SMALL GAP, SHORT PERIOD WIGGLER AT SOLEIL

O. Marcouillé, N. Béchu, P. Berteaud, P. Brunelle, L. Chapuis, M-E. Couprie, J-M. Filhol, C. Herbeaux, M. Massal,K. Tavakoli, M. Valléau, J. Vétéran

Contents

- Constraints
- Choice of the period
- Wiggler design
- Wiggler construction
- Conclusions and overview

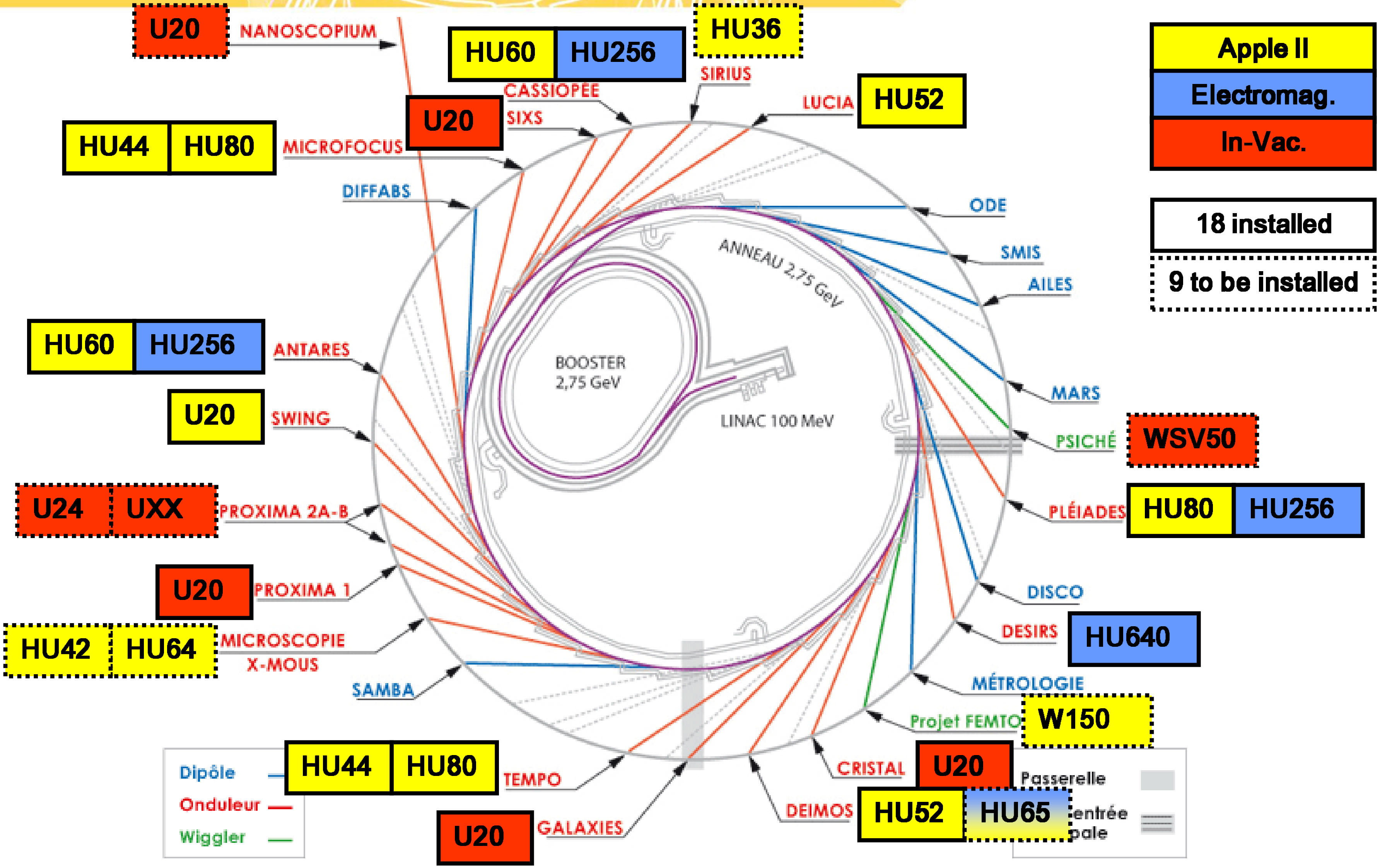
SOLEIL SYNCHROTRON

SOLEIL Parameters

Energy	2.75 GeV
Circumference	354 m
Quantity and length of the straight sections	4 x 12 m 12 x 7 m 8 x 3.5 m
Emittance H Emittance V	3.7 nm.rad 37 pm.rad
Current multi-bunch Beam lifetime	500 mA 18 h
Current (8 bunches) Beam lifetime	90 mA 16 h

