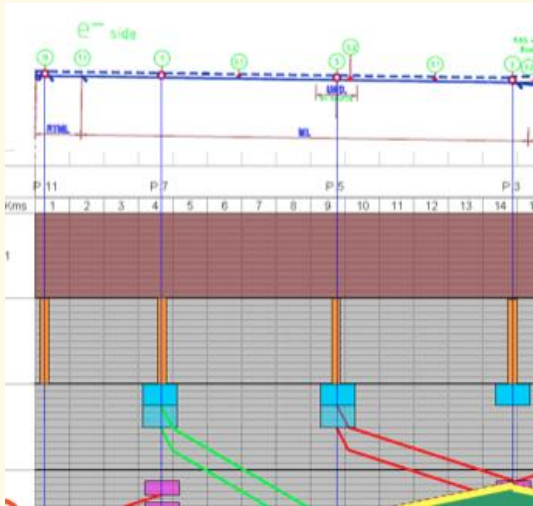


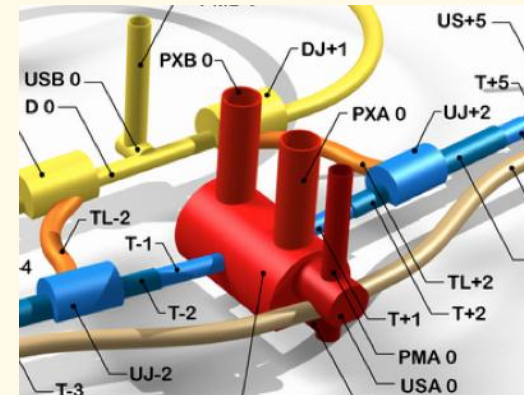
ILC DRAFT CONSTRUCTION SCHEDULE

Flat topography & Mountainous sites



K Foraz & M Gastal

Duration	Hall 1, 2016			Hall 2, 2016			Hall 1, 2017					
	O	N	D	J	F	M	A	M	J	J	F	M
305 days	[Timeline bar]											
0 days	[Timeline bar]											
12 wks	04/01	[Timeline bar]										25/03
3 wks	[Timeline bar]											
48 wks	[Timeline bar]											
24 wks	[Timeline bar]											
75 days	[Timeline bar]											



Many thanks to J Osborne, A Kosmicki, H Mainaud Durand, J Paterson for their help

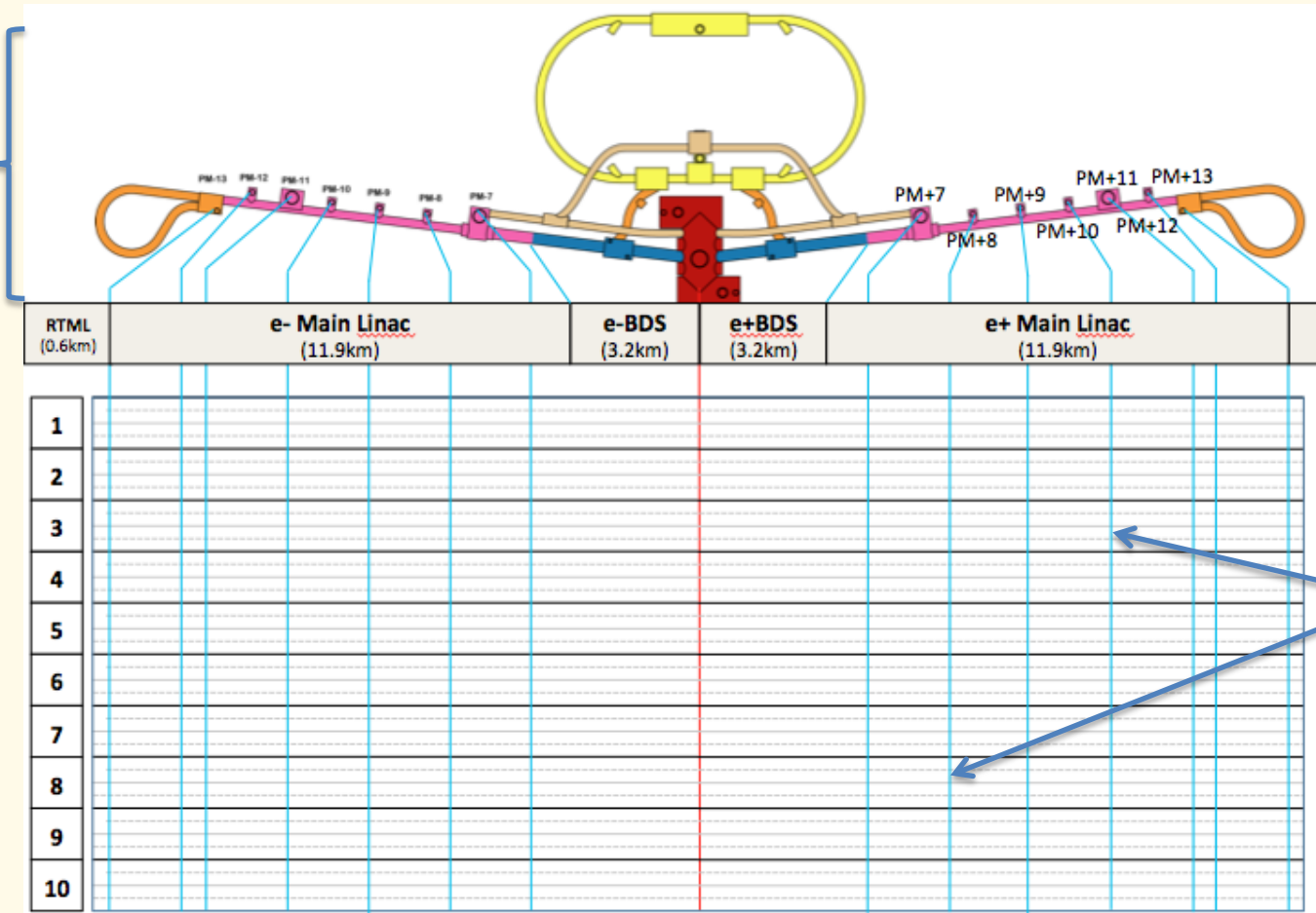
- To provide a consolidated project construction schedule
 - For flat topography sites (Americas, Europe)
 - Mountainous region site (Asia)
- European site primarily used for flat topography
- Focus on the critical path
- From excavation to commissioning of the facility
- Using LHC and XFEL project construction data

- To integrate new data
 - ARUP studies for IR
 - Granada 2011 workshop
 - Draft ILC PIP (Project Implementation Planning)
 - Commissioning priorities
 - Output of KILC2012

- Many parameters can be tuned and affect this draft scenarios
 - Tolerance to co-activity, number of teams deployed...

→ To follow work progress in time and space

ILC layout
(not to scale)

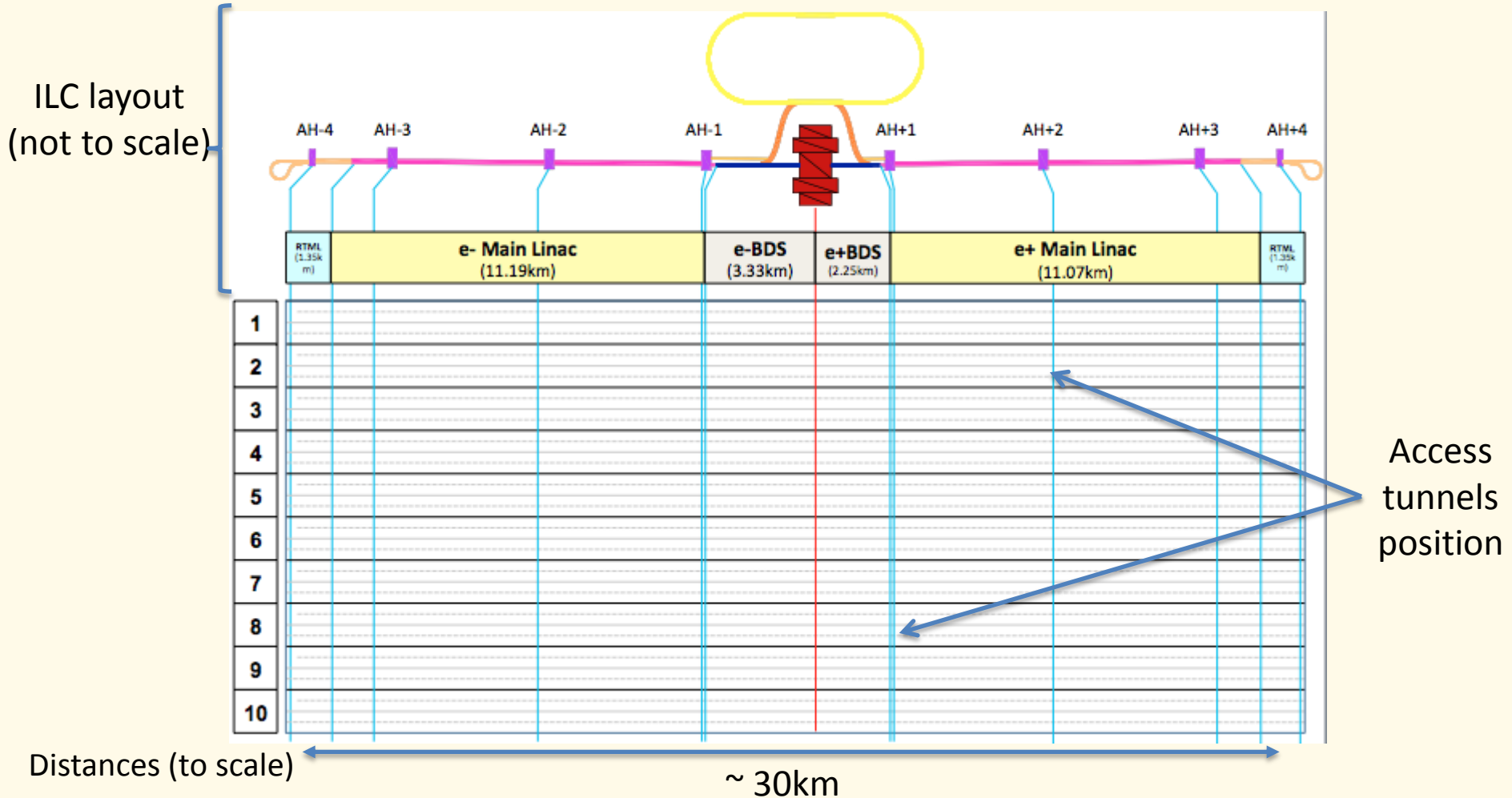


Shafts
position

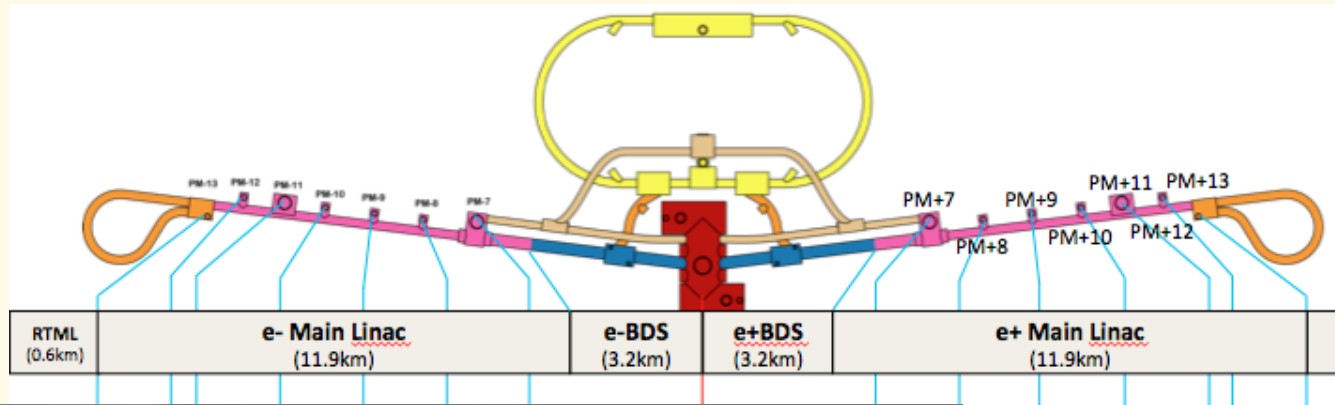
Distances (to scale)

~ 30km

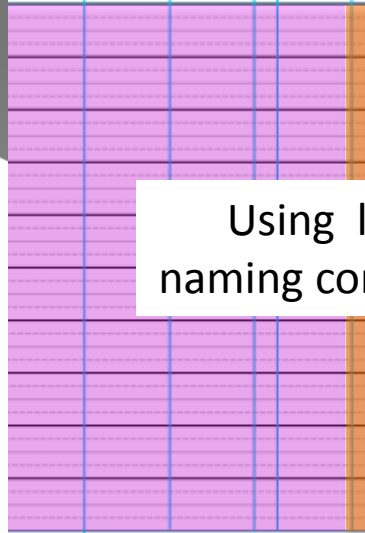
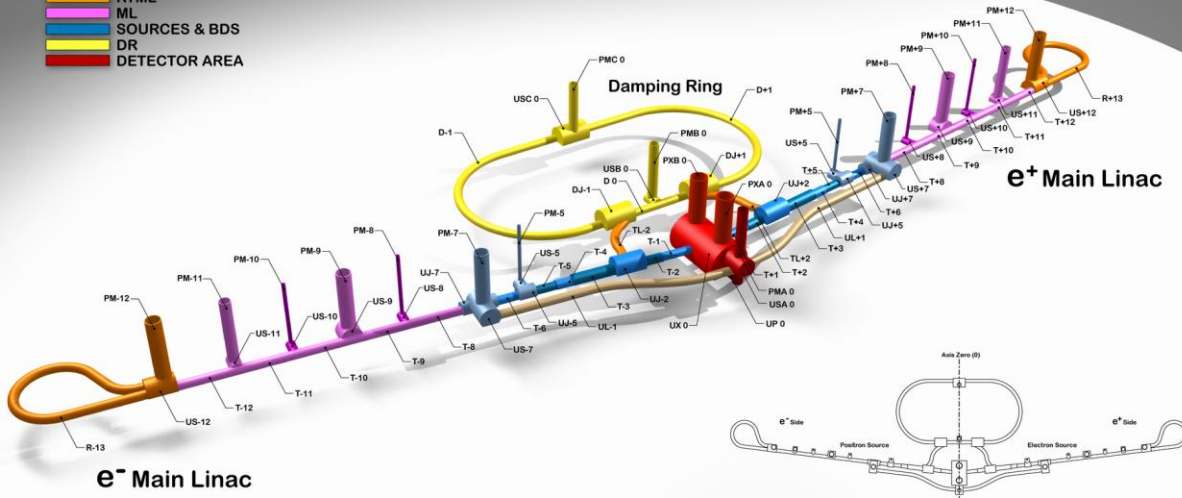
→ To follow work progress in time and space



