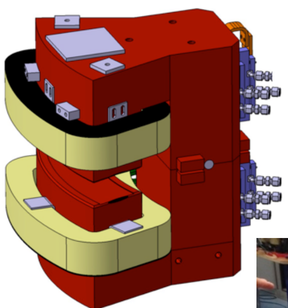
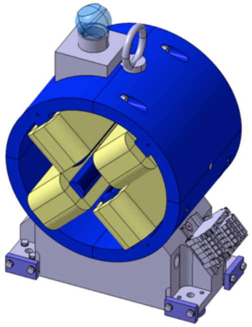
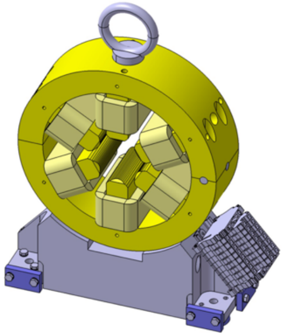
MAGNETS FOR THOMX FACILITY

F. MARTEAU – C. VALLERAND



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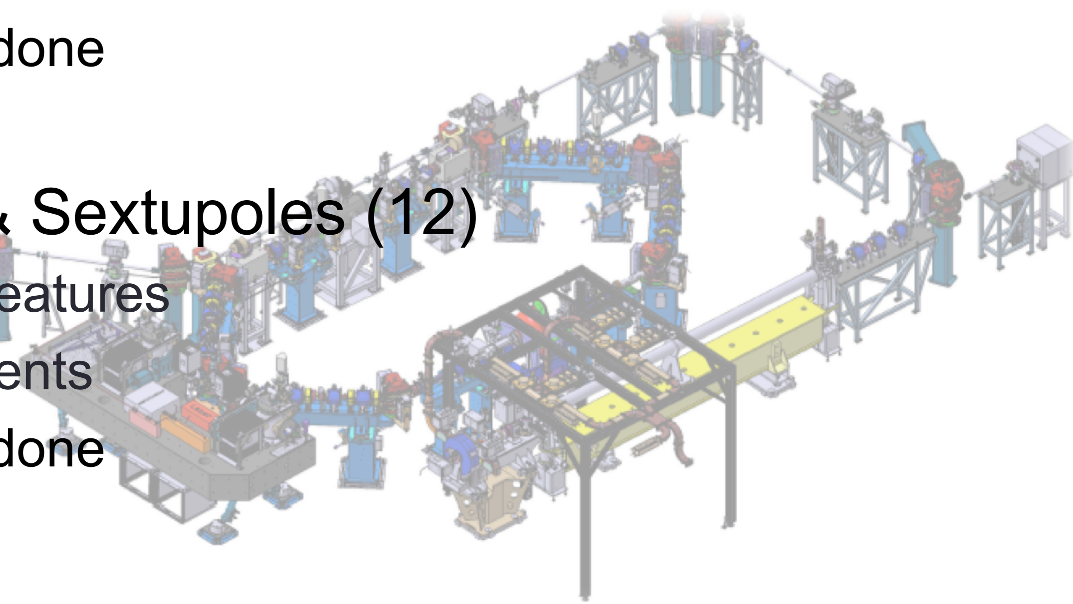
Overview

GOAL :

1) **Outline the status**
2) **Discuss about results**

- Dipoles (15)
  - Magnet design and features
  - Magnetic measurements
  - What remains to be done
- Quadrupoles (34) & Sextupoles (12)
  - Magnet design and features
  - Magnetic measurements
  - What remains to be done
- Conclusion



Dipoles : Magnet design and features

Features of dipoles	
Quantity	**14 + 1** (pre-serie)
Radius of curvature	352 mm
Main field B_0	0.7 Tesla
Gap	42 mm
Good field region	+/- 20mm
Integral of field	184.59 mT.m
Current max.	275 Amp
Beam energy	from 50 to 70 MeV

Design constraints : ThomX ~ 70m^2 on the floor

- Compactness of the ring + position of Fabry-Perot cavity at I.P :

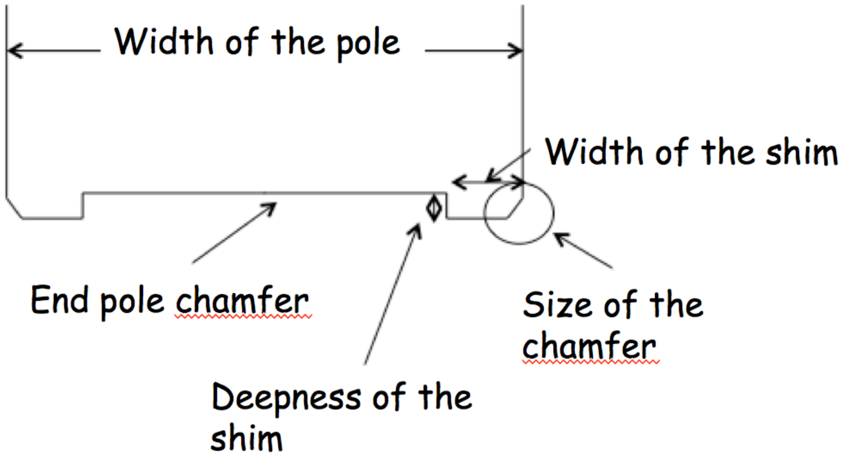
⇒ **C-shaped Dipole** with **Liron ≤ 300mm**

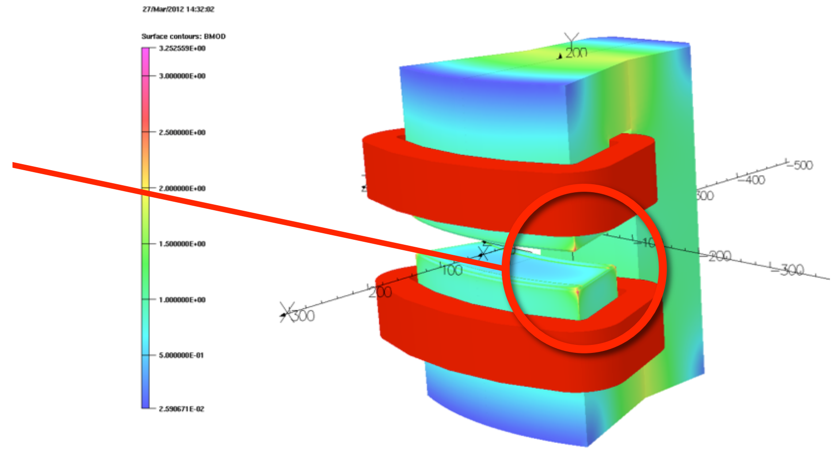
- Stability of the beam in the ring :

⇒ **$\Delta(BL)/BL \leq$ 5 10^{-4}** in the good field region.

Dipoles : Magnet design and features

Parameters of optimization :





Simulated dipole with OPERA

Width of the pole => To prevent saturation

End Pole Chamfer => To adjust the magnetic length in the good field region

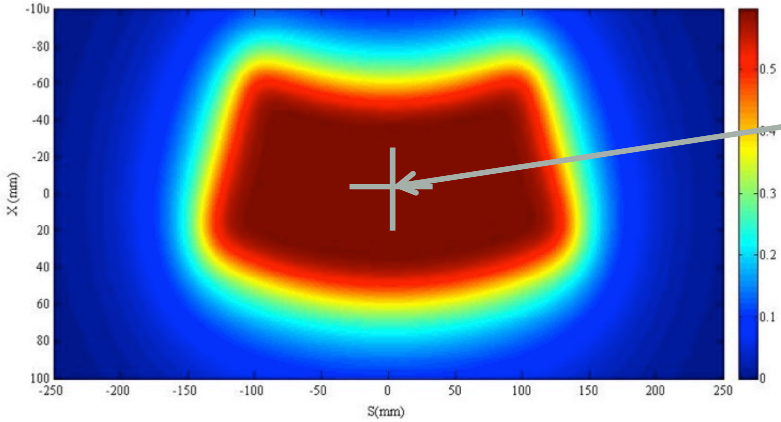
Shims => To obtain flat field and ensure its homogeneity

Back and forth for the design : 32 versions

Dipoles : Magnet design and features

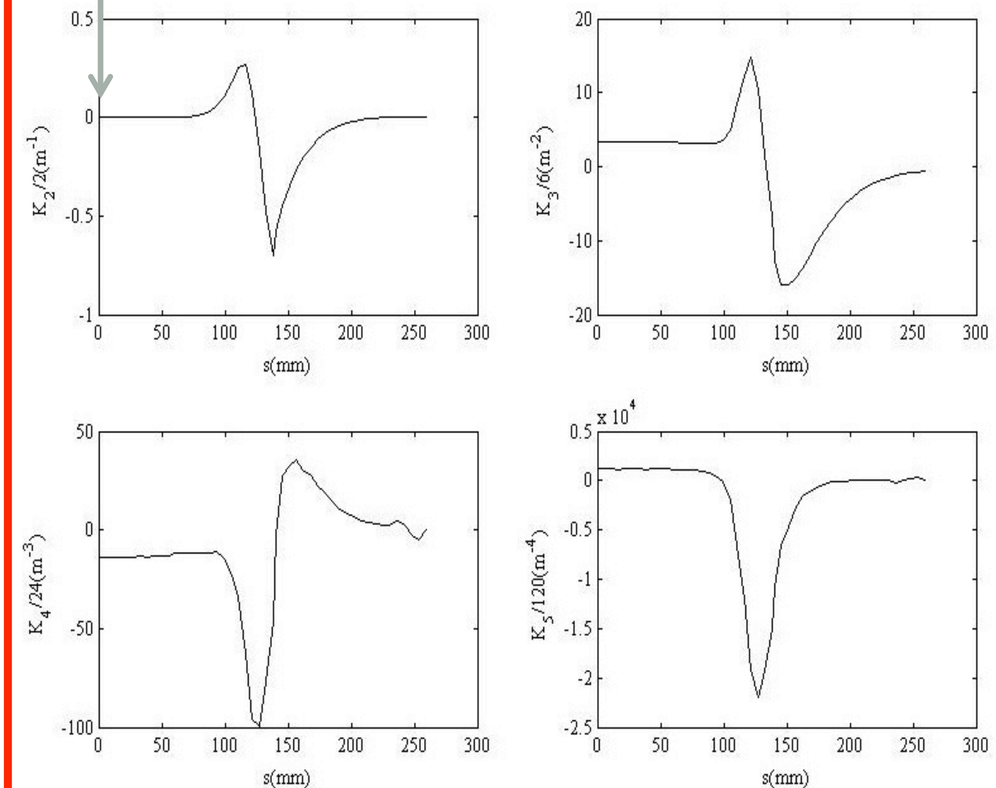
Results from OPERA simulations and analysis with Matlab

Distribution of By with Matlab in the midplane



Analysis is performed on the midplane, where y = 0.
The center of the magnet is then identified by x = z = s = 0

Beta/MadX coefficients



Courtesy to Christelle Bruni

Gradient and higher order multipole terms are taken along directions orthogonal to the integration path : line + circular path + line.

From a Taylor expansion fit :

$$B_y(x).L = B_1.\rho\left(\frac{L}{\rho}+\frac{B_2.x^1.L}{B_1.\rho}+\frac{B_3.x^2.L}{B_1.\rho}+\cdots+\frac{B_n.x^{n-1}.L}{B_1.\rho}\right)$$

Expected multipoles @ 275A		Default on the beam
B_2/B_1	-3,5 10^{-3}	Quad. effect
B_3/B_1	-1,0 10^{-3}	Sextupole effect
B_4/B_1	-2,4 10^{-3}	Octupole effect
B_5/B_1	-1,2 10^{-3}	Decapole effect

$B_n/B_1 < 5.10^{-3}$

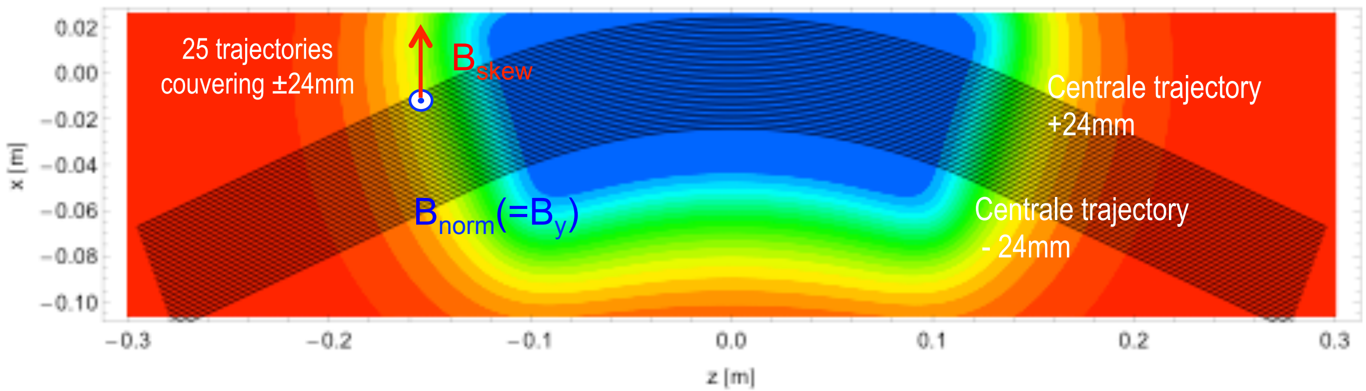
By reducing multipoles, the dynamic aperture is enhanced and became acceptable from beam dynamics point of view.

Dipoles : Magnetic measurements

- ALBA-CELLS magnetic measurement facility. Hall probe bench on-the-fly mode
- Fieldmap measurements have been done on a squared horizontal grid covering a region +/- 24mm, i.e 13 paths, radially separated by 2mm and containing the nominal trajectory :

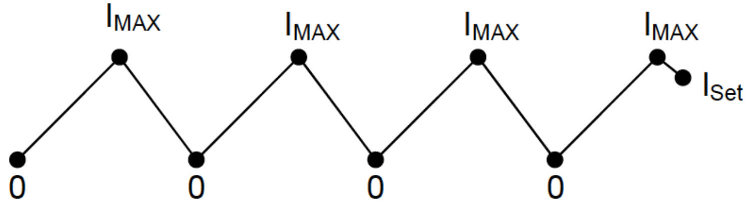
  - for 0Amps to 300Amps, by 10Amps step for the first bending magnet (measurement at 275A has been repeated twice to check the cycling procedure),

  - for 100Amps (≈0.25T), 200Amps (≈0.50T), 275Amps (≈0.70T) for the 14 magnets



Normal and skew components have been evaluated at each point.

Cycling : All magnets have been cycled in the same way to assure the same initial condition for all measurements :



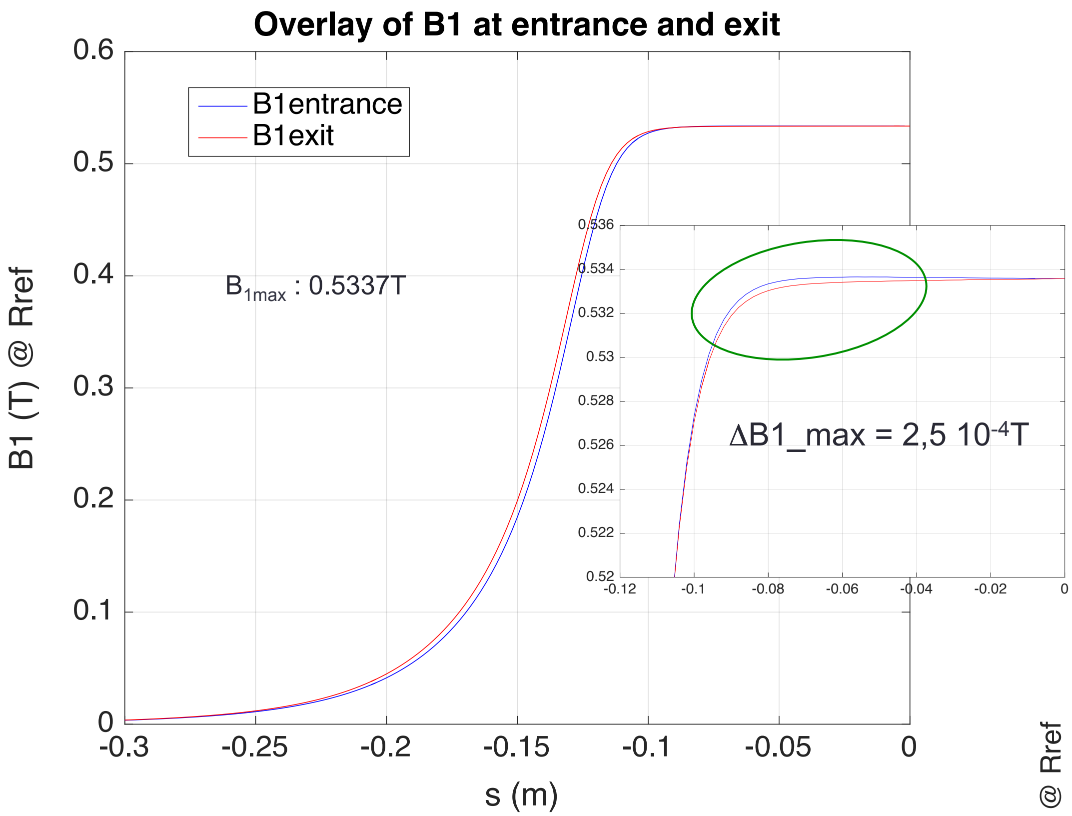
Cycling of magnet prior to measurement.

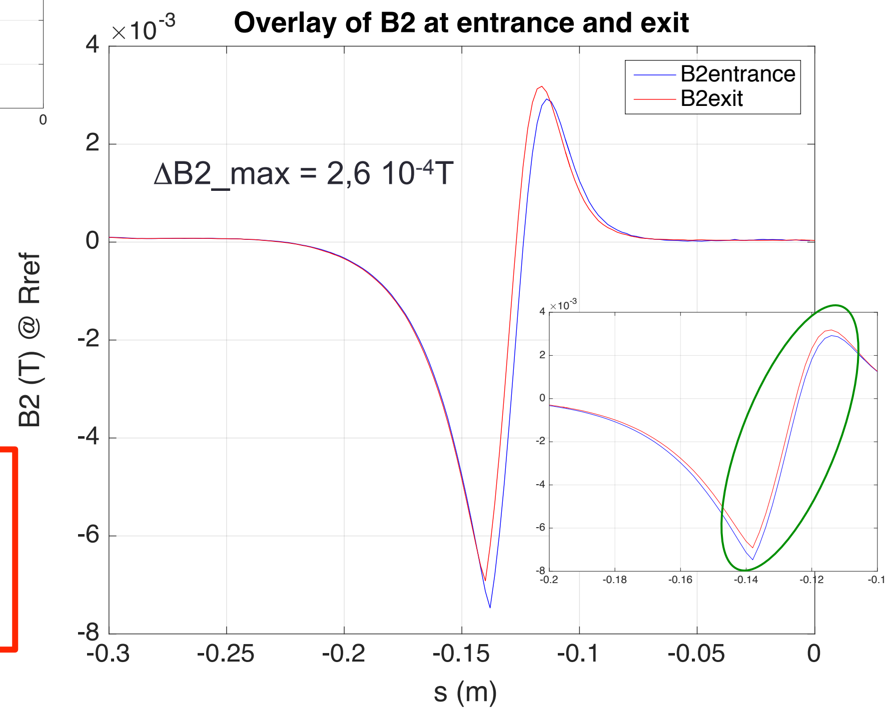
Total cycling time: ~20 min [so ~3 min for 0 to Imax, and the same for Imax to 0).

