Overview of magnetic measurements activities at Sigmaphi

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Agenda

- SIGMAPHI presentation
- What's new at Sigmaphi
- Measurement activities since IMMW19
- End of the FAIR project (quad and dipole magnets)
- coming soon… Tsinghua dipole magnets measurements

Sigmaphi is focused on Accelerator Technologies and Superconducting Magnets

2016 : sales budget 32 M€

200 highly qualified people

- Magnets facility in Vannes (France)
- Electronics facility in Haguenau (France)
- 100% Sigmaphi owned magnets facility in Beijing
- Sales branch in Tokyo (Japan)

Particle beamlines and components

From optics to installation and alignment

Magnets : from small to very large (resistive, SC, PM, AC)

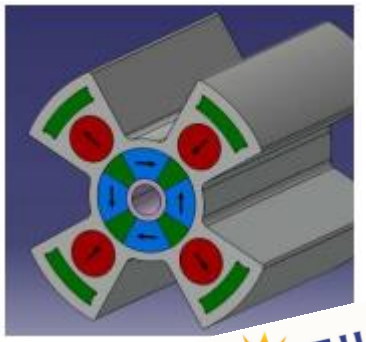
High stability power supplies

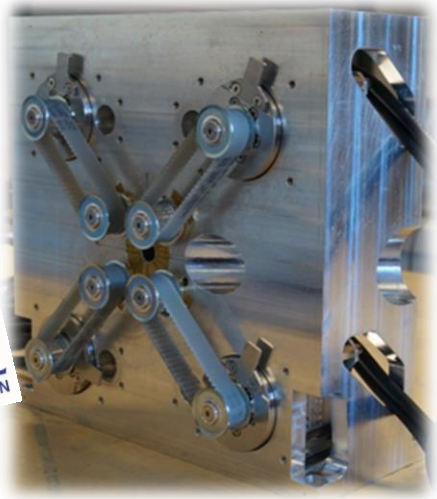
Vacuum

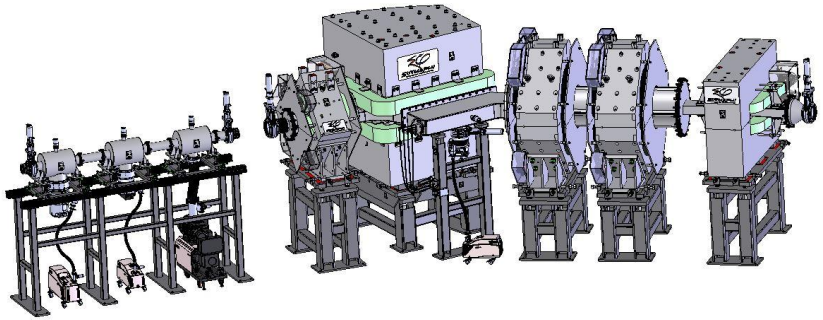
HV Decks

Diagnostics

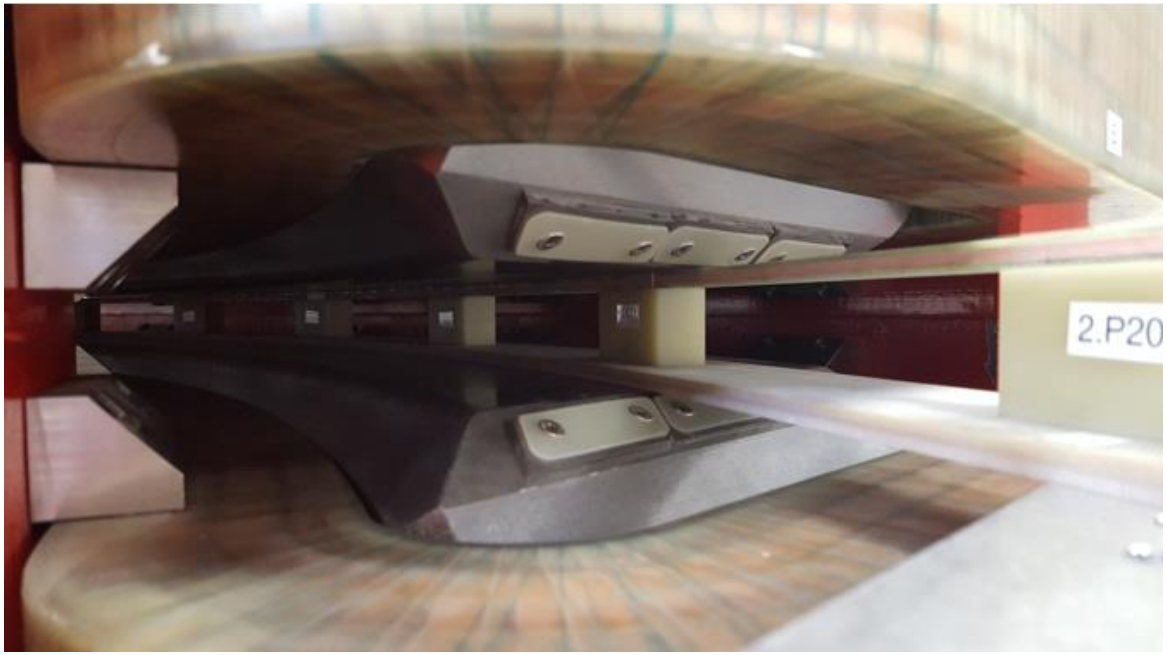
Installation





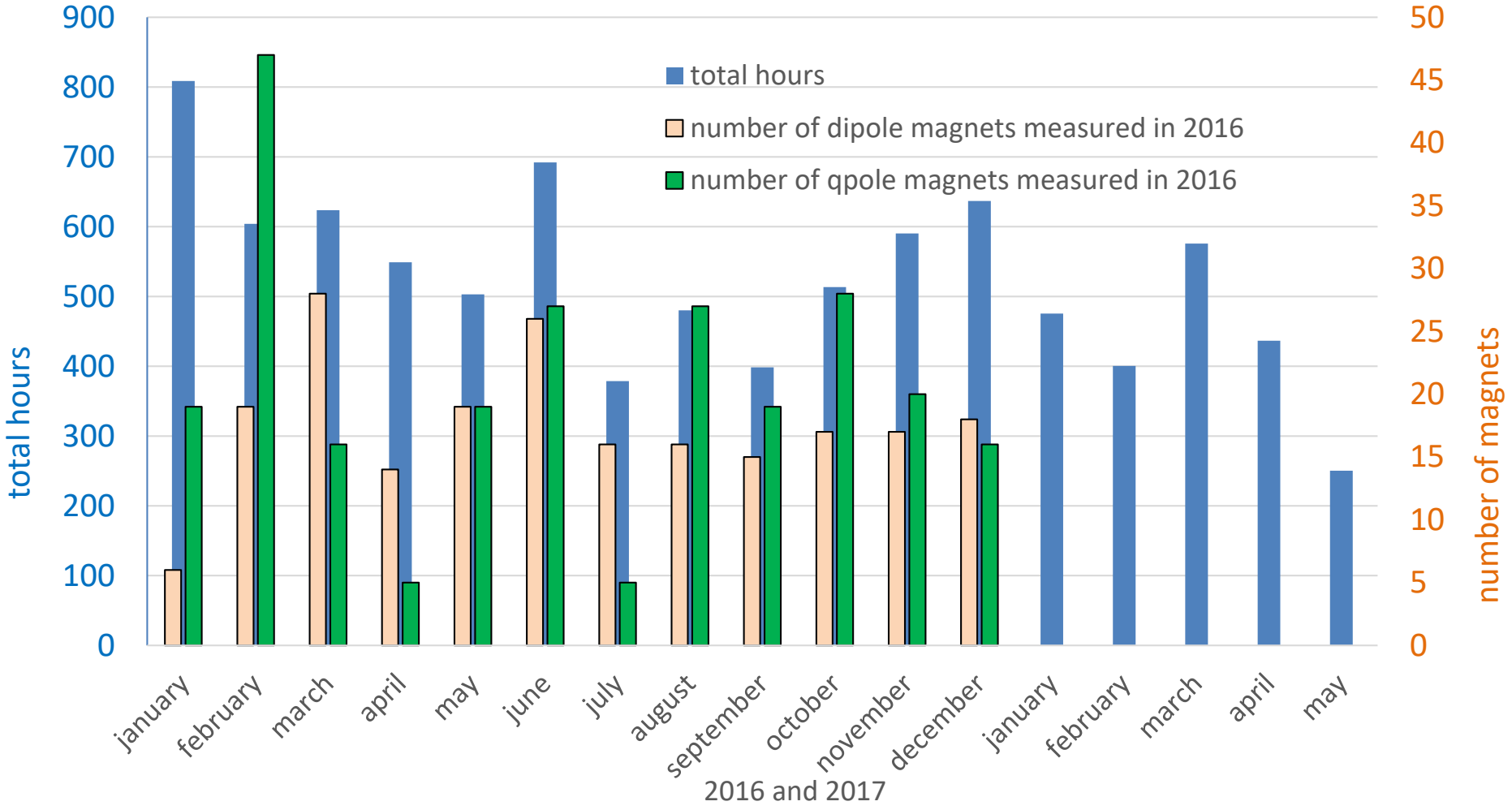


- 4 technicians, 1 engineer
- 2 harmonic benches (< 1 ton, < 6 tons)
- one Hall probe mapping system
- one specific Search coil bench for Fair dipole magnets
- one specific Search coil bench for Tsinghua dipole magnets



Measurement activities since IMMW19

459 magnets measured in 2016
→ 211 dipole, scanning and steering magnets
→ 248 quadrupole magnets

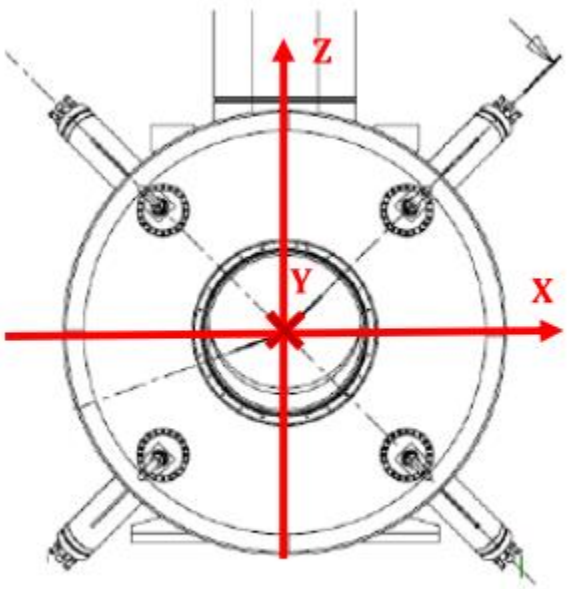


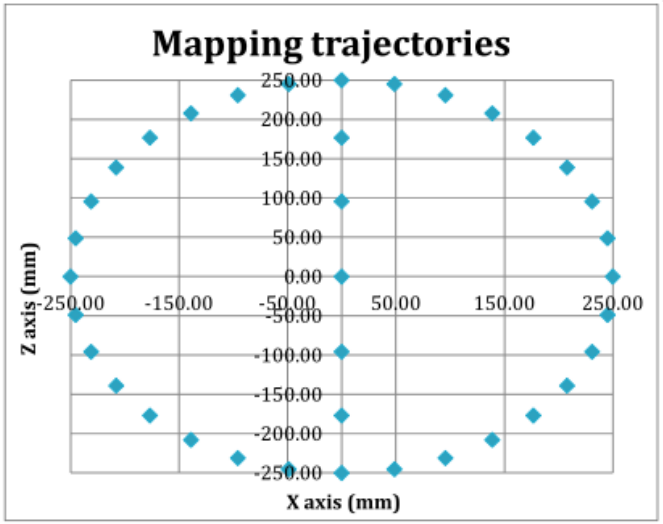
JLAB – SHMS dipole magnet

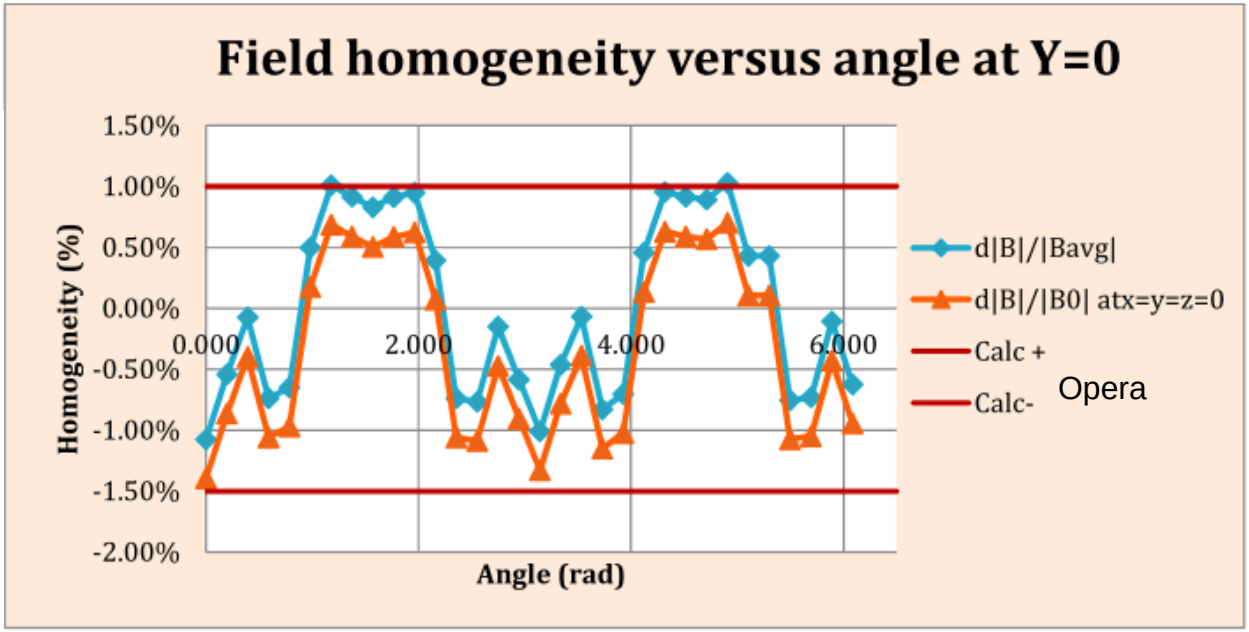
- arm length 2000 mm instead of 800mm
- optical alignment and indexation with laser tracker
- DC measurement @ 50A and ambient t°

