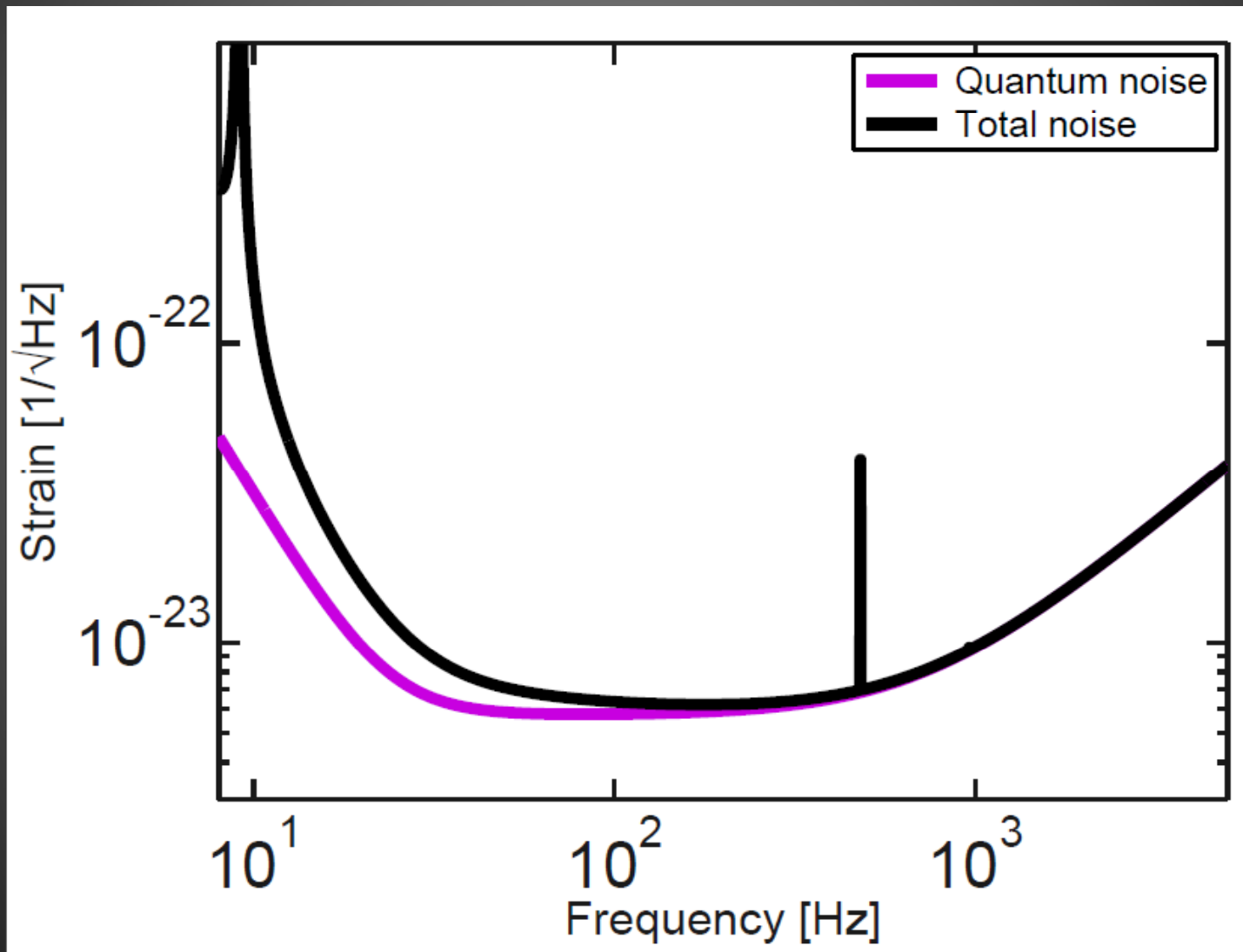# Quantum noise reduction using squeezed states in LIGO
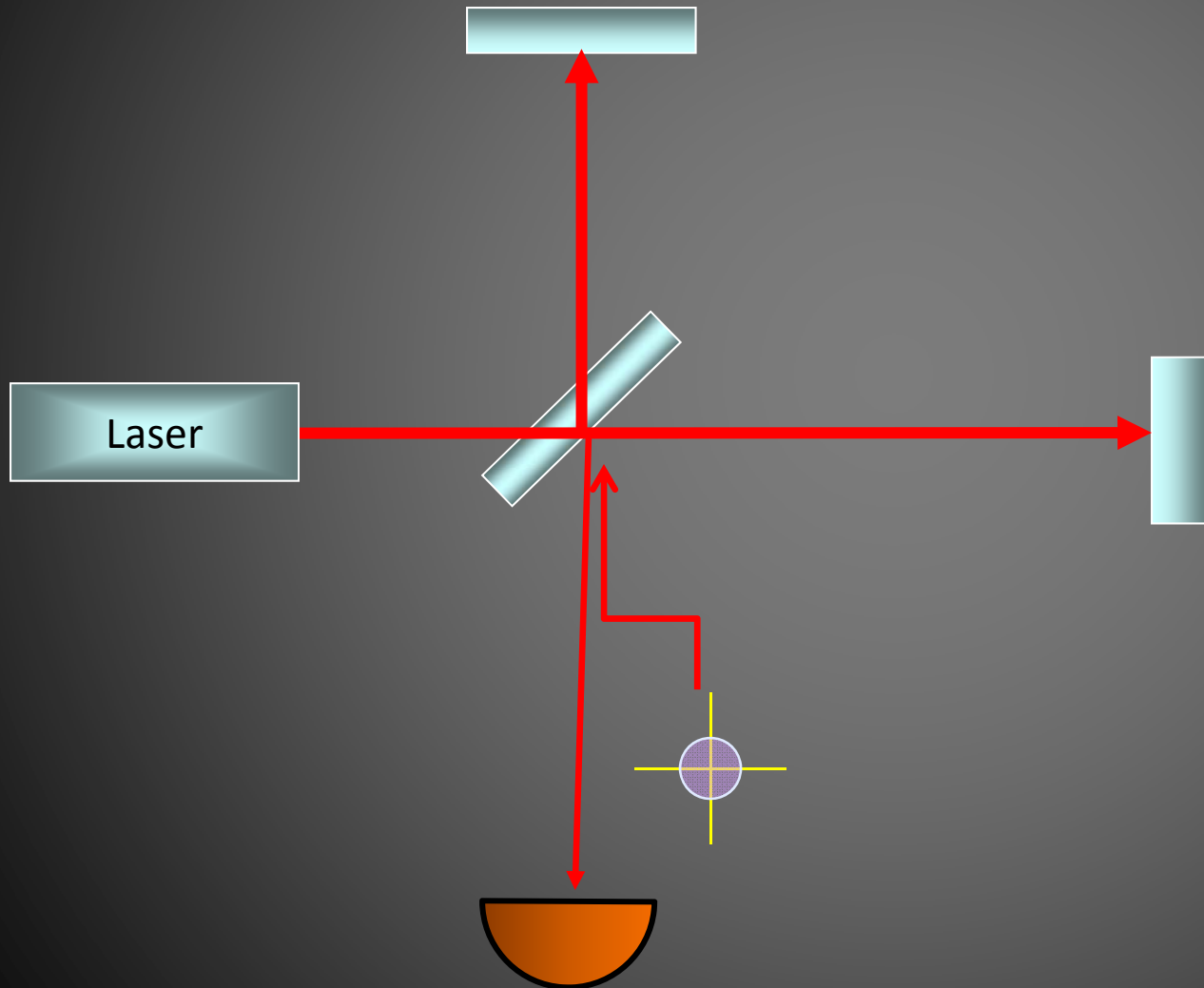
LIGO-G1300698-v1

Sheila Dwyer

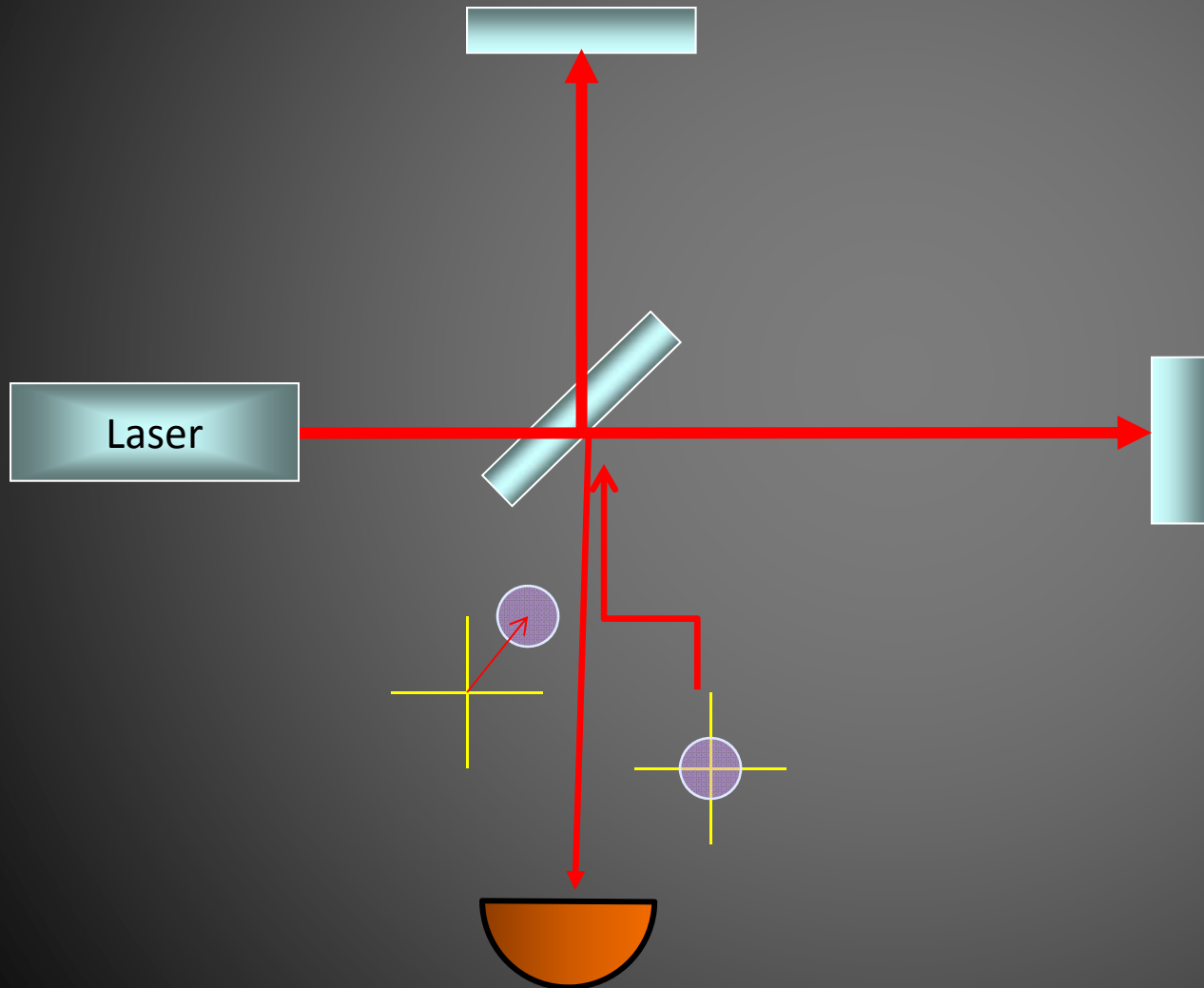for the LIGO Scientific Collaboration

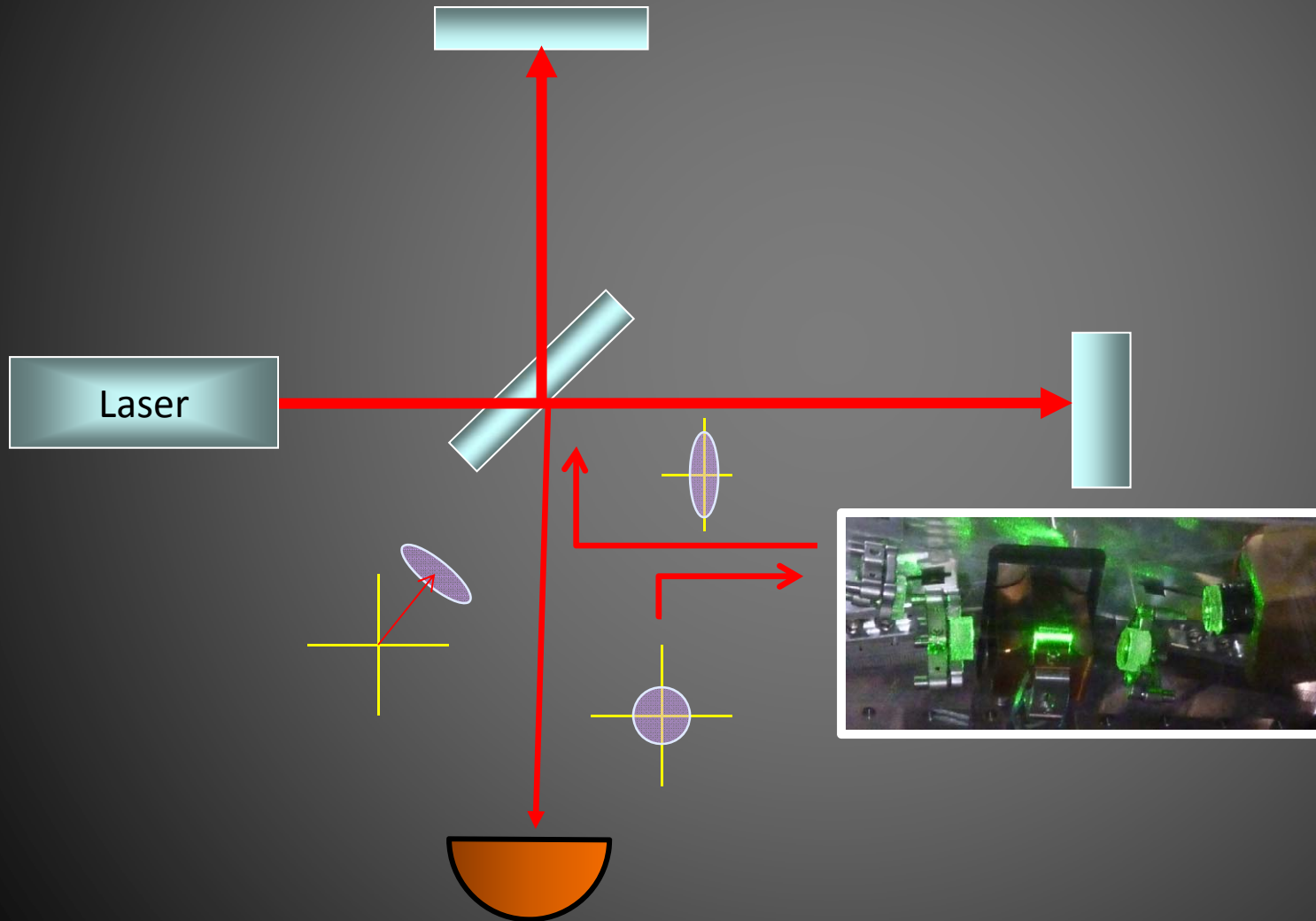# Quantum noise will limit the sensitivity of advanced detectors

