LER 2010

High-field low-period wiggler design for the CLIC damping rings

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Designs Overview

1- Permanent magnets

2- Superconducting Nb-Ti coils

3- Superconducting Nb3-Sn Coils

Permanent magnets

Sintered magnets: $Sm_2\ Co_{17}$ **Bmax 1.2 T**

(VACOMAX 240)

- **To build a suitable wiggler we need pole concentrators**

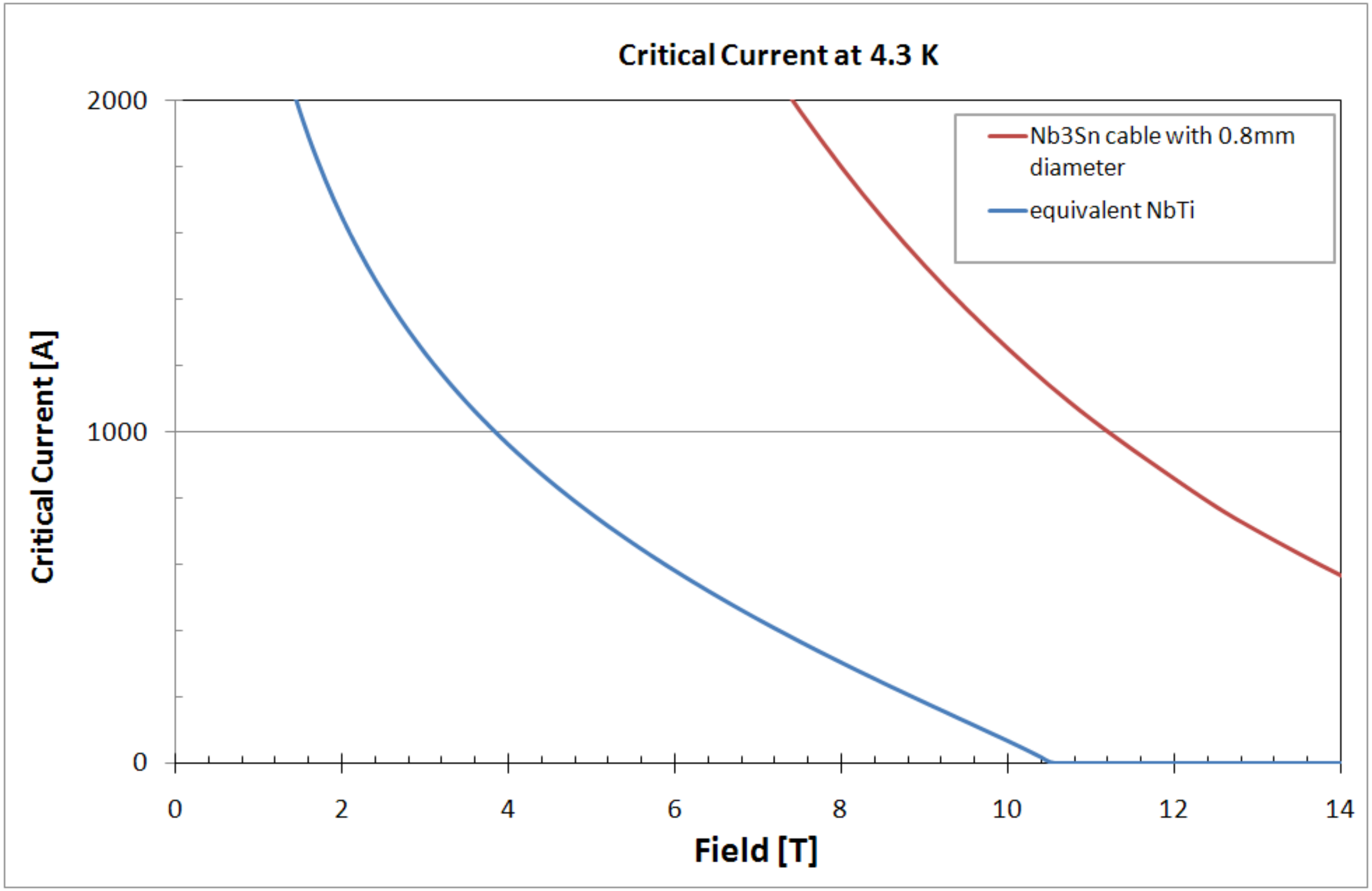
- **We can use permendur but the maximum pole field will not be more than 2.3 T**

- **With a gap of 14 mm and 40 mm period, the peak field on the mid plane will be in the order of 1.1 T !**

- **With the same gap (14mm) and 100 mm period we can reach 1.7 T.**

ADVANTAGE: No Cryogenics !

Nb-Ti → Nb_3-Sn



Critical Current at 4.3 K
Critical Current [A]
2000
1000
0
0
2
4
6
8
10
12
14
Field [T]
Nb3Sn cable with 0.8mm diameter
equivalent NbTi

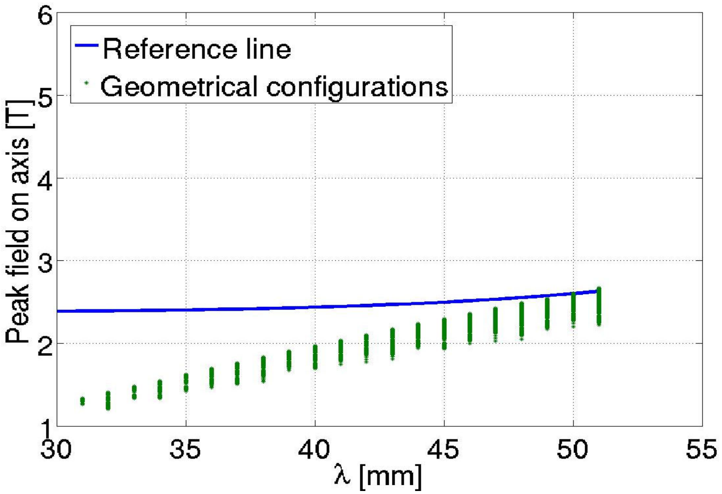
Heat load capabilities

“ sacrificing Nb3Sn current density in favor of temperature margin can provide very good heat transfer capacity: more than 1 order of magnitude bigger than Nb-Ti”

Phys. Rev. ST Accel. Beams **11,** 082401 (2008)

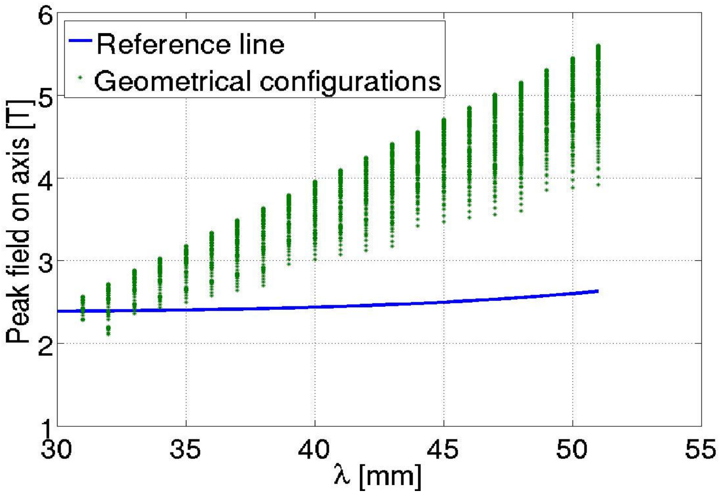
Nb-Ti/Nb_3-Sn Wigglers optimization

NbTi



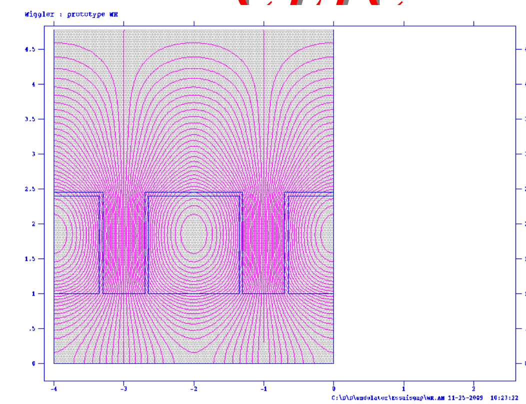
LHC NbTi corrector wire #3, 1.25 x 0.73 mm^2 including insulation, 1.13 x 0.61 mm^2, Cu:Sc 1.71; 70% of maximal current density

