Creating the SRF facility at JINR

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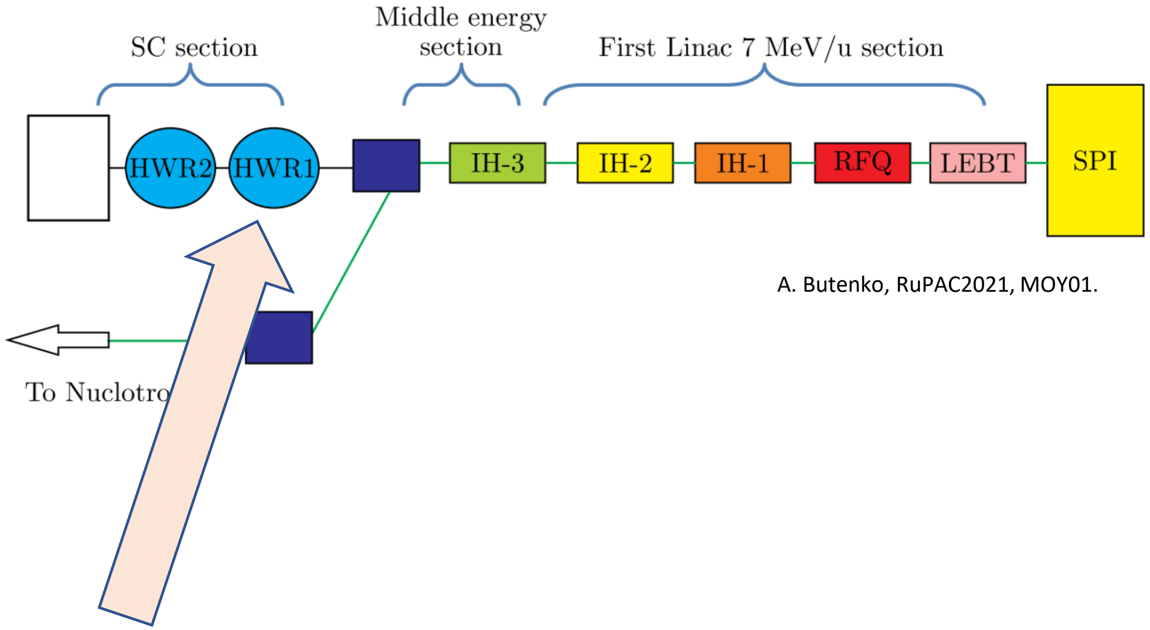
On behalf of JINR, MIPhI, BSU, PhTI colleagues

SRF cryomodule for NICA injector

Ongoing project of the JINR-IMP collaboration
Building SRF cryomodule for the new linac

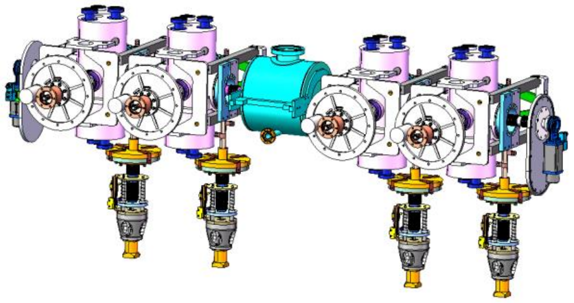


A. Butenko, RuPAC2021, MOY01.

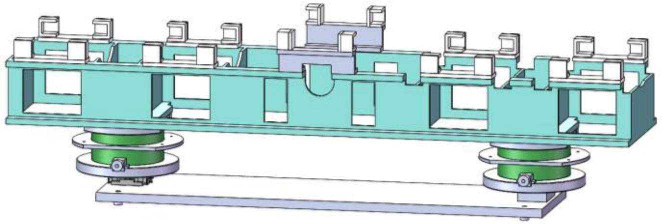
The cryomodule is ready and being tested at IMP

A joint collaboration of
JINR
IMP
MIPhI
BSU
PhTI

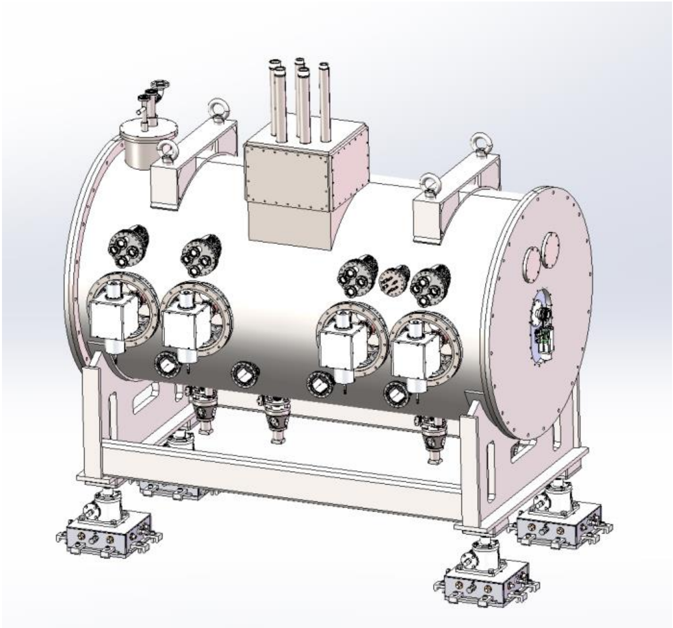
SRF cryomodule designed and built by IMP



