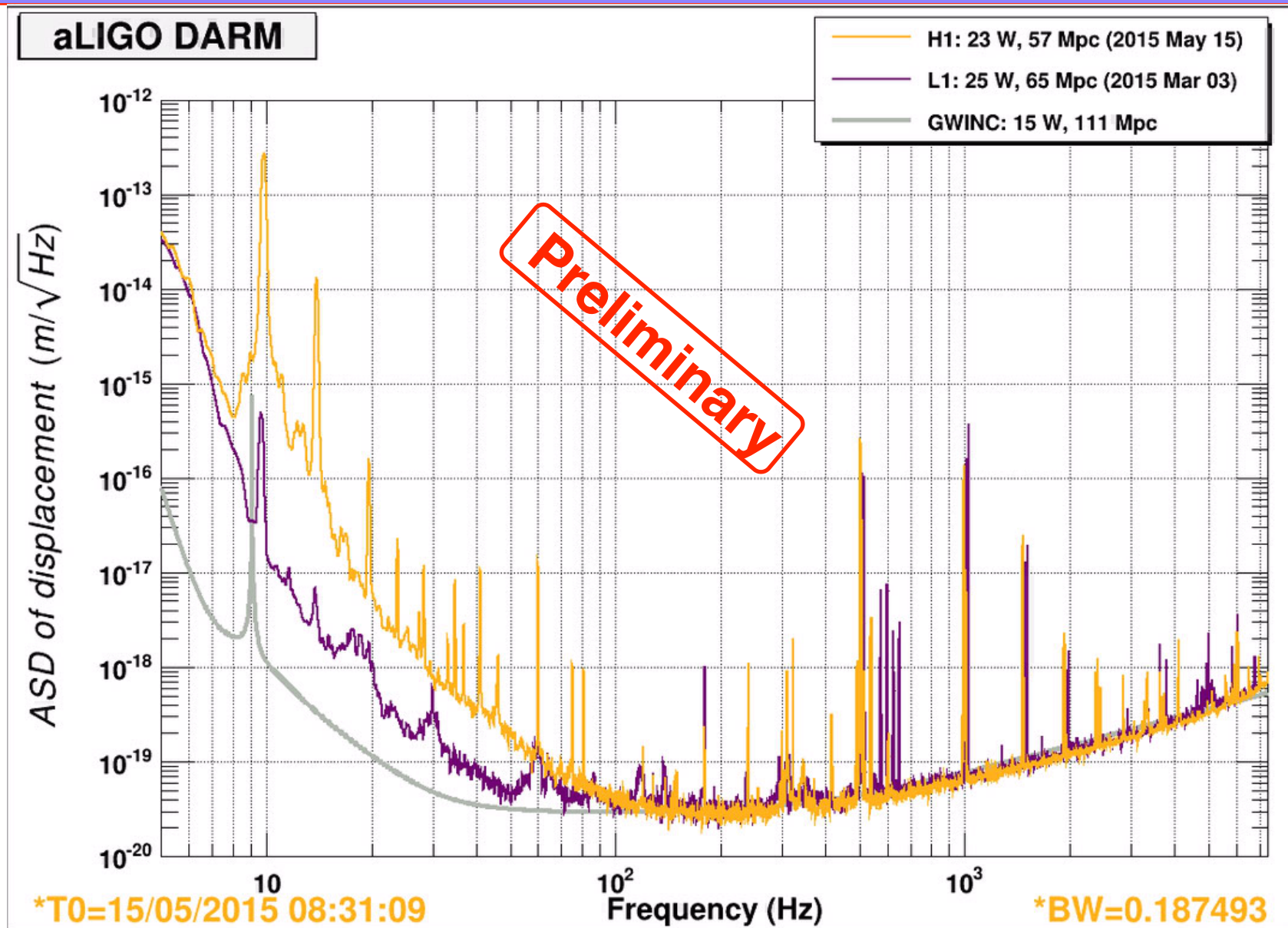


Experimental highlights and challenges in Advanced LIGO



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for LIGO Scientific Collaboration**

Advanced LIGO on track



Experimental Challenge

It is not easy to achieve both robustness and low-noise

Items for robustness

- **Lock acquisition**
- Long run
- Automation
- Alignment control
- Tidal effect
- Thermal lensing
- Opto-mechanical instab.
- etc



