Results of the First Injection of Frequency Independent Squeezing in Advanced Virgo

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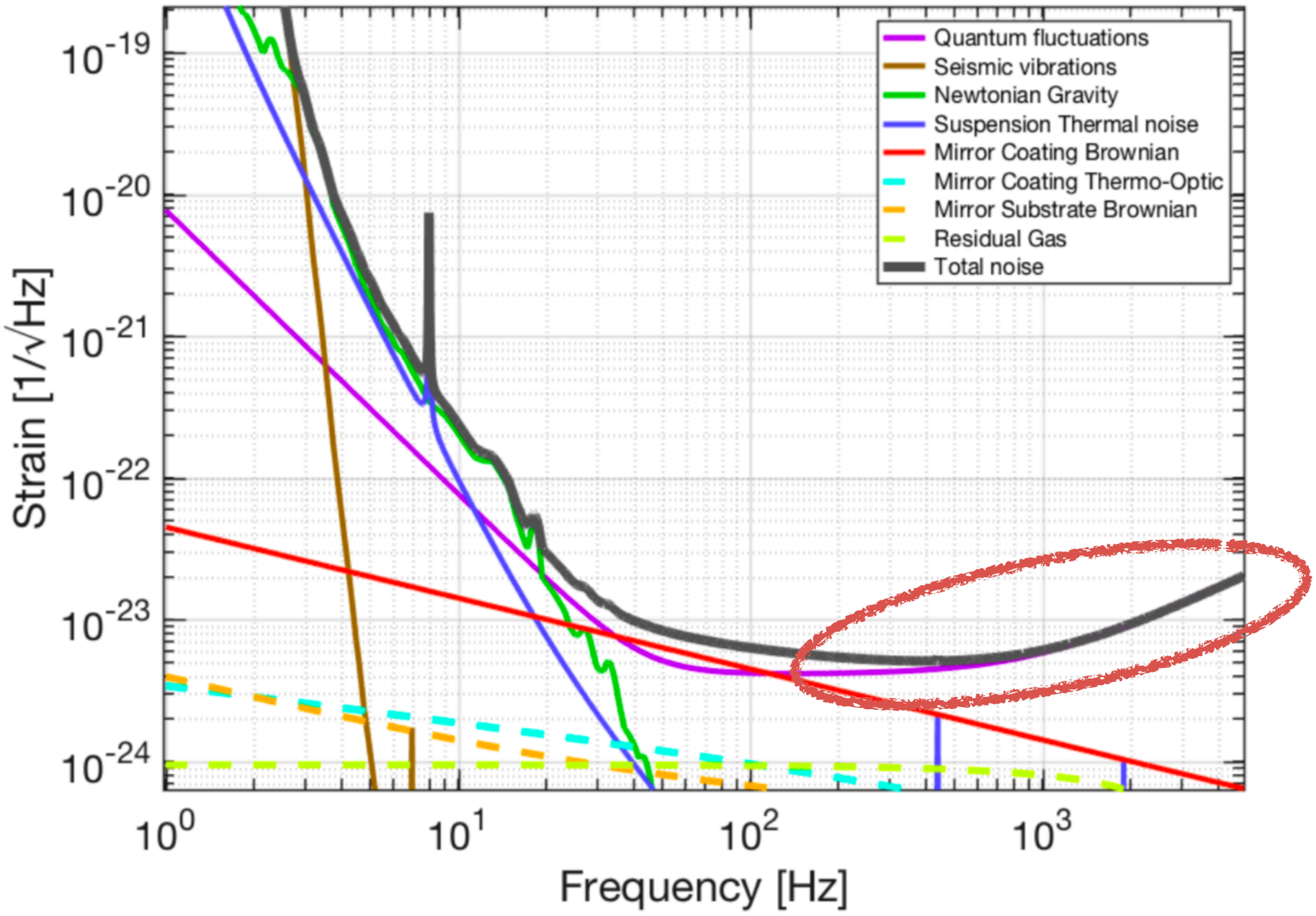
on behalf of the Virgo Collaboration

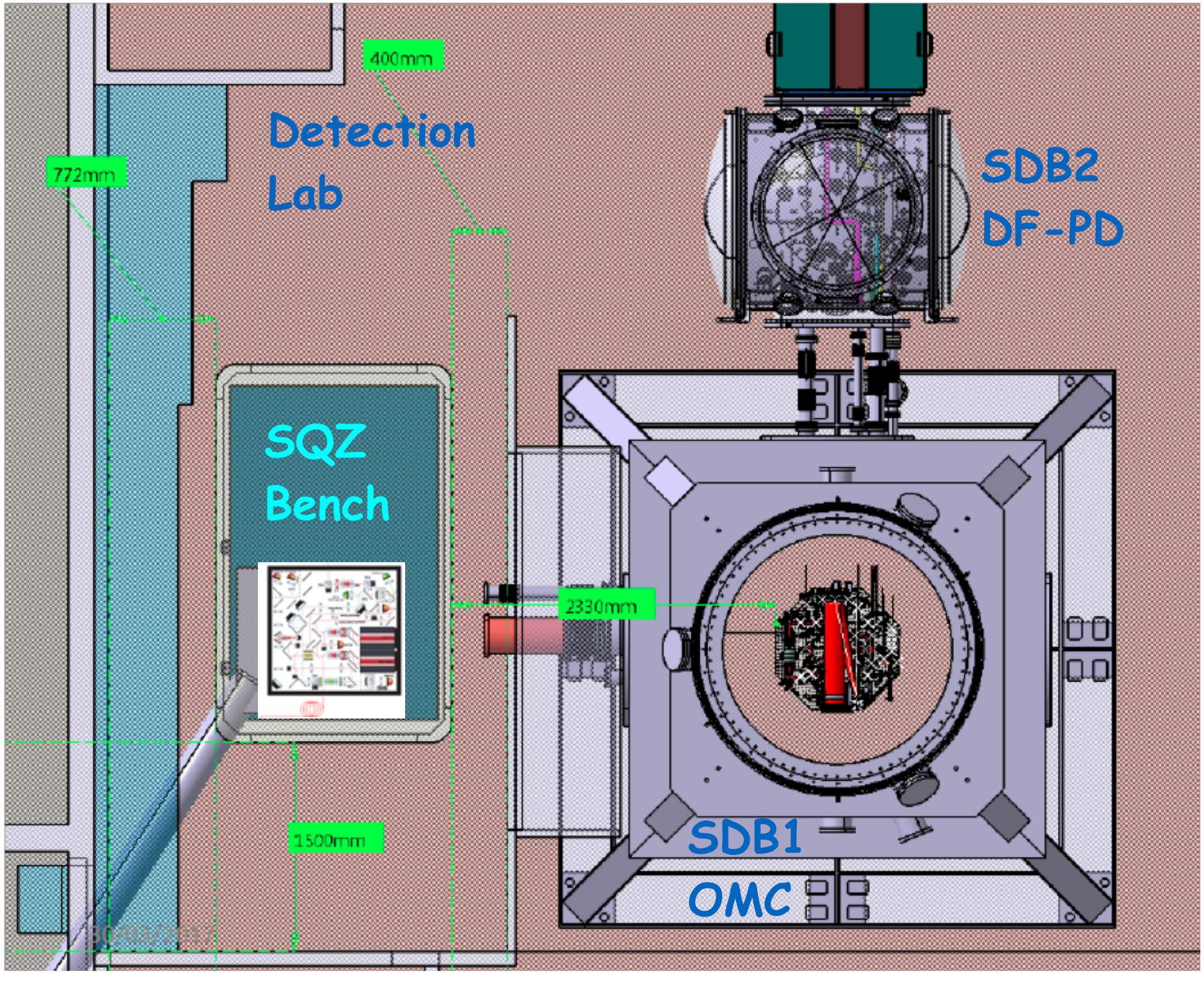
1st KAGRA-Virgo-3G Detectors Workshop - Perugia - 2019 February 16th

