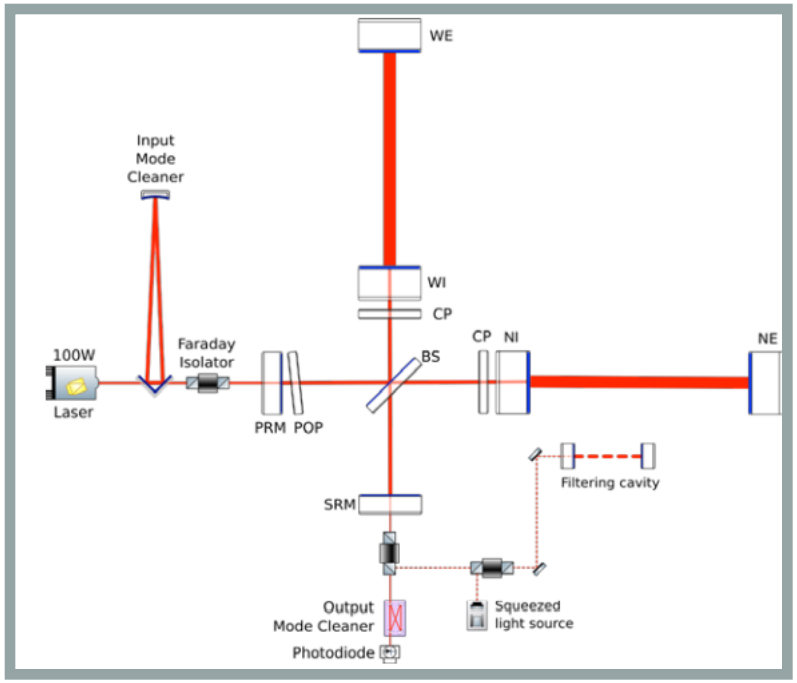
Status of Advanced Virgo+

J. Casanueva for the Virgo Collaboration

Upgrades for AdV+ Phase I

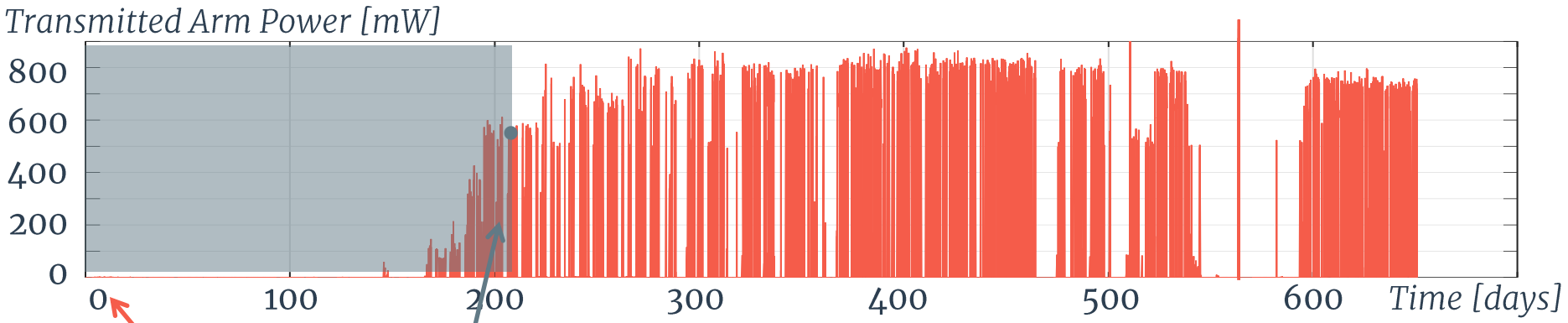
- SR installation
  - Broadband configuration
- Increase Input power
  - Up to 40W
- Frequency Dependent SQZ (see D. Bonavena's talk)
  - 285m filter cavity
  - Only one, high F - 1000, OMC to reduce losses



Advanced Virgo Plus Phase I - Design Report – Virgo Collaboration- VIR-0596A-19

- Installation of Auxiliary Lasers – for SR control
- Installation of diaphragms and baffles – for scattered light mitigation

Commissioning overview



Comissioning start
January 2021 @ 25W

- First period was dedicated to the **lock acquisition** -> reaching the final working point for the 5 longitudinal DOFs

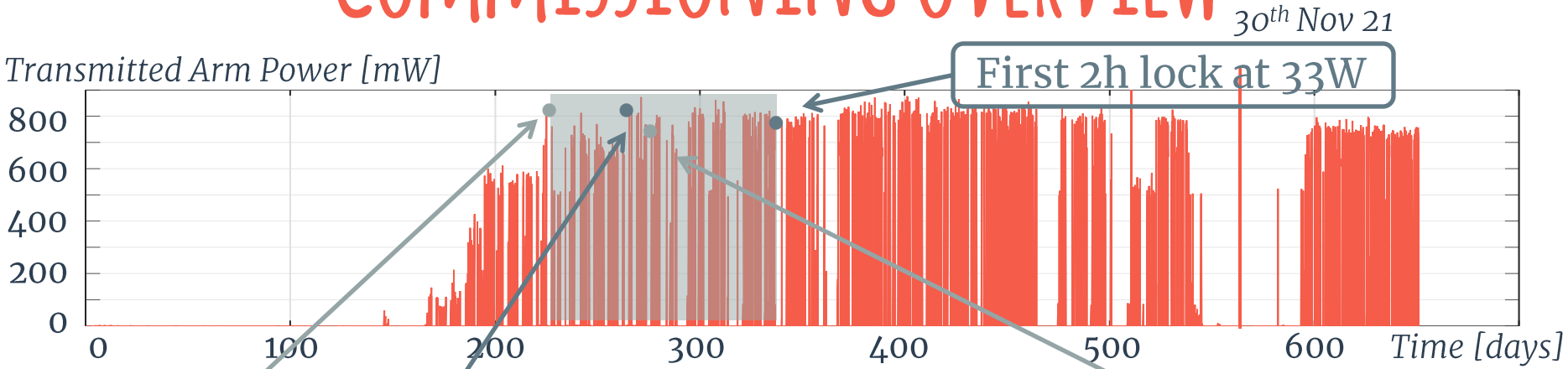
6th Aug 21

First 2h lock at 25W

Very preliminary configuration: no HB frequency stabilization, 3f longitudinal error signals, only few alignment DOFs engaged

Low arms build-up! (see next slide)

