

Goals and roadmap for O5 upgrade

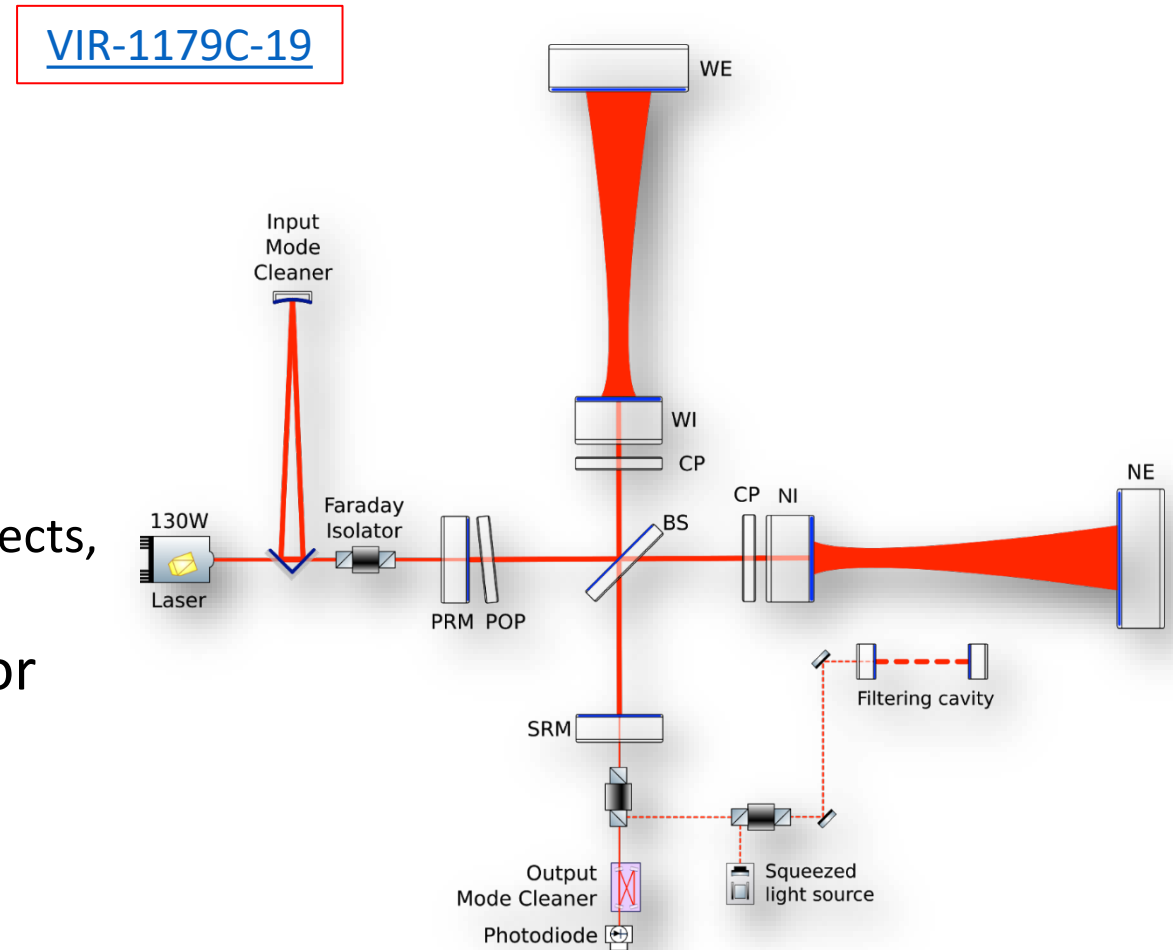
Alessio Rocchi

INFN Roma Tor Vergata

VIR-0336A-24

AdV+ Phase II – original plan (2019)

