Design & Construction

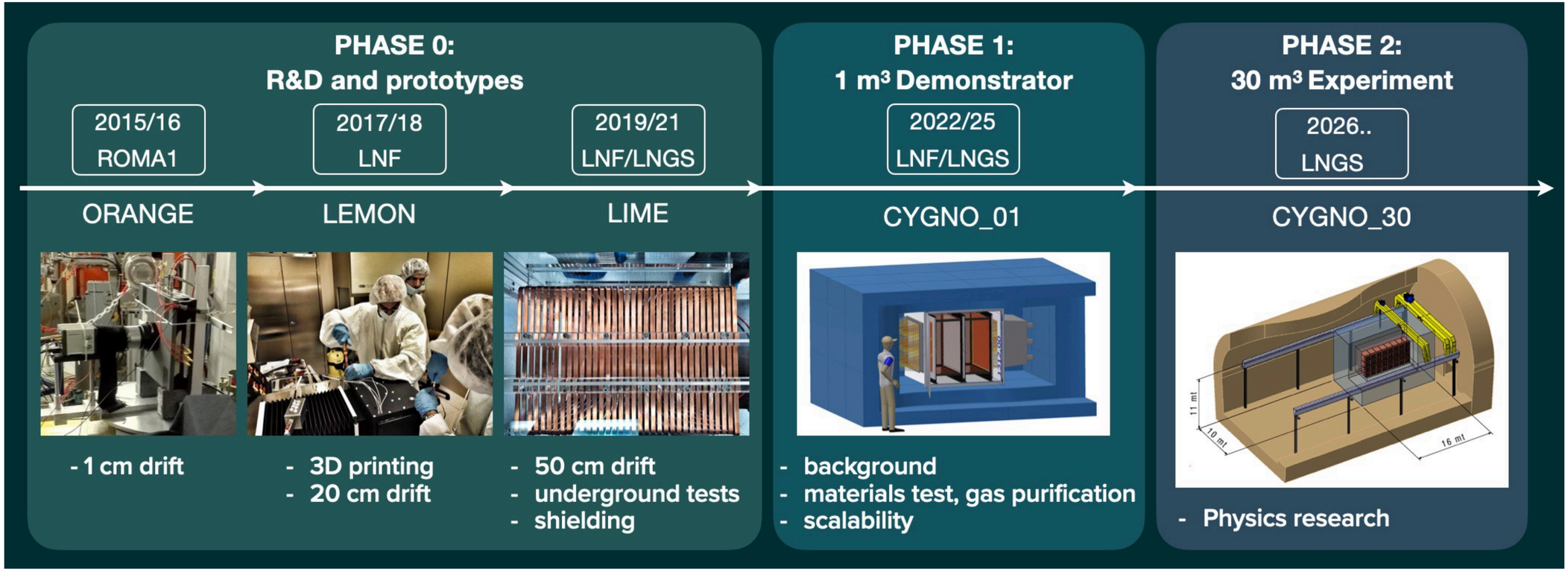
Part 2/3 CYGNO04 TDR

G. Mazzitelli CYGNO annual meeting 19/20-12-2022

why (objective)

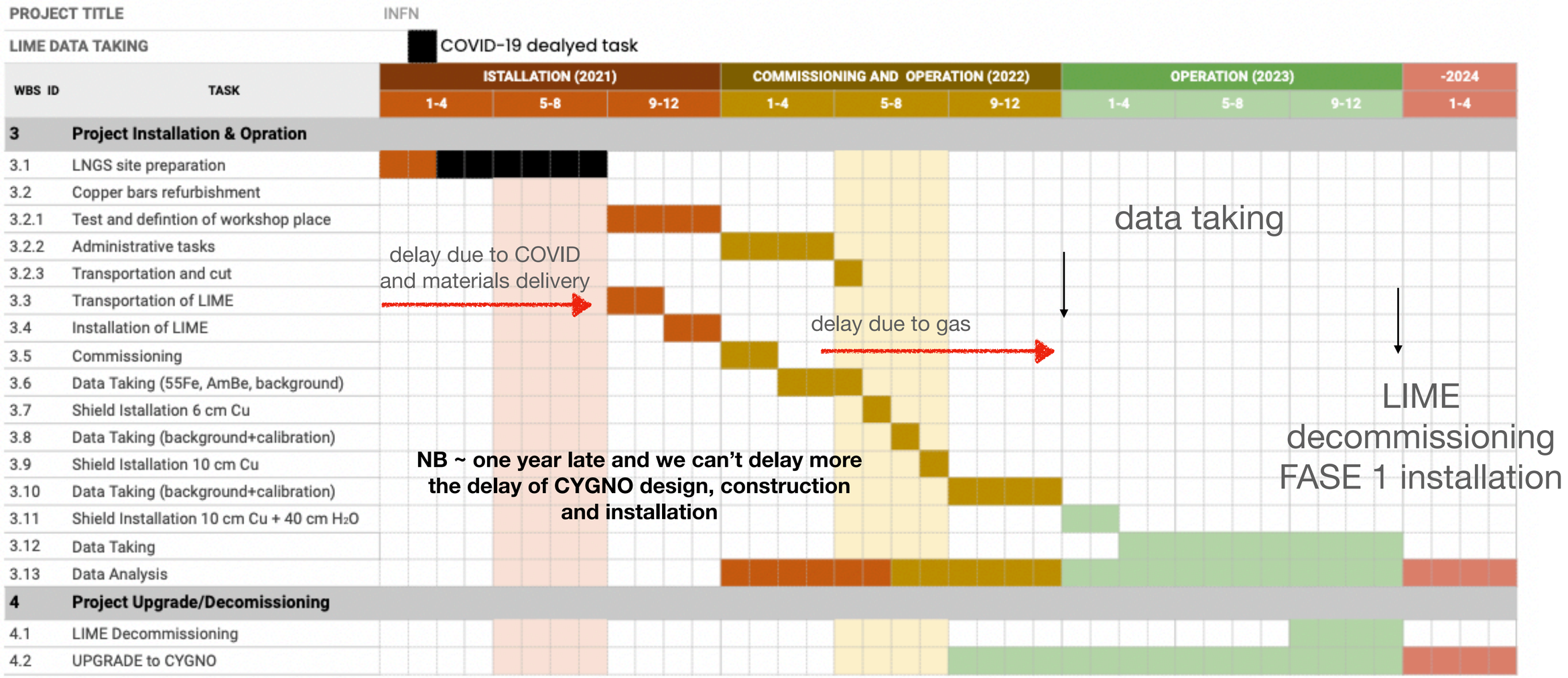
CYGNO a large TPC for dark matter and neutrino study

exploiting the progress in **commercial scientific Active Pixel Sensors (APS)** based on CMOS technology to realise a large **gaseous Time Projection Chamber** (TPC) for **Dark Matter and Solar neutrino search**.