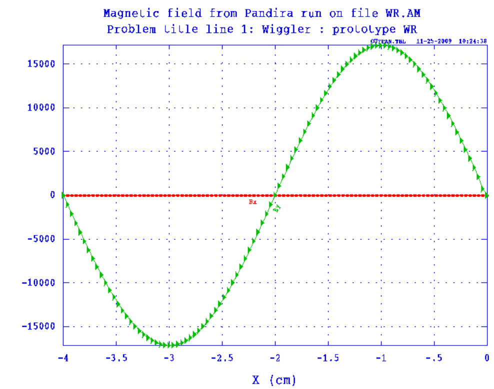
Nb_3Sn

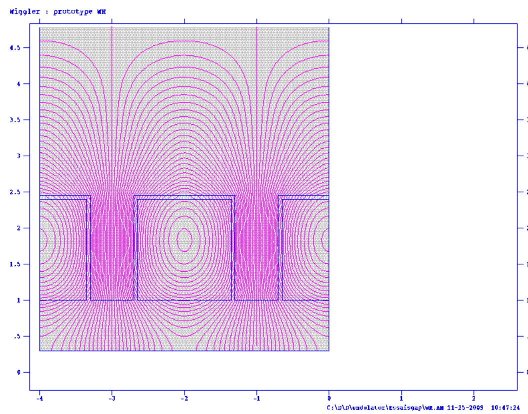


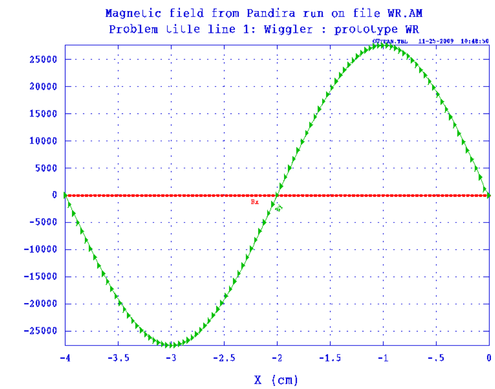
0.8 mm RRP Nb_3Sn Strand; 70% of maximal current density