Dipole field 503 Gauss @ 50A
Leff 2.77m
Dipole field orientation →

JLAB – SHMS dipole magnet

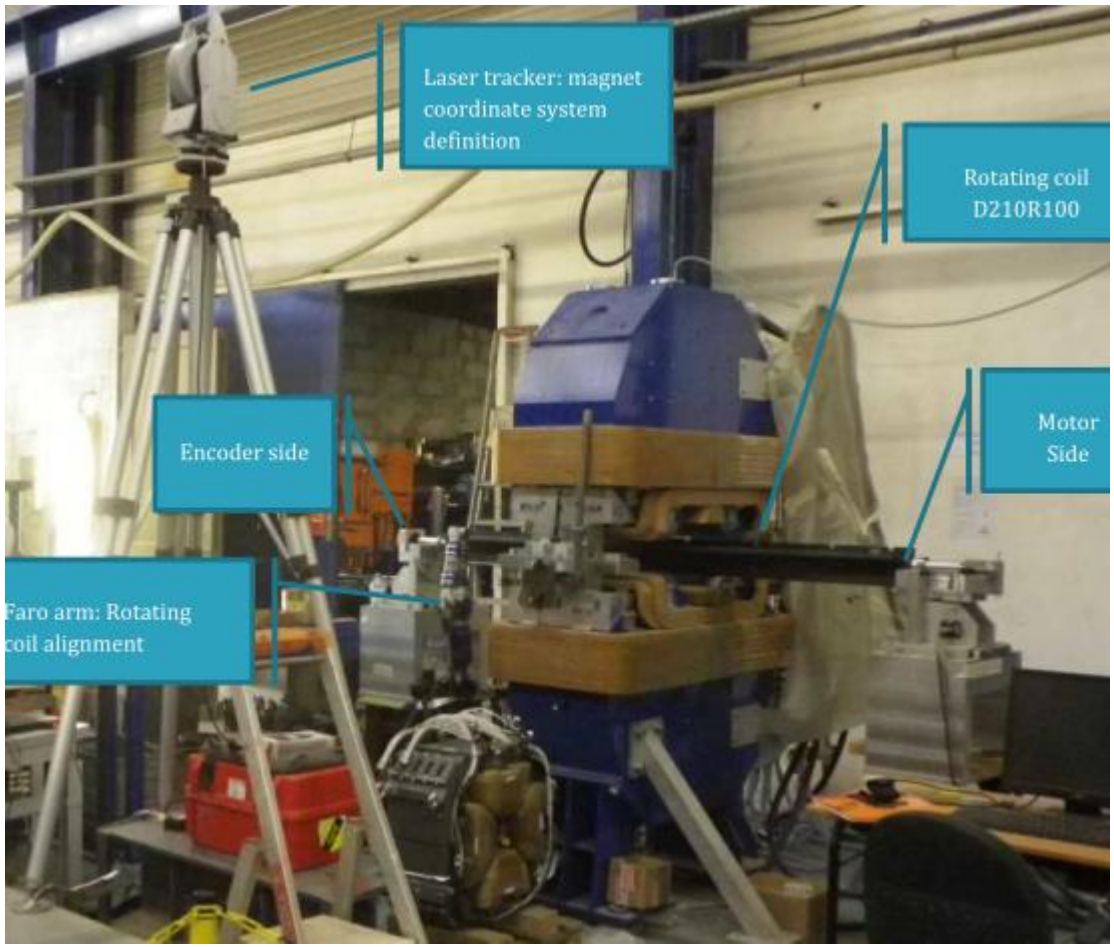


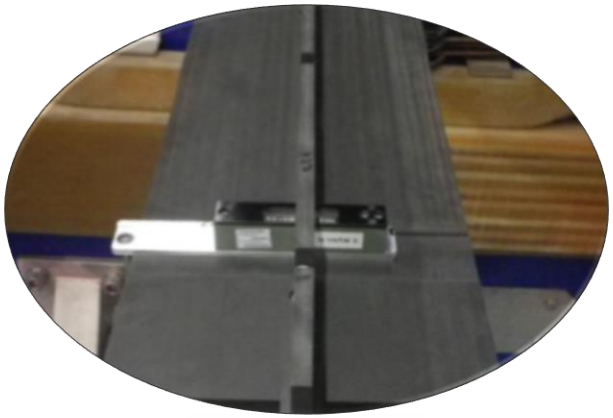


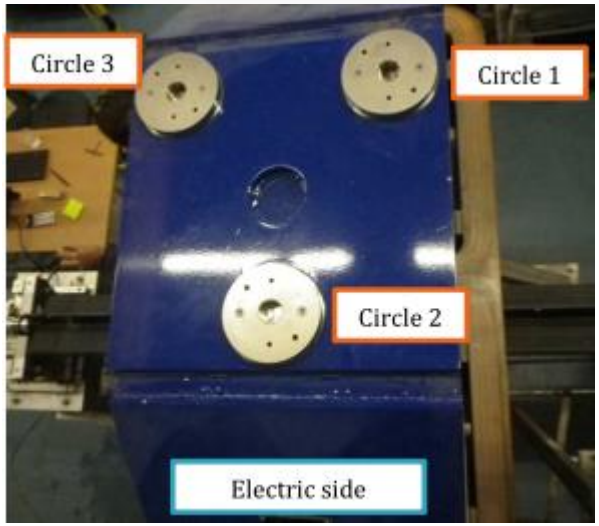


GANIL– S3 triplet

- laser tracker
- faro arm

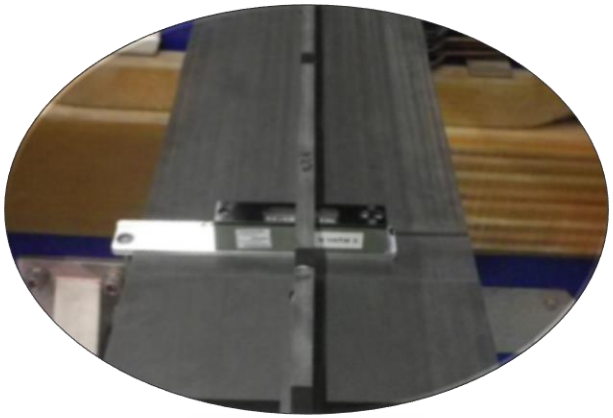




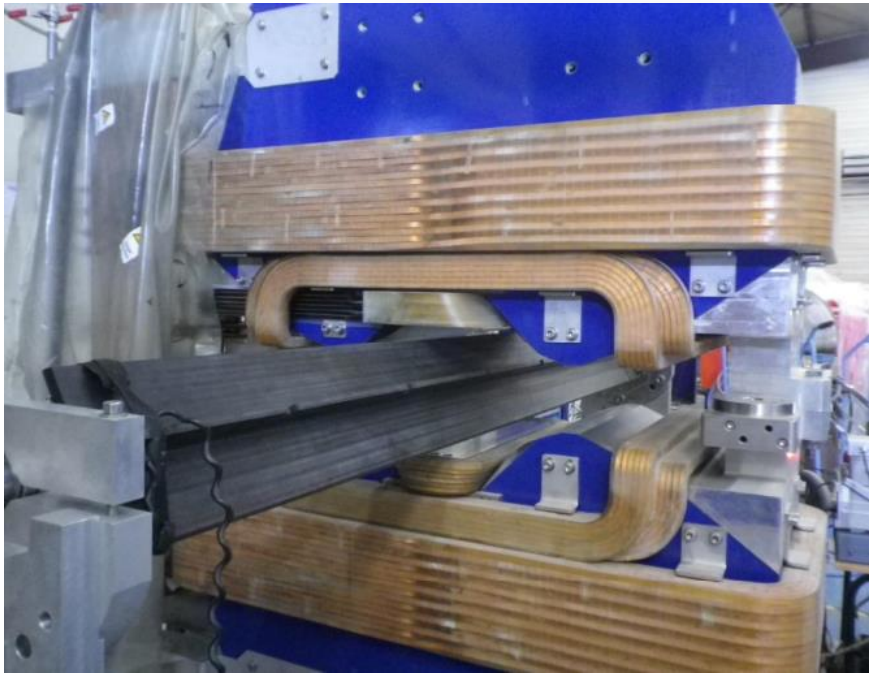


GANIL– S3 triplet

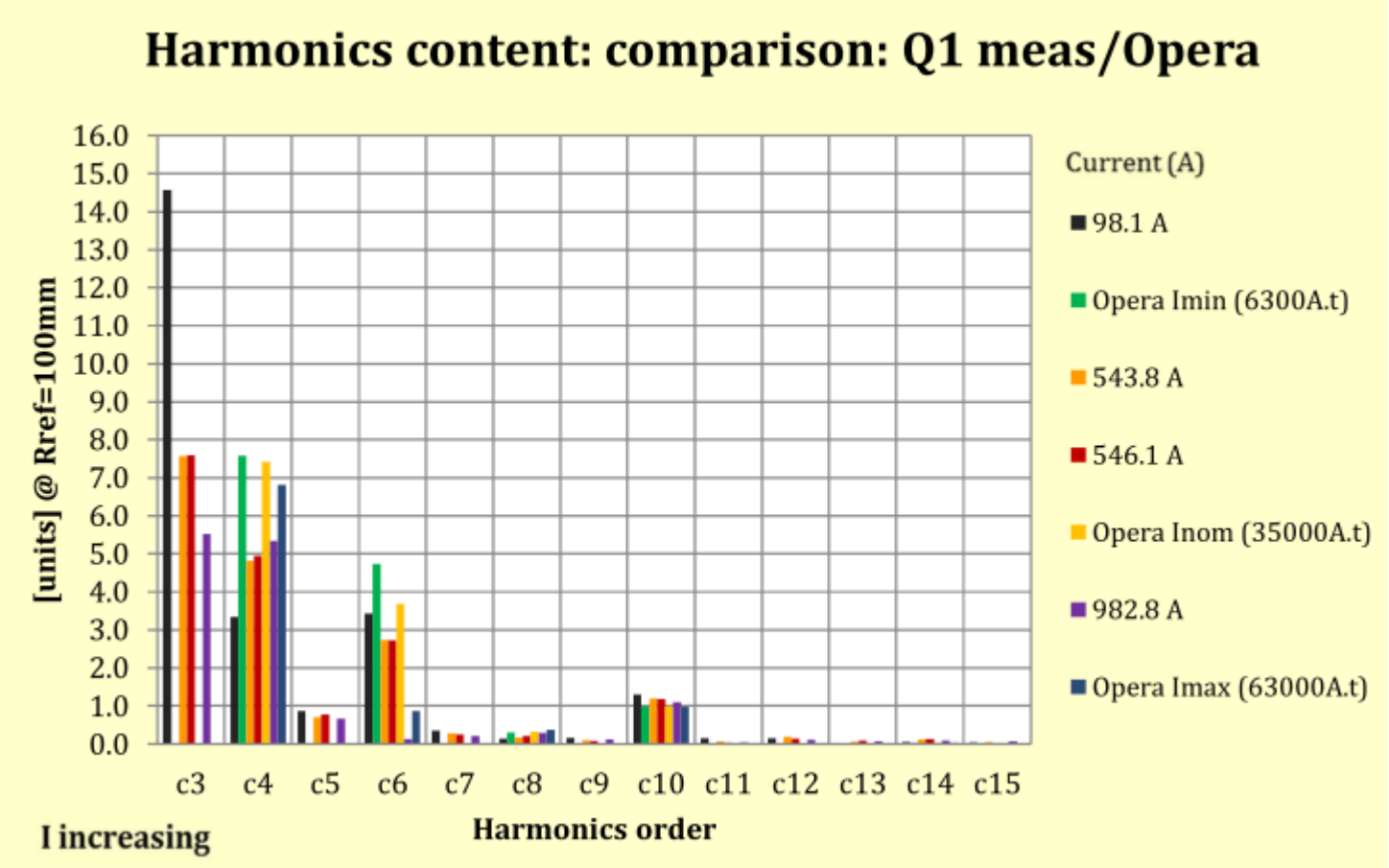
- rotating coil 2.5m (active length 2m), reference radius 100mm
- rotating coil calibration by comparison with a smaller rotation coil



Date	13/10/2015	19/10/2015	
Rotating coil	D98R46 FAIR COIL: Ref radius: 0.046m	D210R100 GANIL COIL: Ref radius: 0.046m (dx= 0.112 mm dy=0.218mm dθ=0.000166rad)	
I(A)	546.1	546.01	DELTA
Dx (mm):	-0.356	-0.369	-0.012
Dy (mm):	-0.004	-0.008	-0.004
Field direction (rad):	0.003	0.003	0.00004
Main field module (T.m) =	0.085	0.085	0.000
Gdl (T.m/m) =	1.852	1.856	0.005
Field direction (mrad):	3.424	3.469	0.045
Gl/I ((T.m/m)/A)	0.003	0.003	0.000
Sum Cn 3to15	2.015	2.733	0.718
C3	0.459	1.658	1.199
C4	1.204	0.911	-0.294
C6	0.143	0.120	-0.024
C10	0.015	0.003	-0.012
C14	0.027	0.000	-0.027