→ To follow work progress in time and space

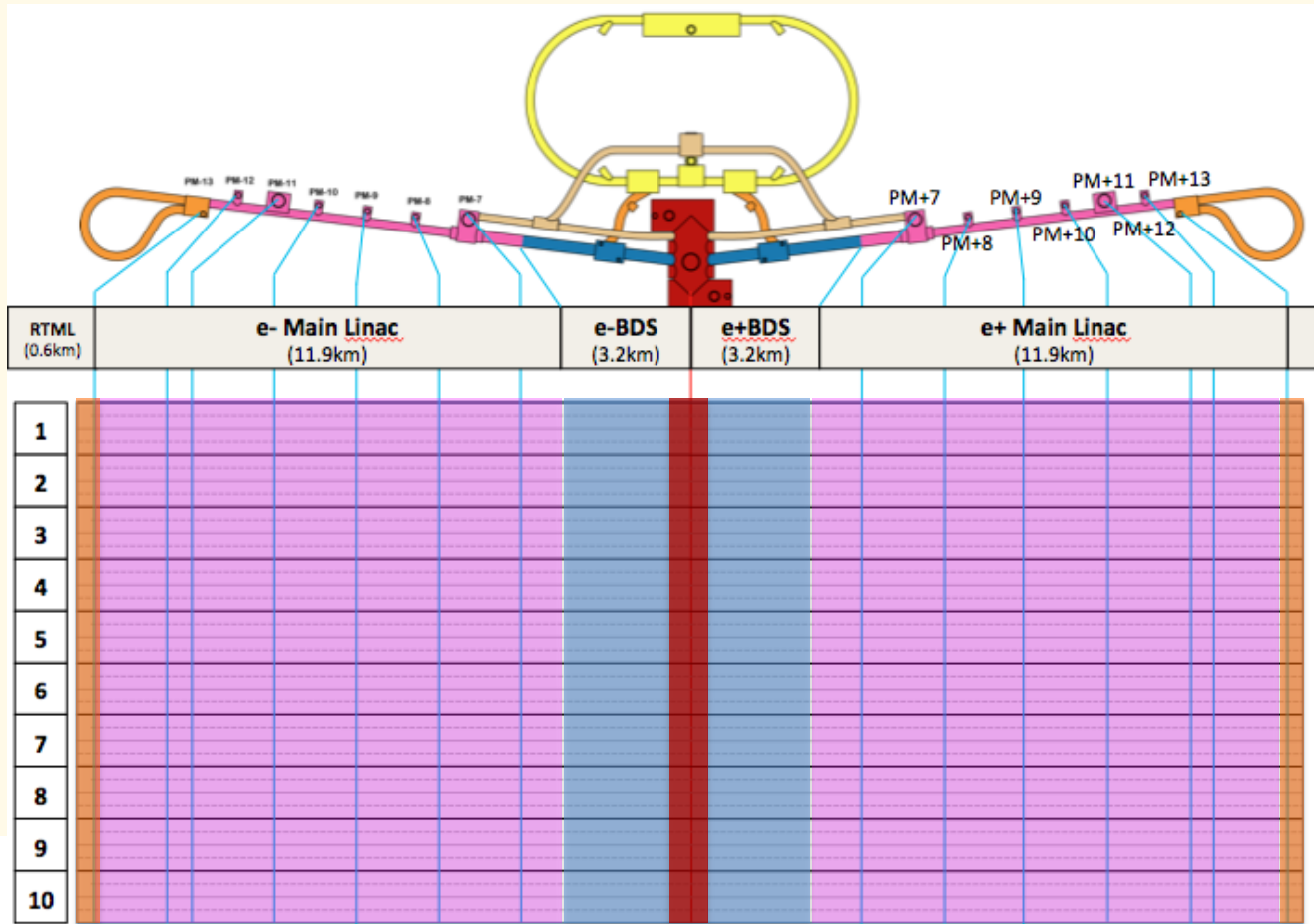


- █ RTML
- █ ML
- █ SOURCES & BDS
- █ DR
- █ DETECTOR AREA



04/07/2012

→ To follow work progress in time and space

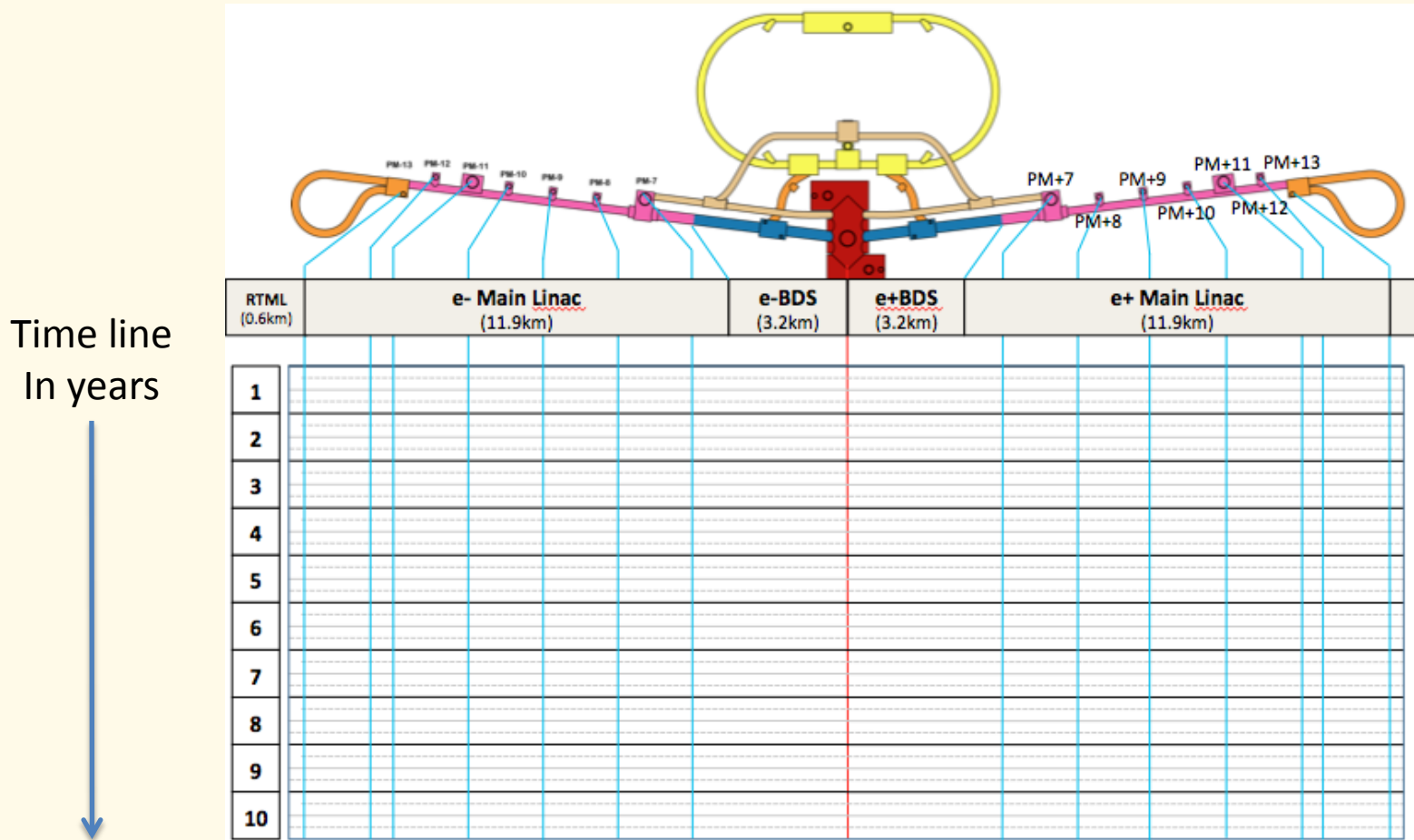


Only for
IR, BDS,
ML & RTML

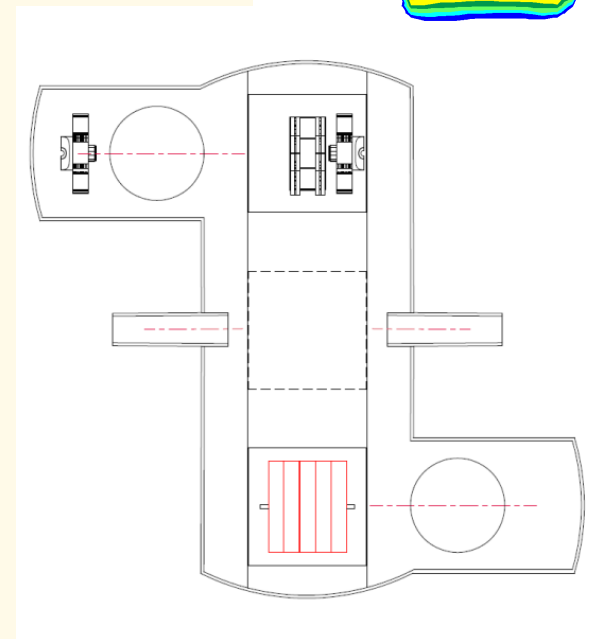
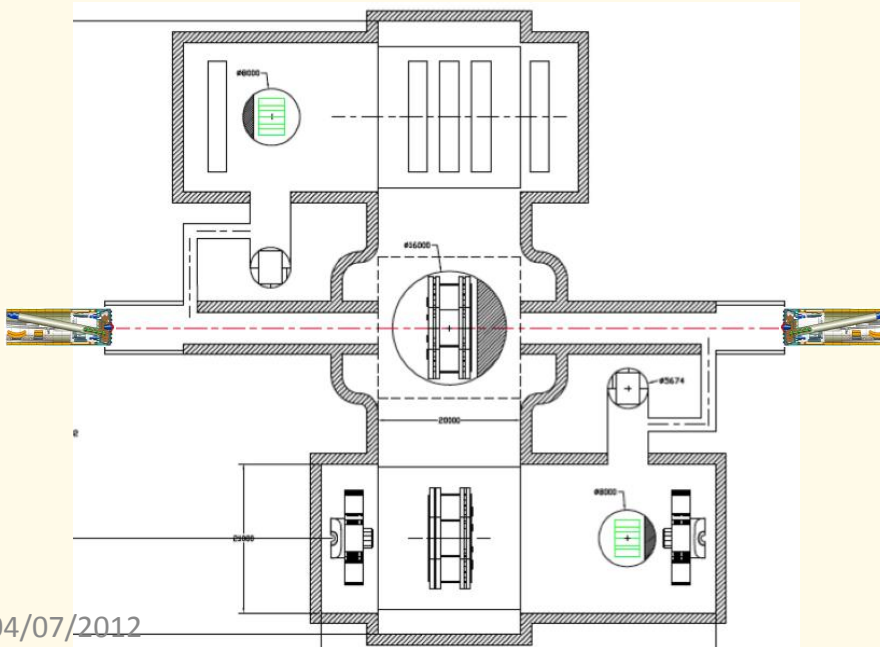
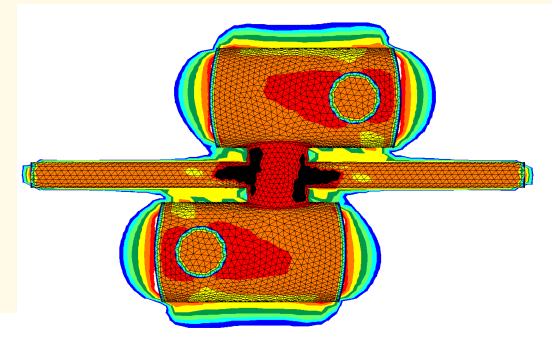
Legend :

- █ RTML
- █ ML
- █ SOURCES & BDS
- █ DR
- █ DETECTOR AREA
- █ SERVICE TUNNEL

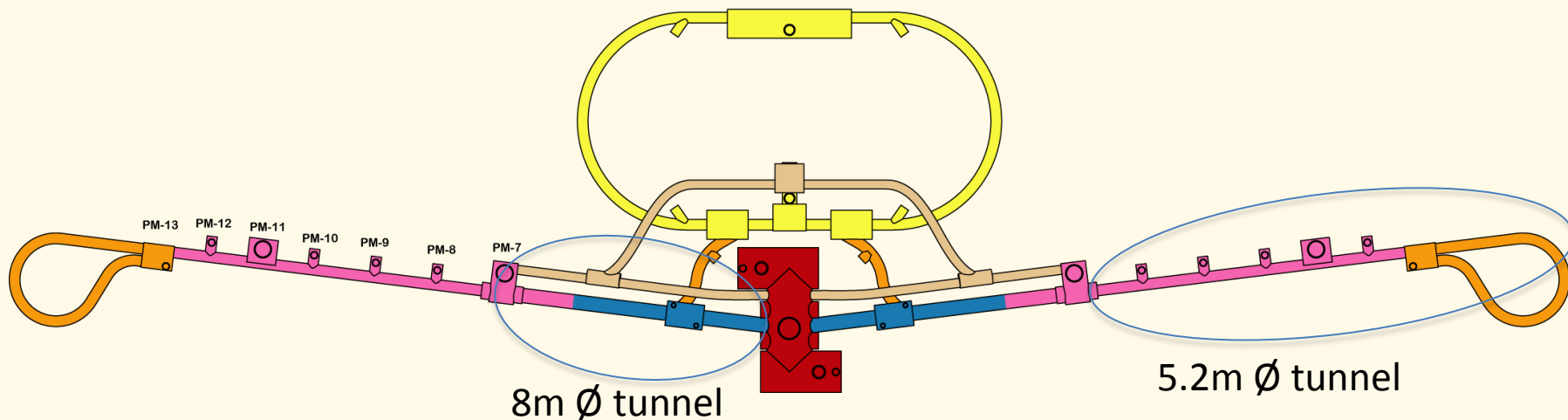
→ To follow work progress in time and space



- Result of the ARUP/J Osborne studies recommends minimising stress concentration on the IP by excavating and finishing the interaction cavern before tackling the tunnels and service caverns
- TBMs launched from adjacent shafts (PM7) and extracted from an IR shaft
 - Allows time for finishing of IR cavern
- Recommendations were made for CLIC IR
- Compatible with both the 2 and 3 shaft IR layouts

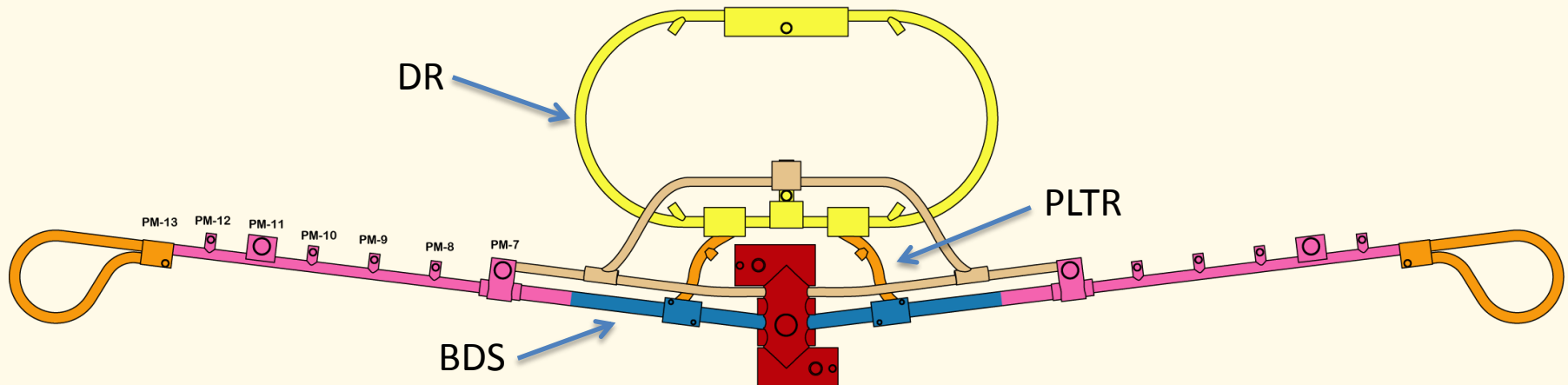


- The BDS tunnel and part of the main linac have a diameter of 8m
 - To minimise cost and speed up excavation
- The rest of the main linac consists of 5.2m diameter tunnel

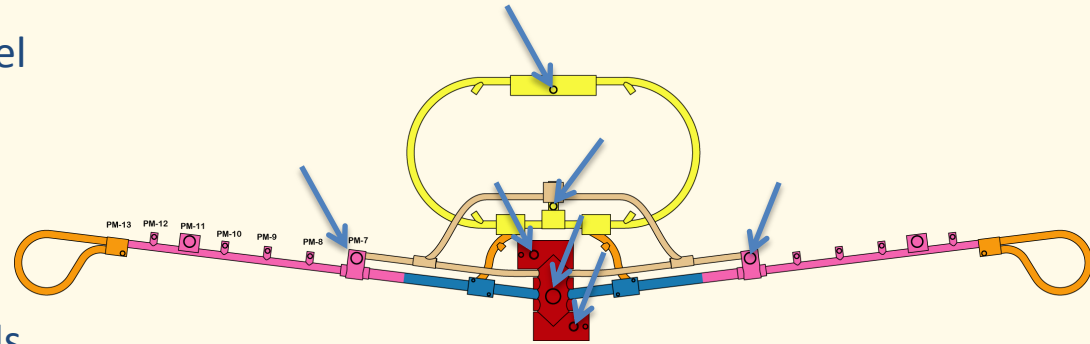


- TBMs cannot be refurbished to accommodate both tunnel sizes
- 2 different machines have to be used
- We are now looking at a 4 TBM scenario in DBS, ML, RTML (2x5.2 + 2x8)

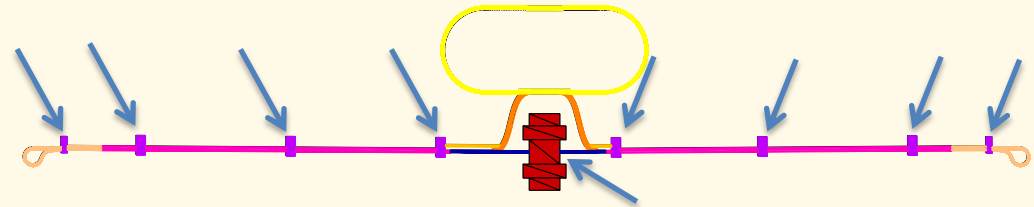
- Requests for early commissioning will set priorities for the delivery of parts of the ILC complex
- When designing the construction schedule, an attempt was made to deliver some components as early as possible:
 - Damping Rings
 - PLTR
 - BDS & ML up to PM7/AH1
- An attempt to design a detailed schedule of the commissioning period will be shown



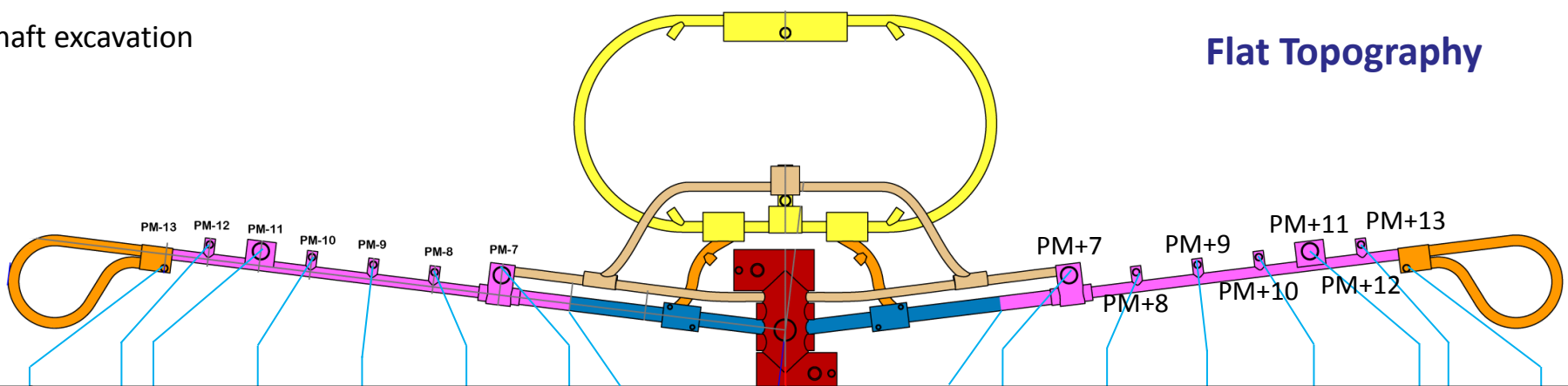
- FT - Excavation of shafts in parallel
 - IR: PX0, PXA0, PXB0
 - ML: PM+7, PM-7
 - DR: PMA0, PMB0
 - 1 year per shaft



- MR – Excavation of access tunnels
 - All 9 of them
 - AH1, AH2, AH3, AH4, IP

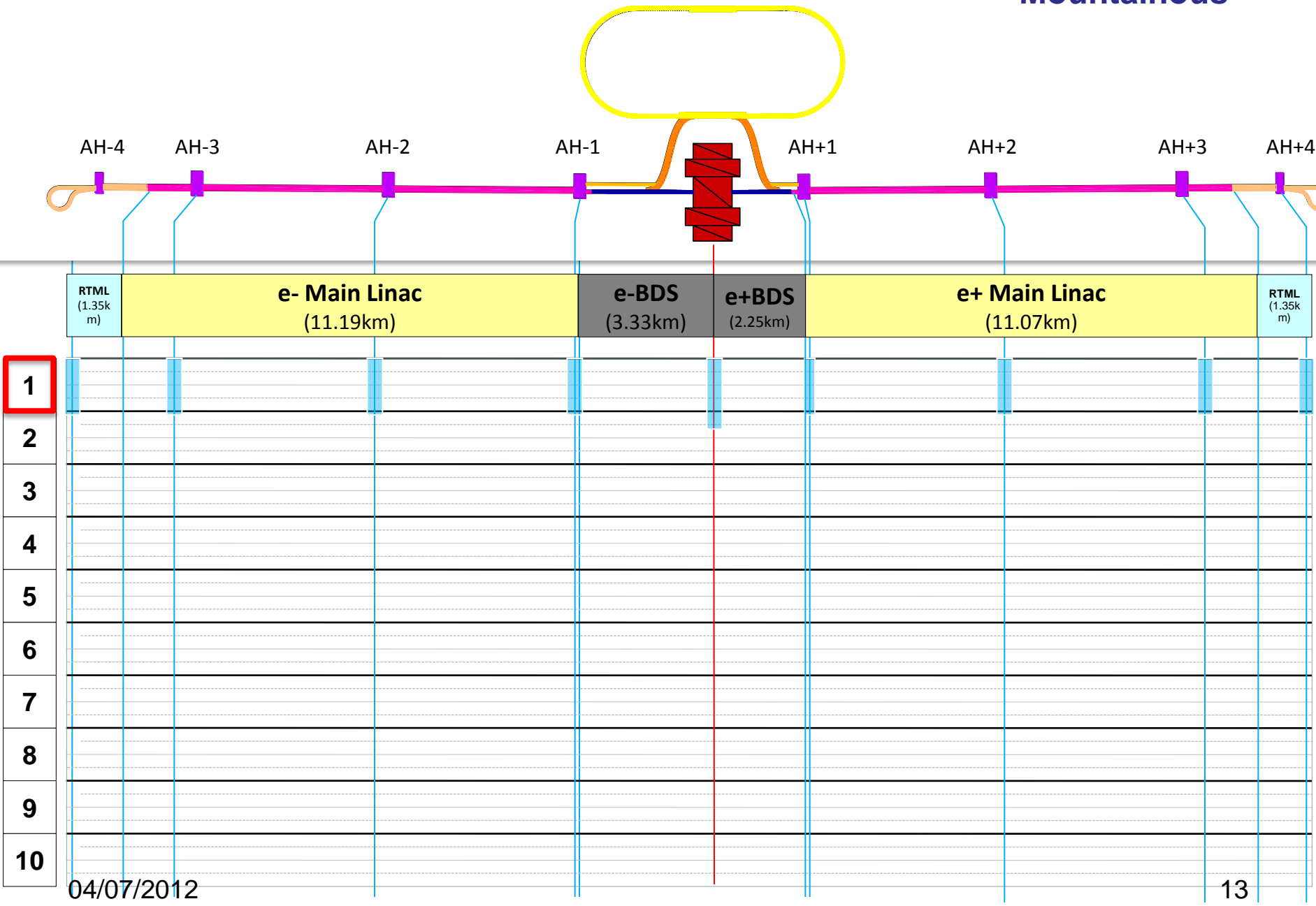


- Launch construction of detector assembly halls on the surface
- Launch construction of service buildings



