Seismic platform interferometer pathfinder at LHO

LVK meeting September 2024

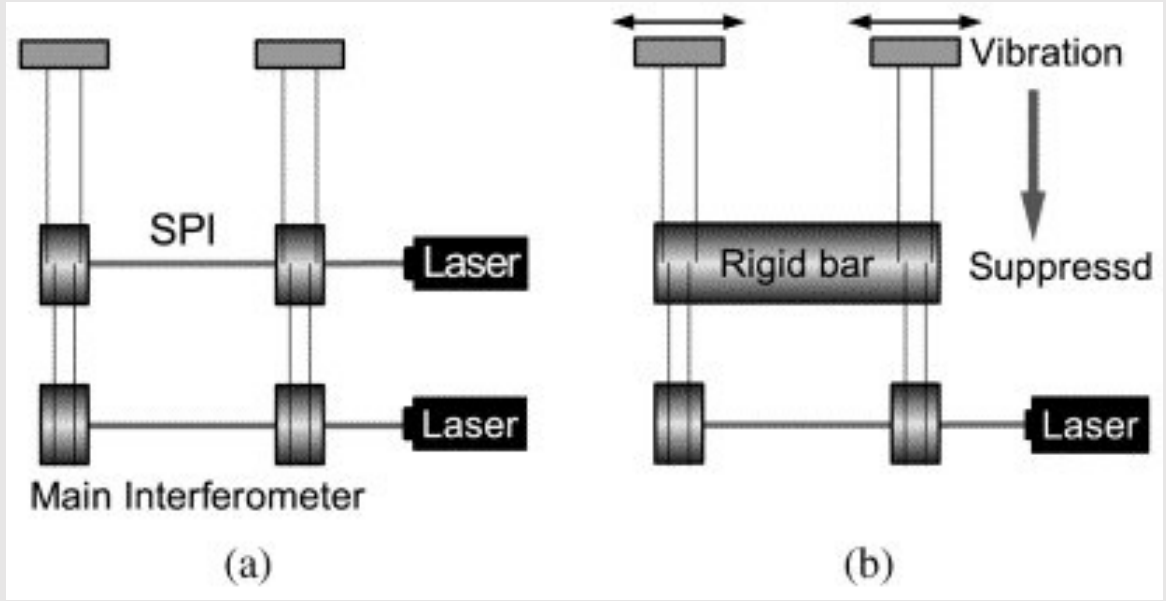
Sina Koehlenbeck, Jeff Kissel, Joshua Freed, Brian Lantz, Bram Slagmolen, Michele Zanolin, Mark Zhu, Marc Pirello, Arnaud Pele, Eddie Sanchez, Jason Oberling, Matthew Heintze, Calum Torrie, Sheon Chua ….

Stanford University

Seismic Platform Interferometer Prototypes

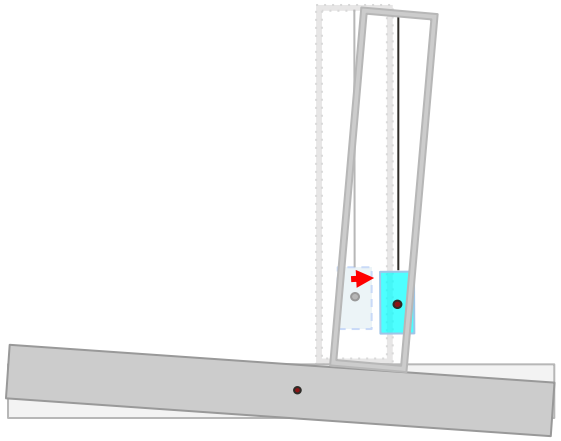
- Concept proposed by Ronald Drever[1]
- Tested at University of Tokyo as Suspension Point Interferometer[2]

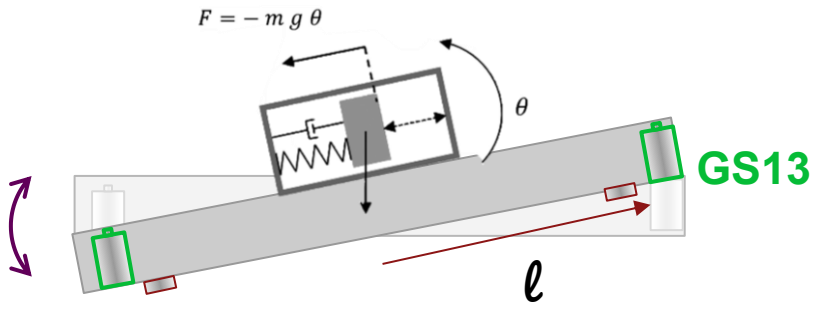
From [2]:

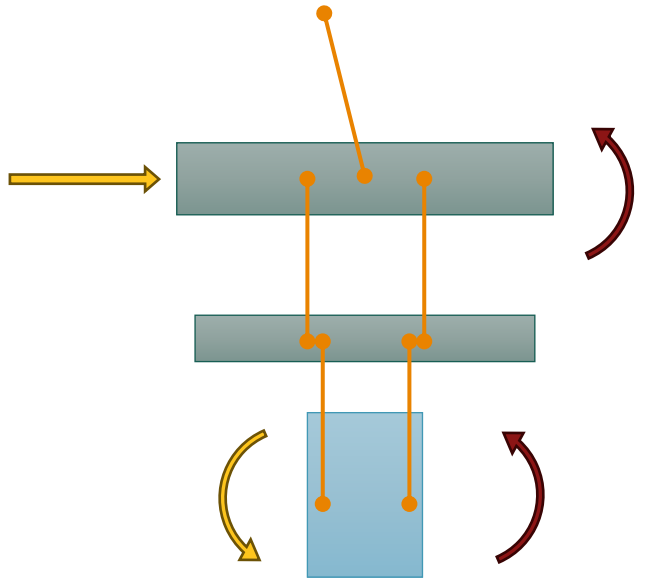


[1] 10.1088/0264-9381/19/7/406
[2] 10.1016/j.physleta.2004.04.066

Tilt and length couplings







Tilt to length coupling

- Suspension points are offset from ISI rotation points
- ISI pitch and yaw move mirrors in horizontal displacement

