Electron cloud observations & activities at ANKA

Sara Casalbuoni

for

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Forschungszentrum Karlsruhe GmbH
und Universität Karlsruhe (TH)

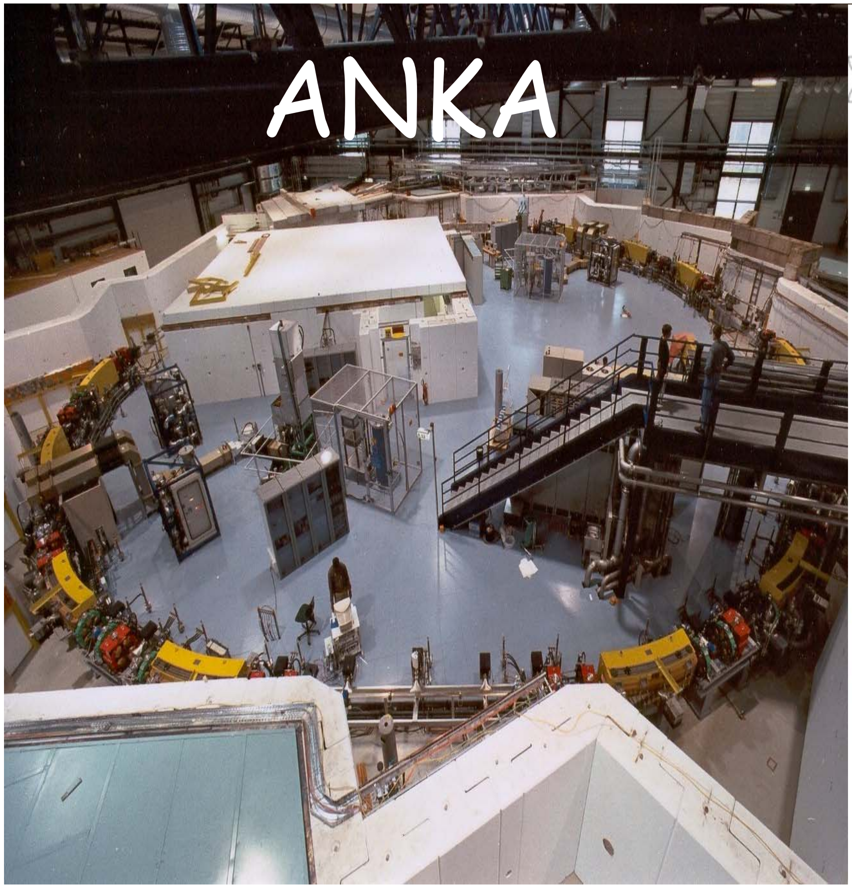
Forschungszentrum Karlsruhe
in der Helmholtz-Gemeinschaft

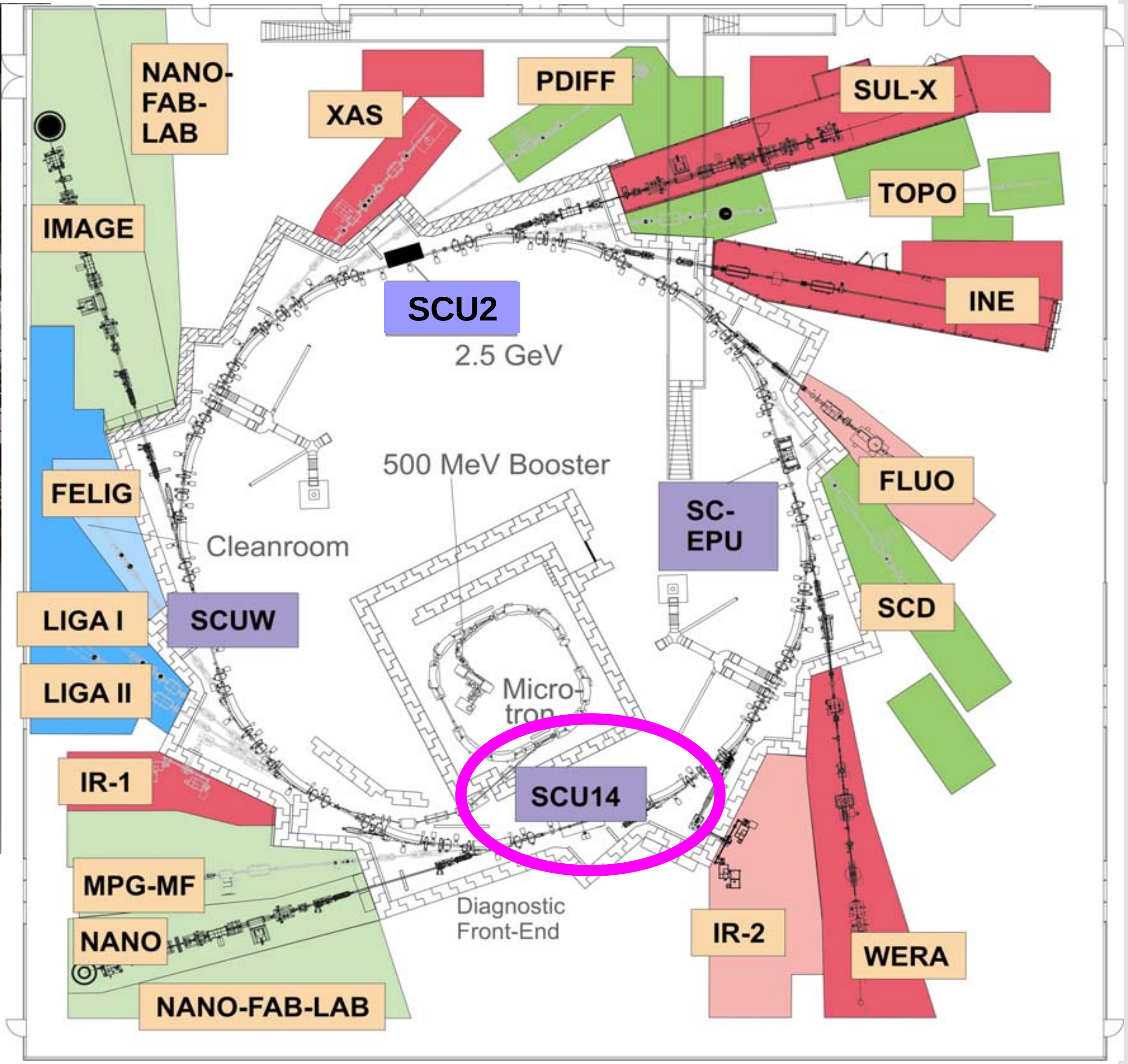
Outline

- Motivation
- Observations:
  - Beam heat load to the cold bore
  - Electron flux in the warm section
- Activities:
  - COLD vacuum chamber for DIAGnostics (COLDDIAG)
  - Electron detectors
  - ECLOUD simulations (see tomorrow talk by U. Iriso)
  - Microwave experiment and comparison with theory (see tomorrow talk by K. Sonnad)

