

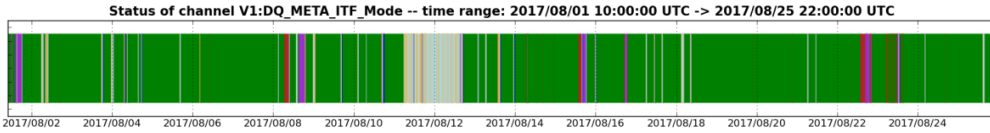
Virgo status

**From O2 to O3 and beyond
Focusing on the detector**

B. Mours (LAPP-Annecy)

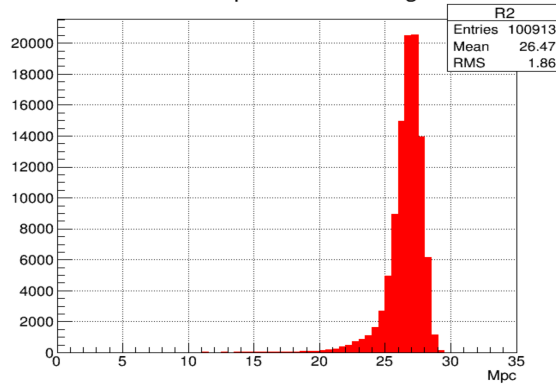
for the Virgo Collaboration

GWADW - May 12, 2018

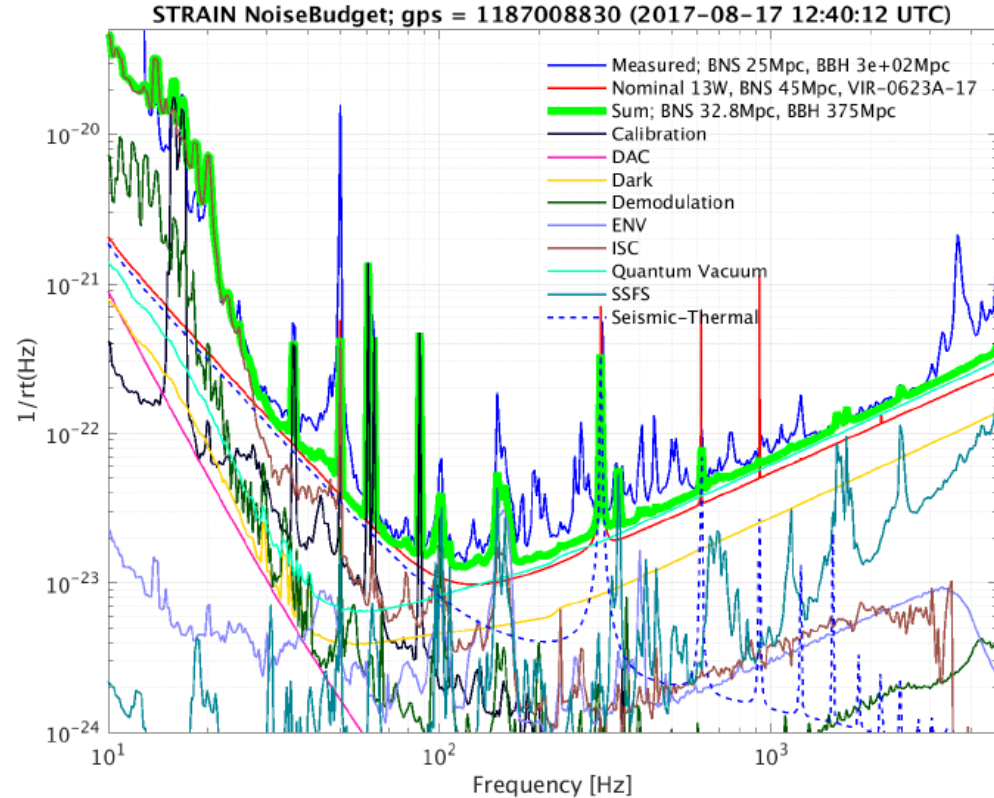


O2 Detector Summary

V1O2Repro2A BNS Range



- ▶ 85 % duty cycle
 - Longest lock segment: 69 hours
- ▶ Mean BNS range: 26.5 Mpc
 - online 25.6 Mpc
- ▶ Noise budget
 - Many bumps and line and some extra broadband noise
 - Scattered light, some sensing noise, unknown....



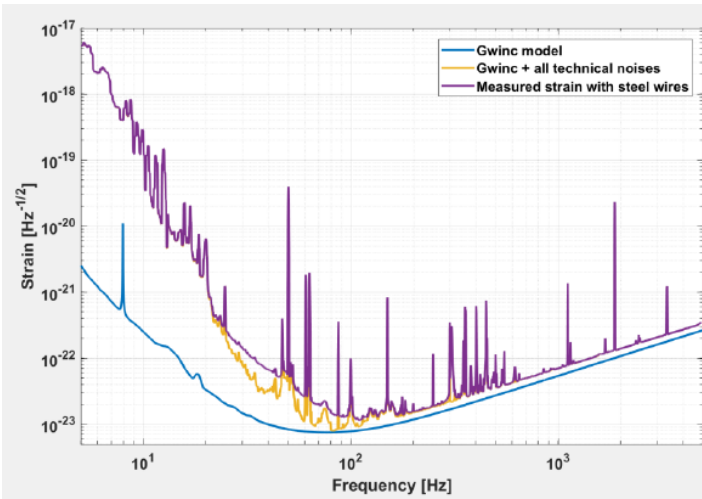
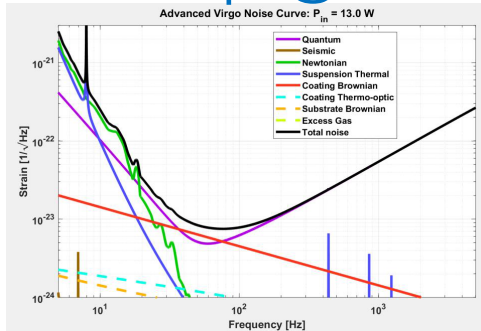
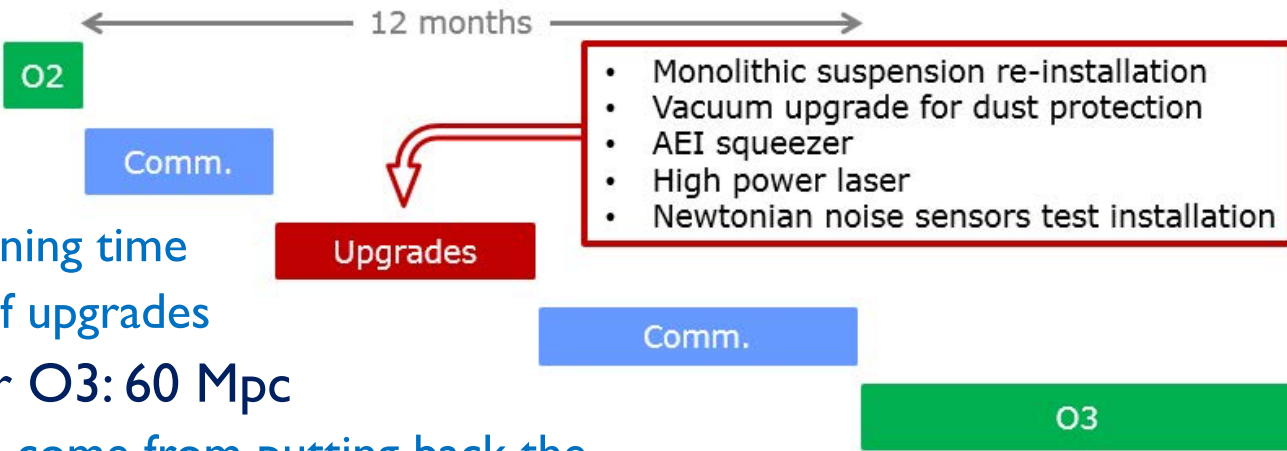
From O2 to O3

