FCCee cryomodules

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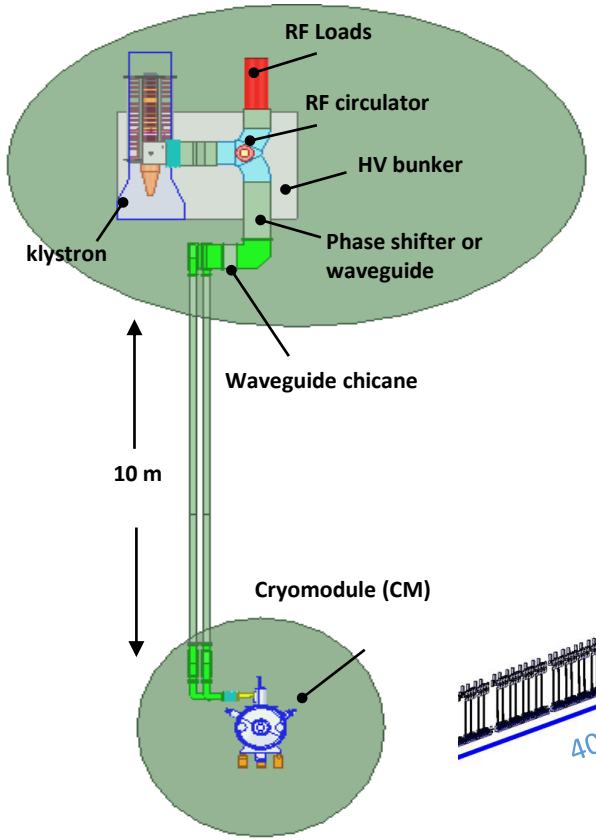
On behalf of the FCC SRF team

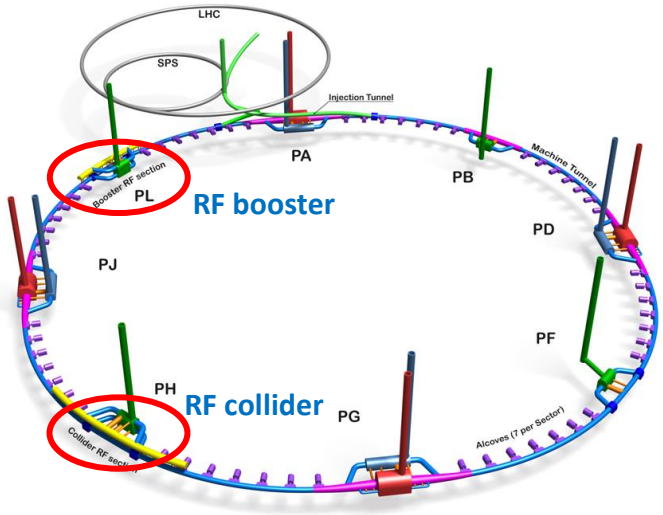
SY-FCC workshop
CERN, 04 October 2024

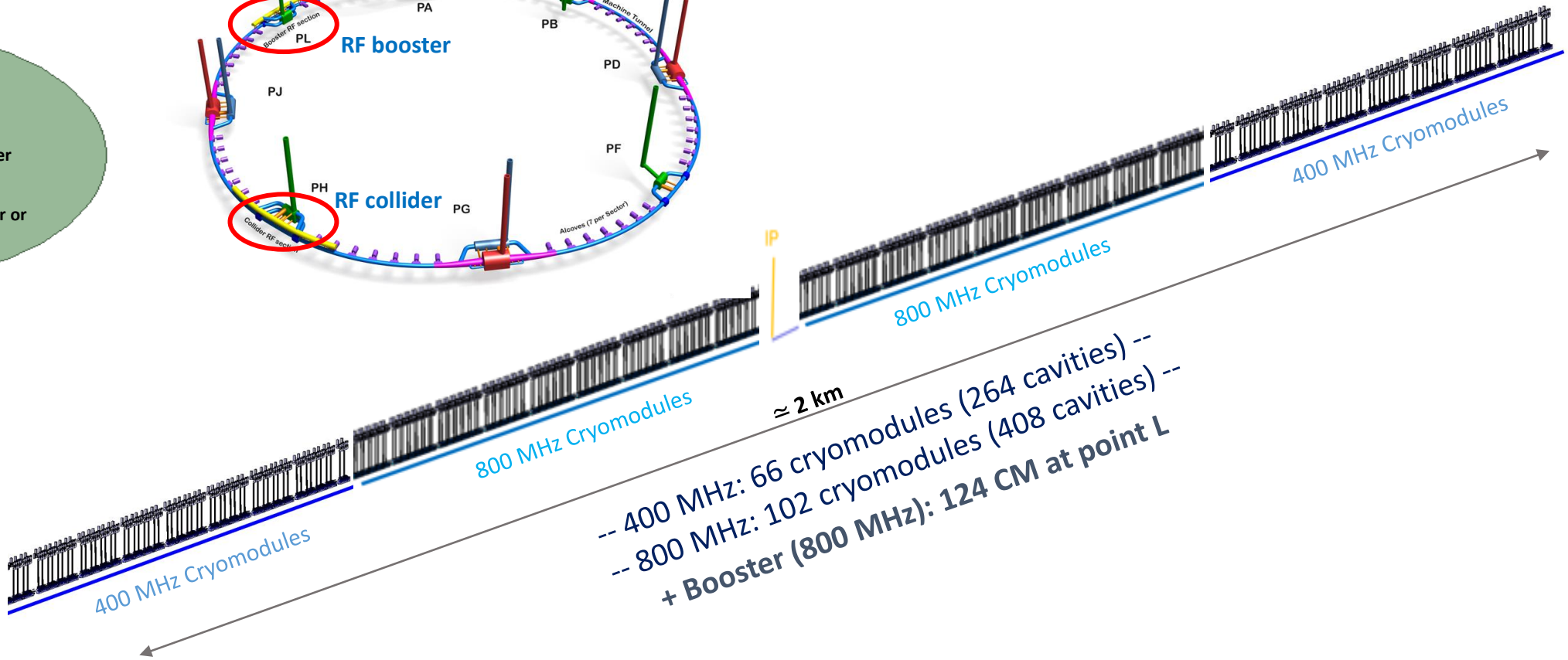
FCCee

RF configuration at PH (ttbar)