Motivation:

study of the beam heat load to a cold bore for R&D of sc IDs





Energy:	2.5 GeV
Current:	200 mA
Circumference:	110.4 m

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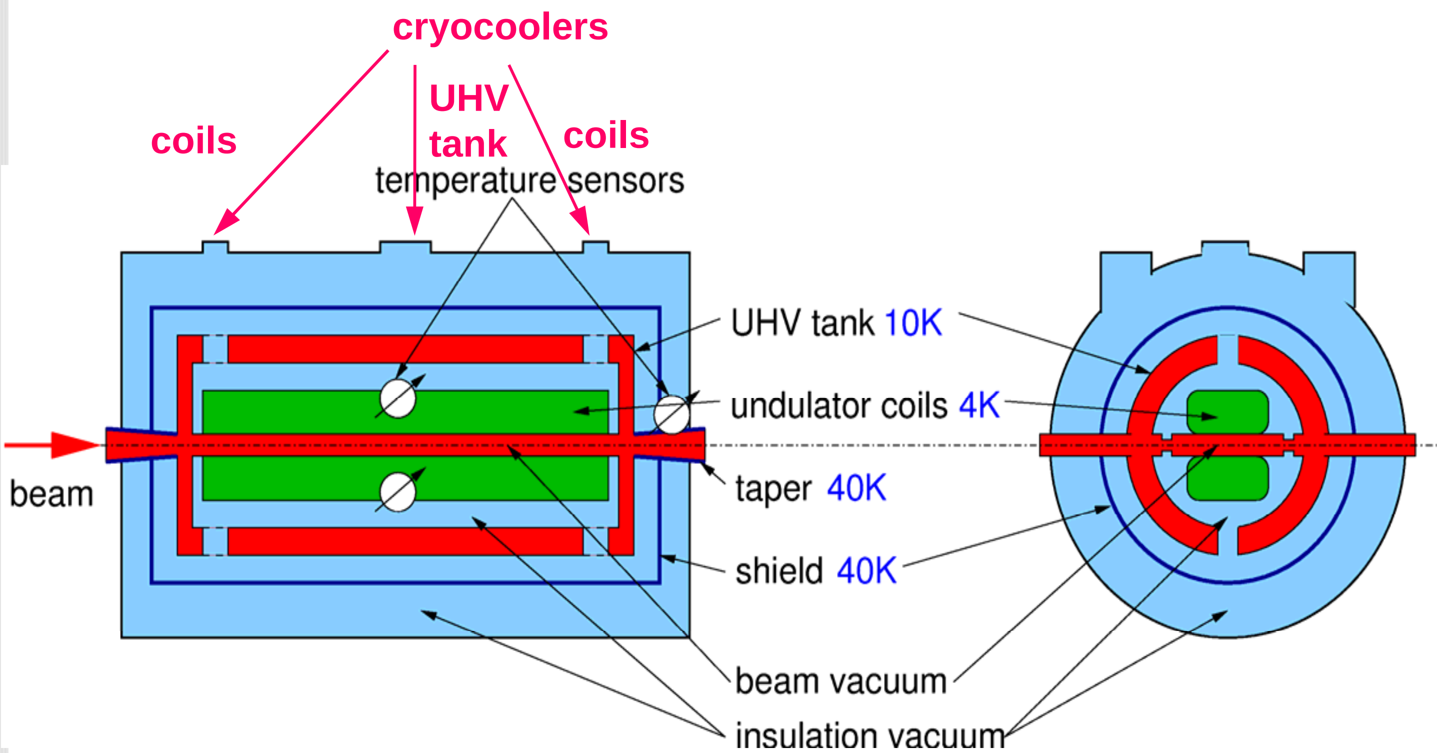
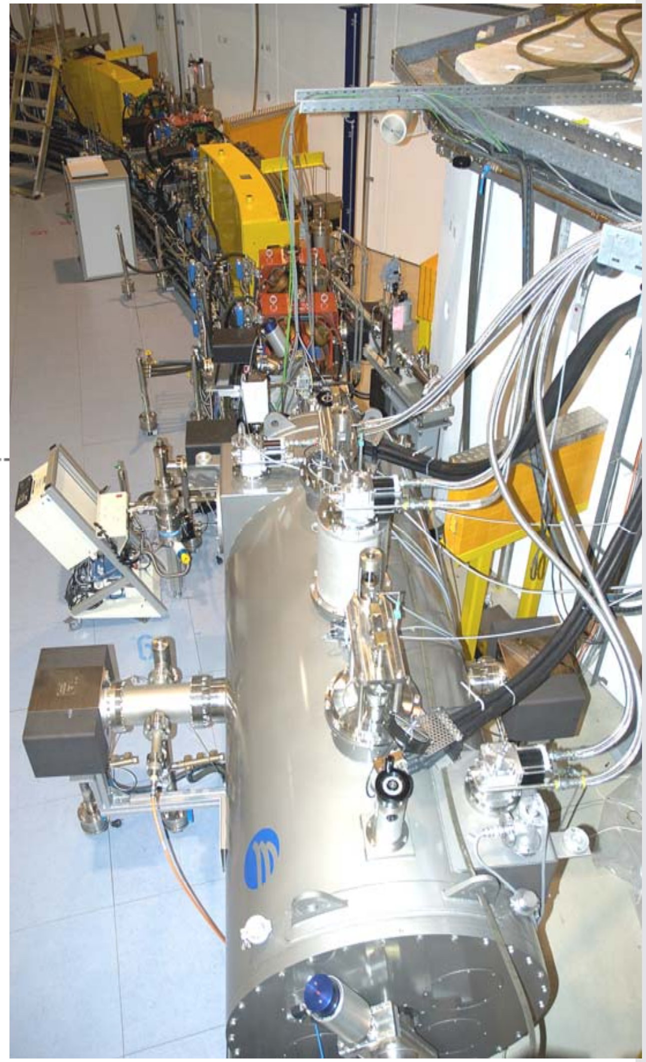
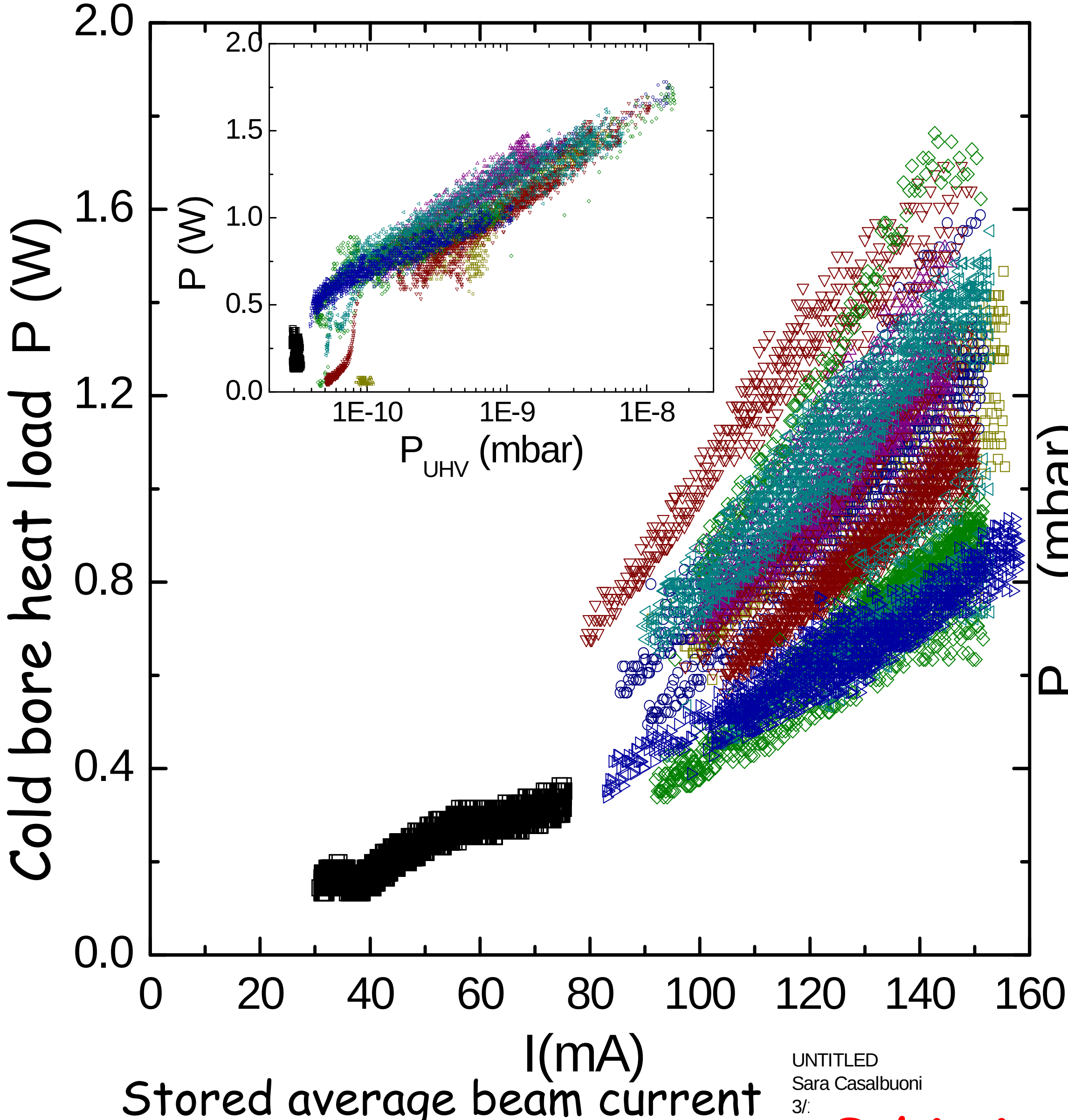
Superconducting undulator: vacuum and cooling system

