



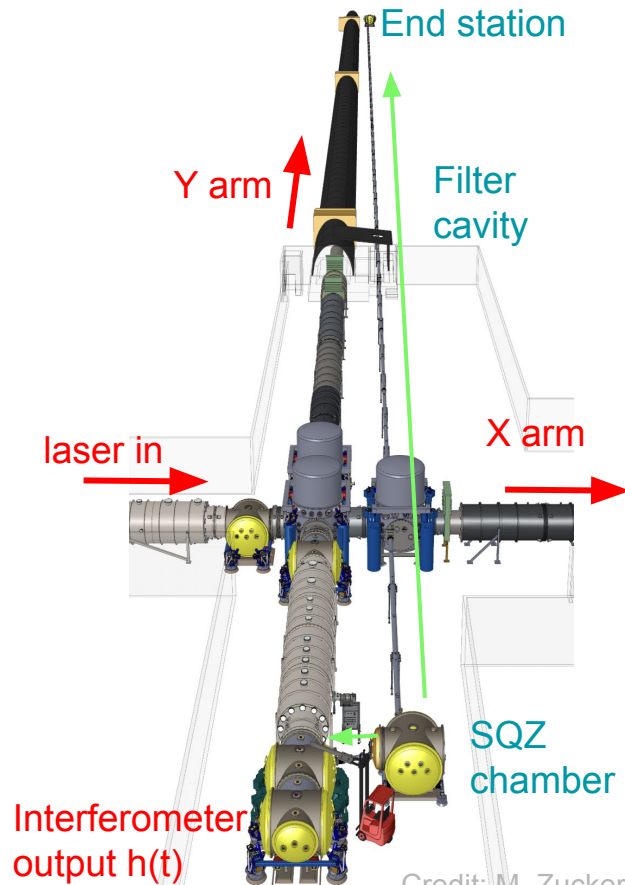
Instruments status

B. O'Reilly for the LVK collaboration

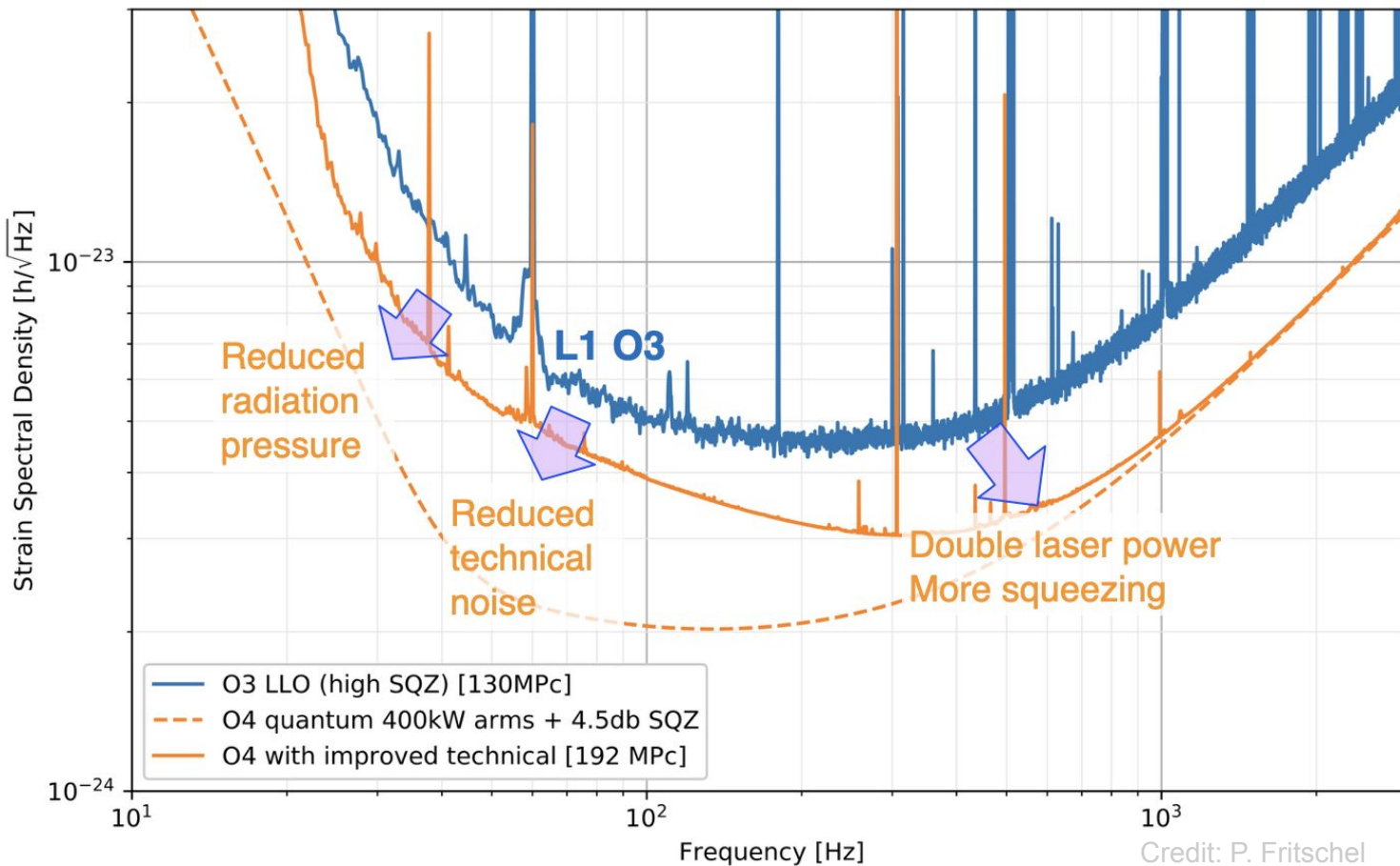
Slides by: J. Driggers, A. Effler, F. Sorrentino, T. Sawada

