EUROPEAN SPALLATION SOURCE

The challenges of neutron guide system installation @ ESS

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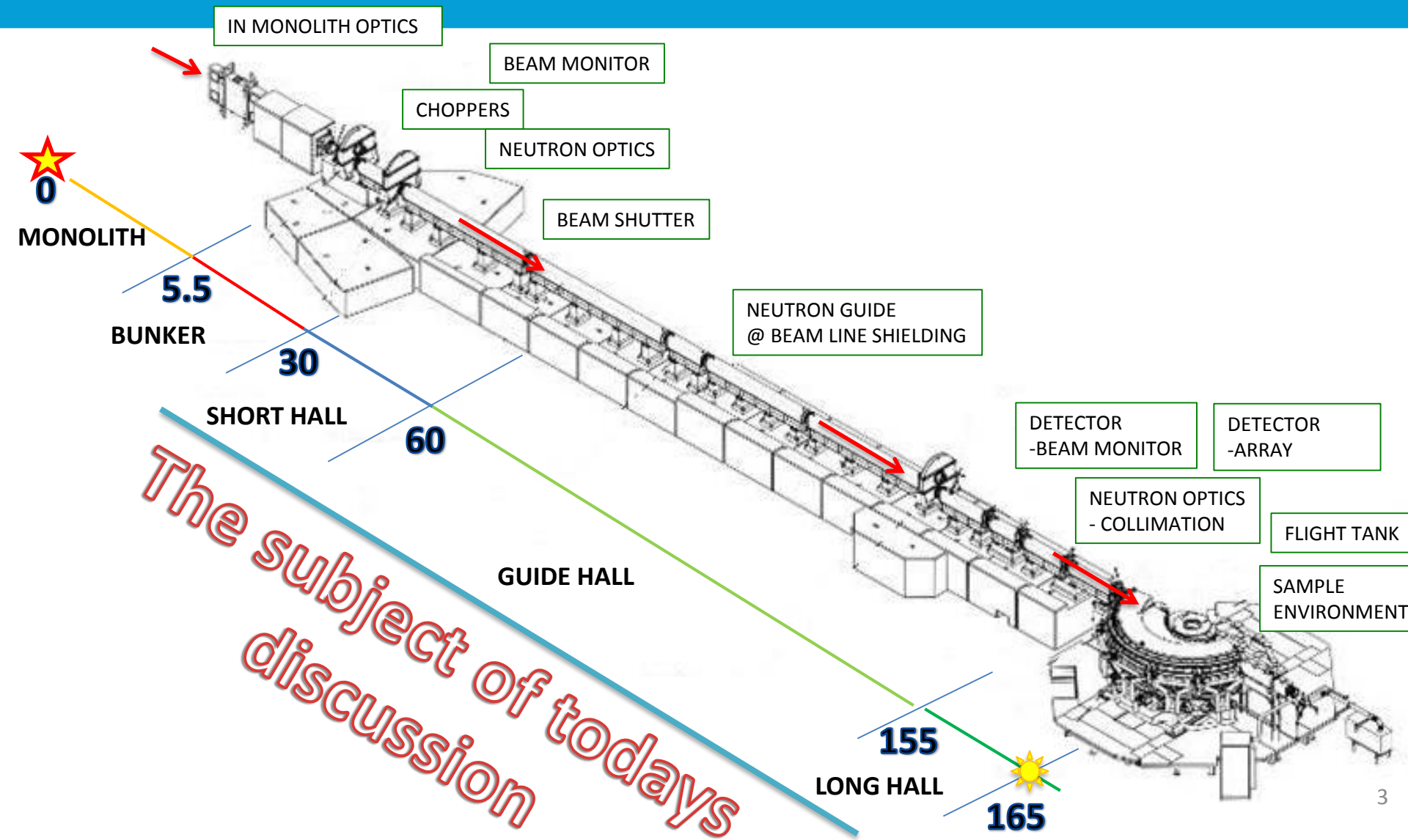
2017 07 11

Game plan

- Context
  - Best practice
- Scheduled mayhem
- Mayhem tamed, an example
- Plan ‘B’
- Start from here (origins)
- Ground movement
- Interfaced

ESS instruments



Guide systems installation
Basic principals ….

Things you know already but may yet forget

Preparation makes perfect

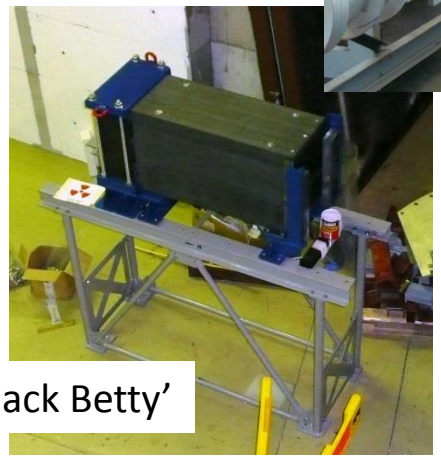
- plan, plan, **PLAN** (& follow up)
- Pre-assembly
- Pre-installation testing

Understand your ‘risks’

Have a ‘plan B’ !

  - Duck tape
  - Bath sealant
  - Lead bricks
  - ‘Black Betty’

Bunker Installation D01 side		522 days	Fri 20-02-28	Wed 22-06-08		
R6 weld-on brackets (n. 22)	BUNK01	22 days	Fri 20-02-28	Mon 20-03-30		
TD installation of light shutter frames and monolith puck	BUNK01	63 days	Tue 20-03-31	Fri 20-07-03	43	
TD fill gap between frame and monolith puck	BUNK01	15 days	Mon 20-07-06	Fri 20-08-21	44	
TD install insert cooling pipes, header pipe+80 branches+NDT	BUNK01	30 days	Mon 20-08-24	Fri 20-10-02	45	
Steel frame structure installation preparation (logistic)	BUNK01	5 days	Mon 20-08-24	Fri 20-08-28	45	
R6 pillars (n. 22)	BUNK01	8 days	Mon 20-08-31	Wed 20-09-09	47	
R6 beams (n. 3)	BUNK01	6 days	Thu 20-09-10	Thu 20-09-17	48	
R6 Skirt shield blocks (n. 28 steel + 72 HDPA)	BUNK01	10 days	Fri 20-09-18	Thu 20-10-01	49	
Instruments baseplates D02 (D01 side) - n. 52 - 80 x 120 cm	BUNK01	42 days	Fri 20-10-02	Mon 20-11-30	50	2 days/po
Pillars baseplates D02 (D01 side) n. 19	BUNK01	5 days	Tue 20-12-01	Mon 20-12-07	51	4 basepl



‘Black Betty’

Install the goal posts
Mark out the pitch

Before you begin …

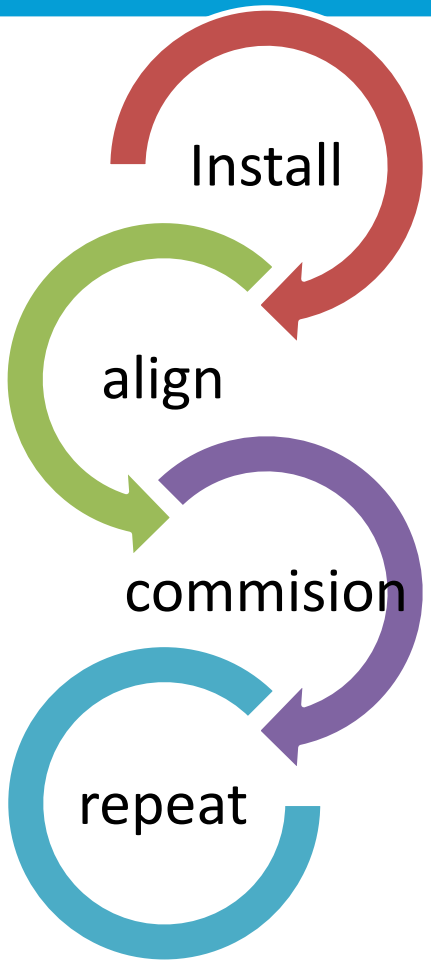
- Sample position
- Beam axis
- Outline
- Perimeter

Day 1 accuracy +/- 3mm

Its already enough to install

- civil works
- supports

Install-Commission



Commission as you go

Progress in sections

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Different strokes

Source to sample

or sample to source

Rebaseline schedule for NBI* Installation (TG4 –> TG5) (V4.0, 11th May 2018)

from Installation workshop with teams building first 8 Instruments (8th May)

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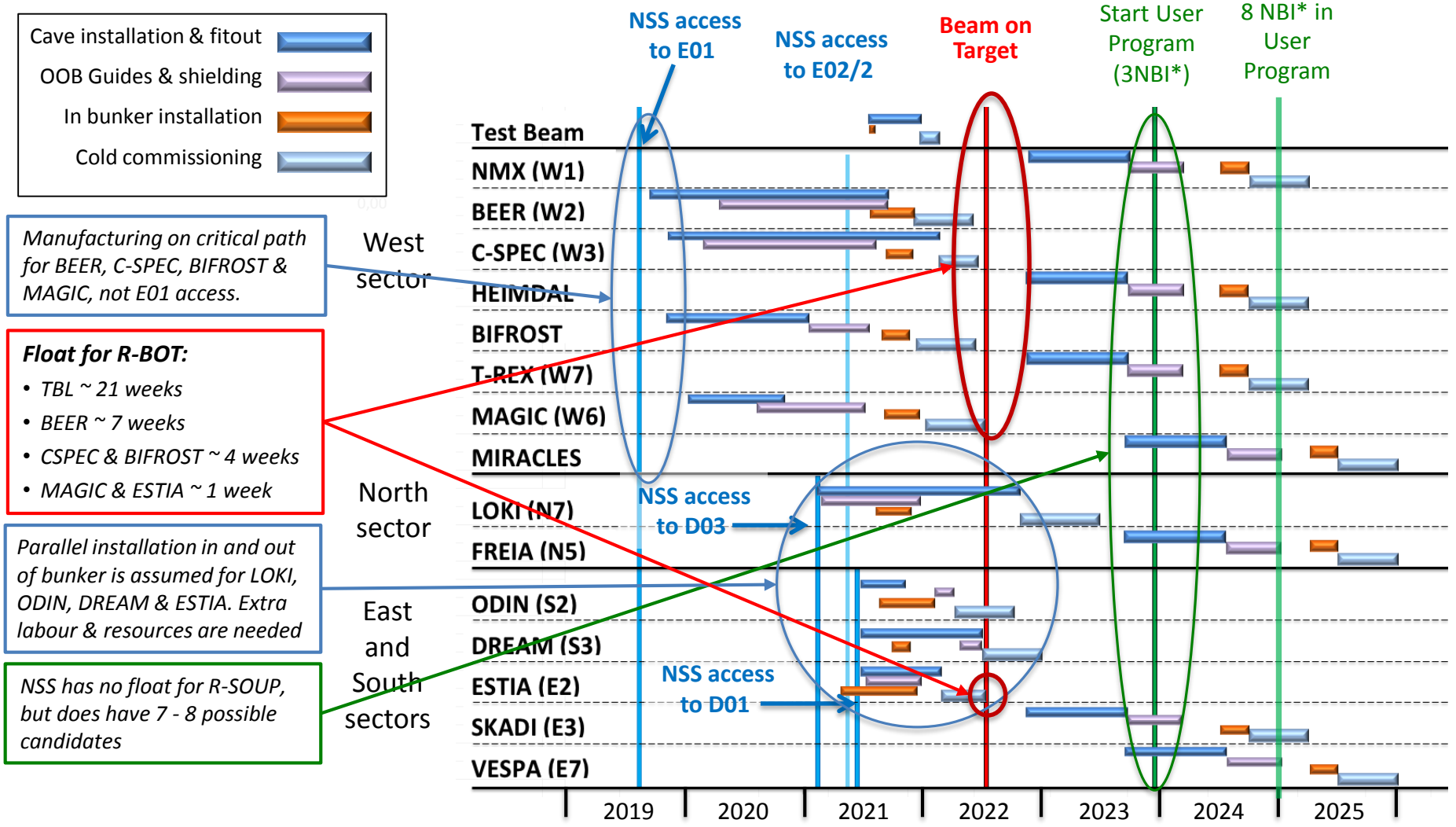

* NBI = Neutron Beam Instrument

Source to sample … almost

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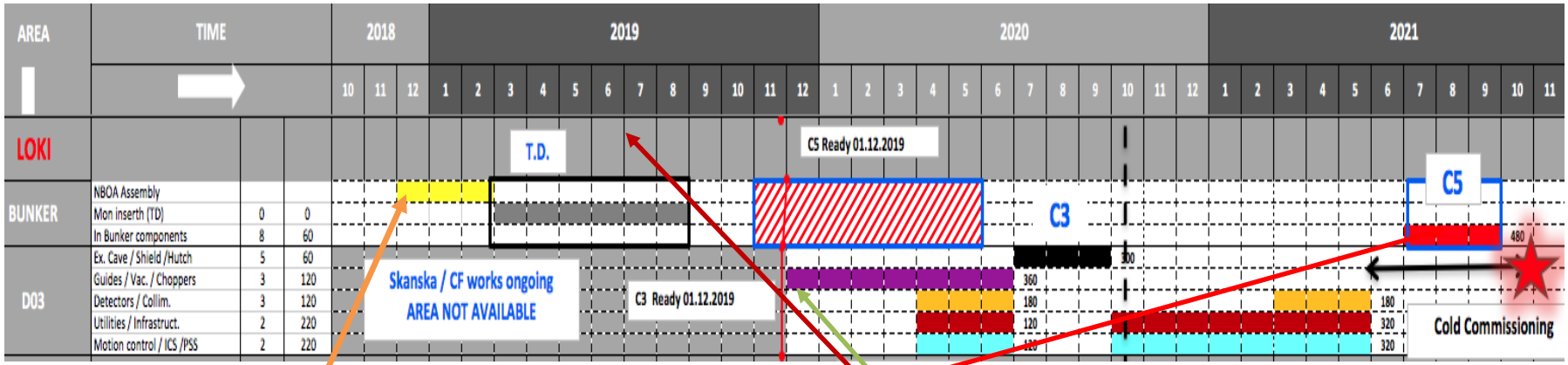
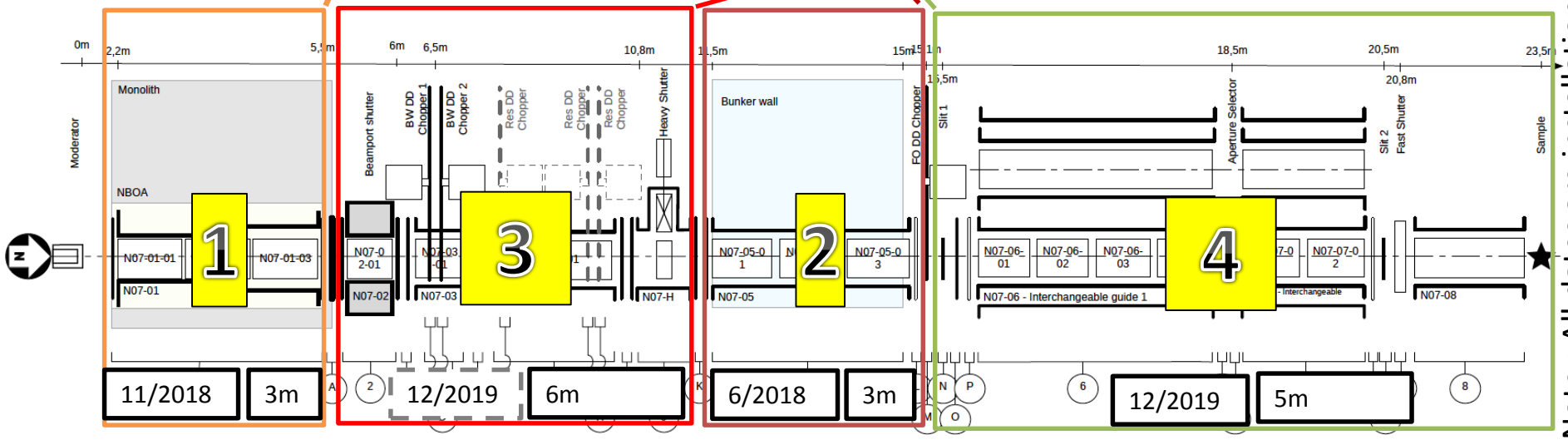
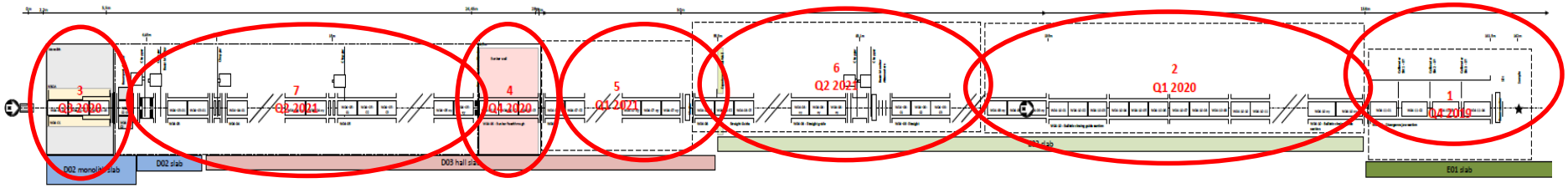




