Upgrade Coordinator Report

Alessio Rocchi

INFN Roma Tor Vergata

VIR-0468A-24

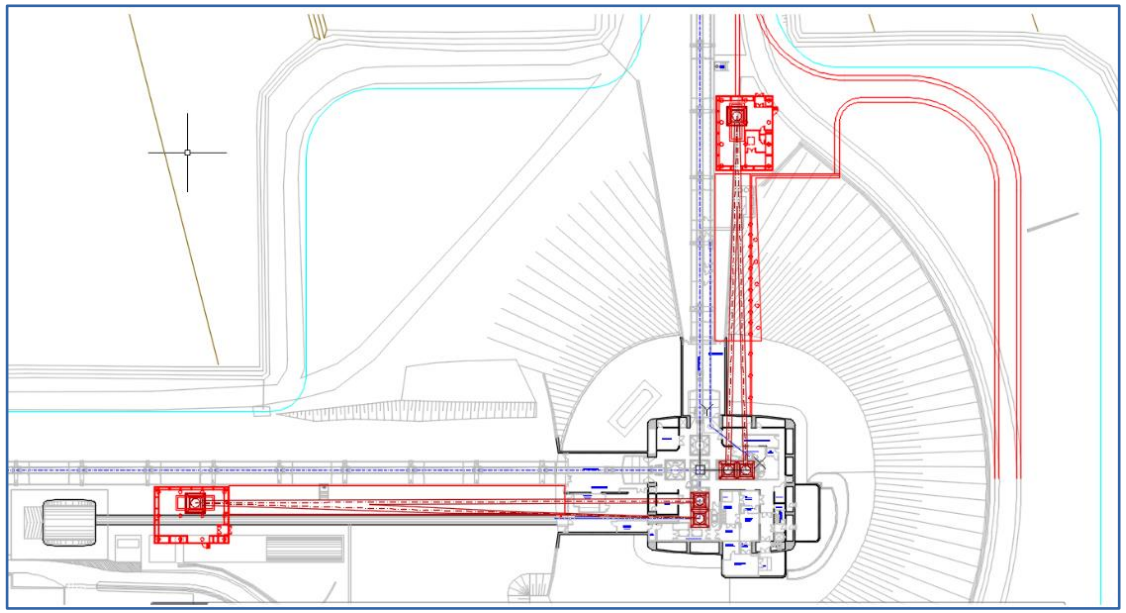
Outline

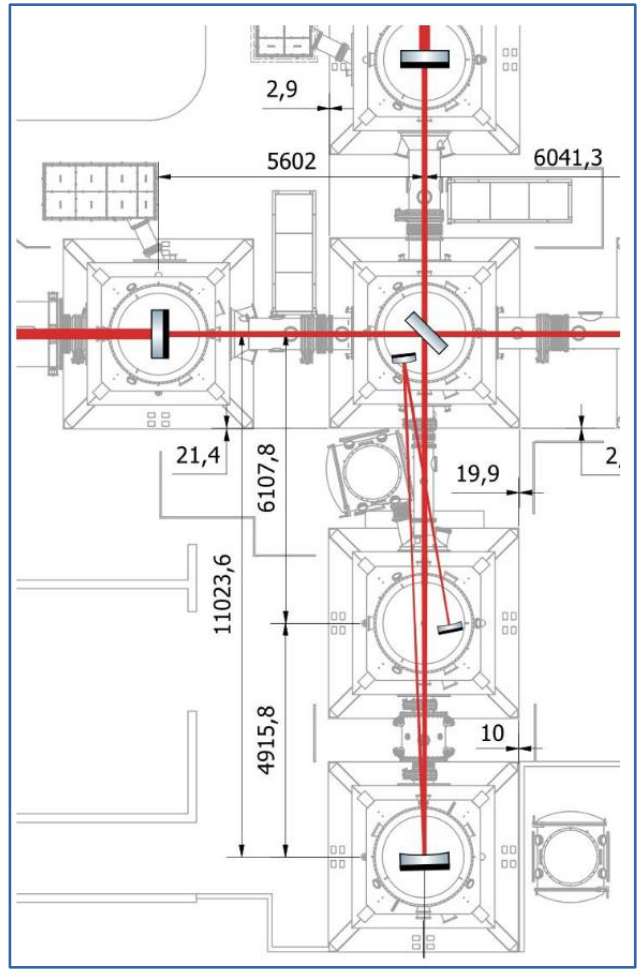
- Stable recycling cavities
  - Studied solutions
  - Internal review committee
  - Baseline solution
- Other upgrades for O5
  - Baseline configuration (Plan A)
  - Emergency plan (Plan B)
- Project Management Structure

Stable Recycling Cavities

The quest for stable cavities in Virgo

- A long story started at the time of the Advanced Virgo Project (2009)
- Long solution (~160 m)
  - Requires additional buildings and vacuum systems
- Short solution (~35 m)
  - Within the present infrastructure; requires modifications to the vacuum system
- LIGO cavities are about 57 m, KAGRA has 66 m
- Both solutions allow Gouy phases ~20 degrees
  - Similar to LIGO/KAGRA; tunings are possible

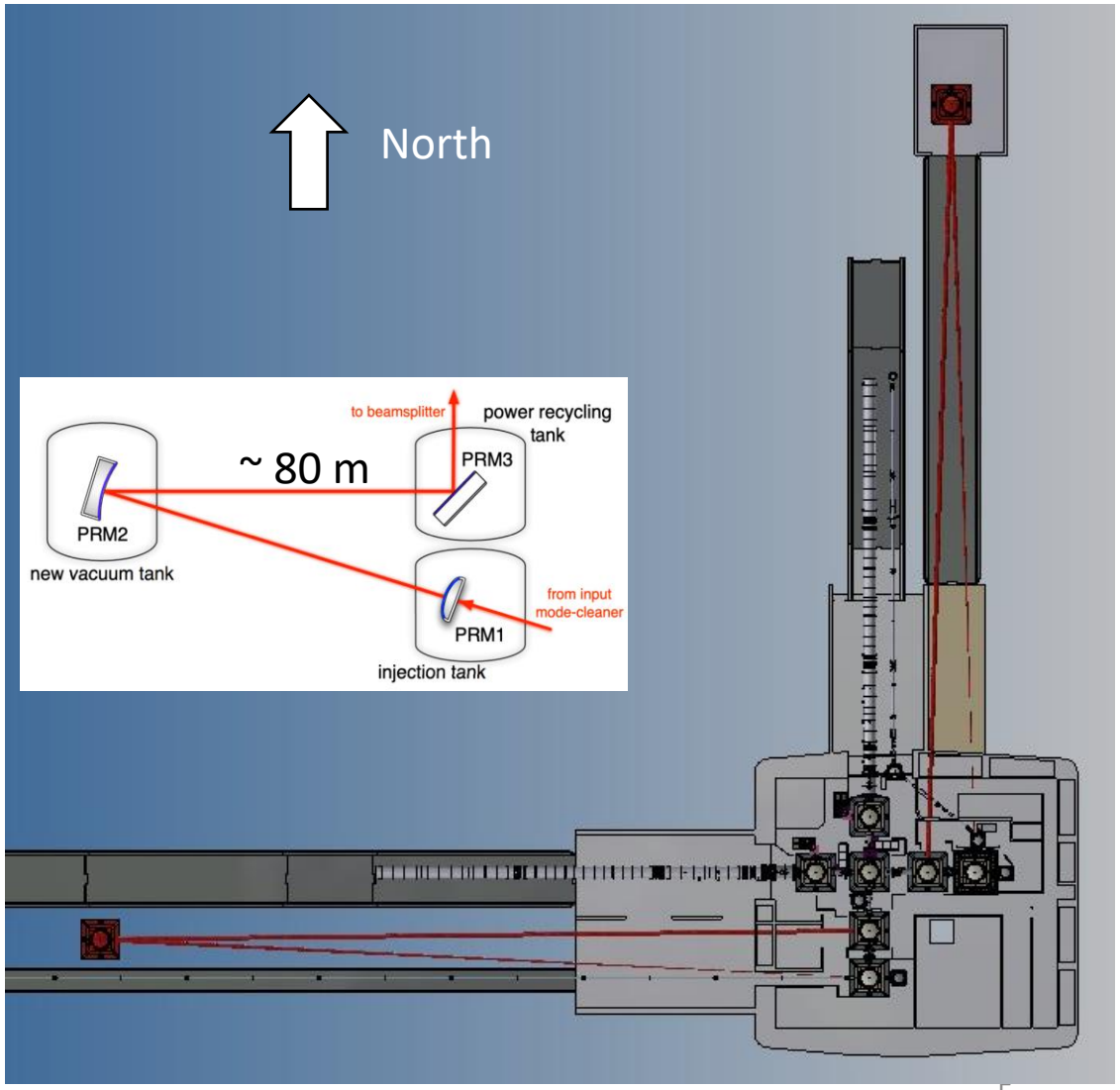




Layout: long option

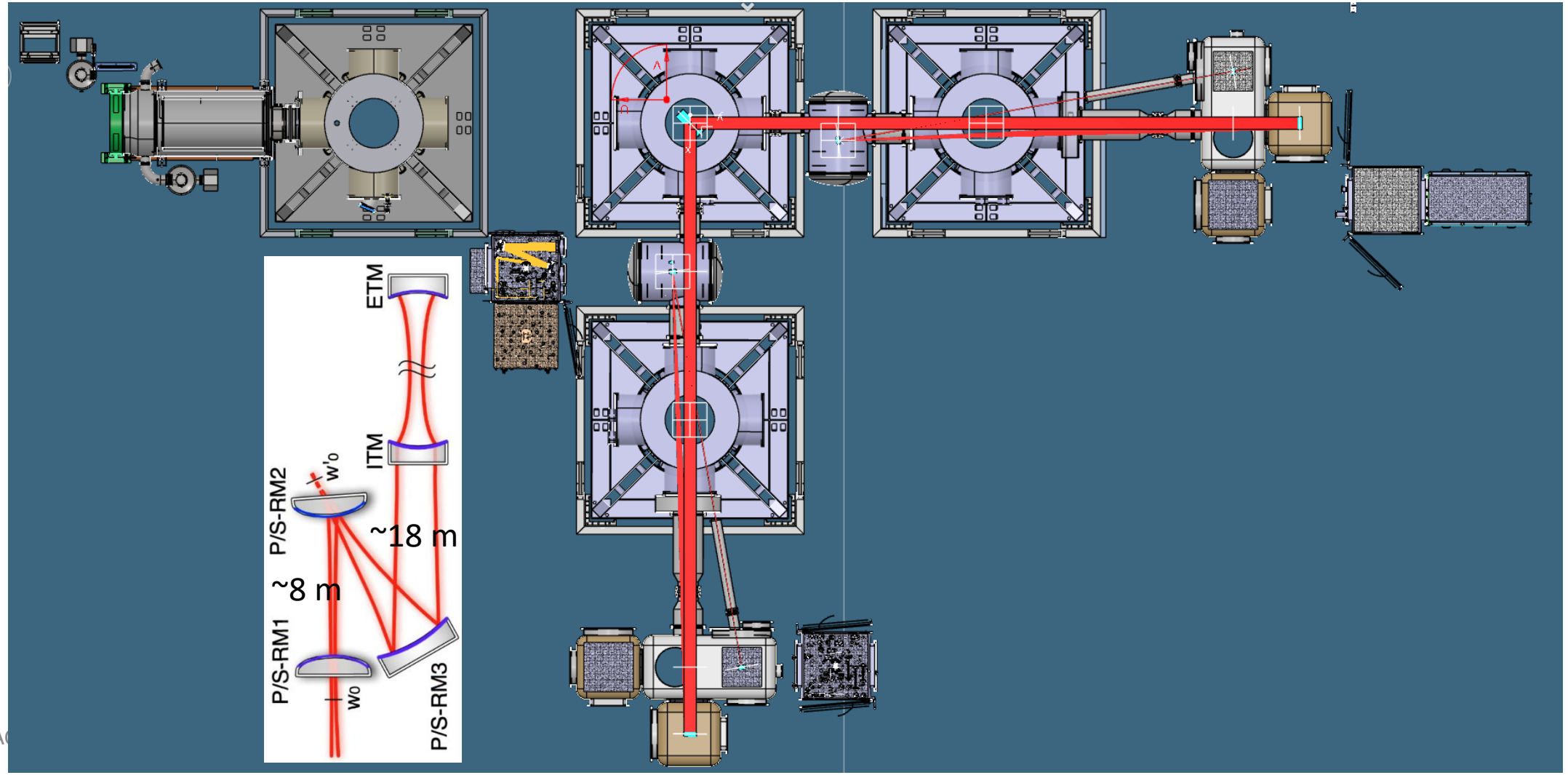
- A symmetrical layout is adopted for the signal recycling cavity

