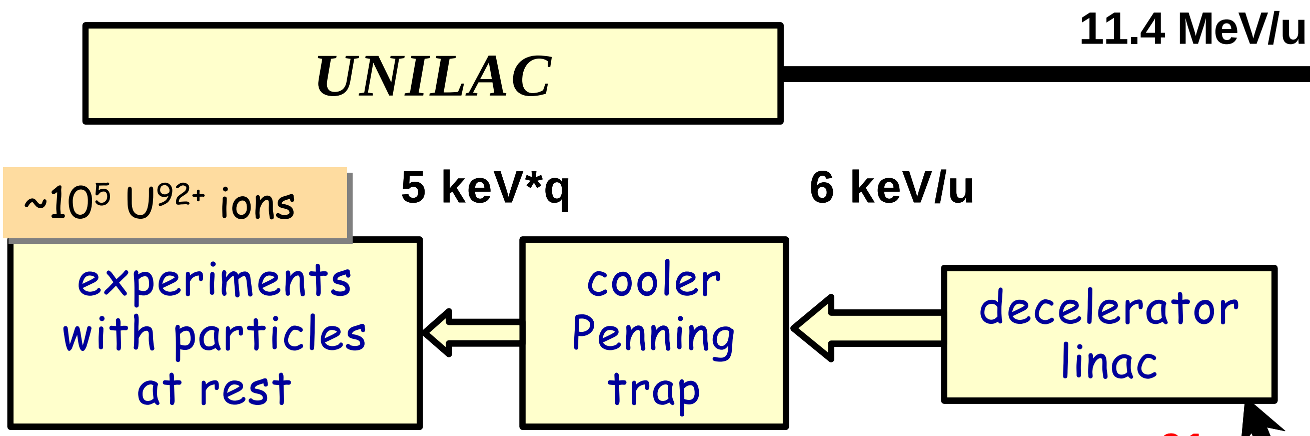
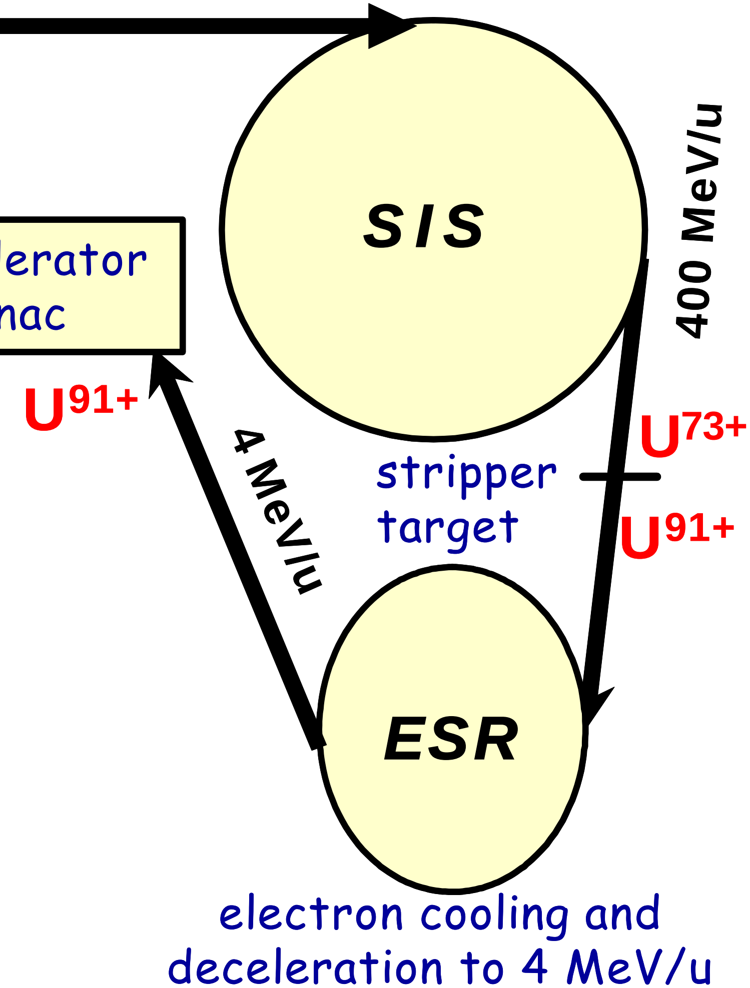
Diamonds for HITRAP and for Future Electron Spectroscopy

Present and future applications of diamond detectors:

- as bunch-length (width) monitors for HITRAP,
- as solid-state targets for low-energy electron spectroscopy,
- as particle counters at ESR and NESR (UHV).

HITRAP schematic overview





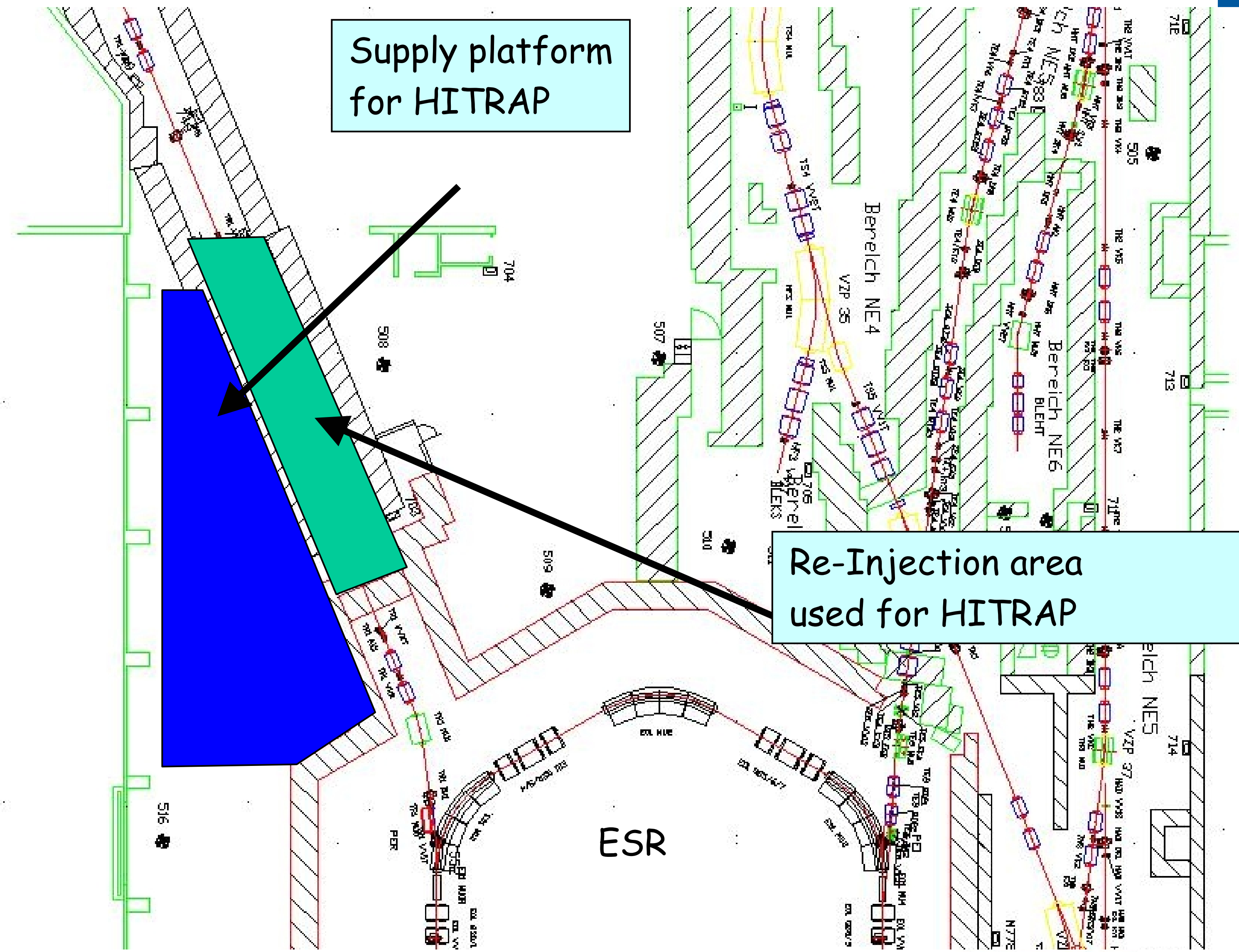
Experiments based on Penning traps

- Laser spectroscopy
- g-factor measurements of the bound electron
- Mass measurements of extreme accuracy
- Polarization of radio nuclides
- Decay spectroscopy of highly-charged radio nuclides

