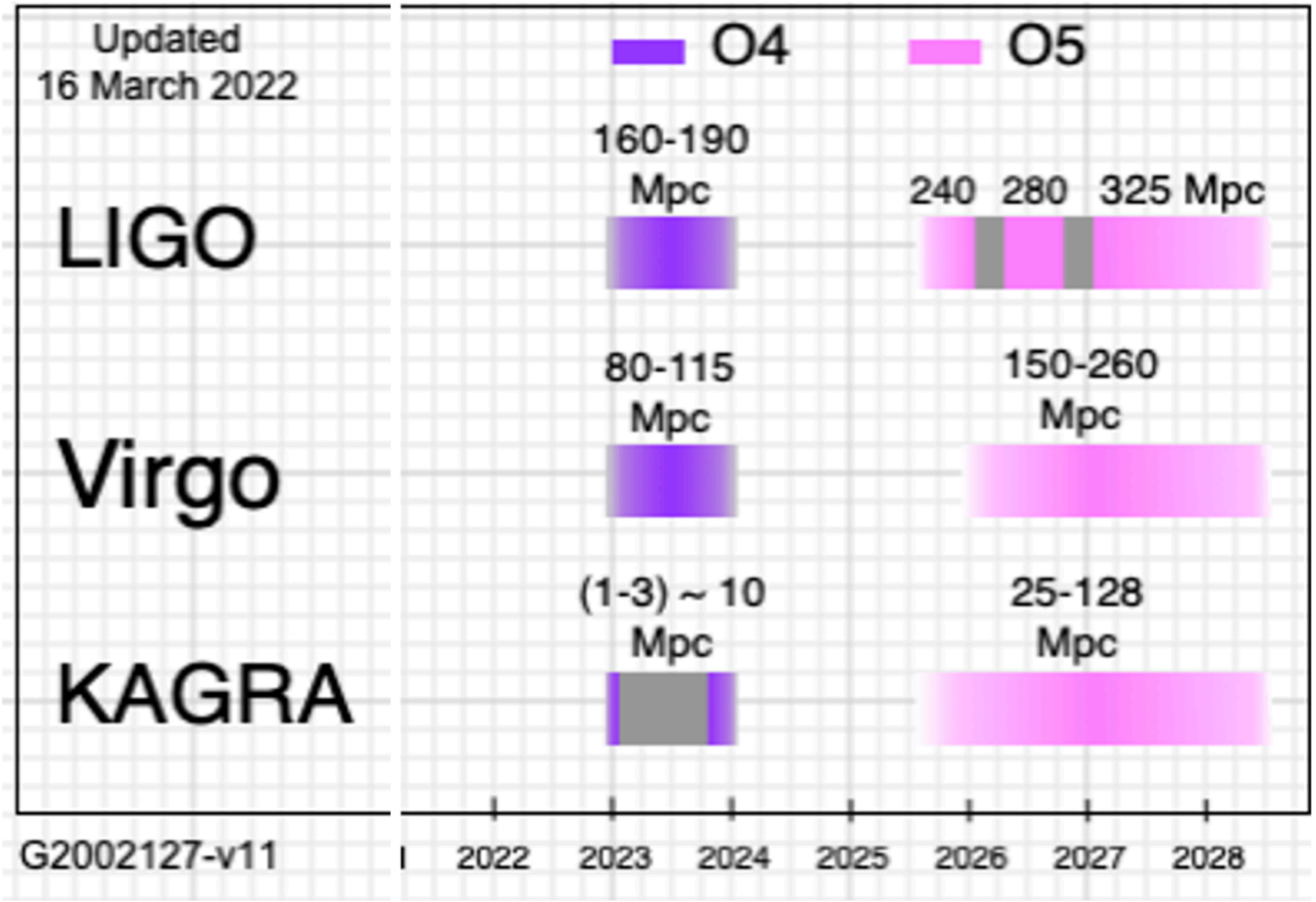
Advanced Virgo Plus Status

M. Tacca on behalf of the Virgo Collaboration

Nikhef Jamboree - 2022 May 10th

AdV+ Timeline



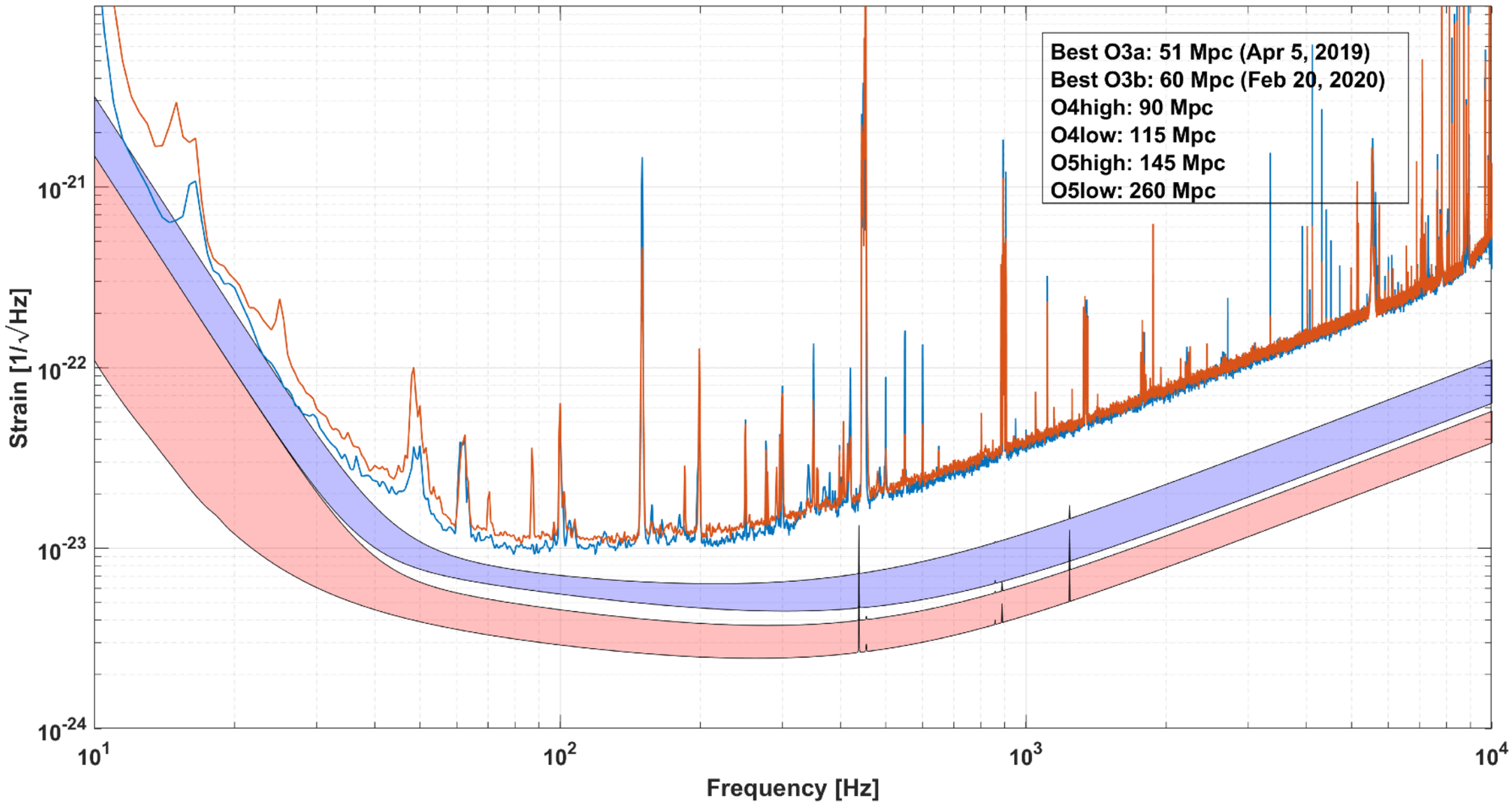
PHASE I:

- Signal recycling mirror;
- Higher input laser power (~ 40 W);
- Frequency dependent squeezing;
- Newtonian noise cancellation.

PHASE II:

- Further increase of laser power (60 W or more);
- Larger beam on end test masses;
- Better coatings.

Advanced Virgo Plus: target sensitivity



Phase I: reduce quantum noise, hit against thermal noise

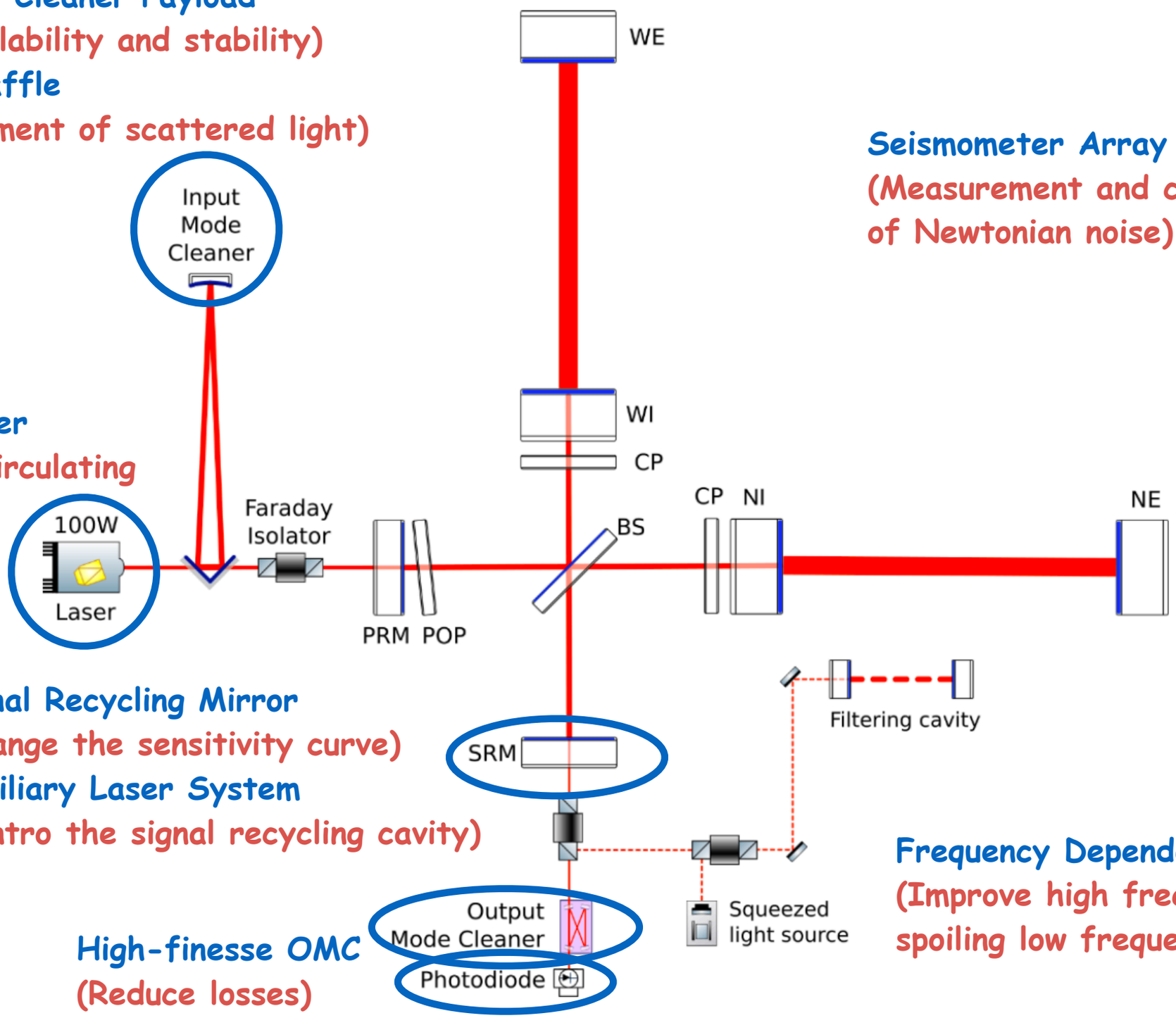
Phase II: push down the thermal noise wall

AdV+ Upgrades for O4

New Input Mode Cleaner Payload
(Improve controllability and stability)
Instrumented Baffle
(Direct measurement of scattered light)

Seismometer Array
(Measurement and cancellation of Newtonian noise)

High-power Laser
(Increase the circulating power)

