

PRFPMI or RSE for Joining O3

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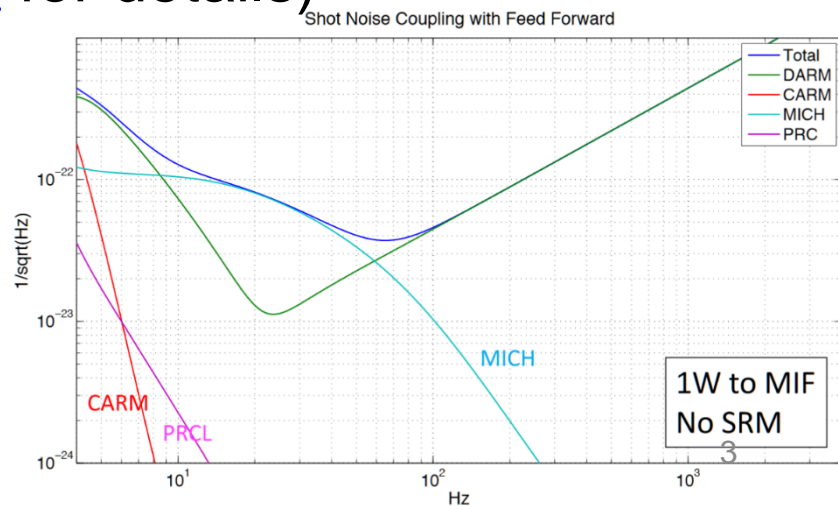
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Summary on PRFPMI or RSE

	PRFPMI	RSE
Locking scheme	green locking + f3 (or develop new scheme from scratch)	green locking + f3
f1 sideband	x10 less signal	default
# of degrees of freedom	LSC: 4, ASC: 10	LSC: 5, ASC: 11 → more DoF
Tolerable excess noise to achieve Adv O2 sensitivity	~ x4 O1 level (with 10 W input) → requires more noise hunting	~ x8 O1 level (with 10 W input)
SRM Installation	Blank SRM (or move OMMT by ~ few cm)	70 % SRM

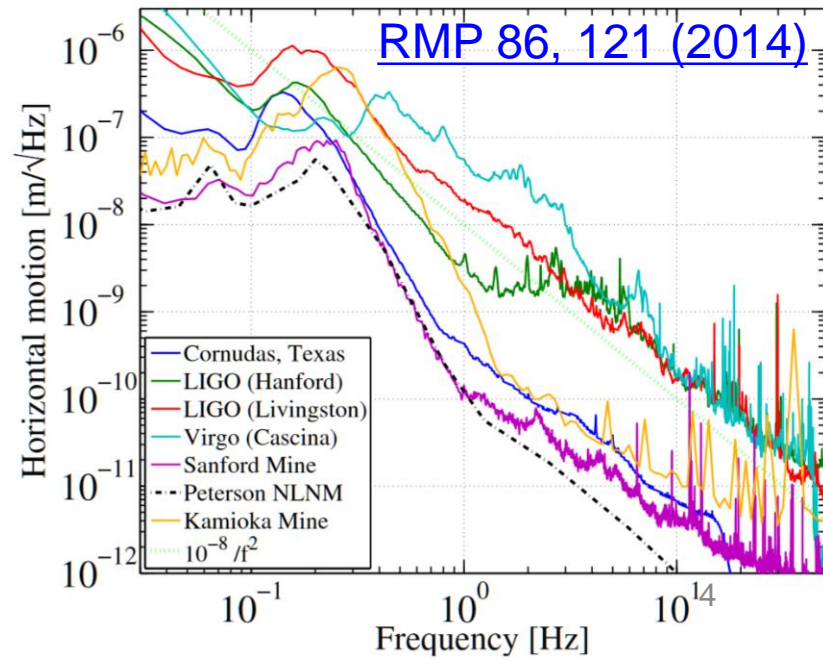
Interferometer Sensing and Control

- Green locking and f3 AM generation is **necessary for both PRFPMI** and **RSE**. With ALS, difficulty of locking DRMI and PRMI is almost the same (Arai, Izumi).
- For **PRFPMI**, other scheme could be possible if we develop new scheme **from scratch**, with **x10 less f1 sideband**. New scheme for **PRFPMI** will likely to be inapplicable to **RSE**.
- In **PRFPMI** case, resonant condition for f1 will change, which result in **~ x3 worse shot noise in MICH**, and couples to DARM (see [JGW-G1707479](#) for details)
- We also need to design **ASC** for **PRFPMI** from scratch
- **RSE** has 1 more degrees of freedom for LSC and ASC



New Locking Scheme for PRFPMI?

