

# KAGRA O4 upgrades



# KAGRA



An underground cryogenic laser-interferometer with 3km arms

Located in Kamioka, Gifu prefecture, Japan

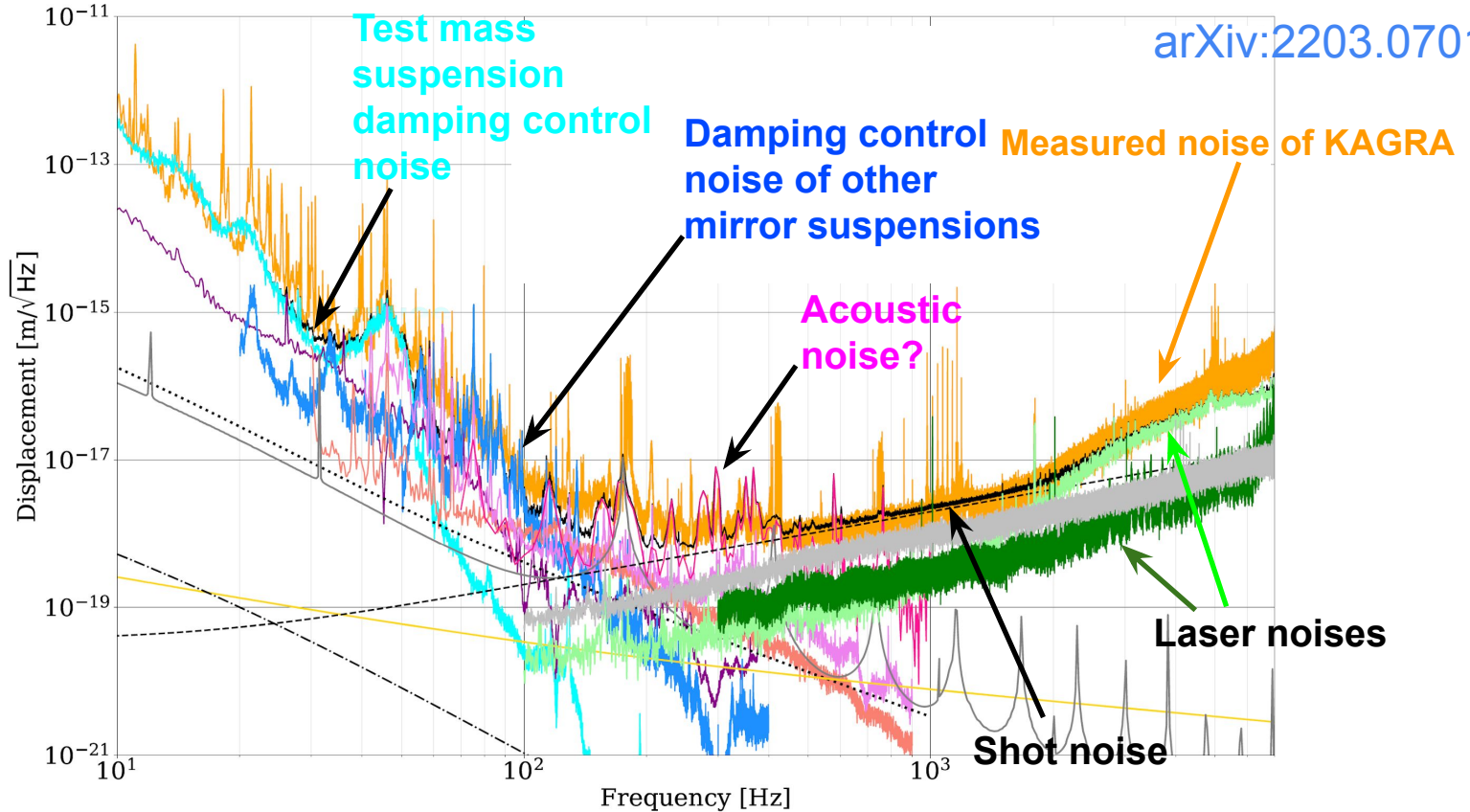


- Project started in 2010
- Initial joint observation in 2020 with GEO600 (O3GK) for 2 weeks
- Best binary range (NS-NS) was about 1Mpc in O3GK