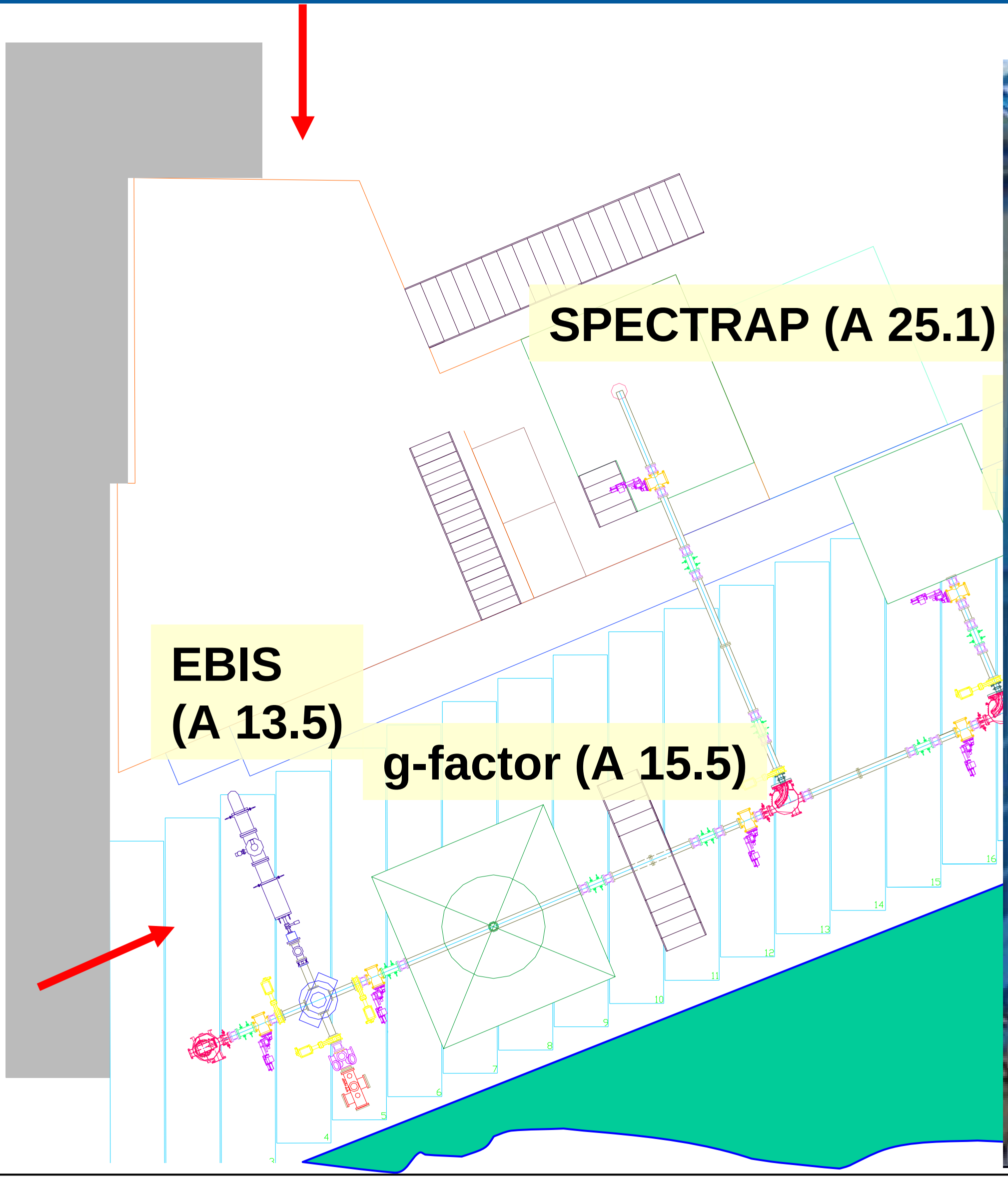
Collision experiments:

- Collisions at very low velocities
- Surface studies and hollow-atom spectroscopy
- X-ray spectroscopy

HITRAP


Supply platform for HITRAP
Re-Injection area used for HITRAP
ESR
Bereich NE4
Bereich NE6
BLEHT
704
508
507
509
510
516
505
713
714
VZP 35
VZP 37

HITRAP experimental area



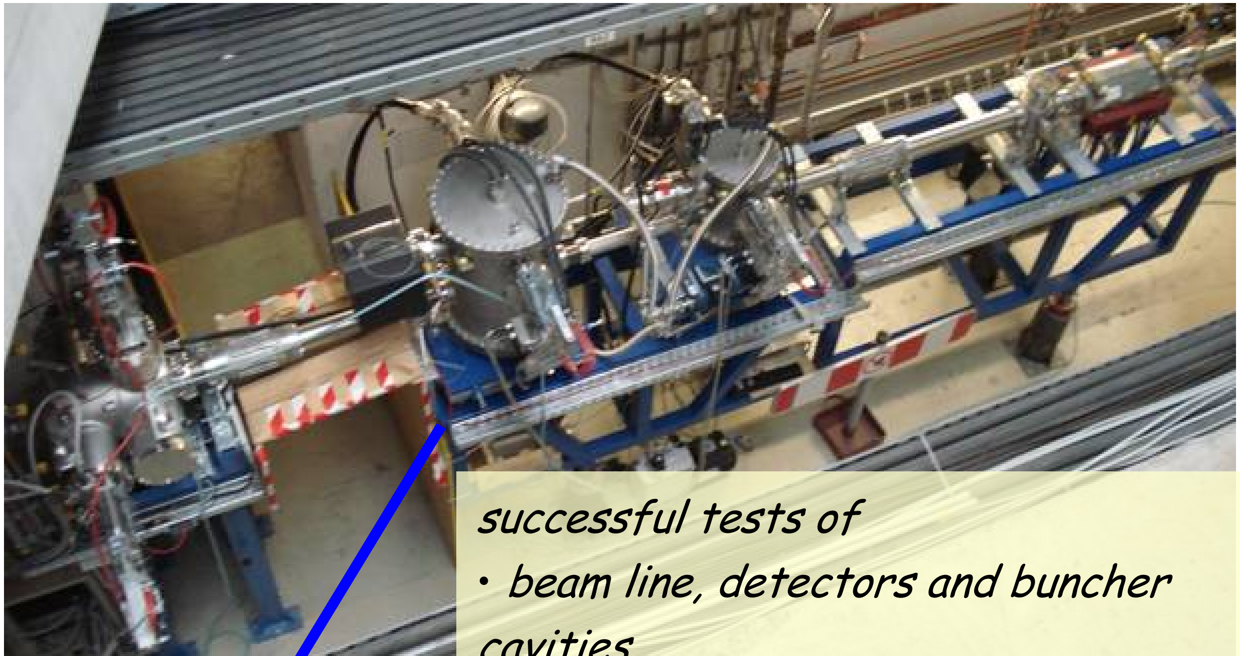
HITRAP – interested?

HITRAP TDR: Thomas Beier, Ludwig Dahl, H.-Jürgen Kluge, Christophor Kozhuharov, Wolfgang Quint (Editors): http://www.gsi.de/documents/DOC-2003-Dec-69-2.pdf

Meeting on HITRAP-Experiments: Friday, June 20, 2008

- 09:00 - 11:00 Precision spectroscopy experiments (microwave, laser, X-ray)
- 11:30 - 13:00 Final discussion on joint technical developments, time schedule, funding, etc.

