Laboratoire Kastler Brossel
Physique quantique et applications

- Advanced Virgo with Squeezing -
-- Sensitivity Curves: An Update --

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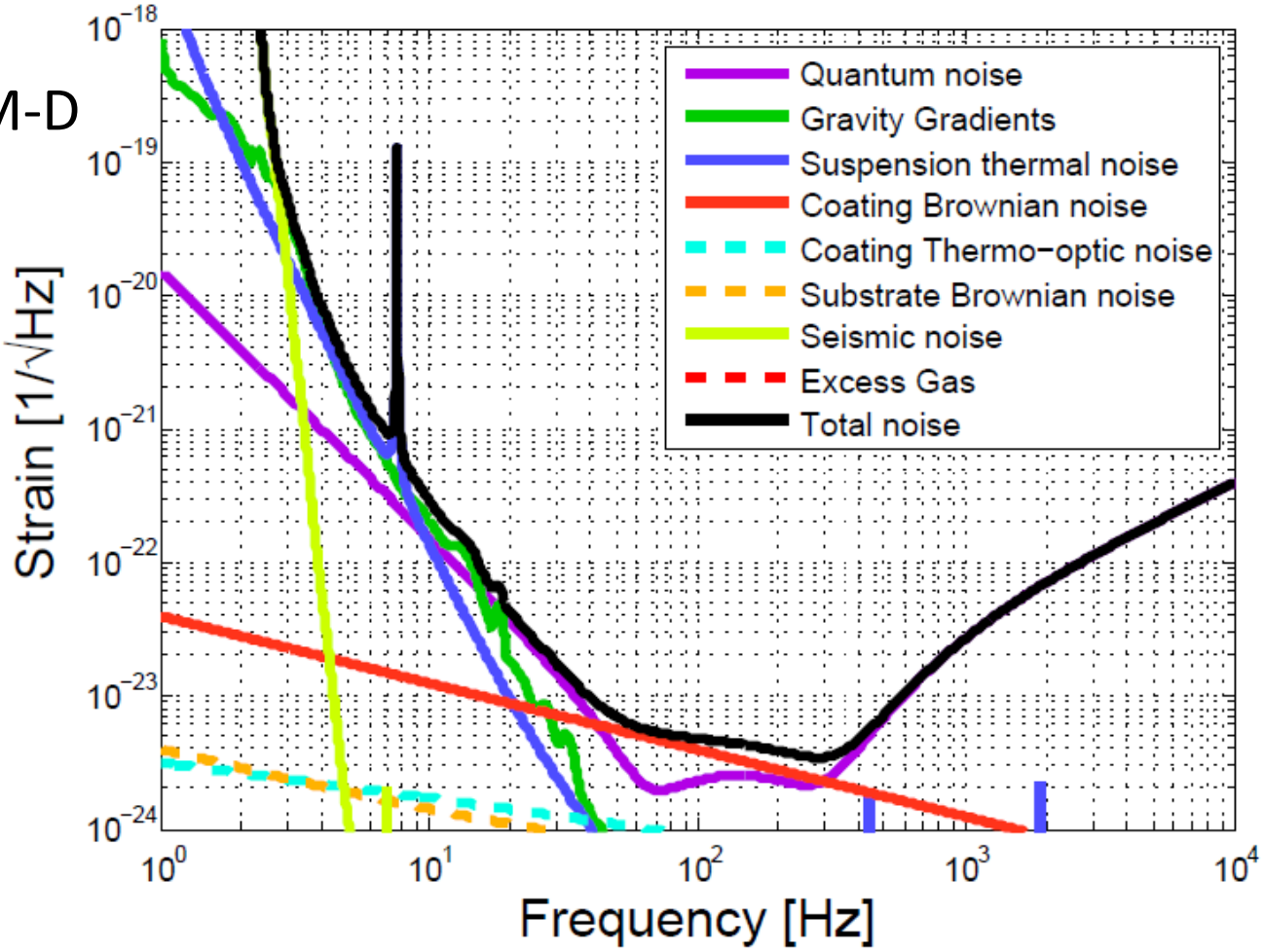
F2F Squeezing Meeting