Commissioning overview



10th Aug 21

Increase input power to 40W

21st Sep 21

Turn on ETMs RH

30th Sep 21

Decrease to 33W of input power

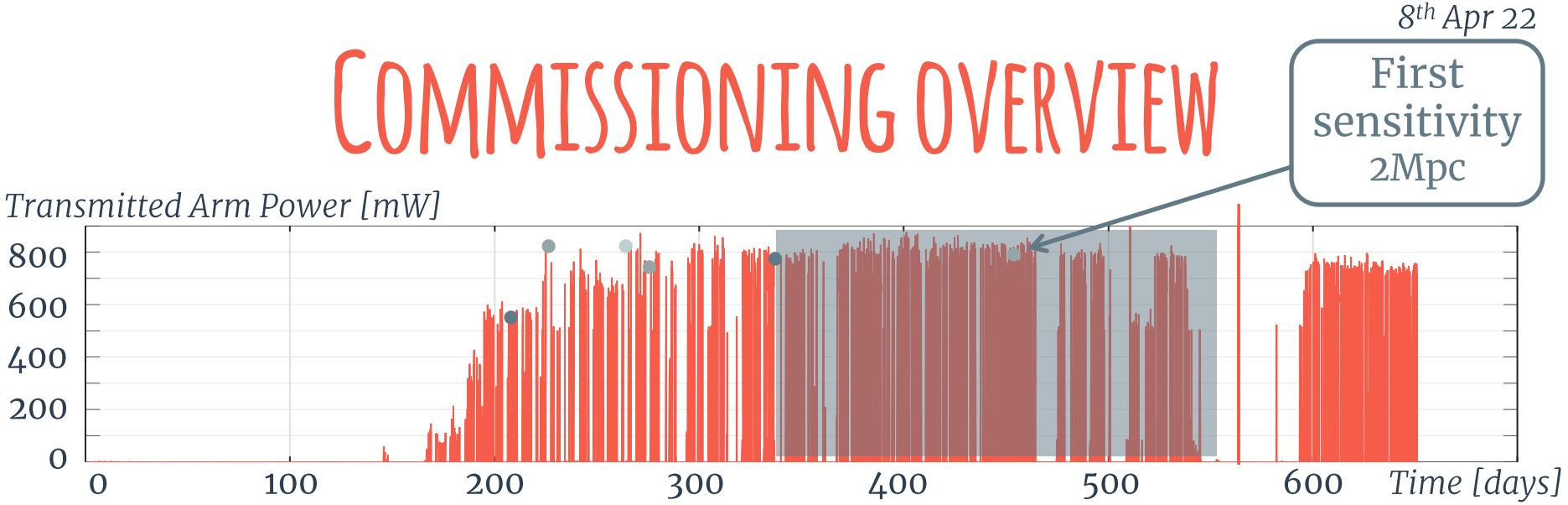
2. The lock acquisition became unreliable

- Lock acquisition recovered and work to finalise longitudinal controls

1. The build-up inside the long cavities was lower than expected (ETM RoC off by 10m)

1. A minimum of ***lock stability*** is necessary for understanding the detector -> Depends on ***arms build-up***

Commissioning overview



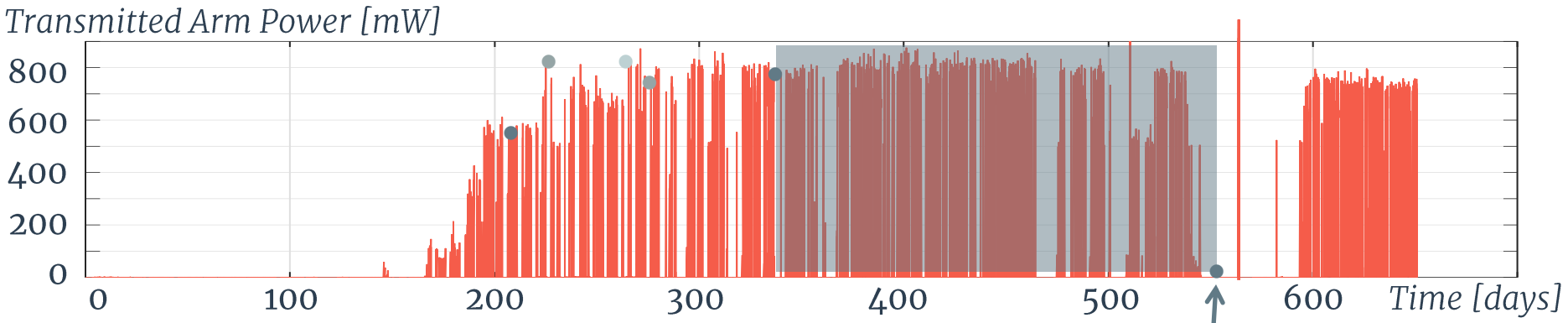
- Locks duration not consistent (few minutes to few hours) so it was difficult to perform proper characterization studies / measurements
- We focused on both finding wavefront signals and the optimal working point for BS, SR and arms common tilt.

We started to observe "jumps"

See P. Spinicelli's presentation

DARM OLTF was not as expected:
High Optical Spring (40Hz) and Low Double Cavity Pole (250Hz)

Commissioning overview



- Simulations of DARM TF (VIR-0282A-22) and LIGO's experience (G220312) pointed towards PRC and SRC mismatch as the cause (#55383)

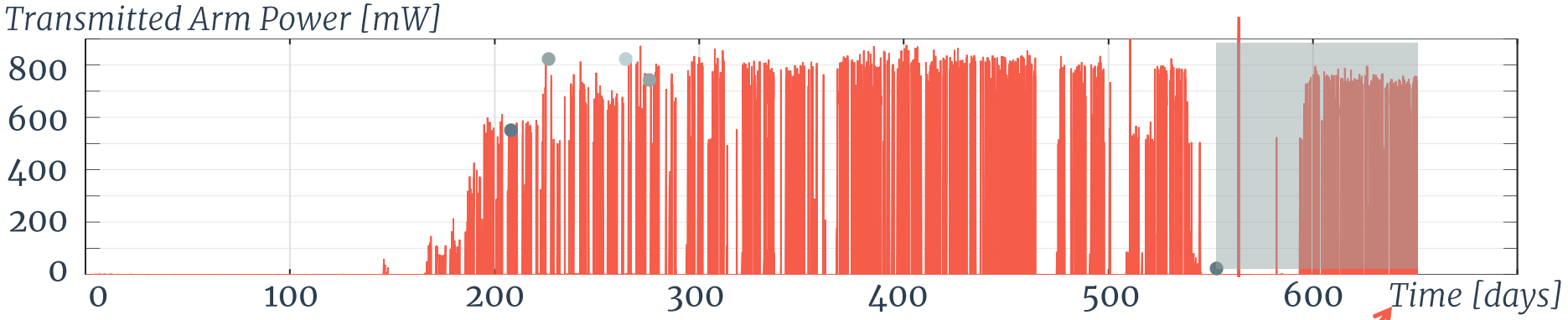
1. The PRM and SRM are mismatched by ~40m
2. The cold PRC is in the unstable region

