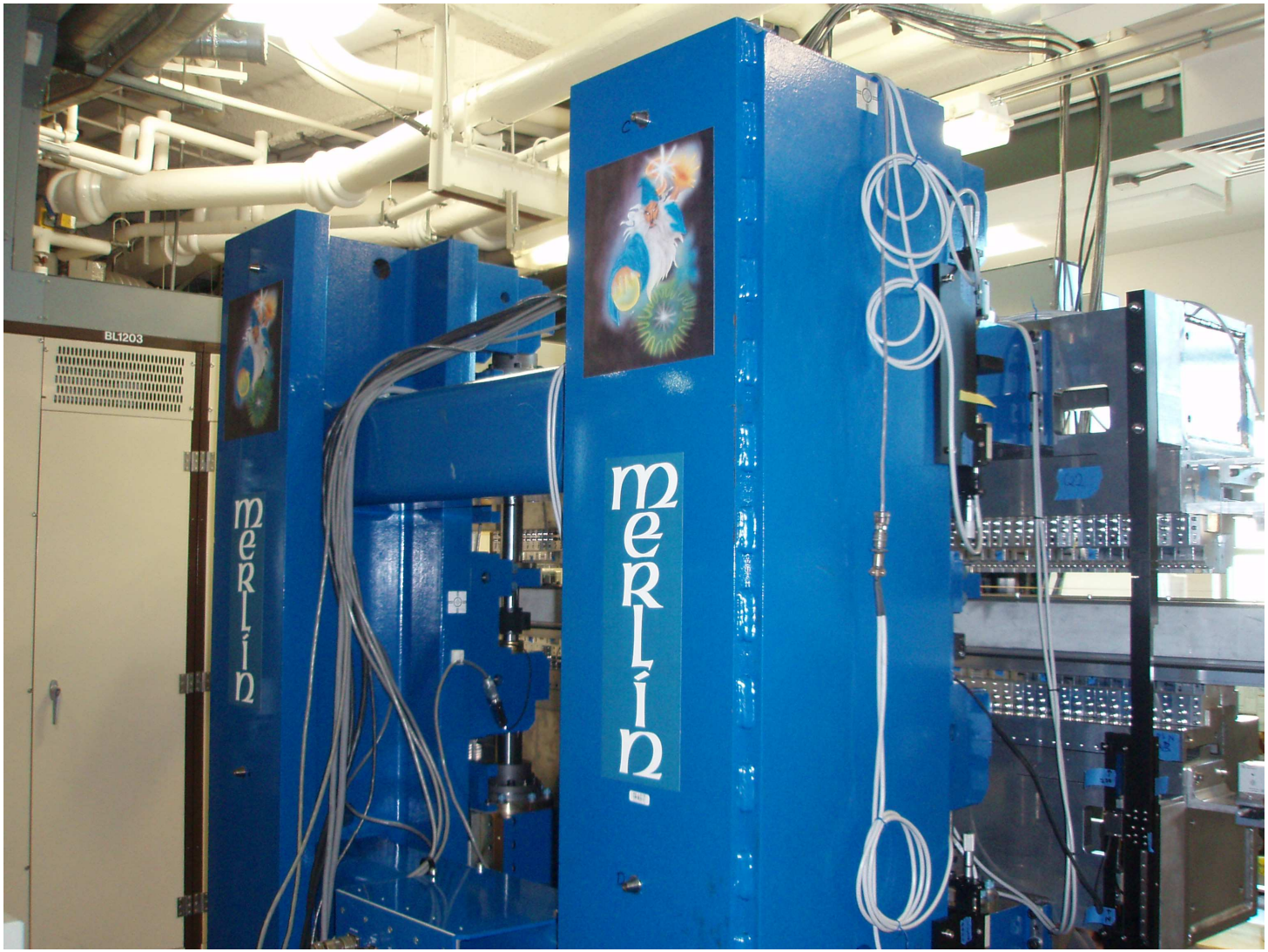
Magnetic Measurements of the new Apple II type EPU for the ALS MERLIN Beamline

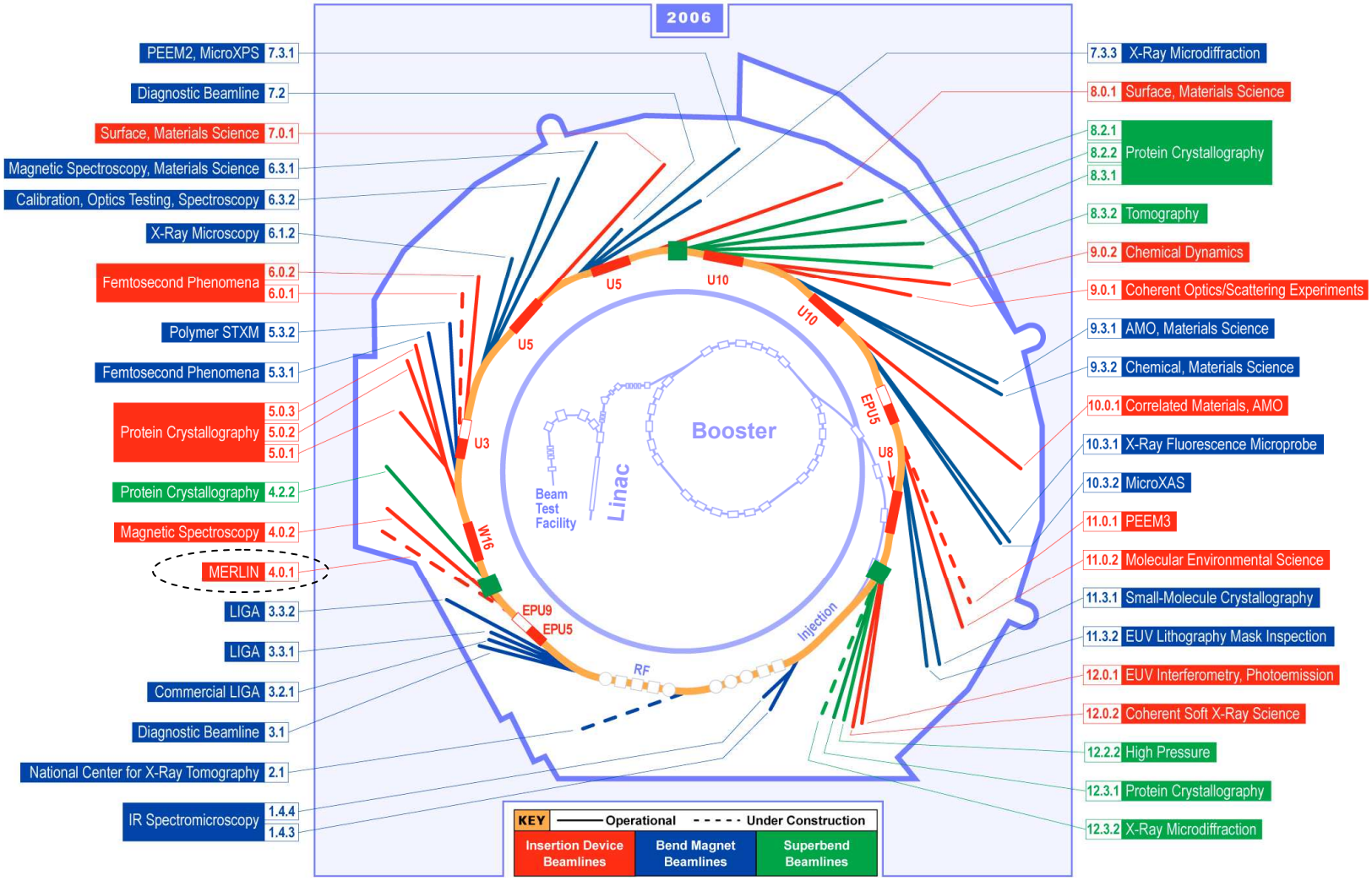


A. Madur, S. Marks, S. Prestemon, R. Schlueter

Content

Advanced Light Source (1)

1.9 GeV, 41 Beamlines



Advanced Light Source (2)

Before Top-Off

- Injection at 1.5 GeV and then ramp
- Inject with insertion devices open
- Average beam current is 250 mA
- Vertical emittance is 150 pm rad
- Lifetime is 8 hours at 400 mA
- Injection period every 2 to 8 hours
  - 1 Hz injection for 4 minutes
    - From 200 to 400 mA
- Photon shutters are closed during injection

After Top-Off

- Full energy injection (1.9 GeV)
- **Inject with insertion devices closed**
- Average beam current is 500 mA
- Vertical emittance is 30 pm rad
- Lifetime is about 3 hours at 500 mA
- Injection period about every 30 seconds
  - 1 pulse
    - From 498.5 to 500 mA
- Photon shutters remain open during inj.