- Main changes
 - Larger beams on end test masses
 - 6 cm radius \Rightarrow 10 cm radius
 - Larger end mirrors
 - 35 cm diameter \Rightarrow 55 cm diameter
 - 40 kg \Rightarrow 100 kg
 - Better mirror coatings
 - Lower mechanical losses, less point defects, better uniformity
 - New suspensions/seismic isolators for large mirrors
 - Further increase of laser power
 - 40W \Rightarrow 60W \Rightarrow 80 W



Abandon Large ETMs

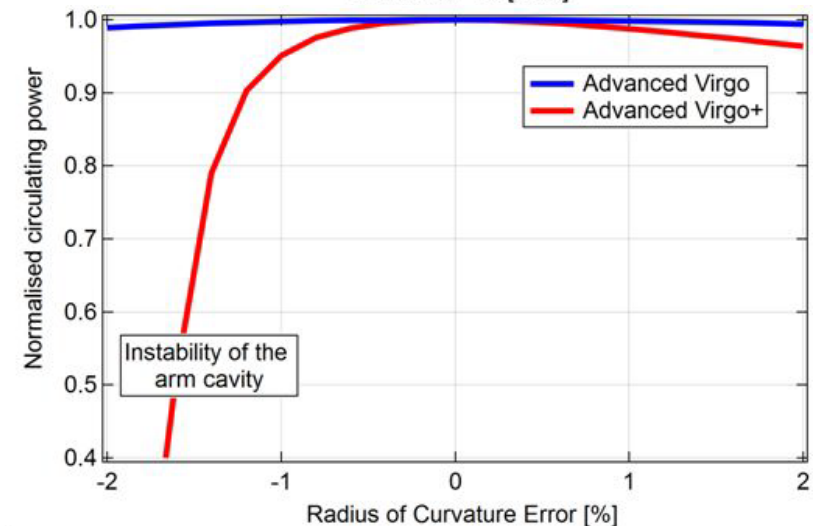
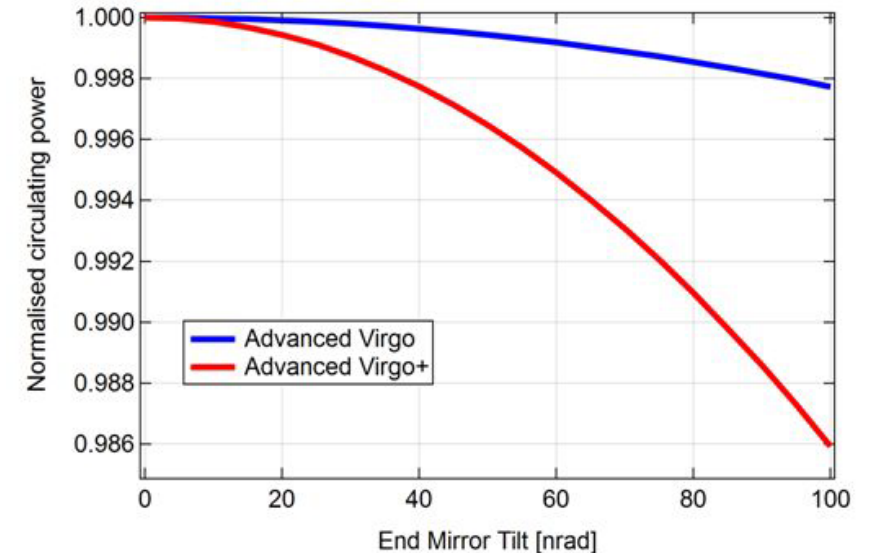
- New baseline: keep the current arm cavities geometry and defer installation of Large Masses to Virgo_nEXT

Parameter	AdV+ O4	AdV+ Phase II Design	AdV+ O5
RoC ITM [m]	1420	1067	1420
RoC ETM [m]	1683	1969	1683
ITM diameter [mm]	350	350	350
ETM diameter [mm]	350	550	350
g-factor	0.87	0.95	0.87
ITM beam size [mm]	49	49	49
ETM beam size [mm]	58	96	58

- Since this represents a major change with respect to the Project baseline configuration, in agreement with the UC mandate ([VIR-0926A-23](#)), a Project Change Request ([VIR-0294A-24](#)) was submitted to the JEVCo (that approved it)