Tilt to horizontal coupling

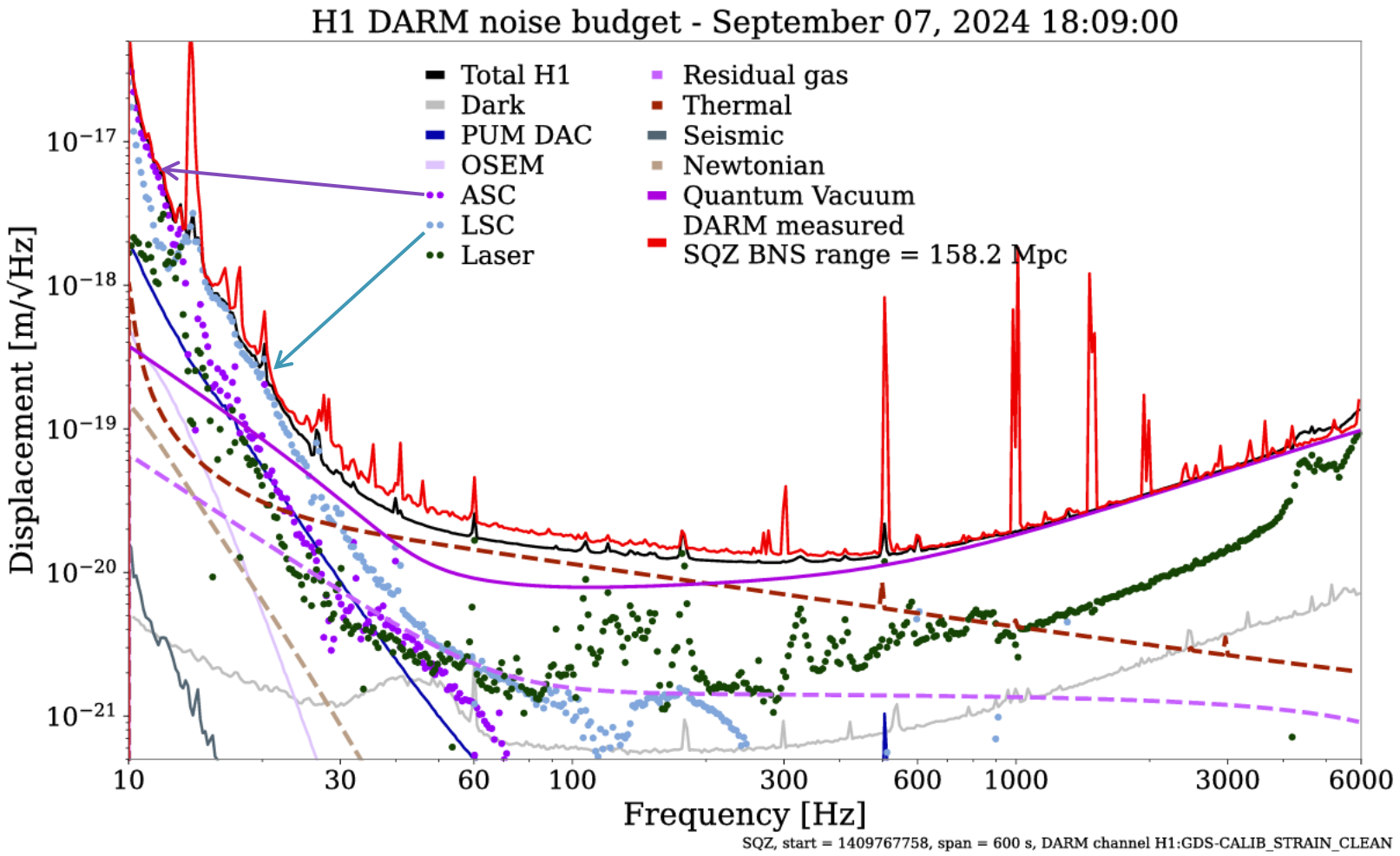
- Differential measurement from vertical seismometers
- Vertical ground motion is large compared to ground tilt
- Tilt of platform is interpreted as horizontal motion

Length to tilt coupling

- 2 wire top mass suspension is soft in pitch
- Length drive pitches top mass
- Top mass pitches test mass

Control noise

LHO log #80215 by Camilla Compton, Sheila Dwyer, Victoria Xu and taken from G2401844 by Elenna Capote