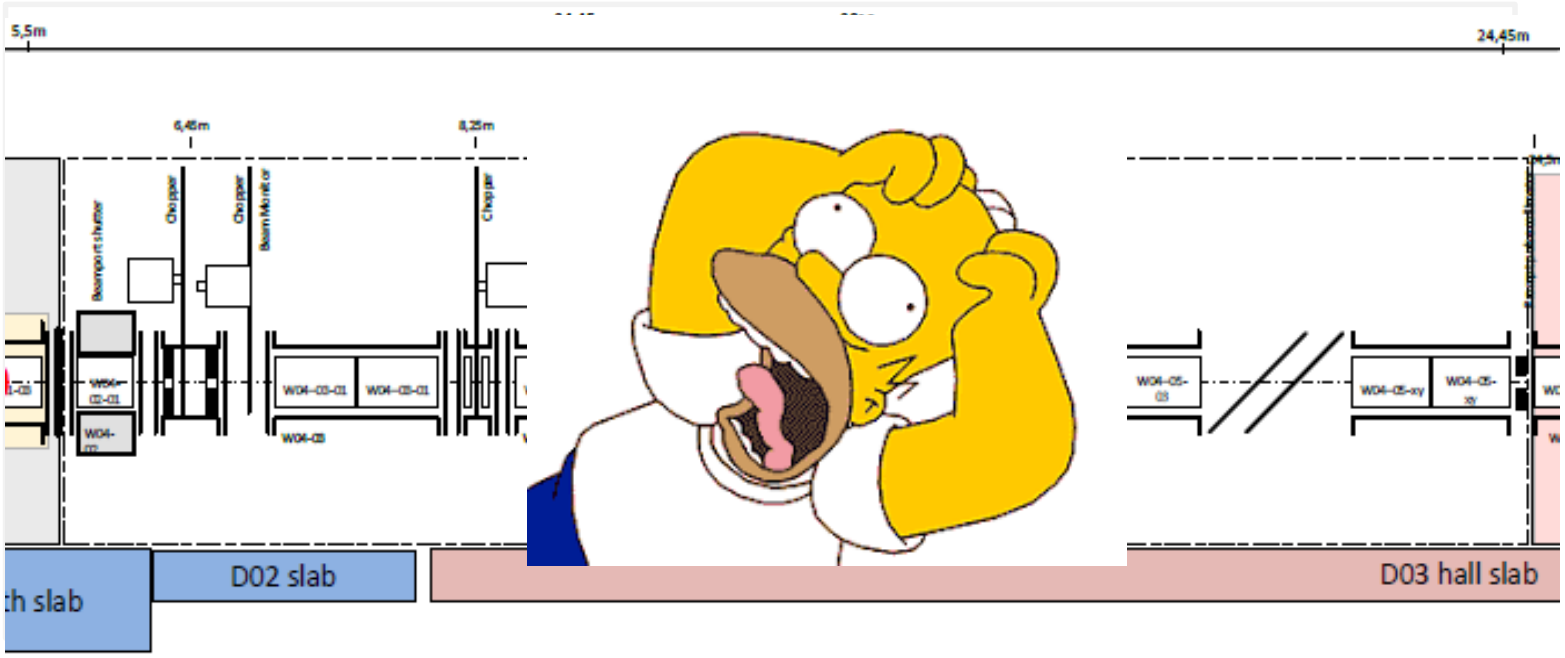
Note : All dates are installation dates, unless indicate with *

Sample to source …
long instrument dilema

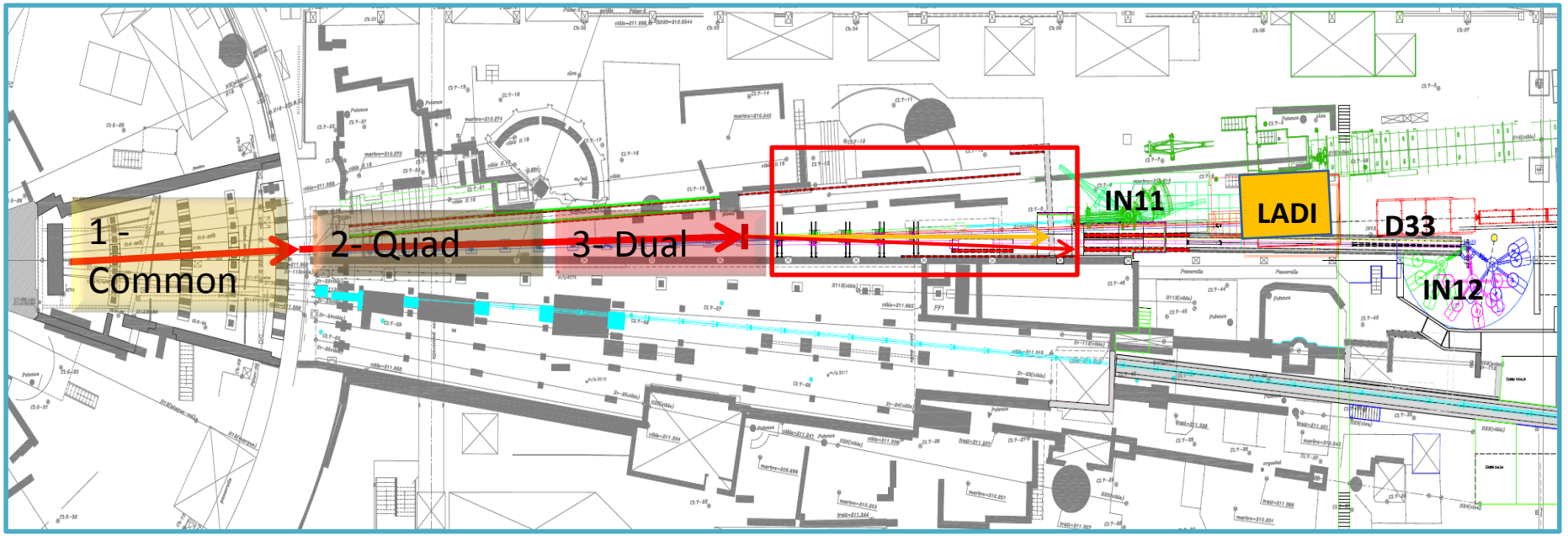
Bunker | D03 Instrument hall | E02 Guide hall | E01 Long hall



3 T+6m | **7** T+18m | **4** T+9m | **5** T+12m | **6** T+15m | **2** T+3m | **1** T=0



Prior art
ILL 2011 H14



Characteristics

- 1 Quad guide system 140m long (but 430m of optics)
- 3 ‘Buildings’
- Disordered Installation sequence
- Simultaneous installation (3 areas)

Installation program
> work areas

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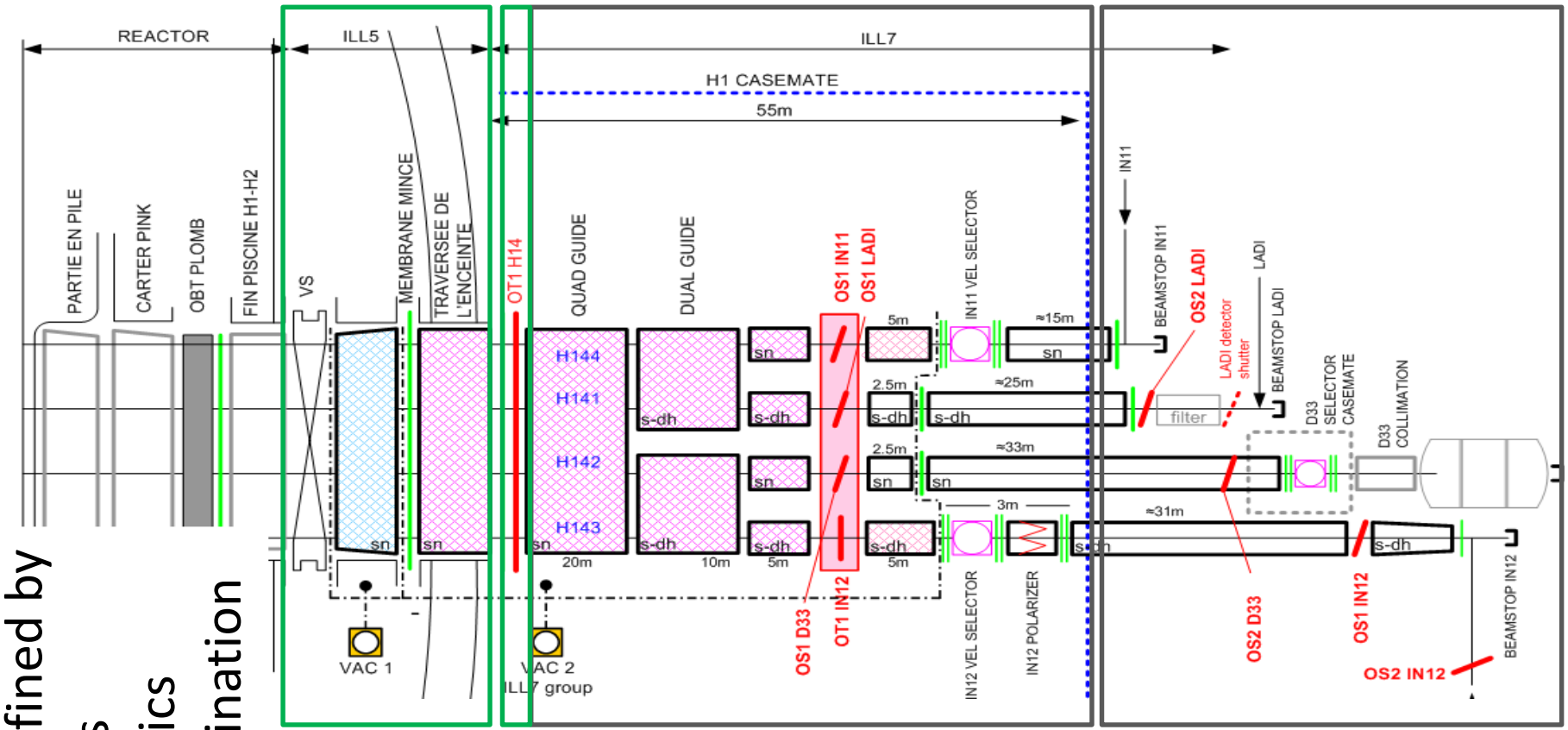


Areas defined by

- access
- Logistics
- coordination

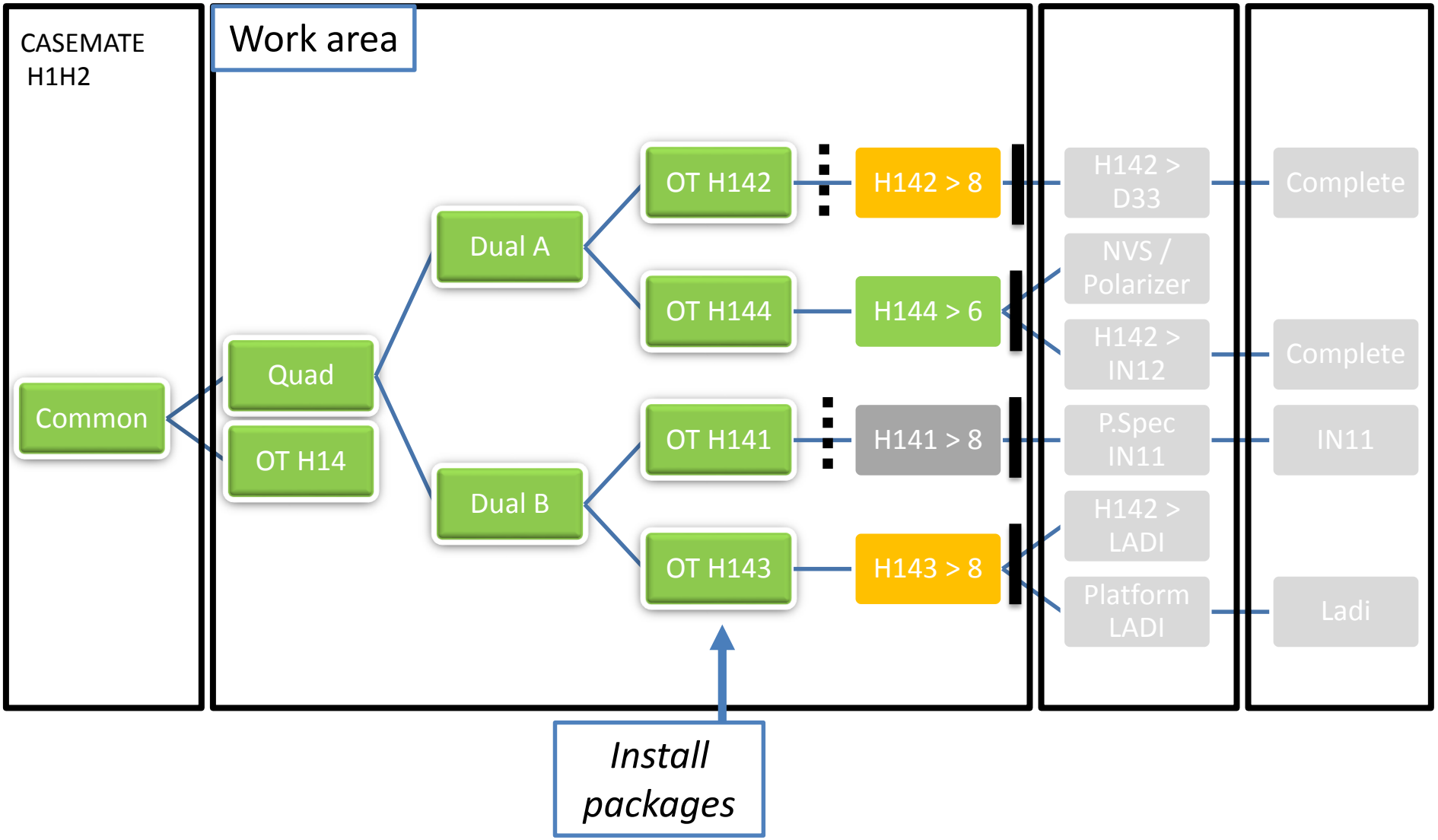
Bunker

Guide hall (E02)