These defects could not be compensated by using the CO2 actuators

18th Jul 22

CHRoCC installation on PR and SR

Commissioning overview



New sensitivity curve (3Mpc) October 2022

- After the CHRoCCs power tuning, the jumps into the "unstable" region had disappeared and we had locks lasting the full night
- Finding: excess of power on dark fringe due to resonance of HOM in the SR cavity (VIR-0972A-22)

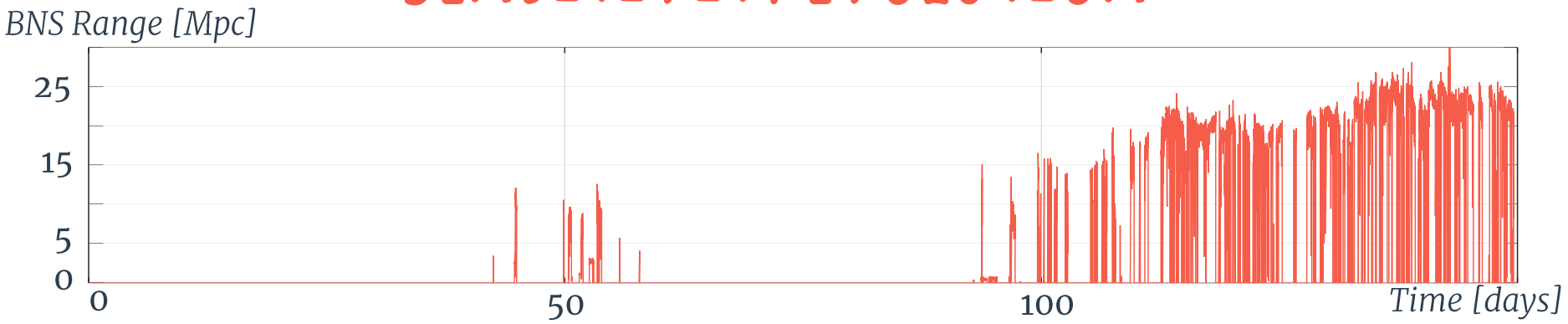
2.

The *Recycling Cavities matching* is key for the detector stability

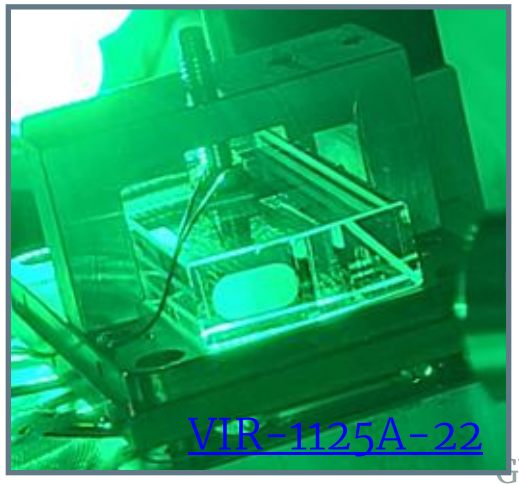
- DARM OLTF problems were not solved -> we focused on the ITF working point: alignment and SRCL tuning

See P. Spinicelli's presentation

Sensitivity evolution



- The OMC had large optical losses leading to a poor sensitivity



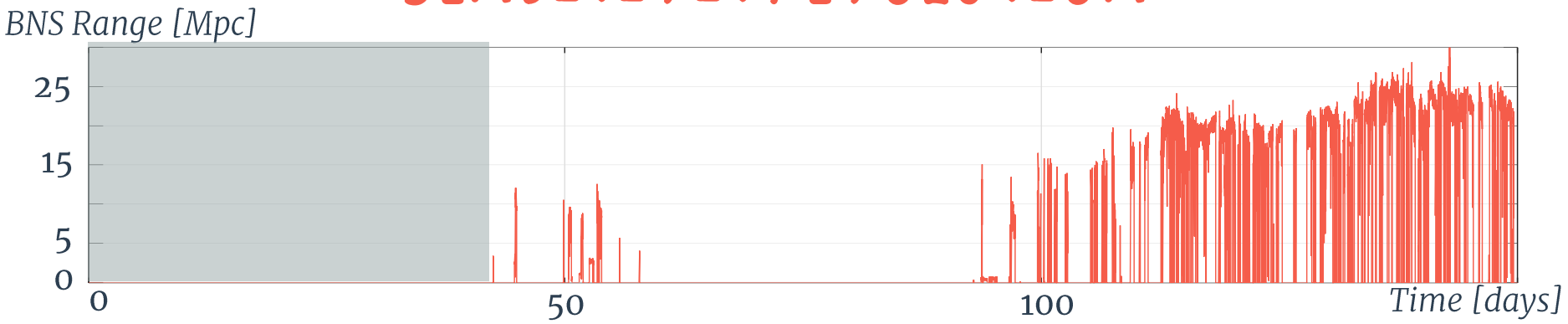
14th Nov 22 – 17th Dec 22

Installation Break

- Replace the OMC
- Install Point Absorbers mitigation system on TMs
- …

WI fibers break

Sensitivity evolution



- After the break the "jumps" were back
  - They could be removed tuning the CHRoCCs and the TCS

