research instruments

Production of accelerators and accelerator components in industry

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RI Research Instruments GmbH

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51429 Bergisch Gladbach

Foundation of RI Research Instruments

1993: Foundation of ACCEL Instruments as management buyout of Siemens/Interatom. Start with about 30 key people, M. Peiniger and U. Klein as managing directors

2000: About 120 people working in the fields: RF cavities, Linacs and special products (AS department), superconducting magnets and circular accelerators (MA department) and optical beamlines (BL department)

2003: The MA department starts development of a superconducting proton cyclotron for medical application (200 MeV)

2004: about 270 people working for ACCEL

2007: Varian Medical Systems acquires ACCEL mainly because of the proton therapy technology (share deal)

2008: Varian divides ACCEL into the PT (proton therapy) branch and the RI (Research Instruments) branch

2009: Bruker Advanced Supercon, Inc acquires the RI branch of ACCEL as an asset deal from Varian. The MA and BL business is further transferred to the new BASC GmbH, a 100% daughter of Bruker, the AS business is transferred to the new RI Research Instruments GmbH a company owned 55% by Bruker and 45% by the management. The special manufacturing department (EB welding, UHV brazing, machining, chemical treatment stay at RI.

RI Research Instruments GmbH

Advanced Technology Equipment and Turn-Key System Supplier for Research, Industry and Medical worldwide

RI Research Instruments -Site in the Technologiepark Bergisch Gladbach (BAB A4)

Linear Accelerators

RF Cavities, Couplers, Auxiliaries

Superconducting Accelerator Modules

Electron and Ion Sources

Beam Diagnostic Elements and Particle Beamlines

Accelerator Equipment for Particle Therapy

Specialized Manufacturing Projects

research instruments

Manufacturing premises

Electron beam welding
UHV brazing
Turning, milling
Chemical treatment facilities
Chemical polishing, electro- polishing

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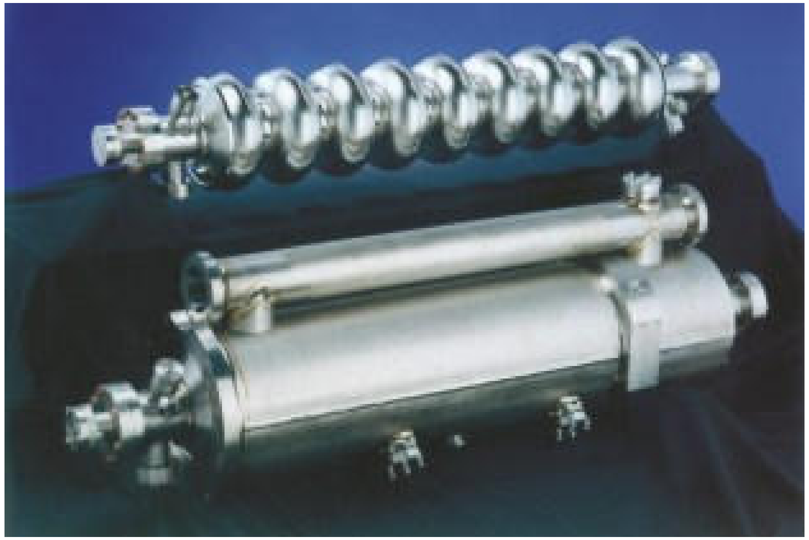
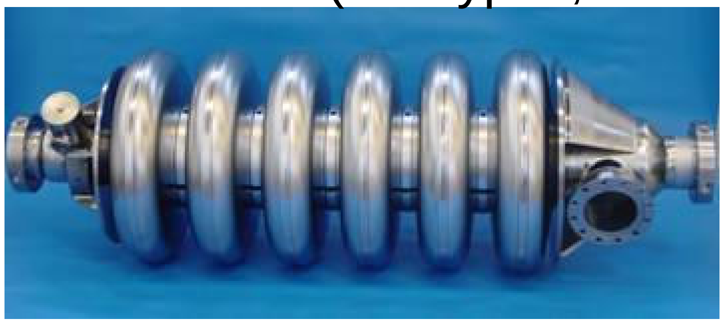
Superconducting cavities – series production

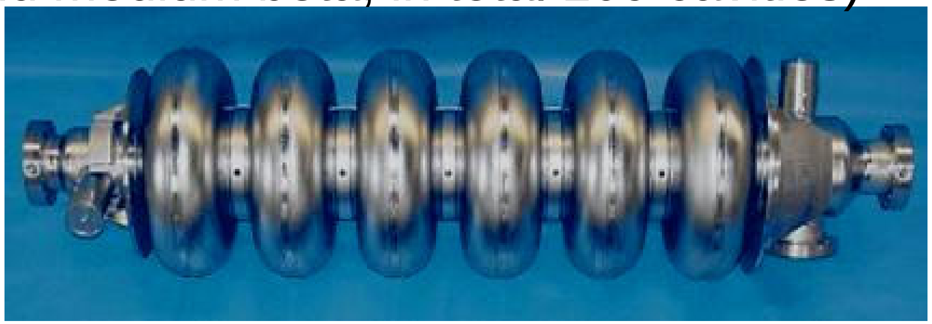
TESLA (XFEL, ILC) cavities (>100)



CEBAF cavities (360)

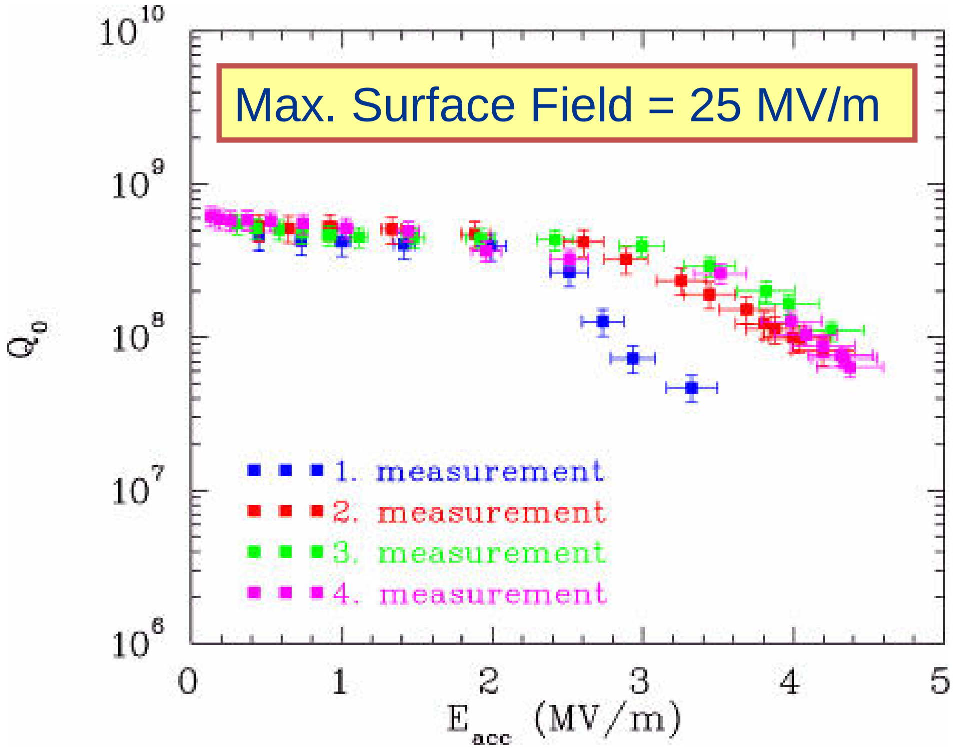
SNS cavities (two types, low and medium beta, in total 109 cavities)





Superconducting cavities - prototypes

Frankfurt CH mode cavity, 357 MHz

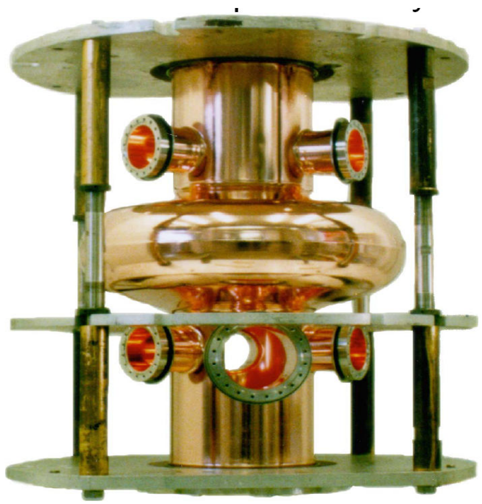


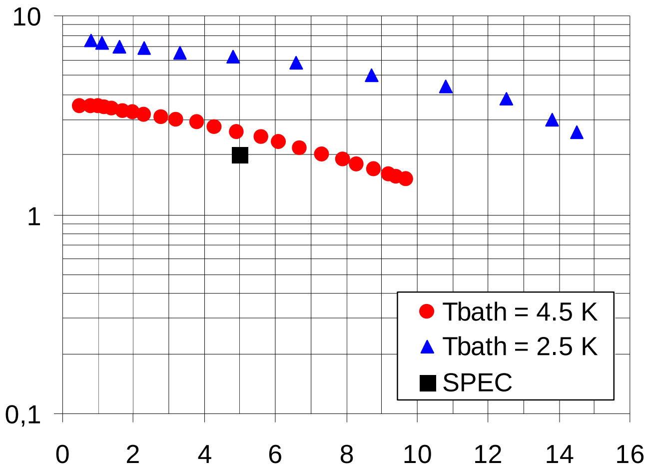
Chemical preparation, High pressure rinsing, assembly in our clean room

Vertical test at University Frankfurt

Nb/Cu coating technology

SRF Cavity production: Niobium on Copper technology for LEP, LHC





Chemical preparation, rinsing,

assembly in clean room at our premises

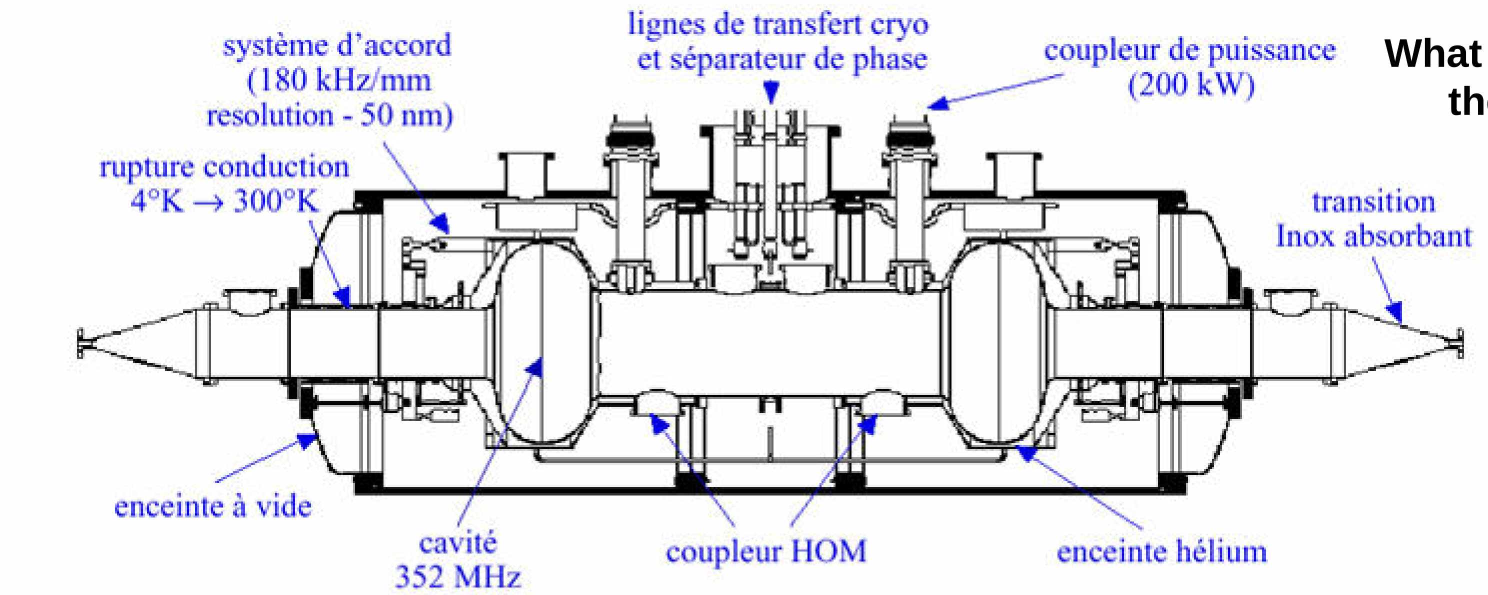
Vertical test at CERN

SOLEIL: Nb/Cu technology

SOLEIL: 2.75 GeV, 500 mA light source

- Nb/Cu single-cell HOM damped cavities
- Designed and built by Saclay/CERN collaboration
- 352 MHz
- 1.5 MV/cavity
- LEP input couplers @ 200 kW
- loop HOM couplers

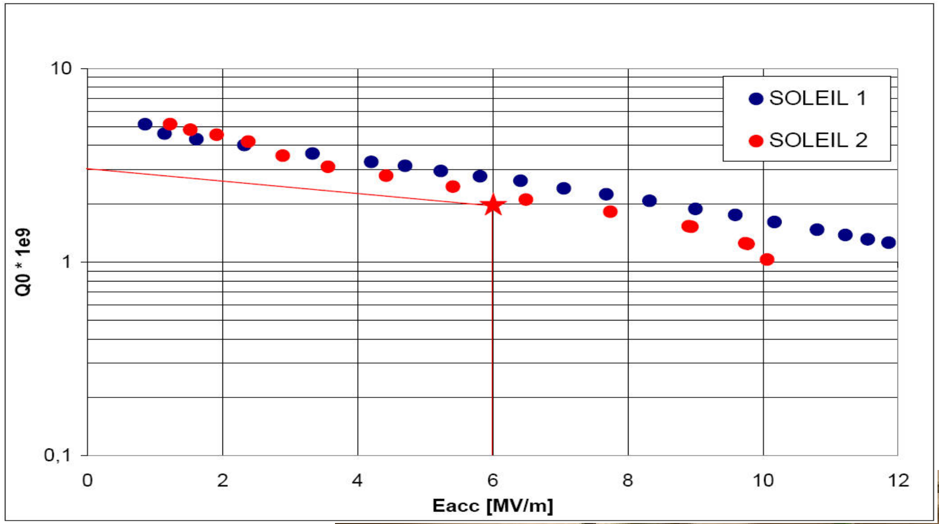
What the beam sees from the SOLEIL module



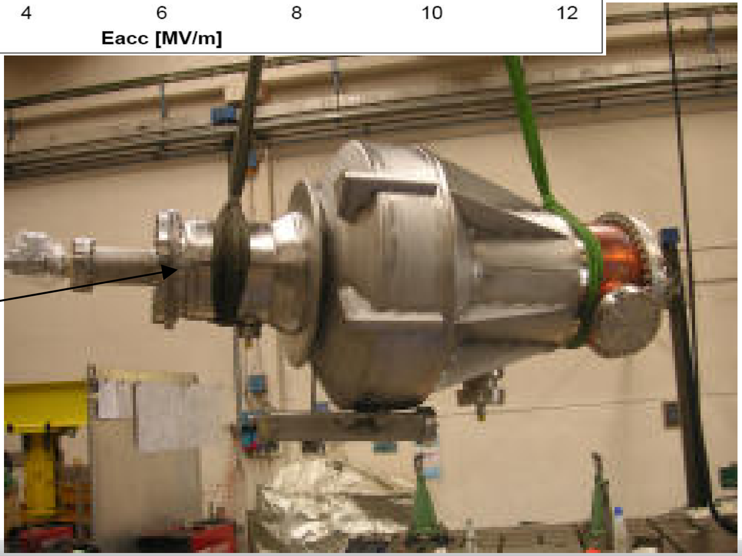
Two single cell cavities (352 MHz) in one vacuum vessel

SOLEIL: 350 MHz storage ring twin module

Module delivered to SOLEIL in May 2008.



