SUPERCONDUCTIVE UNDULATORS/WIGGLERS STATUS-QUO AND FUTURE DEVELOPMENTS

(THE ANKA SC UNDULATOR PROGRAM)

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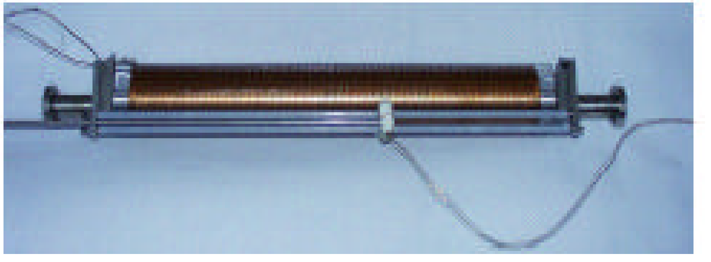
MOTIVATION

- Higher field for given period length
- (or larger gap for same period length and field)
- (or shorter period length for same field)
- Electrical tunability (no mechanically moving parts)

Late 90‘s: beam test at Mainz cw microtron with an in-vacuum sc undulator

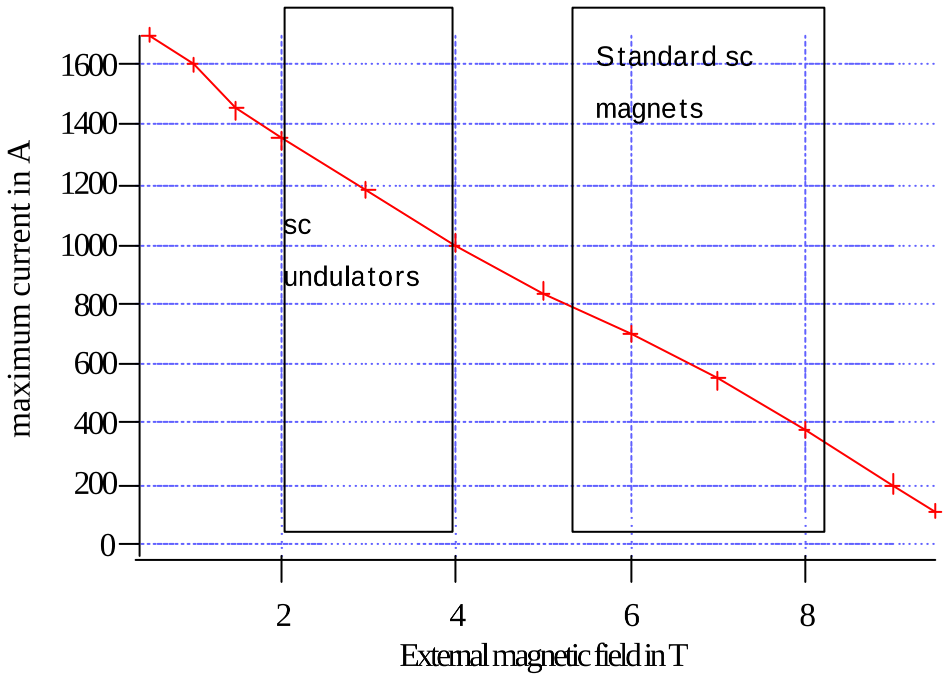


Period length 3.8 mm

100 periods

Fundamental Current Limitation in a superconductive (NbTi) wire

(1.19 x 0.72 mm²) by an external magnetic field



Critical current density with external field = 0

NbTi <2 kA/mm² @ 4 K

NbTi <3.6 kA/mm2 @ 1.8 K

Nb_3Sn <3.5 kA/mm² @ 4 K

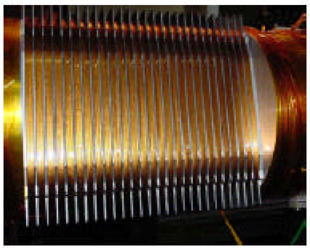
YBCO <1.0 kA/mm² @ 77 K

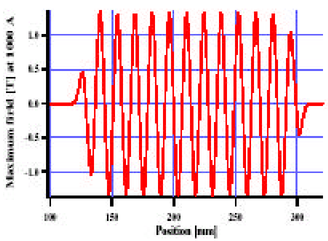
What fields were (and can be) achieved?

