Instrumentation for R&D - COLDDIAG

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Outline

1. Superconducting insertion devices R&D strategy

2. Tools and instruments for R&D

   - CASPERI

   - CASPERII

   - COLDDIAG
     - Motivation
     - The vacuum chamber
     - Diagnostics
     - Planned measurements
     - Timeplan
     - Changes needed for installation at ANKA

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Superconducting IDs R&D strategy

Tasks

- Design and test winding schemes
- Develop and test field correction techniques
- Apply and test different superconducting materials and wires

CASPERI

- Quality assessment of magnetic field properties

CASPERII

- Understand beam heat load mechanisms

COLDDIAG

- Test performance of the device with beam

How to realize this program?

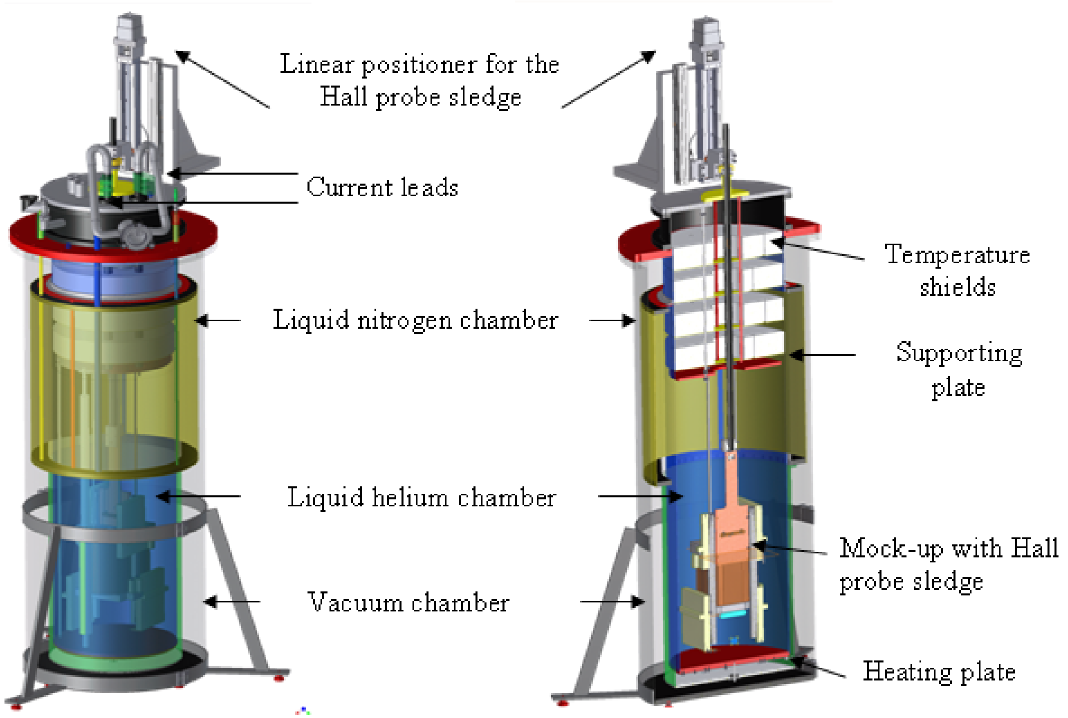
i) Close collaboration with our industrial partner Babcock Noell GmbH

ii) Tools and instruments to improve the magnetic field properties and understand the beam heat load mechanisms

iii) Need of a dedicated straight section and front end for tests

CASPERI

To test:
- **New winding schemes**
- **New superconducting materials and wires**
- **New field correction techniques**



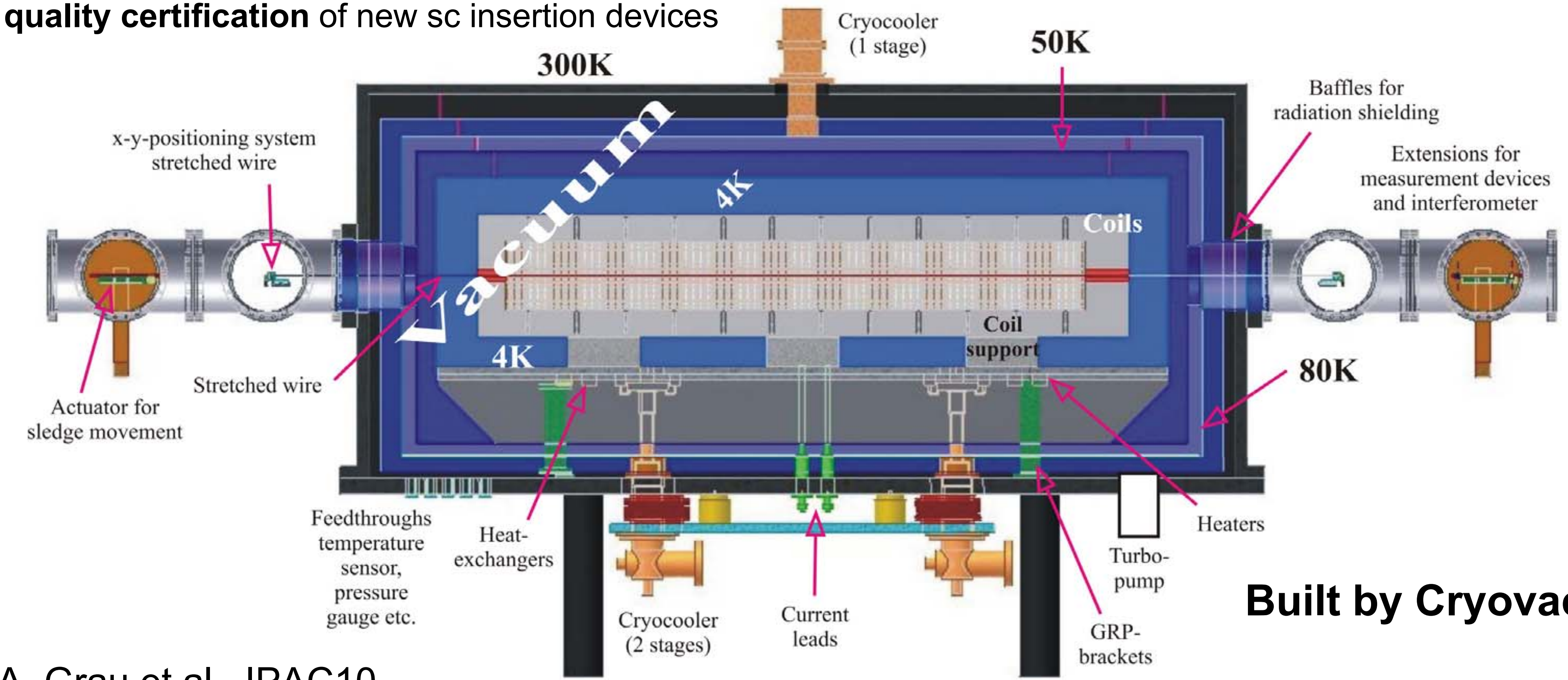
•**Operating vertical test in LHe of mock-up coils** with maximum dimensions 35 cm in length and 30 cm in diameter.

•The magnetic field along the beam axis is measured by Hall probes fixed to a sledge moved by a linear stage with the following precision $\Delta B < 1mT$ and $\Delta z < 3\ \mu m$.

