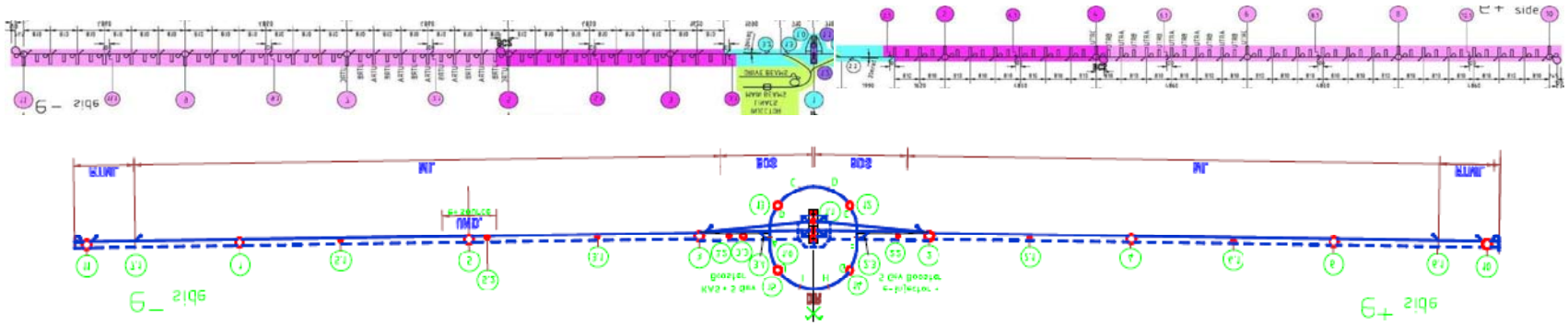
How to apply scheduling work done for ILC to the CLIC project

Prepared by M Gastal

Goal:

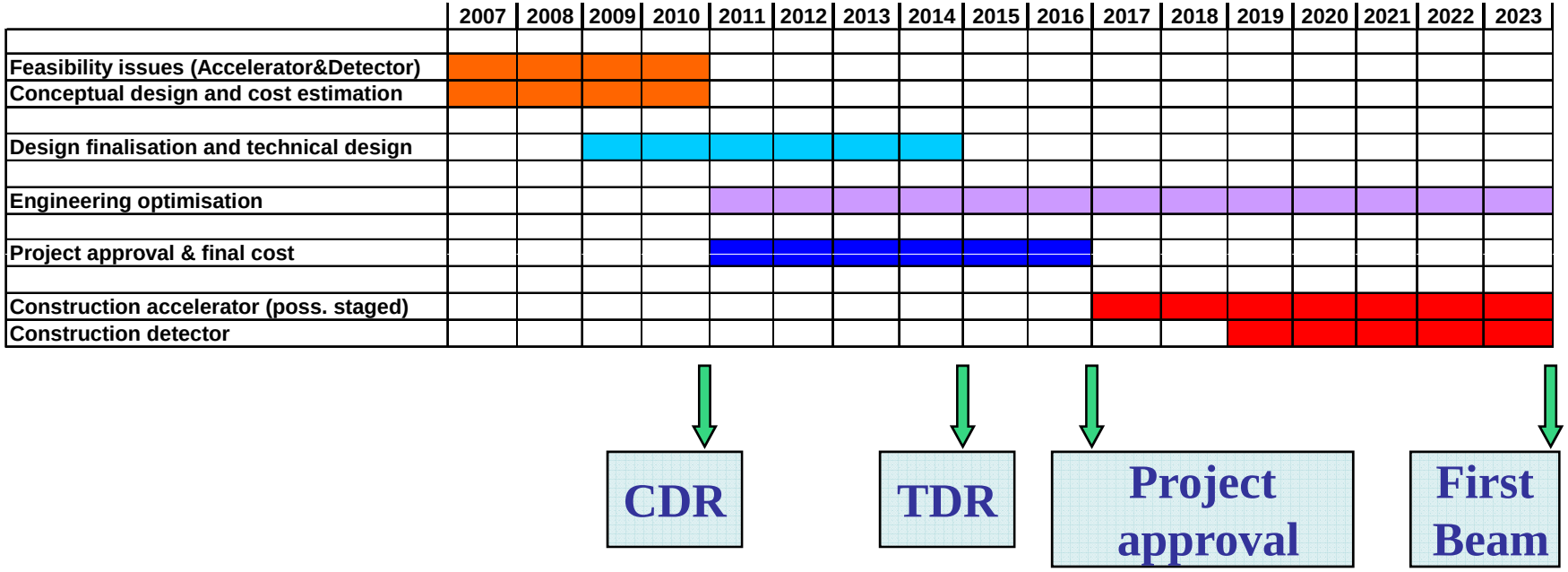
→Present the work done for the construction schedule of ILC project and explore the possibility to apply it to CLIC



Tentative long-term CLIC scenario

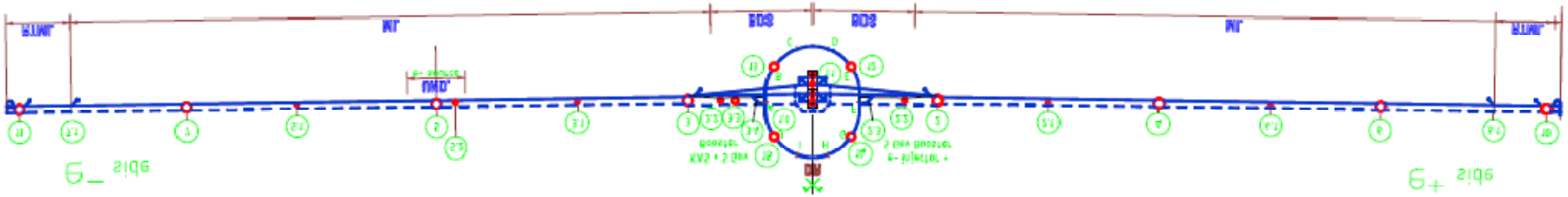
rtest, success oriented and technically limited schedule

Technology evaluation and Physics assessment based on LHC results for a possible decision on Linear Collider funding with staged construction starting with the lowest energy required by Physics



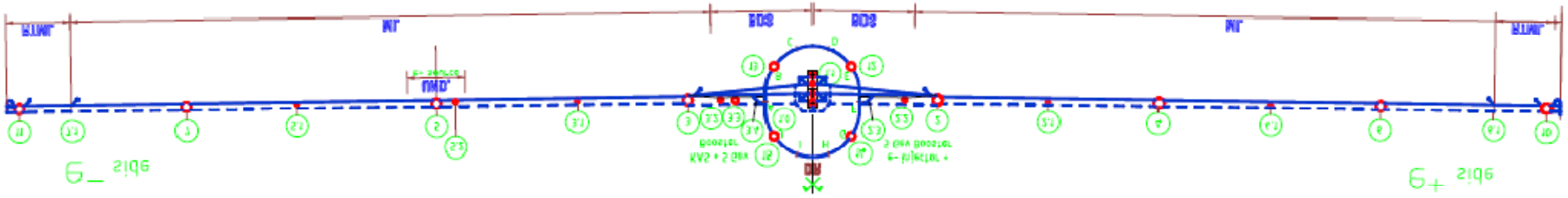
Scope of This presentation

- → Based on ILC presentation made in Valencia workshop
  - → Most assumptions are still valid
- → Highlights areas where more work should be done
  - → Details of CFS services installation
  - → Latest lessons learnt from CMS for Experimental area



Scope of CFS scheduling exercise

- → Studied for all sample sites
  - → CERN & DESY (Europe)
  - → Americas
  - → Asia
- → Shows the critical path for the construction of the ILC
  - → RTML, Main Linac, Beam Delivery system
  - → Not displayed:
    - →DR, e+ & e- tunnels, Dumps, Point 3.3 & 5.2
- → Goal: Check if a 7 year construction time is feasible



Scope of CFS scheduling exercise

- Includes all CFS services
  - Civil engineering (CE)
  - Cranes
  - Electrics (EL)
  - Cooling and ventilation (CV)
  - Metallic structures
- Based on input from:
  - Amberg Engineering Ltd
  - John Osborne (CERN tunnelling expert)
  - LHC project for tunnel construction & CFS services installation

For Civil Engineering work

- CMS project for surface buildings, detector hall construction and CFS services installation
- KEK for Asian construction schedule

Scope of CFS scheduling exercise

→ Method to make time estimates:

→ Use the completion analysis of LHC and CMS work and scale it to ILC project

→ Based on a real-life similar project (good reference)

Civil Engineering

Cooling and Ventilation

Cranes

Electrics

Year by year schedule
Assumptions

→ Start of construction is t_0

→ Start of beam commissioning is 7 years from t_0

→ ILC will be ready for physics run 1year after the beam commissioning

→ The detectors could be assembled on the surface to save time (CE work can be done in parallel)

→ Twin tunnels + 1 single IP

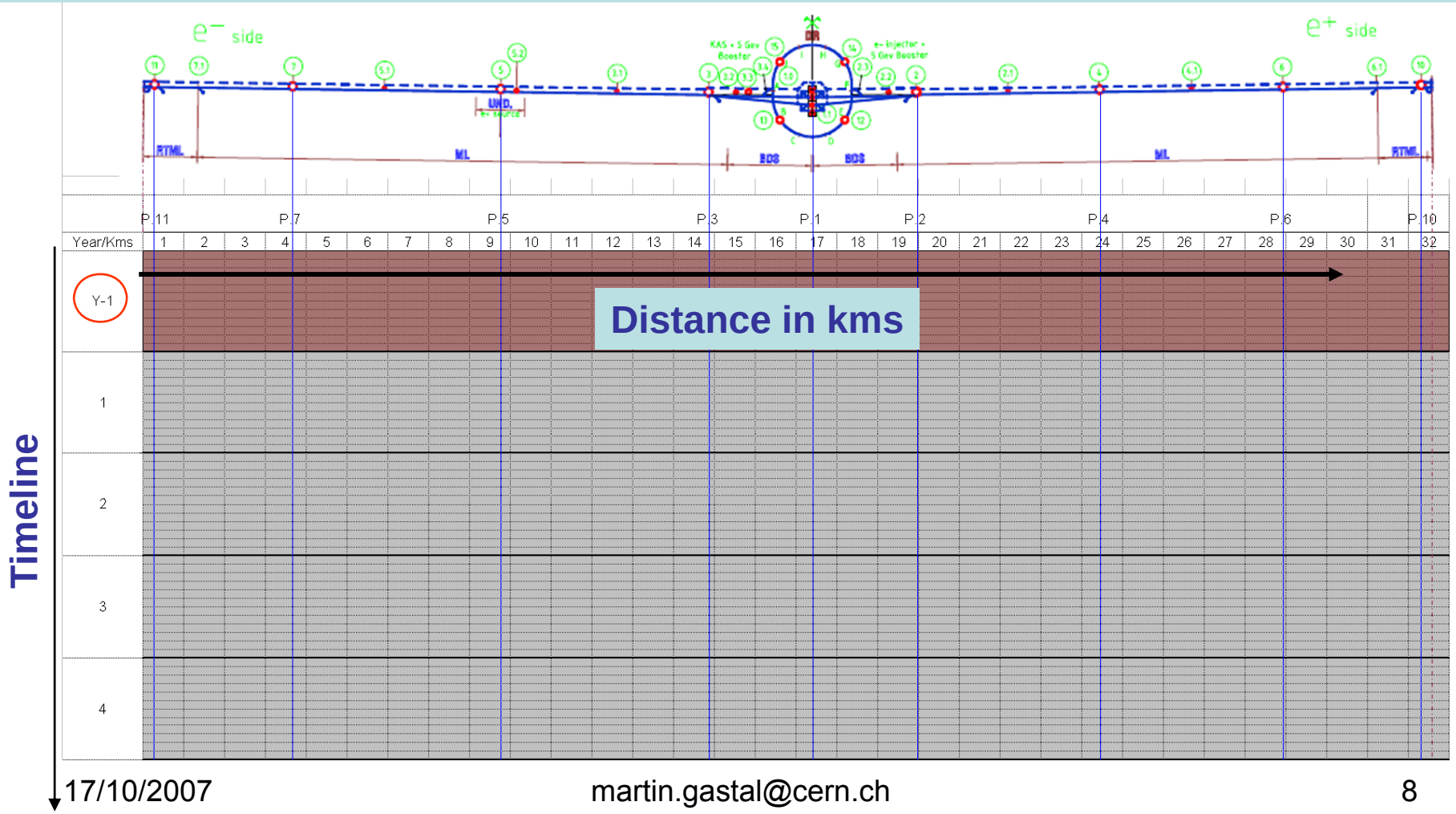
→ CERN/Americas sample site used as illustration

CERN and Americas: Before t_0

→ Market surveys, call for tenders and contractor selection

→ Building permits, Environmental impact studies, Purchase of land

→ Based on experience with LHC - Implies having a frozen design!