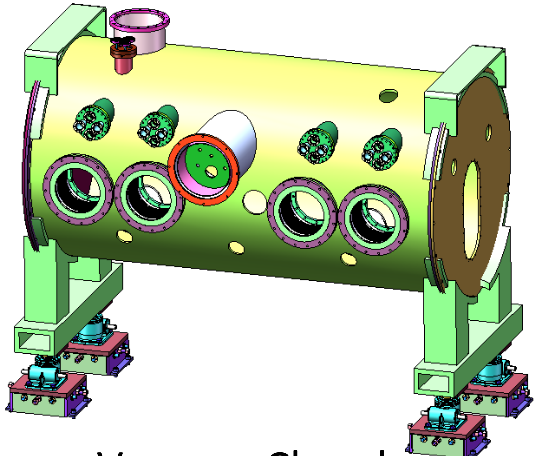
Coldmass



Coldmass frame

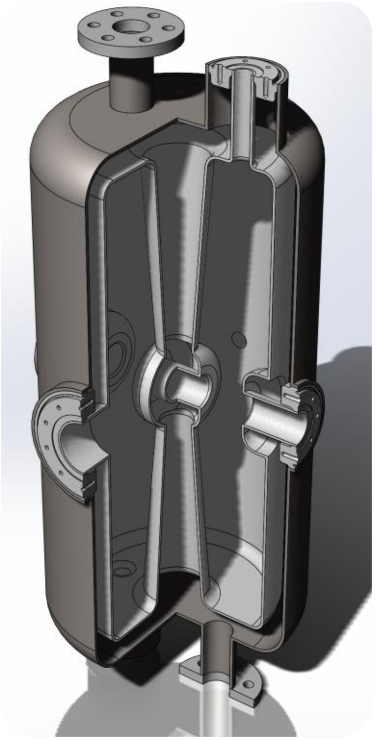


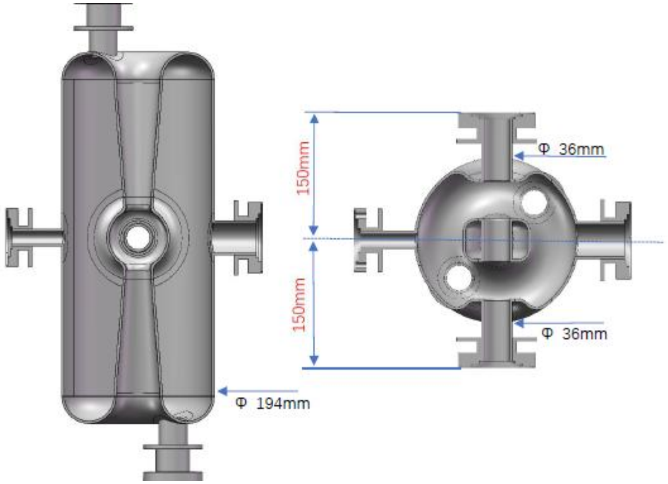
CM assembly

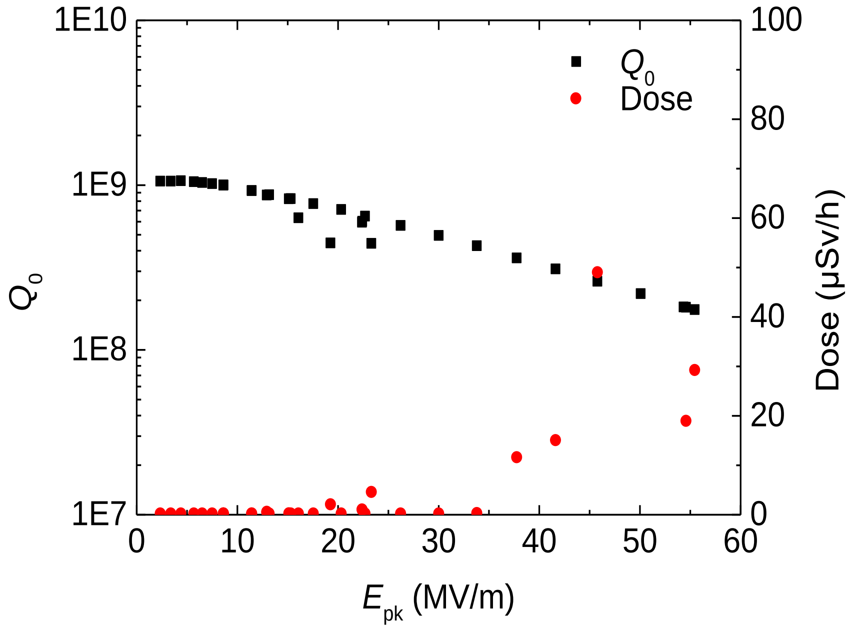


Vacuum Chamber

Niobium HWR cavities

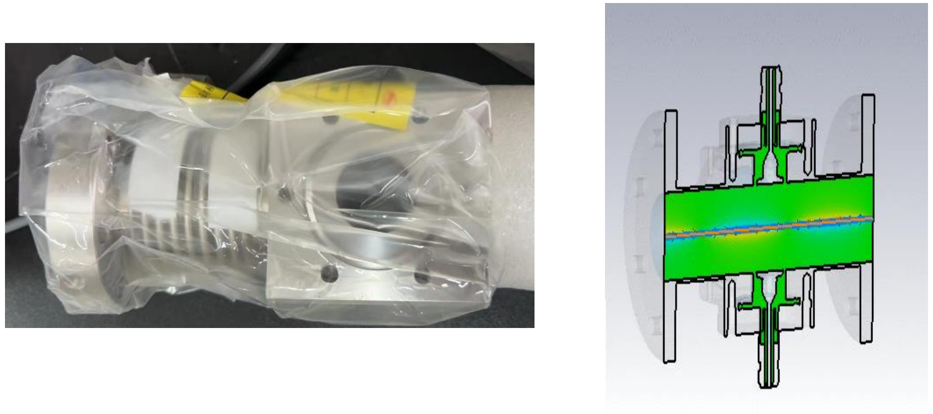






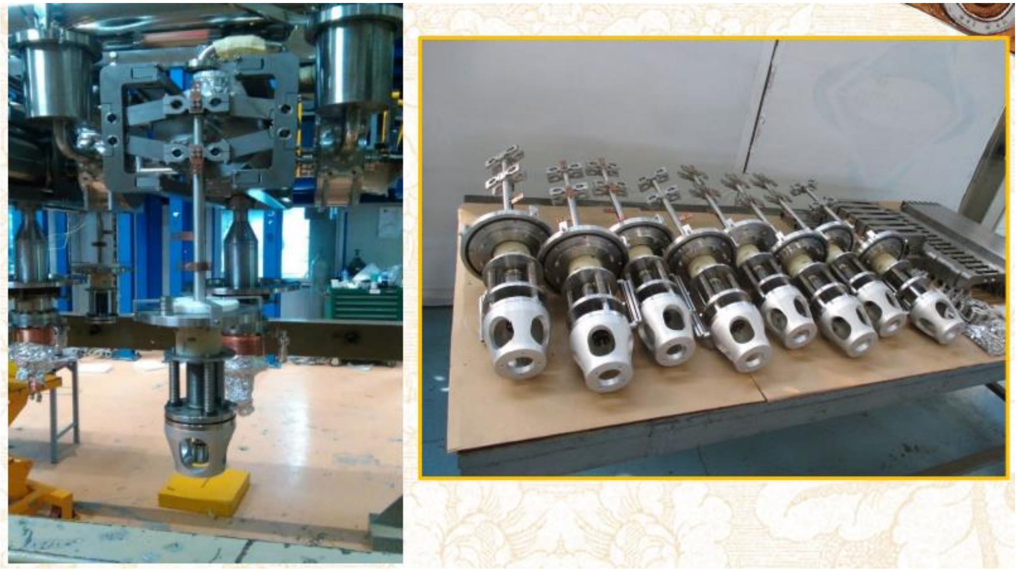
But not only cavities!

SC Solenoids



Beam Positioning Monitor (BPM)