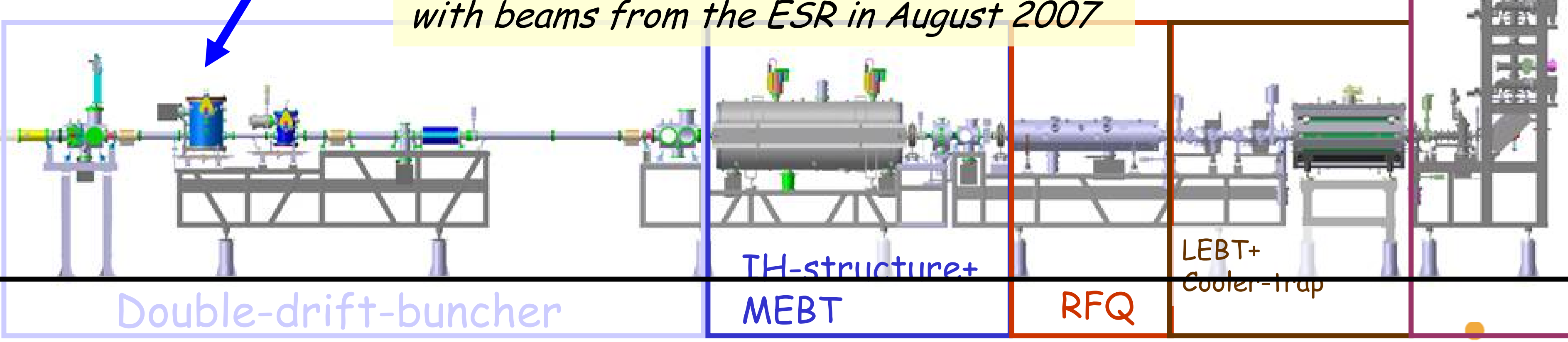
HITRAP Overview
ESR-SIS Re-Injection Tunnel



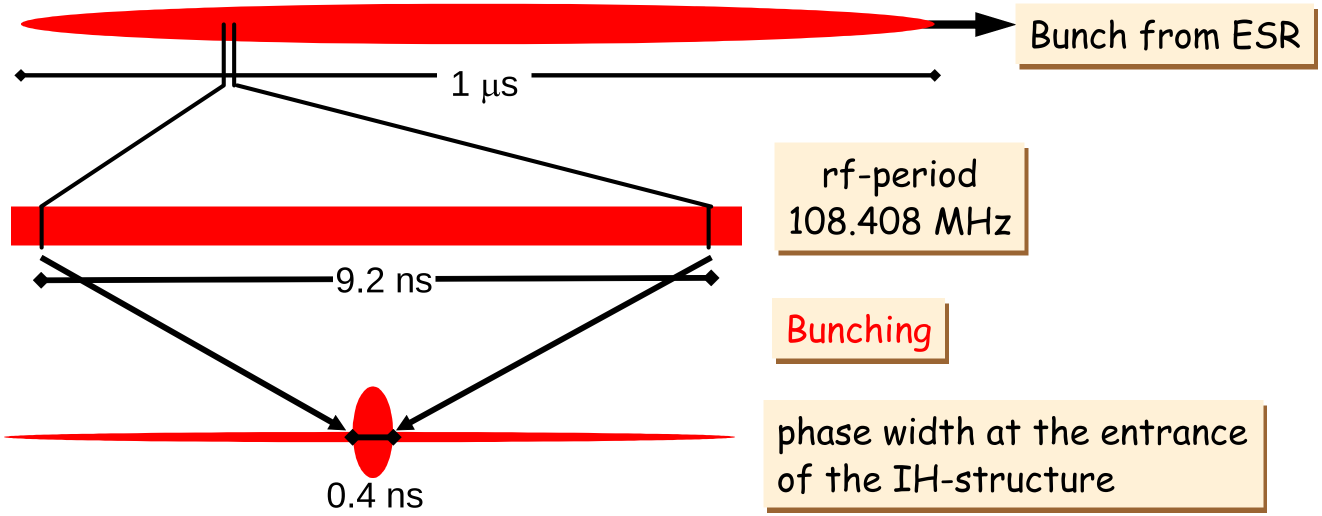
successful tests of

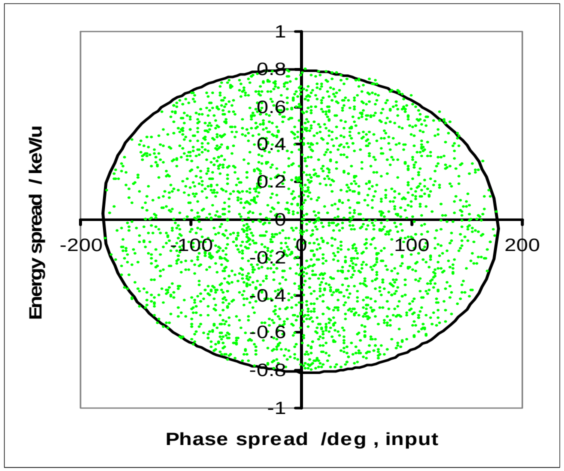
- *beam line, detectors and buncher cavities*