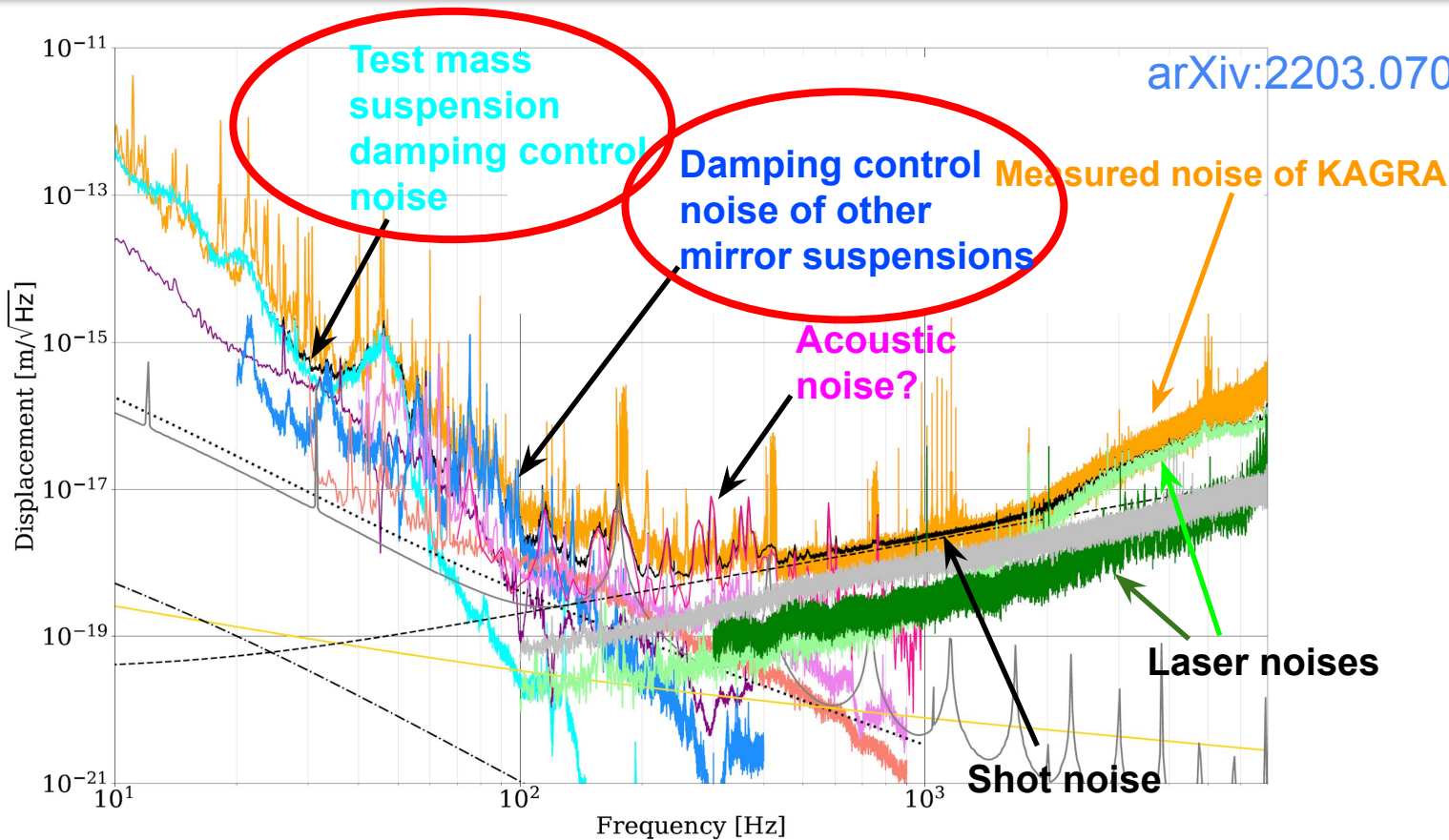
# O3GK Noise Budget



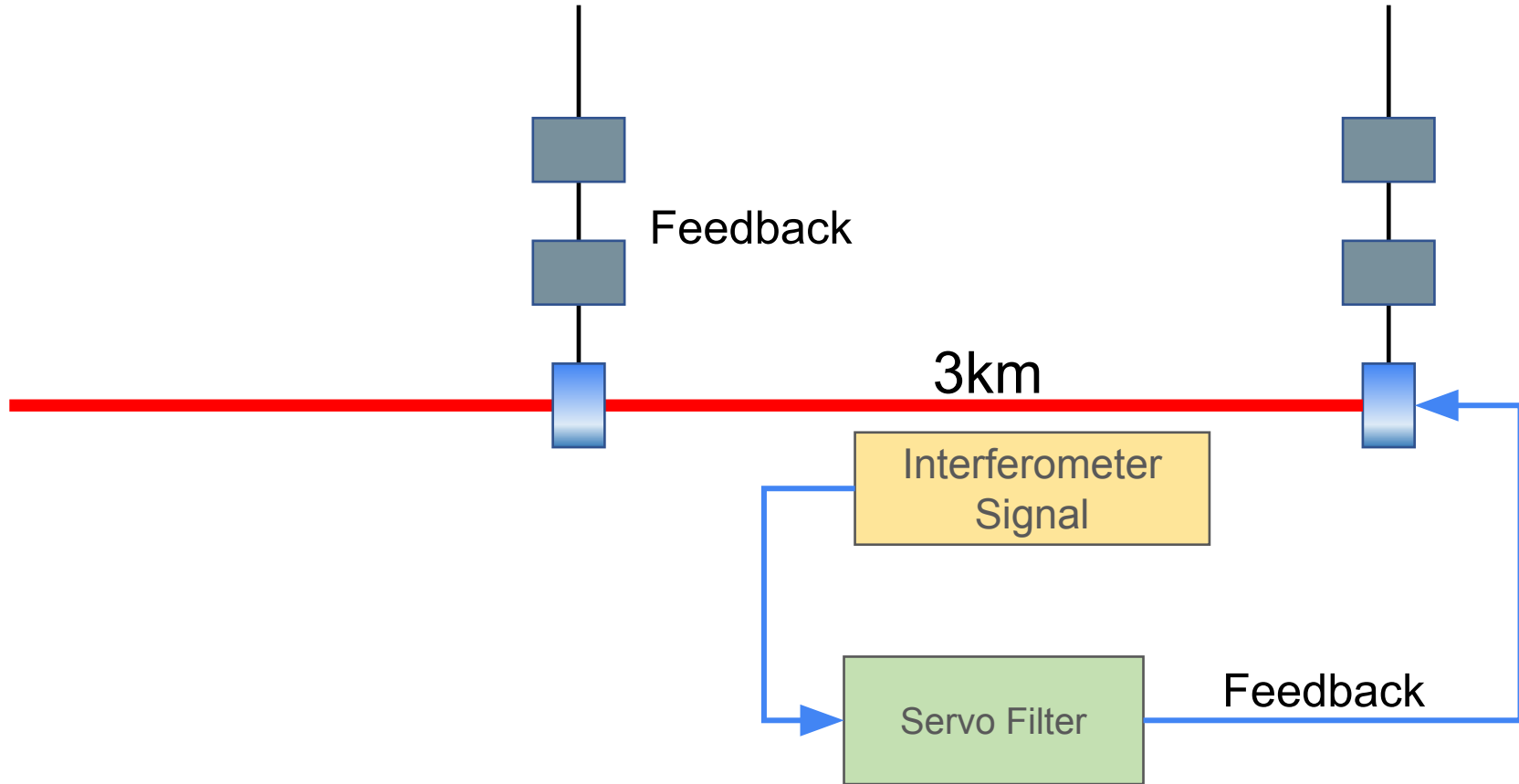
arXiv:2203.07011



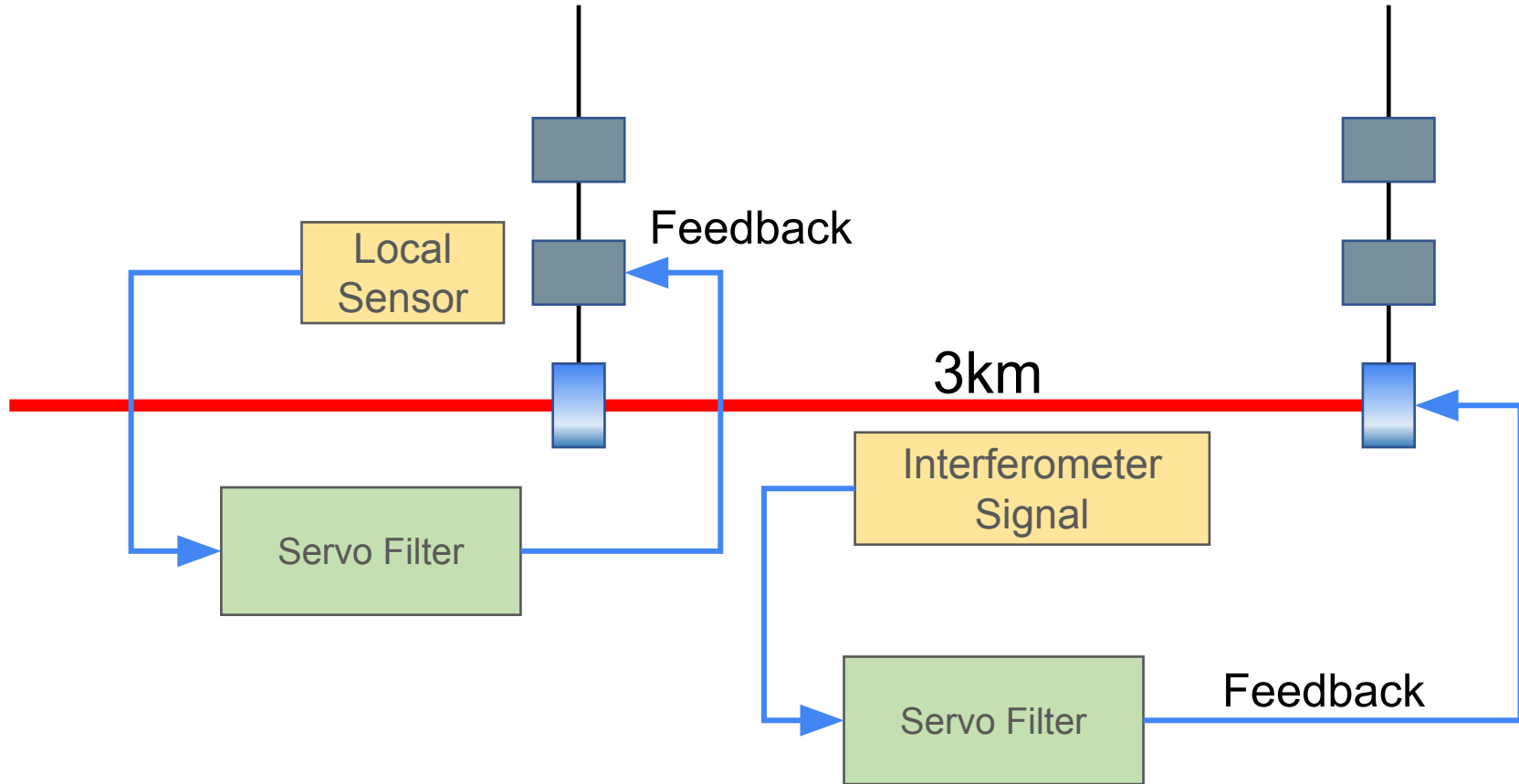
# O3GK Noise Budget



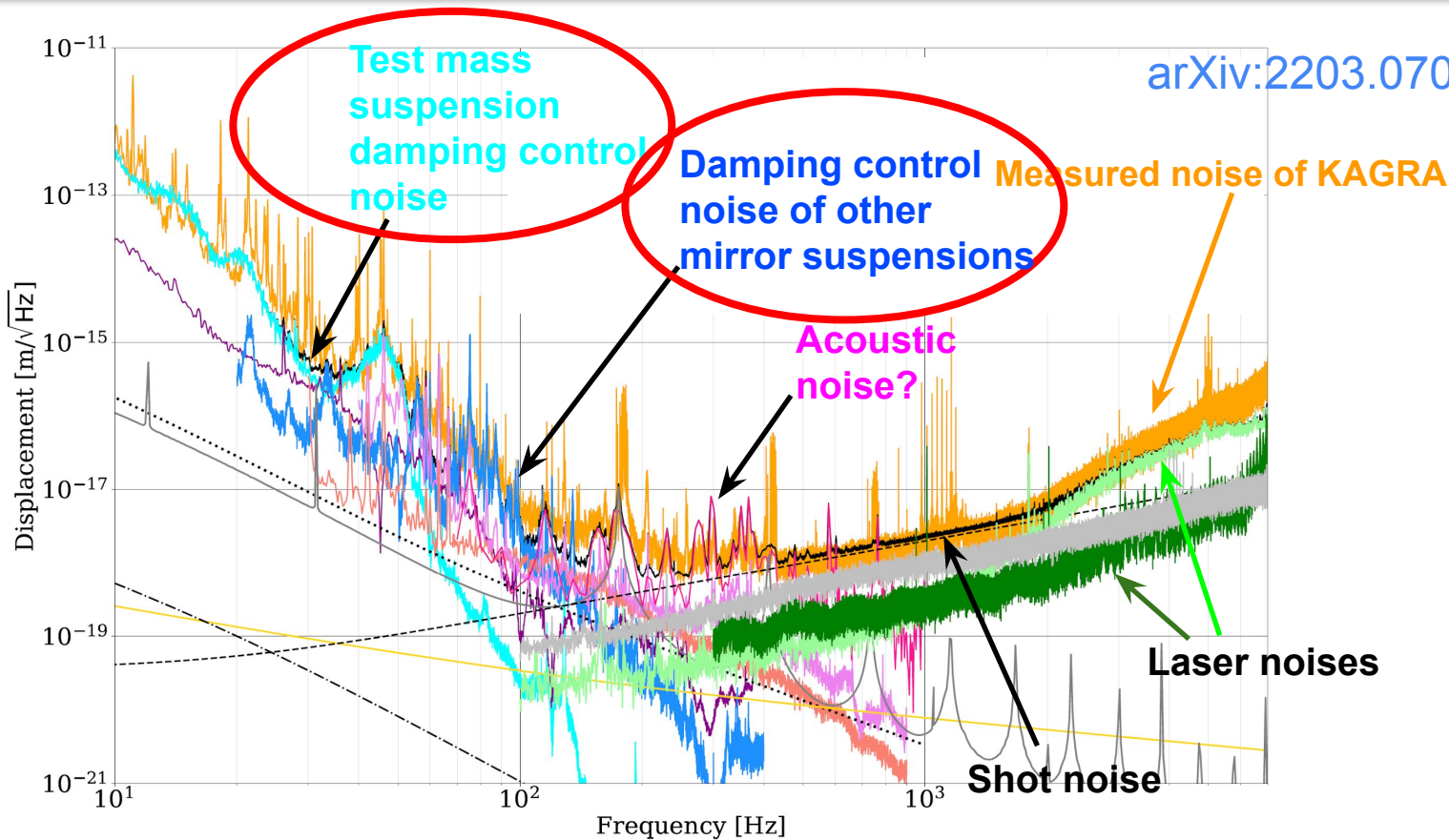
# Local damping control



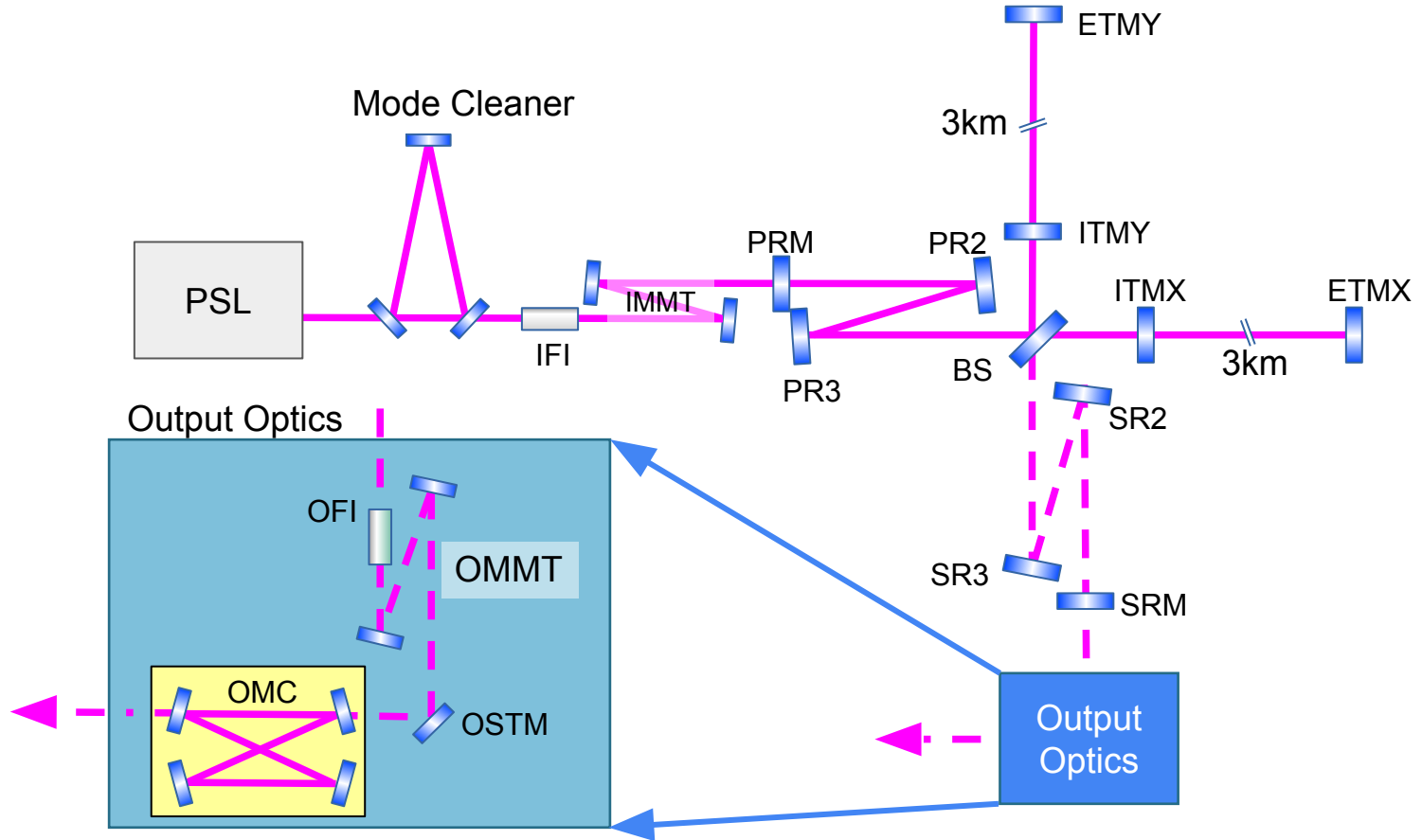
