

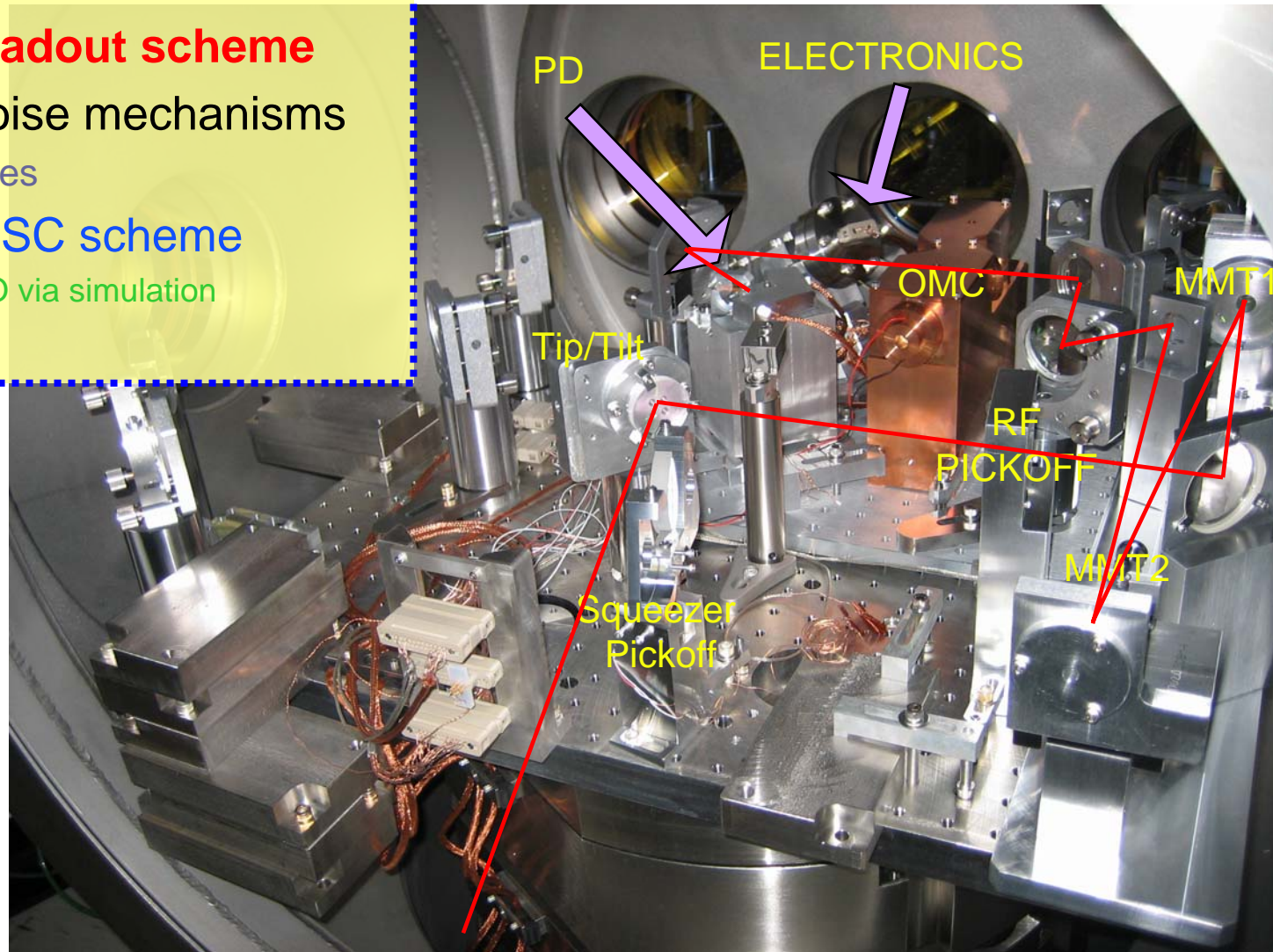
40m TAC Update: Feb. 2007



- Objectives:
- Develop **lock acquisition procedure** of DRSE interferometer, as close as possible to aLIGO optical design