with beams from the ESR in August 2007

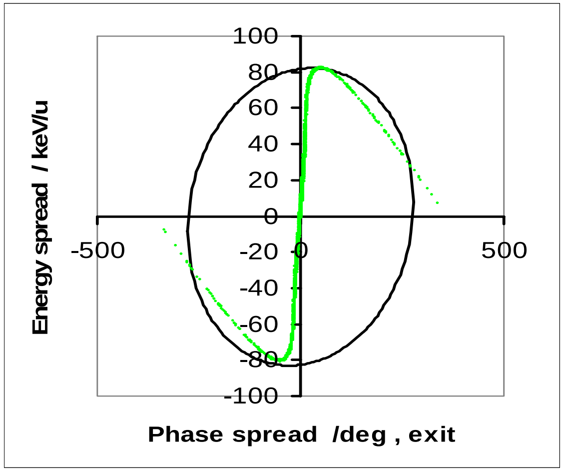


Beam dynamics design: Bunching of the ESR beam

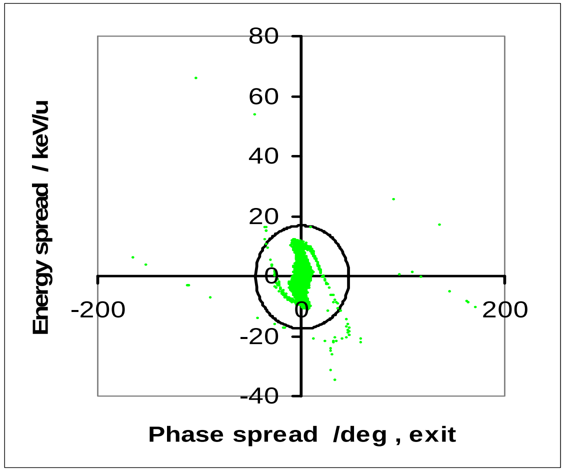




entrance DDB

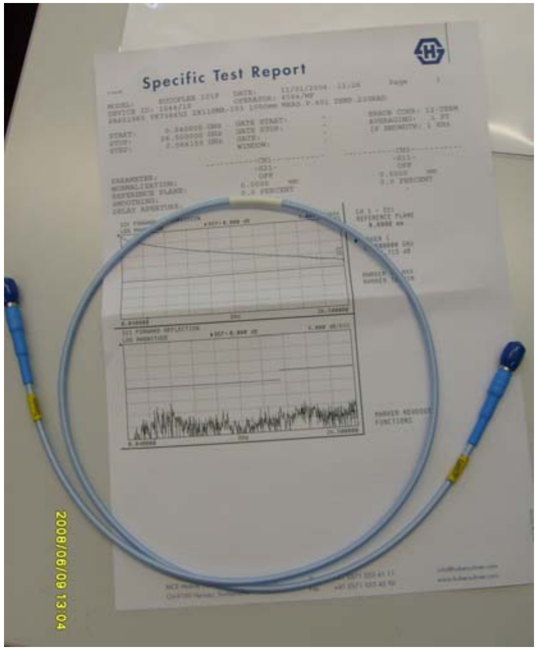


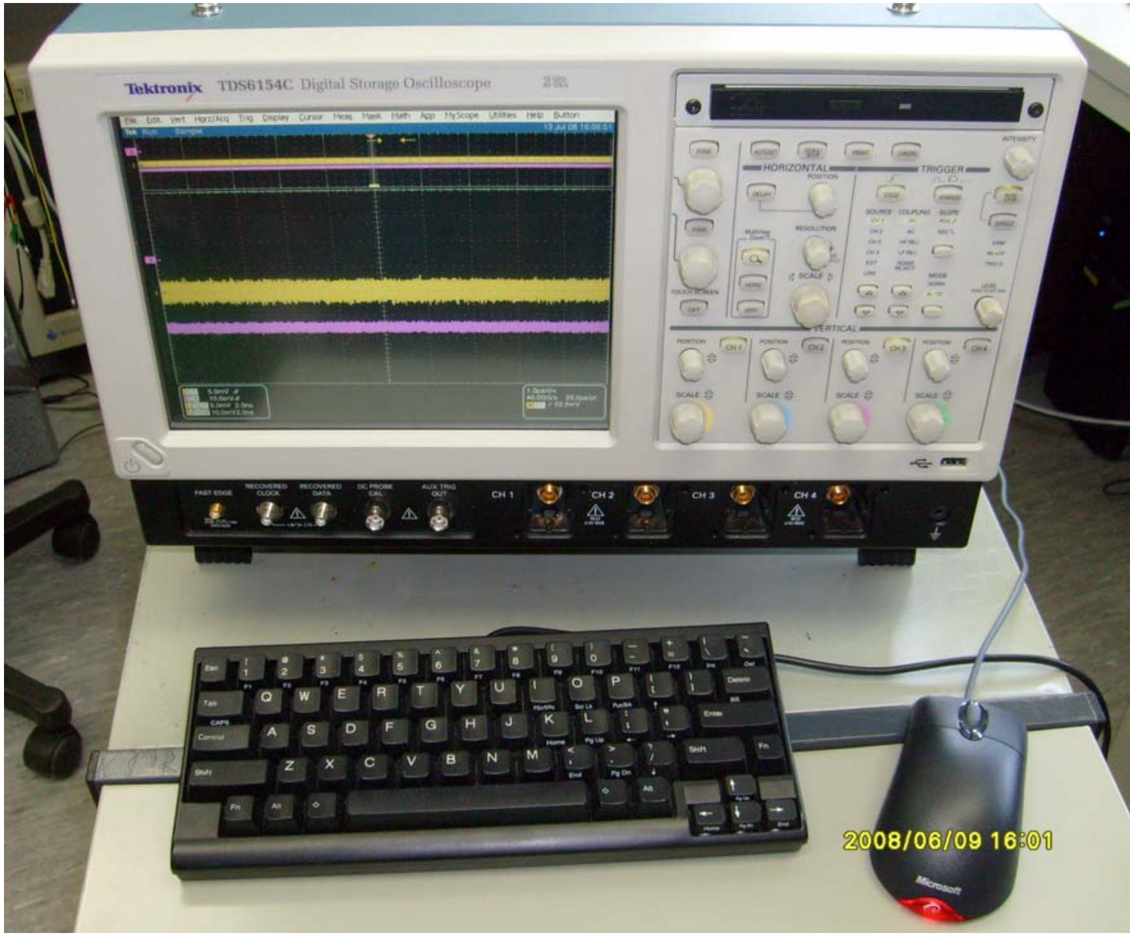
entrance IH-structure



entrance RFQ

Test of a single crystal diamond detector with α-particles



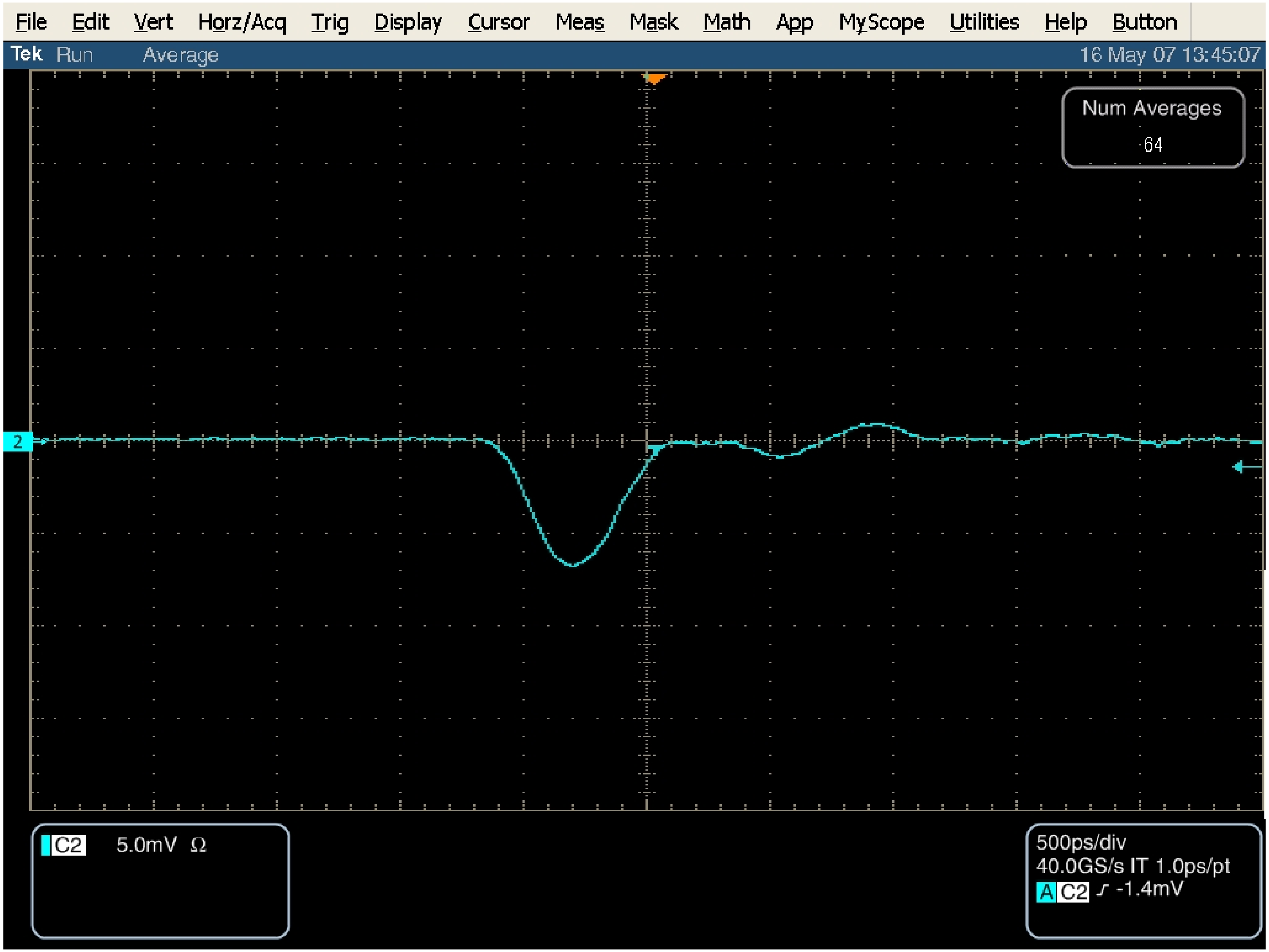


100 µm single crystal
active area 3 mm diameter,

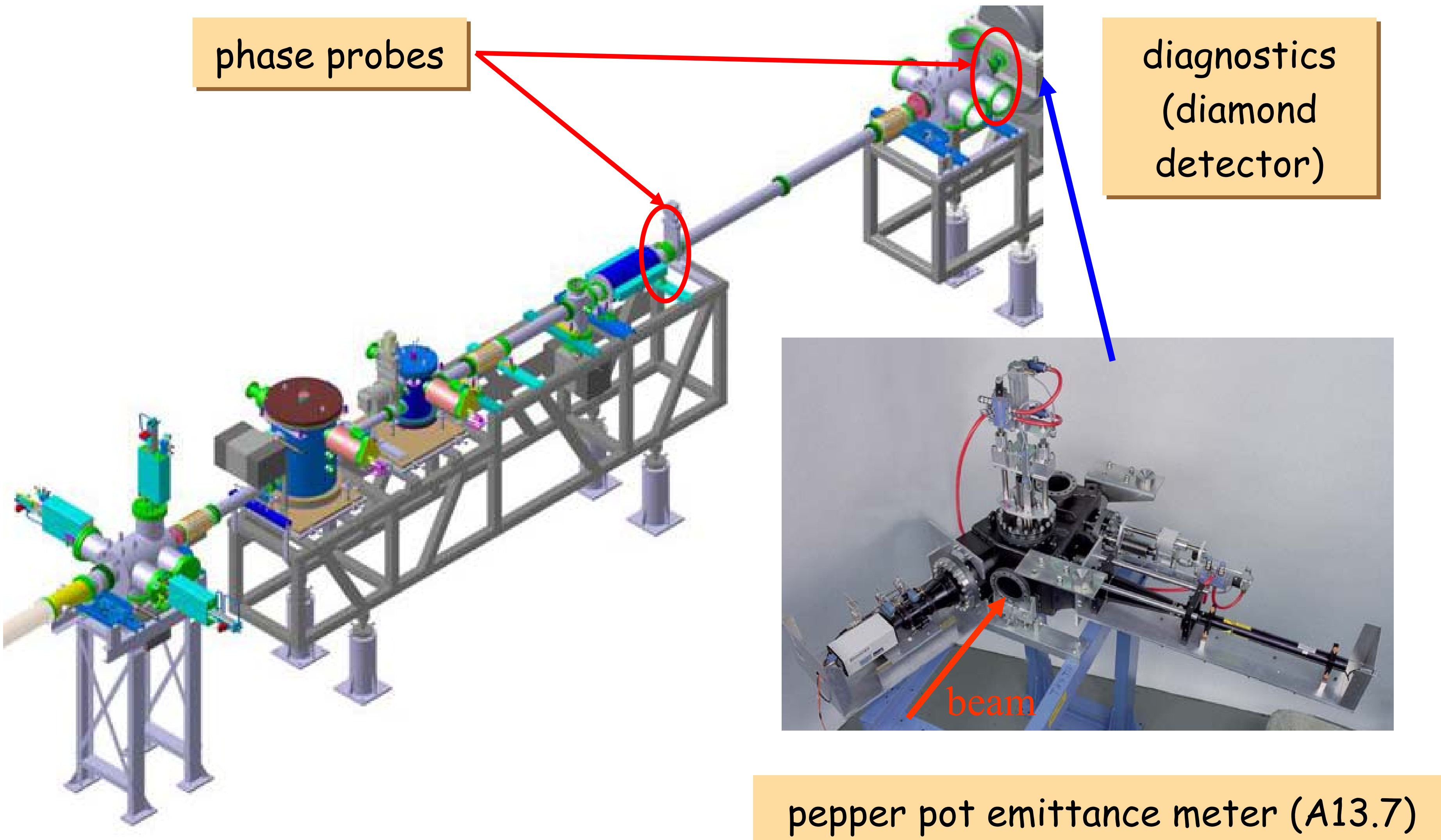
Tektronix TDS 6154C,
