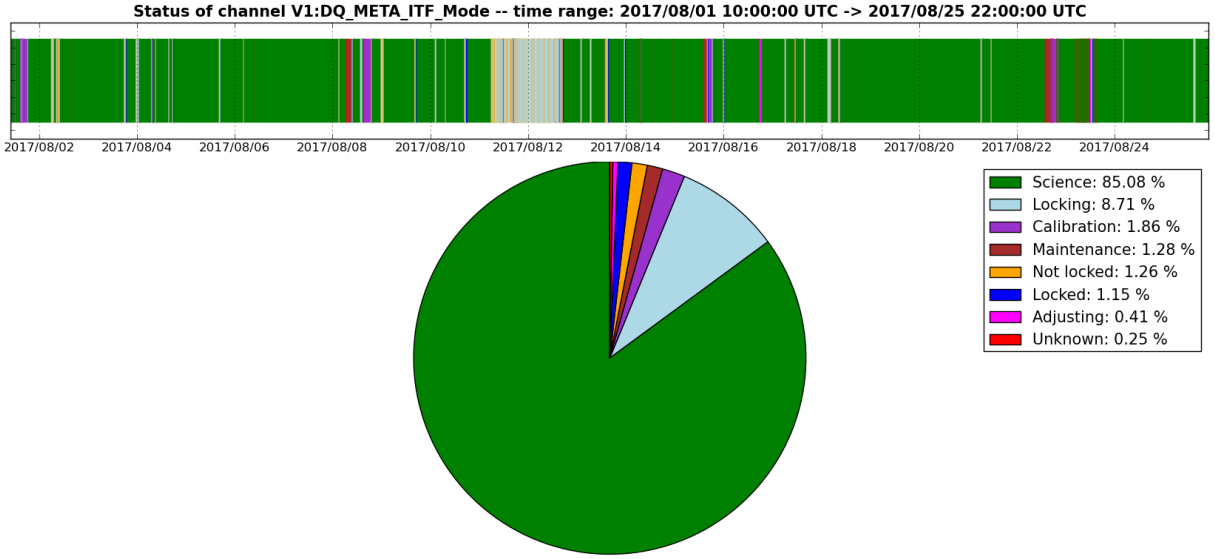
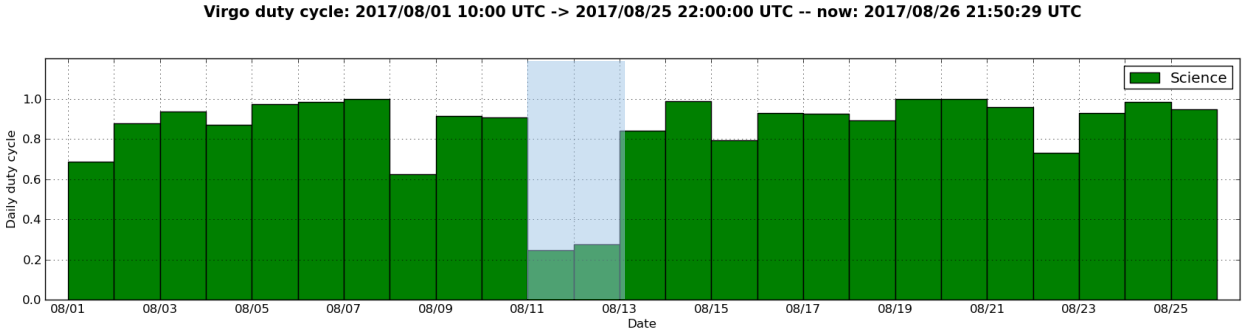
AdVirgo: status and commissioning