Additional buildings to host PR2/SR2
and tunnels with tubes to bring the light there



Layout: short option

- A symmetrical configuration is used on the detection side



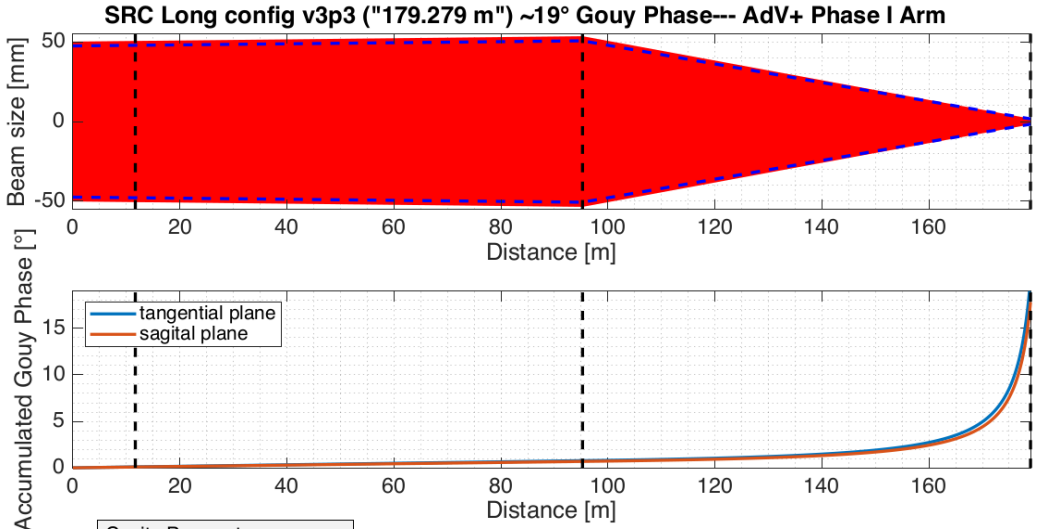
Interferometer studies

- Several preliminary investigations done
  - Required seismic attenuation
  - Astigmatism
  - Beam intensity (Virgo_nEXT)
  - Radiation pressure on power recycling (Virgo_nEXT)
  - Auxiliary beams
  - Gouy phases and modulation frequencies
  - Longitudinal locking signals
  - Needed/available RoC accuracies
  - Needed/available RoC thermal control
  - Thermal effects
  - INJ/DET/QNR modifications studies
  - Suspensions conceptual design
  - Vacuum and Infrastructure modifications
  - Preliminary risk analysis

- See:
  - https://wiki.virgo-gw.eu/AdvancedVirgoPlus/StableRecyclingCavities
  - Conceptual Design document: VIR-0026A-24
  - Q&A Internal Review document: VIR-0082A-24
  - Note on thermal effects evaluation (40 and 80 W): VIR-0031A-24
  - Note on residual motion of the recycling cavity mirrors: VIR-0314A-24
  - Results of Risk Analysis: VIR-0063B-24
  - Internal Review Committee Report: VIR-0325A-24

Optical Design

- Long option
  - Total length 160 m
  - PRC Gouy Phase 25°, SRC 19°



Cavity Parameters:

- SRM3 Roc = 1e+199 m
- SRM2 RoC = 163.6 m
- SRM1 RoC = -3.055 m

- d3 = 11.952 m
- d2 = 83.59 m
- d1 = 83.7374 m

Total Length = 179.279 m

- AOI on SRM3 = 45 °
- AOI on SRM2 = 1.7 °
- AOI on SRM1 = 0 °

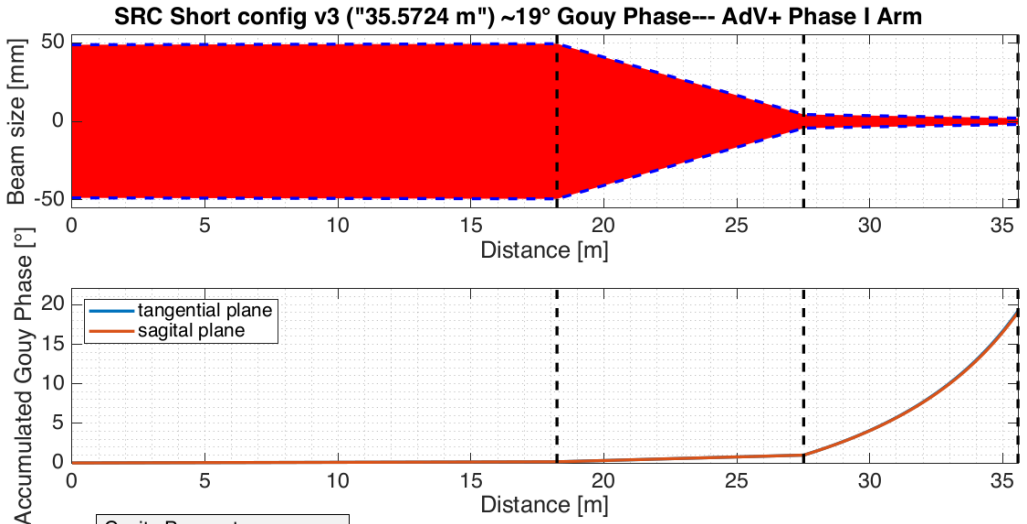
Beam Parameters:

- Size on SRM3 $w_{x/y}$ = 47.79 / 50.53 mm
- Size on SRM2 $w_{x/y}$ = 50.58 / 53.49 mm
- Size on SRM1 $w_{x/y}$ = 1.678 / 1.799 mm

- Beam waist $w0_{x/y}$ = 0.5787 / 0.5478 mm
  @ -2.692 / -2.772 m from SRM1 (outside cavity)

- Gouy Phase on SRM1 x/y = 20.289 / 17.8311 °
- Losses = 781.674 ppm

- Short option
  - Total length 35/38 m (PRC/SRC)
  - PRC Gouy Phase 25°, SRC 19°



Cavity Parameters:

- SRM3 Roc = 20.2 m
- SRM2 RoC = -1.906 m
- SRM1 RoC = -7.811 m

- d3 = 18.2352 m
- d2 = 9.2774 m
- d1 = 8.0598 m

Total Length = 35.5724 m

- AOI on SRM3 = 1.08 °
- AOI on SRM2 = 3.731 °
- AOI on SRM1 = 0 °

Beam Parameters:

- Size on SRM3 $w_{x/y}$ = 49.28 / 49.28 mm
- Size on SRM2 $w_{x/y}$ = 4.324 / 4.341 mm
- Size on SRM1 $w_{x/y}$ = 2.022 / 2.031 mm

- Beam waist $w0_{x/y}$ = 1.098 / 1.096 mm
  @ -5.506 / -5.535 m from SRM1 (outside cavity)

- Gouy Phase on SRM1 x/y = 19.1829 / 19.0245 °
- Losses = 3.66032e-05 ppm

Sensing and control

- Boundary conditions
  - SB1 and SB2 close to anti-resonance in the arm cavities and resonant in the power recycling cavity
  - SB1 low transmission to ASY and anti-resonant inside the SRC.
  - SB2 high transmission to ASY and resonant inside the SRC
  - Two configurations (SRC lengths) explored:
    - Virgo-like: all the odd multiples of SB1 above 45 MHz resonate inside the SRC
    - LIGO-like: SB2 is the only sideband resonant in SRC

	SB1 [MHz]	Offset [kHz]	Tasy	SB2 [MHz]	Offset [kHz]	Tasy	PRC [m]	SRC [m]
Virgo-like	6.320742	0.3	0.2	56.886678	2.7	0.98	35.5724	35.5724
LIGO-like	6.320742	0.3	0.2	56.886678	2.7	0.98	35.5724	38.2074

Decoupling angles of the normalized sensing matrix α and the normalized sensing matrix applying a hierarchical approach α_{hier} for different optical configurations.

	Short Virgo-like	Short LIGO-like	Long Virgo-like	Long LIGO-like	AdV+
α [deg]	2.7	2.6	2.6	2.5	0.39
α_{hier} [deg]	35.8	32.7	35.5	31.8	21.3

Simulation of thermal effects

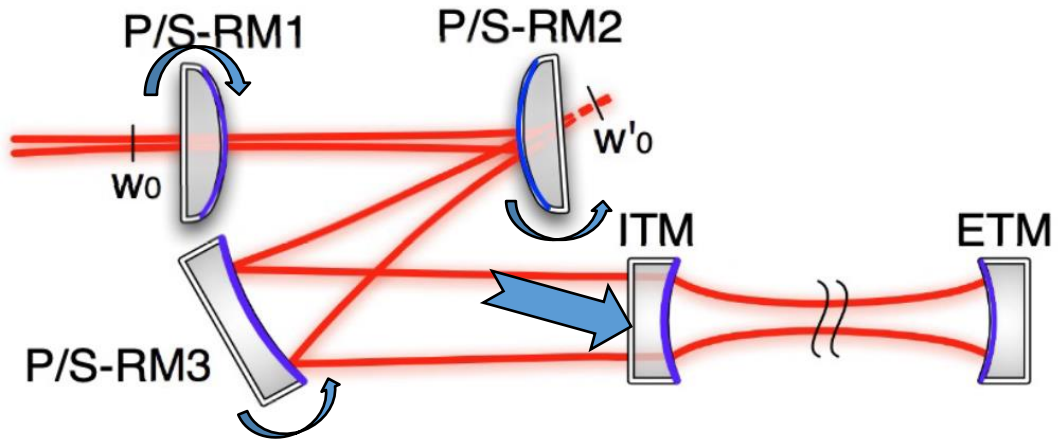
- OSCAR configuration files available for both Short and Long options
- Evaluated thermal lensing both for 40 W and 80 W of input power, with 0.5 ppm absorption

	LONG OPTION				SHORT OPTION			
PRC carrier gain	**All modes**		**TEM00**		**All modes**		**TEM00**	
Without thermal effects	41.7		99.9 %		41.8		99.9 %	
With thermal effects	41.7		99.6 %		41.8		99.8 %	
PRC 6 MHz gain	**All modes**		**TEM00**		**All modes**		**TEM00**	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Without thermal effects	71.5	71.5	99.9%	99.9%	71.9	71.9	99.9 %	99.9 %
With thermal effects	22.1	22.0	89.7%	89.7%	24.7	24.6	92.5 %	92.5 %
PRC 56 MHz gain	**All modes**		**TEM00**		**All modes**		**TEM00**	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
Without thermal effects	52.2	52.1	99.9%	99.9%	52.1	52.1	99.9 %	99.9 %
With thermal effects	22.1	21.2	89.3%	89.2%	21.3	19.9	93.3%	93.4 %

	MARGINALLY STABLE				STABLE			
PRC 6 MHz gain	**All modes**		**TEM00**		**All modes**		**TEM00**	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
With thermal effects	6.0	6.1	10 %	9 %	24.7	24.6	92.5 %	92.5 %
PRC 56 MHz gain	**All modes**		**TEM00**		**All modes**		**TEM00**	
	Upper	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**	**Upper**	**Lower**
With thermal effects	5.0	4.2	9 %	7 %	21.3	19.9	93.3%	93.4 %

