INTERNE

Workshop R&I – SLS II

4-7 May 2026

Removal and Installation: Girder Assembly and Dark Period

F. Trias

on behalf of SOLEIL II Project Team

SOLEIL II

La science éclaire l'avenir

Science lights up the future

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Work in progress

1. Girders assembly: from magnets delivery to girders assembled ready for installation
   - Simulation of an optimized schedule for the assembly

2. Provisional schedule of the dark period
   - Constraints, organization, and challenges

Simulation of an Optimized Schedule for the Girders Assembly

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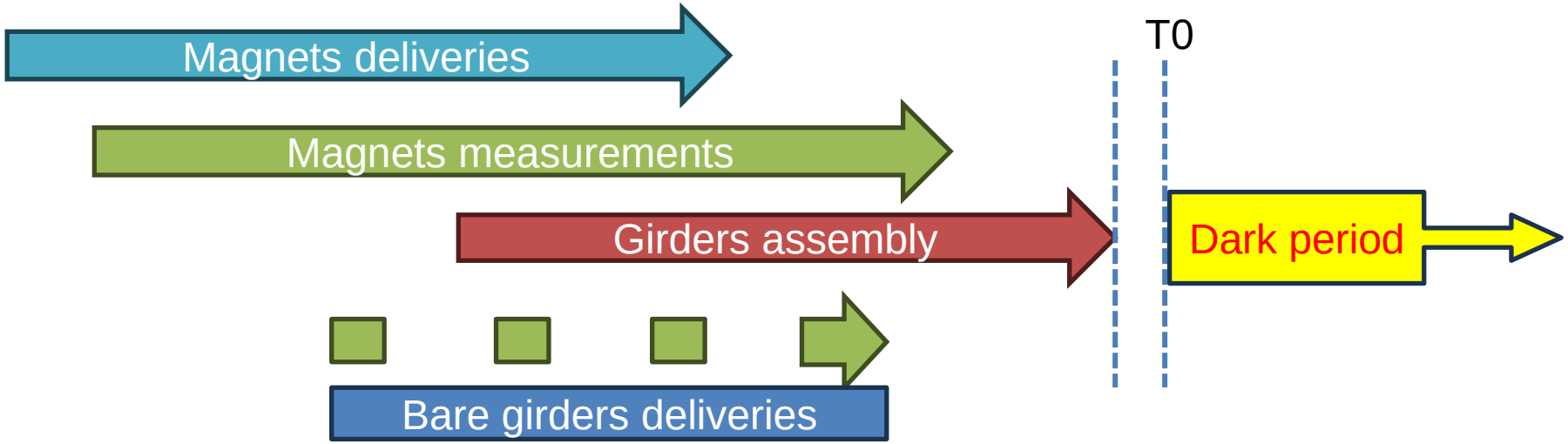
Purpose of simulation study:

- Based on the magnets delivery and measurement schedule established by the Workpackage 1.1.2 (Magnets) in ORCHESTRA, the objective is to investigate the feasibility of starting girders assembly as early as possible, without waiting for all magnets to be measured, in order to estimate the milestone of the dark period start date.



Working Assumptions

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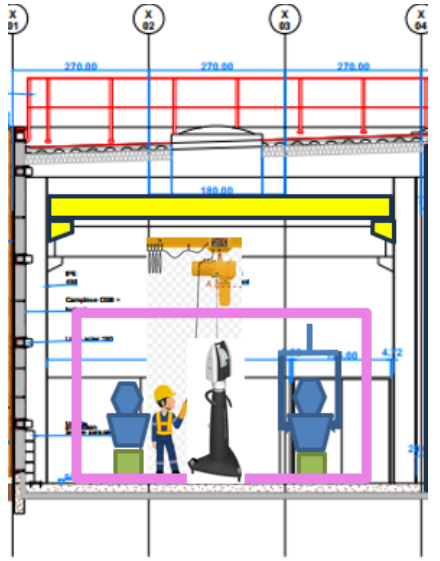
- Initial assumptions:
  - The girders are available: no delays in the delivery of the girder batches, particularly batch 4
  - All equipment to be mounted on the girders is ready (BPM feet, crotch, ion pumps feet, valves...)
  - The facility (girders assembly hall in T5 building) and the two assembly benches are ready
  - The necessary staff is available: mechanics, aligners, and material handlers
  - The necessary tools are available.
  - Since all dipoles must be sorted, assembly cannot begin until all measurements are complete (104 units).
  - Enough EM pairs (SEXT/OCT and SEXT/QUAD doublets) must be measured to begin assembling a girder.

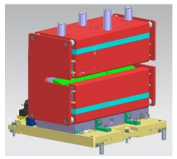
Girder order key dates

Phase	Provisional date
Advertising and application	March 2026
Call for tender	May-June 2026
Analysis of bids	July 2026
SOLEIL council validation	Sept. 2026
Kick-off meeting	Oct. 2026
Batch 0 FAT	Feb. 2027
Batch 1 FAT	June 2027
Batch 2 FAT	Dec. 2027
Batch 3 FAT	June 2028
Batch 4 FAT	Dec. 2028

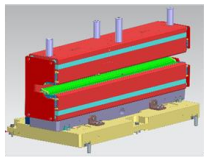
T5 building – partial views



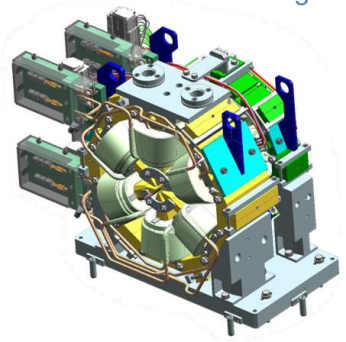
Thermal regulation 21 °C ± 0, 25°C



DNC
Short combined

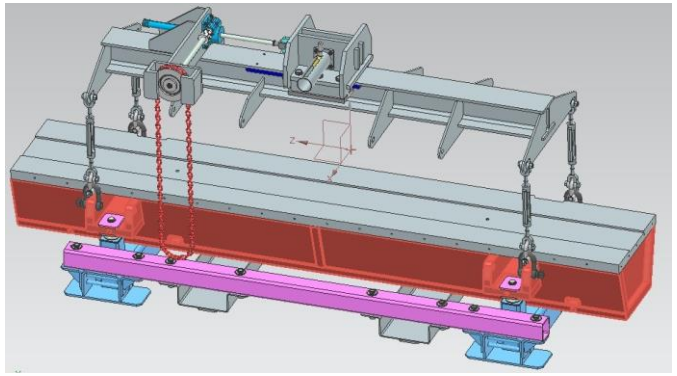


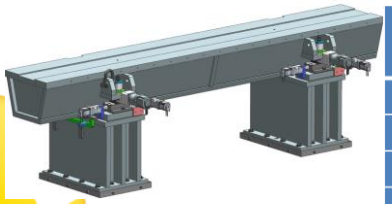
DNL
Long combined



372 doublets

Girder and lifting beam





Girder Family	Quantity	Length (mm)	Girder weight (kg) including plinths
Short	32	2970	2700
Medium	32	3120	2766
Medium Long	4	3280	2836
Long	12	3430	2902
Extra Long	4	3470	2926
Triplet SD06L	1	1000	1800
Triplet SD16L	1	2100	2326

