



Status and plan for magnetic measurement devices

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Outline

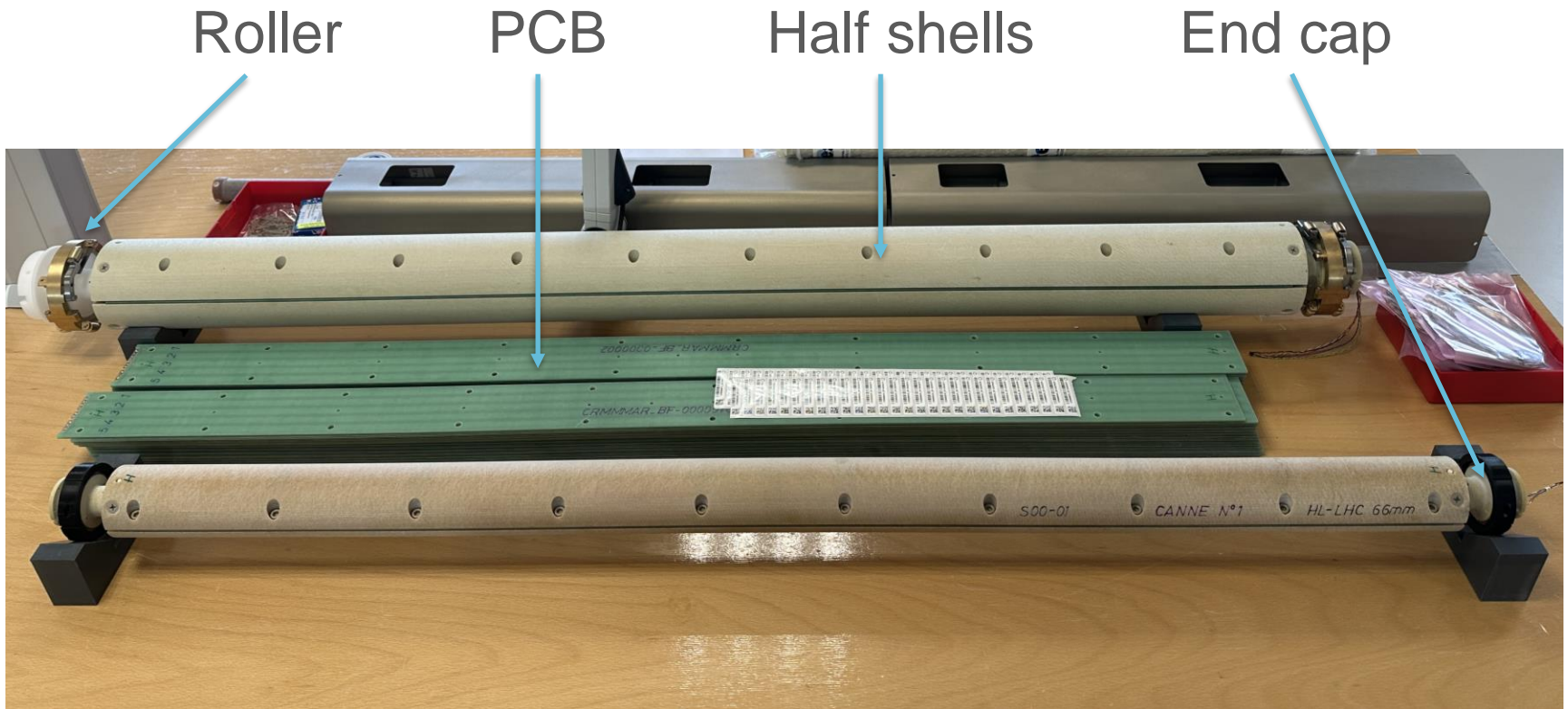
- Rotating coils for tests on horizontal benches
 - Introduction
 - Status
 - Plan
- Quench antennas
 - Introduction
 - Status
 - Plan

WP3 meeting 13 September 2023

<https://indico.cern.ch/event/1323751/>

Other instruments such as rotating-coil scanners and stretched-wire systems are not discussed in this presentation.