Quantum noise in an interferometer

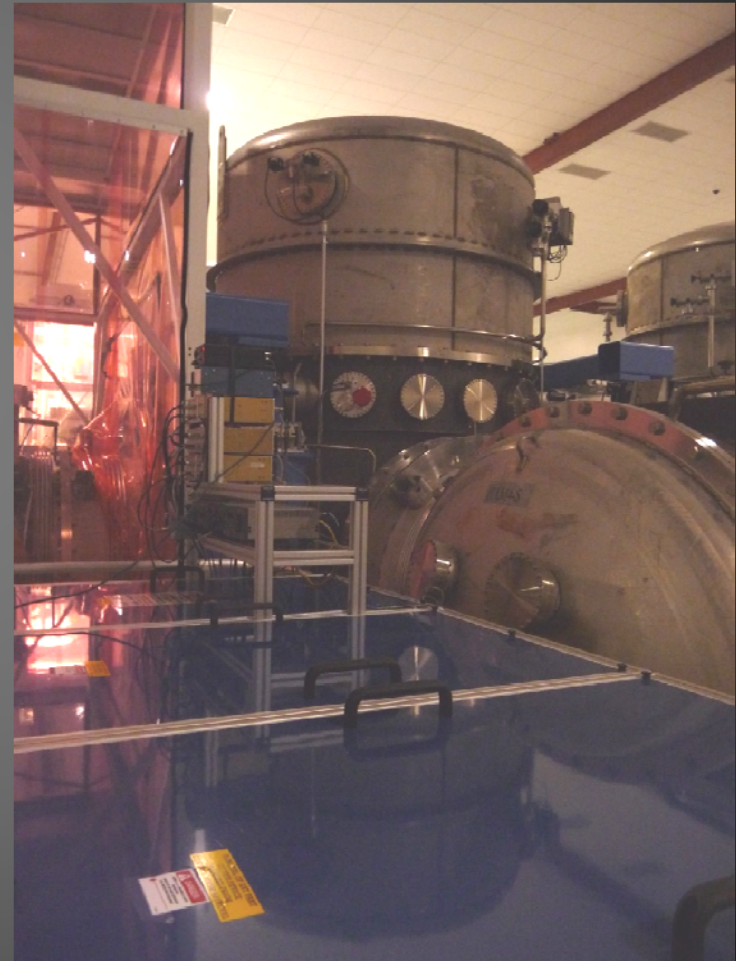# Quantum noise in an interferometer

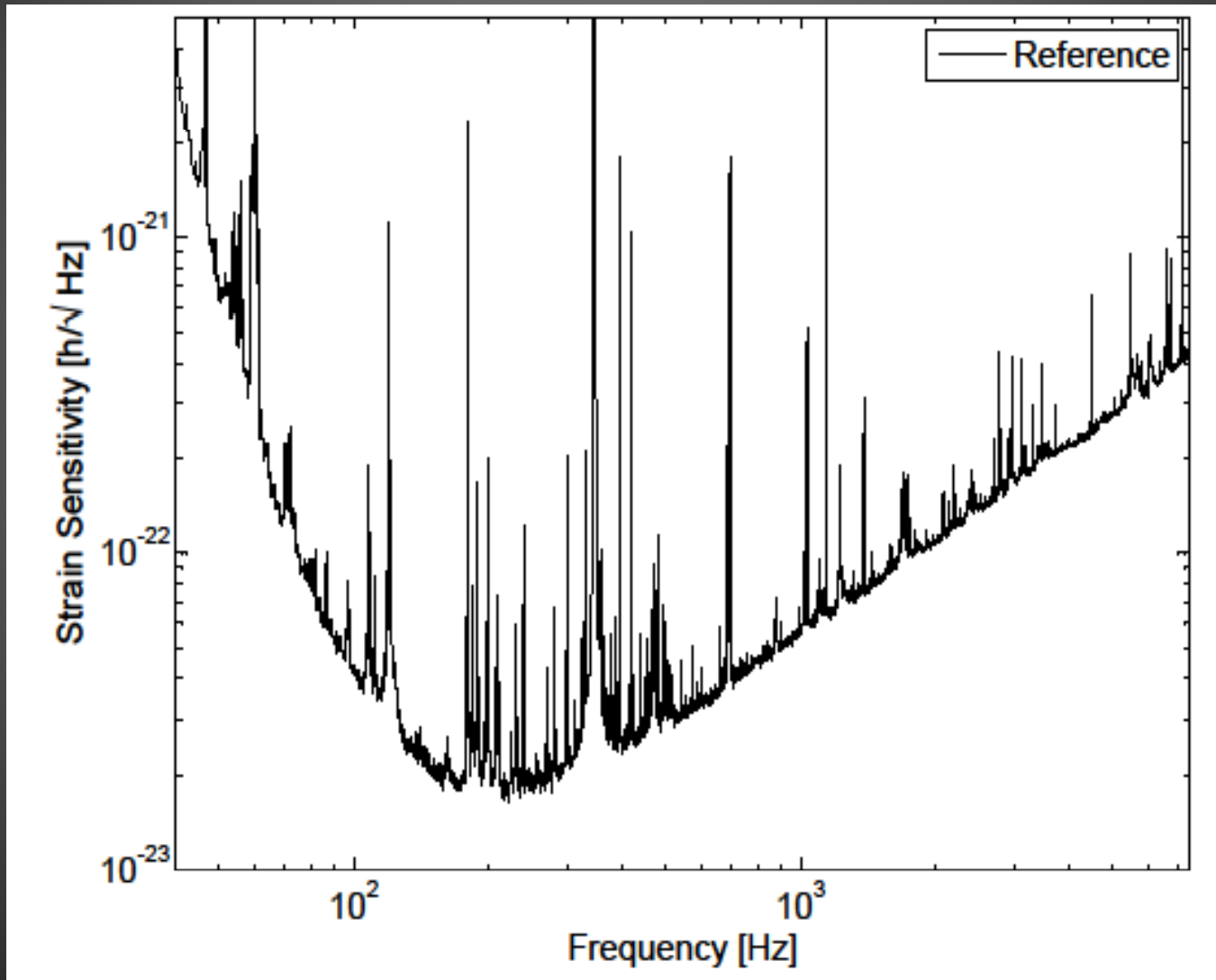# Squeezing in an interferometer
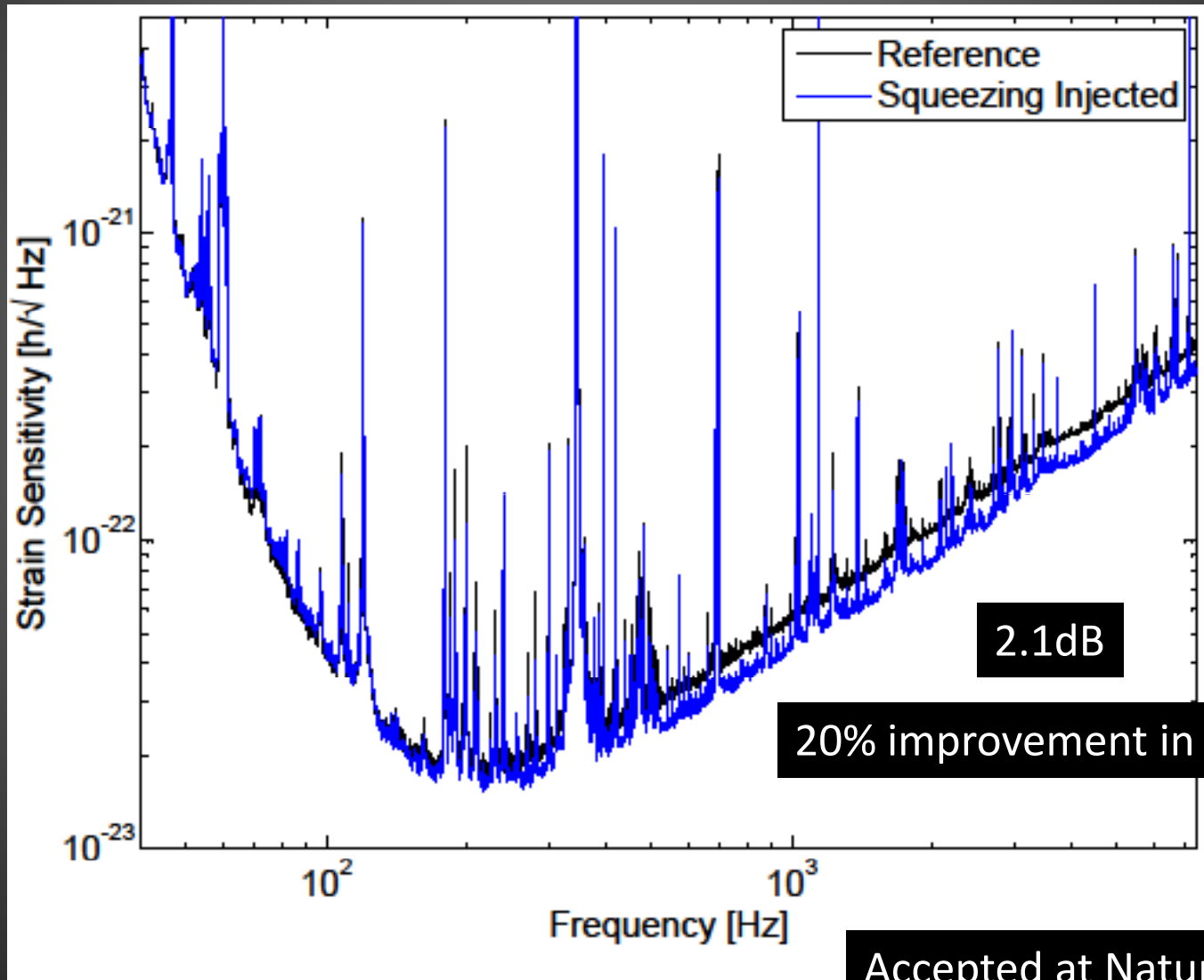
Enhanced LIGO squeezing goals:

- Demonstrate that squeezing does not add noise in the LIGO band
- Study environmental noise couplings
- Understand limits to measured squeezing
- Enable planing for aLIGO+ squeezing
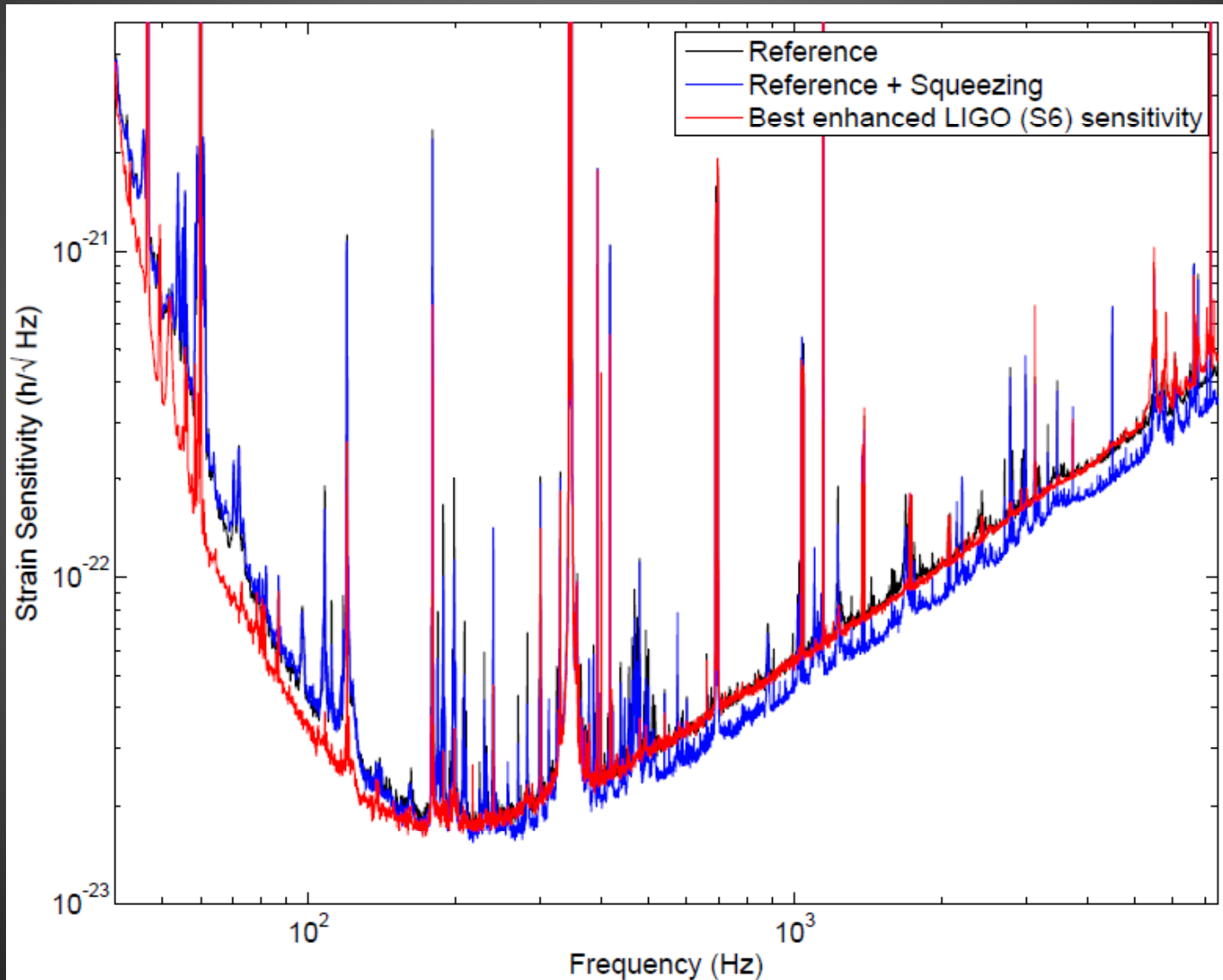
Squeezing in Enhanced LIGO