High duty cycle

Items for low noise

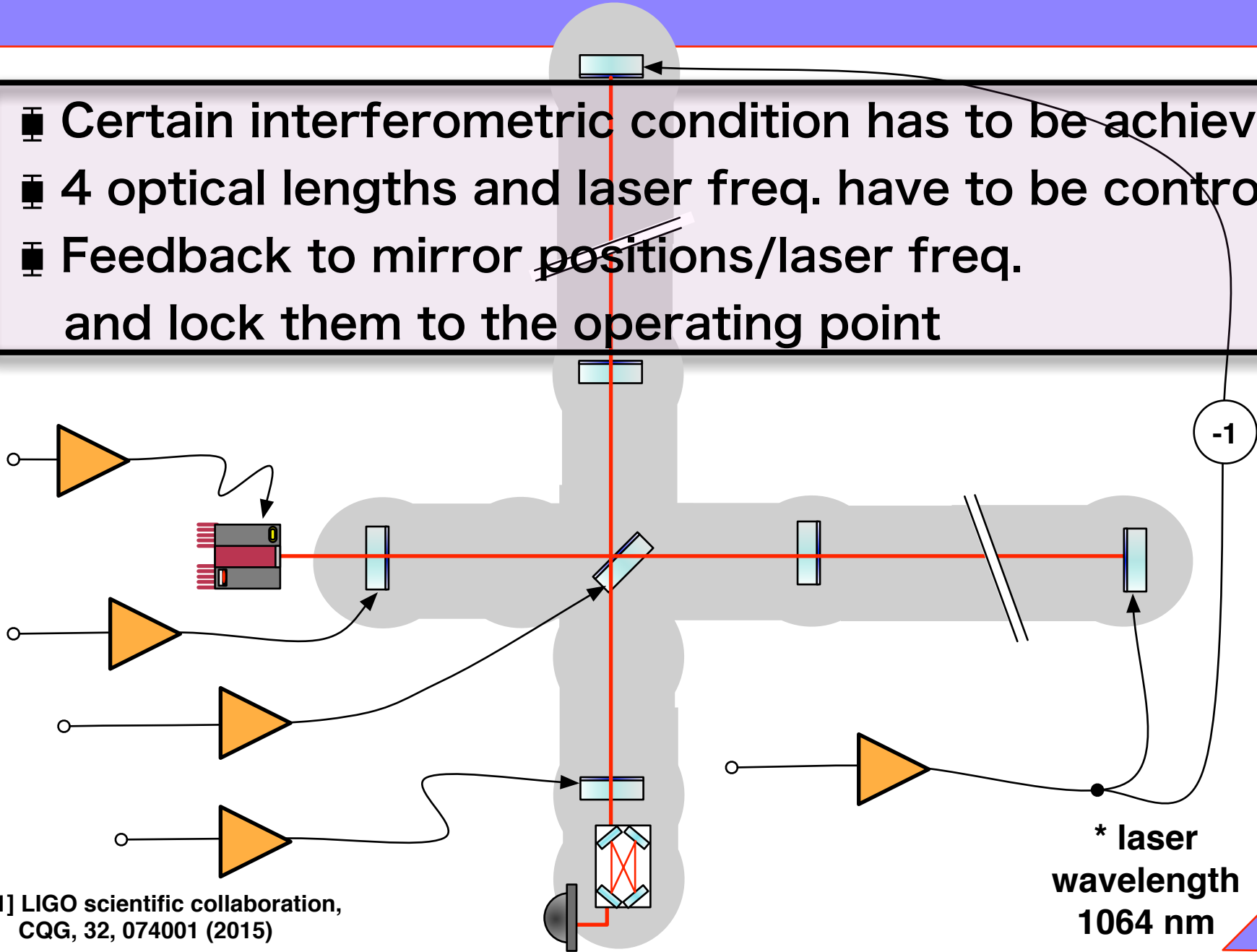
- Quantum noise
- Thermal noise
- Seismic noise
- Electronics noise
- Residual gass
- Scattering noise
- Acoustic coupling
- etc