Preparation & Studies

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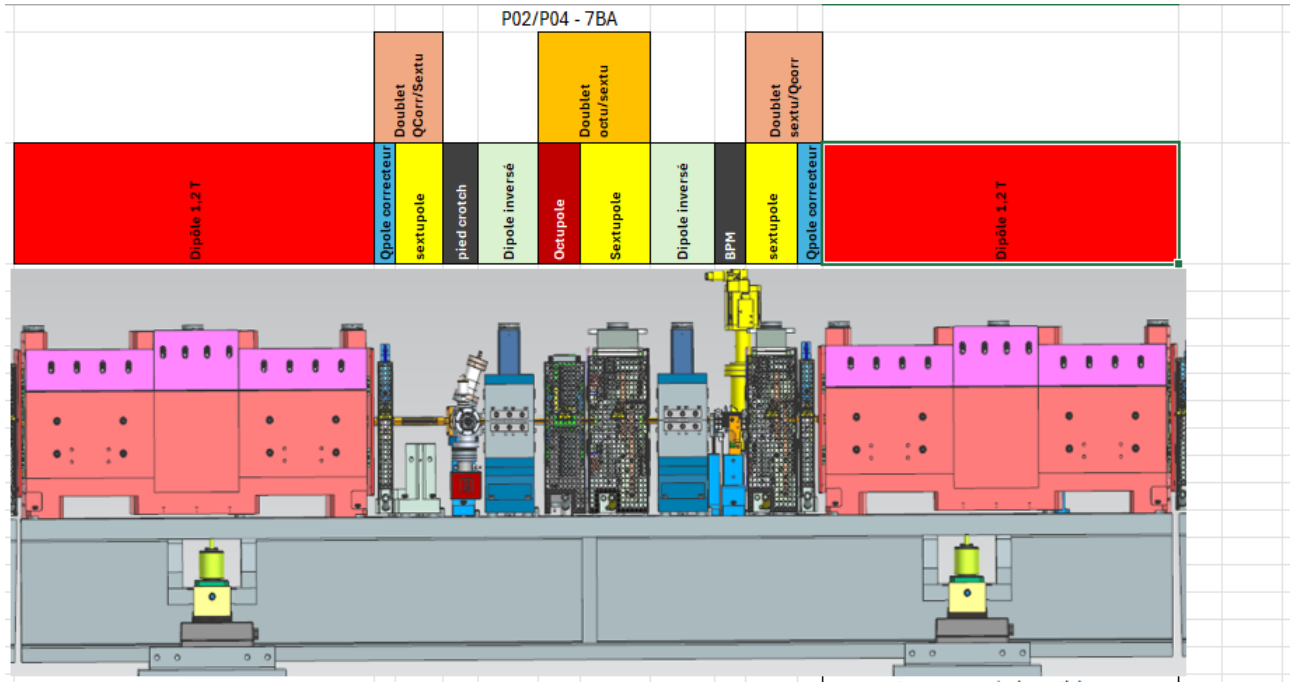
- A study to define the **methodology** for assembling magnets and equipment on all types of girders was conducted.

- **Assembly sequence**: dipoles, other permanent magnets (quadrupoles, RB), doublets, and standalone sextupoles. Install protective measures where necessary to prevent magnetism-related shocks and use non-magnetic tools.

- In parallel, estimated assembly and measurement times—including those for magnetic shimming—have been established to enable planning of the number of girders processed per week and per bench.

- The estimated time for the girder type shown in the picture is **3.7 hours**, including alignment (without shimming)



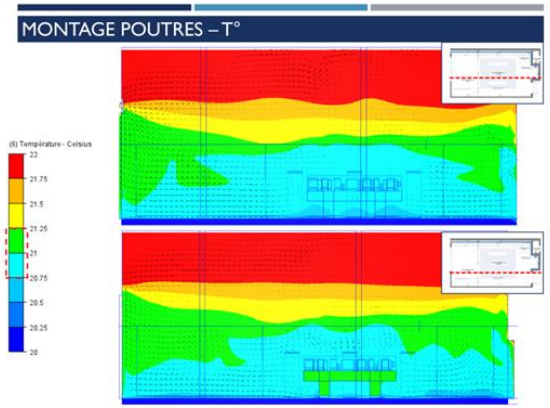
	temps en min hypothèse		
dipôle 1,2 T 2 avec protection magnétique	30	PM	
dipôle 1,2 T 1 avec protection magnétique	30	PM	
dipôle inversé 1avec protection magnétique	20	PM	
dipôle inversé 2avec protection magnétique	20	PM	
doublet octu/sextu 1(avec protection mag dipôles inversés 1 et 2)	30	EM	
doublet Qcorr/sextu 1(avec protection magnétique)	30	EM	
doublet sextu/Qcorr 1(avec protection magnétique)	30	EM	
pied crotch	5		
pied BPM	5		
TOTAL montage	200	3,3	heures
mesures alignement totalité équipements poutres	20	0,3	heures
	220	min	
	3,7	heures	

Assembly Hall and different types of girders

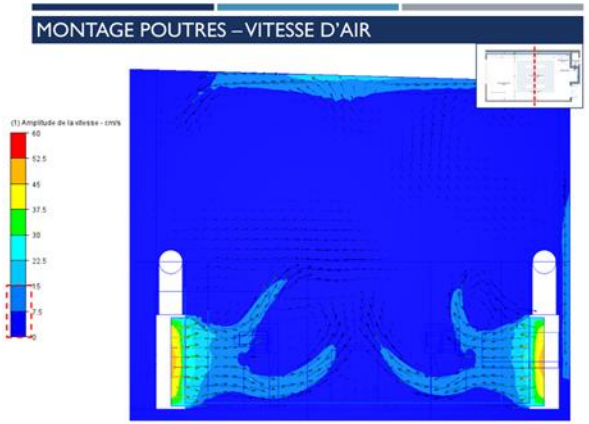
CFD (Computational Fluid Dynamics) Studies for the Girder Assembly Area

