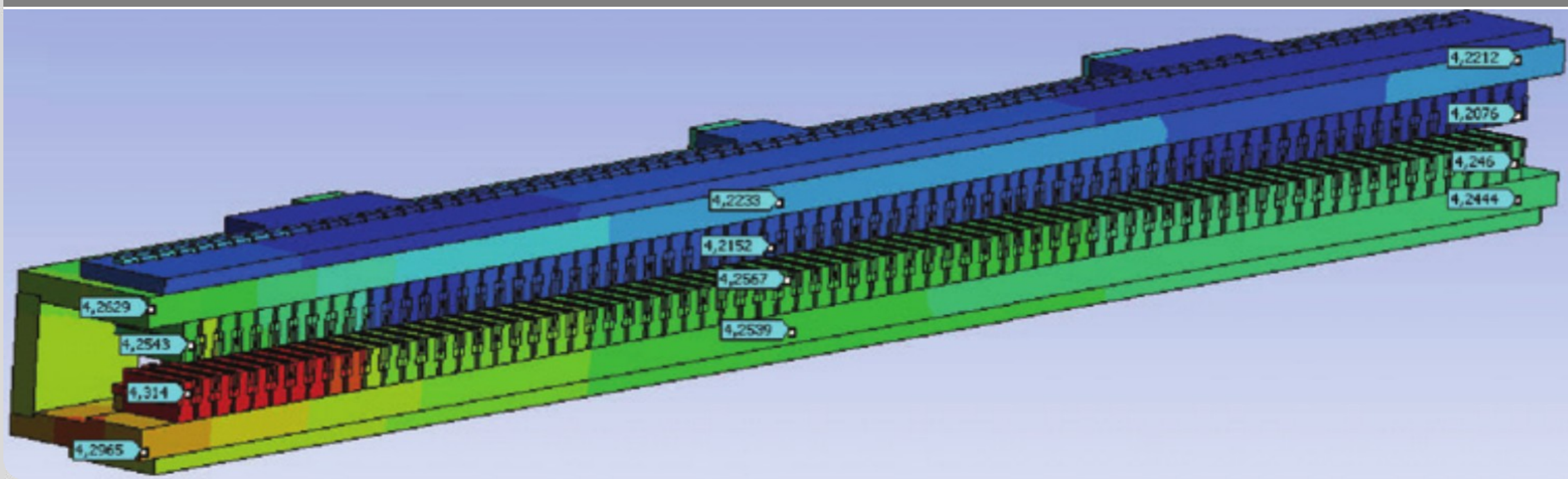
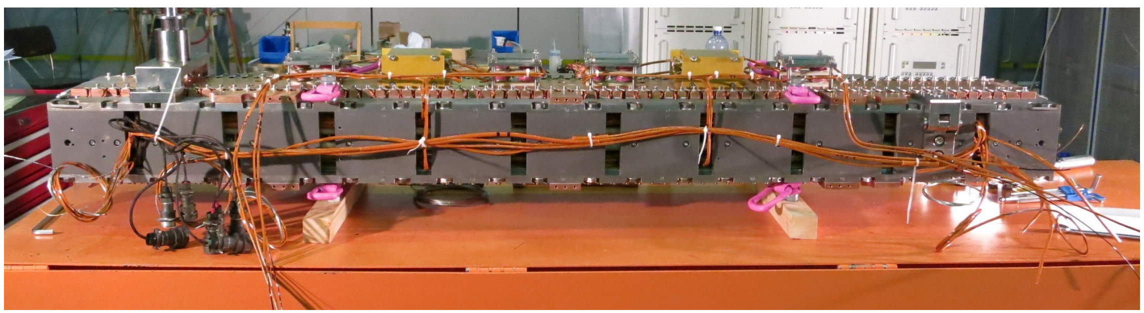
A superconducting Nb-Ti CLIC Damping Wiggler for ANKA

Steffen Hillenbrand,
Axel Bernhard, Alexey Bragin, Laura Garcia Fajardo, Paolo Ferracin,
Erhard Huttel, Anke-Susanne Müller, Robert Rossmanith, Daniel Schörling,
Nikolay Mezentsev, Vasily Syrovatin, Konstatin Zolotarev



Outline

- CLIC Damping Rings (DR)
- ANKA light source
- Superconducting Nb-Ti Damping Wiggler (DW)