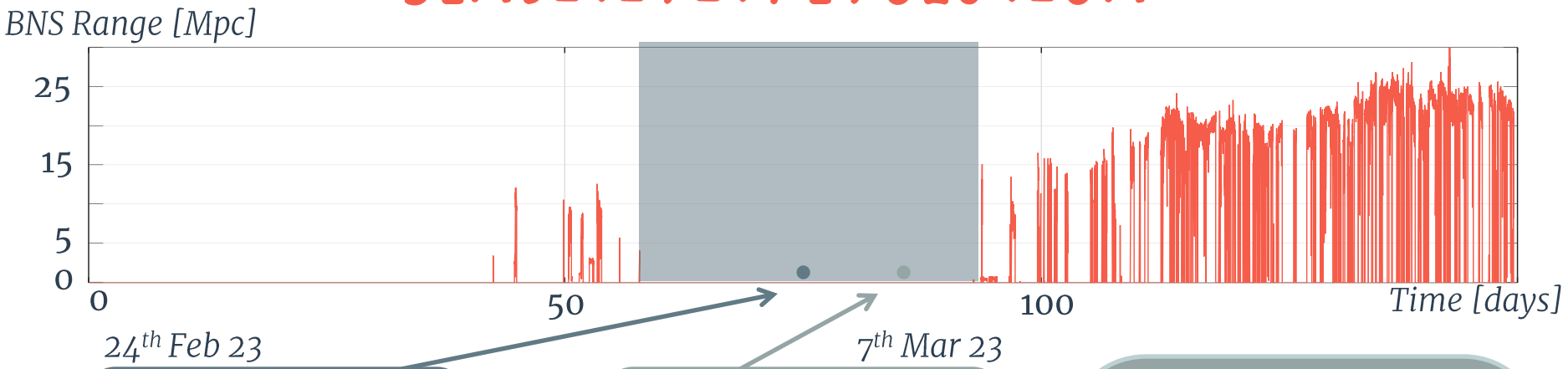
3.

The **jumps** are clearly related to the **stability** of the recycling cavities

- With the new OMC the **sensitivity reached 12Mpc**
- New limiting noises:

1. WI magnet damaged creates a moving structure at 500Hz
2. Laser frequency noise coming from the fiber amplifier

Sensitivity evolution



Decrease input power to 25W

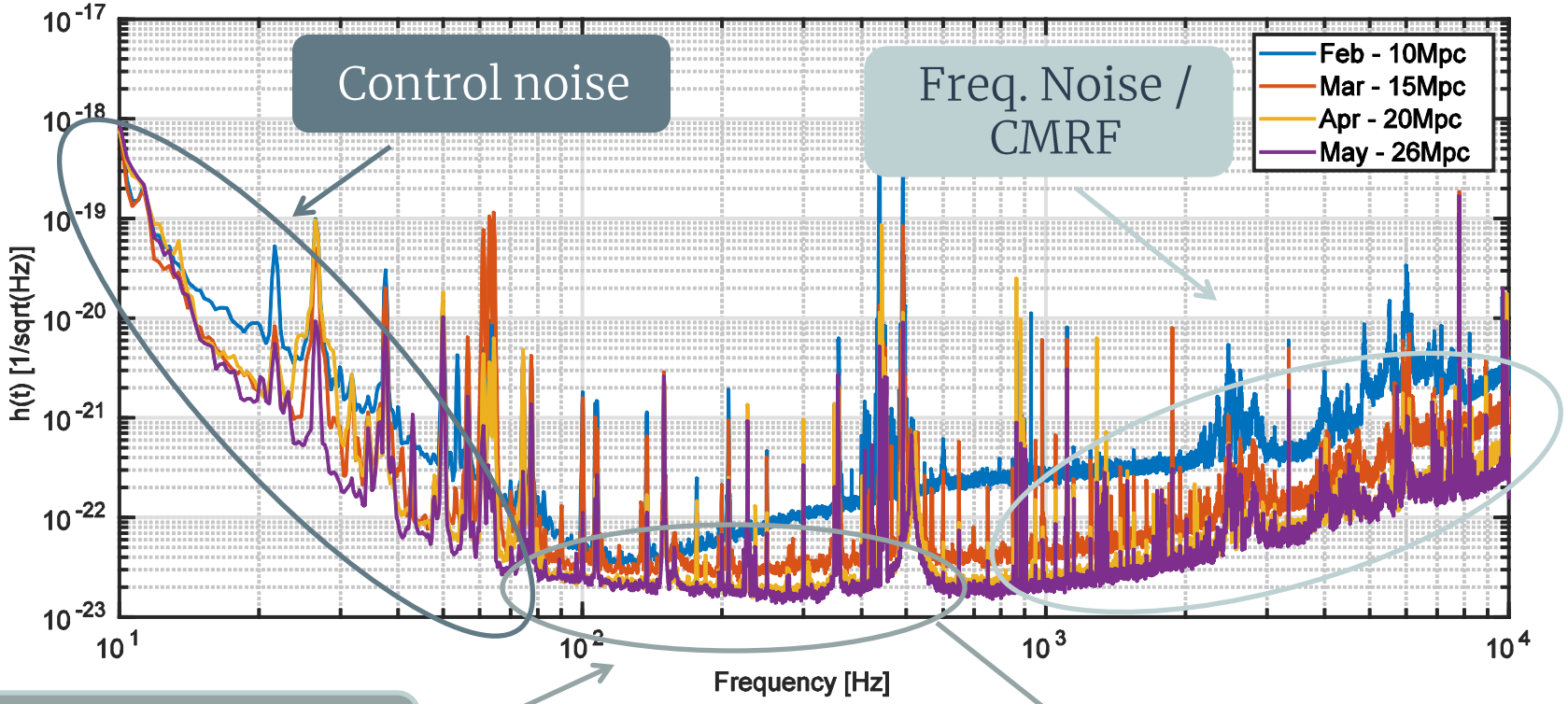
- In order to reduce the power in the Dark Fringe

Go back to the old laser configuration

- In this configuration **sensitivity reached 16 Mpc**

1. Improve control noises by tuning filters and subtractions
2. Reduce RIN coupling (MICH offset)
3. Reduce and stabilize CMRF (alignment working point)

Improving sensitivity



Thermal noise??

- WI magnet creates a structure around 500Hz -> its tail could limit h(t) at low frequencies