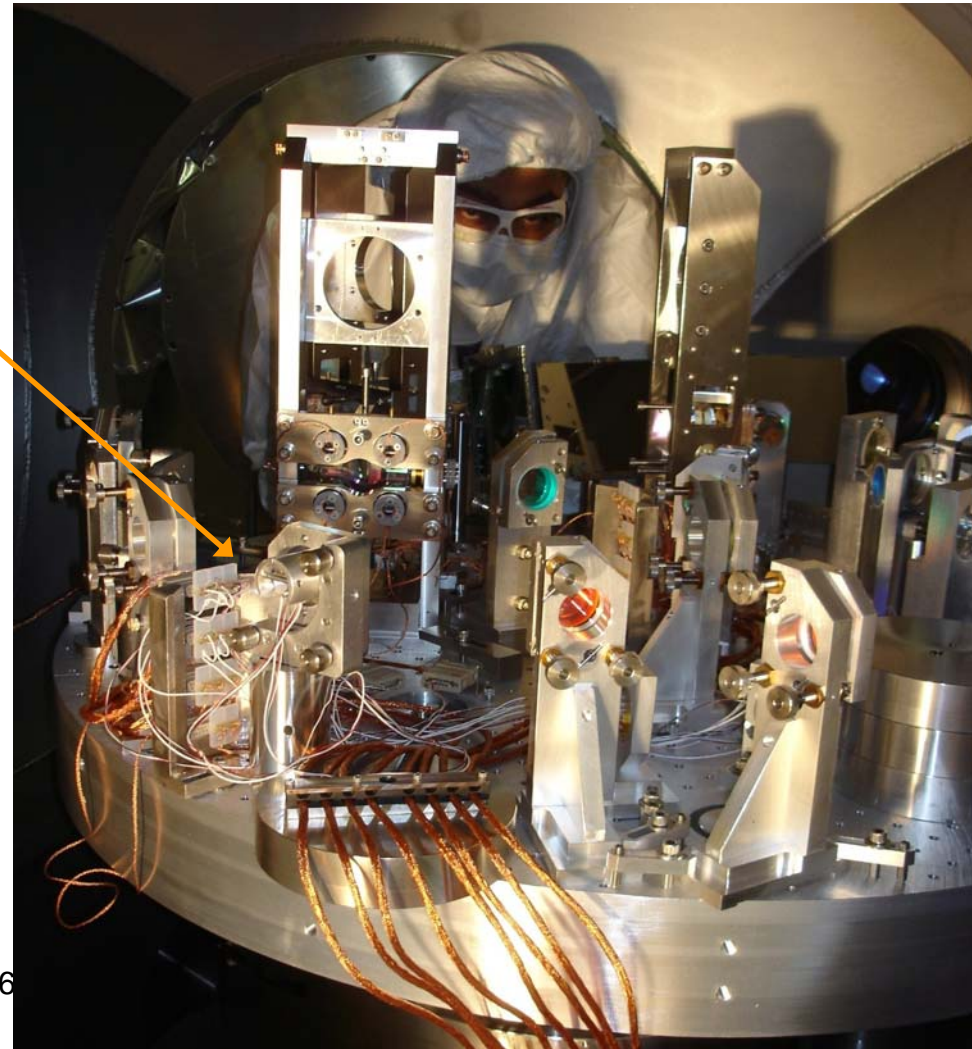
- **Test/Characterize LSC scheme**
- **Develop DC readout scheme**
- Characterize noise mechanisms
- Test QND techniques
- **Develop/Test ASC scheme**
- Extrapolate to AdLIGO via simulation

Prototyping will yield crucial information about how to build and run eLIGO & aLIGO