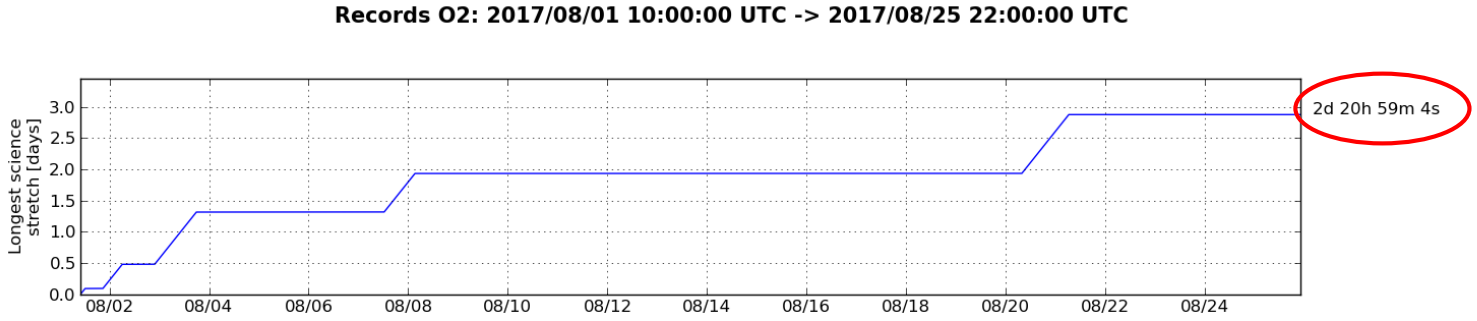
Alessio Rocchi

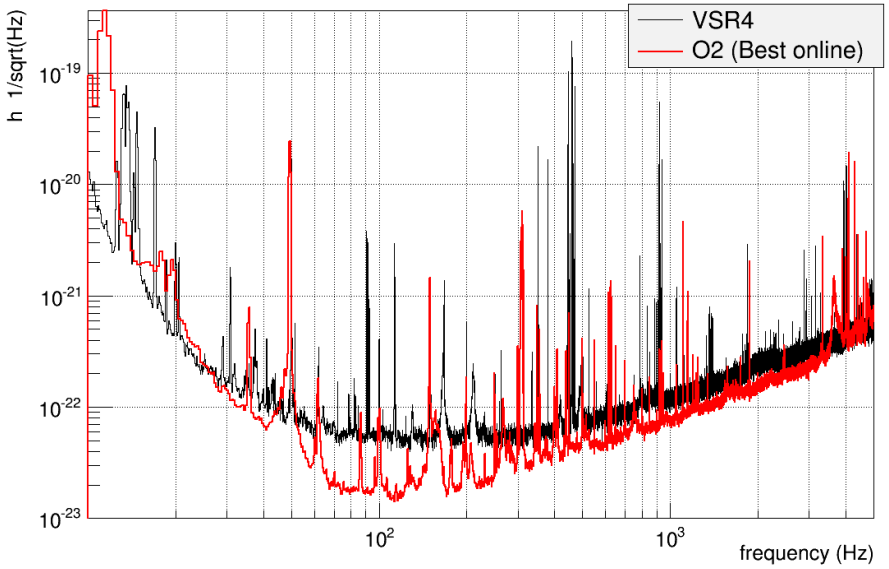
Commissioning Coordinator

O2 Virgo performance

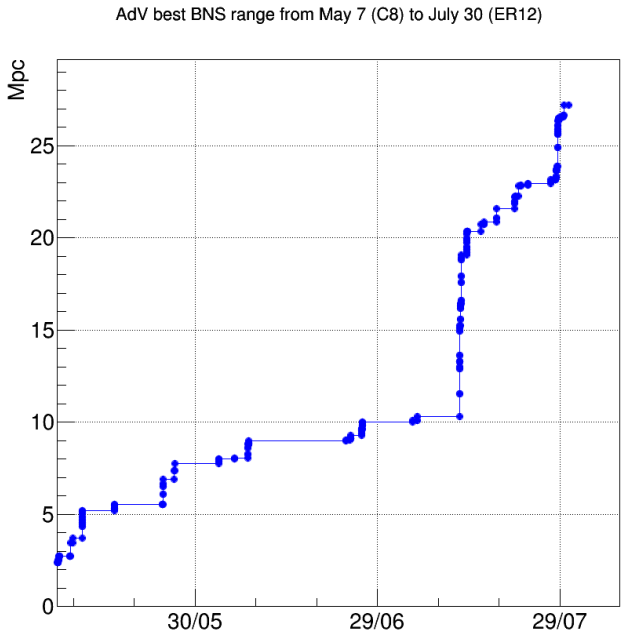


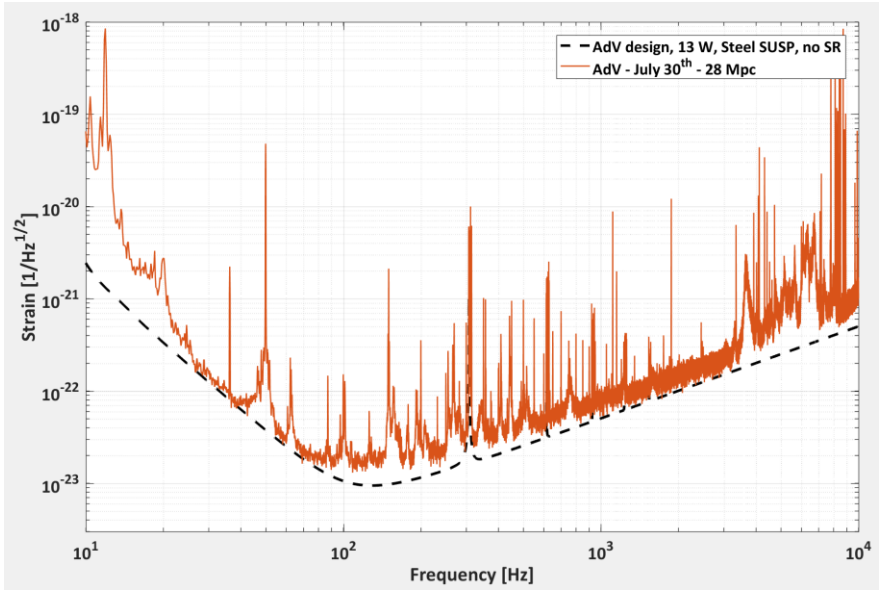


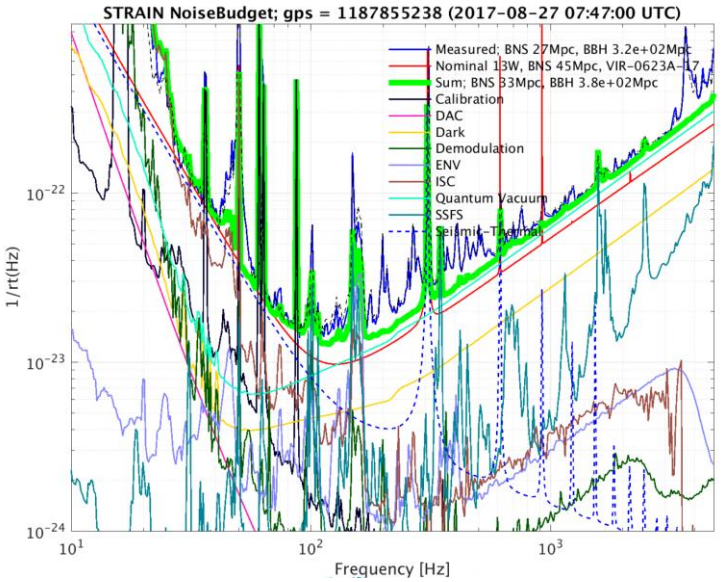


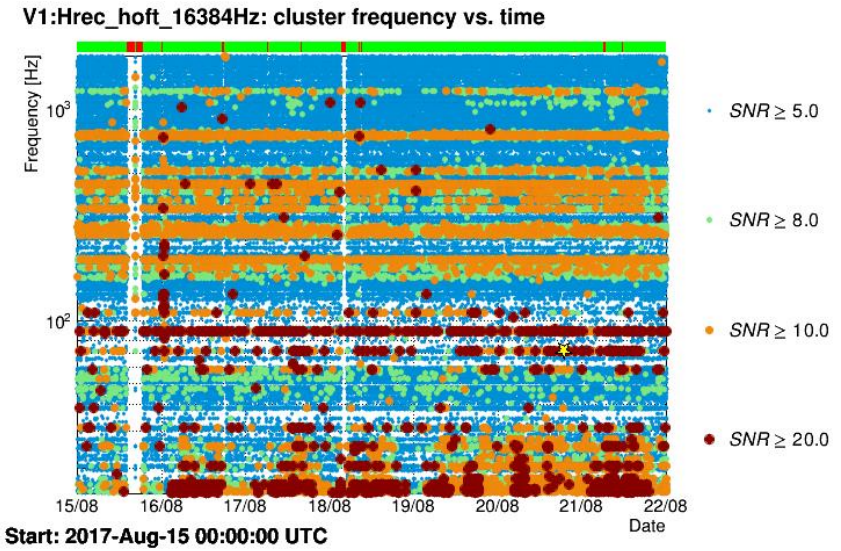


O2 Virgo performance



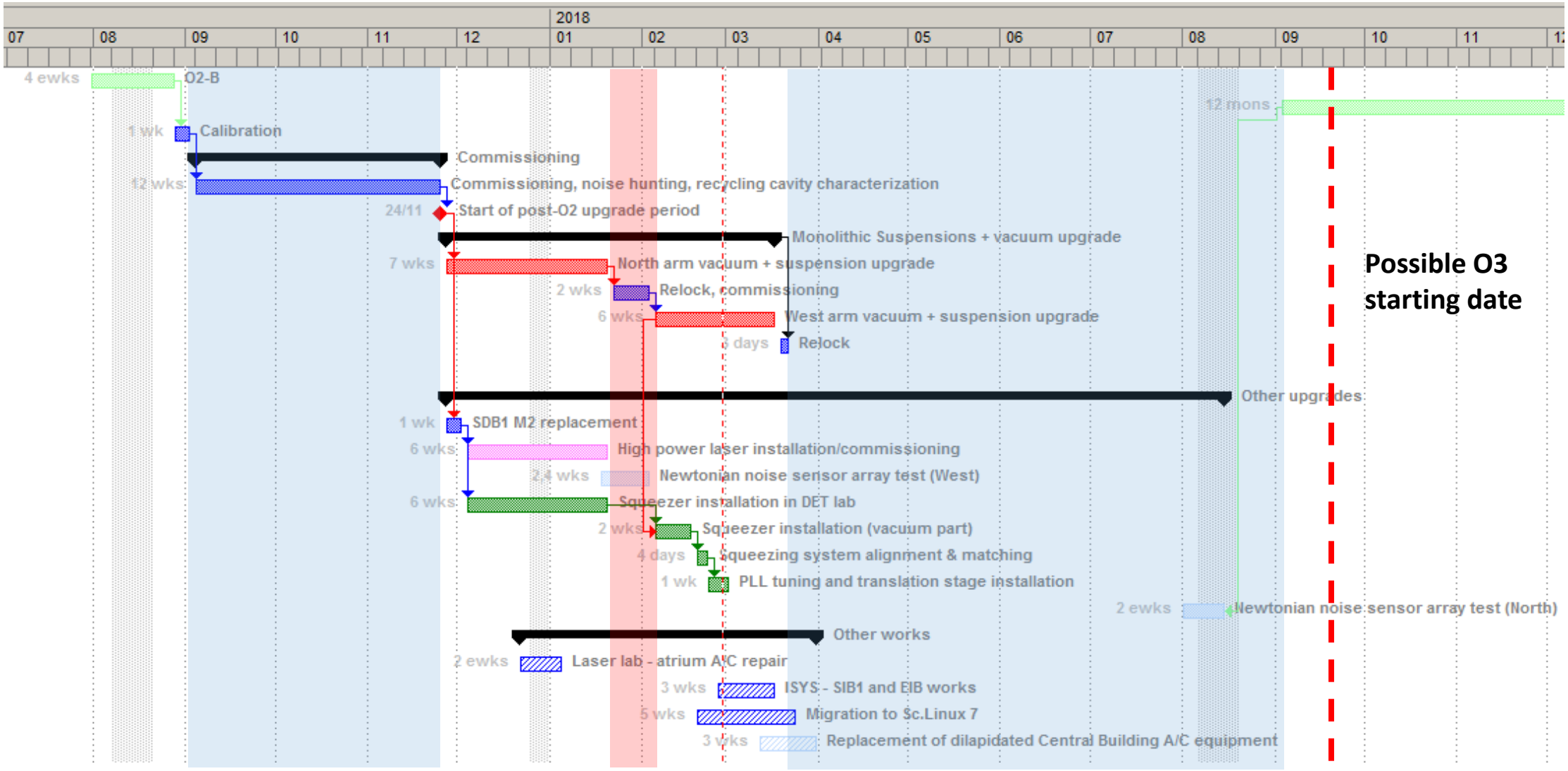






- Incredible rush to join O2:
  - "Temporary" ITF configuration;
  - Low input power;
- Too many glitches.

Activities since the end of O2

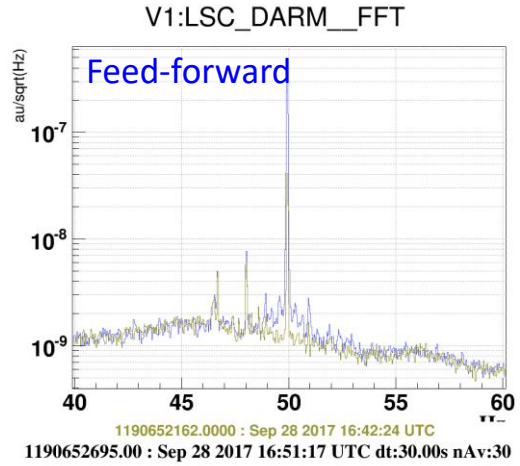


Fall 2017 commissioning

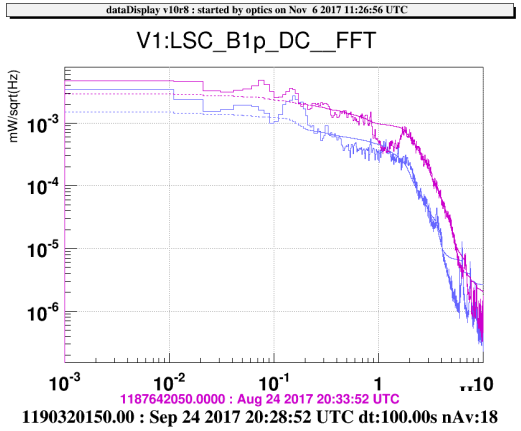
- Three months of commissioning after O2, with the goal to:
  - Better understand the current limits;
  - Carry on left-over activities from before O2;
  - Increase ITF input power to 25 W with TCS;

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



Differential(+) control filter optimized and the driving of the cavity modes (+-modes) has been improved using all the 4 mirrors to actuate



- Some of the main topics:
  - Interventions in SDB1 and PR towers:
    - Baffles installed;
    - Check issue with SDB1 MMT M2 mirror (replaced, see #40189);
  - **SUSP: GIPC now fully engaged**;
  - **ISC: AA in full bandwidth using quadrants (@ 56 MHz)**;
  - TCS: DAS optimized and tested;
  - ISYS/ISC/TCS: ITF input power increased to 26.5 W;
  - **ENV: noise injections and noise sources identification**.

Fall 2017 commissioning

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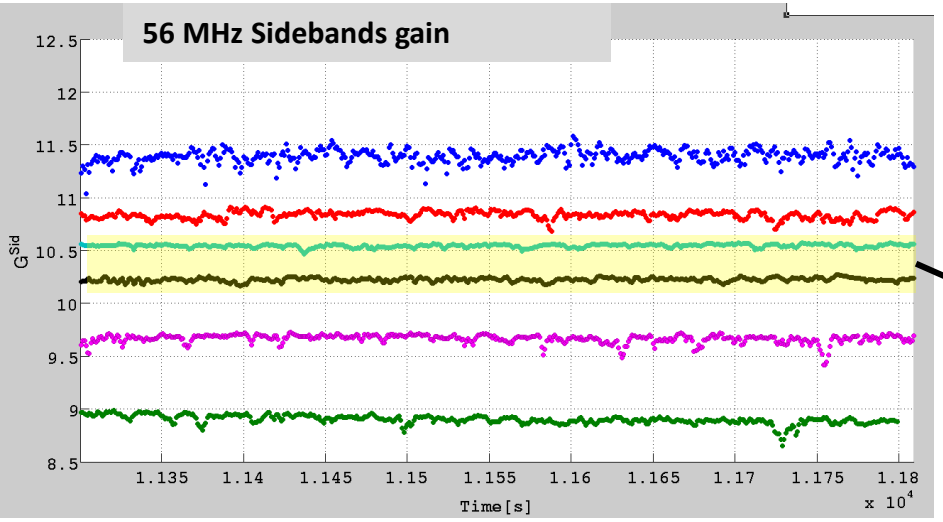

P=14 W
P=17 W
P=20 W
P=26.5 W

P=26.5 W
TCS ON

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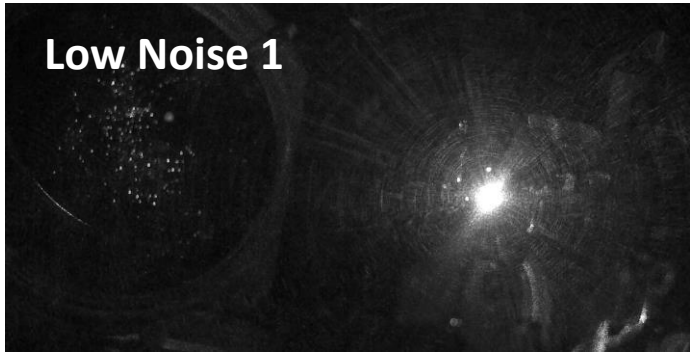
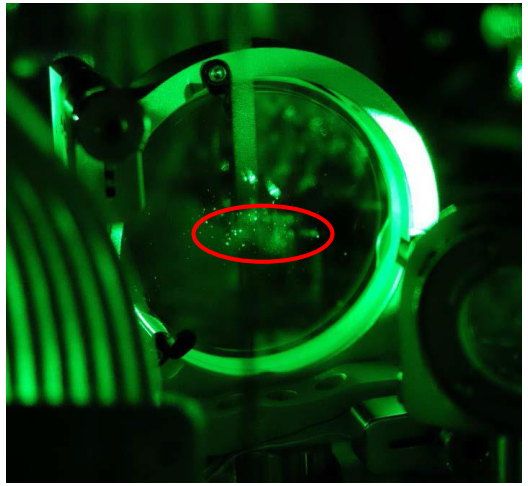
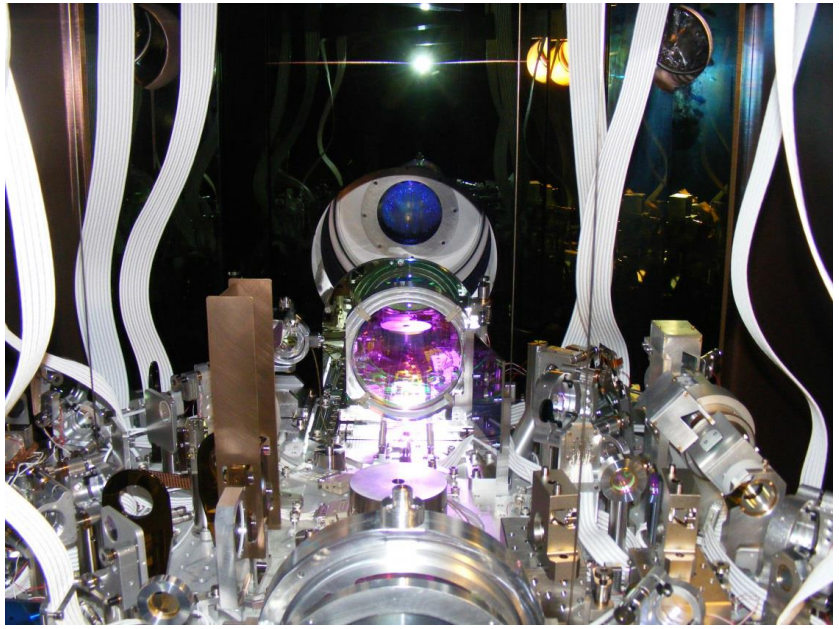
    - Baffles installed;
    - Check issue with SDB1 MMT M2 mirror (replaced, see #40189);
  - SUSP: GIPC now fully engaged;
  - ISC: AA in full bandwidth using quadrants (@ 56 MHz);
  - **TCS: DAS optimized and tested**;
  - **ISYS/ISC/TCS: ITF input power increased to 26.5 W**;
  - ENV: noise injections and noise sources identification.

