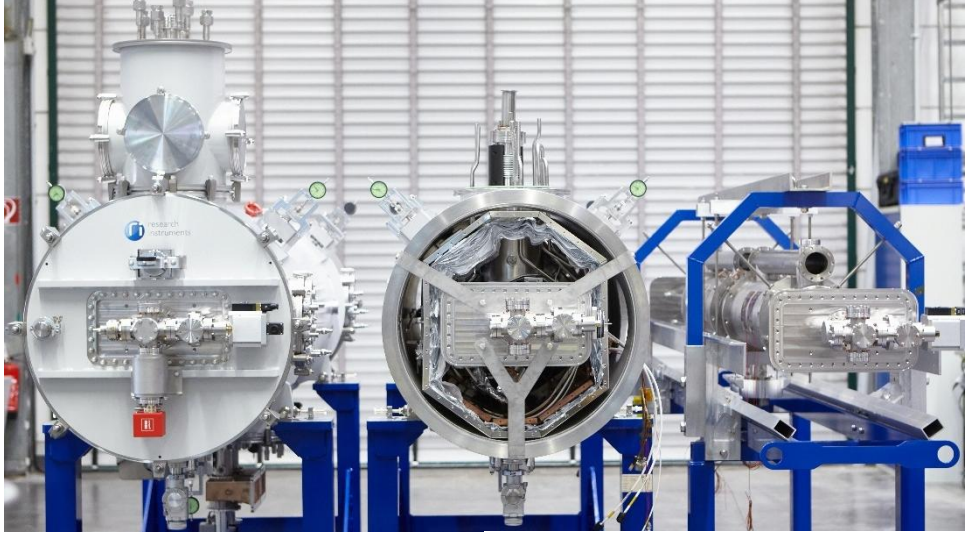
research instruments



12th International Workshop on Thin Films and New Ideas for Pushing the Limits of RF Superconductivity, Sep. 21 – 25, 2026, Chester, United Kingdom

Towards Industrial Nb3Sn-based Turn-Key SRF Systems

Vitalii Shcherbinin

September 22, 2026

RI Research Instruments

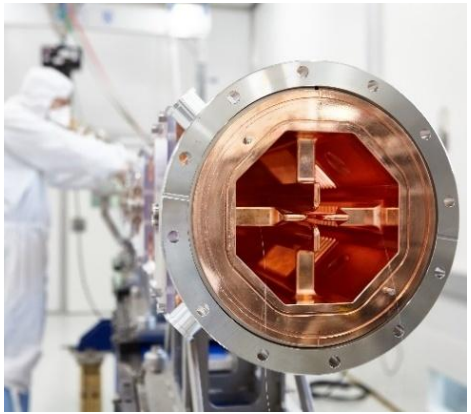
RI at a glance

- Founded in 1994 as ACCEL Instruments GmbH – since 2009 named RI Research Instruments GmbH
- Annual revenue of 90 million EUR (2024)
- Majority (52%) owned by Bruker EST, Management team are additional shareholders
- Headquarters in Bergisch Gladbach, Germany (close to Cologne/Köln)
- Main high-tech business fields
  - Particle accelerators: Super and normal conducting
  - Fusion: Systems and components supplier
  - Semicon: EUV tools and Semicon supply chain