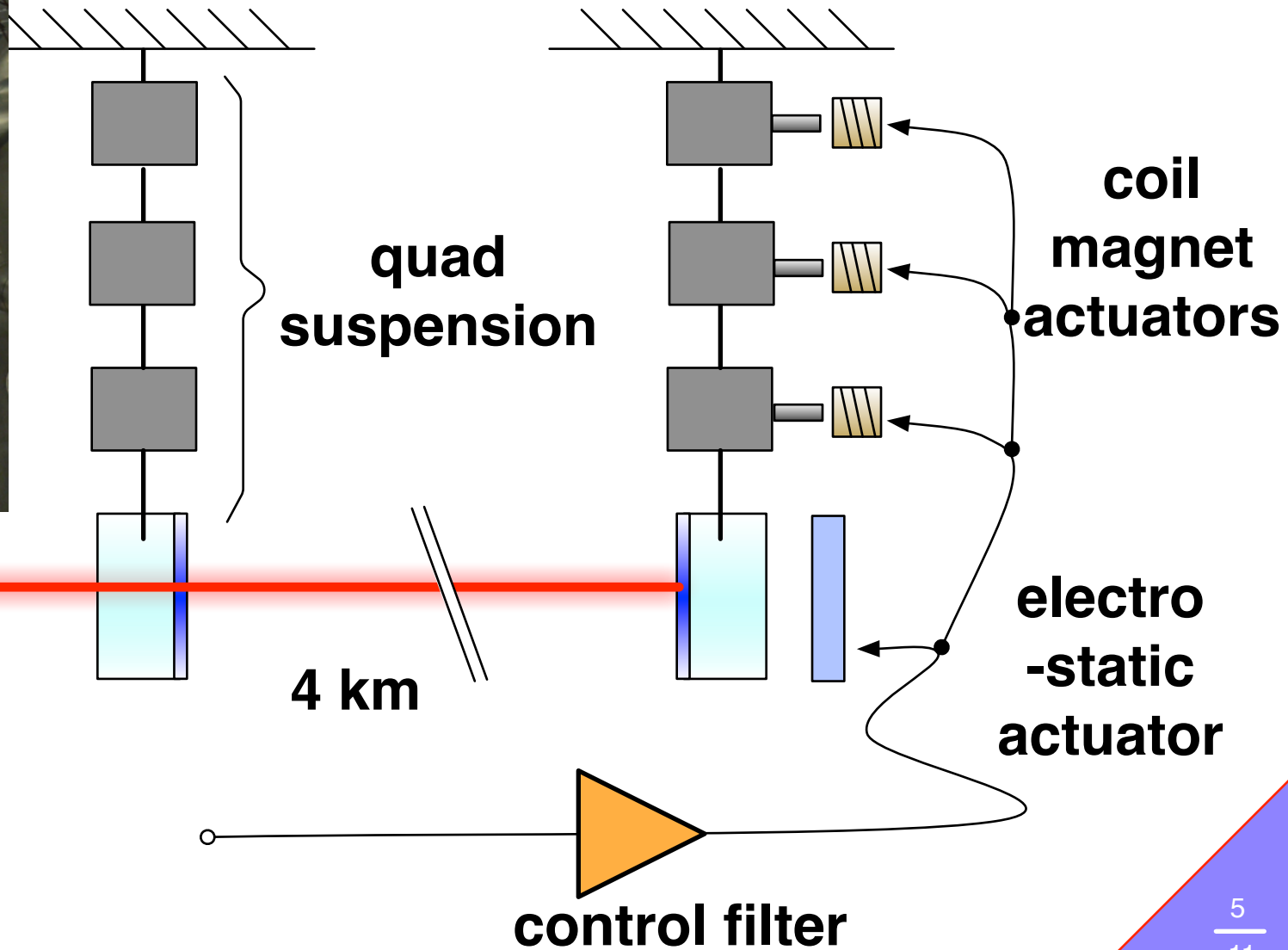
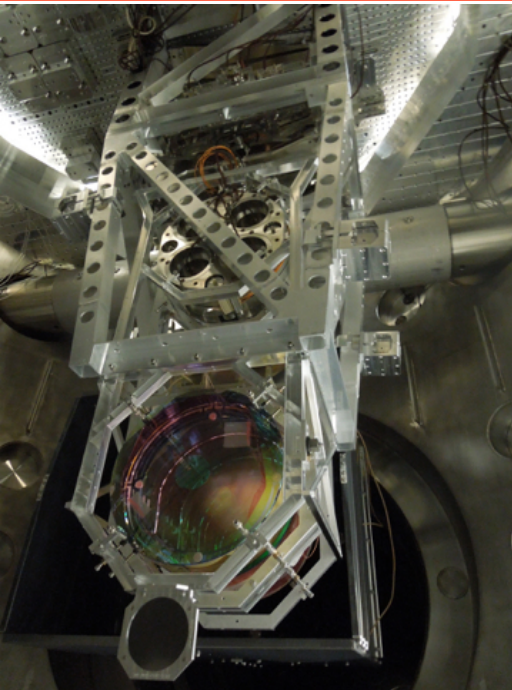
High binary range

