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GOETHE UNIVERSITÄT FRANKFURT AM MAIN

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Cryogenic tests of the superconducting beta=0.069 CH-cavities for the HELIAC-project

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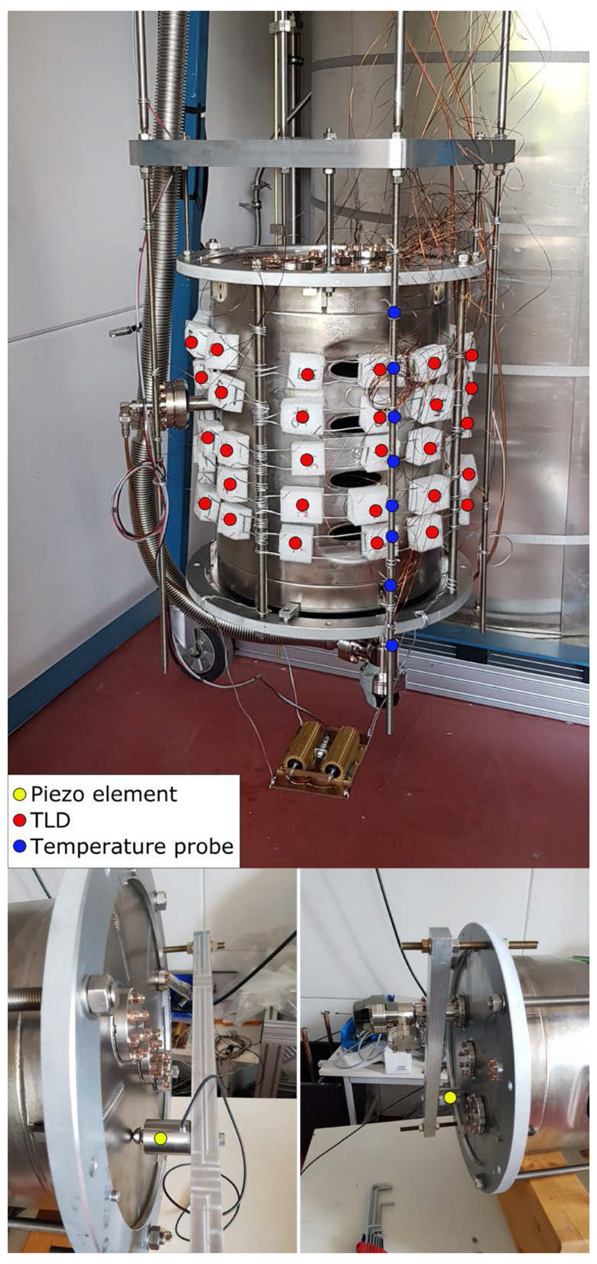
Abstract:

In the future the existing UNILAC (UNIversal Linear Accelerator) at GSI will be most exclusively used as an injector for FAIR to provide short pulse high intensity heavy ion beams at low repetition rates. A new superconducting (sc) continuous wave (cw) high intensity heavy ion Linac should provide ion beams with max. duty factor above the coulomb barrier for the Super Heavy Element (SHE) program at GSI. The fundamental Linac design comprises a low energy beam transport (LEBT)-section followed by a sc Drift Tube Linac (DTL) consisting of sc Crossbar-H-mode (CH) structures for acceleration up to 7.3 MeV/u. After the successful test and commissioning of the first demonstrator section with heavy ion beam from the HLI in 2017, the next two sc CH-structures have been constructed and the first one has been extensively tested at cryogenic temperatures at the Institute for Applied Physics (IAP) at Goethe University Frankfurt (GUF). The results of the final cold test of the first CH-structure as well as the next steps realizing a new sc cw heavy ion LINAC at GSI will be presented.