- Measurements
- Project Status and Outlook

Steffen Hillenbrand,

CLIC Damping Rings

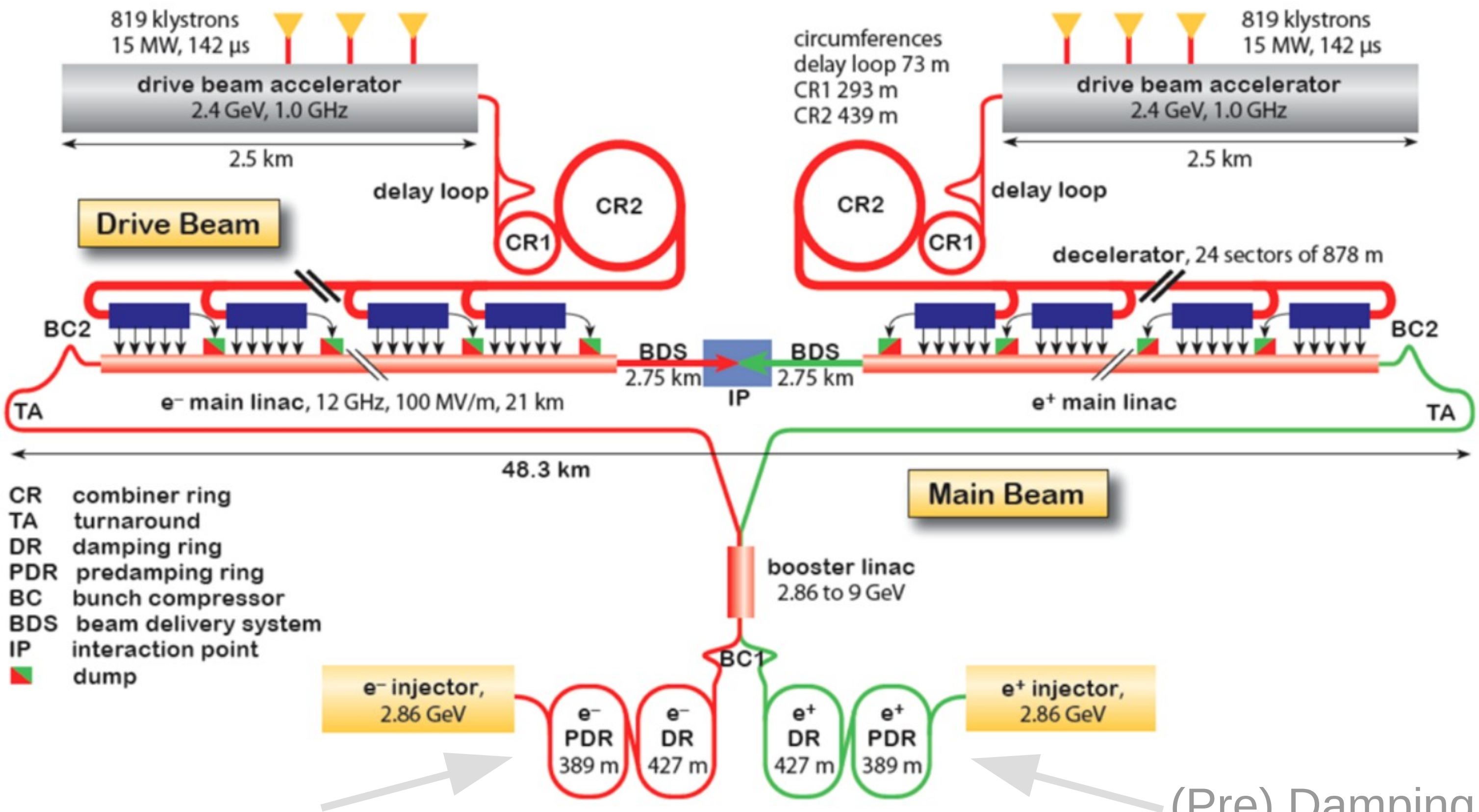


Figure: ICFA beam dynamics newsletter 62

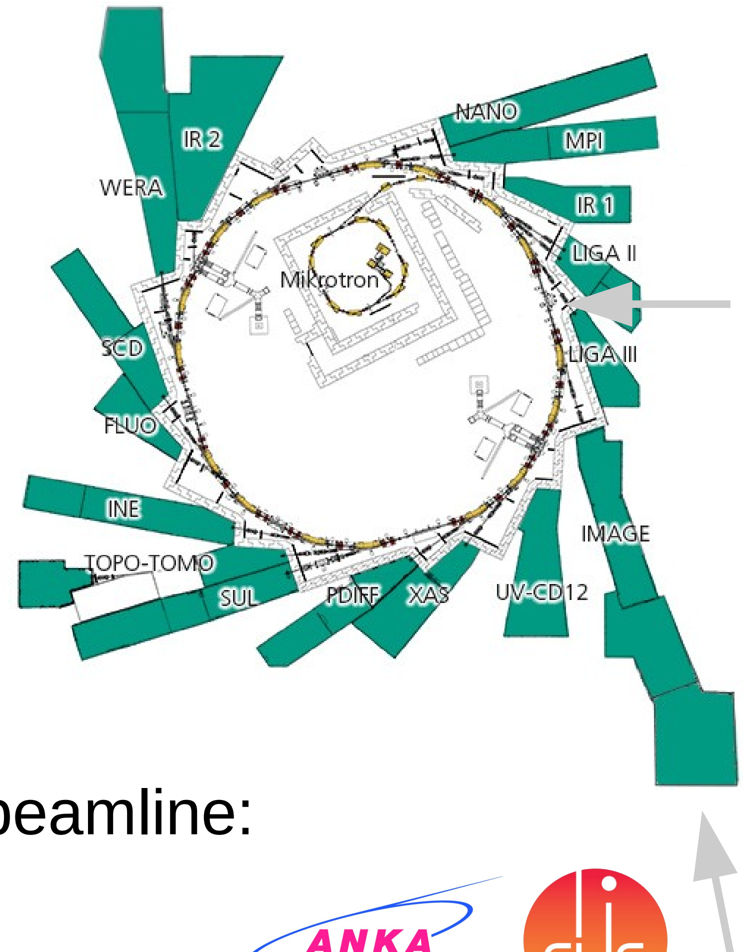
(Pre) Damping Rings

- Very small beam size needed for high luminosity, therefore
- Damping rings (DR) needed to reach emittance requirement.
- Current plan: 2.86 GeV beam energy, 2x26 wiggler.

Steffen Hillenbrand,

Collaboration ANKA - CLIC

- Wiggler parameters interesting for both CLIC DW and as light source found.
- Wiggler developed and produced by BINP (Budker Institute of Nuclear Physics).



- Will provide hard x-rays for IMAGE beamline:
  - Light source for ANKA,
  - Long-term reliability test for CLIC DW.

Wiggler Design Parameter

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

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_1I_1	$62 \times 487A$
3/4 coil, N_2I_2	$124 \times 487A$
Main, inner, N_1I_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

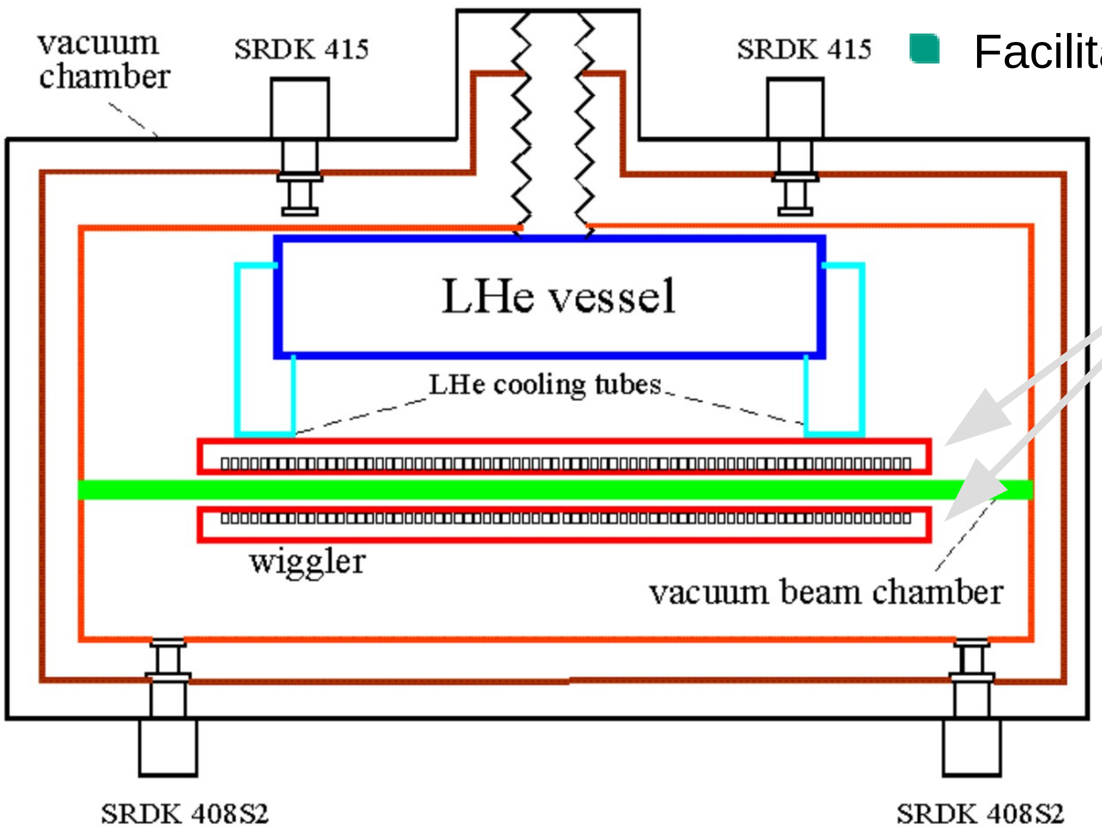
- K = 14, compromise between high field and ANKA acceptance.
- Results in 12 kW radiated power at 200 mA beam current.

- Compensation of field integrals,
- make wiggler transparent to beam.

