TU Darmstadt - Fachbereich Elektrotechnik & Informationstechnik

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- Munteanu – Schöps - Weiland – Ackermann
  - Weiland
    - SIS100 Dipole Magnet Simulation
    - Beam Coupling Impedance Calculation
    - Higher Harmonic Cavity for NESR
    - Beam Dynamics Simulations for Super-FRS
    - Eigenmode Computation for Ferrite-loaded
    - Broad Band Schottky Pickup
    - Simulation of Quadrupole Pick-ups
    - Reliable Confidence Intervals for Accelerator Magnets
    - Robust Optimization for Component Design
  - Ackermann
    - Schottky Sensor für den Collector Ring
    - Numerische Simulationen zur Extraktion von Ionenstrahlen aus einer EZR Ionenquelle
- Zoubir - Mouhammad Alhumaidi
    - Optimal Parametric Estimation of Schottky Spectra
    - Transverse Feedback System for SIS 18 and SIS100

SIS 100 Dipole Simulations

T. Weiland, H. De Gersem, S. Koch

Project finished

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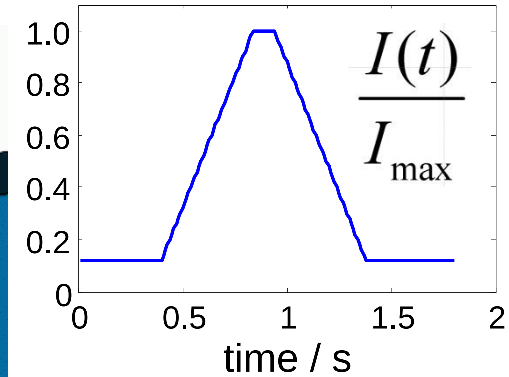
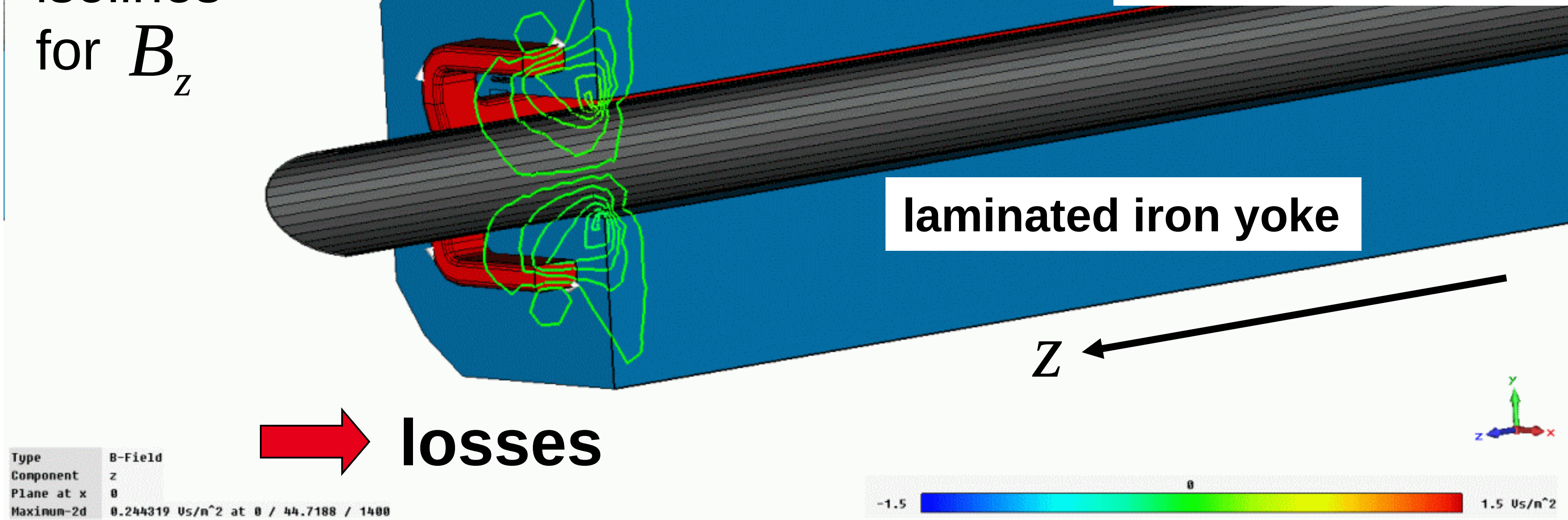
MQS: magnetic flux density

