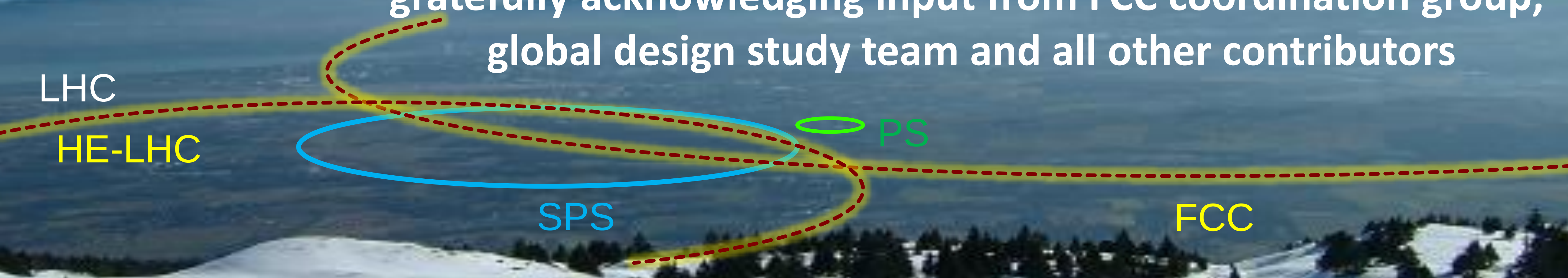
Future Circular Collider Study

Status and Plans

M. Benedikt and F. Zimmermann

gratefully acknowledging input from FCC coordination group, global design study team and all other contributors



http://cern.ch/fcc

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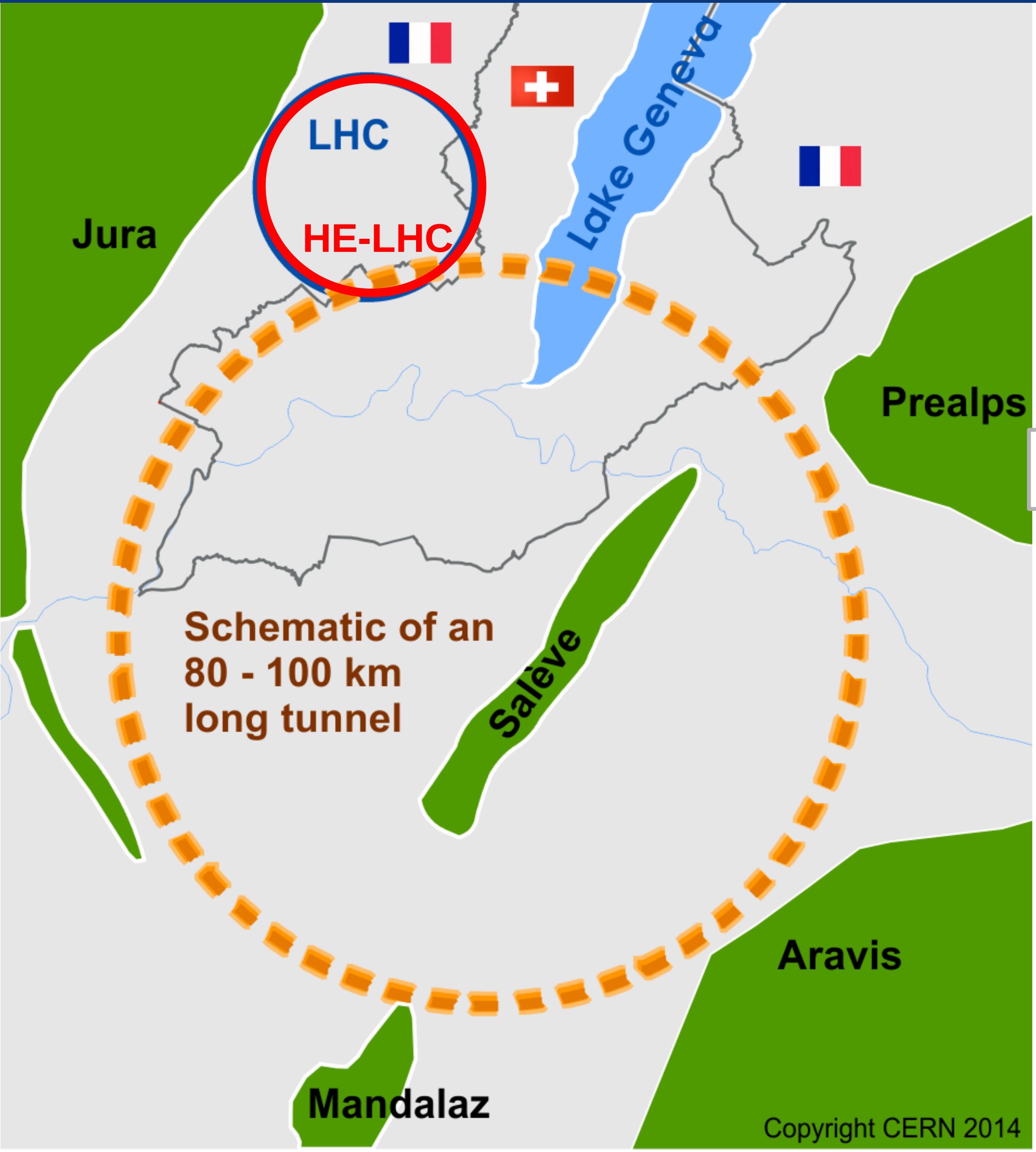
photo: J. Wenninger

Contents

- FCC-ee, HE LHC, FCC-hh progress
  - Focus on areas highlighted by IAC and technical advances
- CE status and schedule considerations
- Further planning

Future Circular Collider (FCC) Study

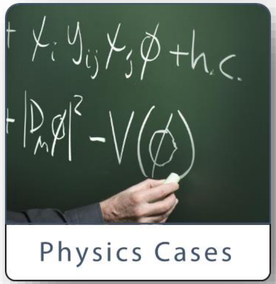


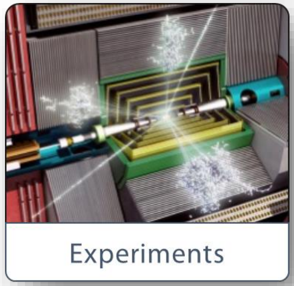
International FCC collaboration (CERN as host lab) to study:

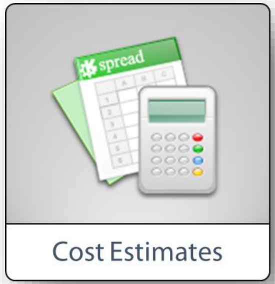
- ***pp*-collider (*FCC-hh*)**
  → main emphasis, defining infrastructure requirements

~16 T ⇒ 100 TeV *pp* in 100 km

- **~100 km tunnel infrastructure** in Geneva area, site specific
- ***e⁺e⁻* collider (*FCC-ee*),** as potential first step
- **HE-LHC** with *FCC-hh* technology
- ***p-e* (*FCC-he*) option,** IP integration, e⁻ from ERL





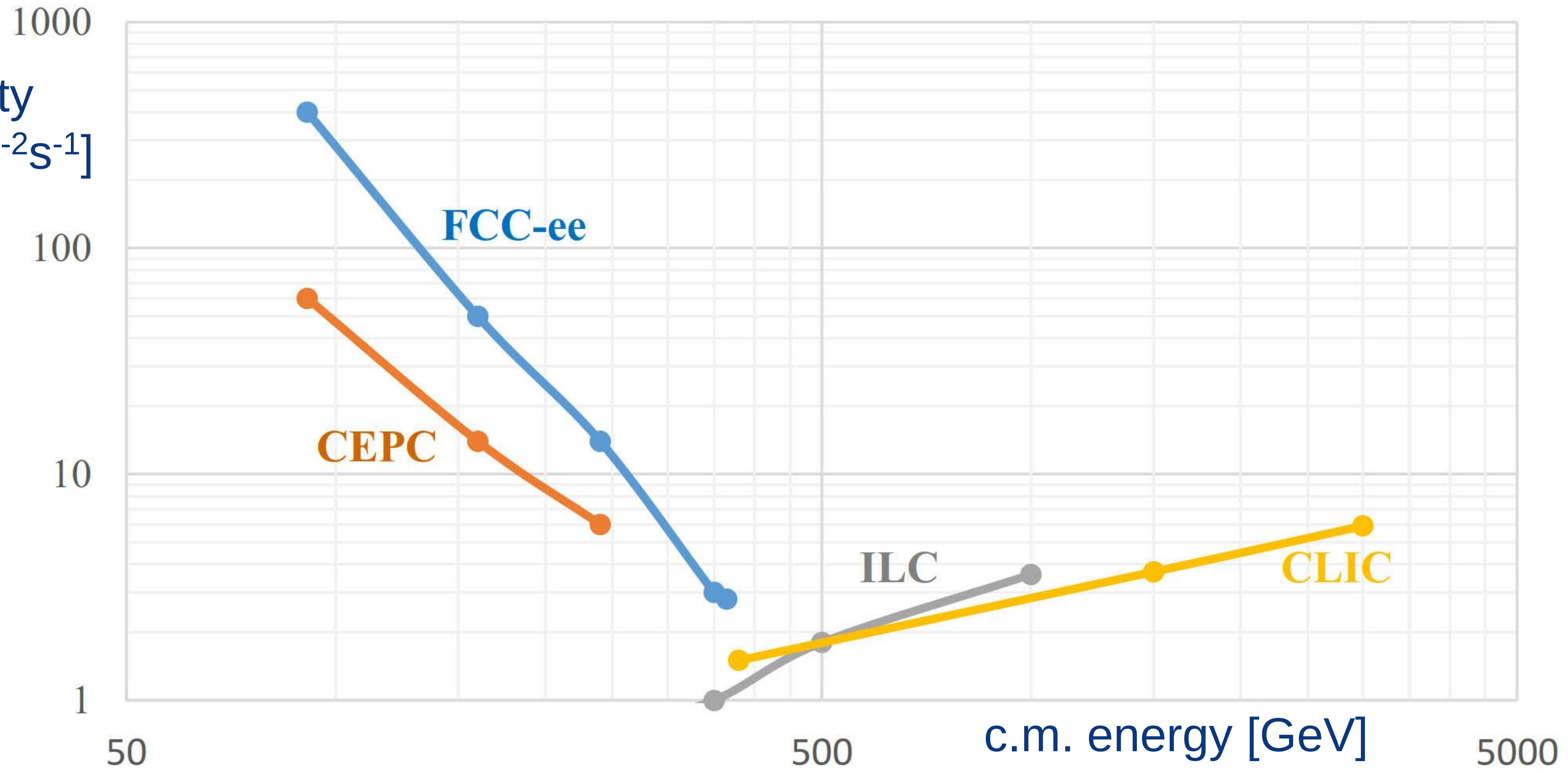


FCC-ee collider parameters

parameter	Z	WW	H (ZH)	ttbar
beam energy [GeV]	45	80	120	182.5
beam current [mA]	1390	147	29	5.4
no. bunches/beam	16640	2000	393	48
bunch intensity [10^{11}]	1.7	1.5	1.5	2.3
SR energy loss / turn [GeV]	0.036	0.34	1.72	9.21
total RF voltage [GV]	0.1	0.44	2.0	10.9
long. damping time [turns]	1281	235	70	20
horizontal beta* [m]	0.15	0.2	0.3	1
vertical beta* [mm]	0.8	1	1	1.6
horiz. geometric emittance [nm]	0.27	0.28	0.63	1.46
vert. geom. emittance [pm]	1.0	1.7	1.3	2.9
bunch length with SR / BS [mm]	3.5 / 12.1	3.0 / 6.0	3.3 / 5.3	2.0 / 2.5
luminosity per IP [10^{34} $cm^{-2}s^{-1}$]	>200	>25	>7	>1.4
beam lifetime rad Bhabha / BS [min]	68 / >200	49 / >1000	38 / 18	40 / 18

lepton collider luminosities

total luminosity [10^{34} cm^{-2}s^{-1}]



c.m. energy [GeV]

FCC-ee operation model

working point	luminosity/IP [10^{34} cm^{-2}s^{-1}]	total luminosity (2 IPs)/ yr	physics goal	run time [years]
Z first 2 years	100	26 ab^{-1}/year	**150 ab^{-1}**	**4**
Z later	200	52 ab^{-1}/year		
W	25	7 ab^{-1}/year	**10 ab^{-1}**	**1**
H	7.0	1.8 ab^{-1}/year	**5 ab^{-1}**	**3**
machine modification for RF installation & rearrangement: **1 year**				
top 1st year (350 GeV)	0.8	0.2 ab^{-1}/year	**0.2 ab^{-1}**	**1**
top later (365 GeV)	1.4	0.36 ab^{-1}/year	**1.5 ab^{-1}**	**4**

total program duration: 14 years - ***including machine modifications***

phase 1 (*Z*, *W*, *H*): 8 years, phase 2 (top): 6 years

FCC-ee Physics and Experiments

1. Evaluation of precision measurements for FCC-ee operation plan

-- ex: **Z, W scan strategies defined.** Masses can be measured to ±0.1 MeV, ±0.6 MeV (all errors) resp. i.e. 20-fold improvement

2. Physics interpretation will not be limited by theoretical prediction

-- **all 'parameters' can be internally measured at FCC-ee** : m_{top}, m_H, $\alpha_{QED}(m_z)$, $\alpha_s(m_z)$, m_Z

-- theoretical calculations can match the precision but **require dedicated effort** as part of next step in the study.

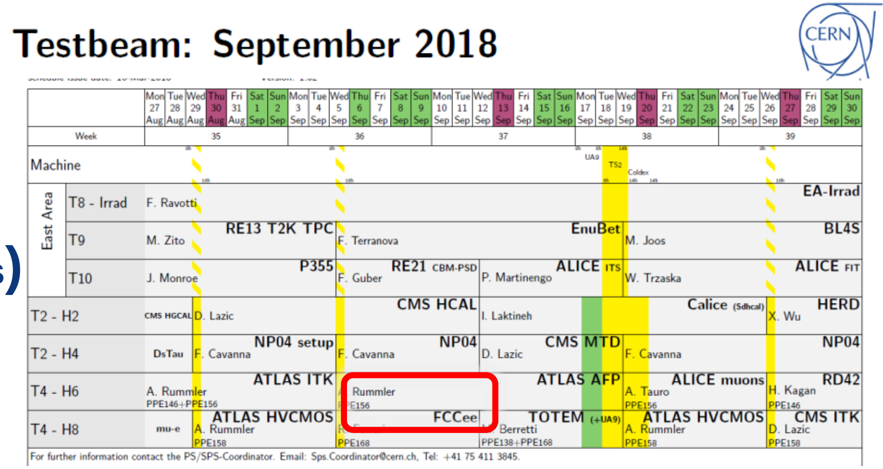
3. Great progress made on detectors

-- **CLIC-like-Detector (CLD) adapted to FCC-ee**:

- lower (2T) mag. field, larger tracker, smaller beam pipe
- Full simulation! similar performance achieved as CLIC model
- provides excellent baseline solution.

