



MQXFB prototype magnet

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on behalf of the MQXF collaboration

WP3 Meeting
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CERN

Acknowledgments

- CERN

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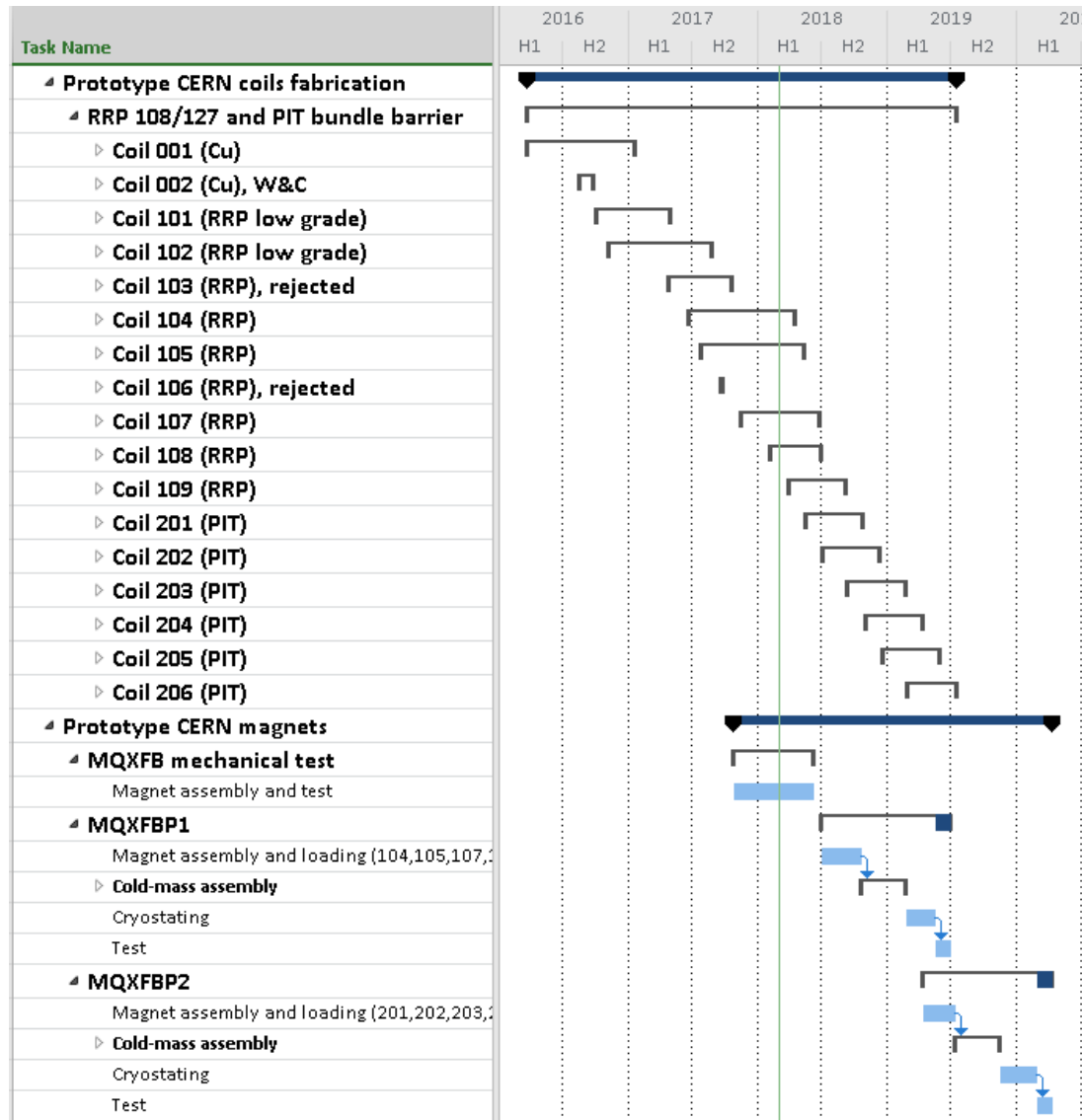
Outline

- Protoype magnet schedule and milestones
 - Status of coil fabrication
 - Now and by the end of the year
 - Support structure
- Status of components for first and second prototype
 - What could we change?
- Some open issues

CERN prototype program

Coil fabrication

- 1 coil with Cu cable and 2 with low grade Nb₃Sn **completed**
- “Old” 1st and 4th prototype coils (**103 and 106**) rejected for major NC
- “New” 1st prototype coils **104** prep for impregnation
- 2nd prototype coils **105** reacted
- The 3rd (**107**) wound
- Winding of 4th (**108**) being wound



CERN prototype program

Coil fabrication

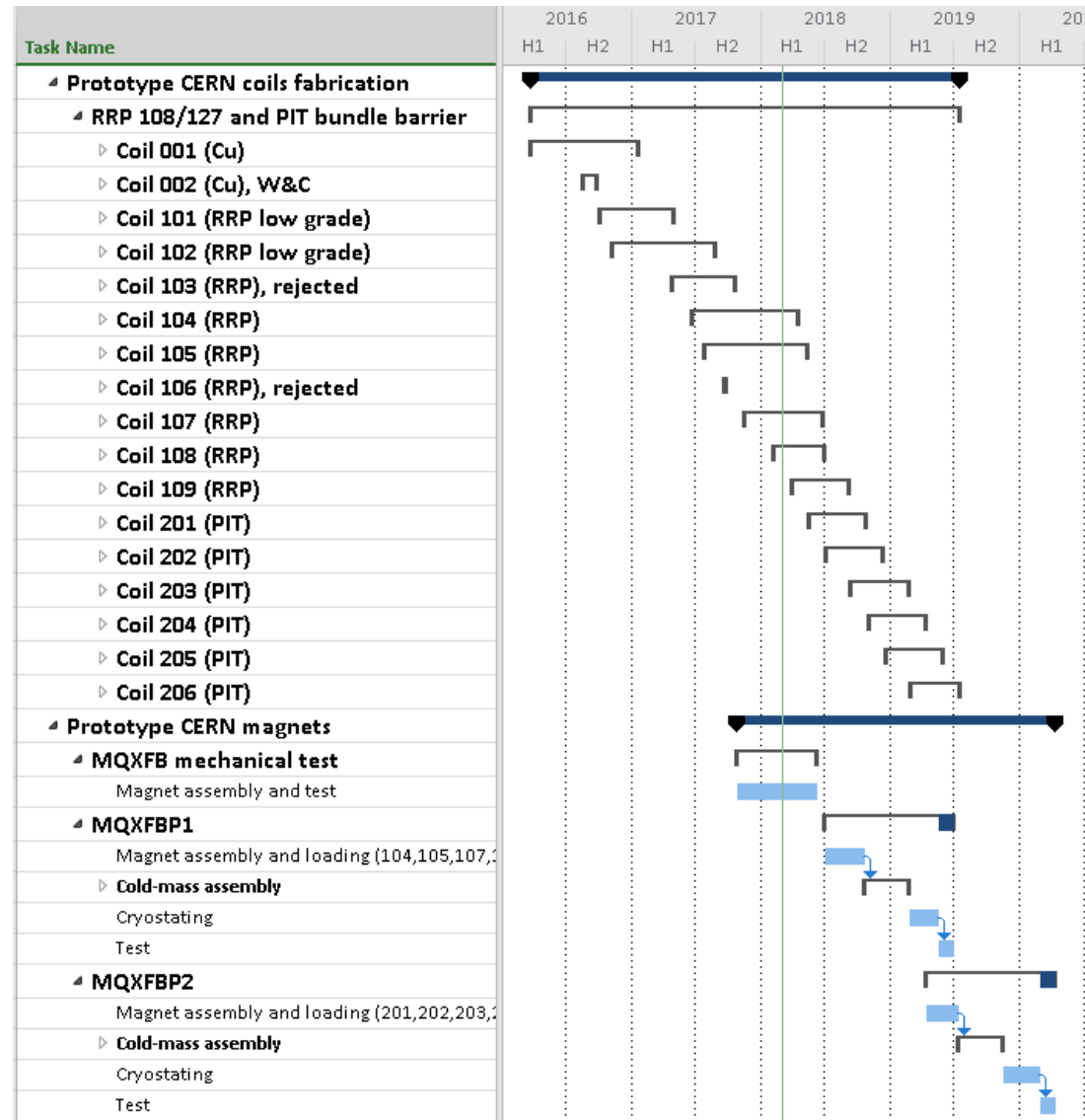
- By the end of 2018

- MQXFBP1

- All coils plus 1 spare completed
 - 104,105,107,108 and 109
 - Cable for 109 not available yet

- MQXFBP2

- 2 coils completed
 - 201 and 202
 - 2 coils started
 - 203 and 204
 - Completed by 04/2019



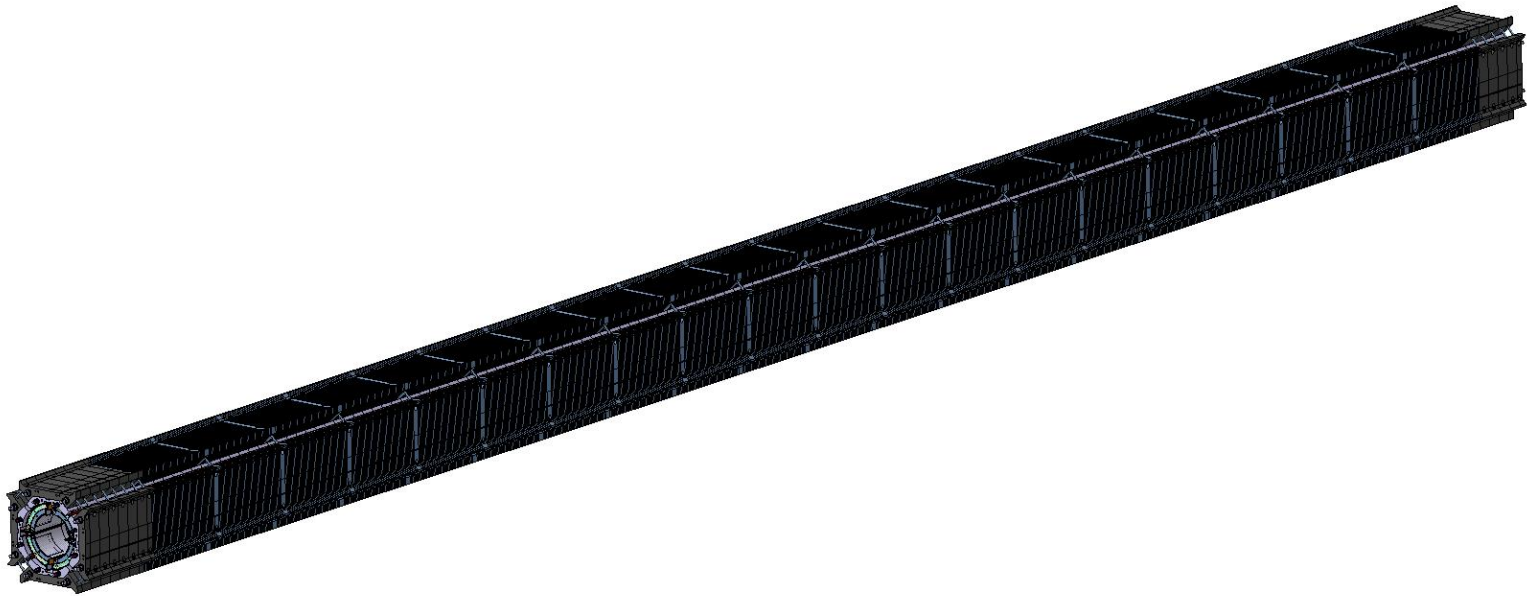
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CERN prototype program