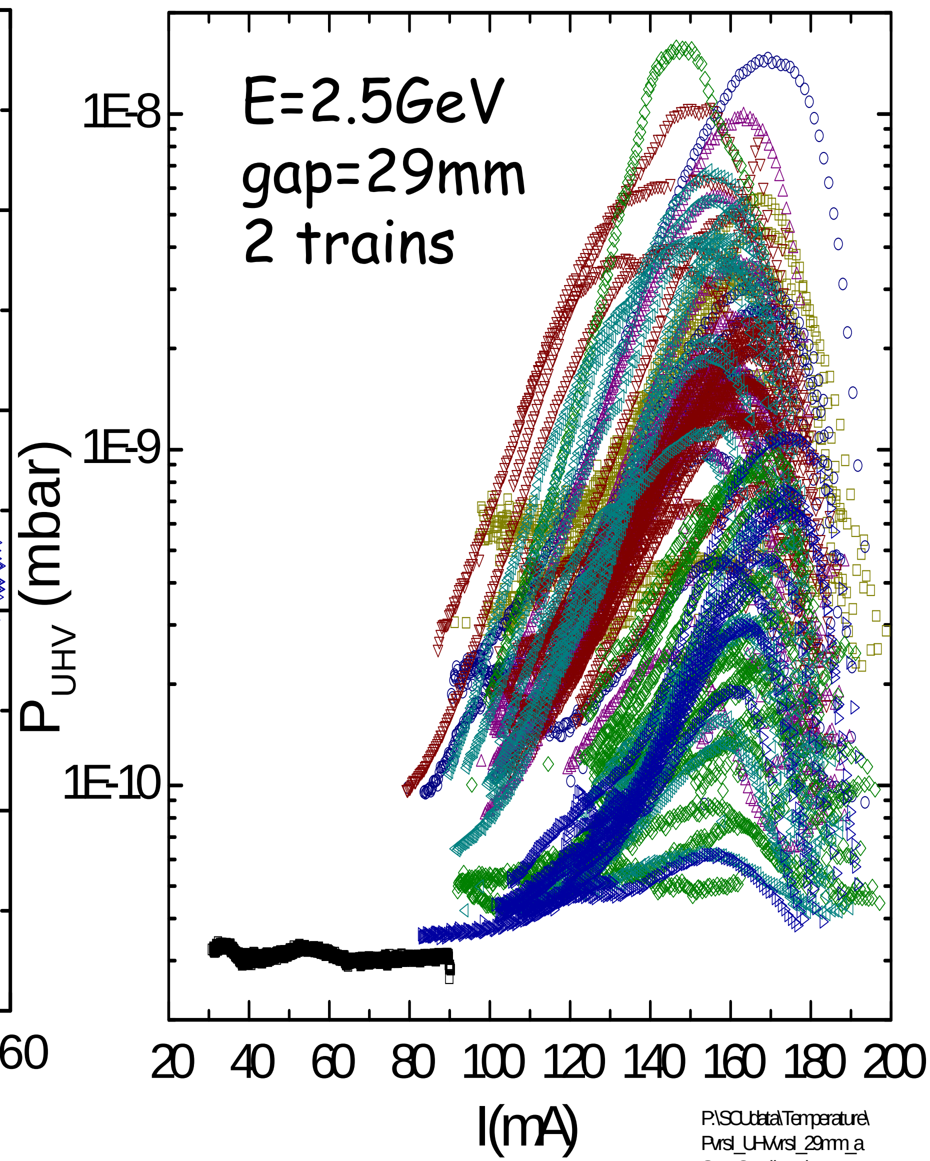




Magnetic gap width: 8, 12, 16 mm
Beam-stay-clear in the open state: 29 mm

Variation of the beam heat load over half a year





Orbit in all cases identical

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

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

The electron bombardment model is consistent with the beam heat load and pressure rise observed during normal user operation.