SDB1 diffused light mitigation

- Detection tower opened during the week of October 9th;
- SDB1 optics shined with green laser:
  - Signs of dirtiness (not dust) on dichroic mirror and meniscus lens → cleaned
  - Scratch (not really…) identified on M2 parabolic mirror
- Baffles installed on the wall of the West flange of the DET tower
- M2 replaced (in tower);
- Scattering coefficient re-measured in February: reduction of a factor of 8.

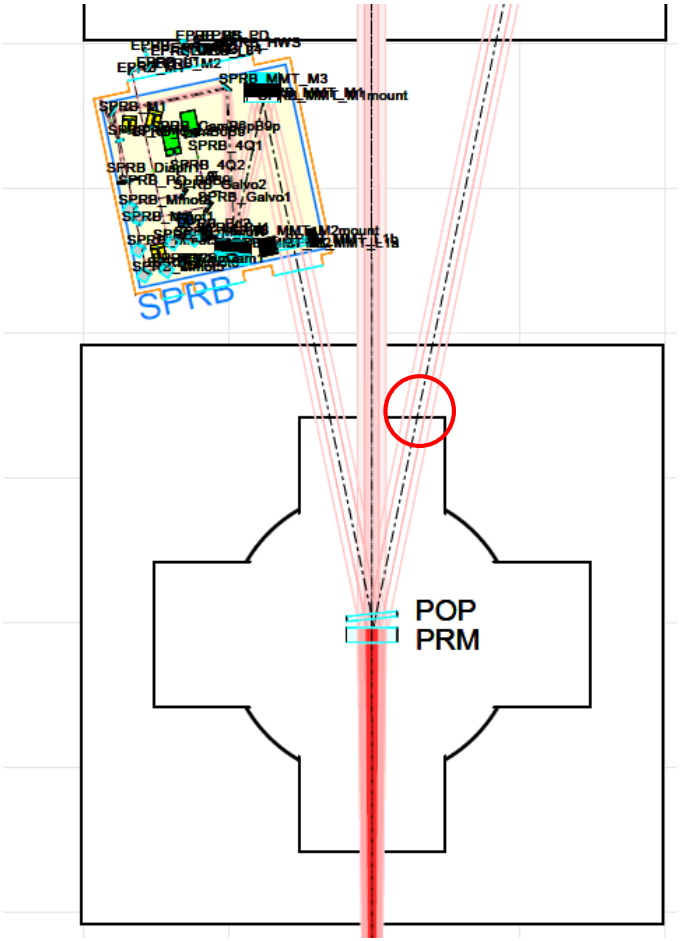




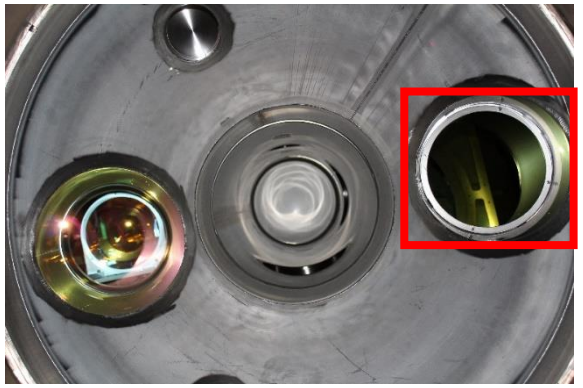


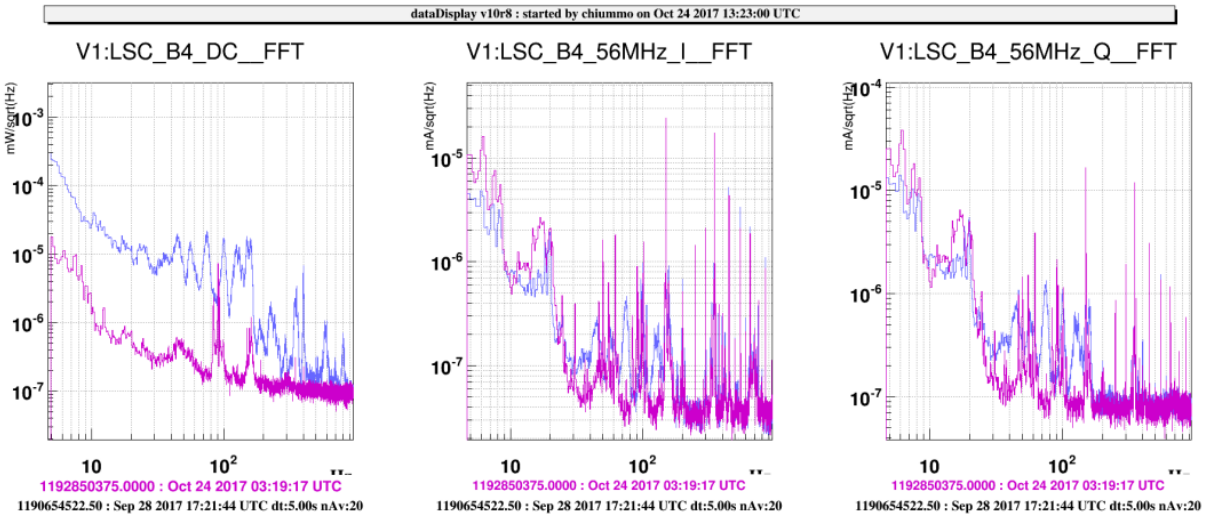
PR baffles installation

- Glass AR coated baffle on B4 ghost beam
- AR-on-steel baffles on PR-BS link



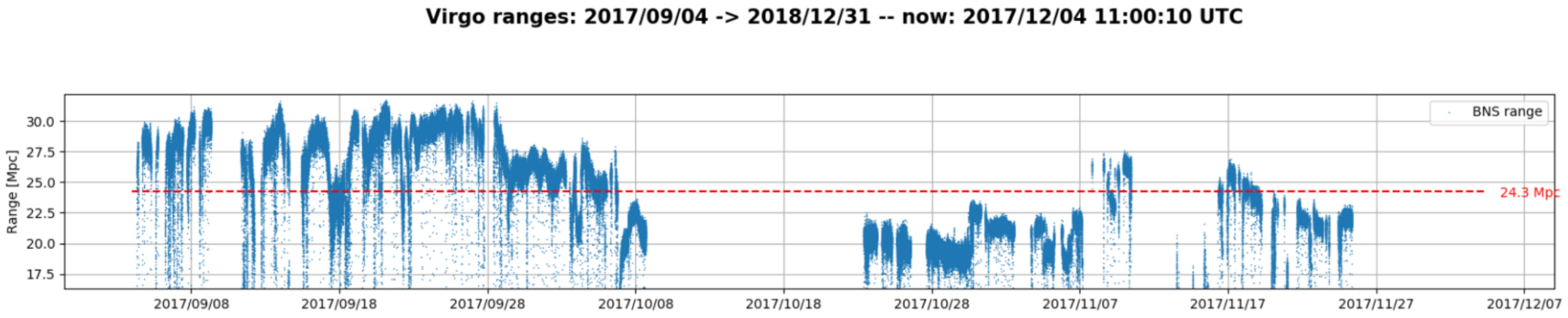
baffle installed on the blind flange



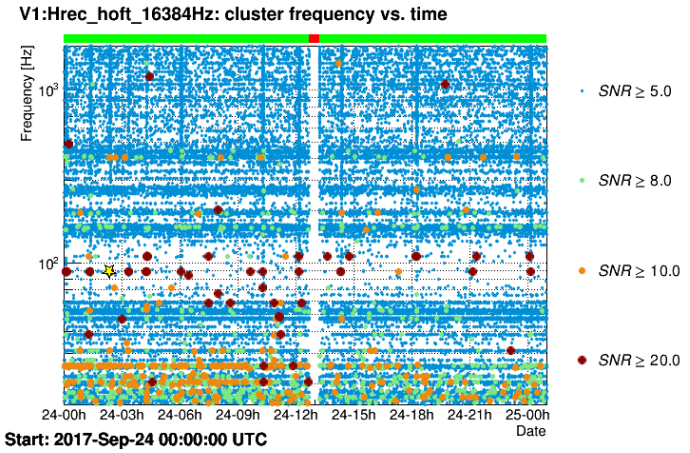


Noise level of B4 beams, MICH and PRCL is now lower by about a factor 10 for f<100 Hz (#39853)

Post-O2 BNS range

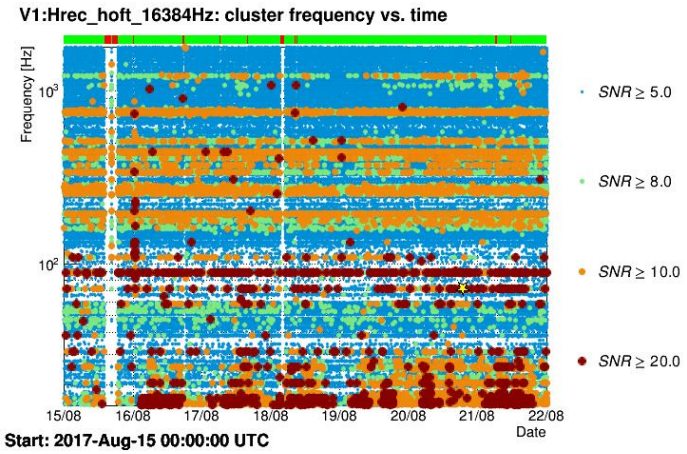


After O2



- BNS range peculiar evolution reflects this intense period of testing.
- About 4 Mpc gained (wrt O2), mostly due to improvements in angular controls.
- Glitch reduction wrt O2.