Motivations

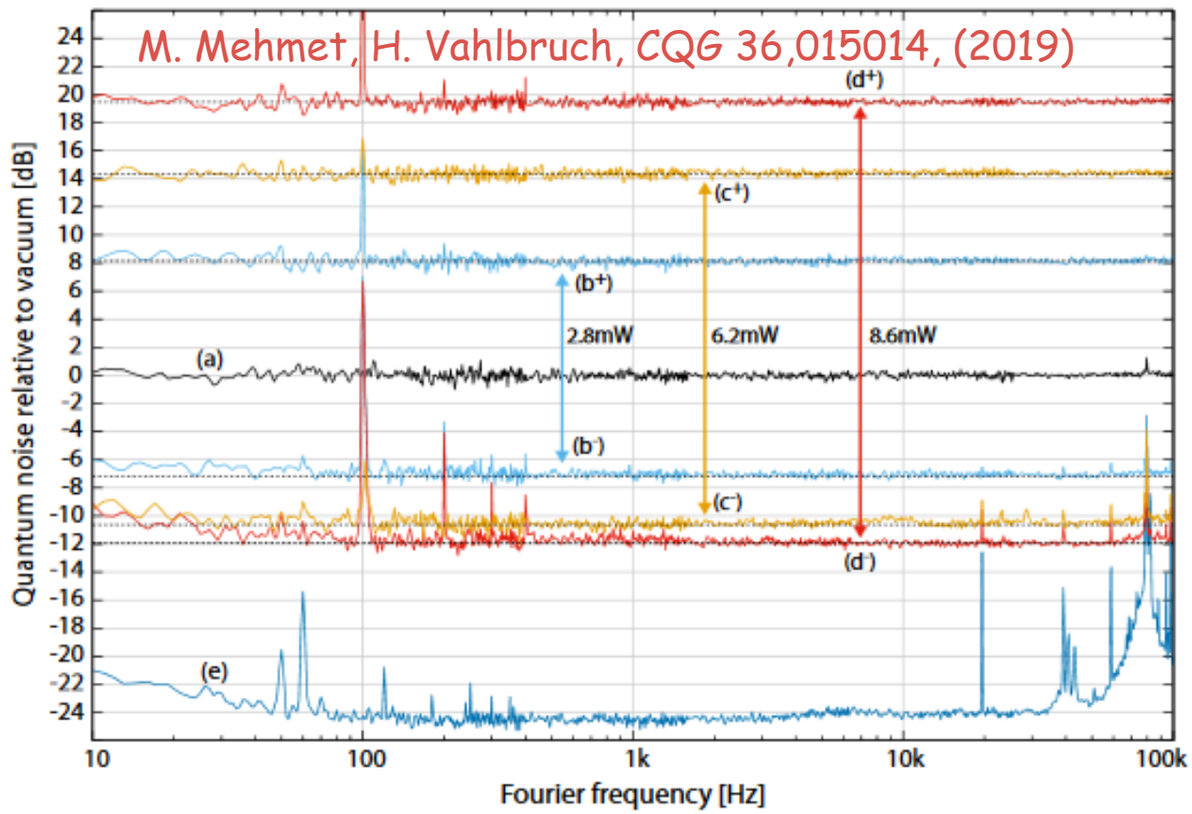


- Improve the sensitivity in the high frequencies for O3
- A fundamental step towards the Frequency Dependent Squeezing