Instrument hall (E01)

Feed through

Within work area
> Installation packages



Installation schedule
Overview (all work areas)

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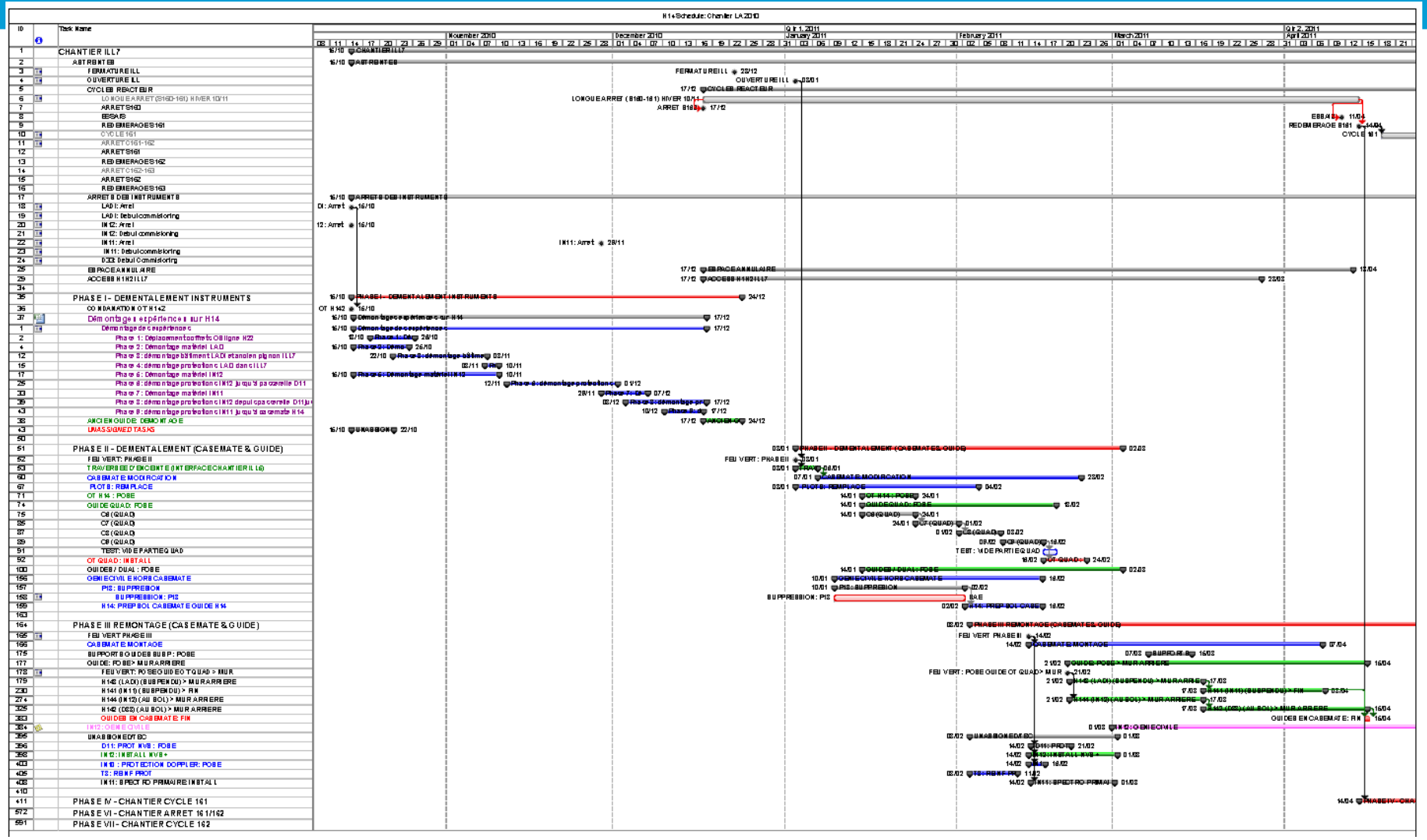

Work area
work schedule (by install package)

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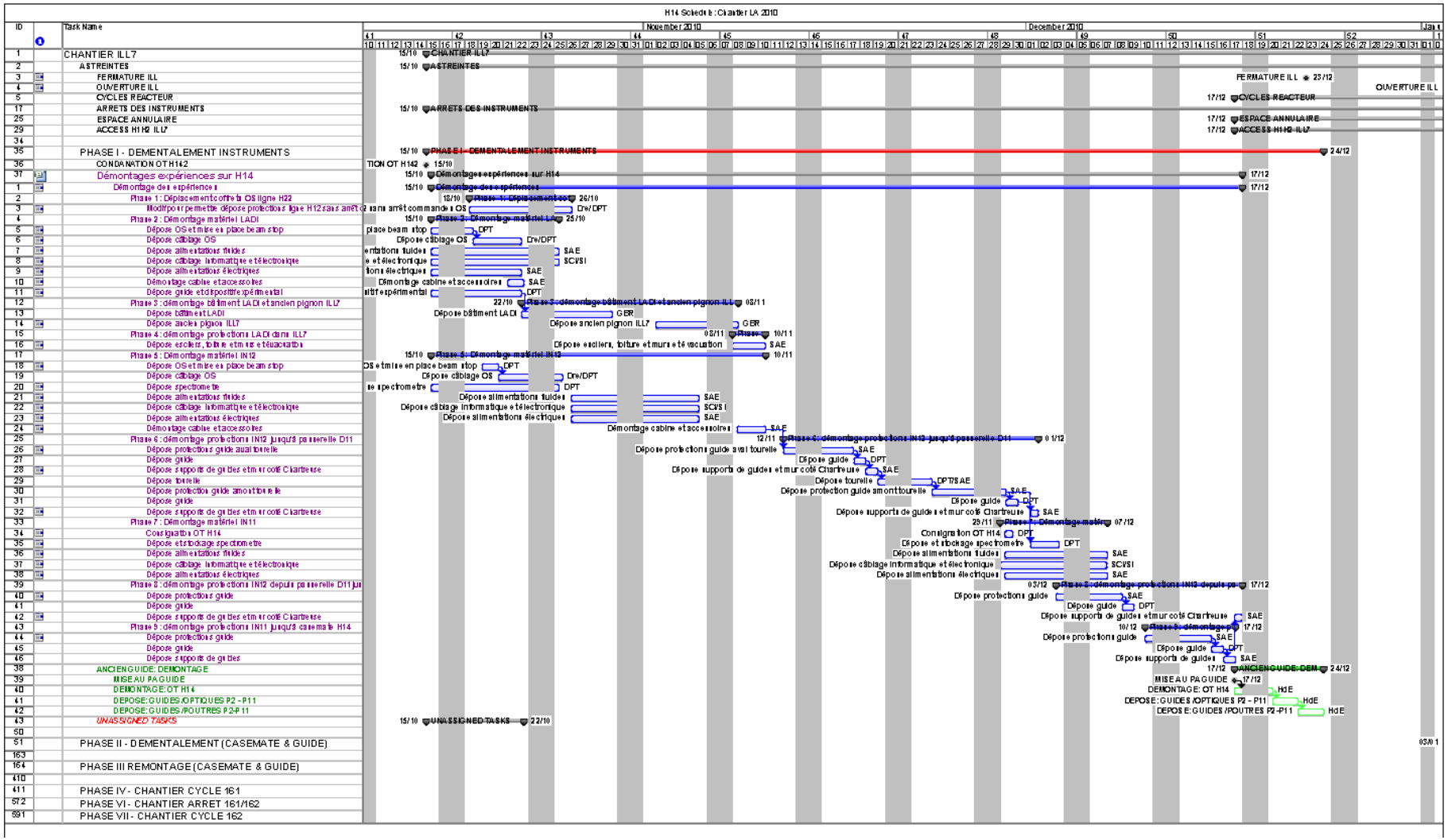
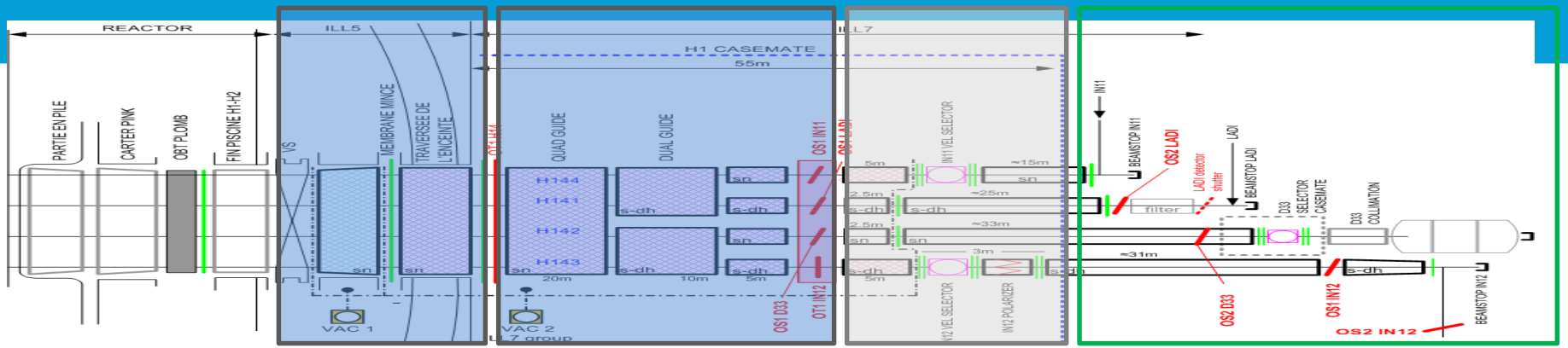