E. Mashkina et al., EPAC08

CASPERII

For **quality certification** of new sc insertion devices



Built by Cryovac

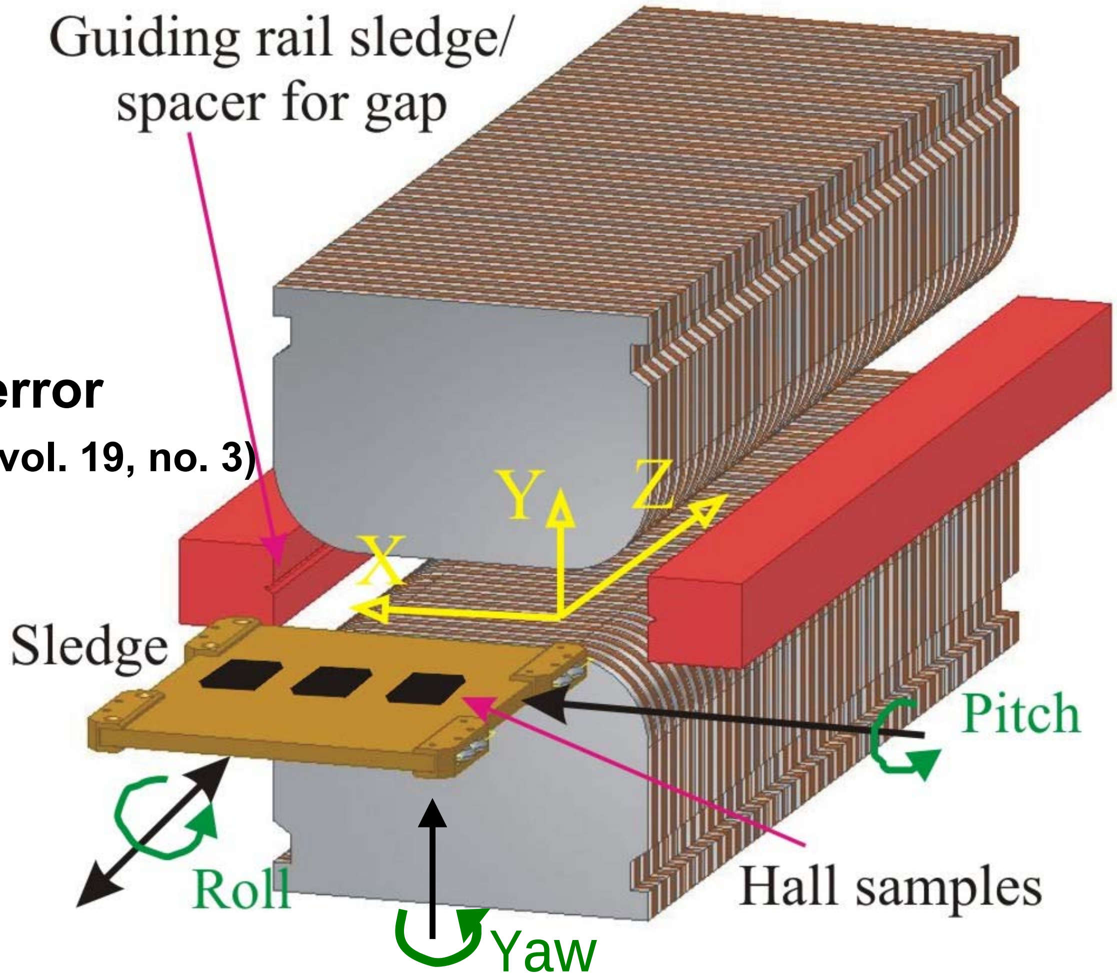
A. Grau et al., IPAC10

•**Under construction horizontal cryogen free test of long coils** with maximum dimensions 1.5 m in length and 50 cm in diameter.

•Local field measurements with Hall probes. Field integral measurements with stretched wire.

The magnetic field along the beam axis is measured by Hall probes fixed to a sledge moved by a linear stage with the following precision $\Delta B < 1mT$ and $\Delta z = 1\ \mu m$.

CASPERII: Local field measurements with Hall probes

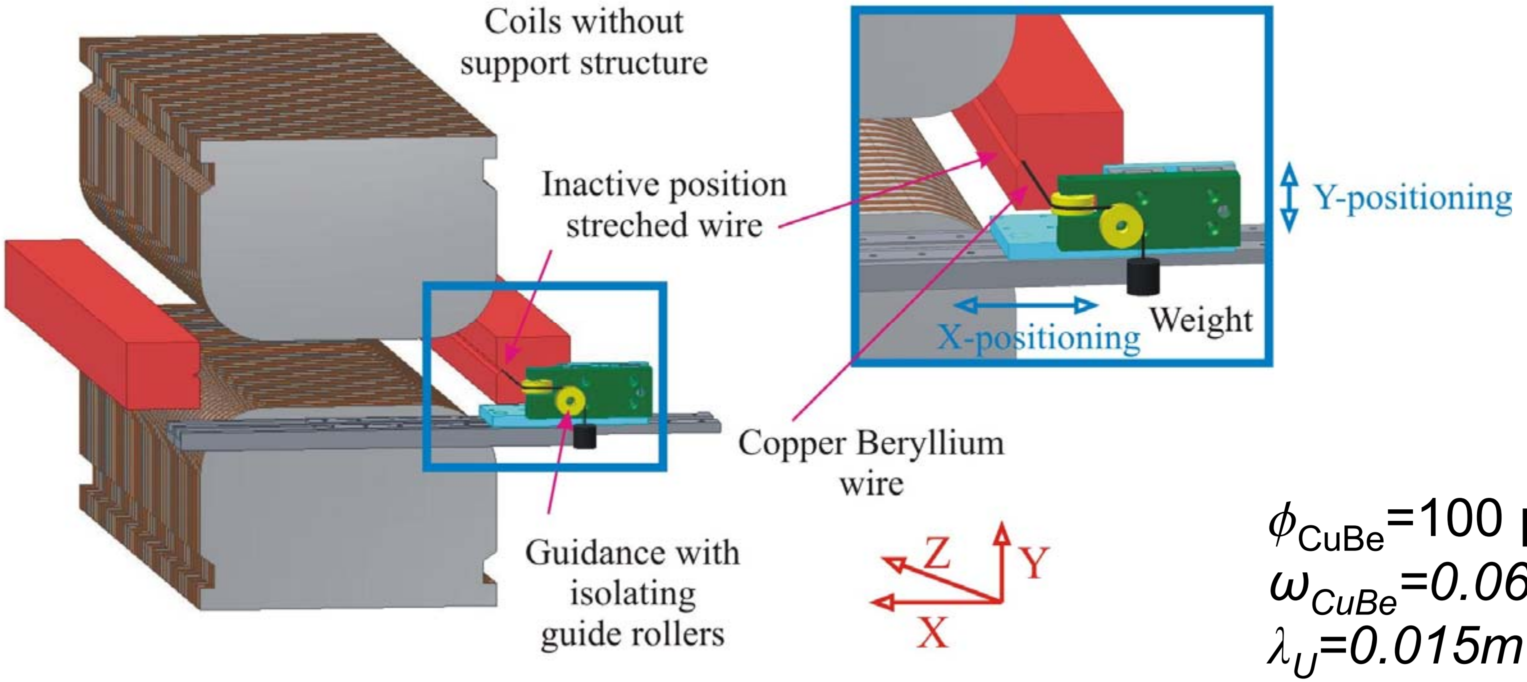


Mechanical requirements to reach measurement accuracy for phase error
(A.Grau et al., IEEE Trans. App. Supercond., vol. 19, no. 3)
$\Delta\phi$ = 1° (λ_U=15mm, K=2):
Δx = 400 µm
Δ y = 50 µm
Δ z = 5 µm
roll = 1 mrad
yaw= 1 mrad
pitch = 30 mrad

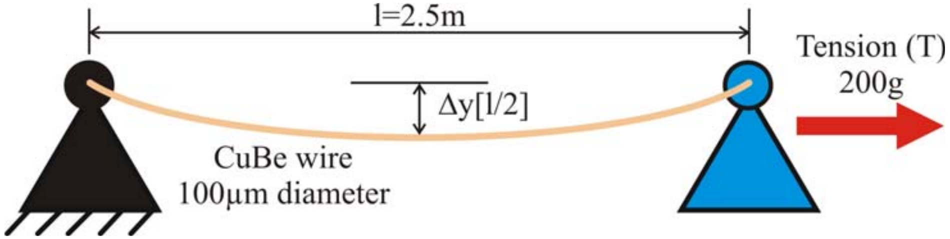
Relative longitudinal position of Hall probes measured with laser interferometer with 1µm accuracy.