Virgo Week September 2014

The Code

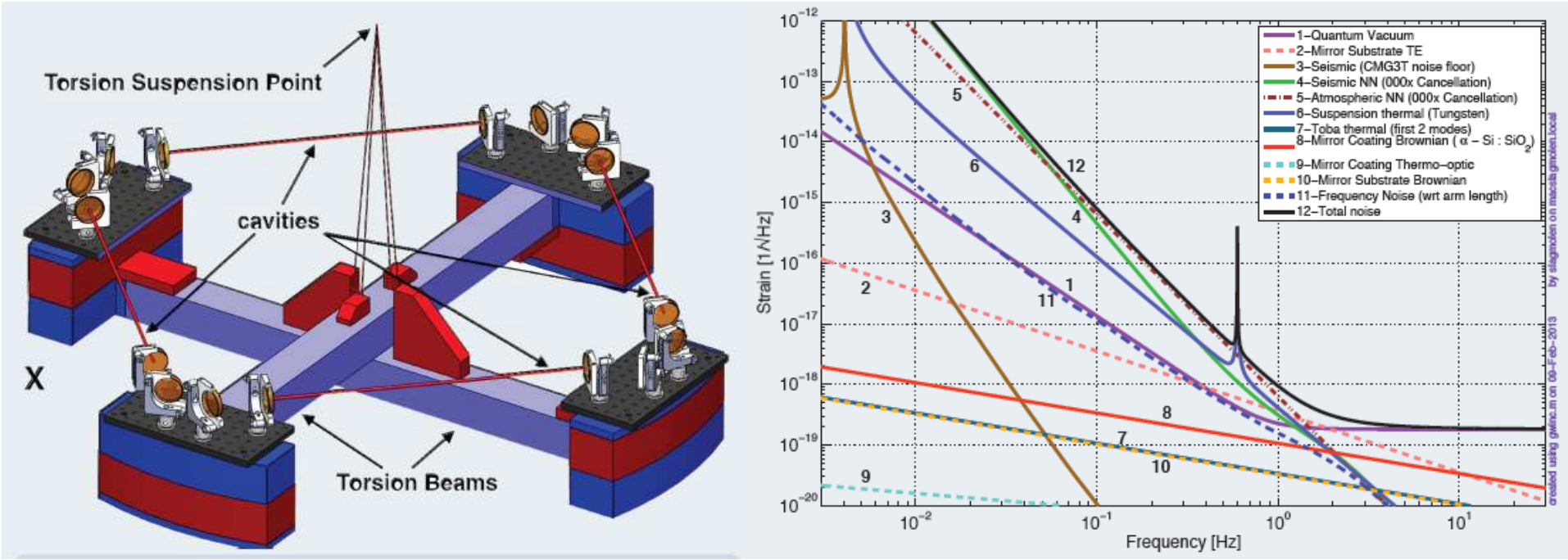
- The platform used is GWINC, and the dominant portion of this model is the Advanced Virgo GWINC code (as at July 2014).

125W DRM-D



The Code

- The quantum noise subroutine of the Advanced Virgo GWINC code is substituted by the LIGO GWINC Developer quantum noise subroutine code, which has squeezing and filter cavities. (Another example the Developer code in use below).



B. Slagmolen and D. McClelland – LIGO-P1300091 (Amaldi 2013)

Important Details

- LIGO Developer QN code is a complete two-photon picture code – the correlations between the amplitude and phase quadratures from Signal Recycling are included.
- Modifications to the two codes were made to make them compatible with each other:
  - The parameters for Power-recycled Advanced Virgo IFO Model only nullifies the SRM reflectivity and not the SR detuning offset. This detuning offset is explicitly set to zero for PRM.
- Functionality added to the code:
  - Inclusion of Squeezing Ellipse Phase Noise.