Steffen Hillenbrand,
LER 2014, Frascati, September 18th 2014

Conduction Cooling I / III

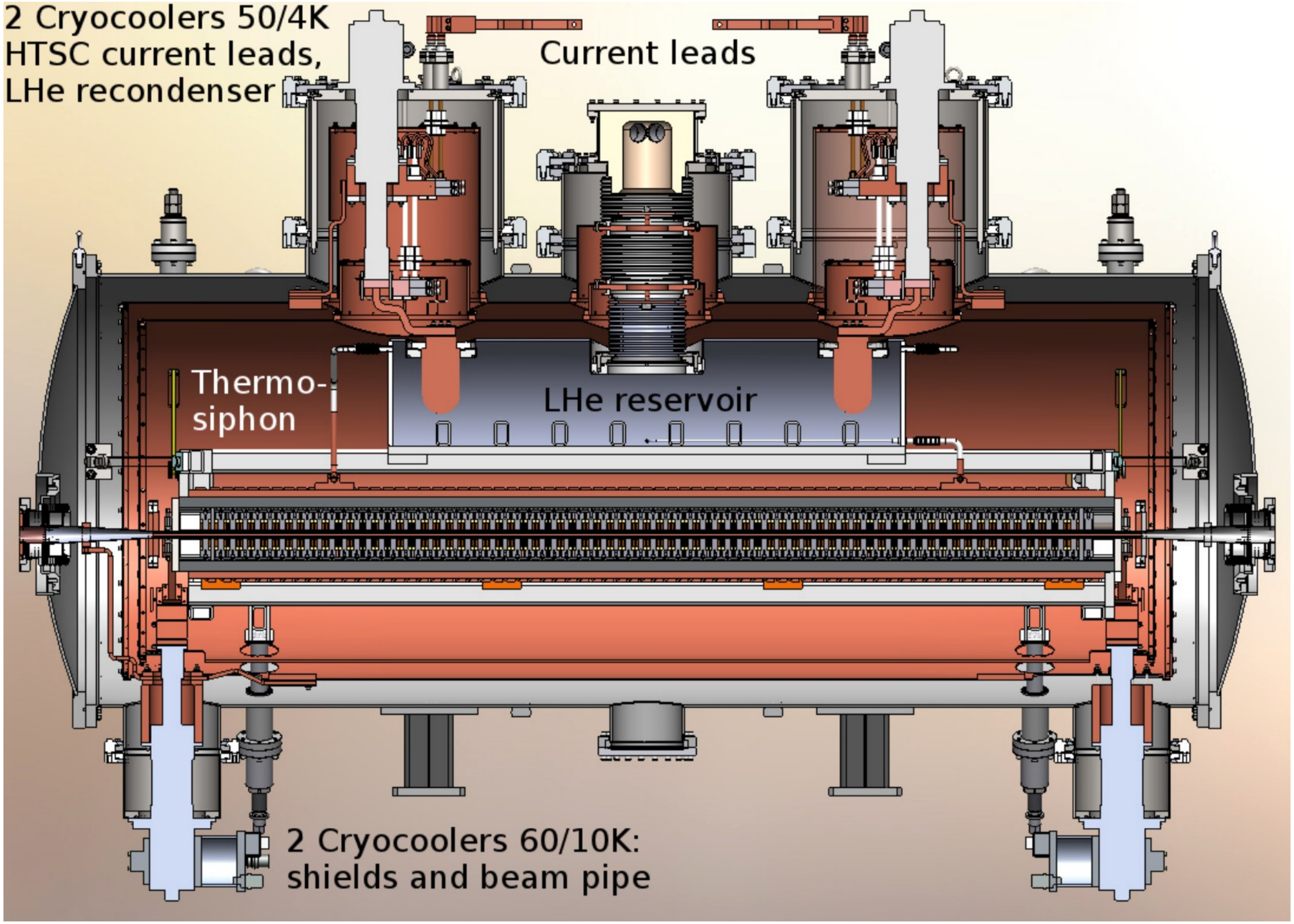
- Bath cooling
  - established technology
- Conduction cooling
  - Minimized coil gap
  - No pressure increase during quench
  - Easier to extract heat from beam pipe
  - Facilitates modular design



Cu-plates,
cooled by boiling LHe

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

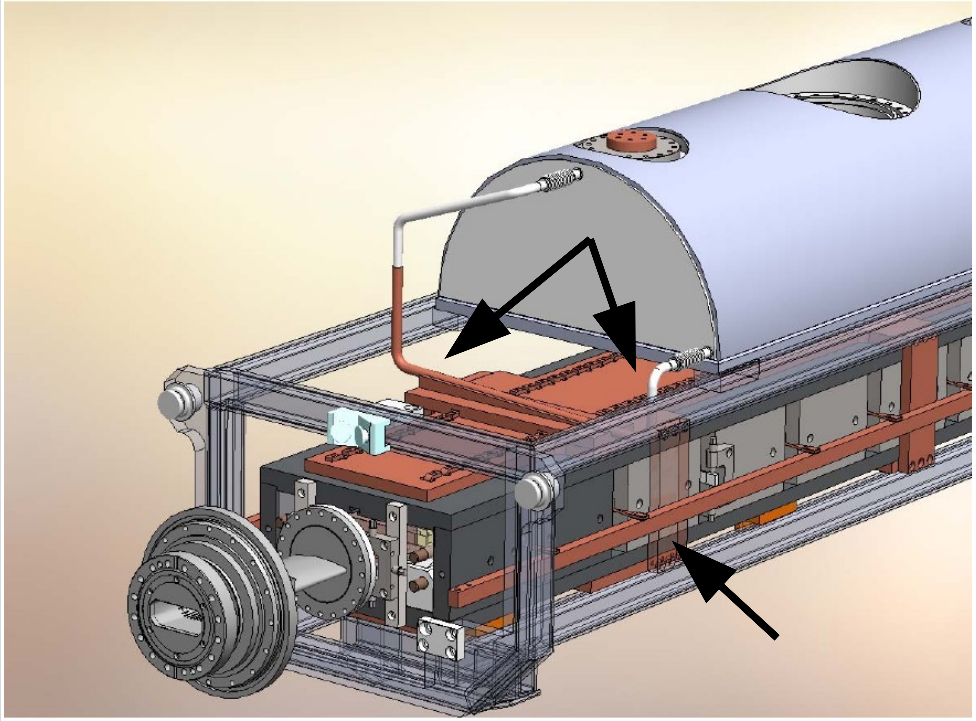
Conduction Cooling II / III

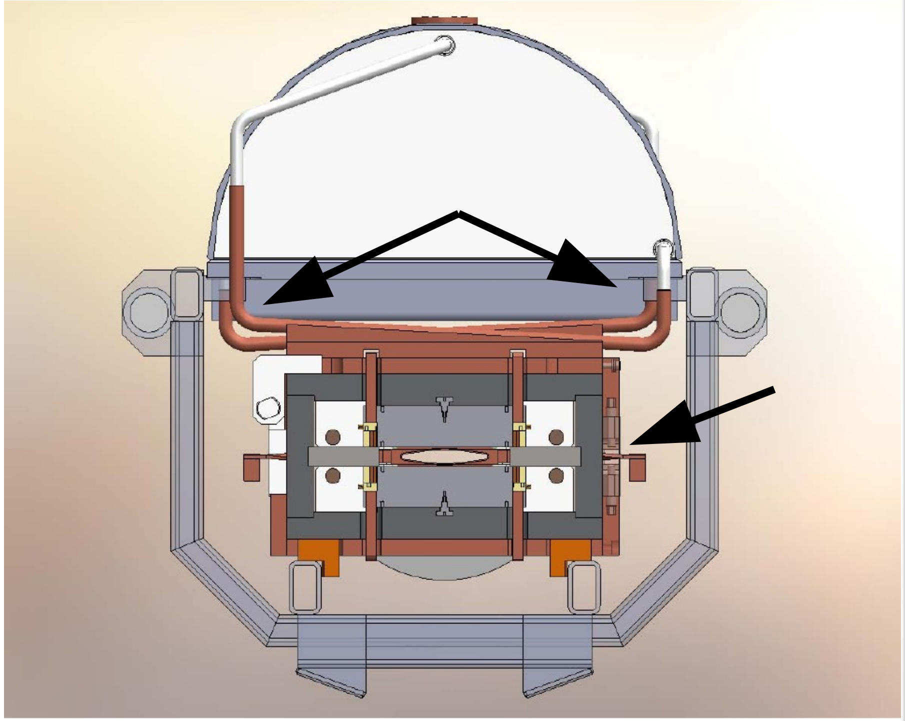


Figures:N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

Conduction Cooling II / III

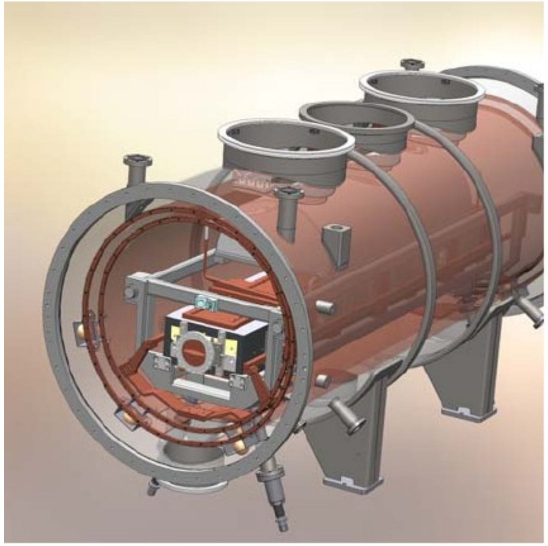
- Top coils cooled via thermo-siphons at the ends.
- Bottom coils connected to top via copper links.





