

Design of a Stochastic Cooling System for EDM

Experiments at COSY

CERN EDM Kick-Off Meeting

March 14th 2017 | Bernd Breitkreutz

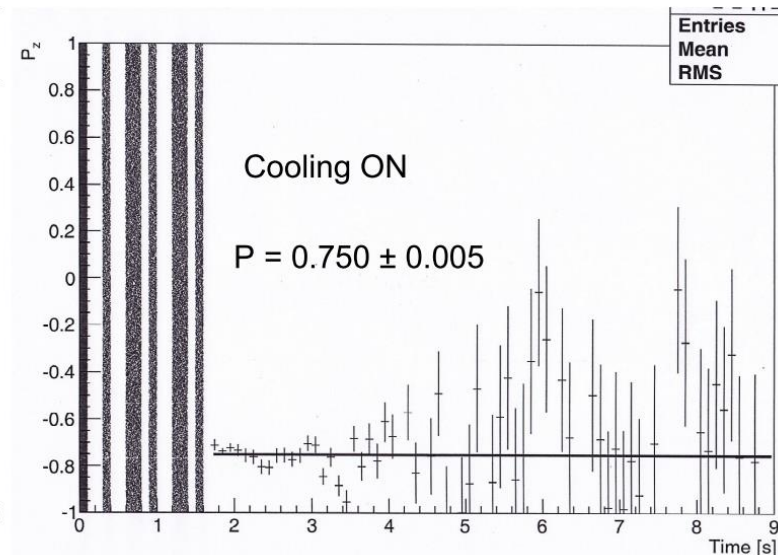
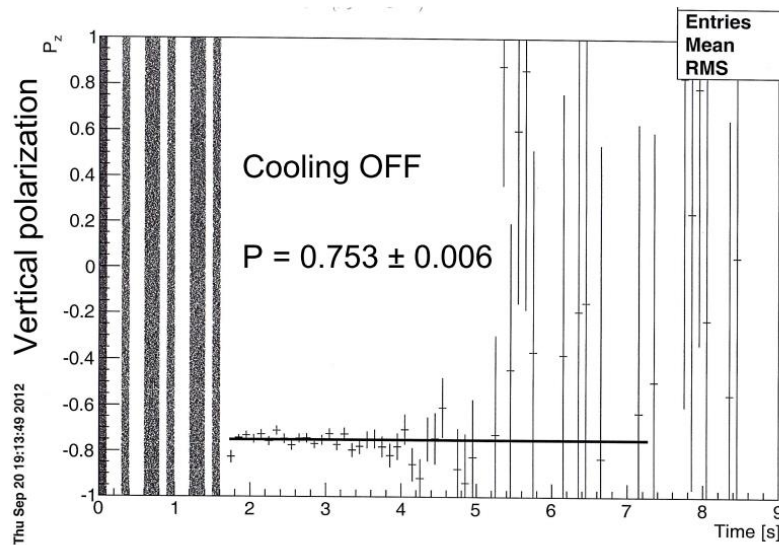
Motivation

- 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

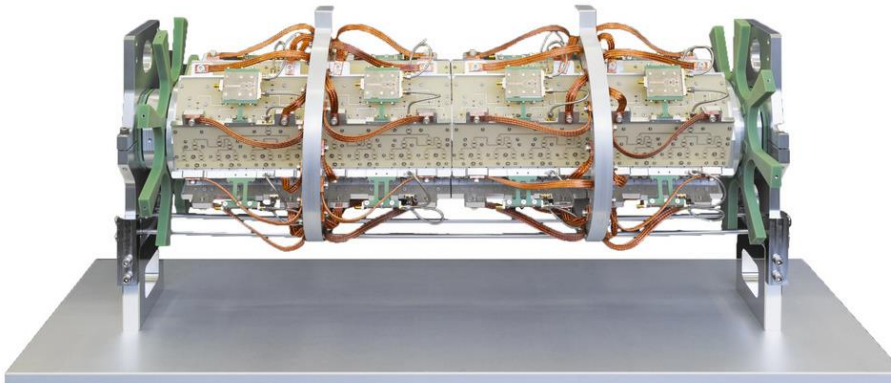
Cooling of Polarized Beams: Proof of principle