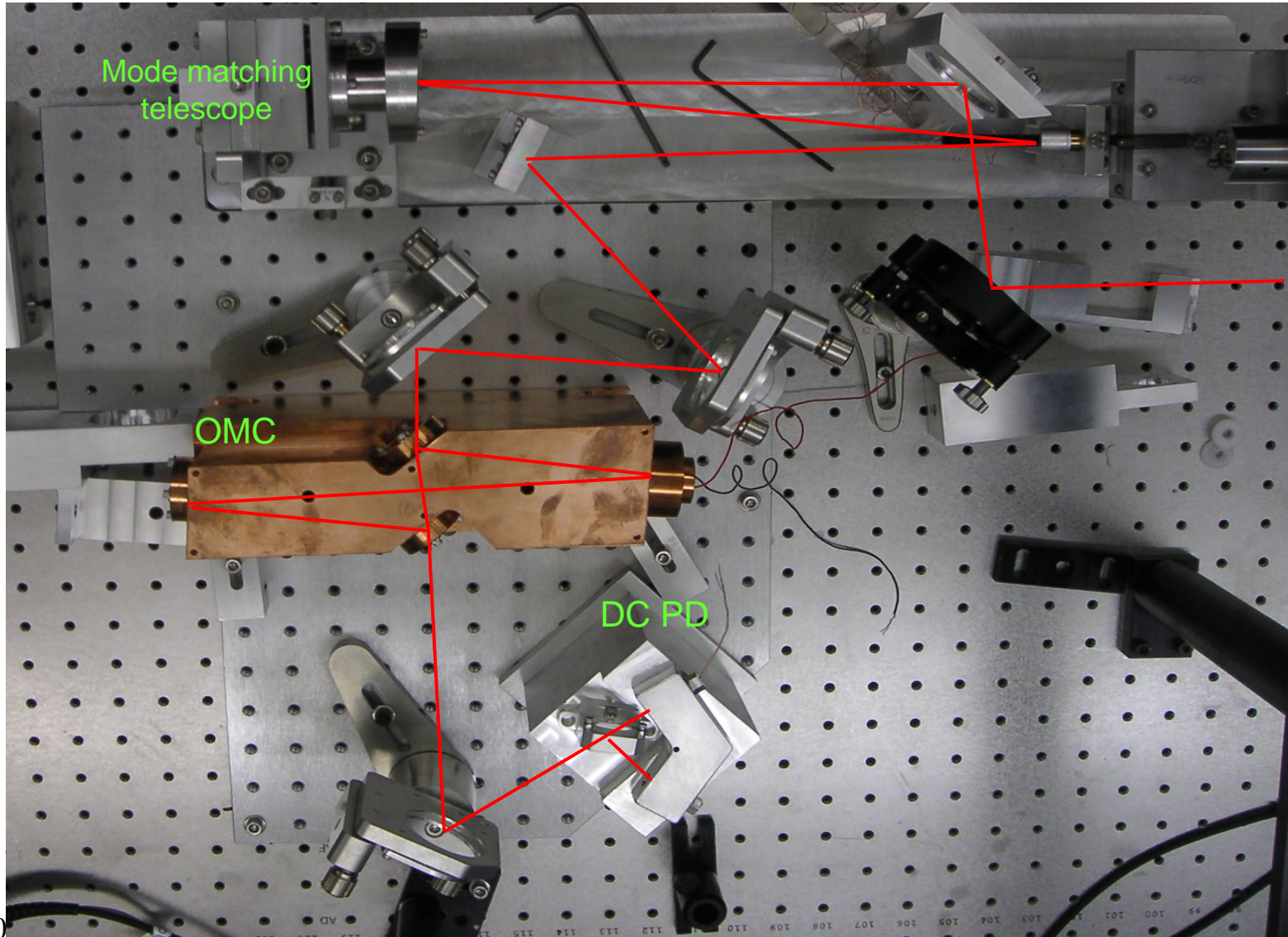


Work since last update (Oct. 06)

- 1) PR FPMI Locking
- 2) **Another Vent for clipping/squeezing**
- 3) Automation/scripting
- 4) Modeling



DC readout beamline



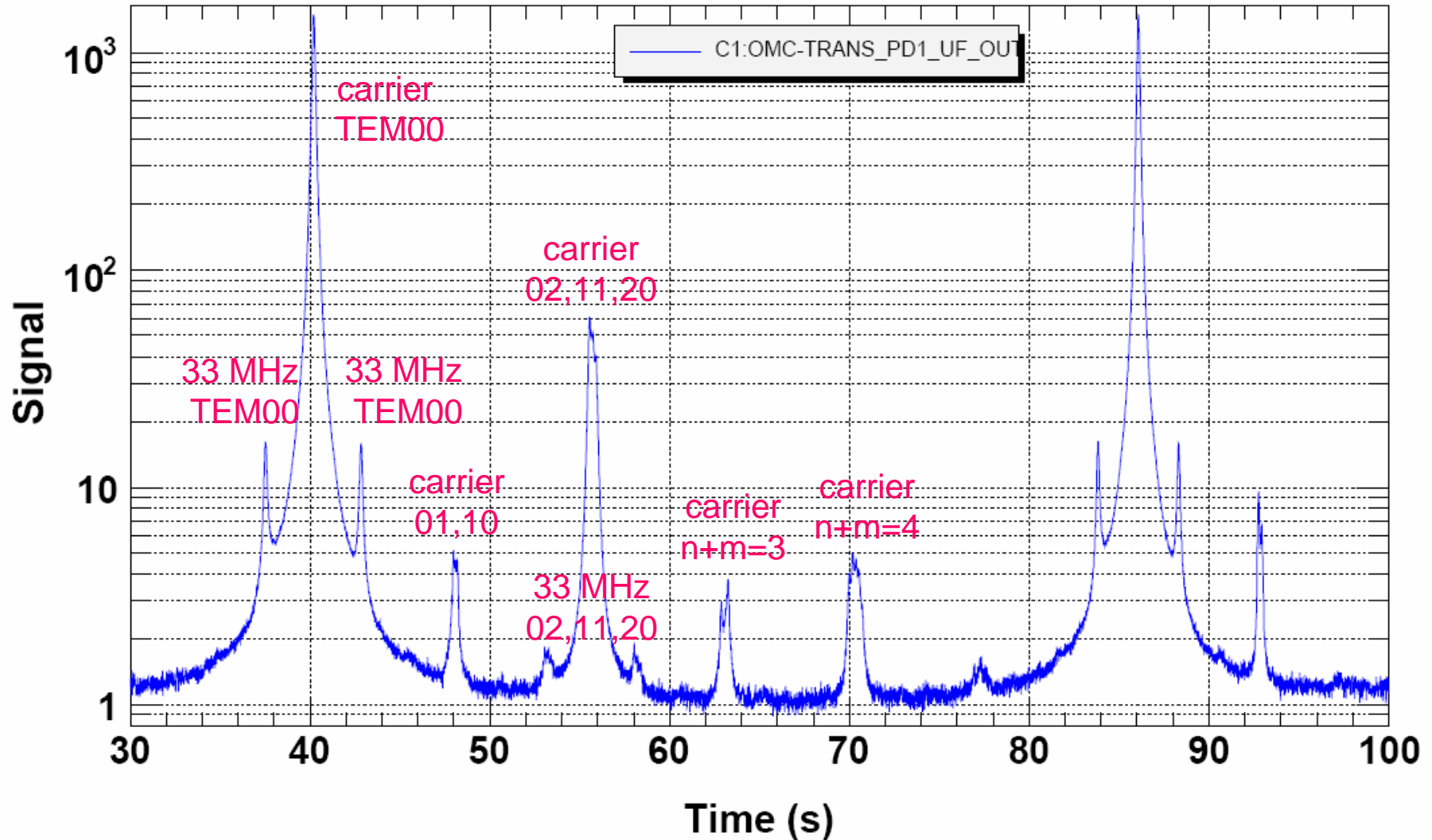
DC Readout components

- Two in-vac PZT tip-tilt steering mirrors (*bad Piezo-Jena*)
 - » SOS-like tip/tilt ‘undulators’ to be used for eLIGO/aLIGO. Development by ANU.
- MMT for OMC (pico-controlled).
 - » Pico signal breaks locks via large EMI from drive signal.
- Output Mode cleaner
 - » Roughly similar to eLIGO design
 - » eLIGO to use more of a LISA-like design
- In-Vacuum Photodetector
 - » 2mm InGaAs diodes, with an amplifier/whitening circuit in a can.
 - » eLIGO to have similar circuit (so far)
- PCIX system for digital control
 - » digital lock-in software for controlling 5 DOFs
 - » “oscillator” generated digitally, all-digital dither-lock-in module
 - » Interfaces to existing RFM network
 - » 32 kHz real time control

