Superconducting wiggler magnets for CLIC. Status and perspectives

CLIC PROJECT MEETING

CERN, 9 JUNE 2015

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Outline

Nb-Ti full length wiggler

- Bath test
- Factory Acceptance Test (FAT)

Nb_3Sn wiggler prototype

- Performed and forthcoming tests

Nb-Ti full length wiggler

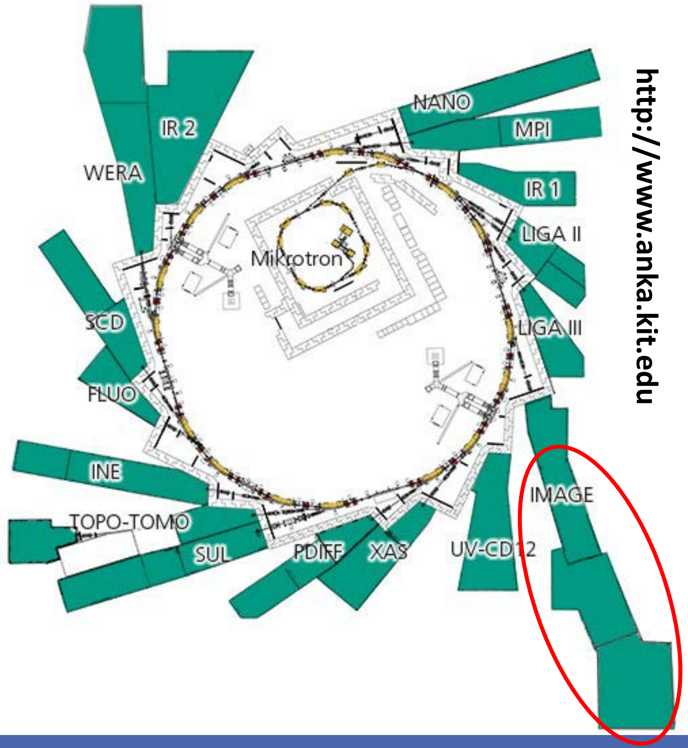
Designed and built at BINP, Novosibirsk, Russia, in the frame of BINP/KIT/CERN collaboration

This wiggler is intended for two operation modes:

- As light source at ANKA-IMAGE beamline
- Like test facility for CLIC damping wiggler prototype

Main parameters:

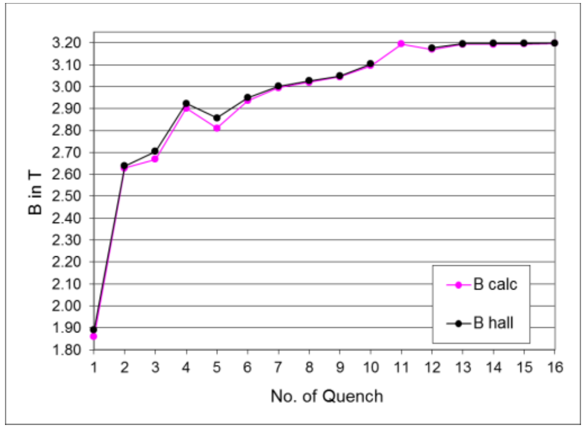
- Period length: 51mm
- Magnetic field: > 3T
- Vacuum gap cold: 13mm
- Magnetic gap cold: 18mm
- Working point: 81% / 86% (inner / outer coil section)



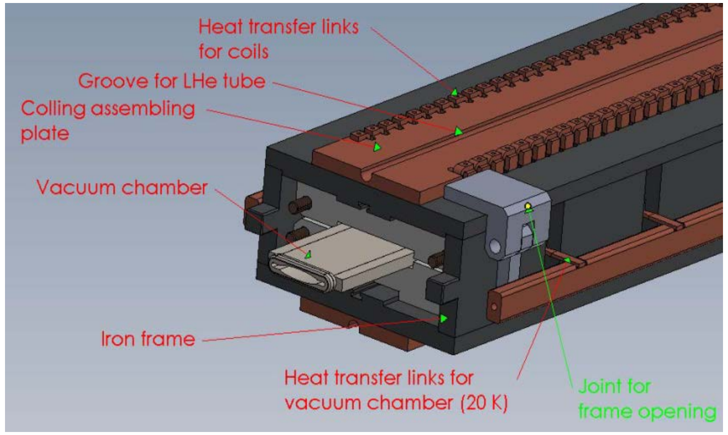
http://www.anka.kit.edu

Nb-Ti full length wiggler – Bath test. March 2014

- The magnet was tested at BINP, Russia, in liquid He bath
- It reached a bore field of 3.2T (91% of short-sample field)