Waiting time at Imax & I=0 ~30 sec.

Dipole#09 : Results - Multipoles

Multipoles along central trajectory

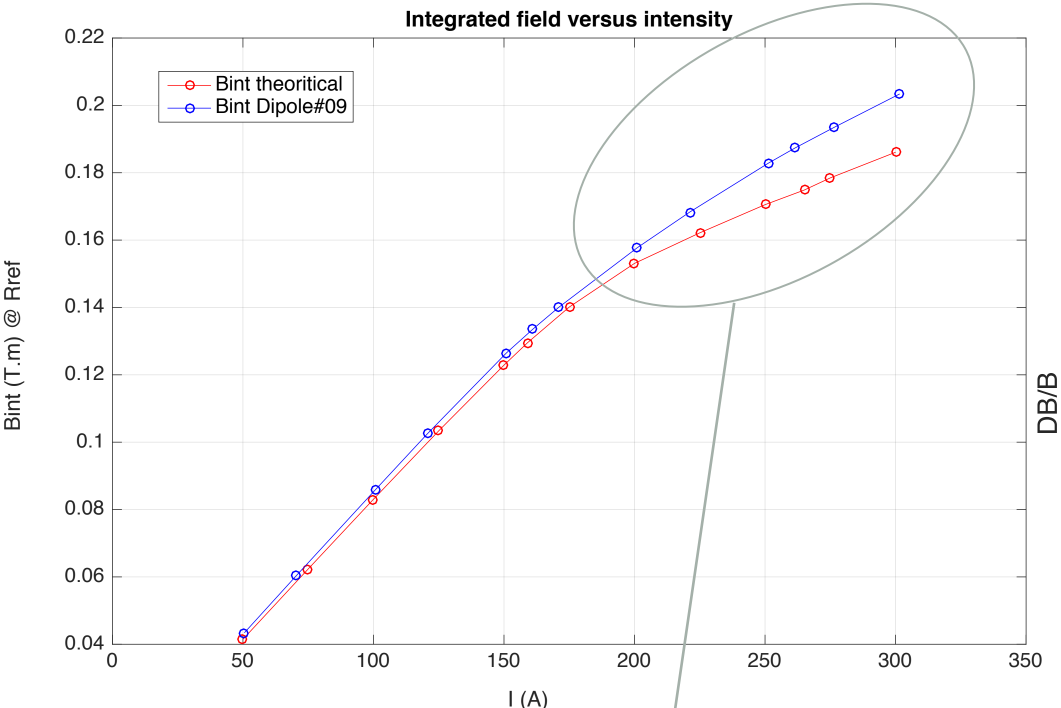


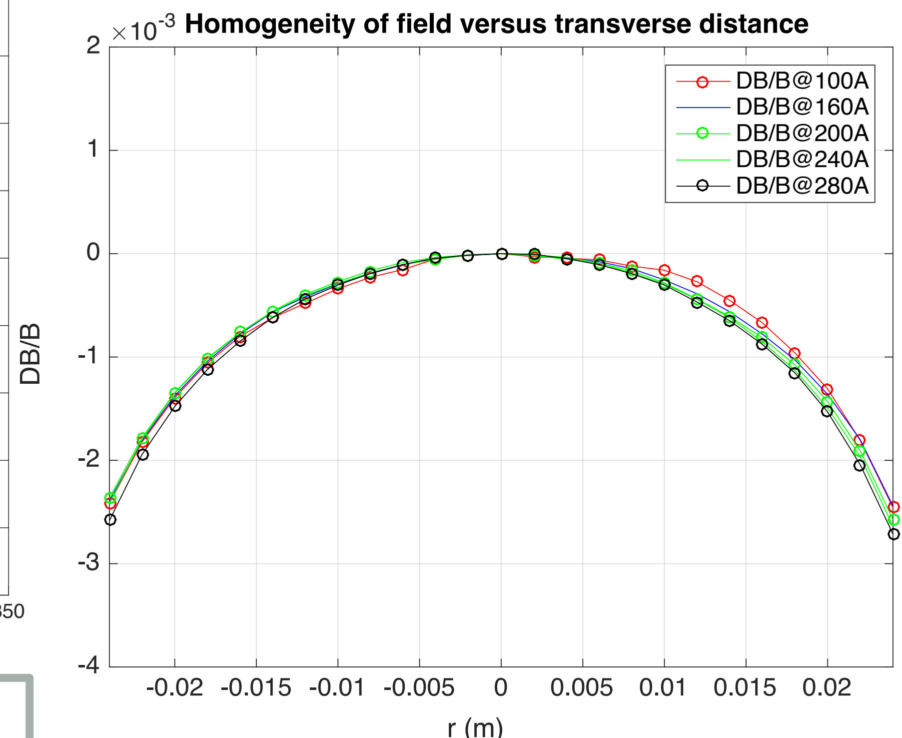


Slight difference between entrance and exit fields for each components B2, B3, B4 and B5.

As usual, this difference is due to the current connections

Dipole#09 : Results – Integrated field





In order to have a relevant design, BH curve is choosen worst than the real one we could expected

Noticable effect of the saturation appears around **200A**

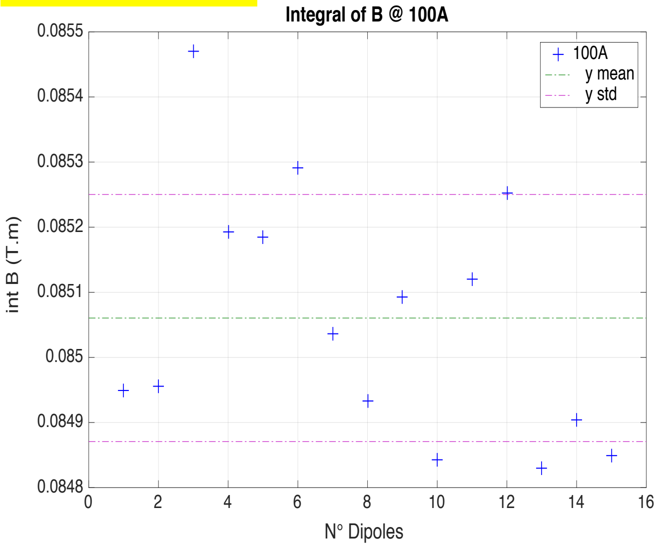
I = 156,29 A for an energy beam of **50 MeV** and a deviation of **45°**

In the good field region : $\left|\frac{\Delta B}{B}\right| \leqq 2.10^{-3}$

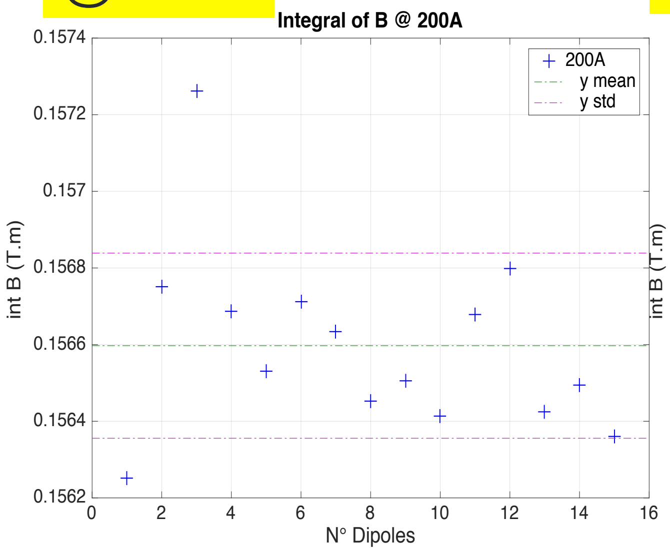
The $\left|\frac{\Delta B}{B}\right|$ confirms the choice of the pole width and shims.

Dipoles : Results - comparison

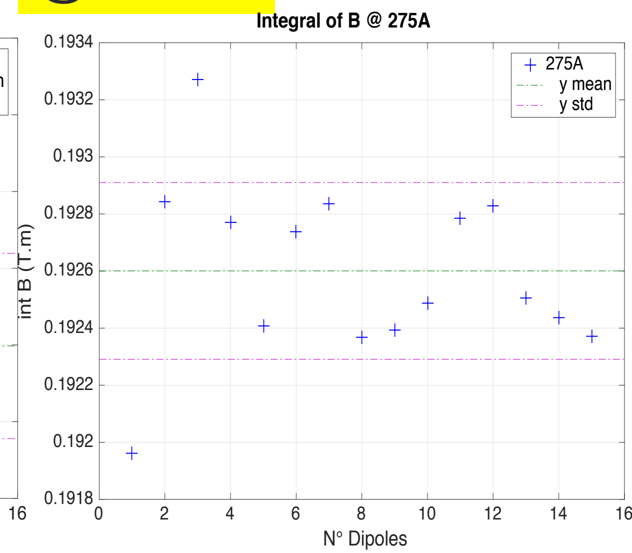
@ I=100A



@ I=200A



@ I=275A



I(A)	Theory Int B(T.m)	Mean Int B(T.m)	Standard Deviation (T.m)
100	0,08305	0,08506	1,93 10^{-4}
200	0,15308	0,15781	2,42 10^{-4}
275	0,17846	0,19386	3,07 10^{-4}

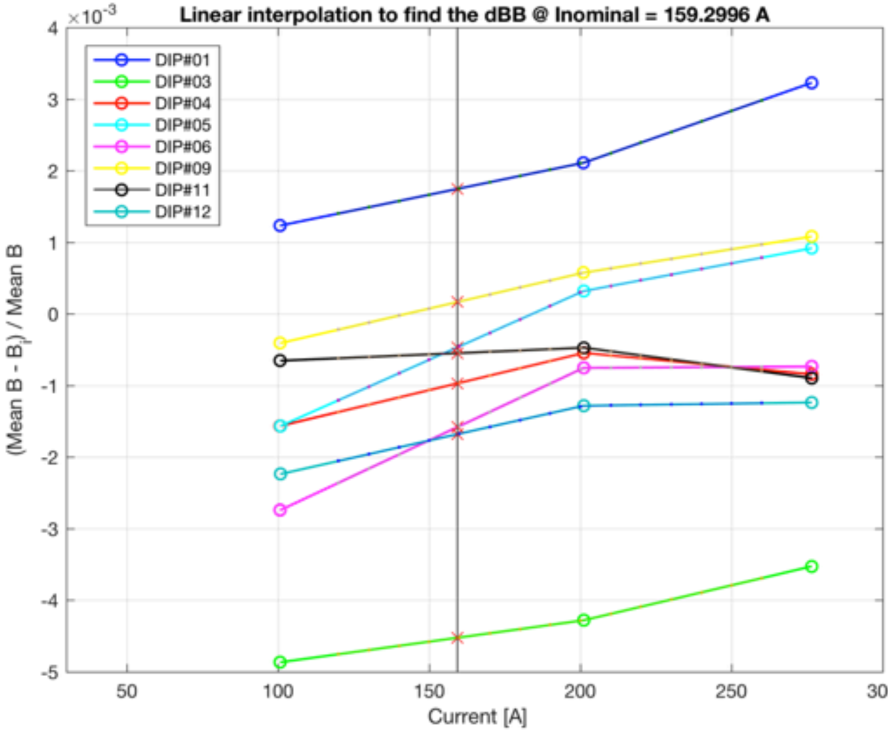
Standard deviation < 3.10^{-4} T.m from a magnet to another magnet

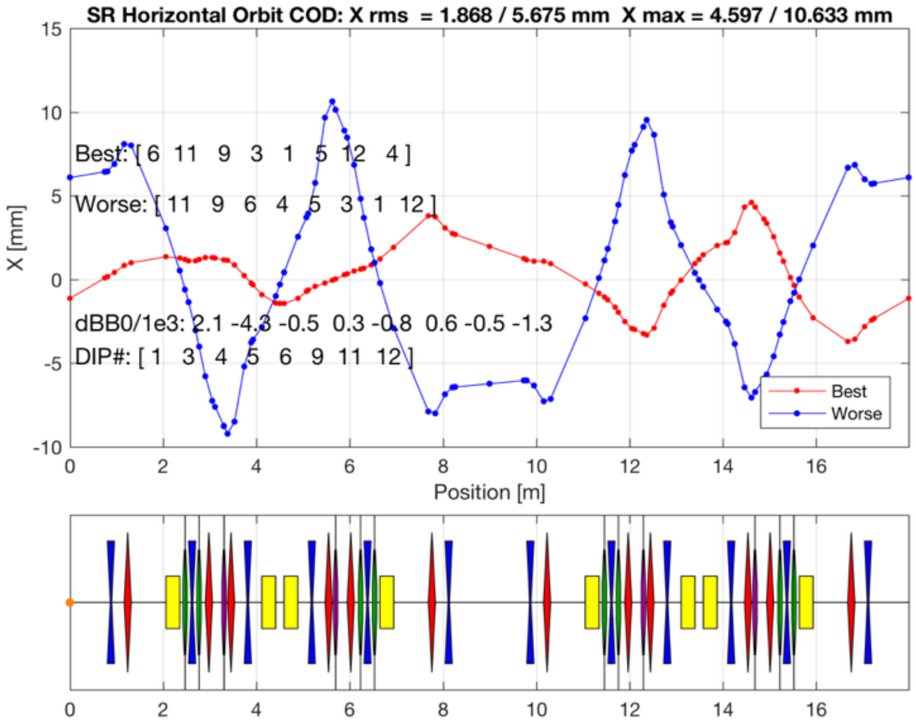
And relative deviation < 3.10^{-3}

Overall reproductibility of the integrals (taking into account alignment errors, cycling effects, Hall probe noise…) is within ± 3.10^{-4} (*TUPMB018, J. Marcos, IPAC16).*

Dipoles : Sorting

- Sorting procedure : choose the « best » 8 DIP out of 13 this time (15 in total) by minimization of the COD
- A vector containing 8 unique integers (dipole indices and corresponding DB/B) are selected randomly from 1 to 13 (or 15 total number of dipoles)
- Then the sorting procedure is performed for 8 dipoles by using the simulated annealing method
- [*William H, Press and Brian P, Flamery, « Numerical Recipes in C:The art of numerical computing » (1988)*] which minimises the beam distorsion according to the constructed cost function : maximum COD or Courant-Snyder invariant,
- After this procedure is repeated for the different random permutations : choose 8 dipoles out of 13 (15),





Courtesy to Iryna Chaikovska

What remains to be done for dipoles

- Characterization of bending magnets is finished.

- Finalisation of sorting is on going.

- One dipole has been measured at SOLEIL→Cross-check is on going.

- Control system OK : The system Magnet+Power+TANGO is fully deployed. Communication to Tango is operational via JIVE or IgorPro Binding.

- Magnetic measurements of injection dipole will be done on April.

- Tests to do before commissioning :
  - Check the polarity of the magnetic field on each magnet
  - Test of the cycling devices

Quadrupoles : Magnet design and features

Features of quadrupoles	
Quantity	33 + 2 (pre-series + spare)
Gradient	5T/m
By (z=0) @ R=18mm	0.0869T
Iron length	140 mm
Effective length	157.31mm
Field integral	13,67 mT.m
Aperture diameter	41 mm
Good field region	+/- 20mm
Nominal current	10.1 Amp
Energy max.	70 MeV

Design constraints :

- Time of life of the beam in the ring

⇒ **Harmonic contents < 5.10^{-4}**

- Compactness of the ring

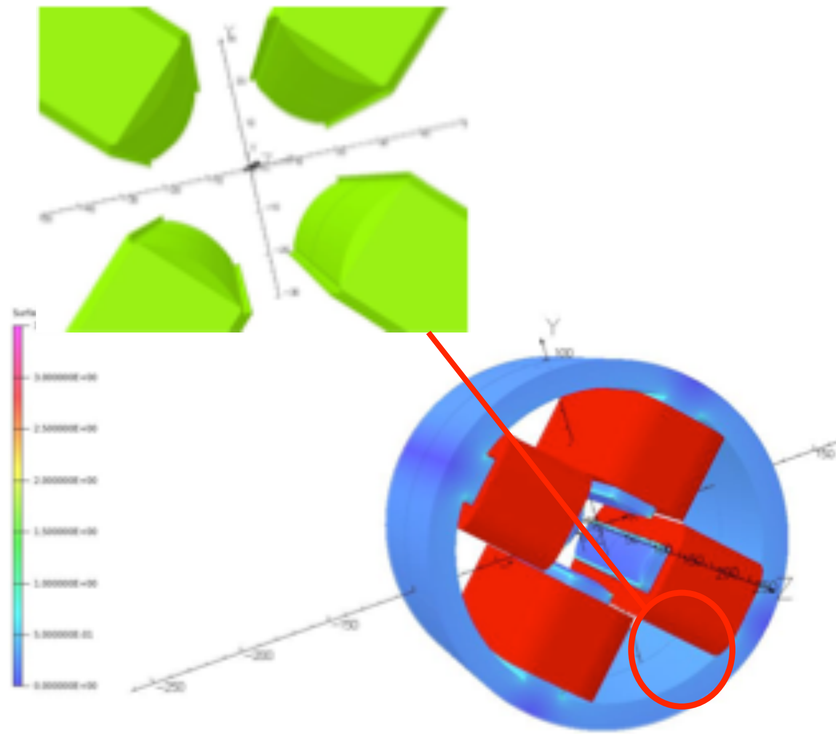
⇒ **L_iron ≈ 140mm**

Quadrupoles : Magnet design and features

5 points of optimization at extremities of pole have been optimized with the module optimizer from OPERA

=> B_{10} and B_{14}

Pole chamfer => B_6



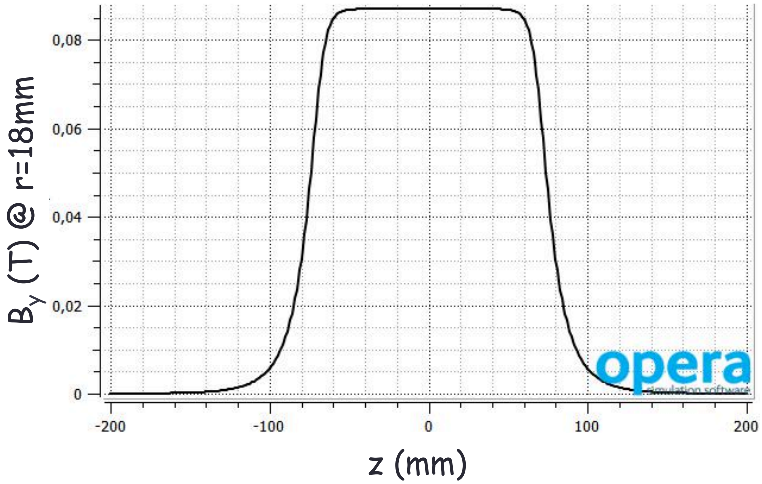
A special endeavour has been done to optimize the profile and the pole chamfer, leading to achieve very small multipolar components and keep a large dynamic aperture.