DC READOUT COMMISSIONING

- **most hardware installed, tested**
 - » **Need rework of the DC PD readout to get above ADC noise**
- **All software installed, “tested”**
 - » **PCIX, Myrinet-RFM, multi-framebuilders, multi-AWG**
 - » **Real shakedown of new/old digital handoffs not done yet; part of the noise hunting.**
- **Simulink generation of FE code (BorkSpace)**
 - » **Auto EPICS generation (screens, dbs, etc.)**
 - » **OMCL dither locked (dither freq 12kHz, UGF 100Hz)**
 - » **OMC ASC dither locked (two tip/tilts, 4 DOFs)**
 - **dither freqs ~4,5,6,7 kHz**
 - **UGFs 2@20Hz, 2@subHz**

OMC mode scan (not yet mode matched!)



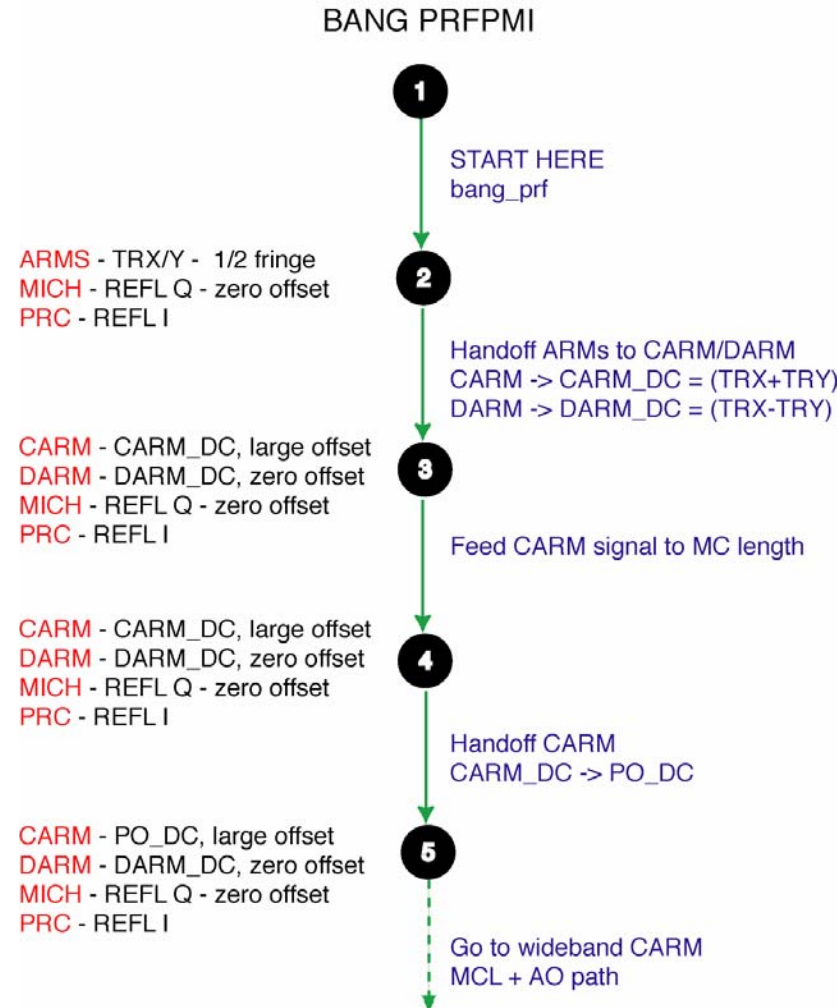
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Lock Acquisition Schemes

