The Payloads of Advanced Virgo current status & upgrades

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on behalf of the Virgo Collaboration

VIR-0404A-17

Amaldi 12

Overview

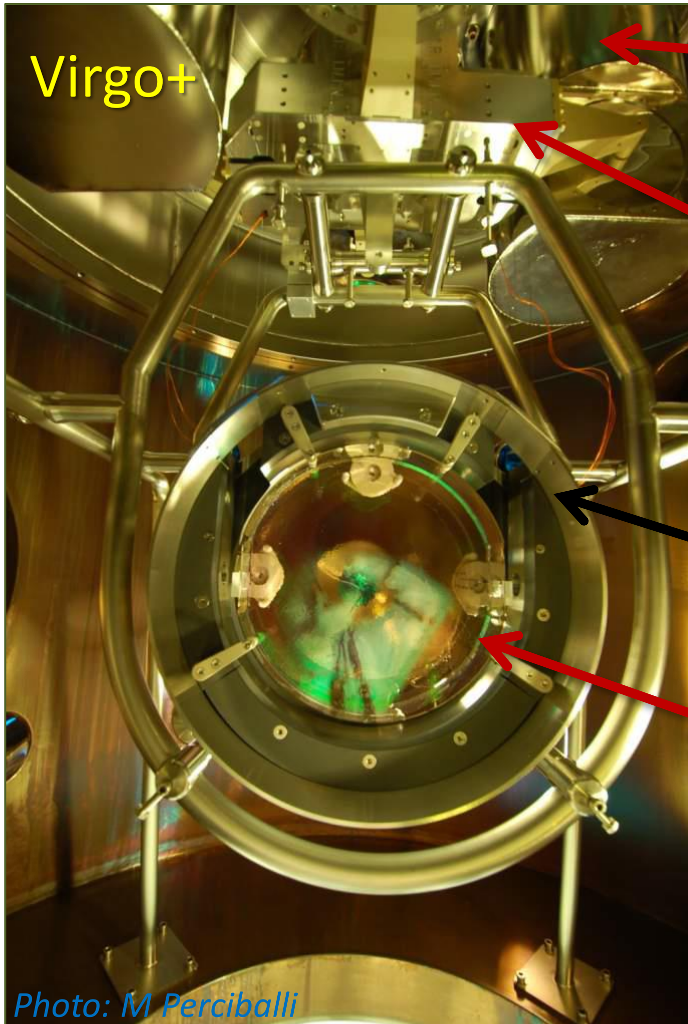
- **AdV Payloads**
  - AdV vs Virgo/Virgo+ Payloads
  - Payload geometry: BS, INPUT, END, PR and SR
  - Integrated Payloads specifics
  - Optical Levers deployment for Payload control

- **Payload characterization**
  - FP Payload pitch, yaw and roll modes
  - FP Payload angular noise projection
  - Mirror suspension Quality Factor (actual steel-wires setup)

- **Payload Upgrades after O2**
  - Back to TM monolithic suspension
  - Fiber guards design
  - Payload upgrade plan