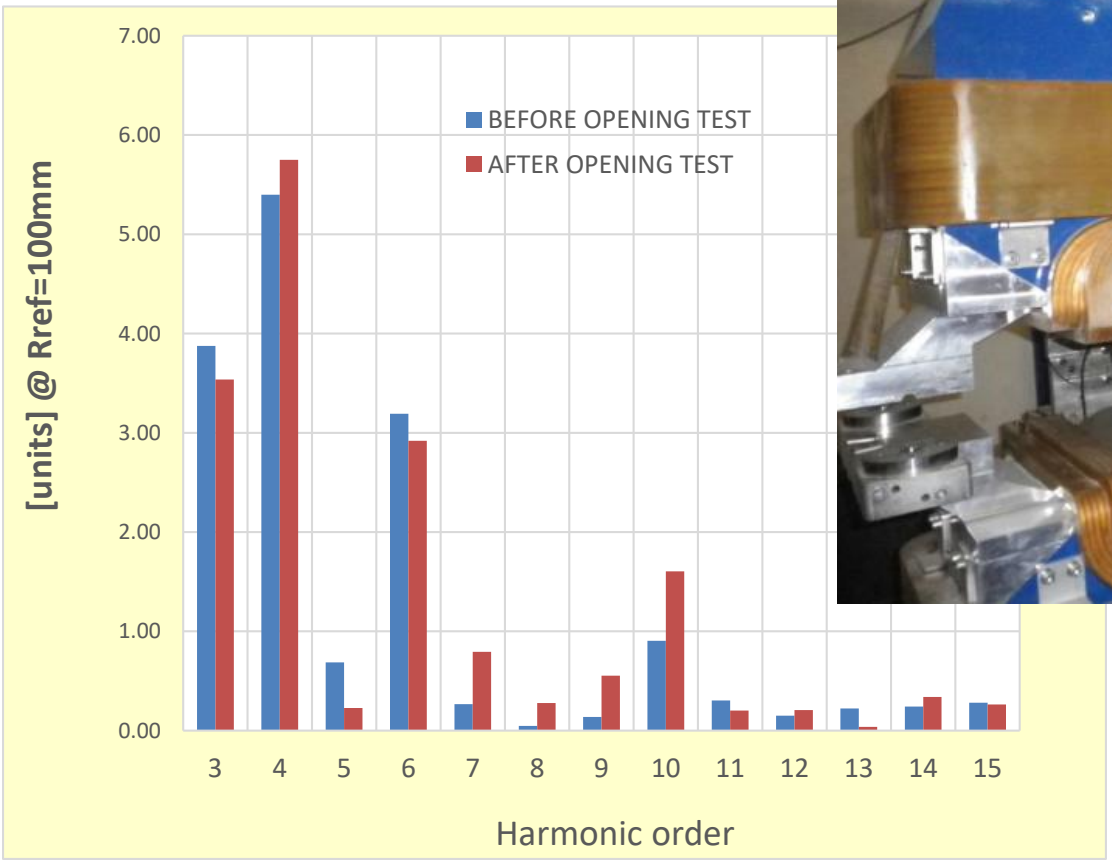


GANIL– S3 triplet comparison with OPERA



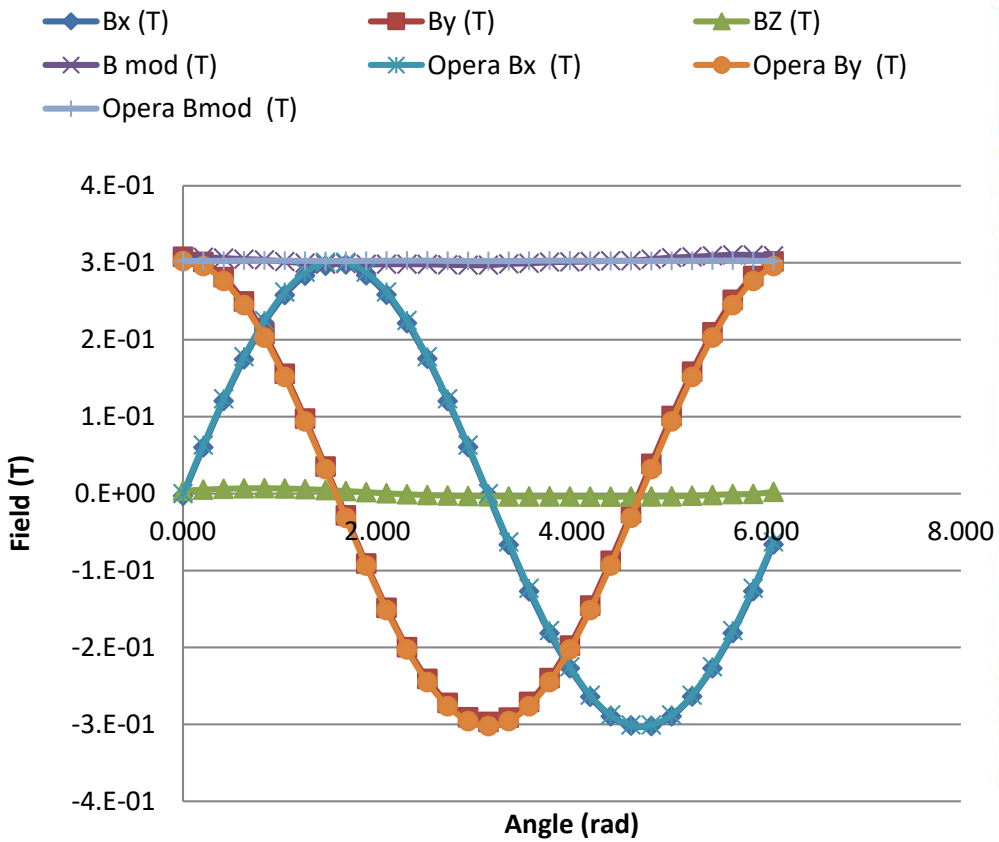
GANIL– S3 triplet
OPENING TEST

Harmonics content - comparison
Before/ After opening test @B1=546A



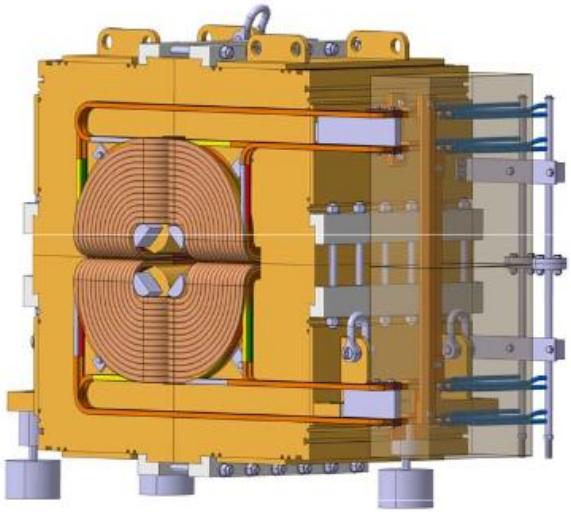
GANIL– S3 triplet
Hall probe

Hall probe measurement (3 axis Hall probe, trajectories along a circle for harmonic reconstruction)
Singulet measurements and doublet with cross field measurements