Squeezing in Enhanced LIGO

Best broadband sensitivity to date
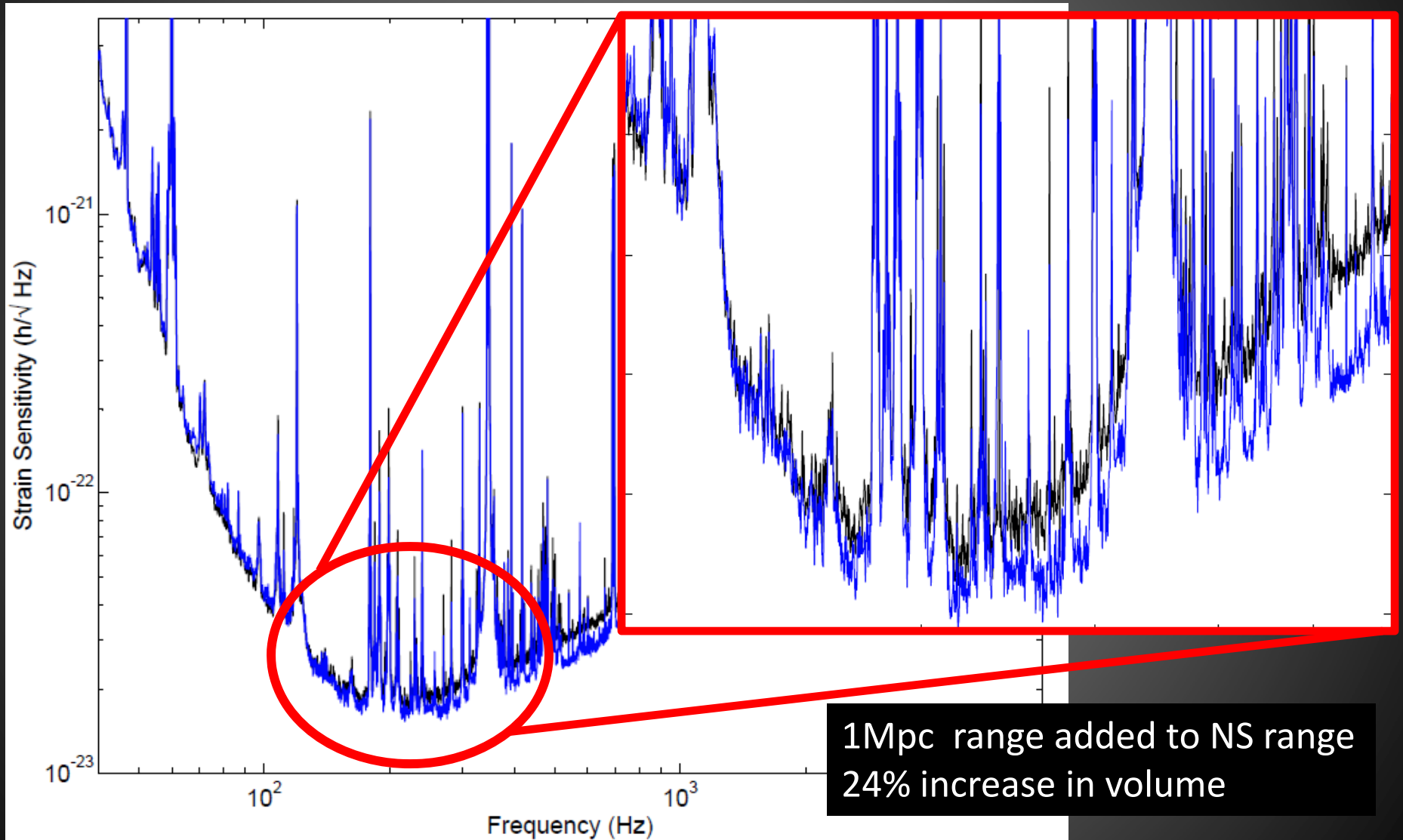
Squeezing in Enhanced LIGO

1Mpc range added to NS range
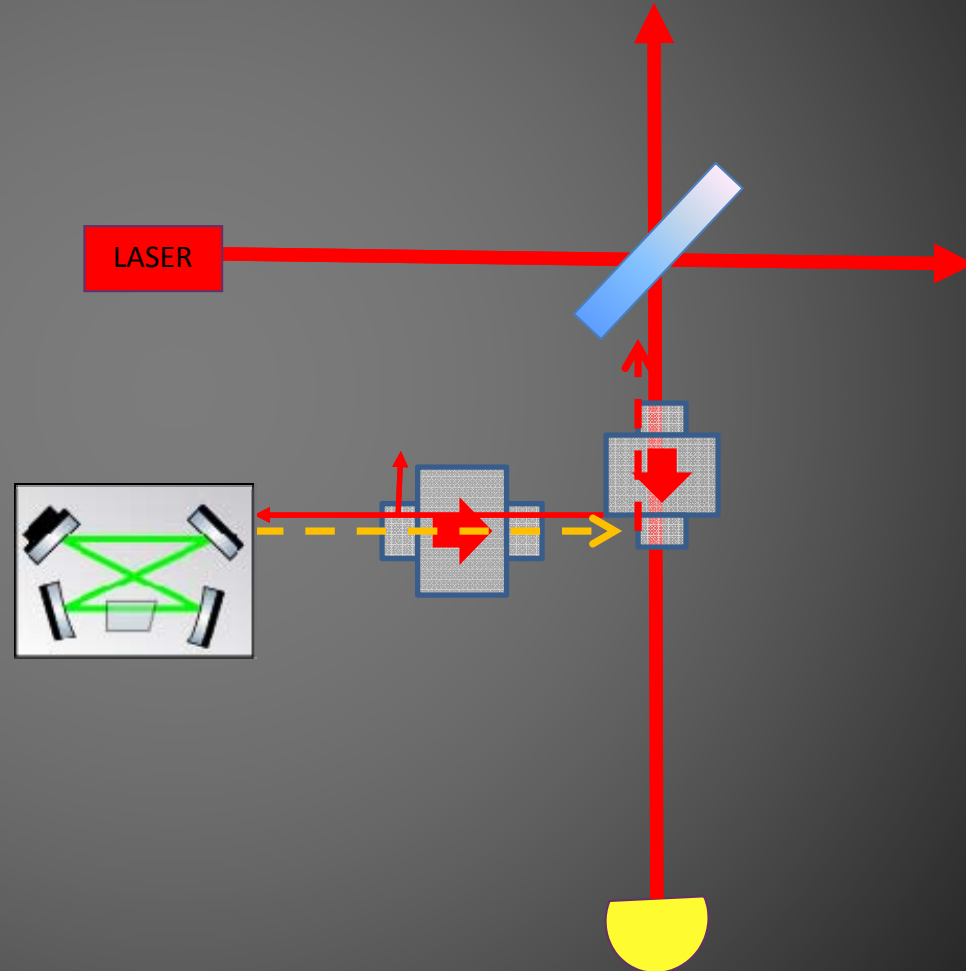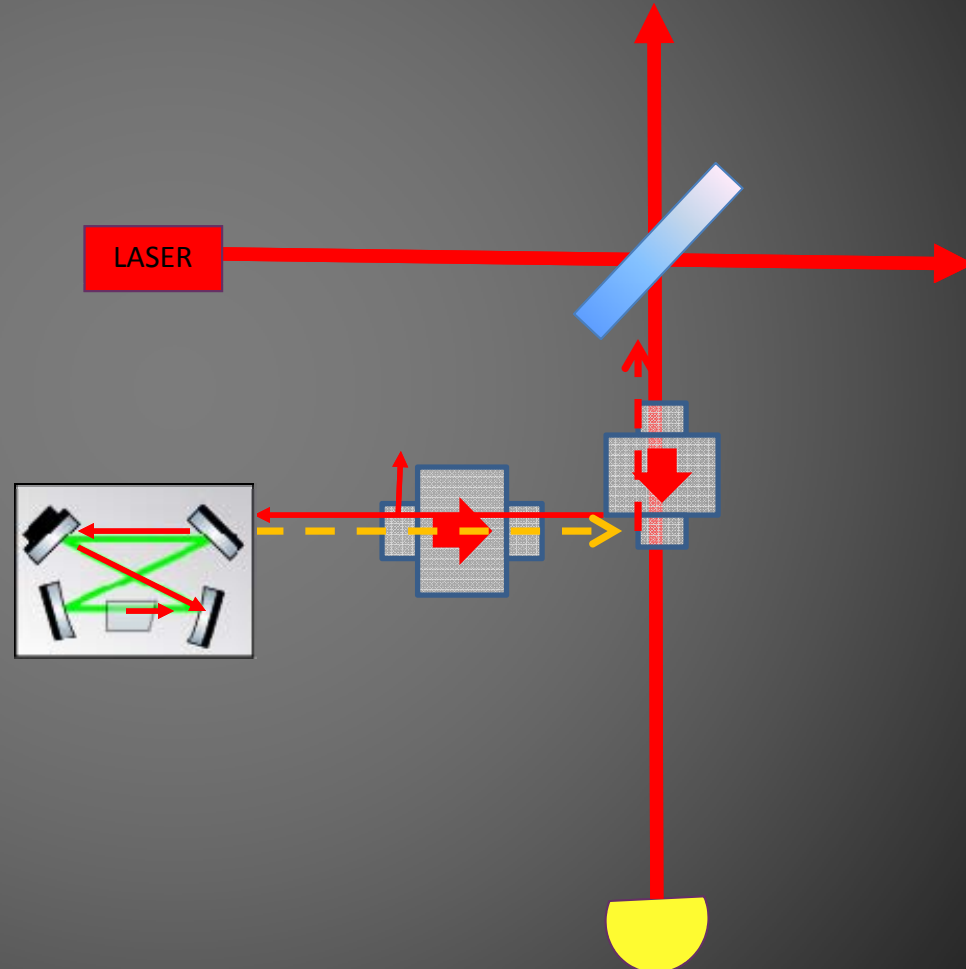24% increase in volume

Backscatter noise

- Light from interferometer is scattered towards squeezer

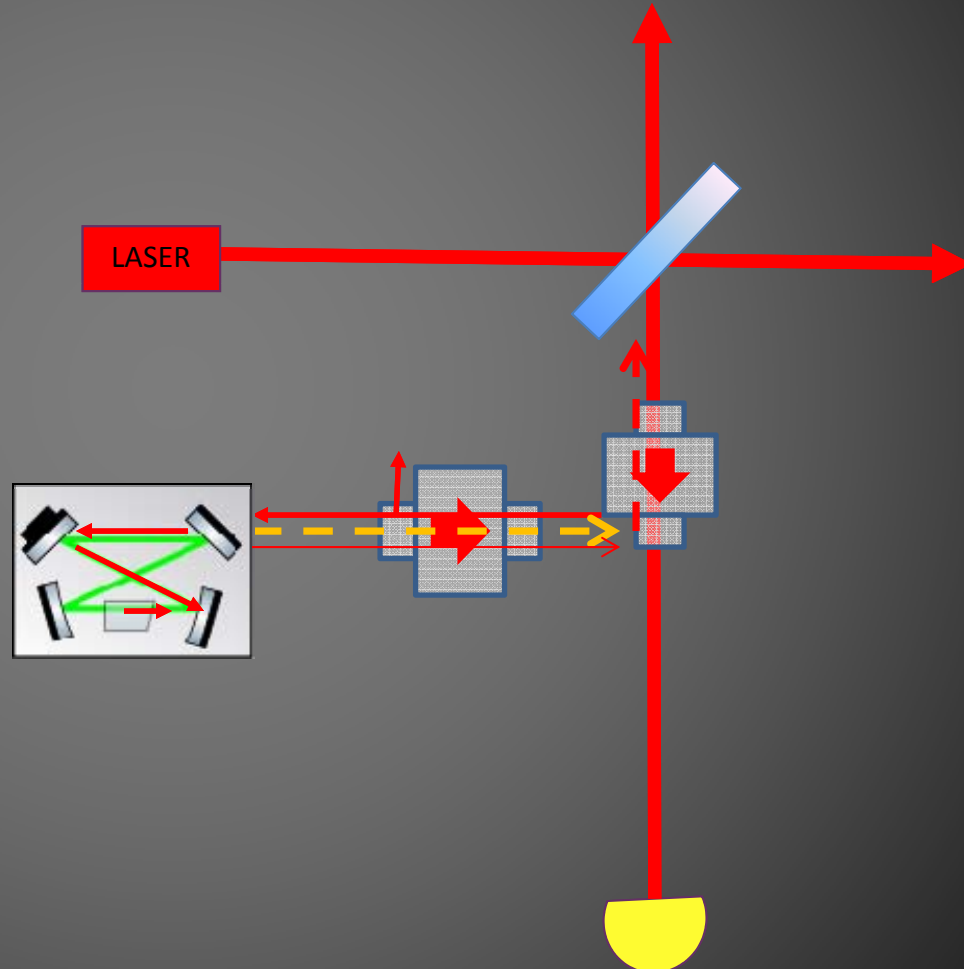See poster by Sheon Chua, presented by Lisa Barsotti

