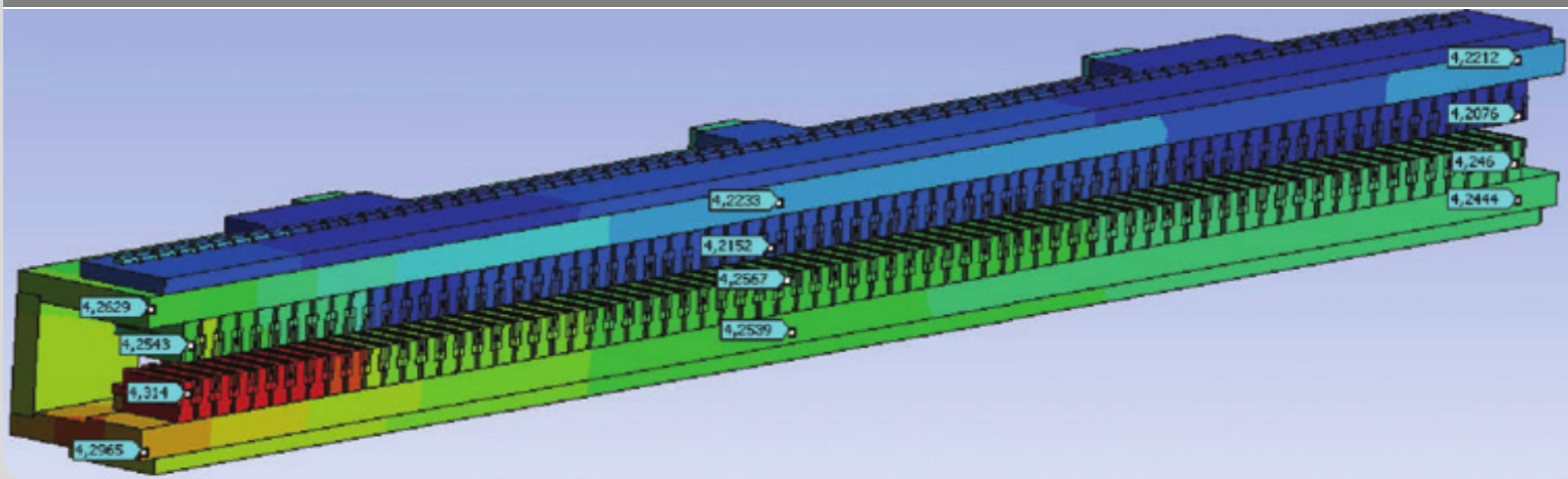
Nb-Ti Wiggler design progress and experimental plan at ANKA

Steffen Hillenbrand,
For the KIT-CLIC collaboration



Outline

- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

Outline

- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

Introduction – CLIC Damping Rings

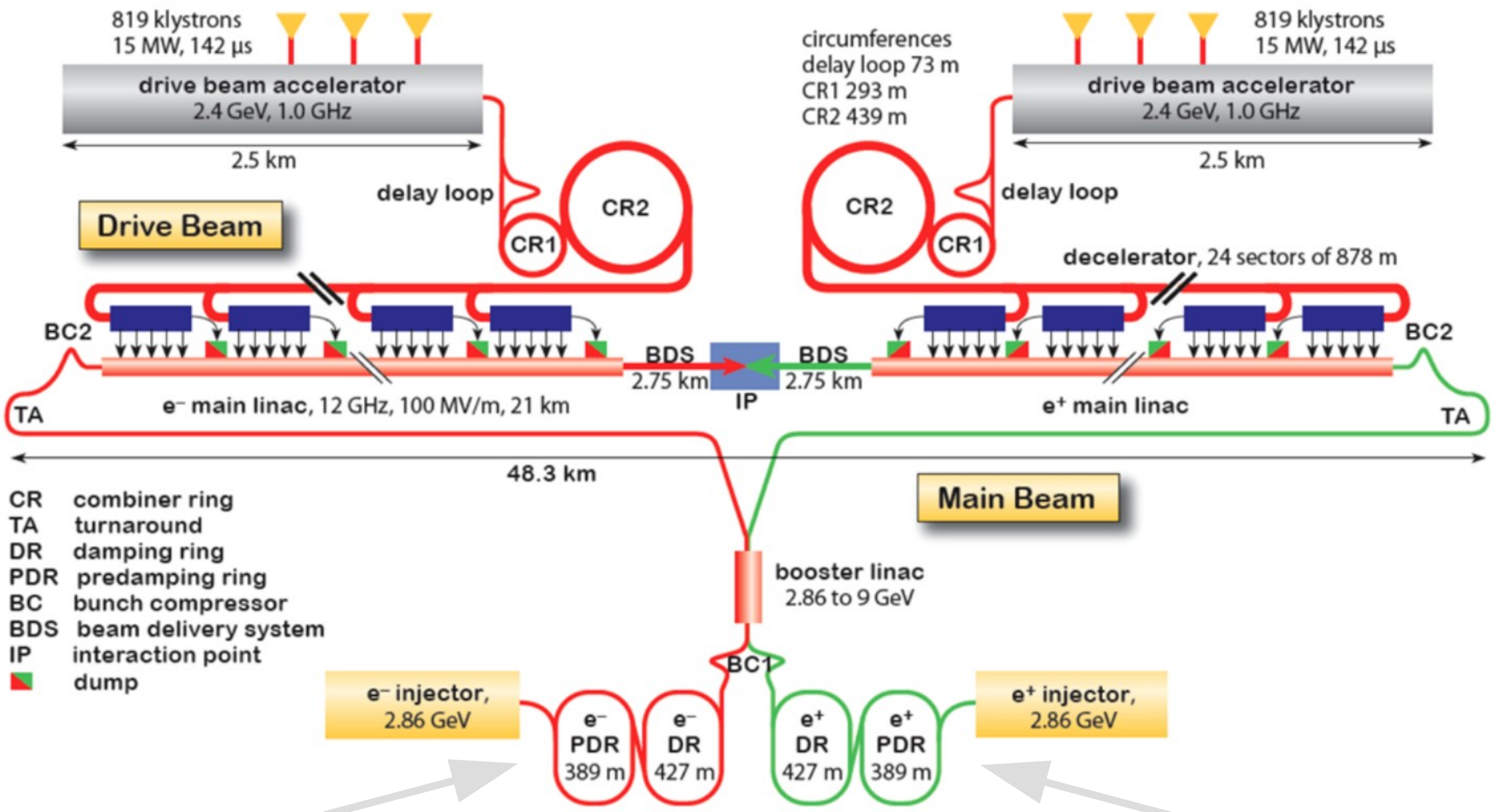
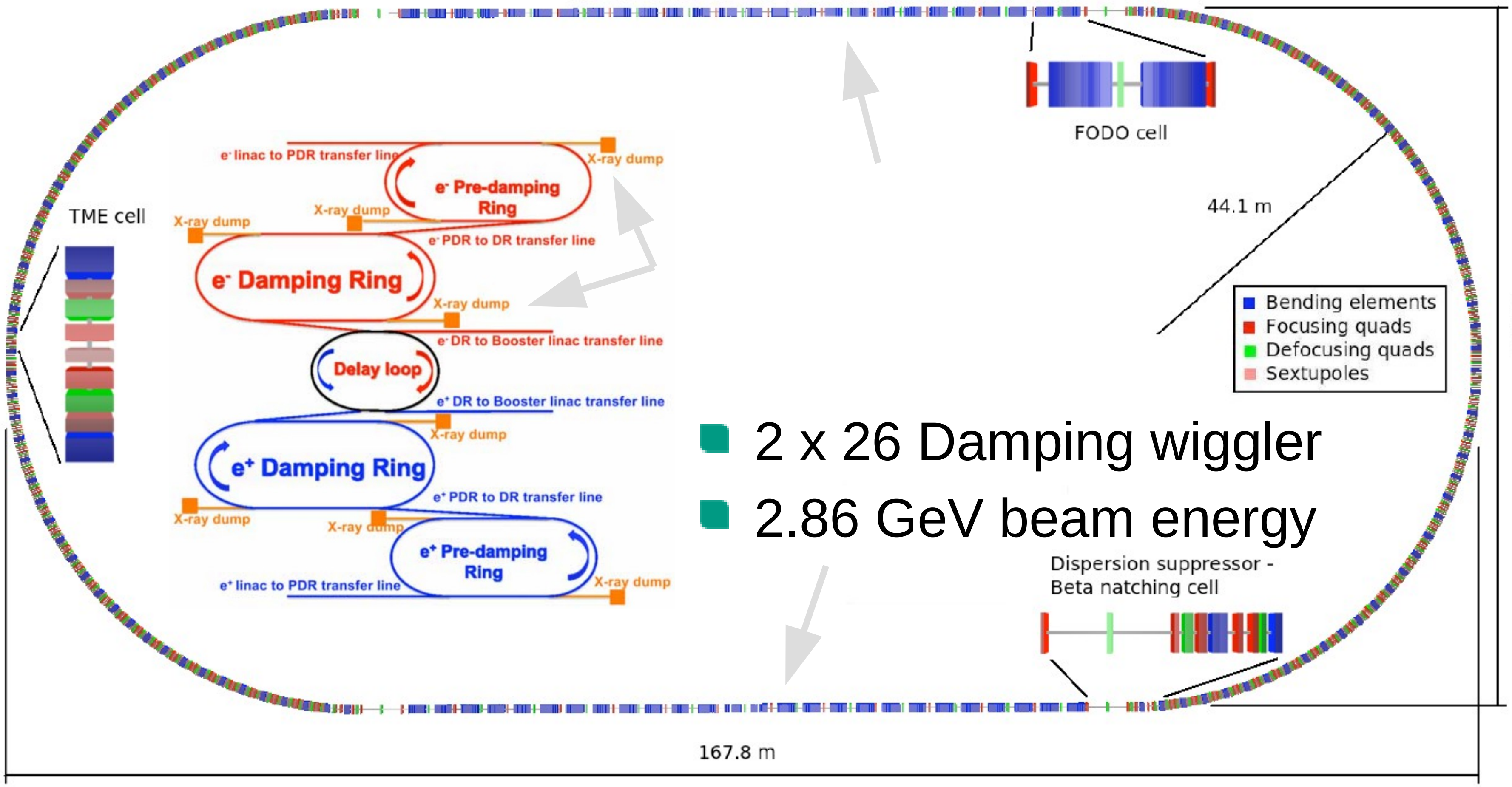


