



3RD HI-LUMI Industry Day

22-23
May 2017
The Park Royal
Warrington
UNITED KINGDOM

Registration before 31 March 2017
<https://indico.cern.ch/event/607165/>

More information on HL-LHC and future needs
<https://project-hl-lhc-industry.web.cern.ch>



AN EVENT FOR
COMPANIES WILLING
TO TAKE ON THE HL-LHC
TECHNICAL CHALLENGES

Cryostats for magnets and superconducting links

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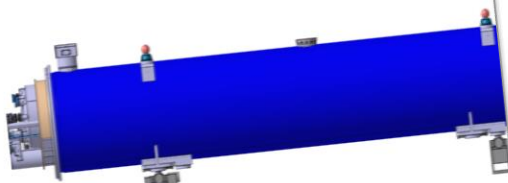


3rd HiLumi Industry Day, Warrington, 22nd–23rd May 2017

Cryostats and SC links in HL LHC: where and when

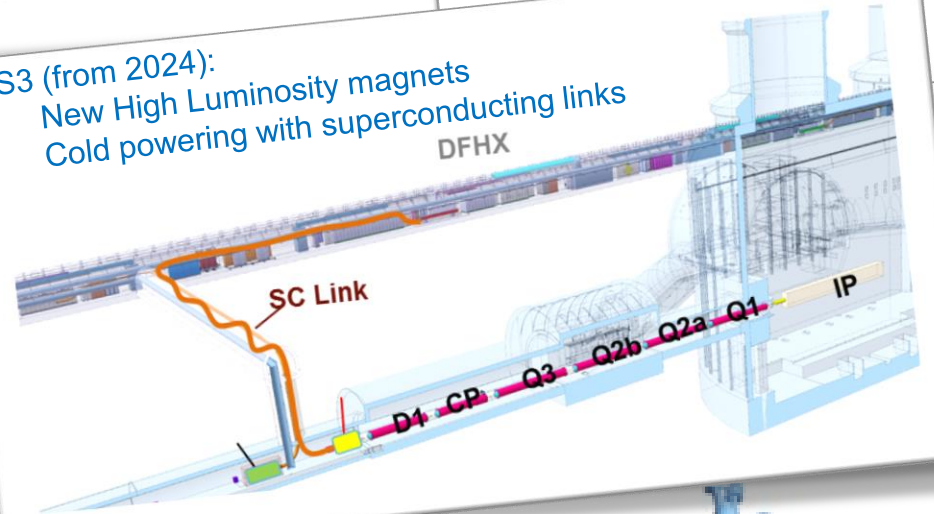


LS2 (from 2019):
- New connect

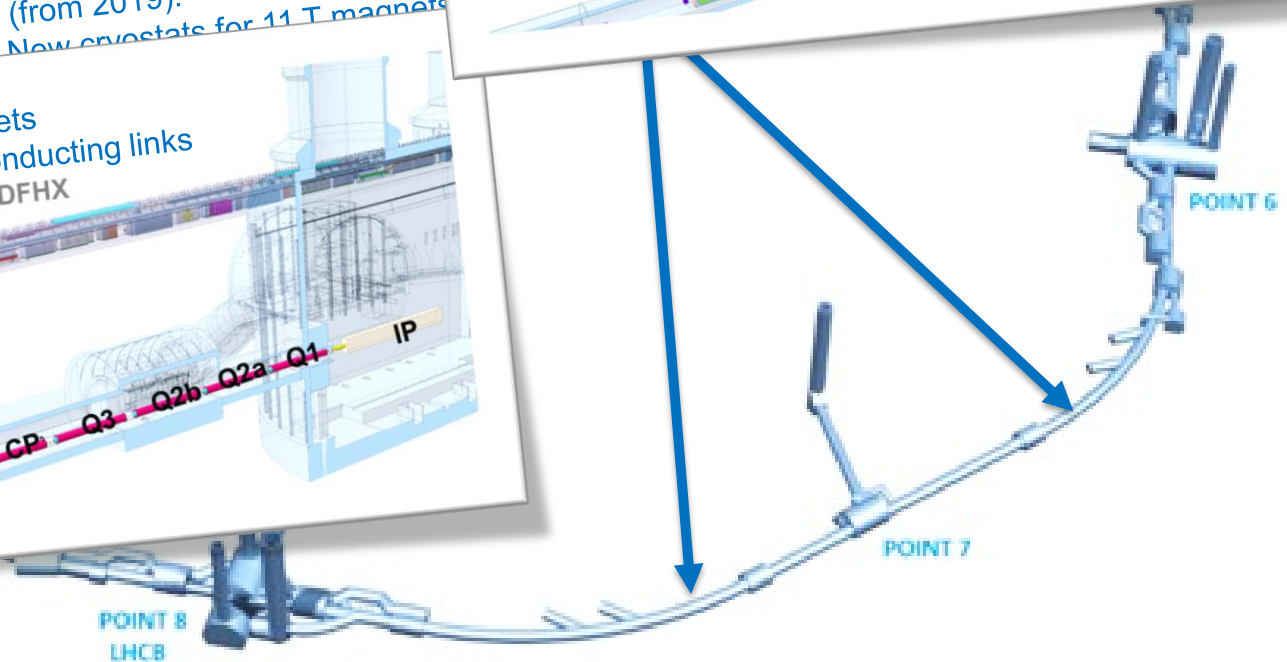
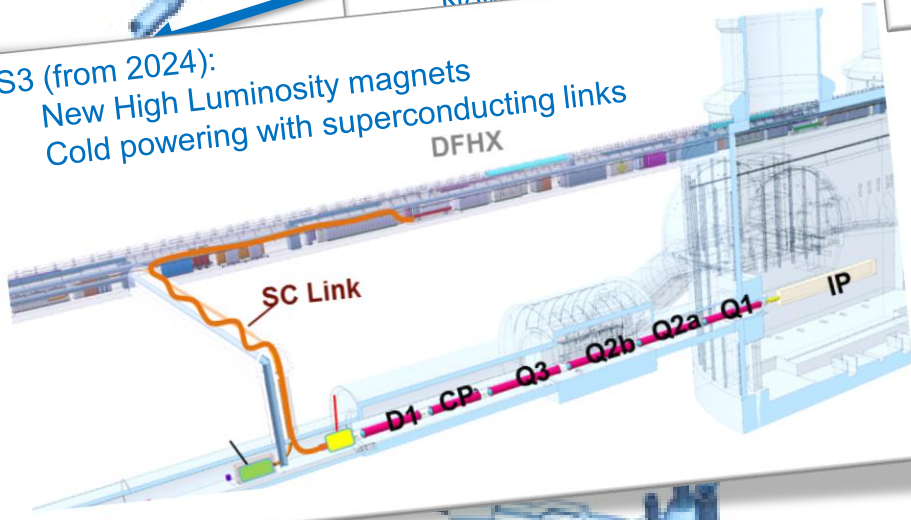