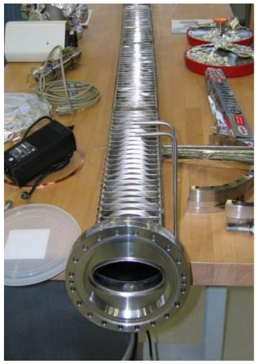
→ eddy-current losses in end regions despite lamination

coil current



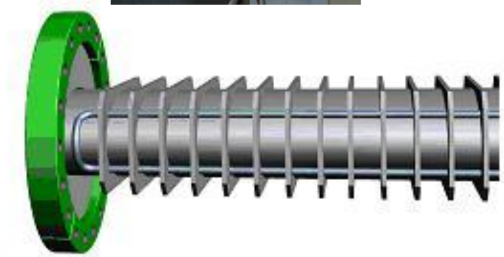


Beam Coupling Impedance Calculation
T. Weiland, O. Boine-Frankenheim, U. Niedermayer



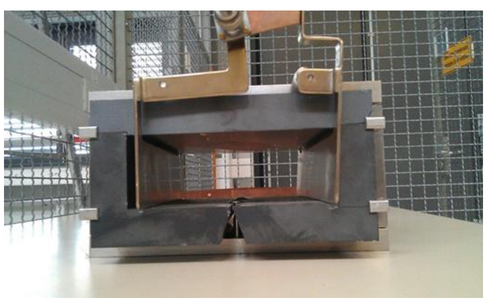
$$Z_{||}(\omega) = \frac{1}{q^2} \int_0^L \int_0^a \int_0^{2\pi} E(\vec{r},\omega)\, J_z(\vec{r},\omega)\, \varrho d\varrho d\varphi dz$$

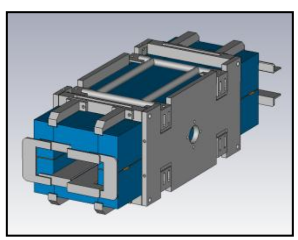
$$Z_x(\omega) = \frac{i}{q^2 \Delta} \int_0^L \int_0^a \int_0^{2\pi} \sigma \left[E_x(\vec{r},\omega) \mp v B_y(\vec{r},\omega)\right] \rho d\rho d\varphi dz$$



Core Issues for FAIR:

- Transverse and Longitudinal Beam Stability
- Effect of material parameter uncertainties
- Energy deposition
- Heating





Project

- Simulation in Time and Frequency Domain
- Simulation with different methods (FI/FE)
- BMBF Matching funds (50%)
- GSI-Contact: O. Boine-Frankenheim

Higher Harmonic Cavity for NESR

Irina Munteanu

New Project

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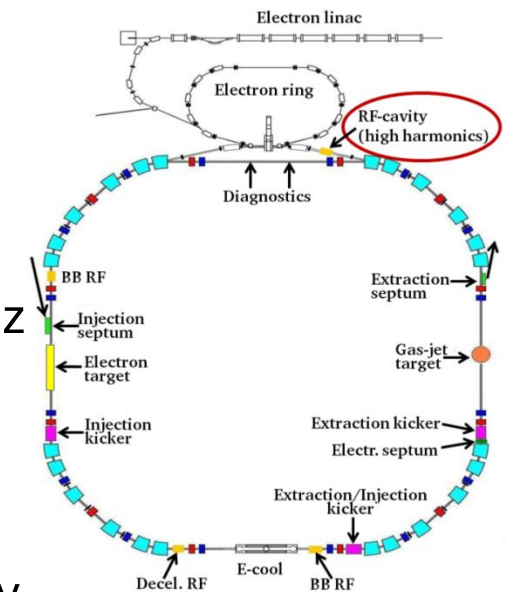
- Component of the „New Experimental Storage Ring“ (**NESR**) at **FAIR**
- Goal of the project:
  Robust numerical design methodology for the Higher Harmon. Cav.
  - Eigenmode computation <u>taking into account manufacturing tolerances</u>
  - Adaptable / tolerance-insensitive coupling schemes
  - Q-factor, RF-power, Heating
  - Investigation of cavity tuning possibilities
- **Project Challenges**
  - Operation at 44.7 MHz, higher order modes up to 1.2 GHz
  - **Multiscale problem:** electrically large cavity, tiny geometric details
  - **Numerous trapped modes:** additional heating, beam instability? → damping strategy might be necessary
- **GSI Contact:** H. Klingbeil