Reasons behind the choice

1. Large ETMs and small ITMs may have an impact on the arms' controls ([VIR-0075A-24](#))
2. LMs + Stable Cavities → change in the optical configuration of the arms and recycling cavities at the same time
 - With LMs, arms closer to instability (g factor from 0.89 to 0.95) and more stringent requirements on AA system and RoC tuning ([VIR-1179C-19](#))
3. Better mirror coatings are not yet available ([VIR-1002A-23](#))
 - Recent update on TiGeO2 ([VIR-0140A-24](#)): promising results with modified deposition parameters (-25% argon in the chamber)



Project cost modification

- Deliverables affected by the CR

Deliverable	Cost change (with tax)	Description
ALS.01	16	ALS - Upgraded SNEB/SWEB green telescopes
DET.03	217	DET - SNEB/SWEB telescopes
PAY.01	175	PAY - Large end payloads (residual not yet invested)
PAY.02	25	PAY - Large mirrors integration tools
SAT.01	336	SAT - End super-attenuators for large payloads (residual not yet invested)
TCS.01	58	TCS - Ring heaters for end mirrors
VAC.02	55	VAC - Modified End chambers (only task 2.4 - production of minilinks)
Total	882 k€	

- The savings will be re-invested either on Stable Cavities or on other upgrades connected to O4 commissioning experience

IRC report on stable cavities

- Report available on the TDS ([VIR-0325A-24](#)) since April 3rd
- Two main highlights

The internal review committee endorses the project management choice to favor the short cavity solution.

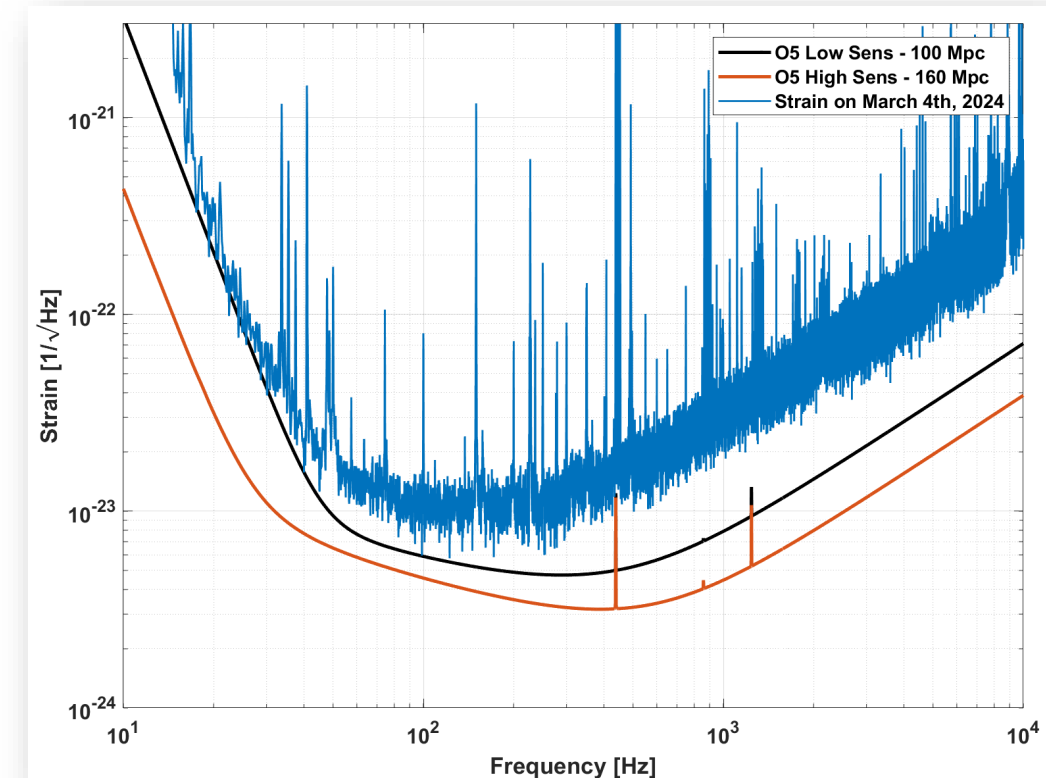
The realization of the stable cavities will require a strong commitment and focus by the Collaboration.