► Strategy:

- Reserve commissioning time
- Limit the number of upgrades

► Target sensitivity for O3: 60 Mpc

- Main benefit should come from putting back the monolithic suspension
 - Removing the steel wire thermal noise from noise budget gives a 20 Mpc range increase
- Theoretical limits: 100 Mpc @ 13W, no squeezing



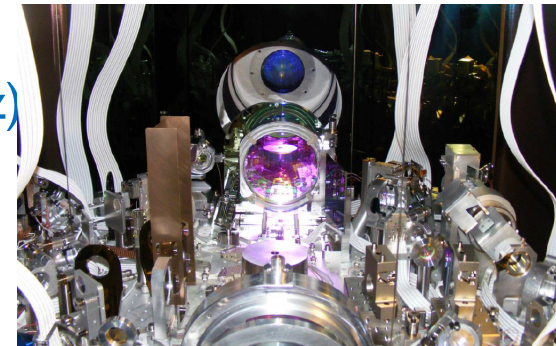
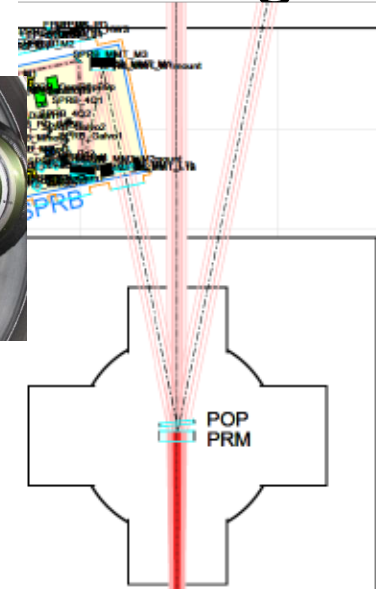
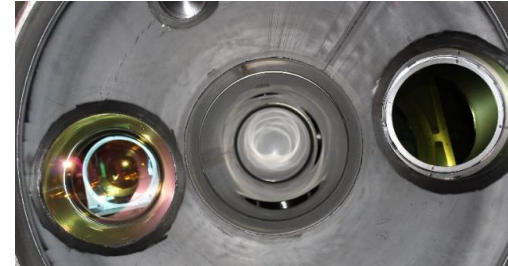
September	October	November
Gen. commissioning	SDB1/PR	TCS and input power increase

SDB1 checks, PR and DET towers baffles installation, SPRB/SWEB suspensions re-tuning

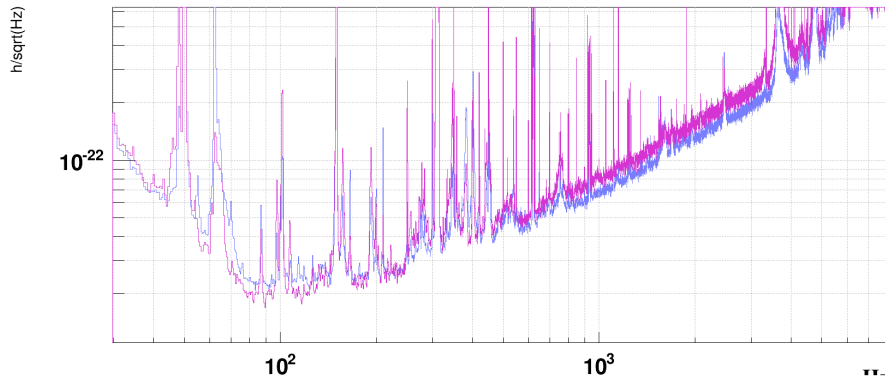
▶ Main topics

- Control filters optimization
- ENV: noise injections and noise sources identification
- Interventions in SDBI and PR towers
 - ▶ Baffles installed
 - ▶ Some MMT optics cleaned/replaced
- SUSP: GIPC now fully engaged
- ISC:AA in full bandwidth using quadrants (@ 56 MHz)
- TCS: DAS optimized and tested
- ISYS: ITF input power increased to 26.5 W
- ...

Post O2 commissioning



V1:Hrec_hoft_20000Hz__FFT

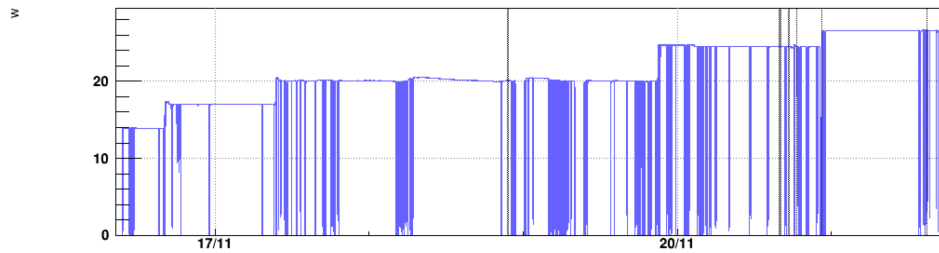


1194868919.0000 : Nov 16 2017 12:01:41 UTC
1195430619.00 : Nov 23 2017 00:03:21 UTC dt:2.00s nAv:200

- ▶ Tests with 14, 17, 20 and 26 W
 - O2: 13W at the ITF input
- ▶ No major issues
 - Done in a few days
 - No need to use TCS
 - Sideband gain reduced
 - ▶ Compatible with simulation
 - But coupling to the ITF degrades
 - ▶ 1.57 power increase in the arms instead of 1.9
 - ▶ No time spent on beam matching
 - No parametric instabilities (so far...)
 - ▶ Modes density smaller than in LIGO and grouped

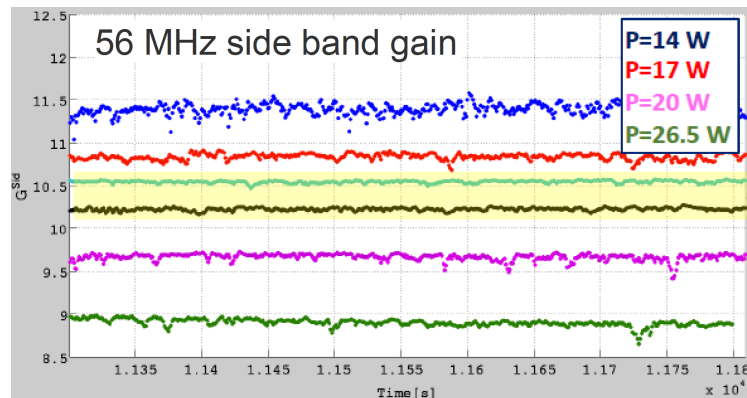
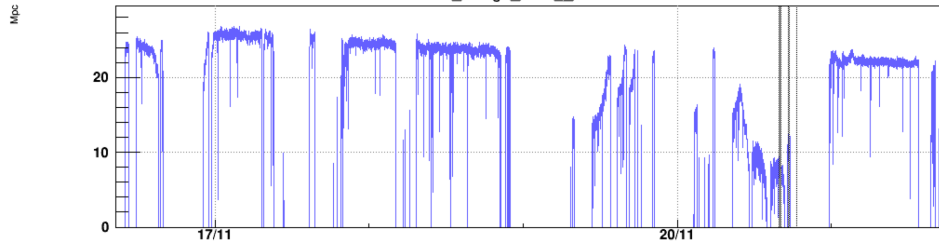
Laser power increase