Summary of LIGO Improvement Goals

- **400kW circulating arm power**
(compare to ~200 kW in O3)
- **Squeezed light efficacy 4.5dB**
(compare to 2-3dB in O3)
- **300m filter cavity** for frequency dependent squeezing
- **Low frequency technical noise reduction**
<100 Hz



Potential Resulting Sensitivity (LIGO)



$$h \sim 1/r$$

$$\text{rate} \sim r^3 * T$$

High Power

- O4 high power laser install complete (serves 100+ W to interferometer)
- Stable operation with 260+ kW arm circulating power achieved (c.f. <200 kW in O3)
 - Brief operation with ~400 kW circulating
- Upcoming commissioning will focus on stable high circulating power operation

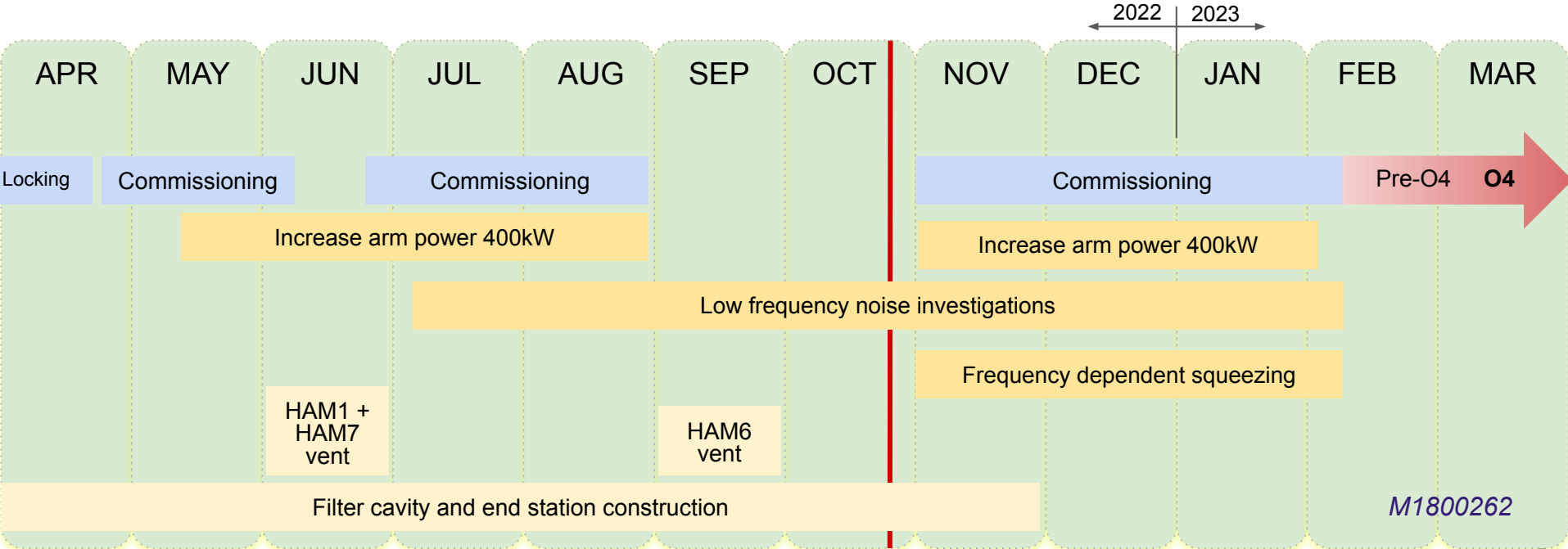
Squeezing

- 4 dB frequency *independent* squeezing achieved
- Installation of filter cavity for frequency *dependent* squeezing (including new buildings and vacuum system to house it) nearing completion

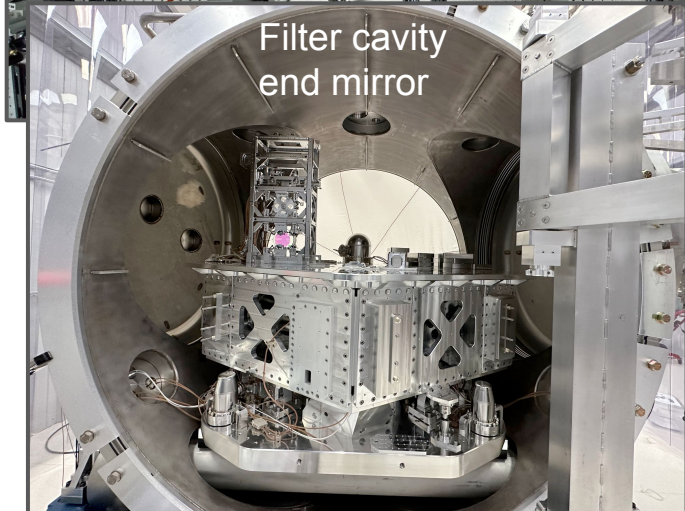
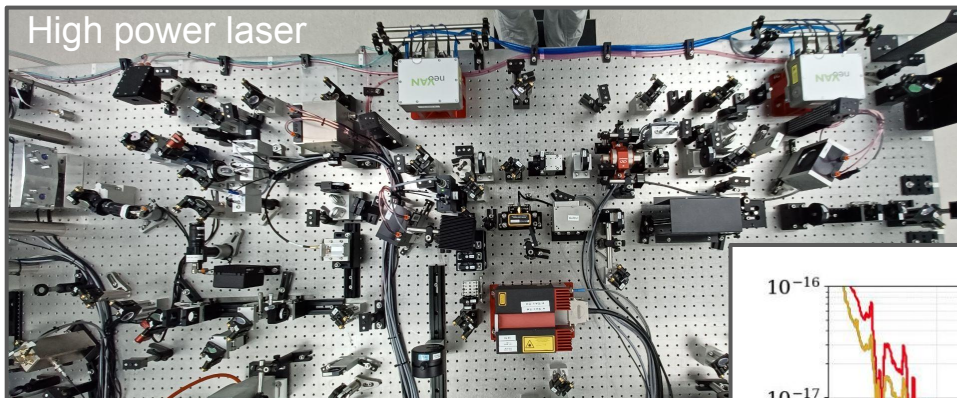
Low Frequency Improvements

- Analog electronics and digital controls improvements to the actuation of most suspended mirrors
- In-vacuum upgrades to mitigate scattered light and improve mode matching recently completed