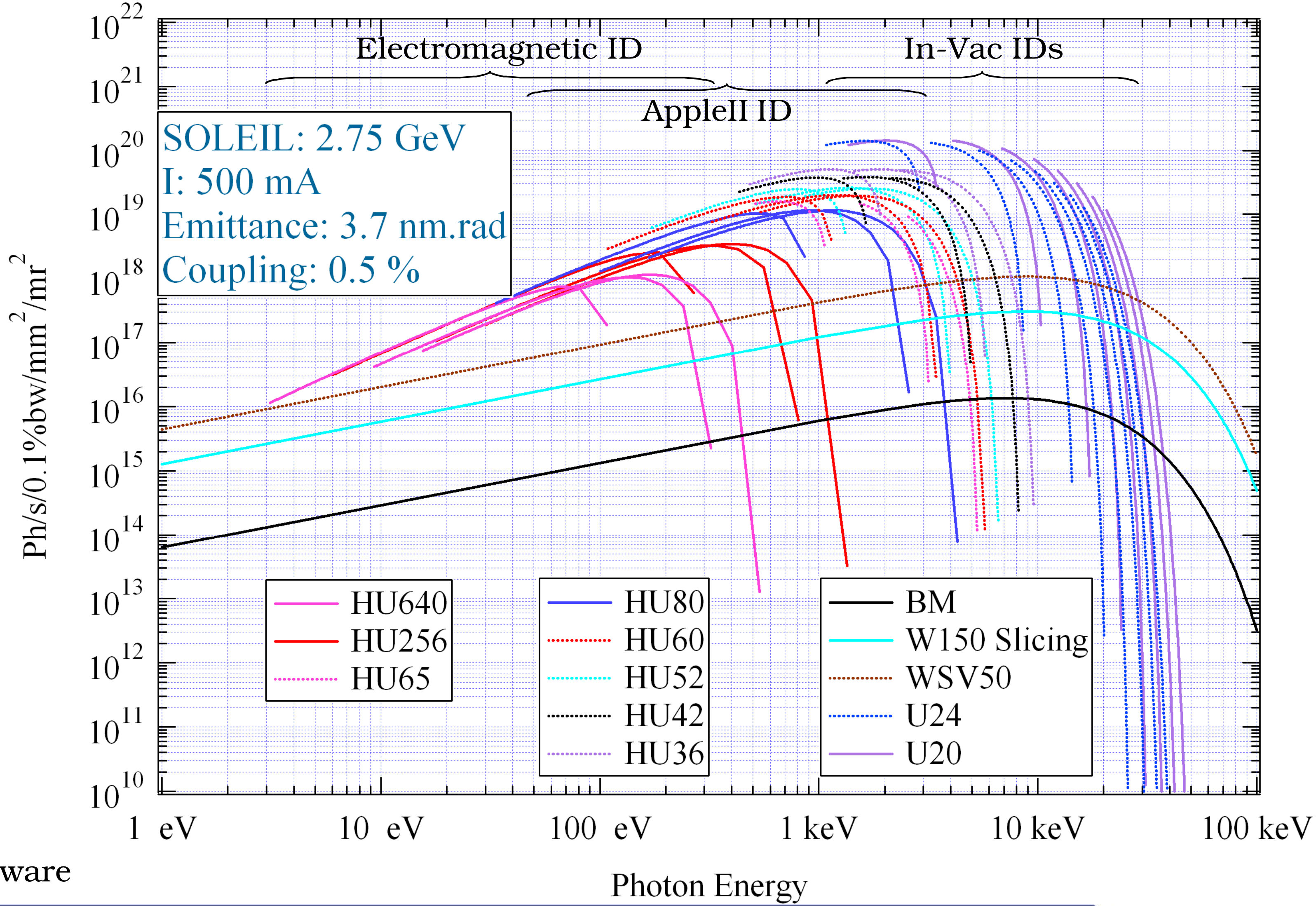
SOLEIL SYNCHROTRON

Built and planned IDs



SOLEIL SYNCHROTRON

Brightness and spectral range

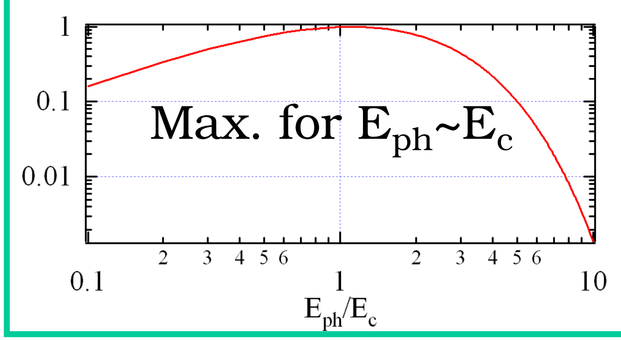


SRW software

Constraints and optimisation

Constraints at SOLEIL

- Experimental constraints
  - Operating range: 20 – 50 keV: High pressure and Temperature experiments
  - Maximum Flux on the experimental site
- Technical constraints
  - Medium energy machine: 2.75 GeV
  - Maximum magnetic system length: 2 m
  - Maximum acceptable power on Front Ends: 25 kW



Angular Flux

$$dF/d\Omega = 2.65\ 10^{16}\ E^2[GeV]\ I[A]\ [E_{ph}/E_c]^2\ K_{2/3}^2[E_{ph}/2E_c]\ L_w[m]/\lambda_0$$