Rotating coils: segments in reality



Rotating coils: shaft configurations

- **4 configurations (see Appendix)**
 - **Q2 (used as well for Q1/Q3)**
2 shafts, 6 segments, 4 coils per segment connected
1 shaft is a spare.
 - **D1**
1 shaft, 5 segments, 5 coils per segment connected
No spare unit but the CP shaft can be used
 - **CP**
1 shaft, 5 segments, 5 coils per segment connected
No spare unit but the D1 shaft can be used
 - **D2**
2 shafts, 10 segments, 2 coils per segment connected
No spare but the other shaft can be used

Spare segments of all types

Rotating coils: number of required segments

		N. shafts	N. segments
Type 1 ∅ 103	Q2	1 + 1 spare	14
	D1	1	6
	CP	1	5
	SPARES		4
	TOTAL		29
Type 2 ∅ 66	D2	2	20
	SPARES		4
	TOTAL		24

The Q1/Q3 tested at CERN will be measured by using the Q2 shaft

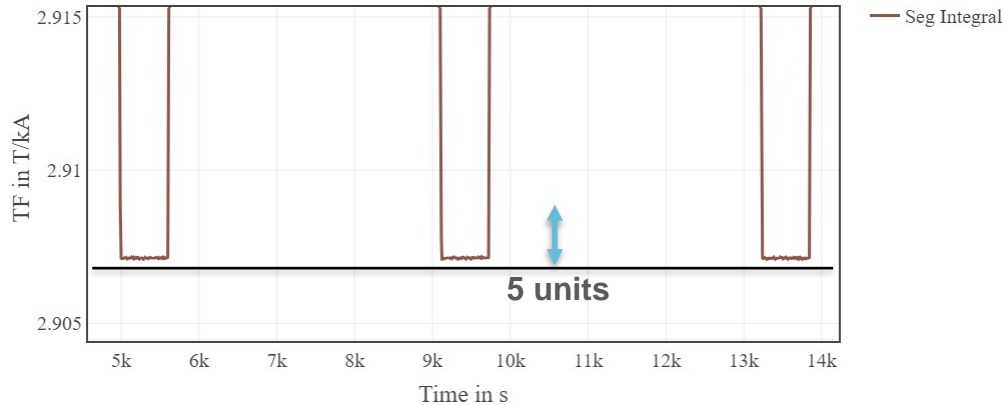
Rotating coils: performed tests

- The MQXFB magnets tested in the temporary cold-mass were measured by using the prototype shaft made of carbon fiber
- The D2 (with MBRDP1) prototype was tested by reusing the LHC MB anti-cryostats. The LHC MB shafts ($R = 17 \text{ mm}$) were the only ones fitting these anti-cryostats. The measurement precision is affected for multipoles $n > 6$.
- The D1 prototype (MBXFP1) was measured by using the prototype shaft (carbon fibre) as well as the new shaft made of glass fibre of 103-mm (first validation test)
- The first Q2b (with MQXFBP2) was not measured
- The first Q2a (with MQXFBP3) was measured by using the new shaft made of glass fibre of 103-mm (second validation test)
- The Q2b (with MQXFB04) is going to be measured by using the new 103-mm shaft made of glass fibre
- The first Q1/Q3, at CERN, will be measured by using the same shaft as Q2 with a change of configuration (additional extension)

Feedback from tests: precision and mechanical stability

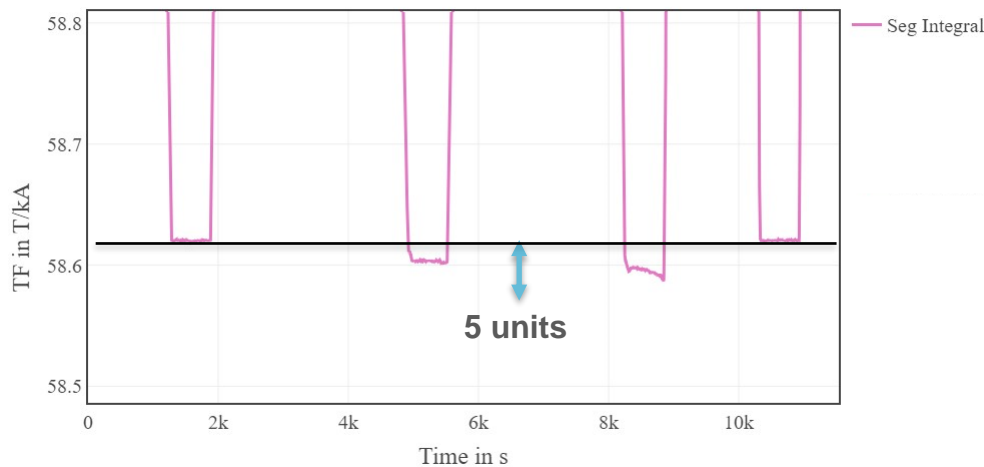
D1 prototype (MBXFP1)