Lock Acquisition

- Certain interferometric condition has to be achieved
- 4 optical lengths and laser freq. have to be controlled
- Feedback to mirror positions/laser freq. and lock them to the operating point

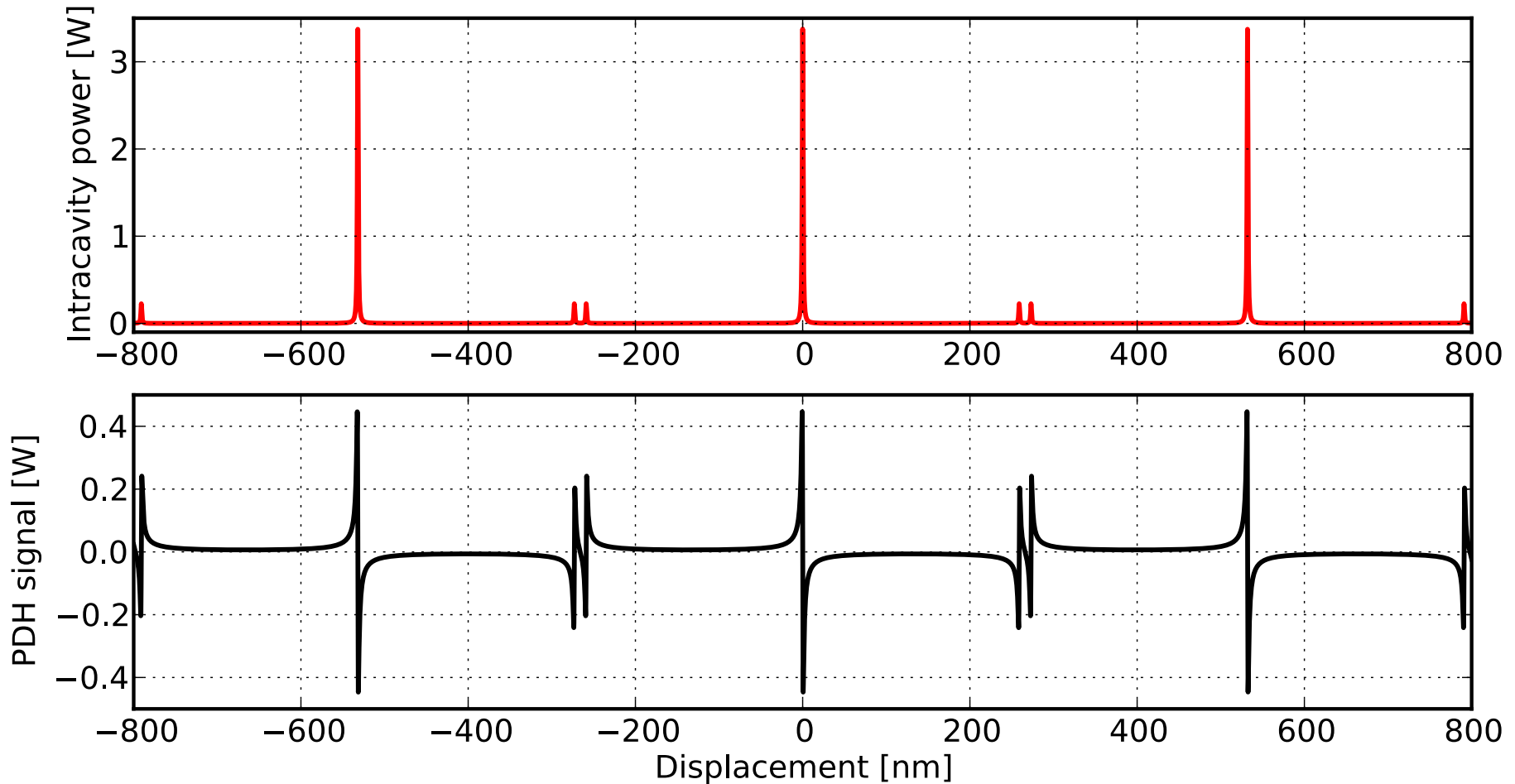


Locking a Fabry-Perot

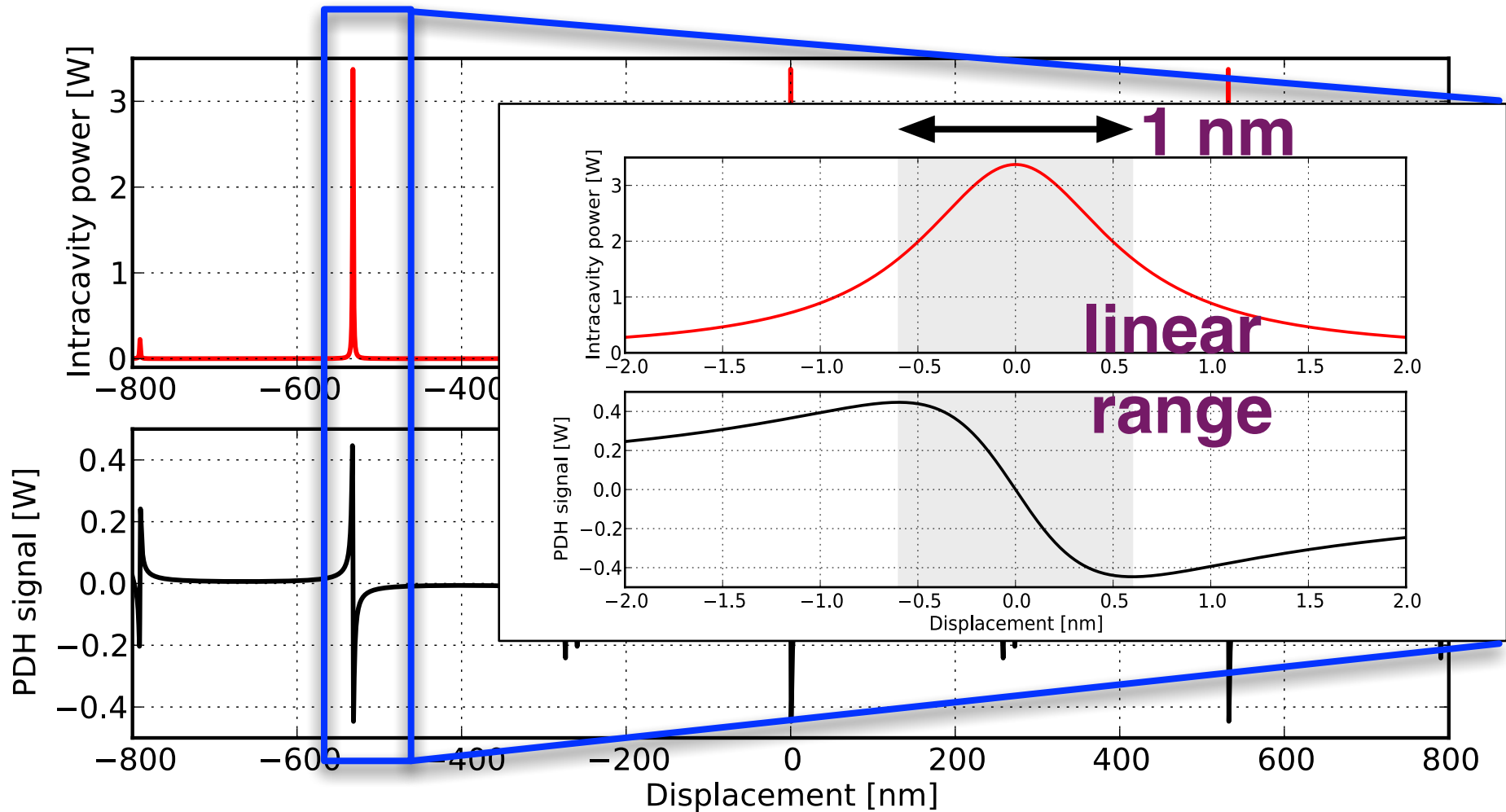


Why difficult ?

■ Optical cavities are nonlinear in general



Why difficult ?



