Computational Electromagnetics for Particle Accelerators

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Wolfgang Ackermann, David Bizzozero, Herbert De Gersem, Erion Gjonaj, Nicolas Marsic, Wolfgang F.O. Müller, Thomas Weiland

Efficient Nonlinear Eigenvalue Solver

W. Ackermann, V. Pham-Xuan, W. Müller, H. De Gersem

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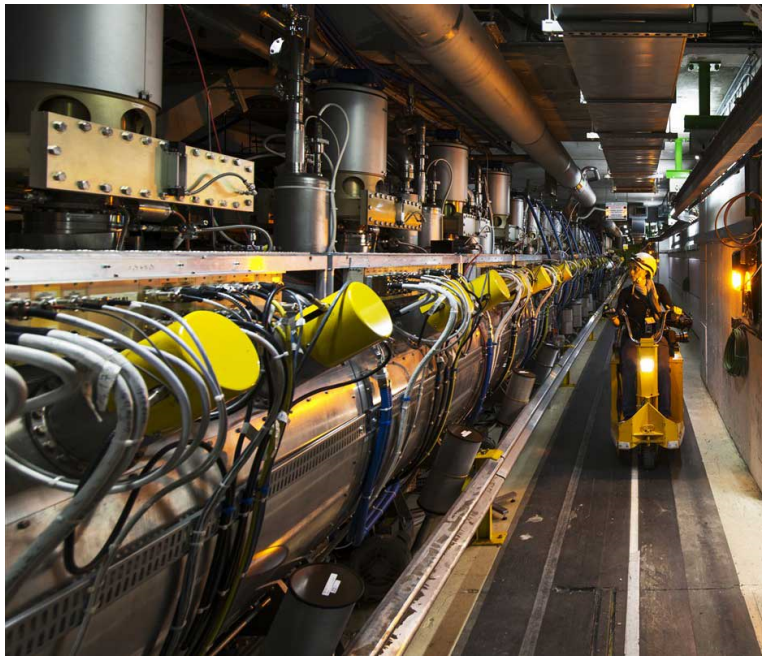
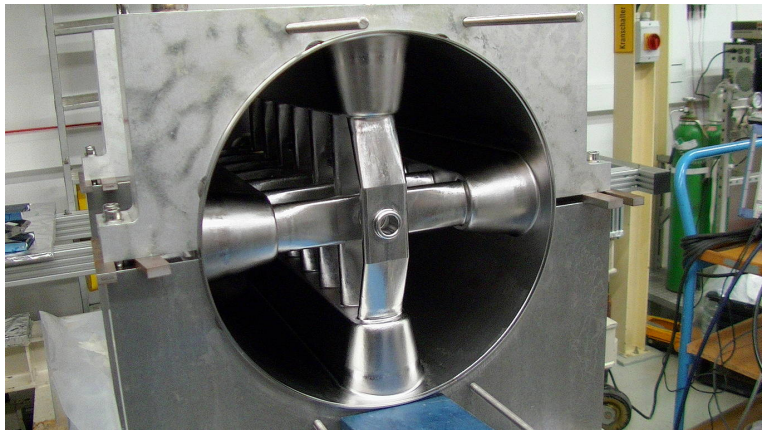
- Simulation of electromagnetic fields in resonating structures
  - High precision cavity simulation including losses