Radiated power

$$P[kW] = 0.633\ B^2[T]\ E^2[GeV]\ I[A]\ L_w[m]$$

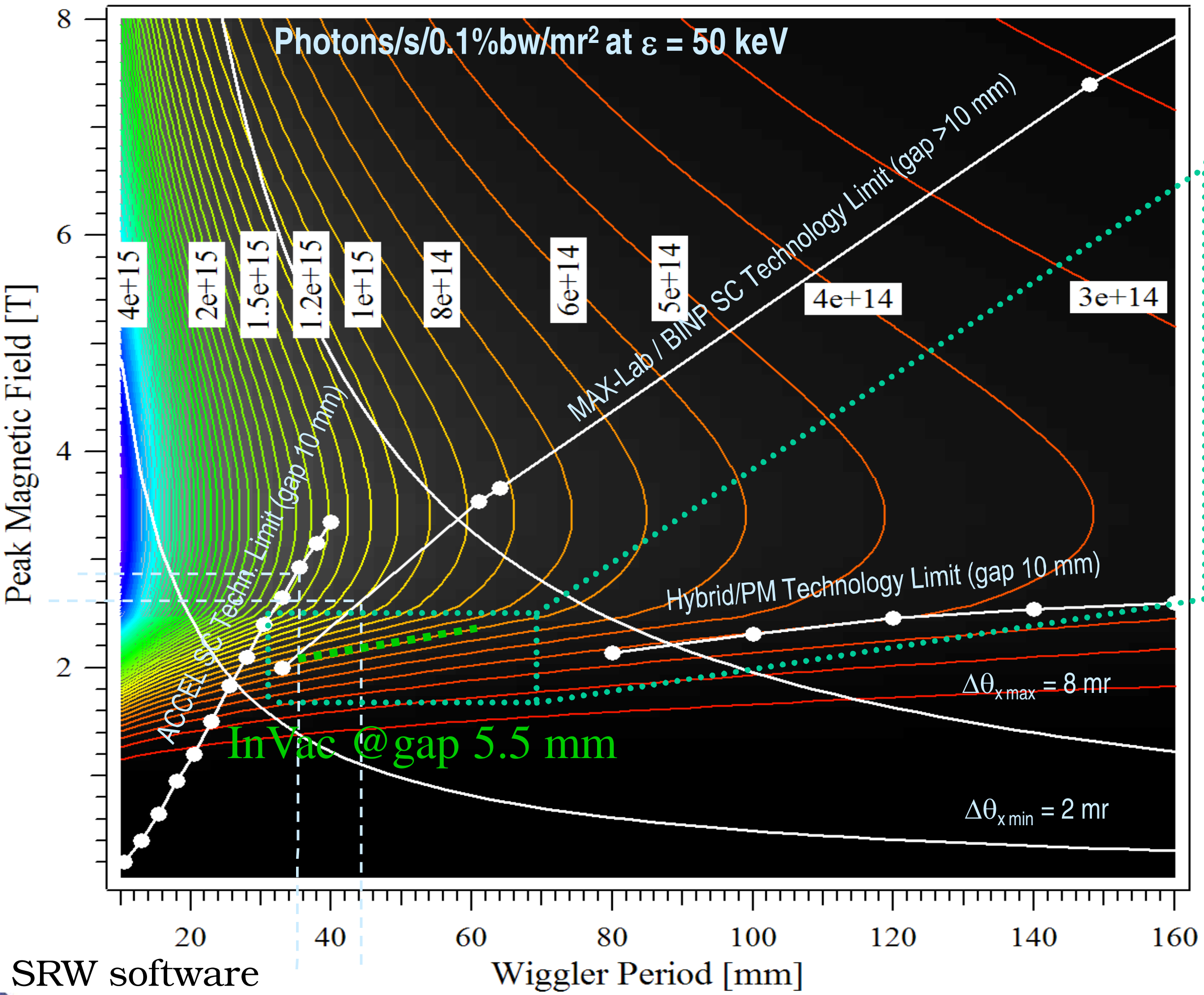
E: Storage ring energy
I: Storage ring current
E_{ph}: photon energy
E_c: Critical energy: 0.665 B[T] E^2[GeV]
λ_0: Wiggler period length
B: Wiggler magnetic field
L_w: Wiggler length

Research of optimum

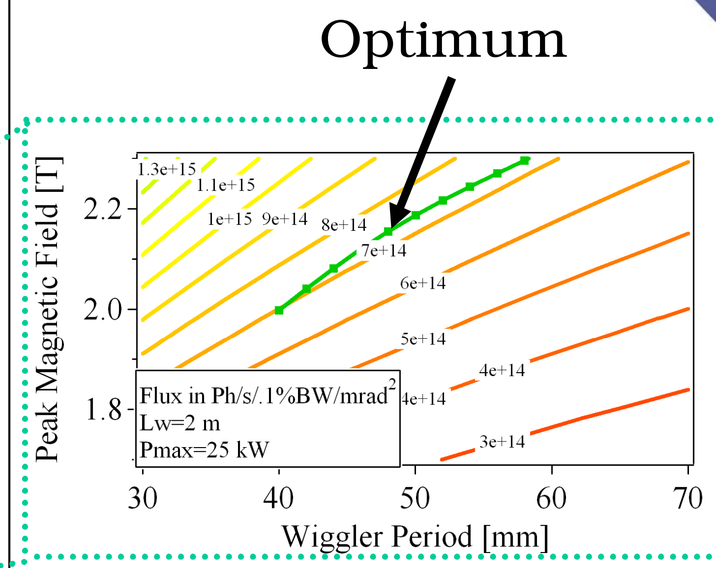
- The radiated power is constant (25 kW)
- Scan of the values of (B, L_w) assumming P=25 kW
- Evaluation of the angular Flux $dF/d\Omega$