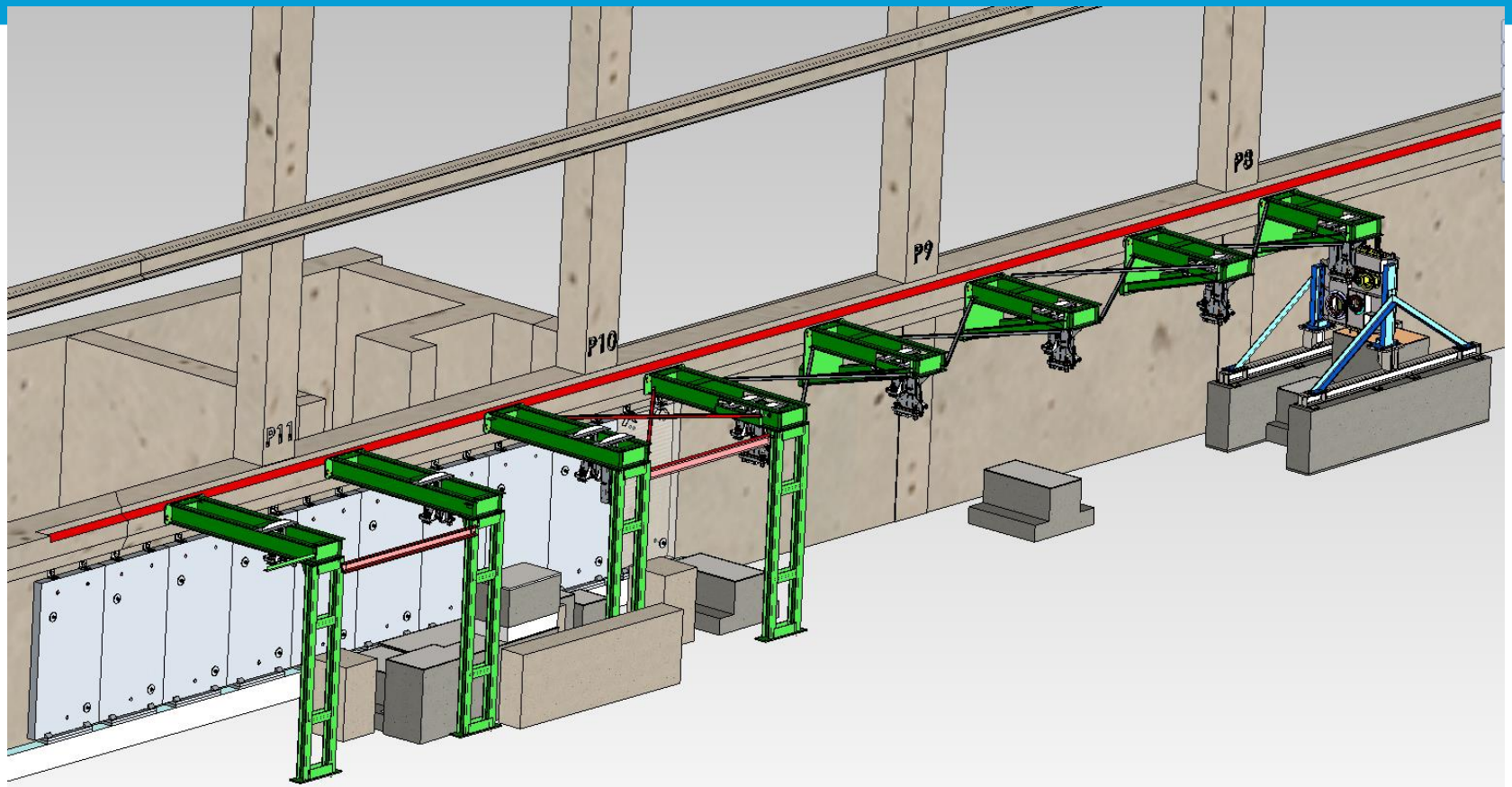
Work area

Installation package

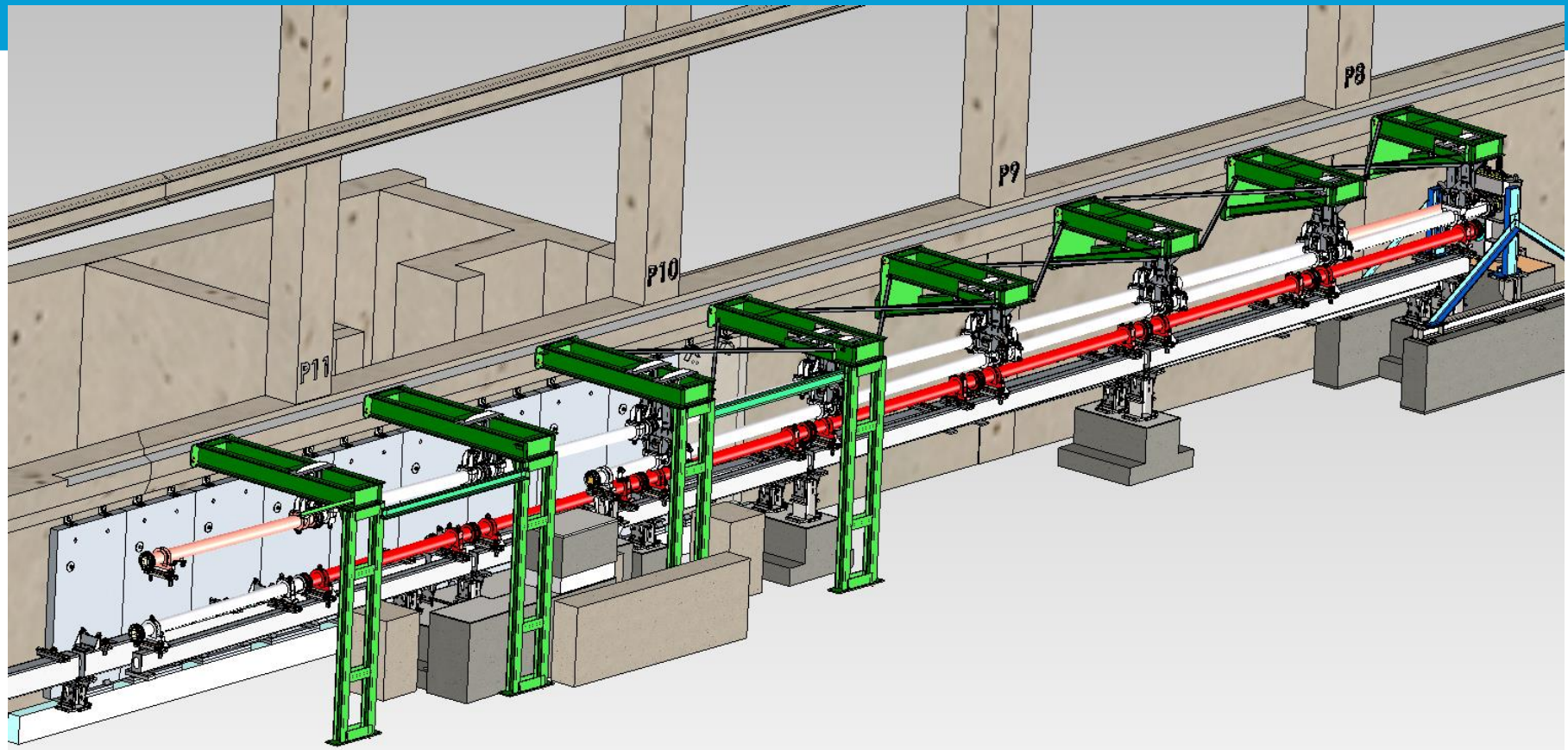


COMPONENTS	VALUE	PRELIM DESIGN	DETAIL DESIGN (BPC)	CONSULT	ORDER	PROC	DEL V	INSTALL
Casemate H14 /Curtain	60K€	COMPLET	IN PROGRESS W44					
Casemate H14 /Barrier internal	35K€	COMPLET	WAITING					
Casemate H14 /Roof	45k€	COMPLET	WAITING					
Casemate H14 Tunnel IN12	300k€	COMPLET	IN PROGRESS W41					
LADI Platform		COMPLET	IN PROGRESS W43	IN HOUSE				
LADI Zone		IN PROGRESS	WAITING	IN HOUSE				
Inst Shutters		WAITING						
IN12 Zone experimental		COMPLET	IN PROGRESS	IN HOUSE				

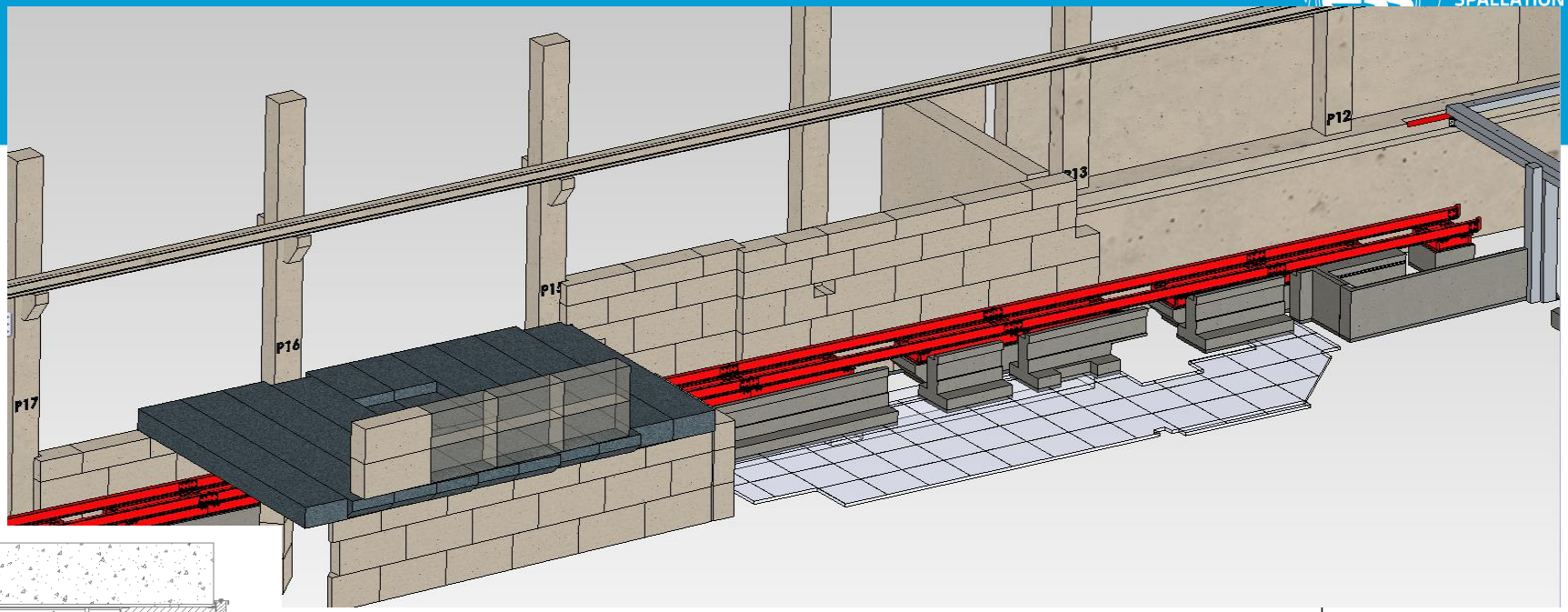
Installation Storybook
(Input to Method statement)

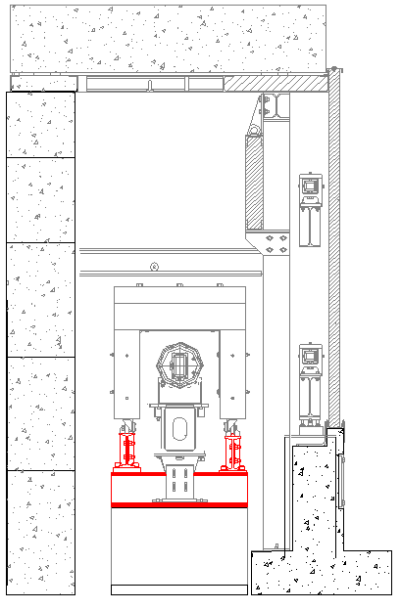


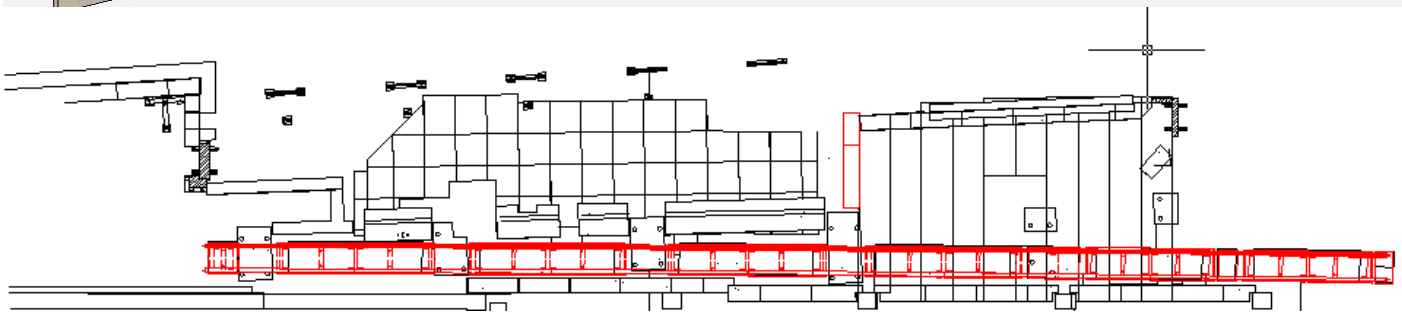
Operation : Mise en place des traverses et remontage des bracons
Equipe :SAE
Quand :Semaine 21 ou debut 22



Operation : Mise en place & Alignement des Guides + carters H141, H142 & D33
Equipe : HdE
Quand : Arret 6 > 13 Juin







Operation :Mise en place des rails ‘tunnel H144’
Equipe : HdE (CM + NN)
Quand : Semaine 21 (25/5 >)

Project Risk
For installation phase

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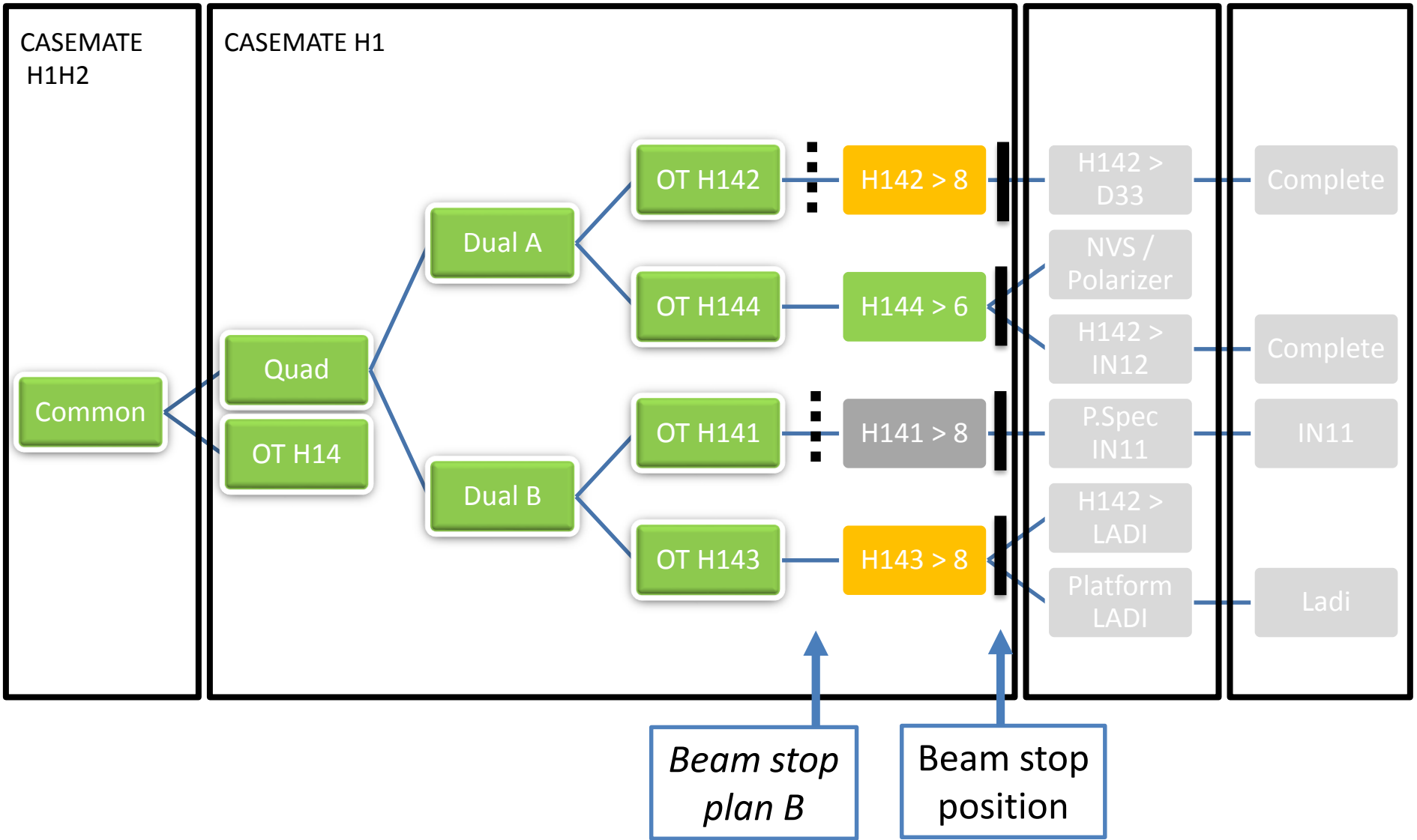
	RISK ANALYSIS DURING INSTALLATION PHASE								
				CURRENT Risk estimation					
	CAUSE	CONSEQUENCES	Effected	Probability	Gravity	Weighted risk	Decision	Preventives Actions	Curatives Actions
T1	CRITICAL COMPONENT NOT DELIVERED	INSTALLATION DELAY	ALL UNITS	2	16	32	Treat	Identify components - Pilot production to insure schedules are respected. Order early	Identify local contractors with skills/capacity/ availability to manufacture
T2	MINOR COMPONENT NOT DELIVERED	INSTALLATION DELAY	ALL UNITS	4	4	16	Tolerate	Identify components - Use checklist to insure all parts are delivery.	Insure that machine shop personnel are available on site
T3	CRITICAL COMPONENT DOES NOT MOUNT	INSTALLATION DELAY	ALL UNITS	2	16	32	Treat	Identify components - test mount parts in hall d'essais before installation date.	Identify local contractors with skills/capacity/ availability to moify or
T4	OTHER COMPONENT DOES NOT MOUNT	INSTALLATION DELAY	ALL UNITS	2	4	8	Tolerate	Identify components - test mount parts in hall d'essais before installation date.	
R1	INSUFFICENT INSTALLATION PERSONNEL AVAILABLE.	INSTALLATION DELAY	ALL UNITS	3	8	24	Treat	Insure availability of personnel well in advance	Hire external personnel / Work in 2 shifts to reabsorb delay
R2	INSTALLATION PERSONNEL SICK (FLU)	INSTALLATION DELAY See R1	ALL UNITS	1	8	8	Tolerate	Identify key personnel Insure good health - propose flu jabs ? Relaxing holidays	Prepare documents for replacement of key personel
R3	INSTALLATION PERSONNEL ABSENT (HOLIDAY)	INSTALLATION DELAY See R1	ALL UNITS	2	8	16	Tolerate	Identify personnel effected - block holidays effected period.	Organise replacement personnel
T5	INSTALLATION DOCUMENTATION INCOMPLETE	INSTALLATION DELAY	PER ASSY	1	4	4	Tolerate	Compile documents checklist - start preparations early	Correct documentation during installation , realign effected units
T6	INSTALLATION DOCUMENTATION IS WRONG	INSTALLATION DELAY OR PERFORMANCE DEGRADED	PER ASSY	1	4	4	Treat	Double check alignment documentation. Develop backup system	Use back up system
E1	NO ACCESS TO SITE - GENERAL	INSTALLATION DELAY	ALL UNITS	3	4	12	Tolerate	Check document requirements in advance Site manager must be available at site	Run around in order to complete papers rapidly
E2	RADIATION LEVELS TOO HIGH ON SITE	NO ACCESS See E1	PER ASSY	1	16	16	Tolerate	Study problem with SPR - prepare sheilding as required	Install Temporary shielding
E3	RADIATION WORK PAPER WORK INCOMPLETE	NO ACCESS See E1	PERSONNEL	1	16	16	Tolerate	Check document requirements in advance Site manager must be available at site	
R4	EQUIPTMENT UNAVAILABLE - ALIGNMENT	ALIGNMENT DELAYED	ALIGNMENT PHASE	2	8	16	Tolerate	Compile alignment tooling list and reserve / purchase equiptment ahead of requirements	Hire alignment equiptment
R5	EQUIPTMENT UNAVAILABLE - LIFTING	INSTALLATION DELAYED	ALL UNITS	1	16	16	Tolerate	Service equiptment Stock components locally	Study lifting requirements Purchase / hire aditional lifting equiptment
R6	EQUIPTMENT UNAVAILABLE - INSTALL TOOLS	INSTALLATION DELAYED	ALL UNITS	3	4	12	Tolerate	Compile tooling list and reserve / purchase equiptment	General tooling available in test hall
T7	OPTICAL UNIT DAMAGED DURING TRANSIT OR INSTALLATION	PERFORMANCE DEGRADED	ALL UNITS	1	16	16	Tolerate	Develop methods to transport safely Training, Order duplicate components	Place order for duplicate components
O1	SPACE CONFLICT WITH OTHER PROJECT	INSTALLATION SLOWED	OT QUAD >	5	16	80	Treat	Manage space requirement during installation. Coordinate with other projects	Work around / Work in shifts
O2	COMPETITITION FOR CRANE	INSTALLATION SLOWED	ALL UNITS	3	8	24	Treat	Reduce dependancy on hall crane Coordinate planning with other users	Work in 2 shifts to reabsorb delay
O2	SAFETY ISSUE - USE OF CRANE	INSTALLATION STOPPED	ALL UNITS	5	8	40	Treat	Coordinate planning with other users	Work in 2 shifts to reabsorb delay

