Design of a Stochastic Cooling System for EDM Experiments at COSY
CERN EDM Kick-Off Meeting

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Motivation

• Requirements for EDM experiments at COSY
  • Small momentum spread for high spin coherence time
  • Small vertical emittance to reduce intrinsic depolarization
  • Small horizontal emittance (betatron coupling)
• Pre-Cooling is done with 100kV e-Cooler
• Emittance blow-up by intra-beam scattering and residual gas scattering
  • Cooling during experiments would be desirable
• Solenoids of e-cooler may not perfectly be compensated, and therefore can influence the spin on a long term behavior
• Existing stochastic cooling system not sensitive at low particle velocities

Development of a dedicated stochastic cooling system for EDM experiments
Cooling of Polarized Beams: Proof of principle

- Is stochastic cooling a source of depolarization?
- Influence of stochastic cooling on beam polarization was investigated at COSY in 2013
  - 1965 MeV/c protons, \( N=3 \cdot 10^8 \)
  - Vertical cooling, to apply horizontal magnetic fields
  - *Within 30 minutes no polarization loss has been observed*
- It was shown that Stochastic Cooling of polarized beams is possible at COSY

\[ P = 0.753 \pm 0.006 \]  
\[ P = 0.750 \pm 0.005 \]
Pick-up and Kicker for HESR

- Ring-slot structures newly developed for HESR
- Currently installed at COSY
- 2-4 GHz cooling band
- Advantages
  - High coupling impedance (9 ohms per ring)
  - Simultaneous 3D operation
  - Static aperture
Pick-up and Kicker for HESR

Design by L. Torndahl (CERN), R. Stassen (FZJ)

Single slot-ring with 8 electrodes
(90mm aperture)

Combiner board (16x1) for one structure

1. Assembly of 16 rings
2. Full structure with 16 rings
3. Stack of 2 structures
System considerations

**Related parameters:**

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Circumference</td>
<td>184 m</td>
</tr>
<tr>
<td>Ions</td>
<td>d+</td>
</tr>
<tr>
<td>Intensity</td>
<td>$10^9$</td>
</tr>
<tr>
<td>Kin. energy</td>
<td>118 MeV/u</td>
</tr>
<tr>
<td>$\beta$</td>
<td>0.46</td>
</tr>
<tr>
<td>$\delta_{\text{rms}}$</td>
<td>$2 \cdot 10^{-4}$</td>
</tr>
<tr>
<td>$\eta$</td>
<td>0.6</td>
</tr>
</tbody>
</table>

New design required for pick-ups and kickers!

- Bad mixing above 700 MHz
- PU/KI performance is insufficient above 1GHz

→ **Frequency Band: 350 – 700 MHz**
Pick-up and Kicker design for EDM experiments

- Based on HESR ring-slot design
- 90 mm aperture
- Frequency tuning: slot width increased from 13mm to 150mm
- Mechanical stiffness: thicker walls, supporting features
- No ferrites needed \((f_{c,TE11} = 1.95\text{GHz})\)
- Only 4 electrodes per ring instead of 8
- First test rings are currently under construction
Kicker Performance

- Longitudinal and transverse kicker shunt impedance have been simulated with CST Microwave Studio.
- The sensitivity of the EDM kicker is comparable to the HESR kicker.

![Electric field at 600 MHz](image)

![Graph showing longitudinal and transverse impedance](image)
**System Performance (Simulation results)**

- **System simulation**
  - Cooling of all three planes simultaneously
  - Intra-beam scattering is considered

- **Anticipated Equilibrium states:**
  - $6 \cdot 10^{-5}$ rms momentum spread
  - 0.35 mm mrad horizontal rms emittance
  - 0.2 mm mrad vertical rms emittance

- **After switching off cooling:** beam blow-up due to intra-beam scattering

- **Microwave power less than 100 mW**
  - Off-the-shelf power amplifiers perfectly good

Dotted curves: cooling is not switched off
Summary

• A stochastic cooling system for polarized low energy beams at COSY is under development
• Experiments showed that beam depolarization by the system is not to be expected
• a satisfying performance is anticipated
• System of manageable cost
  • Standard power amplifiers sufficient
  • Structures of comparatively low complexity