AEI squeezer in Advanced Virgo

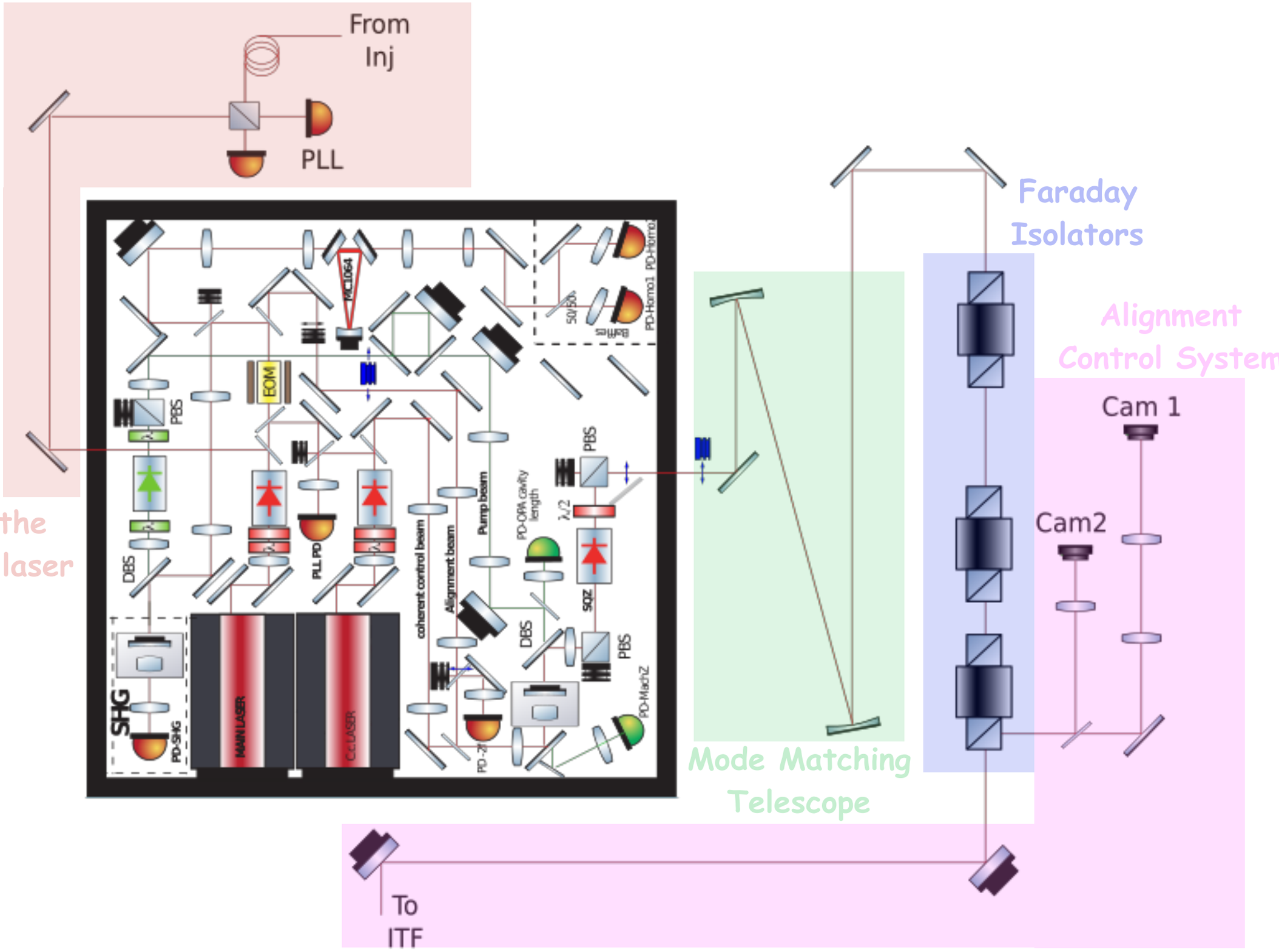


AEI squeezer in Advanced Virgo

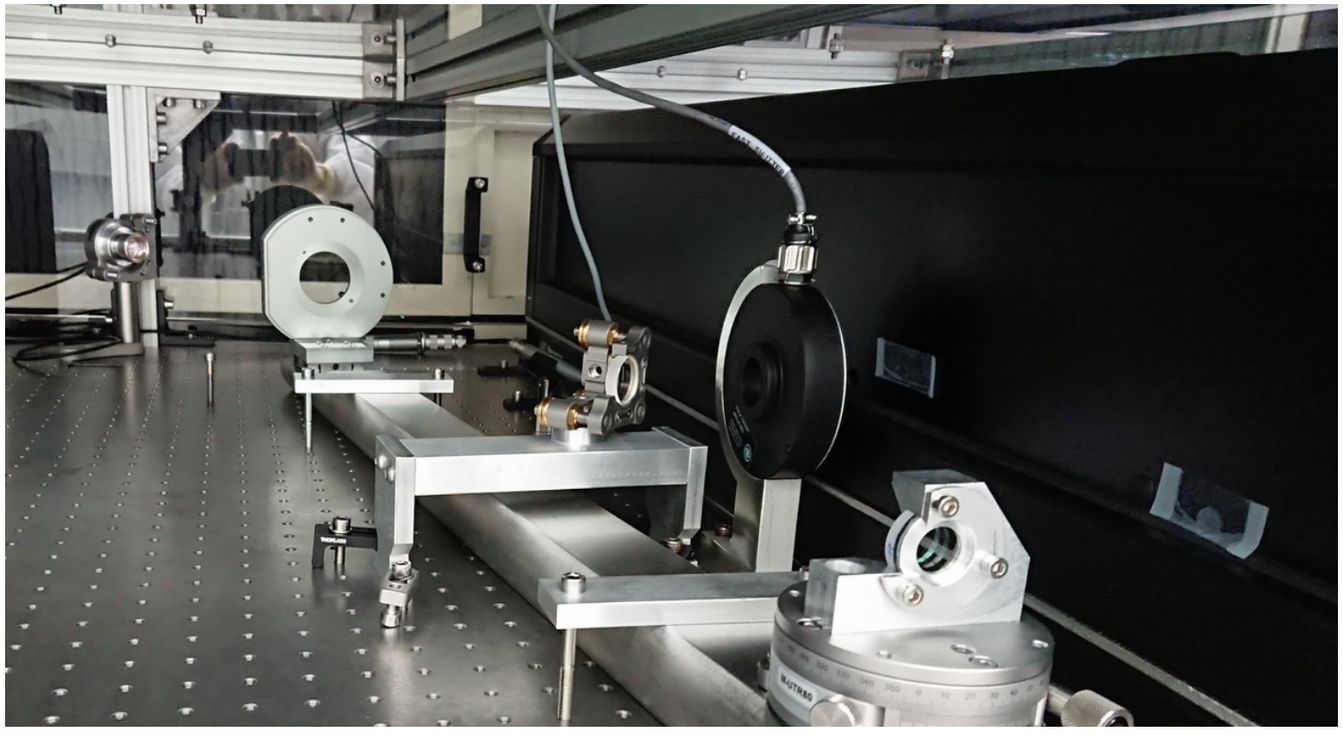


Arrived on site in January 2018 -> installation and commissioning

AEI squeezer in Advanced Virgo

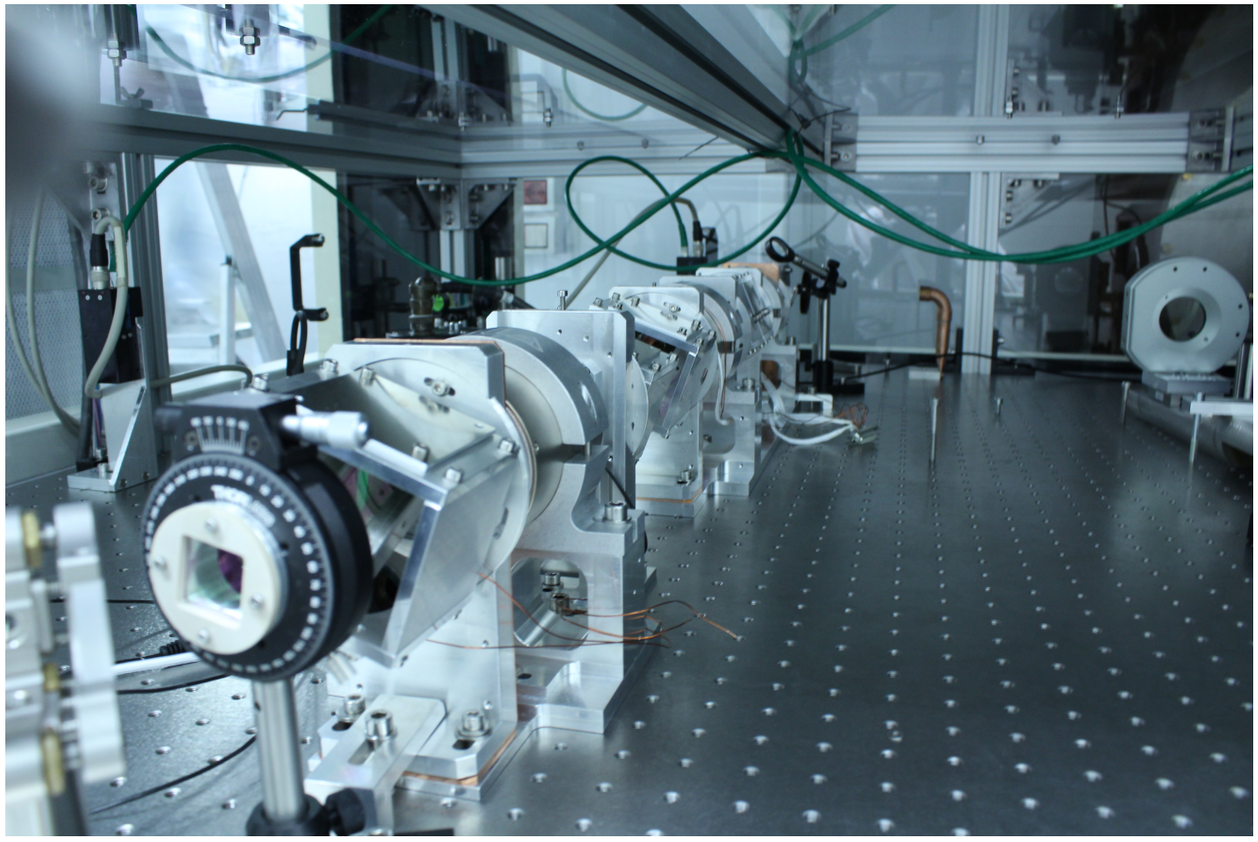


AEI squeezer in Advanced Virgo