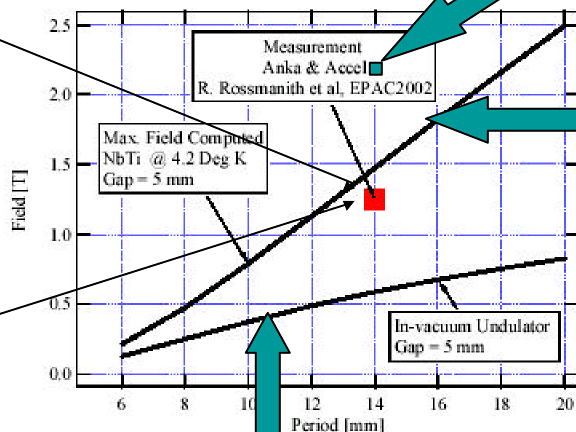
Superconductive 14 mm Period Undulators , EPAC 02,

R. Rossmanith, H. O. Moser, A. Geisler, A. Hobl, D. Krischel, M. Schillo,

ESRF







NbTi 1.8 K
Nb3Sn
Future option

NbSn: Berkeley,

NbTi @ 1.8 K ANKA

NbTi 4.2 K
achieved

ANKA, Argonne

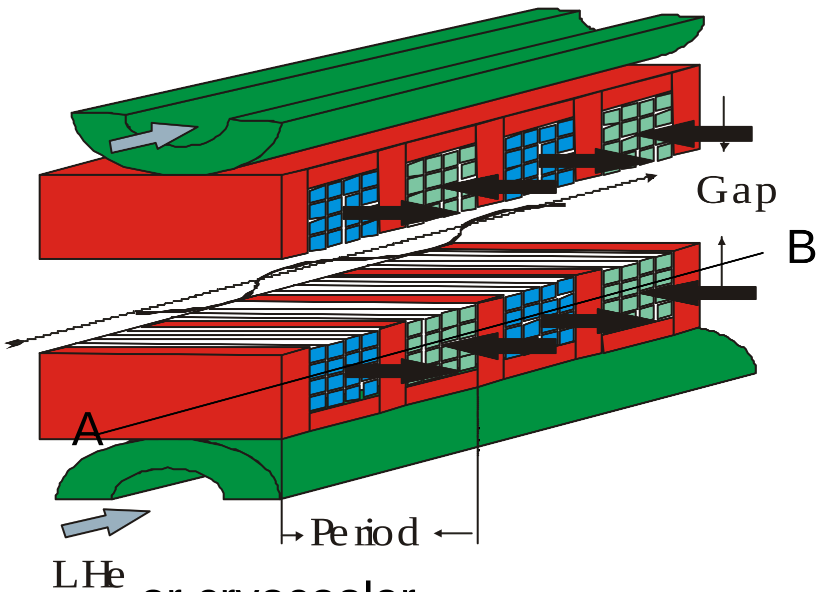
Permanent magnet

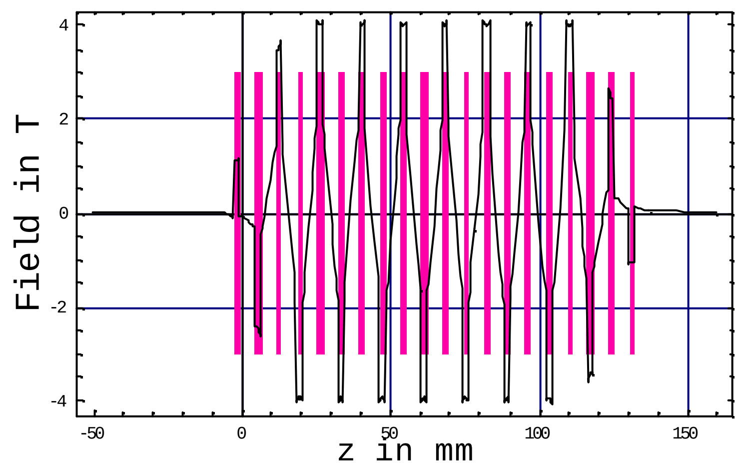
For comparison
YBCO <1.0 kA/mm2 @ 77 K *

