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Integrated Installation, Testing and Commissioning of the ESS Accelerator Systems V1.1

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TB12, March 5, 2015

Outline

- Basis for an integrated accelerator Installation, Testing and Commissioning plan
- Definitions
- Draft sequence
- Next steps
- Open issues

Simultaneous Accelerator Systems Installation, Testing and Commissioning allows for schedule compression

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- Linear accelerators can accommodate for simultaneous installation, testing and beam commissioning
  - This is unlike circular machines
  - Allows for schedule compression…..
  - …..but this does require
    - Careful planning
    - Proper integration
- Installation will be a challenge due to the high density of equipment, both in the tunnel and in the klystron gallery

Careful planning starts with clear definitions

- Phases related to Installation, Testing and Commissioning (ITC) have been defined in ESS-0025640*:
  - ITC Phase A: Installation
  - ITC Phase B: Local testing without beam and without ICS
  - ITC Phase C1: Local testing without beam, with ICS
    - Local test including controls, e.g. controlling a power supply
  - ITC Phase C2: Integrated testing without beam, with ICS
    - End to end test including controls, e.g. controlling a power supply, concomitant magnet, water cooling, interlocks etc
  - ITC Phase D1: Testing diagnostics with beam
    - Will typically make use of a “probe” beam
  - ITC Phase D2: Beam commissioning
    - Goal during this phase is to prepare and deliver the required beam

*Document is not yet approved

Installation/testing/commissioning steps: A preliminary sequence

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- Goal: reach Master Schedule milestone for beam on target
  - 28-Jun-2019 for 570 MeV on target (MS milestone 1G4910)
- Path: understanding boundary conditions, optimizing sequencing
  - Requires multiple iterations
  - This presentation is not the final solution and is far from "complete"! It is a starting point for discussion

Process for integration with P6 proposed

- Get Ready For Installation (RFI) dates from official P6 ACCSYS 11 schedule, as well as durations as needed
- Optimize the installation/testing/commissioning sequence in OpenProject based on the above
- Take OpenProject output in the newly created P6 ACCSYS 11 I schedule (see Luisella's slides)
- After a transition period, the ACCSYS 11 I schedule will become the reference

RFI dates are not necessarily installation dates

Deliverables Tunnel (RFI)	1,239 days	2017/10/02 8:00 AM
ISrc and LEBT	0 days	2017/11/01 9:00 AM
RFQ	0 days	2018/06/20 8:00 AM
MEBT	0 days	2018/05/31 8:00 AM
DTL4	0 days	2017/10/02 8:00 AM
DTL3	0 days	2018/02/01 8:00 AM
DTL1	0 days	2018/06/01 7:00 AM
DTL2	0 days	2018/10/01 8:00 AM
DTL5	0 days	2019/02/01 8:00 AM
SPK Cryomodule 1	0 days	2018/01/08 9:00 AM
SPK Cryomodule 2	0 days	2018/02/01 9:00 AM
SPK Cryomodule 3	0 days	2018/03/01 9:00 AM
SPK Cryomodule 4	0 days	2018/04/02 8:00 AM
SPK Cryomodule 5	0 days	2018/05/01 8:00 AM
SPK Cryomodule 6	0 days	2018/06/01 8:00 AM
SPK Cryomodule 7	0 days	2018/07/02 8:00 AM
SPK Cryomodule 8	0 days	2018/08/01 8:00 AM
SPK Cryomodule 9	0 days	2018/09/03 8:00 AM
SPK Cryomodule 10	0 days	2018/10/01 8:00 AM
SPK Cryomodule 11	0 days	2018/11/01 9:00 AM
SPK Cryomodule 12	0 days	2018/12/03 9:00 AM
SPK Cryomodule 13	0 days	2019/01/07 9:00 AM
MBL Cryomodule 1	0 days	2018/09/03 8:00 AM
MBL Cryomodule 2	0 days	2018/10/02 8:00 AM
MBL Cryomodule 3	0 days	2018/11/02 9:00 AM
MBL Cryomodule 4	0 days	2018/12/03 9:00 AM
MBL Cryomodule 5	0 days	2019/01/07 9:00 AM
MBL Cryomodule 6	0 days	2019/02/04 9:00 AM

- Actual required installation dates may still change as a function of the sequence optimization
- Suggest to not alter current Ready For Installation (RFI) dates

← Example of data currently in OpenProj

Building Access definitions defined

- Definitions of Early Access and Full Access
  - Early Access: The building is weather protected and CF contractors are still doing construction works. Other Division can start to install their equipment, but all works have to be approved and coordinated by CF Contractor. The CF Contractor is responsible for OHS and all works have to be in accordance with the rules and regulations on site.
    - Experience from SNS: Early Access not always useful when overhead work still ongoing
  - Full access: (also known as Beneficial Occupancy Date or BOD) CF has handed the building over to ESS Operations.
    - For ACCSYS this means ACCSYS controls access to that particular ACC building; ACCSYS can start installation

Access dates defined

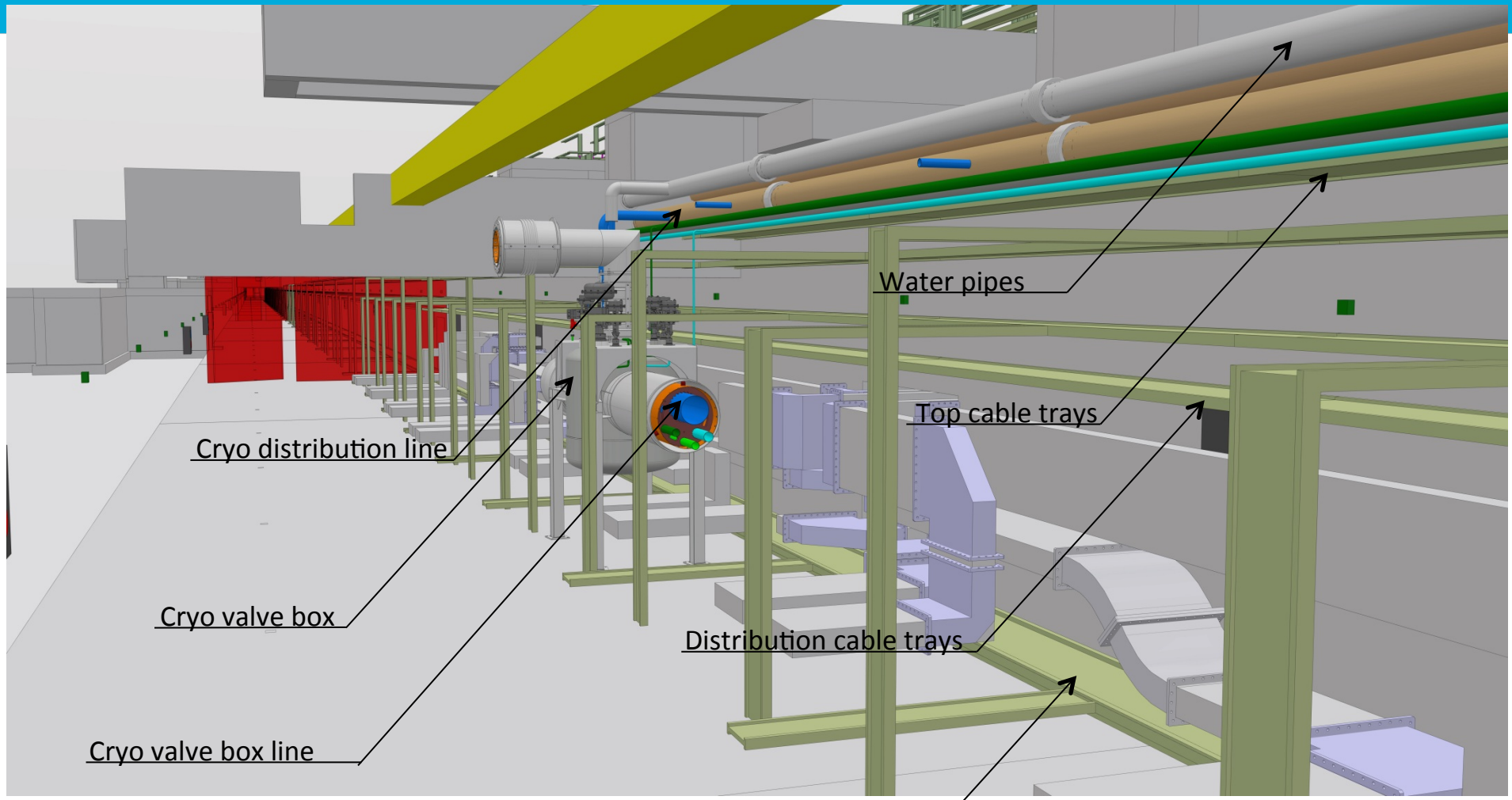
- Access dates for ACCSYS defined
  - Tunnel Full Access 2-May-2017
  - Klystron Gallery (along FE+SPK stubs) Early Access 1-Dec-2017*
  - Klystron Gallery Full Access 31-May-2018
  - Test stand and cryoplant dates consistent with schedule