Quench history during the bath test. Zoloratev K., 2014



Wiggler sketch. Mezentsev N.A., 2012

Magnetic system assembly

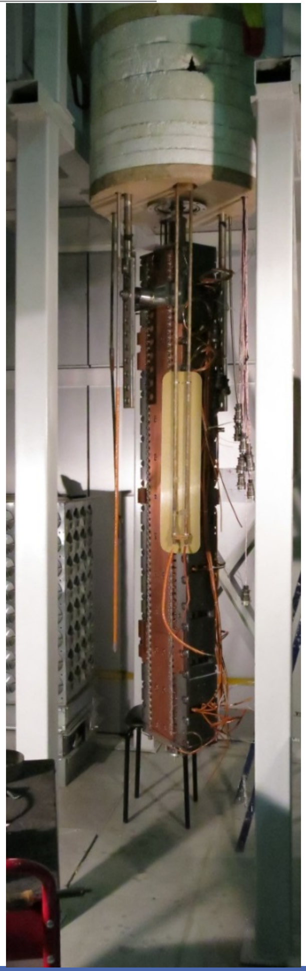


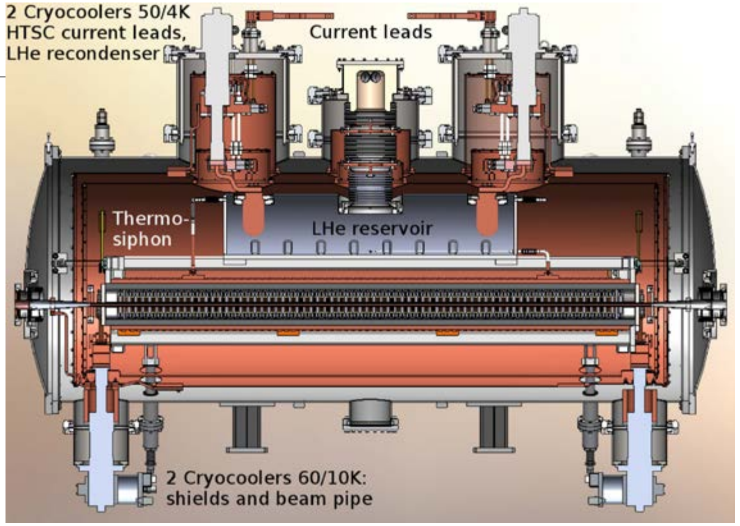
Photo taken during bath test at BINP

Nb-Ti full length wiggler – 1^{st} FAT. May 2014

- The magnet was tested in its own cryostat at BINP, Russia.
- Cooling down to a temperature <= 4.2K (minimum achieved temperature was 3.2K)
- Maximum bore field reached = 3.1T
- It was possible to hold the current for more than 1 hour only up to a field of 2.6T, with the magnet quenching at 2.7T after about 10 minutes

Strategies adopted to increase the field in the gap

- The magnetic gap was reduced from 18mm to 17mm (different spacers installed)
- Copper foils of 0.2mm were installed between the coils, slightly increasing the period length (from 51mm to ~51.5mm)