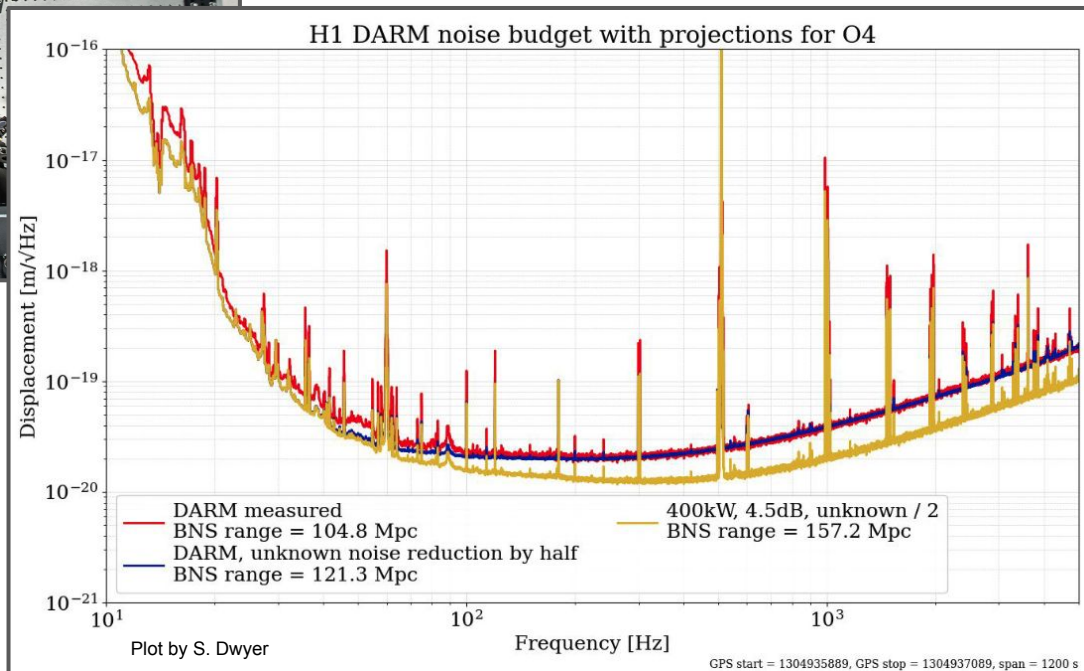
LIGO Hanford



LIGO Hanford



H1's potential sensitivity for O4, if source-unknown low frequency noise contribution is reduced by half during next several months of commissioning