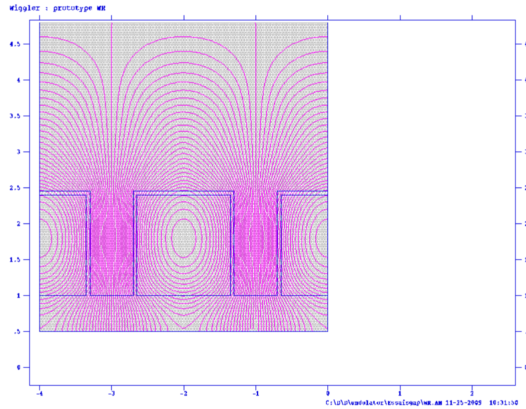
B $_{(peak)}$ → Gap size

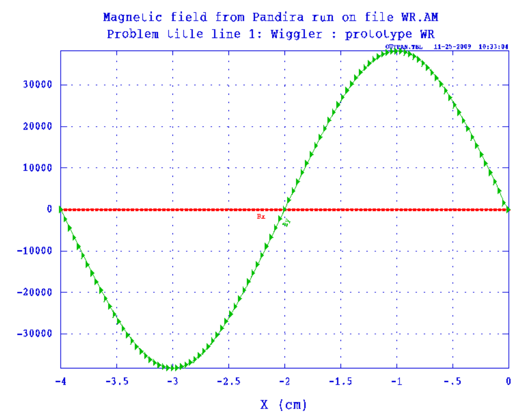


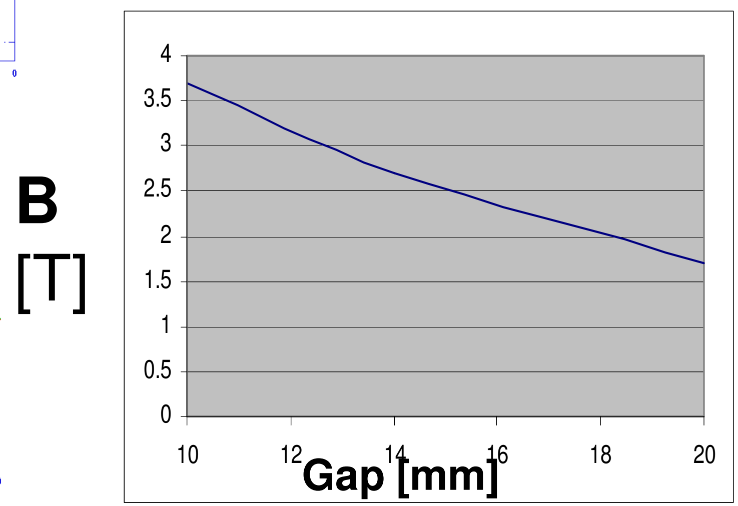




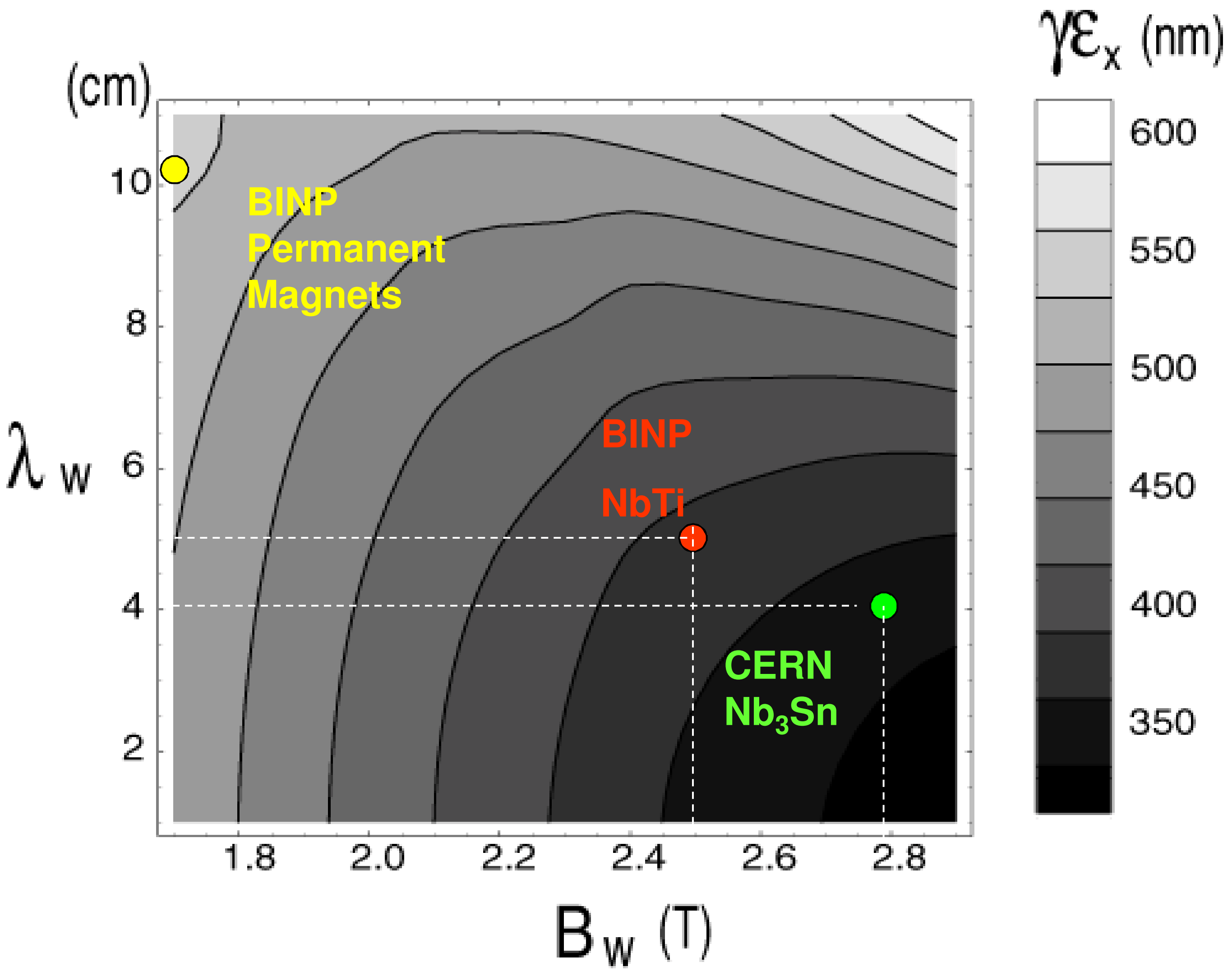




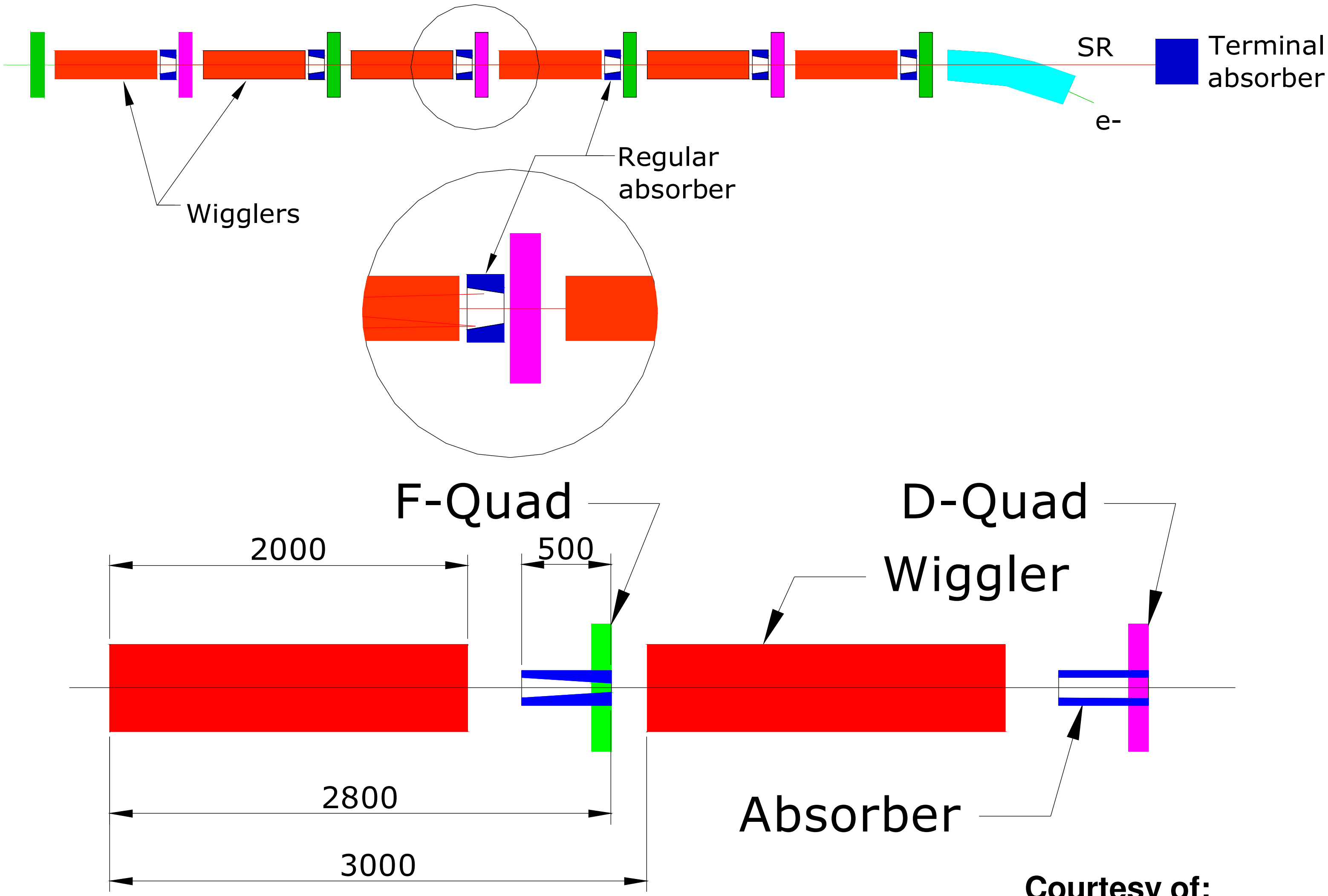




Wigglers → beam size



SR power evacuation strategy

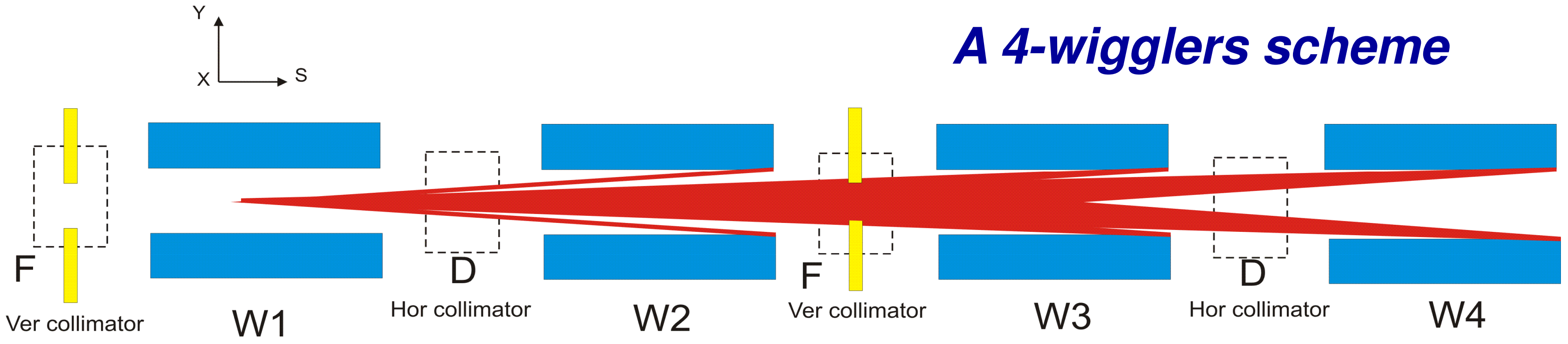


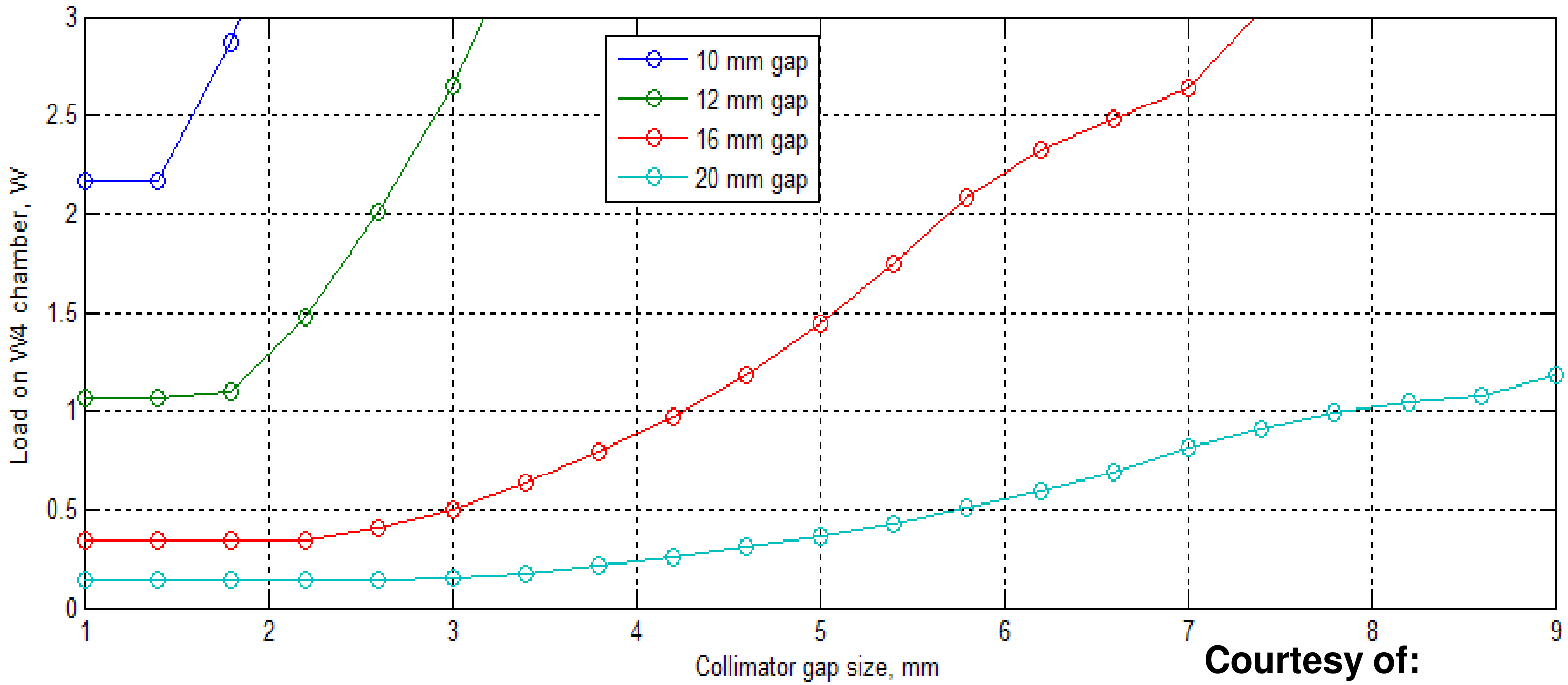
Courtesy of:

Konstantin ZOLOTAREV

SR Heat load estimation

A 4-wigglers scheme

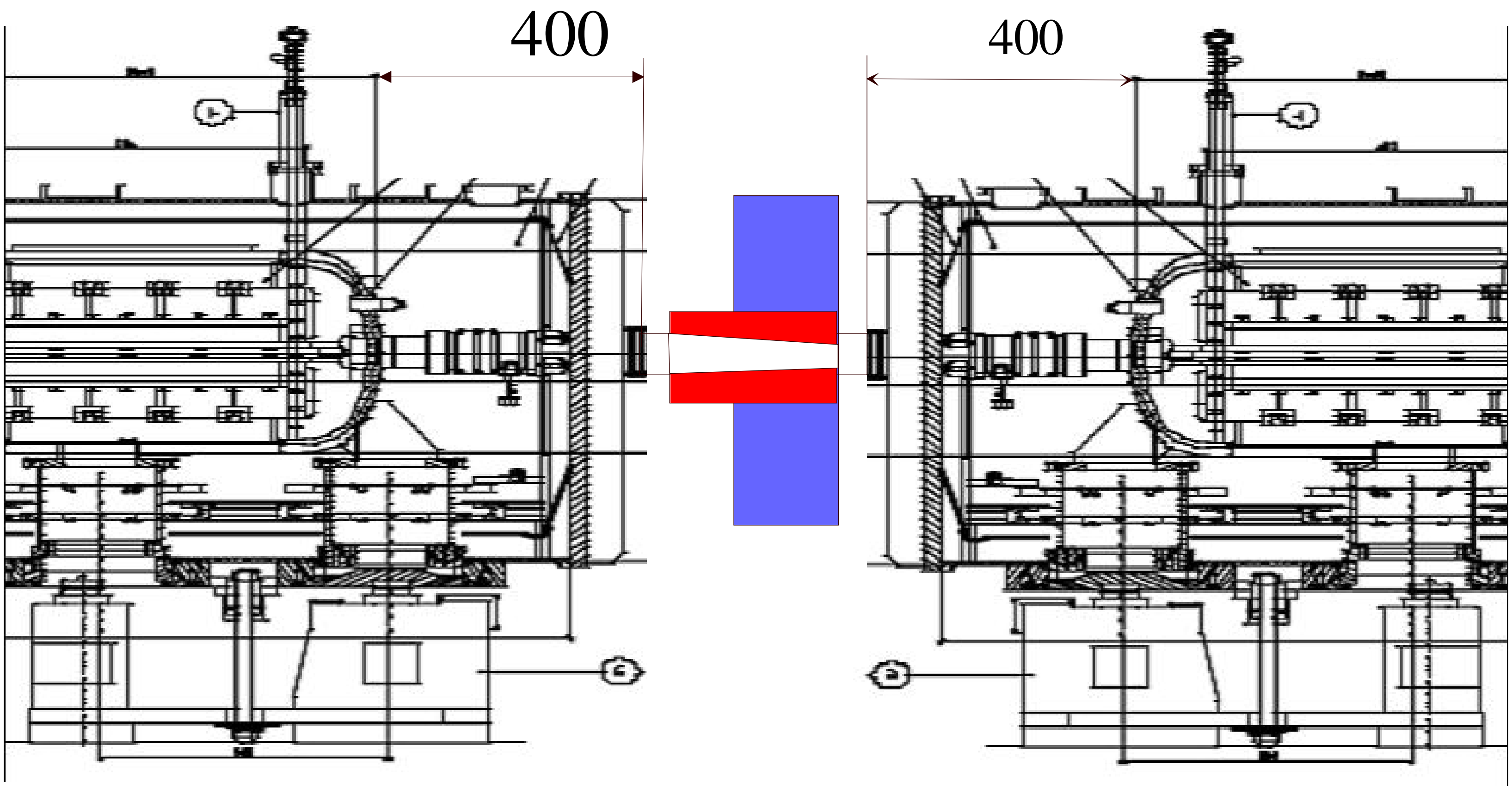




Courtesy of:

Konstantin ZOLOTAREV

Cold/Warm/Cold Transitions



Adopted Program

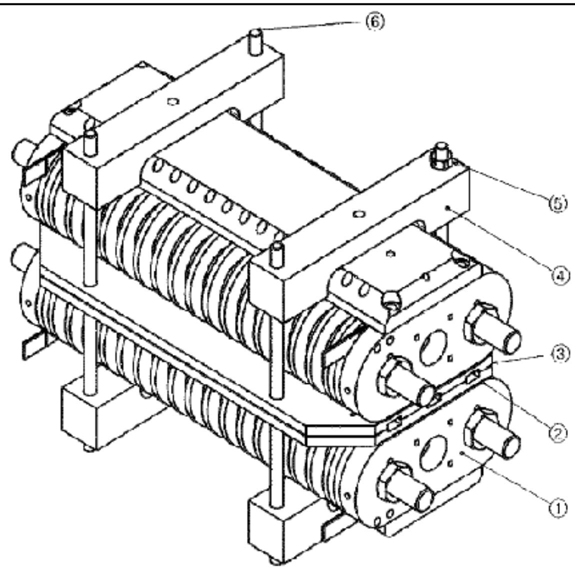
- Two wiggler short-prototypes
  - 2.5T, 5cm period, built and currently tested by BINP
  - 2.8T, 4cm period, designed by CERN/Un. Karlsruhe
- Short prototypes built and magnetically tested (at least one by CDR 2010))
- 2012 Prototype Installed in a storage ring (ANKA, CESR-TA, ATF) for beam measurements (IBS/wiggler dominated regime)

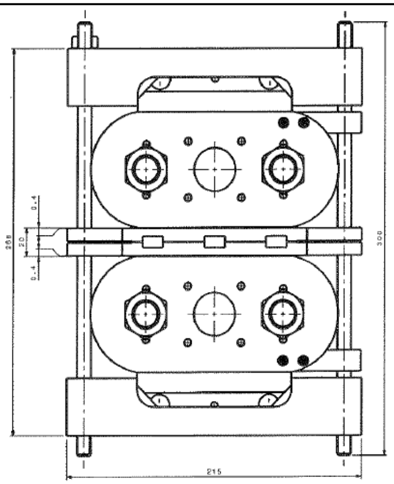
Wigglers Parameters

Parameters	BINP	CERN
B_{peak} [T]	2.5	2.8
λ_W [mm]	50	40
Beam aperture full gap [mm]	12	12
Conductor type	Nb-Ti	Nb_3-Sn
Operating temperature [K]	4.2	4.2