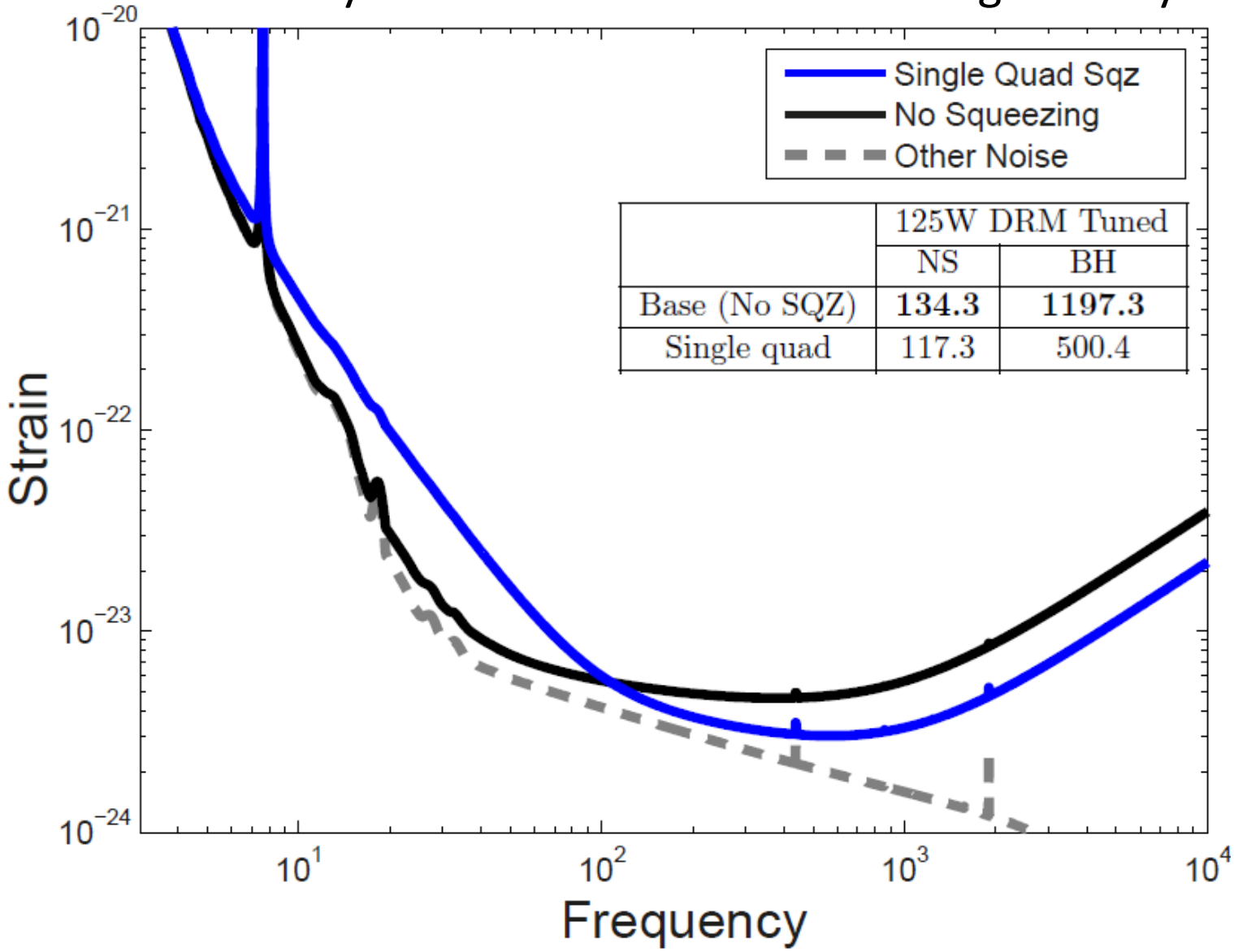
‘Proposal’ Parameters

- Squeezing parameters reflect those given in the Squeezed Light Proposal Document.
  - Frequency **In**dependent Squeezing.
  - Total optical losses of 22%.
  - Squeezing ellipse phase jitter of 20 mrad.
  - 5.9 dB Squeezing, 13.5 dB Anti-squeezing magnitudes at readout.
- The model was run for the three Advanced Virgo configuration stages:
  1. 25 W Power Recycled Michelson
  2. 125 W Dual Recycled Michelson, tuned Signal Recycling
  3. 125 W Dual Recycled Michelson, detuned Signal Recycling.
- This talk only shows configuration [2]. All three configurations are shown as part of “Extra Slides”.

Single Quadrature Squeezing

LKB

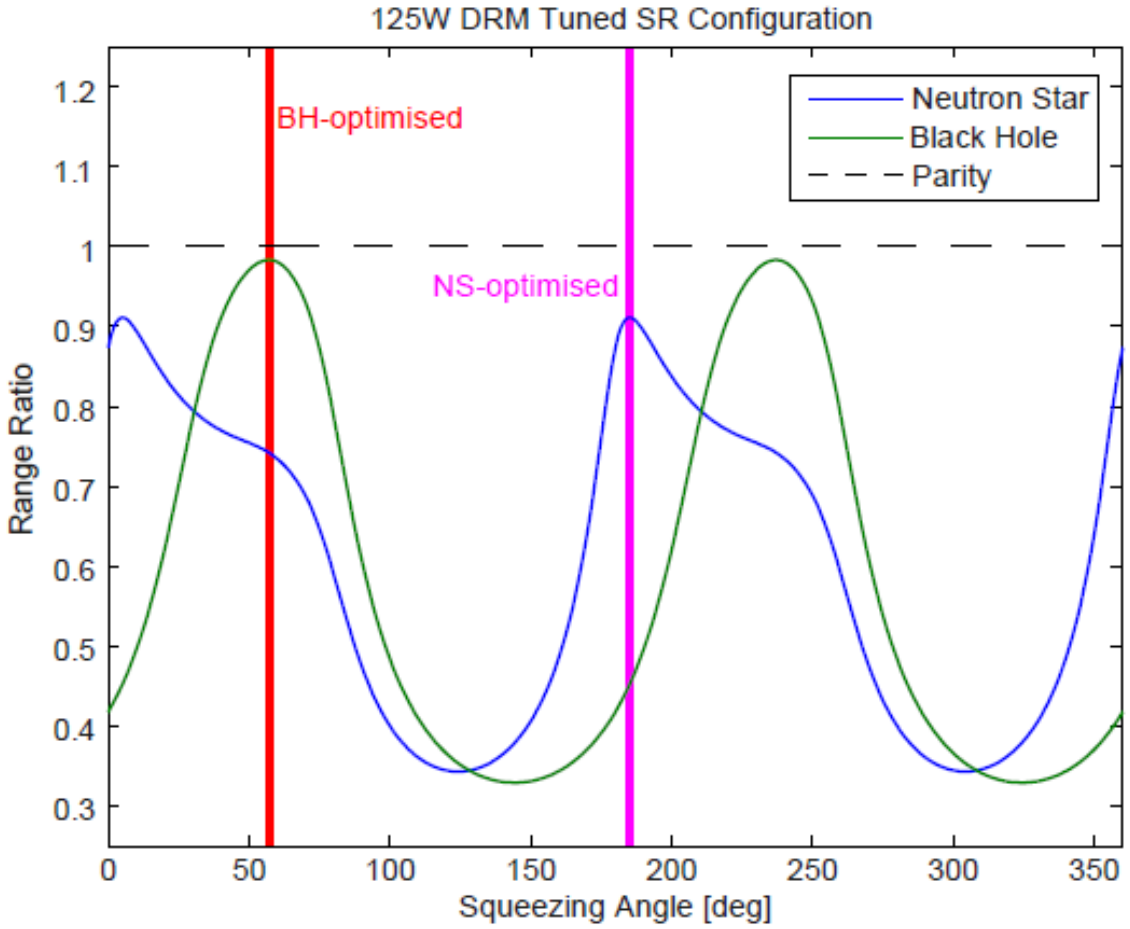
125 W Dual Recycled Michelson with Tuned Signal Recycling



