eLIGO/advLIGO FI update

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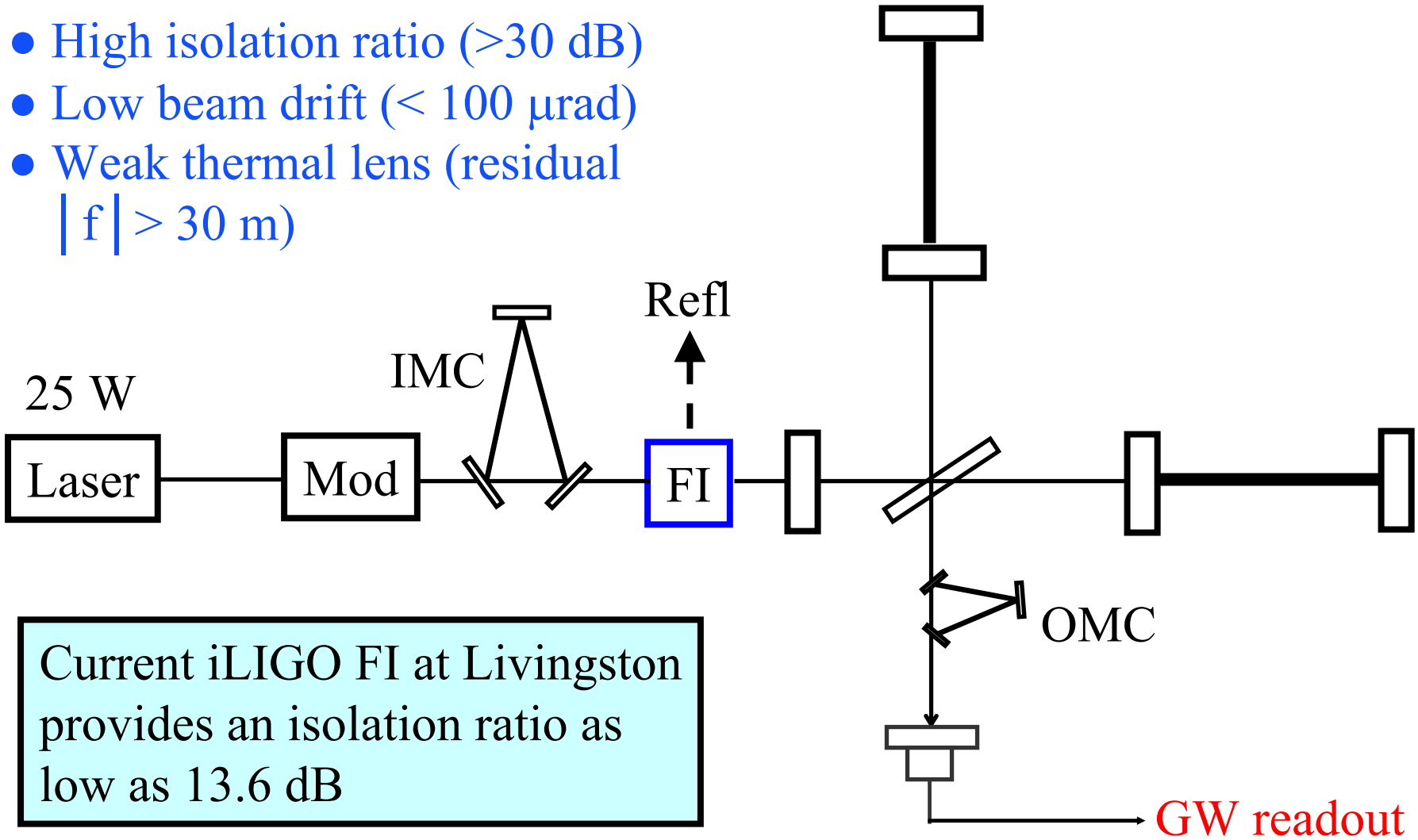
FI for eLIGO