Courtesy O. Brunner

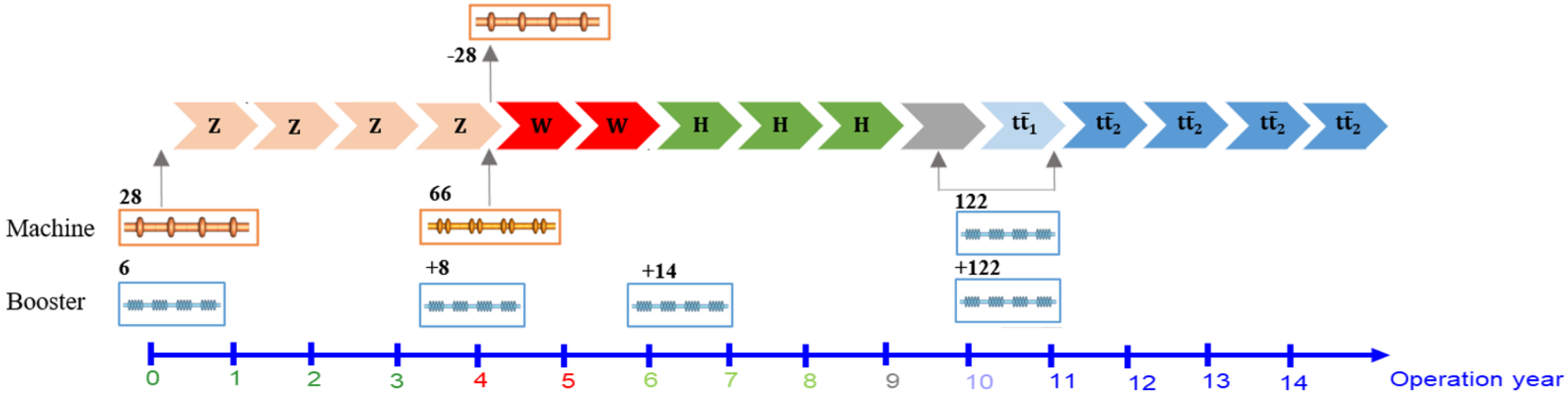






-- 292 cryomodules → **≃ 3 x LEP RF system !! --**

RF system layout - Baseline



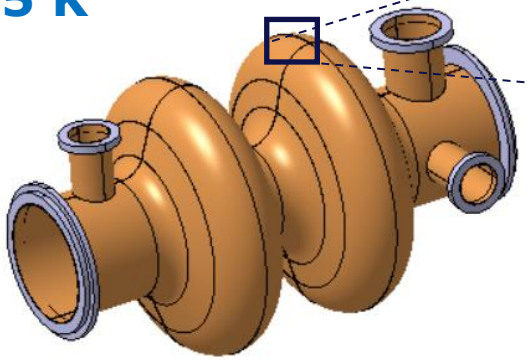
- Physics schedule – number and type of cryomodules to be installed:
- 400MHz single-cell (Nb/Cu): 28 CM @4.5K, removed after the Z working point
- 400MHz two-cell (Nb/Cu): 66 CM @4.5K
- 800MHz five-cell (bulk Nb): 272 CM @2K, 122 CM for the collider and 150 CM for the booster.

R&D strategy on SRF materials

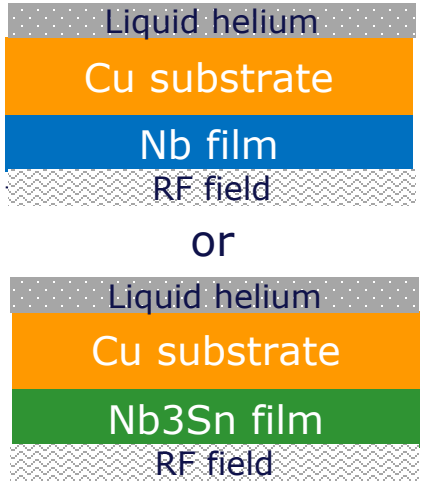
Courtesy F. Peauger

Material	λ(nm)	ξ(nm)	κ	T_c(K)	H_{c1}(T)	H_c(T)	H_{sh}(T)
Nb	40	27	1.5	9	0.13	0.21	0.25
Nb_3Sn	111	4.2	26.4	18	0.042	0.5	0.42

4.5 K



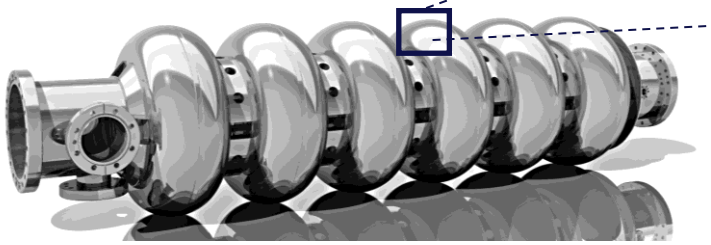
400 MHz cavity



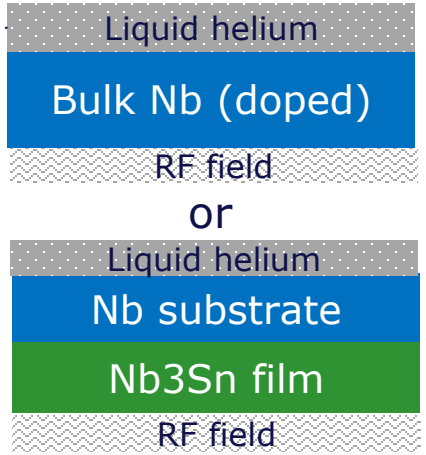
Baseline option: advanced fabrication technics, advanced coating (HiPIMS) & advanced surface preparation recipes

Alternative option to improve the accelerating gradient E_{acc} and the Q_0 factor