Bergisch Gladbach & Dortmund, Germany

Customers in >25 countries

30 years of innovation



Hundreds of Experts / Dozens of Technologies

Large enough to do complex projects & small enough to be flexible

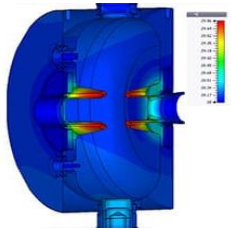
400 Experts

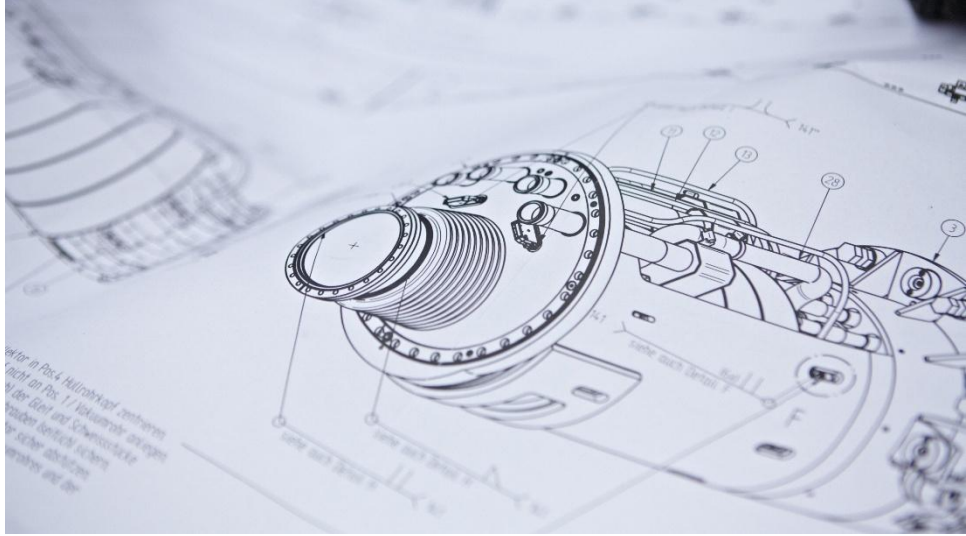
- 140 Engineers & physicists
- 220 Craftspeople
- 40 Finances, HR, IT, ...

400
and growing

End-to-end Engineering and Manufacturing Solutions

- R&D
- Engineering
- Precision Manufacturing
- Qualification & Testing
- Assembly, Integration & Service
- Series production





Deep Dive Engineering Capabilities

RF design of components for accelerators (Poisson Superfish (2D) or CST Microwave Studio(3D)), including cavities, fundamental and HOM couplers, electromagnets, and for ECRH transmission lines (Profusion), including corrugated waveguides, miter bends, diamond window units.

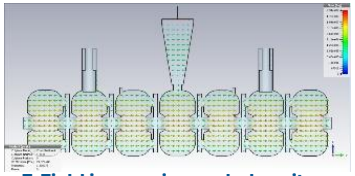
Mechanical design and thermo-mechanical analysis of components and systems with a focus on heat management and structural integrity, using ANSYS Workbench and CST Multiphysics Studio.

Beam dynamics simulations with Tstep/PARMELA (multi-particle tracking + beam optics from SUPERFISH), ELEGENT (for e^- simulations), GPT, CST Particle Studio (multi-particle tracking + particle-in-cell (PIC)). Ray-transfer-matrix analysis-based code Trace3D is employed for fast bunched-beam envelope calculations (incl. linear space-change forces) of standard beam manipulating elements (solenoids, quadrupoles, bends, etc.)

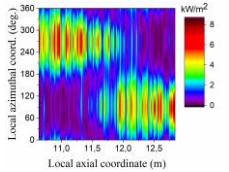
3D-CAD Design for preparation of 3D models and manufacturing drawings utilizing Autodesk Inventor Professional.

Control System Design for control systems/software used in own equipment & turn-key accelerators, as well as for programable logic controllers (PLCs) for hardware control (valves, pumps, power supplies) like Beckhoff TwinCAT, EPICS or Siemens SIMATIC, NI LabView.