Figure: ICFA beam dynamics newsletter 62

- Very small beam size needed for high luminosity, thefore
- Damping rings (DR) needed to reach emittance requirement.

Introduction – CLIC Damping Rings

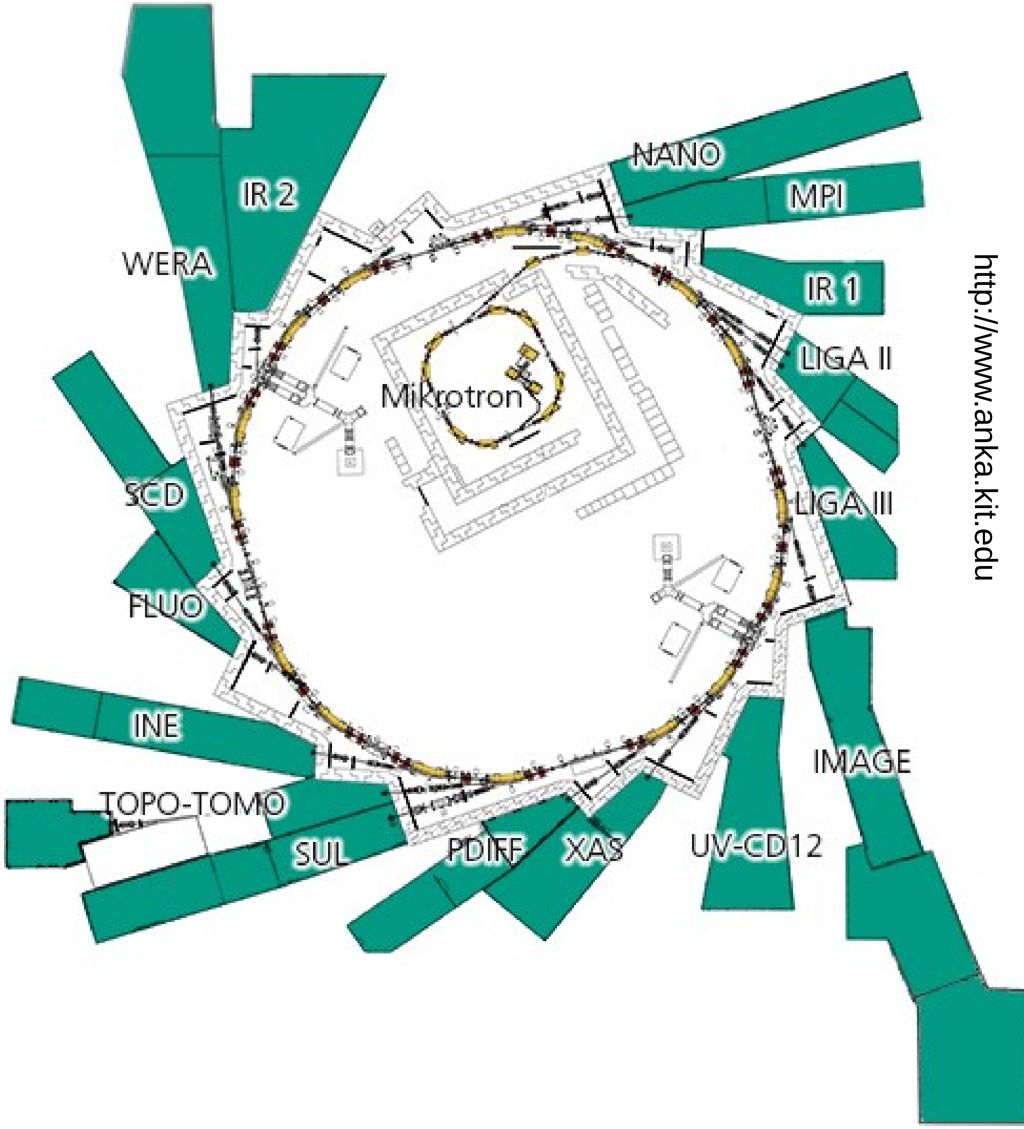


- 2 x 26 Damping wiggler
- 2.86 GeV beam energy

Cf. ICFA beam dynamics newsletter 62

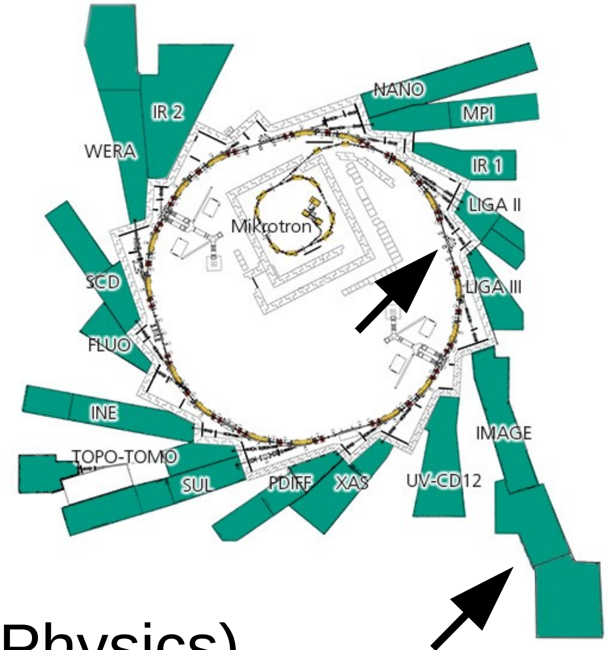
Introduction – ANKA Synchrotron

- 3^{rd} generation Synchrotron light source at KIT Karlsruhe.
- User facility.
- 2.5 GeV beam energy in normal operation.



http://www.anka.kit.edu

Introduction - Collaboration



- Set of wiggler parameters interesting for both CLIC DW and as light source has been found.
