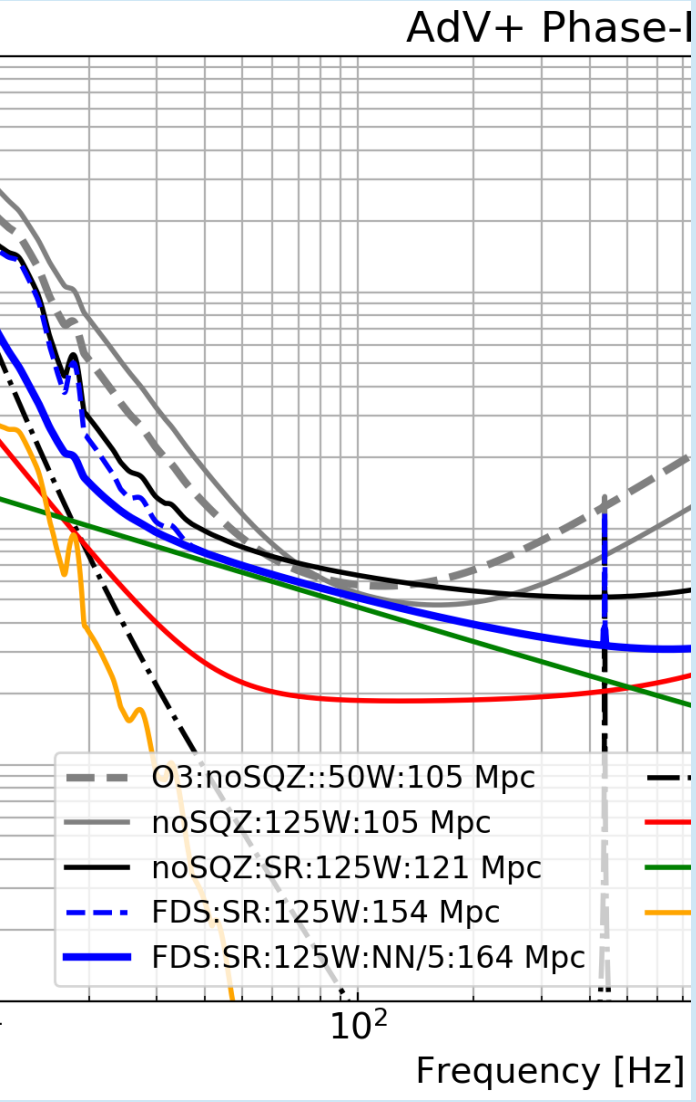
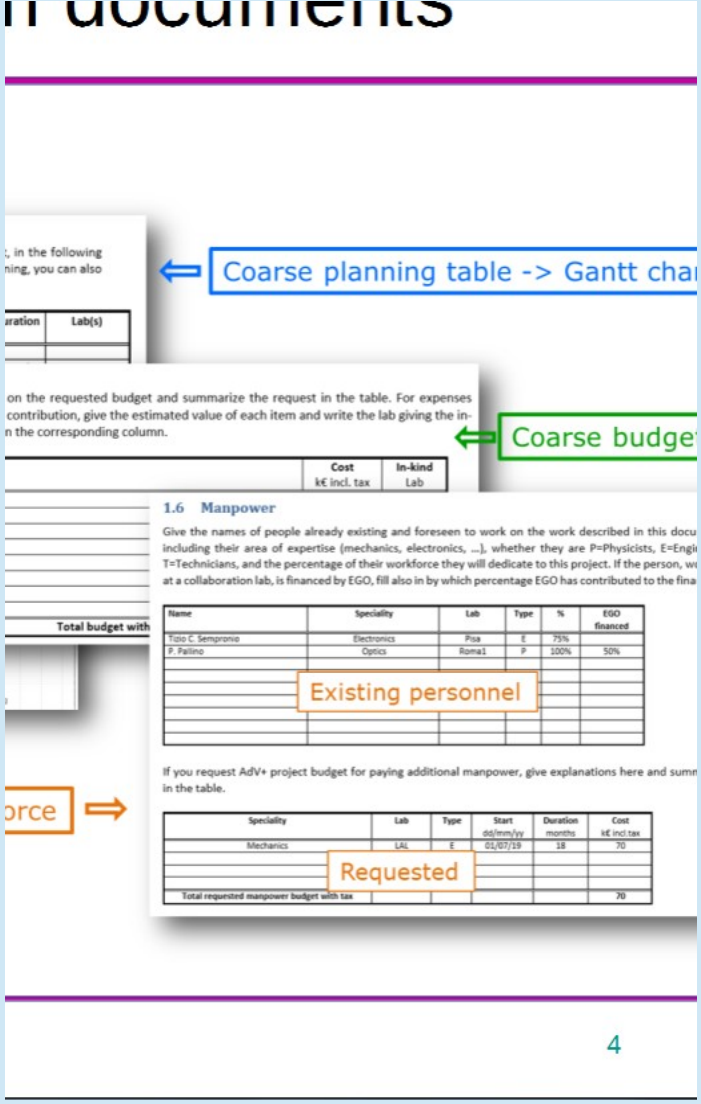




Advanced Virgo +

Jerome Degallaix
for the Virgo Collaboration

LIGO-G1900xxx - VIR-00515A-19

GWADW 2019

Advanced Virgo +

- the next large upgrade of Virgo, synchronised with LIGO
- keep the relevance of the detector in the global network
- will implement technologies for managing large mirrors

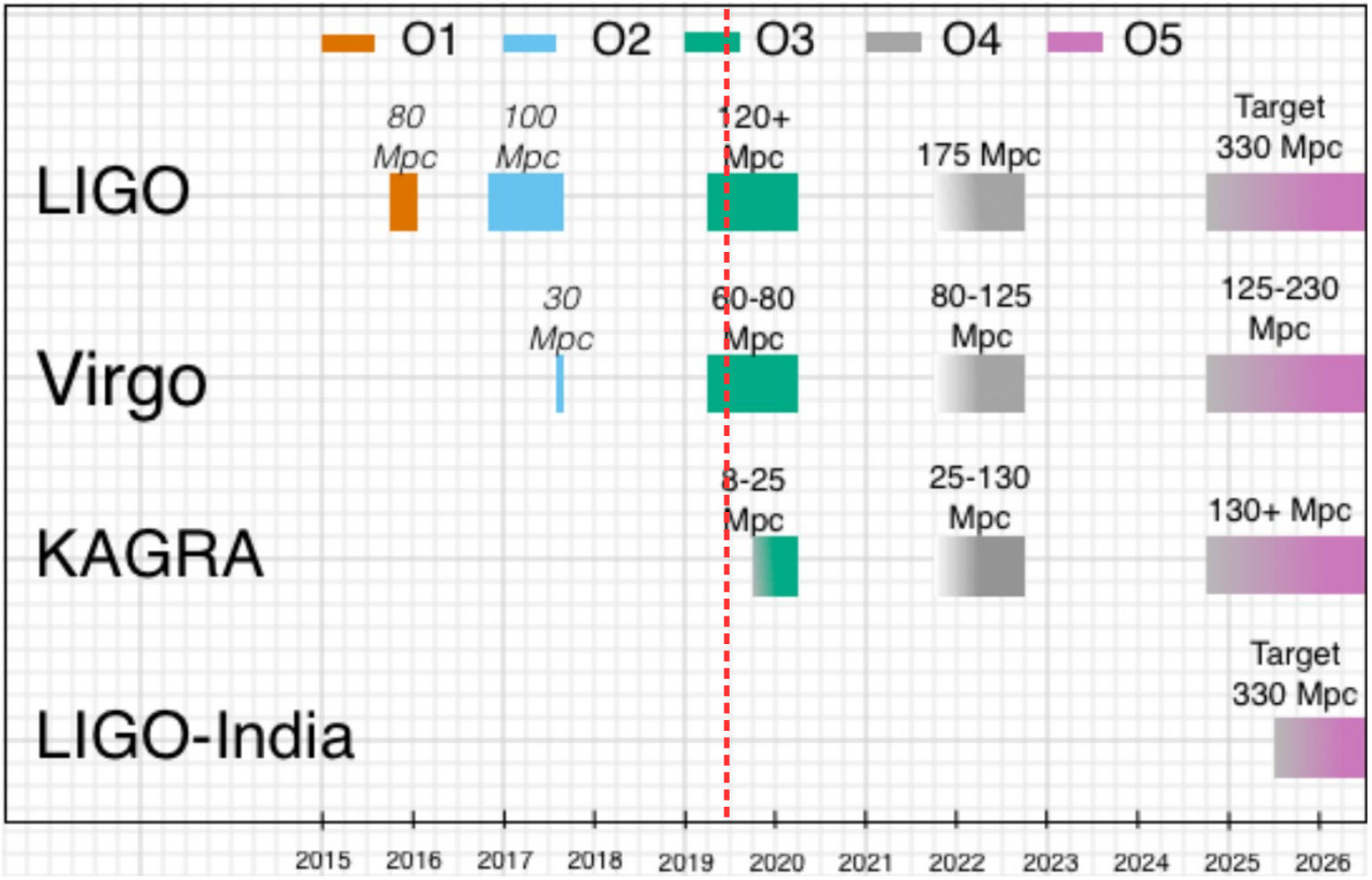
This presentation is not exhaustive, most of the subsystems will improve their performances for AdV+ even if not mentioned here (injection, detection, TCS, baffles,...)