CERN and Americas: Year 1

→Shafts excavation

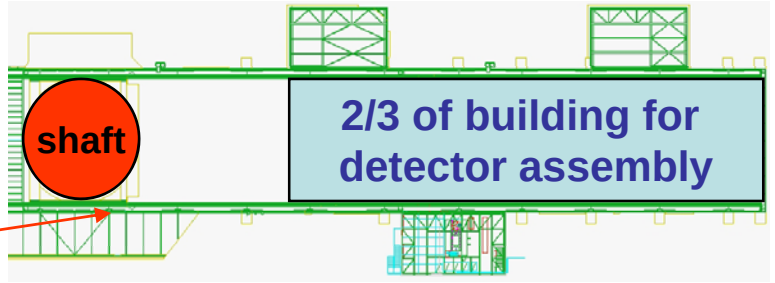
→ Surface Work

→ Service buildings

→ Main EL substation at Point2

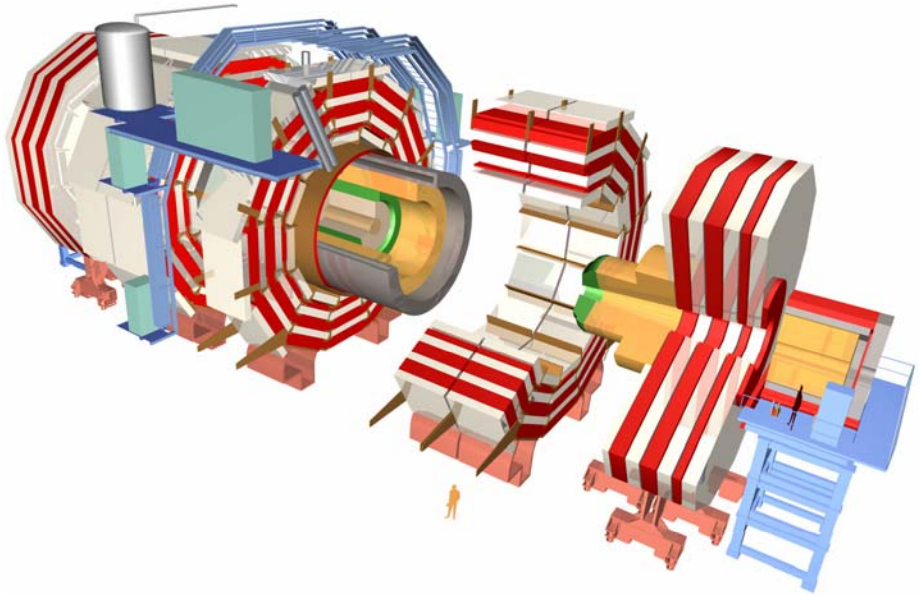
→ Part of surface detector assembly building

10 shafts have to be started together



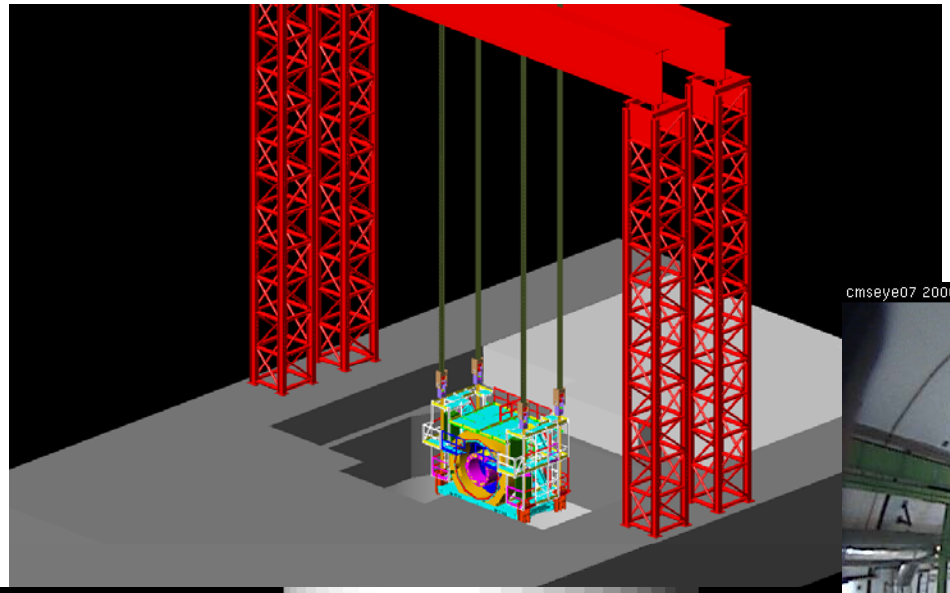
CMS concept

- Key Ideas:
  - Build and commission the detector in a surface assembly building.
  - All services (cabling, piping, fibre optics…) are installed on detector wheels/disks on the surface
  - Only fully commissioned pieces of detector are lowered in the detector hall



CMS concept

- → Impact costs
  - → Work executed underground requires 50% more time than if performed on the surface and can be at least 30% more expensive
  - → Extra costs attached to the CMS concept:
    - →Rented Heavy lifting equipment (1.5MCHF for CMS)
    - →Large detector assembly building (3 MCHF for CMS)
    - →Both costs are already included in the CFS cost estimates for EU sites
- → Impact on schedule
  - → Significant time saving
  - → Detector assembly on the surface runs in parallel with CE work underground