- Wiggler developed and produced by BINP (Budker Institute of Nuclear Physics).
- Installation at IMAGE beamline foreseen for July 2014:
  - Long-term reliability test for CLIC DW,
  - Light source for ANKA.

Outline

- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

Conduction Cooling I / II

- Bath cooling:
  - established technology
- Conduction cooling:
  - Minimized coil gap
  - No pressure increase during quench
  - Easier to extract heat from beam pipe
  - Facilitates modular design

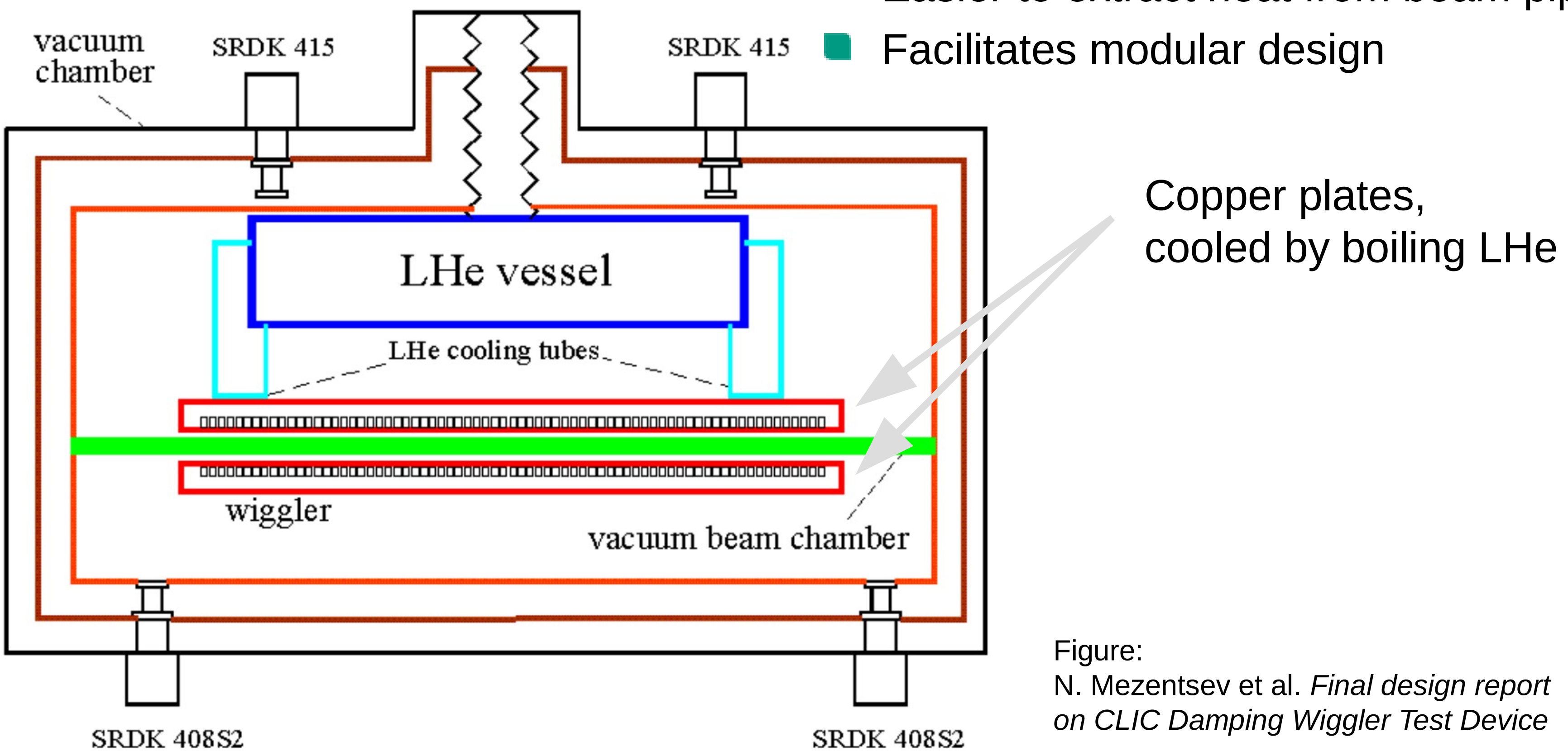
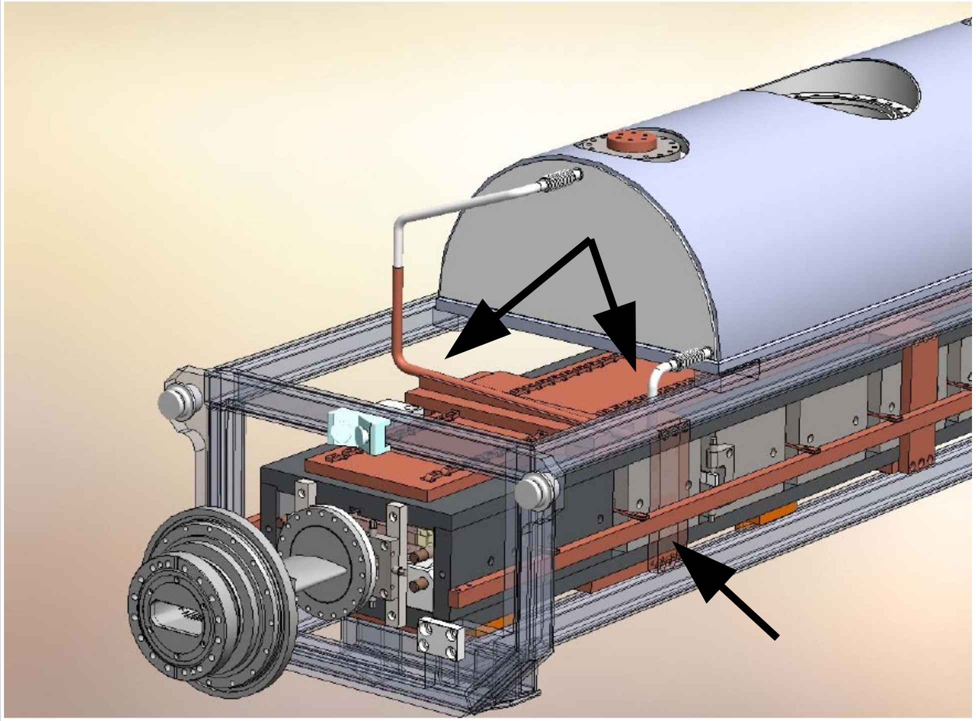
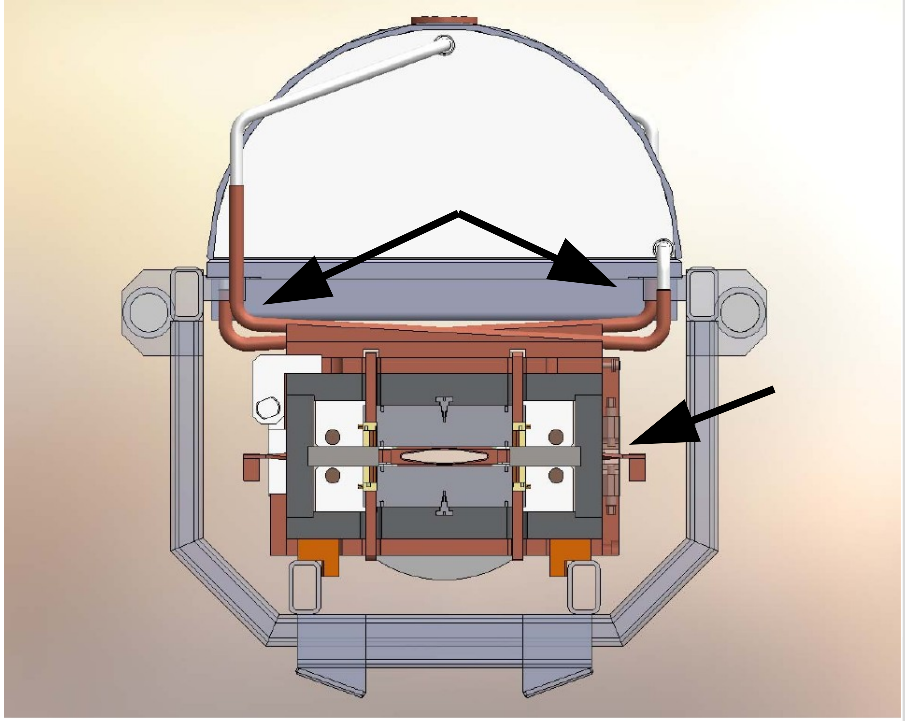