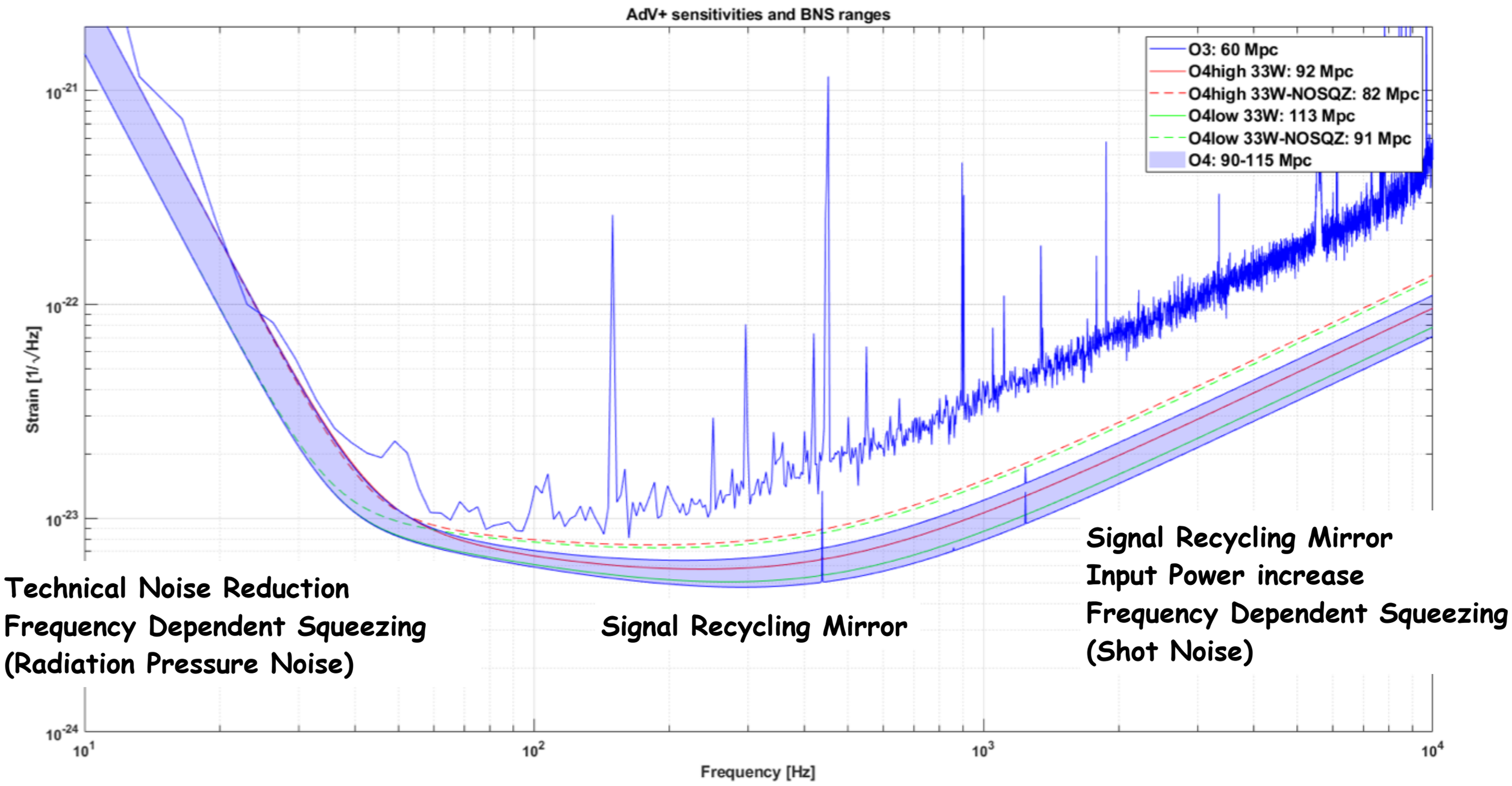


Signal Recycling Mirror
(Change the sensitivity curve)
Auxiliary Laser System
(Contro the signal recycling cavity)

Frequency Dependent Squeezing
(Improve high frequency without spoiling low frequency)

High-finesse OMC
(Reduce losses)
High-power PD
(Reduce electronic nosise)

