La stratégie d'upgrade d'Advanced Virgo: AdV+

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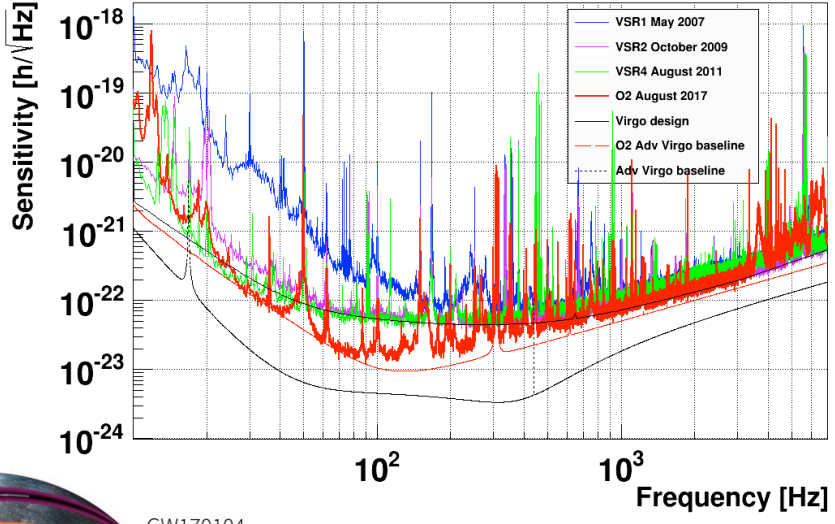
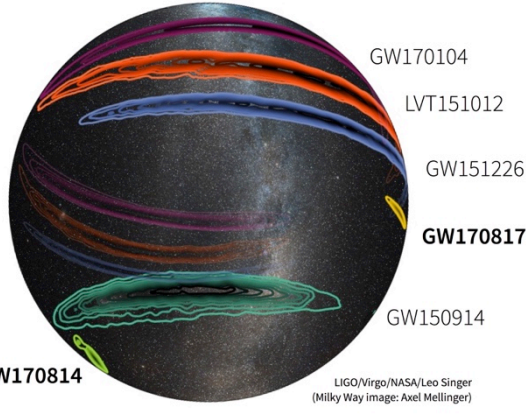
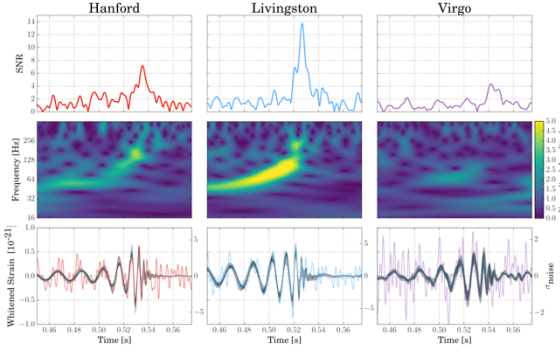
VIRGO

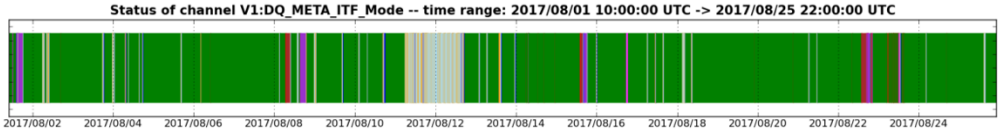
GW science is driven by detector progress

- Best BNS range for initial detectors
  - LIGO: ~ 20 Mpc
  - Virgo: ~ 12 Mpc
- Advanced detectors
  - LIGO O1: ~ 60-80 Mpc
  - LIGO O2: ~ 70-105 Mpc
  - AdV O2: 25-28 Mpc
- First detected BNS:
  - GW170817: BNS @ 40 Mpc
- First detected BBH:
  - GW150914: BBH @ 410 Mpc
  - GW170814: BBH @ 540 Mpc
  - BBH range: ~ 10 x BNS range