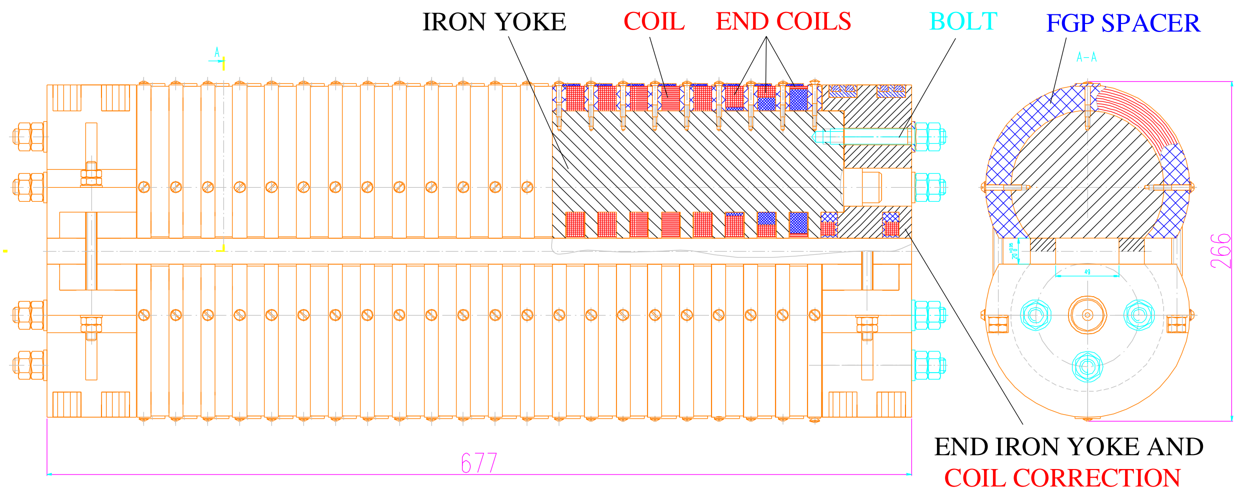
Wigglers Design

CERN

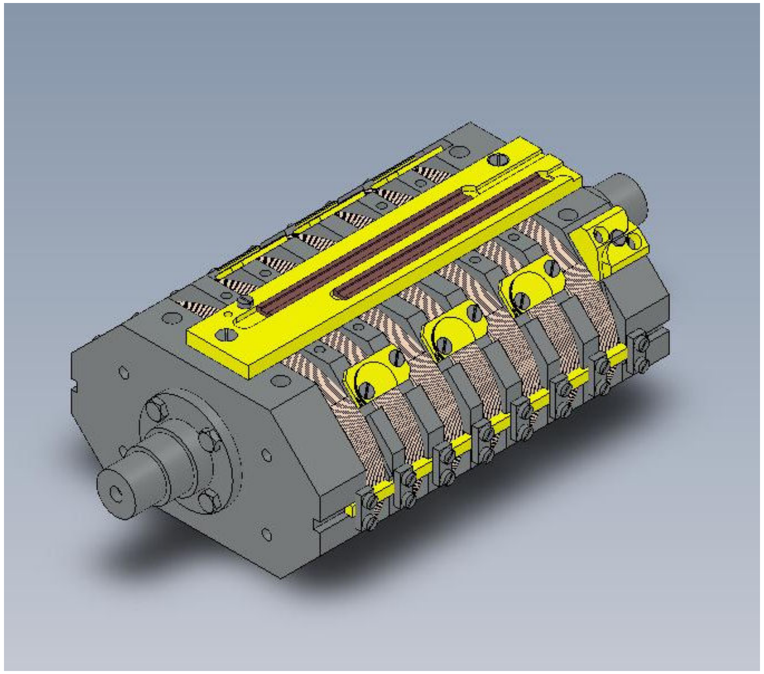




BINP



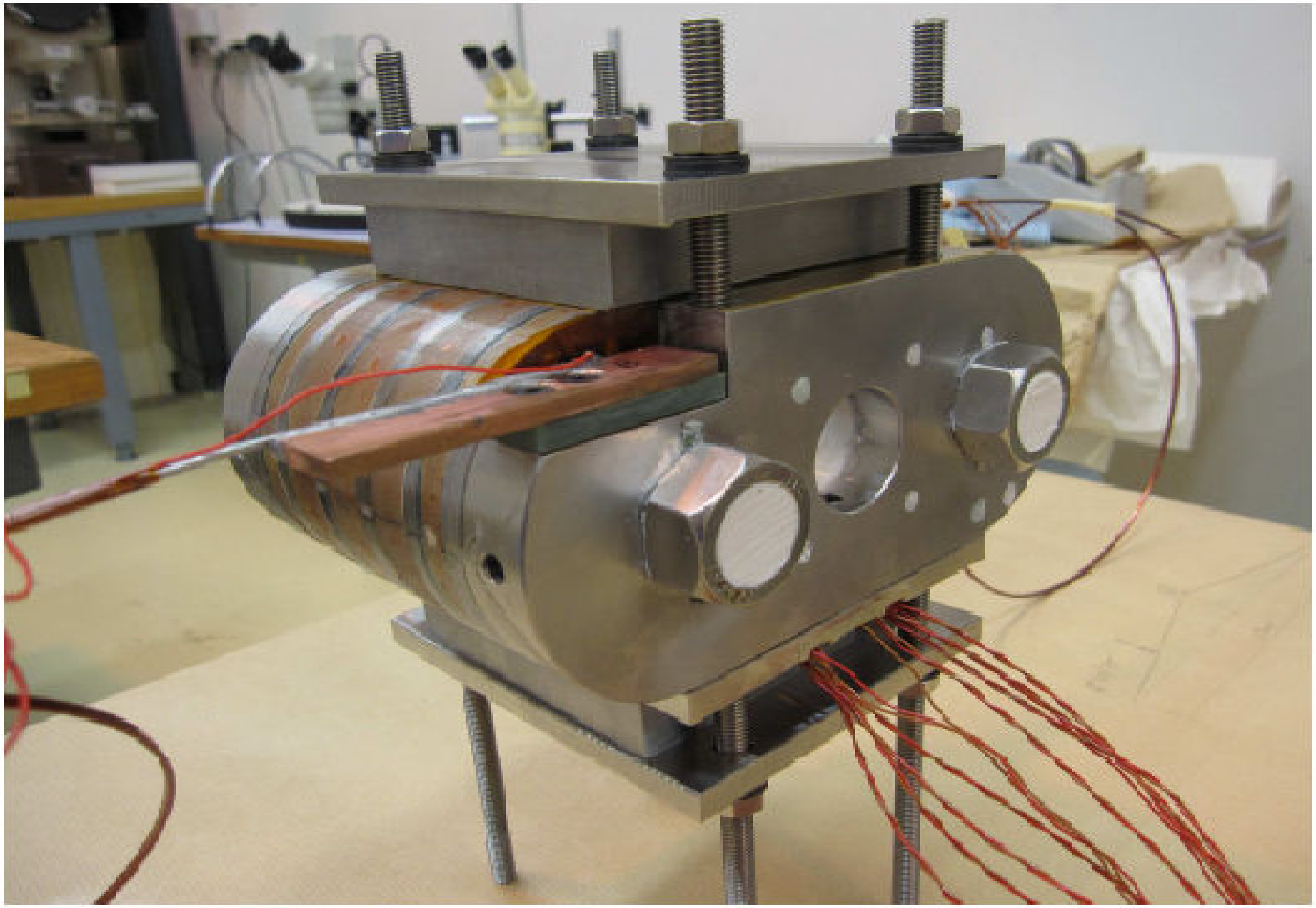
BINP short-prototype



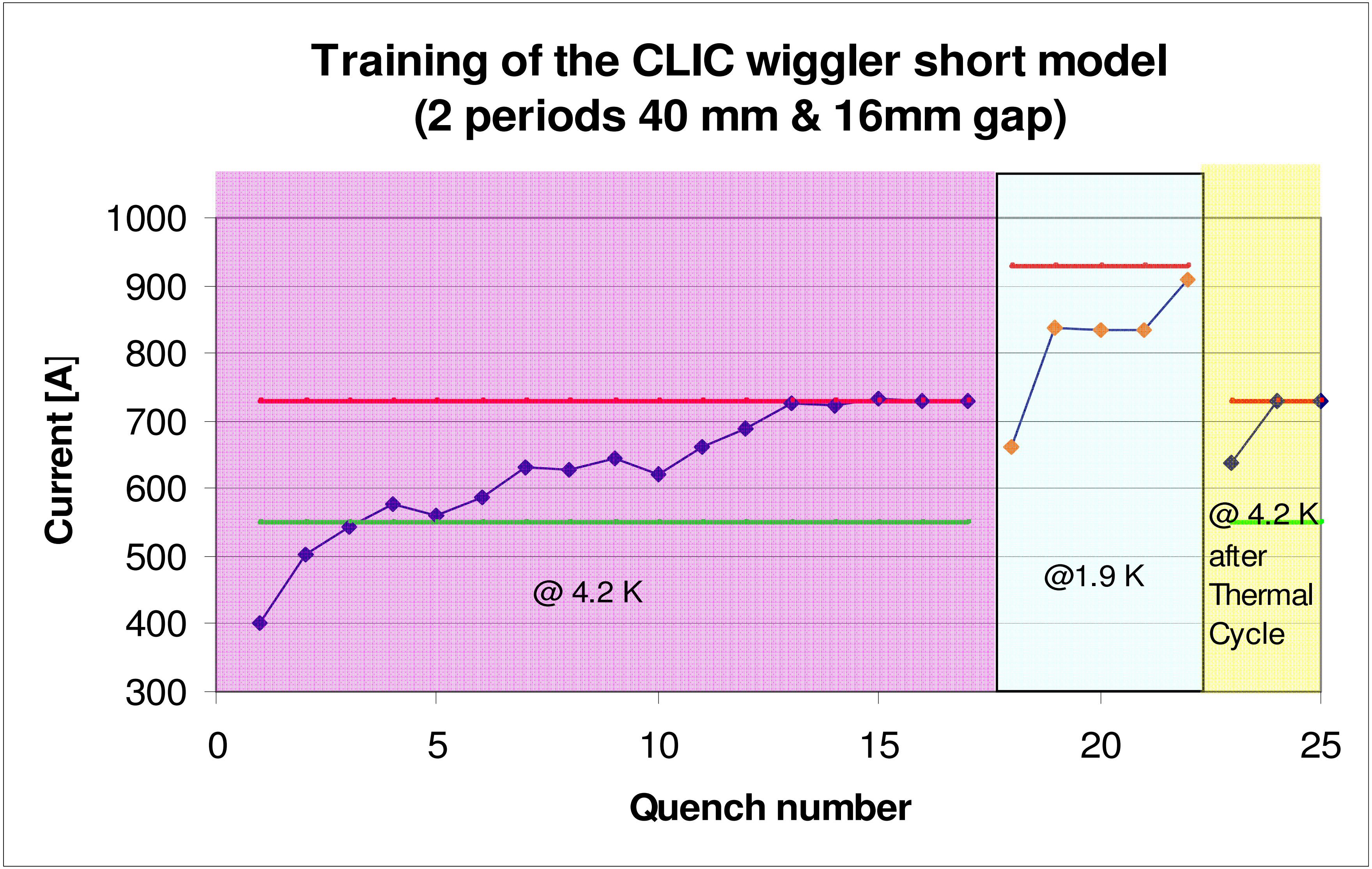
Actual version

New design