phase 0 - GANTT

LIME



phase 1 - CYGNO-04

Hall F - LNGS May 2022

INFN Istituto Nazionale di Fisica Nucleare	DocID	Rev.	Validità
	INFN-PM-QA-504	1.0.1	Rilasciato

Data 29/6/2022

Piano Qualità – CSN2

Technical Design Report - TDR
CYGNO-04/INITIUM

This document identifies and describes the characteristics and technical requirements from the CYGNO-04/INITIUM Experiment related to the installation at Hall F of the Gran Sasso National Laboratories (LNGS)

Autore	Verificato da	Approvato da
E. Baracchini C. Capoccia L. Leonzi G. Mazzitelli D. Pinci F. Rosatelli S. Tomassini		

Distribution list:

- Commissione Scientifica Nazionale 2 (CSN2)
- Direttore LNGS
- Servizi LNGS
- SCICOM LNGS

https://drive.google.com/file/d/1yd6EspIiOAMvgfTMFM2LOPHIjzyzQVpP/view?usp=sharing

phase 1 - CYGNO-04

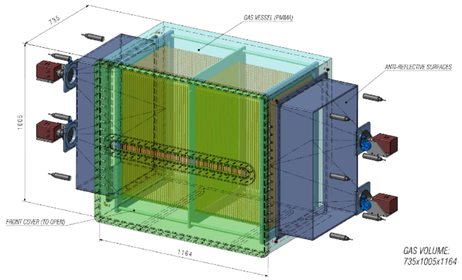
TDR objectives

- the TDR was asked by the LNGS director and the CSN2 to evaluate the **feasibility and economical sustainability** of the project;
- CYGNO experiment have founds to cover cost thanks to ERC-INITIUM for the **“core cost”** that end at the beginning of **2025 (actually end of 2024)**;
- CYGNO need father **“running cost”** to be provide from CSN2;
- the deadline for CSN2 was the **30 of Jun** and we realise the **version v1** included of **preliminary environmental and risks evaluation**
- **1th of Sep** we delivered a **version v2 of TDR** after the review of LNGS services in time for the deadline of the LNGS SCICOM