LS2 (from 2019):
- New cryostats for 11 T magnets

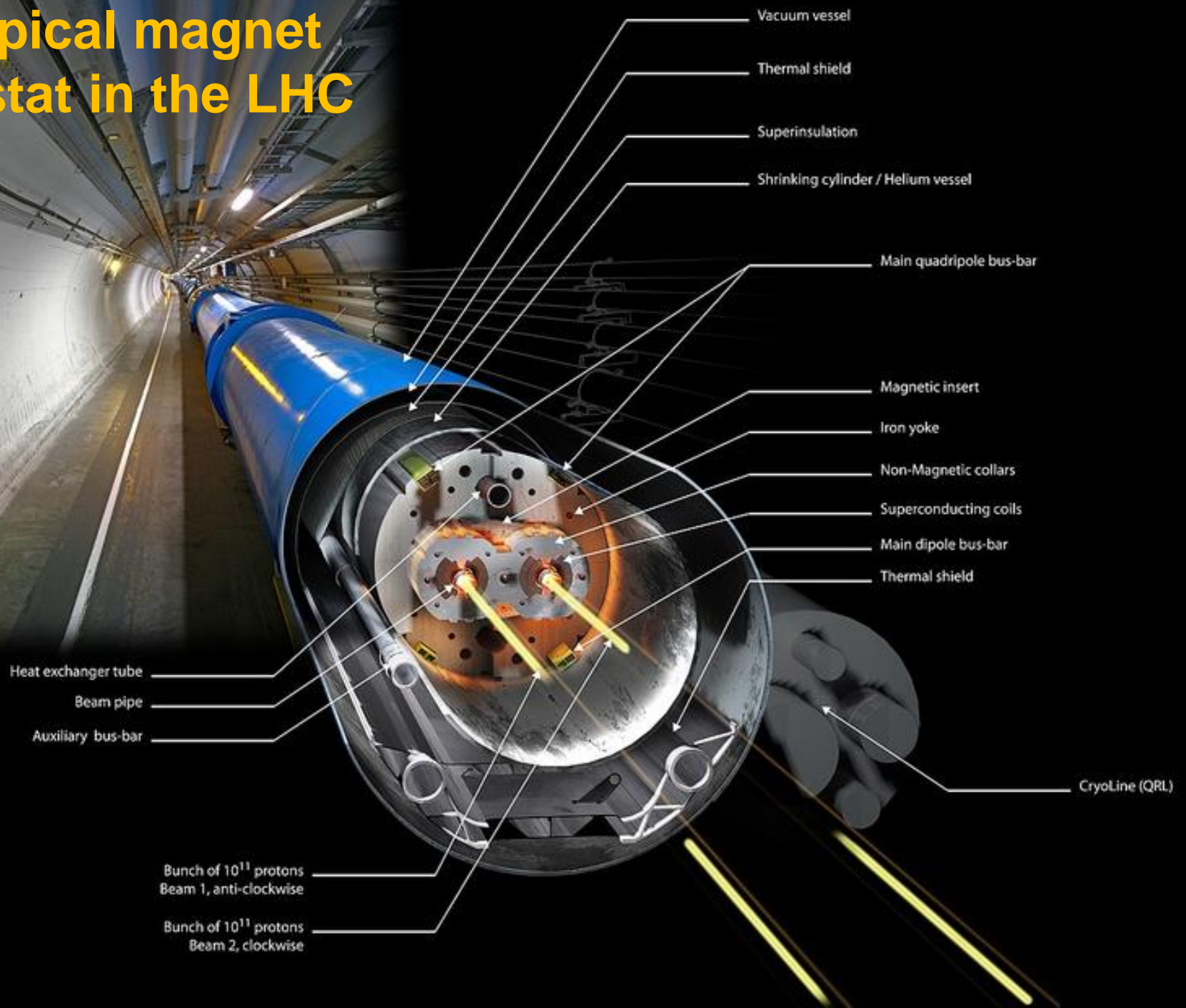
- LS3 (from 2024):
- New High Luminosity magnets
 - Cold powering with superconducting links



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- New High Luminosity magnets
 - Cold powering with superconducting links



A typical magnet cryostat in the LHC



Strategy for construction of Cryostat assemblies

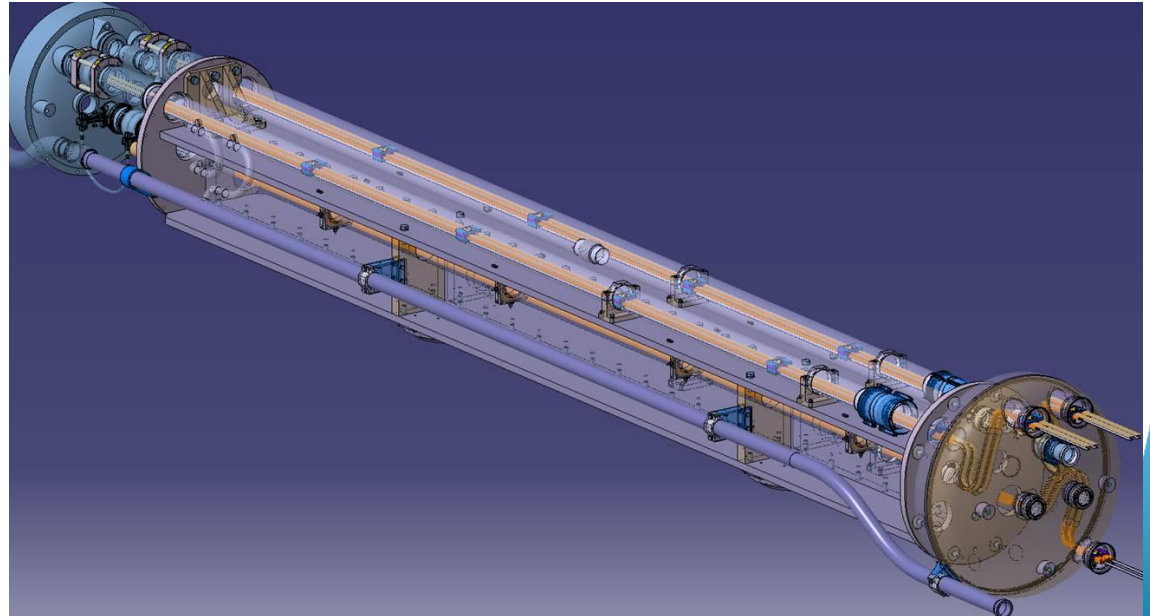
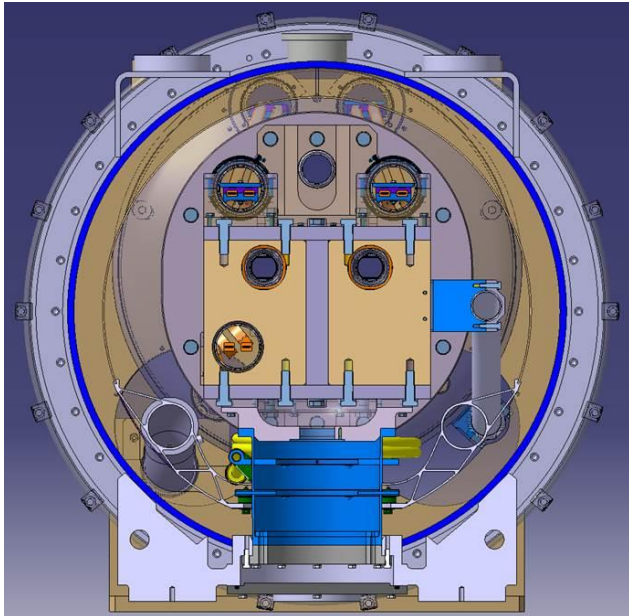
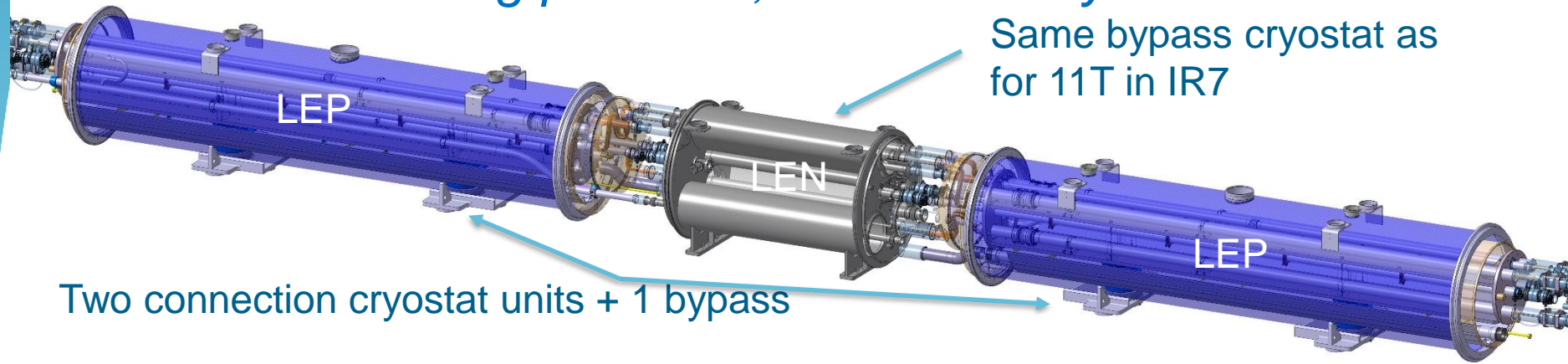
- Engineering and detailed design done by CERN
- “Build-to-Print” procurement of components in industry, based on CERN drawings and detailed specifications
- Cryo-units assembly and qualification testing done at CERN (with on-site support of industrial contractors)
- Material and Services procurement according to CERN purchase rules
- In-kind contributions through collaboration can be a possible alternative for some equipment