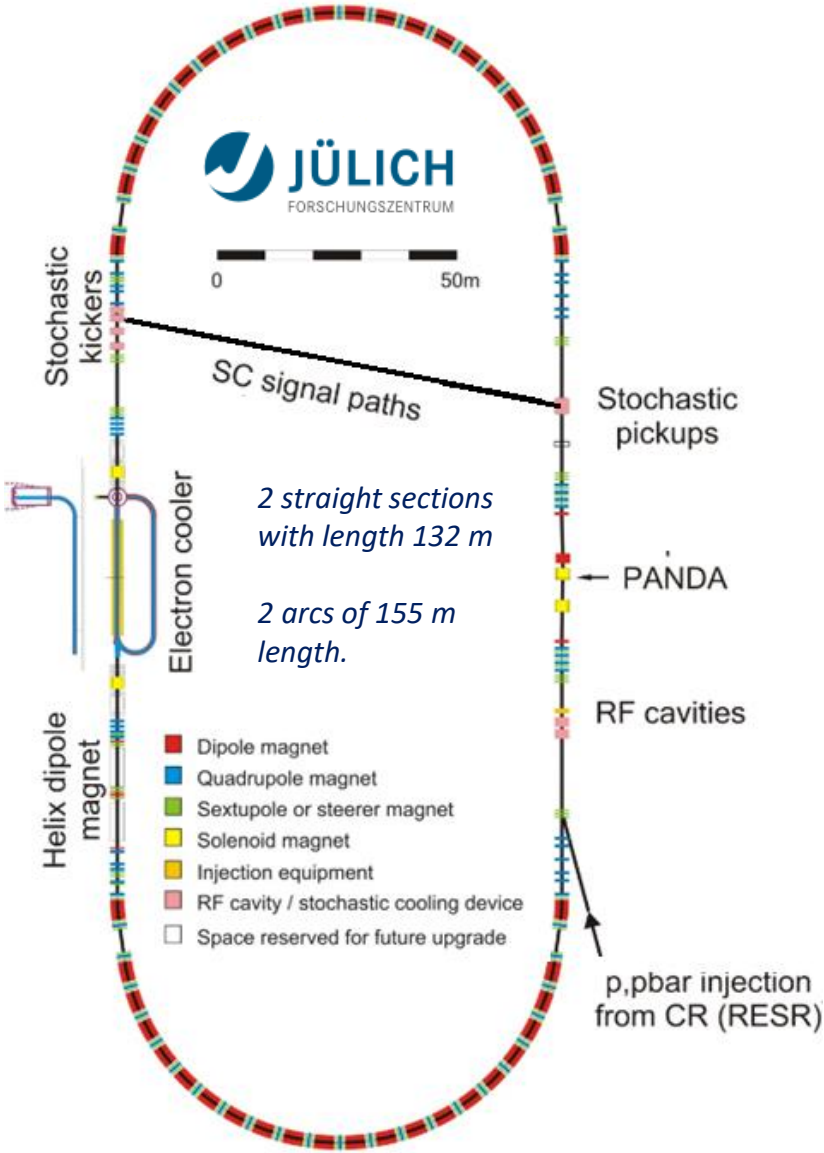
→ Max 60 Gauss between Opera and Meas

FAIR HESR / FZJ and Sigmaphi



84 quadrupole magnets

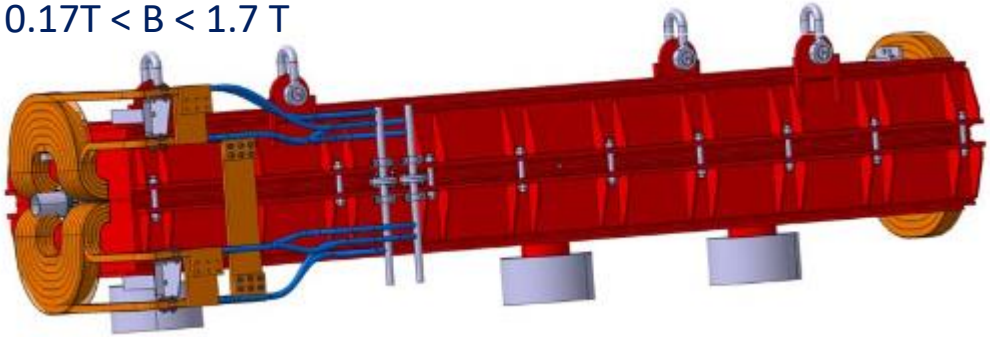
60 cm long, 5.2 t



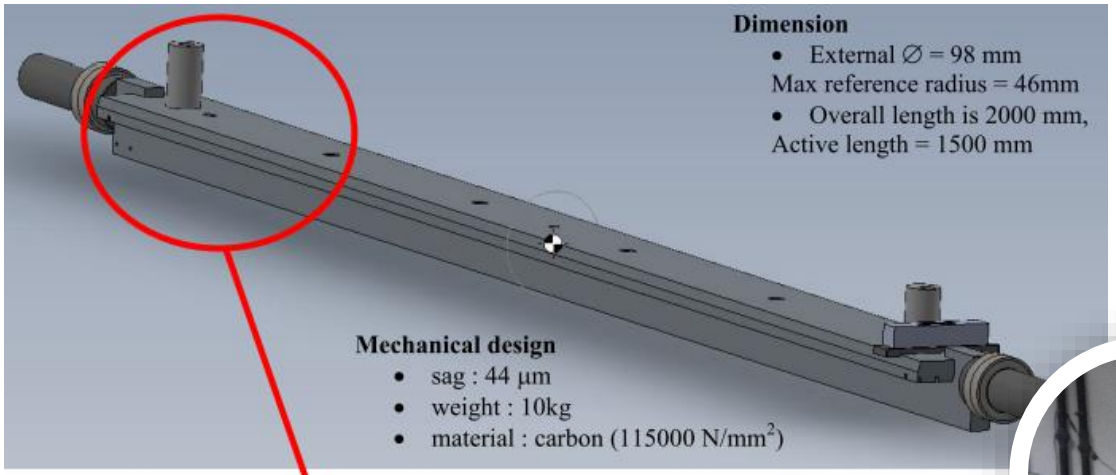
44 dipole magnets

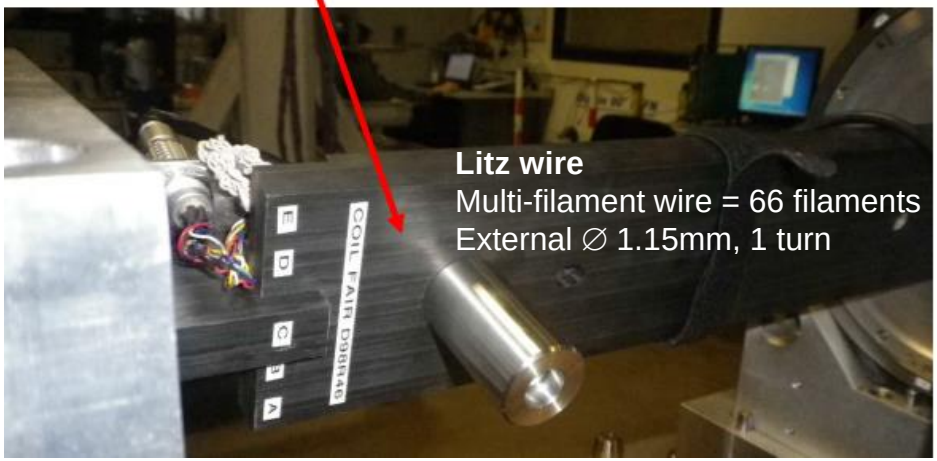
4.2 m long, 35 t

0.17T < B < 1.7 T

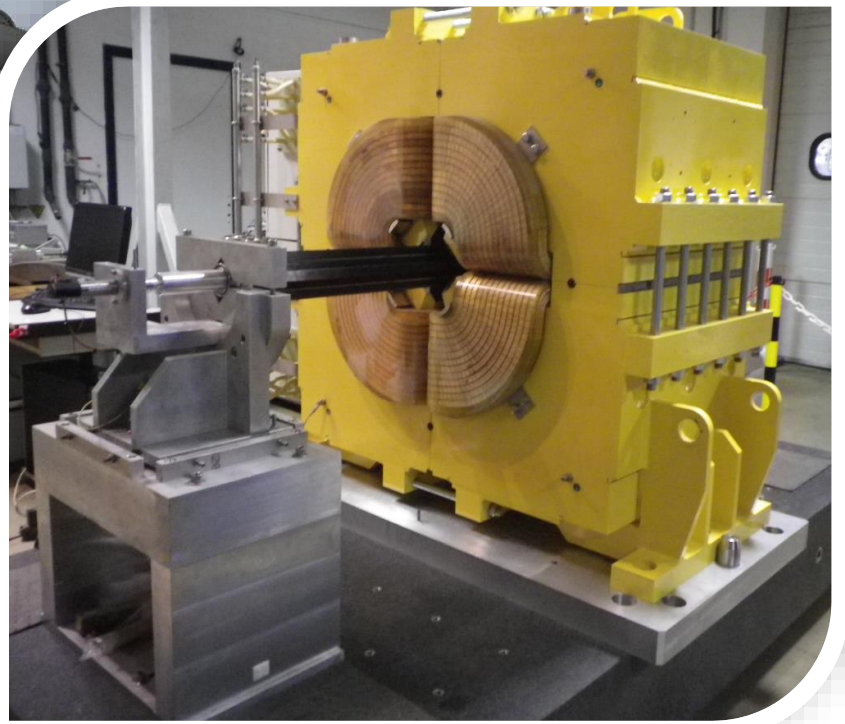


FAIR HESR quad measurements

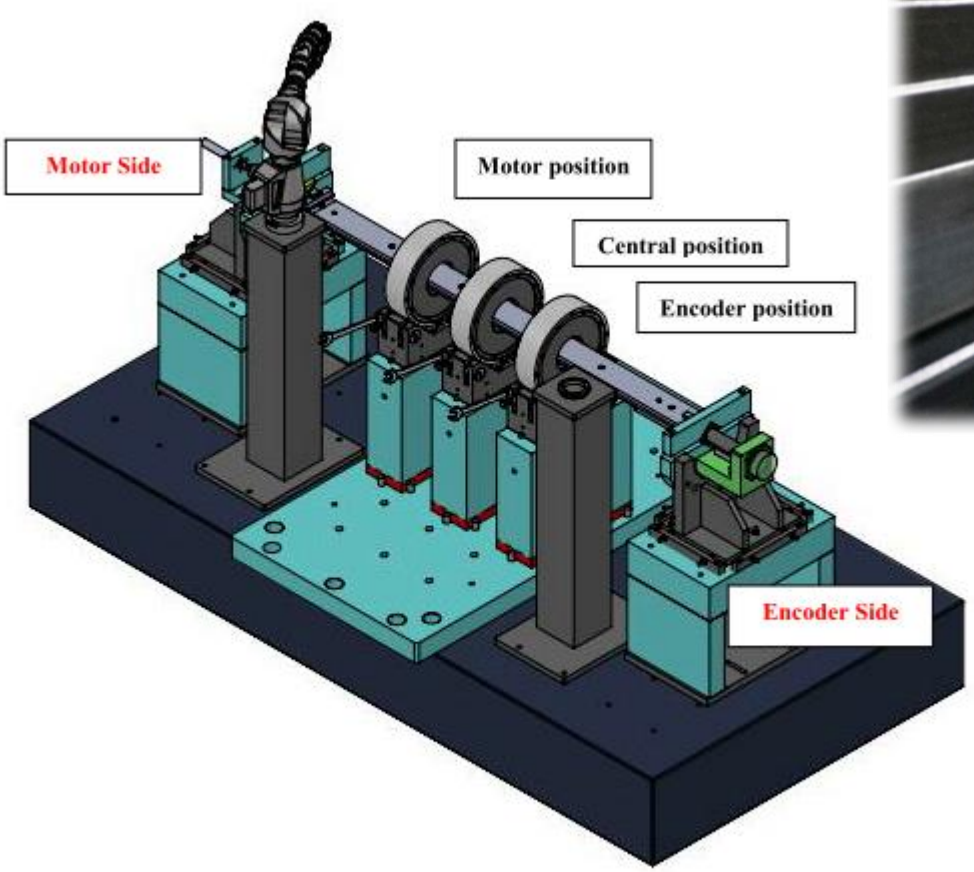


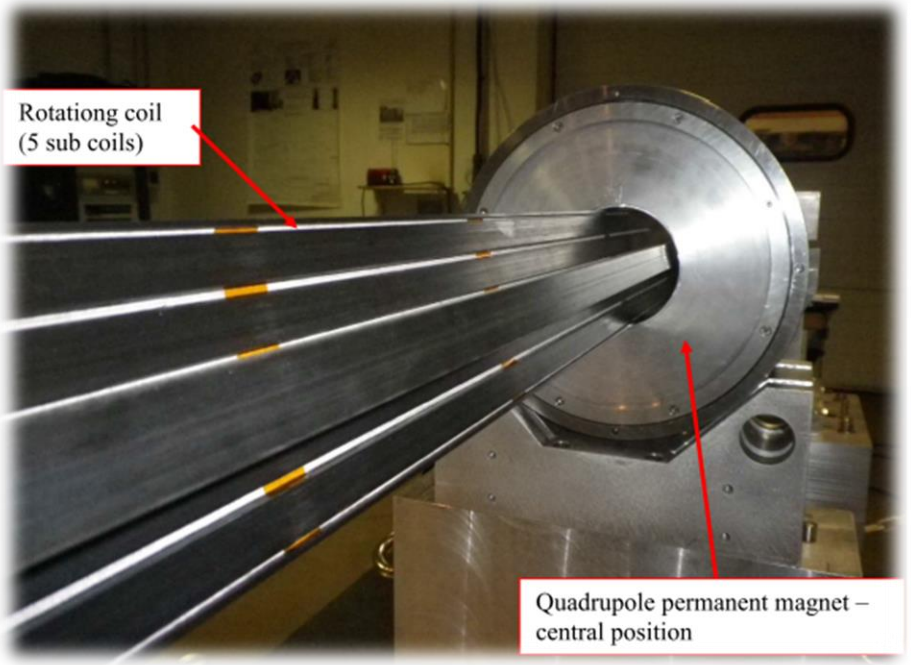


Rotating coil, Design and manufacture



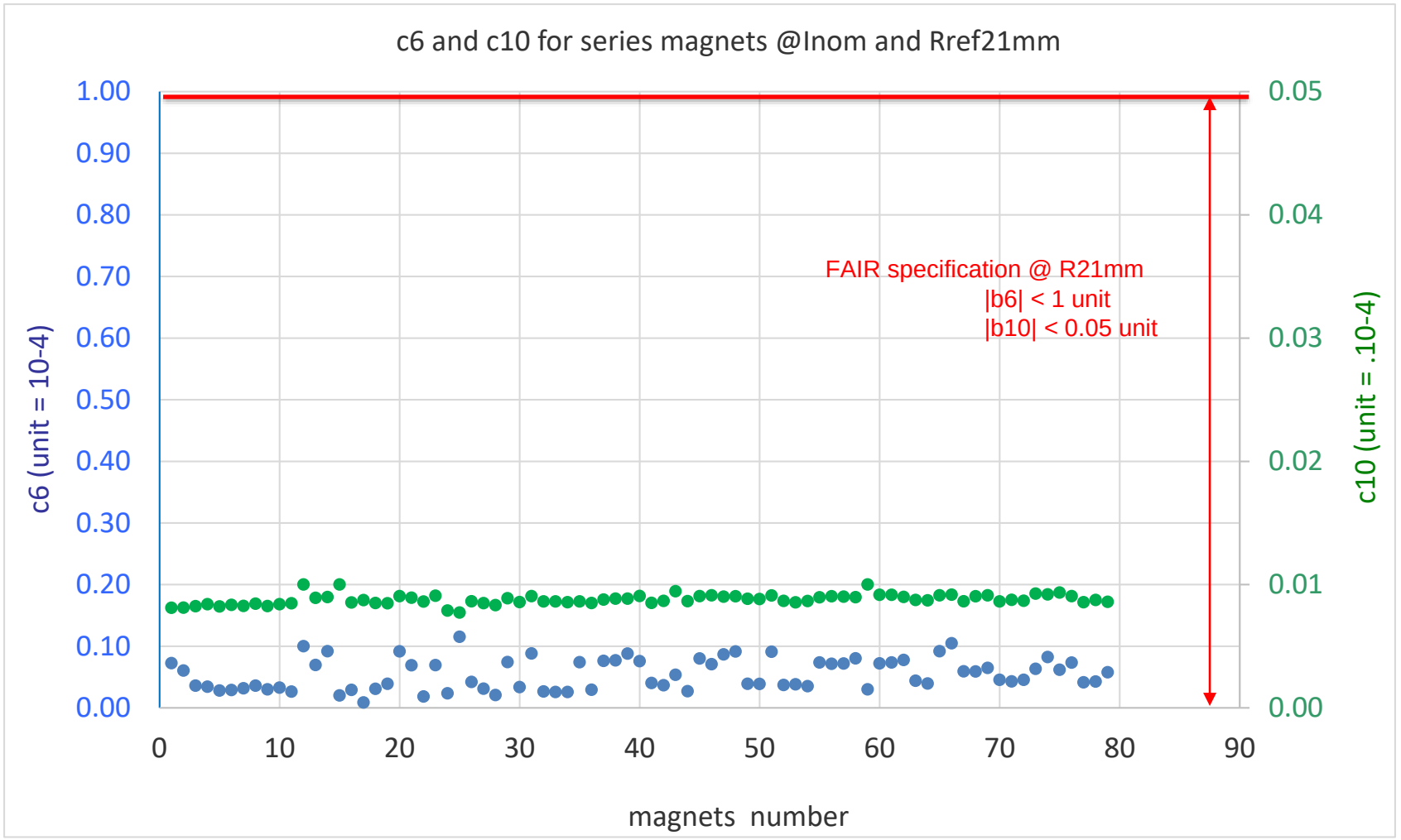
Rotating coil calibration with our quadrupole permanent magnet