Cross-section of the assembled wiggler cryostat. Mezentsev N.A., 2012

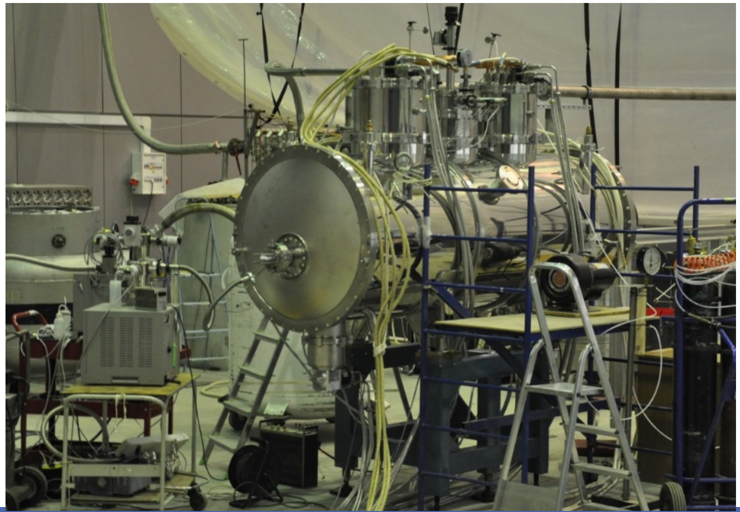


Photo taken during FAT at BINP

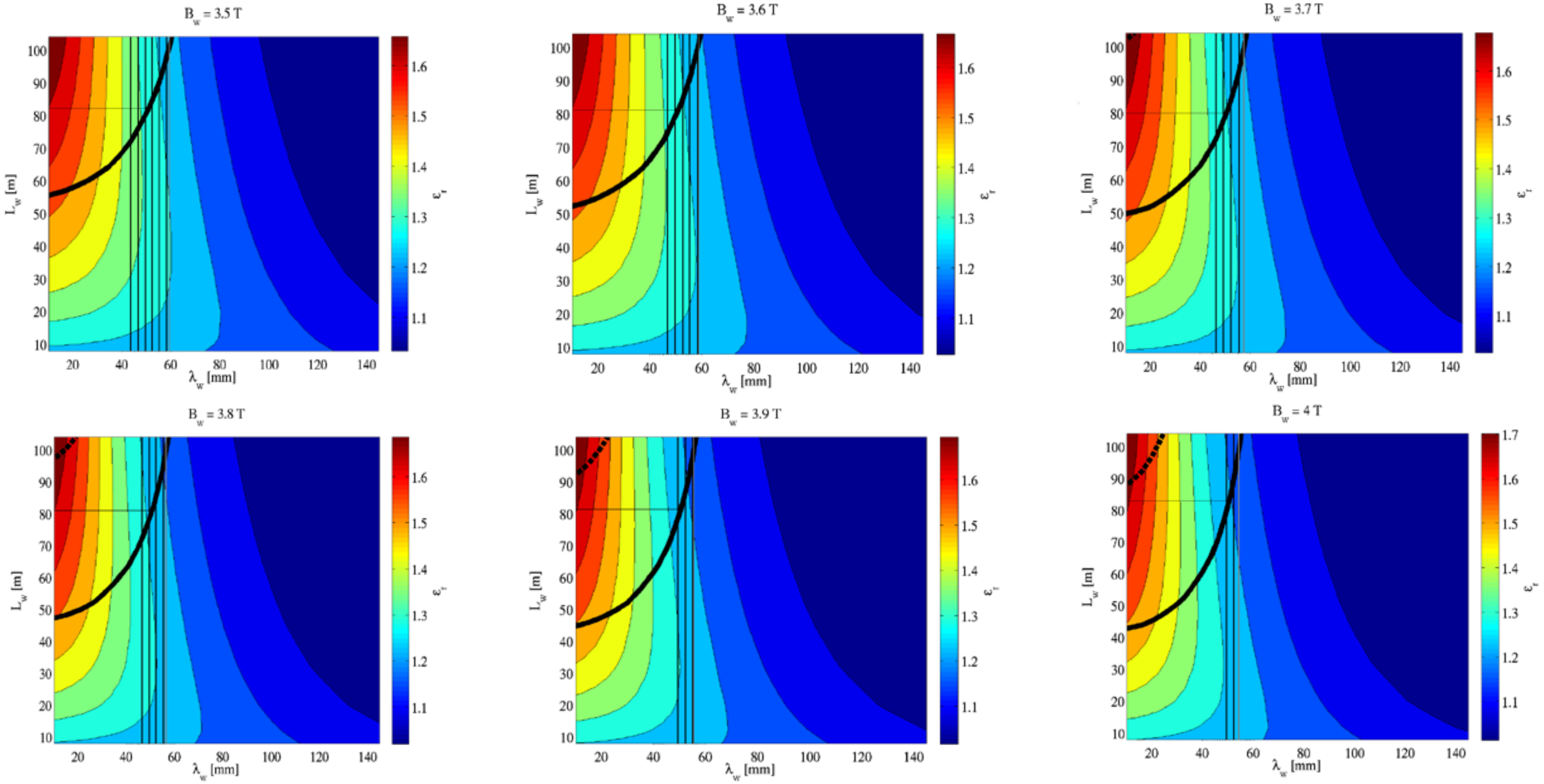
Nb-Ti full length wiggler – 2nd FAT. April 2015