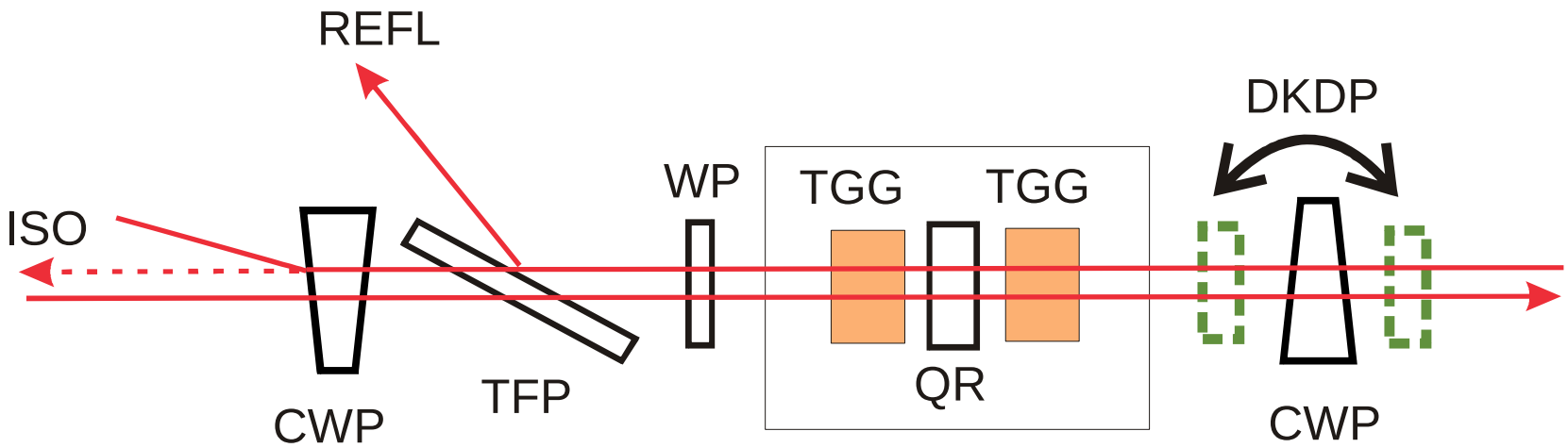
- High isolation ratio (>30 dB)
- Low beam drift (< 100 μrad)
- Weak thermal lens (residual $|f| > 30$ m)



Current iLIGO FI at Livingston provides an isolation ratio as low as 13.6 dB

eLIGO/advLIGO FI configuration

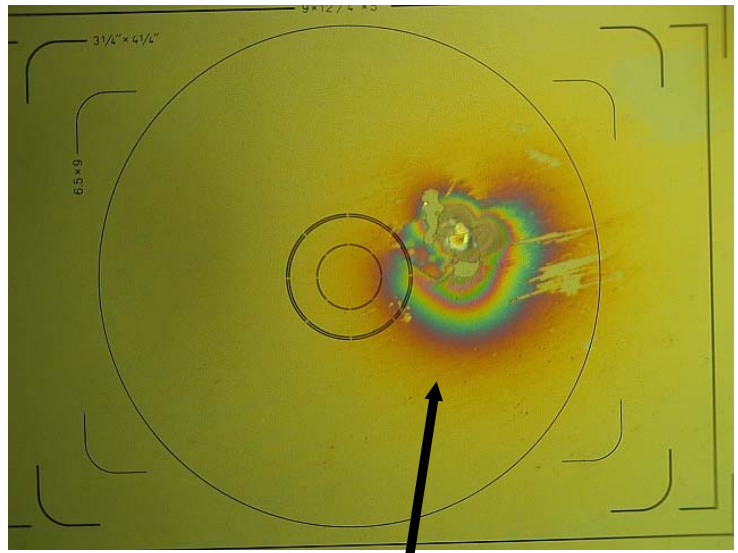
- Faraday Rotator
  - Two 22.5^0 TGG crystals with a reciprocal 67.5^0 QR
- Calcite wedge polarizers (superior to TFPs)
- Thermal lens compensation with - dn/dT material (deuterated dihydrogen phosphate, or 'DKDP')



Problems we have encountered

- TGG and DKDP crystals:
  - surface damage
  - improper AR coatings

SOLUTION: New vendor (NG)