V1:INJ_ITF_INPUT_mean__TIME



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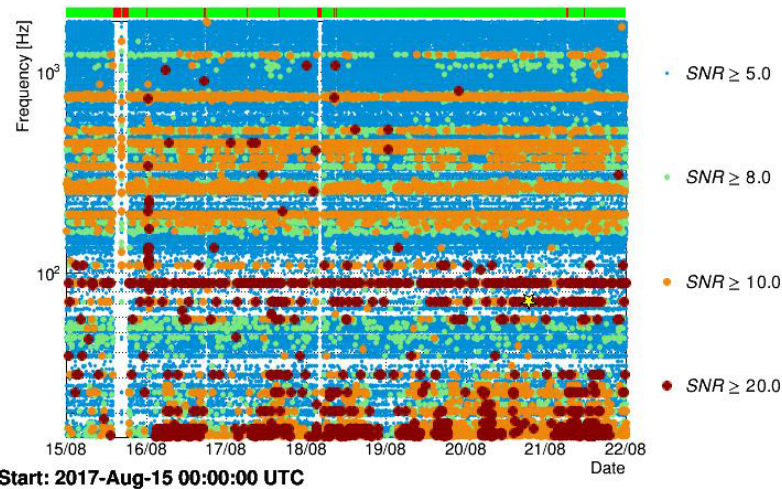
V1:Hrec_Range_BNS__TIME



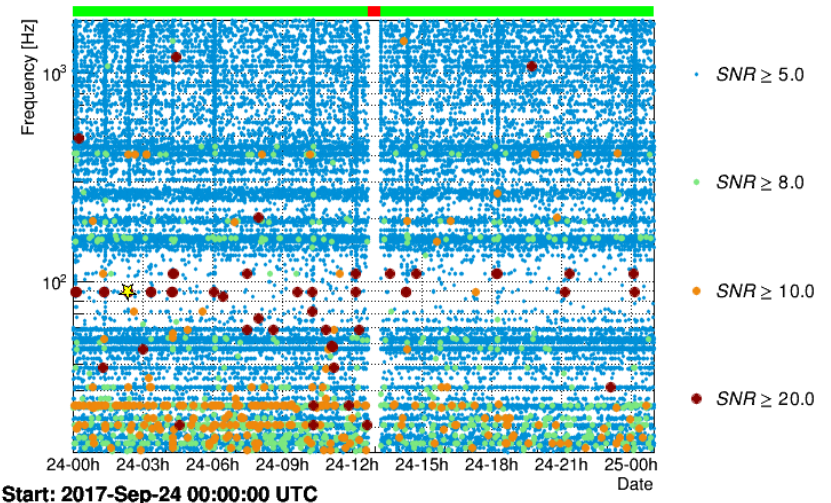
Main results of the post-O2 commissioning

- ▶ Limited BNS range improvement
 - Maximum value reached around 30 Mpc
 - Mean O2 range: 26.5 Mpc
- ▶ Glitch rate much reduced

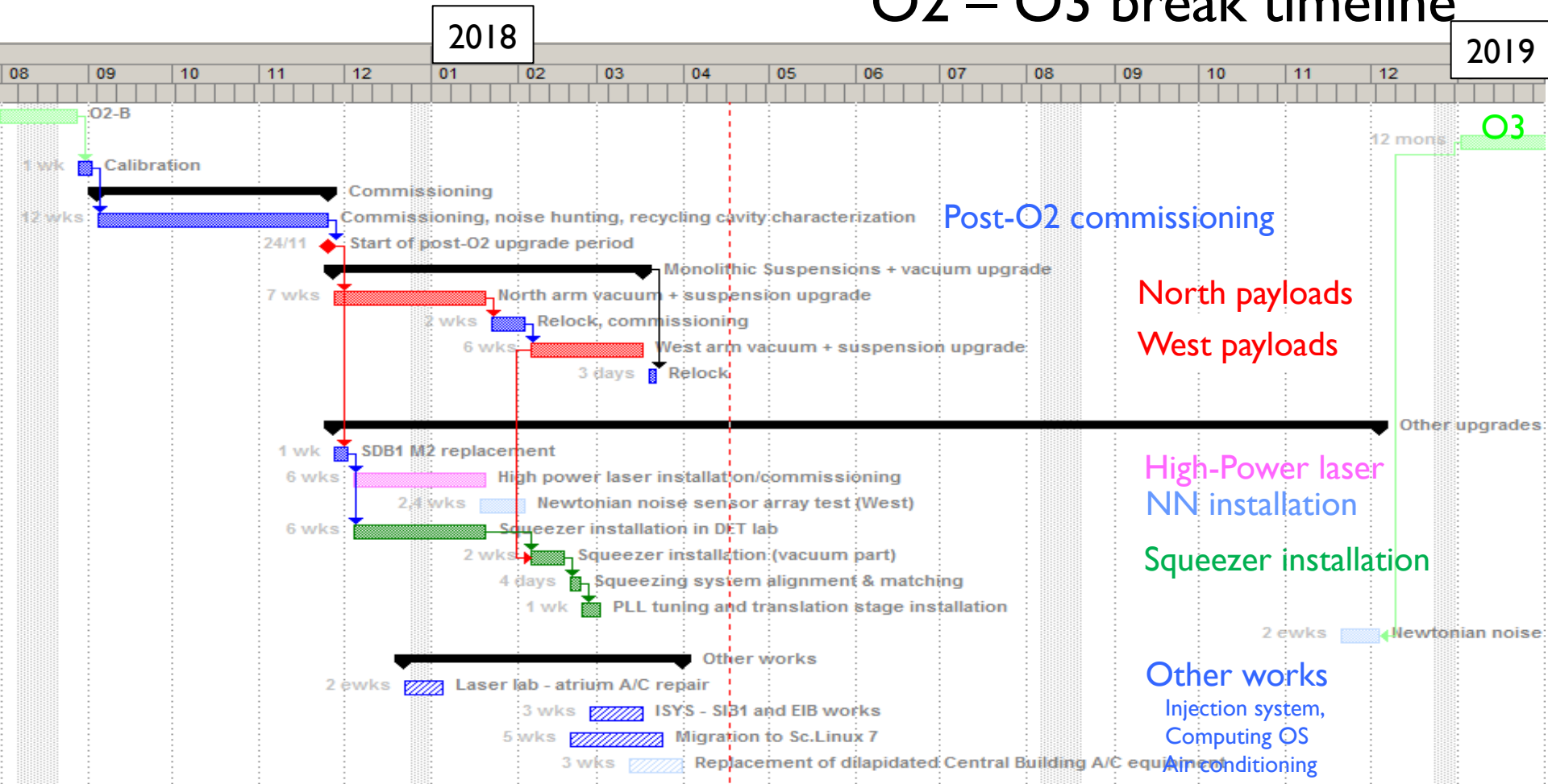
V1:Hrec_hoft_16384Hz: cluster frequency vs. time