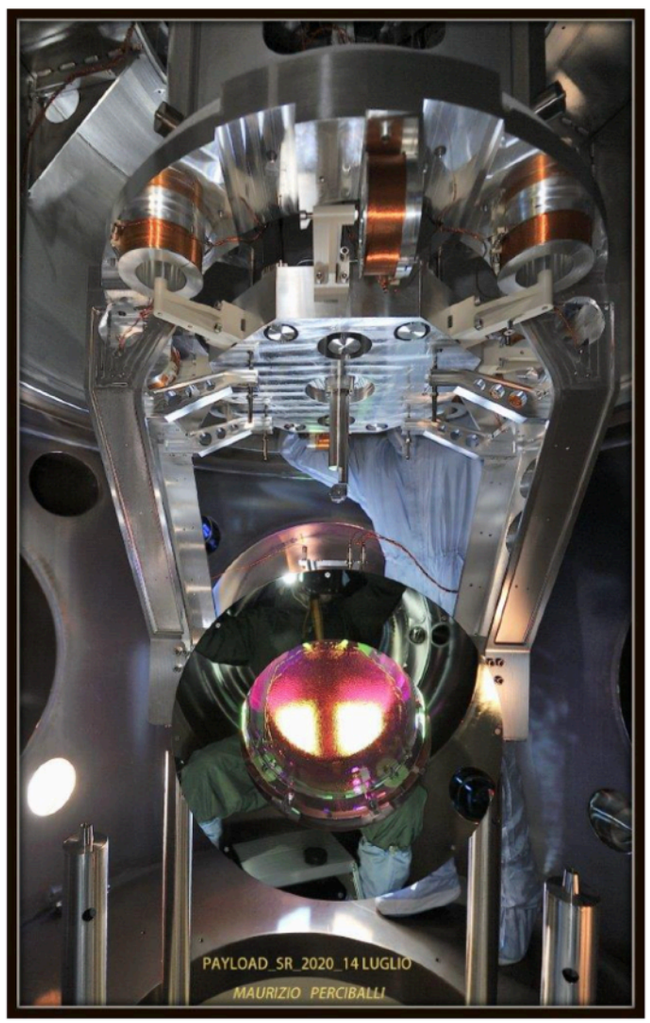
Target sensitivity curve for O4

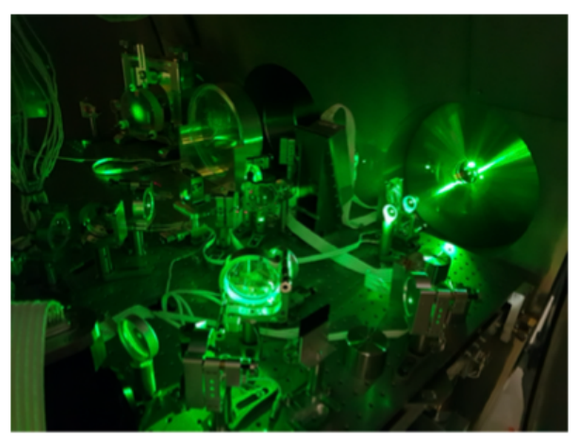


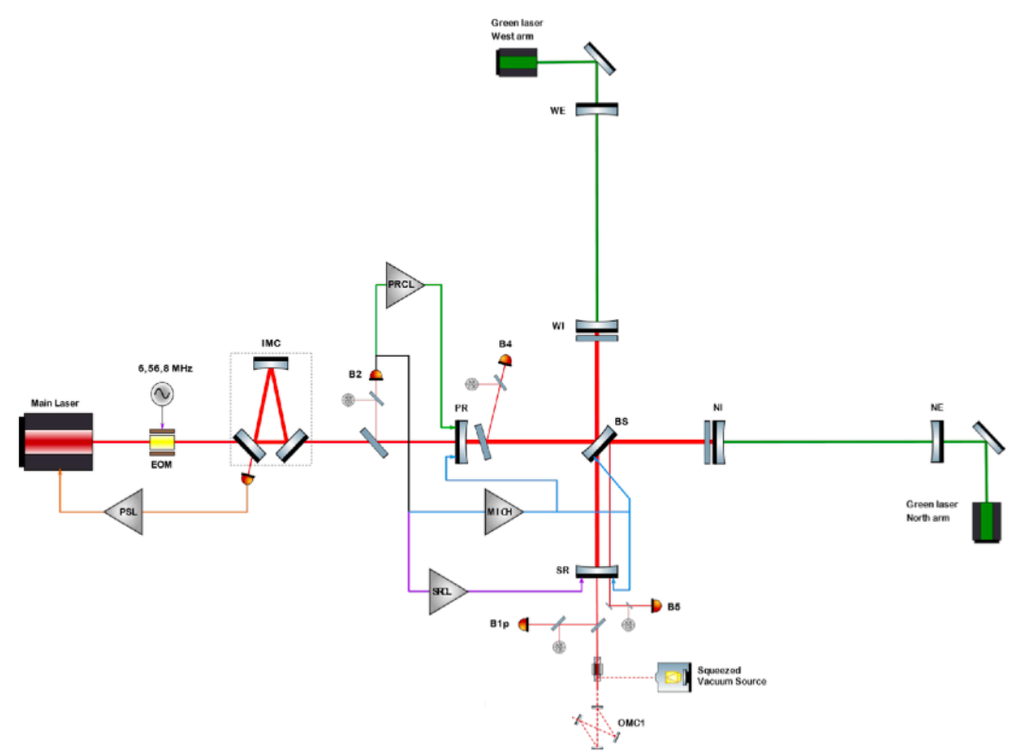
Signal Recycling Mirror & Auxiliary Laser System

Goal: implement the signal recycling cavity to change the shape of the sensitivity curve -> make it working is the most challenging upgrade

- Installation of a new payload (mirror, marionette, thermal actuator, baffle)
- 5 longitudinal degrees of freedom -> installation of the auxiliary laser system to allow the control of the full experiment