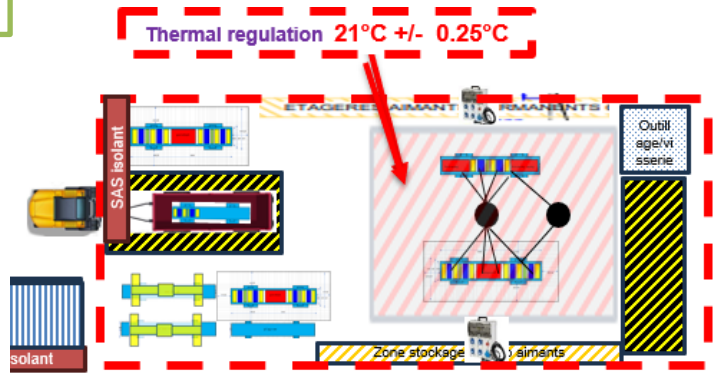
T5 Girders assembly and alignment area

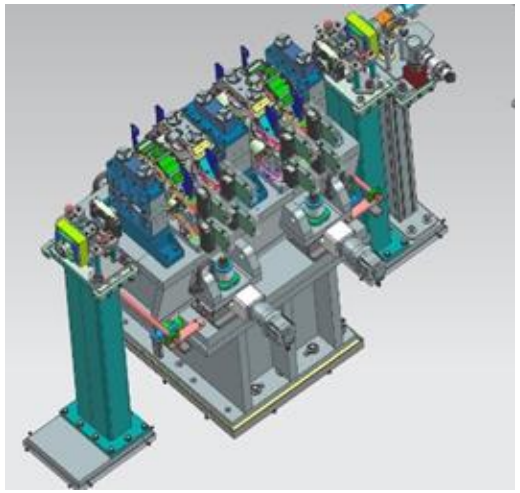
Temperature regulation



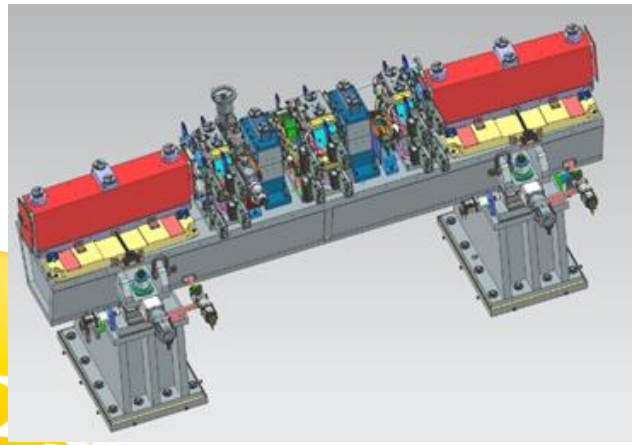
Airflow speed measurement



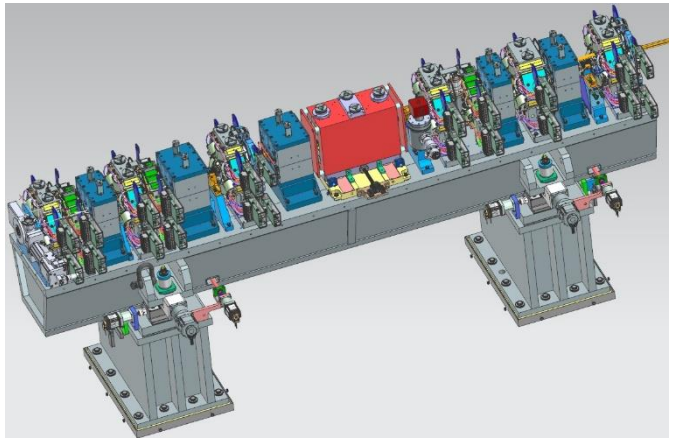




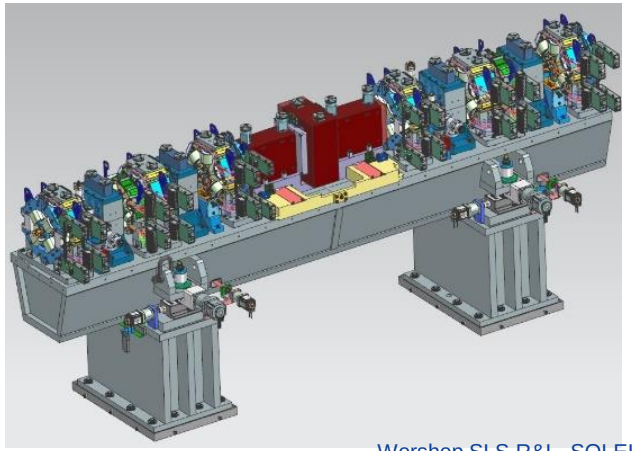
Triplet SD06L



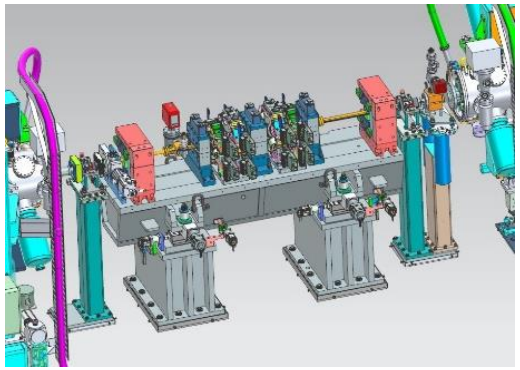
32 Short (P2 & P4)



40 Medium Long (P1 et P5 7BA et P3 4BA)



12 Long (P3-7BA)



Triplet SD16L

Girders Selection to be Assembled First

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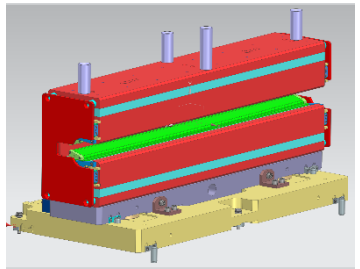
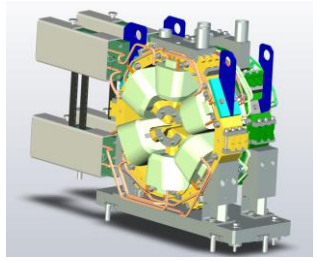
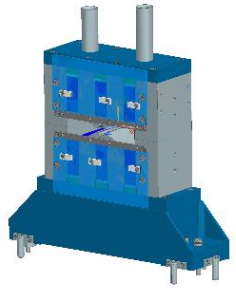
- Analysis of the components of the various girders has shown:

  – The P2 girder (common to 7BA & 4BA achromats) and the P4 girder (of 7BA achromat) are very similar and use only 6 different types of doublets (out of the 27 predefined for the complete SR) – a total of 96 doublets are required for 32 girders.
  – Composition: 7 magnets ((2 long dipoles, 3 doublets, 2 reverse-bend) + 1 BPM) (compared to 13 components on a P1-type girder)
  – Alignment specifications of the magnets are 25 µm rms for the girders of the achromats and 10 µm rms for the magnets on the matching girders.
  – The bare girders (P2 & P4) are all short girders (32): batch 1 and batch 2 delivered (and inspected)

➢ Based on these information, we propose starting the assembly with P2 and P4 girders.
➢ To ensure enough doublets for this type of girder, the doublet types required by the P2 and P4 girder configurations must be available first.


DNL Long combined


Sext.-Oct. Doublet


Reverse bend

Required Magnets & Doublets for the Assembly (previous delivered & measured)

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- Required magnets for the assembly of 32 P2 & P4 girders: 96 doublets (192 magnets) + 128 PM (64 long dipoles and 64 RB), making a total of 320 magnets.

CUMUL AIMANTS	nbre	20 P2	nbre	12 P4	
32	20	OCT_19	12	OCT_19	
16	16	SXT_6,2_16_120_AV_OCT_19_L150			
5	4	SXT_6,2_16_120_AM-OCT_19_L150	1	SXT_6,2_16_120_AM-OCT_19_L150	
11			11	SXT_6,2_16_120_O1_AM-OCT_19_L150	
21	20	SXT_6,2_16_90_AM-QCORR_19_L105	1	SXT_6,2_16_90_AM-QCORR_19_L105	
32	20	SXT_6,2_16_90_AV-QCORR_19_L105	12	SXT_6,2_16_90_AV-QCORR_19_L105	
11			11	SXT_6,2_16_90_C_AM-QCORR_19_L105	
64	40	QCORR_19	24	QCORR_19	
16	16	DI_6.48_21_126_2.38			
48	24	DI_6.48_21_126_2.49	24	DI_6.48_21_126_2.49	
46	23	DNL_7BA	23	DNL_7BA	triés
16	16	DNL_4BA			triés
1	1	DNL2_7BA			triés
1			1	DNL1_7BA	triés
320					

