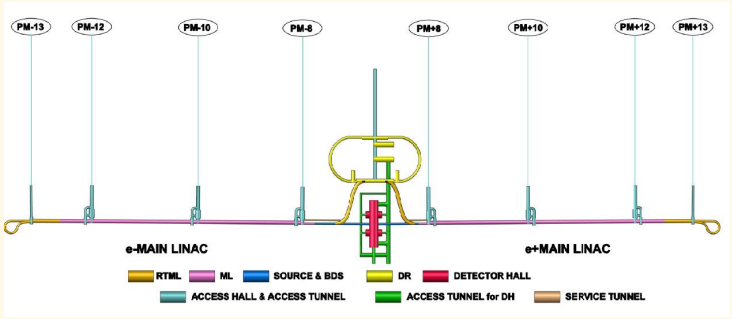
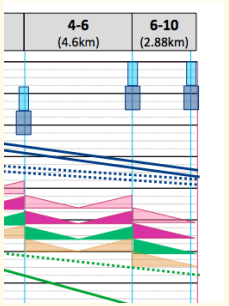
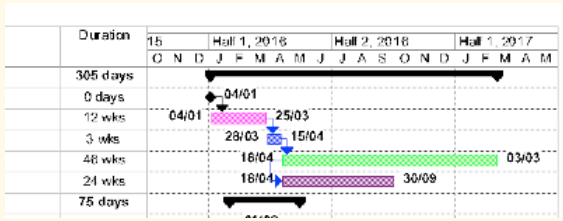
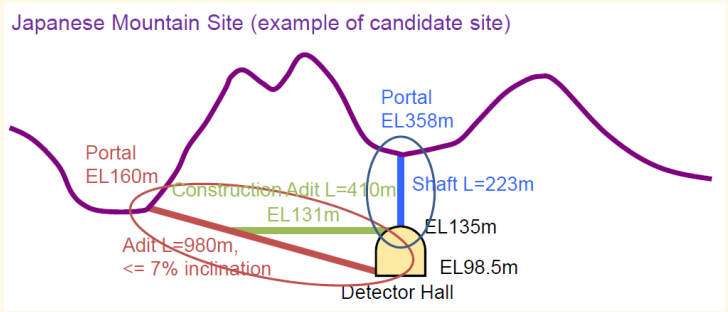


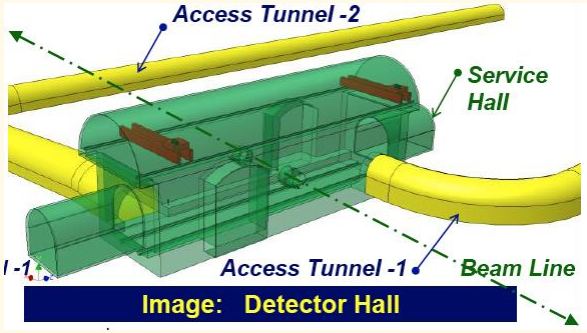


ILC Asian Draft Schedule



K Foraz, M Gastal & J Osborne

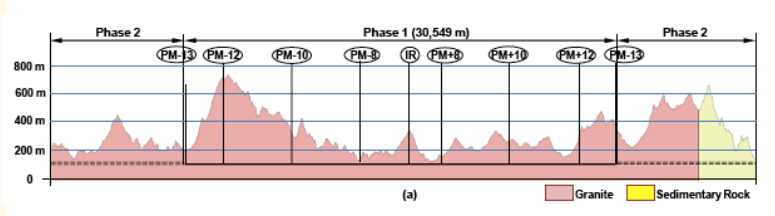




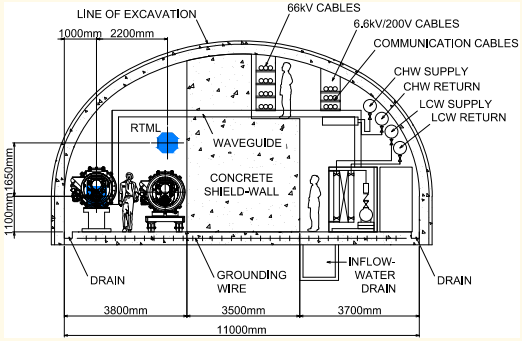
Many thanks to all contributors

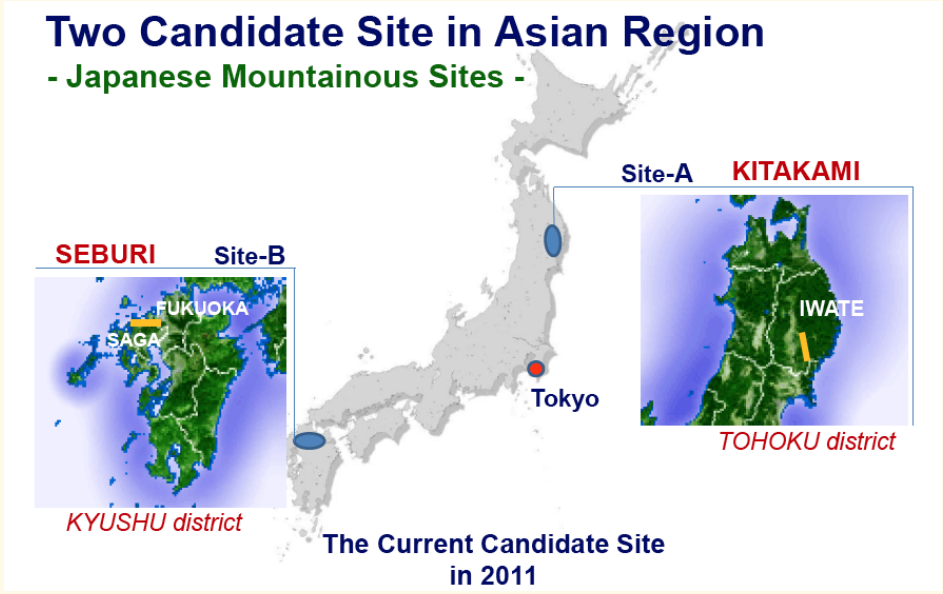
Objectives and scope

- → To provide a target baseline construction schedule for the 2 Asian sample sites
- → Address remarks made during the Windsor (Feb 2013) cost review
- → Assess the impact on schedule of a staged construction approach (preliminary)



Mountainous Region (MR)
Asia
Access Tunnels
2 separate volumes in ML

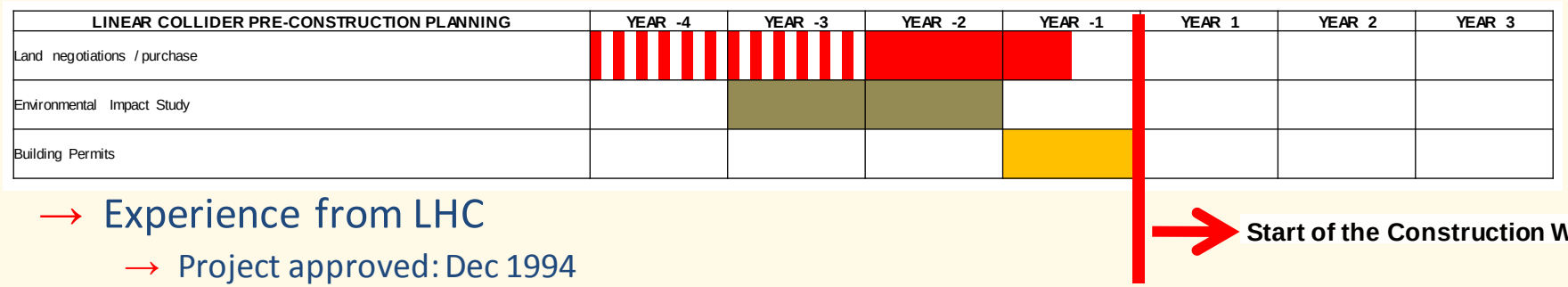




- → Limitations
  - → Focus on the critical path
  - → Many parameters can be tuned and affect these draft scenarios
    - → Tolerance to co-activity, number of teams deployed, shifts…
  - → No contingency to account for the challenges of the in-kind nature of the project have been included
    - → Schedule contingency and warehousing of components should be negotiated at project start

Strategic aspects

- Taking into account activities prior to ground breaking
  - TDR schedule exclude these
  - Comments were made at the Windsor cost review
- List of relevant activities
  - Tendering process for contractors
  - Land negotiation & Purchase
  - Site investigation and potential archeological survey
  - Environmental Impact Studies (typically 3 years in Japan)
  - Building Permits



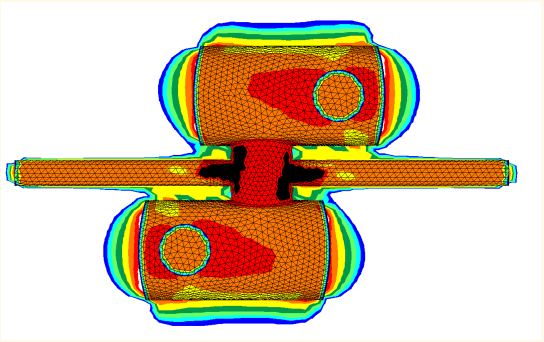
- Experience from LHC
  - Project approved: Dec 1994
  - CE design: 1996-1998
  - Environmental Impact Study published: Mar 1997 (including archeological survey)
  - Decision to expropriate and start purchasing land: Jun 98
  - Ground breaking: Aug 98
  - ~ 4 years in total (for a well established laboratory)

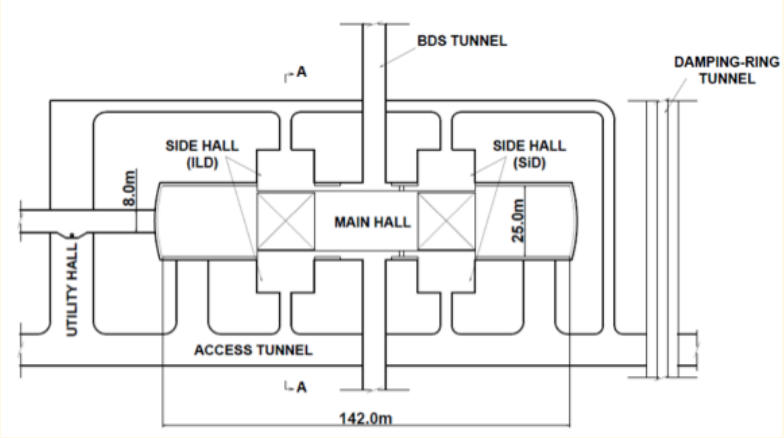
Strategic aspects

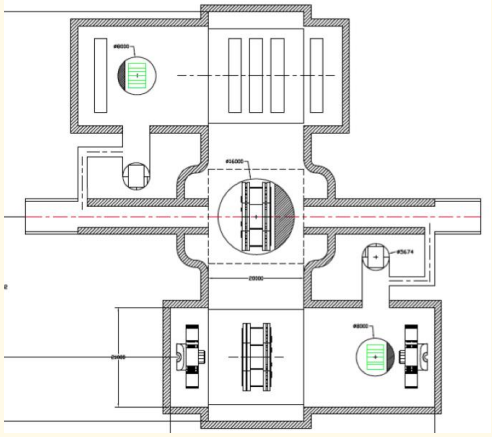
- → Taking into account pre-commissioning constraints
  - → The schedule is built so as to deliver part of the ILC early to allow for pre-commissioning
- → Early Commissioning : Draft program
  - → The e- injector system to 5 GeV and dump : 3 Months
  - → The e+ source and systems to 5 GeV and dump utilizing 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 Access Hall 1
  - → PLTR
  - → Damping Rings

Strategic aspects

- → 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
- → Asian Detector Hall does not use access shafts
  - → Still useful to launch tunnelling crew from adjacent access points
  - → Allows for Hall excavation prior to connection with BDS tunnels

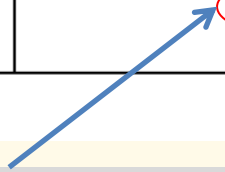






Progress Rates Summary

Activity in Main Linac	Progress rates in m/week	For x Shifts
Tunneling using 6-8m Ø road header	20	3
Concreting lining	25	3
Invert, drainage and finishing	45	3
Survey and set out of components supports	120	1
Electrics General Services	120	1
Piping and ventilation	120	1
Cabling	120	1
Installation of supports for machine components	250	1
Installation of machine components	100	1

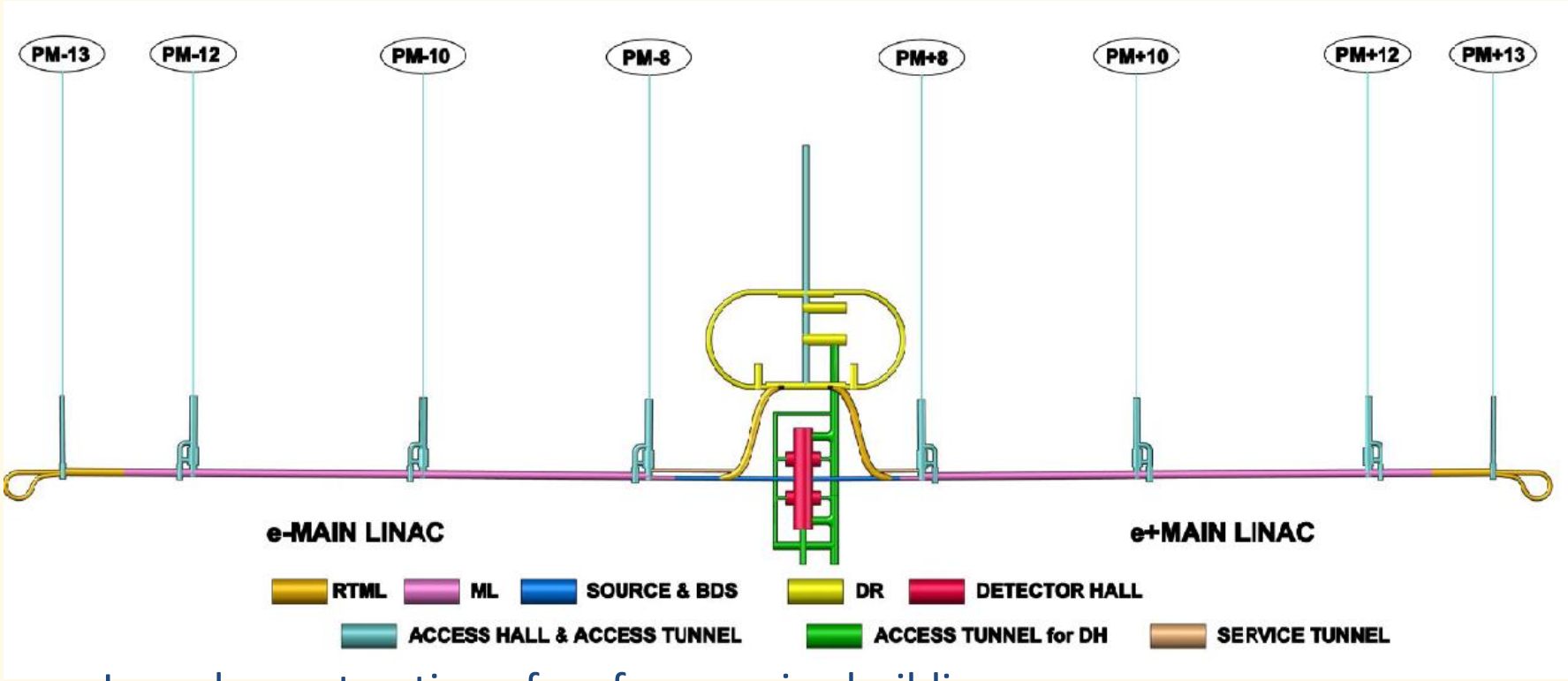


Further studies requested at Windsor

Year 1 – Construction kick-off

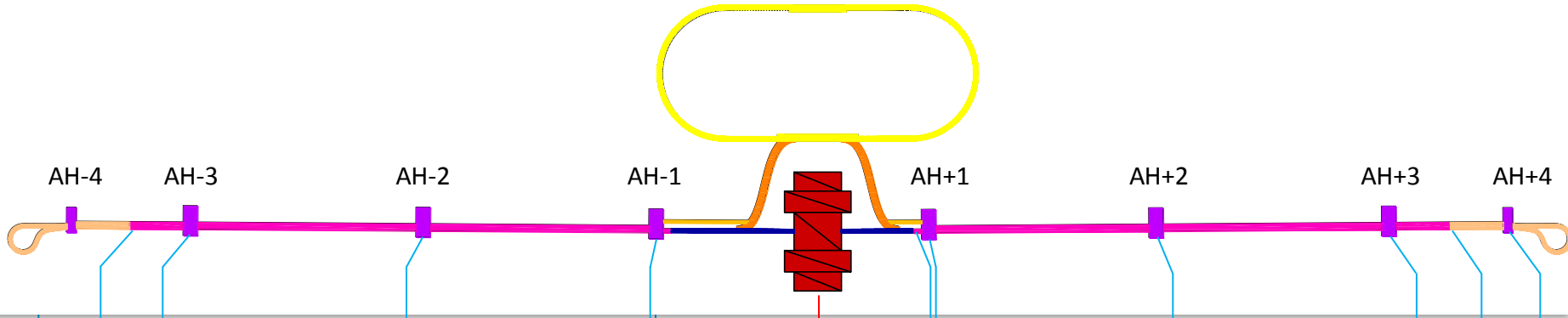
→ Excavation of 10 access tunnels

→ PM-13, PM-12, PM-10, PM-8, IP, DR, PM+8, PM+10, PM+12, PM+13



→ Launch construction of surface service buildings

Access Tunnel 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)

