Status and plans of MQXFBP1 prototype magnet

Paolo Ferracin and Friedrich Lackner
on behalf of the MQXF collaboration

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CERN

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  - T. Salmi

Outline

- Results of the assembly of MQXFBP1 with practice coils

- Status and plans

MQXFBP1 assembled with 4 “practice” coils

- Practice coils
  - 001
    - Cu cable
    - No coating on end-spacer
  - 101 and 102
    - Cable with low-grade RRP strand
  - 103
    - First “real” coil rejected for major non conformity
      - Leads and mid-plan cables broken during reaction

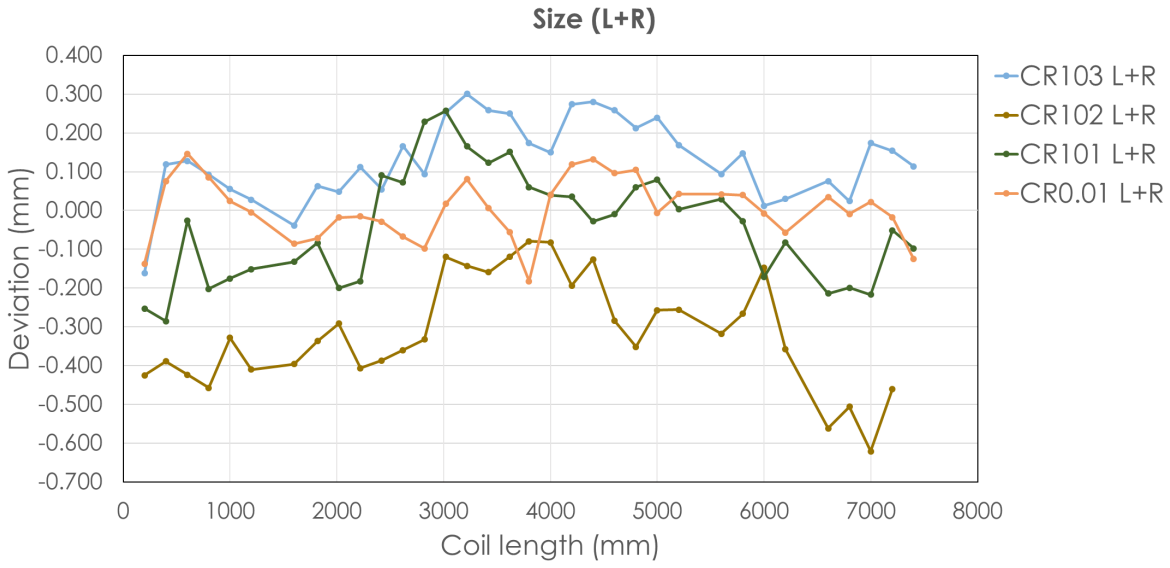
MQXFBP1 assembled with 4 “practice” coils

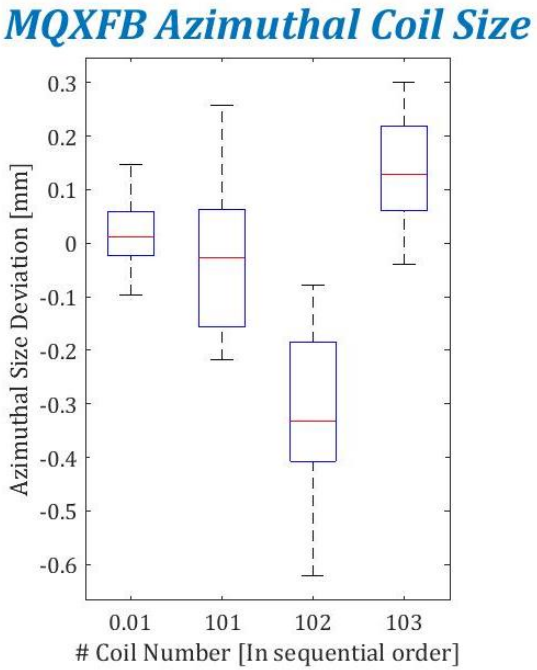
- Practice coils
  - Electrical tests
    - Coil 001
      - Short coil-to-pole
      - Coil-to-endshoe not passed (no coating)
    - Coil 101 and 102 ok
    - Coil 103
      - Weak coil-to-pole
      - Coil-to-endshoe and impulse test not relevant because of broken cables in the end

Coil	Coil-to-pole (V)	QH-to-coil (V)	Coil-to-endshoe (V)	QH-to-endshoe (V)	Impulse test (V)
Coil 001	Short coil to pole	3000 (R=24 GΩ)	Not passed	3000 (R=23 GΩ)	2500
Coil 101	500 (R=0.8 GΩ)	3000 (R=17 GΩ)	1000 (R=15 GΩ)	3000 (R=1.2 GΩ)	5000
Coil 102	500 (R=1.4 GΩ)	3000 (R=1.4 GΩ)	1000 (R=5 GΩ)	3000 (R=94 GΩ)	2500
Coil 103	500 (R=0.3 GΩ)	3000 (R=7 GΩ)	Not done	Not done	Not done

MQXFBP1 assembled with 4 “practice” coils

- Practice coils
  - Dimensional measurements



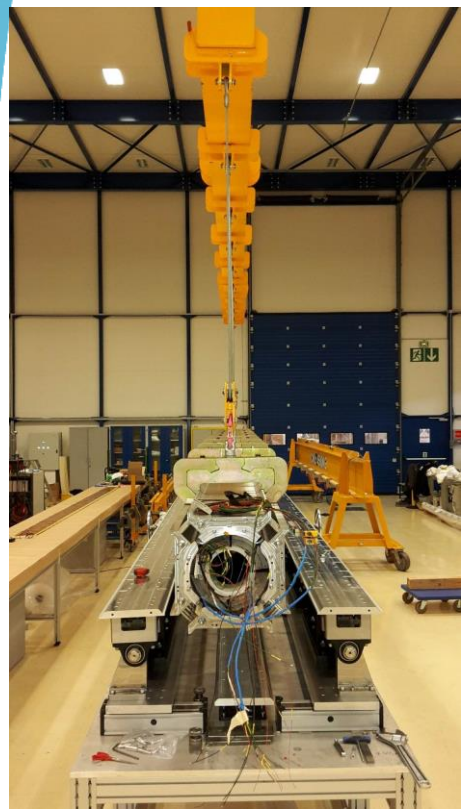


MQXFBP1 assembled with 4 “practice” coils

- Shell-yoke sub-assembly
  - Completed in early 2018

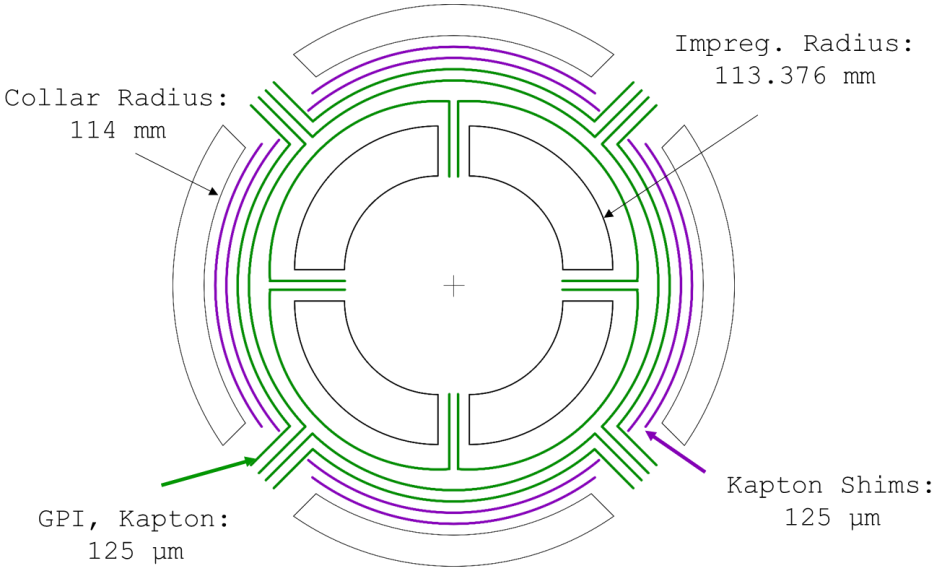
MQXFBP1 assembled with 4 “practice” coils

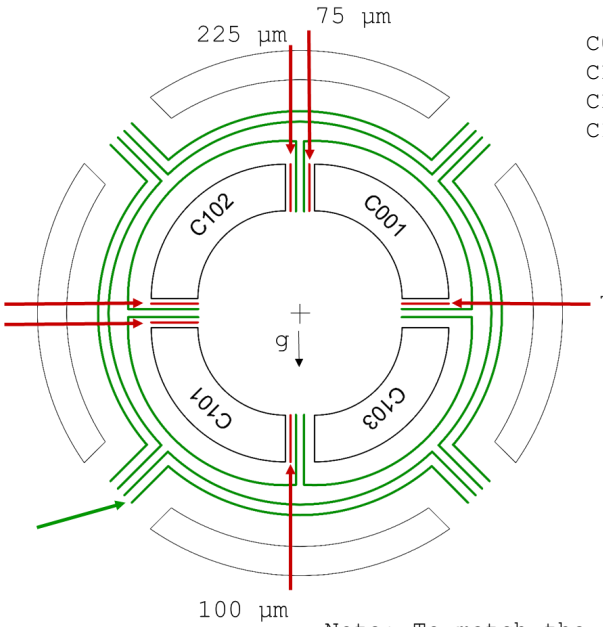
- Coil-pack sub-assembly
  - Work carried-out in 03-04 2018



MQXFBP1 assembled with 4 “practice” coils

- Coil-pack sub-assembly
  - Shimming-plan (nominal vs. “real”)



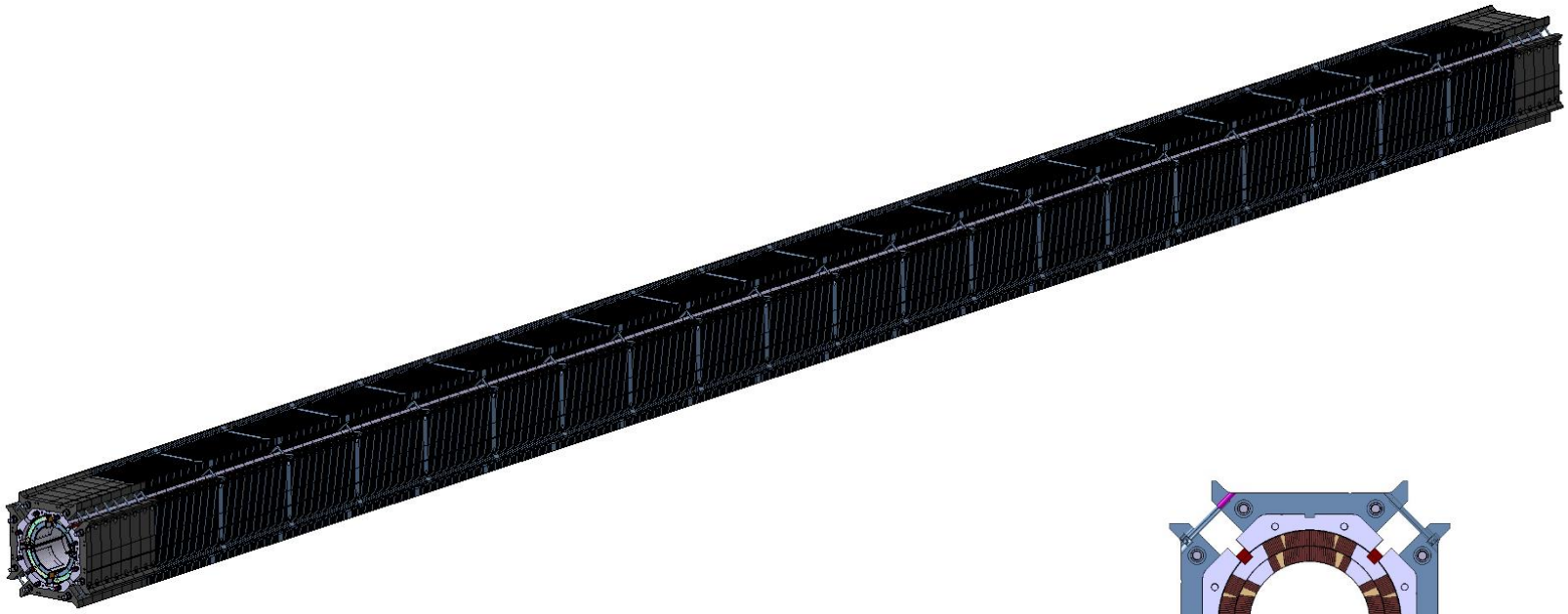


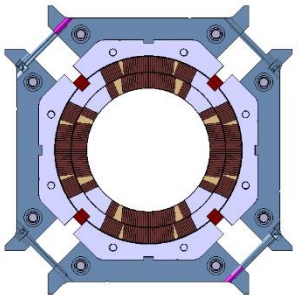
C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Note: To match the 114 mm collar radius, we removed a 125 µm collar shim.
Additional shim removed to improve contact.

Magnet design
MQXFB

See J. C. Perez

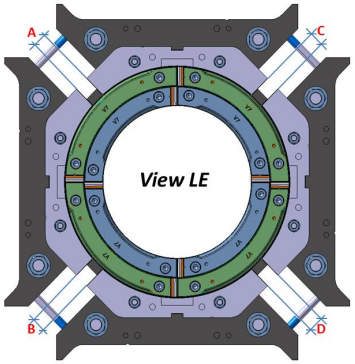


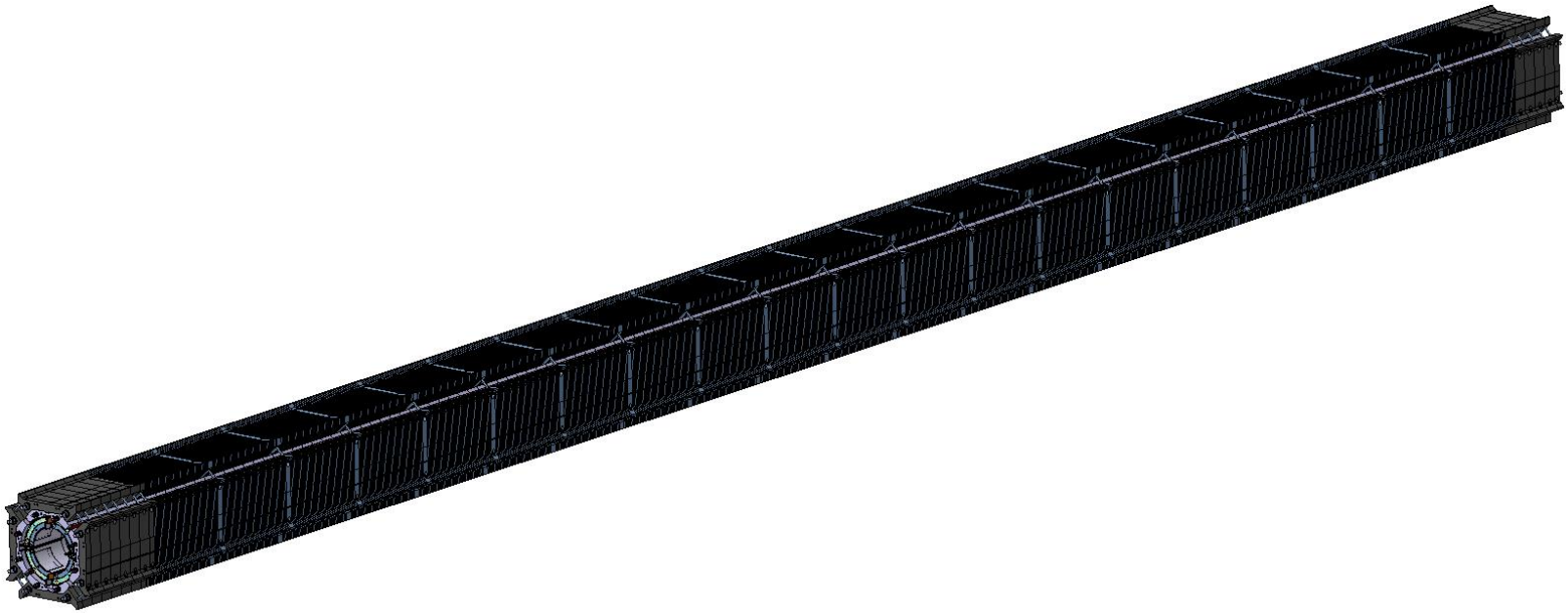


- Bolted iron pad
  - No coil pre-load

MQXFBP1 assembled with 4 “practice” coils

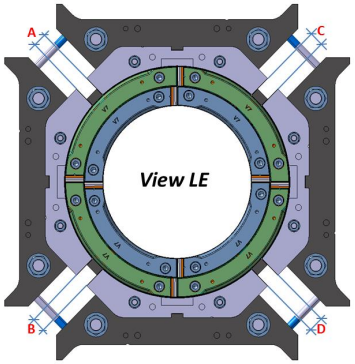
- Coil-pack sub-assembly
  - Fuji test in coil pack #1
  - Important: we bolt only the “thick” pads

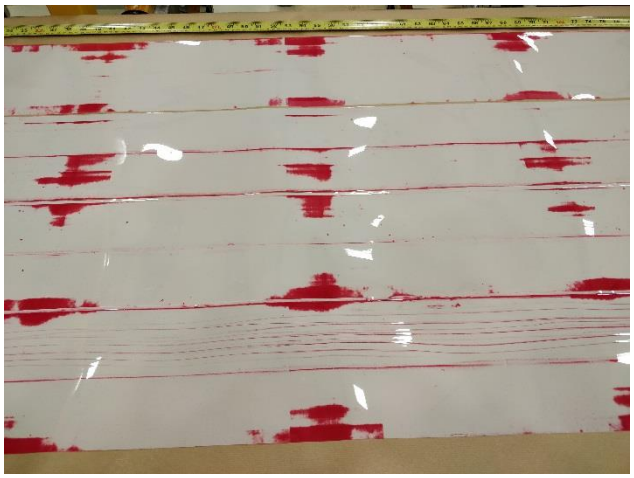


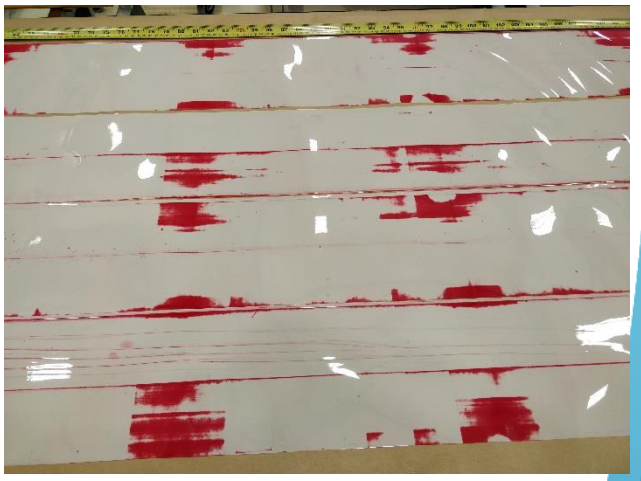


MQXFBP1 assembled with 4 “practice” coils

- Coil-pack sub-assembly
  - Fuji test in coil pack #1
    - As usual, hard to draw conclusions
    - Mark in corresponded of the pads where we bolt

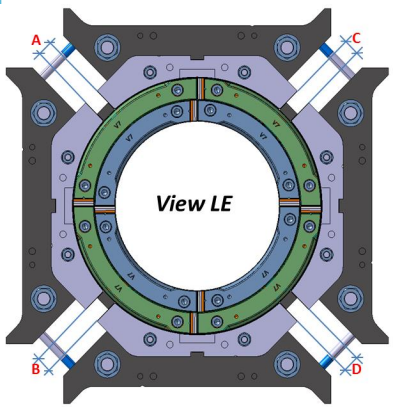


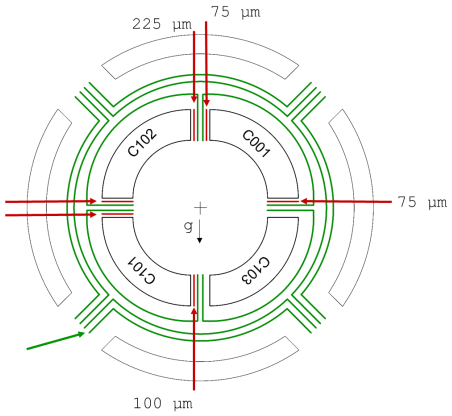


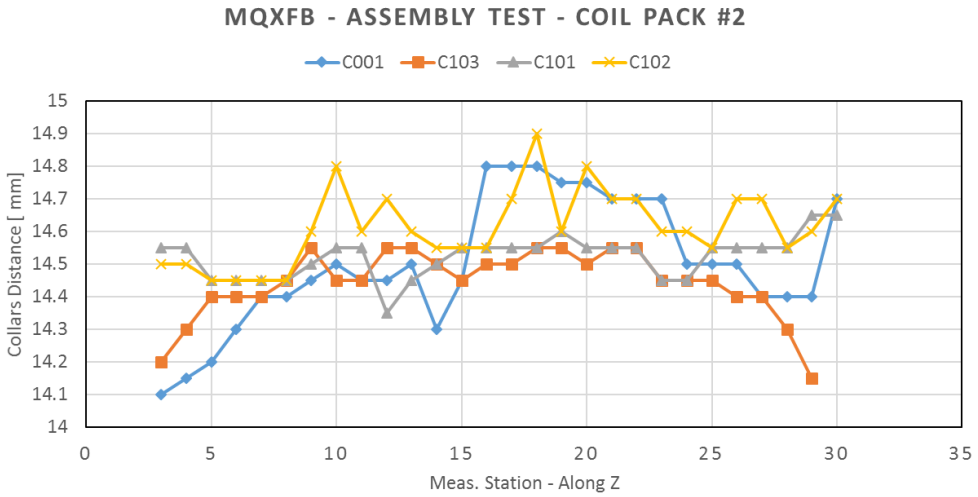


MQXFBP1 assembled with 4 “practice” coils

- Coil-pack sub-assembly
  - Measurements of pole gaps
    - Pole-key + ground insulation: 14.4 mm
    - Coil pack 2 total gap: 100 μm.