SOLEIL SYNCHROTRON

Peak field and Period length



SRW software



Maximum of Flux

Period length: 50 mm

Optimum Peak field: ~2.1 T

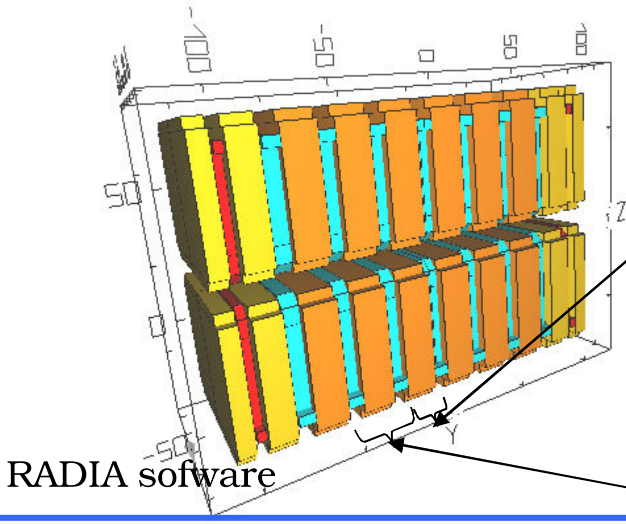
At gap: 5.5 mm

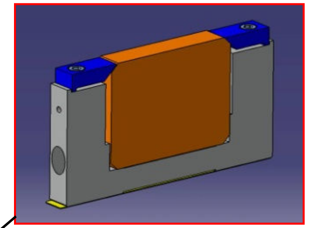
Wiggler Characteristics

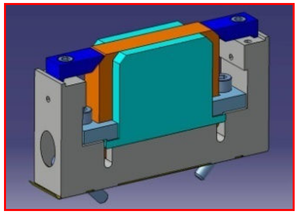
Spectral range	20 keV – 50 keV
Photon polarisation	Linear
Technology Magnetic gap	In-vacuum hybrid 5.5 mm – 70 mm
Magnetic material •Magnets •Poles	 NdFeB (70 mm x 50 mm x 17 mm) Vanadium permendur (60 mm x 40 mm x 8 mm)
Period length	50 mm
Period number	38