During O2

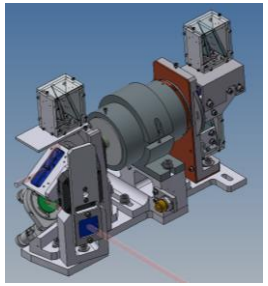


Main upgrades: Nov 2017-Mar 2018

- All test masses suspended with fused silica fibers;


The AEI squeezer installed in the DET lab

- On-site measured squeezing: around 10 dB;
- New Faraday Isolator on SDB1;

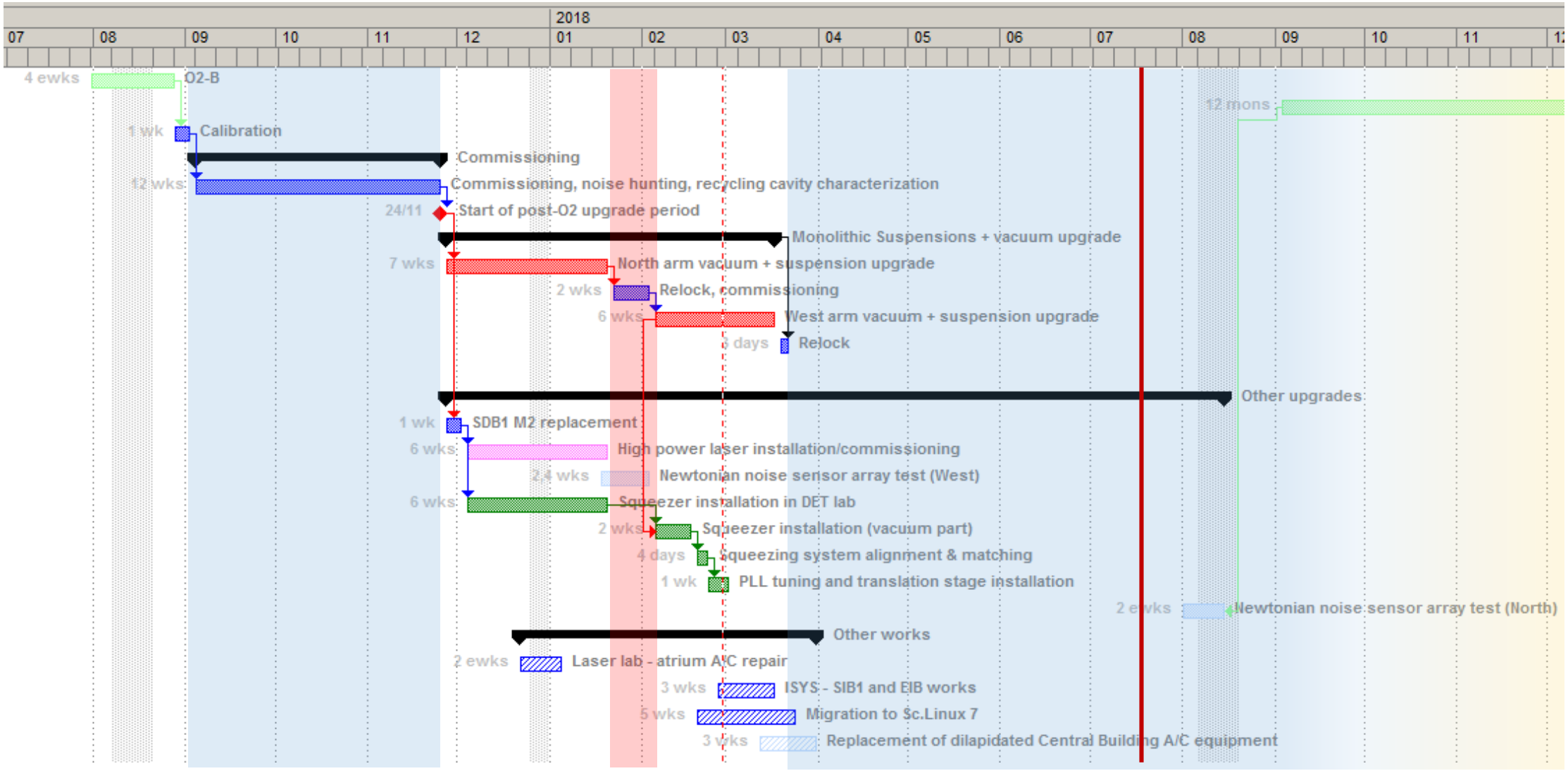



EIB suspended

- New high power laser amplifier: delivers up to 60 to the ITF (after the IMC);
- New monolithic pre-mode-cleaner.

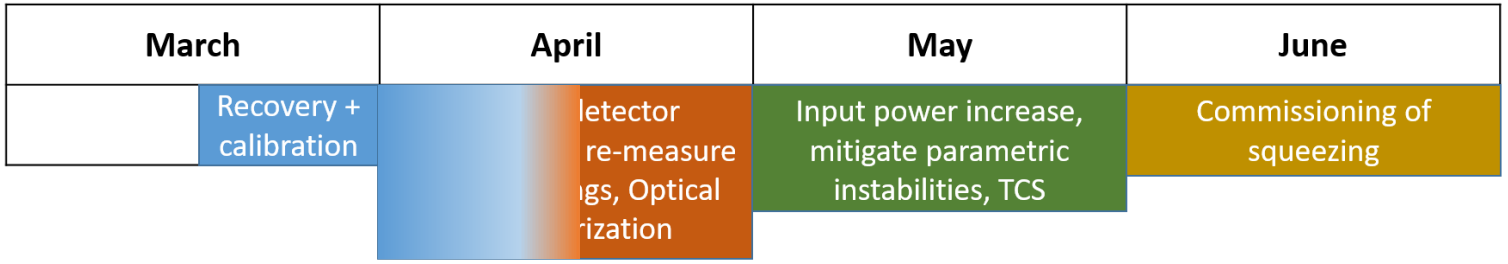

The 100W amplifier on the laser bench

Timeline since the end of O2

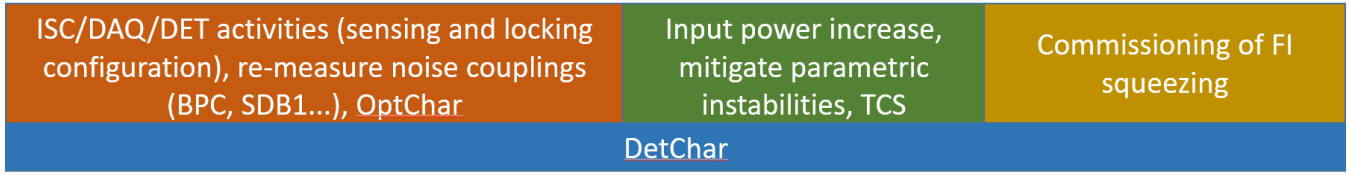


Pre-O3 comm. rough plan

- Valves opened on Monday **19th, March**;
- General plan, discussed in March, priority to problem solving activities
- Indeed, recovery went for the whole April and Low Noise operation recovered on **May 2nd**;



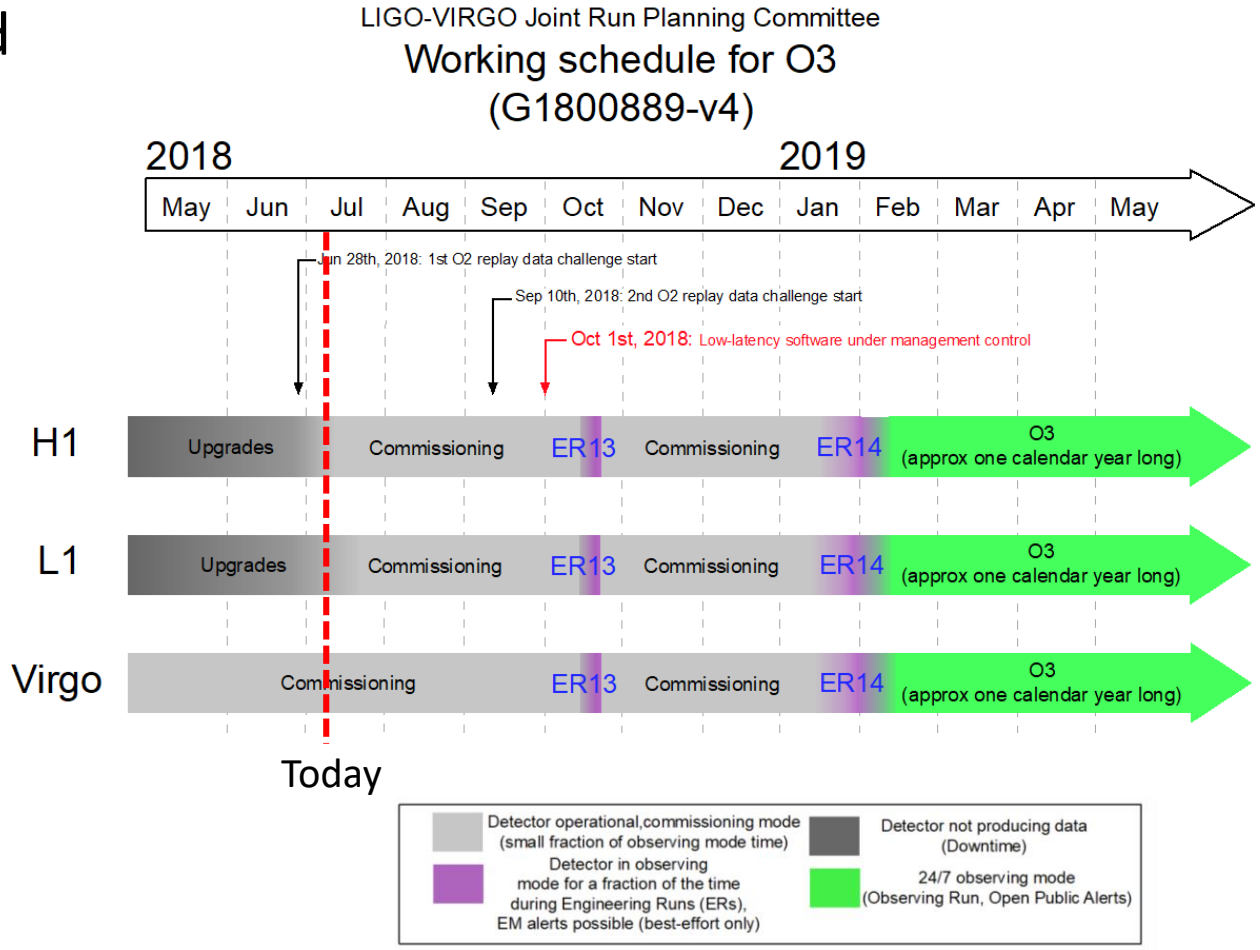
- Planning re-discussed with SSMs in May;



- Priority given to ISC/DET/DAQ/SUSP/ENV and OptChar activities to finalize ITF configuration and improve sensitivity;
- Progress on the other activities (TCS, SQZ…) need to be guaranteed, some shifts (**max. 4 per week**) may be allocated to these topics;
- One commissioning run per month;