MQXFBP1 assembled with 4 “practice” coils

- Insertion of coil-pack sub-assembly in shell-yoke sub-assembly and bladder operation in 06-07 2018

MQXFBP1 assembled with 4 “practice” coils

MQXFBP1 assembled with 4 “practice” coils

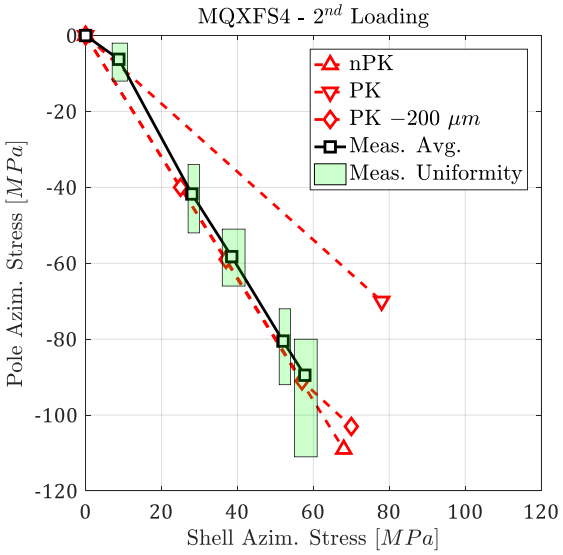
MQXFBP1 assembled with 4 “practice” coils

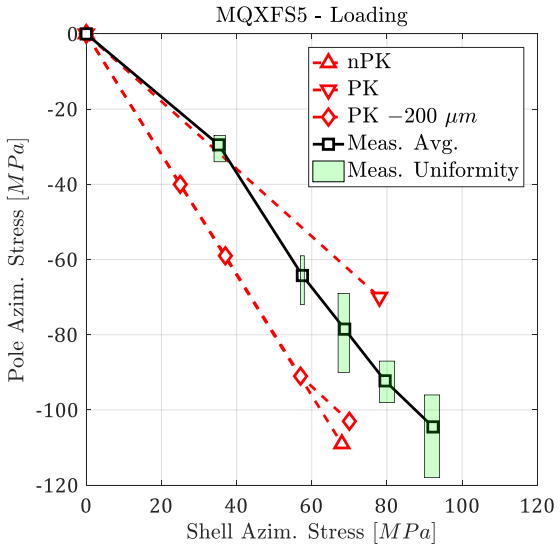
- Strain gauge locations
  - Aluminum shells
    - ϑ,z in 3 axial location, 4 quadrant → 24 gauges

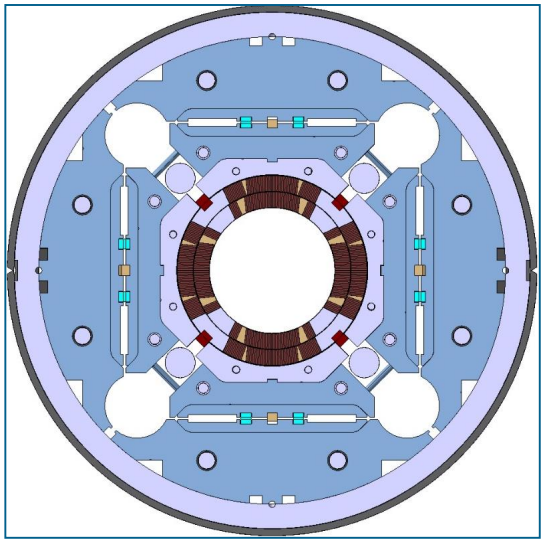
  - Coils
    - ϑ,z in 3 axial location, 4 coils → 24 gauges

MQXFBP1 assembled with 4 “practice” coils

- Bladder operation
  - The MQXFS4 and MQXFS5 cases

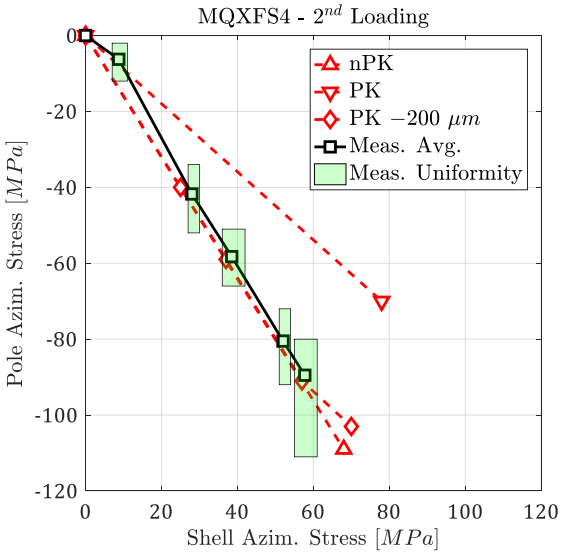


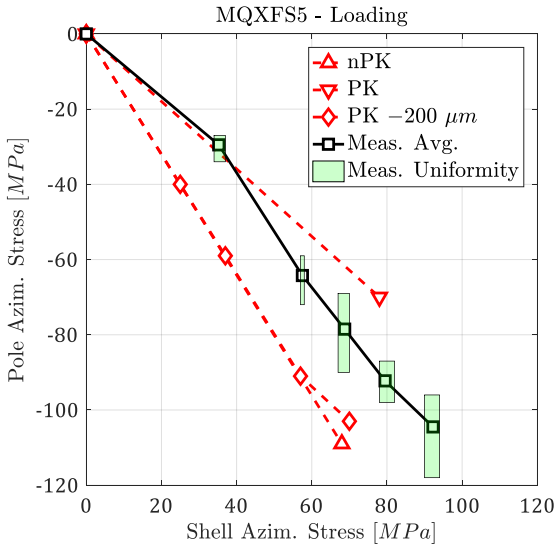


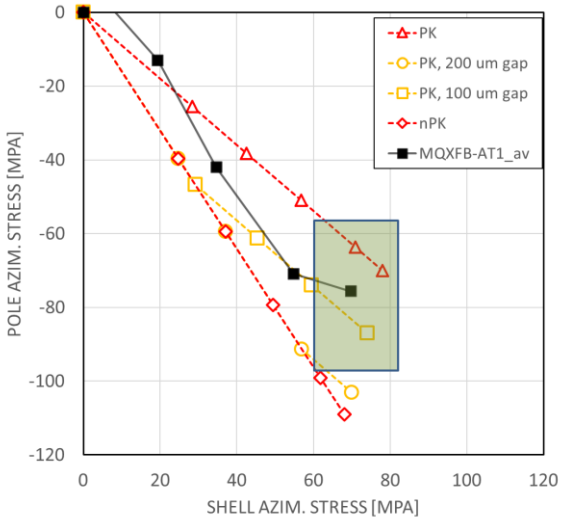


MQXFBP1 assembled with 4 “practice” coils

- Bladder operation
  - MQXFB with practice coil case
    - In between *“pole key”* and *“no-pole-key”* but large spread





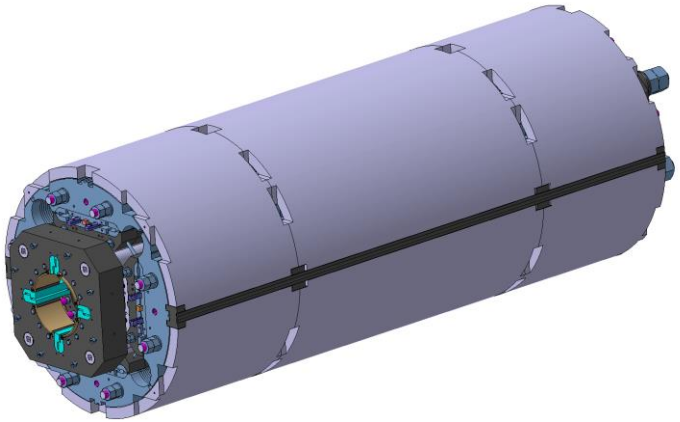


  - Pre-load interrupted due to bladder failure

MQXFBP1 assembled with 4 “practice” coils

- Axial loading
  - No performed since
    - Very different coil lengths
    - Interference axial loading system with aluminum tube

- Modification/update of the axial system in progress



MQXFBP1 assembled with 4 “practice” coils

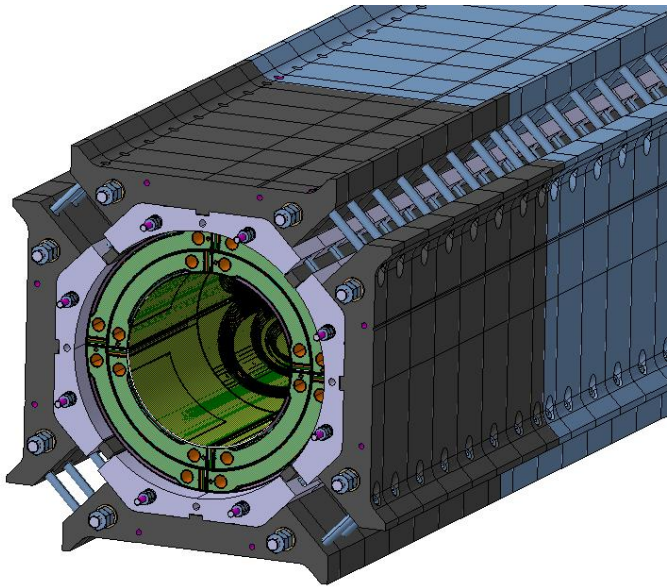
- General comments
  - No show stoppers so far, but some issues to address and modifications to implement
    - Many bladders leaked/failed
      - Sometime due to misalignment inside the groove
      - Then, large stroke due to missing shim
    - New bladders fabricated with extruded tube to be delivered by the end of September
    - New tooling developed to extract bladders

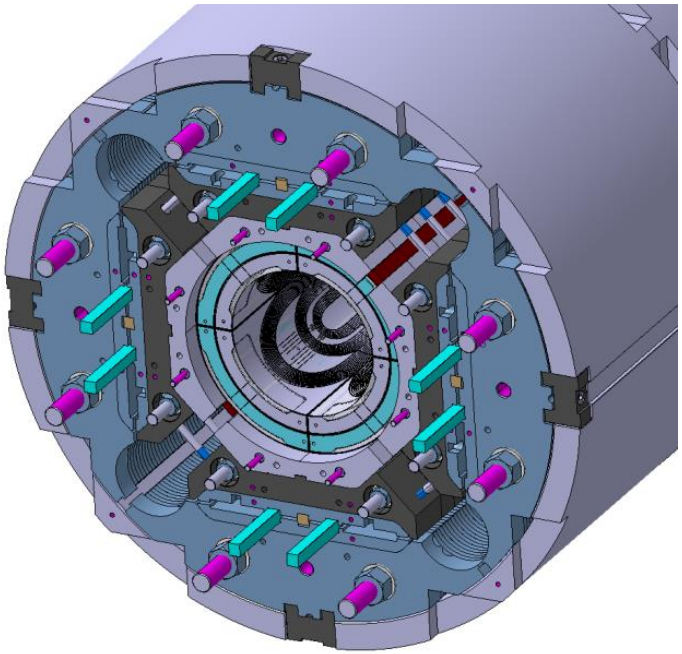
MQXFBP1 assembled with 4 “practice” coils

- Modifications improvement of parts/tooling
  - Masters connected to coil pack before insertion

MQXFBP1 assembled with 4 “practice” coils

- Modifications improvement of parts/tooling
  - Axial loading system
    - Procedure not verified on MQXFB
  - Reduction of magnet length



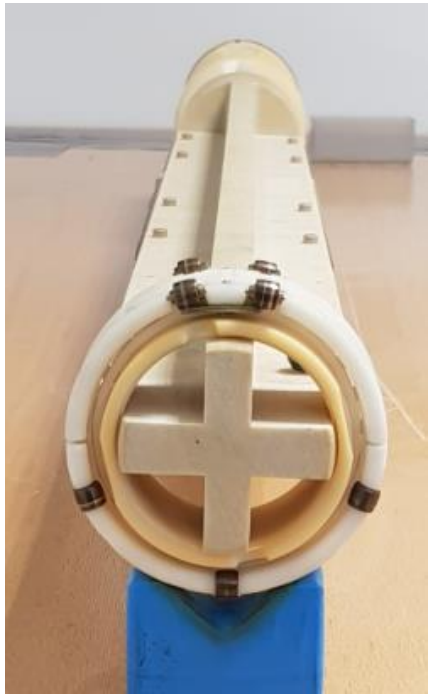


MQXFBP1 assembled with 4 “practice” coils

- Magnetic measurements at room temperature

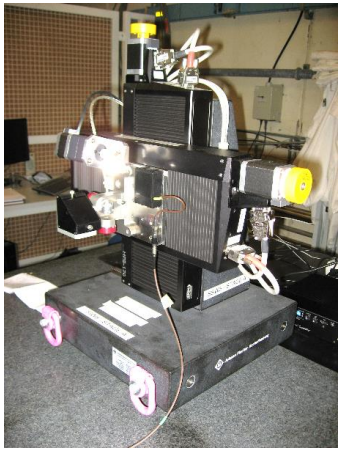
MQXFBP1 assembled with 4 “practice” coils

- Magnetic measurements at room temperature
  - Rotating-coil scanner
    - Same approach as for the old “QIMM”
    - On-board encoder and tilt sensor
    - Motor unit on a “chariot”
    - Mechanical extensions for translating and rotating the probe
    - Supported by a tube ID 100 mm
    - PCB-coil length 500 mm
    - Measurement radius ~ 40 mm
    - CCR targets for referring magnetic axis to external points



MQXFBP1 assembled with 4 “practice” coils

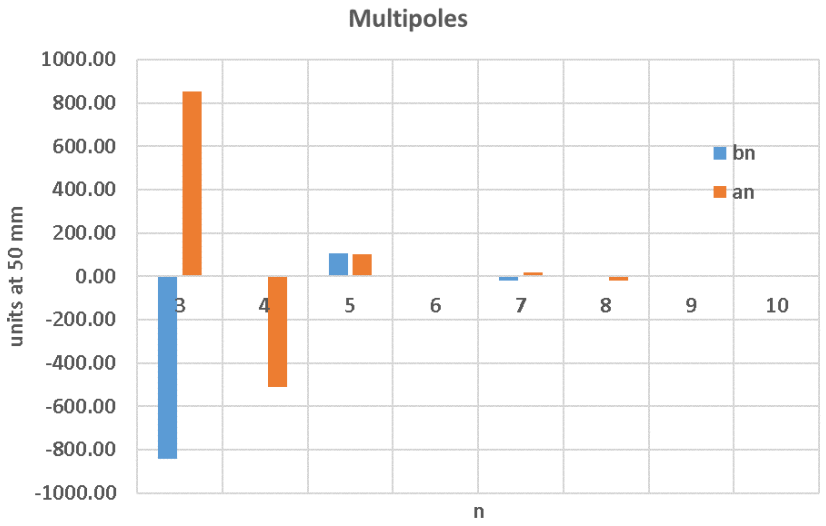
- Magnetic measurements at room temperature
  - Single stretched wire
    - X-Y tables with 155-mm span
    - Fast Digital Integrator
    - FFMM software with user-friendly GUI
    - DC and AC mode



MQXFBP1 assembled with 4 “practice” coils

- Magnetic measurements at room temperature
  - B2 is 20% smaller than expected
  - The magnetic center is displaced toward the quadrant 3 (coil 103)
  - Multipoles show large values with a patter compatible with an issue in quadrant 3 (coil 103)
  - Results from stretched wire not exploitable (the alignment procedure was not converging)

From the inner 12 positions (total 6 m)			
	Average	**STD**	
I	10	-	A
B2	-3.519	0.005	mT
Angle	-	0.91	mrad
X	-10.62	0.23	mm
Y	-10.79	0.12	mm



MQXFBP1 assembled with 4 “practice” coils

- Electrical tests after magnet loading
  - All QH to coil passed

		R (GΩ)					
Borne +	Borne -	500 V / 1'	1 kV / 1'	1.5 kV / 1'	2 kV / 1'	2.5 kV / 1'	3 kV / 1'
4 poles + QHS	Gnd + Cold Bore Tube + All	7.23	6.82	5.8	1.361	1.046	Brk Dwn
Pole 1 + QHS 1	Gnd + Cold Bore Tube + All	17.16	13.61	11.92	3.68	3.69	2.84
Pole 2 + QHS 2	Gnd + Cold Bore Tube + All	18.86	20	18.31	6.85	1.66	7.62
Pole 3 + QHS 3	Gnd + Cold Bore Tube + All	5.59	4.03	4.64	1.419	1.625	2.21
Pole 4 + QHS 4	Gnd + Cold Bore Tube + All	8.71	6.42	6.32	1.952	Brk Dwn	N. A
Pole 1	QHs 1	9.63	10.94	11.23	7.6	7.41	8.33
Pole 2	QHs 2	8.24	8.67	9.64	7.53	11.7	6.56
Pole 3	QHs 3	4.09	4.97	4.35	1.54	5.74	1.673
Pole 4	QHs 4	6.68	6.24	6.16	4.57	4.6	5.05
Pole 1	Gnd + Cold Bore Tube + All	5.46	5.44	3.41	2.87	3.61	2.1
Pole 2	Gnd + Cold Bore Tube + All	5.42	5.4	5.26	2.15	4.48	4.67
Pole 3	Gnd + Cold Bore Tube + All	3.93	2.84	1.123	0.886	1.205	1.04
Pole 4	Gnd + Cold Bore Tube + All	3.98	3.68	1.857	1.514	Brk Dwn	N. A
QHs 1	Gnd + Cold Bore Tube + All	9.63	9.58	8.71	7.57	8.26	12.9
QHs 2	Gnd + Cold Bore Tube + All	7.08	7.28	5.84	5.35	6.07	6.4
QHs 3	Gnd + Cold Bore Tube + All	4	3.82	2.03	1.31	2.35	2.01
QHs 4	Gnd + Cold Bore Tube + All	6.79	6.47	5.57	5.09	5.67	5.34

MQXFBP1 assembled with 4 “practice” coils

- Electrical tests after magnet loading
  - Coil 103 to ground did not pass (only up to 2 kV)
    - To be checked after disassembly

		R (GΩ)					
Borne +	Borne -	500 V / 1'	1 kV / 1'	1.5 kV / 1'	2 kV / 1'	2.5 kV / 1'	3 kV / 1'
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MQXFBP1 assembled with 4 “practice” coils

- Electrical tests after magnet loading
  - Coil 001 (spacer not coated) to QHs didn’t pass at 3 kV
    - Insulation weakness between QH wire & Saddle
    - Test passed at 3 kV by spacing wires from saddle

		R (GΩ)					
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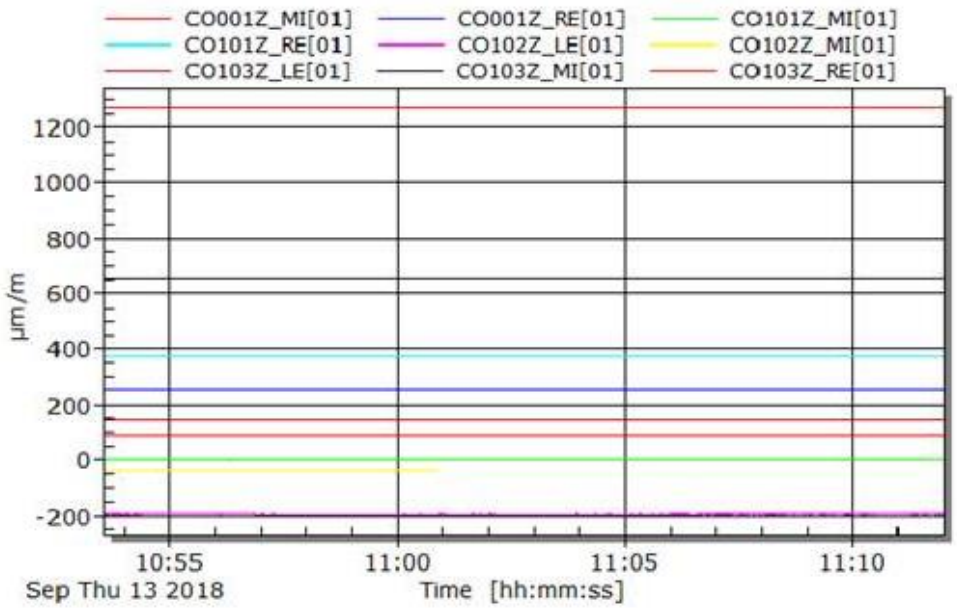
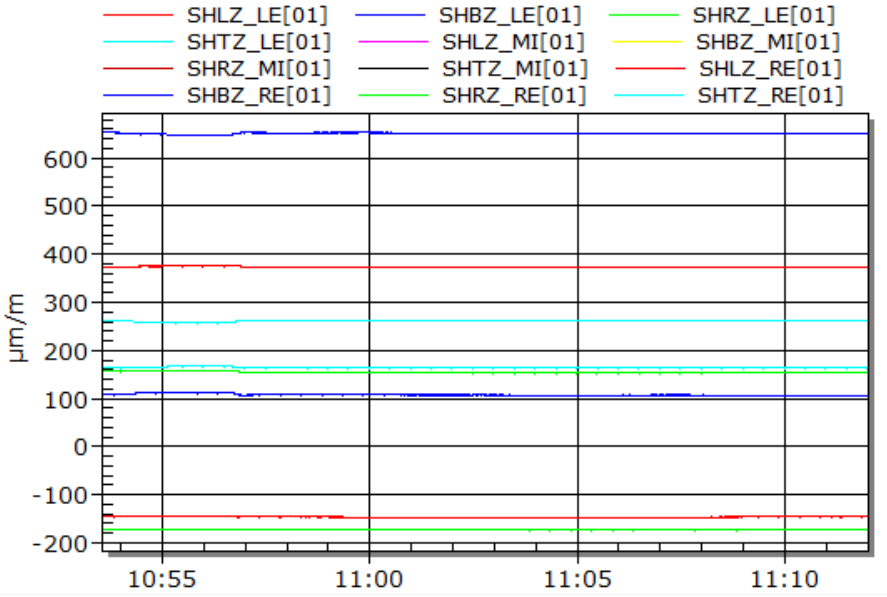
MQXFBP1 assembled with 4 “practice” coils

- Lifting test

MQXFBP1 assembled with 4 “practice” coils

- Lifting test
  - No significant variation of coil and shell axial strain during lifting



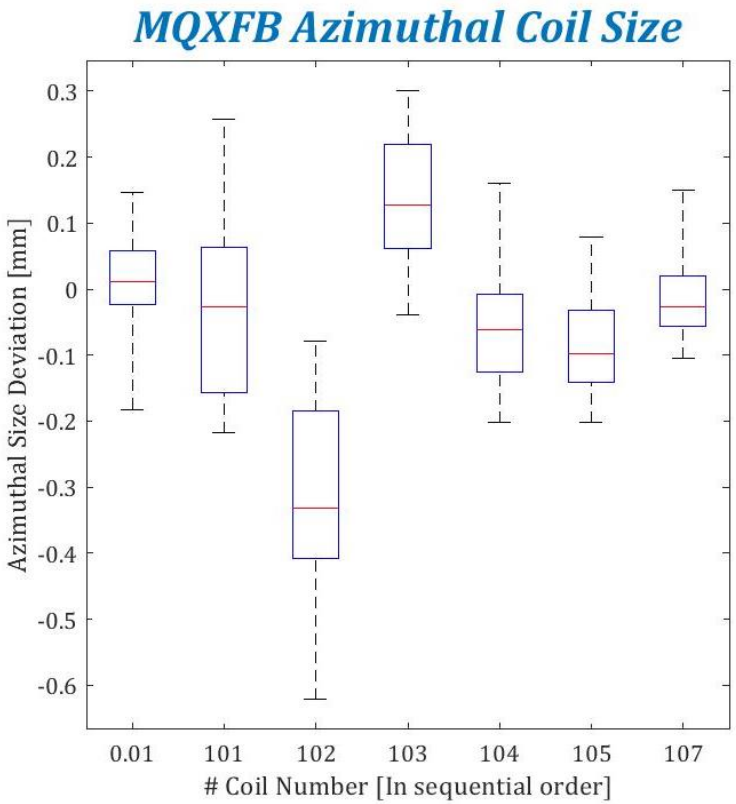


Outline

- Results of the dummy assembly of MQXFBP1
- Status and plans

Next steps

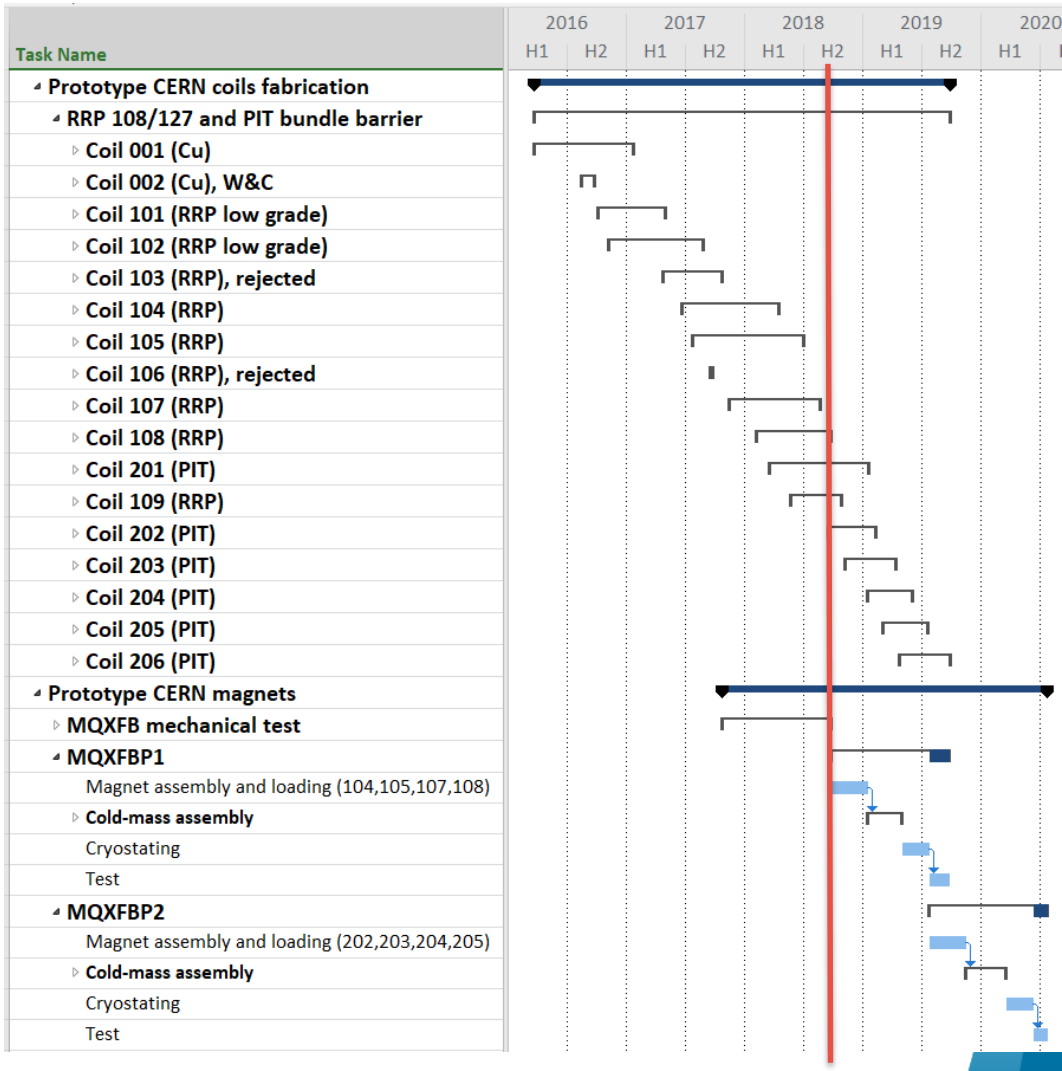
- Disassembly of magnet and coil-pack (09/2018)
- Assembly of the MQXFBP1 magnet with coils 104, 105, 107, 108 (?) in 10-12/2018
  - Better results for dimensional measurements in 104,105,107
  - Weak insulation coil to pole on coil 104 and 105, but still >MΩ