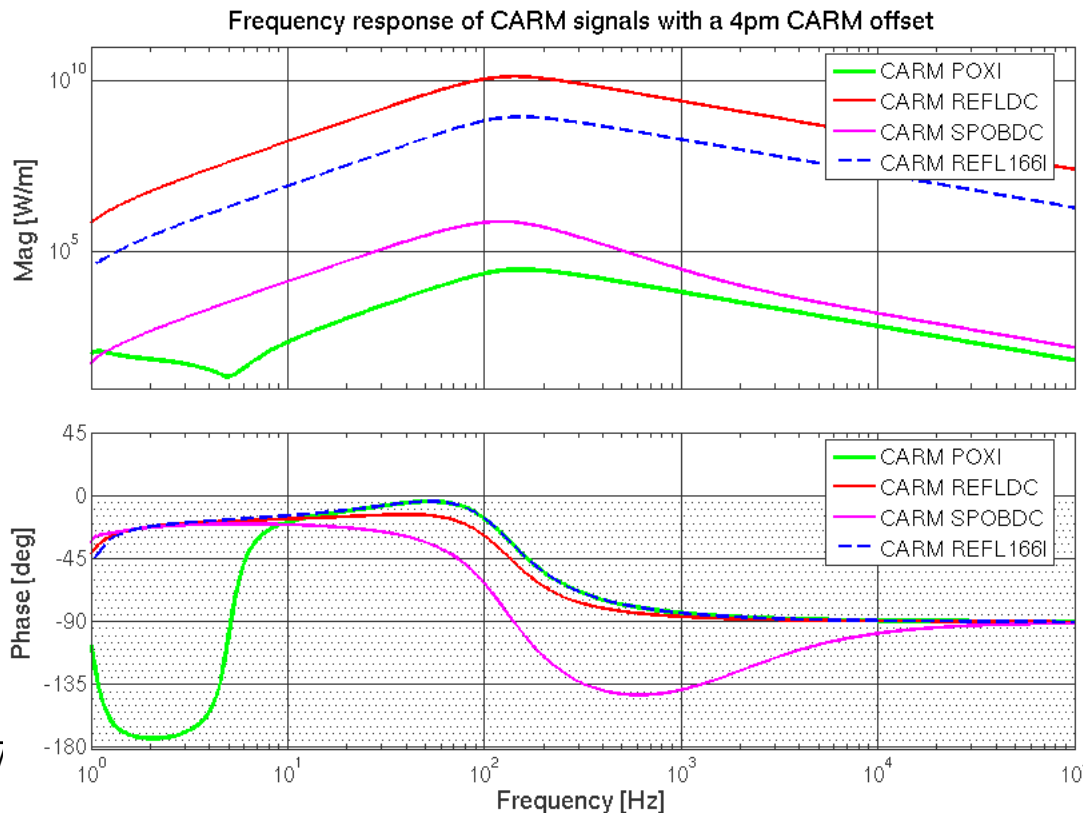
Three lock acquisition schemes are currently pursued:

- » **'Smooth' PRFPMI:** early stages.
 - Initially lock using DC signals for ARMs and MICH with large offsets.
 - Transition to CARM/DARM, but with large offset for MICH to minimize arm coupling until we feedback CARM wideband.
 - Then reduce MICH offset.
- » **'Bang' PRFPMI: works, needs tuning**
- » **DRSE.**
 - **Needs more work on the initial acquisition.**



Lock Acquisition and Optickle Modeling

- When developing lock acquisition schemes we use Optickle to;
 - Find error signals to navigate locking space.
 - Check error signal sign and amplitude whilst various parameters are varied.



e.g. For Bang PRFPMI, we check the phase differences for a CARM handoff from SPOB_DC to POXI.

It can be seen that there is a phase difference around the MCL - MCF crossover.

DC Readout DARM noise

- PRFPMI (like iLIGO)