S. C. et al., Phys. Rev. ST Accel. Beams 10, 093202 (2007)

The beam heat load measurements on different cold vacuum chambers installed in synchrotron light sources presented at the Mini-Workshop on a Cold Vacuum Chamber for Diagnostics - Karlsruhe, 31st January-1st February 2008

http://ankaweb.fzk.de/conferences/Mini%20workshop/karlsruhe.html

	Beam heat load measured (W)	Beam heat load calculated from synchrotron radiation and resistive wall losses (W)	Beam heat load measured -calculated (W)
ANKA@ 100mA, 10mm long bunches	0.4-1	< 0.085	0.3-0.9
DIAMOND @ 125mA, 5mm long bunches	3	~ 0.5	2.5
MAXII @ 200mA, 24mm long bunches	1.6	~ 0.9	0.7

The difference between beam heat load measured and calculated is
not understood

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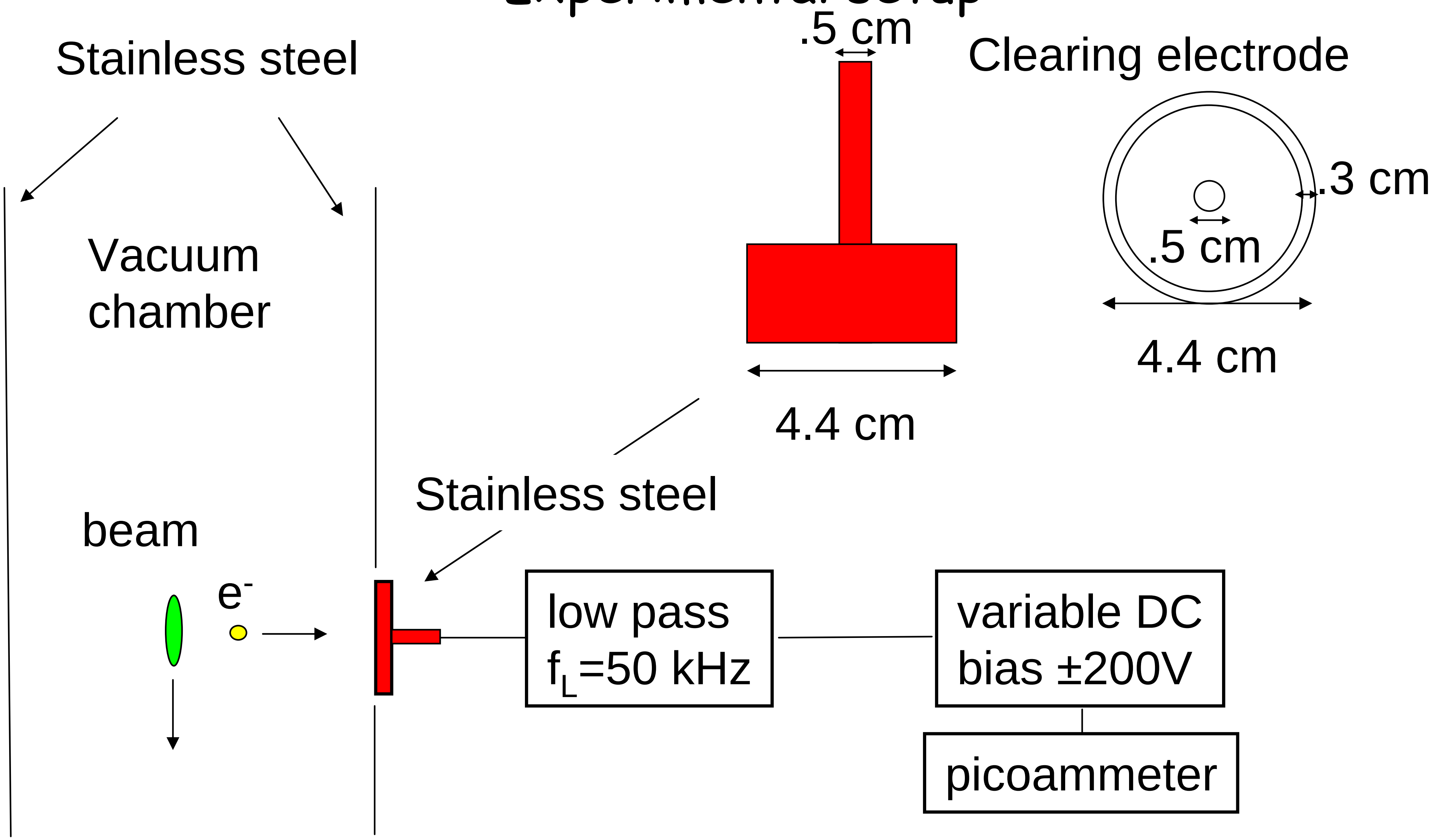
Direct detection of ecloud at ANKA @300K