-- **FCC-ee dedicated detector (InternationalDetectorElectronAccelerators)**

- now defined and simulations started (tracker)
- well suited to bunch crossing rate
- transparent and cost efficient
- **«slice» of critical element will be in T4 test beam in Sept. 2018 →**



FCC-ee MDI & Detector

Beam pipe R ≤1.5 cm

VTX: 4-7 layers

Wire Drift Chamber:
4 m long, R 30-200 cm
He 90% - iC4H10 10%
1cm drift, <400ns

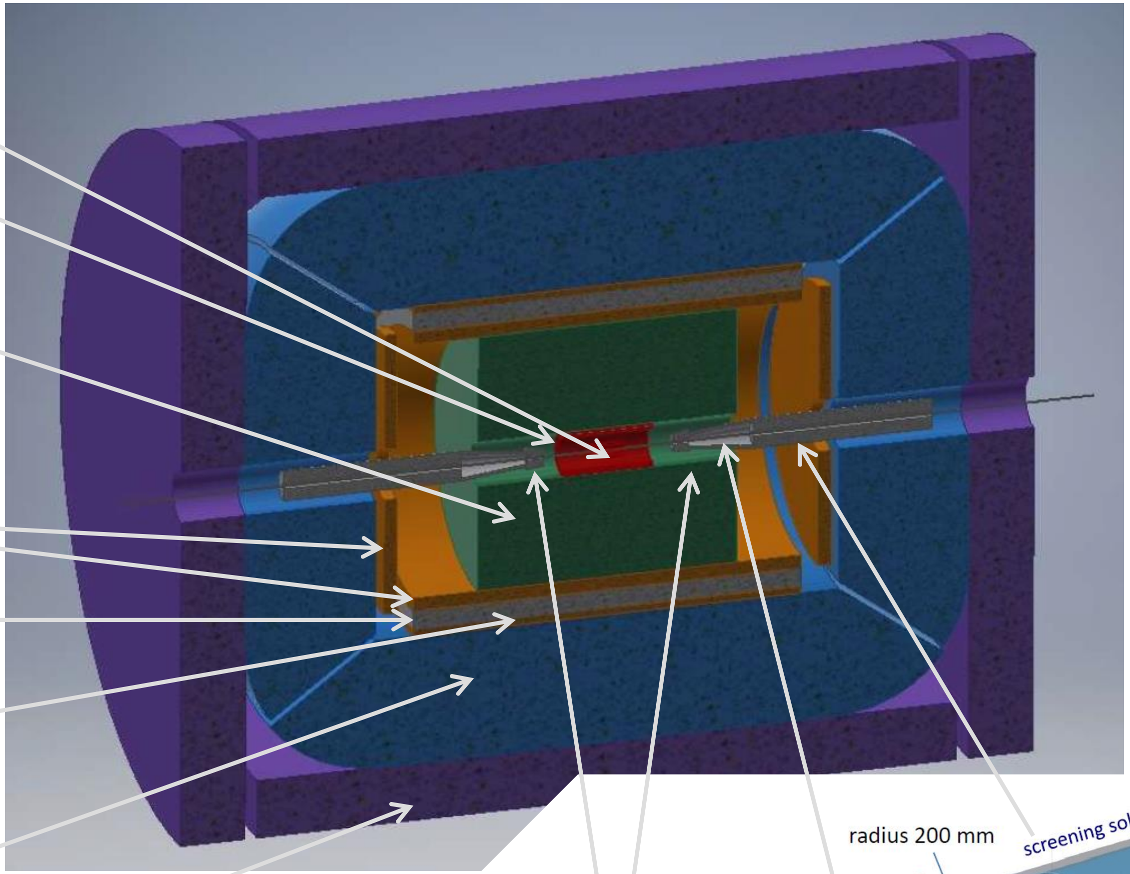
Outer Silicon Layer

thin SC Coil inside calos.:
2 T, R~2 m 0.79X_0

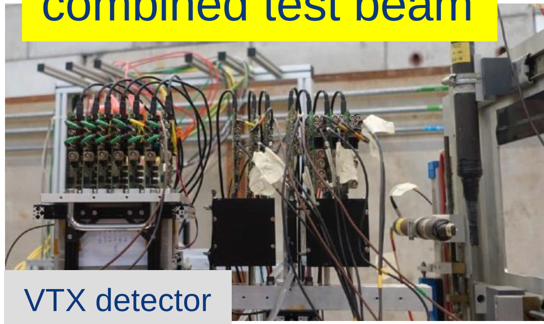
Preshower: ~ 1-2 X0

Dual Readout calorimeter
2 m/7λ_I

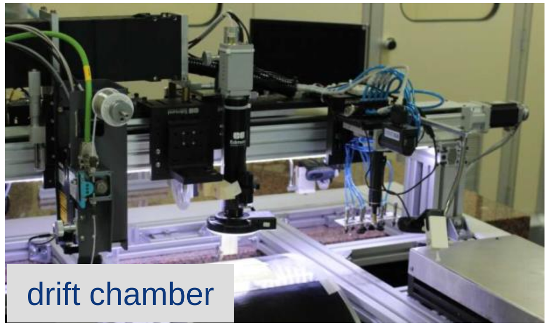
Yoke / muon chamber



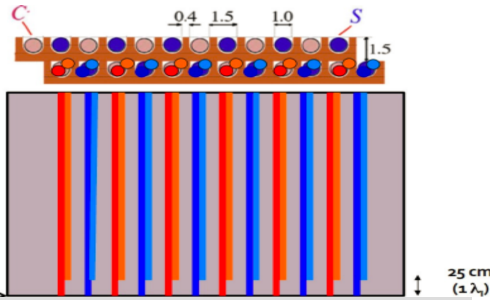
combined test beam



VTX detector

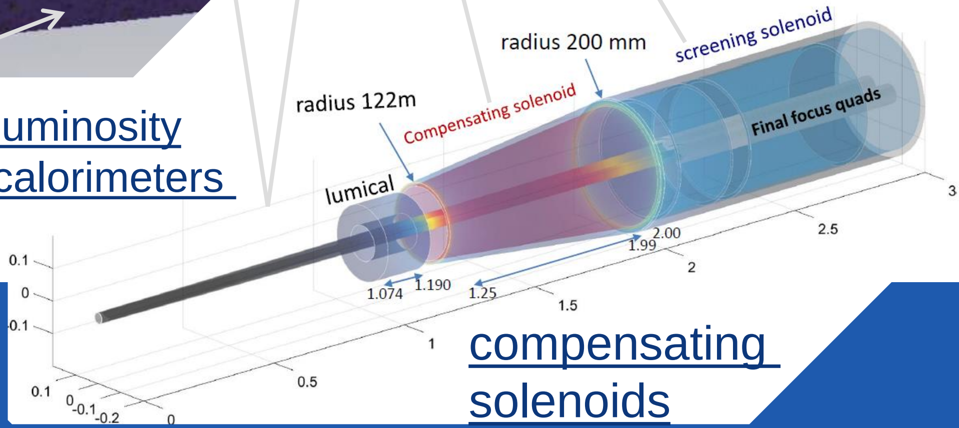


drift chamber



DR calorimeter with shifted fibers

luminosity calorimeters



compensating solenoids

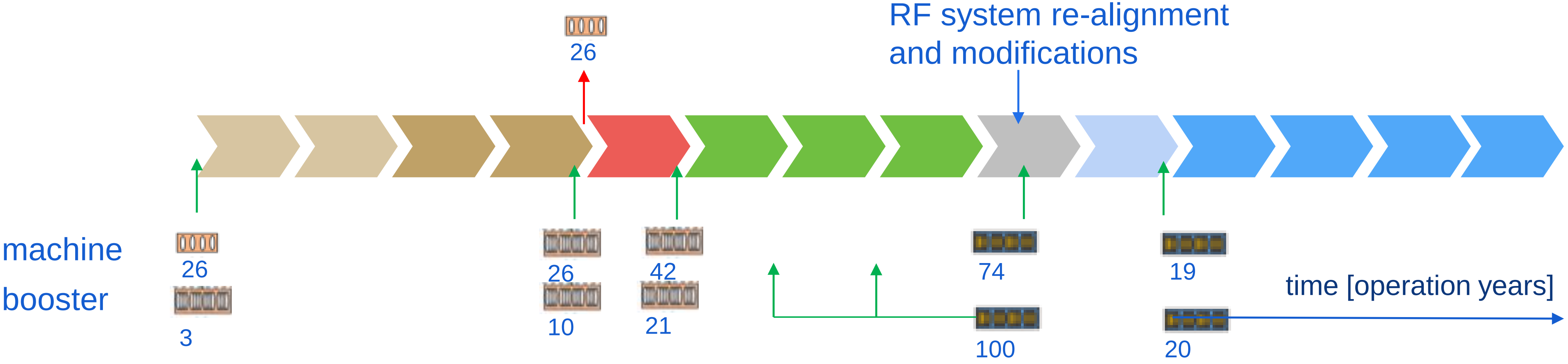
FCC-ee RF staging scenario

WP	V_{rf} [GV]	#bunches	I_{beam} [mA]
Z	0.1	16640	1390
W	0.44	2000	147
H	2.0	393	29
ttbar	10.9	48	5.4

“high-gradient” vs high-current machine

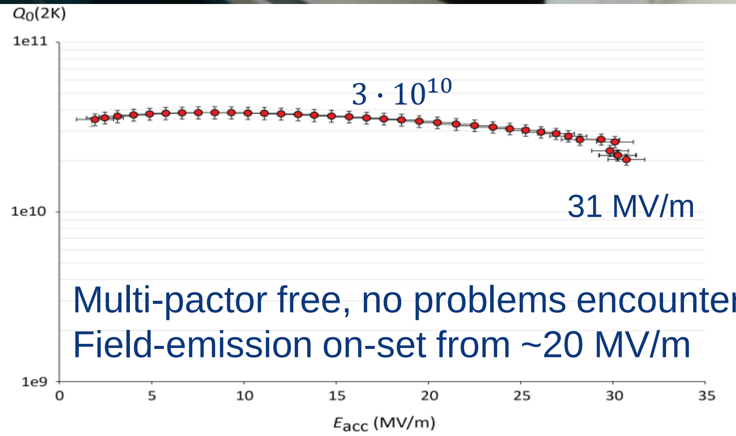
three sets of RF cavities to cover all options for FCC-ee & booster:

- **high intensity (Z,** FCC-hh**): 400 MHz mono-cell cavities (4/cryom.)**
- **higher energy (W, H, t): 400 MHz four-cell cavities (4/cryomodule)**
- **ttbar machine complement: 800 MHz five-cell cavities (4/cryom.)**
- **installation sequence comparable to LEP (≈ 30 CM/shutdown)**



SRF cavity development (examples)

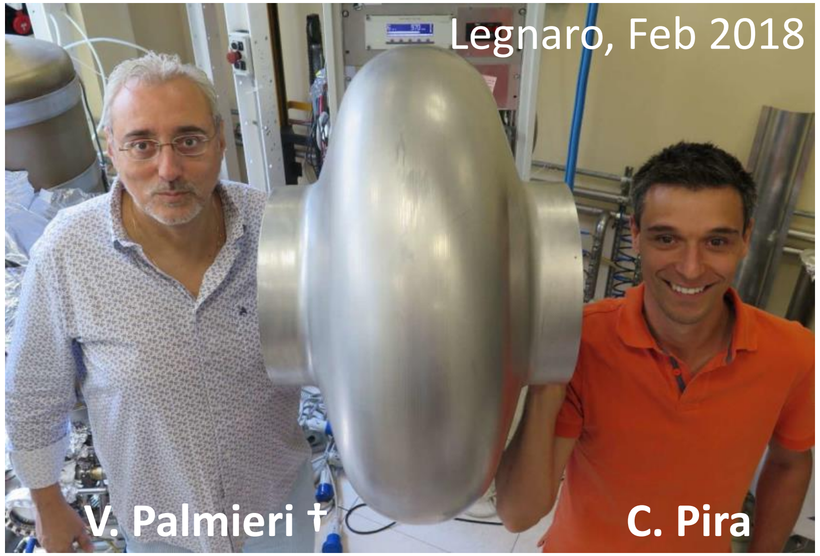
5-cell 800 MHz cavity, JLAB prototype for both FCC-ee (t-tbar) & FCC-eh ERL



Multi-pactor free, no problems encountered,
Field-emission on-set from ~20 MV/m

Seamless 400 MHz single-cell cavity formed by spinning at INFN-LNL

Tooling fabricated and successfully tested with an Aluminium cavity.

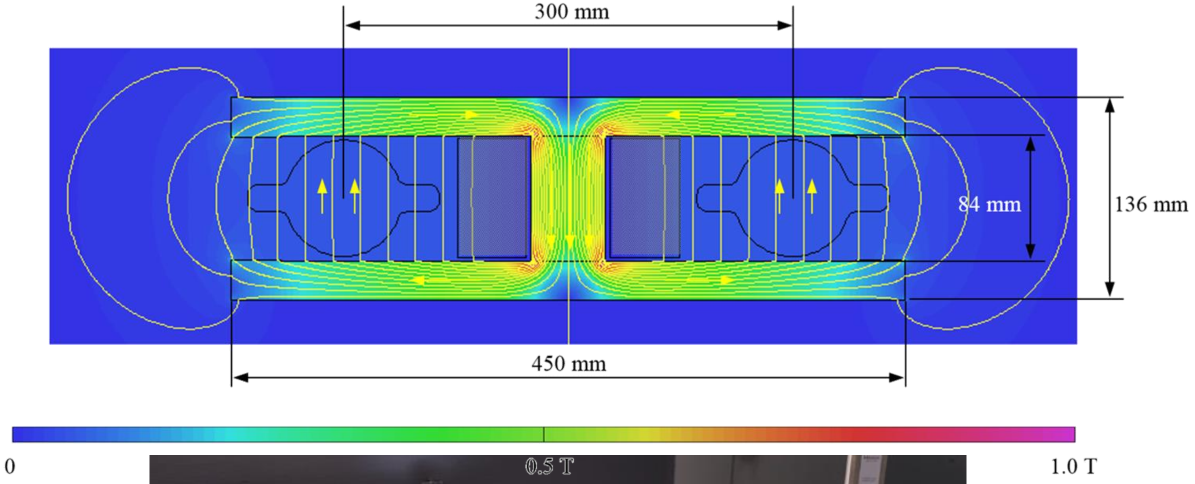


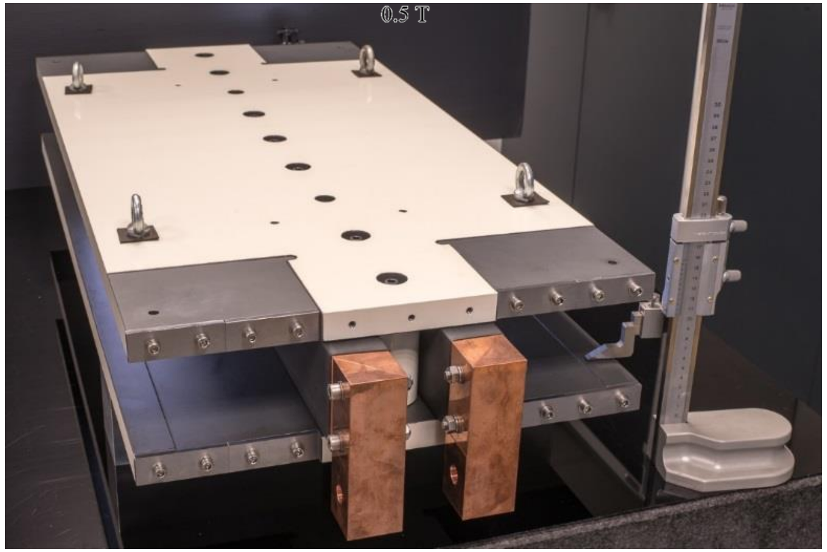
† We're very saddened about the sudden death of Vincenzo Palmieri a month ago.

CERN half-cells formed using Electro-Hydro-Forming (EHF) at Bmax.

High strain rate technology using shockwaves in water from HV discharge. EHF investigated for half-cells and seamless Nb and Cu cavities.

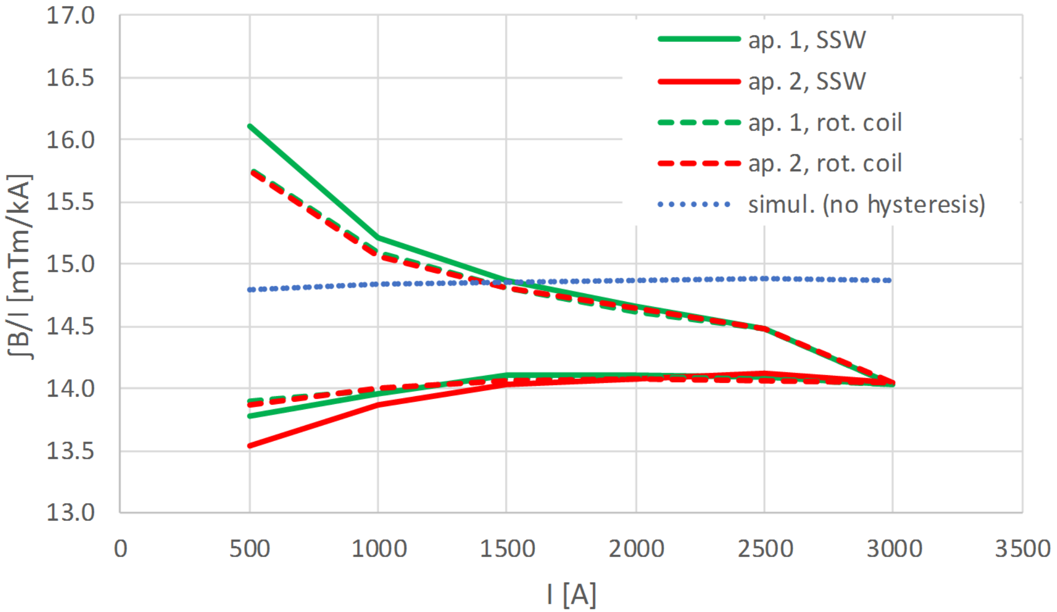
Low-power low-cost design for FCC-ee dipoles