* Critical current density with external field = 0

Field Limitations

Field cut A-B (red are the poles)



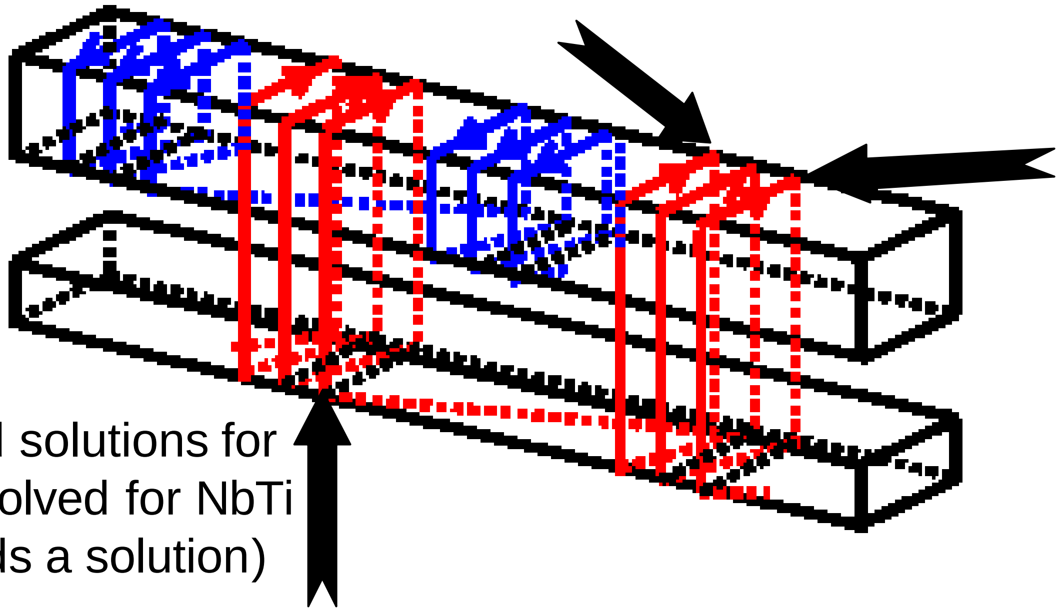


or cryocooler

Danger: magnetic forces try to move wires ➡ quench

Three critical points in the construction of a sc undulator

I.) Magnetic forces try to move wires ➡ quench: 2 critical zones

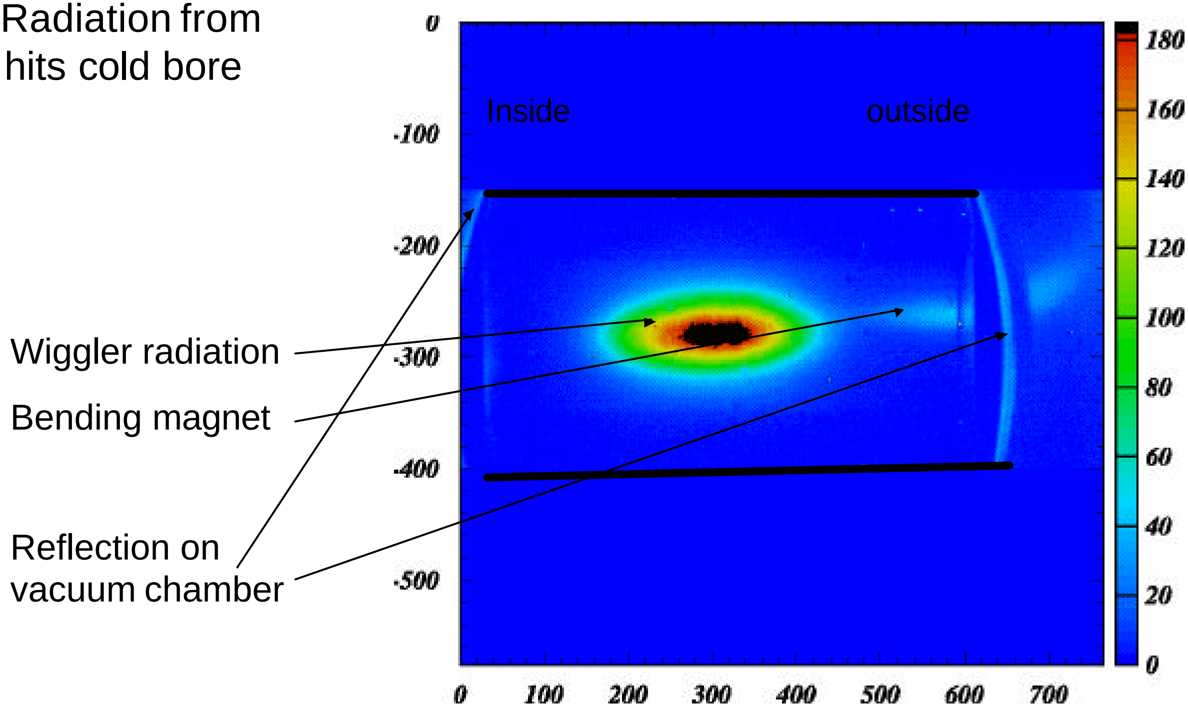