V1:Hrec_hoft_16384Hz: cluster frequency vs. time



O2 – O3 break timeline



Vacuum chamber upgrades



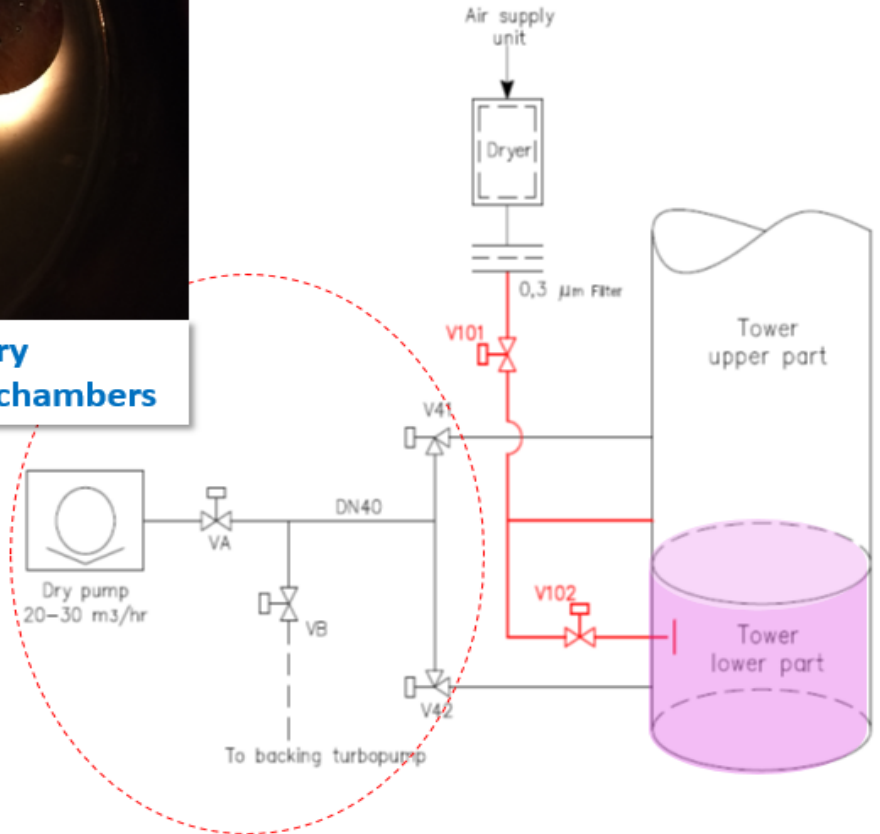
1) Venting circuit separation



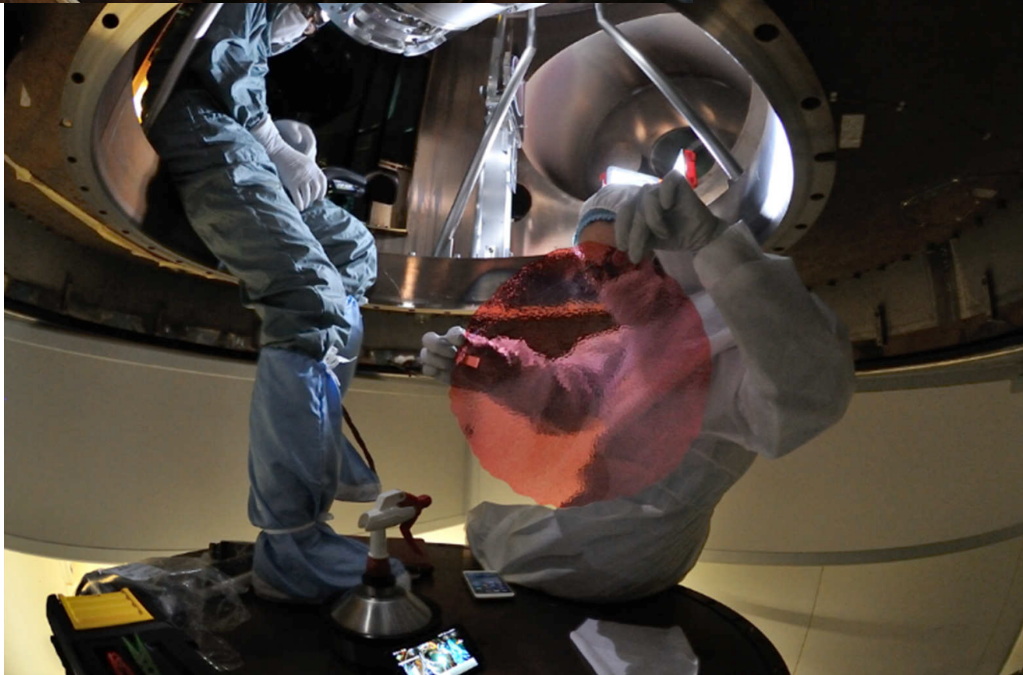
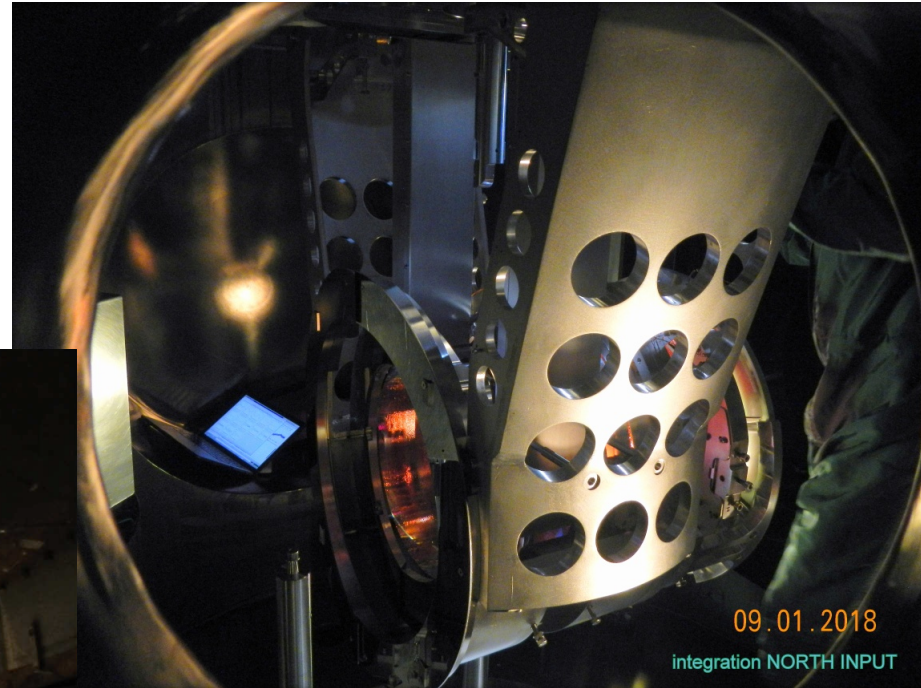
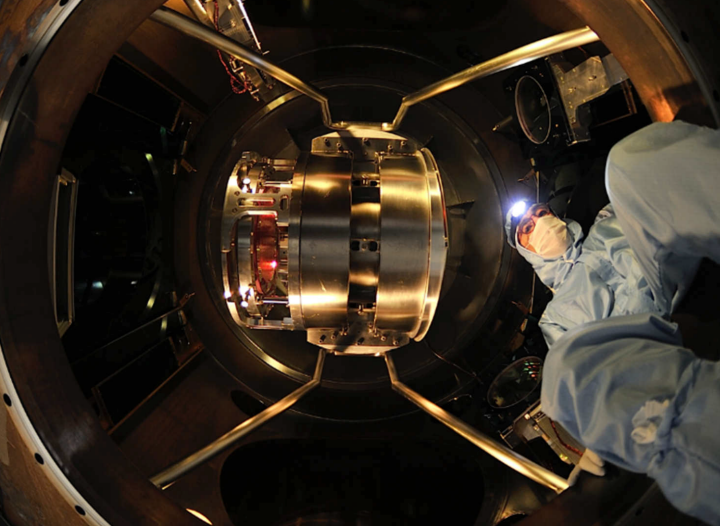
3) Extraordinary cleanliness of chambers