first 1 m long prototype

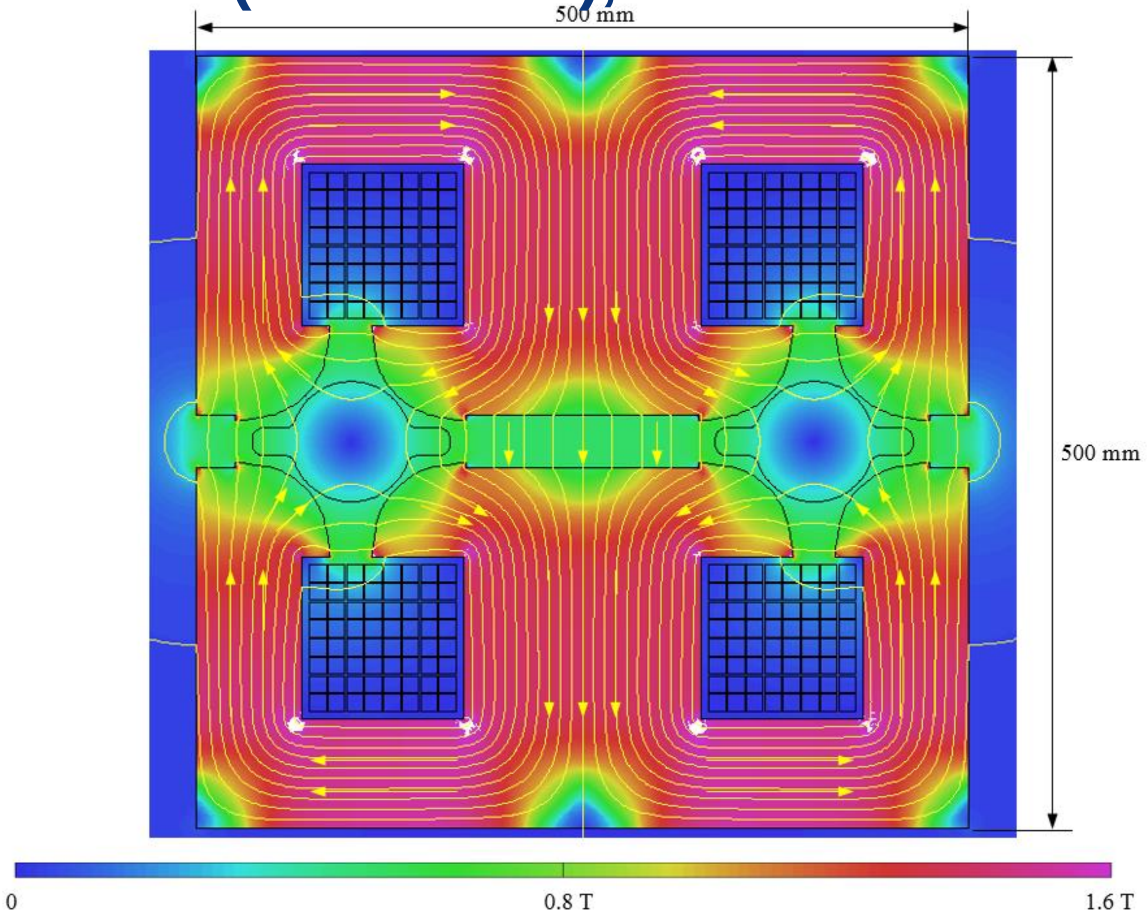
Twin-dipole design with 2× power saving 16 MW (at 175 GeV), with Al busbars



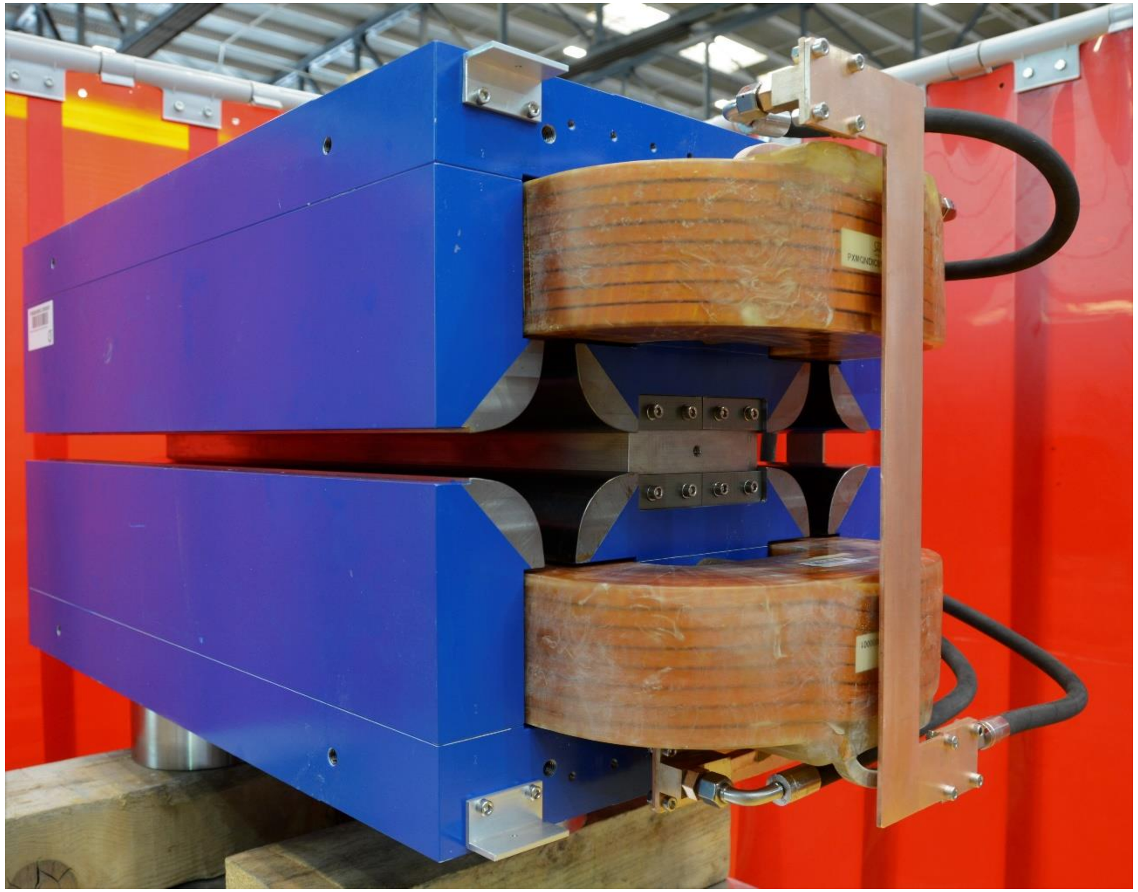
the twin behaviour is confirmed: more measurements are planned for the low field effects and the multipoles

Low-power twin design for FCC-ee quadrupoles

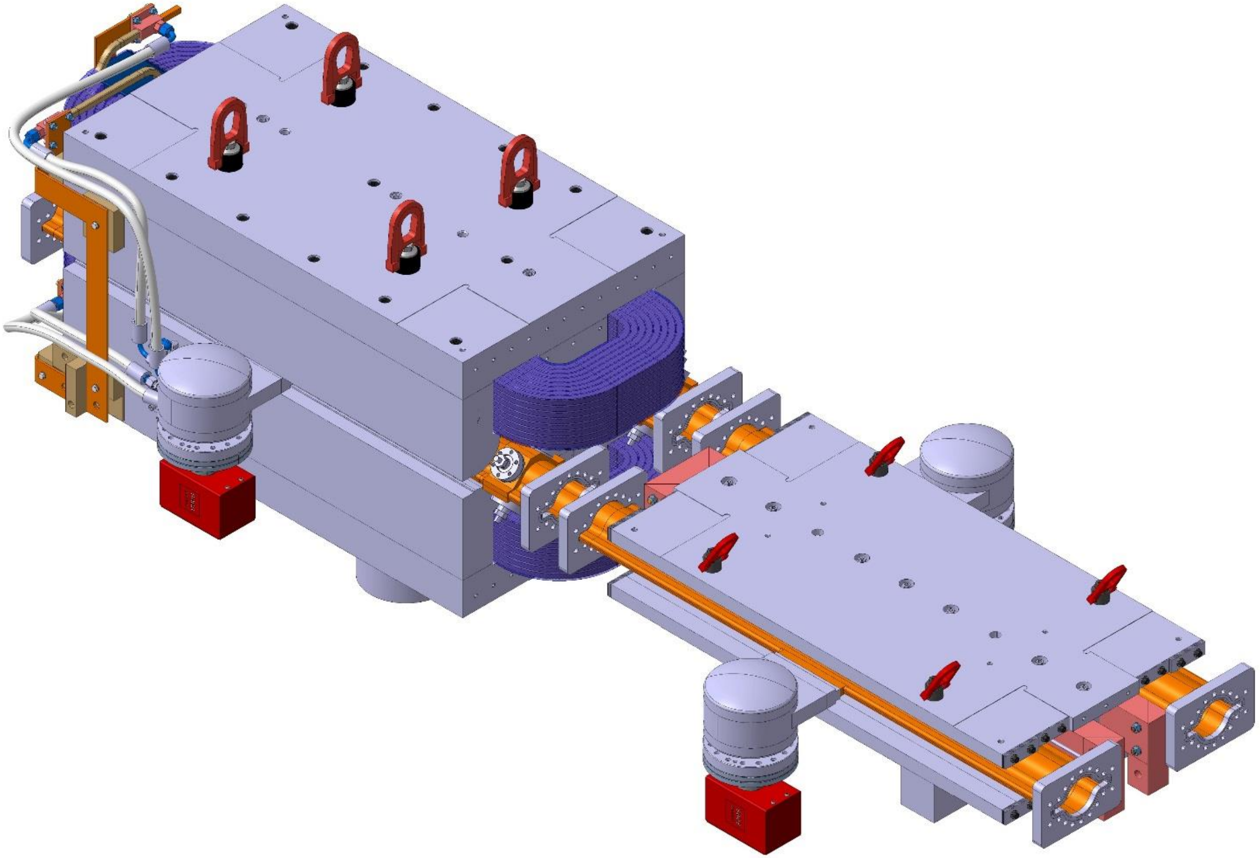
twin F/D design with 2× power saving
25 MW (at 175 GeV), with Cu conductor



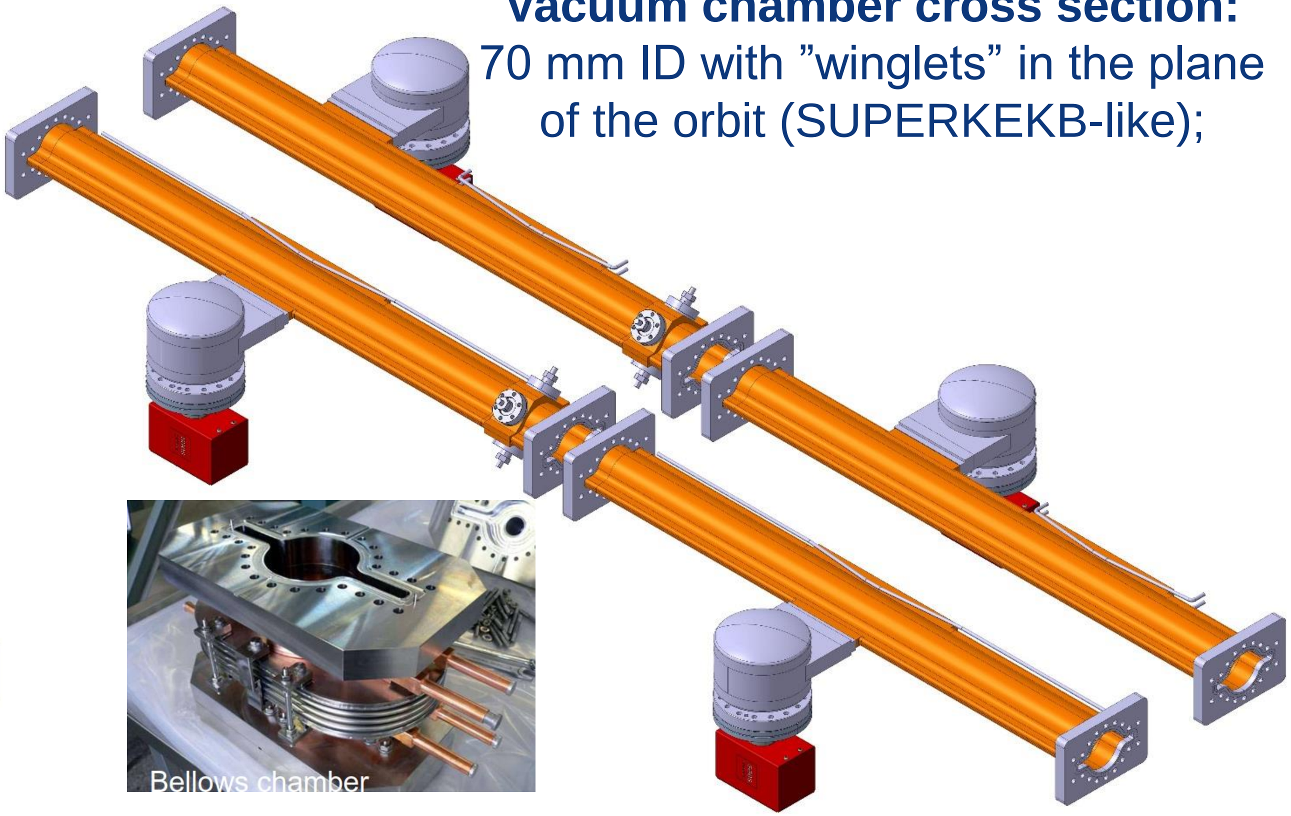
first 1 m long prototype
magnetic measurements pending



FCC-ee arc vacuum prototyping & integration

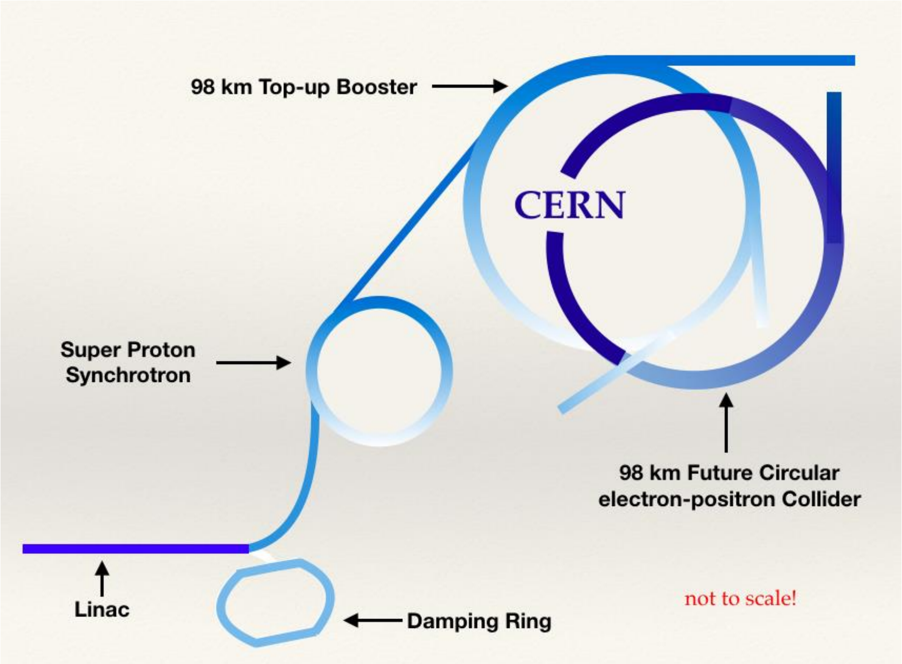


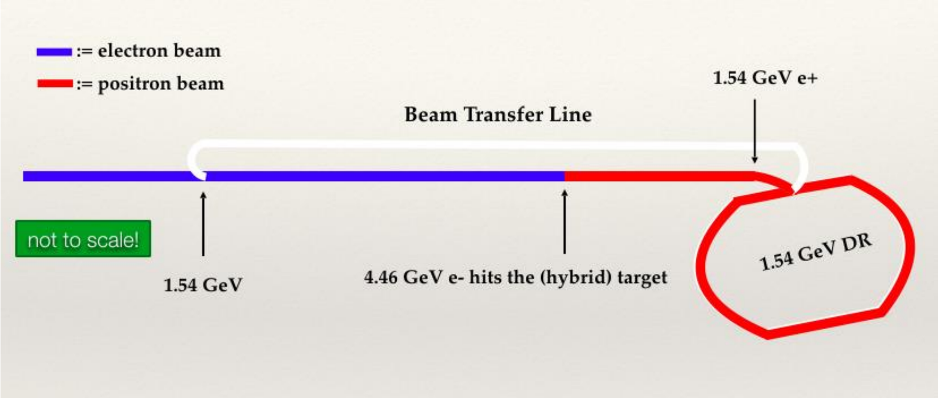
Vacuum chamber cross section:
70 mm ID with ”winglets” in the plane of the orbit (SUPERKEKB-like);



- CAD model of the1m-long twin dipole and quadrupole prototypes with arc vacuum chambers.
- The chambers feature lumped SR absorbers with NEG-pumps placed next to them.
- **Construction of chamber prototypes in coming months and integration with twin magnets**

FCC-ee injector layout





- SLC/SUPERKEKB-like linac accelerating **1** or **2** bunches with repetition rate of **100-200 Hz**
- **Same linac** used for positron production @ **4.46 GeV** Positron beam emittances reduced in DR @ **1.54 GeV**
- Injection @ **6 GeV** into of Pre-Booster Ring (SPS or new ring) and acceleration to 20 GeV
- Injection to main Booster @ **20 GeV and interleaved** filling of e+/e- (below **20 min** for full filling) and continuous top-up