3053210_machine_cycle



Q2a (MQXFBP3)

3052993_ramp_rate



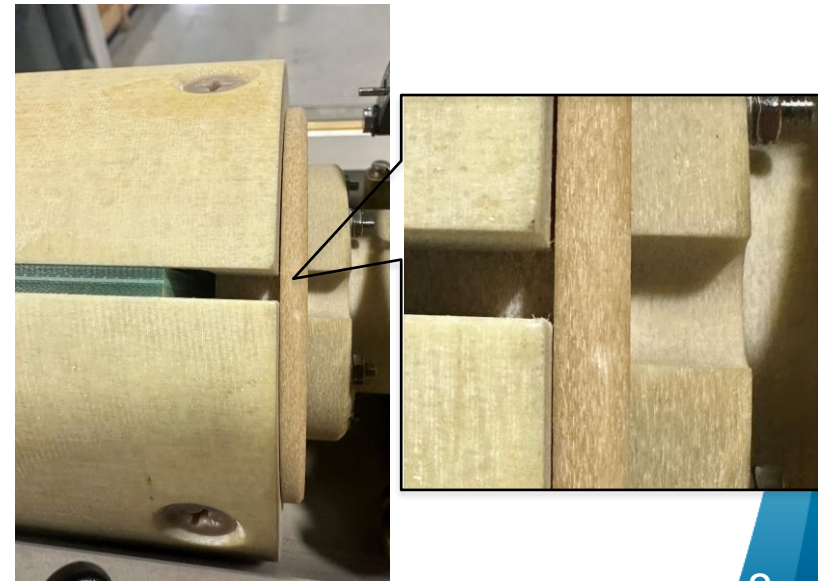
The results of tests performed so far show:

- Excellent precision in the dipole (<1 unit)
- Deviations up to ~3 units in the quadrupole

A mechanical instability is affecting one of the segments. It seems to be caused by the tolerances of the half-shell length.

To improve :

- Sorting of the half shells to match the length
- Addition of a 0.4-mm washer to be sure that the “end caps” are in compression



Feedback from tests: friction of rollers

The sliding of the new shafts, made of fiberglass therefore heavier than carbon fiber, is difficult due to the friction of the roller wheels.

- Some metallic dust is produced by the friction of the wheel against its axle
- The dust accumulates on the sides of the wheel and fills the small gap in between the wheel and the support arm

Improvements are under test:

- Modification of the wheel (narrower and with a larger hole)
- Addition of bushing elements between wheel and axle



Rotating coils: plan

- **For the D2 series - 66 mm (higher priority)**
 - Main components are available (half shells and PCB's)
 - Rollers (old design) should arrive in 1 week
 - Extensions should arrive in 2 weeks
 - Cables are in stock
 - Assembly and calibration process already started (2 weeks/shaft)
- **The two shafts will be normally available for the test of the next D2**

- **For the D1 series and CP series - 103 mm**
 - Half shells are available for all required segments
 - PCB's production about to be started (~3 months)
 - Rollers: order after modification of wheel design (~2 months)
 - Cables: stock not enough, a new order is required (~4 months)
 - Assembly and calibration (2 weeks/shaft)
- **The additional 103-mm shafts available in ~October 2024**