Seismic Platform Interferometer Prototypes

- Concept proposed by Ronald Drever[1]
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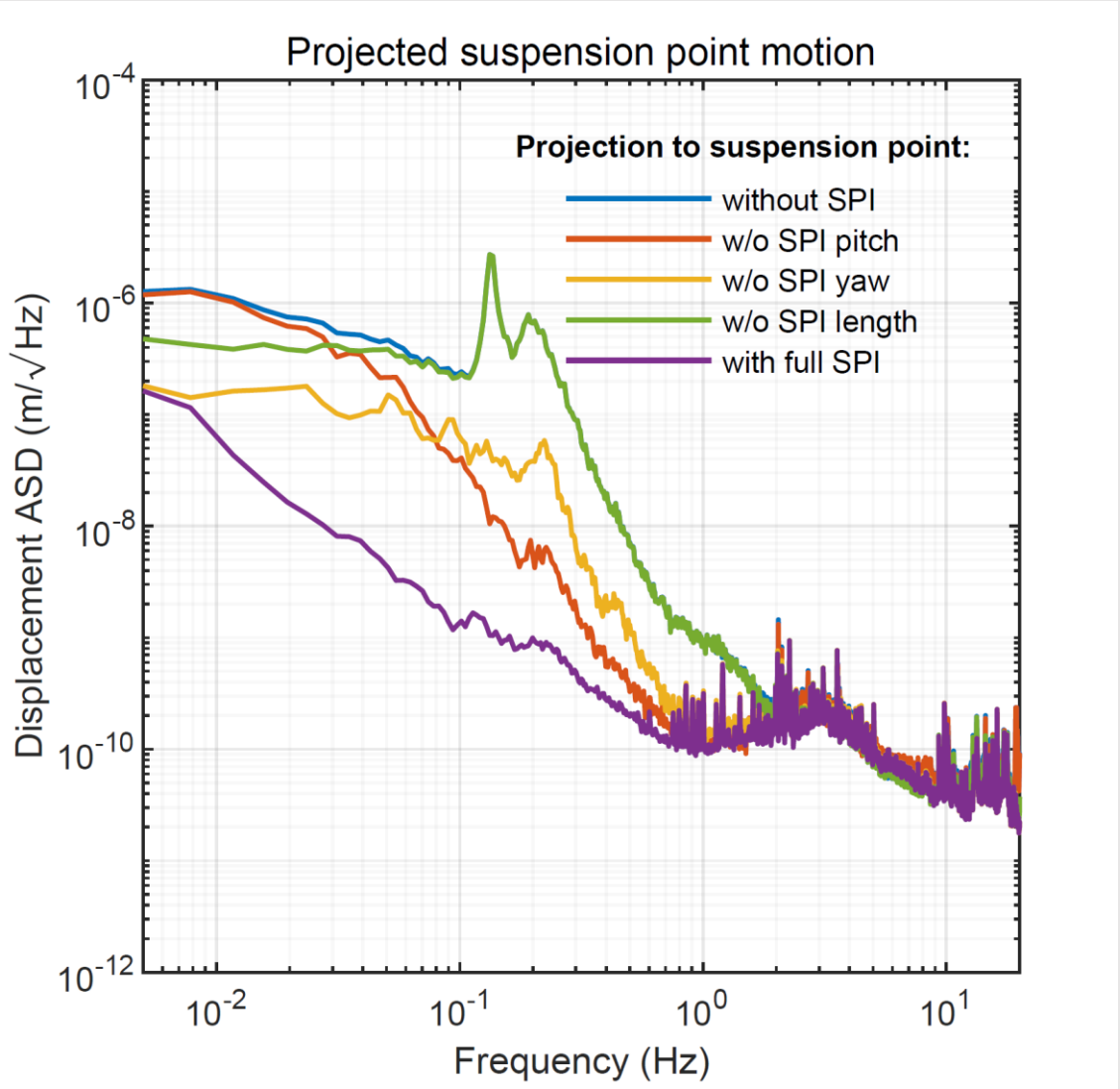
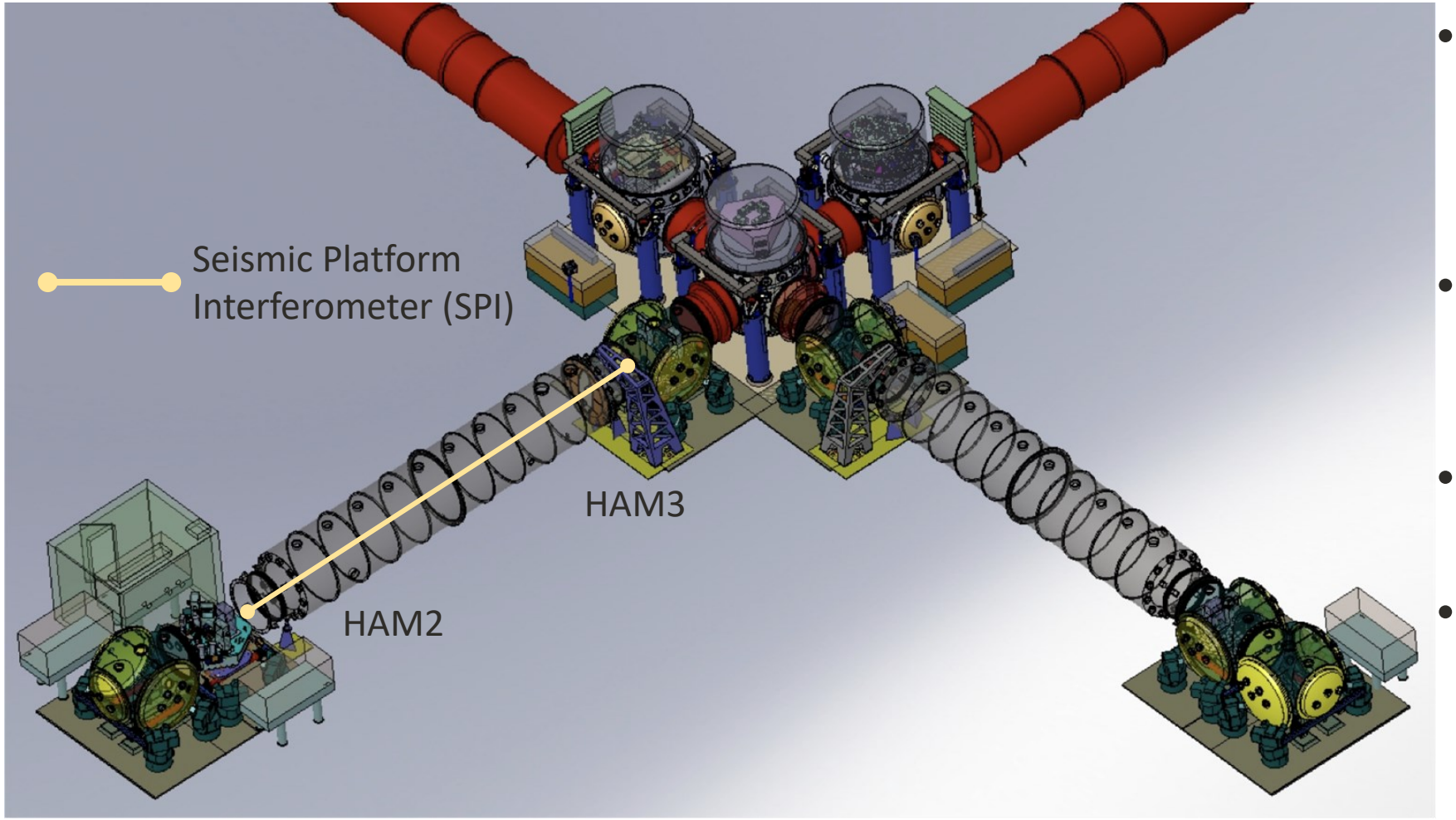
- Test at Stanford University[3] and AEI Hannover[4] as Seismic Platform Interferometer