Figure:
N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

Conduction Cooling II / II

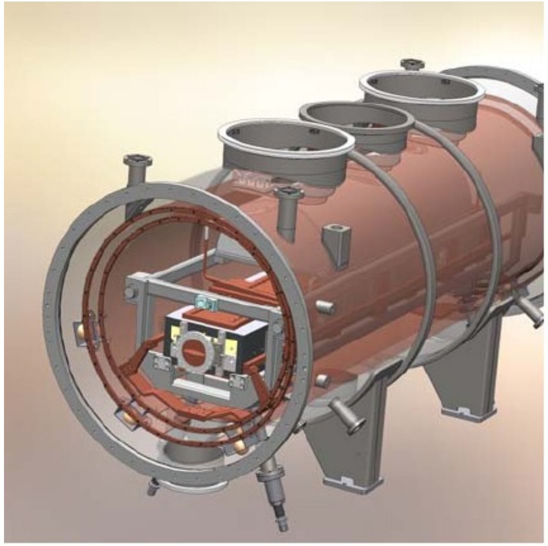
- Top coils cooled via thermosiphons at the ends.
- Bottom coils connected to top via copper links.





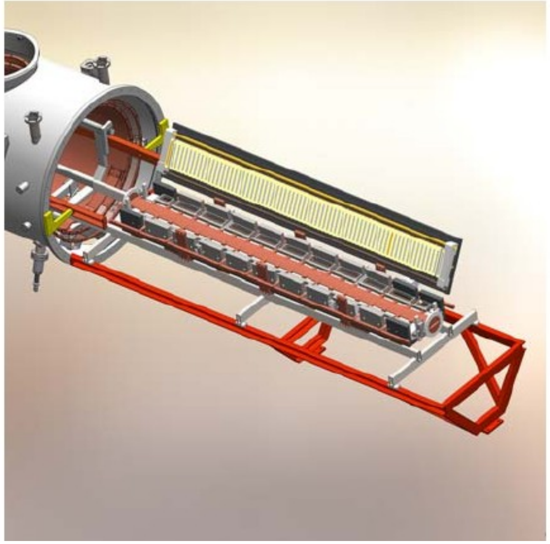
Figures:N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

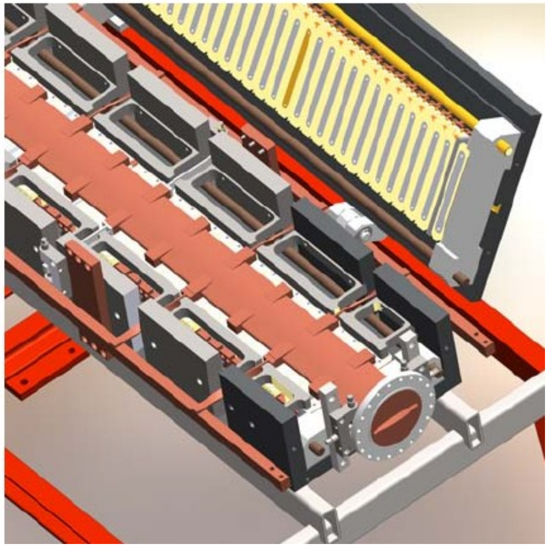
Modular Design – Easy Access



Figures:N. Mezentsev et al.
Final design report on CLIC Damping Wiggler Test Device