# Local damping control



# O3GK Noise Budget

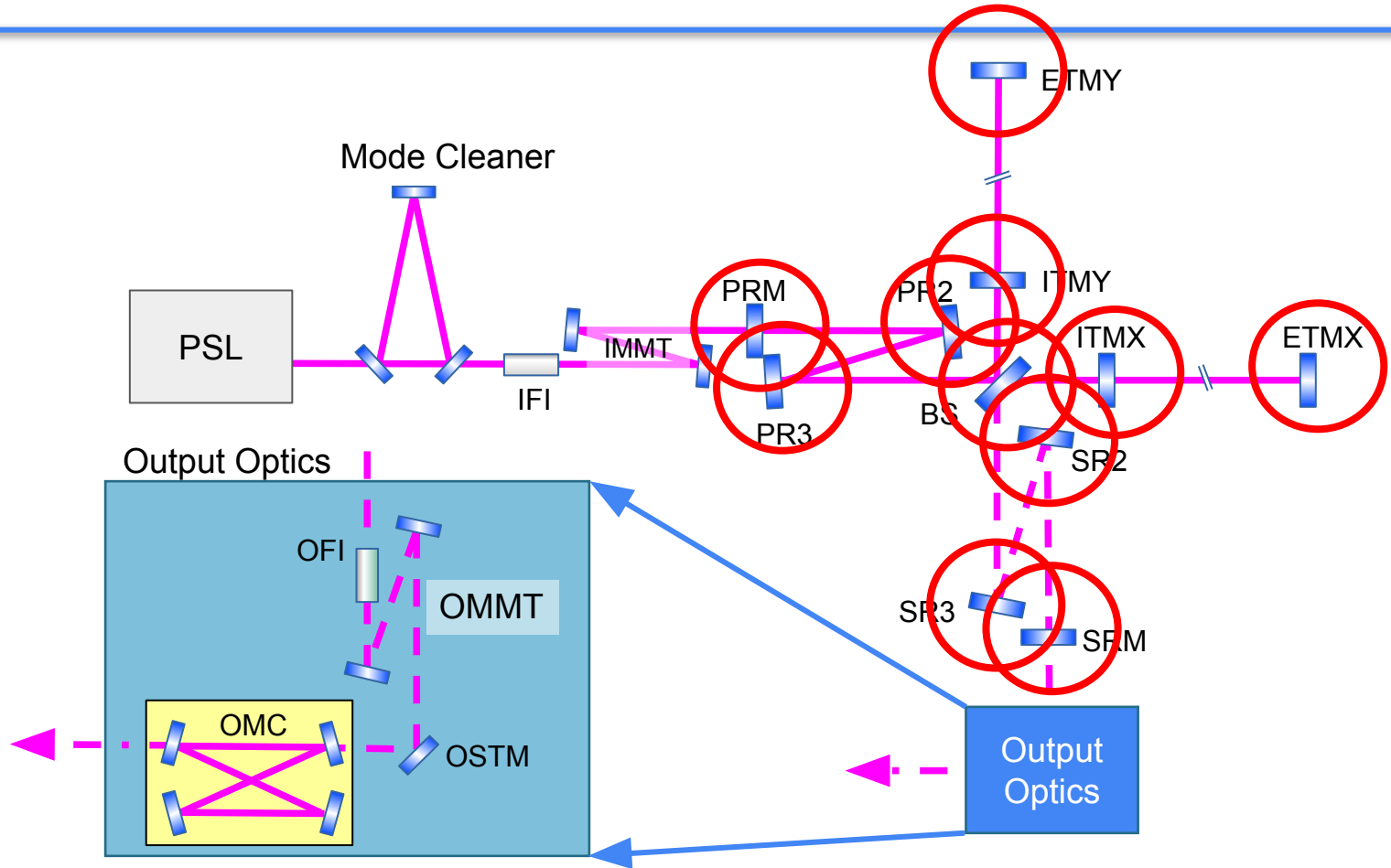


# Schematic of KAGRA





# Suspension Upgrades

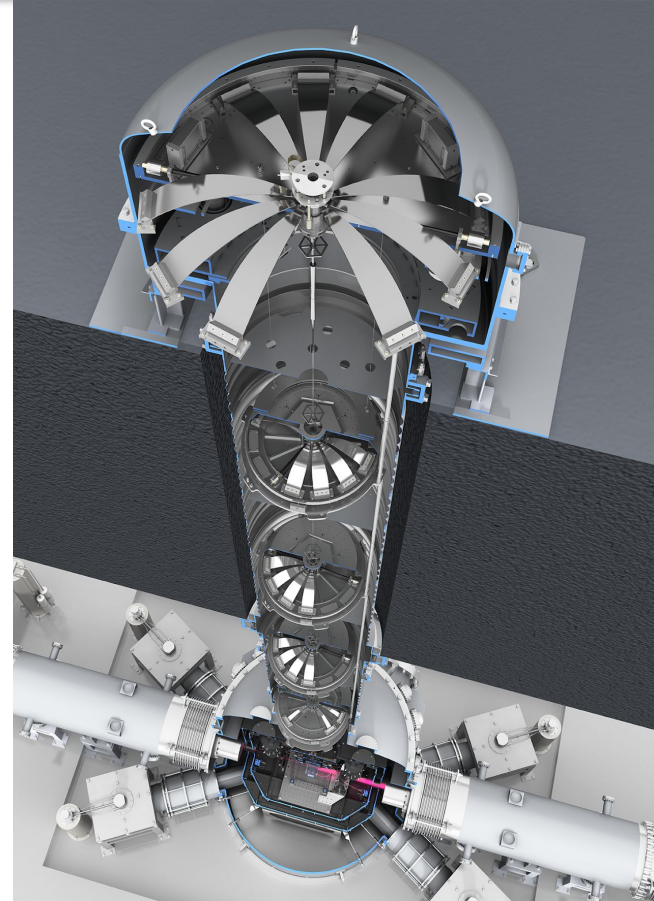


# Suspension Upgrades

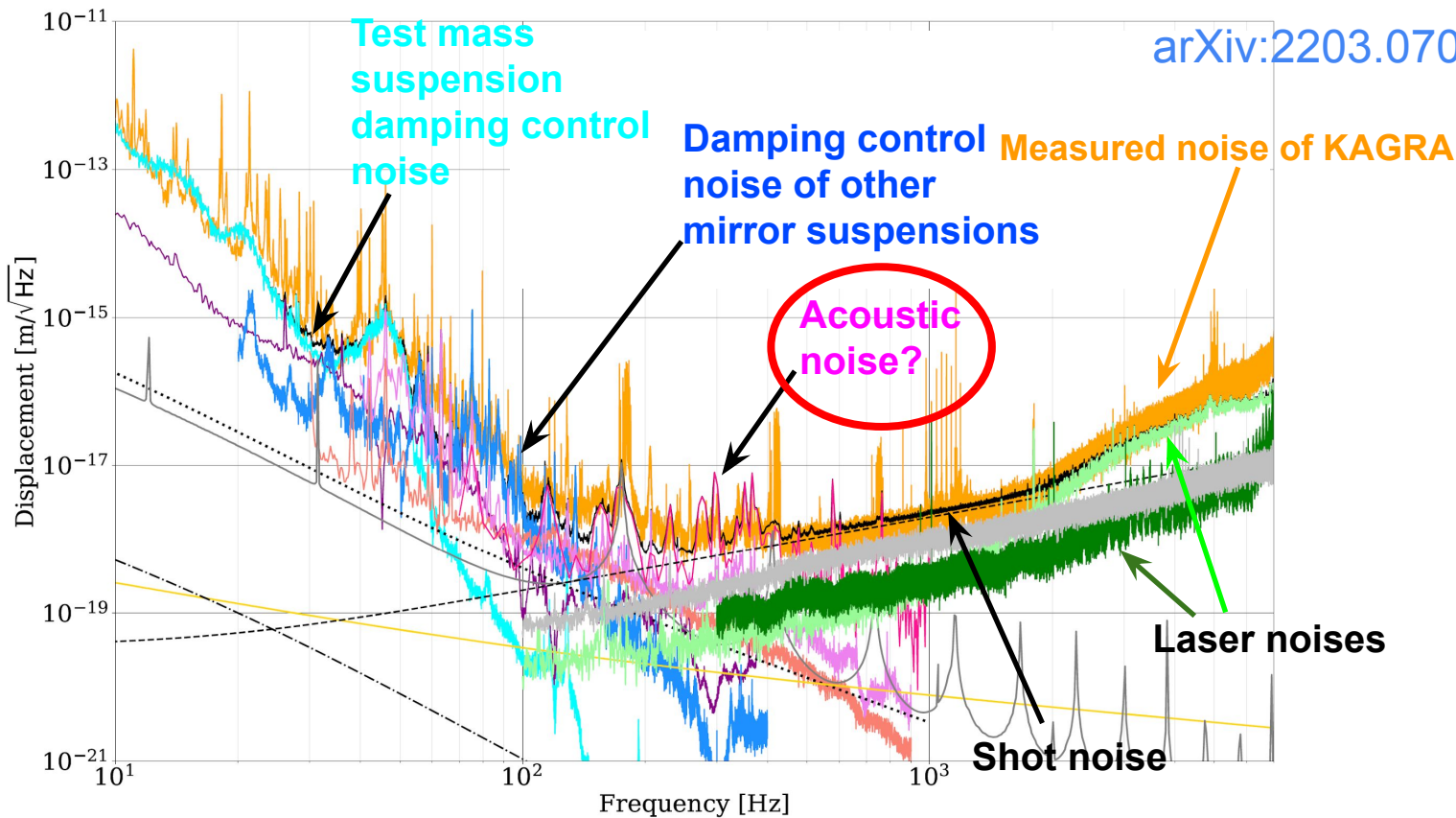
- Fixed mechanical failures