➢ Prototype for LIGO Hanford Detector



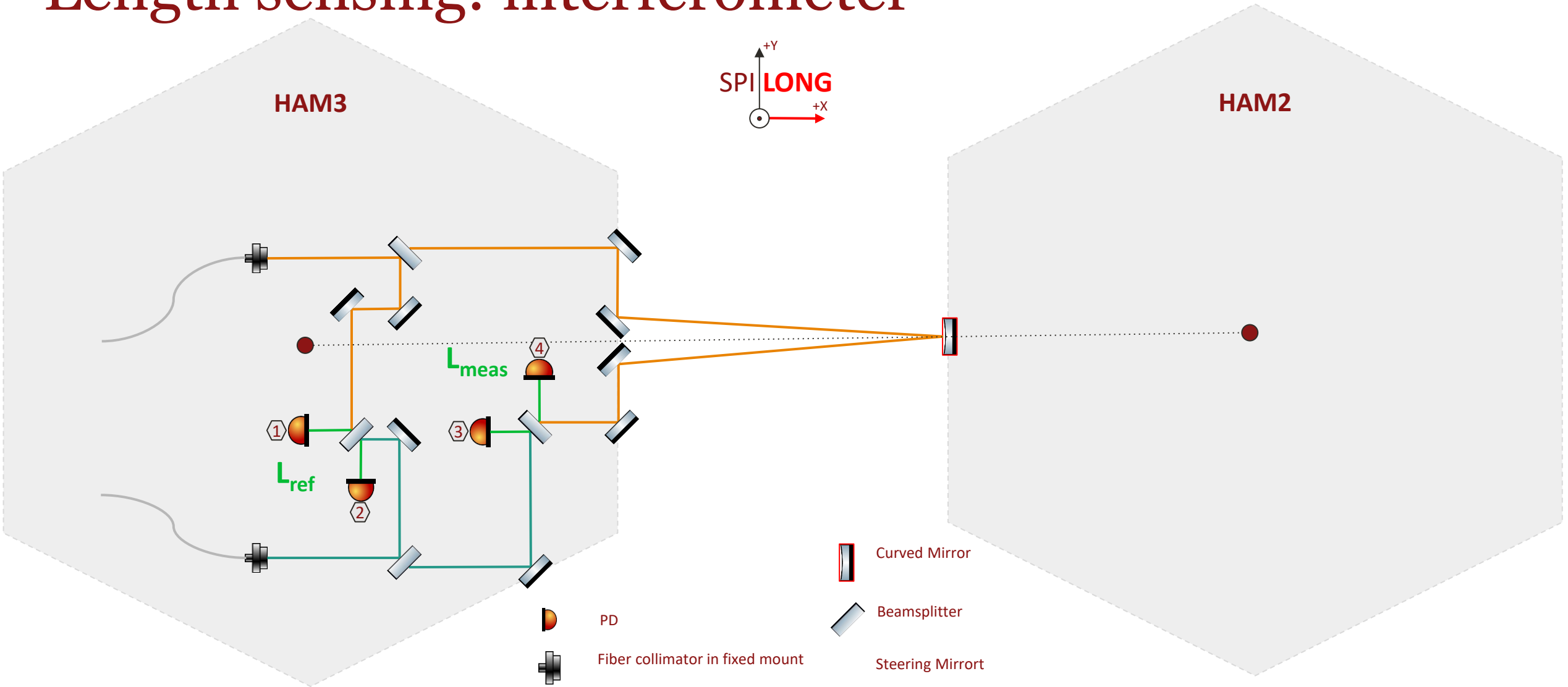
[1] 10.1088/0264-9381/19/7/406
[2] 10.1016/j.physleta.2004.04.066
[3] LIGO-P1300043
[4] 10.1038/s41598-023-29418-x