- ANKA:
  test of different coils and beam pipes
- CLIC-DR:
  repair / maintenance





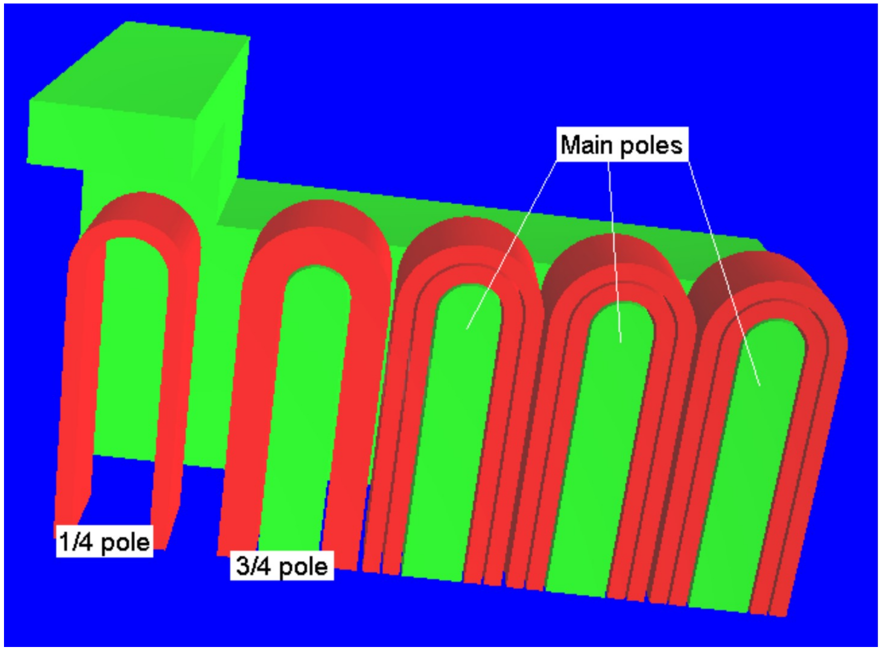
Outline

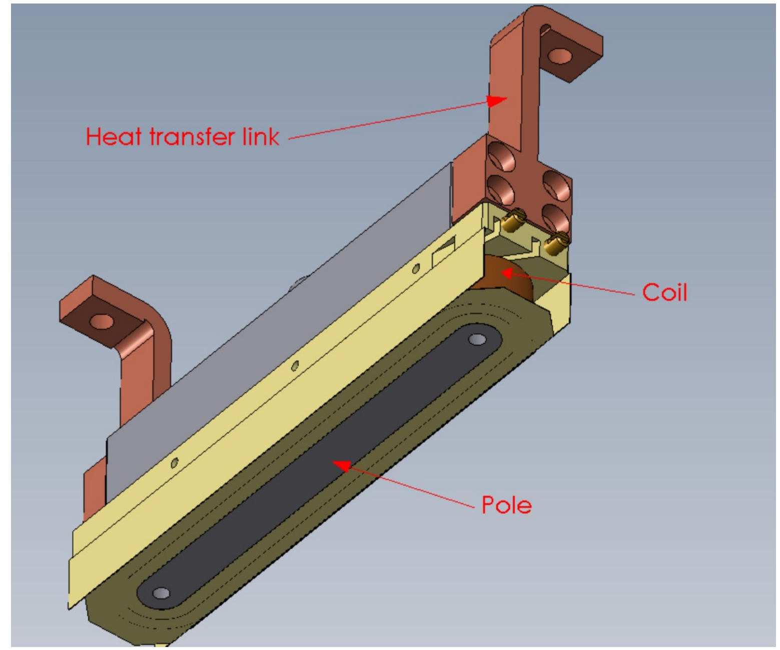
- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

Nb-Ti vs. Nb_3Sn

- Nb_3Sn technology offers larger parameter range than Nb-Ti, but is technically more challenging.
- Nb-Ti as more mature technology chosen for first full-scale prototype.
- Nb_3Sn R&D performed in parallel at CERN.
- See following talk by Laura GARCIA FAJARDO *Nb_3Sn wiggler design, test and plans.*

Hor. vs. Vert. Coil Geometry





A. Bernhard et al., in *ICFA BDN 62*,
N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

- *Horizontal Racetrack geometry chosen*
  - *More efficient design wrt. vertical winding, but*
  - *Coils connected by splices, higher forces on end coils.*

Outline

- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

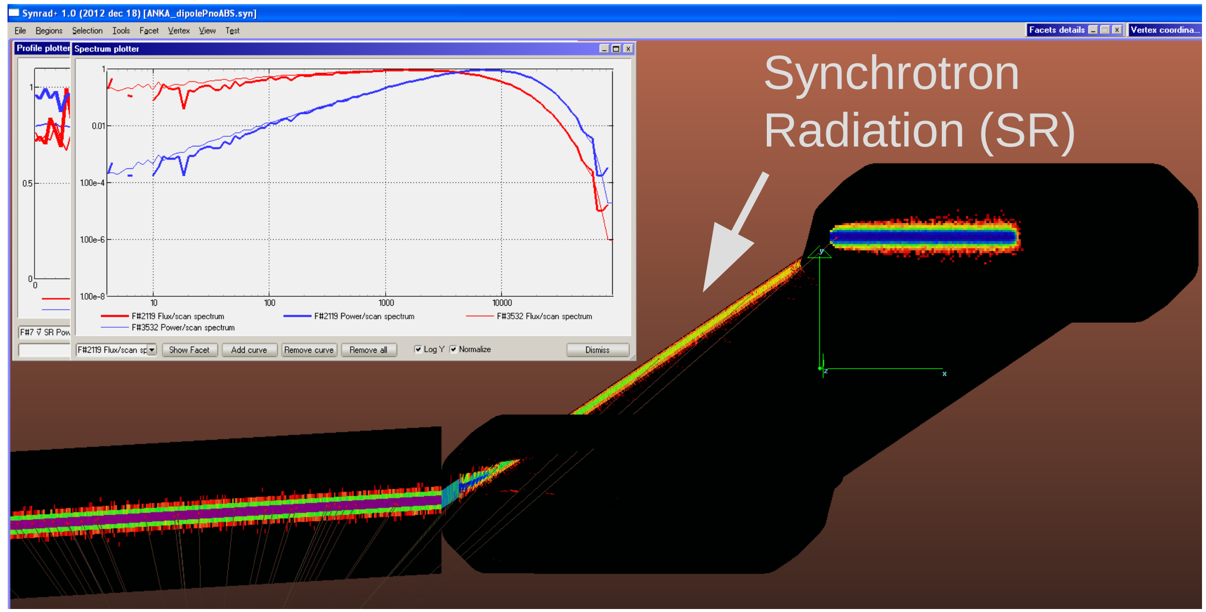
Early Experiments

- Influence on beam:
  - Tune shift, orbit changes,
  - Change in vacuum pressure / Beam lifetime,
  - Map higher order multipole-field via orbit variation.