- 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



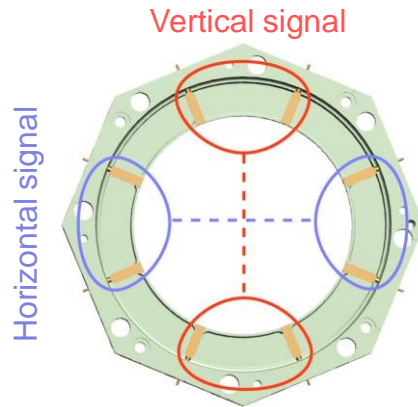
Pick-up and Kicker for HESR

- 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

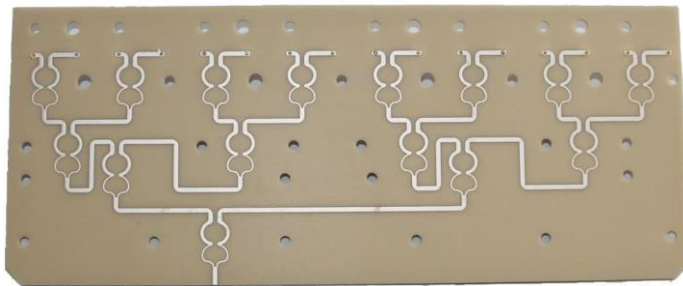


Pick-up and Kicker for HESR

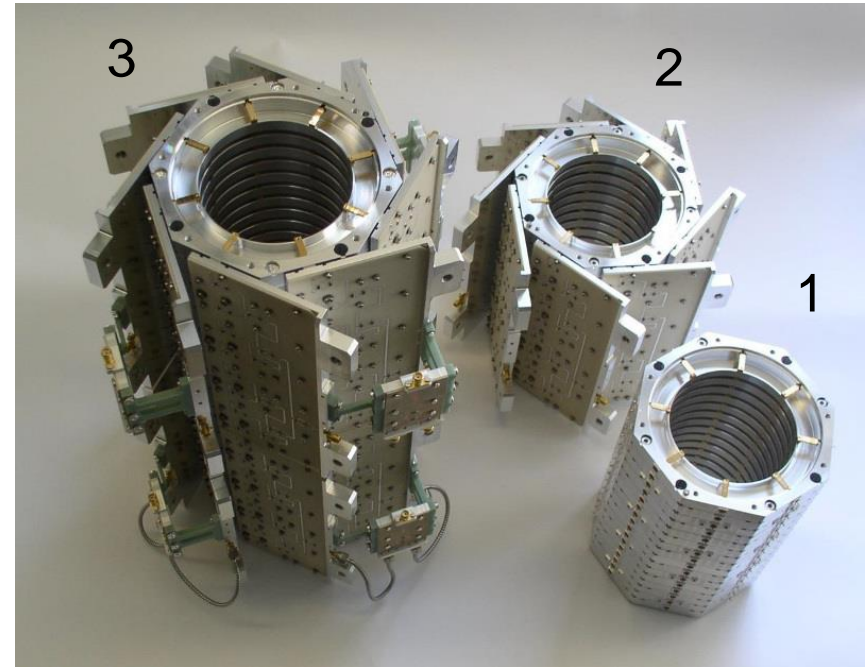
Design by L. Torndahl (CERN), R. Stassen (FZJ)