For doing business with CERN → : <http://procurement.web.cern.ch/>

Connection cryostats+bypass (installation in 2019-2020)

2 full assemblies needed.

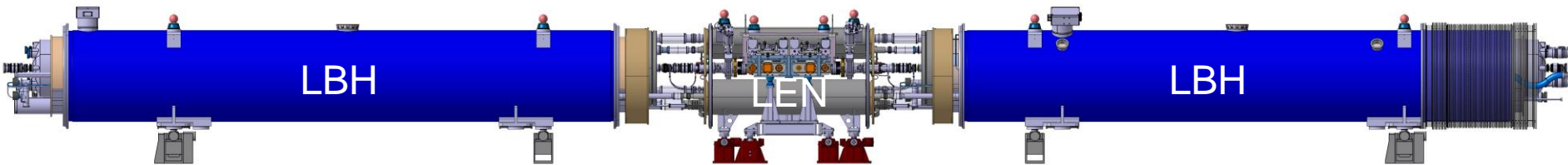
Parts being procured, first assembly starts in 2017.



Overall integration length: ~13 m

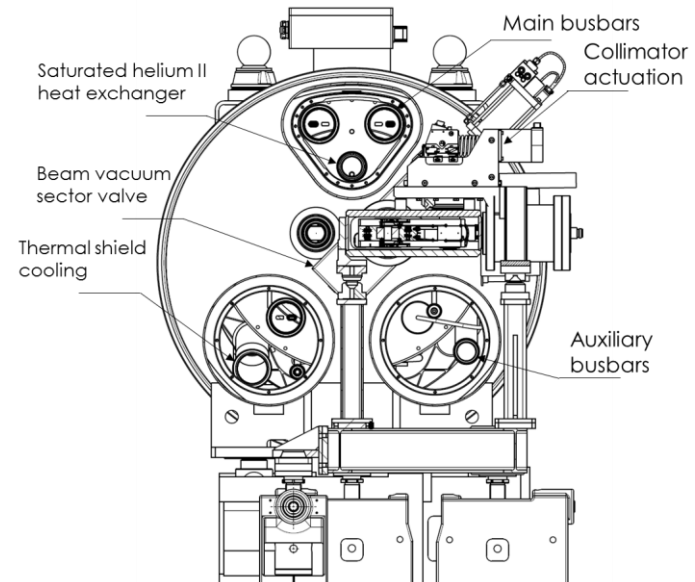
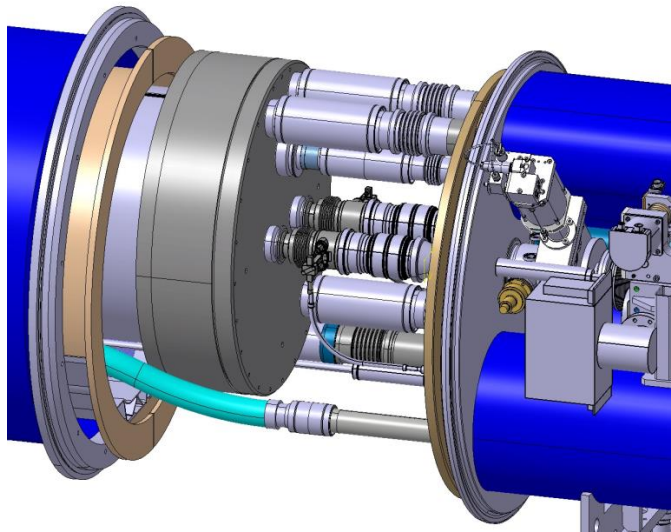
11 T magnet cryostats+bypass (installation in 2019-2020)

11 T magnet will be the first Nb_3Sn high field magnet in a particle accelerator



2 full assemblies needed.

Components being procured, first assembly of prototype in 2017.



Overall integration length: ~15.5 m

Procurement status and Upcoming procurement contracts (main items)

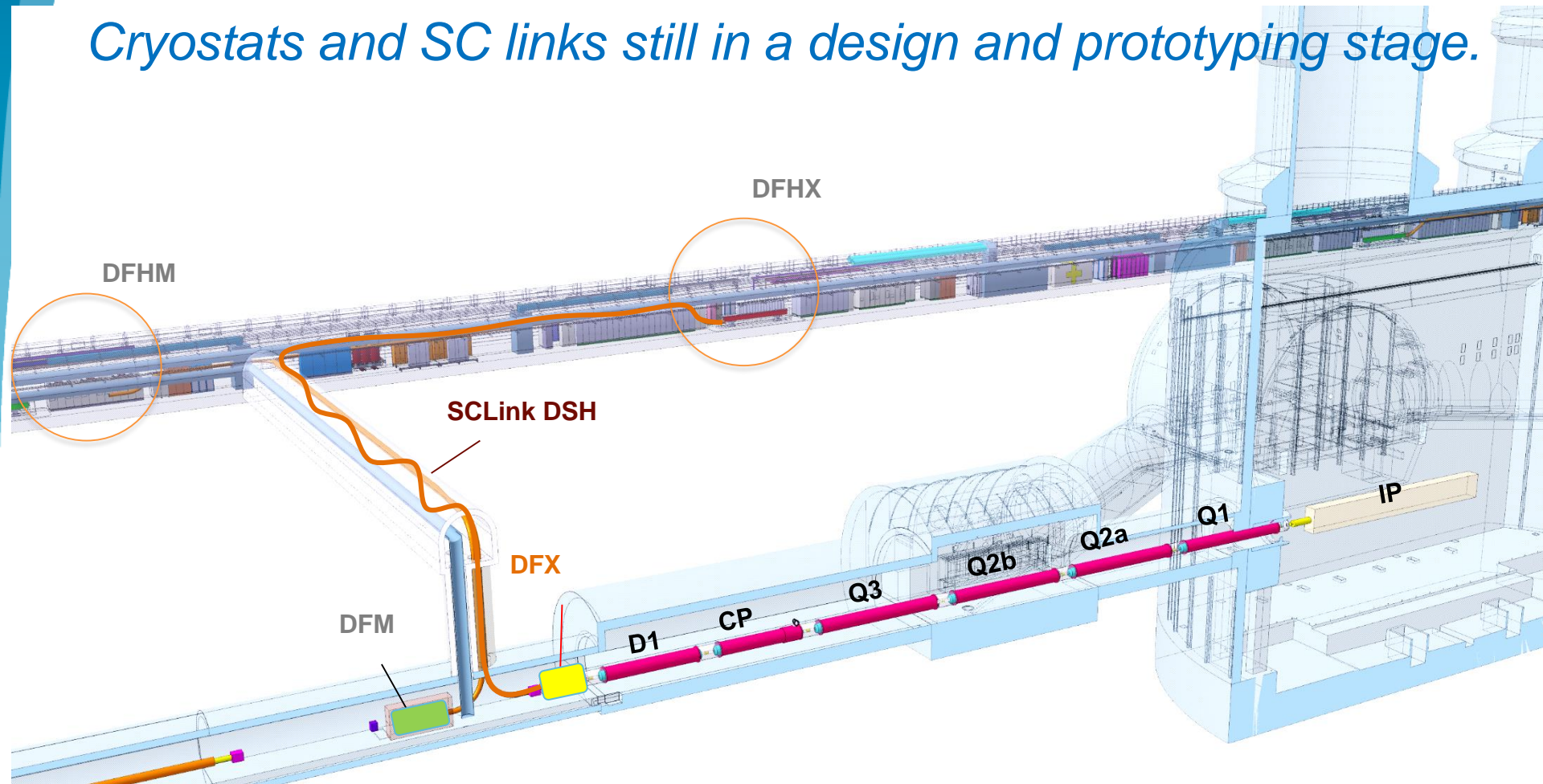
Item	Quantity	Milestones	Status
Bypass proto vacuum vessel	1 unit	Order issued Oct 2016 Delivery April 2017	Delivered
11T and Connection Cryostat series vacuum vessels	13 + 6 optional	Contract signed Delivery of first unit Oct 2017 Delivery of last unit Apr 2018	Fabrication
Bypass series vacuum vessels	6 units	Tender closed Delivery of first unit June 2017 Delivery of last unit June 2018	Contract signature
Expansion joints for bypass cryostat	8 sets	Order: to be issued June 2017 Deliveries from Sep 2017 to Feb 2018	Price enquiry on-going
End covers for connection cryostat cold masses	24 units	Tender under preparation Order to be issued: July 2017 First units: Oct 2017 Delivery completed: March 2018	Specifications under preparation
MLI blankets	20 sets	Order for bypass prototype issued Tender for series starts June 2017 Delivery series: August 2017 to Feb 2018	Specifications under preparation