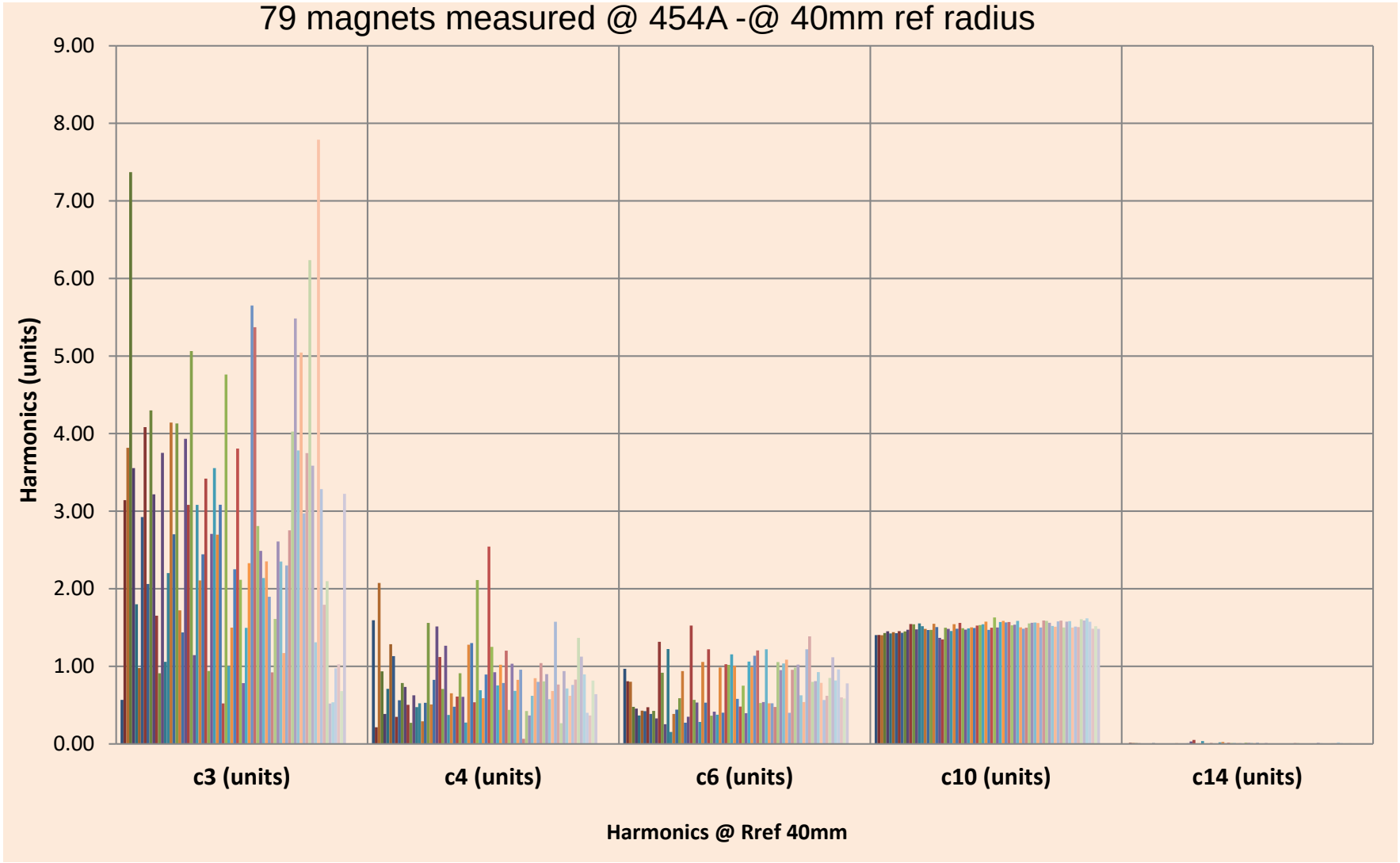


Parameters	Repeatability
Coil sensitivity Dx	22 μm (on 200 μm)
Coil sensitivity Dy	10 μm (on 85 μm)
Horizontality 10 level measurements	0.026 mrad
10 successives measurements	Δdx < 1 μm Δdy < 1 μm ΔdΘ < 0.03 mrad

Series measurement results



Series measurement results

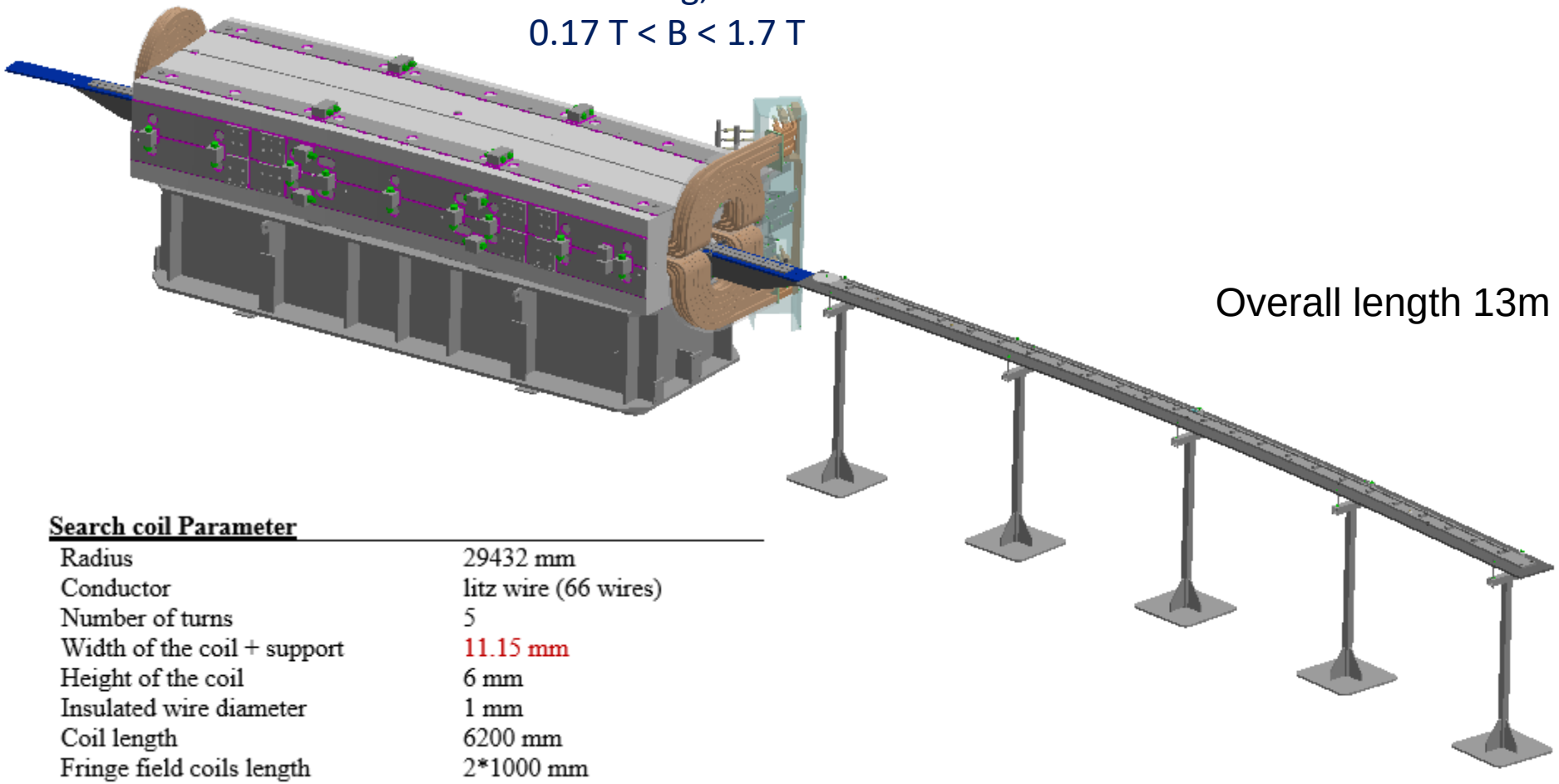


FAIR dipole – search coil bench

HESR FAIR dipole

4.2 m long, 35 t

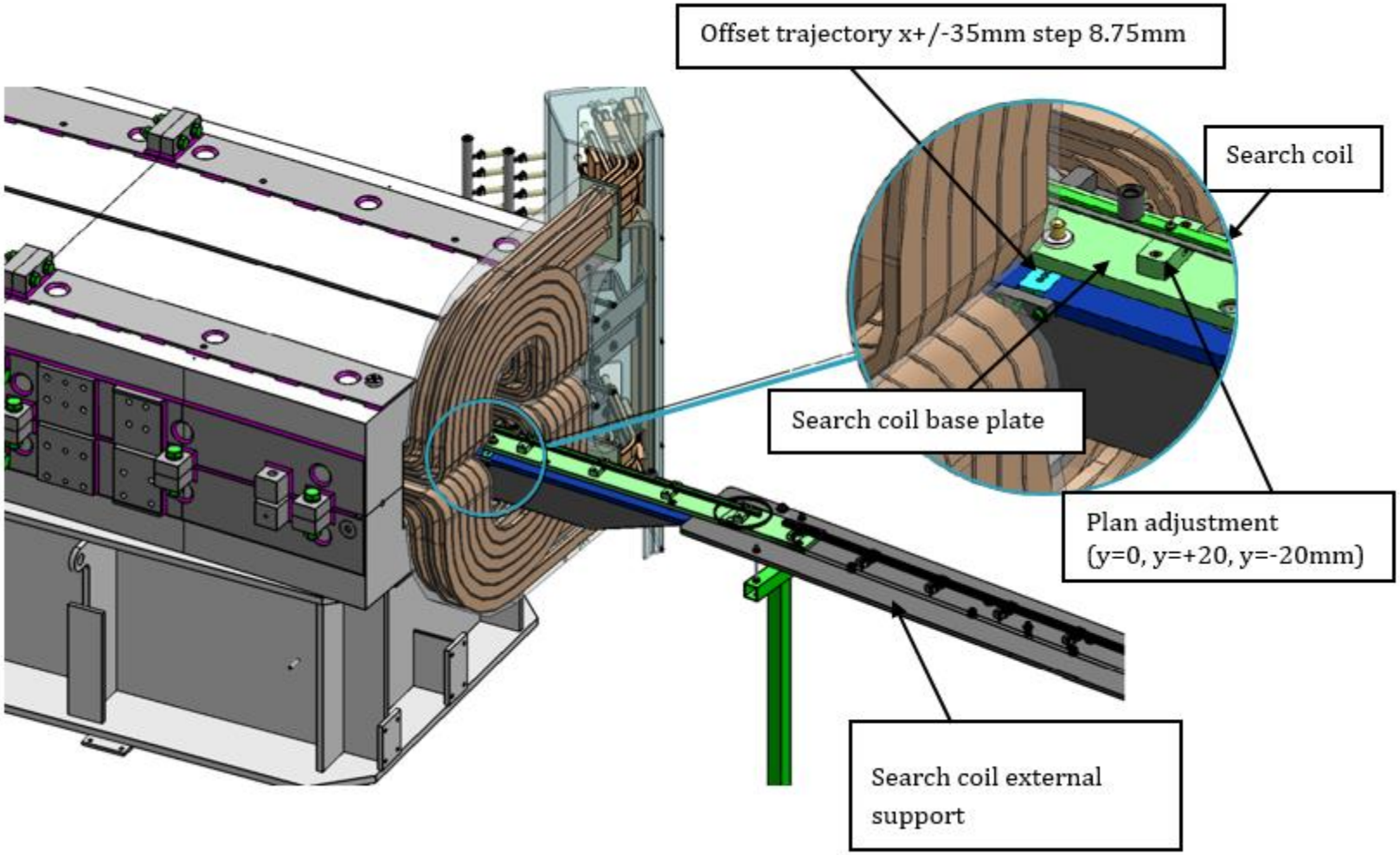
0.17 T < B < 1.7 T



Overall length 13m

Search coil Parameter	
Radius	29432 mm
Conductor	litz wire (66 wires)
Number of turns	5
Width of the coil + support	11.15 mm
Height of the coil	6 mm
Insulated wire diameter	1 mm
Coil length	6200 mm
Fringe field coils length	2*1000 mm
Substrate material	GP03