8 2) Scroll pump substitution



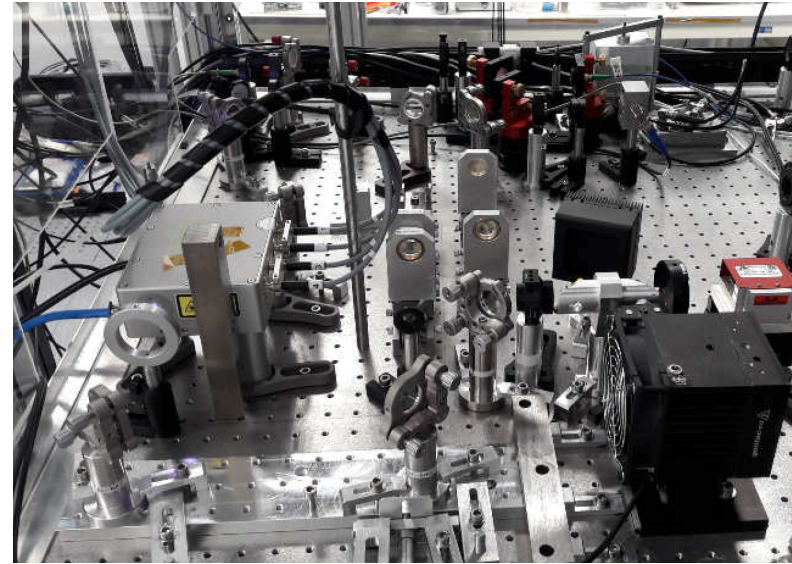
Monolithic suspensions are back



- ▶ Done in less than four months
 - Arm valves closed on Nov 27, reopen March 19
 - Include two weeks of commissioning
 - Faster than scheduled

Laser improvement

- ▶ 70 W amplifier replaced by a 100 W
 - Max input power in the ITF: around 50 W
 - 100 W fiber laser tests ongoing at Nice
- ▶ New pre-mode cleaner
- ▶ External Injection Bench “suspended”

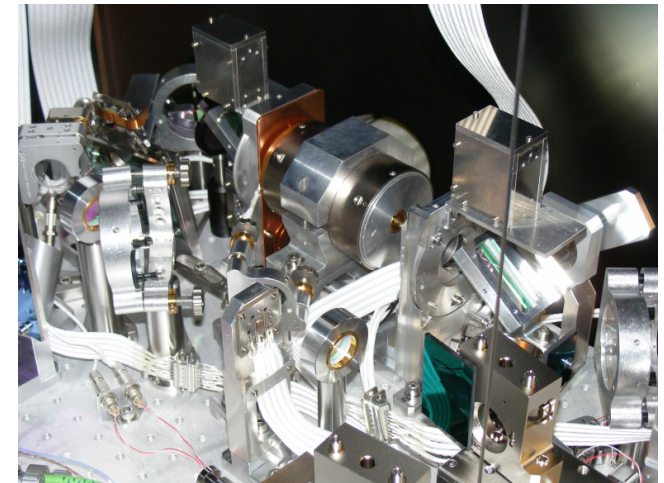


Squeezing

- ▶ AEI squeezer box installed at Virgo
 - About 10 dB of squeezing
- ▶ Integration
 - Extra clean air, cabling, DAQ,...
 - Telescope, auto-alignment alignment
 - Lock main squeezer laser to AdV laser
 - Detection system modifications
 - ▶ New Faraday isolator, extra flange...
- ▶ Maximum possible HF gain: 4.7 dB

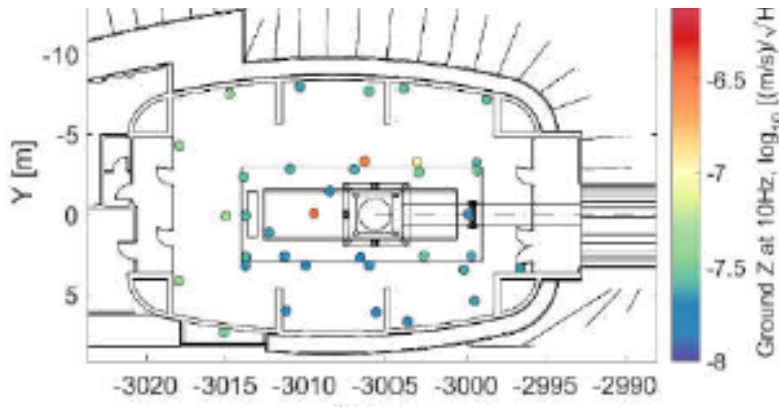
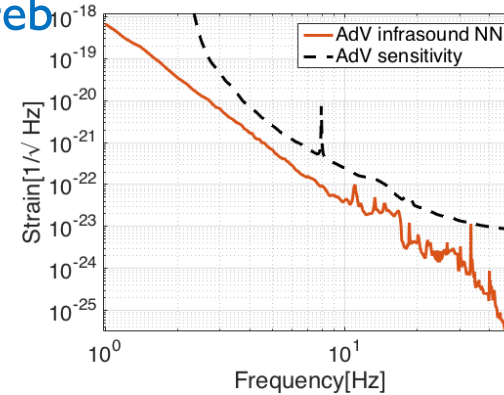


	Loss Mechanism	Present (O2)	Expected (O3)
L1	Imperfect OPO Escape Efficiency	1 %	1%
L2	Pick-off on SDB1	1.5 %	1.5%
L3	Detection Faraday	2×7%	2×1.5%
L4	Injection Faradays	4×1.5 %	4×1.5 %
L5	OMC throughput	3.9%	3.9%
L6	ITF to OMC losses	5.4%	4.5 %
L7	Mode matching squeez- OMC	8%	8%
L8	Photodiodes QE	7%	1%
L9	Arms cavity losses	2.7%	2.7%
L10	Other	6%	6%
	TOTAL	44%	32%