Note: more details on technologies can be found in annex to this presentation

New High Luminosity magnets

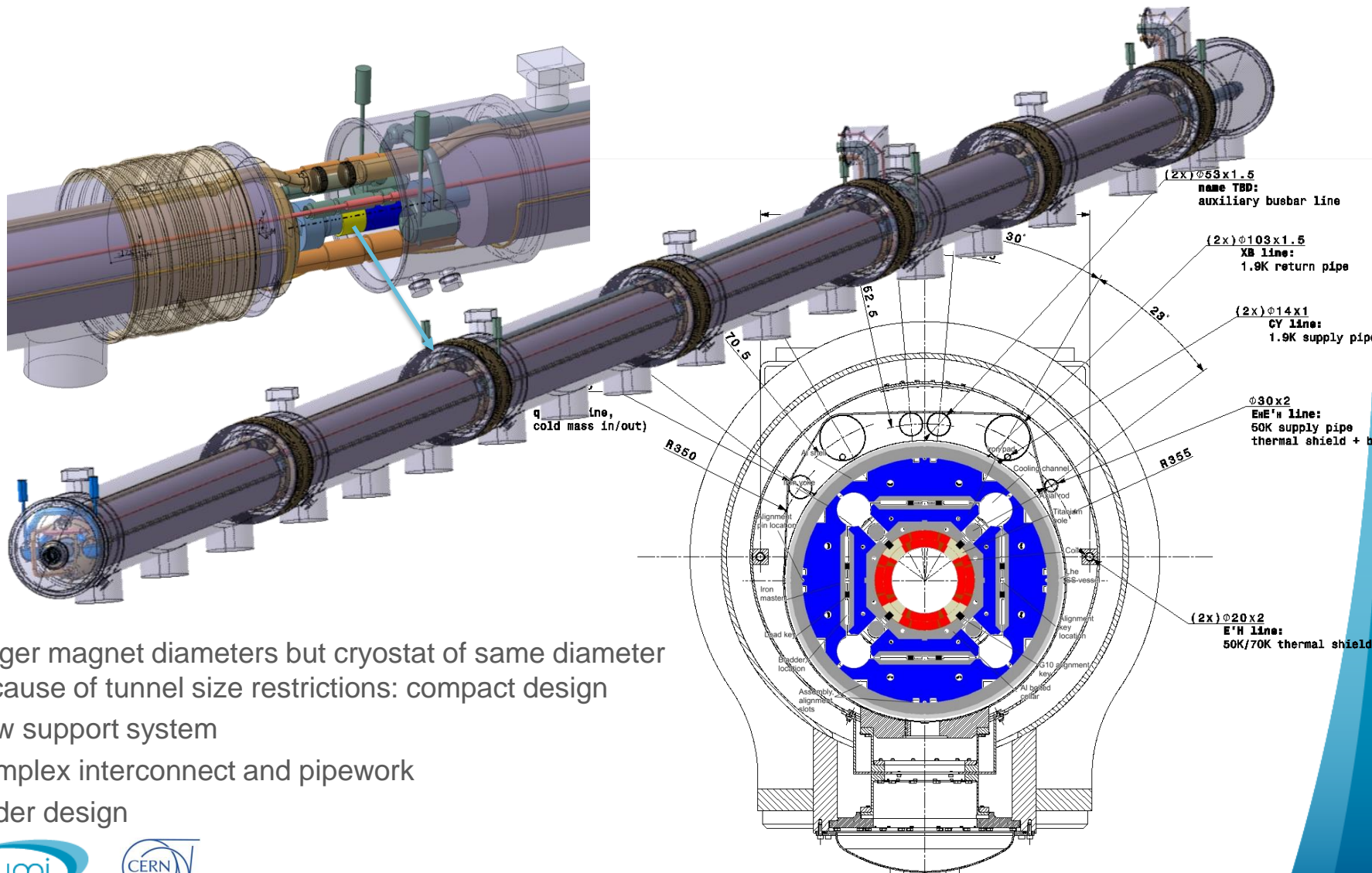
Cold powering with superconducting links

Cryostats and SC links still in a design and prototyping stage.



Insertion region magnets. Installation in 2024-2025

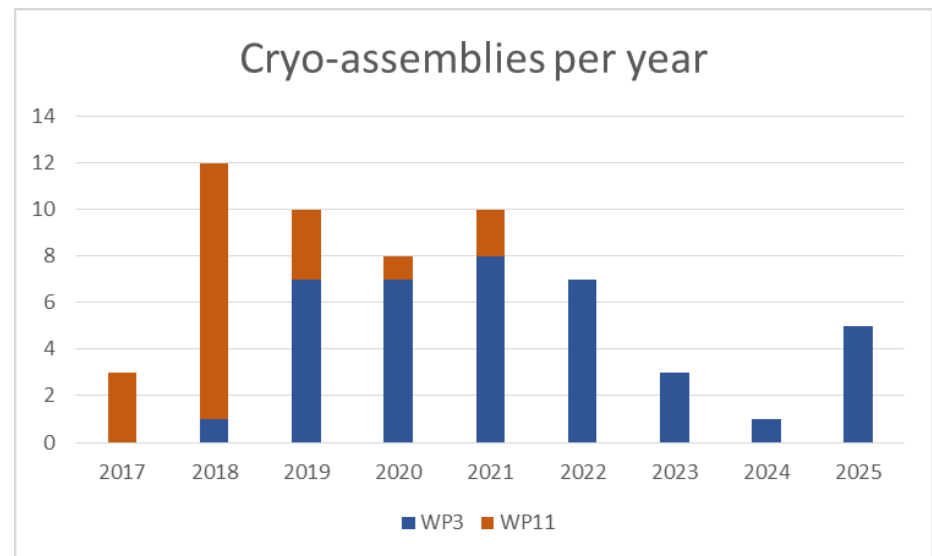
Nb₃Sn quadrupoles, separation dipoles and others magnet types