Mitigation

▣ To stop the mirror within linear range ΔL with force F , the work has to be greater than mirror's kinetic energy

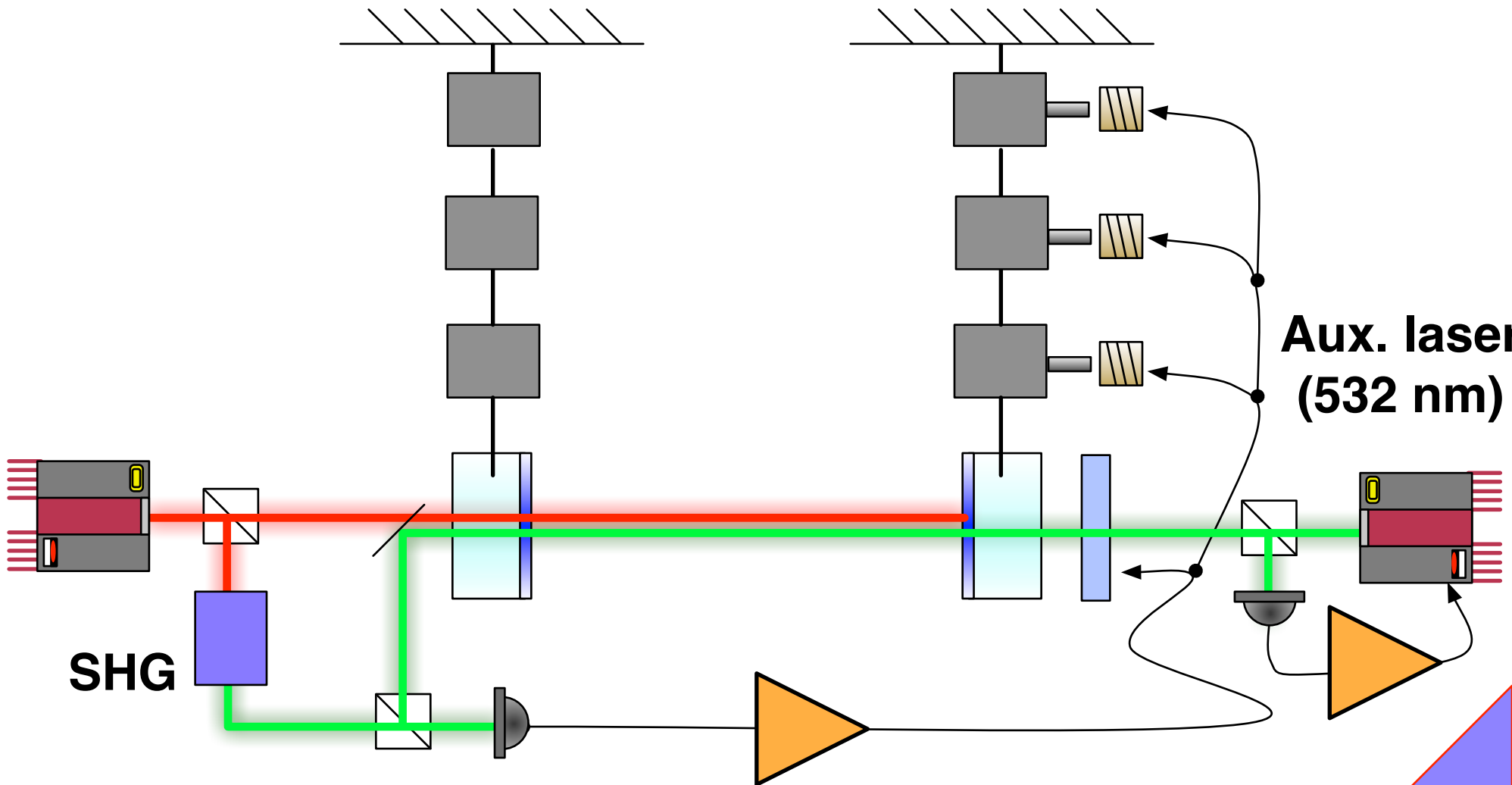
$$\frac{1}{2}mv^2 \leq F\Delta L$$

can not increase due to
noise requirement

let's try widening this

Arm Length Stabilisation (ALS)