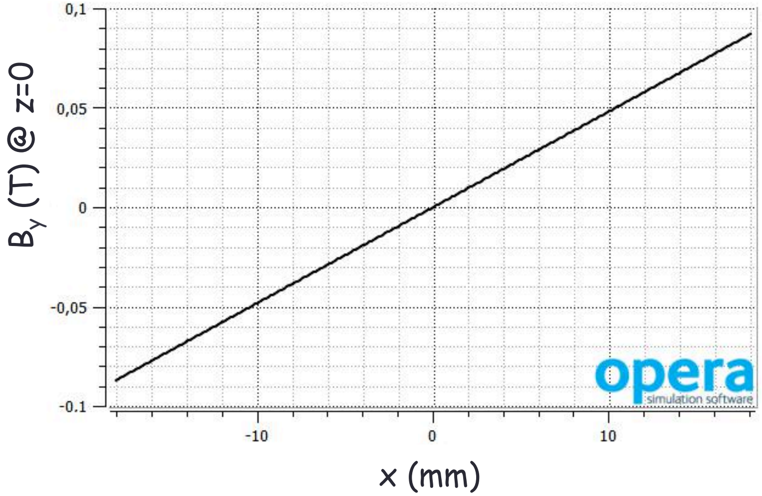
Quadrupoles : Magnet design and features

OPERA 3D/TOSCA was used to estimate the field integrated along the magnet trajectory and individual multipole components were evaluated by Fourier analysis on a cylinder.

The lateral chamfer has been set at 2*2mm in order to facilitate the insertion of the coil around the pole and to minimize harmonic contents.

Harmonic Contents B_n/B_2 (1.10^{-4}) @ R=18mm	End pole chamfer 0*0mm	End pole chamfer 1*1mm	End pole chamfer 2.6*2.6mm
B_6	-34	-21	3
B_{10}	1	-4.5	-6.5
B_{14}	-10	-8.2	-9



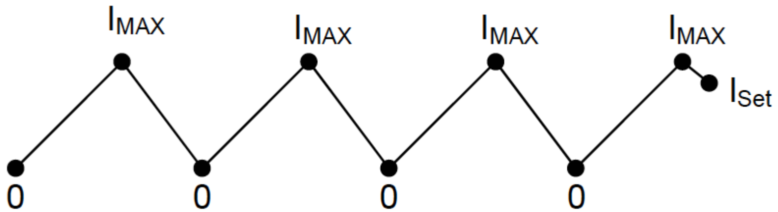


B_y(z=0) = 0.0869 T @ r=18mm ; Integral = 13.6702 mT.m ; L_{mag} = 157.16 mm

Quadrupôles & Sextupoles : Magnetic measurements @ ALBA and SOLEIL

- On each magnet, following tests have been done :
  - Visual inspection
  - Resistance and inductance checks
  - Ground isolation of coils (5kV)
  - Inter-turn insulation (5kV) test
  - Thermal switches performance check
  - Alignement on the bench, using a FARO laser-tracker (Model Xi V2)

- Cycling :



Cycling of magnet prior to measurement.

Total cycling time: ~5 min [so ~1 min for 0 to Imax, and the same for Imax to 0).

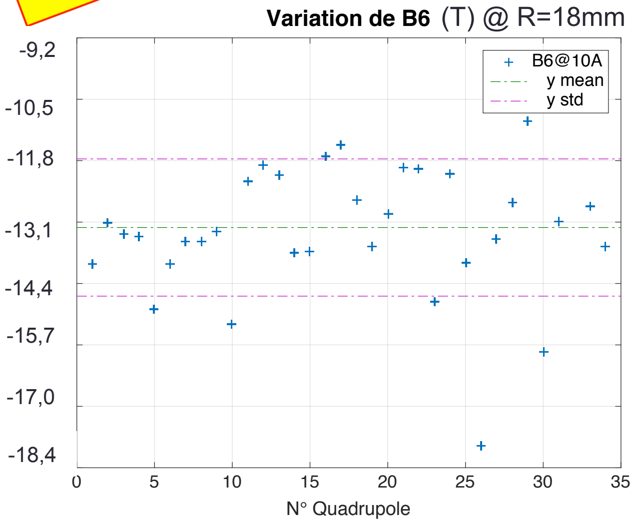
Waiting time at Imax & I=0 ~10 sec.

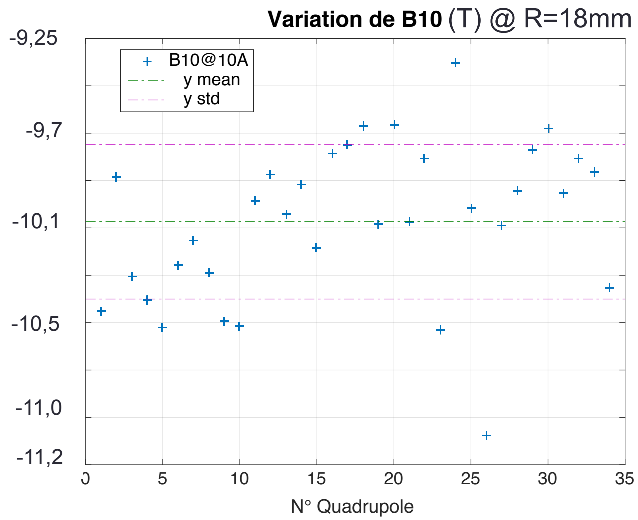
- Measurement of magnetic axis
- Harmonics up to 31 will be measured at 7 current levels : 0A, 2A, 4A, 6A, 8A, 10A, 12A

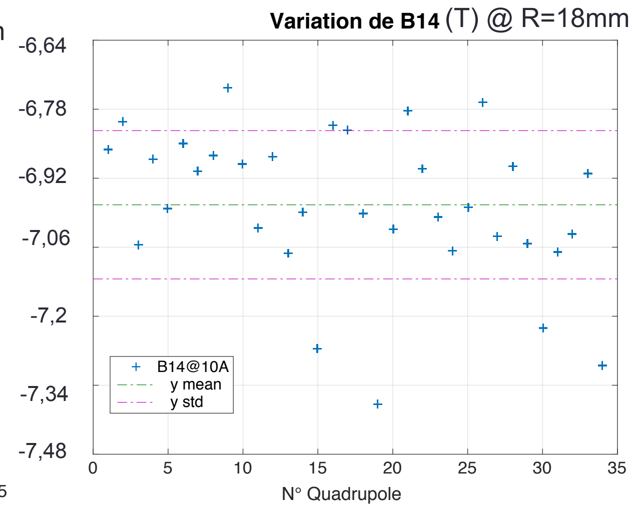
Qpoles : Magnetic measurements

35 Qpôles @ R=20mm

High harmonic content
(spec <10 units)







Measurements @ R=18mm
B_6_Mean = -13.2 units
B_6_σ = 1,5 units

Theory @ R=18mm
B_6/B_2 = 3.3 units

Measurements @ R=18mm :
B_{10}_Moyenne = - 10.1 units
B_{10}_σ = 0,4 units

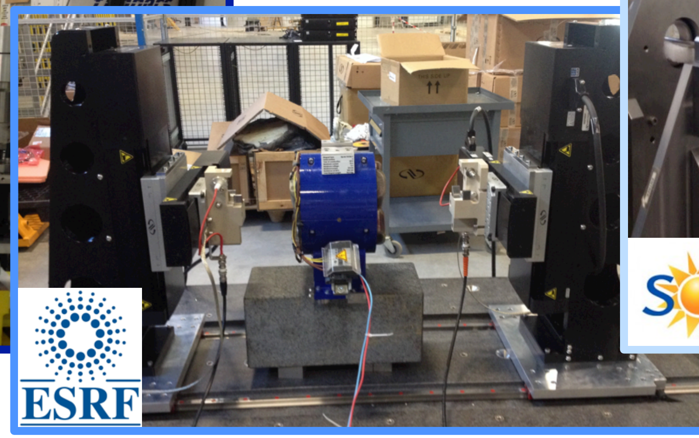
Theory @ R=18mm
B_{10}/B_2 = -6.5 units

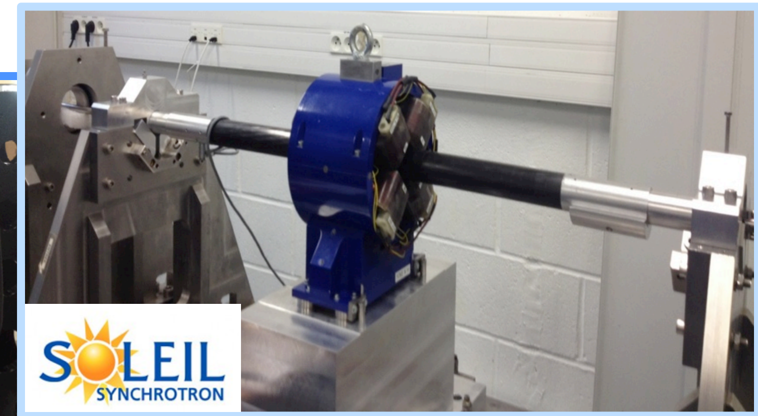
Measurements @ R=18 mm
B_{14}_Moyenne = -7.0 units
B_{14}_σ = 0,2 units

Theory @ R=18mm
B_{14}/B_2 = -9.1 units

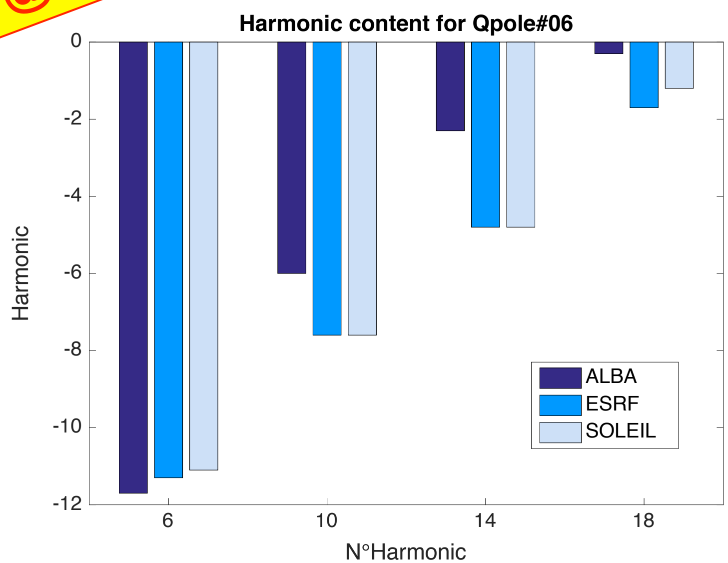
⇒ Investigation on difference for B_6 is still on going. But the main hypothesis seems to be the diameter of the wire for the manufacturing of pole by electro-erosion.

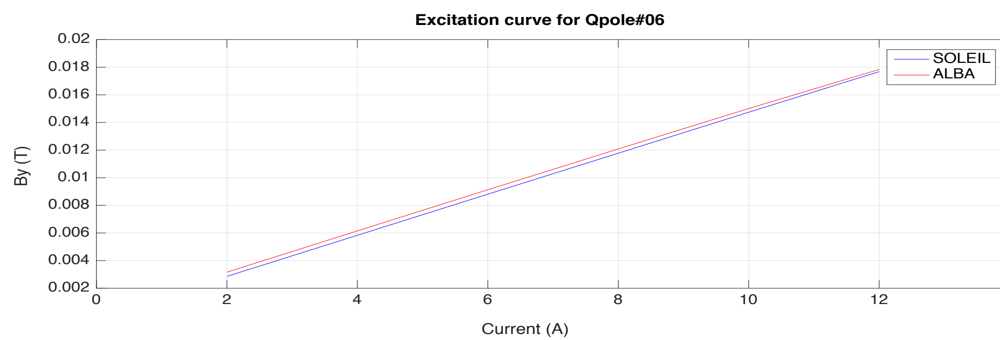
Quadrupoles : Cross-check

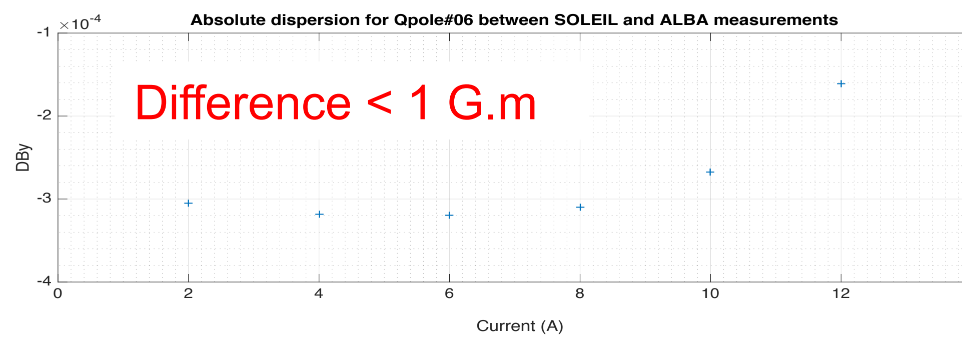




Qpôle #06 @ R=18mm







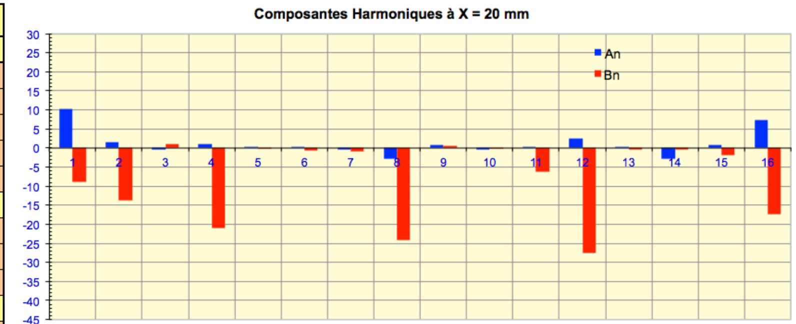
Quadrupole : Data sheet model

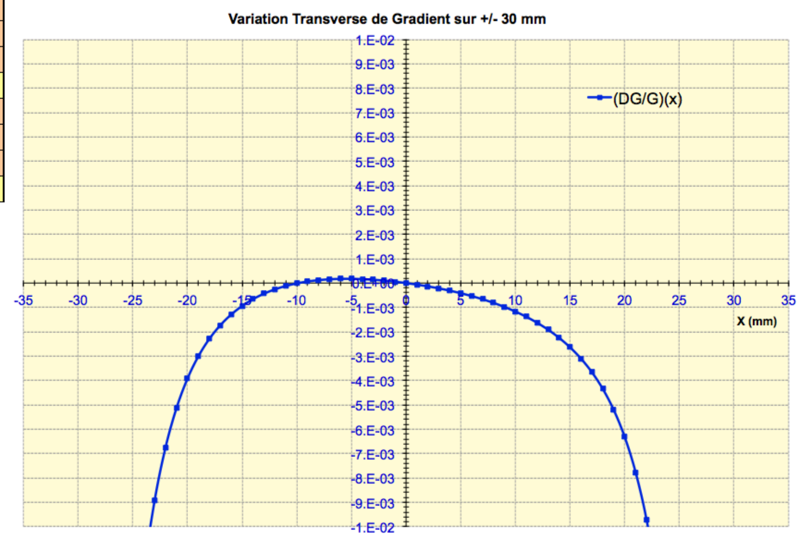
Fiche de Mesures Magnétiques des Quadrupôles

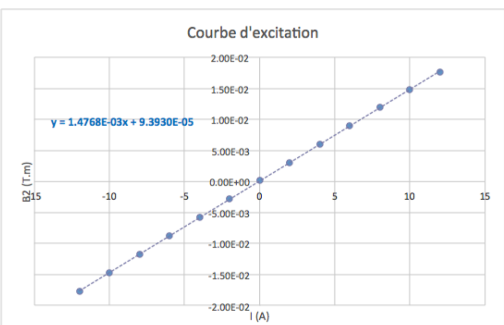
Qp 001	
Courant (A) :	10.0
Banc de mesure :	BMS
Opérateurs :	CV et FM
Date :	12/01/17
N° Culasse :	
N° Inventaire :	
Nomenclature THOMX :	
Gradient nominal :	
Rréf (mm) :	20

B2 (T.m) =	0.014711
ΔX (µm) =	-30.711
ΔZ (µm) =	125
Δθs (mrad) =	0.15

	Composantes Harmoniques à X = 20 mm	
n	An	Bn
1	-4.15E-04	-2.76E-03
2	0	10000
3	10.30	-8.90
4	1.50	-13.75
5	-0.42	1.07
6	1.15	-21.10
7	0.05	-0.24
8	0.07	-0.52
9	-0.28	-0.79
10	-2.92	-24.12
11	0.89	0.64
12	-0.37	-0.14
13	0.02	-6.25
14	2.51	-27.56
15	0.21	-0.46
16	-2.93	-0.41
17	0.78	-1.89
18	7.36	-17.36







Sextupoles : Magnet design and features

Features of sextupoles	
Quantity	12 + 1 (pre-series + spare)
Strength	$40T/m^2$
By (z=0) @ R=18mm	0.0114T
Iron length	60 mm
Effective length	73.25 mm
Field integral	0.8343 mT.m
Aperture diameter	41 mm

Design constraints :

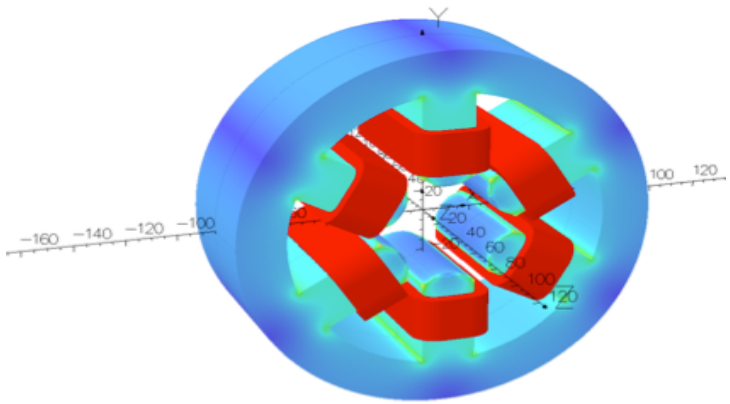
- Time life of the beam in the ring => **Harmonic < 5.10^{-4}**