- Advanced Virgo could lock **PRFPMI** because they had long experience on their variable finesse scheme
 - detailed time-domain simulation (e2e)
 - guided lock
 - experienced people from Initial Virgo
- KAGRA has **higher arm cavity finesse** (1530) than Advanced LIGO (450) and Advanced Virgo (460), or any other 1st gen. detectors
 - New scheme necessary
- Unlike iLIGO etc, KAGRA is not designed for **PRFPMI**
- Micro-seismic noise for KAGRA is not low
 - Locking KAGRA **PRFPMI** without green **will be tough**



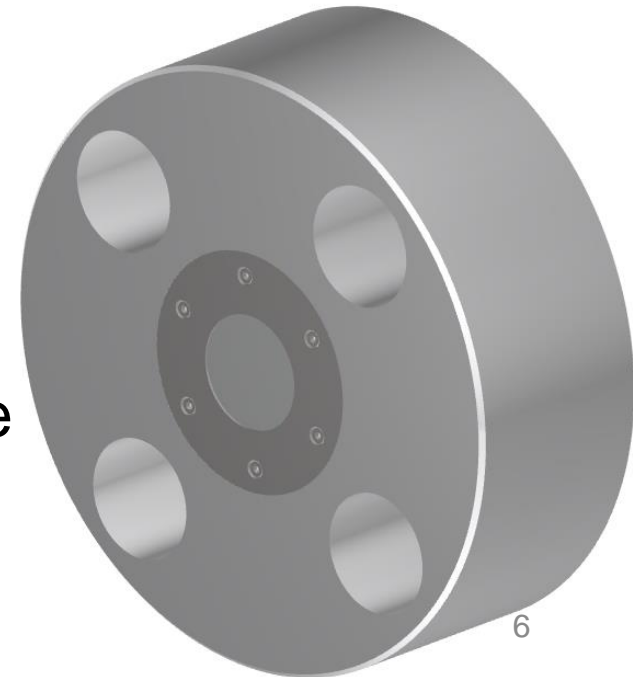
Sensitivity

- Inspiral range of **PRFPMI** relies on low frequencies
- **PRFPMI** requires **more noise hunting** than **RSE** to achieve same inspiral range
- see [JGW-T1707334](#) for details
 - * Assumed 10 W input for inspiral range calculation.
 - Includes shot noise coupling **with feedforward**.

Excess noise	PRFPMI	RSE
No excess	BNS: 58 Mpc BBH: 0.82 Gpc	BNS: 93 Mpc BBH: 1.4 Gpc
x1 O1 level (~ KAGRA suspension thermal noise)	BNS: 48 Mpc BBH: 0.66 Gpc	BNS: 71 Mpc BBH: 1.1 Gpc
x4 O1 level (AdV O2 level)	BNS: 27 Mpc BBH: 0.37 Gpc	BNS: 42 Mpc BBH: 0.62 Gpc
x8 O1 level	BNS: 19 Mpc BBH: 0.26 Gpc	BNS: 30 Mpc BBH: 0.45 Gpc

Schedule

- Both **PRFPMI** and **RSE** requires SRM and OMC installation
 - Blank SRM for **PRFPMI** for mode-matching to OMC
(w/o SRM is possible by moving OMMT by ~ few cm)
- Both **PRFPMI** and **RSE** requires green locking and f3 AM
 - If we give up green locking, **PRFPMI** requires development of new locking scheme (high finesse, x10 less f1)
- **PRFPMI** will also require full SR2 and SR3
 - scattering, mode-matching to OMC, continuous beam steering to OMMTs ...
- We already ordered blank SRM and 70% SRM. Switching to blank one can be done **at later stages** if we had some trouble in locking DRMI (~Dec 2018) or RSE (~ March 2019)



Check Before Changing Our Mind

- Omit green locking?
 - Simulations, calculations, new electronics for new locking scheme
- Omit OMC?
 - How much is the sensitivity degradation if there's no OMC?
- Omit full Type-B SR2 and SR3?
 - Installation and preparation of electronics really unfeasible for O3?
 - Scattered light
- Omit SRM?
 - SRM really unfeasible for O3?
 - Doughnut metal mass status? Black coating?
 - Mode-matching to OMC (-> OK by moving OMMTs)
- Do PRFPMI?
 - Really feasible with high arm cavity finesse and x10 less f1?
- How much is the required sensitivity?
 - People say different things. 10 Mpc gives only 10 % improved sky localization ([Haino MCMC](#)). But maybe any contribution is OK

Our Suggestion: RSE for O3

- PRFPMI is harder than RSE, because it requires more noise hunting at low frequencies and f1 sideband is x10 less without SRC. KAGRA is not designed for PRFPMI, and it seems almost impossible even to feasibly lock PRFPMI.
- With green locking, difficulty of locking PRFPMI and RSE is almost the same.
- PRFPMI can be done without green only if we successfully develop new locking scheme from scratch, which will likely to be inapplicable to RSE. Concentrating our resources to green (not new scheme) seems to be a better idea.
- RSE requires SRM and one more degrees of freedom to lock. PRFPMI requires new locking scheme and more noise hunting. Latter is more unpredictable in terms of scheduling. Making a solid schedule is important for joining O3. PRFPMI relies more on fragile assumptions.