Seismic Platform Interferometer Pathfinder

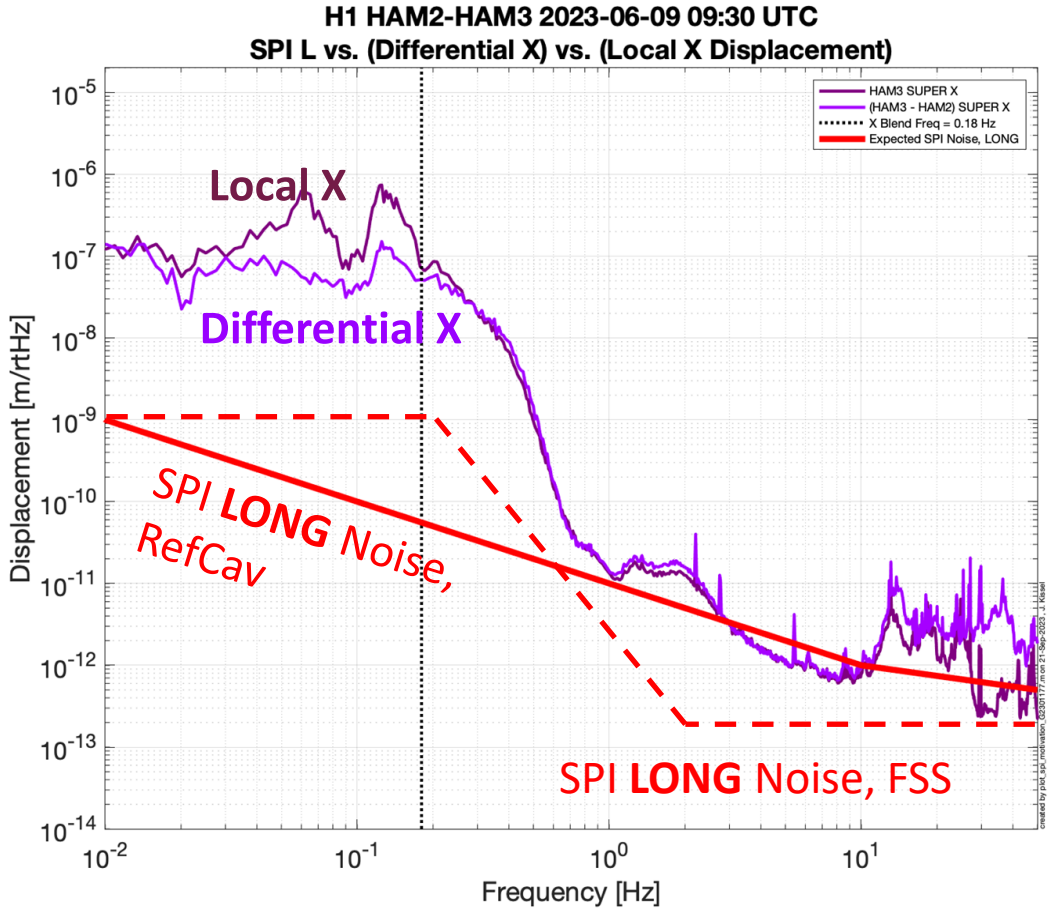


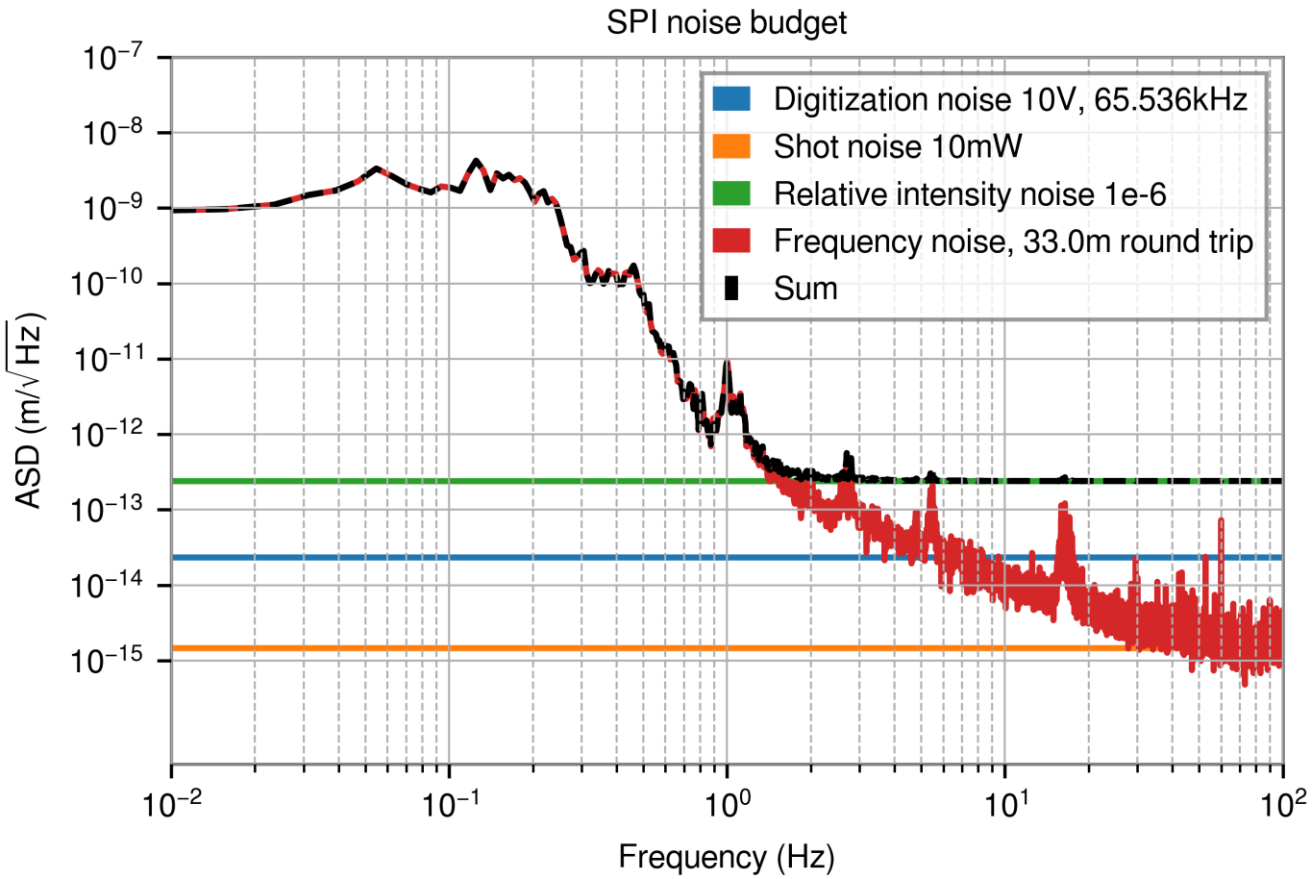
- Measure tilt and differential displacement between Internal Seismic Isolation (ISI) systems
- Explorative pathfinder between vacuum chambers HAM2 and HAM3 at **LHO**
- Host to input mode cleaner and power recycling mirrors
- Installation after O4!