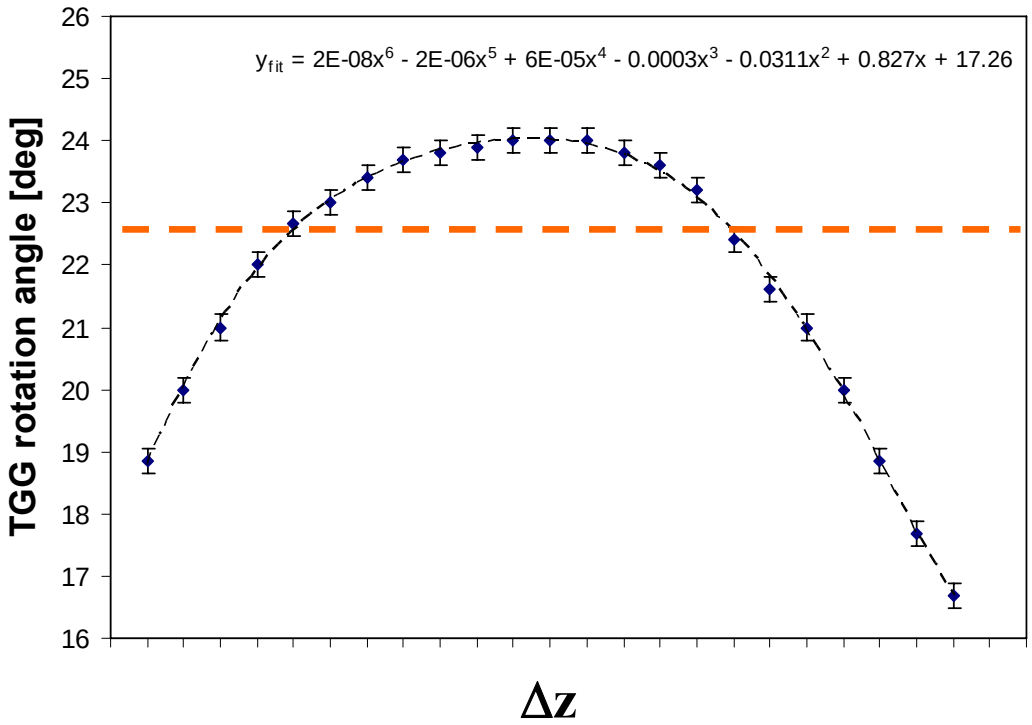


Diameter ~ 200 μm

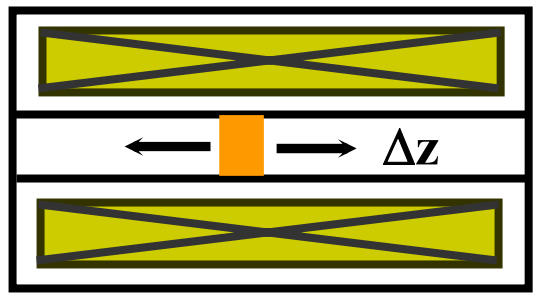
- Magnet

FI magnet ring failure

Characterization of individual TGGs