Sensitivity to recycling mirrors motions

- Discussions about the effect of the recycling mirror motions on the beam spot motion
  - Summary document: VIR-0314A-24

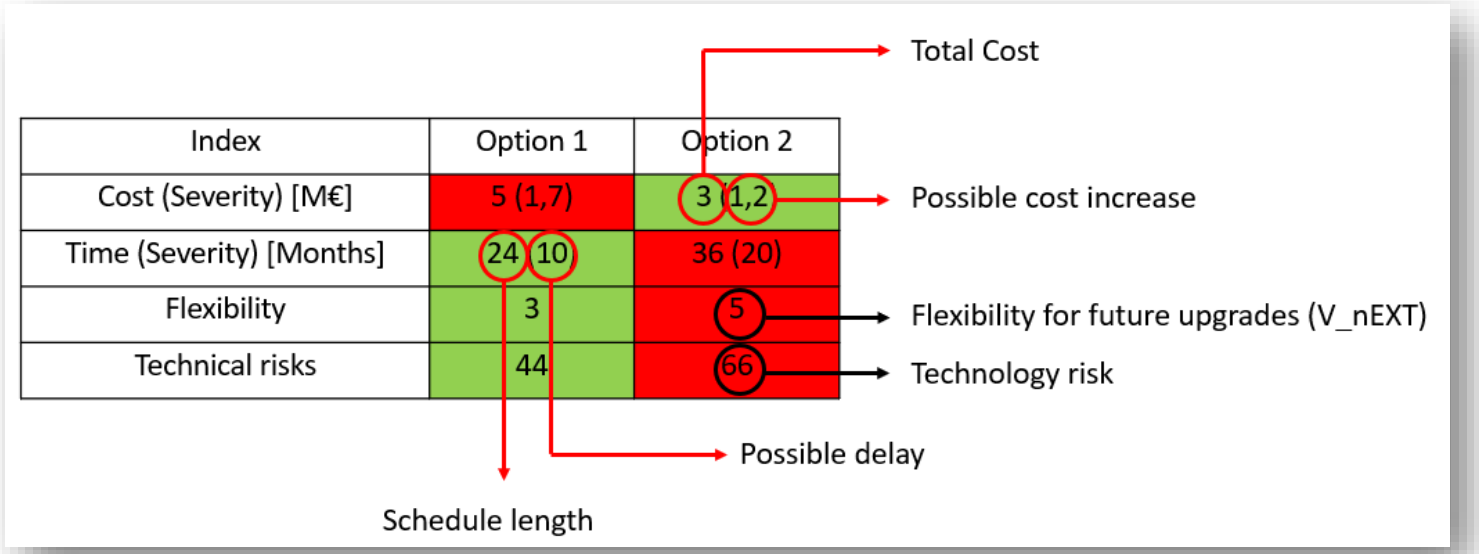


Short (35m)		RM1	RM2	RM3
Shift [nm]	Iterative Method	550	41.3	38.2
	4x4 ABCD	548	40	37
	2x2 ABCD	550	40	37
	Skew Beam Simulation	558	40.5	37.5
Tilt [nrad]	Iterative Method	110	21.4	1.9
	4x4 ABCD	105	21	1.83
	2x2 ABCD	106	20.7	1.83
	Skew Beam Simulation	106	21	1.85
Long (179m)		**RM1**	**RM2**	**RM3**
Shift [nm]	Iterative Method	4.85e+3	4.85e+3	6.41e+4
	4x4 ABCD	302	284	3.0e+5
	2x2 ABCD	324	305	4.32e+5
	Skew Beam Simulation	312	293	2.22e+5
Tilt [nrad]	Iterative Method	2.17e+3	29.9	31.9
	4x4 ABCD	125	1.75	1.87
	2x2 ABCD	126	1.76	1.88
	Skew Beam Simulation	129	1.81	1.93
LIGO PRC		**RM1**	**RM2**	**RM3**
Shift [nm]	Iterative Method	/	/	/
	4x4 ABCD	589	49	44
	2x2 ABCD	601	49.6	45.2
Tilt [nrad]	Iterative Method	/	/	/
	4x4 ABCD	54	10.7	1.23
	2x2 ABCD	54.6	10.9	1.25

- Bottom line
  - No large difference between Short and Long options
  - No large differences compared to the LIGO configuration
  - Results depend on Gouy phase, not on the optical design

Two options, one solution

- Two different viable configurations for stable recycling cavities have been studied.
- The set of criteria for comparing the two options and the metric to guide the selection have been defined (VIR-1088B-23 and VIR-1112A-23), based on risk analysis:
  - Technical risks
  - Limitations for Virgo_nEXT
  - Schedule
  - Costs
- Goal: produce a single comparison table for the two options



Not meant to be the implementation of the full risk management lifecycle (as foreseen in the current Risk Management Plan – VIR-1060A-23). This will be done during the production of the TDR.

Result of Risk Analysis

- Risk and Flexibility registers frozen on January 23rd (open since end of November 2023)
- Information available on January, Friday 25th, delivered to the Internal Review Committee (VIR-0063B-24)

Index	Long	Short
Cost (Severity) [M€]	20 (0.05)	10 (0)
Time (Severity) [Months]	42 (6)	30 (7)
Flexibility	-7	3
Technical risks	12	16

Based on the overall outcome of this risk analysis, the preferred solution is the Short option.

Internal Review Committee

- Committee appointed by the VSC in December 2023
- Mandate on the TDS (VIR-1162A-23)
- Two main highlights

Matteo Barsuglia[1], Livia Conti[2], Giovanni Losurdo[3], Christophe Michel[4], Lluïsa-Maria Mir[5], Fulvio Ricci[6], Bas Swinkels[7], Maria C. Tringali[8]

[1] APC, Paris, France
[2] INFN Sezione di Padova, Padova, Italy
[3] INFN Sezione di Pisa, Pisa, Italy
[4] IP2I-LMA, Lyon, France
[5] IFAE, Barcelona, Spain
[6] *Sapienza* University of Rome and INFN Rome, Italy
[7] NIKHEF, Amsterdam, The Netherlands
[8] EGO, Cascina, Italy

1. **Review the document** delivered by the project management **with the risk assessment** and **proposal of a baseline configuration for stable cavities**, the methods used, the results obtained, and the conclusions drawn. Highlight any gaps in the risk assessment or aspects that require further investigation and could lead to a different conclusion.

2. **Write a report** that summarizes the main points of the document, **highlights its strengths and weaknesses**, and **provides** constructive **criticism** and **recommendations**.

IRC report on stable cavities

- Report available on the TDS (VIR-0325A-24)

Main reasons to endorse (unanimously) the choice

From VIR-0342A-24

- the technical risks of the two options, identified up to now, are almost at same level and no show-stoppers have been found;
- the short cavity solution requires a considerably lower budget and one year less for the implementation;
- the LIGO successful experience is made with an optical configuration *similar* to the short cavity solution;

IRC report on stable cavities

- Report available on the TDS (VIR-0325A-24)
- A relevant highlight

> A person power plan is missing. We recommend to pursue the preparation of such plan along with the TDR for the construction of the short recycling cavity solution.

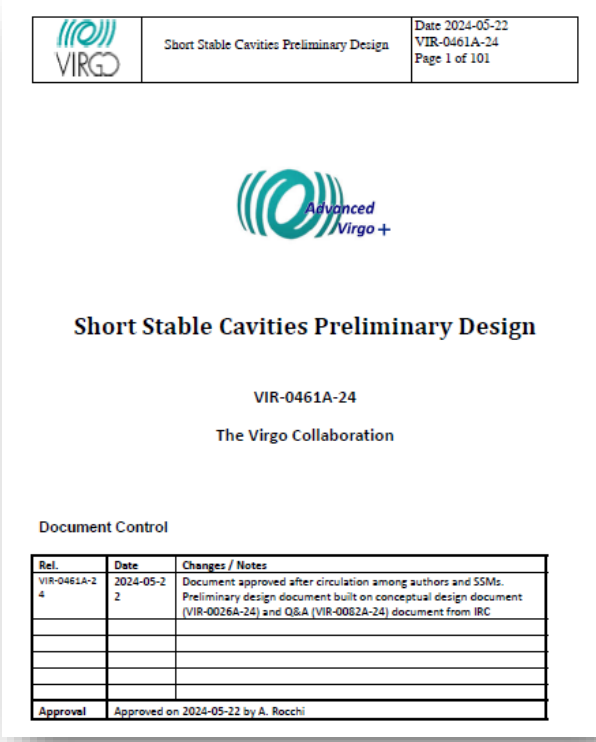
- Several other specific recommendations/suggestions, that we agree with
  - Some require ad hoc meetings and re-organization (OSD-ISC interface, Stray Light Control, Suspensions WG)
  - Some will fall into the SSs WBS

Preliminary Design Document

- Following a discussion with the Council on the possibility to start the activity of the External Review Committee before the delivery of the full TDR;

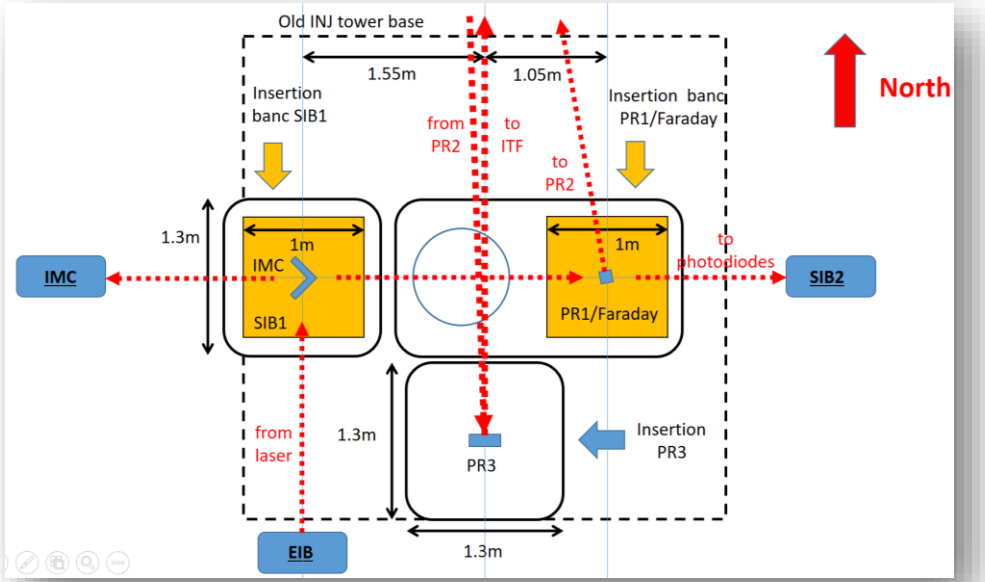
- The Conceptual Design Document (VIR-0026A-24), delivered for Internal Review Committee, has been updated with the answers provided in the “Q&A document” (VIR-0082A-24);

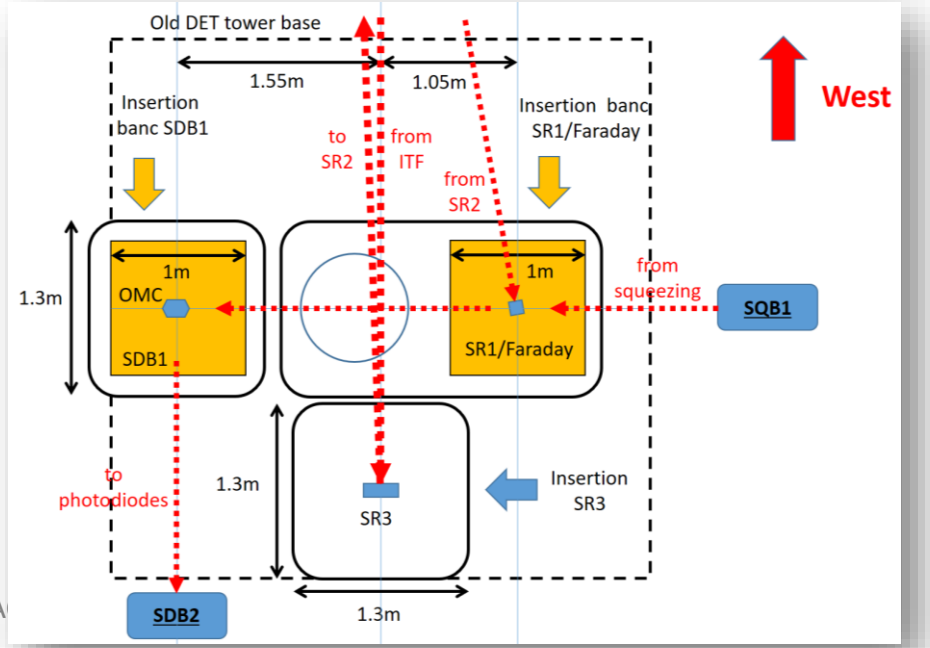
- We consider the recently released document (VIR-0461A-24) as a **Preliminary Design Document** for the implementation of the Short Stable Recycling Cavities in view of O5