- Larger magnet diameters but cryostat of same diameter because of tunnel size restrictions: compact design
- New support system
- Complex interconnect and pipework
- Under design

Magnet Cryostats: in a few numbers

- ~70 cryostat units procured by CERN, incl. prototypes and spares (~15 now in construction, ~ 55 as from 2019)
- Diameter ~1 m
- Unit lengths vary from 2 m up to 15 m
- Roughly 500 m of new cryostats to be installed in the LHC
- Carbon steel, stainless steel, aluminium, glass fiber composites...
- Production from now until 2025



Assembly schedule at CERN

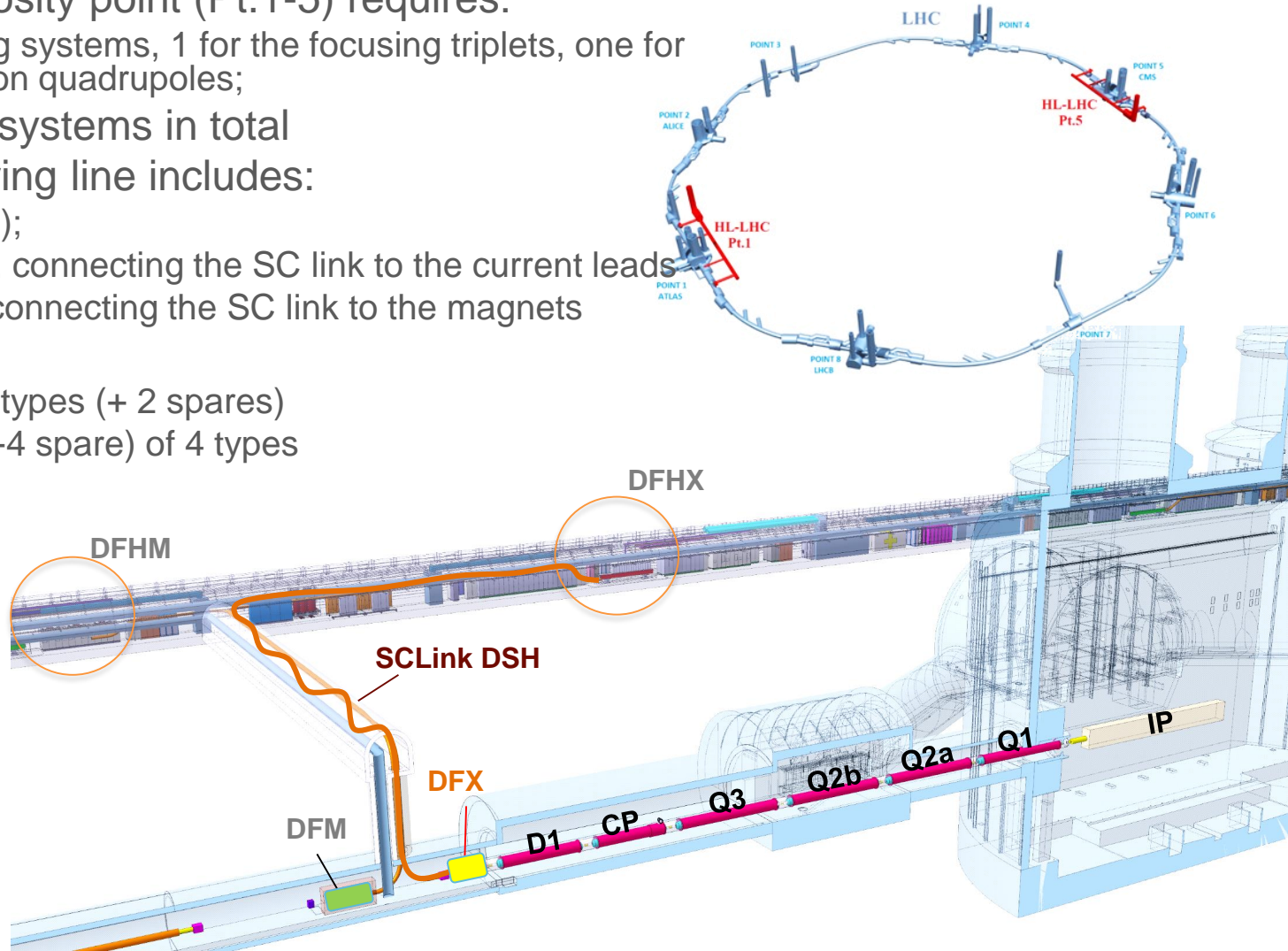
Assembly tooling

- New assembly bench needed to cover various type of assemblies



Cold powering

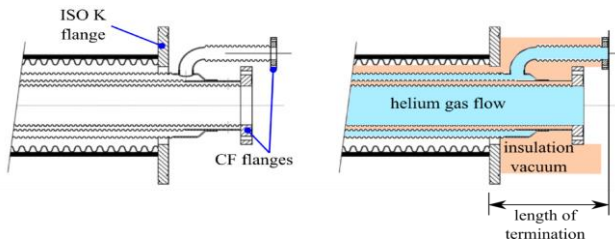
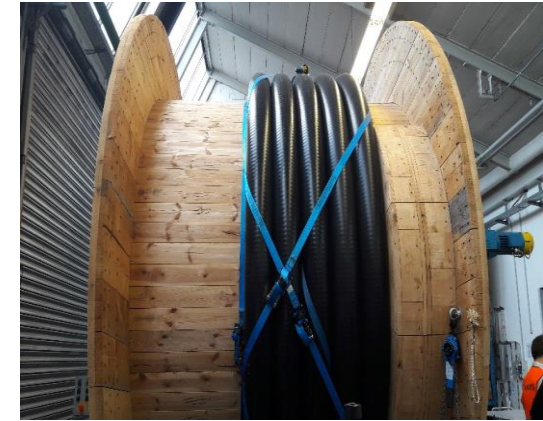
- Each high luminosity point (Pt.1-5) requires:
 - 2 cold powering systems, 1 for the focusing triplets, one for matching section quadrupoles;
- 8 cold powering systems in total
- Each cold powering line includes:
 - 1 SC link (DSH);
 - 1 DFH(X or M), connecting the SC link to the current leads
 - 1 DF(X or M), connecting the SC link to the magnets
- In total:
 - 8 SC links of 2 types (+ 2 spares)
 - 16 DF boxes (+4 spare) of 4 types



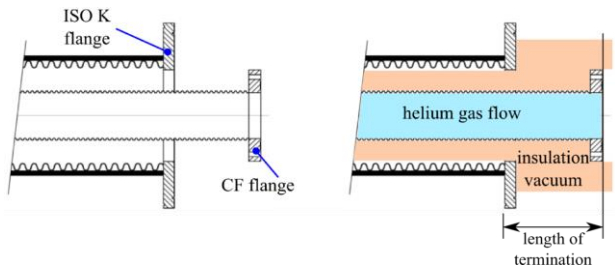
SC link flexible cryostats envelope

- *Still in a design phase*
- *Qualifying prototypes from 3 companies*
- *Flexibility and thermal performance are key requirements*
- *Choice of types still pending*