- Several other specific recommendations/suggestions, that we agree with
 - Some require ad hoc meetings and re-organization (OSD-ISC interface, Stray Light Control, Suspensions WG)
 - Some will fall into the SSs WBS

AdV+ in O5 – baseline (VIR-0217A-24)

1. Stable Recycling Cavities
2. NO Large ETMs
3. Other Phase II upgrades not connected to LMs
4. Other upgrades coming from commissioning experience ([VIR-0120A-24](#))

Parameter	O5 «Low sensitivity»	O5 «High sensitivity»
Recycling cavity	Stable	Stable
FP cavity power	190 kW	380 kW
SQZ measured	4.5 dB	6.0 dB
Coating thermal noise	1	0.7
Low Freq. Tech. noise	High	Low
BNS range	100 Mpc	160 Mpc
BBH range	1 Gpc	1.42 Gpc



PSDs on the TDS: [VIR-0218A-24](#)

Available to DA colleagues for simulations

Project tasks list

1. Final configuration for O5 defined
2. Choice of stable cavities configuration done
3. Production of the PBS (list of deliverables) for O5 ongoing (process expected to end within April 23rd)
4. Deliver (late due to lack of person-power in the PO) and implement a Requirements Management Plan
5. Implement the existing Risk Management Plan
6. Assemble the WBS and TDR for O5
7. Assemble global planning for installation and commissioning for O5 upgrades

Planned delivery date of TDR: October

Preliminary global planning

- High-level planning assembled to:
 - have more detailed overview of project development
 - have a rough estimate of the spending profile
- Based on Short Cavity planning presented last December (Vacuum recently updated)
- Final (and more consolidated) version available with TDR

	2024				2025				2026				2027				2028				2029				
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	
Plan A	Construction and civil works + vac installation								*	* end of vacuum system installation															
New TMs	** to be confirmed when installation and commissioning plans are available																								
«05»																	[Red bar]								
«04»	[Grey bar]																								