LIGO Livingston

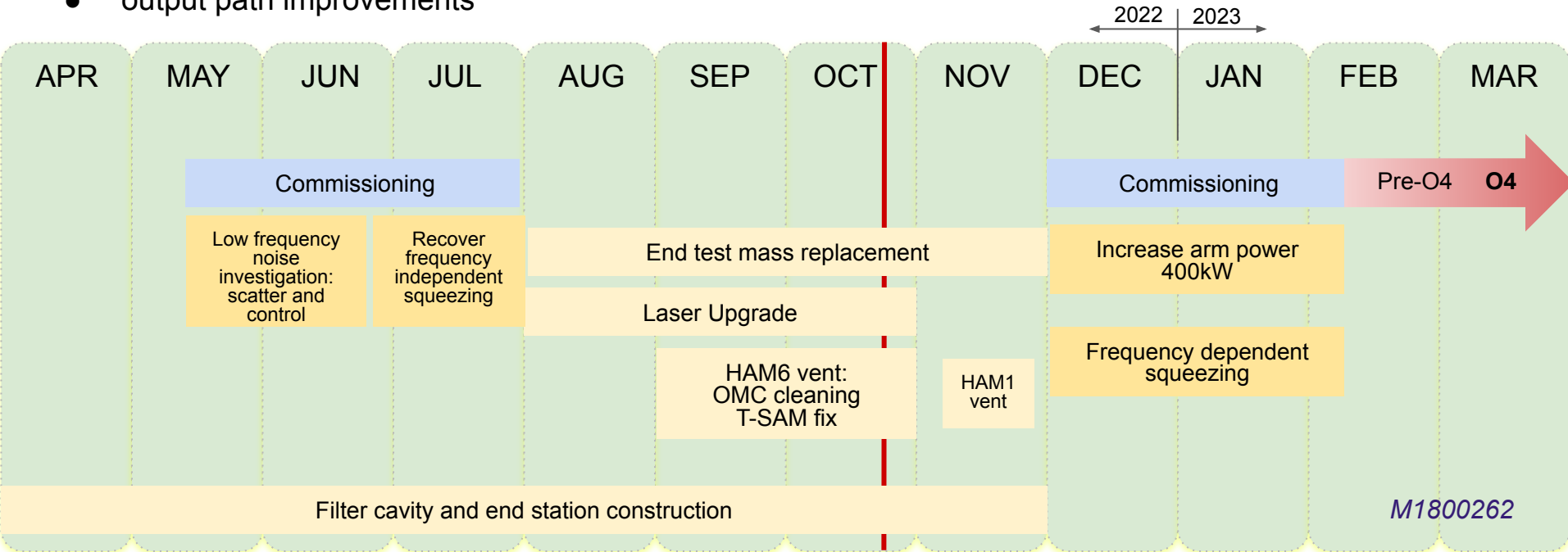


DONE

- Technical noise improvements
- Recover freq-*independent* squeezing
- Laser upgrade
- output path improvements