Length sensing: interferometer

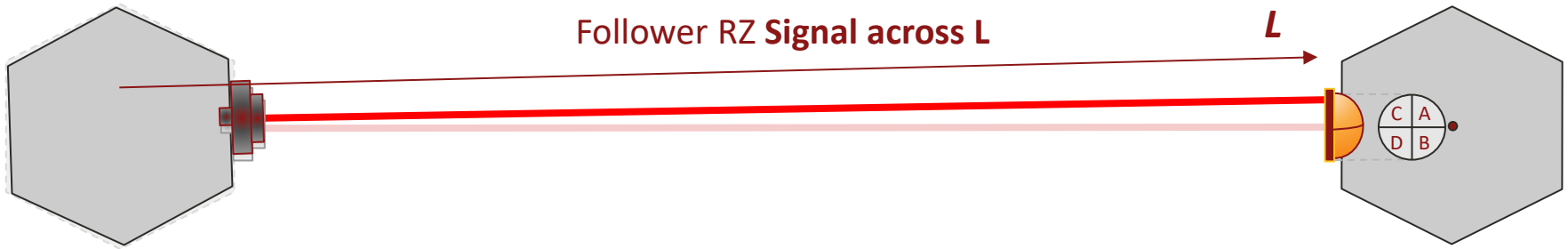


Performance



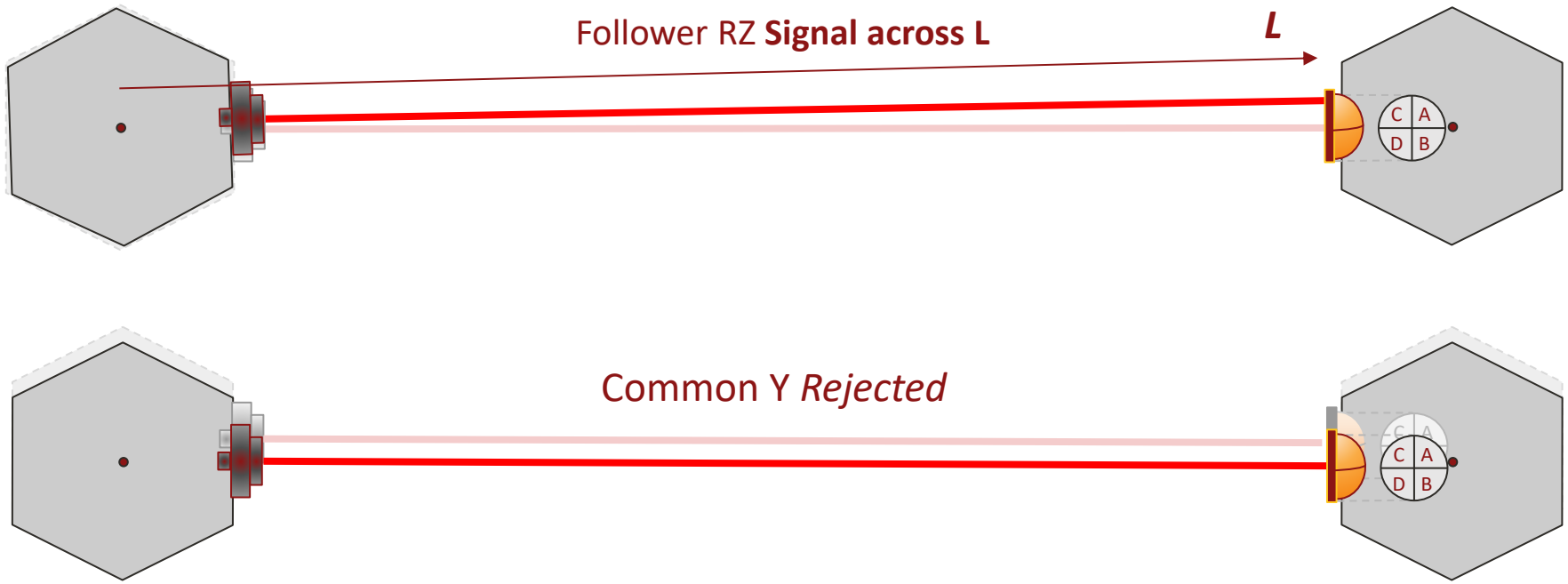


Angular sensing: optical lever



L = ~16 m

Angular sensing



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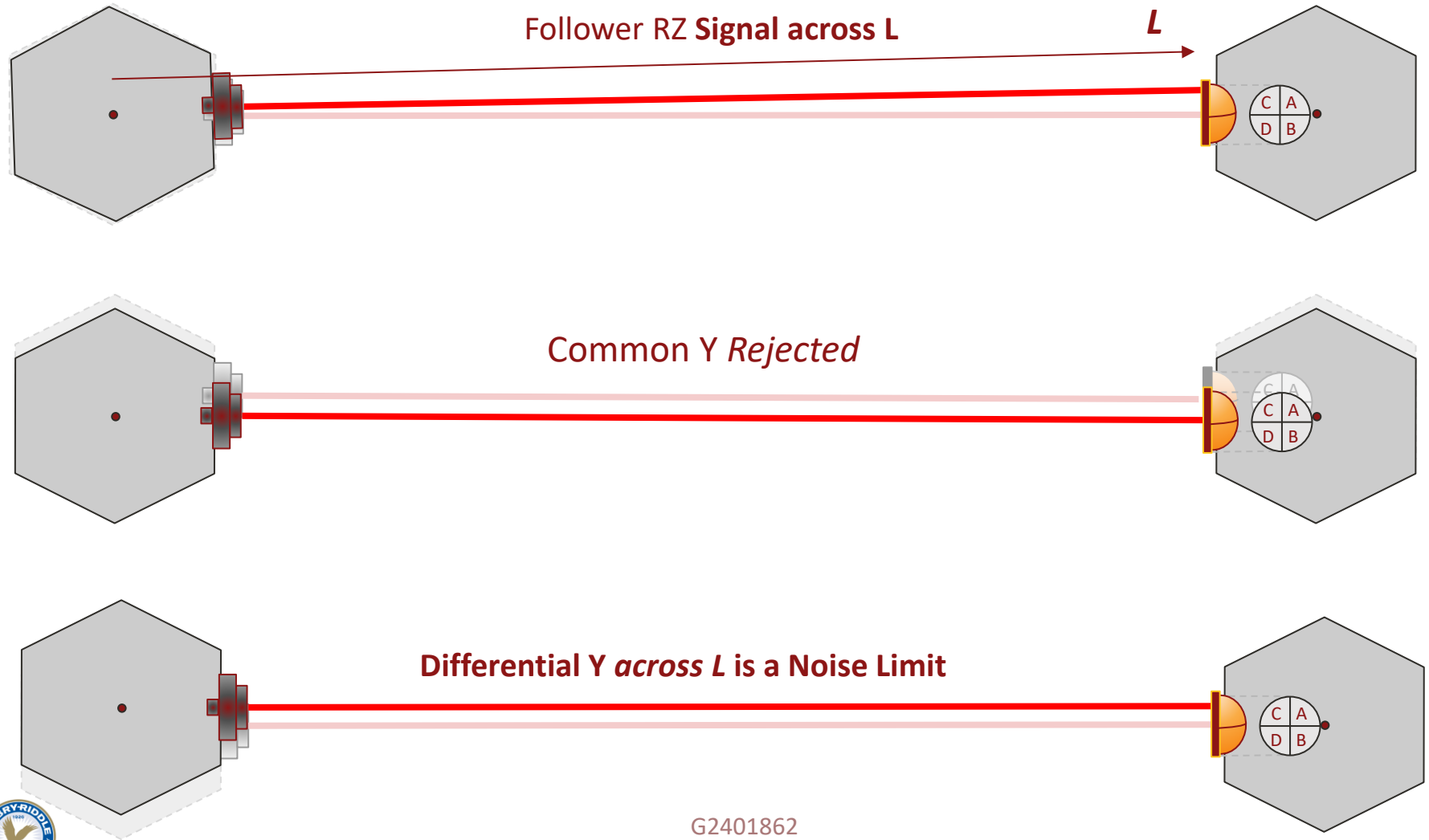
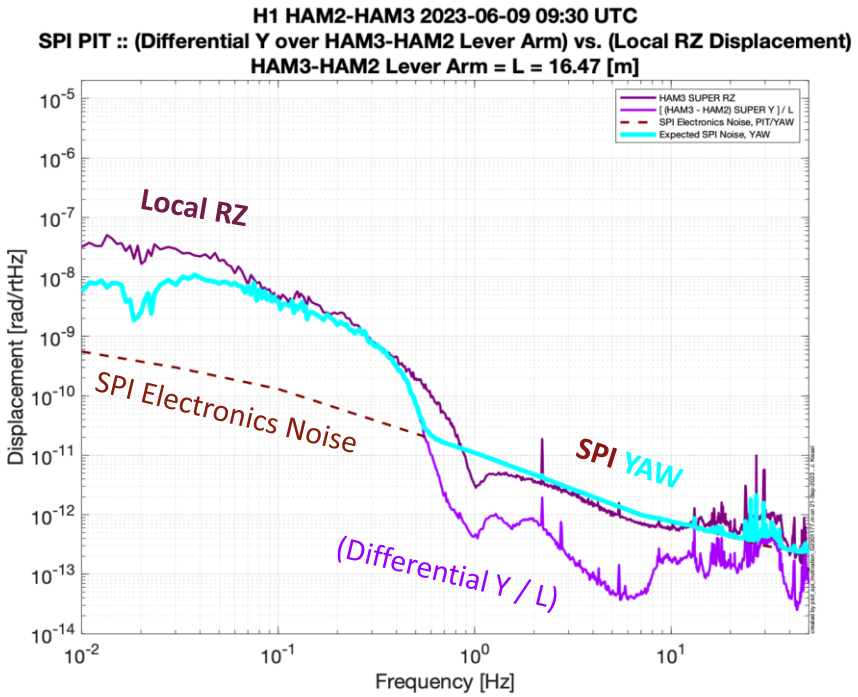
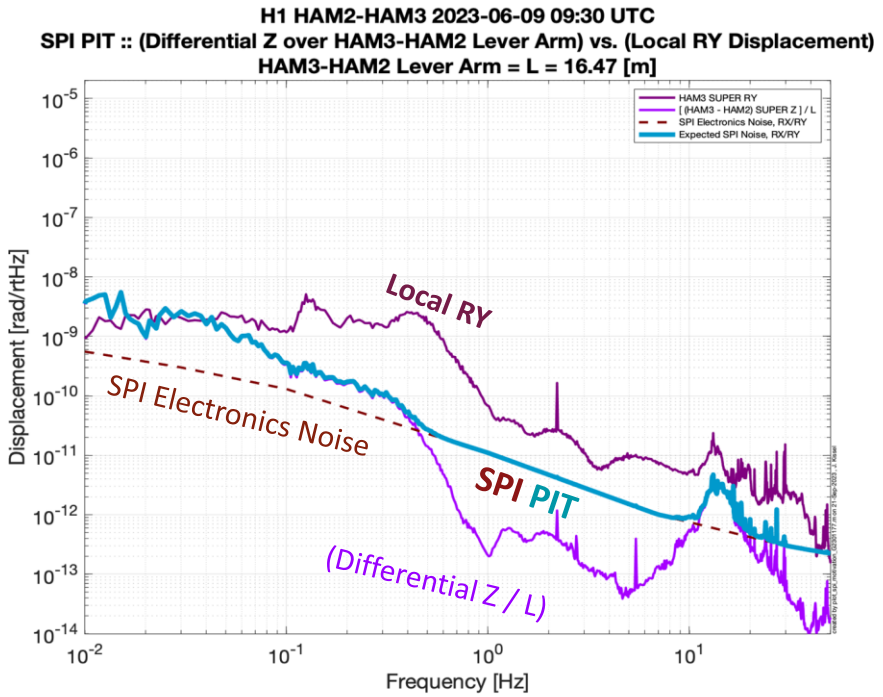
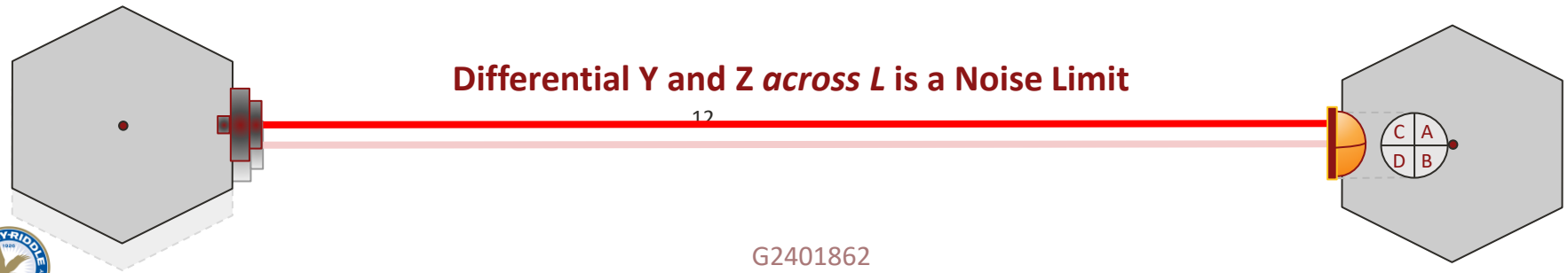