Magnet fabrication

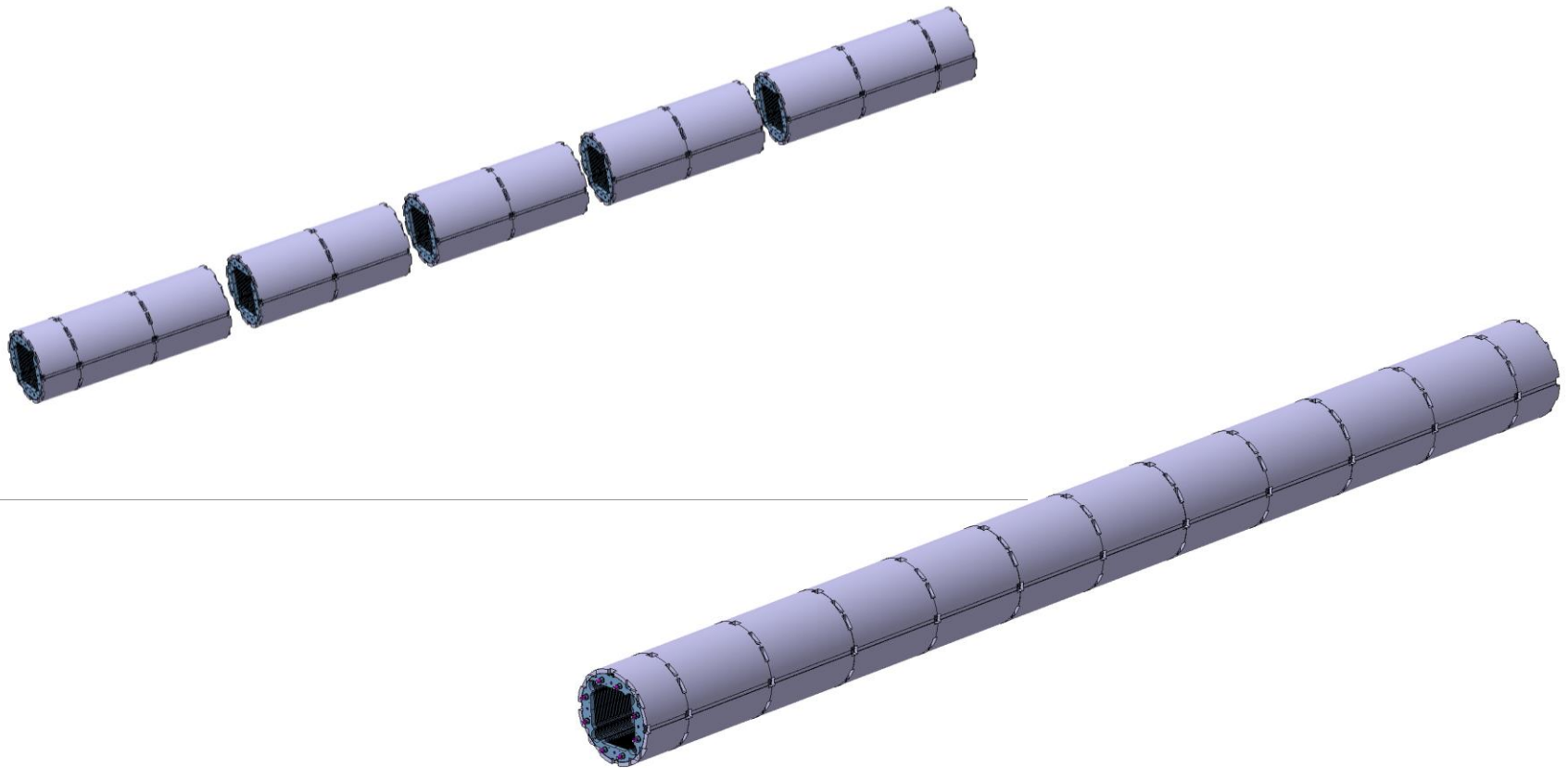
- Coil-pack sub-assembly



CERN prototype program

Magnet fabrication

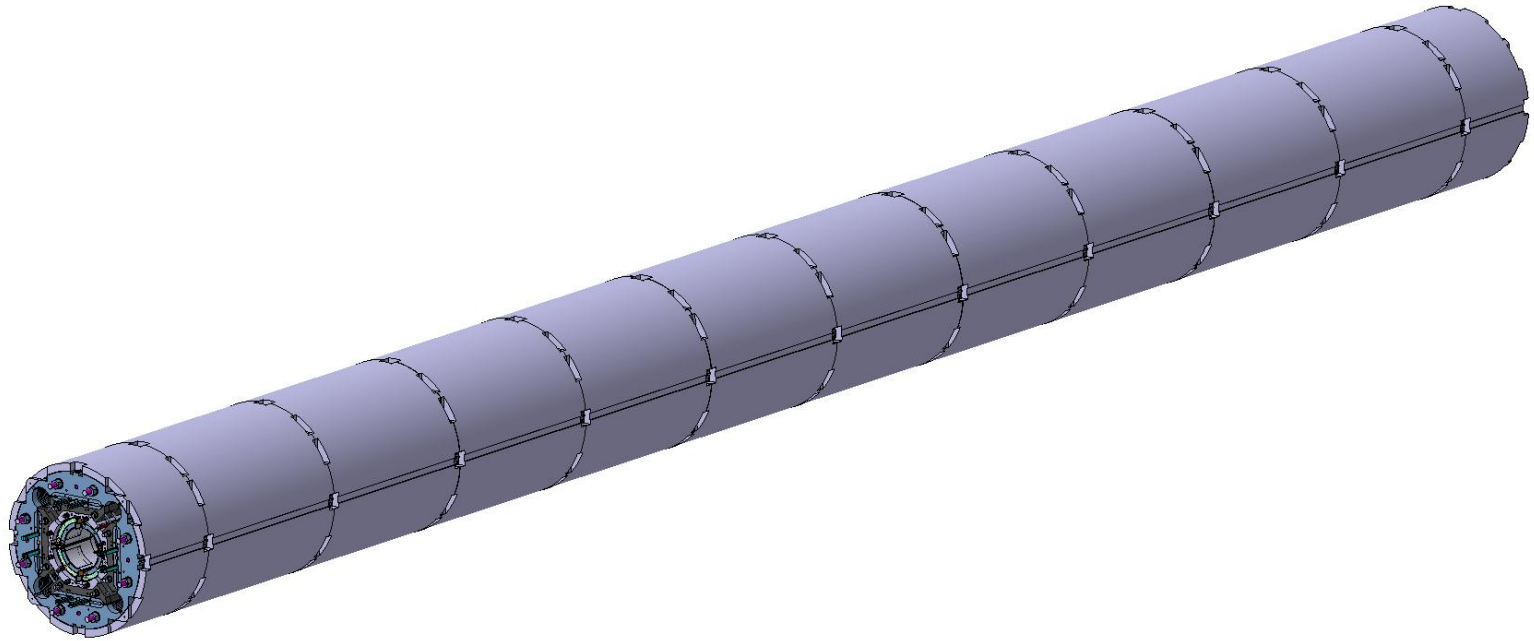
- Shell-yoke sub-assembly



CERN prototype program

Magnet fabrication

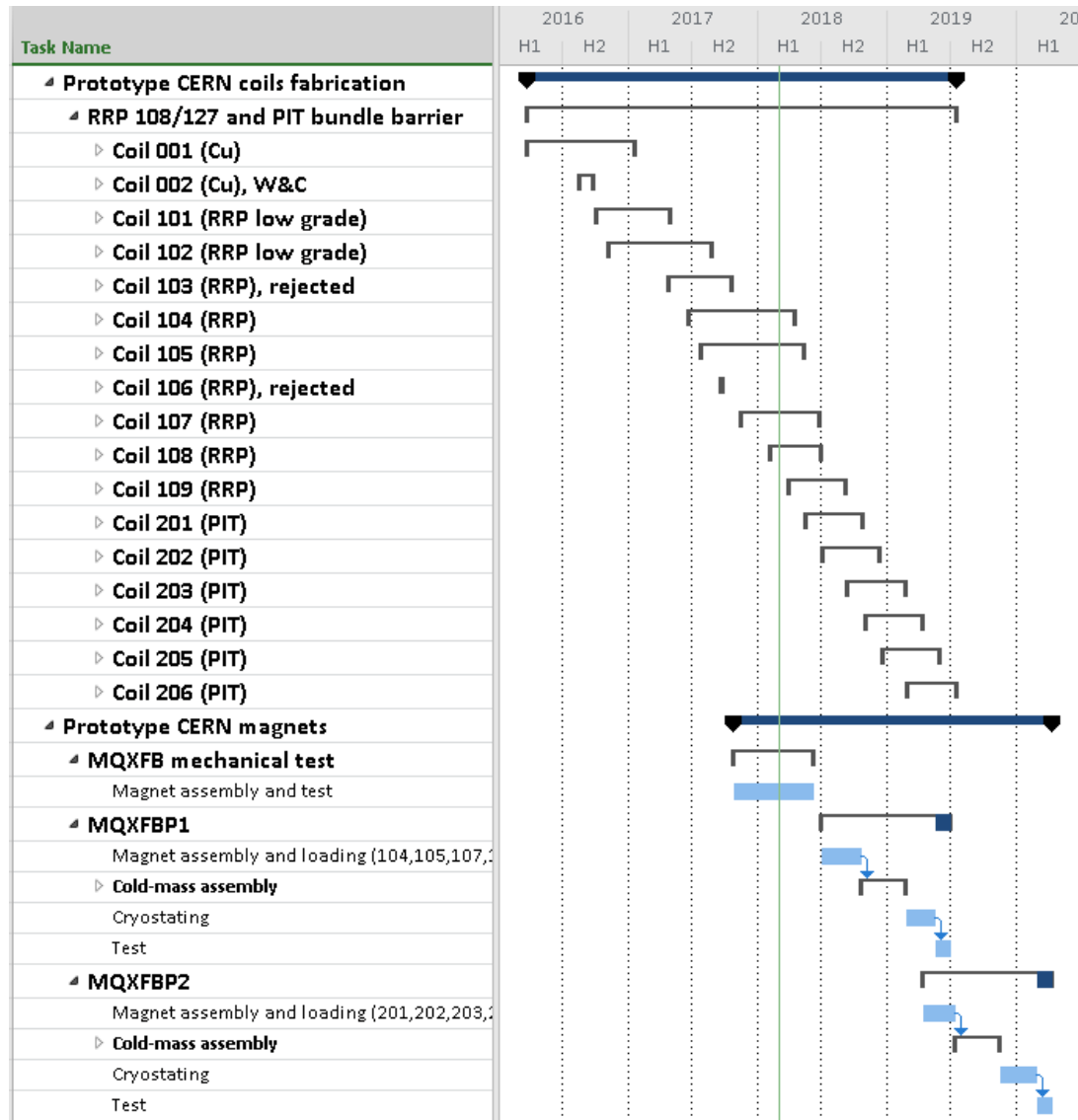
- Magnet assembly



CERN prototype program

Magnet fabrication

- 4 practice coils available
 - 001,101,102,103
- Assembly of MQXFB mechanical model started in 11/17
 - Goal: full loading by 04/18
- Strain gauges installed in all coils and structure



CERN prototype program

Magnet fabrication

- Coil-pack sub-assembly



CERN prototype program

Magnet fabrication

- Shell-yoke sub-assembly (± 0.15 mm vertical and horizontal direction)