Need: 8 units + 2 spares



Functional sketch of Type A cryostat termination



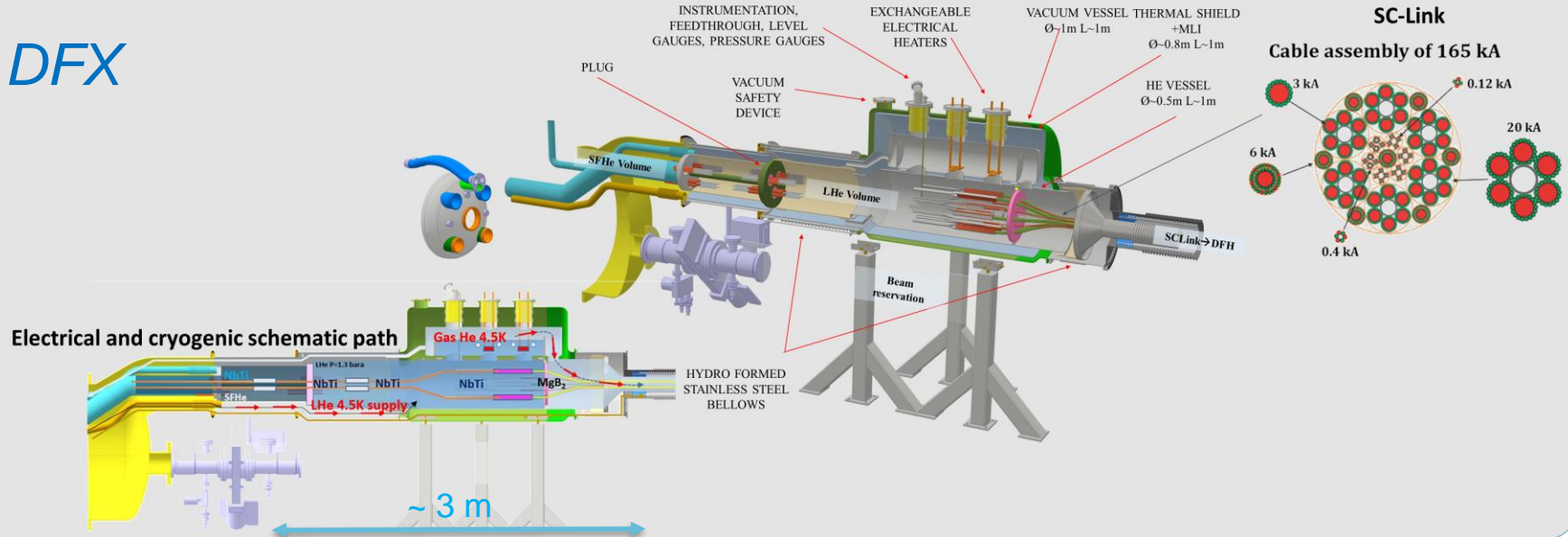
Functional sketch of Type P cryostat termination



(sketches and pictures, courtesy P.Retz)

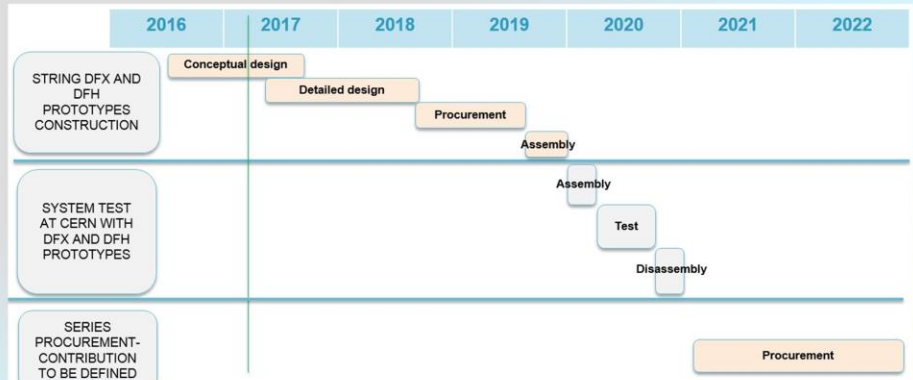
DF boxes

DFX



Need: 16 units (4 types) + 4 spares

ROAD MAP



- Still in a design phase
- Collaboration with Univ. of Southampton for one full-scale DFX prototype
- Series production from 2021

Procurement status and Upcoming procurement contracts (main items)

Item	Quantity	Milestones	Status
Q1/3 proto, Q2 proto 2	3 units + 1 optional	Start procurement procedure Nov 2017 Order issued Mar 2018 Delivery first unit Sep 2018 Delivery last unit Oct 2018	Design phase
Q4 and Q10	8 + 2 optional	Start procurement procedure June 2019 Fabrication 2020-2021	Planning
Q1/3 series, Q2 series, all CP, all D2	33 units	Start procurement procedure June 2018 Order issued May 2019 Delivery first unit Nov 2019 Delivery last unit Dec 2022	Design
Assembly bench	1+1	Start procurement procedure June 2017 Order issued Jan 2018 Installation at CERN Sep 2018 Installation at Fermilab (US) Apr 2019	Specifications under preparation
Industrial service contract for assembly of cryostats at CERN	1	Start procurement procedure: May 2017 Place contract: July 2018 Contract duration: 2018-2025	Specifications under preparation
DFX prototype through collaboration with Univ. of Southampton	1	Construction: Oct. 2018 –Oct. 2019	Design
DFH prototype	1	Construction: Oct. 2018 –Oct. 2019	Design
DF boxes series	16 + 4 units	Procurement & assembly at CERN: 2021-22	Planning

Note: More details on technologies can be found in annex to this presentation



Thank you for your attention!



For doing business with CERN → : <http://procurement.web.cern.ch/>



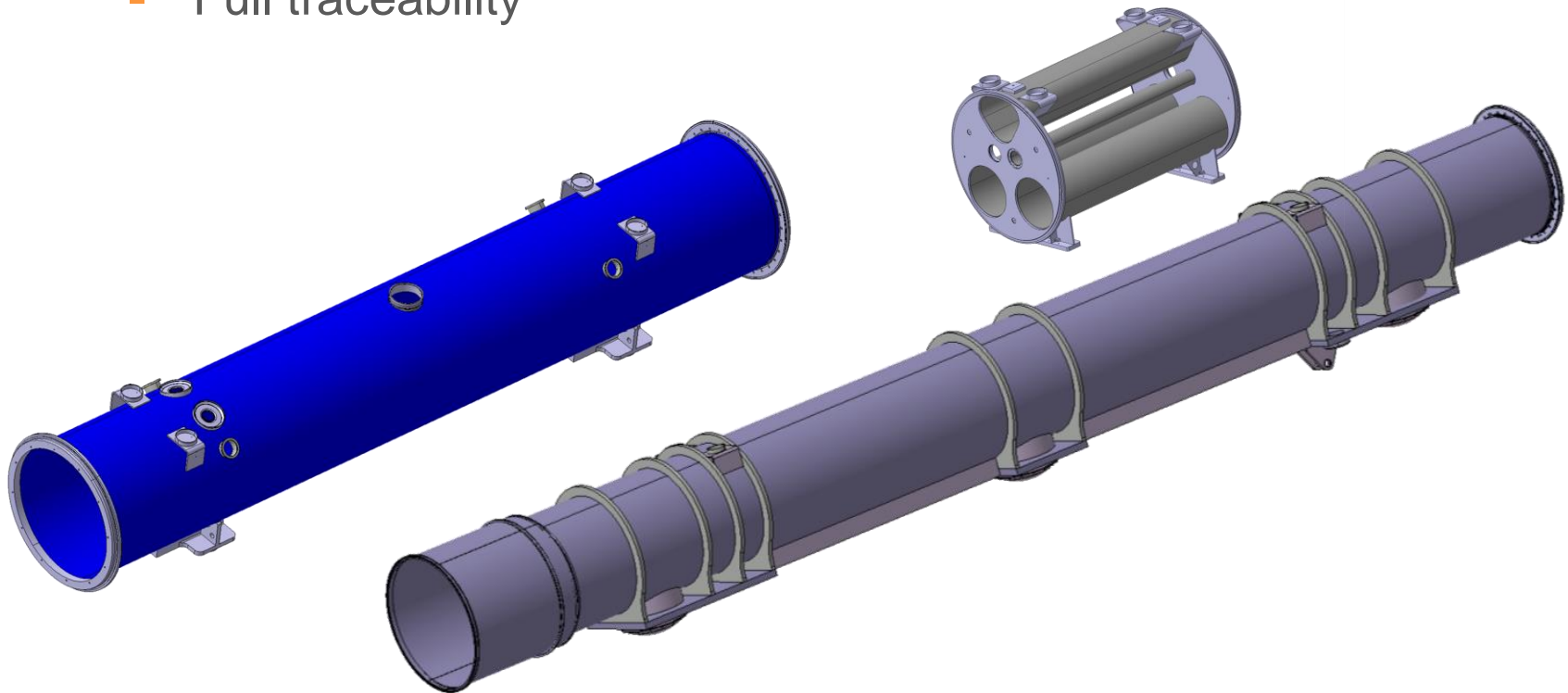
Annex:

Facts sheet by technology



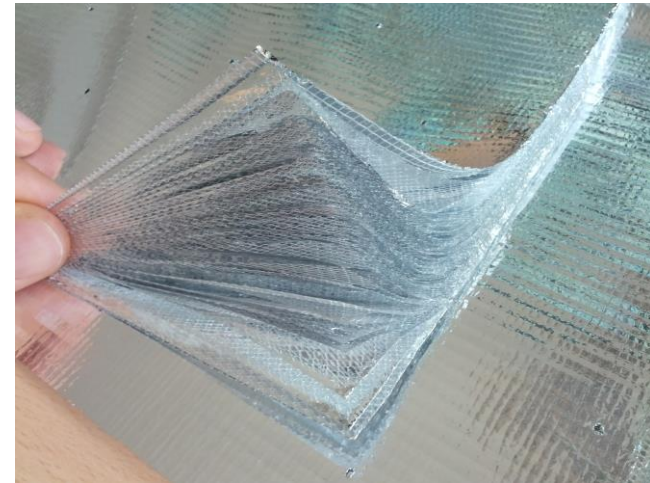
Vacuum vessels

- Cylindrical sections in carbon steel (certified for pressure applications at -50°C) with flanges in stainless steel
- Precisely machined interfaces (large milling machines needed)
- Qualified welders and welding procedures
- Leak detection, welding NDT, 3D metrology
- Full traceability



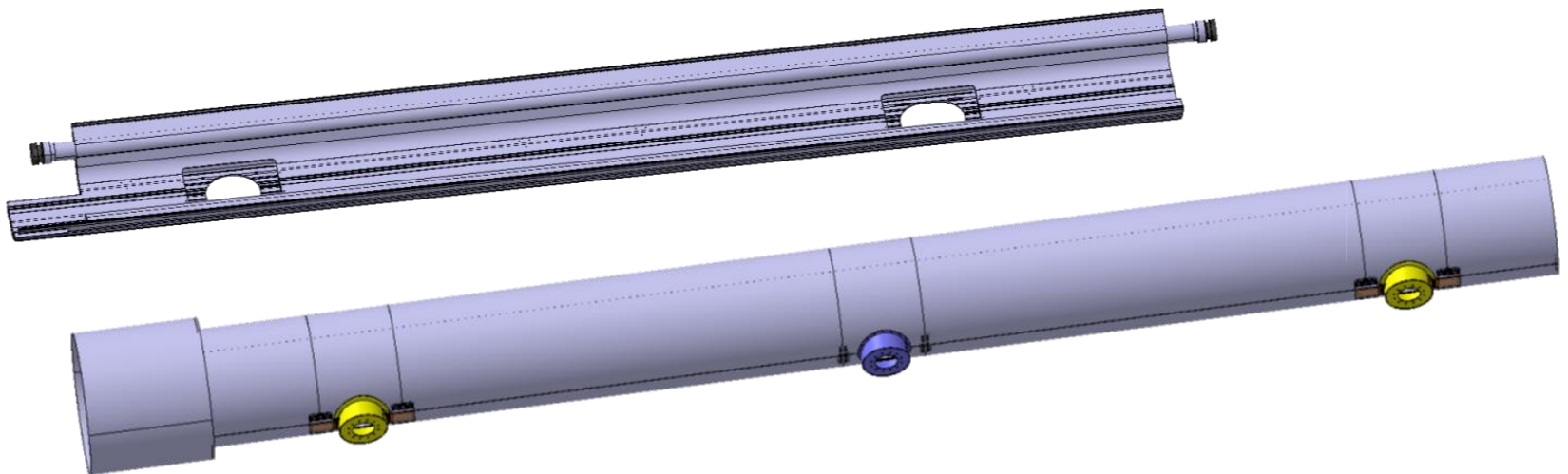
Multi-layer insulation

- Reflective sheets made from polyester film with aluminium thin coating on both sides
- Supplied in blankets of 10 or 15 reflective layers interleaved with insulating spacer layers made from polyester net
- Blankets joined with Velcro[®] tape
- Shape and size of the blankets to be designed by the manufacturer
- About 50'000 m² of reflective layer!



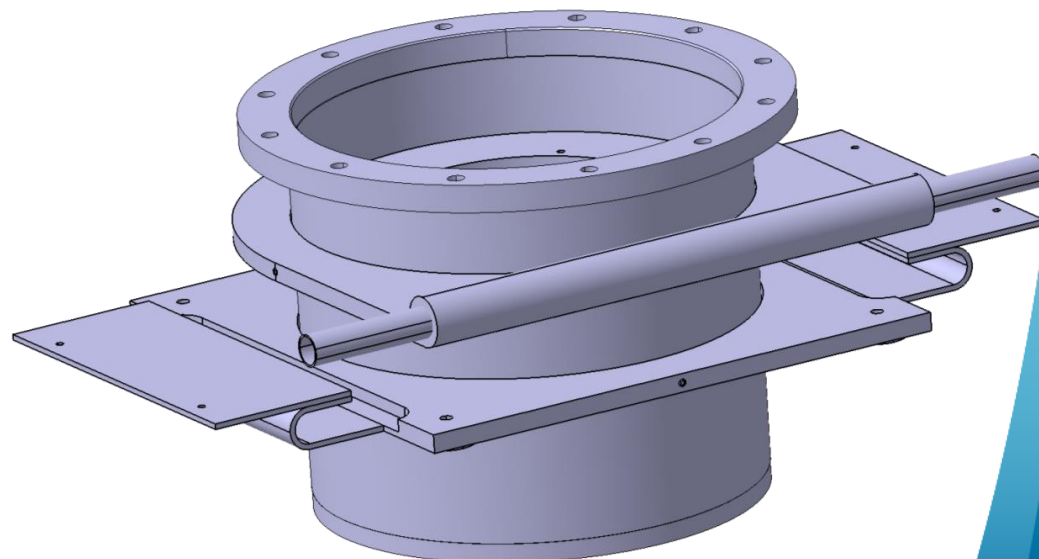
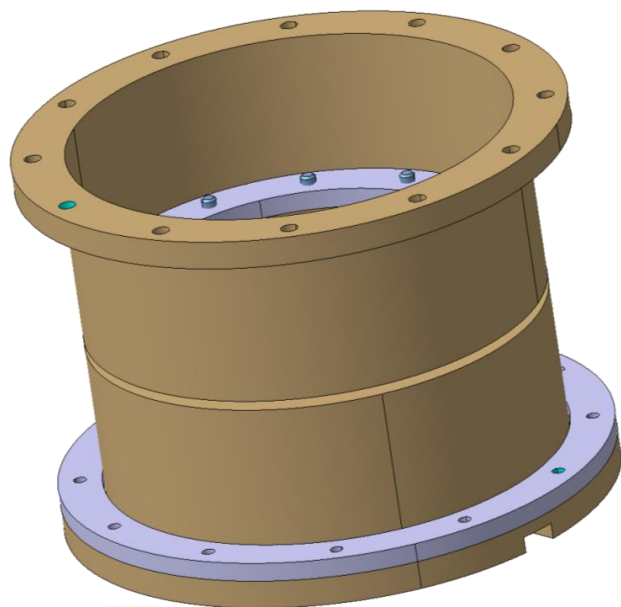
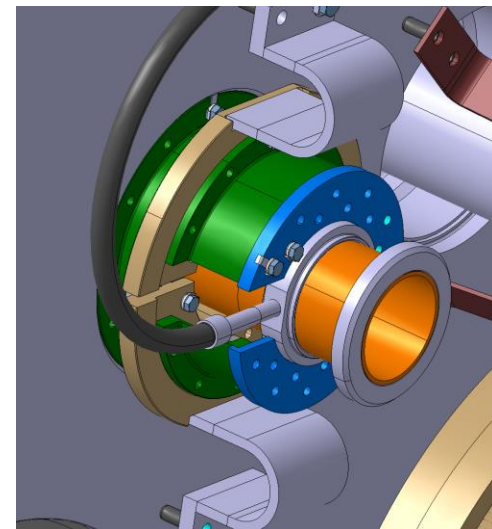
Thermal shields