FCC-pp collider parameters

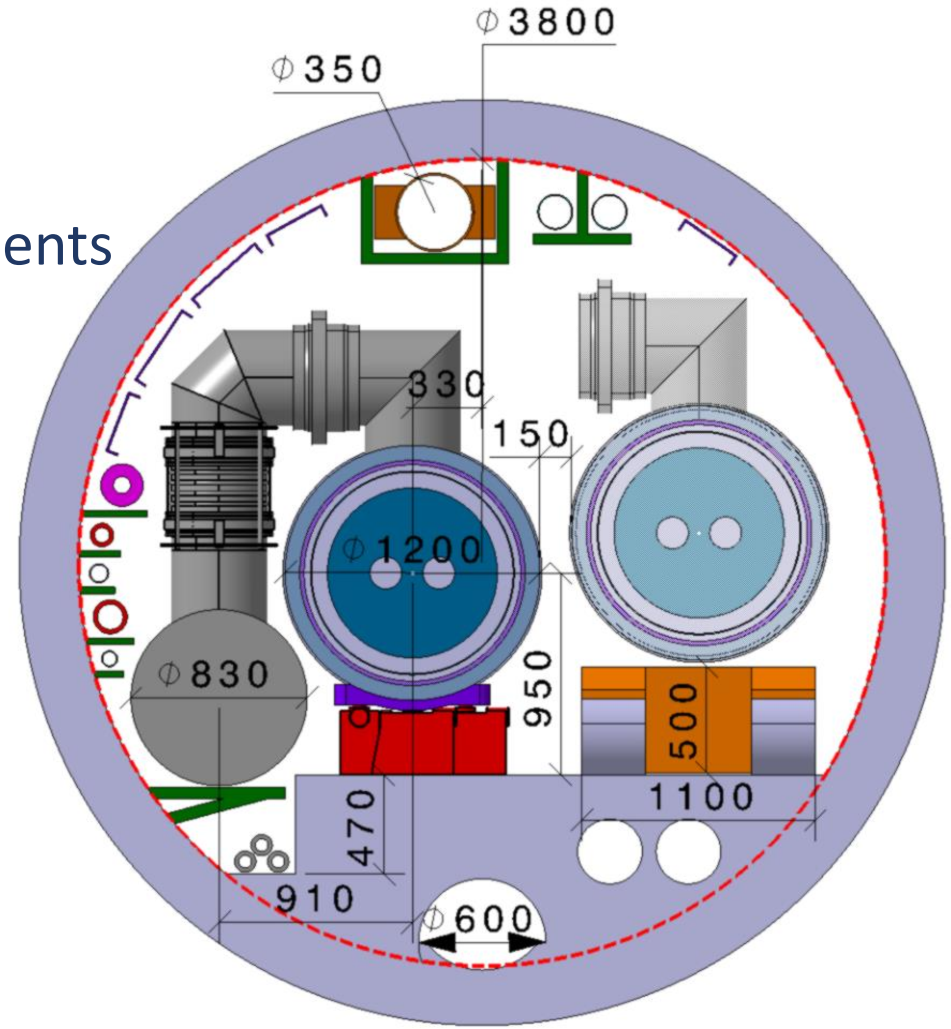
parameter	FCC-hh		HE-LHC	HL-LHC	LHC
collision energy cms [TeV]	100		27	14	14
dipole field [T]	16		16	8.33	8.33
circumference [km]	97.75		26.7	26.7	26.7
beam current [A]	0.5		1.1	1.1	0.58
bunch intensity [10^{11}]	1	1	2.2	2.2	1.15
bunch spacing [ns]	25	25	25	25	25
synchr. rad. power / ring [kW]	2400		101	7.3	3.6
SR power / length [W/m/ap.]	28.4		4.6	0.33	0.17
long. emit. damping time [h]	0.54		1.8	12.9	12.9
beta* [m]	1.1	0.3	0.25	0.15 (min.)	0.55
normalized emittance [μm]	2.2		2.5	2.5	3.75
peak luminosity [10^{34} $cm^{-2}s^{-1}$]	5	30	28	5 (lev.)	1
events/bunch crossing	170	1000	800	132	27
stored energy/beam [GJ]	8.4		1.3	0.7	0.36

HE-LHC integration aspects

Working hypothesis for HE LHC design:

No major CE modifications on tunnel and caverns

- Similar geometry and layout as LHC machine & experiments
- **Maximum magnet cryostat diameter ~1200 mm**
- **Maximum QRL diameter ~830 mm**

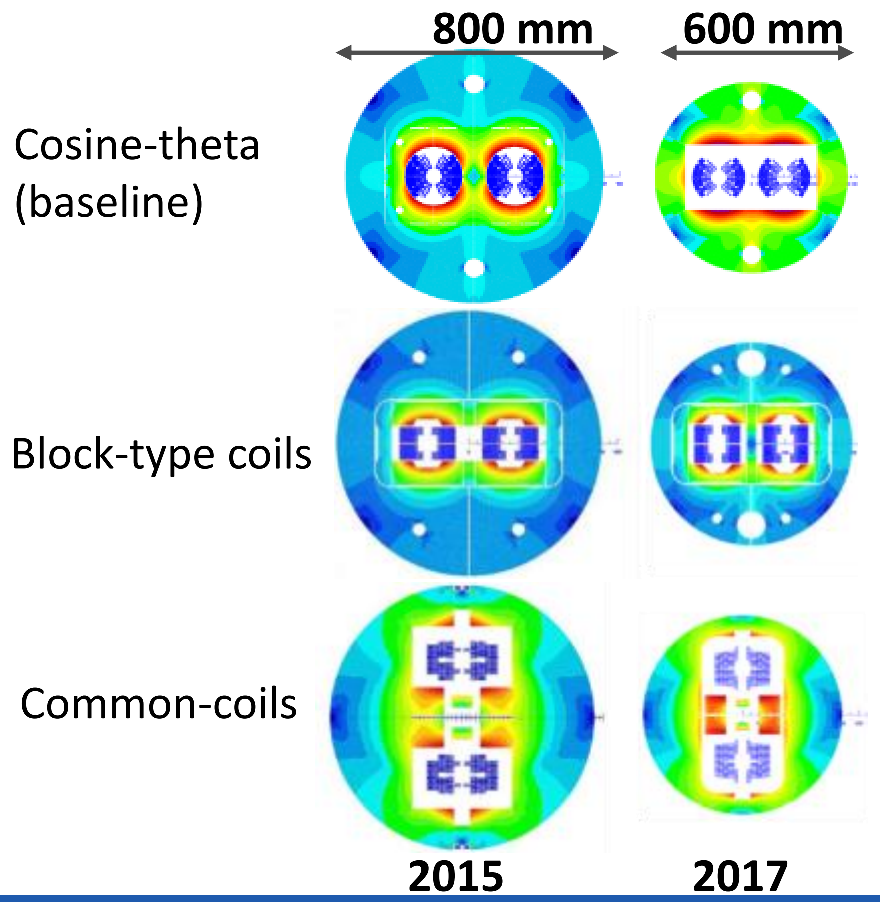


Integration strategy:

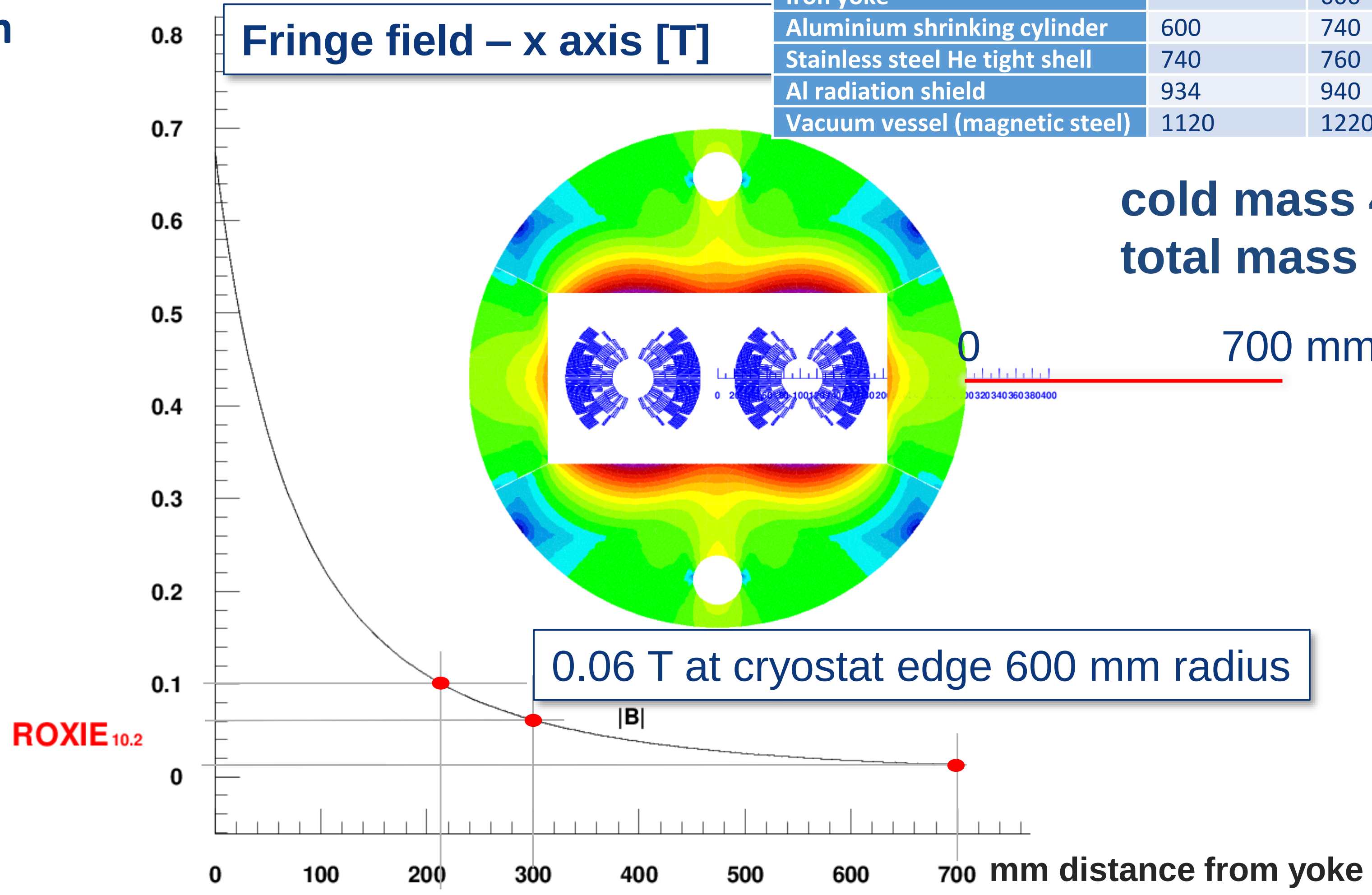
- Development of optimized 16 T magnet, compatible with both HE LHC and FCC-hh
- New cryogenic layout to limit QRL dimension

16 T dipole design evolution

- Coil optimization and margin 18 → 14%
- Inter-beam distance 250 → 204 mm
- Stray-field < 0.1 T at cryostat



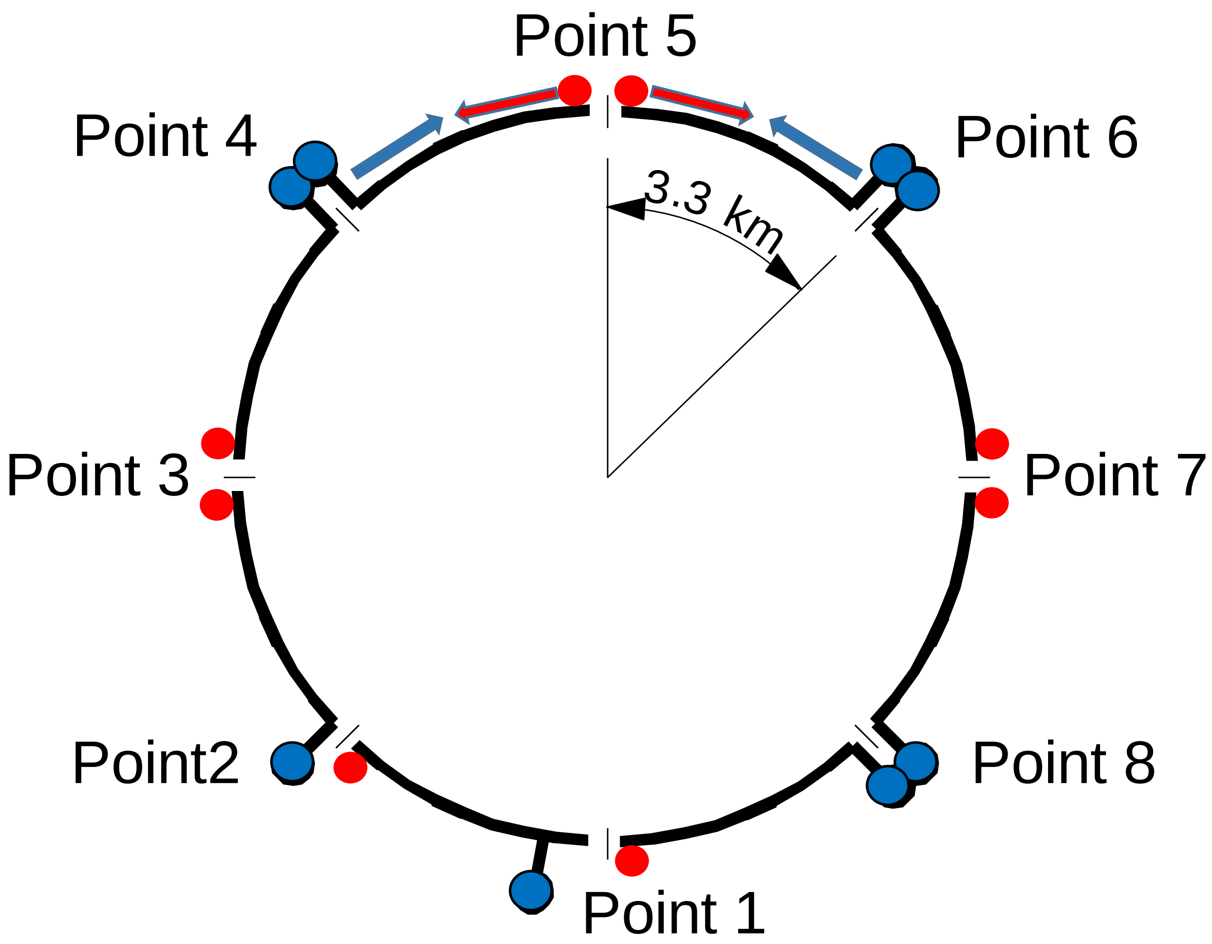
Description	ID in mm	OD in mm
Iron yoke	-	600
Aluminium shrinking cylinder	600	740
Stainless steel He tight shell	740	760
Al radiation shield	934	940
Vacuum vessel (magnetic steel)	1120	1220



cold mass 40t
total mass 62t

HE-LHC cryogenic layout

Half-sector cooling instead of full sector (as for LHC) to limit cross section of cryogenic distribution line