1
2
3
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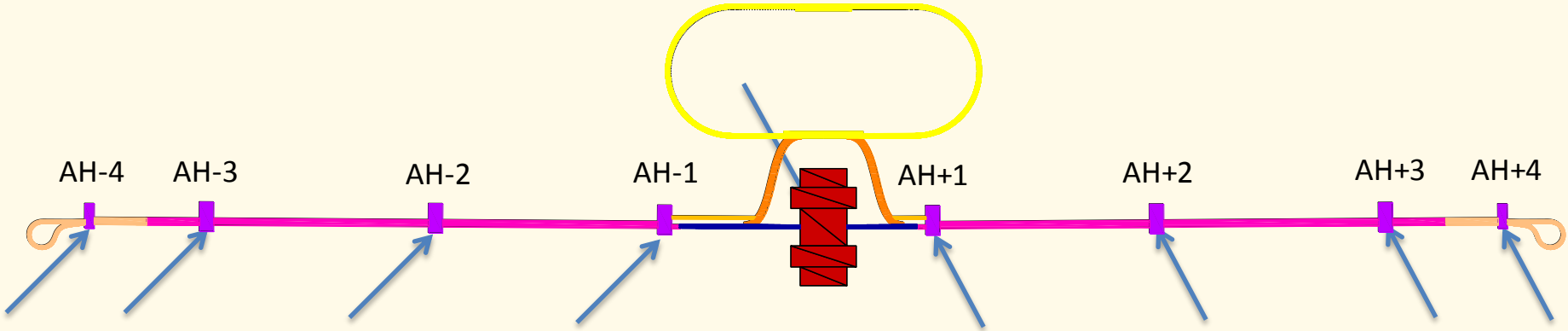
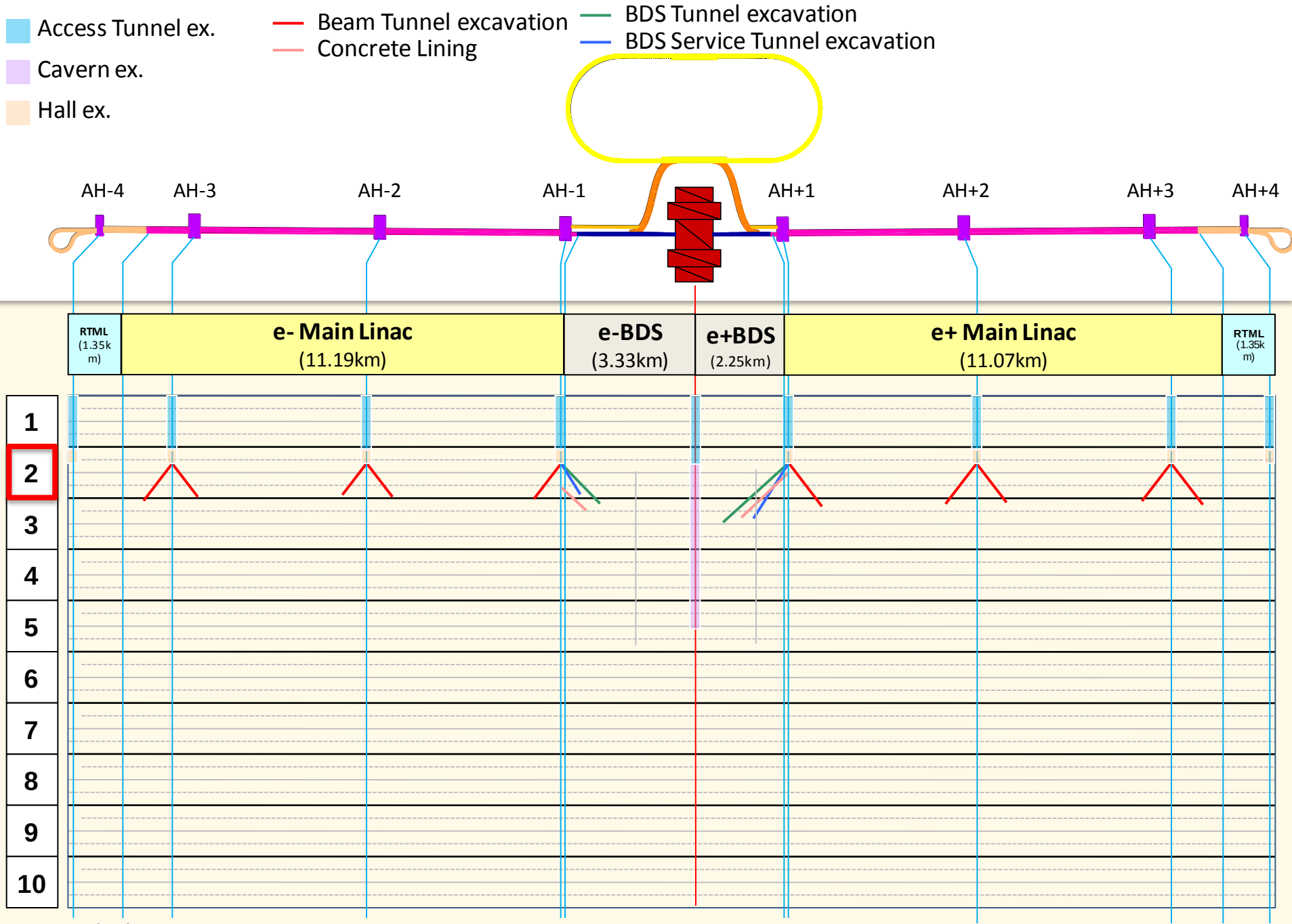
Year 2 – Tunneling MR

- → 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)
  - → 15 tunneling crews are sent from each access tunnels – progress rate: 20m/week
  - → Excavation of IR Cavern started
  - → Start concrete lining in sectors IP-AH-1 and IP-AH+1



Drill & Blast → Mucking → Shotcrete → Rock Bolt → Steel Support


Access Tunnel ex.
Cavern ex.
Hall ex.
Beam Tunnel excavation
Concrete Lining
BDS Tunnel excavation
BDS Service Tunnel excavation
AH-4
AH-3
AH-2
AH-1
AH+1
AH+2
AH+3
AH+4
RTML (1.35k m)
e- Main Linac (11.19km)
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e+BDS (2.25km)
e+ Main Linac (11.07km)
RTML (1.35k m)
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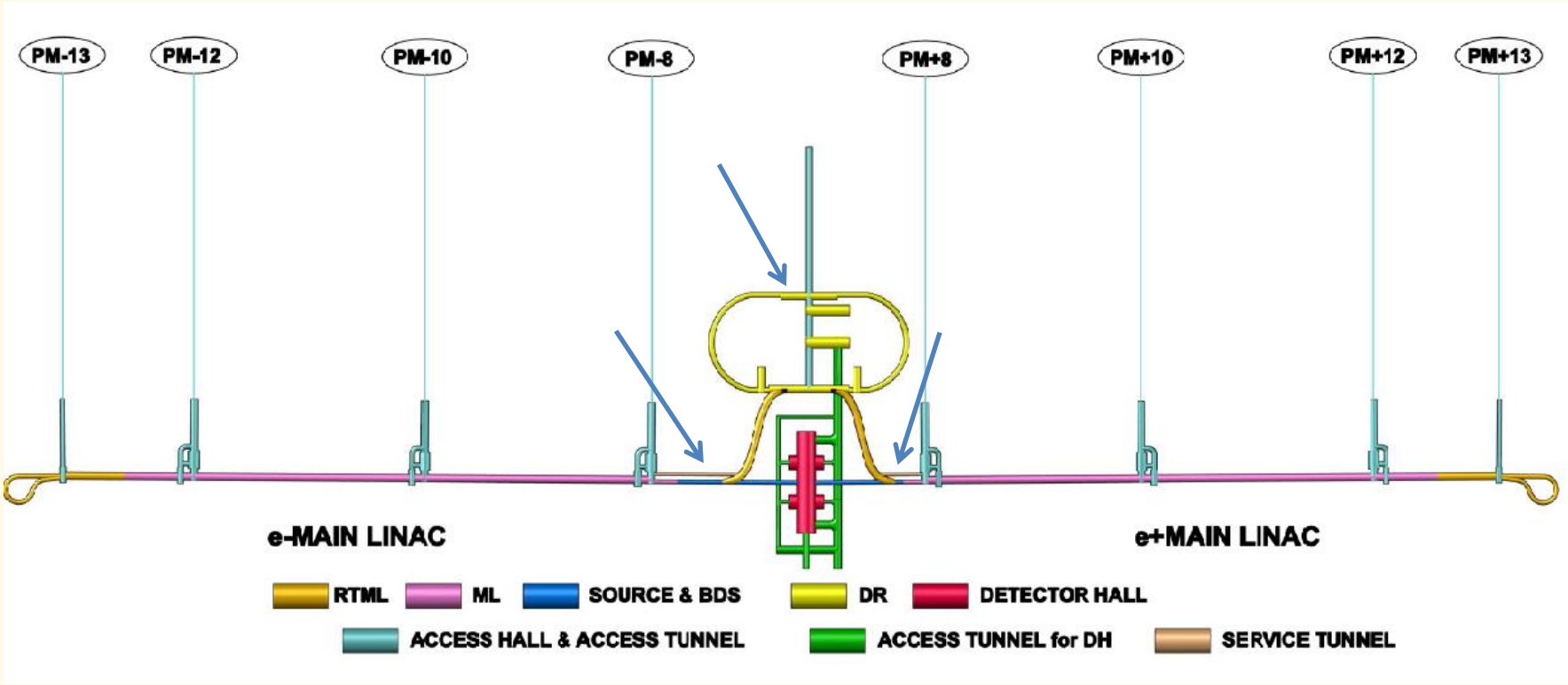
Year 2 – Tunneling

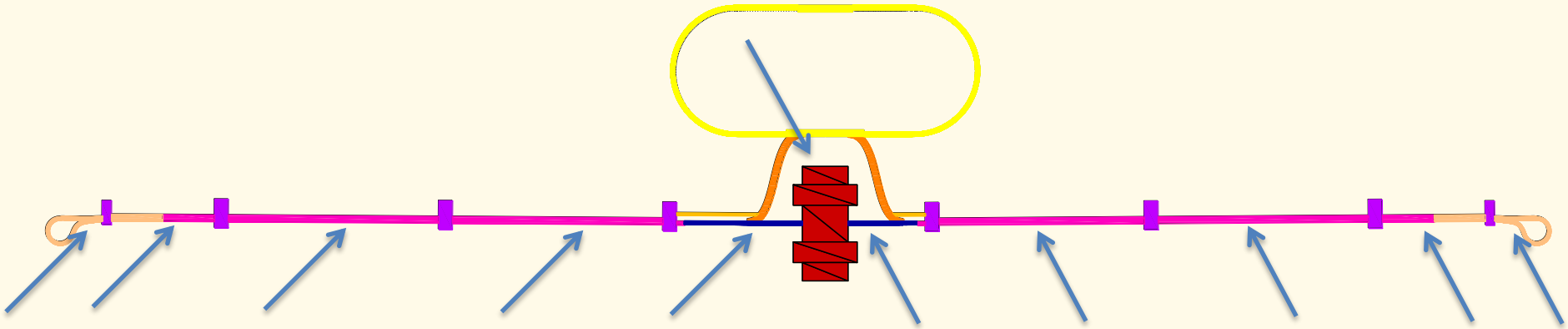
→ Excavation of BDS service tunnel will require 2 tunneling crews

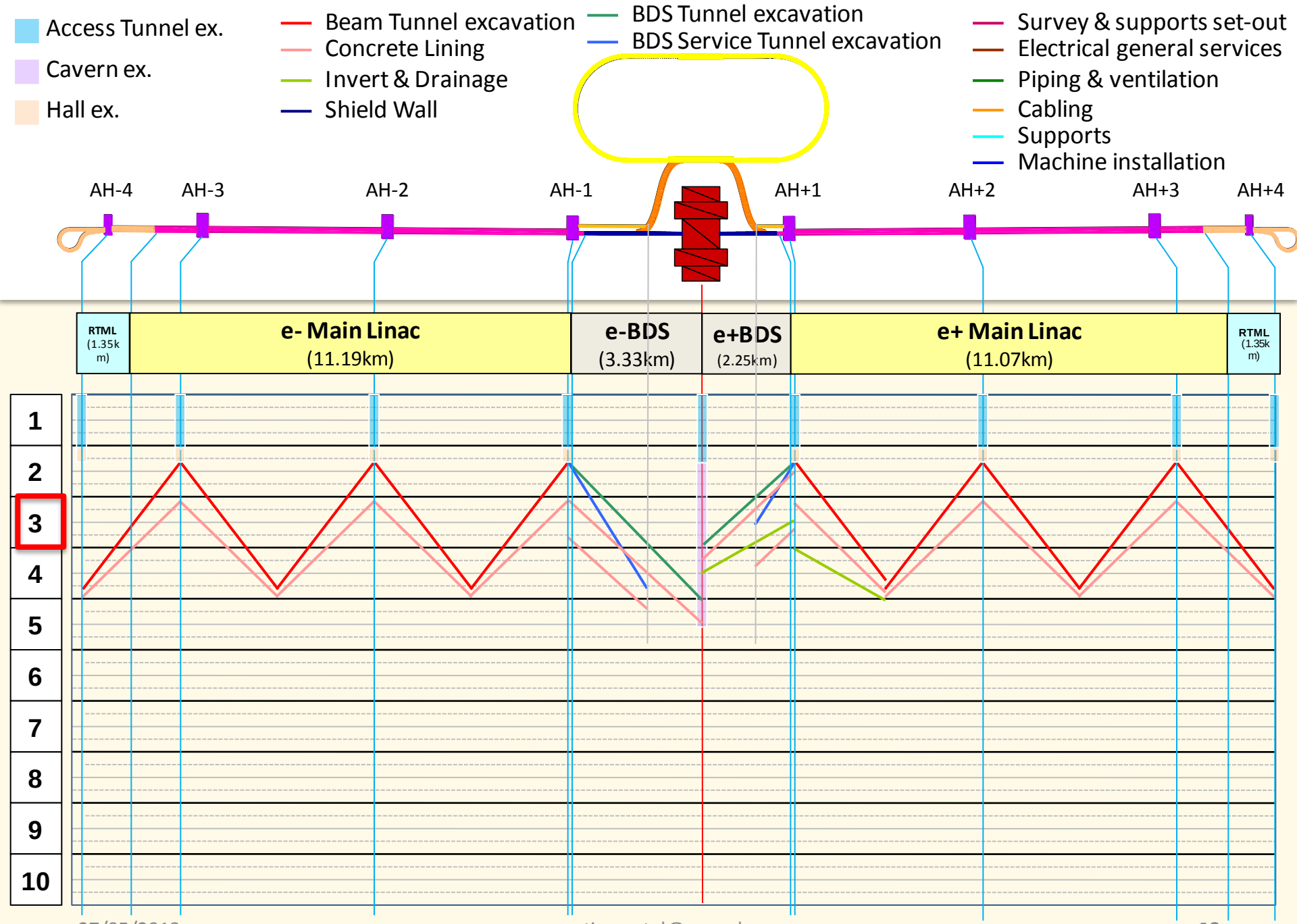
→ Excavation of DR tunnel will require 1 tunneling crew