6 types du point de vue BE

CUMUL DOUBLETS P2 P4	nbre	P2	Aimant 1	Aimant 2	nbre	P4	Aimant 1	Aimant 2
21	20	Sextu/QCORR	SXT_6,2_16_90_AM-QCORR_19_L105	QCORR_19	1	Sextu/QCORR	SXT_6,2_16_90_AM-QCORR_19_L105	QCORR_19
32	20	QCORR/sextu	QCORR_19	SXT_6,2_16_90_AV-QCORR_19_L105	12	QCORR/sextu	QCORR_19	SXT_6,2_16_90_AV-QCORR_19_L105
5	4	Sextu/octu	SXT_6,2_16_120_AM-OCT_19_L150	OCT_19	1	Sextu/octu	SXT_6,2_16_120_AM-OCT_19_L150	OCT_19
16	16	Octu/sextu	OCT_19	SXT_6,2_16_120_AV_OCT_19_L150				
11					11	Sextu/octu	SXT_6,2_16_120_O1_AM-OCT_19_L150	OCT_19
11					11	Sextu/QCORR	SXT_6,2_16_90_C_AM-QCORR_19_L105	QCORR_19
96	60				36			

Assembly of the 54 Remaining Girders

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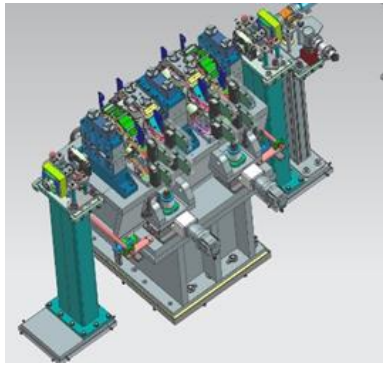
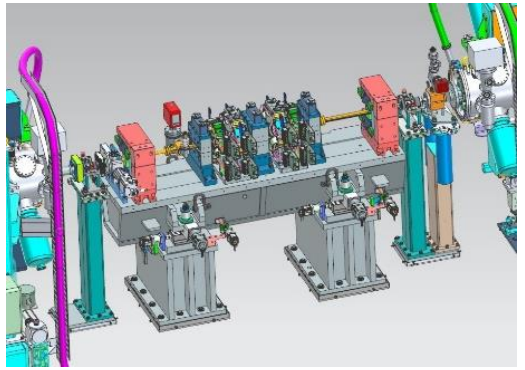
- Next types of assembled girders:
  - 12 X girders P3 7BA
  - 20 X girders : 12 X P5 girders (matching 7BA) and 8 X P3 girders (matching 4BA) :
  - 20 X P1 girders (matching 7 and 4BA)
  - 2 X specials girders for the straight sections (SD06L and SD16L)



Triplet SD06L

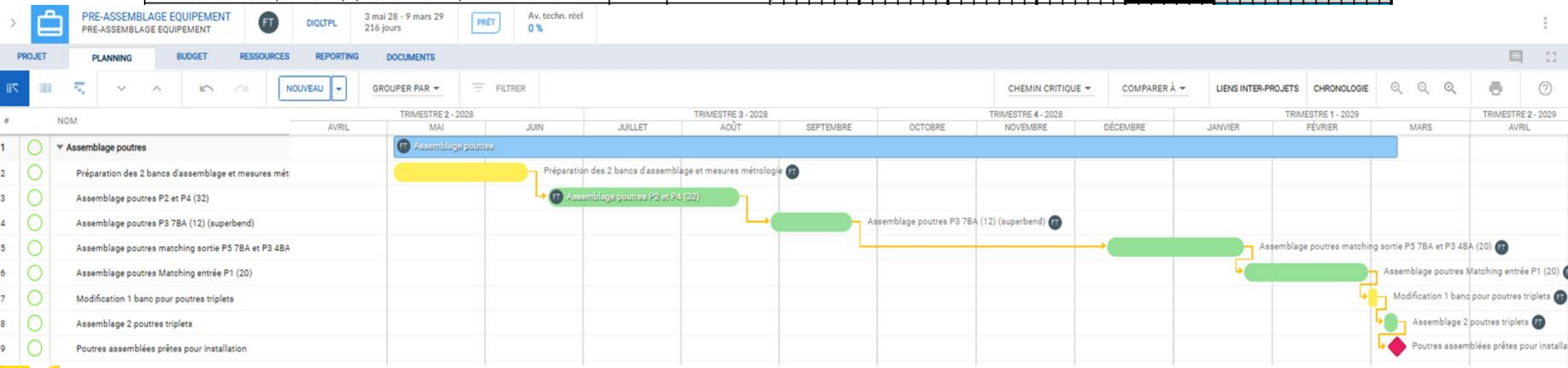


Triplet SD16L

Girders Assembly Schedule

INTERNE

	Banc	Ressources Hu
Poutres P02(20) et P04(12)		
Assemblage P02-1	Banc 1	Monteurs 1
Mesures P02-1	Banc 1	Aligneurs 1
Dépose P02-1/Mise en place P02-3	Banc 1	Monteurs 1
Assemblage P02-3	Banc 1	Monteurs 1
Mesures P02-3	Banc 1	Aligneurs 1
Dépose P02-3	Banc 1	Monteurs 1
Assemblage P02-2	Banc 2	Monteurs 2
Mesures P02-2	Banc 2	Aligneurs 2
Dépose P02-2/Mise en place P02-4	Banc 2	Monteurs 2
Assemblage P02-4	Banc 2	Monteurs 2
Mesures P02-4	Banc 2	Aligneurs 2
Dépose P02-4	Banc 2	Monteurs 2
Manutention : évac poutres équipées + transfert poutres nues +aimants		Monteurs 1 et 2



Total duration assembled schedule: 8 months

Human Resources and T5 Girders Assembly Area

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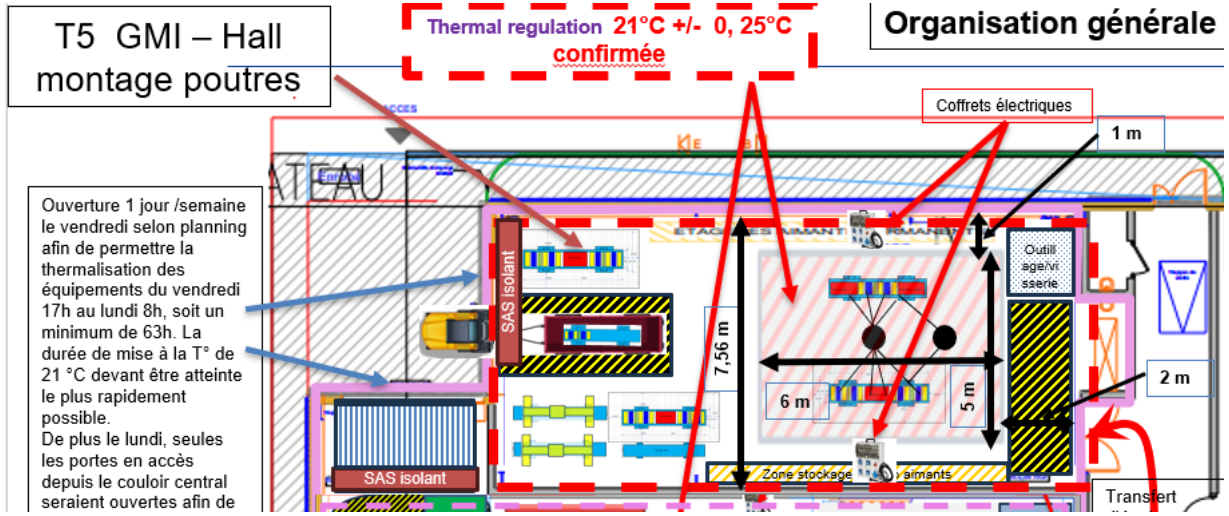
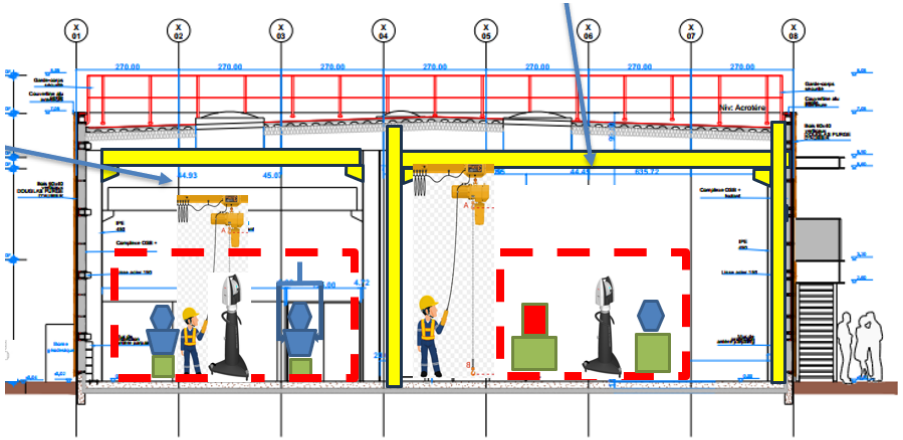
Human Ressources