AdV Payloads vs Virgo/Virgo+

to SA F7



to SA F7

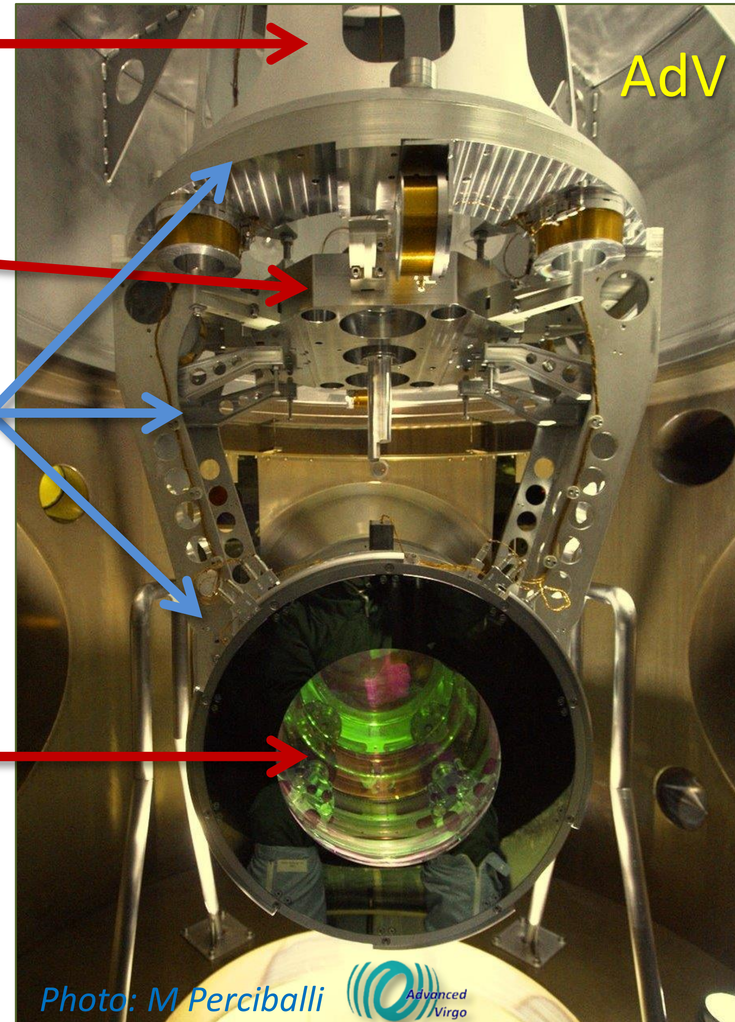
Interface to steering filter

Marionette

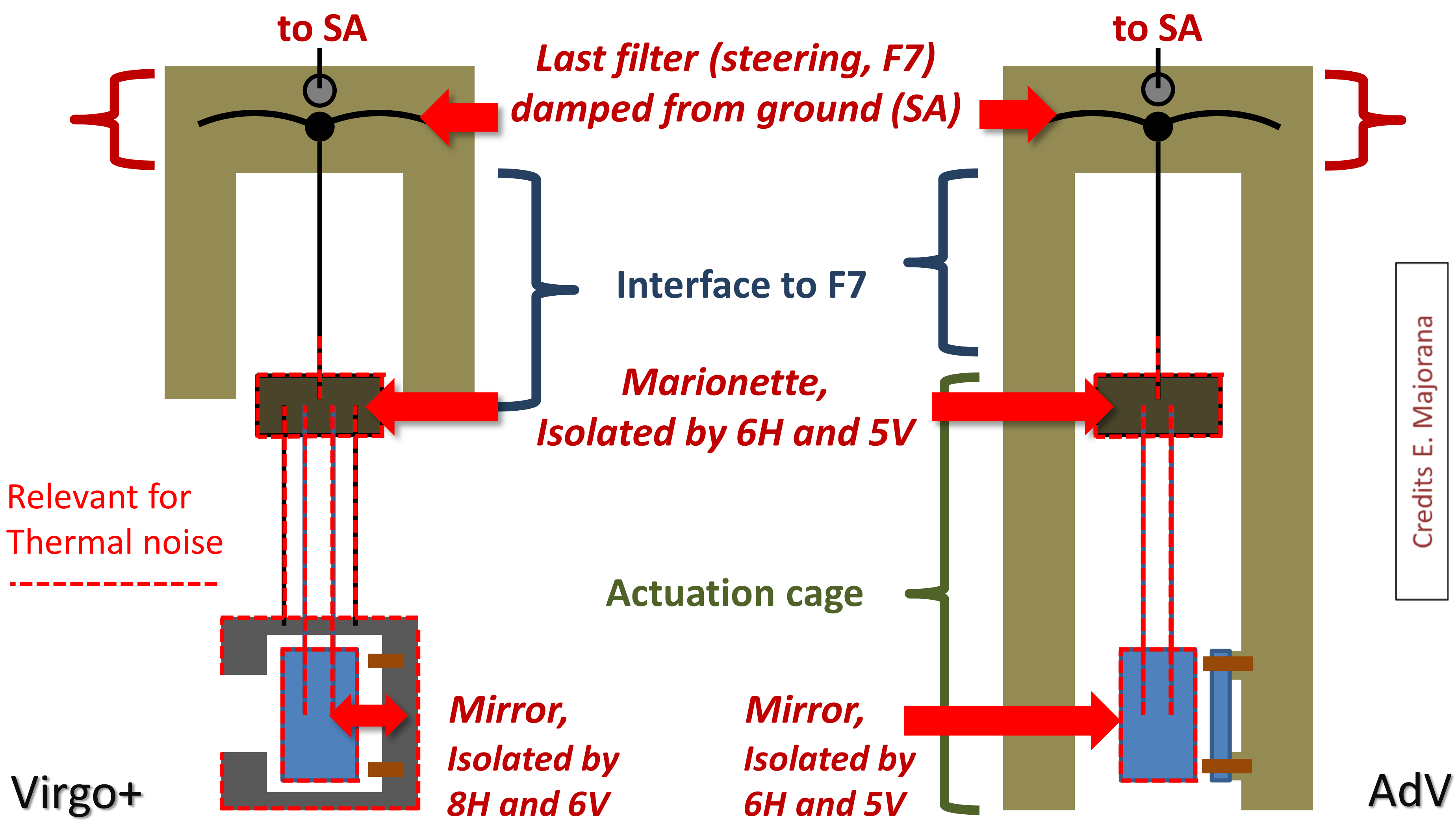
Actuation Cage

Recoil Mass

Mirror

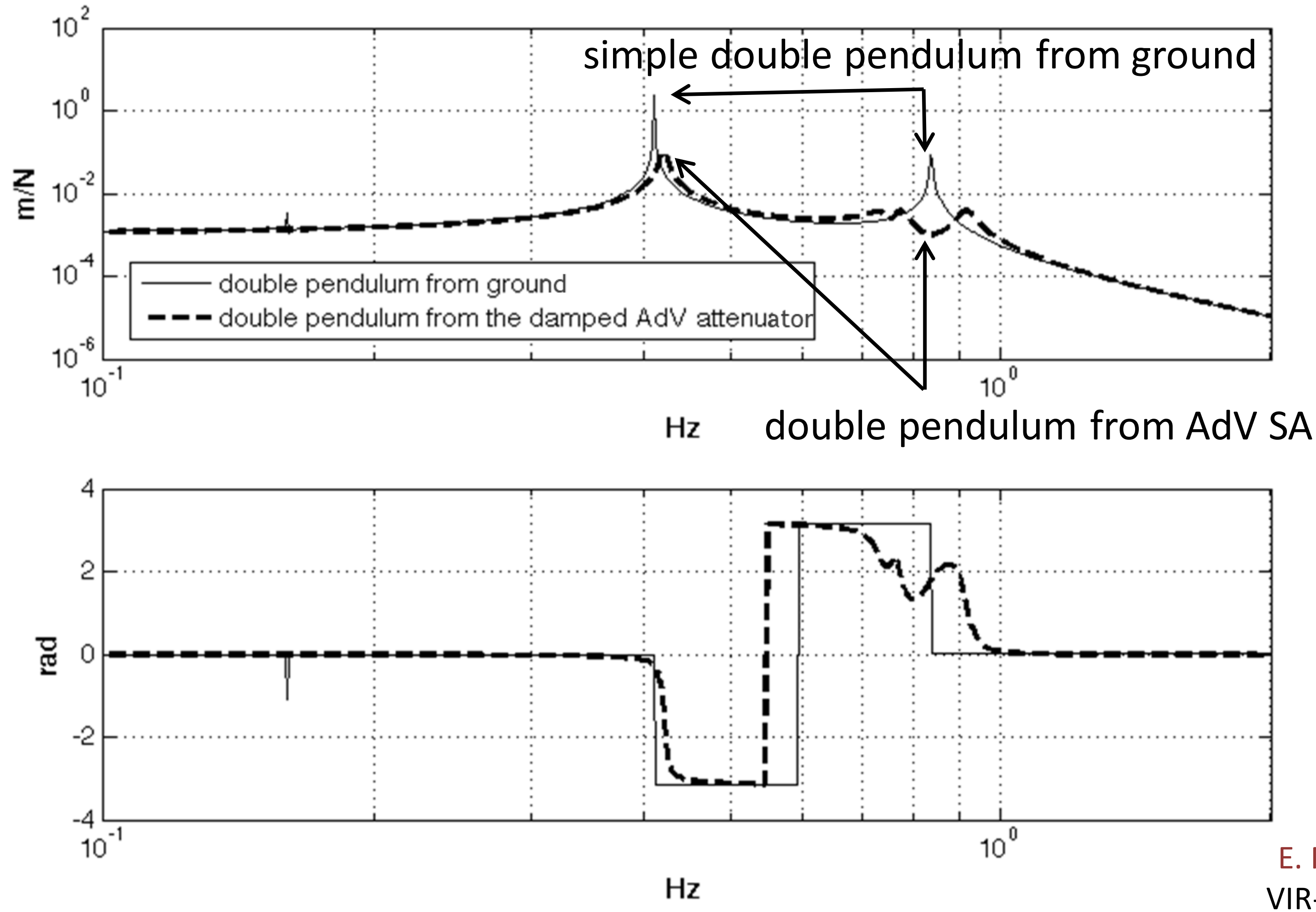


AdV Payloads vs Virgo/Virgo+



AdV Payloads

Payload TF VS top-stage inertial damping activation



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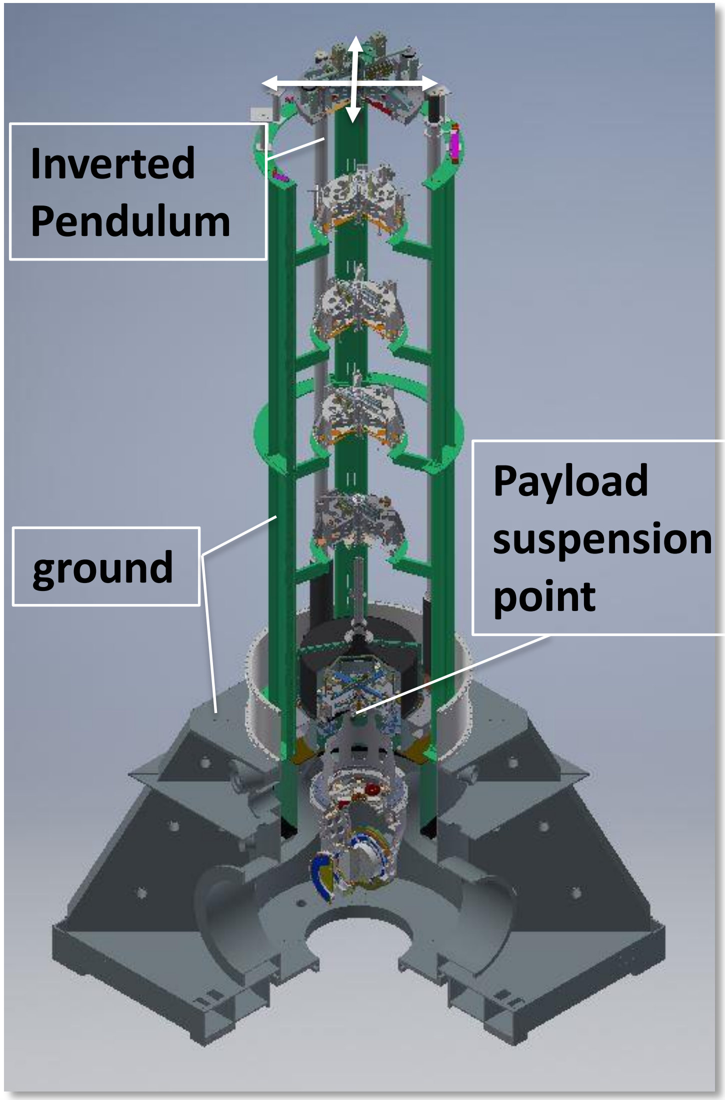
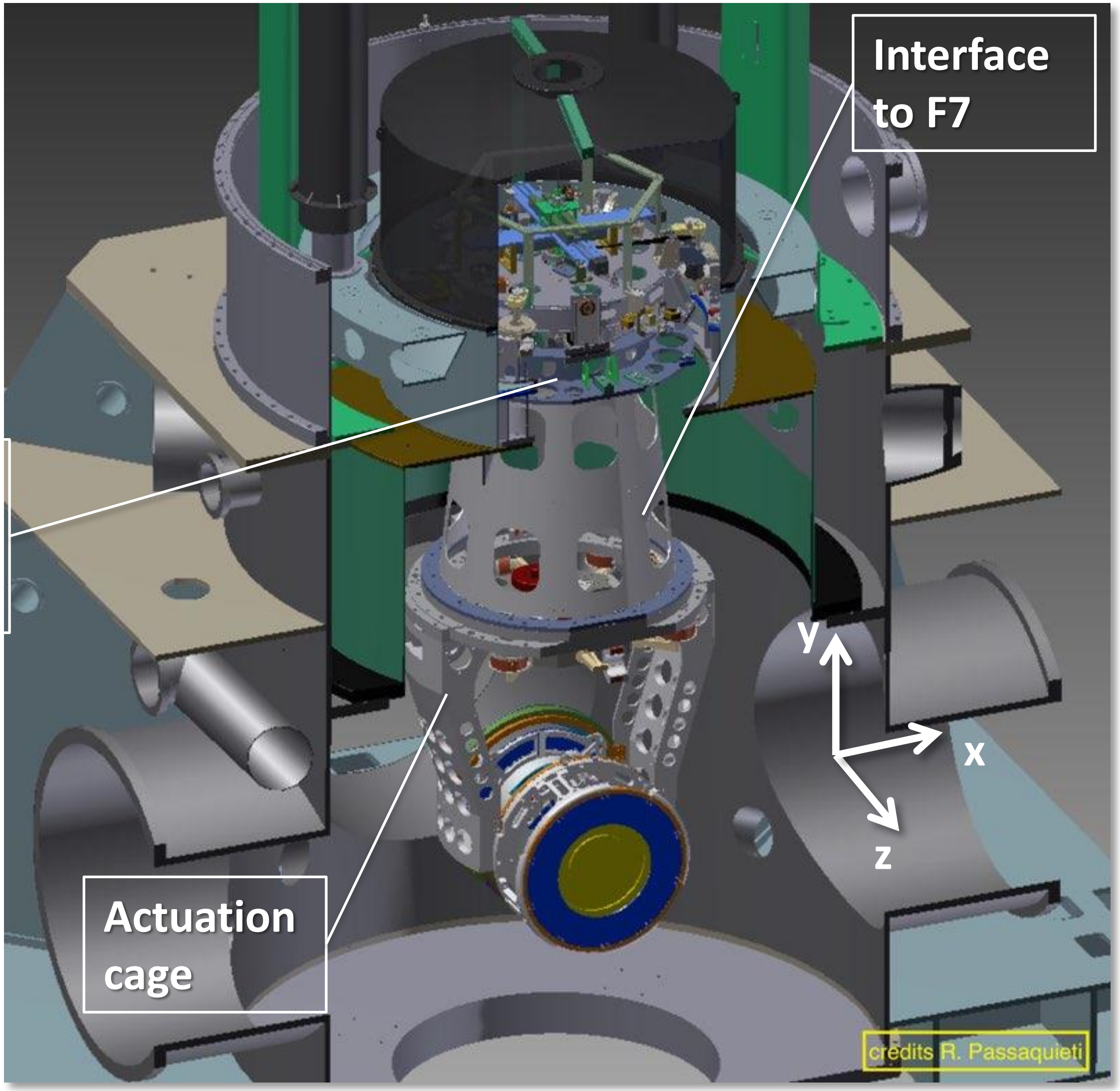
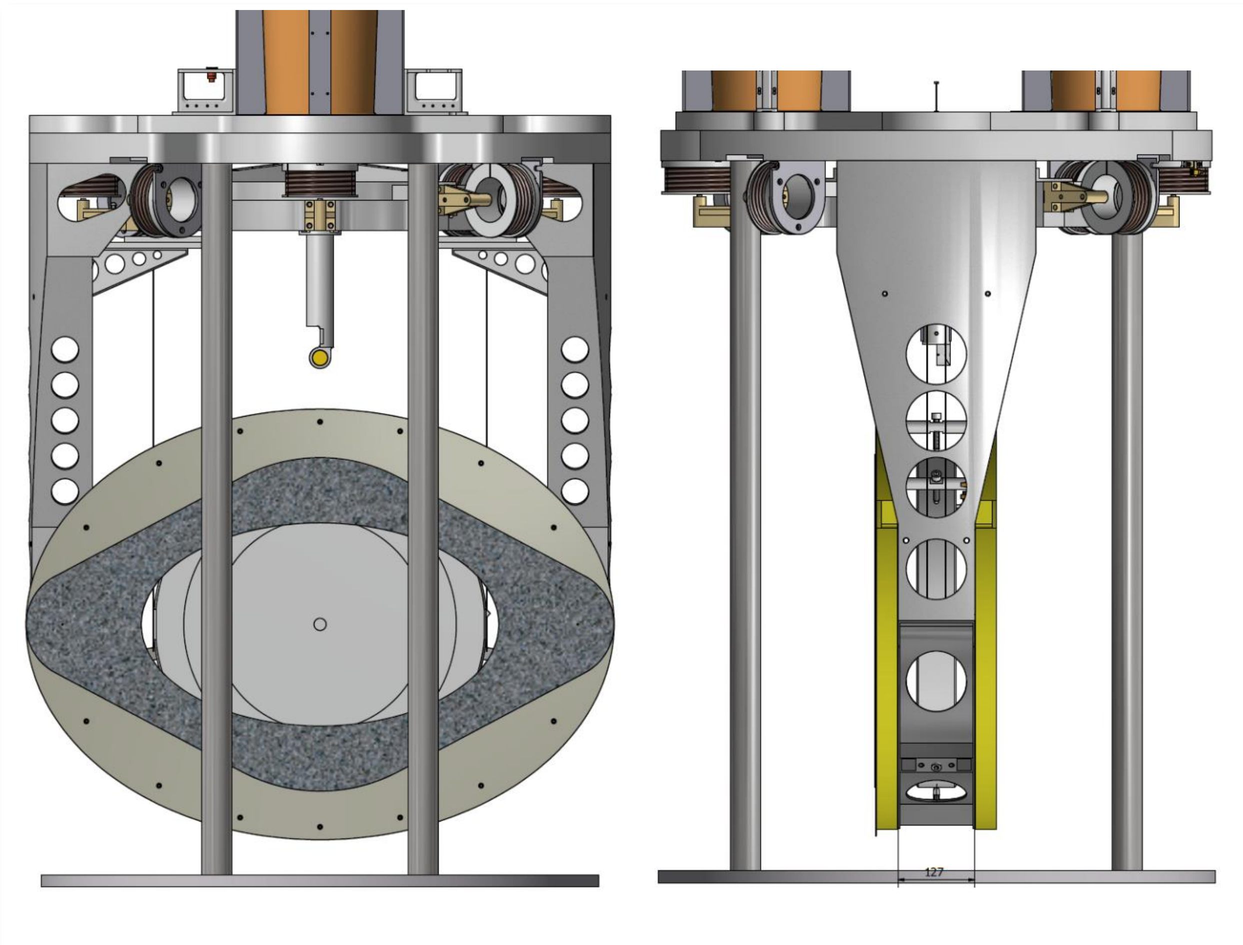
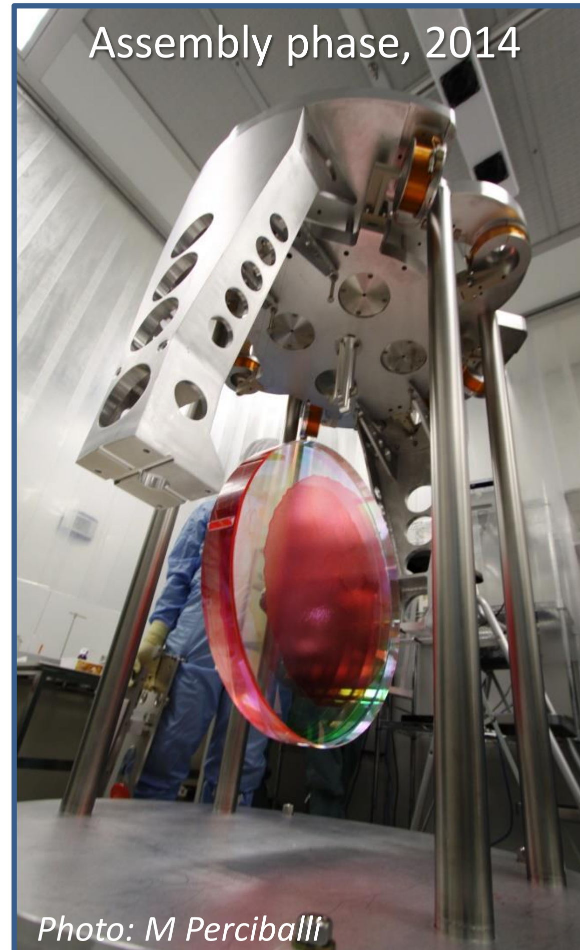
AdV Payloads