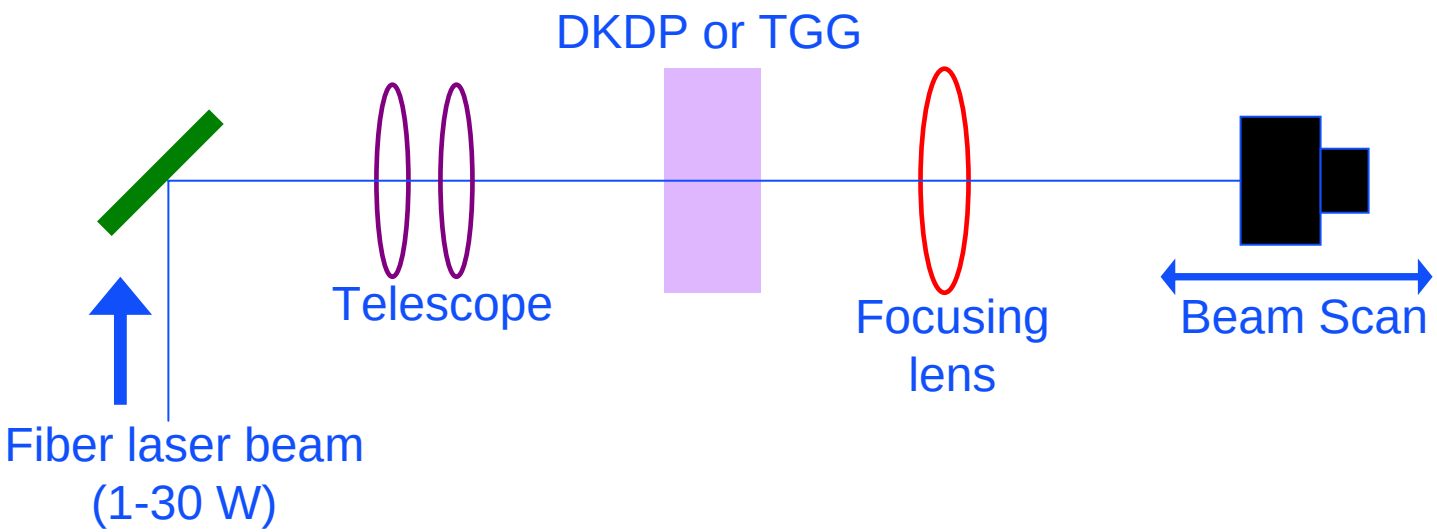
- Incident laser power: 1 W

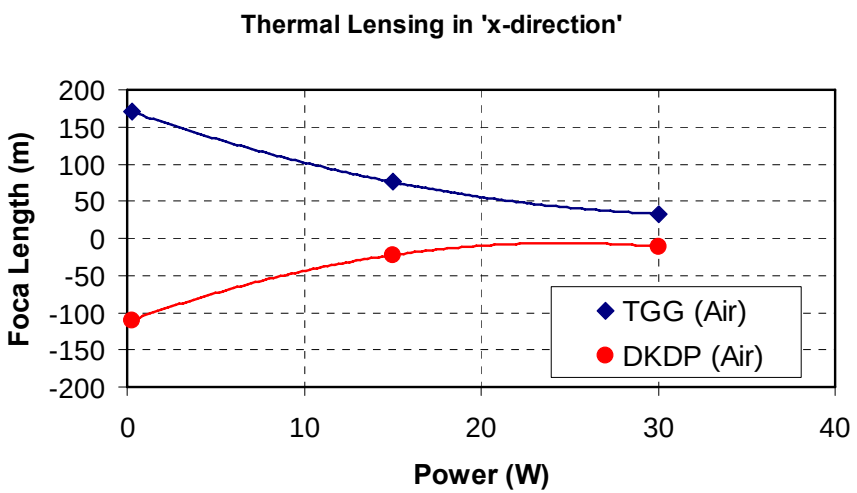


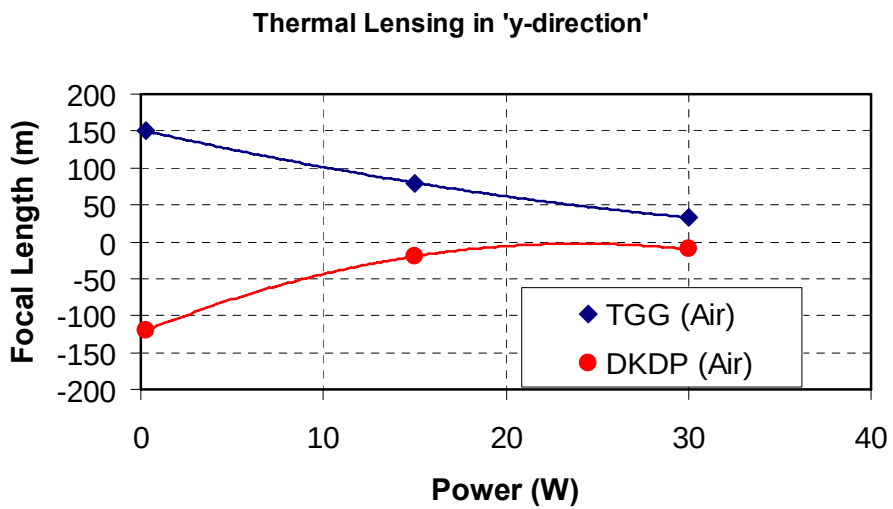
Result from 6th order polynomial fit:

Max TGG rotation angle (crystal #2): 24.03 deg +/- 0.01 deg

Thermal lens created by TGG and DKDP



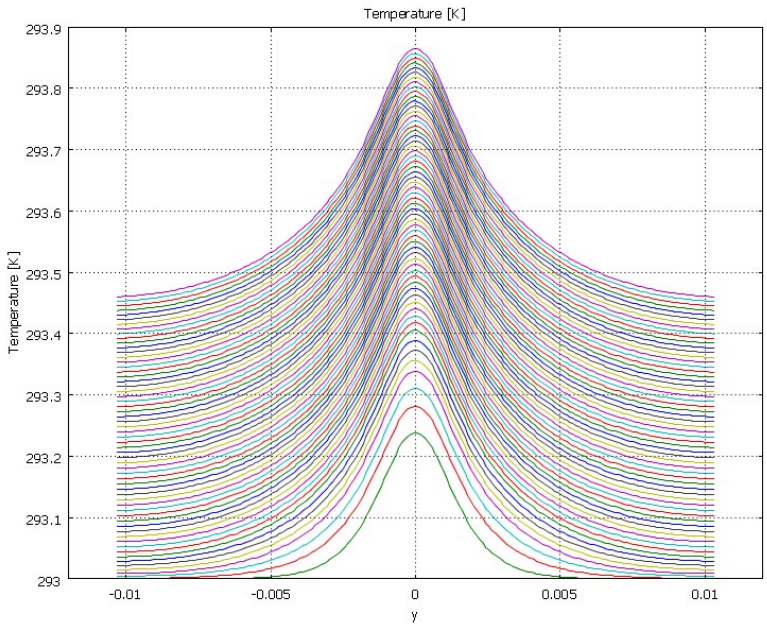


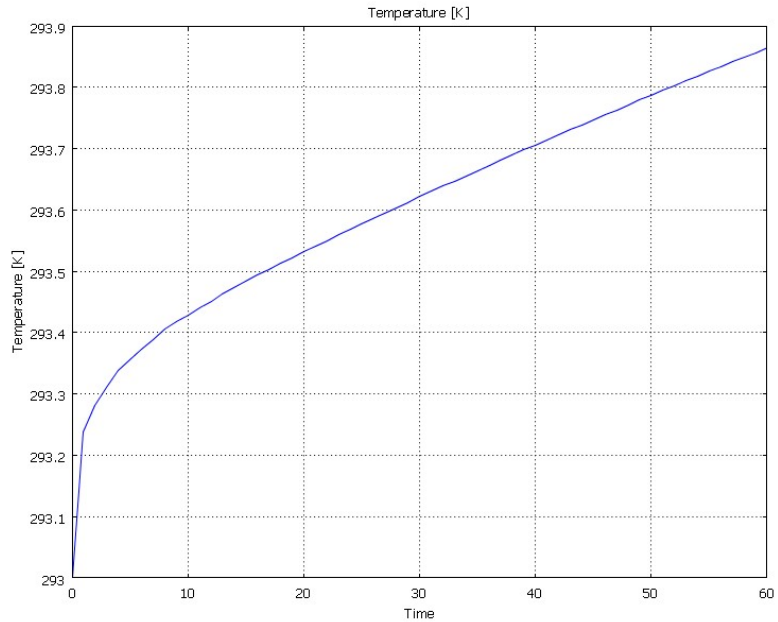


COMSOL Simulation (radiation enabled on faces and edges)

30 W incident power
Time from t = 0s to t = 60s with a line every 1s

Temperature in the center of the pumped face (point [0,0,0])