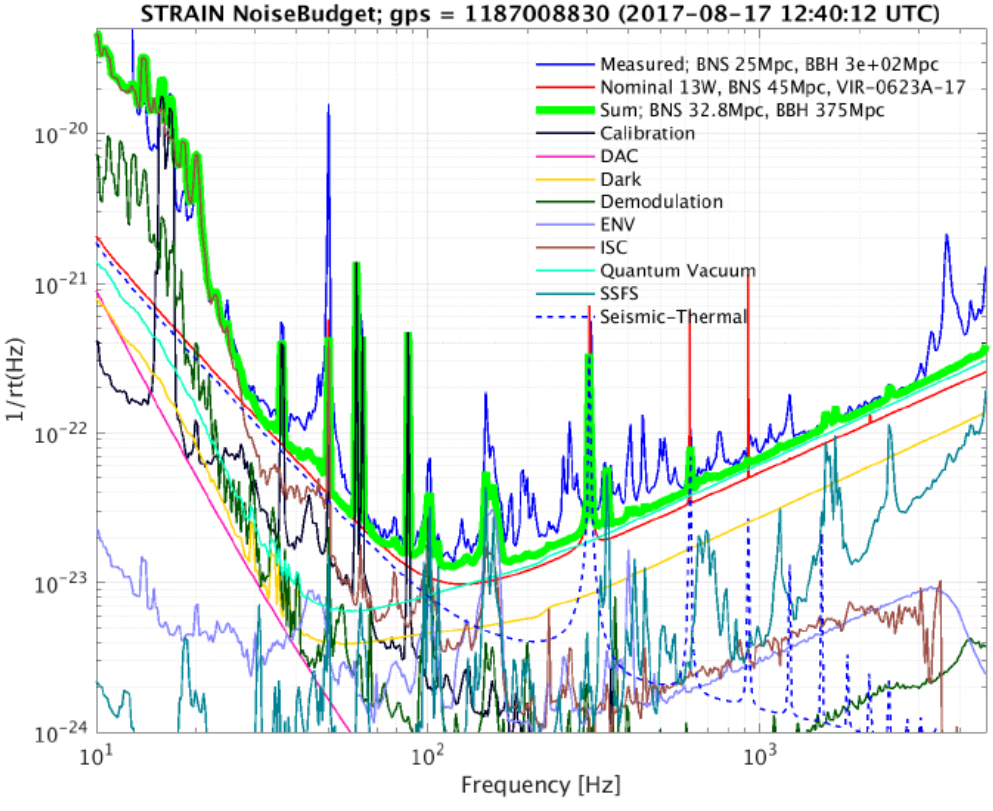




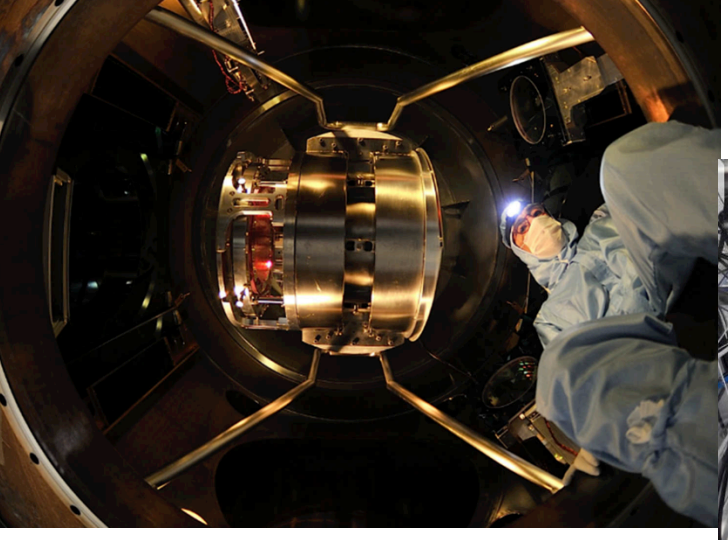


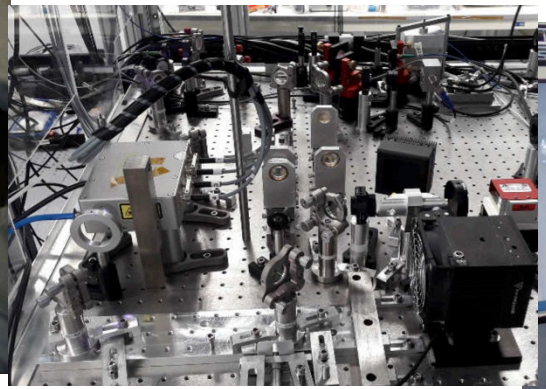
O2 Detector Summary

- Mean BNS range: 25-28 Mpc
  - Limit was 45 Mpc
- Noise budget
  - Many bumps and lines and some extra broadband noise
- 85 % duty cycle
  - Longest lock segment: 69 hours