Backscatter noise

- Light from interferometer is scattered towards squeezer

- Squeezer scatters light back towards IFO

LASER

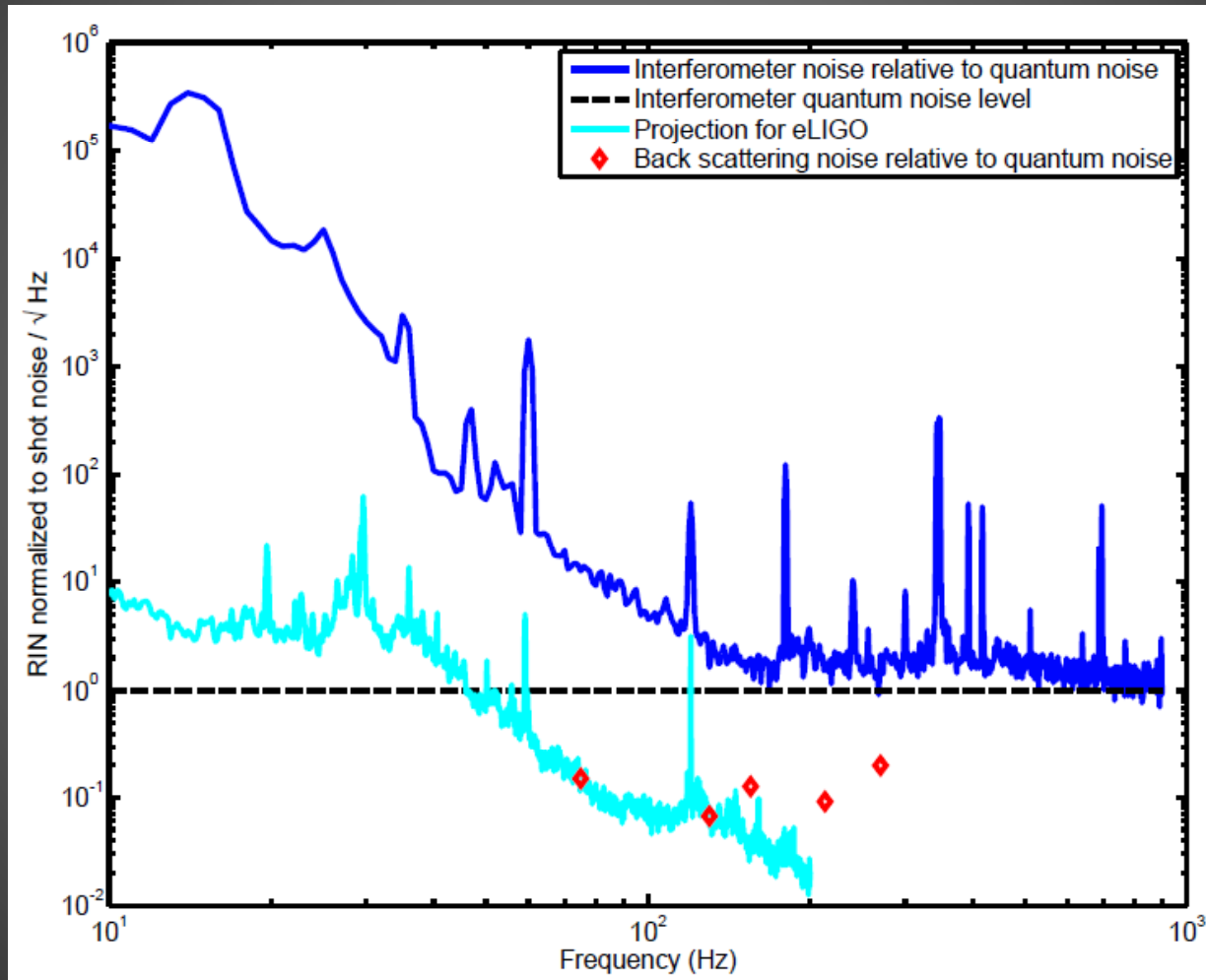See poster by Sheon Chua, presented by Lisa Barsotti

Backscatter noise

- Light from interferometer is scattered towards squeezer

- Squeezer scatters light back towards IFO
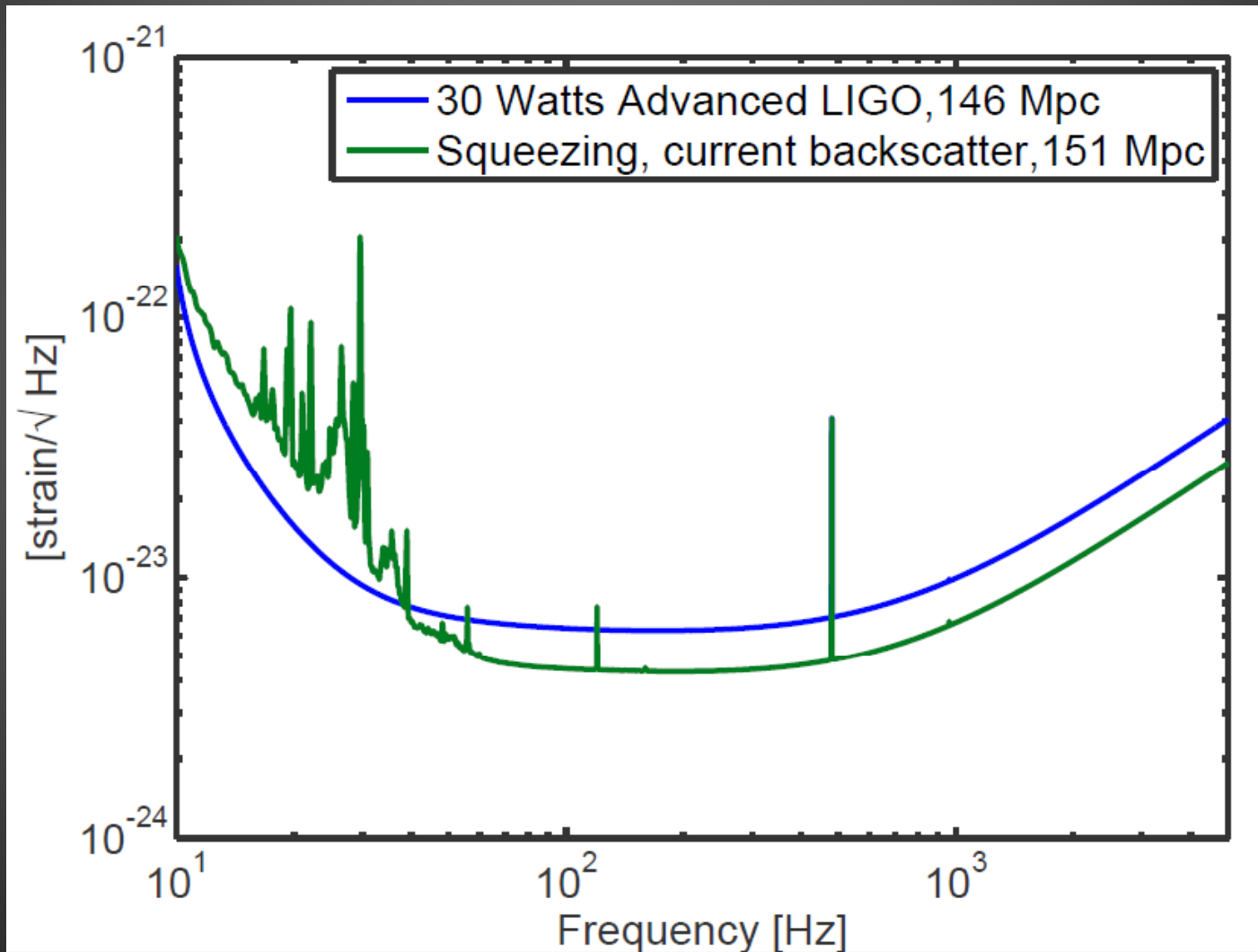
- Spurious interferometer adds noise

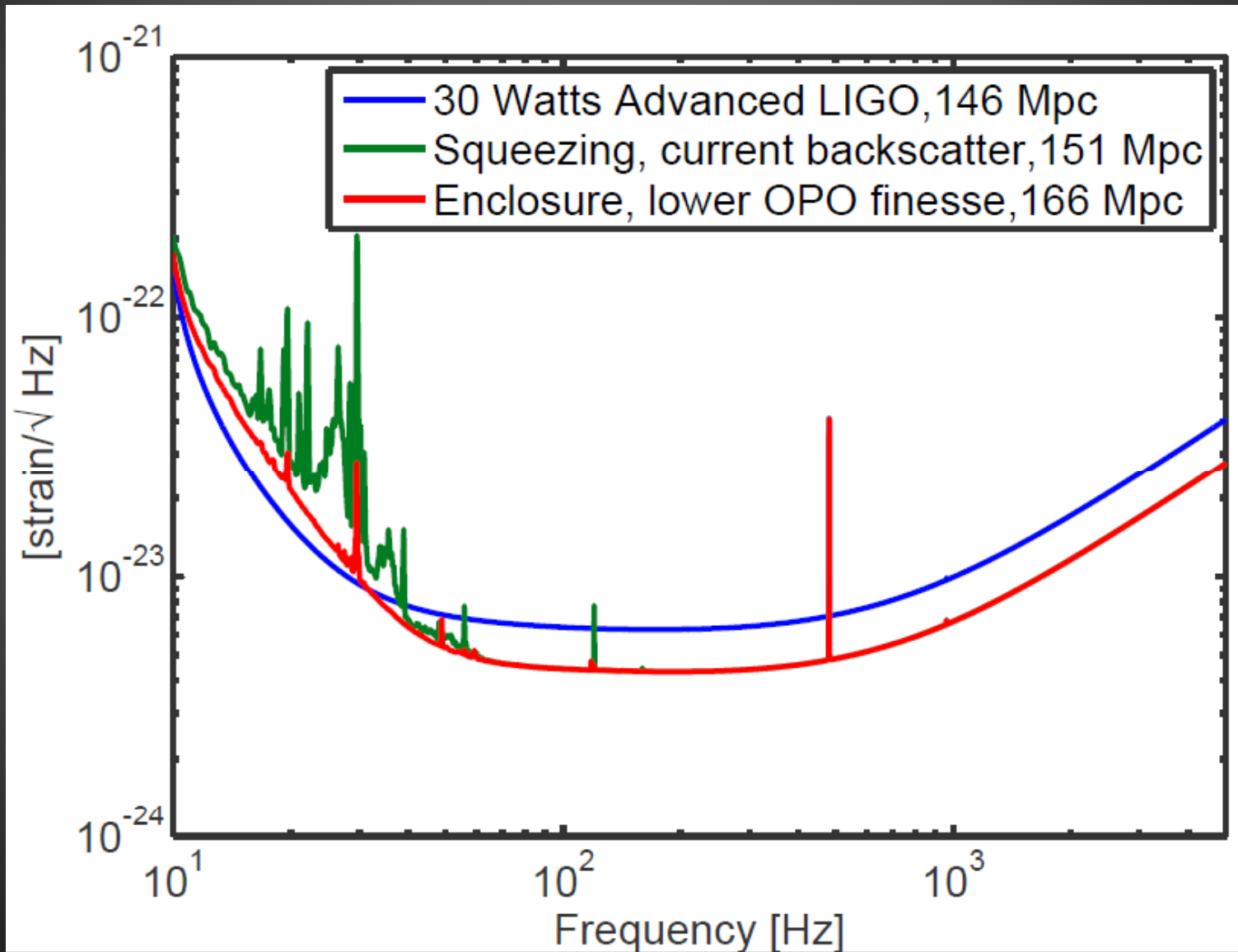See poster by Sheon Chua, presented by Lisa Barsotti