Quelle: C. Dimopoulou (GSI)

Beam dynamics Simulations for Super-FRS
Weiland, Müller

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- Simulation of magnetic fields of dipoles (normal conducting & superconducting)
- Comparison with field measurements from prototype magnets
- Beam optics simulations with full 3D magnetic fields

- Optimization of setup to improve particle separation
- Project: supplement BMBF project 06DA7058
- GSI Contact: Martin Winkler and John S. Winfield
- Matching Project (50% BMBF)

Eigenmode Computation for Ferrite-loaded Cavity Resonators / Weiland, Ackermann, Klopfer

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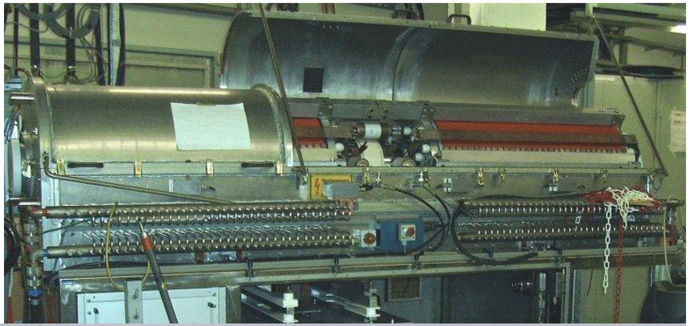
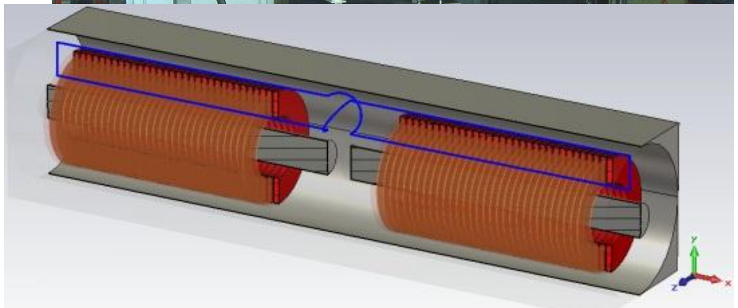
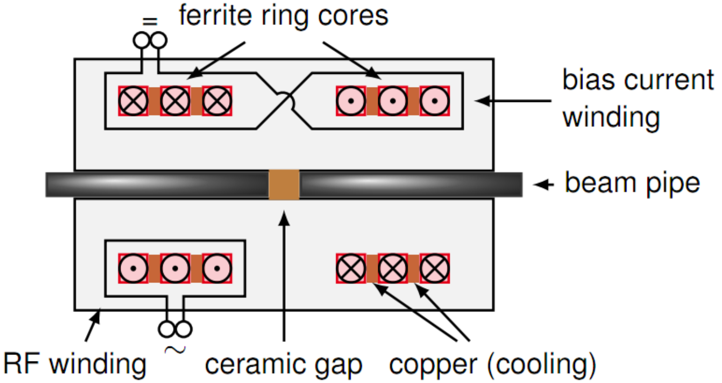
- The cavity is tuned by bias currents
- Calculation of the material parameters at the working point with magneto-static solver
- Development of a solver for the non-linear eigenvalue problem
- Simulation of the existing SIS-18 cavity and the new SIS-100 cavity
- Work by Klaus Klopfer (since 2011)
- GSI Contact: Harald Klingbeil