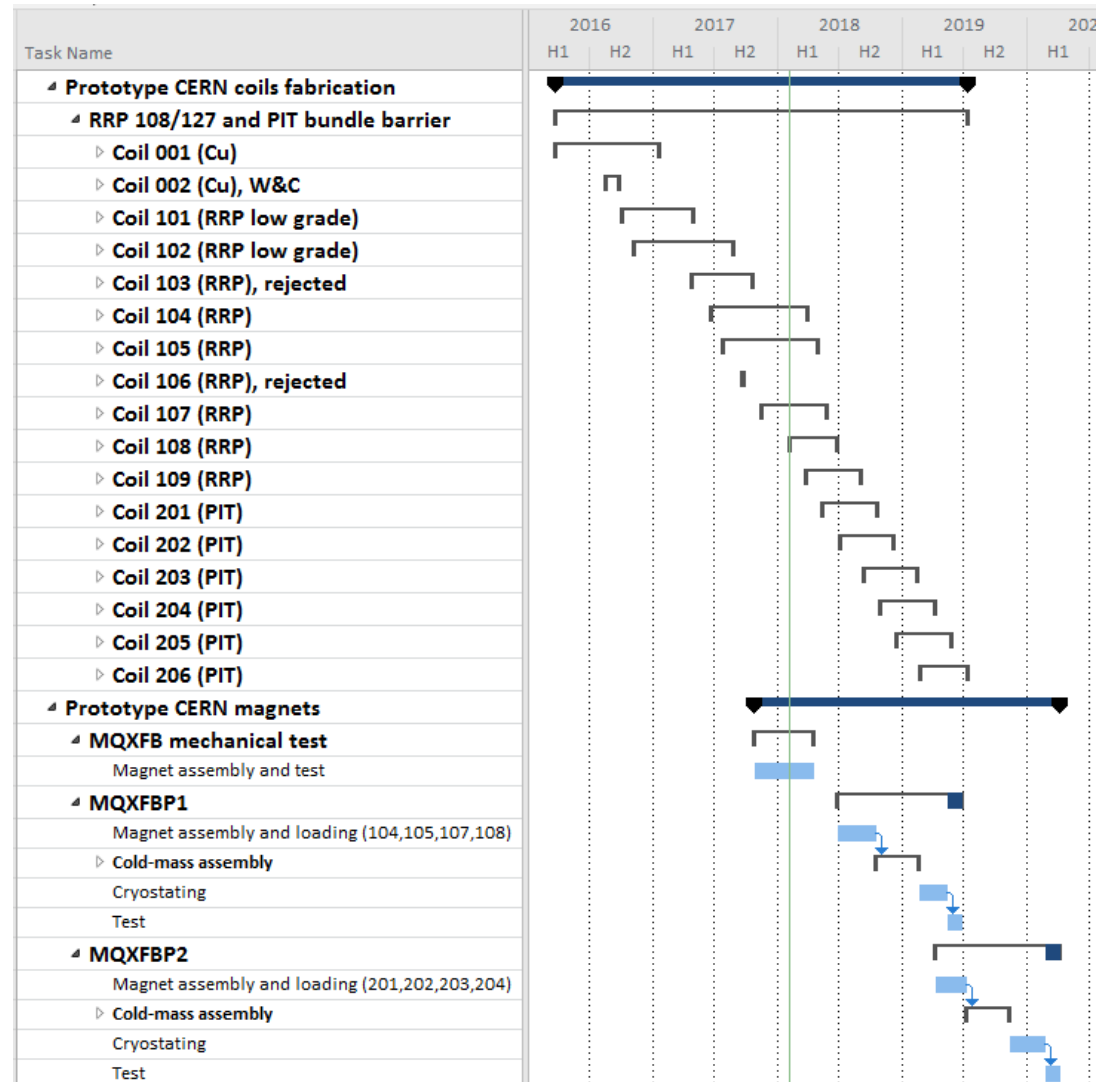


CERN prototype program

Magnet fabrication

- MQXFBP1

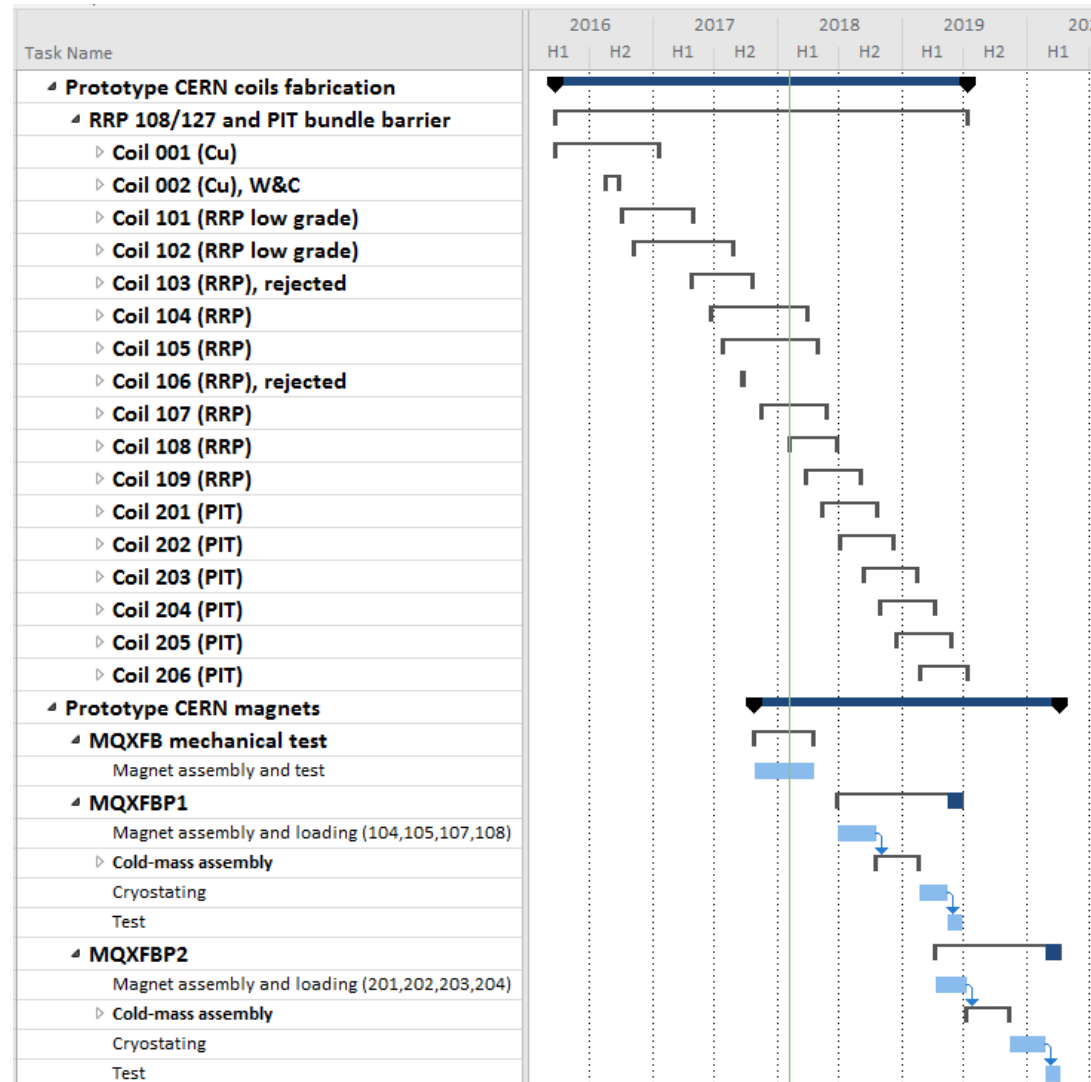
- Coil 104, 105, 107, 108 (109 spare)
- Magnet assembly starts in 07/18
- Cold-mass assembly starts in 10/18
- Cryostating starts in 02/19
- Test in 05-06/19



CERN prototype program

Magnet fabrication

- **MQXF BP2**
 - Coil 201, 202, 203, 204 (205-206 spare)
 - Magnet assembly starts in **04/19**
 - Cold-mass assembly starts in **07/19**
 - Cryostating starts in **11/19**
 - Test in **02-03/20**



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Status of components for MQXFB magnet

- What could we still change?

Coil parts	MQXFBP1	MQXFBP2	Series	Comments
Cable insulation	On going	Order placed	Order placed	
End-parts (spacers, end-shoe)	Delivered	Delivered	All by 08/18	
Poles and end-shoe extensions	Delivered	Delivered	All by 08/18	
Coating for end-parts	Delivered	Order placed	Order placed	
Wedge	Delivered	Delivered	All by 08/18	
Traces	Delivered	Order placed	Order placed	IT completed
Mid-plane shim	Delivered	Delivered	Delivered	
Magnet support structure	MQXFBP1	MQXFBP2	Series	Comments
Nitronic material (no armco)	Delivered	Delivered	Delivered	
Thick ARMCO	Delivered	Delivered	All by 04/18	
Aluminum material	Delivered	Delivered	Starting in 03/18	
Aluminum shell	Delivered	All by 10/18	Starting in 01/19	MQXFBP2 order after mech test
Thick yoke	Delivered	All by 10/18	Starting in 04/19	MQXFBP2 order after mech test
Thick pad	Delivered	All by 10/18	Starting in 04/19	MQXFBP2 order after mech test
Collars	Delivered	All by 10/18	Starting in 04/19	MQXFBP2 order after mech test
Master	Delivered	All by 10/18	Starting in 01/19	MQXFBP2 order after mech test
End-plate	Delivered	All by 10/18	Starting in 01/19	MQXFBP2 order after mech test
Thin yoke	Delivered	All by 10/18	MS to be (re)done	MQXFBP2 order after mech test
Thin pad	Delivered	All by 10/18	MS to be (re)done	MQXFBP2 order after mech test
Keys	Delivered	Delivered	Delivered	
Bushings	Delivered	Delivered	Delivered	
Tie-rods	Delivered	Delivered	Delivered	
Rods	Delivered	Delivered	Delivered	
Pushers SS	Delivered	Delivered	Delivered	
Pushers G11	Delivered	Delivered	Delivered	
Bullets	Delivered	Delivered	Delivered	
Welding blocks	Delivered	Delivered	Delivered	
Backing strip	Delivered	All by 04/18	All by 04/18	
Pole key	Delivered	Delivered	Delivered	
Bladder yoke-shell long	From MQXFS	All by 04/18	For 4 by 04/18	40 (1 set = 8) ordered, delivery by 04/18
Bladder yoke-shell short	From MQXFS	All by 04/18	For 2 by 04/18	40 (1 set = 12) ordered, delivery by 04/18
Bladder loading	All by 04/18	Not ordered	Not ordered	1 set = 20; waiting for feed-back from first delivery