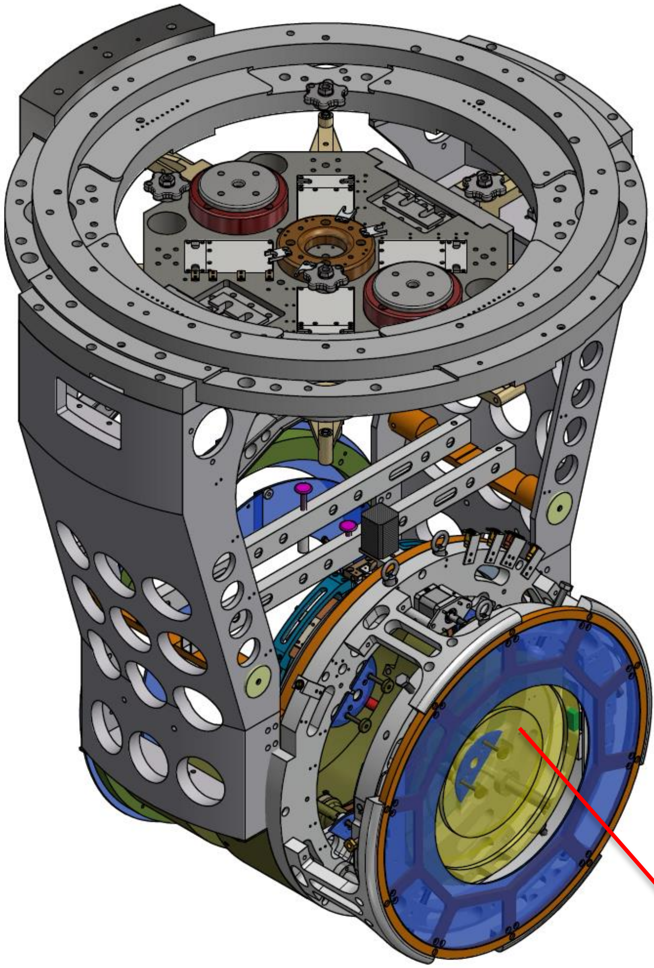


Beam Splitter Payload





Input Payloads



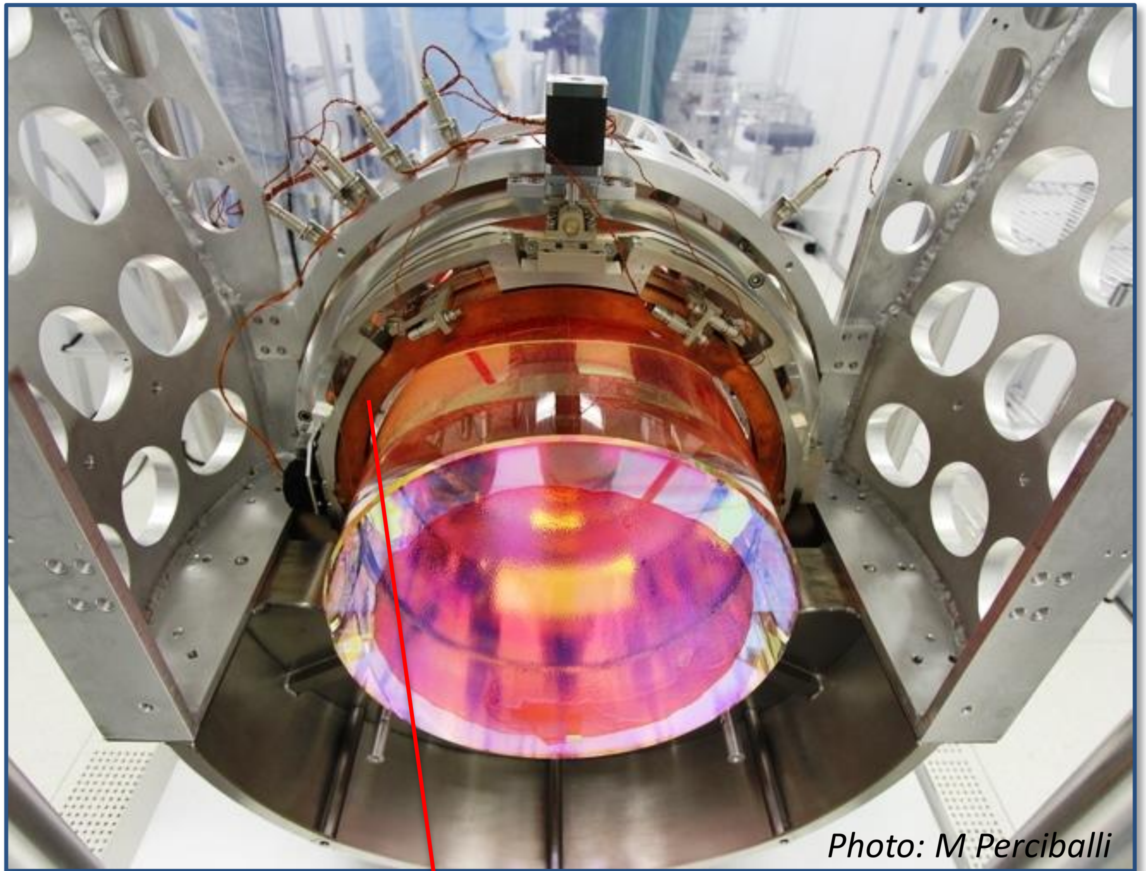


Photo: M Perciballi

TCS: thermal compensation
(Compensation Plate and Ring Heater)

Input Payloads

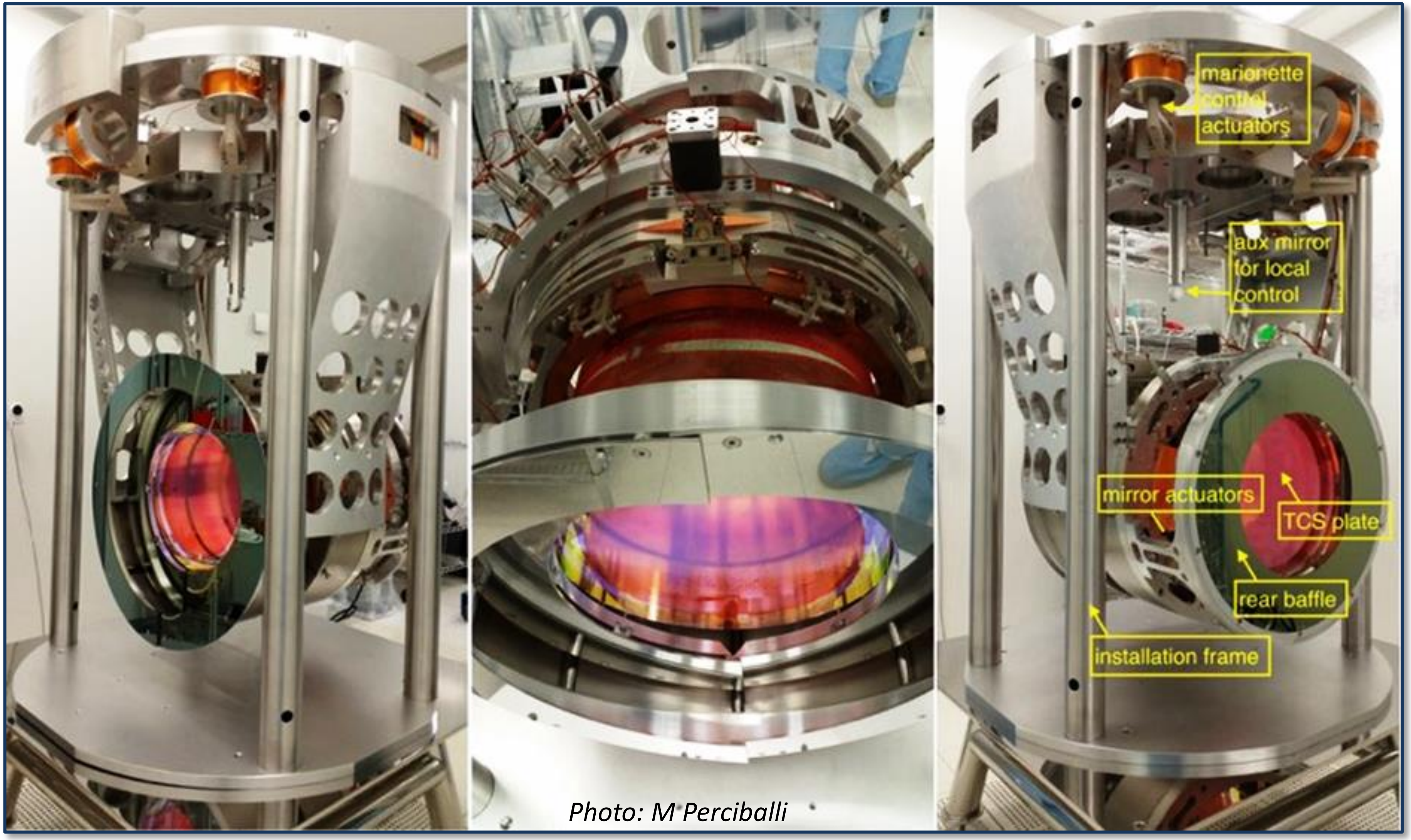
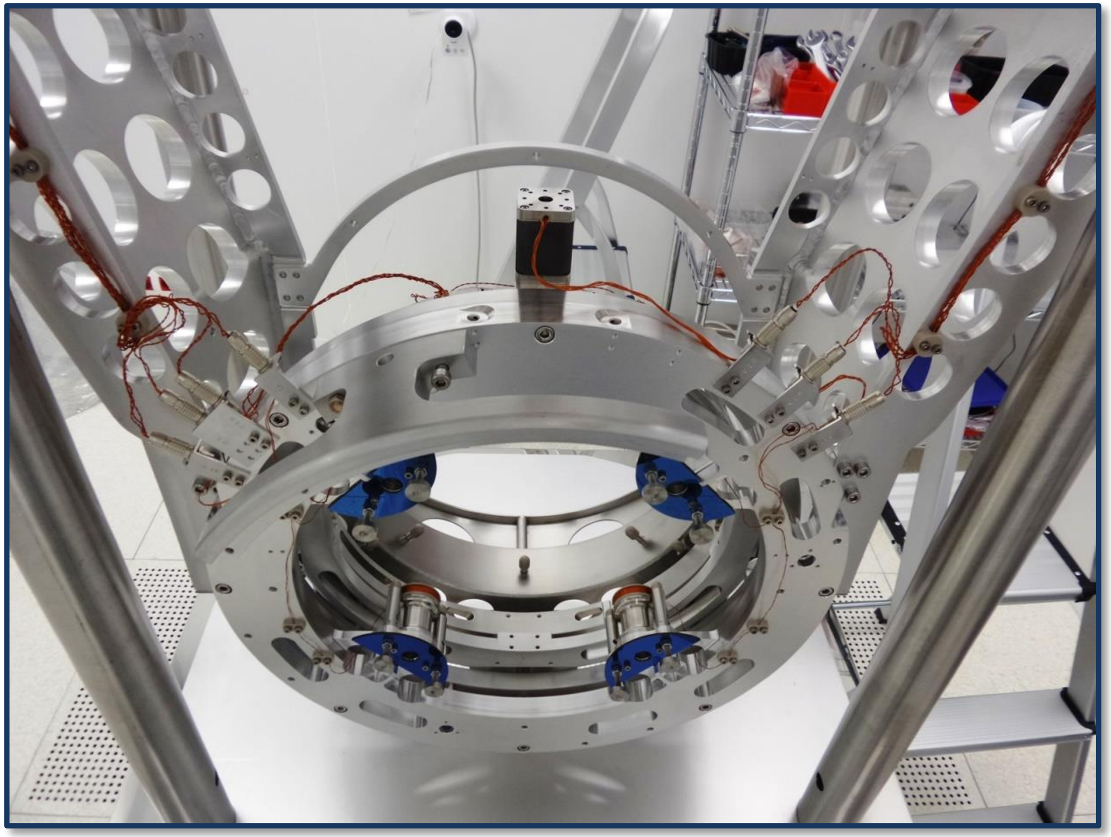
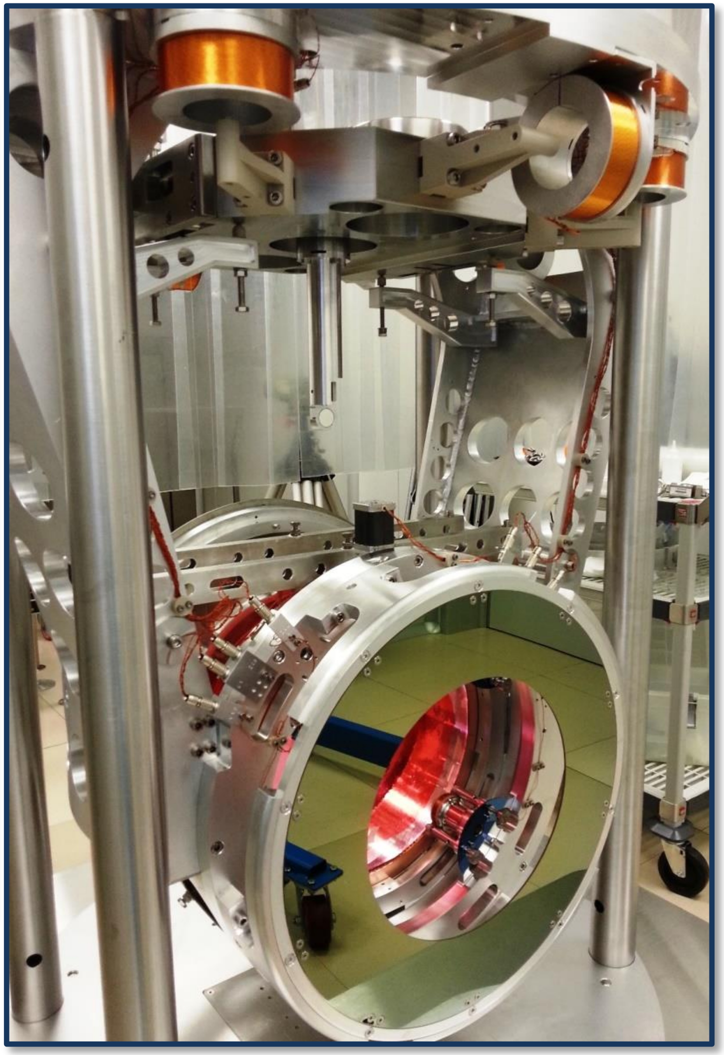