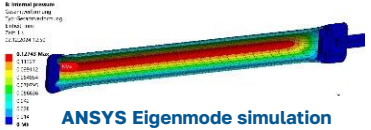
Cryogenic engineering, including process calculations, definition of pressure relief/safety systems, calculation of thermal insulations, heat load optimization, choice of materials, testing at LT



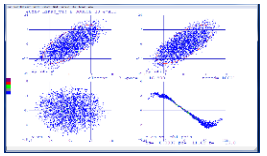
E-Field in on-axis coupled cavity



Waveguide wall loading

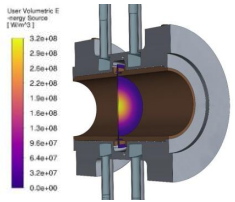


ANSYS Eigenmode simulation of Control Rods

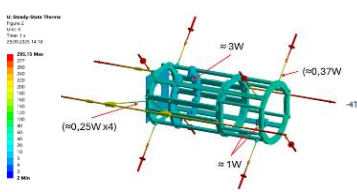


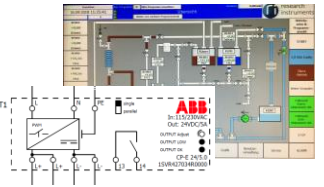
STEP multi particle simulation

Cryopump in Autodesk Inventor Professional



Heat in diamond window





EPlan and PLC of BCP system

Deep Dive Production Capabilities

Technology Park, Bergisch Gladbach (≈8000 m²)

Technologies

- Vacuum Brazing
- Heat Treatment

- Leak & Vacuum Tests
- Pressure Test
- RF Testing
- X-Ray
- RGA

- Electropolishing
- Surface Treatment

- Vacuum
- Cryogenics
- Clean-Rooms ISO 4
- Assembly

Dortmund (≈1200 m² acquired 2019)

- Pulsed Power Systems
- Customized Control Systems

New site "Obereschbach" (≈6000 m² since 2022)

Technologies

- CNC Milling & Turning
- Forming
- Bending

- TIG Welding
- Laser Welding
- Electron-beam Welding
- Welding Cobot

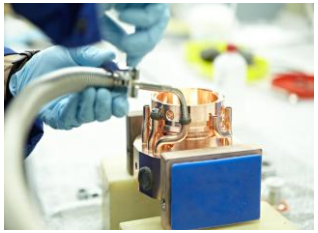
- Surface Treatment
- Cleaning
- Polishing
- Pickling

- Leak Testing
- Pressure Testing
- Dimensional Control



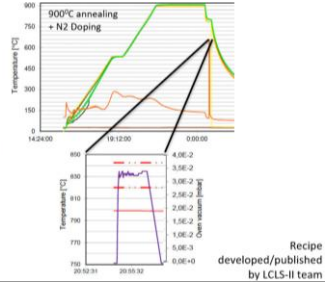






Example: Surface treatment

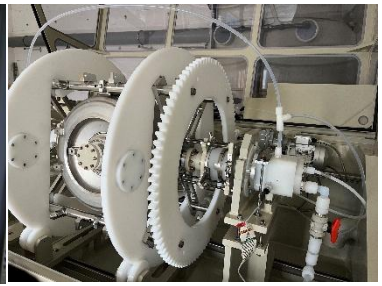
Annealing, hydrogen degassing and doping



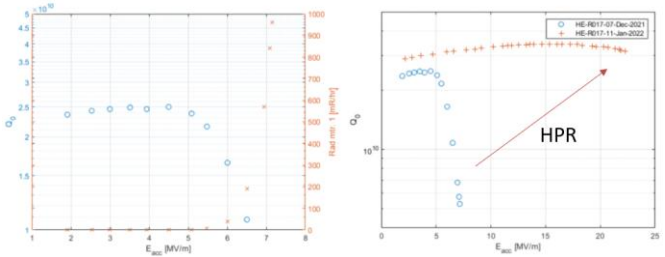
Recipe developed/published by LCLS-II team

Electropolishing

BCP: Stationary and rotational



HPR



Example from LCLS-II (J. Maniscalco at TTC2023)