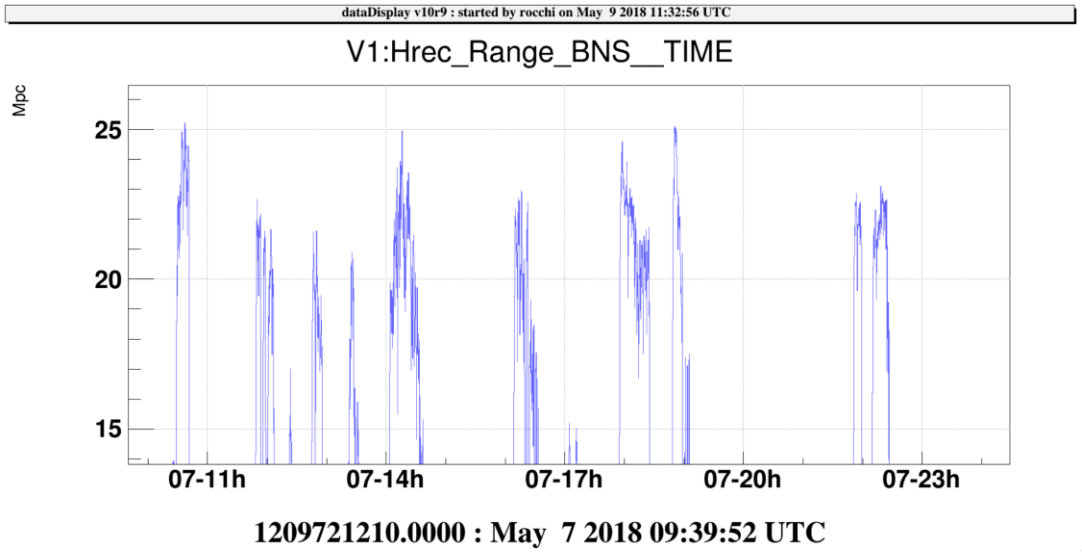
Pre-O3 comm. rough plan

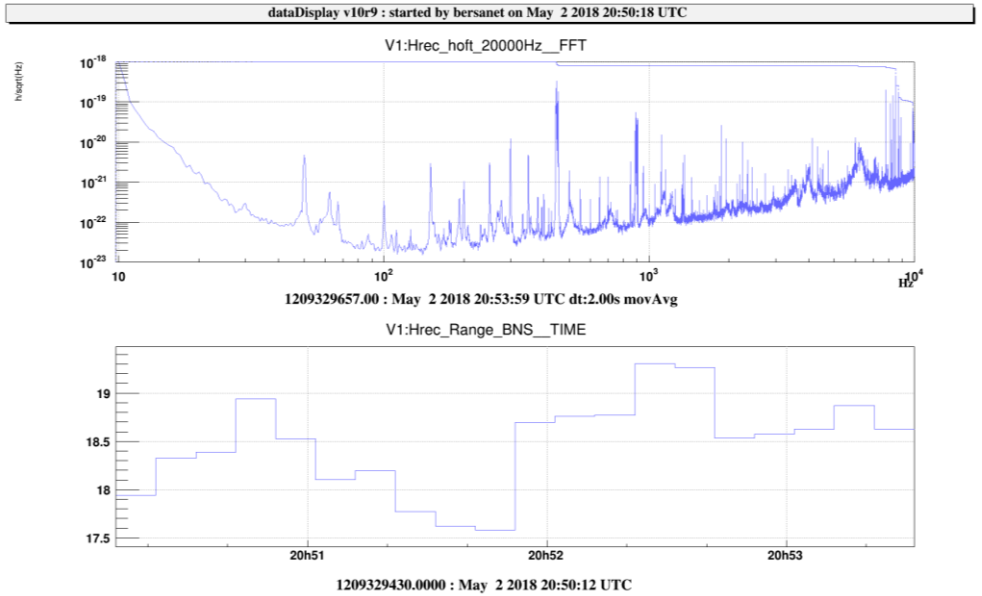
- OMT memo (LIGO-L1800091) circulated on April 21st:
  - LIGO commissioning to begin in late June;
  - O3 officially starting in **Feb 2019** (but ER14 in Jan);
- Next common milestone: ER13 (with **Virgo @ 60 Mpc**);
- LIGO commissioning started few weeks ago (due to fibers braking…);
- Feeling that ER13 may be shifted forward;
- No new official statement for O3…

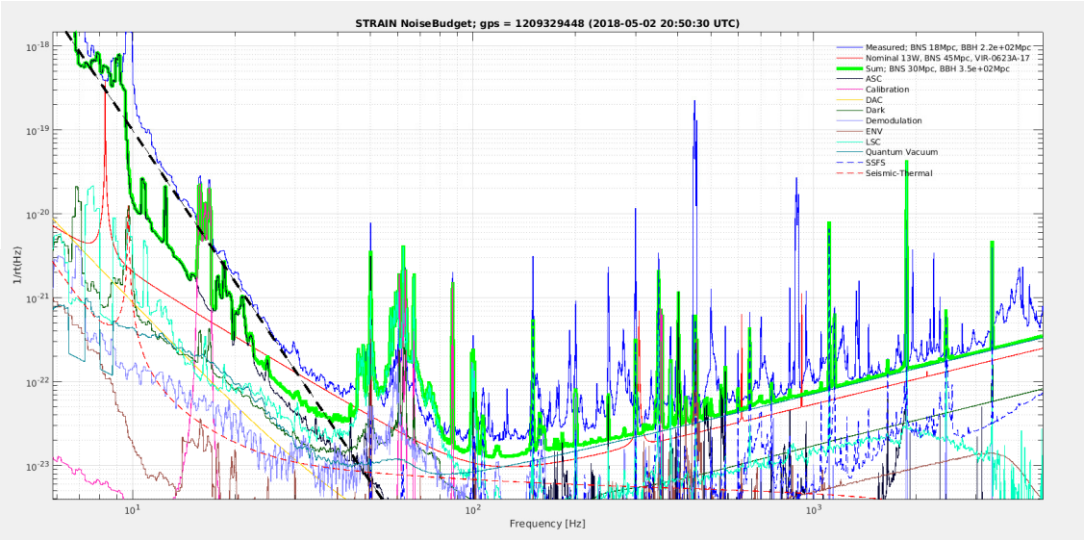


ITF status

- Low noise operation recovered on **May 2nd**:
- BNS range ~ 25 Mpc (lower than O2);
- Since then sensitivity improvements!

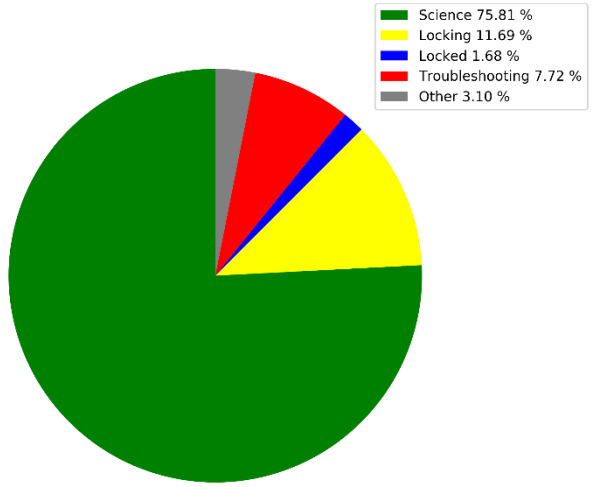


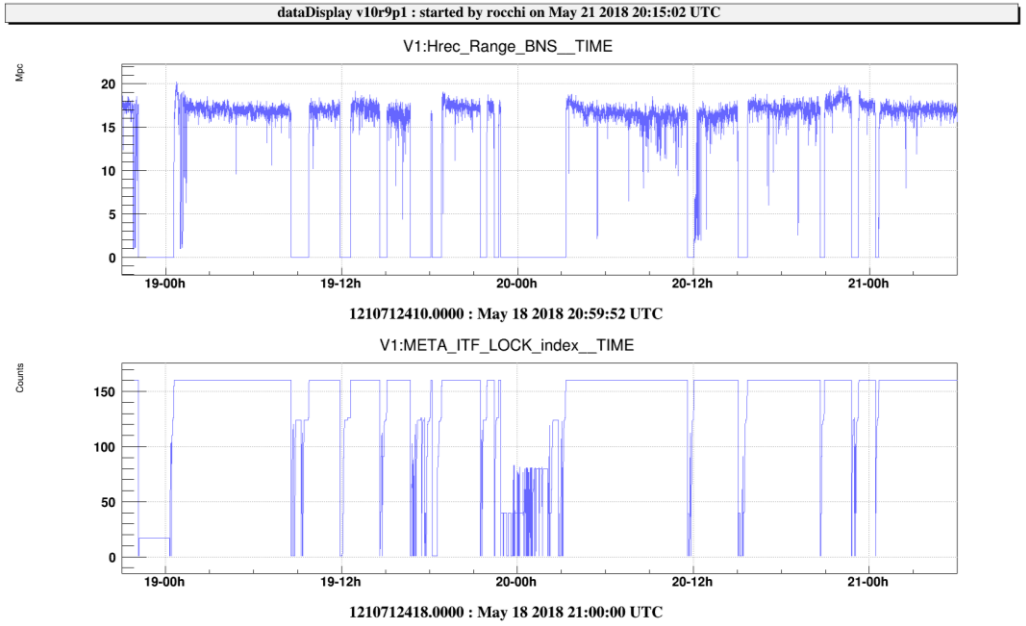


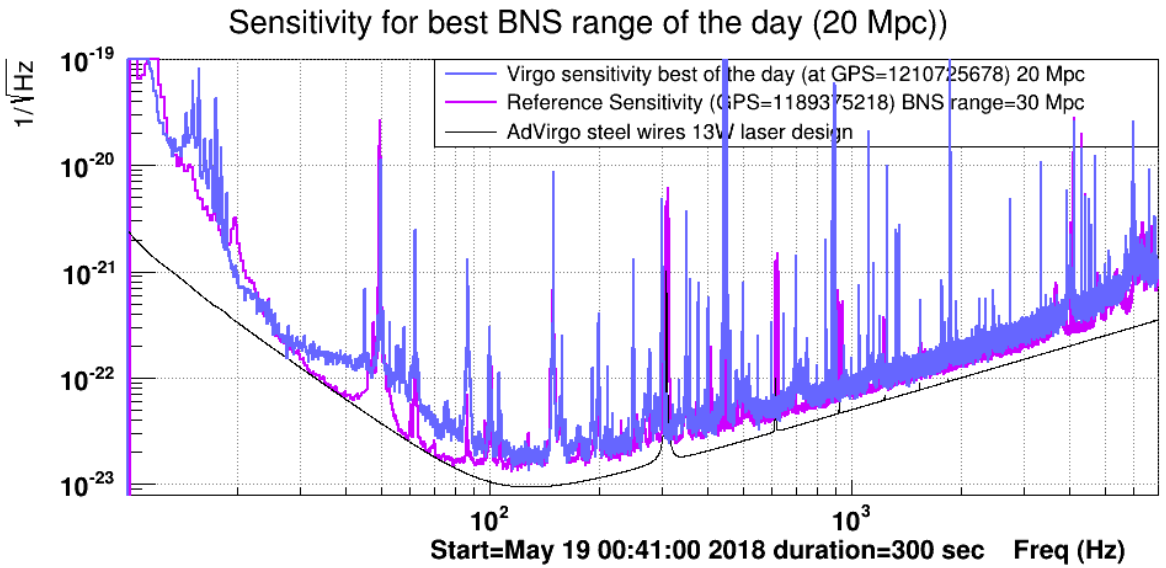


Commissioning Run (C9)

- Started on May Friday 18th at 21:00 UTC and finished on Monday 21st at 6:00 UTC
- Some numbers
  - Science Mode duty cycle (~ 75%)
  - BNS range around 17-20 Mpc
- Operators and on-calls in shift 24/24
- Dedicated page on the Wiki (in progress) to gather information
- Dedicated task in the logbook