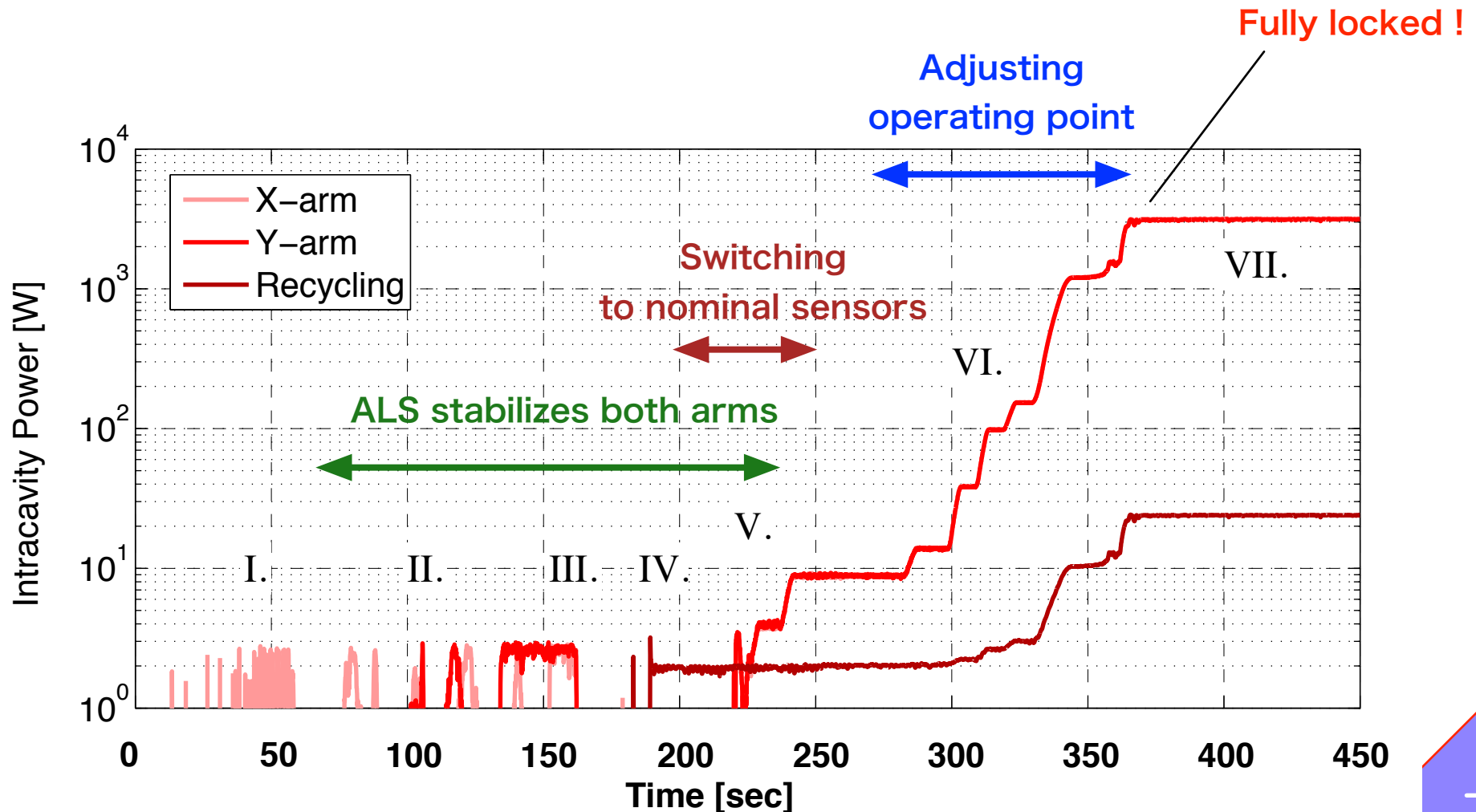
▣ Provides a linear range wider than 10 μm



[2] A.Mullavey et al., Opt. Express, 20, 1, 81 (2012)
[3] KI et al., J.Opt.Soc.Am.A, 29,10,2092 (2012)

Full lock achieved

- Achieved at Livingston in May 2014
- Achieved at Hanford in Feb. 2015



Conclusions

- It is a challenge to achieve both robustness and low-noise
- Lock acquisition has been improved by ALS
- Both observatories achieved full lock
- We are getting ready for the 1st observation run (starts at Sep. 2015)