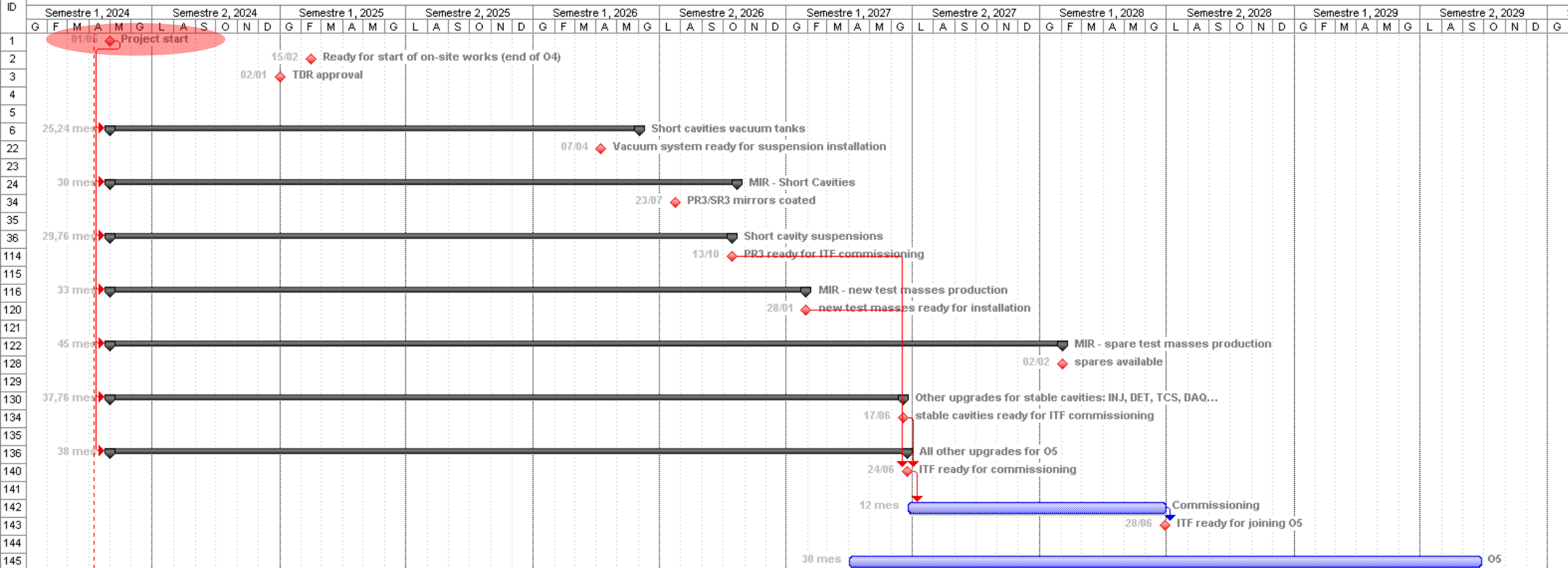
Not enough details

* end of vacuum system installation

EGC ** to be confirmed when installation and commissioning plans are available

Preliminary global planning

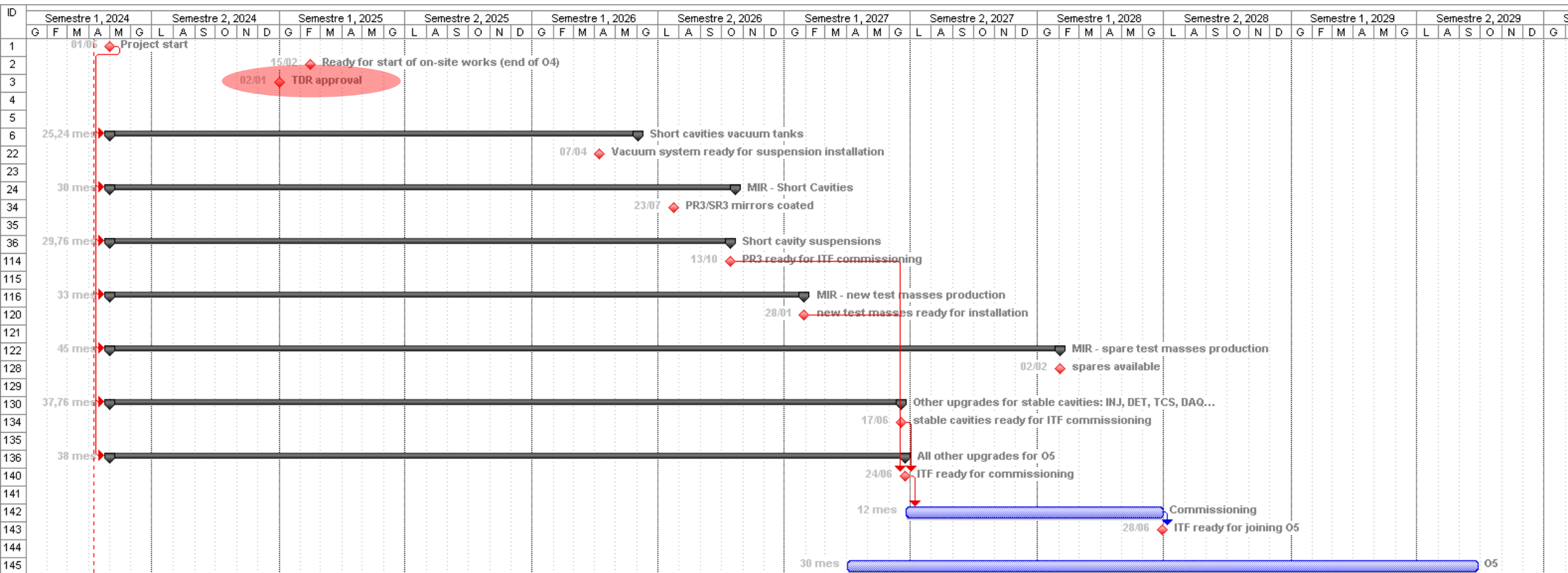
Project «Start» (May 1st)
defined as beginning of
design phase (for TDR)