Coil	Coil-to-pole (V)	QH-to-coil (V)	Coil-to-endshoe (V)	QH-to-endshoe (V)
Coil 104	500 (R=20 MΩ)	3700 (R=8.5 GΩ)	1000 (R=18 GΩ)	3700 (R=19 GΩ)
Coil 105	500 (R=30 MΩ)	3700 (R=13 GΩ)	1000 (R=110 GΩ)	3700 (R=26 GΩ)
Coil 107	500 (R=510 MΩ)	3700 (R=12 GΩ)	1000 (R=54 GΩ)	3700 (R=30 GΩ)
Coil 108	To be done	To be done	To be done	To be done

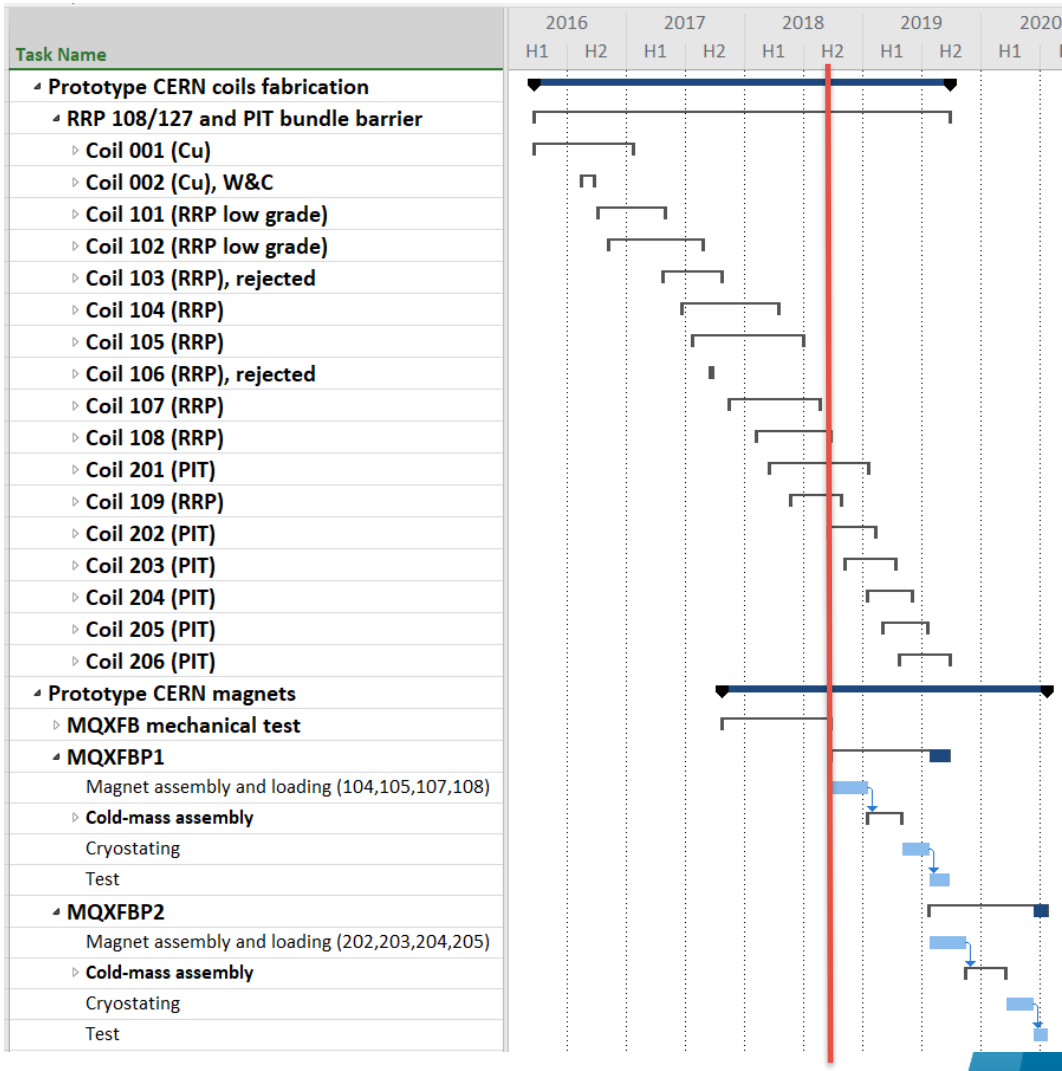
CERN prototype program
Coil fabrication

- 1 coil with Cu cable and 2 with low grade Nb_3Sn completed
- 1st prototype coils
  - "Old" 1st and 4th coils (103 and 106) rejected for major NC
  - Coils 104, 105, 107, 108 completed
  - Spare coil 109 prepared for impregnation



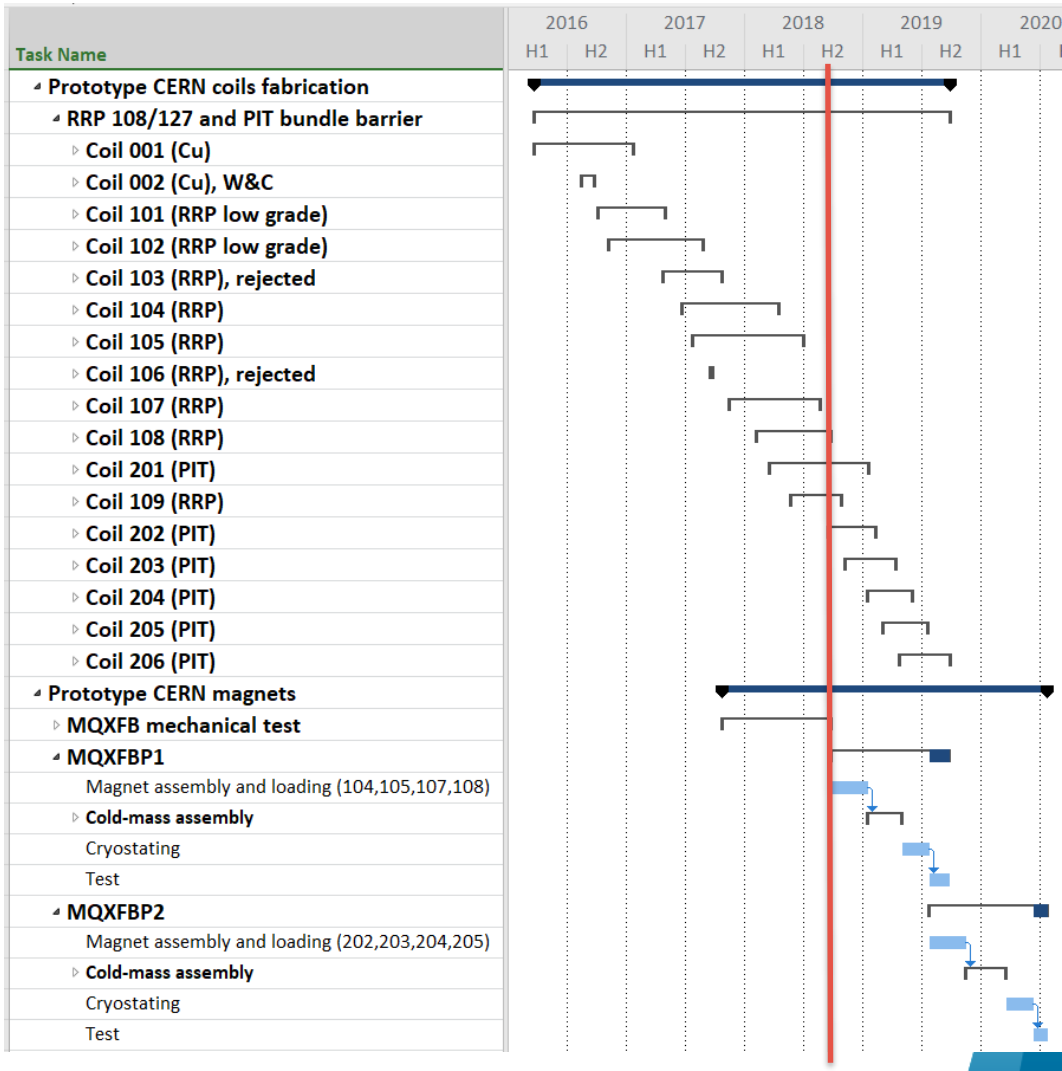
CERN prototype program
Coil fabrication

- 2nd prototype coils
  - Coil 201 with major NC, dismissed unless needed
    - Wound and ready for reaction
  - Coil 202 to be wound starting next week
    - First coil to correct b_6



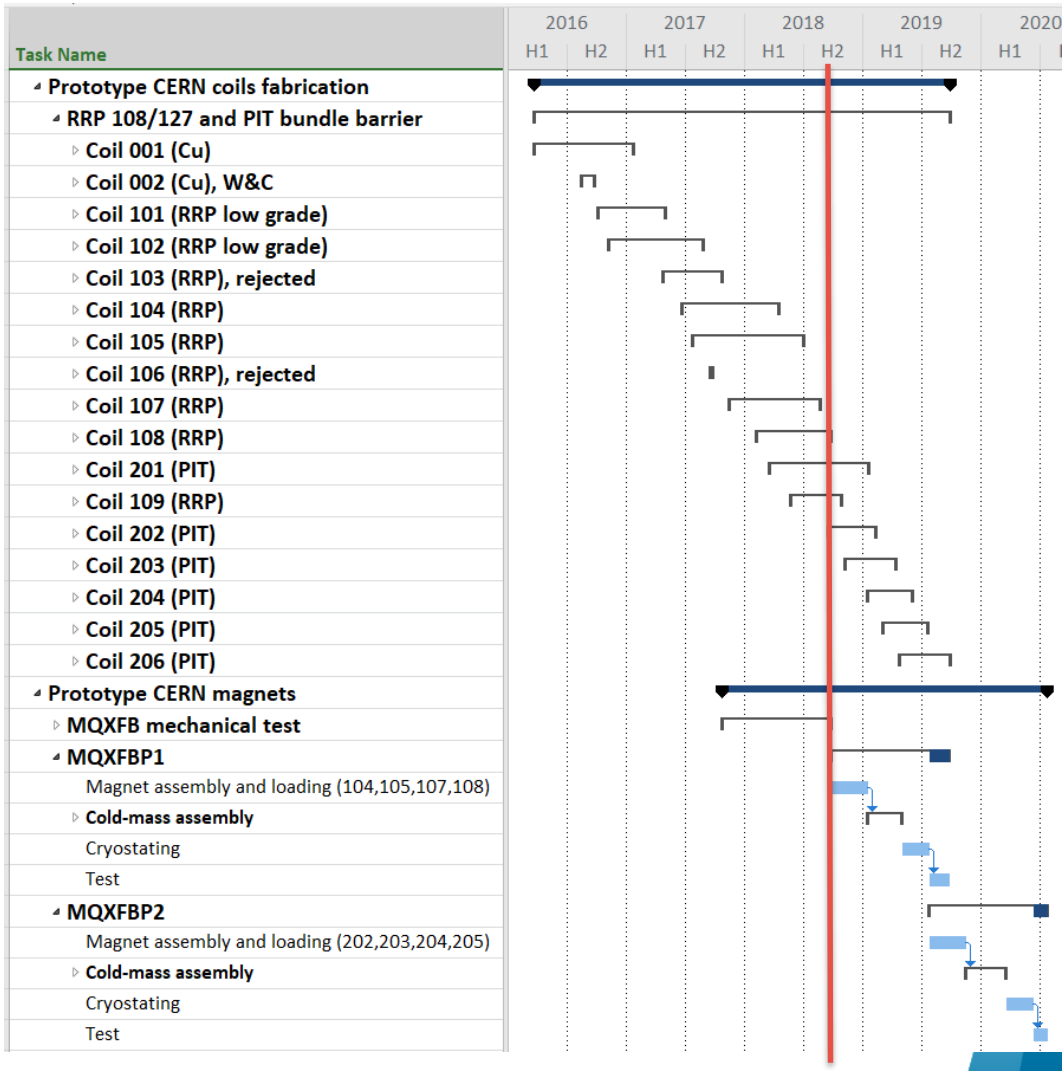
CERN prototype program
Magnet fabrication

- MQXFBP1
  - Coil 104, 105, 107, 108 (109 spare)
  - Magnet assembly starts in 10/18
  - Cold-mass assembly starts in 01/19
  - Cryostating starts in 04/19
  - Test in 07-08/19



CERN prototype program
Magnet fabrication

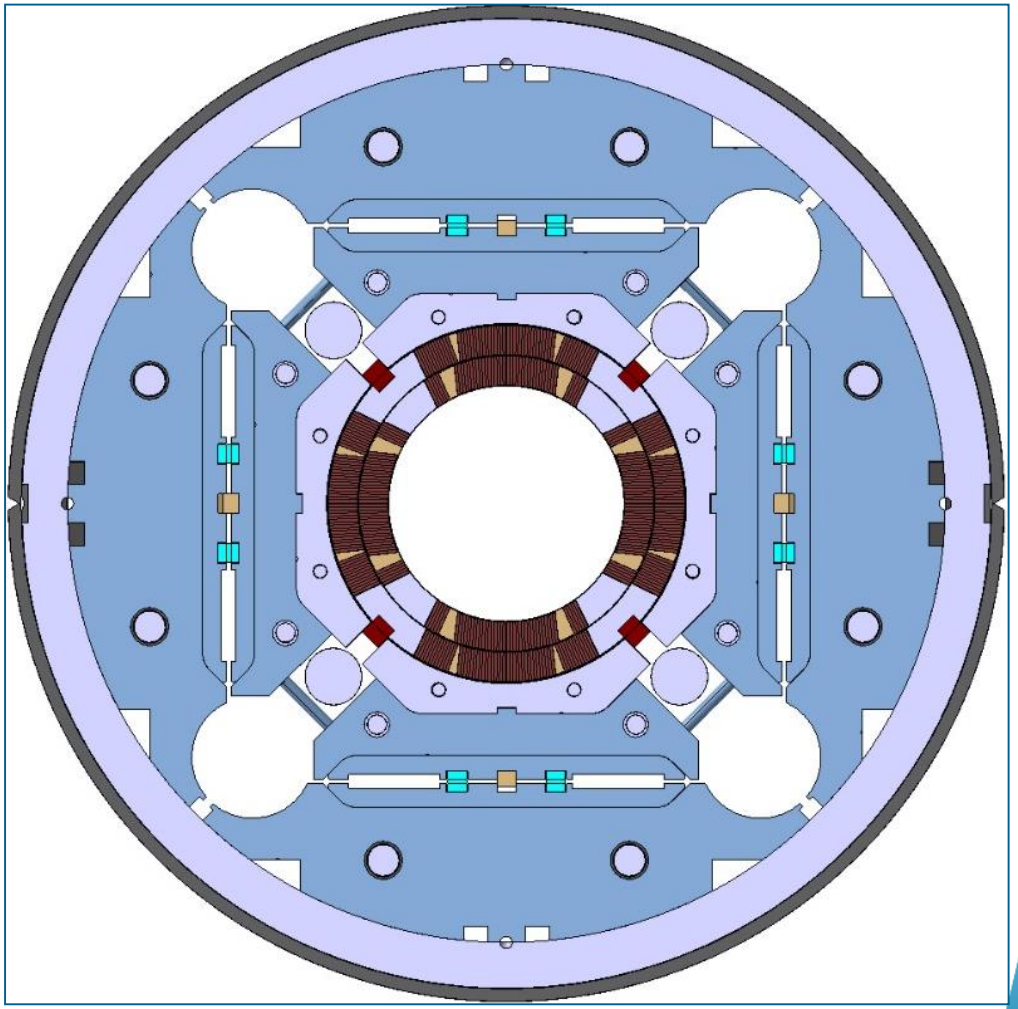
- MQXFBP2
  - Coil 202, 203, 204, 205 (206 spare)
  - Magnet assembly starts in 08/19
  - Cold-mass assembly starts in 11/19
  - Cryostating starts in 02/20
  - Test in 05-06/20



Appendix

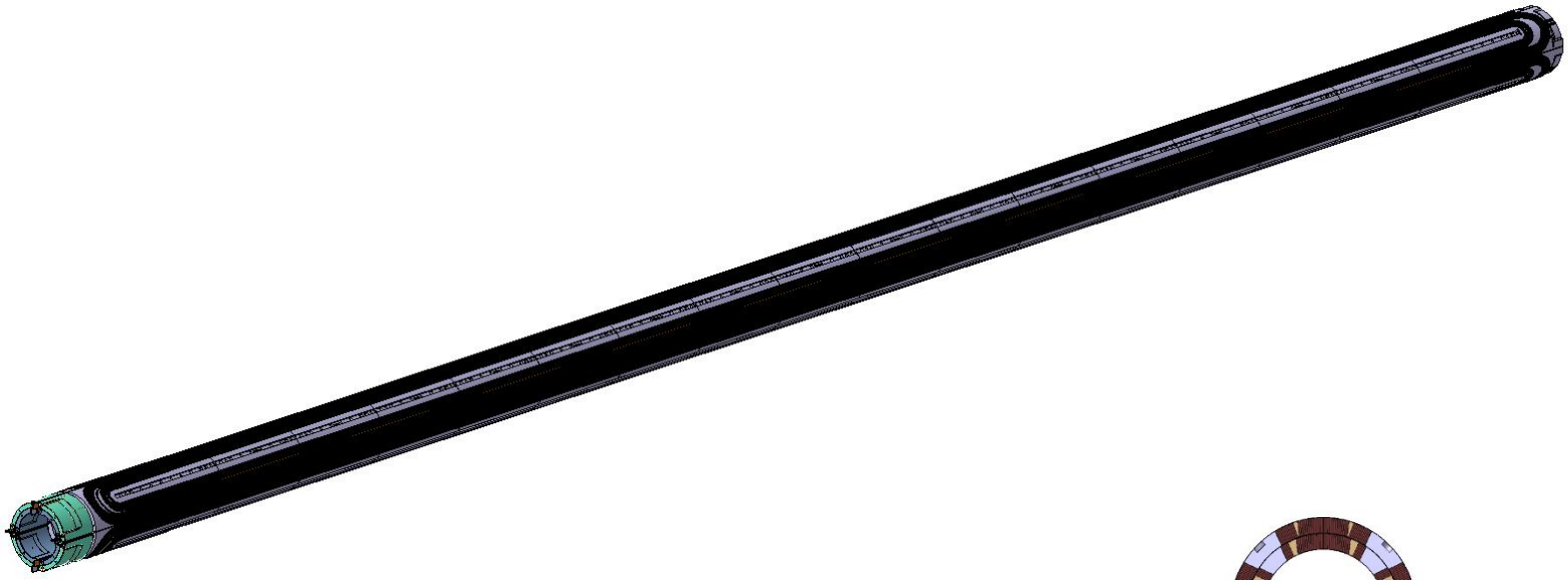
Overview of MQXF design

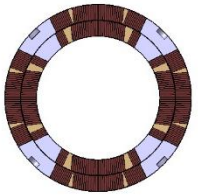
- OD: 630 m
- Stainless steel shell
  - 8 mm for LHe containment
- Aluminum shell
  - 29 mm thick
- Iron yoke
  - Gaps open
  - 4-fold symmetry
- Iron master plates
  - Bladder and keys
- Iron pad
- SS axial rods
- Aluminum collars
- G10 pole key
- Ti alloy poles