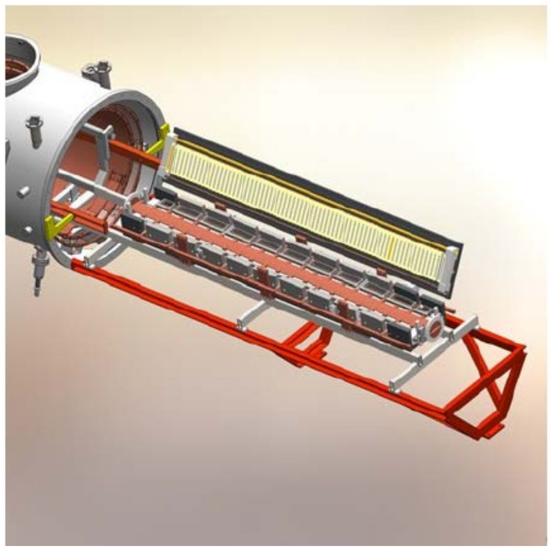
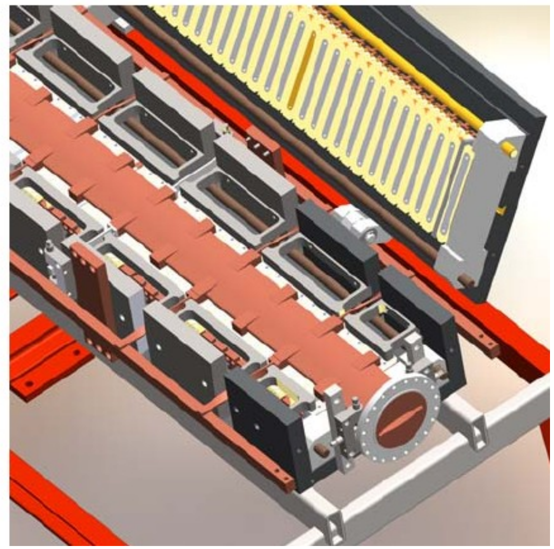
Figures: N. Mezentsev et al. *Final design report on CLIC Damping Wiggler Test Device*

Modular Design – Easy Access

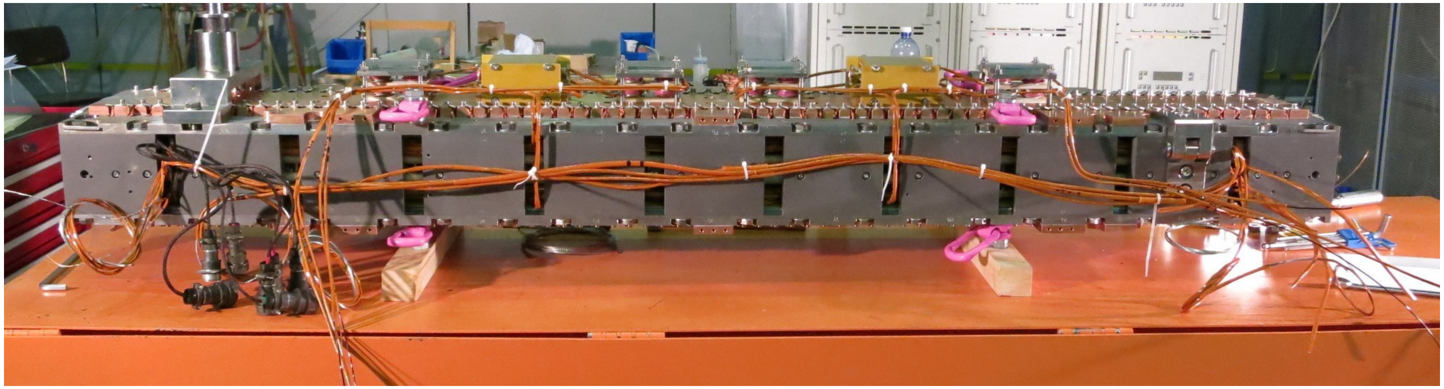


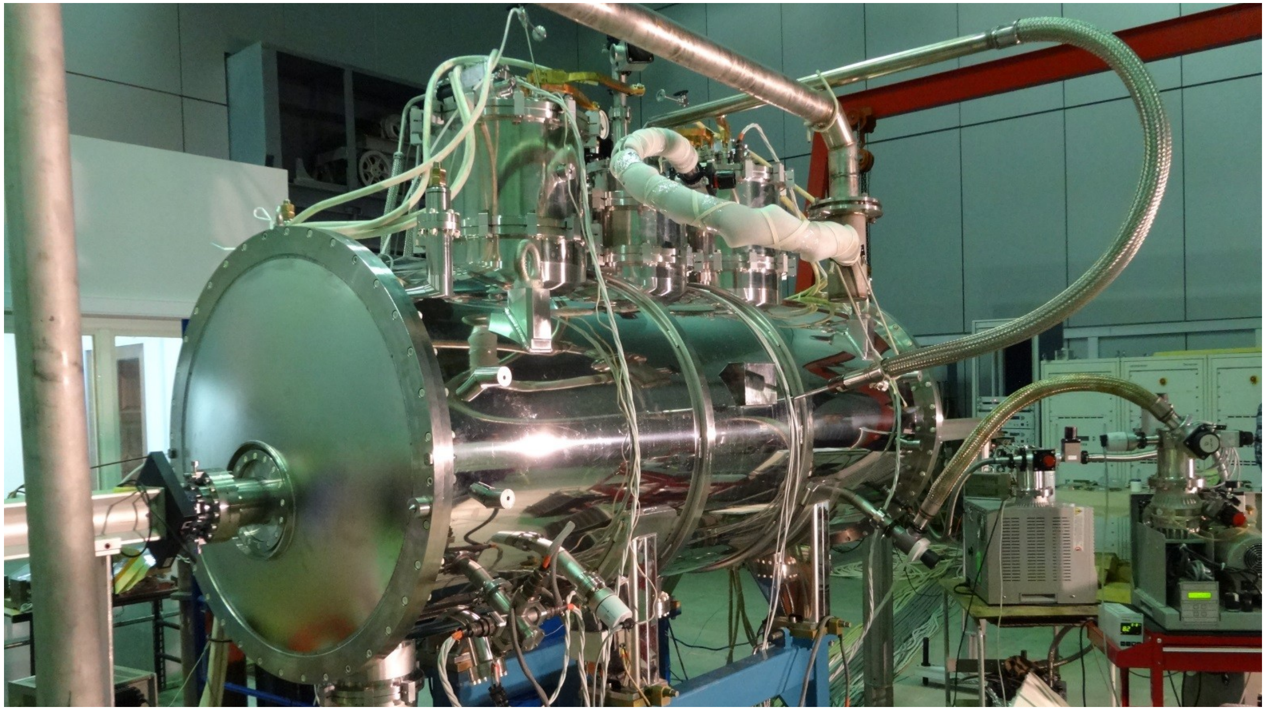
Figures:N. Mezentsev et al.
Final design report on CLIC Damping Wiggler Test Device

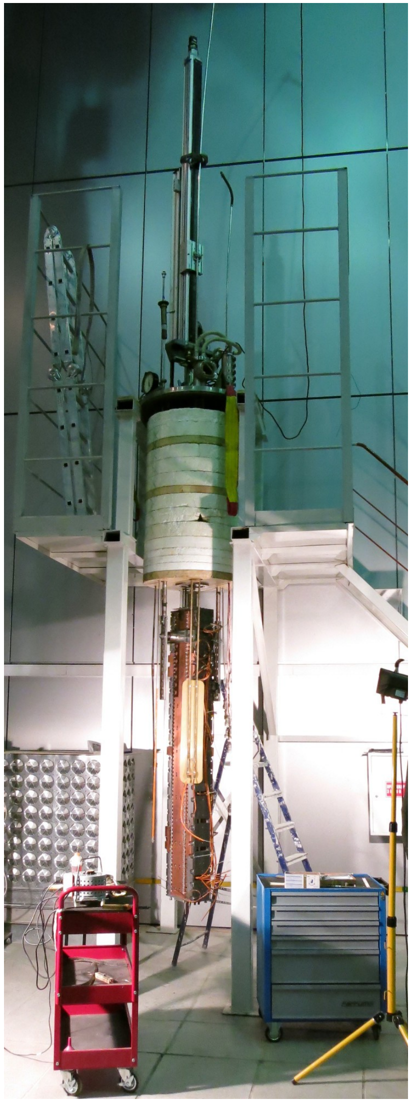
- ANKA
  - different coils
  - different beam pipes
- CLIC-DR
  - easy repair
  - easy maintenance