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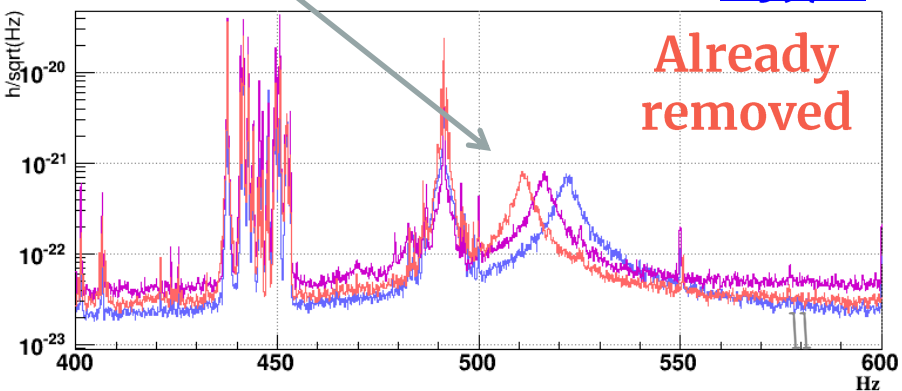
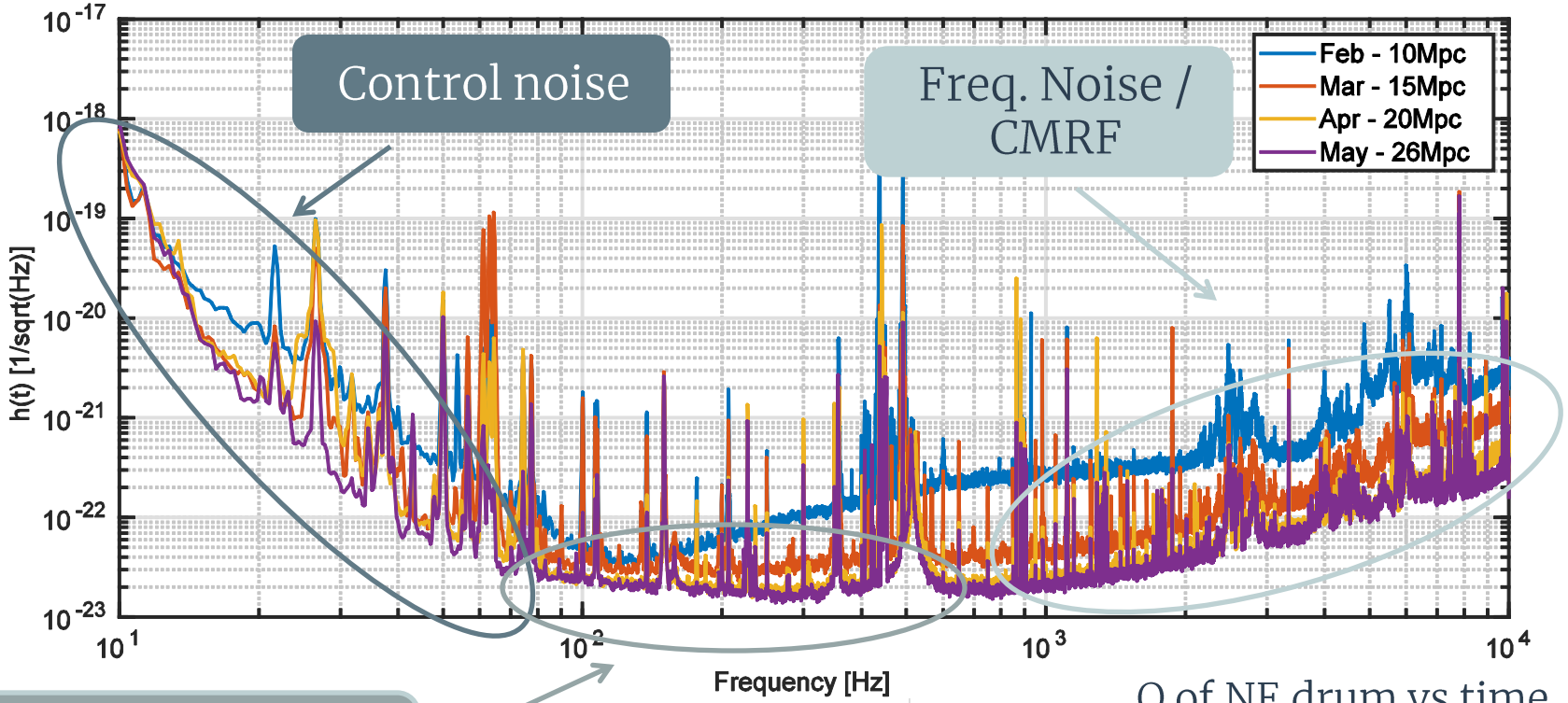


Improving sensitivity



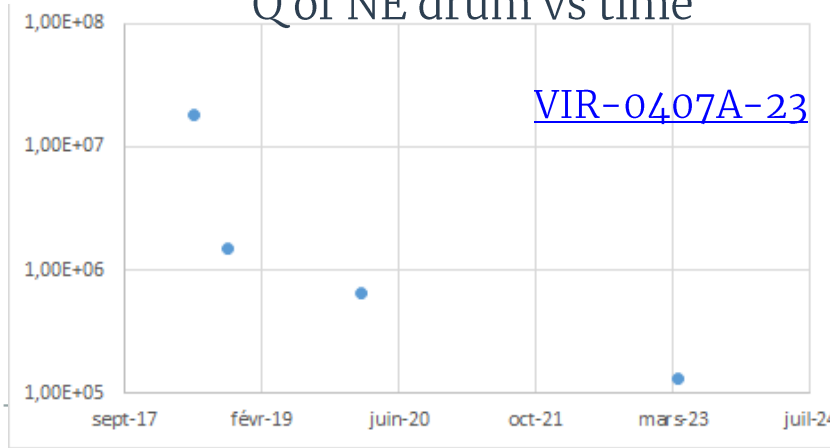
Thermal noise??

- NE mirror has a crack
- Q of its drum mode has worsened

Upper limit

Will be replaced soon

Q of NE drum vs time



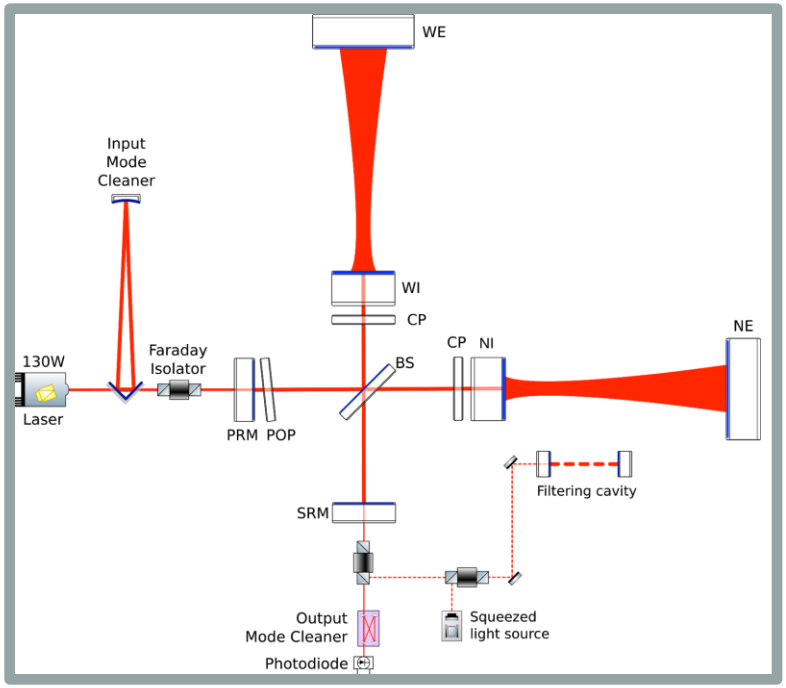
VIR-0407A-23

Future: AdV+ Phase II

Advanced Virgo Plus Phase II - Design Report – The Virgo Collaboration – VIR-0501C-22