- Improved various local sensors
  - Accelerometers
  - LVDTs
  - Optical Levers
- Improved actuator balances



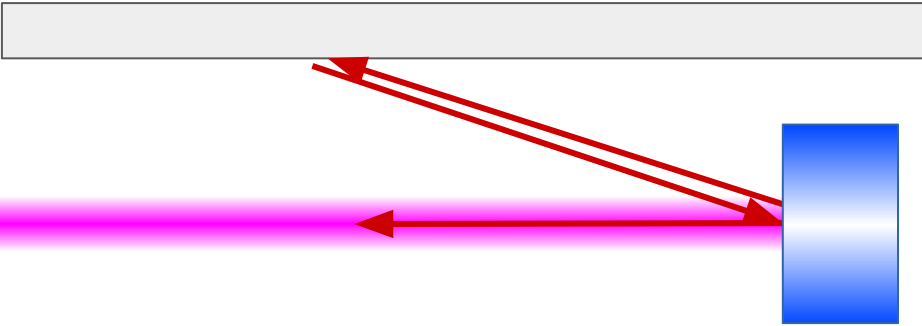
Better optimization of damping control filters



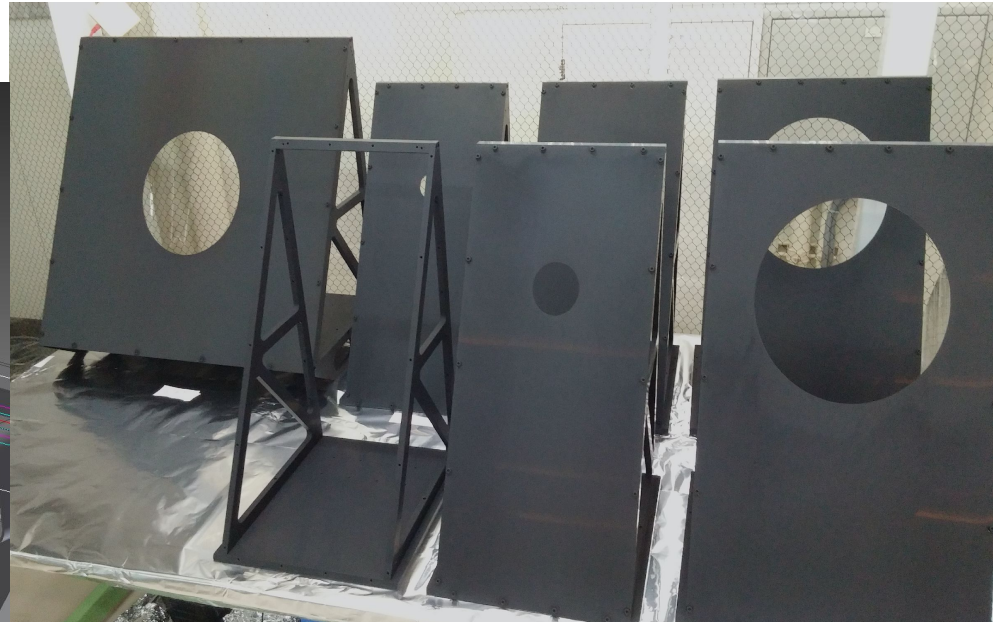
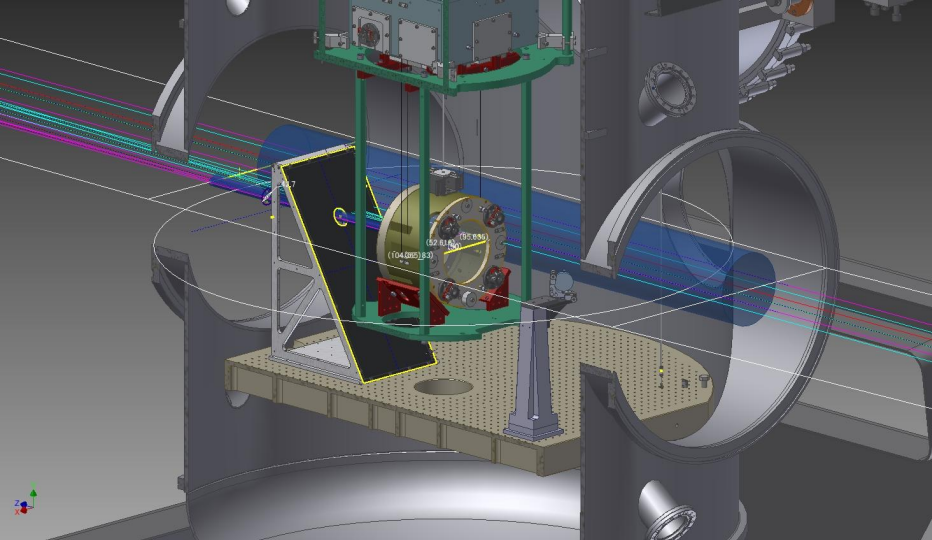
# O3GK Noise Budget