The Wiggler at BINP

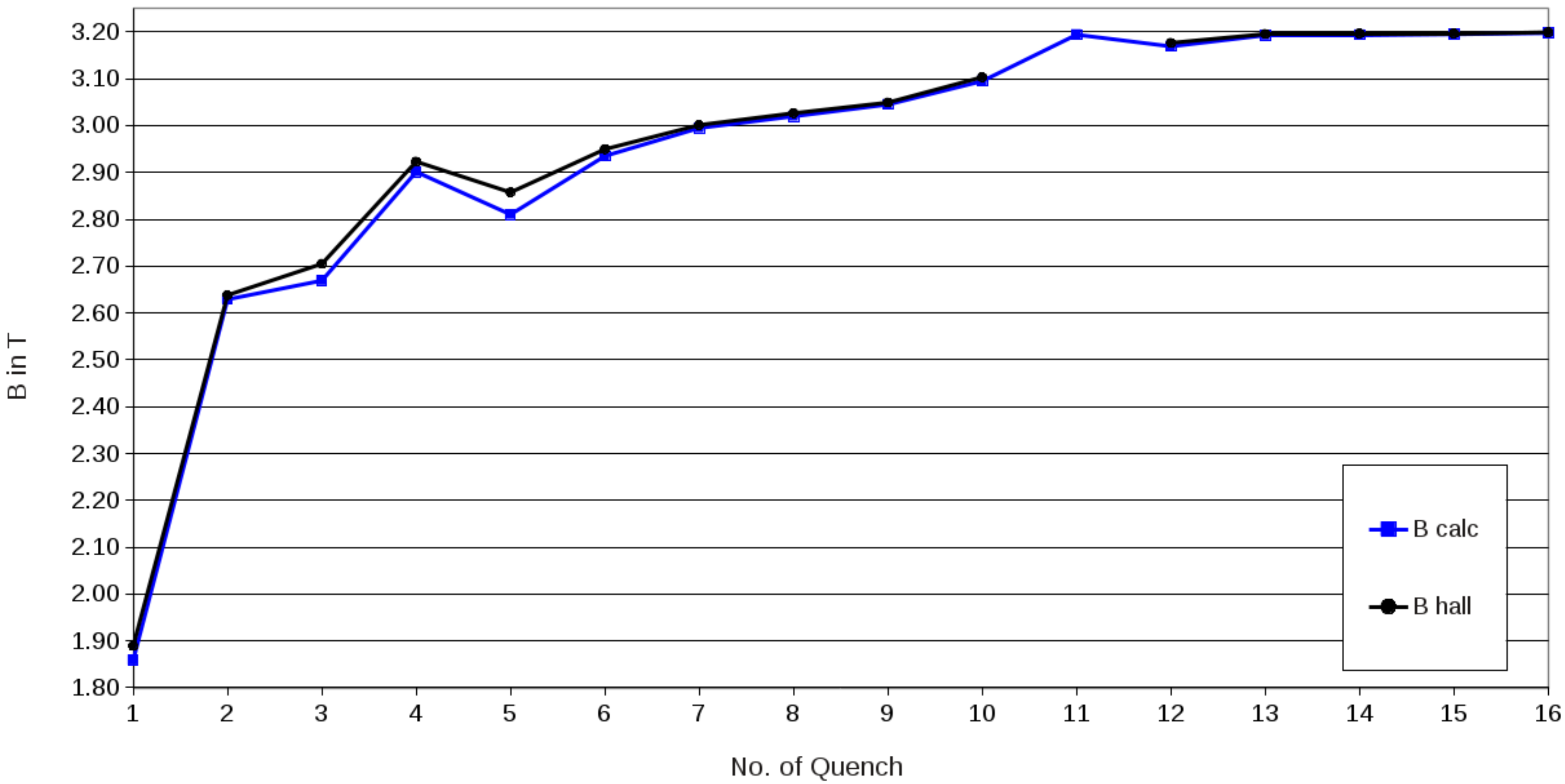






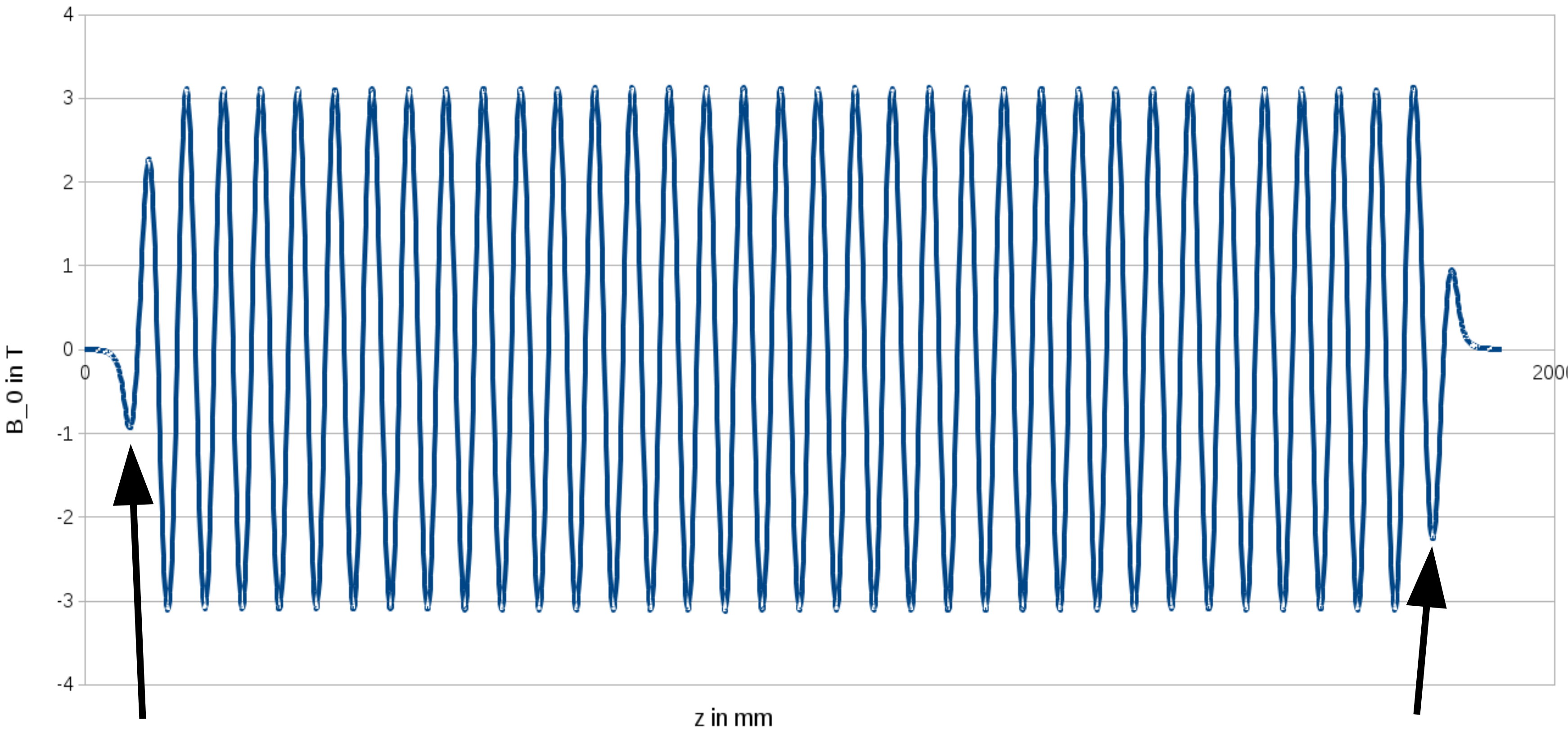
Bath test at BINP I / II

- Field of 3.2 T reached after 13 quenches at T≈4.3 K
- Lower temperature expected for final cryostat, leaving enough margin for operation at 3 T.