Quench antenna

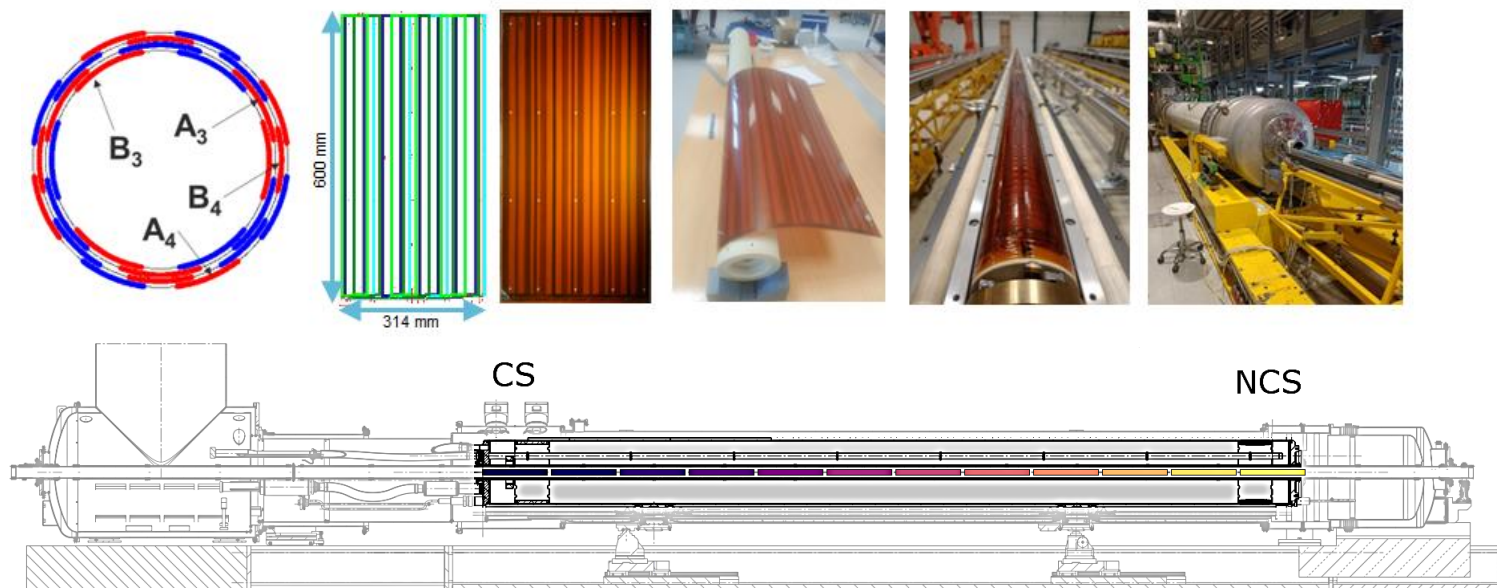
For the precise (few millimeters) quench localization, a different device is used:

- the “quench antenna”

Similarly to the rotating coils, it is a segmented shaft equipped with pickup coils

- It is not rotating (but can be oriented at different angles)
- The sensitivity of the pickup coils is different (sensitive to specific single multipoles)

The rotating coils can be used for quench localization but with much less resolution (!)



12 segments to cover the length of a MQXFB

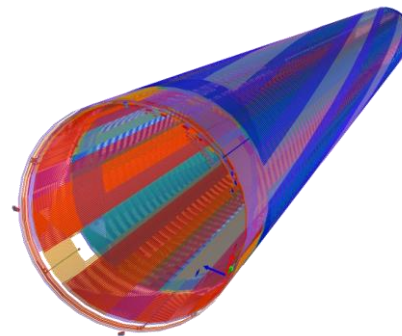
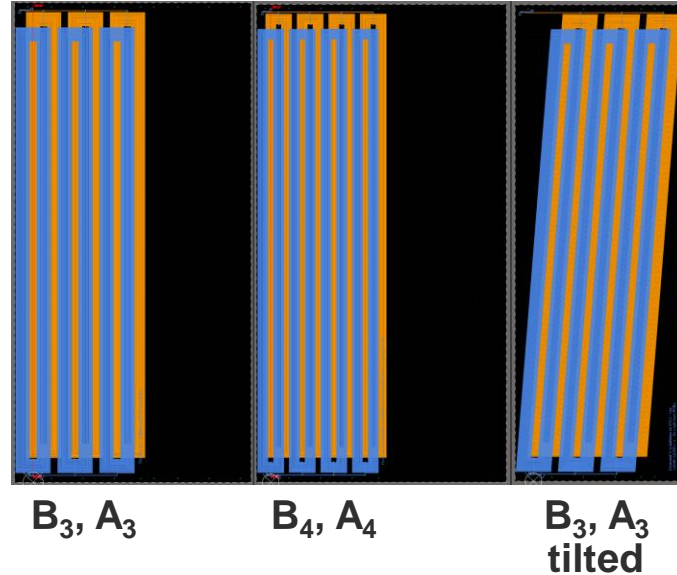
Recent development for precise localization