Good designs have to find solutions for these two critical zones (solved for NbTi 4.2 K. 1.8 K or NbSn needs a solution)

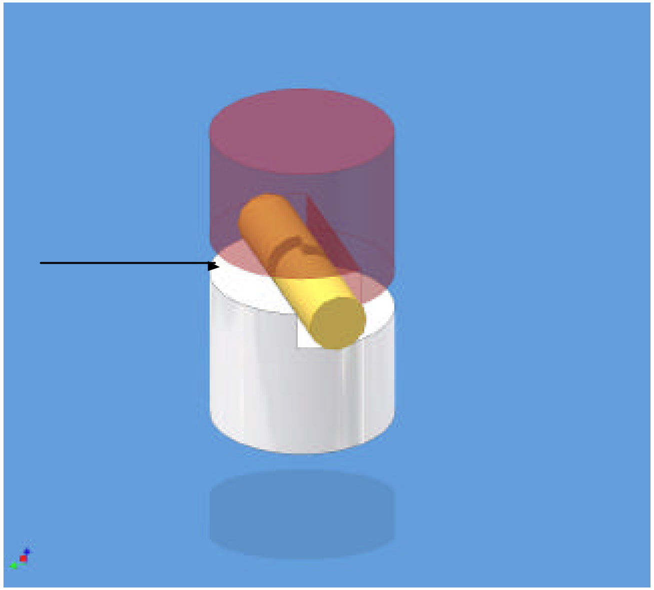
II.) Heating of the cold bore

a.) Synchrotron Radiation from bending magnet hits cold bore

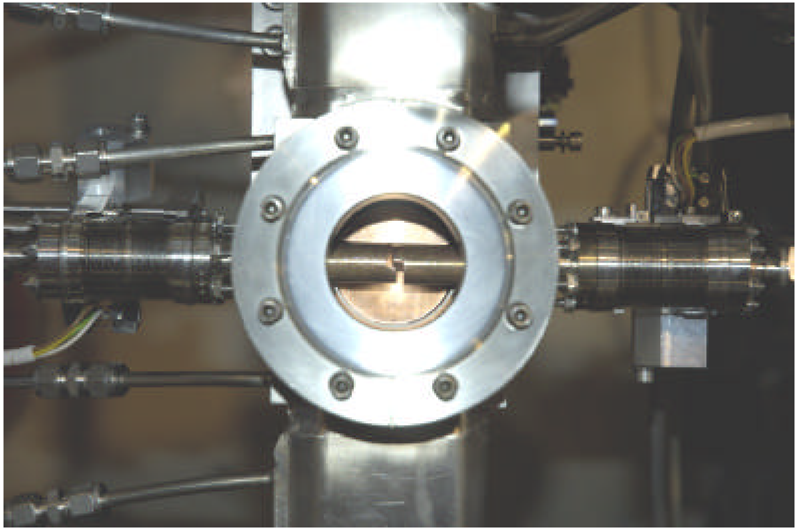
Example: SUL wiggler radiation at ANKA



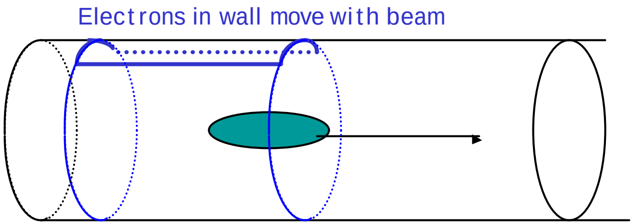
Collimator system in front of undulator (example for ANKA)