- Compactness of the ring => **L_iron ≈ 60mm**

- Insertion of horizontal and vertical corrector inside sextupoles

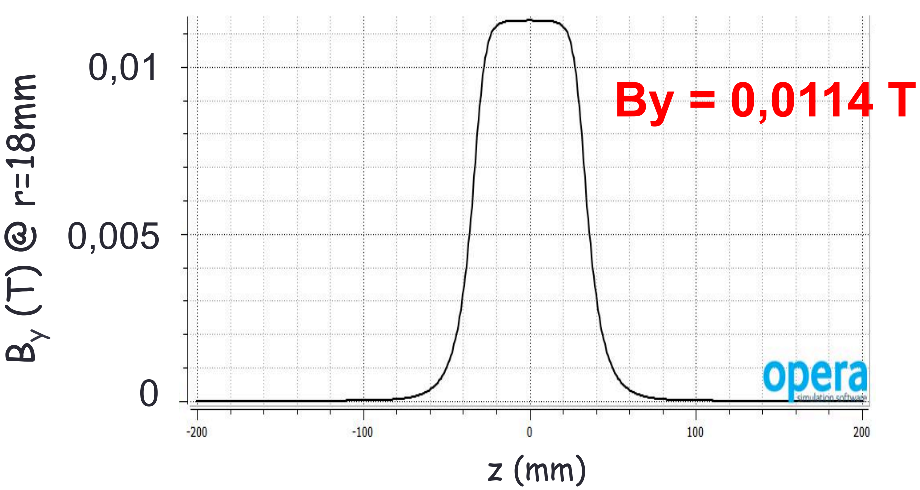
Sextupoles : Magnet design and features

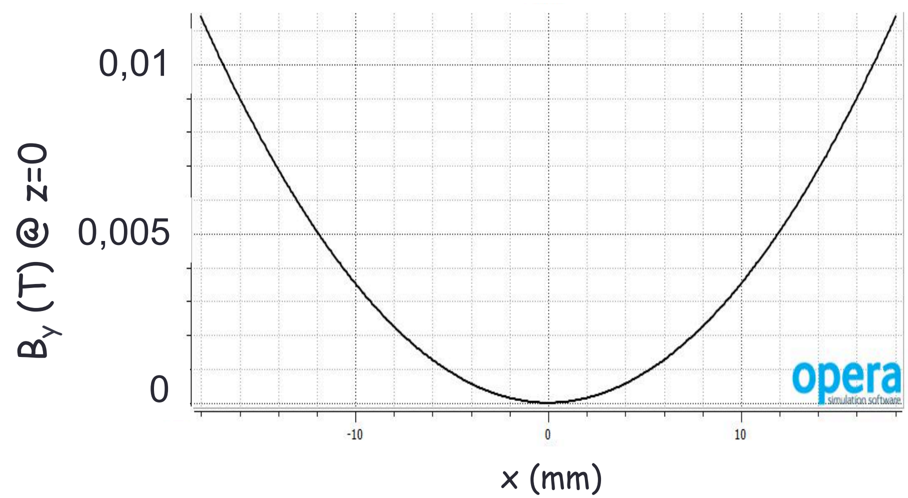
The pole shape of the sextupole has been done by fitting the pole end chamfer and by applying the ideal pole shape equation : $3x^2y - y^3 = \pm R^3$



@ R=18mm

Harmonic Contents B_n/B_3 (1.10^{-4})	Values
B_9	-19.00
B_{15}	-4.08
B_{21}	-0.17

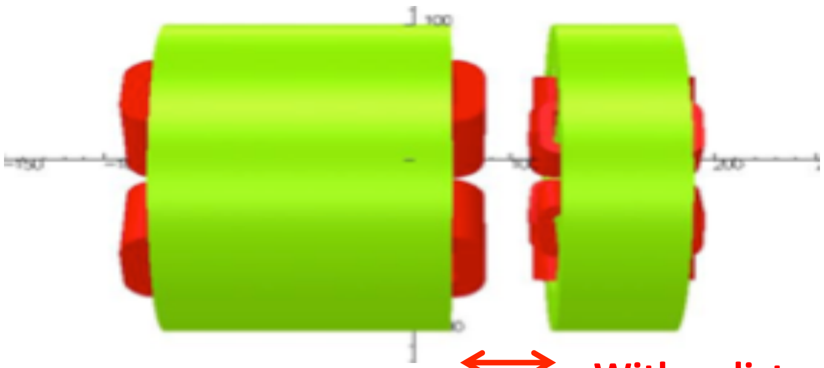




For 10A : Horizontal corrector : B_1 = 8.7 10^{-4}T

Vertical corrector : A_1 = 8.1 10^{-4} T => **Kick angle of 5 mrad**

Cross-talk simulation results with OPERA



With a distance D_{min} = 50mm

Harmonic contents	Quad alone	Quad ON Sextu OFF	Quad ON Sextu ON
B_4	0.00	-1.25	-1.25
B_6	2.32	2.28	2.28
B_{10}	-6.38	-6.48	-6.48
B_{14}	-9.15	-9.19	-9.19
B_{18}	-3.65	-3.66	-3.66

Results of sextupole influence on field quadrupole

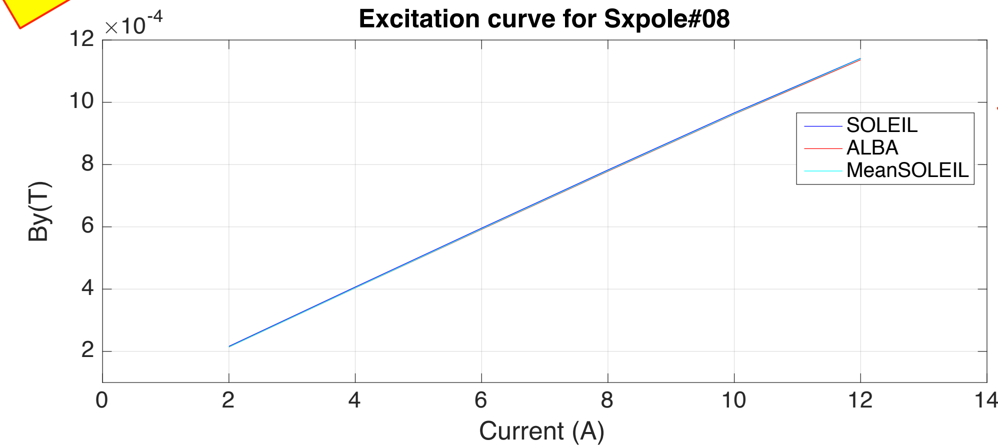
Harmonic contents	Quad alone	Quad ON Sextu OFF	Quad ON Sextu ON
B_1	0.00	-2.94	-3.38
B_5	0.00	-0.99	-1.99
B_9	-19.00	-19.08	-19.31
B_{15}	-4.08	- 4.09	- 4.09
B_{21}	-0.17	- 0.17	-0.11

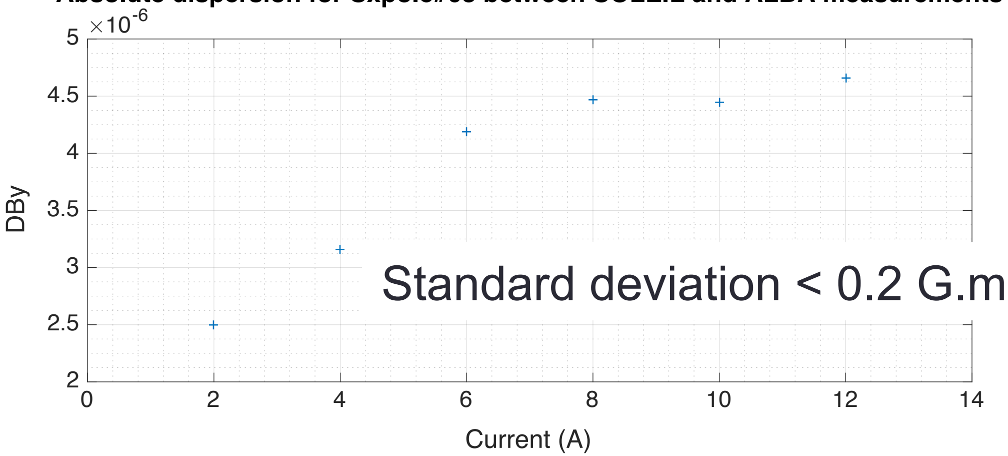
Results of quadrupole influence on field sextupole

Cross-talk simulations have shown that sextupole doesn't affect allowed harmonics of quadrupole but creates an octupolar harmonic. Regarding the effect of quadrupole, nor it doesn't affect allowed harmonic of sextupoles but creates a dipolar and decapolar components, convenable for the beam dynamics.

12 Sxpôles

Sextupoles : Magnetic measurement





Sxpôle #08

Check of linearity, influence of CV and CH on main field B3 componant

En T.m	
B3 SP10	-9,62E-04
B3 CH10	-2,08E-07
B3 SP10_CH10	-9,72E-04
B3 SP10+B3_CH10	-9,62E-04

Difference of 10^{-6} T.m

En T.m	
B3 SP10	-9,62E-04
B3 CV10	1,67E-06
B3 SP10_CV10	-9,65E-04
B3 SP10+B3_CV10	-9,60E-04

Difference of 5. 10^{-6} T.m

	ALBA		SOLEIL	
n	An	Bn	An	Bn
9	-0,25	-34,75	10,72	-40,29

Expected theoretical results

B_9/B_3 = -34.5 10^{-4} @ R=20mm

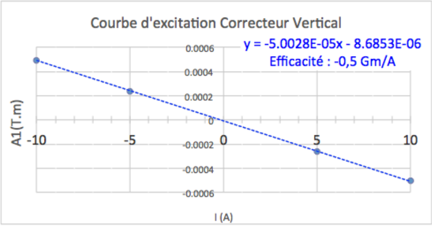
Sextupoles : Data sheet model

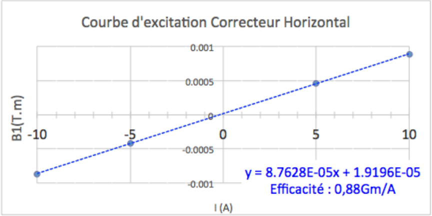
Fiche de Mesures Magnétiques des Sextupôles

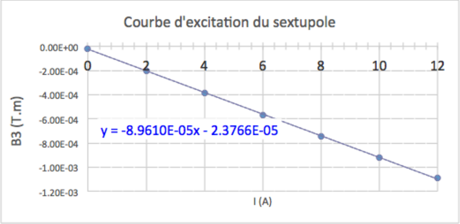
Sp 001	
Courant (A) :	10.0
Banc de mesure :	BMS
Opérateurs :	CV & FM
Date :	12/01/17
N° Culasse :	
N° Inventaire :	
Nomenclature THOMX :	
Rréf (mm) :	20

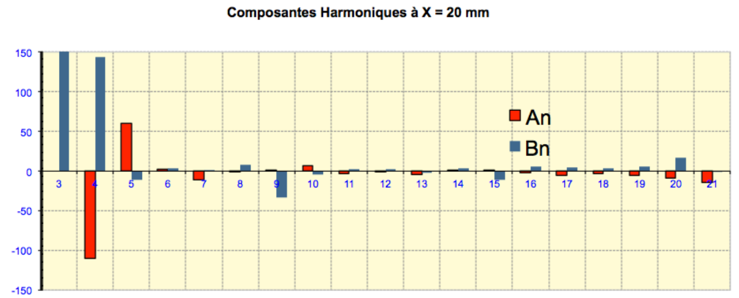
B3 (T.m) =	-0.000922
ΔX (μm) =	-238.51
ΔZ (μm) =	-192.87
Δθs (mrad) =	-1.03

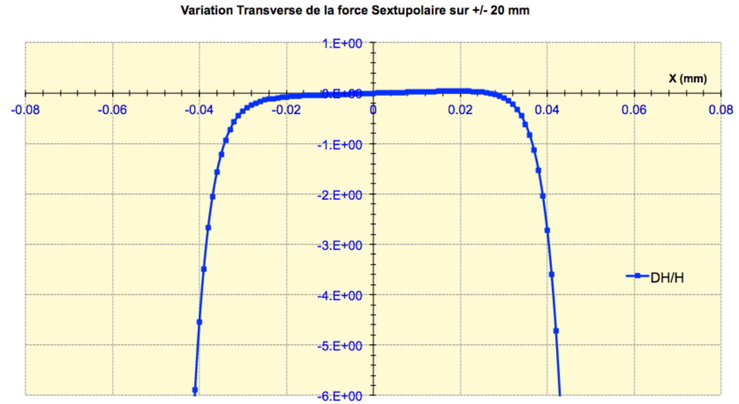
n	Composantes Harmoniques à X = 20 mm An	Bn
1	-34.13	-228.02
2	0.01	-0.02
3	0.00	10000.00
4	-110.23	143.93
5	60.61	-11.04
6	2.64	3.31
7	-11.30	0.41
8	-0.83	7.44
9	0.32	-32.83
10	6.33	-4.49
11	-2.91	2.92
12	-1.48	1.92
13	-4.15	-2.41
14	1.15	3.80
15	0.14	-10.43
16	-1.95	6.26
17	-5.44	4.51
18	-2.93	3.18
19	-5.07	5.48
20	-8.50	16.78
21	-14.25	-0.71



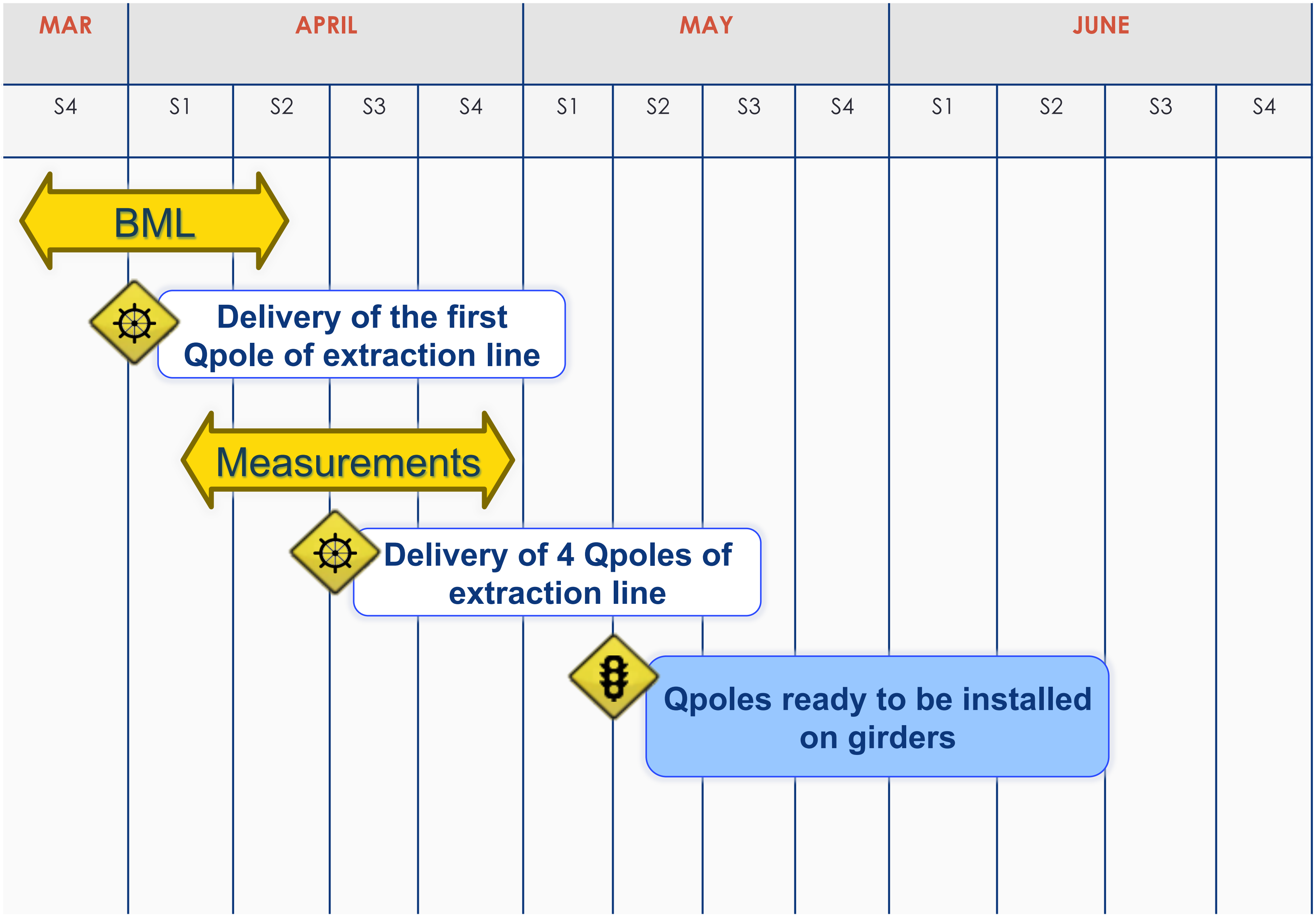








Conclusion : MACRO-PLANNING



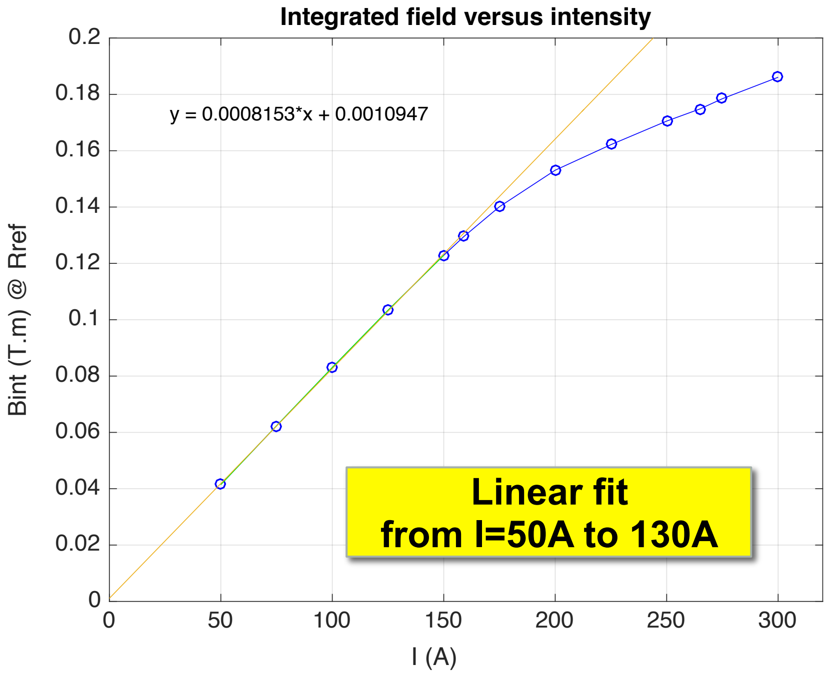
Thanks for your attention

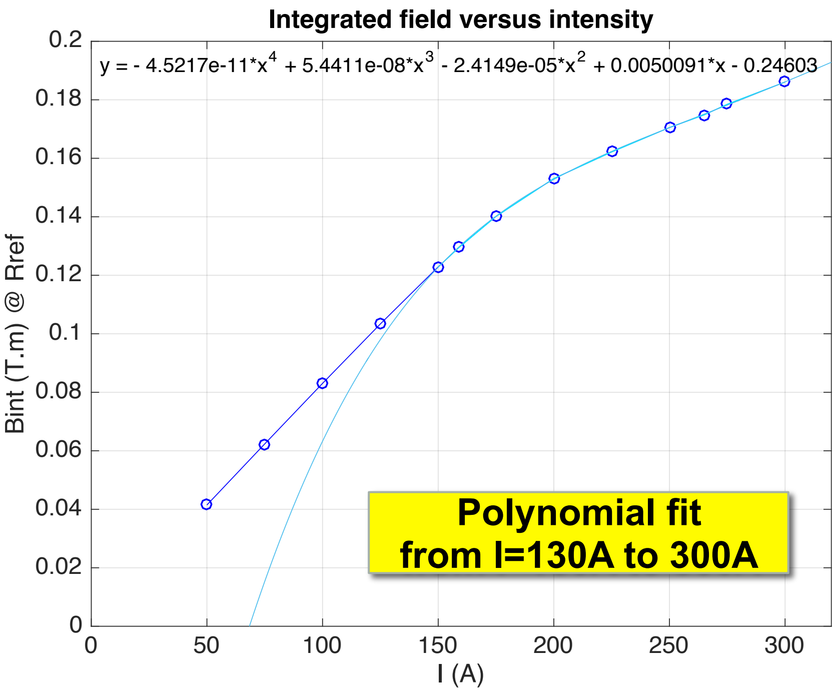
Thanks to all of those
who helped us at SOLEIL and LAL,
to ALBA team and ESRF team.

