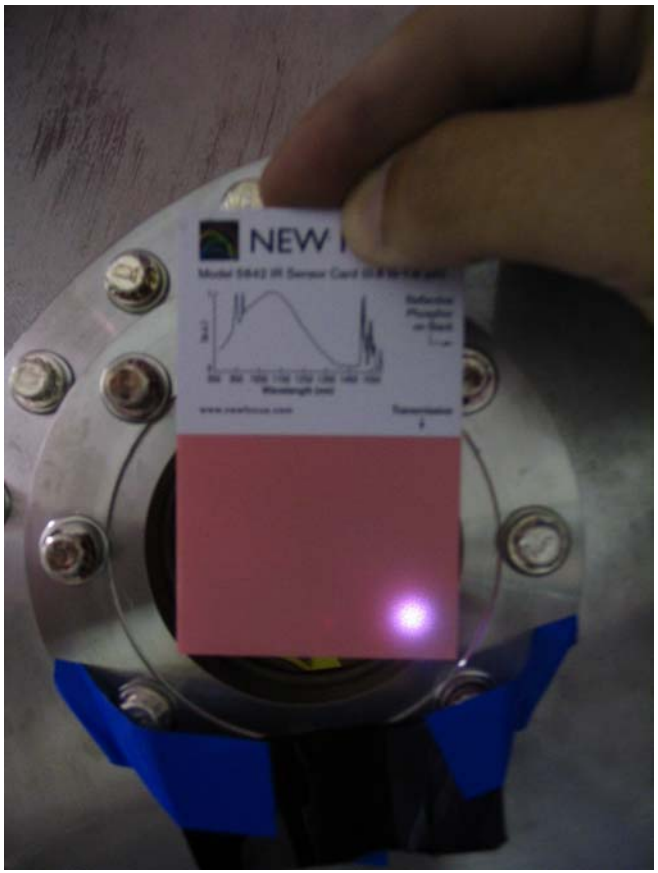

MMT3
MMT1
Anti-
REFL
TFP
FARADAY
REFL

In-vacuum measurements

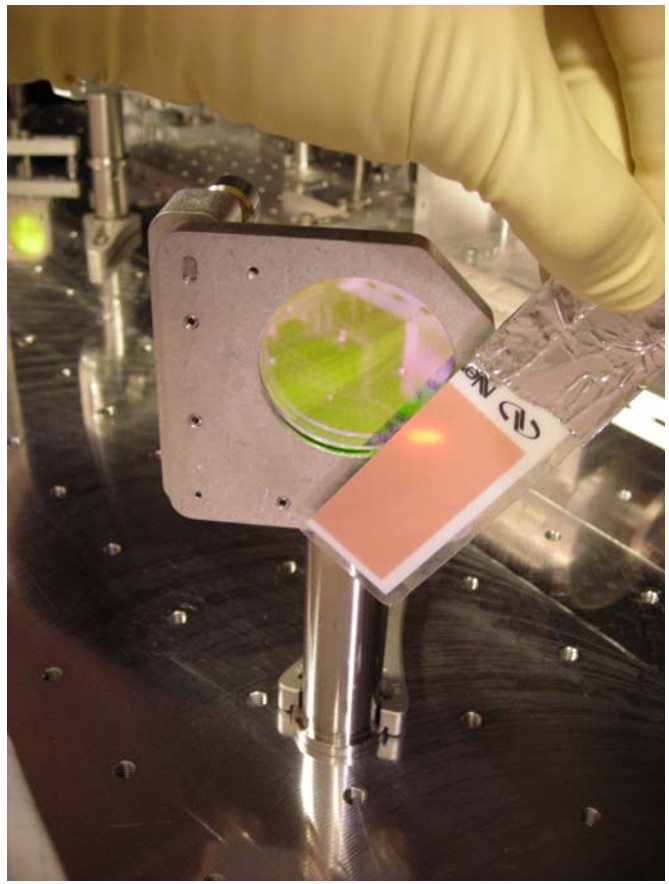
Beam powers were measured using a lo-power Ophir meter attached to a vacuum-compatible telescoping mount.