Broad Band Schottky Pickup

New Project

Weiland, Jakoby, Müller, Penirschke, Angelowski

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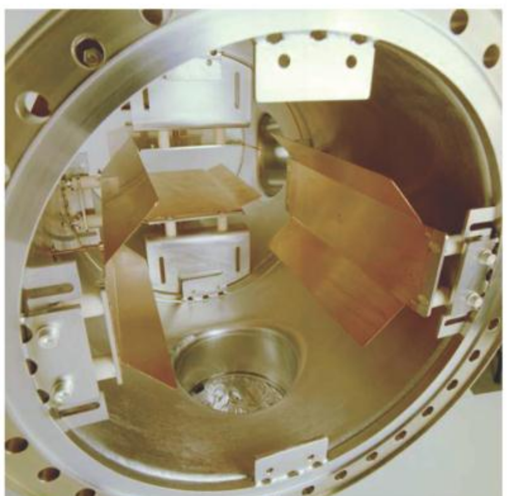
Schottky spectra allow for the extraction of

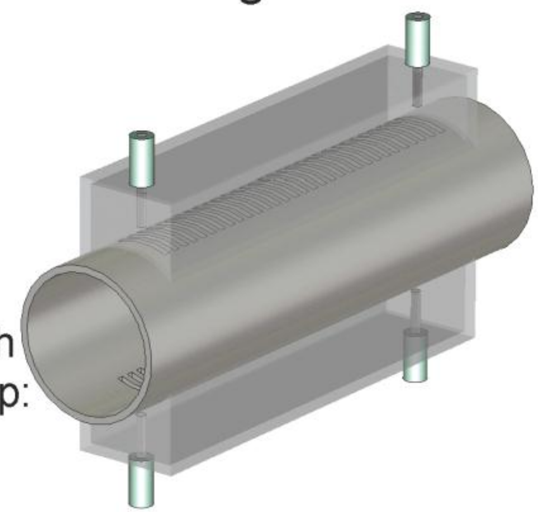
- tune
- chromaticity
- momentum spread

in a single measurement



ESR capacitive Schottky Pickups at GSI.

- Measuring high harmonics reduce/eliminate space charge driven signal deformation
- Extraction of bunch-by-bunch information requires high frequency observation
- This requires the design of a new pickup

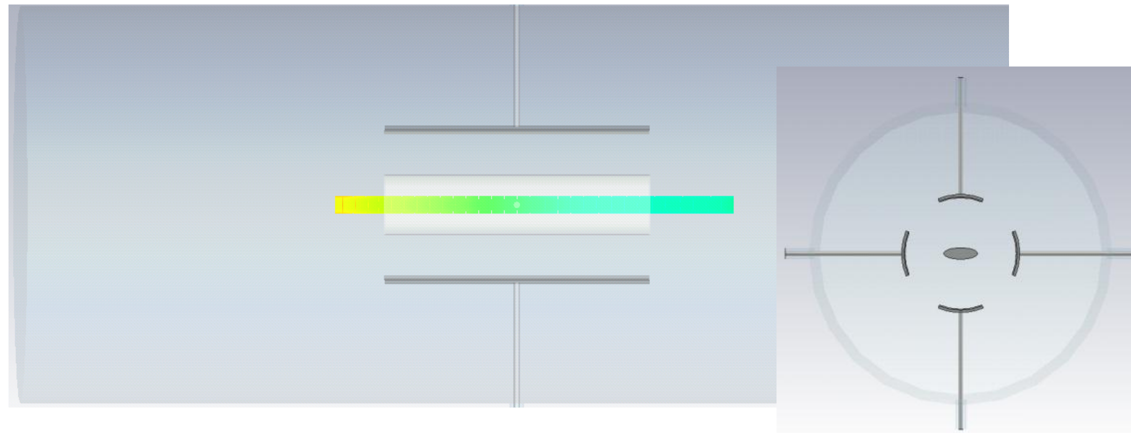


High Bandwidth Schottky Pickup: e.g. 'slotted waveguide'

Simulation of Quadrupole Pick-ups

Weiland, Müller, Tsemo

- Pick-up design with CST Particle Studio:



- In a standard capacitive pick-up the beam size signal has to be separated from the much higher position signal
- Future direction: Design of a position independent pick-up (Quadrupole Magnetic Coupling, A. Jansson, CERN-PS)
- Work by Alain Tsemo (started in 2012)
- GSI Contact: Piotr Kowina and Marcus Schwickert