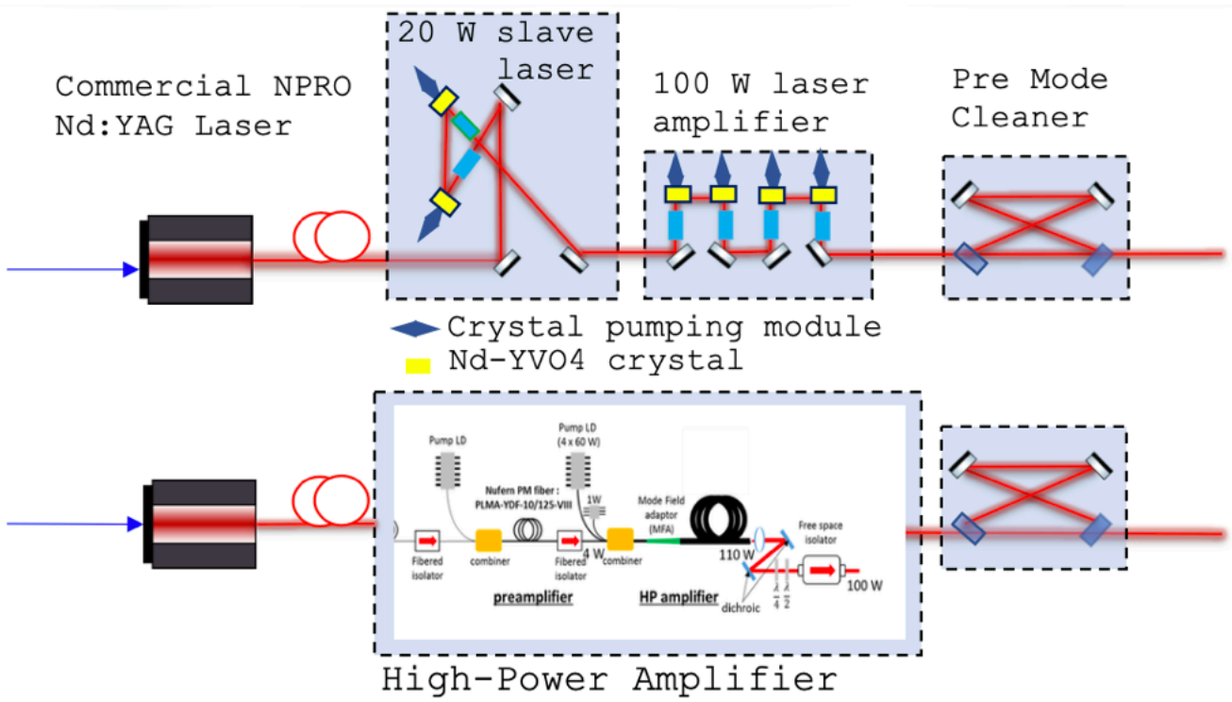


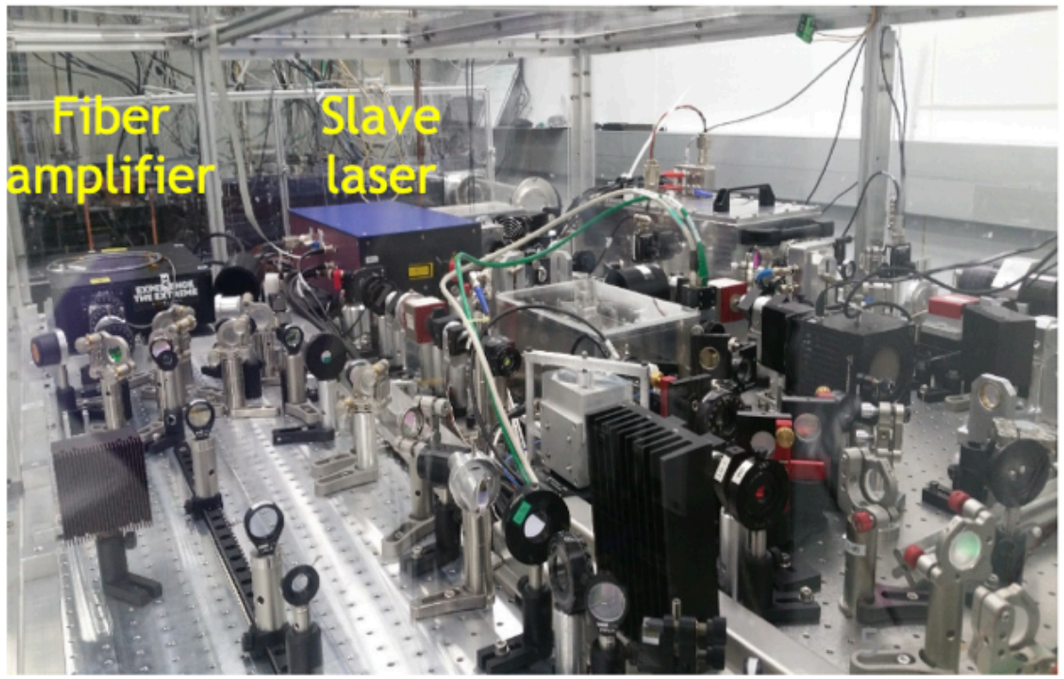


Laser System Upgrade

Goal: power of about 40 W at the input of the interferometer -> power of about 200 kW circulating in the arm cavities

- 100 W monolithic fibered system -> maximum power of about 75 W injected into the interferometer
- former multi-stage amplification system kept as spare