AdV+ project is divided into 2 phases

- Phase I — *next 2 years* / *this presentation*
  - 40-50W input power
  - signal recycling mirror
  - Newtonian noise cancellation
  - frequency depend squeezing
  - preparatory work for phase II

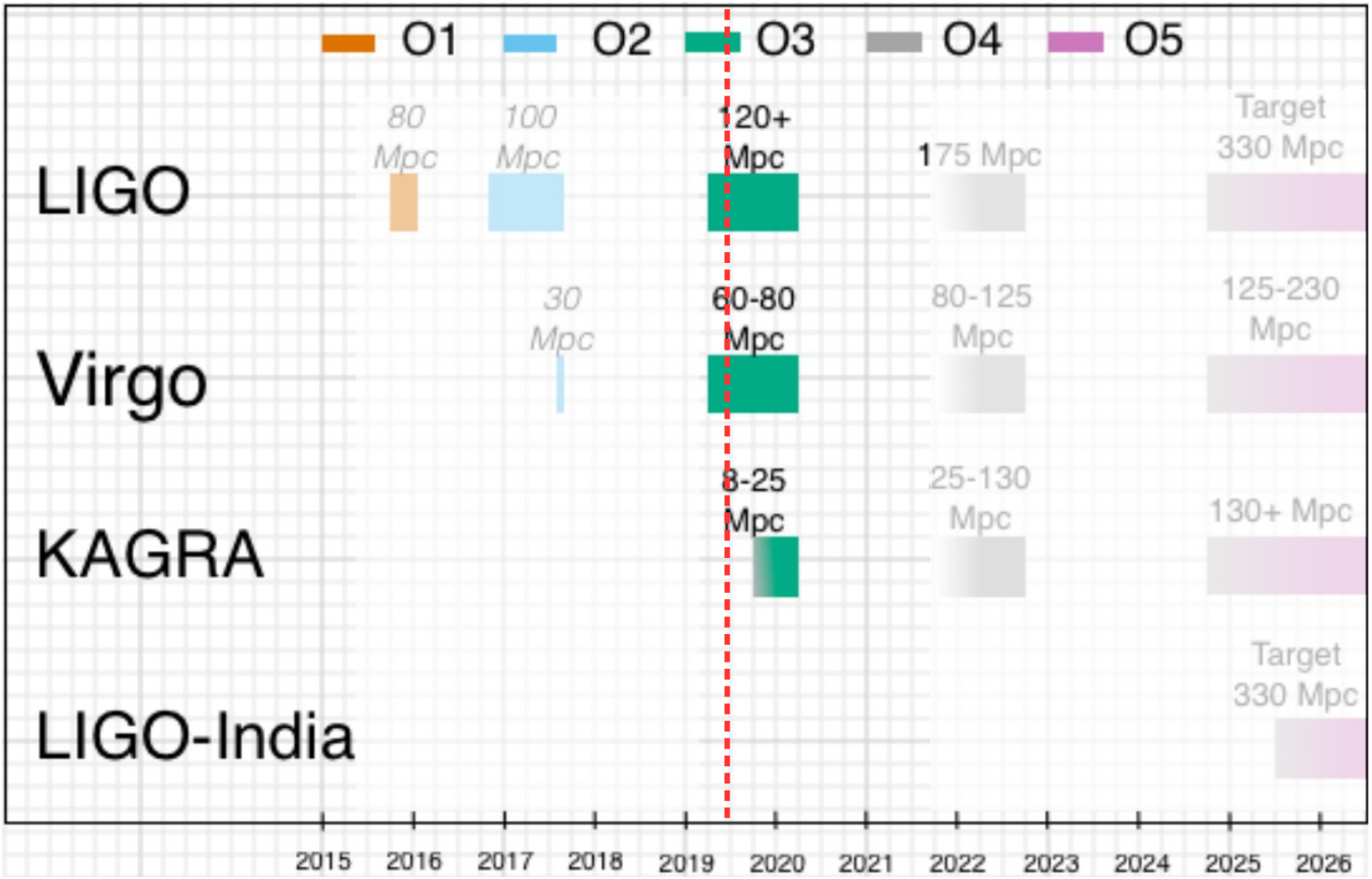
- Phase II — *beyond 2022*
  - large mirrors implementation

