Room temperature magnetic measurements of D1 prototype at CERN

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M. Pentella, C. Petrone, TE-MSC-TM

https://indico.cern.ch/event/1269740/

Outline

- Introduction and measurement goals
- MM workflow
- Measurement procedure
- Reference system definition
- Measurement results
- Comparison with previous measurement
- Summary and conclusions

Introduction and goal of the measurements

- **Goal**: room temperature magnetic measurements of the D1 cold mass prototype
- **Reference**: HCLMBXF004-KJ000001

Mesurement requirements expressed in terms of 3-σ uncertainty [1]

Roll angle (mrad)	Transverse center (mm)
0.3	0.6

[1] Engineering Specification, LHC-G-ES-0023

MM Workflow

Magnet reception Hall 180	Cold mass 180-R-V33	Cryogenic temperature SM18

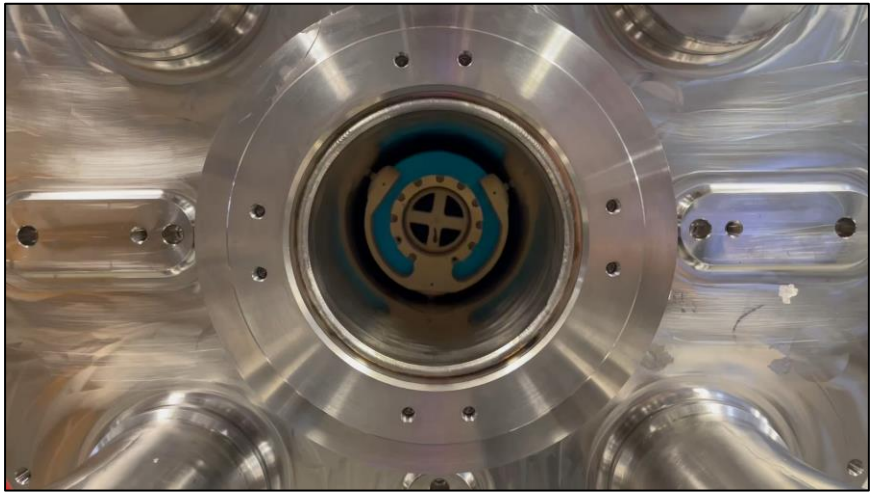
Integrated field, roll angle and transverse axis referred to reference points
Rotating coil scanner

Magnet powering

Field homogeneity
Rotating coil/SSW

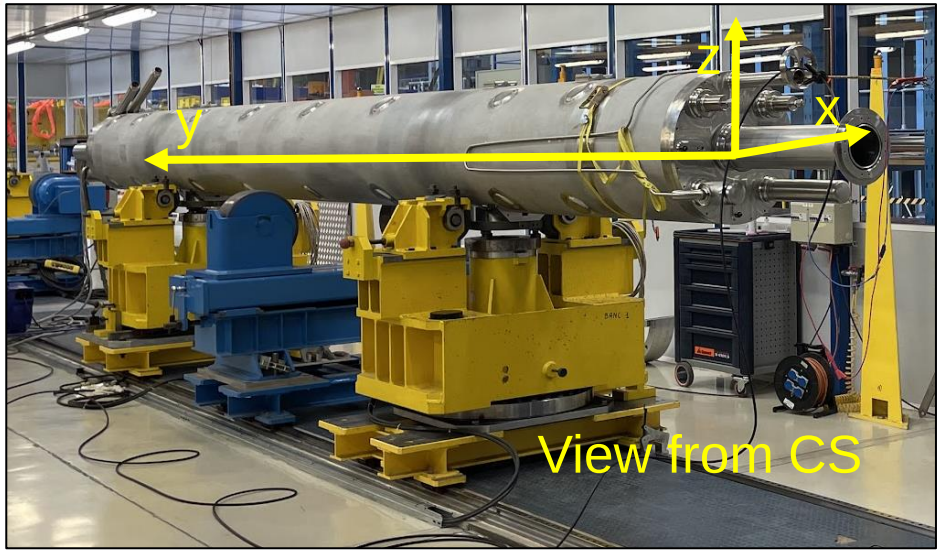
Measurement procedure

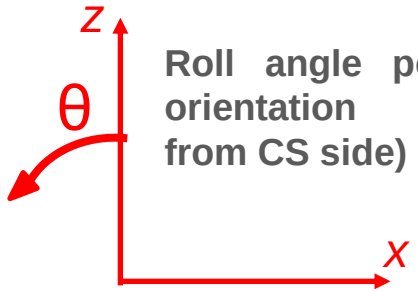
- Measurements performed by **rotating coil scanner** (RCS, or mole), a short 600-mm rotating coil displaced along the magnet longitudinal axis
- Measurements performed in correspondence with **13 longitudinal positions**, covering the entire **magnetic length** (~6.26 m), at an excitation current of 10 A
- **Transducer position** monitored by a **laser tracker** throughout the duration of the measurement campaign
- **Standard harmonic analysis** to post-process data