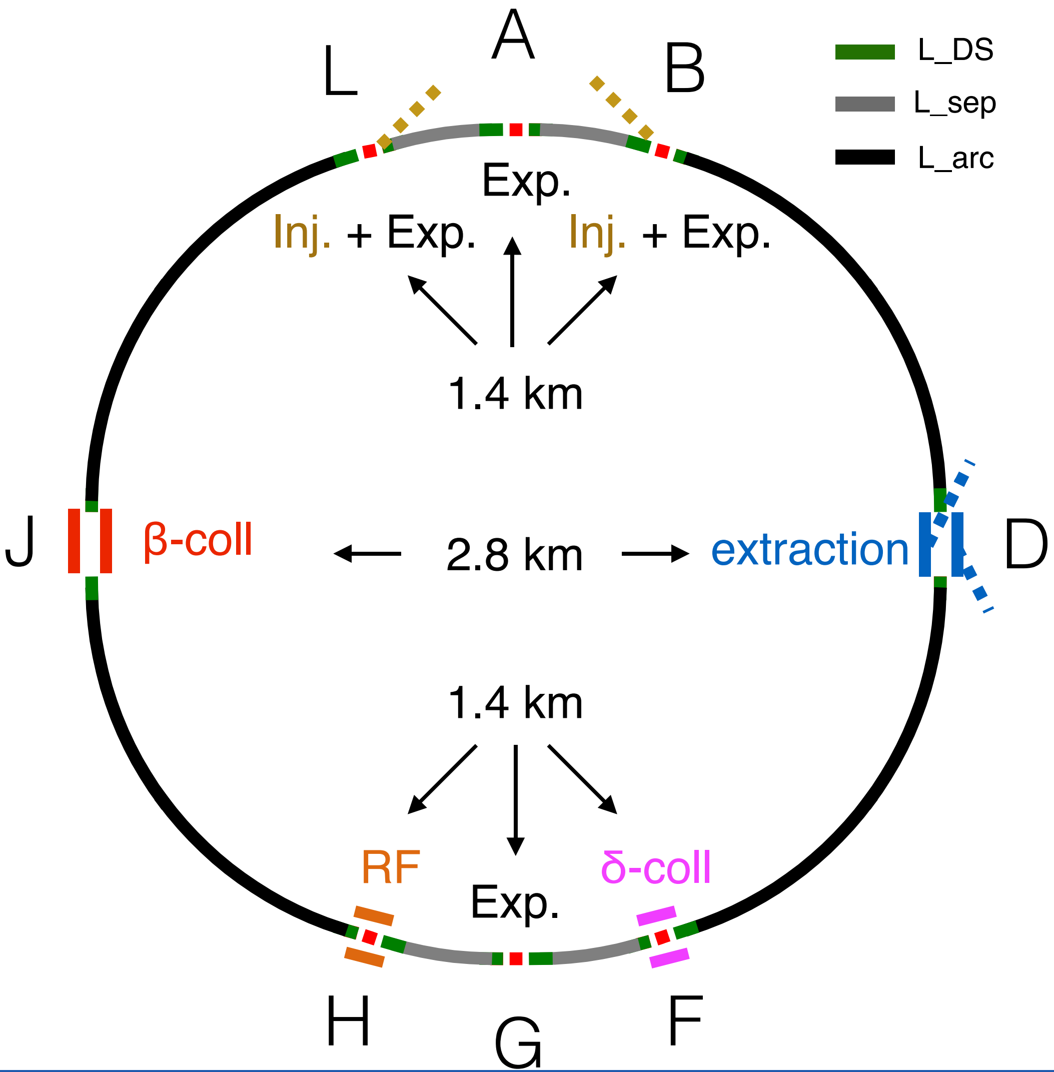


Higher heat load and integration limitations (Cryo-line diameter) requires installation of

- **8 additional 1.8 K refrigeration units wrt. LHC**
  - 2.3 kW @ 1.8 K (~ LHC size)
  - P elect: ~500 kW per unit

- **8 new higher-power 4.5 K cryoplants**
  - 28 kW @ 4.5 K (including 2.3 kW @ 1.8 K)
  - P elect: ~6500 kW per cryoplant (cf. 4200 kW for LHC cryoplant)

FCC-hh design – evolution since Berlin



- L* 40 m
- Experimental insertion adaption
- Overall lenght 1.400 m

- Optimisation work on betatron and momentum collimation systems

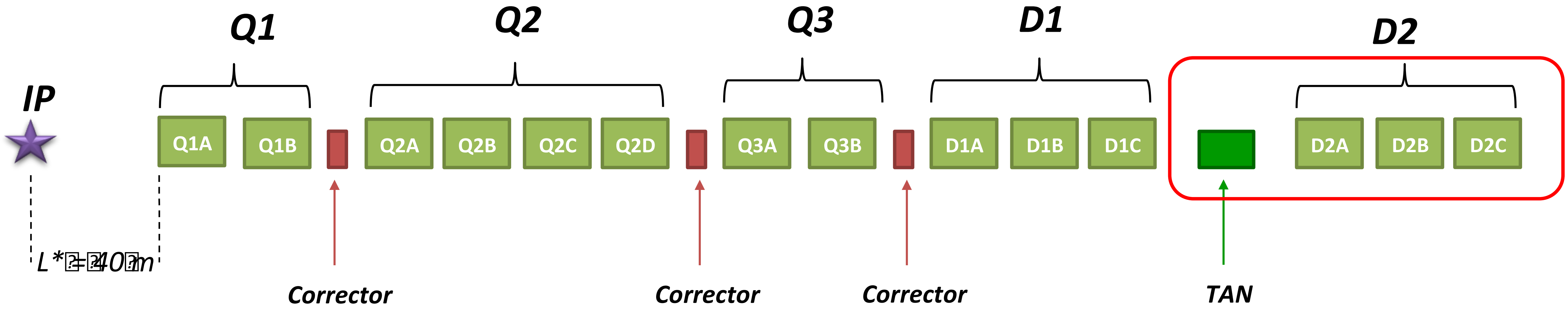
- Optimisation of extraction/dump line design
- Vertical extraction

FCC-hh beam power handling: collision debris

500kW debris per experiment (HL-LHC x 42)

triplets protected by 35 mm inner lining (tungsten shielding)

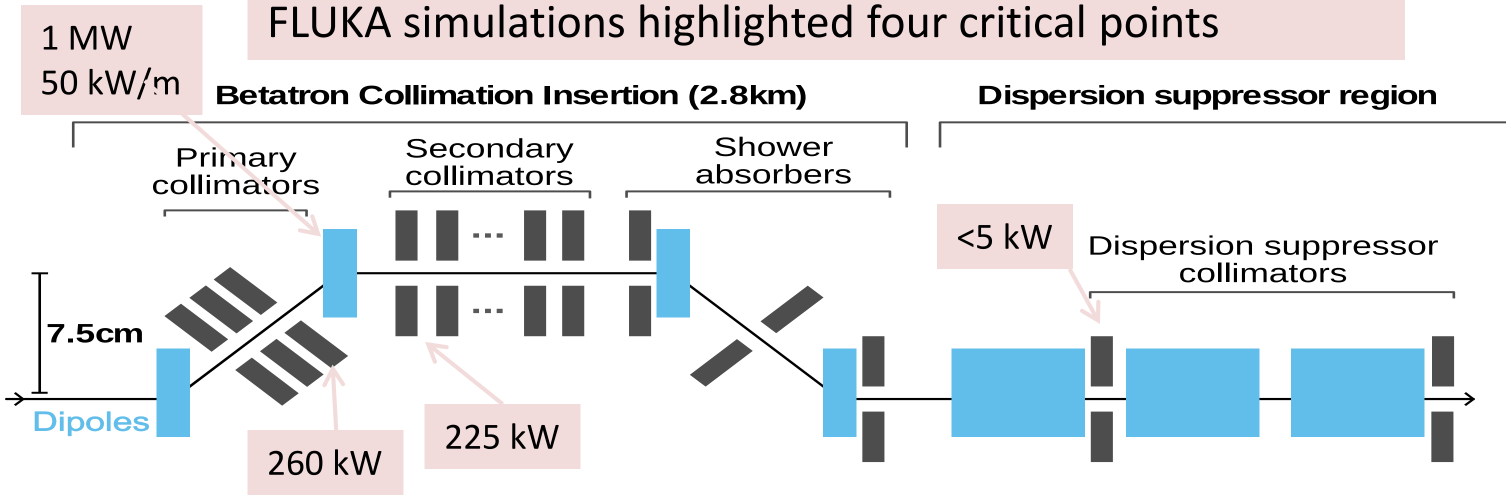
For 30 ab-1	max. dose	Comment
radiation in triplet	70 (40) MGy	today's limit 30 Mgy (for rotated crossing)
heat load In triplet	4.5 mW	expected limit (with safety margin) 5 mW
radiation in dipole	90 MGy unshielded	today's limit 30 MGy; better protection possible



Beam power handling: robust low-loss collimation

Complete designs of collimation insertions, main issue: sustain beam lifetime of 12 mins (12 MW loss)

FLUKA simulations highlighted four critical points



Primary Collimators

- Active length halved

⇒ Max. power reduced from 260 kW to 80 kW

⇒ 50 to 100 kW considered OK

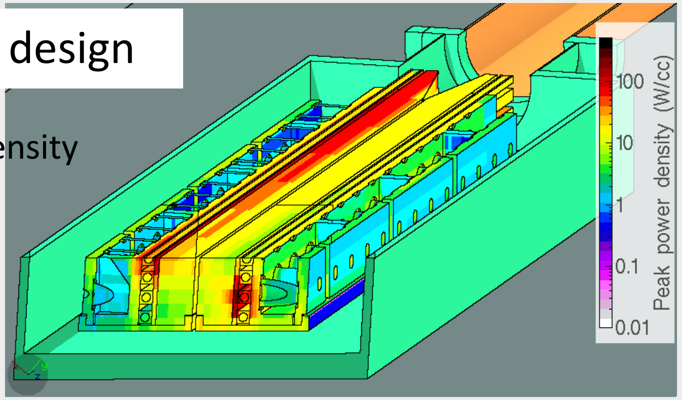
Arc protection Protection design offers sufficient margin

1st Secondary Collimator

Old design

max power density
800 Wcm^{-3}

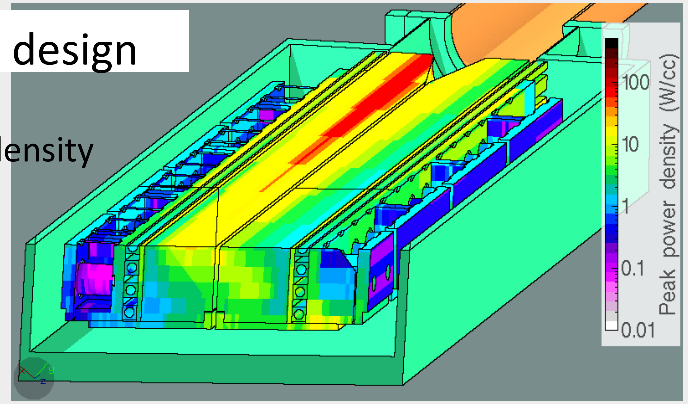
total power
225 kW



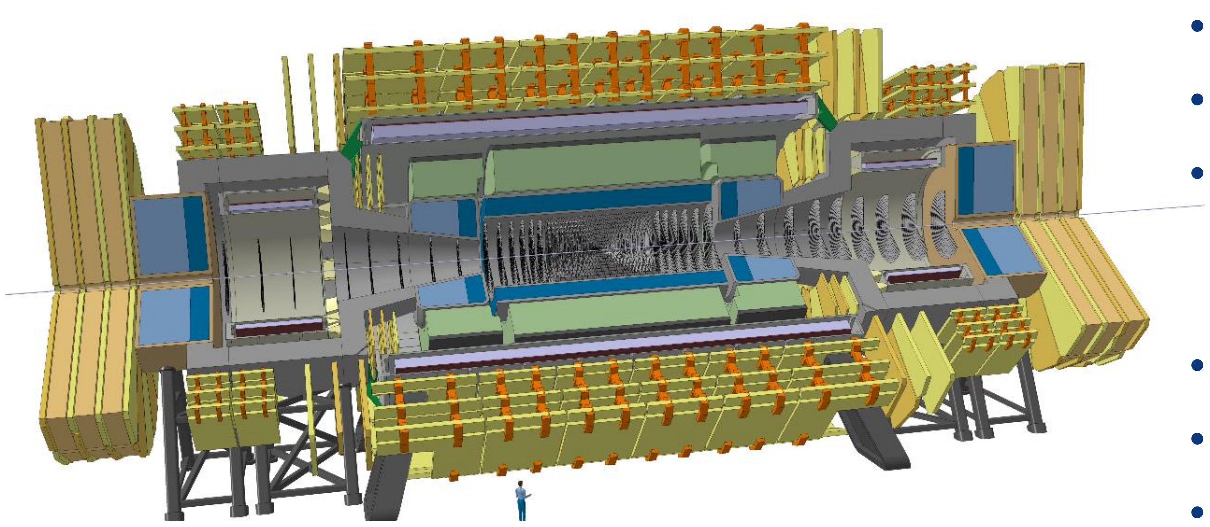
New design

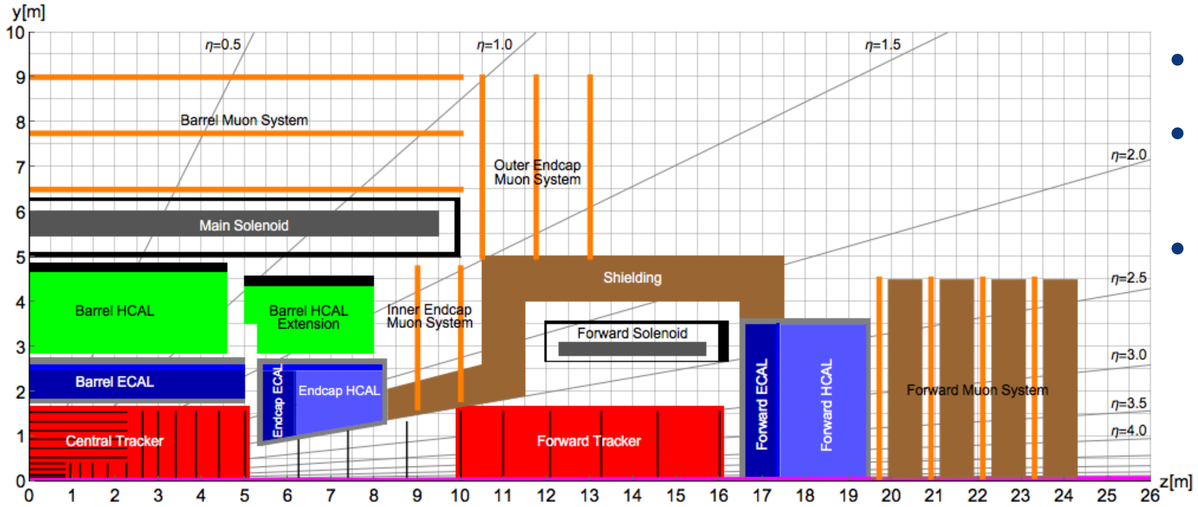
max power density
115 Wcm^{-3}

total power
92 kW



FCC-hh reference detector



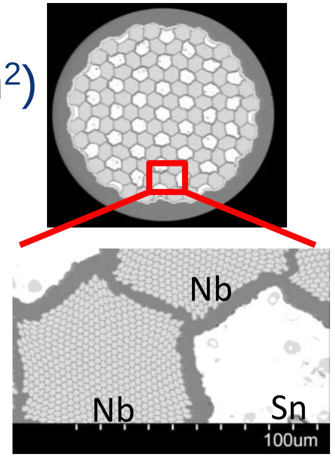


- **Detector concept unchanged since last year.**
- **Central Solenoid, 4T, 10m free bore, unshielded**
- **Forward Solenoids, 4T, 5m free bore, unshielded**
  - **→ Service cavern at 50m distance from detector cavern for magnetic shielding <0.5 mT and CE optimization.**
- Silicon Tracker 400m^2 total surface up to η=6
- Precision momentum measurement up to η=4
- ECAL & HCAL up to η=6
- Granularity about 4x ATLAS/CMS
- Muon system for trigger, identification, momentum resolut.