TO DO

- double arm power
- freq-*dependent* squeezing
- more scatter reduction

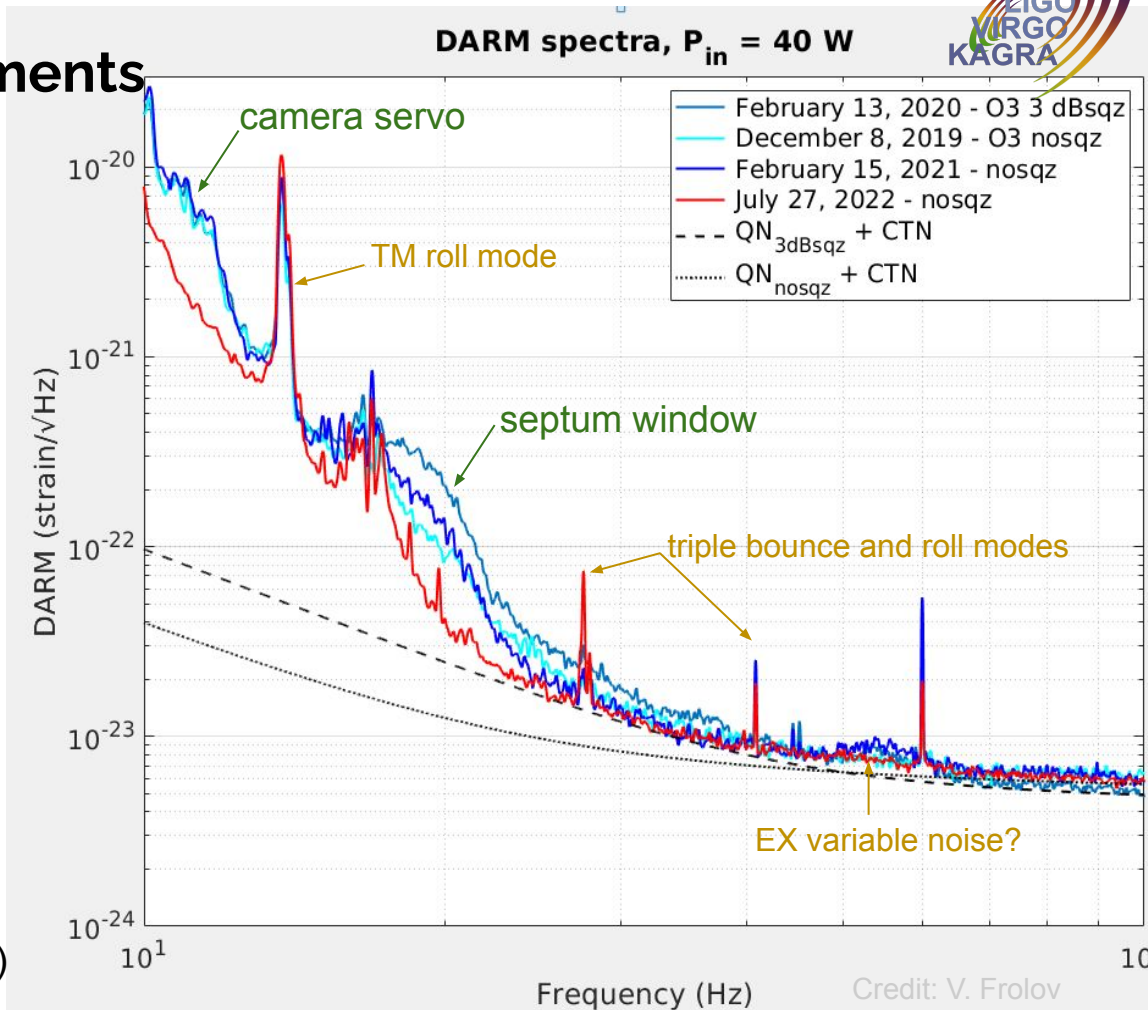


LIGO Livingston Technical Noise Improvements



- Output septum window (between Signal Recycling Cavity and Output table) was removed
- Scatter work (more baffles)
- Controls improvements
- Fixed ETMY ISI 1.2 Hz resonance