Provisional Installation status at ‘beam on’



Resource estimations
Typical Neutron guide - instrument

	Leader	Design	heavy gang	Craft (mason)	Craft (Elec-fluids)	Vacuum	M.tech	ES&H	RP	Survey
Site preparation	1	1	0	0.5	0	0	0	1	0.5	2
Civil works	0.5	0.5	2	2	2	1	1	0.2	0	0.5
Installation	0.5	0.5	2	1	2	0.5	2	0.2	0	0.5
Cold commisioning	0.5	0.2	0	0	0.5	2	1	0.2	0	0
Alignment	0.5	0.5	0.5	0	0	0	0.5	0.2	0	2
Closure	0.5	0.5	2	0	0	0.5	2	0.5	1	0
Hot commisioning	1	0.2	0	0	0	0	0	0.2	2	0

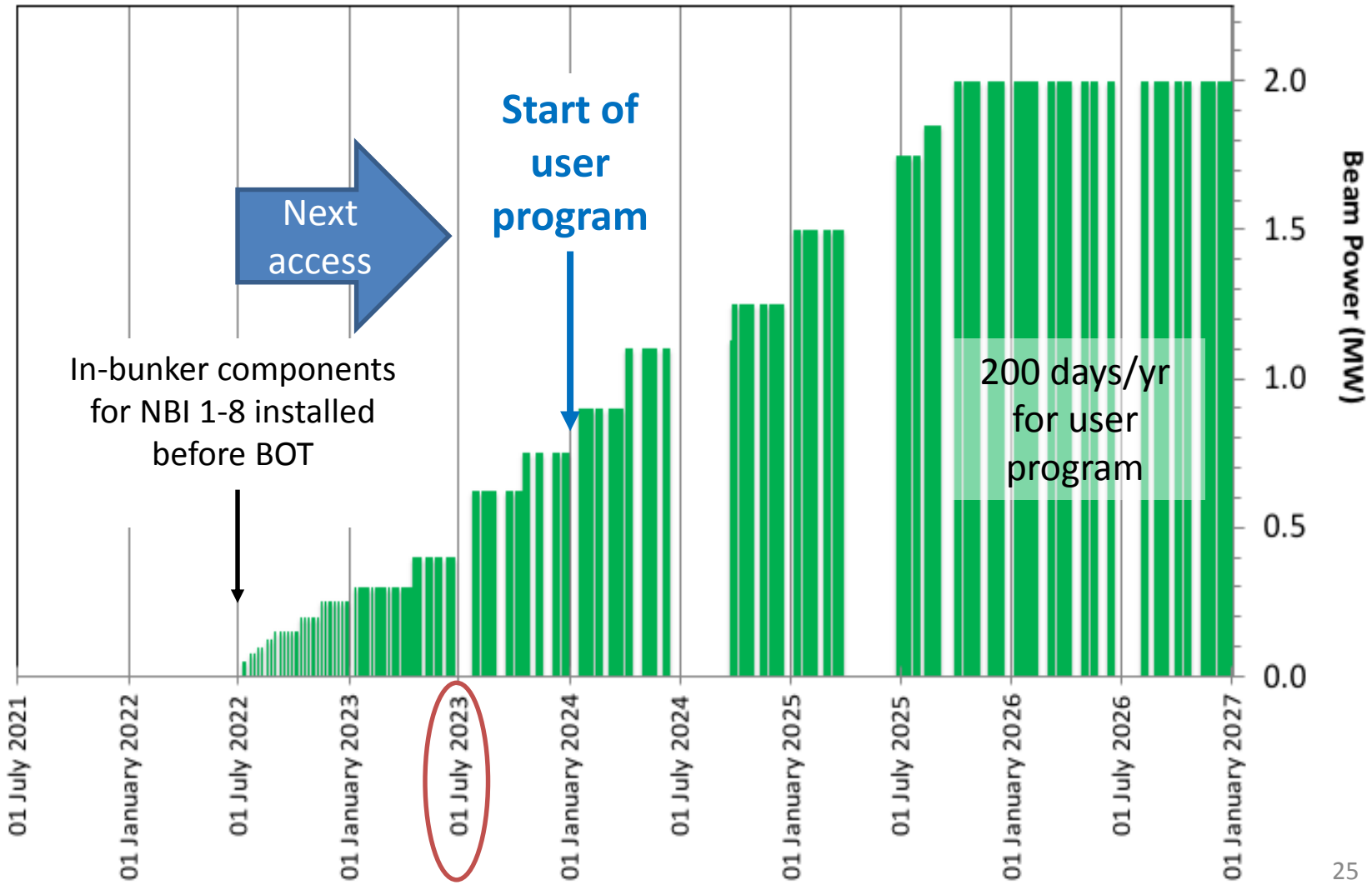
Plan ‘B’

Sh** happens

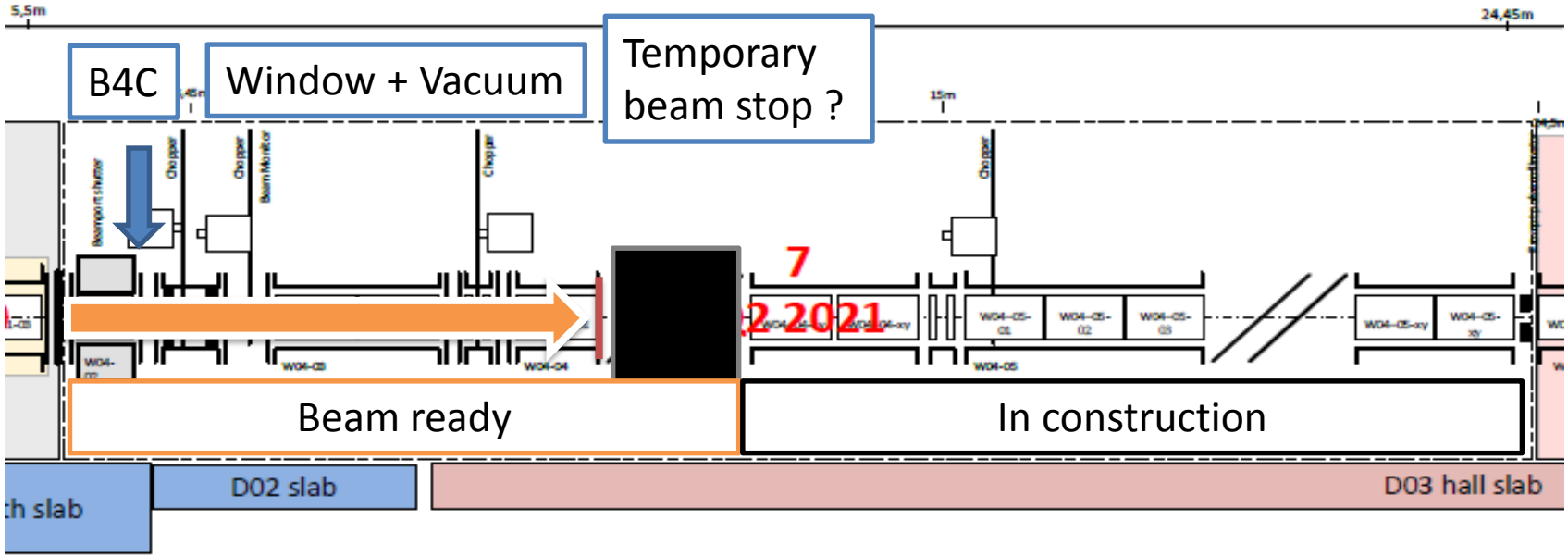
But it doesn’t have to be the end of the world

Source Power ramp up *from NSS Master Schedule (V4.0 – 11th May 2018)*

(Work in progress: - discussion with Accelerator & Target Project teams is ongoing)



Before the beam comes on ….
Making it safe



Whether you have completed install or not …. a ‘TG5’ needs to be performed for all systems receiving beam.

- Verified configuration
- Under vacuum
- Beam stop
- Consider the placement of beam stop carefully

Plan ‘B’
‘Black Betty’

risk mitigation against in-completing build is part of TG4

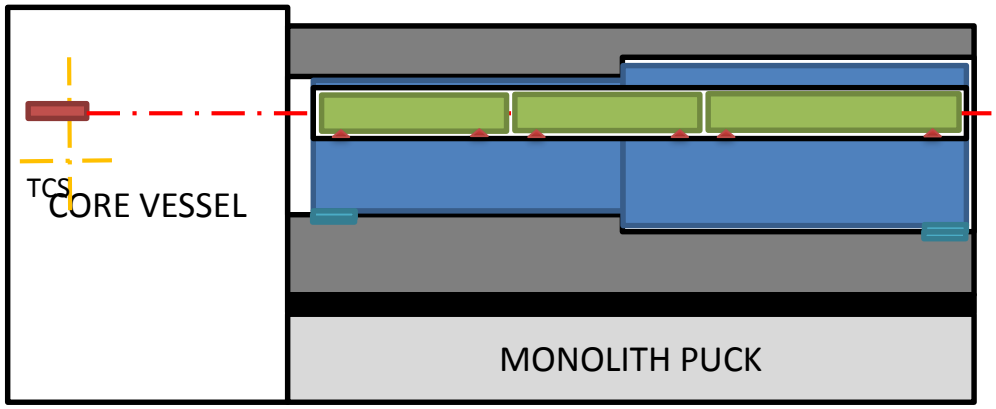
Consider the use of Temporary beam-stop for instrument builds

Dimensioned for Thermal & Fast neutrons
Installation within shielding (gamma shielding)

- Compact
- Modular
- Reusable
- Man portable (no crane required)