	125W DRM Tuned	
	NS	BH
Base (No SQZ)	**134.3**	**1197.3**
Single quad	117.3	500.4

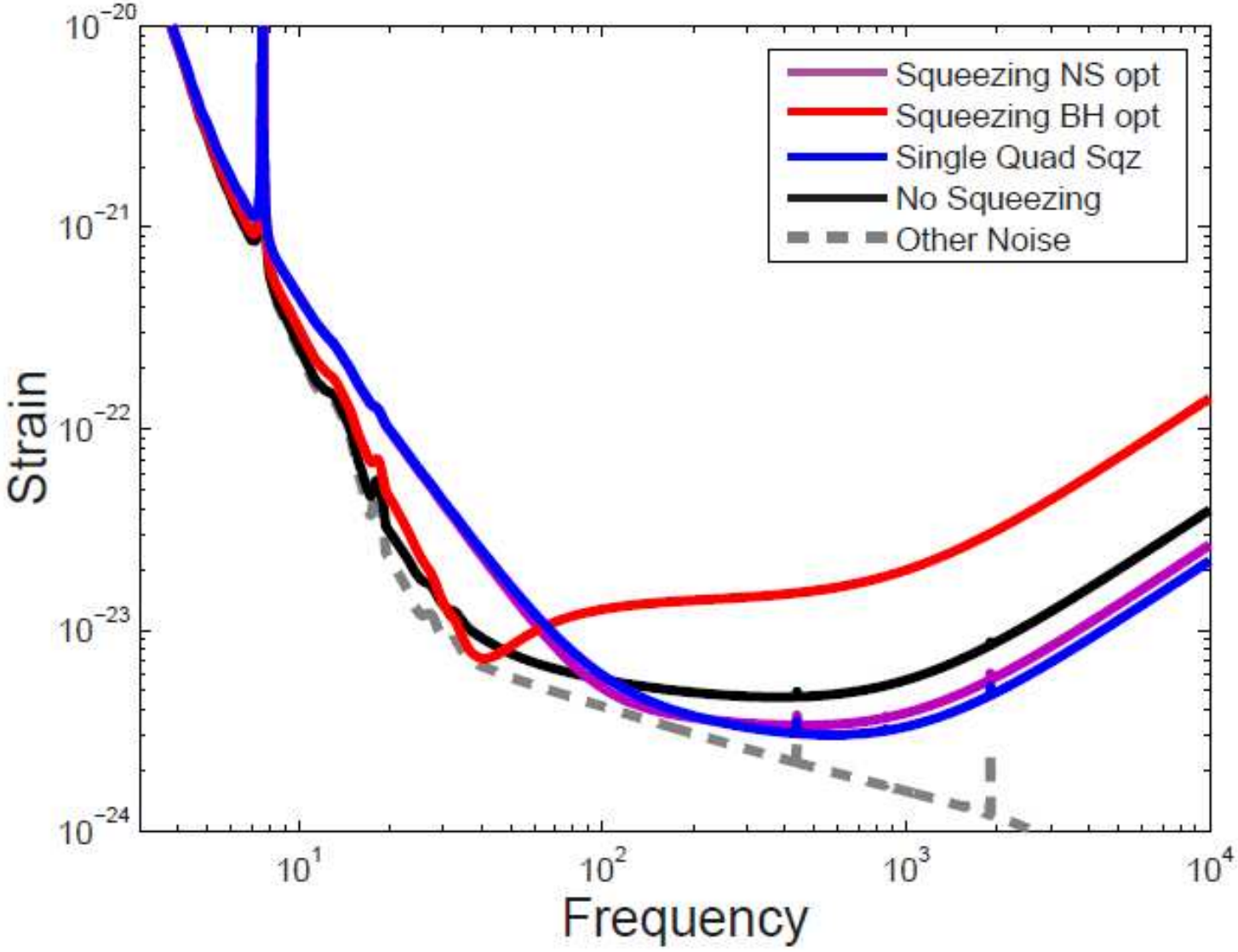
Squeezing-Angle Optimisation

- The Mpc-ranges for Binary Neutron Stars and Binary Black Holes were calculated over a full squeezing angle revolution, then normalised to the values of the (unsqueezed) Base case.