The overall planing



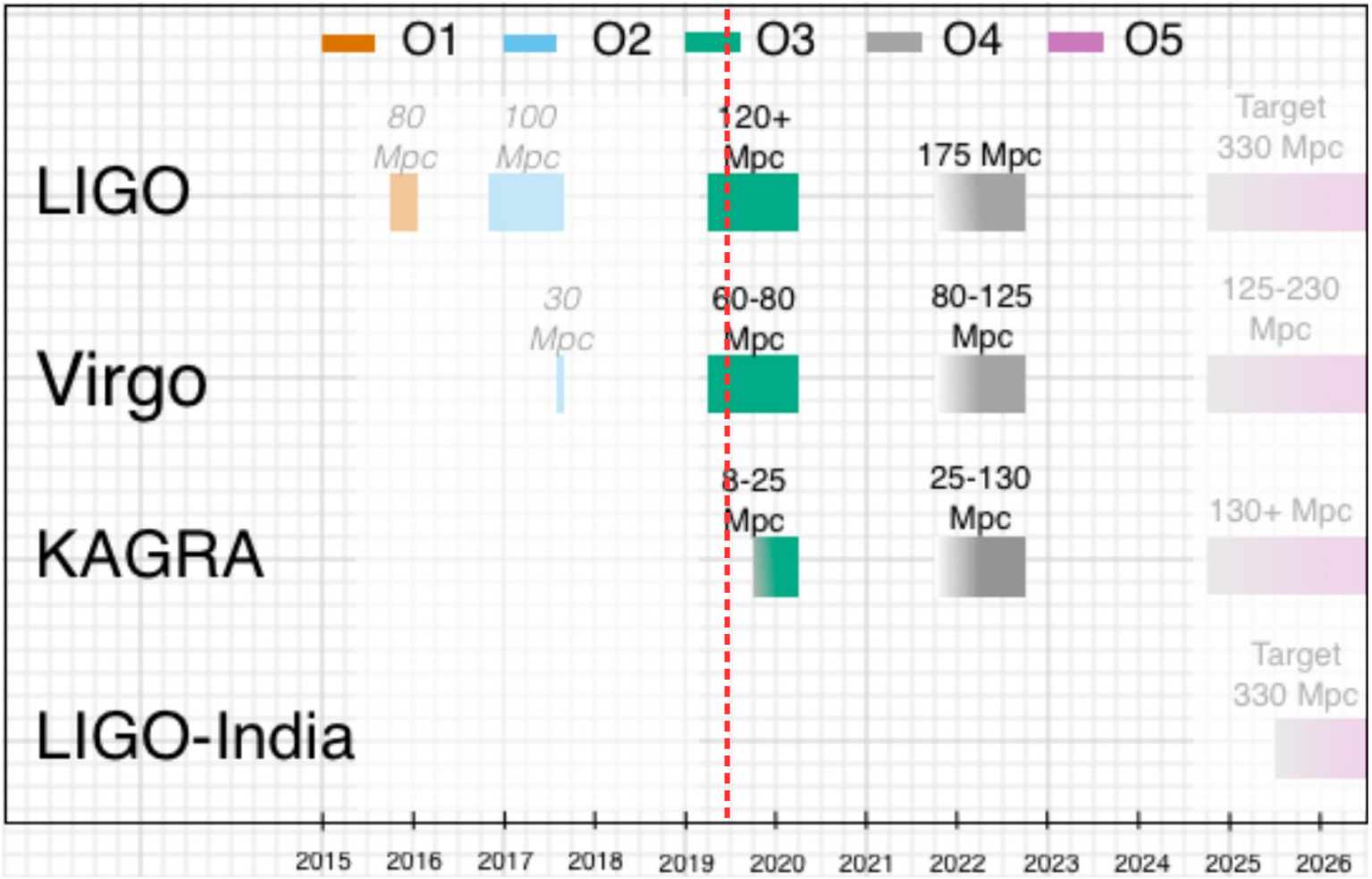
The overall planing

Phase I, preparation during O3, installation before O4

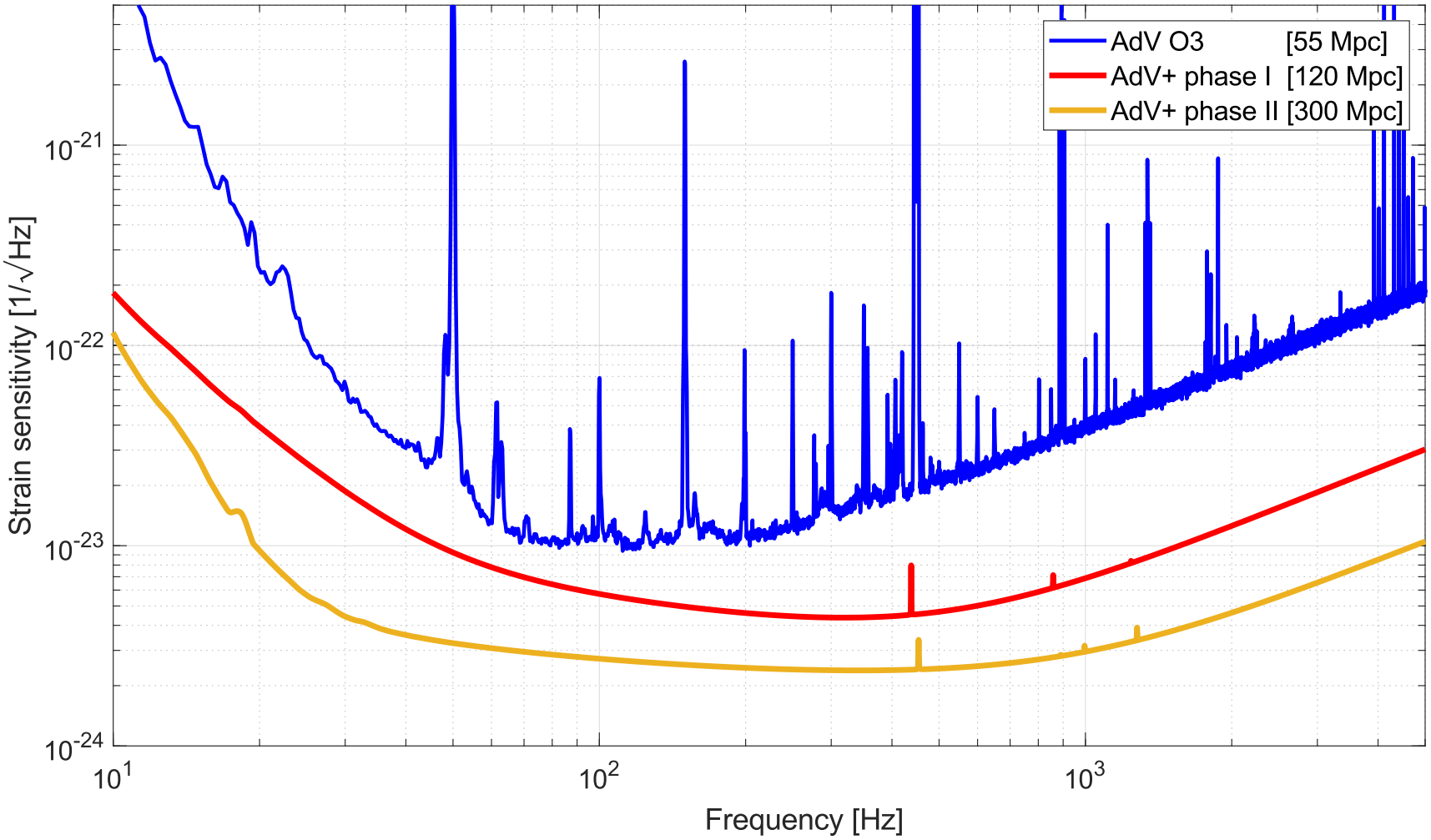


The overall planing

Phase II, preparation during O3-O4, installation before O5

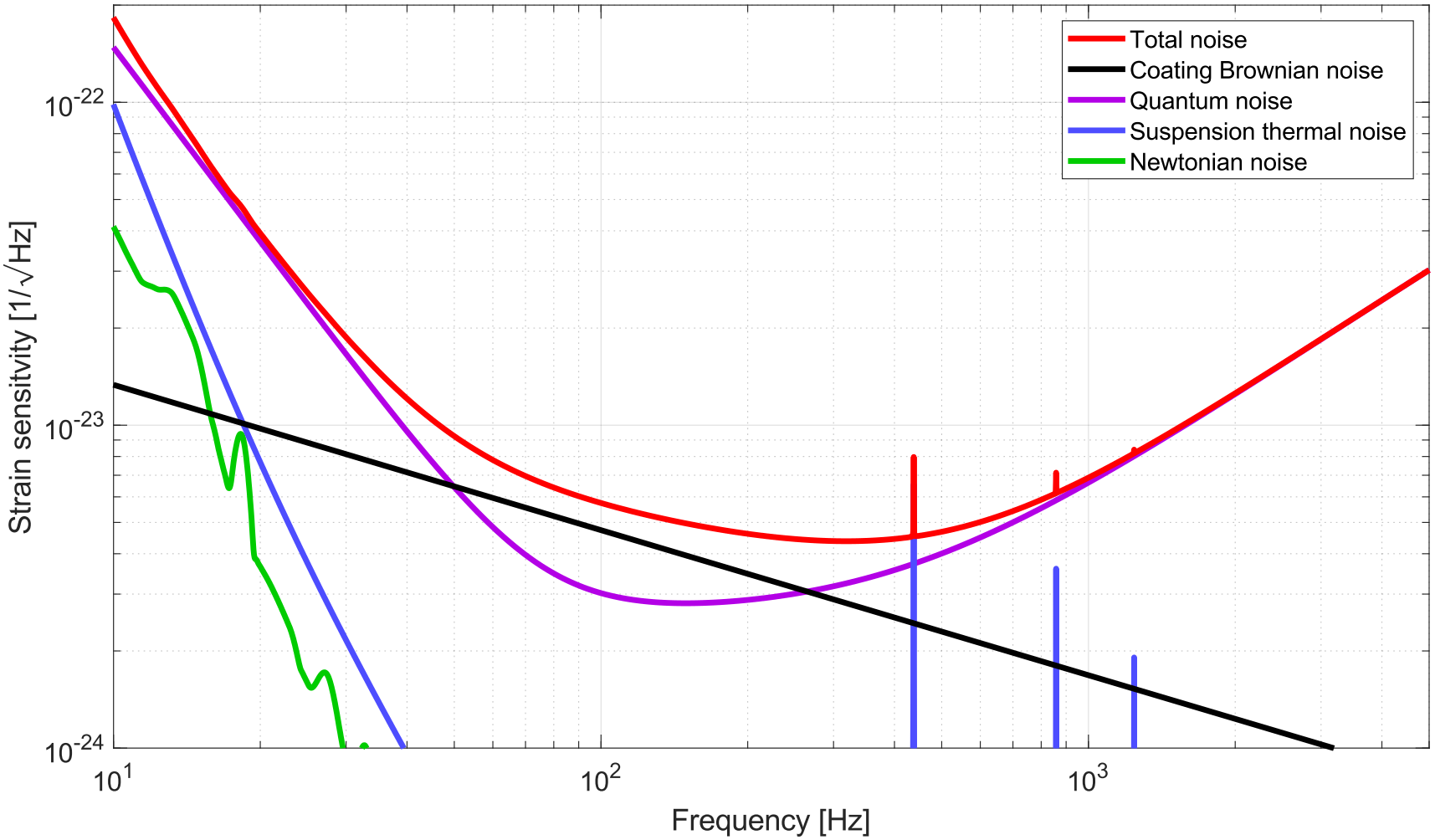


Expected sensitivity for phase I



For phase II that is the absolute best possible with large input and end mirrors and reduction of coating thermal noise

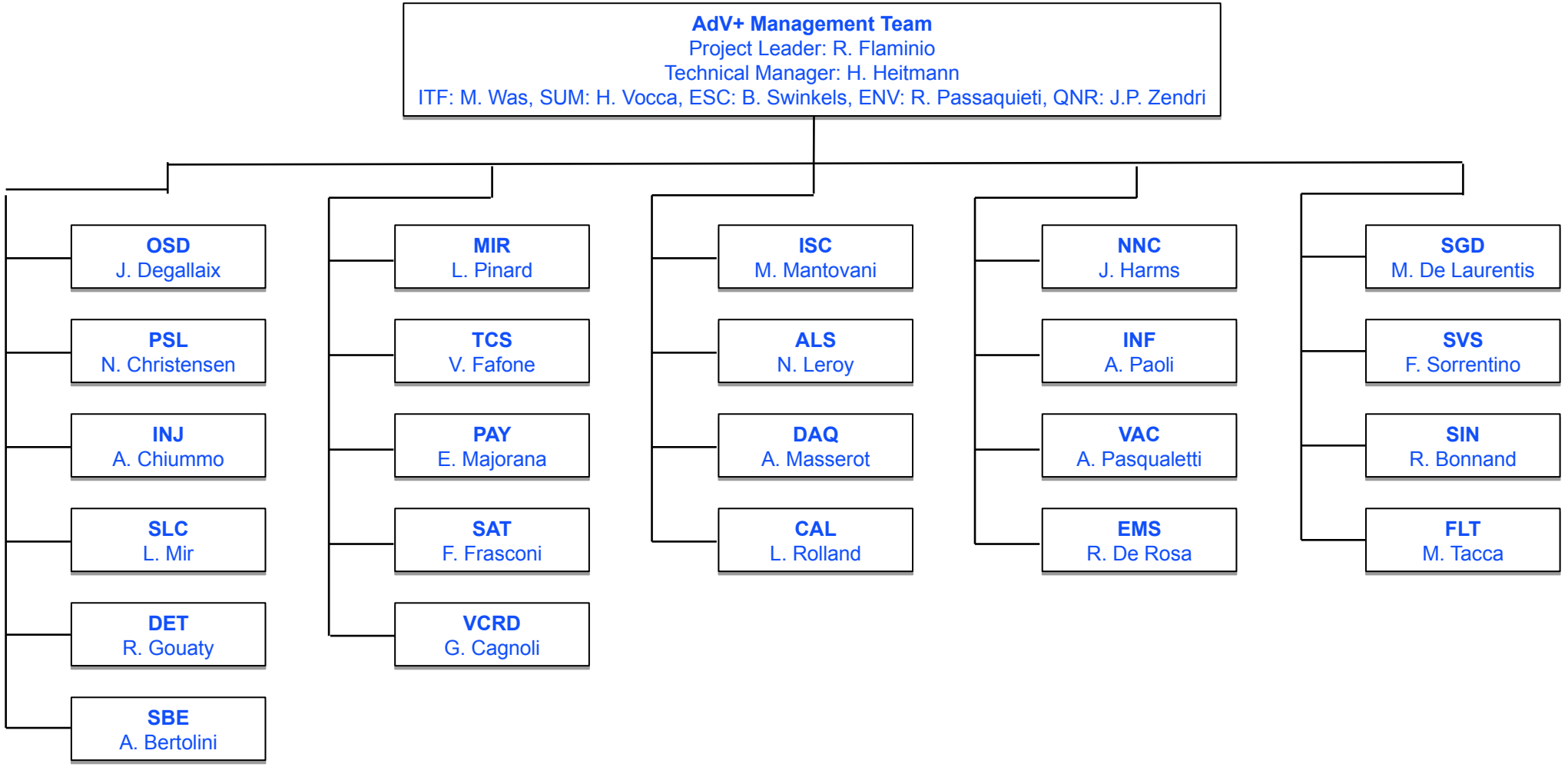
Main source of noise for Phase I



Only known fundamental noises are represented here

Input power: 40W

Organisation: the systems / subsystems



System: ITF	SUM	ESC	ENV	QNR
Interferometer	Suspensions & mirrors	Electronics, Software & Controls	Environment	Quantum noise reduction