On one segment there are 3 sets of coils:

- Straight coils sensitive to B3/A3 and B4/A4
- Additional tilted coils sensitive to B3/A3

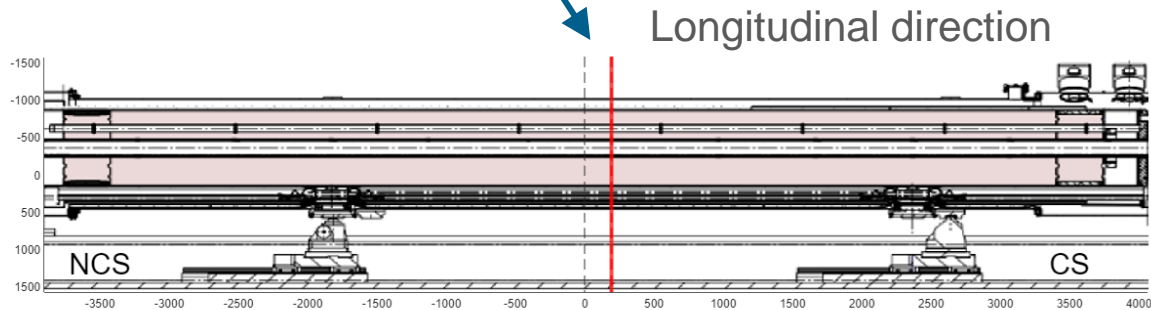
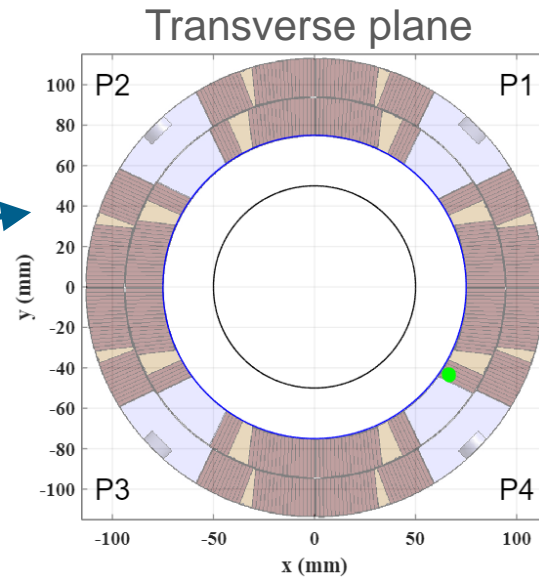
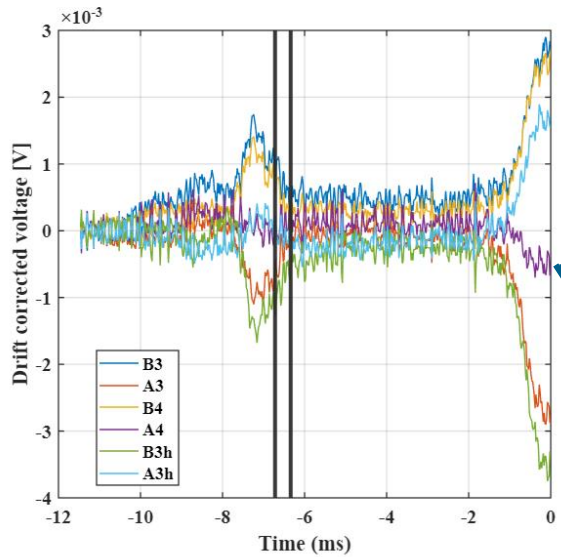
The transversal position is obtained from B3/A3 and B4/A4 measured with straight coils.

The longitudinal position is proportional to the phase shift of the signals from tilted coils respect to the signals from the straight coils.