A. Grau et al., IPAC10

CASPERII:
Integral field measurements with stretched wire



ϕ_{CuBe}=100 µm
ω_{CuBe}=0.064g/m
λ_U=0.015m



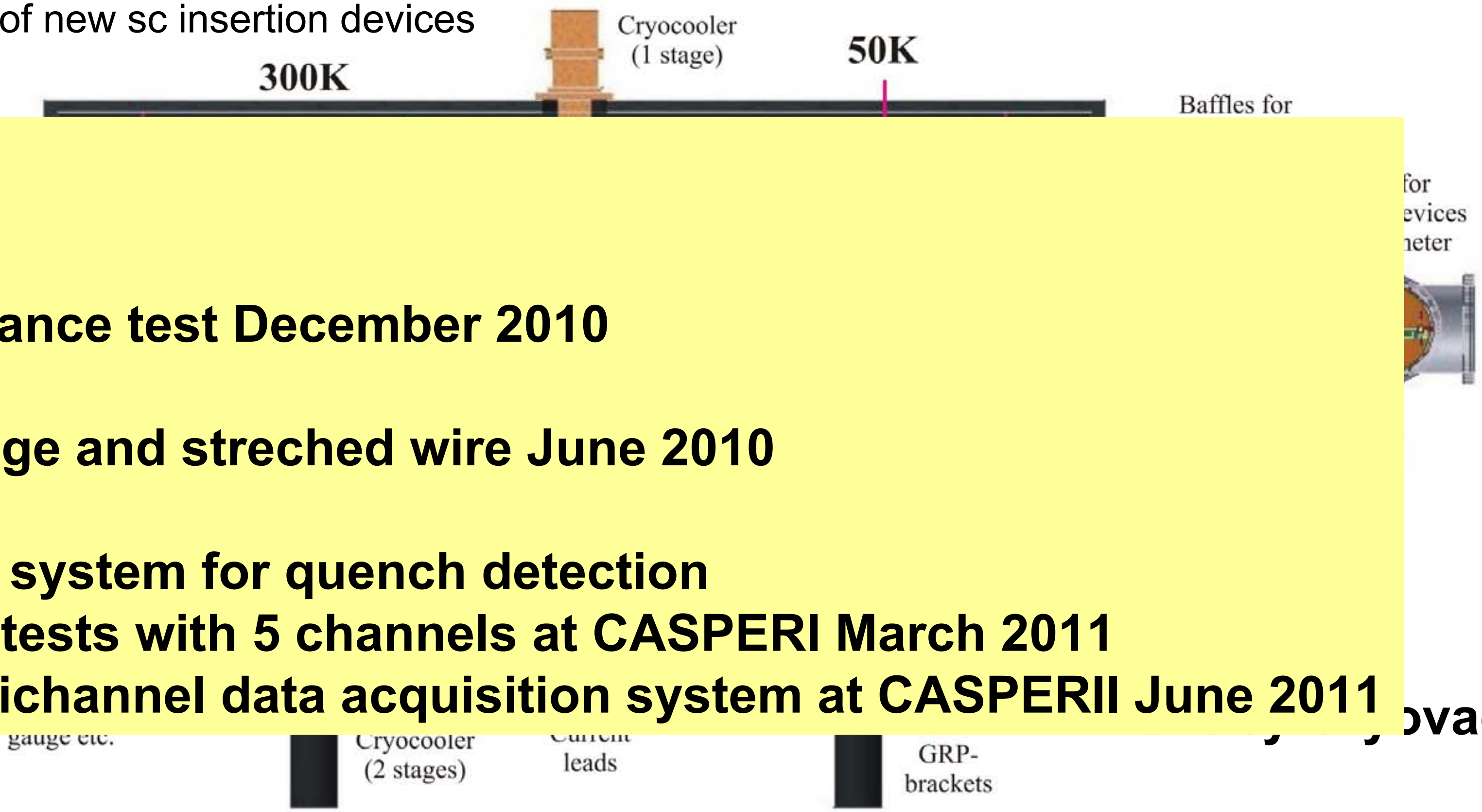
$$\Delta y\left(\frac{l}{2}\right) \cong -\frac{\omega_{CuBe}\, l^2}{8T}$$

$$\frac{\Delta I_y}{I_y} \approx \frac{1}{2}\left(\frac{2\pi}{\lambda_U}\right)^2 \cosh\left(\frac{2\pi}{\lambda_U}\Delta y\right)(\Delta y)^2 \approx 5\times 10^{-3}.$$

A. Grau et al., IPAC10

CASPERII

For **quality certification** of new sc insertion devices



Timeplan

- **Factory acceptance test December 2010**
- **Hall probe sledge and streched wire June 2010**
- **Fast aquisition system for quench detection**
  - **1) first tests with 5 channels at CASPERI March 2011**
  - **2) multichannel data acquisition system at CASPERII June 2011**

•**Under construction horizontal cryogen free test of long coils** with maximum dimensions 1.5 m in length and 50 cm in diameter.

•Local field measurements with Hall probes. Field integral measurements with stretched wire.

The magnetic field along the beam axis is measured by Hall probes fixed to a sledge moved by a linear stage with the following precision ΔB < 1mT and Δz = 1 µm.

COLDDIAG

Under construction cold vacuum chamber for diagnostics to **measure the beam heat load** to a cold bore in a storage ring. The beam heat load is needed to specify the cooling power for the cryodesign of superconducting insertion devices.

In collaboration with
BNG: C. Boffo, G. Sikler
CERN: V. Baglin
LNF: R. Cimino, M. Commisso, B. Spataro
University of Rome ‚La sapienza‘: A. Mostacci
DIAMOND: M. Cox, J. Schouten
MAXLAB :Erik Wallèn
Max-Planck Institute for Metal Research: R. Weigel,
STFC/DL/ASTeC:J. Clarke, D. Scott
STFC/RAL: T. Bradshaw
University of Manchester: I. Shinton, R. Jones

A first installation at the synchrotron light source DIAMOND is foreseen in June 2011.

S. Gerstl et al., IPAC10

Motivation:
Beam heat load on the Diamond wigglers

Beam Heating and Helium Consumption at 250mA and 686 bunches

•**SCW-1(3.5T):**
20 Watt
2.5 liter/hour **68.000 £ (80.700 Euro) pa**

•**SCW-2 (4.2T)**
11.6 Watt
1.1 liter/hour **34.000 £ (40.300 Euro) pa**

Courtesy of J. Schouten

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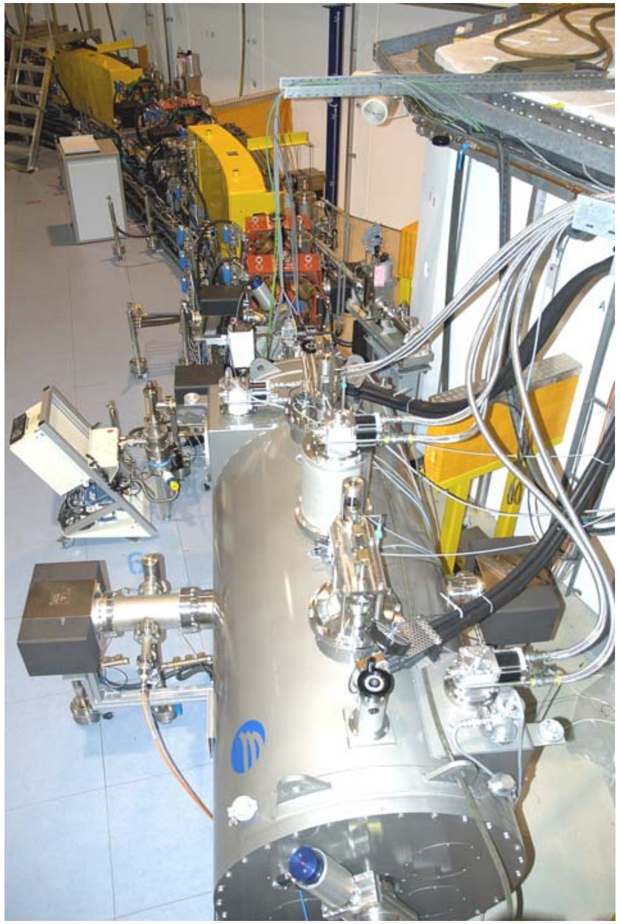
Motivation:
Beam heat load studies at ANKA

- **Cryogen free magnet**
- **Period length: 14 mm**
- **Length: 100 periods**
- **NbTi - coils**



0.4 W < Observed heat load (I_{beam}=100mA) < 1 W

Performance limited by too high beam heat load: beam heat load observed cannot be explained by synchrotron radiation from upstream bending and resistive wall heating.