Year 3 – Tunneling, and concrete lining

- → Excavation of IP cavern
- → Tunneling will proceed in all 15 tunnel 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
AH-4
AH-3
AH-2
AH-1
AH+1
AH+2
AH+3
AH+4
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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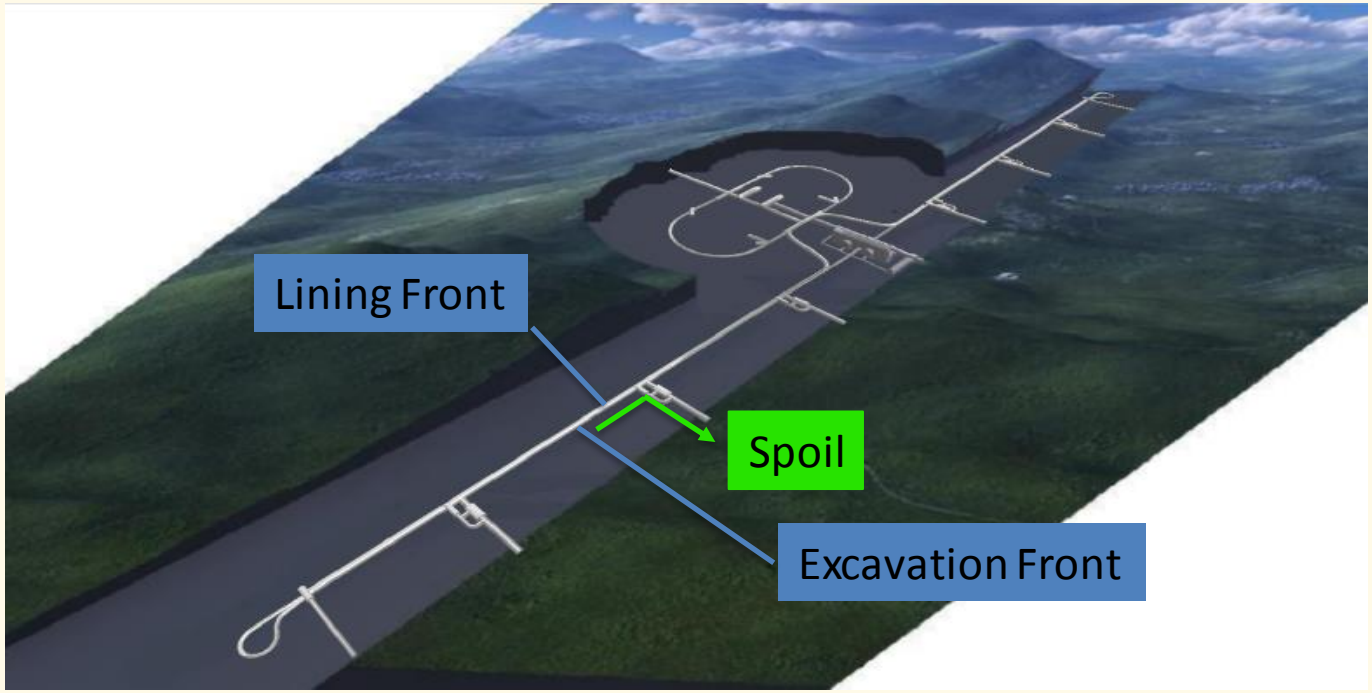
Year 3 – Spoil Management

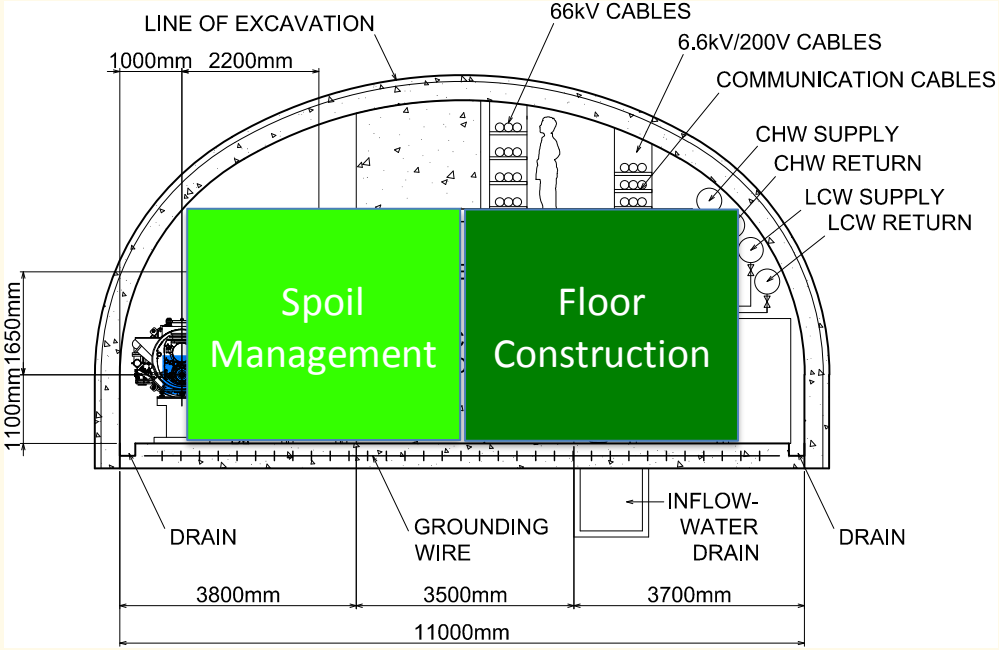
→ Spoil management is to be carried out in parallel with the lining work

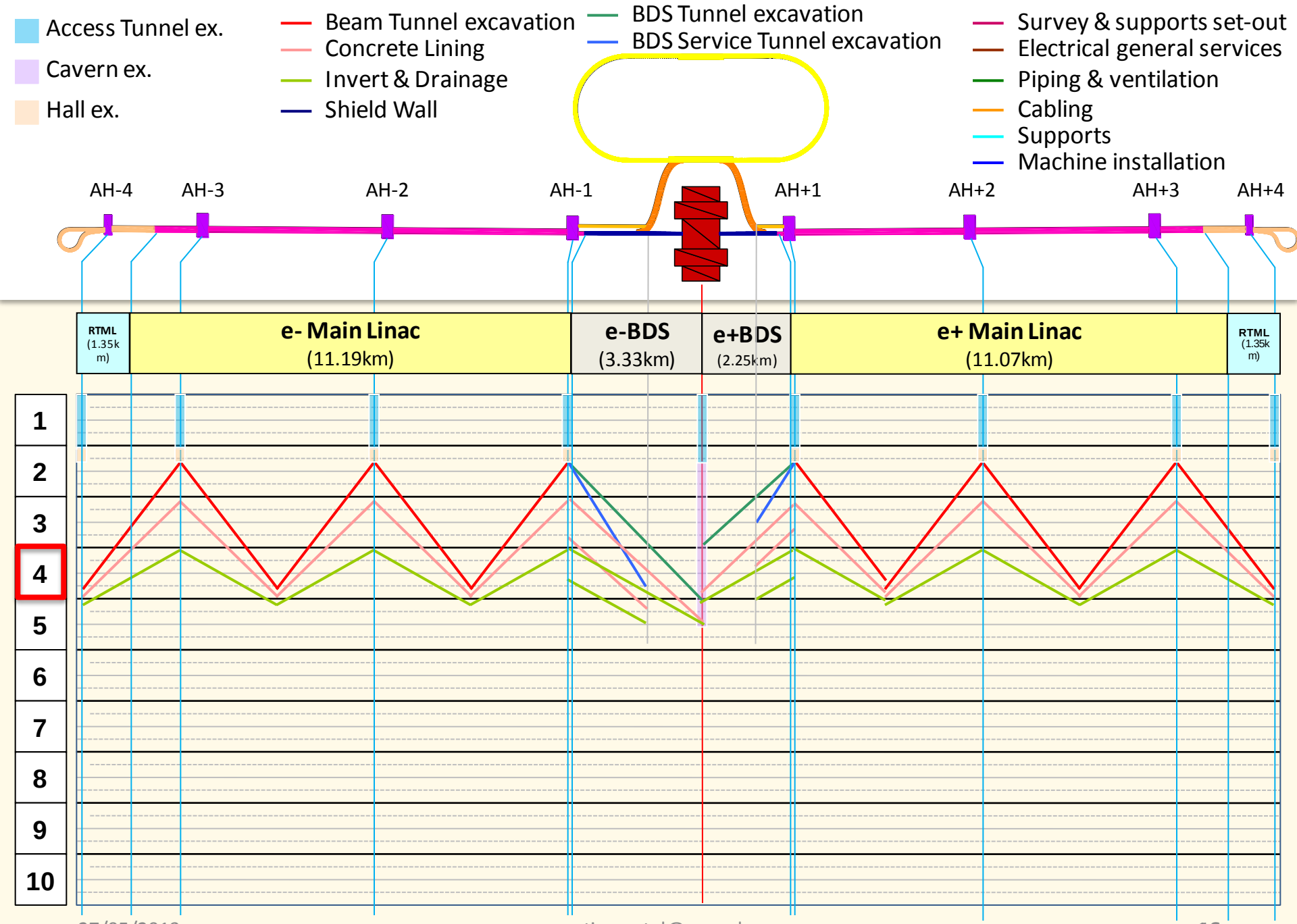
→ Lining work 200m behind the excavation front



Year 4 – End of tunneling in Main Linac, finishing

- → End of tunnel excavation phase in Beam Tunnel, BDS Tunnel and BDS service tunnel
- → Excavation, lining and Invert & drainage take place in parallel
  - → Invert & Drainage Progress rate: 45m/week
  - → Lining work 200m behind the excavation front
  - → 100m further down, the floor construction will alternate between the service tunnel side and beam tunnel side – typical method for highway construction

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AH+4
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e+ Main Linac (11.07km)
RTML (1.35k m)
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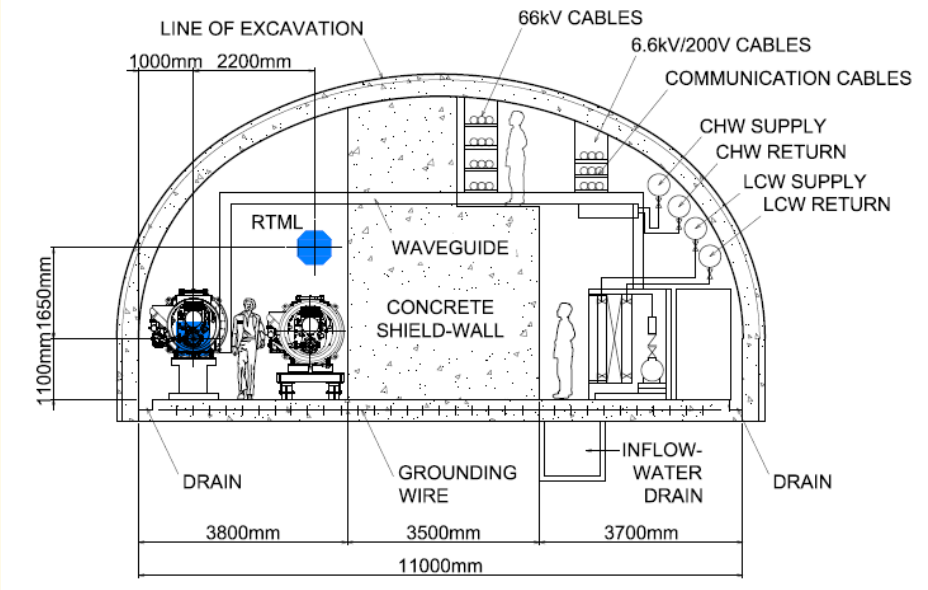
Year 5 – Finishing phase in Main Linac, End of Detector Hall excavation

→ Year 5 is dominated by the construction of the Concrete Shield-Wall in the Beam tunnel