- SRM mis-aligned

- DARM offset: ~ 15 pm

Control Scheme

- DARM: OMC Transmission

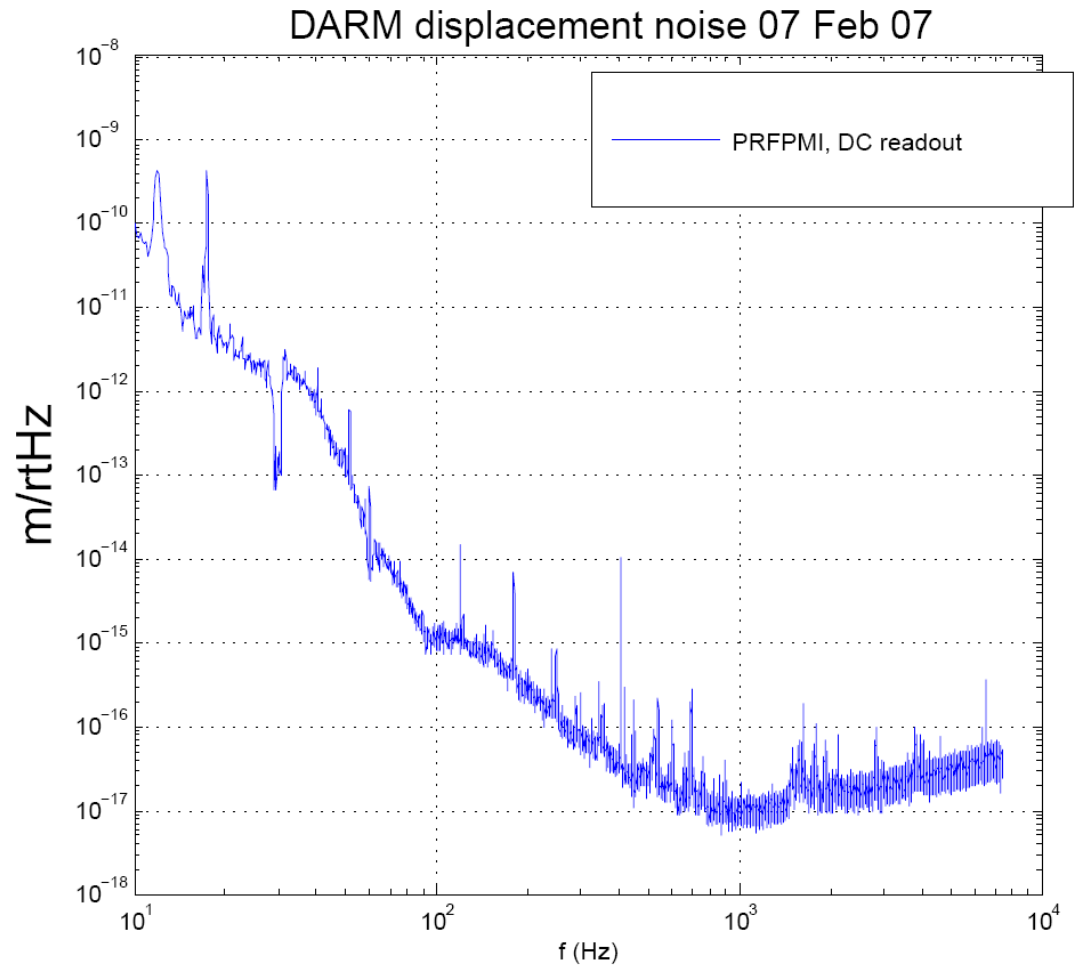
- MICH: REFL_Q

- PRC: REFL_I

- Com Mode: POY_I

UP NEXT:

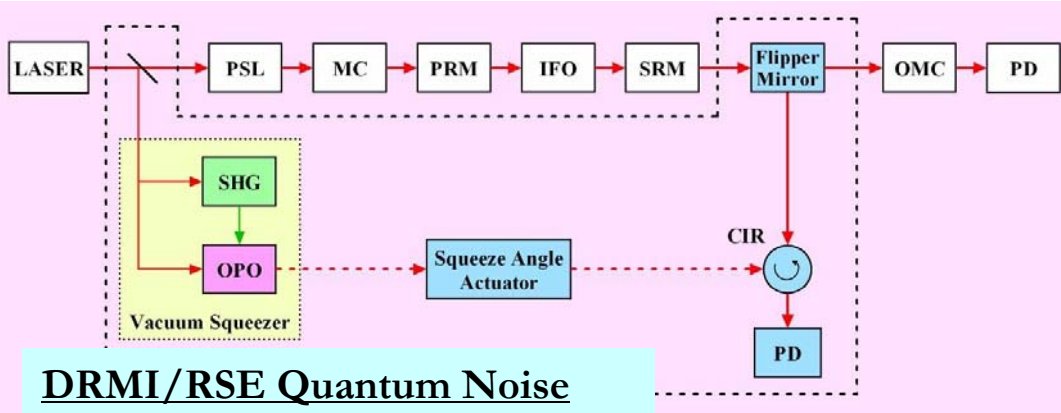
- Noise characterization



Goal:

Squeezing Work

Demonstration of a Squeezing-Enhanced Interferometer Sensitivity



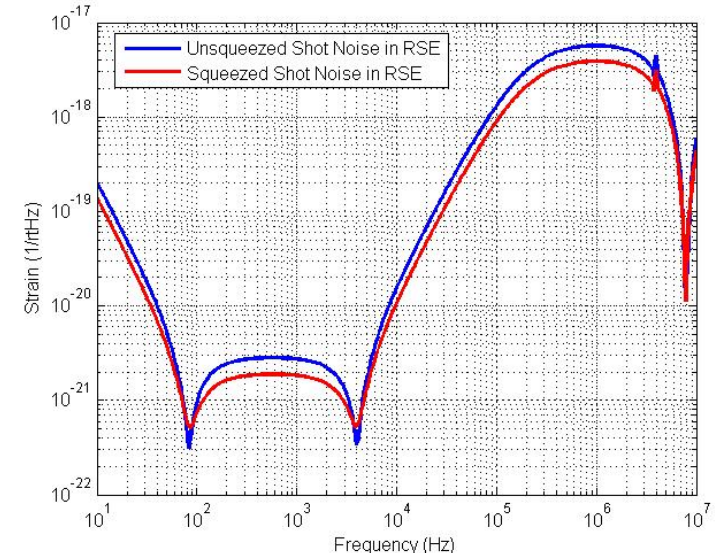
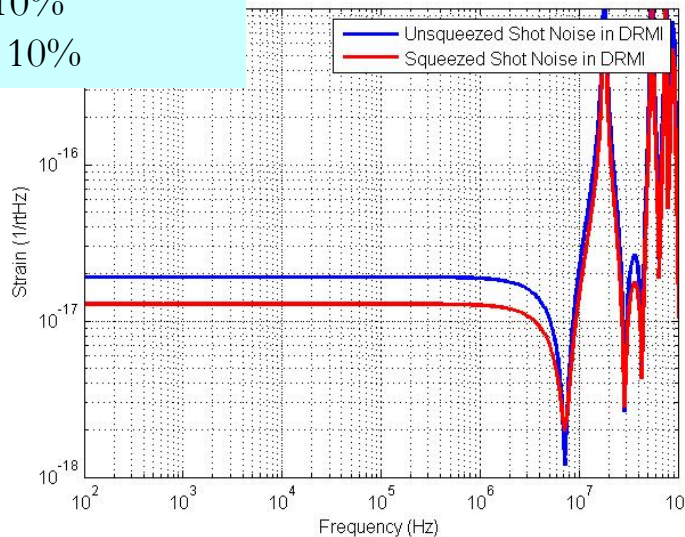
DRMI/RSE Quantum Noise