Top view (completely closed)



b.) Resistive wall beam heating



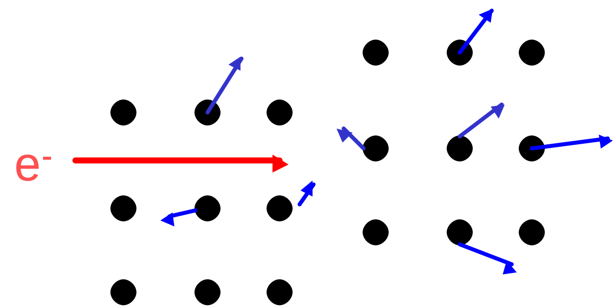
Inner wall:

Cu or HTSC

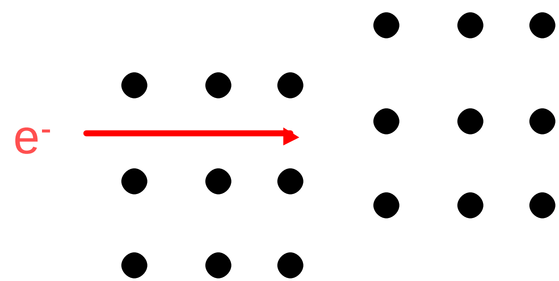
$R_{room\ temp}/R_{4K}$ = RRR-factor

(typically 60 -100)