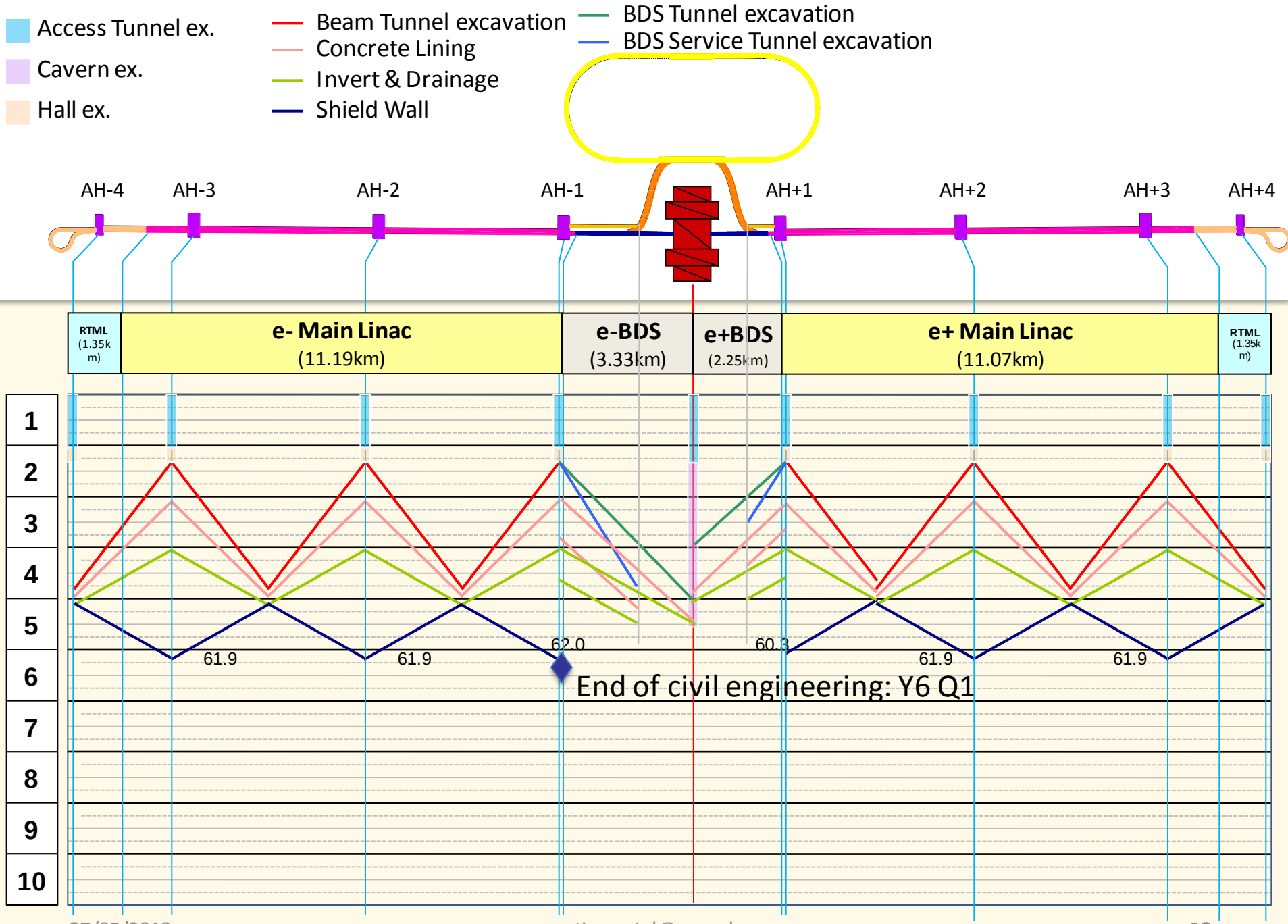
→ Progress rate: 45m/week



→ Survey and supports set-out taking place in BDS

→ End of Detector Hall excavation and finishing

→ 39 months vs 24 for Flat topography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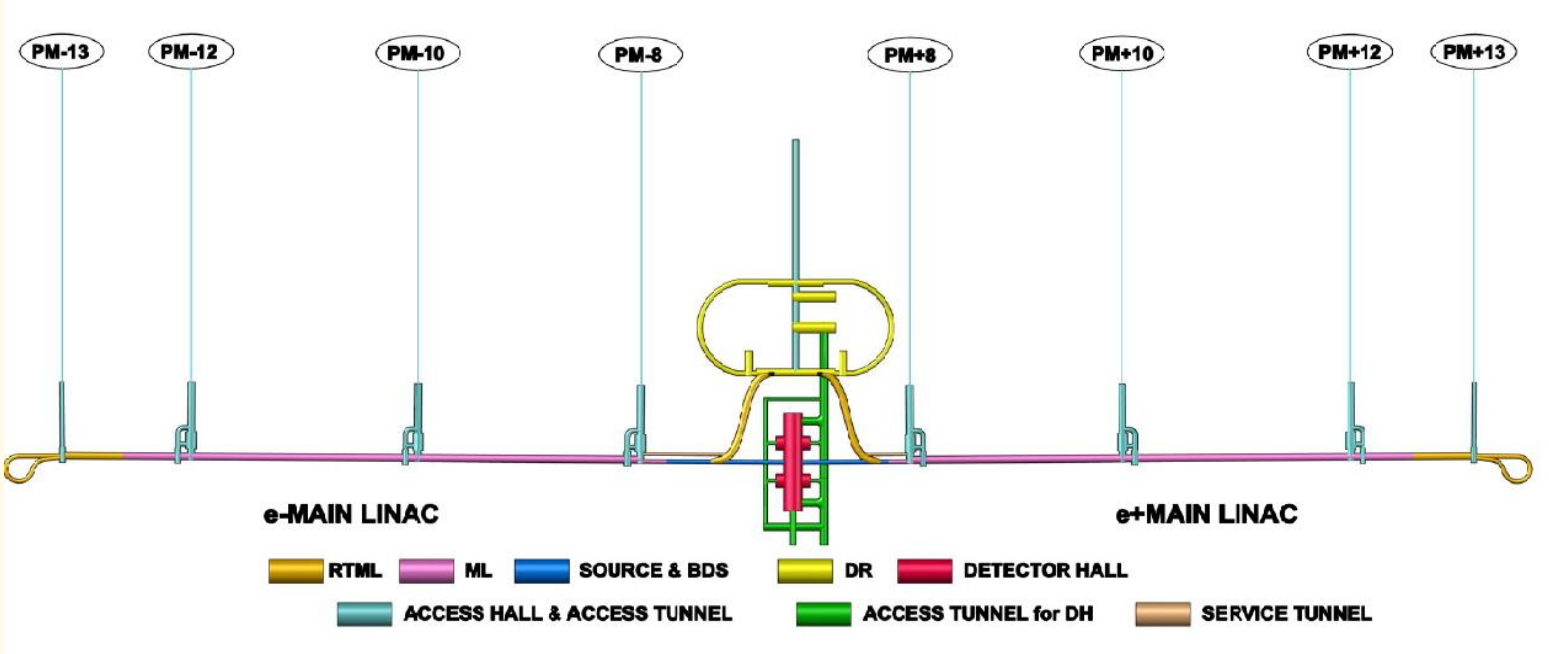
61.9
End of civil engineering: Y6 Q1

Civil engineering – Milestone Summary

Milestone	Date
End of CE work in Main Linac	Y6 Q1
End of CE work in BDS	Y5 Q2
End of CE work in BDS service	Y5 Q2



Access Tunnel ex.

Cavern ex.

Hall ex.

Beam Tunnel excavation

Concrete Lining

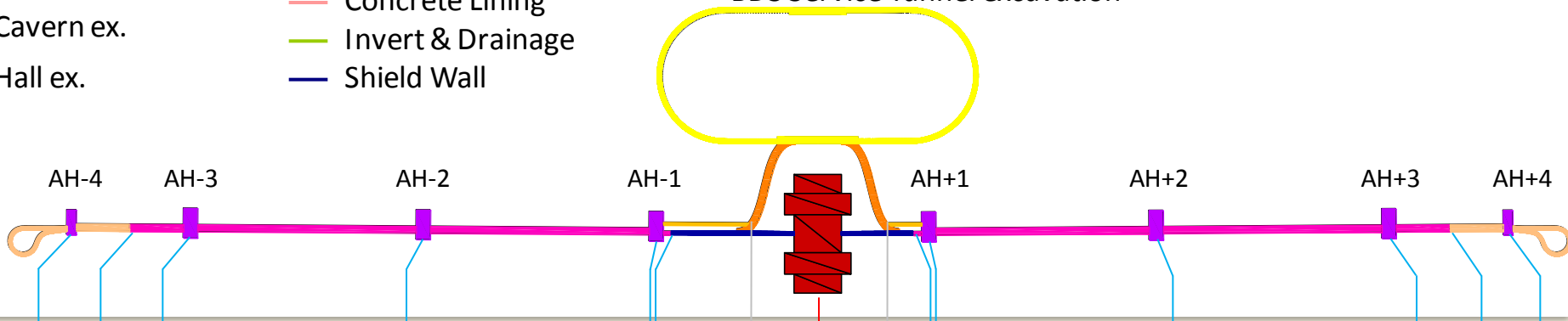
Invert & Drainage

Shield Wall

BDS Tunnel excavation

BDS Service Tunnel excavation

Survey & supports set-out



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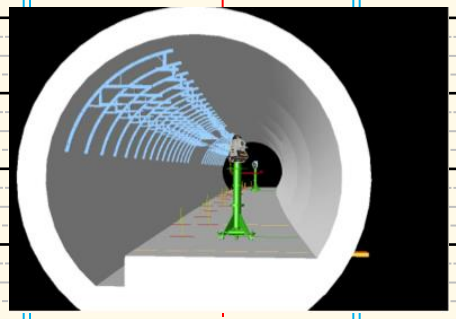
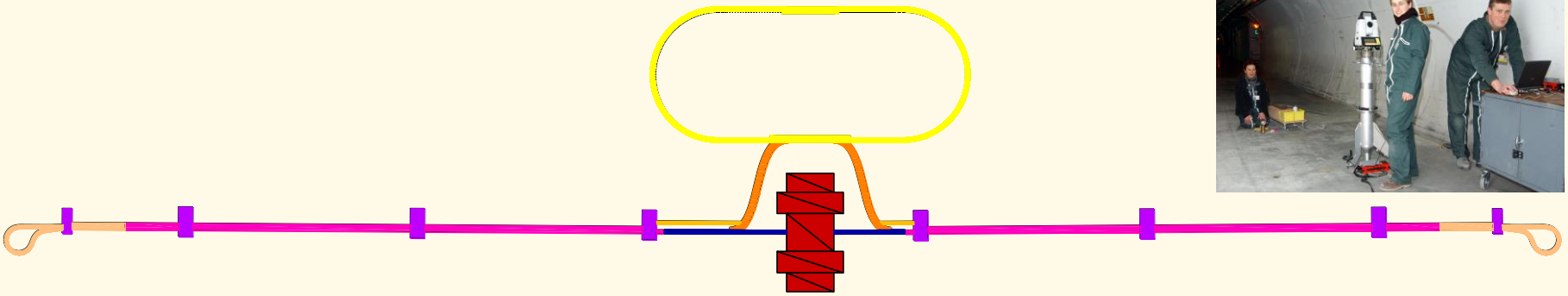
61.9 61.9 62.0 60.3 61.9 61.9



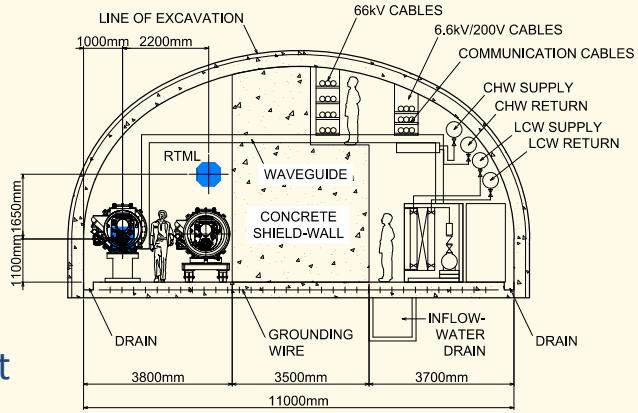
Year 6 7 8– Getting ready for machine components installation

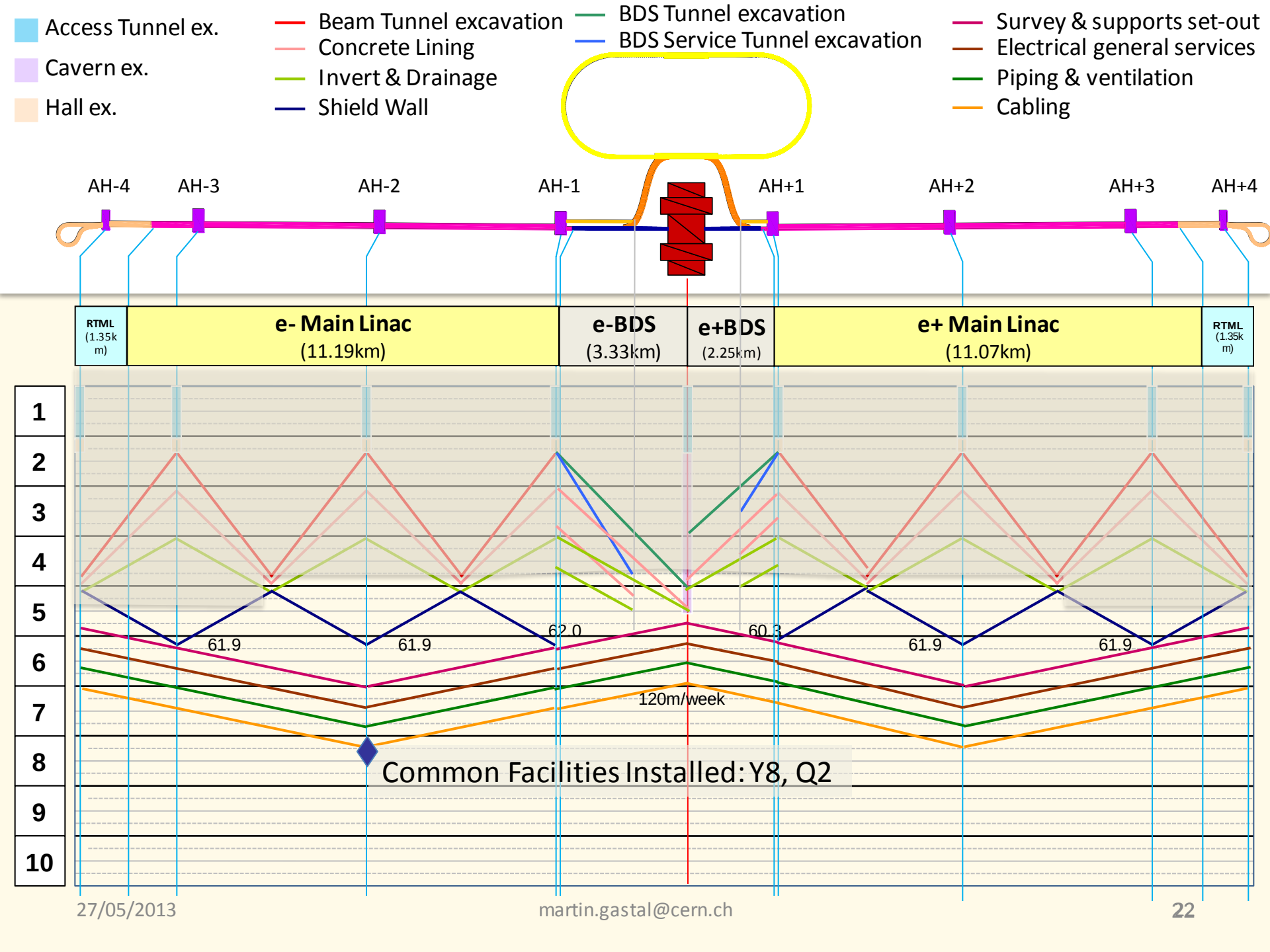
→ Installation of infrastructure
- → Survey and set out of components supports
- → Electrics General services
- → Piping and ventilation
- → Cabling

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 e.g. in e-BDS between electrical teams and piping teams
- → Having a shielding wall makes this possible
- → Shifts to be introduced to reduce co-activities
  - → E.g. Electrics during day shift, piping during night shift

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61.9
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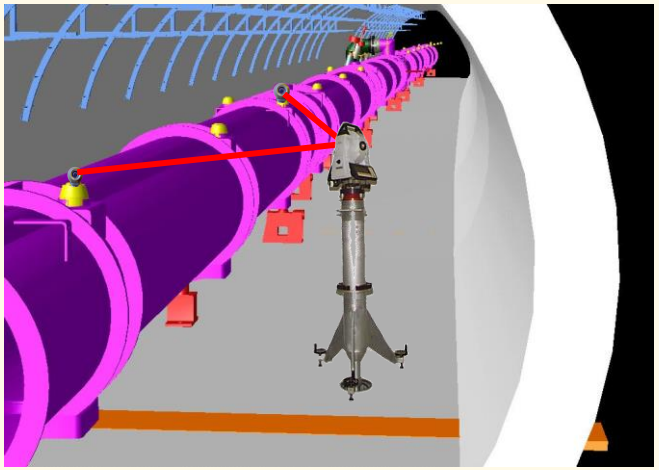
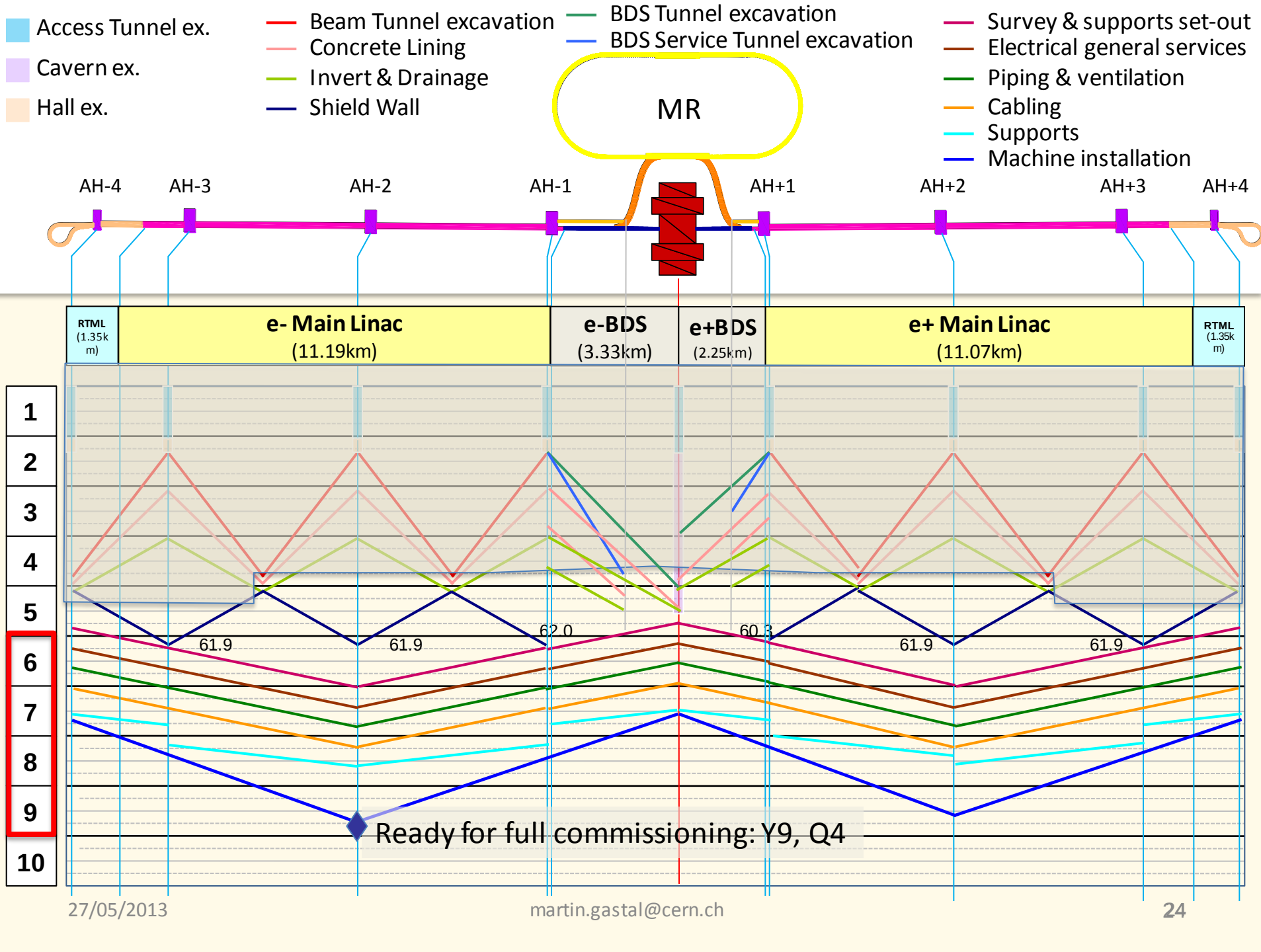
61.9
120m/week
Common Facilities Installed: Y8, Q2

