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HZB Helmholtz Zentrum Berlin
bERLinPro

TUPCR015

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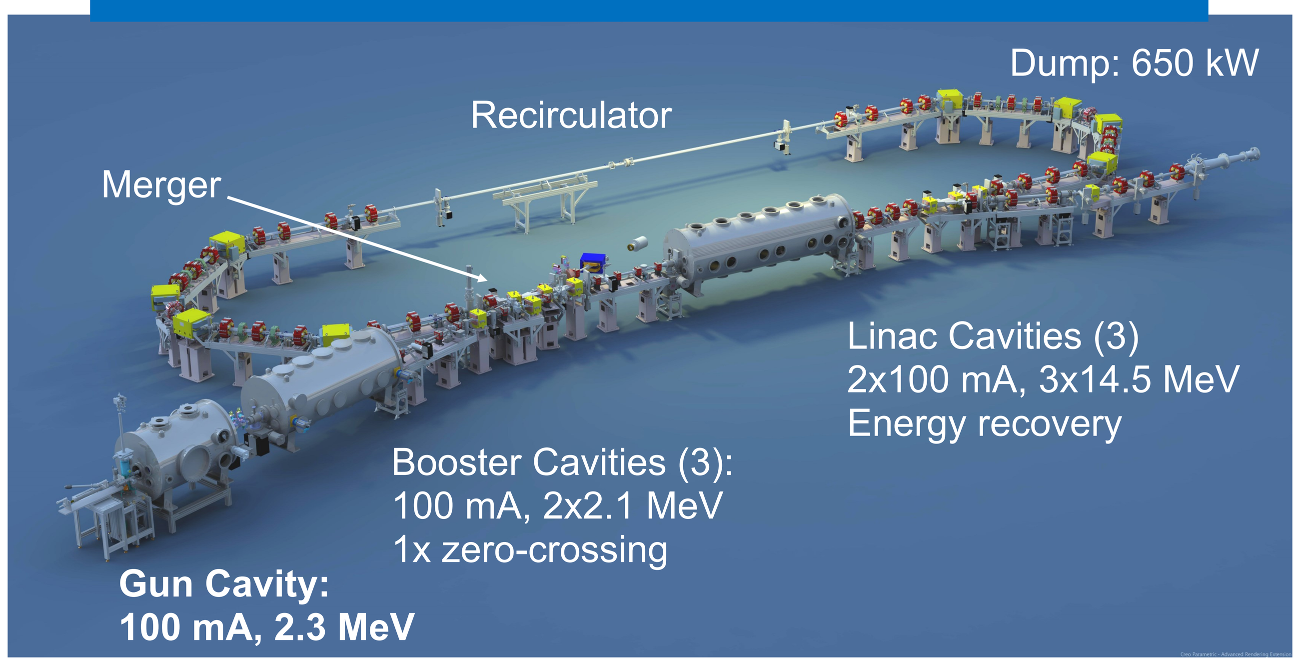
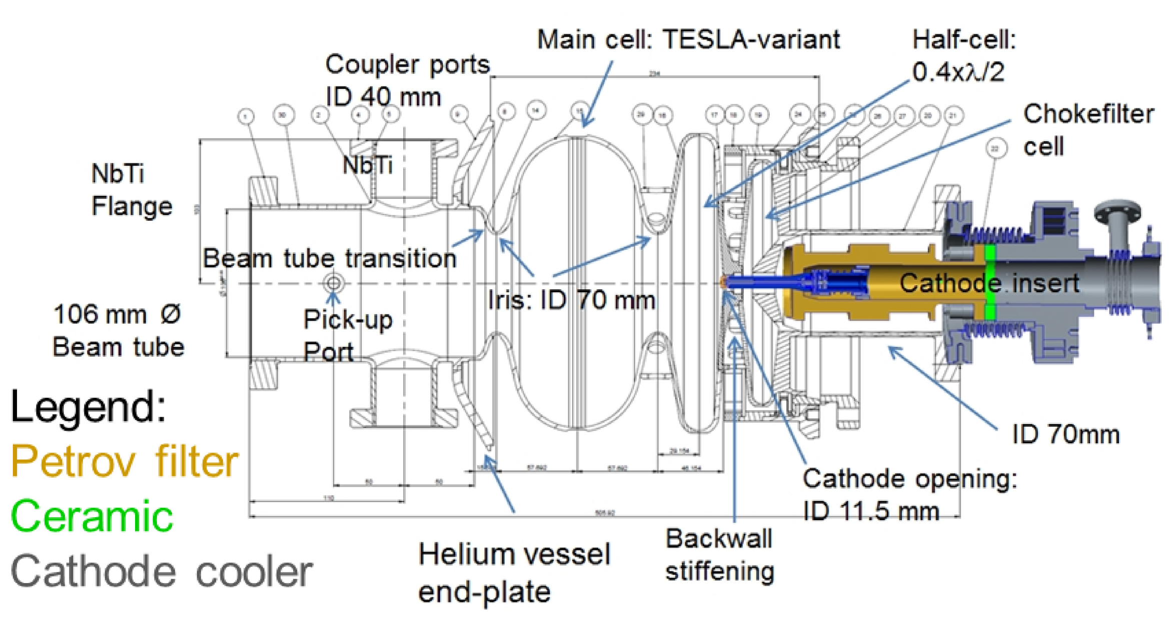
FINAL ACCEPTANCE TEST OF SRF PHOTO-INJECTOR COLD STRING FOR THE bERLinPro ENERGY RECOVERY LINAC