Magnetic design

Short model of 3 periods + end corrections

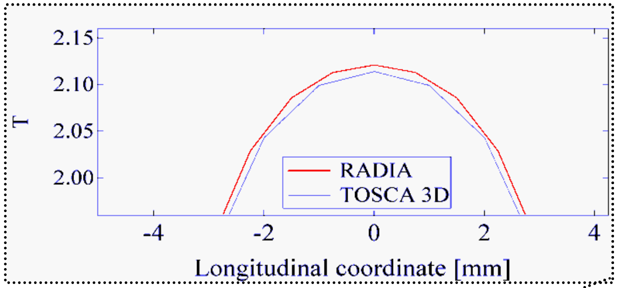




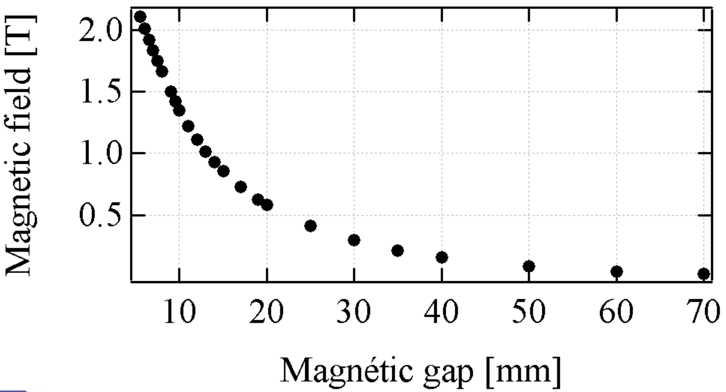


RADIA: O. Chubar et Al, proc. of the PAC97, Conference May 1997, p.3509-3511

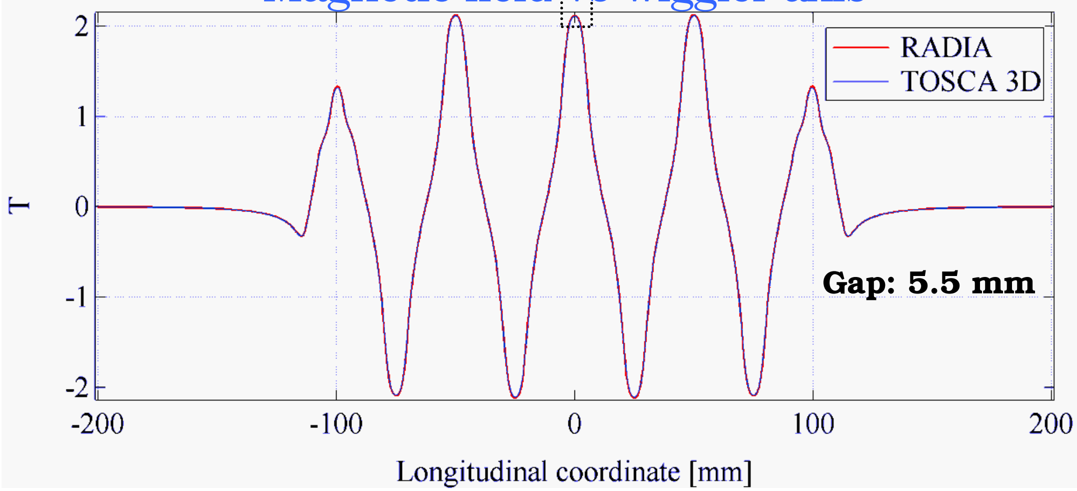
Cross-check at gap: 5.5 mm



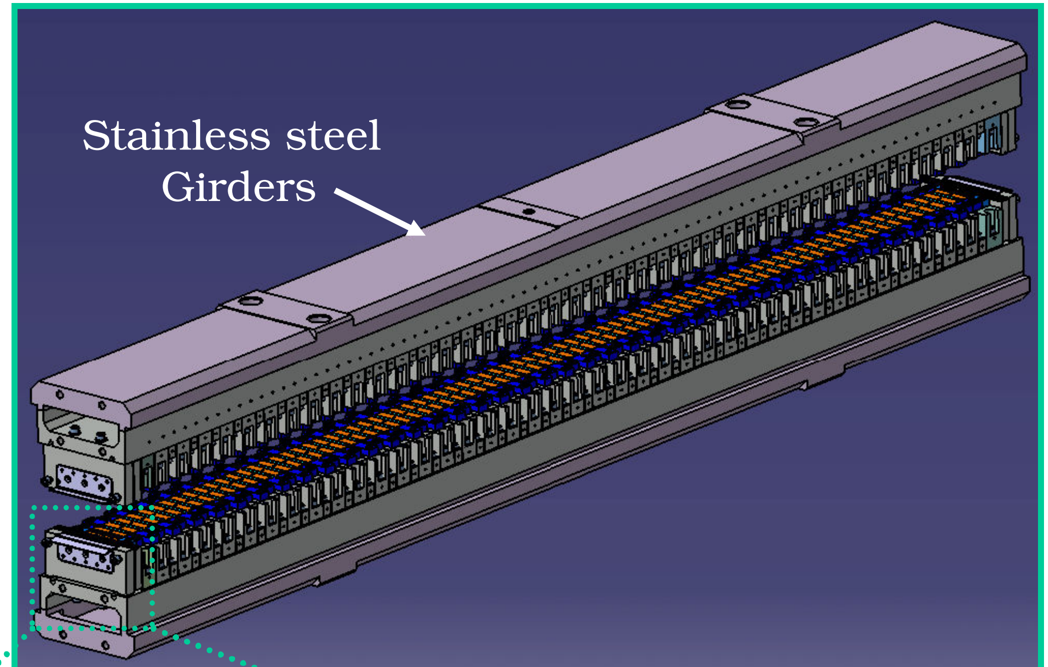
Magnetic field vs wiggler gap

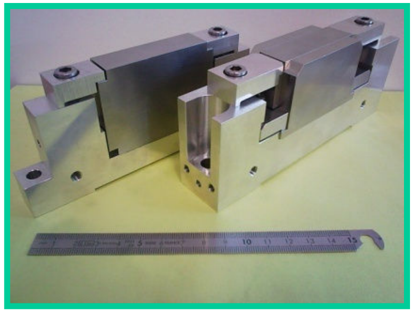