ANNEXES

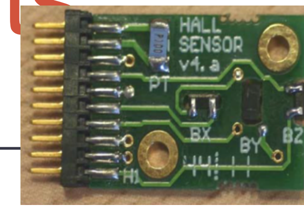
Dipoles : Magnet design and features

Results from OPERA simulations



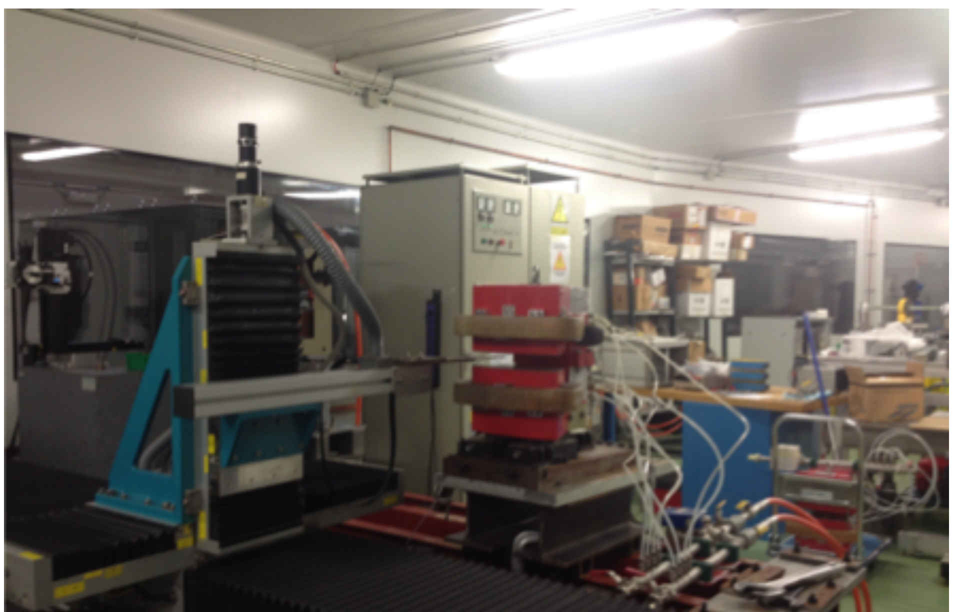


Dipôles : Set-up of measurements

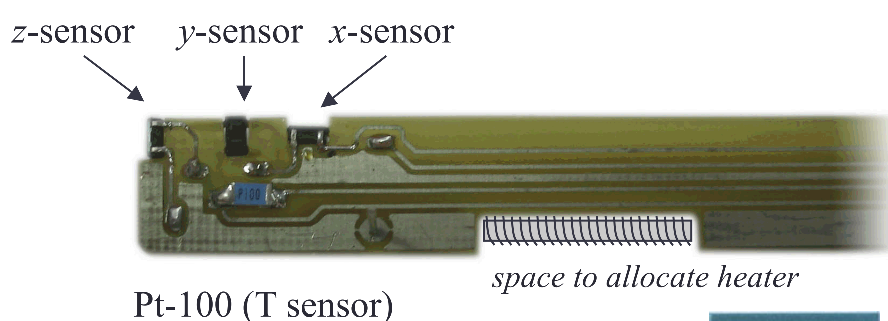


Dimensions : l=2.5m; L=0.5m; H=0.25m
Probes F.W Bell GH700 in 3 axes
Système de régulation de T de la sonde Hall
Accuracy of positionnement ~ 30 µm
Repeatability of positionnement ~ 1 µm

Model GH-700
Gallium Arsenide
Nominal current: I_{nom} =5 mA
Magnetic Sensitivity ~ 1 V/Tesla
Max. linearity error (±1 Tesla): ±2%
Temperature coefficient: -0.07%/ºC



Detail of Hall probe circuit board :



The temperature sensor and the manganine heater, in combination with a PID controller (*Eurotherm 3508*) allow to control the temperature of the probe within ±0.05ºC

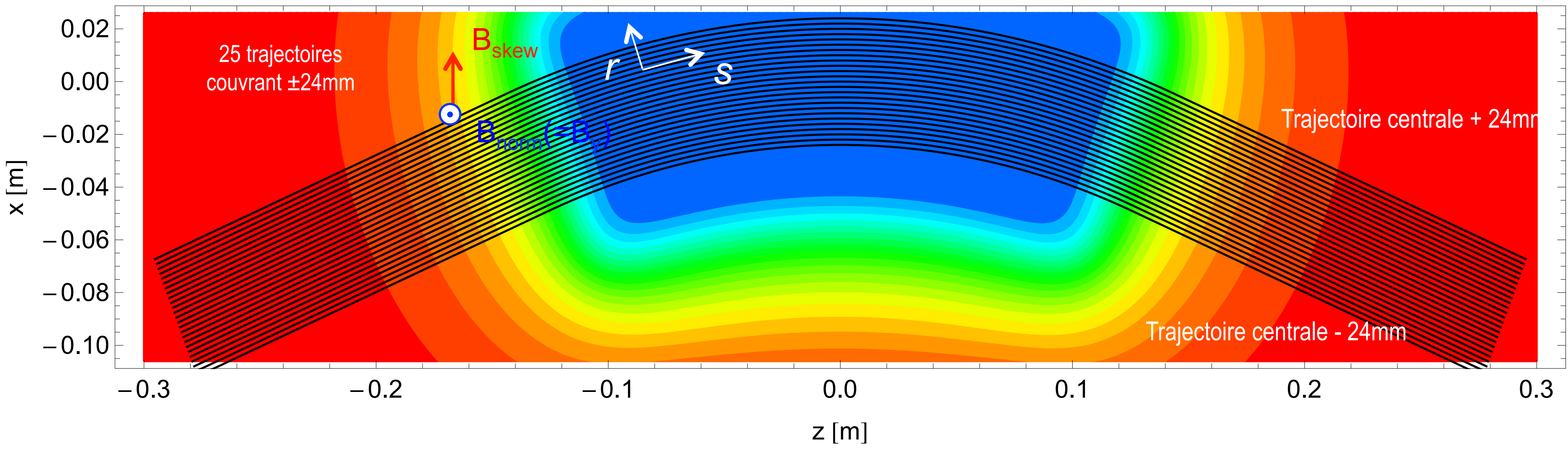
Absolute accuracy ± 0.05 mT
Repeatability between different scans **~0.5 Gauss *rms***

Courtesy to ALBA team

Dipoles : Magnetic measurements

Mesures des cartes de champs => Tracking

- La carte de champ est mesurée en vol via la sonde Hall décrite précedemment, dans une “région” couvrant +/- 24mm autour de la trajectoire centrale
- La région mesurée est une grille rectangulaire de 600mm*48mm par pas de 2mmx2mm (longitudinal x horizontal)
- Les composantes Normales et Tournées du champ magnétique sont déterminées à chaque position
- Les composantes multipolaires sont extraits de la décomposition en série de Taylor, le long de la trajectoire centrale :

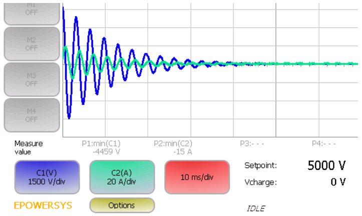


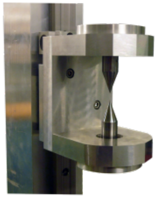
Dipoles : Protocol of mesurements

Manipulation, visual inspection & installation dans le Hall de mesures

Tests électriques
- Vérification de la résistance
- Vérification de l'inductance
- Vérification de l'isolation
- Vérification de l'isolation entre-bobines
- Vérification des thermoswitches

Alignement et fiducialisation





Caractérisation magnétique

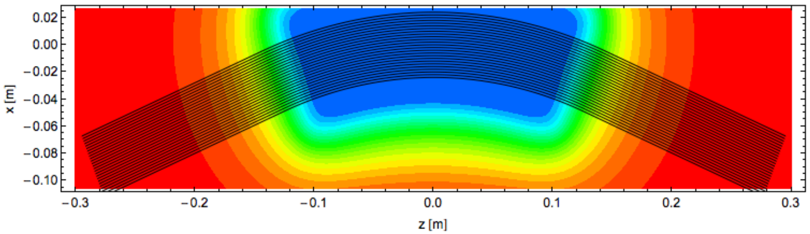
1-2 days/dipole
33 field mapping : Dipole#09 / 3 field mapping for Dipole#i

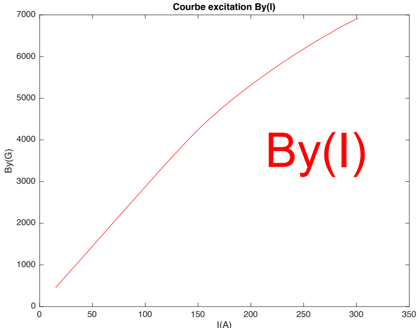
Caractérisation magnétique
- Calibration des capteurs via 5 sondes RMN
- Calibration de l'offset des capteurs
- Calibration des positions des capteurs
- Calibration des erreurs d'angle des capteurs

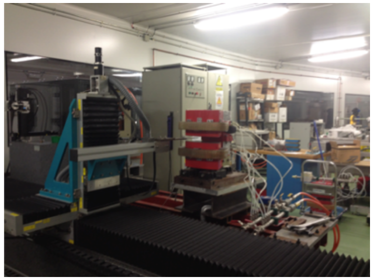
Field mapping @ 200A (1 day)

Field mapping @ 100A (1 day)

Field mapping @ 275A (1 day)





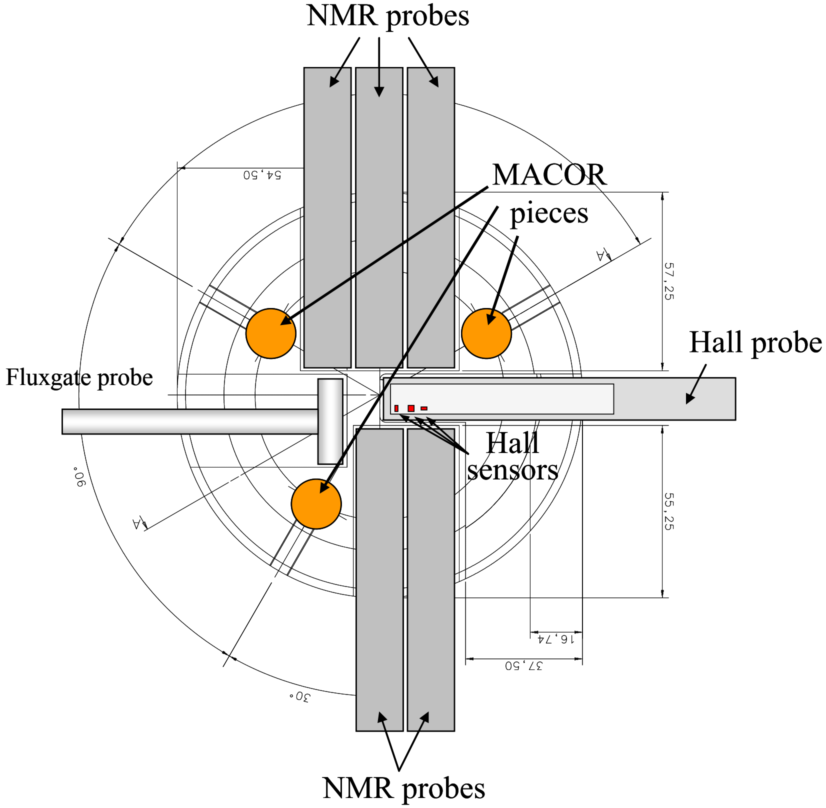


Dipôles : Protocole de mesures

1) Calibration des champs des 3 capteurs avec des sondes RMN

Système de calibration :

- Aimant Dipole *GMW 3473-50 150 MM*
- Alimentation *Danfysik 858*
- Magnétomètre RMN *Metrolab PT 2025*
- Magnétomètre Fluxgate *Bartington Mag-01*



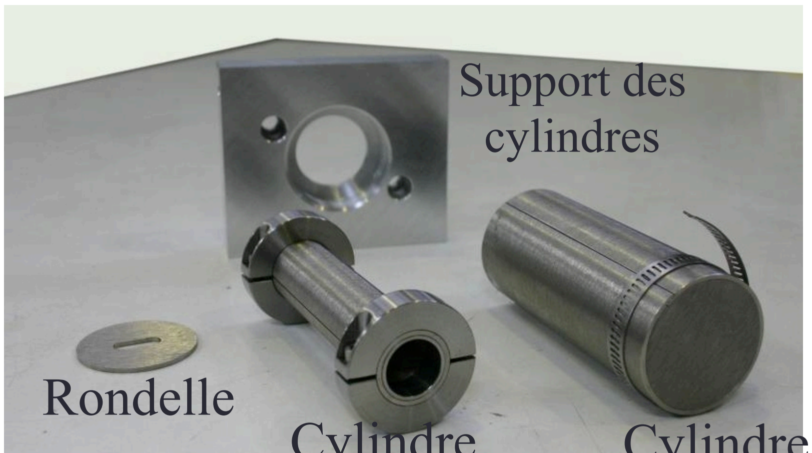
Magnet's air gap: 15mm

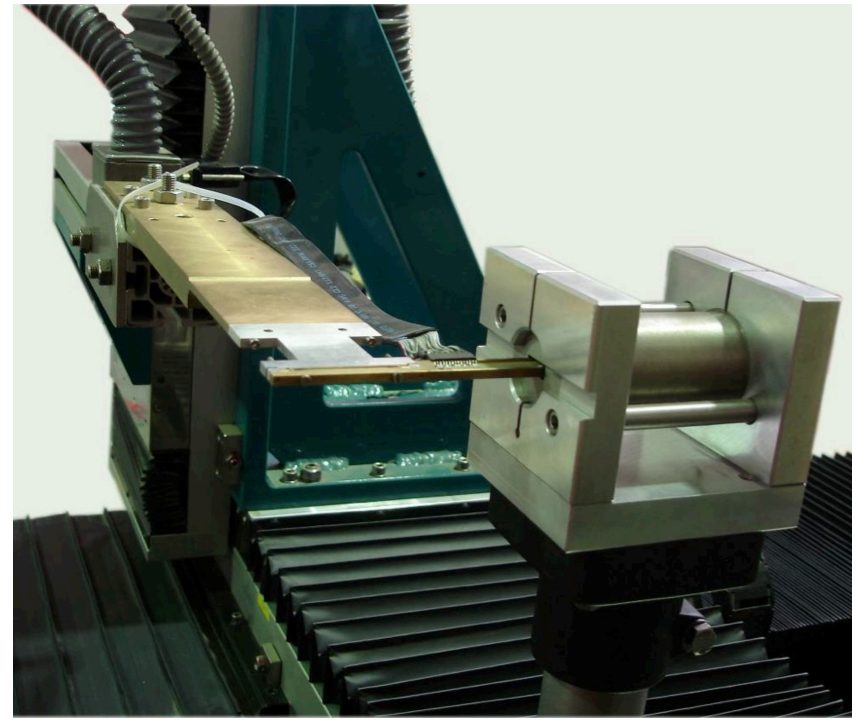
5 NMR probes: |B|= 500 Gauss–2.1 Tesla

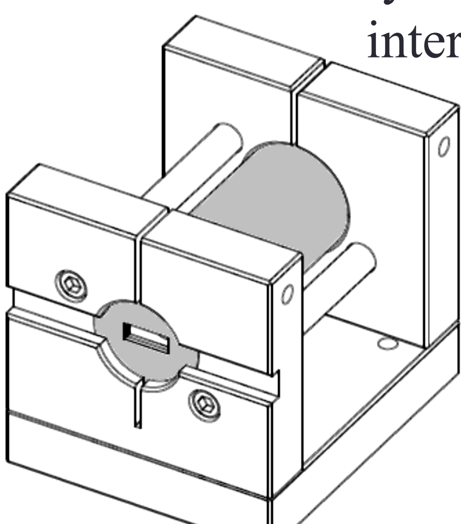
Fluxgate probe: |B|< 150 Gauss

Dipôles : Protocole de mesures

2) Calibration de l'offset des 3 capteurs avec une chambre à double paroi en μ-métal







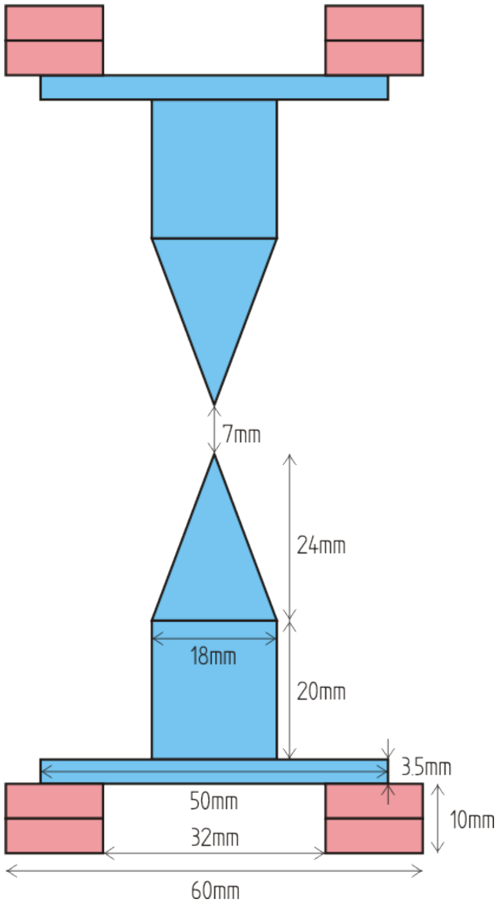
Selected material:

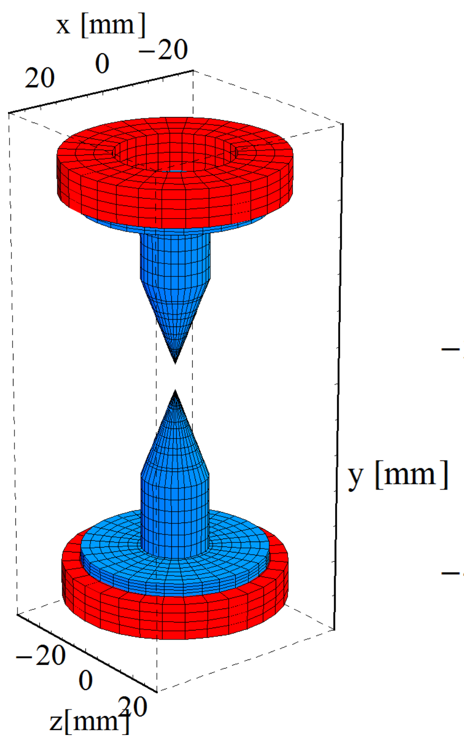
80%Ni-Fe μ-metal from ***Amuneal Manufacturing Corp.*** in the form of 0.062″=1.575 mm thickness sheets

Dipôles : Protocole de mesures

3) Détermination de la position des éléments sensibles de la sonde Hall

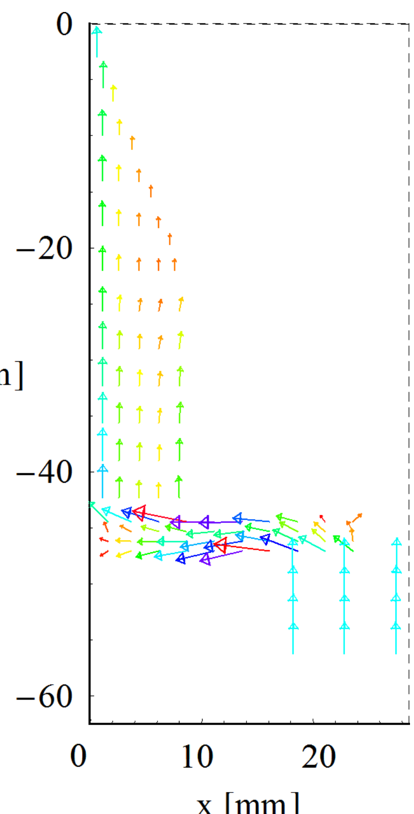
Basé sur le design de SLAC, Ref. LCLS-TN-05-10



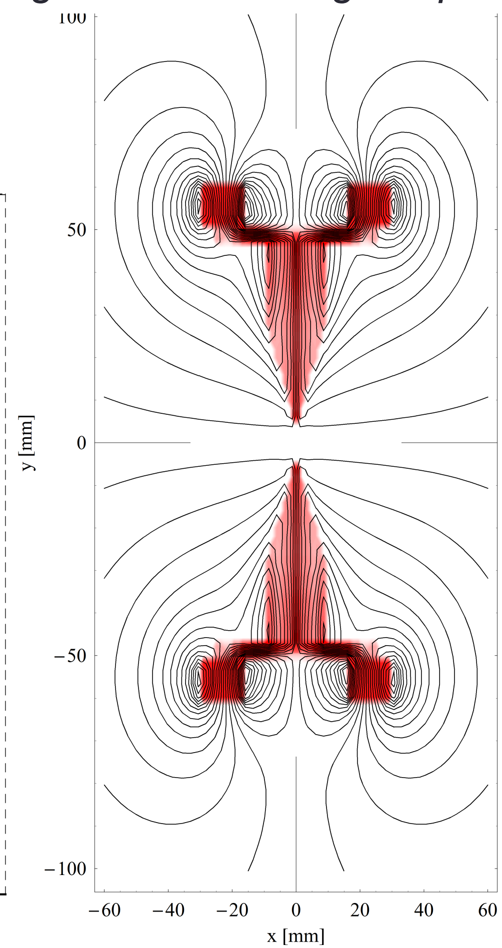


RADIA model

Magnétisation

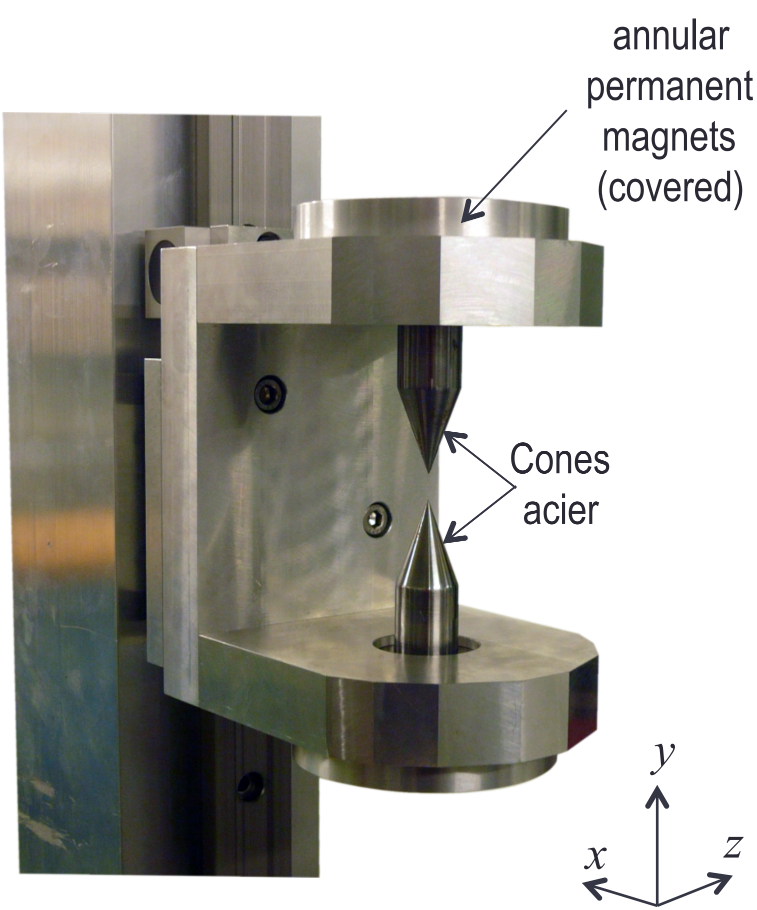


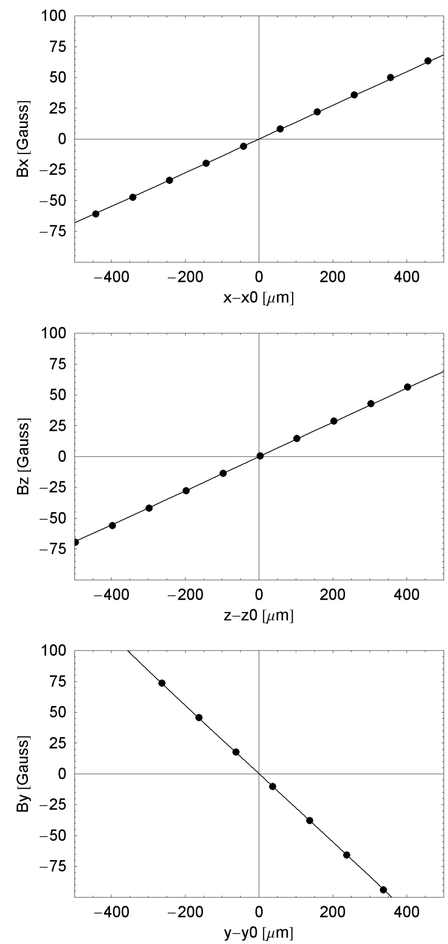
Lignes de flux magnétiques



Dipôles : Protocole de mesures

3) Détermination de la position des éléments sensibles de la sonde Hall





$$\frac{\partial B_x}{\partial x} = 14\mu T/\mu m$$

$$\frac{\partial B_y}{\partial y} = -28\mu T/\mu m$$

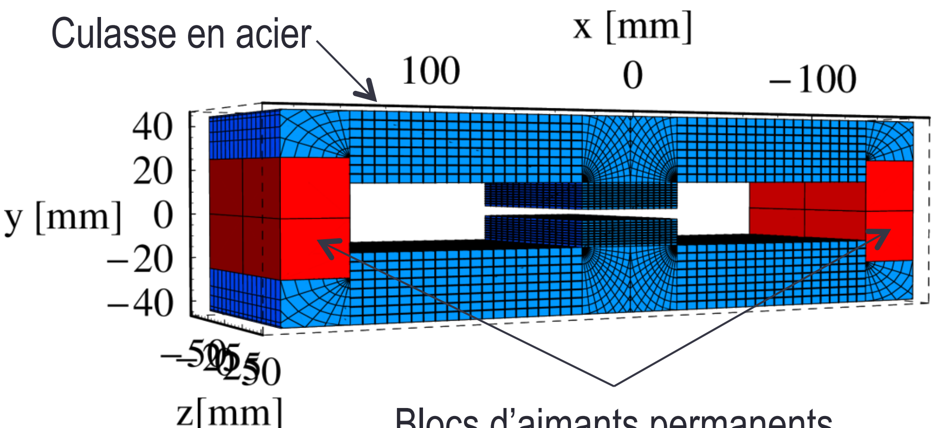
$$\frac{\partial B_z}{\partial z} = 14\mu T/\mu m$$

Une erreur de champ de **10µTesla** génère une erreur de positionnement **<1µm**

Dipôles : Protocole de mesures

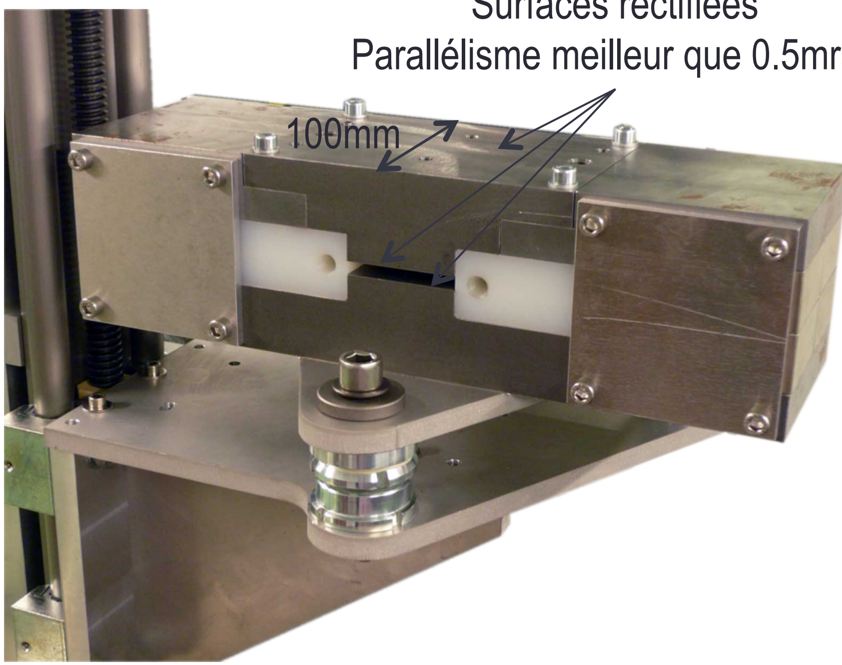
4) Détermination de l'orientation de la sonde Hall dans les 3 plans en fonction de la gravité

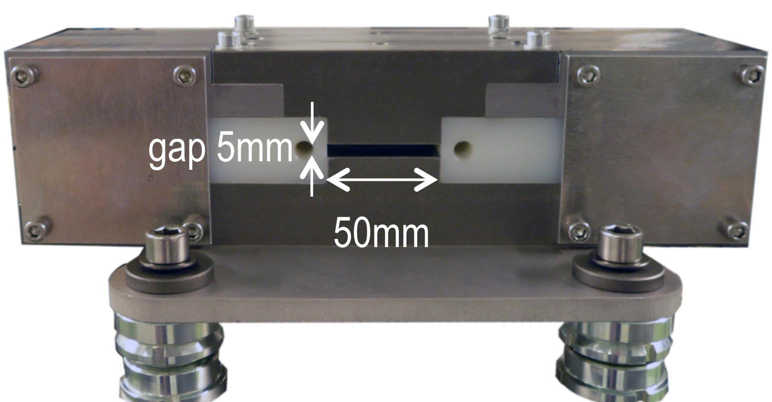
Culasse en acier



Blocs d'aimants permanents
(8 pièces, 25×30×50mm^3 chacun)

Surfaces rectifiées
Parallélisme meilleur que 0.5mrad

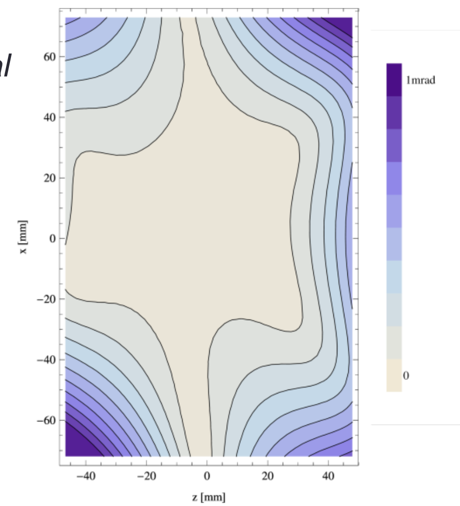




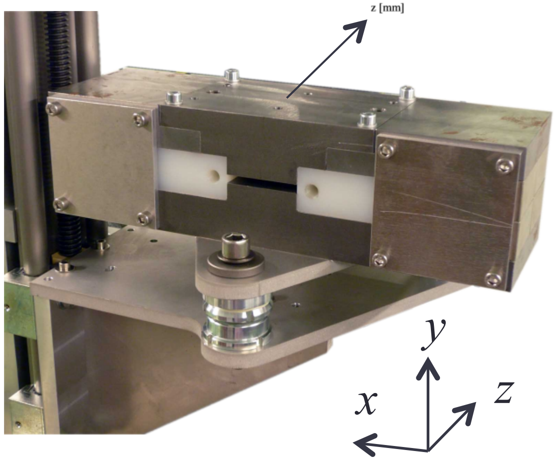
Dipôles : Protocole de mesures

Flatness check of reference top surface:

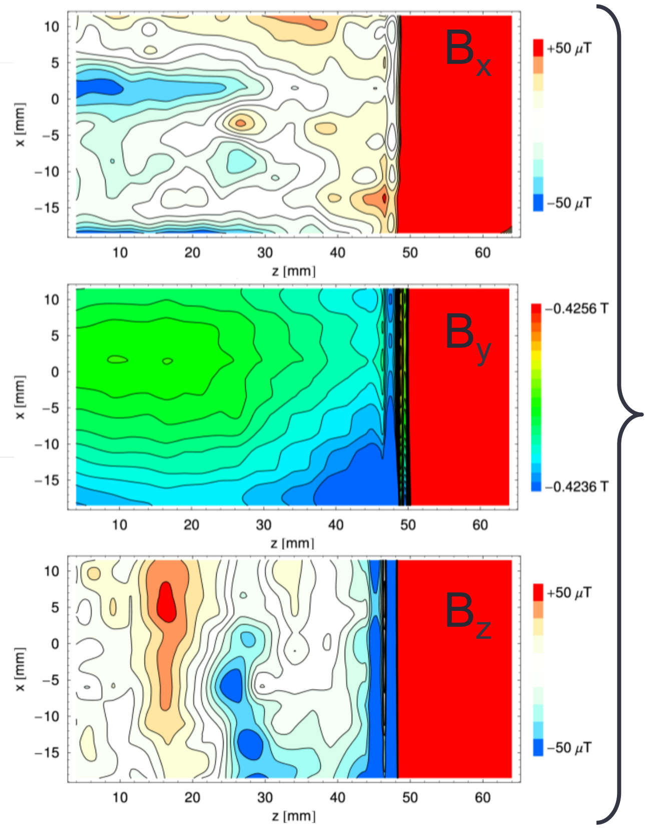
Polar angle of surface's normal vector



flatness within **0.2mrad** in the central region



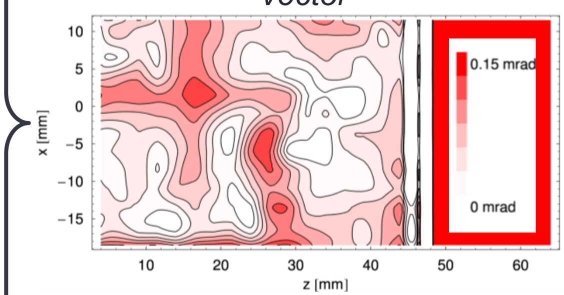
Field map in the central region:



Major component (B_y) homogeneous within **±0.5mT**

Minor components (B_x & B_z) smaller than **±0.05mT**

Polar angle of magnetic field vector

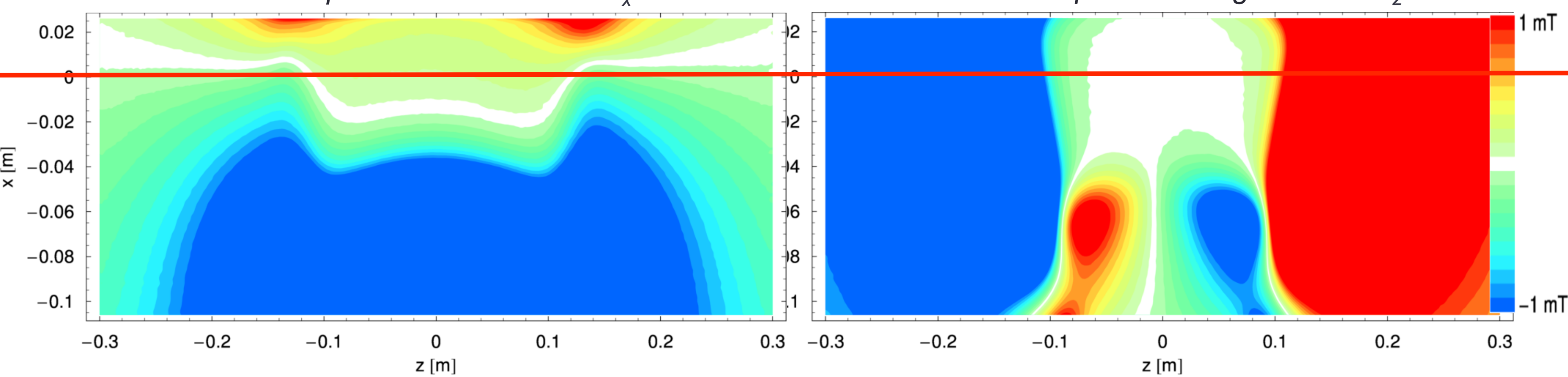


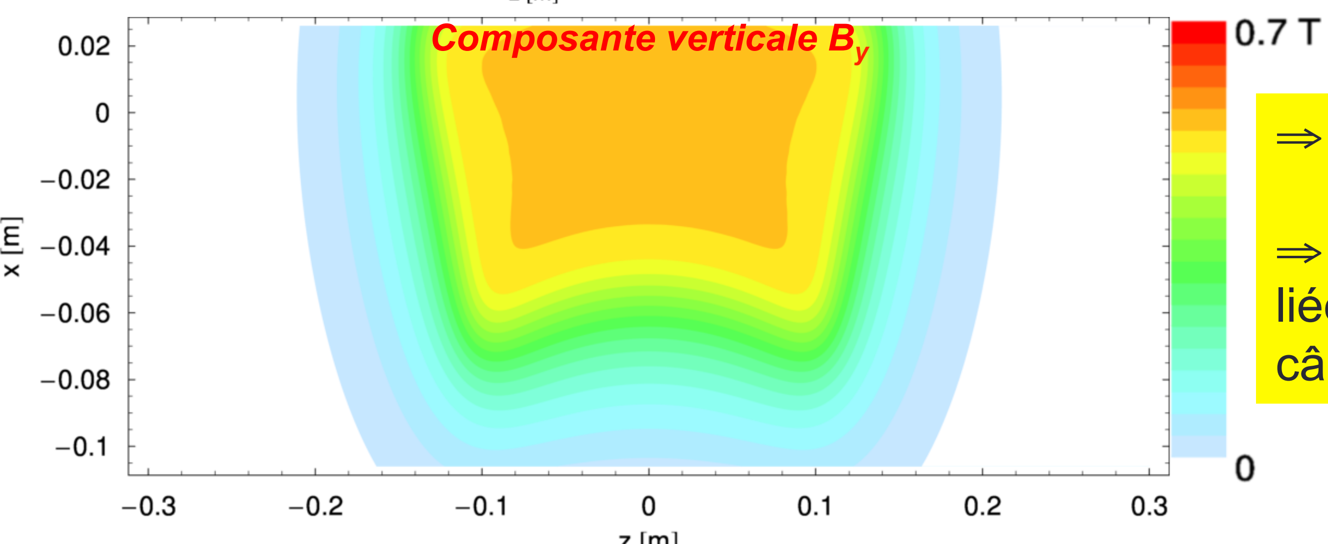
Magnetic field vector vertical within **0.15mrad**

Dipoles : Magnetic measurements

Mesures des cartes de champs => Composantes du champ magnétique à 200A du dipole #04 dans le plan médian

Composante horizontale B_x *Composante longitudinale B_z*

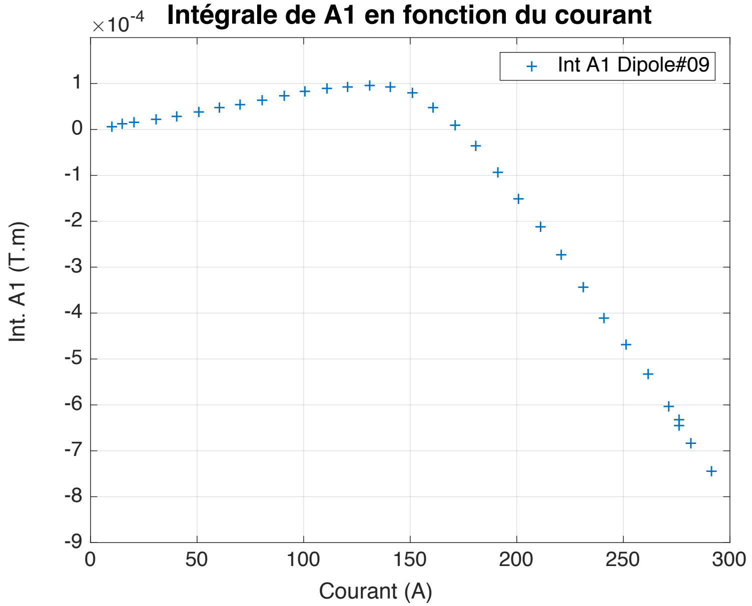


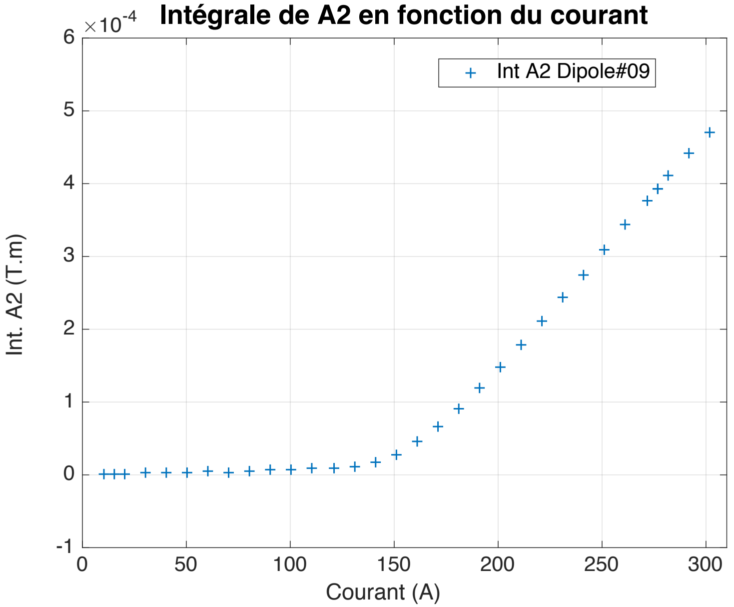


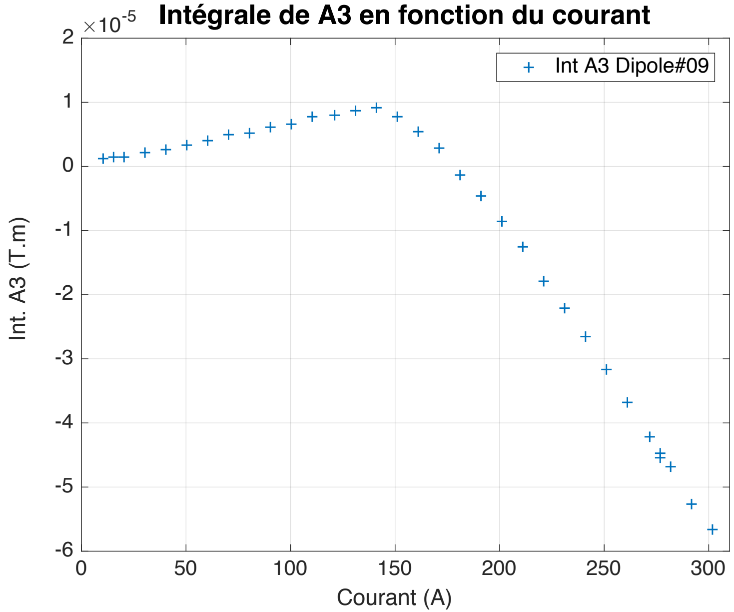
⇒ En théorie, dans le plan médian : $B_x = B_z = 0$
⇒ En pratique : $B_x = B_z \neq 0$ liée à la présence des câbles