- **The magnet was cooled to 3.8K**
  - Cool-down can be performed without using any liquid Helium or Nitrogen within around 7 days, and can also be accelerated by several days if LN and LHe is available
- **With conduction cooling the magnetic field was limited**
  - Acceptance criterion: > 95% at 4.2K, stable over 2 weeks. Achieved: 3.2T at ramping corresponding to 80 / 88% (inner / outer coil section) and 2.95T stable over 2 weeks corresponding to 72 / 81%
  - BINP will continue searching for an explanation of the observed limits by using the conduction-cooled short model
- **The wiggler passed the FAT and was shipped to ANKA. The Site Acceptance Test (SAT) is scheduled to take place in July 2015**

Nb_3Sn prototype

Goal: To test the Nb_3Sn technology for building wiggler magnets for CLIC to decrease the size of the damping rings while increasing the working margin of the magnet

Plots by F. Antoniou



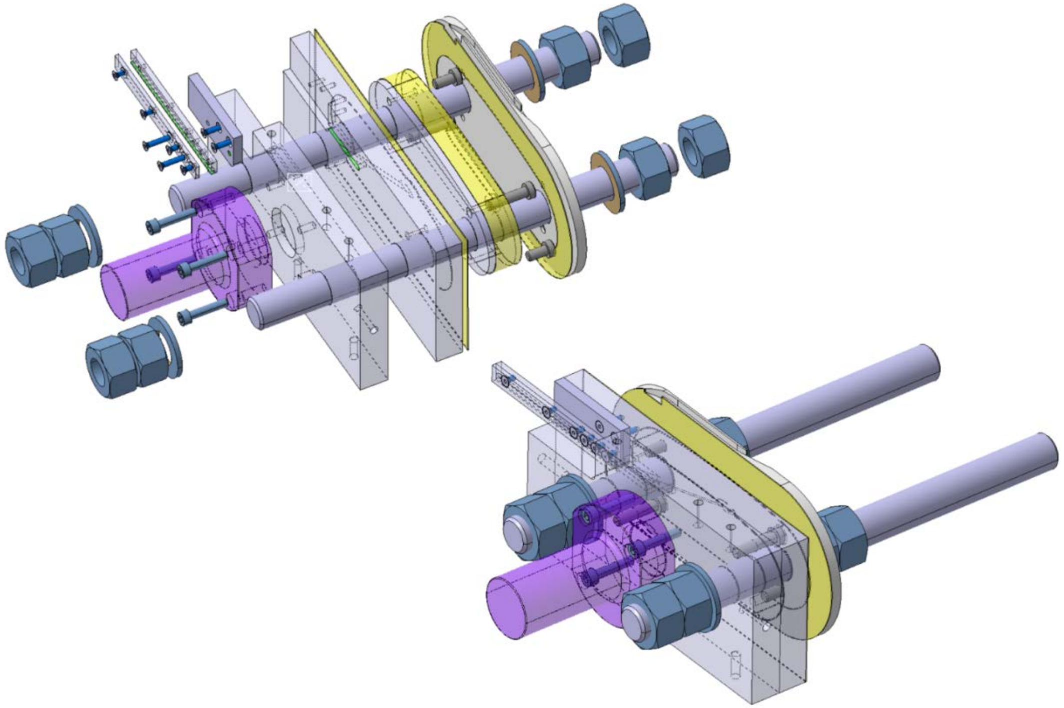
Period length: 49.5mm
Magnetic gap: 15mm