- Better Output Mode Cleaner Photodiode amplifier and ADC

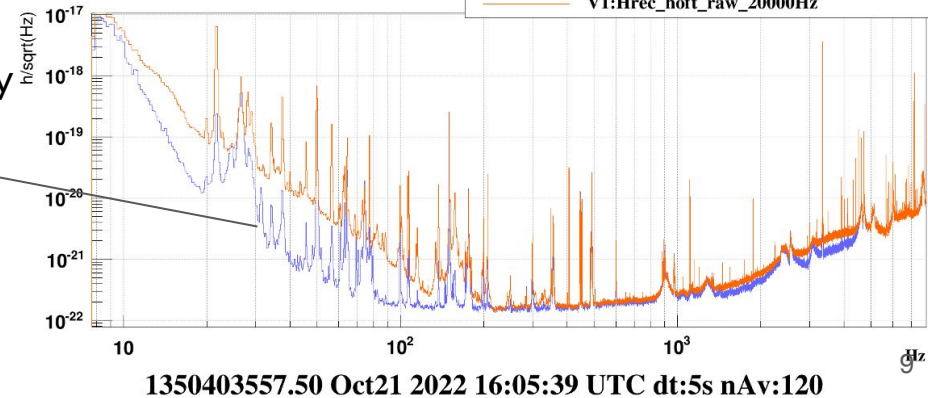
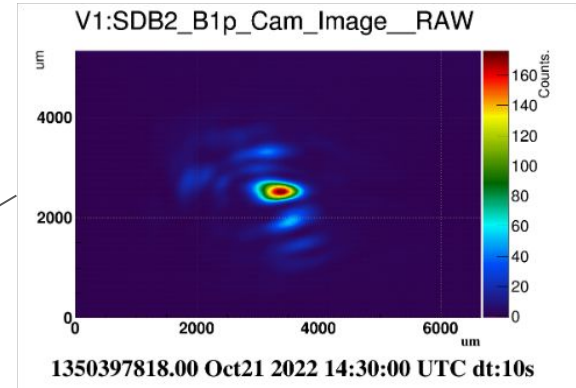
- 130 Mpc w/o squeezing! (red trace) (early BNS warning time 16s in O3 -> 28s now)
- best “only” ~145 Mpc with 3dB freq independent squeezing (can get 4 dB but ~40% loss so anti-squeezing hurts)