Mode Matching Telescope

Faraday Isolators



Main Target Requirements

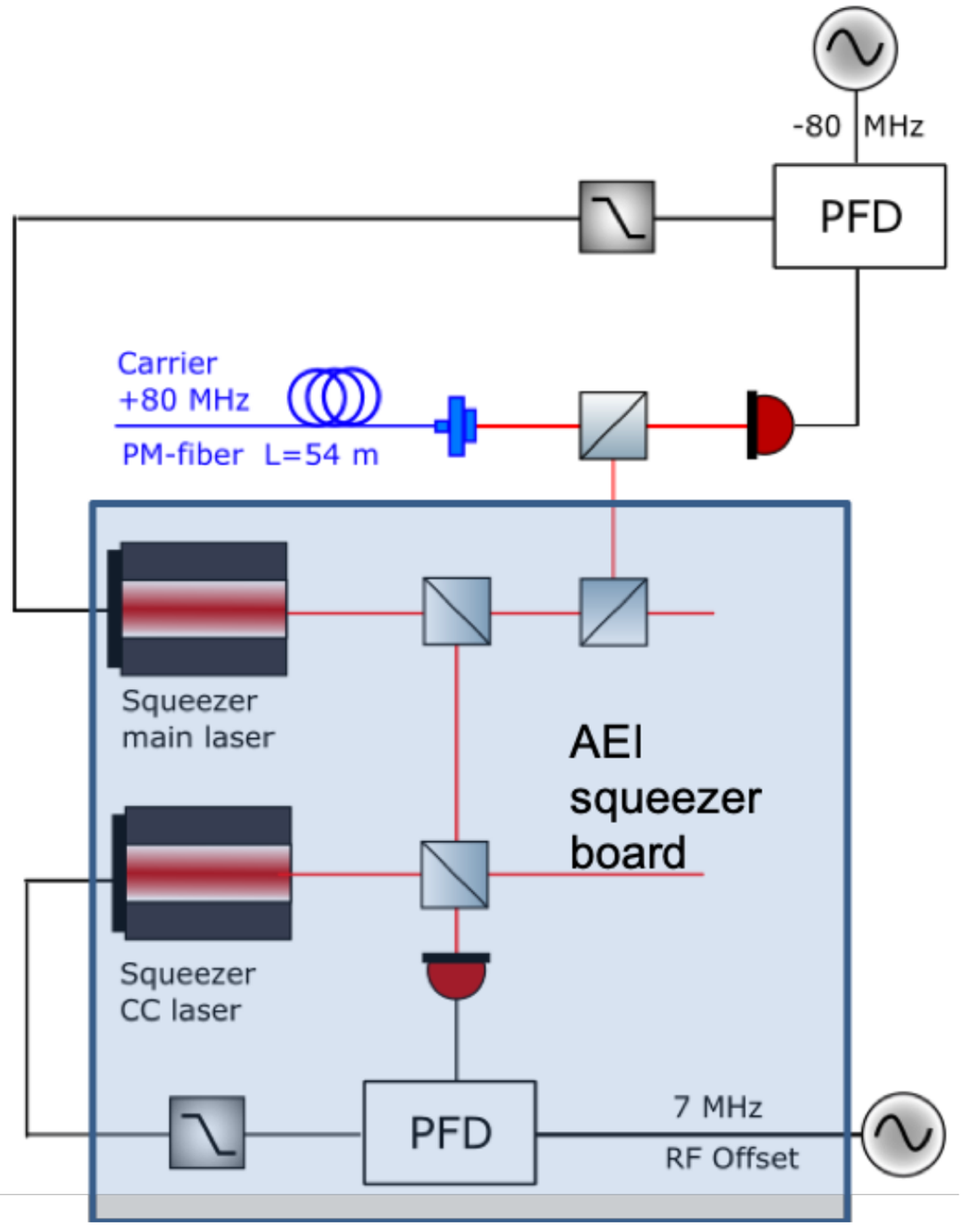
- **Measure 3-4 dB of squeezing in the ITF -> improve the sensitivity**

- Optical losses < 32 %
- Squeezing ellipse angular jitter < 30 mrad
- PLL residual phase noise < 20 mrad