B_w [T]	Working point [%]
3.5	64.5
3.6	66.7
3.7	68.9
3.8	71.1
3.9	73.3
4.0	75.5

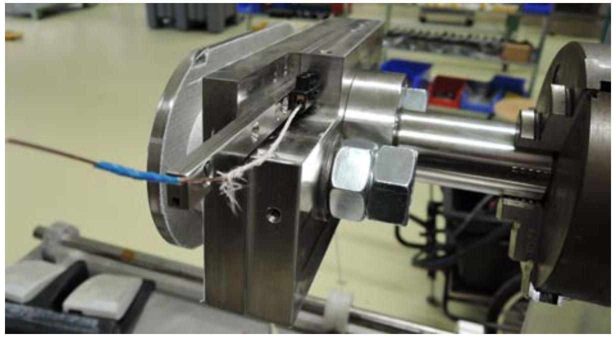
B_w: Maximum mag. field dens. in the gap
L_w: Total length of wigglers in the damping rings
ε_r: Intra-beam scattering effect
λ_w: Period length

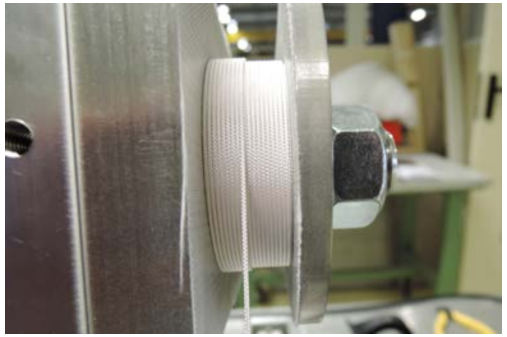
Nb_3Sn prototype - Performed and forthcoming tests

- First winding test of 1 coil using copper strand insulated with fiberglass to check the thickness of the coils before heat treatment **(accomplished in May 2015)**



Drawings by J. Parrilla Leal





Photos taken during the first winding test. Cern, bldg. 927

Nb_3Sn prototype - Performed and forthcoming tests

- Second winding test of 1 coil using low grade Nb_3Sn insulated with fiberglass to check growth of the coils' dimensions after heat treatment and perform electrical tests after impregnation
  - *1) Insulating the wire; 2) Manufacturing the wiggler pieces and plasma coating the ARMCO poles; 3) Winding, reacting and impregnating the coil; 4) Performing electrical tests*
- Bath test of 5 coils prototype using Nb_3Sn strand insulated with fiberglass
  - *Same steps as the second winding test, plus: 1) Manufacturing the impregnation mould; 2) Installing the quench protection system; 3) Testing the prototype in liquid helium*

Conclusions

- The Nb-Ti wiggler magnet passed the FAT and will be installed at ANKA for the SAT. It meets the requirements of CLIC damping rings although for future magnets that use conduction cooling it is necessary to increase the working margin. The magnet will stay at IMAGE beamline in ANKA as light source
- The Nb_3Sn short prototype is expected to be built and tested by the end of the present year. Future plans regarding the full size magnet would depend on finding a collaborator like ANKA to share the expenses of the project, the interest from CLIC in using Nb_3Sn technology for the damping rings wigglers and on availability of resources in the MSC group. Work in progress.

THANK YOU FOR YOUR ATTENTION

References

- Bernhard A. Protocol Factory Acceptance Test CLIC Damping Wiggler Prototype, April 21 - 30, 2015.
- Mezentsev N.A. et al. CLIC/ANKA Wiggler Factory Acceptance Test. Results. BINP, 2015.
- Mezentsev N.A. et al. Final Design Report on Superconducting Wiggler Serving as CLIC Damping Wiggler Test Device and Light Source for ANKA-IMAGE-Beamline at KIT. BINP, 2012.
- Zolotarev, K. The results of Hall probes measurements of the ANKA/CLIC wiggler. BINP, 2014.
- Notes from Daniel Schoerling after the FAT, 2015.