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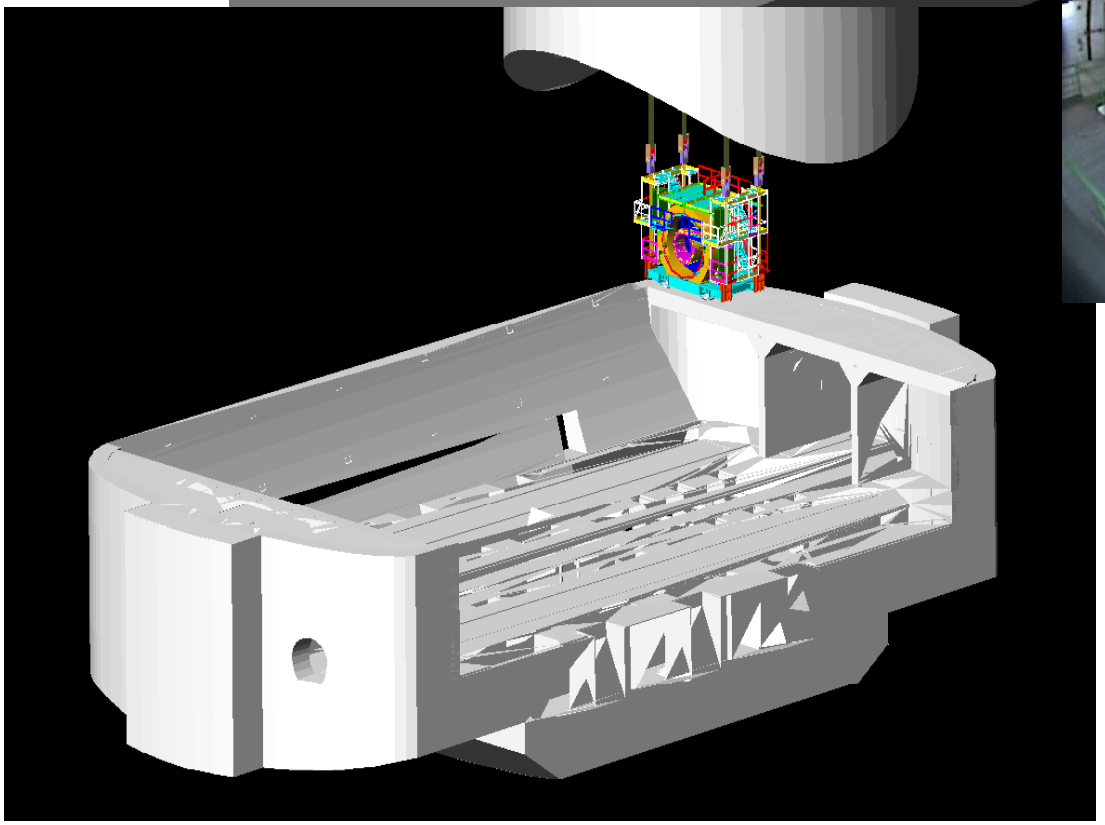
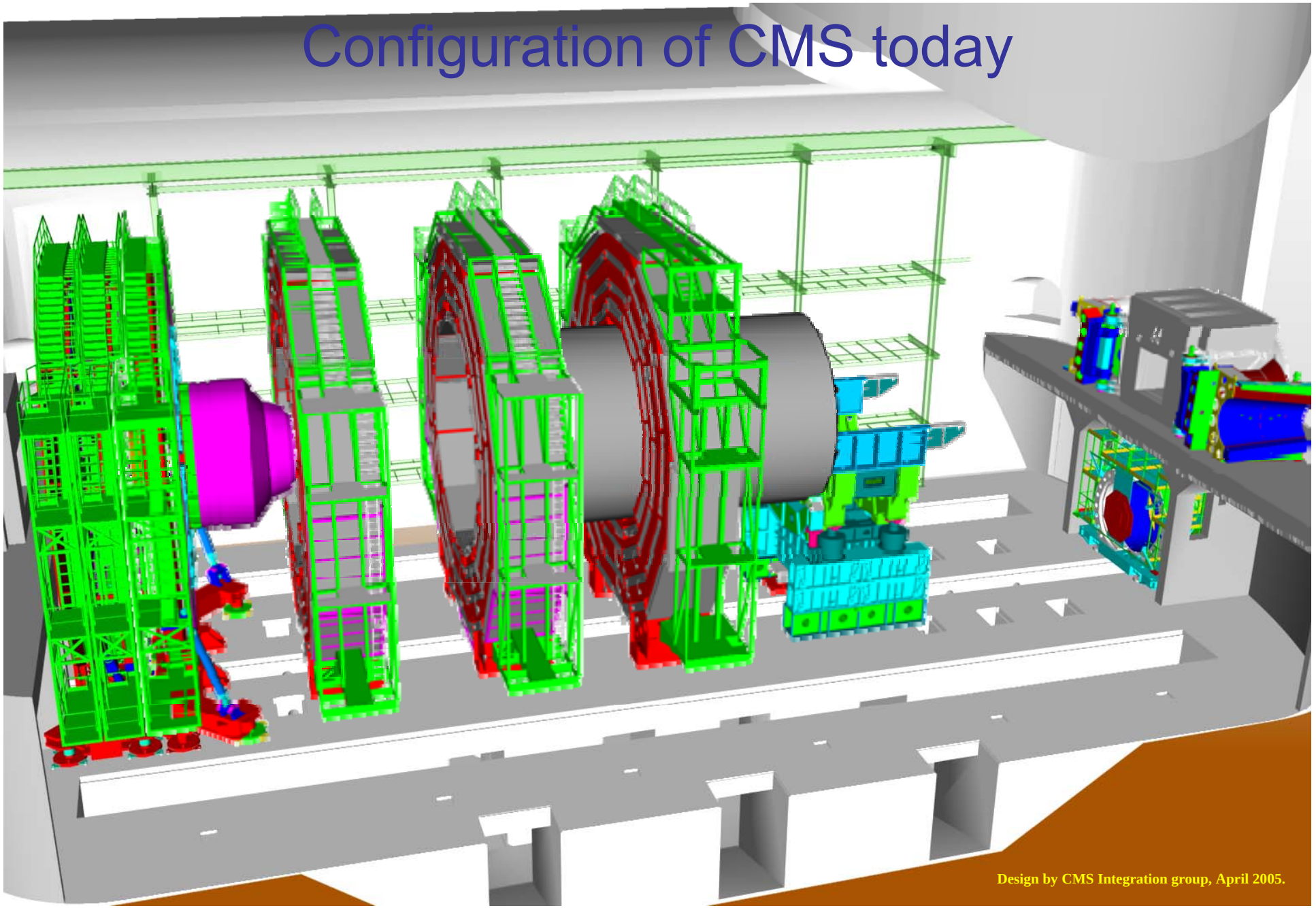
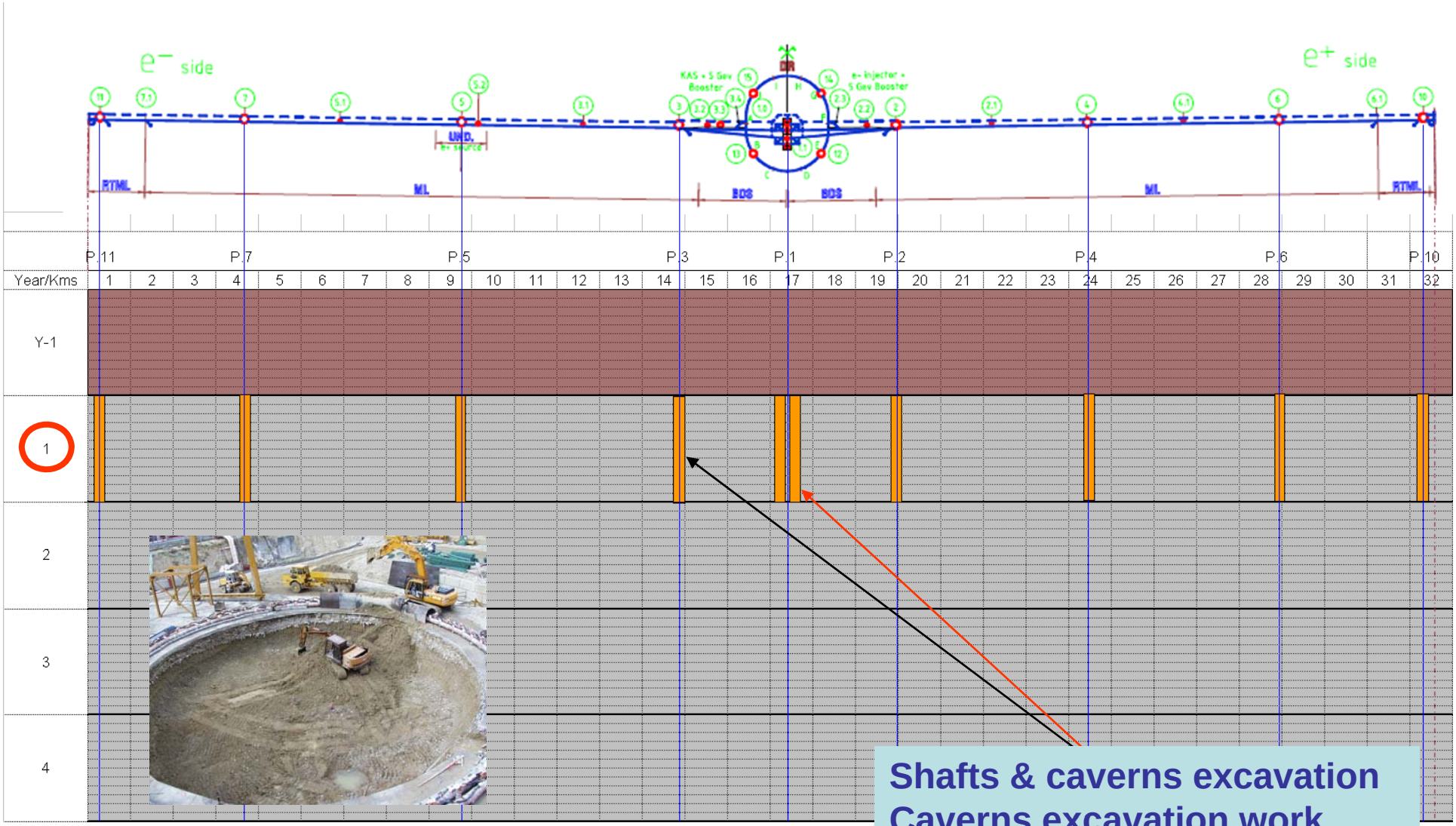


Configuration of CMS today

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Year/Kms
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29 30 31 32
Y-1
1
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TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
Shafts & caverns excavation
Caverns excavation work includes preliminary lining to allow the setup of TBMs