Budget of components for MQXFB magnet

Coil parts	MQXFBP1	MQXFBP2	Series	Comments
Cable insulation	59850	59850	498750	11.06 euro/m --> 13.3 CHF per m
End-parts	38842	38842	194211	271896 CHF for 70 sets
Poles and extensions	65815	65815	581369	(672000+41000)=713000 CHF for 65 set
Coating for end-parts	37200	7200	60000	980.63 €/set
Wedge	34200	34200	281000	5700 CHF per set. 281000 CHF for 50 sets
Traces	33600	33600	312000	2750 CHF per trace for prototype, 2600 CHF for the series
Epoxy for 1 coil	5100	5100	42500	15 kg per coi, 54 US\$ per kg --> 850 CHF per coil
Binder for 1 coil	3000	3000	25000	265 US\$/kg, about 2 kg per for MQXFB coil
Different insulation layers	12000	12000	100000	About 2000 CHF per MQXFB coil
Mid-plane shim	2500	2500	12000	5000 CHF for 2 prototypes and 12000 CHF for 10 series magnet
Magnet support structure	MQXFBP1	MQXFBP2	Series	Comments
Nitronic material (no armco)	5000	5000	54000	10000 CHF for 2 prototypes and 54000 CHF for 10 series magnet
Thick ARMCO for yoke, pad, master	21500	21500	200000	43000 CHF for 2 prototypes and 200000 CHF for 10 series magnet
Aluminum material	54000	54000	487180	108000 CHF for 2 prototypes and 487180 CHF for 10 series magnet
Aluminum shell	33500	33500	201000	67000 CHF for 2 prototypes and 201000 CHF for 10 series magnet
Thick yoke	49000	49000	109000	98000 CHF for 2 prototypes and 109000 CHF for 10 series magnet
Thick pad	24000	24000	216000	48000 CHF for 2 prototypes and 216000 CHF for 10 series magnet
Collars	71500	71500	381000	143000 CHF for 2 prototypes and 381000 CHF for 10 series magnet
Master	48500	48500	189000	97000 CHF for 2 prototypes and 189000 CHF for 10 series magnet
End-plate	6500	6500	50000	13000 CHF for 2 prototypes and 50000 CHF for 10 series magnet
Thin yoke	126000	126000	410000	252000 CHF for 2 prototypes (material taken from stock MAGNETIL)
Thin pad	82500	82500	274000	165000 CHF for 2 prototypes (material taken from stock MAGNETIL)
Keys	42500	42500	75000	85000 CHF for 2 prototypes and 75000 CHF for 10 series magnet
Bushings	14000	14000	53000	28000 CHF for 2 prototypes and 53000 CHF for 10 series magnet
Yoke tubes	3500	3500	25000	7000 CHF for 2 prototypes and 25000 CHF for 10 series magnet
Tie-rods	4000	4000	50000	8000 CHF for 2 prototypes and 50000 CHF for 10 series magnet
Rods	4500	4500	37000	10000 CHF for 2 prototypes and 37000 CHF for 10 series magnet
Pushers SS + bullets + welding blocks	3000	3000	24000	6000 CHF for 2 prototypes and 24000 CHF for 10 series magnet
Backing strip	3000	3000	12000	6000 CHF for 2 prototypes and 12000 CHF for 10 series magnet
Pole key and G11 pushers	2000	2000	14000	4000 CHF for 2 prototypes and 14000 CHF for 10 series magnet
Pions	1000	1000	8000	2000 CHF for 2 prototypes and 8000 CHF for 10 series magnet
Transport+packing	3333	3333	33333	40000 CHF in total
Bladder yoke-shell long	0 (MQXFS)	730	7300	1 set = 8 *91 CHF = 728 CHF
Bladder yoke-shell short	0 (MQXFS)	900	9000	1 set = 12 *75 CHF = 900 CHF
Bladder loading	48300	5300	53000	Mech-model: tooling 23 kCHF, bladders 20 kCHF; prototype and series: 1 set = 20 * 265 = 5300 CHF

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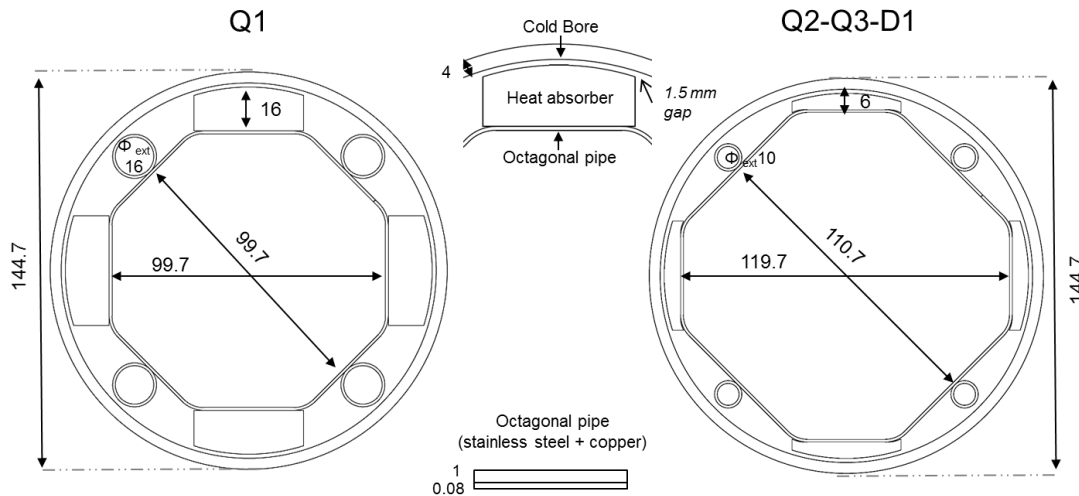
Inner layer quench heater delamination

- 2 solutions under study on short models
 - Encapsulated trace tested in MQXFS4 (04/18)
 - Coil 108: standard trace,
 - Coil 109: standard trace
 - Coil 110: encapsulated trace (pressed)
 - Coil 111: encapsulated trace (laminated)
 - Trace replaced by glass tested in MQXFS5b (06/18)
 - Coil 207
 - Also field quality
 - Check impact of mixing virgin and not virgin coils
- First prototype coil without inner layer quench heaters

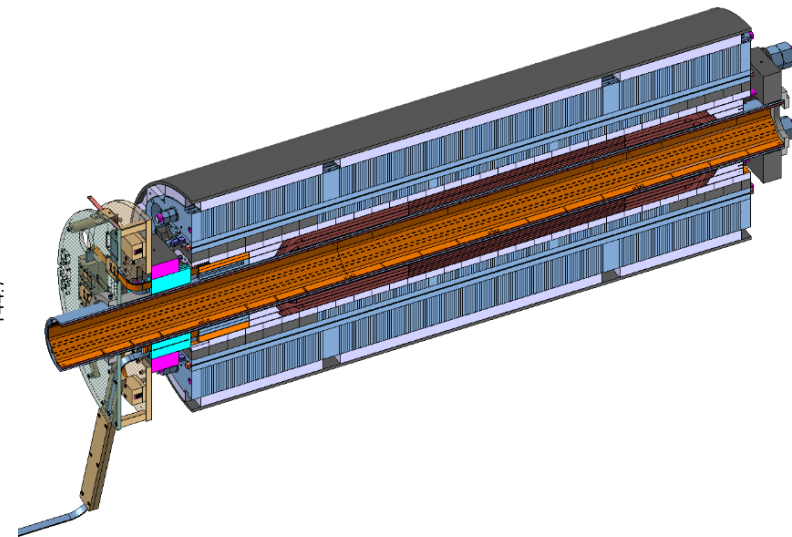


Beam screen deformation during CLIC discharge

- Beam screen to be inserted in MQXFS4 (05/18) and tested as MQXFS4b in 07/18, together with ss shell



*The dimensions are given in mm



Other issues

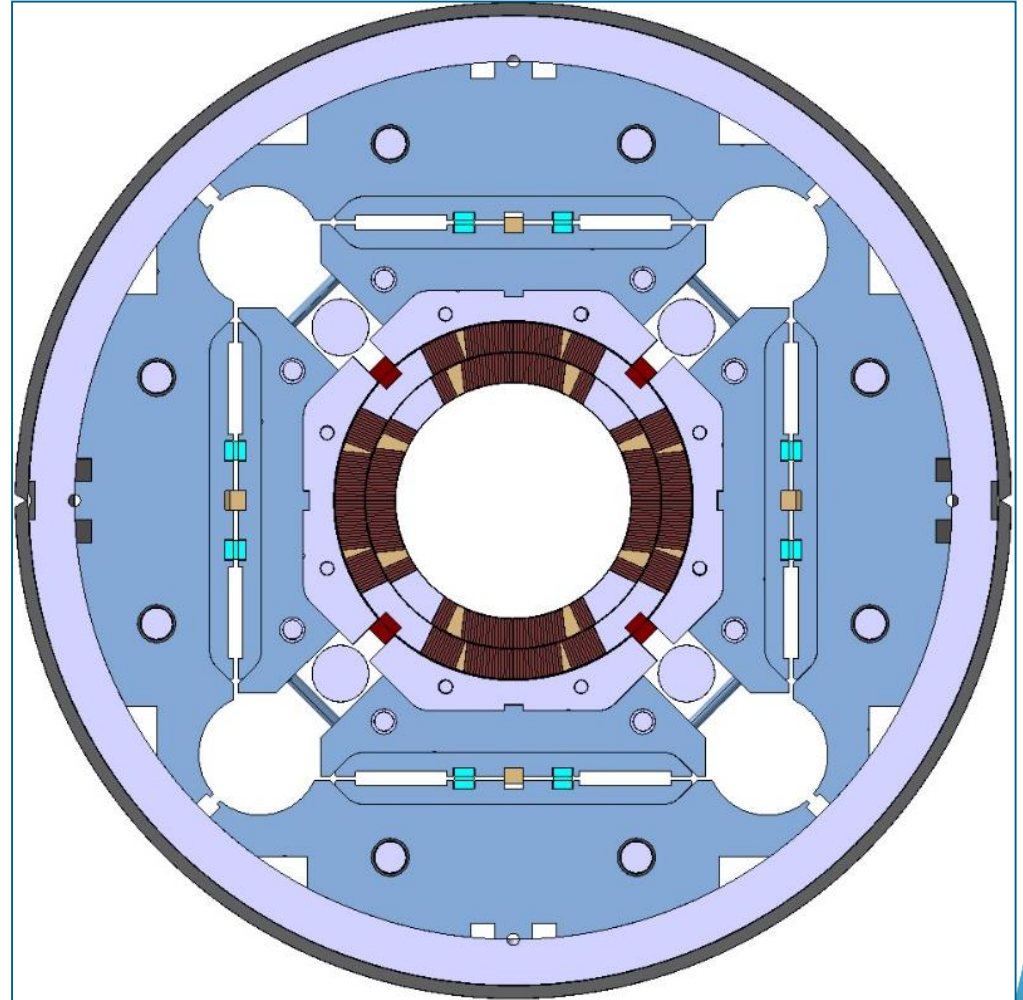
- Fine blanking of iron laminations
 - First MS+IT resulted in large overcost
 - Possibility of reduction of cost if iron provided in coils (currently in plates)
 - Work in progress
- **Anti-cryostat** for prototype magnetic measurements
 - Define responsibility between different sections
- Magnetic measurements with beam screen
 - Possible in MQXFBP1b after test of MQXFBP1 (05-06/19)