Target: decrease thermal noise

- Increase beam size on ETMs
  - Bigger (55cm Ø) and heavier (104 kg)
- Better mirror coatings



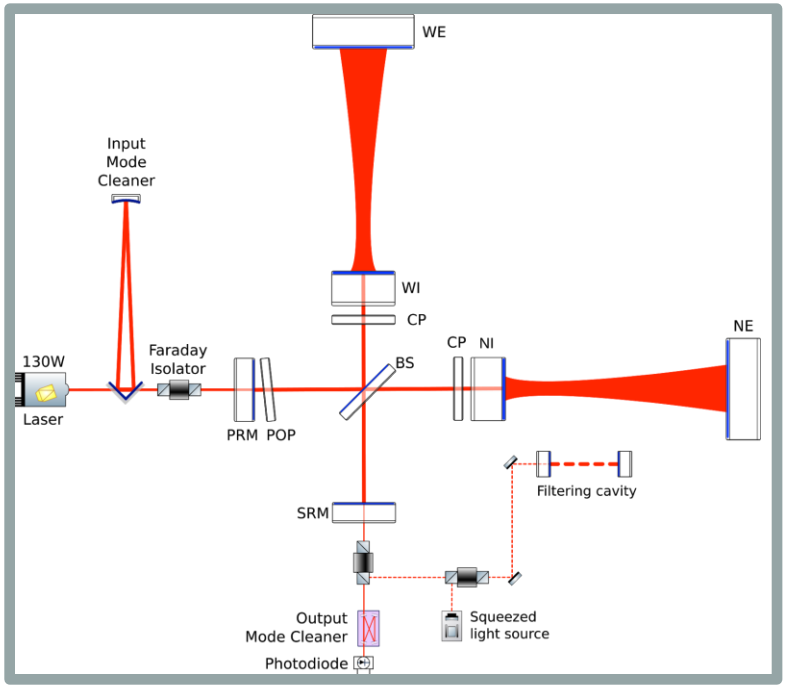
- New suspensions for the larger test masses
- New terminal optical benches

Future: AdV+ Phase II

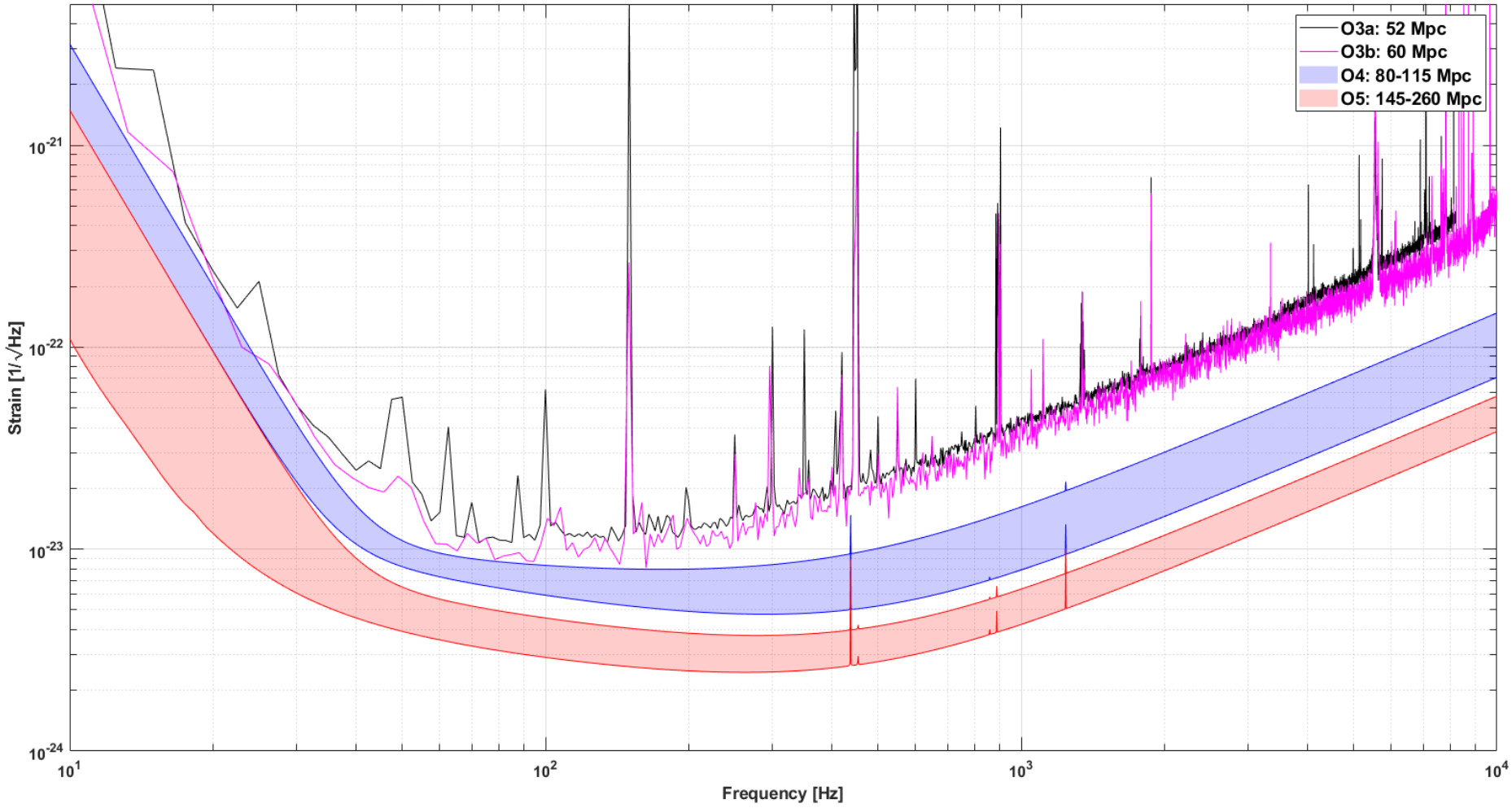
Advanced Virgo Plus Phase II - Design Report – The Virgo Collaboration – VIR-0501C-22