Fundamental Power Couplers

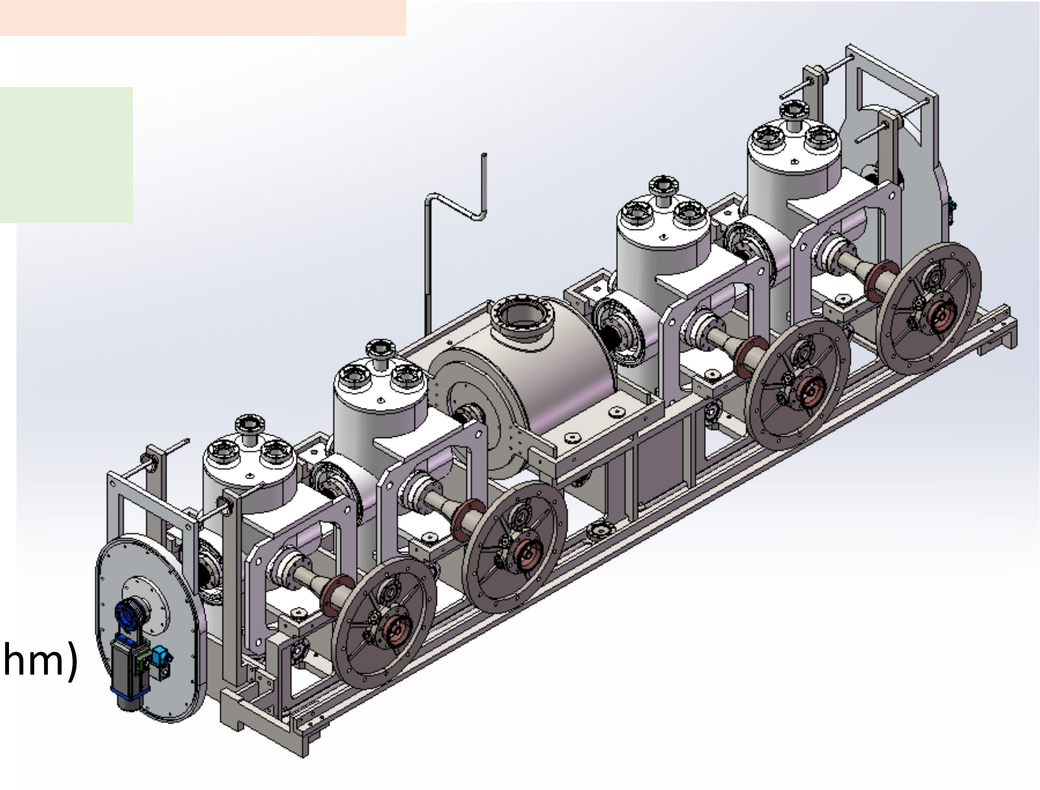


Tuners

Infrastructure required

World-wide problem (DESY, FNAL, JLAB, KEK etc.):
1. High probability of Field Emission (FE) after the cryomodule transportation
2. FE gradually increases during module operation.
3. Some maintenance is periodically required.

World-wide solution:
SRF “retreatment facility” close to the accelerator



Basic retreatment includes:
- Removing the cold-mass from the module
- Couplers dismounting
- Cavities dismounting
- Slow pump/ Slow vent (SPSV) is mandatory
- Ultra-sonic bath cleaning of every part
- Cavities: High Pressure Rinsing (HPR) with Ultra-pure water (18 MOhm)
- “Ion gun” cleaning of every part (also every nut and bolt)

Basic retreatment requires: ISO5 (ISO4) cleanroom with tooling and equipment, UPW facility, SPSV systems

and **TRAINED PERSONNEL**

SRF technology

SRF cavities require extremely high cleanliness:
- Any particle large than 0,3 um inside the cavity can cause a field emission and a cavity quench
- Any surface contamination (at ppm scale) can reduce the quality factor of the cavity

50 years of the world's SRF experience shows that a **dedicated facility is required**
- In general: tools and equipment should not be used for non-SRF activity
- Recleaning and refurbishing of the equipment after improper use often is more expensive than building a new one

To operate and maintain the cryomodule a dedicated SRF infrastructure is required

New JINR-IMP project

Building basic SRF infrastructure at JINR

Based on our previous project and experience (with IMP, BSU, MIPhI):
- We already have many of the components/technologies required for SRF
- However, they are not SRF-dedicated
- Some of them (clean-room, UPW) are not of a required scale
- Many components are located in different cities and countries
- Some of the available components/technologies are quite advanced
- We are lacking of a BASIC INFRASTRUCTURE making impossible use of already available technologies.

With the support of IMP we are going to create a **dedicated SRF facility at JINR**
- We start with a **minimal facility required** to maintain an SRF cryomodule
- However, we design it in the way to allow JINR to develop a full-scale SRF program in the future

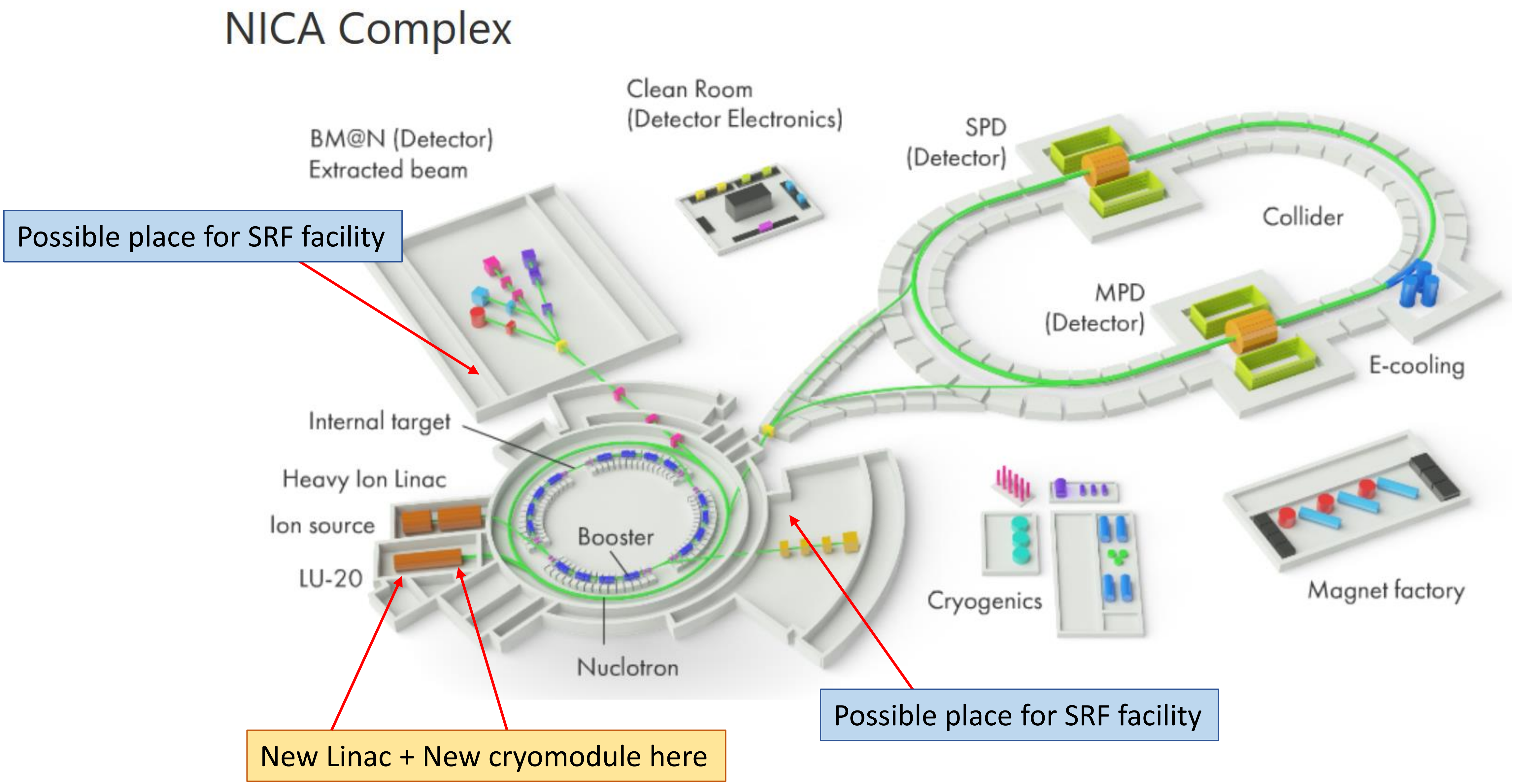
Basic facility:
ISO 5 clean room with an HPR setup and an ultra-pure water setup

All other SRF technologies require this basic facility!!!