	Calculated heat load (W) for I_{beam}=100mA
Synchrotron radiation from upstream bending	**< 0.063**
Resistive wall heating	**< 0.022**

Simple model of electron bombardment appears to be consistent with the beam heat load and pressure rise observed in the cold bore of the SCU14 at ANKA.

S. C. et al., PRSTAB2007

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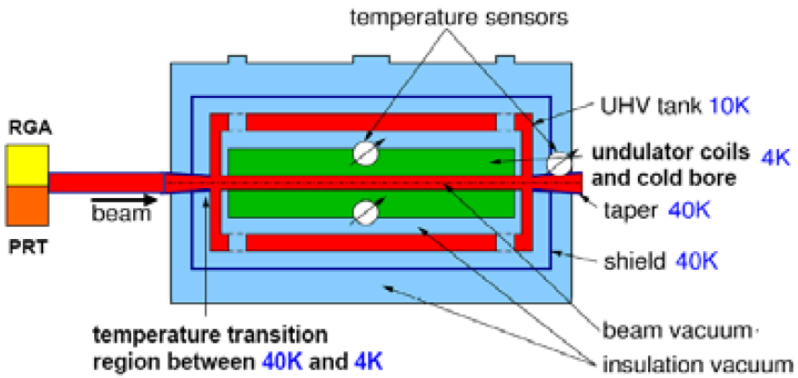
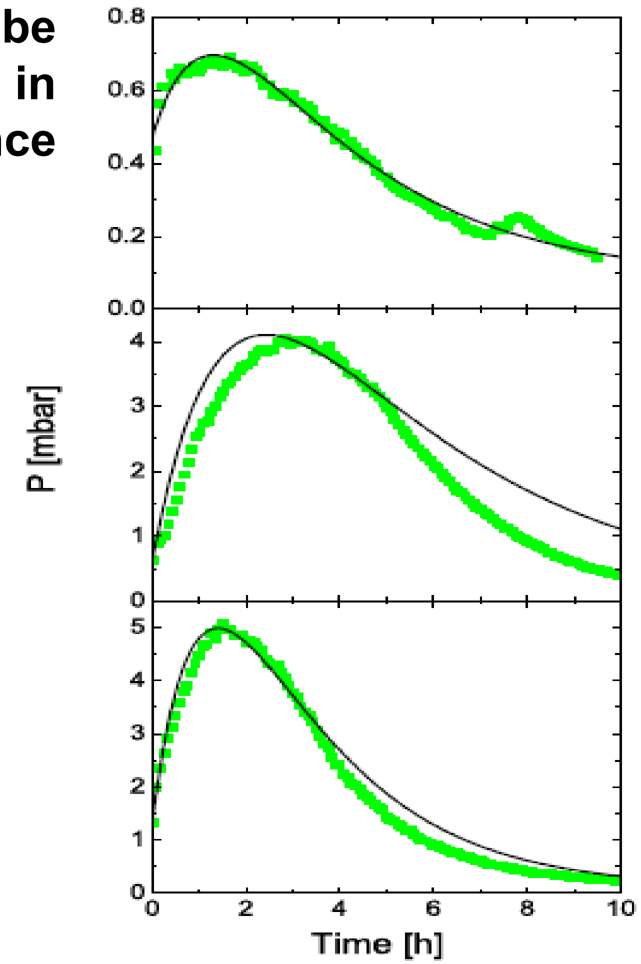
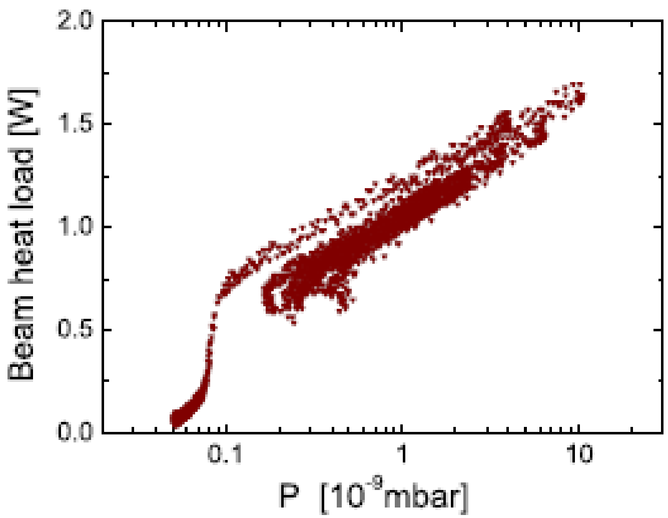
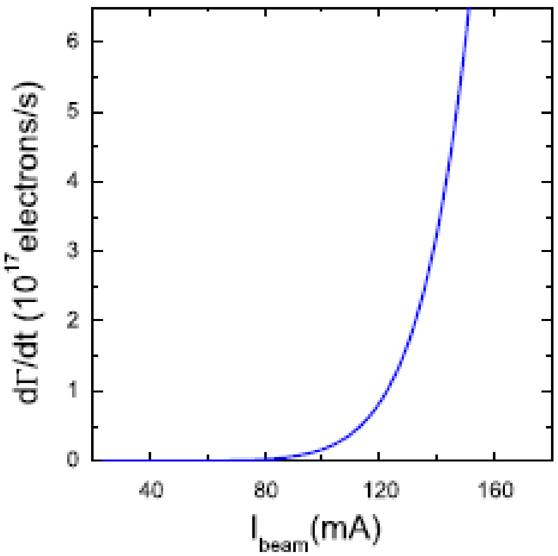
Motivation:
Dynamic pressure studies



Pressure rise can be explained by including in eq. of gas dynamic balance electron multipacting.
S. C. et al., PRSTAB2010







Possible beam heat load source: electron bombardment of the wall, beam dynamics under study