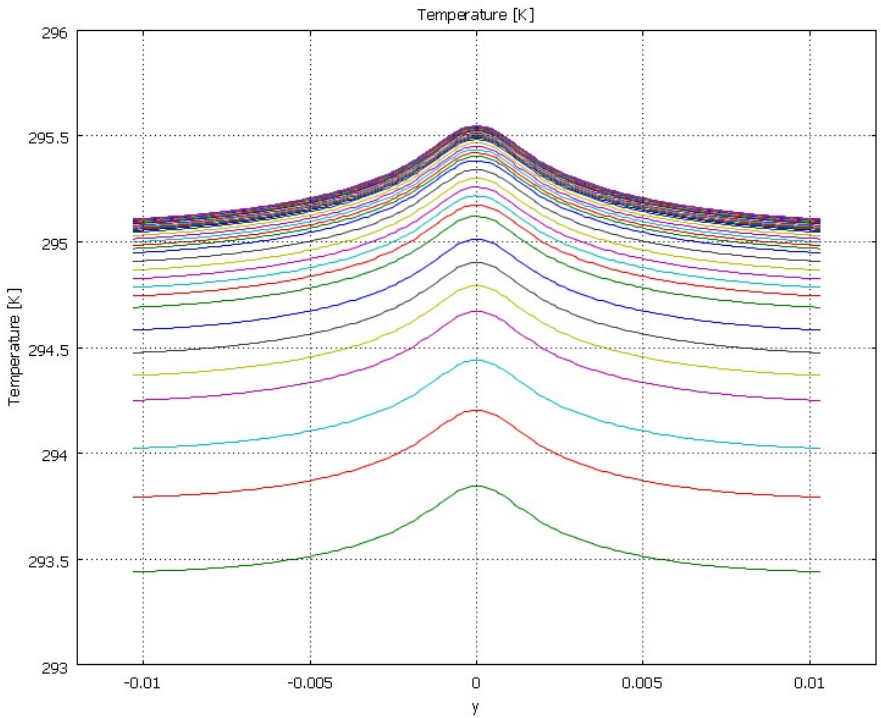


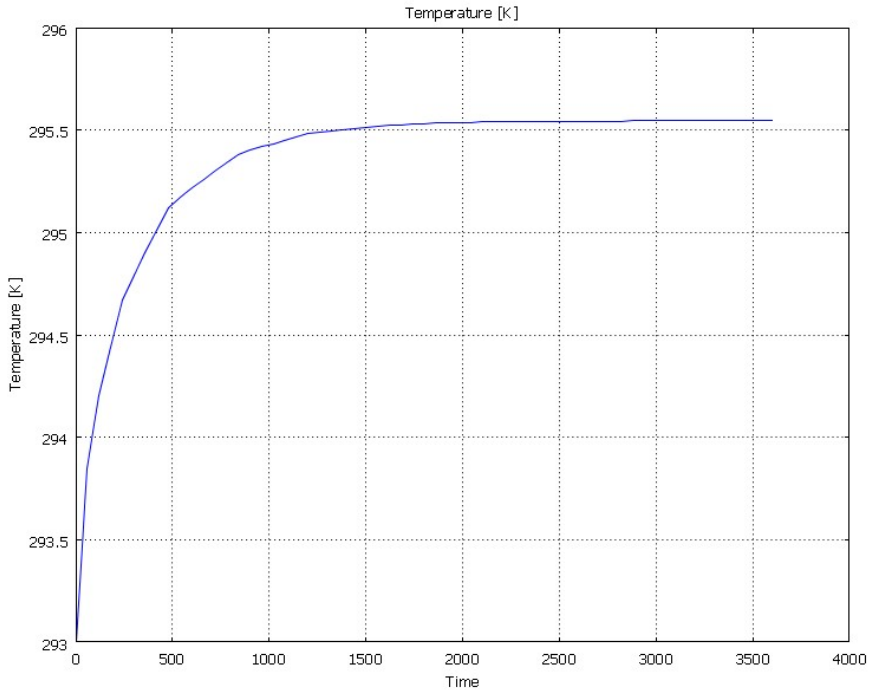
Parameters:
TGG radius = 10.3 mm
Laser beam radius = 1.5 mm

The time constants of thermal lensing are in the order of seconds

COMSOL Simulation (radiation enabled on faces and edges)

30 W incident power
Time from t = 0s to t = 3600s (60min) with a line every 60s (1min)

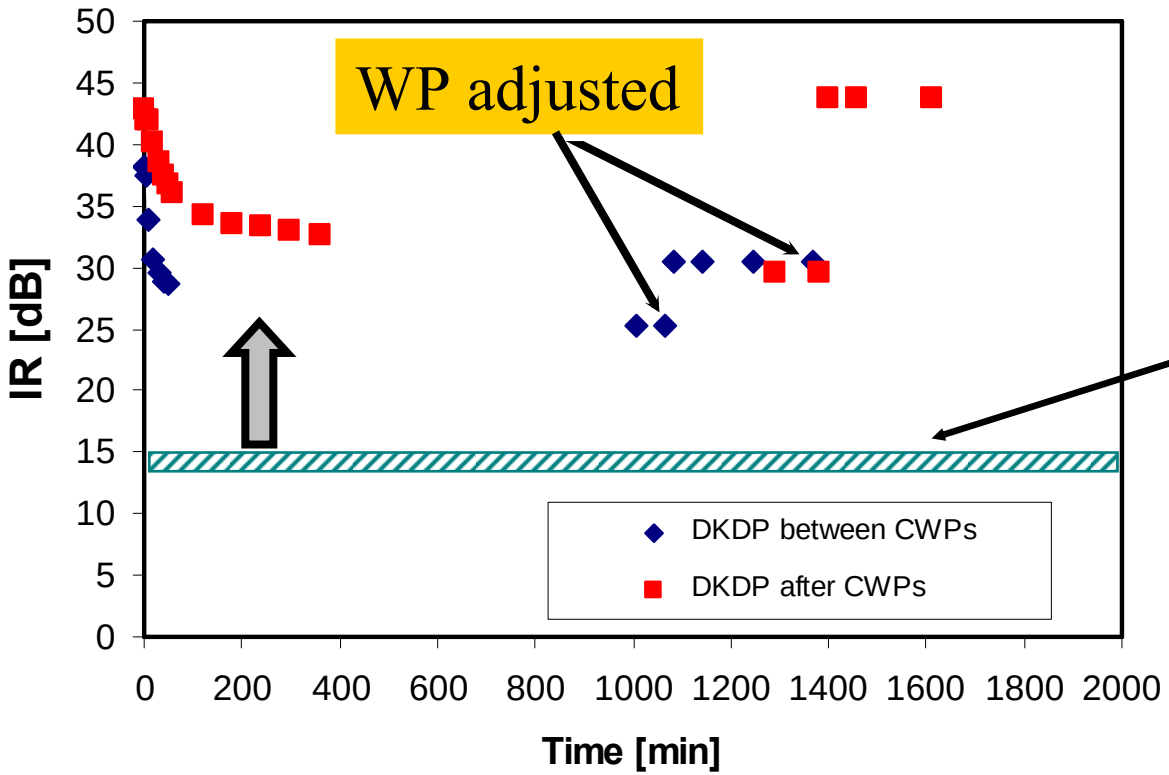




Parameters:
TGG radius = 10.3 mm
Laser beam radius = 1.5 mm

Temperature in the center of the pumped face (point [0,0,0])