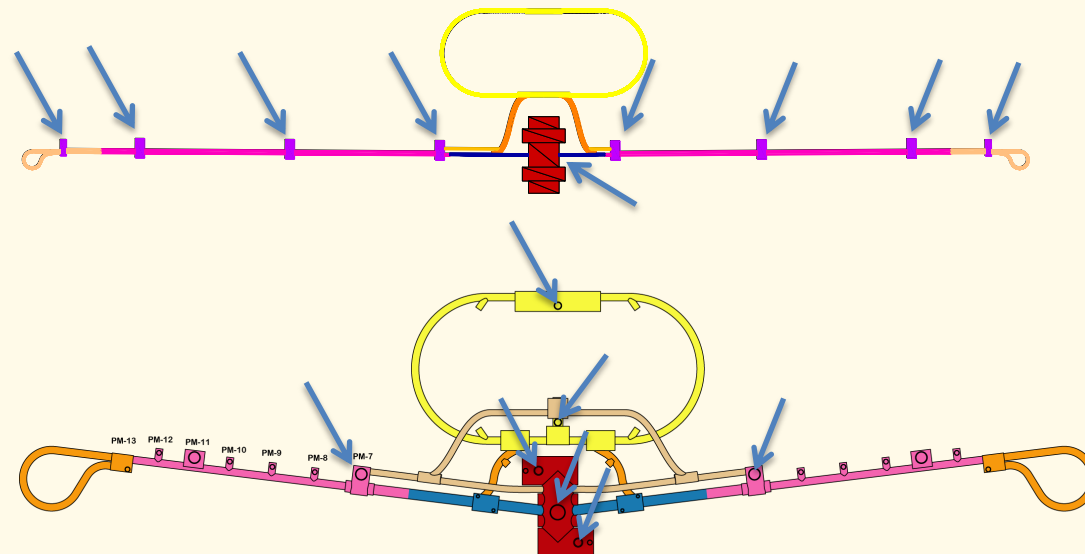
RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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1																				
2																				
3																				
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5																				
6																				
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8																				
9																				
10																				

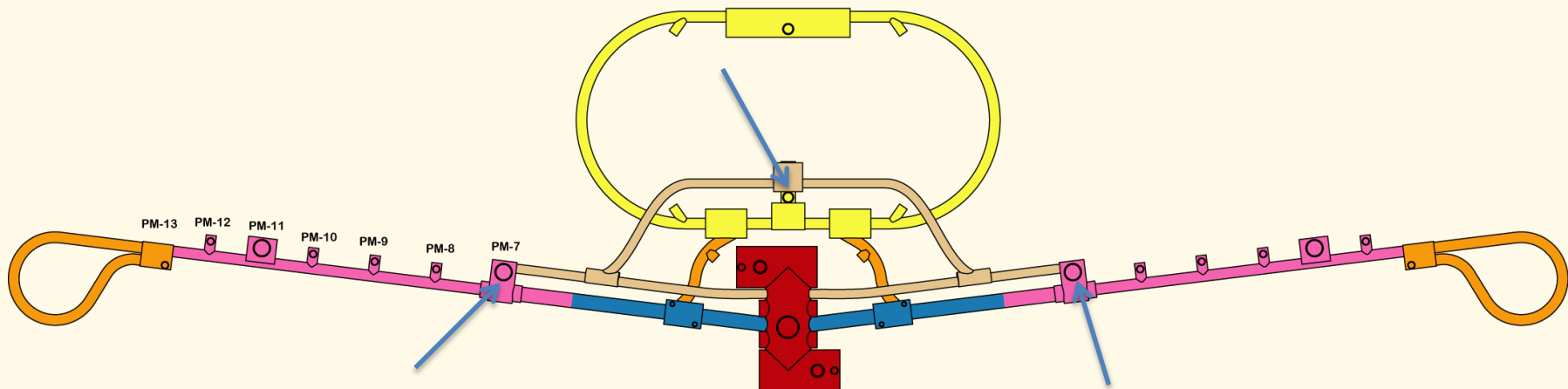


→ Launch of works

- FT: Not all access shafts to the underground facilities are started together
- FT: 7 excavation crews in action over 4 sites
- FT: site setup not included, T0 is ground breaking
- MR: Quick deployment of resources to excavate all access tunnels
- MR: 9 excavation crews in action over 9 sites
- MR: Sites setup included?

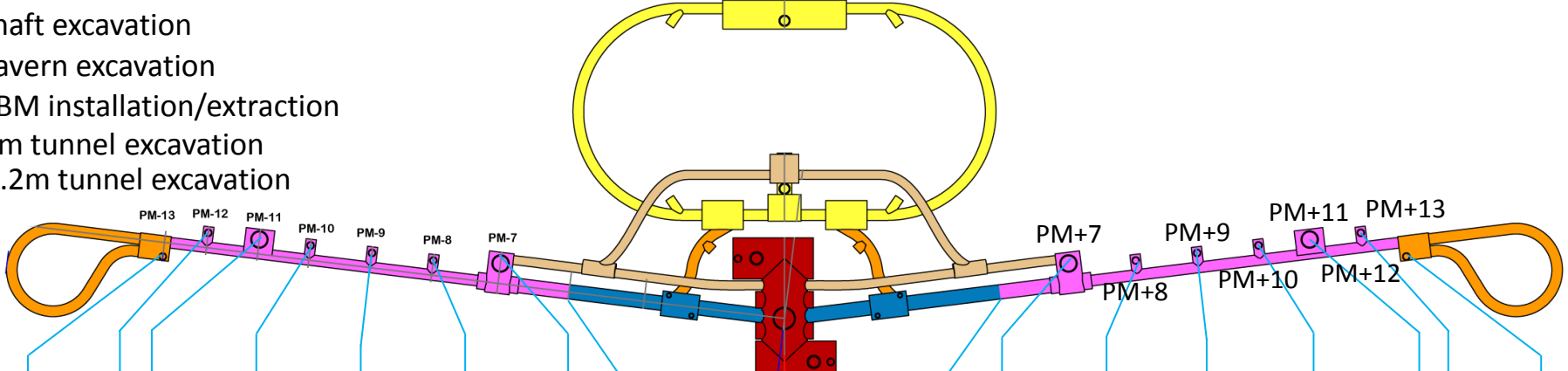


- Tunneling has to start in various parts of the facility
 - Shafts excavation of PM8,9,10,11,12,13
 - Shaft based caverns have to be excavated (IR cavern, US-7, US+7, USB0)
 - Two 8m diameter TBMs: ML + BDS
 - Two 5.2m diameter TBMs: ML
 - One 5.2m diameter TBM: DR

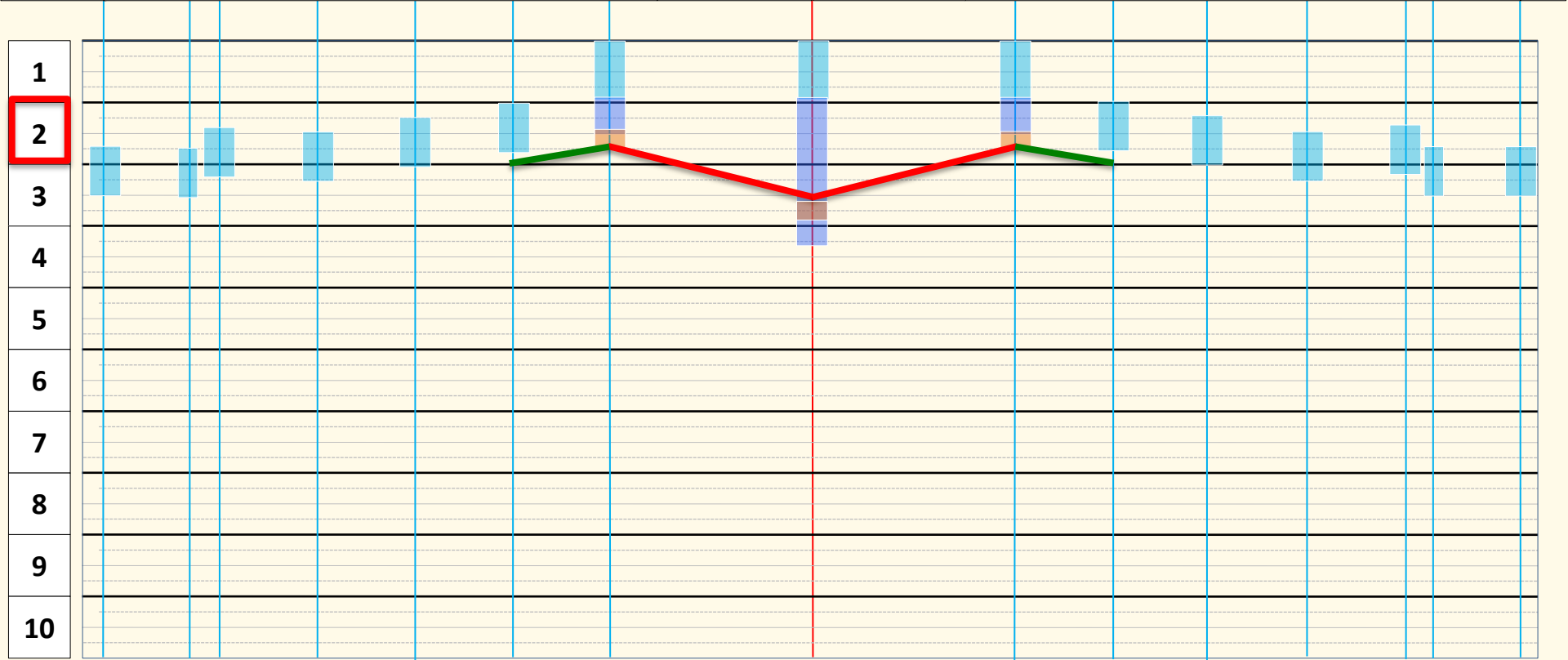


- Progress rates for European site:
 - 8m: 100m/w (3 shifts)
 - 5.2m: 150m/w (3 shifts)

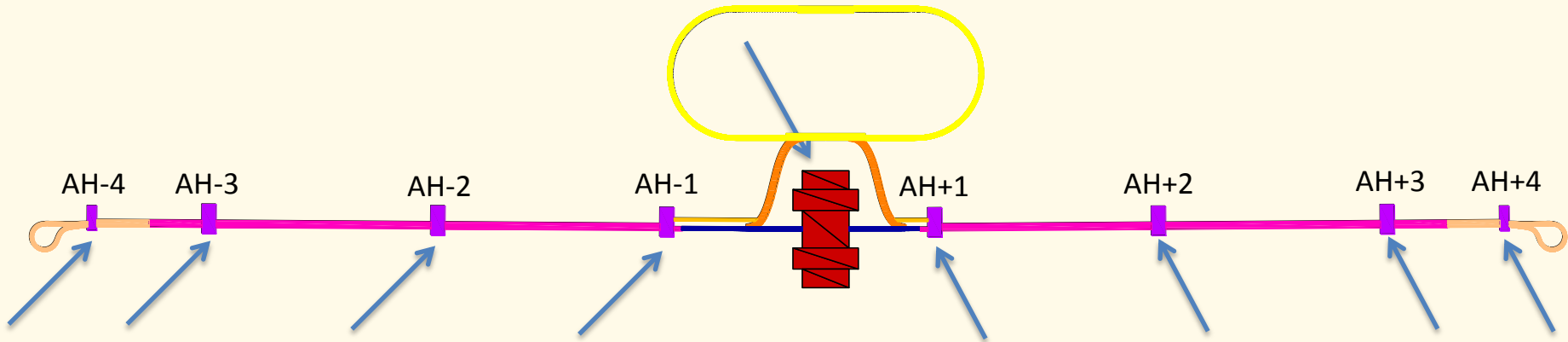
- Shaft excavation
- Cavern excavation
- TBM installation/extraction
- 8m tunnel excavation
- 5.2m tunnel excavation



RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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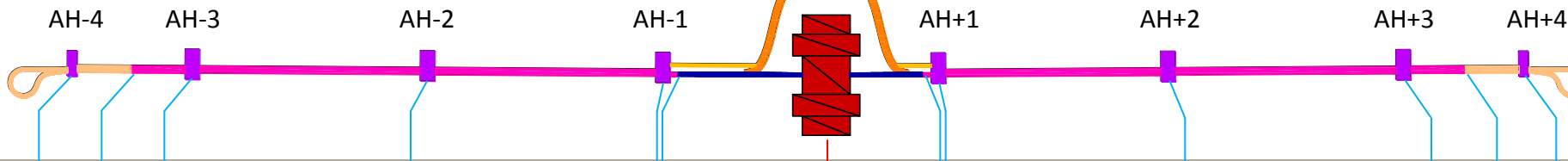


- Tunneling has to start in various parts of the facility
 - 8 Access halls have to be excavated (AH-4, AH-3, AH-2, AH-1, AH+1, AH+2, AH+3, AH+4)
 - Tunneling crews are sent from access tunnels AH-3, AH-2, AH-1, AH+1, AH+2, AH+3
 - Excavation of IR Cavern started
 - Start concrete lining in sectors IP-AH-1 and IP-AH+1

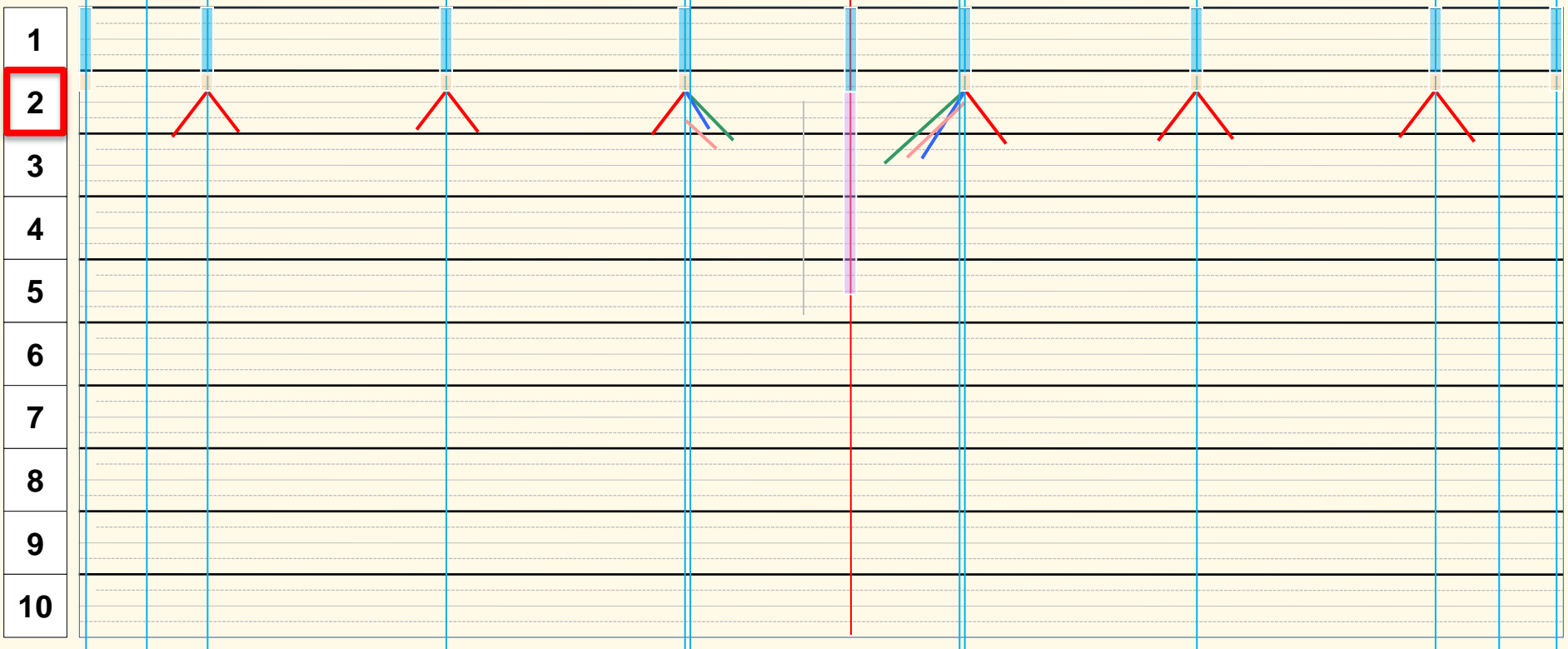


- Progress rates:
 - Tunneling: 20m/week

■ Access Tunnel ex. — Beam Tunnel excavation — BDS Tunnel excavation
■ Cavern ex. — Concrete Lining — BDS Service Tunnel excavation
■ Hall ex.