Appendix



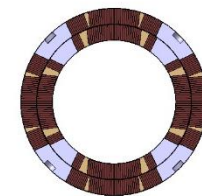
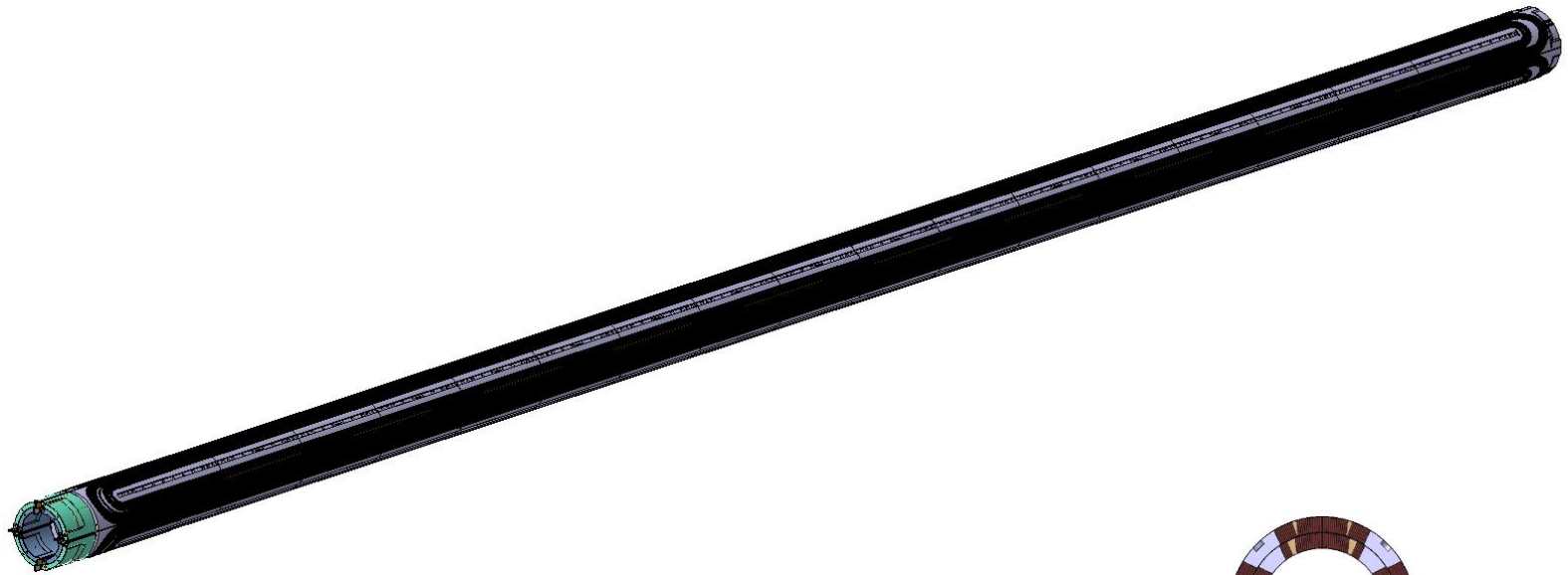
Overview of MQXF design

- OD: 630 m
- Stainless steel shell
 - 8 mm for LHe containment
- Aluminum shell
 - 29 mm thick
- Iron yoke
 - Gaps open
 - 4-fold symmetry
- Iron master plates
 - Bladder and keys
- Iron pad
- SS axial rods
- Aluminum collars
- G10 pole key
- Ti alloy poles



Magnet design MQXFB

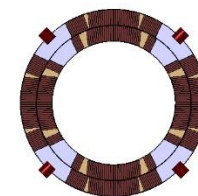
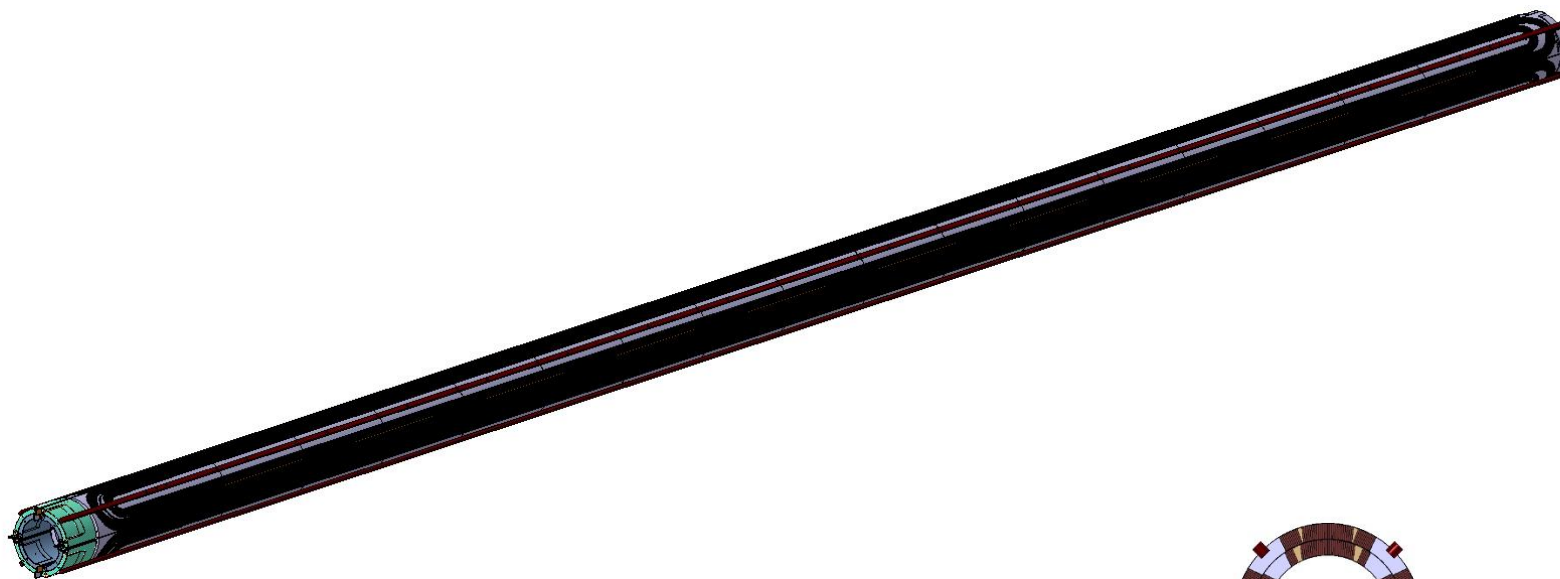
See J. C. Perez



- Superconducting coil

Magnet design MQXFB

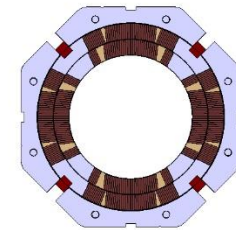
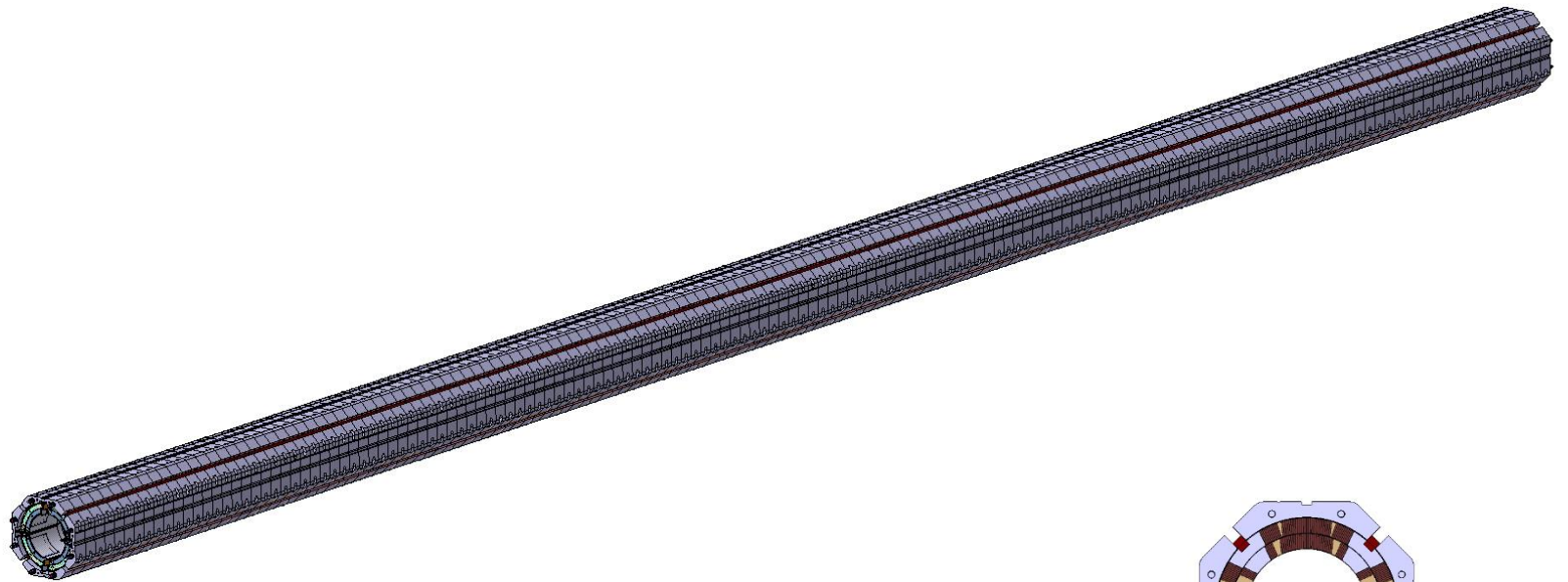
See J. C. Perez



- Pole key for alignment

Magnet design MQXFB

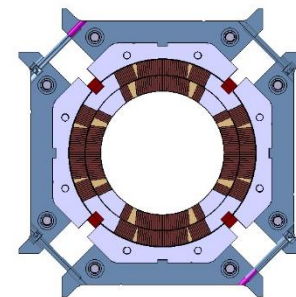
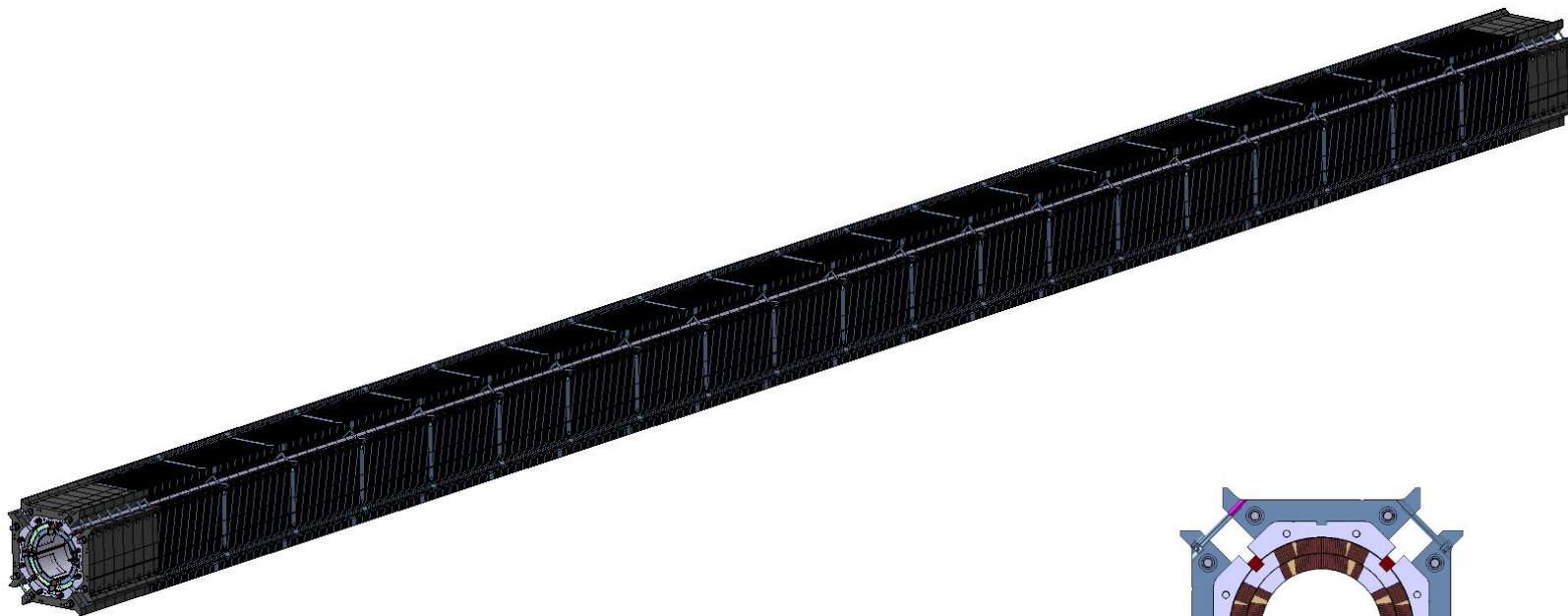
See J. C. Perez