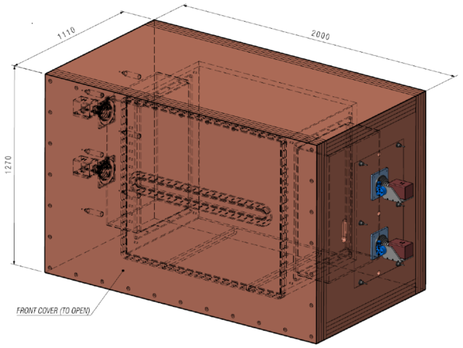
phase 1 - CYGNO-04

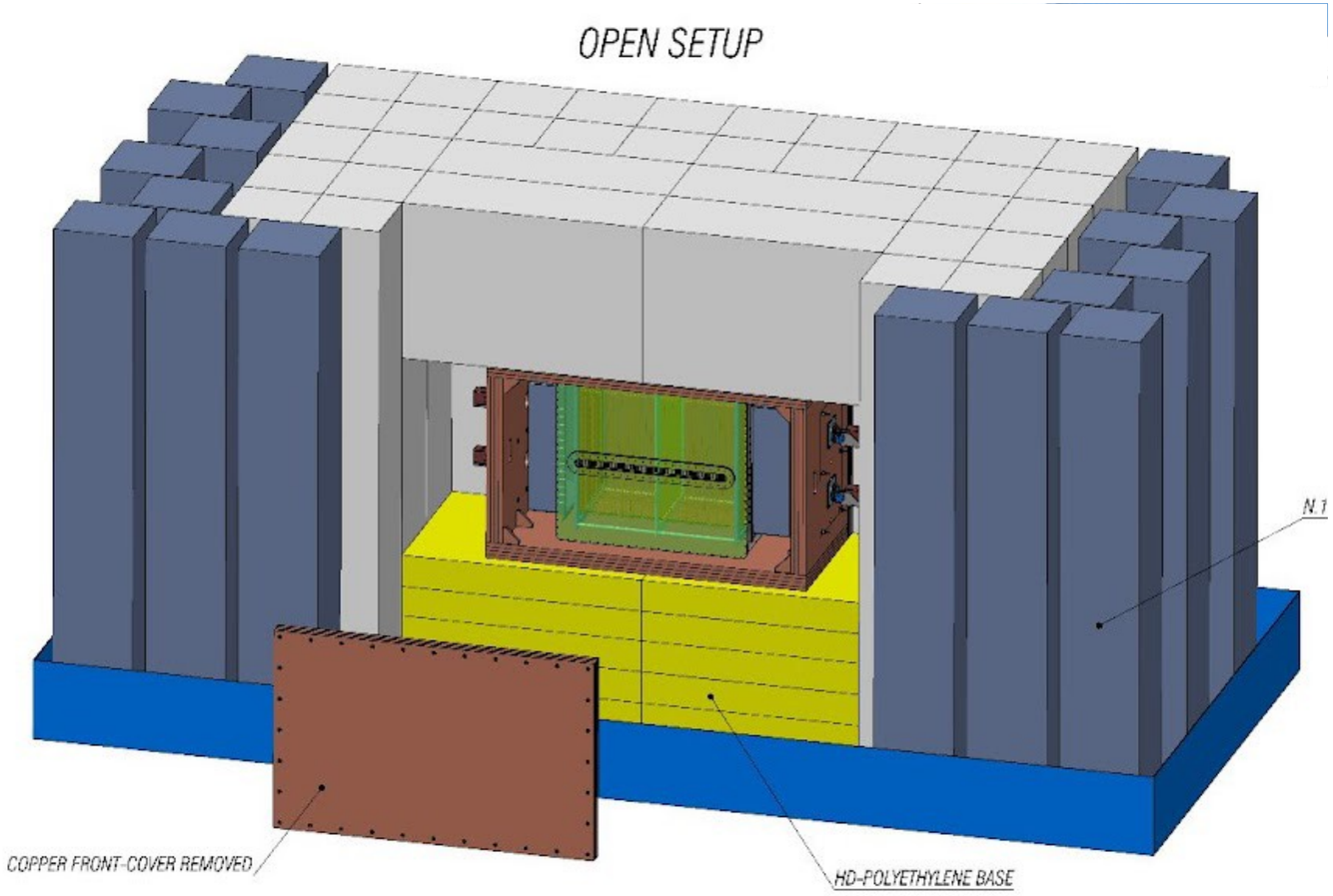
preliminary design

gas vessel & readout



detractor &
copper shield

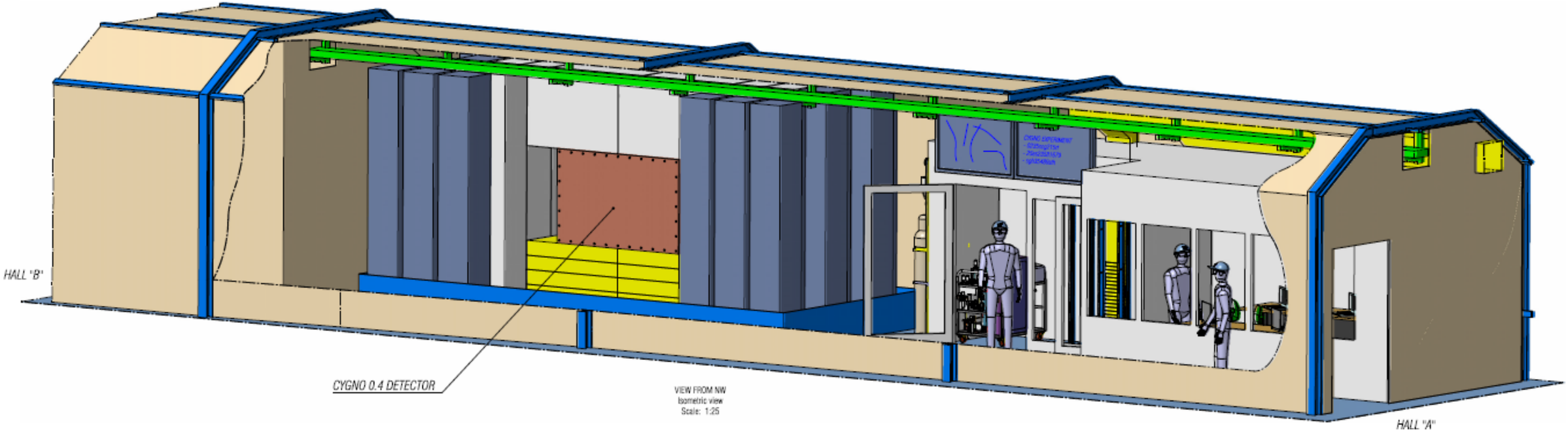




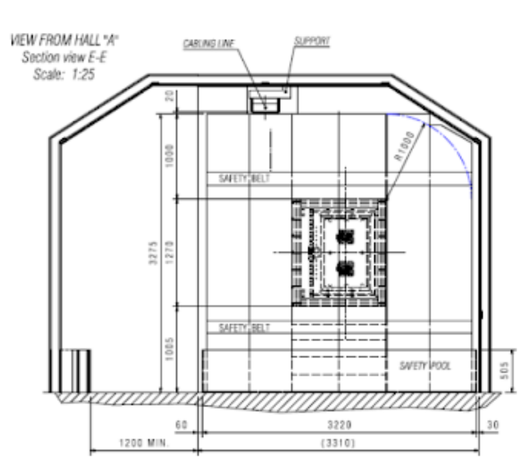
full detector shielded (Cu+water)