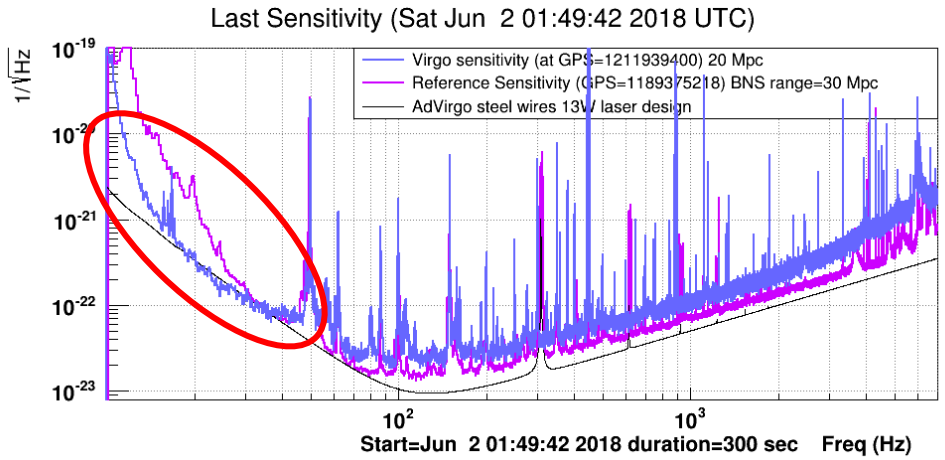




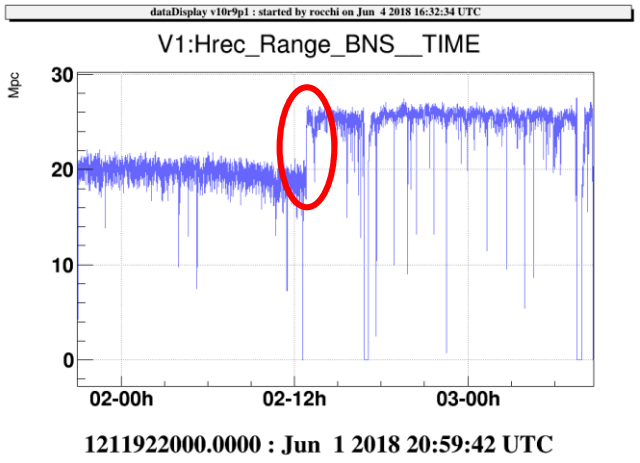


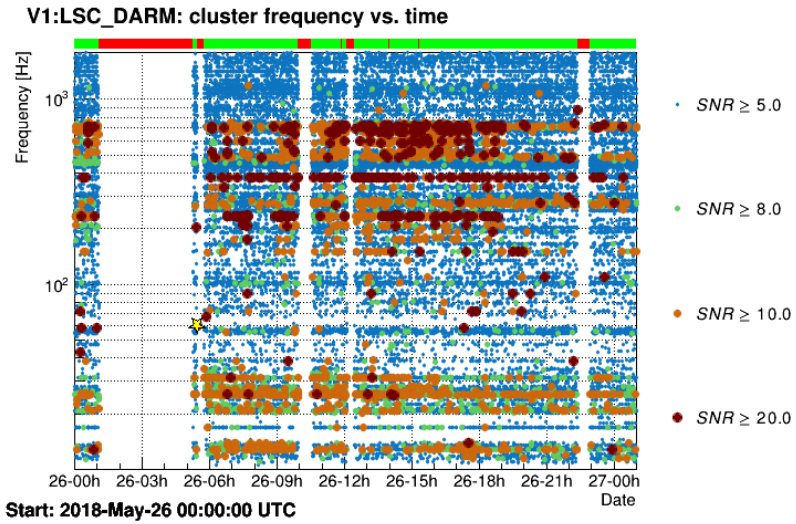
Sensitivity improvements

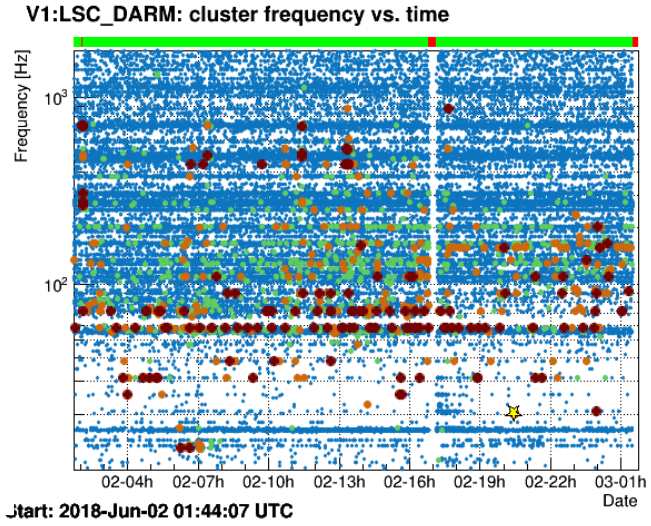
- Glitches reduction;
- Sensitivity improvement at low frequencies: damping of 7 Hz line;



- Online frequency noise subtraction in h(t) activated;
  - Jump in the BNS range (6-7 Mpc);

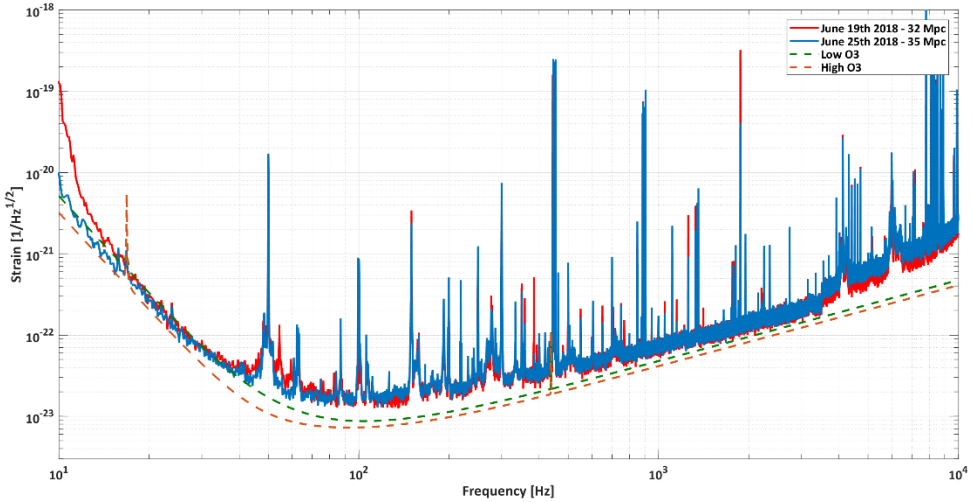


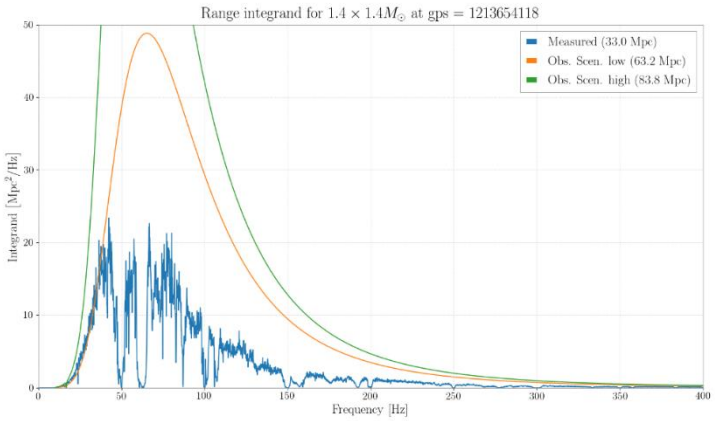


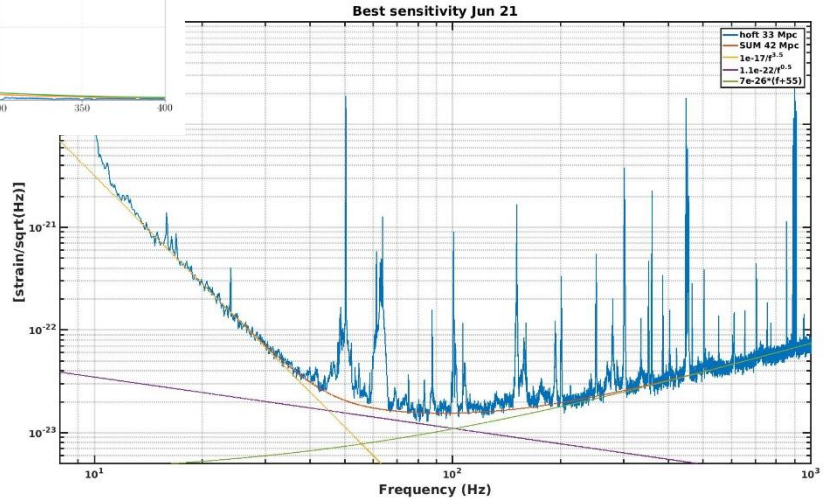


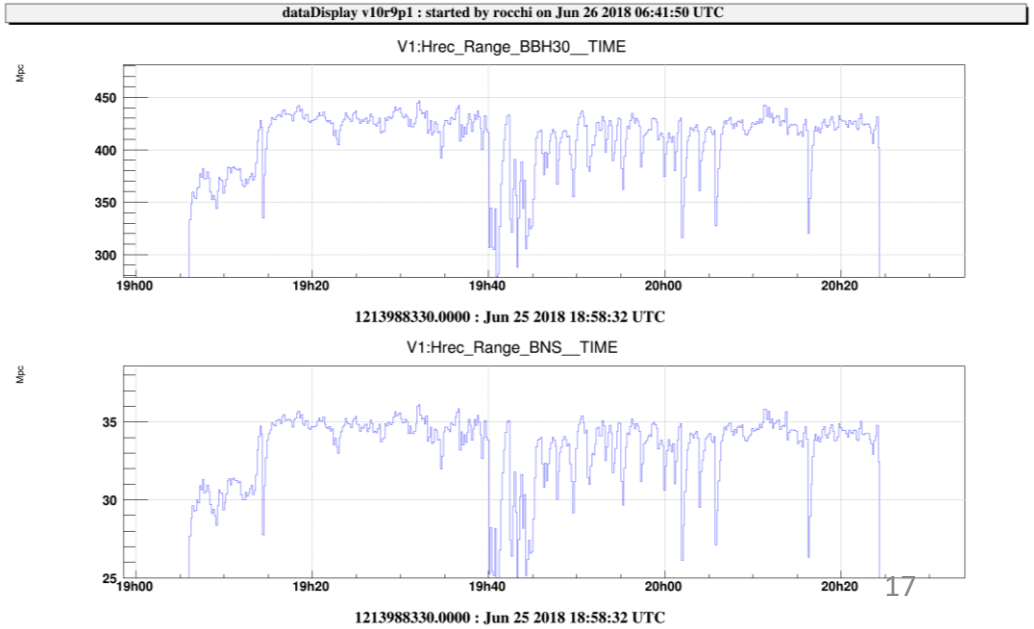
Sensitivity improvements

- Further low frequency sensitivity improvements;
- 30 Msol BBH range exceeding 400 Mpc;
- Sensitivity studies:
  - About 7 Mpc in the peaks;
  - Most rewarding region for BNS 50<f<150 Hz (as expected);