Year 7, 8, 9 – Installing machine components

- Installation of supports for machine components
  - Progress rate: 250m/w for 1 shift
  - Installation of supports started: Y7 Q3
- Installation of machine components
  - Transport
  - Interconnections
  - Alignment
  - Progress rate: 100m/w for 1 shift (Average value from LHC) – other shifts kept available as contingency
- 4 teams for each activity

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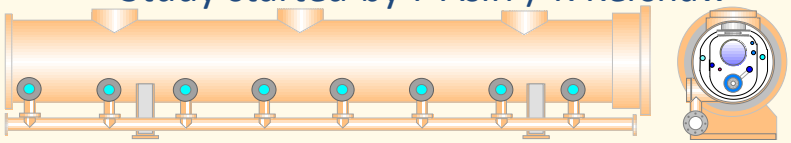
Ready for full commissioning: Y9, Q4

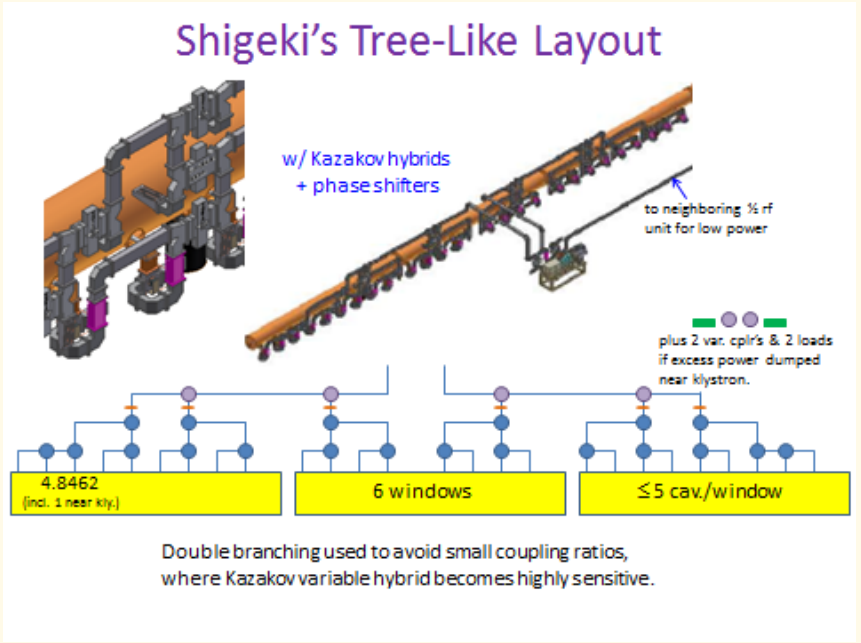
Studying the installation sequence further…

- → Rate of installation of machine component was chosen to be 100m/week for 1 shift
  - → Based on LHC as built
- → Proposed approach to go into further details: bottom up
  - → Define an appropriate length of tunnel (quantum), e.g. 200m for LHC
  - → Define the installation sequence, with inputs from all actors
  - → Estimate completion time for each phase using expert knowledge
  - → Extrapolate for full length
  - → Mini workshops would be most useful to gather relevant data from experts (XFEL?)
- → Study started by F Asiri / K Kershaw



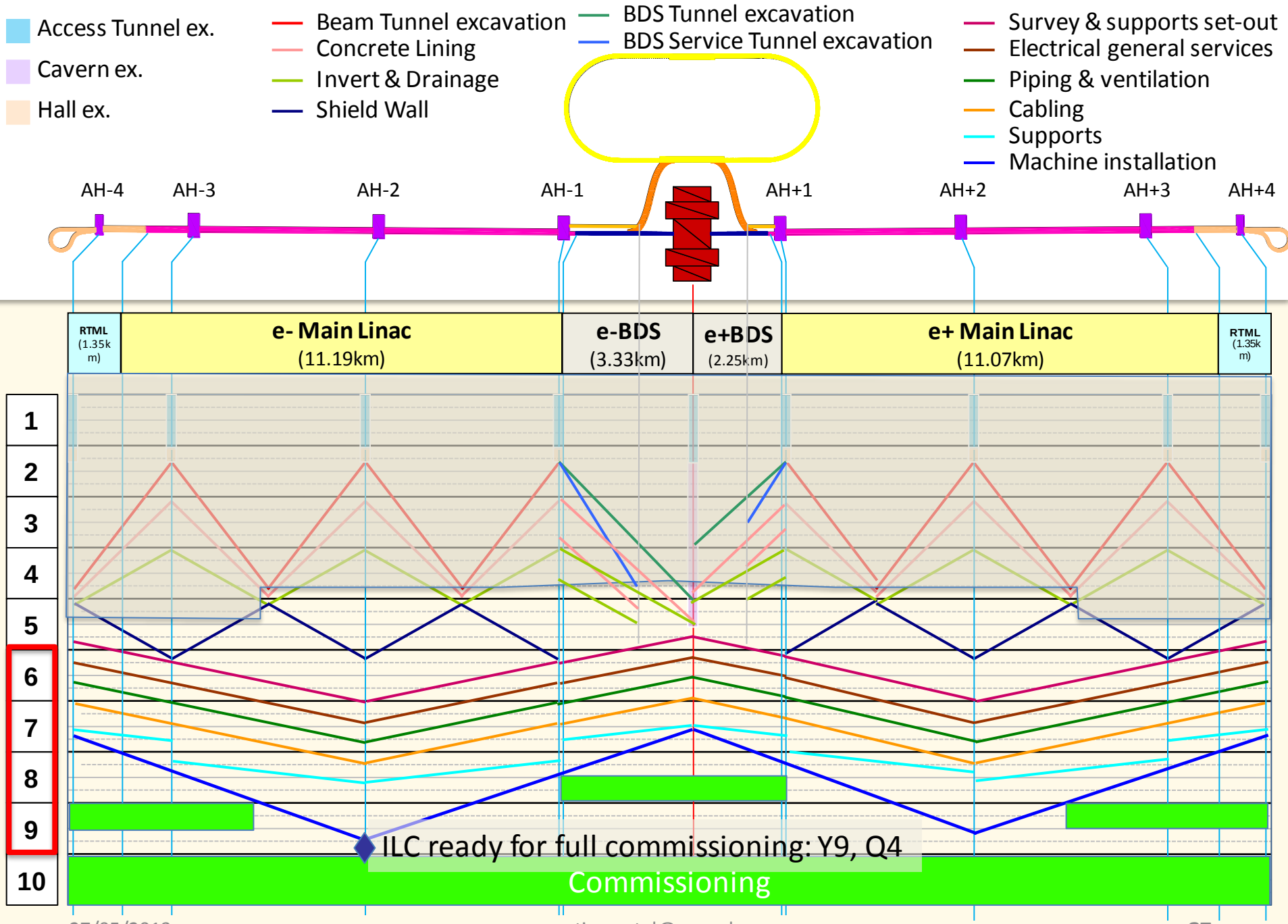
Installation Sequence

1. **Prepare tunnel section for installation…**
2. **Move, place, adjust and fix Cryomodule supports…**
3. **Move Cryomodules from access shaft to installation section…**
4. **Install, adjust, fix, prepare section for Cryo & Beam Pipe connections…**
5. **Complete Cryogenic and Vacuum connections, leak check, then connect the Cryomodule sleeve coupling**



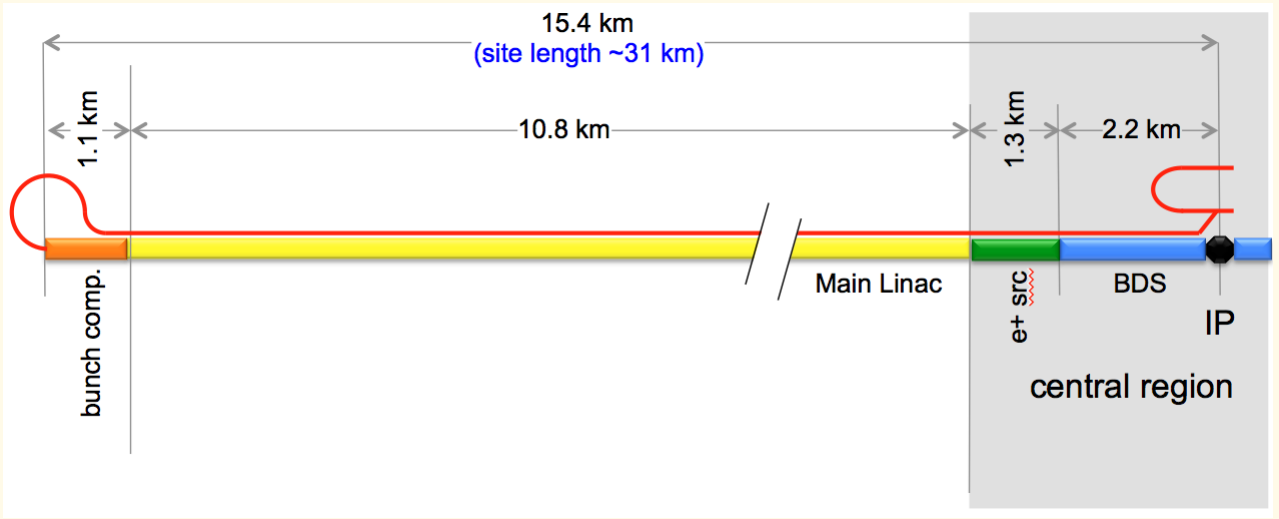
Commissioning & Staged options

- → The Asian site schedule is labor intensive
- → Building the shielding wall takes an entire year of the schedule
- → The installation of infrastructure is fast thanks to the deployment of many teams and great tolerance to coactivity
- → For the installation of machine components, 4 teams are deployed
- → Milestone: BDS and ML up to AH1 ready for early commissioning
  - → Y8 Q2… but what about DR and RTML?
- → Milestone: Ready for Full commissioning (whole accelerator available)
  - → Y9 Q4
- → Milestone: ILC ready for beam
  - → Y10 Q4 (commissioning program to be fine tuned)
- → Commissioning programs still under study…
- → What would be the impact on the construction schedule to choose a staged approach?


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
AH-4
AH-3
AH-2
AH-1
AH+1
AH+2
AH+3
AH+4
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)
1
2
3
4
5
6
7
8
9
10
ILC ready for full commissioning: Y9, Q4
Commissioning