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



Combiner board (16x1) for one structure

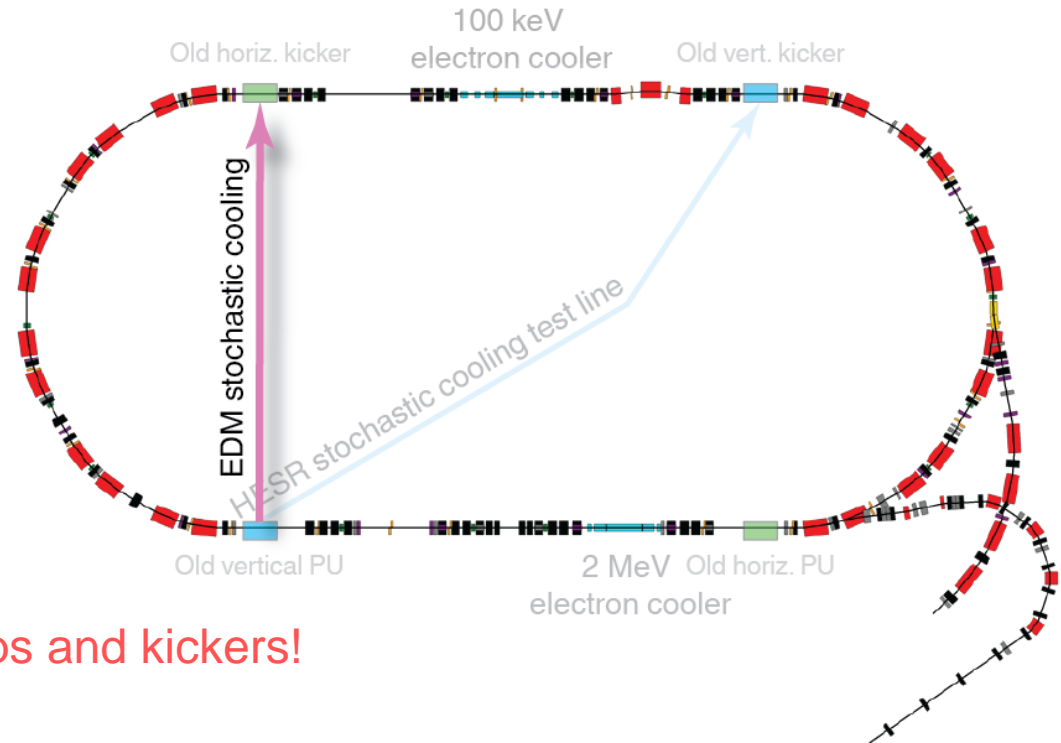


1. Assembly of 16 rings
2. Full structure with 16 rings
3. Stack of 2 structures

System considerations

Related parameters:

Circumference	184 m
Ions	d+
Intensity	10^9
Kin. energy	118 MeV/u
β	0.46
δ_{rms}	$2 \cdot 10^{-4}$
η	0.6

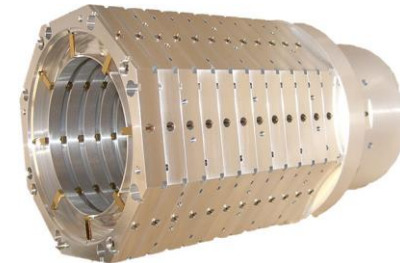


New design required for pick-ups and kickers!

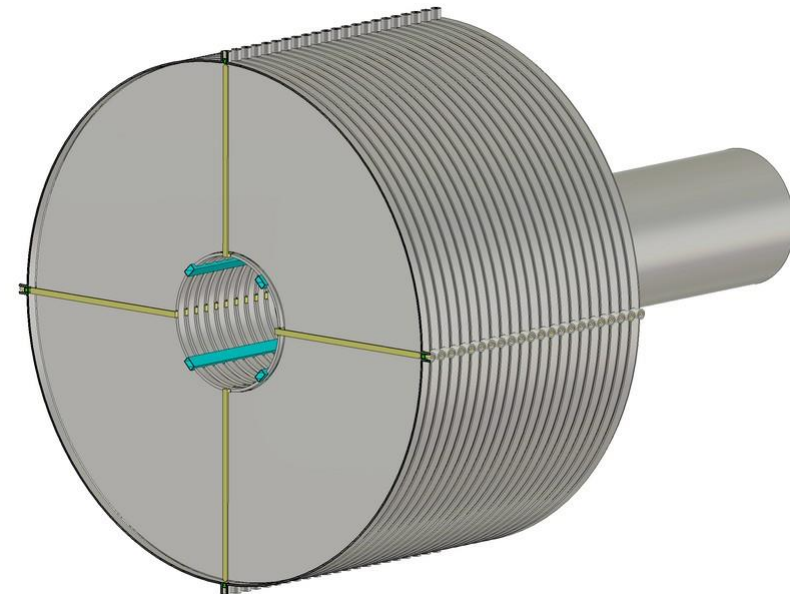
- Bad mixing above 700 MHz
 - PU/KI performance is insufficient above 1GHz
- Frequency Band: 350 – 700 MHz