CERN



GSI



DESY

Efficient Nonlinear Eigenvalue Solver

W. Ackermann, V. Pham-Xuan, W. Müller, H. De Gersem

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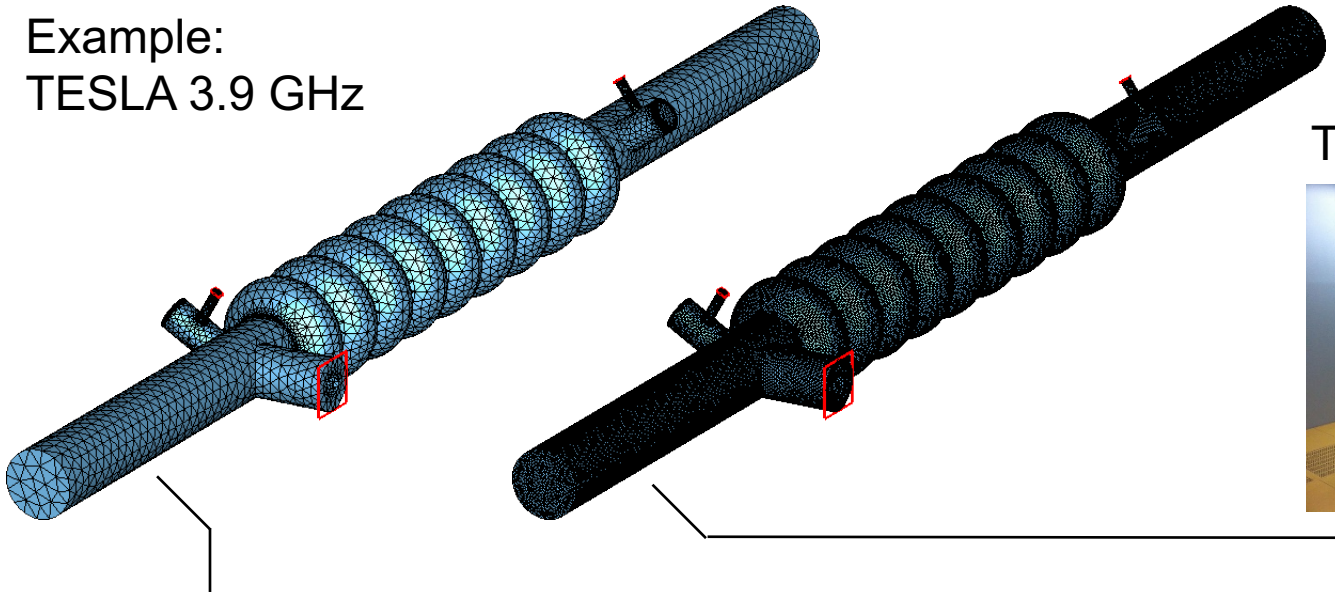
- Simulation of electromagnetic fields in resonating structures
  - Implementation based on existing FEM-based cavity simulation tool

Example:
TESLA 3.9 GHz



TEMF Cluster

LPW	4	6	8	10	12	14	16	18	20	22
Tetrahedrons	136.443	187.435	304.833	480.376	767.271	1.177.883	1.704.528	2.432.978	3.337.736	4.464.452
Complex DOF	761.820	1.079.488	1.802.314	2.885.154	4.668.072	7.227.096	10.509.404	15.064.232	20.721.334	27.736.496