Scanner in operation during the measurement

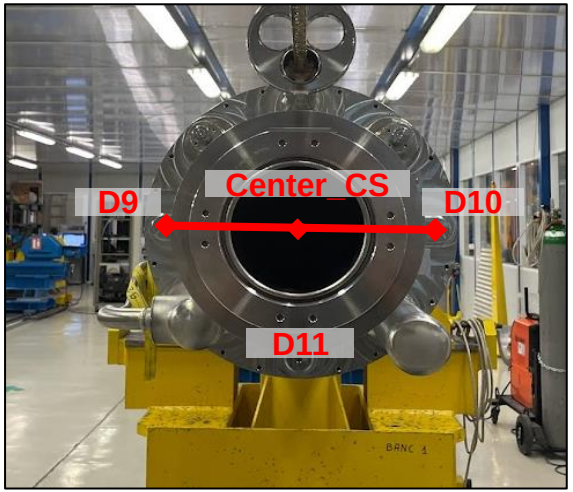
Reference system definition - 1





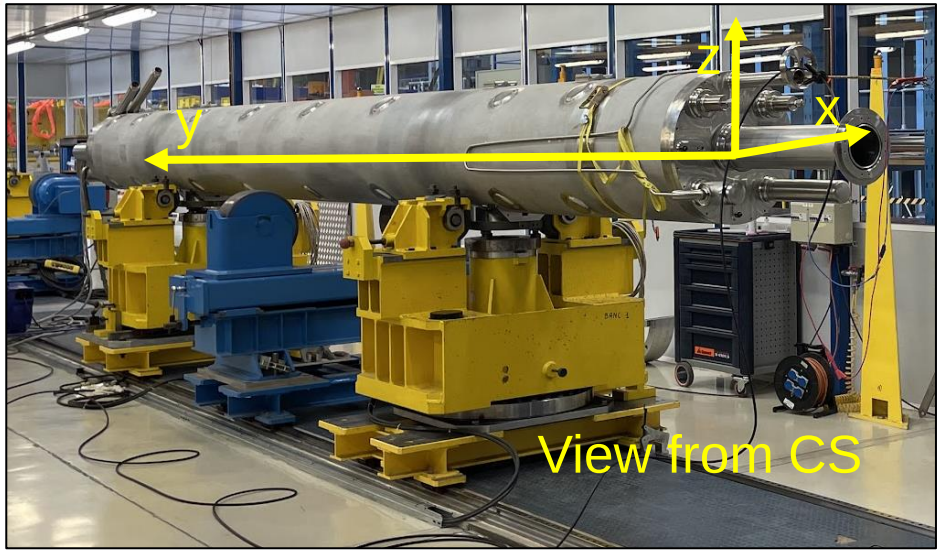
Roll angle positive orientation (view from CS side)

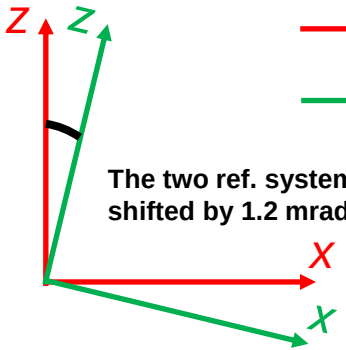
- Reference system defined according to the **cold mass fiducials** on the endcovers, D9, D10, and D11, and the **gravity**



- *z*-axis chosen coincident with **gravity**
- *y*-axis on the **line between the two centers** of the endcovers, defined by the fiducials, with **positive orientation** from CS to NCS
- **All the results** are expressed in this reference system