Noise Coupling

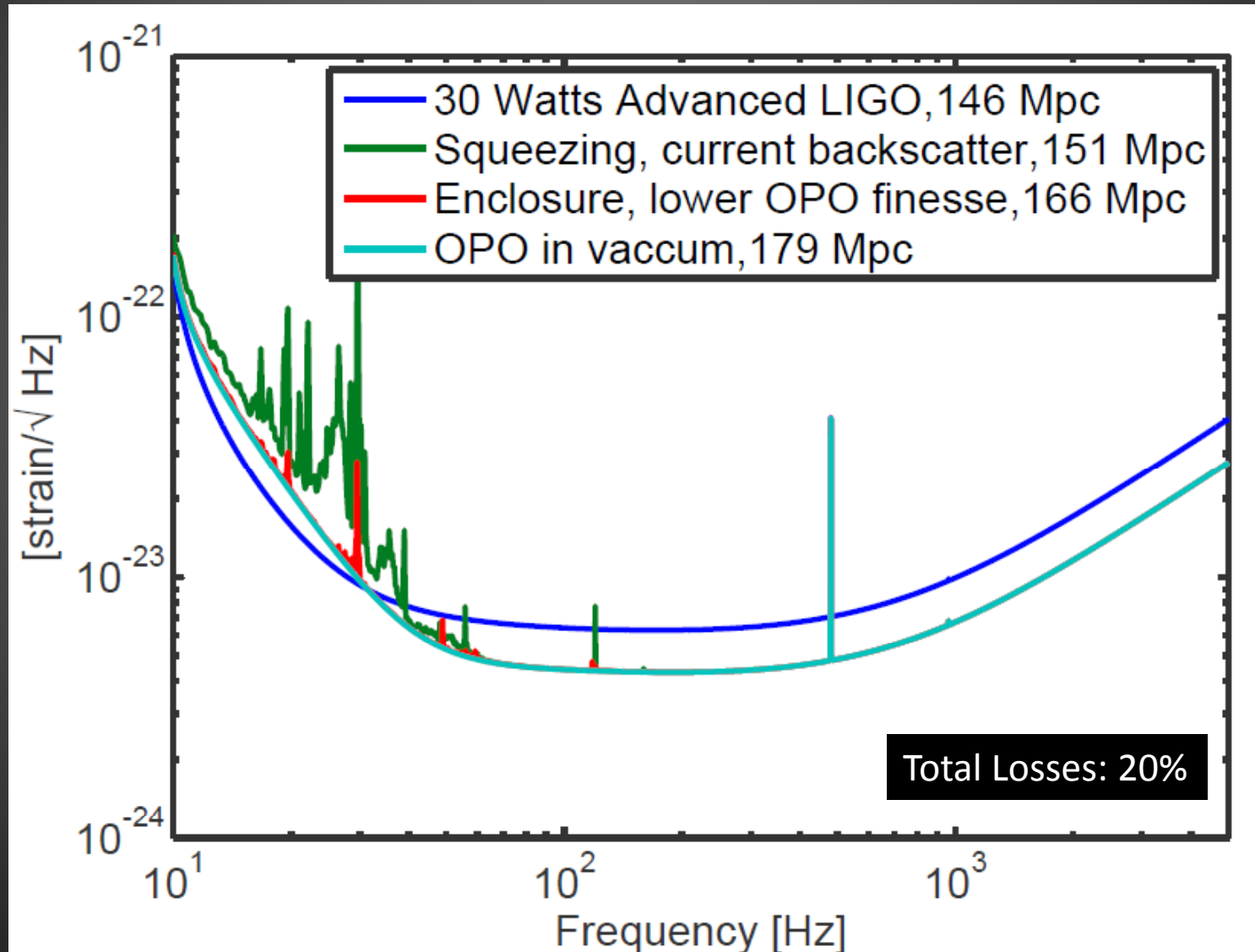260±40 fW of backscattered power at detector
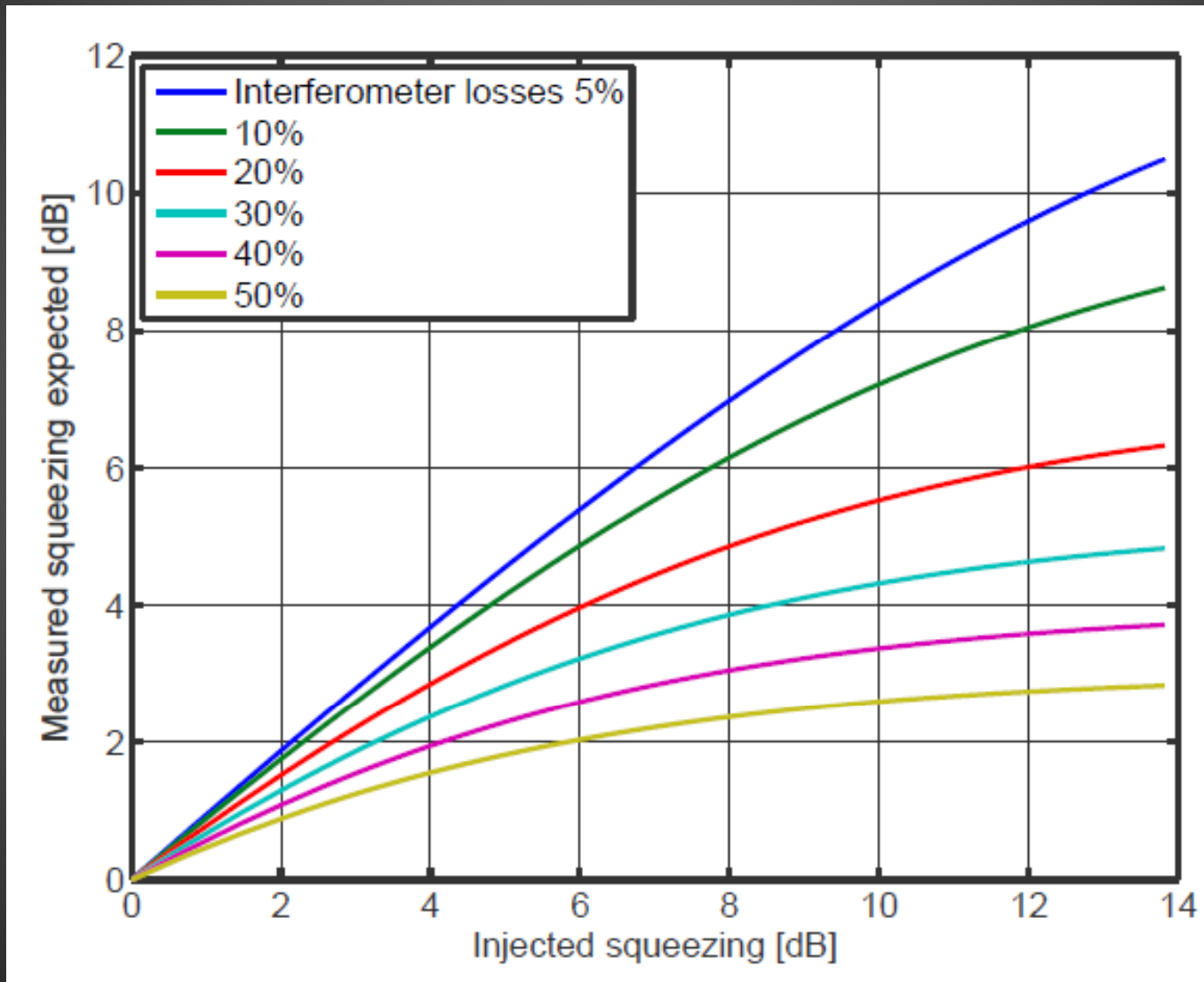
Backscatter in ALIGO

Backscatter in ALIGO
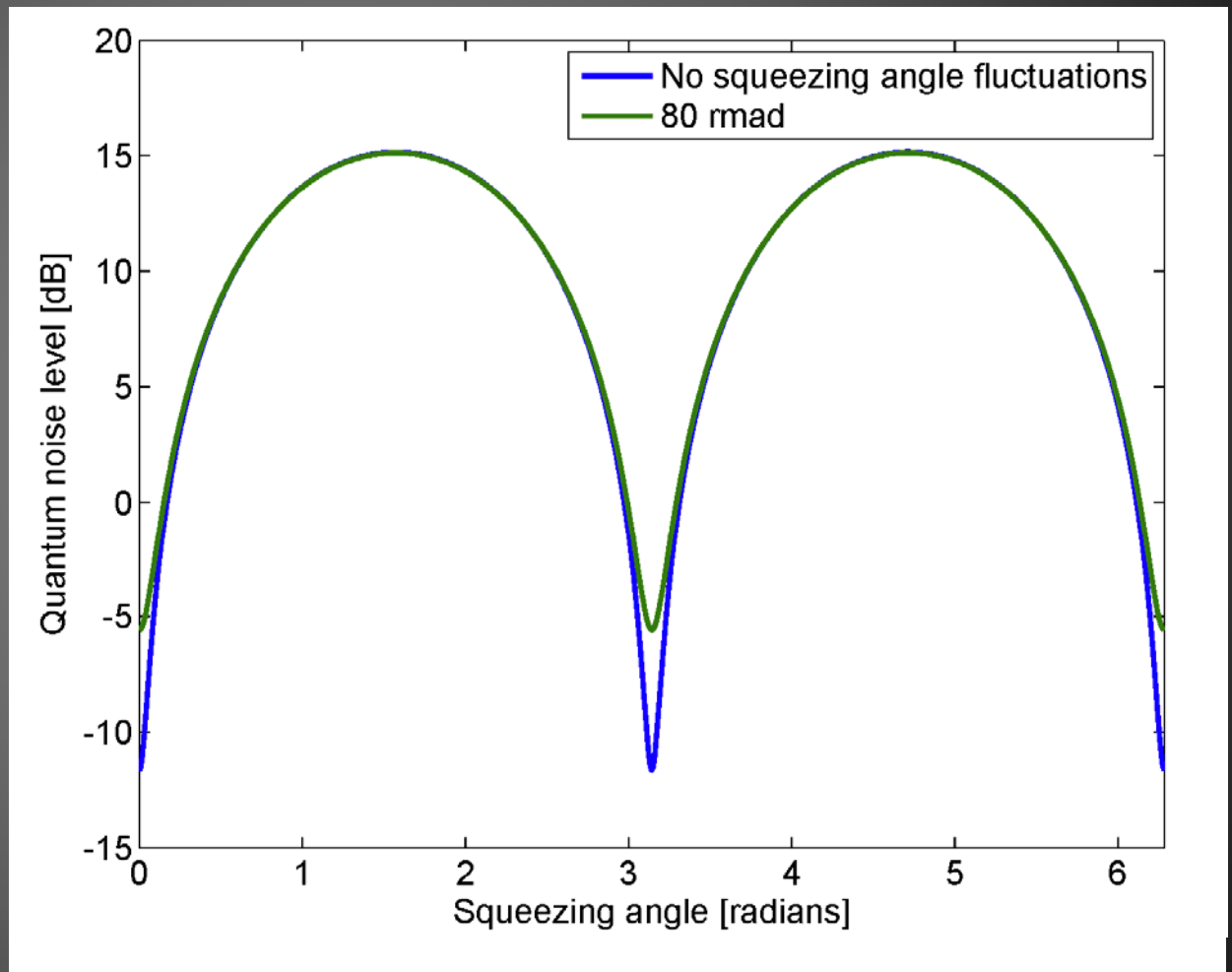
Backscatter in ALIGO

What's the catch? Losses

Loss budget and goals

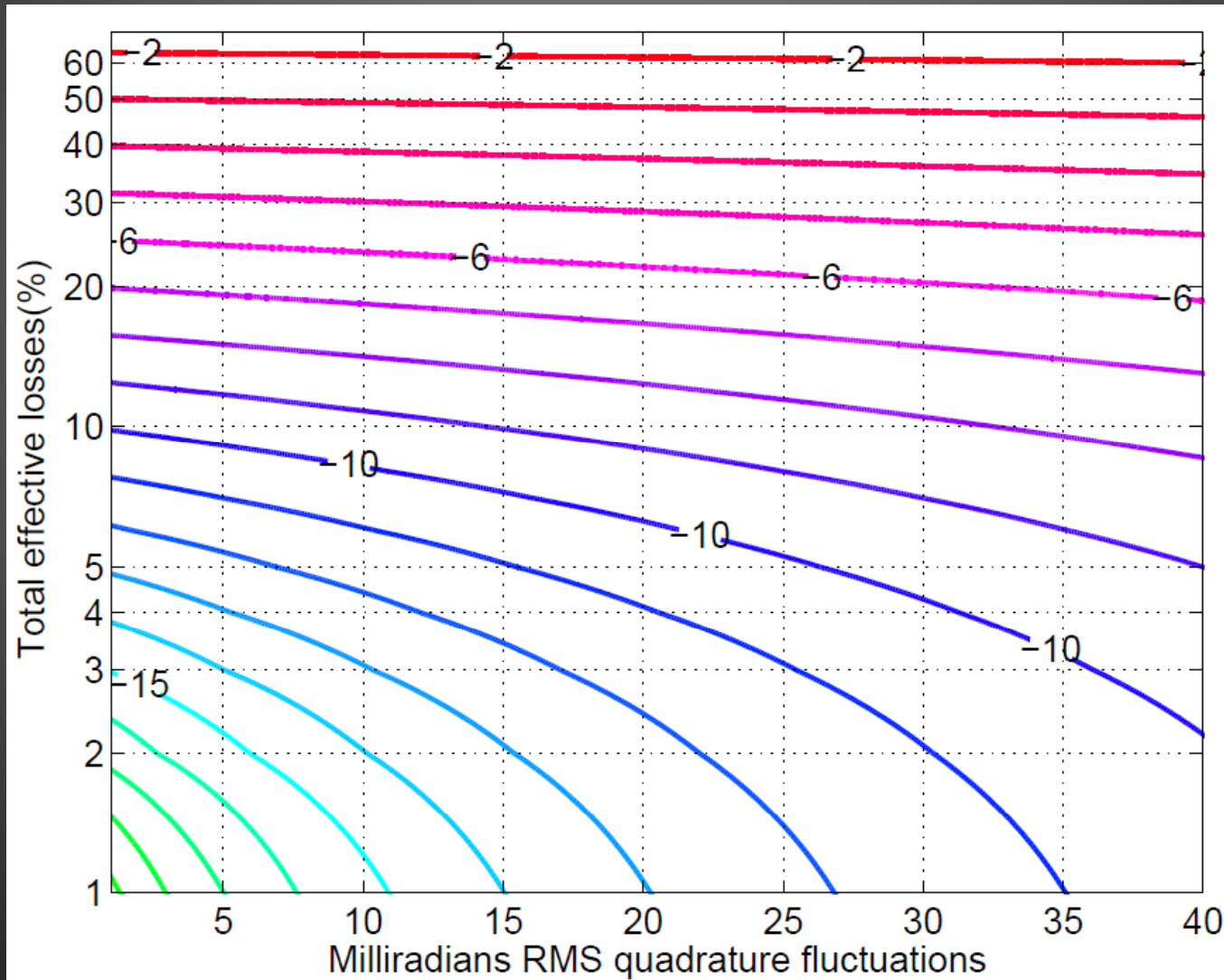|	Enhanced LIGO squeezing	Advanced LIGO assumptions
3 faraday passes	5% each	3% each
Mode matching	30%	4%
Output mode cleaner	19%	3%
Total losses	55-60%	20-25%