	Early Access	Full Access
Compressor bldg.	9-Sep-2016	1-May-2017*
Coldbox bldg.	7-Oct-2016	1-May-2017*
KG (Test stand)	7-Oct-2016	1-May-2017*

- Usage of Early Access and Full Access dates
  - Example use cases for early access: setting up the alignment network, start drilling holes for bolting down equipment
  - Adjust as needed & possible to match ACCSYS requirements

*Preliminary dates, being negotiated with CF

Installation/testing/commissioning steps: Example of ACC "Utilities" to be sequenced



Installation/testing/commissioning steps (1 out of 18)

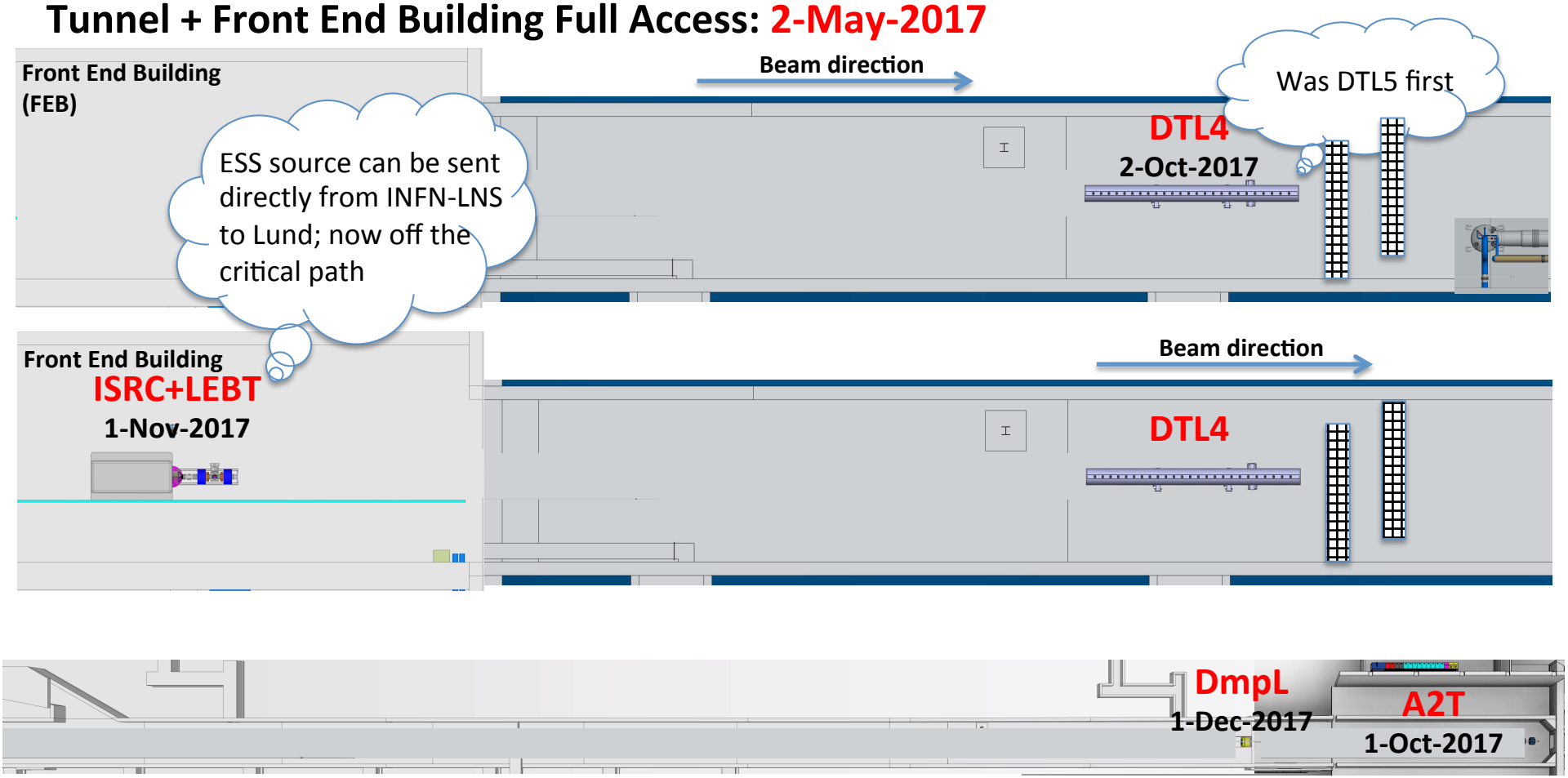
- Preliminary installation sequence for ACC “utilities” in the tunnel established

Installation in ACC tunnel	Preferred	
	Option 1	Option 2
Cable Tray	1	2
Water	2	1
Cryogenics Distribution	3	3
Waveguide in Stub*	4	4
Cables	5	5
Waveguide to CM (without final connection)	6	6

* not or barely sticking out into tunnel

Installation/testing/commissioning steps (2 out of 18) Tunnel

Tunnel + Front End Building Full Access: 2-May-2017

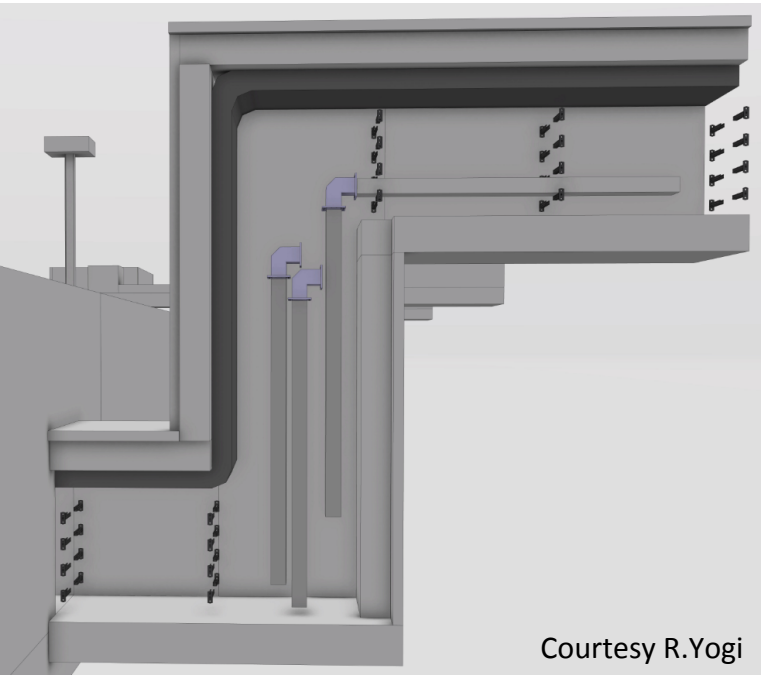


Dates are (approximated) installation start dates

Installation/testing/commissioning steps (3 out of 18)