Virgo

ITF control, working point tuning & first sensitivity

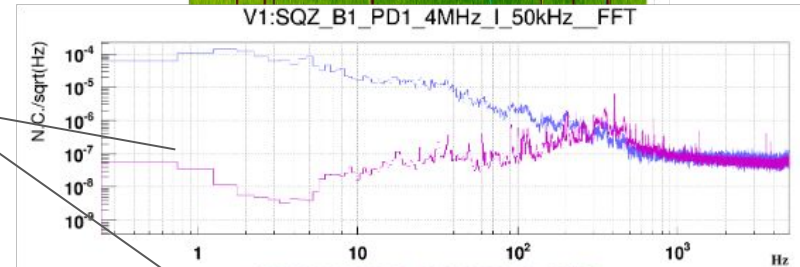
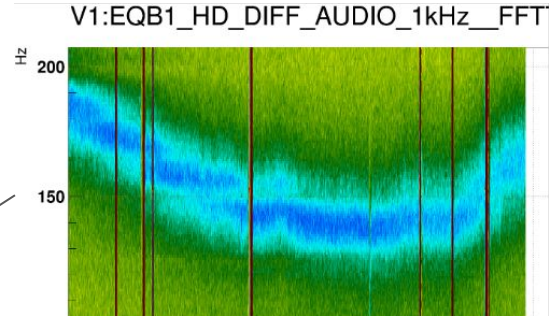
- HOM recycling in SRC generates large DC and fluctuations on dark fringe power (~1 W)
 - improved by SRCL control with optical spring
- SRM automatic alignment by maximizing DCP, now full AA engaged
- tuning of thermal actuators (ETMs RH, DAS on ITMs CPs, PRM & SRM curvatures) to mitigate dark fringe power
- First calibration in DC readout: 2÷4 Mpc, mostly limited by control noises & OMC
- OMC damaged by fast flashes
 - ~80% losses
 - safety trigger recently improved



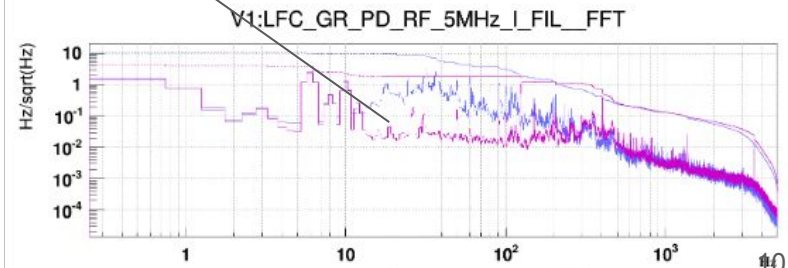
Virgo

FDS, residual installations, noise hunting

- FDS commissioning on external homodyne detector:
 - mitigation of technical noises
 - long term stability of SQZ level and FDS detuning
- SQZ on ITF
 - aligned to OMC, ~90% matching
 - CC loop on B1, reduce FC longitudinal noise
 - next steps:
 - automatic alignment to OMC
 - FIS & FDS after OMC replacement
- ~2 wks downtime in November & December for
 - OMC replacement
 - point absorbers mitigation system
- Noise hunting to start in November
 - control noises first (SSFS, LSC & ASC couplings)
 - technical noises until February



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1350420542.0000 Oct21 2022 20:48:44 UTC
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KAGRA

IFO commissioning

- Shifting phases from instrument upgrade/integration to IFO commissioning.
- Realized stable FPMI control using DARM RF signal:
 - Continuous lock for 12.5 hours
 - Better than the 3 Mpc curve in the low frequency range
- Currently trying to realize PRMI and PRFPMI using DARM RF signal

OMC and High Power Laser

- The preparation of OMC in November and tuning of the laser intensity stabilization system will improve in the high-frequency range.
- Noise curve will be available once they are ready.

Preparations for O4 are generally progressing well.

Summary

- Scientists, Engineers, Technicians, and Students at LIGO, Virgo and KAGRA working to:
 - Finalize the installation of upgrades;
 - Commission the detectors to reach the expected sensitivities;
- Some technical uncertainties still remain, which may impact our schedule.
(Potential risks)

Summary

- Much work has been done on the instruments, but quite a bit remains to be done.
- Next few months will be critical for O4 sensitivity and schedule
- We will continue to update the schedule regularly: Next update November 15th.

Thank you for your time and attention.