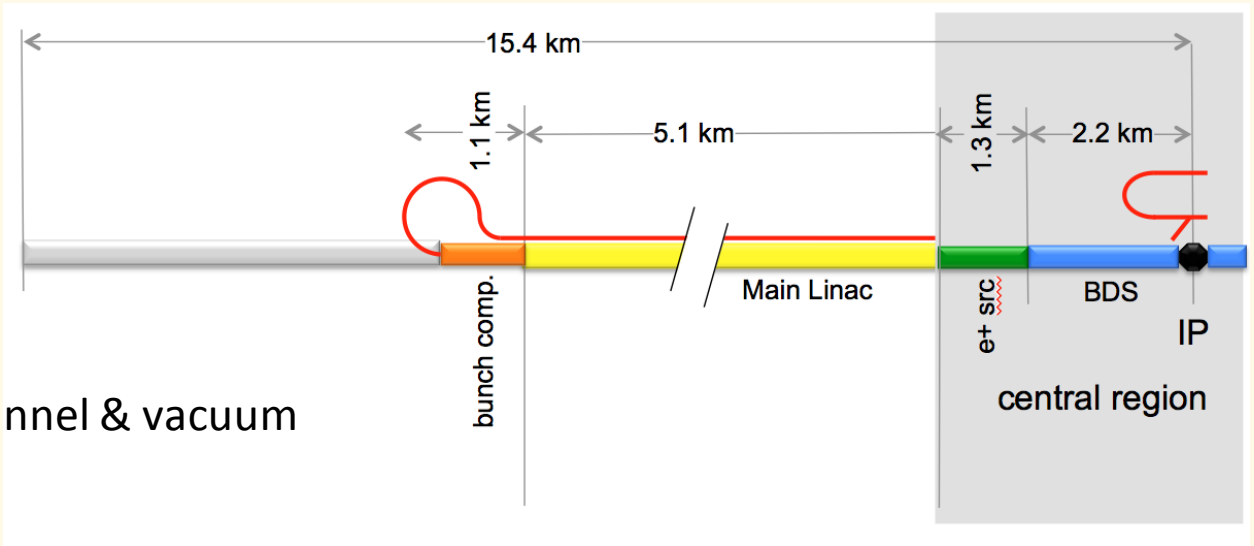
Staged Scenario 1

→ Baseline:
500GeV

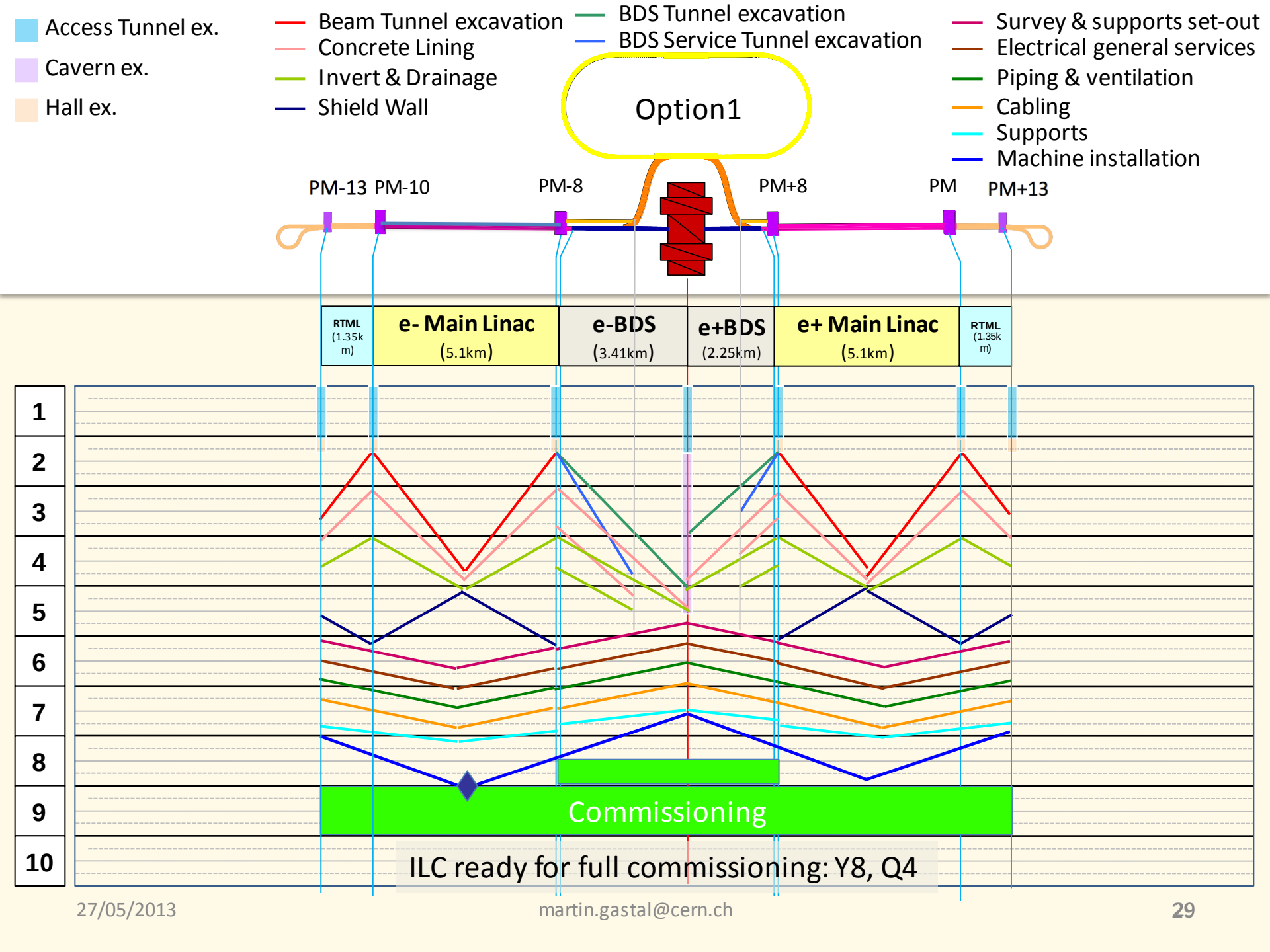


15 tunnelling Crews for ~4 y
4 CF crews for 2.5y

→ Scenario 1:
250GeV

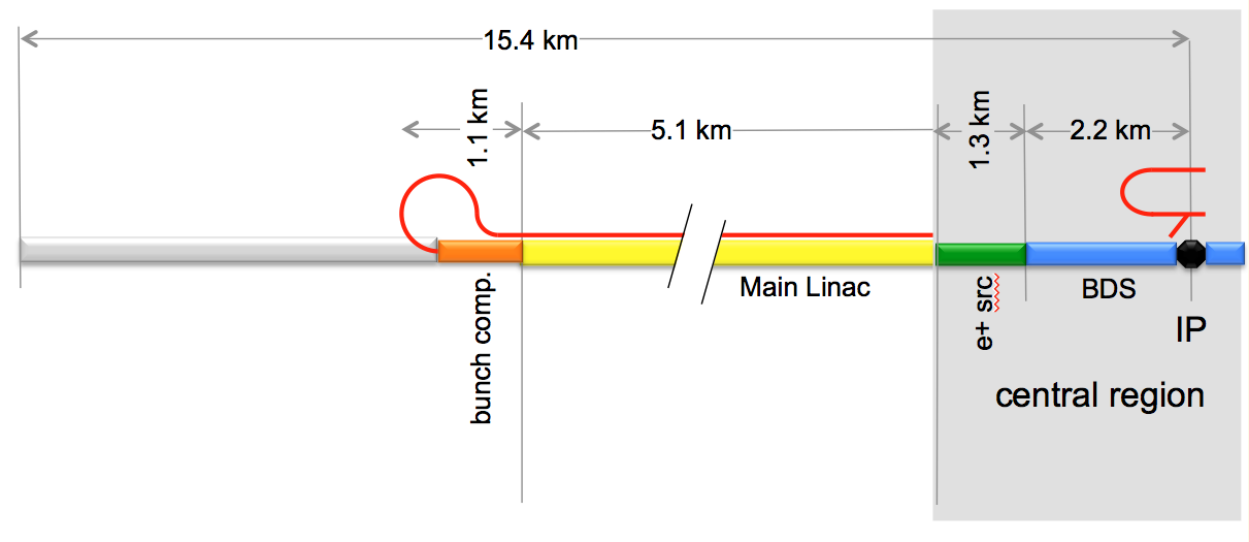


Half the linac
Full-length BDS tunnel & vacuum


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
Option1
PM-13
PM-10
PM-8
PM+8
PM
PM+13
RTML (1.35km)
e- Main Linac (5.1km)
e-BDS (3.41km)
e+BDS (2.25km)
e+ Main Linac (5.1km)
RTML (1.35km)
1
2
3
4
5
6
7
8
9
10
Commissioning
ILC ready for full commissioning: Y8, Q4

Staged Scenario 1

→ Scenario 1:



→ Only 11 tunneling crews (15 for baseline)

→ Deployment of resources to install common facilities can be optimised

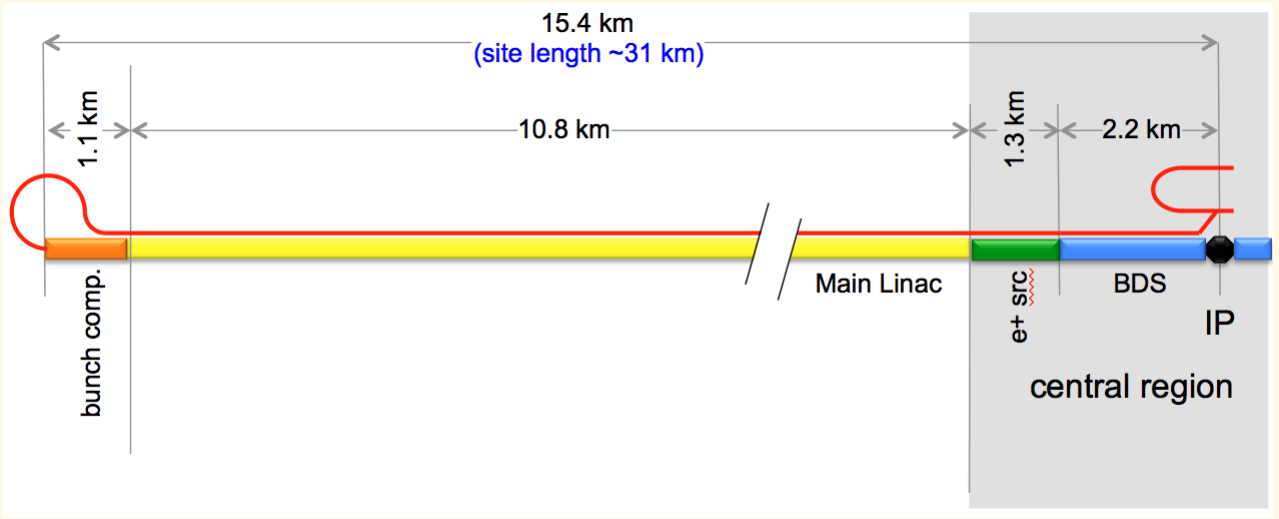
  → Only 2 years to install the common facilities (2.5y for baseline)

→ The central region (IP, BDS, DR) un-affected, consistent with goal to perform early commissioning

→ Potential time saving: 1 year

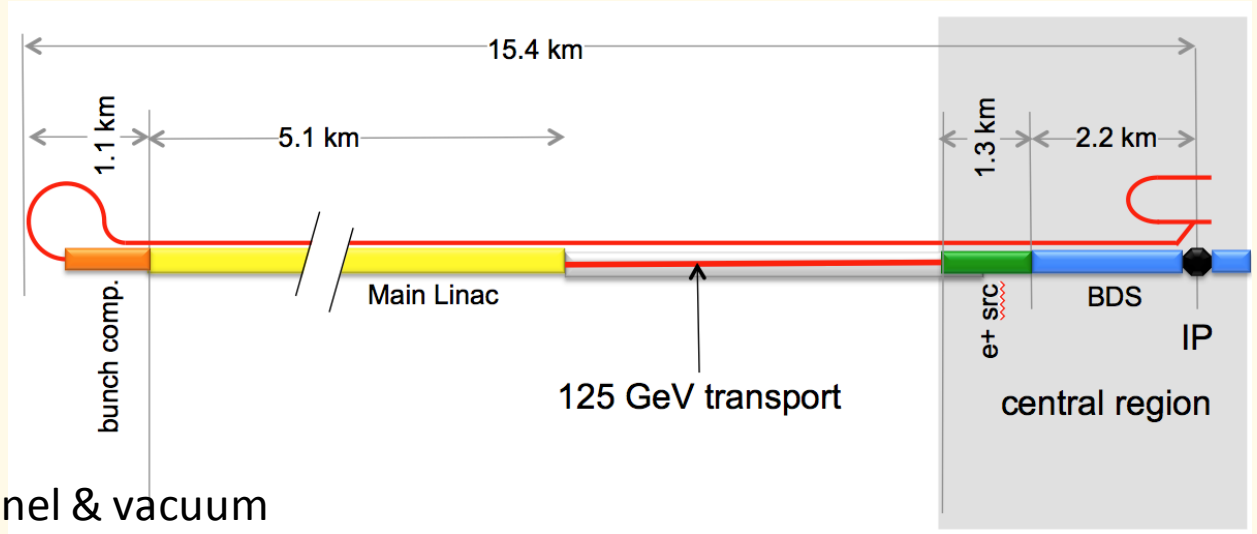
Staged Scenario 2

→ Baseline:
500GeV



15 tunnelling Crews for ~4 y
4 CF crews for 2.5y

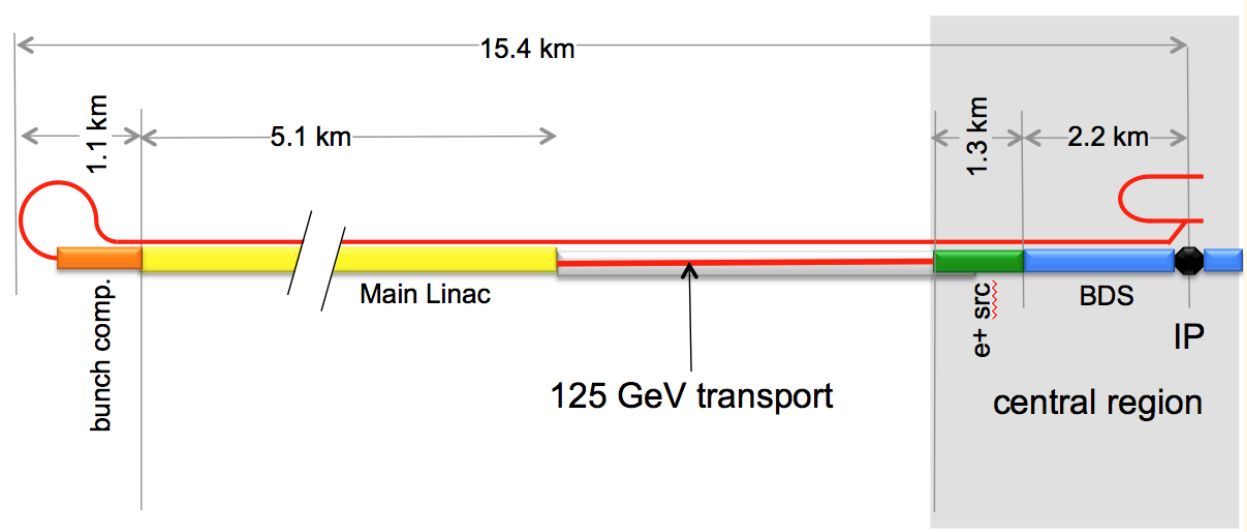
→ Scenario 2:
250 GeV



Half the linac
Full-length BDS tunnel & vacuum
5km 125 GeV transport line

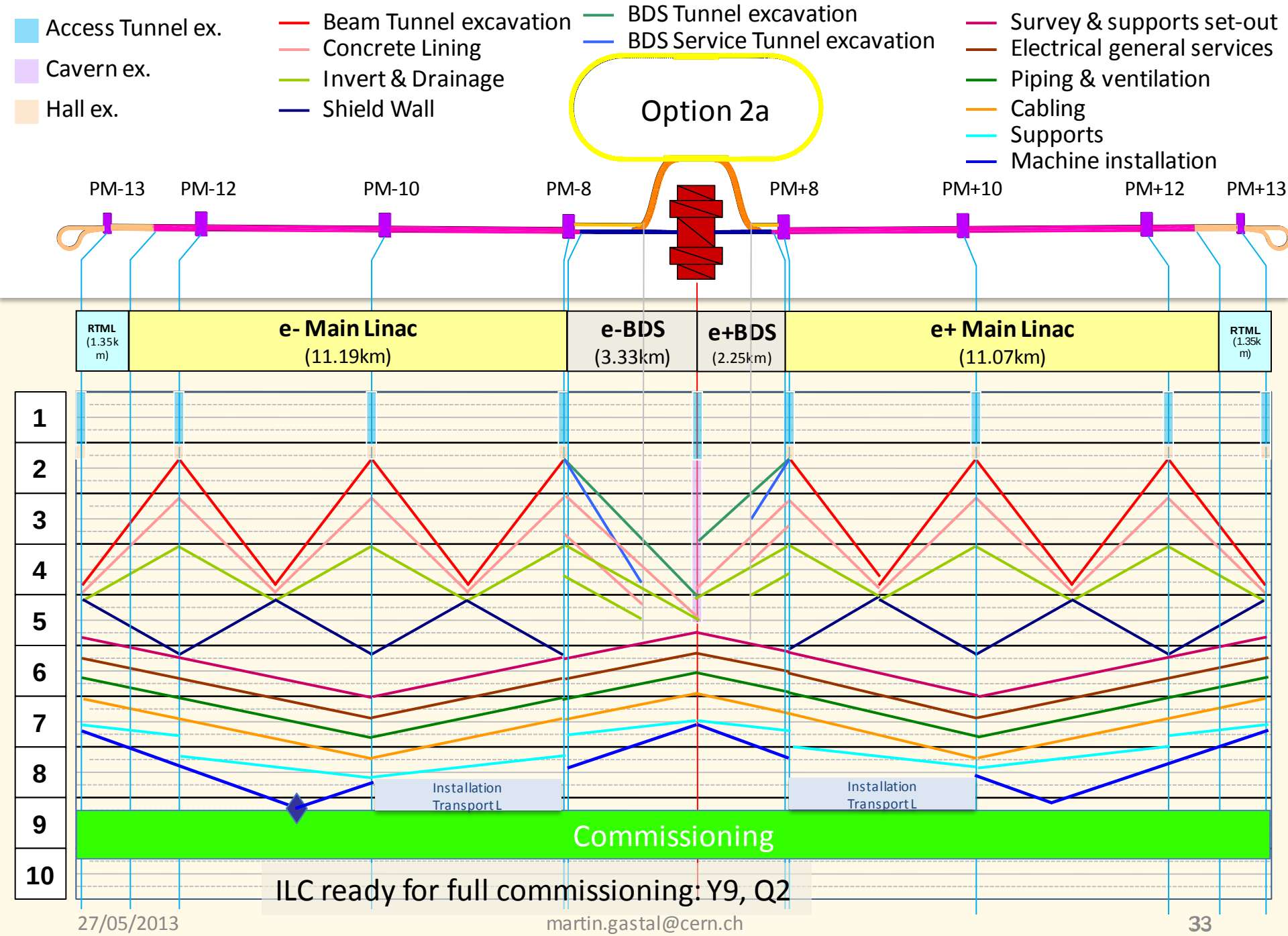
Staged Scenario 2

→ Scenario 2:
250 GeV

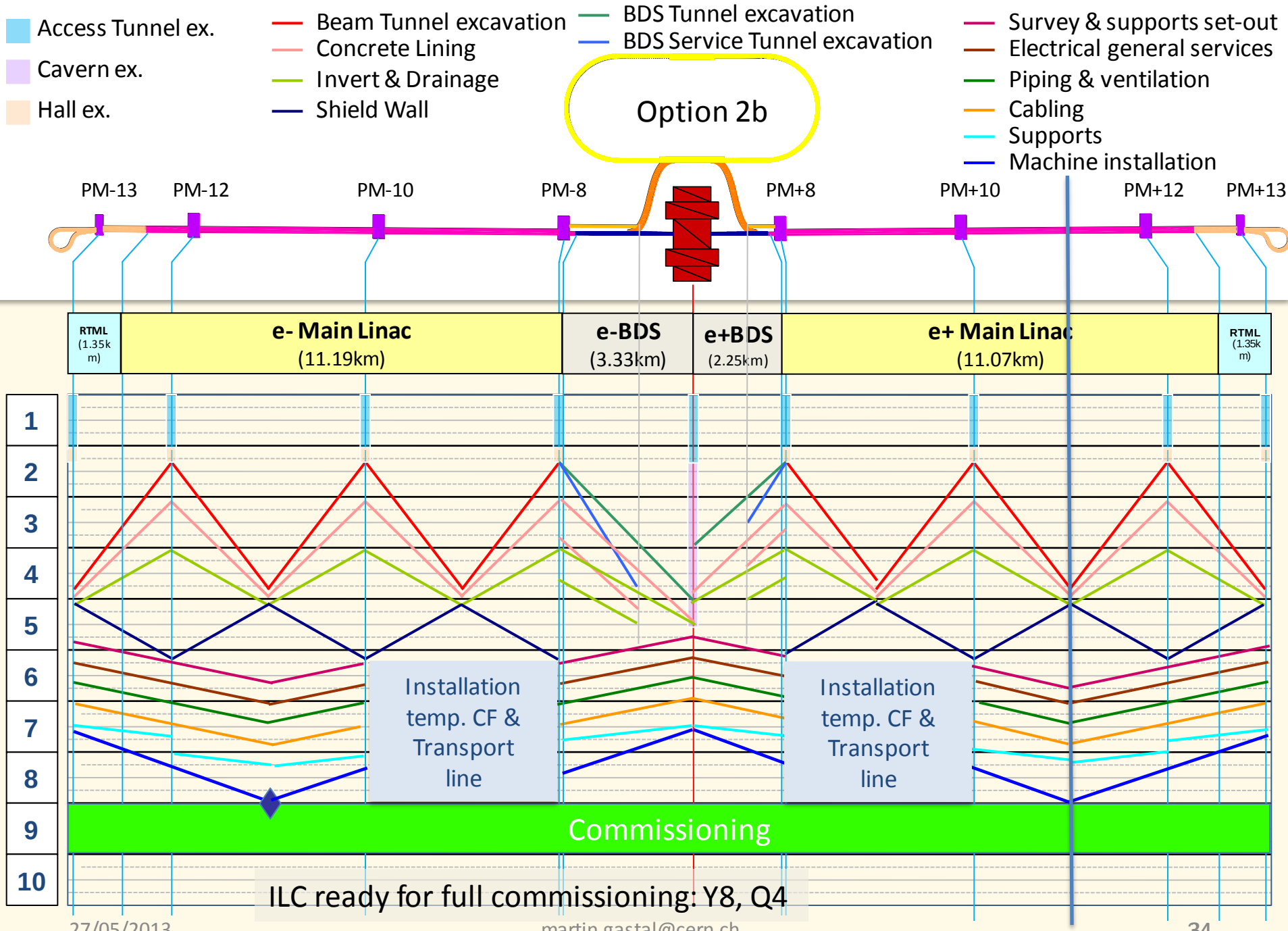


15 tunnelling crews

→ 2 flavors of this option could be considered
- → 2a. Install all the final common facilities in the 125GeV transport tunnel section
  - → Compatible with 500GeV ILC
  - → No time saving with respect to baseline for Cfacilities installation
- → 2b. Install only minimum required services for 125GeV transport line
  - → Implies faster installation of Cfacilities
  - → Implies the re-work of cables pipes at a later stage to implement 500GeV ILC
  - → Assumption: the installation of the 125GeV transport line never comes on the critical path