MERLIN: Milli-Electron volt Resolution beamLINe

Beamline Requirement:

- Ultra-high energy resolution from ~10eV to 150eV (~1meV resolution up to 100eV)
- Polarization control (linear + circular)
- Dual operation modes: high-resolution (HR) and high-flux (HF) modes

Purpose:

To better understand the strong electronic correlation effects in materials

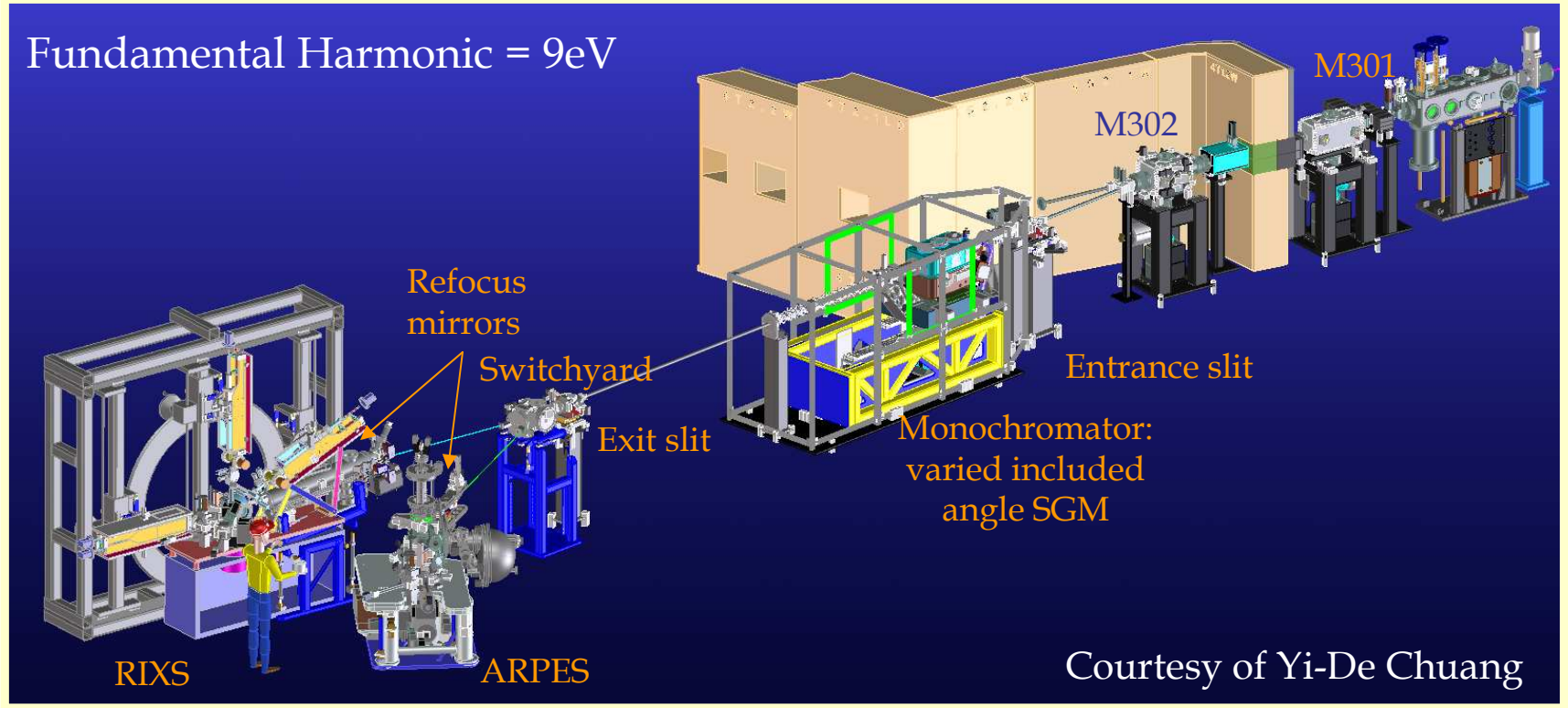
Proposed probes:

How quasiparticles retain their properties? **ARPES** = **A**ngle-**R**esolved **P**hoto**E**mi**S**sion

How quasiparticles loose their properties? **RIXS** = **R**esonant **I**nelastic **X**-ray **S**cattering spectroscopy

Courtesy of Yi-De Chuang

MERLIN: Beamline Layout



At low energy, monochromators cannot filter 3rd and 5th harmonics (27 eV & 45 eV).

They have to be cancelled upstream i.e. right at the light source = the undulator

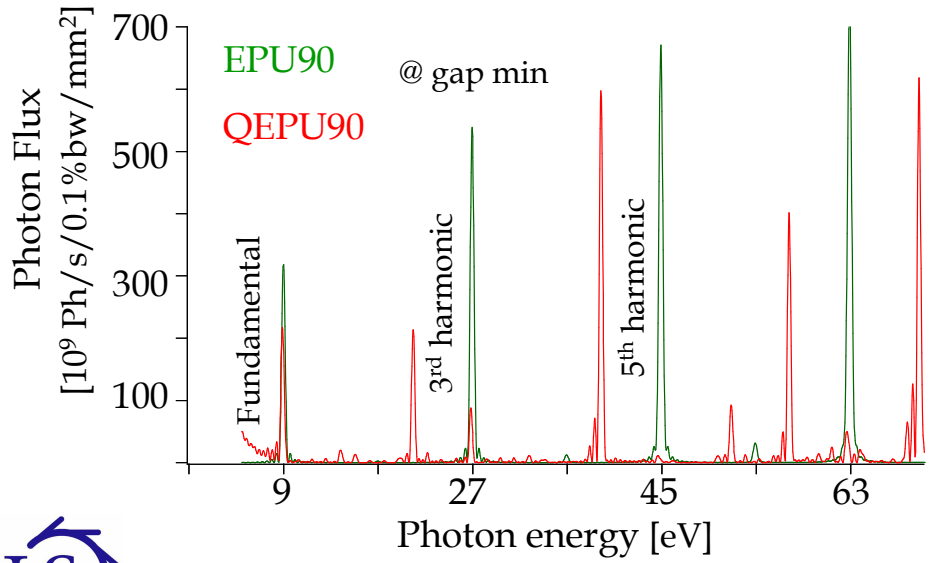
MERLIN EPU Magnetic Design : 2 main features (1)

"Quasi" periodicity (introduced by Sasaki) :

-In the case of low energy undulator, monochromators are unable to distinguish integer multiple of the fundamental (Here 3rd and 5th).

- Optimized spectral properties by varying parameters:
  - * interlattice ratio
  - * block strength.

- Varying vertical blocks rather than horizontal
  - *More effective at generating anharmonic spectrum.



Quasi periodic blocks

MERLIN EPU Magnetic Design : 2 main features (2)

Dynamic ticklers:

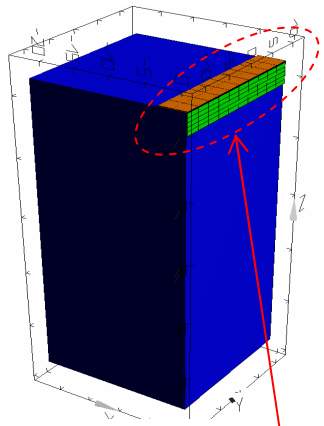
Beam Dynamics issue= EPU fields reduce the dynamic aperture of the beam.

- Especially harmful in Top-off mode operation (=Injection with a closed EPU)
- These effects are polarization mode dependent.

Dynamic multipoles cannot be seen by classic integral measurement.

(Need particle tracking analysis to be quantified)

Idea (first proposed at the ESRF) = Introduce passive correction by adding sheets of iron called here "Dynamic Ticklers".



