

Squeezing Research Highlights

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Dawn Workshop, Syracuse
July 6th, 2017

G1701266

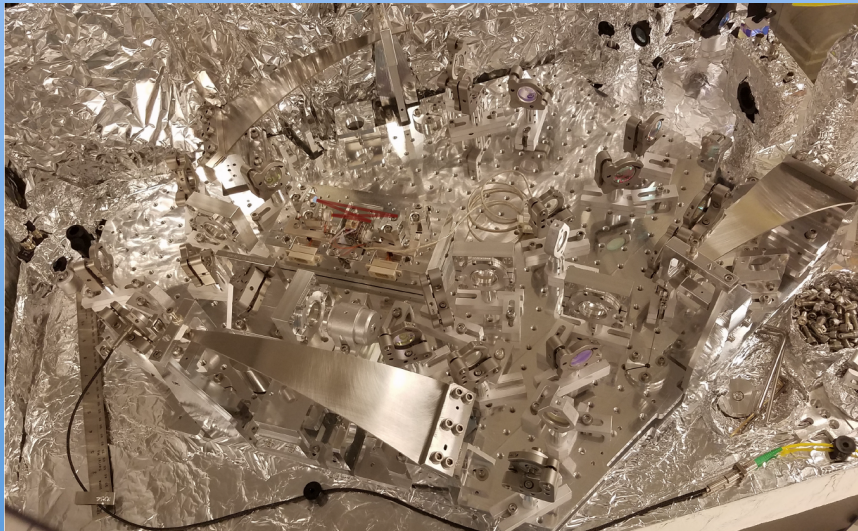
Research Areas

- ✧ Squeezing generation and control
 - ✧ Low loss read-out
- ✧ Frequency dependent squeezing
- ✧ Balanced homodyne readout
- ✧ Alternative wavelengths: 2 μm squeezing
- ✧ Alternative configurations/techniques

Squeezing 2G (it is happening)

Squeezing in Advanced LIGO:

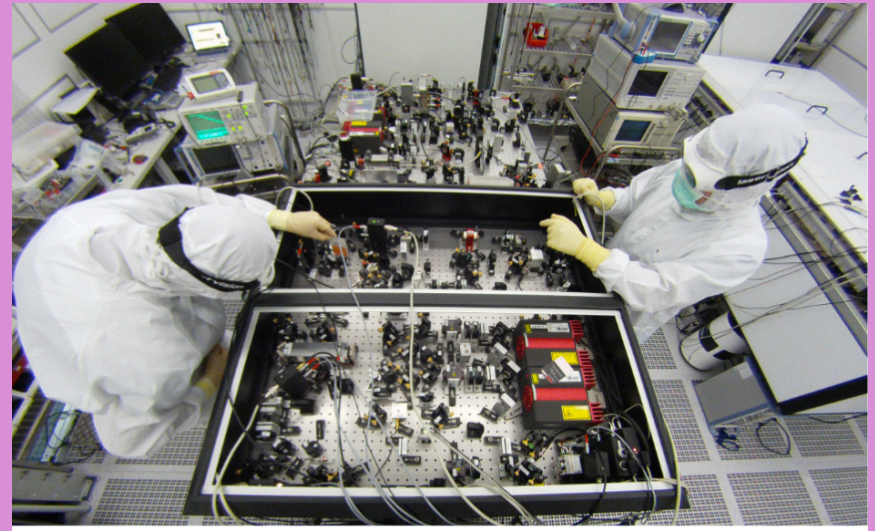
- LIGO Laboratory/ANU funds
- Squeezer assembly started in April at LLO
- Installation scheduled post-O2



Prototype at MIT of Advanced LIGO suspended platform with in-vacuum OPO

Squeezing in Advanced Virgo:

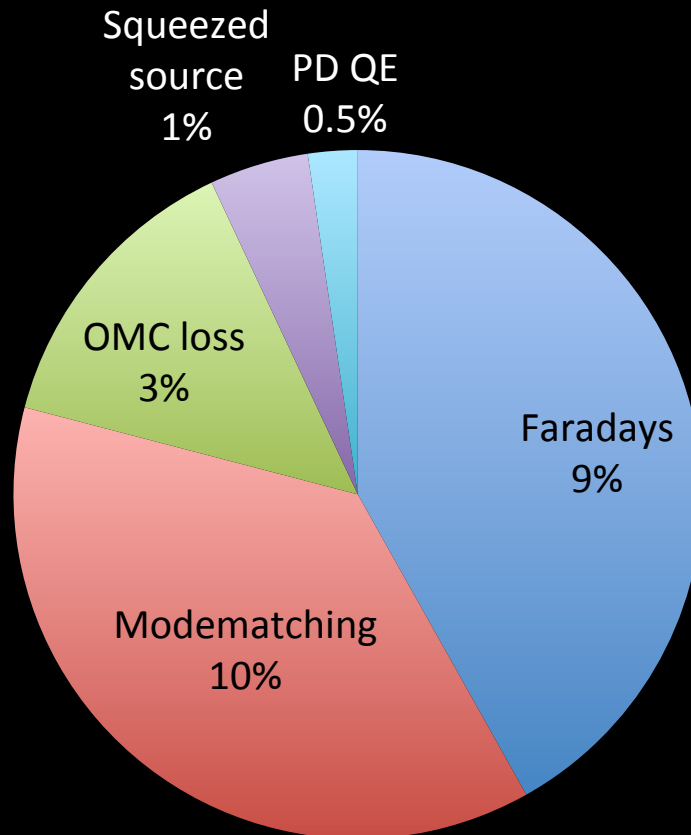
- Design with in-vacuum OPO, dedicated “mini-tower”
- Collaboration with AEI for post-O2 in-air squeezer



AEI in-air squeezer for Advanced VIRGO

Loss

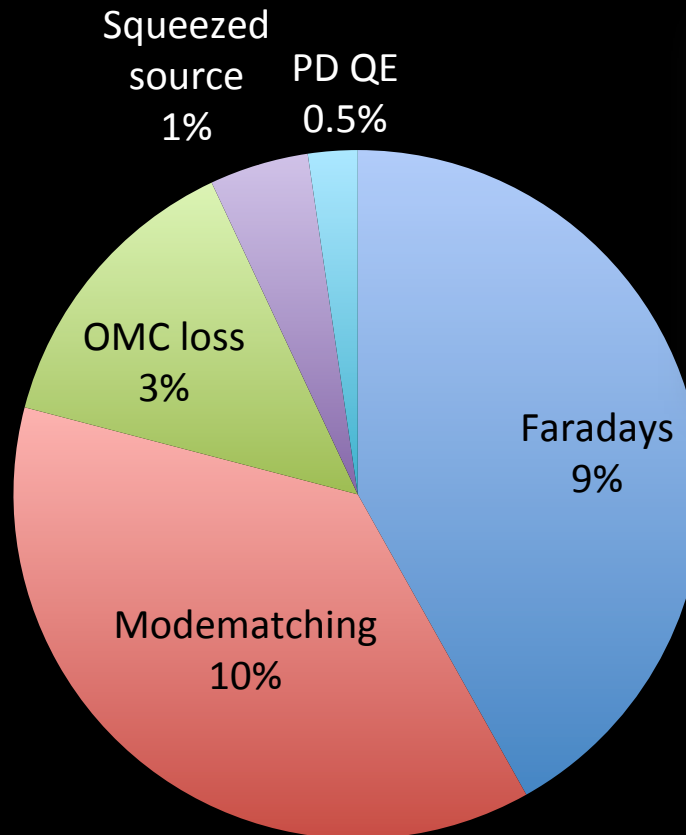
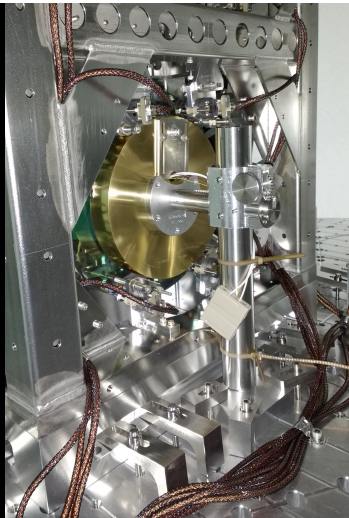
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we would have AT LEAST 25% loss coming from well quantified sources
(MAX 6 dB of squeezing enhancement)



