Position Pickups for the Cryogenic Storage Ring

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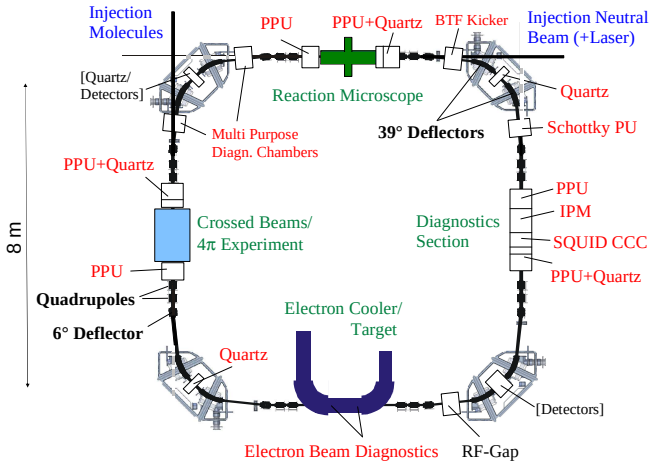
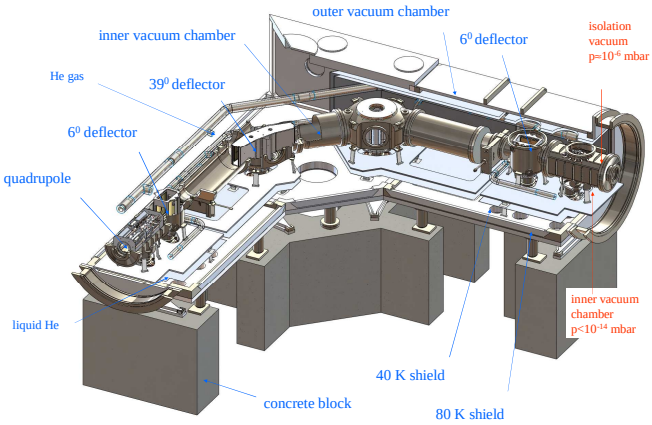
The Cryogenic Storage Ring, currently under construction at the Max-Planck-Institut für Kernphysik in Heidelberg, will be used to cool molecular ions to their rotational ground state. This, amongst other planned experiments, demands a very low level of blackbody radiation and a vacuum in the XHV range (10^{-15} mbar, 10^{-13} mbar room temperature equivalent) which is achieved by cryogenic cooling of the ion beam vacuum enclosure to 2-10K. The projected beam current will be in the range of 1nA - 1µA. The resulting low signal strengths together with the cold environment, put strong demands on the pickup amplifier electronics. We plan to make use of a resonant amplifying system. Using cooled coils made from high purity copper, we expect quality factors of ~1000.

The ring and its diagnostics elements

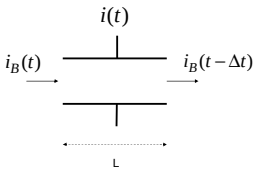


One corner of the ring with the electrostatic optical elements

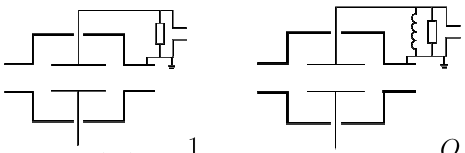


Position Pickup principle

Beam to signal current



Conventional and resonant amplification



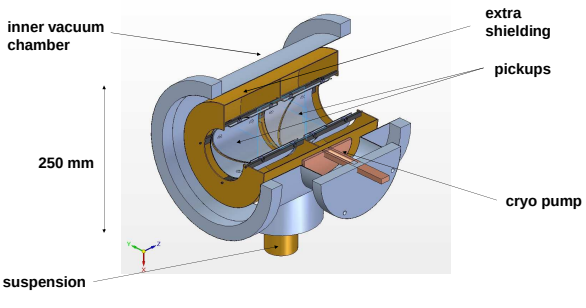
impedances: $|Z| \approx \frac{1}{\omega C}$ $\quad |Z| \approx \frac{Q}{\omega C}$

knot rule:

$$i(t) = i_B(t) - i_B(t-\Delta t) \approx \frac{d\, i_B(t)}{dt} \frac{\mathrm{L}}{\mathrm{v}}$$

Increase of signal by the size of the quality factor Q of the resonant circuit!

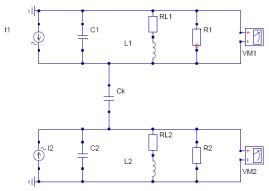
Preliminary mechanical design



Proof of amplification principle at the Test Storage Ring (TSR)

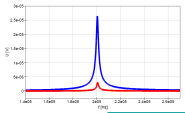
Crosstalk due to coupling capacity

Equivalent circuit of a pickup with both electrodes resonantly amplified

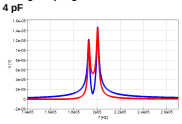


Strong crosstalk due to ever present capacity between electrodes makes simultaneous resonant measurement at both electrodes of one pickup impossible.

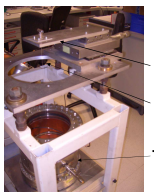
weak coupling: 0.04 pF



strong coupling: 4 pF



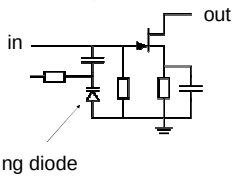
Calibration of the TSR pickups with a wire



Conclusions

- Achieved increase of sensitivity of a factor of ~90 (~Q)
- Resonant determination of beam displacement possible
- Strong HF-buncher signal present in the pickup signal reminds us to take extra care in shielding

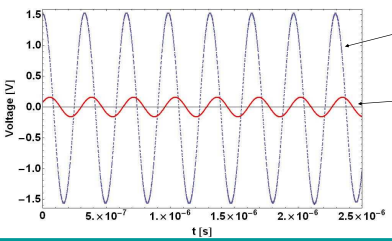
First amplifier stage with tuning capacity



Inductance with its shielding case

Q~100

Resonant and non-resonant signal strengths



- resonant amplification
  - beam current 2.5 µA
  - amplifier gain 450
- non-resonant amplification
  - beam current 15 µA
  - amplifier gain 735

References:

• **The cryogenic storage ring project at Heidelberg.** R. von Hahn, K. Blaum, J. Crespo López-Urrutia, M. Froese, M. Grieser, M. Lange, F. Laux, S. Menk, J. Varju, D.A. Orlov, R. Repnow, C.D. Schröter, D. Schwalm, T. Sieber, J. Ullrich, A. Wolf, M. Rappaport, D. Zajfman, X. Urbain, H. Quack. **Proc. 11th European Particle Accelerator Conference (EPAC'08), Genova, Italy, 23-27 June**

• **Beam Diagnostics Development for the Cryogenic Storage Ring CSR.** T. Sieber, H. Fadil, M. Grieser, A.Wolf, R. von Hahn. **Proceedings of DIPAC 2007, Venice, Italy**

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