Magnet design
MQXFB

See J. C. Perez

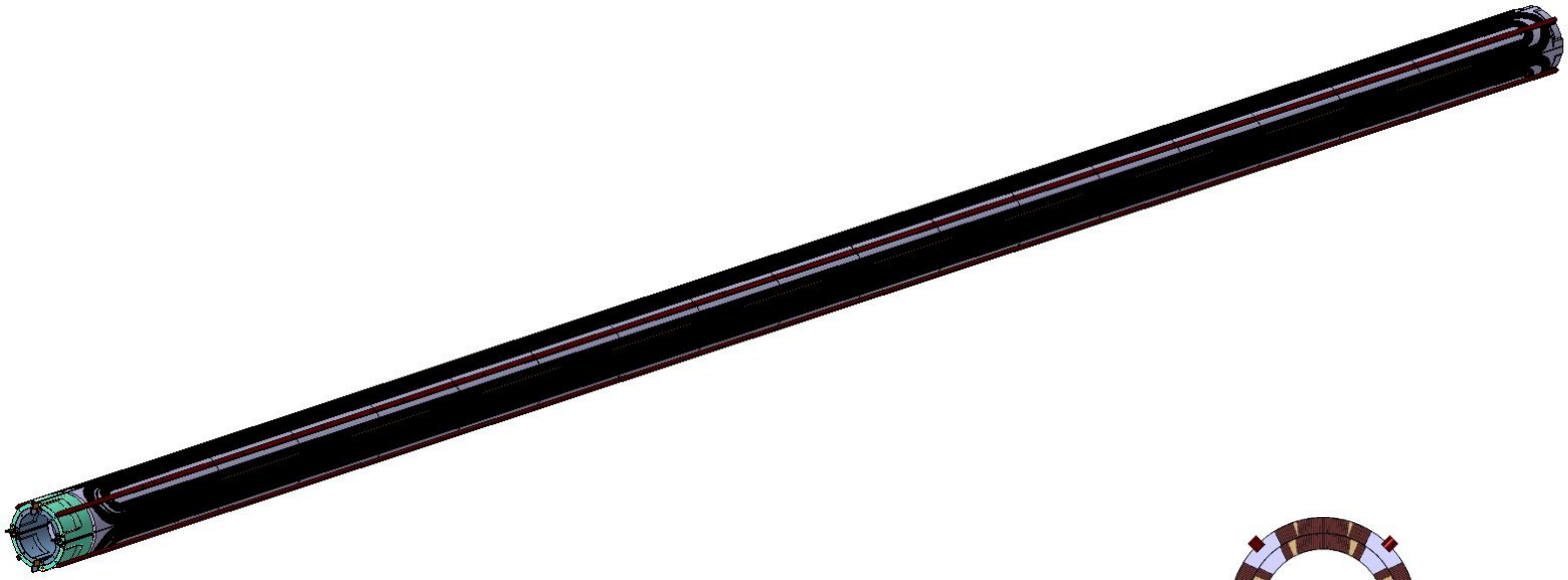




- Superconducting coil

Magnet design
MQXFB

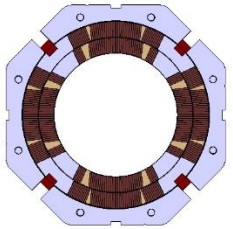
See J. C. Perez



- Pole key for alignment

Magnet design
MQXFB

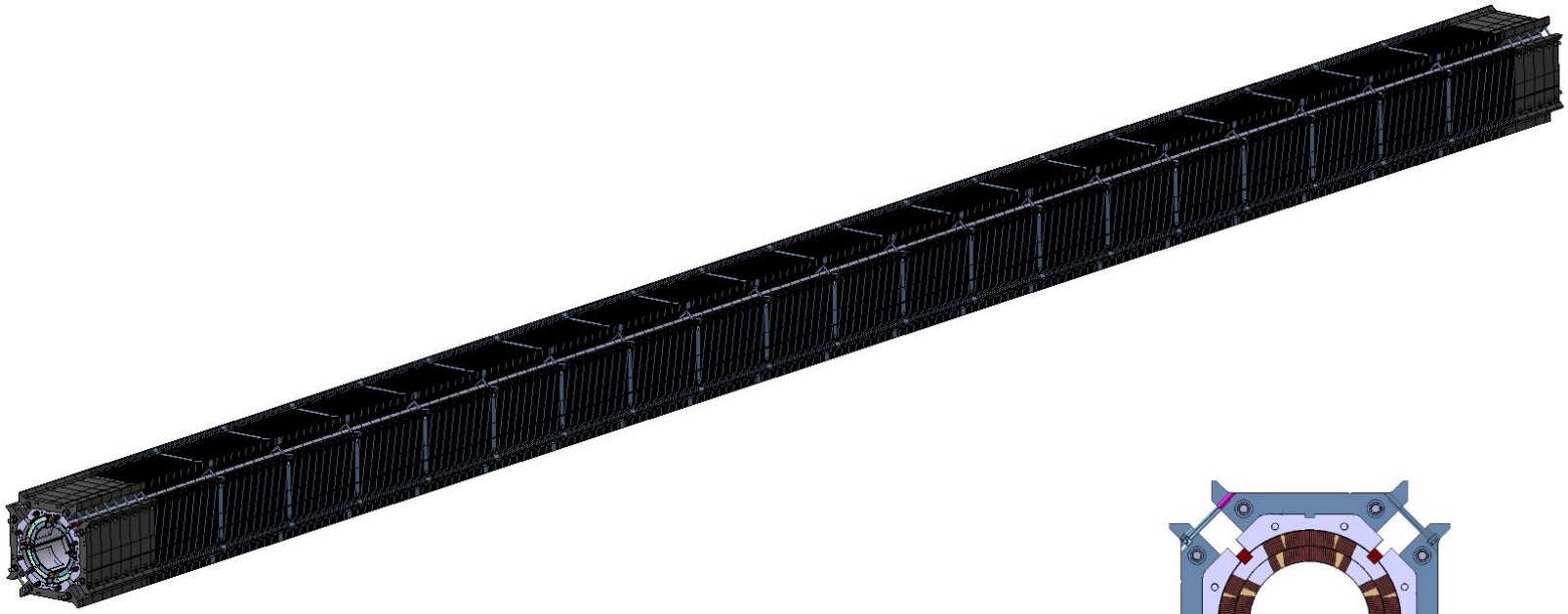
See J. C. Perez

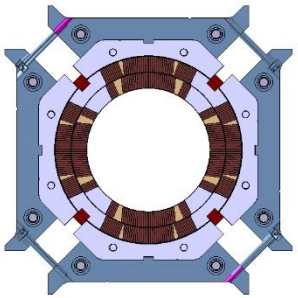


- Aluminium collar
  - No coil pre-load

Magnet design
MQXFB

See J. C. Perez

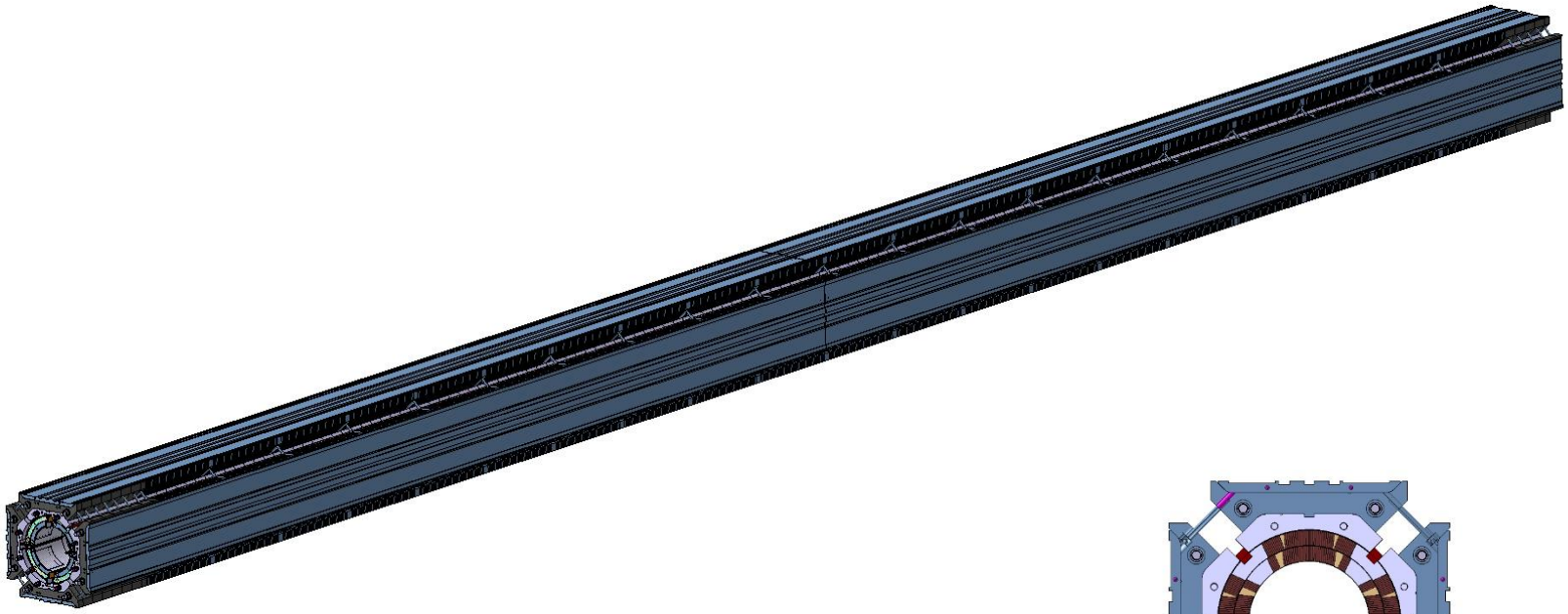


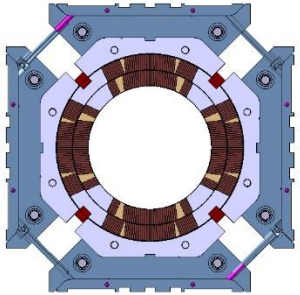


- Bolted iron pad
  - No coil pre-load

Magnet design
MQXFB

See J. C. Perez

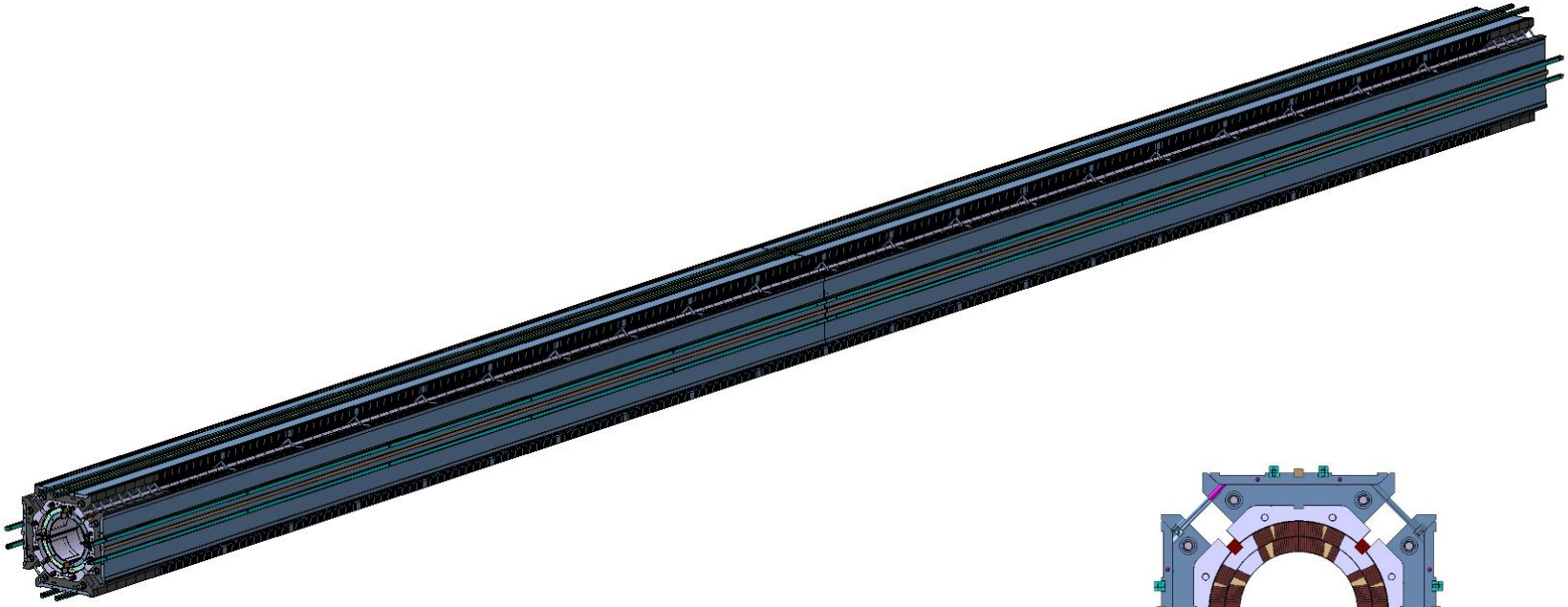


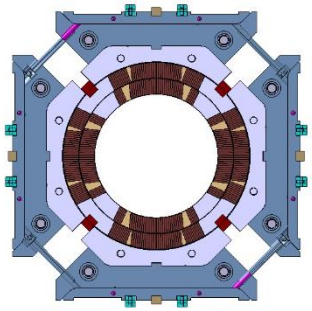


- Iron master
  - Half-length plates for bladders and keys

Magnet design
MQXFB

See J. C. Perez

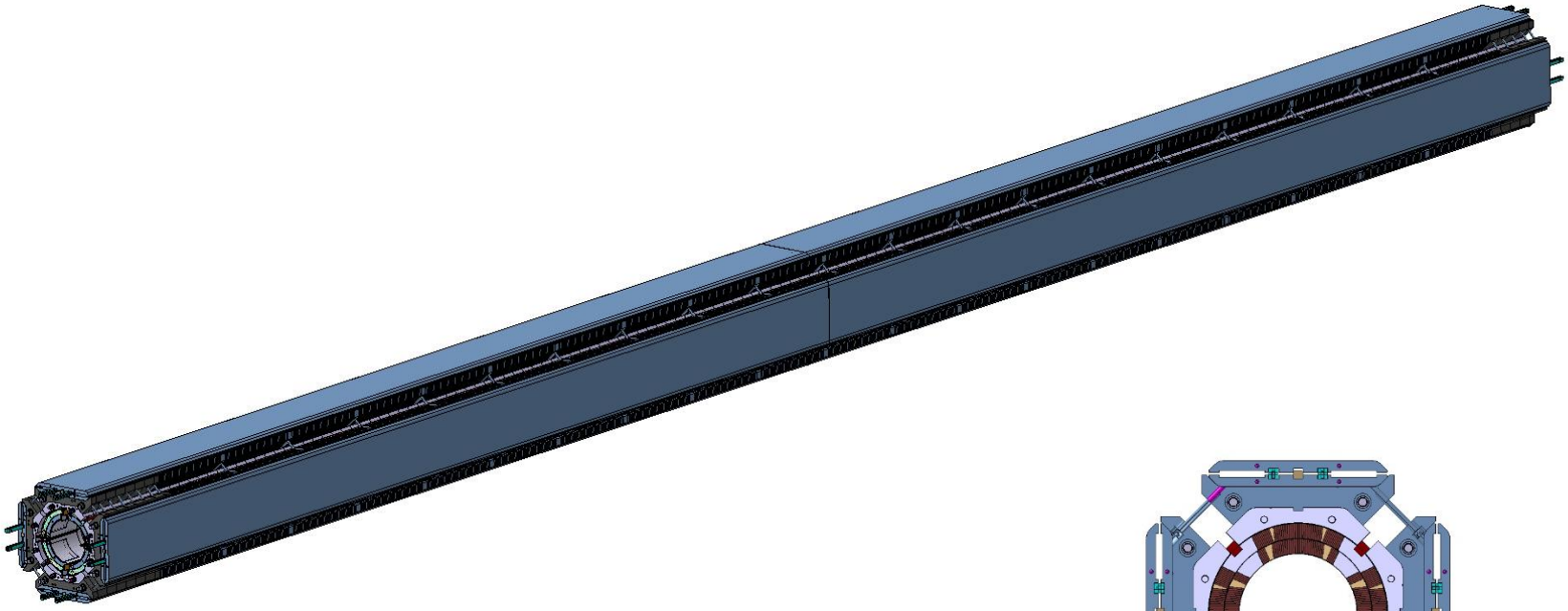


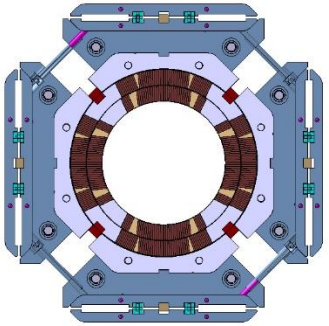


- Loading and alignment keys

Magnet design
MQXFB

See J. C. Perez

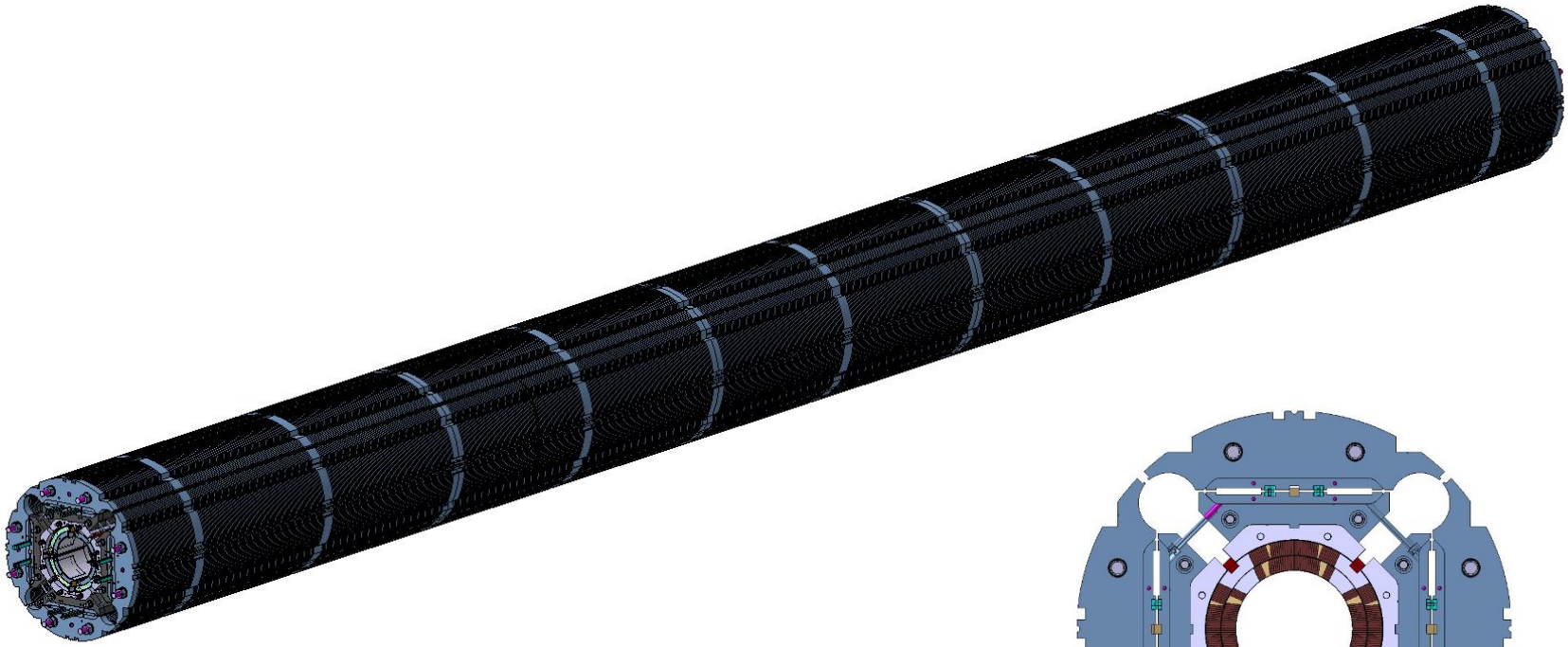




- Second iron master
  - Coil-pack sub-assembly

Magnet design
MQXFB

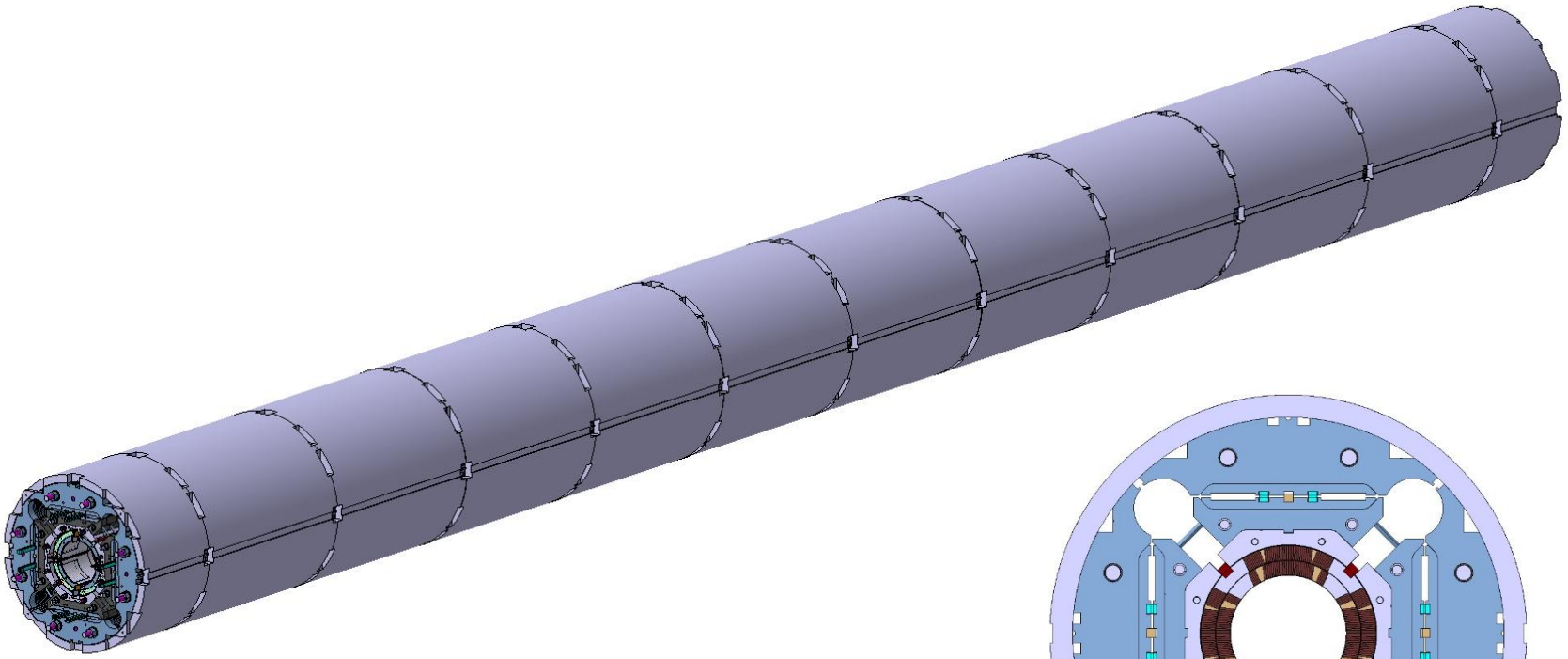
See J. C. Perez



- Iron yoke laminations

Magnet design
MQXFB

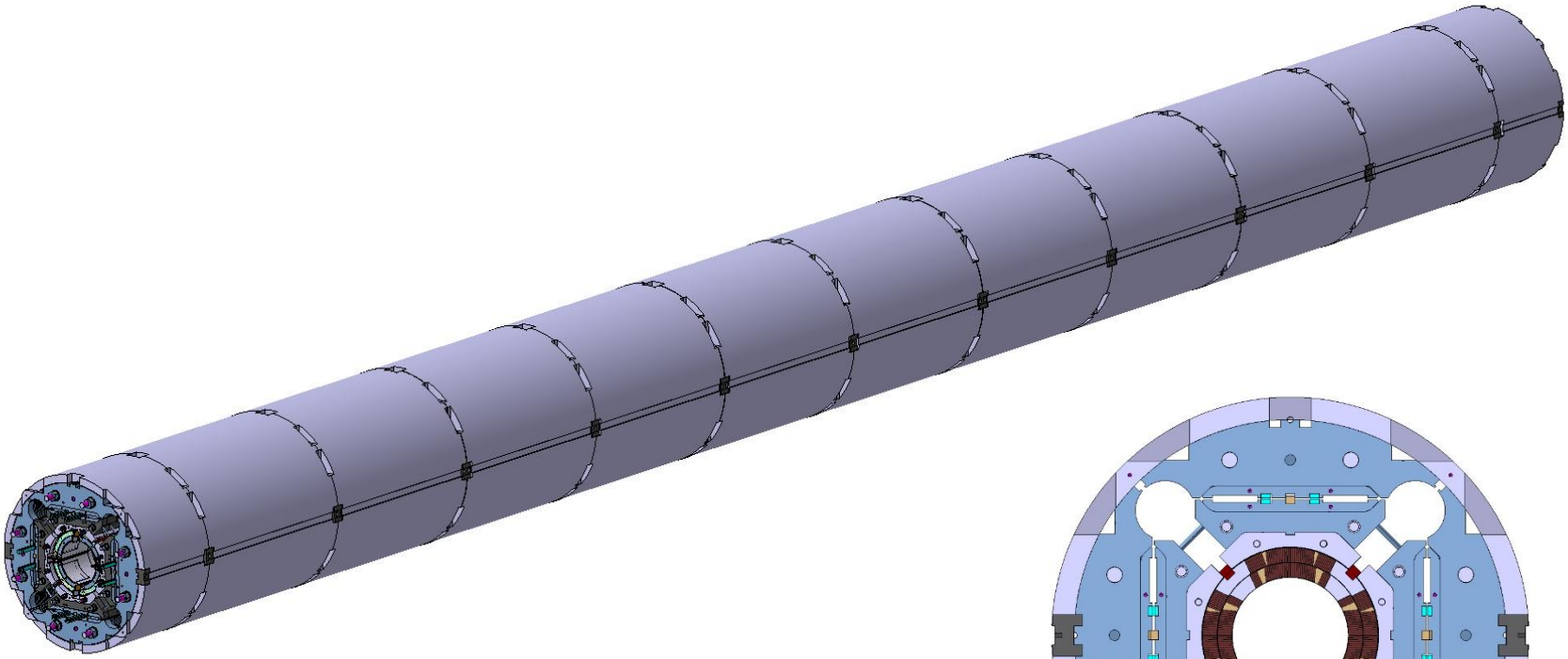
See J. C. Perez



- Segmented aluminium shell

Magnet design
MQXFB

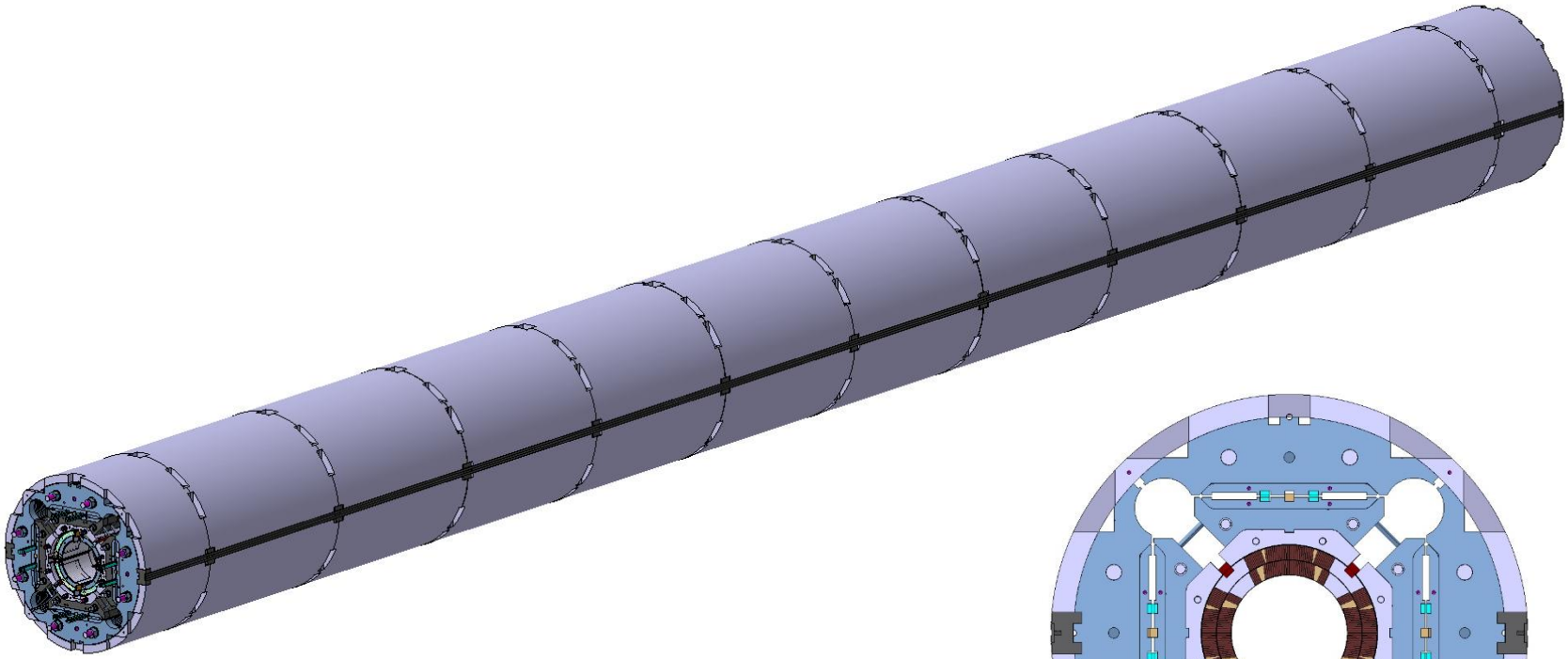
See J. C. Perez



- Tack-welding blocks
  - Aligned to the yoke

Magnet design