Example of quench localization

Test of the first Q2a with MQXF BP3



Long. loc.: 194 mm

Quench antennas: status and plan for Q2

- **For the Q2 (compatible for the D1)**
 - A full-length quench antenna (12 segments of 600 mm) is in operation since August 2022
 - One additional segment, implementing the new design for precise longitudinal localization, was added in December 2023 and later validated
 - Given the intense use of the device, a spare unit would be beneficial
 - **Plan to build a new full-length quench antenna with all segments based on the new design with longitudinal localization**
 - Design of coils finished and production about to start (~3 months for production)
 - Reuse of the design for all mechanical component (~3 months for production in parallel with the coils)
 - Cables must be procured (~4 months pending agreement with procurement office)
 - Assembly more complex than a rotating coil (~1 month/shaft)
- The new quench antenna for Q2 will be ready in ~November 2024

Quench antennas: status and plan for D2

- **For the D2 (not compatible with the Q2!)**
 - Baseline was to use the rotating coil as quench antenna
 - The localization would be much less precise
 - Coil sensitivity is not optimized for quench measurement (difficult detection)
 - The length of segments is 1.2 m (poor longitudinal resolution)
- **Plan to change the baseline (if agreed)**
 - Improve the sensitivity by connecting 3 coils per segment
 - Reduce the total number of segments from 10 to 7 (MCBRD's will not be covered!) to cope with the limited number of available sliding contacts (~50)
 - Equip the 2 extreme segments with flex PCB's that allows a precise transversal and longitudinal localization
 - Design of coils (~1 month)
 - Production of PCB coils (~3 months)
 - All other components are already available (same as rotating coils)
- The new segments with precise quench localization would be ready in ~October 2024

In summary

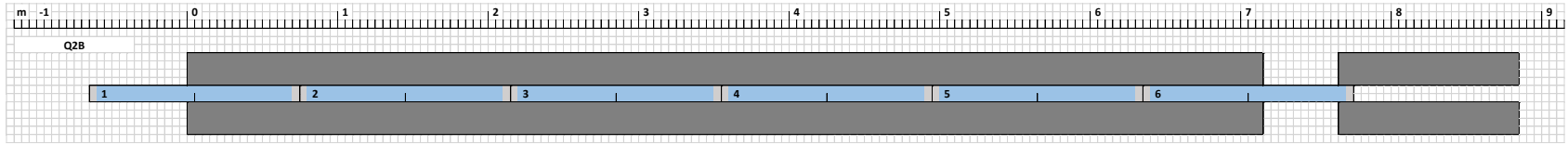
- Rotating coils
 - For the 150-mm magnets (Q2, D1, CP)
 - One shaft is in operation
 - The additional units, required to optimize operations and to have spares in case of major issues, will be ready in ~4/5 months
 - Based on the feedback from tests, some improvements will be implemented
 - For the 105-mm magnets (D2)
 - Assembly of the 2 required shafts is already ongoing
 - They will be normally ready for the test of the first D2 series

- Quench antennas
 - For the 150-mm magnets (Q2, D1, CP)
 - One quench antenna is in operation
 - One additional unit, to optimize operations and to have a spare in case of major issues, will be ready in ~5 months
 - The new unit will be based on the new design with high longitudinal resolution
 - For the 105-mm magnets (D2)
 - If agreed, change of baseline to improve quench localization
 - Shorter rotating-coil shafts (correctors will not be covered!)
 - Integration of quench localization coils on the rotating-coil shafts

Appendix

Configuration for Q2

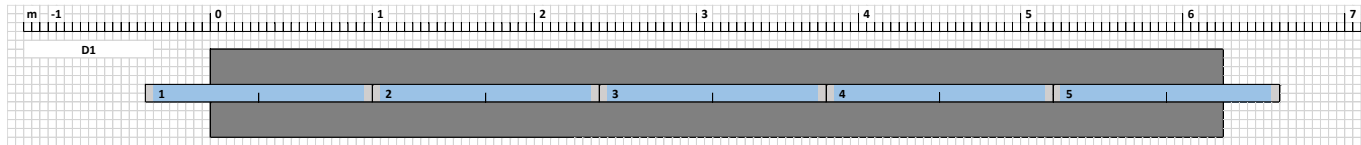
Segments of type 1 (103 mm)



- 2 shafts (1 spare)
- 6 segments each
- Extension of 2 m
- Cabling: 4 coils connected ($4 \times 2 \times 6 = 48$ contacts)