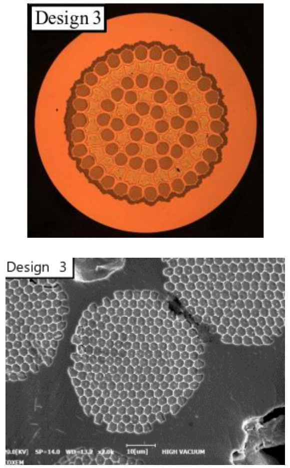
- **Challenges:**
  - **Pileup of 1000 vs. 140 at HL-LHC**
  - **Radiation levels up to 10^{18} cm^{-2} 1MeV neutron equivalent vs. 10^{16} cm^{-2} at HL-LHC**
  - **Total data rate of 1-1.5 PByte/s**
  - **Integration, opening and maintenance scenarios**

Global Nb_3Sn wire development program

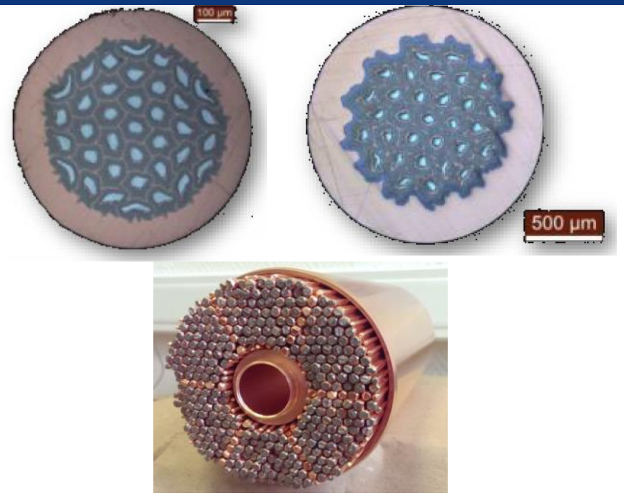
- After one year development, prototype **Nb_3Sn wires achieving the HL-LHC performance** (~ 1000 A/mm^2) **already produced** by several industrial partners.
- **Impressive progress** for companies starting production of internal-tin high field wire
- **Innovative wire layouts** proposed and produced
- Strong **motivation of industrial partners** and **confidence on achieving performance and cost.**



Jastec - Japan



Kiswire KAT - Korea



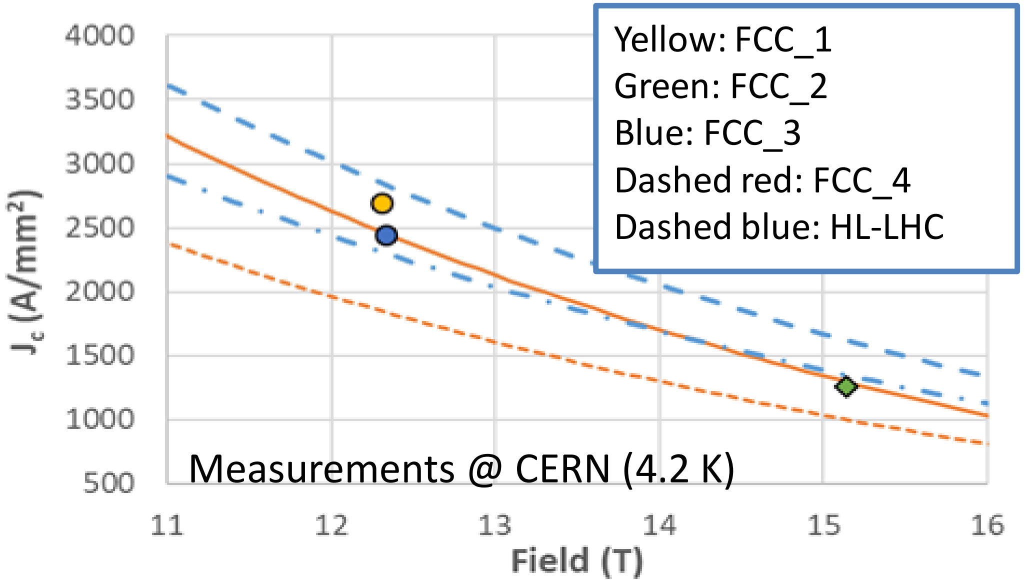
Bochvar/TVEL - Russia

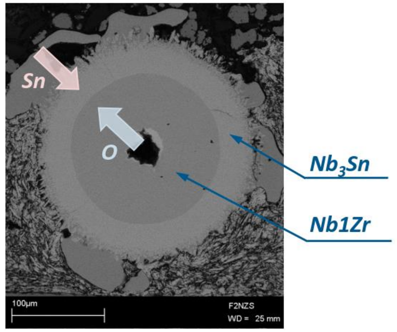
Conductor activities for FCC started in 2017:

- **Bochvar Institute** (production at **TVEL**), **Russia**
- **KEK** (**Jastec** and **Furukawa**), **Japan**
- **KAT**, **Korea**
- **Columbus, Italy**
- **University of Geneva, Switzerland**
- **Technical University of Vienna, Austria**
- **SPIN, Italy**
- **University of Freiberg, Germany**

In addition, being finalized agreements with:

- **Bruker (Germany)**
- **Luvata Pori (Finland)**

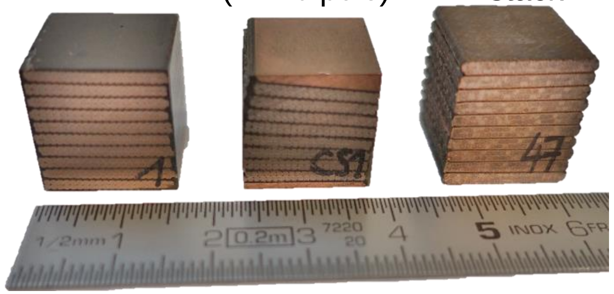




Internal oxidation Unige

Nb_3Sn wound conductor tests

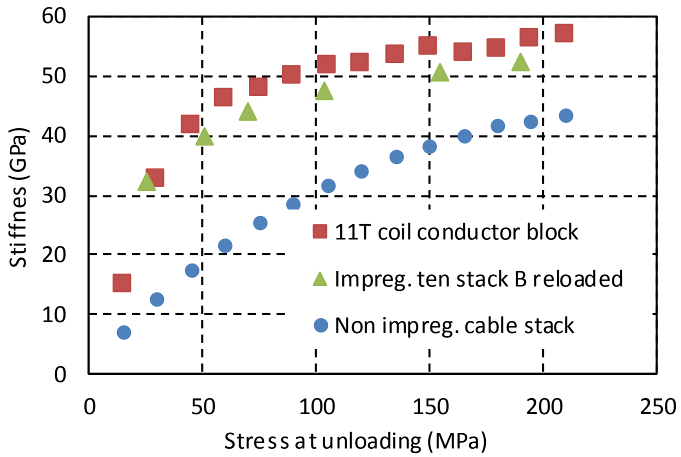
Ten stack | Coil block (11T-dipole) | Non-imprg. ten stack



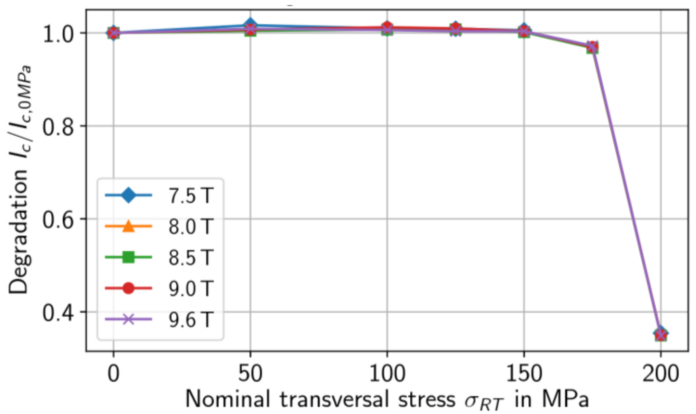
Cubic samples (width = 15 mm)

Various tests relevant for coil and magnet production, using Rutherford cable, stacks or coil blocks:

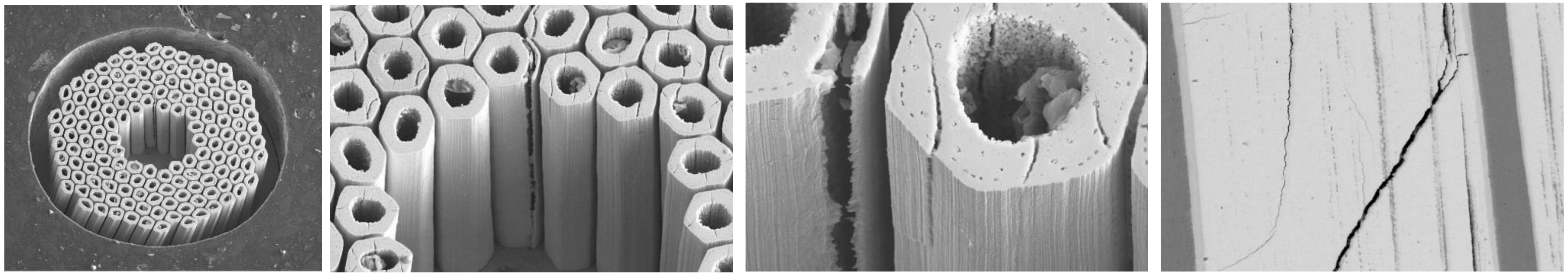
- Impact of transverse stress
- Stiffnes of reacted coil samples
- Windability of cables
- Etc.



Stiffness comparison of impregnated and non impregnated samples (Influence of pre-stress, compaction during heat treatment, load direction, Impregnation)

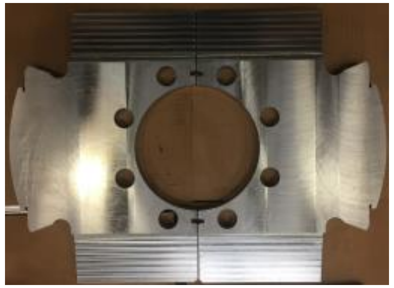


Relative **critical current degradation** as function of **transversal compressive stress** at room temperature



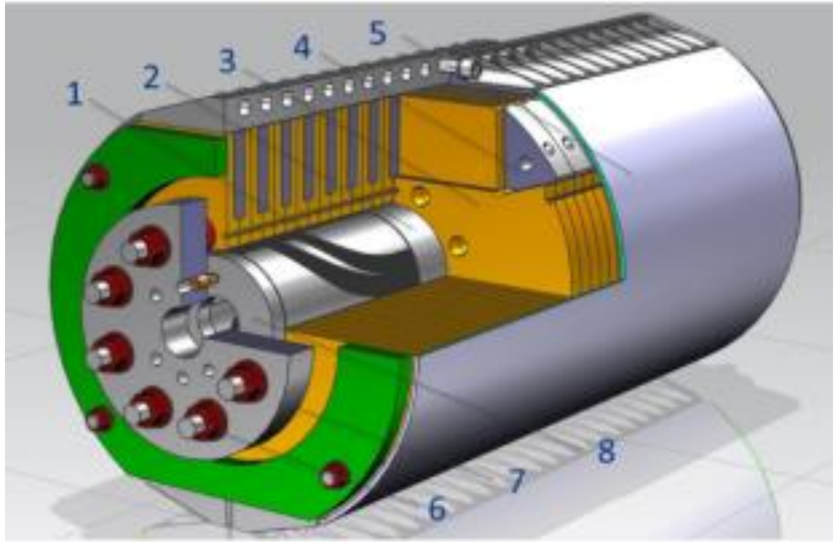
Cracks in Nb_3Sn subelements after applied transverse stress at RT.
Microscopy by CERN MME and USTEM (Vienna)

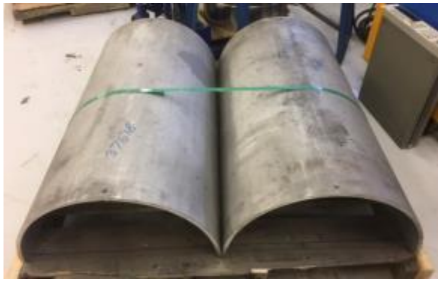
15 T dipole demonstrator (US-MDP)



Iron Laminations

AL I-Clamps





StSt Skin

End Plates

Fillers

Axial Rods

- **All coil parts, structural components and tooling are available at FNAL**
- **Coil fabrication and the work with mechanical structure are in progress**
- **Magnet first test in September 2018**

16 T ERMC construction at CERN

First ERMC coil winding

Aluminum shell

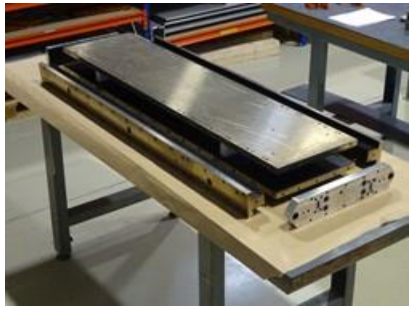
Magnet yoke

Coil fabrication

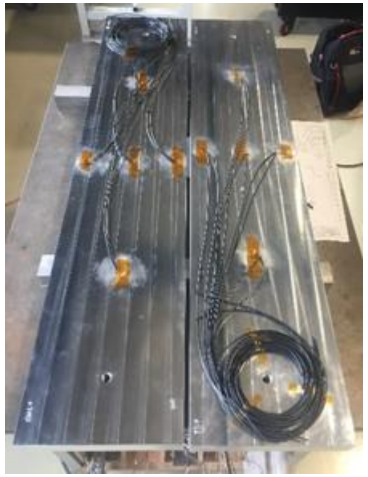
- Winding of the first coil has been completed
- Preparation for reaction on-going
- All tooling for coil production ready

- **Magnet assembly**
  - components and tooling ready
  - Dummy assembly to characterize the structure behavior on-going.

Coil Reaction Tool



Coil Impregnation Tool

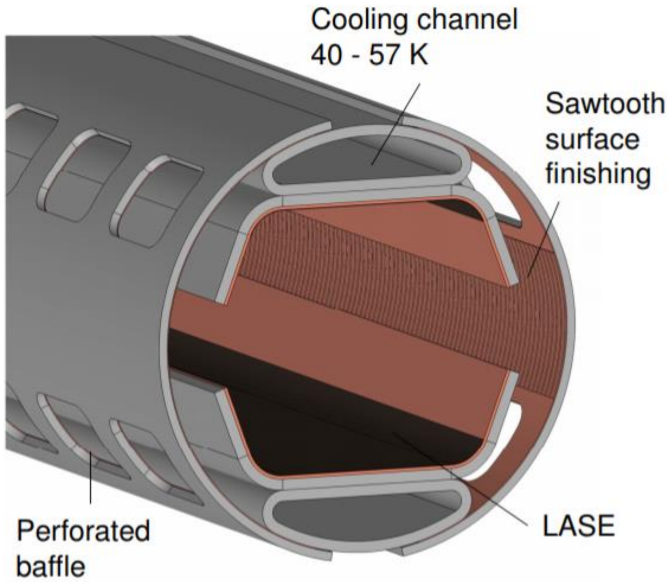


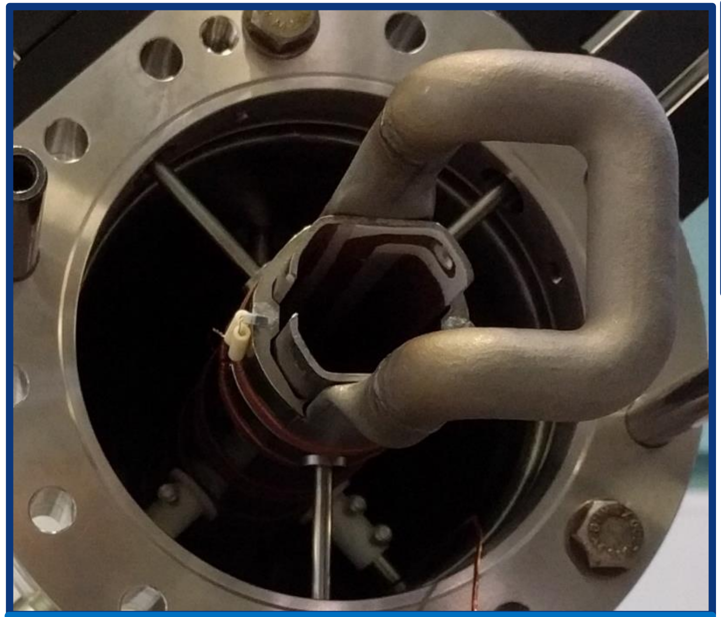
Dummy coils

Axial rods

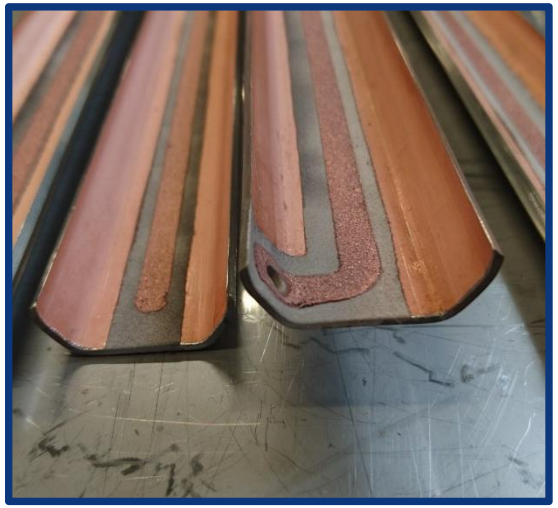
FCC-hh: beam screen evolution & tests

Simplified BS design in view of:
- Mass production
- Impedance optimization
- e- cloud mitigation
- latest version to be tested summer ‘18





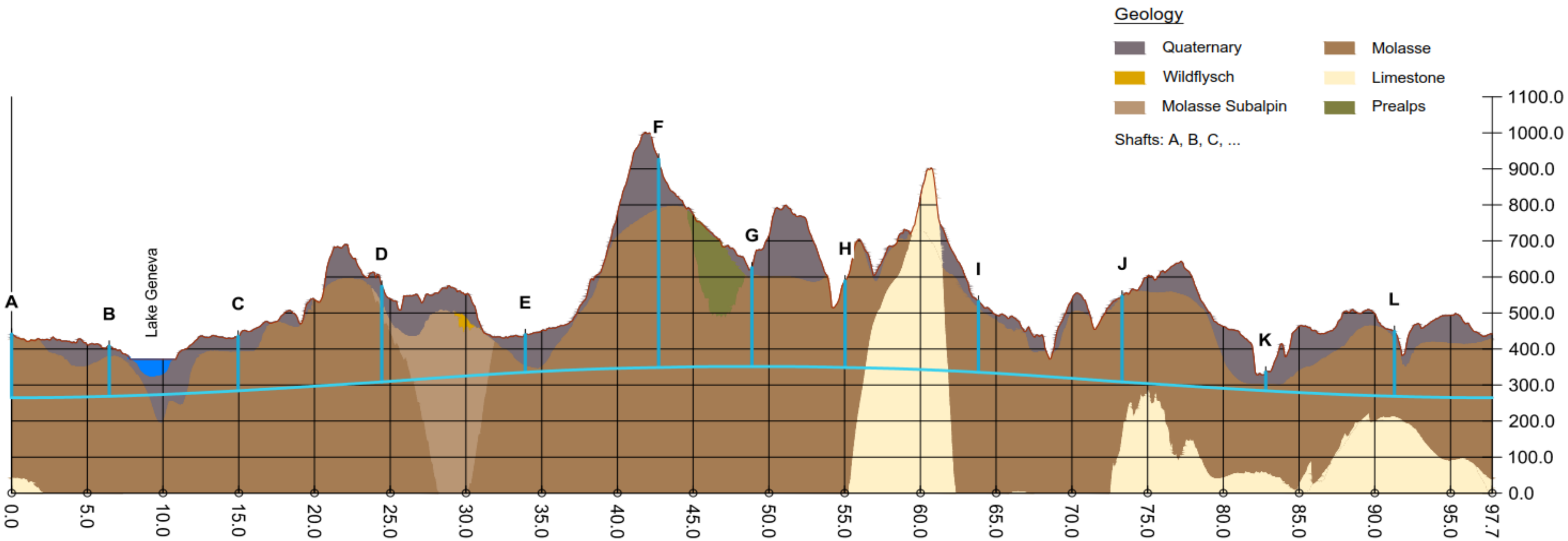
Cold Sprayed Isolated Electrode
(e-cloud mitigation option)