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Signal Recycling
Cavity mirror (SR3)
heating element
already installed at
LLO



Univ. of Florida concept
for low loss Faraday

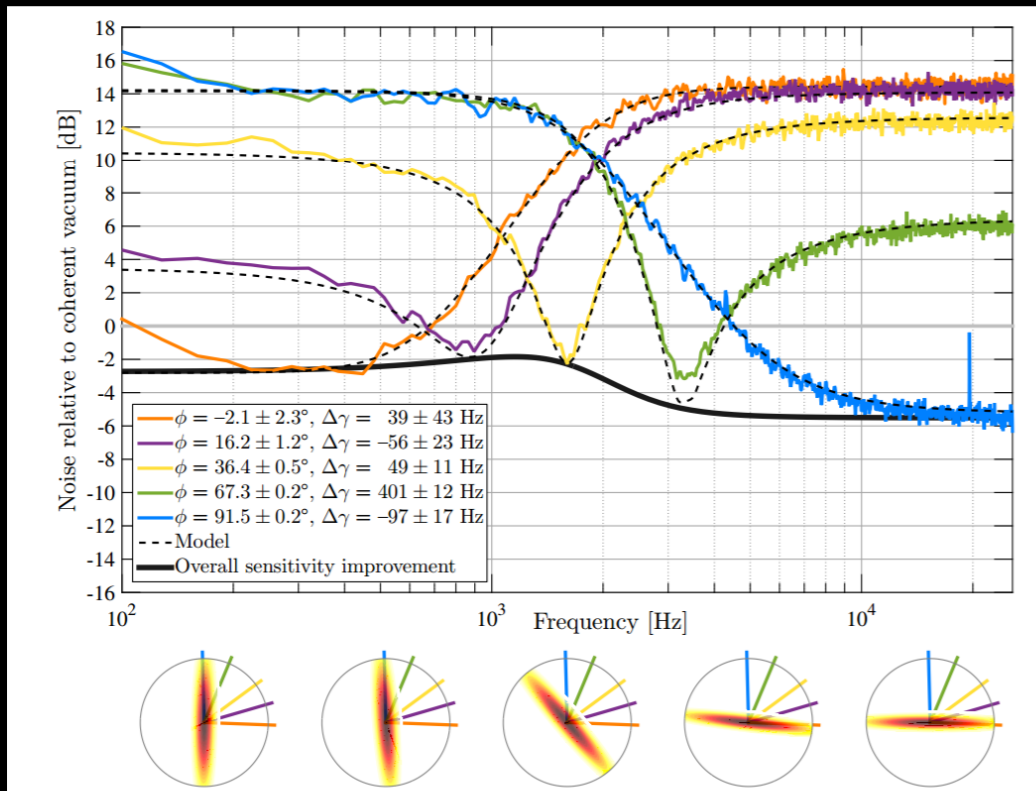


- Loss budget based on individual loss measurement of components: <math><0.7\%</math> (single pass)