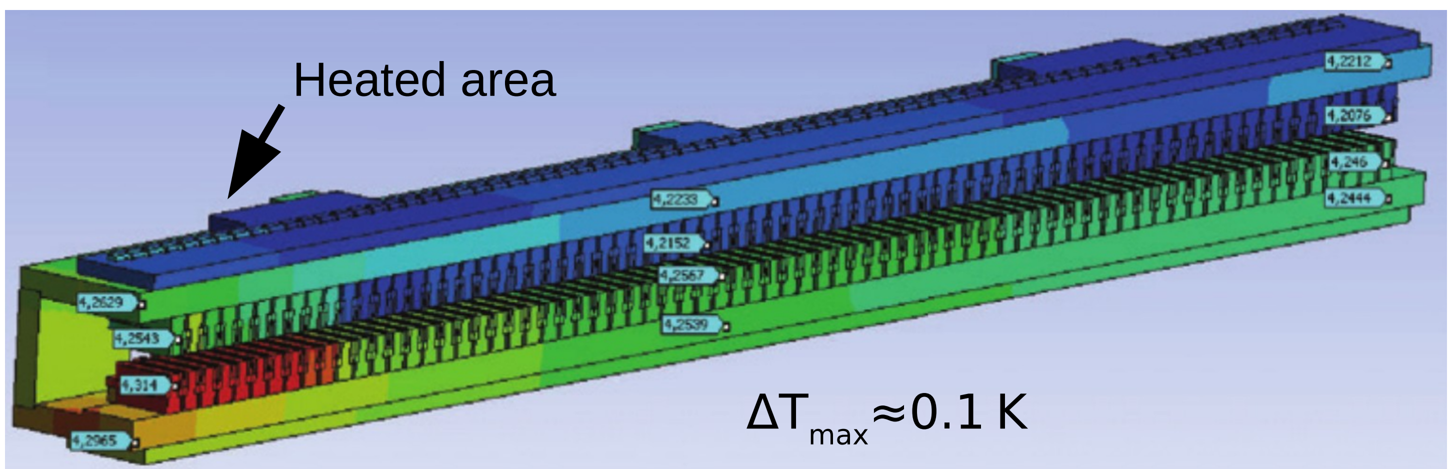
- Confirmation of cooling concept:
  - Synchrotron Radiation (SR) in different modes of operation,
  - Added heaters.

Early Experiments - Cooling

- Top:
  SR on side
  of chamber
- Bottom:
  Heaters to simulate
  DR load



M. Ady, R. Kersevan, priv. com.

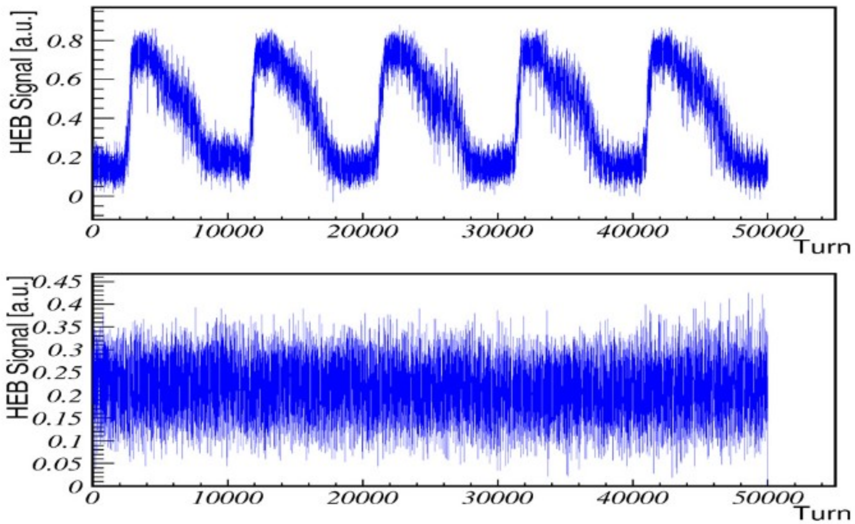


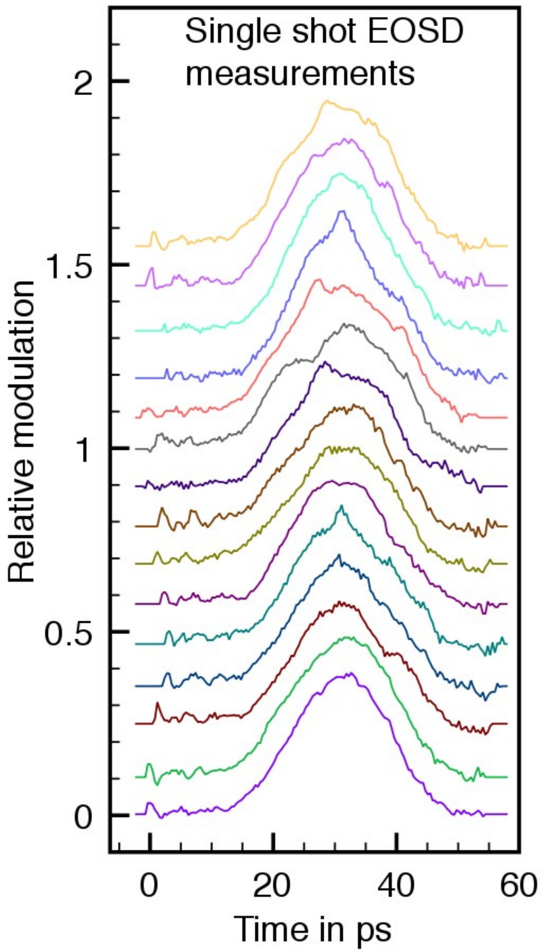
A. Bernhard et al., TUPME005, IPAC13

Advanced Experiments

- Emittance coupling horizontal / vertical
- Low-α_c at 1.3 GeV– short bunch lengths:
  - Bunch structure, CSR bursting patterns
  - Multibunch effects

See presentation *Experiments with short bunches at ANKA* at 17:00.





Figures:
V. Judin et al., Observation of Bursting Behavior Using Multiturn Measurements at ANKA, IPAC10
N. Hiller et al., Electro-Optical Bunch Length Measurements at the ANKA Storage Ring, IPAC13

Outline

- Introduction:
  CLIC Damping Rings (DR) and ANKA light source
- The superconducting Nb-Ti Damping Wiggler (DW)
  - Demonstration of novel concepts
  - Technical choices
- Planned Experiments
- Project Status and Outlook

Timeline

- Production of wiggler is almost finished
- March 2014: Wiggler bath test
- April 2014: Factory acceptance test
- July 2014: Installation at ANKA, commissioning
- September 2014: Start of experimental program
- 2015: Decision on Nb_3Sn option

Summary

- Production of a superconducting Nb-Ti wiggler with
  - conduction cooling,
  - modular design

  at BINP is almost finished.

- It will serve both as
  - light source at ANKA,
  - long-term test of damping wiggler prototype.

- Installation at ANKA is foreseen for summer 2014.

The End

Thank you for your attention!