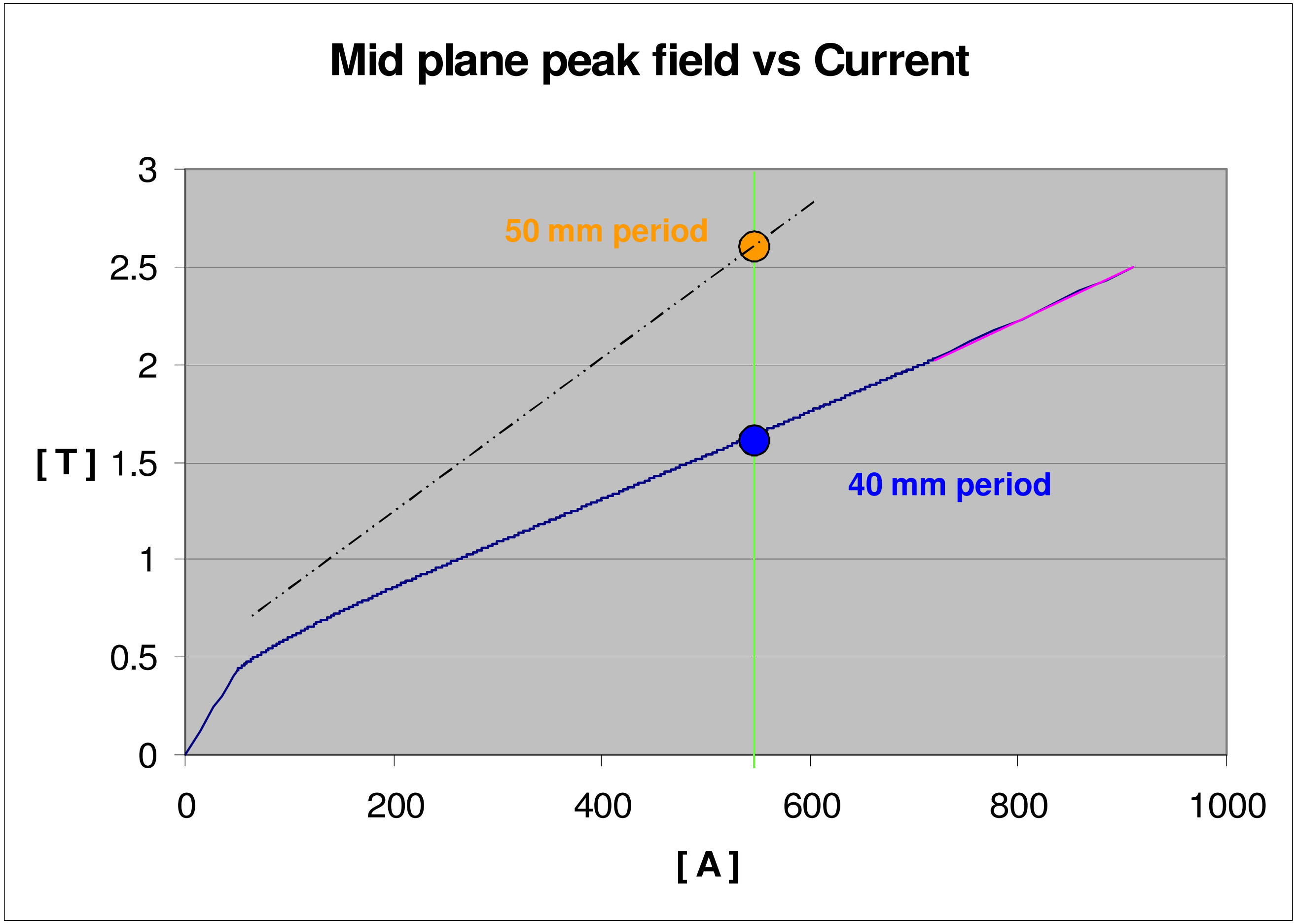
CERN short-prototype



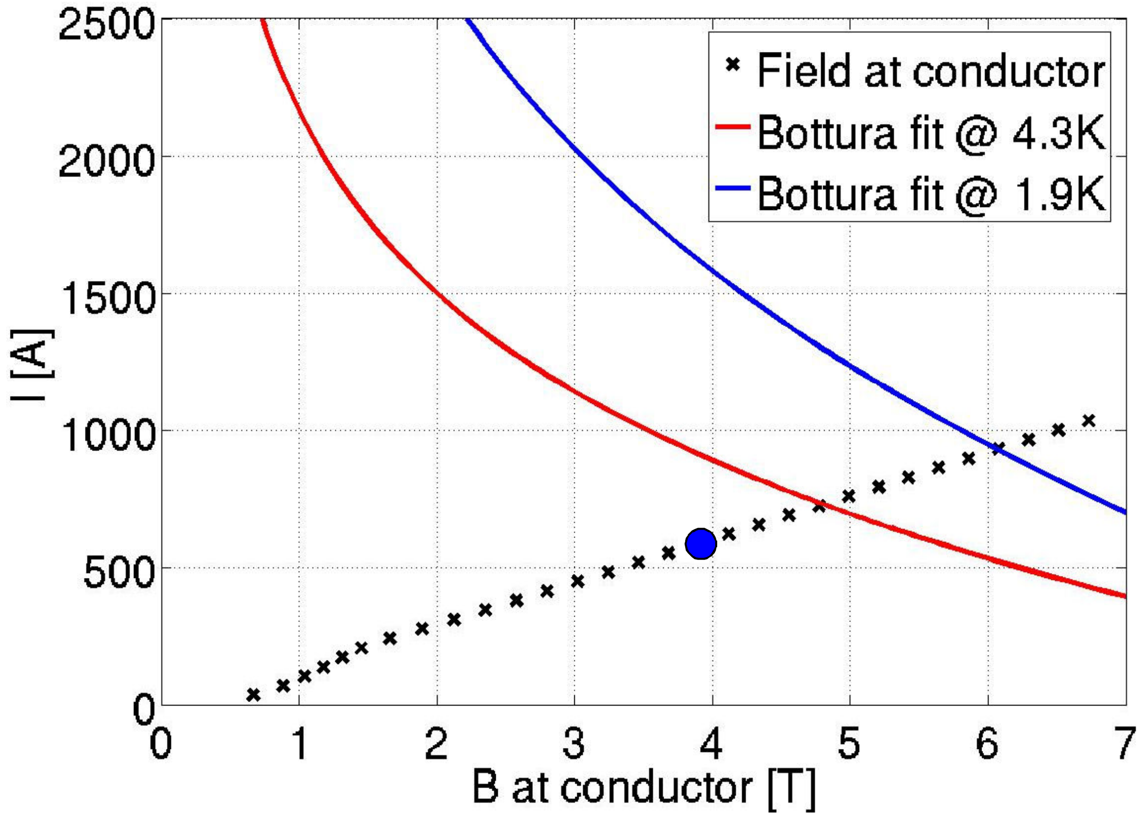
CERN short prototype test



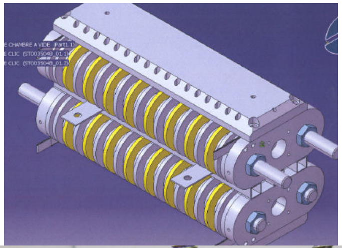
Obtained Mid-plane peak field vs. current for 40 mm period and scaling for 50mm period