Bath test at BINP II / II

- Field maps have been taken for different B_0.



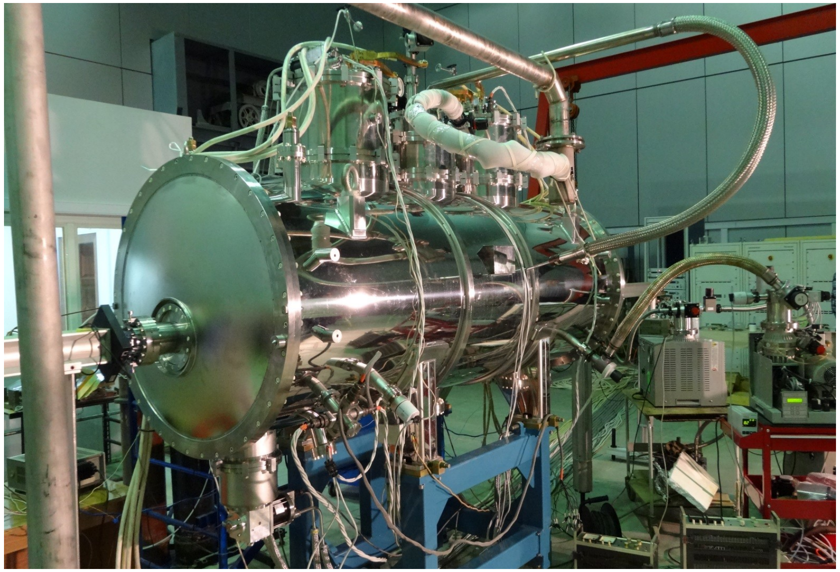
Vary I_1 / I_2 to minimize field integrals

Test in own cryostat

- Wiggler reached T <3.8 K in its cryostat,
- confirming cooling concept.

- B >3 T reached with fast ramping of magnets.
- Holding quenches happened for B > 2.7 T.

- Modifications finished.
- Bath test repeated successfully.



Vision: Nb_3Sn Wiggler

- Nb-Ti as more mature technology chosen for first full-scale prototype.
- Nb_3Sn technology offers larger parameter range than Nb-Ti, but is technically more challenging.

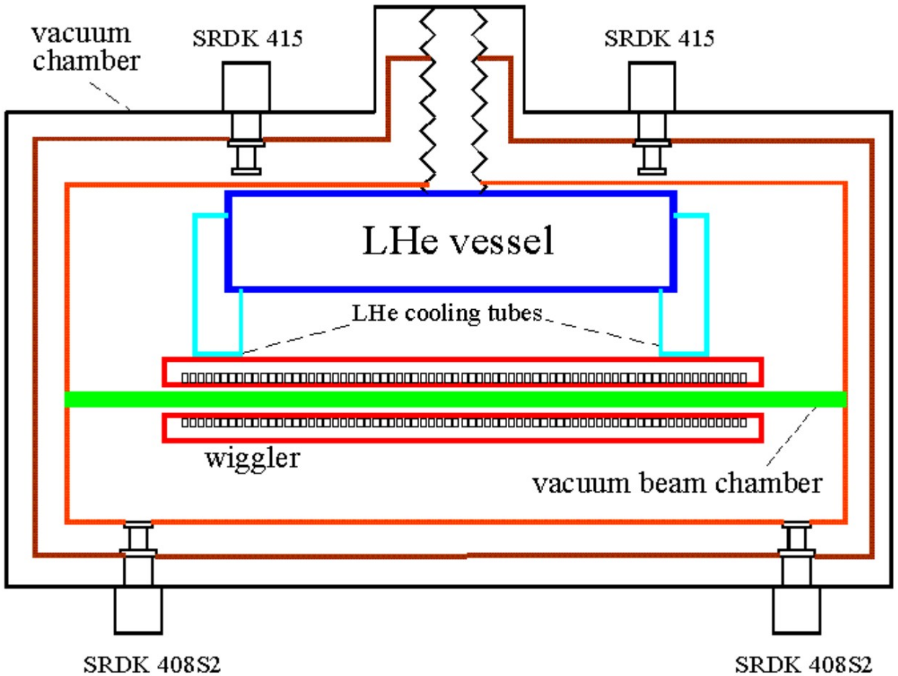
- Nb_3Sn R&D performed in parallel at CERN.

Figure: L. Garcia Fajardo, *Nb3Sn damping wiggler development at CERN,* Low Emittance Ring workshop 2013

Summary

- Superconducting Nb-Ti wiggler with
  - conduction cooling,
  - modular design

  at BINP in final stage.



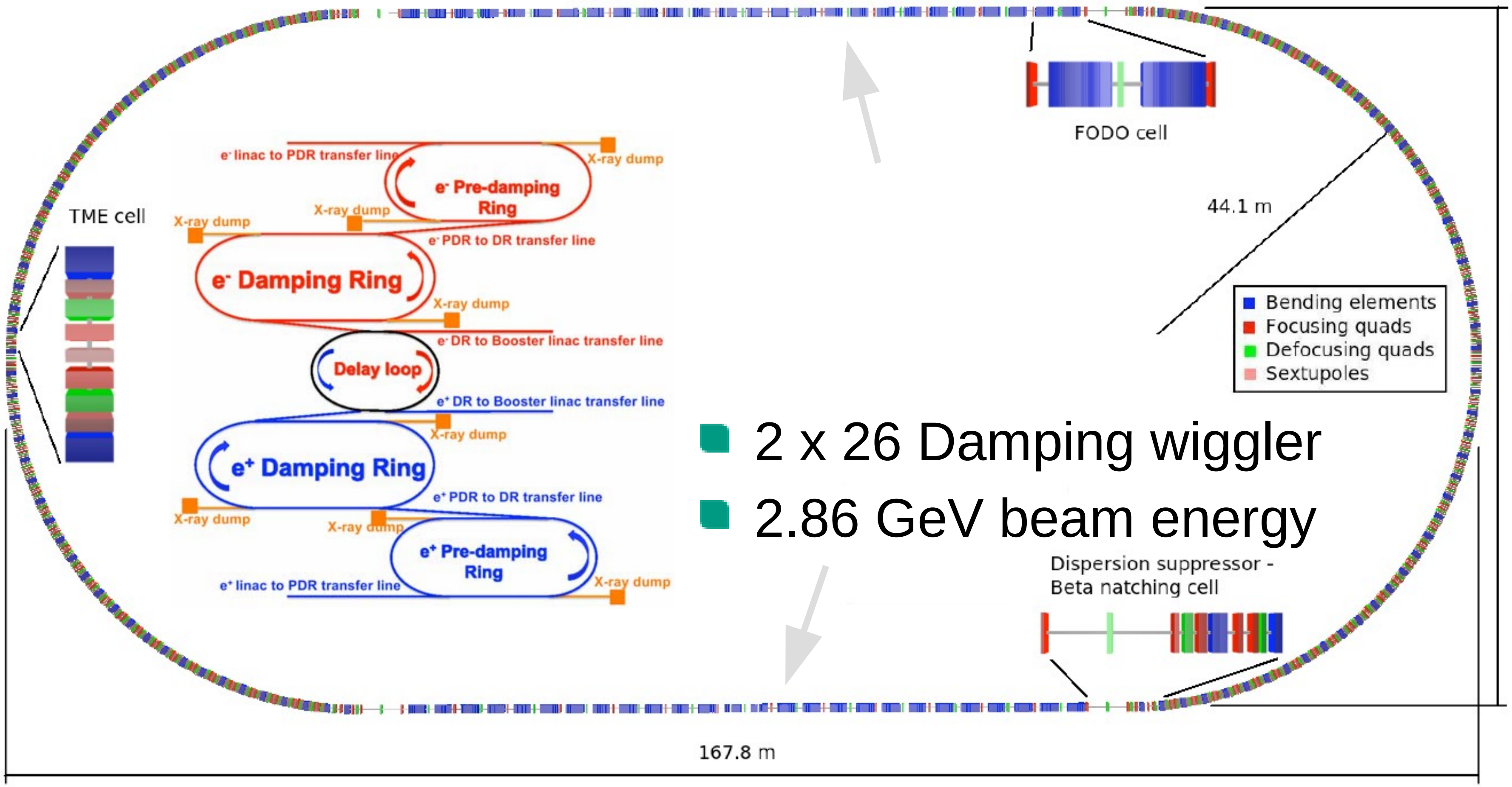
- It can serve both as
  - light source at ANKA,
  - long-term test of damping wiggler prototype.