Squeezing-Angle Optimisation

125 W Dual Recycled Michelson with Tuned Signal Recycling



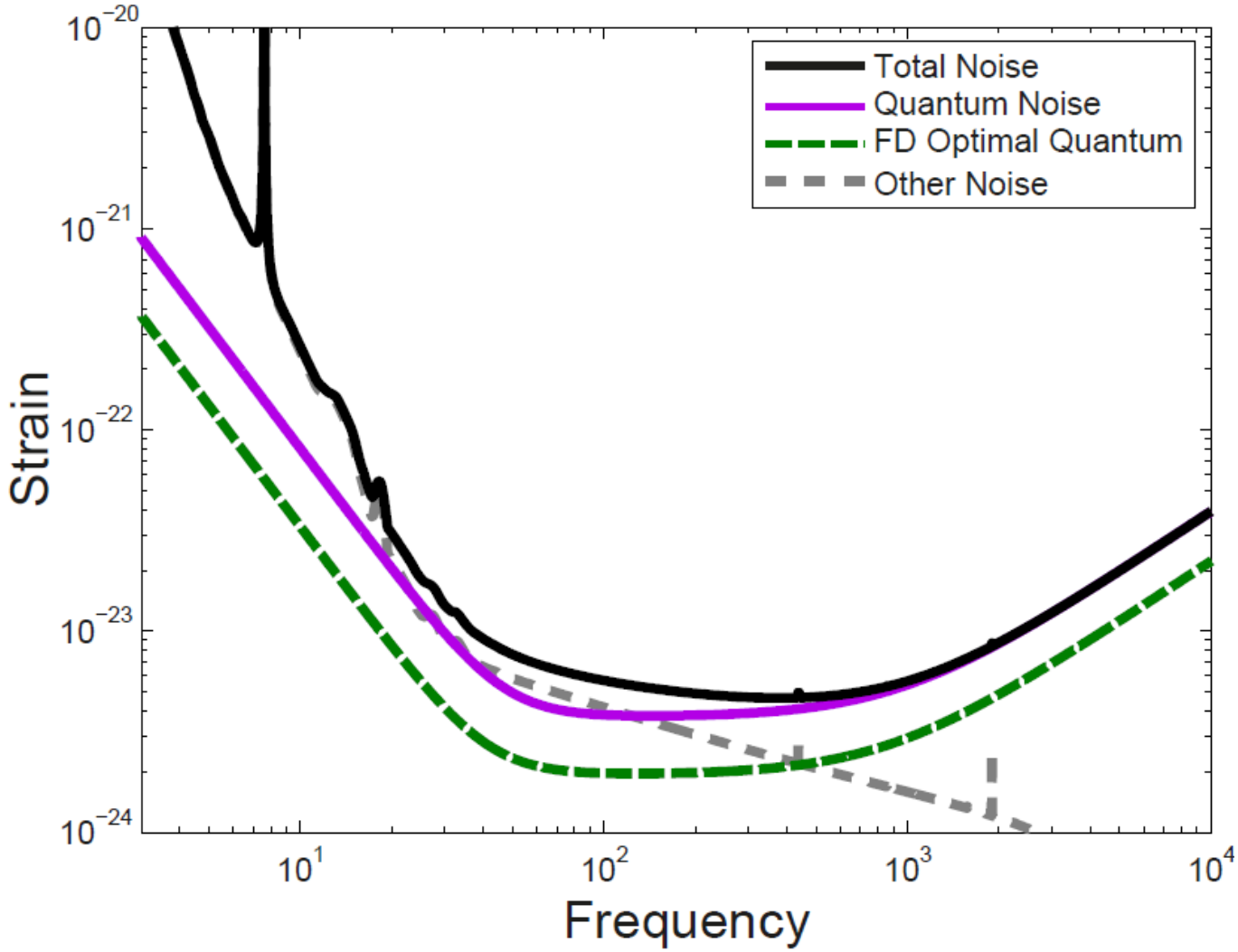
Angle-Optimised Range Values

	25W PRM		125W DRM-Tuned SR		125W DRM-Detuned SR	
	NS	BH	NS	BH	NS	BH
Base	**111.4**	1029.2	**134.3**	**1197.3**	**146.4**	1164.6
Single quad	88.8	341.8	117.3	500.4	81.8	493.4
NS Opt	92.6	360.0	122.4	541.3	114.9	443.7
BH Opt	91.0	**1129.3**	99.4	1177.1	107.4	**1202.3**

- Across the three configurations, frequency independent squeezing only enhances on two situations.
- These results are expected, given the nature of the sources and the 7/3 range integrand.
- There will be a trade-off between choice of amplitude quadrature or phase enhancement - the increase from anti-squeezing is detrimental to sensitivity.