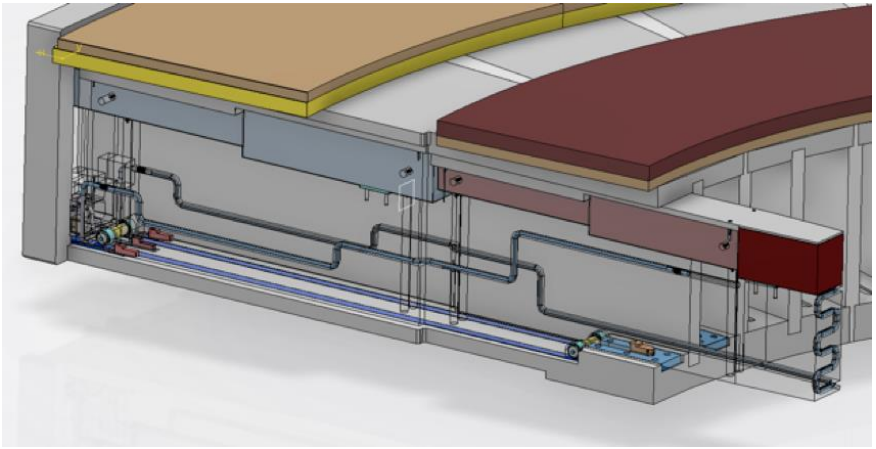
Aligning to what
The start of something

TODAY
'TCS Theoretical'
position accuracy +/- 2mm
- Beam axis +/- 2mm

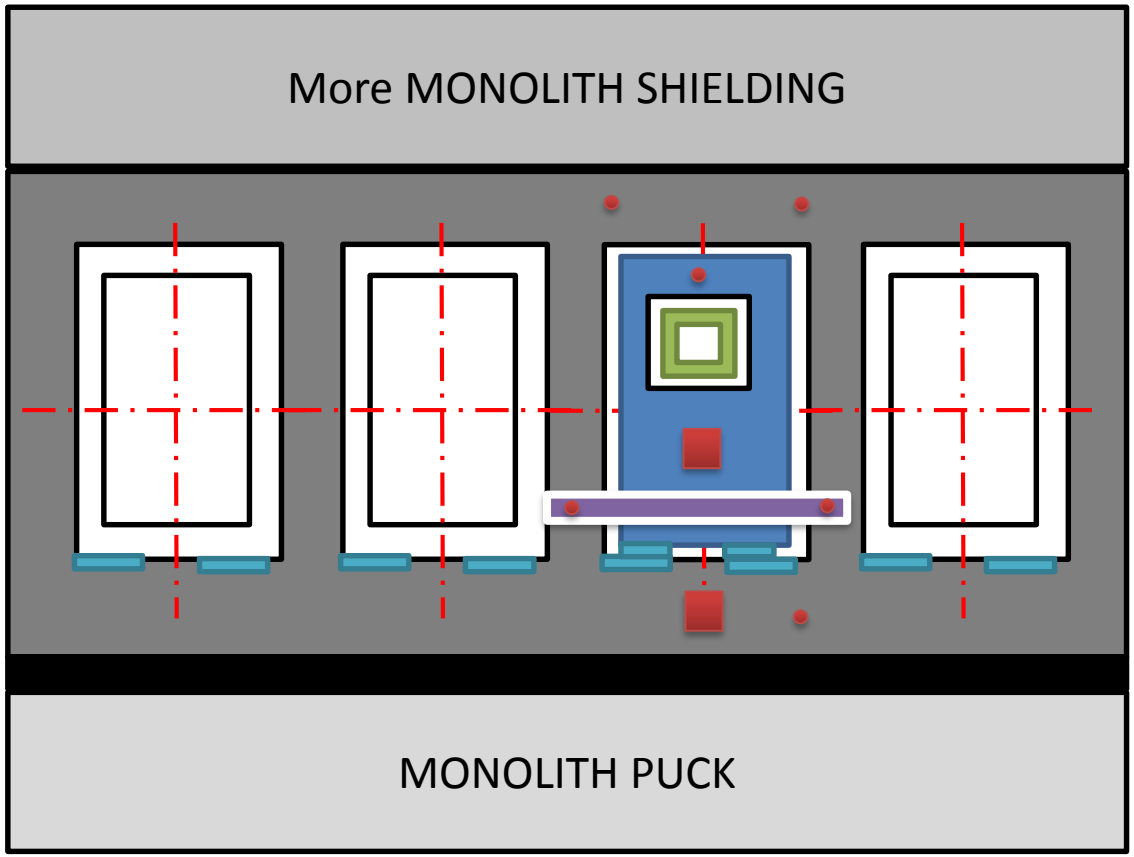


TOMMOROW
TCS measured 20-09-2020
accuracy +/- 0.05 (?)

Beam axis measured 01-02-2021
accuracy +/- 0.02 (?)



Beam port axis
Transfer of references

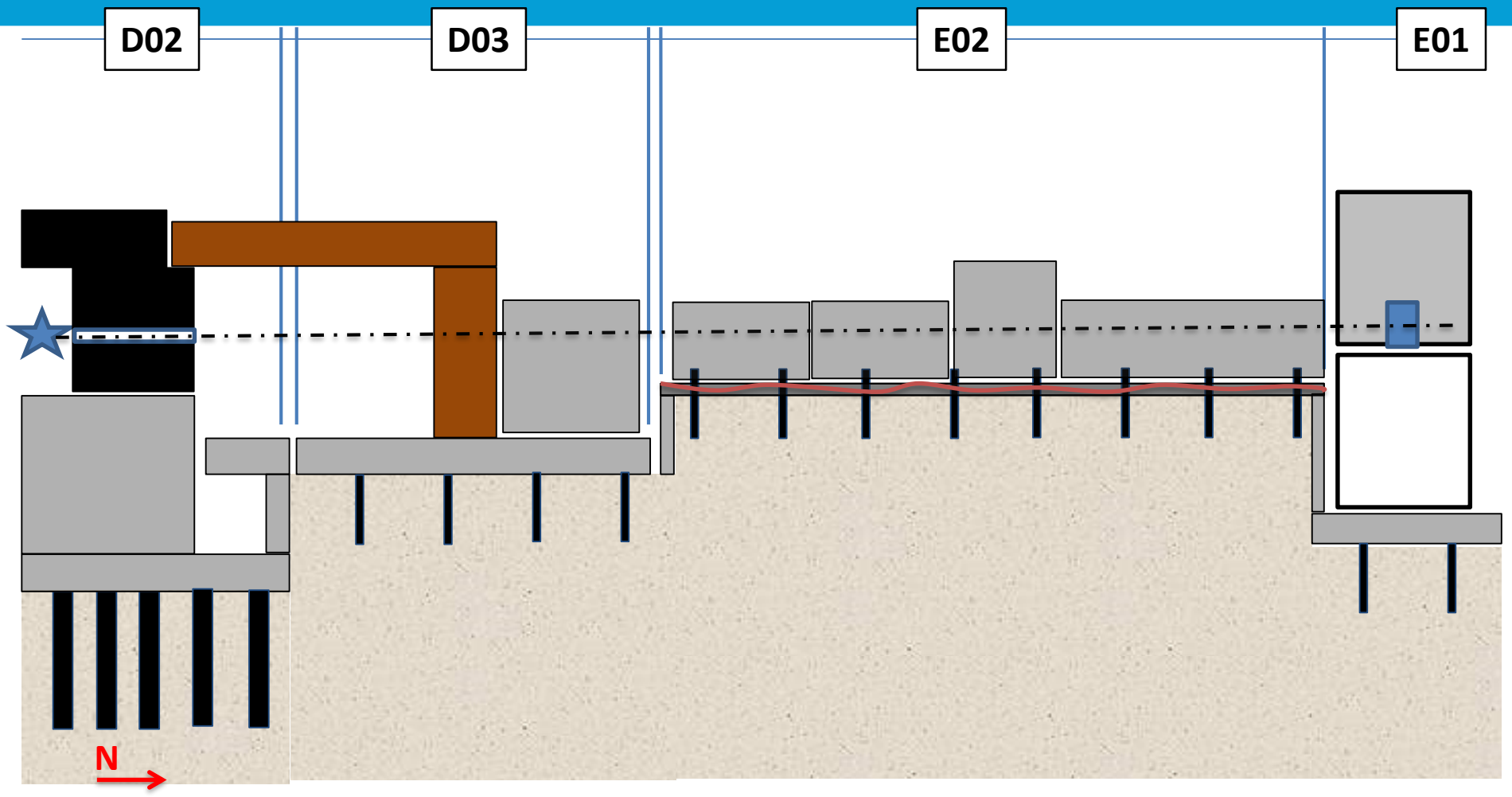


- Real position on NBEX (thus NBOA) may be measured before BP Window installation and referenced with respect to BP reference features.

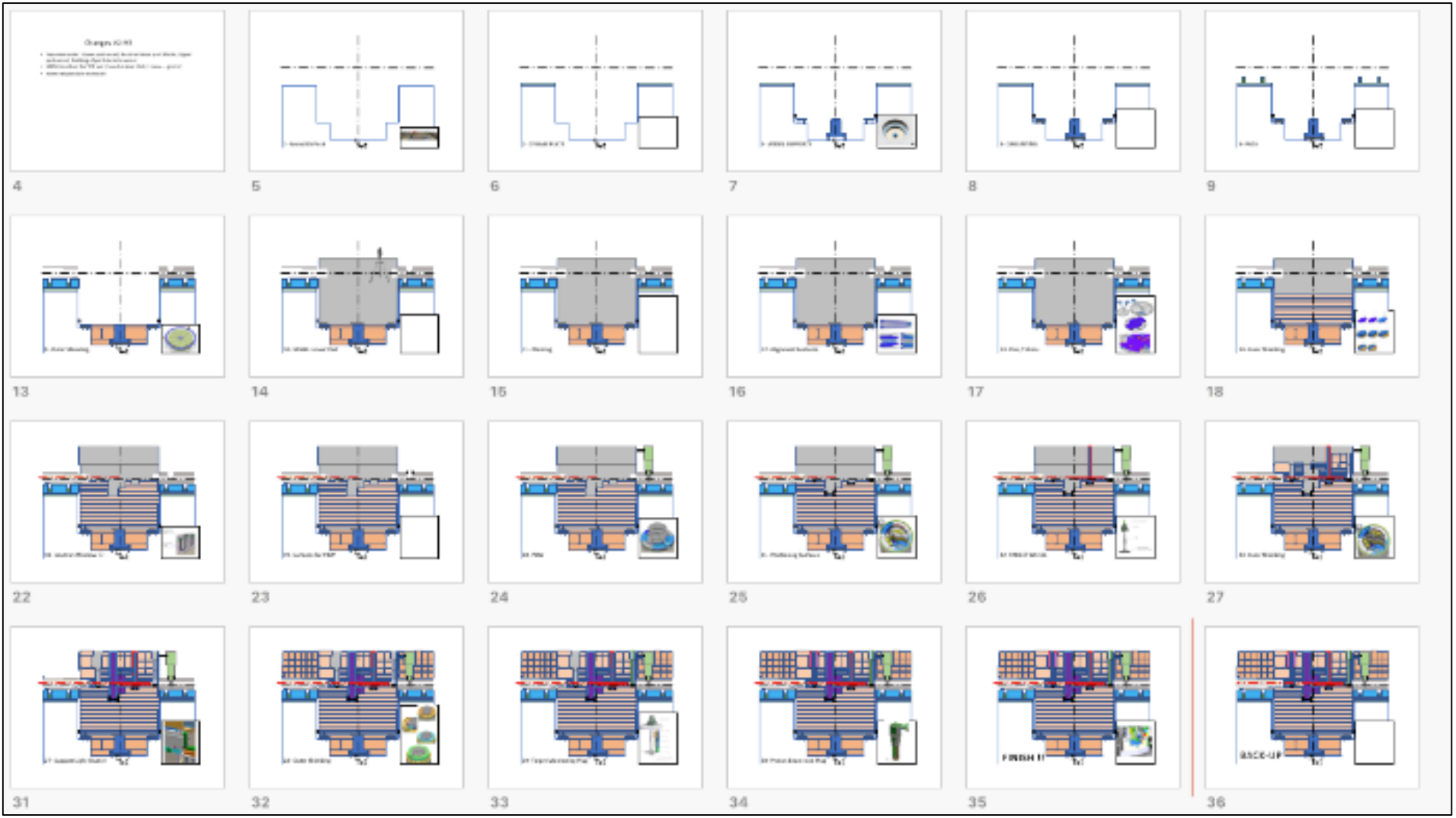
Ground settlement

Did the earth move for you ?

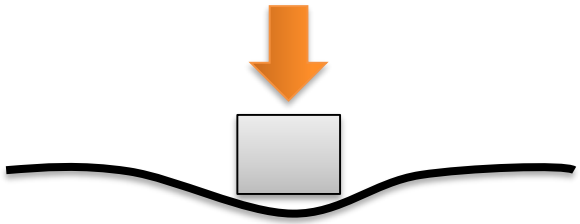
Overview

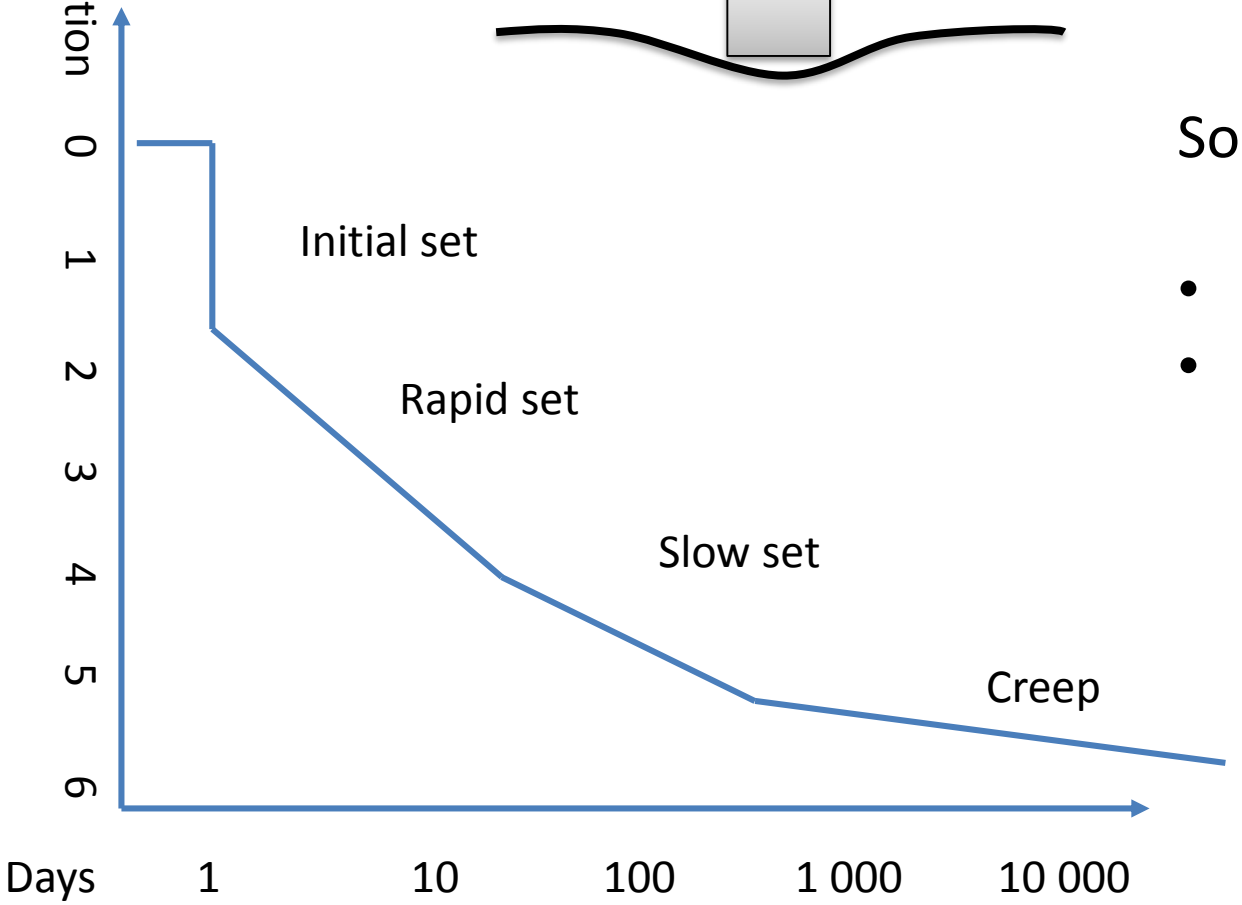


Monolith
One heavy ….