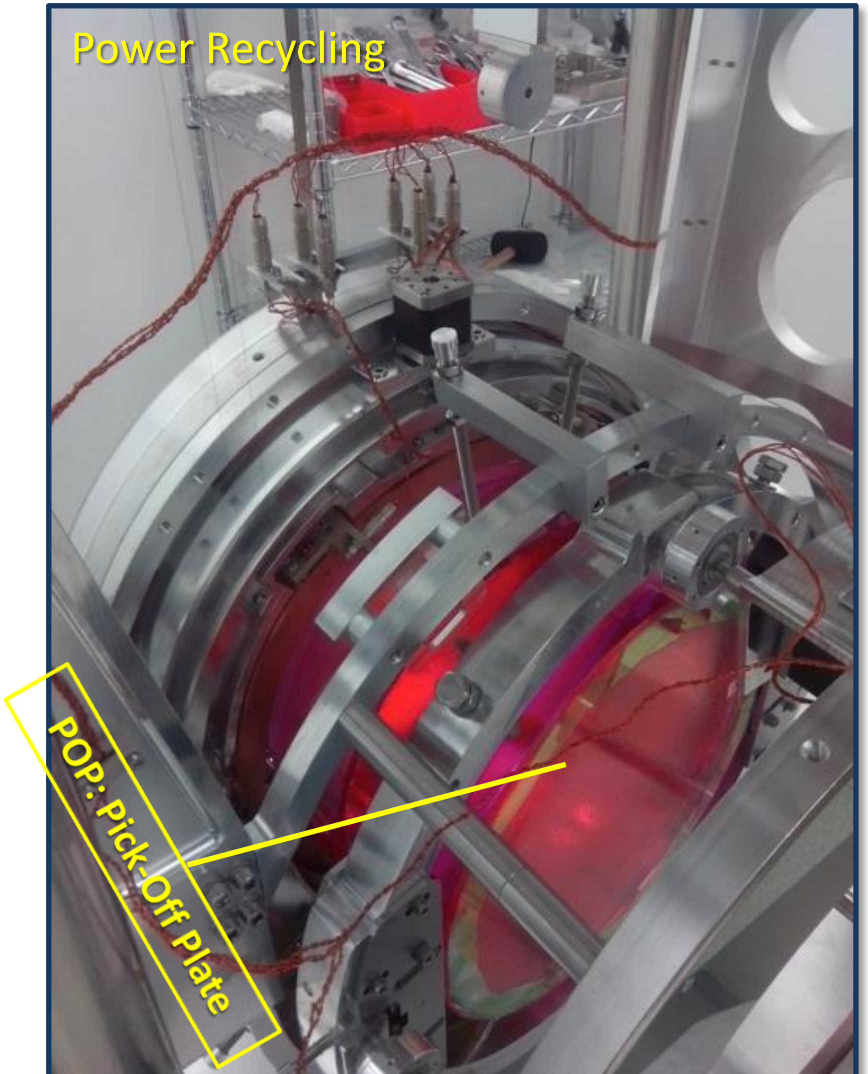
Photo: M Perciballi

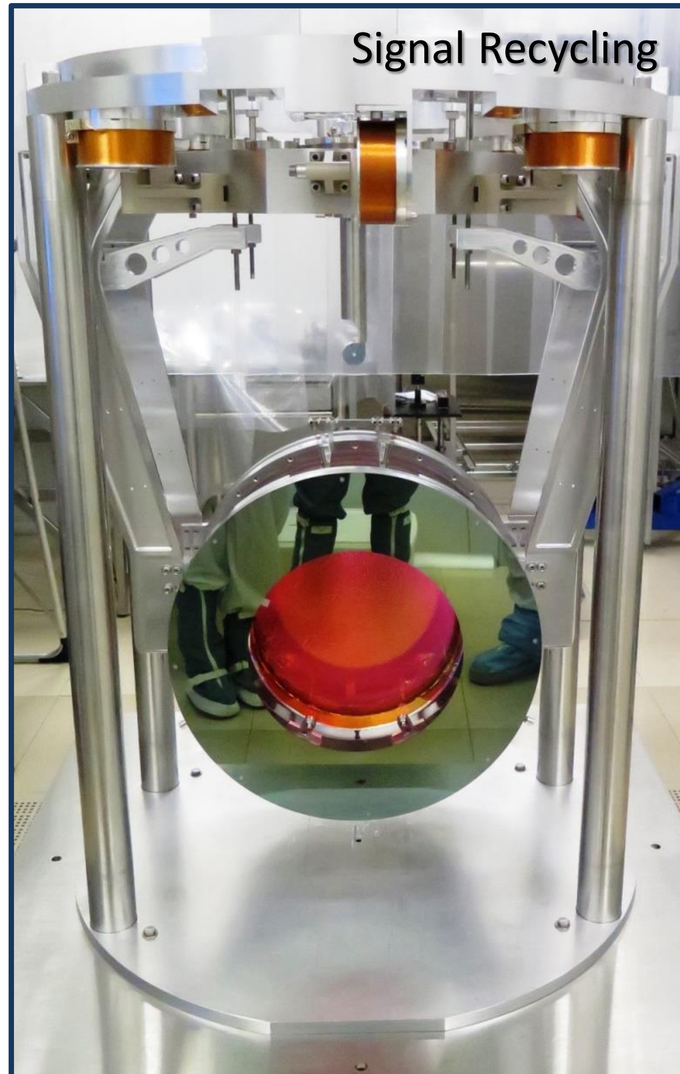
End Payloads





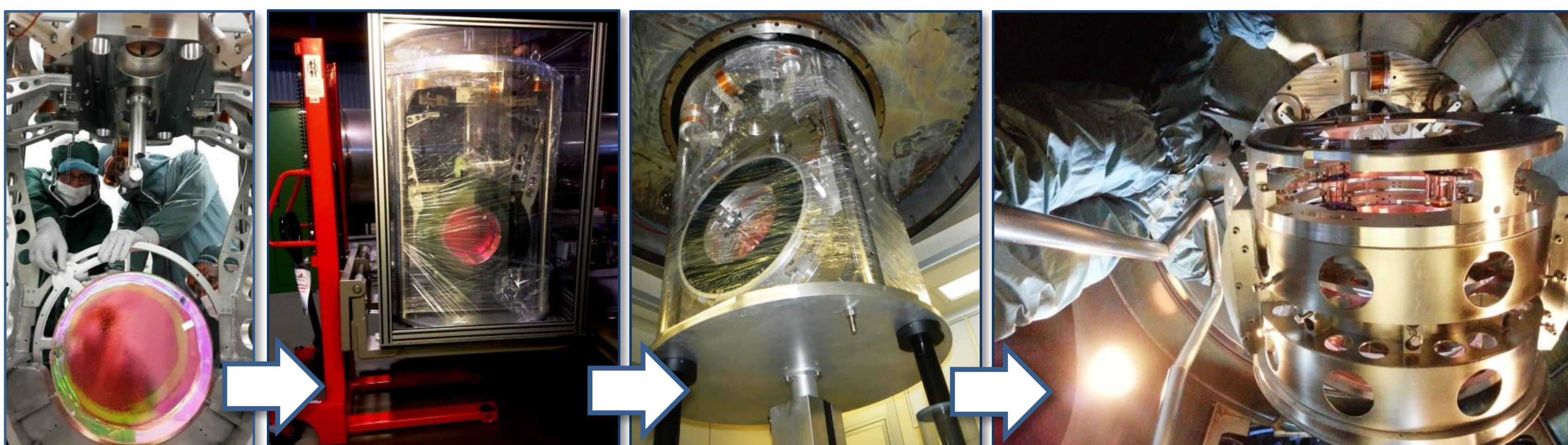
PR & SR Payloads





Payload Integration

	Last Integration	Payload Weight*	Mirror Weight	Mirror Suspension
Beam Splitter	2014/12/17th	100.5 kg	34.2 kg	steel wires
West Input	2016/07/19th	145.2 kg (avg)	42 kg	steel wires+
West End	2016/07/26th	145.2 kg (avg)	42 kg	steel wires+
North Input	2016/10/19th	145.2 kg (avg)	42 kg	steel wires+
North End	2016/10/26th	145.2 kg (avg)	42 kg	steel wires+
Power Recycling	2015/11/19th	85.9 kg	21 kg	steel wires
Signal Recycling	2016/01/12th	85.9 kg	21 kg	steel wires

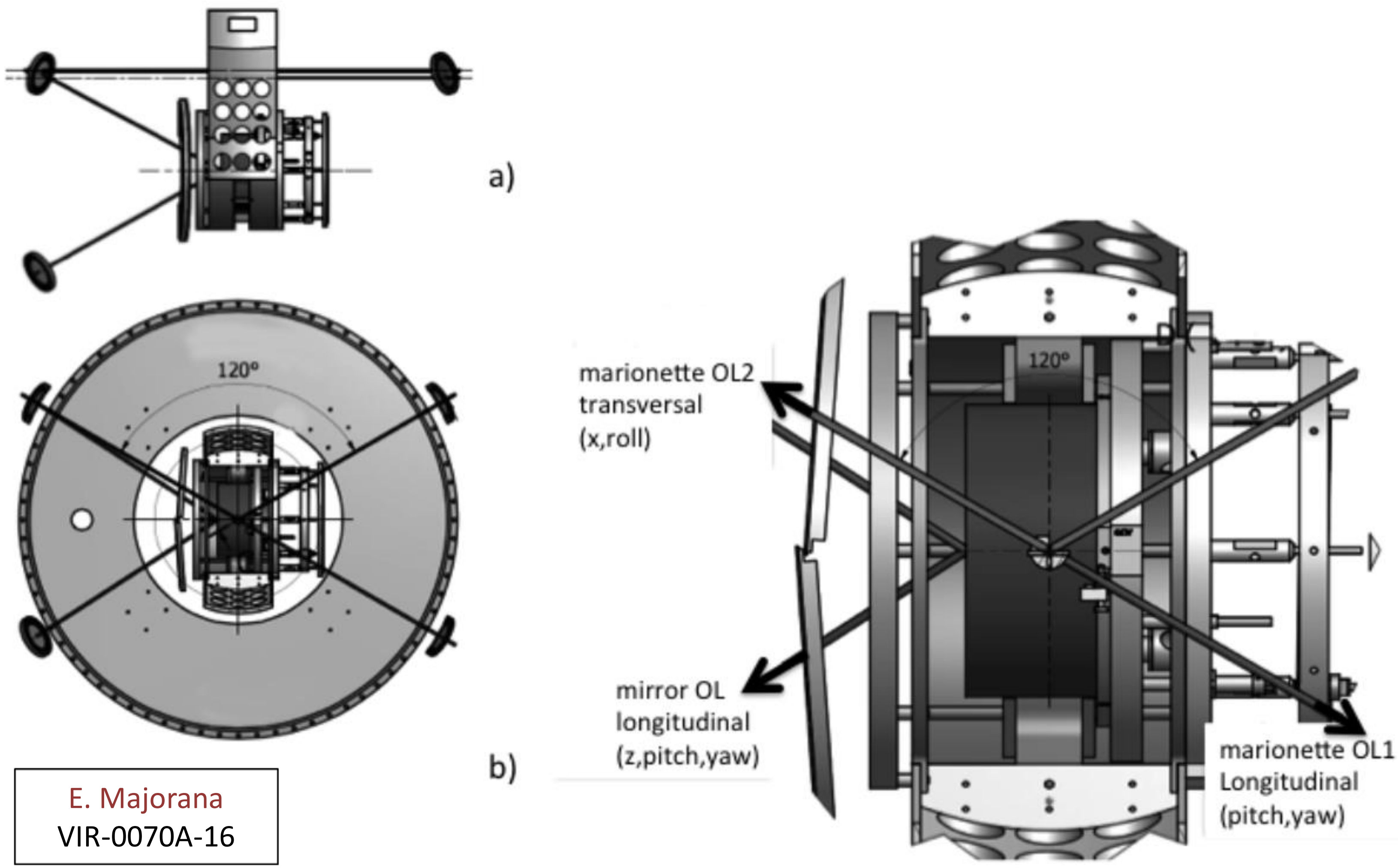


** Marionette + Mirror*

+ SiO_2 fibers after O2

Payload Integration

Optical Levers for payload control



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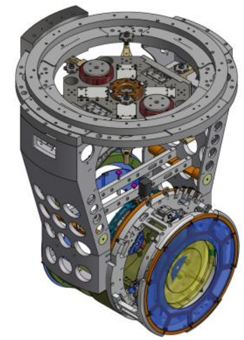
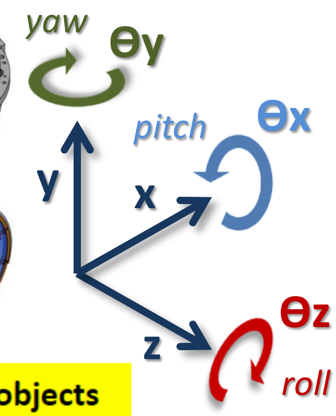
Optical Levers for payload control