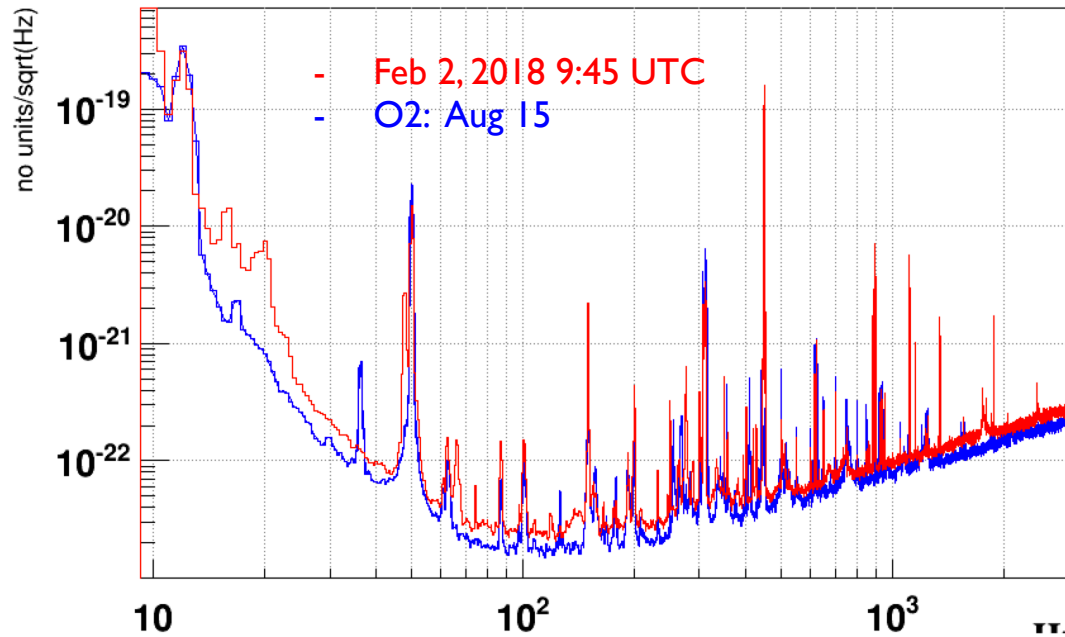
Newtonian Array

- ▶ Array of 38+9 sensors installed at west end building
 - Two weeks of data collected in Jan-Feb
 - Analysis on going
 - Sound NN as large as seismic NN
 - ▶ High sound level in Virgo building



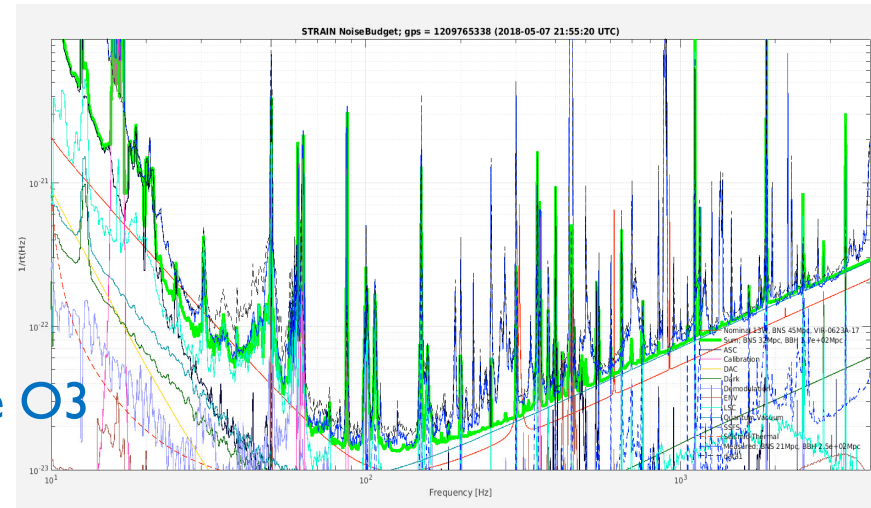
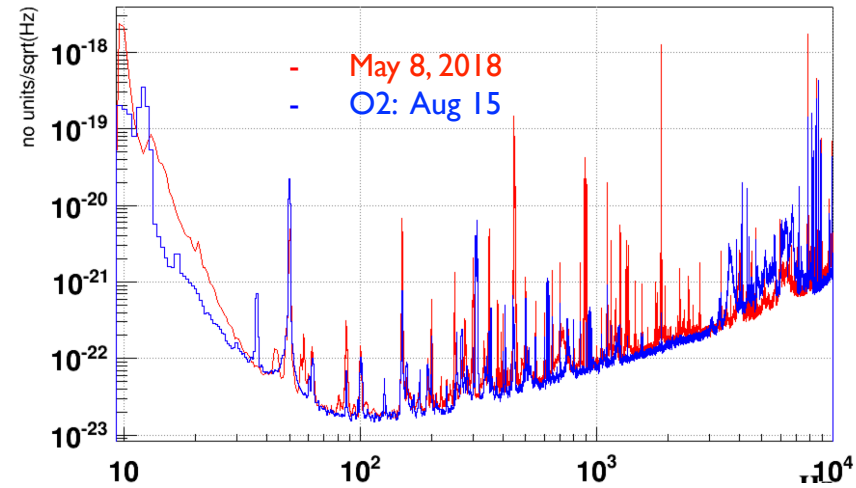
The first recovery after North Arm upgrade

- ▶ Two weeks of recovery; manage to lock the full ITF
- ▶ Sensitivity reached a few hours after the full relock: 19 Mpc
 - New violins modes well visible
 - ▶ Losses larger than nominal but should not limit the O3 sensitivity



The second recovery

- ▶ Took a bit longer than expected...
 - Arm valves reopen on March 19
 - Other activities than just ITF recovery
- ▶ Back in “low noise 3” on May 2nd,
 - First BNS range: 19 Mpc
- ▶ Reach up to 25 Mpc
 - Preliminary calibration
- ▶ First noise budget
 - Touching steel wires thermal noise ?
- ▶ Back to commissioning
 - No major shutdown scheduled before O3



Commissioning toward O3

► Commissioning

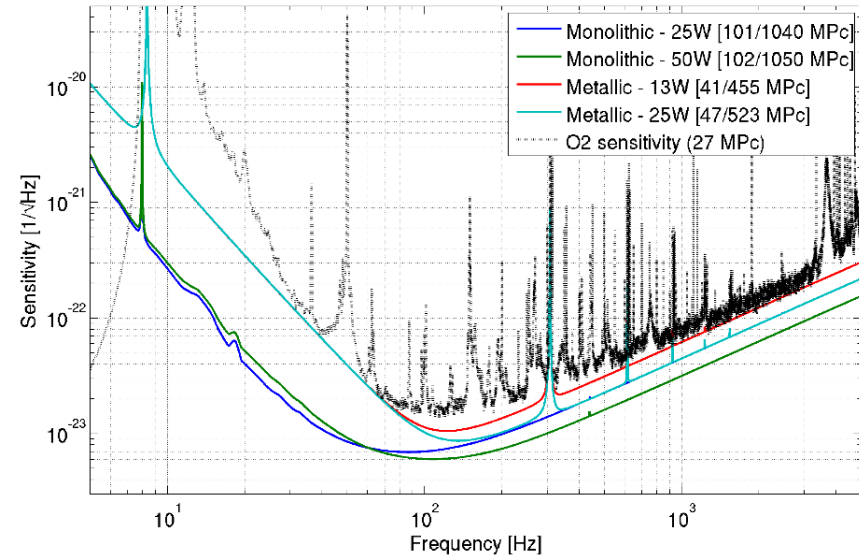
- Usual noises/glitches reduction
- Robustness
- Commissioning of the squeezer
- Power increase

- Max power for O3: 50W
 - Not critical for the BNS range...