2 K (→ 4.5 K?)



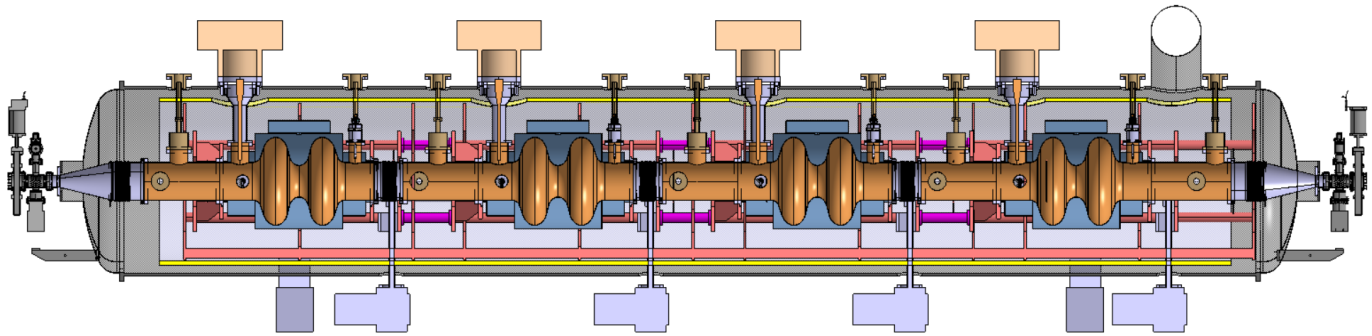
800 MHz cavity



Baseline option: special surface processing (doping) to improve the Q_0 factor

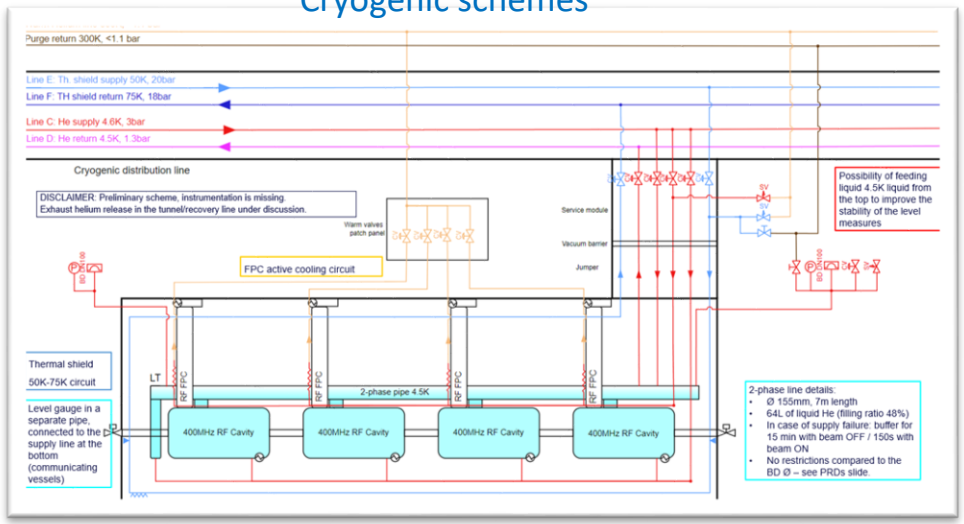
Alternative option cavities to operate at 4.5 K instead of 2 K

400 MHz CM conceptual and integration studies



- 400 MHz CM (based on LHC) for W to ttbar (also Z? >> FPC and HOM power extraction)
- Prototype to be built at CERN (under SRF-D project)

Cryogenic schemes

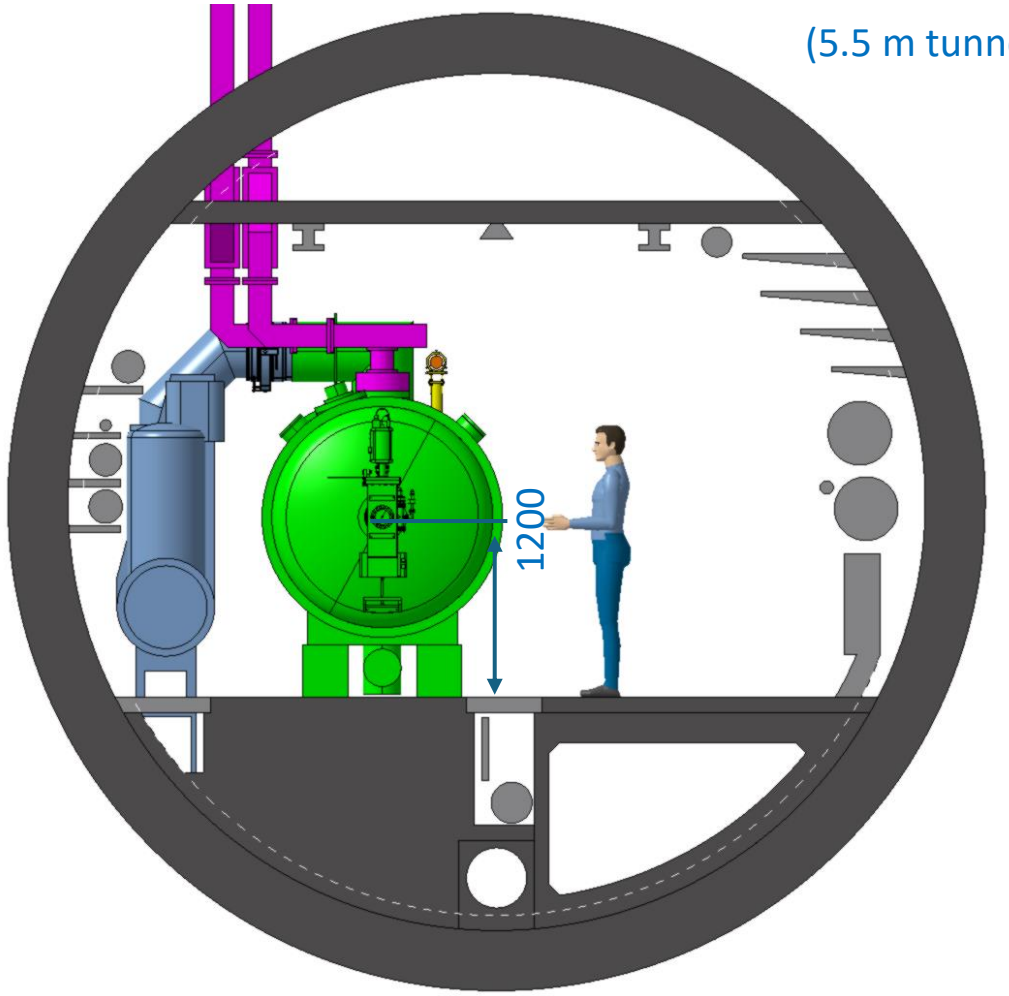


K. Canderan, SY-RF

66 units

400 MHz in collider

(5.5 m tunnel)



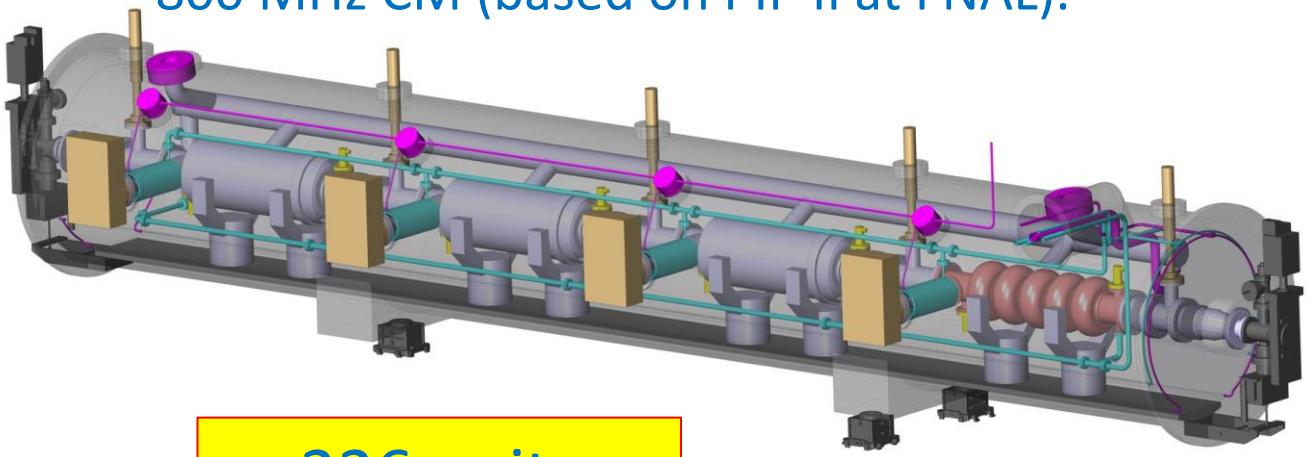
beam height in RF points : 1200mm > 980mm beam height in the arcs