Klystron Gallery BOD in ACC schedule: 31-May-2018

Planning to use Early Access ~ 1-Dec-2017*



- Mount RF waveguide in stubs
  - RFQ-DTL completed by 31-Dec-2017???
- Ready For Installation (RFI) dates for some equipment earlier than building Early Access date
  - MEBT RF amps 9-May-2017
  - RFQ klystron 8-Sep-2017
  - First DTL klystron 2-Oct-2017
- RFI dates are based on input from Master Schedule

*Meetings are being held with SI scheduler to optimize building access dates as needed

ACCSYS will require a temporary "RATS" facility

- SNS had RATS facility:
  - Receiving, Acceptance, Testing and Storage facility
  - ~5600 m^2 including 50 offices
  - Truck access (2) and loading docks (2)
  - 20 ton crane
  - Heavily used prior and after BOD tunnel/KG
    - Project Receiving/Material accountability
    - Magnet measurements & ion source testing
    - Mock-ups
    - Cryoline, DTL&CCL assembly
    - PS and low power RF testing
- ESS ACCSYS is establishing detailed needs for a similar facility for acceptance testing, assembly, storage etc.

Installation/testing/commissioning steps (4 out of 18)

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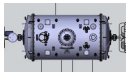
RATS

CMs stored in RATS until cryoline test with jumpers completed

Storage of klystrons, modulators etc in RATS may be needed, but not shown in these slides

SPK1

8-Jan-2018



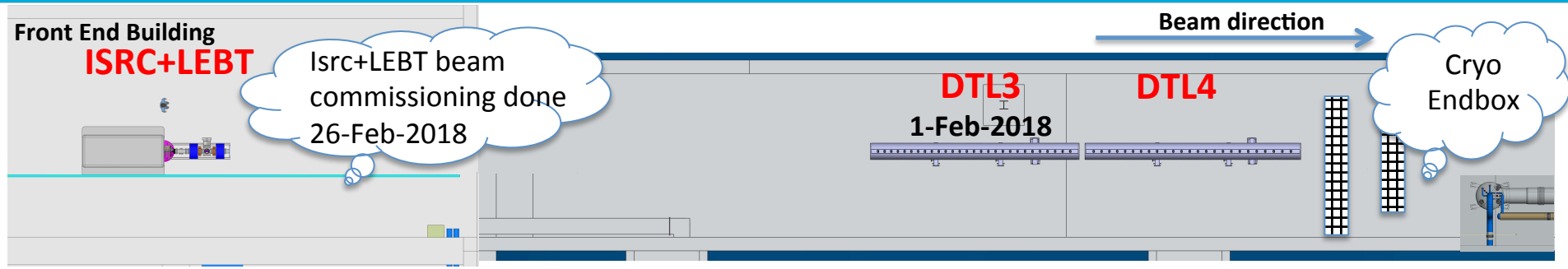
Beam direction

HBL-LWU1

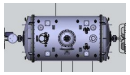
1-Jan-2018

Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

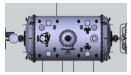
Installation/testing/commissioning steps (5 out of 18)

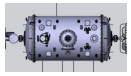


SPK2
1-Feb-2018



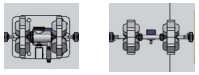
SPK3
1-Mar-2018





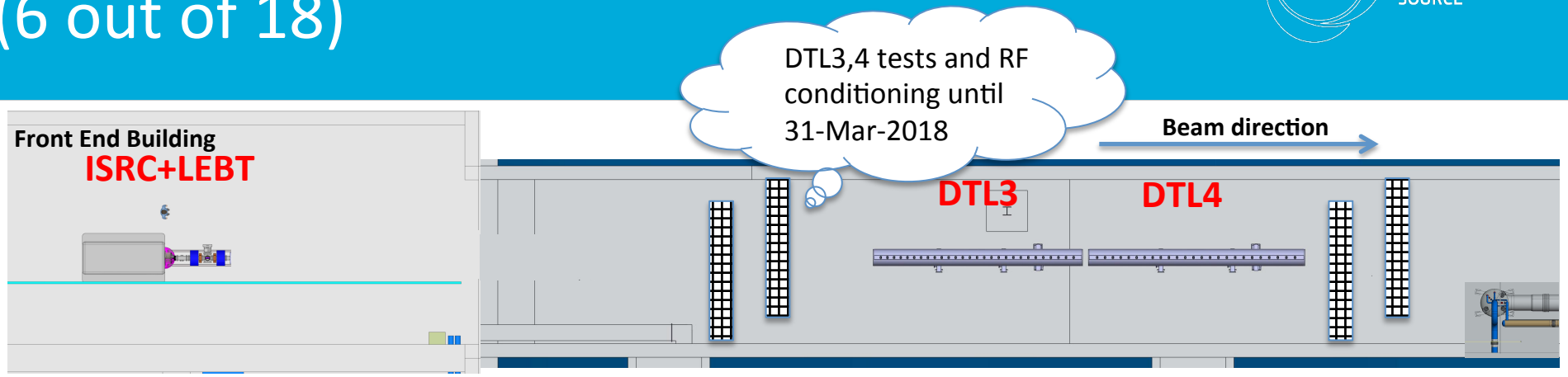
For installation of LWUs, it is preferred to have a series of CMs pre-installed (as opposed to just pairs)