Injection/Detection modifications

- Requirement
  - Need to place PRM3, PRM1, Input Faraday and IMC dihedron in the Injection area
- Two benches instead of one
  - More space available
  - Compatible with IMC dihedron suspension, if needed



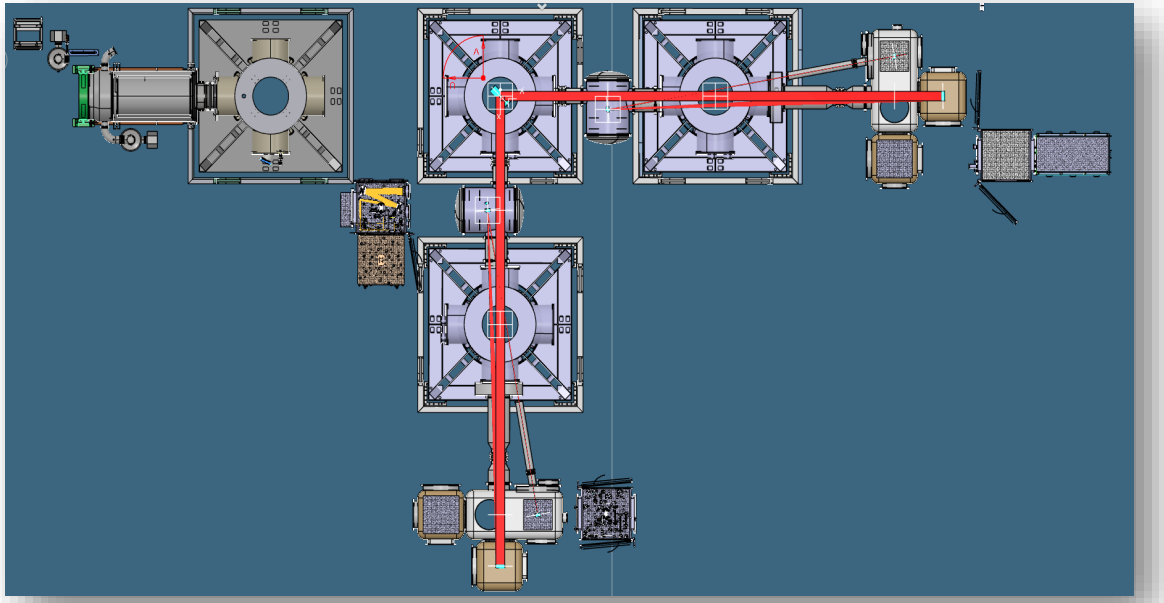


- Requirement
  - Need to place SRM3, SRM1, Output Faraday and Output mode-cleaner in the detection area
- Two benches instead of one
  - More space available
  - Already compatible with homodyne detector for Virgo_nEXT

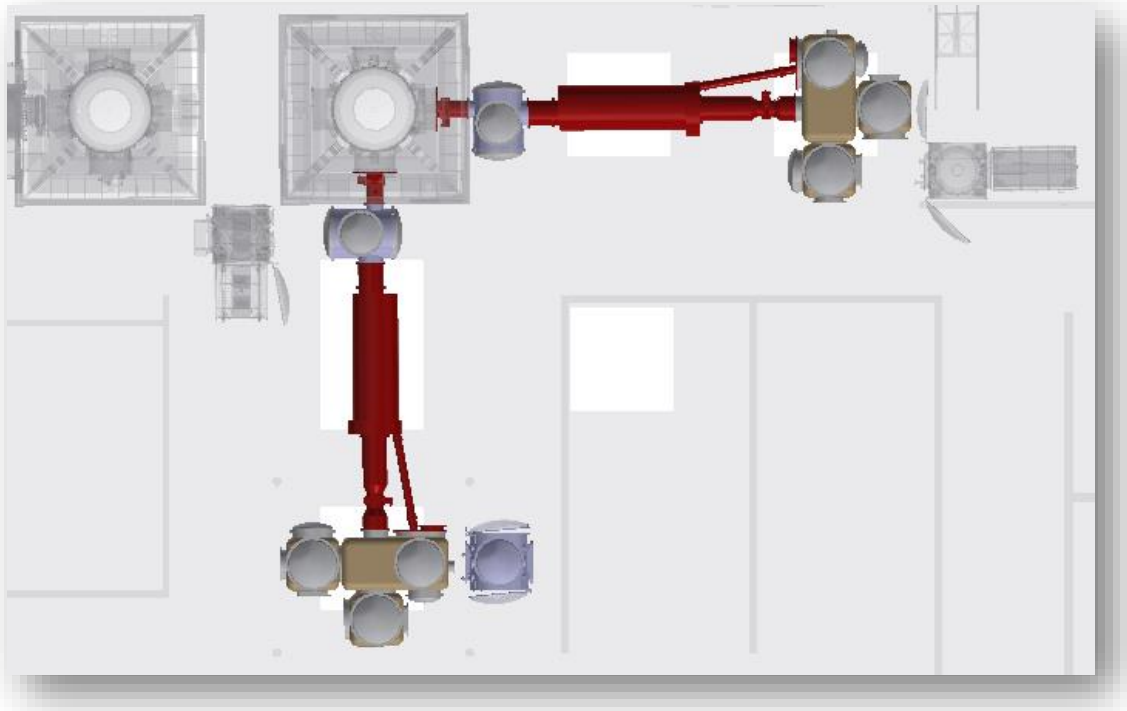
Seismic Isolation system

- Needed suspensions for the recycling cavities optics
  - PRM3/SRM3 (12 kg)
  - PRM2/SRM2 (3 kg)
  - PRM1/SRM1 (1.3 kg)
    - Mirror suspended on top of suspended bench
  - Two seismic isolators for the injection and detection benches
    - IMC flat mirrors
    - Output mode-cleaner
- To finalize the design of the suspensions, a working group has been formed, comprising members from: EGO, Nikhef, Perugia, Pisa and Sapienza
- Information available on dedicated Wiki page: https://wiki.virgo-gw.eu/AdvancedVirgoPlus/SuspensionsWG

Vacuum modifications



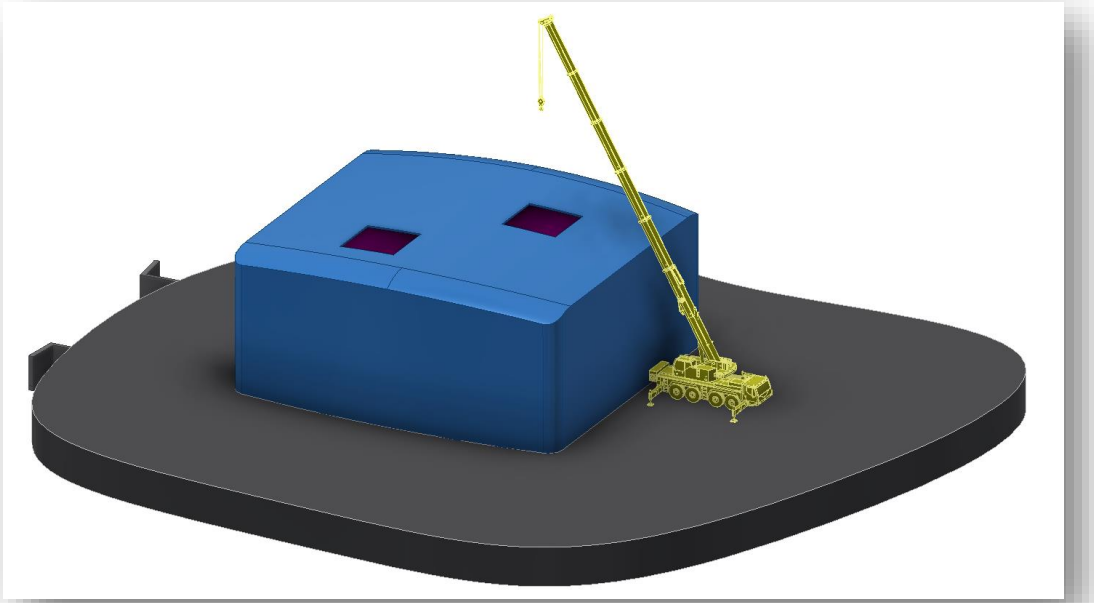
- Baseline configuration: DET and INJ towers only removed



- New configuration being considered: removal also of the PR and SR towers;
- Would free more space in the CEB;
- Would allow for larger clean areas around the new towers.

Vacuum modifications

- To remove the two (or four) tower bases, two solutions are under study:
  1. **Open the roof of the building** to remove the entire tower bases. In this case, removing the four towers **will be faster** than in the second solution. Possibly, this option could allow tanks of similar size and weight to be inserted in same way. The confirmation of this option **is pending from EGO INF Dept.** and could be the **baseline solution**;
  2. Enclose the towers in a structure to **cut with plasma** one tower base into 8 pieces (of masses less than 3 tons or 5 tons if the unit load of the trolleys is increased), then remove the structure and remove the pieces using the two trolleys of the main building crane. This solution preserves the integrity of the building, **but it is dirtier and requires more time to complete.**

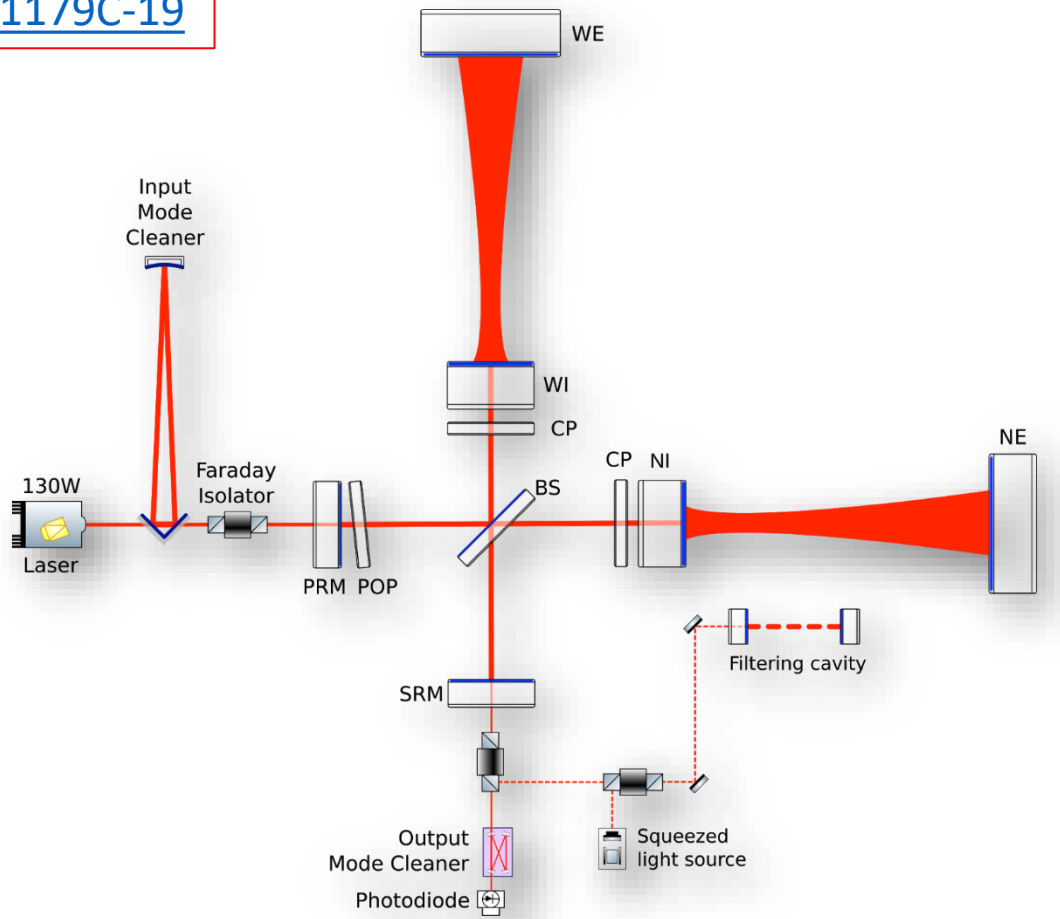


Other upgrades for O5

AdV+ Phase II – original plan (2019)