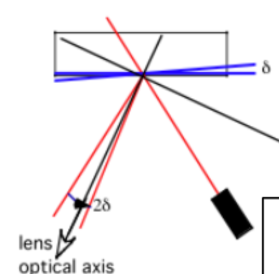
N Lever	Suspension	Reflection	PSD location	D.o.F.	N D.o.F.	N sensors
1	INJ	Bench	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
2	INJ	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
3	MC	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
4	MC	RmT	Focal	$\theta_y\ \theta_z\ x$	2 (3)	1
5	PR	Mario	Focal	$\theta_x\ \theta_y$	2	1
6	PR	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
7	PR	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
8	BS	Mario	Focal	$\theta_x\ \theta_y$	2	1
9	BS	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
10	BS	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
11	NI	Mario	Focal	$\theta_x\ \theta_y$	2	1
12	NI	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
13	NI	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
14	NE	Mario	Focal	$\theta_x\ \theta_y$	2	1
15	NE	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
16	NE	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
17	WI	Mario	Focal	$\theta_x\ \theta_y$	2	1
18	WI	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
19	WI	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
20	WE	Mario	Focal	$\theta_x\ \theta_y$	2	1
21	WE	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
22	WE	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2
23	PR	Mario	Focal	$\theta_x\ \theta_y$	2	1
24	PR	MarioT	Focal	$\theta_y\ \theta_z$	1 (2)	1
25	PR	Mirror	Focal, Image	$\theta_x\ \theta_y\ z$	3	2





- **9 suspended objects**
- **34 PSD sensors**
- **51 (60) D.o.F.**

T= transversal
(n) available (redundant)



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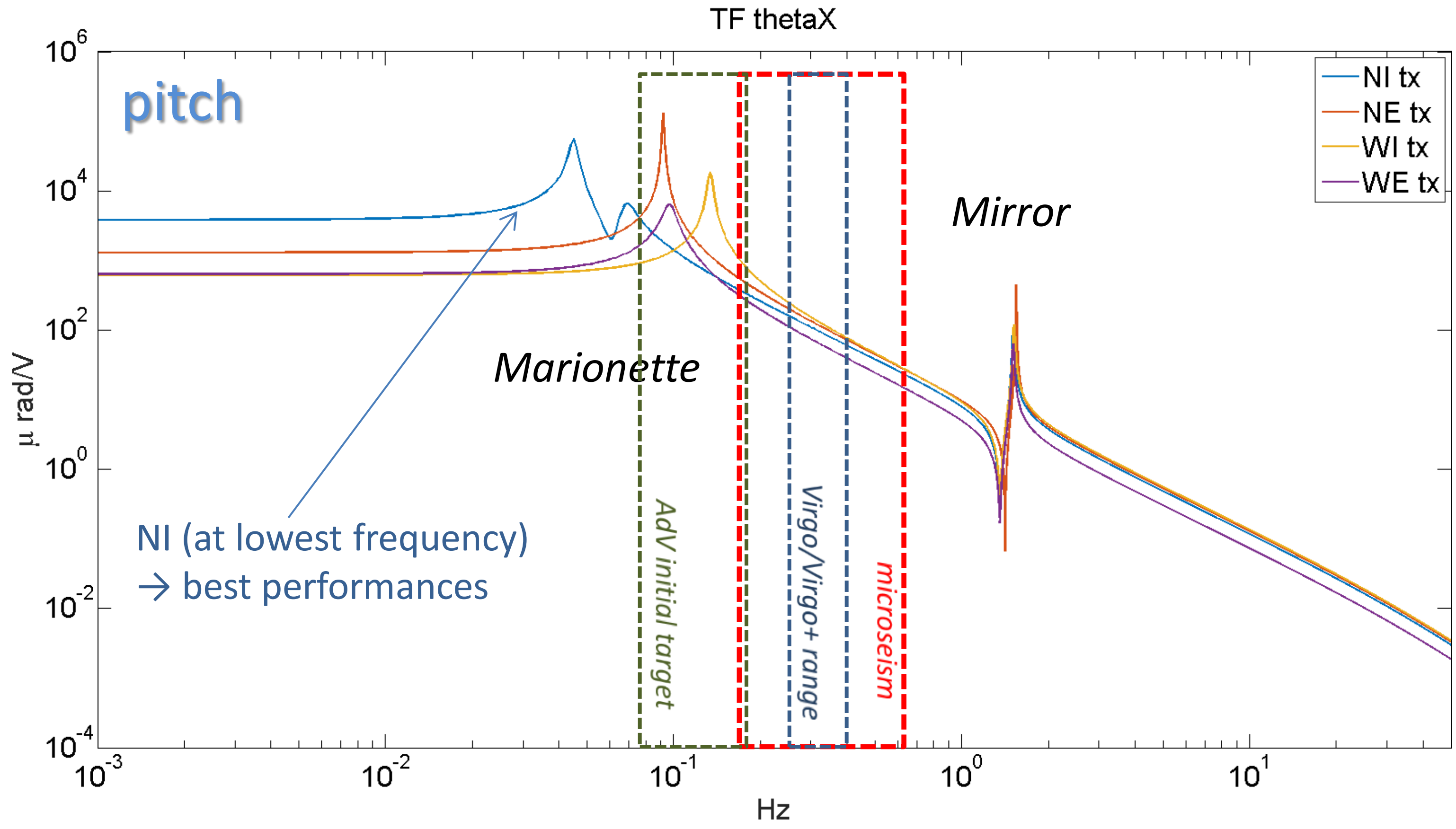
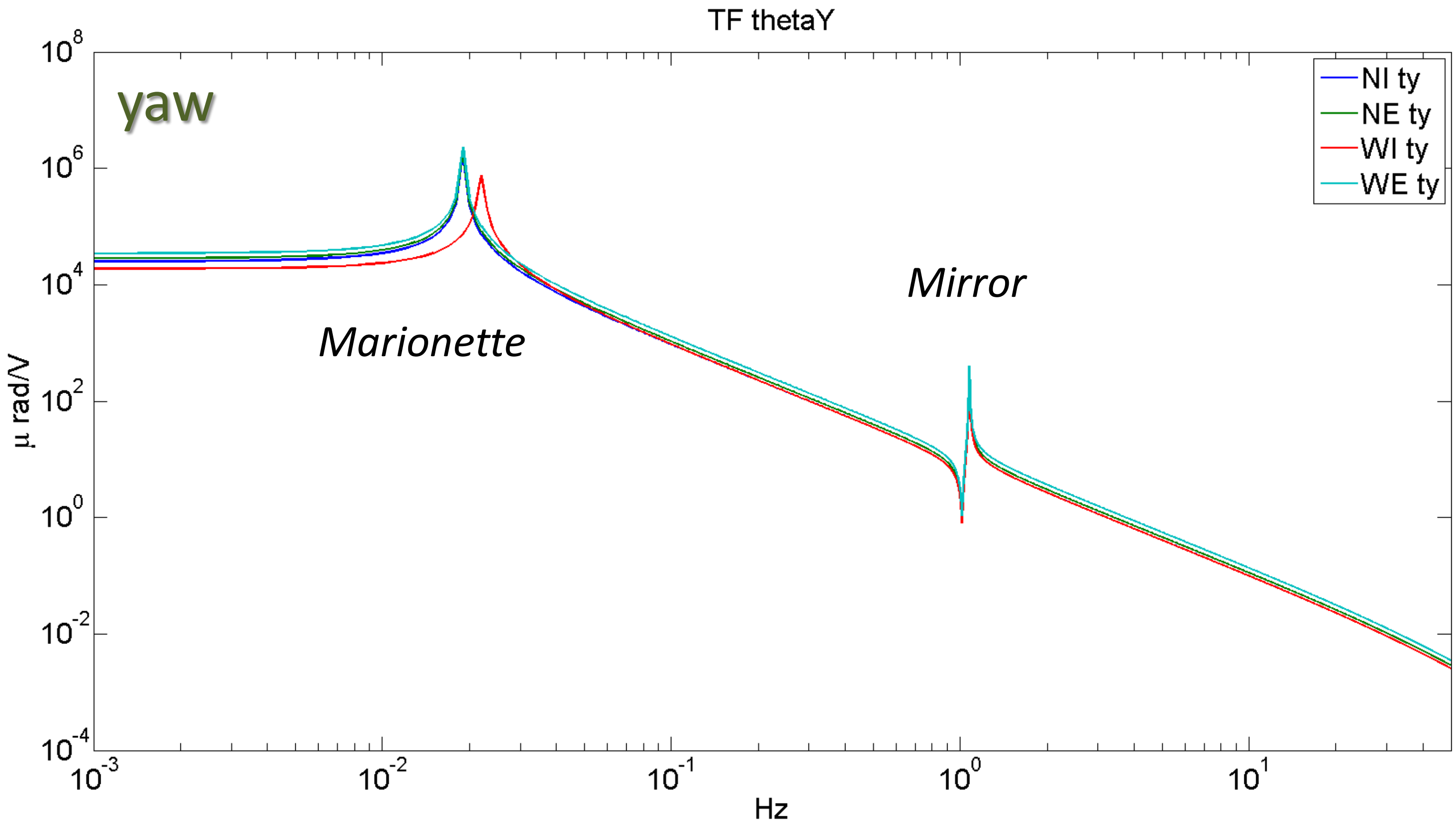
FP Payloads pitch, yaw and roll



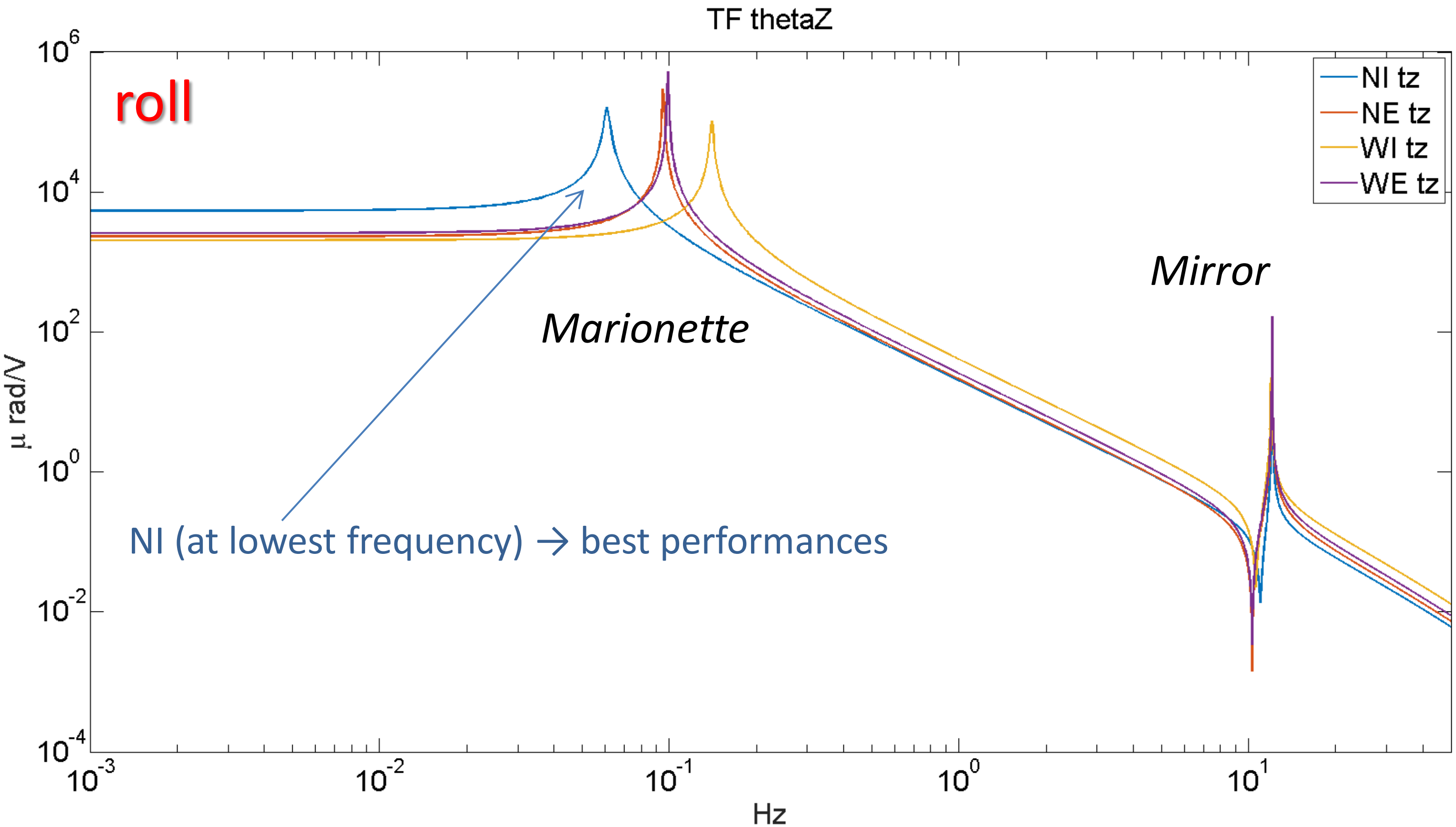
Pitch and Roll around (or even below) 100mHz → reduced microseism impact on residual tilt