Time & Motion

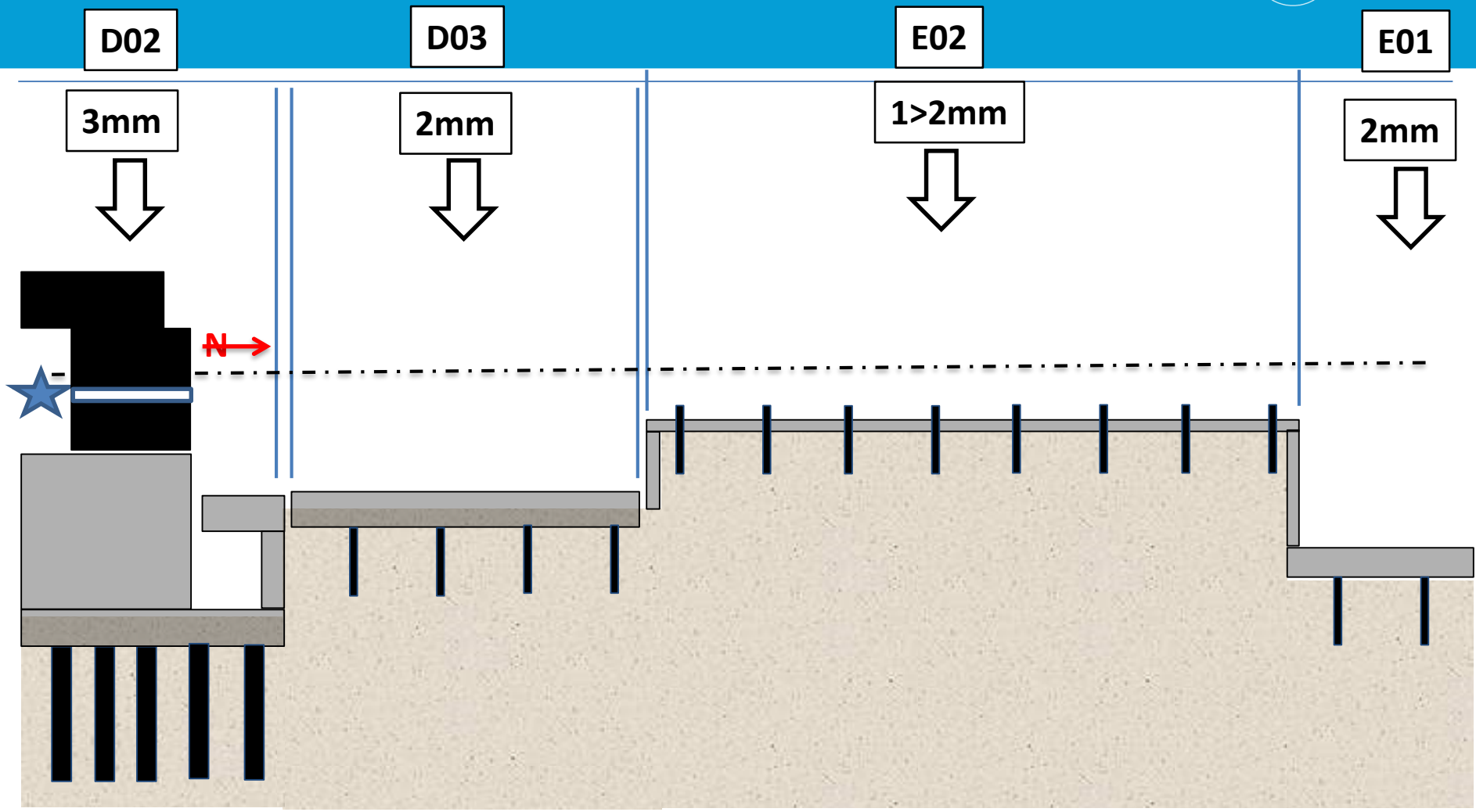




Some causes

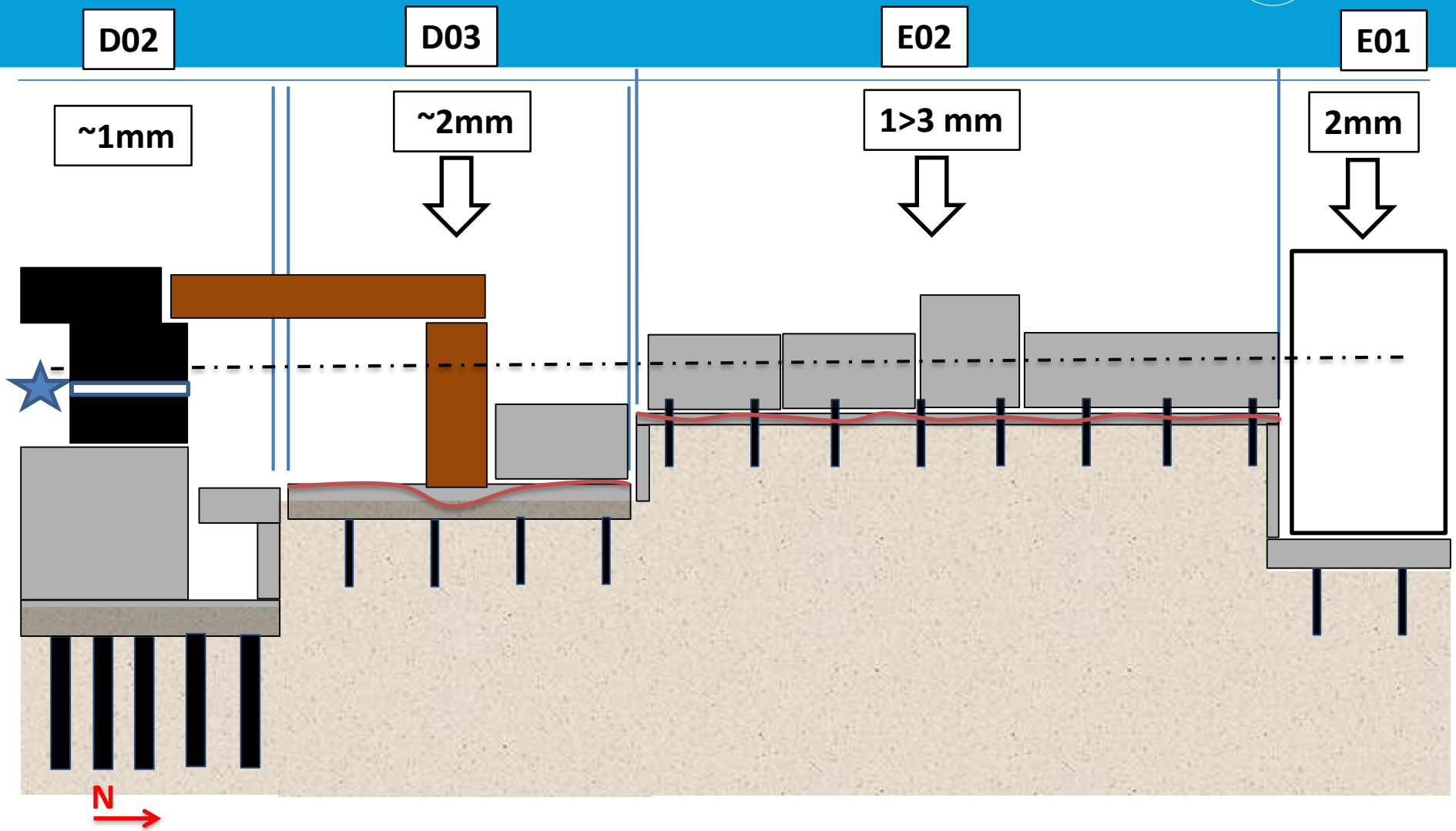
- Elastic deflection
- Plastic deformation
  - Closing gaps
  - Pile tip breakage
  - Flow

Settlement macro scale



- Buildings settle onto foundations (piles or soil)

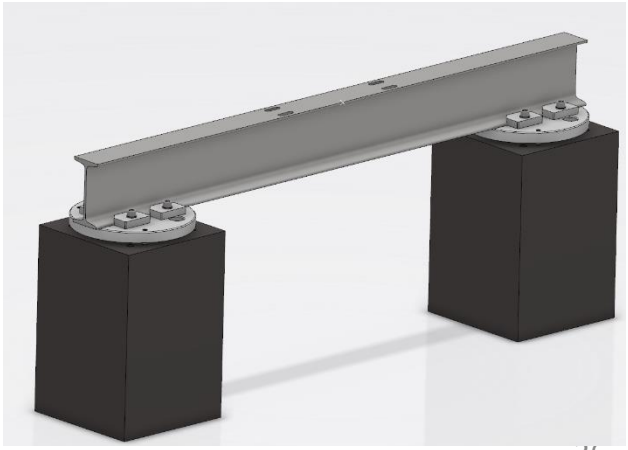
Slab deflection



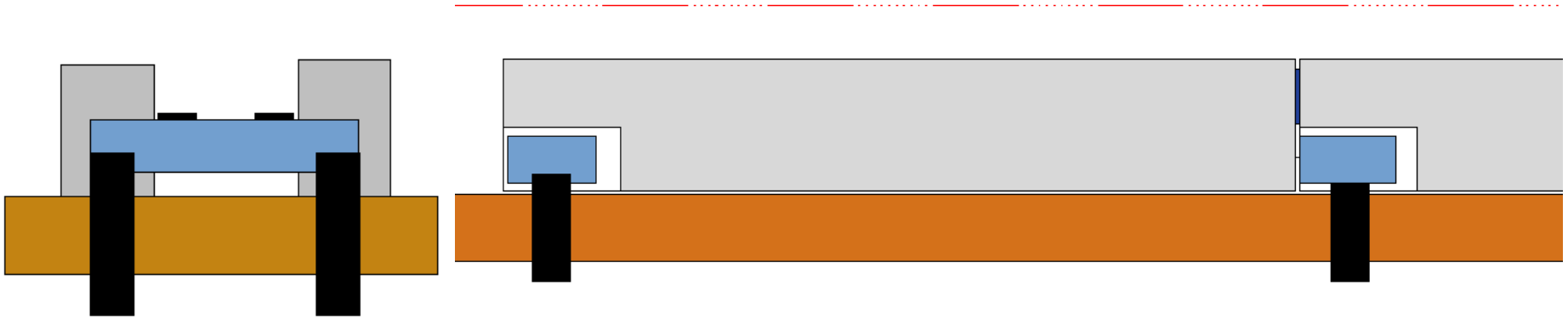
- Local loads deflect slab.
- Load may be transferred to piles

E02
Decoupled guide supports

Note
The piles are largely decoupled from floor slab loading but probably worth preloading before use



Shielding base



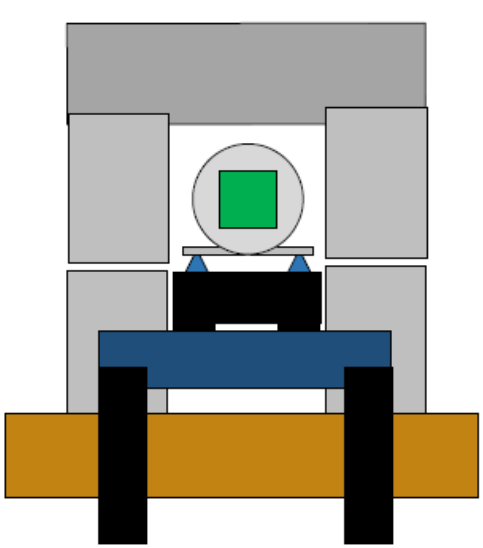
What

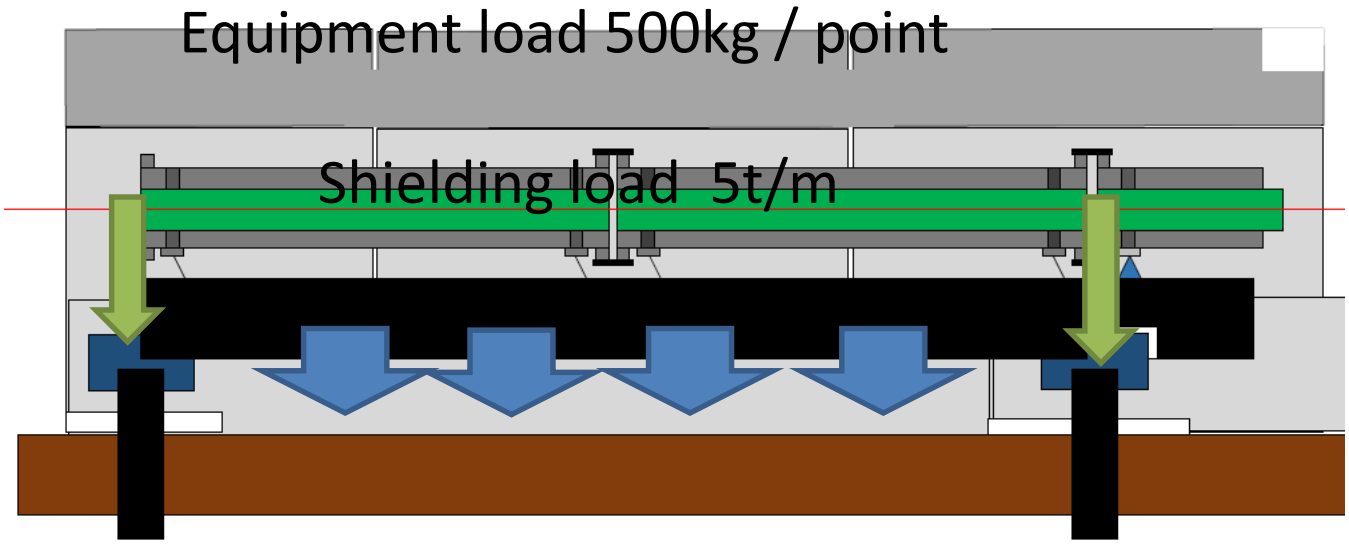
- Install thick (concrete) base beams
- Both sides of beamline