High temperature: R defined by lattice vibrations and imperfections

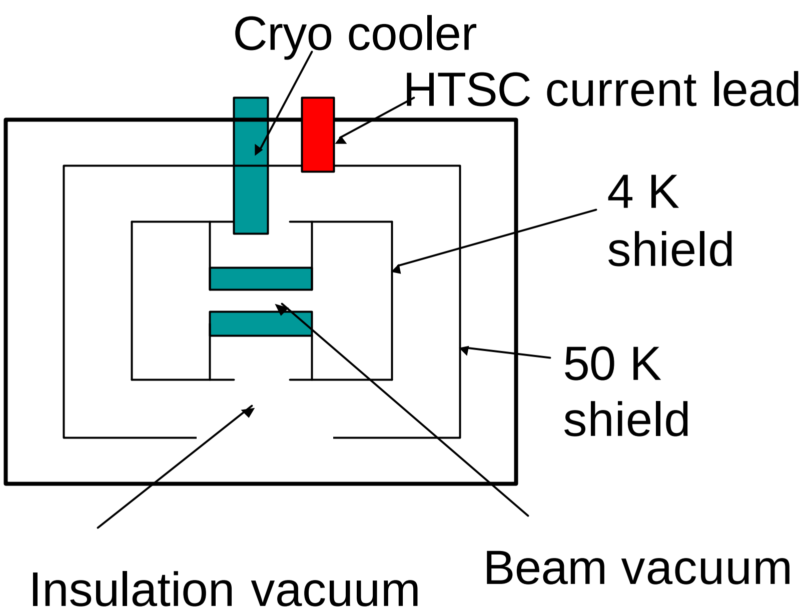


Low temperature: R defined by imperfections only



ANKA Undulator

100 periods, 14 mm period length, gap 5 or 8 mm, max. 1.5 T @ 5mm



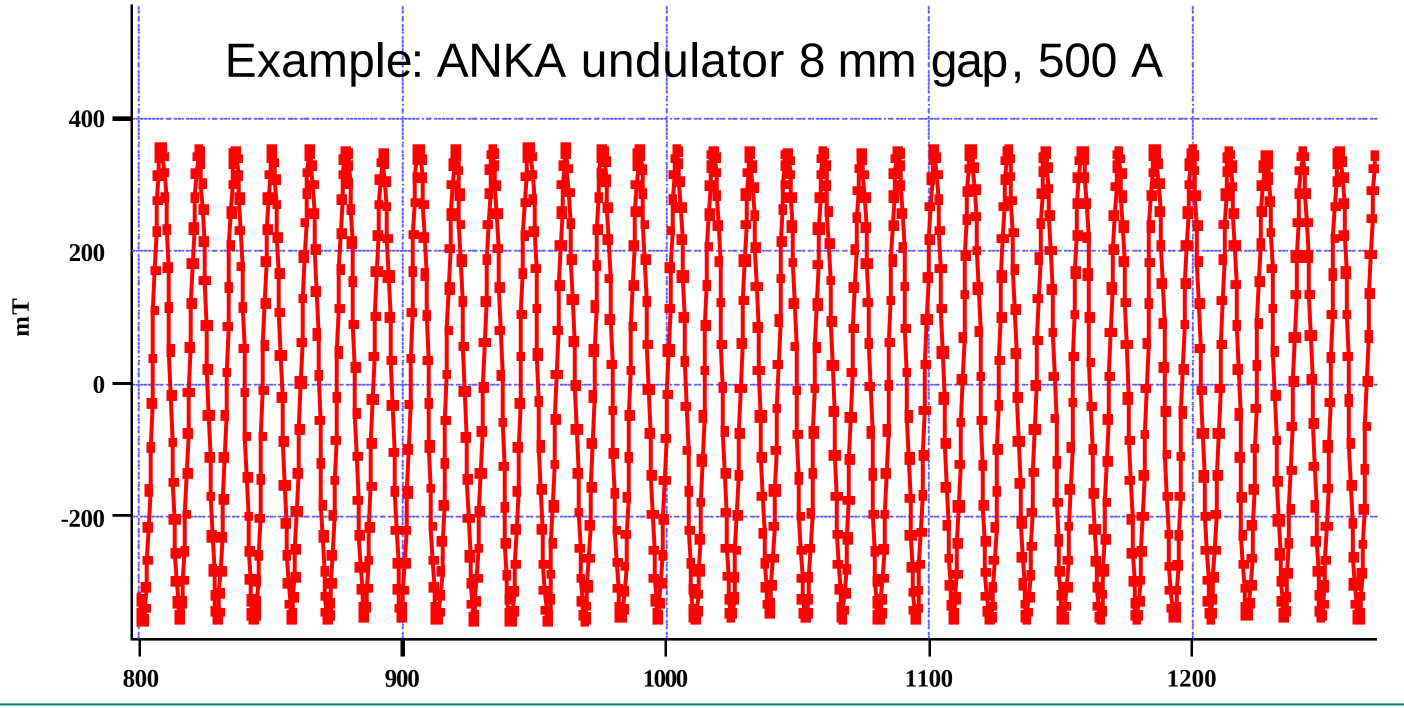
Stretched wire field masuement

(integral measurements)

III. Field quality (phase error):

different to permanent magnet undulator only mechanical errors

Field measurements with Hall probes calibrated at 4.2 K (or 1.8 K)