- Aluminium collar
 - No coil pre-load

Magnet design MQXFB

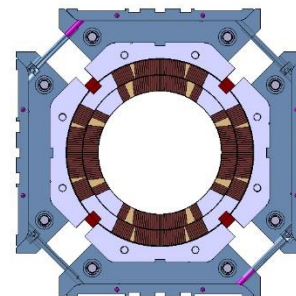
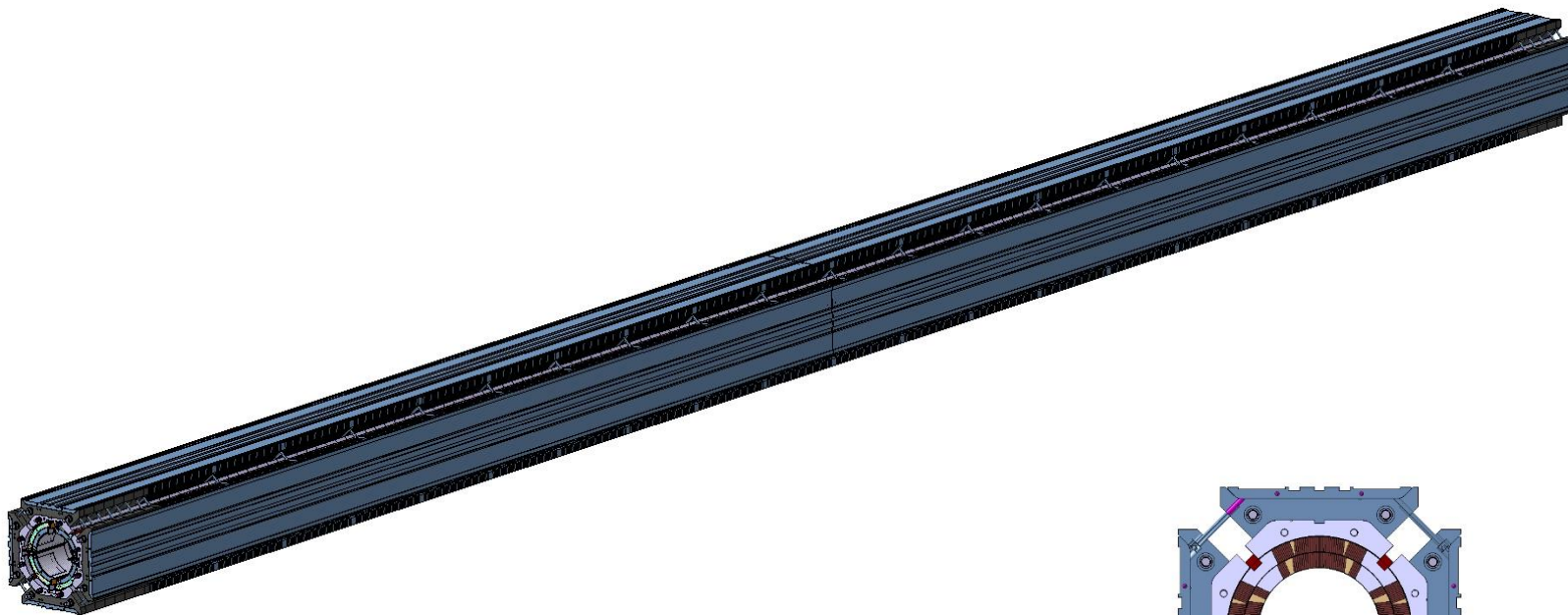
See J. C. Perez



- Bolted iron pad
- No coil pre-load

Magnet design MQXFB

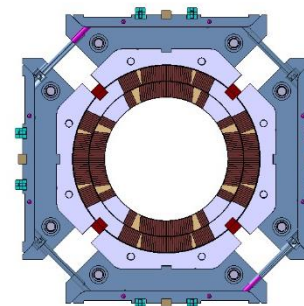
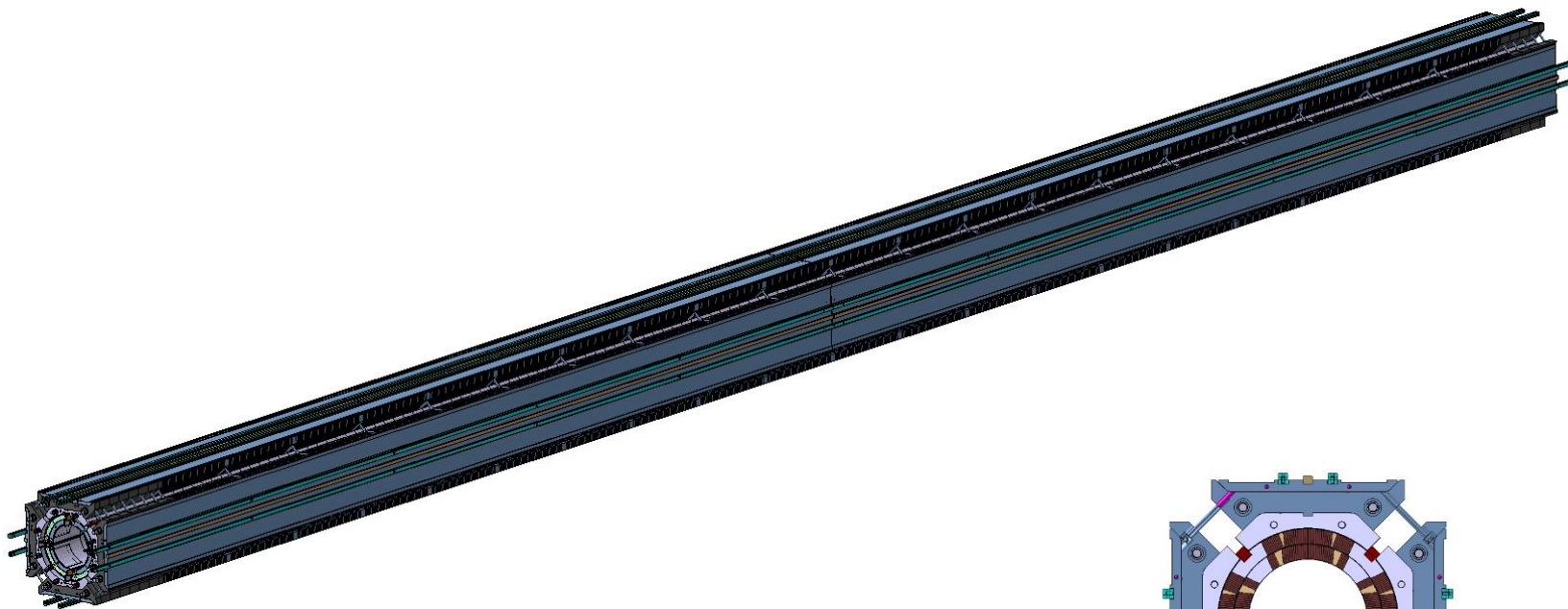
See J. C. Perez



- **Iron master**
 - Half-length plates for bladders and keys

Magnet design MQXFB

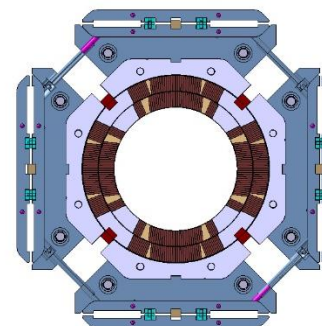
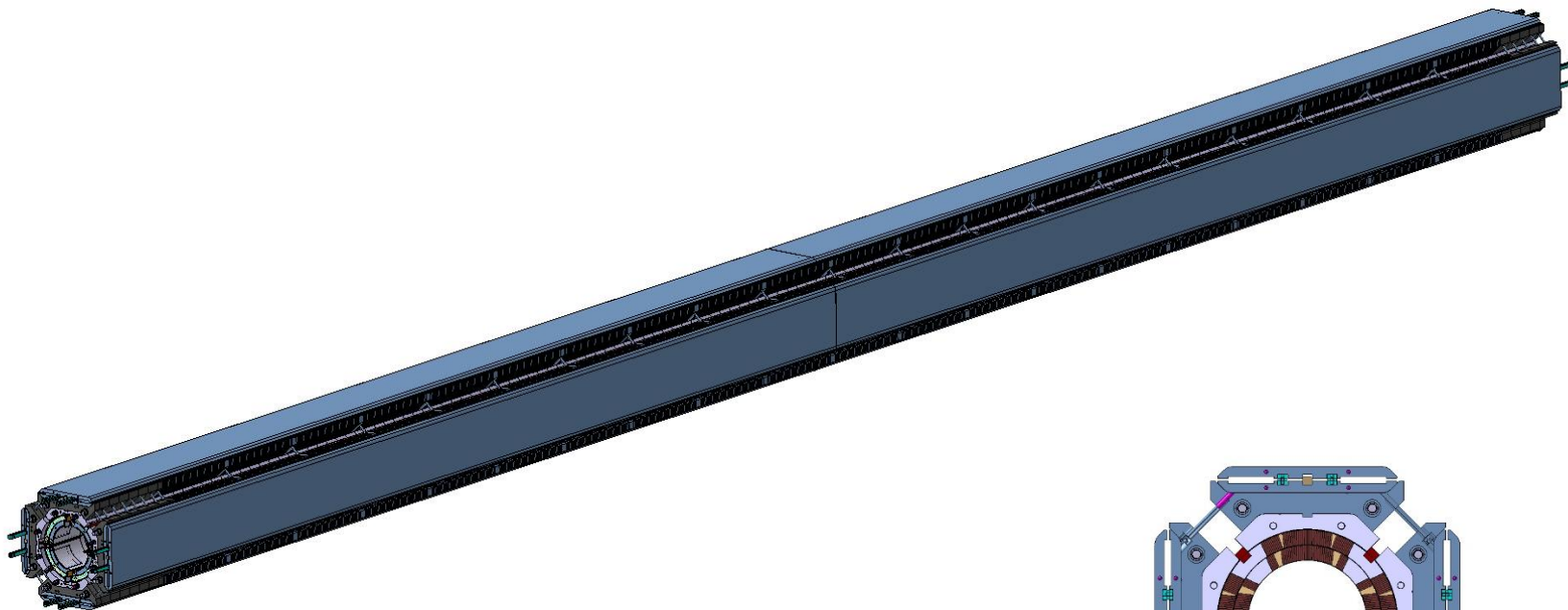
See J. C. Perez