CERN and Americas: Year 2

→ Set-up and launch of TBMs both for RTML, ML, BDS and DR

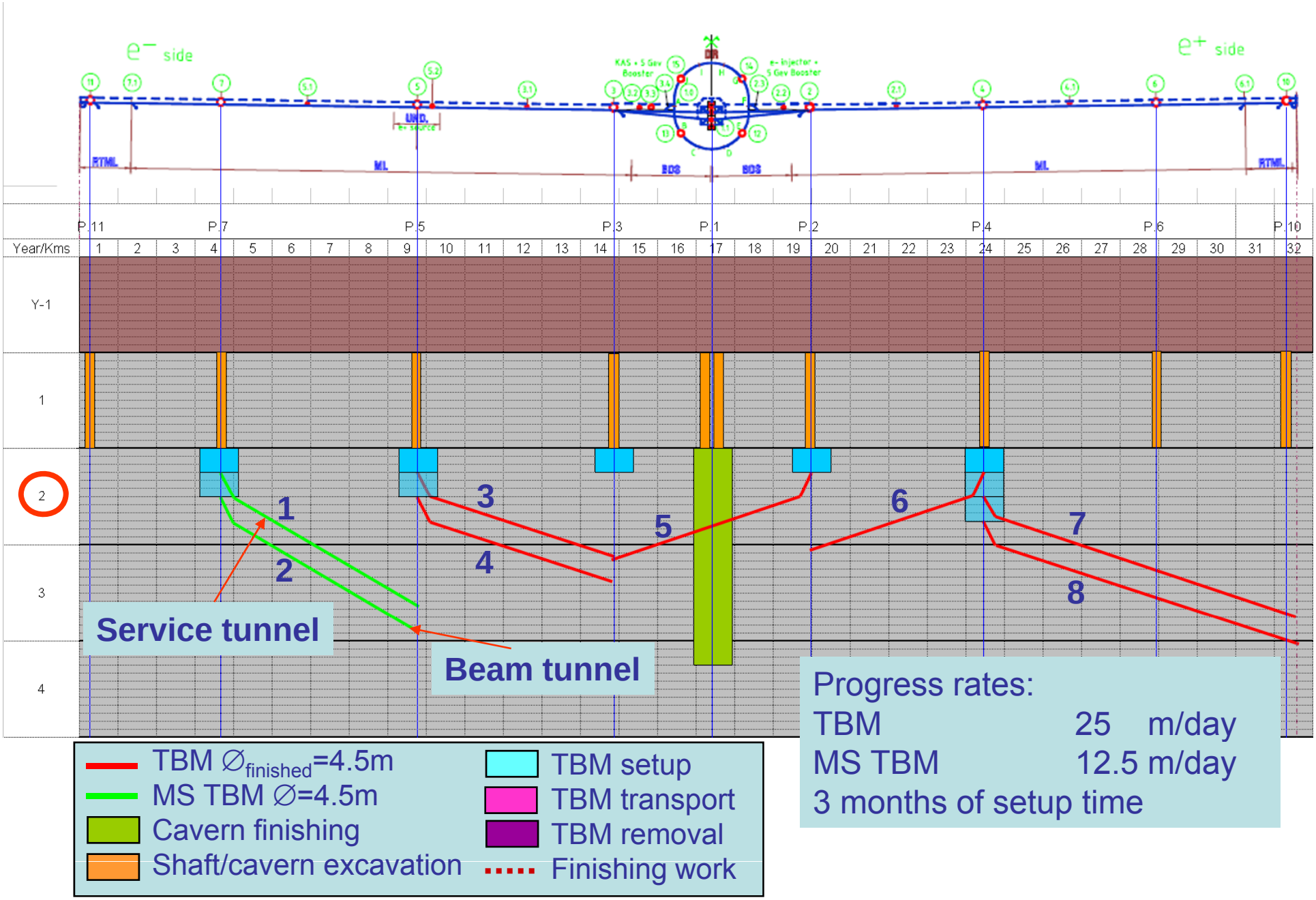
→ Service tunnels formed first

→ Detector hall construction

→ Surface work

→ Construction of secondary EL substations

9 TBMs have to be started simultaneously (1 for DR)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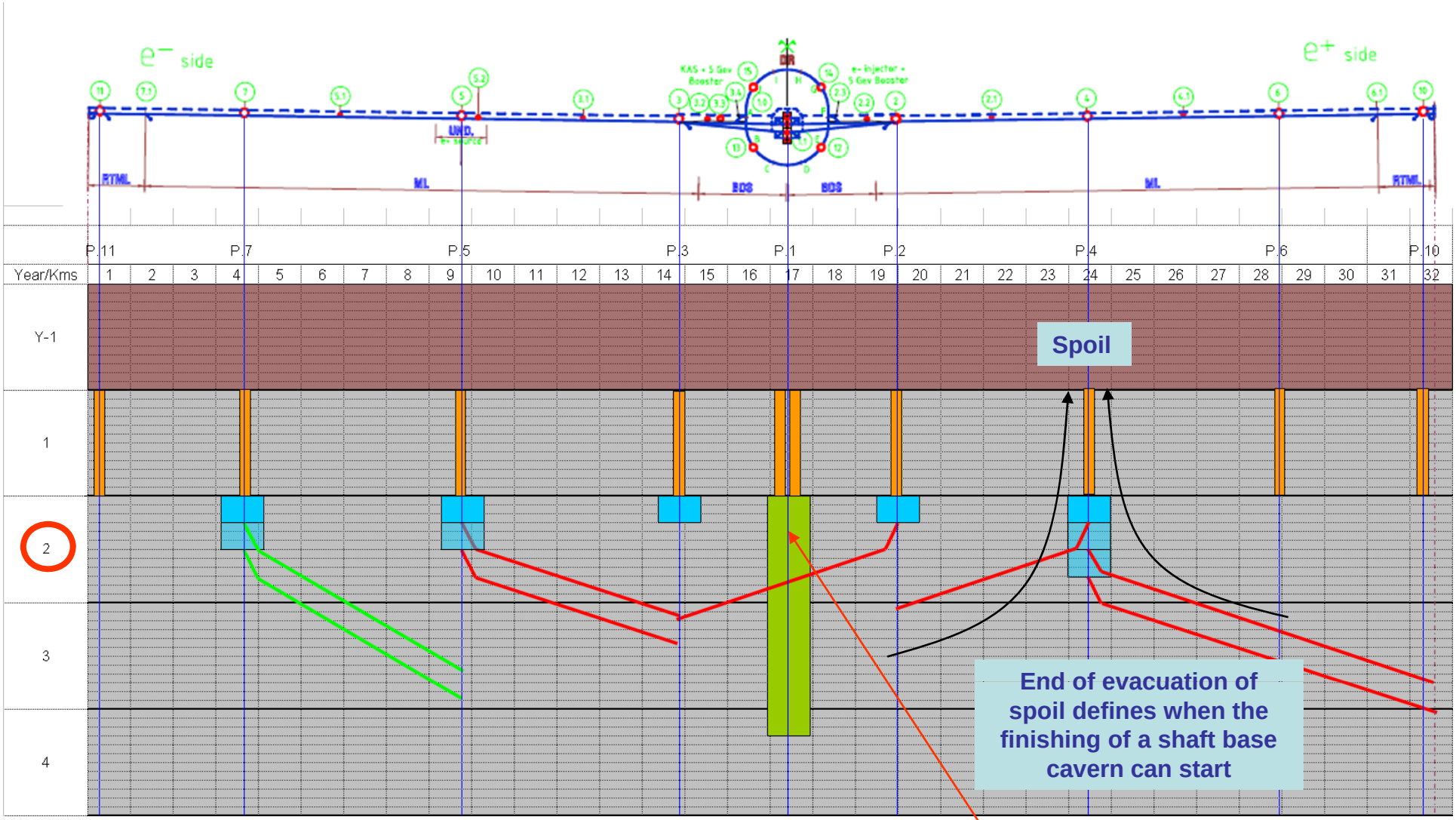
Service tunnel
Beam tunnel
Progress rates:
TBM 25 m/day
MS TBM 12.5 m/day
3 months of setup time
TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work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Year/Kms
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Spoil
End of evacuation of spoil defines when the finishing of a shaft base cavern can start
TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
Detector hall finishing starts when excavation is complete

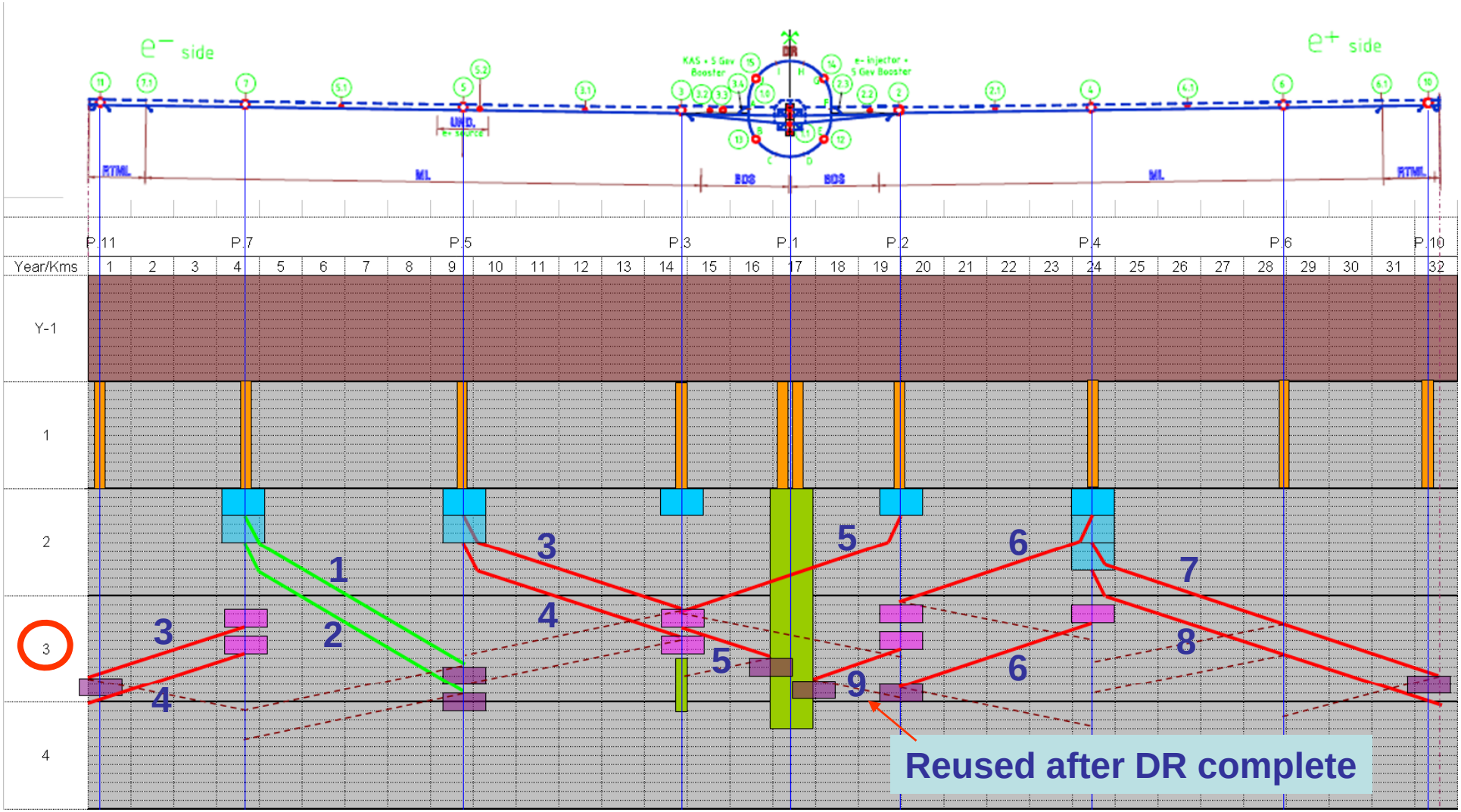
CERN and Americas: Year 3

→ Most resource intensive year:

→ 8 TBMs in action for RTML, ML, BDS + 1 for DR

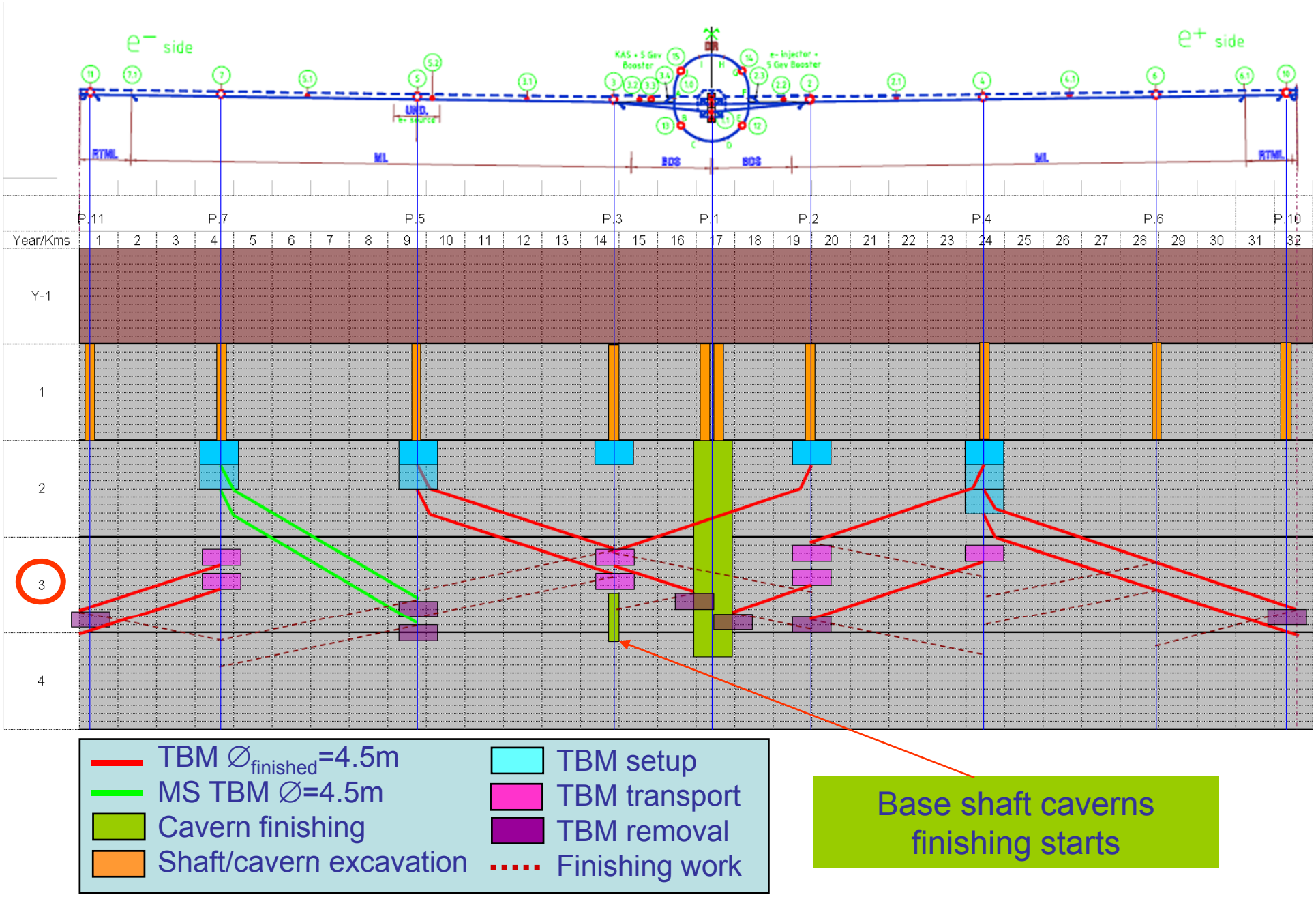
→ Completion of detector hall + on-going work for shaft base caverns

→ Finishing of tunnels + start of CFS services installation



TBM $\varnothing_{finished}$=4.5m
MS TBM $\varnothing$=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work