Acknowledgment

- BINP:

  Alexey Bragin, Nikolay Mezentsev, Vasily Syrovatin, Konstatin Zolotarev

- CERN:

  Marton Ady, Paolo Ferracin, Laura Garcia Fajardo, Roberto Kersevan, Yannis Papaphilippou, Daniel Schörling

- KIT:

  Axel Bernhard, Sergey Gasilov, Andreas Grau, Erhard Huttel, Anke-Susanne Müller, Robert Rossmanith

Backup slides

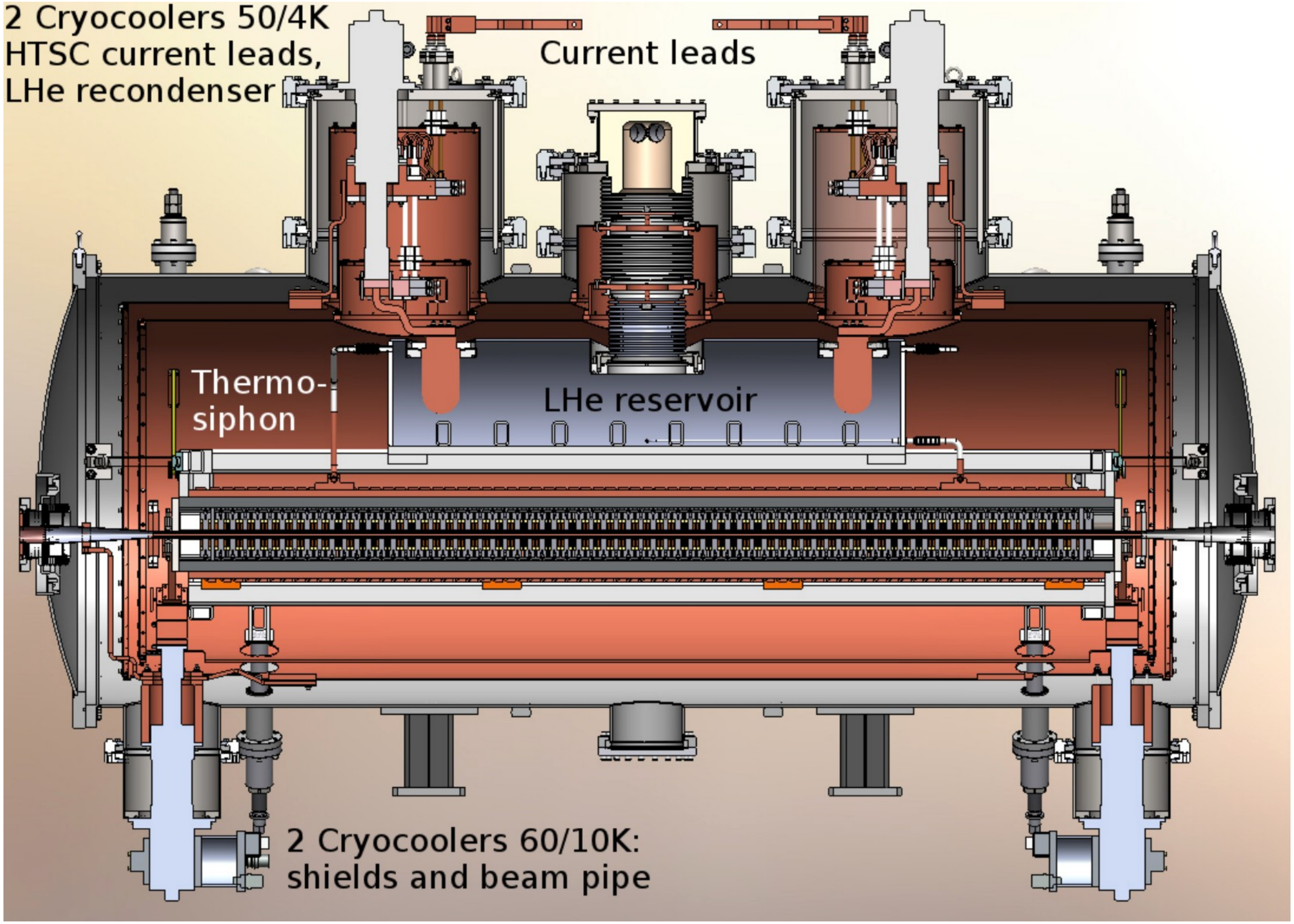
Wiggler Parameter

Design parameters of the CLIC damping wiggler prototype

Basic parameters	
Wiggler period λ_w	$51mm$
Magnetic gap	$18mm$
Flux density amplitude on axis $\widetilde{B_y}$	$3T$
I/I_c on load line @ $T = 4.2K$	86%
$T_{quench}@\widetilde{B_y} = 3T$	$4.8K$
Number of main poles	68
Winding scheme	
1/4 coil, $N_1 I_1$	$62 \times 487A$
3/4 coil, $N_2 I_2$	$124 \times 487A$
Main, inner, $N_1 I_1$	$62 \times 487A$
Main, outer, $N_1(I_1 + I_2)$	$62 \times 974A$
Wire parameters	
Diameter (bare)	$0.85mm$
Nb-Ti:Cu ratio	1.1:1
Filaments	312