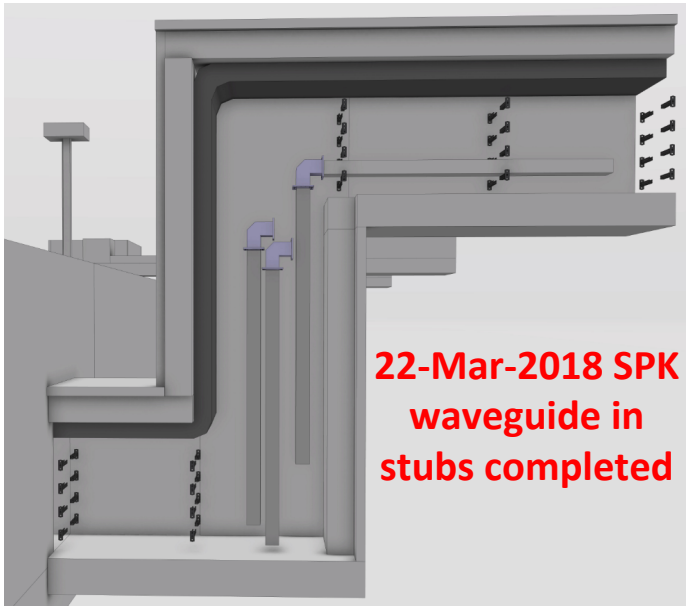
LWUs

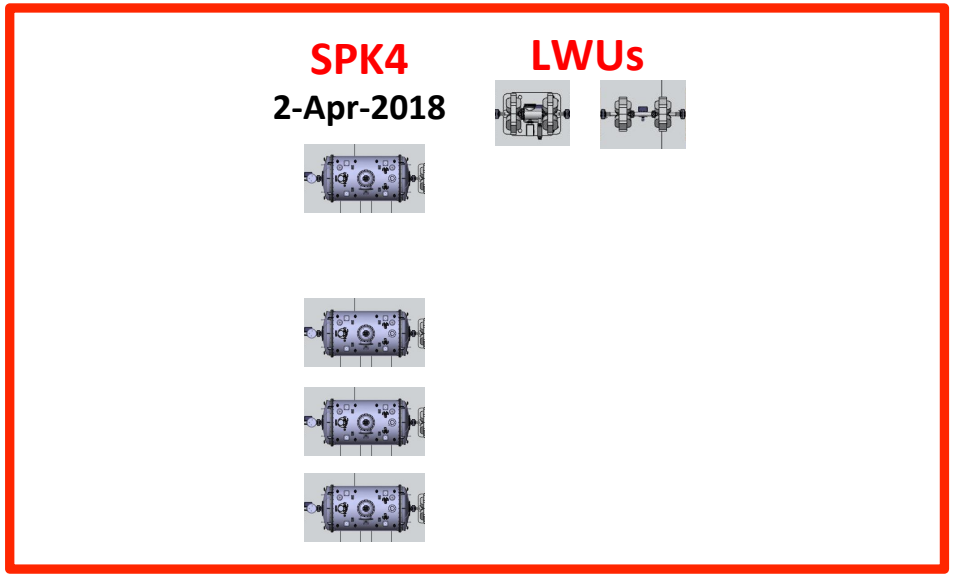


Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

Installation/testing/commissioning steps (6 out of 18)







Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

Installation/testing/commissioning steps (7 out of 18)

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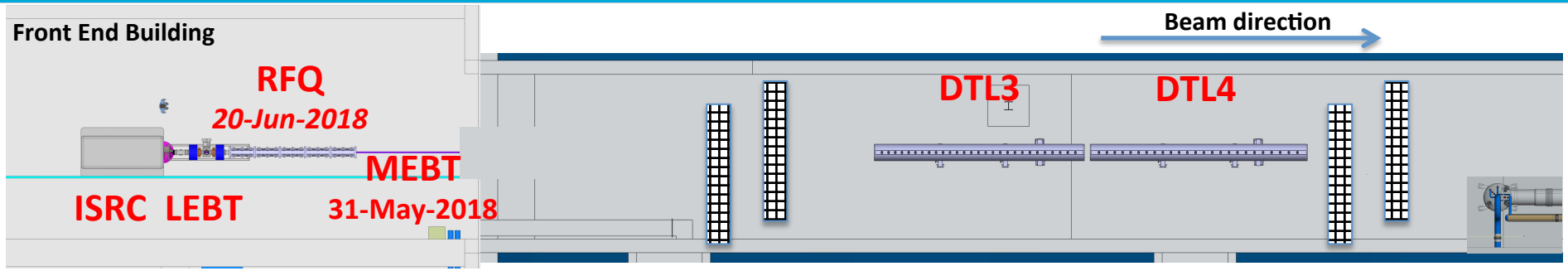
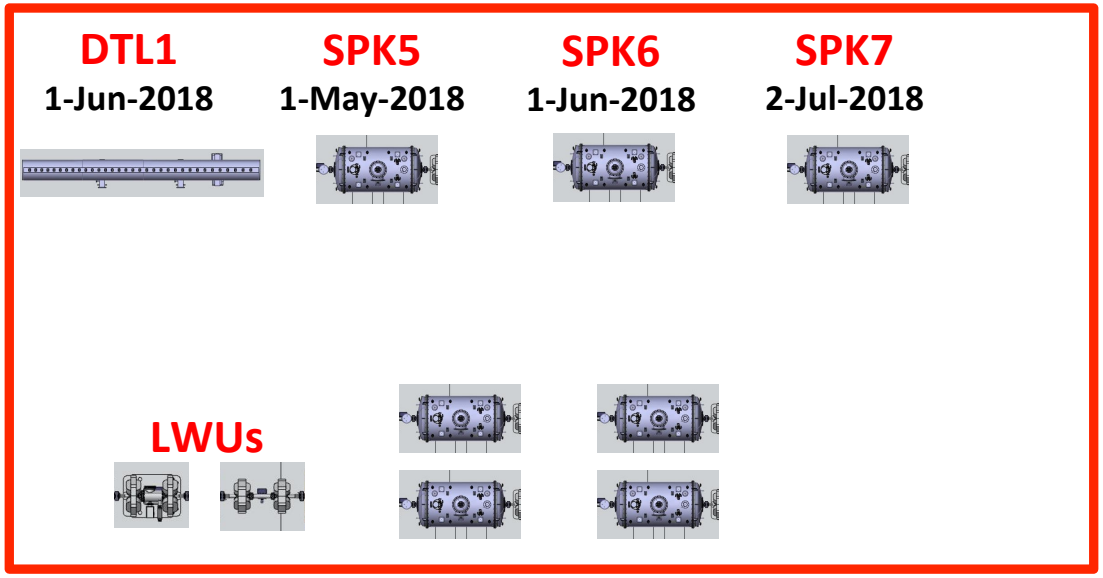
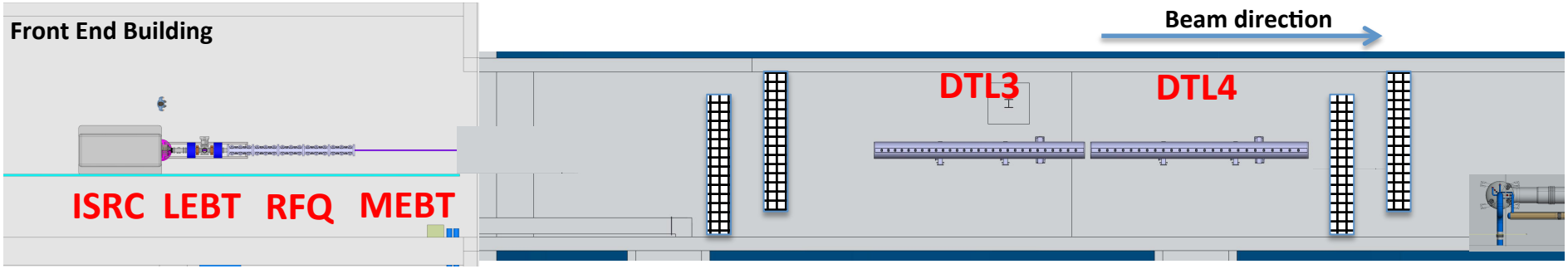




Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

Installation/testing/commissioning steps (8 out of 18)



- RFQ and MEBT *phase D*: beam commissioning with inline MEBT diagnostics and low power end cup/beam stop
  - RFQ and MEBT beam commissioning for 6 weeks
  - RFQ+MEBT beam commissioning completed by 22-Oct-2018

Installation/testing/commissioning steps (9 out of 18)