bERLinPro Energy Recovery Project



bERLinPro's main **goal** is the ERL operation of a **low emittance**, **high current beam** (ε_n < 1 mm mrad, I_{beam} = 100 mA, σ_t= 2 ps).
Its basic concept starts with a 6.5 MeV injector consisting of a **1.4·λ/2 cell SRF gun** followed by a booster section with three 2-cell-cavities.
The beam is merged into the main linac via a dogleg merger and accelerated by three 7-cell SC cavities to 50 MeV.
After the following recirculation via a racetrack shaped return arc, the decelerated beam is dumped in a 650 kW, 6.5 MeV beam dump.

SC RF Photoinjector (Gun)



Mounting of cathode carrier challenging because of small diameters involved. New assembly procedures in the clean room had to be developed.

The SRF Photoinjector is a 1.4 cell cavity optimized for high emission phase and peak on-axis longitudinal electric field close to the cathode within the half-cell.
The cathode carrier is a demountable, thermally and electrically isolated stalk on which multi-alkali photocathodes will be deposited, similar to the HZDR system for the 3.5-cell SRF gun at ELBE.
The pictures to the left shows a cross-section of the cavity highlighting the cathode insert section.
The prototype medium power cavity delivering potentially up to 5 mA beam current was manufactured at JLab.

Parameter	Design	As built
TM_{010} freq. (MHz)	1300	1300
$R/Q(\Omega)$ $\beta = 1$	150	132.5
$G(\Omega)$	174	154
$P_{forward}$ max. (kW)	20	20
E_{peak}/E_0	1.45	1.66
B_{peak}/E_{peak} (mTMV^{-1}m)	2.27	2.18
E_{kin} (MeV)	3.5	2.5-3