Organisation: the very short term

- intensive work to complete a Technical Design Report with a detailed planning of tasks and resources required
- thoughtfully internal review

Review planning

Review	Concerned SS	Reviewers	Date	Deadline	Review slides	Review report
SR control	ALS, ISC	A. Rocchi (chair), E. Tournefier, L. Di Fiore	16/04 11:00	10/04	VIR-0405A-19,VIR-0408A-19	VIR-0430A-19 (prelim.)
VAC	VAC	Ch. Michel (chair), I. Fiori, M. Doets	18/04 14:00	10/04	VIR-0441A-19	VIR-0450A-19
HVAC	INF	Ch. Olivetto (chair), R. Passaquieti, N.Arnaud	19/04 09:00	12/04	VIR-0431A-19	VIR-0448A-19
Large mirrors	MIR	N. Christensen (chair), B. Mours, F. Fidecaro, V. Loriette	19/04 13:30	10/04	VIR-0432A-19	VIR-0500A-19
OSD/DET	OSD, DET	M.Barsuglia (chair), P.Hello, E.Calloni	23/04 14:00	15/04	VIR-0443A-19,VIR-0444A-19	VIR-0485A-19
PSL	PSL	P. Rapagnani (chair), M. Punturo, A. Chiummo	24/04 09:00	14/04	VIR-0417A-19	VIR-0475A-19
IMC payload	INJ, SLC	A.Bertolini (chair), F.Bondu, P.Puppo	24/04 14:00	14/04	VIR-0435A-19,VIR-0449A-19	VIR-0465A-19

	Works			Schedule information		Progress				Resou
No.	Task	Subtask	Type	Duration	Predecessors	%done	Committed	Cost	In-kind lab	Manpower
1		Subsystem management	M	24 months	01/05/2019					0.2P
2		Choice of the beam size in the recycling cavities		7 months	01/06/2019					
2.1		Under the current aperture limitation from the vacuum		3 months	01/06/2019					0.1vP
2.2		Under the current aperture limitation from the baffles		3 months	01/06/2019					0.1oP
2.3		Under the current aperture limitation from the mirrors		3 months	01/06/2019					0.1oP
2.4		Under the current limitation on the detection side		3 months	01/06/2019					0.1oP
2.5		Under the current limitation on the injection side		3 months	01/06/2019					0.1oP
2.6		Impact of increasing the beam side in the central area - VAC view		3 months	2.1					0.1vP
2.7		Impact of increasing the beam side in the central area - MIR view		3 months	2.3					0.1oP
2.8		Impact of increasing the beam side in the central area - DET view		3 months	2.4					0.1oP
2.9		Impact of increasing the beam side in the central area - INJ view		3 months	2.5					0.1oP
2.10		Impact of increasing the beam side in the central area - OSD with interacti		3 months	01/09/2019					0.4oP
2.11		Conclusion and final discussion		1 month	2.6,2.7,2.8,2.9,2.10					0.4op
3		Derive the optimal arm finesse, recycling gains for a given input power		5 months	2.11					
3.1		Finesse and GWINC simulations		2 months	2.11					0.8op
3.2		Review of the results and compatibility with other SS - tuning of the result		3 months	3.1					1op
4		Geometry of the arm cavities and surface specifications		5 months	3.2					
4.1		Arm mirrors radius of curvature		2 months	3.2					0.8op

- compilation of an exhaustive work breakdown structure
- International Review Committee beginning of July
- this summer: release money for phase I

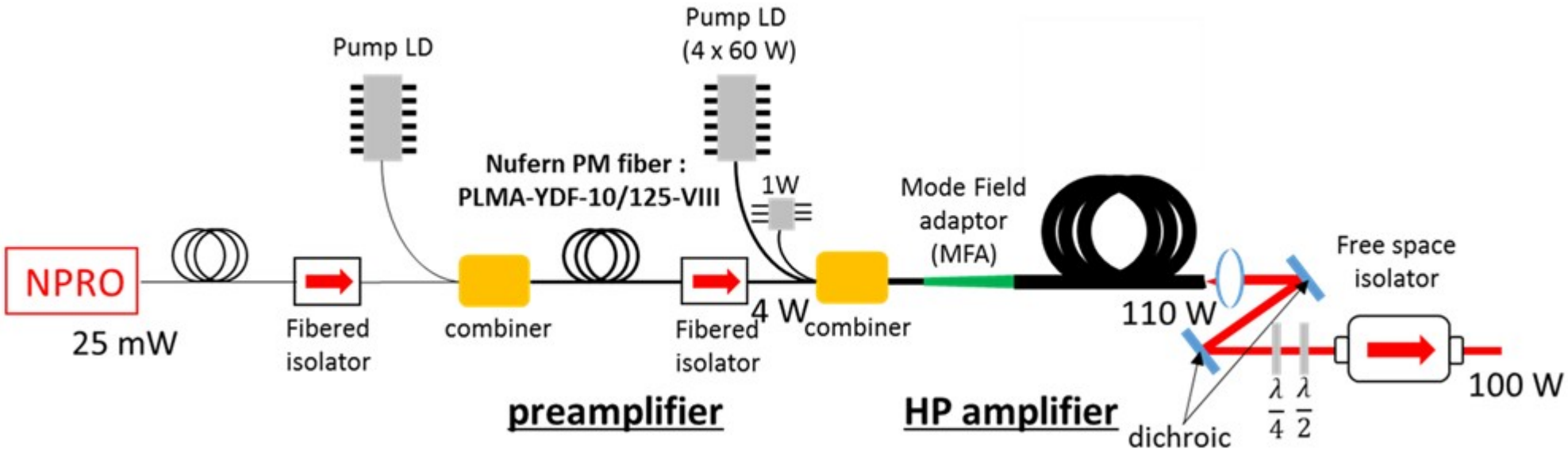
I

Work for Phase I

(ready for installation end of O3)

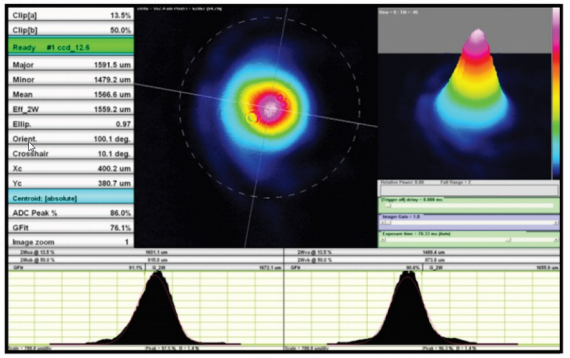
The input laser

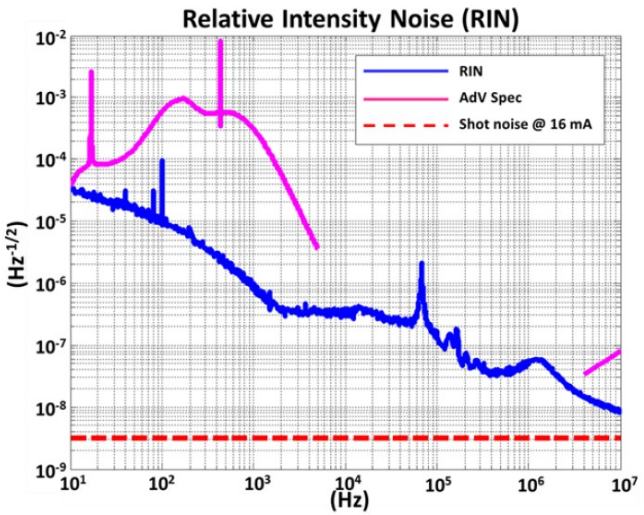
- ITF input laser goal: 40W-50W
  (2.5 times O3 power, lead to 200 kW in the arms)
- at the limit of the current laser, not compatible for Phase II
- installation of a 100W fiber laser, more reliable, more compact, upgradable to 200W