Staff for assembling :

- 2 aligners for alignment and preparing the necessary shims
- 2 assembly mechanics
- 1 warehouse worker for handling
- 1 warehouse workers more to prepare magnets and girders before transport and storage for thermalization in T5 and to handle the removal of the assembled girders on Friday

T5: girders assembling Area

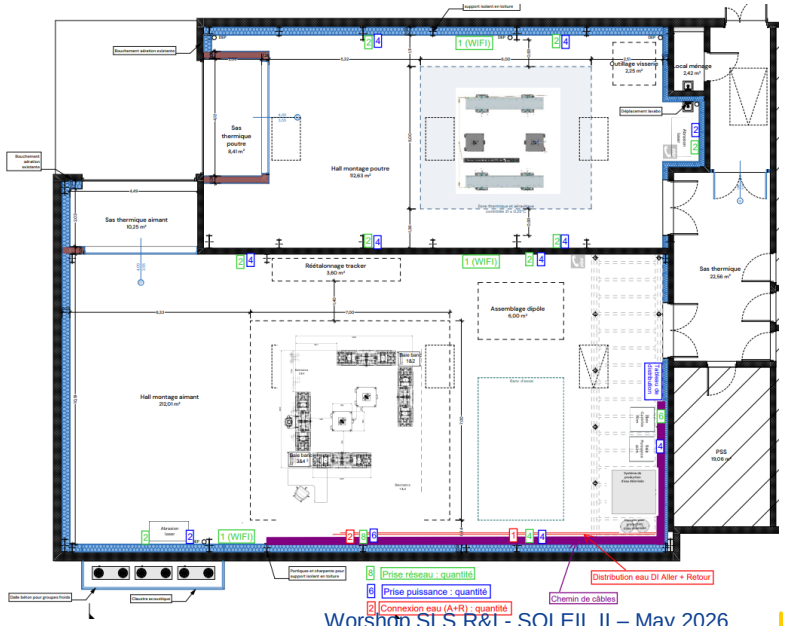




BB

Thermal regulation 21 °C ± 0, 25°C

Thermal regulation 21 °C ± 0, 25°C



Conclusion

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The total assembly period spans approximately 8 months, but not continuously, and at a pace that allows for managing potential unforeseen circumstances.

This scenario optimizes overall planning by scheduling assembly as soon as possible without waiting for all the magnets to be measured.

The conditions for successfully meeting this challenge include:

- The ability to organize the manufacturing order of the magnets;
- The ability to plan the assembly and measurement order of the magnets while managing the use of the four designated test benches;
- The availability of the necessary human and materials resources.

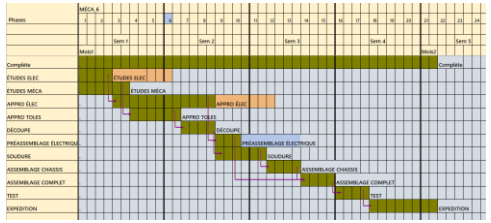
➢ This study demonstrates that, given the current state of supply schedules, a shutdown is conceivable for spring 2029, with regard to the equipment concerned (bare girders and magnets).

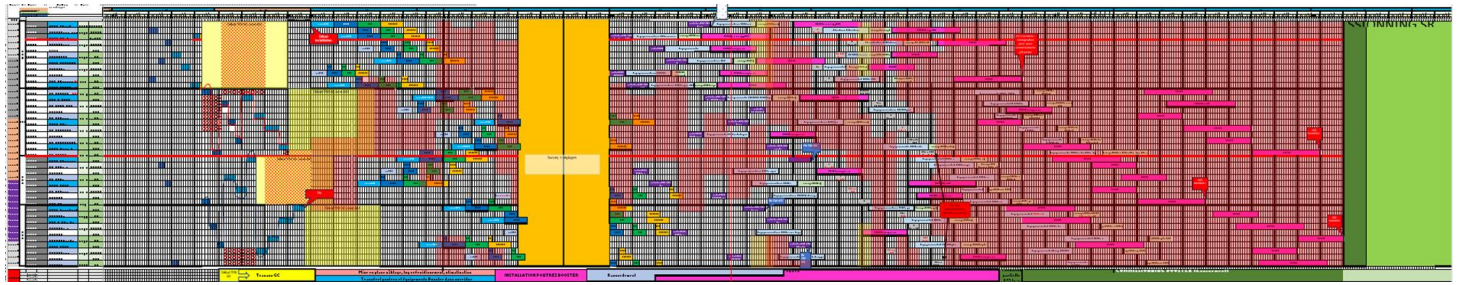
Preliminary Schedule for the Dark Period

INTERNE

- Constraints, organization, and challenges

- Start date of the dark period
- Duration of the dark period
- Planning and monitoring tools
- Overview of the current schedule
- Activities to be refined
- Excerpt from the ORCHESTRA schedule
- Excerpt from the MS Project schedule
- Perspectives





Start date of the Dark Period

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Principles to be validated:

- All administrative authorizations (safety/health program, ASNR (Nuclear Safety Authority), etc.) have been or will be approved before T0 or when needed
- All necessary infrastructure is ready: storage and technical buildings (T5,T3,T2,T1), temporary buildings, subcontractor site accommodation, Radiation safety building, heavy handling equipment,
- All critical pre dark period phase works are ready: Removal/Installation: subcontractors engaged, cabling + piping (with maximum advance planning), technical and needed resources validated, SOLEIL II supervision and organization validated
- Planning and availability of utilities/services (IT networks, water, air conditioning, compressed air, LN2, etc.)
- All supporting documents are (must be) ready (assembly plan)
- All critical equipment is ready: equipment related to the Machine (SR and Booster) must be ready when needed for installation without disrupting the progress of the works (to avoid overlapping or concurrent use of resources (human or tools)
- All the 86 girders assembled are ready

⇨ Drawing up a list of critical points or key milestones in the master schedule required to confirm a T0

⇨ Defining the minimum lead time required to confirm this date, after which it cannot be changed without significant consequences

⇨ Determining the best time to implement the dark period, accounting for the French summer break.