LSC effort on-going for "active" mode matching strategy

Frequency dependent squeezing

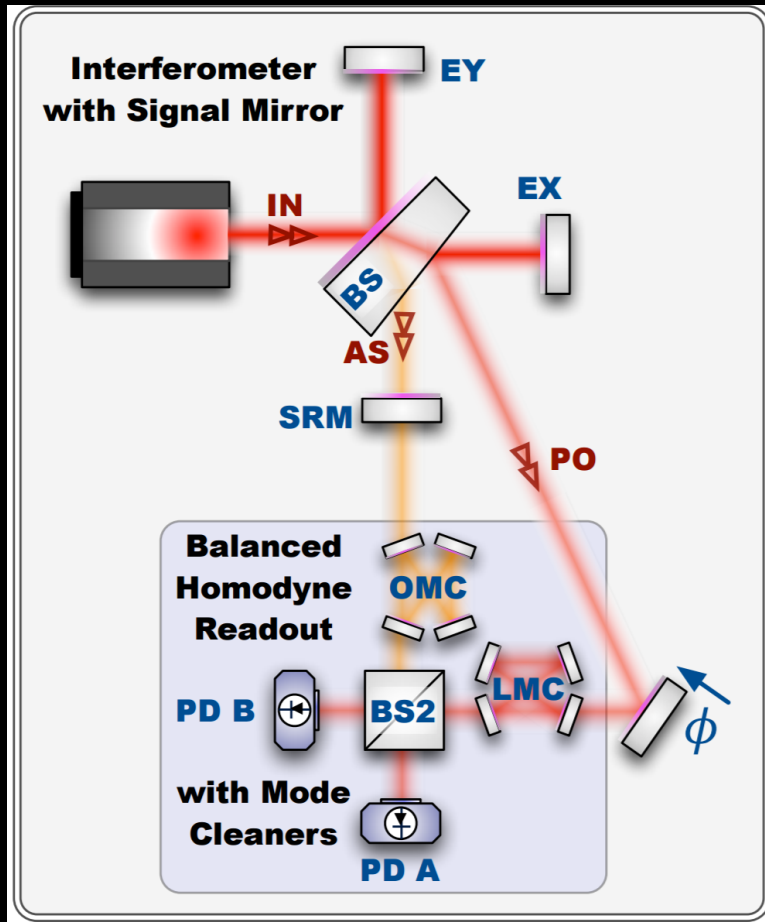
Audio-band frequency dependent squeezing in proof of principle table top experiment at MIT



- Suspended filter cavities under constructions (16m @ MIT, 300m @ NAOJ)
- Control scheme and noise analysis for 2G detectors on-going
- A+ concept: ~ 100 m filter cavity

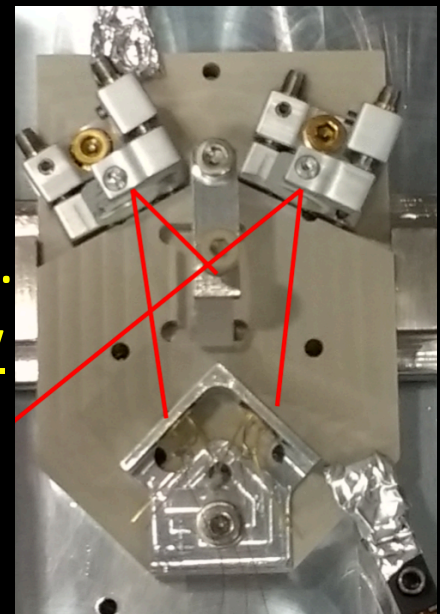
Oelker et al PRL **116** 041102 (2016)