Preliminary global planning



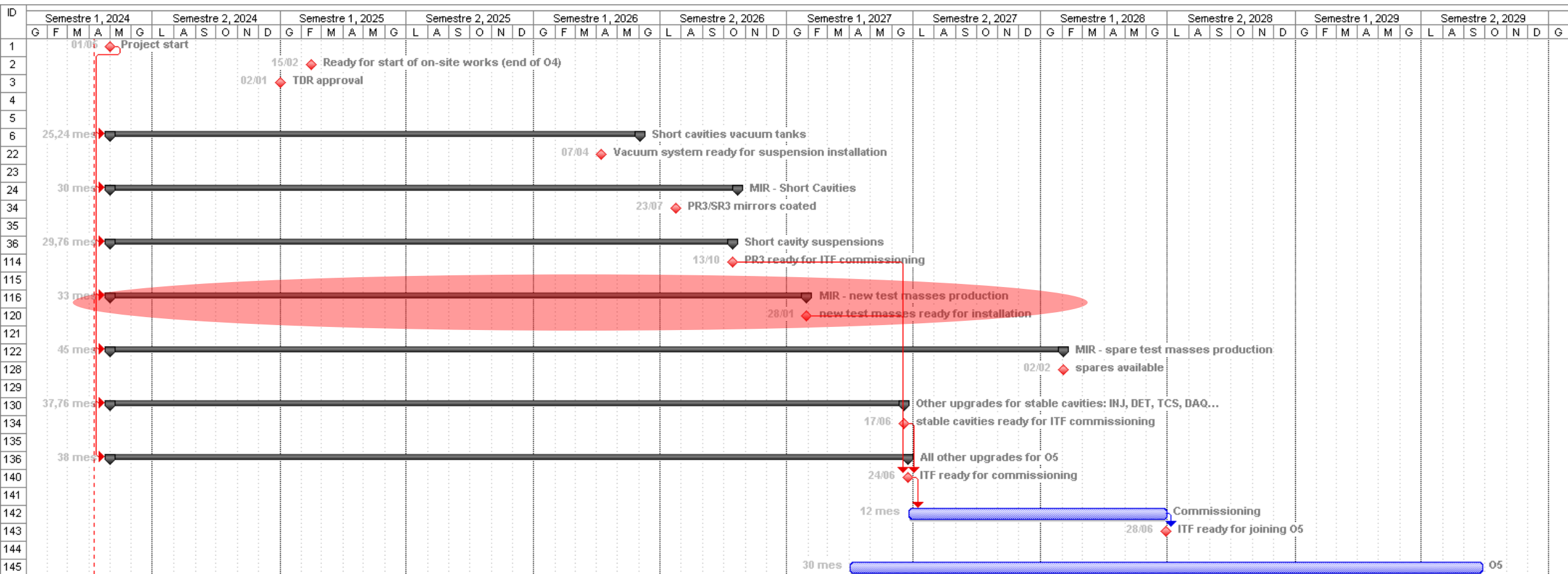
Jan 1st 2025 - TDR approval = green light for procurements



Preliminary global planning



Production of new TMs well within the planning

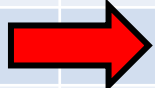


Preliminary spending profile

Without new TMs

	2024	2025	2026
Stable cavities	2 M€	7 M€	3 M€
Other upgrades		2.5 M€	2.5 M€
Total	2 M€	9.5 M€	5.5 M€