Problems found…

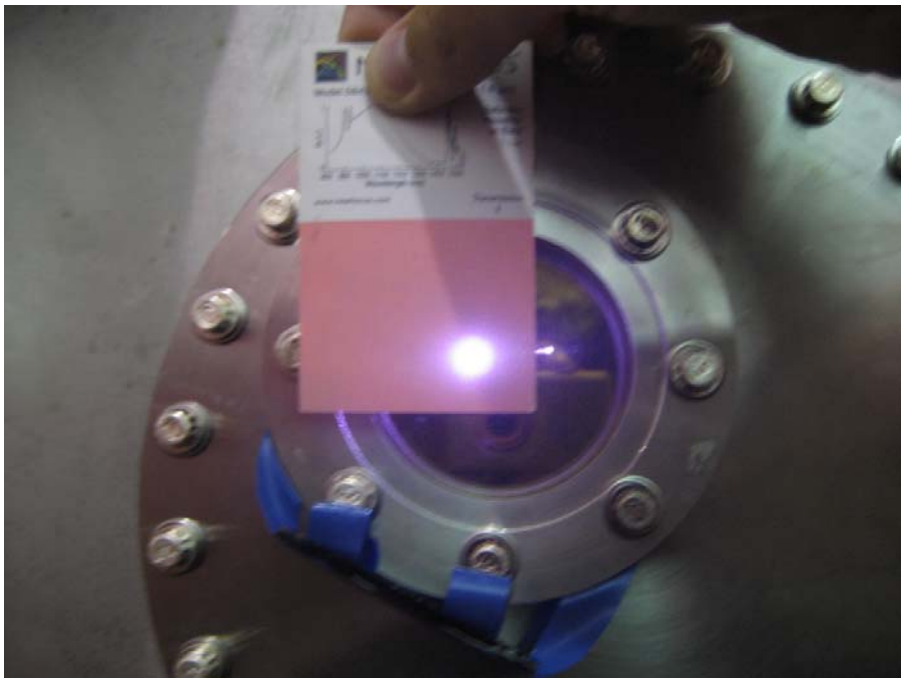


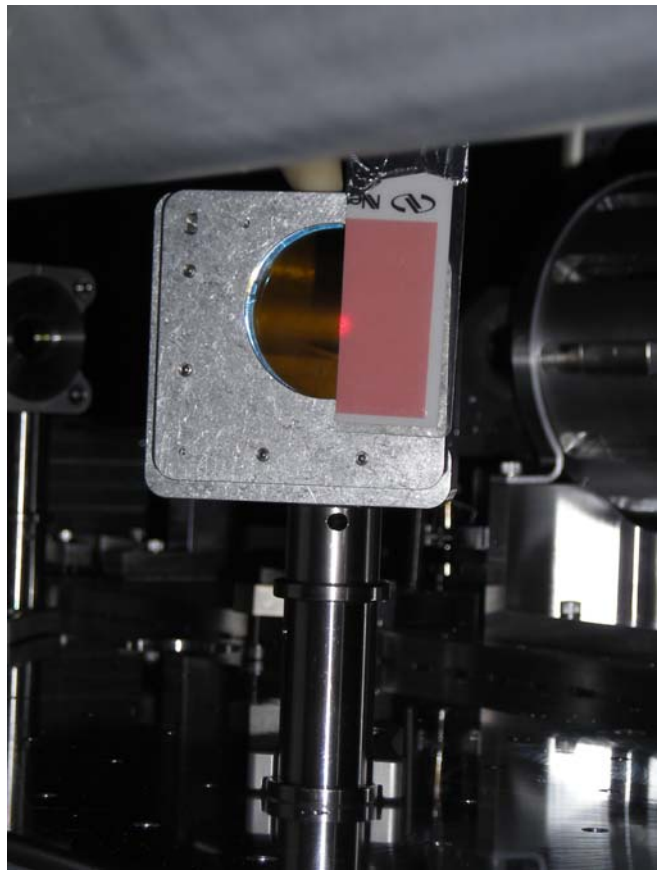
LLO



LHO

… and resolved

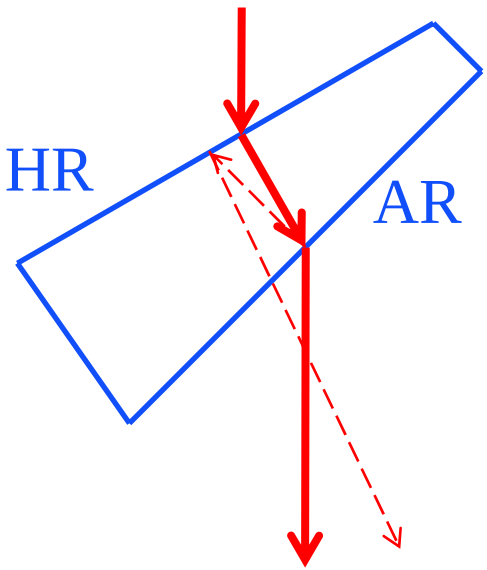


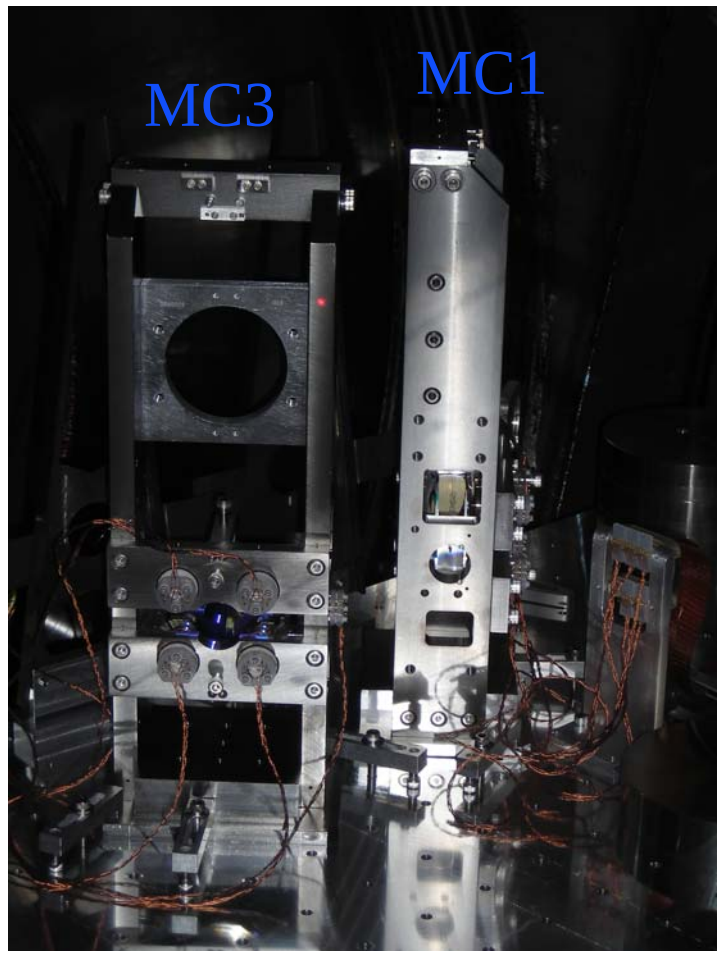


LLO LHO

Surprises

- MC AR coating losing 1.2 – 1.3% of the light
  - Measured for MC3 at LHO
  - Measured for MC1 at LLO





Raw power measurements

	Livingston	Hanford
Top of PSL periscope	32.8 mW = 100%	32.85 mW = 100%
After PSL—HAM1 viewport	98.2%	
Before MC1	94.8%	
➢ MC REFL after viewport	89.6%	95.6%
Before Faraday *	75.6%	82.2%
➢ Anti-REFL *	2.9%	2.3%
After Faraday *	69.5%	77.3%
REFL before viewport *	65.5%	71.5%

➢ Note that both sites lose a significant amount of power to anti-REFL. Also, the MC REFL path for L1 is particularly lossy.

* These numbers cannot be directly compared due to MC visibility differences between the sites at the time of the measurements.