Balanced Homodyne Readout

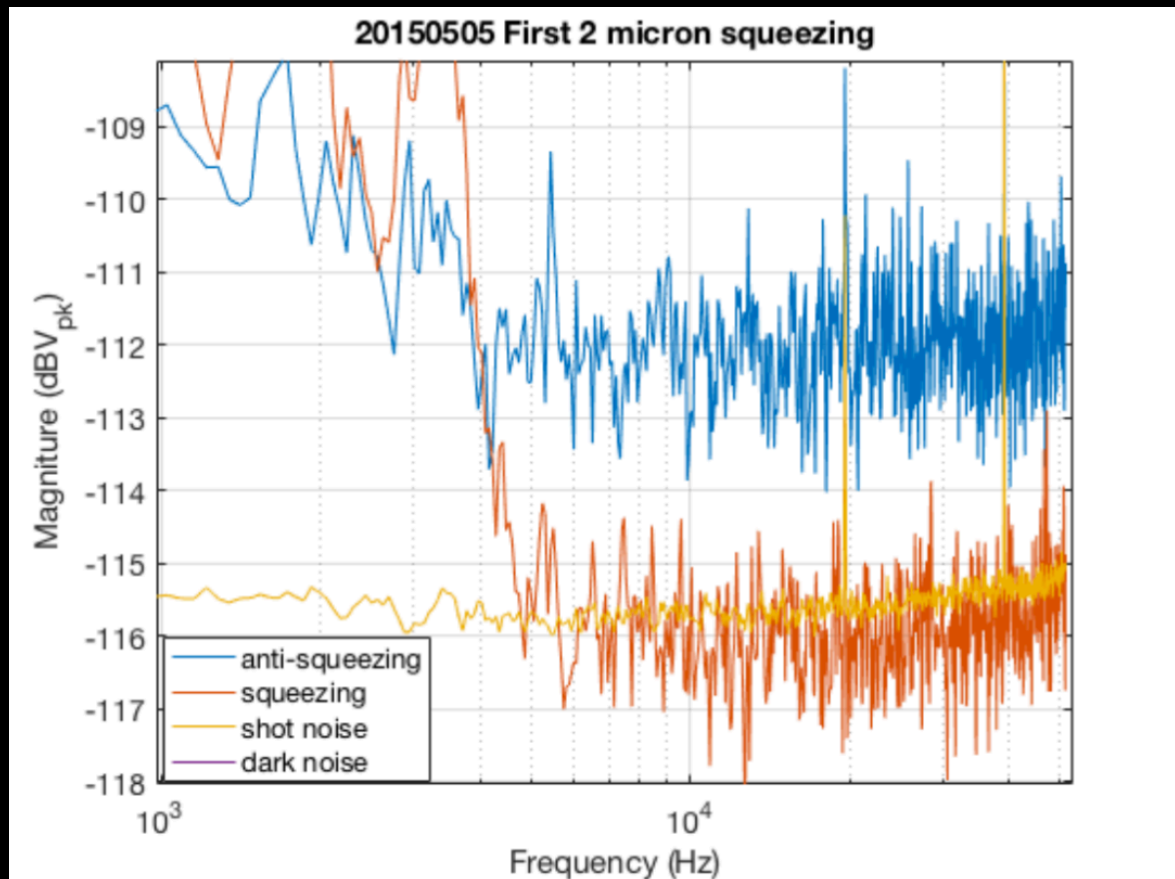


Fritschel et al., Opt Express. 2014

- First look at requirements for Advanced detectors: Steinlechner et al., PRD 2015
- UHV compatible suspended balanced homod. built for Glasgow speed-meter
- Design for Advanced detectors still to be done



First measurement of squeezing at 2um (Georgia Mansell, ANU)



- 4 dB antisqueezing, <1 dB squeezing
- 87% quantum efficiency diodes commercially available; need higher efficiency

Alternative configurations/techniques

- Speed-meter concept: design and experiments on-going (see S. Hild, [GWADW 2017: G1700832](#))
- EPR entanglement concept: frequency dependent squeezing without filter cavity (Ma et al., Nature Physics 2017)
 - remove need of filter cavity, but has double loss penalty
 - proposal to apply it in GEO with detuned Signal Recycling
[Freise GWADW 2017: G1700899](#)

Some thoughts

- Reaching high levels of squeezing (6-10 dB) will be very challenging
 - It seems doable, but only if it becomes top priority
 - Very best observed at some point in GEO is 4.5 dB
- Filter cavity for frequency dependent squeezing and balanced homodyne readout within reach – still need to finalize control scheme and noise couplings
- Is there something better than frequency dependent squeezing for 3G to achieve a broadband reduction of quantum noise?