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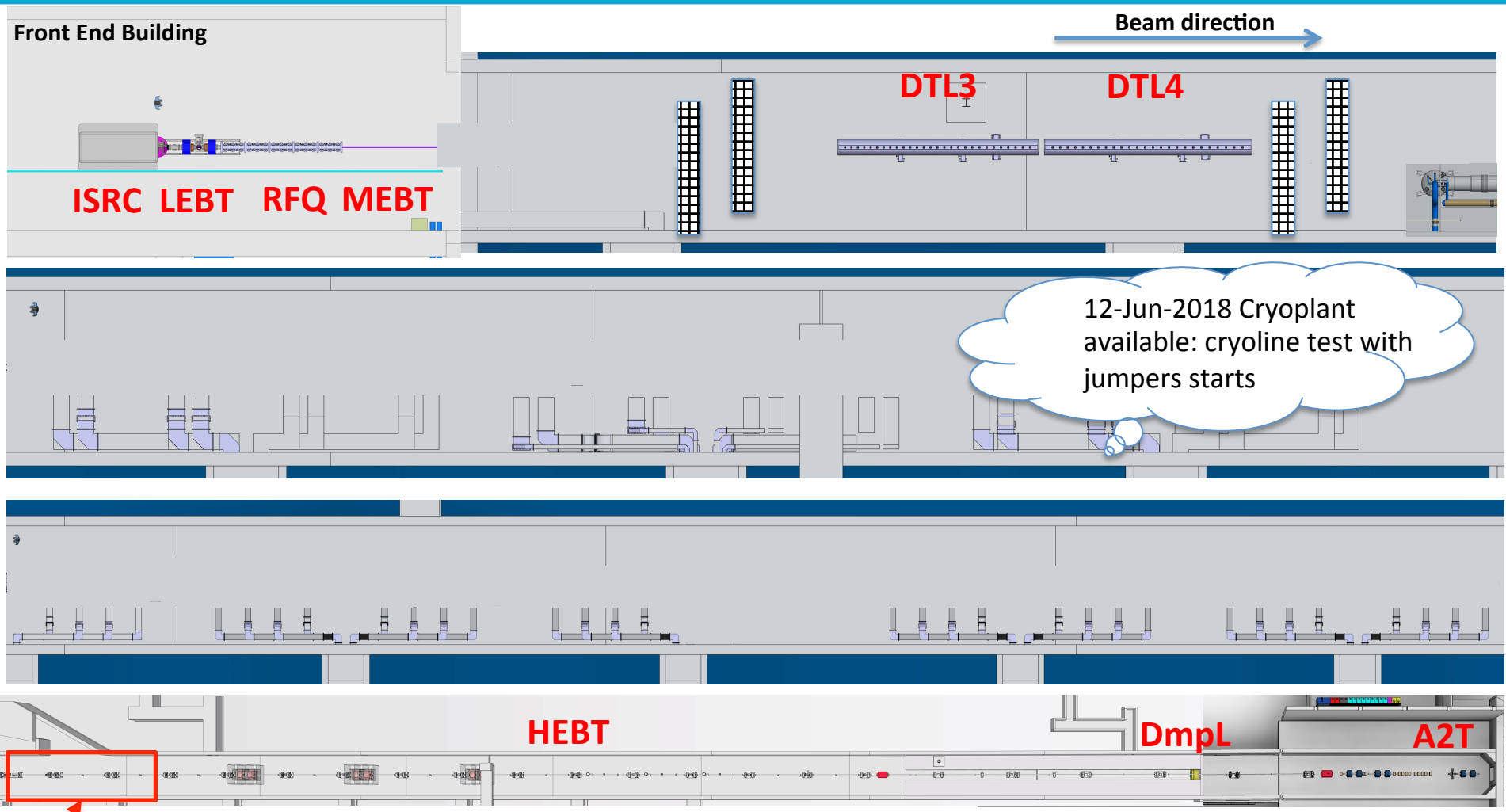

Dates are (approximated) installation start dates

Installation/testing/commissioning steps (10 out of 18)

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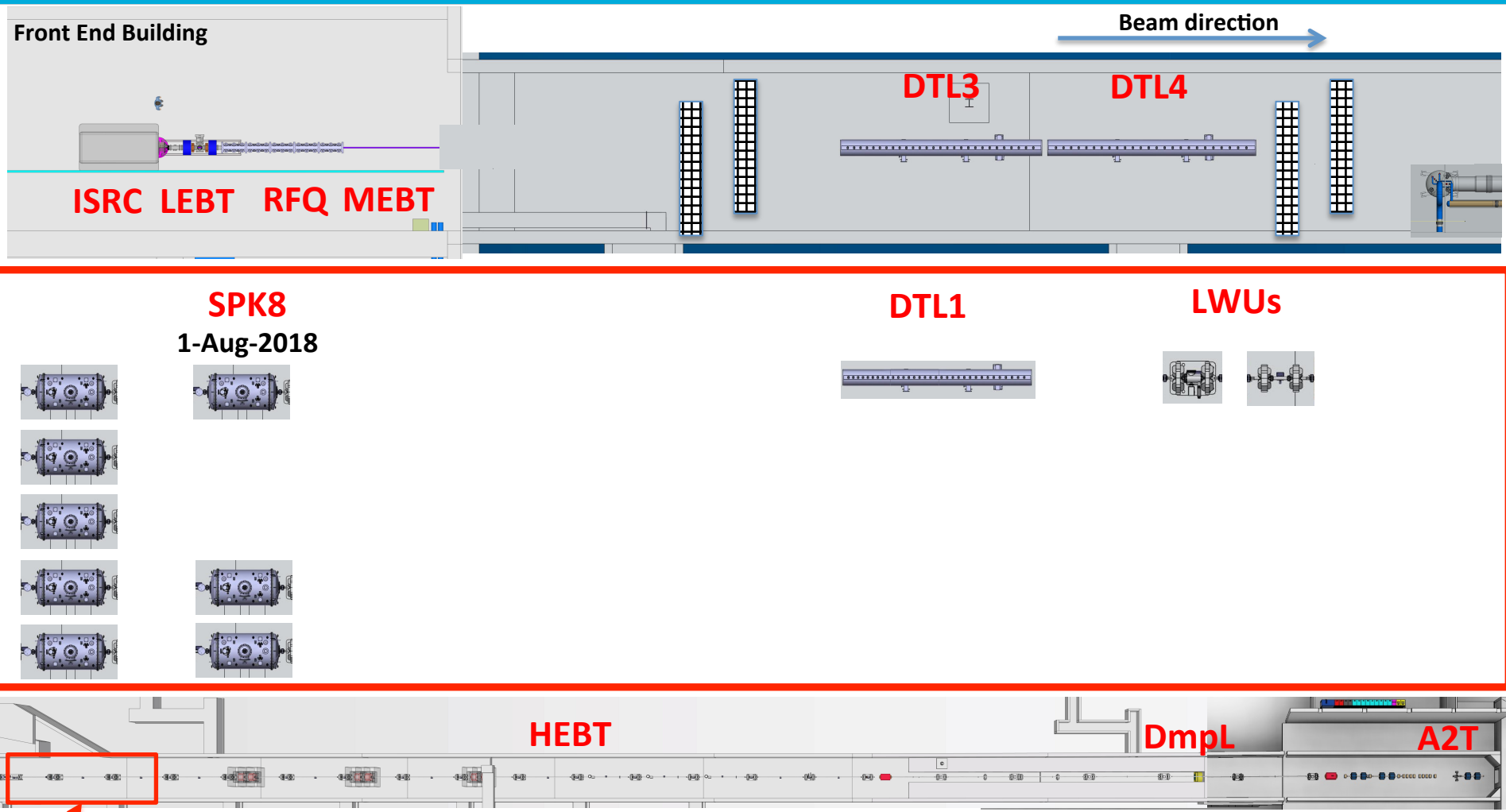

Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

Installation/testing/commissioning steps (11 out of 18)

