

Main Interferometer Meeting

2011/2/9

Agenda

- SRC Folding, Yes or No ?
- Decide on the Arm cavity g-factor
- Dynamic range
- f1 frequency. Is 11.25MHz really OK ?
- ASC status
- Green lock design
- Mirror specs
- Task assignment

SRC Folding

Reason for PRC Folding

- If straight: PRC g-factor = 0.9996 -> Transverse mode spacing = FSR/158
- PRC Finesse = 57 ---> Up to 3rd order HOMs are well within the cavity resonance.
- Unpredictable spatial mode of RF SBs in the PRC

How about SRC Folding

- Straight SRC is equally unstable to the PRC
- f1 SB resonates in the PRC-SRC coupled cavity
- HOMs not resonating in PRC won't resonate in the coupled cavity
- SRC could be unstable for f1 in principle.
- Yi Pan and others suggested the GW SBs may be lost by the unstable SRC.

Cavity g-factor

Relevant Issues

- Beam spot size --> Mirror Thermal Noise
- Angular radiation pressure (Sidles-Sigg Instability)
- Parametric Instability

Proposed g-factors from Detector Configuration Group

$$g_1 = 0.87, g_2 = 0.6 \rightarrow R_1 = \underline{23\text{km}}, R_2 = 7.7\text{km}$$

or

$$g_1 = -0.87, g_2 = -0.6 \rightarrow R_1 = 1.6\text{km}, R_2 = 1.9\text{km}$$

Possible ?



Old g-factors

$$g_1 = g_2 = 0.586 \rightarrow R_1 = R_2 = 7.2\text{km}$$

or

$$g_1 = g_2 = -0.586 \rightarrow R_1 = R_2 = 1.9\text{km}$$

Sidles-Sigg Stiffness Matrix

Angular Optical Spring Constant k [N*m/rad]

New g-factors

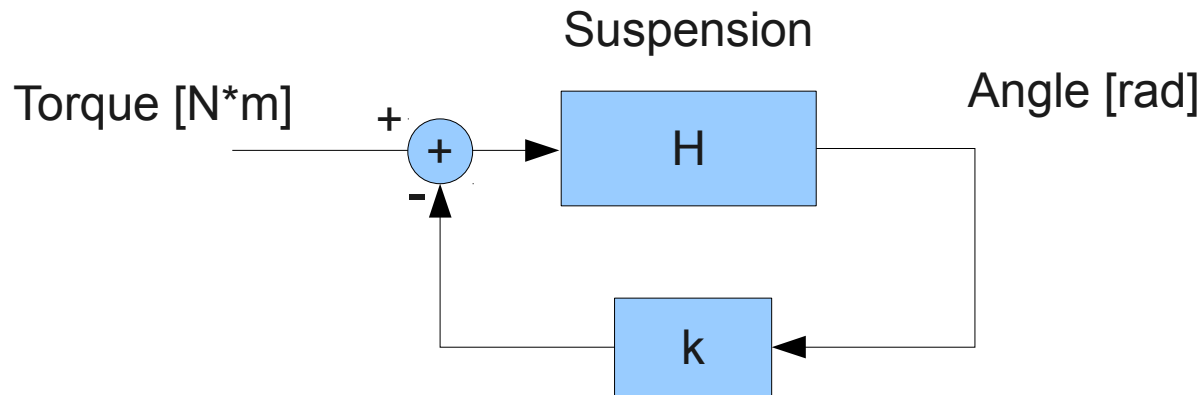
4.59, -29.2 ($g_1 = 0.87$, $g_2 = 0.6$)

-4.59, 29.2 ($g_1 = -0.87$, $g_2 = -0.6$)

Old g-factors

5.0, -19.33 ($g_1 = g_2 = 0.586$)

-5.0, 19.33 ($g_1 = g_2 = -0.586$)