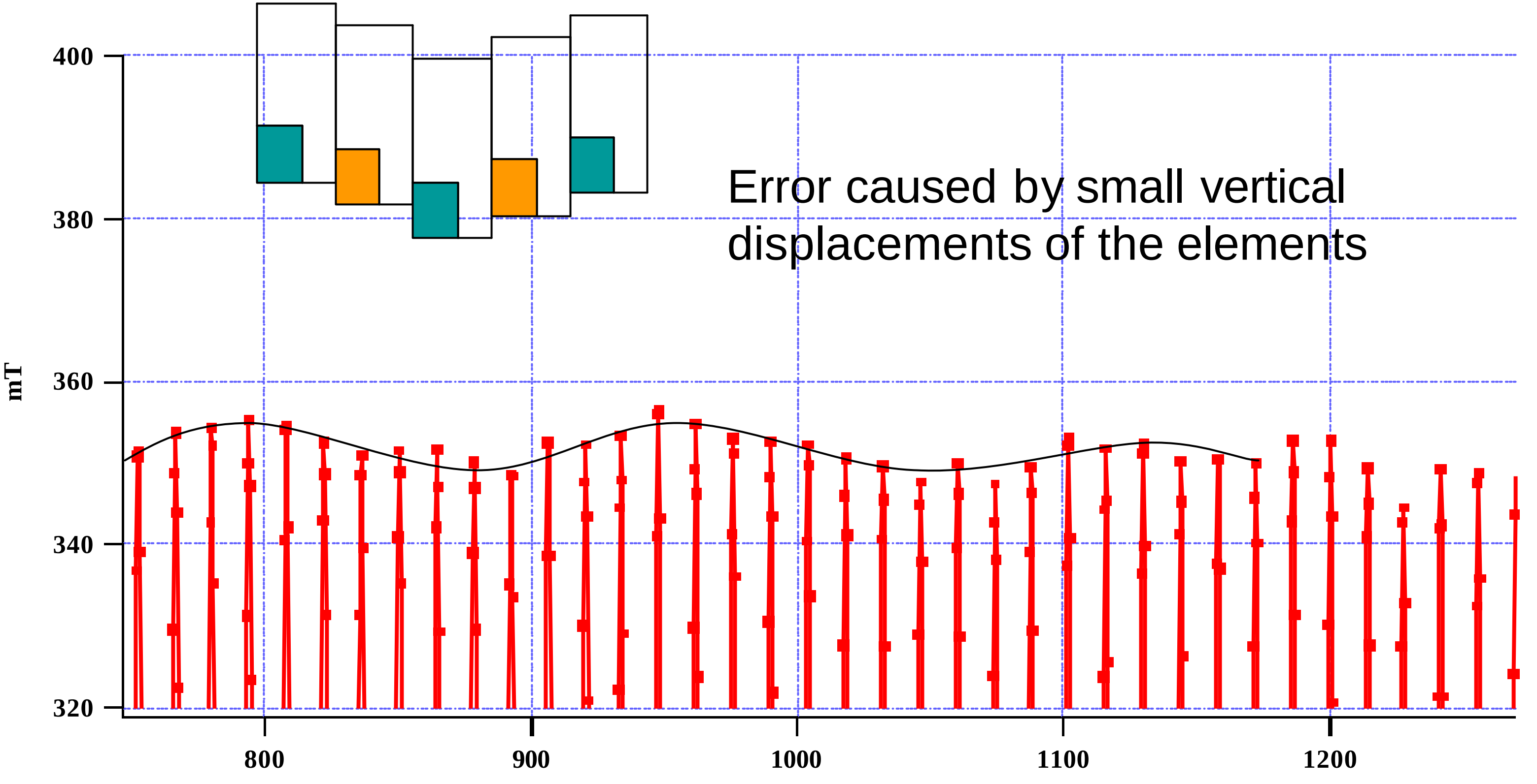


Mechanical errors
(can be compensated by classical shimming techniques)

a.) temperature effects (bi-metal)

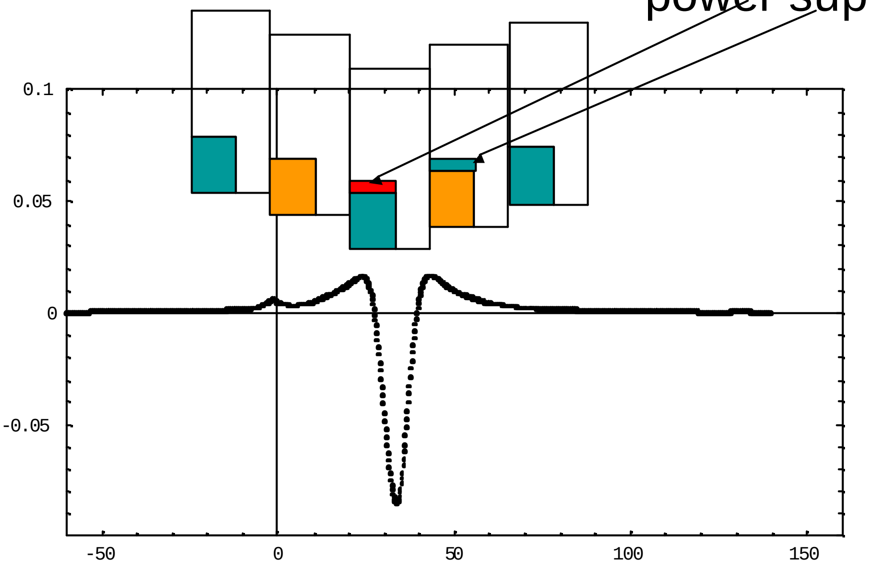
b.) Position errors of the individual building elements