- Main changes
  - Larger beams on end test masses
    - 6 cm radius ⇒ 10 cm radius
  - Larger end mirrors
    - 35 cm diameter ⇒ 55 cm diameter
    - 40 kg ⇒ 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 ⇒ 60W ⇒ 80 W

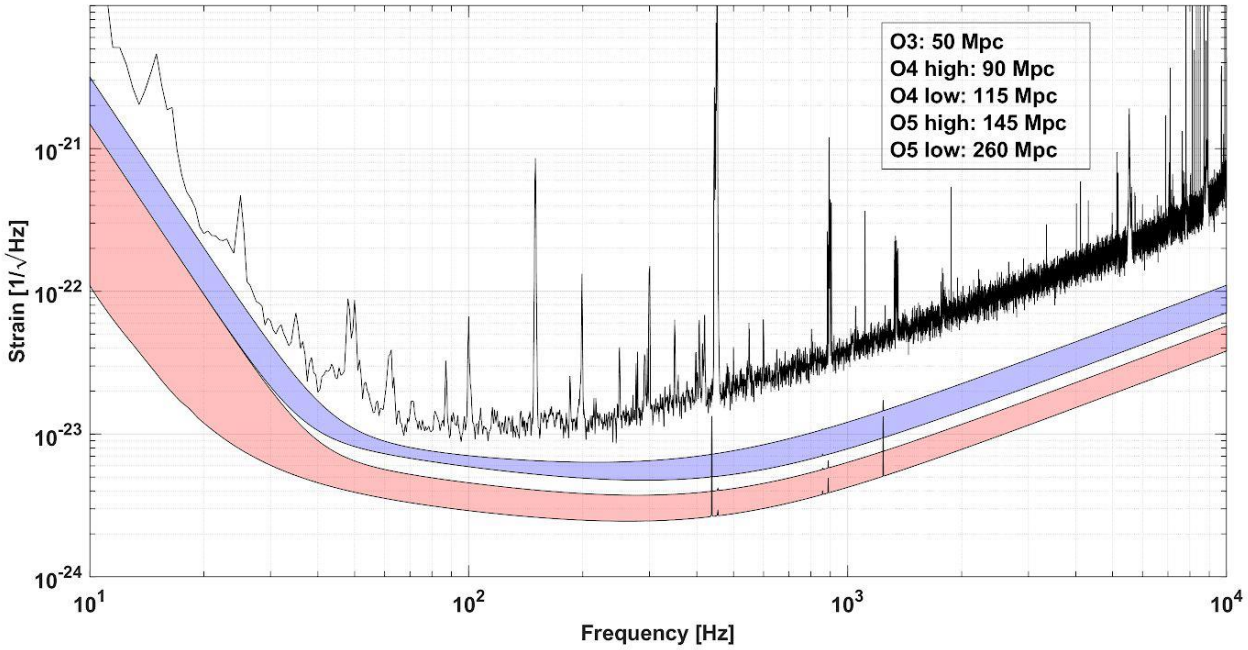
VIR-1179C-19



AdV+ Phase II – original plan (2019)

- Main changes
  - Larger beams on end test masses
    - 6 cm radius ⇒ 10 cm radius
  - Larger end mirrors
    - 35 cm diameter ⇒ 55 cm diameter
    - 40 kg ⇒ 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 ⇒ 60W ⇒ 80 W

VIR-1179C-19



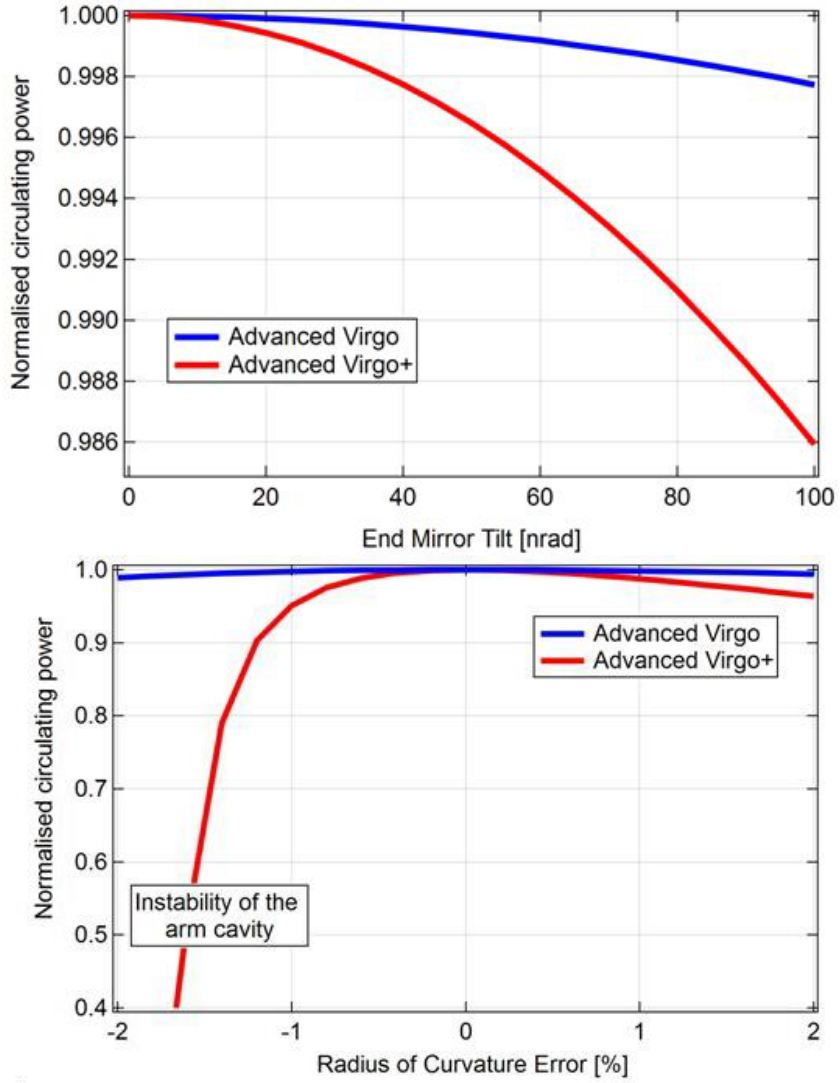
Target: BNS range 145-260 Mpc
(LIGO aims at 240-320 Mpc)

New players in the game

- Since 2019, two major factors have entered the horizon:
  - Stable cavities
    - Major investment, in terms of schedule, person-power and budget
  - O4 target sensitivity not reached (90-115 Mpc for Phase I – VIR-0596A-19)
- These have pushed for a review of the baseline design for O5
- **Decision**: postpone Large ETMs (and all related activities) to Post-O5
  - Following the current decisional path, a Project Change Request has been submitted to the JEVCo (that approved it)

Technical 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)

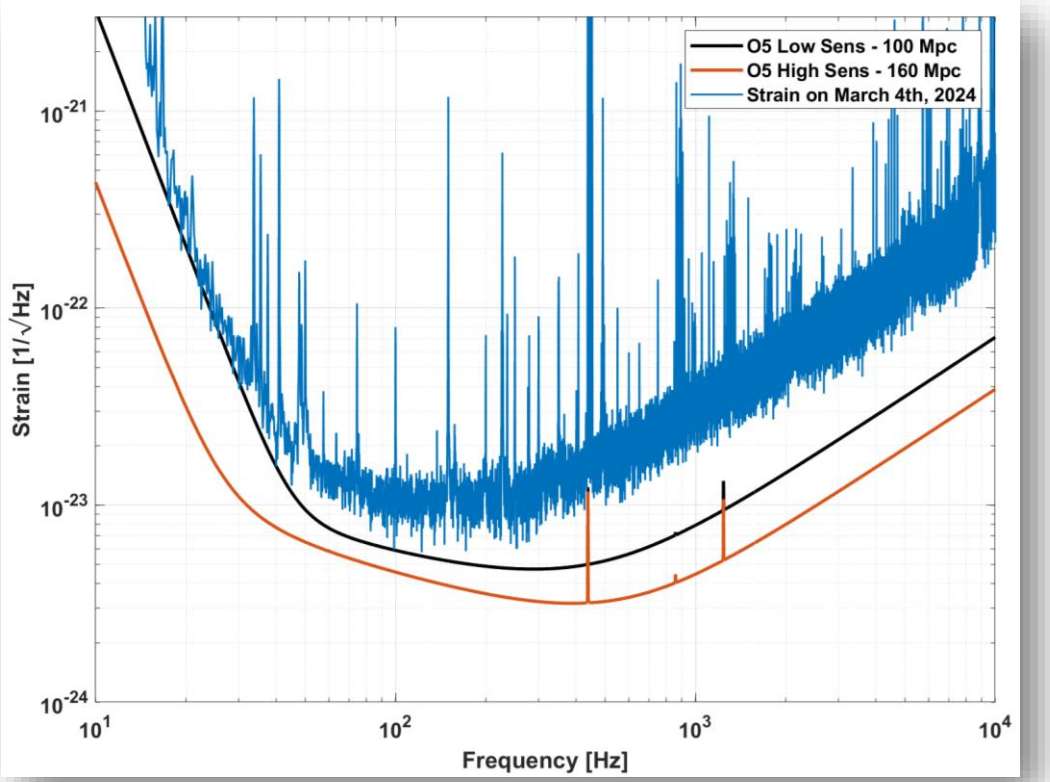


AdV+ in O5 – baseline (Plan A)

1. Short Stable Recycling Cavities
2. NO Large ETMs
3. Other Phase II upgrades not connected to LMs (from VIR-1179C-19)
4. Other upgrades coming from commissioning experience (VIR-0120A-24)