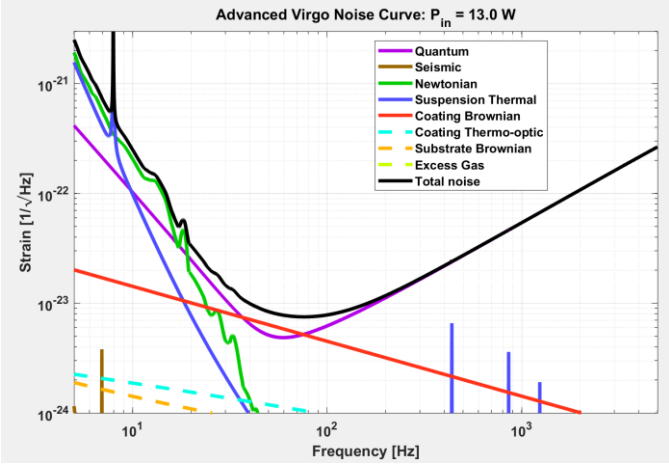




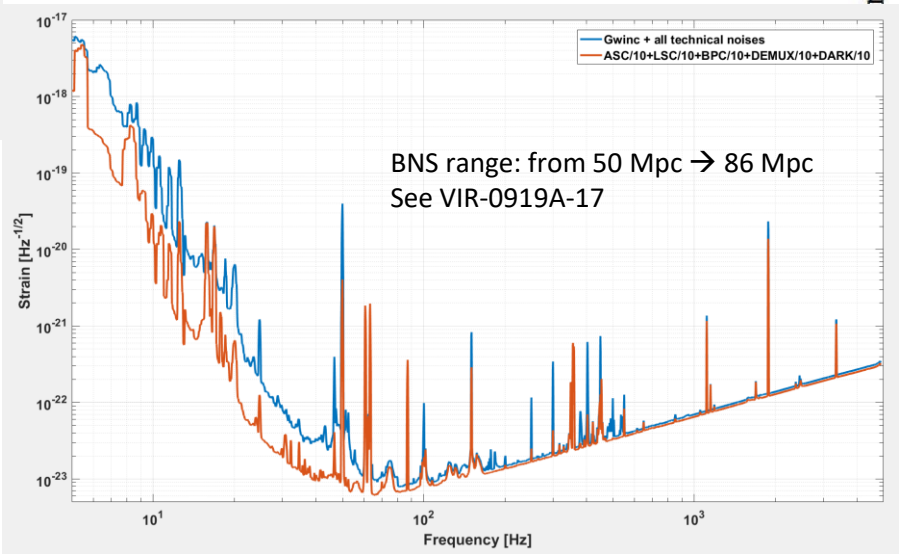


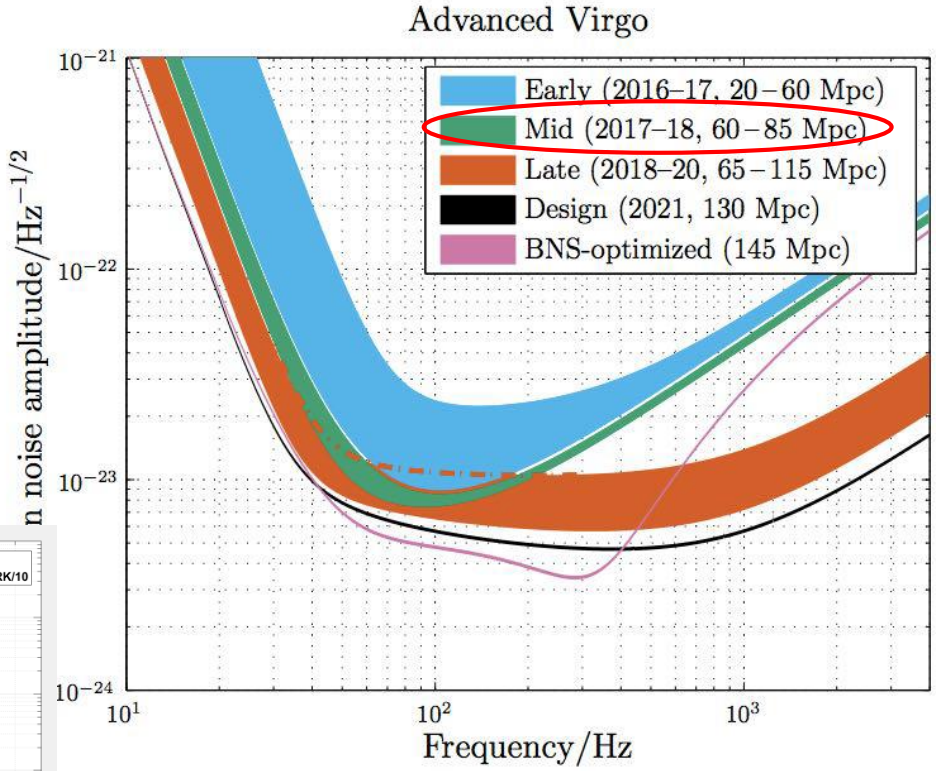
O3 sensitivity target

- Target BNS range: between 60 and 85 Mpc;
- Upgrades promise a boost of the frequency sensitivity at all frequencies: range as high as 100 Mpc, no SQZ, low input power.



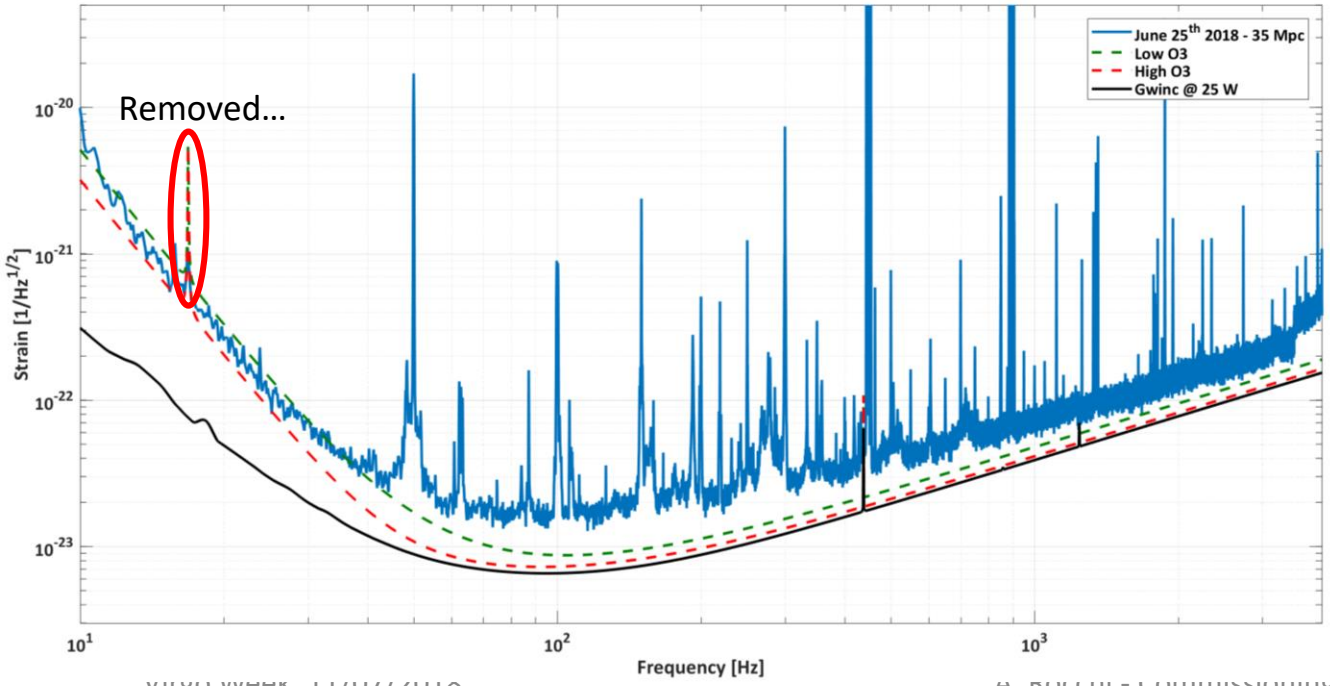
- …and by reducing technical noises.

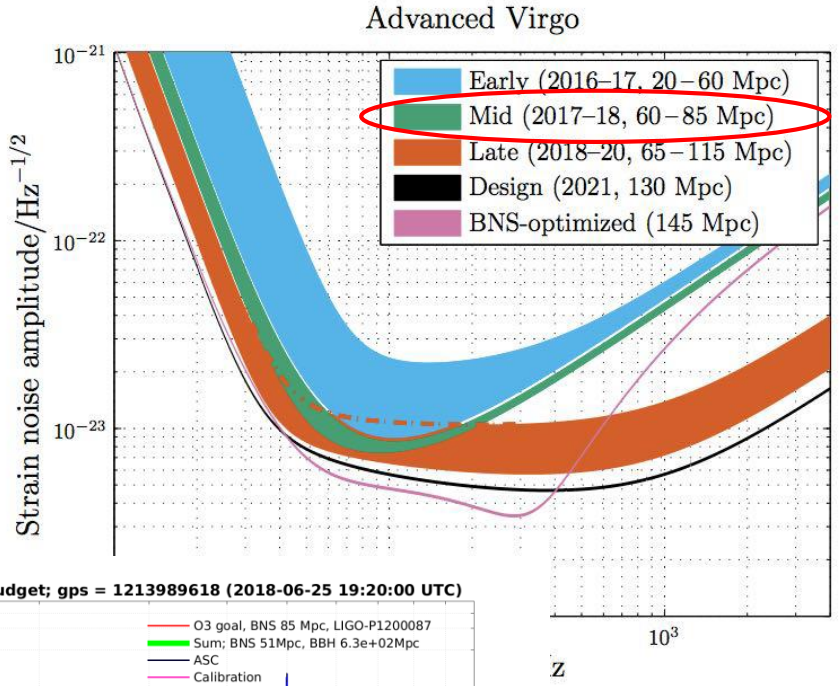


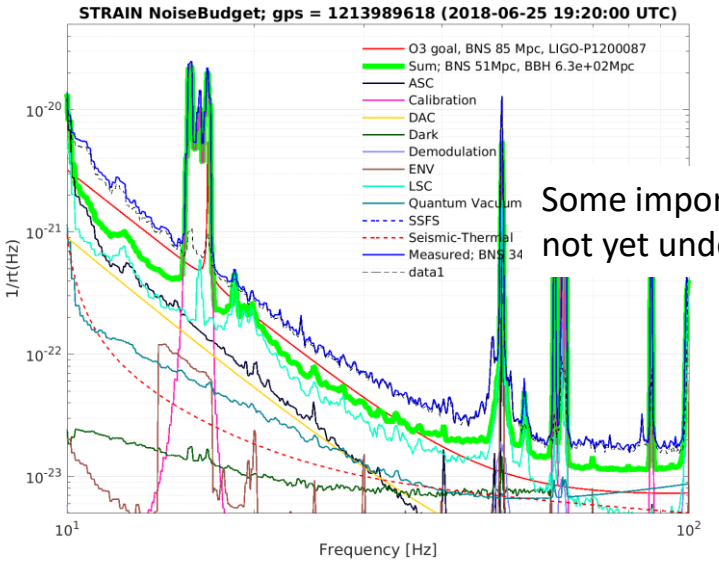


O3 sensitivity target

- Target BNS range: between 60 and 85 Mpc;
- Comparison with GWINC model (sensitivity limited only by fundamental noises): range as high as 100 Mpc;
- Best BNS range reached 35 Mpc;
- Best 30 Msol BBH reached 450 Mpc (~300 Mpc in O2);