Target: decrease thermal noise

- Increase beam size on ETMs
  - Bigger (55cm Ø) and heavier (104 kg)
- Better mirror coatings
- Increase Input Power (up to 80W)
  - Phase I commissioning showed it is critical



- Simulation effort key to better understand its effects and how to compensate for them
- Implement a system to increase power while locked
- Study of stable recycling cavities started again



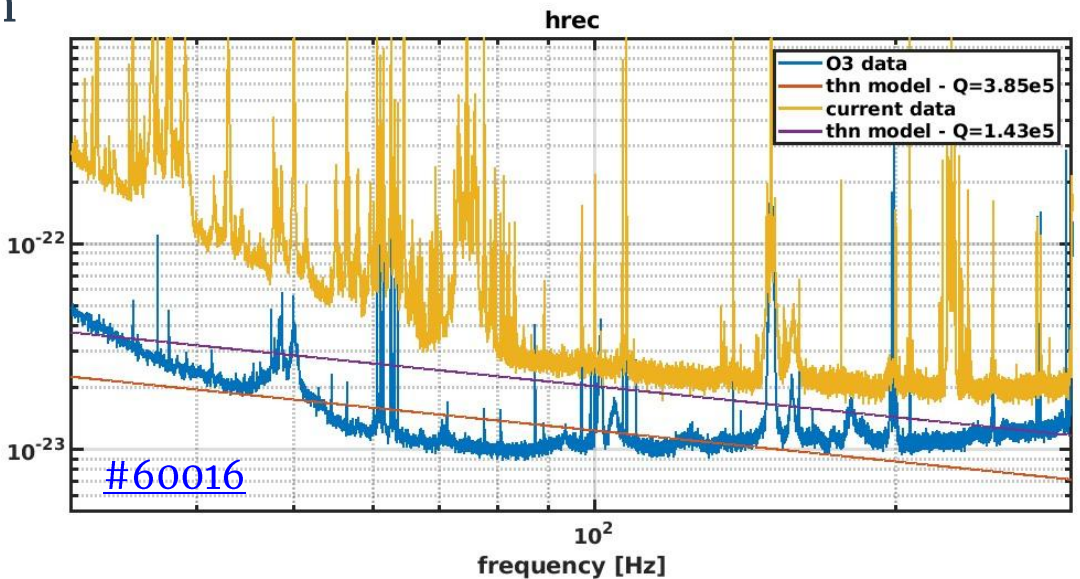
Work in progress…

Improving sensitivity

- When suspending the NE on 2017, a shackle damaged the barrel of the mirror
  - We were removing the steel fibers and replacing them with the monolithic ones
  - It was an internal crack and initially its dimension was ~5mm

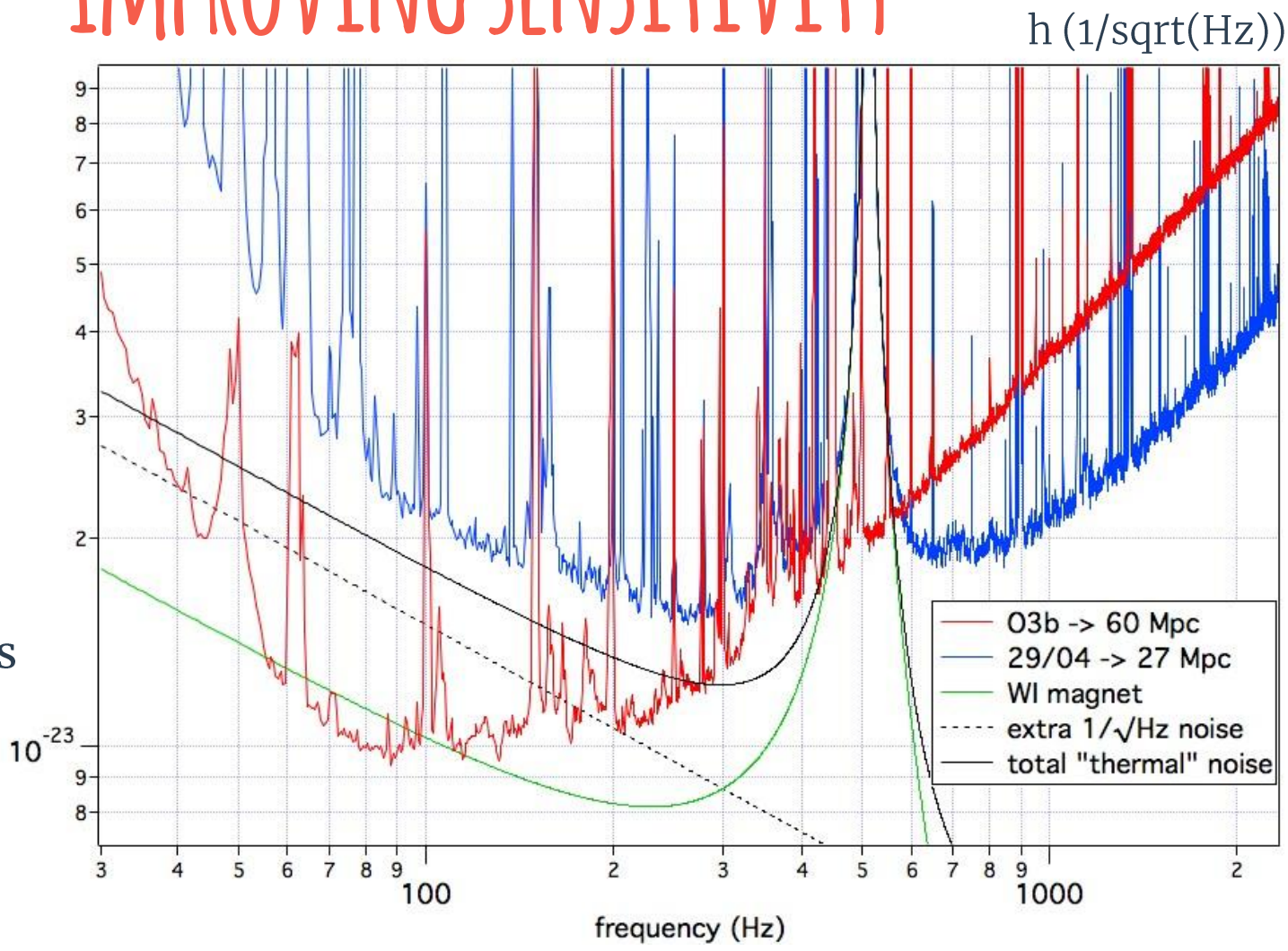
Thermal noise??