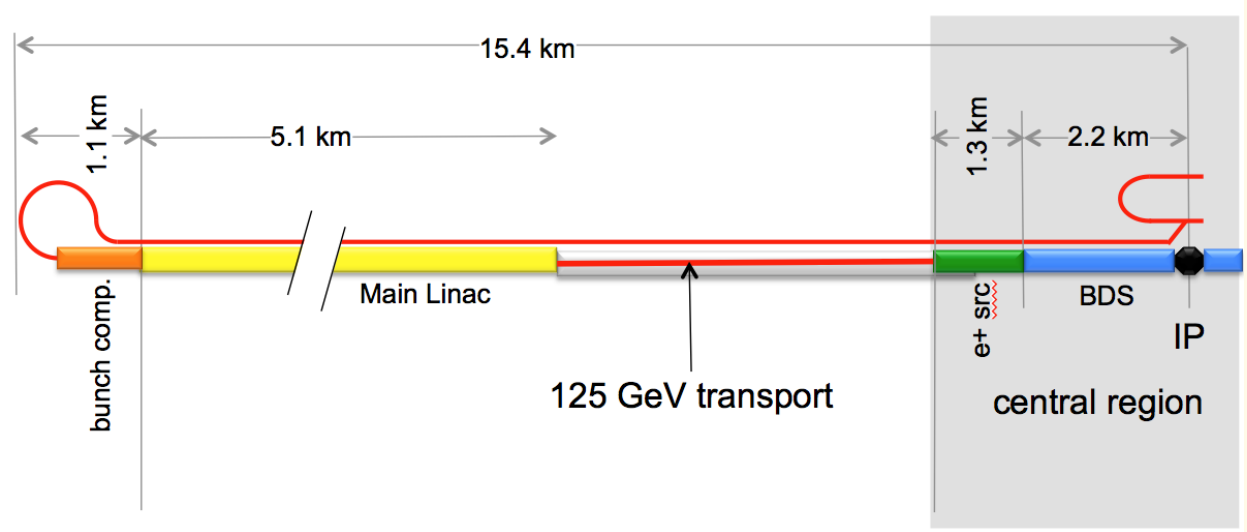


ILC ready for full commissioning: Y9, Q2


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
Option 2b
PM-13
PM-12
PM-10
PM-8
PM+8
PM+10
PM+12
PM+13
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)
1
2
3
4
5
6
7
8
9
10
Installation temp. CF & Transport line
Installation temp. CF & Transport line
Commissioning
ILC ready for full commissioning: Y8, Q4

Staged Scenario 2

→ Scenario 2:
250 GeV



15 tunnelling crews

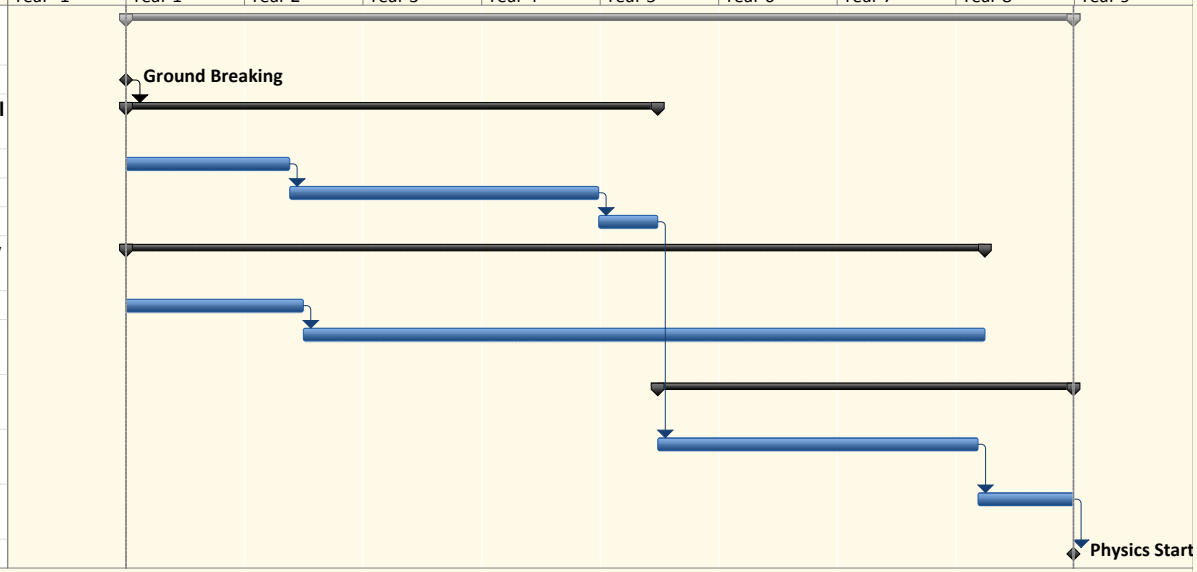
→ Costs and benefits of Option 2

- → 2a. Install all the final common facilities in the 125GeV transport tunnel section
  - → 9 months could be save by redeploying the machine installation crews
  - → The installation of the final common facilities hardly comes on the critical path
  - → 6 months could be dedicated to the installation of the 125GeV transport line
- → 2b. Install only minimum required services for 125GeV transport line
  - → 1 year could be saved by redeploying the CF and machine installation crews
  - → 2.8 years could be dedicated to the installation of the "temporary" CF and the 125GeV transport line

Detector Construction Schedule

→ Draft study produced by ILD community

ID	Task Name
0	**Experimental Area in Mountainous Sites**
1	Ground Breaking
2	**Underground Experimental Hall**
3	Access Tunnel
4	Cavern
5	Services
6	**Surface Detector Assembly**
7	Surface Assembly Hall
8	Surface Detector Assembly
9	**Underground Detector Work**
10	Underground Detector Assembly
11	Detector Commissioning
12	Physics Start



→ Items to be further studied

→ Installation of CF in Detector Hall - 44month for flat topography, including push pull

→ Detailed underground assembly/commissioning sequence

→ Check compatibility with accelerator commissioning objectives

→ Check impact of staged scenarios… even less time for detector underground assembly

Conclusions

→ This draft schedules shows how the ILC could be built and commissioned in less than 10 years

→ Staged scenarios provide some time savings

→ Consolidated scheduling studies for the construction and installation of the detectors should be further carried out

→ A commissioning plan should be designed

Milestone	Asian Schedule
Civil Engineering work complete	Y6, Q1
Common Facilities installed	Y8, Q2
Accelerator ready for early commissioning	Y8, Q2
ILC ready for full commissioning (whole accelerator available)	
Baseline	Y9, Q4
Staged scenario 1	Y8Q4
Staged scenario 2a	Y9Q2
Staged scenario 2b	Y8Q4
ILC ready for beam	Y10, Q4
Detector Hall ready for CF installation	Y5Q3
Detector Hall ready for beneficial occupancy	tbd
Detector ready to be lowered	tbc
Detector ready for commissioning with beam	tbc

To Do List

- → Prepare a schedule for activities prior to ground breaking
- → Prepare dedicated schedule for the installation of machine component
  - → Mini workshop
- → Prepare a schedule for the installation of CF in the Detector Hall
- → Review the Detector underground assembly sequence and schedule
  - → Including compatibility with various staged scenarios

Reserve Slides

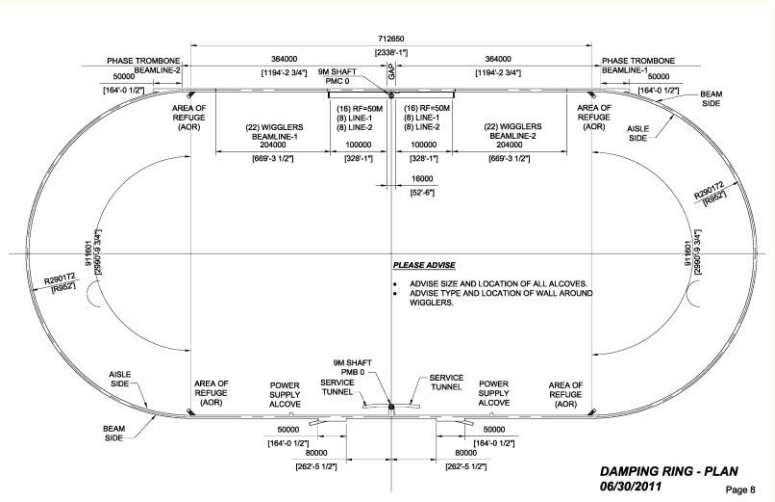
Commissioning

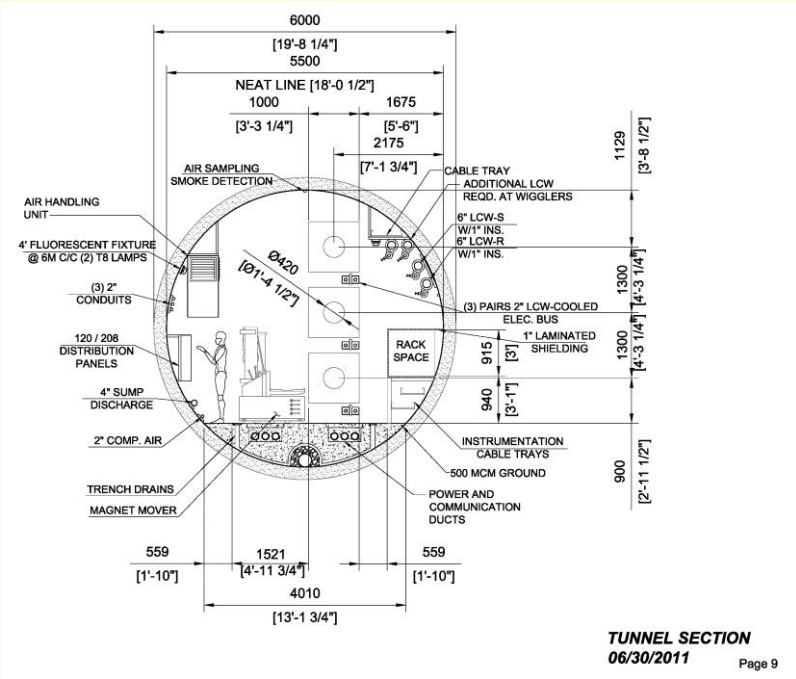
- Early Commissioning : Draft program
  - The e- injector system to 5 GeV and dump : 3 Months
  - The e+ source and systems to 5 GeV and dump utilizing the auxiliary low current e- source to produce e+ : 3 Months
  - Hardware commissioning of injection lines and both Damping rings : 3 months
  - Commission 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

Early Commissioning – FT only

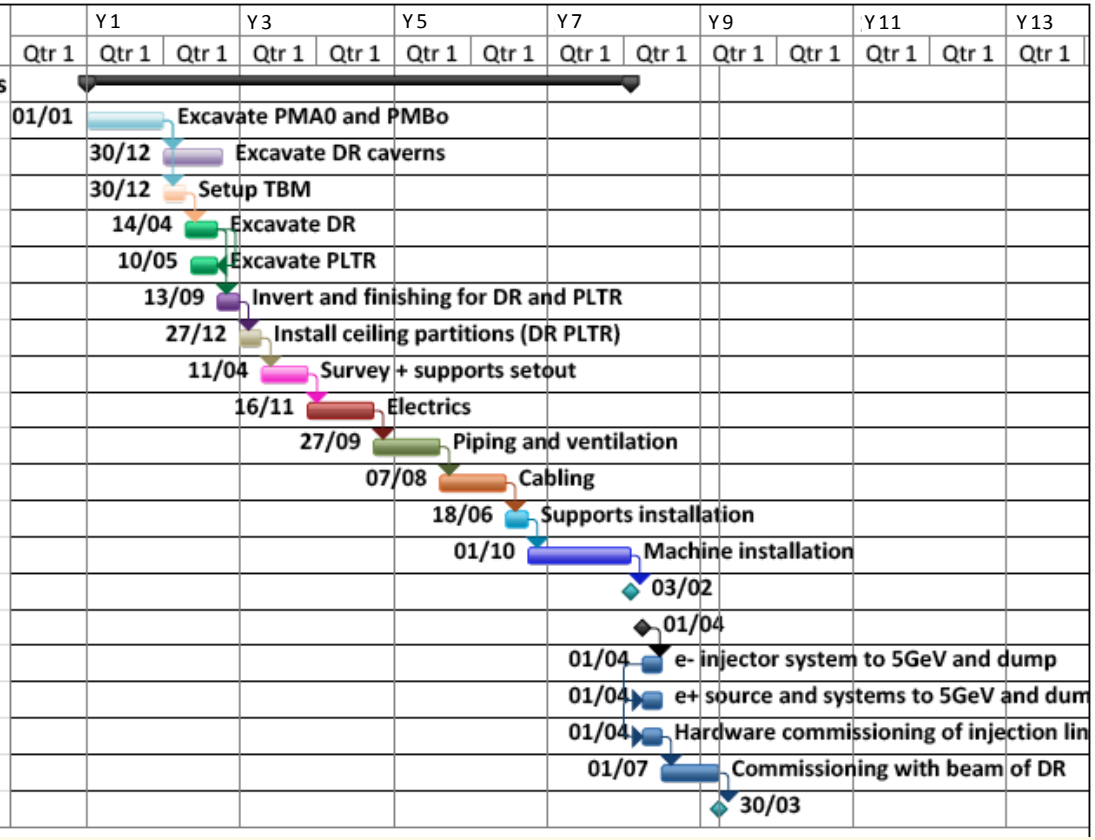




- → CE phase
  - → Invert and finishing: 250m/w
  - → Ceiling ducts: 250m/w
- → Installation of infrastructure in DR and PLTR
  - → Survey: 120m/w 120m/w
  - → Electrics: 80m/w 120m/w
  - → Piping & ventilation: 80m/w 120m/w
  - → Cabling: 80m/w 120m/w
- → Installation of machine components
  - → Supports: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

Delivery of DR and PLTR for commissioning FT only

ID	Task Name	Duration
1	**DR and PLTR construction**	**1850.5 days**
2	Excavate PMA0 and PMBo	52 wks
3	Excavate DR caverns	40 wks
4	Setup TBM	15 wks
5	Excavate DR	21.6 wks
6	Excavate PLTR	18 wks
7	Invert and finishing for DR and PLTR	15 wks
8	Install ceiling partitions (DR PLTR)	15 wks
9	Survey + supports setout	31.5 wks
10	Electrics	45 wks
11	Piping and ventilation	45 wks
12	Cabling	45 wks
13	Supports installation	15 wks
14	Machine installation	70 wks
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
18	e+ source and systems to 5GeV and dump	13 wks
19	Hardware commissioning of injection lines and DR	13 wks
20	Commissioning with beam of DR	39 wks
21	Early commissioning complete	0 days