Phase-Locked Loops

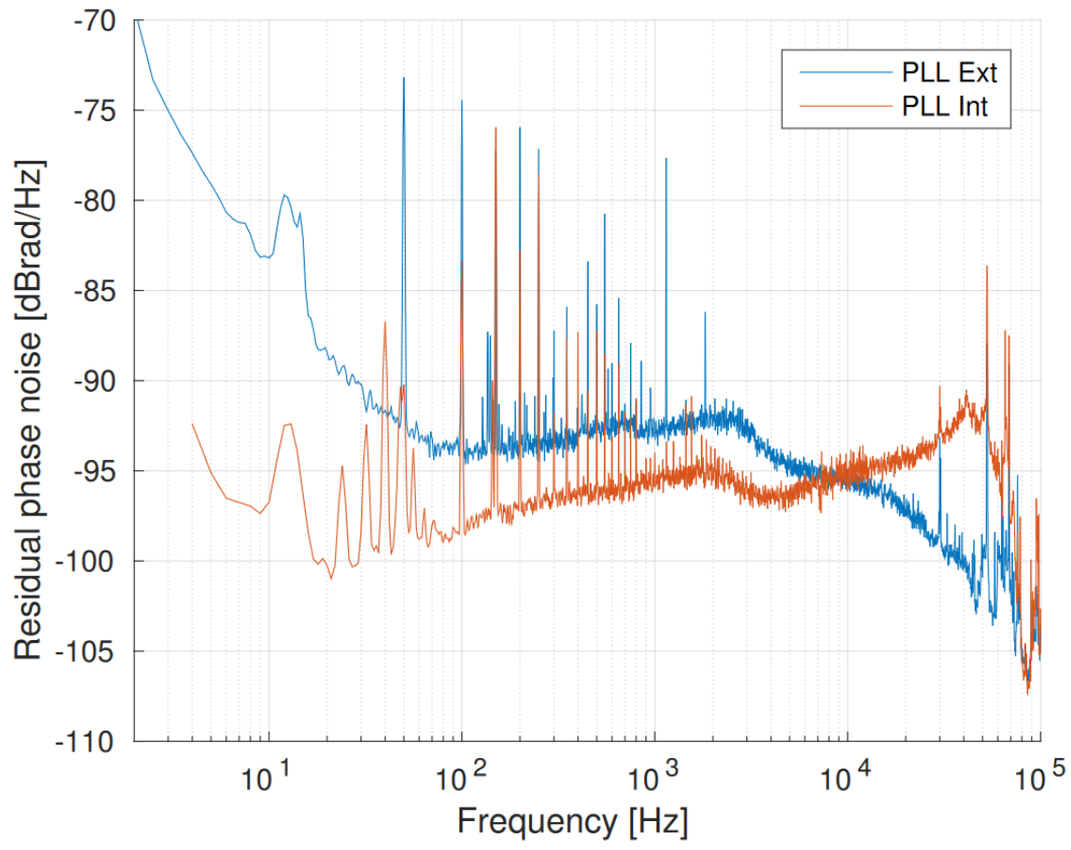
External PLL

Internal PLL



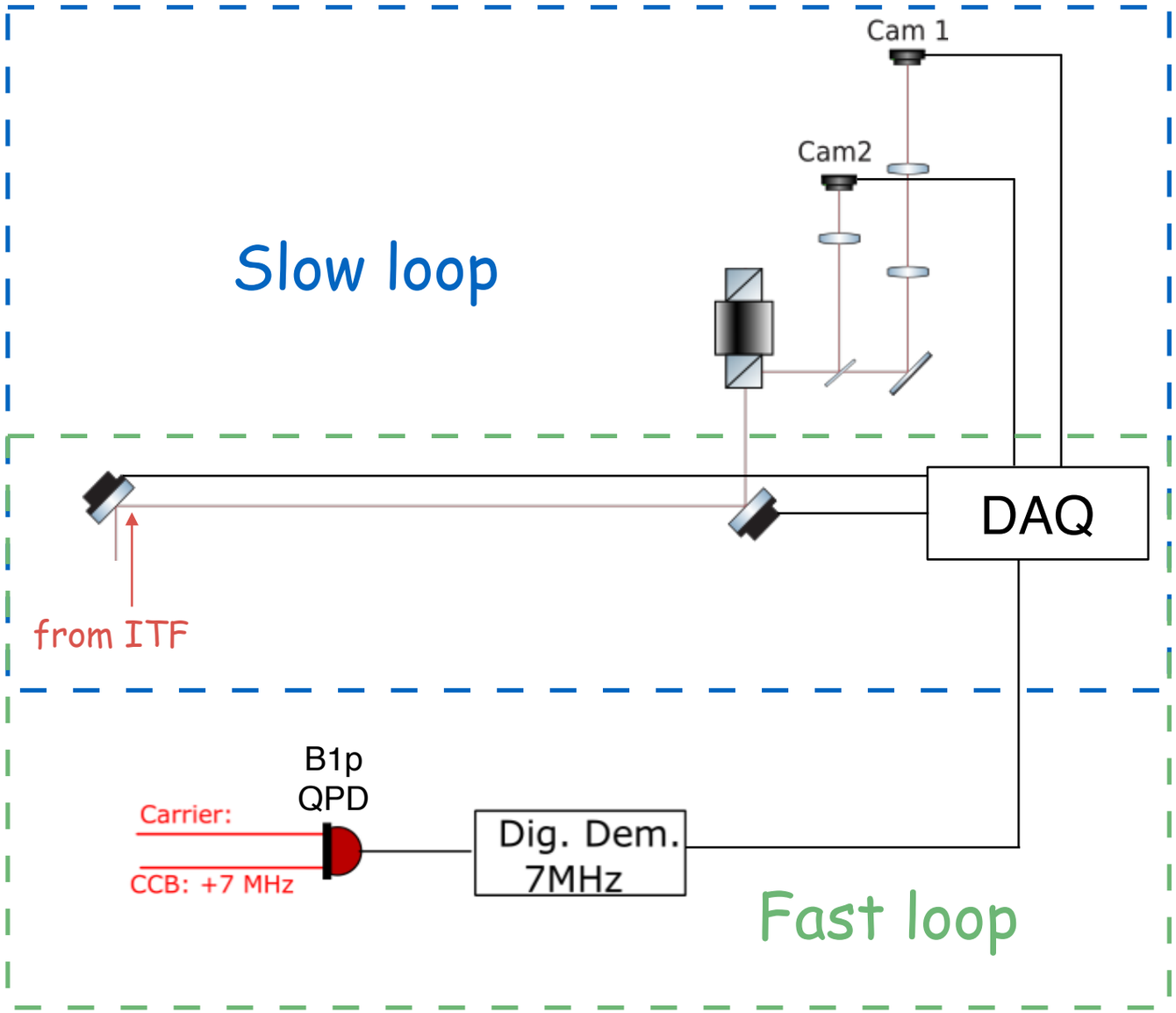
2 PLLs:

- with the Virgo main laser
- between the 2 squeezer lasers



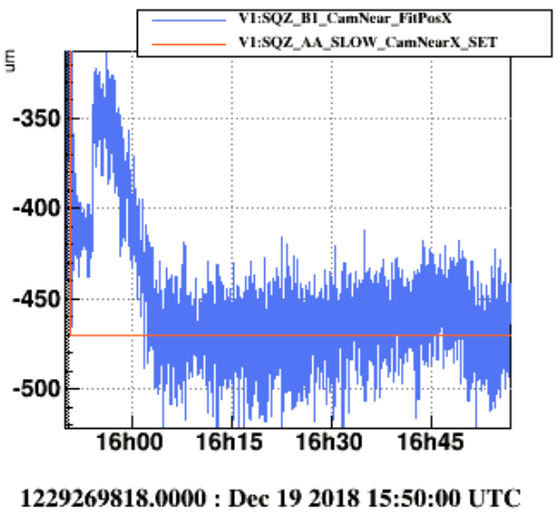
RMS Residual phase noise ~ 5 mrad -> well below the requirements