Frequency Dependent Squeezing

- The code for Filter Cavities and Frequency Dependent Squeezing is <u>implemented</u> – just need the cavity parameters

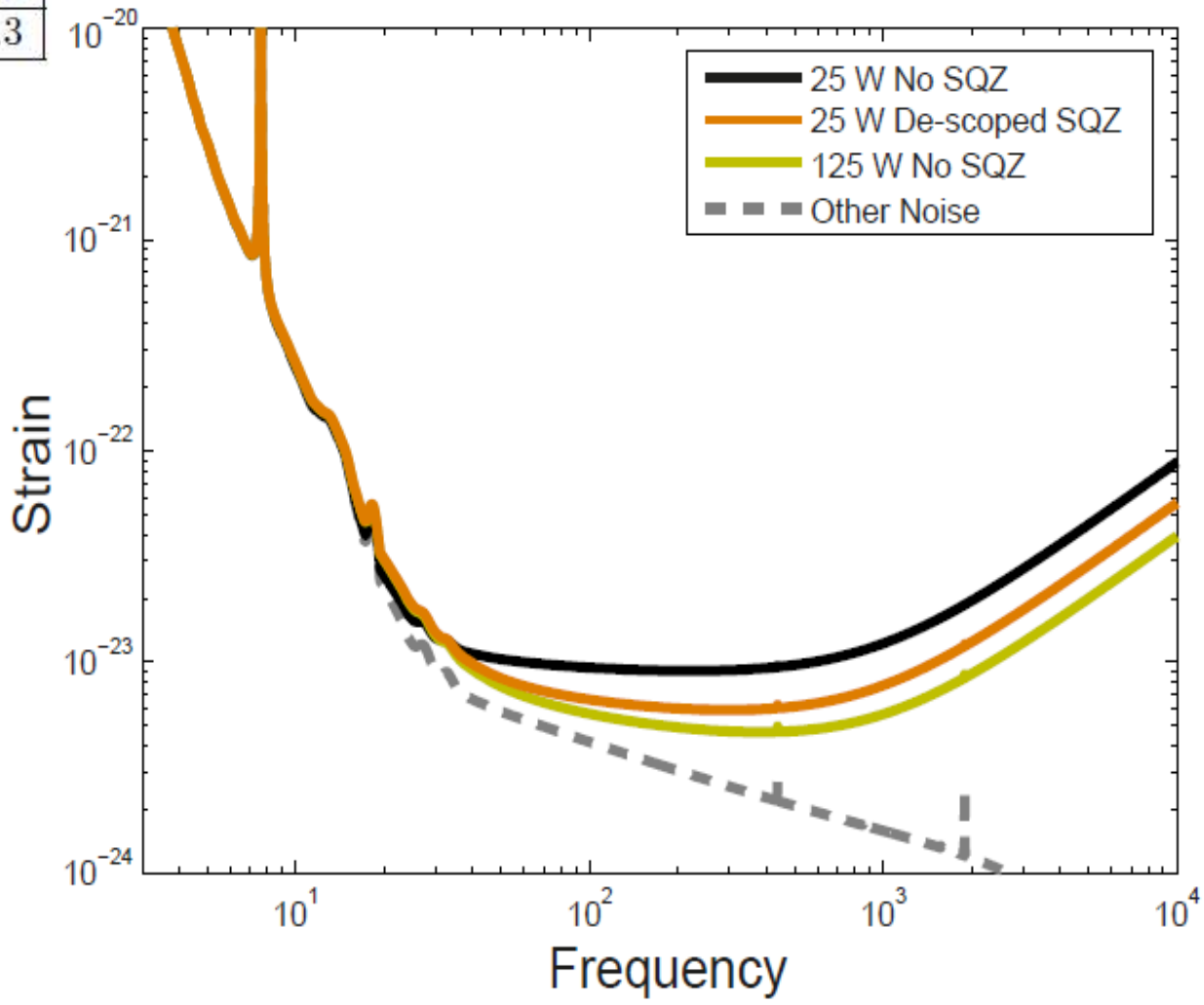


High Power Risk Mitigation

	NS	BH
25W No Sqz	99.4	1063.6
25W De-scoped Sqz	118.9	1123.5
125W No Sqz	134.3	1197.3

- 25W → 125W is a 7dB increase in power.
- De-scope squeezing/ antisqueezing magnitude, so that the anti-squeezed magnitude (after losses and phase jitter) is 7 dB, to match an equivalent QRPN increase as from high power.

Towards Sensitivity Recovery!