After EB welding



After helium vessel welding

500 MHz SRF modules

NSRRC decided 1999 as the first Light Source to use SRF modules for TLS. CORNELL allowed a technology transfer to us of their technology.

Since then, the following contracts were awarded:

2000:	2 SRF modules	for NSRRC,	Taiwan
2000:	2 SRF modules	for CORNELL,	USA
2000:	2 SRF modules	for CLS,	Canada
2003:	3 SRF modules	for DLS,	Great Britain
2005:	3 SRF modules	for SSRF,	PR China

In total 12 RF modules have been produced and all modules are delivered, installed and accepted.

For comparison, to our knowledge:

Cornell built	5 SRF modules
KEK built	9 SRF modules
Mitsubishi built	2 SRF modules

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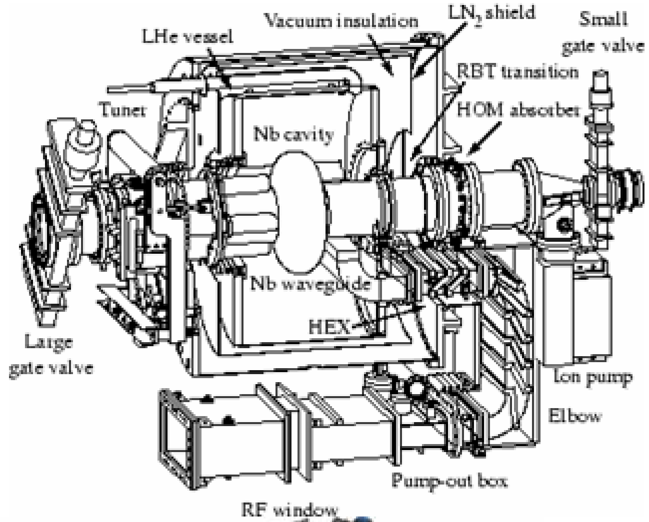
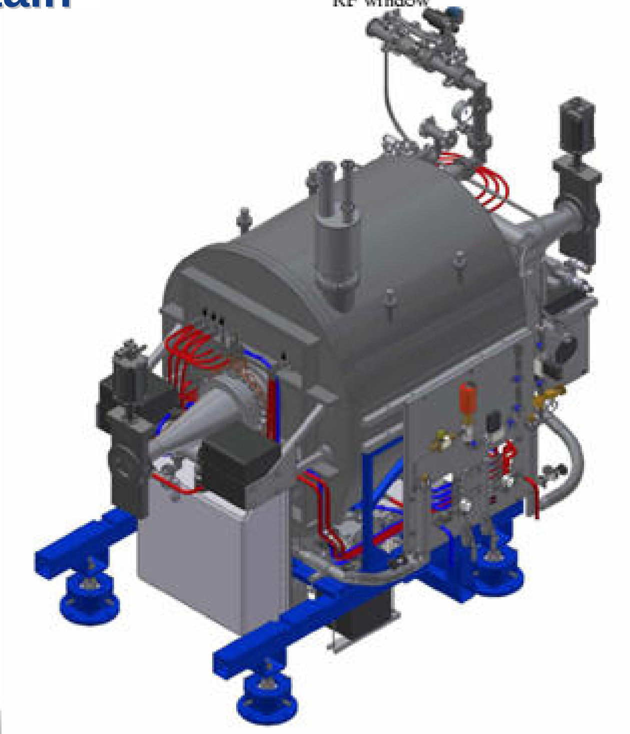
CORNELL UNIVERSITY





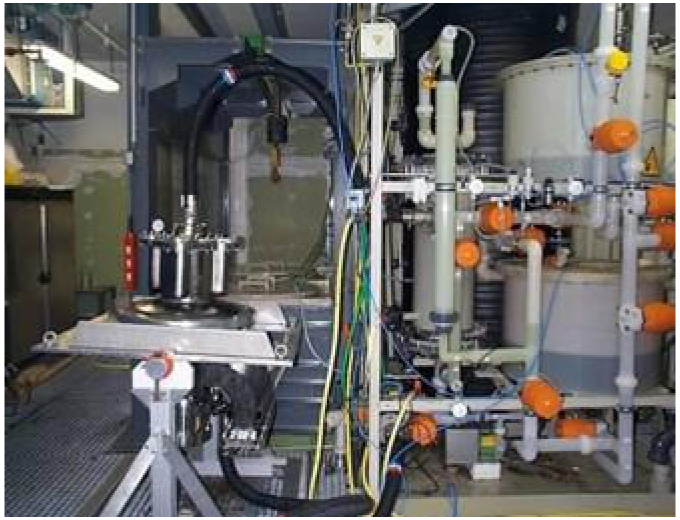
Turn key Cornell style SRF modules

Scope can cover

- Cavity production
- Cavity surface preparation
- Cavity vertical test
- Coupler production
- Coupler conditioning
- HOM loads
- Module assembly
- Installation
- Commissioning
- Valve boxes
- transfer lines
- SRF Electronics
- Interlock and data acquisition system

Module performance:
to be discussed with customer
$V_{acc} < 2$ MV, $Q_0 = 5 \times 10^8$

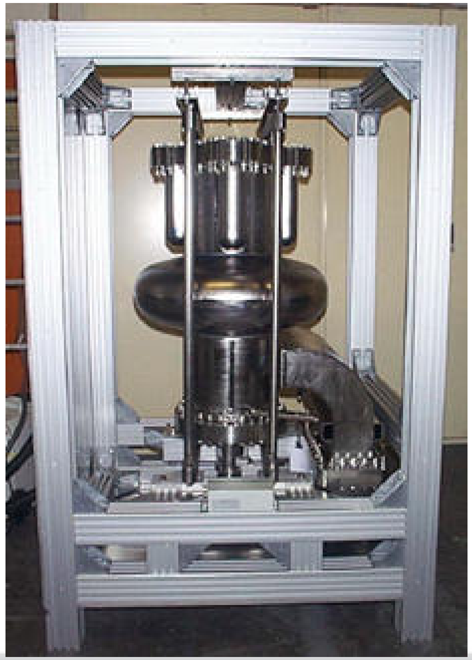
Cavity preparation for vertical test



Closed loop BCP →

HPR

Assembly in clean room



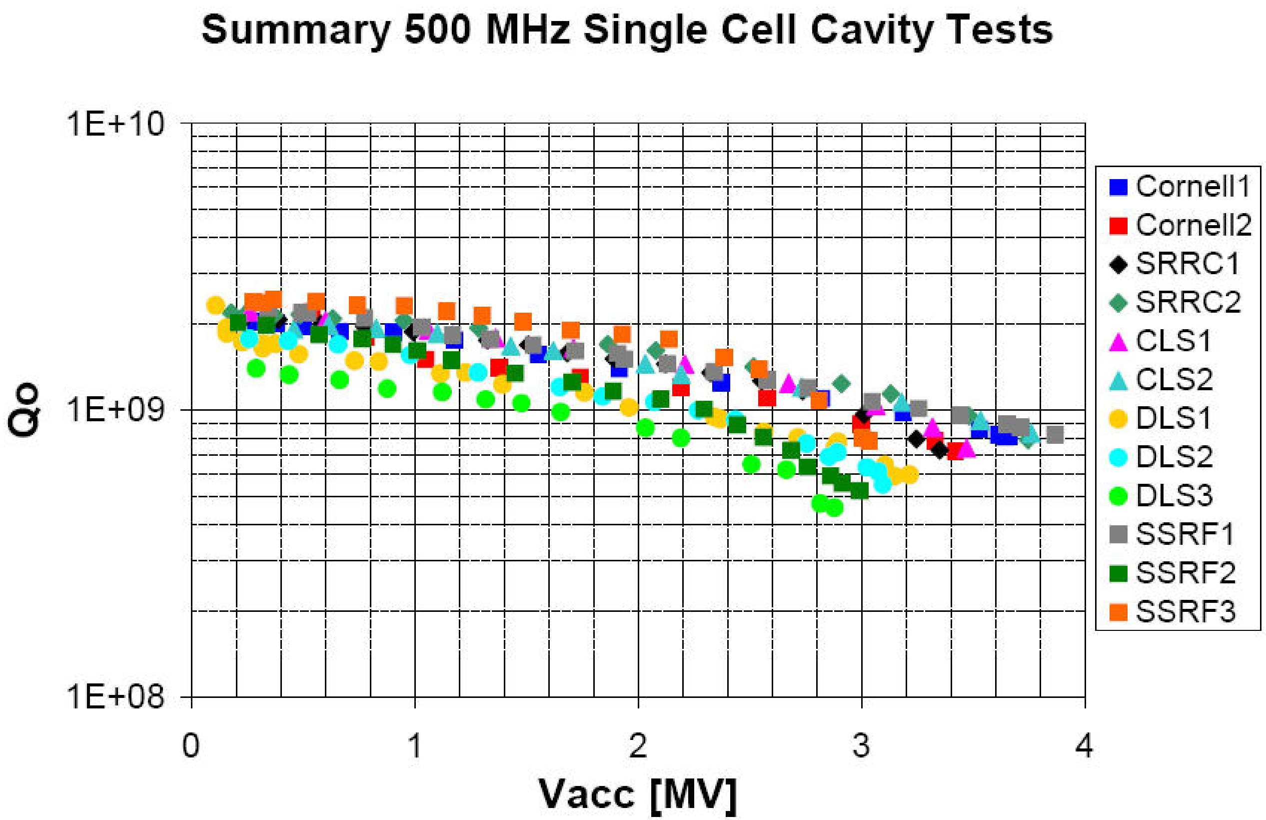
Packing and shipping for vertical test

Cavity preparation and vertical test results

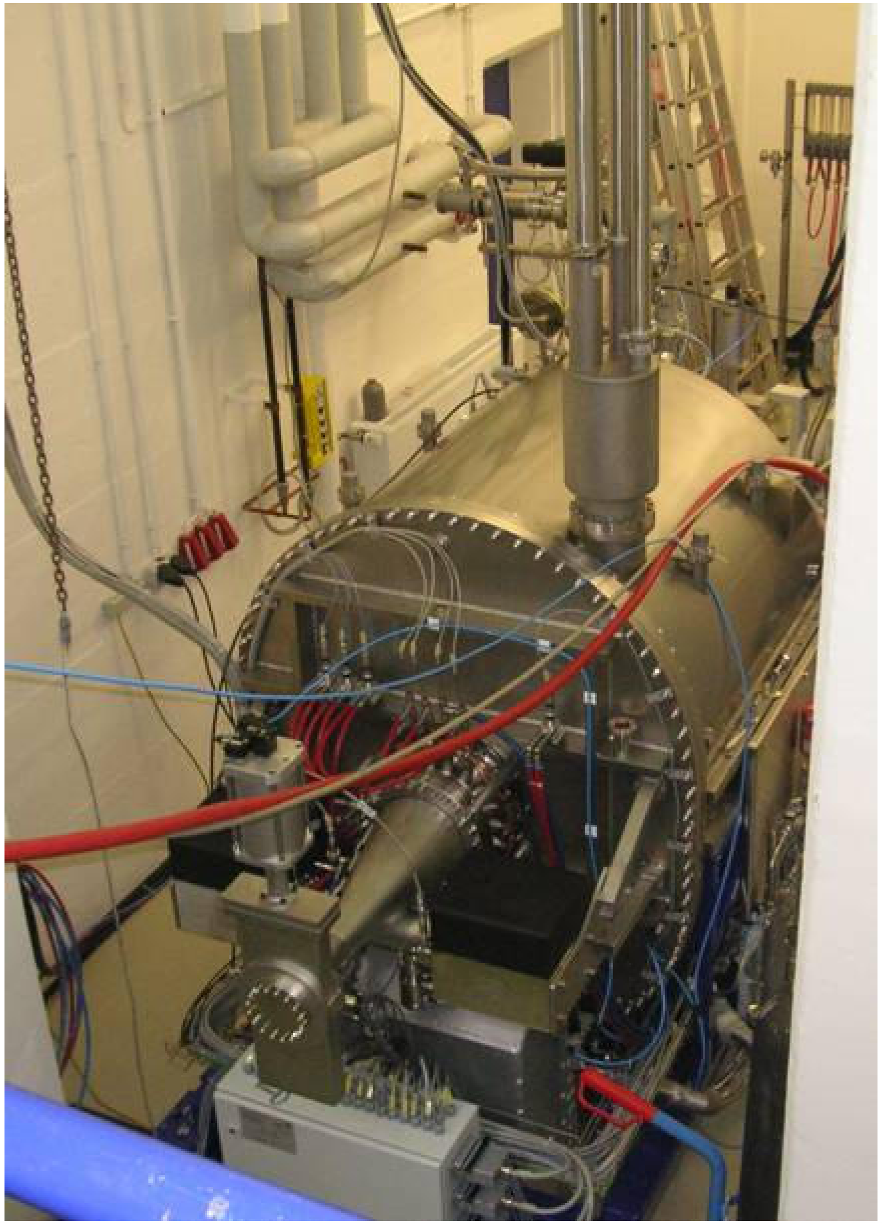
Preparation is done as follows:

- **Degreasing**
- **Buffered chemical polishing (1:1:2), in closed loop chemistry, acid actively cooled to temperatures below 15 ° C**
- **Water Rising > 17 MWcm**
- **High pressure water rinsing (100 bar)**
- **Drying by pumping**
- **Assembly in class 100 clean room**

- **All test results achieved in consecutive preparations / tests**
- **All field values limited by available RF power**