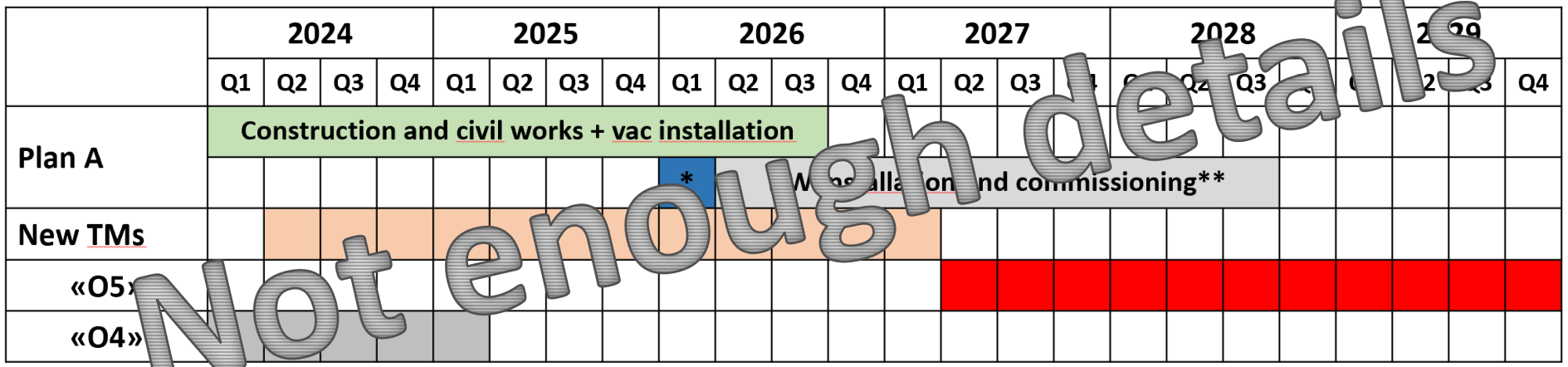
Parameter	O5 «Low sensitivity»	O5 «High sensitivity»
Recycling cavity	Stable	Stable
FP cavity power	190 kW	380 kW
SQZ measured	4.5 dB	6.0 dB
Coating thermal noise	1	0.7
Low Freq. Tech. noise	High	Low
BNS range	100 Mpc	160 Mpc
BBH range	1 Gpc	1.42 Gpc

PSDs on the TDS: VIR-0218A-24
Available to DA colleagues for simulations



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)
- Resource Loaded Schedule will be released with TDR