Reliable Confidence Intervals for Accelerator Magnets / Schöps, Römer

New Project

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Uncertain inputs

Modeling

Numerical Simulation

Uncertain outputs

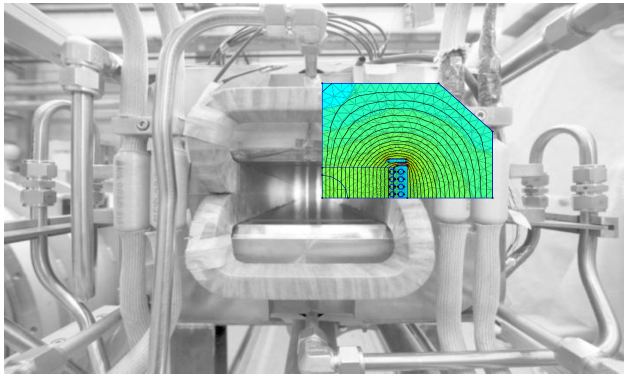
Sources of uncertainty:

- Material properties
- Geometrical variations
- Manufacturing imperfections
- Coil/cable positioning
- Excitation currents

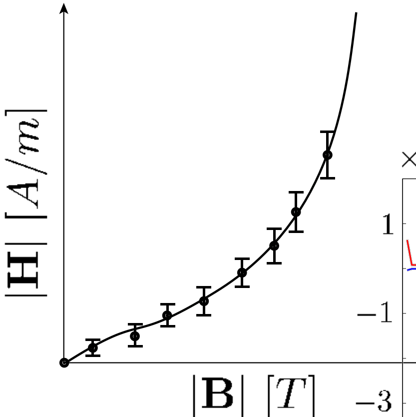
Beam dynamics (multipoles) inherit uncertainties!

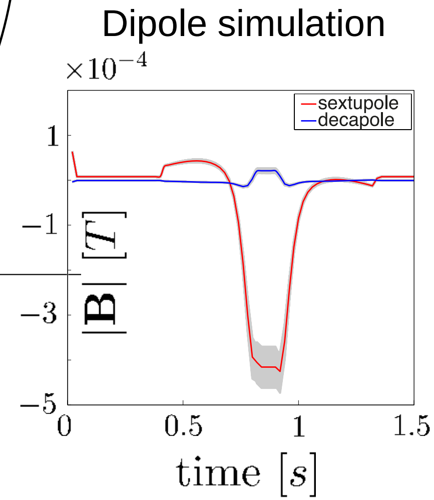
Proposed solution: Derivation of confidence intervals

➔ Reliable fabrication tolerances



Source: C.Grau GSI





Robust Optimization for Component Design

Schöps, Römer

New Project

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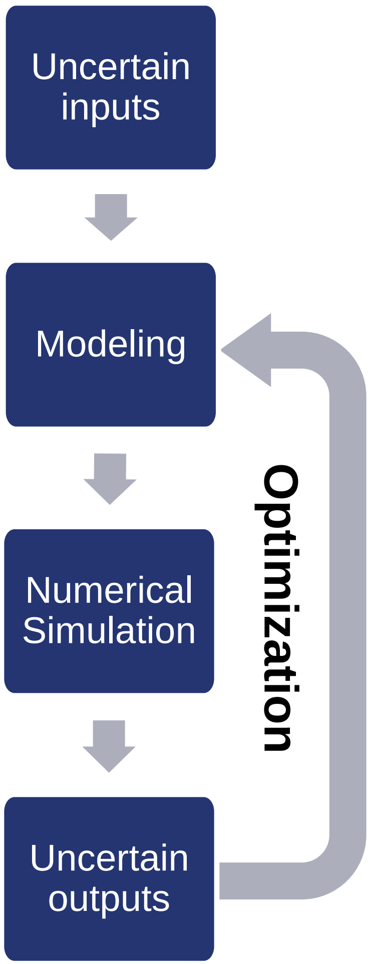