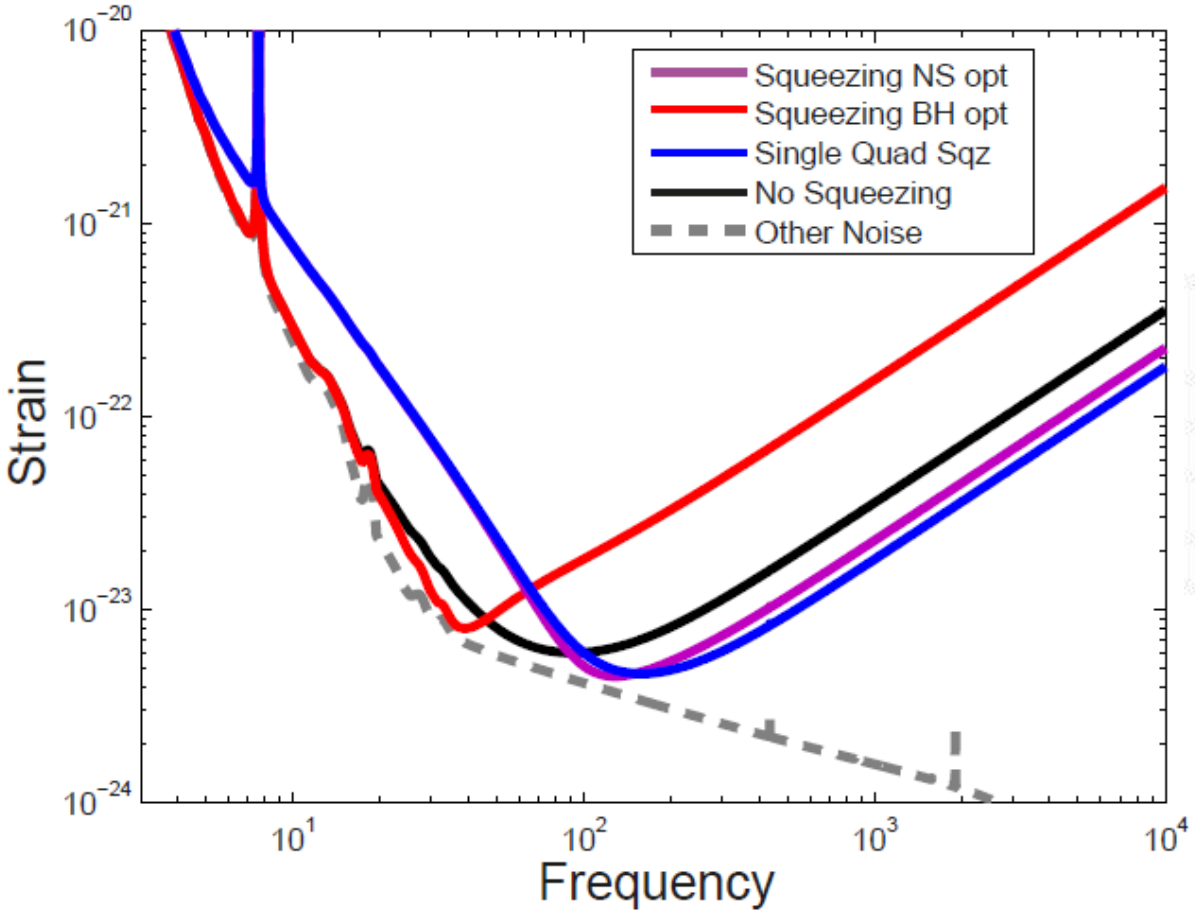


The Message

- The Code is very far advanced!
- The increase from anti-squeezing is detrimental to sensitivity range – filter cavity discussion important to the TDR.
- Squeezing still remains a high optical power risk mitigation strategy to partially recover sensitivity.

Extra Slide – AdV Configuration 1

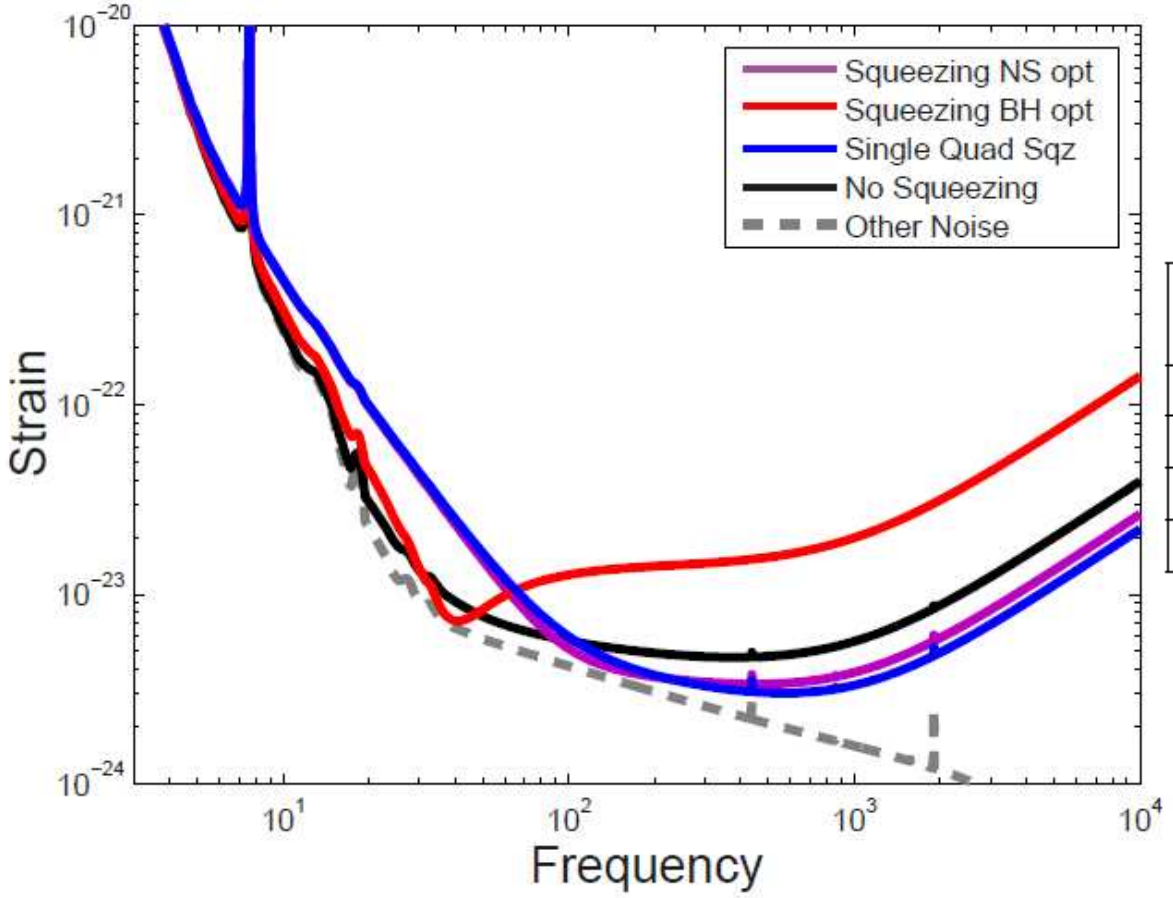
“Squeezing Proposal Document” Parameters