With new TMs

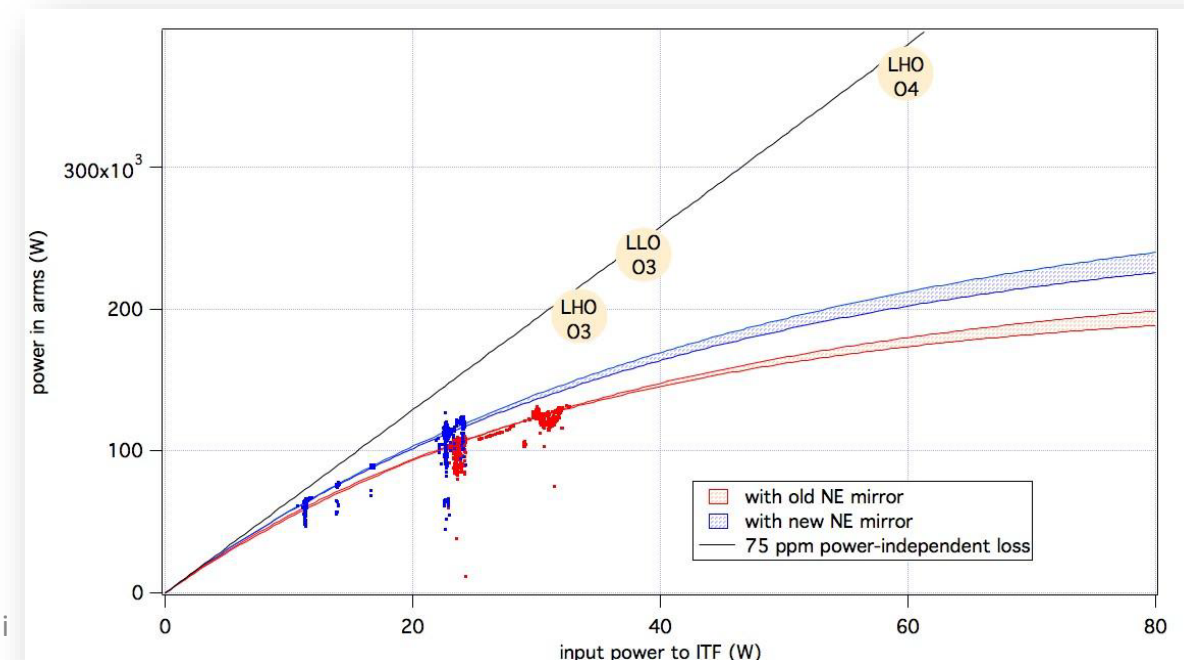
	2024	2025	2026
Stable cavities	2 M€	7 M€	3 M€
Other upgrades		2.5 M€	2.5 M€
New TMs	4 M€ 		
Total	6 M€	9.5 M€	5.5 M€

- Urgent expenses for 2024:
 - 1.5 M€ for recycling cavity mirrors
 - 0.4 M€ for suspensions prototyping
 - 0.1 M€ for SAT control electronics development (being internally reviewed)
 - **0.36 M€ for PR2/SR2 vacuum chambers (standard design)**

New mirrors

- Several good technical reasons to replace the test masses ([VIR-0330A-24](#) and [VIR-0332A-24](#))
 - Lower arm cavity losses allow for storing more power (shot noise reduction)
 - Less point absorbers
 - Less HOMs in the recycling cavities → lower coupling of control noises (low frequency sensitivity)
 - Lower coupling of noise sources
 - Lower coating mechanical losses → lower thermal noise (sensitivity in the bucket)
- Open points:
 - Quality of WE current spare (coated in 2018), since 25% improvement achieved with NE replacement
 - Identification of most offending mirror(s)
 - Evidence that some point absorbers can be cleaned

• **Urgent: characterize the old NE mirror**



Conclusions

- Choice for stable cavities option → Done
- Definition of the overall detector configuration for O5 (besides stable cavities) → Done
- Preliminary global plan for “Plan A” → Done
- Initial steps for TDR production started
- Urgent expenses in 2024
 - Mirrors for recycling cavities
 - Suspensions prototypes
 - Suspension control electronic prototype
- Building plan for “Plan B” (no stable cavities)