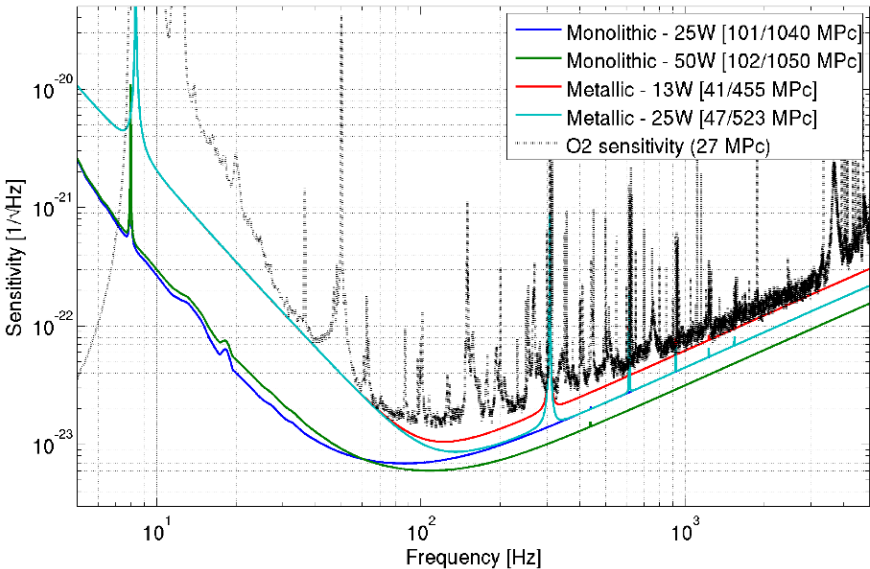


From O2 to O3



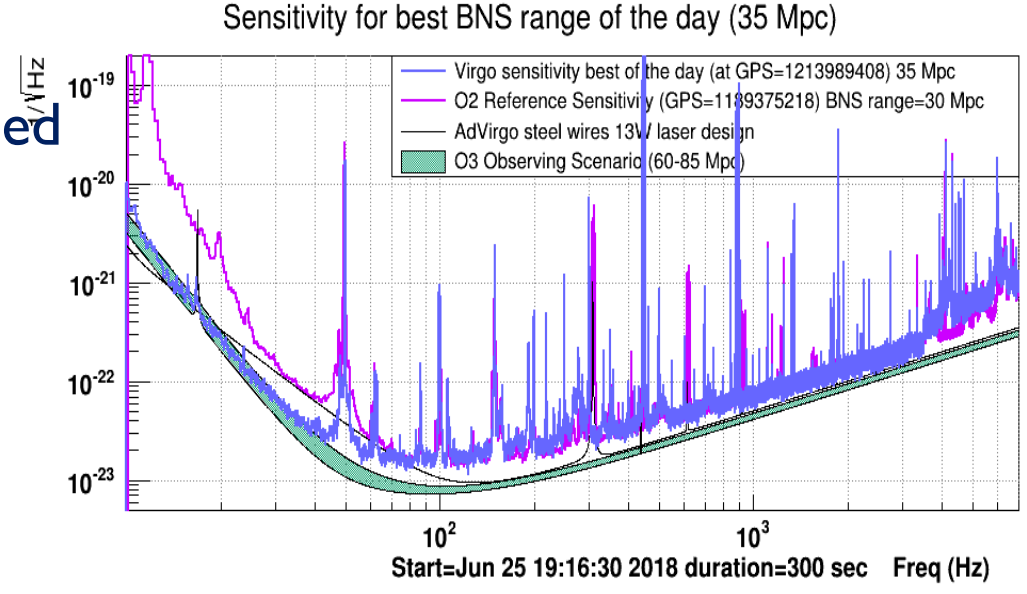


- Main changes
  - Monolithic suspensions
  - Laser power: 70 W → 100 W
  - Frequency independent squeezer
- O3 Goal: 60 Mpc
- Installation completed on April 19
  - Back to commissioning