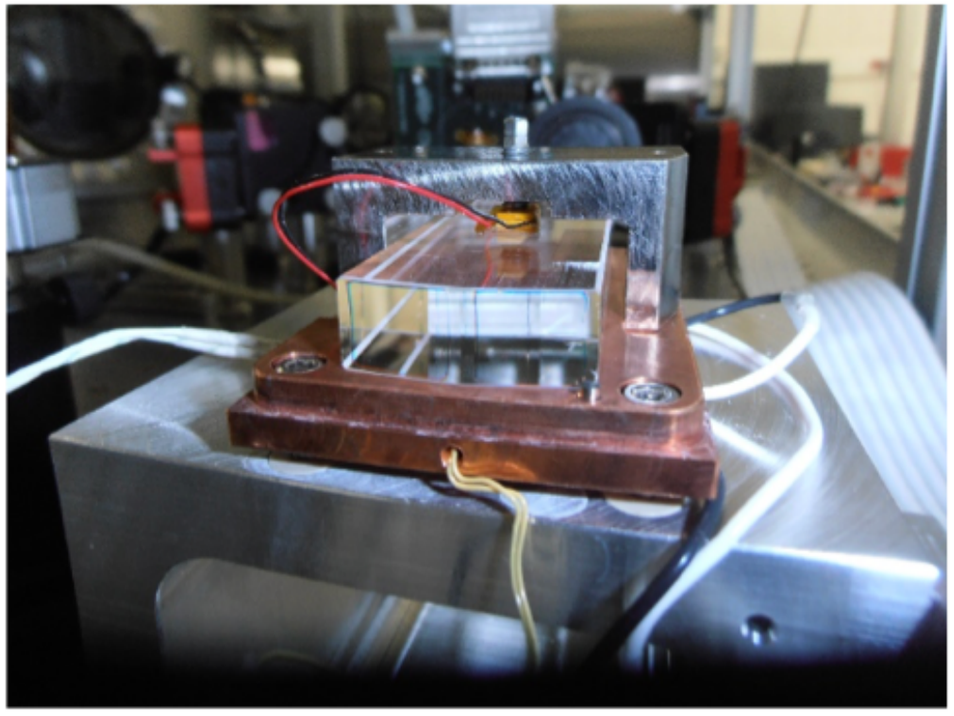


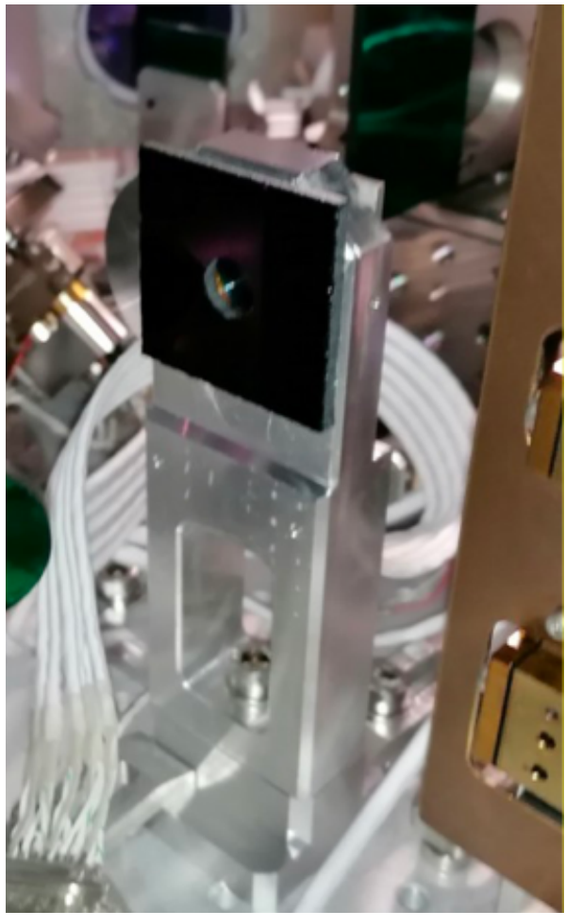


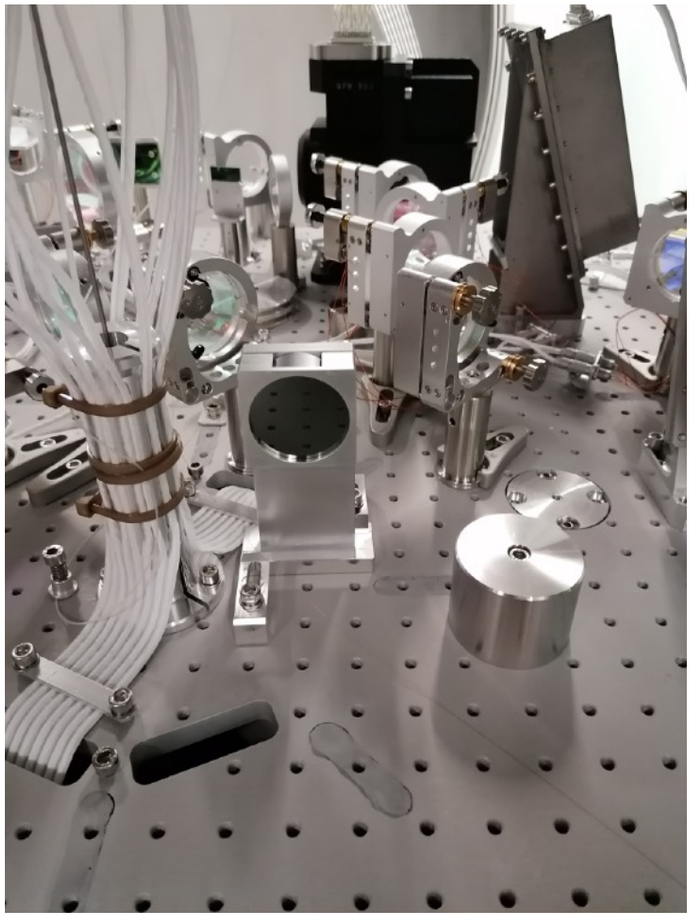
Detection System Upgrade

Goal: reduce the losses by a factor 2 at the output of the interferometer, improve the filtering of spurious beam by 1 order of magnitude, mitigation of scattered light

- Installation of a single high-finesse Output Mode Cleaner Cavity
- Installation of baffles, beam dumps, absorbing glasses



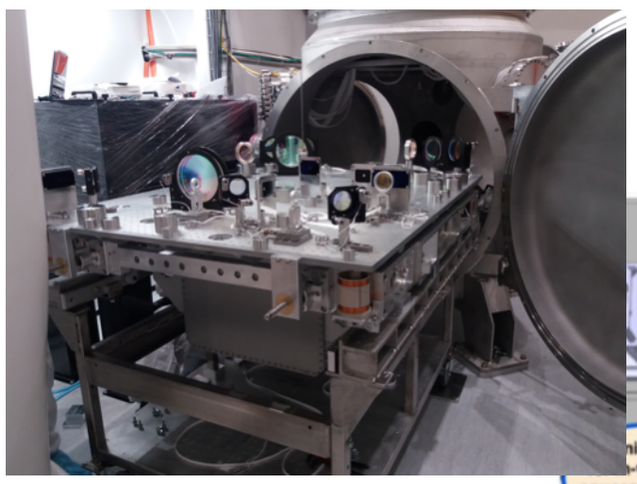


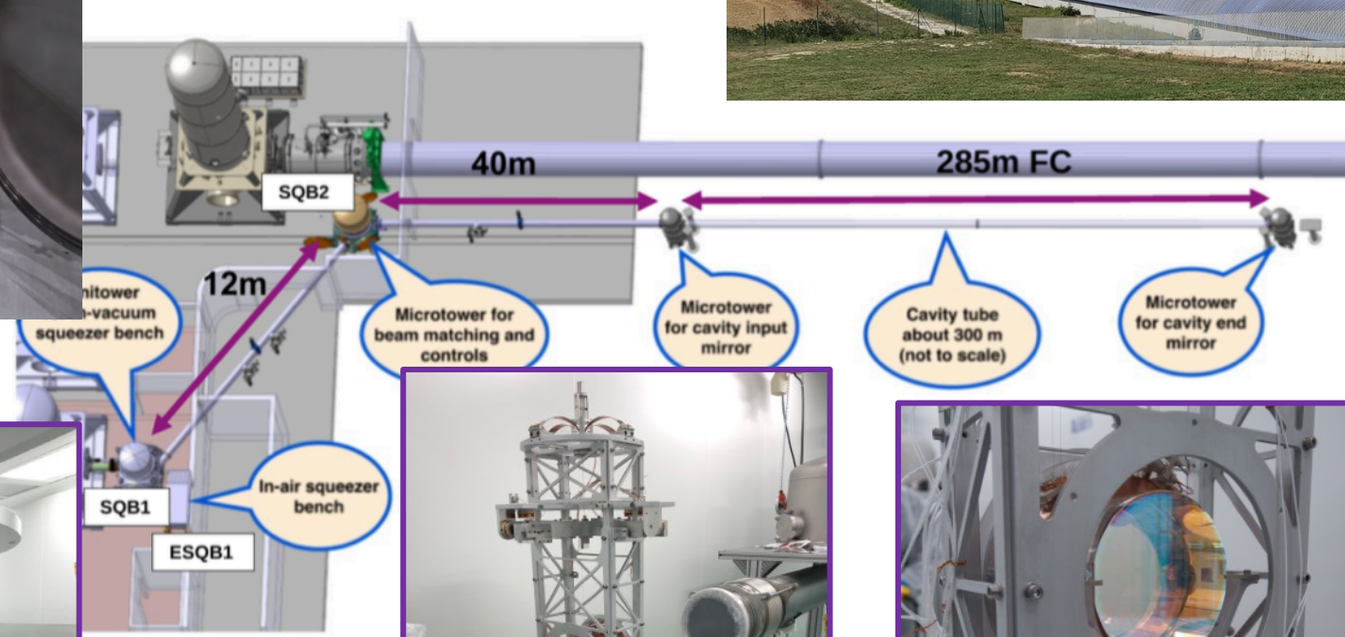


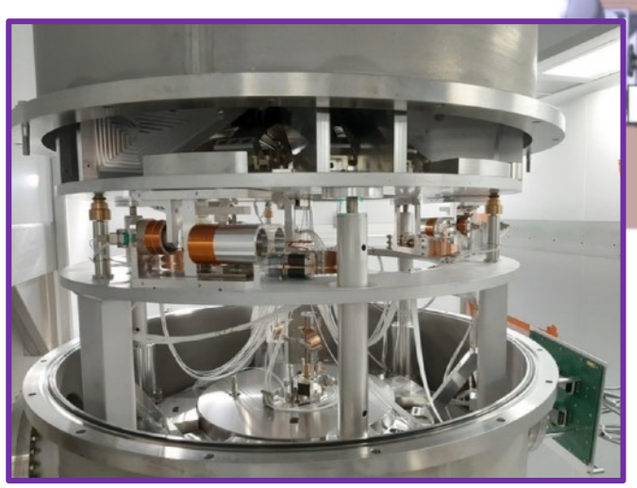
Frequency Dependent Squeezing

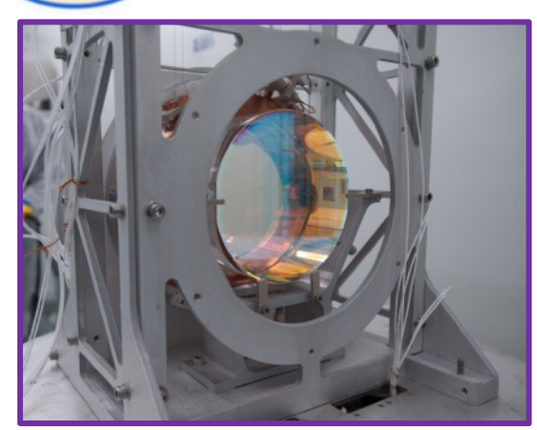
Goal: reduce the impact of the shot noise at high frequency without spoiling the low frequency