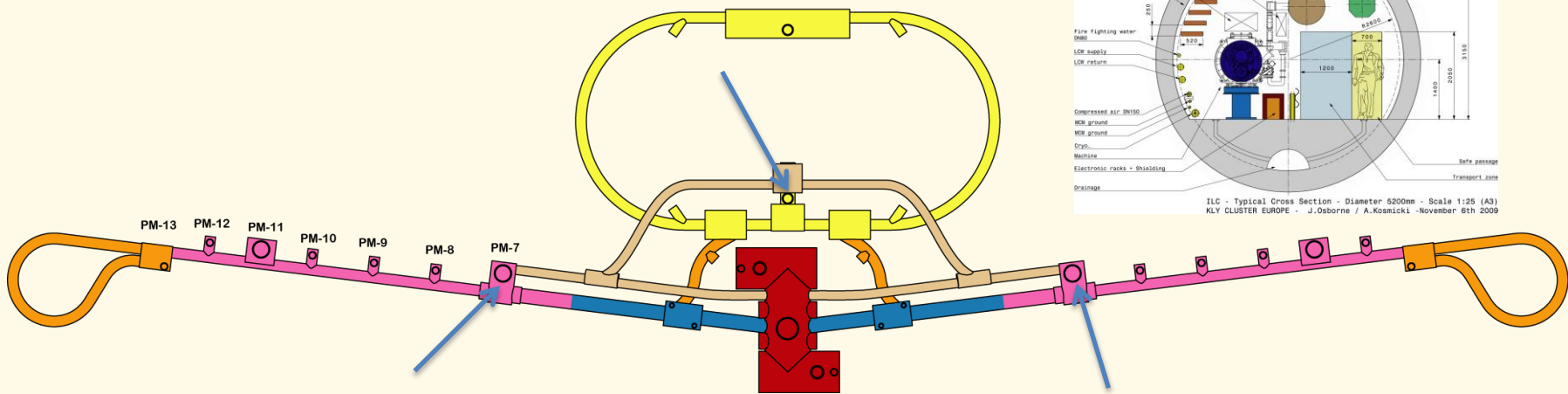


RTML (1.35k m)	e- Main Linac (11.19km)	e-BDS (3.33km)	e+BDS (2.25km)	e+ Main Linac (11.07km)	RTML (1.35k m)
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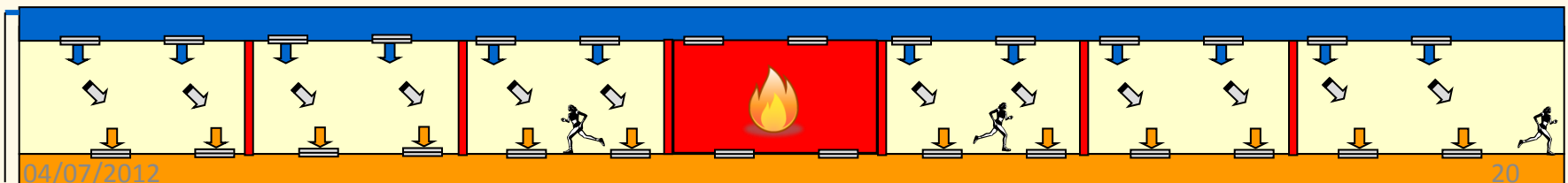


- Tunneling effort is most significant in the Asian region
- During Year 2 the Flat topography regions would be still providing access to the underground worksite by excavating shafts
- The Asian worksite looks a lot more labor intensive with 8 access halls excavation proceeding in parallel with the IP cavern excavation.
- The Asian also foresees the construction of 14 tunnels in parallel

- Tunneling will proceed in BDS, ML and DR
 - Spoil to be evacuated through PM8
- Invert concreting and tunnel finishing will start as soon as spoil management allows
 - Progress rate: 50m/d for 3 shifts



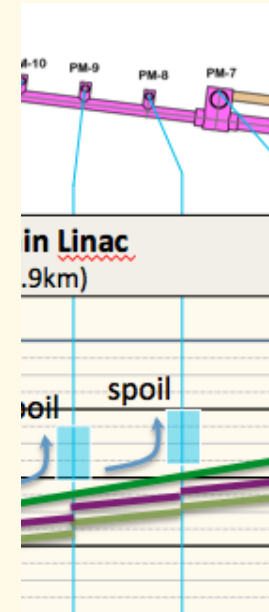
- Ceiling ducts for fire safety purposes
 - Progress rate: 50m/d for 3 shifts

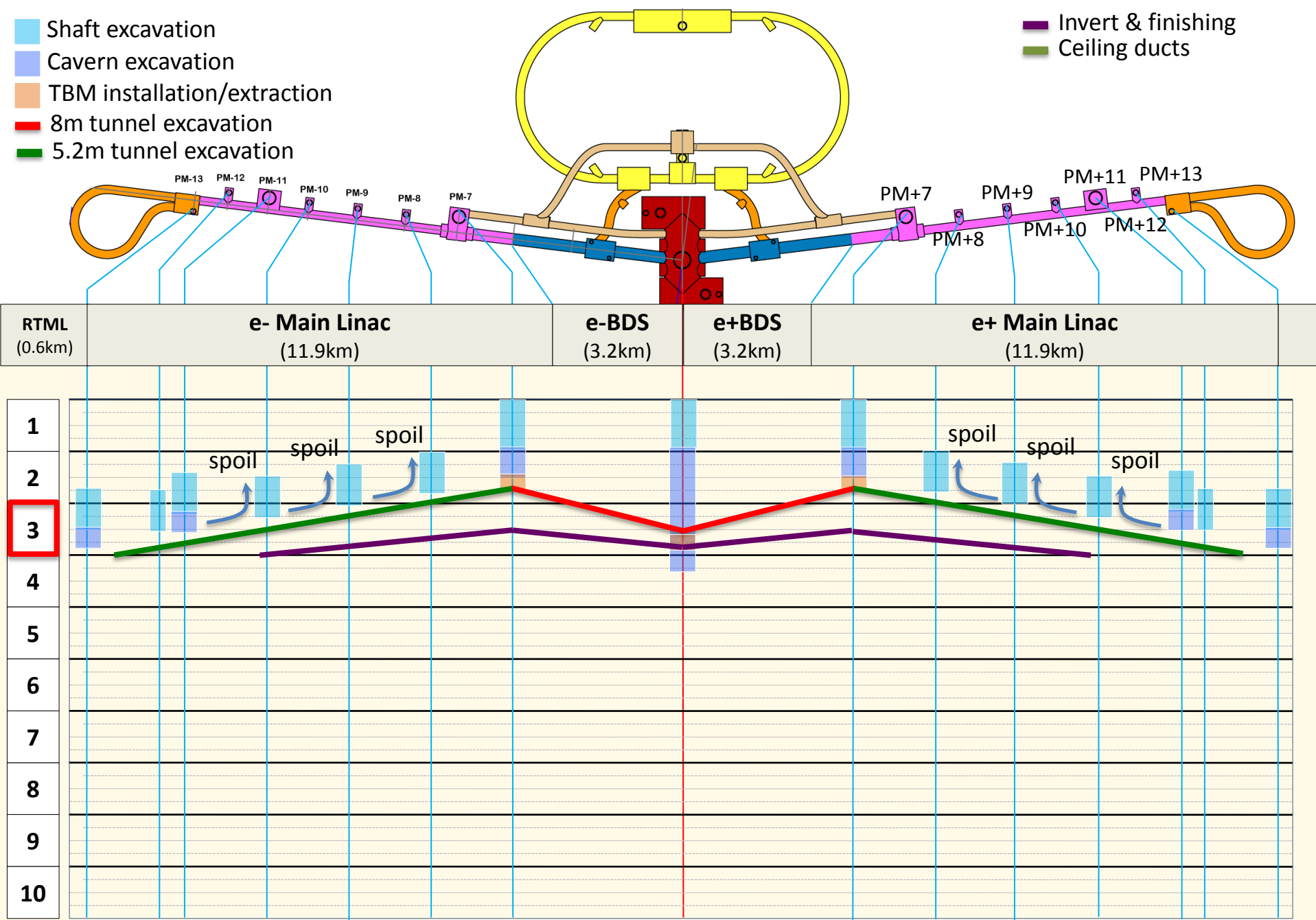


→ Work in a tunnel section, e.g. T-8, can only start once the conveyor belt evacuating the spoil produced by the TBM is redirected to the nearest shaft

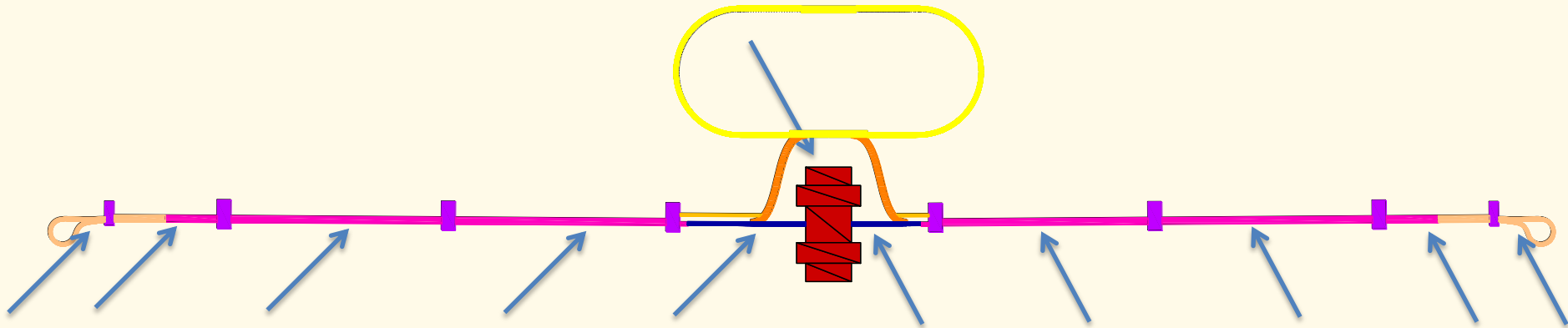


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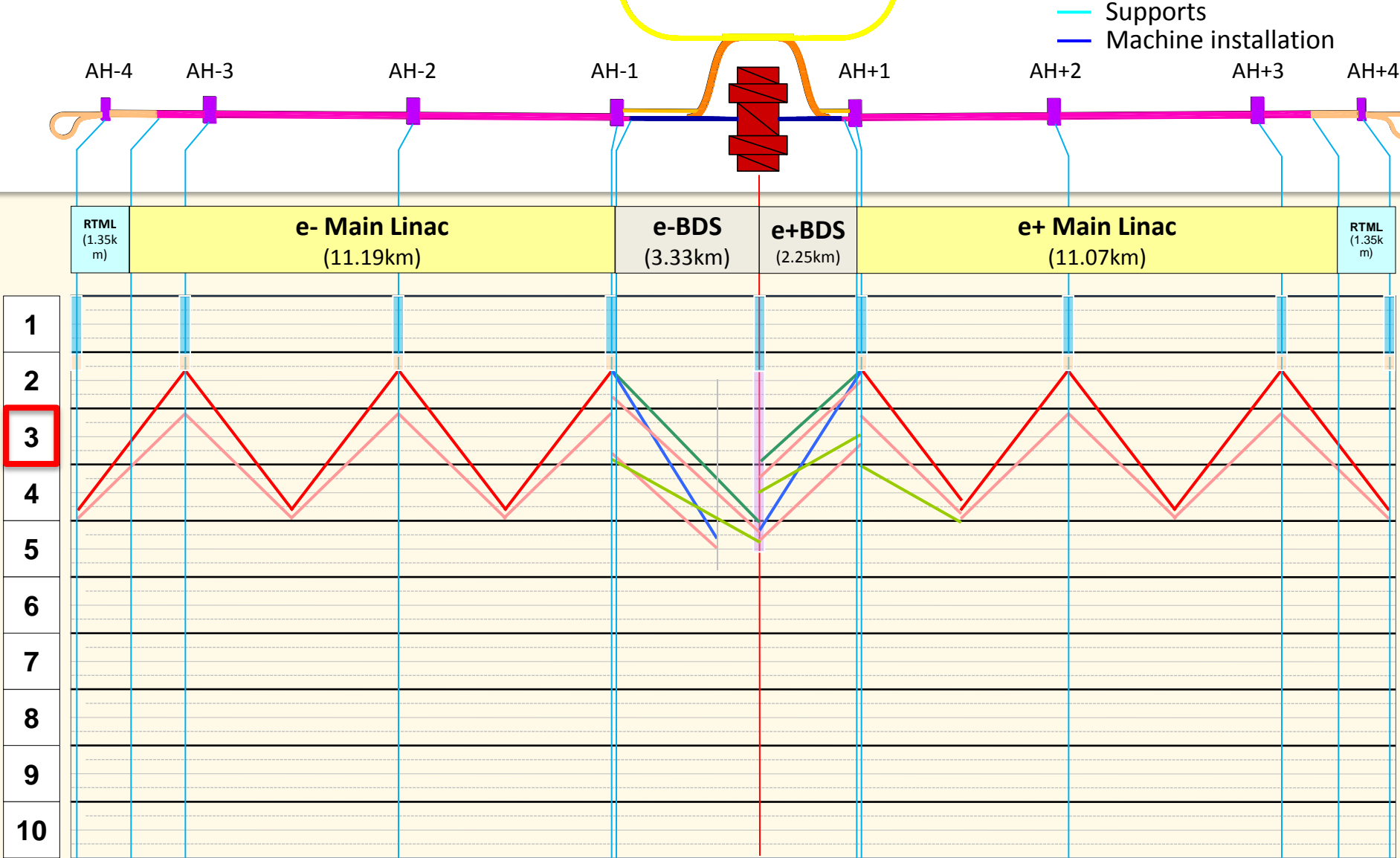




- Excavation of IP cavern
- Tunneling will proceed in all 14 tunnels sections
- Concrete lining to follow
 - Progress rate: 25m/week
 - Spoil to be carefully managed once concrete lining starts in the same tunnel section



- Access Tunnel ex.
- Cavern ex.
- Hall ex.
- Beam Tunnel excavation
- Concrete Lining
- Invert & Drainage
- Shield Wall
- BDS Tunnel excavation
- BDS Service Tunnel excavation
- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling
- Supports
- Machine installation



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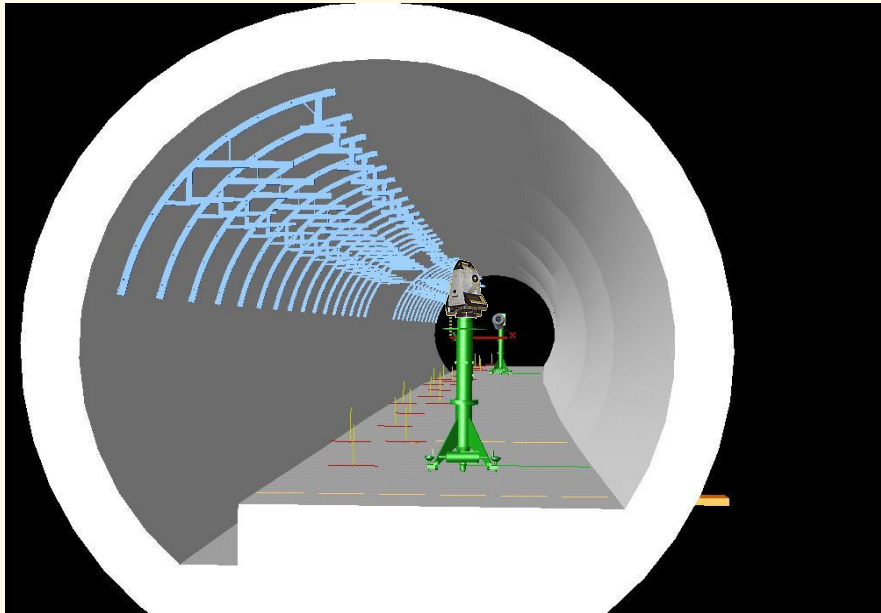
24

- Thanks to a higher progress rate the tunneling in the FT site is catching up with the MR.
- Spoil management will be a critical challenge

- End of CE phase
 - BDS: Q2 ; ML: Q4 ; RTML: Q4
- Start of infrastructure installation
 - Survey and set out of components supports
 - Electrics General Services
 - Piping and ventilation
 - Cabling