L = ~16 m

Performance: upper limit



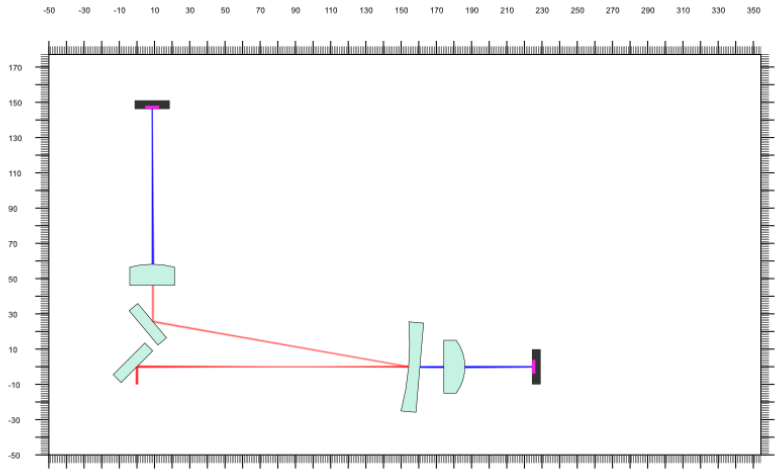




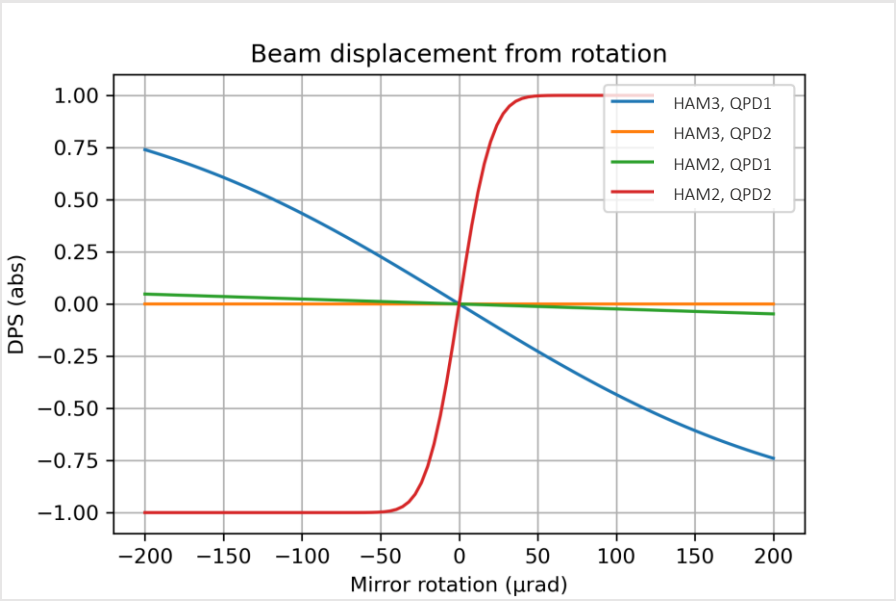
Differential Y and Z *across L* is a Noise Limit