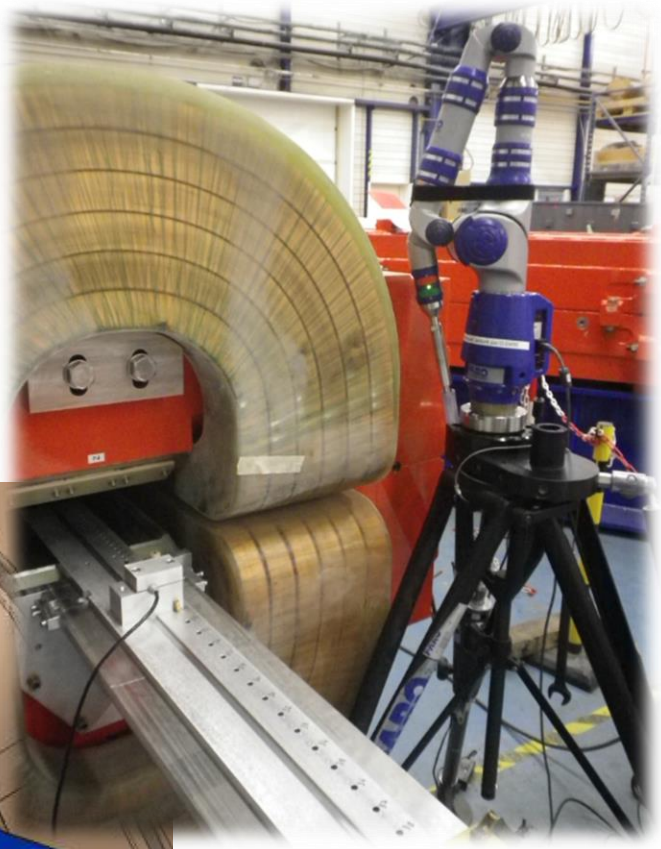
FAIR dipole – search coil bench

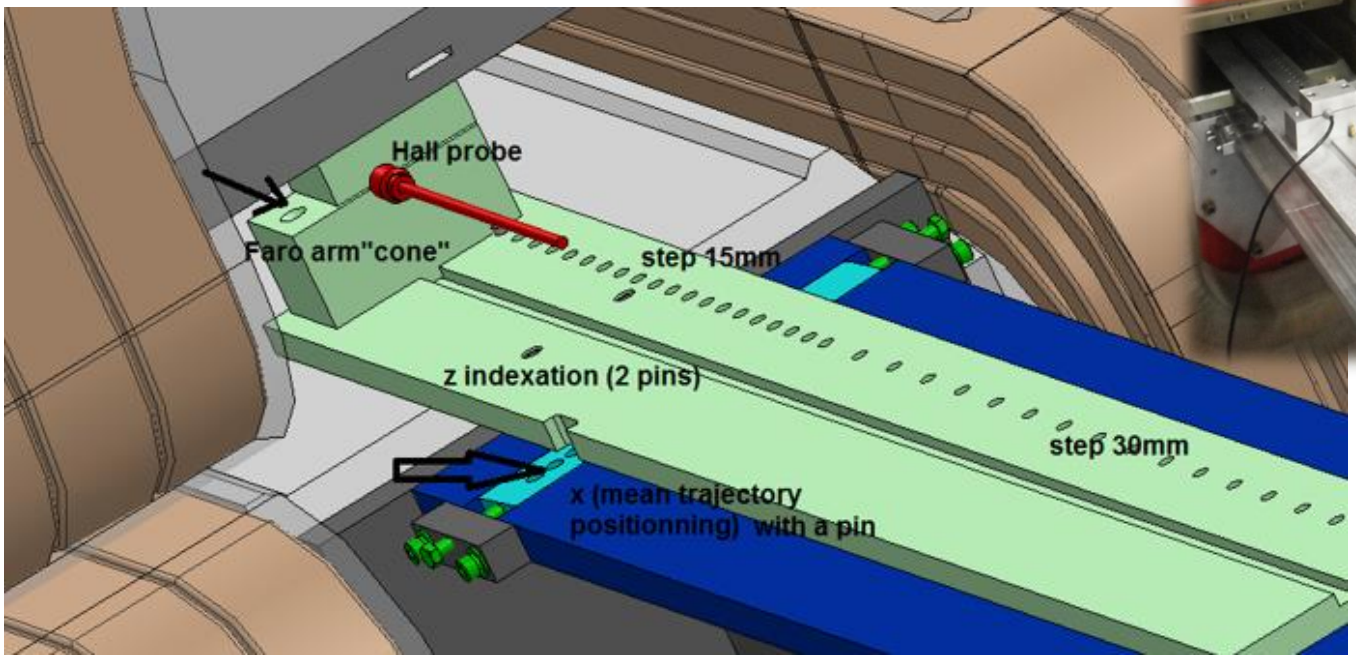


Fringe field measure with Hall probe

specific tool for the fringe field measurement

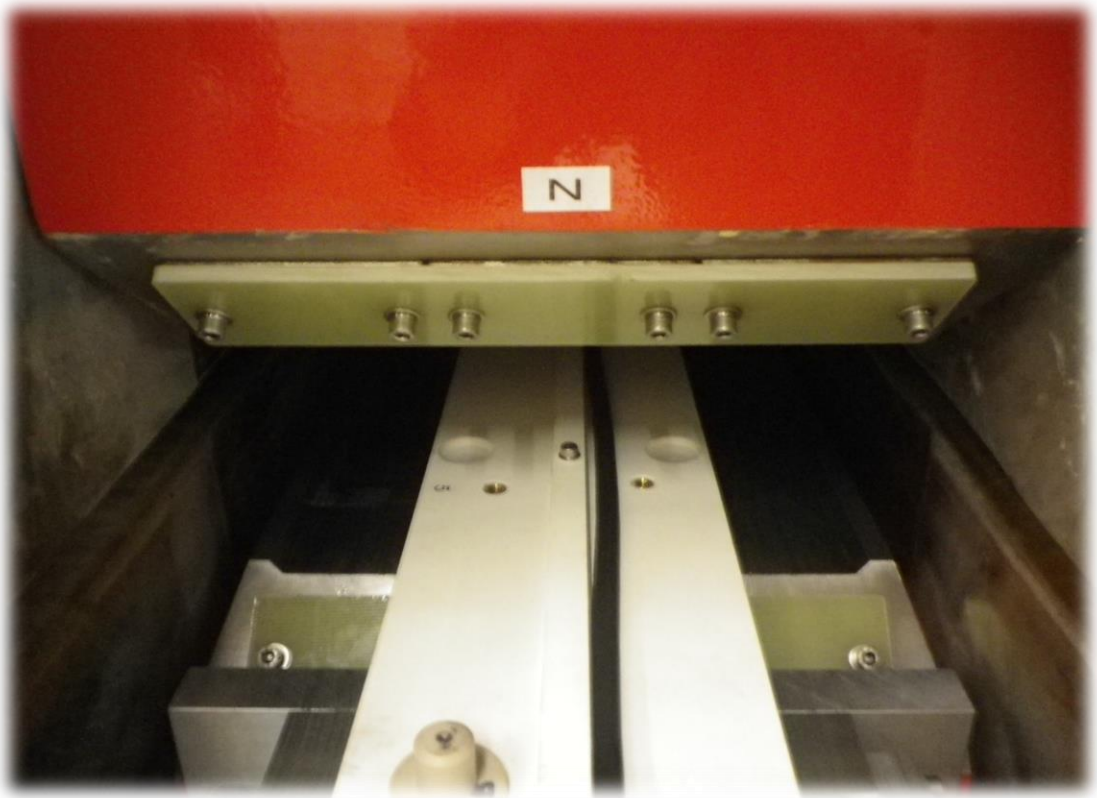
~~Faro arm~~ → laser tracker

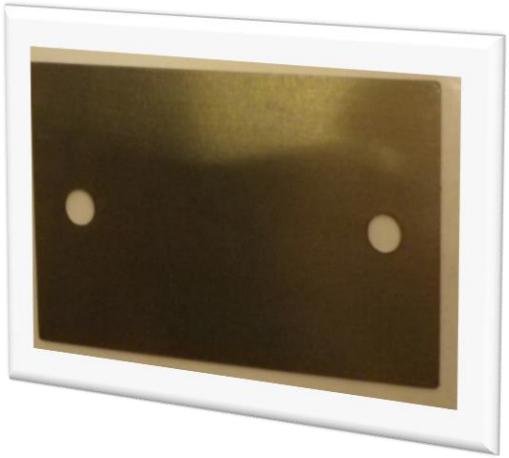




Repeatability
ΔLeff = 0.25mm

Magnets identity

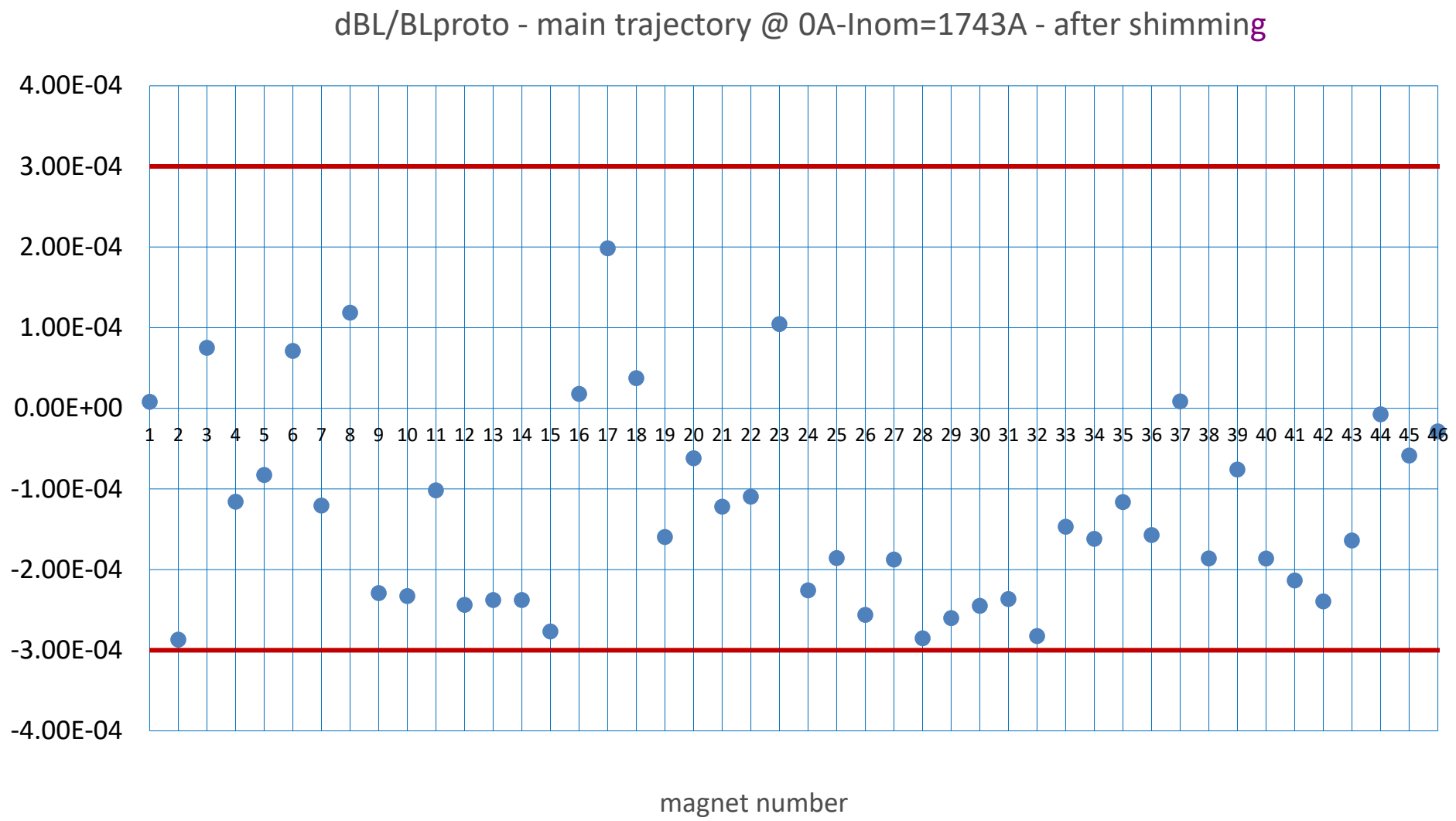




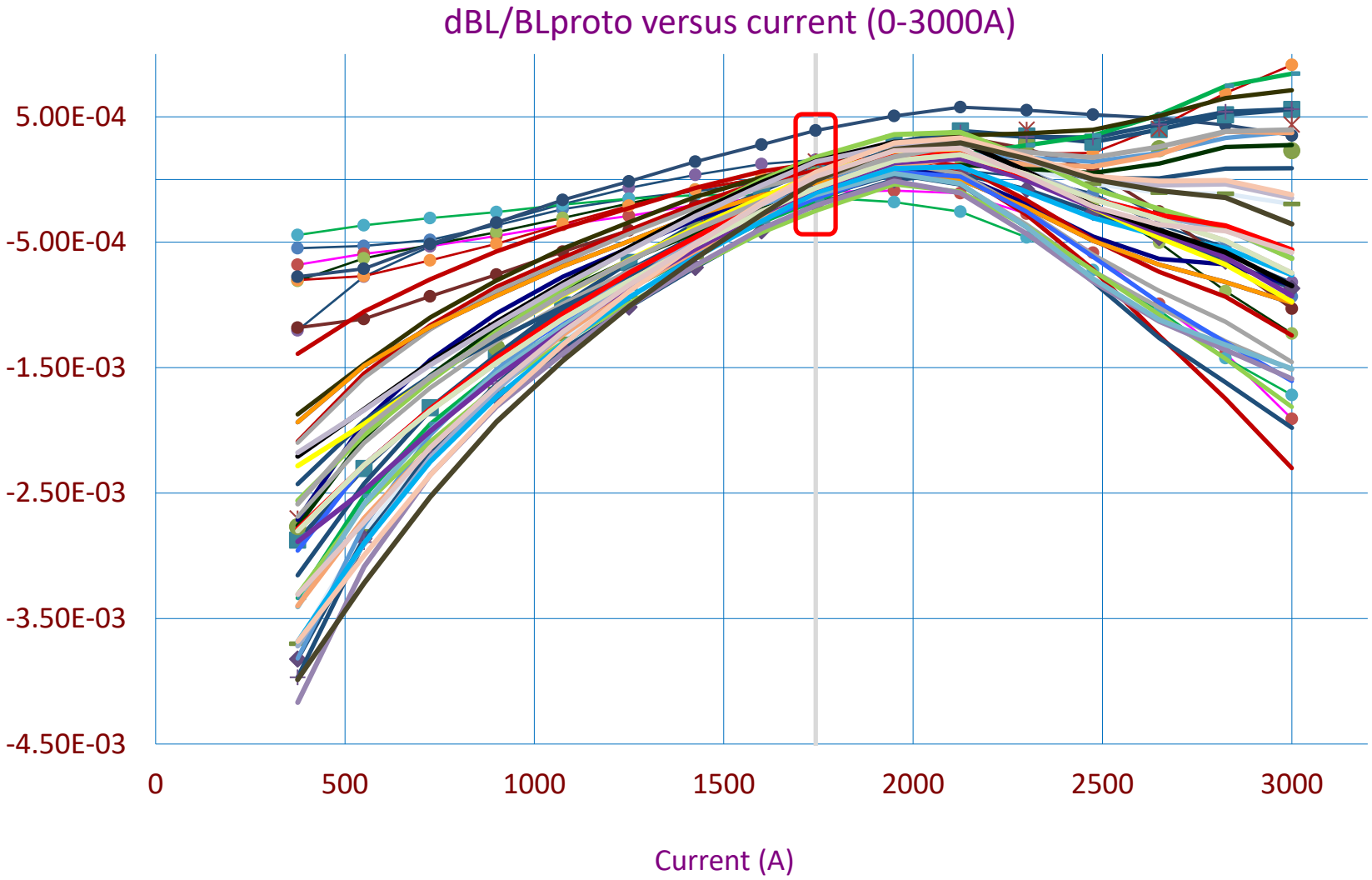
Shim, 0.35mm thickness

On each side

SERIES measurement results



SERIES measurement results



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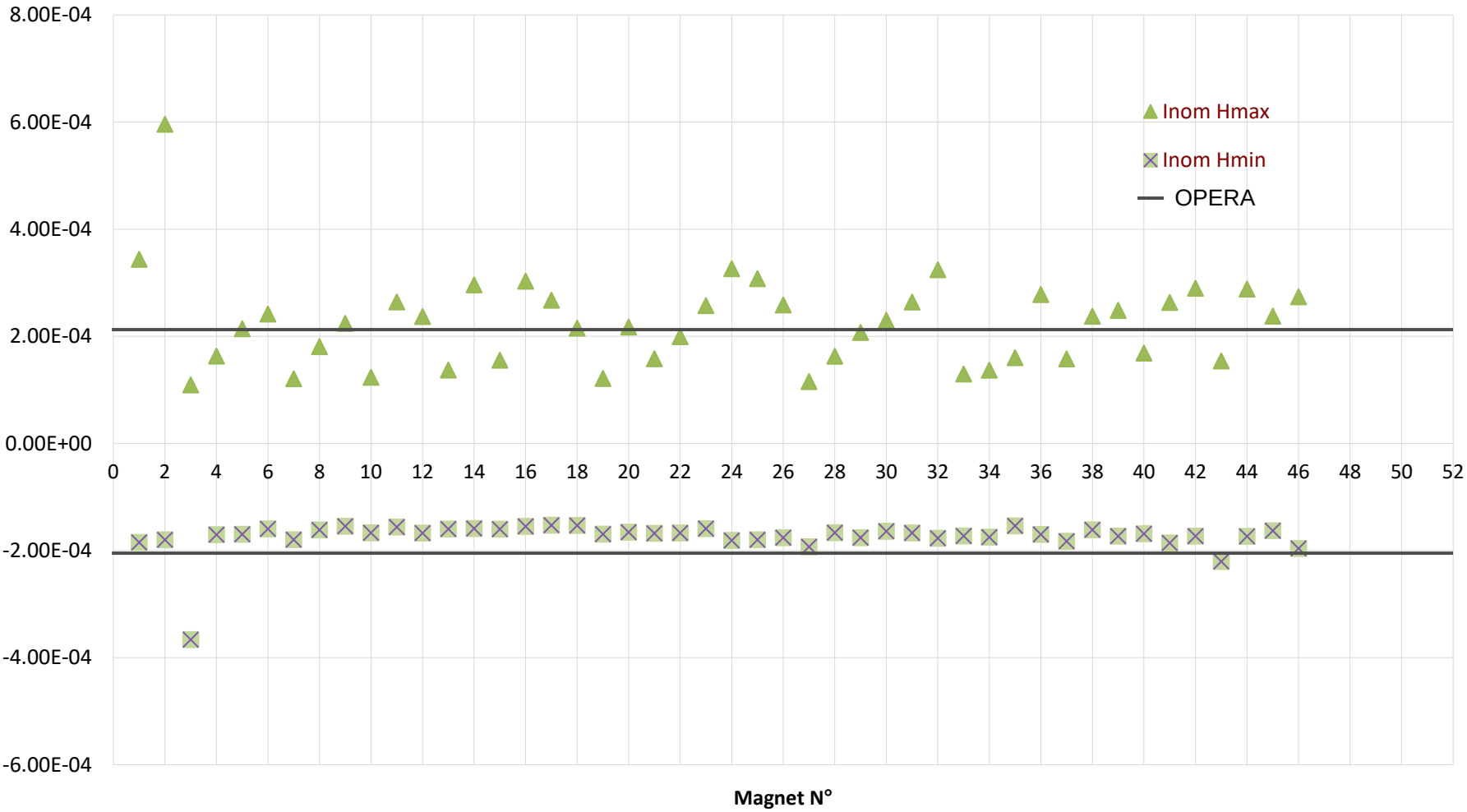
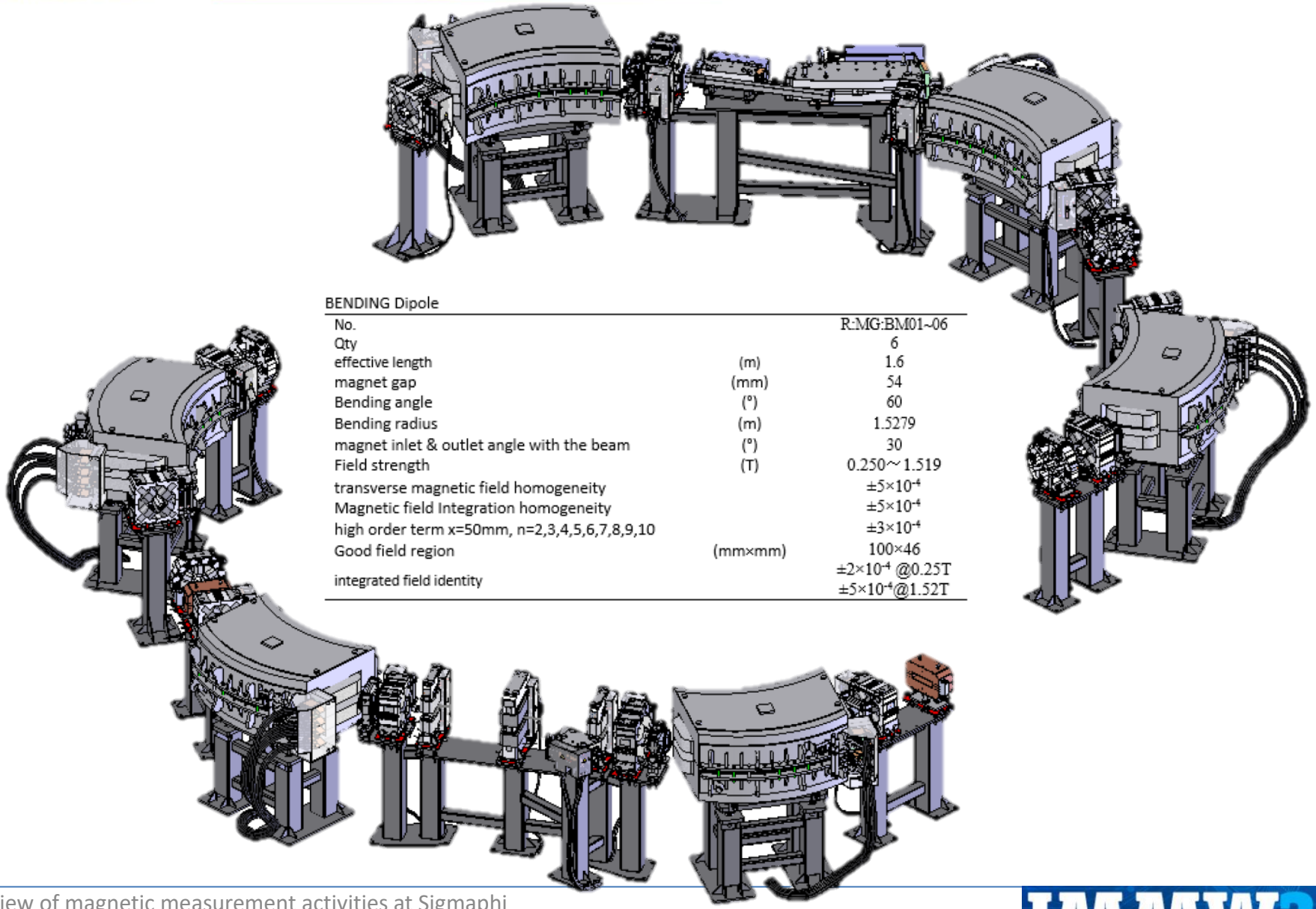