- Aluminium extrusions or roled sheets as structural elements
- Up to 14 m long
- Precise machining of support interfaces and extremities
- Aluminium to stainless steel transistons
- Leak tigth aluminium welds



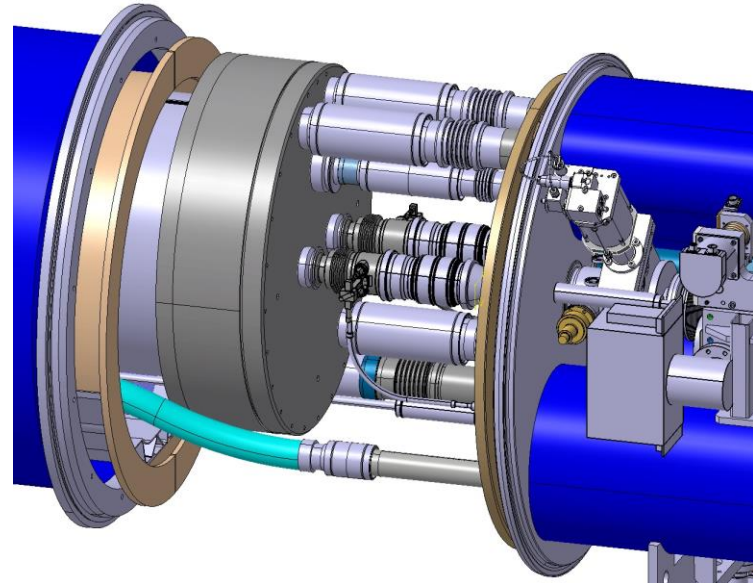
Composite material supports

- Designed for stiffness and strength with minimum heat load
- **Glass fibre** reinforced epoxy
- Tight control of packing factor
- Equal and repeatable thermal contraction
- Finish machining after moulding



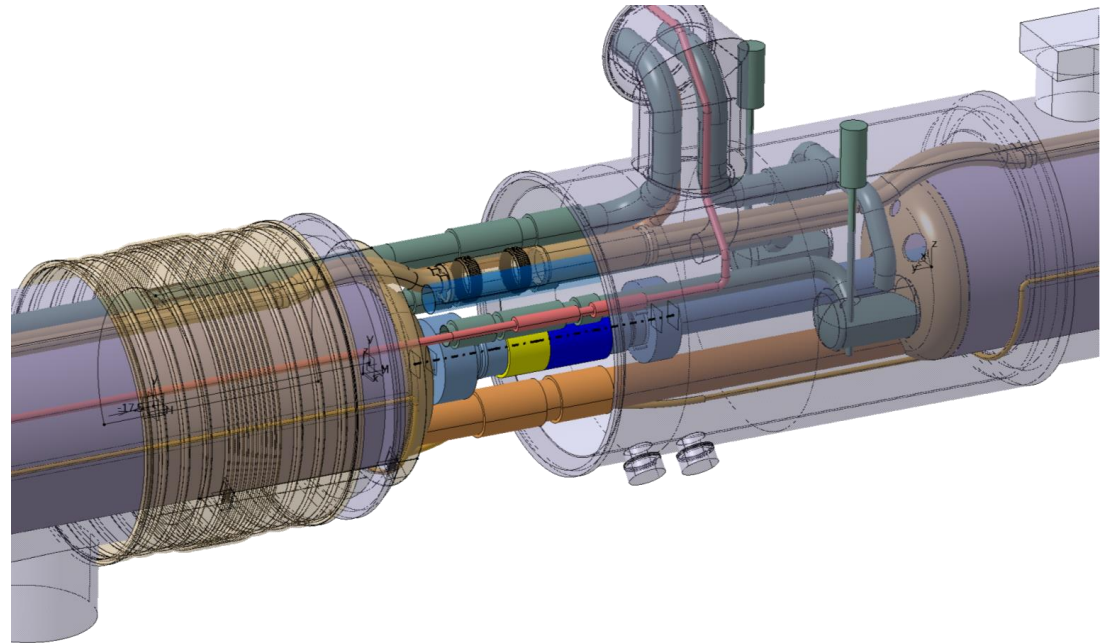
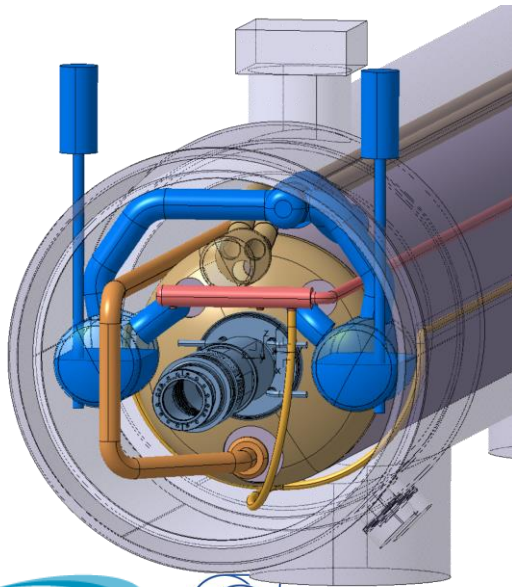
Expansion joints

- Compensation for thermal contraction during cooldown
- Reliability, leak tightness over the machine lifetime
- From vacuum to 20 bar
- EJMA, EN 13445
- Strict material specifications
- Full traceability of materials, manufacturing and QC
- ~500 units



Piping and ancillaries

- Required inside most cryostats for helium distribution and routing of superconducting cables
- Pressurised up to 20 bar
- EN 13480
- Qualified welders and welding procedures
- Extensive welding QC



Facts sheet by technology

Mass for connection cryostats

- Used in cold parts of the accelerator without magnets, to route cryogenic services and superconducting cables
- Precise alignment
- Uniformity of temperature
- **Pressure vessel 20 bar**
- **EN 13458, EN 13445**
- **Stainless steel with cobalt content < 0.10%**
- 4 units plus 2 spares
- Assembly in 2018