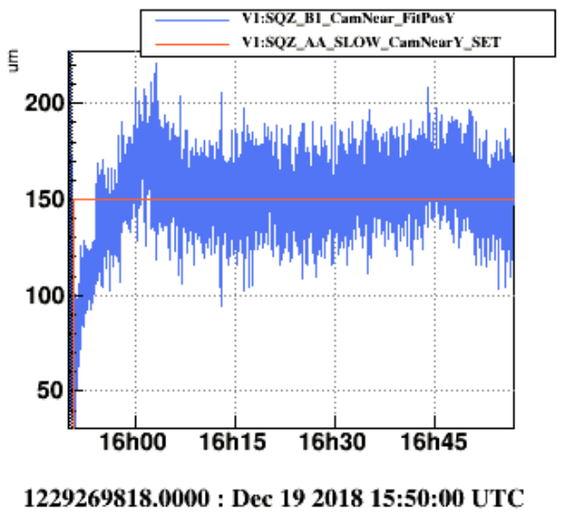
Automatic Alignment Loops



2 AA Loops:

- slow: based on tracking position of the ITF beam on cameras
- fast: based on demodulated signals on QPDs





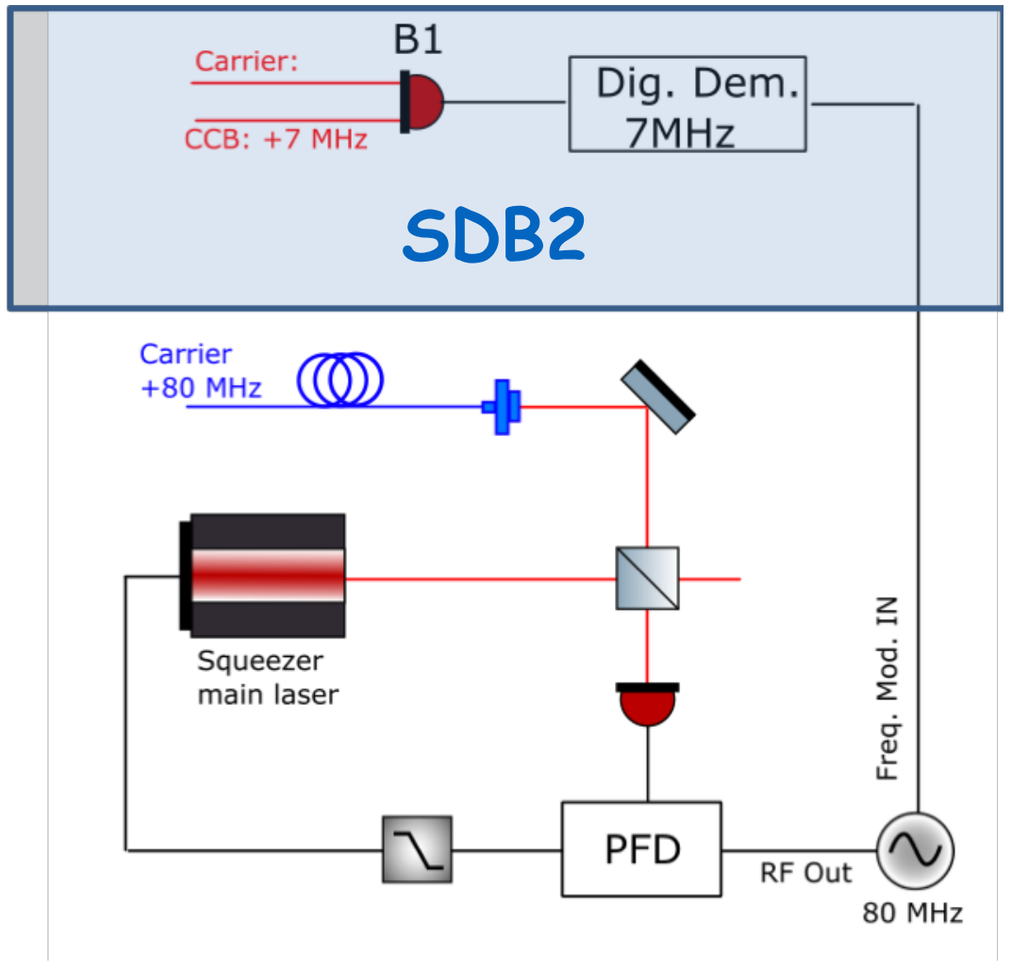
Slow Automatic Alignment Loop engaged

Some drawbacks: sensed only ITF misalignments; maximum sensing rate ~ 5 Hz; residual angular motion observed

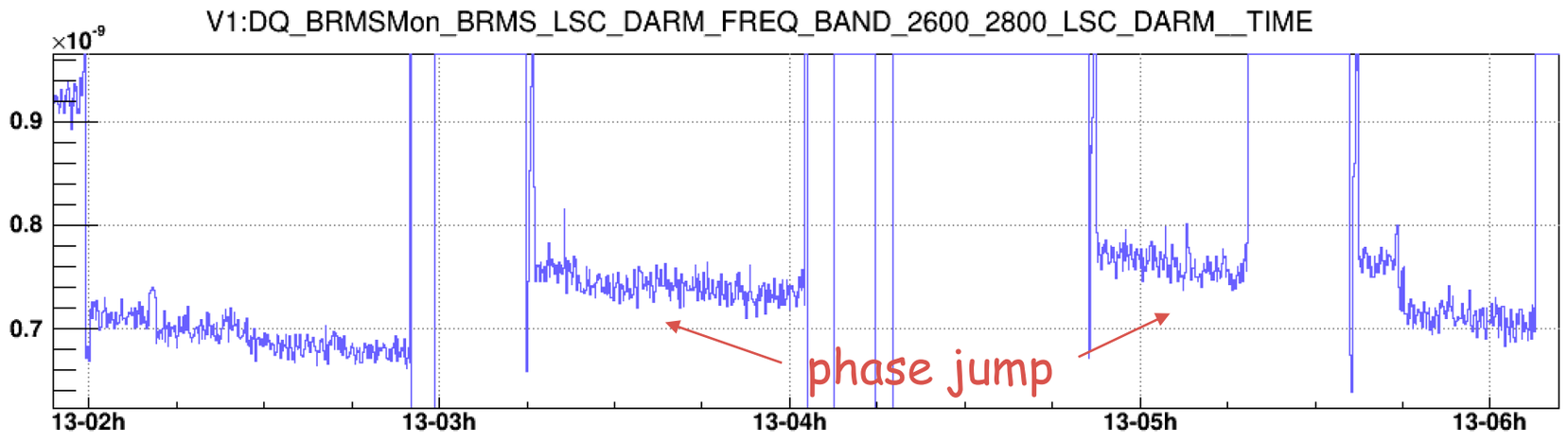
Fast Automatic Alignment Loop in progress