Our Customers

Diversified high-tech portfolio

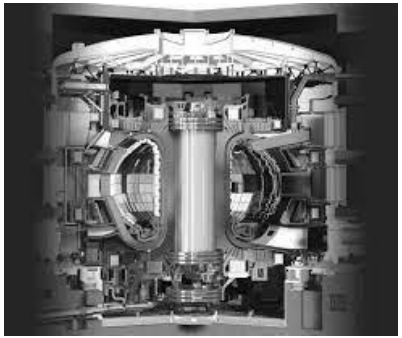
“Big Science”: 70%

1. Superconducting RF cavities and accelerator modules
2. Normal conducting RF cavities, RFQs, linacs, accelerators for medical isotopes & radiation therapy including pulsed power equipment
3. Fusion equipment (ITER, JT60…)

“High-tech industry” (partly confidential): 30%

4. EUV metrology tools including photon instrumentation
5. Components for EUV lithography machines

Others e.g. Nuclear, Pulsed Power, Space



Superconducting RF Cavities and Modules

SRF cavities are produced from ultra-pure niobium

Production requires following technologies: sheet metal forming, precision machining, metrology, EB welding, RF measurement, cryogenics, surface treatment, annealing, clean room assembly, RGA and leak check

Worldwide leading company in SRF cavity production

Since 2012 more than 1000 XFEL type cavities produced for major SRF projects at DESY (European XFEL), SLAC (LCLS-II and LCLS-II-HE) and SARI (Shine)

Only company in the world that can deliver turn-key SRF modules including controls and cryogenic supply valve boxes

SRF modules delivered to various Synchrotron Radiation Light Sources and Research Institutes

What We Bring To the Table

✓ **Experience in R&D, Prototyping, Series Manufacturing & Industrialization**

Contributor to: ITER, CERN, SLAC, DESY, and more

✓ **Cross-Domain Expertise:**

SRF, NCRF, Vacuum, Cryogenics, Fusion, Pulsed Power

✓ **Vertically Integrated**

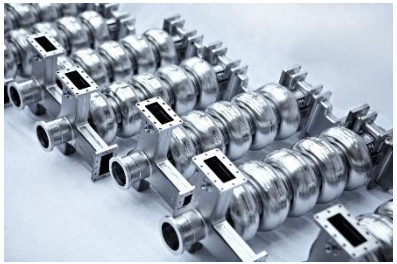
One partner for the entire project: Engineering, Design, Manufacturing, Supply Chain, Assembly, Testing, Integration, Service

✓ **Strategic Positioning & Heritage**

With roots in European mega-projects like CERN, ITER, GSI, and DESY, our work bridges scientific innovation and industrial reliability.

✓ **Open to new ideas**

RI has a long-term interest in the development of technologies and is constantly innovating to stay at the technological forefront. This is particularly true for Nb3Sn technology, which requires joint efforts of science and industry for the advancement from R&D phase toward industrial turn-key SRF systems.