- Loading and alignment keys

Magnet design MQXFB

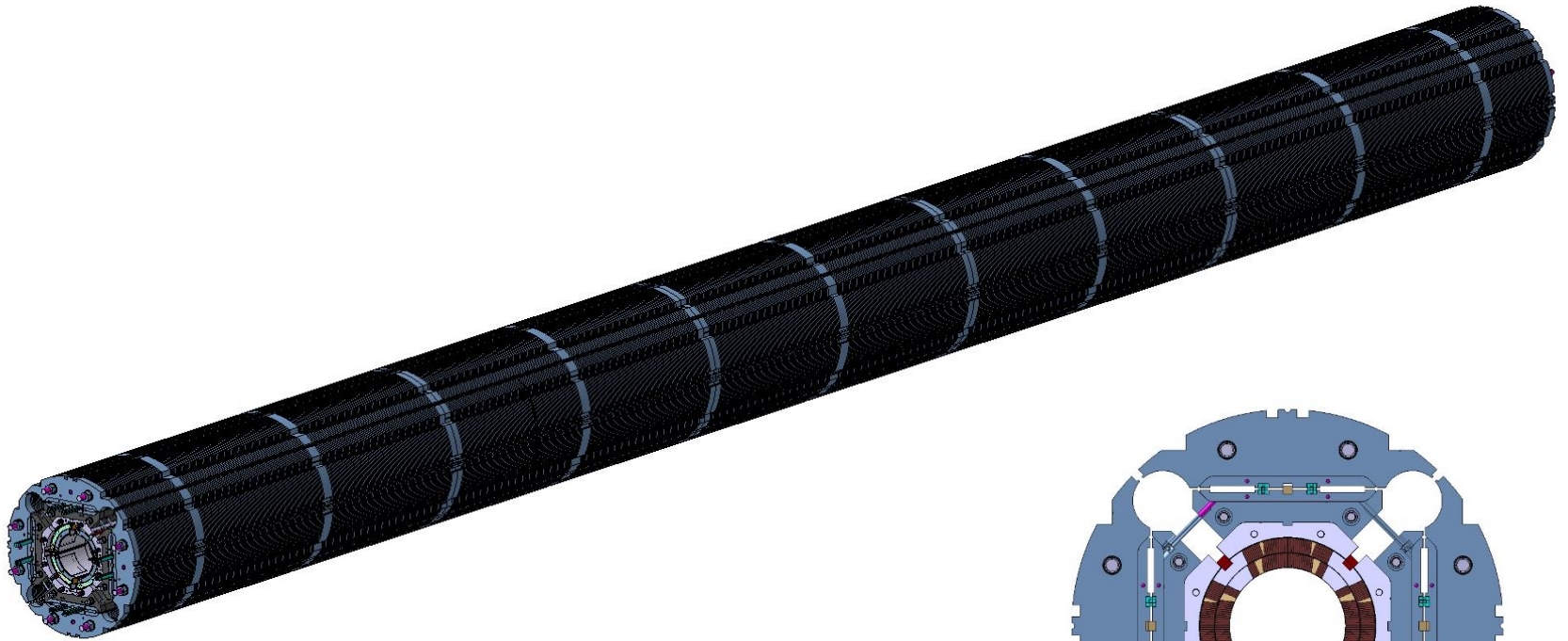
See J. C. Perez



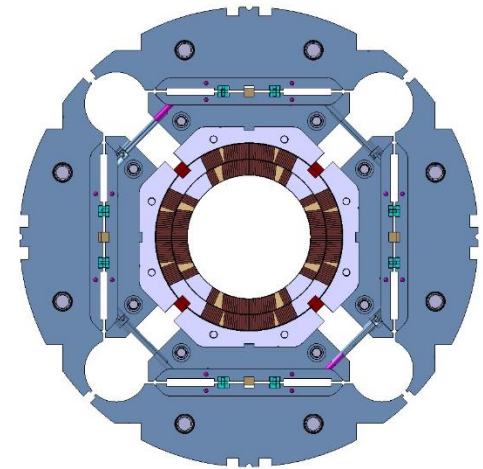
- **Second iron master**
 - Coil-pack sub-assembly

Magnet design MQXFB

See J. C. Perez

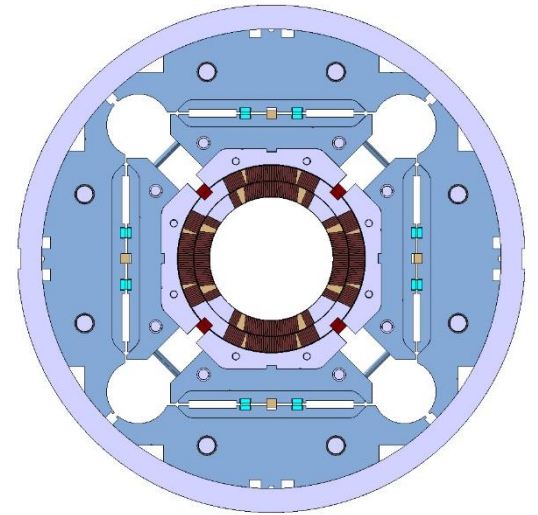
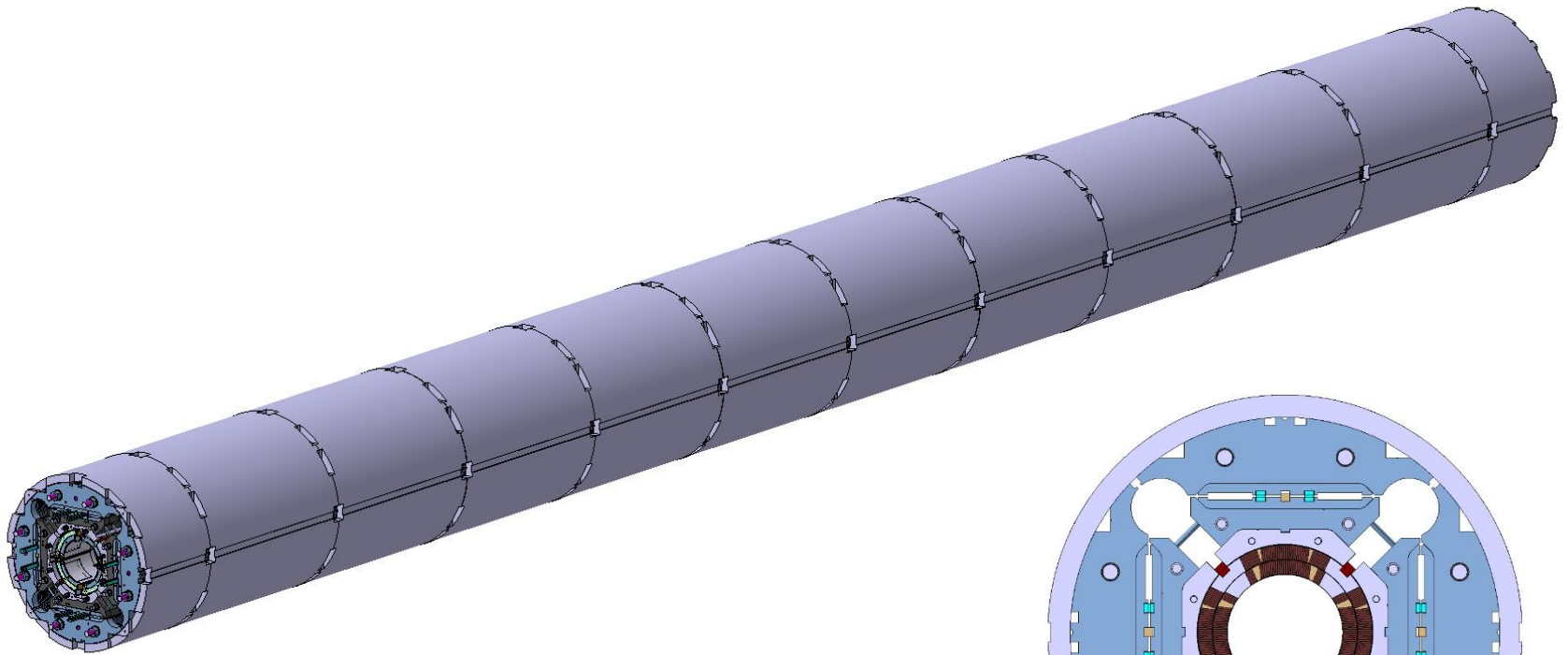


- Iron yoke laminations



Magnet design MQXFB

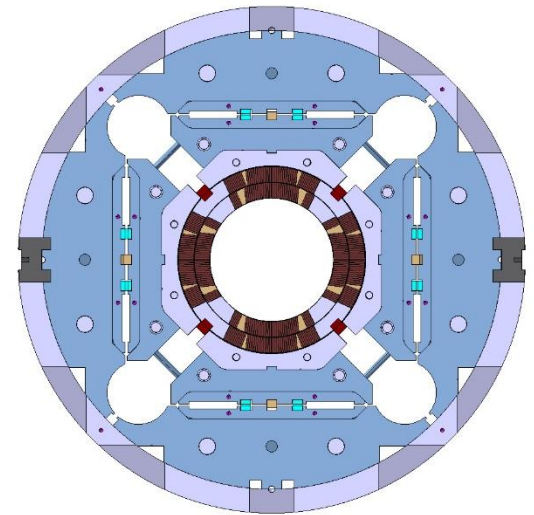
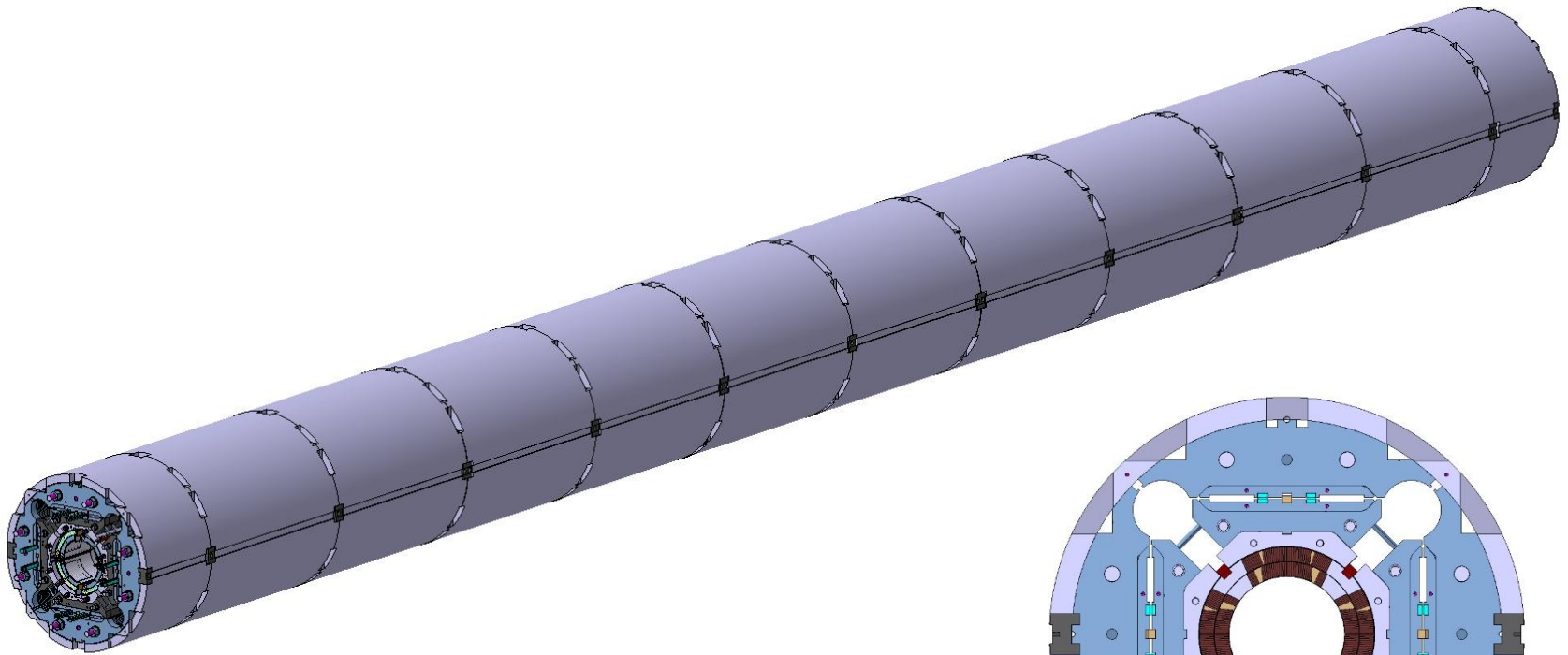
See J. C. Perez