Dynamic ticklers

MERLIN EPU Magnetic Design : General

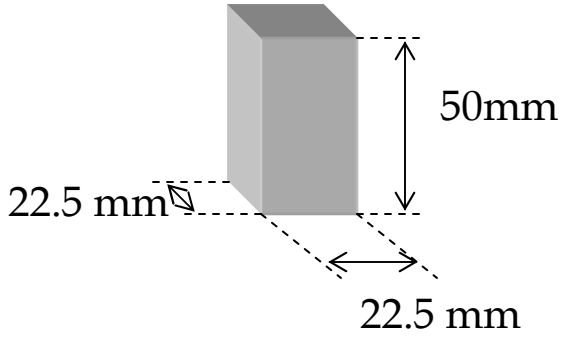
Nb period: 19

Period Length: λ = 90mm

Undulator length: 1.85m

Minimum gap: 15 mm

Magnet Material: NdFeB



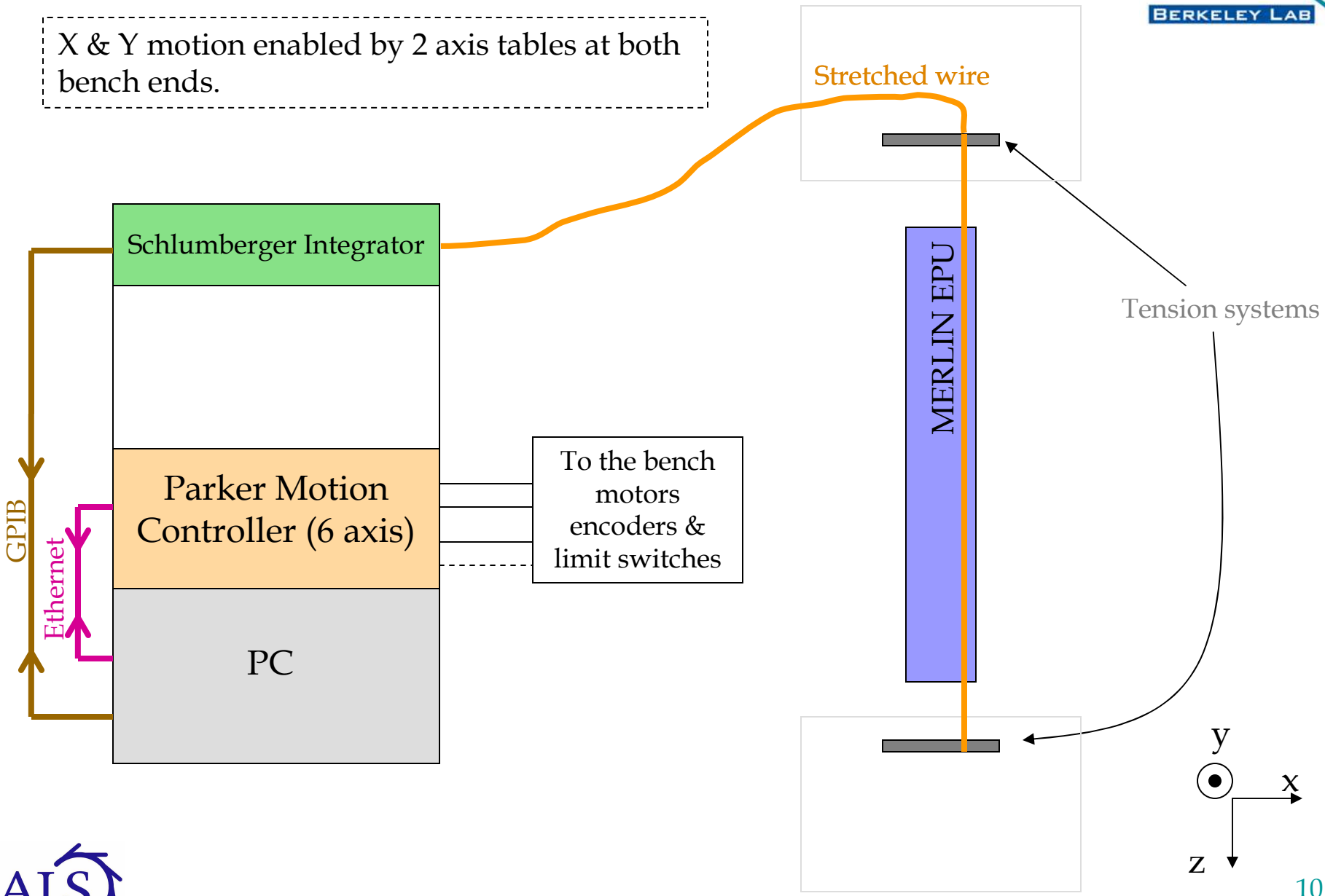
Magnetic structure : Halbach periodic structure with 12 "Quasi" periodic blocs per quadrants.

"Quasi" periodic blocks are shorter : height=42mm

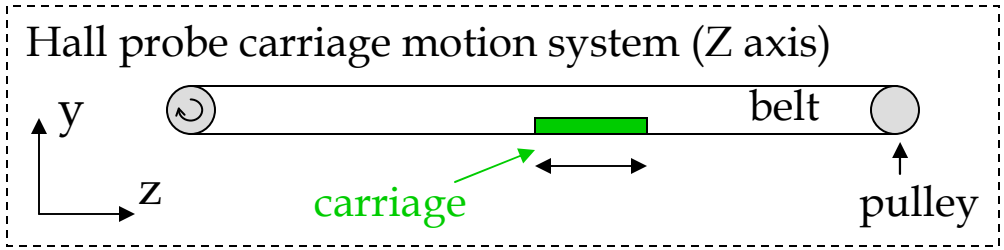
Simulations performed with Radia (initially developed at ESRF France)

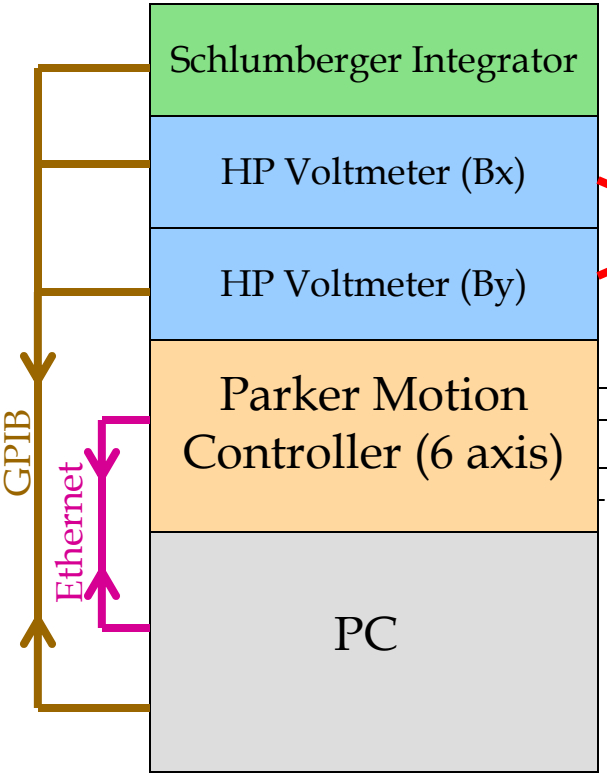
Magnetic Measurement Bench Configuration: Integral Measurements

X & Y motion enabled by 2 axis tables at both bench ends.



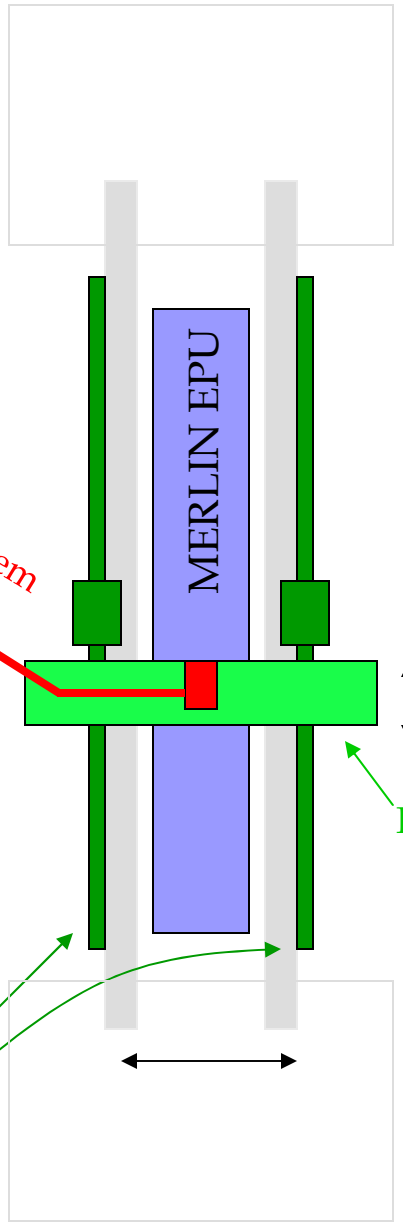
Magnetic Measurement Bench Configuration: Hall Probe



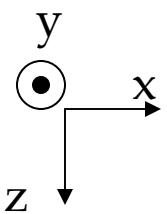


To the bench motors encoders & limit switches

Hall probe system (2 axis)



X & Y motion enabled by 2 axis tables at both bench ends.