→ can be matched with ~ 0.15% tunnel slope in separation/recombination zones (150m long)

M.Timmins, F. Cottenot, EN-MME

800 MHz CM conceptual and integration studies

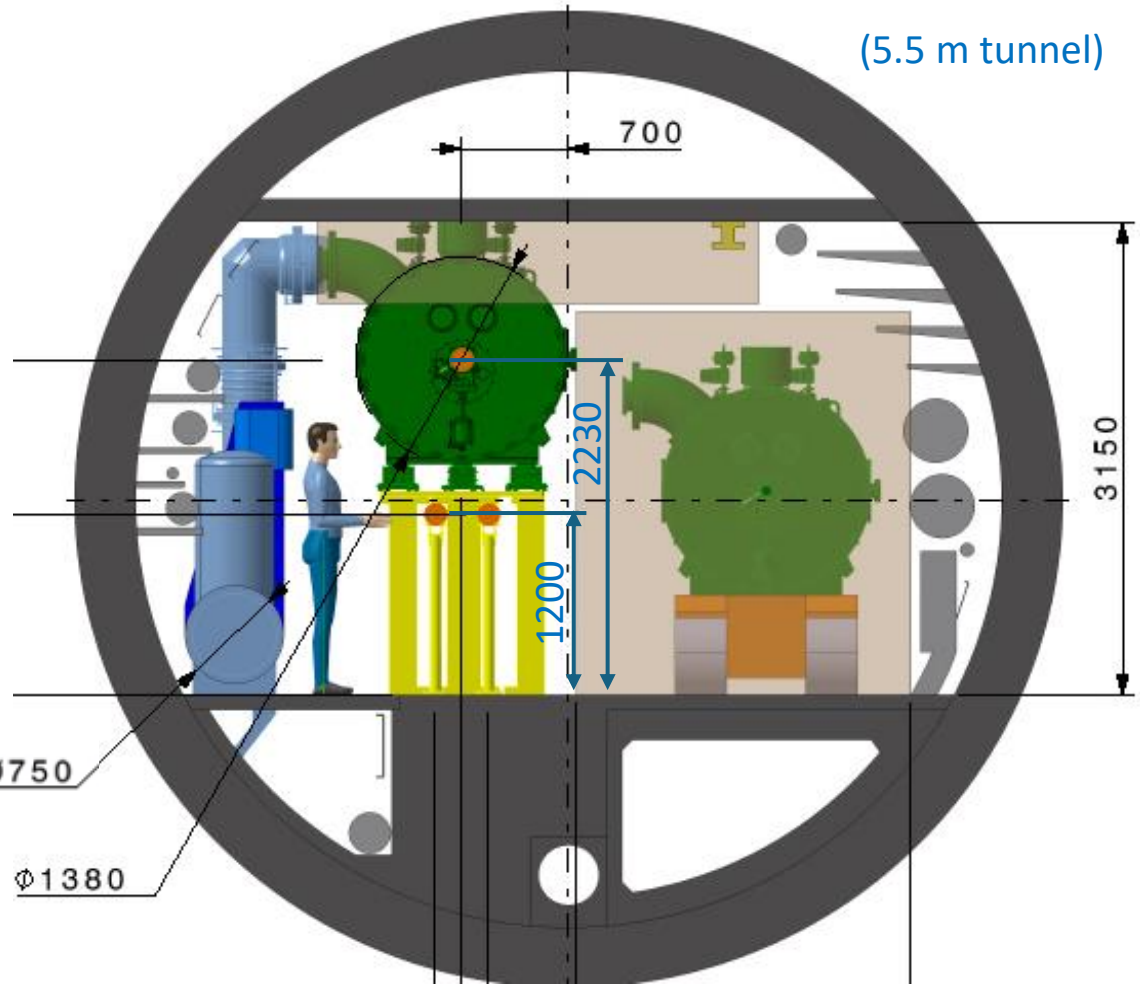
800 MHz CM (based on PIP II at FNAL).



226 units
(over 10 yrs)

800 MHz booster

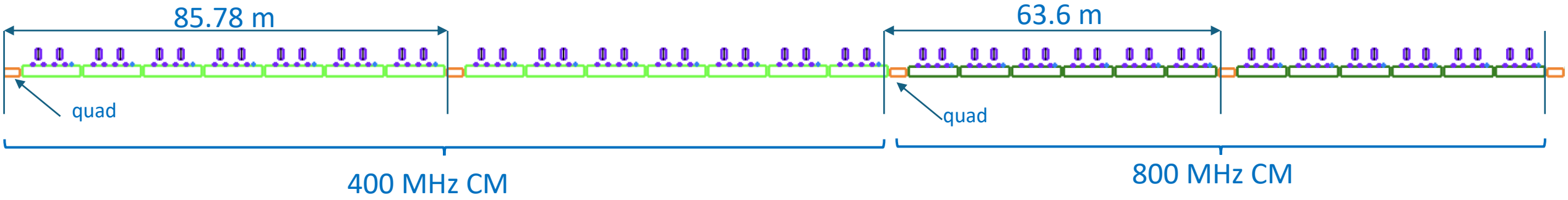
(5.5 m tunnel)



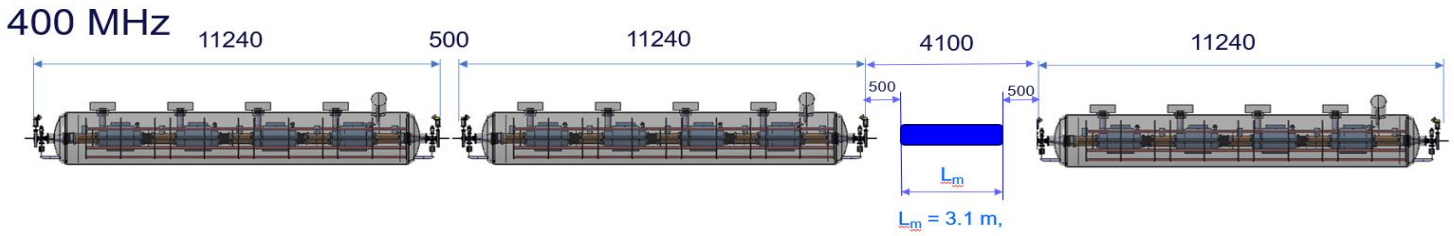
- ✓ Some integration issue still to be tackled (ceiling height, robot space reservation to be reviewed)
- ✓ MOU CERN/FNAL in preparation:
  - ➢ 800 MHz CM prototype by FNAL by about 2031
  - ➢ In view of a potential significant US contribution to FCC