Faraday Isolator performance Isolation ratio (CWPs)



$P_L = 25W$

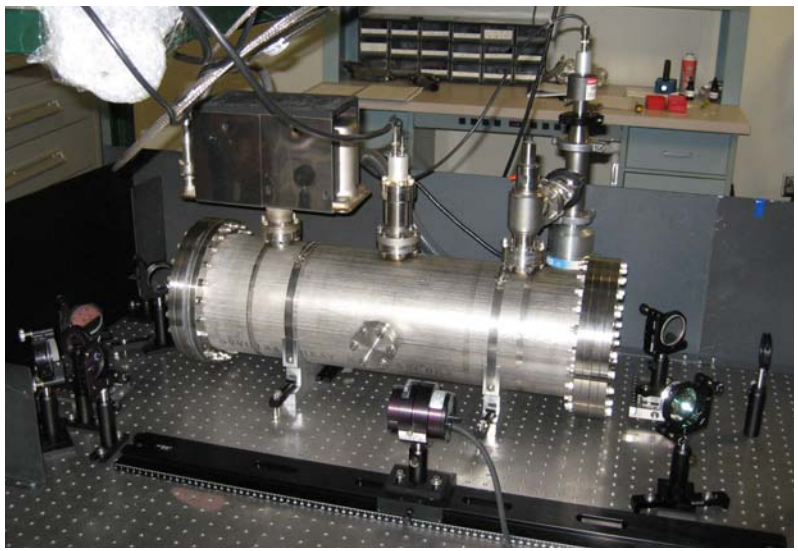
$p = 4*10^{-6}$ Torr

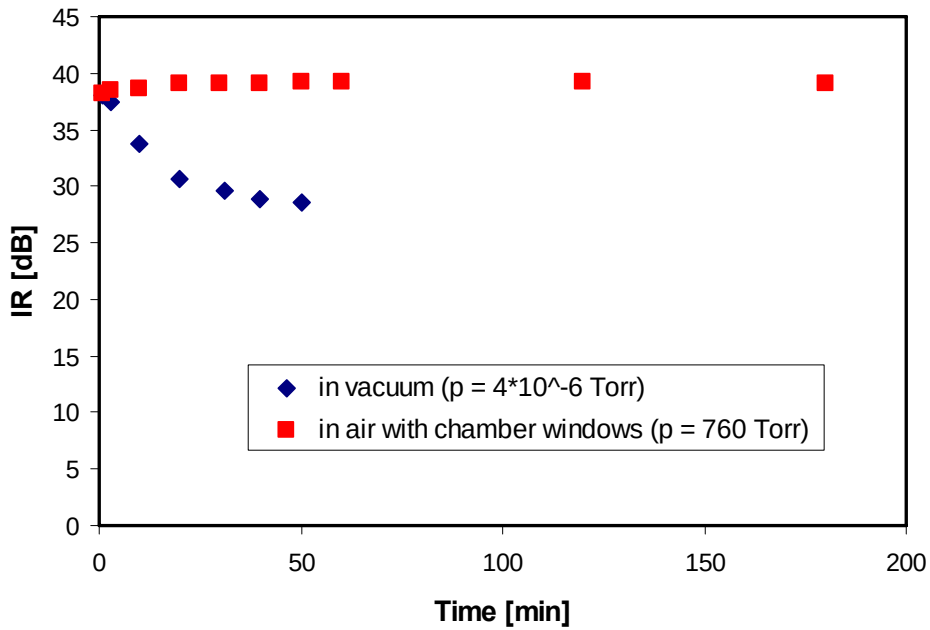
IR of iLIGO FI (LLO)

- Decrease in isolation ratio under vacuum as time went on
- Could be recovered by < 2 degree rotation of waveplate