Factory acceptance test with valve box and SRF electronics



Transport/Logistics

Special transport frame
for shock absorption

Transport in air ride
truck

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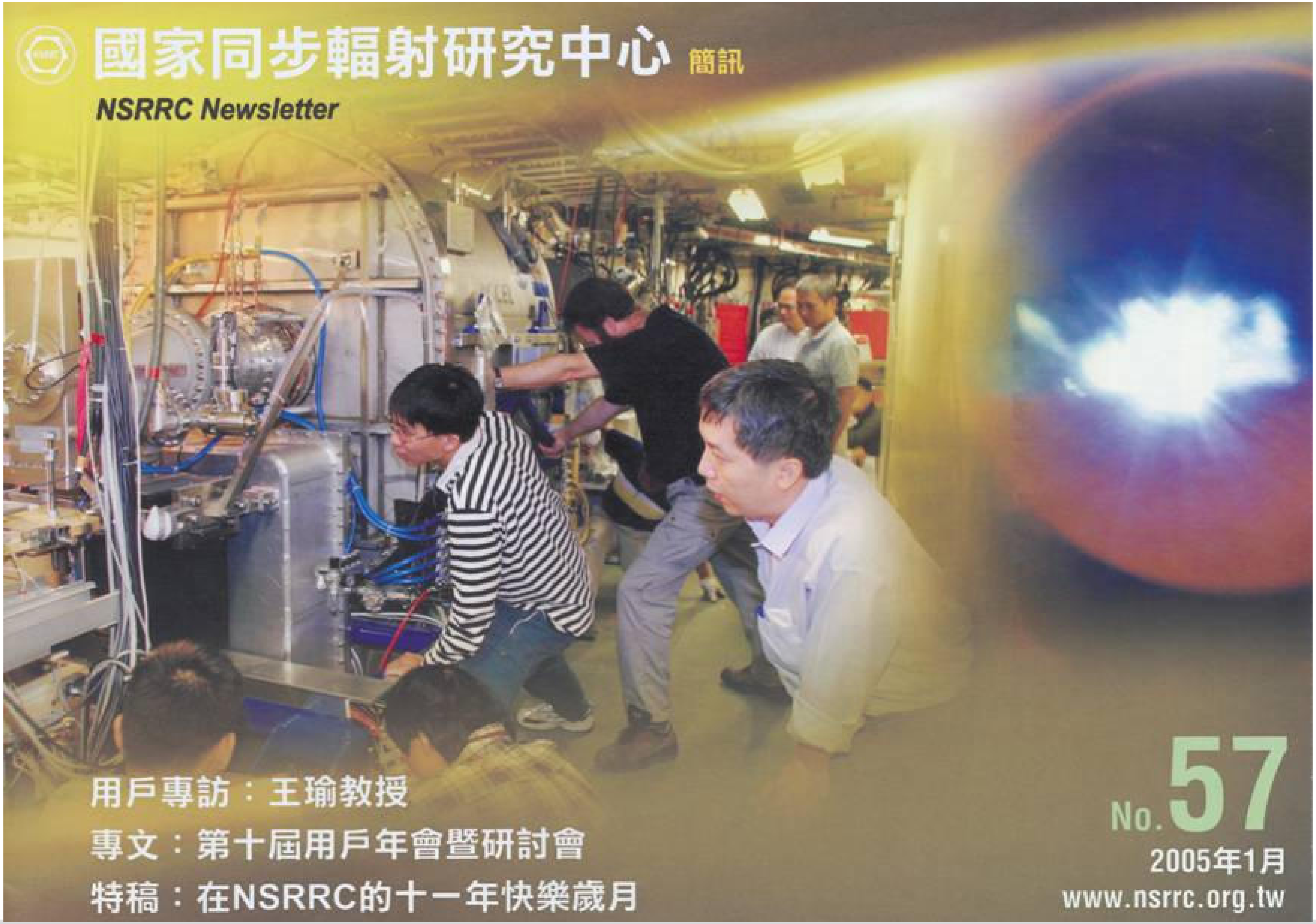
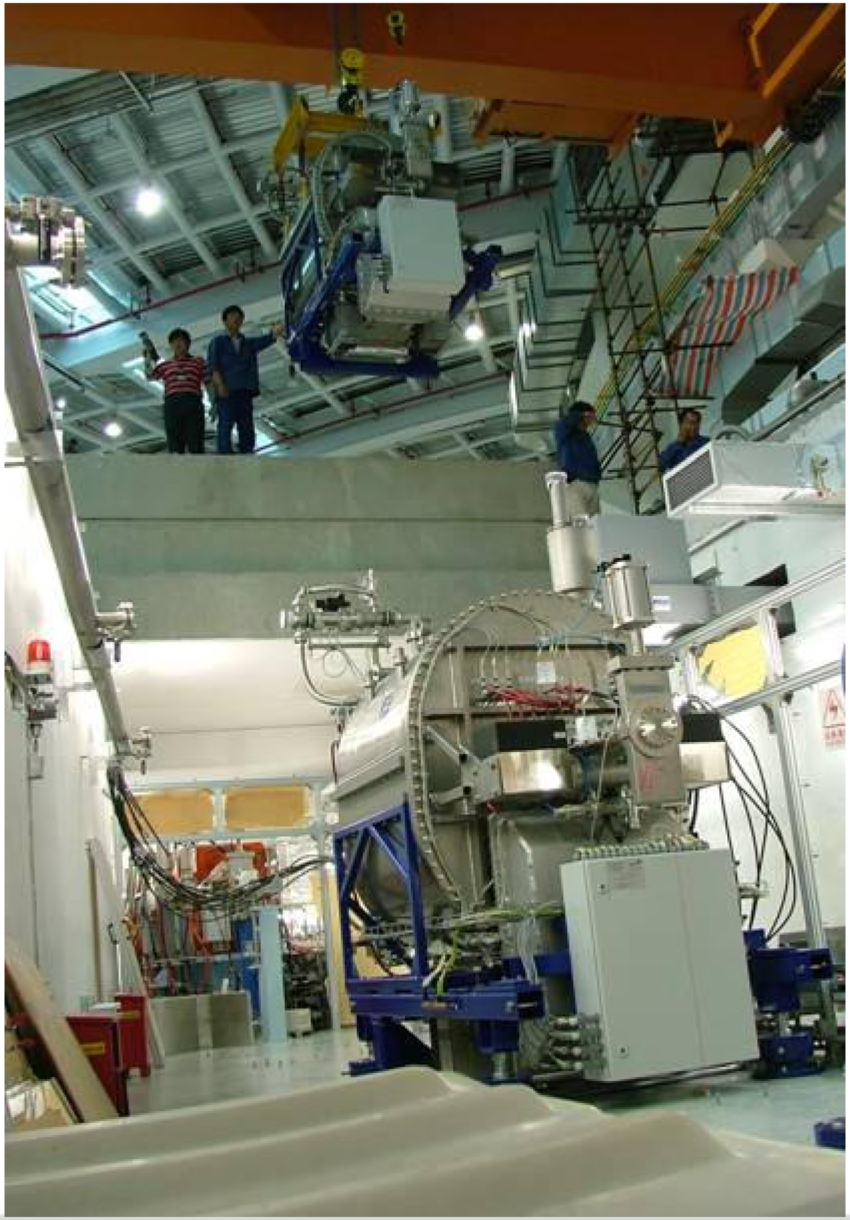
Overseas transport