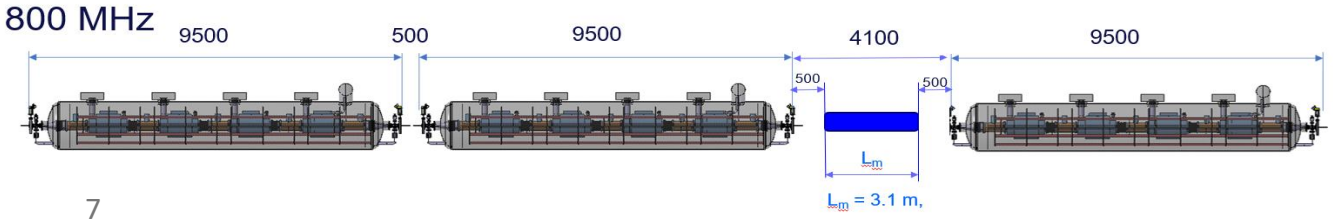
M.Timmins, F. Cottenot, EN-MME

Longitudinal integration study



- Collider SRF system **length** at the ttbar is **marginally exceeding** allocated length in PtH (2x1015m)
- Optimising for **more compact SRF** configurations (**6-cell 800 MHz cavity, RF and mechanical design**)

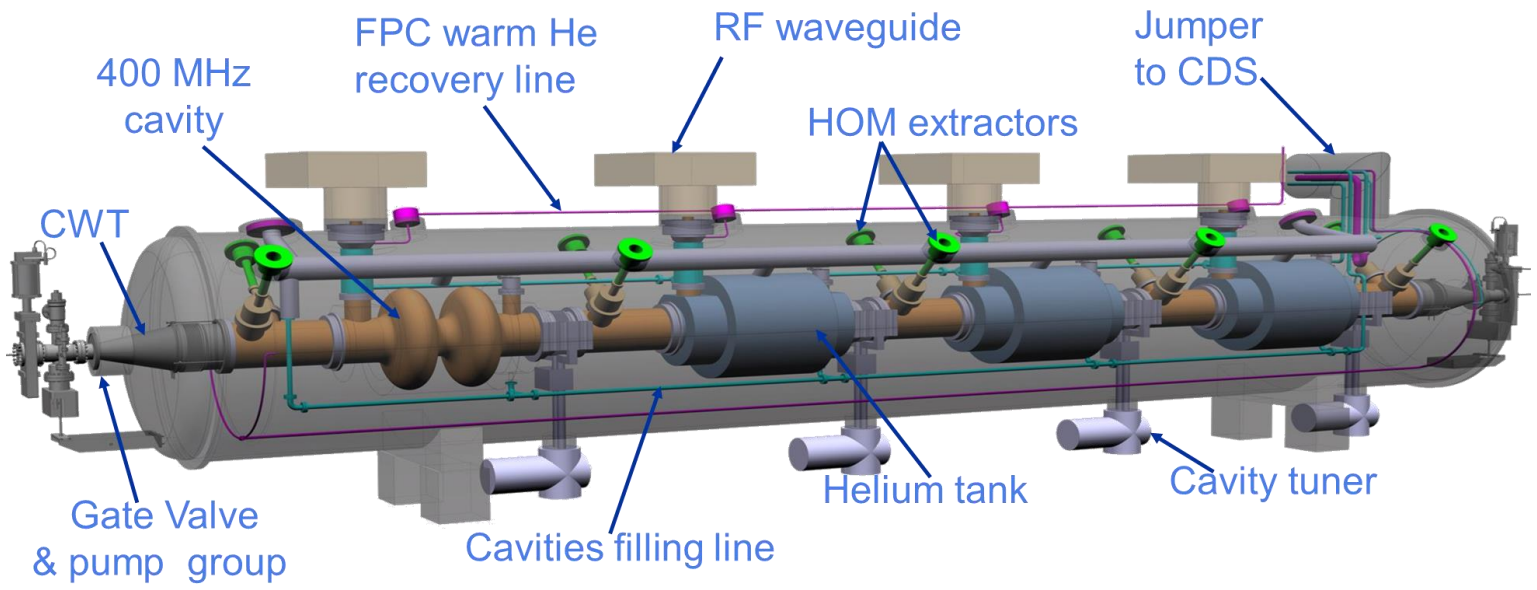




SRF R&D-D

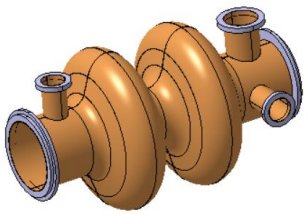
A new project. What is it about ?

Build 400 MHz Demo, an FCC 2-cell cavity full size cryomodule

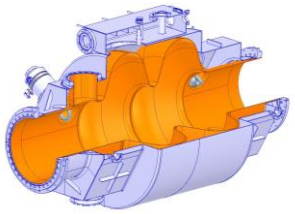


Parameter	Value	Remarks
No. cryomodules	66	
2-cell cavities per cryomodule	4	
CM length (GV flange to flange)	~ 11 m	
Cavity gradient Eacc (MV/m)	12 / 10.6	*CM test / CM in accelerator*
Qo	3.0E+09 / 2.7E+09	*CM test / CM in accelerator*
Dyn. HL (CW)/cavity at 4.5 K	129 W	(Z?) W, H, ttbar
Stat. HL/CM	197 W	Includes 50% margin (design maturity)
Environ. Magnetic field	≤ 5 mG	Shielding needs TBD
Max FPC power/cavity (kW, CW) (Z)/ W / H / ttbar	(894)/374/378/78	FPC type/assembly TBD (WG with windows?)
FPC orientation/WG connection	Vertical/Top	accessible from CM top
Q_{ext} W / H / ttbar	9.2E+05/9.1E+05 /4.5E+06	Fixed antenna, adjustable on wave guide
HOM power per CM: (Z?)/ W / H / ttbar	(~45 kW)/~15 kW/ ~6 kW/ ~3 kW	HOM hook-type and coax.extract.

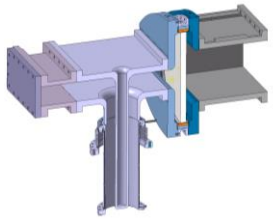
Items to be designed, built and qualified (non exhaustive list!)