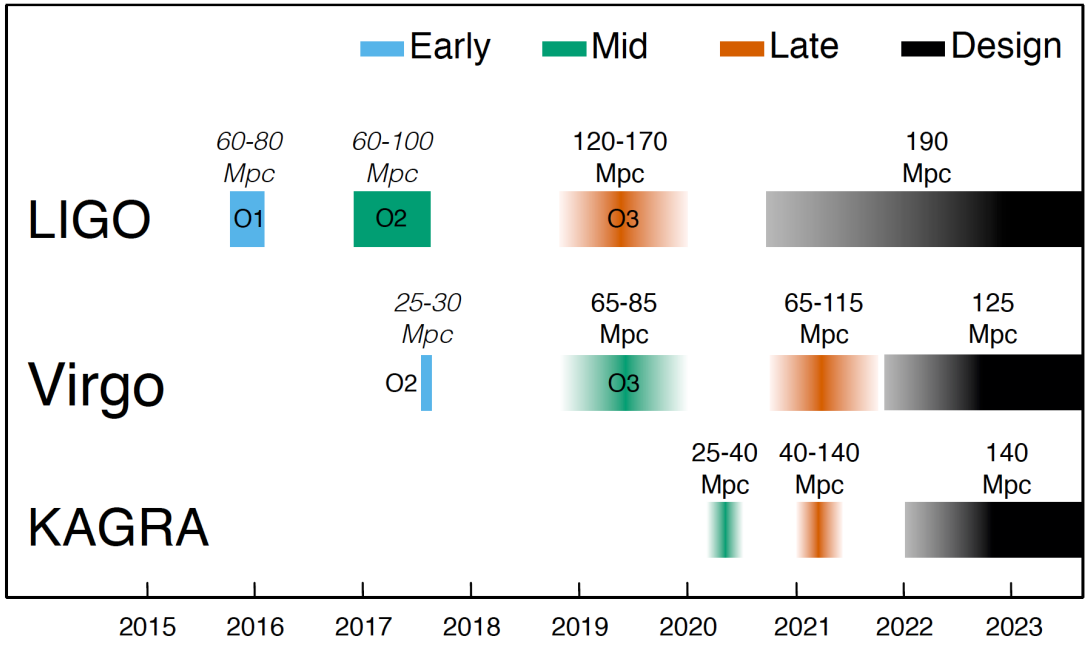


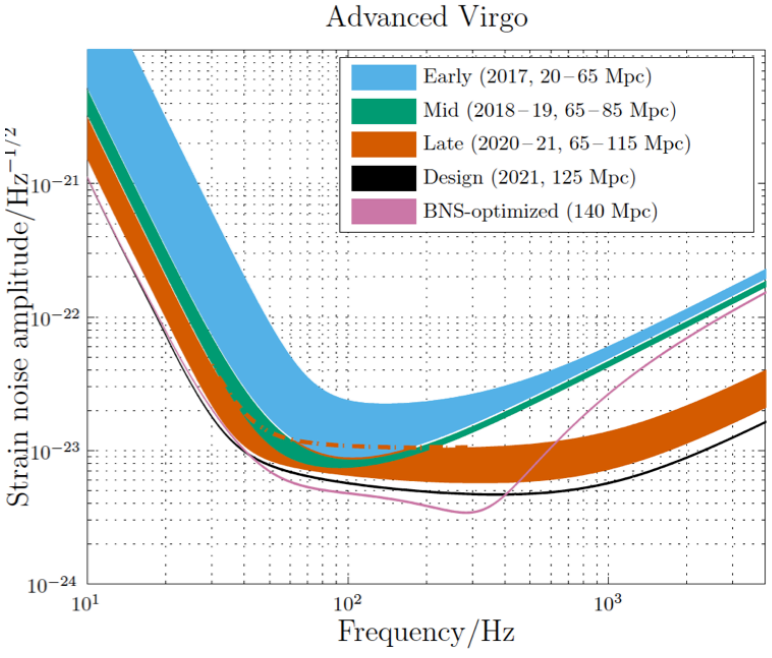
Toward O3: back to commissioning

- First: noise reduction at low frequency
  - Improvement observed
- Then injected power increased
  - From 13 to 25 W
  - Learning how to use it
- Next: using the squeezer
- Plus the usual:
  - Noises/glitches reduction