Cavity integration

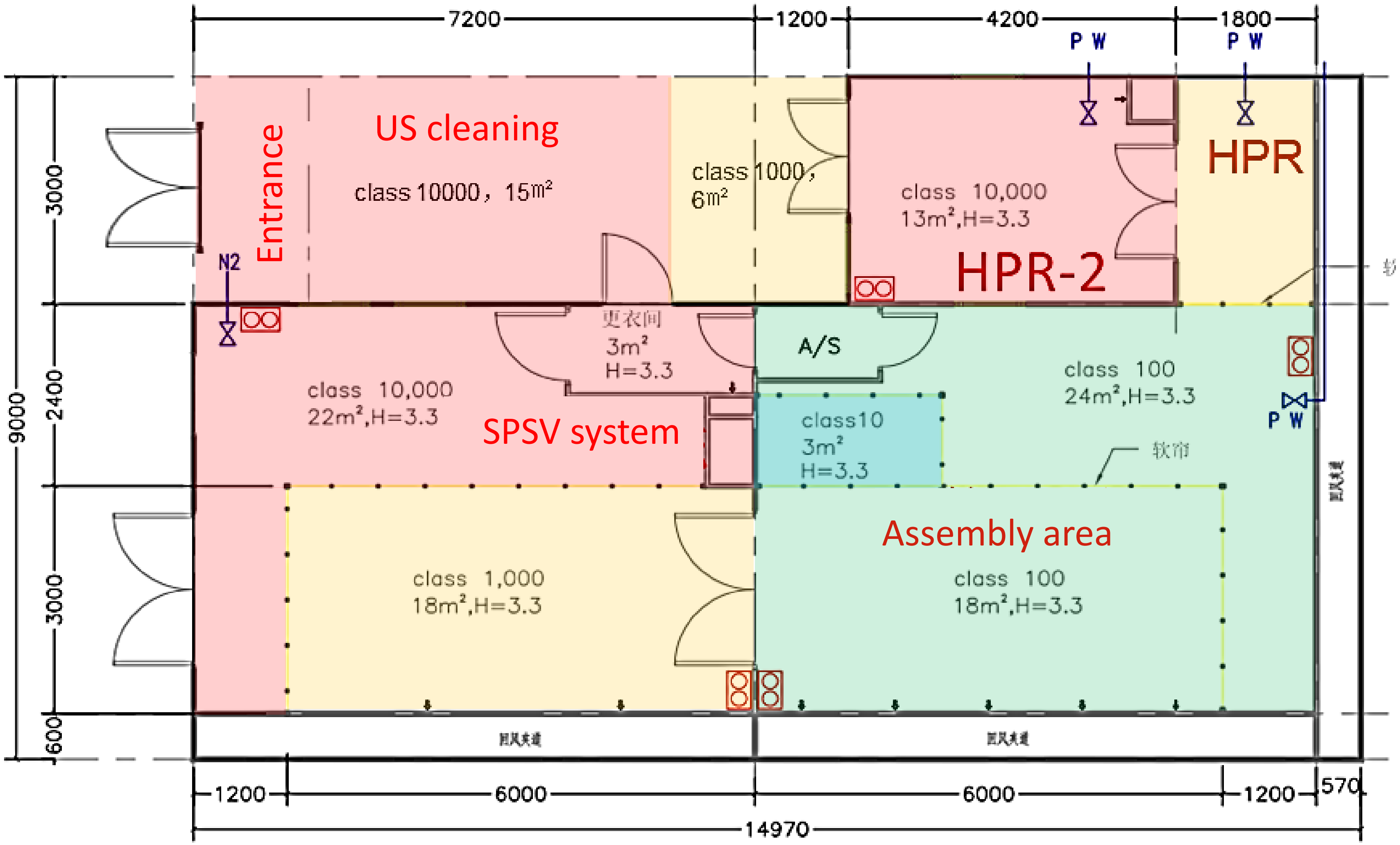
In addition in the next project two more cavities will be built by IMP
Should be integrated into the cryomodule at JINR