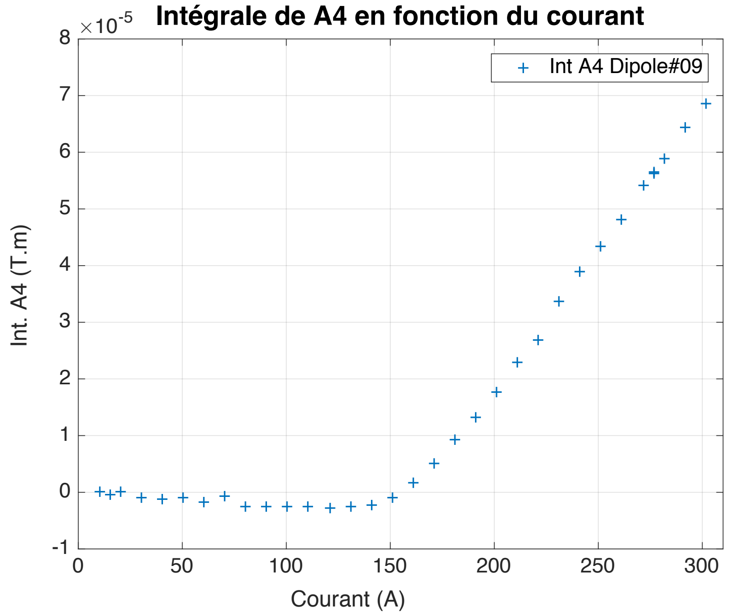
By est homogène

Dipole#09 : Magnetic measurements

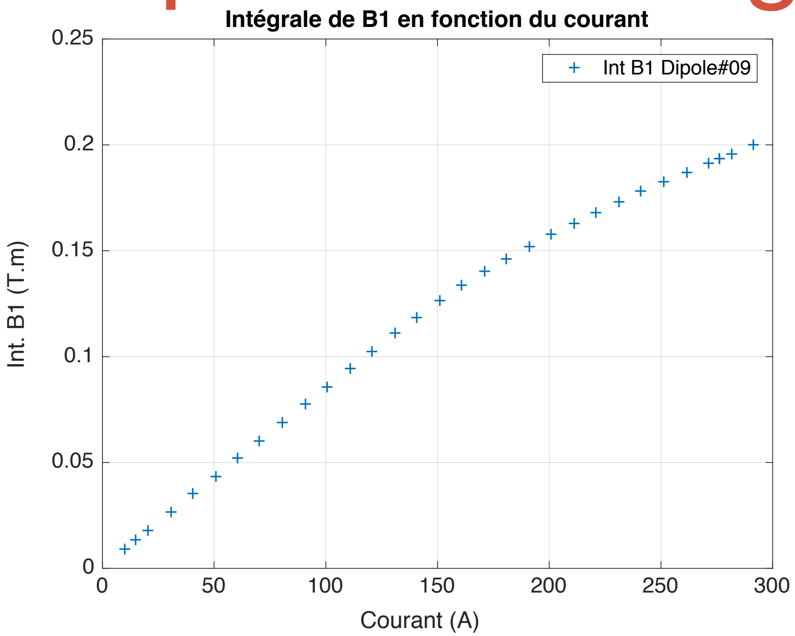


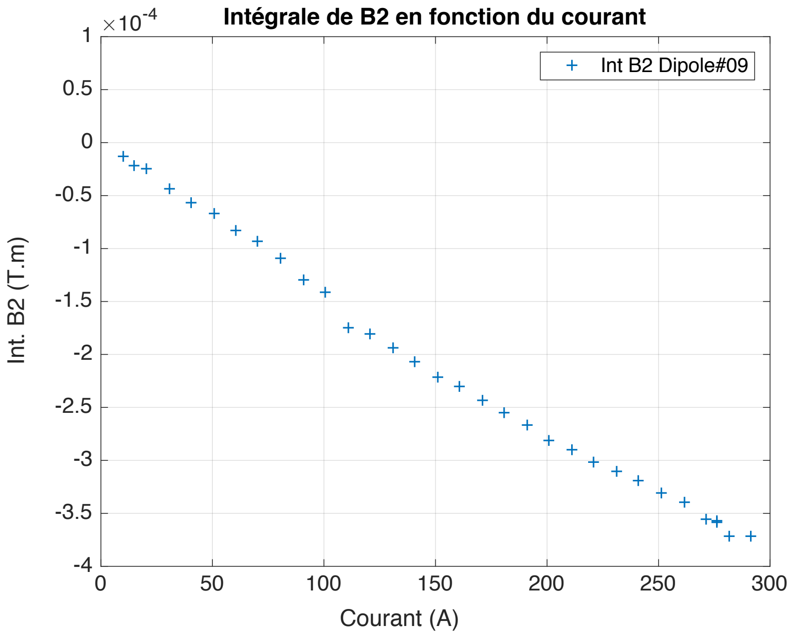


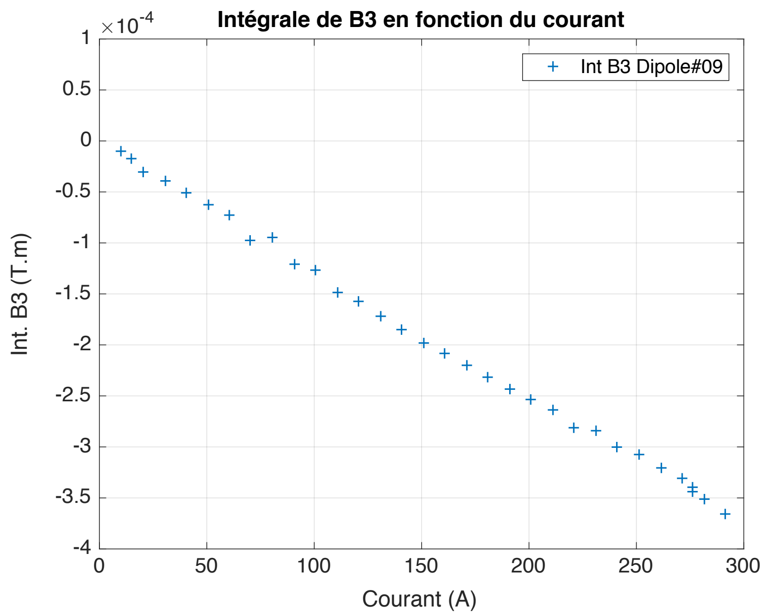


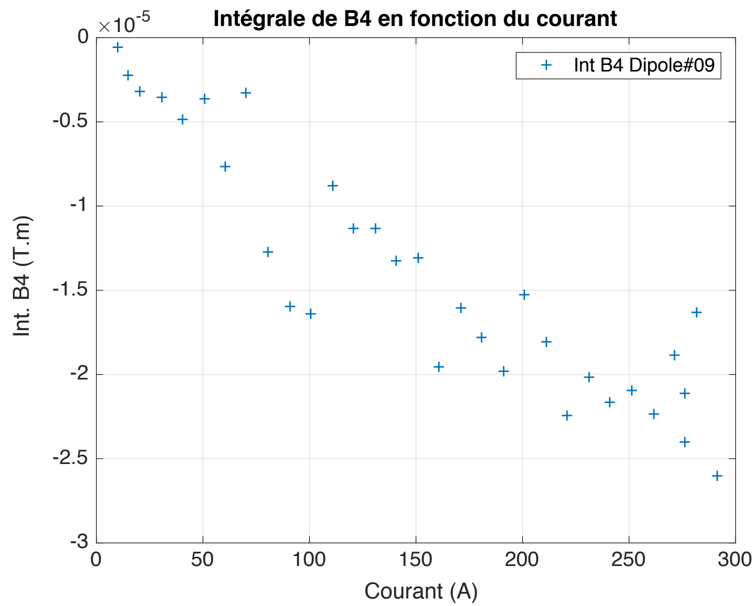


Dipole#09 : Magnetic measurements

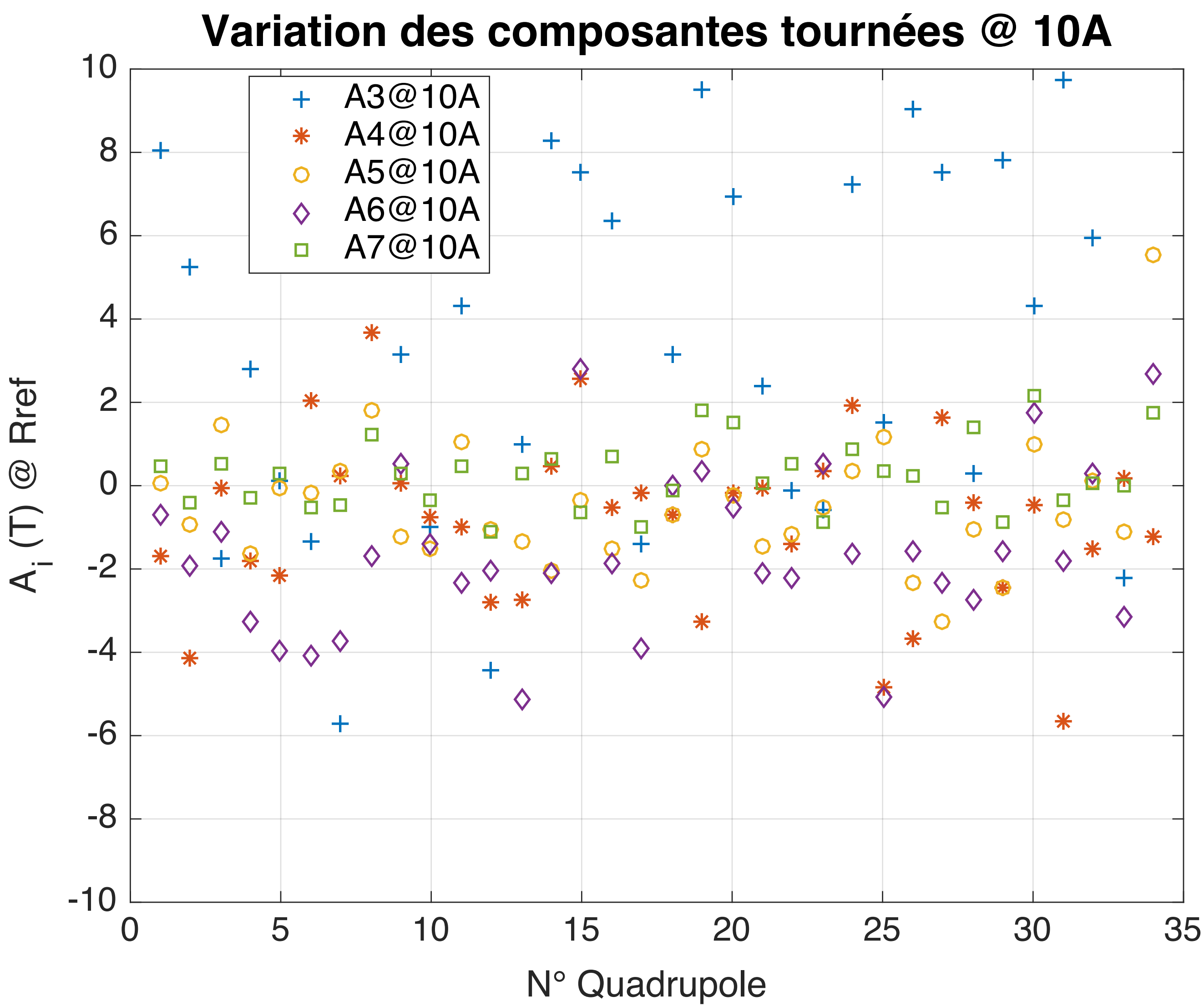








Qpôles : Mesures magnétiques



Moy_A3 = -2.81 unités
σ = 5.85 unités

Moy_A4 = -0.90 unités
σ = 2.09 unités

Moy_A5 = -0.45 unités
σ = 1.60 unités

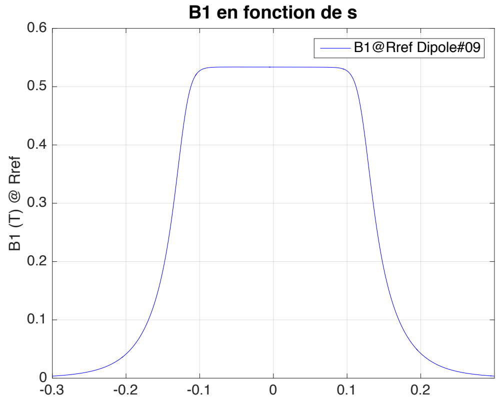
Moy_A6 = -1.62 unités
σ = 1.95 unités

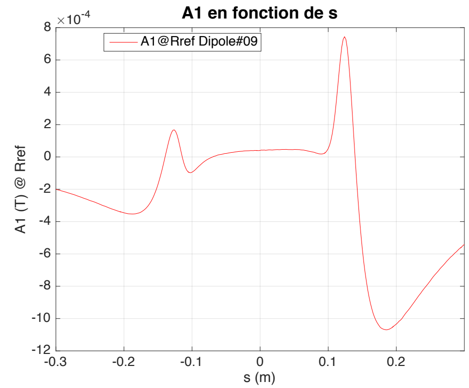
Moy_A7 = 0.24 unités
σ = 0.85 unités

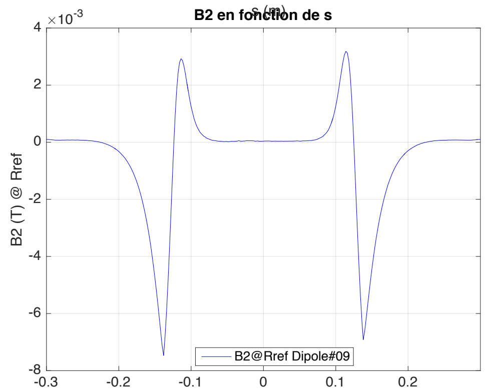
Dipole#09 : Magnetic measurements

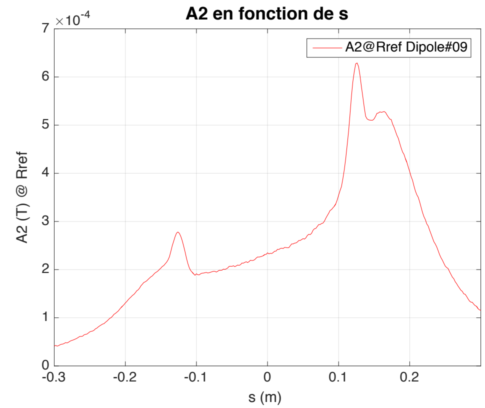
Multipoles along central trajectory

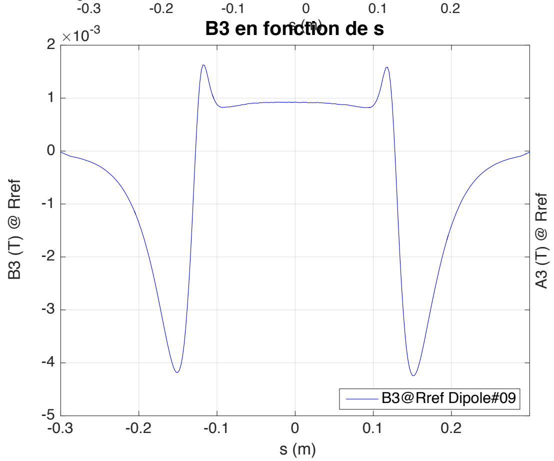
- **R_{ref}=20mm**
- Up to n=3 (sextupole) at **±24mm**

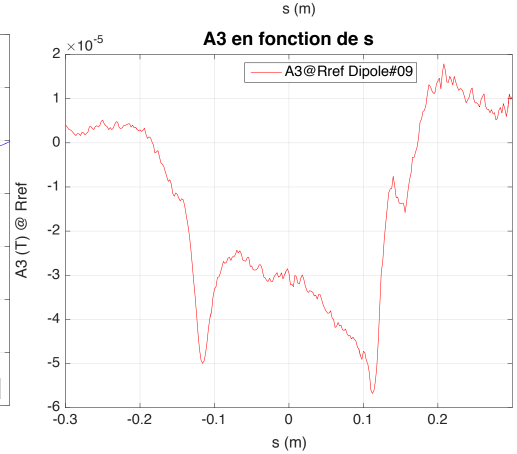


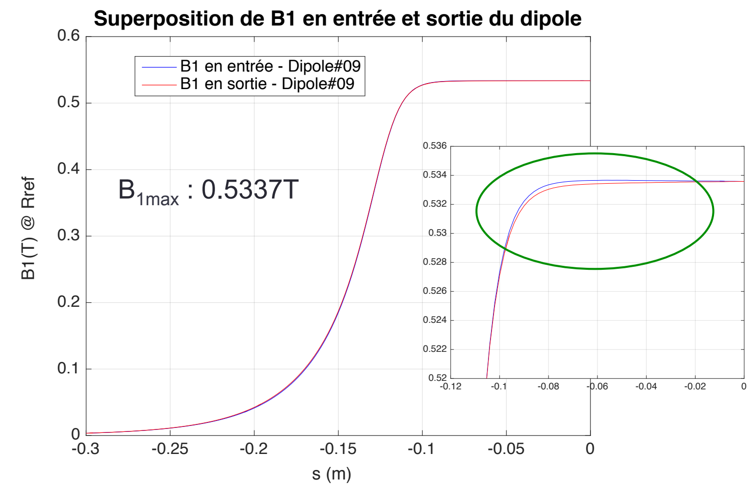


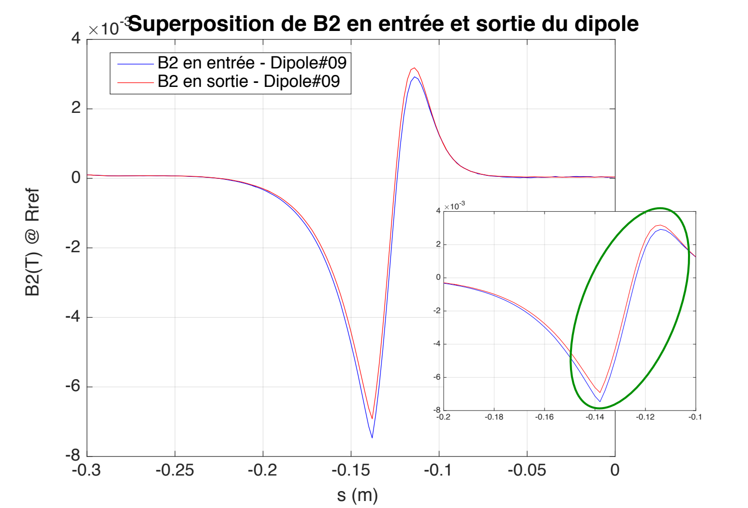




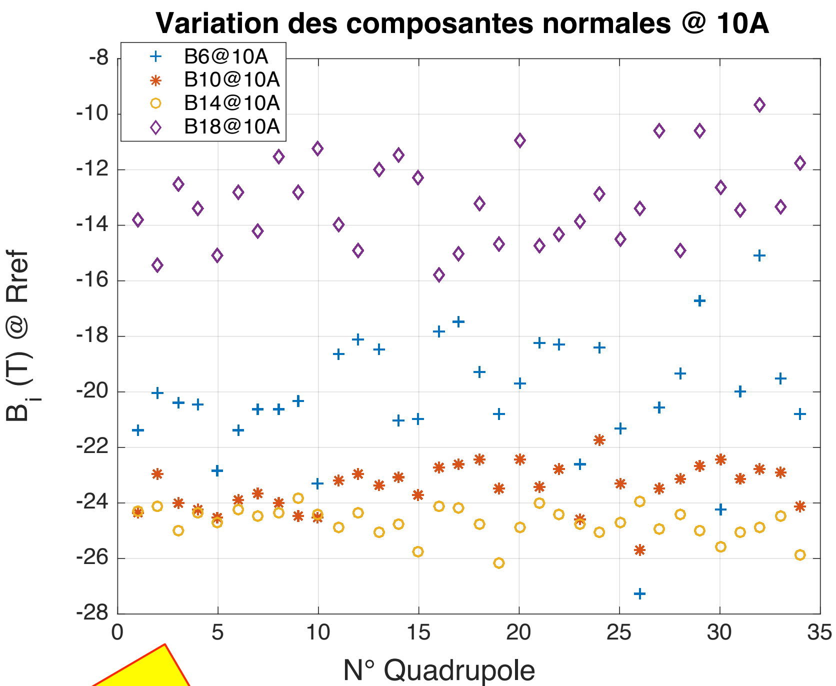








Qpoles : Magnetic measurements



Moy_B6 = -20.18 unités
σ = 2.23 unités

Moy_B10 = -23.43 unités
σ = 0.82 unités

Moy_B14 = -24.69 unités
σ = 0.54 unités

Moy_B18 = -13.17 unités
σ = 1.54 unités

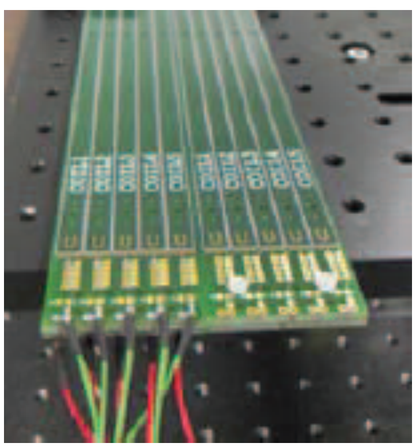
35 Qpoles

I(A)	Moyenne B(T.m)	ecart-type	Abs(ecart-type/ moyenne)
12	8,91E-01	1,16E-03	1,30E-03
10	7,50E-01	9,07E-04	1,21E-03
8	6,04E-01	7,44E-04	1,23E-03
6	4,56E-01	6,26E-04	1,37E-03
4	3,07E-01	5,26E-04	1,71E-03
2	1,58E-01	4,60E-04	2,91E-03

→ Ecart-type < 0.2 G.m

Qpoles & Sxpoles : Set-up of measurements

Dimensions du banc :
Support PCB de 40mm contenant 5 bobines radiales; une bobine principale et 4 bobines de compensation
Détermination de l'axe de rotation : ±25 µm en x et en z; 60 µrad en tilt selon les valeurs des cales fabriquées
Positions des cales en x et en z
Répétabilité de l'harmonique principal : 1.10-4
Répétabilité des ordres supérieurs à l'ordre 15 > 0.1%



Précision globale de positionnement ±50µm

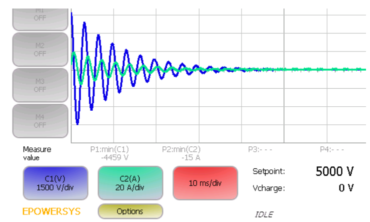
Dispersion 17µm/43µrad

Précision globale de mesures < 1.10-4 T dans la gamme de 0-2T
avec une répétabilité < 0.5 10-4 T

Qpoles : Protocole de mesures

Manipulation, inspection visuelle & installation dans le Hall de mesures

Tests électriques
- Vérification de la résistance
- Vérification de l'inductance
- Vérification de l'isolation
- Vérification de l'isolation entre-bobines
- Vérification des thermoswitches



Alignement and fiducialisation

Caractérisation magnétique

1 jour / quadrupole

Caractérisation magnétique
- Mesure de l'offset de l'intégrateur
- Cyclage de l'aimant
- Mesure du contenu harmonique à 10A
- Cyclage
- Mesure du contenu harmonique à 10A

Mesures du contenu harmonique jusqu'à n=31 @ I_i, i=+12A à 0A par pas de 2A, et @ **Rréf=20mm**
(1 jour)

Rotation Qpole 180°

Mesures du contenu harmonique jusqu'à n=31 @ I_i, i=+12A à 0A par pas de 2A, et @ **Rréf=20mm**
(1 jour)

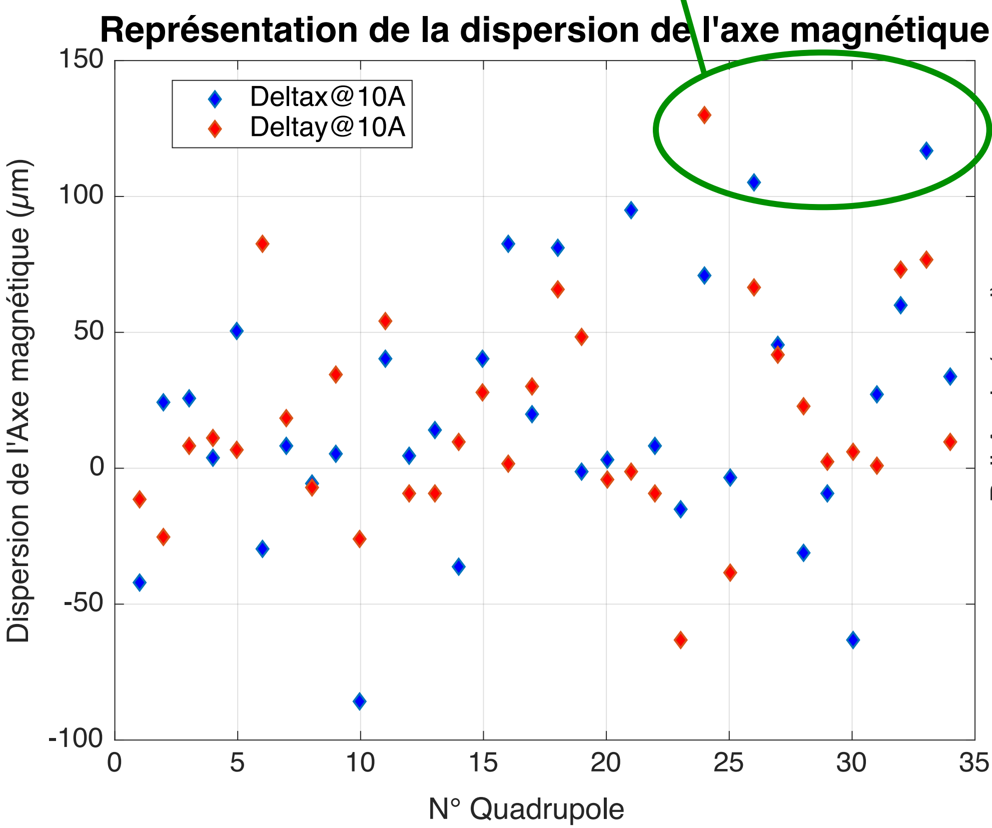
Détermination de l'axe magnétique (Δx et θ)

Qpoles : Magnetic measurements

Magnetic axis

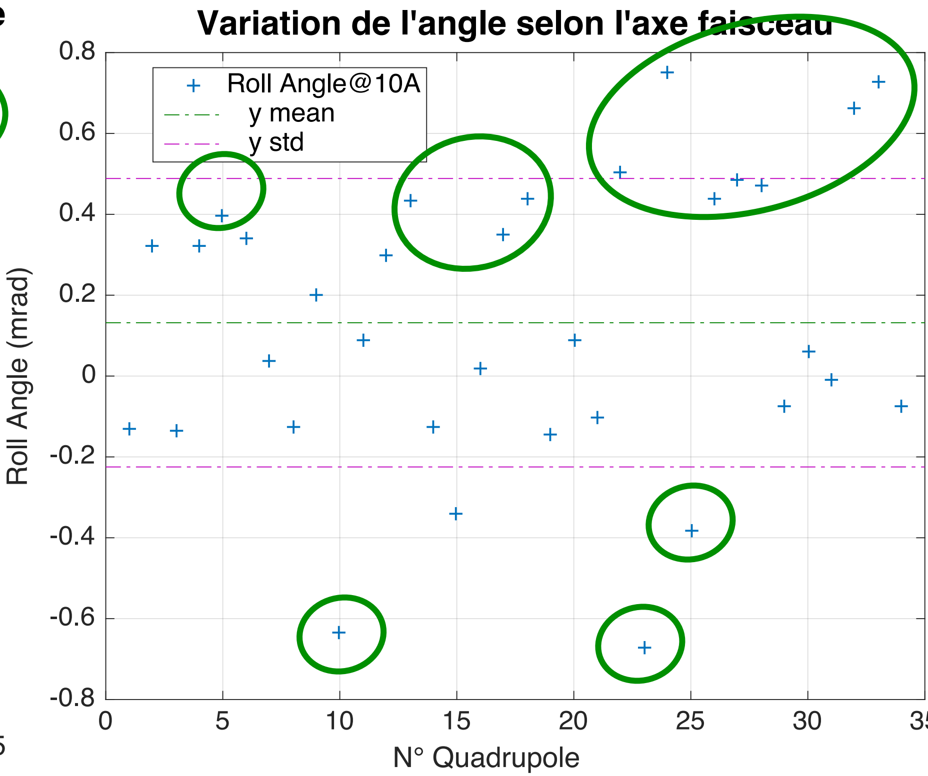
(spec <±100µm)

3 Qpoles hors tolérance
QP_24; QP_26; QP_34



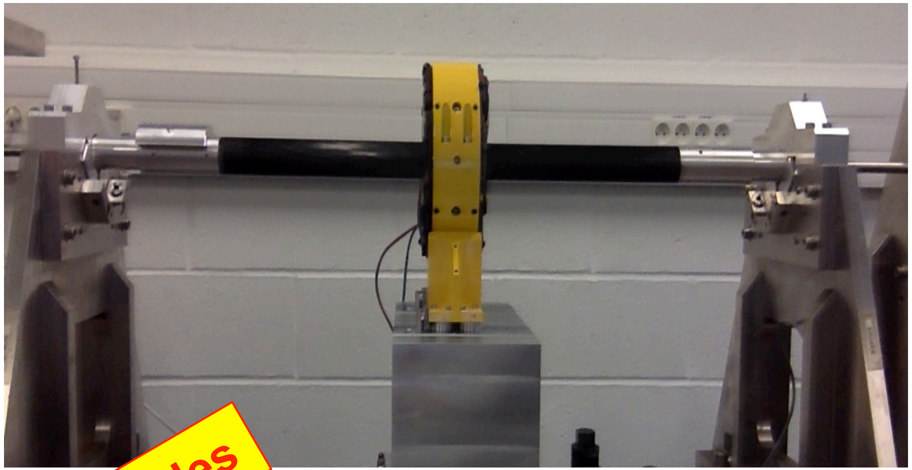
Roll Angle

(spec <±300µrad)



Moyenne = 0.1319 mrad
σ = 0.3567 mrad

Sextupoles : Magnetic measurement



12 Sxpôles

I(A)	Moyenne B3(T.m)	ecart-type	Abs(écart-type/ moyenne)
12	1,14E-03	1,87E-05	1,64E-02
10	9,63E-04	1,61E-05	1,67E-02
8	7,80E-04	1,33E-05	1,70E-02
6	5,93E-04	1,04E-05	1,75E-02
4	4,04E-04	7,48E-06	1,85E-02
2	2,14E-04	4,63E-06	2,16E-02

Ecart-type < 0.2 G.m