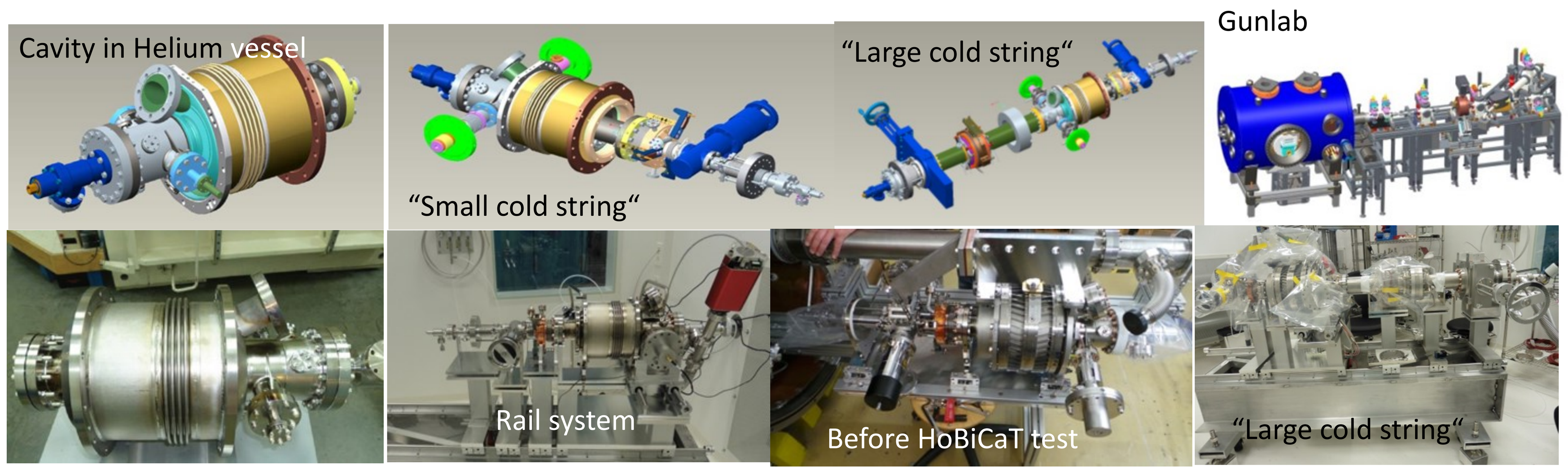
RF design parameters and values estimated/ measured for the prototype as produced

Parameter	VTA JLab	HTA HZB	Cold string HZB
E_0 (MVm^{-1})	34.9	34.5	28.5‡
E_{peak} (MVm^{-1})	58	57.3	47.3
B_{peak} (mT)	111.8	110.4	91.2
low field Q_0	$1.2 \cdot 10^{10}$	$1.1 \cdot 10^{10}$	$9.6 \cdot 10^{9}$
$\Delta f/\Delta E_0^2$ (HzMV^{-1}m)^2	-4.7	-3.7	-3.4
$\Delta f/\Delta P_{LHe}$ (Hzmbar^{-1})	-561	150	33

Administrative limit

Achieved RF figures of merit during the different test/assembly stages at JLab and HZB → the level of degradation is small