Operating load line



CLIC CERN short model status



Modeling:

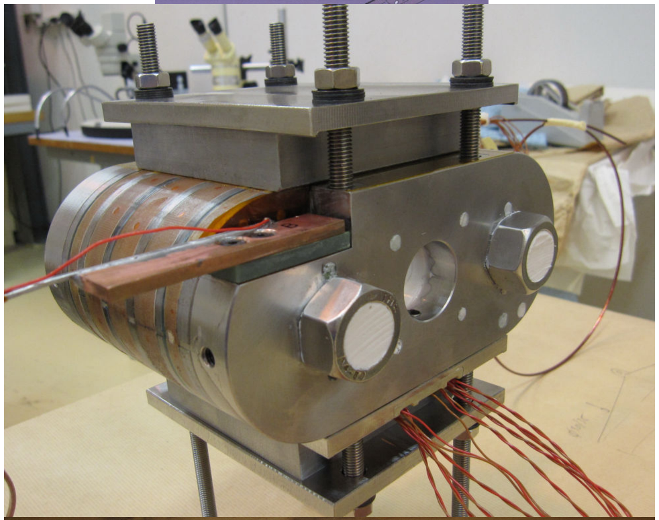
-Magnetic 2D : Done (Maccaferri, Schoerling)

-Forces calculations : Done (Maccaferri, Schoerling)

-Magnetic 3D : Done (Schoerling, Bernhard)

--Multipole analysis : Done (Schoerling, Bernhard)

-ANSYS : To be done (Schoerling end 2010)

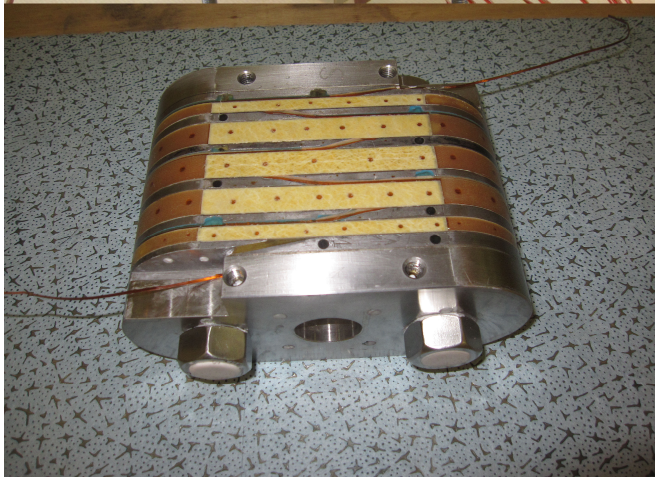


Prototyping (NbTi):

-Mechanical design : Done(to be updated)

-Winding and impregnation : Done (J.Mazet, JC Clement)

-Cold test : Done week 41 (09)



Milestones

- **2009**
  Electromagnetic and mechanical design of a NB-Ti and Nb3-Sn short prototype (Done)
- **End 2009**
  Manufacture and test of a Two periods Nb-Ti model(Done)
- **Mid 2010**
  Manufacture and test of a Two periods Nb3-Sn model
  Manufacture and test of a new BINP design Nb-Ti model
- **Mid 2011**
  Design of a Full scale prototype
- **Mid 2012**
- Manufacture & test of a full scale prototype

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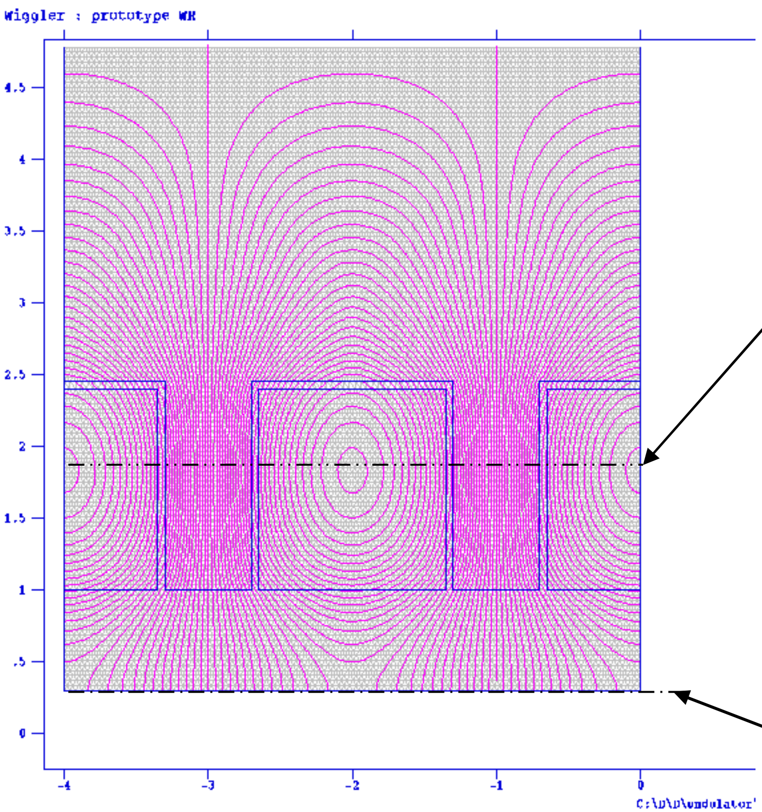
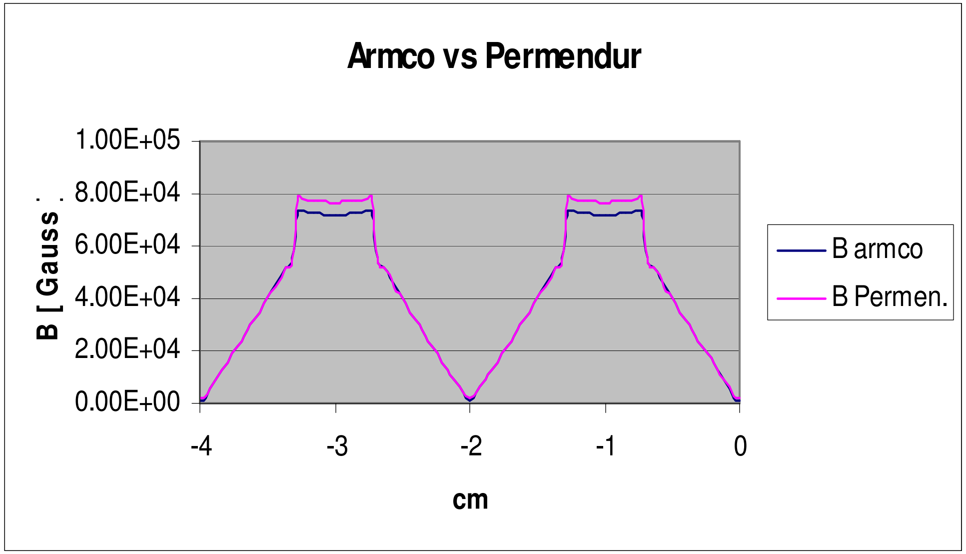
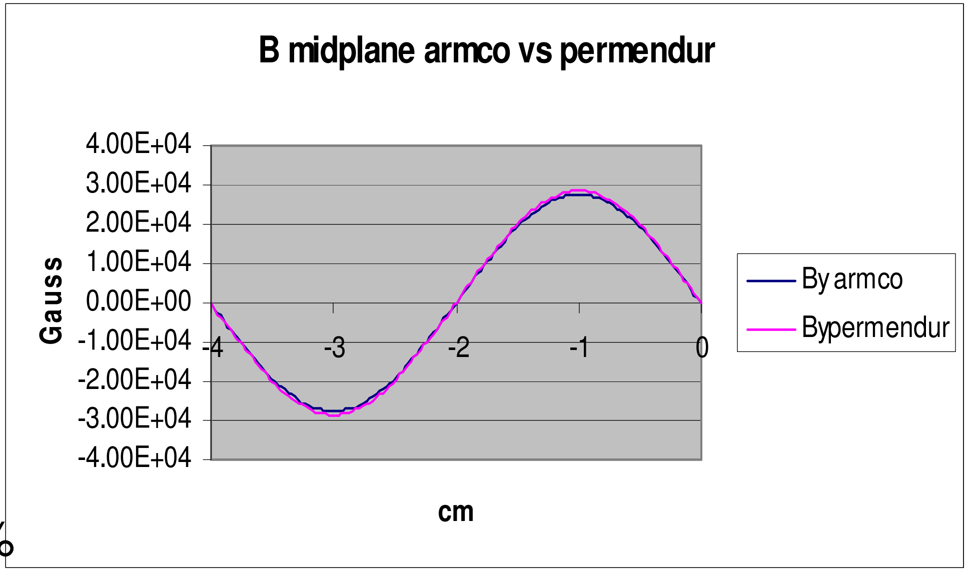
Alfons Ams, TU Bergakademie Freiberg
Robert Rossmanith, Karlsruhe Institue of Technology
Axel Bernhard, Karlsruhe Institute of Technology
Johann Peter Peiffer, Karlsruhe Institute of Technology

Thank You !