	25W PRM	
	NS	BH
Base (No SQZ)	**111.4**	1029.2
Single quad	88.8	341.8
NS Optimal	92.6	360.0
BH Optimal	91.0	**1129.3**

Extra Slide – AdV Configuration 2

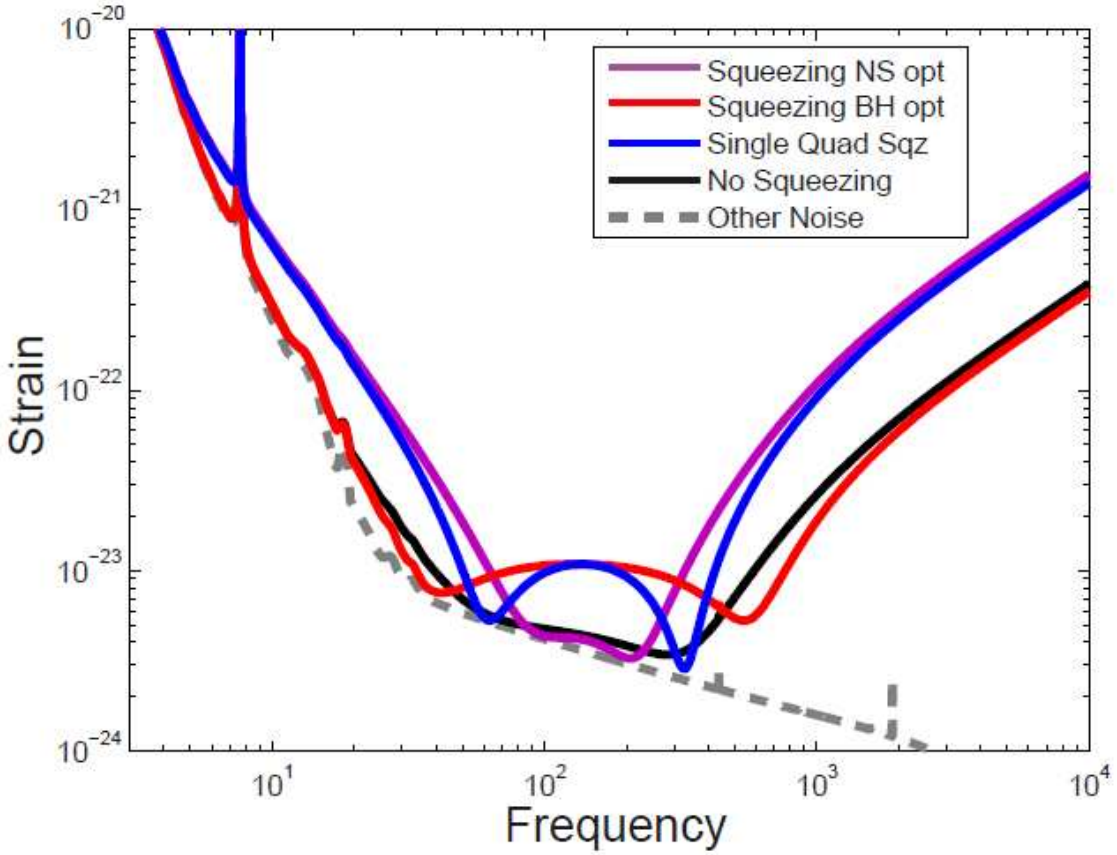
“Squeezing Proposal Document” Parameters



	125W DRM Tuned	
	NS	BH
Base (No SQZ)	**134.3**	**1197.3**
Single quad	117.3	500.4
NS Optimal	122.4	541.3
BH Optimal	99.4	1177.1

Extra Slide – AdV Configuration 3

“Squeezing Proposal Document” Parameters



	125W DRM Detuned	
	NS	BH
Base (No SQZ)	**146.4**	1164.6
Single quad	81.8	493.4
NS Optimal	114.9	443.7
BH Optimal	107.4	**1202.3**