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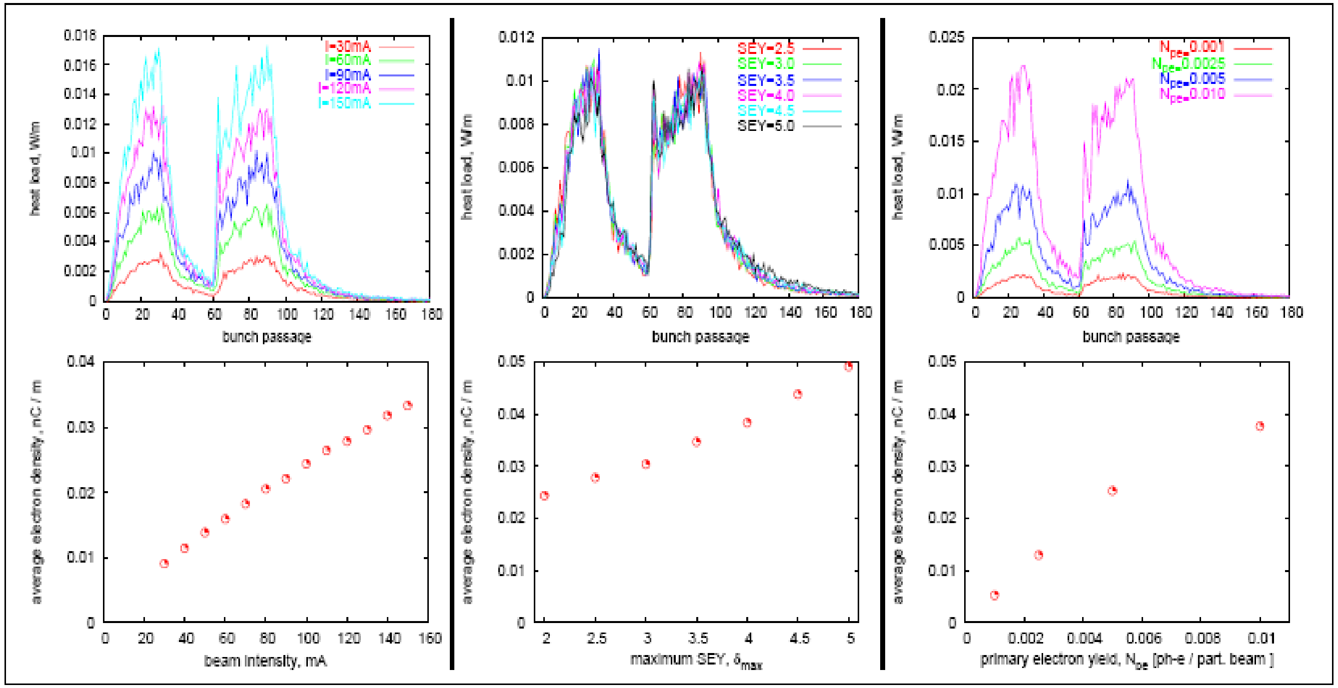
Motivation: Beam dynamics studies

Simulations with ECLOUD code for the SCU14 demonstrator at ANKA

Table 1: ECLOUD input parameters.

Parameter	ref. value	scan
beam intensity (mA)	100	30 - 150
bunches / train	32	...
# trains	2	...
bunch charge (e-)	3.5e9	(1 - 5.4)e9
bunch spacing (ns)	2	...
energy (GeV)	2.5	...
rev. period (ns)	360	...
hor beam size (mm)	0.840	...
ver beam size (mm)	0.063	...
long beam size (mm)	12	...
hor aperture (mm)	80	...
ver aperture (mm)	30	8 - 30
SEY at zero energy, δ_0	0.5	0.5 - 0.9
max SEY, δ_{max}	2.0	1.5 - 5
energy for δ_{max} (eV)	290	150 - 290
peak energy ph-e (eV)	7.0	...
energy ph-e, sigma (eV)	5.0	...
energy ph-e, sigma (eV)	1.8	...
primary e- yield, N_{pe} (ph-e/part. beam)	0.005	0.001- 0.01

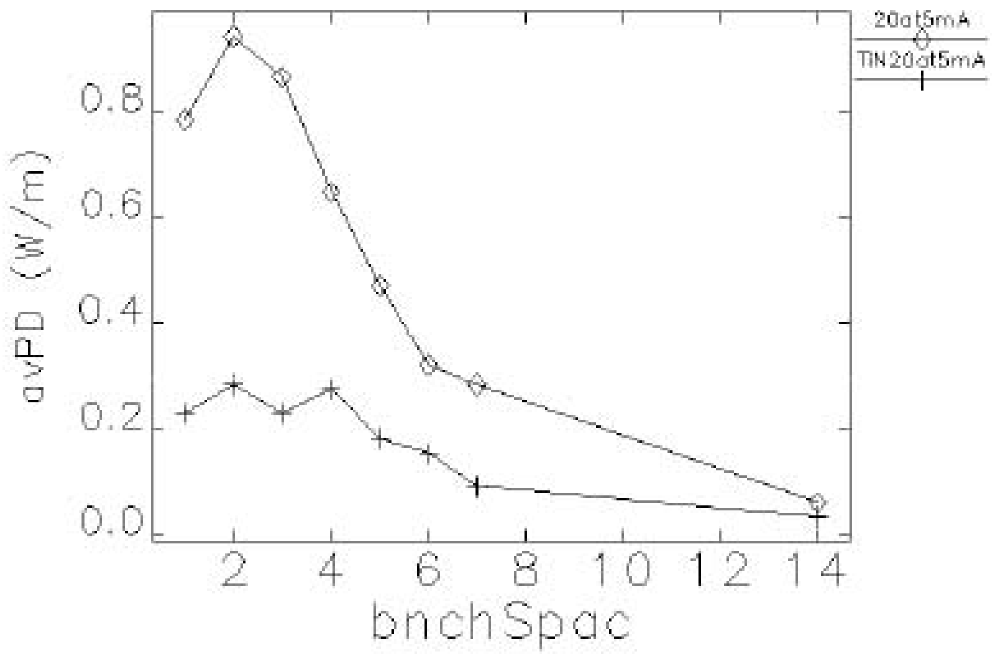


The maximum heat load inferred from the ECLOUD simulations ~ 20mW.

The calculated energy spectrum shows that there are barely no electrons above 40 eV.

U. Iriso, S. Casalbuoni, G. Rumolo, F. Zimmerman, PAC'09

Preliminary calculations: electron cloud heat load vs. bunch spacing



posinst simulation for 8-mm ID, electron beam

Assumptions (*posinst*):

- 8 mm vacuum chamber, field-free
- 20 bunches, 5 mA/bunch
- Al: δ_{max} = 3.0; TiN: δ_{max} = 1.1
- Simple photon reflectivity model

Uncertainty for electron beam:

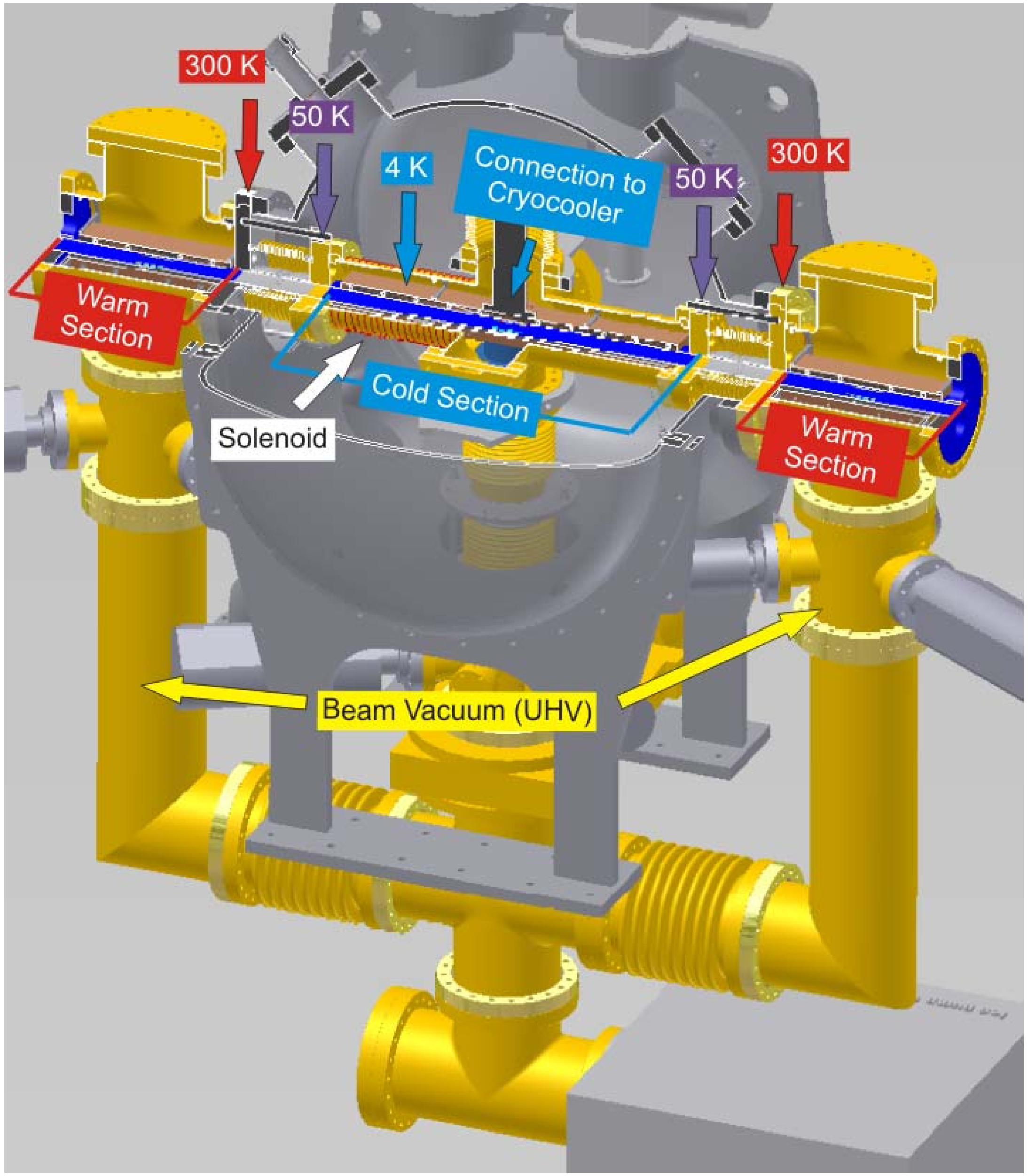
- APS positron modeling results agreed well with RFA data
- APS electron beam modeling did not agree well
- Data also from CesrTA suggest that photoemission model needs improvement.