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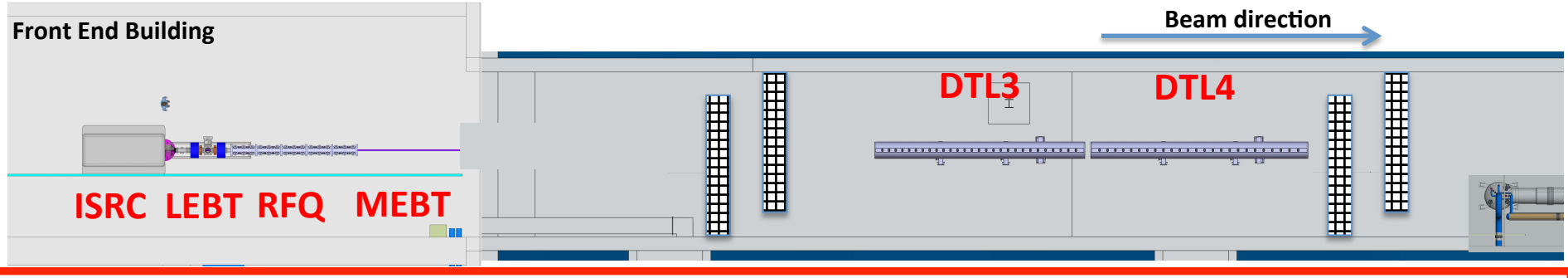
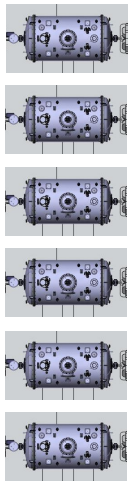
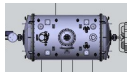
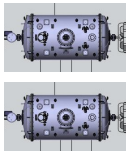


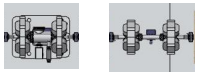


SPK9
3-Sep-2018





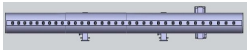
LWUs



MBL1
3-Sep-2018

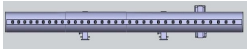
MBL2
2-Oct-2018

DTL2
1-Oct-2018



1-Oct-2018
cryoline test with
jumpers finished
in linac tunnel

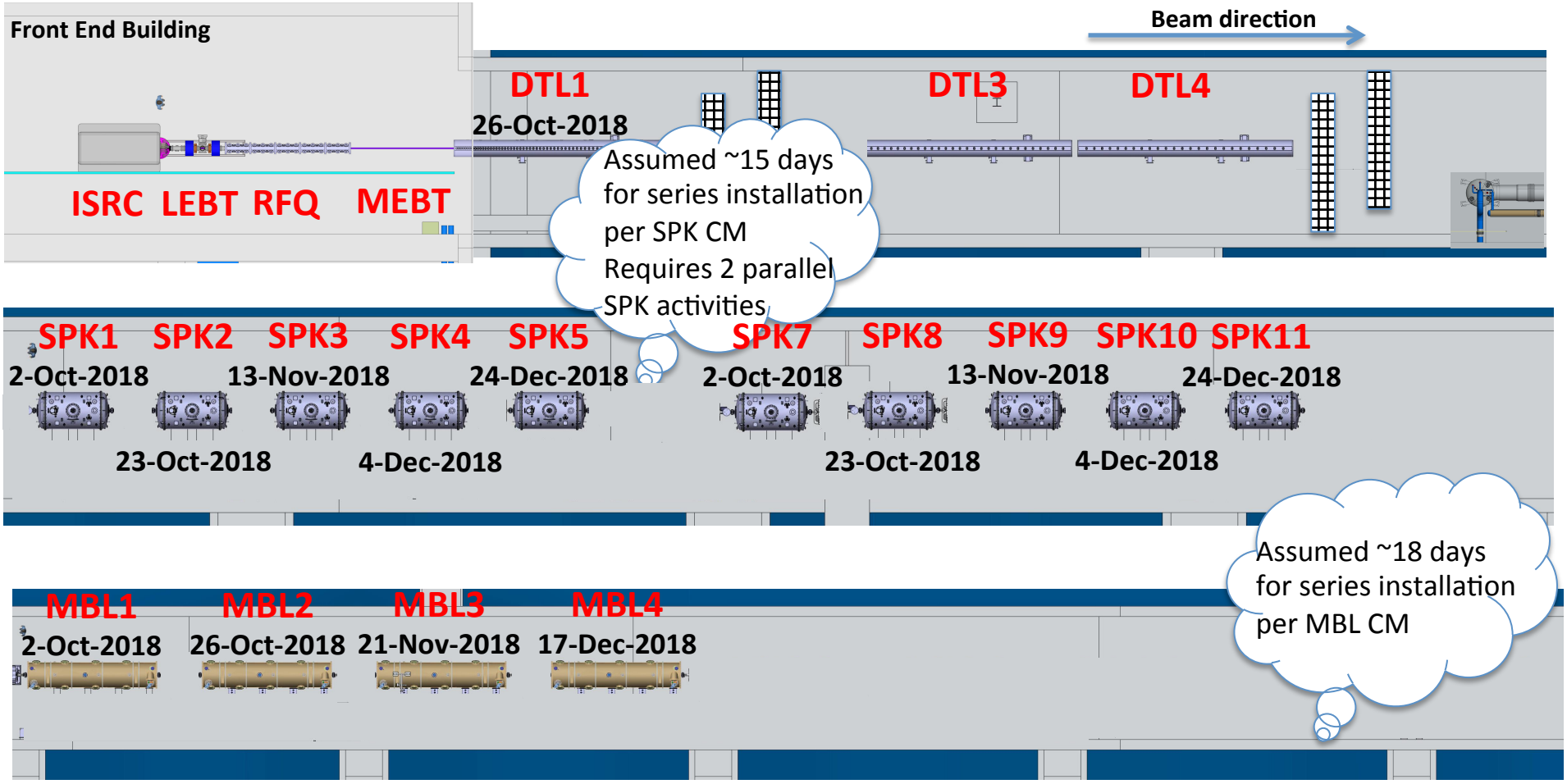
DTL1



5-Mar-2015

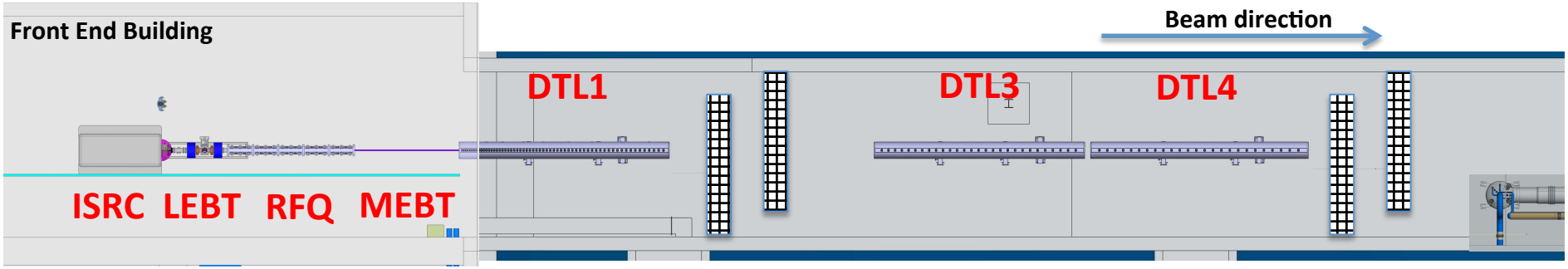
Dates are (approximated) RFI dates for equipment in RATS, installation dates for the tunnel