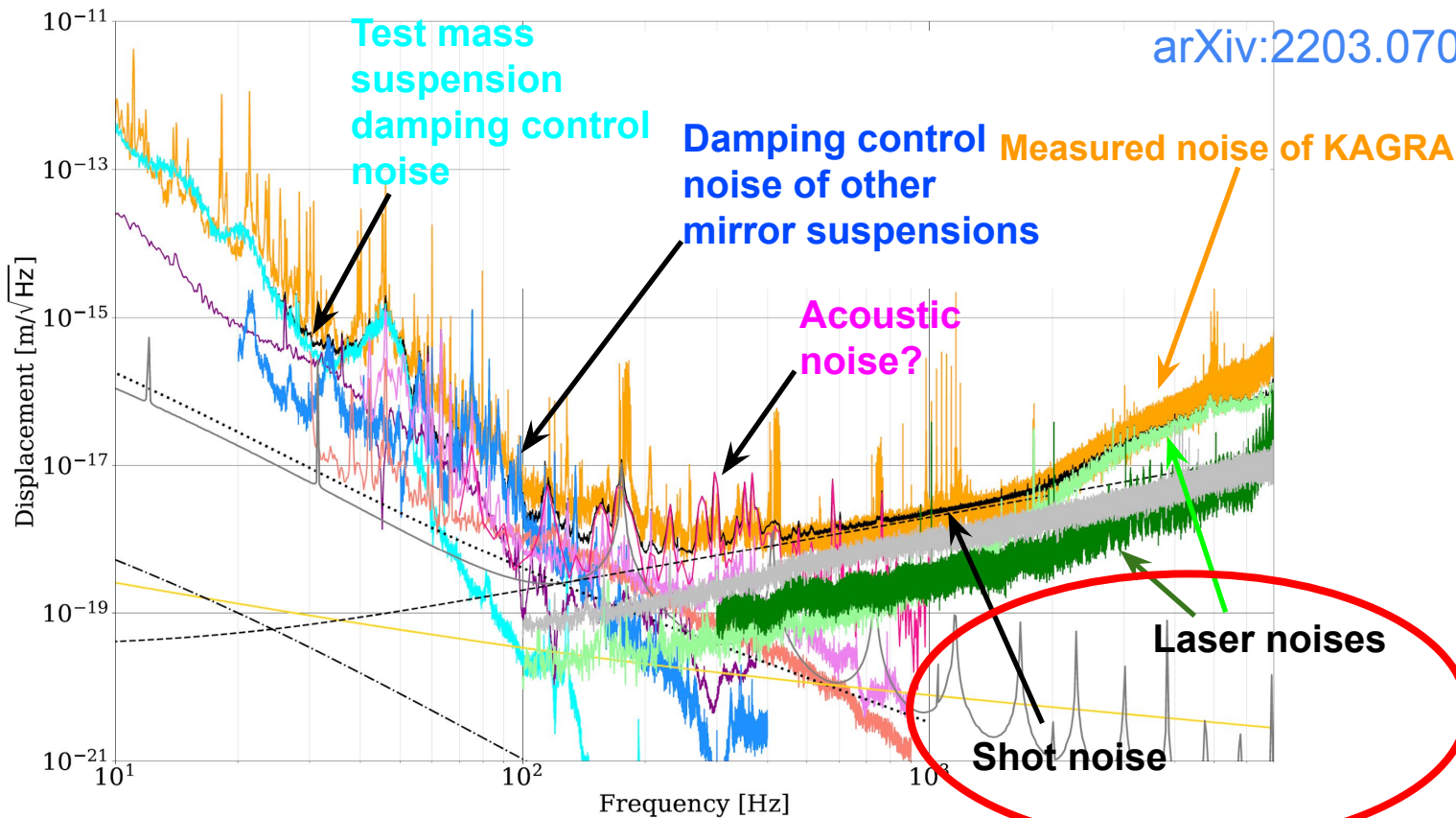
# Scattered Light Noises



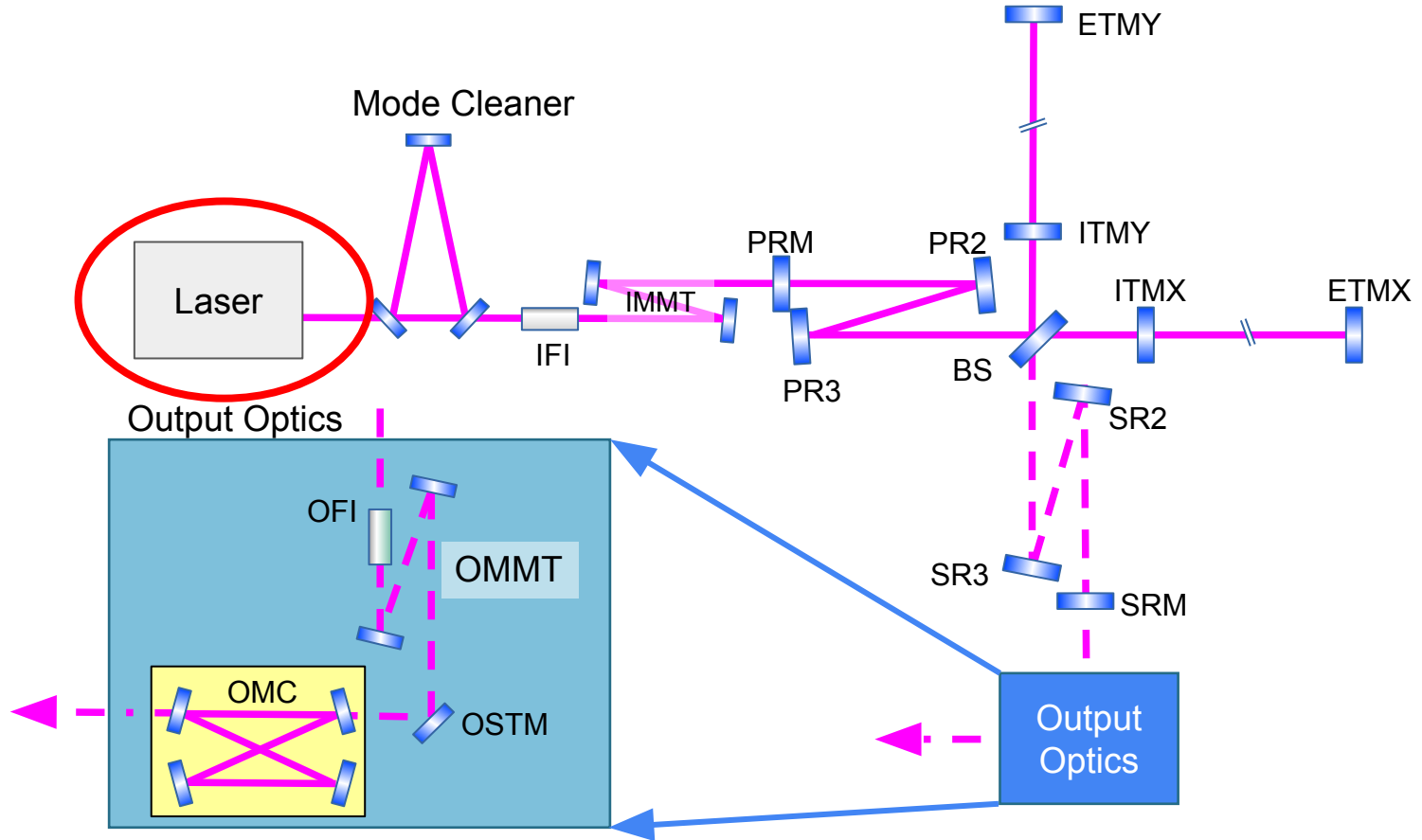
Additional baffles



# O3GK Noise Budget

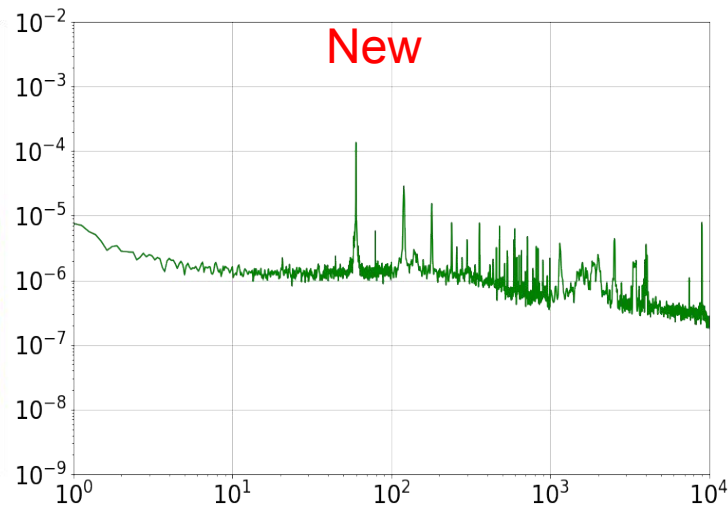
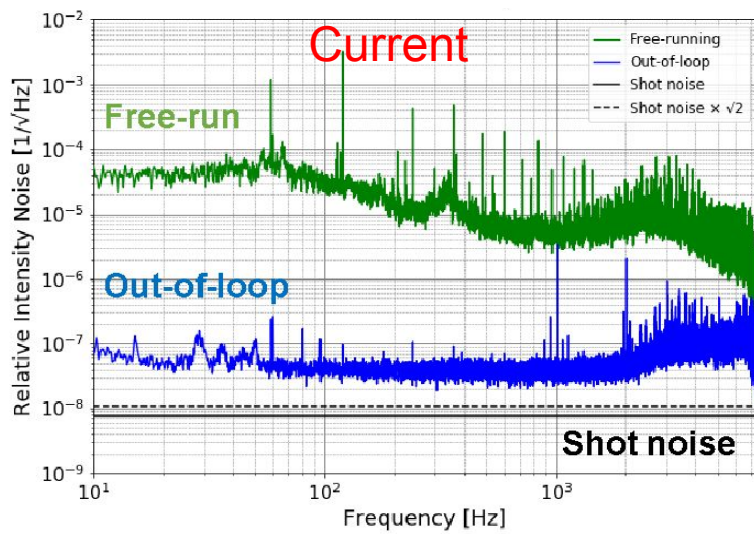
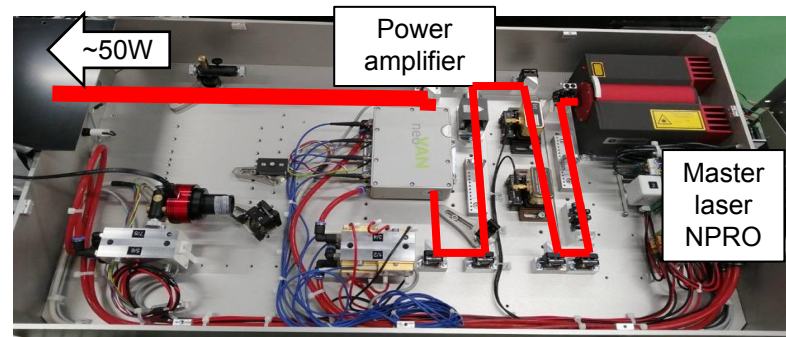