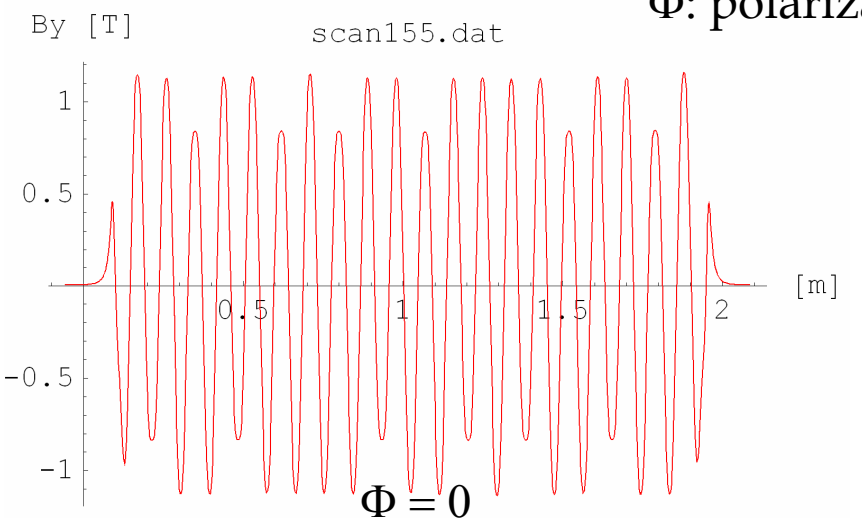


Magnetic Measurement Bench

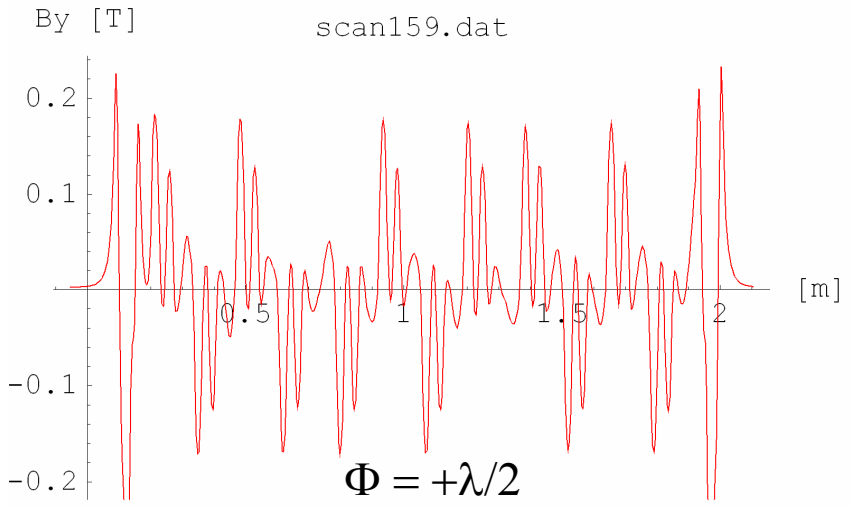
Only Q1 & Q3 are moving along z

Hall Probe Measurements

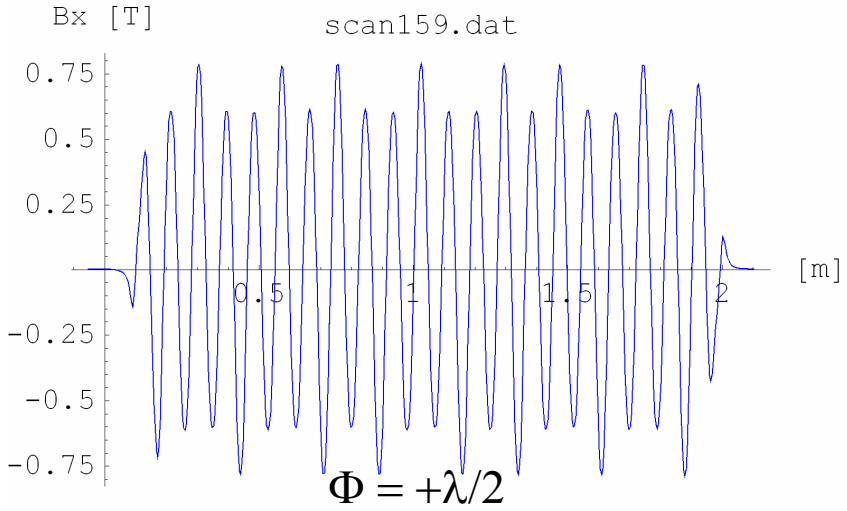
Φ: polarization phase



$\Phi = 0$



$\Phi = +\lambda/2$

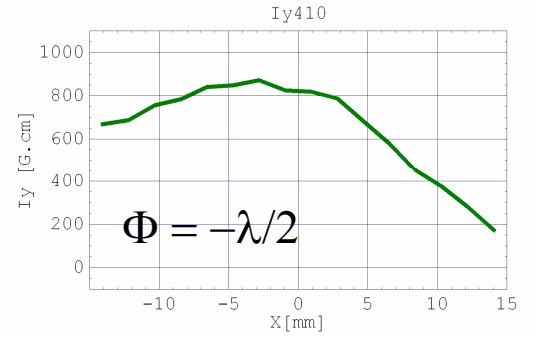


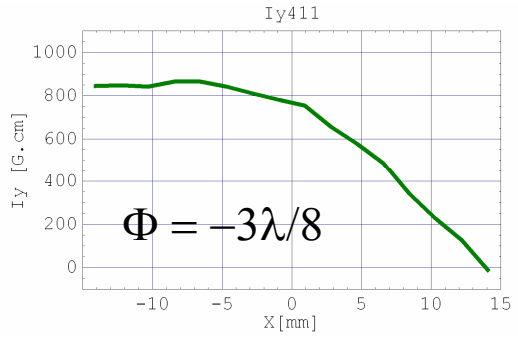
$\Phi = +\lambda/2$

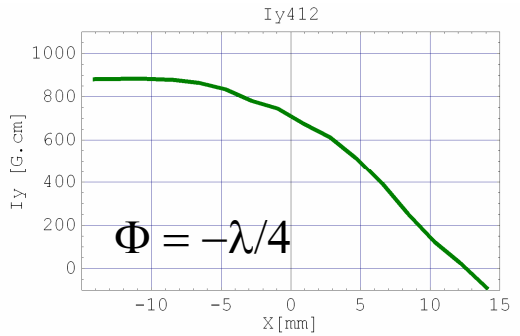
Accuracy= 1%, Step by Step : Every 4mm

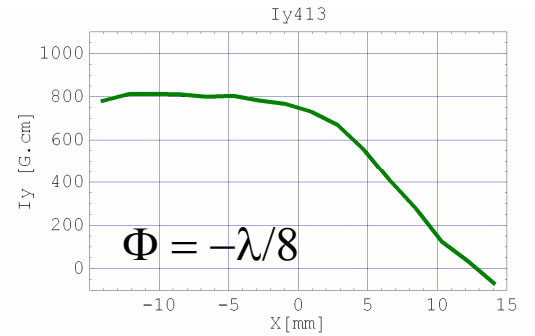
Integral Measurements: Vertical Component

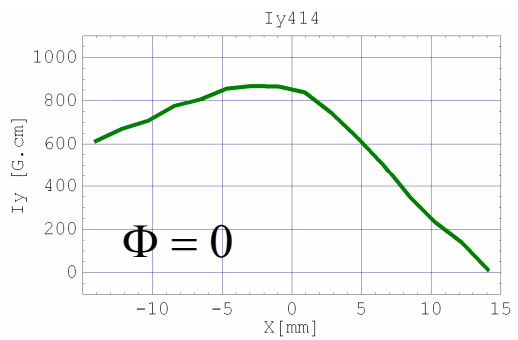
$$I_y = \int_{-\infty}^{+\infty} B_y \, dz$$