Reference system definition - 2



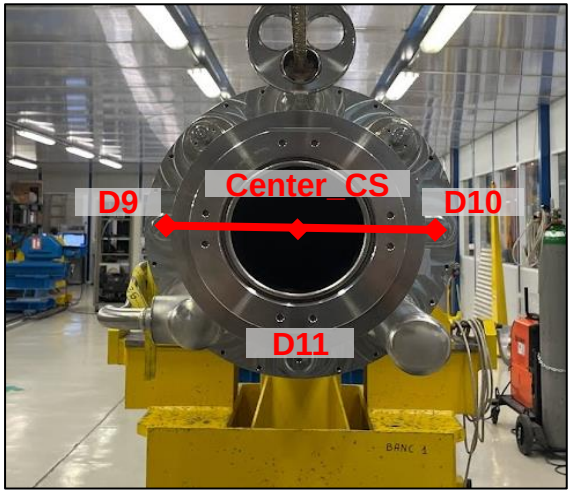


z-axis chosen coincident with gravity (Slide 6)

***x*- axis chosen on the line between D9-D10**

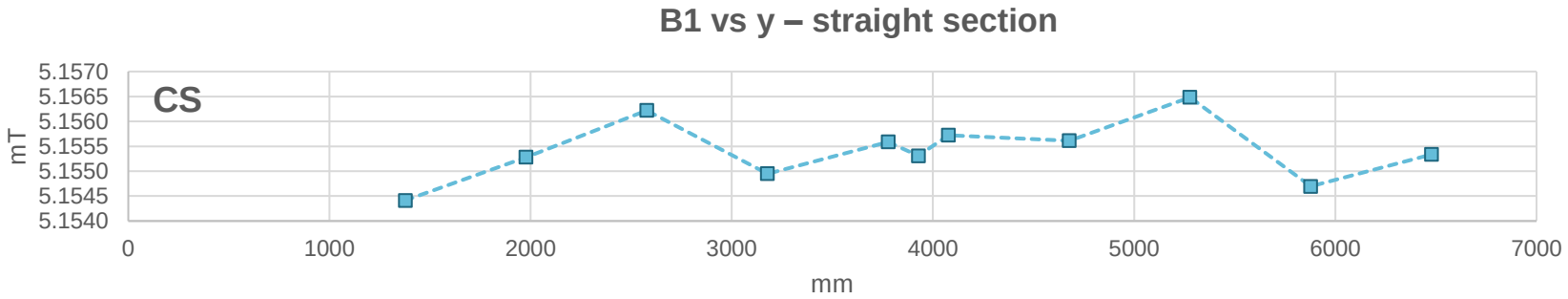
The two ref. systems are shifted by 1.2 mrad

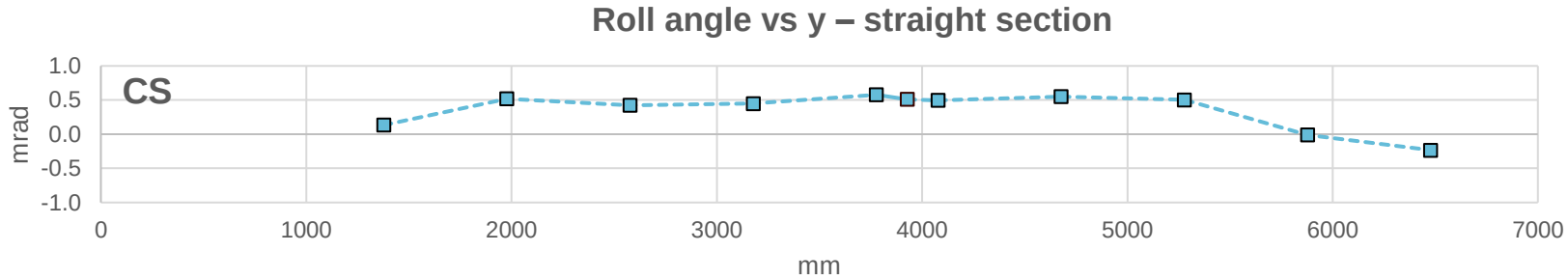
- Reference system defined according to the **cold mass fiducials** on the endcovers, D9, D10, and D11



- *x*-axis chosen coincident with the **line between D9 and D10**
- *y*-axis on the **line between the two centers** of the endcovers, defined by the fiducials, with **positive orientation** from CS to NCS
- This reference system is used to **compare** the roll angle measurement with KEK's