NICA complex layout



Very important: the cleanroom

"Old" IMP cleanroom: ca. 135 m^2



ISO 7
ISO 6
ISO 5
ISO 4

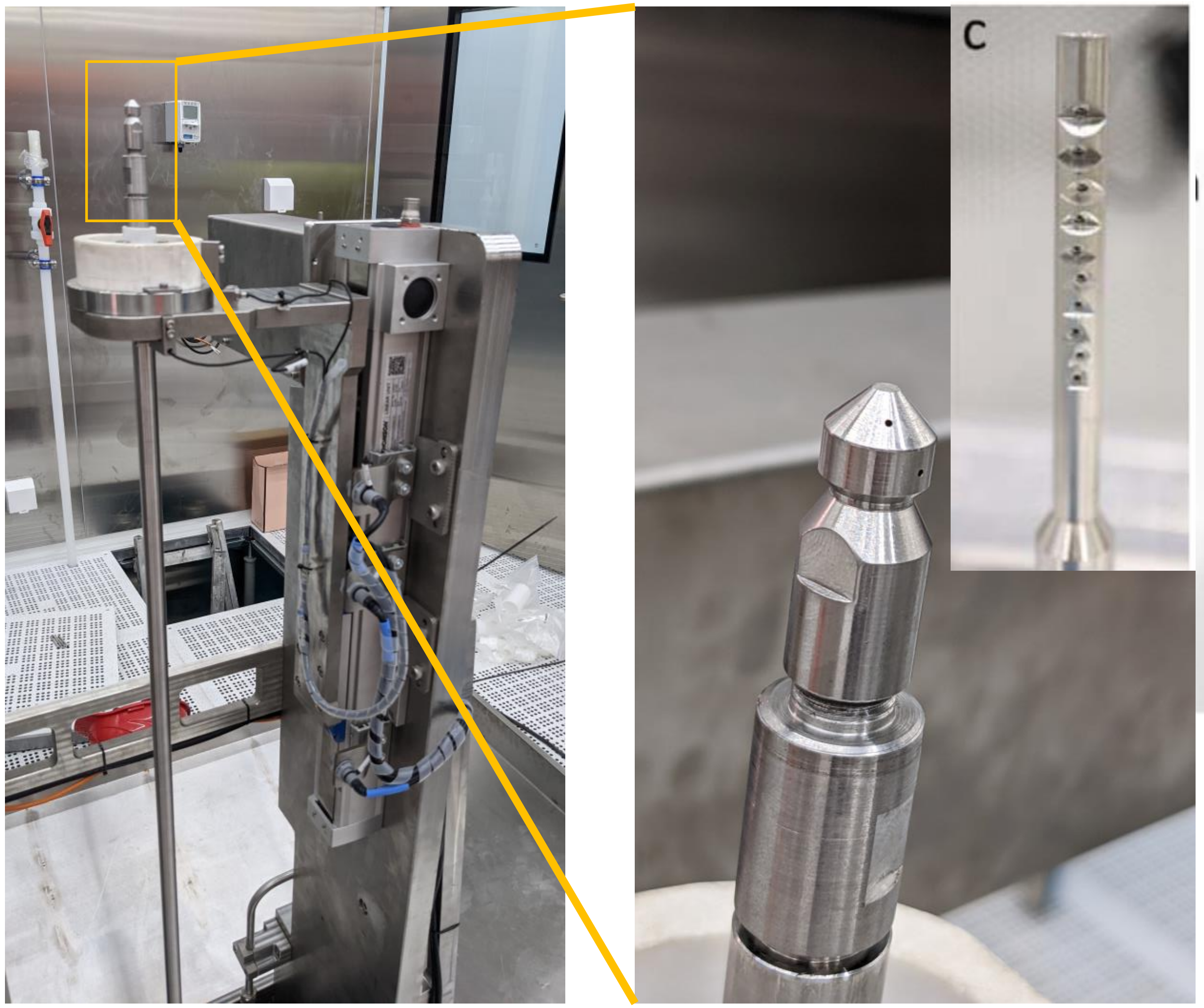
Very important: the cleanroom

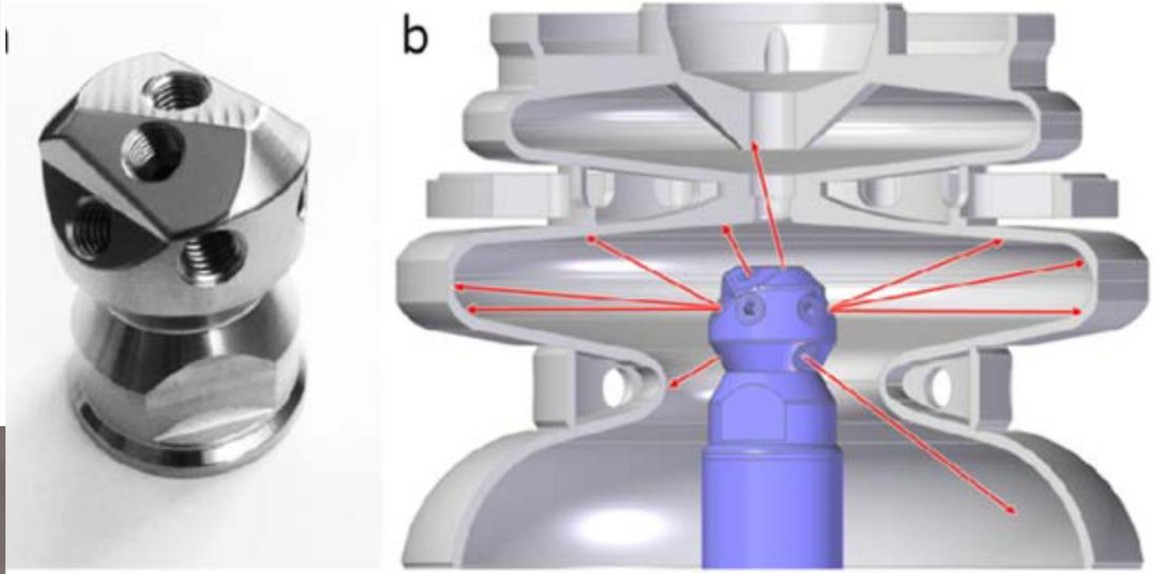
HPR system inside a cleanroom (HZB, Berlin)

Very important: ultra-pure water facility

UPW plant at IMP

High Pressure Water Rinsing





RF Testing after retreatment is required

Cold RF Testing of a single cavity with a High-Q antenna – **“Vertical” test**

Cold RF Testing of a single cavity with a FPC and a tuner – **“Horisontal” test**

Built by BSU

A complete set of tests of an assembled cryomodule

Vertical Test Stand at HZB

Horizontal Test Stand at HZB

SRF facility stages

1

Clean room
- Class ISO 5 (locally ISO 4)
- Particle counter
- Ion gun blow
- Slow pumping/slow venting
- US bath
- Leak checking

Ultrapure Water Plant
- Volume: 3000 l
- TOC control
- UV flow-through reactor

High Pressure Water Rinsing (HPR)
- Clean pump: 100 bar
- Holding frame
- Translation and Rotation

We do not have it!

2

Buffer Chemical Polishing setup
- Closed Loop
- UPW rinsing

Vertical Cryostat
- Closed He loop
- Radiation protection

High-Q RF measurements
- Power up to 300 W CW

Diagnostics
- Field profile control (bead-pull)
- 3D measurements

We have most of this!

3

Vacuum furnace (900C)

Electron-beam welding

Metallography

Cryotesting with reduced pressure (T<4.2K)

Electro-chemical polishing (EP)

Cryomodule and cavities assembly/disassembly
Cavity rinsing (HPR)

Cavity testing (warm and cryogenic)
Cavity repair/retreatment (BCP, local polishing)
Cavity production in collaboration

Full circle of cavity production and testing

Fundamental and Applied Science

SRF is a relatively new field of science, in which discoveries are made almost every year.

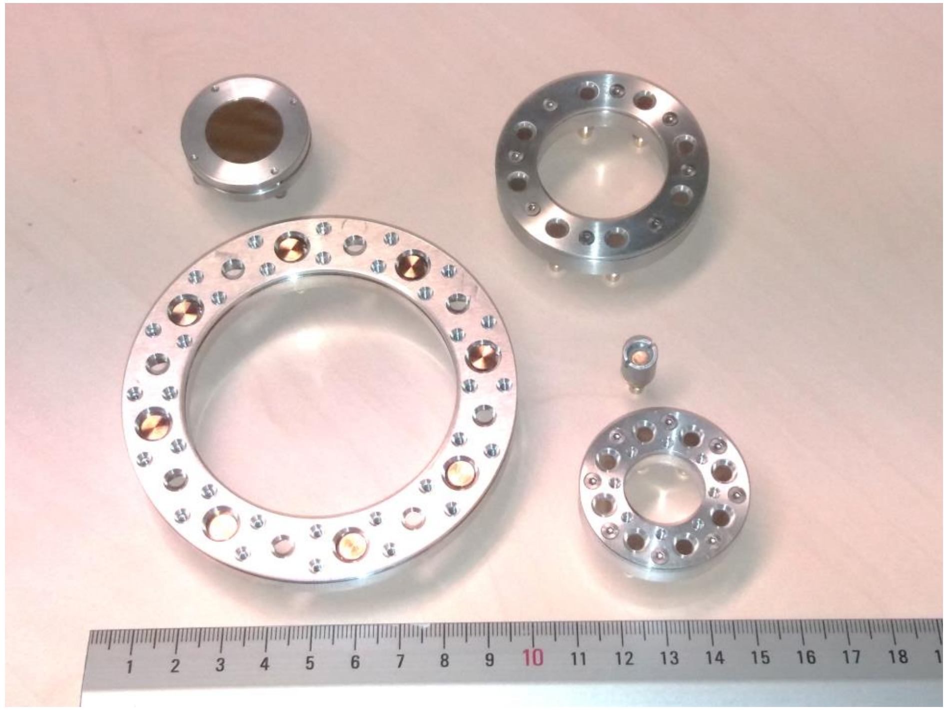
We are collaborating on **basic SRF research** and development currently based on IMP infrastructure:

- Diagnostics development
- Material treatment
- Fundamental material research

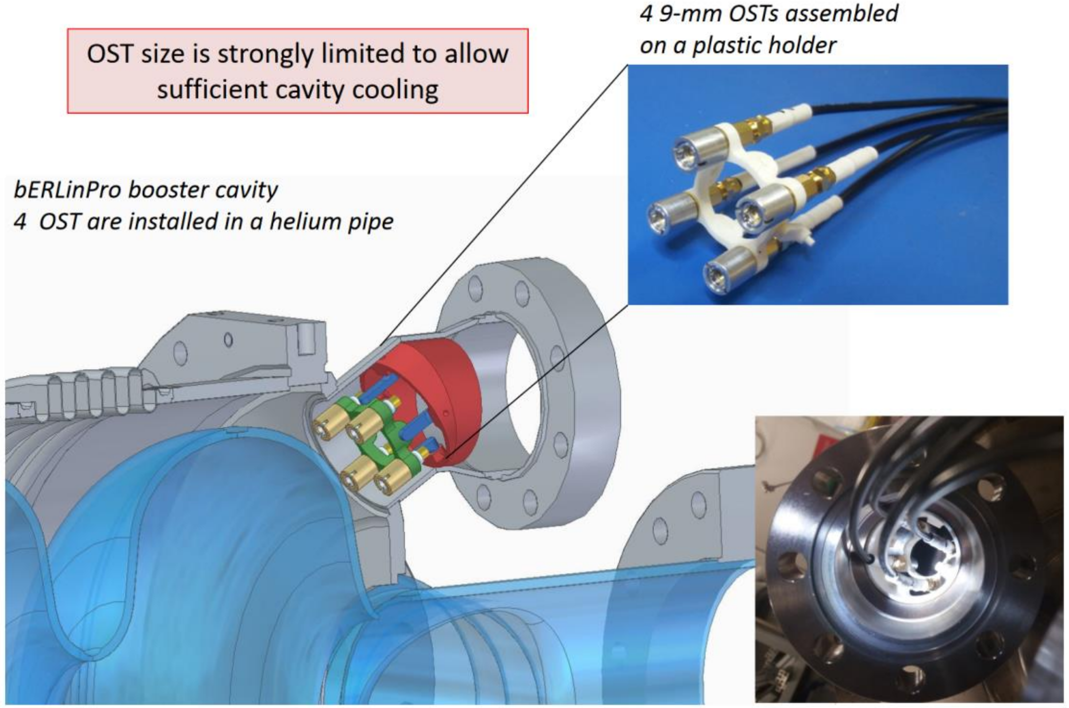
We are going to establish a student exchange program between all partners

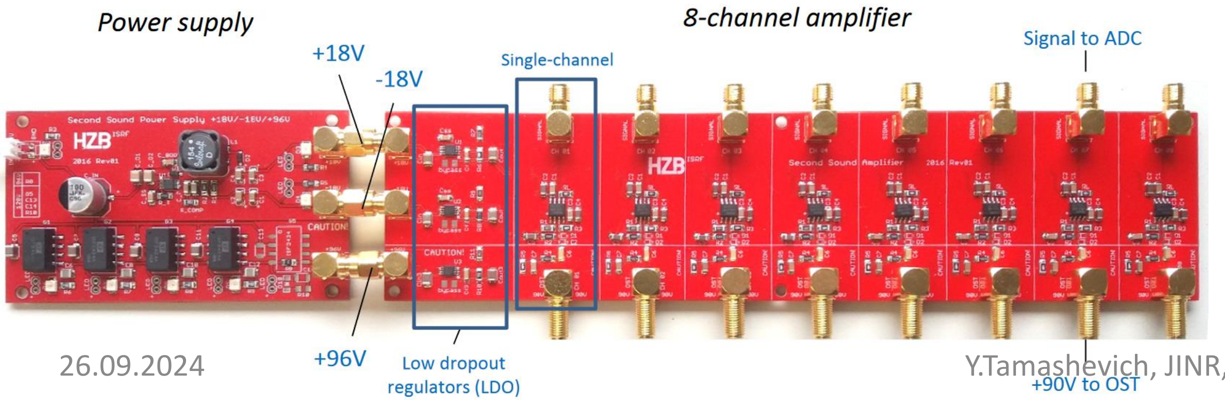
Collaboration on SRF R&D

Quench detection system for IMP: Oscillating Superfluid Transducers



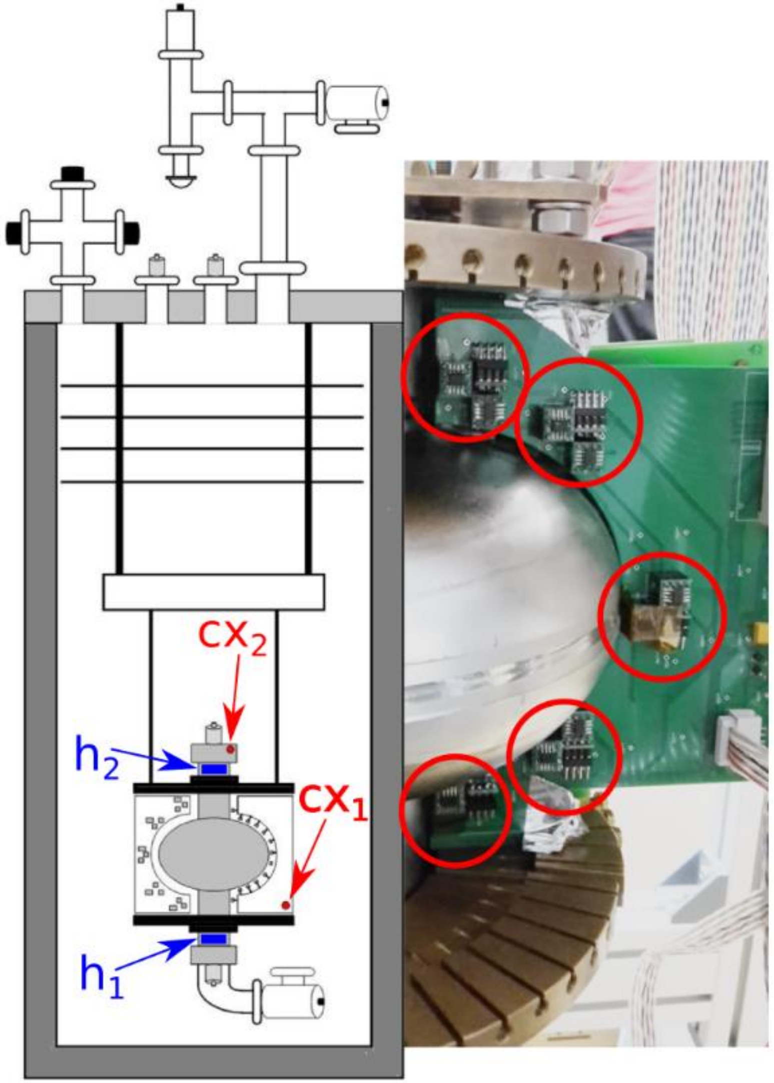
OST size is strongly limited to allow sufficient cavity cooling