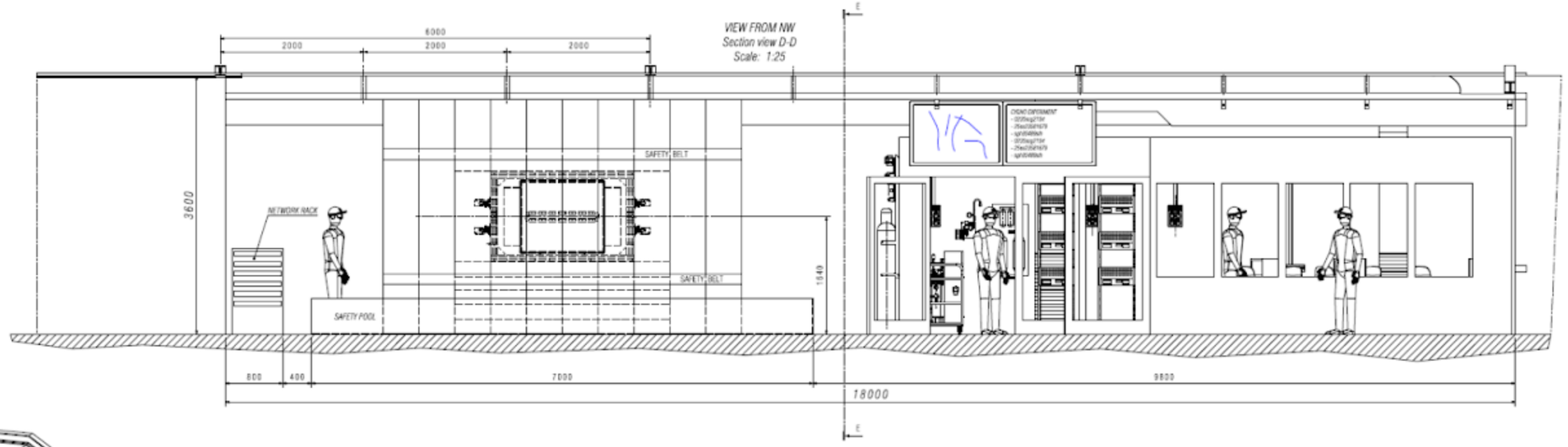
phase 1 - CYGNO-04

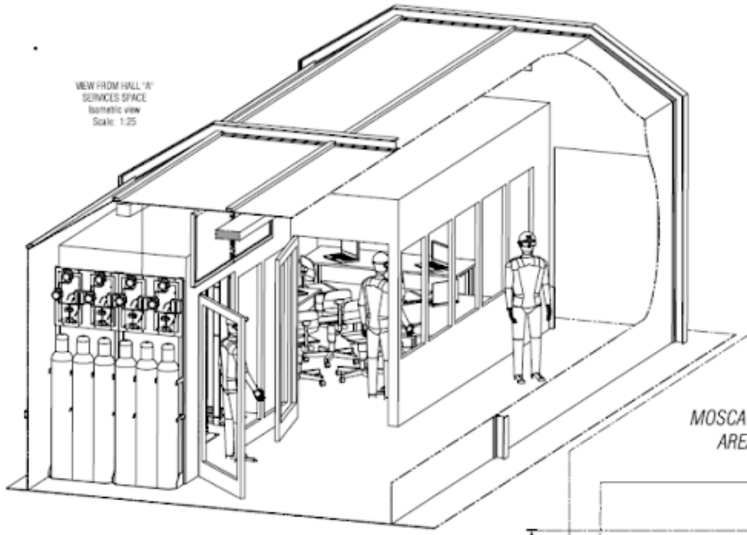
hall F preliminary setup

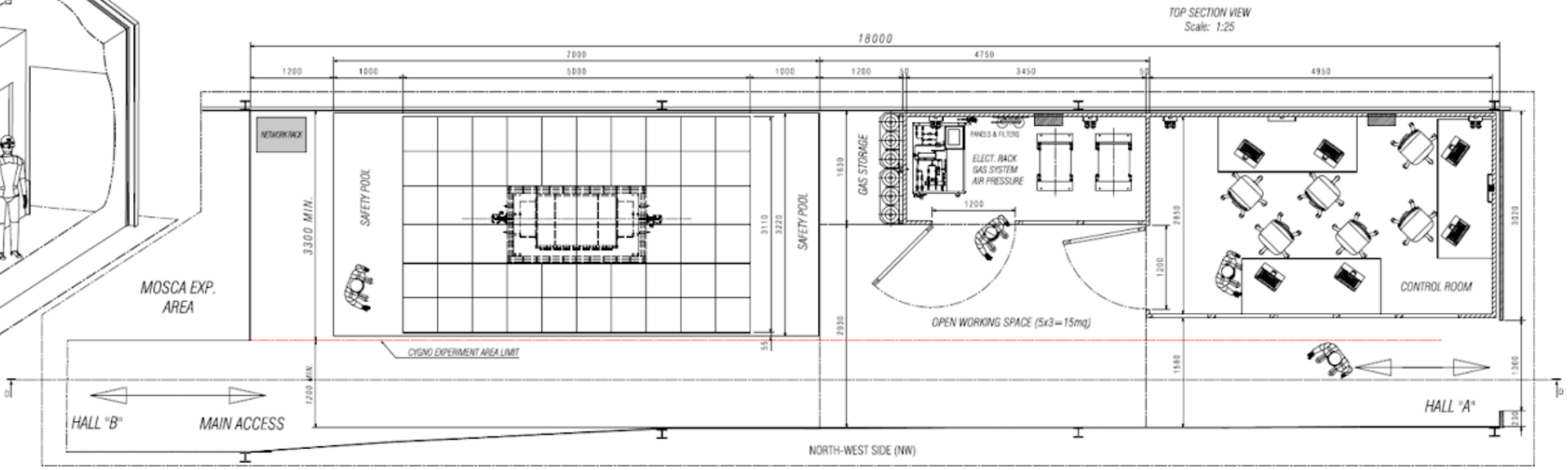


phase 1 - CYGNO-04



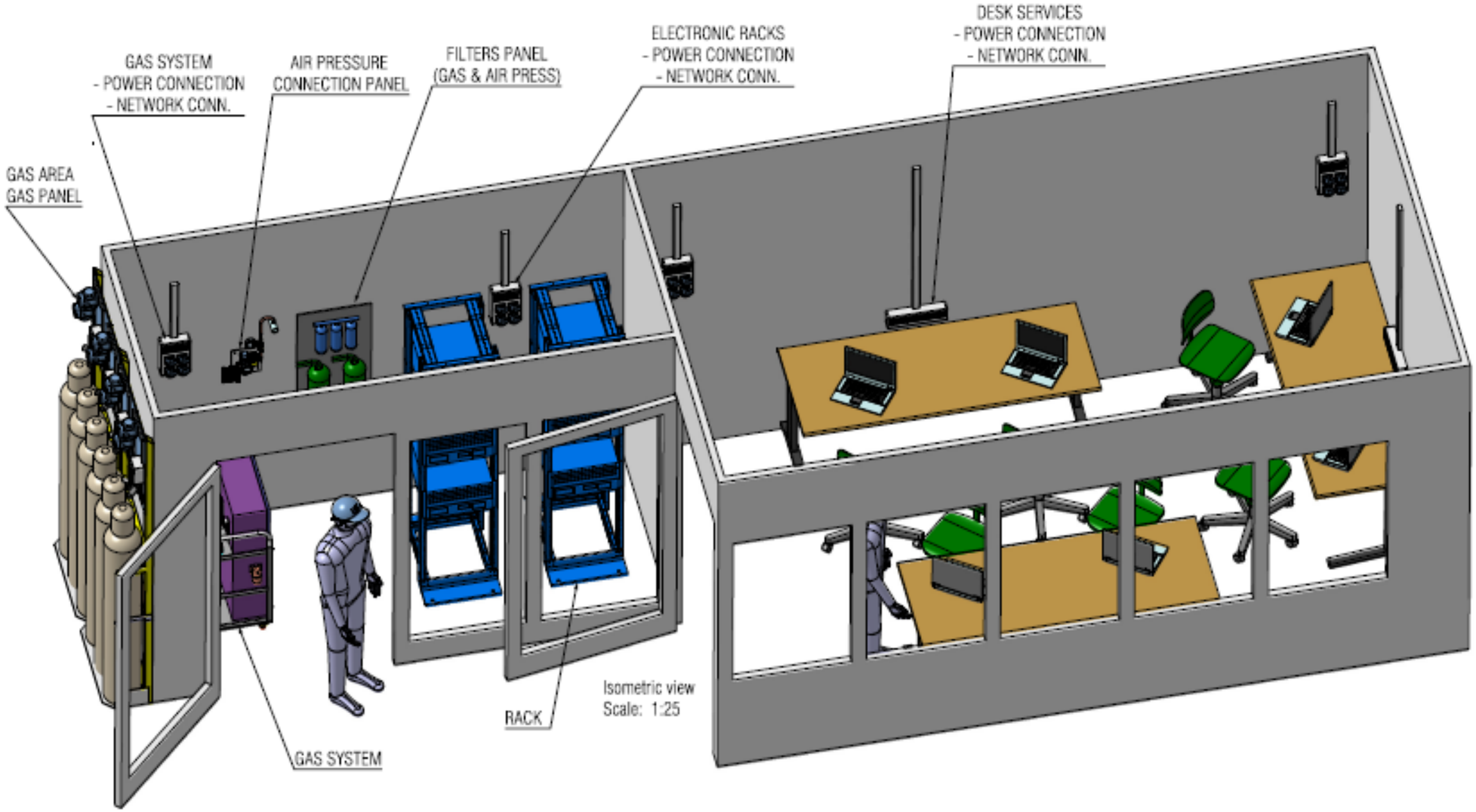






phase 1 - CYGNO-04

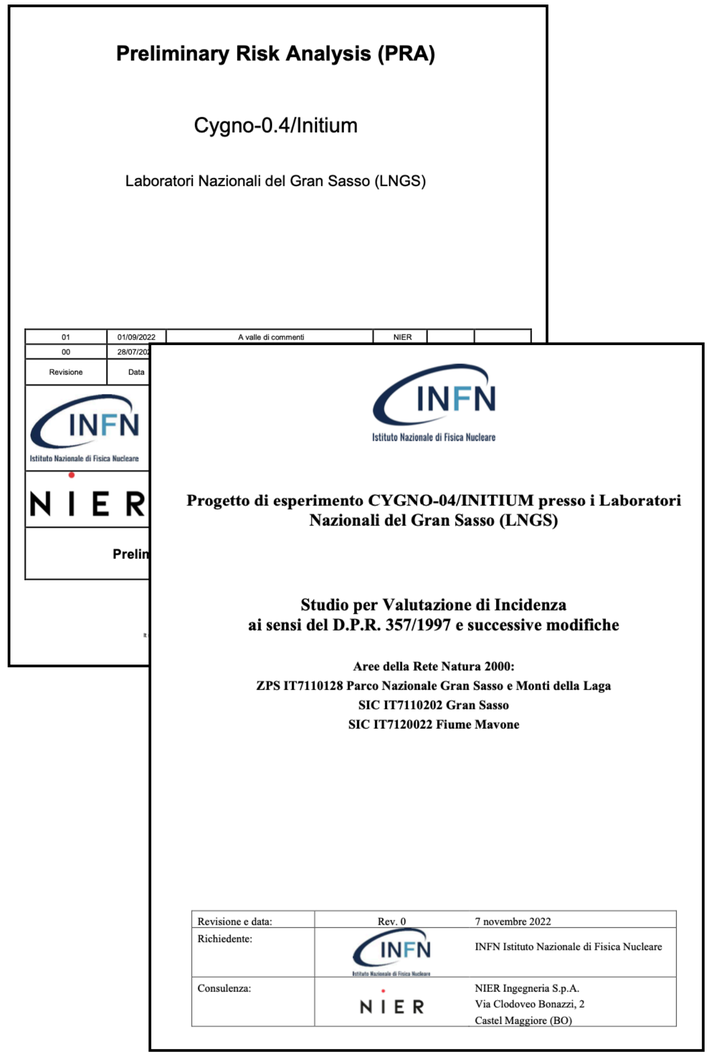
services area



phase 1 - CYGNO-04

status and update

- a TDR v2 has been done and integrated with the cost, and missing items discussed with the LNGS services
- the project has been “approved” by CSN2/LNGS
- PRA, PRE and **VINCA** has been realised and integrated in v2
- we are still waiting for the feedback from LNGS due to the firefighting requirement due to the large amount of polietilene (>5t) that our installation require.
- all the documents are collected https://drive.google.com/drive/folders/13QG3oYn-R4BrwagGPfeQfBBgc4Z6sgQ0



phase 1 - CYGNO-04

status and update

- The **core costs** are estimated to be 912 k€:
  - 233 k€ of equipments and spares have already been purchased
  - 679 k€ to be covered by the fundings illustrated in Sec. 8.5. In addition,
  - 4500 kg of Copper bars (9000*100*10 mm) for a value of 90 k€ have been secured by the CYGNO collaboration from the decommissioning of the OPERA experiment and could be used as contingency.