ARMCO vs PERMENDUR







Vanadium Permendur:

$B_{sat} > 2.3$ T

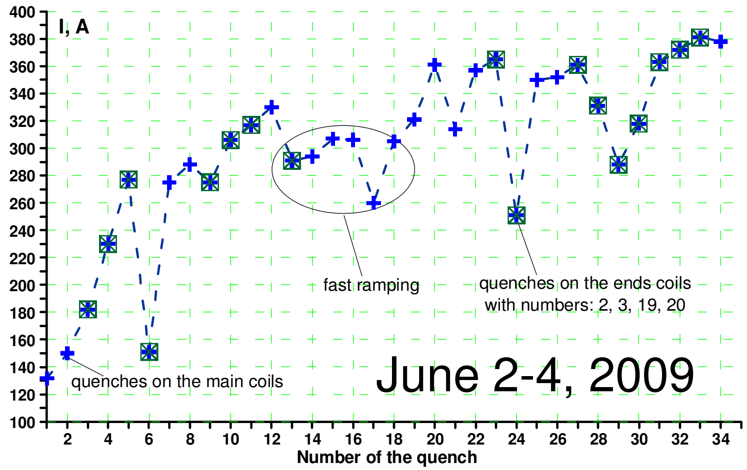
Soft magnetic alloy of 2% vanadium, 49% cobalt and 49% iron

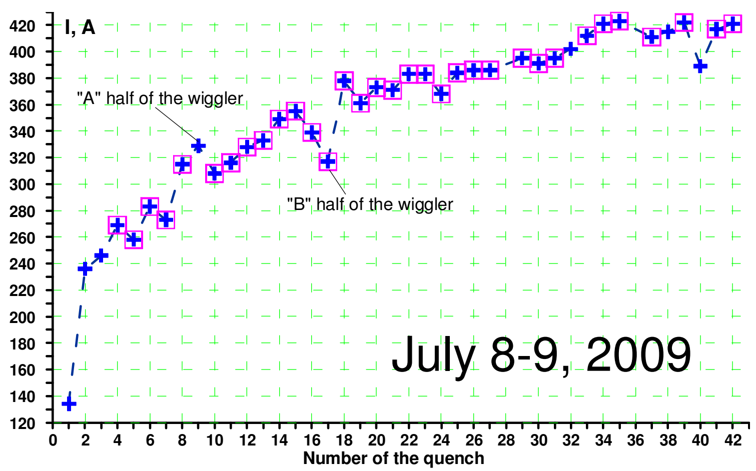
Conclusions on the tests

CLIC

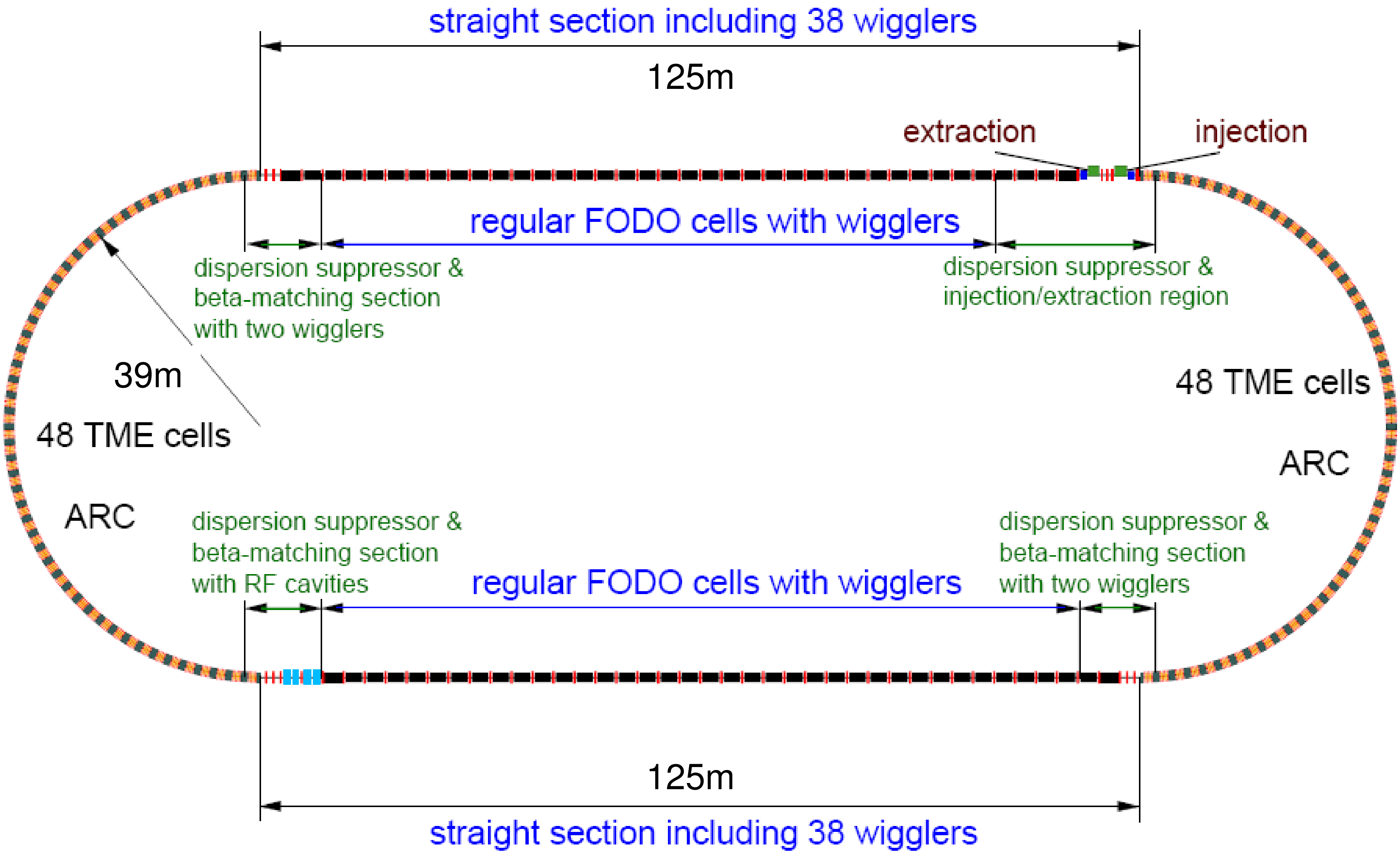
(For the BINP model from BINP team)

- The training was too long. The 420 A current was achieved instead 661 A of the design current.
- The most quantity of quenches, 33 out of 40, was in one – the "B" half of the wiggler.
- The protection system worked well. The maximal voltage on the first quenched coil was about 100 V.
- The significant difference of the quantity of quenches between the two halves. One of the reasons of this may be the different epoxy impregnation: difference in epoxy mixtures, quantity of powder, etc.
- The use GFP spacers, of those thermal expansion coefficient is up to 6 times larger than for the iron, may only impair the imperfect epoxy impregnation. But we don't see the clear evidence that the reason of degradation lays on the spacers.





DR layout



straight section including 38 wigglers
125m
extraction
injection
regular FODO cells with wigglers
dispersion suppressor &
beta-matching section
with two wigglers
dispersion suppressor &
injection/extraction region
39m
48 TME cells
48 TME cells
ARC
ARC
dispersion suppressor &
beta-matching section
with RF cavities
regular FODO cells with wigglers
dispersion suppressor &
beta-matching section
with two wigglers
125m
straight section including 38 wigglers