9 TBMs for RTML, ML, BDS
But 5 are transported and reused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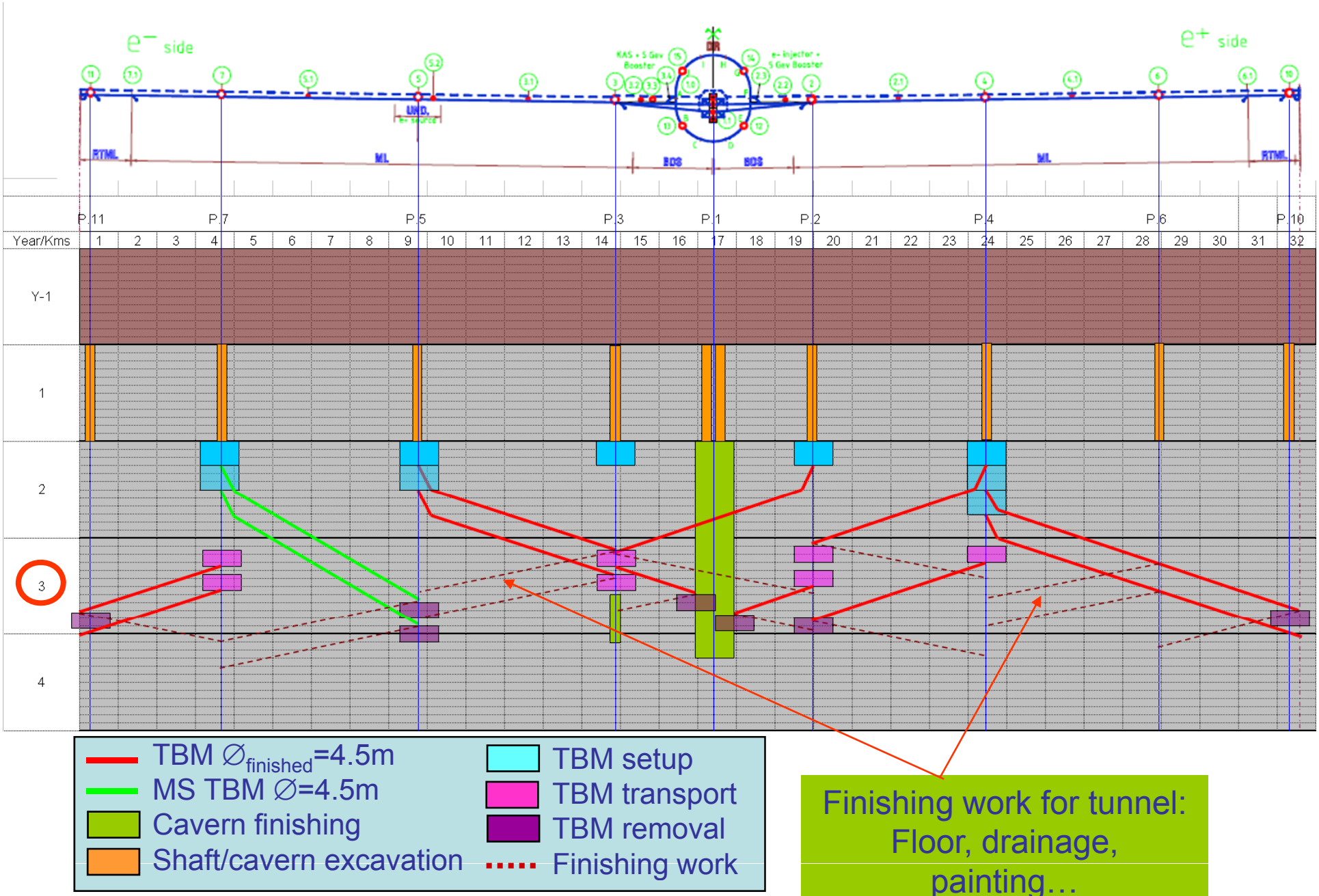
TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
Base shaft caverns finishing starts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Year/Kms
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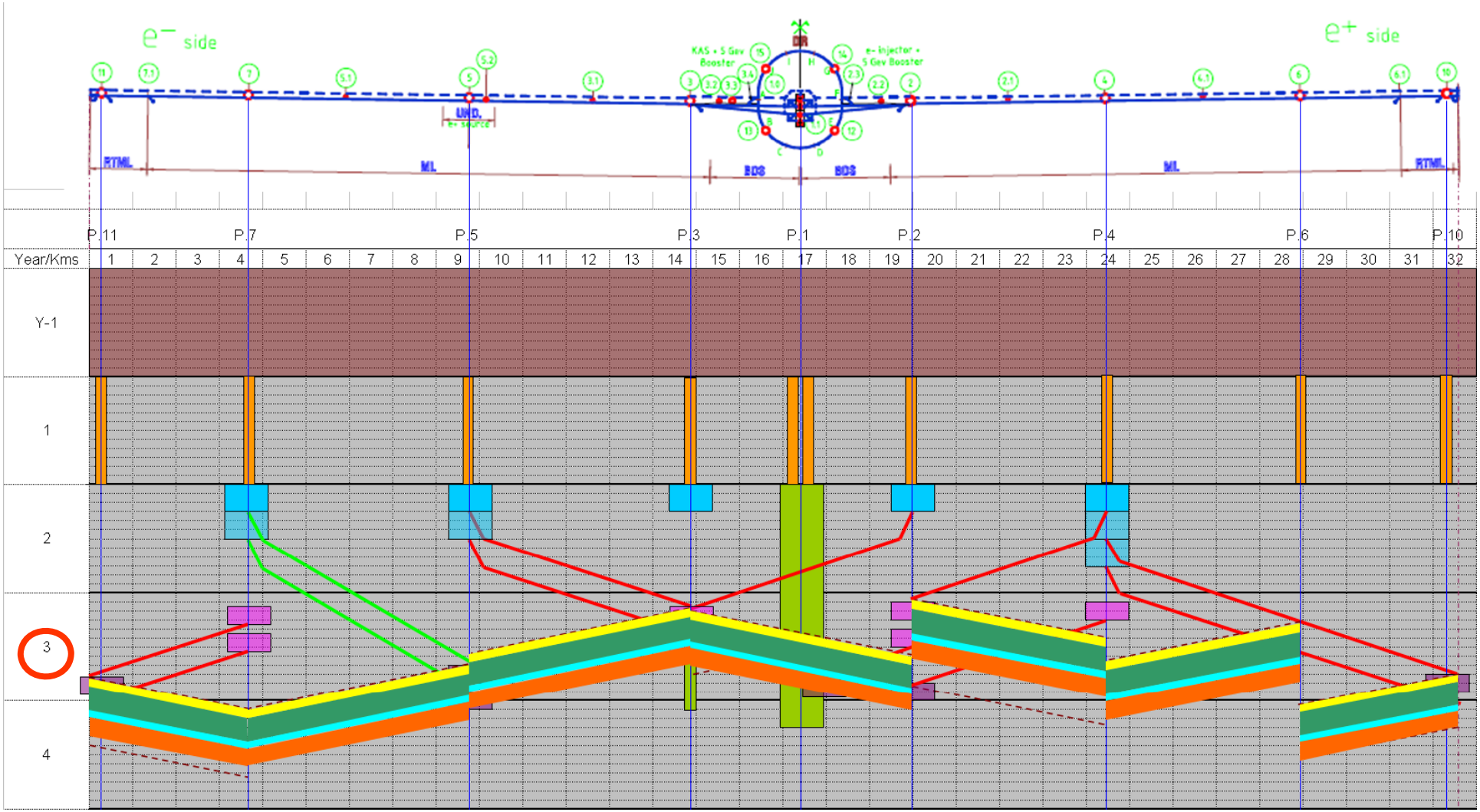
TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
Finishing work for tunnel: Floor, drainage, painting…

CFS services installation in tunnels

→ **Work should be broken-down in 1km sections**
- → Based on experience at LHC
- → No more that 3 teams per km
- → Activities are mutually exclusive

→ **Service tunnel should be installed first**
- → CV work takes longer than in beam tunnel
- → EL work is needed there before beam tunnel can be installed
- → Also reason why the service tunnel is being excavated first

→ **Basic sequence for service tunnel:**
- → 1- Installation of cable trays and pipes supports (4weeks /km)
- → 2- Installation of cooling pipes (14weeks/km)
- → 3- Installation of cables + connection (3weeks /km)
- → 4- Installation of electrics equipment (Transformers, Switchboards, RMUs) (8weeks /km)



- Cable trays + pipes supports
- CV pipes
- EL cables + connection
- Transformers, switchboards…

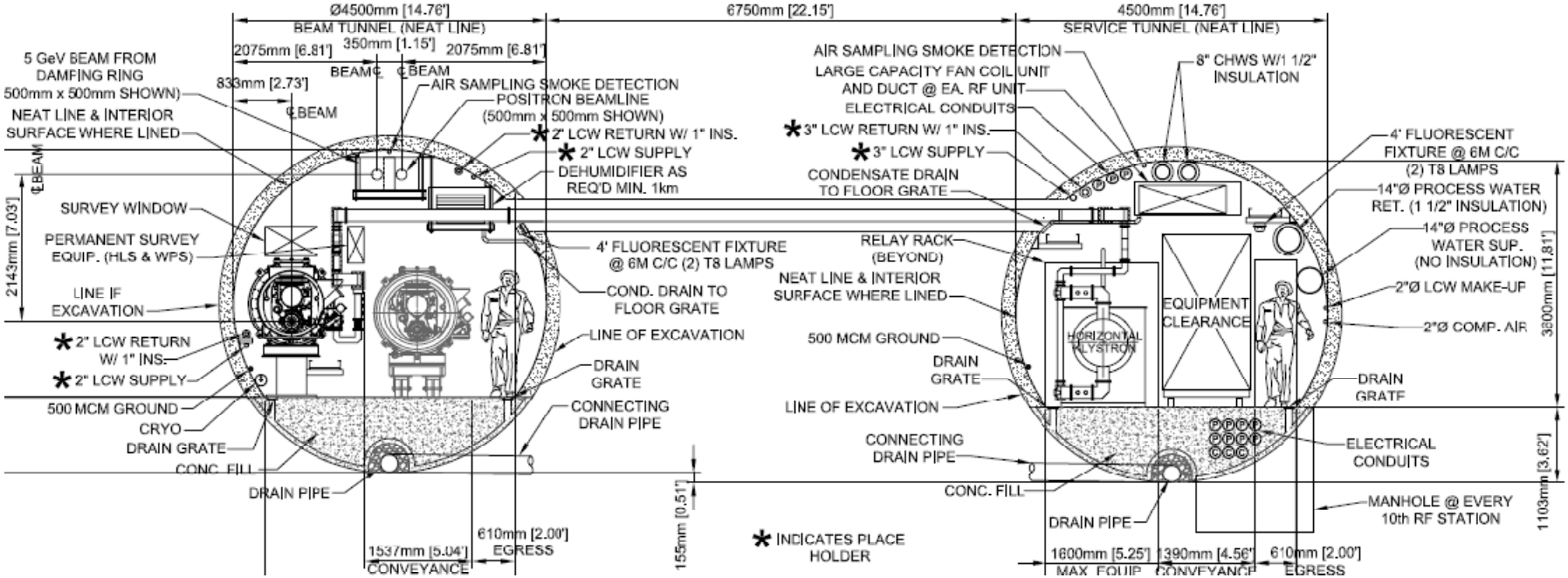
→ All sections of the service tunnel should be installed with general services by