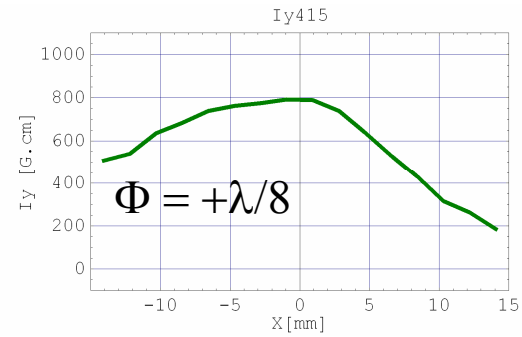


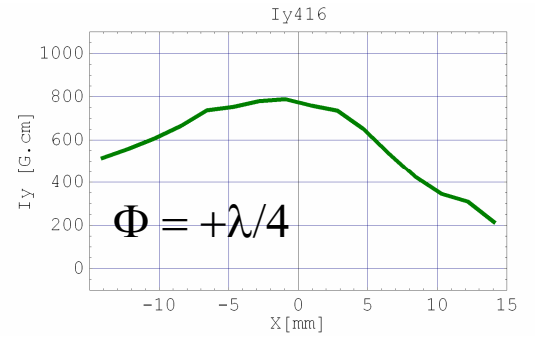


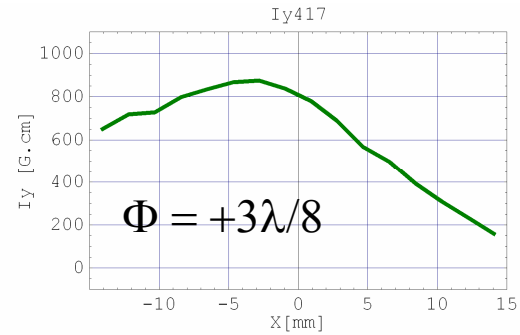


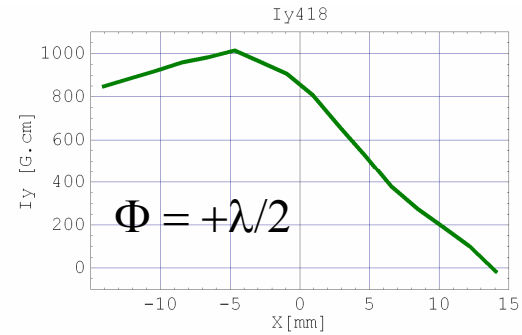








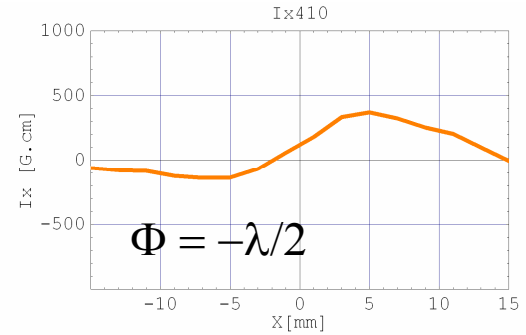


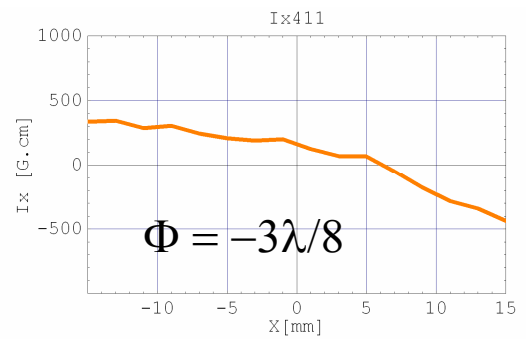


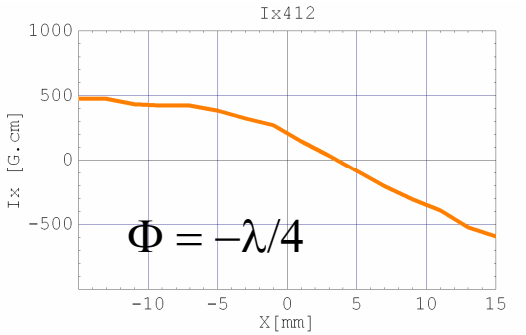
Main offset can be corrected by shimming (= magnet block displacement)

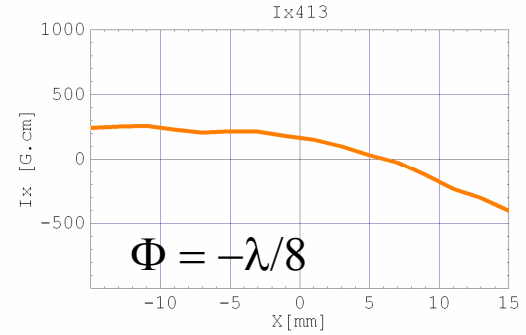
Integral Measurements: Horizontal Component

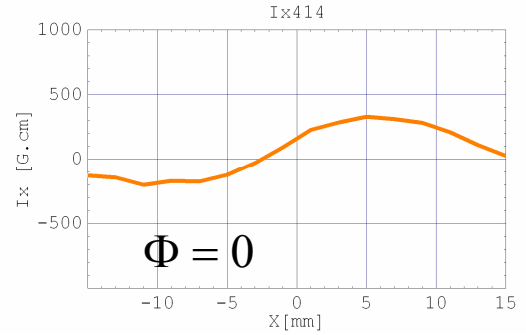
$$I_x = \int_{-\infty}^{+\infty} B_x \, dz$$

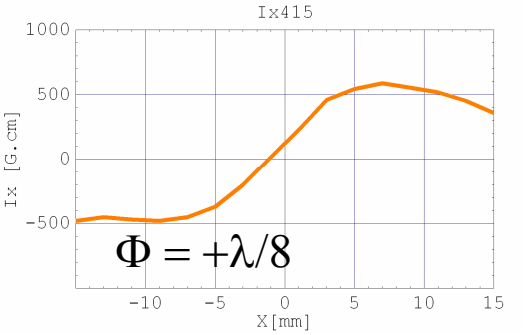


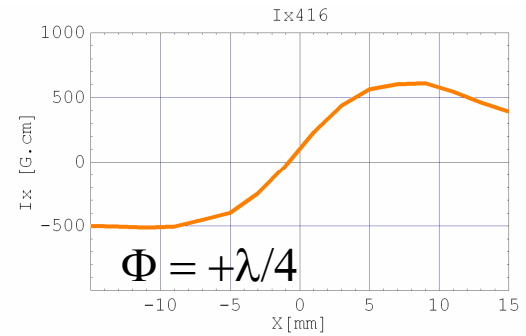


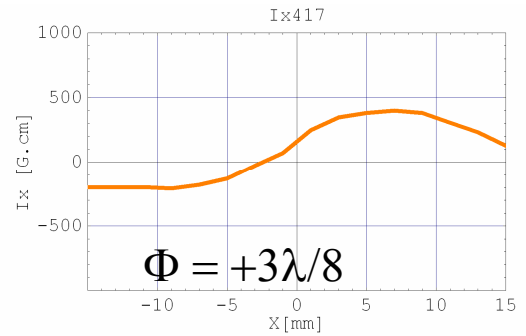


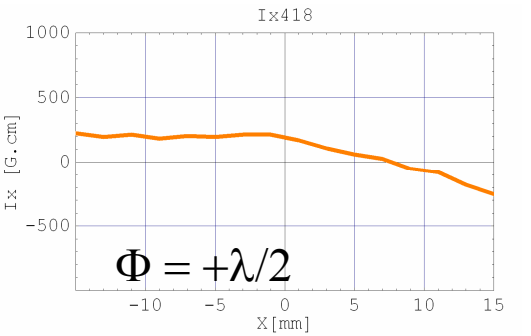










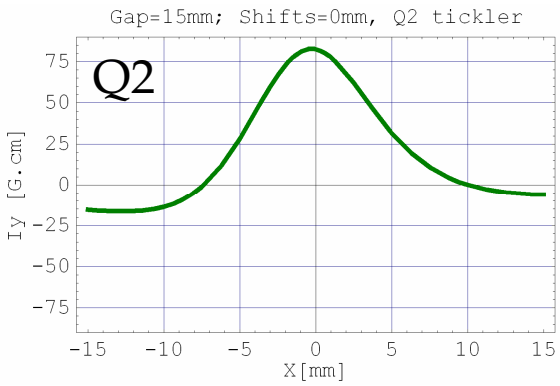


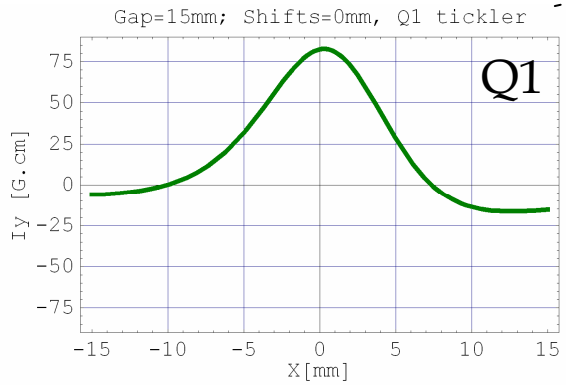
Ongoing investigations to understand Ix(Φ) evolution

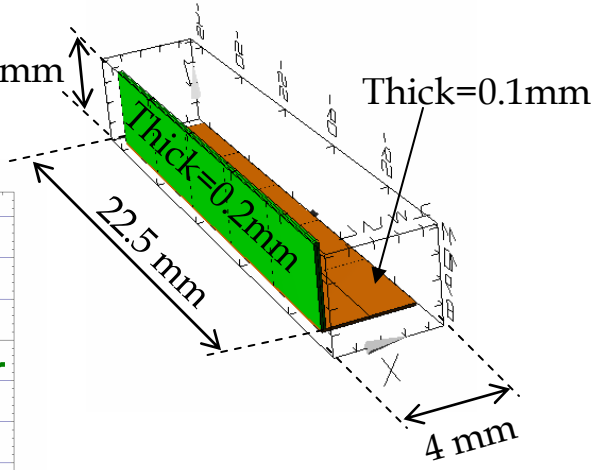
Signature of Dynamic Ticklers: Iy integral

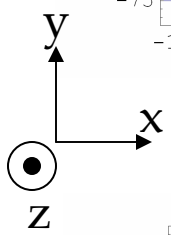
Integral effect of adding iron shim on **positive vertical blocks**