Clean room assembly and testing



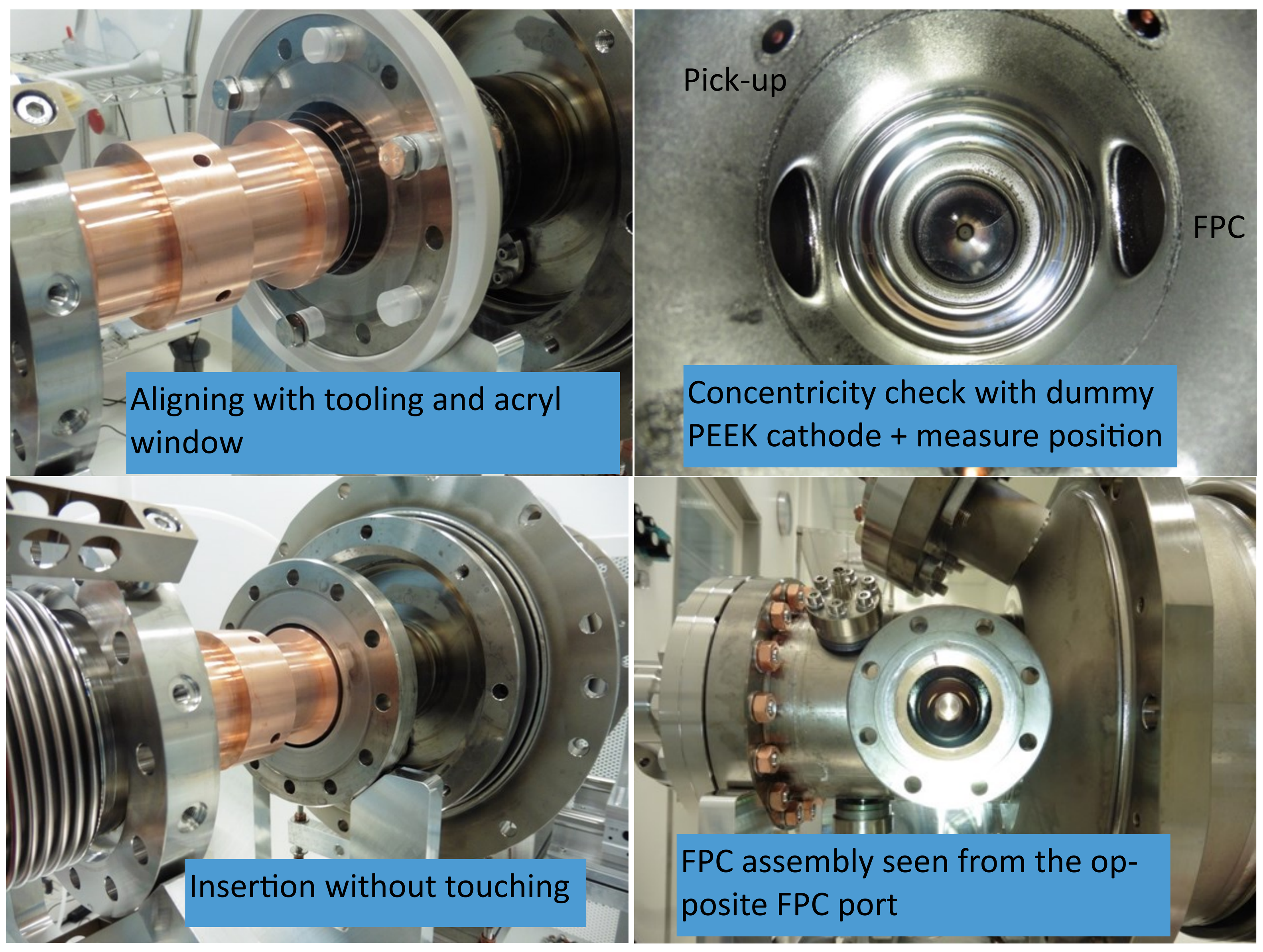
Assembly stages from VTA and HTA test with helium vessel, cold string assembly with cathode insert and TTF-III couplers, extension of string with HOM load and SC solenoid to Gunlab for beam test

Twin waveguide with phase shifter for couplers

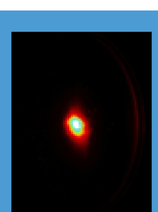
Cryomodule with local cleanrooms and coldbox

- Developed new assembly procedures to avoid contamination/damage of SRF cavity by insertion of cathode holder
- HZB personell went through clean room training at DESY (MKS-3)
- Two dummy assemblies performed to test tooling and fine tune procedures, documentation of each step
- All components Ethanol rinsed and ultrasonic cleaned
- Preassembly as much as possible, number of operations next to open cavity minimized, marriage of sub-assemblies under N_2 overflow —> wait for particle count to settle to minimum
- Assembly performed in a ISO class 4-5 cleanroom
- Tools developed to measure future cathode position and concentricity