Installation into the NSRRC storage ring

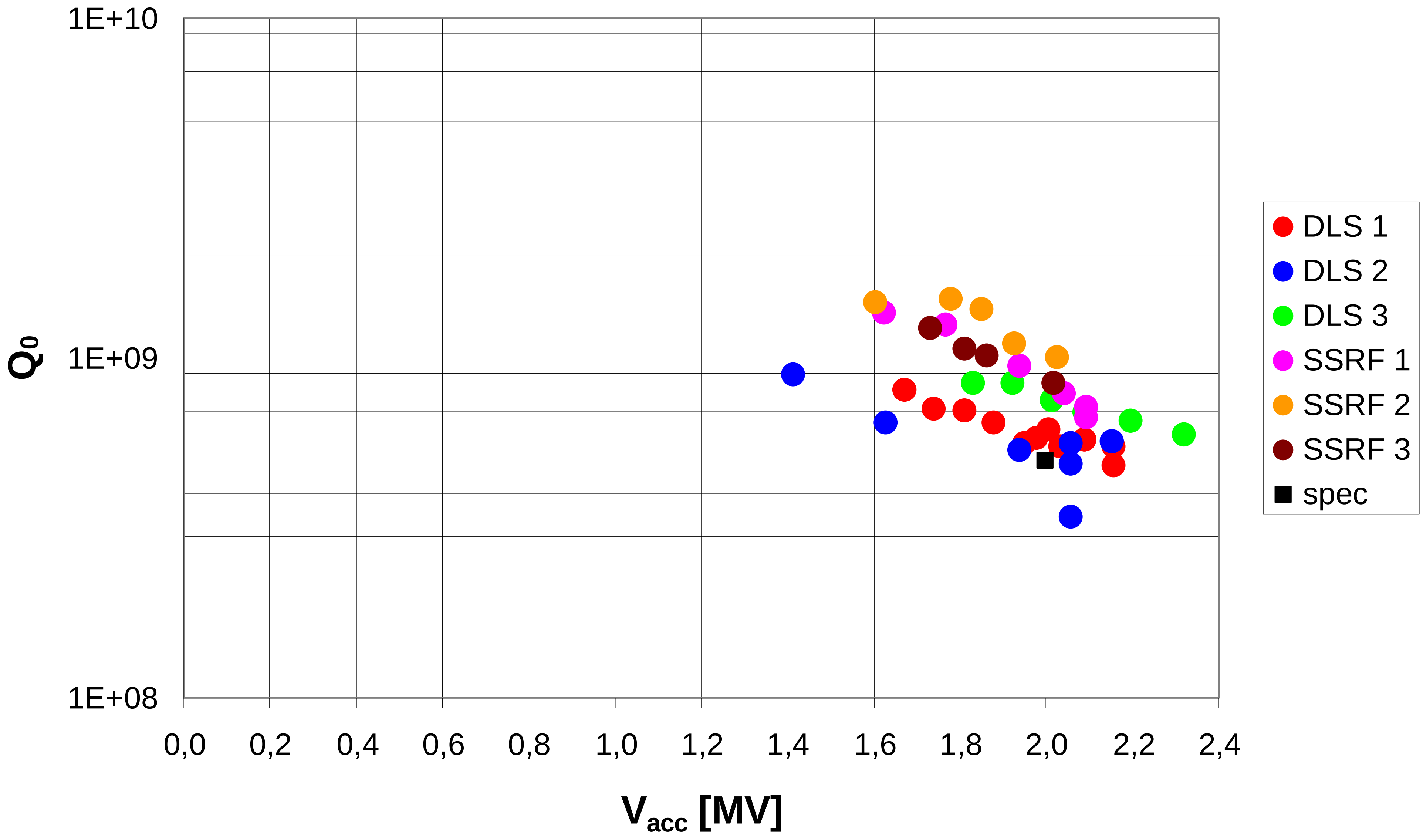


Module to be placed at its final position in the DLS storage ring

Installation into the SSRF Storage Ring



Performance of DLS and SSRF modules



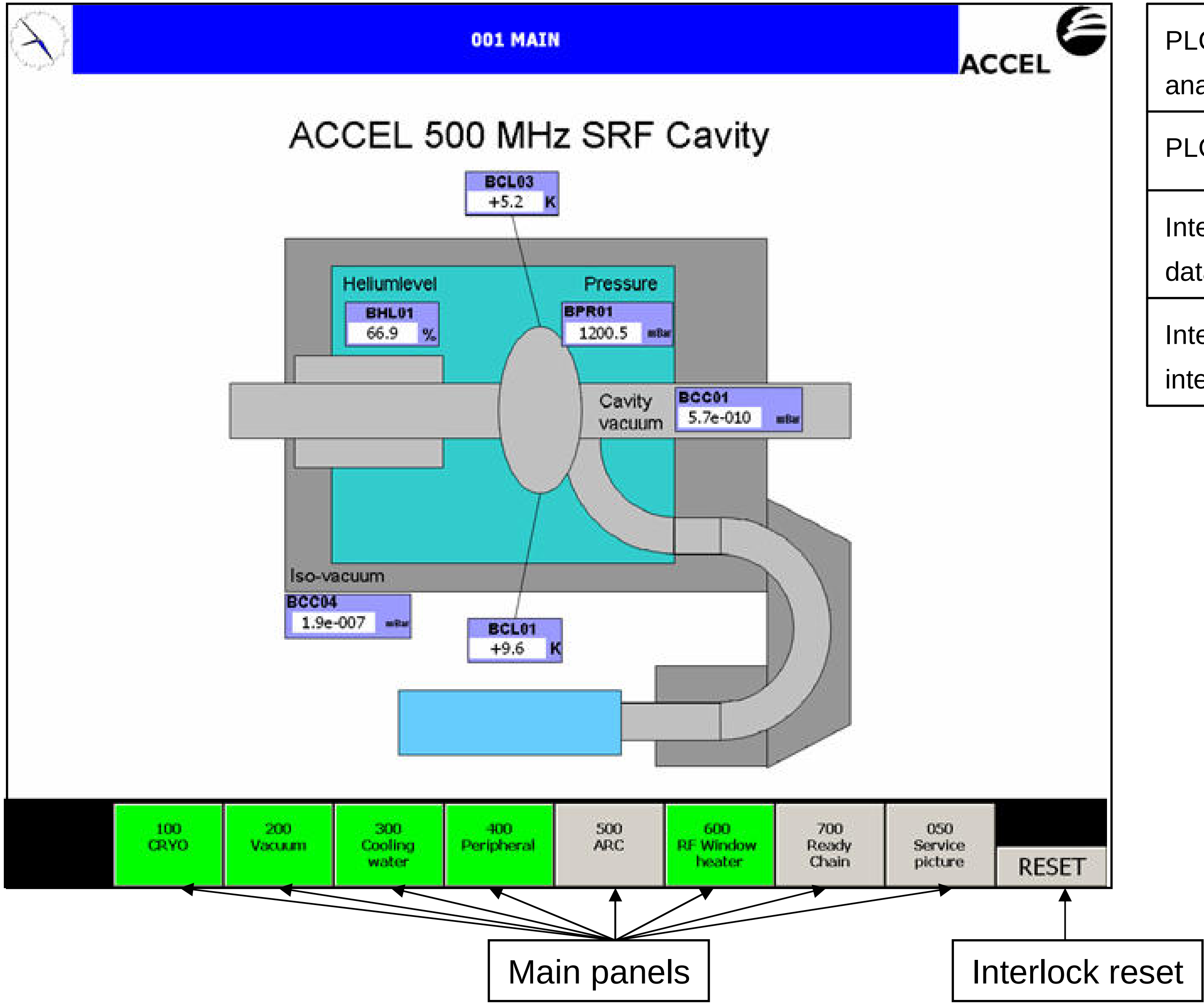
Valve boxes and transfer lines

Valve box for 3 SRF modules

for 2 SRF modules

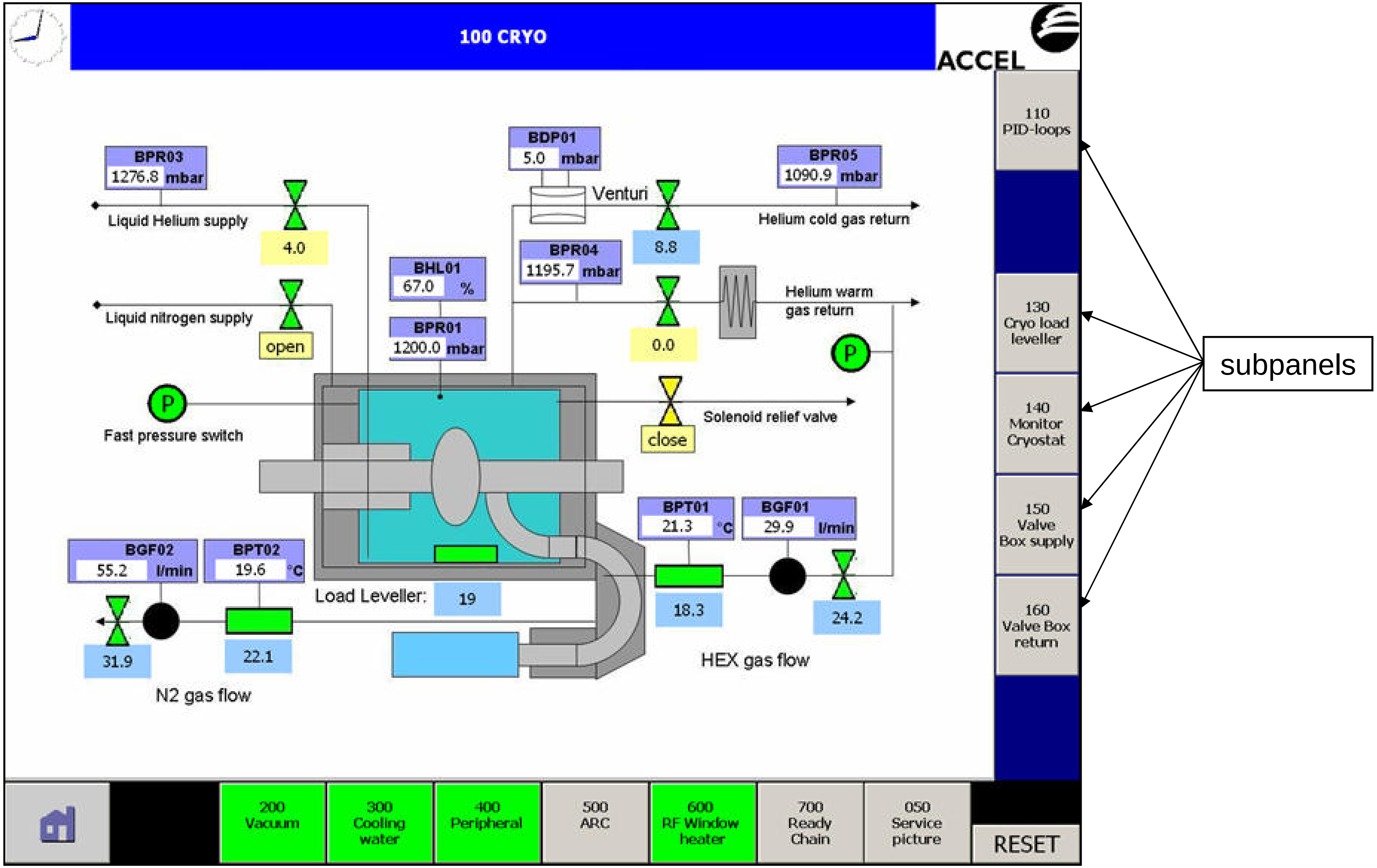
for a single SRF module

Data Acquisition and Operator Panels



PLC for analogue output	Siemens S7-300
PLC for interlock	Siemens S7-300
Interface for data monitoring	Ethernet
Interface for interlock signals	Open collector / dry contact

Main panel for cryogenic operation



1.3 GHz twin cavity SRF modules

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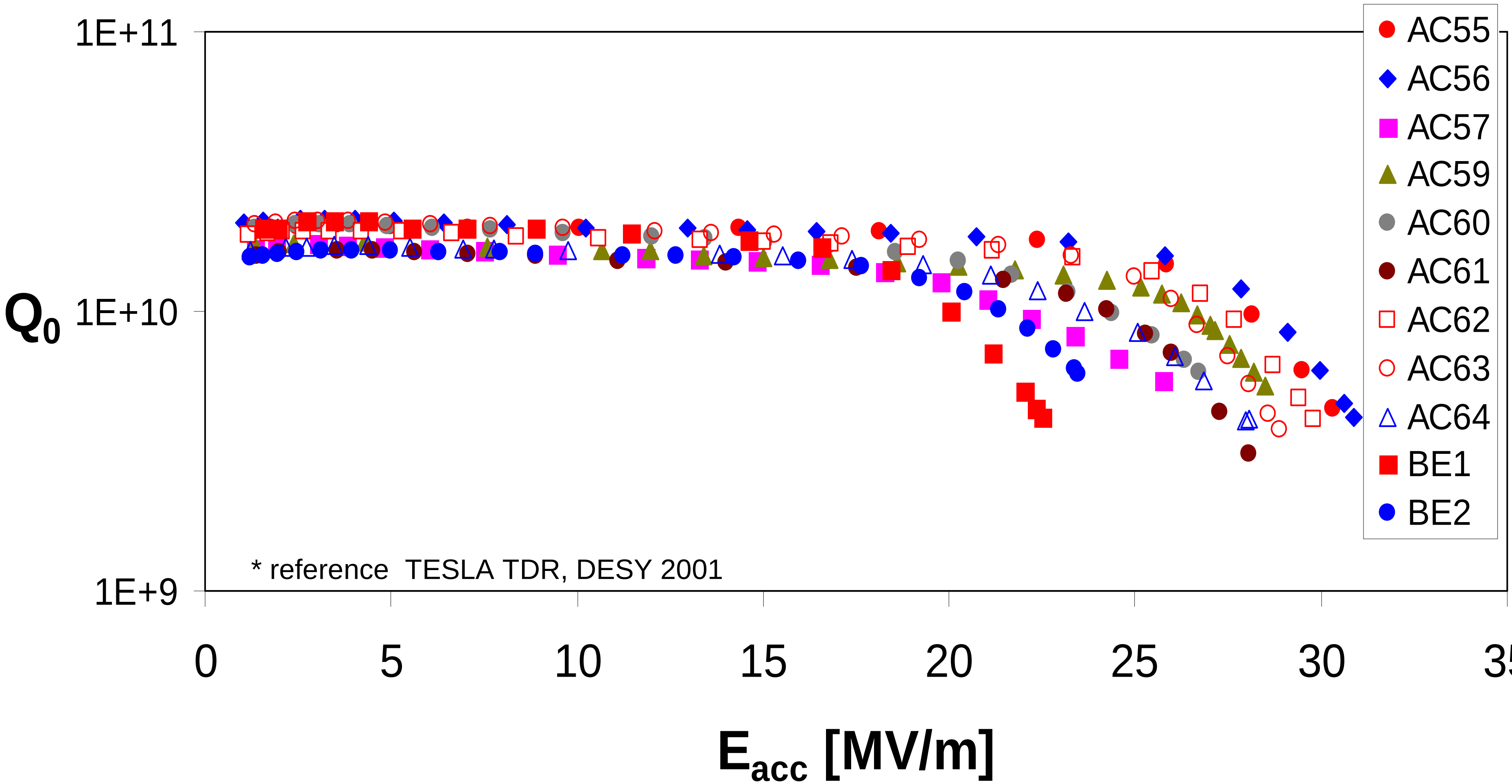
Preparation steps of 1.3 GHz 9-cell cavities

Preparation steps	Done at
Manufacturing	ACCEL
100 µm BCP (closed loop)	ACCEL
Heat treatment 800 ° C	DESY
20 µm BCP (closed loop)	ACCEL
High pressure rinsing (HPR)	ACCEL
Assembly in cleanroom	ACCEL
Transport under vacuum	ACCEL
Vertical test	DESY

All steps under our responsibility but using existing DESY furnace and test infrastructure

Vertical test results of 9-cell 1.3 GHz cvities

TESLA cavities for BESSY and DESY*



AC cavities prepared by DESY: **BCP, heat treated at 800 C and 1400 C**

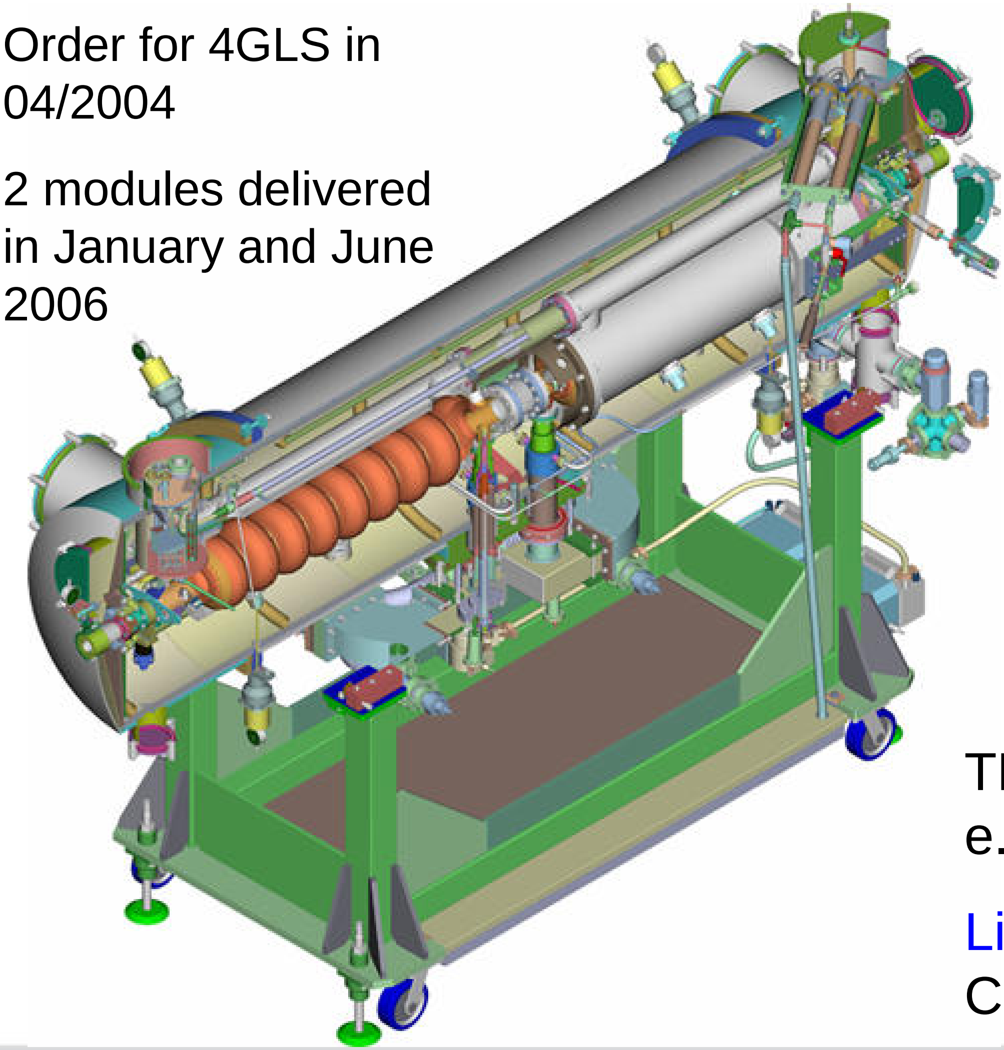
BE cavities prepared by ACCEL: **BCP, only heat treated at 800 C**

SRF module production (1.3 GHz)

Twin TESLA Cavity Accelerator Module as Turn-Key System for FEL and ERL Application

Order for 4GLS in 04/2004

2 modules delivered in January and June 2006



Target Values cw:

Eacc > 15 MV/m
@ Cavity Q > 1 E10

Prf > 8 kW per Coupler

TESLA Technology Transfer from e.g. DESY, JLAB, Cornell,

License Agreement on the Twin Cavity Module with FZ Rossendorf

Twin TESLA cavity module after assembly and just before delivery to Daresbury

„Series“ preparation of 1.3 GHz 9-cell cavities equipped with helium vessel

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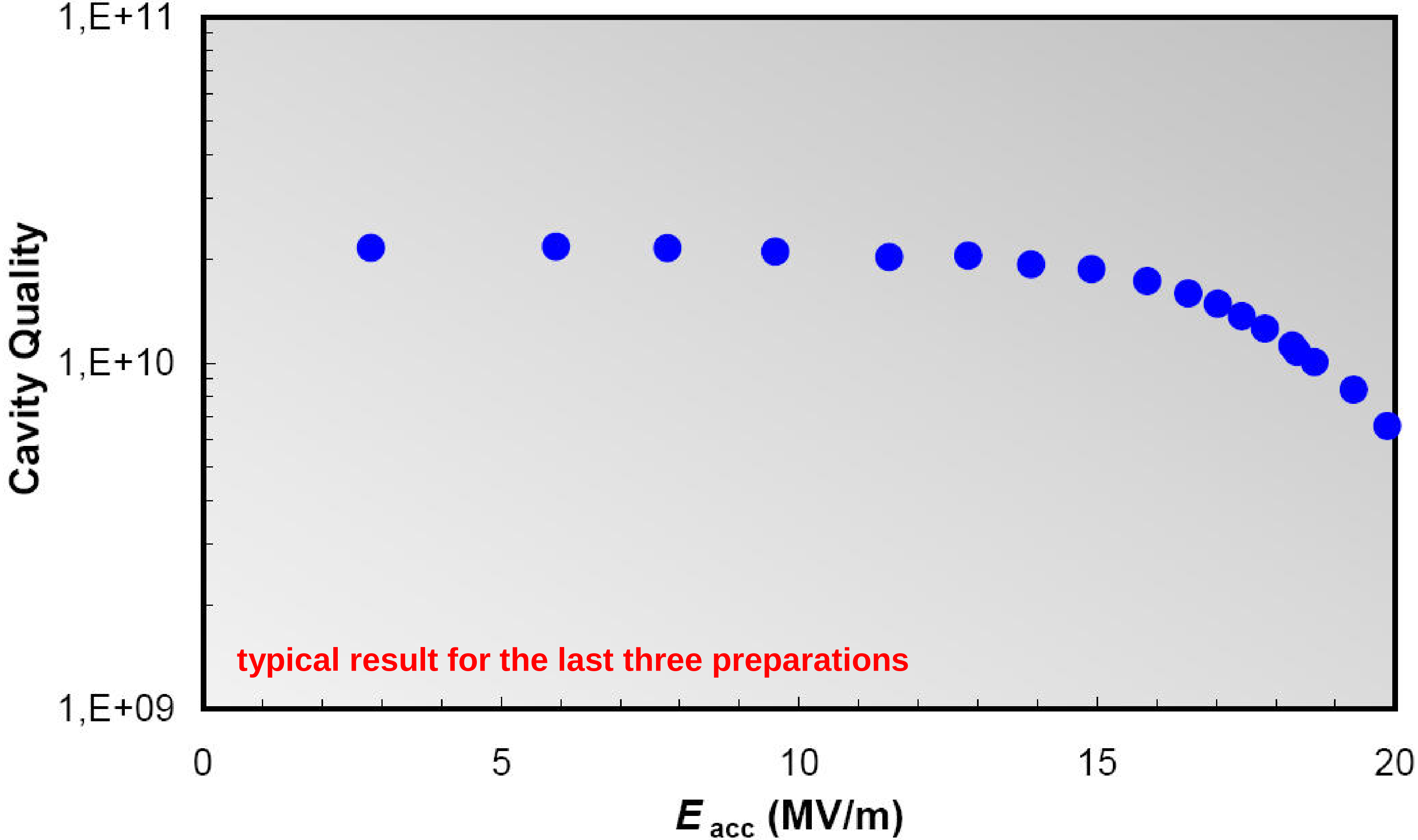
Contract from BESSY for 5 preparations (BCP, HPR) and clean room assembly with high power coupler for test in HOBICAT



Turn-Key S-Band electron linear accelerators for synchrotron light sources

SLS/PSI, CH

Delivered:

SLS/PSI, CH	100	MeV
DLS, UK	100	MeV
ASP, Australia	100	MeV

Final acceptance:

PTB, Germany	0,5-50	MeV

In Production:

Taiwan Light Source 150 MeV

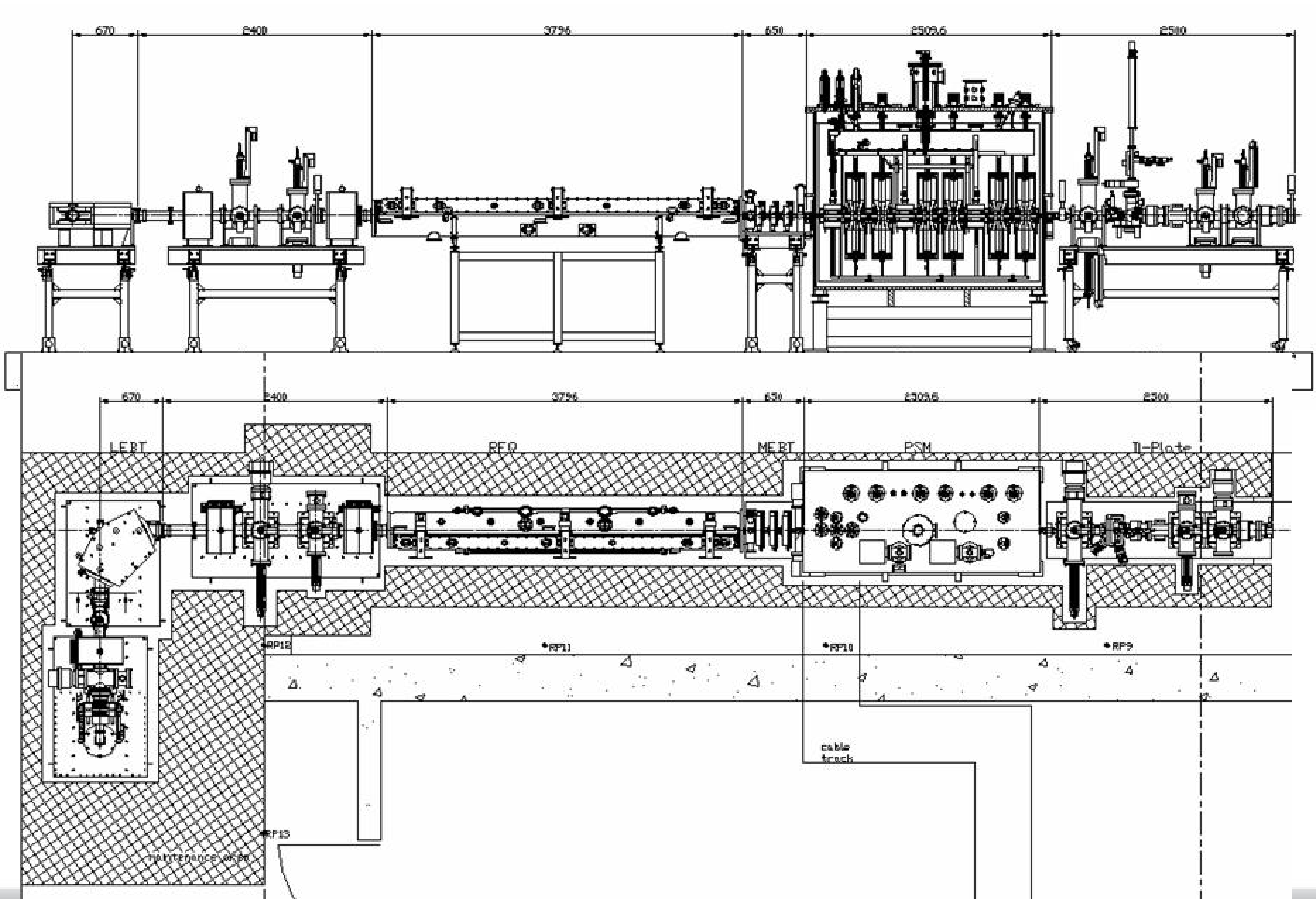
Offered:

Uni Nijmegen

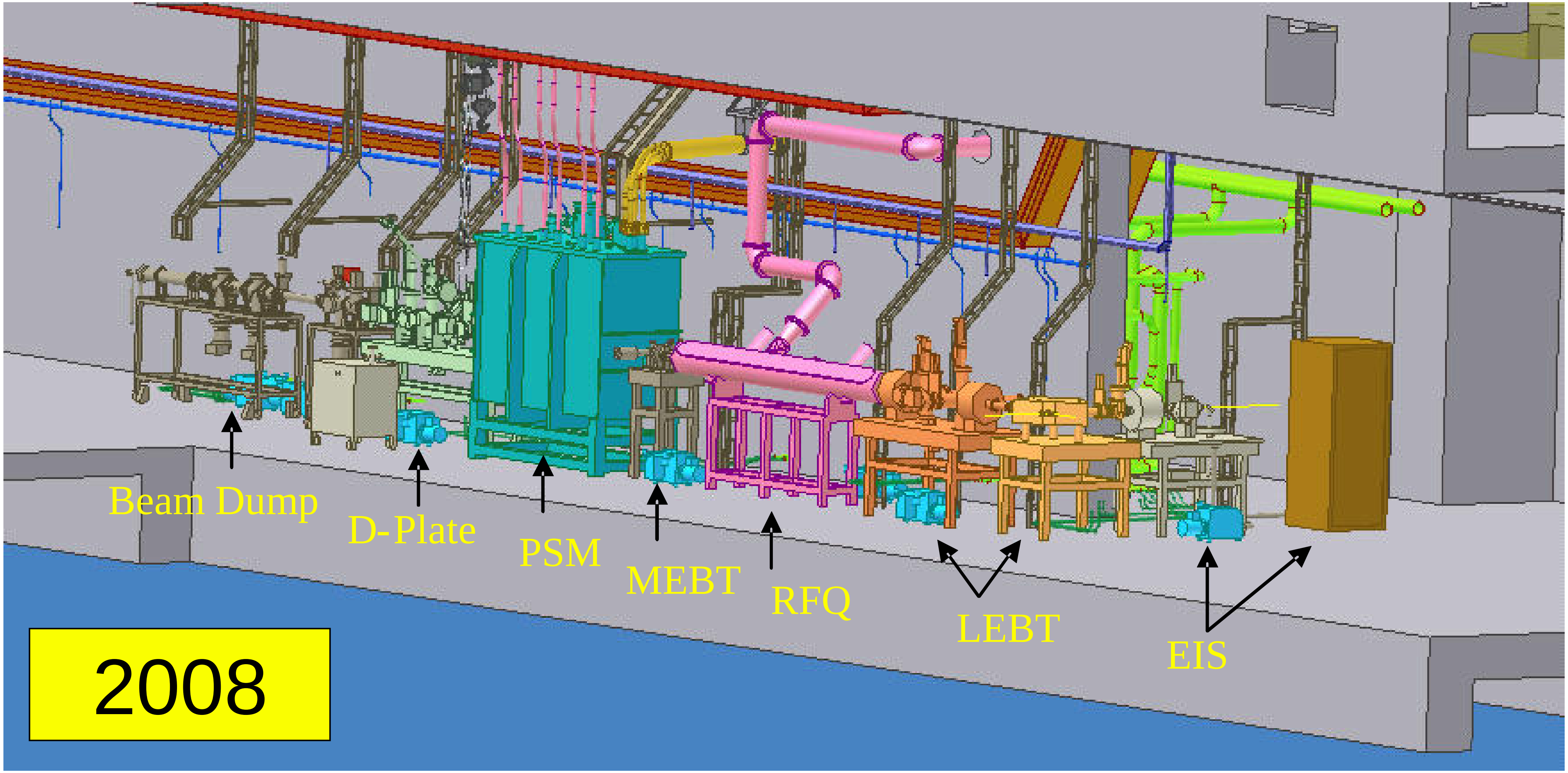
Technology Transfer from DESY (Dortmund Univ.)

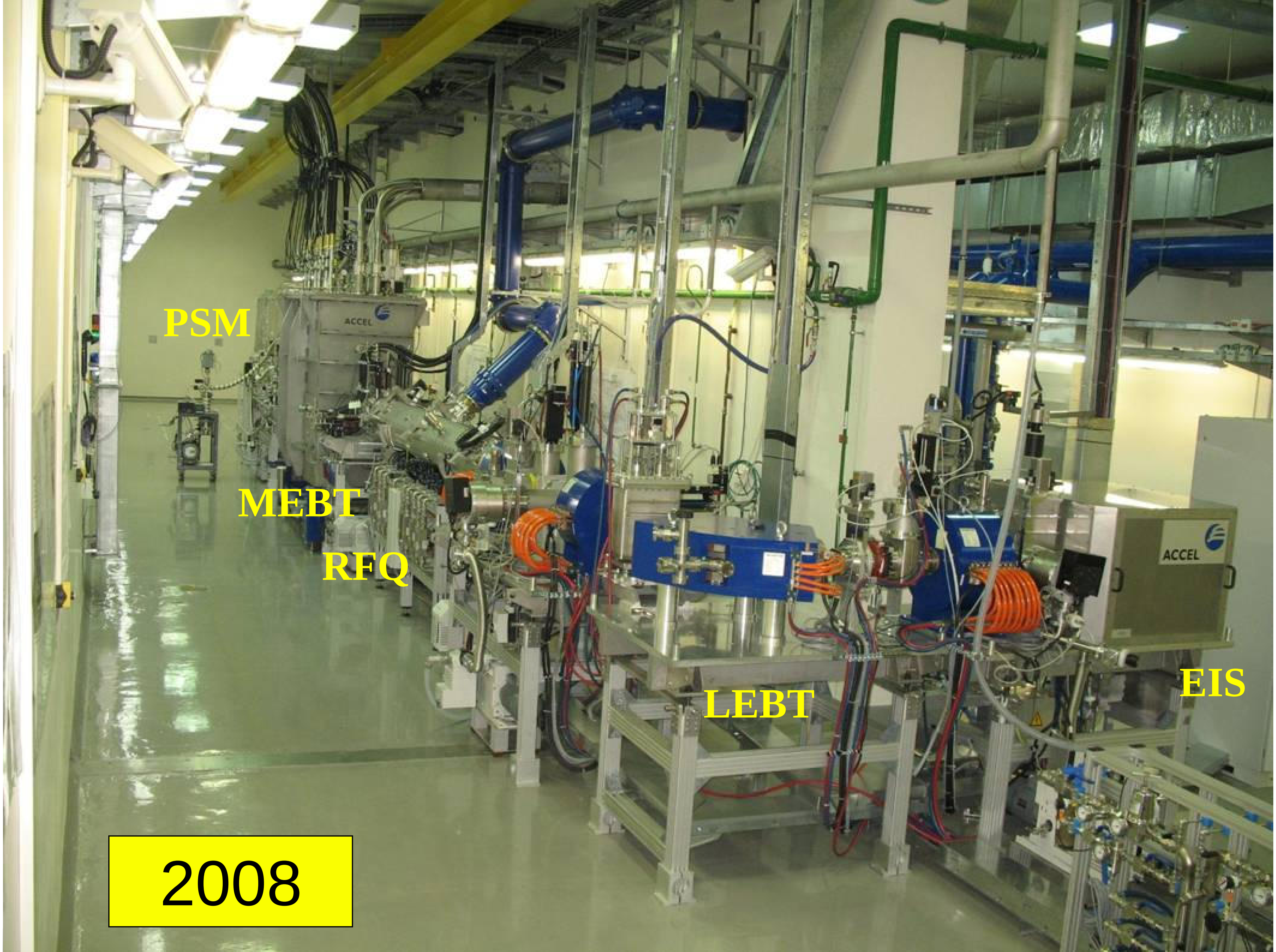
License Agreement on S-Band Lin. Collider Components with DESY

A 40 MeV cw proton / deuteron Linac for Israel



Set up for phase I beam characterization




PSM
ACCEL
MEBT
RFQ
ACCEL
LEBT
EIS
2008

Source: Status and specification

Parameter	Unit	Specification Value
Maximum beam current H^+, H_2^+, D^+	mA	5, 5, 5
Minimum beam current H^+, H_2^+, D^+	mA	0.04, 0.04, 0.04
Beam current spread (ripple) at maximum current	%	4
Beam current spread (ripple) at minimum current	%	6
Beam current stability	% @ 5mA	+/- 2.5
Beam current stability	% @ 0.04mA	+/- 5
Beam current adjustment accuracy for high current > 1mA	mA	0.1
Beam current adjustment accuracy for low current < 0.1mA	mA	0.005
Extraction energy	keV/nucleon	20
Extraction energy spread	eV/nucleon	+/- 30
Extraction energy stability	eV/nucleon	+/- 30
Extraction energy adjustment accuracy	eV/nucleon	100
Normalized rms emittance x/y	π mm mrad	< 0.2/0.2

Table 2–1 EIS specification (to be measured at the LEBT diagnostics)

Particles / Beam current	Protons	H2+	Deuterons
5.0 mA	☑	☑	☑
2.0 mA	☑	☑	☑
0.04 mA	☑	☑	☑