MQXFB

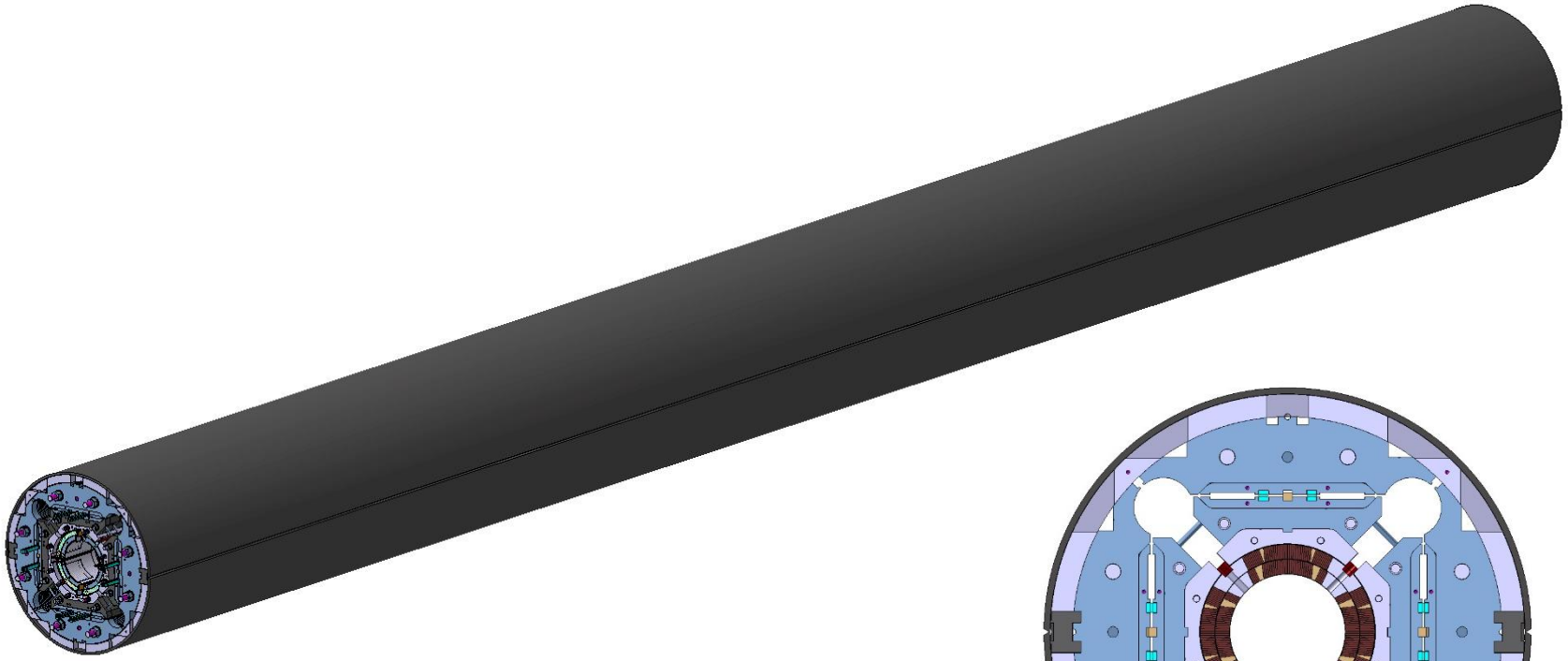
See J. C. Perez



- Backing strip
  - For Lhe vessel welding

Magnet design
MQXFB

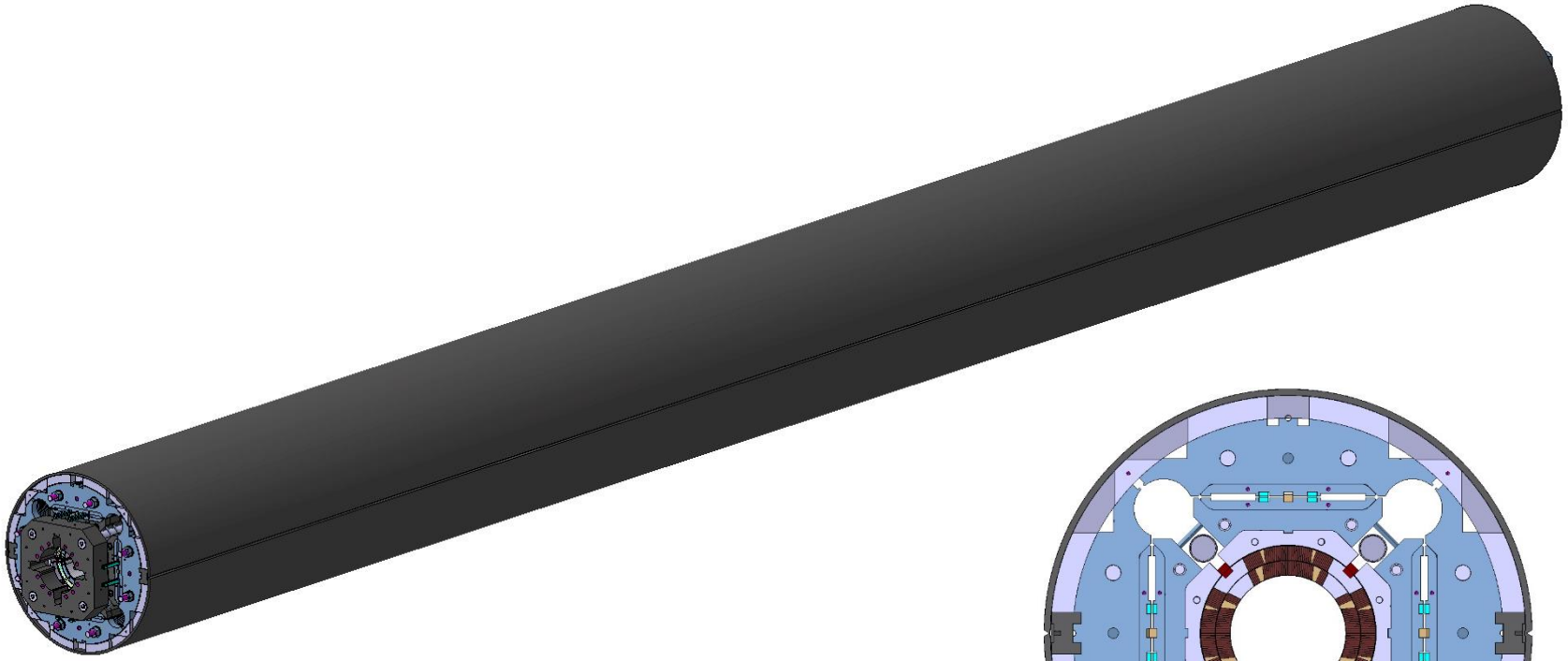
See J. C. Perez



- Welded LHe vessel
  - Minimum welding tension

Magnet design
MQXFB

See J. C. Perez



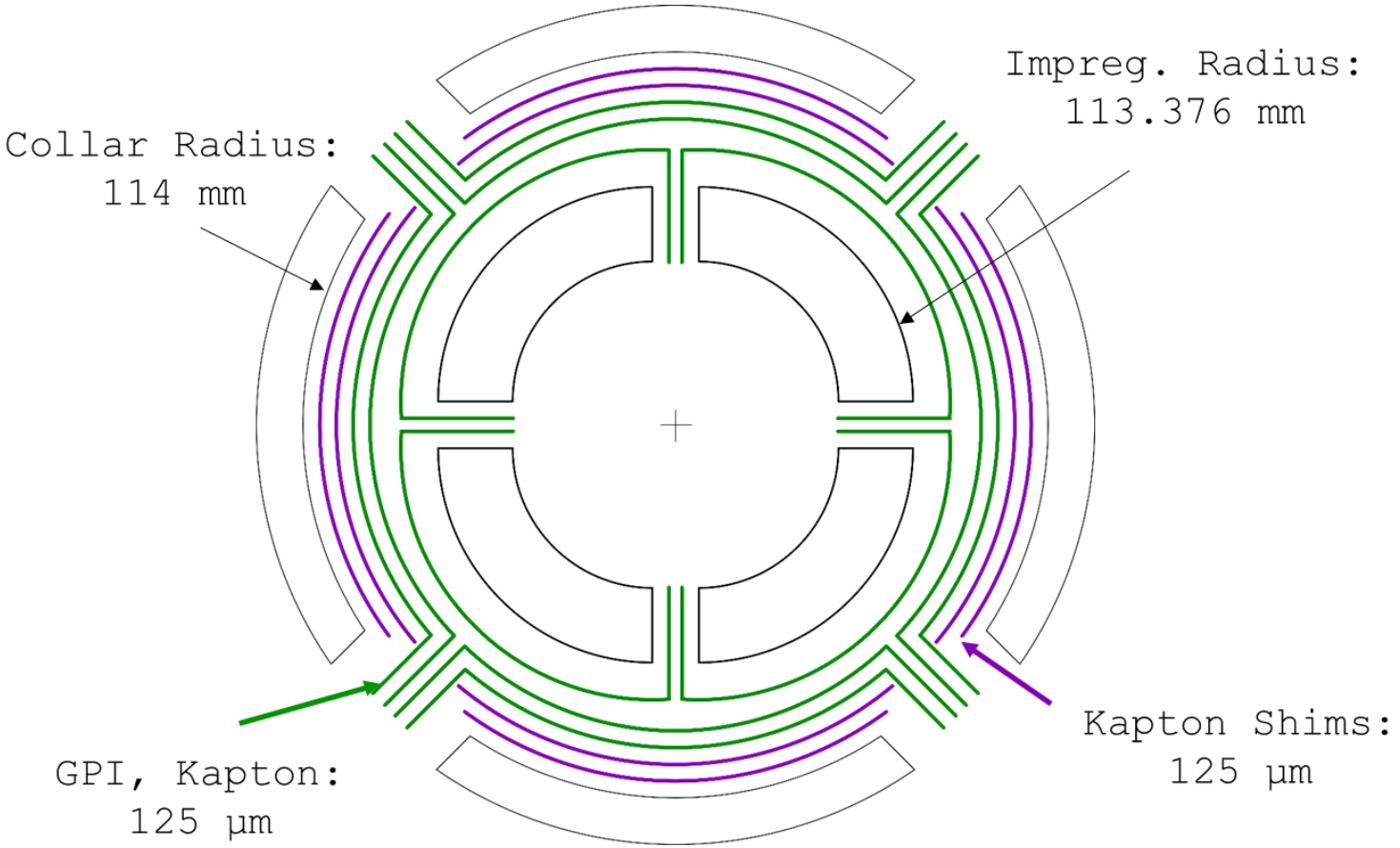
- Axial support system
  - SS rods and end-plates

Outline

- Standard Shimming Layouts
- Coil Size Measurements
- Coil Pack Layouts – Shimming Plan
- Coil pack results
- Extra:
  - Coil Positioning
  - MQXFS5 Fuji paper

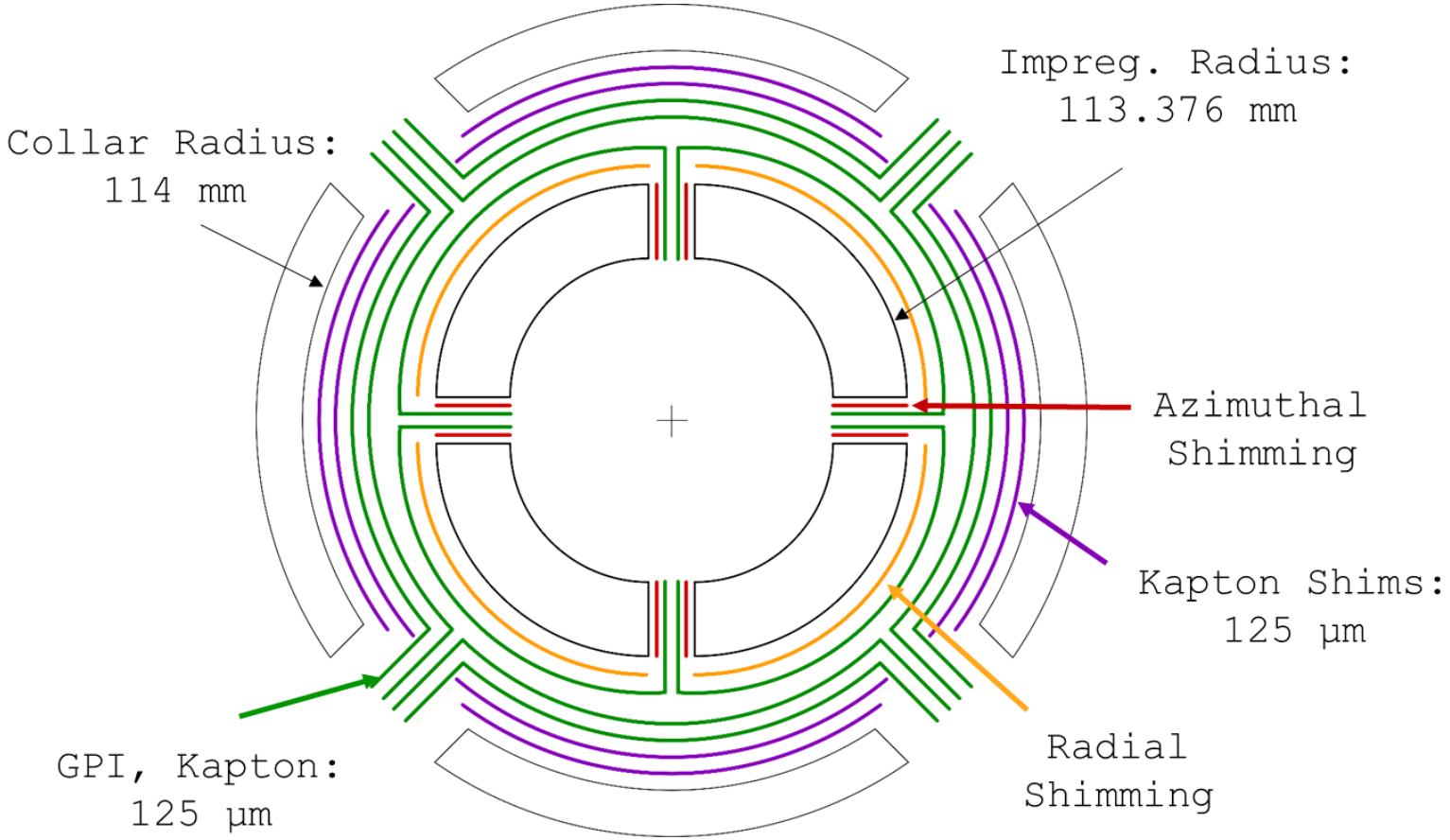
Shimming Layouts

Nominal Shimming Layout



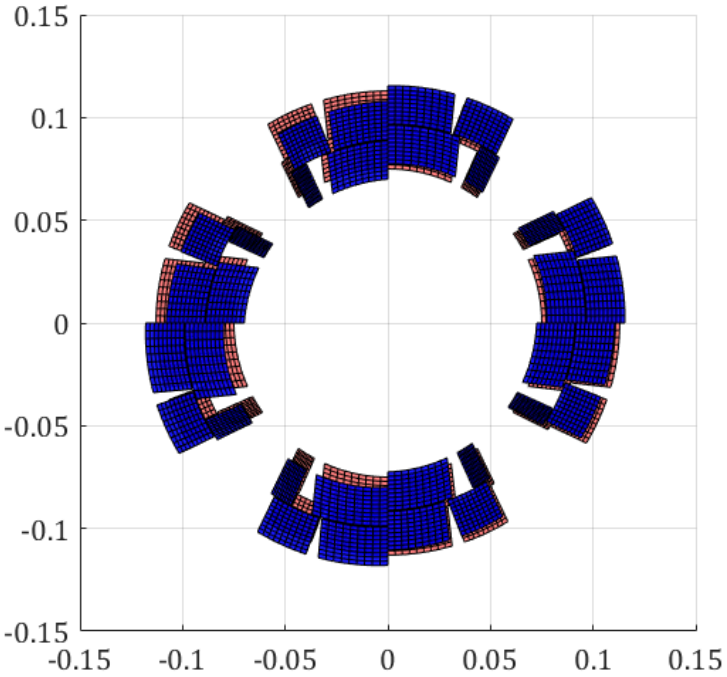
Total nominal radial shimming: 625 µm

Shimming Options (1)

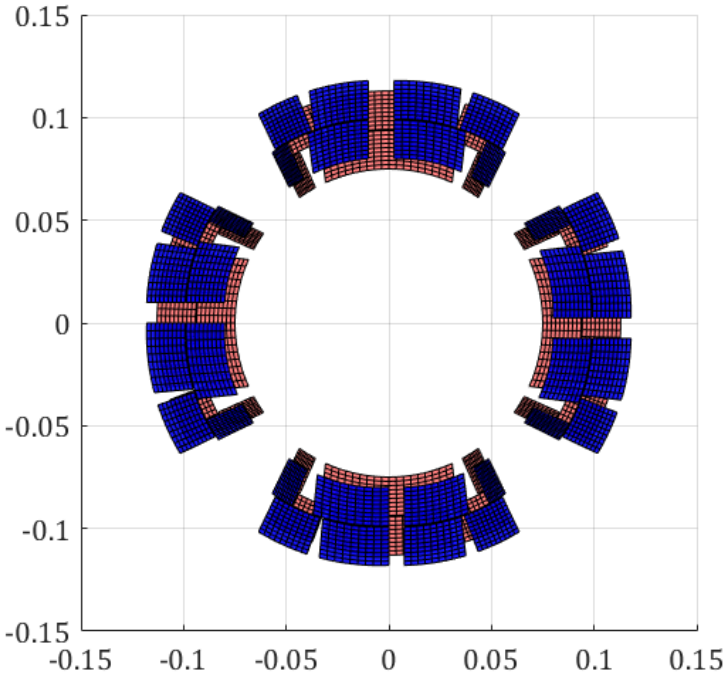


Total nominal radial shimming: 625 µm

Shimming Options (2)

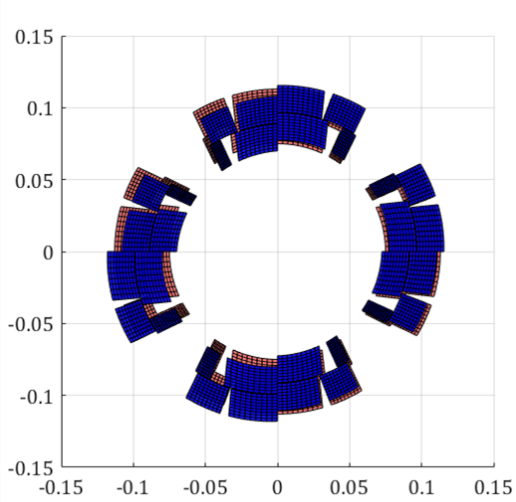


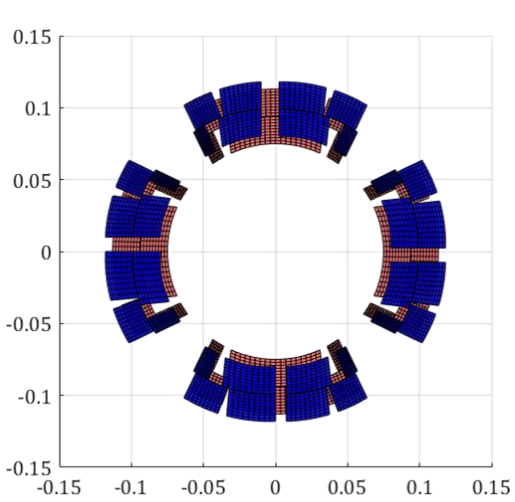
Radial Shimming



Mid-Plane Shimming

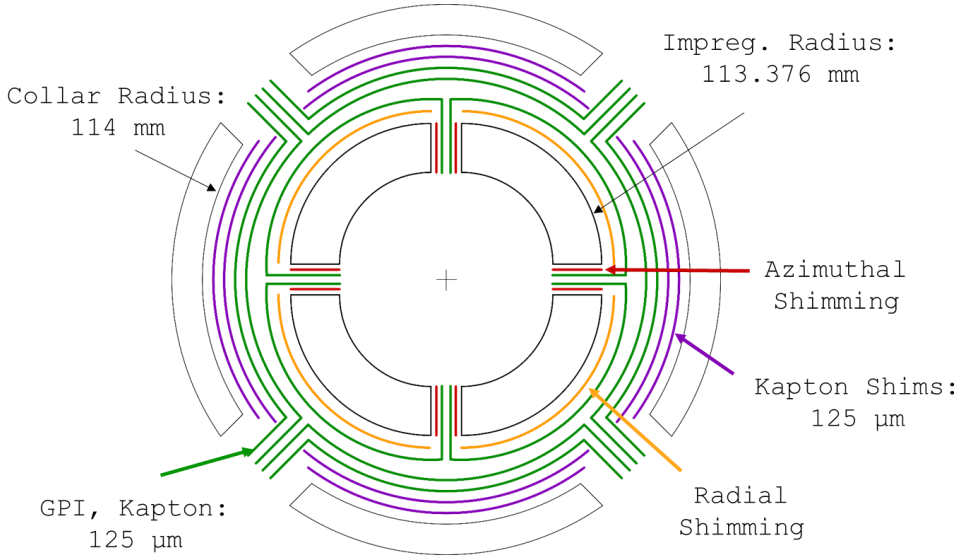
Shimming Strategy (1)





- Short models experience:
  - In MQXFS1we have used a mix of radial and mid-plane shimming
  - In MQXFSS3/S5 we have used only mid-plane shimming
- For FQ purposes is in general efficient to bring all the coils to the same inner radius (high field region…).
- As a consequence, we generally assume to shim using only on the mid-plane.