Magnétic field vs wiggler axis

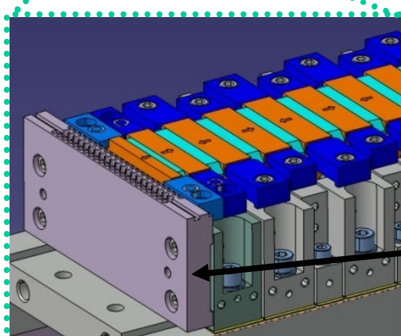


Assembly of the magnetic system

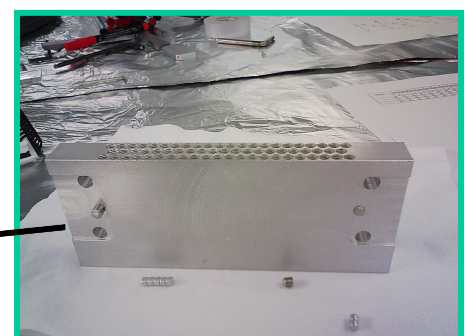




Magnets and poles
On holders



End part



Magic finger holder

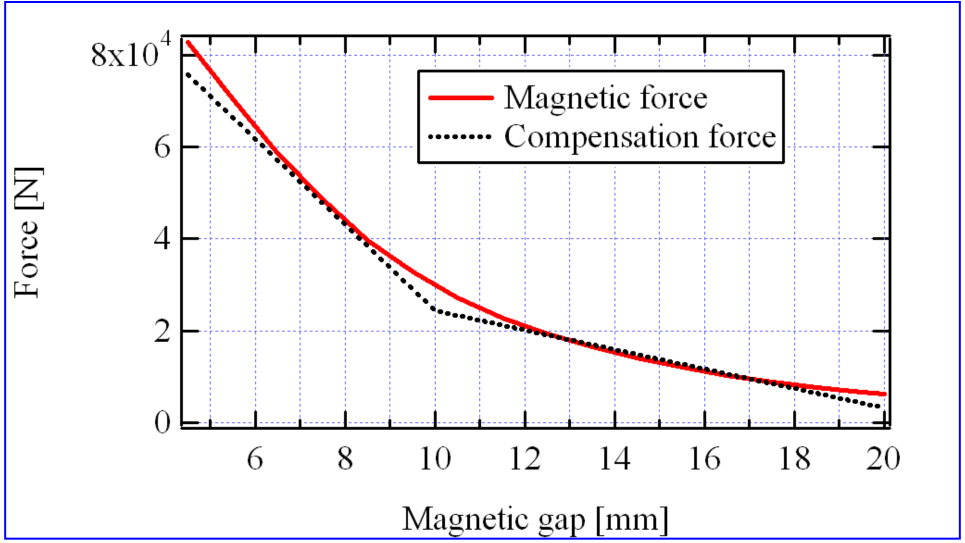
Magic finger

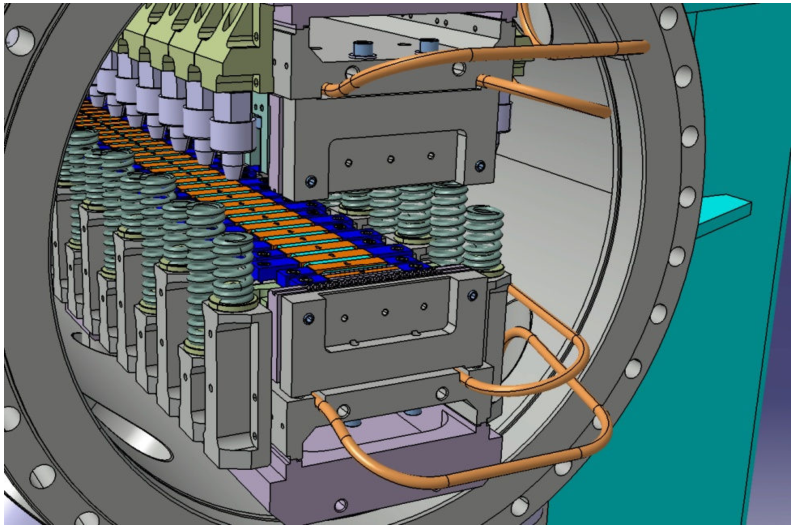
Magnetic forces and compensation

Force Compensation: WHY?