- Installation of a Frequency Independent Source
- Inject the squeezed beam into a filter cavity before sending it into the interferometer







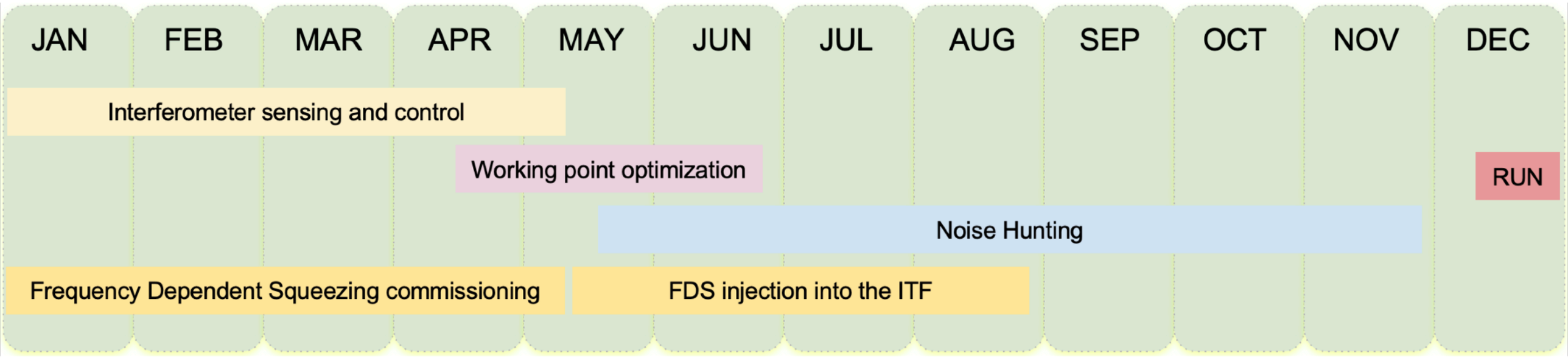


Current Status

- All the major upgrades have been successfully installed
- Power injected into the interferometer about 33 W -> power circulating into the cavity about 140 kW
- Full interferometer controlled in a not optimal working point -> many indications about the current limitations
- Current main activity on the interferometer: optimization of the working point (mode matching, global alignment, thermal state tuning)
- Frequency dependent squeezing commissioned in parallel -> frequency dependent squeezing measured around 40 Hz

Next Steps

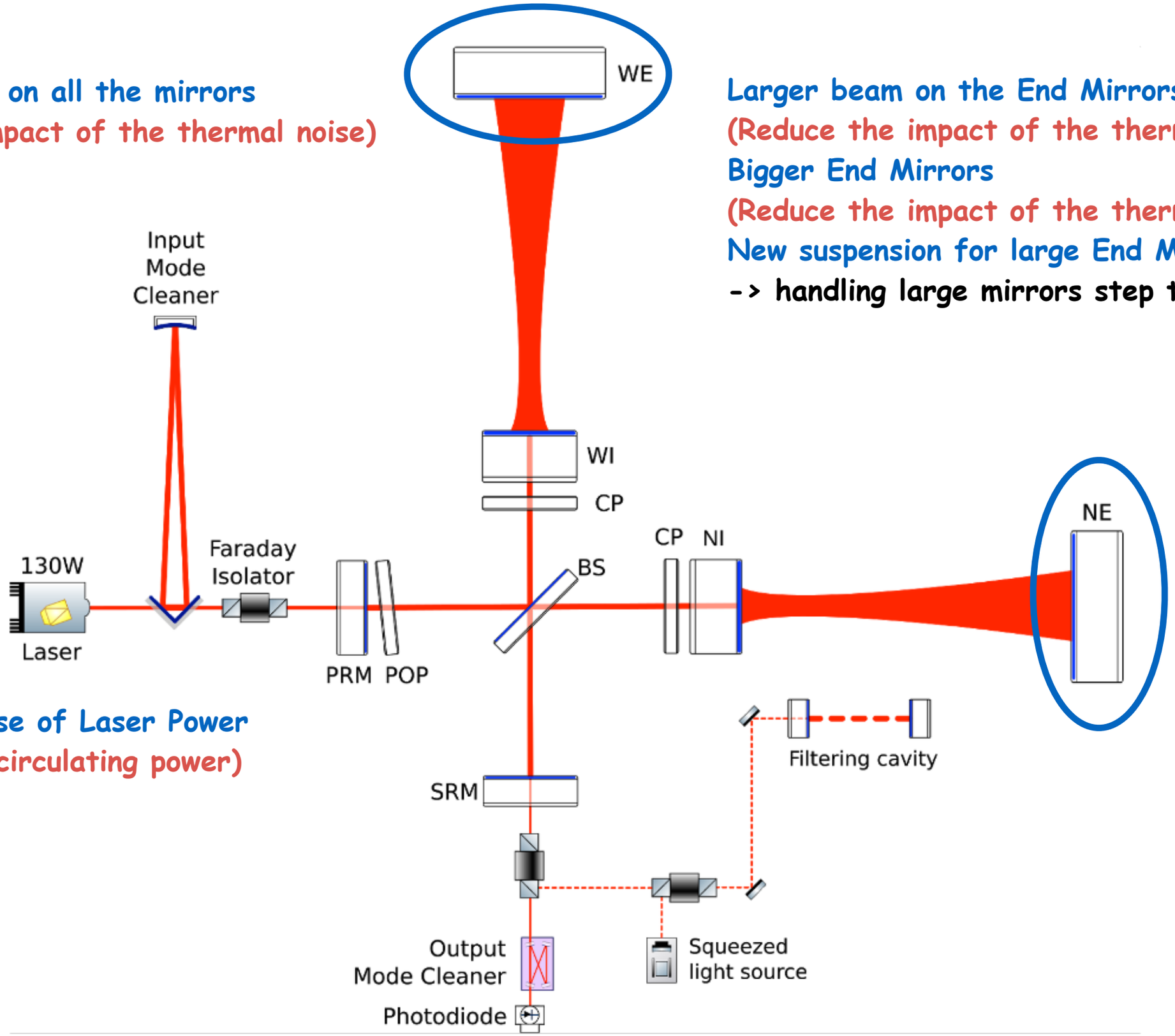
- Improvement of the interferometer working point: mode matching, global alignment, reduction of the control noise, fine tuning of the thermal state
- Have a repeatable estimation of the sensitivity curve
- Optimization of the Frequency dependent squeezing system to improve the stability
- Noise hunting to reduce the impact of the technical noises and improve the sensitivity
- Injection of the frequency dependent squeezing into the interferometer