Measurement results - 1





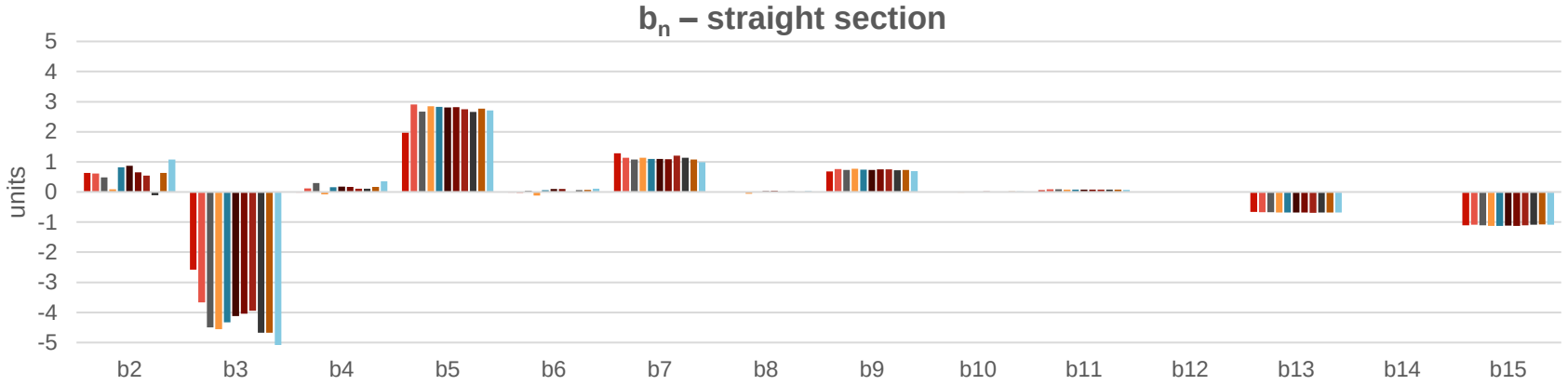
- Roll angle affected by the field behavior at the **two magnet ends**

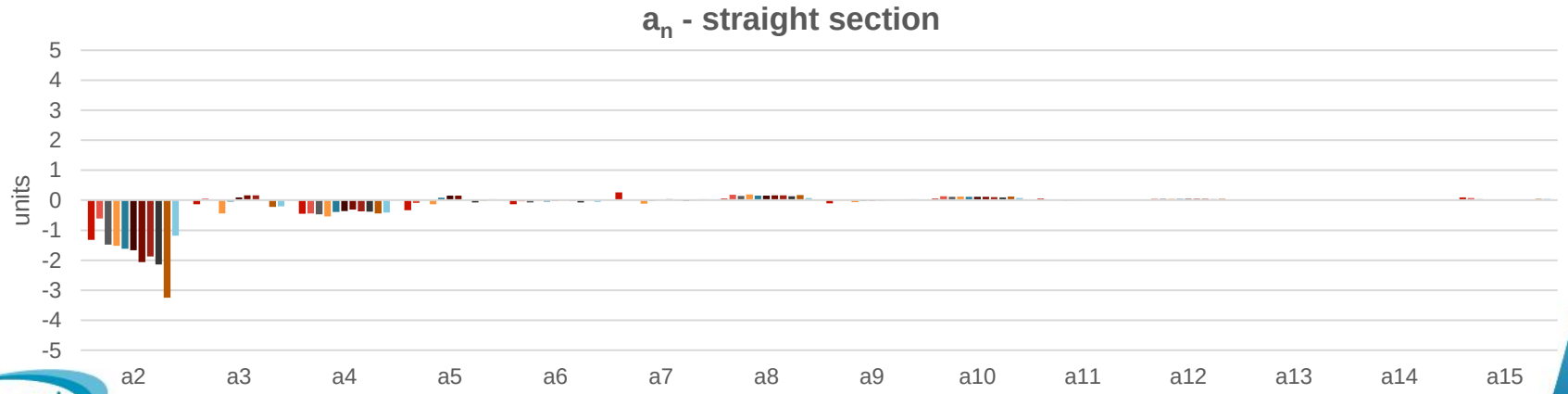
	Central	Average SS	Std.	Integral
B1	5.155 mT	5.155 mT	1.2 units	32.240 mT m
Roll wrt gravity	0.51 mrad	0.355 mrad	0.3 mrad	-0.39 mrad
Roll wrt D9-D10	1.75 mrad	1.591 mrad	0.3 mrad	0.85 mrad