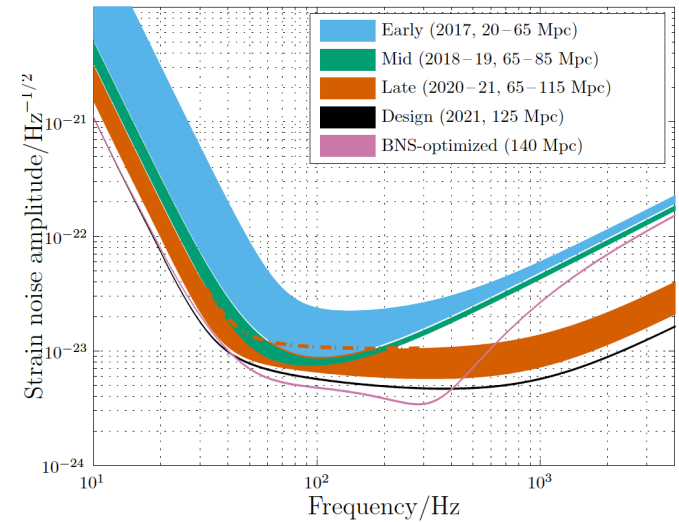
► Engineering Runs

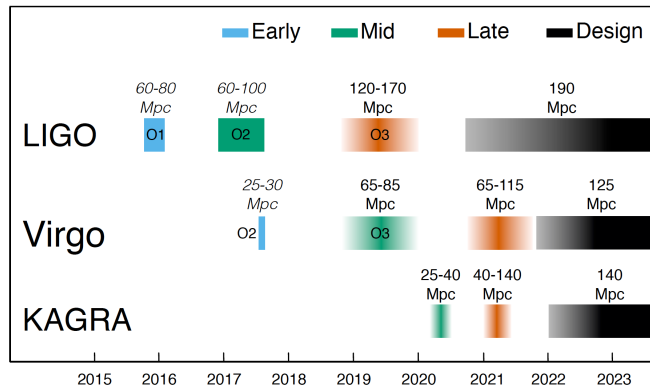
- Once per month over a weekend
- Long ER priori O3

► O3 start early 2019; aligned with LIGO



Advanced Virgo



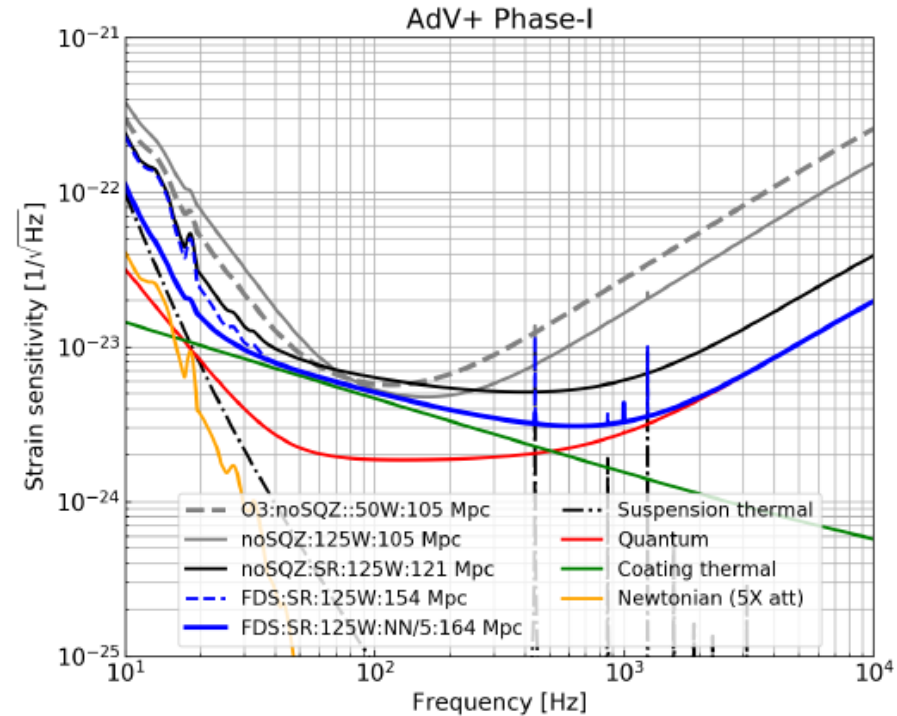
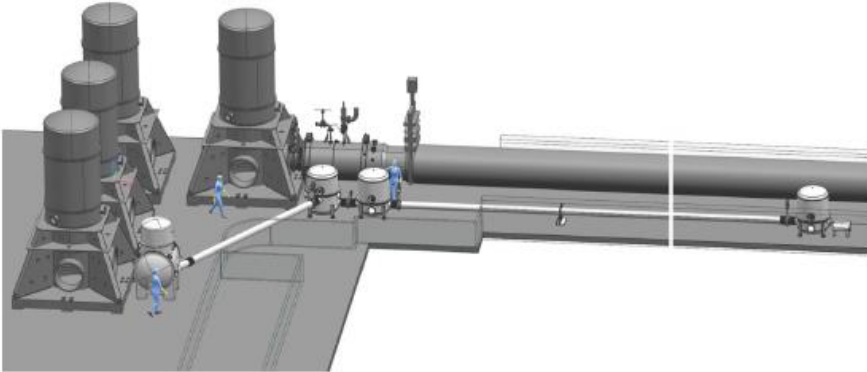


Beyond O3: AdV+

- ▶ Could we do better than AdV?
- ▶ AdV+ proposed to the EGO council last December
- ▶ A two steps approach:
 - For O4: Frequency dependent squeezing
 - ▶ Add a filtering cavity
 - For O5: Reduce the coating thermal noise
 - ▶ Larger beam: Four test masses or just the end test masses?
 - ▶ Improved coating
- ▶ More on the AdV challenges in Jerome's talks

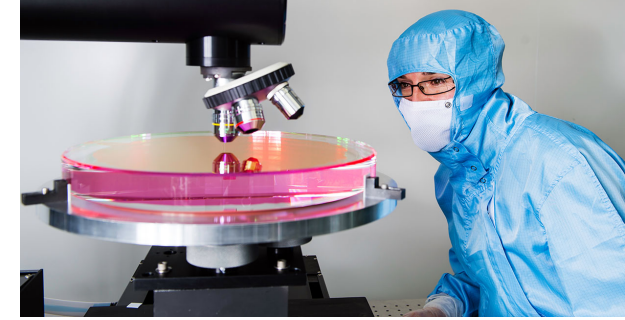
AdV+ phase I

- ▶ Complete the AdV program:
 - 200 W laser; 125W at the ITF input
 - Signal recycling \rightarrow 120 Mpc
- ▶ Frequency dependent squeezing
 - \rightarrow 150 Mpc
 - New filtering cavity