# Improving the Shot Noise

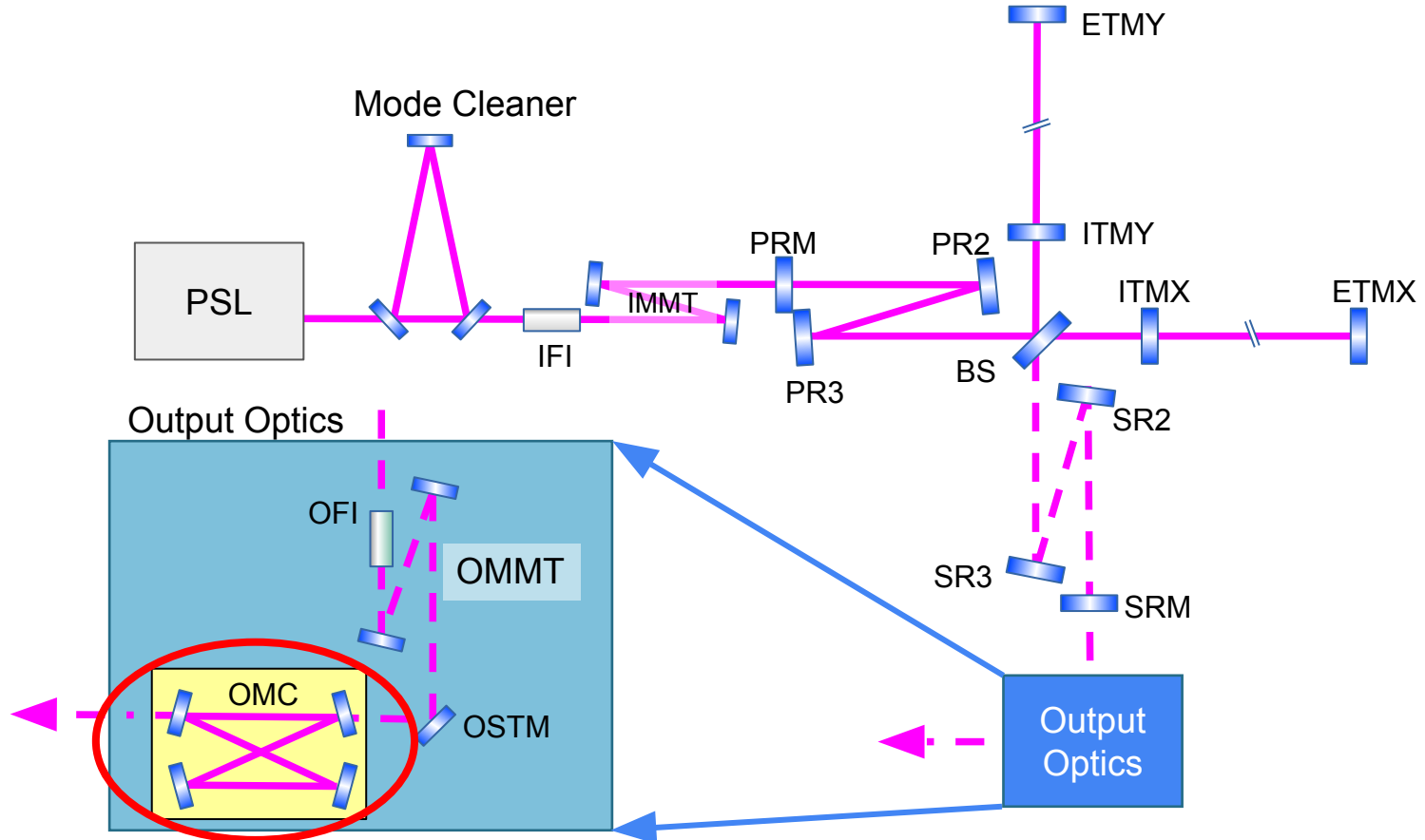


# High Power Laser

- 40W  $\rightarrow$  60W
  - Only 5W used during O3GK
- Lower intensity noise than the current laser



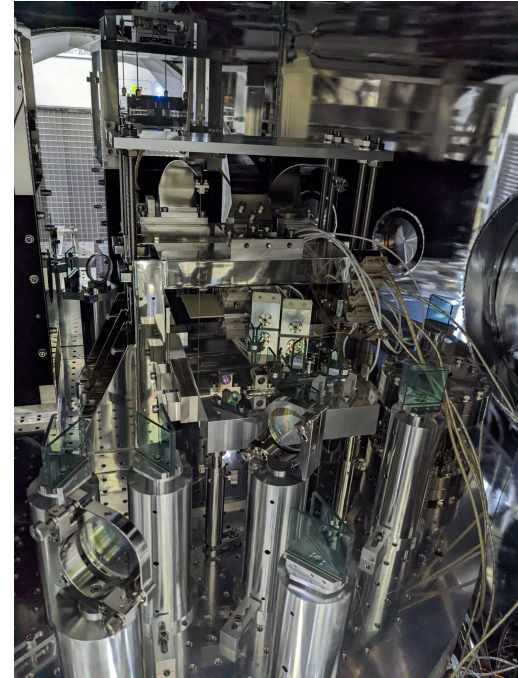
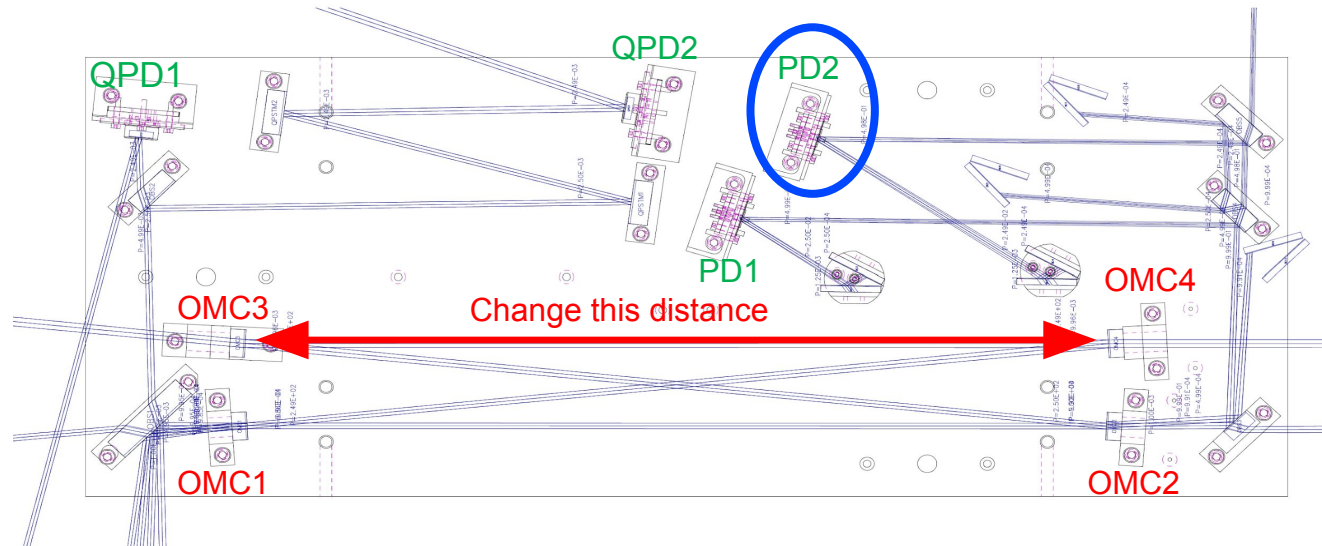
# Improving the Shot Noise