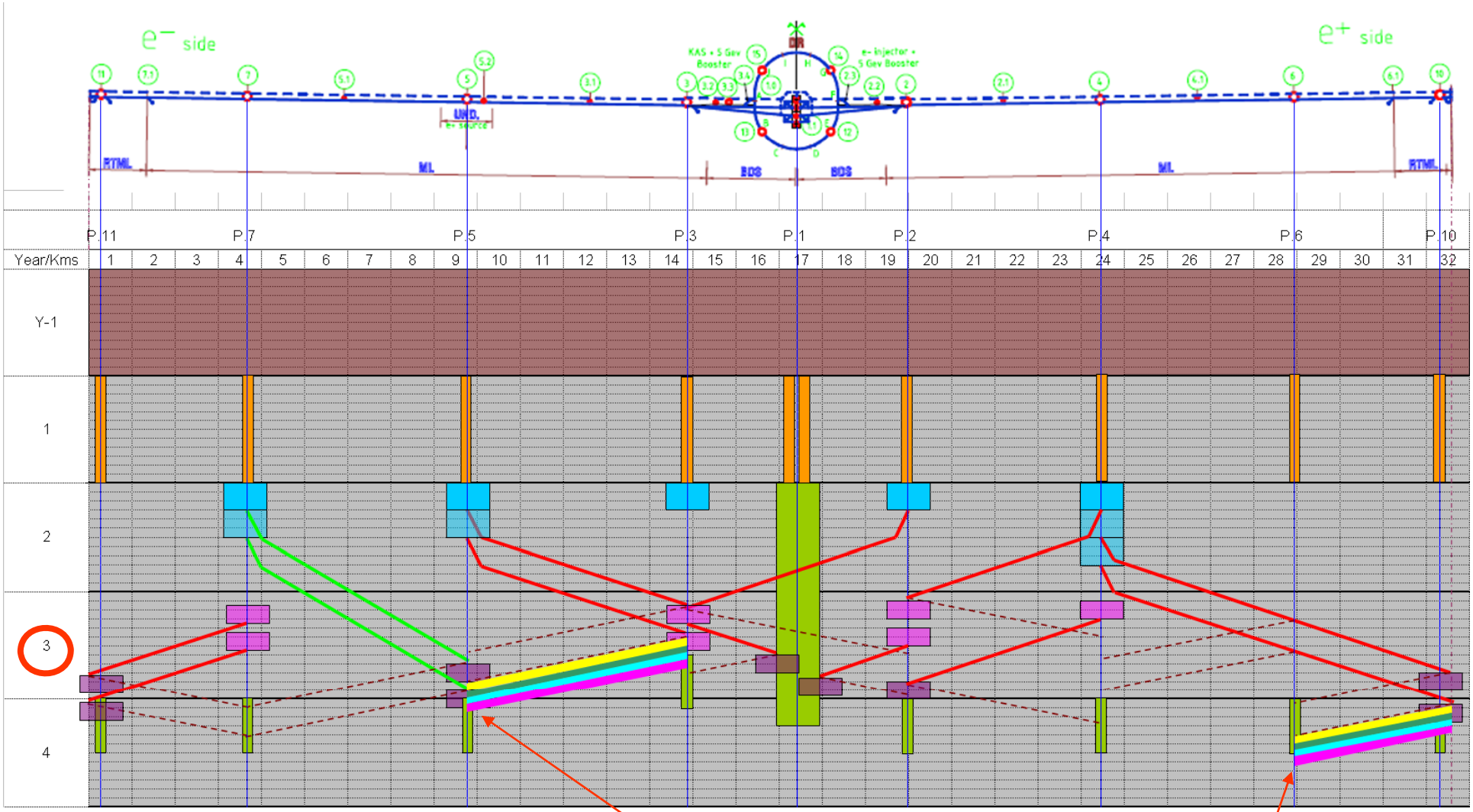
t_0 + 3.5 Years

CFS services installation in tunnels

→ **Basic sequence for Beam tunnel:**

- → 1- Installation of cable trays and pipes supports (4weeks /km)
- → 2- Installation of cooling pipes (3weeks /km)
- → 3- Installation of cables + connection (3weeks /km)
- → 4- Installation of lighting and sockets (4weeks /km)





Cable trays + pipes supports
CV pipes
EL cables + connection
Lighting + sockets

First section finished:
t_0 + 3y2m
Machine installation can start!

Last section
Installed
t_0 + 3y7m

Compatibility with 7year project time

→ The first section of tunnels (beam + service) would be fully installed with services at ~ t_0+3 years

→ If the machine can be installed in the next 4 years then the 7 year project time is still manageable

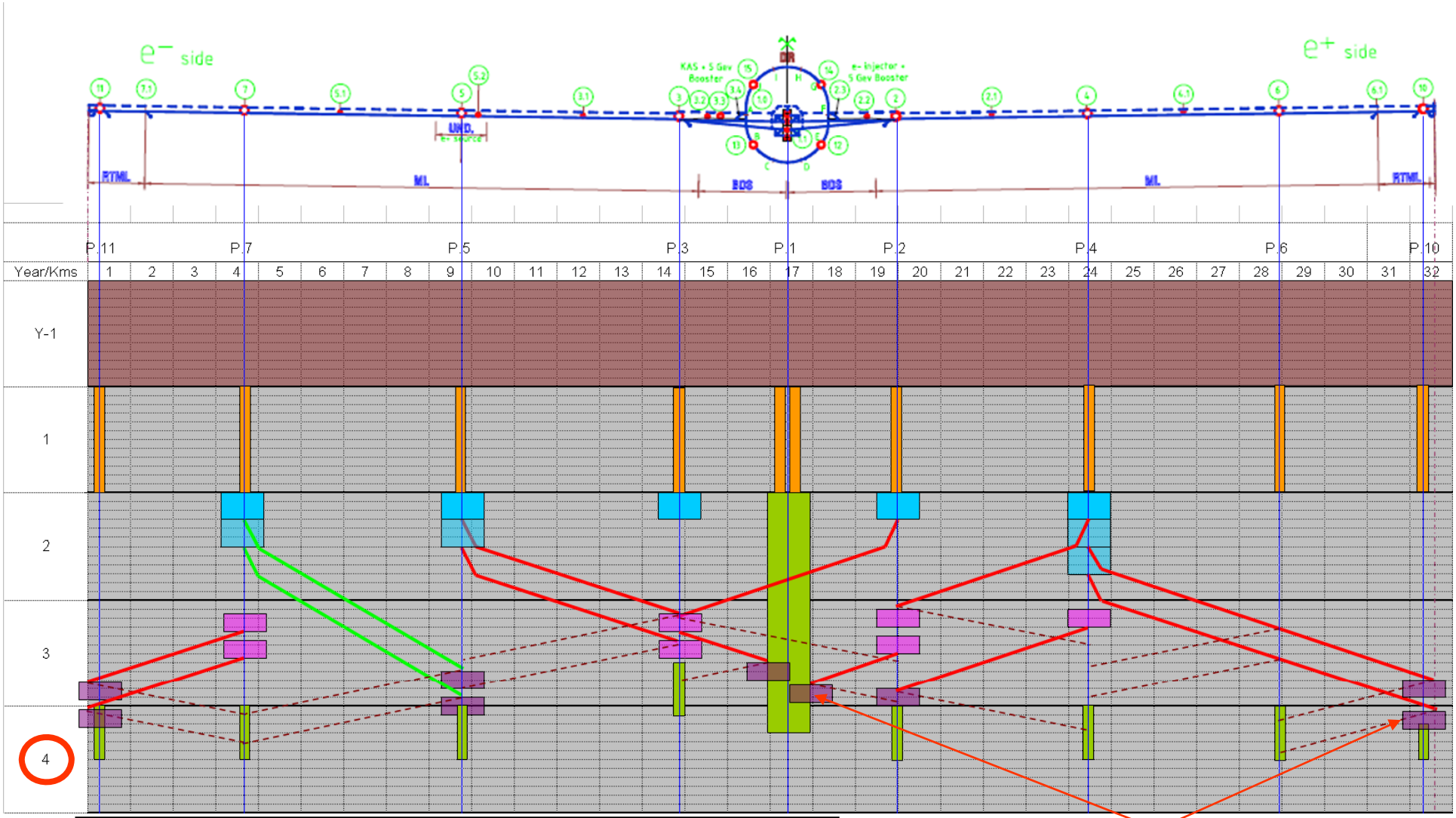
→ However:

- → Procurement time has been assumed done before t_0
- → Not all tunnels sections are made available for machine installation at the same time
- → Machine installation strategy will have to be carefully designed so as to avoid bottle necks created by the discontinuity of the sections available for installation

CERN and Americas: Year 4

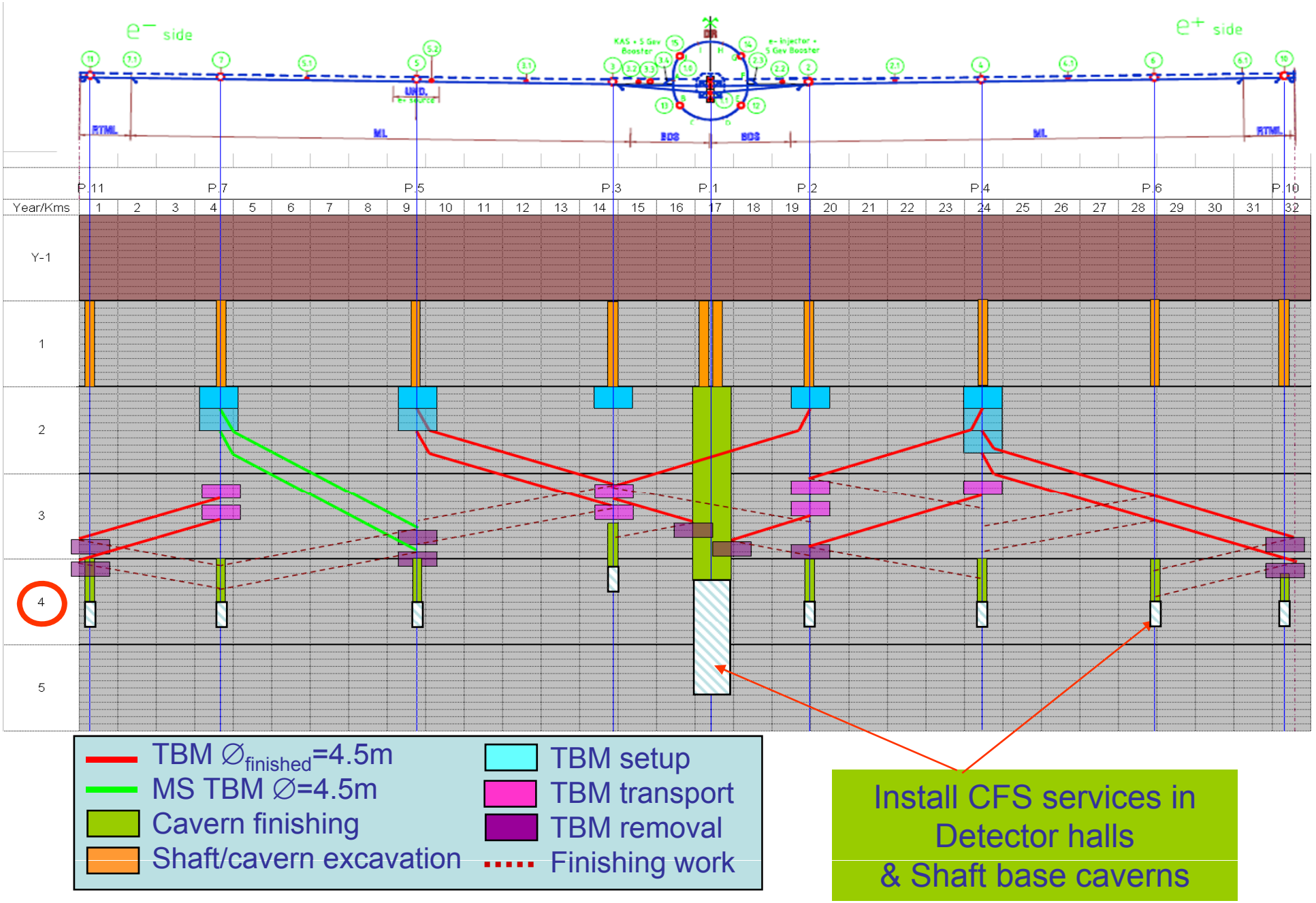
→ Last year of underground CE work:

- → Extraction of TBMs
- → Start of installation for infrastructure in Detectors Halls
- → Completion of shaft base caverns + Shaft access building for point 1
- → Finishing of tunnels + CFS services installation



Extraction of TBMs

End of all CE work: t_0 + 3.5 years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TBM ∅finished=4.5m
MS TBM ∅=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work
Install CFS services in Detector halls & Shaft base caverns