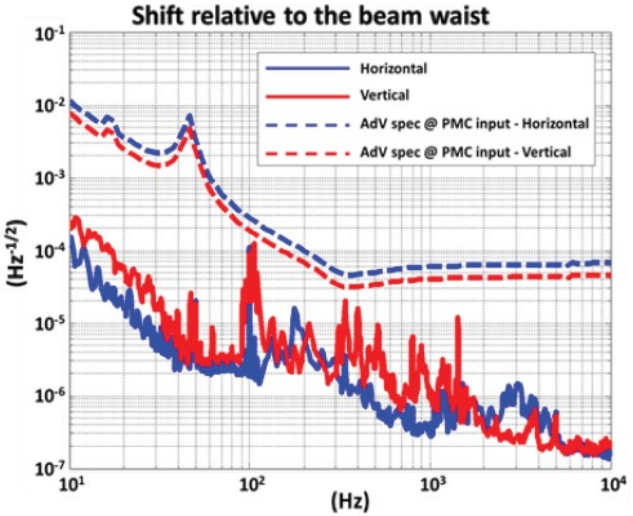


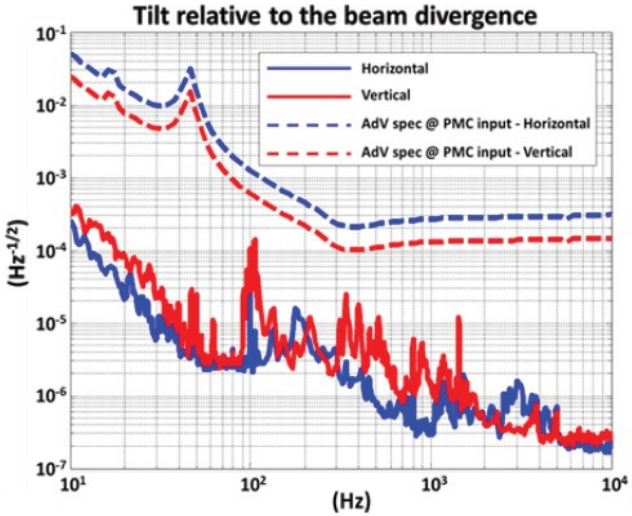
The input laser

- system already tested for 2500 hours
- compliant with AdV specifications





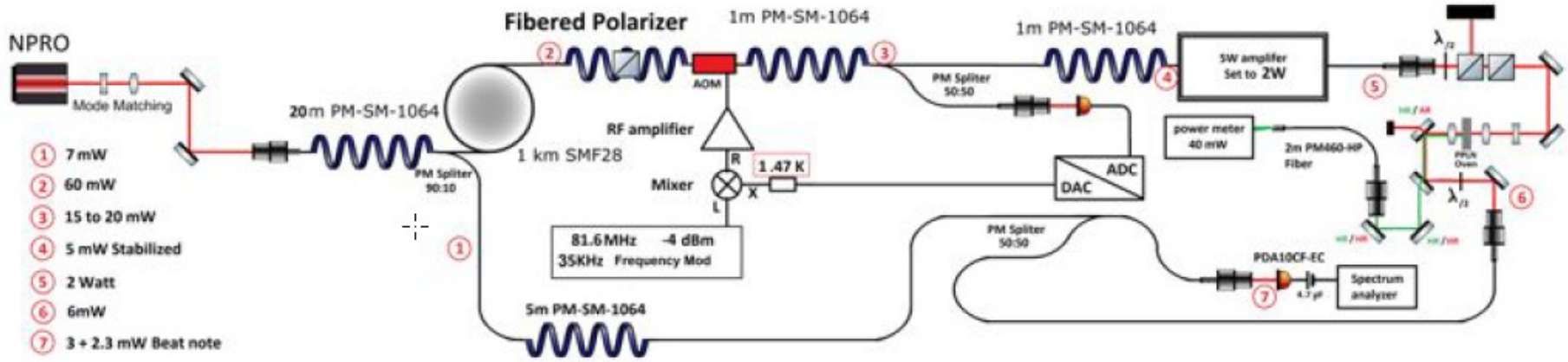




- installation planed right after O3
- implementation optimised to maximise beam availability

Signal recycling installation

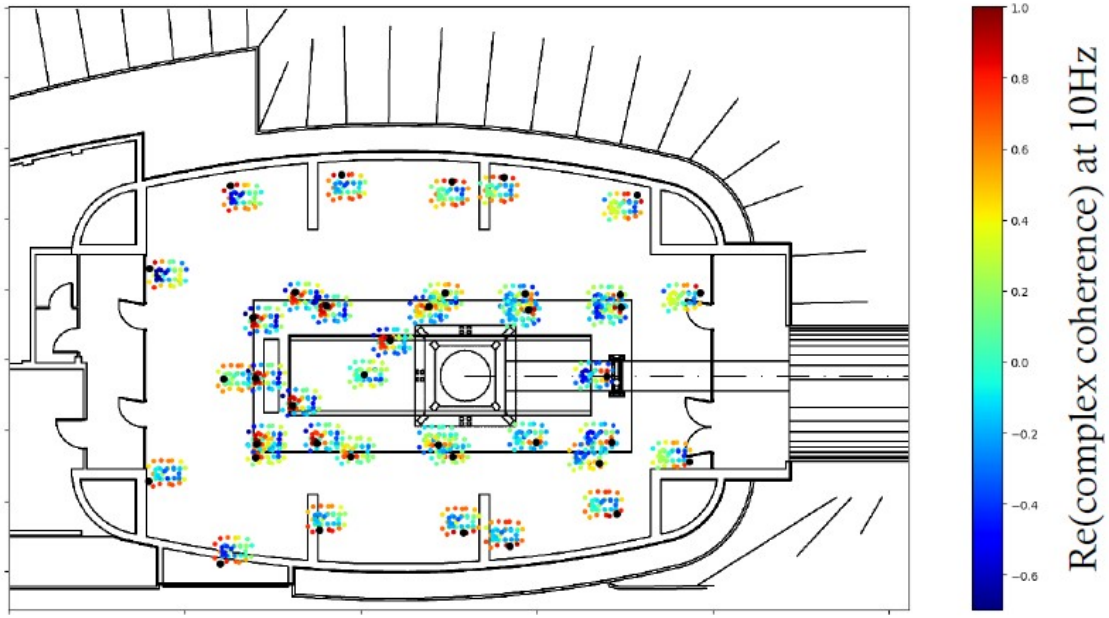
- currently only a lens used in transmission
- will coat a new SR substrate, T=40%
- locking strategy similar to the LIGO one
  - all optics already coated with the green control in mind
  - injection of green light by the end mirrors

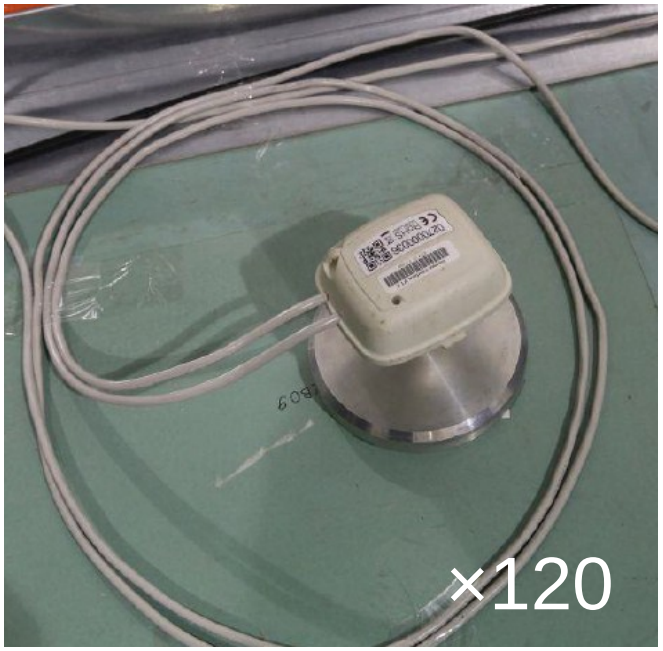


- Error signals derive from beat note in the central part

Newtonian noise cancellation

- Goal: reduce the Newtonian noise induced by the seismic field by a factor of 3 (10-20 Hz)
- indoor seismometers array around the test masses

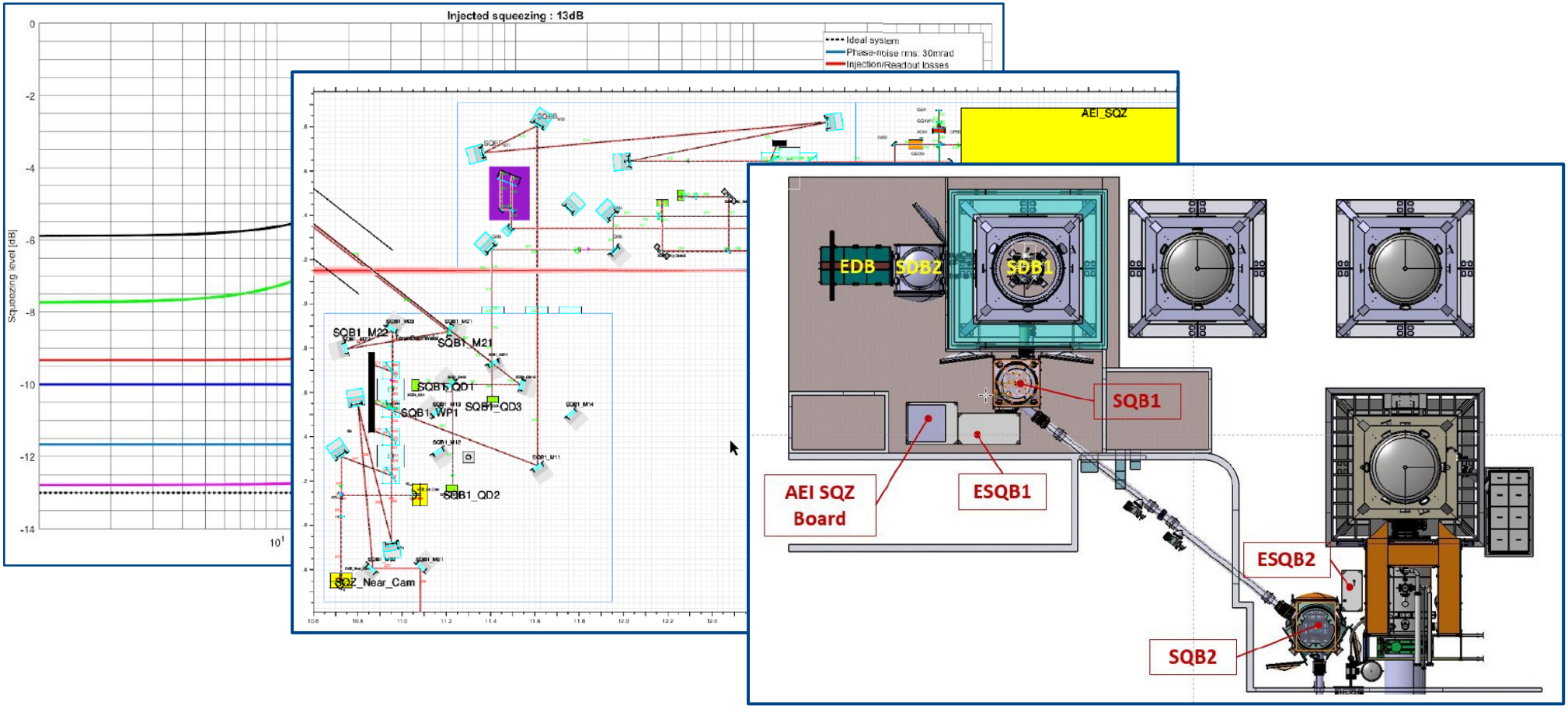




- Presence of tiltmeter under consideration to reduce the number of seismometers

Quantum noise reduction

- Goal 6 dB of squeezing at high frequency
- Addition of a 285m filtering cavity (F~ 10000, RTL~ 40 ppm)
- Reduction of optical losses on the squeezing path from 32% to 18%