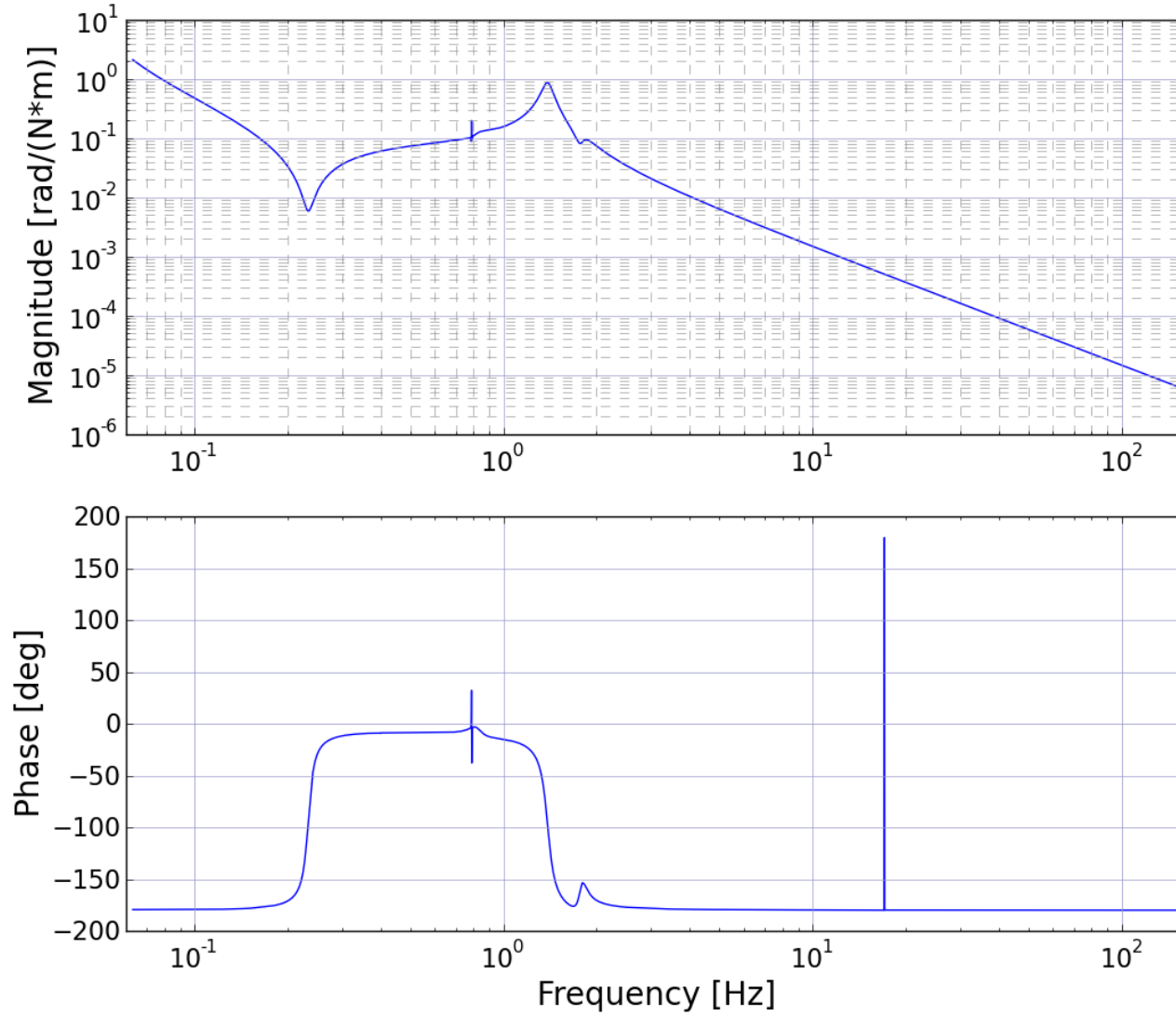
Optical angular spring constant

Open Loop Gain: $G = k \cdot H$

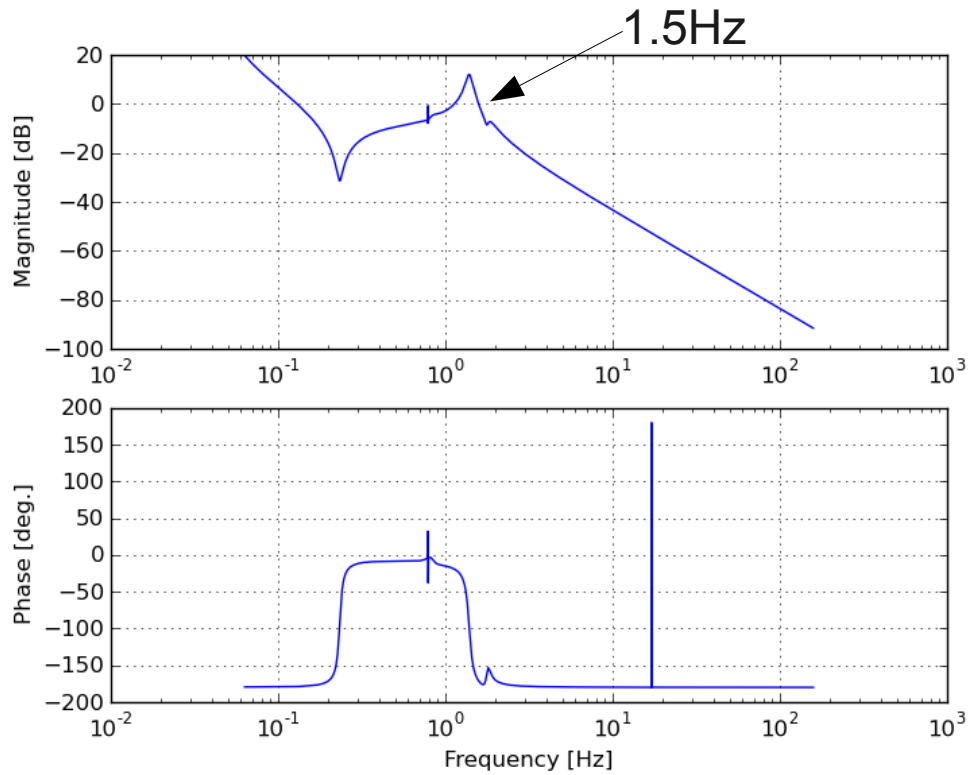
Check Stability

Suspension TF (by Sekiguchi-kun)

Yaw Torque -> Yaw Angle



This is H



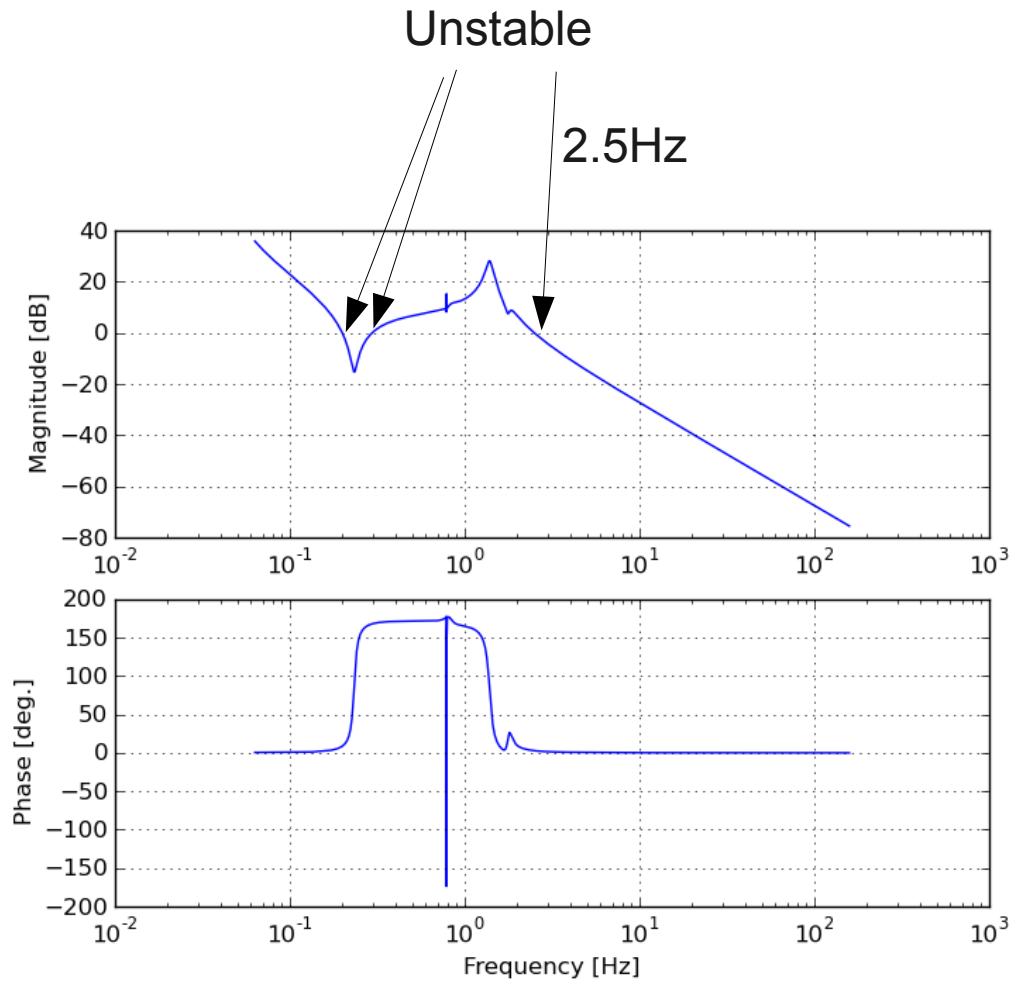
Unstable frequency

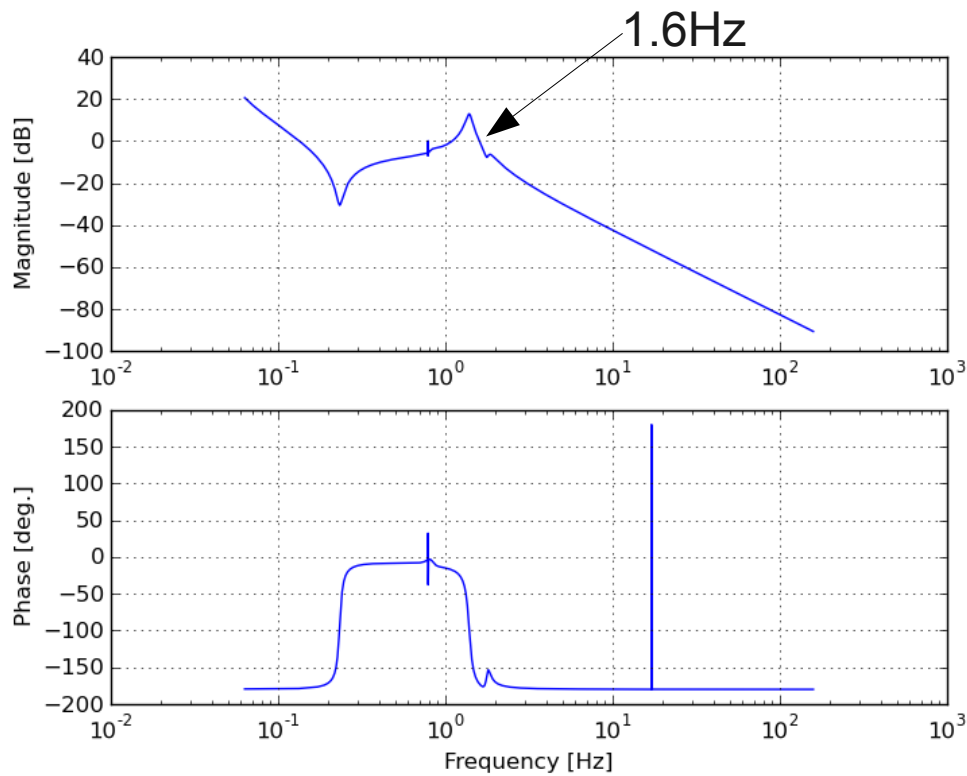
Positive g-factor: 2.5Hz
 Negative g-factor: 1.5Hz