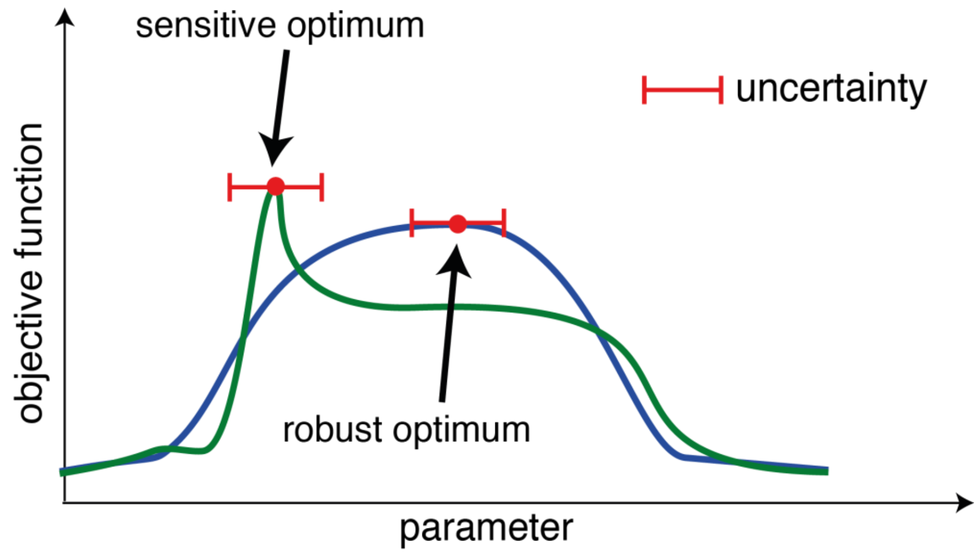

Optimization: Design of components can be improved significantly by optimization techniques

Conventional optimization cannot guarantee robust optima!

Proposed solution: Robust design procedures optimize both the objectives and reduce their variance

➔ Reliable component design

Schottky Sensor für den Collector Ring
Jakoby, Weiland, Penirschke, Ackermann

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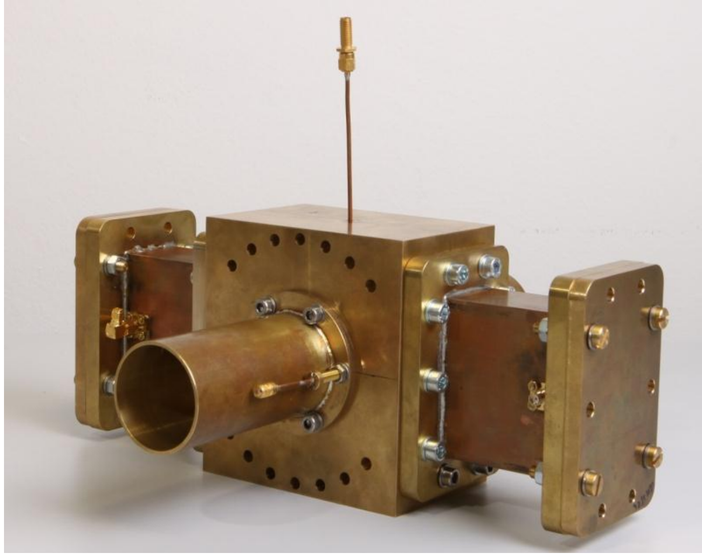
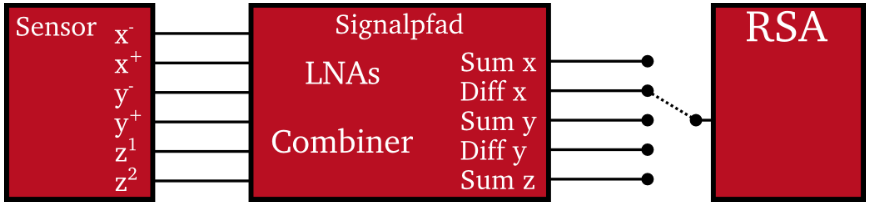
- Physikalische Zielsetzung
  - Entwicklung eines hoch empfindlichen, kavitätsbasierenden Schottky-Sensors für den „Collector Ring" (CR)
- Bisherige Arbeiten
  - BMBF-Projekt (GSI + TU Darmstadt) „Schottkysonden für Energie- und Tune-Messung"
  - Realisierung eines (skalierten) Demonstrators
  - Vermessung der Anordnung in Bearbeitung
- Projektziel
  - Optimierung der vorgeschlagenen Struktur bezüglich Auskopplung der Signale (3D Feld- und Schaltungssimulationen)
  - Unterstützung bei der technischen Realisierung der Schottky-Sonde
  - Auslegung, Design und Optimierung des erforderlichen Signalpfades