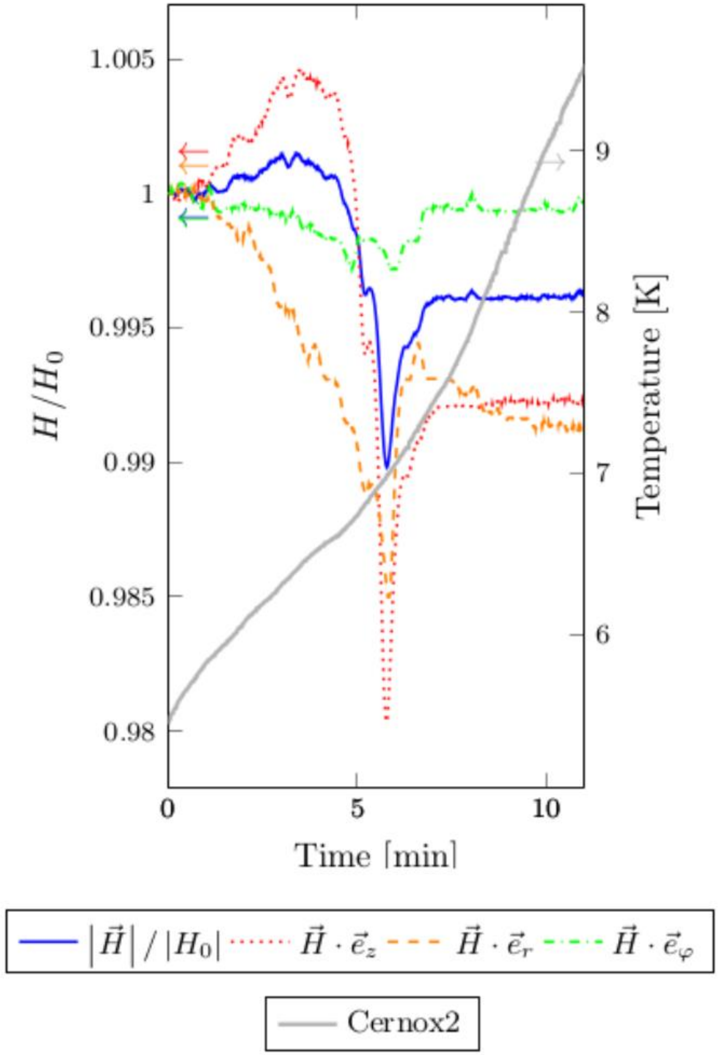




Collaboration on SRF R&D

Magnetometry mapping of trapped flux

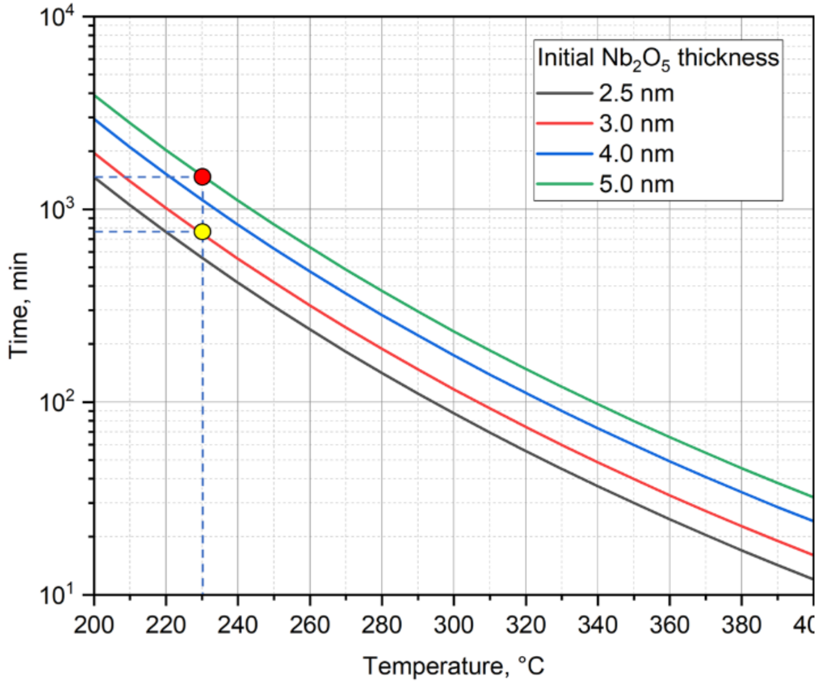




Collaboration on SRF R&D

Moderate Temperature Baking of SRF cavities

Will be presented at TTC2024 (Nov.2024, Lund)