Open Loop TF

New g-factor, positive

← Stable





Unstable frequency

Positive g-factor: 2.2Hz

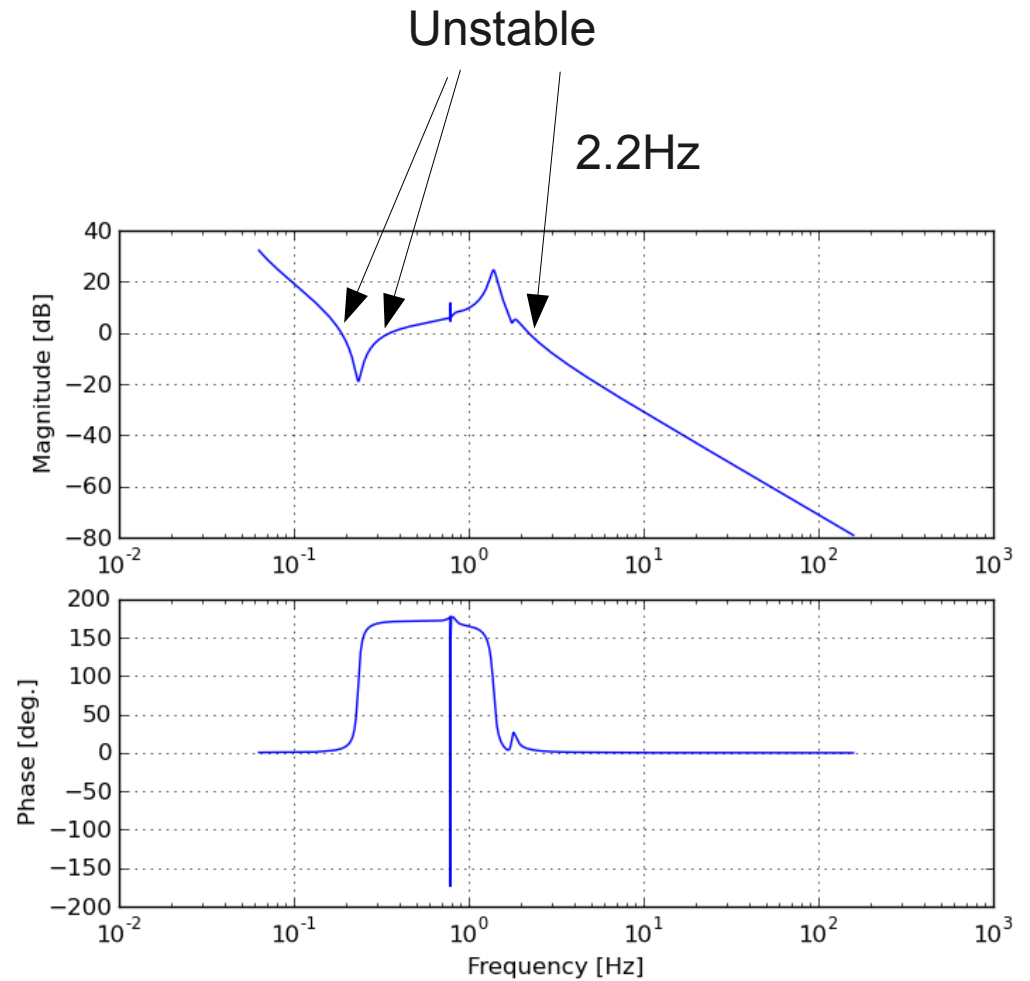
Negative g-factor: 1.6Hz

No big difference in terms of the Sidles-Sigg instability

Open Loop TF

Old g-factor, positive

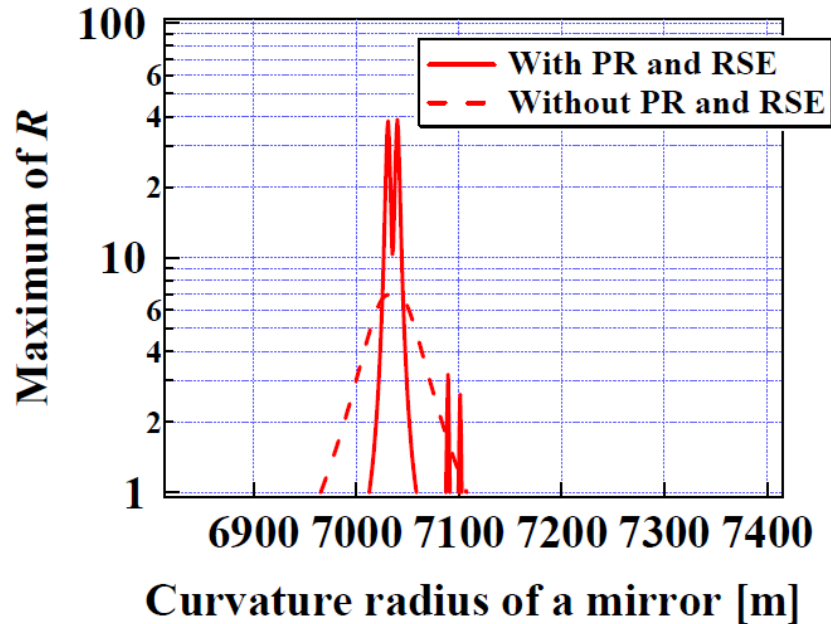
← Stable



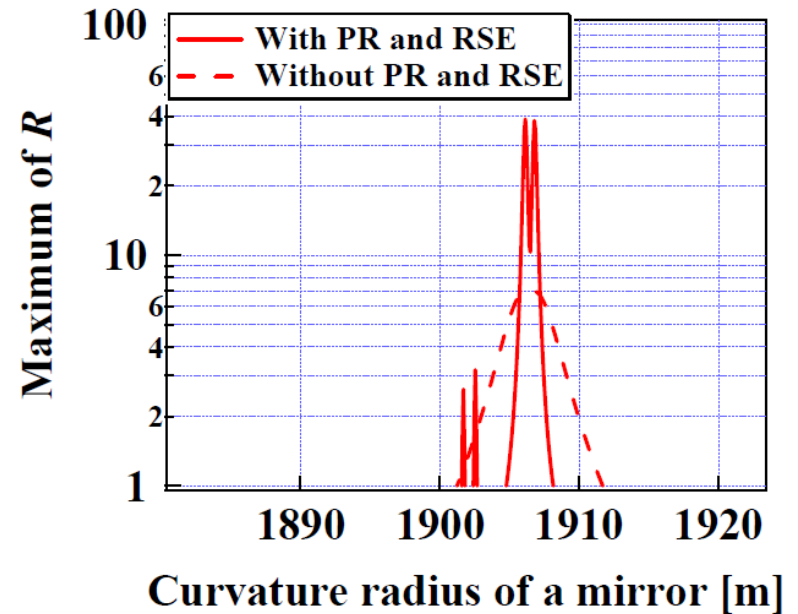
Parametric Instability

There are dangerous regions to avoid in the g-factor space

Positive g-factor



Negative g-factor



The error requirement on the mirror ROC is stricter for the negative g-factor.
by (R_p/R_n)

Negative g-factor: $R \sim 1.9\text{km}$
Positive g-factor: $R > 7\text{km}$



Negative g-factor is about 3.7 times more severe to ROC error in terms of PI

10m ROC error for 1.9km mirror -> 0.5% error
100m ROC error for 7km mirror -> 1.5% error

Conclusion on g-factor

Please vote !

		Thermal Noise (IR) DRSE/BRSE [Mpc]	Optical Spring Unstable Freq.	PI	Other
(a)	$g_1=0.87$ $g_2=0.6$	273/245	1.5Hz	Easy	ROC=23km may not be possible
(b)	$g_1=-0.87$ $g_2=-0.6$	273/245	2.5Hz	Severe	
(c)	$g_1=0.586$ $g_2=0.586$	266/241	2.2Hz	Easy	iLIGO mirrors can be used.
(d)	$g_1=-0.586$ $g_2=-0.586$	266/241	1.6Hz	Severe	

Modulation Frequencies

Concerns about 11.25MHz scheme

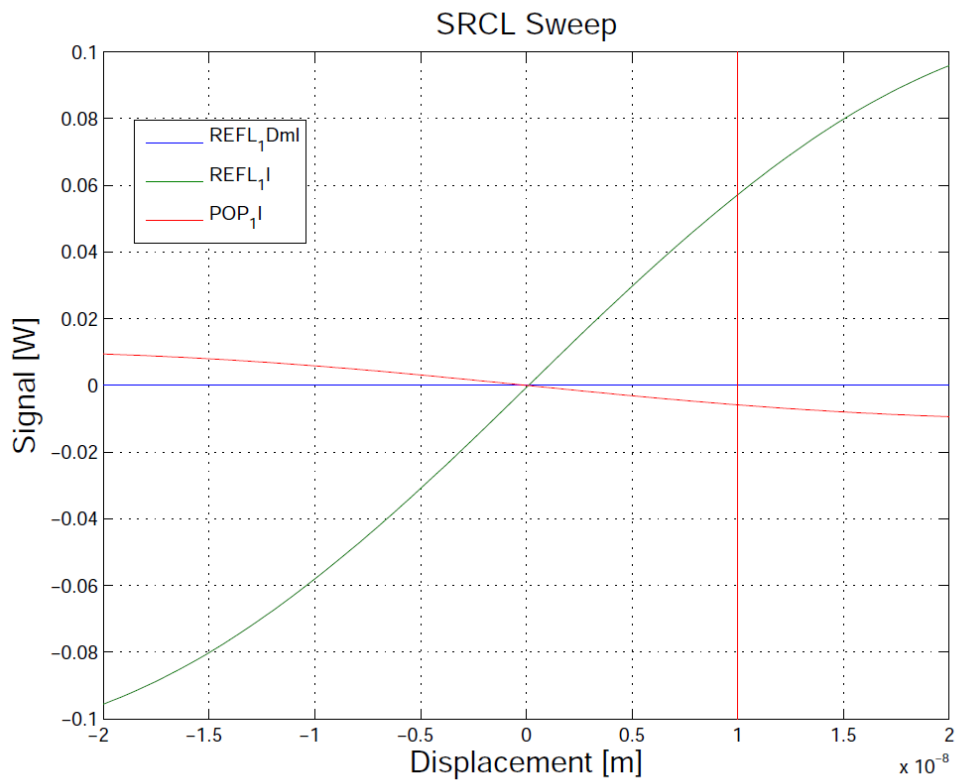
- $f_1:f_2 = 1:4$ prohibits the use of 3rd harmonics demodulation
- $f_3 = 7/2*f_1 \rightarrow f_2 - f_3 \sim 5.6\text{MHz}$ too low ?
- MICH reflectivity for f_1 is about 50%, SRC resonance is not sharp
 \rightarrow MICH signal may be too small.