Installation/testing/commissioning steps (12 out of 18) CMs have been pre-tested



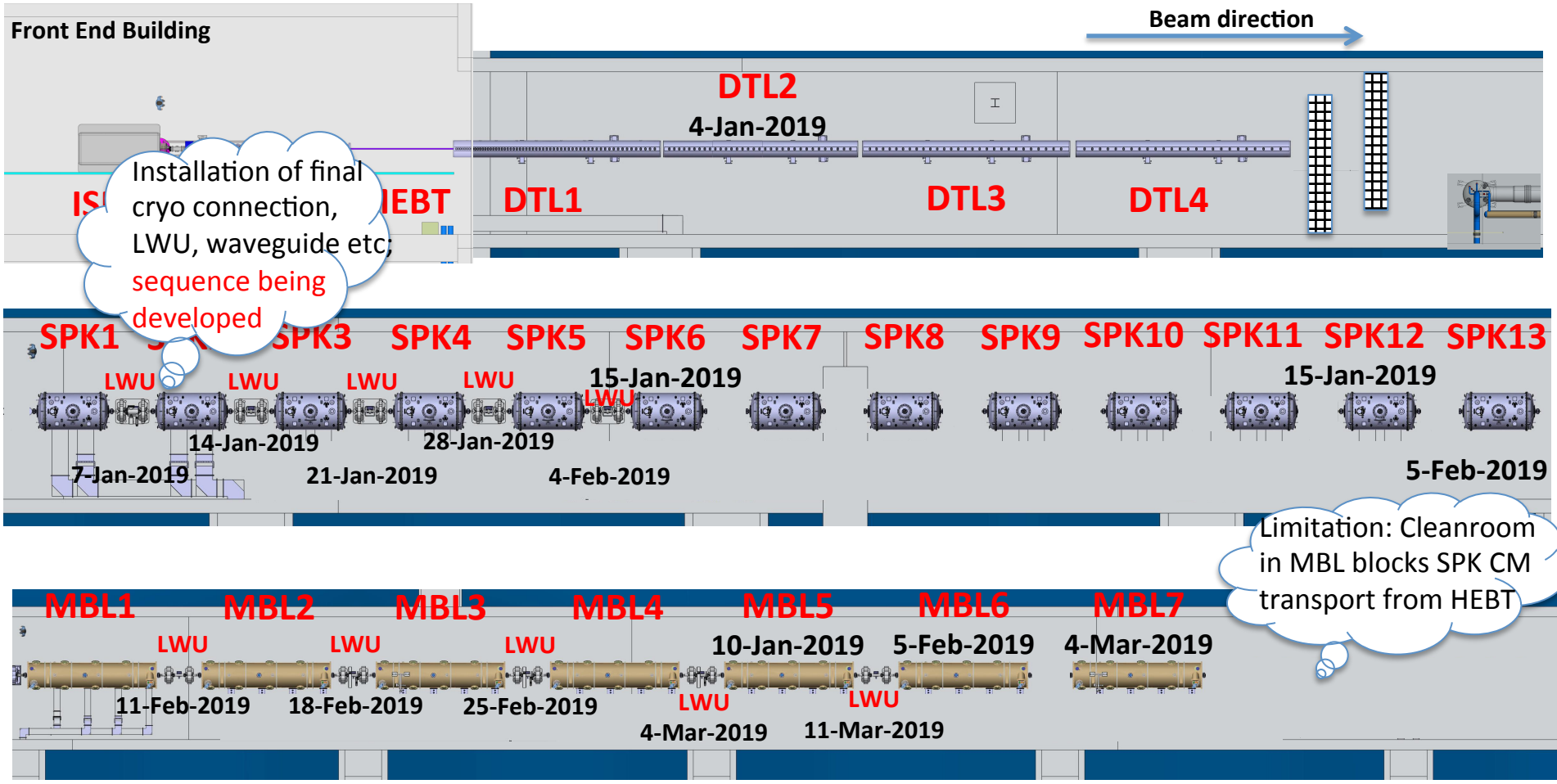
Dates are (approximated) installation start dates

Installation/testing/commissioning steps (13 out of 18)



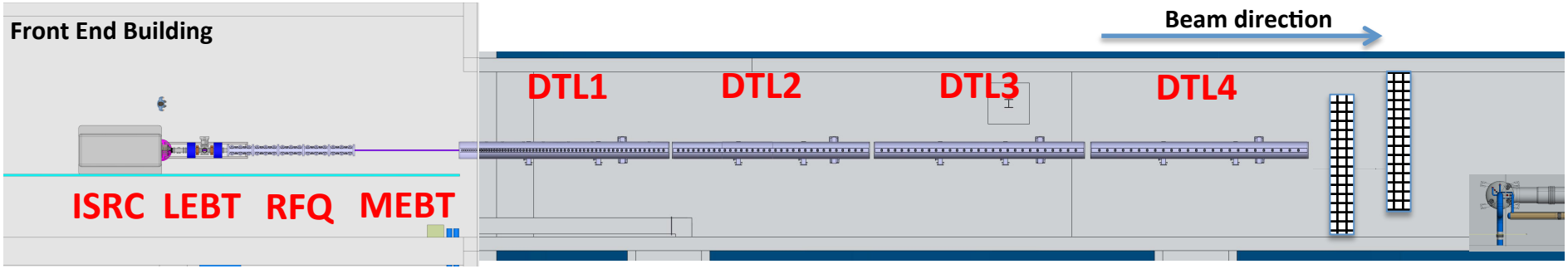
- DTL1 *phase D*: beam commissioning with low power end cup/beam stop
  - Does not affect downstream installation/testing
  - Assuming 7 weeks of installation/testing
  - 2 weeks of commissioning with beam, completed by 3-Jan-2019
- Beam commissioning DTL tank 1 most critical of all DTL tanks; this has been recognized at other projects, e.g.
  - CERN Linac3, SNS DTL, CERN Linac4

Installation/testing/commissioning steps (14 out of 18)



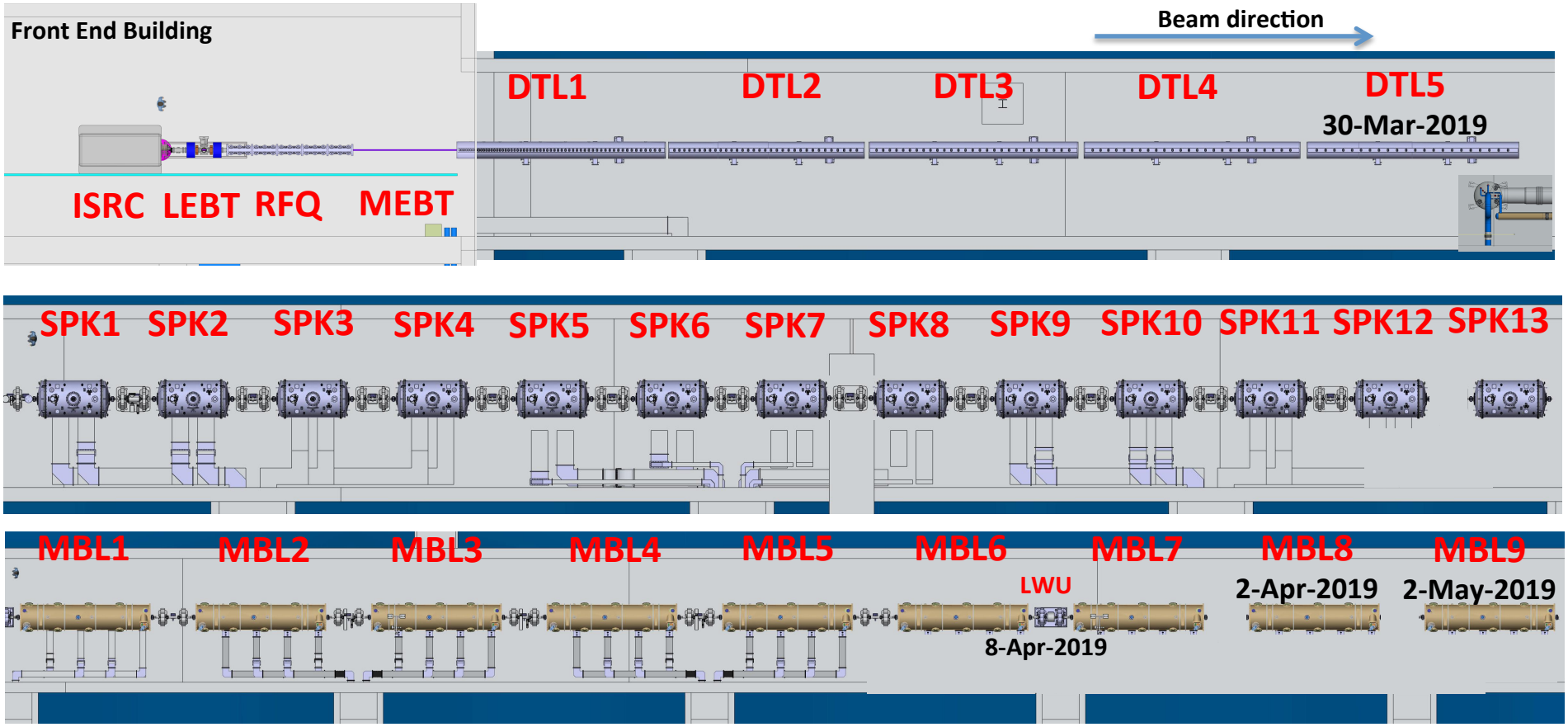
Dates are (approximated) installation start dates