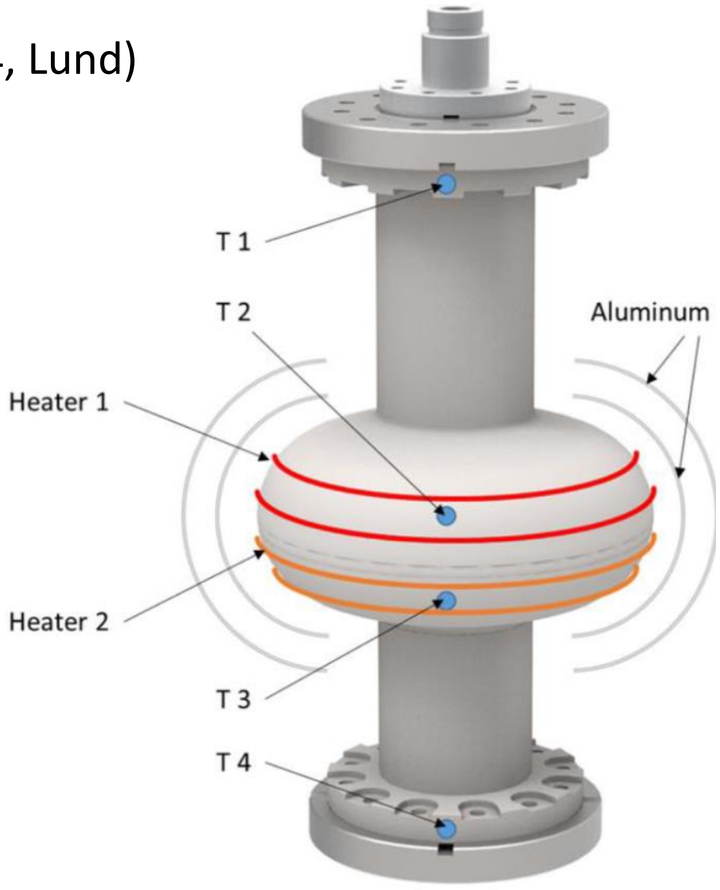


Figure 1: *Schematic view of the experimental setup.*

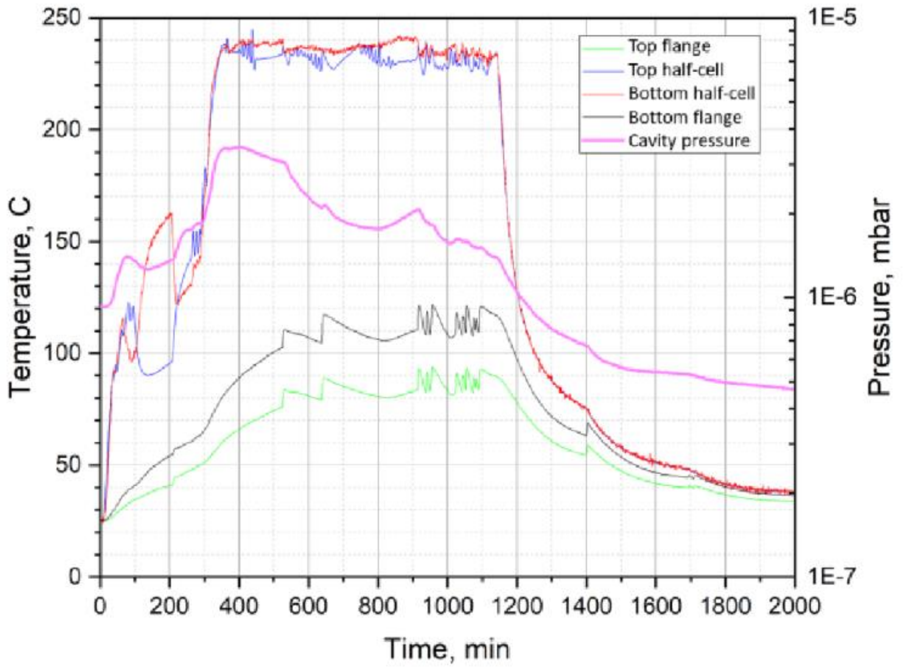
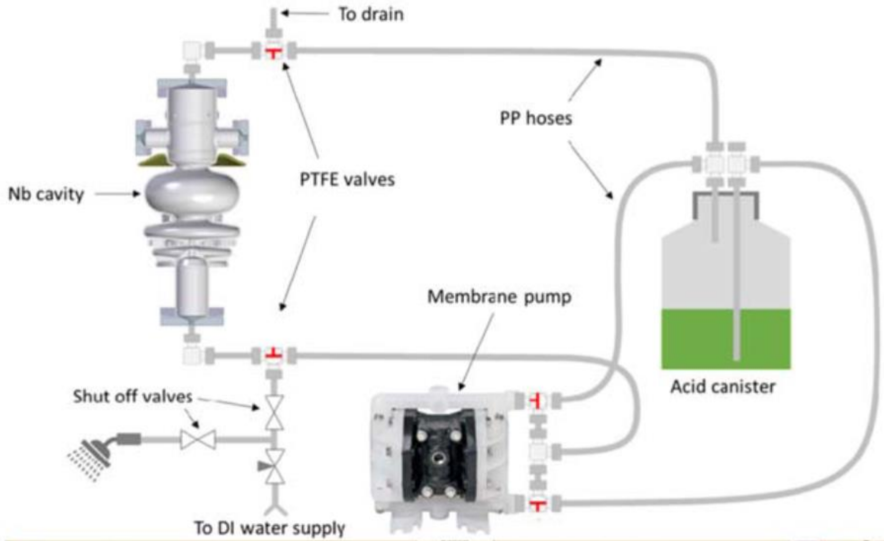
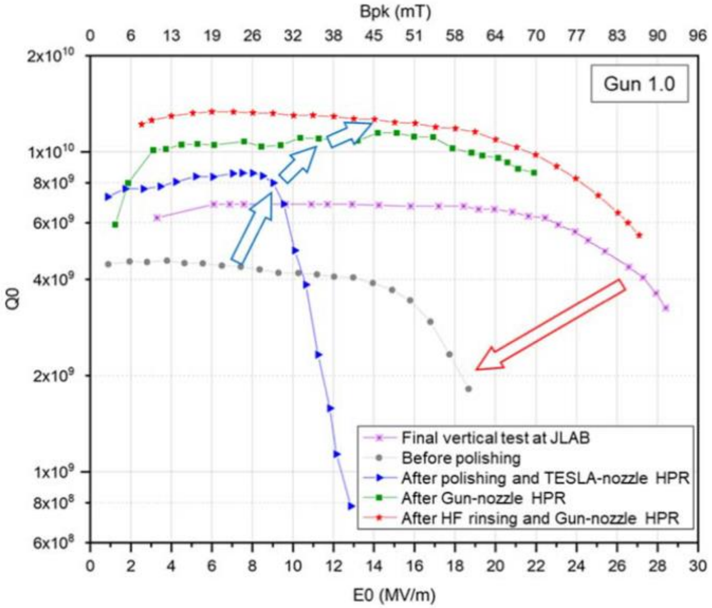
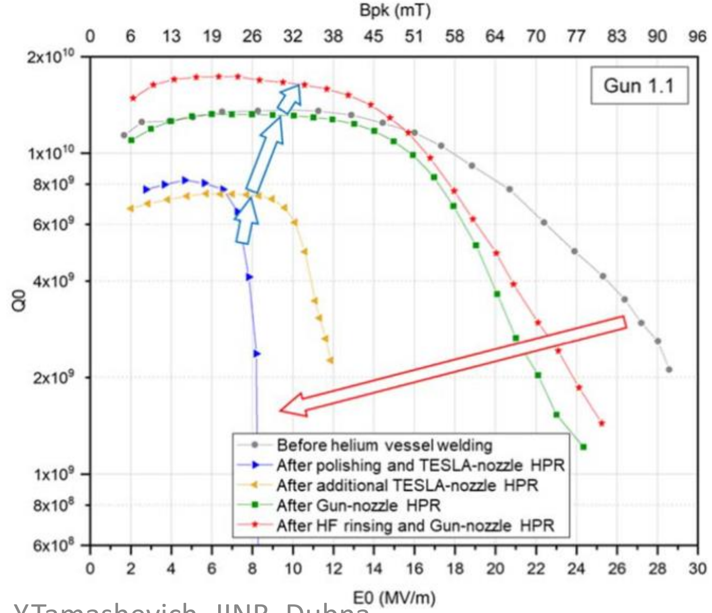


Figure 4: *Temperature and pressure plots during the first heat treatment.*

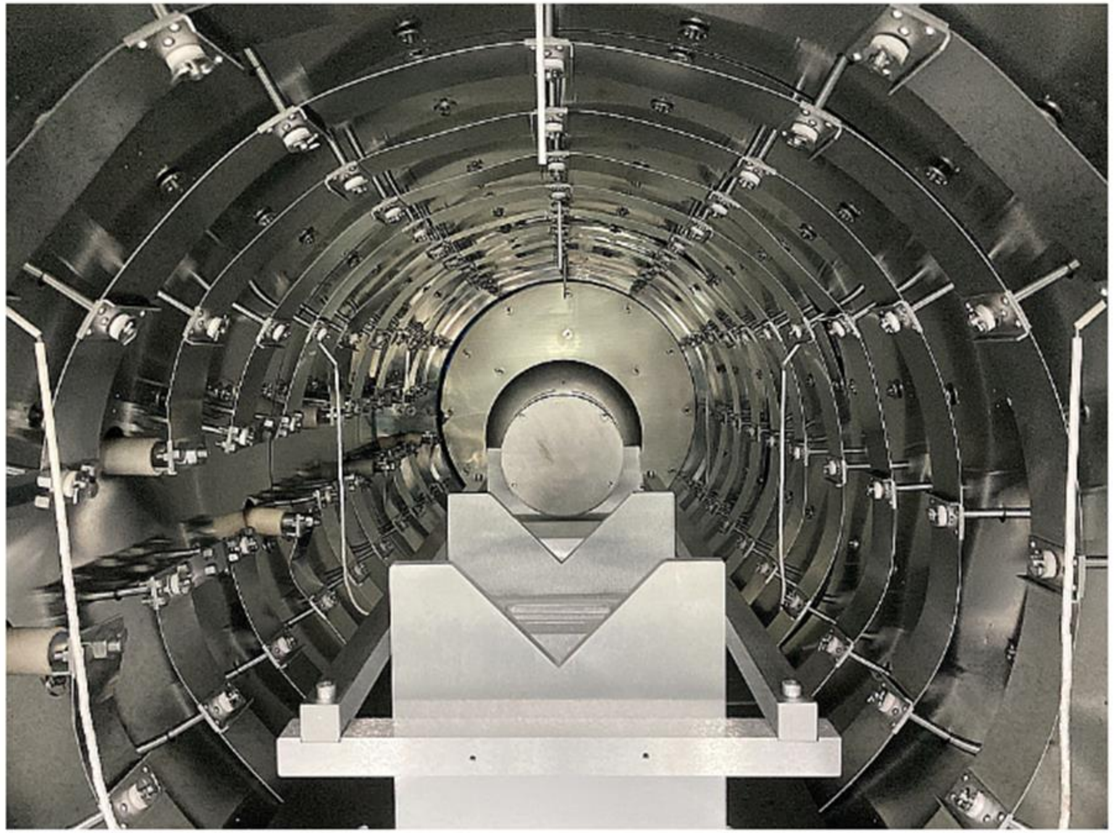
Future steps: Chemical Etching







Future steps: High Temperature Annealing



Future steps: Electron Beam Welding

千里之行，始于足下

万事开头难

Thank you!