Test other frequencies

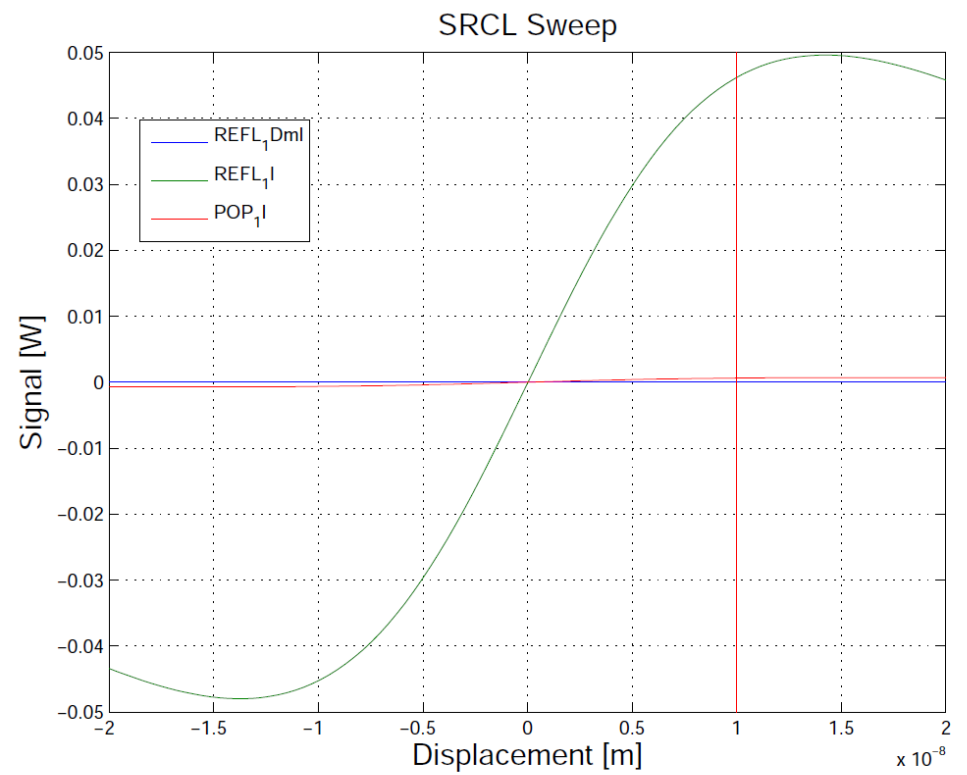
- (a) 11.25MHz - 45MHz: $L_{mc} = 26.6\text{m}$, $L_{prc} = L_{src} = 73.3\text{m}$, $L_{as} = 3.3\text{m}$, $R_{mi}=50\%$
- (b) 9MHz - 45MHz: $L_{mc} = 33.3\text{m}$, $L_{prc}=L_{src}=74.9\text{m}$, $L_{as} = 6.6\text{m}$, $R_{mi}=10\%$
- (c) 12.857MHz - 45MHz: $L_{mc}=23.3\text{m}$, $L_{prc}=L_{src}=81.6\text{m}$, $L_{as}=6.6\text{m}$, $R_{mi}=5\%$
- (d) 13.5MHz - 45MHz: $L_{mc} = 33.3\text{m}$, $L_{prc}=L_{src}=83.3\text{m}$, $L_{as}=3.3\text{m}$, $R_{mi} = 34\%$