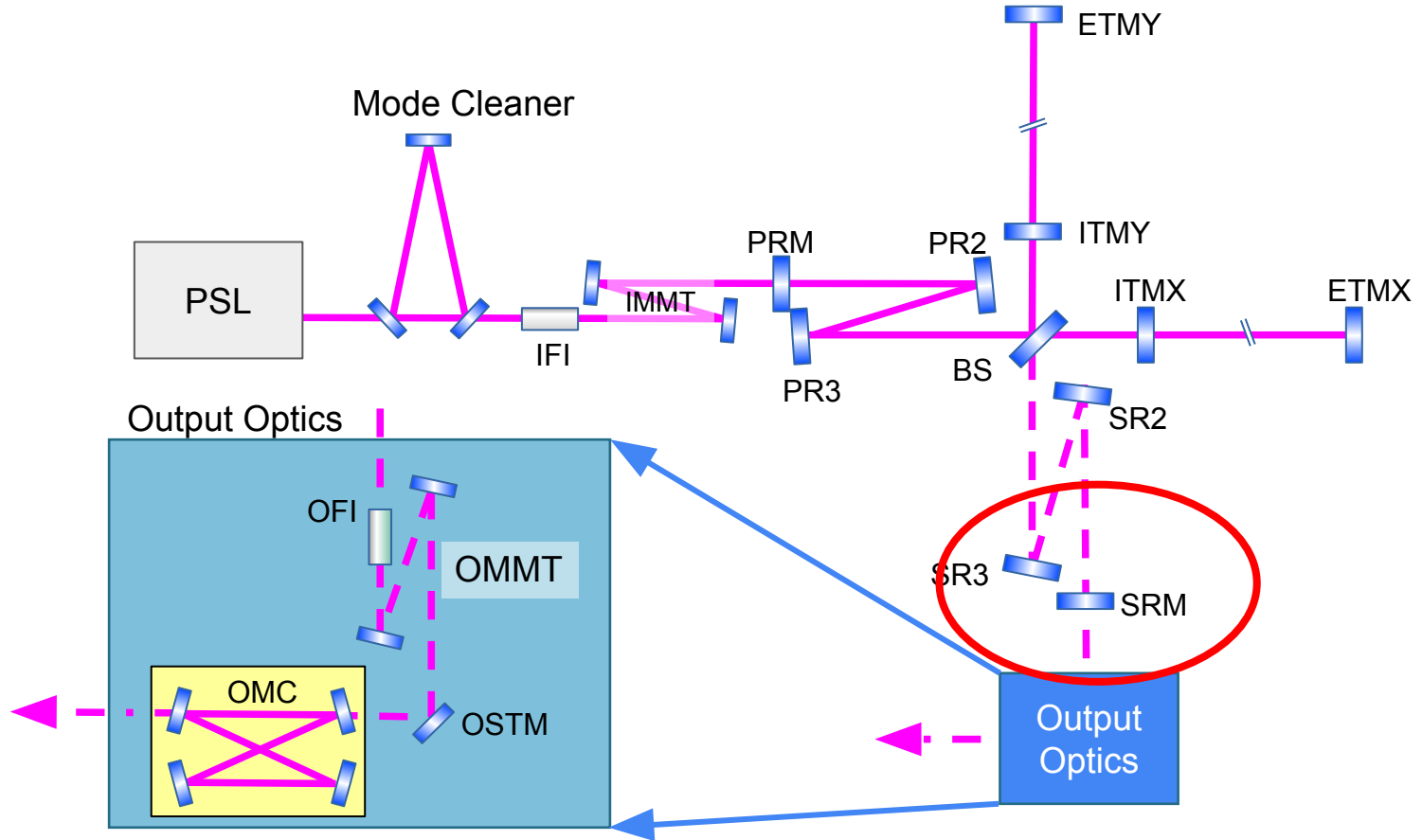


# Output Mode Cleaner Upgrade

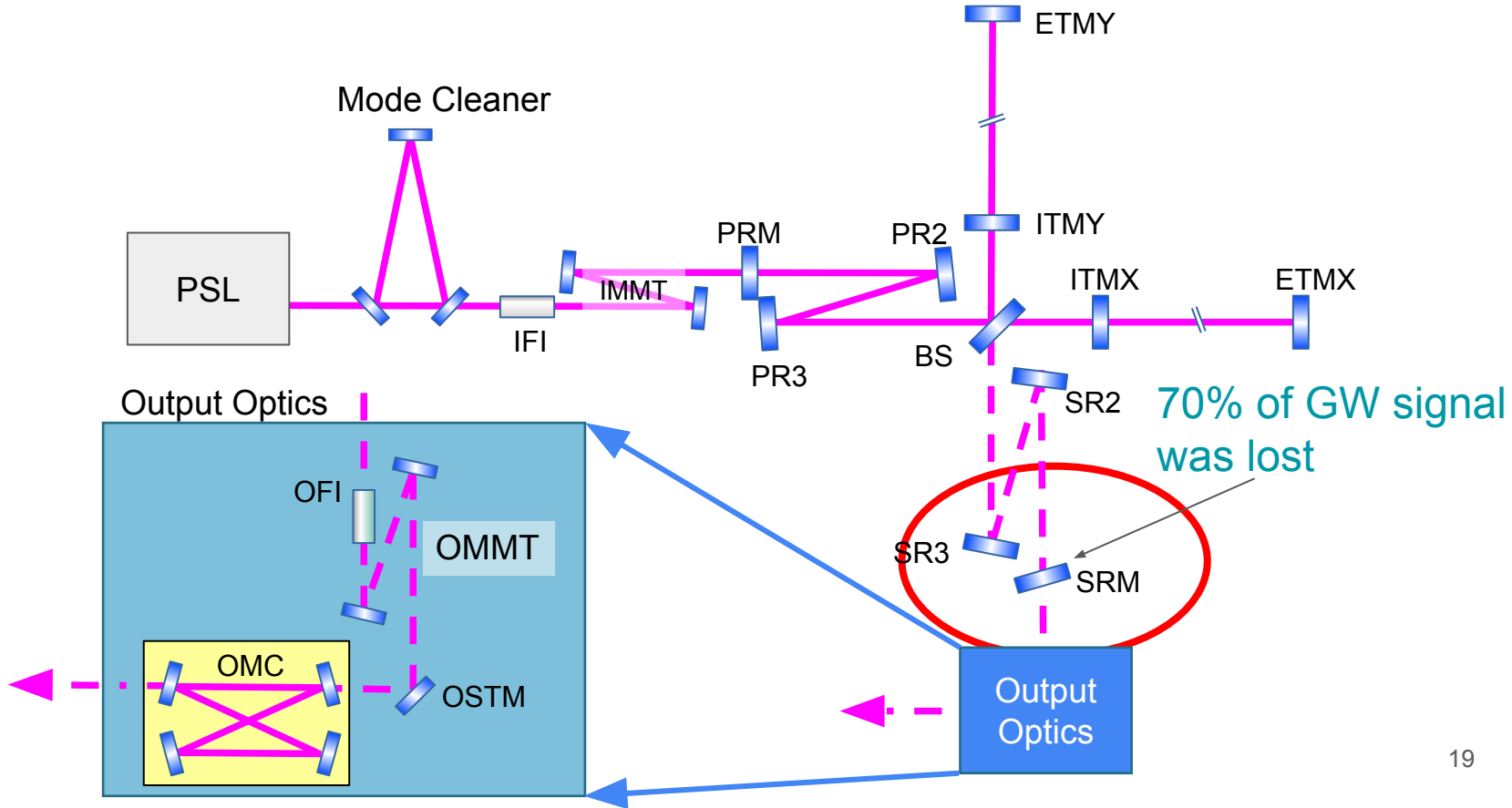
- Higher transmissivity: 80% → 95%
- Fix the broken DCPD → **Double** the GW signal