Budget

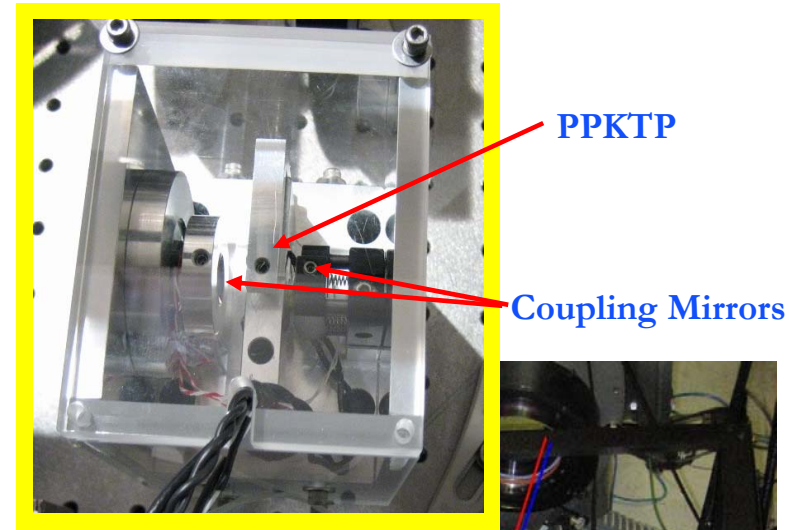
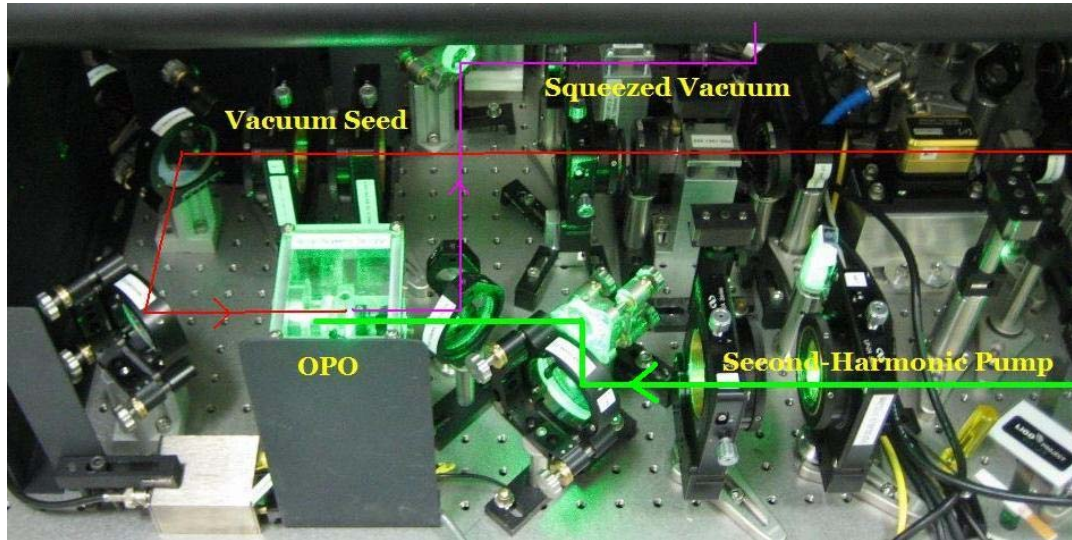
- Input Power to BS = 700mW
- Homodyne Angle = 0
- Squeeze Angle = $\pi/2$
- Initial Squeezing Level = 5dB
- Injection Loss = 10%
- Detection Loss = 10%

- Flipper inserted between SRM and OMC
- The squeezed vacuum is injected into the **dark port** via the optical circulator (Faraday isolator and PBS).
- Noise-locking technique is used to **lock the squeeze angle** so that broadband reduction of the IFO shot noise can be achieved.