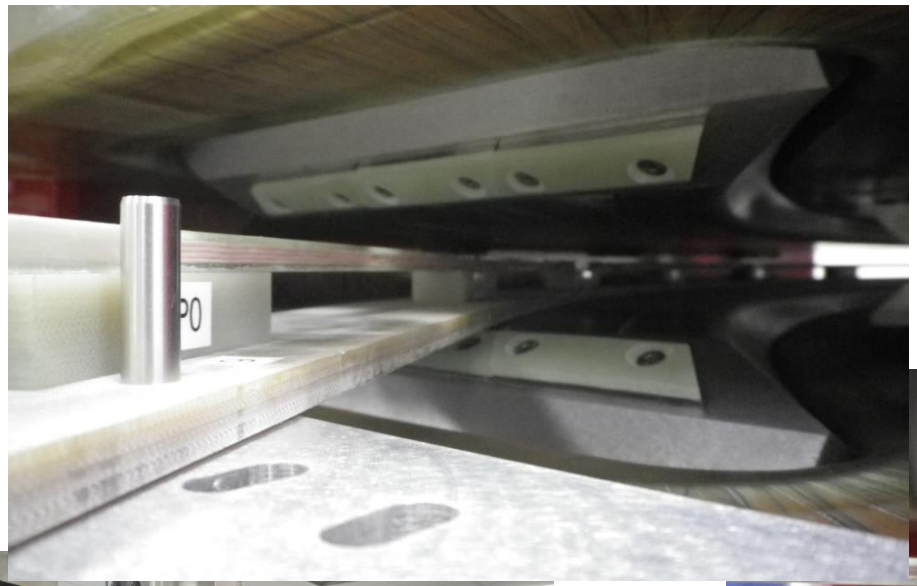
Coming soon… Tsinghua measurements

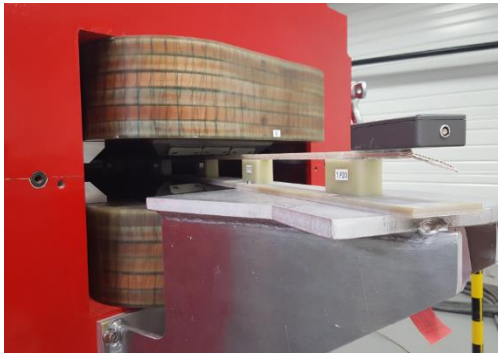


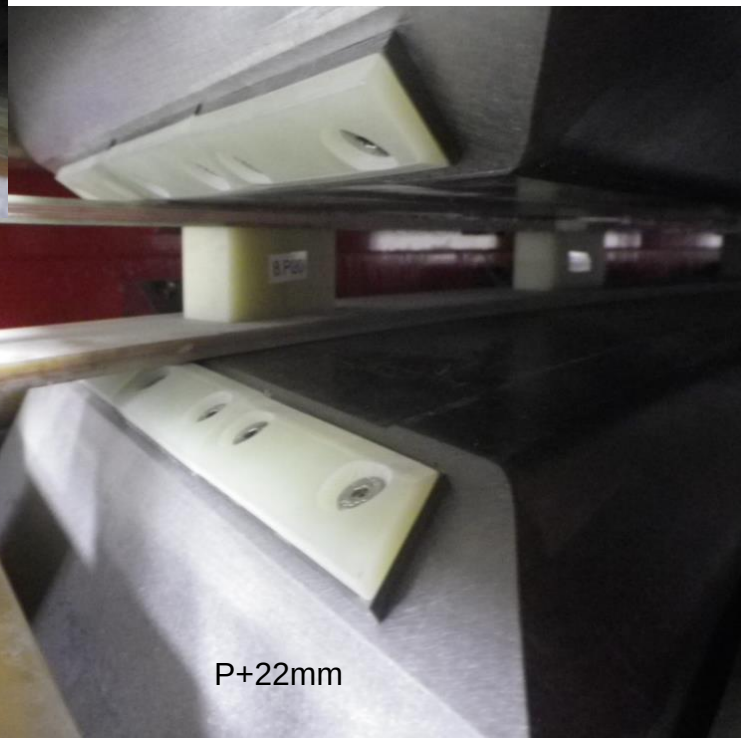
BENDING Dipole

No.		R:MG:BM01~06
Qty		6
effective length	(m)	1.6
magnet gap	(mm)	54
Bending angle	(°)	60
Bending radius	(m)	1.5279
magnet inlet & outlet angle with the beam	(°)	30
Field strength	(T)	0.250～1.519
transverse magnetic field homogeneity		$\pm5\times10^{-4}$
Magnetic field Integration homogeneity		$\pm5\times10^{-4}$
high order term x=50mm, n=2,3,4,5,6,7,8,9,10		$\pm3\times10^{-4}$
Good field region	(mm×mm)	100×46
integrated field identity		$\pm2\times10^{-4}$ @0.25T $\pm5\times10^{-4}$@1.52T