Sensing matrix measurements, actuation matrix implementation

Coherent Control Loop



- CC bright beam 7 MHz shifted wrt the ITF carrier
- Beat note between the ITF carrier and 7 MHz shifted CC beam sensed by the dark port photodiodes
- After digital demodulation and DA conversion, correction signal sent to the RF generator (pll reference)

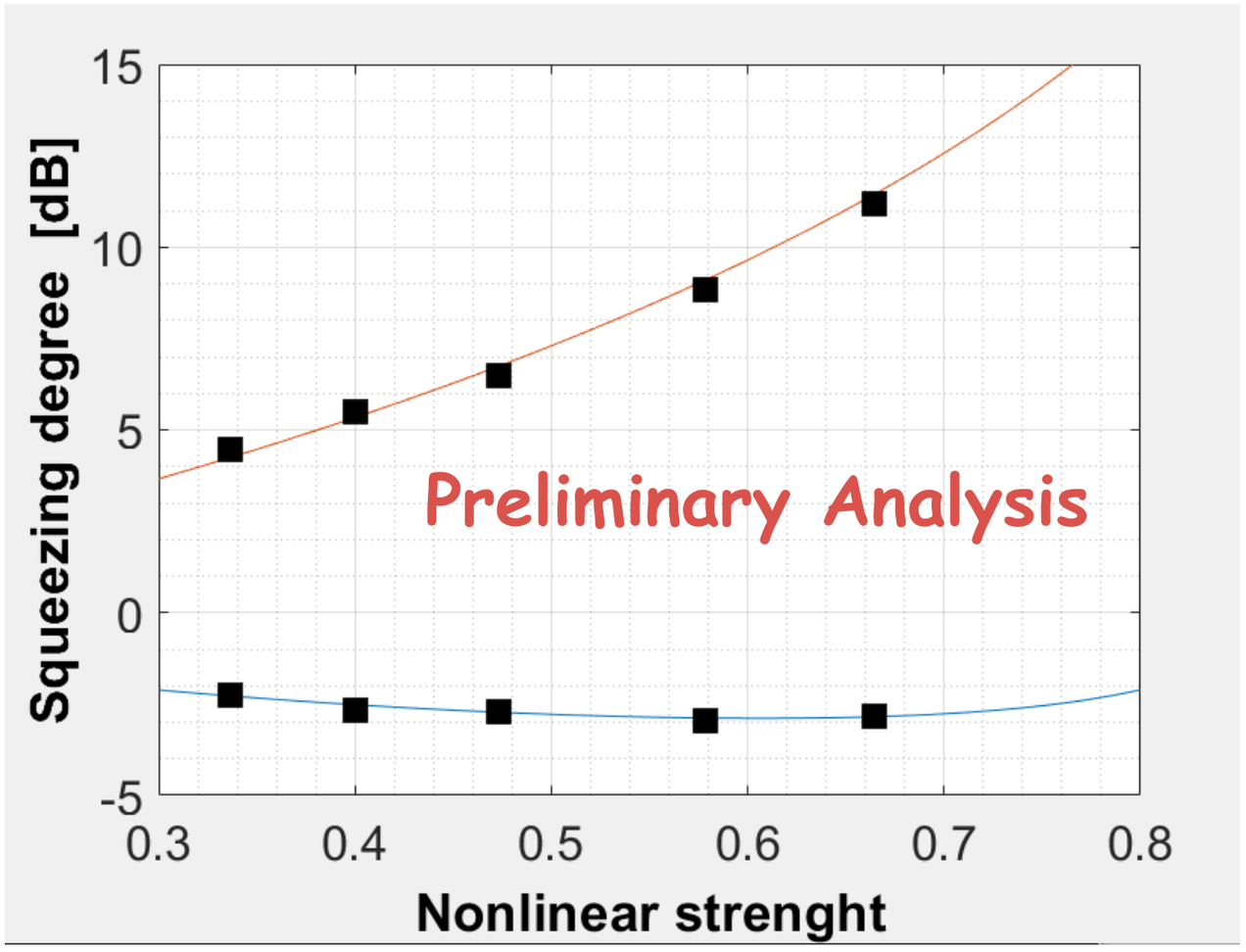


CCL engaged BUT still some phase jumps and too high drift and jitter

Results (i)

Injection of different levels of squeezing

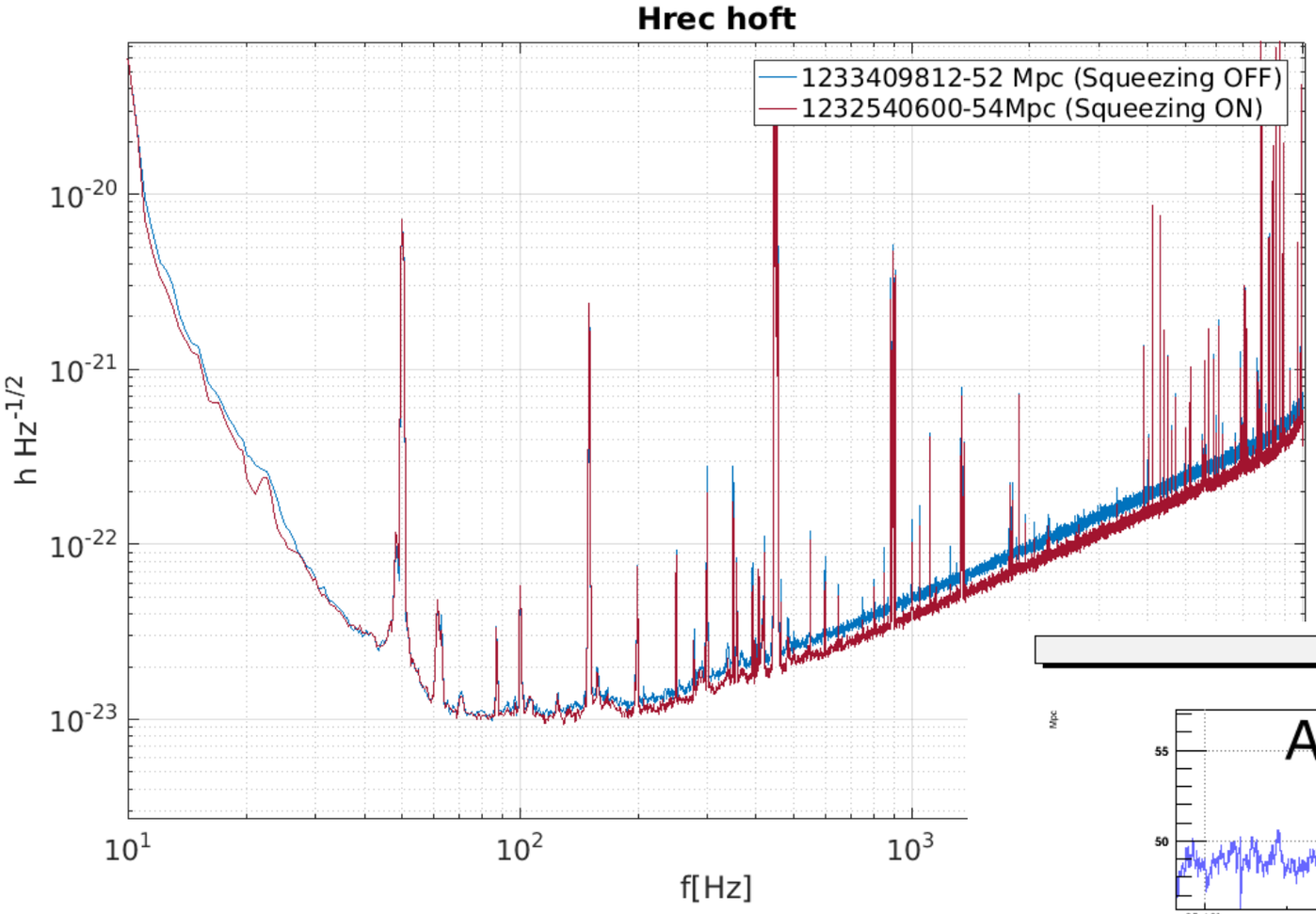
Pump Power [mW]	Squeezing [dB]	Anti-Squeezing [dB]
2.3	-2.3	4.5
3.3	-2.7	5.5
4.5	-2.7	6.5
6.75	-3	8.9
9	-2.9	11.2