- It starts to be worrying since we observe a compatible shape on h around 100Hz

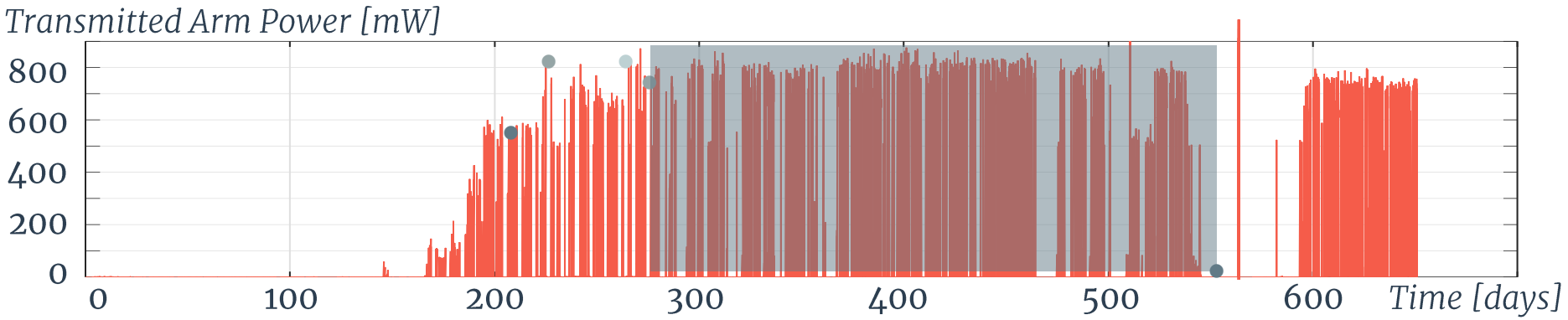


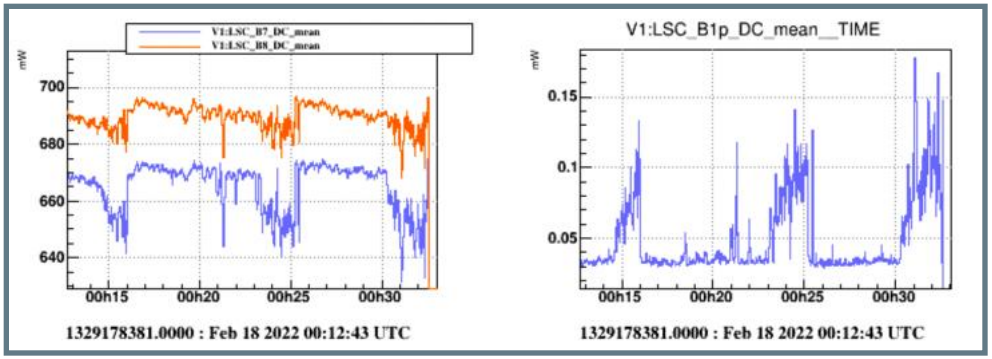
Improving sensitivity

- No thermal noise in O3
- Better sensitivity at high f -> SRC
- Worse sensitivity at low f -> control noises

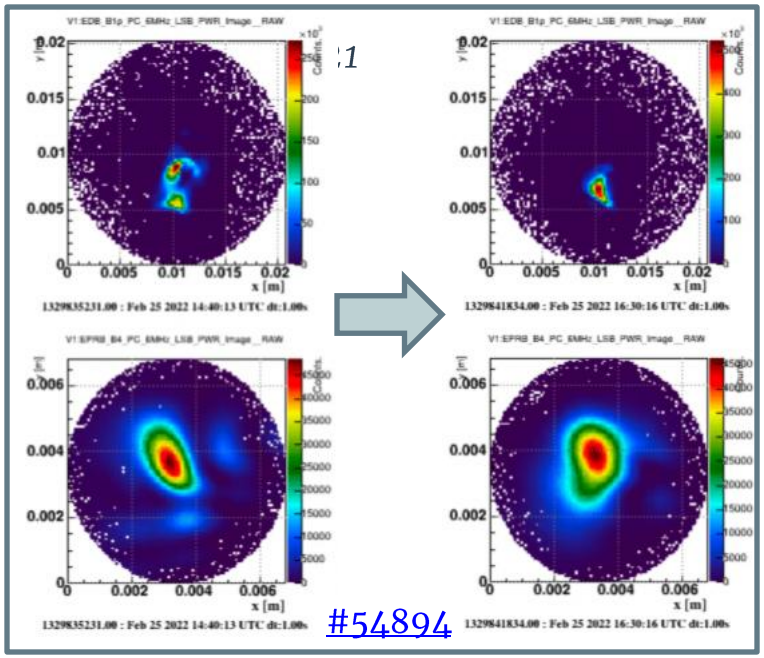


Commissioning overview





We started to observe "jumps"



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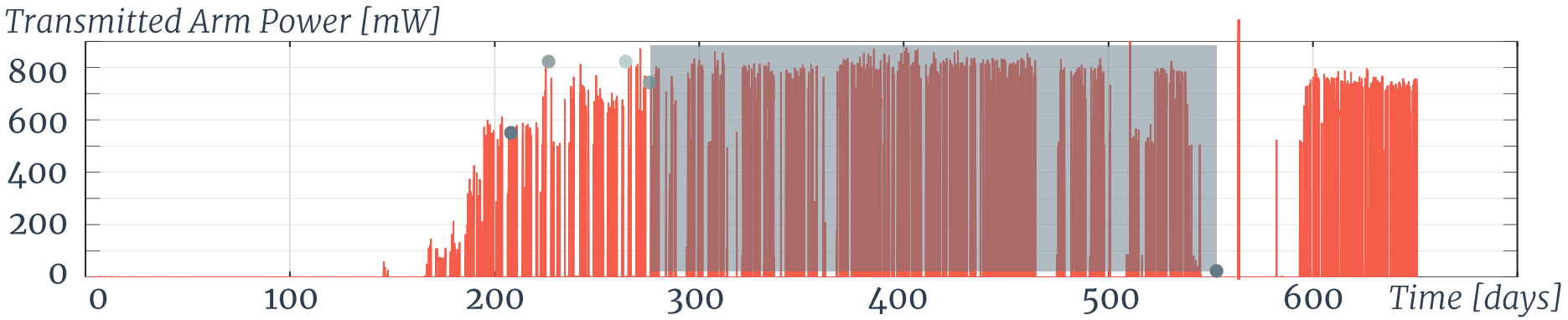
Commissioning overview



- Optical spring was much higher (up to 30HZ)
- Double Cavity Pole was much lower (450 Hz)

DARM OLTF was not as expected