  - Robustness
- No major shutdown scheduled before O3
  - O3 start: Feb. 2019, aligned with LIGO



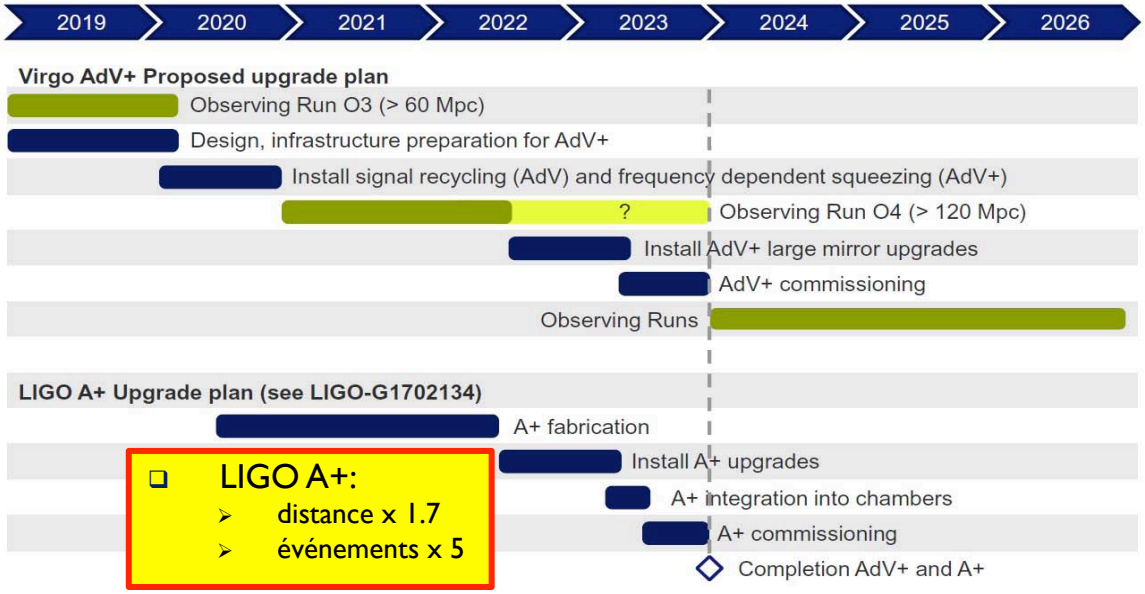
Beyond O3 ?



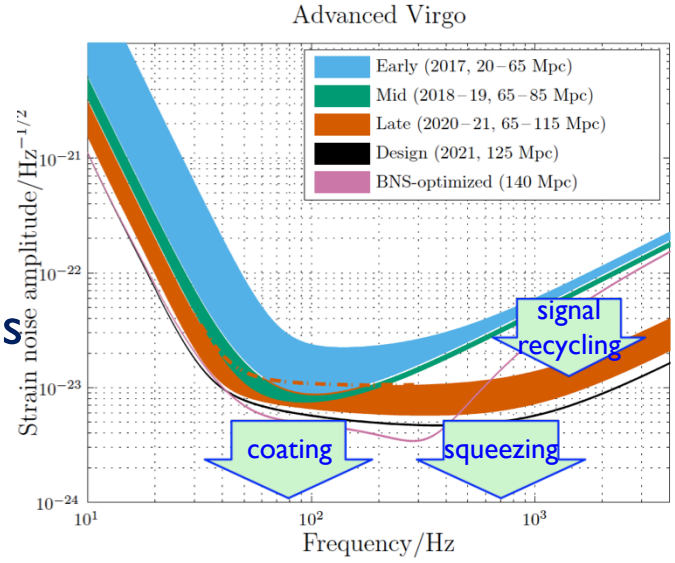


- AdV design range: 125 Mpc
- Could we do better than AdV?
- Could we stay competitive?
- Could we prepare the way to ET?