SRC Detuning

(a) 11.25MHz-45MHz

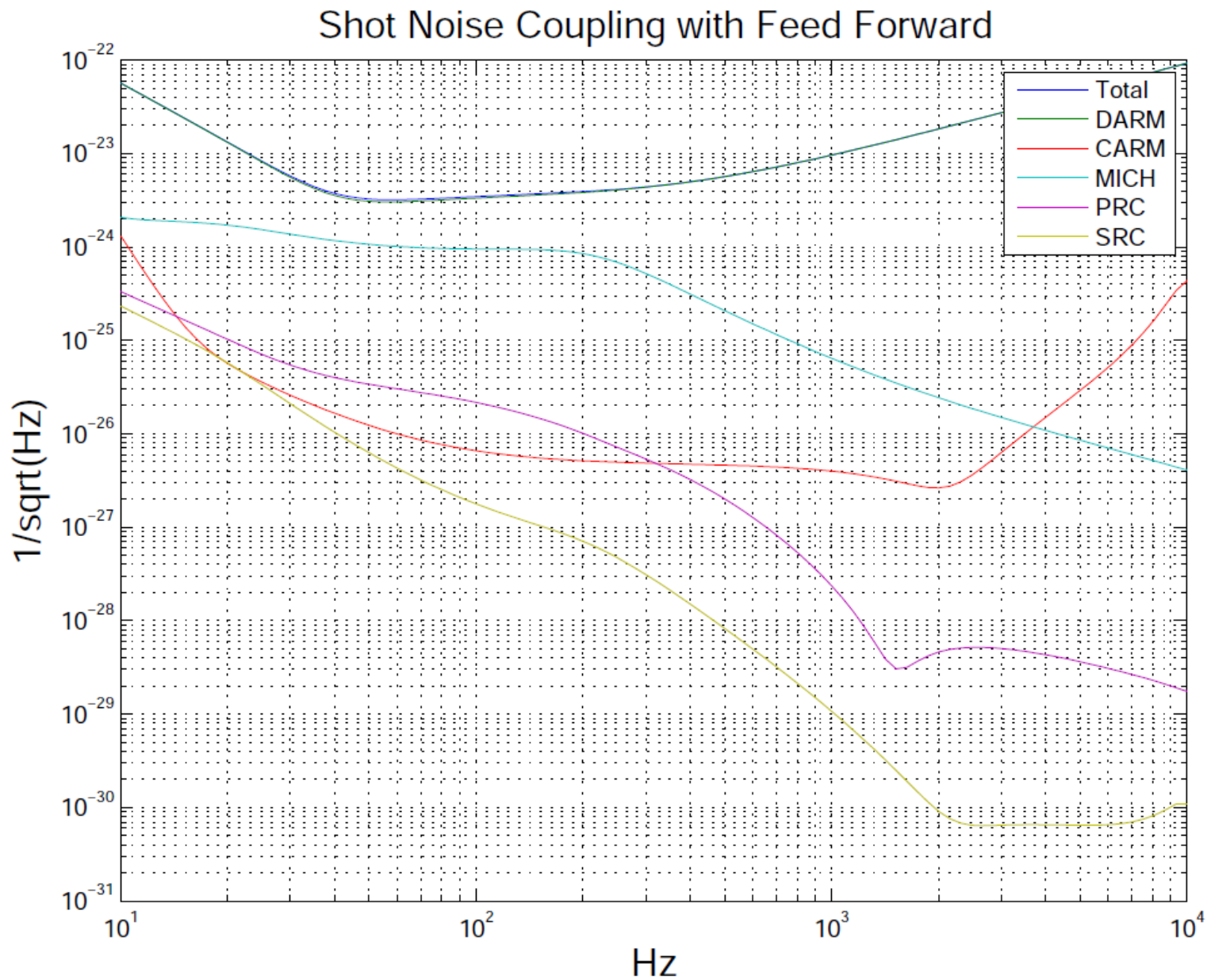


(b) 9MHz-45MHz



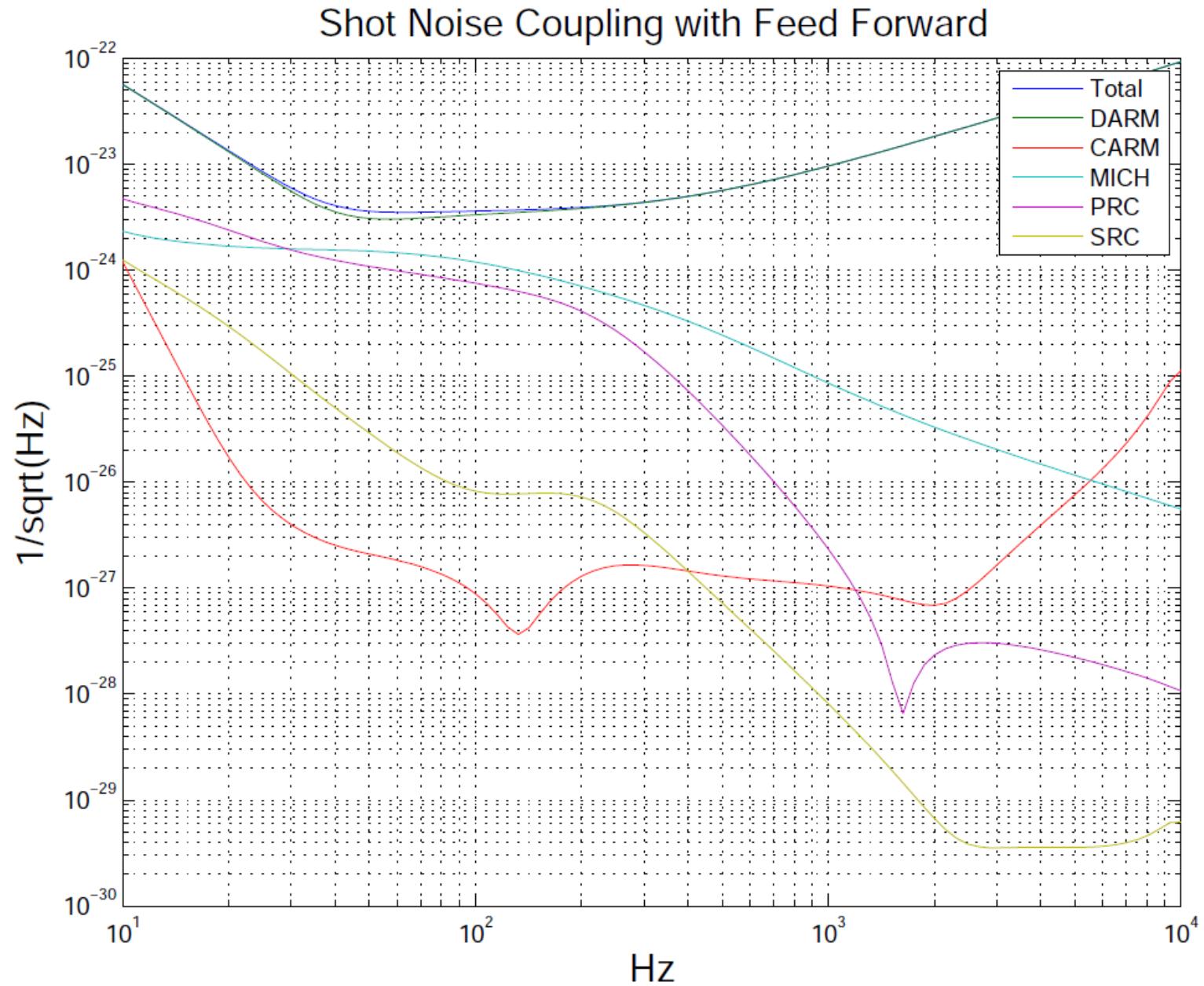
Loop Noise: BRSE 11.25MHz DDM with NRS

Feed forward gain = 100, MICH UGF=50Hz



Loop Noise: BRSE 11.25MHz SDM

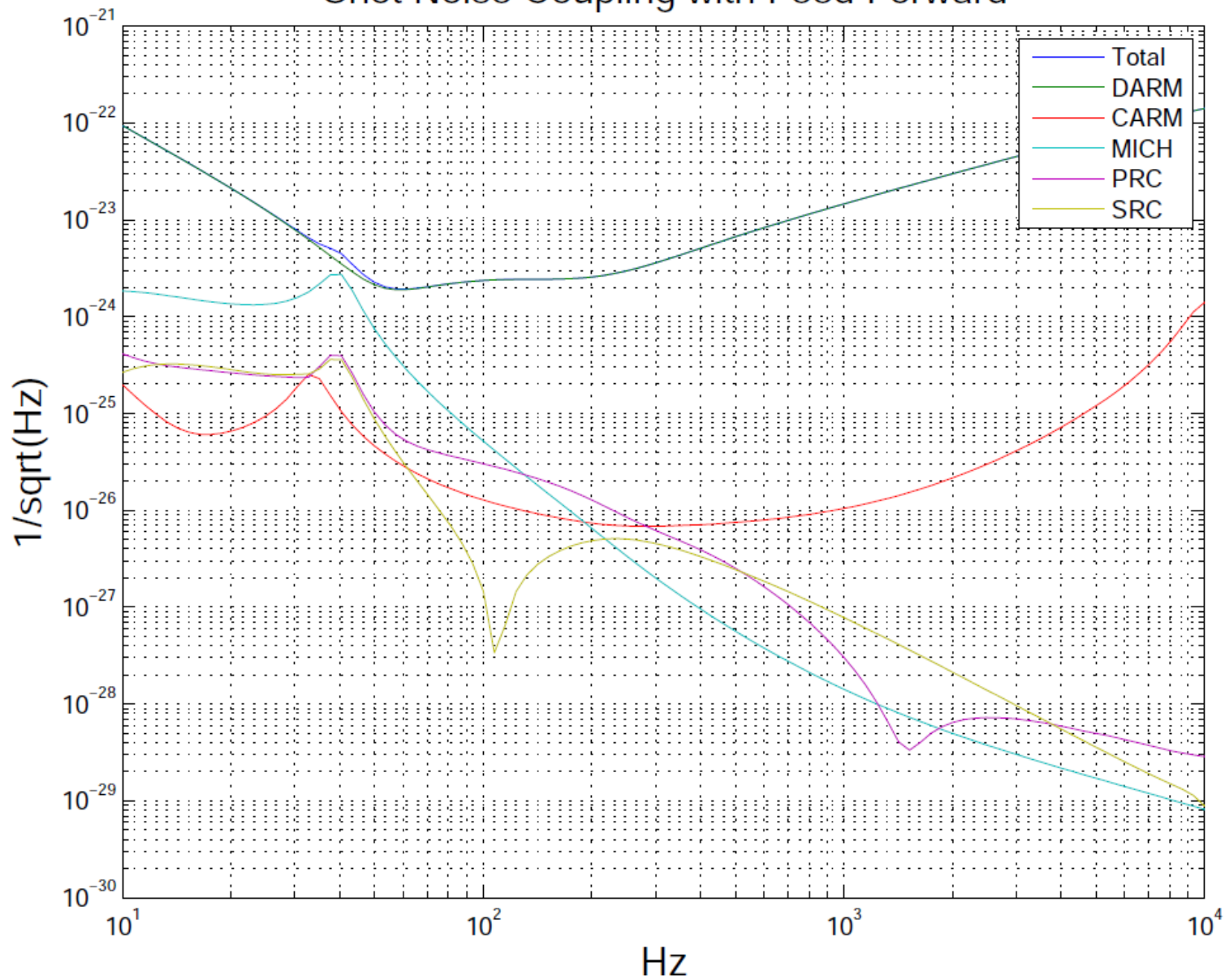
Feed forward gain = 100, MICH UGF=50Hz



Loop Noise: DRSE 11.25MHz DDM with NRS

Feed forward gain = 100, MICH UGF=10Hz

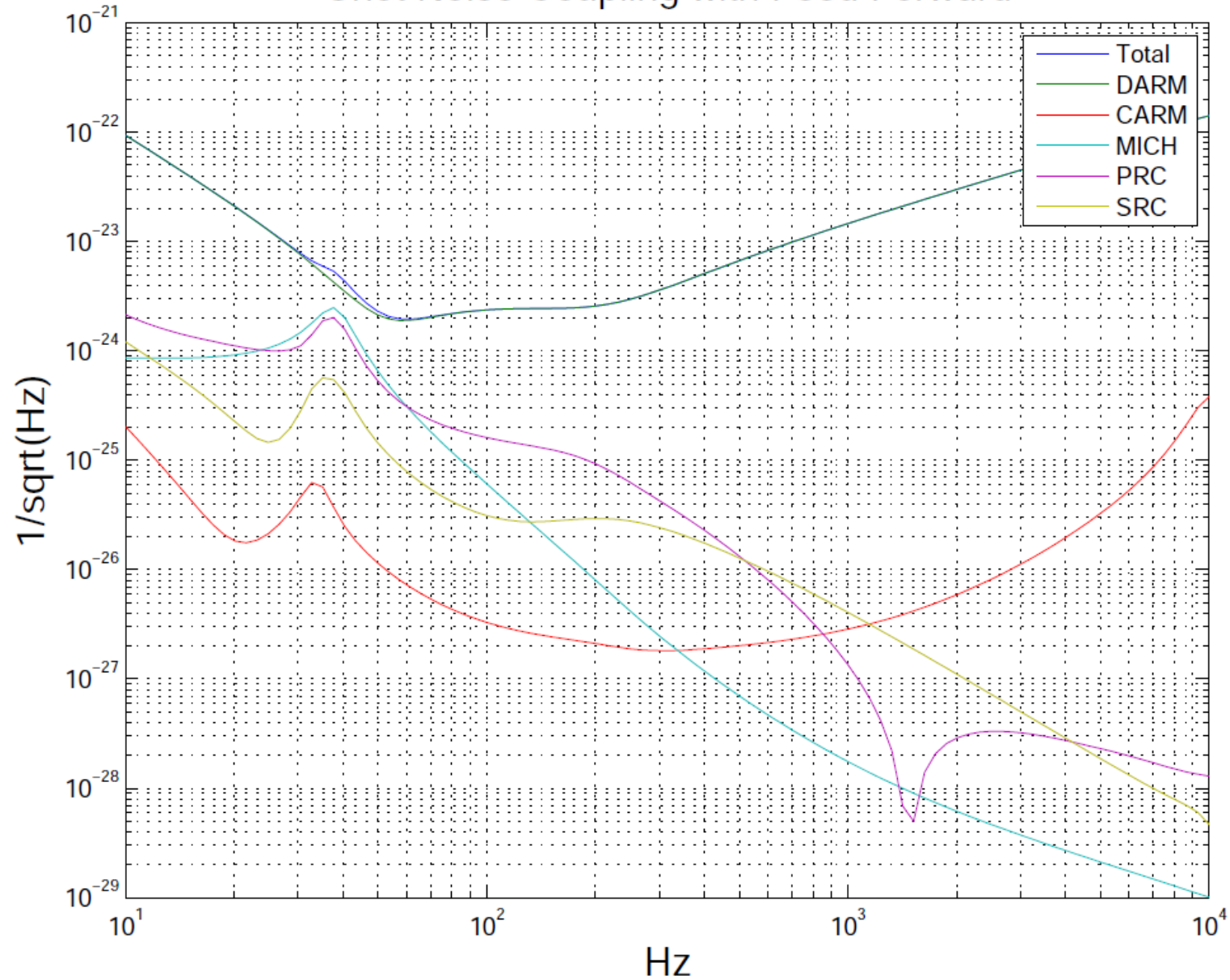
Shot Noise Coupling with Feed Forward



Loop Noise: DRSE 11.25MHz SDM

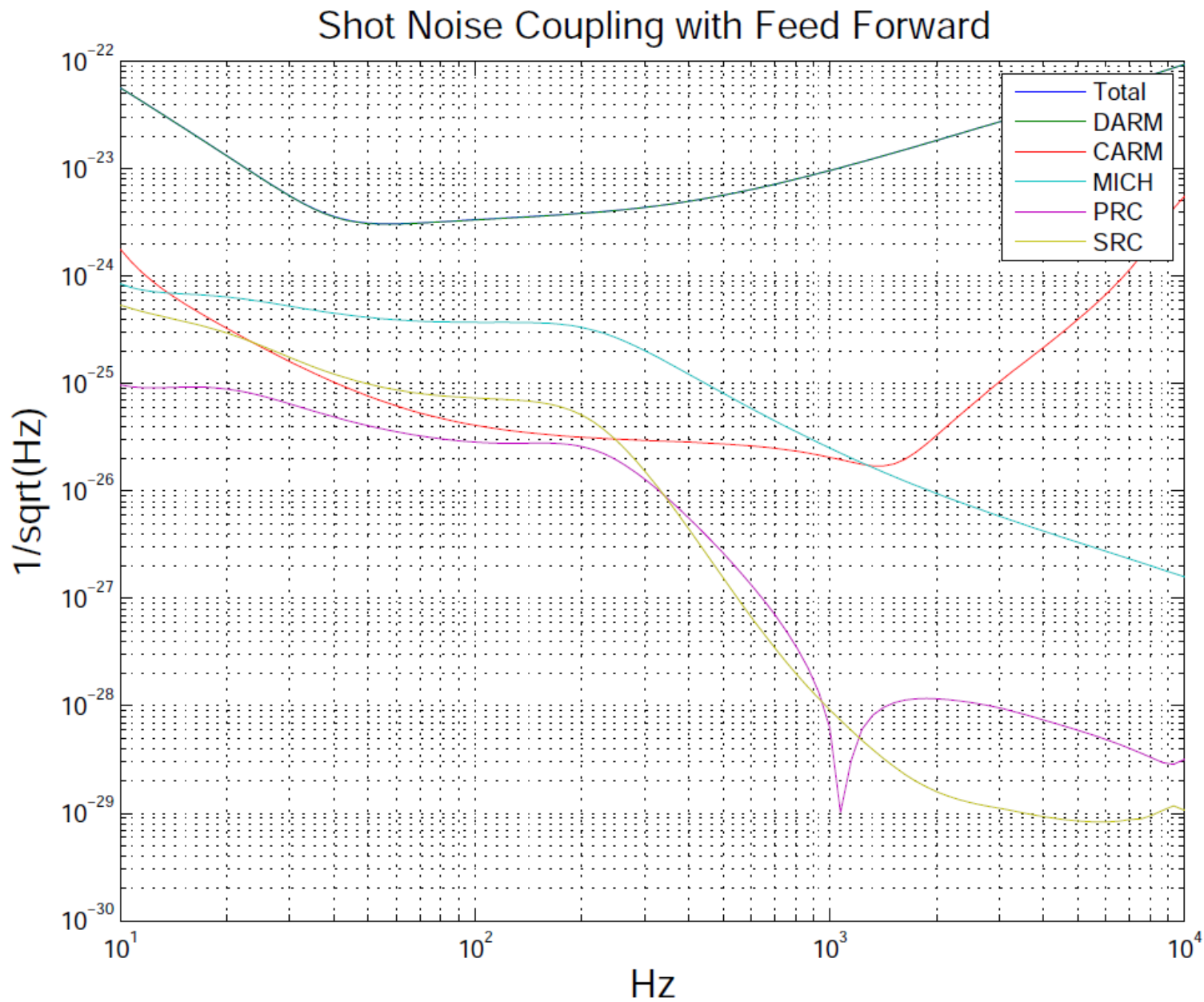
Feed forward gain = 100, MICH UGF=10Hz

Shot Noise Coupling with Feed Forward



Loop Noise: BRSE 9MHz DDM with NRS

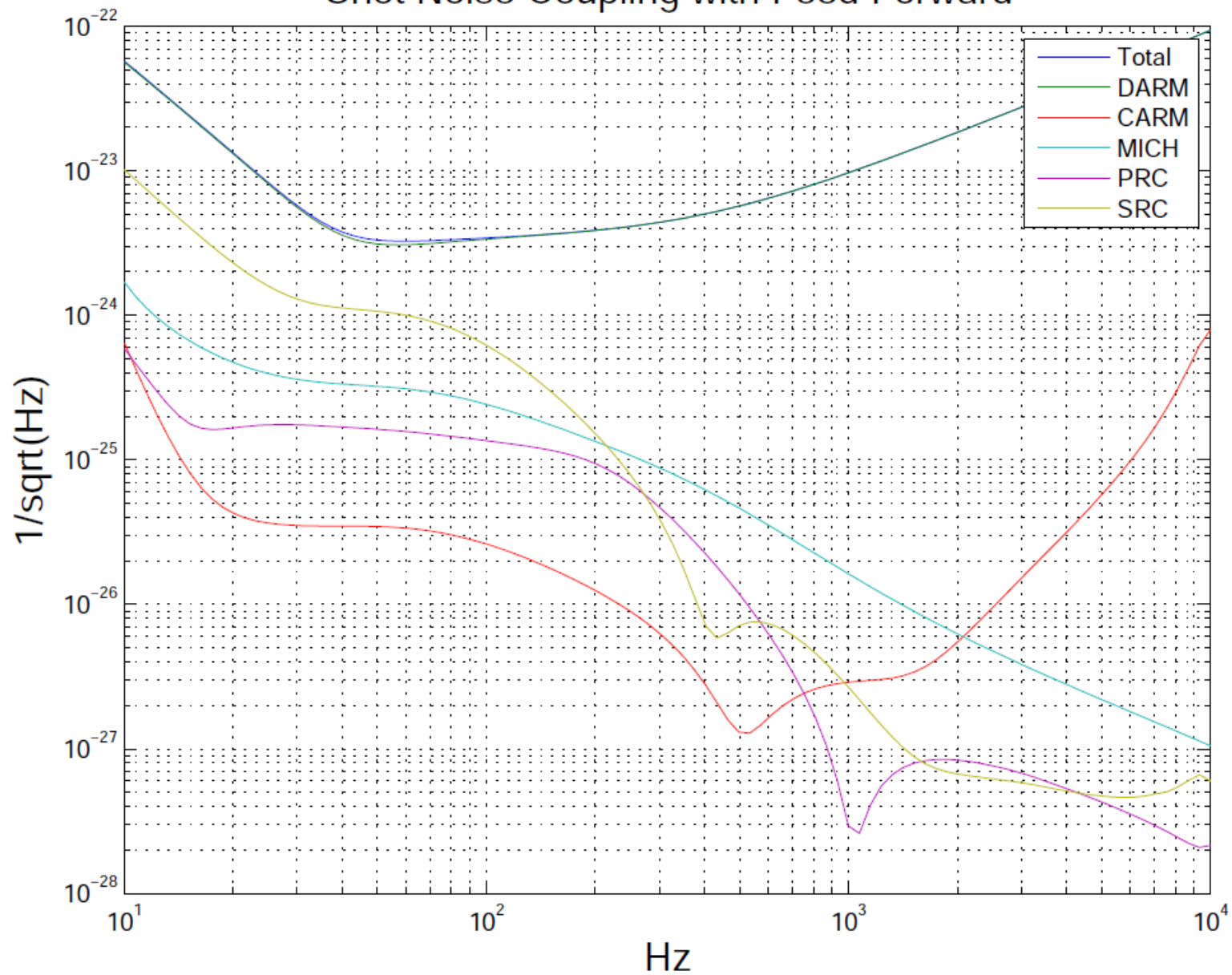
Feed forward gain = 100, MICH UGF=50Hz



Loop Noise: BRSE 9MHz SDM

Feed forward gain = 100, MICH UGF=50Hz