CFS services installation schedule for Detector Halls and Base Shaft Caverns

Post completion analysis of cable chains installation now available from CMS

→ Based on experience with CMS

→ Time estimates for site work only

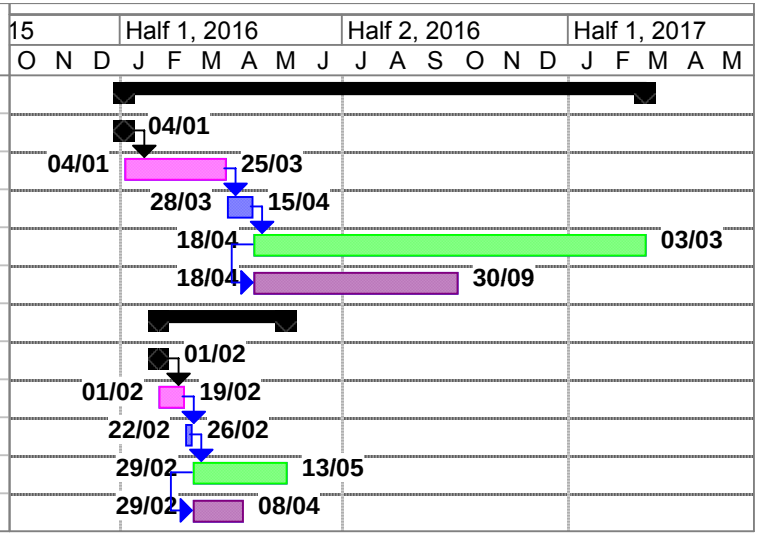
Cavern	Dimensions L x W x H	Metallic structures	Cooling and ventilation	Electrics General Services	Crane installation
CMS	53 x 26 x 25	5w	19w	10w	1w
ILC detector halls	120 x 25 x 35	12w	46w	24w	3w
ILC Shaft base caverns	49 x 16 x 18	3w	11w	6w	1w

Completion examination figures

Estimates

CFS services installation schedule for Detector Halls and Base Shaft Caverns

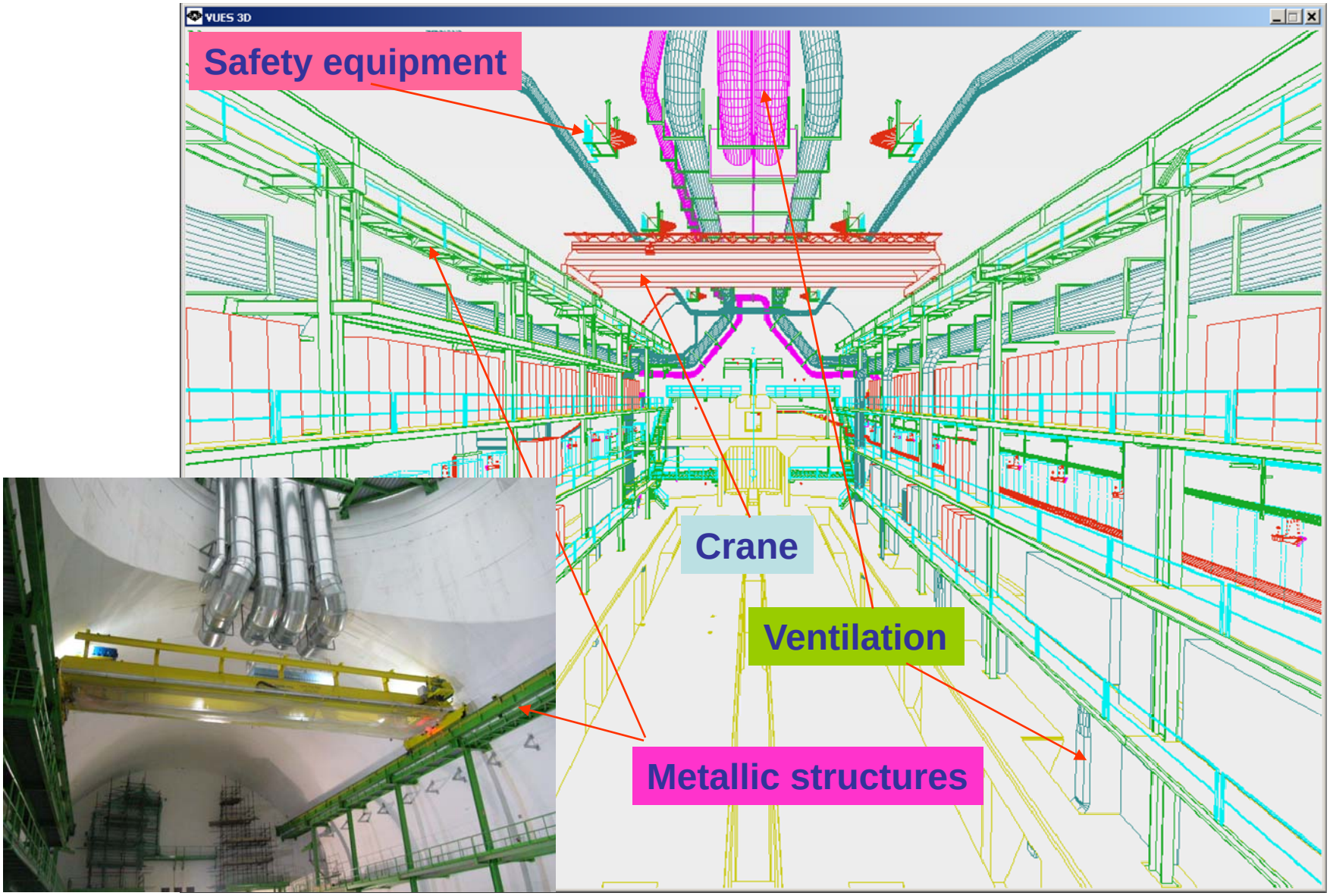
ID	Task Name	Duration
1	Underground Detector Hall	**305 days**
2	Detector Hall construction complete	0 days
3	Install metallic structures	12 wks
4	Install overhead crane	3 wks
5	Install cooling and ventilation	46 wks
6	Install EL general services	24 wks
7	Shaft Base Caverns	**75 days**
8	Cavern construction complete	0 days
9	Install metallic structures	3 wks
10	Install overhead crane	1 wk
11	Install cooling and ventilation	11 wks
12	Install EL general services	6 wks



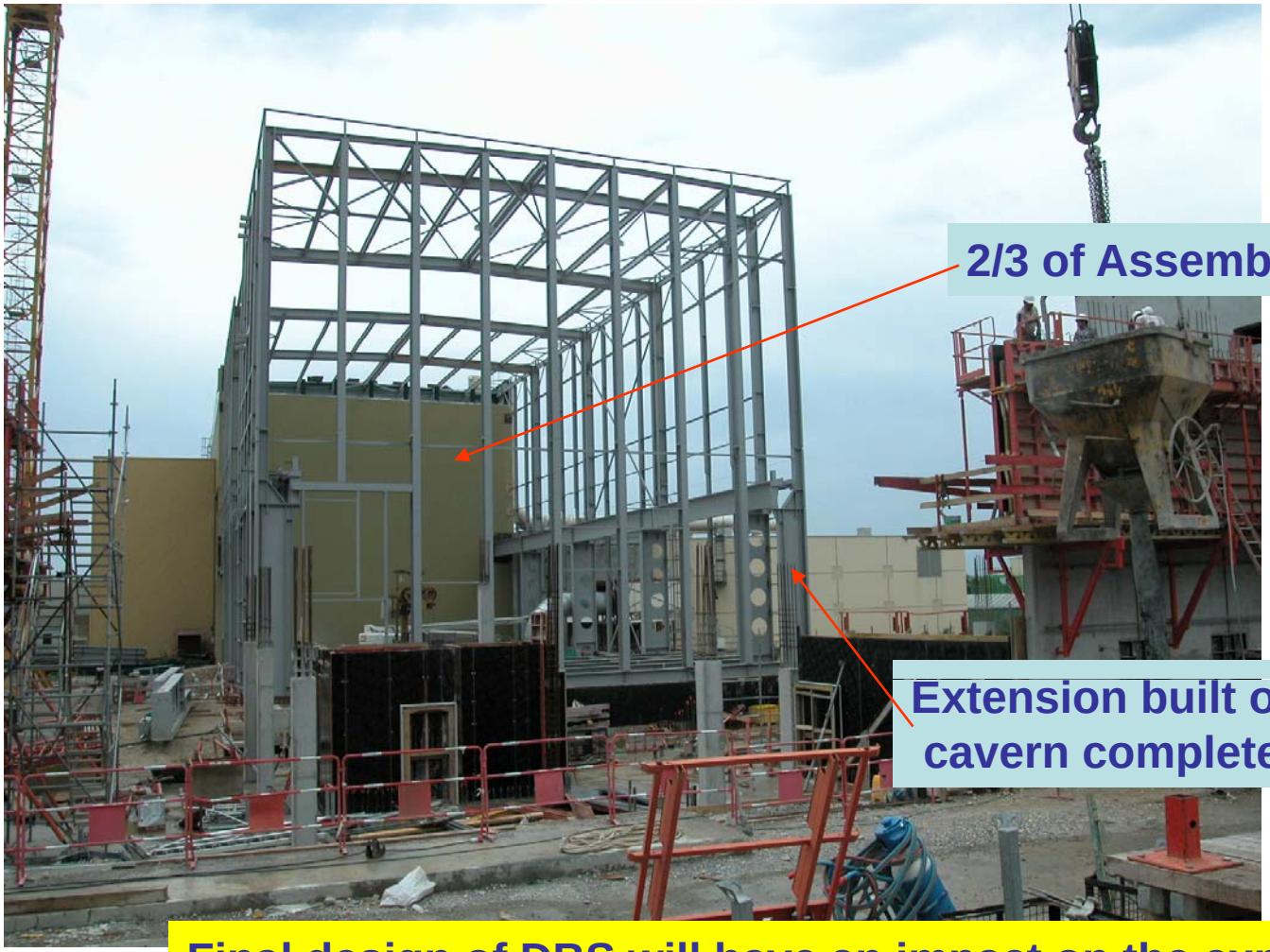
→ CFS services ready:

- → Detector Halls: 14 months after hall construction complete
  - → Ready for detectors: t_0 + 4 years (possible overlap with CV)
  - → Pre-commissioning carried out in surface building
  - → Once design of experimental area is final, new detailed schedule should be made
- → Shaft base caverns: 3.5 months after cavern completion

CFS services installation in detector hall



Shaft access building for point 1



Final design of DBS will have an impact on the experimental area installation schedule

CERN and Americas: Year 5

→ Installation of infrastructure in detector hall

→ Installation of infrastructure in tunnels

→ Construction of Shaft access buildings (pt1 already complete)

Building and CFS services installation schedule for shaft access buildings

→ Based on experience with CMS

→ Time estimates for site work only

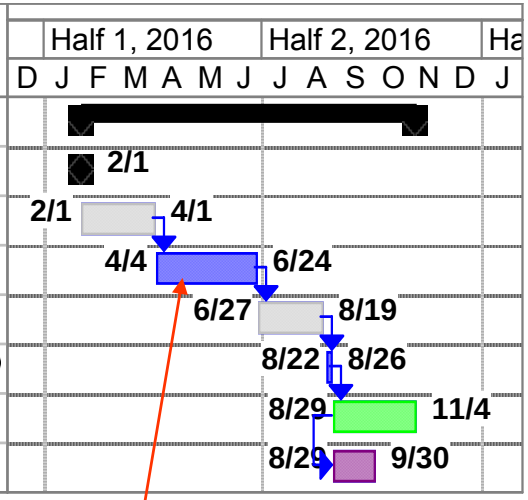
Building	Dimensions L x W x H	CE work Slab, shaft head	Metallic structures	Cooling and ventilation	Electrics General Services	Crane installation
CMS SDX5	36 x 17 x 15.5	15w	17w	18w	12w	1w
ILC Shaft access building	30 x 12 x 12	9w	8w	8w	5w	1w

Completion examination figures

Estimates

Installation schedule for shaft access buildings

ID	Task Name	Duration	Owner
13	Shaft access building	**200 days**	
14	Shaft Base Cavern construction complete	0 days	TS-CE
15	Concrete slab	9 wks	TS-CE
16	Install shaft with infrastructure	12 wks	
17	Build steelworks	8 wks	TS-CE
18	Install overhead crane	1 wk	TS-IC-HM
19	Install cooling and ventilation	10 wks	TS-CV
20	Install EL general services	5 wks	TS-EL