Ref. system defined in Slide 6 →

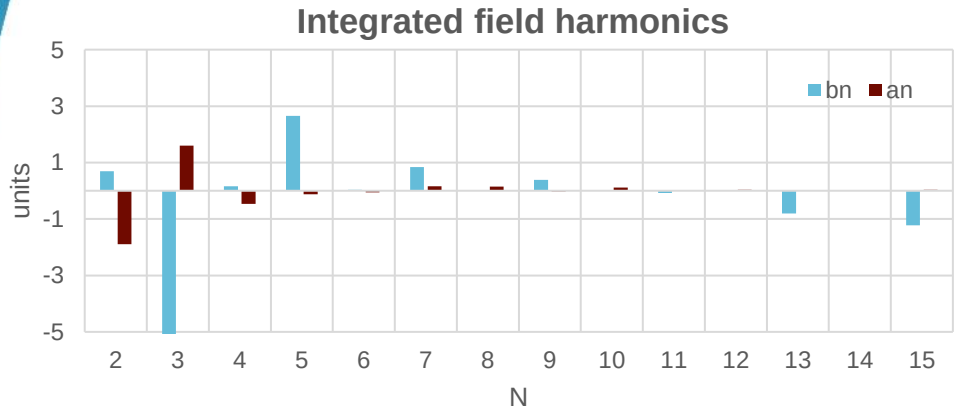
Ref. system with *x*-axis chosen on the line between D9-D10 (Slide 7) →