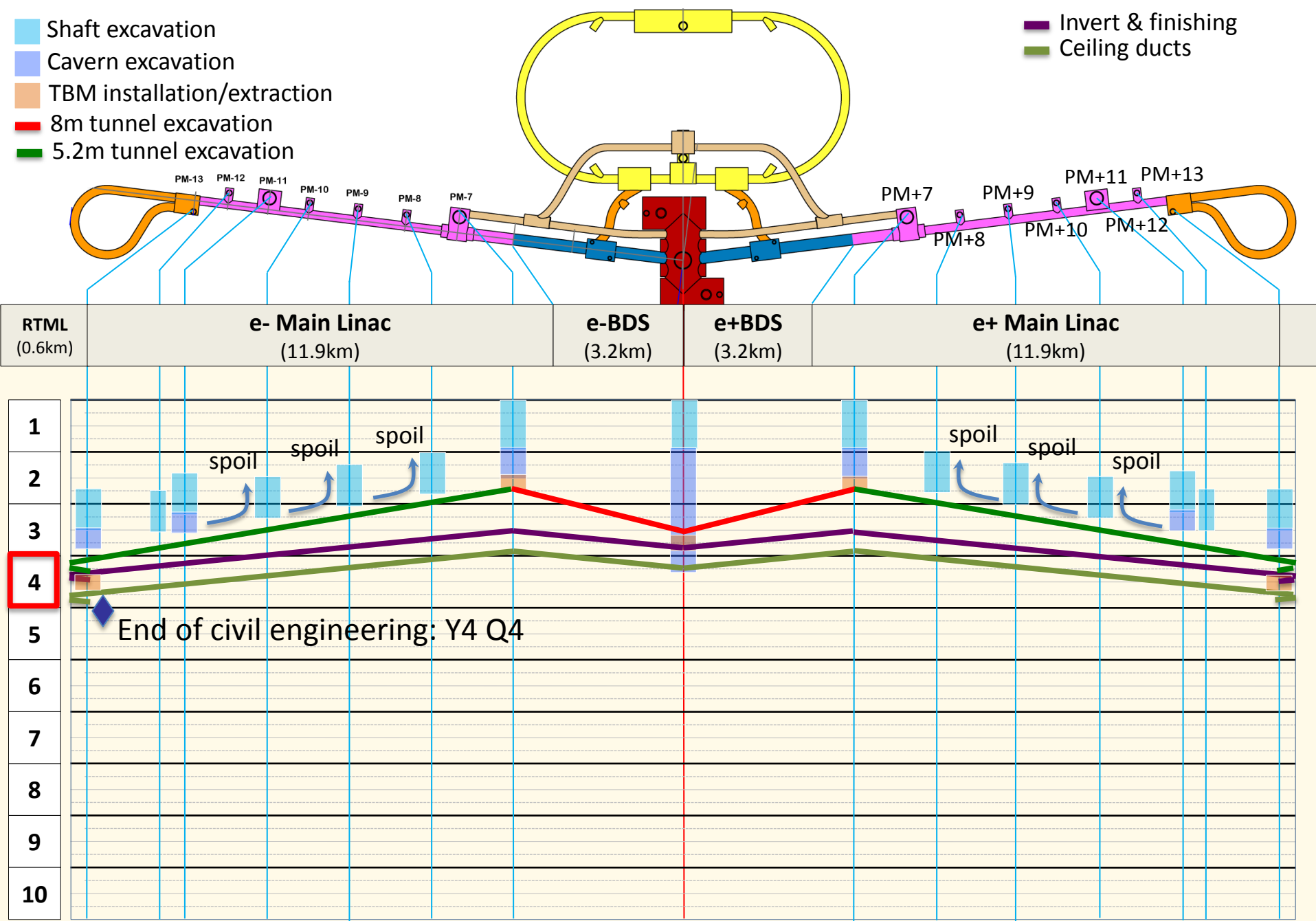


Progress rate 120m/w for 1 shift

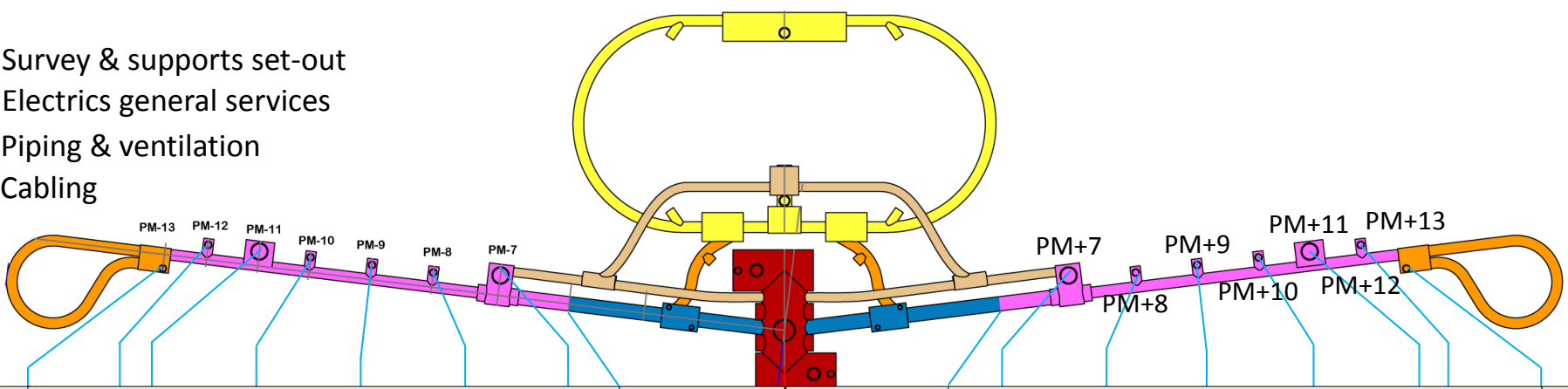


Courtesy of BE-ABP-SU

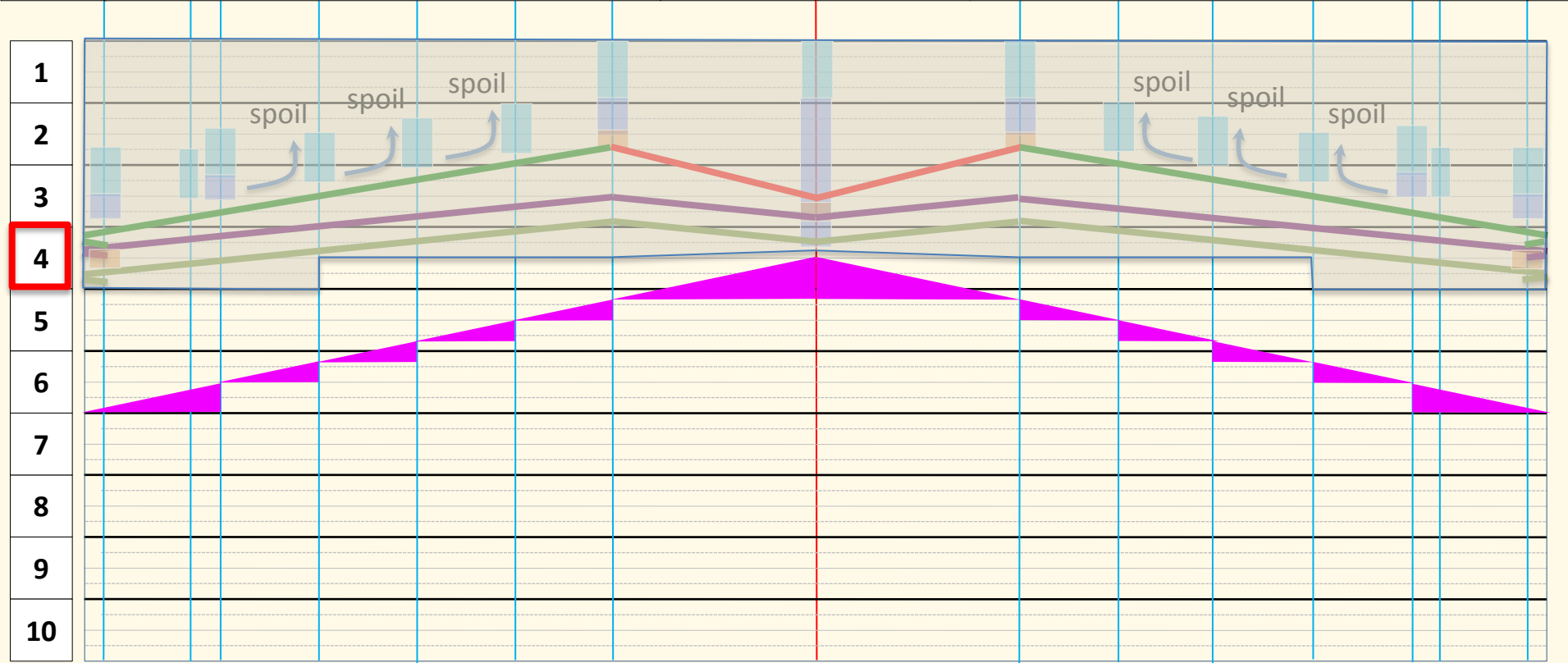




- Survey & supports set-out
- Electrics general services
- Piping & ventilation
- Cabling

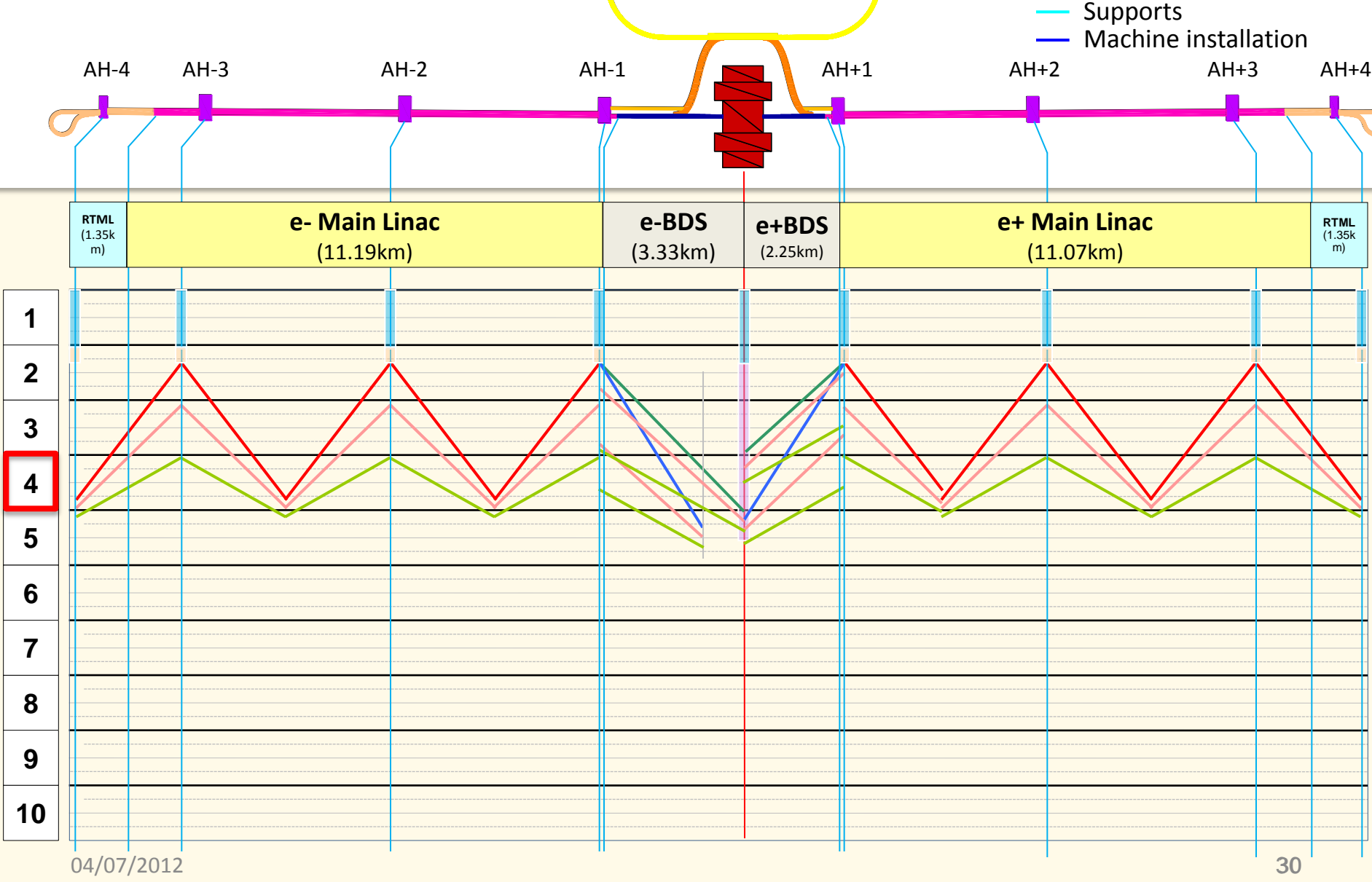


RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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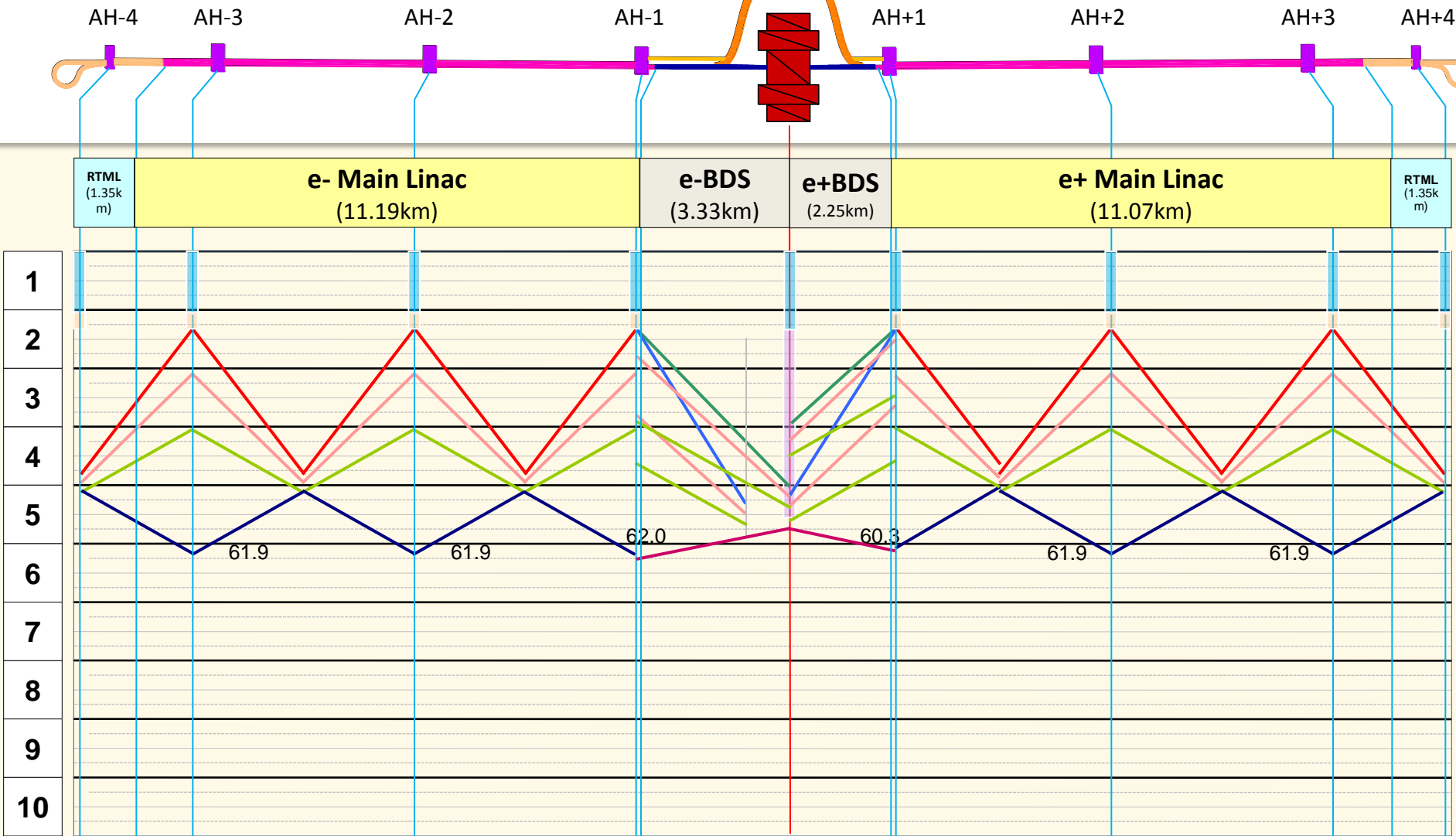
- End of tunneling phase in Beam Tunnel and BDS
- Tunneling to proceed in BDS service tunnel
- Concrete lining to proceed in Beam Tunnel
- Invert and drainage work to start
 - Progress rate: 45m/week

- Access Tunnel ex.
- Cavern ex.
- Hall ex.
- Beam Tunnel excavation
- Concrete Lining
- Invert & Drainage
- Shield Wall
- BDS Tunnel excavation
- BDS Service Tunnel excavation
- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling
- Supports
- Machine installation



- The civil engineering work reaches completion during Year 4 in the flat topography site
- Due to slower tunneling progress rates the MR civil engineering work will need one more year to reach completion
- Year 5 for MR is dominated by the construction of the Shield wall
 - Progress rate: 45m/week
- Milestones: Civil engineering work complete
 - FT: Y4 Q4
 - MR: Y5 Q1

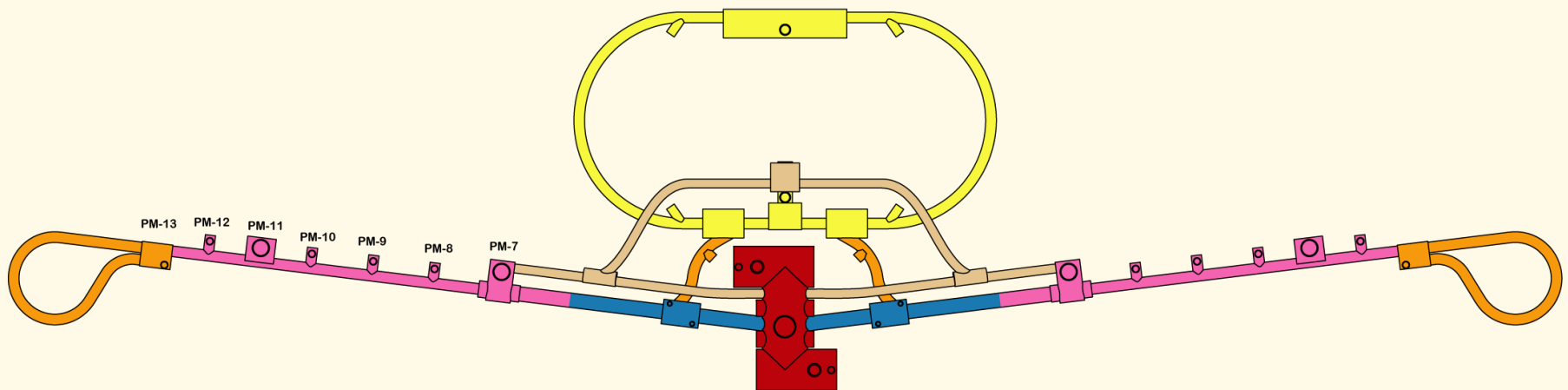
- Access Tunnel ex.
- Beam Tunnel excavation
- BDS Tunnel excavation
- Cavern ex.
- Concrete Lining
- BDS Service Tunnel excavation
- Hall ex.
- Invert & Drainage
- Shield Wall



→ Installation of infrastructure

- Survey and set out of components supports
- Electrics General services
- Piping and ventilation
- Cabling