Configuration for D1

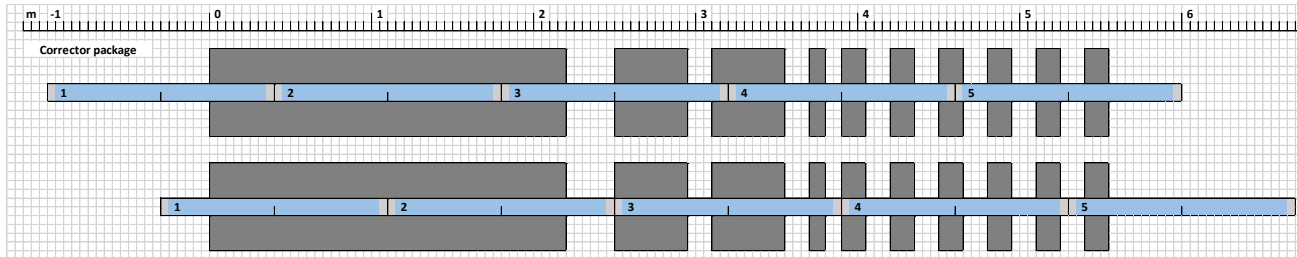
Segments of type 1 (103 mm)



- 1 shaft (the shaft for CP can be as well used)
- 5 segments
- Extension of 2 m
- Cabling: 5 coils connected ($5 \times 2 \times 5 = 50$ contacts)

Configuration for CP

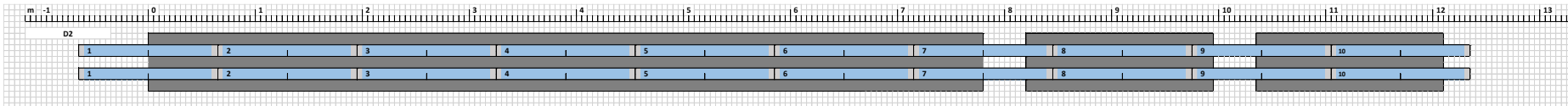
Segments of type 1 (103 mm)



- 1 shaft (the shaft for D1 can be as well used)
- 5 segments
- Extension of 2 m
- Cabling: 5 coils connected ($5 \times 2 \times 5 = 50$ contacts)
- A displacement is required to cover all magnets

Configuration for D2

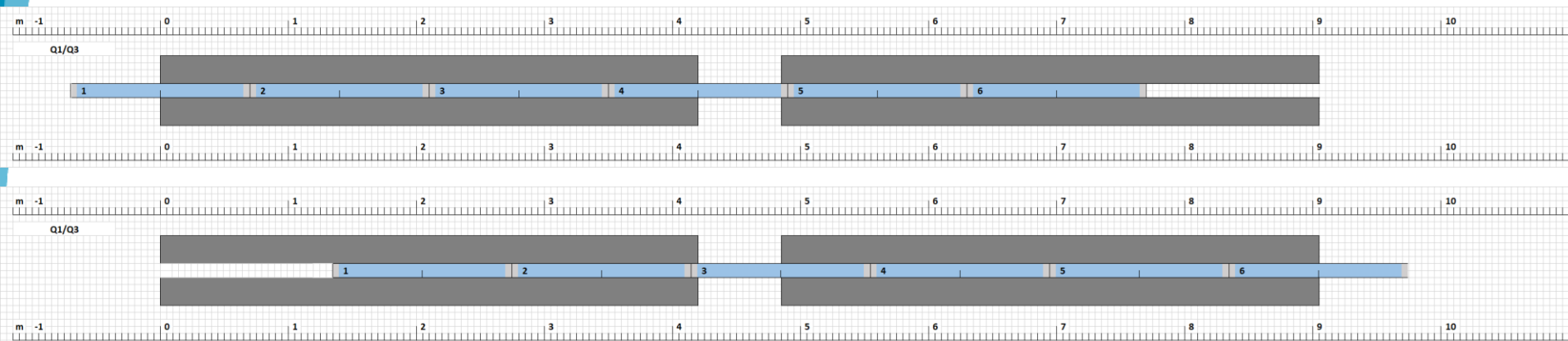
Segments of type 2 (66 mm)



- 2 shafts (no spare)
 - option 1: 10 segments to cover MBRD and MCBRD's
 - option 2: 7 segments to cover the MBRD only
- Cabling:
 - option 1: 2 coils connected ($2 \times 2 \times 10 = 40$ contacts)
 - option 2: 3 coils connected ($3 \times 2 \times 7 = 42$ contacts)
- Extension of 2 m

Configuration for Q1/Q3

Segments of type 1 (103 mm)



- No specific shaft – the one for Q2 can be used
- Extra extension required
- Measurement in two steps