Beyond O3: AdV+

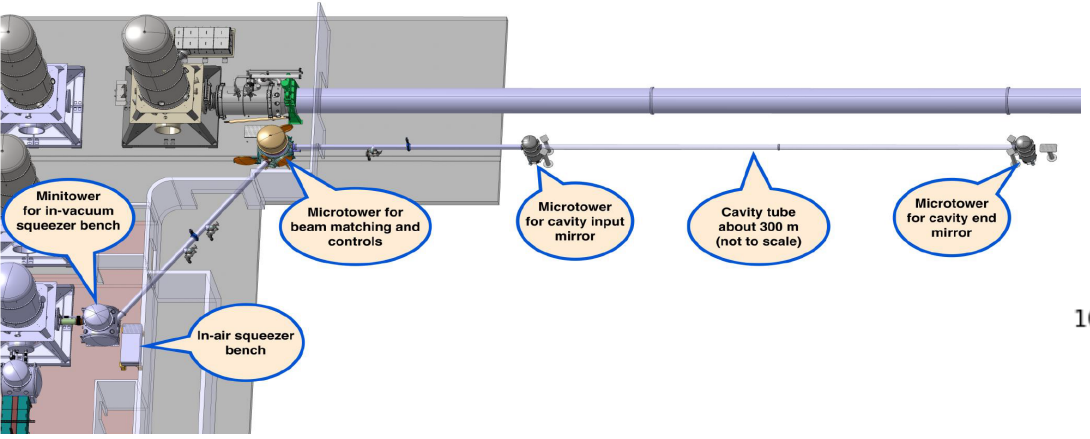


- LIGO A+:
  - distance x 1.7
  - événements x 5

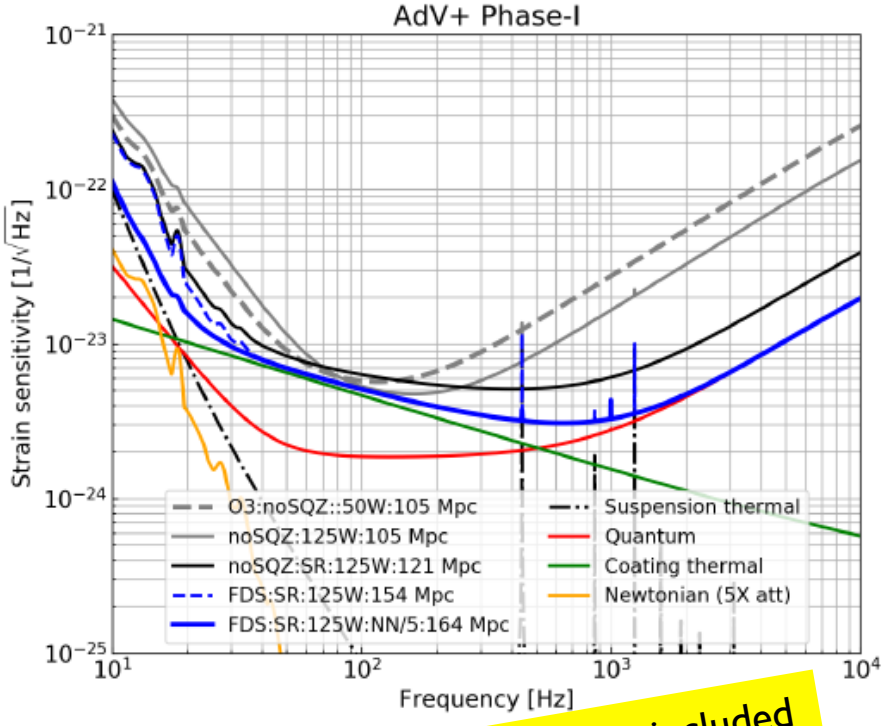


- Strategy: long observing runs and AdV+ upgrades
- A two step approach:
  - For O4: Frequency dependent squeezing
    - + Complete AdV: signal recycling
  - For O5: Reduce the coating thermal noise
    - Larger beam: Four test masses or just the end test masses?
    - Improved coating
- AdV+ proposed to the EGO Council last December