- Girder deformations
- Limited torque of motors
- Limited space
    - No secondary girders
    - Integration of counter system to the Magnetic system

Type of spring	Cycle number	Time	Rigidity K [N/mm]	σ_K [N/mm]
Long	1	170h	61	0.2
Long	190	2h	62	0.3
Short	1	170h	163	0.3
Short	500	5 s	164	0.5

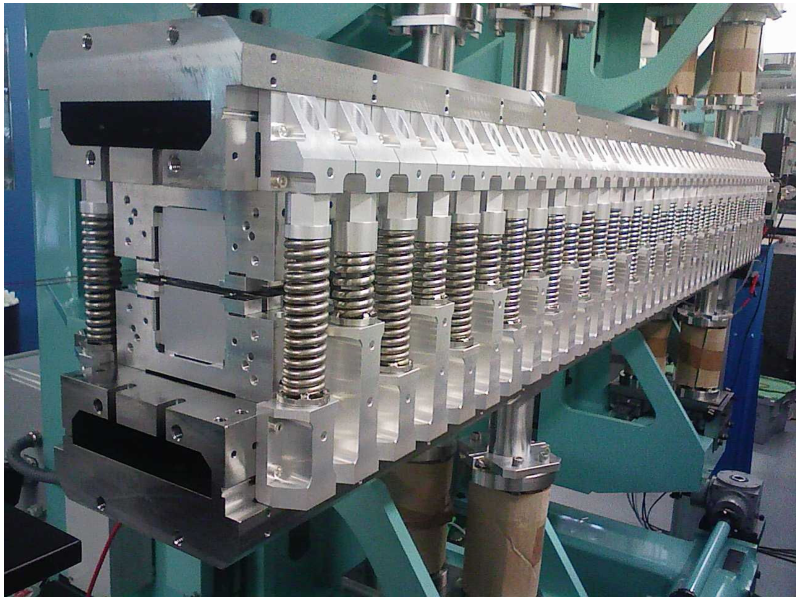




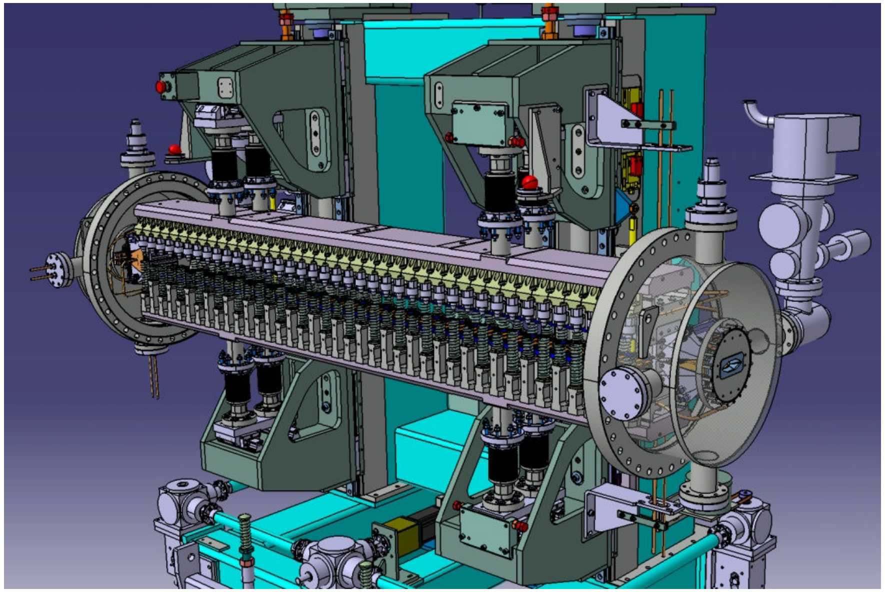
SOLEIL SYNCHROTRON

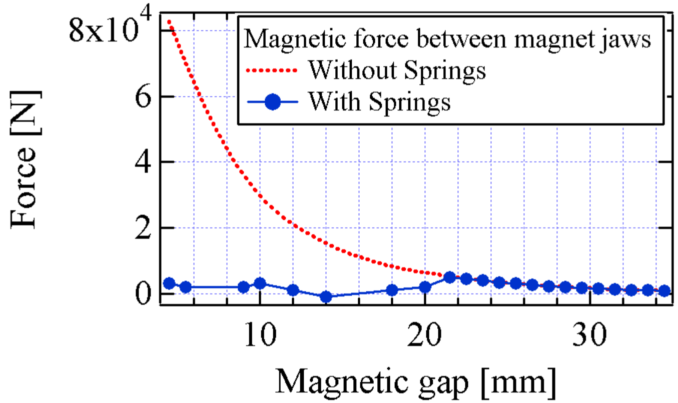
Magnetic forces and compensation

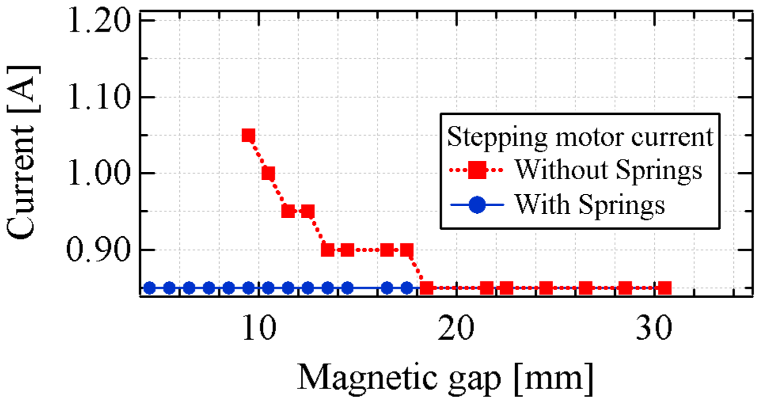
Magnetic system and counter force system



Carriage, magnetic system and Vac. Chamber ends

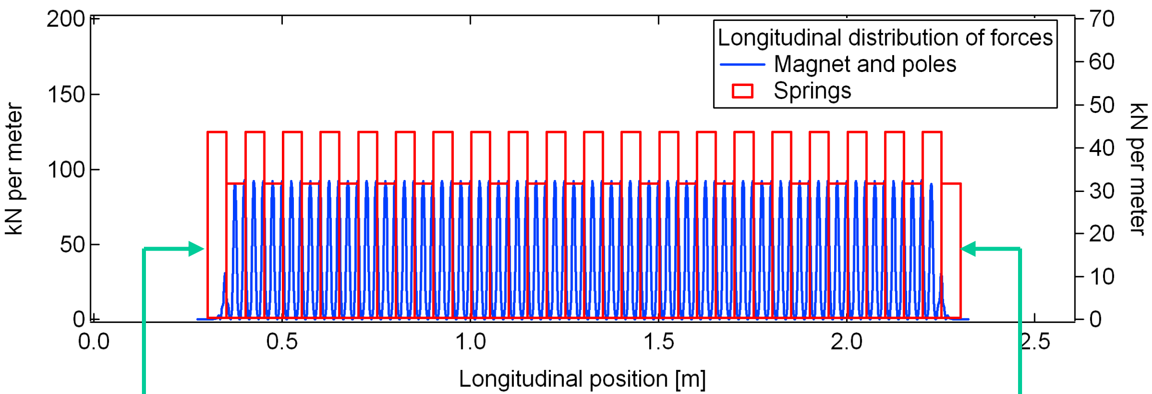






SOLEIL SYNCHROTRON

Control of girders deformations



Springs to be removed

Girders deformations results in:

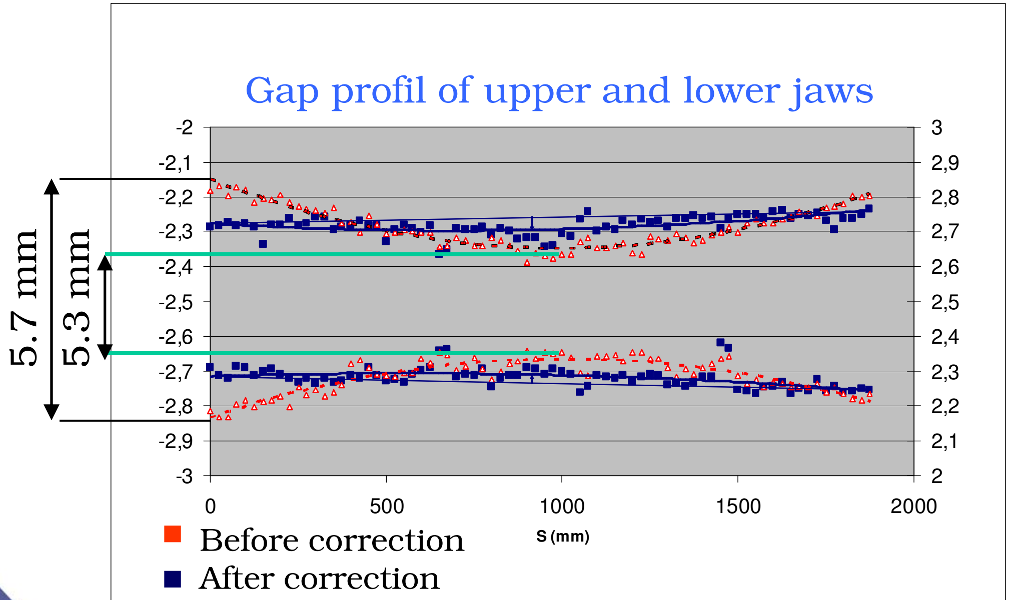
- The increase of photon phase errors
- The limitation of the useful vertical physical aperture