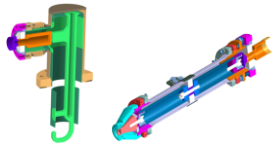
Cavity Nb sputtered



He tank (LHC design shown)/cavity assy



FPC (new !, with WG windows)

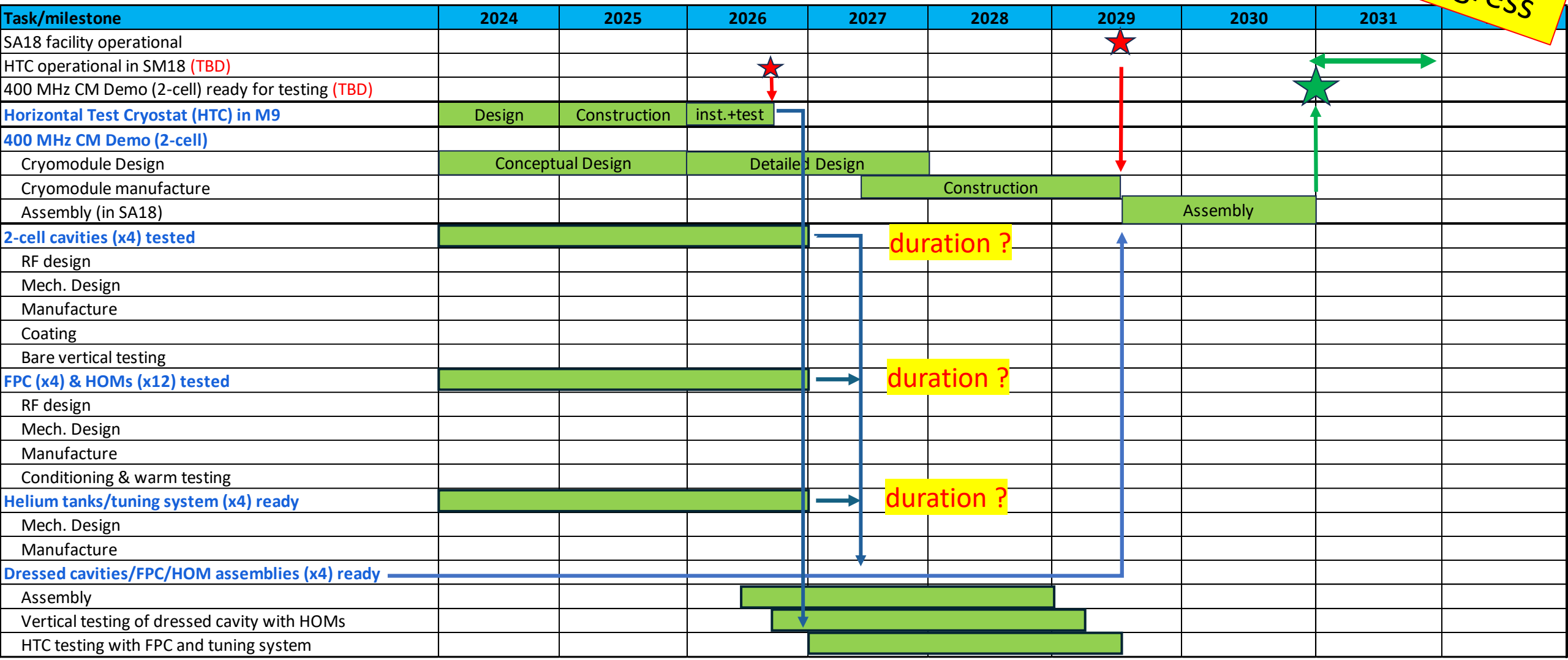


HOMs, RF extraction lines (LHC/Crab designs shown)

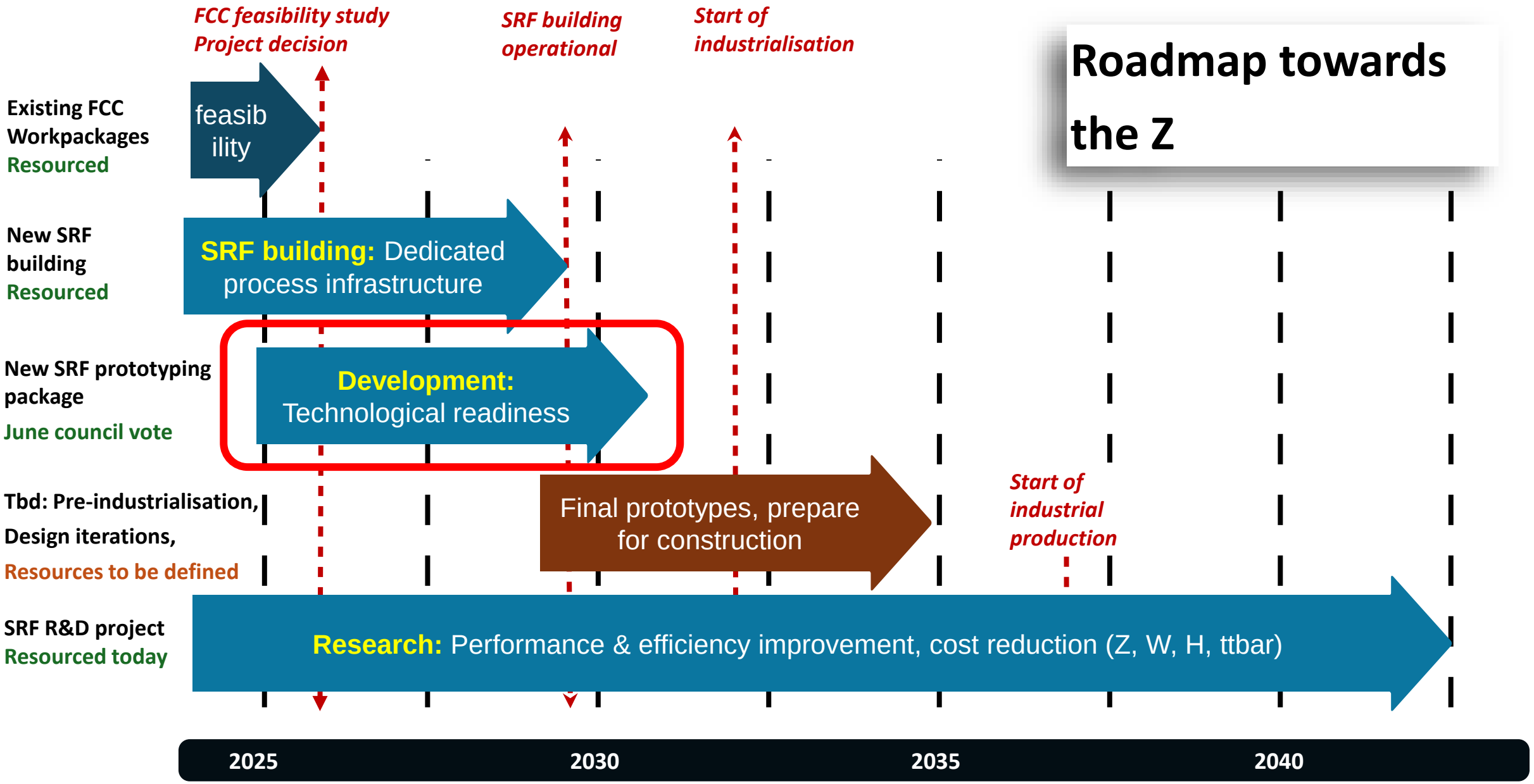
Lots of resemblances to LHC CM, but **final designs may be considerably different !**