- Segmented aluminium shell

Magnet design MQXFB

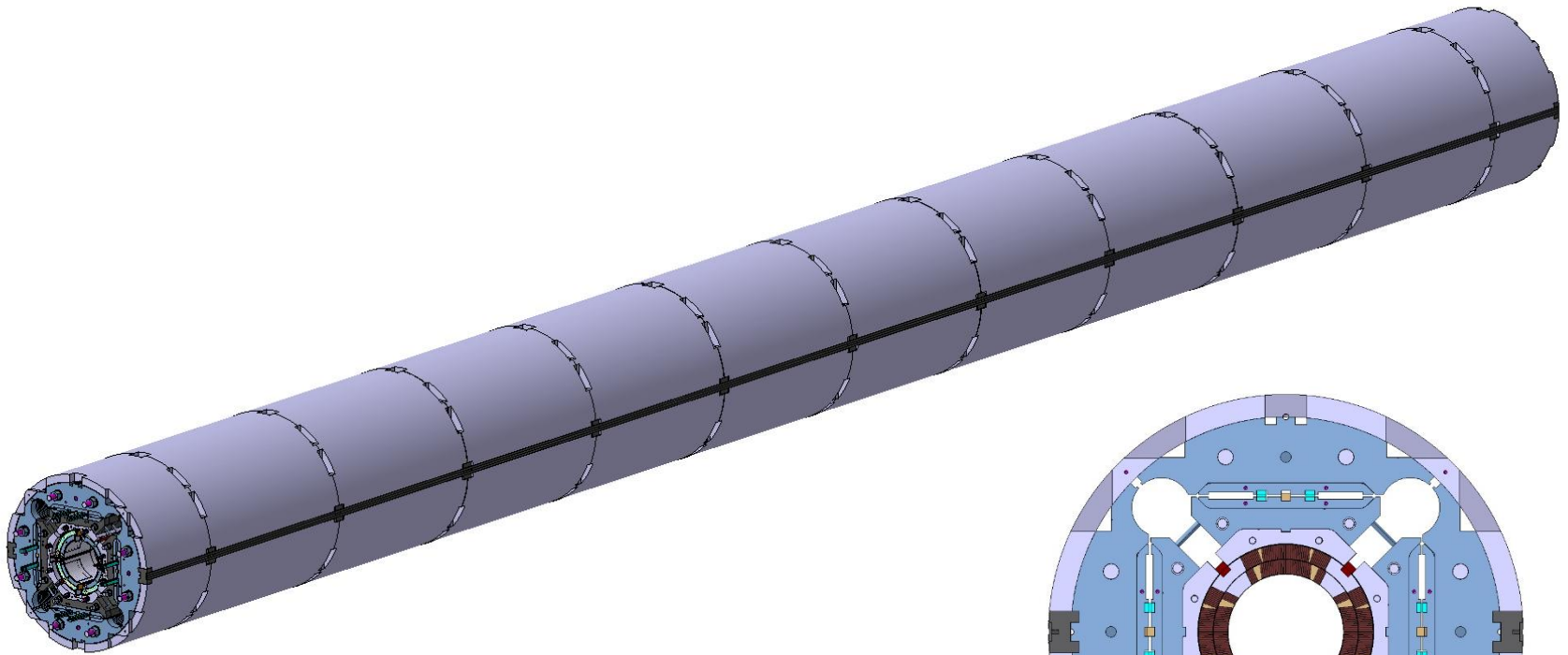
See J. C. Perez



- Tack-welding blocks
 - Aligned to the yoke

Magnet design MQXFB

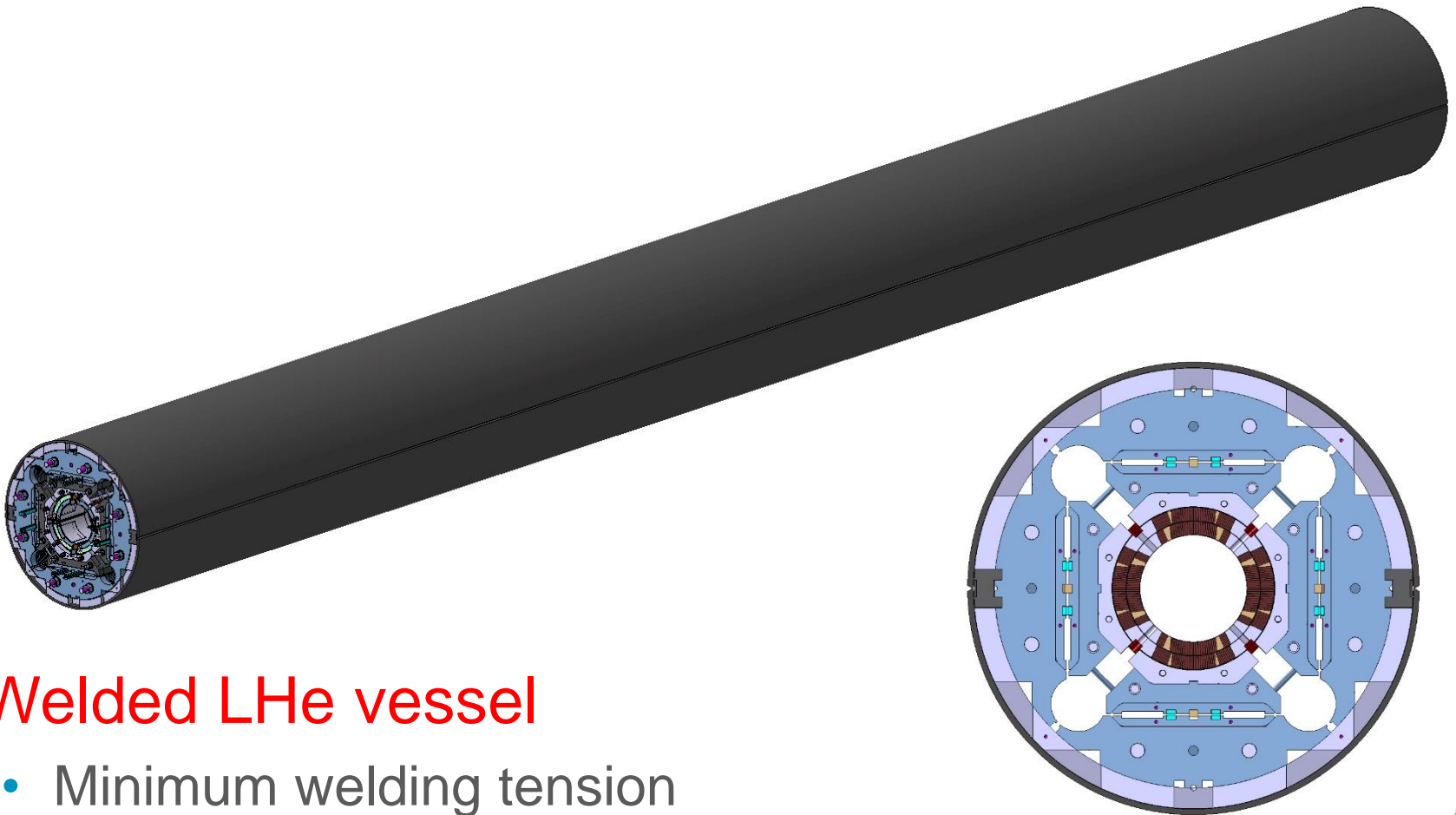
See J. C. Perez



- **Backing strip**
 - For Lhe vessel welding

Magnet design MQXFB

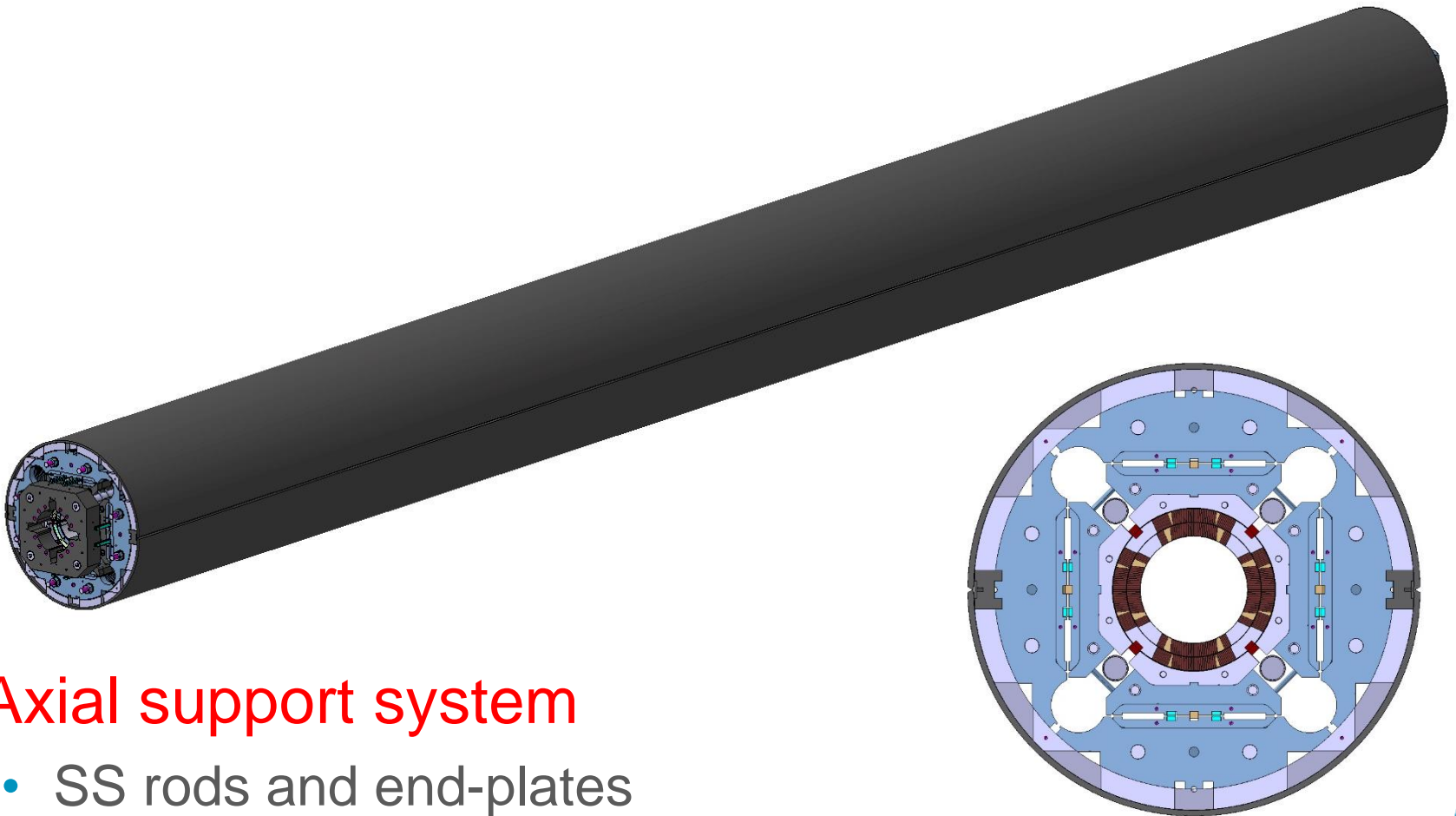
See J. C. Perez



- **Welded LHe vessel**
 - Minimum welding tension

Magnet design MQXFB

See J. C. Perez



- **Axial support system**
 - SS rods and end-plates