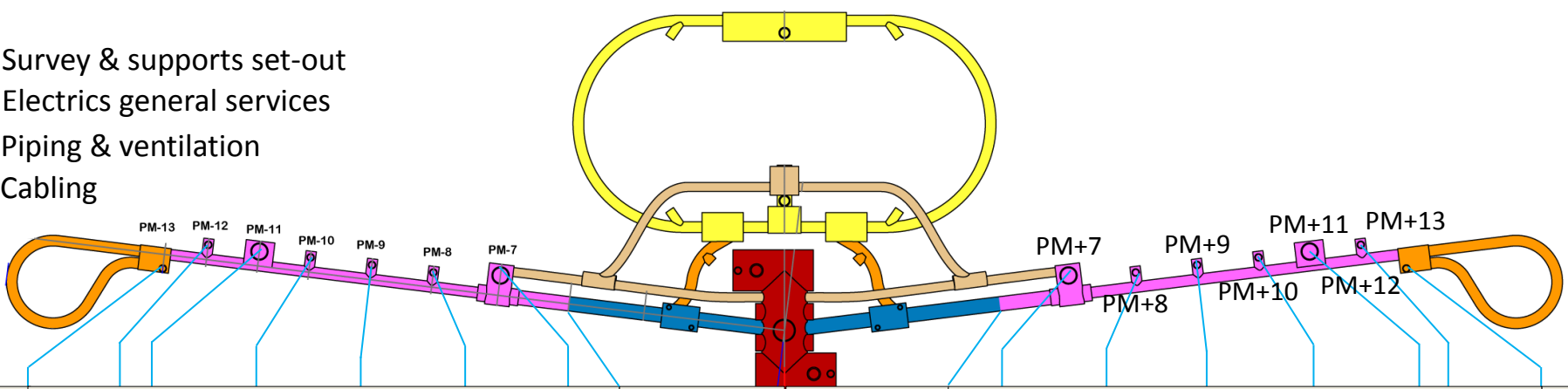
Progress rate 120m/w for 1 shift



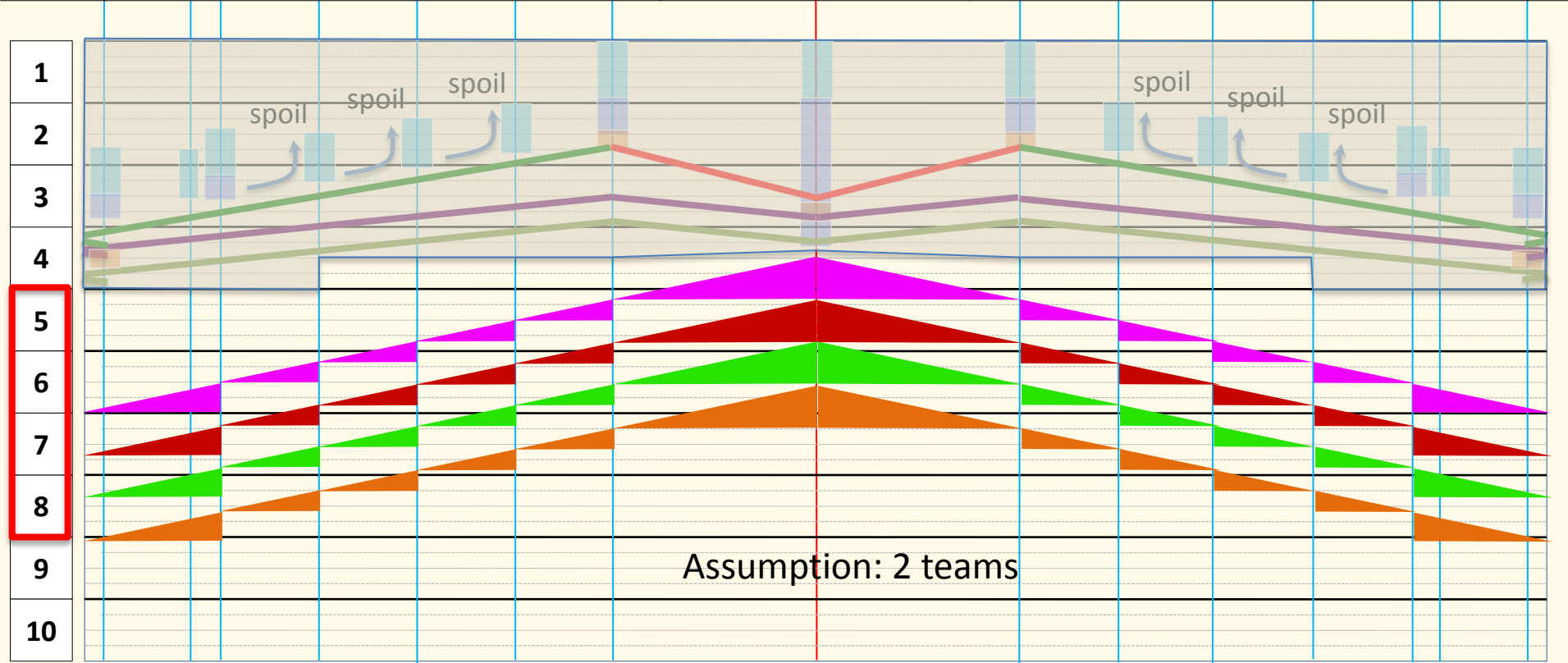
→ Impact of the number of teams deployed is significant

- Baseline: 2 teams
- Option: 4 teams

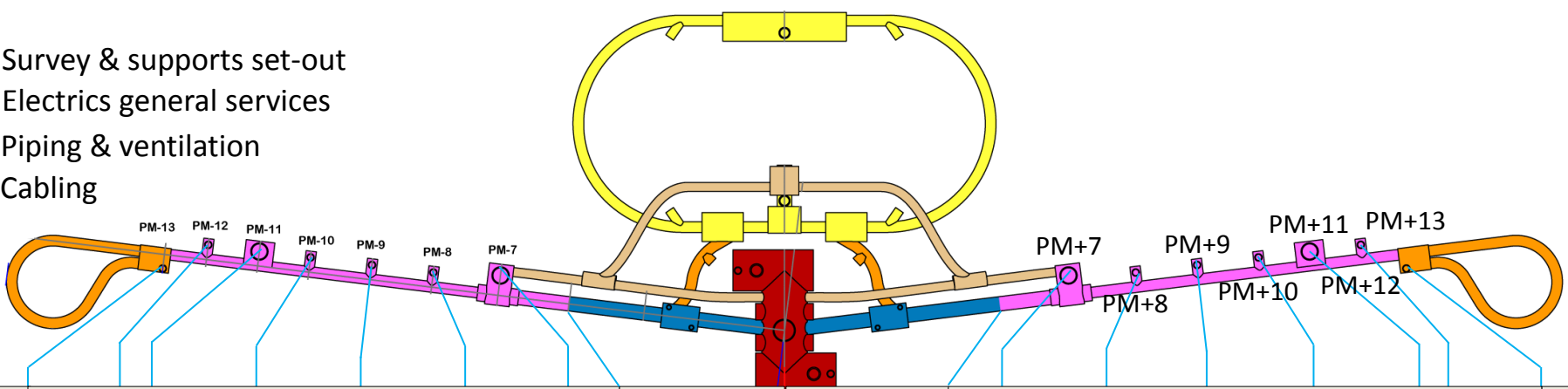
- Survey & supports set-out
- Electrics general services
- Piping & ventilation
- Cabling



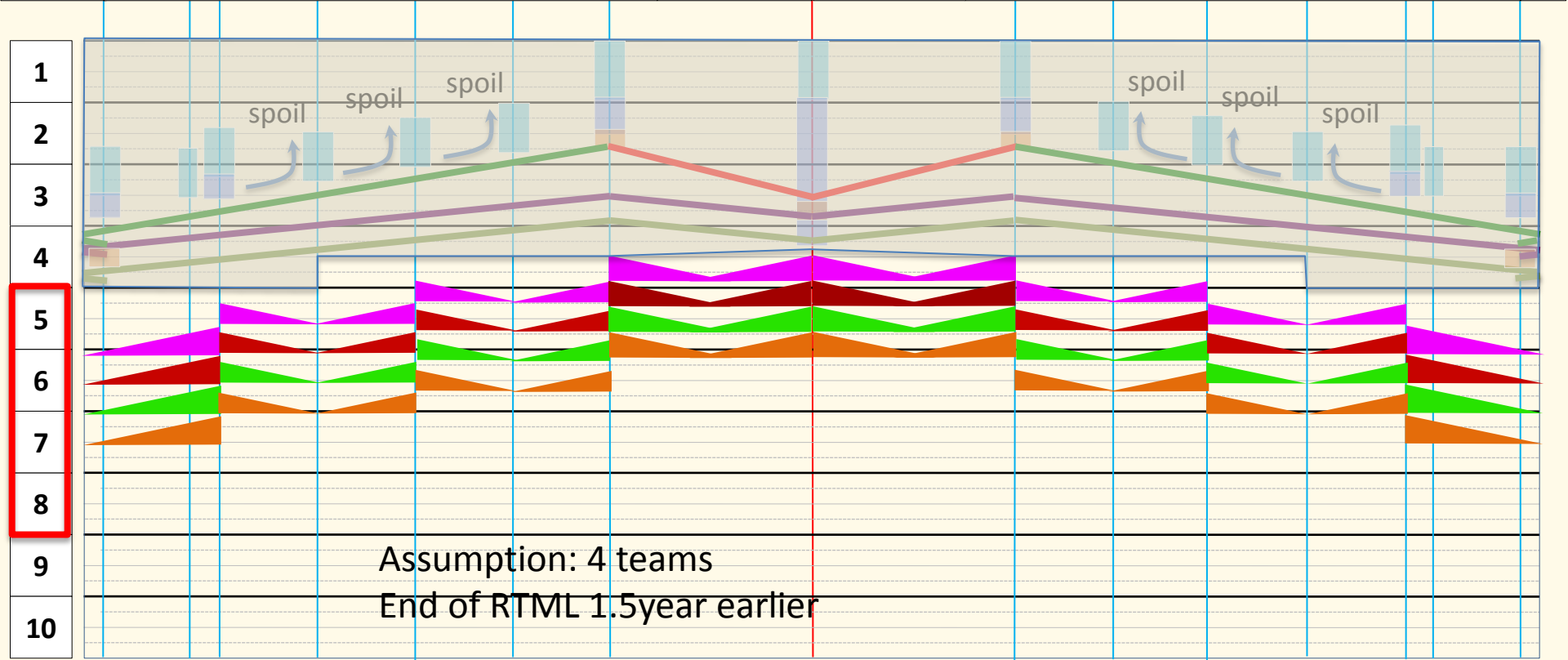
RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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- Survey & supports set-out
- Electrics general services
- Piping & ventilation
- Cabling



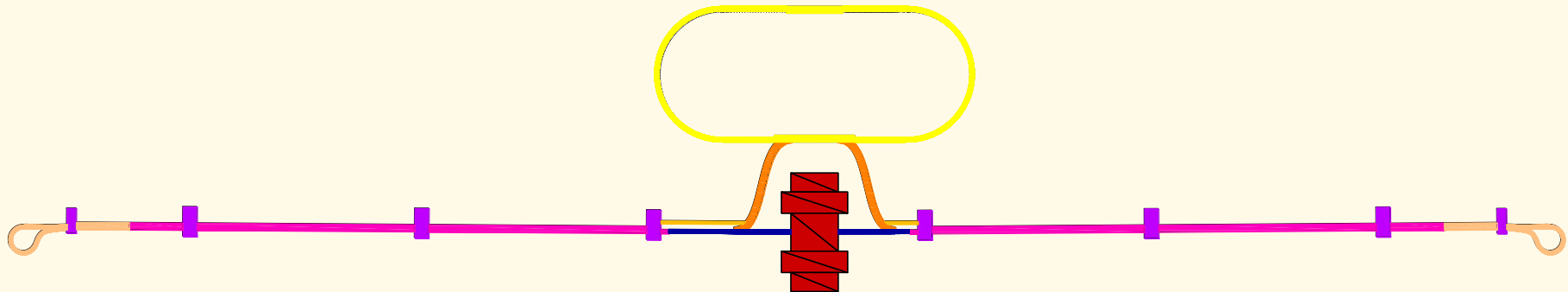
RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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→ Installation of infrastructure

- Survey and set out of components supports
- Electrics General services
- Piping and ventilation
- Cabling

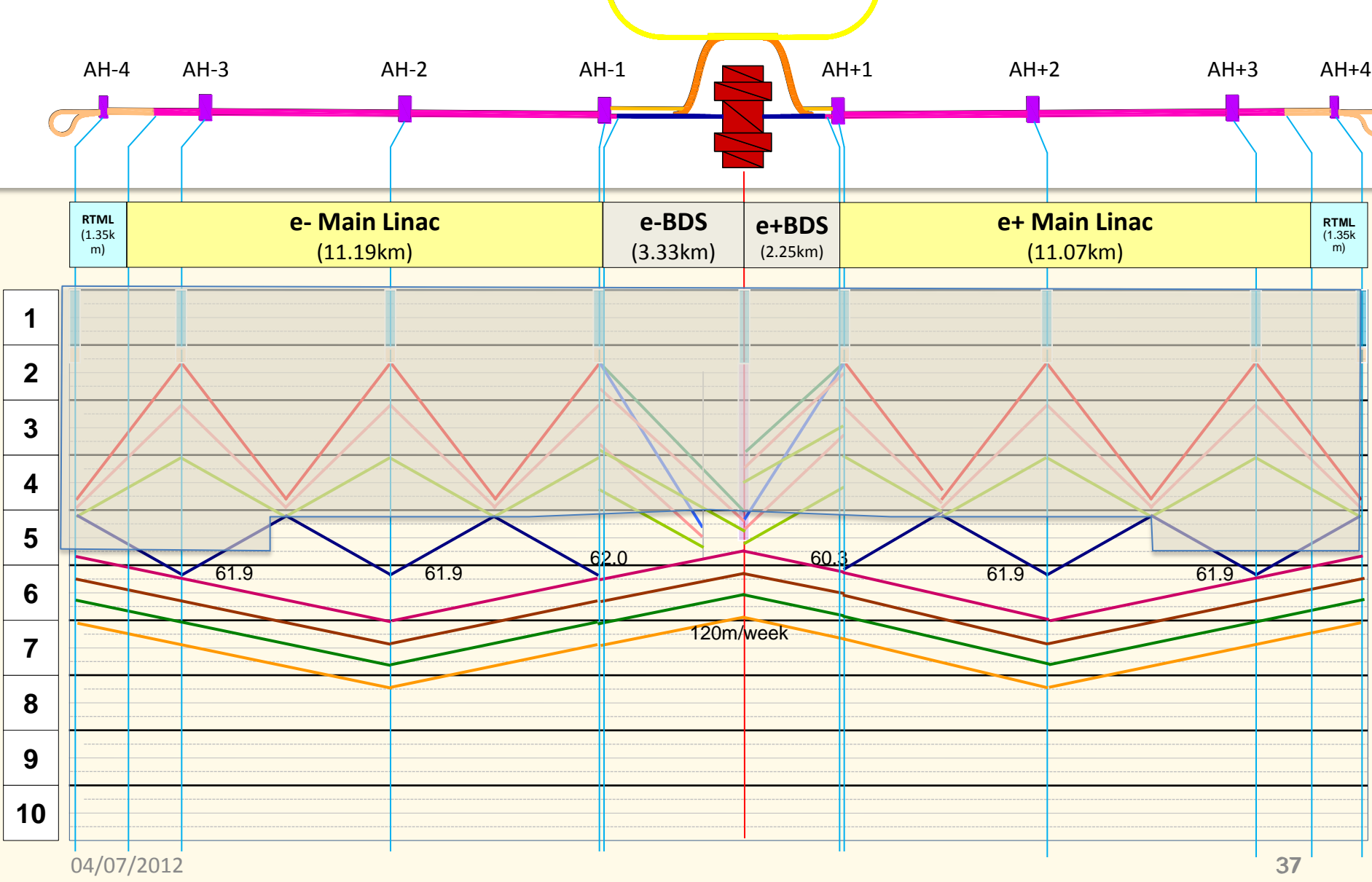
Progress rate 120m/w for 1 shift



→ 4 teams deployed

- In the Asian schedule, teams from different activities are allowed to work in one same sector ex in e-BDS between electrical teams and piping teams
- Having shield wall might make this possible

- Access Tunnel ex.
- Cavern ex.
- Hall ex.
- Beam Tunnel excavation
- Concrete Lining
- Invert & Drainage
- Shield Wall
- BDS Tunnel excavation
- BDS Service Tunnel excavation
- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling

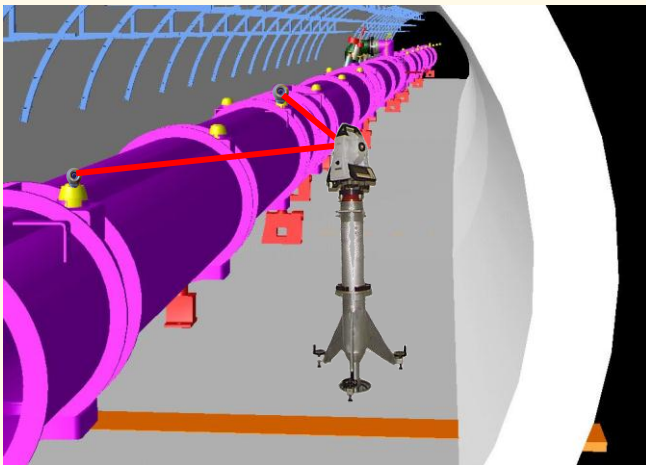


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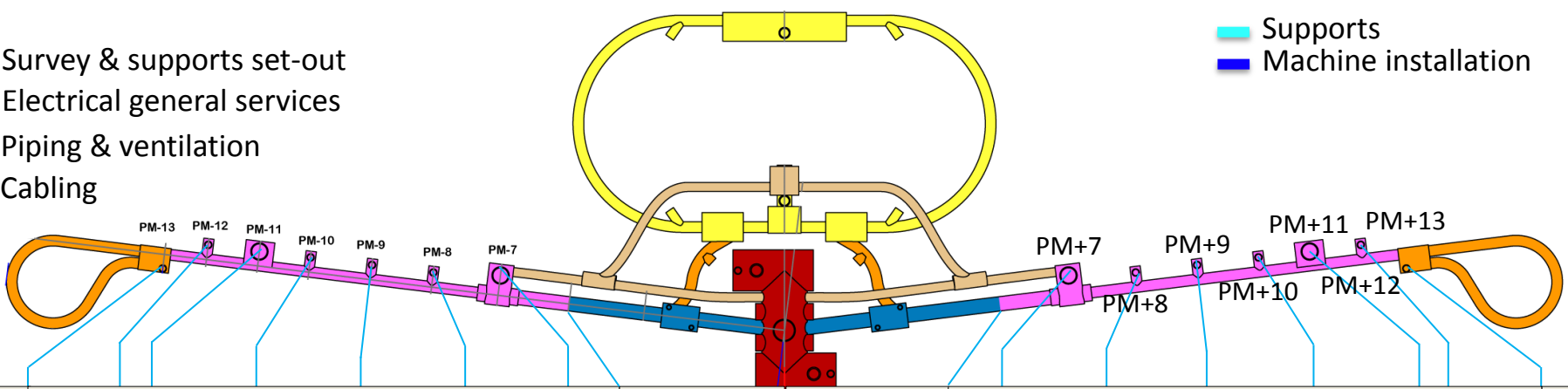
- Progress rates used for the Installation of infrastructure are the same for both regions
 - Survey and set out of components supports
 - Electrics General services
 - Piping and ventilation
 - Cabling
- Allowing multiple types of activities in a same tunnel section allows the MR schedule to catch up slightly with the FT one
- Milestones: Installation of infrastructure complete
 - FT: Y7 Q3
 - MR: Y8 Q1
- Milestone: Installation of machine components in BDS started
 - FT: Y6 Q1
 - MR: Y7 Q2

- Installation of supports for machine components
 - Progress rate: 250m/w for 1 shift
- Installation of machine components
 - Transport
 - Interconnections
 - Alignment
 - Progress rate: 100m/w for 1 shift (Average value from LHC, to be further defined...)
- 2 teams for each activity for FT; 4 teams for each activity for MR