Dark Period Duration

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- Validate a tentative duration

  - Secure the critical path
  - Define the main phases: dismantling, civil engineering, installation, commissioning (Linac, Booster, SR, and Beamlines)
  - Integrate the Beamline program (1.2)
  - Pre-define activities not essential to the restart
  - Identify risks of deviation: activities not fully defined from a technical perspective, need for additional information, validation by external third parties (ASNR – nuclear authority, technical certifications...), and validation of partners and subcontractors.
  - Multi-level activity monitoring structure (overall, monthly, weekly, daily): PSC Coordinator (Project Scheduling & Coordination) + Project Management

Target: 12 months for dismantling, civil engineering, installation and Linac and Booster Commissioning Periods

Planning and monitoring tools

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- Overview using Orchestra
- More detailed and operational monitoring view using MS Project
- Excel format for an initial overview
- Work organization:
  - Work in two shifts whenever possible
  - Work carried out simultaneously in several areas: management of concurrent activities, management of slabs opening/closing, resources (overhead cranes in particular), access (doors, walkways, SR and Booster doors, staircases, etc.), safety management (classic and RS)
- Site traffic management
- Saturdays and Sundays reserved for other work, with exceptions (e.g. preventive maintenance of cranes on certain Saturdays, etc.)

Activities to Refine and Monitor

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- Phasing of fluid and electrical utilities (SR and booster)
- Air conditioning work scope
- Drilling in the ratcheted wall (methodology, scope of work, phasing, lead, and concrete with hematite wall drill)
- Alignment phase duration, particularly adjustments following the survey
- Testing period validation
- Work phasing and duration beneath the technical hall's raised floors
- Simultaneous multi-zone work management
- Commissioning task breakdown to assess durations in greater detail
- Three crane work organization (two for the machine and one for the beamline program), with beamline program choice and priority validation

Storage Ring Installation: Synopsis

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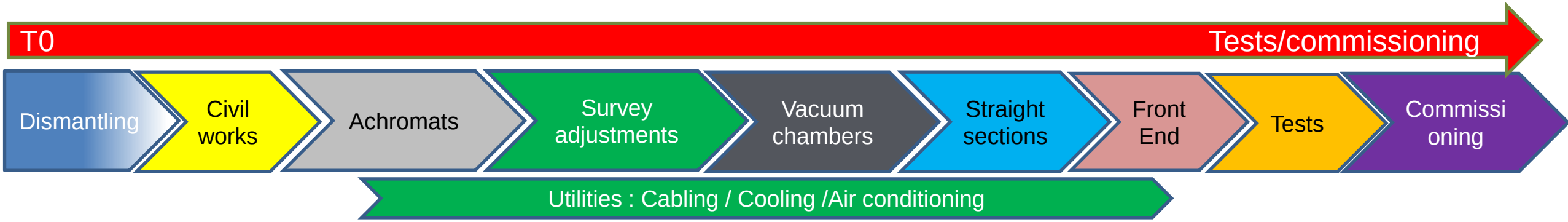


± long operations depending on the phases of:

- Alignment
- SSRA (Personal Safety System and Radiation Monitors)
- Infrastructures for indoor tunnel utilities
- RF and Pulsed Magnets in limited areas

Interfaces for Booster installation and handling for the Beamline program to be done :

- Cranes and traffic management
- Technical zone works, mainly cabinets
- Planning coordination

Storage ring and Booster Installation: General Overview

INTERNE

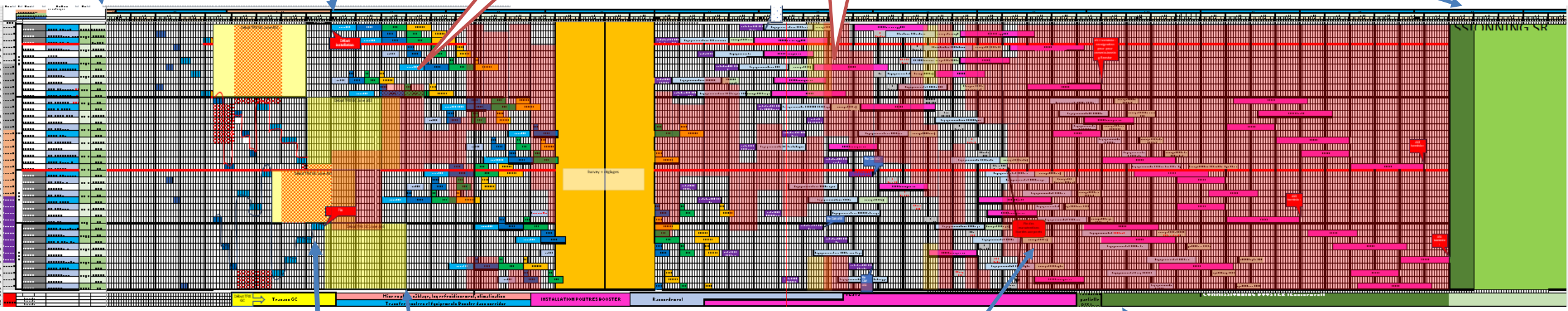
T0
28/10/28

Starting
Installation:
T0 + 2 months
Jan 2029

Zoom#1

Zoom#2

Starting commissioning
of the SR:
T0 + 12 months
Nov 2029



Ending removal :
T0 + 2 months
end of Dec 2028

End of civil work:
T0 + 2.5 months
mid Jan 2029

End of mechanical installation:
T0 + 8.5 months
Mid July 2029

Starting commissioning Linac
and Booster:
T0 + 9 months
august 2029

Removal: 2 months

Civil work duration: 2 months

Installation duration:
7 months

Test duration: 6 months

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Zoom#1 on Girders and 1st Step Utilities Installation

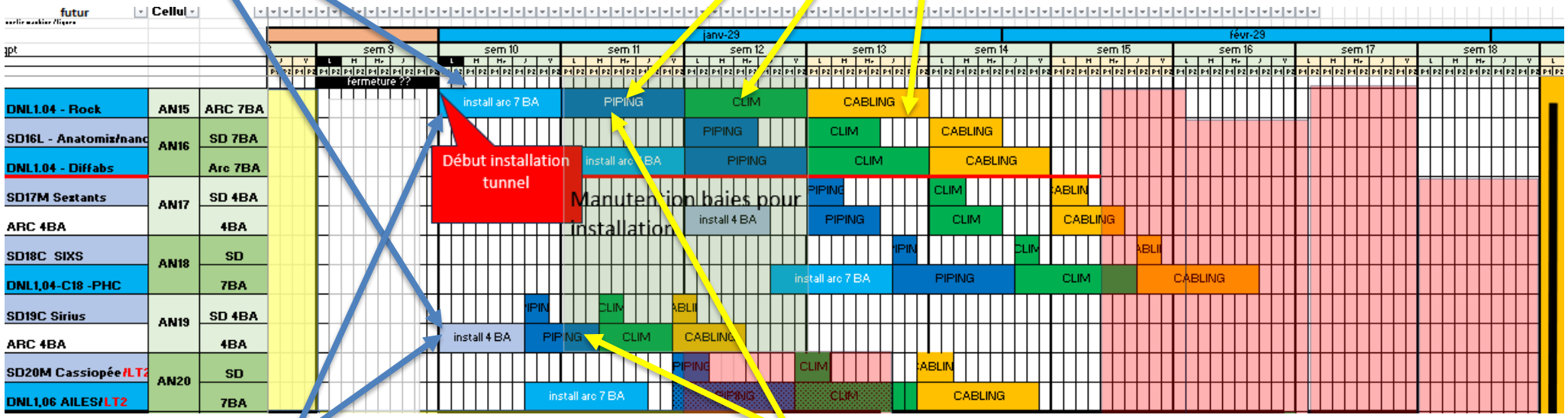
INTERNE

7BA (5 girders) and 4BA (3 girders) achromats installation:

- Roof slabs opening
- Girders + cooling piping (1 per girder) installation
- Roof slabs closing

Activities when the tunnel closed:

- Cooling piping mounting
- Air conditioning modification
- Starting cable routing



2 open cells processed simultaneously at all times: 2 teams in 2 shifts with 2 cranes

Tunnel closed: 2 similar activities (achromats or straight section) processed in 2 different areas at all time: 2 teams in 2 shifts without cranes

Zoom#2 Vacuum Chamber and Straight Section Installation

Vacuum chambers installation:
- Roof slabs opening
- Magnet Upper yokes removing
- Vacuum chamber installation
- Magnet upper yokes reassembly
- 1st step front-end installation
- Roof slabs closing

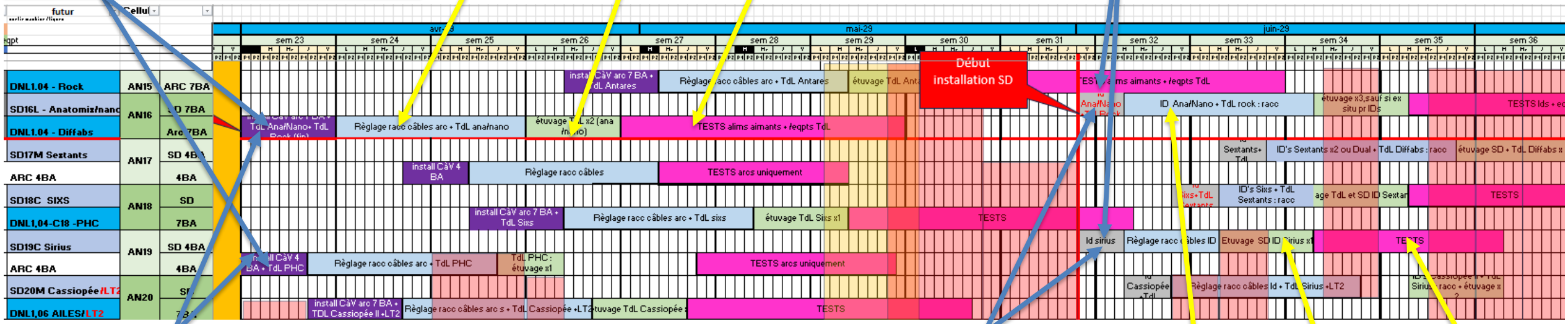
Electrical and hydraulic connections

Vacuum drying when necessary

First level equipment tests

2 open cells processed simultaneously at all time: 2 teams in 2 shifts with 2 cranes

Tunnel closed: 2 similar activities (achromats or straight section) processed in 2 or more different areas at all time: 1 or more teams in 2 shifts

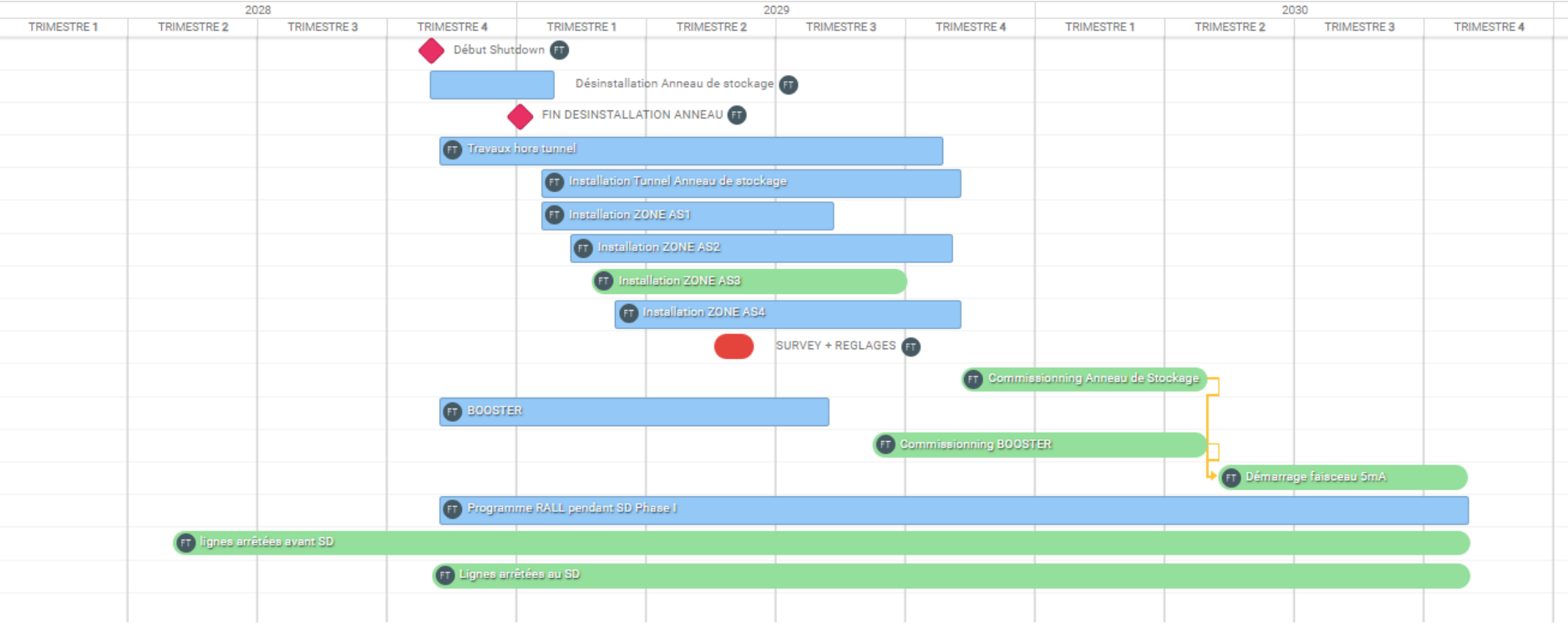


Straight section installation:
- Roof slabs opening
- Insertions devices installation
- 2 nd step front-end installation
- Roof slabs closing