Presented by K. Harkay at ECLOUD'10

Posinst physics: M.A. Furman and M.T. Pivi, Phys Rev ST Accel Beams 5, 124404 (2002).

Do the ecloud build up codes contain all the physics going on for e^- beams?
•APS change photoelectron model in POSINST
•ANKA include ion cloud potential in ECLOUD (S. Gerstl)

COLDDIAG: the vacuum chamber



- Cryogen free: cooling with Sumitomo RDK-415D cryocooler (1.5W@4.2K)

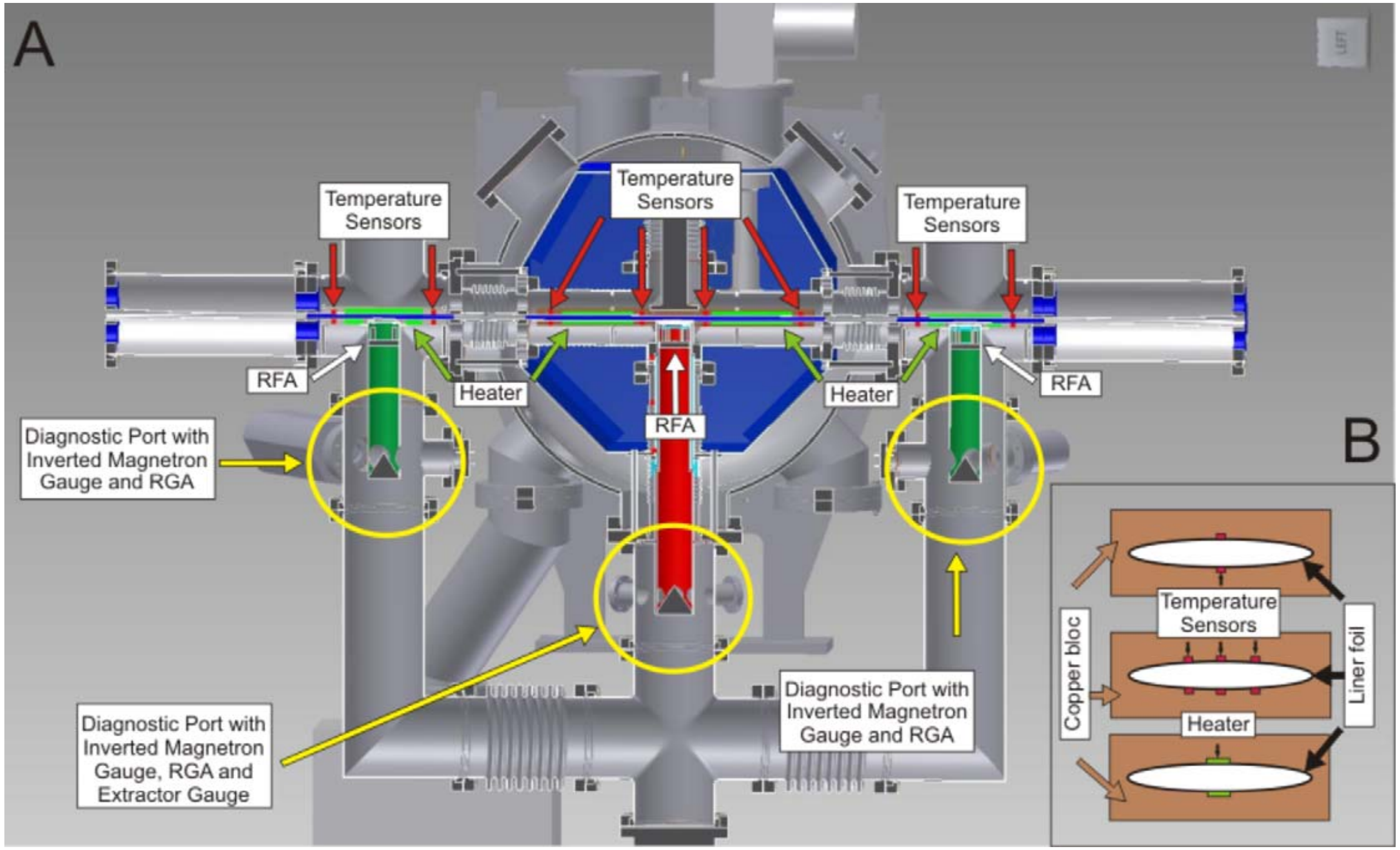
- Cold vacuum chamber located between two warm sections to compare beam heat load with and without cryosorbed gas layer
- 3 identically equipped diagnostic ports with room temperature connection to the beam vacuum

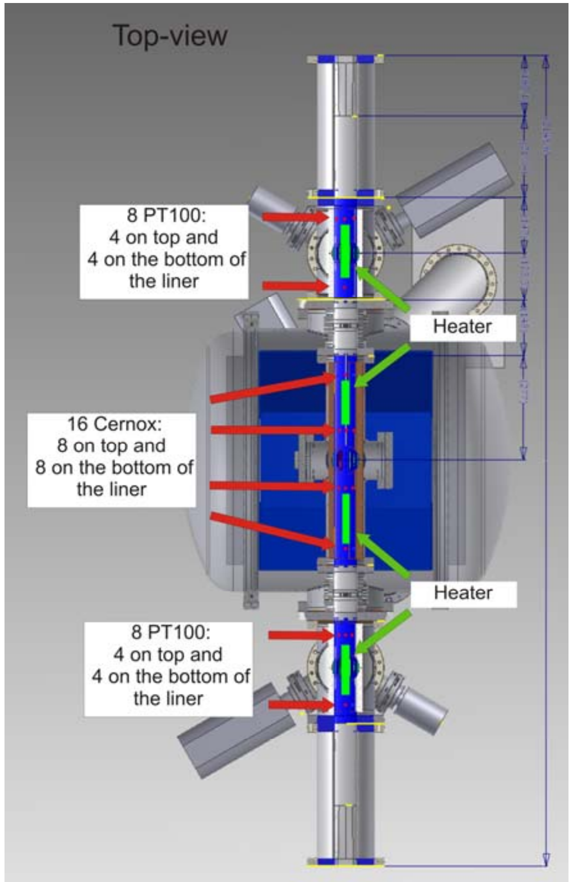
- Exchangeable liner to test different materials and geometries
- Copper bar copper plated (50µm)

S. Gerstl et al., IPAC10

COLDDIAG: diagnostics

Possible Beam Heat Load Sources: 1)Synchrotron radiation from upstream bending magnet, 2) Resistive wall heating, 3) RF effects, 4) Electron and/ or ion bombardment





The diagnostics will include measurements of the **heat load**, the **pressure**, the **gas composition**, and the **electron flux of the electrons bombarding the wall**.