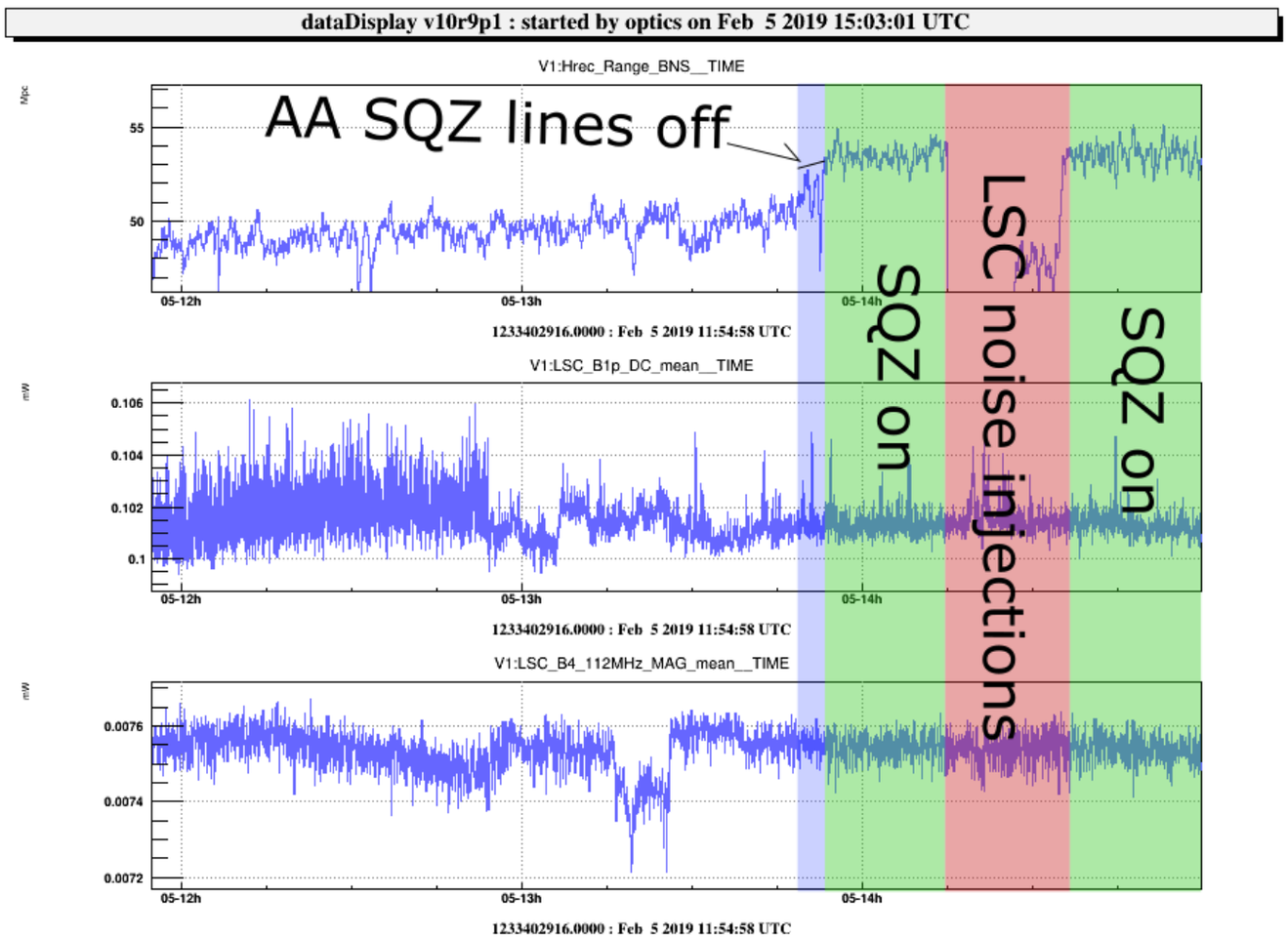
Slow drift in the alignment of the beam
Phase not always optimized

Optical Losses ~ 45 %
Squeezing Ellipse Angular Jitter ~ 60 mrad

Results (ii)



Optimized ITF working point



Clear improvement in sensitivity and in BNS range

Summarizing

- Measure of 3 dB of squeezing done 🙂
- Improvement of the sensitivity -> Almost constant gain of 2 Mpc 🙂
- Phase-Locked Loops engaged within the requirements 🙂
- Slow Automatic Alignment Loop engaged 🙂
- Coherent Control Loop engaged 🙂
- Automation of the squeezer tested and ready 🙂
- Performances dominated by optical losses and dark noise ☹️
- Some jumps in the optimal phase ☹️
- Some drift of the squeezed beam, adding also scattered light noise ☹️

What's next?

- Stabilization Loop to keep the optimal phase
- Engage the Fast Automatic Alignment Loop
- Remove the remaining scattered light noise sources
- Install High Quantum Efficiency photodiode with the corresponding low noise electronics
- Fine tuning of the squeezing injection
- Integration of the automation of the squeezing in the lock acquisition