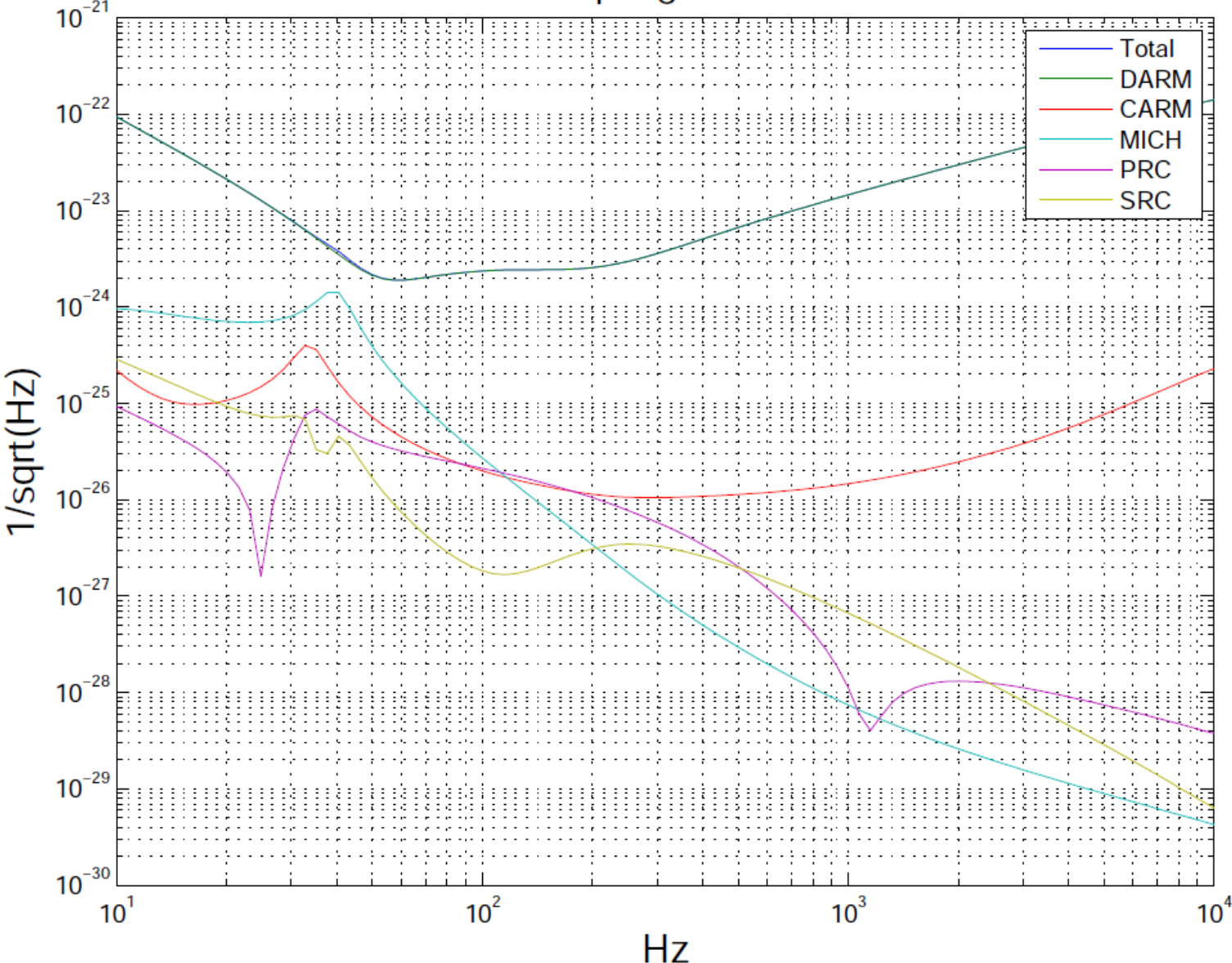
Shot Noise Coupling with Feed Forward



Loop Noise: DRSE 9MHz DDM with NRS

Feed forward gain = 100, MICH UGF=10Hz

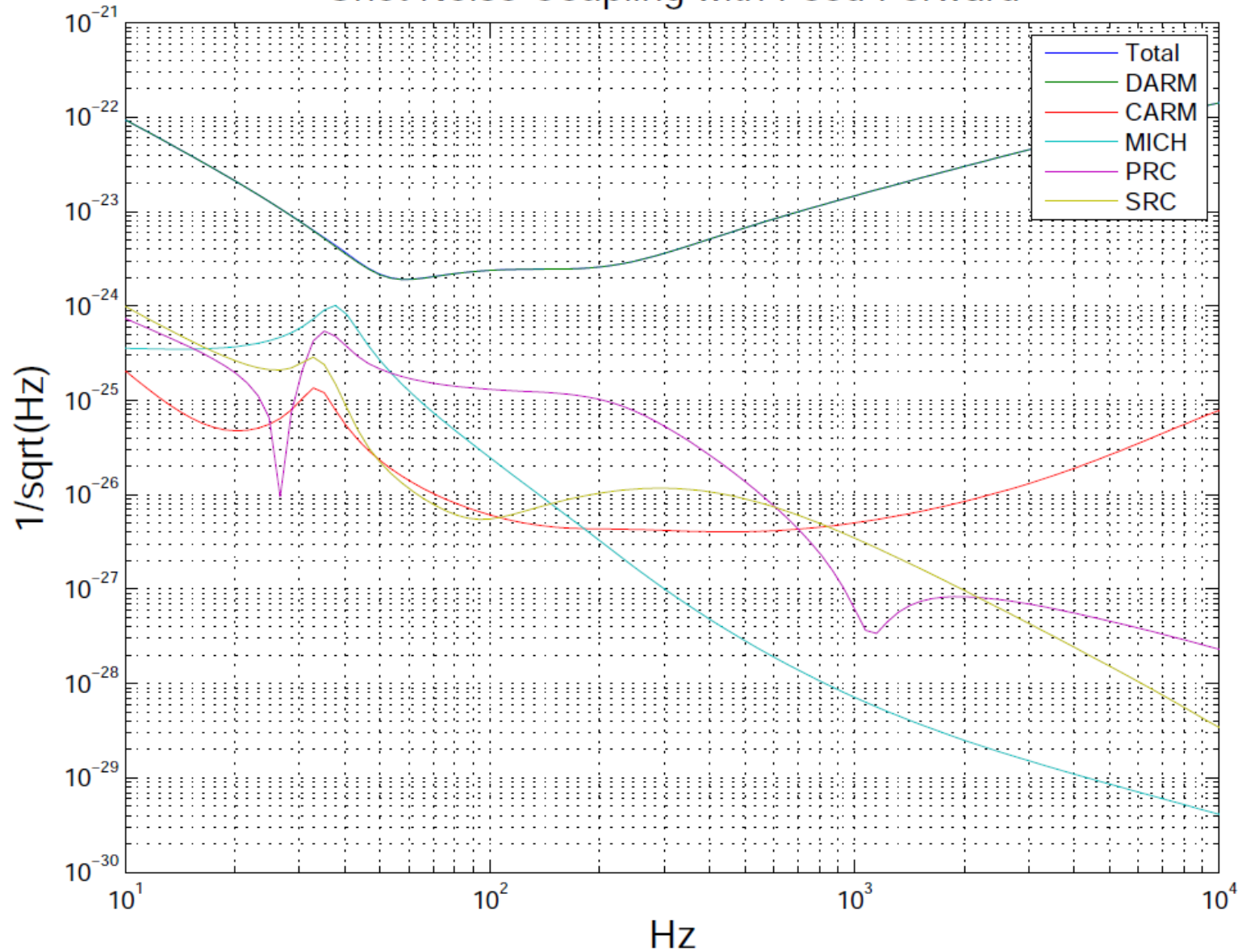
Shot Noise Coupling with Feed Forward



Loop Noise: DRSE 9MHz SDM

Feed forward gain = 100, MICH UGF=10Hz

Shot Noise Coupling with Feed Forward



Change the modulation frequencies ?

- 9MHz seems better than 11.25MHz
- $f_3 = 7/2 * 9\text{MHz} = 31.5\text{MHz}$, $f_3 - f_1 = 22.5\text{MHz}$, $f_2 - f_3 = 13.5\text{MHz}$
- Lmc and Las are a bit longer
- (d) is not much different from (a)
- (c) is not as good as (b) (have to check why)

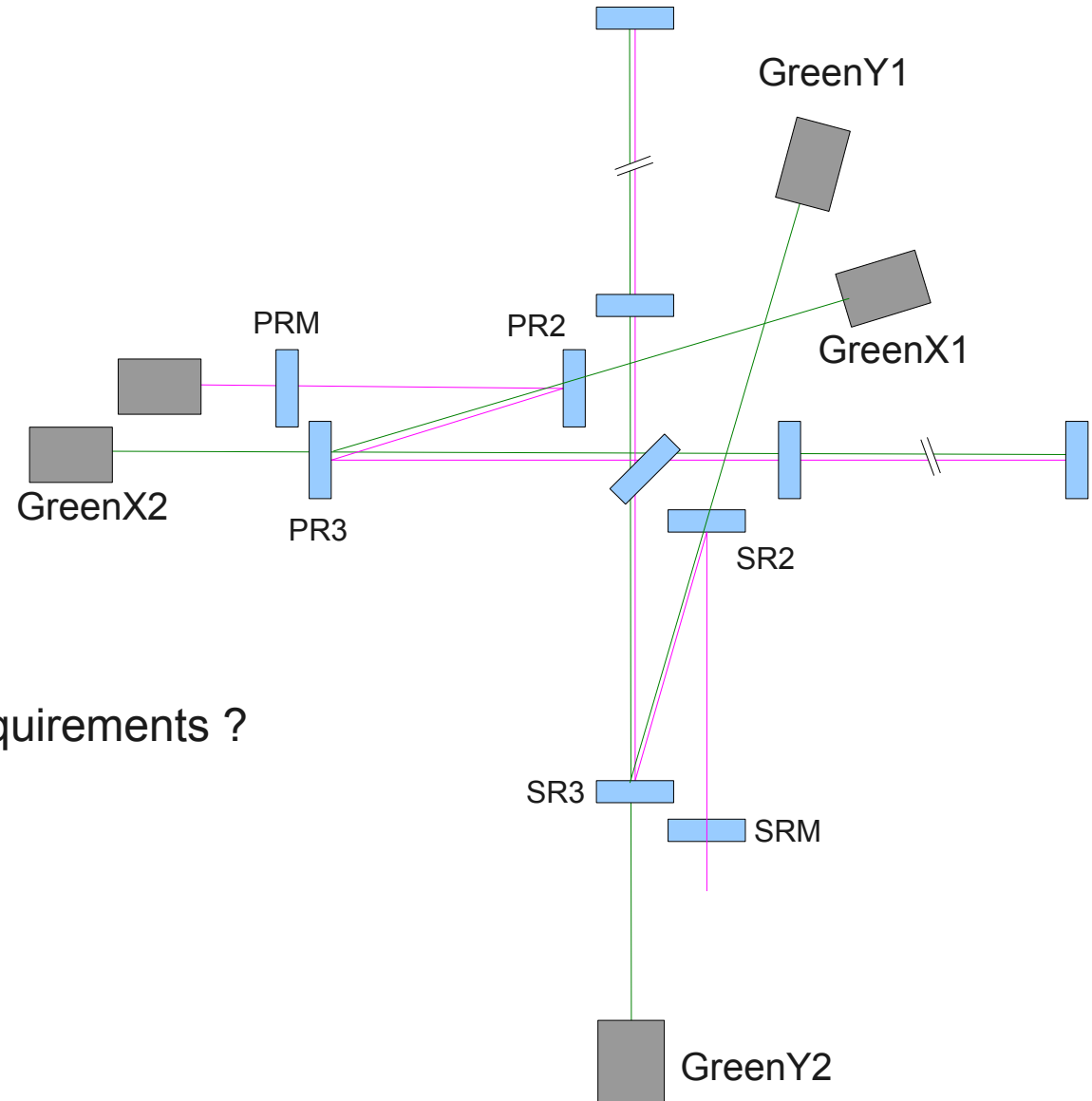
We have to decide Now !

Green Lock Scheme

We need to have mirror specs for 532nm soon.

Where to inject green ?
PR2 or PR3

PR2: Beam size is smaller