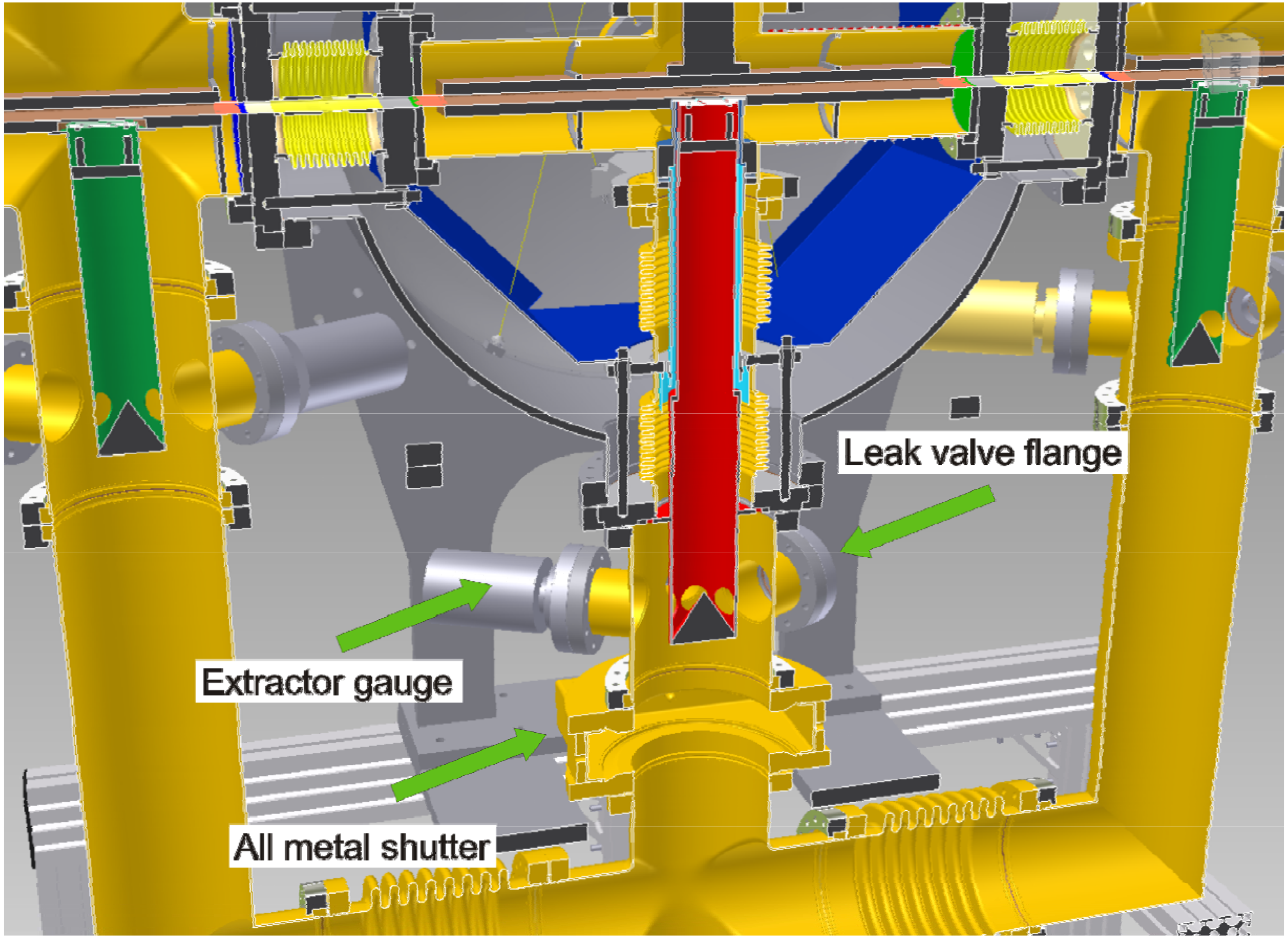
S. Gerstl et al., IPAC10

Planned Measurements at Diamond

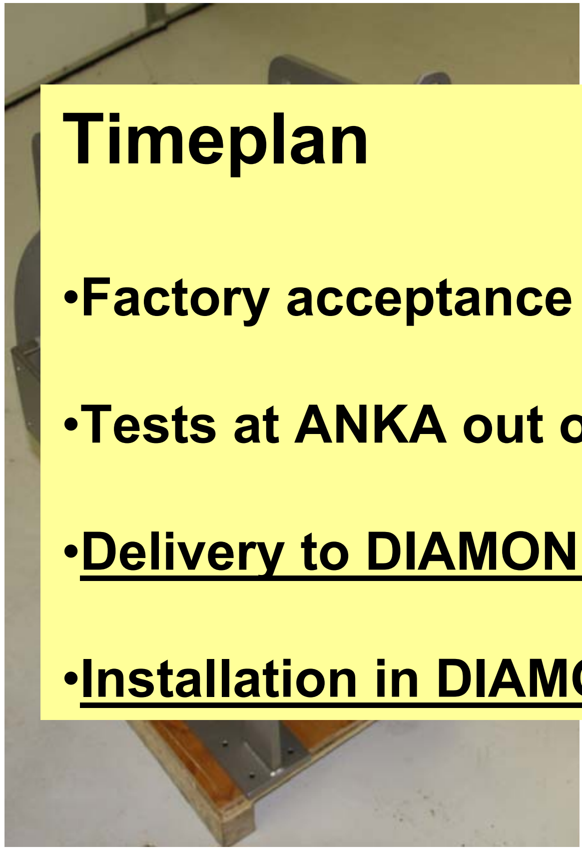
Monitoring the temperature, the electron flux, pressure and gas composition with different:

- **average beam current** to compare the beam heat load data with synchrotron radiation and resistive wall heating predictions
- **bunch length** to compare with resistive wall heating predictions
- **filling pattern** in particular the bunch spacing to test the relevance of the electron cloud as heating mechanism
- **beam position** to test the relevance of synchrotron radiation and the gap dependence of the beam heat load
- **injected gases** naturally present in the beam vacuum (H_2, CO, CO_2, CH_4) to understand the influence of the cryosorbed gas layer on the beam heat load

COLDDIAG
Gas injection



COLDDIAG



Under construction cold vacuum chamber for
at load to a
heat load is
wer for the
on devices.