15 GHz band width,
40 GS/s, 64 MB memory

Suhner Sucoflex 101P

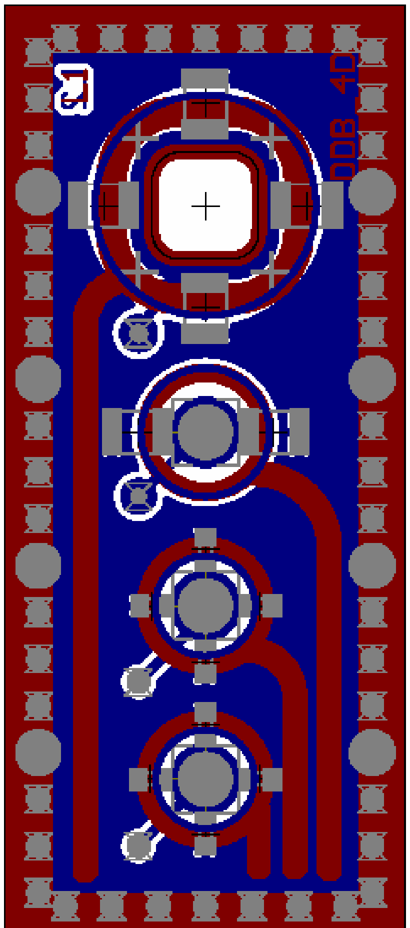
Direct α- signal from ^{241}Am

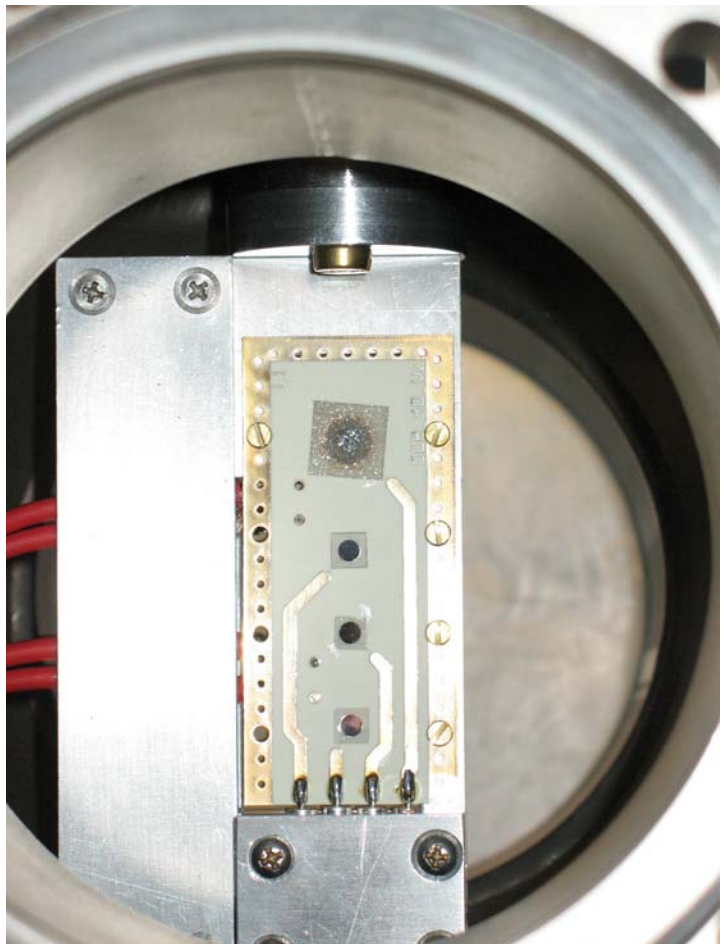


DDB commissioning setup



HITRAP Commissioning Detectors





^{20}Ne, E/A = 4MeV/u

Detectors:

- Poly-crystalline CVD 600 µm
- Single crystal CVD 480 µm
- Poly-crystalline CVD 15 µm thick
- Poly-crystalline CVD 10 µm thick

Diameter of the active areas for all detectors = 3 mm (smaller capacitance)

Fast amp for the pc-CVDs.