Efficient Nonlinear Eigenvalue Solver

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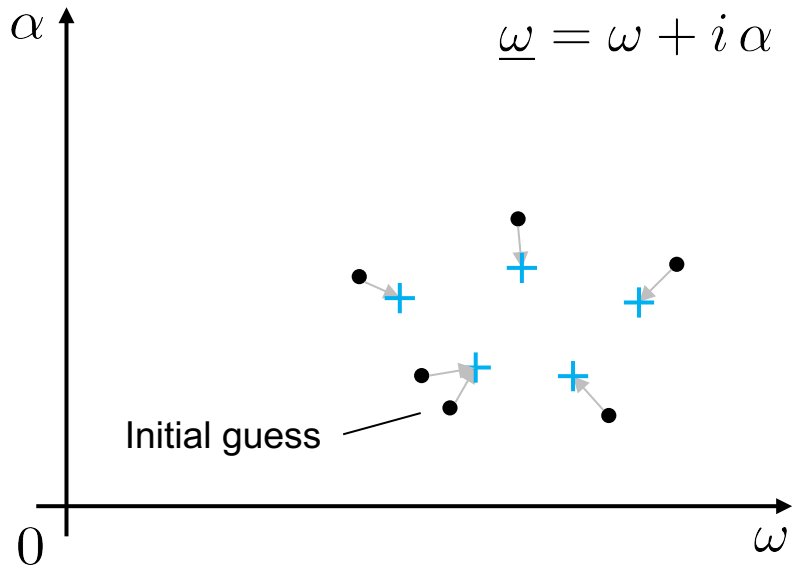
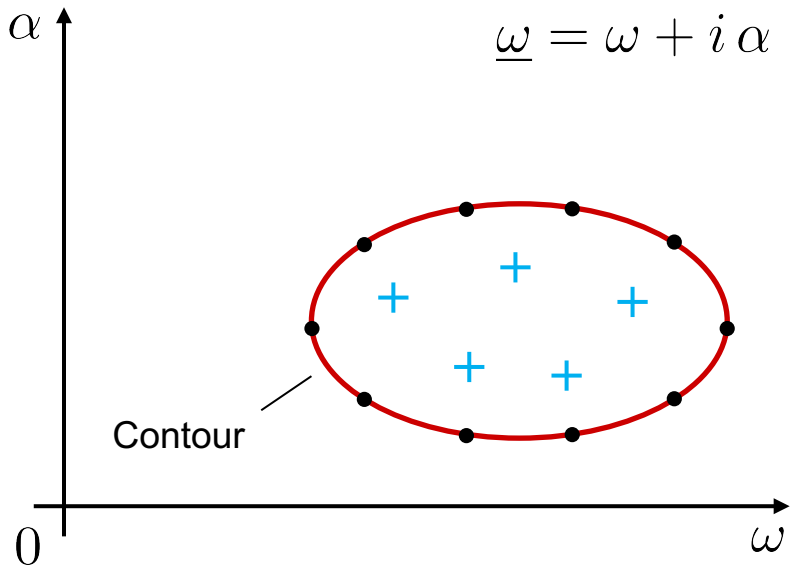
- Simulation of electromagnetic fields in resonating structures
  - Complex eigenpairs due to port boundary conditions or surface losses

Iterative search method



Contour integral method



Cryogenic Current Comparator (CCC)

N. Marsic, W.F.O. Müller, H. De Gersem,
T. Sieber, F. Kurian, M. Schwickert

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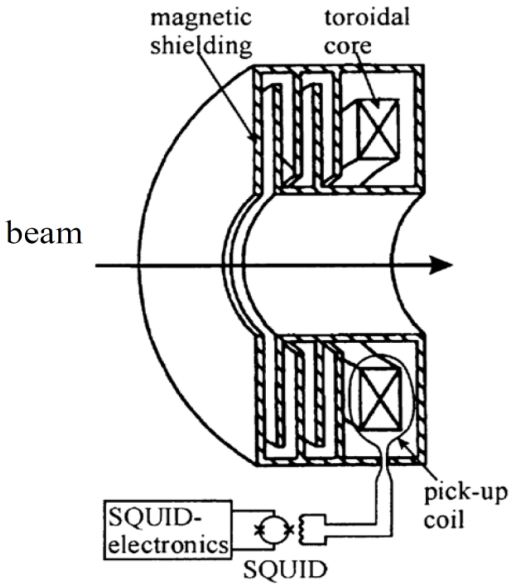
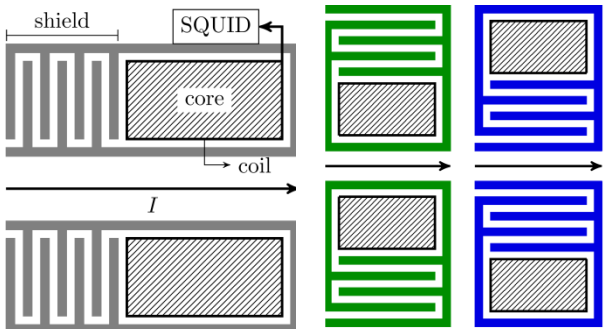
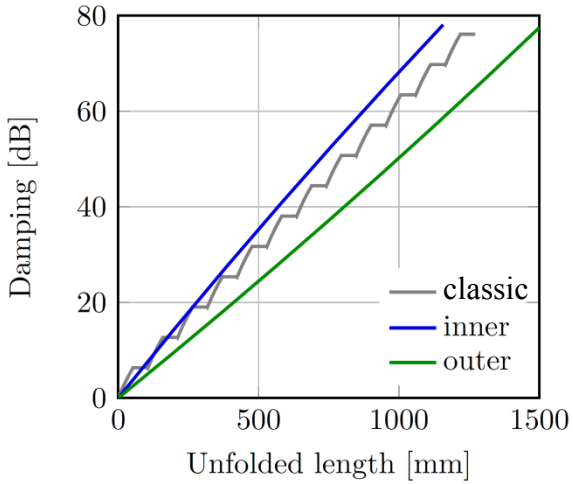
▪ Working principle