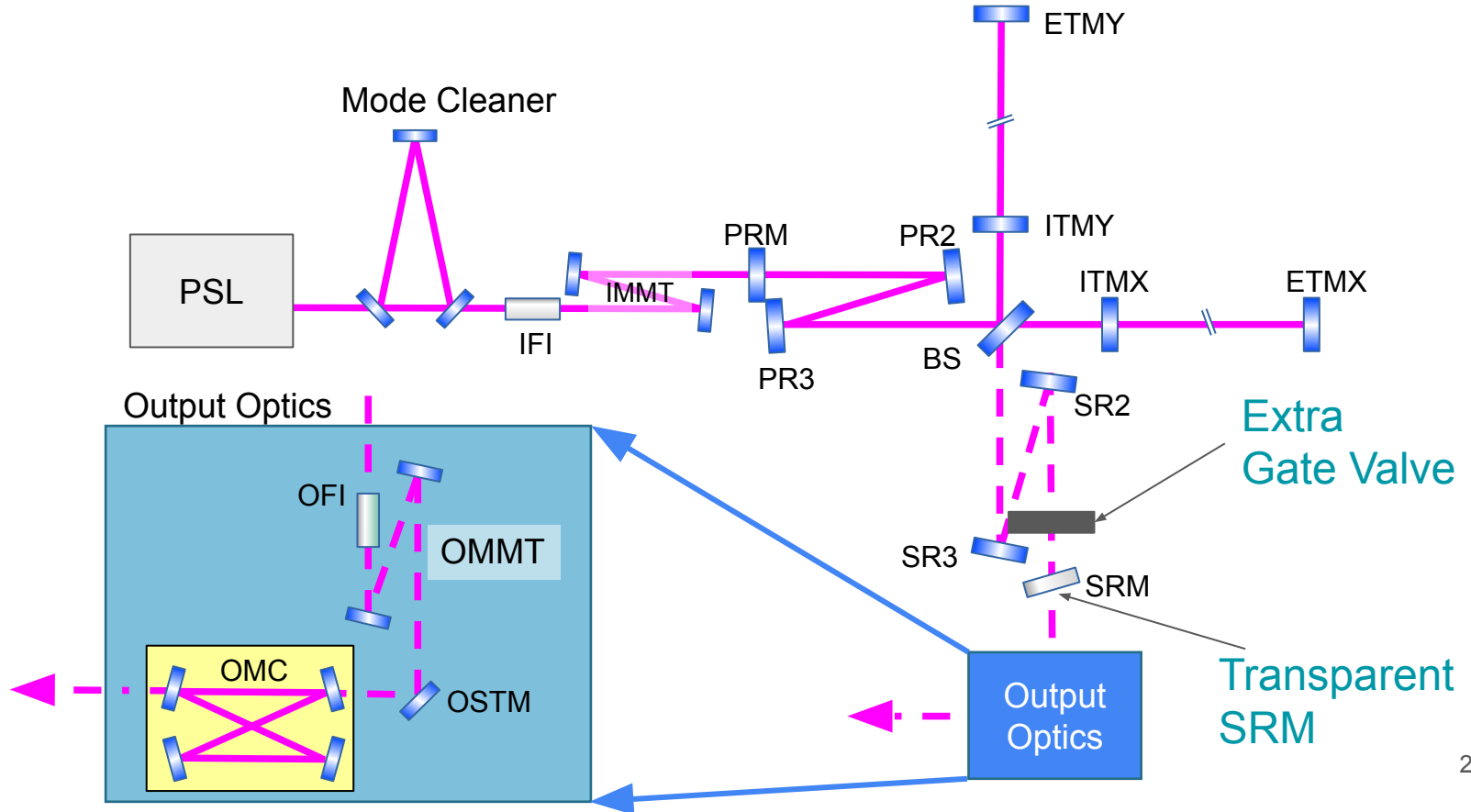
# Improving the Shot Noise



# O3GK Interferometer Configuration (PRFPMI)

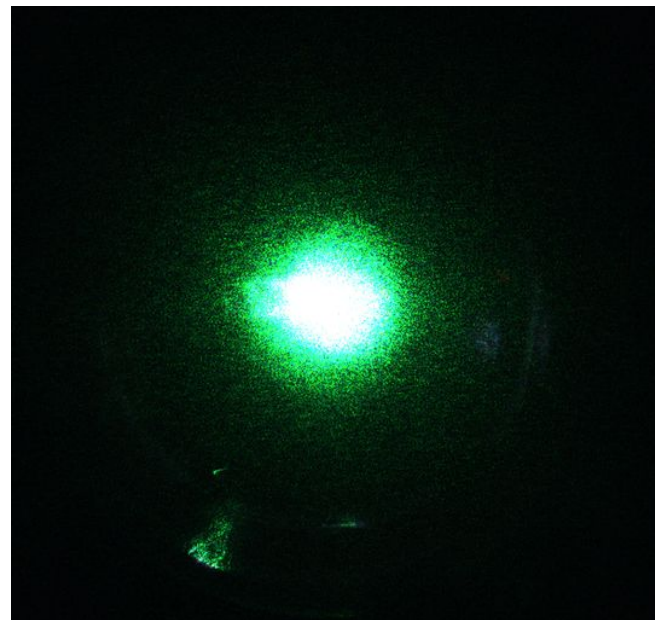


# Initial Configuration of O4 (PRFPMI)



# Vacuum & Cryogenic Upgrades

- Additional vacuum pumps
  - 12 more ion-pumps
  - 10 more turbo molecular pumps
- Better vacuum
- Avoid molecular adsorption on mirrors during cooling
- Defrosting heaters

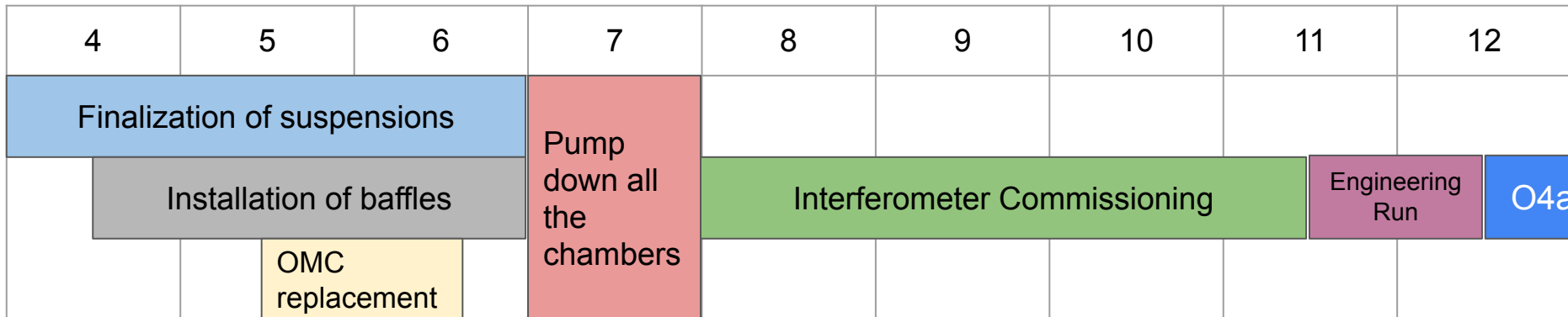


Frosted mirror surface

# Schedule towards O4



2022



- KAGRA will join O4 from the beginning with about 1Mpc BNS range
- After 1 month, KAGRA will go back to the commissioning mode
- KAGRA will come back to the observation during O4b with an improved sensitivity (~ 10Mpc?)
  - About 3 months of participation in O4b

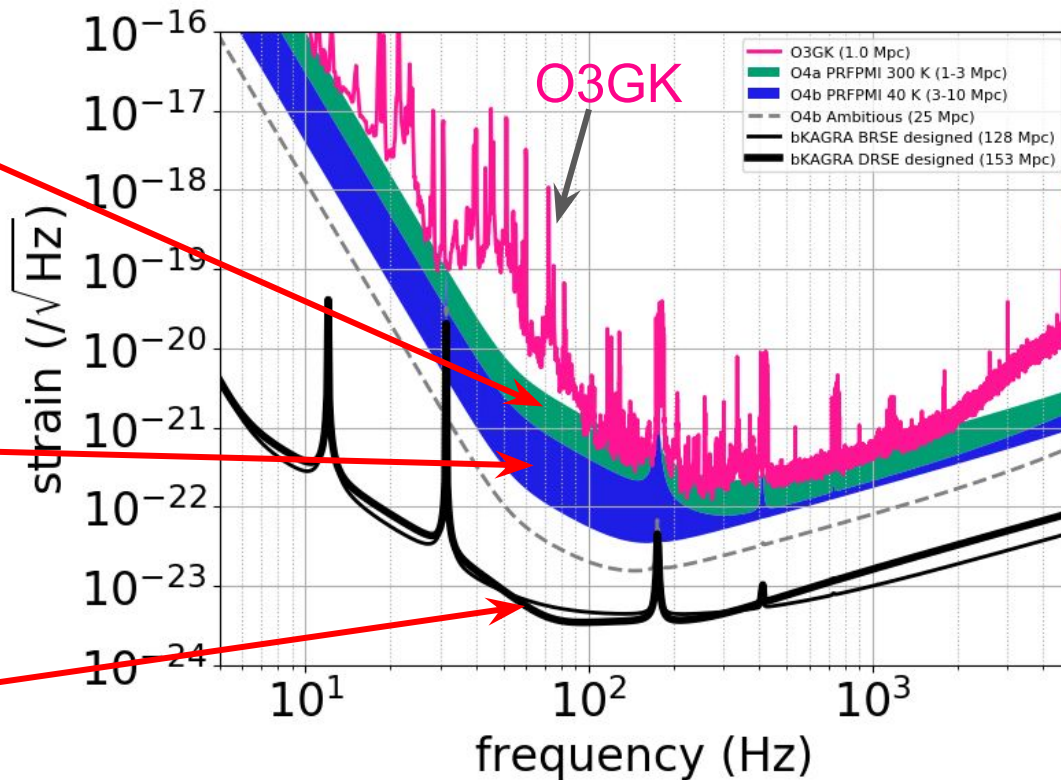
# Possible scenarios for O4 sensitivity

## O4a (1-3Mpc)

- Transparent SRM
- 1/3 technical noises

## O4b (10-25Mpc)

- Cryogenic operation
- 1/25 to 1/77 technical noise reduction



KAGRA design sensitivities  
(128Mpc-153Mpc)

# Summary

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- KAGRA has been conducting upgrades in various subsystems to fix problems identified during O3GK
- KAGRA plans to join O4 from the beginning with about **1Mpc** BNS range
- KAGRA will leave the observation for improving the sensitivity in the middle of O4
- Sometime during O4b, KAGRA will be back to the observation with an improved sensitivity
  - About **3 months** of participation in O4b
- Possible O4b sensitivity: **10Mpc** (25Mpc for optimistic scenario)