Blow-up of the measurements of one of the built undulators.



Electric shimming

Coils connected to additional (small) power supply



First undulator equipped with electrical shimming will be EU project.
ESRF undulator (ANKA – ELETTRA – MAXLAB - ESRF collaboration)

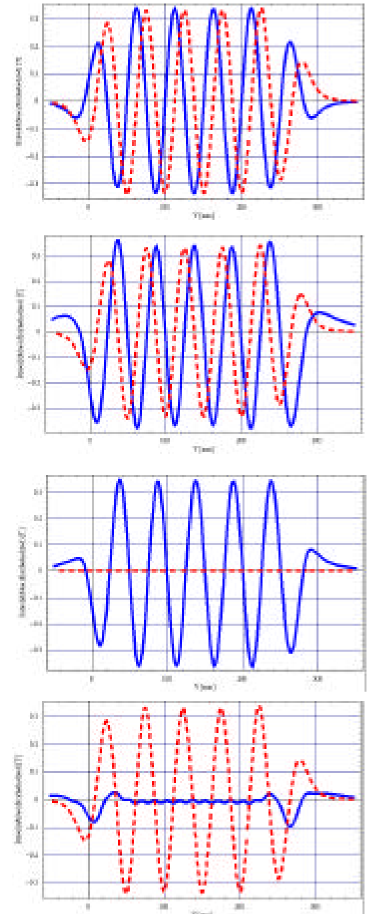
New project: SC undulator with electrically

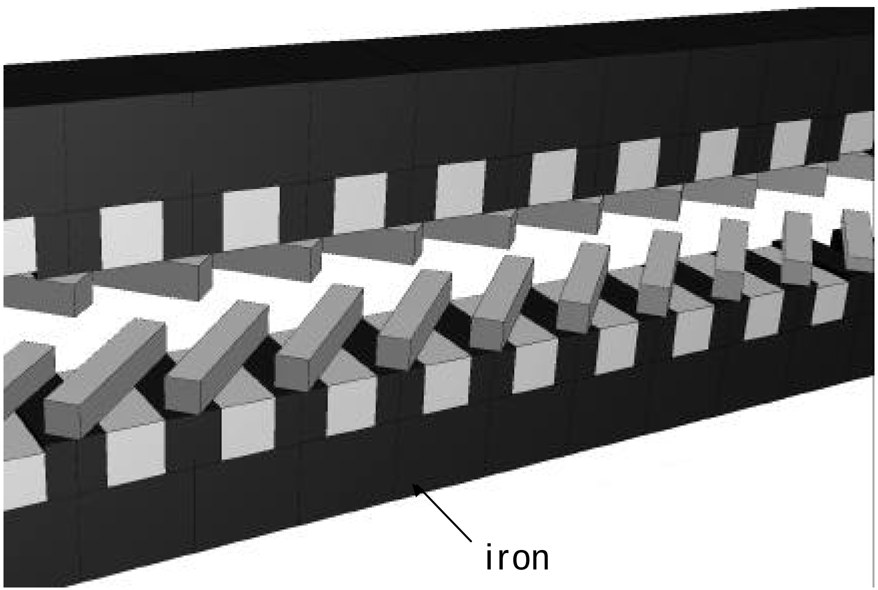
Variable polarization

Example:

Blue vertical field

Red horizontal field





Summary:

Achieved: field factor 2 higher than in-vacuum room temperature permanent magnet devices

Beam tests with single pass beams successful

Storage ring test very soon (next weeks)

Undulators with intelligent electrical shimming under construction (EU-Project)

Next generation with factor 3 higher field under way