Shimming Strategy (2)

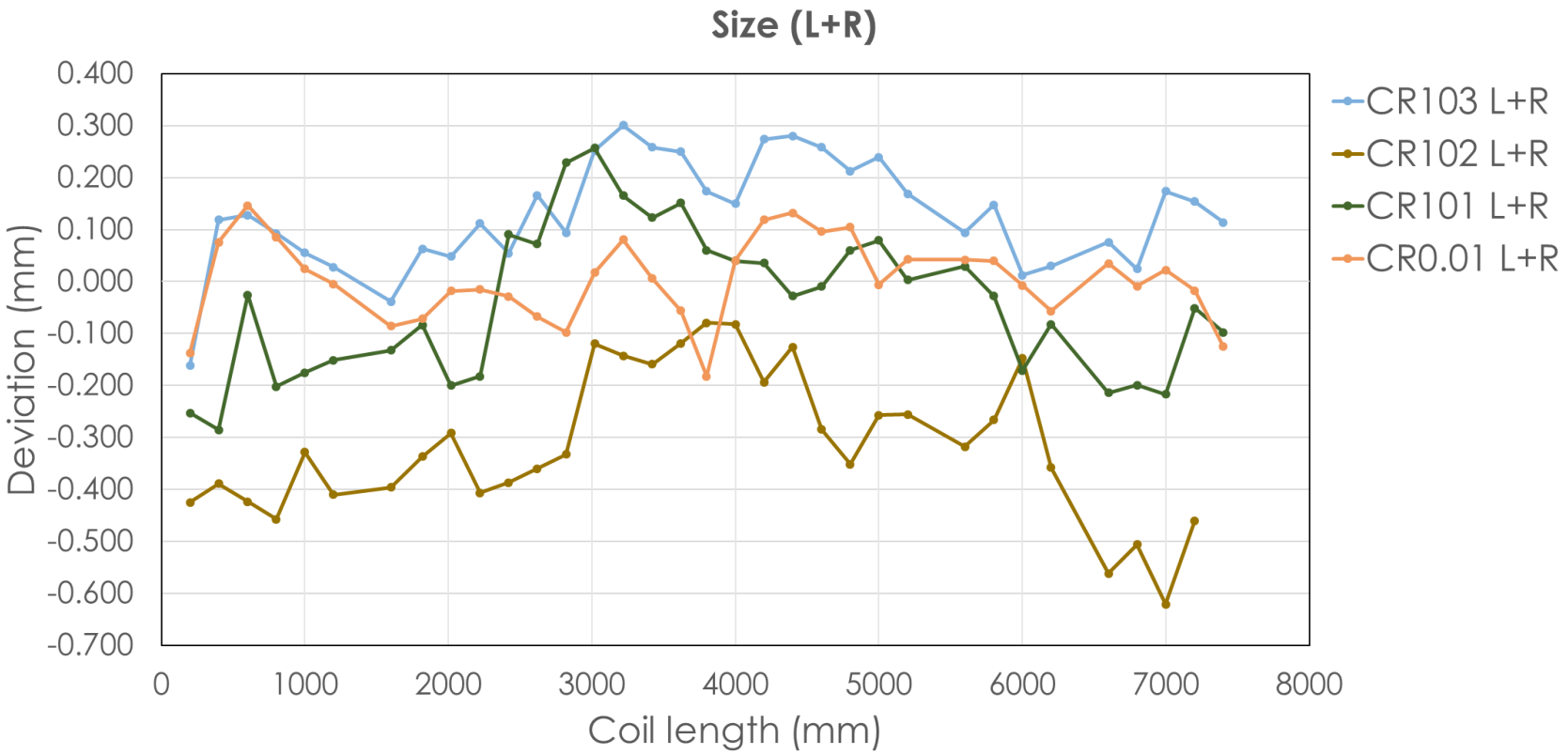


- Shimming *algorithm*:

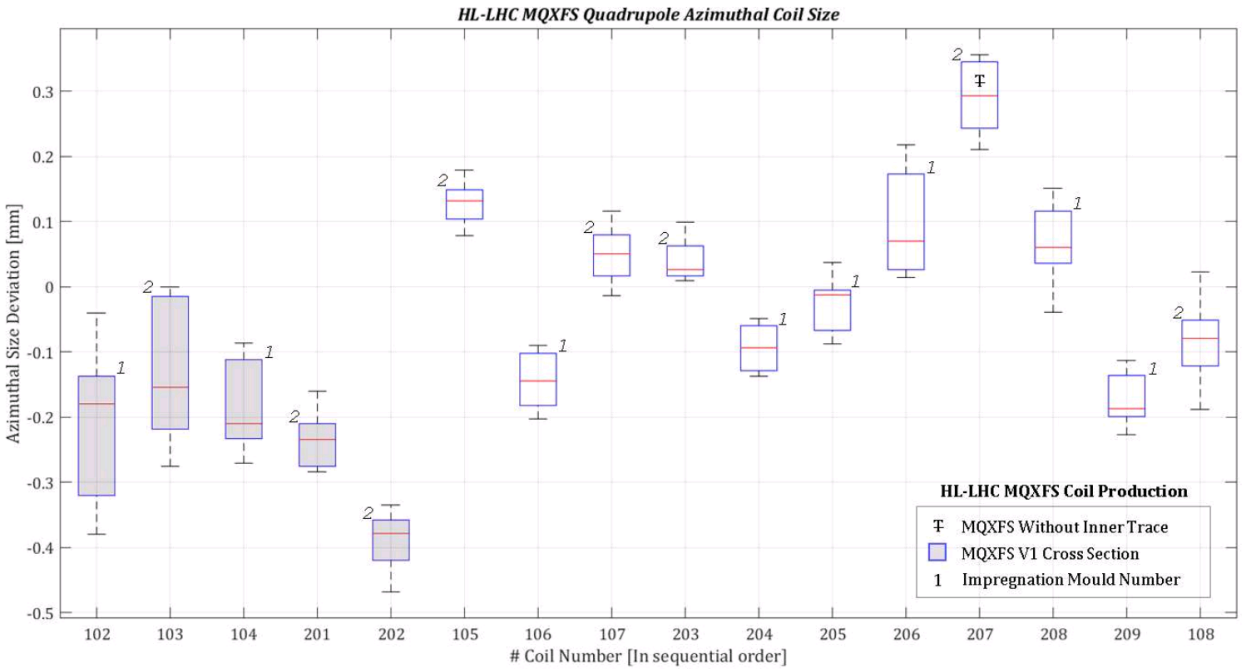
1. Establish coil positioning/order (FQ considerations, see extra slides)
2. Identify the bigger coil
3. Remove/add collar shims in order to match the bigger coil outer radius to the collar radius
4. Shim all the other coils on the mid plane in order to get them to the same outer radius

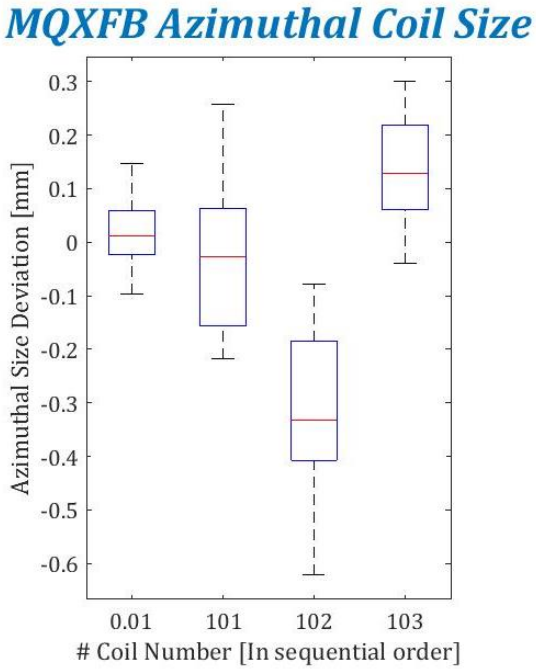
Coil Size Measurements

Coil Measurements (1)



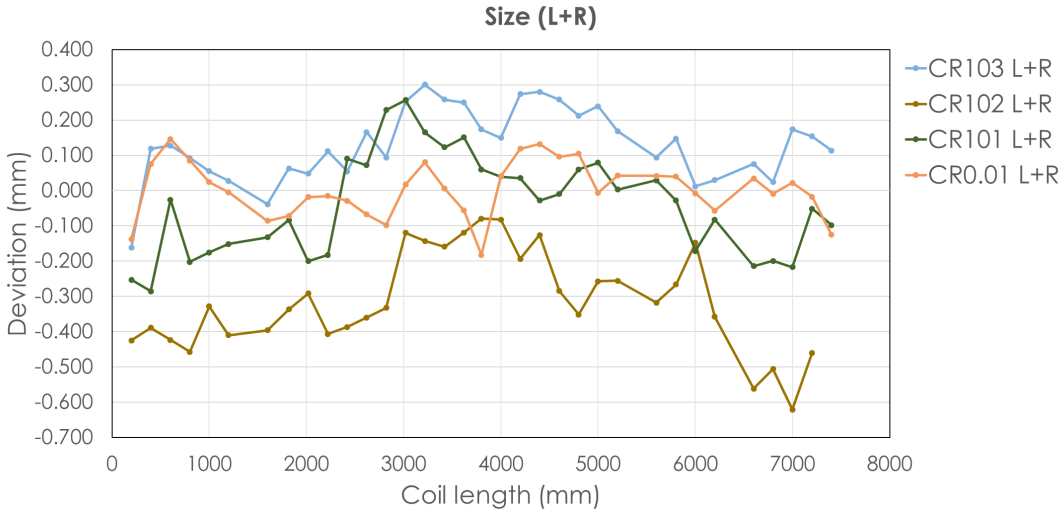
Coil Measurements (2)





- MQXFB coils exhibit larger variations (up to now)

Coil Measurements (3)



Coil	L+R μm
C0.01	12
C101	-28
C102	-314
C103	138

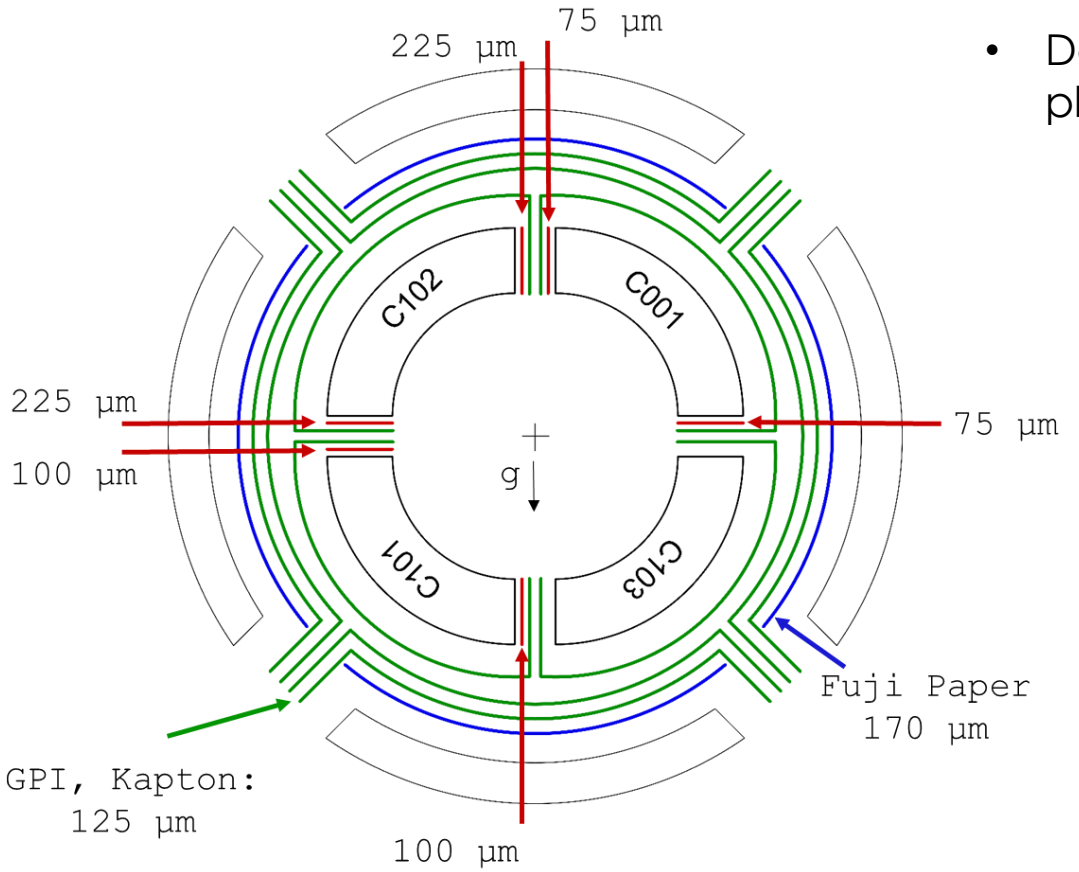
Coil	L+R μm	(L+R)/2 μm
C0.01	0	0
C101	-50	-25
C102	-300	-150
C103	150	75

- As the smaller shim that we are using is 25 μm, we cannot correct less than 50 μm
- Why: if we shim on the mid plane we need two shims. On the azimuthal direction we need to apply $\frac{4}{2\pi}(L+R)$, with similar results.

Coil Pack Layouts

1st Coil Pack Layout – Fuji Test

View from the Lead End



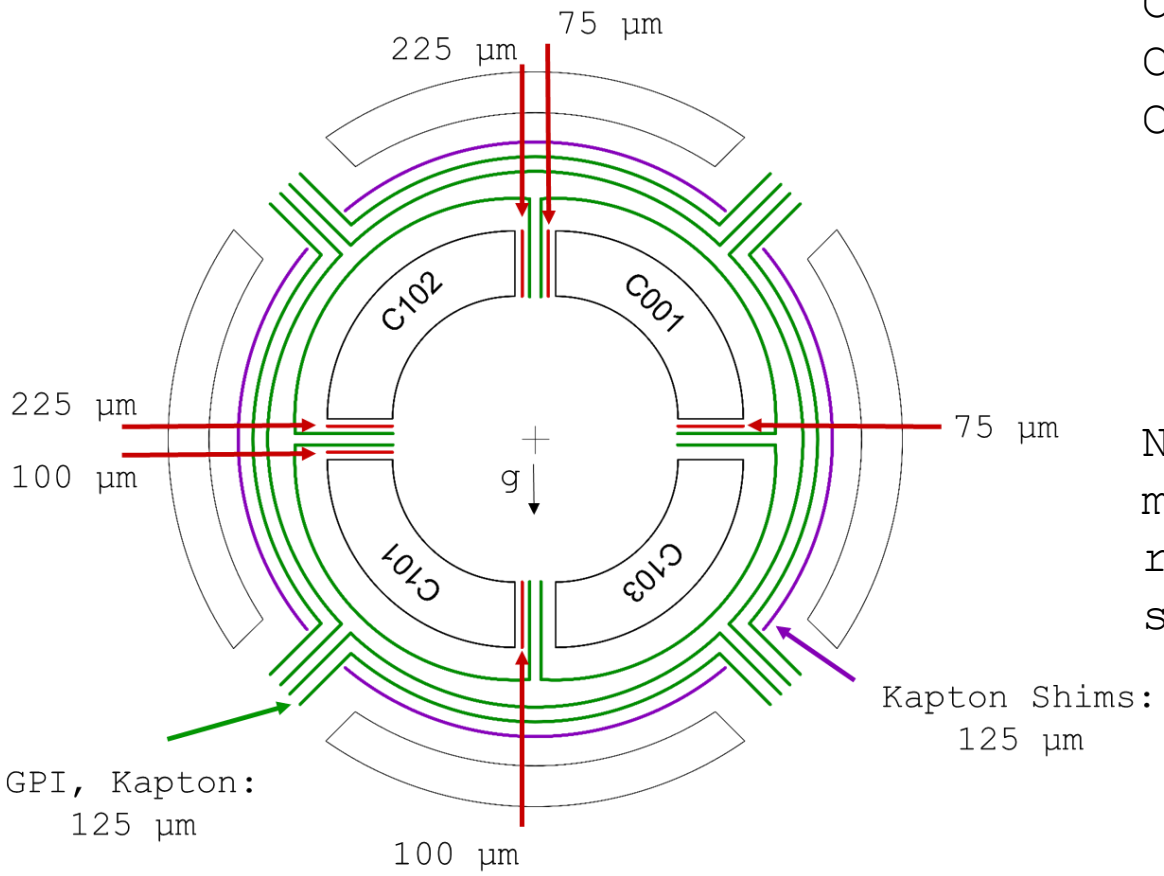
- Test coil pack: fuji paper radially
- Do we want to test also the mid-plane contact?

C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Note: To match the 114 mm collar radius, we removed a 125 µm collar shim.

2nd Coil Pack Layout – Nominal

View from the Lead End

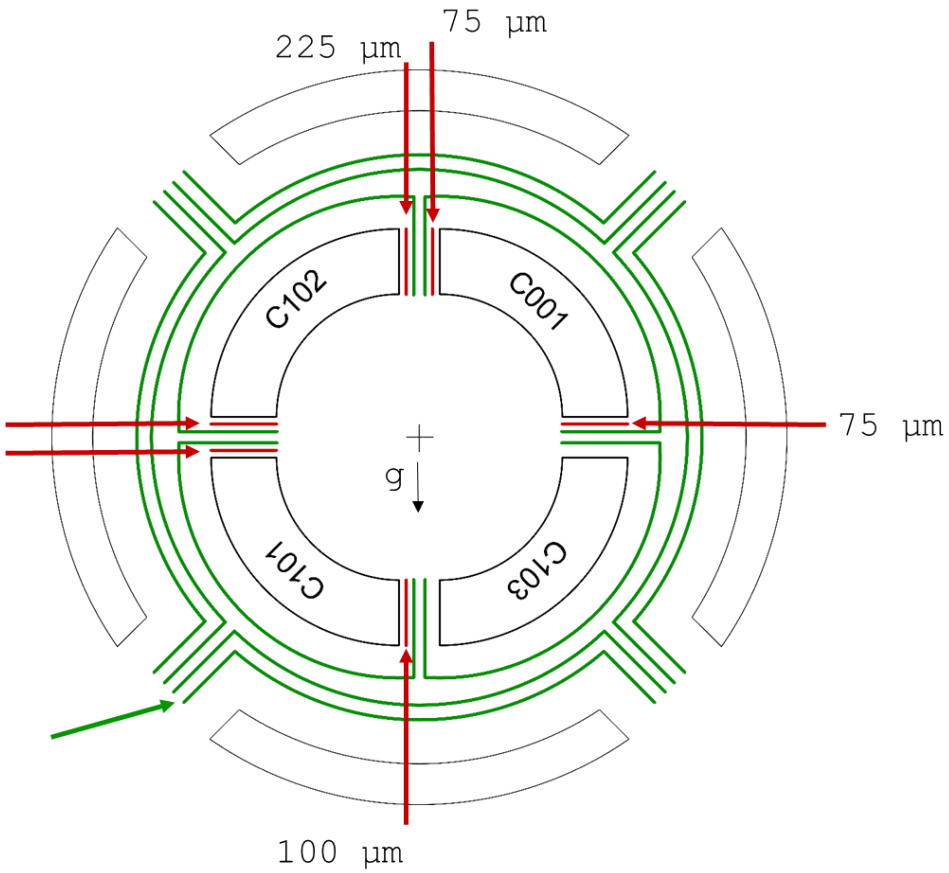


C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Note: To match the 114 mm collar radius, we removed a 125 µm collar shim.

Coil Pack Layout – Reduced

View from the Lead End



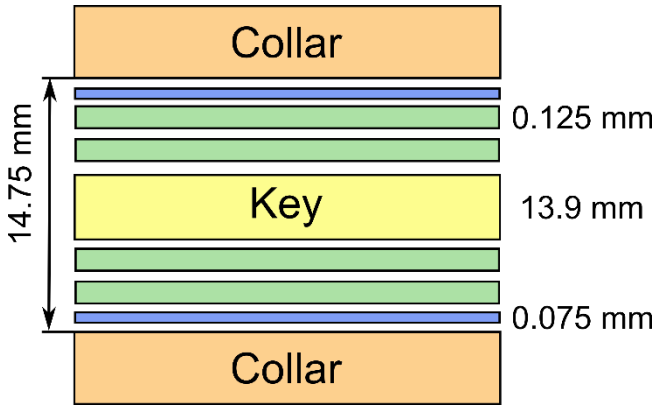
C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Note: To match the 114 mm collar radius, we removed a 125 µm collar shim.
Additional shim removed to improve contact.