Experimental setup



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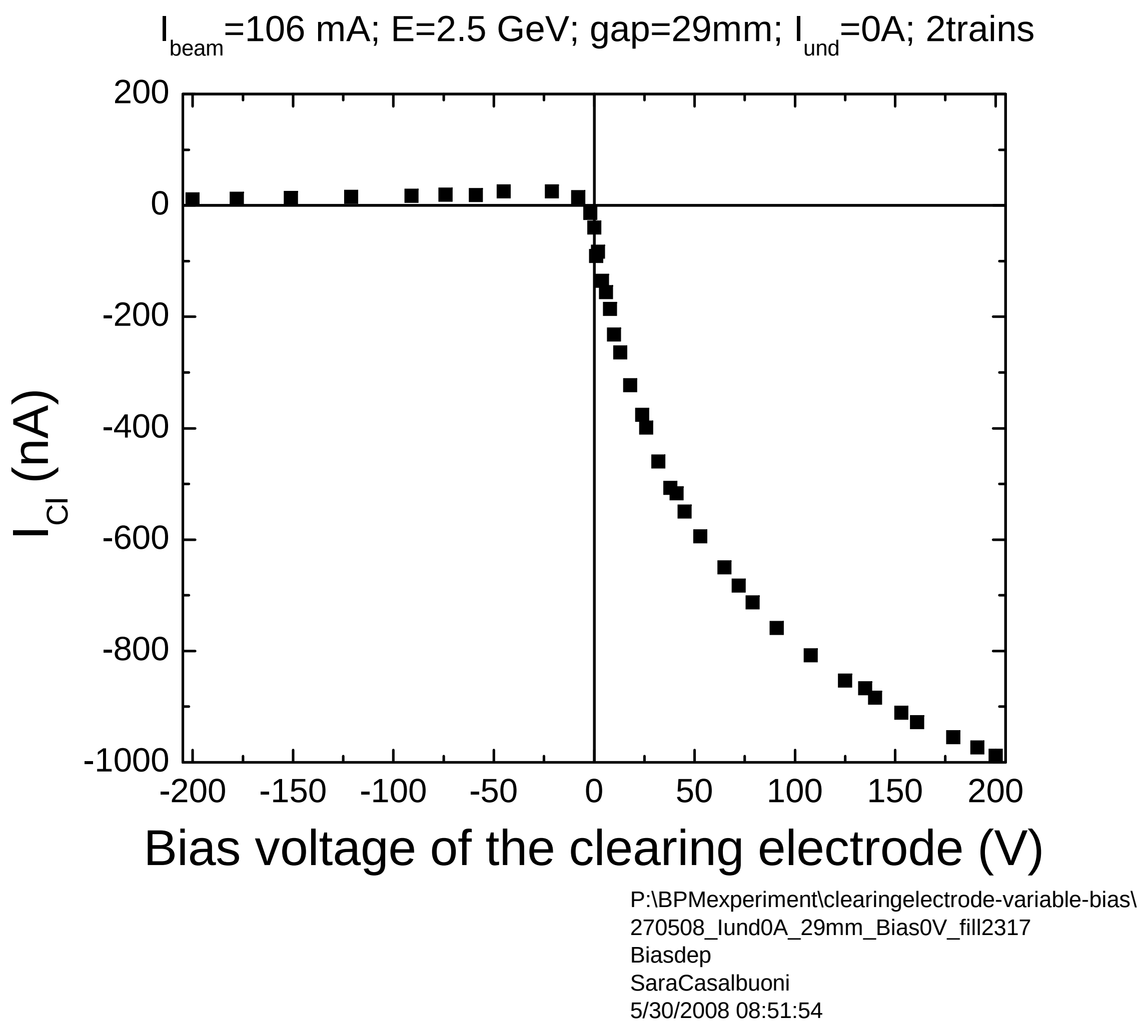
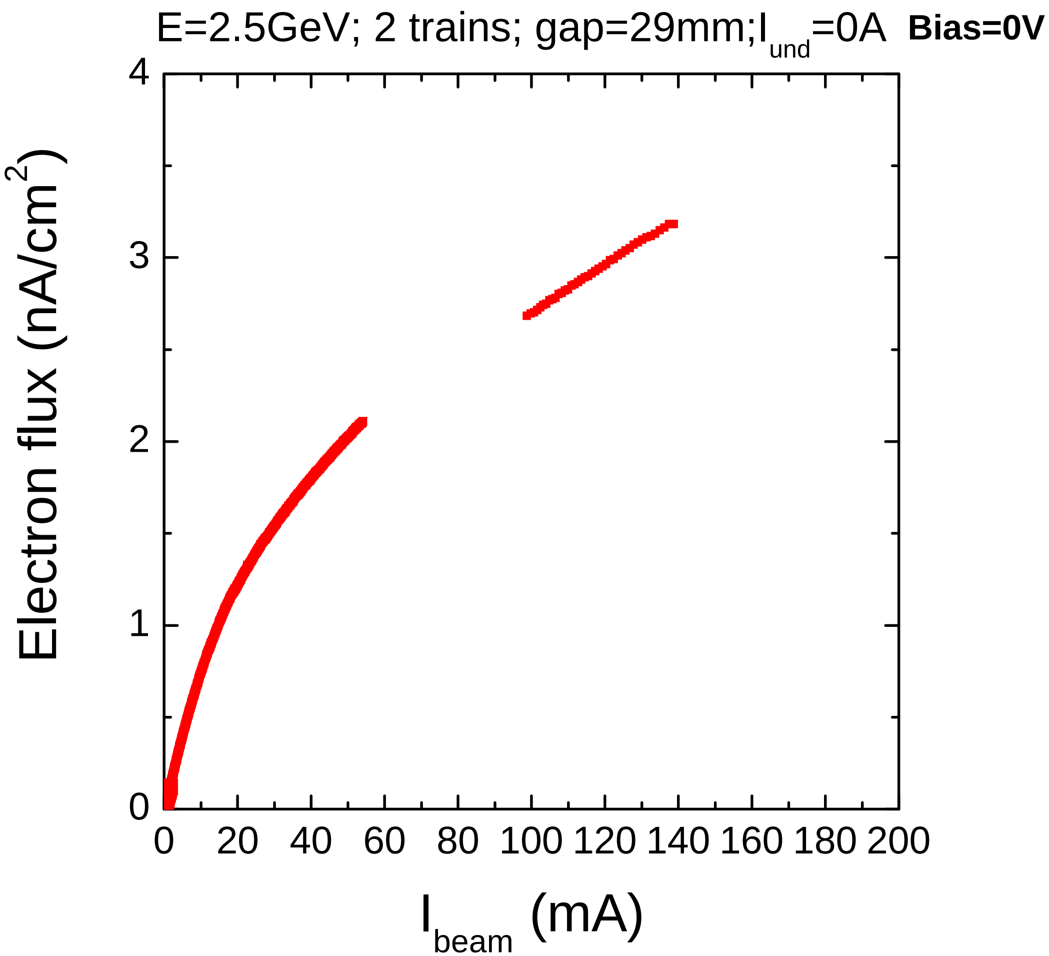
Results



S. C., A. Grau, M. Hagelstein, A.-S. Müller, U. Iriso, E. Mashkina , R. Weigel, Proceedings EPAC08

Results: beam current dependence



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Graph11
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I_{beam}=100mA; E=2.5 GeV; bunch length=10mm