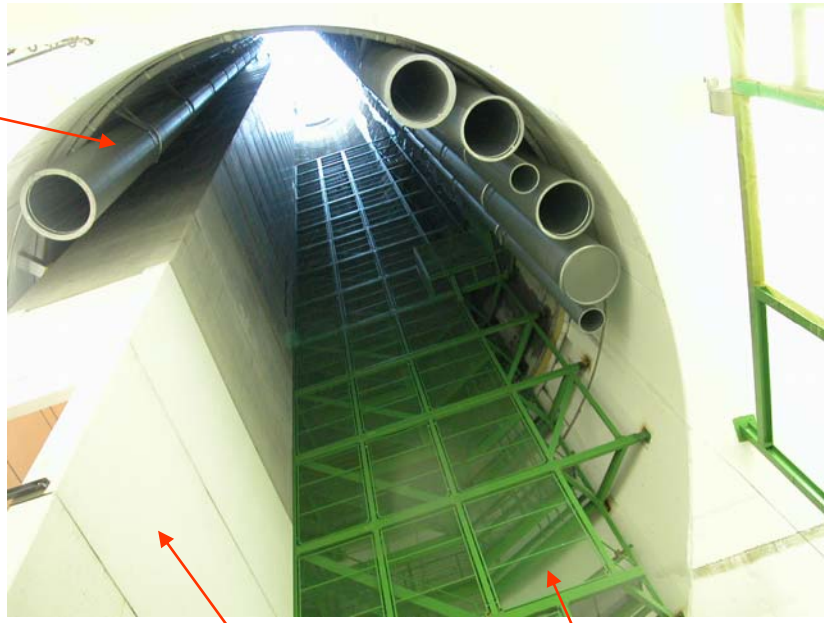
→ Bigger shaft access building complete in 10 months

→ A 12 week window is needed to install CFS infrastructure in shaft:

- → Concrete lift modules
- → Ventilation ducts
- → Cooling pipes
- → Cable trays
- → Metallic staircase

→ Last shaft access building complete by t_0 + 4.5Y

Ventilation ducts



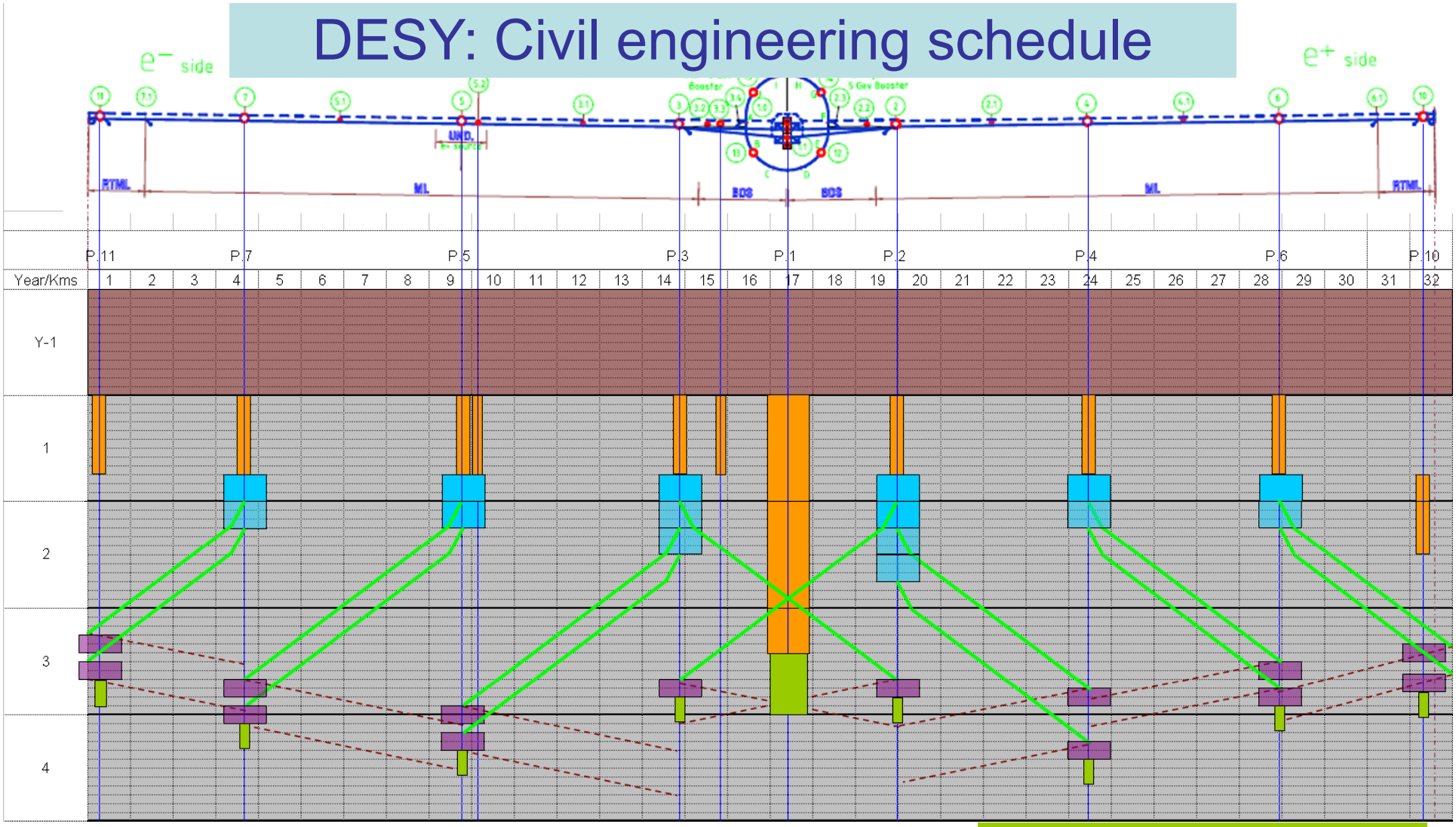
Crane

Concrete lift modules

Metallic staircase

Building complete

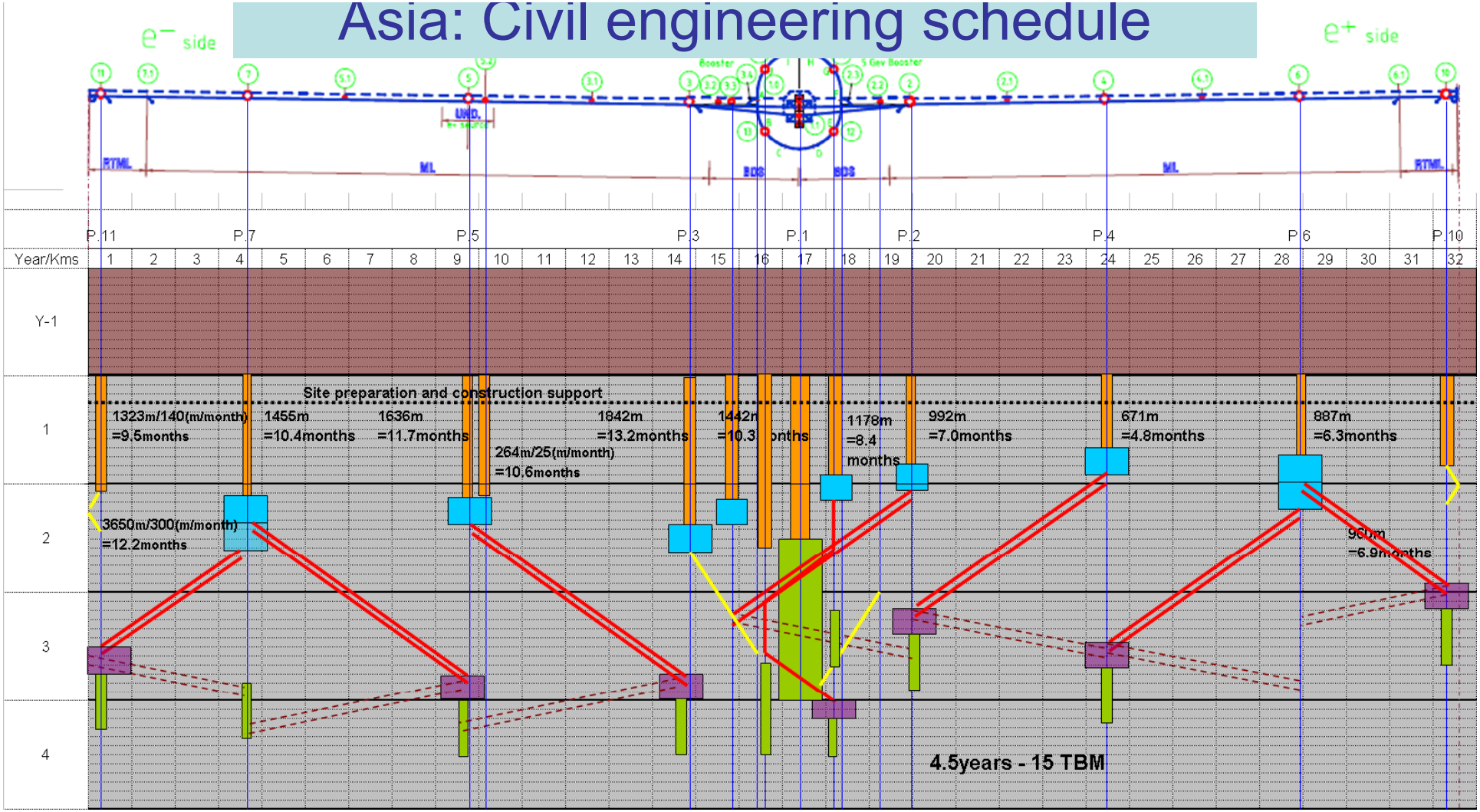
DESY: Civil engineering schedule



TBM $\varnothing_{finished}$=4.5m
MS TBM $\varnothing$=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM transport
TBM removal
Finishing work

15 TBMs needed – 4.5 years
Schedule compatible with
CERN for surface buildings

Asia: Civil engineering schedule



TBM $\varnothing_{finished}$=4.5m
NATM $\varnothing$=4.5m
Cavern finishing
Shaft/cavern excavation
TBM setup
TBM removal
Finishing work

15 TBMs – 4.5years
Schedule compatible with
CERN for surface buildings

Conclusions

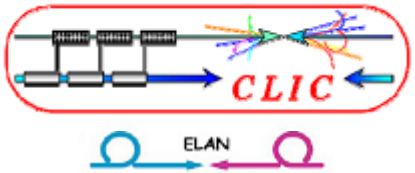
→ Key milestones:

- → Surface Detector Assembly Building ready for detector: t= t_0 + 2Y
- → First tunnel sections ready for services installation: t= t_0 + 2.5Y
- → Detector Hall (cavern) ready for detector: t= t_0 + 4Y
- → First beam tunnel section ready for machine installation: t= t_0 + 3Y

→ More efforts needed to load resources into the schedule and assess coactivity more thorough fully

→ The installation sequence for the machine and detectors have to be designed and inserted in the general schedule

→ A post completion analysis of the CMS project will be presented in early 2008. It should provide useful insight in the installation schedule for the ILC experimental areas



Conclusions

→A draft construction schedule for CLIC could be produced using the same methods used for ILC

→Starting this exercise soon is crucial for the lessons learnt from the LHC project are still fresh in people's mind

→Sources of information to feed into the schedule are available at CERN and come from all departments.

→Keeping a link between the two projects can be mutually beneficial