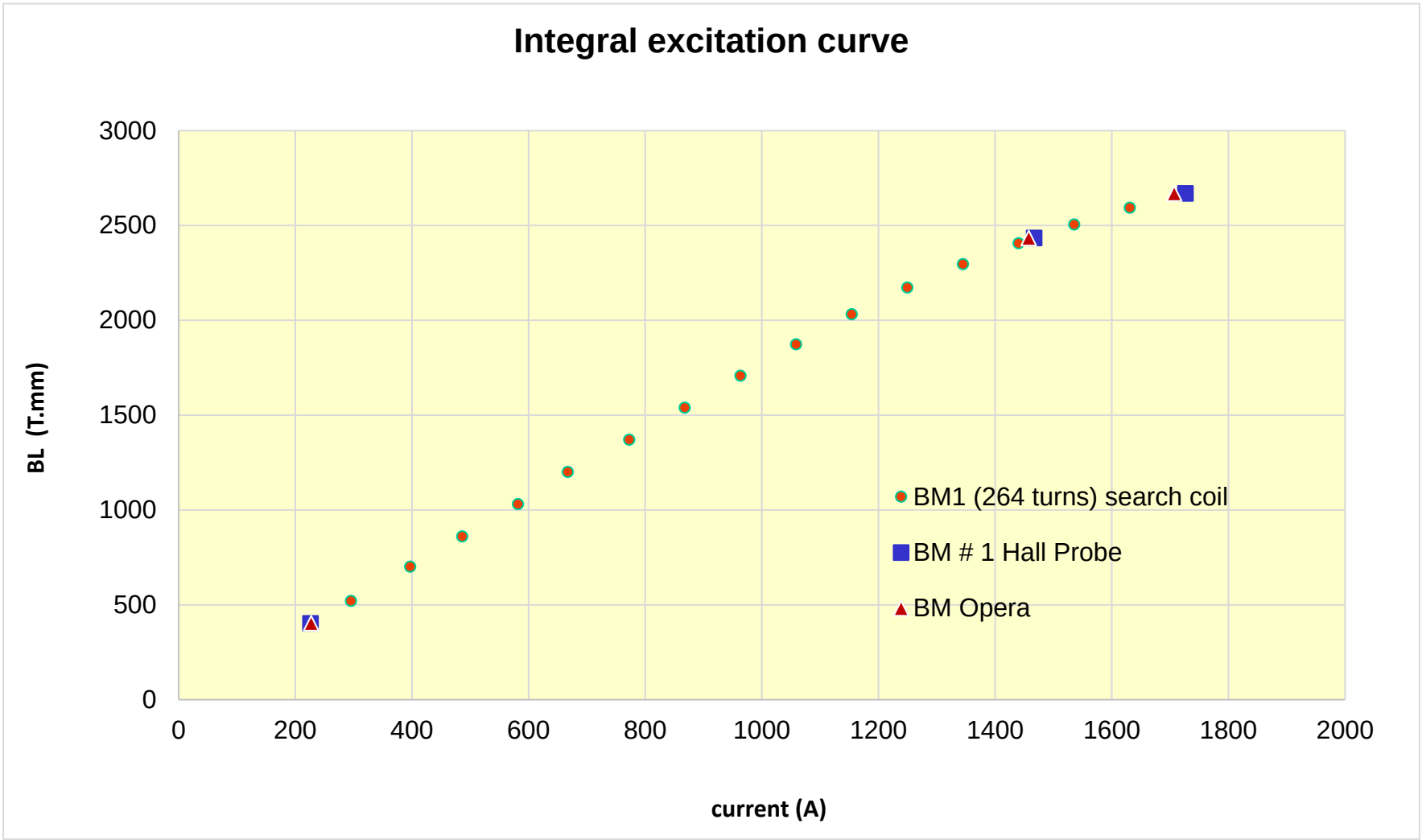
Tsinghua measurements measurement setup



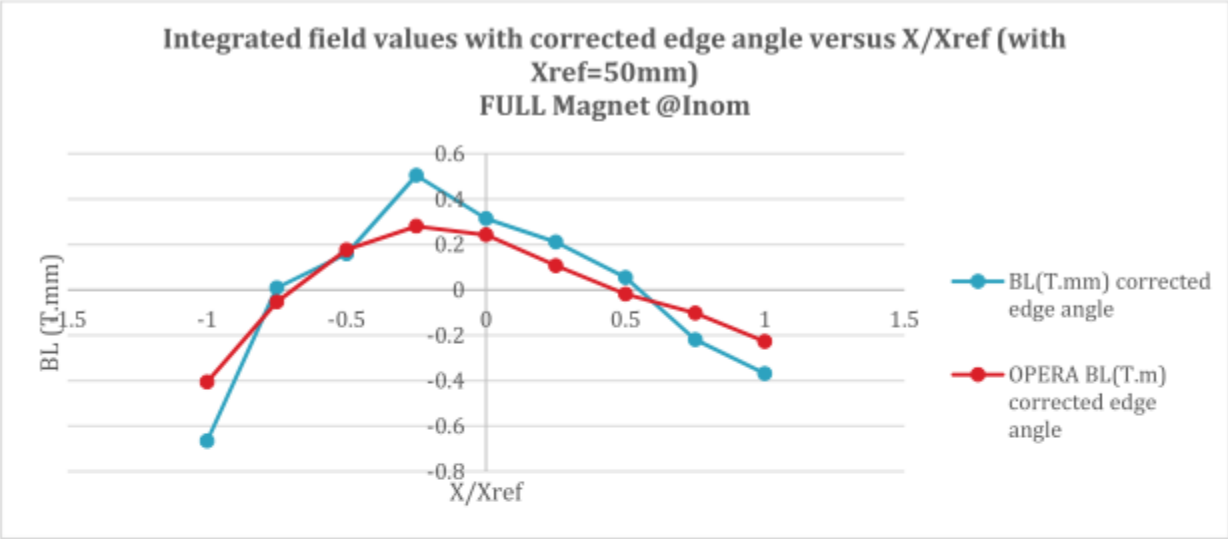




Tsinghua measurements
Prototype measurement results

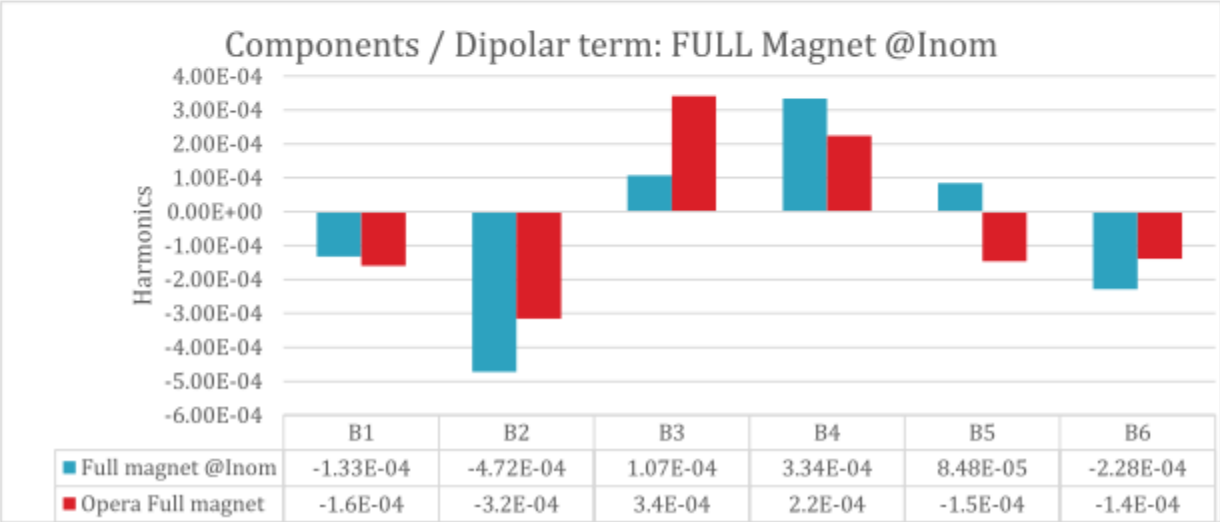


Tsinghua measurements
Prototype measurement results



Full magnet @Inom

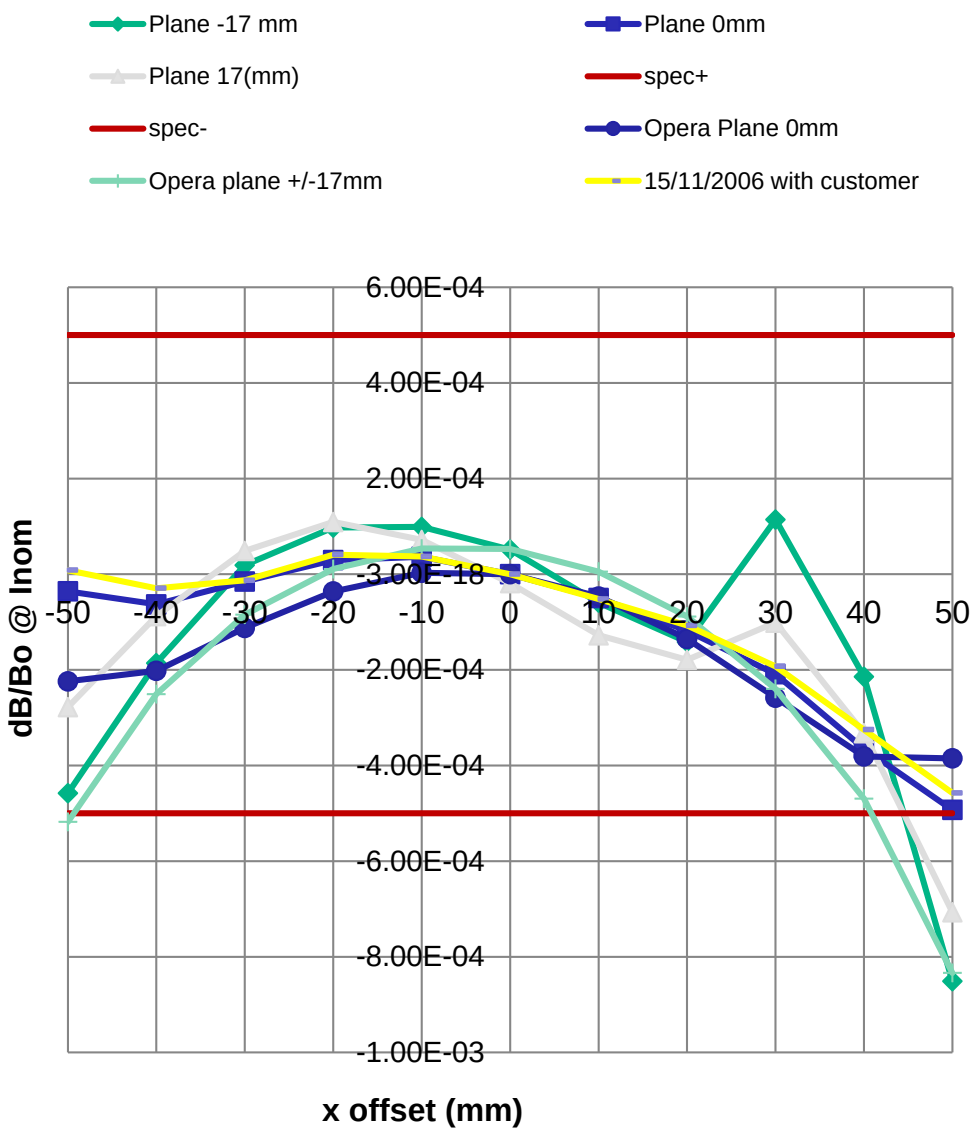
B0	2433.40274	Comp./Dip. term
B1	-0.32257	-1.33E-04
B2	-1.14976	-4.72E-04
B3	0.25932	1.07E-04
B4	0.81297	3.34E-04
B5	0.20625	8.48E-05
B6	-0.55579	-2.28E-04

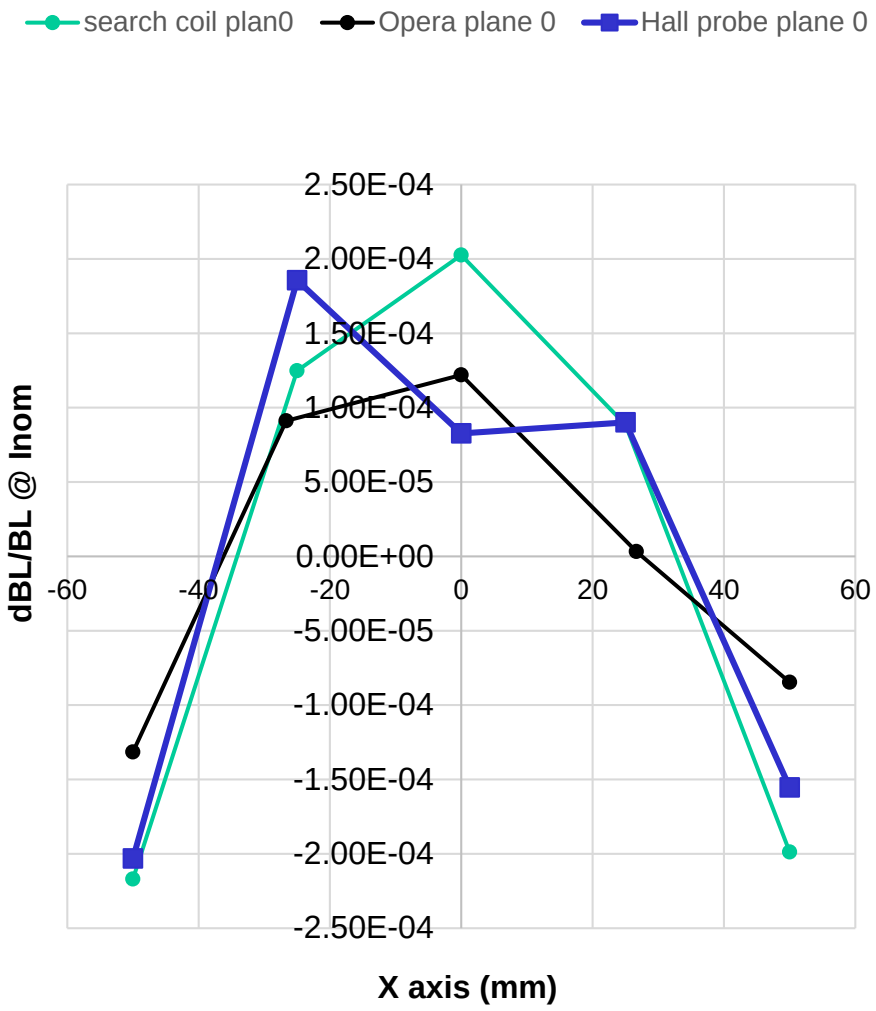


	B1	B2	B3	B4	B5	B6
Full magnet @Inom	-1.33E-04	-4.72E-04	1.07E-04	3.34E-04	8.48E-05	-2.28E-04
Opera Full magnet	-1.6E-04	-3.2E-04	3.4E-04	2.2E-04	-1.5E-04	-1.4E-04

Design – High order term
Target value +/-3.10^{-4}

Tsinghua measurements
Prototype measurement results





Coming soon…


Coming soon.. All measurement benches in our new magnetic measurement laboratory

Coming soon…

Thank you for your attention