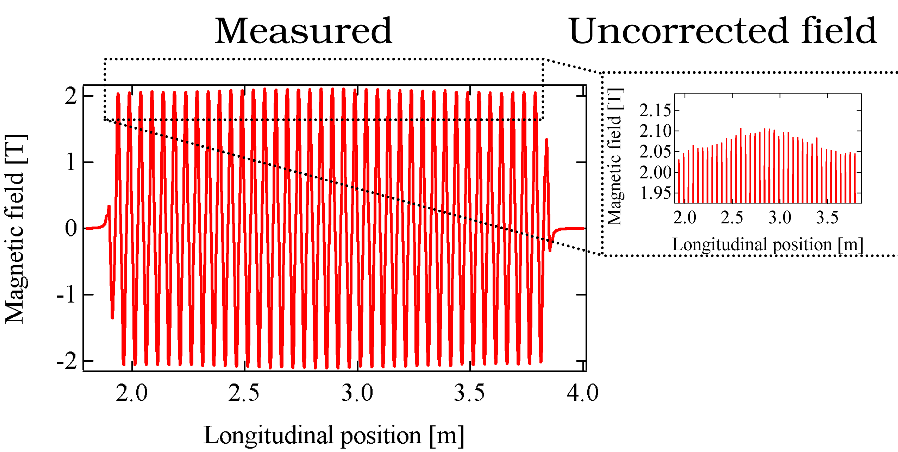
Corrections

- Adequate distribution of springs: removed springs at ends
- Calibration of springs along the axis by using shims (Matrix response inversion)

Results:

- Phase error: 19° to 5°
- Gap variation: 400 µm to 80 µm (taper)





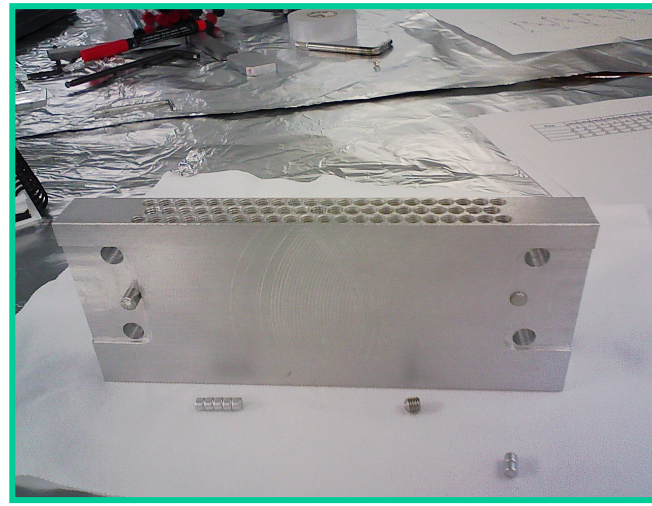
SOLEIL SYNCHROTRON

Non linear effects of the In-vac Wiggler WSV50

- InVac Hybrid
- 20 keV-50 keV
- 38 periods of 50 mm
- 2.1 T at min. gap of 5.5 mm
- <u>Tight poles: 60 mm </u>(minimizing Mag. Forces)
- Field homogeneity area<Physical aperture (-35mm-25mm)
- **COMPENSATION** of the dynamic field integral with Magic Fingers

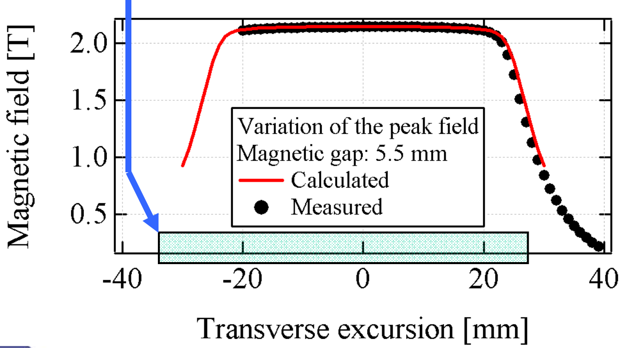
J. Safranek et al, PRST-Accelerators and Beams, Vol.5,010701 (2002)

COMPENSATION with MF

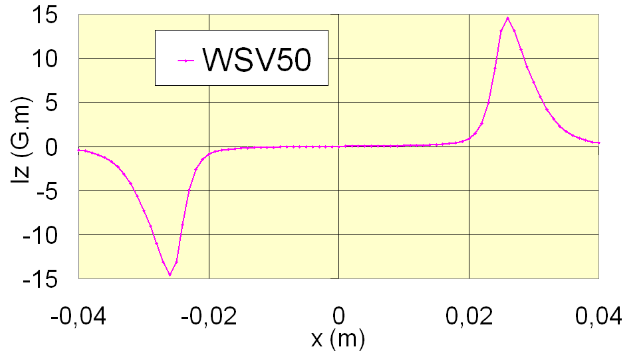


Phys Aperture

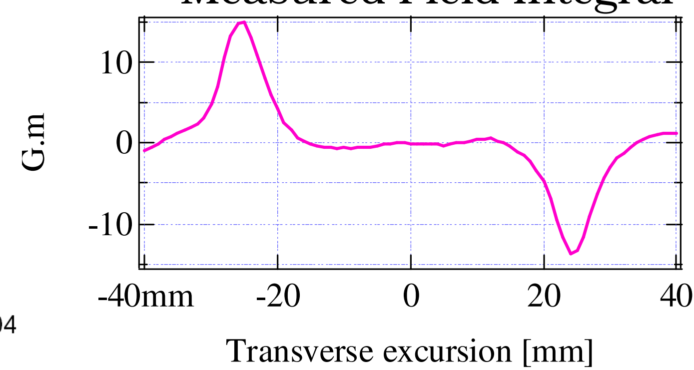
Transverse variation



Dynamic integral



Measured Field Integral



Conclusions and overview

- In vacuum technology: Small gap Short period
- Compact system
  - Magnetic force compensation
  - Dynamic integral compensation
- Improvements
  - Short term: Decreasing of the gap from 5.5 mm to 4.5 mm (+10% on the mag. field)
  - Long term: Cryogenic version :
    - Magnet operating at low temperature (LN: 120°K-150°K)
    - Increase of the magnetic field by 20%