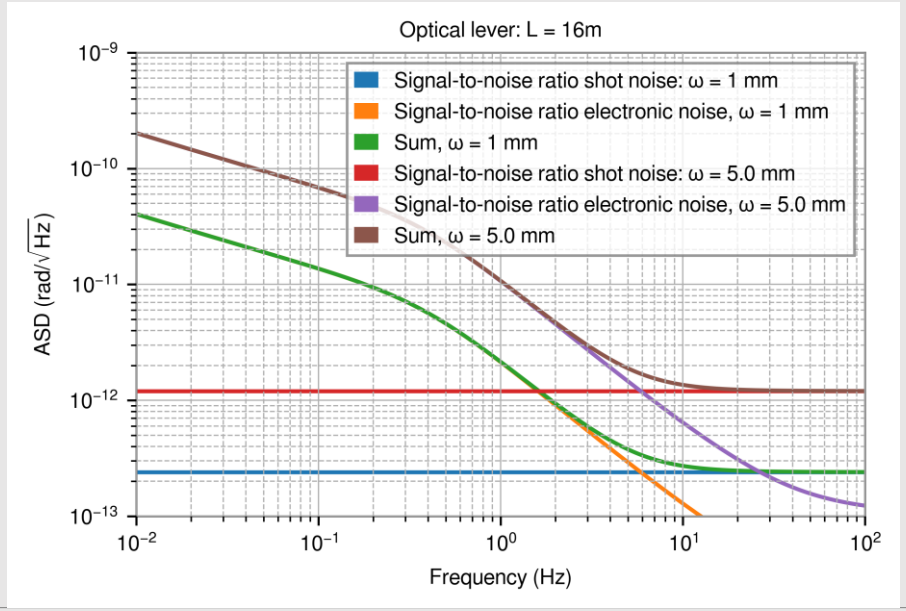
Responsivity

- Simulation with IfoCAD available on git.ligo.org



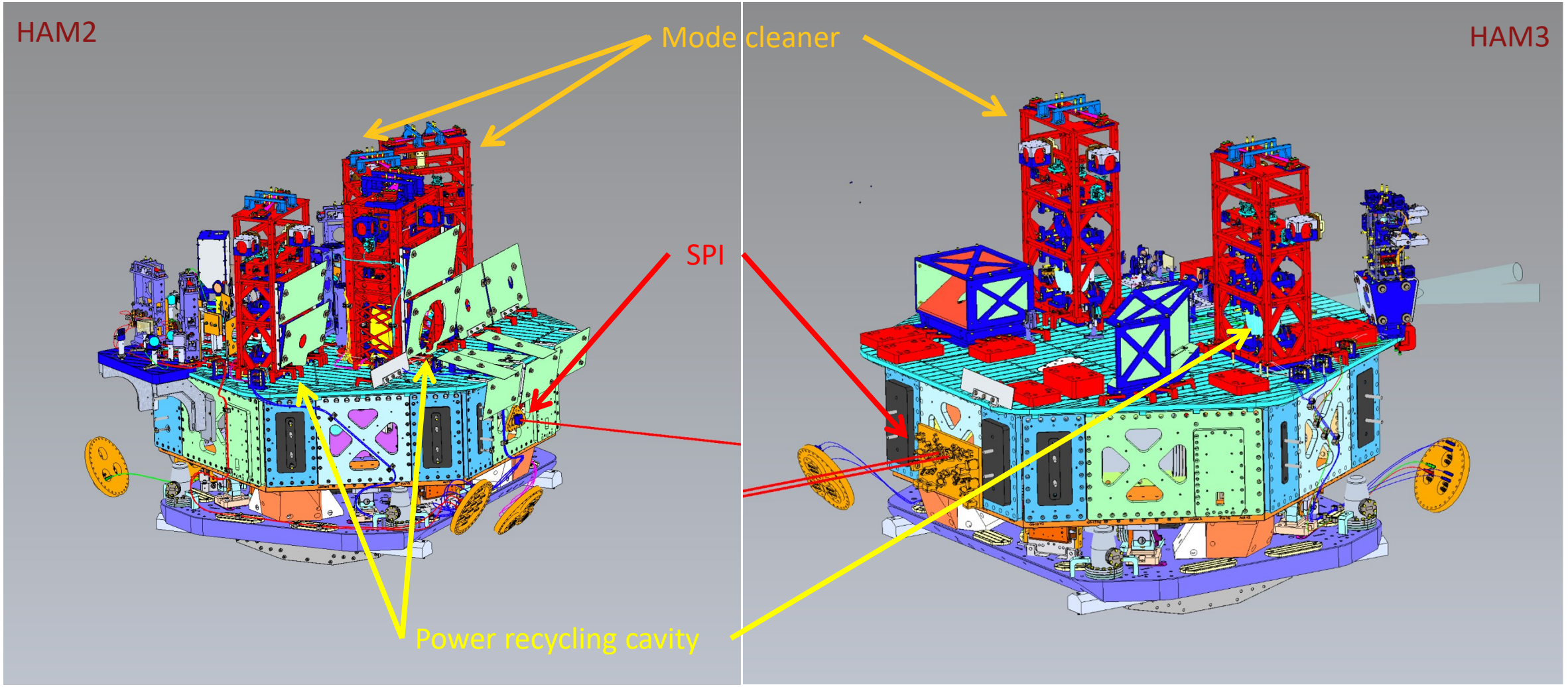
Coupling coefficients (abs/rad)	QPD1 (abs)	QPD1 lens (abs)	QPD2 (abs)
HAM3 (rad)	-4611	-5118	0
HAM2 (rad)	-239	-242	48325



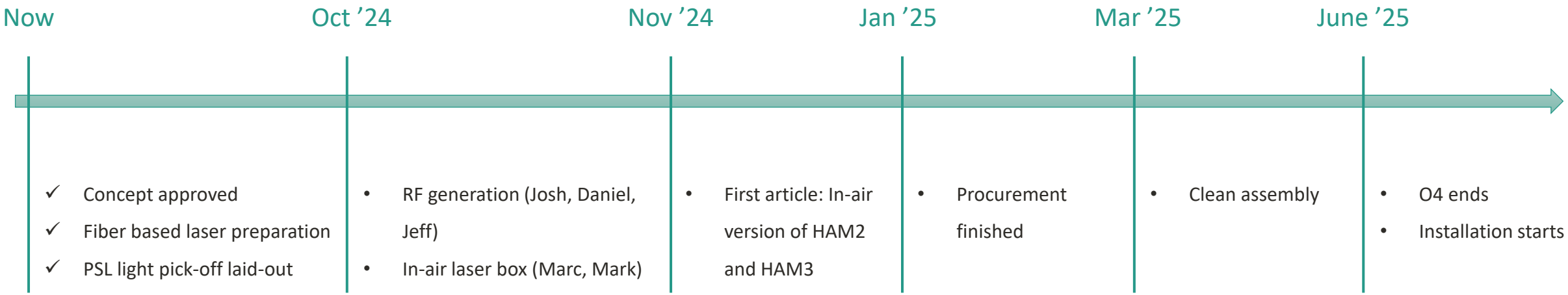


Integration

Arnaud Pele, Eddie Sanchez



Timeline and status



- ✓ Concept approved
- ✓ Fiber based laser preparation
- ✓ PSL light pick-off laid-out
- ✓ Transport fibers ordered
- ✓ Electronics and wiring diagram
- ✓ Small footprint mirror mount

- RF generation (Josh, Daniel, Jeff)
- In-air laser box (Marc, Mark)
- HAM3 breadboard (Eddie)
- HAM2 breadboard (Bram+)
- QPD cleaning (Josh)
- Fiber collimator (Sina/Arnaud)
- Electronics (Jeff+)
- CDS model, screens, filters (Sina, Jeff)

- First article: In-air version of HAM2 and HAM3 breadboard
- Final design report

- Procurement finished

- Clean assembly

- O4 ends
- Installation starts

Resources

- SPI Document Tree Trunk
- Bill of materials
- Git repository
- Detailed presentation
- Initial design report
- Final design report