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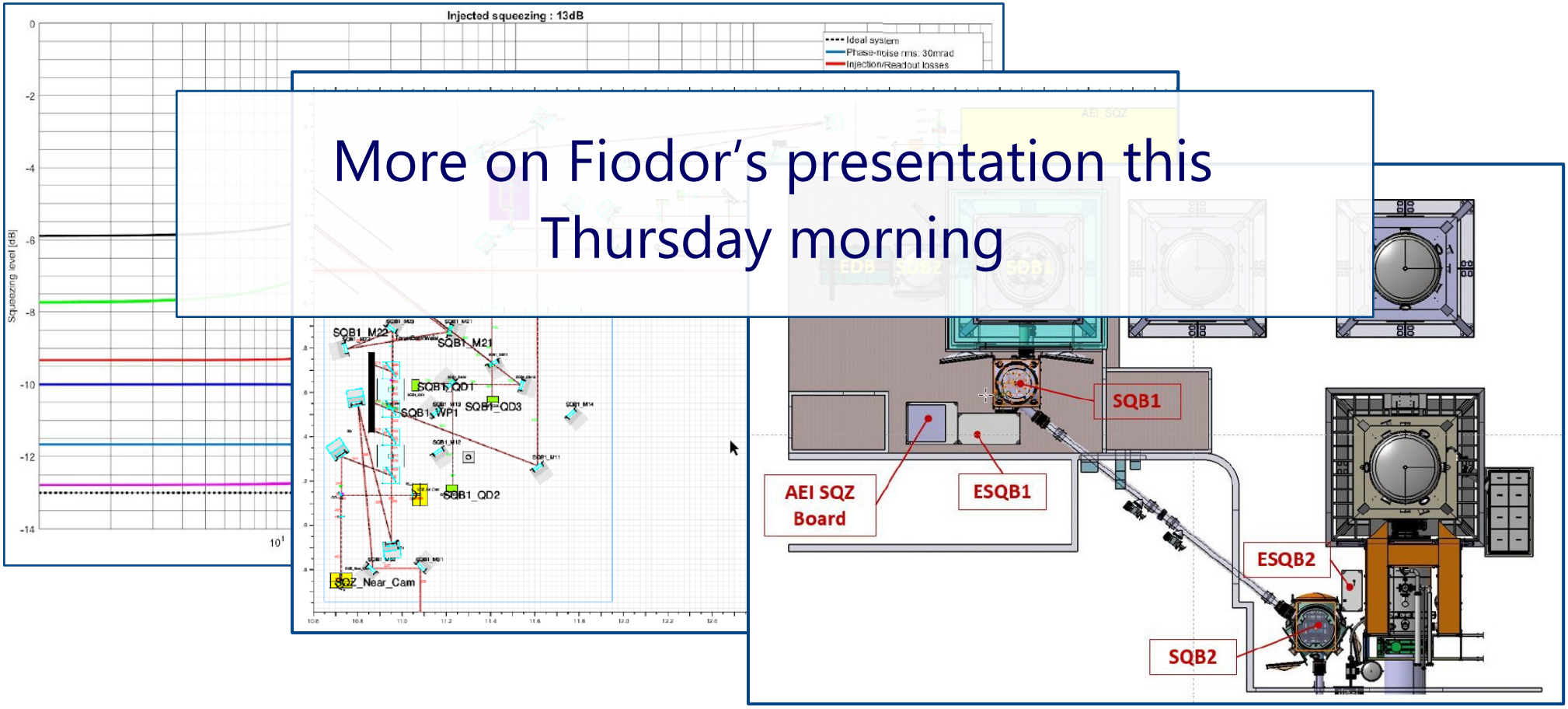


More on Fiodor's presentation this Thursday morning

II

Preparatory work for Phase II

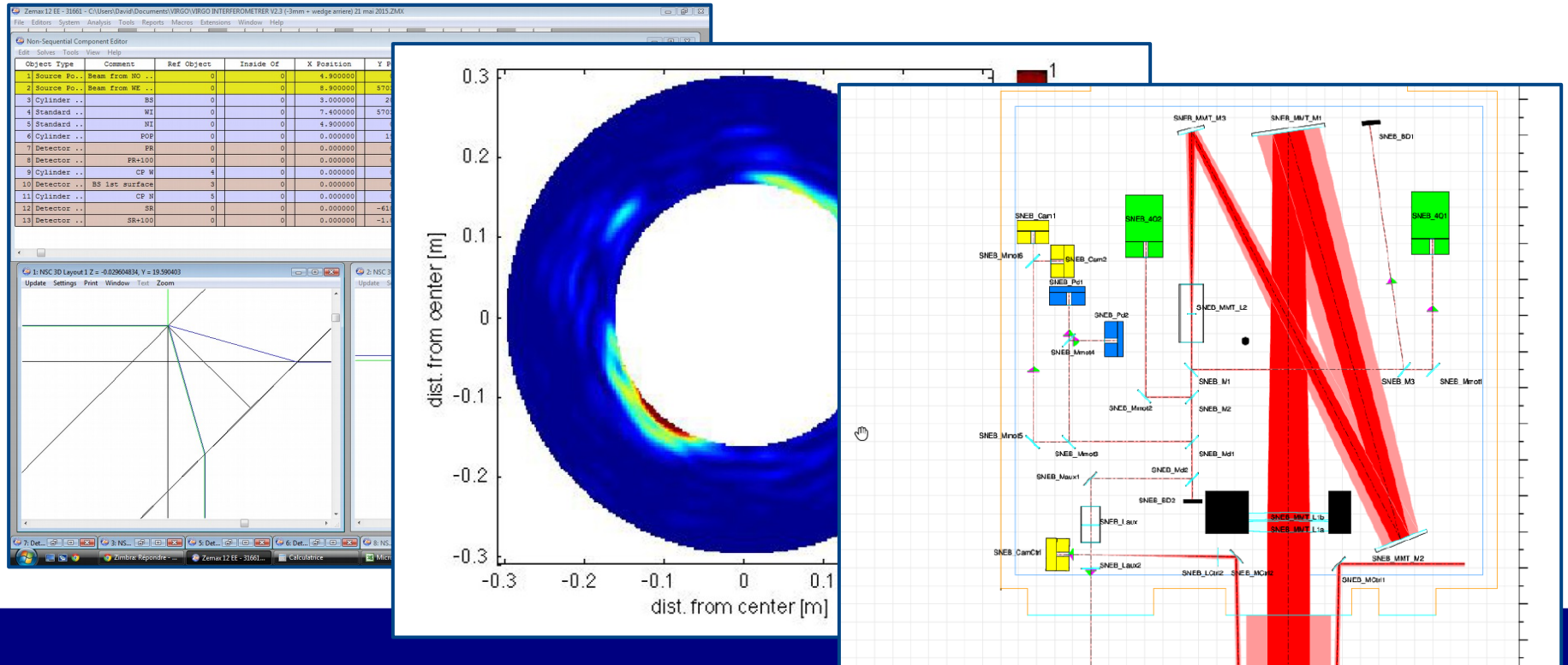
(ready for installation end of O4)

Reducing the coating thermal noise

- One possible knob to turn is to enlarge the laser beam size on the test masses
- Larger beams means larger mirrors (to have similar losses)
- geometry of the new end test mass:
  - Ø 550 mm diameter (same as current BS)
  - 200 mm thick (compatible with LMA cleaning machine)
  - 105 kg (2.5 times heavier)

New optical design

- Like to have only end large mirrors and same size input mirrors. So same size of the beam in the central part
- Still all the large curved optics will be upgraded
- Then simulations to optimal finesse/gain, position, radius of curvature, flatness,….