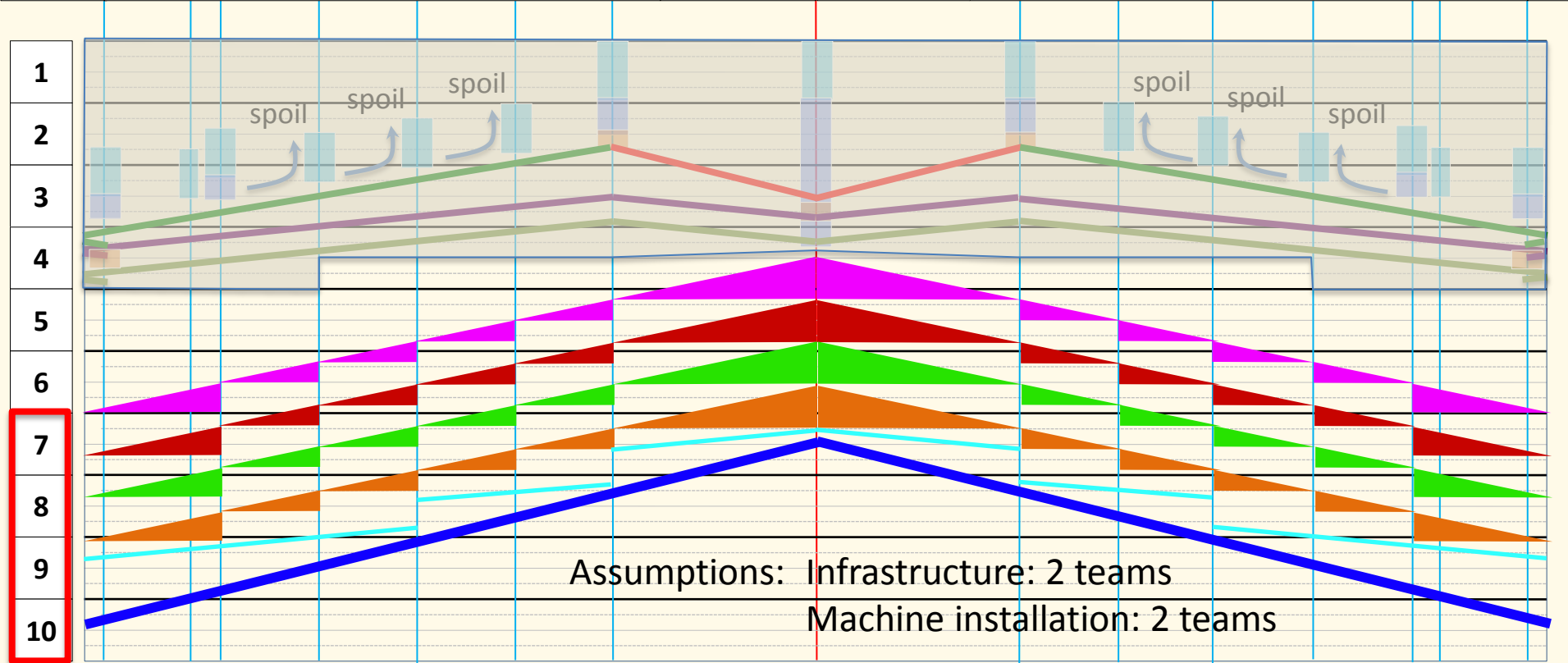


- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling

- Supports
- Machine installation

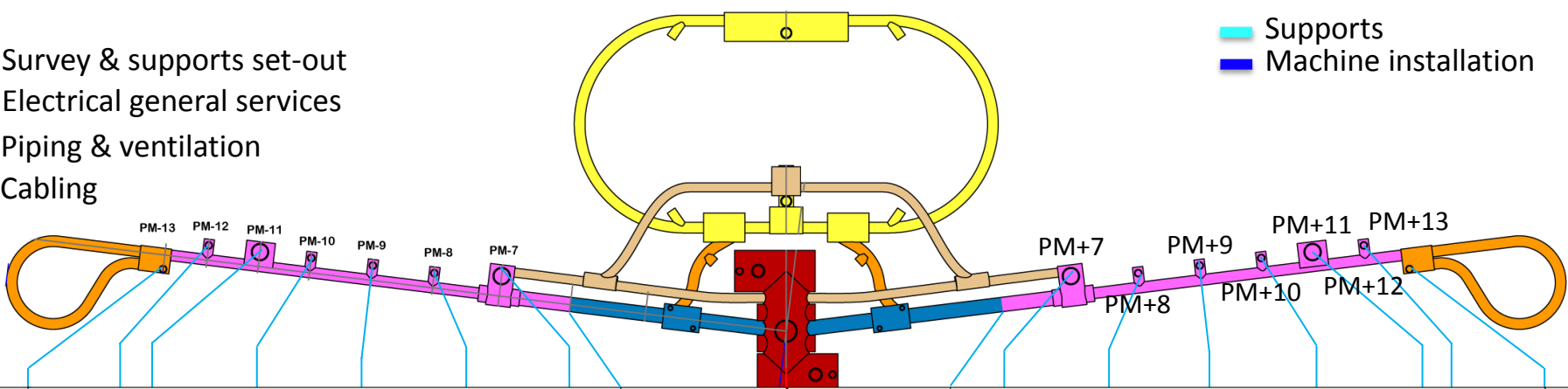


RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+ BDS (3.2km)	e+ Main Linac (11.9km)
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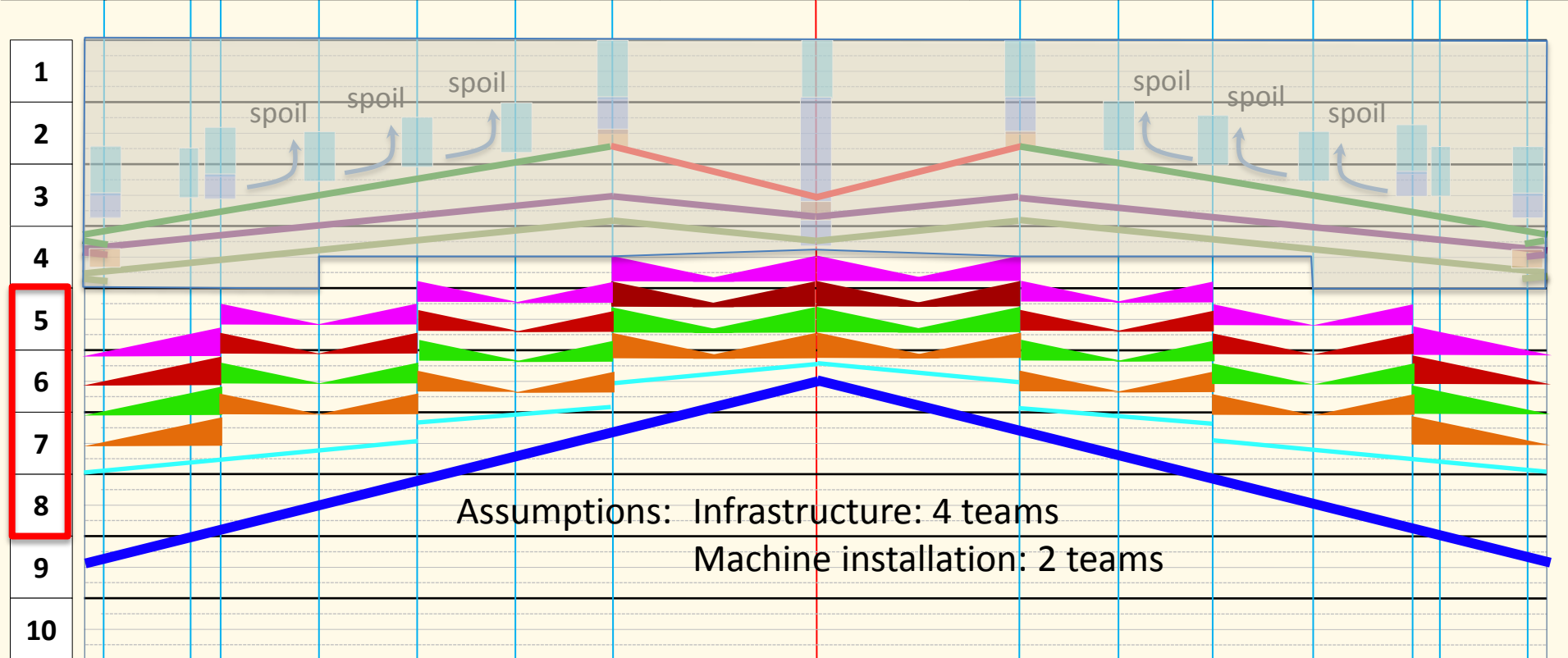


- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling

- Supports
- Machine installation



RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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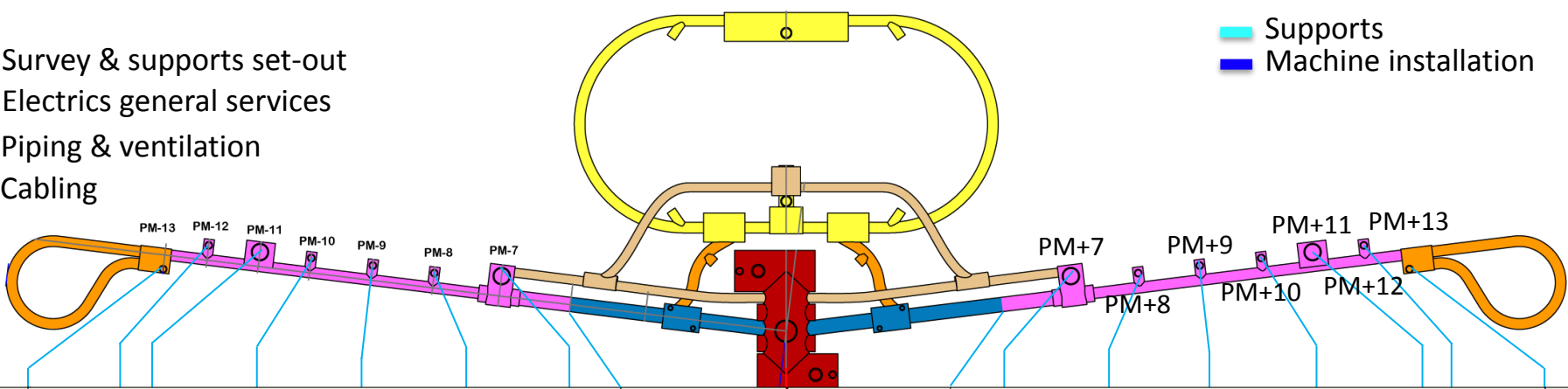


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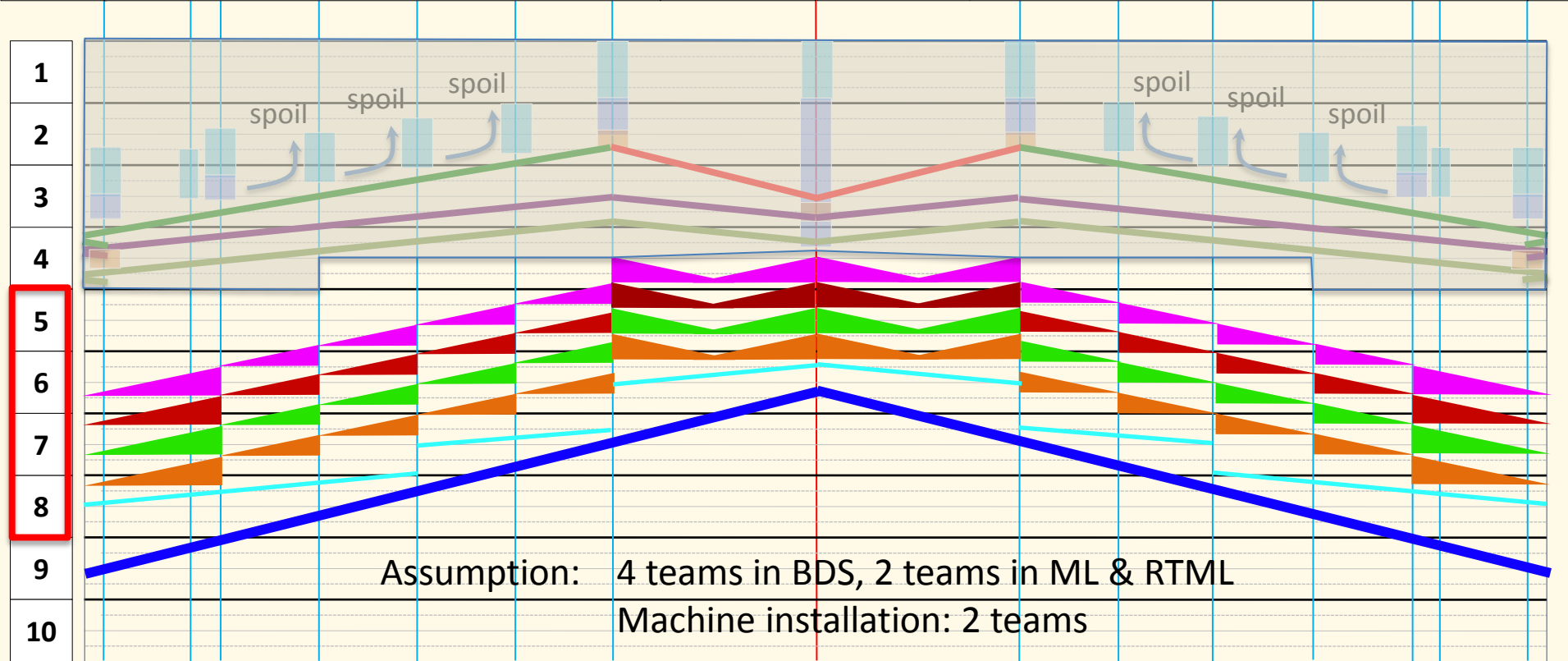
Completion date depends heavily on what happens in BDS region

- Survey & supports set-out
- Electrics general services
- Piping & ventilation
- Cabling

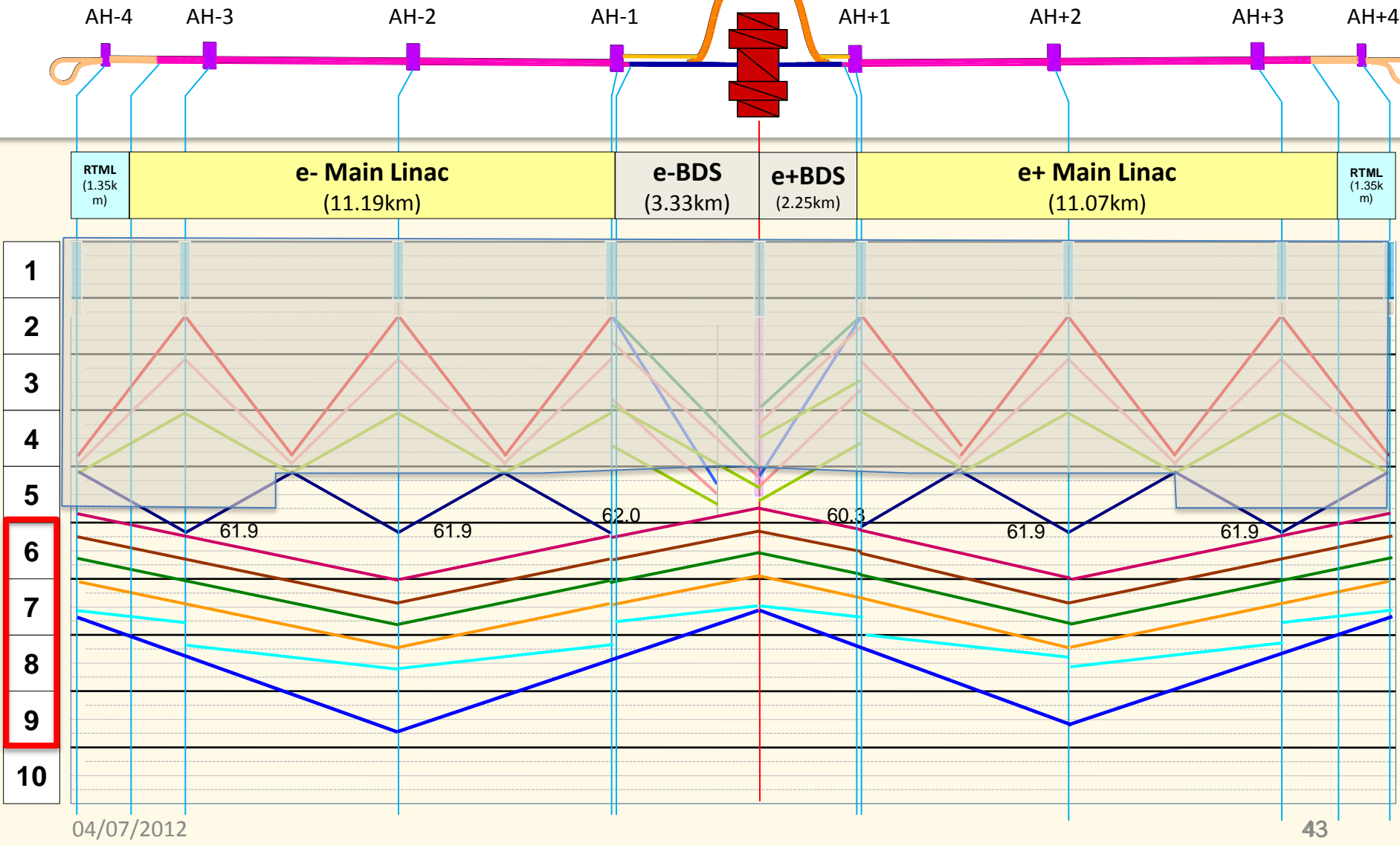
- Supports
- Machine installation



RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+BDS (3.2km)	e+ Main Linac (11.9km)
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- Access Tunnel ex.
- Cavern ex.
- Hall ex.
- Beam Tunnel excavation
- Concrete Lining
- Invert & Drainage
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- Supports
- Machine installation



- The Asian site schedule is a lot more labor intensive
- The faster rate of TBMs allows for a faster completion of the civil engineering work in the FT schedule
 - Spoil management to be studied carefully
- Building the shield wall takes an entire year in the MR schedule
- The installation of infrastructure is slightly faster in the MR region thanks to the deployment of more teams and greater tolerance to coactivity
- Allowing the installation of the machine components to be carried out by 4 teams allows the MR schedule to catch up with the FT schedule
- Milestone: Ready for early commissioning (BDS and ML up to PM7/AH1)
 - FT: Y7 Q2
 - MR: Y8 Q2
- Milestone: Ready for Full commissioning (whole accelerator available)
 - FT: Y10 Q1
 - MR: Y10 Q1
- Milestone: ILC ready for beam
 - FT: Y10 Q4
 - MR: TO BE FURTHER STUDIED (commissioning program to be fine tuned)

- Light blue: Pre-production or pre-industrialization stage (or preparation for full production)
- Yellow : Full production of material and components/parts.
- Orange: Full assembly stage and test stage in parallel.