Electron flux measured at the clearing electrode **(300 K)**

$$= 1.6 \cdot 10^{14} \frac{el}{m^2 \cdot sec}$$

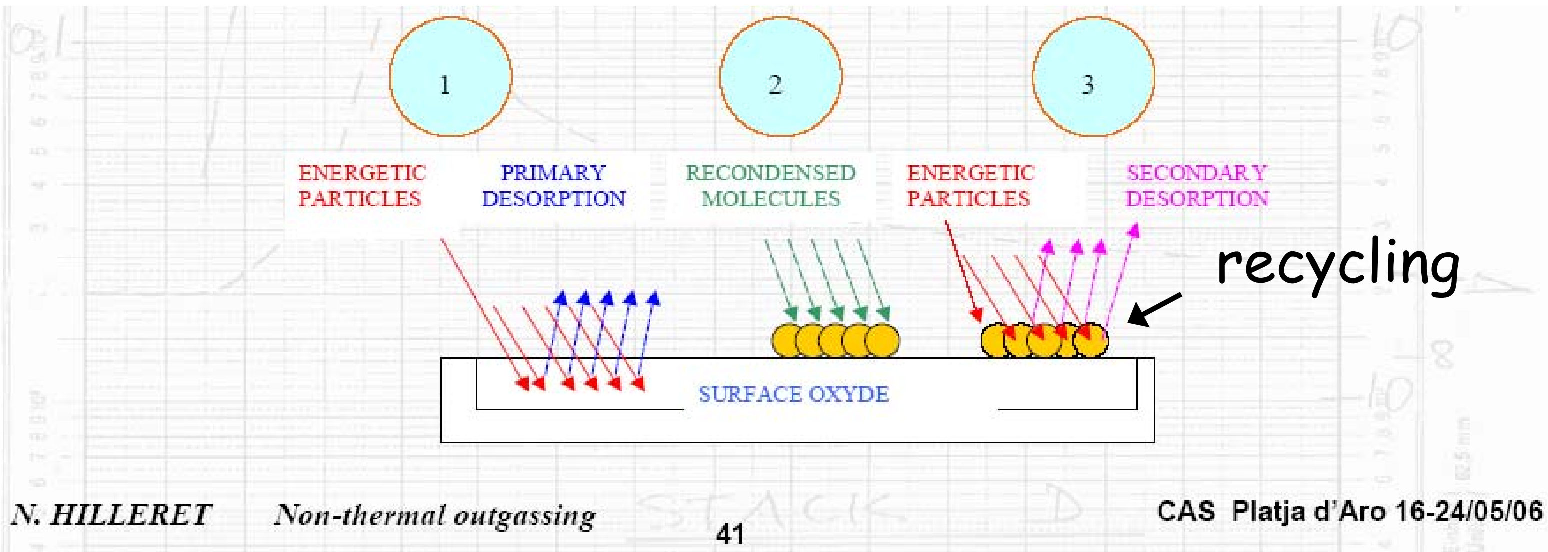
Electron flux needed to explain the beam heat load due to electron bombardment in the undulator cold bore **(4 K)**

$$= 2.2 \cdot 10^{18} \frac{el}{m^2 \cdot sec}$$

Surface seen by the beam

300 K: surface oxide

4K: cryosorbed gas layer



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Scientific Objectives of COLDDIAG

- In order to develop new superconducting insertion devices it is of interest to understand the still unexplained data of beam heat load onto cold vacuum chambers in the different synchrotron machines.

- To this end it would be useful to have a dedicated experiment to measure:
  - the heat load
  - the pressure
  - the gas composition
  - the electron energy and flux of the electrons bombarding the wall in a cold vacuum chamber.

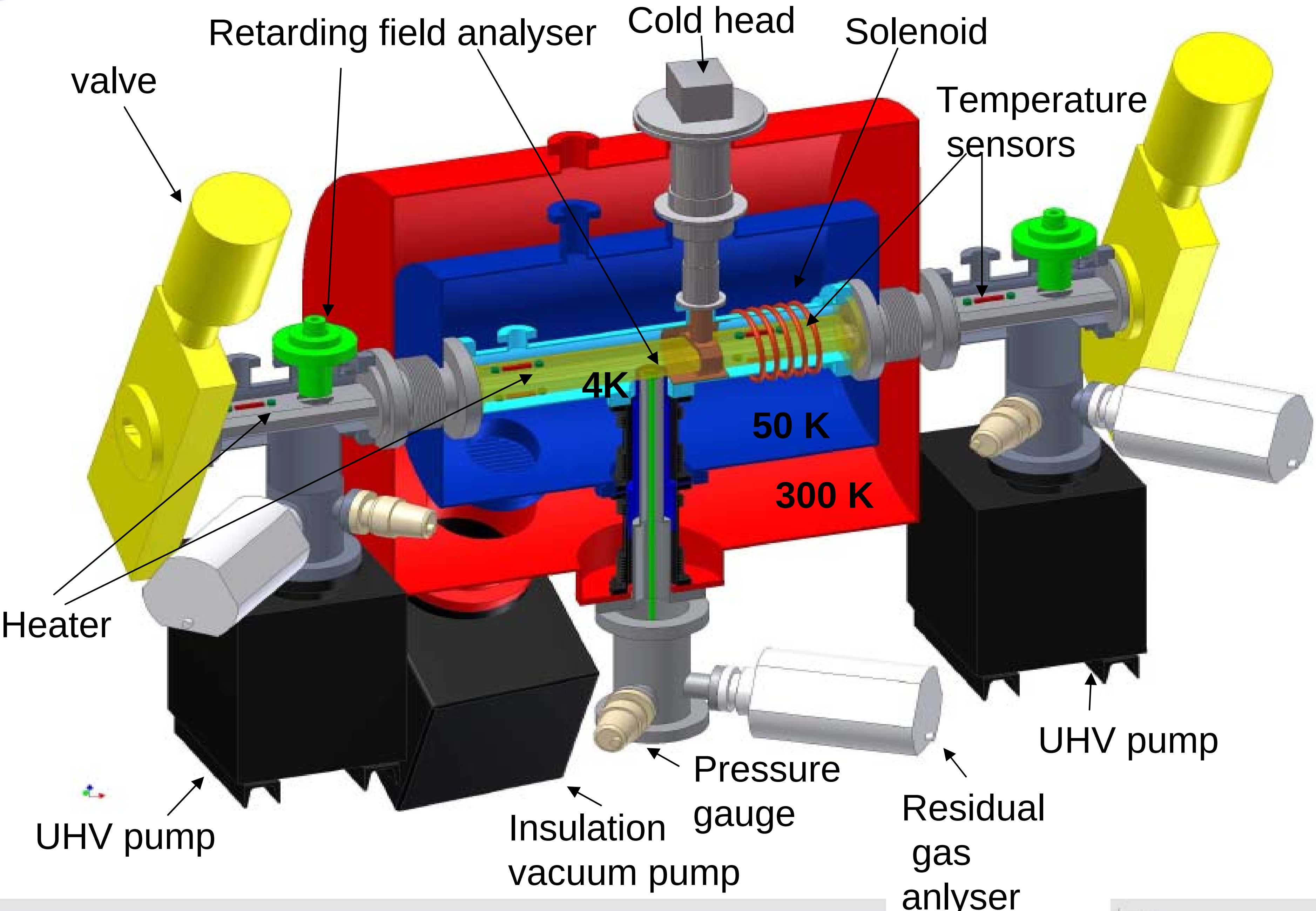
- The scientific results might be of interest also for the LHC , for the positron source of the ILC and for the CLIC damping rings.

Technical specifications of COLDDIAG

The cryostat should be:

- Cryogen-free system. Operating temperature 4 K, with the possibility to operate at higher temperatures up to 300K.
- Compare measurements at cryogenic temperatures and 300K.
- The inner vacuum chamber should be build to be removable in order to test different geometries and materials, and to be tested in different light sources (DIAMOND, ANKA).