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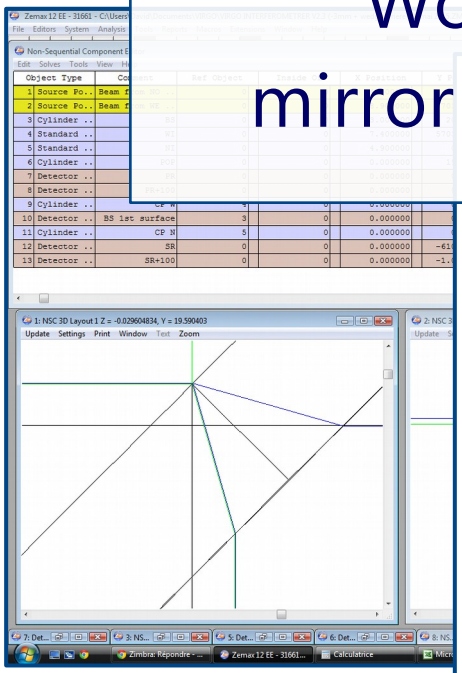
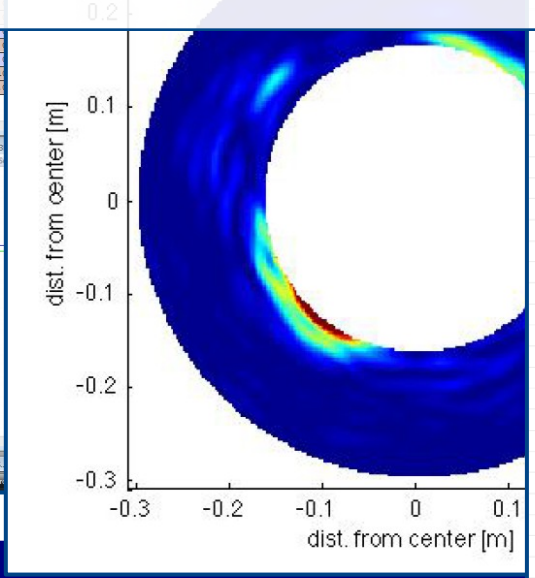
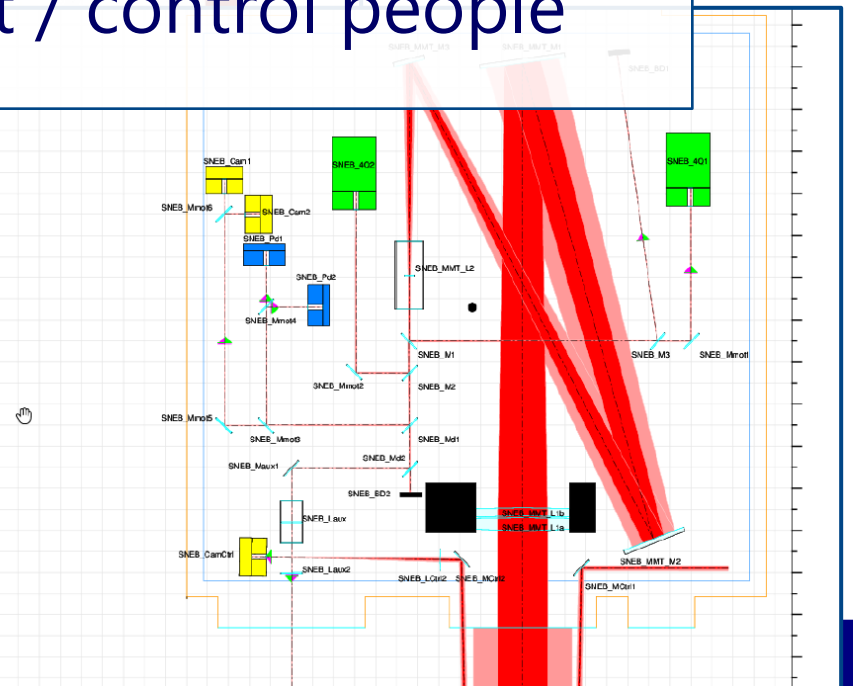
Work with injection / detection /
mirror / scattered light / control people

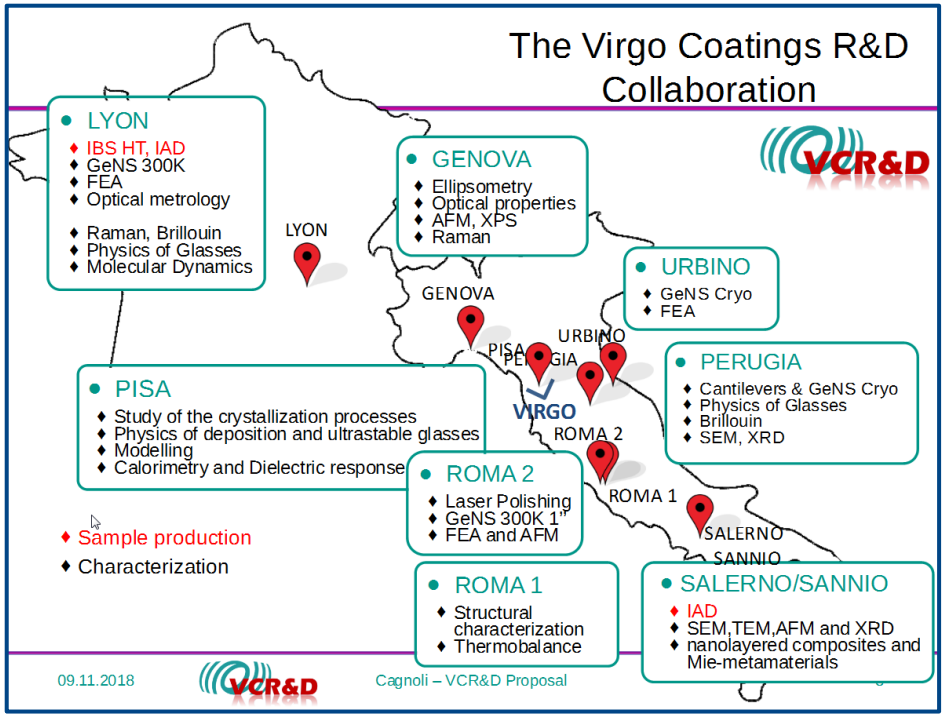


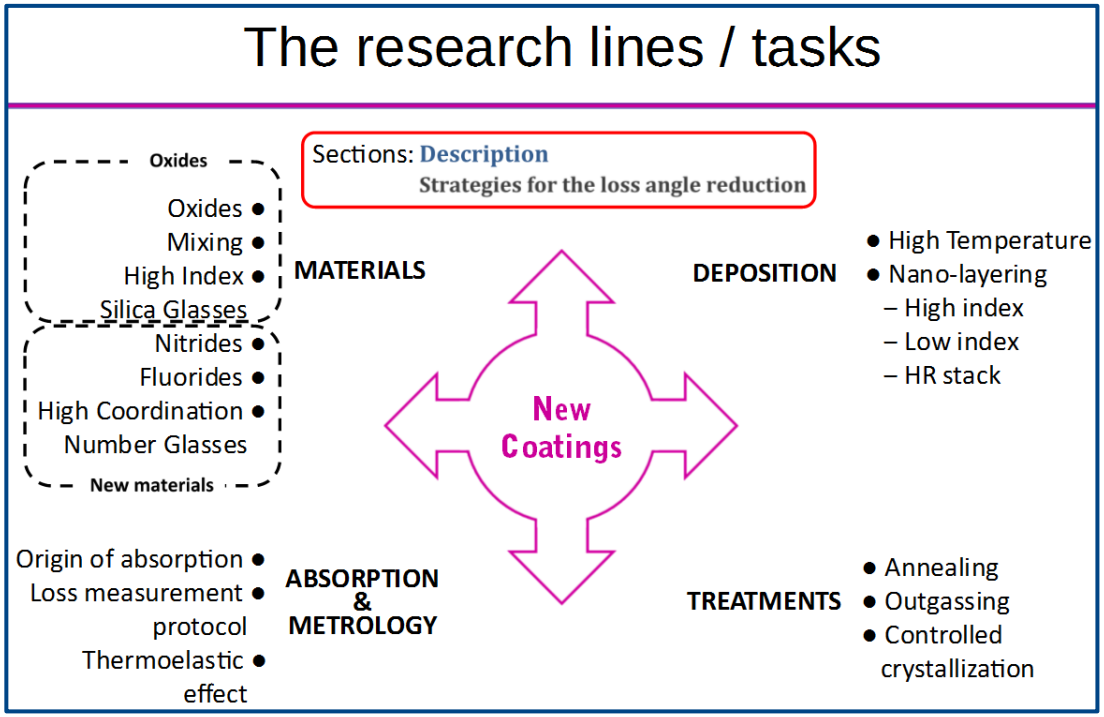




Which coating materials ?

- Extensive research effort on both sides of the Atlantic
- Could permit further sensitivity gain in the mid frequencies
- A collaboration wide effort