FP Payloads pitch, yaw and roll



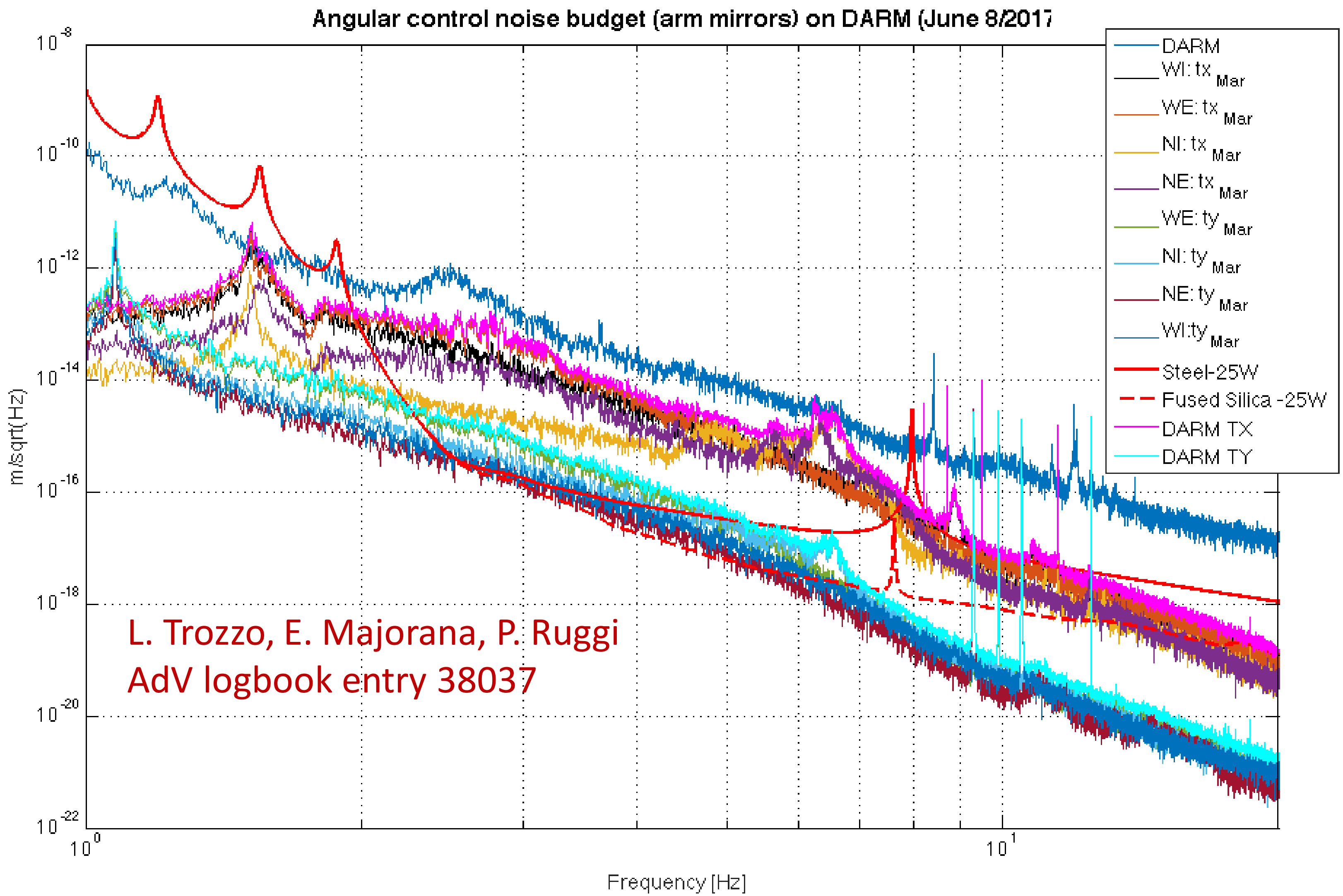
Pitch and Roll around (or even below) 100mHz → reduced microseism impact on residual tilt

FP Payloads pitch, yaw and roll

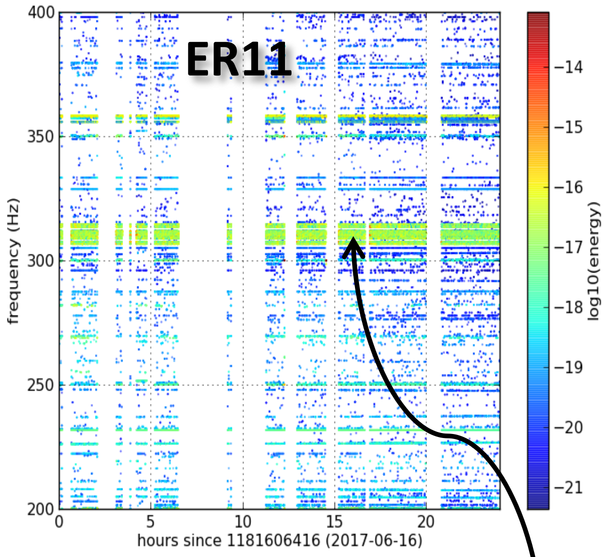


Pitch and Roll around (or even below) 100mHz → reduced microseism impact on residual tilt

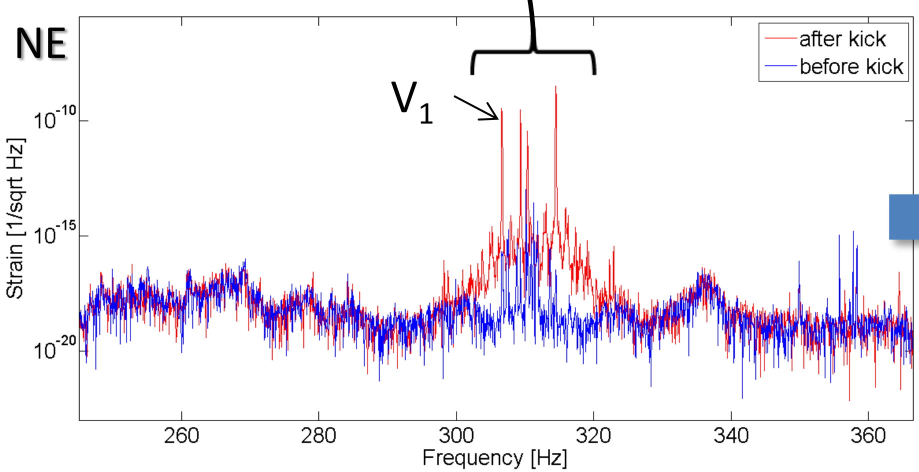
FP Payloads angular noise projection

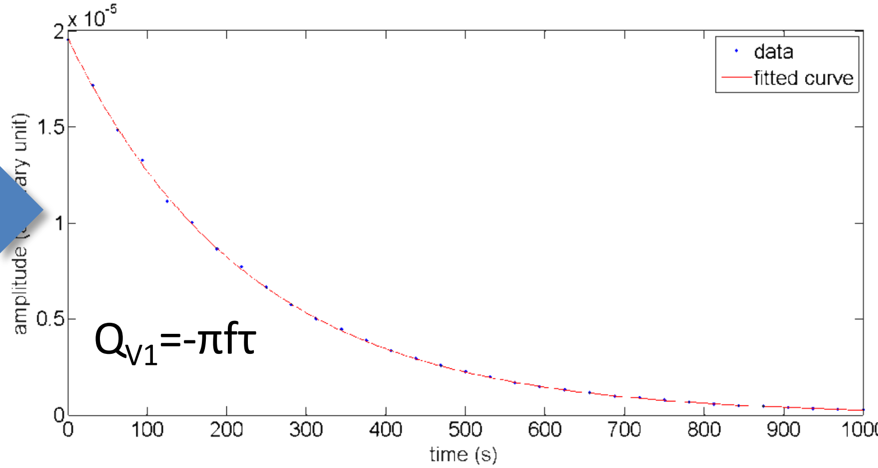


FP Payloads Q of steel-wire suspension



Violin Modes	FREQUENCY RANGE (Hz)	QUALITY FACTOR RANGE	LOSS ANGLE Φ *average*
NORTH INPUT	$306.7 \div 313.6$	$(2.18 \div 2.71) \times 10^5$	$\sim 1.7 \times 10^{-3}$
NORTH END	$306.6 \div 314.5$	$(2.21 \div 2.37) \times 10^5$	$\sim 1.8 \times 10^{-3}$
WEST INPUT	$307.3 \div 311.8$	$(2.03 \div 2.69) \times 10^5$	$\sim 1.5 \times 10^{-3}$
WEST END	$308.8 \div 311.7$	$(1.94 \div 2.92) \times 10^5$	$\sim 2.0 \times 10^{-3}$

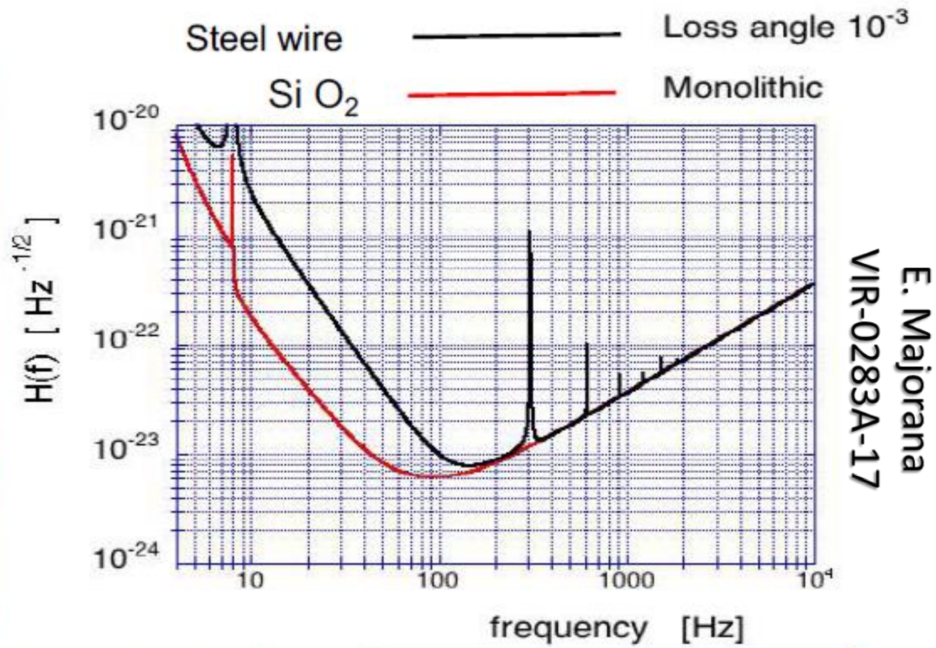




Back to the Future :

monolithic suspension of FP Payloads

→ F. Travasso's talk!