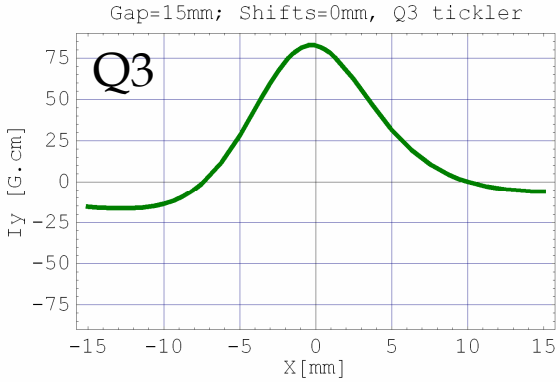
$\Phi = 0$

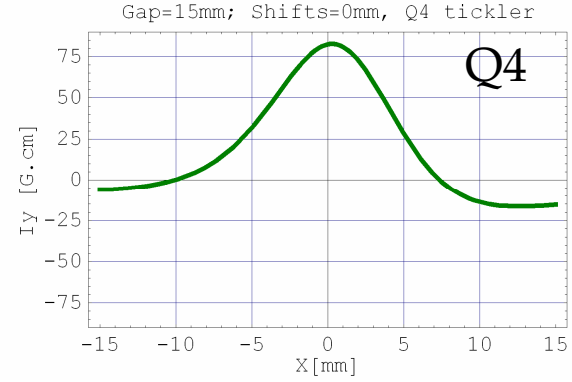


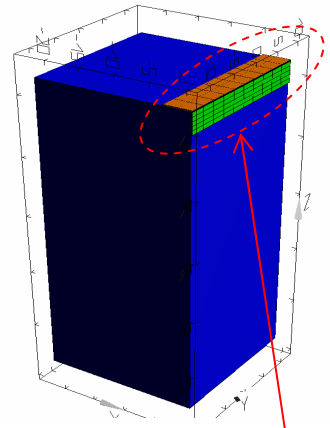












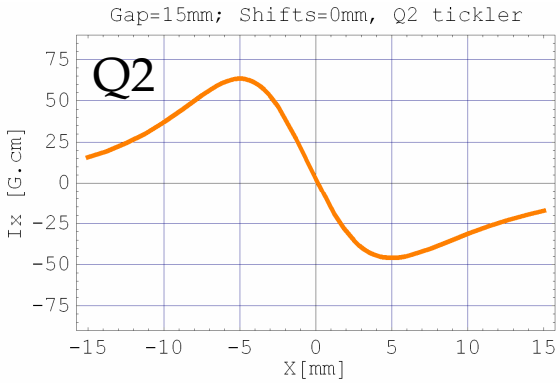
Dynamic ticklers

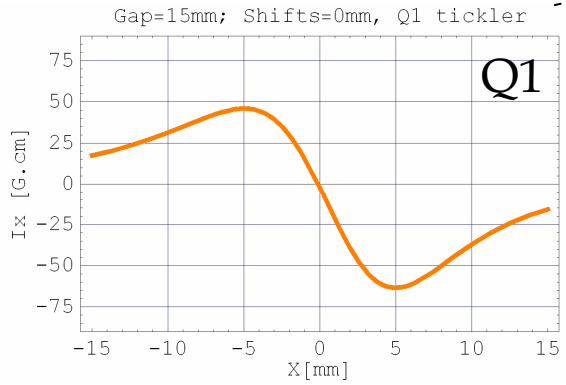
To obtain the signatures with negative vertical blocks, the opposite of the previous ones must be taken.

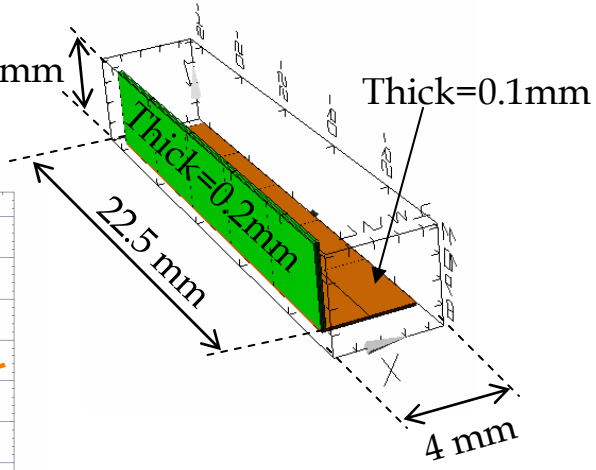
Signature of Dynamic Ticklers: Ix integral

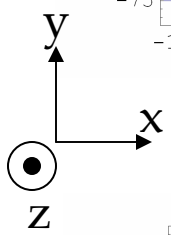
Integral effect of adding iron shim on **positive vertical blocks**

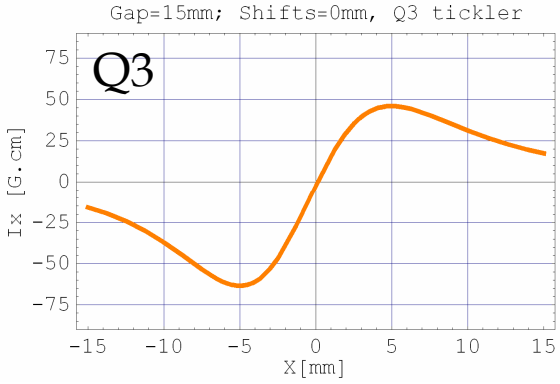
$\Phi = 0$

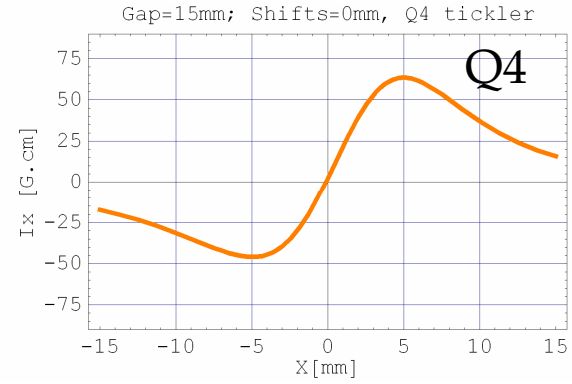


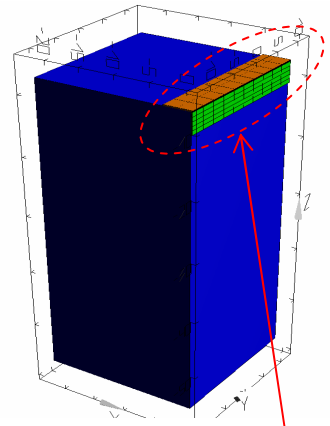












Dynamic ticklers

To obtain the signatures with negative vertical blocks, the opposite of the previous ones must be taken.

Effect of Dynamic Ticklers: Optimization

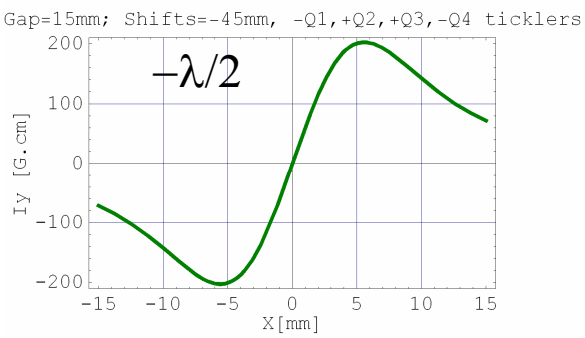
Purpose: Correct the horizontal "kick" (px)

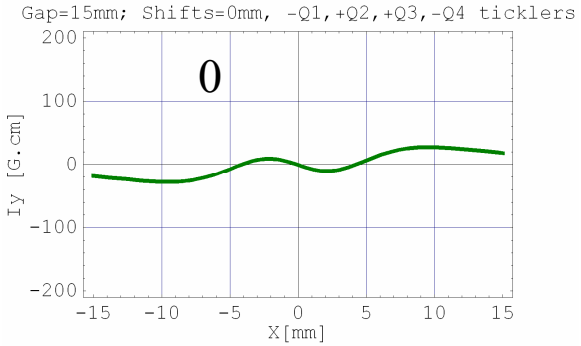
Get a gradient (dIy/dx) without skew quadrupole (dIx/dx)

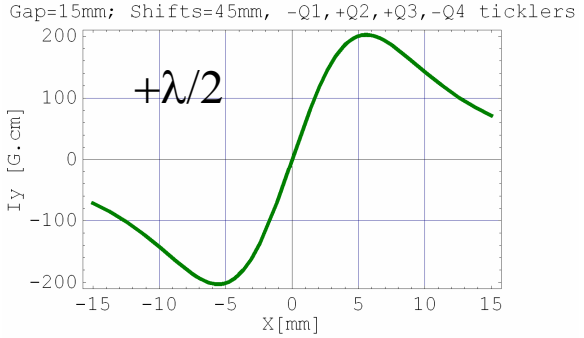
Maximum at maximum phase positions (+/- λ/2)

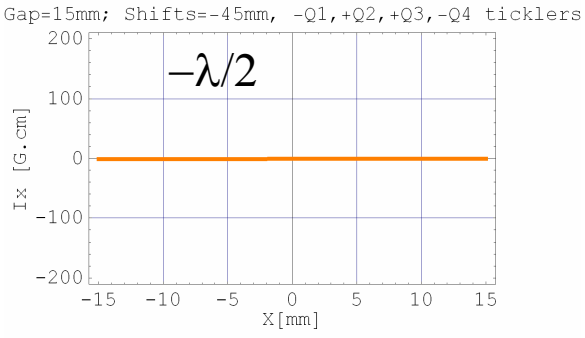
16 Combinations possibilities with one tickler per quadrant on positive or negative vertical blocks.