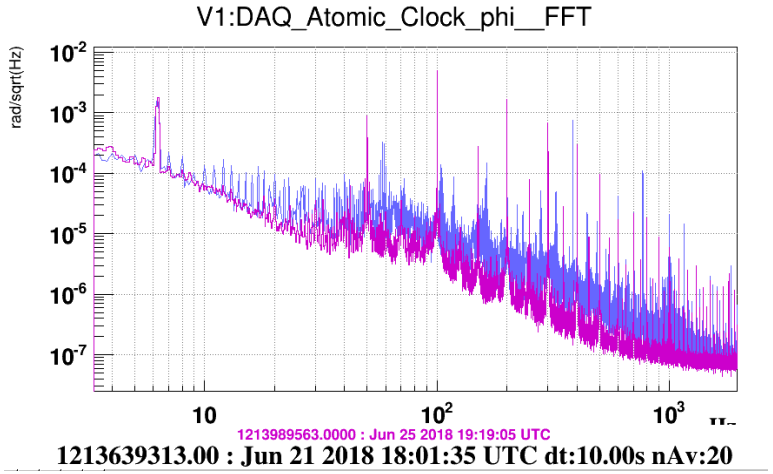


Some important contributions not yet understood (VIR-0481A-18)

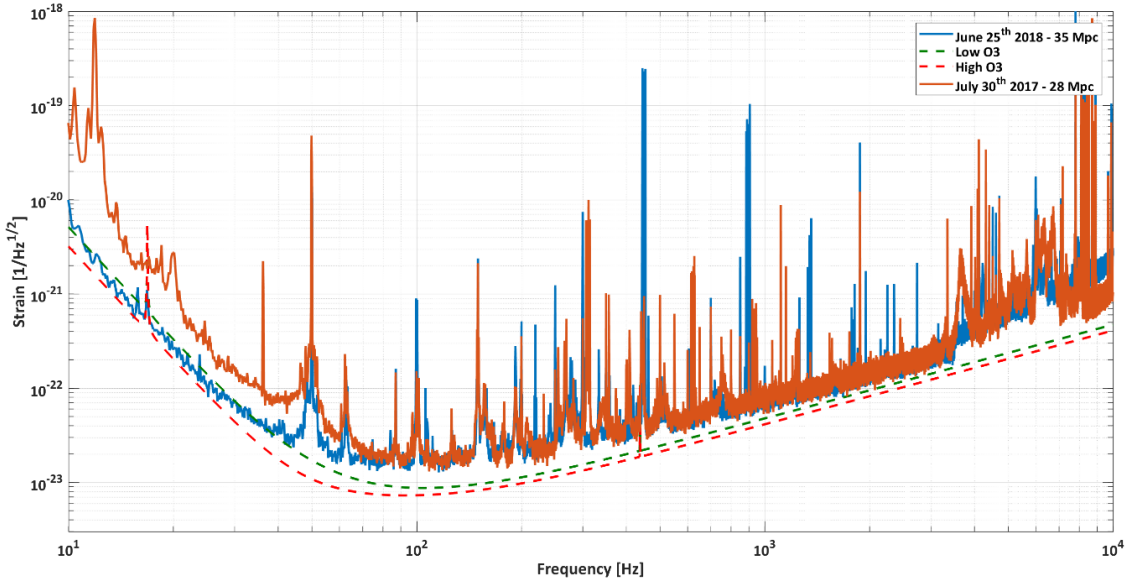
Sensitivity improvements

- Best BNS range reached 35 Mpc;
- Reduction of timing noise:
  - Several issues happened in the last months;
  - Upgrade for O3 planned in August;

ISC/DAQ/DET activities (sensing and locking configuration), re-measure noise couplings (BPC, SDB1...), OptChar	Input power increase, mitigate parametric instabilities, TCS	Commissioning of FI squeezing
DetChar		

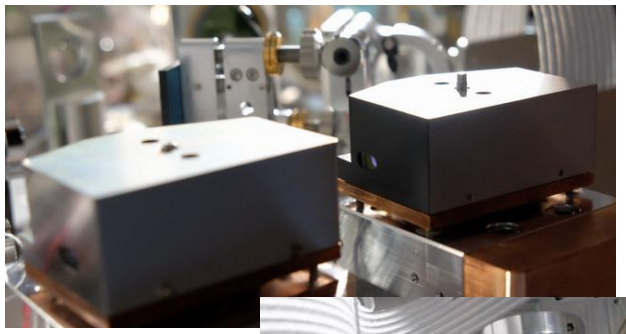


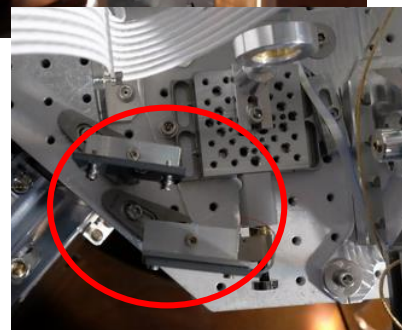
- Decision to move forward in the planning:
- ITF input power increased to 25 W;
- Recovery more difficult than November 2017;
- Main issue related to PDs saturations;
- ISC and DET (LAPP) coordinated work to solve the issue;

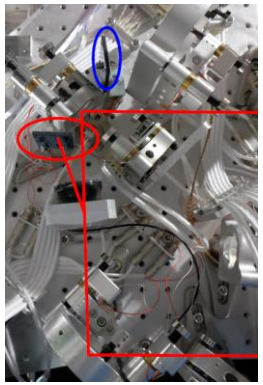


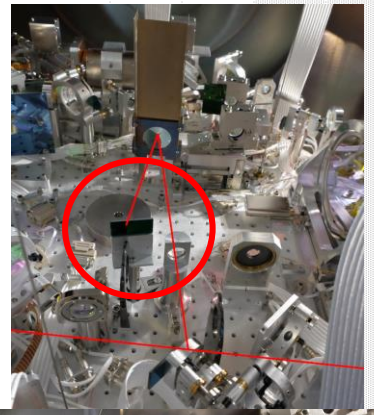
Latest activities

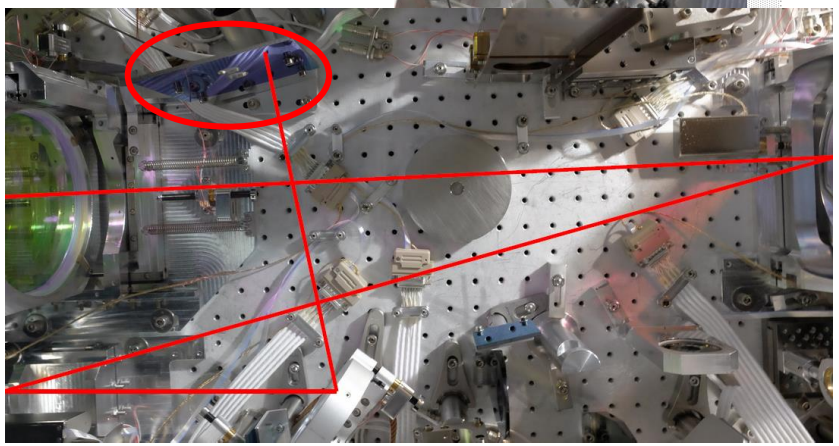
- Commissioning break:
  - Investigation of scattered light on Detection bench;
    - With “custom” lock acquisition close to DF;
  - Investigation of scattered light in injection tower;
  - SQZ MMT upgrade;

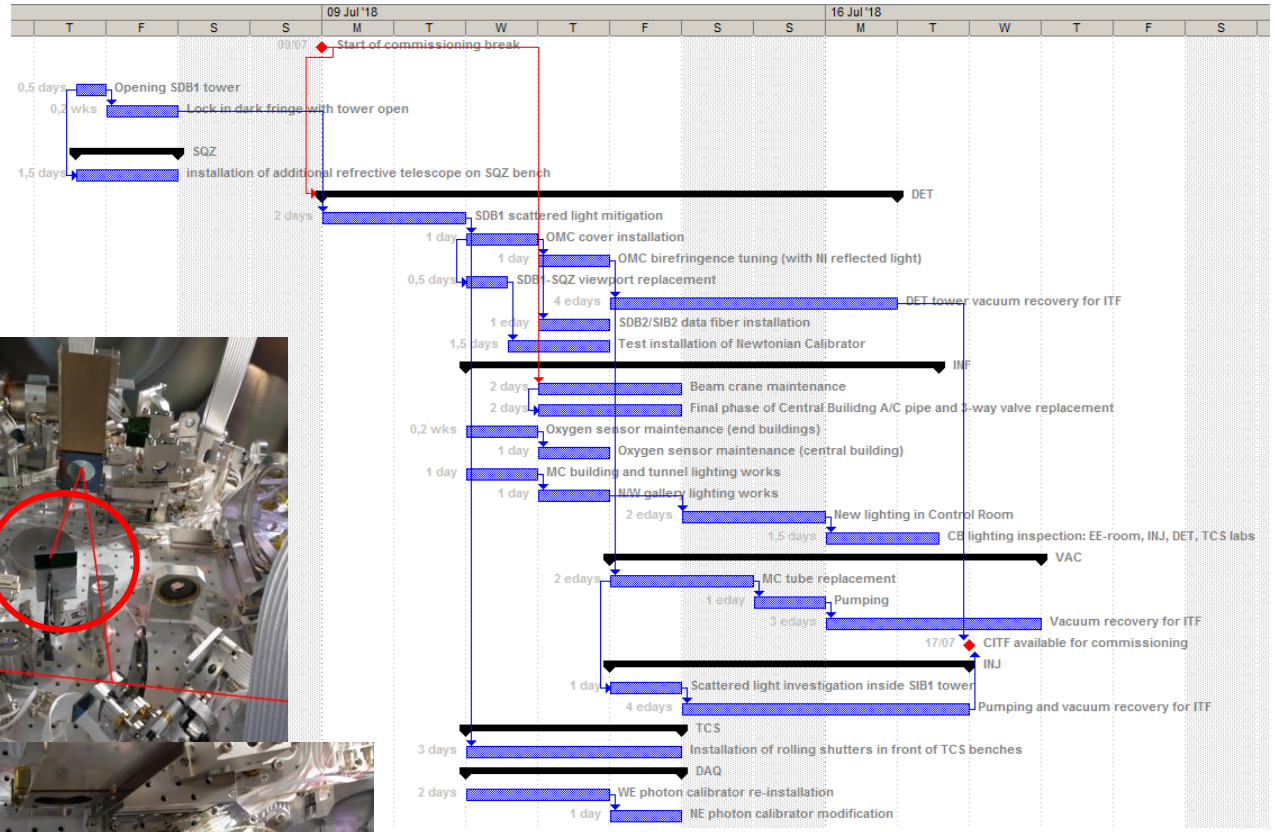












Conclusions 1/2

- The big rush to join O2 was successful:
  - Incredible effort of the commissioning team and of the collaboration;
  - Virgo ran with a good duty cycle (85%) and BNS range (27 Mpc);
  - Most important, it contributed to GW science.
- Time between O2 and O3 shared between commissioning and installation of upgrades:
  - Many leftovers from the initial rush;
  - Commissioning of new hardware;

Conclusions 2/2

- Commissioning of the full ITF restarted **on March 19th**;
- Low noise operation recovered in May;
- Sensitivity improvement in the low frequency range;
  - Already compliant with O3 requirement (30 Msol BBH range exceeding 450 Mpc, ~ 300 Mpc in O2);
  - Virgo (again) the best ITF below 20 Hz;
- ITF input power increased to 25 W, to see improvement of high frequency sensitivity (O3 goal for ITF input power set at 50 W);
- Recovery in progress;
- Best BNS range: 35 Mpc, need to understand what is in the bucket!
- Next commissioning run planned for the beginning of August.