Since November 2007 accepted

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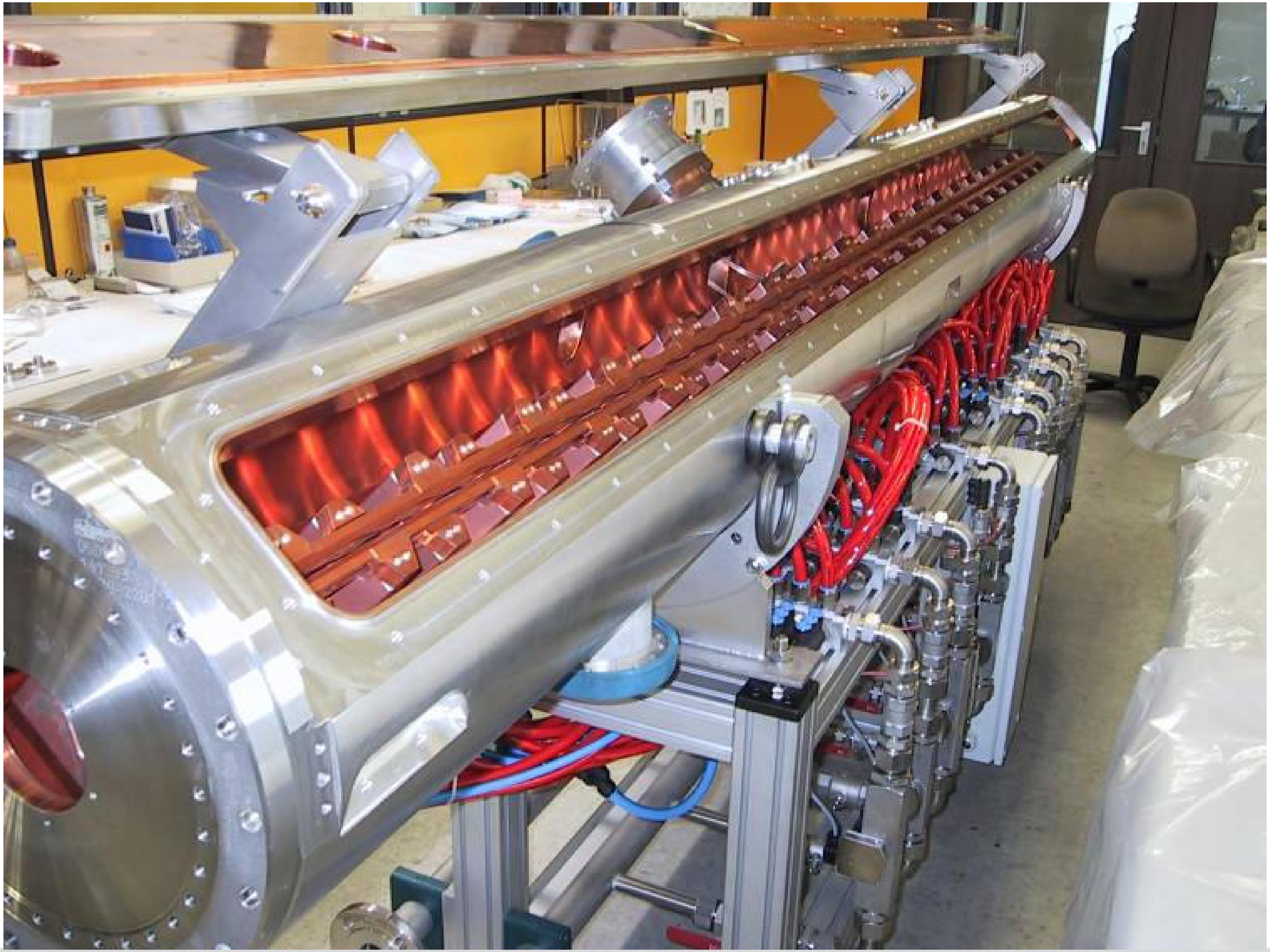
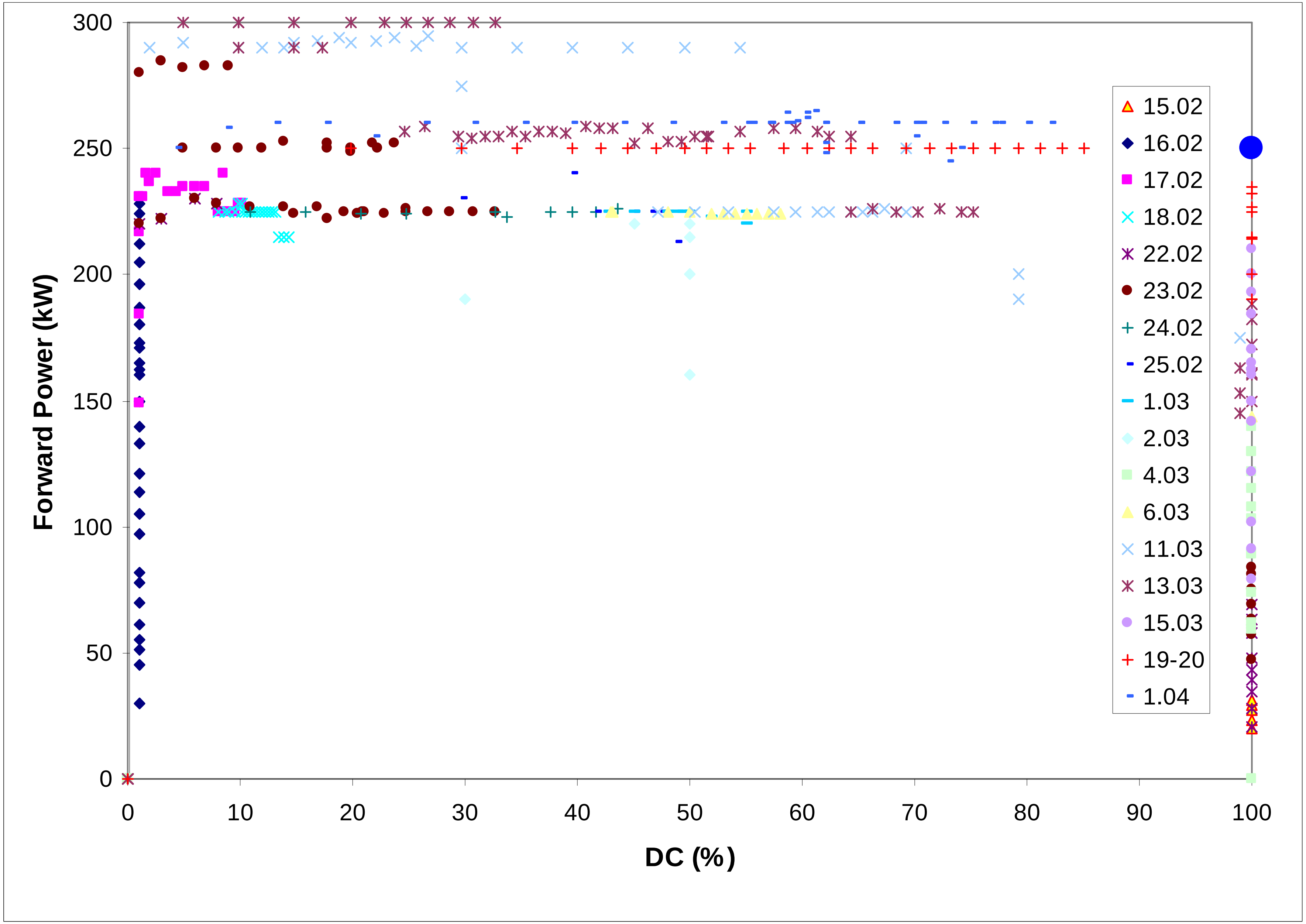
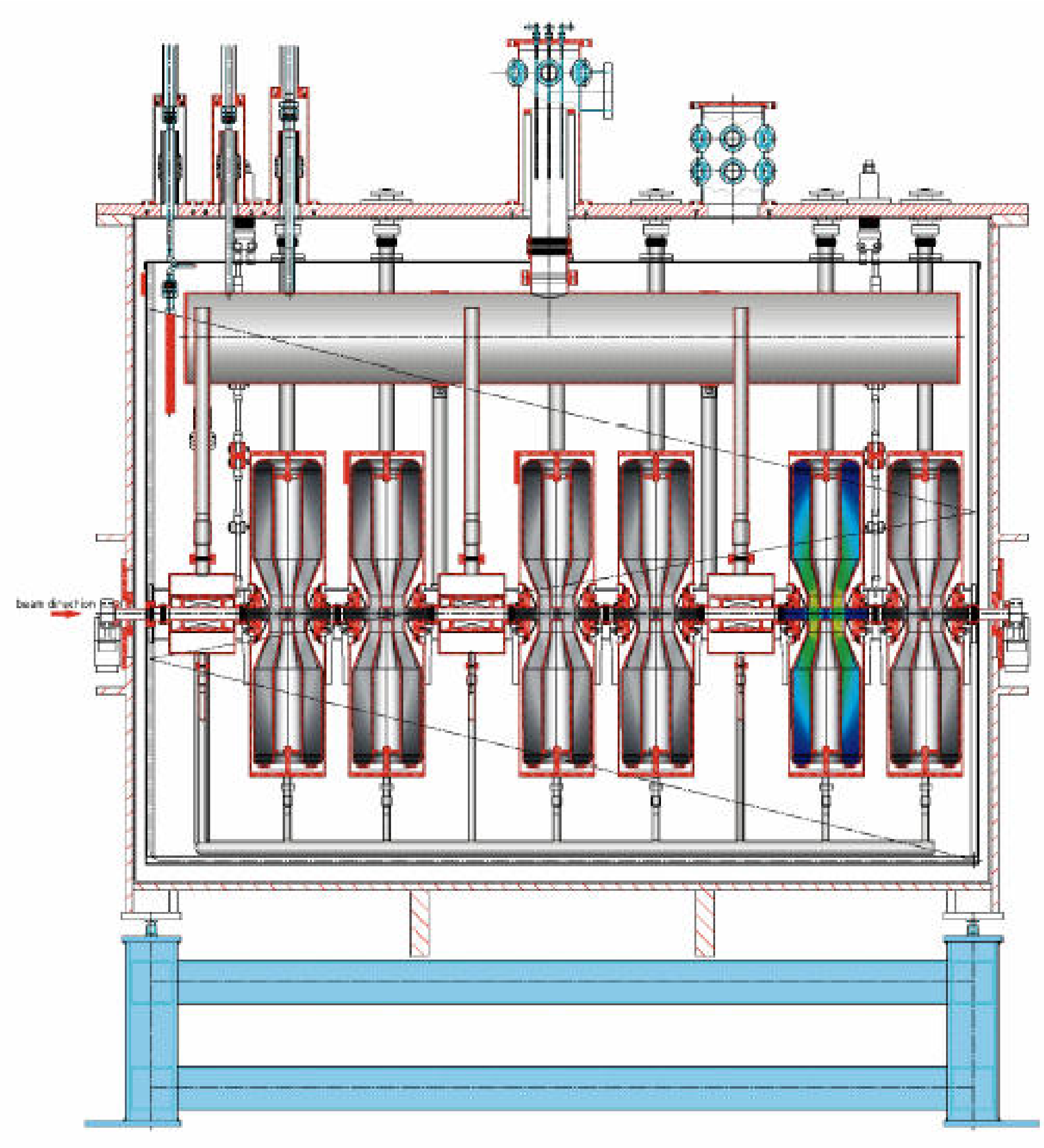
RFQ: RF installation finalised



RFQ conditioning status

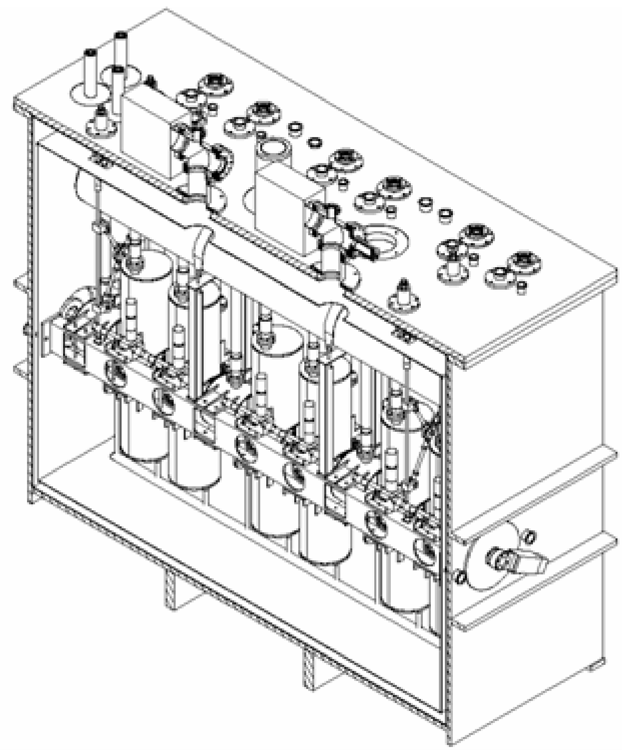


Prototype supercondcuting module



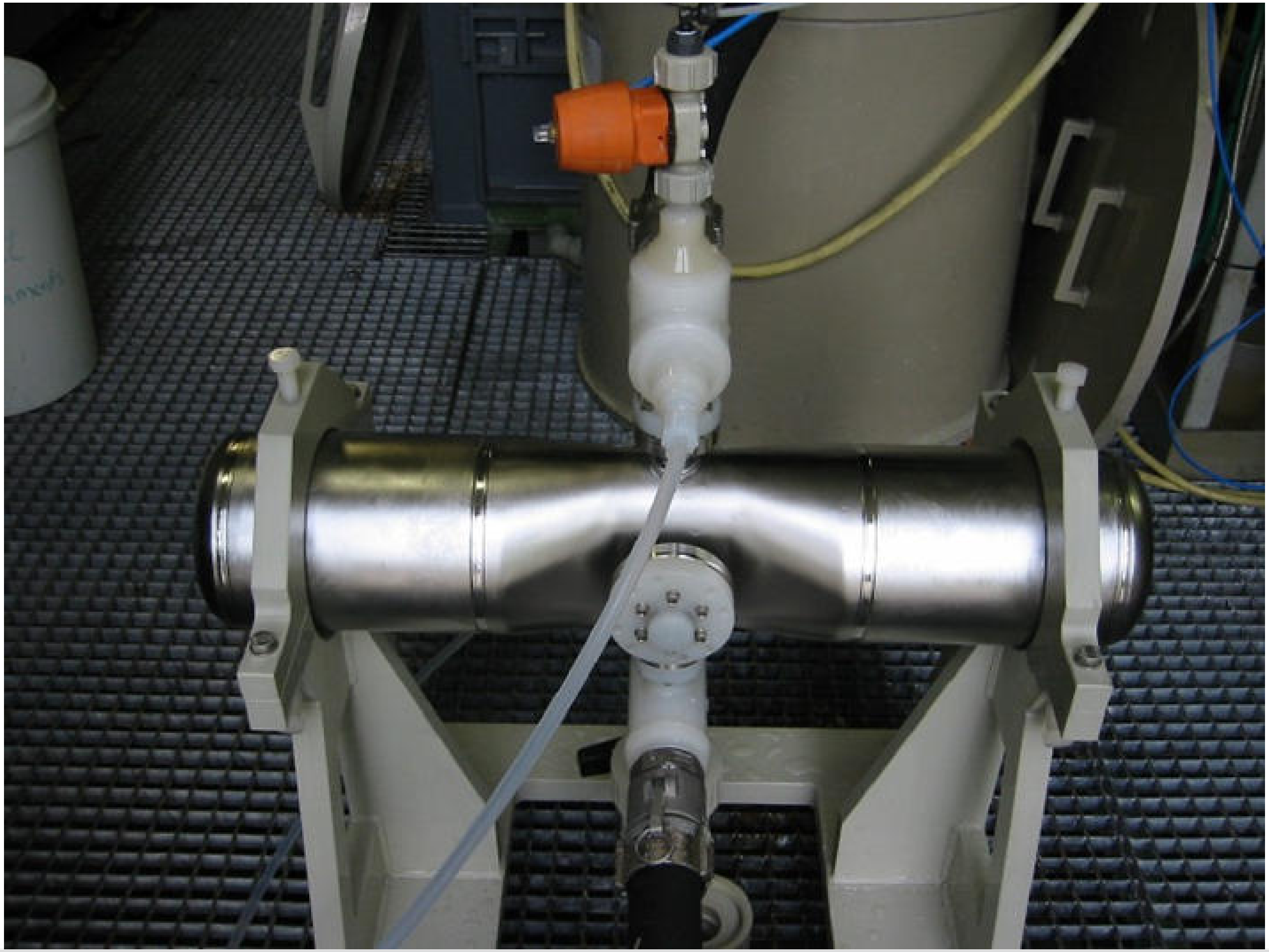
General Design

- Houses 6 HWR and 3 superconducting solenoids for focusing
- Acceleration of protons and deuterons from 1.5 MeV/u on
- Very compact design in longitudinal direction
- Cavity vacuum and insulation vacuum separated