AdV+ phase I



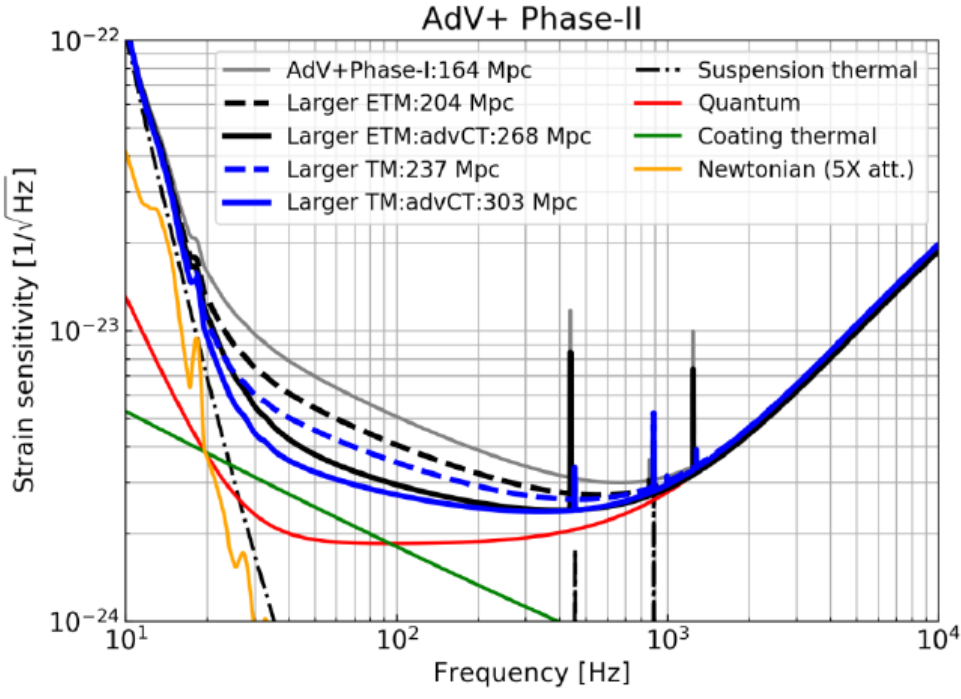
- Complete the AdV program:
  - 200 W laser; 125W at the ITF input
  - Signal recycling → 120 Mpc
- Frequency dependent squeezing
  - New filtering cavity
  - →150 Mpc
- Newtonian noise cancellation
  - →160 Mpc
- Target: O4 run



Warning: no "technical" noises included

AdV+ Phase II

- Larger mirrors/beams
  - 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+ upgrade budget

Phase	Item	Completed	BNS range [Mpc]	Cost [M€]
AdV-O3		2019	65 - 80	
AdV design	Tuned signal recycling + 125 W	2021	120	
Phase I	Frequency dependent squeezing (FDS)	2021	150	3.5
	Newtonian noise cancellation (NNC)	2021	160	1.0
Phase II	Scenario 1: Large mirrors, ETM-only (LM1)			11.7
	Scenario 1 net cost: FDS + NNC + LM1			16.2
	Contingency (20 %)			3.2
	Scenario 1 - ETM-only upgrade cost	2023	200 - 260	**19.5**
	Scenario 2: Large mirrors, full upgrade (LM2)			20.8
	Scenario 2 net cost: FDS + NNC + LM2			25.3
	Contingency (20 %)			5.1
	Scenario 2 - Full upgrade cost		230 - 300	**30.4**
	Risk reduction NDRC			8.5

- Not yet approved…

AdV+: a step toward 3G

- 3G detectors
  - Could see some sources all over the Universe
- Detector and Data Analysis challenges