Commissioning August 2007

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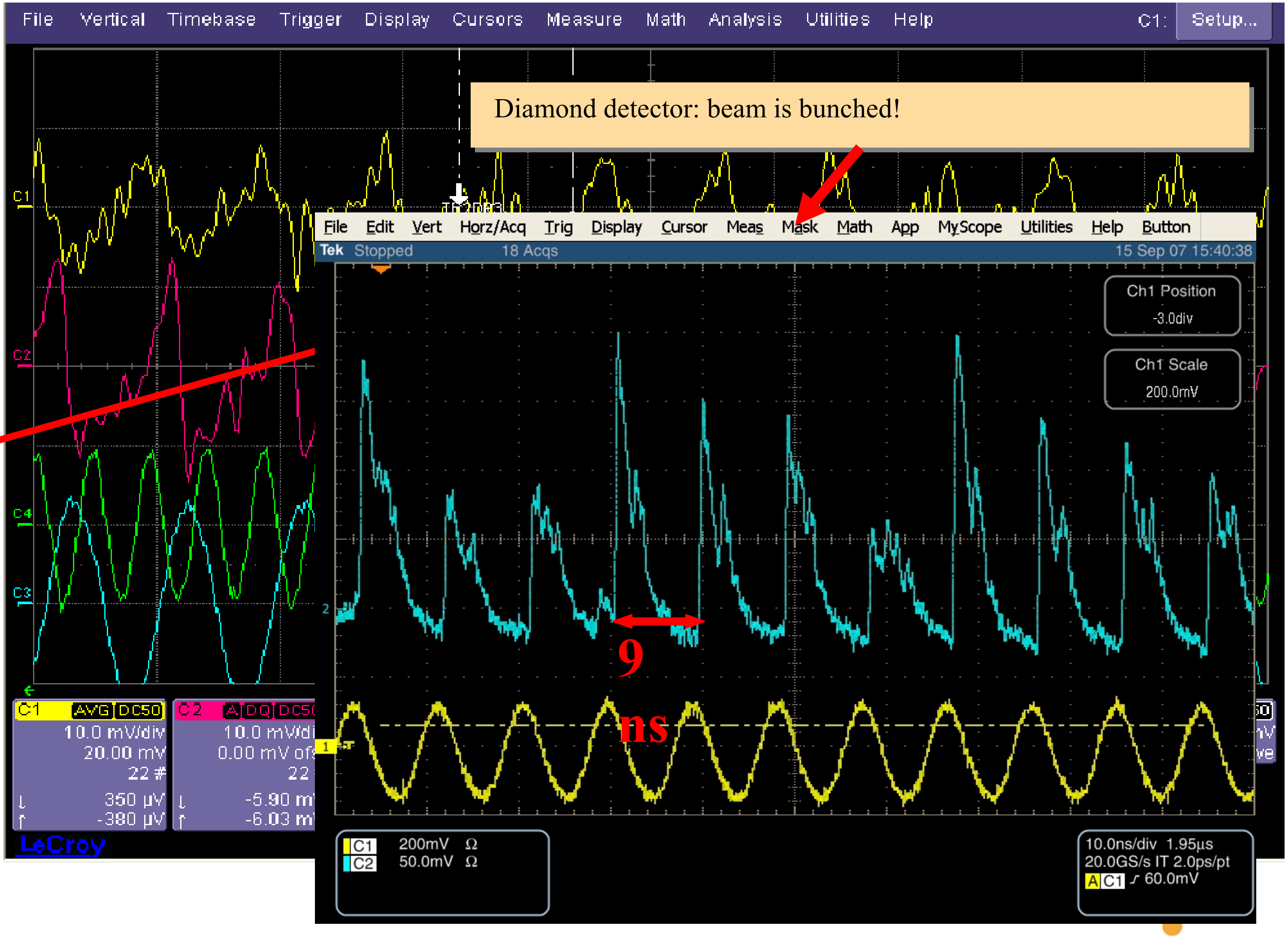
Bunched beam detected with phase probe in front of IH-structure



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HITRAP Commissioning

HITRAP Conclusions:

We have tested a novel diagnostics tool for the measurement of sub-ns bunch lengths in accelerator structures.

The method is feasible but still a challenge.

We have measured directly the signals of a single crystal CVD diamond as a spin-off.

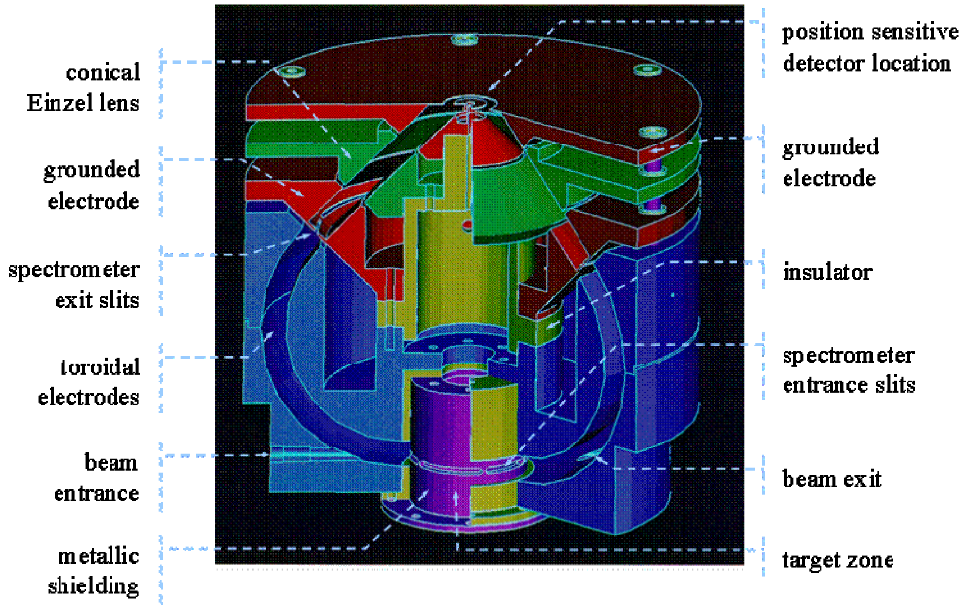
(this is not the last slide; part two follows)

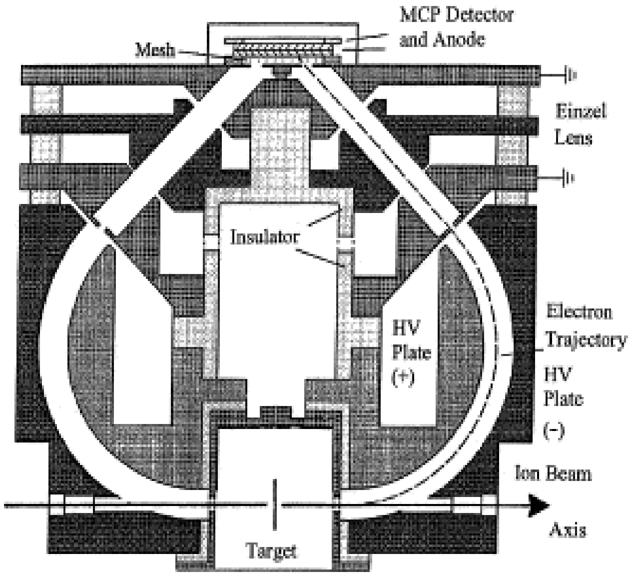
Diamonds as Future Targets

Energy Spectra and Angular Distribution of Low-Energy Electrons

- Detailed knowledge of low-energy electron emission in collisions of ions with solids and gases is of utmost importance for the modeling of dose distributions and track structures needed for the prediction of ion radiation effects in radiotherapy and related fields.
- The used data originate predominantly from measurements with gaseous targets, scaled up to the density of liquids and solids.
- Methods are needed to identify, study and analyze problems that mask the complex and interdependent processes of electron emission and transport

Toroid Electron Spectrometer





The spectrometer is rotationally symmetric.
Electrons emitted in the plane perpendicular to the symmetry axis are energy and angle analyzed.

Measurements with an electron beam

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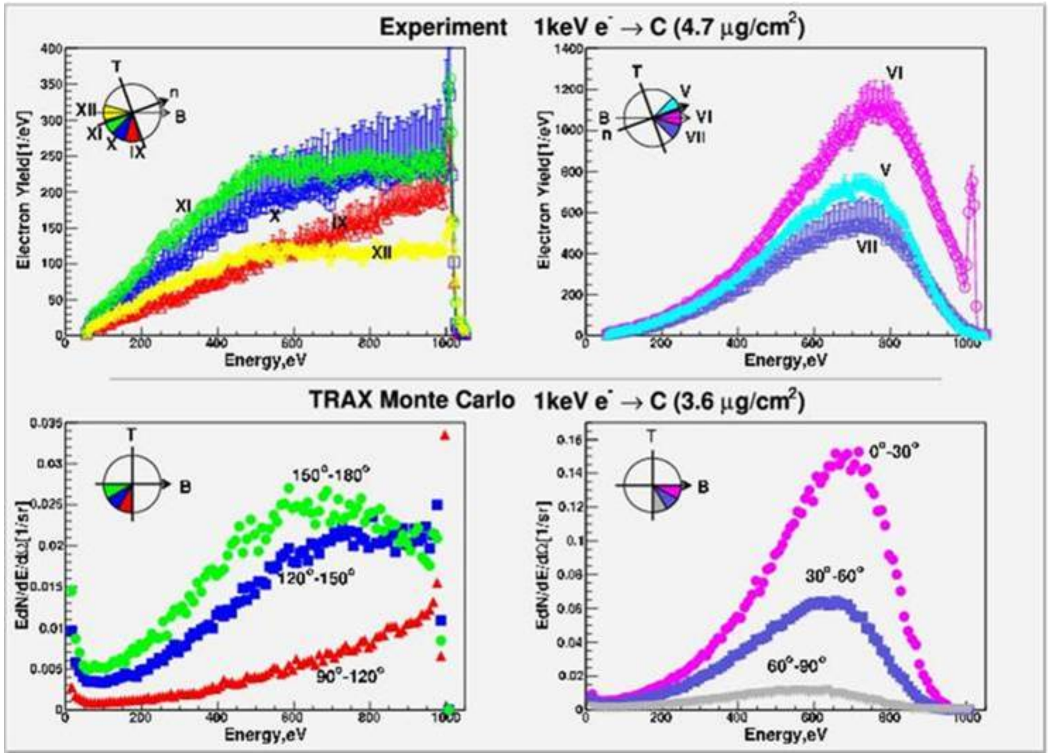