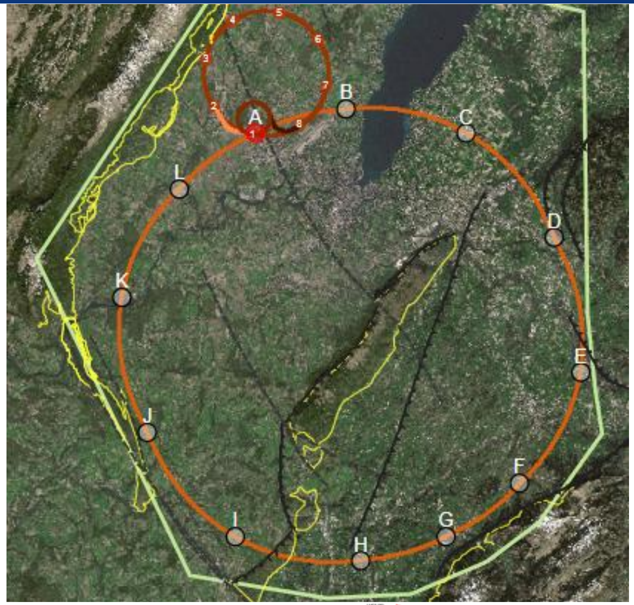


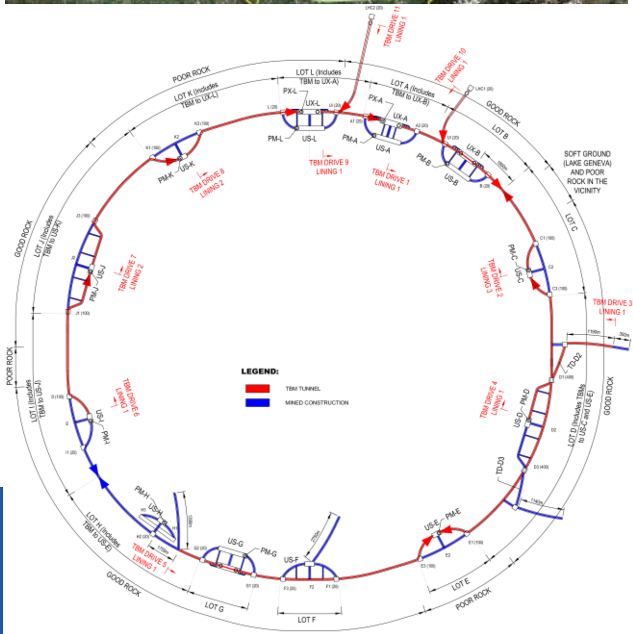
Design optimisation:
- Ribs removed; Optimization of thickness of copper and steel
- Connection absorber/cooling tube, and welding positions

- **Measurements at KARA/KIT (pressure evolution) confirm MC vacuum simulations**
- Confident to use simulations for all vacuum design

Implementation - new footprint baseline





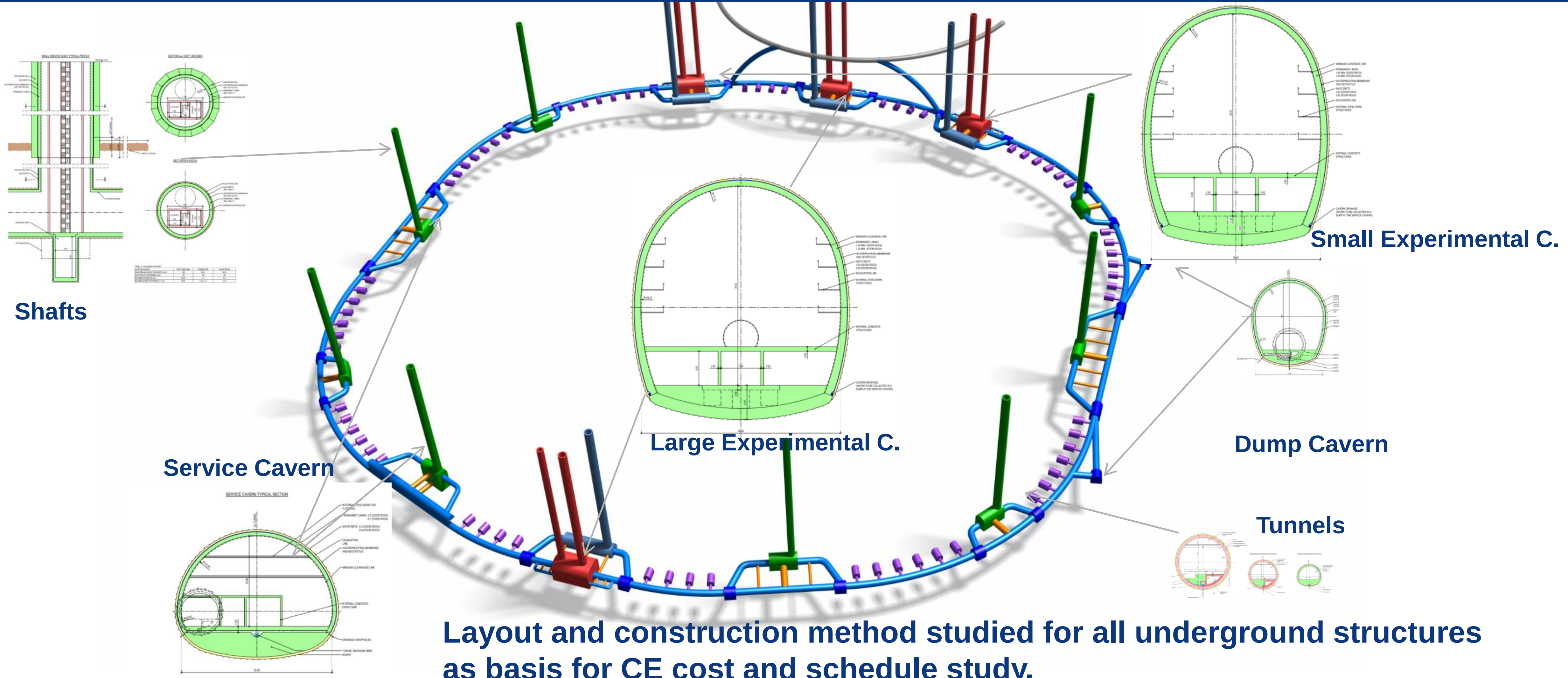


Following geological review of the most challenging areas a new baseline position was established considering:

- Lowest risk for construction
- Fastest and cheapest construction
- Feasible positions for large span caverns (the most challenging structures)

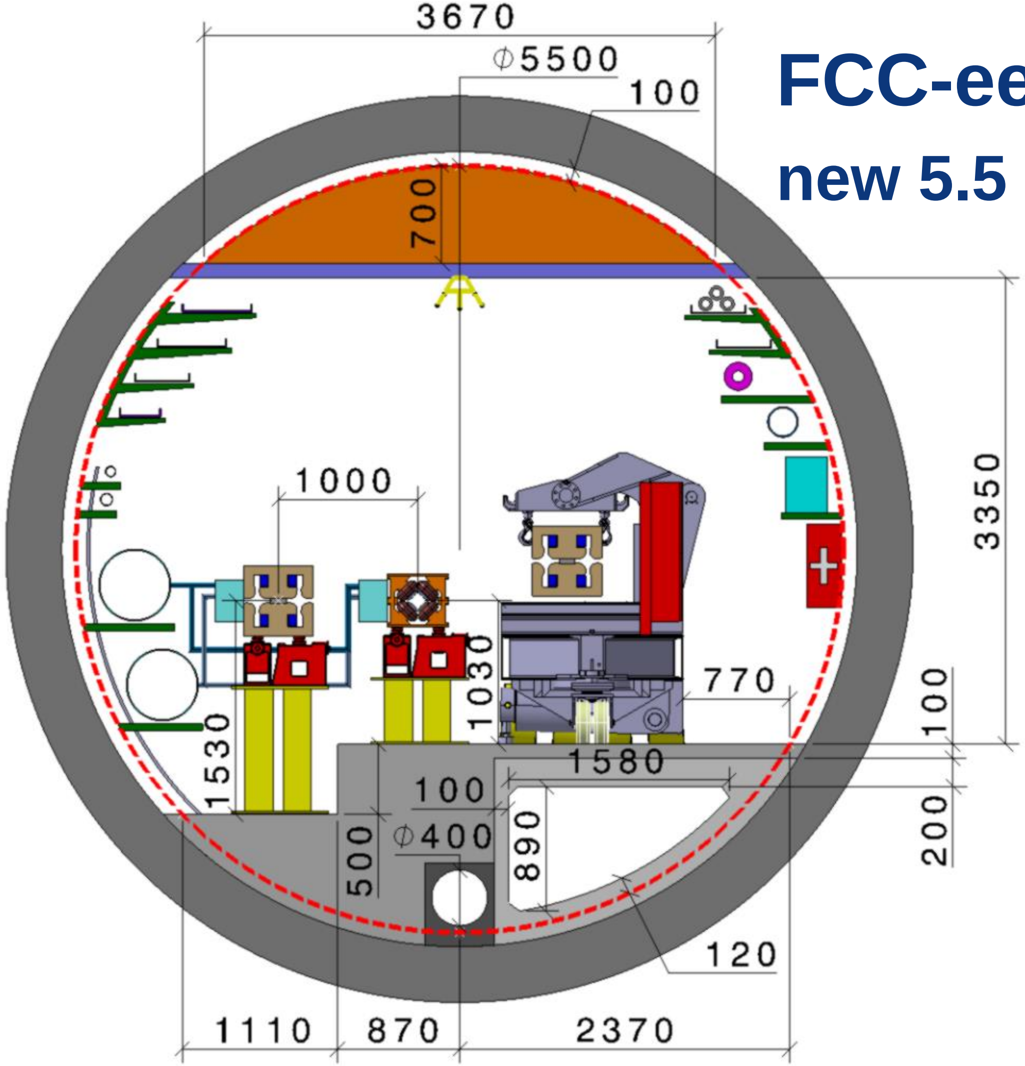
Next step: iteration with review on surface site locations and machine layout

CE underground schematic



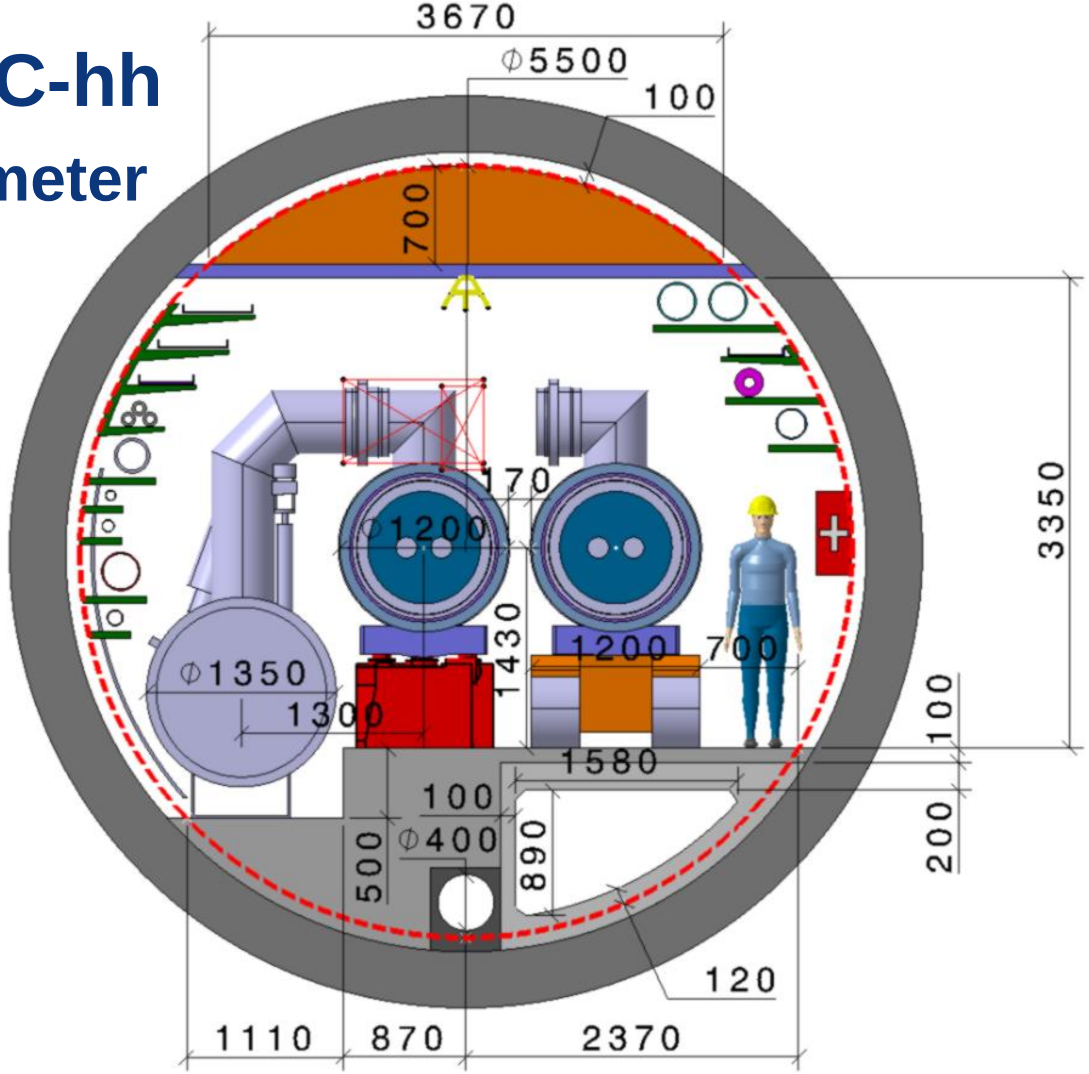
Layout and construction method studied for all underground structures as basis for CE cost and schedule study.