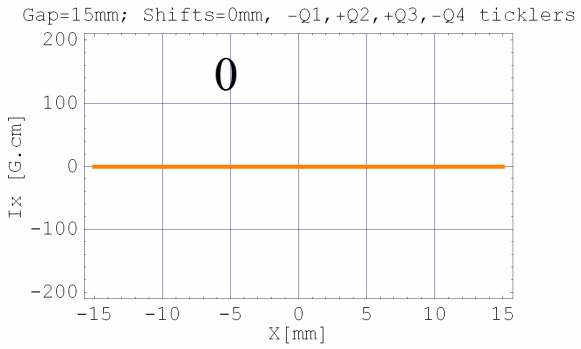
Right Dynamic Ticklers Combination : -Q1,+Q2,+Q3,-Q4 on vertical blocks

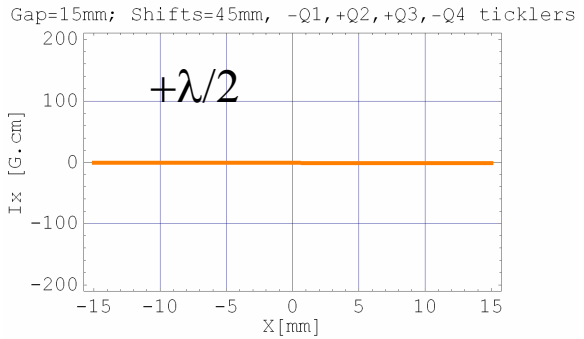








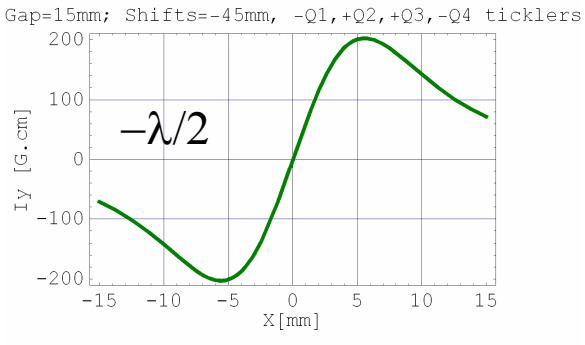


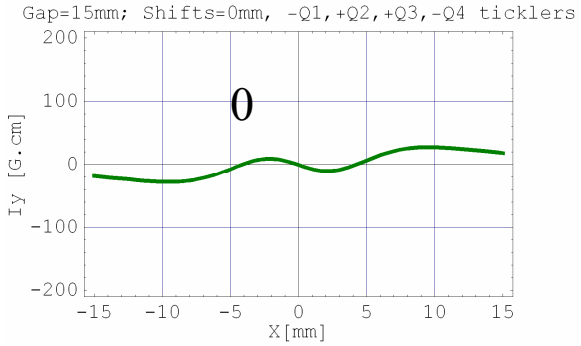


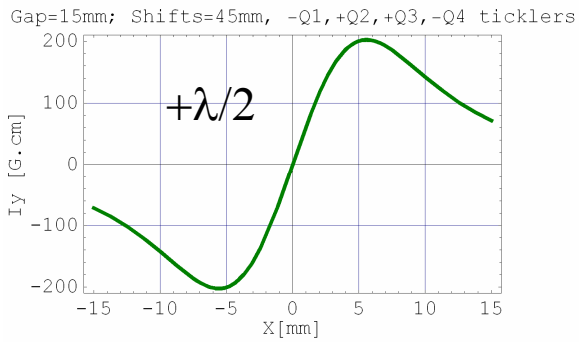
-Q1 = Dynamic tickler on a vertical negative block of Quadrant 1

Effect of Dynamic Ticklers: Measurements

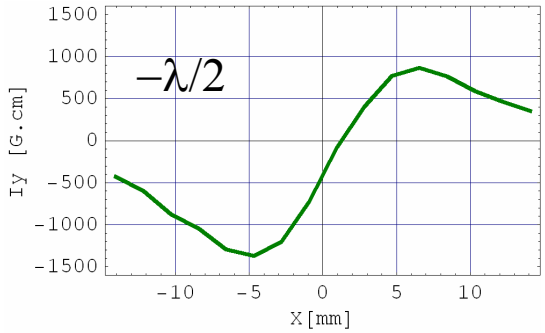
Simulations (for 1 set of Ticklers)

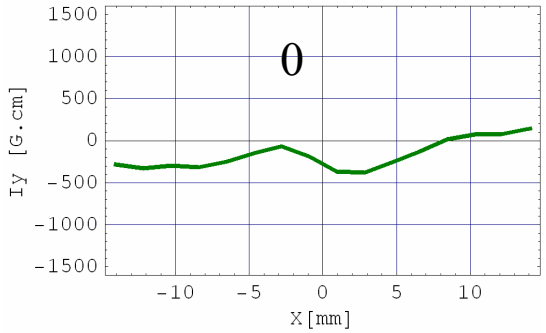


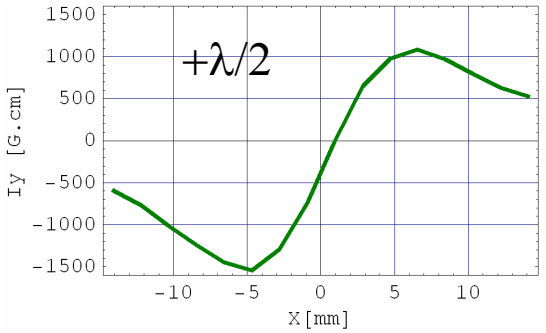




Measurements (for 6 sets of Ticklers)



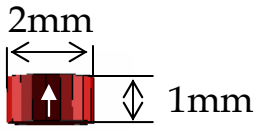




No measured Ix contribution from ticklers on axis

Conclusion : The measured signatures fit the simulations

Optimization of the residual first integral :