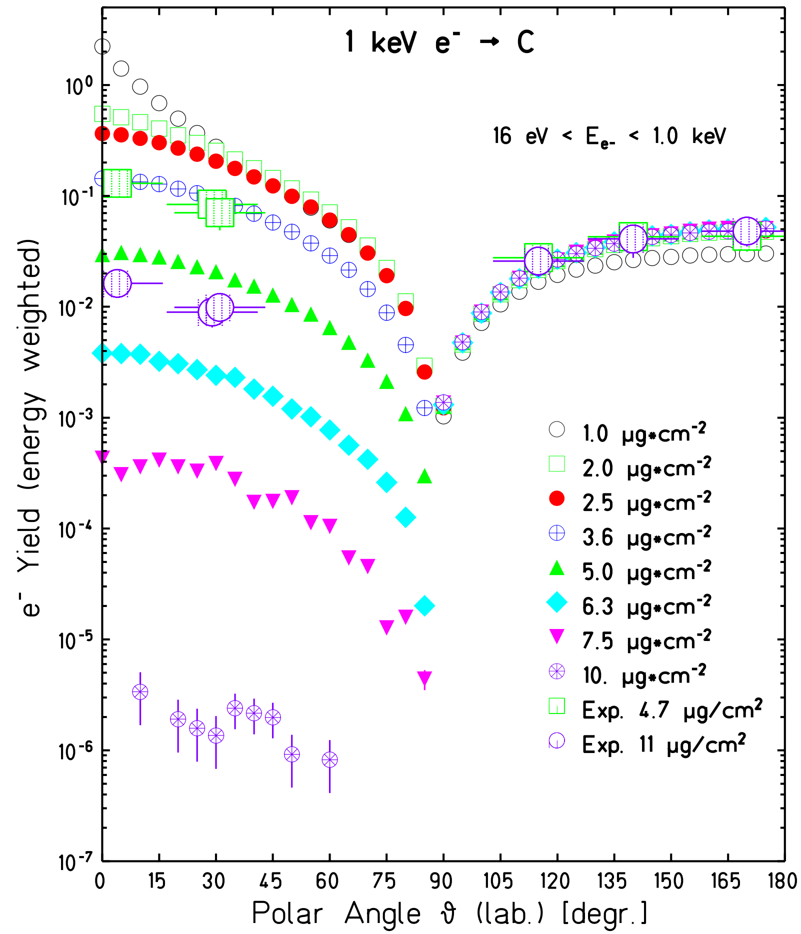

Measured and simulated spectra of electrons from a carbon target bombarded with 1 keV electrons

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Measurements with Carbon Beam

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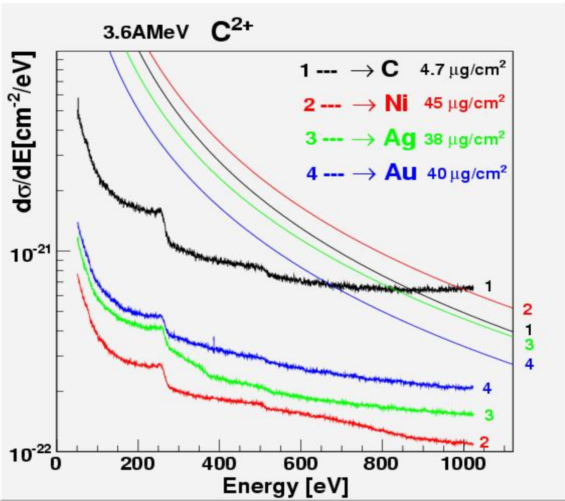

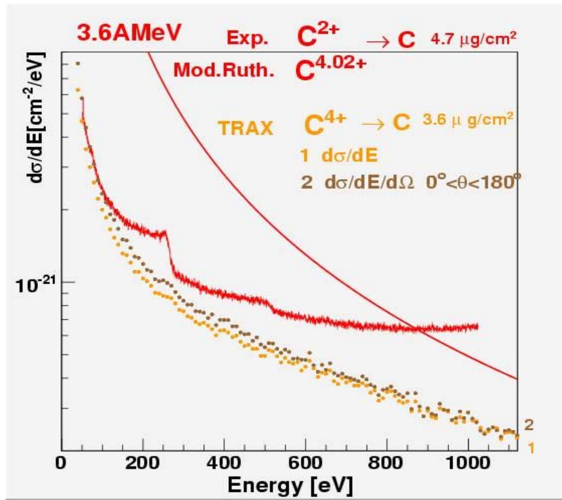

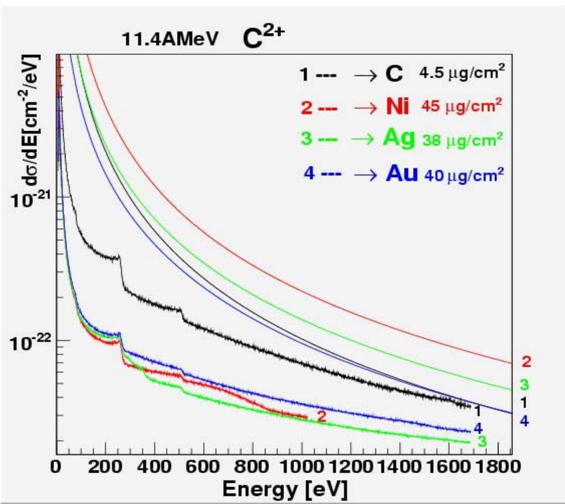

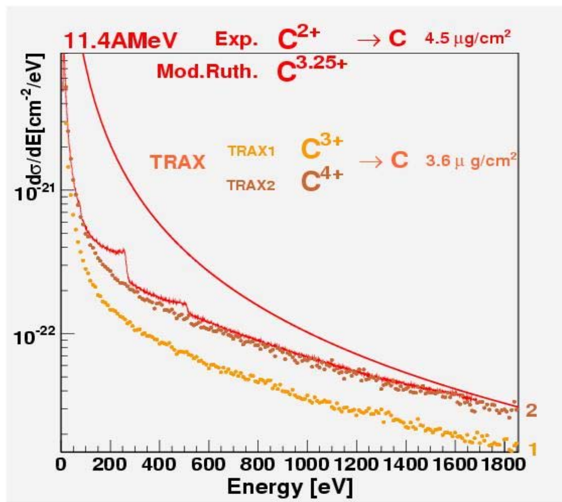

Electrons emitted in collisions of C^{2+} projectiles with C, Ni, Ag, and Au targets.

Bombarding energy E/A = 3.6 and 11.4 MeV/u

Solid lines - measured and/or calculated spectra for all projectile-target combinations

Dotted line - simulated spectra for the carbon target.

Conclusions and Outlook

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We have initiated a series of measurements of electrons emissions of heavy ions at UNILAC bombarding energies (up to $v/c \approx 0.16$) with solid-state targets.

Prior to analyzing our heavy ion measurements, we developed a method to investigate the structure of solid state targets by combining TRAX simulations with measured data for 1 keV electron beam.

The target thickness and its fluctuations are a challenge, especially when dealing with problems that do not scale linearly with it (as for instance the transport phenomena and the charge state evolution).