Pole Key Shimming - Example

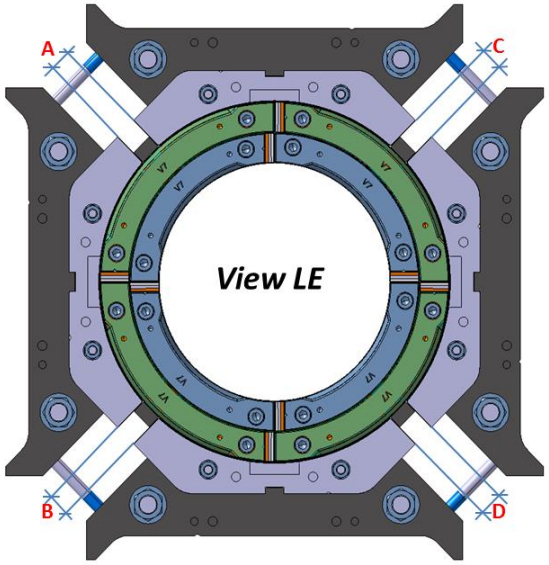
- Average distance between collar sides has to be measured during coil pack 2. E.g. 14.75 mm
- Key thickness is 13.9 mm
- 0.2 mm removed to increase pole stress (e.g.)
- 0.5 mm of GPI Kapton wrapped on the collar sides
- Total shimming required computed as:

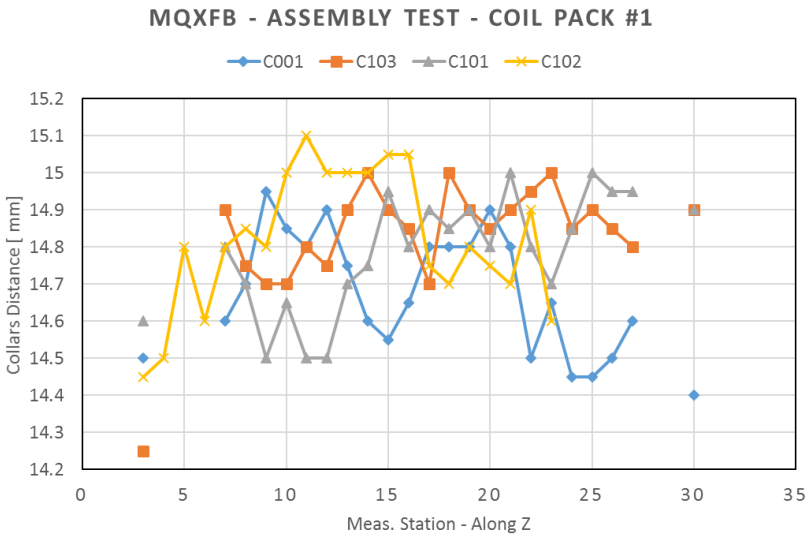
$$t_{shimming} = \Delta t_{collars} - t_{key} - t_{kapton} - 0.2$$



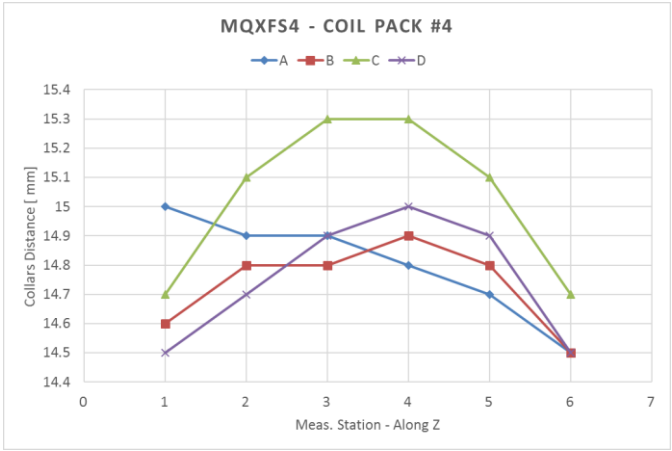
Coil Pack #1
Results

Gap Measurement

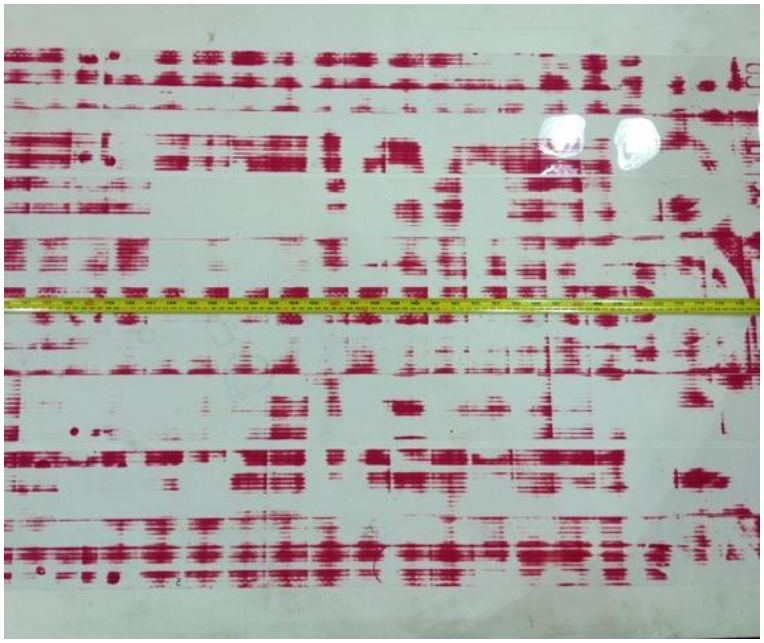




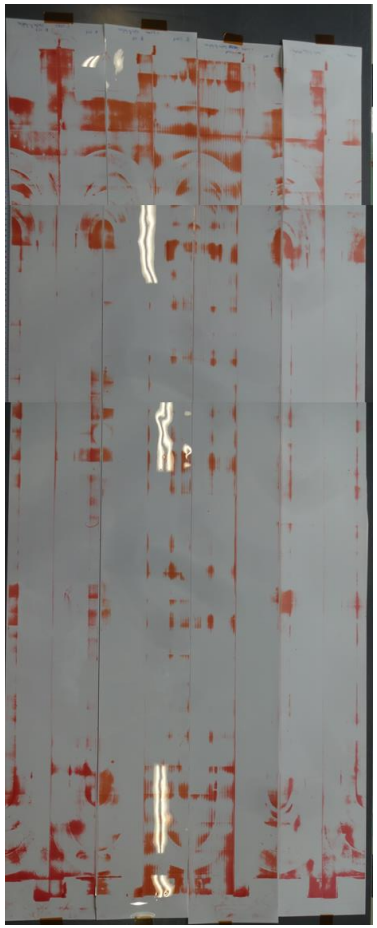
- Distance range: $\pm 300\ \mu m$. Similar to what is usually seen on the short model
- No clear pattern (meas. seem ~randomly distributed) – to be verified
  - In the short models we usually see a pattern



Fuji Film - Introduction



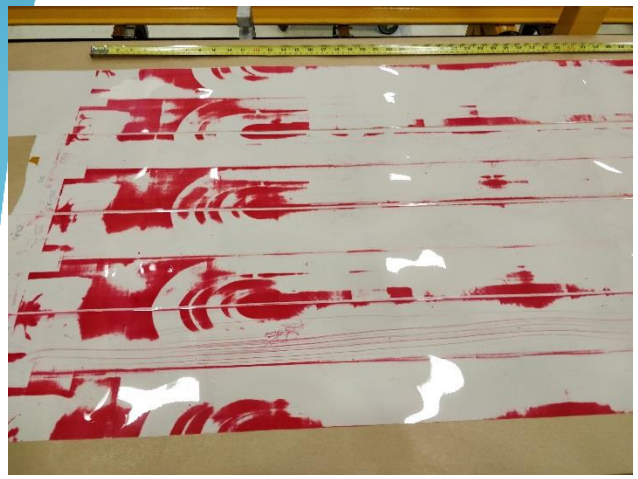
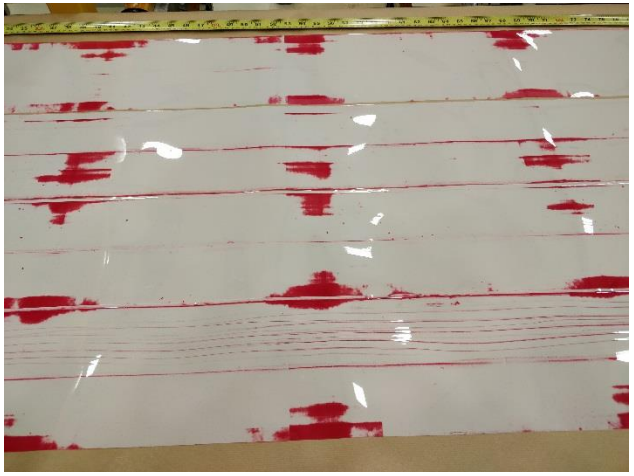
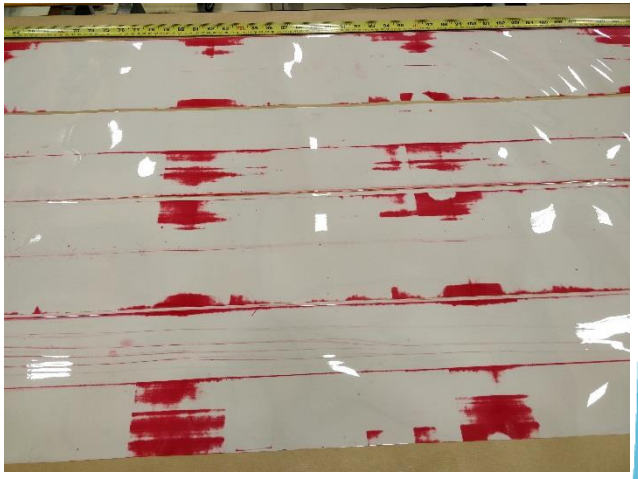
MQXFAP2



MQXF3c

- MQXFAP2 Fuji paper as a reference:
  - Coils were ~perfect in size
  - Bolting on tick laminations
  - Contact on pole and mid-plane
- This MQXFS3c paper shows ~no contact on the mid-plane

Fuji Film (1)

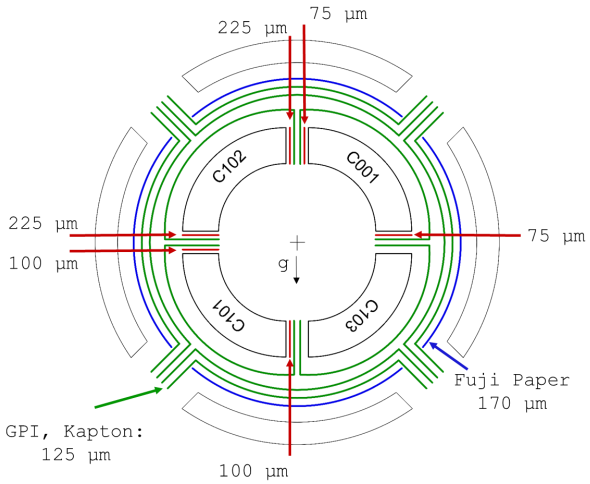
CR102T

CR001

CR103

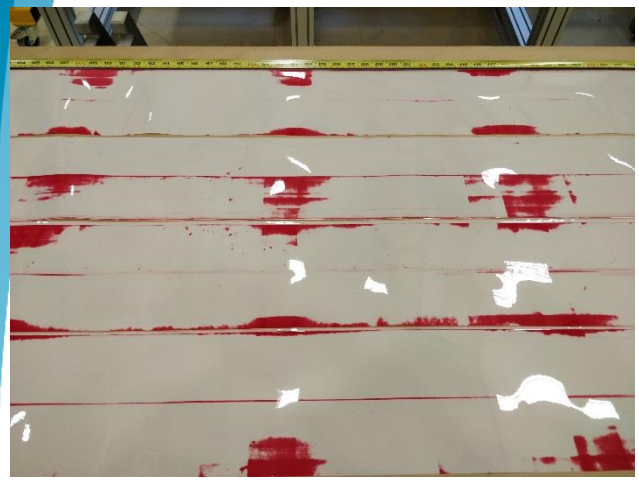
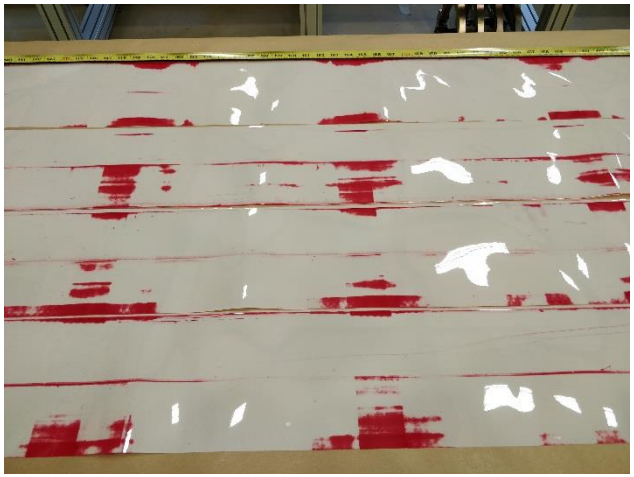
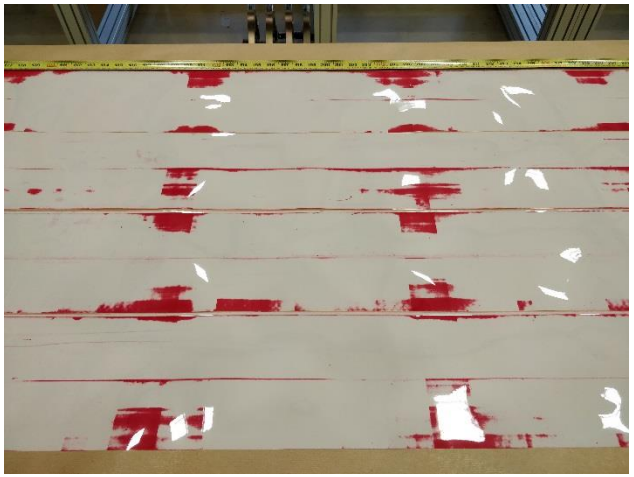
CR101

CR102B



C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Fuji Film (2)

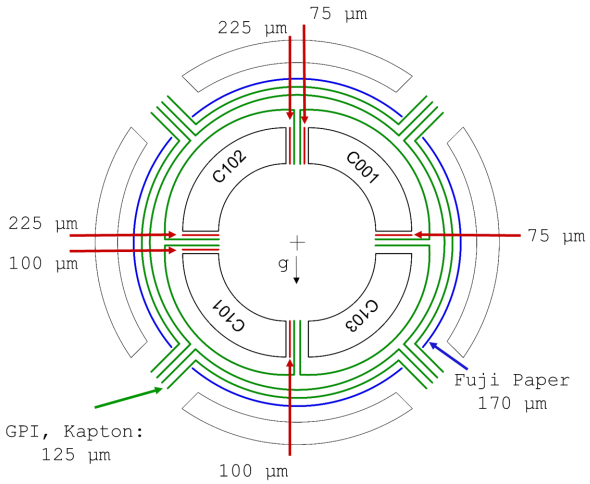
CR102T

CR001

CR103

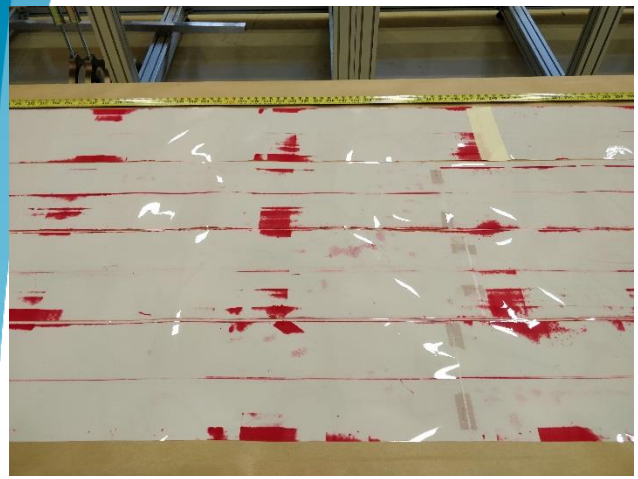
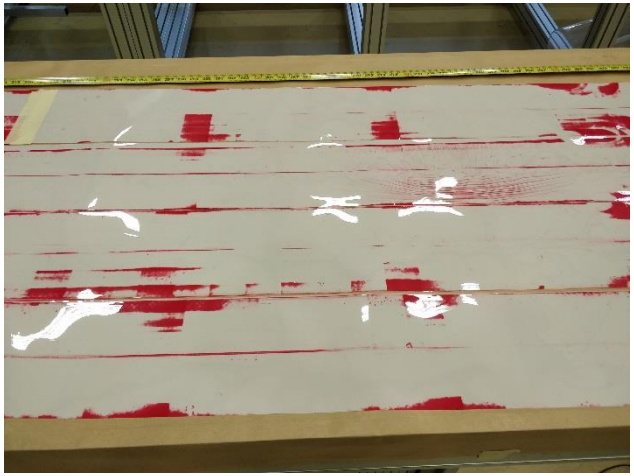
CR101

CR102B



C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Fuji Film (3)

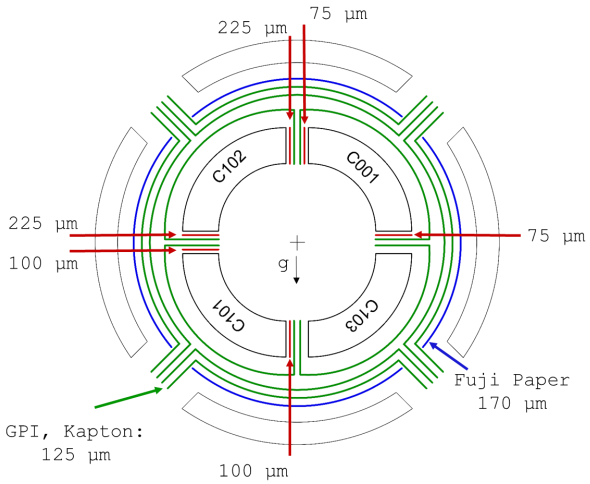

CR102T

CR001

CR103

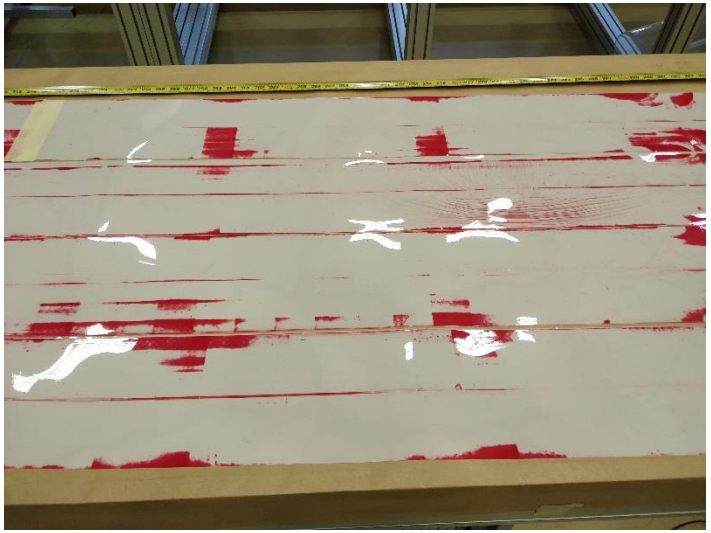
CR101

CR102B

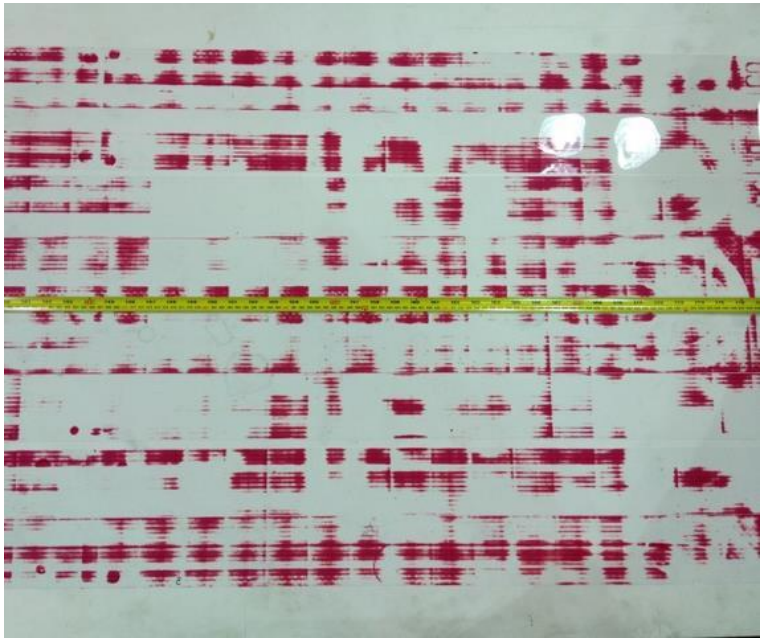


C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Fuji Film - Comments



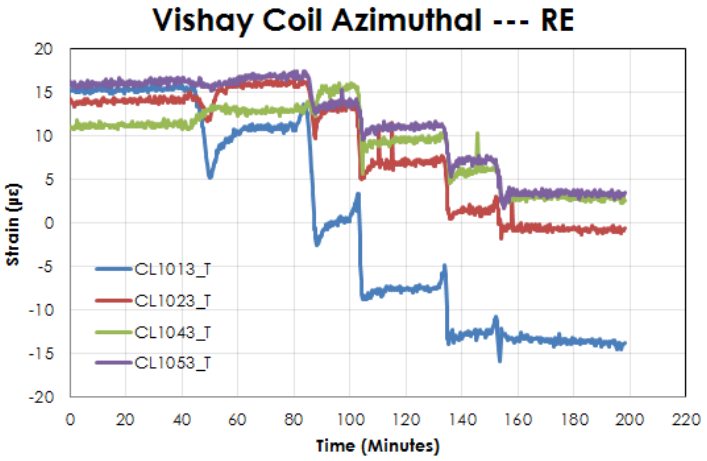
MQXFBP1 Test – Coil Pack 1



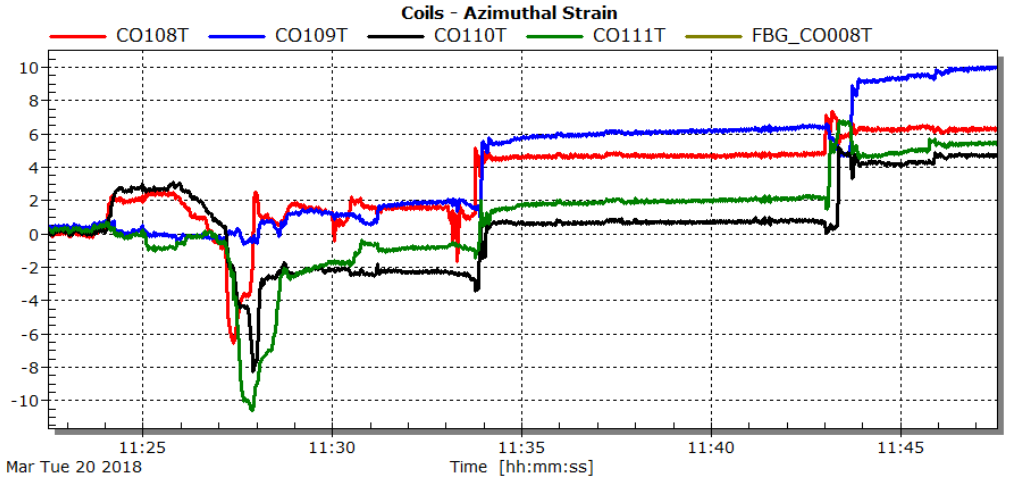
MQXFAP2

- In very few areas there is good contact on both pole and mid-plane
- In other zones we see no contact at all
- Can we improve this result with a different shimming plan?

Strain Gauges - Introduction



MQXFAP2



MQXFS4

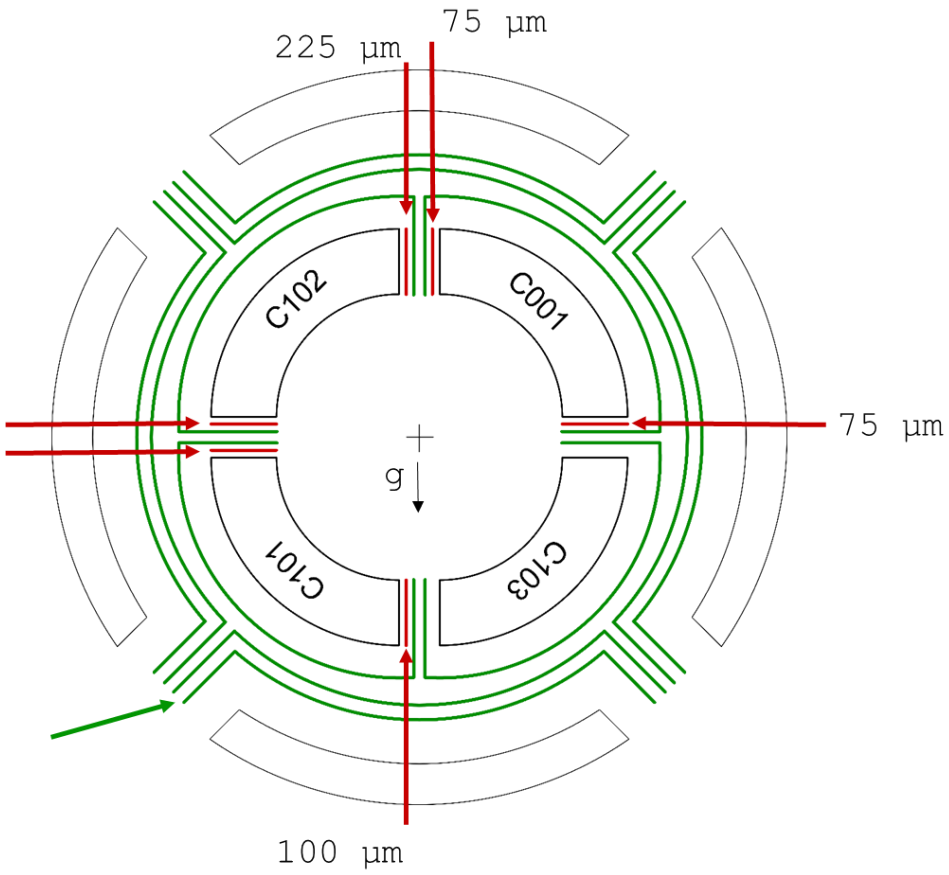
- MQXFB - Waiting for the data – some sensors were swapped (azim./long.)