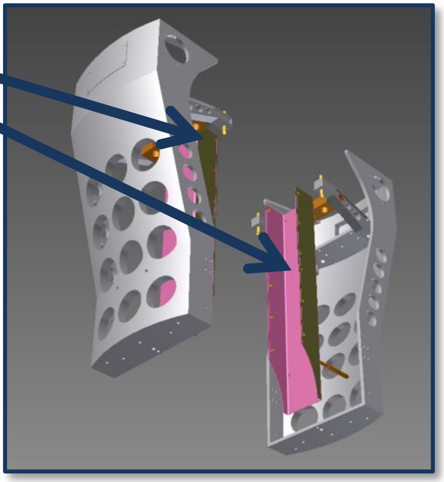
Metallic ($\phi=10^{-3}$)
Horizon NS-NS - 45 Mpc
Horizon BH-BH - 202 Mpc

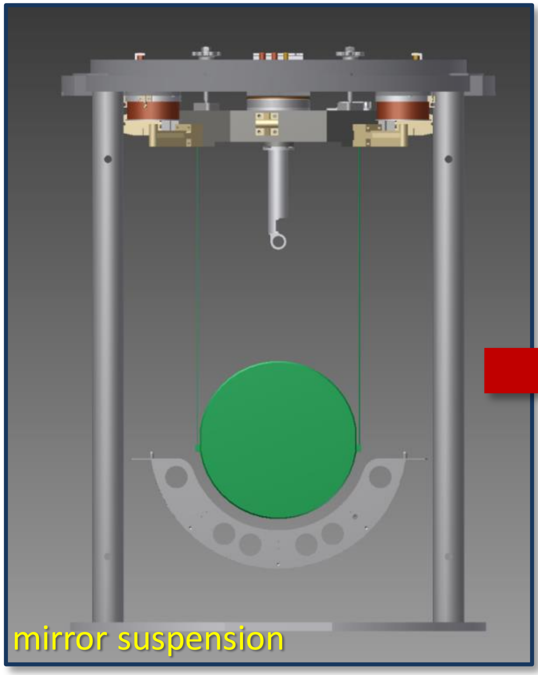
Monolithic
Horizon NS-NS - 101 Mpc
Horizon BH-BH - 985 Mpc

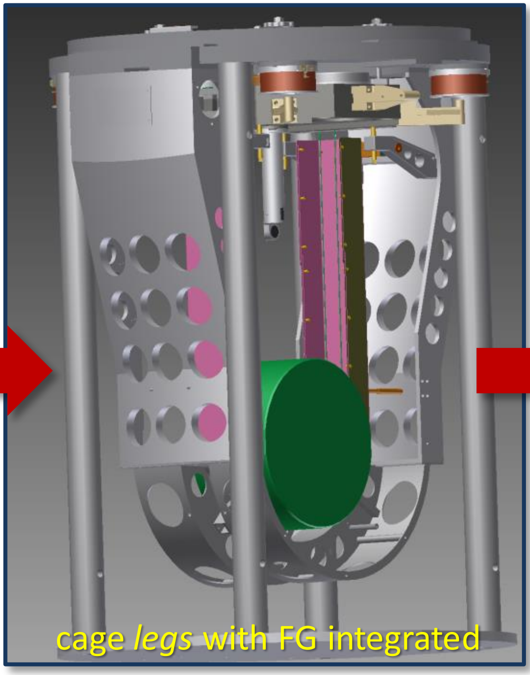
Payload Upgrades after O2

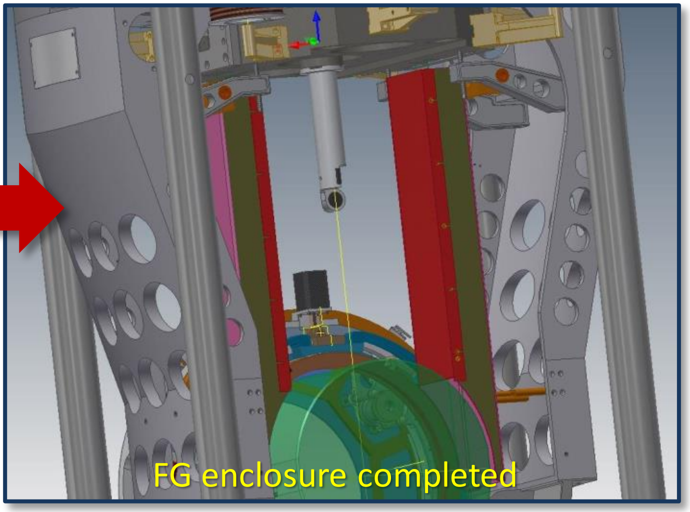
Integration of Fiber Guards (FG) to avoid any possible failure due to the impact of high speed particles related to vacuum operations

Constraints:
- FG must be clamped to the actuation cage
- FG size must be compatible with local controls
- FG integration must be compatible with the assembly procedure
- FG must not change significantly the overall suspended weight



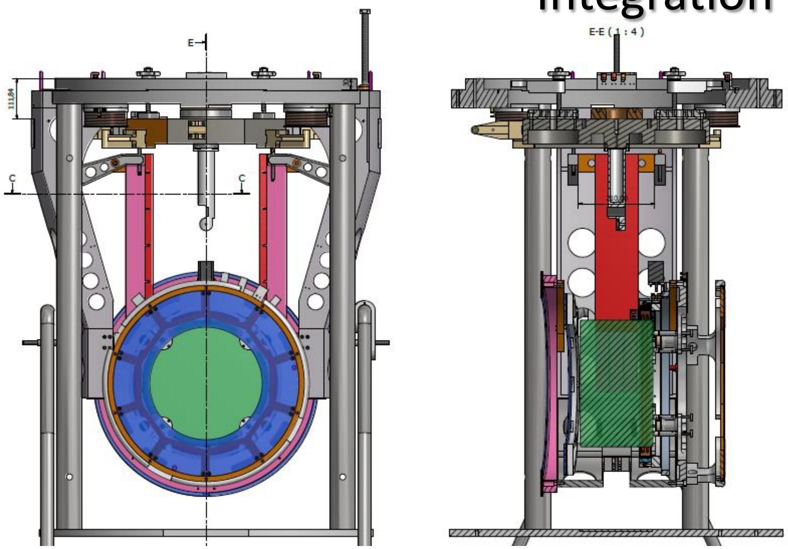

mirror suspension


cage *legs* with FG integrated


FG enclosure completed

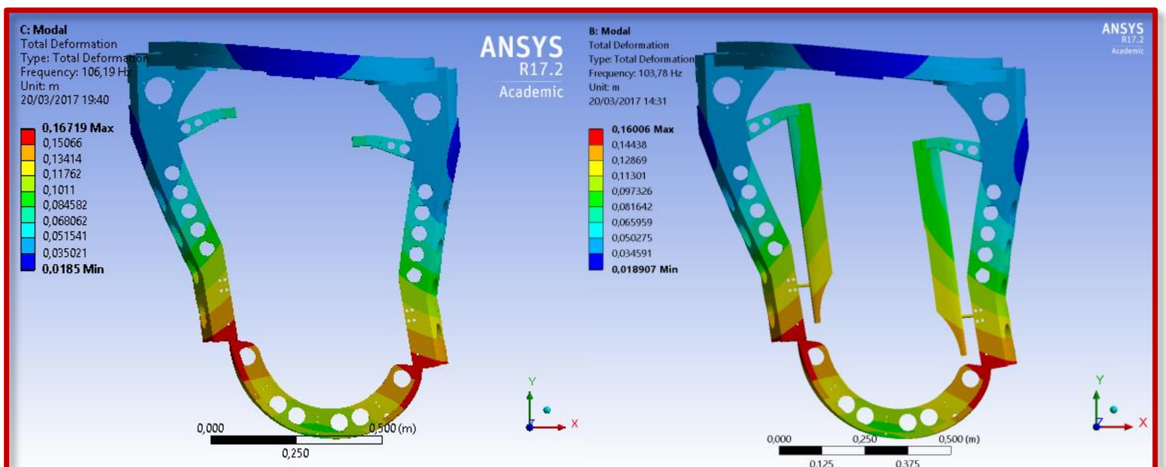
Payload Upgrades after O2

Integration of Fiber Guards (FG)



Final Design:

- FG integrated to the cage legs
- FG compatible with local controls and marionette/mirror max oscillations
- FG overal (both sides) weight: 3.2 kg
- Cage+FG resonant frequencies variation has been computed with FEM (< 3% at f < 250Hz)



e.g. 1° mode:
from 106.19 Hz to 103.78 Hz

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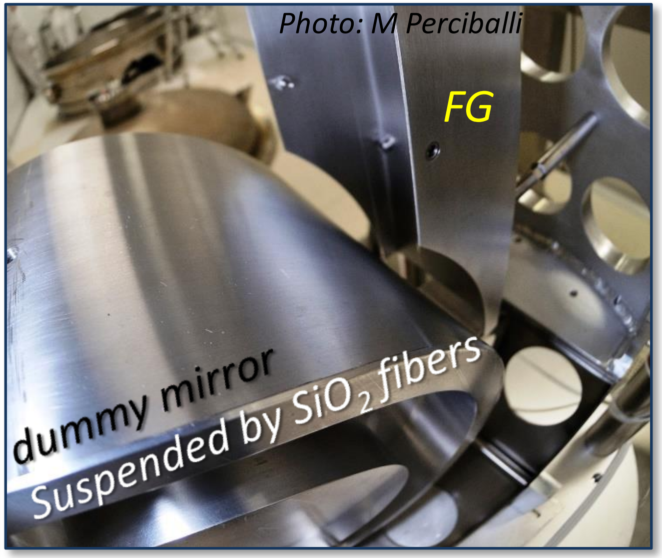
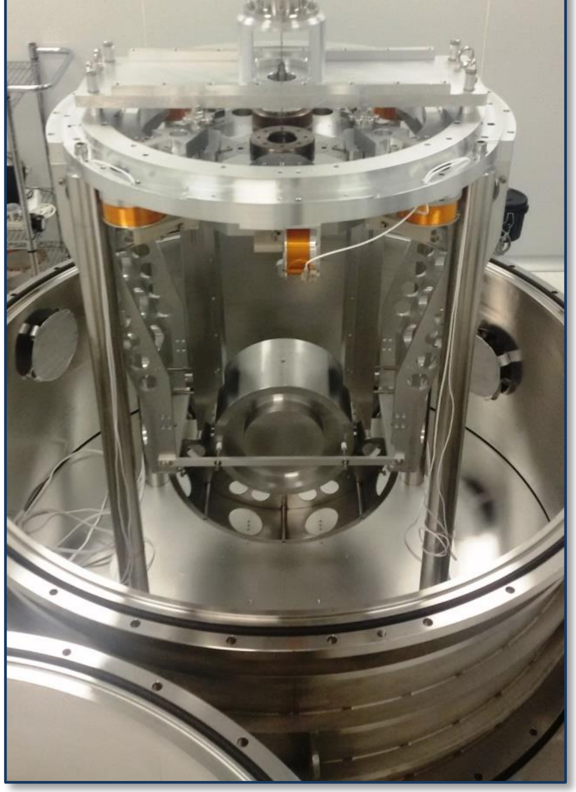
Payload Upgrades after O2

Integration of Fiber Guards (FG)



Test Payload with monolithic suspension and Fiber Guards assembled and in-vacuum …

→ **F. Travasso's talk**



Payload Upgrade Planning

- Payload upgrade activities will start in September
- Expected time required to *extract*, *disassemble*, *re-assemble* with monolithic suspension + fiber guards and *re-integrate* one Payload: ~ 3 weeks
- Minimal time required for 4 FP Payloads: 3 months

- Partial overlap of extraction and integration phases of two payloads is possible → required time may be reduced with appropriate schedule;

The upgrade planning also depends on *commissioning activities* on single ITF arm (TBD) after reintegration of FP In & End Payloads, and other ITF upgrades (e.g. vacuum system, integration of squeezer , etc.)