Based on the present results of our investigations we would like to implement Vitaly Liechtenstein's extremely thin diamond-like targets.

Additionally, we propose to use a single crystal CVD-diamond detector both as a target as well as a projectile detector. This will allow us to measure electron-particle coincidences together with the deposited dose in the target.
(The electrons are measured with the spectrometer, the projectiles—with the single crystal diamond)

Experimental Storage Ring (ESR)

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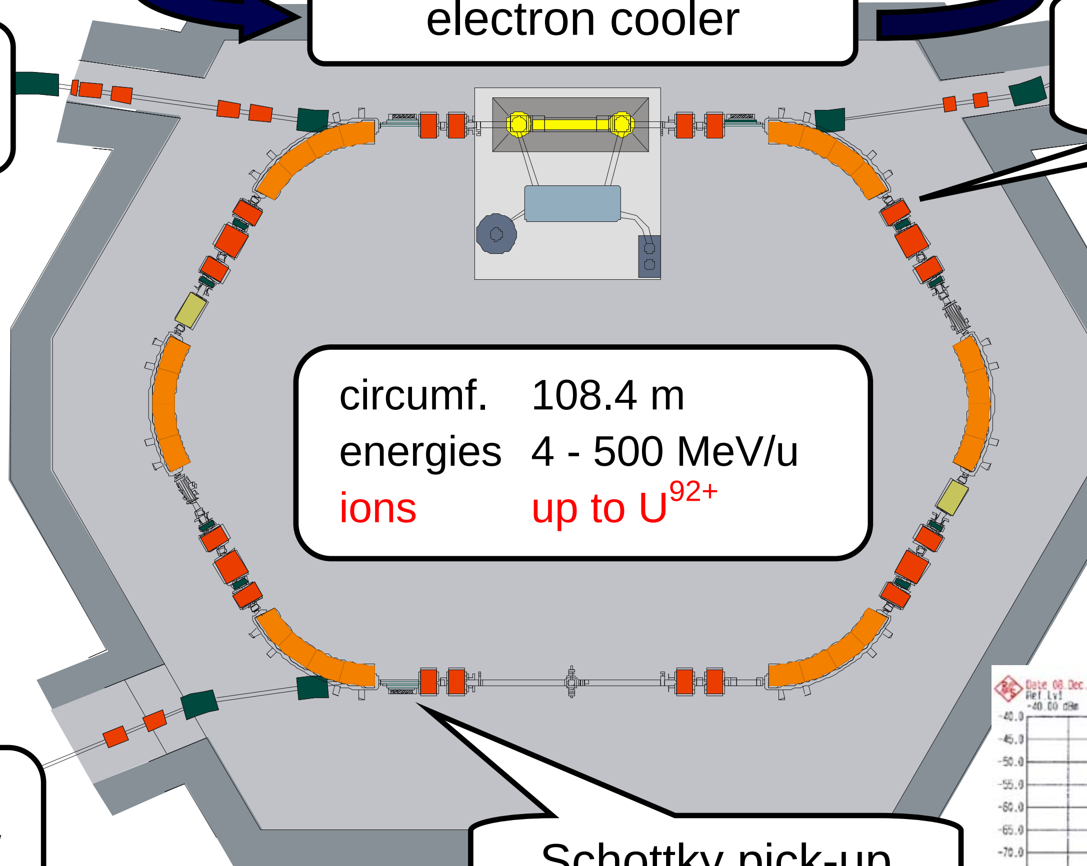
electron target

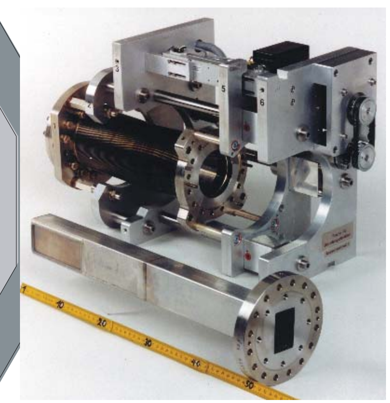
electron cooler

injection from SIS/FRS

recombination detector

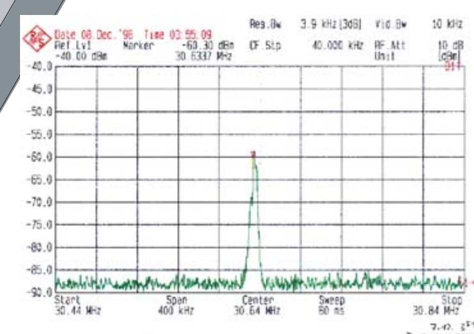


circumf.	108.4 m
energies	4 - 500 MeV/u
ions	up to U^{92+}

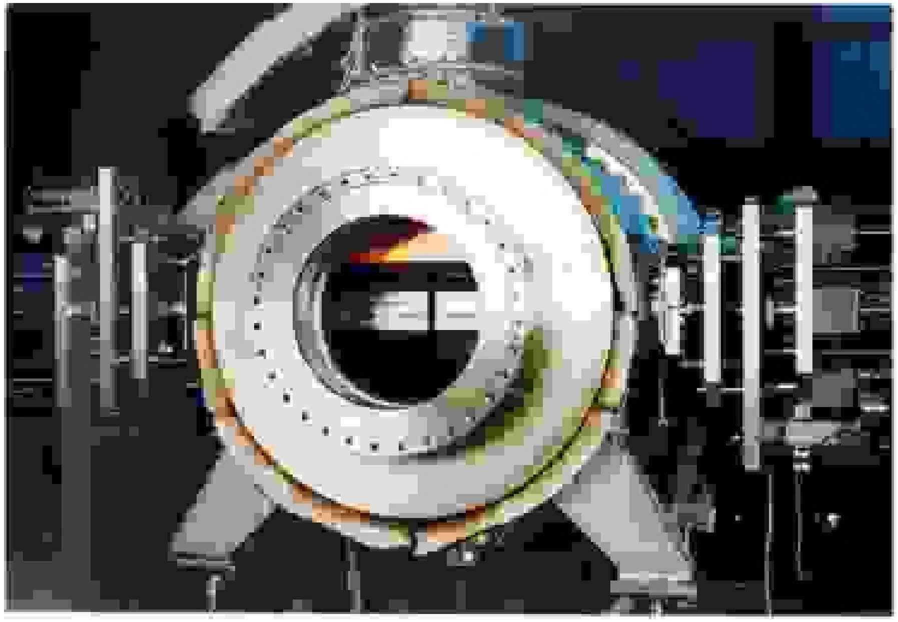


extraction to HITRAP (2007) / reinjection to SIS

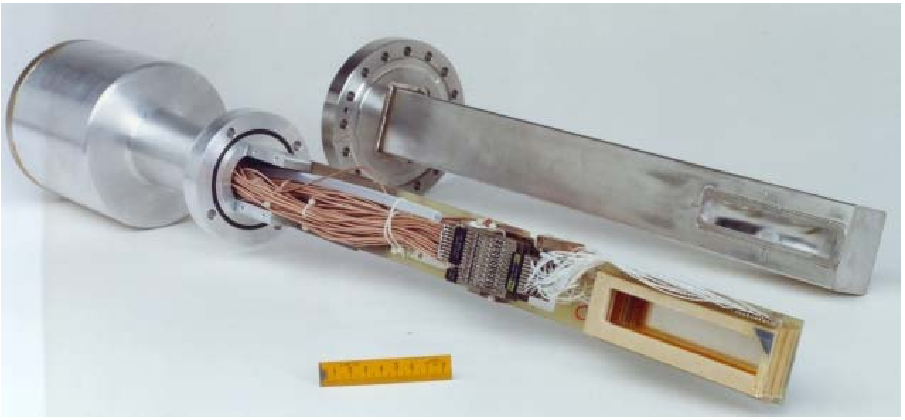
Schottky pick-up



Particle Detectors



ESR scraper chamber with both detector pockets (ionization and capture) visible.



Presently, positions sensitive gas filled proportional counters in vacuum pockets are used. The vacuum window is 25 µm stainless steel. The detectors are moved and positioned by pneumatic actuators.

Positions sensitive diamond detectors in the UHV are needed.