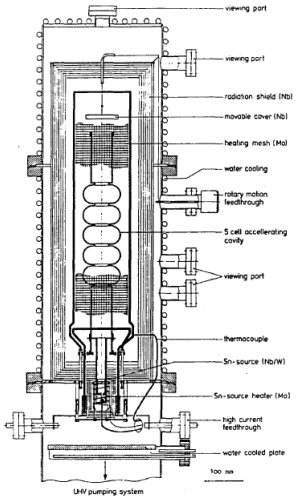


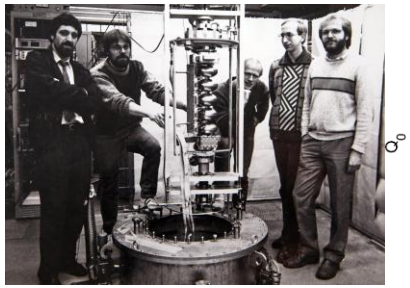
“Nb_3Sn-Related” Facts From Our Story

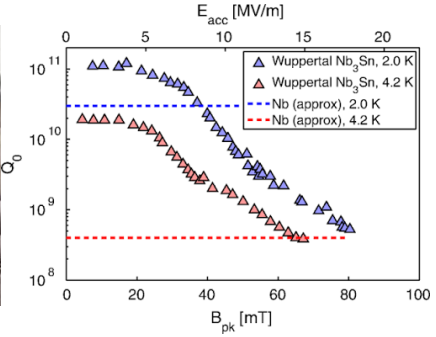
1980s: Cooperation with Uni. Wuppertal

“RI team” was involved into pioneering experiments with Nb_3Sn coating of high-purity Nb cavities at Uni. Wuppertal.

M. Peiniger et al. **1987** *Proc. Workshop on RF superconductivity* https://jacow.org/srf87/papers/SRF87E04.pdf



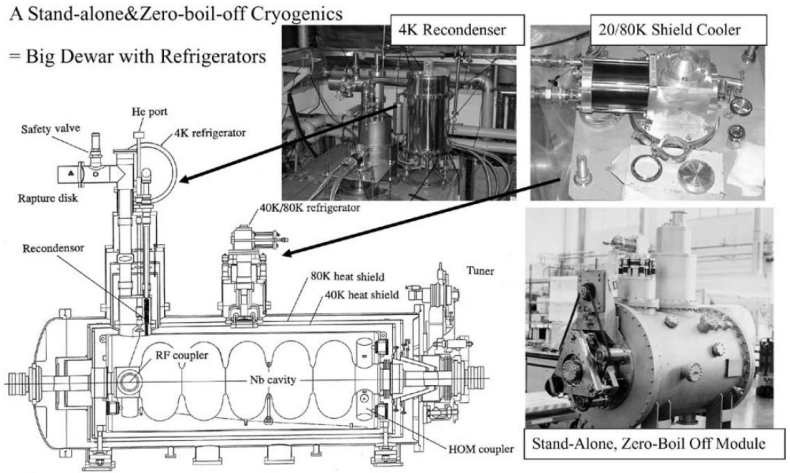




1990s: Turn-key stand-alone cryomodules for the JAERI FEL

“RI team” has performed final design, manufacturing, assembly and testing of 4 SRF modules equipped with compact 40K/80K shield-cooler and 4K He-recondenser refrigerators.

E.J. Minehara **2002** *Nucl. Instrum. Methods Phys. Res. A* https://doi.org/10.1016/S0168-9002(02)00277-2



“Nb_3Sn-Related” Facts From Our Story

1990s: Cooperation with CERN on Nb sputtering

For the Large Hadron Collider (LHC) at CERN, 21x superconducting 400 MHz single cell cavities have been produced by ACCEL (later RI) using the technology of magnetron sputtering of niobium on copper cavities. This technology was developed by CERN and transferred to industry within the scope of the LEP 200 project.

S. Bauer et al. **1999** *Proc. Workshop on RF superconductivity*
https://proceedings.jacow.org/SRF99/papers/wep016.pdf?n=SRF99/papers/WEP016.pdf

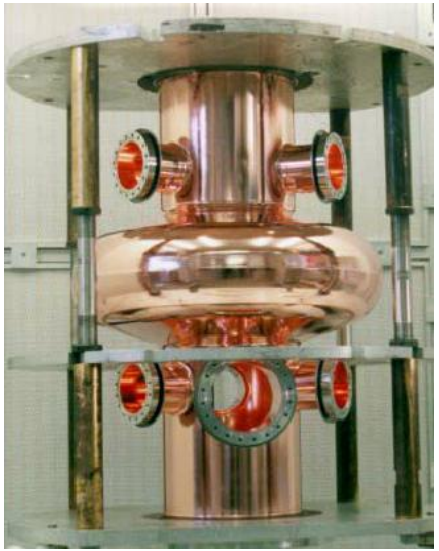


Fig. 11. A 400 MHz single cell copper cavity for the LHC before sputtering the 1–2-μm-thick niobium film.