Based on a tally of 11 different loss sources

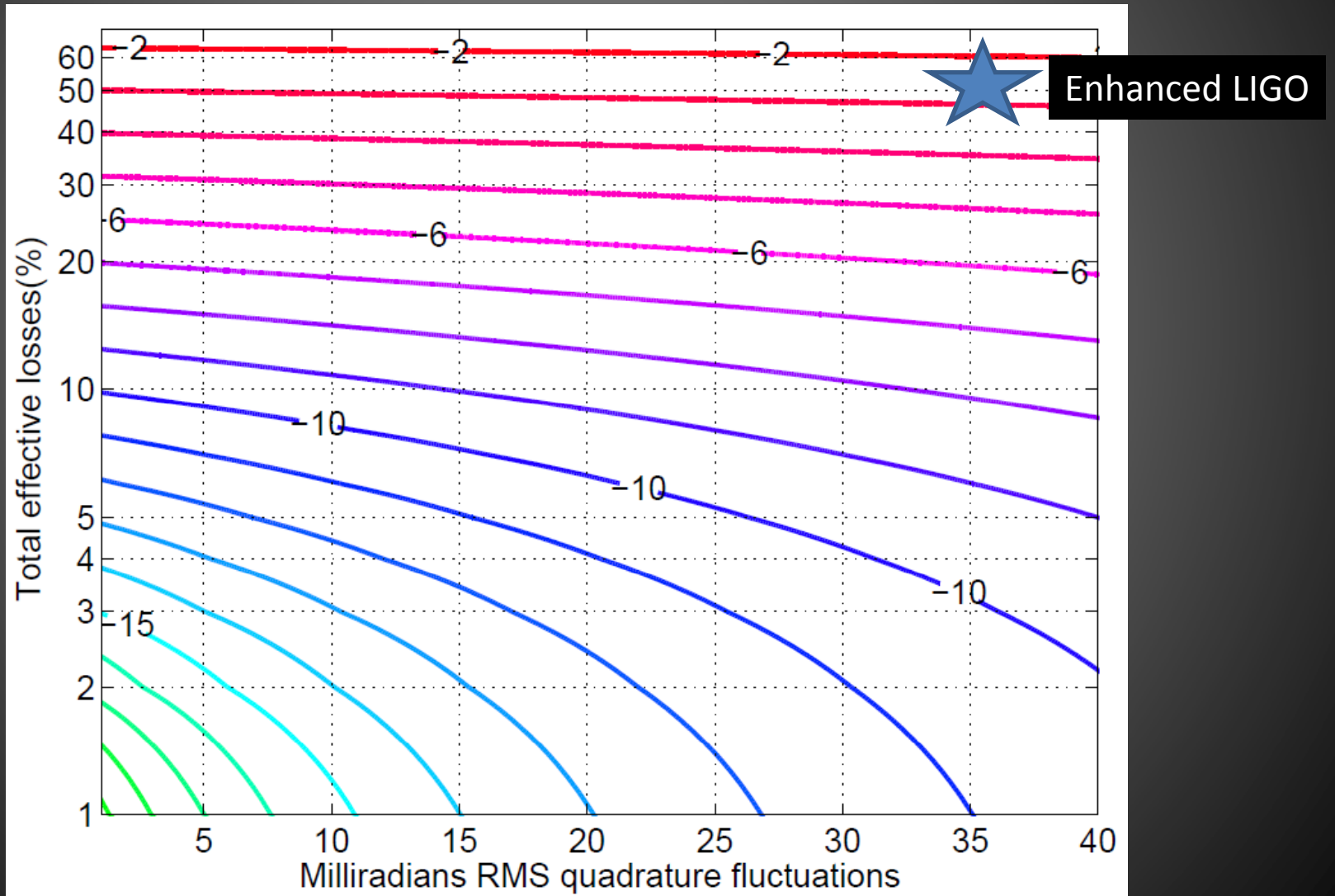## Reducing losses is a major challenge for squeezing commissioning
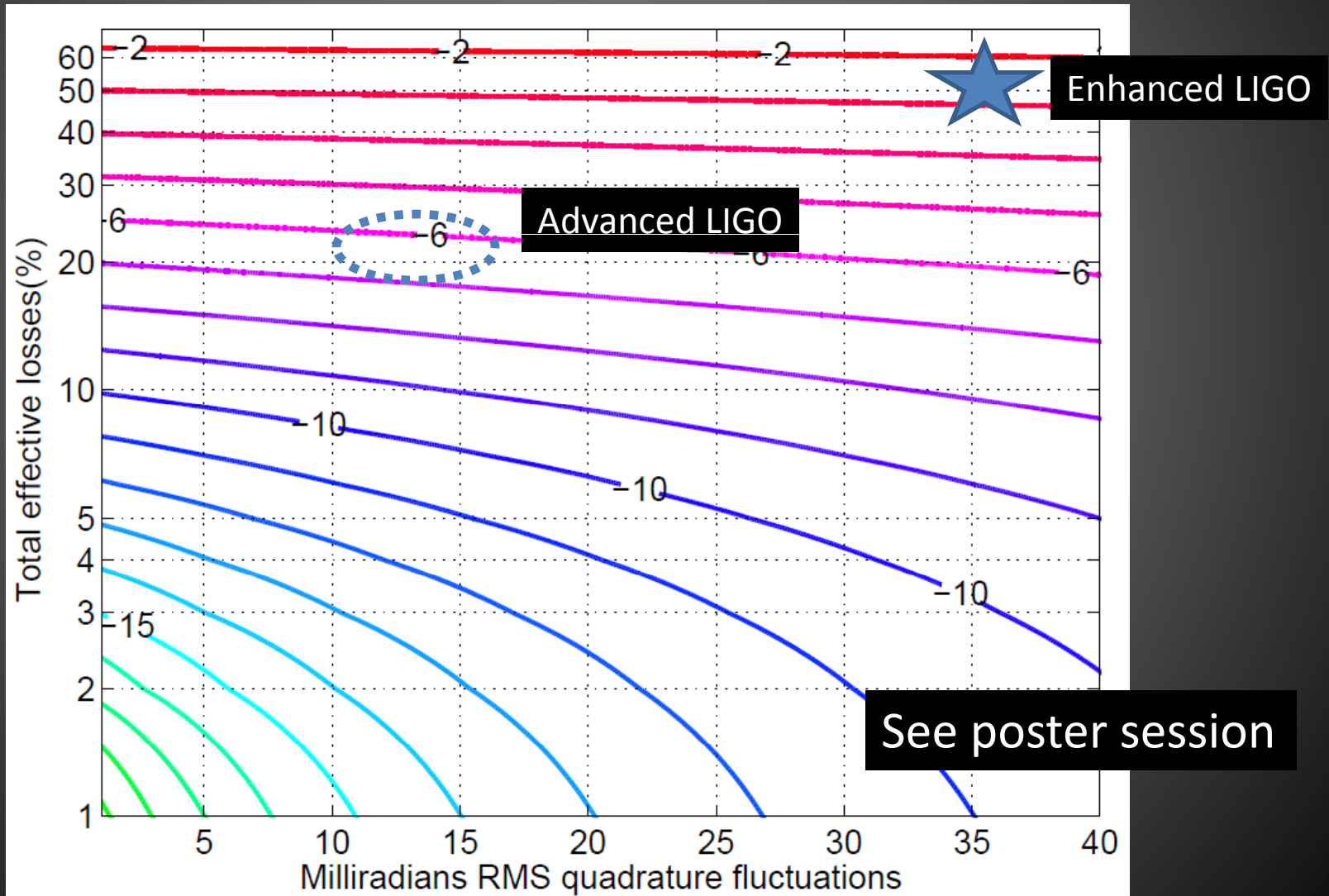
Squeezing Angle Fluctuations
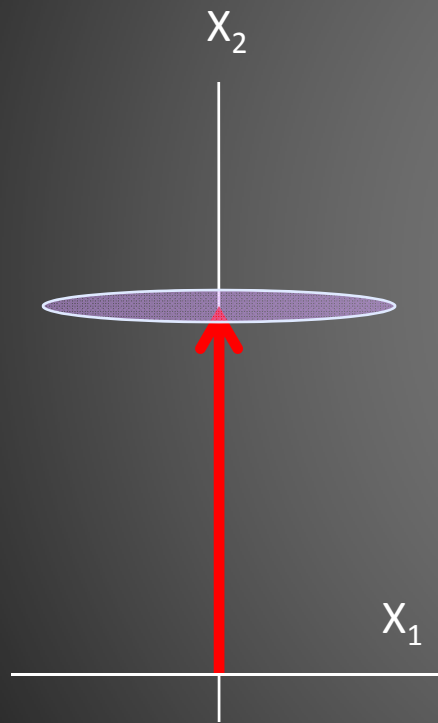
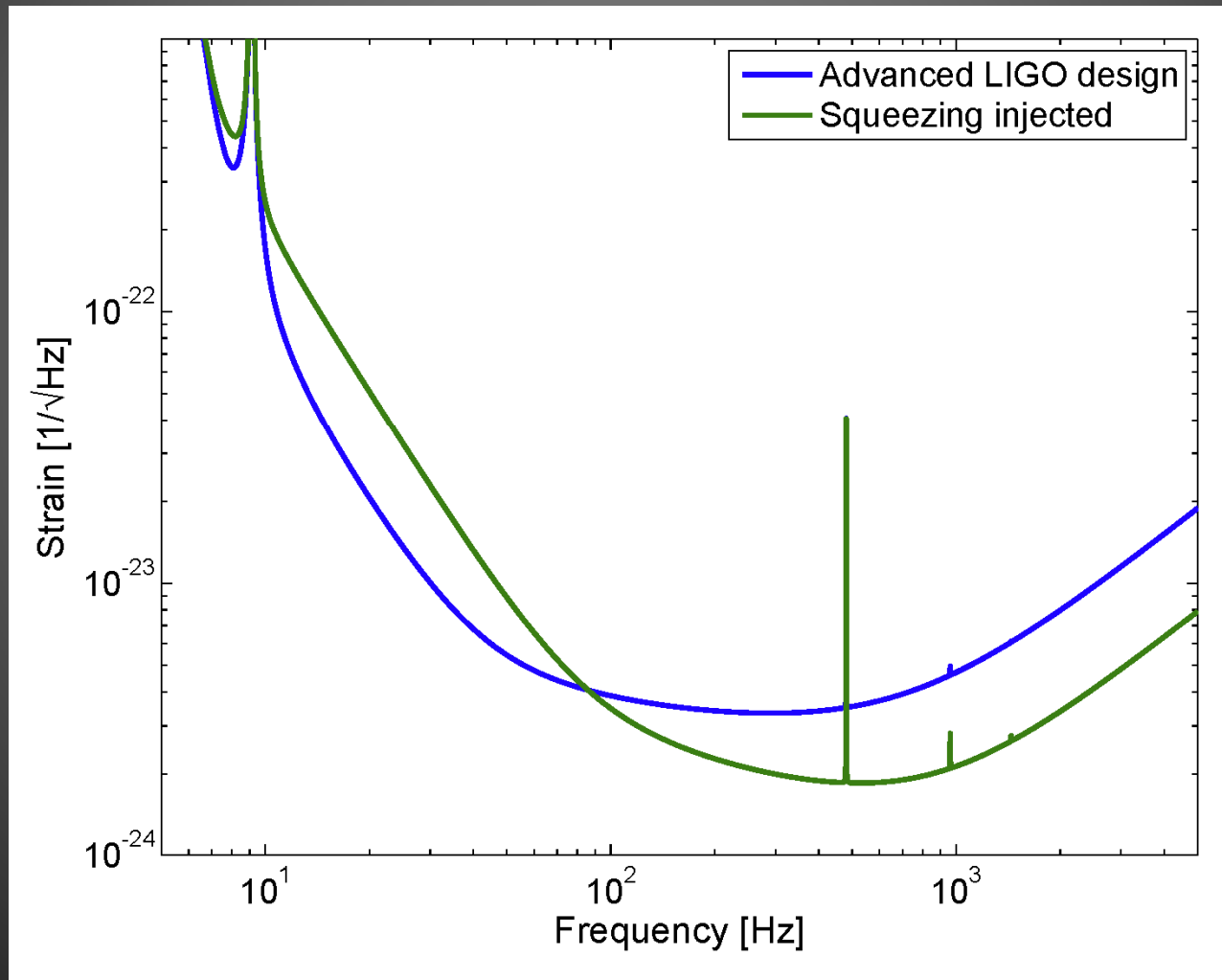# Losses and squeezing angle fluctuations limit squeezing level

Losses and squeezing angle fluctuations limit squeezing level

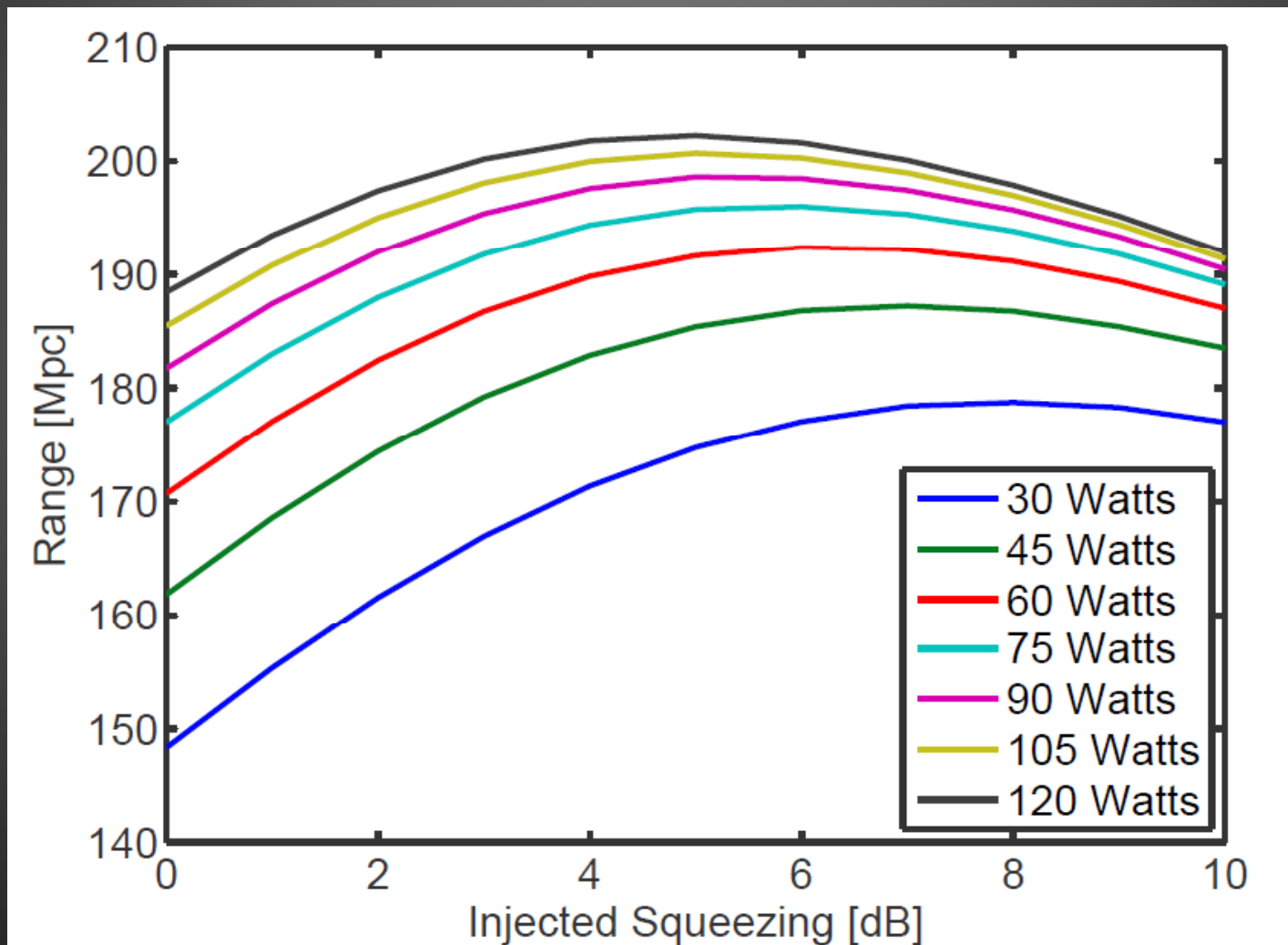# Losses and squeezing angle fluctuations limit squeezing level