- ▶ Newtonian noise cancelation \rightarrow 160 Mpc

AdV+ Phase 2



▶ Larger mirrors

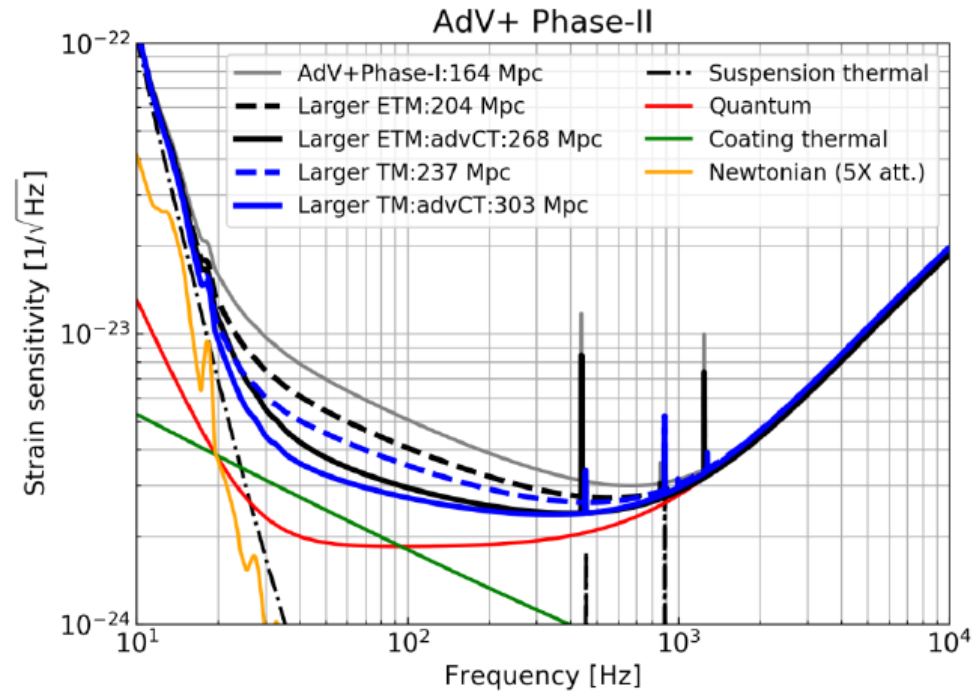
- Diameter: 550 mm, thickness: 200 mm, mass: 105 kg (?)
- Scenario 1: ETM-only → 200 Mpc
- Scenario 2: full upgrade → 230 Mpc

▶ Coating improvements

- If factor three reduction in CTN:
 - ▶ Scenario 1: ETM-only → 260 Mpc
 - ▶ Scenario 2: full upgrade → 300 Mpc

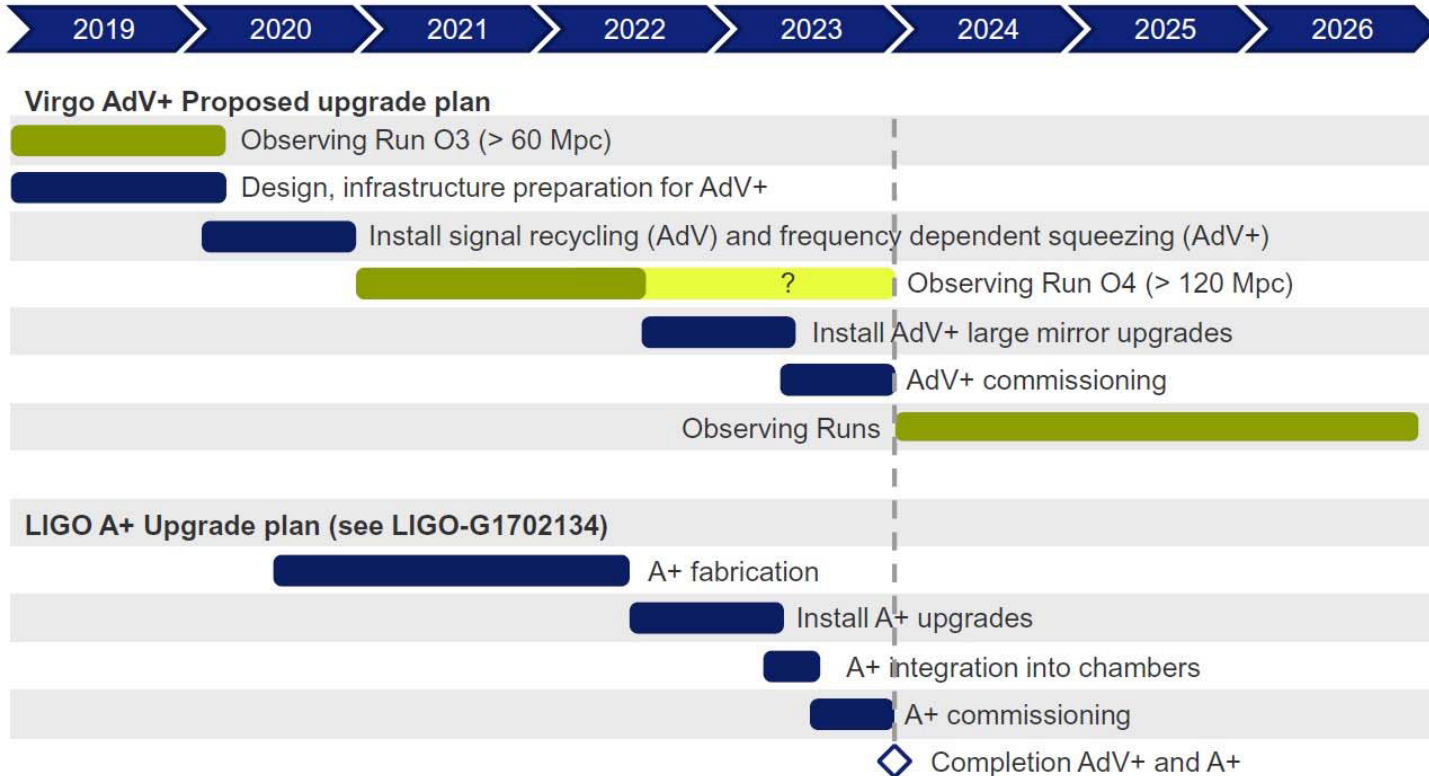
▶ Many challenges and activities

- Grand Coater upgrade
- Vacuum, infrastructure
- Payloads and superattenuators
- Aberration control



AdV+: Tentative timeline

Five year plan for observational runs, commissioning and upgrades



Note: duration of O4 has not been decided at this moment

Summary

- ▶ Main AdV upgrades for O3 are done
- ▶ Back to commissioning mode
 - Several months of commissioning foreseen
- ▶ AdV+ plan setup for after O3
 - Cost: up to 30 ME for full test masses upgrade
 - A very challenging phase II ...
 - Hope to get some approval during the June EGO council meeting