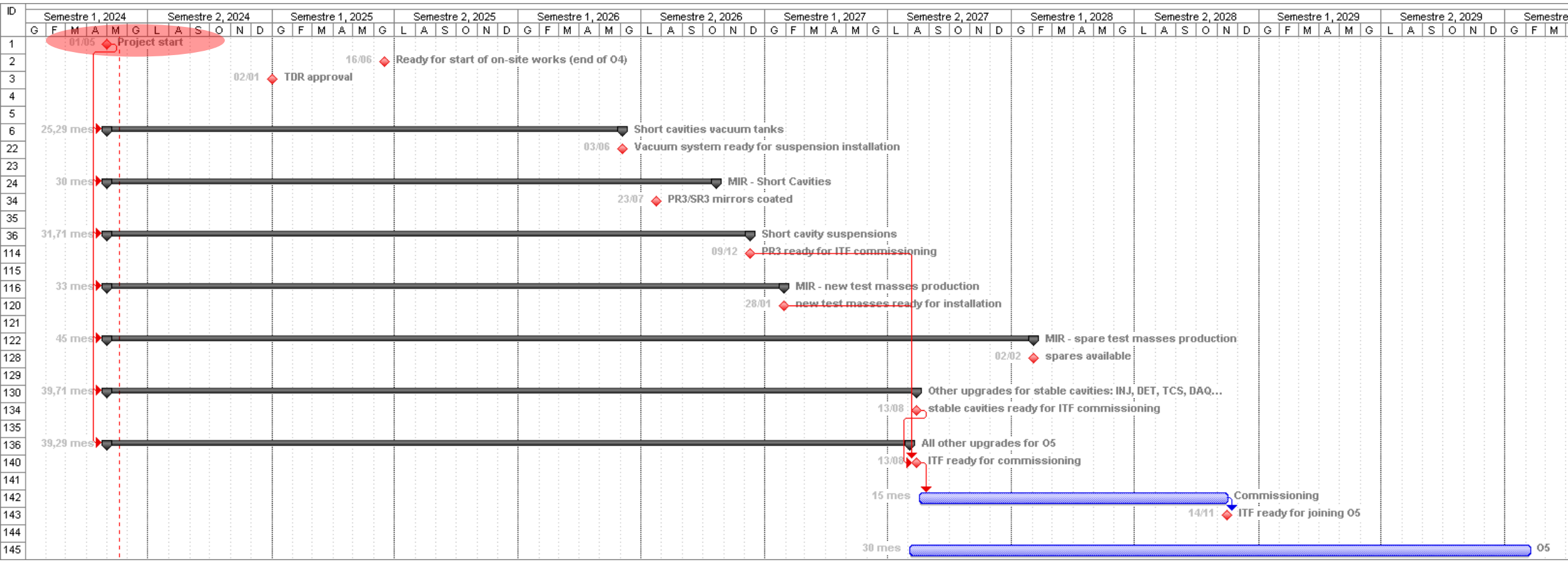


* end of vacuum system installation

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

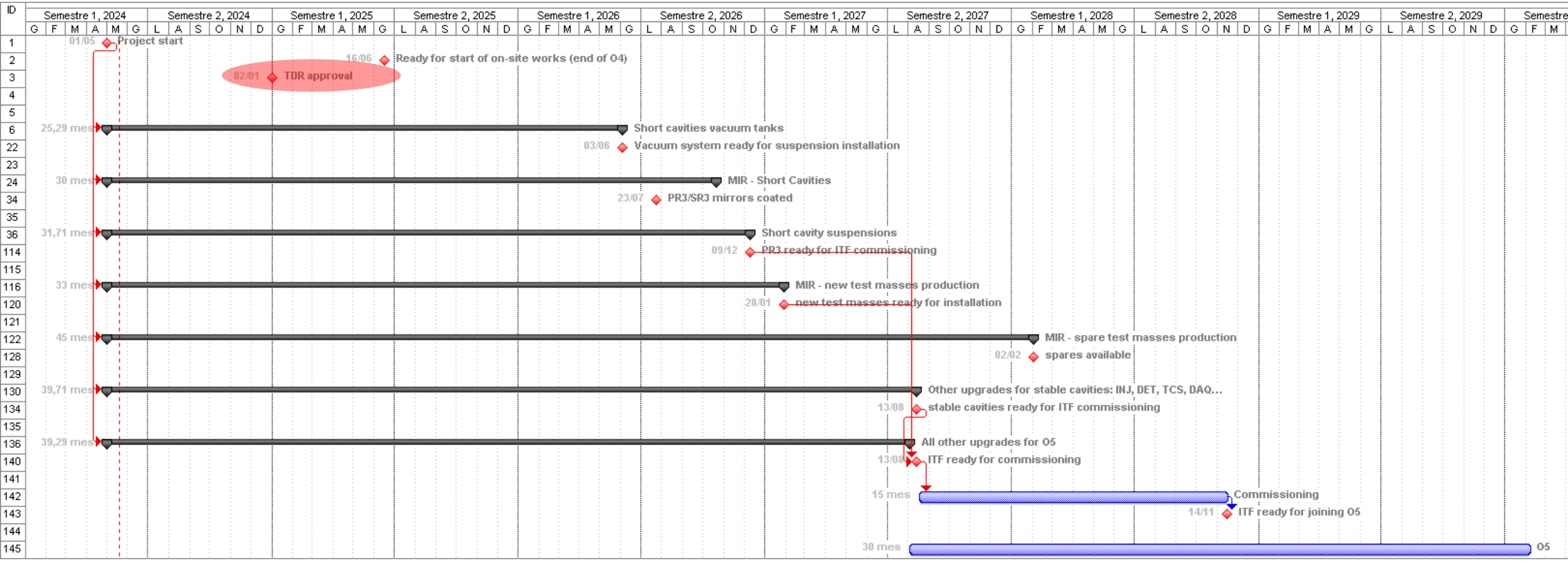
Preliminary global planning

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



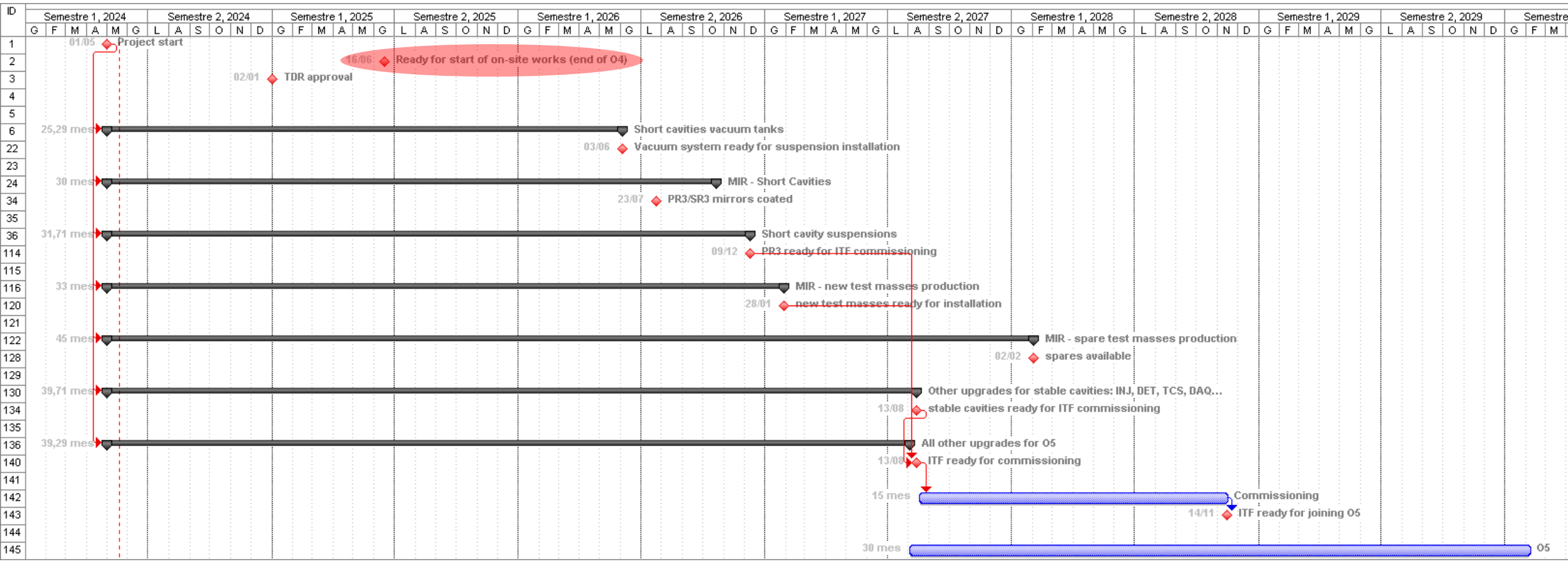
Preliminary global planning

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



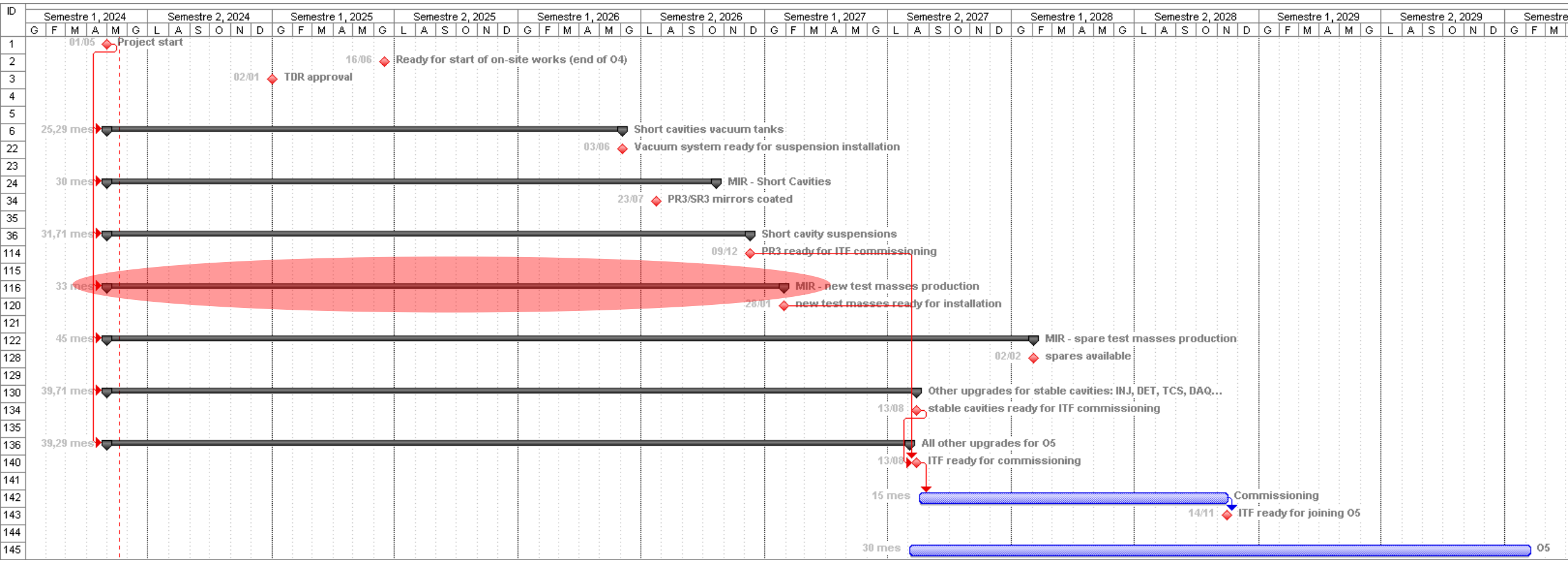
Preliminary global planning

Shift of the end of O4b considered in the plan



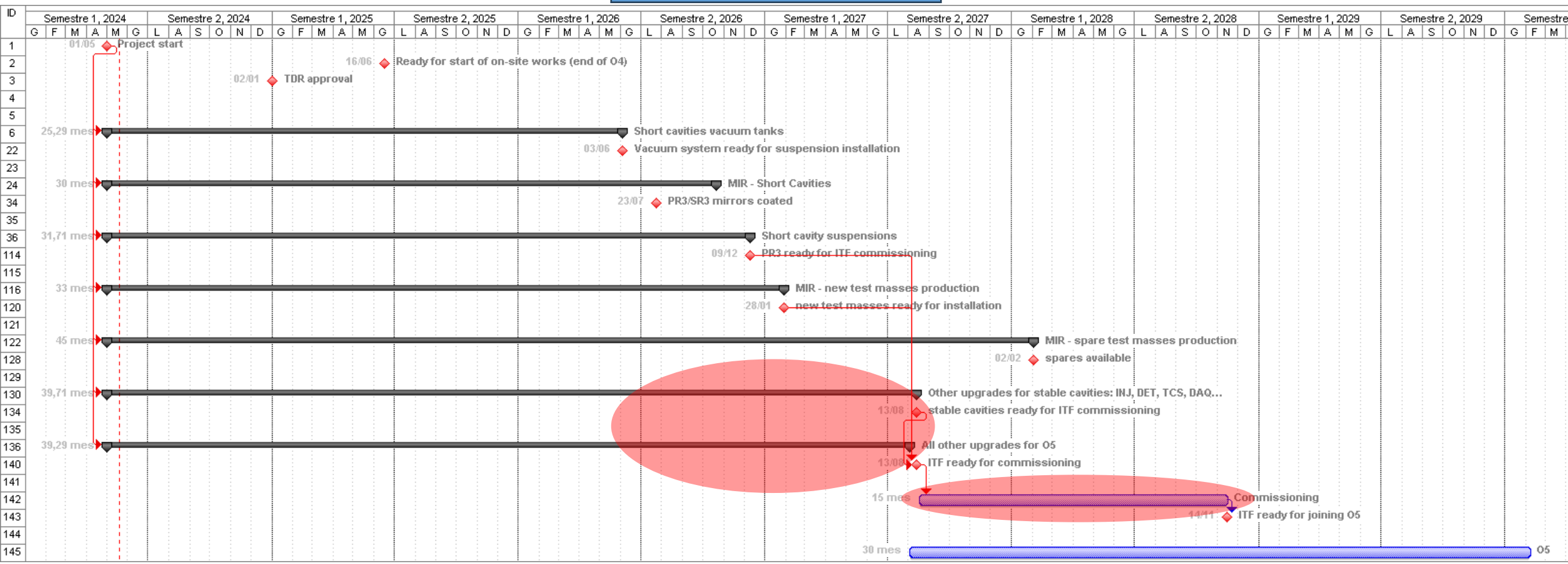
Preliminary global planning

Production of new TMs well within the planning

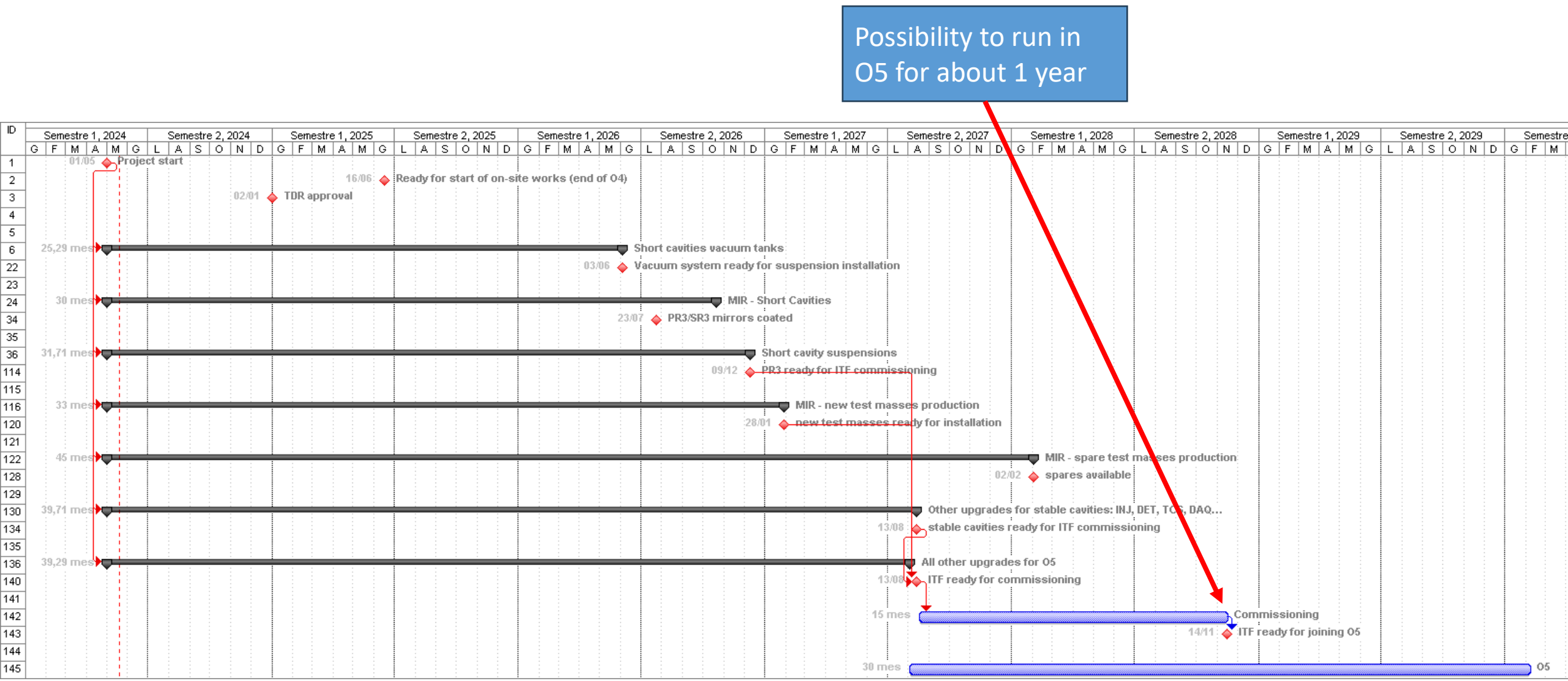


Preliminary global planning

Installation and commissioning planning to be refined



Preliminary global planning



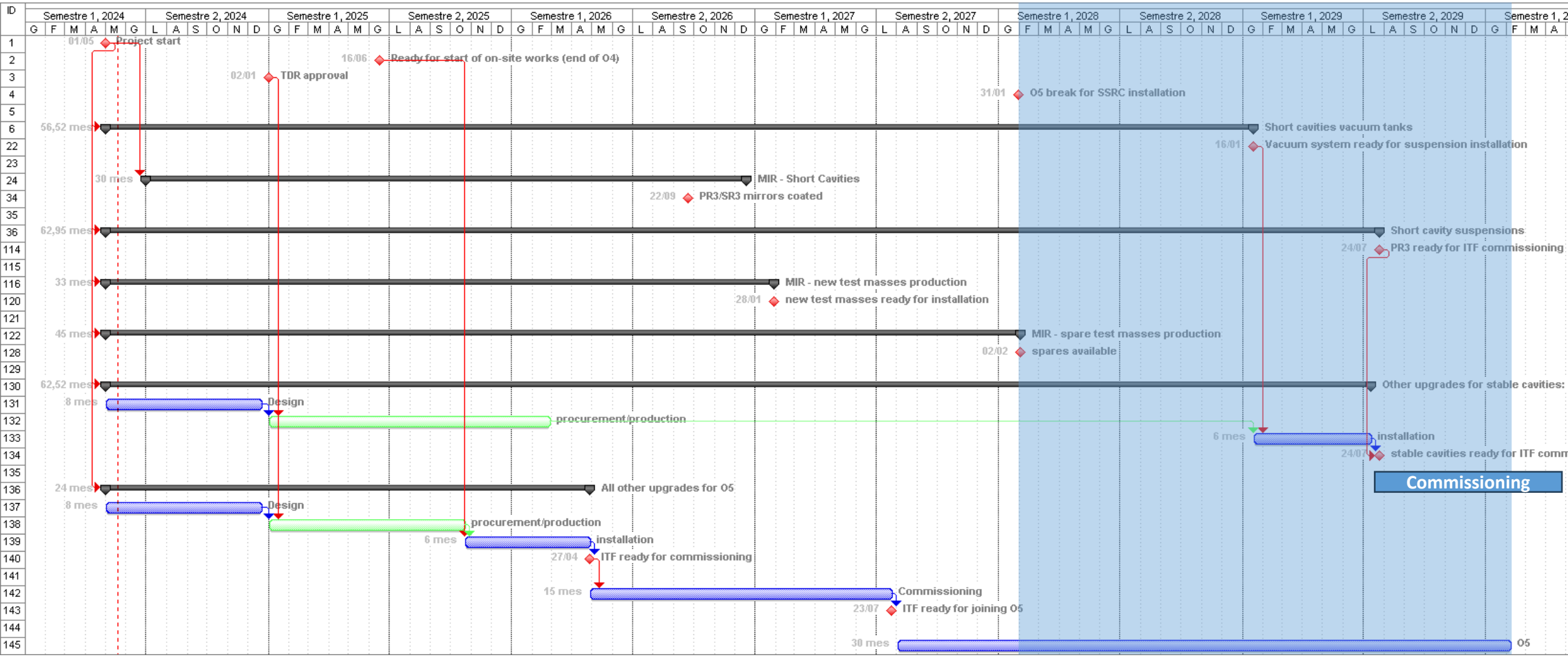
Urgent expenses

- Current schedule relies on the possibility to anticipate some urgent expenses (mostly related to stable cavities) before the delivery of the TDR
- Urgent expenses for 2024:
  - 1.5 M€ for recycling cavity mirrors (convention with LMA needed – EGO not allowed for this kind of CfTs)
  - 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)
- EGO Council will decide on these at the July meeting

The Plan B (emergency plan)