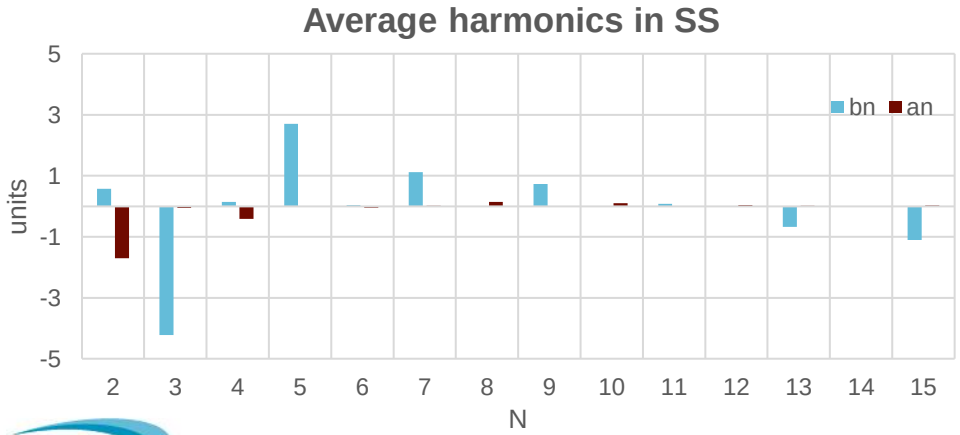
Measurement results - 2

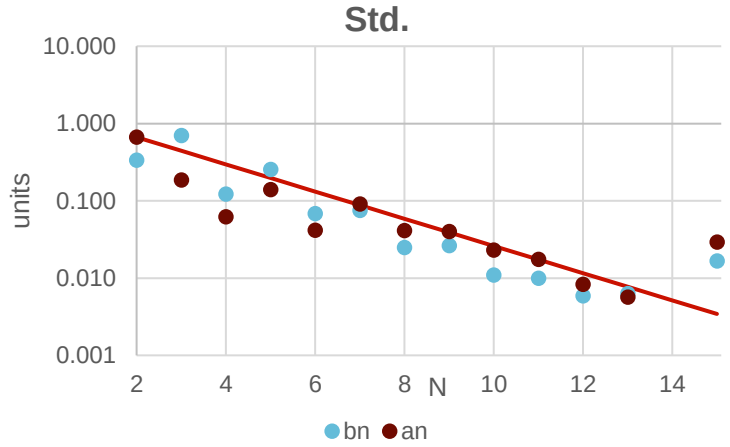




Measurement results - 3







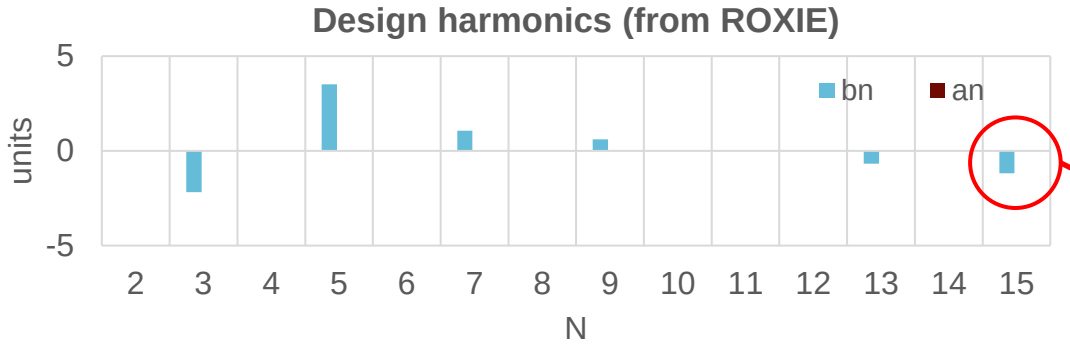
- b_3 influenced by the **magnet ends**
- All the other harmonics **differ** by **a few sub-units** with respect to their average in the SS
- Harmonics in the SS **comparable with simulations**

Measurement results - 4

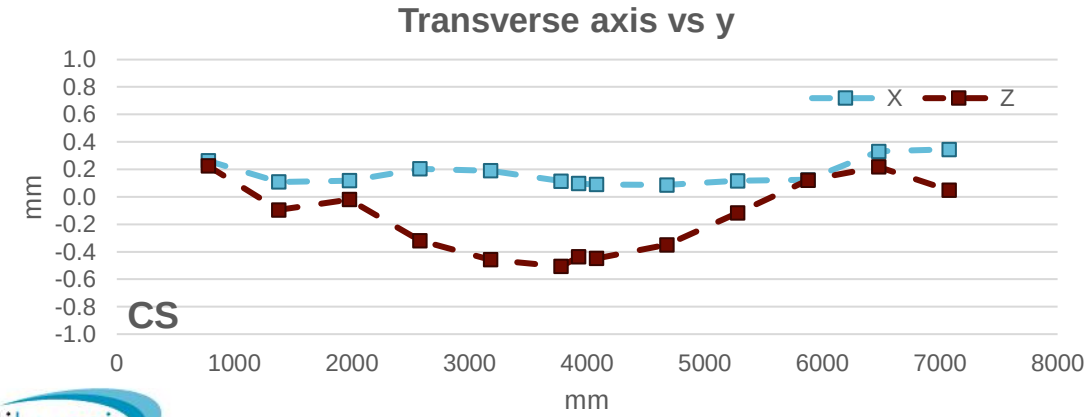
	b_n					a_n				
N	**Central**	**Average SS**	**Std.**	**Integral**	**ROXIE**	**Central**	**Average SS**	**Std.**	**Integral**	**ROXIE**
2	0.87	0.58	0.33	0.69	0.00	-1.67	-1.70	0.67	-1.89	0.00
3	**-4.12**	**-4.22**	**0.70**	**-14.88**	**-2.19**	**0.09**	**-0.05**	**0.19**	**1.60**	**0.00**
4	0.18	0.14	0.12	0.16	0.00	-0.37	-0.42	0.06	-0.46	0.00
5	**2.81**	**2.70**	**0.26**	**2.66**	**3.51**	**0.16**	**-0.02**	**0.14**	**-0.13**	**0.00**
6	0.10	0.04	0.07	0.04	0.00	-0.02	-0.04	0.04	-0.05	0.00
7	**1.09**	**1.12**	**0.07**	**0.84**	**1.05**	**0.02**	**0.02**	**0.09**	**0.16**	**0.00**
8	0.03	0.01	0.02	0.01	0.00	0.15	0.14	0.04	0.15	0.00
9	**0.74**	**0.74**	**0.03**	**0.39**	**0.61**	**-0.02**	**-0.01**	**0.04**	**-0.02**	**0.00**
10	0.01	0.01	0.01	0.01	0.00	0.11	0.10	0.02	0.11	0.00
11	**0.08**	**0.08**	**0.01**	**-0.08**	**0.04**	**0.00**	**0.01**	**0.02**	**0.02**	**0.00**
12	0.00	0.00	0.01	0.00	0.00	0.05	0.04	0.01	0.04	0.00
13	**-0.68**	**-0.68**	**0.01**	**-0.80**	**-0.68**	**0.02**	**0.02**	**0.01**	**0.02**	**0.00**
14	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
15	**-1.11**	**-1.10**	**0.02**	**-1.23**	**-1.18**	**0.01**	**0.03**	**0.03**	**0.03**	**0.00**