Master schedule for 400 MHz CM demo

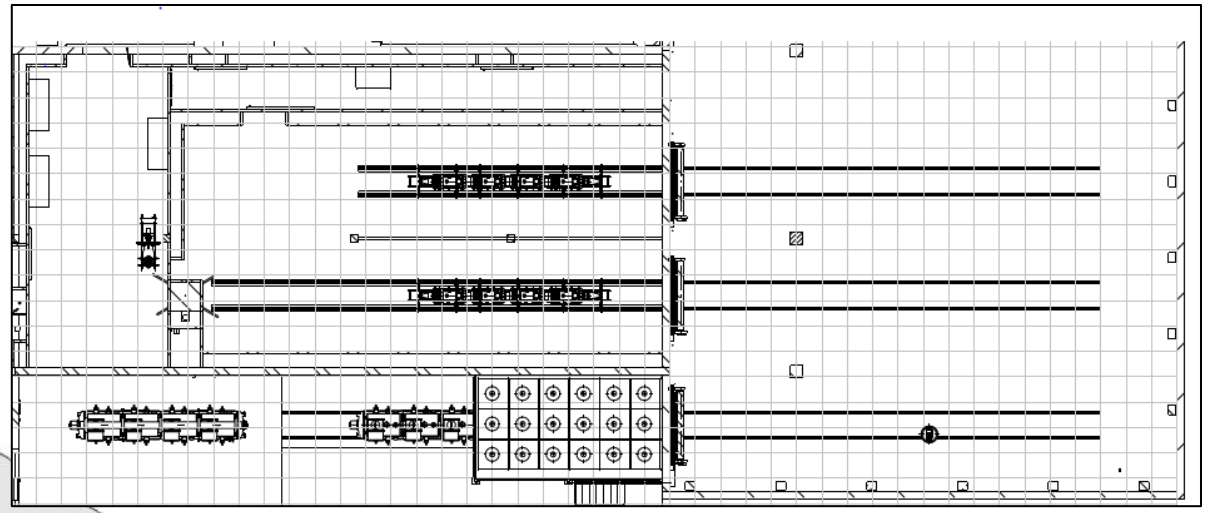
Work in progress

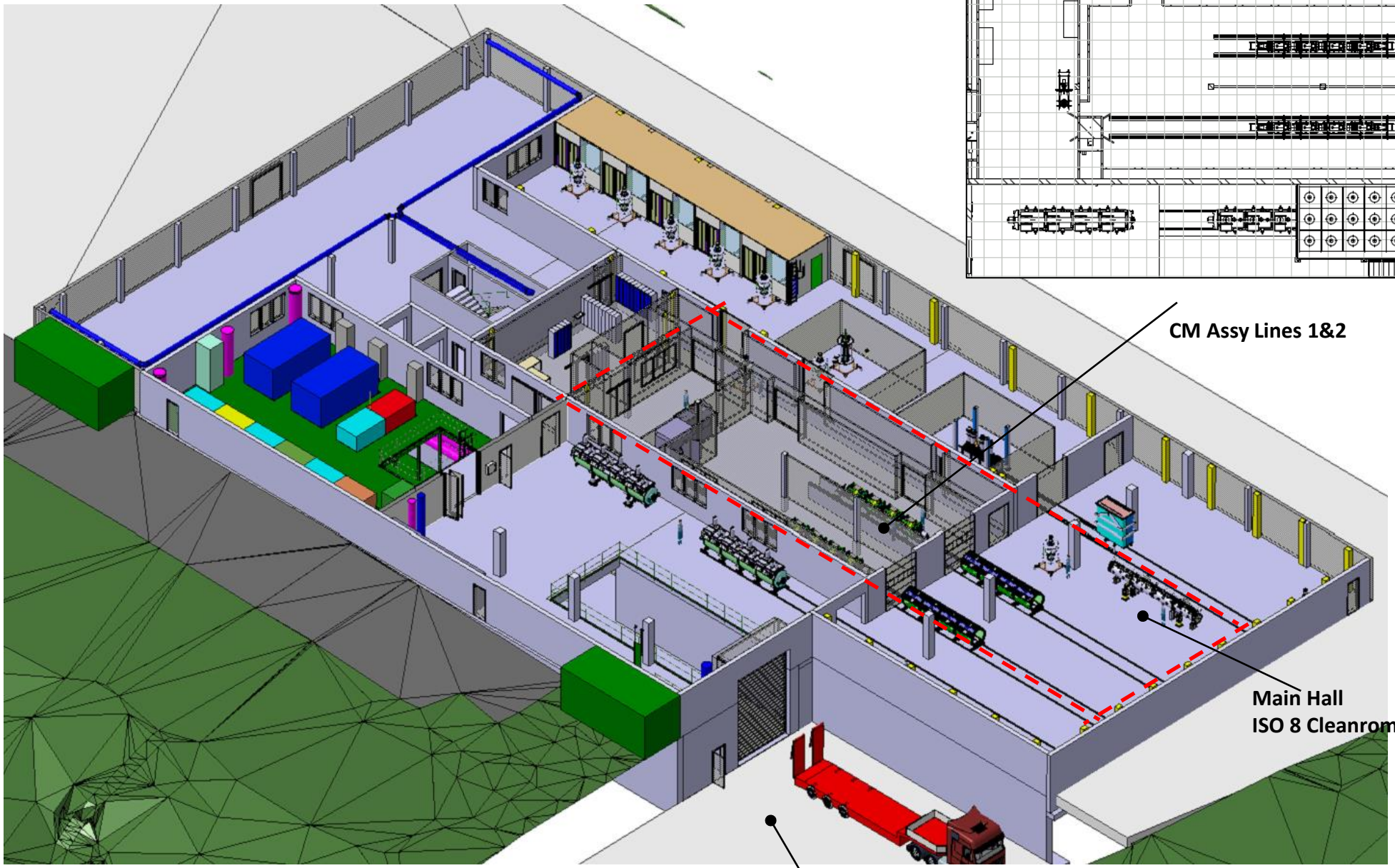


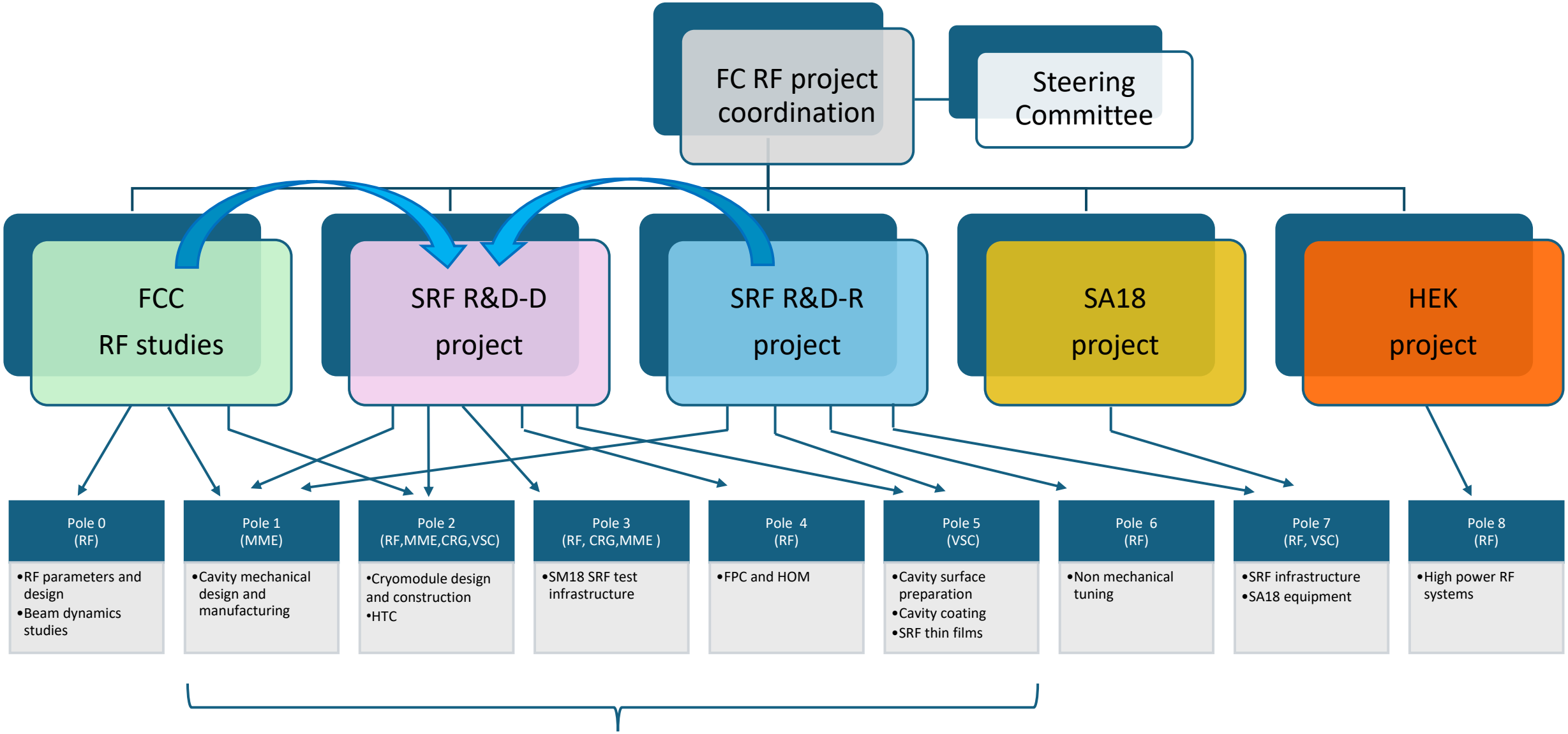
Roadmap towards the Z



SA18 Layout







EN-MME, TE-VSC/CRG, SY-RF, a major ATS endeavor !

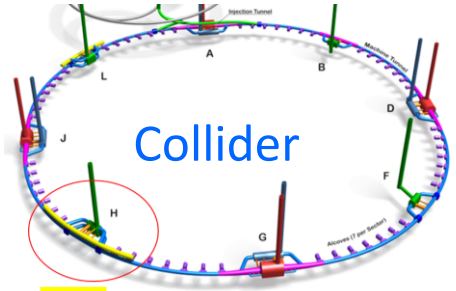
Summary

- Conceptual design of CM 400 MHz and 800 MHz well advanced
- Tunnel integration studies in progress
- 5.5 m tunnel cross-section integration tight but feasible but with higher beam height than the arcs:
  - ✓ Proposed matching the arcs beam height with a slight tunnel slope
  - ✓ Some integration issues can be easily tackled
- Finalize integration study by end of 2024
- Design and build 400 MHz CM Demo (at CERN) and 800 MHz CM prototype (FNAL collaboration?)