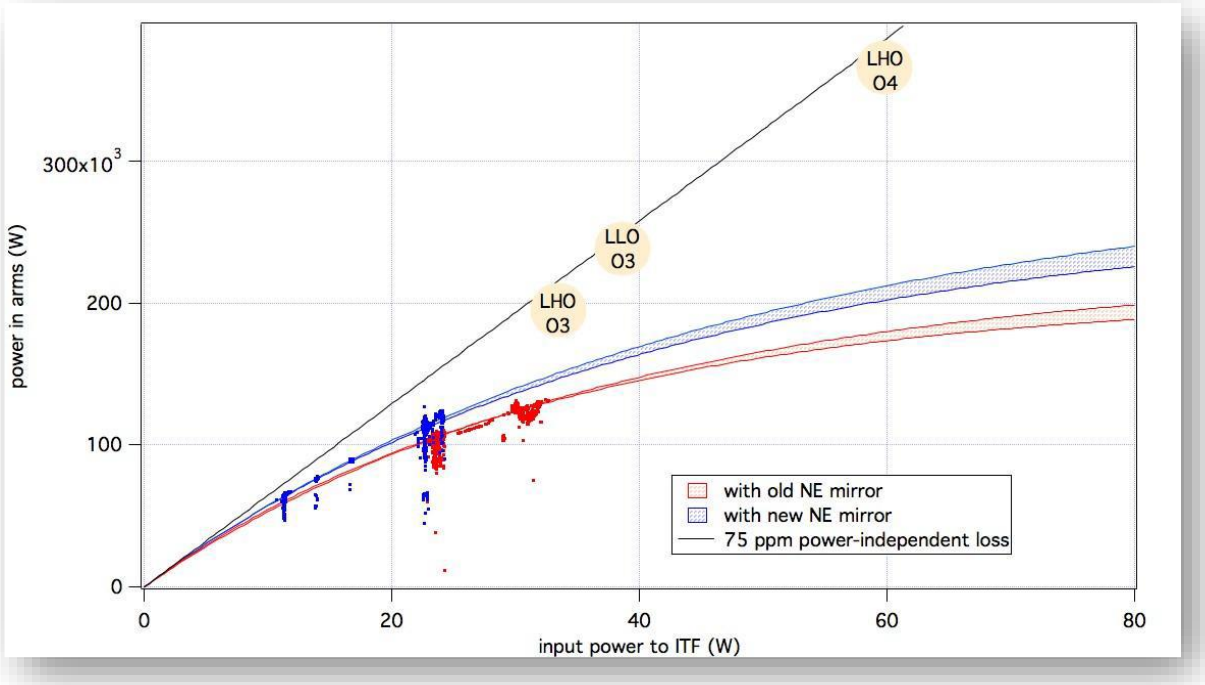
- Proceed with stable cavities production, but defer installation to the future (start after O5) → keep unstable cavities in O5
- Replace PRM and North CP (major sources of optical aberrations)
- Install some upgrades coming from commissioning experience
- Open points:
  - **Replacement of TMs**
  - What **input power** (or how much power in the arms)
  - **Squeezing** effectiveness with high SRC losses
- Very difficult to make projections on achievable sensitivity, likely in the 60-80 Mpc range
- Would allow to join O5 from the beginning

The Plan B (emergency plan)



New test masses (for Plan A or B)

- 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



Project Management Structure

Project Management Structure

- Previous Management Team (VIR-0597C-19) included:
  - The Upgrade Coordinator (aka the Project Leader)
  - The Technical Manager
  - The System Engineer
  - Five System Managers, each managing a fraction of the SubSystems:
    - ITF – for OSD, PSL, INJ, SLC, DET, SBE
    - SUM – for MIR, TCS, PAY, SAT, CRD
    - ESC – for ISC, ALS, DAQ, CAL
    - ENV – for NNC, INF, VAC, EMS
    - QNR – for SGD, SVS, SIN, FLT
  - The division in “Systems” did not help managing interfaces between SS belonging to different Systems
  - Substantial overlap between the mandates of the SMs and SSMs
  - Not enough person-power for some crucial processes for the Project Management
    - Enforce Risk Management Plan
    - Enforce Requirements Management Plan

Project Management Structure

- New structure of the AdV+ Project Office since February 2024:
  - Technical Manager (H. Heitmann)
  - Configuration Manager (H. Heitmann – ad interim)
  - System Engineer (F. Carbognani)
  - QA/QC Manager (---)
  - Risk Manager (F. Sorrentino – ad interim)
  - On-site Integration Manager (---)
  - Liaison to Commissioning (M. Was)
  - Liaison to V_nEXT (V. Fafone)

AdV+ PO description document

- Document released to describe structure of the AdV+ Project Office:
  - Description of the roles of the members (Technical Manager, Configuration Manager, System Engineer, Quality & Risk Manager, On-site Integration Manager)
  - Focuses on integration phase of the project
  - Available on the TDS: VIR-0390A-24
- Used to test new infrastructure for Document Lifecycle Management
  - Document approval process managed through Google environment with authentication
  - Approved document automatically uploaded on the TDS on a specific series
  - It will be extended to SSs documents

Project Management Structure

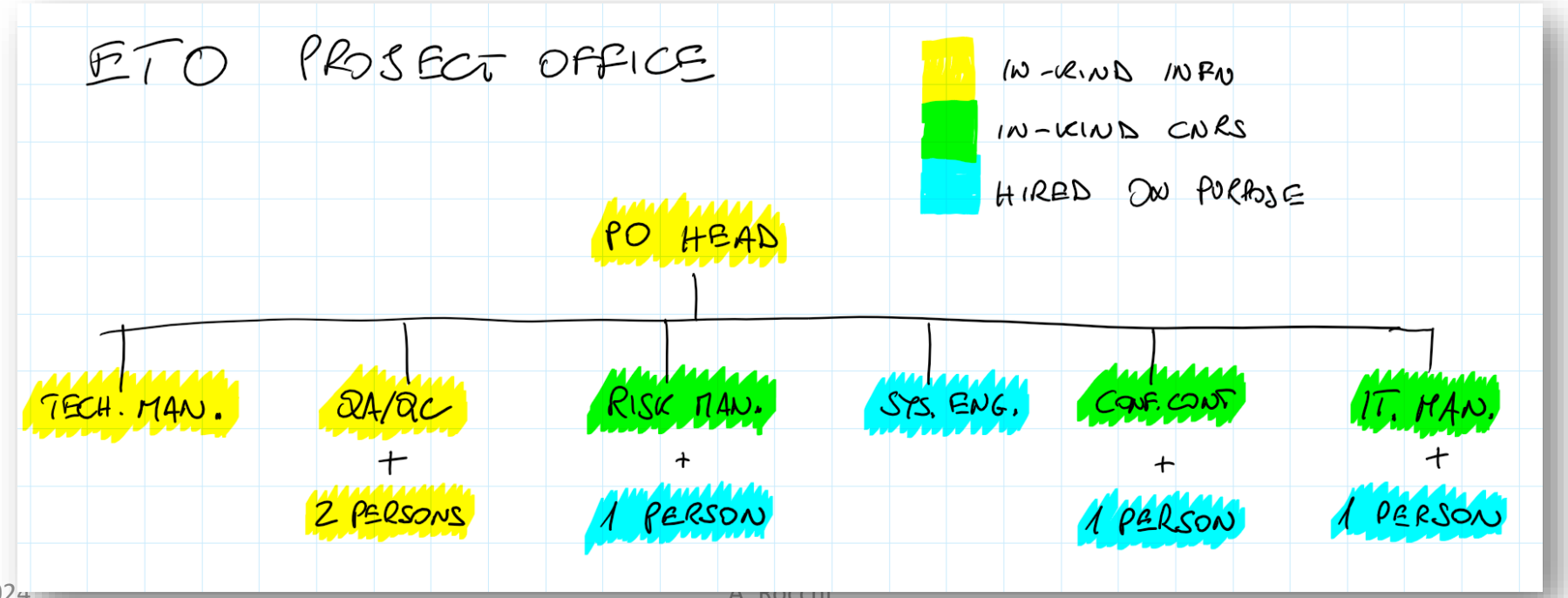
AdV+ Project Management Team

AdV+ Project Office
Upgrade Coordinator: A. Rocchi
Technical Manager: H. Heitmann
System Engineer: F. Carbognani
QA/QC Manager: TBD
Risk Manager: F. Sorrentino – ad interim
On-site Integration Manager: TBD
Configuration Control Manager: H. Heitmann – ad interim
Liaison to Commissioning: M. Was
Liaison to Virgo_nEXT: V. Fafone

OSD S. Steinlechner	**SBE** H. Bulten	**CRD** M. Bazzan	**NNC** J. Harms	**SGD** M. Vardaro
PSL W. Chaibi	**MIR** L. Pinard	**ISC** J. Casanueva	**INF** A. Paoli	**SVS** M. De Laurentis
INJ M. Gosselin	**TCS** I. Nardecchia	**ALS** A. van de Walle	**VAC** A. Pasqualetti	**SIN** R. Bonnand
SLC L-M. Mir	**PAY** E. Majorana	**DAQ** N. Letendre	**EMS** R. De Rosa	**FLT** A. Bertolini
DET R. Gouaty	**SAT** V. Boschi	**CAL** L. Rolland		

Project Management Structure

- Missing positions are preventing to start relevant processes in the TDR preparation (such as requirements management)
- Survey in the Collaboration had negative outcome, as expected since these competences are not usually within scientific collaborations
- Could we adopt the “ET-O Project Office Scheme”



AdV+ Phase II - O5 Sys Eng

- Reorganizing AdV+ Reviews (DR, PRR, VRR) support for the being defined Phase II – O5 set of deliverables.
- Added support for Document approval workflow, both for the AdV+ Project Office relevant documents and the documents embedded into the reviews' workflow
- Finalized some of the Design Reviews (DR) which could progress independently from the Phase II - O5 reorg (ex: MIR.12 - New characterization bench to quantify coating absorbing points)
- Validation/Reception Reviews (VRR)
  - templates and procedures have been updated to make it as light as possible but still effective. Main outcome in the form of a simple and predefined checklist worksheet covering the integration relevant points
  - VRR management added into the automation procedures developed for DR and PRR
- The introduced automation suite to support the reviews workflow (See VIR-0540C-22) are proving effective in the management of the associated hundreds of mails, documents and follow up actions. Development is ongoing to make the software able to support an increased number of workflows and users (and possibly be adopted in other projects, ex: Virgo_nEXT)

Project tasks list

1. Final configuration for O5 defined
2. Choice of stable cavities configuration done
3. AdV+ Project Office Description Document delivered
4. Short Stable Cavities Preliminary Design Document delivered
5. Production of the PBS (list of deliverables) for O5 almost done
6. Delivery (late due to lack of person-power in the PO) and implementation of a Requirements Management Plan
7. Delivery of the Project Management Plan (interaction with the “VirgoLab” process)
8. Implementation the existing Risk Management Plan
9. Production of the WBS and assembly of the TDR for O5
10. Assemble global planning for installation and commissioning for O5 upgrades

Planned delivery date of TDR: October 2024

EGO Experts on site

- The figure was introduced back in Nov. 2020:
  - Presentation at the VSC (VIR-0982-20)
  - Approved by the VSC (VIR-0993-20)
- However, no clear mandate was devised, only a brief description (sent by e-mail to the SSMs in Nov. 2020), that leaves some open (relevant) points

It should be clear that if a subsystem has a trouble, **the first call for help should go to the on-call** and that the **on-call service** should be **ensured by the laboratories in charge of the subsystem**. The on-call might be able to solve the problem remotely with the support of the operator. If this is not enough to solve the problem, **the EGO expert support should be in position to intervene**.

- When is the expert supposed to act? Any time of day/night? What happens when the expert is on vacation? How fast should the group intervene?
- What kind of intervention? Put the SS in safety and wait for the group members to arrive at the site?
- Work in progress with V. Dattilo (Head of EGO ITF Tech. Dept.), N. Arnaud (RC), M. Was (CC), D. Bersanetti (Deputy CC on site) and M. Mantovani (EGO Group leader)

Conclusions

1. Overall detector configuration for O5 (Plan A) defined
   - Increase detector robustness with short stable recycling cavities
   - Target sensitivity in the range 100-160 Mpc
   - Schedule for O5 is tight (room for planning optimization)
   - Detailed list of upgrades (and costing) to be finalized

2. Emergency Plan (B)
   - Very limited modifications to the detector
   - Would allow to join O5 in time
   - Achievable sensitivity in the 60-80 Mpc range

3. Project Management Structure
   - Reviewed for a more "**rigorous project management structure**"
   - At present missing some key members…
   - …limited capability to start all the planned management processes