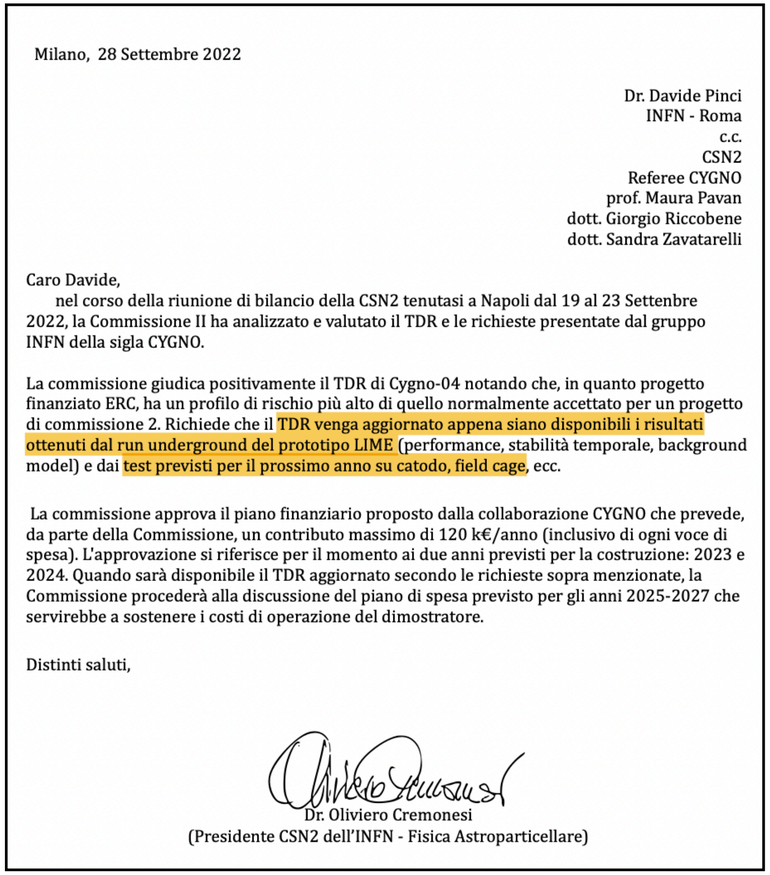
Ref.	WBS NUMBER							DESCRIPTION	UNIT	QUANTITY AT WBS LEVEL							TOTAL	COMPONENT COST AT WBS LEVEL (kEuro)							CORE COST already covered	CORE COST to be covered	NOTES
	1	2	3	4	5	6	7			1	2	3	4	5	6	7	(kEuro)	Unit Cost	7	6	5	4	3	2	1			
GM	1							CYGNO/INITIUM Project	EACH	1															912.75		679.45	
GM	1	1						DETECTOR	EACH		1													752.75			
GM	1	1	1					TPC	EACH			1											268.20				
GM	1	1	1	1				GAS VOLUME	EACH				1									33.20					
ST	1	1	1	1	1			PMMA gas vessel	EACH					1				30.00			30.00						
ST	1	1	1	1	2			PMMA cameras cones	EACH					4				0.30			1.20						
ST	1	1	1	1	3			PMMA GEM frame holder	EACH					2				1.00			2.00						
DP	1	1	1	2				READOUT	EACH					4								190.00					
LB	1	1	1	2	1			GEM foil	EACH						2			3.00		6.00							
CC	1	1	1	2	2			GEM frame	EACH						2			0.20		0.40							
LB	1	1	1	2	3			GEM holder	EACH						3			0.20		0.60							
LB	1	1	1	2	4			GEM connectors	SET						2			0.20		0.40							
DP	1	1	1	2	5			Cameras	EACH						1			32.00		32.00							
DP	1	1	1	2	6			Optics	SET						1			2.20		2.20							
RO	1	1	1	2	7			Cameras holedrs mechanics	SET						1			3.00		3.00							
DP	1	1	1	2	9			PMTs	EACH						3			0.80		2.40						4.8	
DP	1	1	1	2	10			Cable & connectors	SET						1			0.50		0.50							
	1	1	1	3				CATHODE	EACH				1									17.00					
	1	1	1	3	1			Feed through	SET					1				1.00			1.00						
CC	1	1	1	3	2			Cathode frame	SET					1				1.00			1.00						
	1	1	1	3	3			Cathode foil	SET					1				15.00			15.00						quotation based on experince of DRIFT collaborator
	1	1	1	4				FIELD CAGE	EACH				1									13.00					
CC	1	1	1	4	1			Cu rings	EACH					100				0.10			10.00						quotation by ELTOS
	1	1	1	4	2			Resistors	EACH					100				0.01			1.00						quotation by RS for standard restori
CC	1	1	1	4	3			PMMA box	EACH					1				2.00			2.00						
RO	1	1	1	5				CALIBRATION SYSTEM	EACH					1								15.00					
	1	1	1	5	1			Calibration source	EACH					1				5.00			5.00					5.00	device purchased
RO	1	1	1	5	2			Mechanics	EACH					1				5.00			5.00						cost based on LIME experince
RO	1	1	1	5	3			Stepper motors	SET					1				5.00			5.00						cost based on LIME experince
	1	1	2					SHIELDING	EACH			1											281.05				
CC	1	1	2	1				Cu bricks	SET				9500					0.019				180.50					estimation based on CSN Carl Schreiber GmbH quotation
CC	1	1	2	2				Water tanks	SET				48					1.300				62.40					estimation based on MULDING quotation
CC	1	1	2	3				Frame (consumable/carpentry)	SET				1					20.000				20.00					LNF workshop estimation based on LIME costs
CC	1	1	2	4				Politilene base	SET				3300					0.006				18.15					estimation based on ADVIPLAST quotation
	1	1	3					GAS SYSTEM	EACH			1											123.00				
	1	1	3	1				gas system	EACH				1					85.00				85.00				85.00	device purchased
	1	1	3	2				gas distribution	SET				1					5.00				5.00					
	1	1	3	3				gas system mechanics	SET				1					5.00				5.00					
	1	1	3	4				gas contingency (consumable)	SET				1					5.00				5.00					
	1	1	3	5				gas purification system	SET				1					10.00				10.00				10.00	device purchased
	1	1	3	6				CF4 analyzer	SET				1					13.00				13.00				13.00	device purchased
	1	1	4					HV SYSTEM	EACH			1											35.00			35.00	device purchased
	1	1	4	1				CAEN LV crate	SET				2					5.00				10.00					
	1	1	4	1				CAEN LV board	SET				2					5.00				10.00					
	1	1	4	1				ISEG HV PS	SET				3					5.00				15.00					
	1	1	5					DAQ & SLOW CONTROLS	EACH			1											45.50			45.50	device purchased
	1	1	5	1				server	SET				2					10.00				20.00					
	1	1	5	2				aux pc	SET				4					1.00				4.00					
	1	1	5	3				monitors	SET				5					0.30				1.50					
	1	1	5	3				aux readout board	SET				1					5.00				5.00					
	1	1	5	4				aux readout sensor	SET				1					5.00				5.00					
	1	1	5	5				triggger system	SET				1					5.00				5.00					
	1	1	5	6				cables & connectors	SET				1					5.00				5.00					
	1	2						COMPRESSED AIR SYSTEM	EACH		1														12.00			
	1	2	1					air distribution system	SET			1						5.00					5.00			5.00	device purchased
	1	2	2					air filter	SET			1						2.00					2.00			2.00	device purchased
	1	2	3					tubes & connectors	SET			1						5.00					5.00				
	1	3						ELECTRIC SERVICES	EACH	1														20.00			cost estimated by LNGS services
	1	3	1					power distribution system	SET			1						10.00					10.00				
	1	3	2					cables & connectors	SET			1						5.00					5.00				
	1	3	3					UPS	SET			1						5.00					5.00				
	1	4						NETWORK DISTRIBUTION	EACH	1														13.00		13.00	device purchased
	1	4	1					network distribution system	SET			1						5.00					5.00				
	1	4	1					switch	SET			1						1.00					1.00				
	1	4	2					router	SET			1						5.00					5.00				
	1	4	3					cables & connectors	SET			1						2.00					2.00				
	1	5	4					COOLING and CONDITIONING	EACH		1													29.00			
	1	5	1					Conditioning	SET			1						20.00					20.00				cost estimated by LNGS services
	1	5	2					Cameras chiller	SET			1						5.00					5.00			5.00	device purchased
	1	5	3					PMTs flow system	SET			1						2.00					2.00				
	1	5	4					Cables & connectors	SET			1						2.00					2.00				
	1	6						SAFETY (PRA-VIA)	EACH		1													41.00			
	1	6	1					PRA	SET			1						2.50					2.50			2.50	device purchased
	1	6	2					VIA+VINCA	SET			1						3.50					3.50			2.50	device purchased VICA to be done, cost estimated by NIER
	1	6	3					fire detection system	SET			1						10.00					10.00				cost estimated by LNGS services
	1	6	4					gas monitor system	SET			1						15.00					15.00				cost estimated by LNGS services
	1	6	5					fire safety design and adminstration	SET			1						10.00					10.00				cost estimated by LNGS services
	1	7						CIVIL WORK	EACH		1													40.00			
	1	7	1					controll room container	SET			1						25.00					25.00				cost estimated by LNGS services
								gas system box										10.00									cost estimated by LNGS services
	1	7	2					water tub	SET			1						15.00					15.00				cost estimated by LNGS services
	1	8						DESIGN AND DOCUMENTATION	EACH		1													5.00			
	1	8	1	1				software	SET			1						5.00					5.00			5.00	