A. Bernhard, P. Ferracin, K. Zolotarev, in *ICFA beam dynamics newsletter 62*

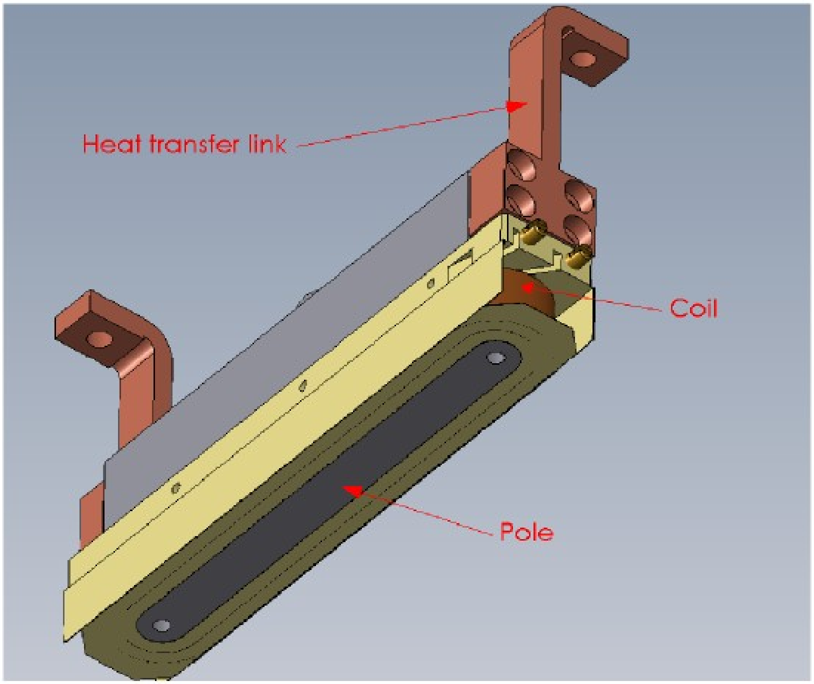
Conduction Cooling III / III



Figures:N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

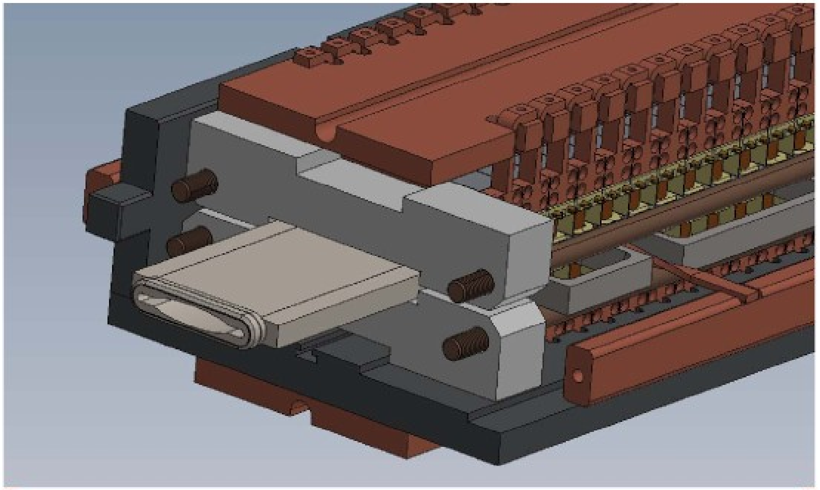
Cryo Design: Coil Cooling

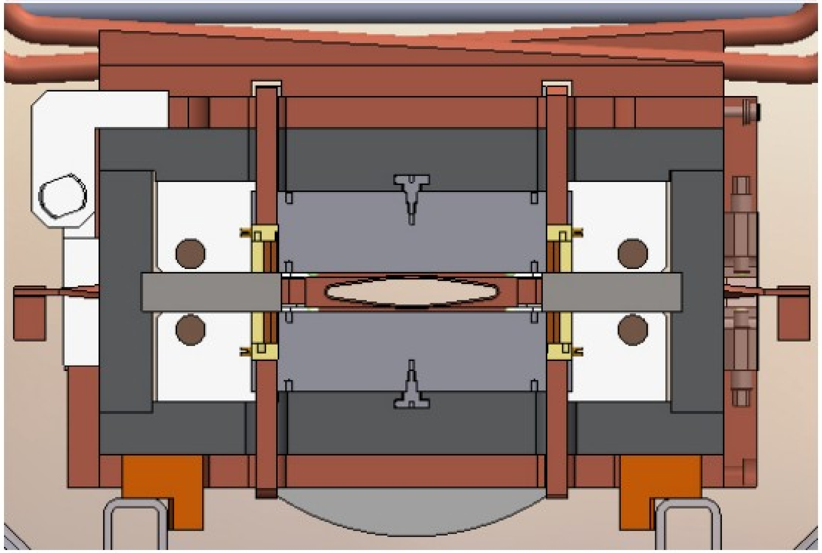
Heat transfer: Extended iron pole→Cu plate→LHe channel



K. Zolotarev et al., ibid.

Figure: Top: single indirectly cooled horizontal racetrack coil; right: Pole array and cross-section of assembled magnet system



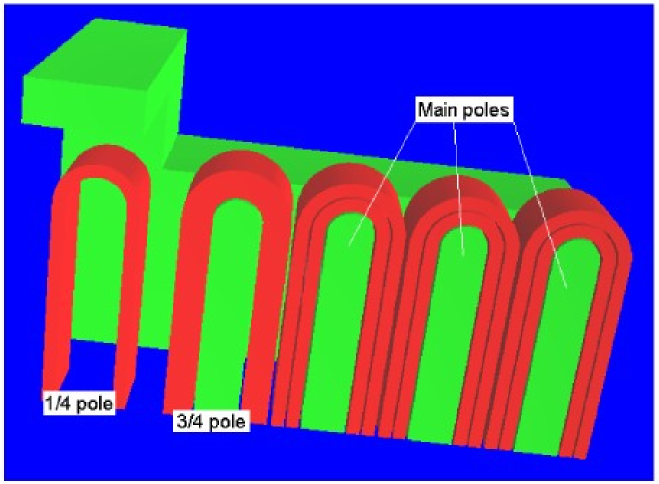


Project Timeline and Status

Karlsruhe Institute of Technology

4/2009	KIT joins CTF3 Collaboration
7/2010	First discussions on CLIC/IMAGE wiggler test at ANKA
02/2011	Start of negotiations for CERN/KIT collaboration agreement (k-contract)
12/2011	KIT orders wiggler from Budker Institute, Novosibirsk
05/2012	Conceptual Design Review in Novosibirsk
11/2012	CERN and KIT sign k-contract
12/2012	Short model tests
01/2013	Final Design Review in Karlsruhe
01-02/2014	Factory Acceptance Test
03-04/2014	Delivery and Site Acceptance Test
06/2014 (?)	Installation, Final Acceptance Test
2014–2015	Joint experimental program, decision on second project step

Magnetic Design

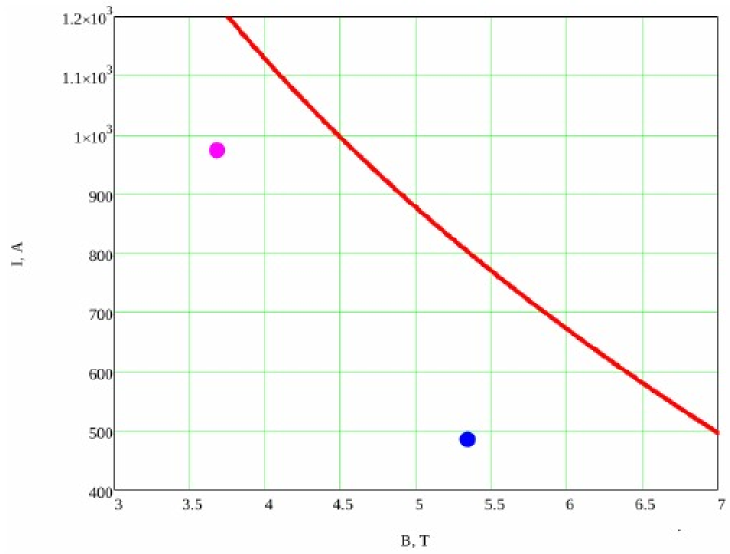


K. Zolotarev et al., Final Design Report, Novosibirsk (2012)

λ_W	51 mm
magn. gap [mm]	18 mm
$\tilde{B}_y$	3 T
main poles	68
$\frac{1}{4}$ coil, NI_1	62×487 A
$\frac{3}{4}$ coil, NI_2	124×487 A
main, inner, NI_1	62×487 A
main, outer, $N(I_1 + I_2)$	62×974 A

SC Wire

Diameter (bare)	0.85 mm
Nb-Ti:Cu	1.1
Filaments	312



K. Zolotarev et al., ibid.

Figure: Critical current at 4.2 K and operating points of outer (pink) and inner (blue) coil section