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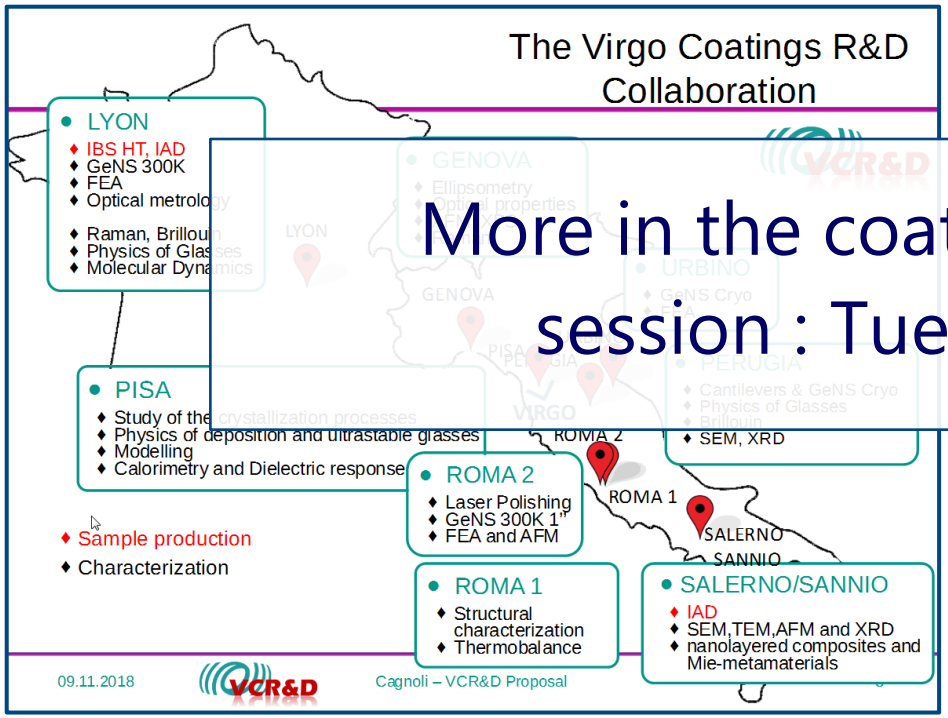
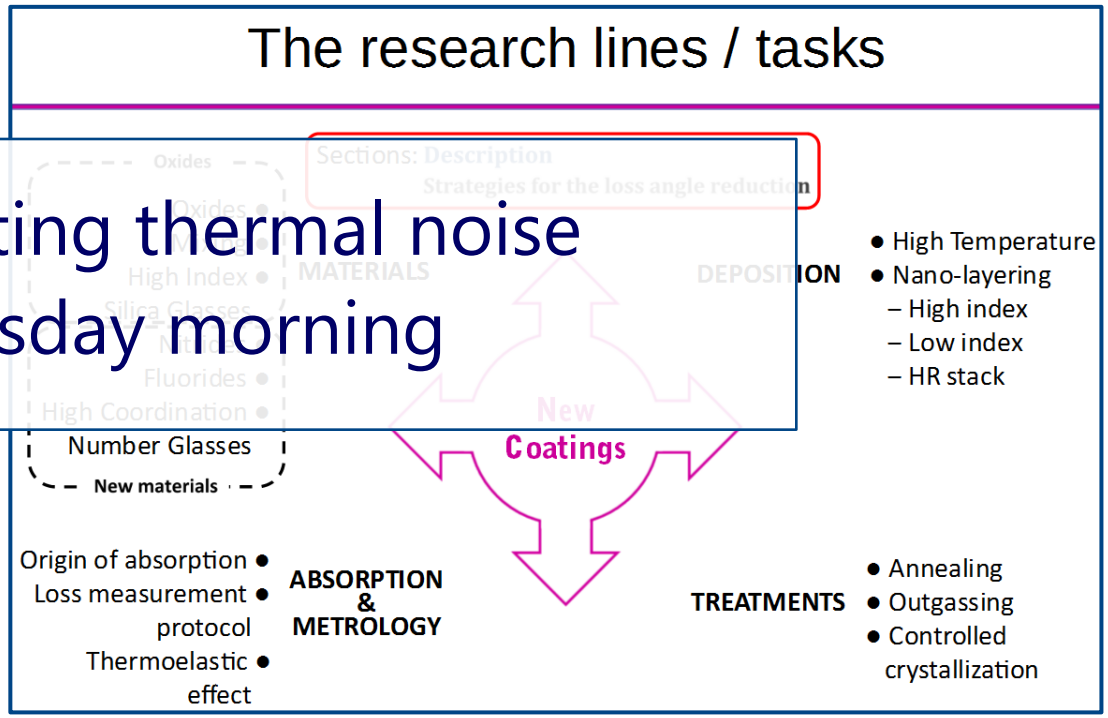
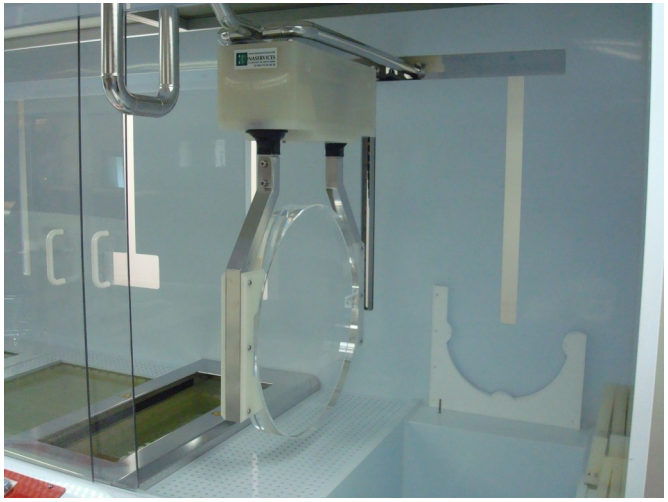




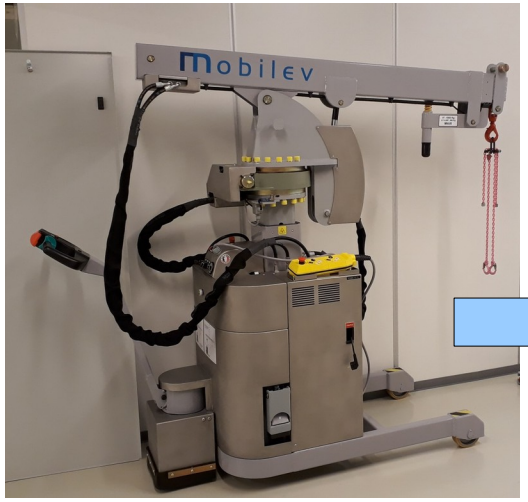
More in the coating thermal noise session : Tuesday morning

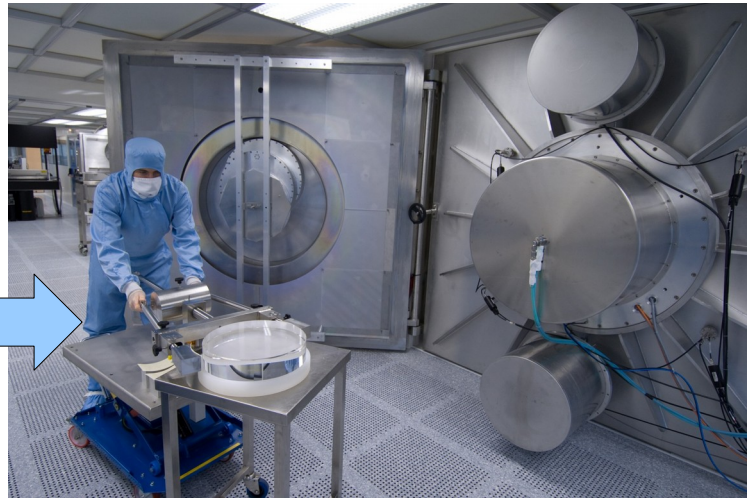
Anticipating large mirrors production

- new optical profilometer, study of point defects
- extension of the clean room
- development new tools for handling /cleaning
- practice with a 100 kg substrate



Cleaning machine upgrade

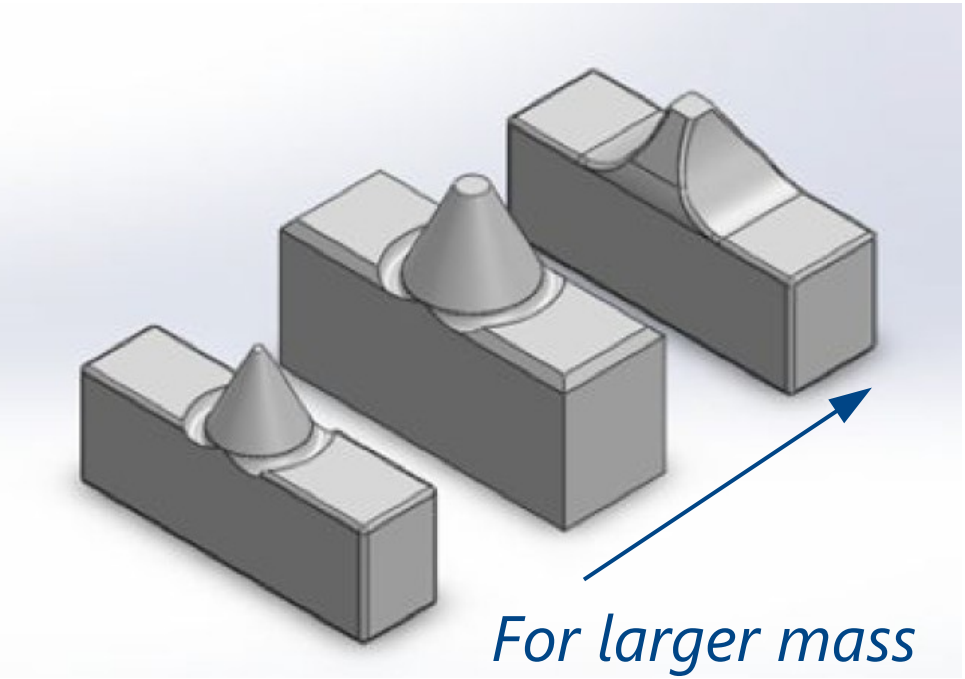




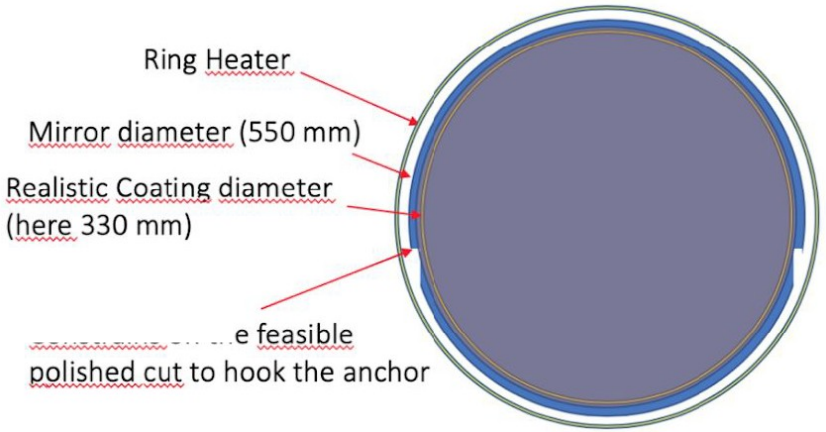
New crane for mirror handling

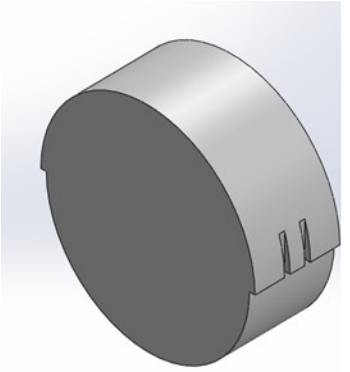
Upgrading the suspension

- upgrade of the superattenuator for 100 kg mirrors (new blades, wires, joints)
- new payload with improved design



For larger mass





Proposed mirror shape

Conclusion

- AdV+ project is now at full speed with a defined structure
- Ambitious program with more laser power, SR, NN cancellation, frequency dependent squeezing
- O3 time is critical to prepare the phase I and planning is essential because installation/commissioning time will be short
- at the same time, developing technologies for managing large mirrors