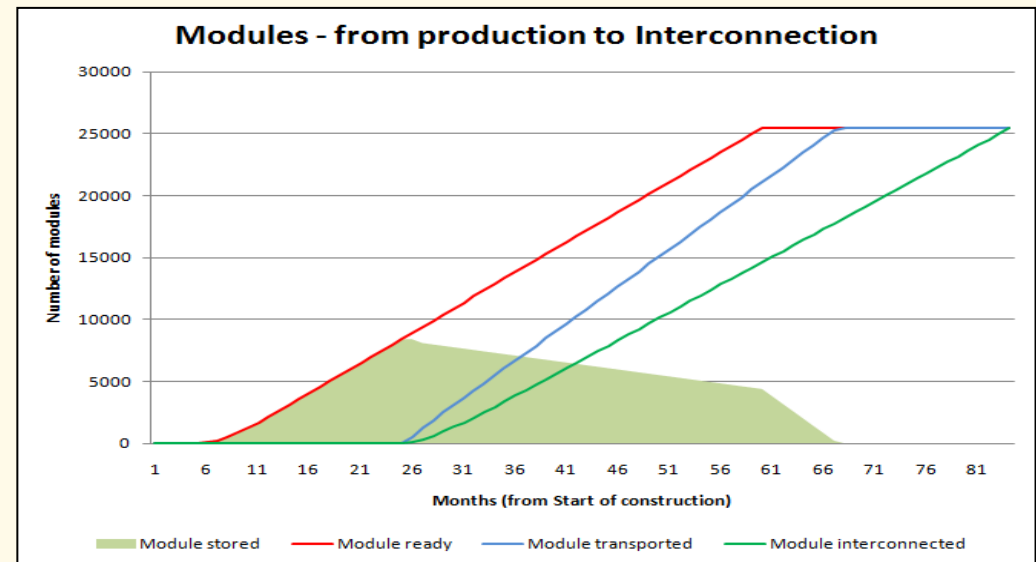
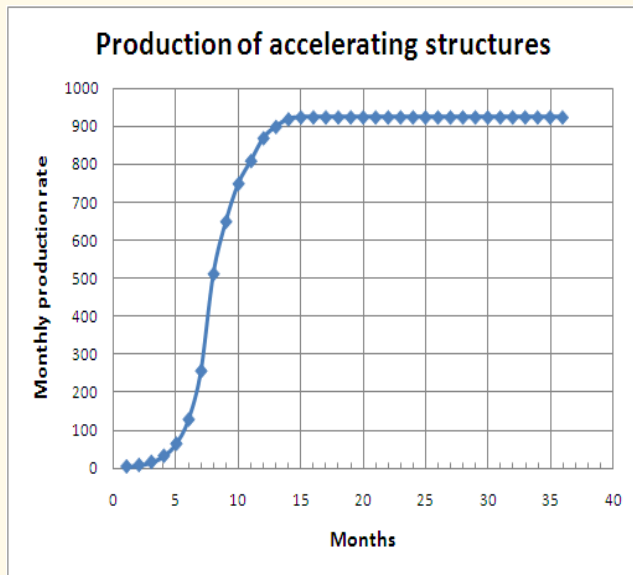
yr	Step	SC material	SCRF cavity	CM parts	CM ass. and test	RF parts	RF ass. and aging
1	Prep.						
2							
3	Production						
4							
5							
6							
7							
8							
9							
10							

Installation of machine components - FT

yr	Step	SC material	SCRF cavity	CM parts	CM ass. and test	RF parts	RF ass. and aging	
1	Prep.							
2								
3	Production							
4								
5								
6								
7								
8								
9								
10								

Installation of machine components - MR

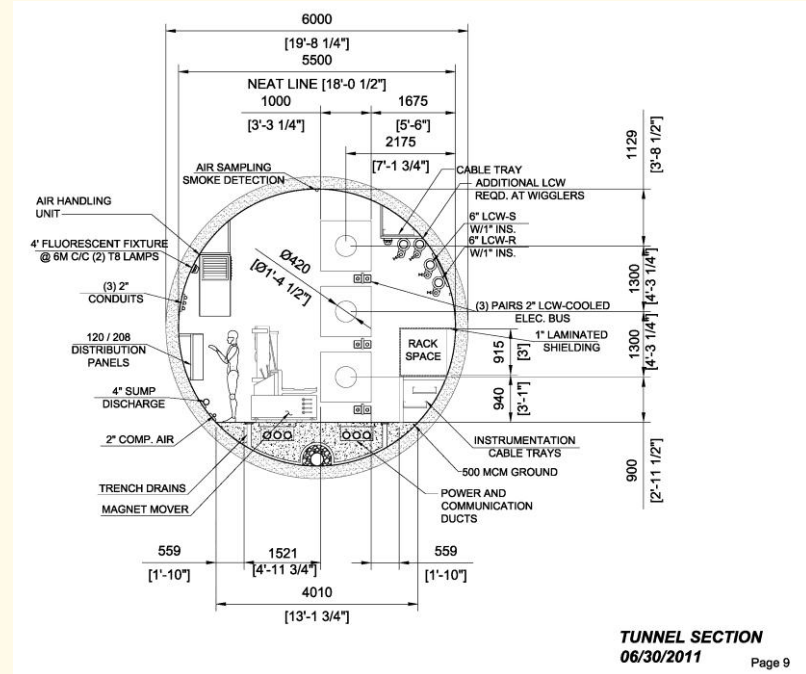
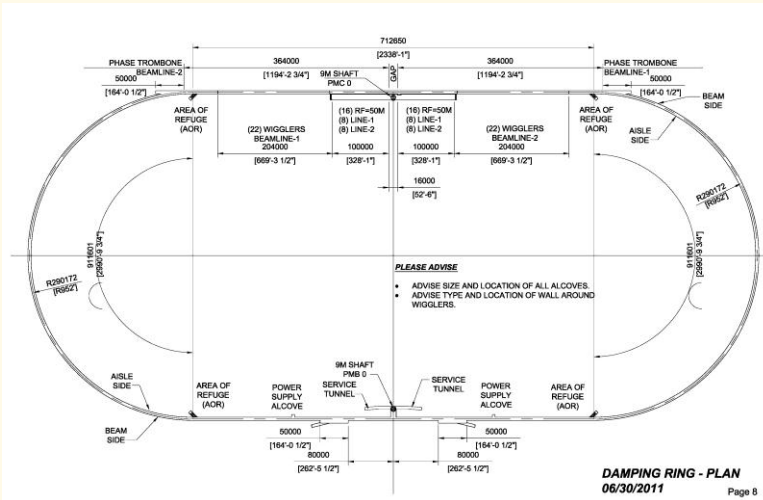
- The Asian region schedule allows for a longer production time of the accelerator parts
- Next step: come up with a production schedule compatible with an installation schedule, ex for CLIC shown below



- Early Commissioning : Draft program (Ewan):
 - The e- injector system to 5 GeV and dump : 3 Months
 - The e+ source and systems to 5 GeV and dump utilizing the auxiliary low current e- source to produce e+ : 3 Months
 - Hardware commissioning of injection lines and both Damping rings : 3 months
 - Commission both rings with beams from injectors with extraction only into first dump in the PLTR (beam still in injection/extraction tunnels): 9 months

- Requires the availability of:
 - BDS and ML up to PM7/AH1 (FT: Y7 Q2)
 - PLTR
 - Damping Rings

- Draft schedule for the construction and installation of the DR+PLTR – FT only
 - DR: One 6m diameter, 3240m long tunnel – excavation using TBM at a rate of 150m/w for 3 shifts
 - PLTR: Two 6-8m diameter, 270m long tunnels – excavation using road headers at a rate of 30m/w for 3 shifts
 - When possible, the RD and PLTR are treated as one 3780m tunnel



- CE phase
 - Invert and finishing: 250m/w
 - Ceiling ducts: 250m/w
- Installation of infrastructure in DR and PLTR
 - Survey: 120m/w 120m/w
 - Electrics: 80m/w 120m/w
 - Piping & ventilation: 80m/w 120m/w
 - Cabling: 80m/w 120m/w
- Installation of machine components
 - Supports: 250m/w
 - Machine elements: DR: 50m/w ; PLTR: 100m/w
- Many more components per meter to install in DR

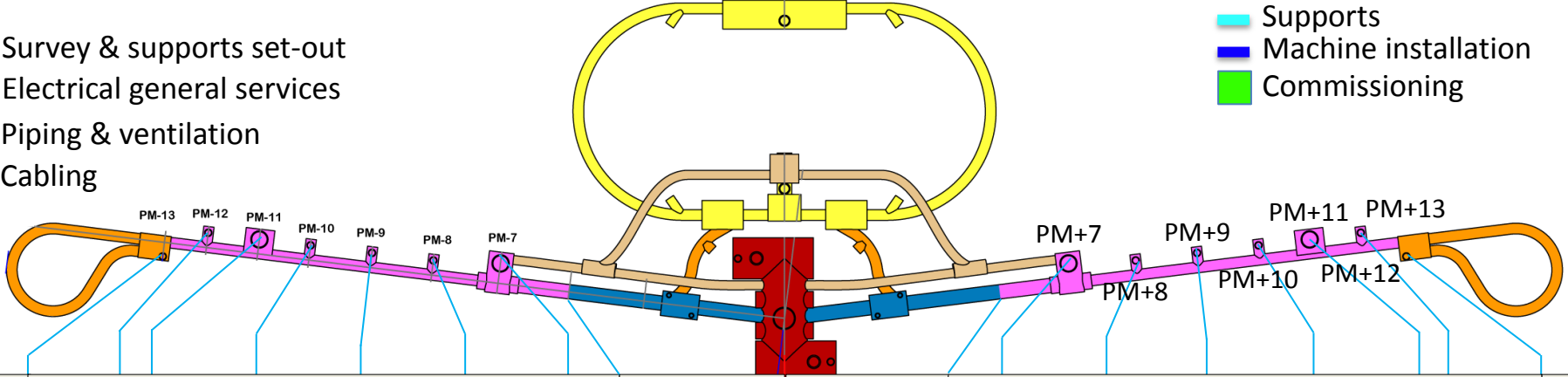
ID	Task Name	Duration	2020		2022		2024		2026		2028		2030		2032		
			Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	Qtr 1	
1	DR and PLTR construction	1850.5 days															
2	Excavate PMA0 and PMBo	52 wks	01/01														
3	Excavate DR caverns	40 wks	30/12														
4	Setup TBM	15 wks	30/12														
5	Excavate DR	21.6 wks	14/04														
6	Excavate PLTR	18 wks	10/05														
7	Invert and finishing for DR and PLTR	15 wks	13/09														
8	Install ceiling partitions (DR PLTR)	15 wks	27/12														
9	Survey + supports setout	31.5 wks	11/04														
10	Electrics	45 wks	16/11														
11	Piping and ventilation	45 wks	27/09														
12	Cabling	45 wks	07/08														
13	Supports installation	15 wks	18/06														
14	Machine installation	70 wks	01/10														
15	DR and PLTR ready for commissioning	0 days															
16	BDS ready for commissioning	0 days															
17	e- injector system to 5GeV and dump	13 wks	01/04														
18	e+ source and systems to 5GeV and dump	13 wks	01/04														
19	Hardware commissioning of injection lines and DR	13 wks	01/04														
20	Commissioning with beam of DR	39 wks	01/07														
21	Early commissioning complete	0 days															

- Under our set of assumptions, the DR and PLTR would be made available to commissioning before the BDS becomes available
- The early commissioning would be over during Y8 Q3

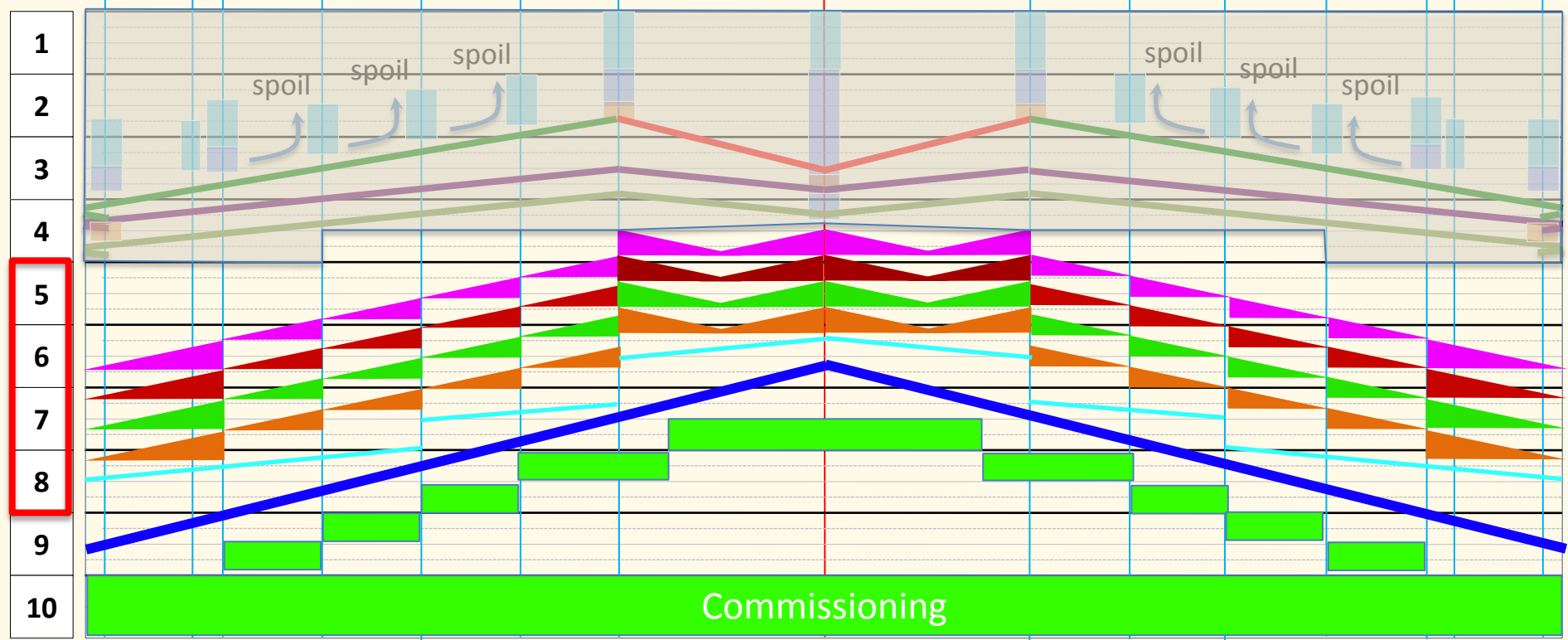
- Still quite early to come up with precise estimates
- Based on LHC:
 - 6 month of pre-commissioning per sector
 - 12 months of global commissioning
- Key dates
 - BDS ready for commissioning: Y7 Q2
 - ML ready for commissioning: Y9 Q3
- Pre-requisite to launch commissioning with beam IF detectors not available
 - Temporary vacuum pipe through IR area
 - Temporary QD0
 - Temporary shielding

- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling

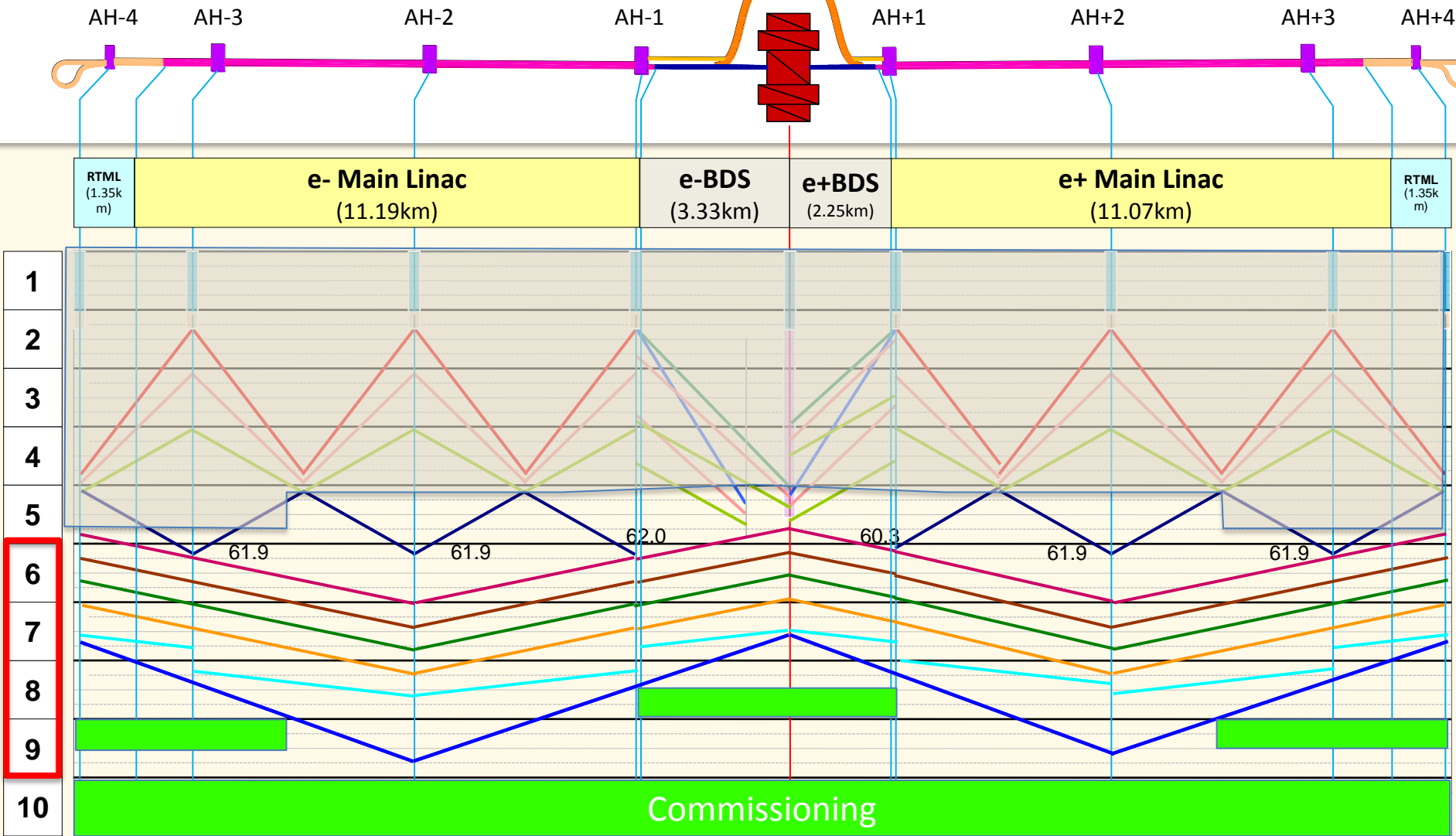
- Supports
- Machine installation
- Commissioning



RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.2km)	e+ BDS (3.2km)	e+ Main Linac (11.9km)
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- Access Tunnel ex.
- Cavern ex.
- Hall ex.
- Beam Tunnel excavation
- Concrete Lining
- Invert & Drainage
- Shield Wall
- BDS Tunnel excavation
- BDS Service Tunnel excavation
- Survey & supports set-out
- Electrical general services
- Piping & ventilation
- Cabling
- Supports
- Machine installation



04/07/2012

53

Commissioning

1
2
3
4
5
6
7
8
9
10

RTML (1.35k m) e- Main Linac (11.19km) e-BDS (3.33km) e+BDS (2.25km) e+ Main Linac (11.07km) RTML (1.35k m)

AH-4 AH-3 AH-2 AH-1 AH+1 AH+2 AH+3 AH+4

- This draft schedules shows how the ILC could be built in less than 9 years
- Many additional studies will be necessary to finalise the work plans
- New iteration would be necessary if layouts are modified
- The commissioning of the Asian region has to be further studied

- Next steps:
 - Include waveguide and RTML (input needed from installation studies)
 - Include Service Tunnel and its cavern
 - Include Surface buildings
 - Consolidate scheduling studies for the construction and installation of the detectors in both FT and RM regions – synergies with CLIC