Excerpt from the Orchestra Schedule

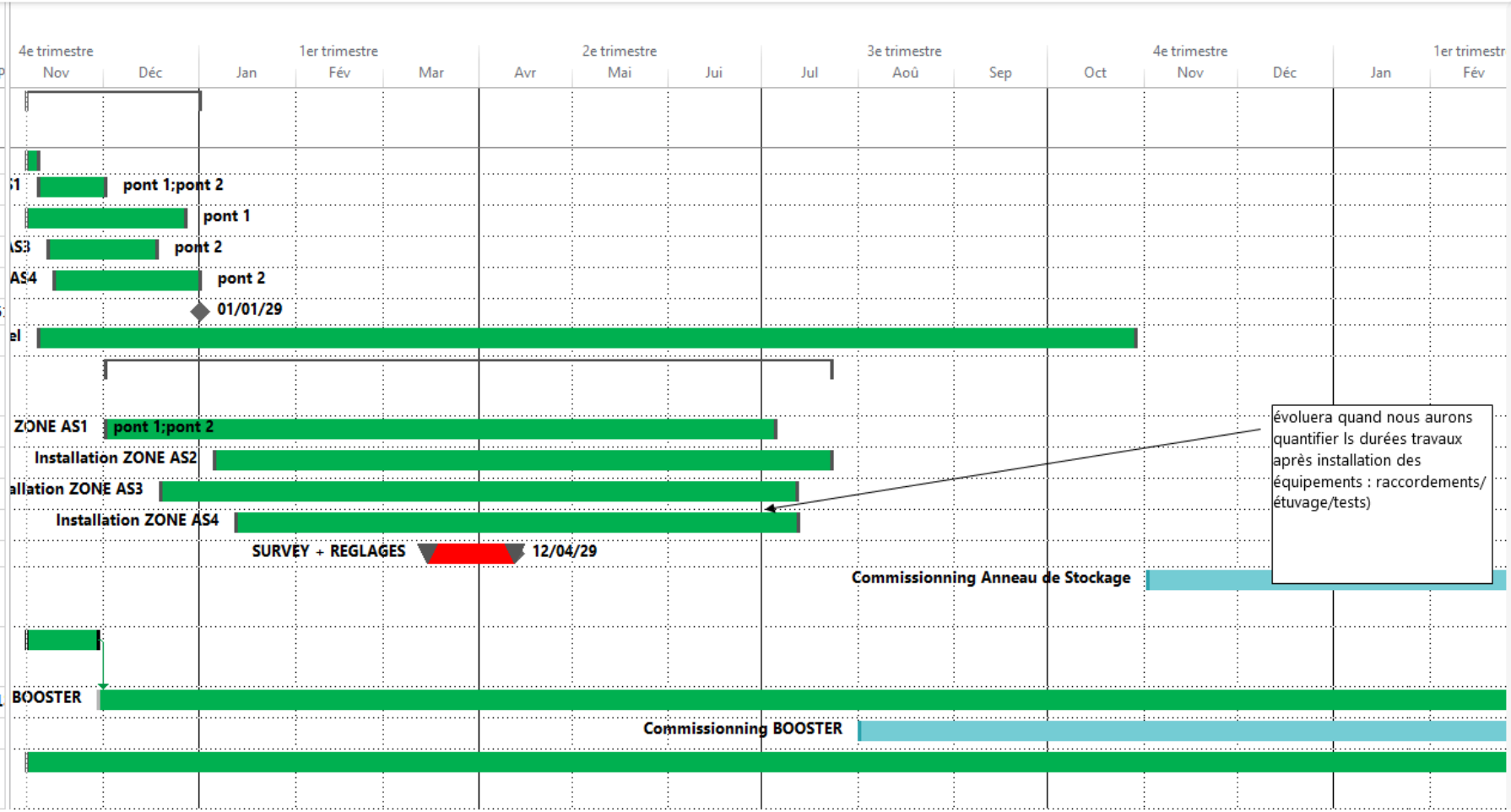
ERNE

#	NOM	RESP...	DÉBUT	FIN	DUR...	PF
1	Début Shutdown	FT Fr	1 nov. 28			
2	**Désinstallation Anneau de stocka...**	FT Fr	**30 oct. 28**	**25 janv. 29**	**58**	
12	FIN DESINSTALLATION ANNEAU	FT Fr	3 janv. 29			10
13	**Travaux hors tunnel**	FT Fr	**6 nov. 28**	**26 oct. 29**	**249**	
27	**Installation Tunnel Anneau de sto...**	FT Fr	**17 janv. 29**	**8 nov. 29**	**212**	
28	**Installation ZONE AS1**	FT Fr	**17 janv. 29**	**9 août 29**	**147**	**5**
38	**Installation ZONE AS2**	FT Fr	**6 févr. 29**	**1 nov. 29**	**194**	**7**
48	Installation ZONE AS3	FT Fr	21 févr. 29	1 oct. 29	159	9
49	**Installation ZONE AS4**	FT Fr	**9 mars 29**	**8 nov. 29**	**175**	
52	SURVEY + REGLAGES	FT Fr	18 mai 29	14 juin 29	20	50
53	Commissionning Anneau de Stoc...	FT Fr	9 nov. 29	29 avr. 30	115	51
54	**BOOSTER**	FT Fr	**6 nov. 28**	**6 août 29**	**190**	
58	Commissionning BOOSTER	FT Fr	7 sept. 29	29 avr. 30	160	57
59	Démarrage faisceau 5mA	FT Fr	8 mai 30	30 oct. 30	126	53,
60	**Programme RALL pendant SD Ph...**	FT Fr	**6 nov. 28**	**31 oct. 30**	**506**	
63	lignes arrêtées avant SD	FT Fr	2 mai 28	1 nov. 30	640	
64	Lignes arrêtées au SD	FT Fr	1 nov. 28	1 nov. 30	510	
	Nouvelle tâche (Maj + N)		1 nov. 27	12 nov. 27	10	



Excerpt from the MS Project Schedule: SR, Booster, Beamlines

Nom de la tâche	Durée	Début	Fin
Désinstallation Anneau de stockage	40,07 jours	Lun 06/11/28 07:00	Lun 01/01/29 08:39
préparation tunnel	4 jours	Lun 06/11/28 0	Ven 10/11/28
Désinstallation AS1	15,75 jou	Ven 10/11/28 (	Ven 01/12/28
Désinstallation AS2	36,86 jou	Lun 06/11/28 1	Mer 27/12/28
Désinstallation AS3	25,32 jou	Lun 13/11/28 0	Lun 18/12/28
Désinstallation AS4	33,07 jou	Mer 15/11/28 (	Lun 01/01/29
FIN DESINSTALLATION ANNEAU	0 jour	Lun 01/01/29 0	Lun 01/01/29
Travaux hors tunnel	251,07 jo	Ven 10/11/28 (	Lun 29/10/29
Installation Tunnel Anneau de stockage	165,78 jours?	Ven 01/12/28 17:49	Lun 23/07/29 17:33
Installation ZONE AS1	153,21 jo	Ven 01/12/28 :	Jeu 05/07/29
Installation ZONE AS2	140,65 jo	Ven 05/01/29 :	Lun 23/07/29
Installation ZONE AS3	146,35 jo	Mar 19/12/28 :	Jeu 12/07/29
Installation ZONE AS4	128,73 jo	Ven 12/01/29 :	Jeu 12/07/29
SURVEY + REGLAGES	20 jours	Jeu 15/03/29 1	Jeu 12/04/29
Commissionning Anneau de Stockage	127,85 jours	Ven 02/11/29 07:00	Mar 30/04/30 21:00
Désinstallation-Installation Booster V4 - 2025-03-26 bis	17,21 jours	Lun 06/11/28 07:00	Mer 29/11/28 10:11
INSTALLATION BOOSTER	173,57 j	Mer 29/11/2	Ven 29/03/3 1
Commissionning BOOSTER	171,8 jou	Mer 01/08/29 (	Ven 29/03/30
Programme BL2 pendant Dark Period Phase I	509,39 jours?	Lun 06/11/28 07:00	Lun 21/10/30 07:01



Removal and Installation (R&I) Perspectives

INTERNE

- **Consolidation of Human Resources**
  - Staffing for girder assembly and R&I activities (include lastest update of the magnetic measurement planning and magnet delivery after the signature of the major contracts)
  - Coactivity management across concurrent operations
  - Identification of mitigation plans

- **Consolidation of the R&I Planning**
  - Alignment across all four programs
  - Injector work (Booster, TL2)
  - Civil works update following consultation with companies specialized in shielding wall drilling
  - Cabling & piping schedule
  - Cabinets refurbishment and installation schedule
  - Beamline installation and modifications
  - Utilities planning
  - Building planning update

- **Preparation for the Dark Period**
  - Identification of preparatory work to be completed during upcoming shutdown periods
    - Accelerator activity, beamline activity, utility pre-work, third crane installation...

Shutdown Provisional Schedule

INTERNE

- Thanks for listening

- Questions