Assembly steps and acceptance test

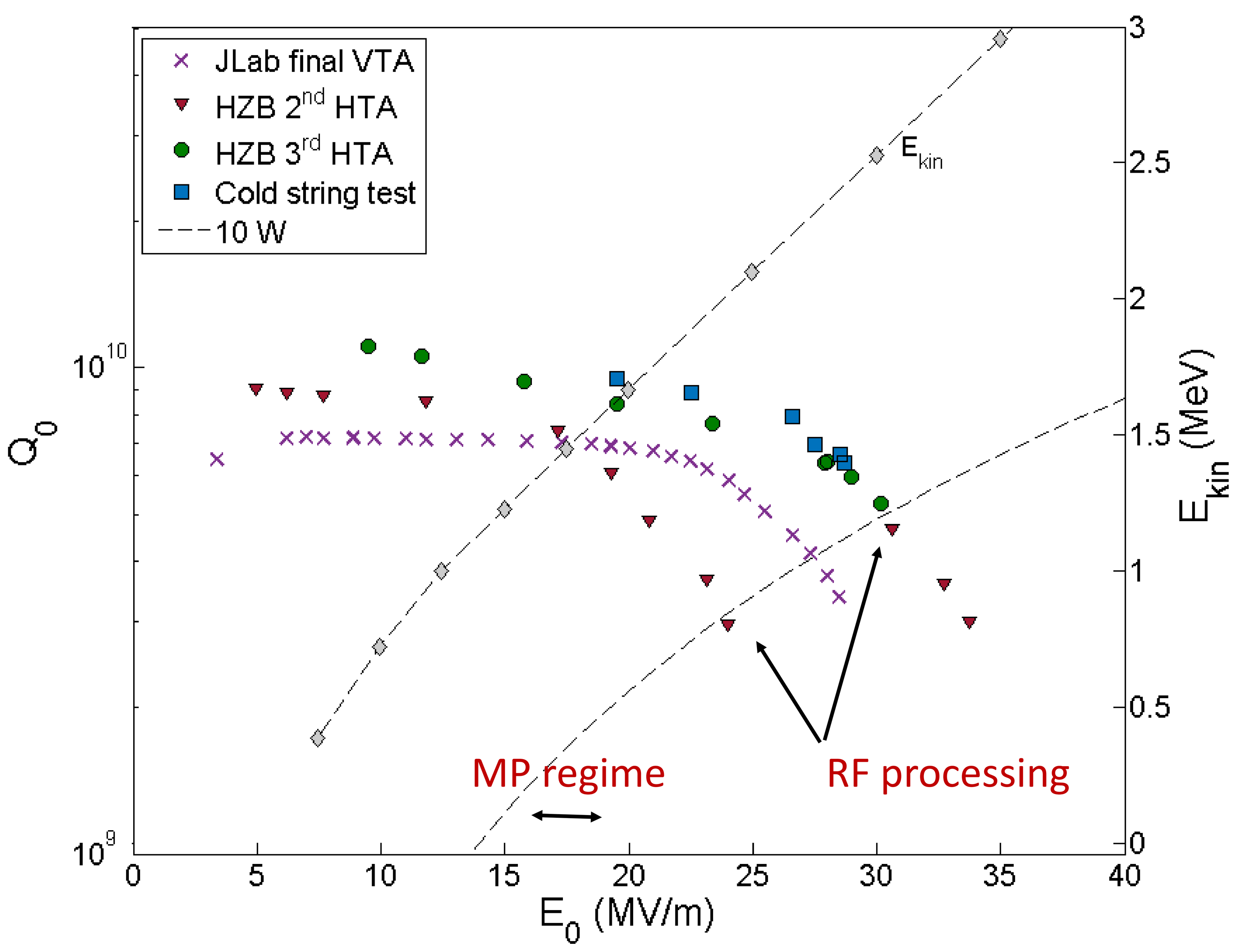


Next steps: BEAM!



- Complete cold mass, equipp with sensors/diagnostics
- Commissioning of module: Vacuum, cryogenics, RF
- Setup of Gunlab beamline, Cathode Laser, Cathode transfer system

Cold string test compared to VTA/HTA



All measurements with critical coupling except cold string:
Here 2K helium flow based technique used

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