- 400 MHz Demo, a big endeavor across ATS sector (project being set up, recruitment of new staff started)

Thank you ! Questions ?

Backup slides

TLSS length: 2032 m



Access Point H

Z machine

(0.24 GV, 100 MW)

400MHz/1 Cell

800MHz/2 Cell

Beam 1

Beam 2

Booster

WCS

LCB

14 CMs

4.5K

2K

180m

184m

W machine

(2.1 GV, 100 MW)

400MHz/2 Cell

800MHz/5 Cell

WCS

UCB

LCB

33 CMs

435,9m

H machine

(4.2 GV, 100 MW)

ttbar machine

(22.6 GV, 100 MW)

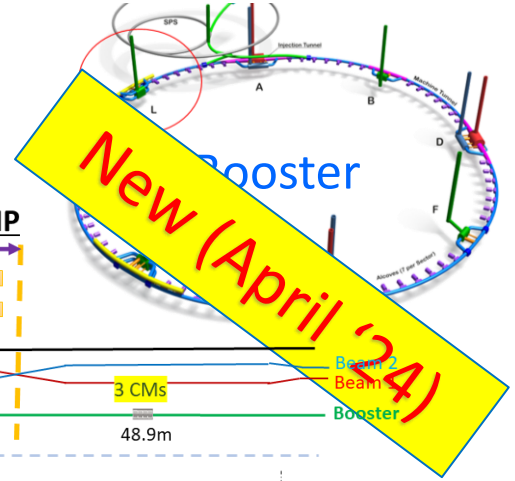
61CMs

539,2m

TOTAL RF LENGTH: 1950,2 m

TLSS length: 2032 m

New (April '24)



Access point L

IP

500 m

300 m

Z machine

(0.14 GV, 5 MW)

3 CMs

48.9m

W machine

(1.05 GV, 5 MW)

7 CMs

120.7m

H machine

(2.1 GV, 5 MW)

14 CMs

232.8m

223.1m

ttbar machine

(11.3 GV, 5 MW)

75 CMs

147.5m

671.6m

200m

663.7m

Midpoint RF section

TOTAL RF LENGTH: 1335.3m

Inside the 400 MHz CM