- In the meanwhile we can look at two reference cases:
  - MQXFAP2 – compression everywhere → contact on the pole
  - MQXFS4 – tension everywhere → more contact on the mid-plane

Coil Pack #2
Results

Coil Pack #2 - Layout

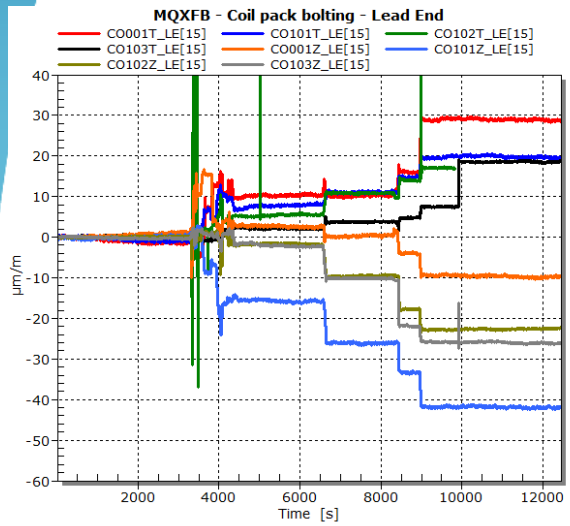
View from the Lead End

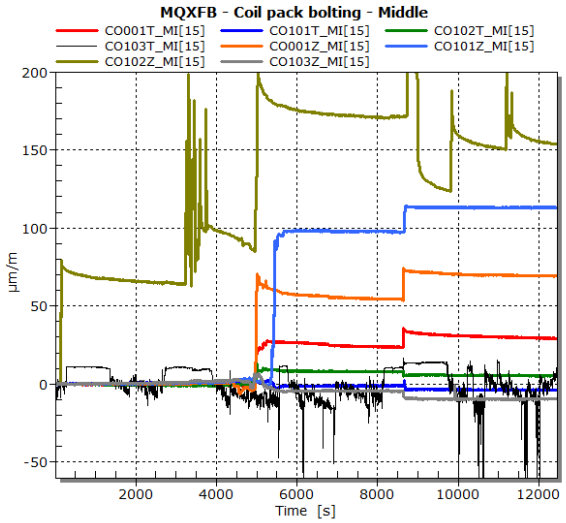


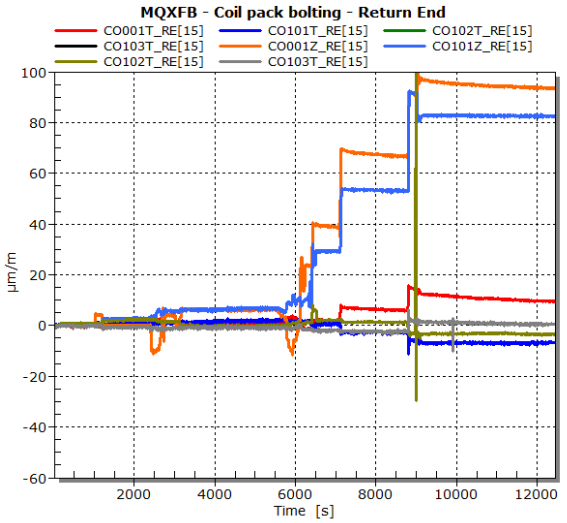
C001: L+R = + 0 µm
C102: L+R = - 300 µm
C101: L+R = - 50 µm
C103: L+R = + 150 µm

Note: To match the 114 mm collar radius, we removed a 125 µm collar shim.
Additional shim removed to improve contact.

Coil Pack #2 - Strain Gauges

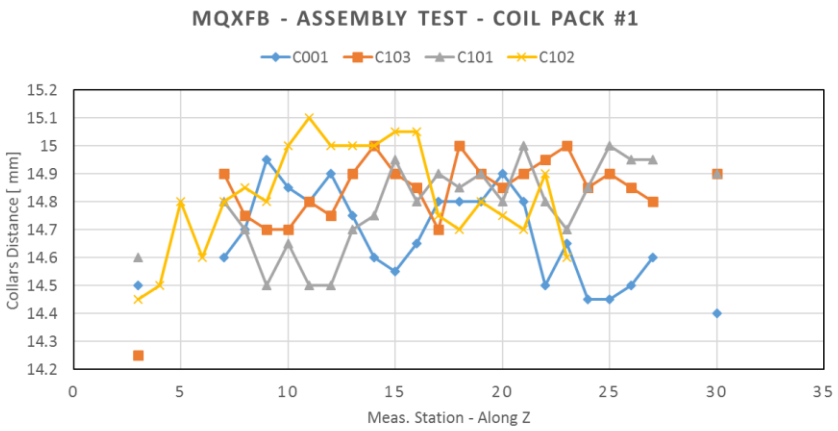


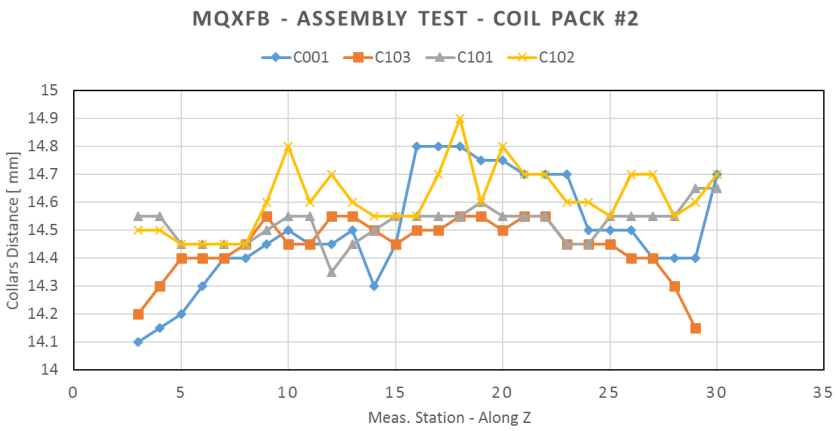




- Data is difficult to read, probably better to remove the noisy signals
- Philippe suggests that some signals seem still inverted. We will have to wait for the loading to be sure.
- In general, it seems that we have tension everywhere

Coil Pack #2 - Gap Measurement

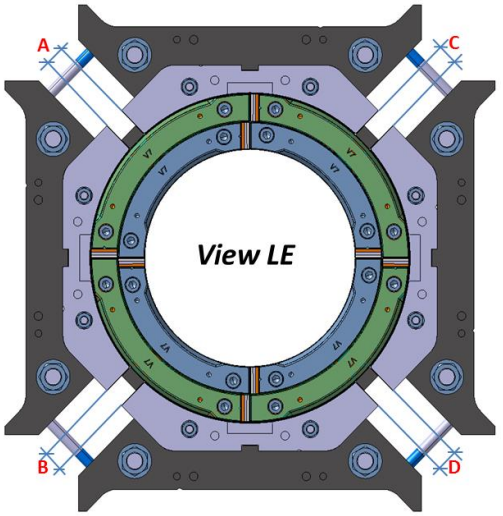




- Distance range for both coil packs: $\pm 300\ \mu m$, consistent with the short models

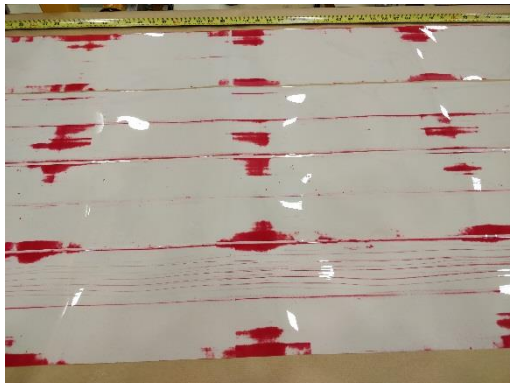
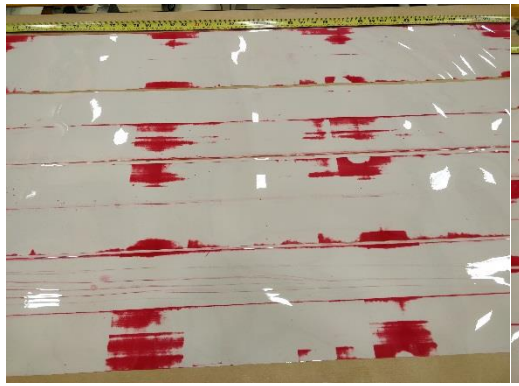
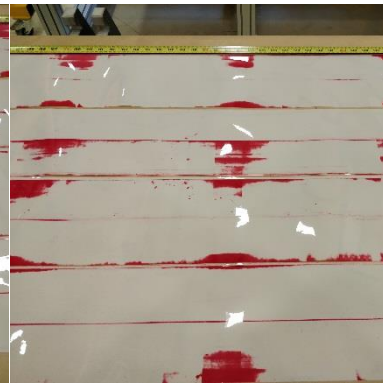
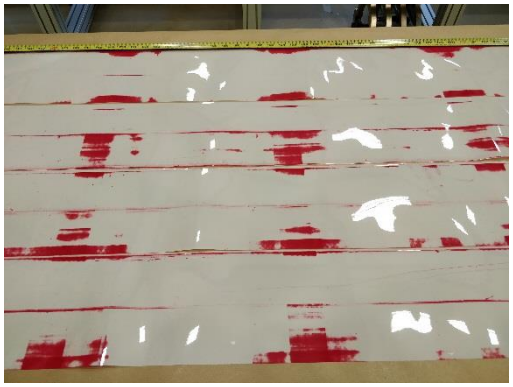
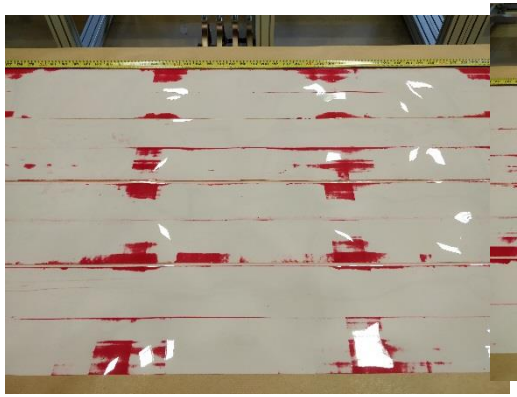
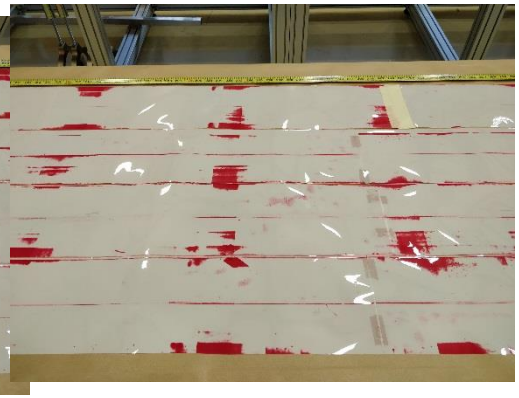
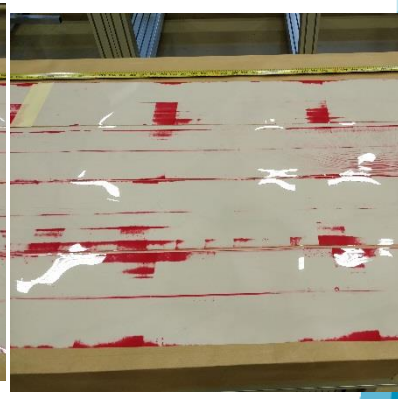
- Coil pack 1 total gap: $400\ \mu m$
- Coil pack 2 total gap: $100\ \mu m$. Gap reduction expected as we removed radial shims

- Coil pack 2 is more uniform. This is probably due to the fact that with the reduced gap we are *using* the PK



EXTRA

Fuji Film - All

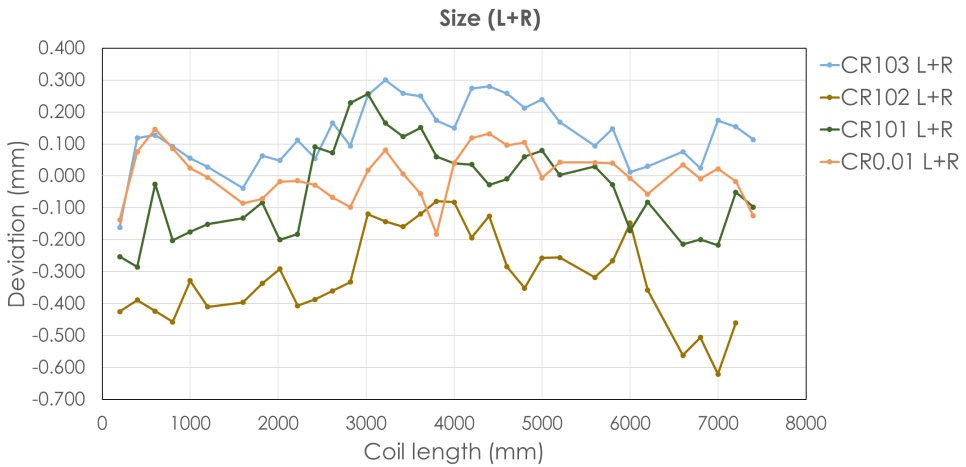
Coil Position

Coil Pack Layout (1)

- We have to decide the relative position between the coils. Assumptions:
  - Only mid-plane shimming (more effective for FQ)
  - Smallest shim is 25 μm (rounded coil size)
  - Thickness neglected
- Possible coil combinations:

1 2 3 4 1 2 4 3 1 3 2 4
1 3 4 2 1 4 2 3 1 4 3 2

	L+R µm	(L+R)/2 µm	dshim µm	mid-shim µm
C0.01	12	6	0	75
C101	-28	-14	-25	100
C102	-314	157	-150	225
C103	138	69	75	0



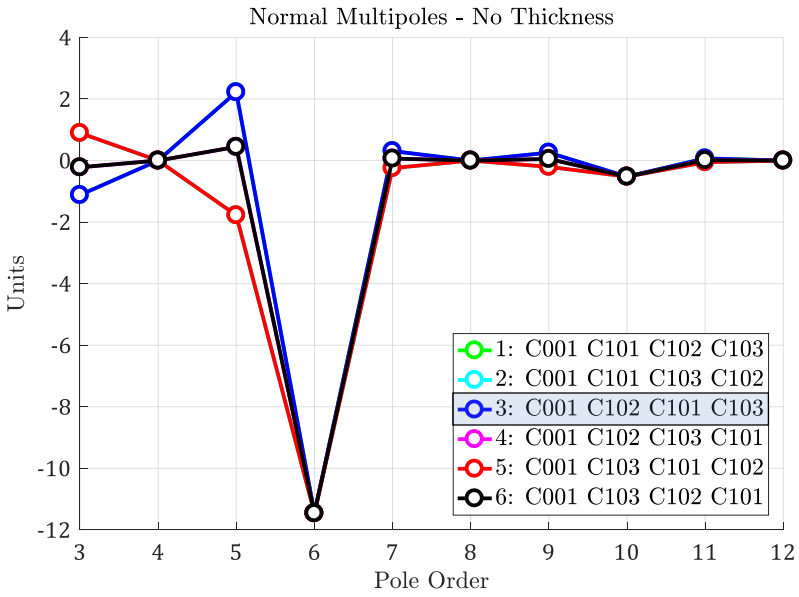
Coil Pack Layout (3)

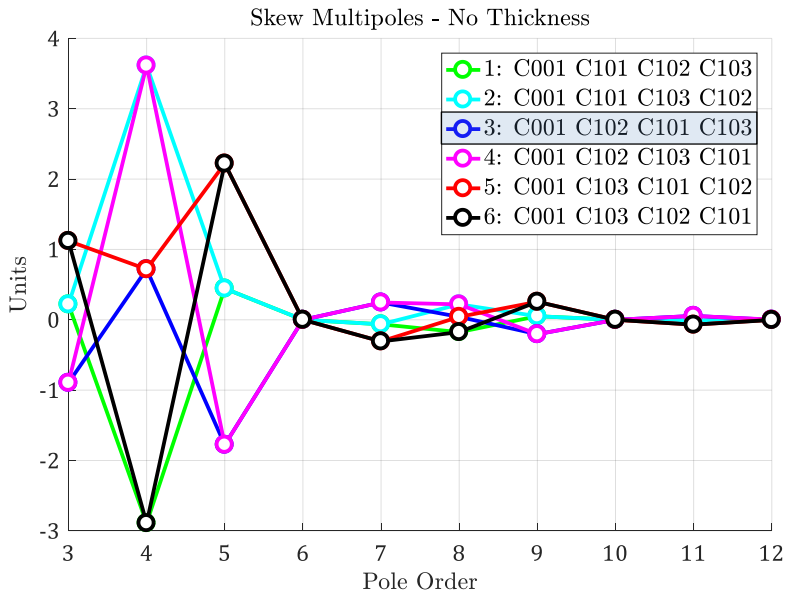
	Coil Positioning Case					
bn	1	2	3	4	5	6
3	-1.12	0.90	-1.12	-0.22	0.90	-0.22
4	0.00	0.00	0.00	0.00	0.00	0.00
5	2.22	-1.78	2.22	0.44	-1.78	0.44
6	-11.46	-11.46	-11.46	-11.46	-11.46	-11.46
7	0.31	-0.25	0.31	0.06	-0.25	0.06
8	0.00	0.00	0.00	0.00	0.00	0.00
9	0.26	-0.20	0.26	0.05	-0.20	0.05
10	-0.52	-0.52	-0.52	-0.52	-0.52	-0.52
11	0.07	-0.06	0.07	0.01	-0.06	0.01
12	0.00	0.00	0.00	0.00	0.00	0.00

	Coil Positioning Case					
an	1	2	3	4	5	6
3	0.22	0.22	-0.90	-0.90	1.12	1.12
4	-2.89	3.61	0.72	3.61	0.72	-2.89
5	0.44	0.44	-1.78	-1.78	2.22	2.22
6	0.00	0.00	0.00	0.00	0.00	0.00
7	-0.06	-0.06	0.25	0.25	-0.31	-0.31
8	-0.18	0.22	0.04	0.22	0.04	-0.18
9	0.05	0.05	-0.20	-0.20	0.26	0.26
10	0.00	0.00	0.00	0.00	0.00	0.00
11	-0.01	-0.01	0.06	0.06	-0.07	-0.07
12	0.00	0.00	0.00	0.00	0.00	0.00

- Full results for reference
- Our models have shown in the past errors of the order of ~1 unit
  - In reality most of the results are comparable…

Coil Pack Layout (4)



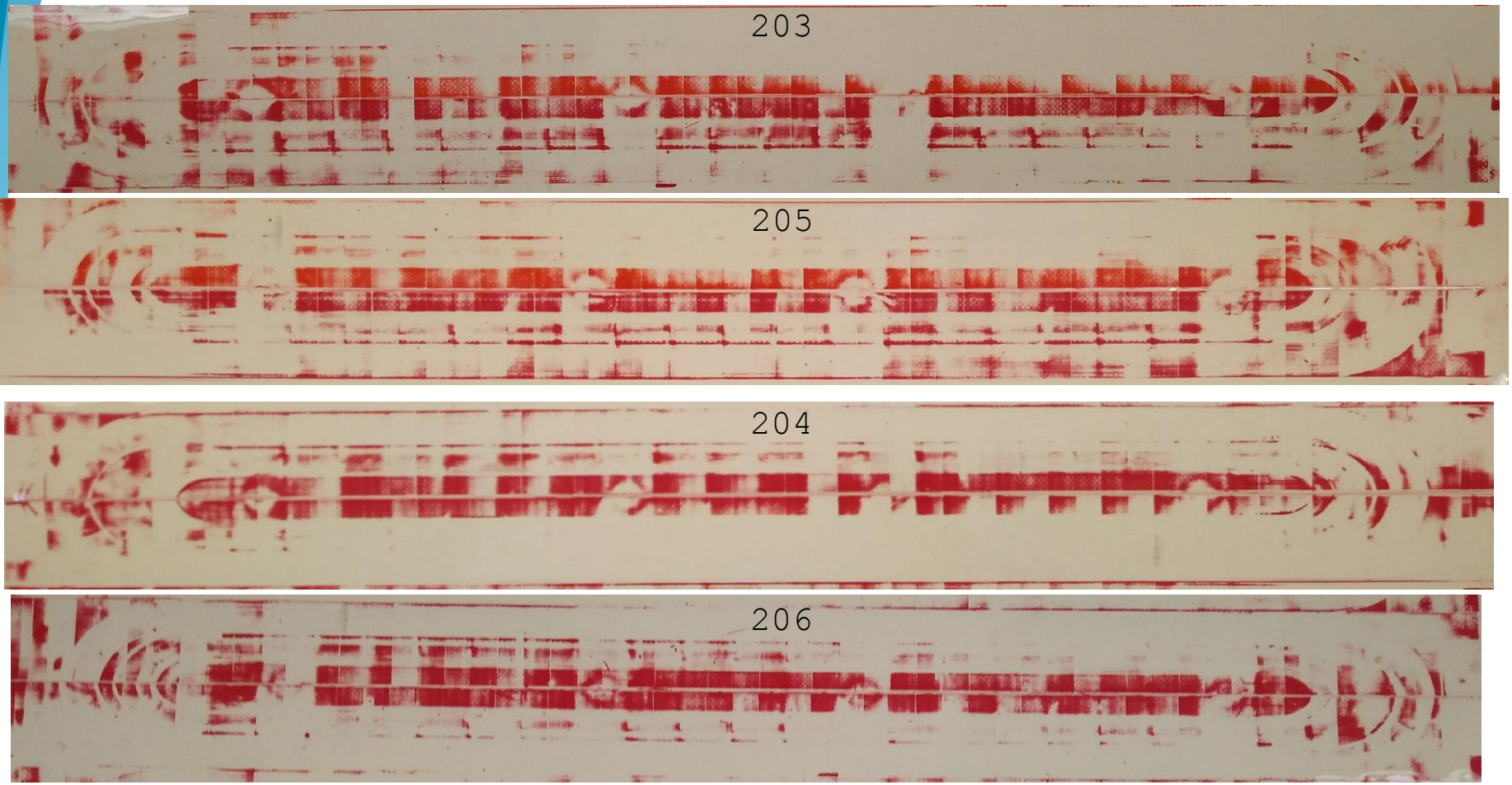


- Consider only the harmonics with *meaningful* variations
- Discard 2, 4 to avoid a large a_4
- Either we get b_3, b_5 or a_3, a_5
- $a_4 \rightarrow$ sets 3/5 could be the best

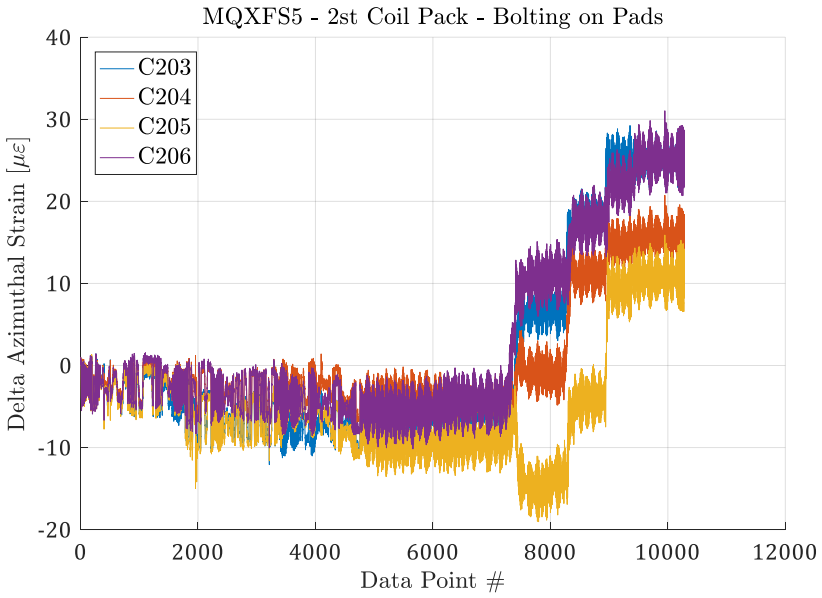
	Coil Positioning Case					
	1	2	3	4	5	6
b3	-1.12	0.9	-1.12	-0.22	0.9	-0.22
b5	2.22	-1.78	2.22	0.44	-1.78	0.44
a3	0.22	0.22	-0.9	-0.9	1.12	1.12
a4	-2.89	3.61	0.72	3.61	0.72	-2.89
a5	0.44	0.44	-1.78	-1.78	2.22	2.22

MQXFS5
Fuji and Bolting

MQXFS5 - Fuji Paper: Coil/Collar



Bolting on Pads



- Tension on all the coils