- SC shielding for non-azimuthal fields
- SC pickup coil with toroidal core ($\mu_r \approx 50000$)
- Low noise, high performance DC SQUID + control electronics (FSU Jena) → commercial products (MAGNICON, SUPRACON)

▪ Optimised topology





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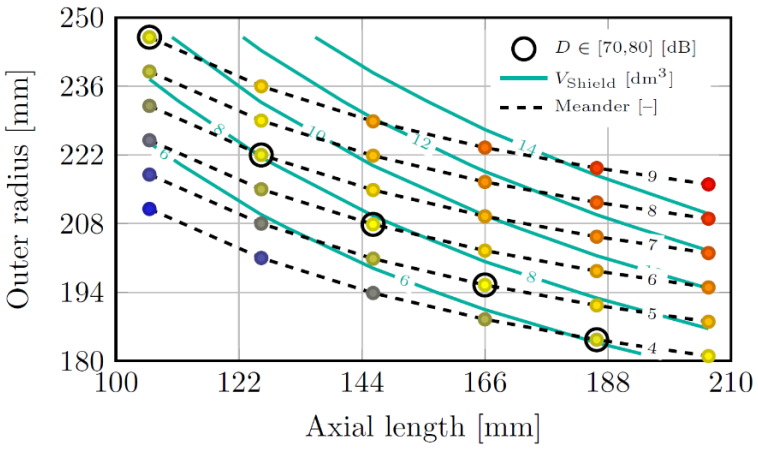
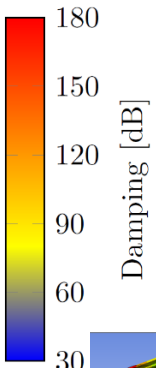
- Geometric optimisation





- Vibrations

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▪ Consortium

- **HI Jena:** Collaboration management, CCC development and test, MSR / cold lab operation
- **FSU Jena:** CCC electronics development, magnetic shielding optimization, MSR / cold lab
- **IPHT Jena:** SQUID + shielding optimization, hardware development, new CCC concepts and experimental verification
- **TEMF Darmstadt:** Numerical simulation of shielding efficiency, mechanical and electromagnetic. eigenmodes
- **CERN Geneva:** Test of CCC and components under real conditions, control system
- **GSI Darmstadt:** Definition of requirements, test of CCC and components under real conditions, magn. shielding optimization, cryostat design

Magnet Quench Simulation

S. Schöps, I. Cortes-Garcia, H. De Gersem,
B. Auchmann, L. Bortot, M. Maciejewski, A.P. Verweij

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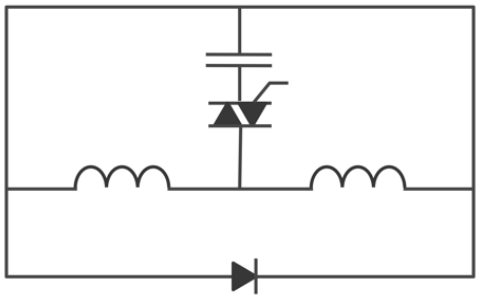
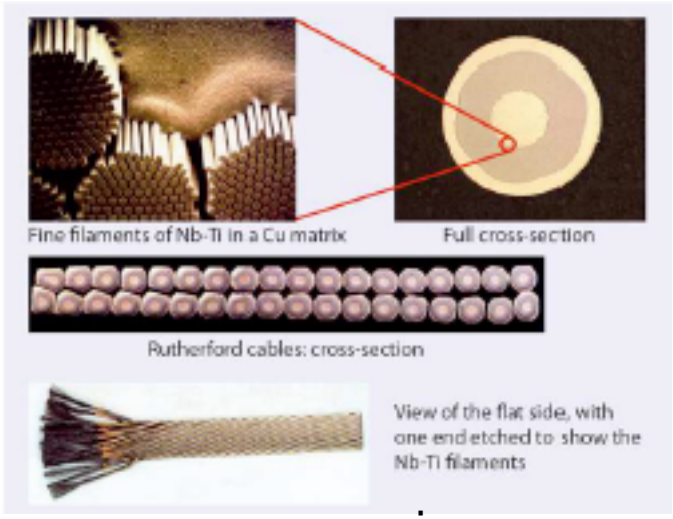
- STEAM co-simulation framework
- e.g. Coupling loss induced quench (CLIQ)