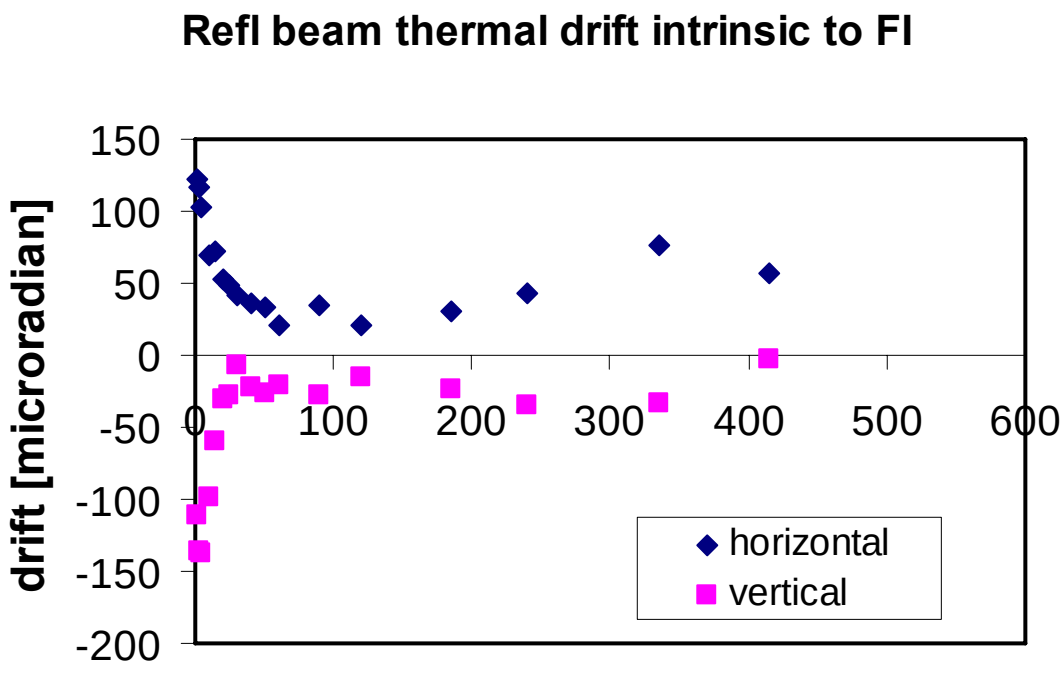
Faraday isolator performance
Effect of vacuum

- $P_L = 25$ W
- DKDP between CWPs





Faraday isolator performance thermal drift (CWPs)

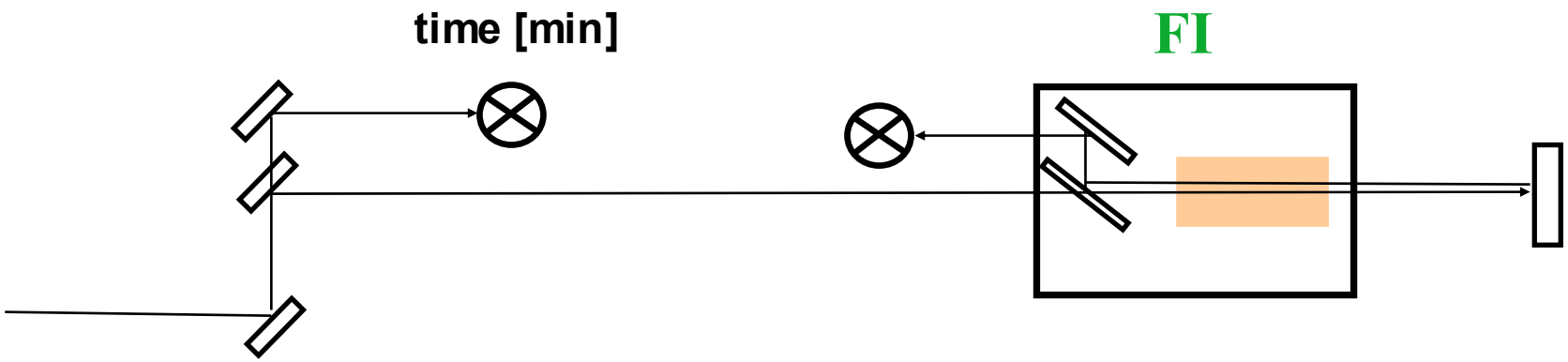


$P_L = 25W$

$p = 4*10^{-6}$ Torr

Result:

Over the course of six hrs the horizontal and the vertical intrinsic drifts are < 50 microradians



ELIGO FI Schedule

LLO

- Assembly, final test and measurements of the FI will be done in the clean optics lab at the LIGO Livingston Observatory
- Installation of the FI for LLO will start on Nov 13, 2007.
- Integration and commissioning of the FI and Input Optics with PSL is planned to start on June 3, 2008.

LHO

- Installation of the FI at LHO is planned to start in December 2007 or January 2008.
- Integration and commissioning of the FI and Input Optics with PSL is planned to start on Feb. 19, 2008.

Conclusions

- Initial LIGO FI measurements reveal that isolation requirements for E-LIGO are very relaxed

  ⟶ 20 dB will work well

- Obtained 43 dB isolation ratio with CWPs in vacuum
  Decrease in isolation ratio under vacuum should be recovered by < 2 degree rotation of waveplate.
  Intrinsic thermal drift of the reflected beam was < 50 microradians for the horizontal and vertical axes

- Performance is expected to improve with Northrop Grumman crystals (TGG/DKDP) and new precision mount for DKDP with tip/tilt positioning