The End

Thank you for your attention!

Backup slides

Introduction – CLIC Damping Rings



- 2 x 26 Damping wiggler
- 2.86 GeV beam energy

Cf. ICFA beam dynamics newsletter 62

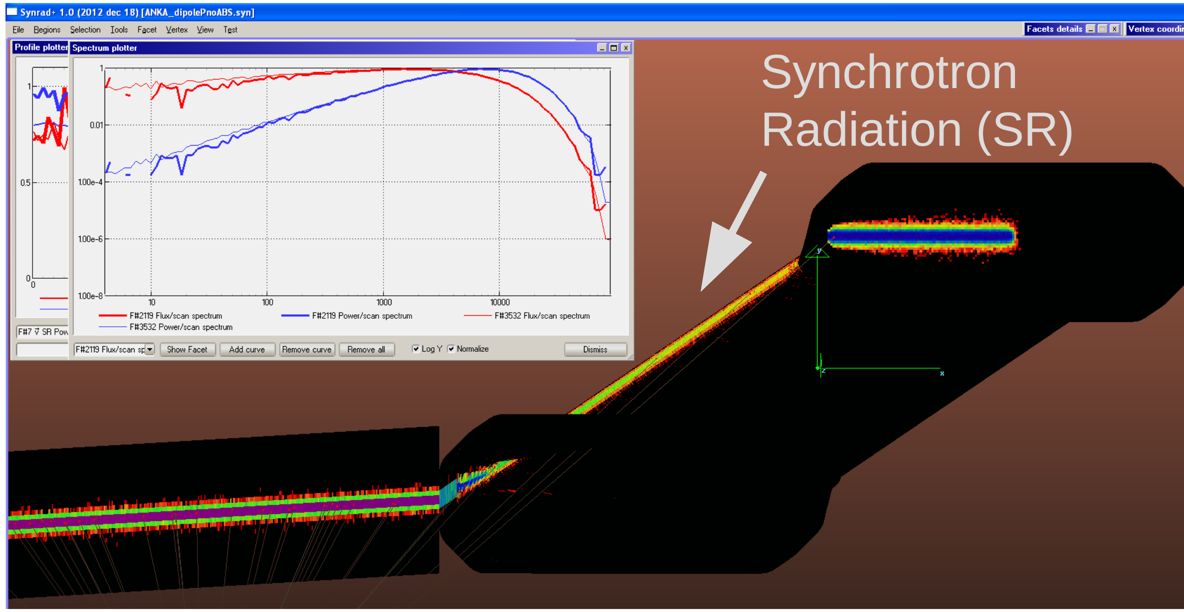
Early Experiments

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

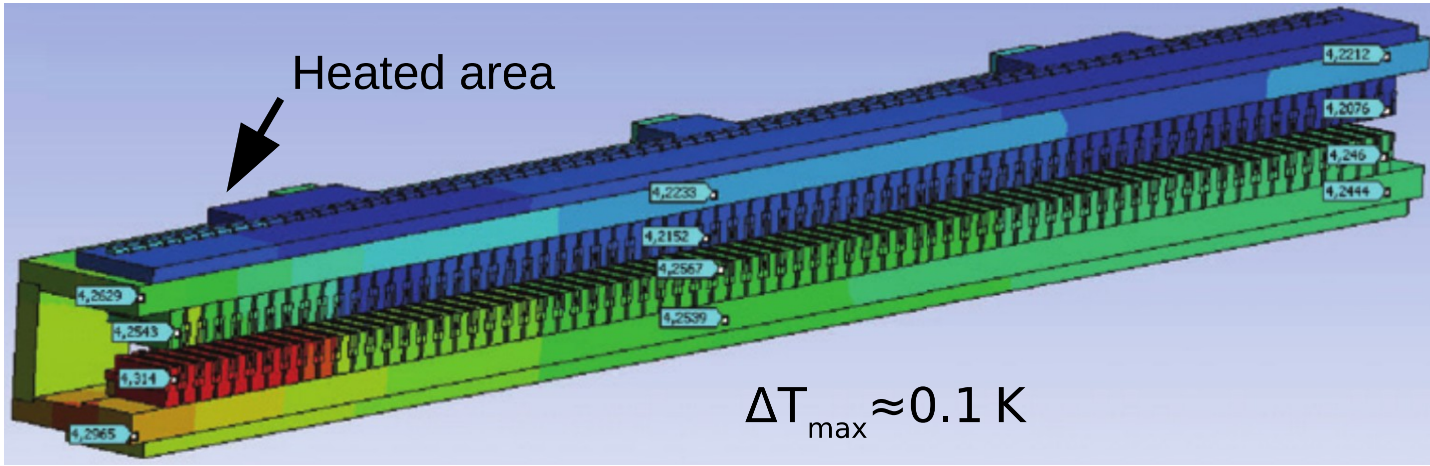
- Confirmation of cooling concept:
  - Synchrotron Radiation (SR) in different modes of operation,
  - Added heaters.

Early Experiments - Cooling

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



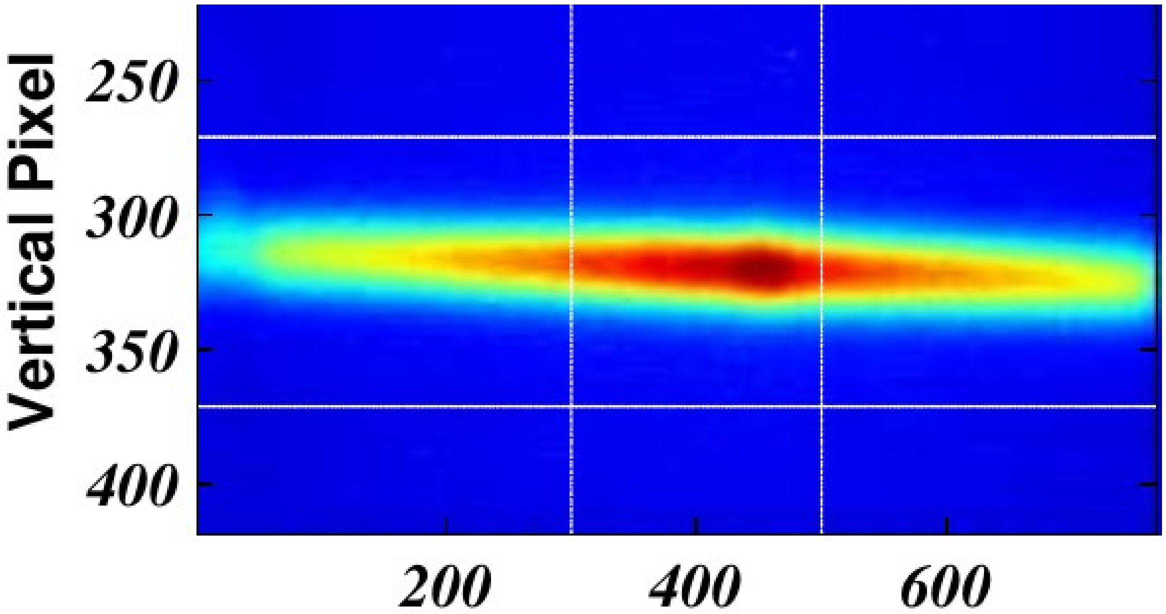
M. Ady, R. Kersevan, priv. com.