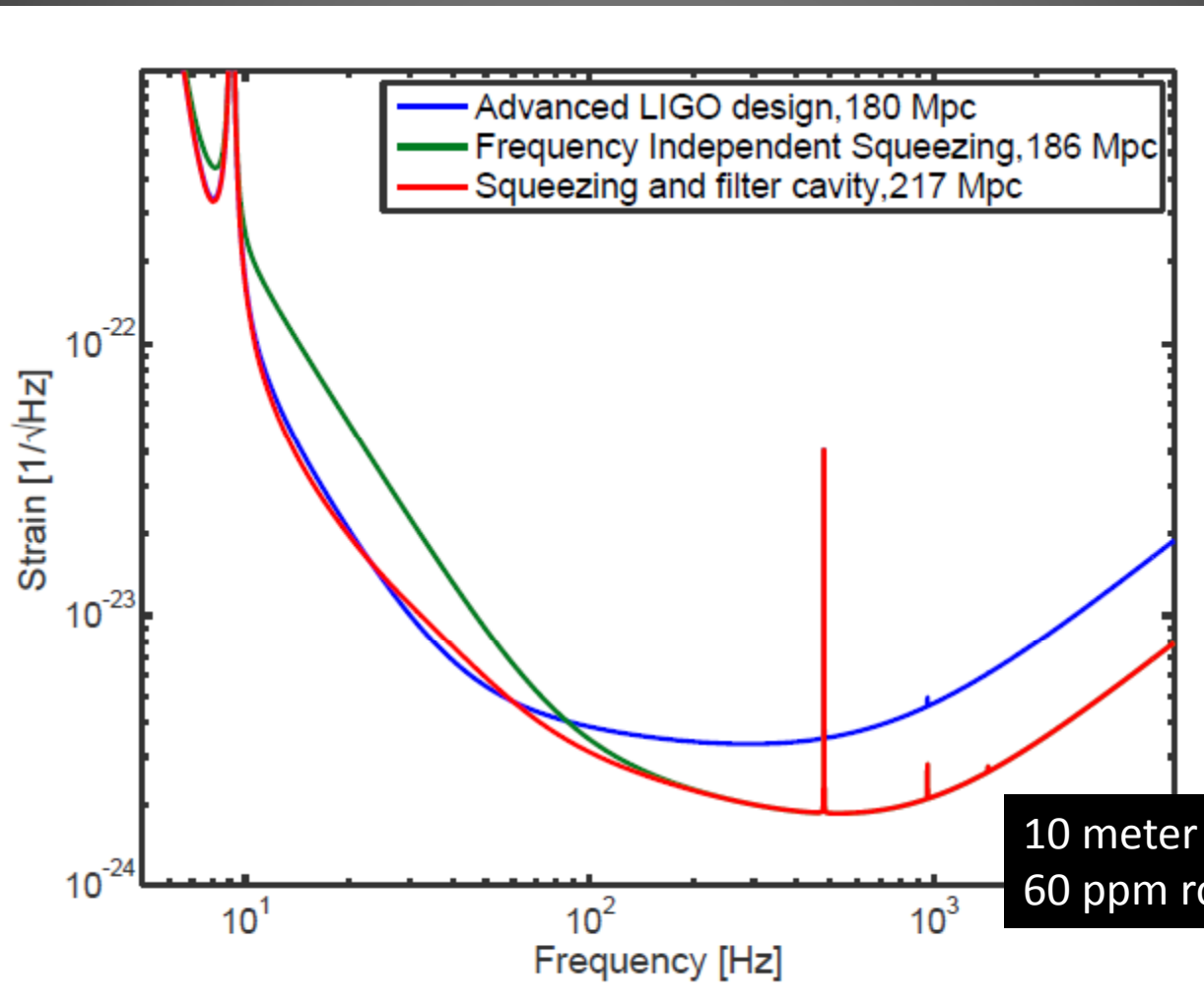# Squeezing with a radiation pressure limited interferometer