screenshot of the CBS[67]

phase 1 - CYGNO-04

status and update

- The CSN2 **approved** the TDR and the budget for running costs, but:
  - we have to reach the **milestones for 2023 for LIME** (low noise - consistence with expectation - energy spectra and Montecarlo comparison)
  - we have to reach the **CYGNO04 milestones 2023** (gas, FC and GEM)
- moreover an unified **review committee CSN2-LNGS** is seated up to follow the project



Milano, 28 Settembre 2022

Dr. Davide Pinci
INFN - Roma
c.c.
CSN2
Referee CYGNO
prof. Maura Pavan
dott. Giorgio Riccobene
dott. Sandra Zavatarelli

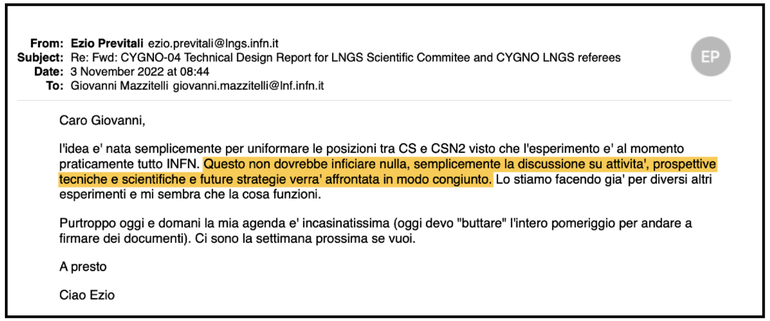
Caro Davide,
nel corso della riunione di bilancio della CSN2 tenutasi a Napoli dal 19 al 23 Settenbre 2022, la Commissione II ha analizzato e valutato il TDR e le richieste presentate dal gruppo INFN della sigla CYGNO.

La commissione giudica positivamente il TDR di Cygno-04 notando che, in quanto progetto finanziato ERC, ha un profilo di rischio più alto di quello normalmente accettato per un progetto di commissione 2. Richiede che il TDR venga aggiornato appena siano disponibili i risultati ottenuti dal run underground del prototipo LIME (performance, stabilità temporale, background model) e dai test previsti per il prossimo anno su catodo, field cage, ecc.

La commissione approva il piano finanziario proposto dalla collaborazione CYGNO che prevede, da parte della Commissione, un contributo massimo di 120 k€/anno (inclusivo di ogni voce di spesa). L'approvazione si riferisce per il momento ai due anni previsti per la costruzione: 2023 e 2024. Quando sarà disponibile il TDR aggiornato secondo le richieste sopra menzionate, la Commissione procederà alla discussione del piano di spesa previsto per gli anni 2025-2027 che servirebbe a sostenere i costi di operazione del dimostratore.

Distinti saluti,

Dr. Oliviero Cremonesi
(Presidente CSN2 dell'INFN - Fisica Astroparticellare)



From: **Ezio Previtali** ezio.previtali@lngs.infn.it
Subject: Re: Fwd: CYGNO-04 Technical Design Report for LNGS Scientific Commitee and CYGNO LNGS referees
Date: 3 November 2022 at 08:44
To: Giovanni Mazzitelli giovanni.mazzitelli@lnf.infn.it

EP

Caro Giovanni,

l'idea e' nata semplicemente per uniformare le posizioni tra CS e CSN2 visto che l'esperimento e' al momento praticamente tutto INFN. Questo non dovrebbe inficiare nulla, semplicemente la discussione su attivita', prospettive tecniche e scientifiche e future strategie verra' affrontata in modo congiunto. Lo stiamo facendo gia' per diversi altri esperimenti e mi sembra che la cosa funzioni.