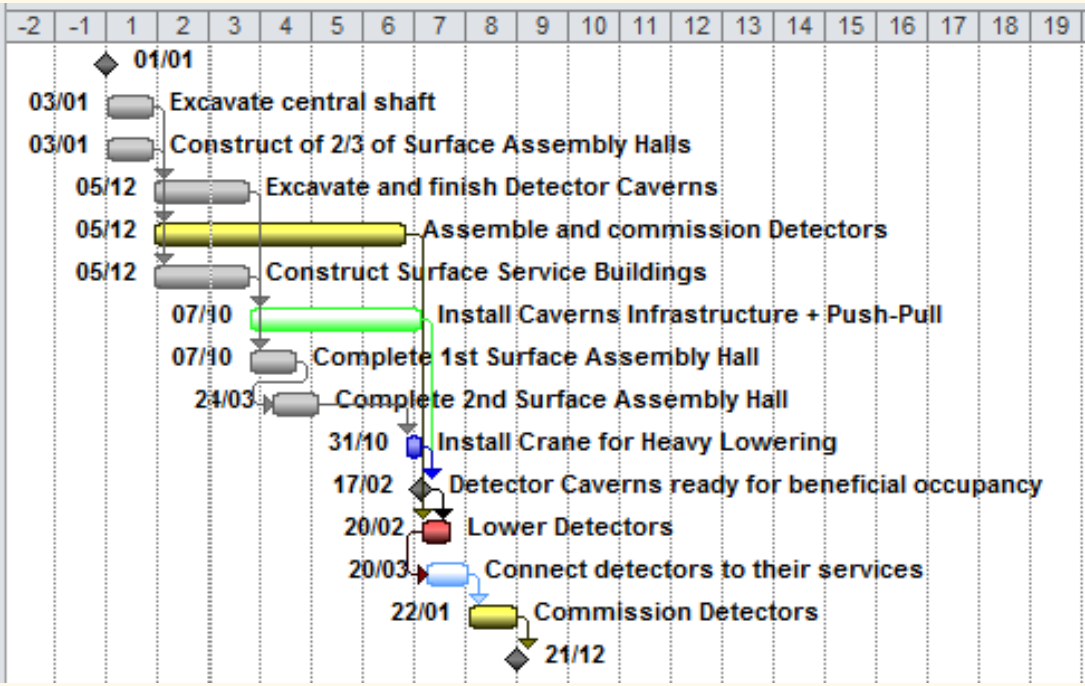
- → Under our set of assumptions, the DR and PLTR would be made available to commissioning by Y8Q1
- → Early commissioning complete- FT:Y9 Q2
  - → All systems tested but full performance not yet reached
- → It has been assumed that the same approach could be used for the MR sites

Global Commissioning

- → Still quite early to come up with precise estimates
- → Based on LHC:
  - → 6 months of pre-commissioning per sector
  - → 12 months of global commissioning
- → Key dates
  - → Ready for Early Commissioning: Y8Q2
  - → Early Commissioning Complete: Y9Q2
  - → Ready for Global Commissioning- FT:Y9Q4 ; MR:Y9Q4
- → Pre-requisite to launch Global Commissioning with beam IF detectors not available
  - → Temporary vacuum pipe through IR area
  - → Temporary QD0
  - → Temporary shielding

Detector Construction Schedule (FT)

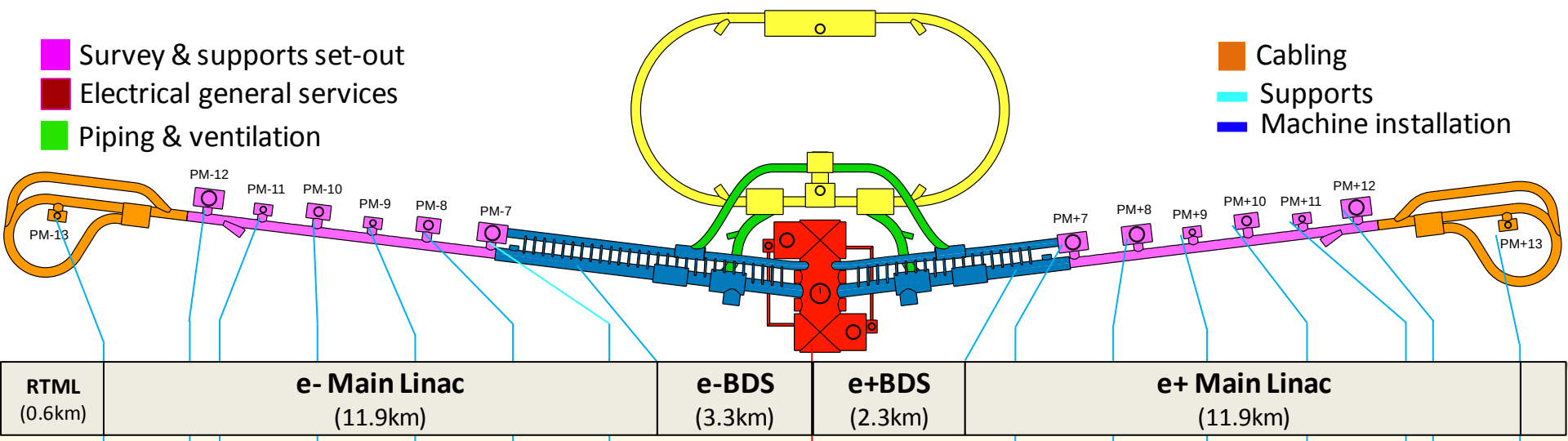
	Task Name	Duration
1	ILC construction started	0 days
2	Excavate central shaft	12 mons
3	Construct of 2/3 of Surface Assembly Halls	12 mons
4	Excavate and finish Detector Caverns	24 mons
5	Assemble and commission Detectors	1280 days
6	Construct Surface Service Buildings	24 mons
7	Install Caverns Infrastructure + Push-Pull	44 mons
8	Complete 1st Surface Assembly Hall	12 mons
9	Complete 2nd Surface Assembly Hall	12 mons
10	Install Crane for Heavy Lowering	4 mons
11	Detector Caverns ready for beneficial occupancy	0 days
12	Lower Detectors	150 days
13	Connect detectors to their services	11 mons
14	Commission Detectors	12 mons
15	Ready for commissioning with beam	0 days



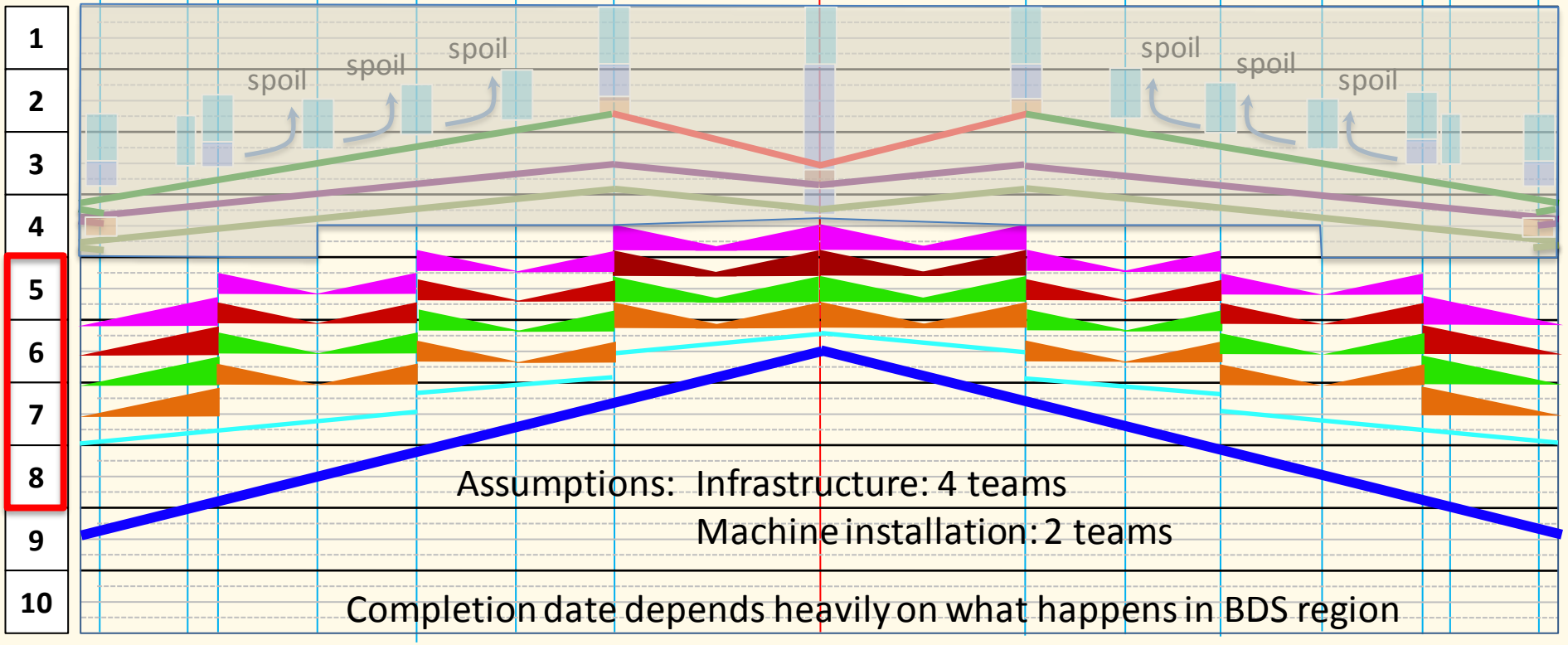
→ The detector cavern should be ready on time for the detector to be lowered.

→ Managing access to the single shaft and coordinating the 2 push-pull systems will be challenging

→ Preliminary studies of ILD and SiD assembly in the IR vault with horizontal access through a large tunnel with less than 10% slope, can be consistent with the accelerator schedules



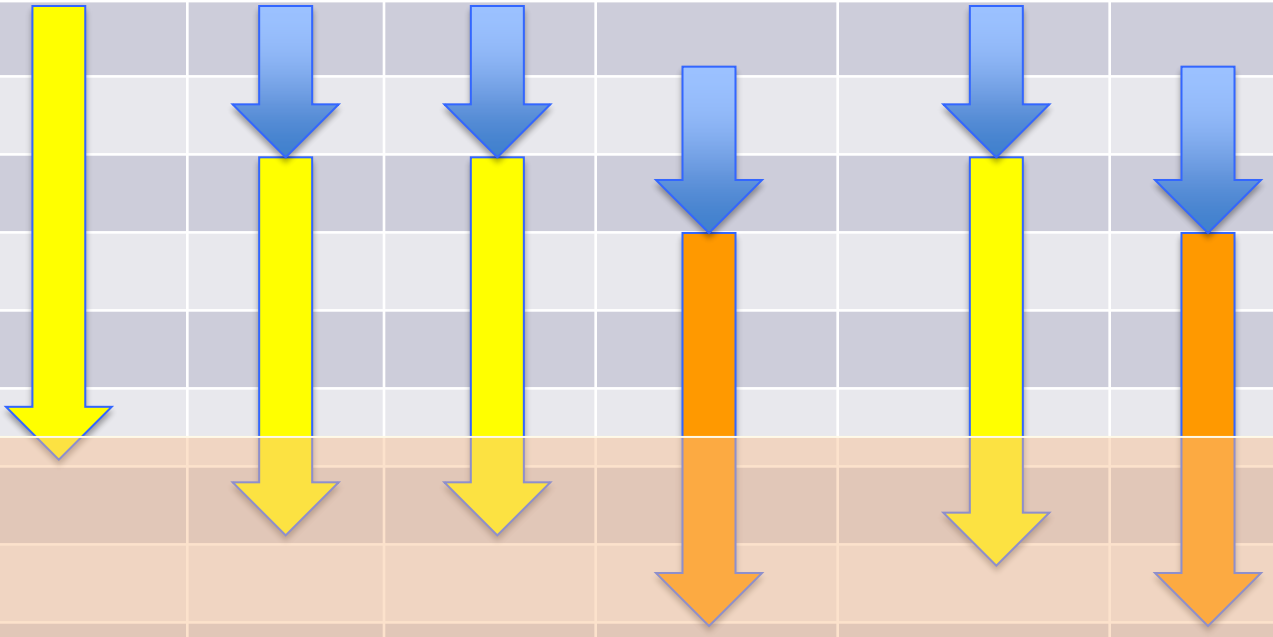
RTML (0.6km)	e- Main Linac (11.9km)	e-BDS (3.3km)	e+BDS (2.3km)	e+ Main Linac (11.9km)



Considerations of the high-tech mass production schedule

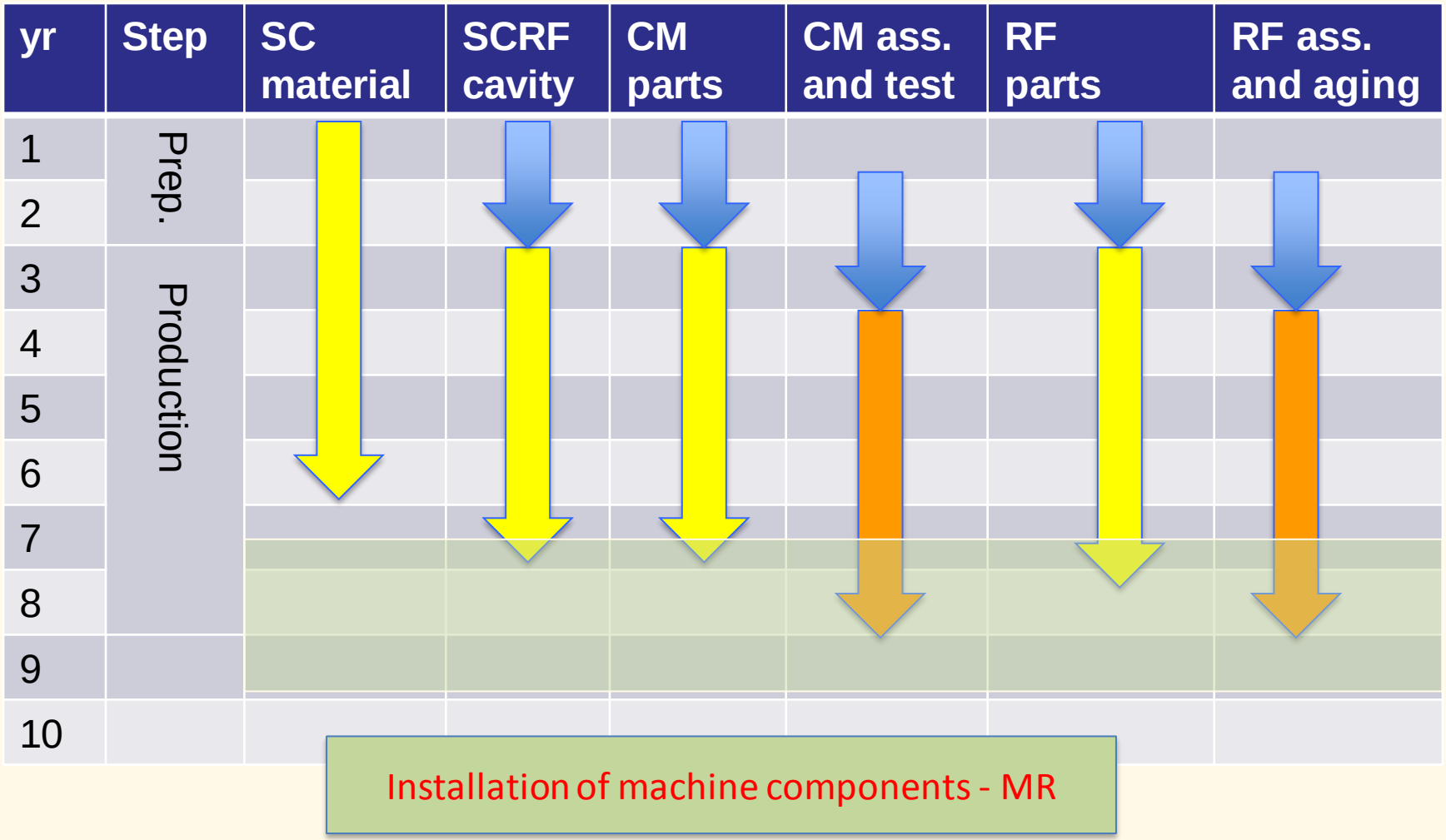
- Light blue: Pre-production or pre-industrialization stage (or preparation for full production)
- Yellow : Full production of material and components/parts.
- Orange: Full assembly stage and test stage in parallel.

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

consideration of the high-tech mass production schedule



Considerations of the high-tech mass production schedule

→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