AdV+ for O5

Better coating on all the mirrors
(Reduce the impact of the thermal noise)

Larger beam on the End Mirrors
(Reduce the impact of the thermal noise)
Bigger End Mirrors
(Reduce the impact of the thermal noise)
New suspension for large End Mirrors
-> handling large mirrors step towards ET



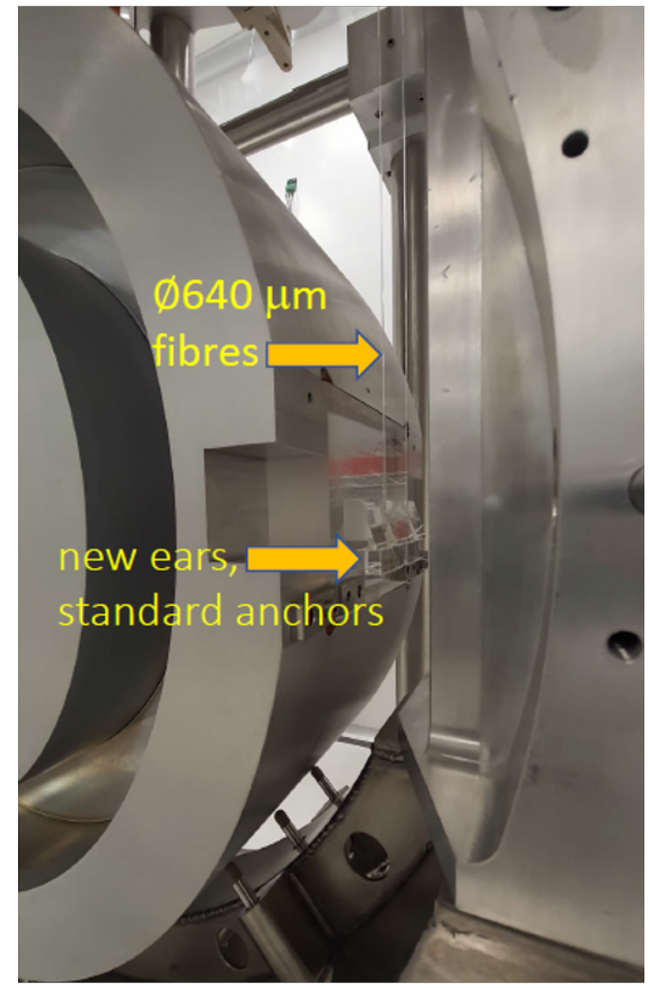
Further increase of Laser Power
(Increase the circulating power)

AdV+ Optical Scheme for O5

Large mirror

Large ring heater

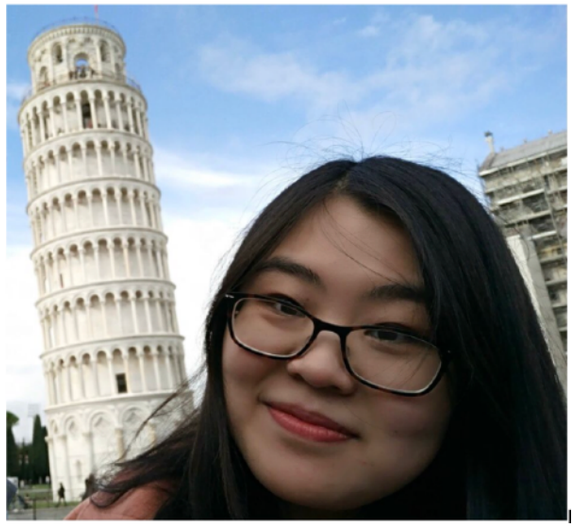
Large payload prototype



Silica fibers

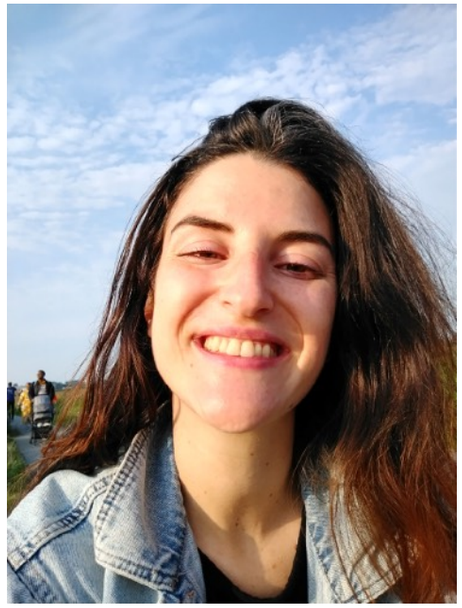
Nikhef people on site

Marco - PostDoc
ITF Controls & Squeezing

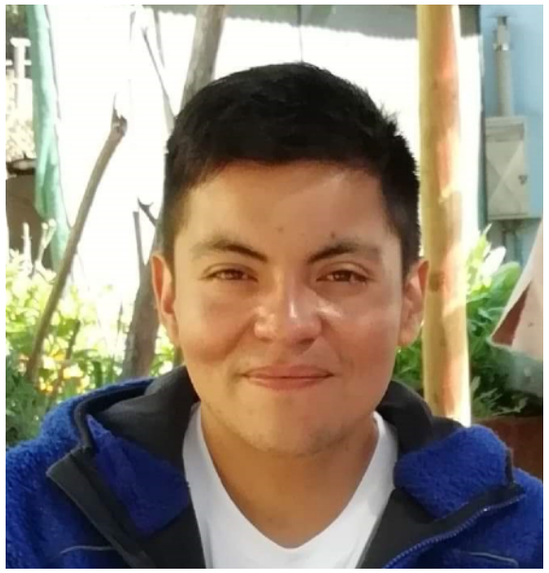


Yuefan - PhD
Squeezing & ITF Optical Characterization

Mathyn - PhD
ITF Controls



Antonella - PhD
ITF Optical Characterization



Enzo - PhD
ITF Controls & Noise Study

Alexandra - PhD
ITF Noise Study

Riccardo - PhD
ITF Optical Studies

… and some more to come