Why

- Spread load of shielding
- Standardized / cheap
- Mid height

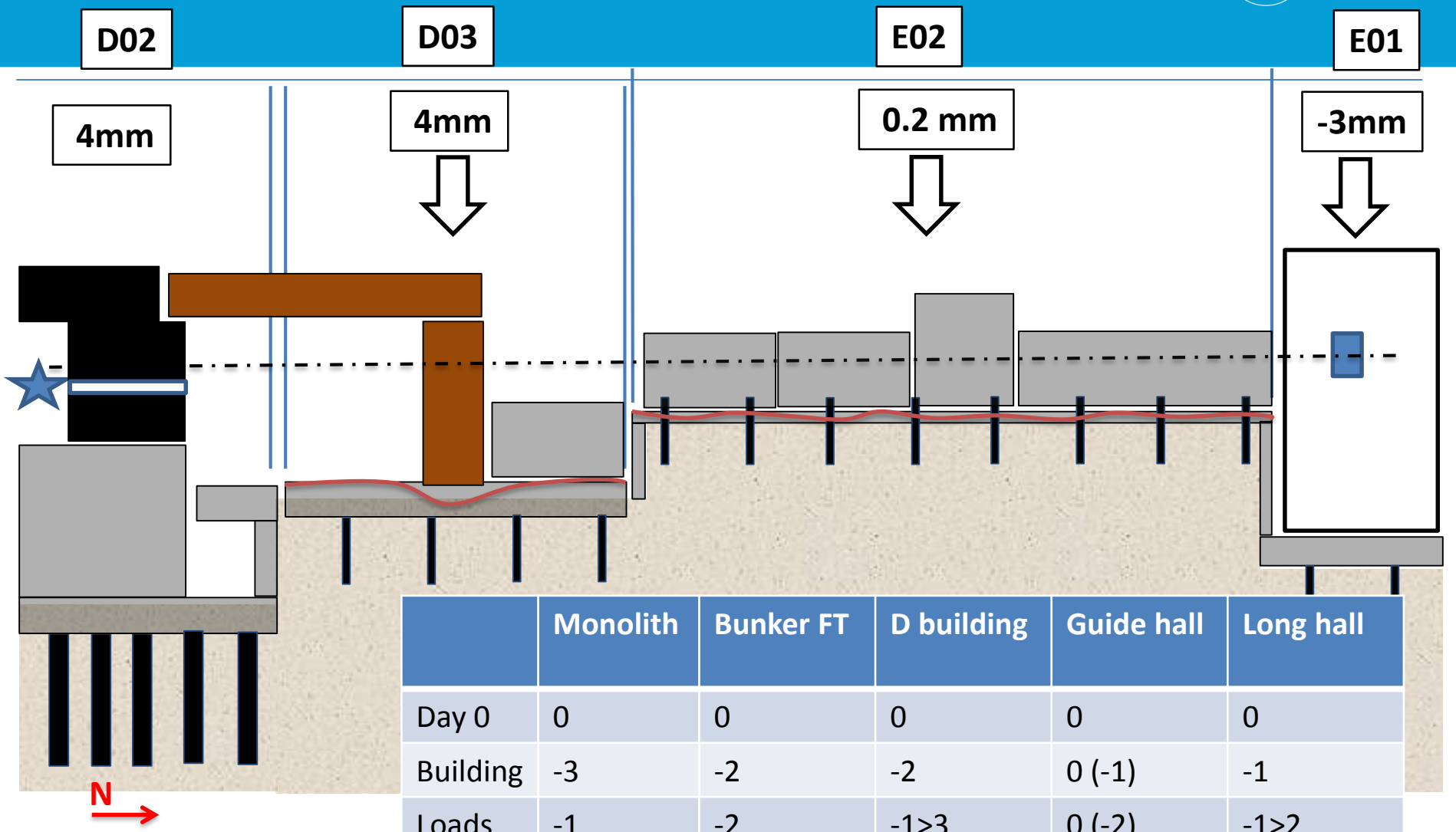
Install
rough align





Pre-load the floor to ‘set’ it before alignment

Total movement wrt original source



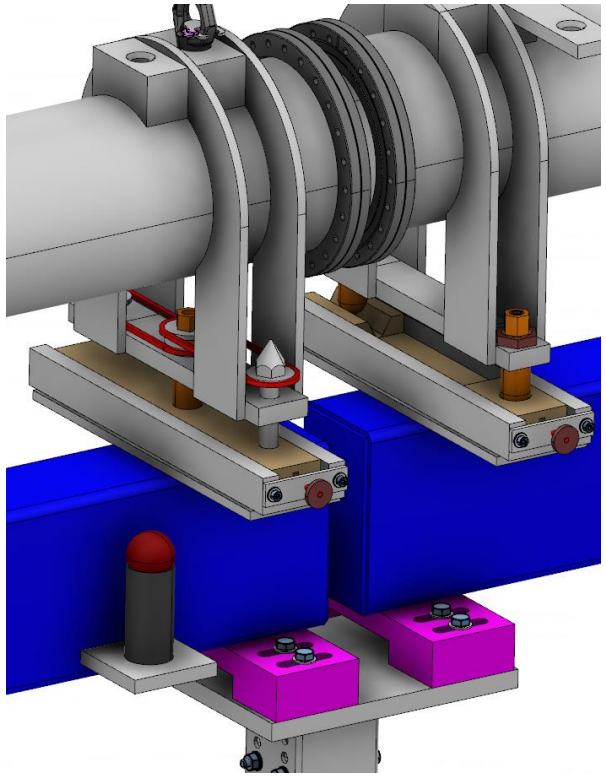
	Monolith	Bunker FT	D building	Guide hall	Long hall
Day 0	0	0	0	0	0
Building	-3	-2	-2	0 (-1)	-1
Loads	-1	-2	-1>3	0 (-2)	-1>2
Totals	**-4**	**-4**	**-3>5**	**<0.2 (-3)**	**-2>3**

Ground movement Recommendation

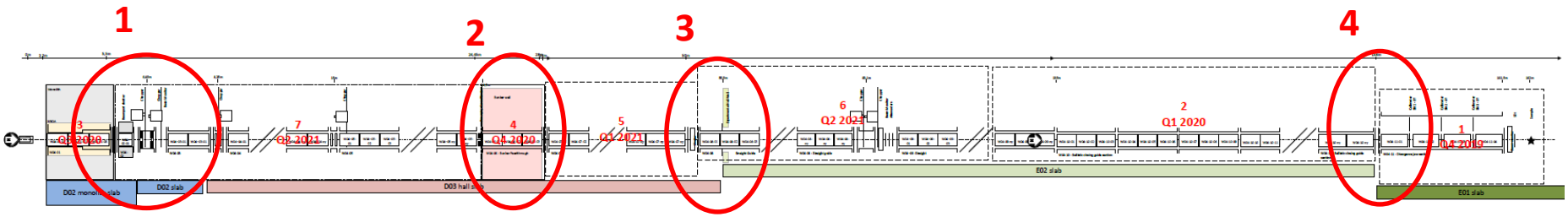
Leave fine alignment to the end !

Strategy

- Ensure provisions for post install inspection & adjustment
  - Fiducial pucks
  - +/- 10mm screws +10 spacer
- Install all supports / housings / optics
  - commission vacuum systems as you go ‘in section’
    - Temporary caps and force legs
- Do install ALL shielding to preload floor
- If not completing installation only ‘rough’ align (+/- 1mm)



Interfaces management



Differential movement at the junction between slabs (mm level)

Interfaces management strategies

- Bridge or Break ?

- previsions required for
- monitoring
- adjustment
- Flux measurement also

ESS Strategy for guide Control & re-alignment

Preliminary

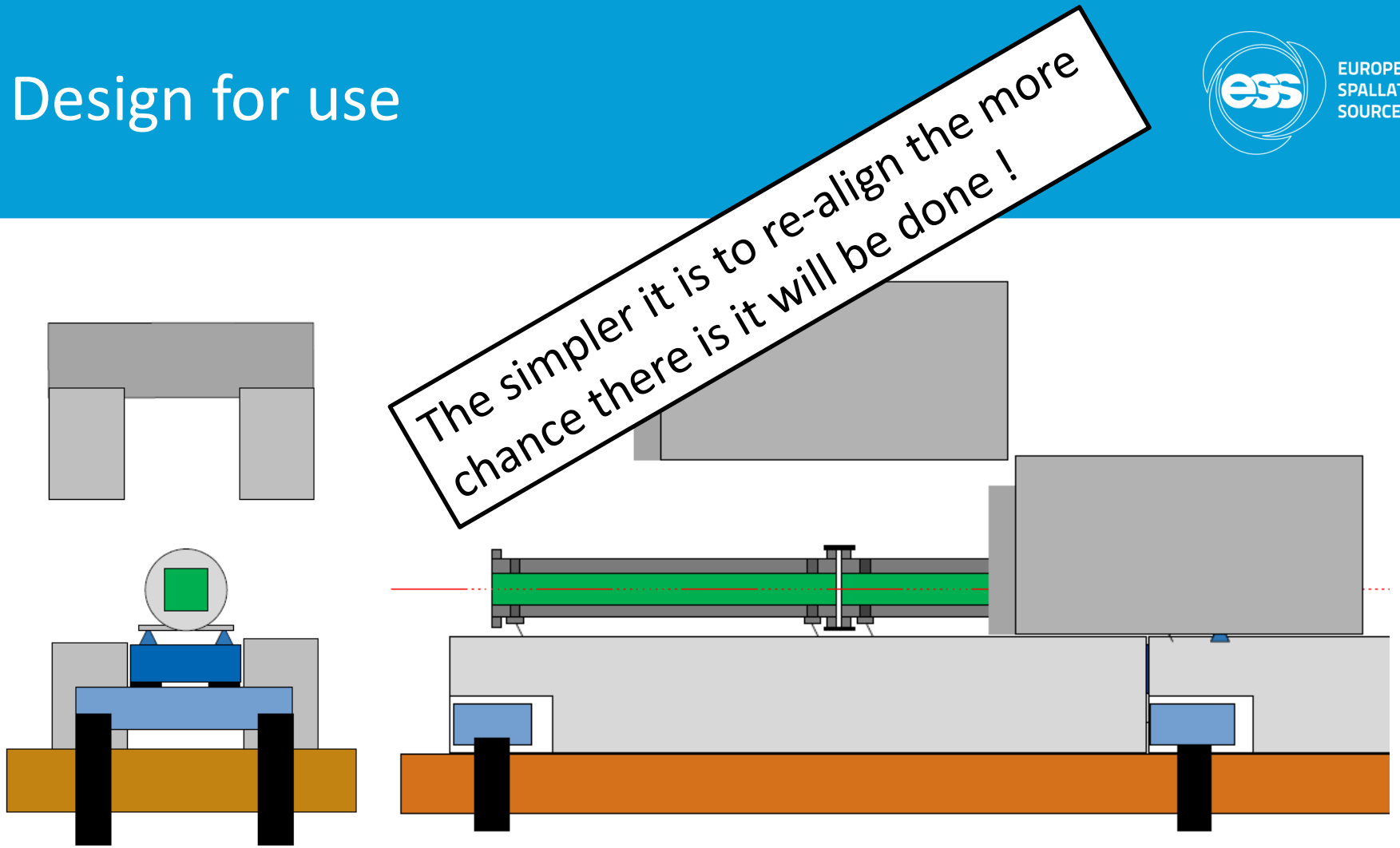
Monitoring

- Strategic monitoring of slab movement (interfaces)

Periodic maintenance

- Complete control ‘as-built’
- 1st control +2 yrs
- 2nd control +5 yrs

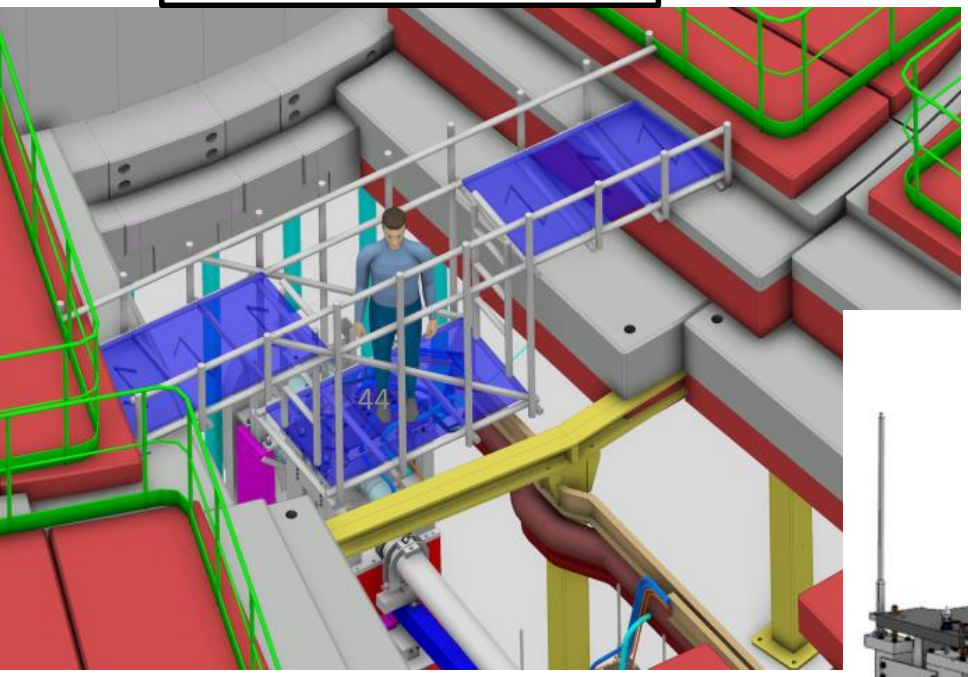
Design for use



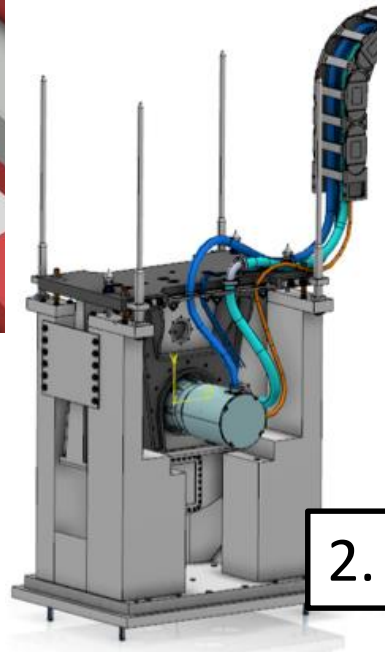
- Design shielding to facilitate (re)alignment
- Discrete blocks around control & alignment locations
- Minimised removal = better chance of regular alignment

Control & (Re-alignment) in the bunker

1. Vertical access



3. Long manual tools



2. RH Ready equipment

Active alignment

Monitoring

Knowing when to intervene.

- Monitor support movement
- Tech exists on X-ray beamlines

- Use at on critical beamlines or interfaces
  - Remote adjustment ?
  - Over illumination

- If in doubt leave space and retrofit if required !

Take away

- plan Plan PLAN! (including plan B)
- Ensure provisions for post install inspection & adjustment
- Do install ALL shielding to preload floor
- Install , rough align and commission as you go …
- But leave fine alignment to the end

EUROPEAN SPALLATION SOURCE

Thank you for your attention !