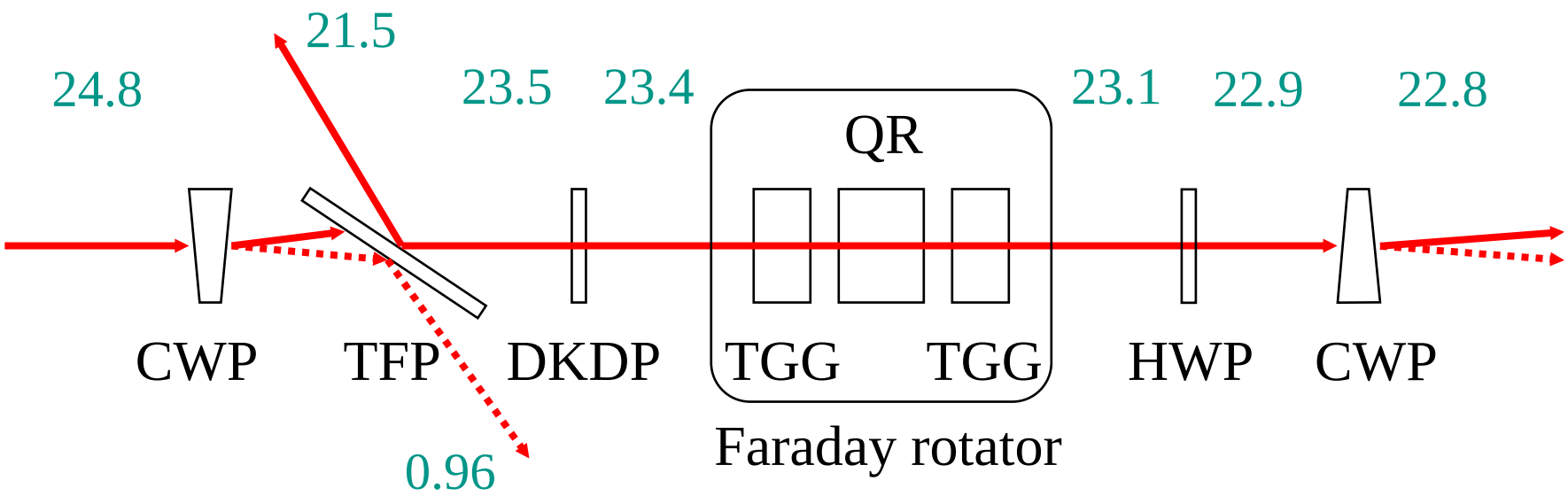
Energy budget comparison

- Main in-vacuum numbers

	Livingston	Hanford
SM transmission	0.26%	0.262%
TFP loss due to anti-refl	3.9%	2.2%
MC AR ghost	1.2%	1.3%
Faraday transmission	91.4%	93.3%
MC transmission	91.3%	

Losses in the Faraday Isolator

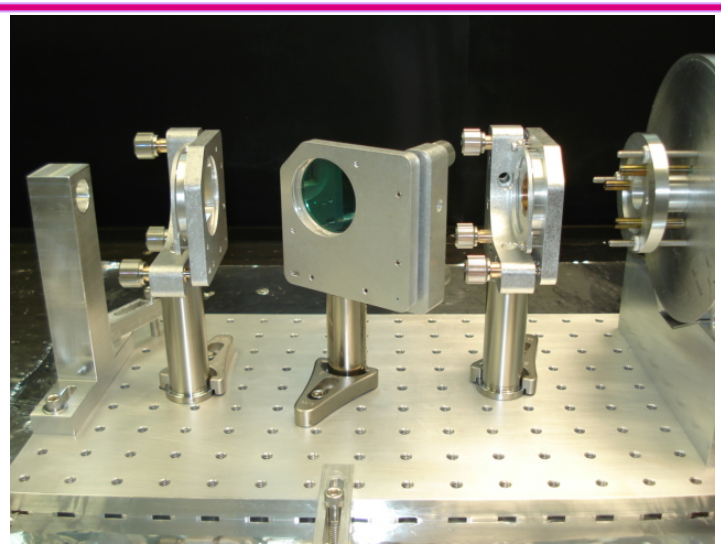
Power, measured at L1, in mW:



Losses from each element: 3.9% 0.4% 1.3% 0.9% 0.4%

➢ At L1, Largest loss is from TFP

Thin Film Polarizer



- Mystery at LHO
  - » Poor transmission; rotated in yaw 3 deg; better transmission
    - – Accidentally bumped?
    - – DLC mount ball bearings not sitting properly?
- Greatest Faraday loss
- In the lab, measured 1.5% loss in transmission
  - – Therefore, seeing 1-3% extra loss than we should
- UF plans research on FI polarizing components for advLIGO

LIGO

Summary

- Mode cleaner mirrors' AR coatings bad at both sites
- Found and fixed beam clipping at both sites
- LHO has the better TFP
- LHO gets 6% more power than LLO from periscope to MC (viewports?)
- IO efficiency (PSL to RM):
  - » LLO: 70% (MC visibility of 93%)
  - » LHO: 77% (MC visibility of 92% +/- 2%)

(compare with 55%-65% for iLIGO, LHO elog Dec 31, 2002)

Acknowledgements

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- Luke Williams

Energy budget comparison

- Calibrations for out of vacuum measurements
  - Use this to calculate MC transmission and IO efficiency

	Livingston	Hanford
REFL before viewport / Faraday output *	94.3%	92.7%
MC input / top of PSL periscope	94.8%	
MC trans after viewport / after MC3	0.252%	0.258%

* Need to know viewport transmission and periscope losses