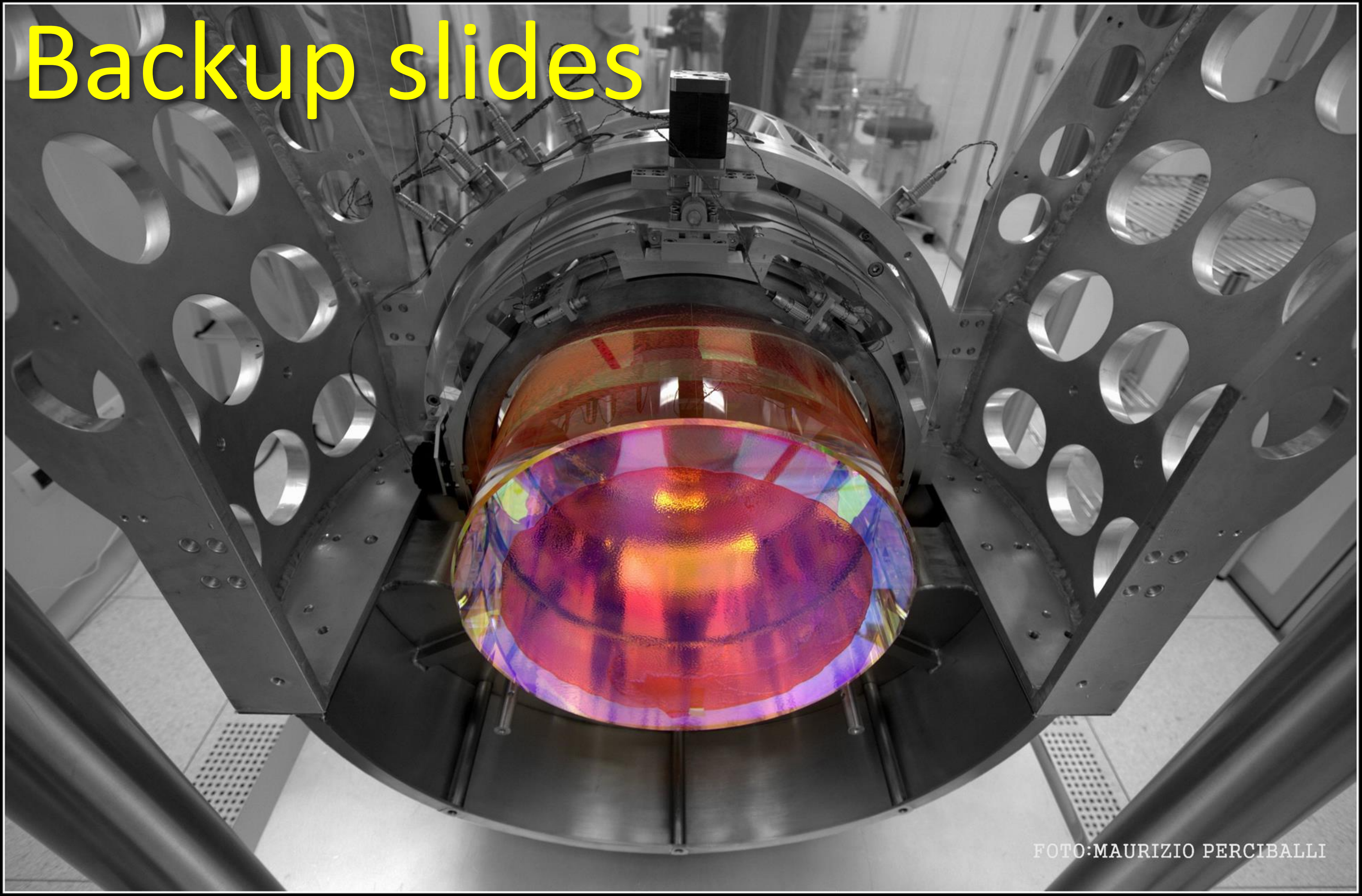
From 3 to 4 months starting from September 2017

Conclusions

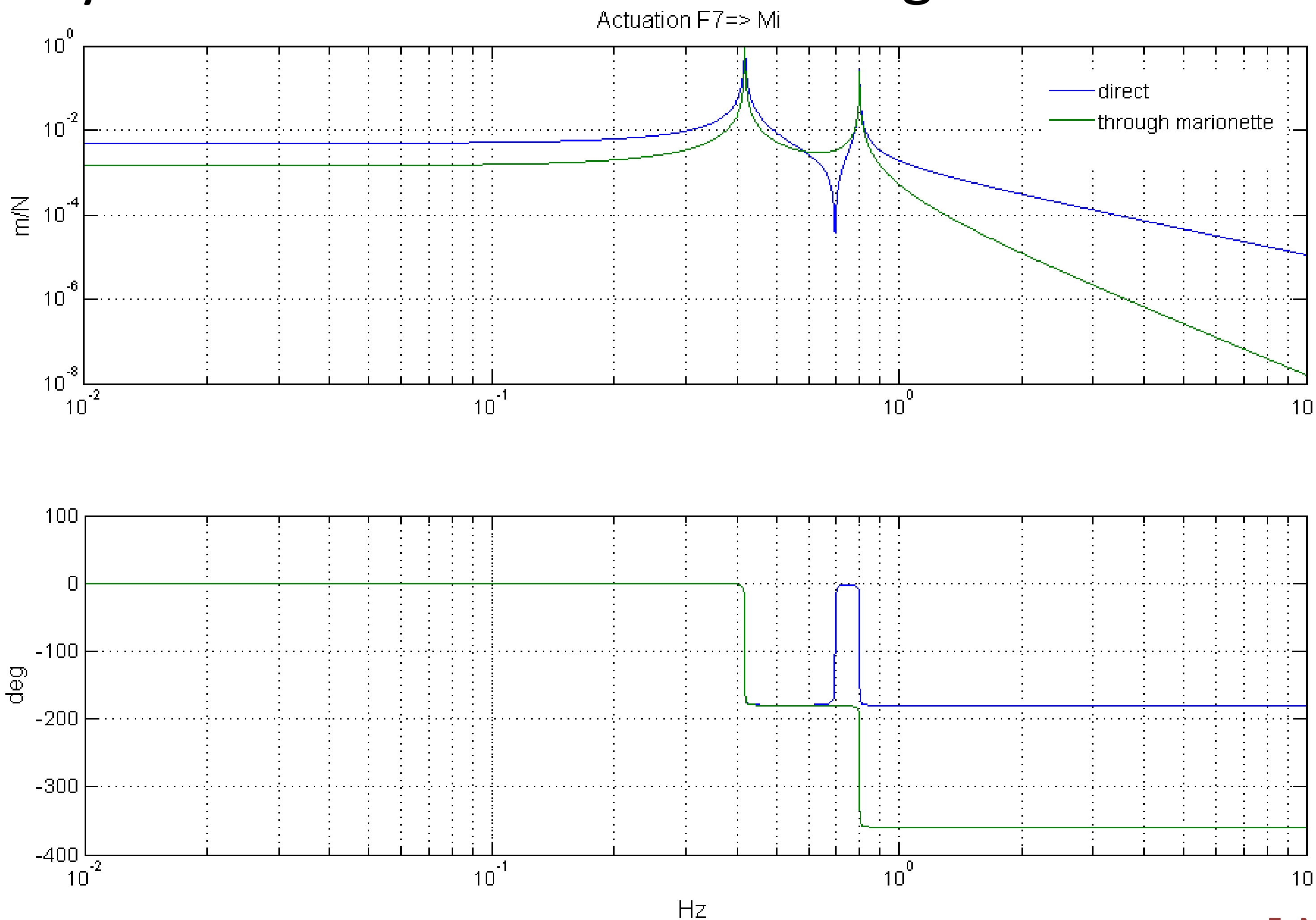
- AdV Payload integration started on 2014 (BS) and ended on 2016 (FP Payloads re-integration);
- The temporary setup with the steel-wires suspension of TMs in FP Payloads allowed the full ITF commissioning of Advanced Virgo and to join Advanced LIGO during O2;
- Mirror (steel-wires) suspension Quality Factor consistent with expectations;
- Reduced impact of microseismic noise on Payloads due to low frequency pitch and roll;
- After O2 we will upgrade AdV FP Payloads: **monolithic suspension**, installation of **Fiber Guards**, re-integration of FP Payloads with low frequency pitch and roll (NI case) ;
- Payload Upgrades will last 3-4 months, starting from September 2017.

Thank you for your attention!

Backup slides



Payload TF from the actuation cage to the mirror



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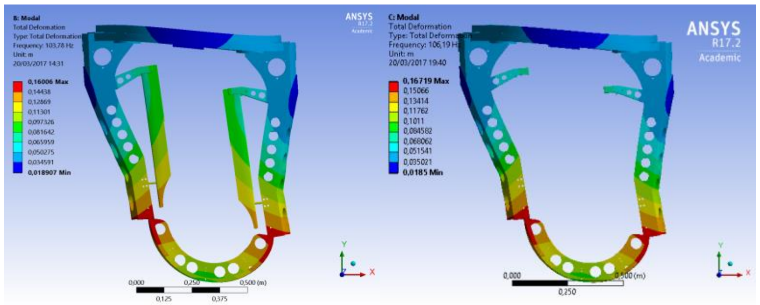
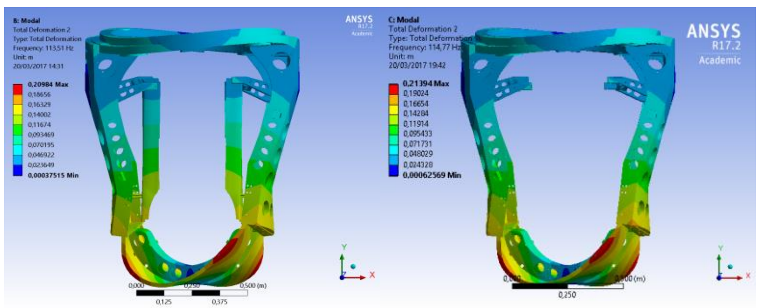
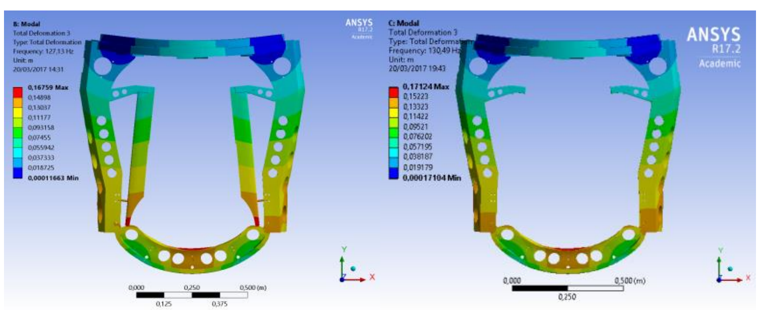
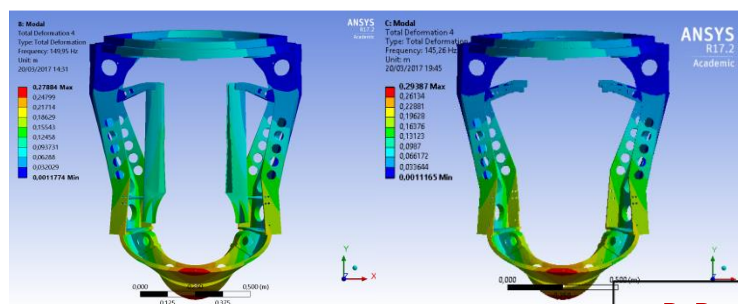
Payload actuation cage + Fiber Guards FEM simulations







mode	With guards	No guards
1,	103,78	106,19
2,	113,51	114,77
3,	127,13	130,49
4,	149,95	145,26
5,	244,38	251,79
6,	245,88	262,54
7,	263,37	263,9
8,	272,12	333,03
9,	292,11	343,07
10,	306,31	368,51



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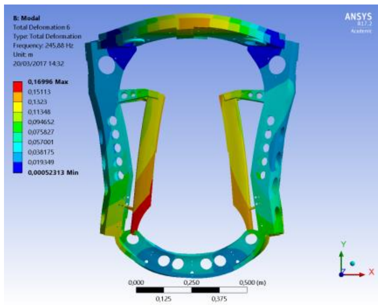
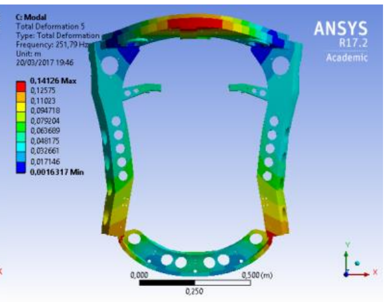
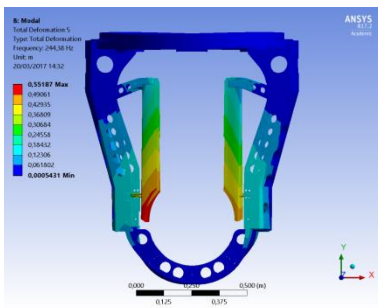
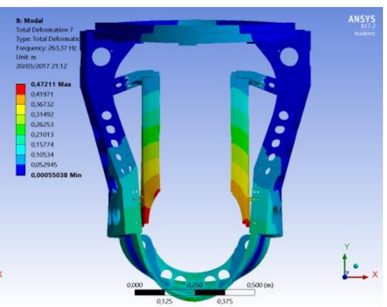
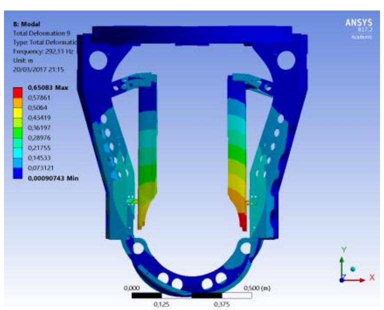

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