Timeplan

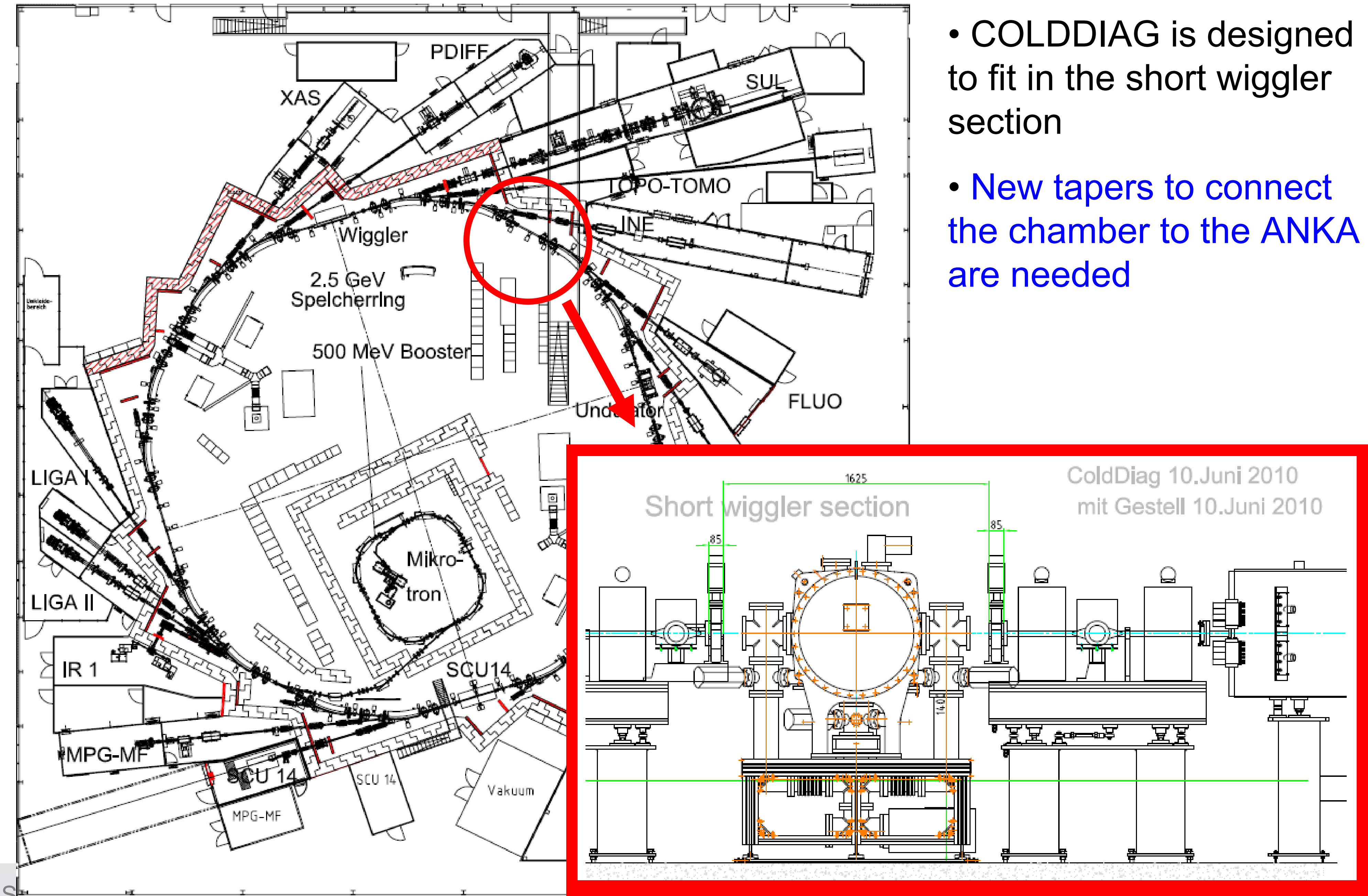
- **Factory acceptance test December 2010 - January 2011**
- **Tests at ANKA out of the storage ring January-March 2011**
- **Delivery to DIAMOND end March 2011**
- **Installation in DIAMOND June 2011**

,STFC/RAL,
rford Labs, Rome
stitute for Metal

A first installation at the synchrotron light source DIAMOND is foreseen in June 2011.

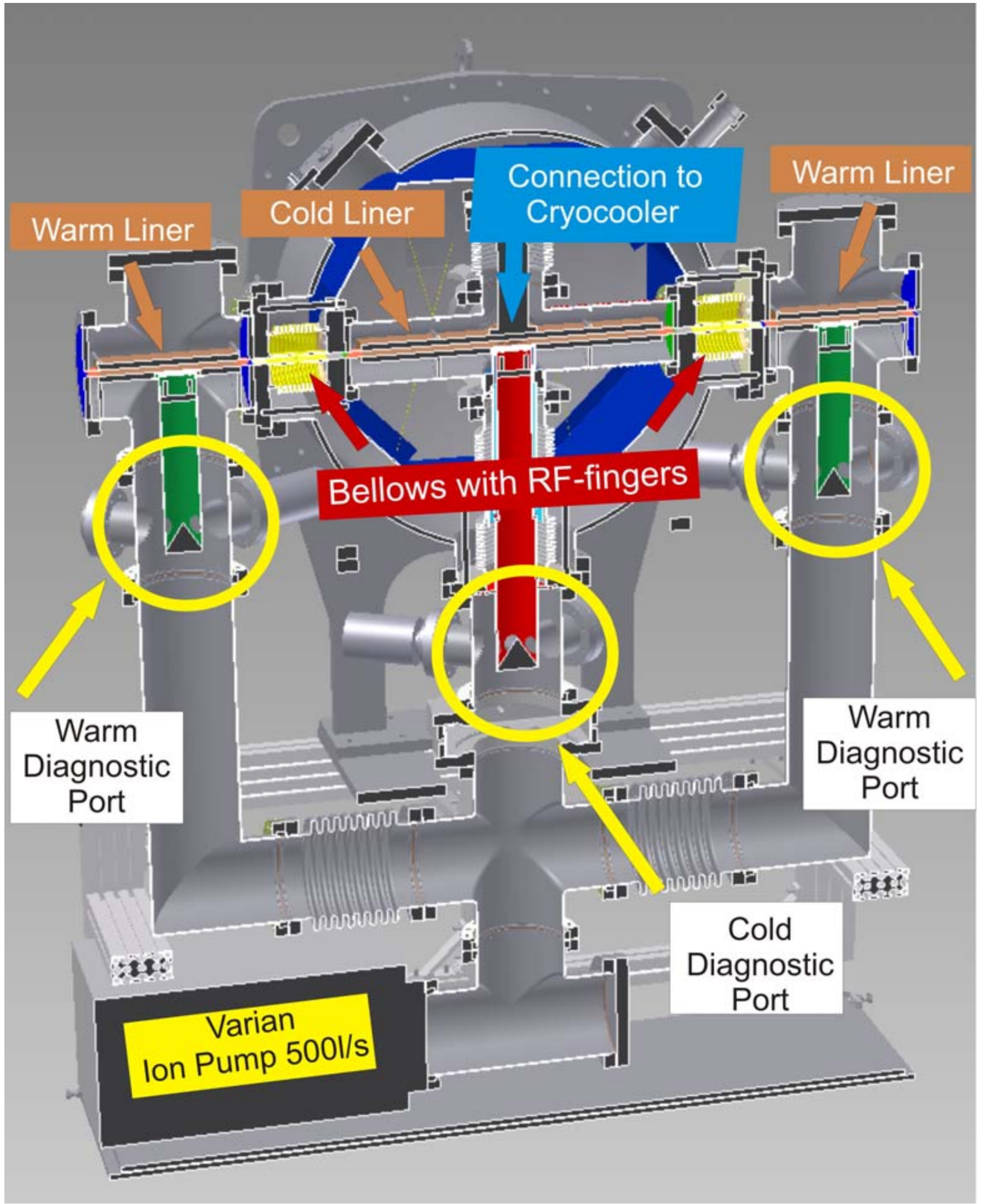
S. Gerstl et al., IPAC10

COLDDIAG installation at ANKA



- COLDDIAG is designed to fit in the short wiggler section
- New tapers to connect the chamber to the ANKA are needed

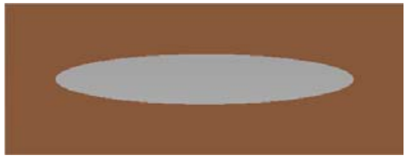
COLDDIAG installation at ANKA



As ANKA requires a larger beam stay clear the aperture liner and the RF-bellows need to be adapted.

Current design (DIAMOND):

Ellipse 10 mm x 60 mm



Tapering angle < 0.1 rad

ANKA design (example):

Min beam stay clear ~16mm

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