A. Bernhard et al., TUPME005, IPAC13

Advanced Experiments I / II

- Grow-Damp measurements to measure damping time.

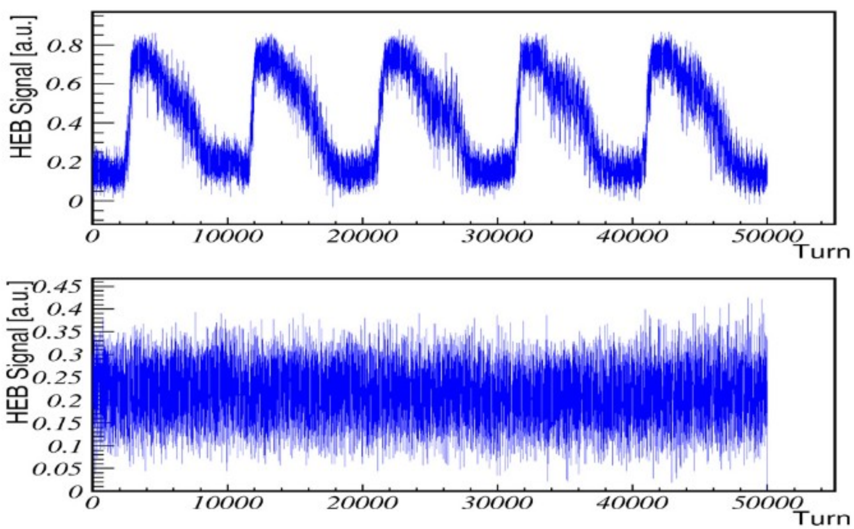


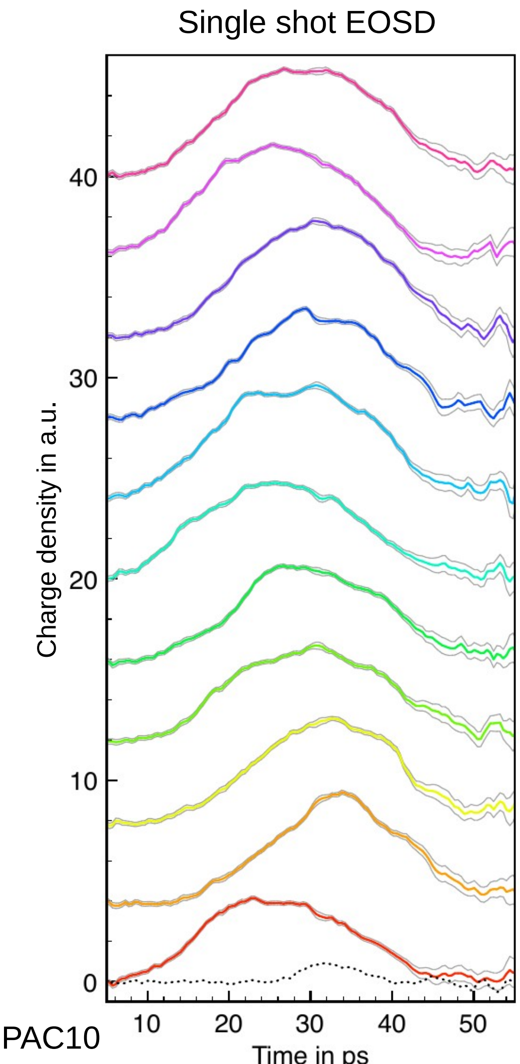
A.-S.- Müller et al., EPAC06

- Emittance measurement via synchrotron radiation based beam size measurement.

Advanced Experiments

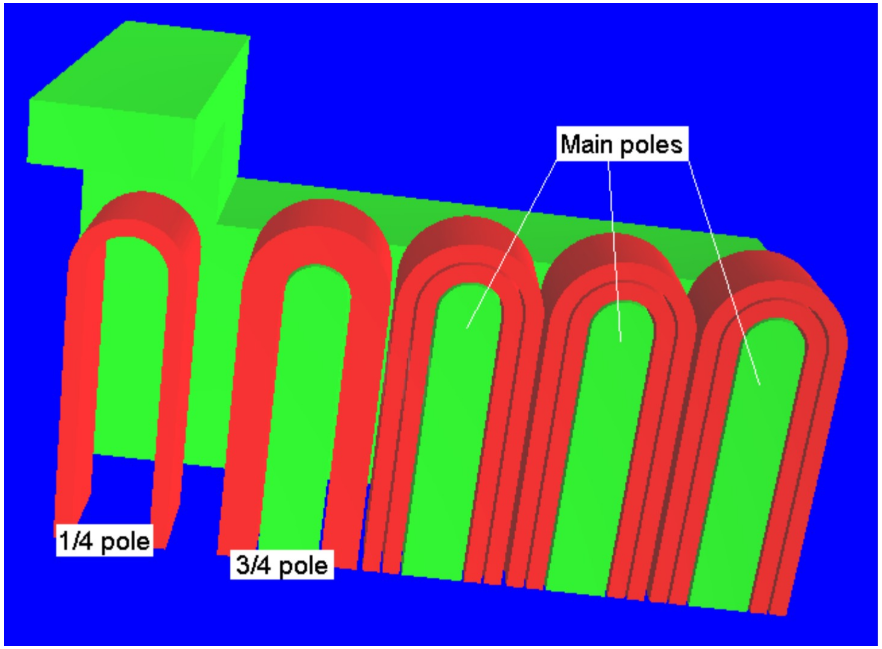
- Emittance coupling horizontal / vertical
- Low-α_c at 1.3 GeV– short bunch lengths:
  - Bunch structure, CSR bursting patterns
  - Multibunch effects

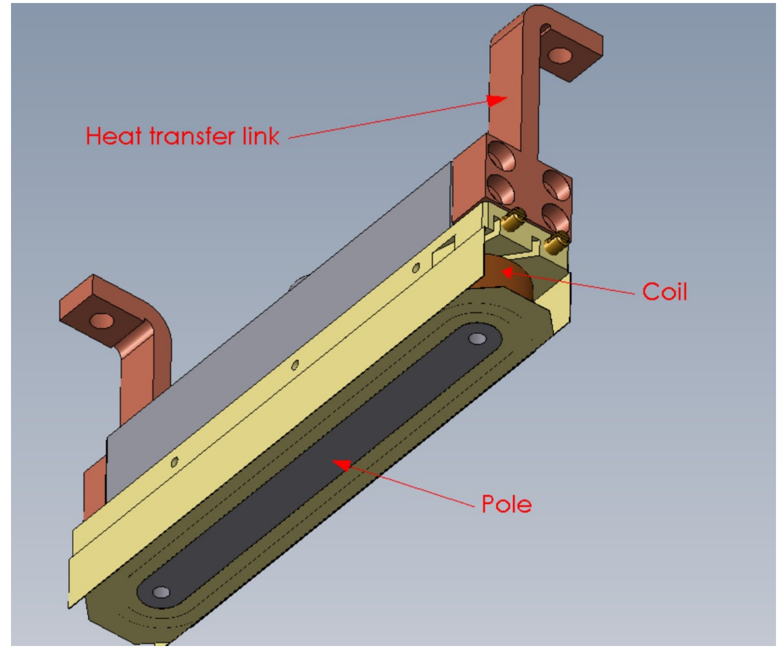




Figures, cf.:
V. Judin et al., Observation of Bursting Behavior Using Multiturn Measurements at ANKA, IPAC10
N. Hiller et al., Electro-Optical Bunch Length Measurements at the ANKA Storage Ring, IPAC13

Coil Geometry





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

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, $N_1(I_1 + I_2)$	$62 \times 974A$

- Powering outer poles separately allows to compensate field integrals, i.e. influence on beam.
- Main poles powered by I_1+I_2.

Superconductive Coils II / II