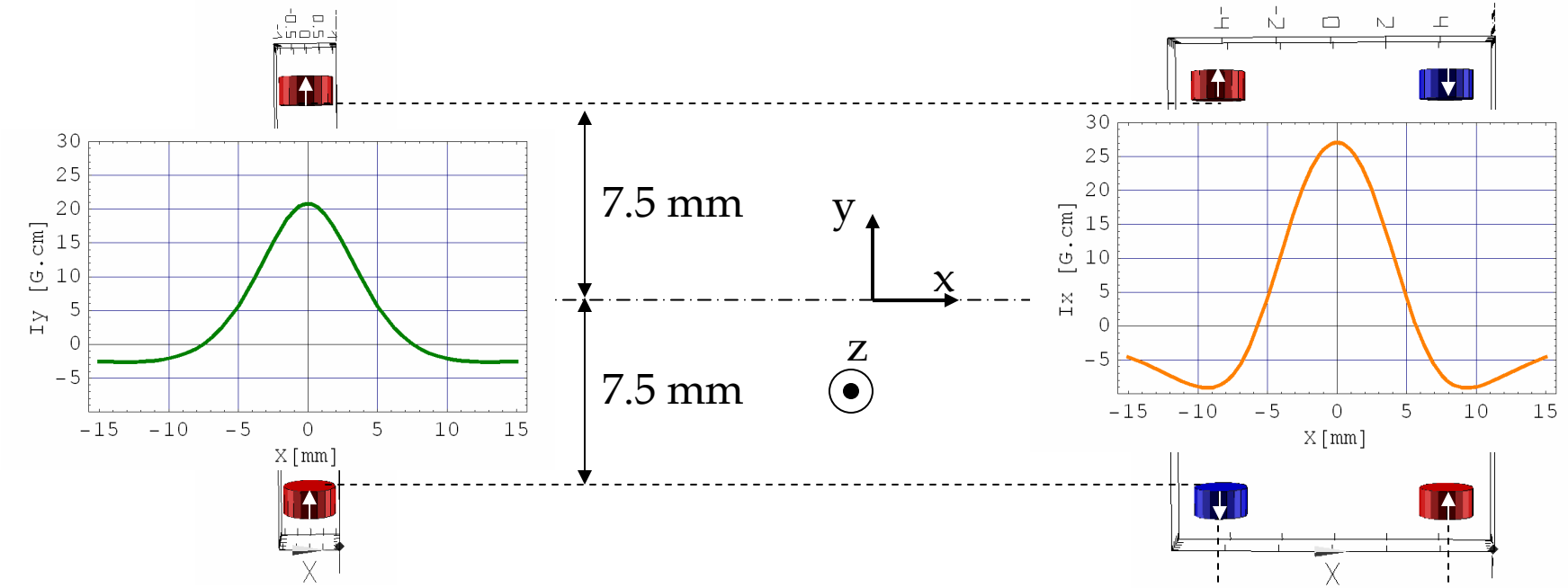
Magic Fingers 

Vertical Magnetization

Max correction with 200 magic fingers = 250G.cm

Pure Iy correction

Pure Ix correction



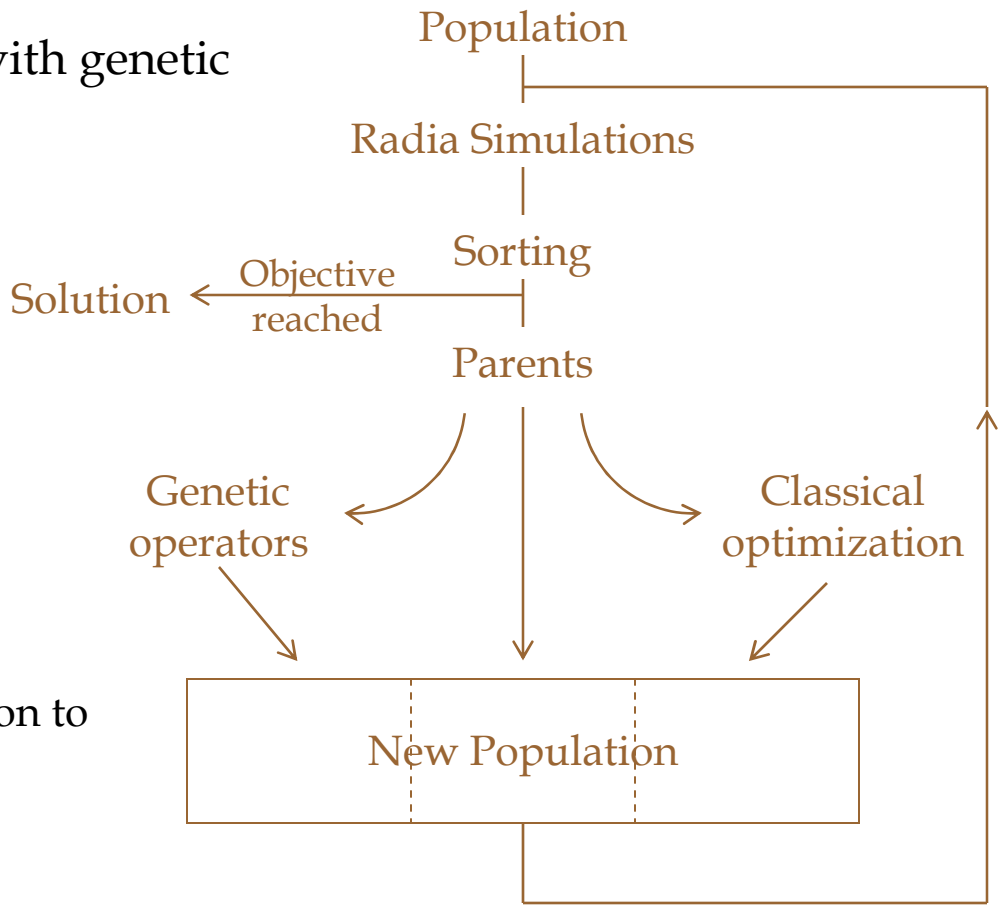
Pure correction = up/down symmetry

Optimization of the first integral : Method used

Objective: magic finger distribution optimization

Main Issue: To combine Ix and Iy corrections

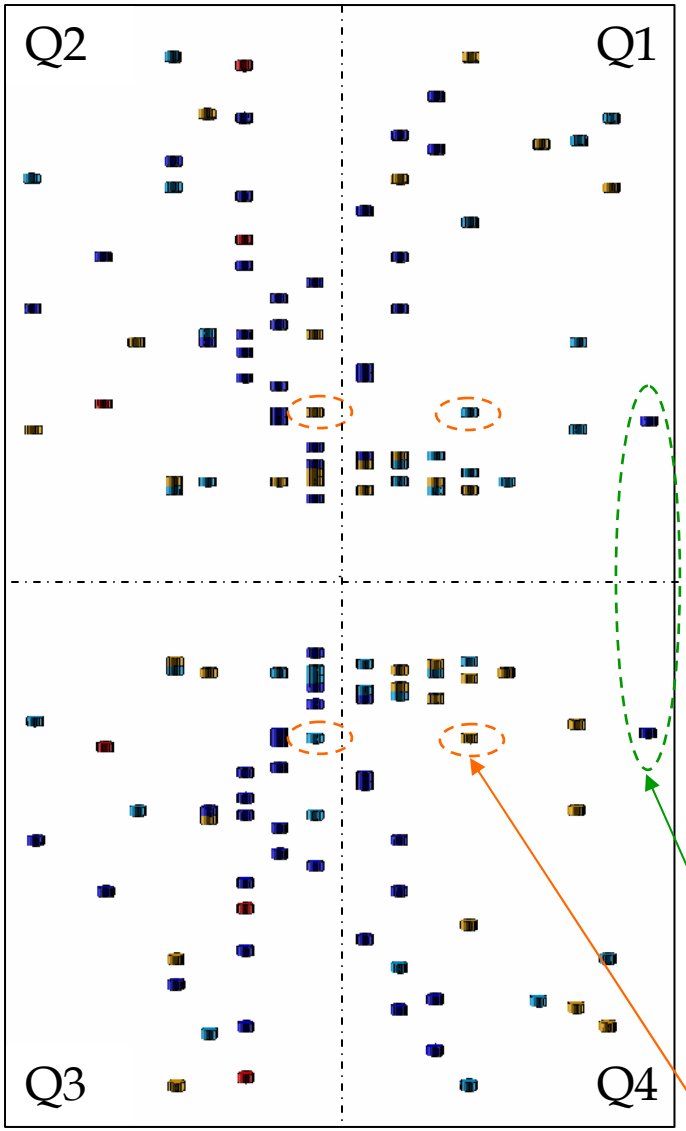
Method: Radia simulations coupled with genetic algorithm

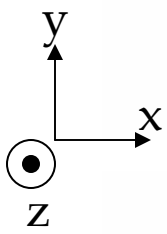


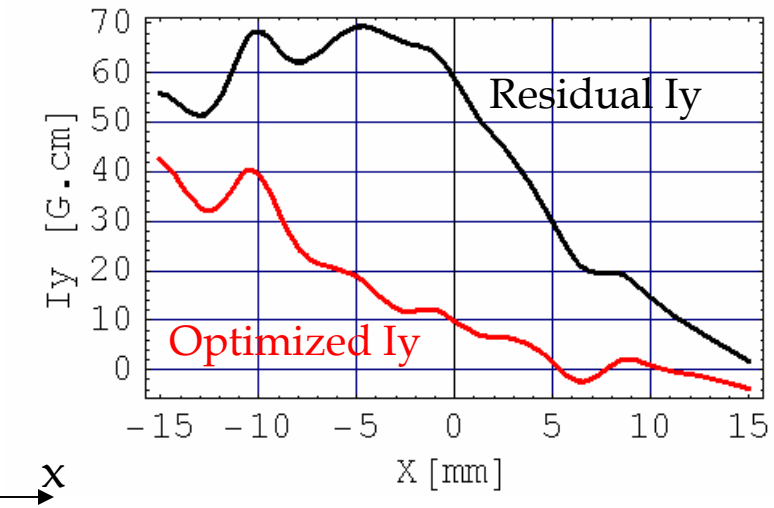
Population = a set of N magic finger combinations

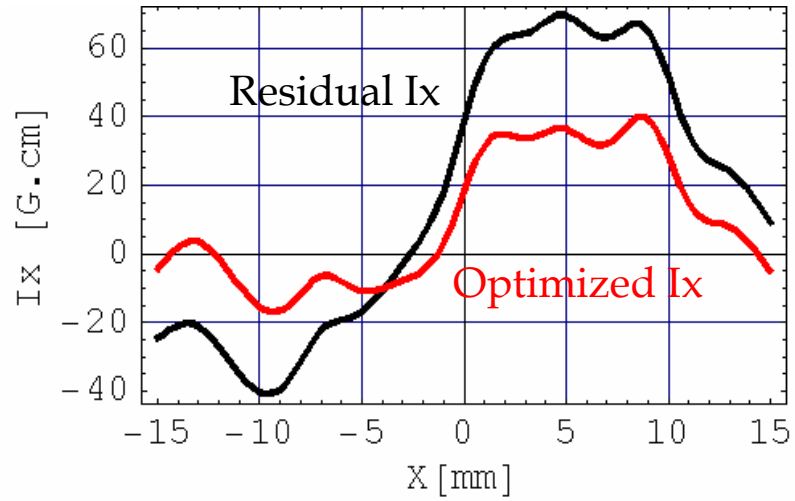
Radia Simulations evaluate each combination to enable sorting. (weighted ranking)

Optimization of the first integral : Solution example (136 magic fingers)









Iy correction: = positive block ; = negative block

Ix correction: = positive block ; = negative block

Conclusion

-The magnetic measurement bench is operational

-MERLIN EPU will be optimized soon

* Optimization of Ix versus phase variations
* Shimming: Rough integral correction
* Dynamic ticklers: Effectiveness was demonstrated
* Magic Fingers: Preliminary tests will be performed (signature measurements)

-MERLIN EPU will be installed by the end of 2007

Thank you