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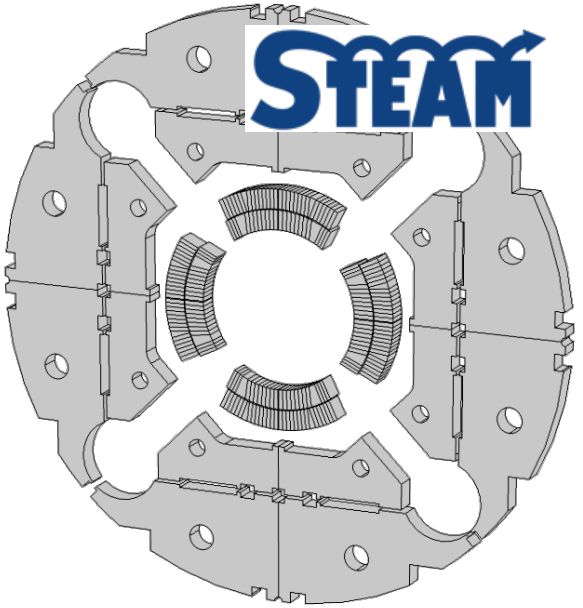
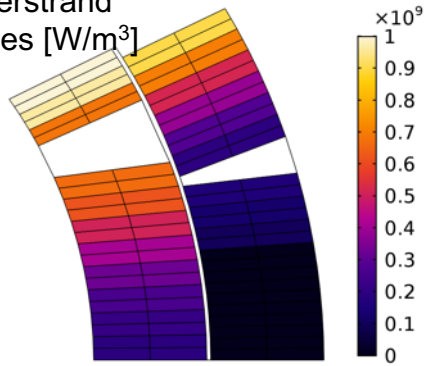


Interstrand Losses [W/m^3]



- field + circuit solvers
- multiscale and multi-rate techniques

Robust Optimization of Accelerator Chains

S. Appel, O. Boine-Frankenheim, S. Schöps, H. De Gersem

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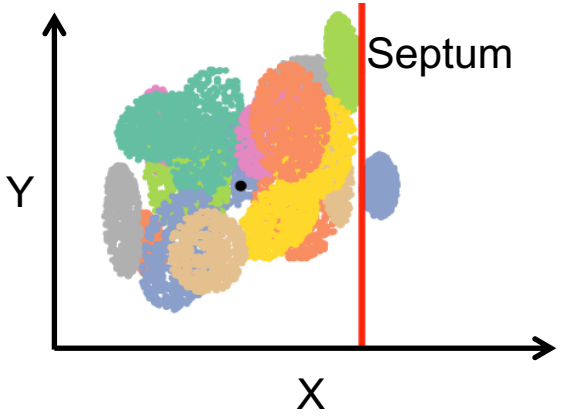
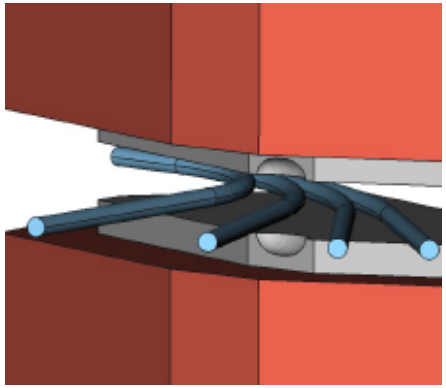
- robust optimization schemes
- surrogate modelling
- space mapping
- uncertainty quantification



S. Appel, multi-turn jnjection



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