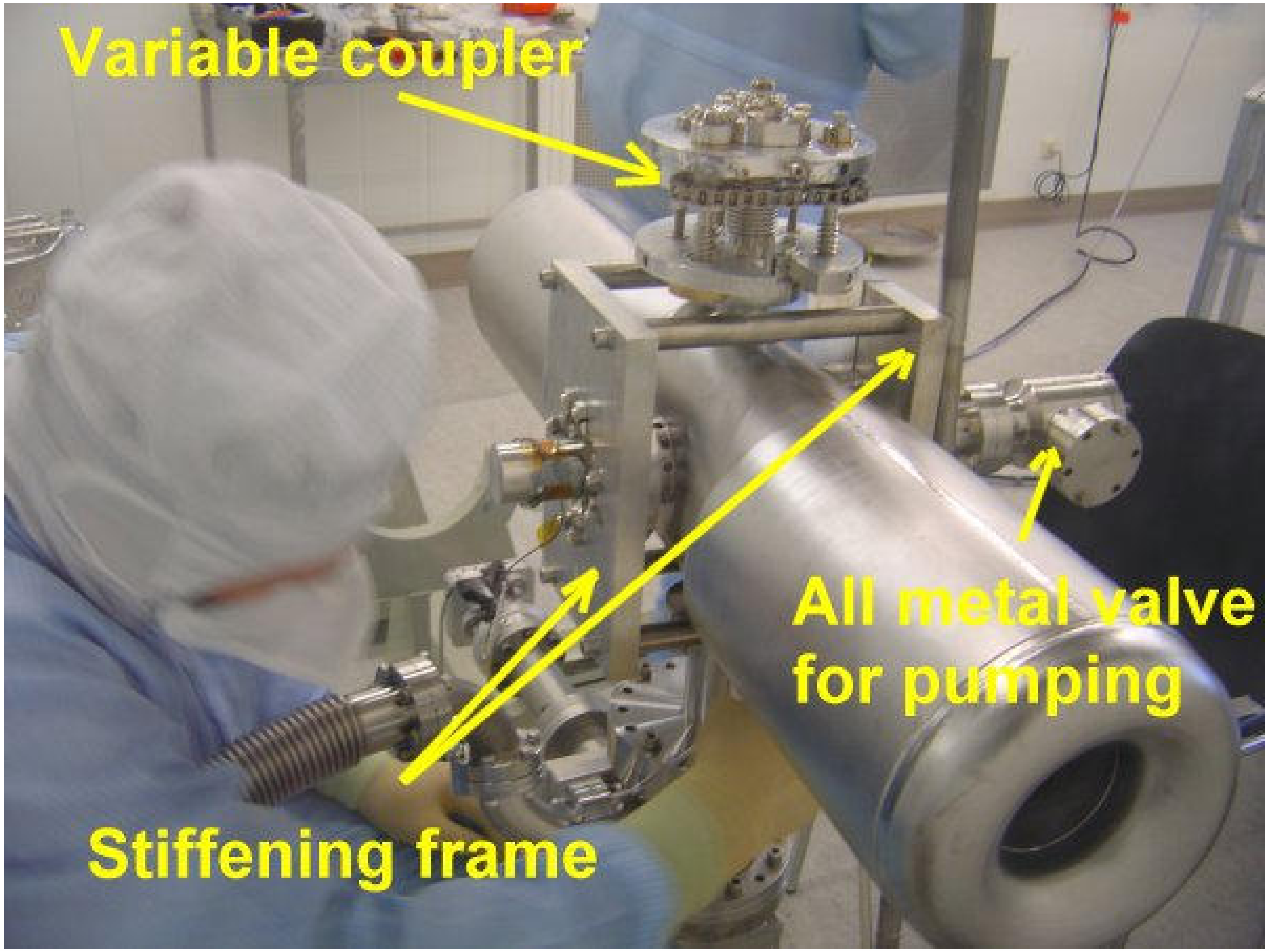
Chemical treatment of HWR: closed loop BCP 1:1:2

All cavities received a new preparation after vertical test and helium vessel welding
Closed loop BCP also possible with helium vessel welded.

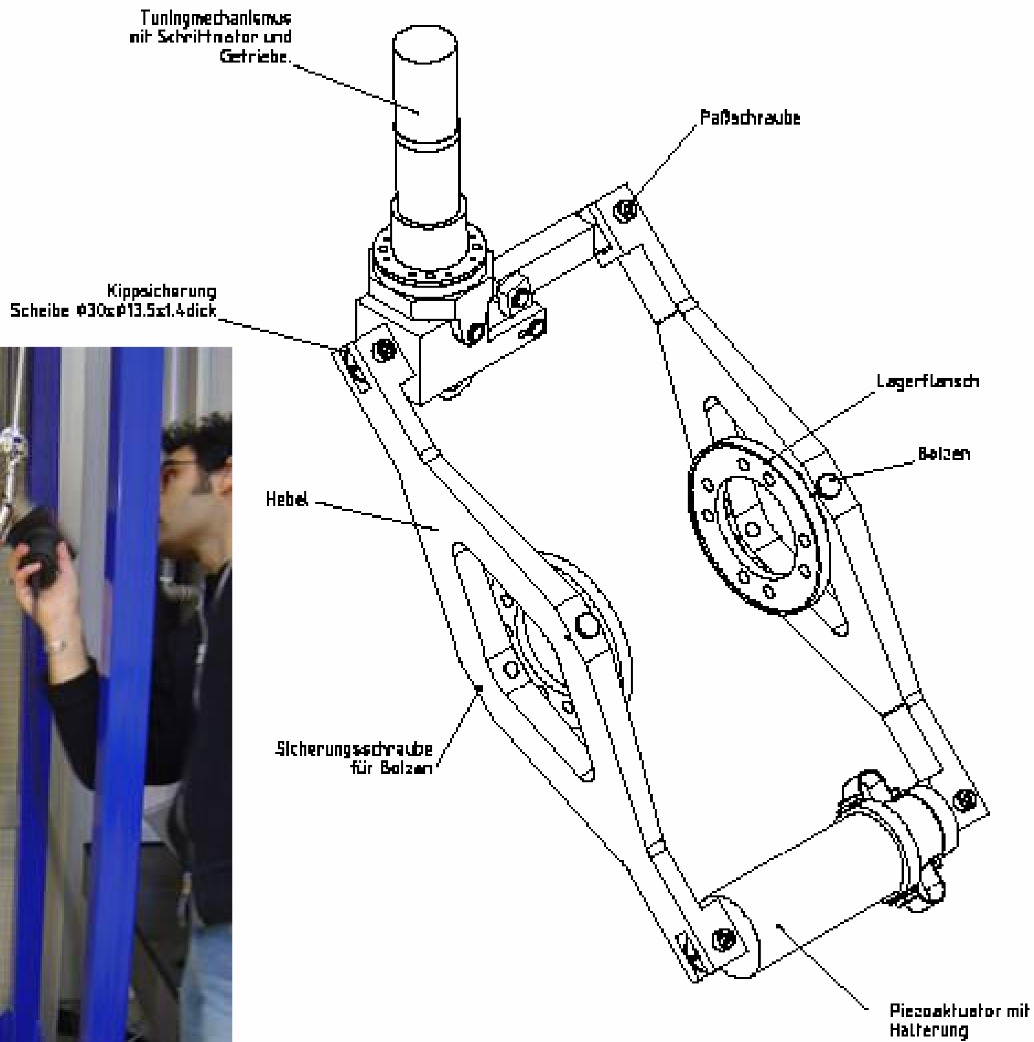


Preparation of series cavity for vertical test

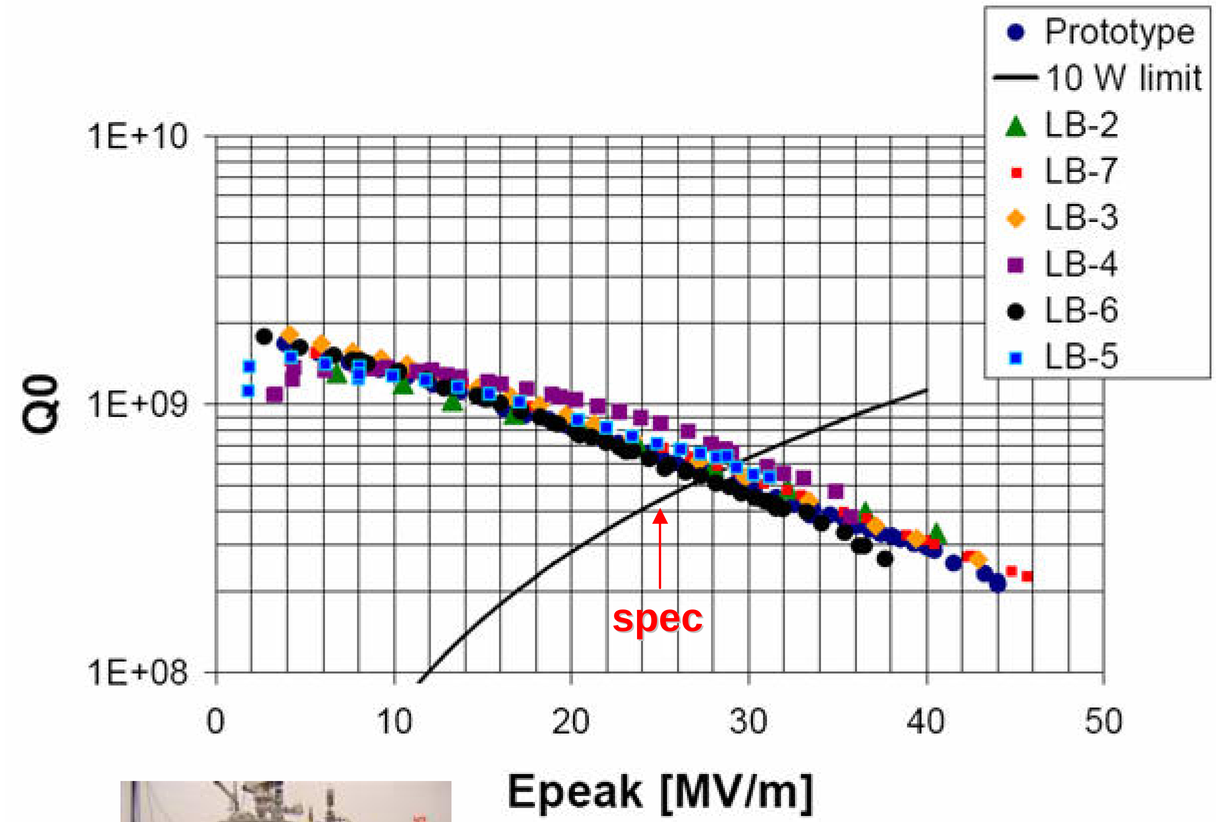
Preparation of a cavity without helium vessel welded



Test of cavity with helium vessel welded and tuner mounted



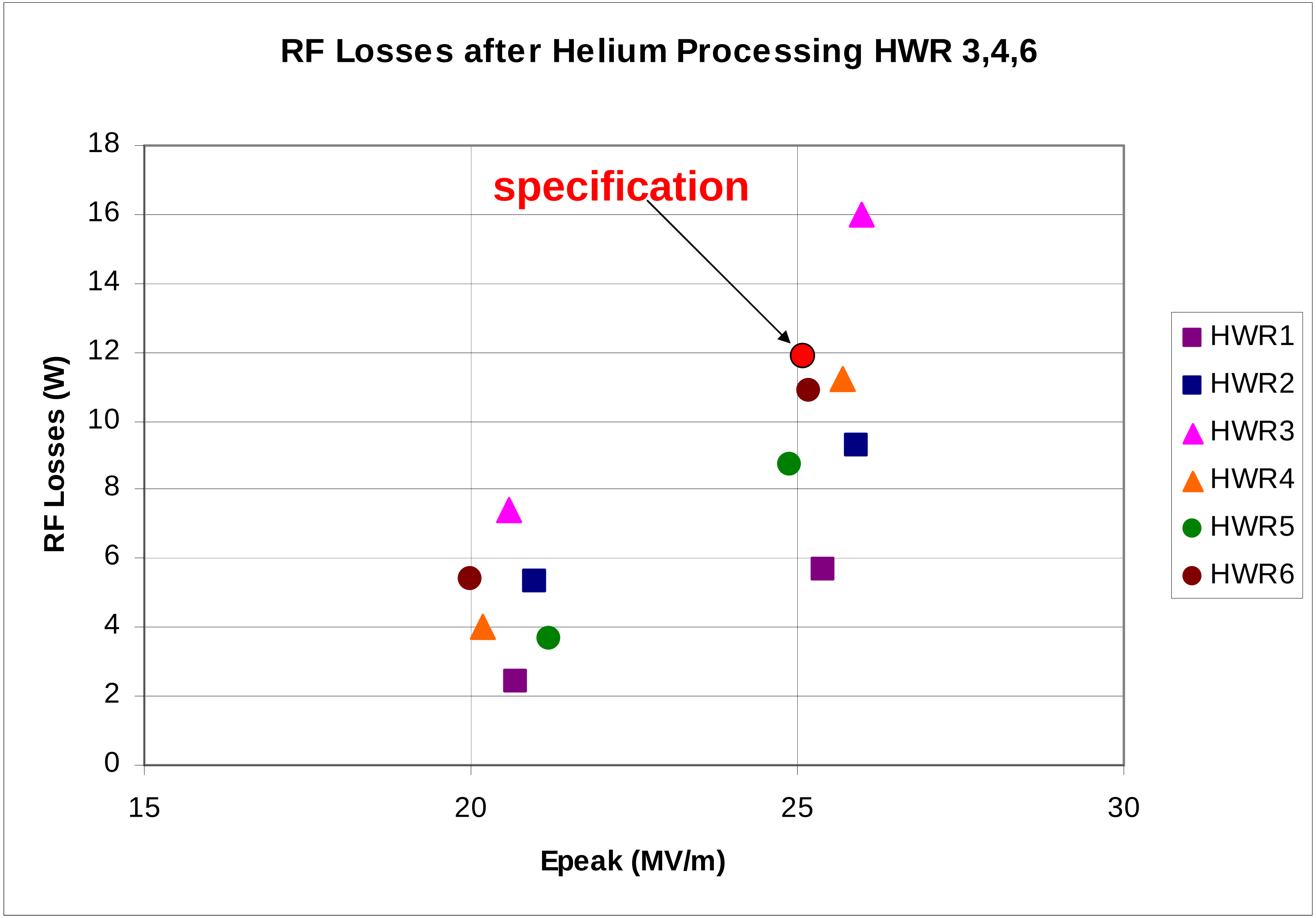
Summary of cavity test results



Cavity performance:

- LB-2, LB-7, LB-3, and LB-4 tested before helium vessel welding
- LB-6 and LB-5 tested after helium vessel welding
- In all test of series cavities, multipacting was much reduced compared to the prototype cavity
- Field emission only seen at very high field levels