COLDDIAG


Retarding field analyser
Cold head
Solenoid
valve
Temperature sensors
4K
50 K
300 K
Heater
UHV pump
Pressure gauge
Insulation vacuum pump
Residual gas anlyser
UHV pump

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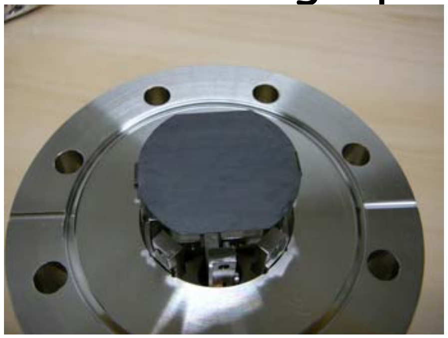
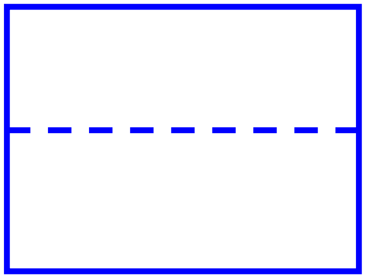
Retarding field analyser

Stainless steel 0.5 mm thick
coated with graphite





Collector +50V

Variable bias -200 ÷ +200 V

Ground stainless steel

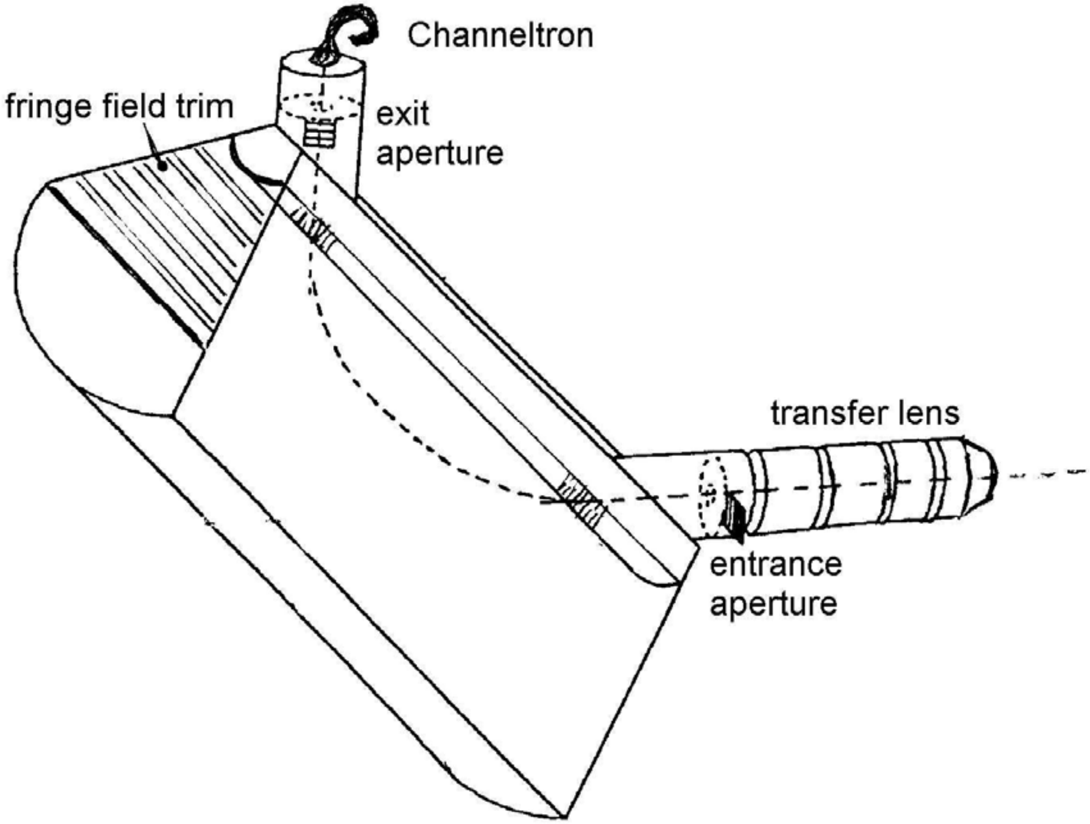
Tungsten grid
mesh width= 149 µm
wire diam. = 20 µm

Courtesy of R. Weigel

Electron energy analyser

CSA200 DN 100CF

12.5 kg, slit to slit distance=200mm,
lens to sample=50mm, flange to sample=254mm



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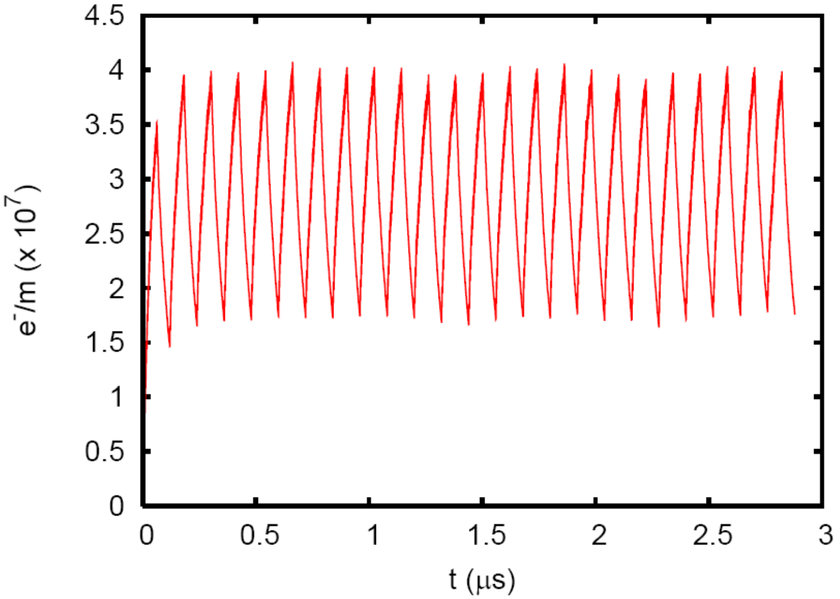
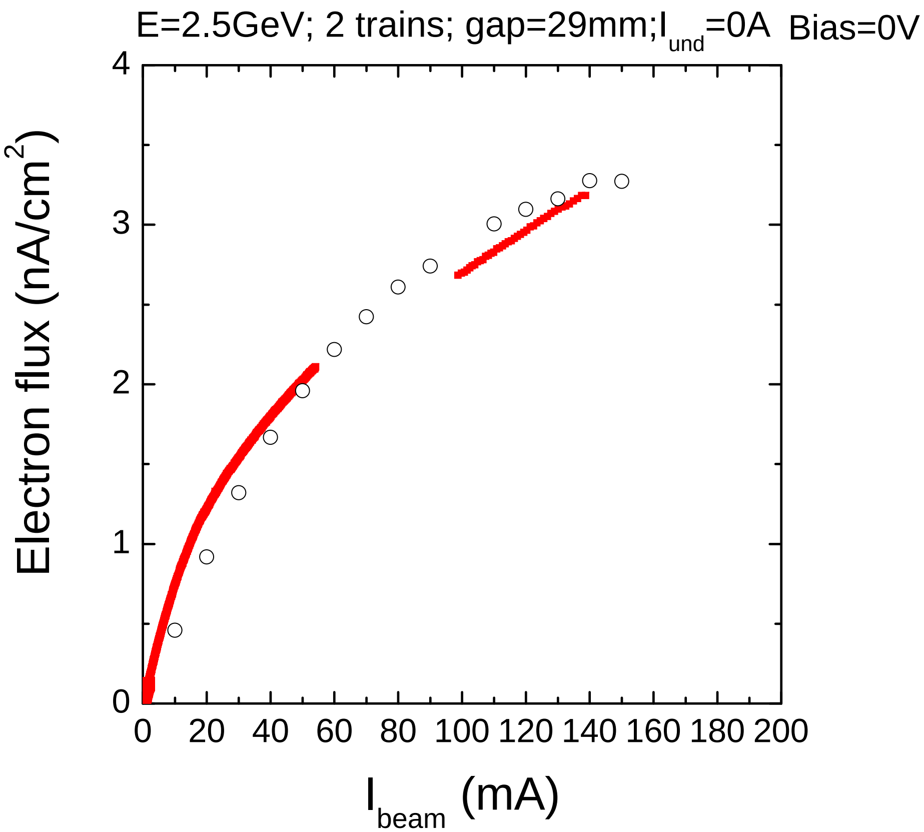
ECLOUD simulations