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



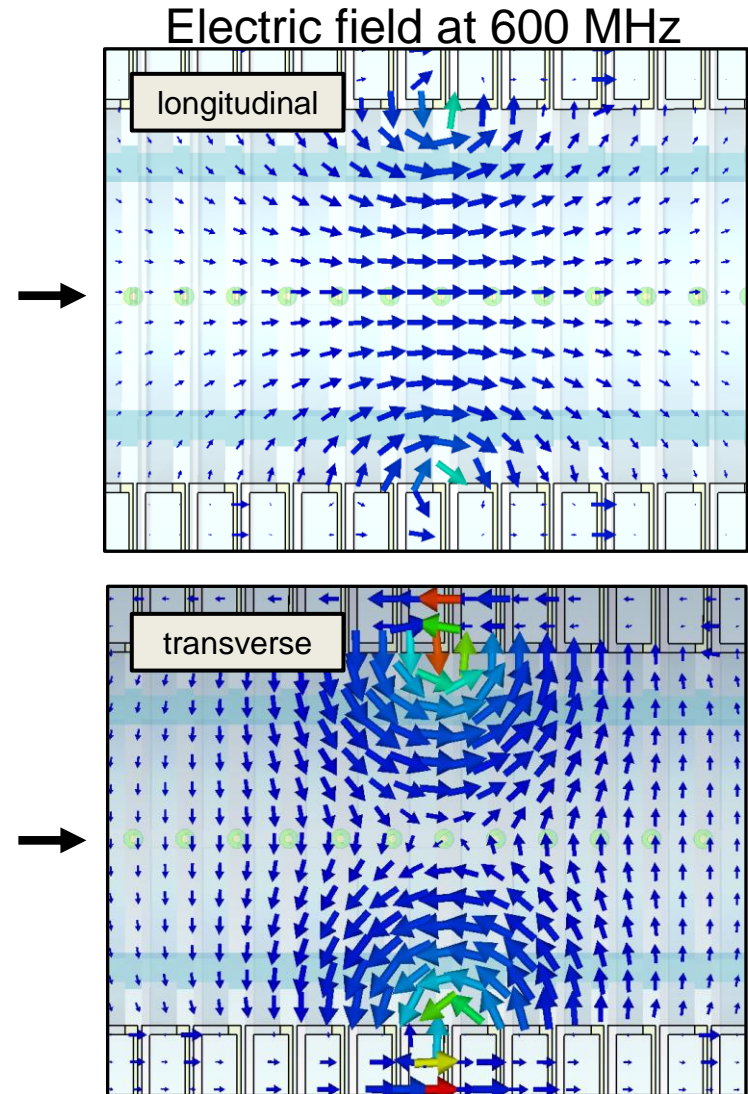
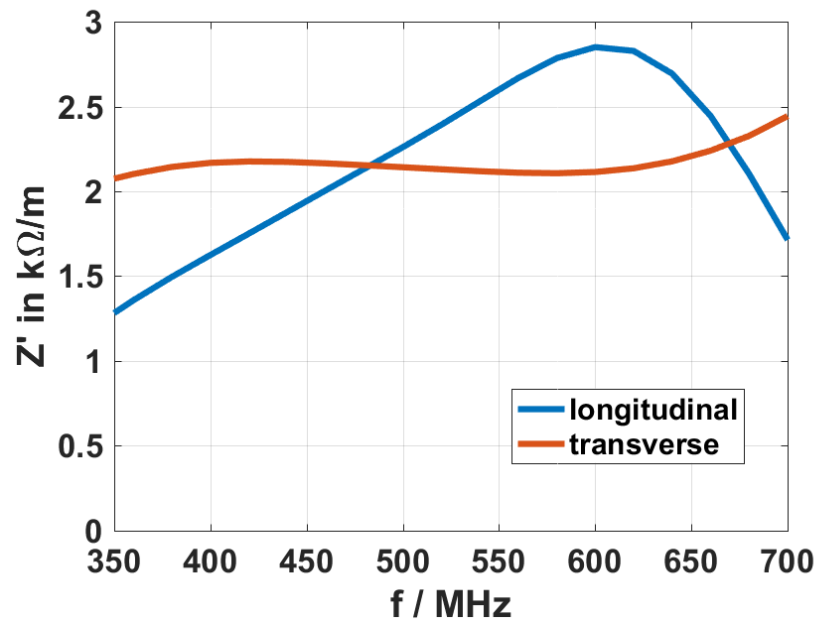
HESR ring-slot coupler



New ring-slot coupler design

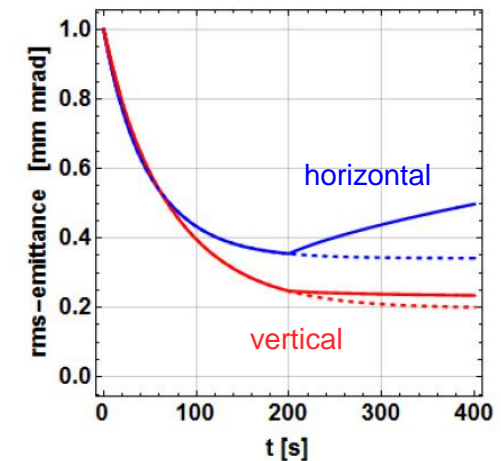
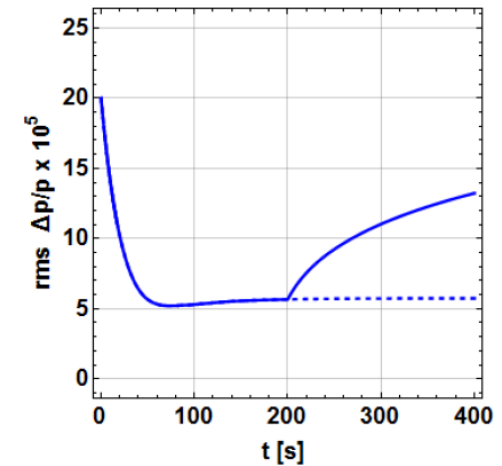
Kicker Performance

- 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.



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