Measurement results - 5

- **Proposal**: finding the transverse center using the feed-down correction of C_{14} on C_{15}

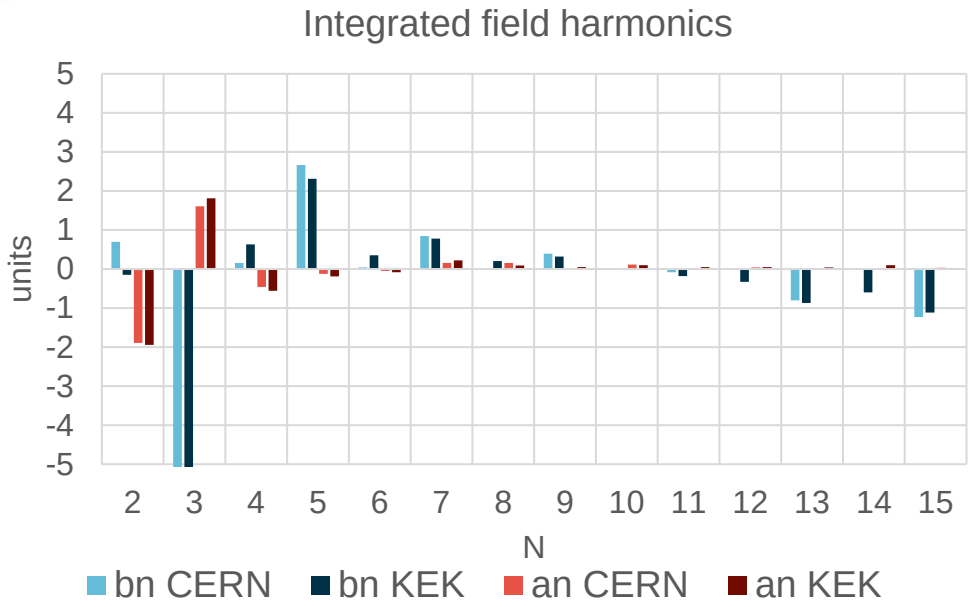


Expected large b_{15} (~ 1 units)



Integral	
x (mm)	z (mm)
0.16	0.19

Comparison with previous measurements - 1



	CERN	KEK-Hitachi
Integrated roll angle	0.85	1.14

	CERN	KEK-Hitachi
Integrated B1 (mT m)	32.240	32.251

	b_n		a_n	
N	**CERN**	**KEK-Hitachi**	**CERN**	**KEK-Hitachi**
2	0.69	-0.15	-1.89	-1.94
3	**-14.88**	**-14.38**	**1.60**	**1.81**
4	0.16	0.63	-0.46	-0.56
5	**2.66**	**2.31**	**-0.13**	**-0.19**
6	0.04	0.35	-0.05	-0.08
7	**0.84**	**0.78**	**0.16**	**0.22**
8	0.01	0.2	0.15	0.09
9	**0.39**	**0.32**	**-0.02**	**0.05**
10	0.01	-0.01	0.11	0.1
11	**-0.08**	**-0.18**	**0.02**	**0.05**
12	0.00	-0.33	0.04	0.05
13	**-0.80**	**-0.87**	**0.02**	**0.04**
14	0.00	-0.6	0.00	0.1
15	**-1.23**	**-1.12**	**0.03**	**0.02**

[2] KEK warm MM - https://edms.cern.ch/document/2747573/1.0

Summary and conclusions

- The **first cold mass prototype** of D1 was delivered at CERN and it was measured at **room temperature** by RCS
- Measurement results in **very good agreement** with the measurements performed at KEK-Hitachi, where the two **integrated main fields** differ by only **3 units,** and the field harmonics are comparable at **sub-unit** level
- Measurement of the transverse center position is **viable** if using the feed-down correction of C_{14} on C_{15}.

Acknowledgements

I wish to thank P. Rogacki, L. Fiscarelli, H. Prin, N. Bourcey, U. M. Hernandez, R. B. Mercadillo, D. Giloteaux for the great help they provided with the magnetic measurements

Thank you for the attention
Any questions?