FCC – tunnel integration in arcs

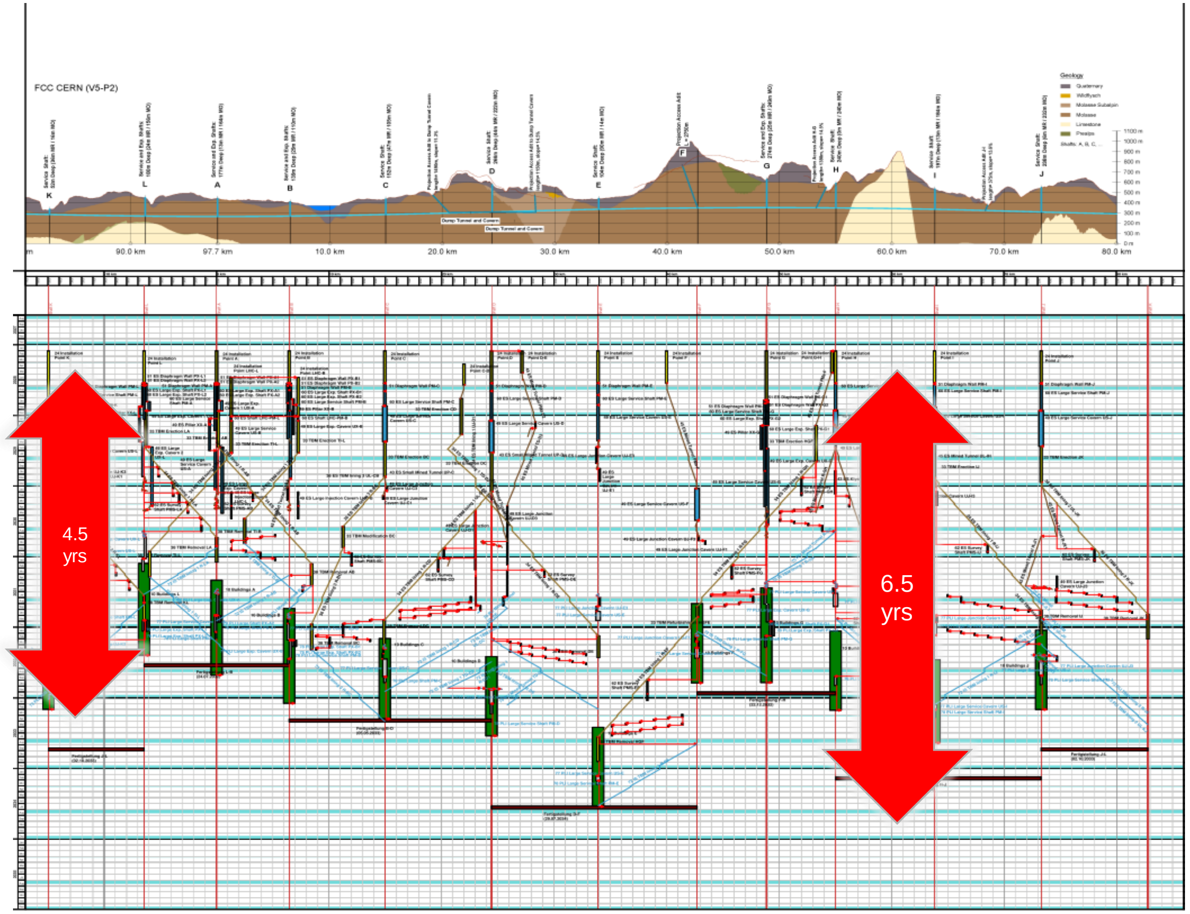


FCC-ee **FCC-hh**

new 5.5 m inner diameter



CE schedule studies



- Detailed study confirmed 2017 numbers
- Construction duration 5 – 7 years

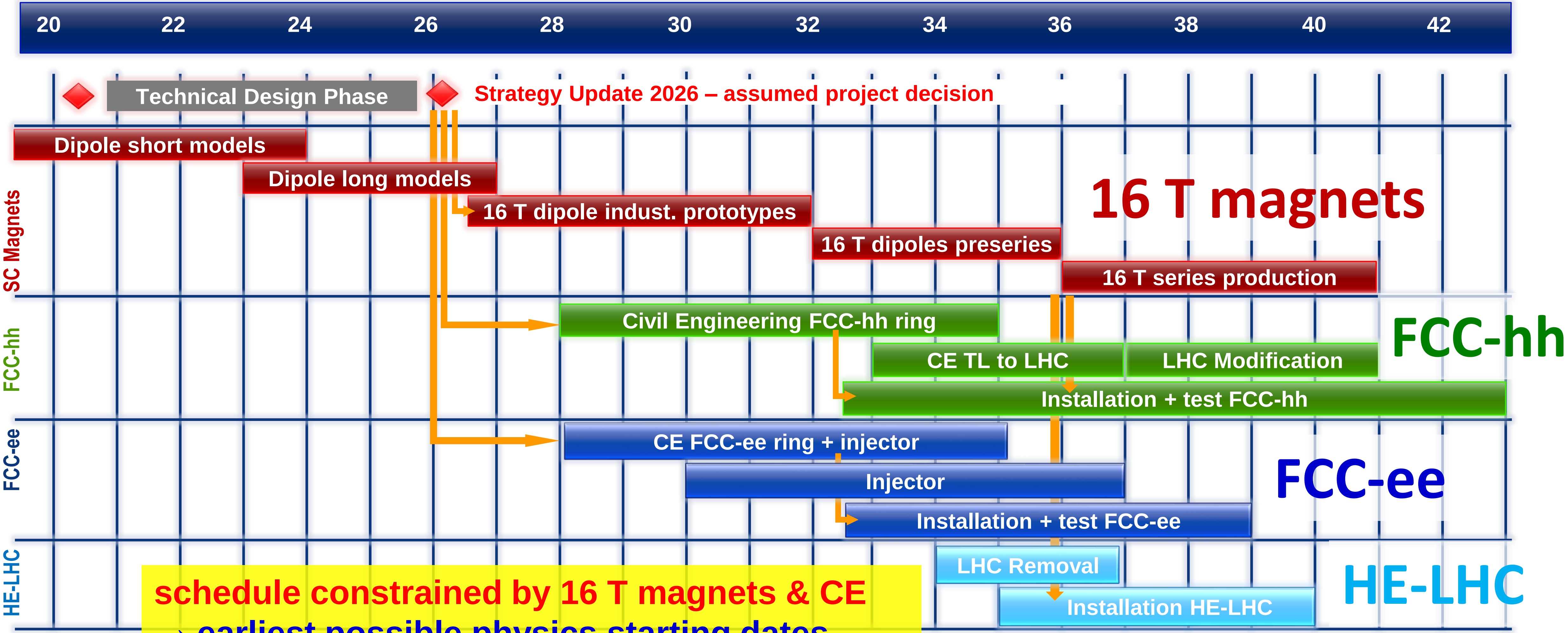
Excavated Spoil Schedule

Extraction Site	Volume (m^3)			
	Soft Ground	Limestone	Molasse	Total
Shaft at LHC1	11,031	0	133,735	144,765
Shaft at LHC2	0	0	202,589	202,589
Shafts at Point A	26,469	0	791,948	818,417
Shafts at Point B	35,161	0	326,482	361,643
Shaft at Point C	181,807	0	385,920	567,727
First Construction Tunnel at Point D	0	0	709,452	709,452
Shaft at Point D	15,992	8,806	668,961	693,760
Second Construction Tunnel at Point D	0	0	235,355	235,355
Shaft at Point E	6,528	0	174,792	181,320
Tunnel at Point F	0	1,206	375,414	376,621
Shaft at Point G	33,086		471,215	504,301
Tunnel at Point H	0	244,081	750,620	994,701
Shaft at Point H	0	7,329	421,401	428,730
Shaft at Point I	6,528	0	796,634	803,161
Shaft at Point J	6,528	0	805,629	812,157
Shaft at Point K	13,381	0	610,972	624,353
Shafts at Point L	29,990	0	671,700	701,690
Total Spoil Volume	**366,500**	**261,422**	**8,532,821**	**9,160,743**

Next step:
study of excavation material management

- Total of 9 million cubic meters to dispose
- Reuse of molasse?

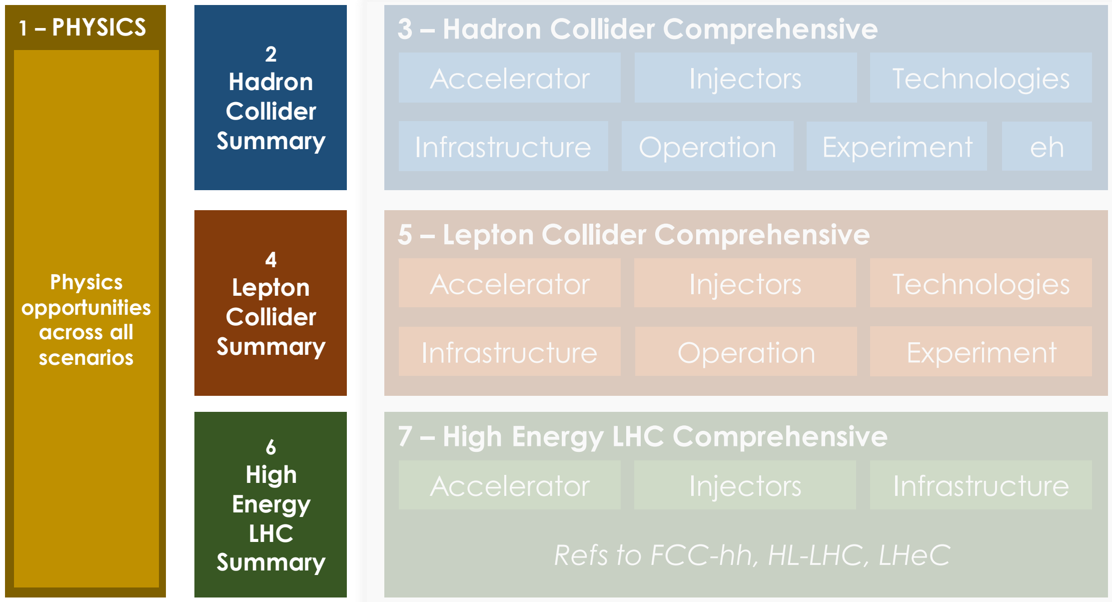
Technical Schedule for each of the 3 options



schedule constrained by 16 T magnets & CE
→ earliest possible physics starting dates
- **FCC-hh: 2043**
- **FCC-ee: 2039**
- **HE-LHC: 2040 (with HL-LHC stop LS5 / 2034)**

Further Planning – CDR Production

- CDR Concise summary volumes 1 (PH), 2 (hh), 4 (ee), 6 (HE):
  - Completion of design work, coherent and consistent contents for concise volumes by end June 2018.
  - Overall final editing July – August 2018
  - Proof reading and approval September – October
  - “Print-ready” versions by November 2018



- CDR long technical volumes 3, 5, 7:
  - Collection of input (from status June 2018) during July – October 2018.
  - Overall volume editing November 2018 – January 2019
  - Proof reading and approval February – March 2019

- Cost study based on CDR status (June 2018), other documents for ESU, June - November 2018

FCC Week Program – IAC Review

Tuesday (10 APRIL)				
Parallel 1 **Room 0.4** Effectenbeurszaal	Parallel 2 **Room 0.5** Graanbeurszaal	Parallel 3 **Room 1.1** Administratiezaal	Parallel 4 **Room 1.9** Berlage zaal	Parallel 5 **Room 1.20** Veilingzaal
FCC-hh accelerator: design I (review)	Conductor Nb3Sn: State of the art & characterization	FCC-ee Physics & Exp.: Detector Designs (review)	SRF Direction for R&D	Special Tech.: Beam Vacuum System Conceptual Design I
Coffee Break (0.2 Grote Zaal)				
FCC-hh accelerator: design II (review)	Conductor: Development for FCC	FCC-ee Physics & Exp.: Machine detector interface (review)	SRF cavity technology	Special Tech.: Beam Vacuum System Conceptual Design II
Lunch (0.2 Grote Zaal)				
FCC-hh accelerator: collimation (review)	Conductor: Other superconductors	FCC-ee Physics & Exp.: EW precision measurements (review)	SRF studies	HE LHC Options and beam-beam 1.2 Mendes kamer
Coffee Break (0.2 Grote Zaal)				
FCC-hh: Collider beam transfer and injector I (review)	EuroCirCol 16 T Designs for the FCC CDR	FCC-ee Physics & Exp.: Higgs, flavour, neutrinos, QCD (review)	SRF Innovation	

Wednesday (11 APRIL)				
Parallel 1 **Room 0.4** Effectenbeurszaal	Parallel 2 **Room 0.5** Graanbeurszaal	Parallel 3 **Room 1.1** Administratiezaal	Parallel 4 **Room 1.9** Berlage zaal	Parallel 5 **Room 1.20** Veilingzaal
FCC-ee accelerator: parameters and optics (review)	EuroCirCol 16 T Other tasks	FCC-physics	Civil engineering, geodesy, alignment, transport, logistics (review)	Special Tech.: Injection & extraction I
Coffee Break (0.2 Grote Zaal)				
FCC-ee accelerator: MDI (review)	16 T R&D Magnets and models	FCC-physics	Cryogenics (review)	Special Tech.: Injection & extraction II
Lunch (0.2 Grote Zaal)				
FCC-ee accelerator: collective effects and top-up (review)	Other programs	FCC-hh Physics & Exp.: Higgs, top and electroweak precision physics	Cooling & ventilation, electr. distribution, energy management (review)	EASItrain CC (closed session) 1.4 Vervey kamer
Coffee Break (0.2 Grote Zaal)				
CEPC and others	Other magnets for FCC	FCC-hh Physics & Exp.: Searches	Operation, reliability, radiation (review)	FCC-hh: Collider beam transfer and injector II (review)

Thursday (12 APRIL)				
Parallel 1 **Room 0.4** Effectenbeurszaal	Parallel 2 **Room 0.5** Graanbeurszaal	Parallel 3 **Room 1.1** Administratiezaal	Parallel 4 **Room 1.9** Berlage zaal	Parallel 5 **Room 1.20** Veilingzaal
FCC-hh Physics & Exp.: Detector Magnet, Tracker, ECAL	FCC-ee injector (review)	Special Tech.: Beam stoppers, collimators and dumps	FCC-eh: Technical developments	Safety (review)
Coffee Break (0.2 Grote Zaal)				
FCC-hh Physics & Exp.: Detector HCAL, Muons, Trigger	FCC-ee accelerator: energy calibration & polarization (review)	Special Tech.: Electronics & instrumentation	FCC-eh: physics	EASItrain: superconducting thin films and manufacturing
Lunch (0.2 Grote Zaal)				
Common software	HE LHC Parameters and optics (review)	Special Tech.: Development of new manufacturing technologies	FCC-hh accelerator: collective effects I (review)	EASItrain: superconduct. wires
Coffee Break (0.2 Grote Zaal)				
Common technologies	HE LHC collimation and beam dynamics (review)	Special Tech.: Machine protection, circuit and powering	FCC-hh accelerator: collective effects II (review)	EASItrain: cryogenics

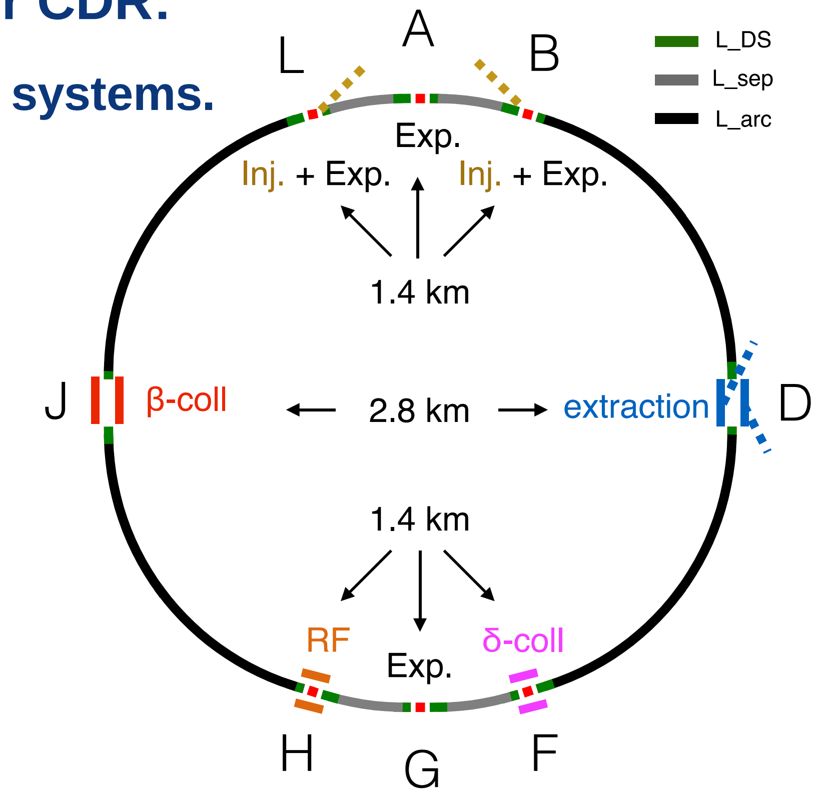
Review Information

- **All sessions marked in red / green are earmarked for phyics / machine-technical review by IAC.**

Further Planning – Design Work

In parallel to European Strategy process:

- **Full iteration of all designs based on coherent documentation for CDR:**
  - **Parameters and requirements: machines – experiments – technical systems.**
  - **Machine layouts and space allocation for straight sections**
  - **Iteration of layout & subsequent implementation study**



- **Continuation of technical design work:**
  - **Nb_3Sn wire and 16 T short model programs**
  - **SRF cavity production and efficient RF power sources**
  - **Cryogenics and key technologies**
- **Identification of potential topics for FP9 funding and preparation of project proposals**

Collaboration & Industry Relations

124 Institutes

30 Companies

32 Countries

EC
H2020

EASITrain Marie Curie Training Network

European Advanced Superconductivity Innovation and Training Network

➢ **Started 1 October 2017, by now 14 of 15 Early Stage Researchers hired & active.**

- SC wires at low temperatures for magnets (Nb_3Sn, MgB_2, HTS)
- Superconducting thin films for RF and beam screen (Nb_3Sn, Tl)
- Electrohydraulic forming for RF structures
- Turbocompressor for Nelium refrigeration
- Magnet cooling architectures

Horizon 2020 program

Funding for 15 Early Stage Researchers over 3 years & training

13 Beneficiaries

12 Partners

Summary

- Fast advancement of the FCC study in all areas
- Collider concept designs ready for CDR
- Worldwide R&D programme in place, on Nb_3Sn superconductor, high-field magnets, and on highly-efficient SC RF
- Good progress on all key technologies
- International FCC collaboration growing steadily, focusing now on completing the CDRs as input for European Strategy Update
- Have a productive time and enjoy the FCC Week 2018!