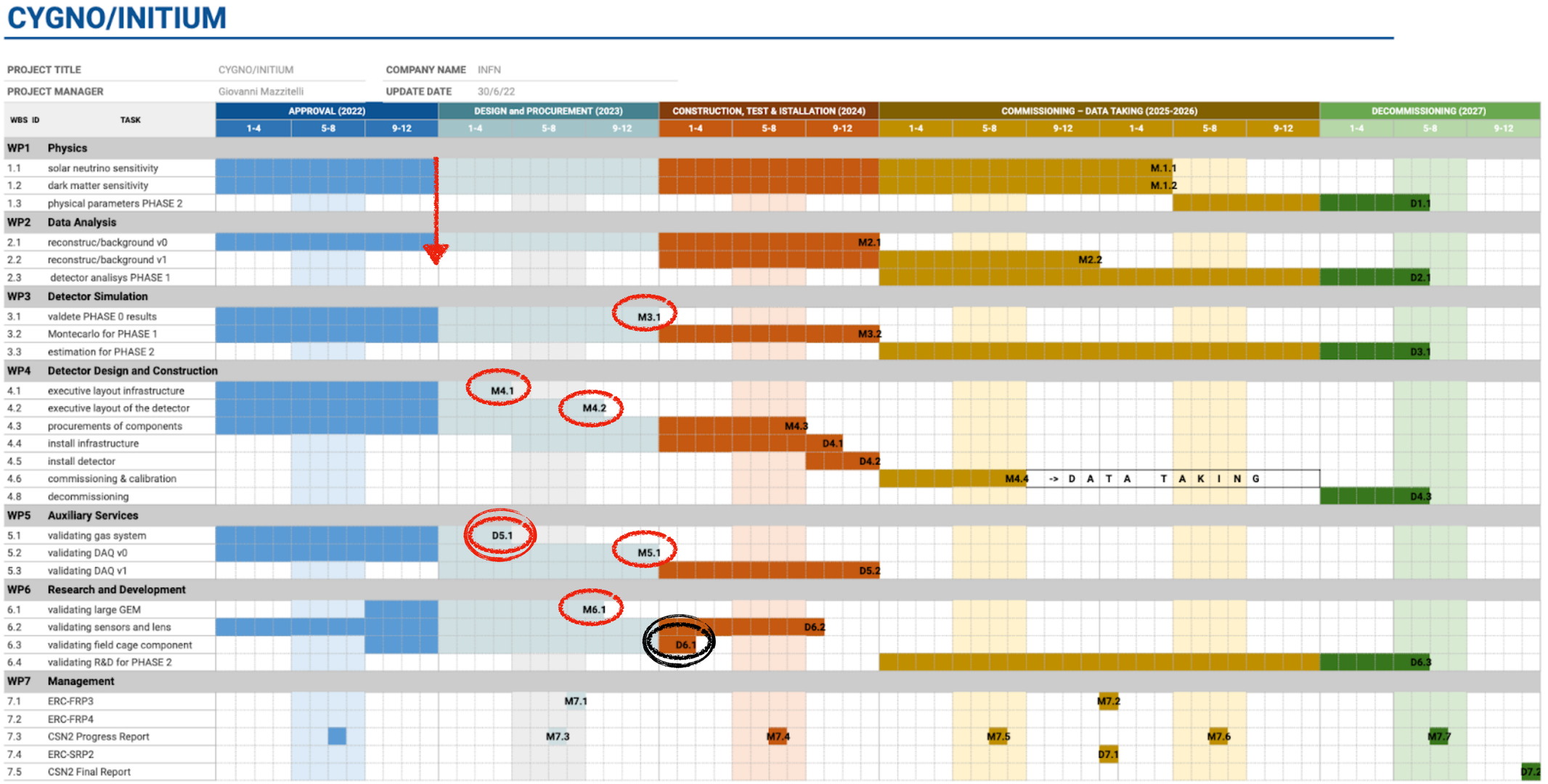
Purtroppo oggi e domani la mia agenda e' incasinatissima (oggi devo "buttare" l'intero pomeriggio per andare a firmare dei documenti). Ci sono la settimana prossima se vuoi.

A presto

Ciao Ezio

FASE 1 - CYGNO-04

TDR V1



phase 1 - CYGNO-04

what next steps for 2023?

- WP3 Detector Simulation, Dr. G. D'Imperio INFN-ROMA1. The WP is in charge to develop fast and full **simulation of the detector background** and to evaluate systematics and uncertainty of detection resolution, efficiency, discrimination, directionality, ecc, ecc.. The WP can exploit the results of LIME detector by validating the simulation that should be fully scaled and applied to PHASE 2 expected results:

  - **validate Montecarlo simulation from the PHASE 0 results (M3.1)**
  - implement final Montecarlo for PHASE 1 based on the executive detector layout (M3.2)
  - elaborate the estimation for PHASE 2 (D3.1)

phase 1 - CYGNO-04

what next steps for 2023?

- WP4 Detector Design and Construction, Dr. G. Mazzitelli INFN-LNF, the WP is in charge of the **design, construction and implementation of the detector**, the shielding and infrastructures. It is also in charge to coordinate installation and maintenance activities and to ensure the application of safety and environmental regulations of the area and its infrastructure
  - **executive layout of the area and its infrastructure (M4.1)**
  - **executive layout of the detector (M4.2)**
  - procurements of components (M4.3)
  - infrastructure installation (D4.1)
  - detector installation, gas system, electronics, computing, ecc. (D4.2)
  - commissioning and calibration (M4.4)
  - decommissioning (D4.3)

phase 1 - CYGNO-04

what next steps for 2023?

- WP5 Auxiliary Services, Dr. F. Renga INFN-ROMA1. The WP is in charge of all **Axillary System** (6.3-6.7): Gas System, HV and LV, DAQ and computing. All Hardware of those systems has been purchased for PHASE 0 and is under test at LNGS as well as the software needed to control equipment and acquire data.
  - **validating gas system (included purification and recycle) (D5.1)**
  - **validating DAQ, slow controls and data quality monitor v0 (M5.2)**
  - validating DAQ multi camera and data quality monitor v1 (D5.2)

phase 1 - CYGNO-04

what next steps for 2023?

- WP6 Research and Development , Dr. Davide Pinci INFN-ROMA1. The WP is in charge of the **development ongoing for PHASE 1** (chapter 3) and the study needed to enhance the performance for PHASE 2 (chapter 4)
- **validating large GEM (M6.1)**
- **validating low radioactivity field cage component (D6.1)**
- validating large sensors and low radioactivity lens (D6.2)
- validating R&D for PHASE 2 (D6.3)

conclusion
and critical issues

- **LIME is producing data** and we are starting the detector shielded phase
  - the strong **delay in LIME** data taking due to gas system (still not fully resolved) and delivery of hardware needs, are **delaying analysis and consequent Montecarlo comparison.**
  - because next steps are **not reversible** (data lost, are lost!) and we still do not have a **stable DAQ/quality monitor** as well as **qualification of materials** used in the Montecarlo this item and have to go straight and needs of **strong interaction among the groups** (eg. full reco vs online reco, computing infrastructure ecc)
- the **CYGNO04 preliminary project and TDR are ready** and approved, costs are evaluated within the review of the LNGS services, administrative tasks are well ahead
  - all the effort are now on LIME installation while milestones for the design of executive project are close. Something needs the LNGS feedback to be completed but time is running and we are far from **executive infrastructure and detector design** (see next).

conclusion
and critical issues

- **The gas system and DAQ** are in operation and allows us to go ahead.
  - nevertheless, the gas system is critical, **recycle and purification** are not possible up to now and the deliverable is close.
  - **DAQ and Middle Ware** needs more stability and care to production/development implementation (eg. software/hardware at LNF/LNGS have to be aligned; tests have to be performed at LNF and then implemented at LNGS)
- **development for CYGNO04 started**, GEM as been acquired with low radioactivity frame, FC materials is purchased and under mechanical test.
  - these are crucial for detector design, moreover we **need to qualify the choice and the procedure of assembly** this components as required by our reviewers for this and other materials used.