PR3: No 532nm coating for PR2



- End injection ?
- How tolerant are the green coating requirements ?
- How much is the power necessary ?

Mirror Specs

We have to provide more detailed mirror specs to Mio-san as soon as possible.

TM Specs (Draft)

HR@1064nm=99.6%+/-0.01%(ITM), >99.9945% (ETM)
HR@1064nm imbalance between X and Y: ???

HR@532nm = 80%+/-10% (R_ITM < R_ETM)
HR loss@1064nm < 45ppm (loss imbalance: ???)
HR loss@532nm < 1%

AR@1064nm=200ppm+100/-0ppm
AR@532nm<5%

ROC = 7177m +50/-20m
Wedge angle = 0.25deg (+/-0.01deg?)

POX, POY
~ 100mW

BS Specs (Draft)

HR@1064nm=50%+/-0.1%

HR@532nm = 10%

HR loss@1064nm: 0.01%? Set from thermal lens

HR loss@532nm < 10%

AR@1064nm < 50ppm

AR@532nm < 10%

ROC = flat (how flat ?)

Wedge angle = 0.48deg (+/-0.01deg?)

PRM Specs (Draft)

HR@1064nm=90%+0/-0.1%

HR loss@1064nm: < 100ppm

AR@1064nm < 50ppm

ROC = 316m +/-1m

Wedge angle = 2deg (LIGO mirror)

SRM Specs (Draft)

HR@1064nm=84.64%+/-0.01%??

HR loss@1064nm: < 100ppm

AR@1064nm < 50ppm

ROC = 316m +/-1m

Wedge angle = 2deg (LIGO mirror)

PR2/SR2 Specs (Draft)

HR@1064nm = 99.95%+/-0.01%

HR@532nm < 10%

HR loss@1064nm: < 100ppm

HR loss@532nm: < 1%

AR@1064nm < 500ppm

AR@532nm < 10%

ROC = -3.964m +/-1cm

Wedge angle = 2deg (LIGO mirror)

PR3/SR3 Specs (Draft)

HR@1064nm > 99.95%

HR@532nm > 80%

HR loss@1064nm: < 100ppm

HR loss@532nm: < 1%

AR@1064nm < 1000ppm

AR@532nm < 10%

ROC = 32.1m +/-10cm

Wedge angle = 2deg (LIGO mirror)

Task Assignment

LSC: Aso + ...

ASC: Michimura, Agatsuma

ISC Check: Somiya, Miyakawa + ...

Optical Layout: Aso --> Manual check by some student

Mirror Specs: Aso ->

Green Lock: Akutsu, Izumi