Installation/testing/commissioning steps (15 out of 18)



- DTL1-4 *phase D*: beam commissioning with low power end cup/beam stop
  - ➢ Does not affect downstream installation/testing
  - ➢ Assume 7 weeks for installation and testing of DTL2 leaves 1 month for beam commissioning DTL1-4
  - ➢ DTL1-DTL4 beam completed by 29-Mar-2019

Installation/testing/commissioning steps (16 out of 18)

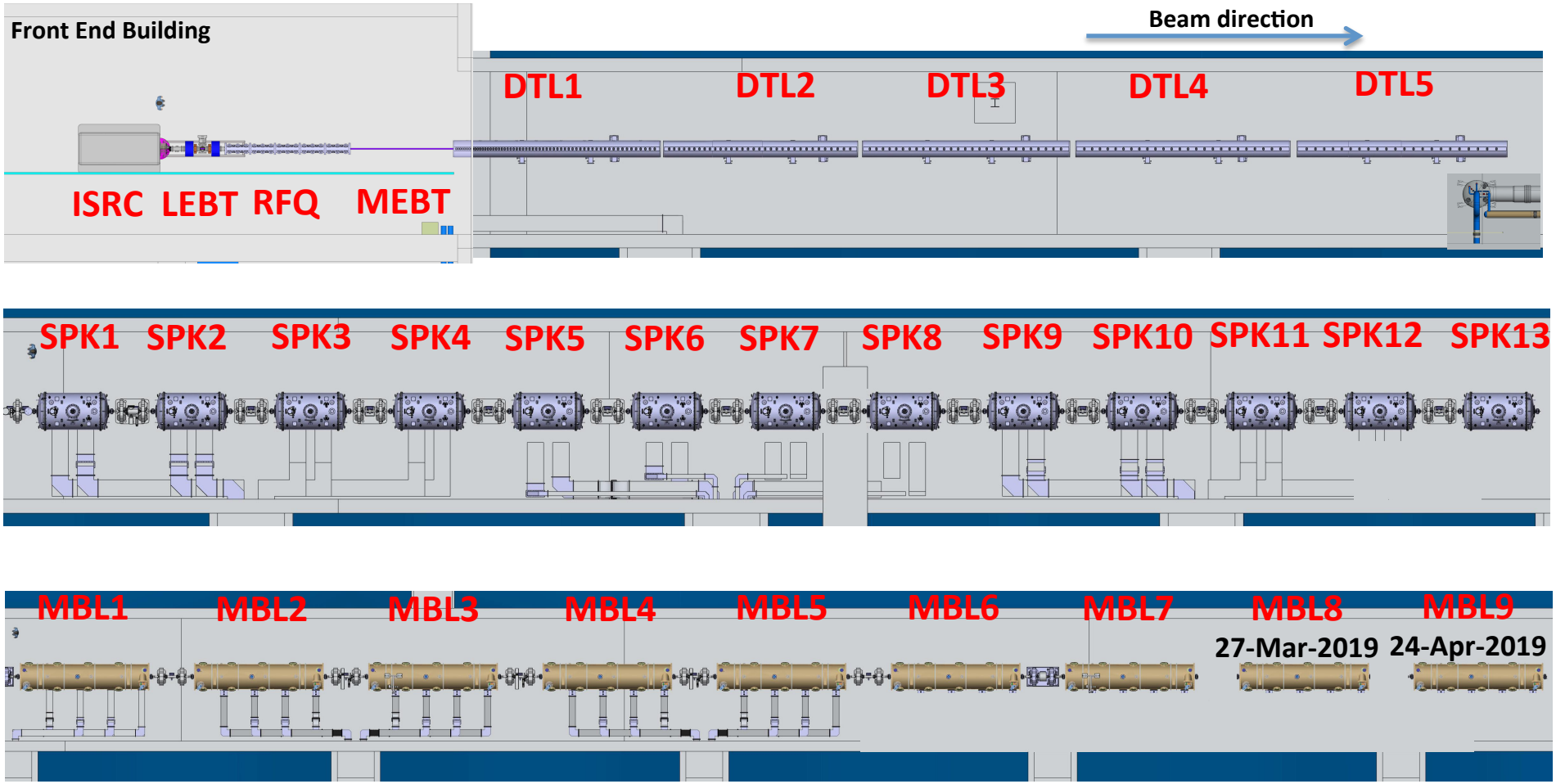


Dates are (approximated) installation start dates

MBL installation schedule limited by MBL CM production rate and final test

- Could consider to test MBL CM8 and CM9 in final location in the tunnel
  - Would be able to produce neutrons with these last 2 CMs turned off (but 470 MeV protons, not 570 MeV on target)
  - Finish installation last MBL by 24-Apr-2019
- Next slides assume this mitigation

Installation/testing/commissioning steps (17 out of 18)



Dates are (approximated) installation **finish** dates

Installation/testing/commissioning steps (18 out of 18)

- In May 2019 CM cool down and testing, but…
  - All based on a success oriented schedule
  - Concern about delivery schedule of LWUs
    - Different mitigation options are being looked into
  - Just one month for the following beam commissioning steps:
    - DTL5-SPK-MBL-HEBT beam to the linac beam dump
    - HEBT-A2T beam to Target

Next steps

- Currently being prepared in OpenProject:
  - Klystron Building installation sequences
    - Based on input from WPs, LEs etc
  - Additional details on HEBT and A2T
  - Prerequisites: e.g. availability of AC power, water cooling etc

Open Issues (being worked upon)

- Ascertain FE delivery dates
- Need to confirm Early Access dates with SI
  - Need to define access dates for A2T
- Adopt/further develop FE beam commissioning steps shown:
  - ISrc-LEBT
  - ISrc-LEBT-RFQ-MEBT
  - ISrc-LEBT-RFQ-MEBT-DTL1
  - ISrc-LEBT-RFQ-MEBT-DTL1-DTL2-DTL3-DTL4
    - Next steps would be DTL5 with cold linac (beam to dump, then to target)

It is not rare for haste to cause delay.
Olaf Hoenson