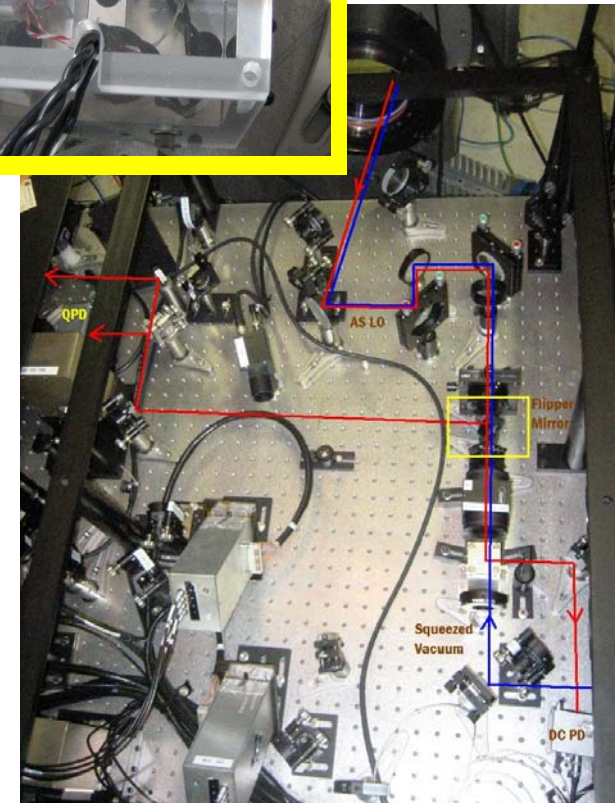
Modeled Improvement



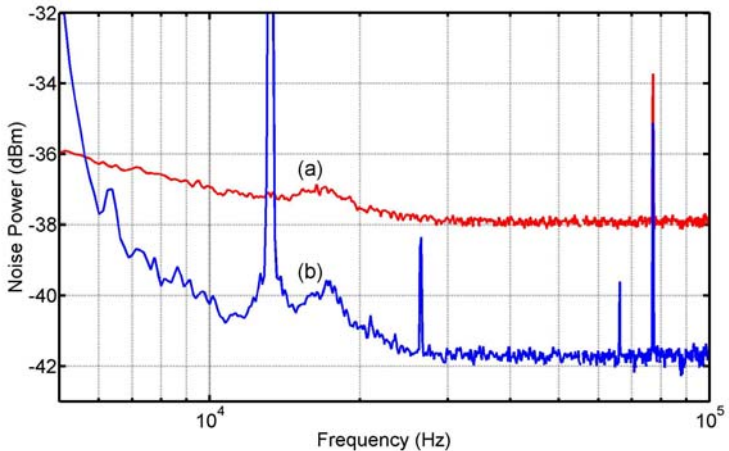
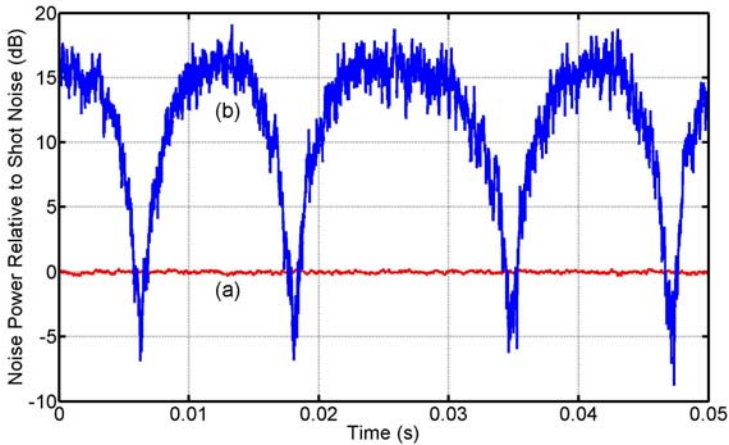
Generation of Squeezed Vacuum in Optical Parametric Oscillation and Injection of Squeezing to the IFO



- The **OPO** is a 2.2cm long cavity composed of a periodically poled KTP crystal with flat/flat AR/AR surfaces and two coupling mirrors ($R = 99.95\%$ at 1064/532nm and $R = 92\%/4\%$ at 1064/532nm).
- The OPO is pumped by 300 mW of **second-harmonic light** at 532nm.
- **Quasi-phase matching** is used and both the seed and pump are polarized in the same direction.
- Frequency-shifted, orthogonally polarized light is used to lock the OPO cavity so that a vacuum field at 1064nm can couple to the cavity and get squeezed by its nonlinear interaction with the pump field in a TEM₀₀ mode.
- The **picomotor mirror** can be inserted in or out for squeezing-enhanced IFO measurements.
- **Isolation of a GW signal** from the injection of squeezing is done by Faraday isolation.
- The squeezing-enhanced GW-signal/shot-noise ratio is measured by the DC PD with high quantum efficiency (93%).

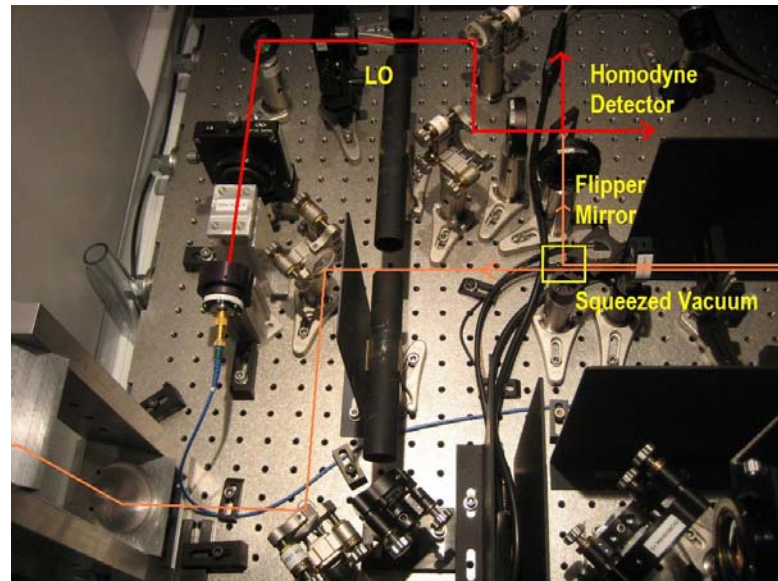


Some Results & Future Work



- (a) Shot noise
- (b) Squeezed shot noise

- ❖ About **6dB** of scanned squeezing
- ❖ About **4dB** of phase-locked squeezing
- ❖ Measured by the squeezing monitoring homodyne detector



- ❖ Ready to be injected into the IFO in the next few weeks to **demonstrate squeezing-enhanced IFO**