Cavity tests after installation into the linac



Why Proton Therapy for cancer treatment

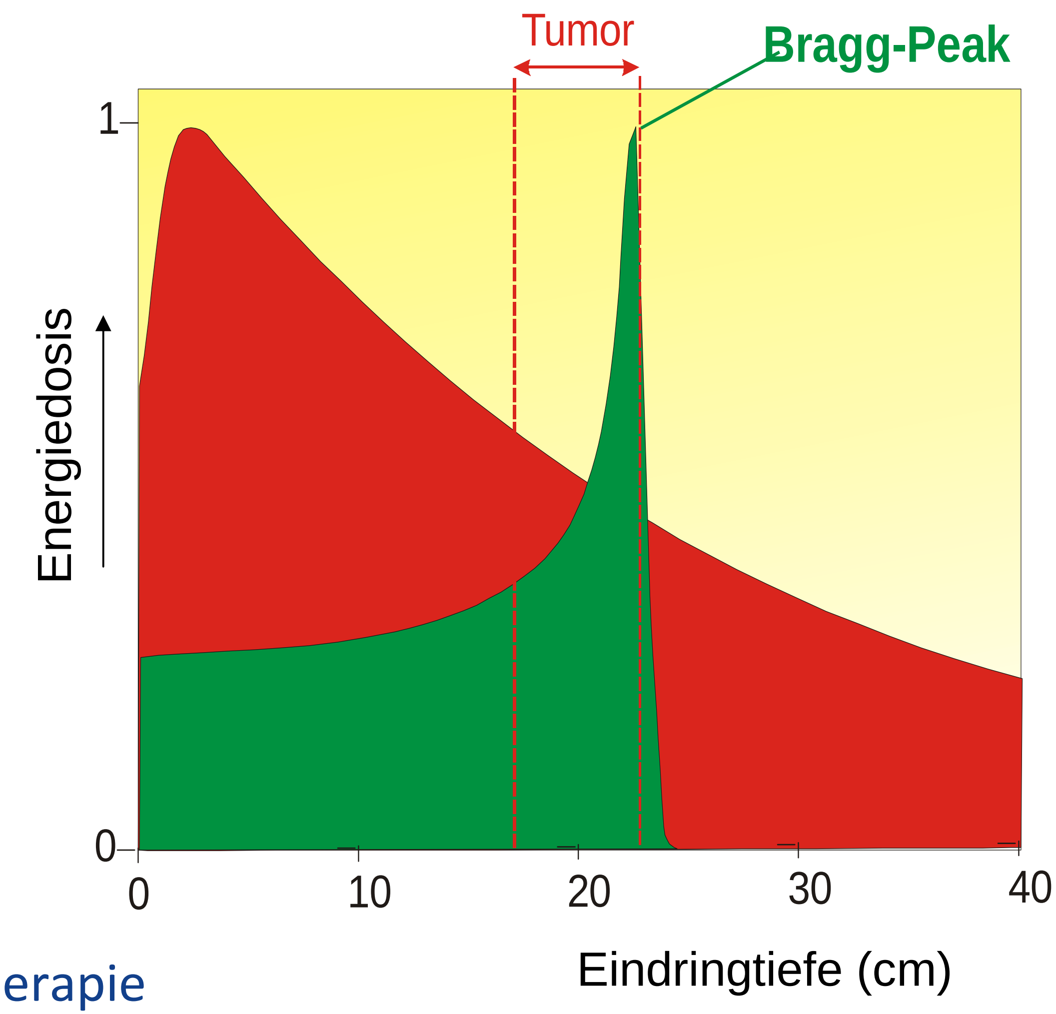
Photonen

Linearbeschleuniger 15 MV

Protonen

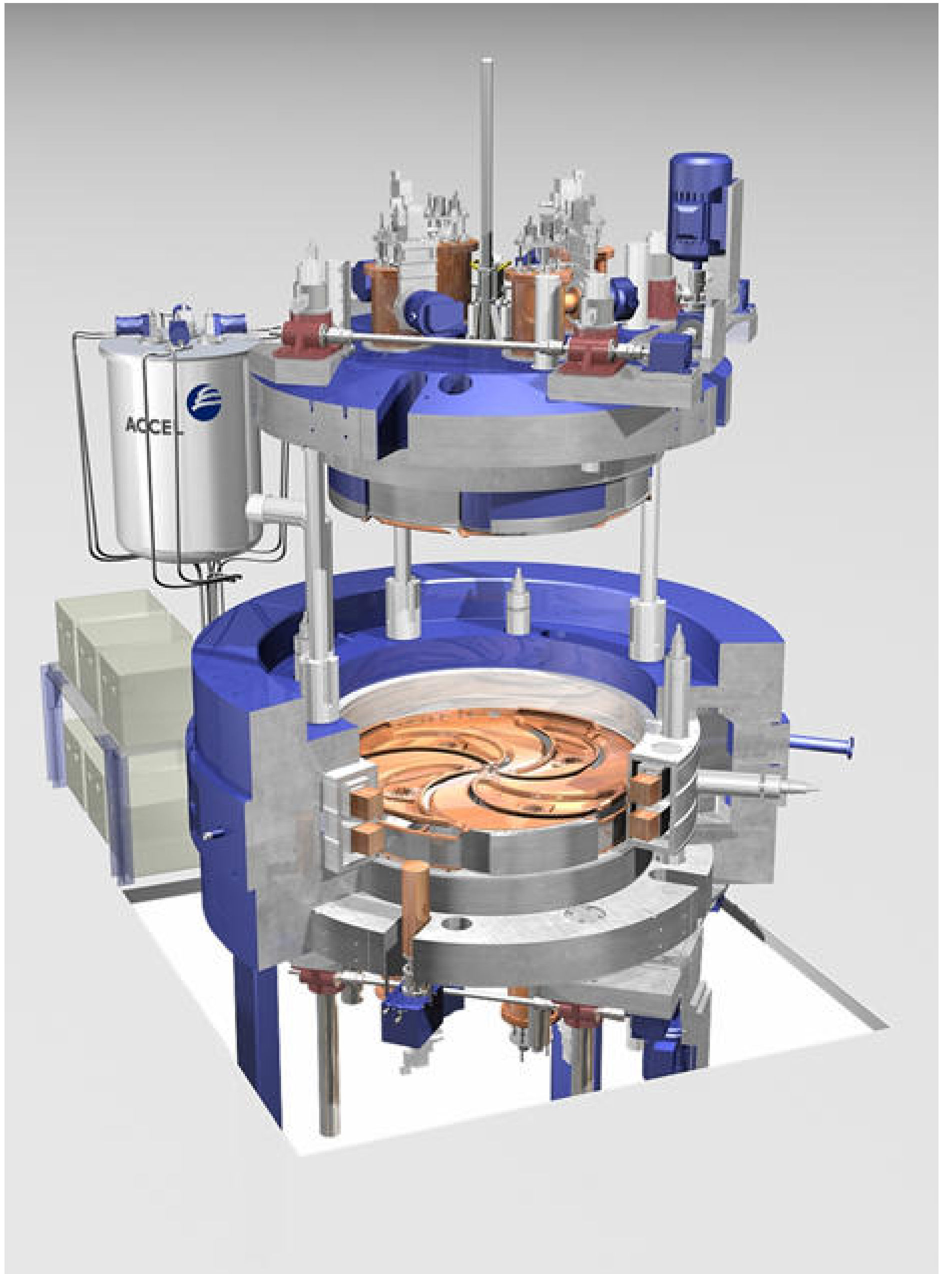
190 MeV kinetische
Energie= 25 cm Einringtiefe

Strahlrichtung



Protonen vs. Photonen in der Krebstherapie

Superconducting Proton Cyclotron



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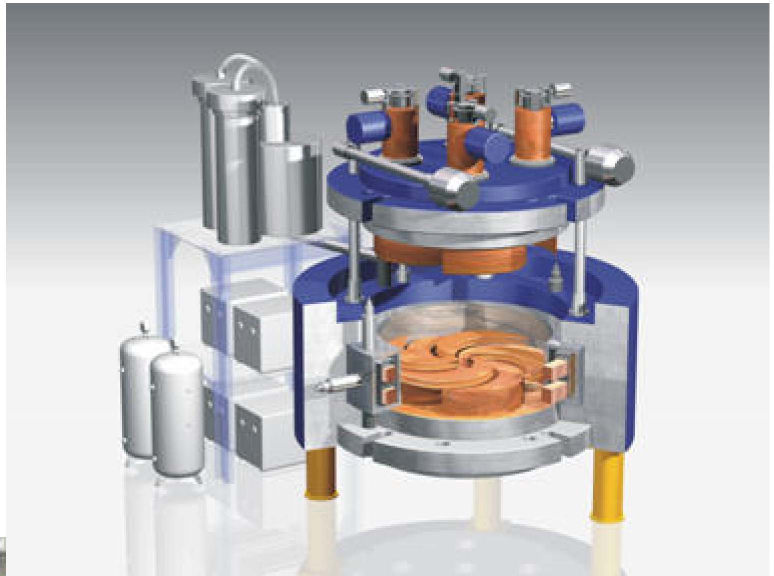
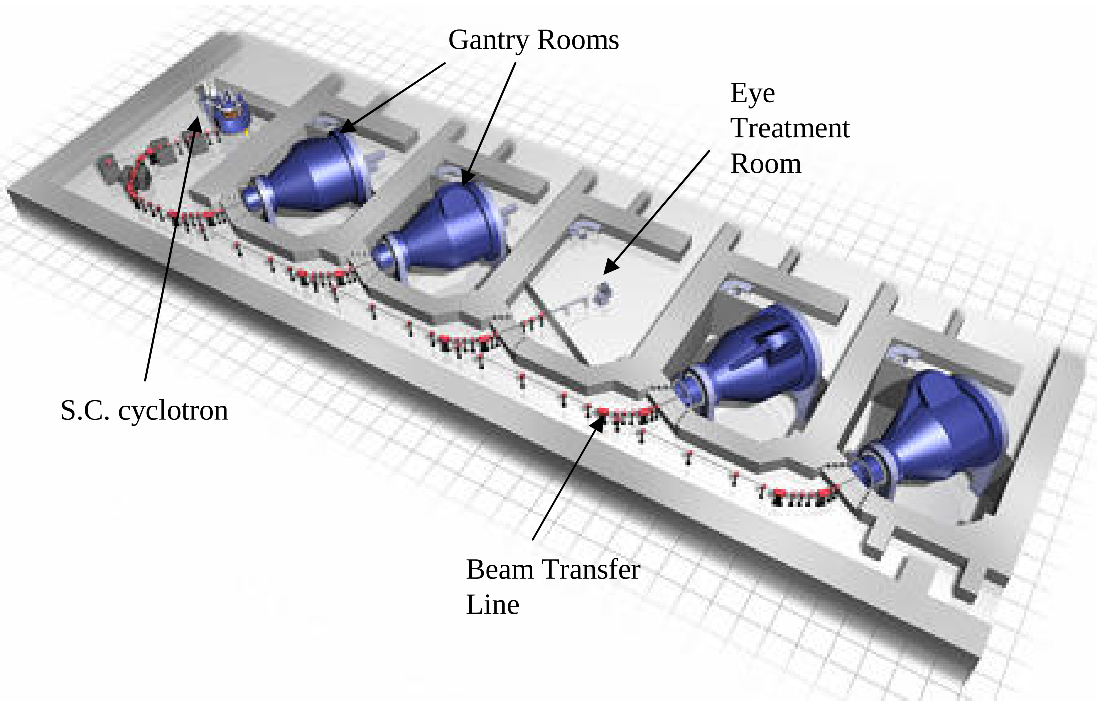
Proton Therapy Systems



Superconducting 250 MeV Cyclotron for Paul Scherrer Institute (PSI) and RPTC, Munich



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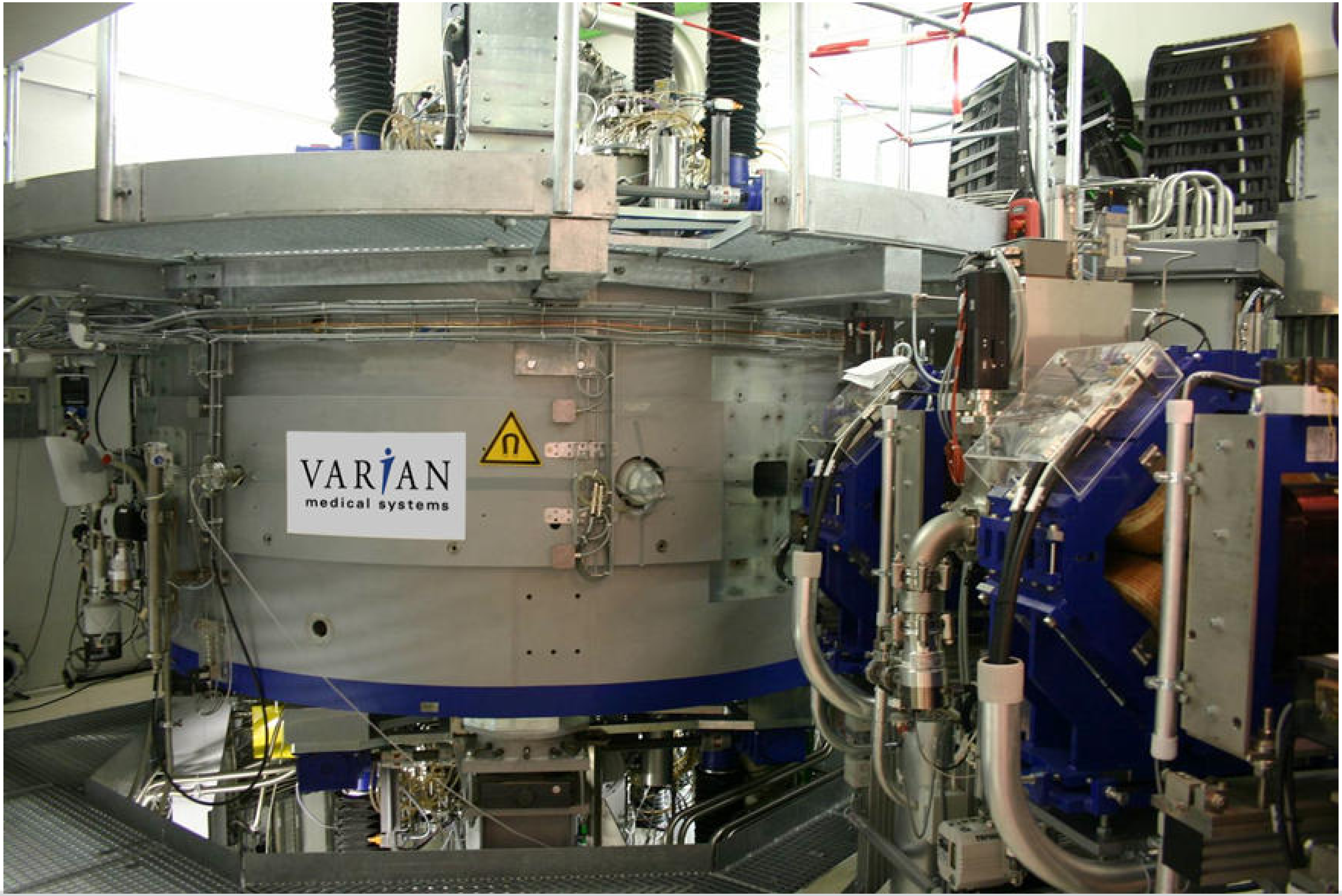
Superconducting Proton Cyclotron installed



Components and Subsystems of a 250 MeV Cyclotron for Varian Medical Systems

Liner, Dee's and inner region

Components and Subsystems of a 250 MeV Cyclotron for Varian Medical Systems

150 kW rf Power Amplifier. Based on innovative semiconductor technology