# Squeezing level and angle optimized for NS binaries

Frequency Dependent Squeezing

10 meter Filter Cavity
60 ppm round trip losses

Summary

- Squeezing works in the LIGO band!
- Backscatter reduction will allow squeezing to be used as an alternative to high power in aLIGO
- Losses and squeezing angle jitter limit squeezing
- Frequency dependent squeezing could improve sensitivity beyond advanced LIGO design
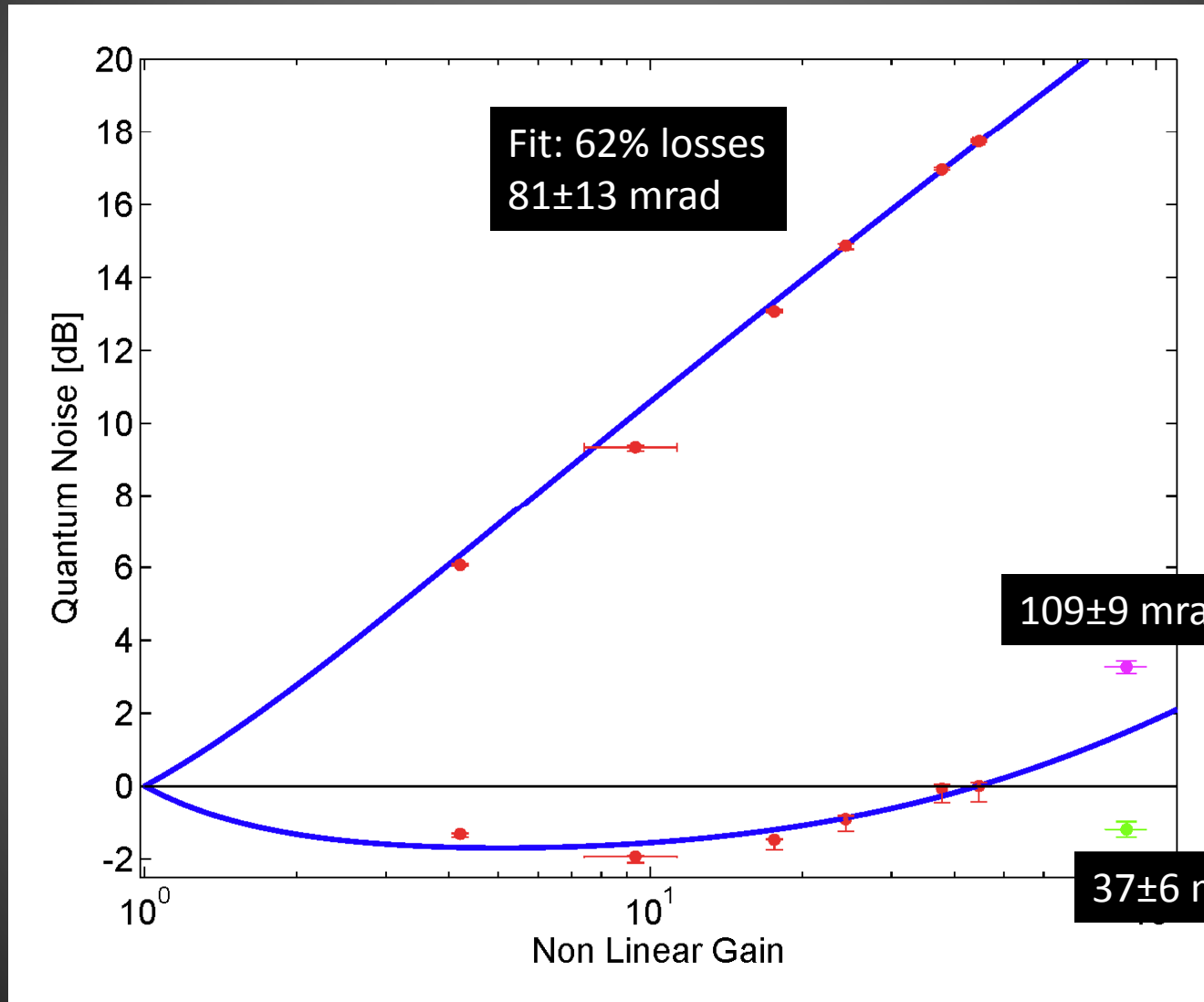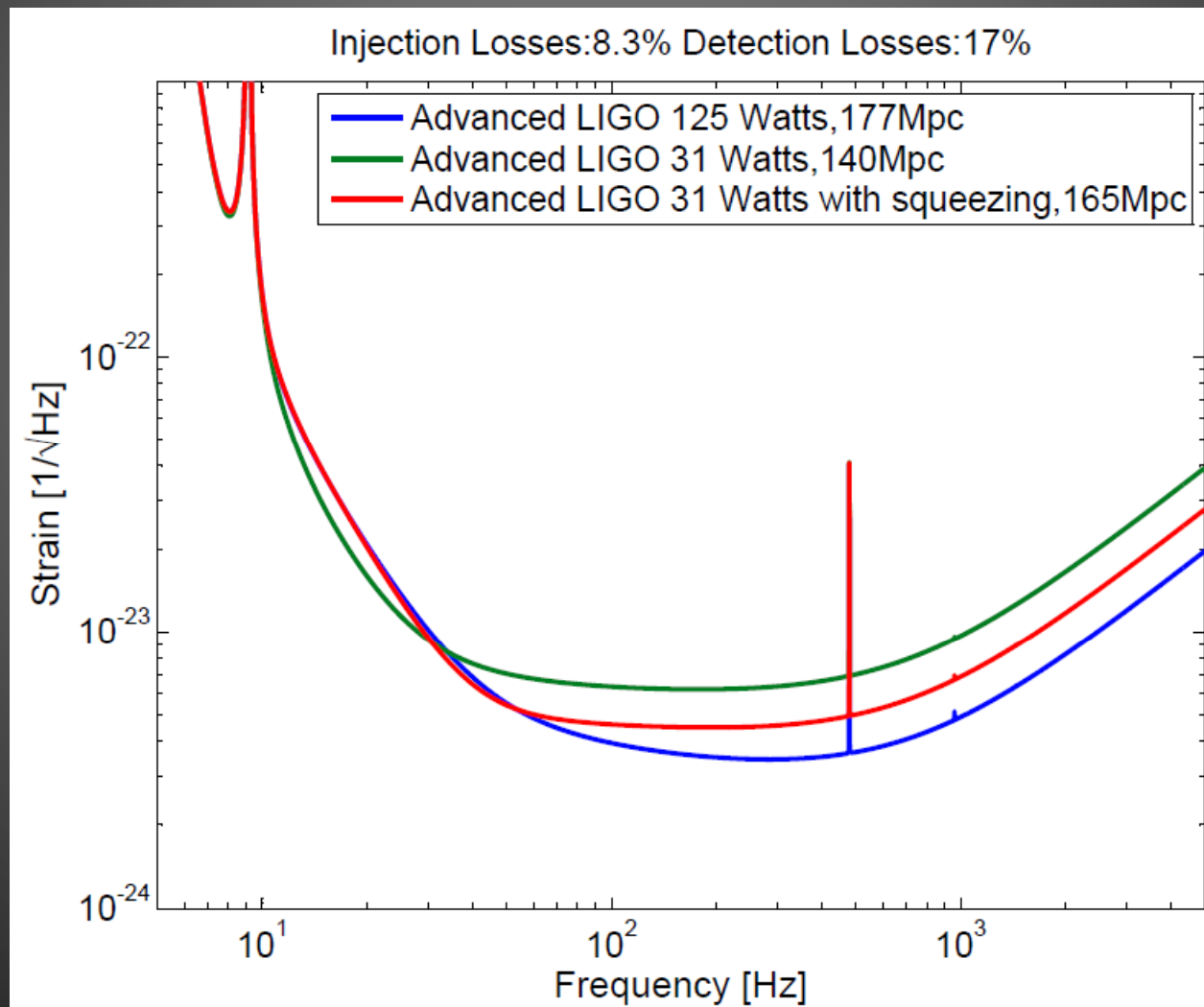
Squeezing angle fluctuations
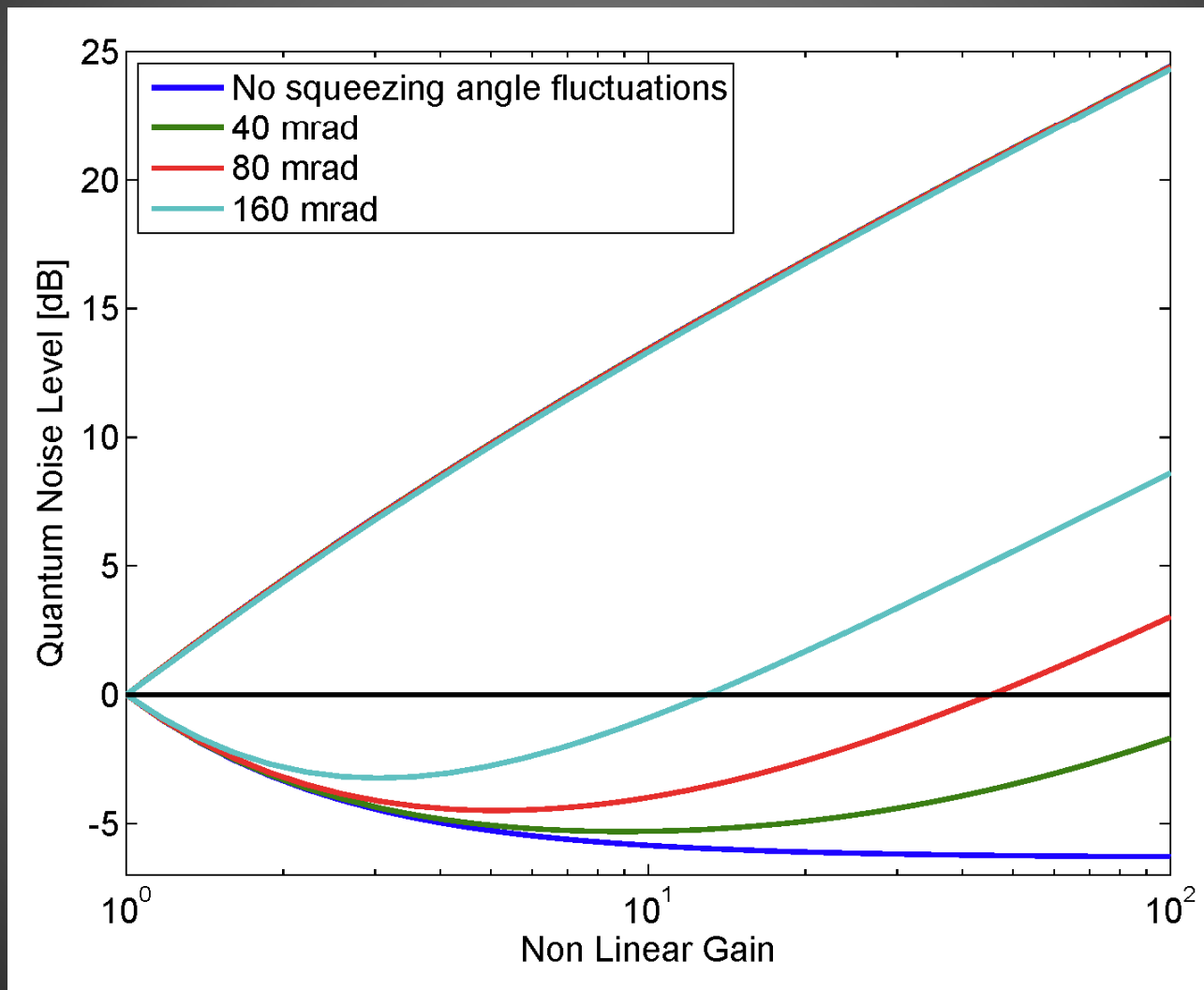
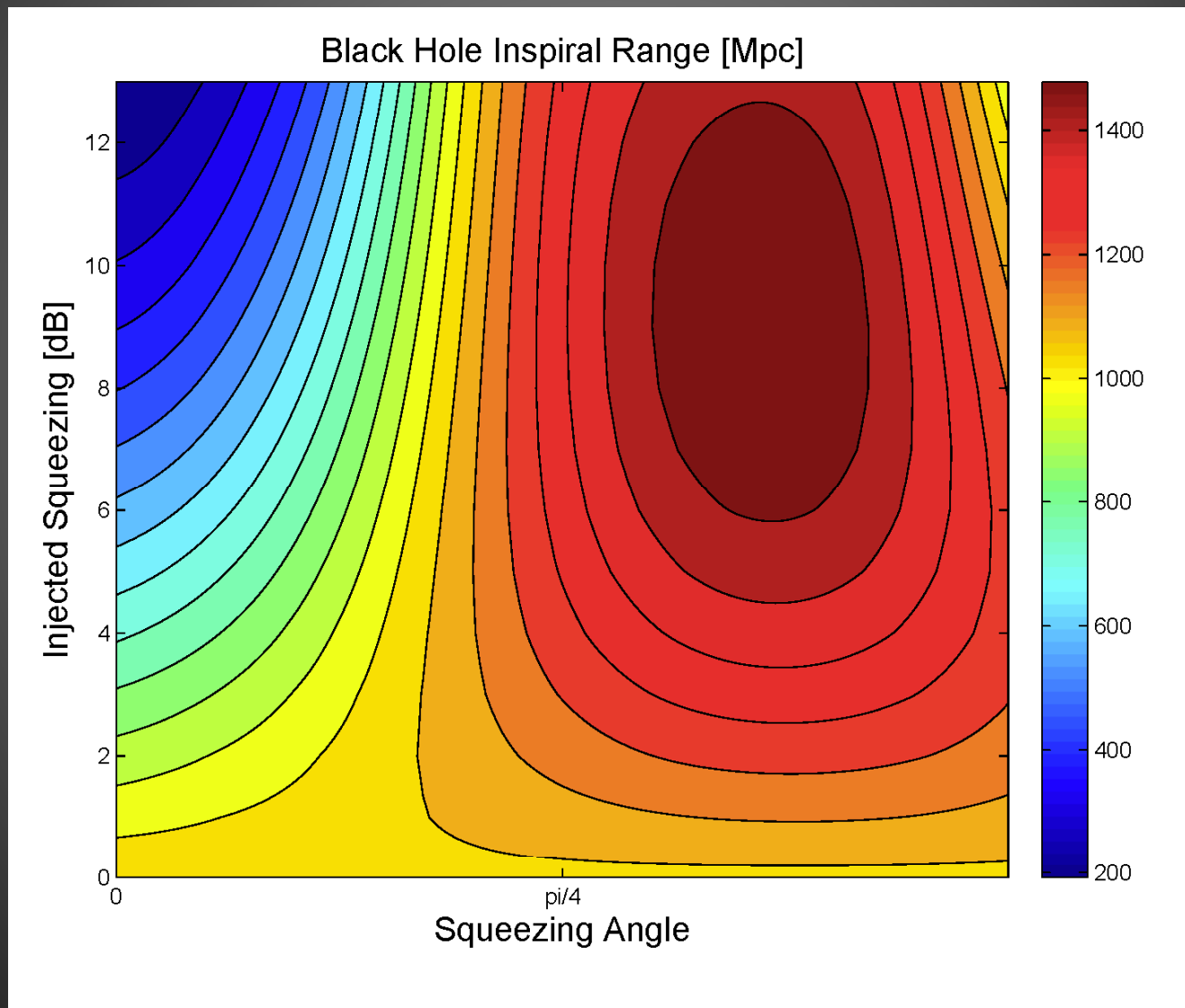# Measurement of squeezing angle fluctuations and losses
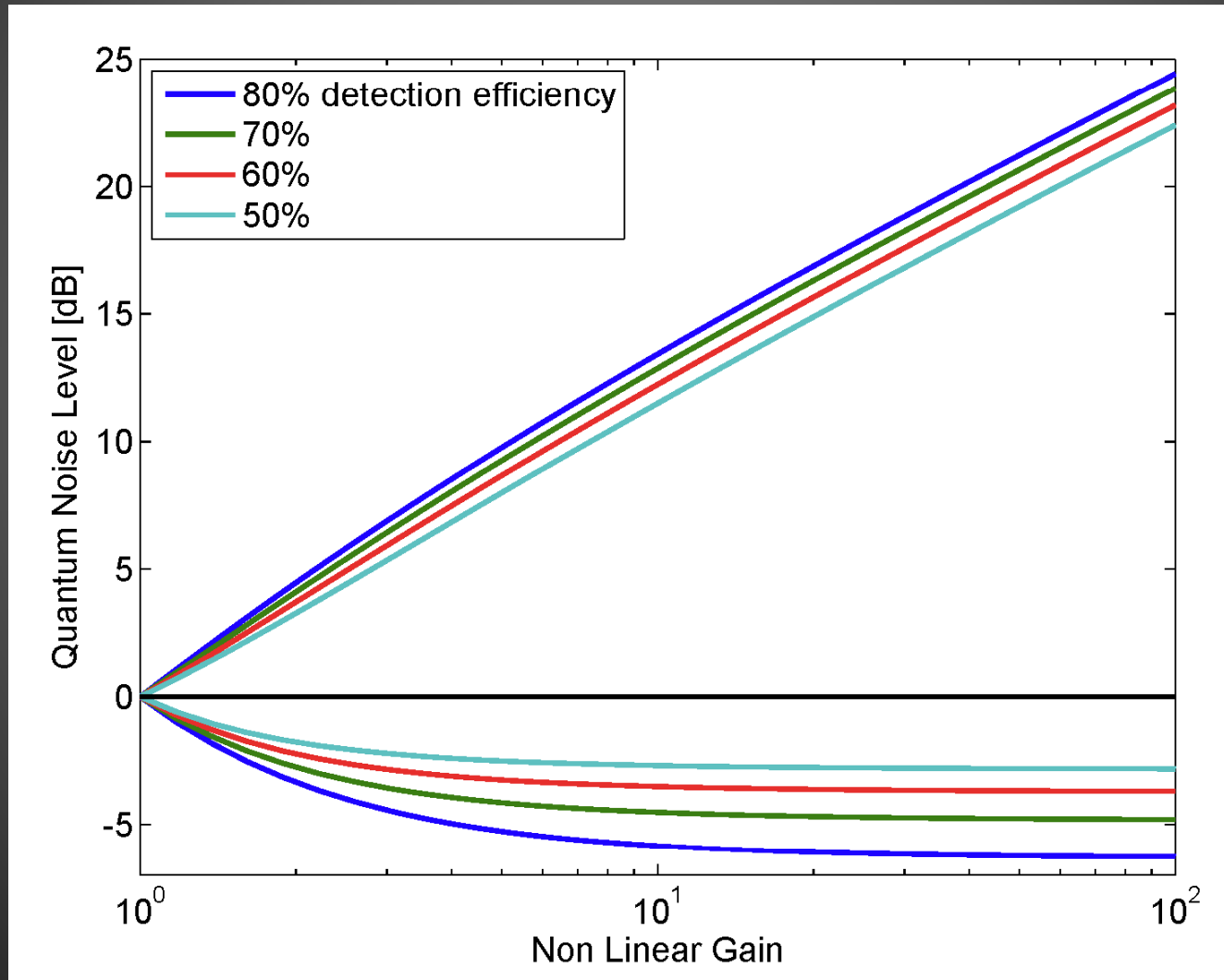
Squeezing angle fluctuations

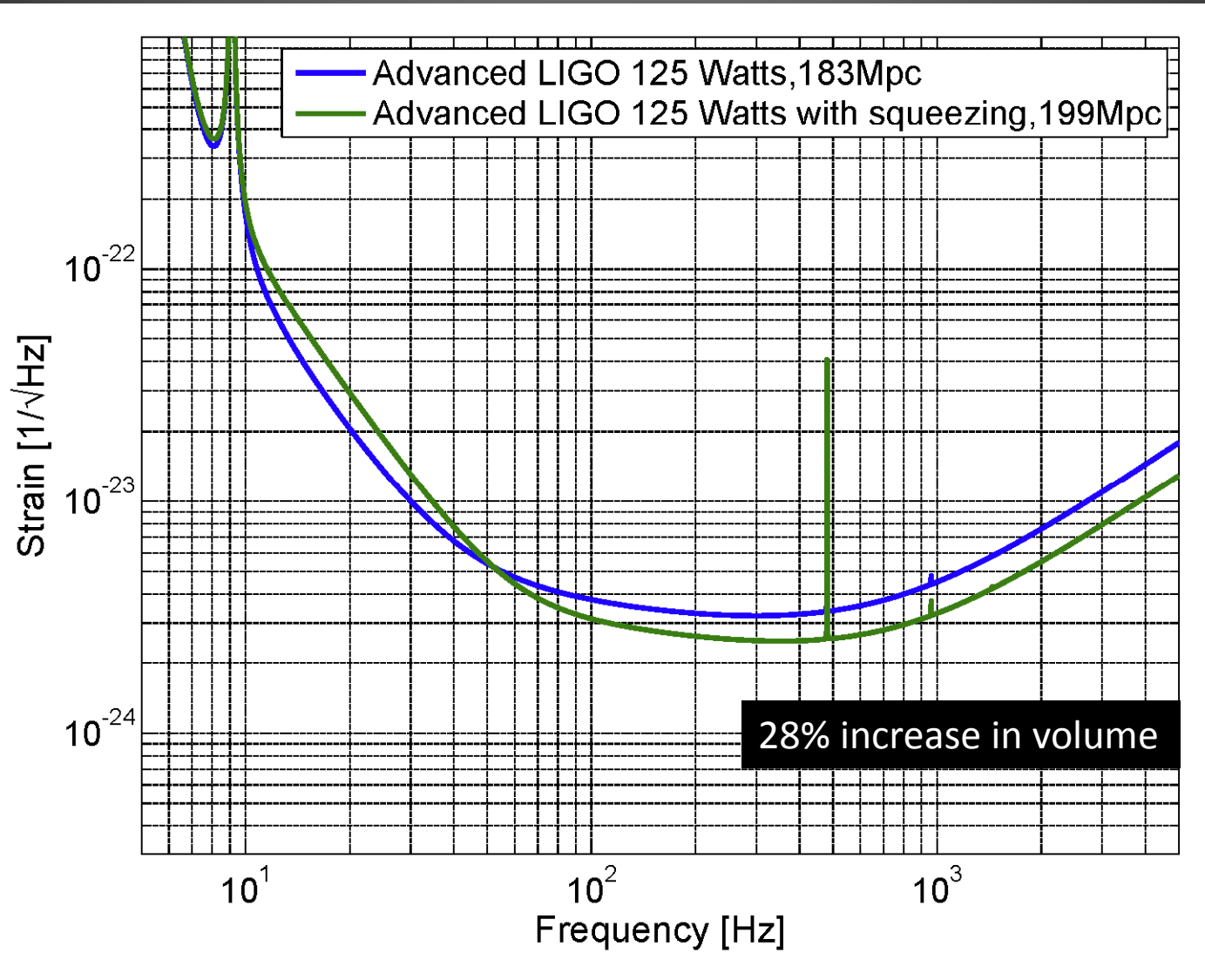# An alternative to high power operation in Advanced LIGO

Injection Losses:8.3% Detection Losses:17%

Squeezing in Advanced LIGO

Black Hole Inspiral Range [Mpc]

Squeezing with full power

Squeezing Angle Fluctuations