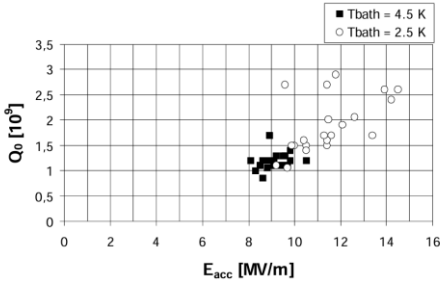


Figure 3: Highest gradients E_{acc} and quality factors Q_0 at the highest gradients achieved at bath temperatures of 4.5 K and 2.5 K in the LHC 400 MHz single cell cavities. The tests were carried out at CERN. The preparation of the cavities prior vertical test was done at ACCEL.

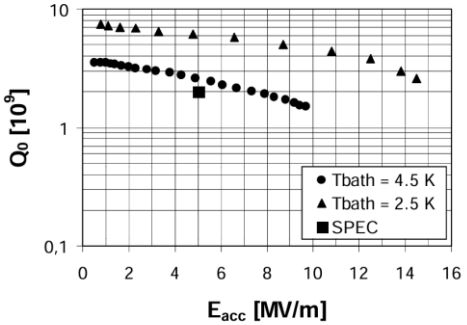
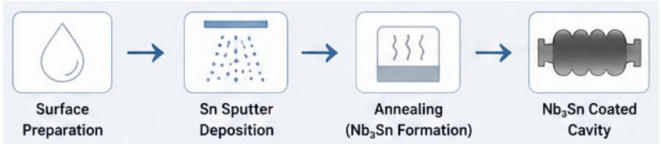


Fig. 4: Performance of cavity A11 at 2.5 K and 4.5 K bath temperature.

Technical Aspects and More

Technique (diffusion, PVD ...) of Nb3Sn coating on Nb or Cu cavities

- High-quality, Reliable, Reproduceable, Scalable...



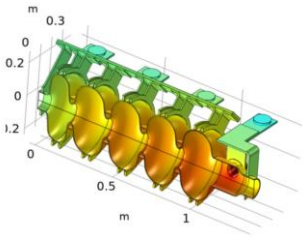
Brittleness of Nb3Sn films

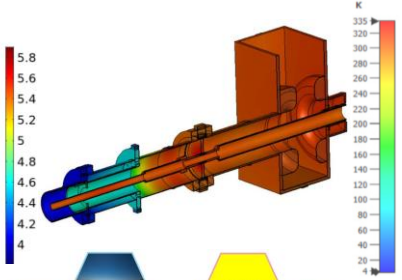
- Interlayer(s) between Nb3Sn film and bulk cavity
- Special procedures for assembly, testing, tuning and handling

R. C. Dhuley et al. **2022**
Phys. Rev. Accel. Beams.

Thermal management

- Controlled, uniform cavity cooldown (thermal links, outer Cu ...)
- Specialized design of low-loss high-power FPC





Example:
CryoMech PT450
5.0 W @ 4.2 K/ 65 W @ 45 K
Power consumption ≈ 25 kW

Cryocooler

- Cooling capacity versus power consumption
- Damping of vibrations

Potential applications

- Applications beyond wastewater treatment, medical sterilization...

Industrialization roadmap (TBD)

Industry scope

- Provide cavities for coating
- Engineering and design He-free cryomodules
- Manufacturing of a prototype

- Find business opportunities and first customers
- Mature systems for market entry

- Industrialized coating facility
- Provide turnkey cryomodule systems

short term

long term

Science scope

- Mature recipes for coating (reliability & repeatability)
- Coating and qualification of industry cavities for CM production

- Technology transfer/licensing to industry
- Support to industry on special topics

Continue technology improvement ;-)

- *Questions?*

Feel free to contact us.

+49-2204-7674-100

www.research-instruments.de