Demonstrator der vorgeschlagenen resonanten Schottkysensor-Stuktur



Signalpfad vom Sensor zum Spektrumanalysator

Numerische Simulationen zur Extraktion von Ionenstrahlen aus einer EZR Ionenquelle

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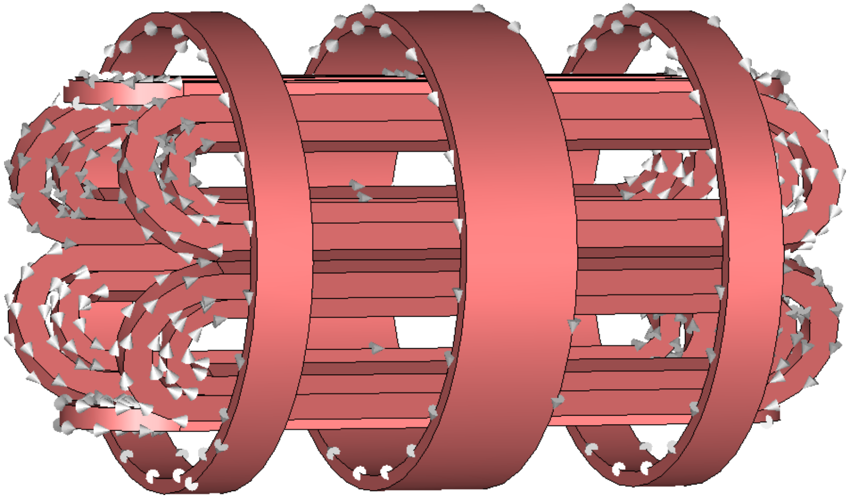
Weiland, Ackermann

- Physikalische Zielsetzung
  - Entwicklung leistungsfähiger Quellen mit höheren Strahlintensitäten bei höheren Ladungszuständen
  - Anstieg der Teilchendichte im Plasma durch eine Erhöhung der Frequenz der eingestrahlten Mikrowellenfelder erreichbar
  - Resonanzbedingung erfordert gleichzeitig Erhöhung der magnetischen Flussdichte
- Technische Schwierigkeiten
  - Kräfte auf das Magnetsystem abfangen für quenchfreien Betrieb
  - Extraktion bei veränderter Teilchendynamik



Prinzipdarstellung der Solenoid- und Sextupolspulenanordnung (CST Studio Suite)

- Projektziel
  - Weiterentwicklung und Implementierung von effizienten Algorithmen zur Simulation der physikalischen Vorgänge in einer Elektronen-Zyklotron-Resonanz Ionenquelle (EZR)
  - 50% matching project (BMBF)

GSI and TU Darmstadt (SPG)
Optimal Parametric Estimation of Schottky Spectra

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- Estimation of schottky spectra based on parametric models with high precision and high resolution
- Extraction of important parameters, such as tune, chromaticity and momentum spread

Challenges

- Disturbances from the environment and the schottky PUs
- Signal deformation by space charge effects

Research

- Develop advanced robust signal processing tools for large dynamic range of parameters

Transverse Feedback System for SIS 18 and SIS 100

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– Design and implementation of a new Transverse Feedback System (TFS) to suppress coherent instabilities for coasting and bunched beam

- Noise Minimization Using Multiple Pickups
  - Optimal weighted sum of multiple PU signals that gives minimum noise power & unbiased estimation of beam angle
- Robust TFS Against Optics Uncertainties
  - Introduce perturbation terms to the transfer matrices. Subsequently, use the EKF to estimate feedback signal and optics
- In progress: * Implementation on FPGA
  * study non-linearities
- Publications at IPAC11 & 12. PRST-AB submitted