Parameter	value
# of bunches / turn	64
particle beam energy, E[GeV]	2.5
# parts per bunch, N_b [e-/bunch]	[0.35 - 5.4] e9
bunch spacing, sb [m]	0.6
bunch length, σ_z [mm]	12
hor / ver rms beam size, mm	.840 / .063
hor / ver chamber aperture, mm	80 / 29
secondary emission yield, δ_{max}	2.0
energy for max SEY, E_{max} [eV]	290.
primary ph-e emission yield	0.005
energy ph-e, position of peak [eV]	7.
energy ph-e, sigma distrb. [eV]	5.
energy sec. e-, sigma distrb. [eV]	1.8





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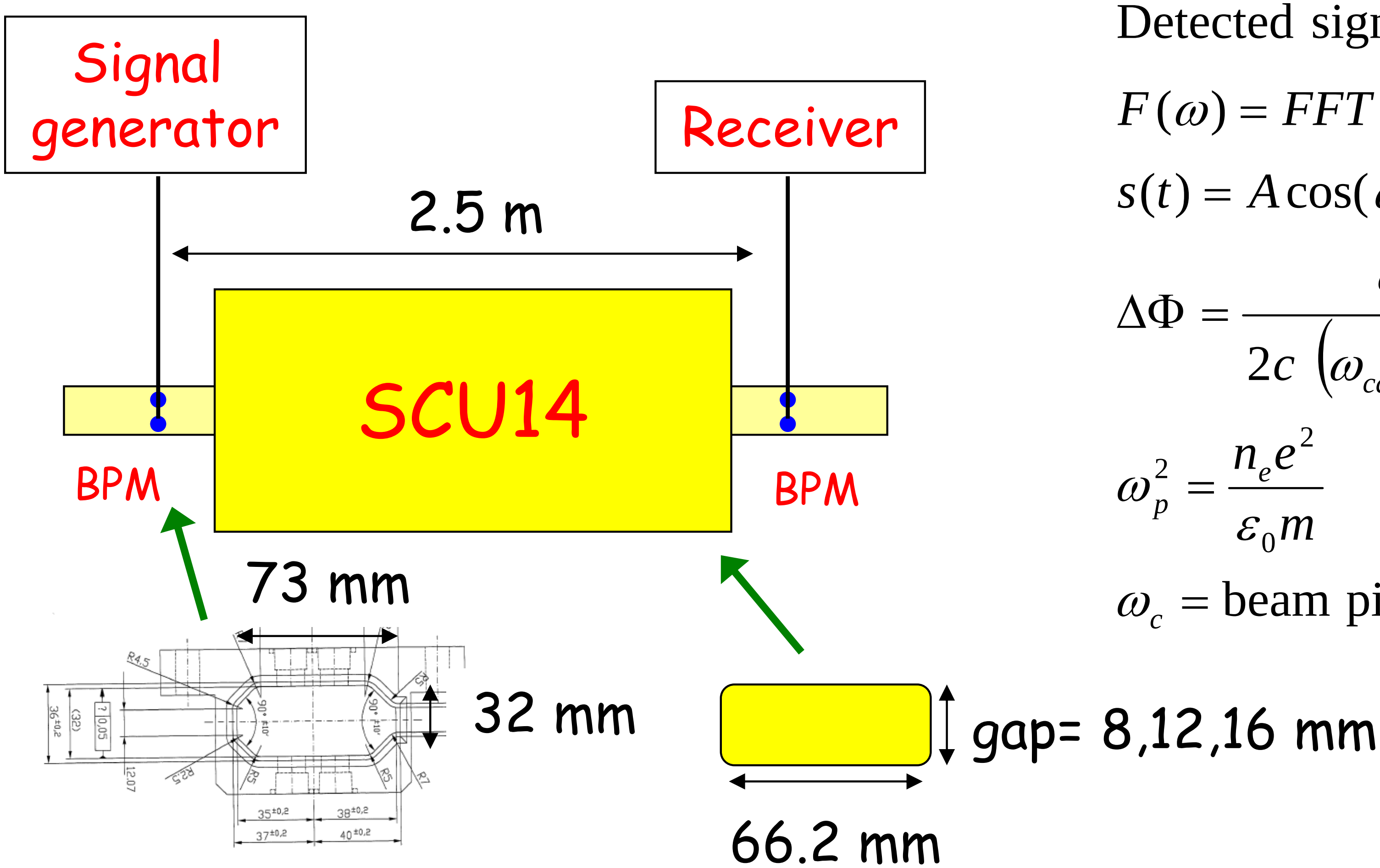
see tomorrow
talk by U. Iriso

Microwave experiment and comparison with theory

Measure the electron cloud density via the phase shift induced in a TE wave transmitted through the cold bore of the superconducting undulator installed at ANKA.



Detected signal $\left|F(\omega)\right|^2$

$$F(\omega) = FFT(s(t))$$

$$s(t) = A\cos(\omega_{car} t + \Delta\Phi(t))$$

$$\Delta\Phi = \frac{\omega_p^2 L}{2c\left(\omega_{car}{}^2 - \omega_c^2\right)^{1/2}}$$

$$\omega_p^2 = \frac{n_e e^2}{\varepsilon_0 m}$$

ω_c = beam pipe cutoff frequency

see tomorrow talk by K. Sonnad