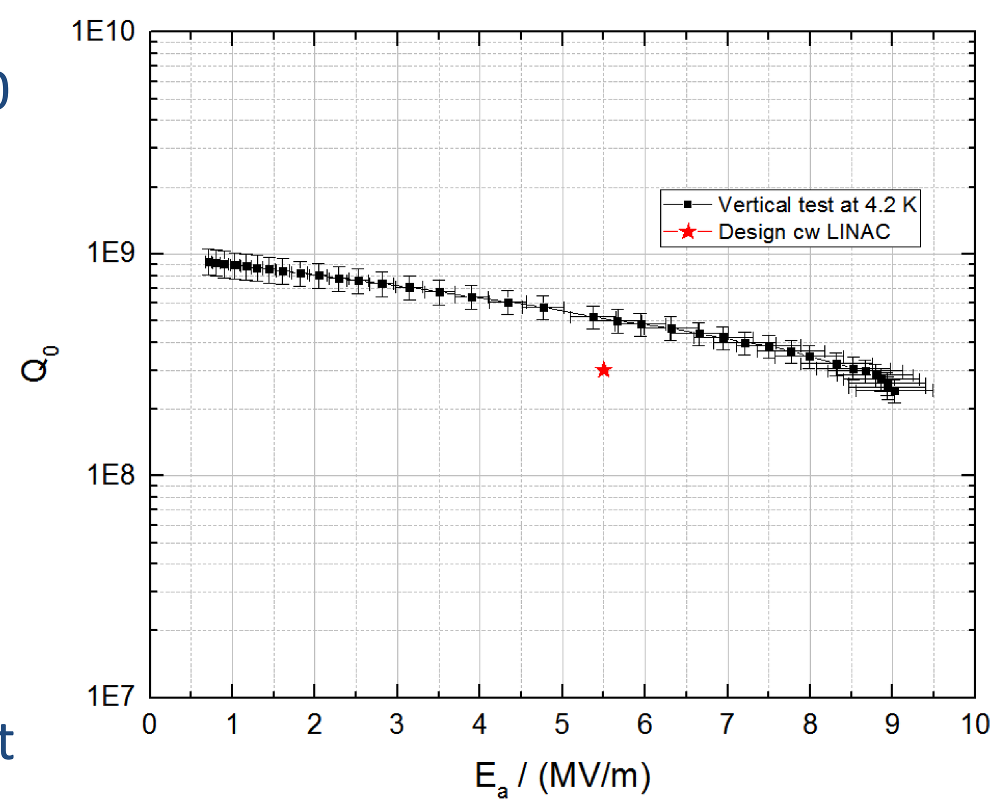
Measurement setup & Structural layout



Parameter	β	f	Eff. Length (βλ-def.)	Inner diam.	E_a	E_p/E_a	B_p/E_a	G	R/Q
Unit	-	MHz	mm	mm	MV/m	-	mT/(MV/m)	Ω	Ω
Value	0.069	216,816	381.6	400	5 .5	< 6	< 10	50	1070

RF performance at 4.2 K

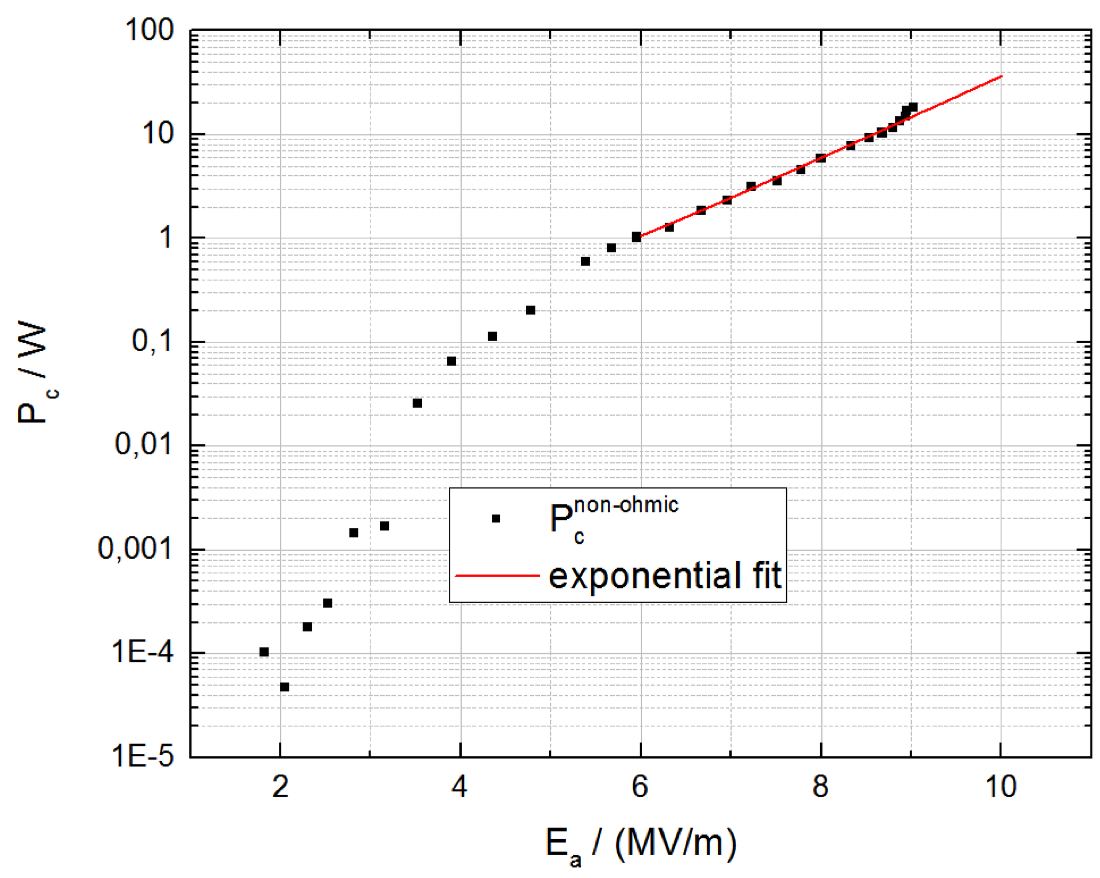
- fast cooldown with approx. 1.8 K/min in the region between 150 K and 60 K to avoid hydrogen related Q-disease
- low level conditioning with various power levels and sweep times to permanently overcome multipacting barriers
- High power test with 50 W amplifier resulted in the adjacent Q_0 versus E_a curve
- The maximum unloaded Q value **Q_0 = 1*10⁹** drops down to **2.43*10⁸** at an accelerating gradient of **E_a = 9MV/m** corresponding to **U_{eff} = 3.32 MV** voltage
- The design Q-value of **Q_0 = 3*10⁸** is reached at **E_a = 8.52 MV/m** which is 55% more than the design gradient of E_a = 5.5 MV/m

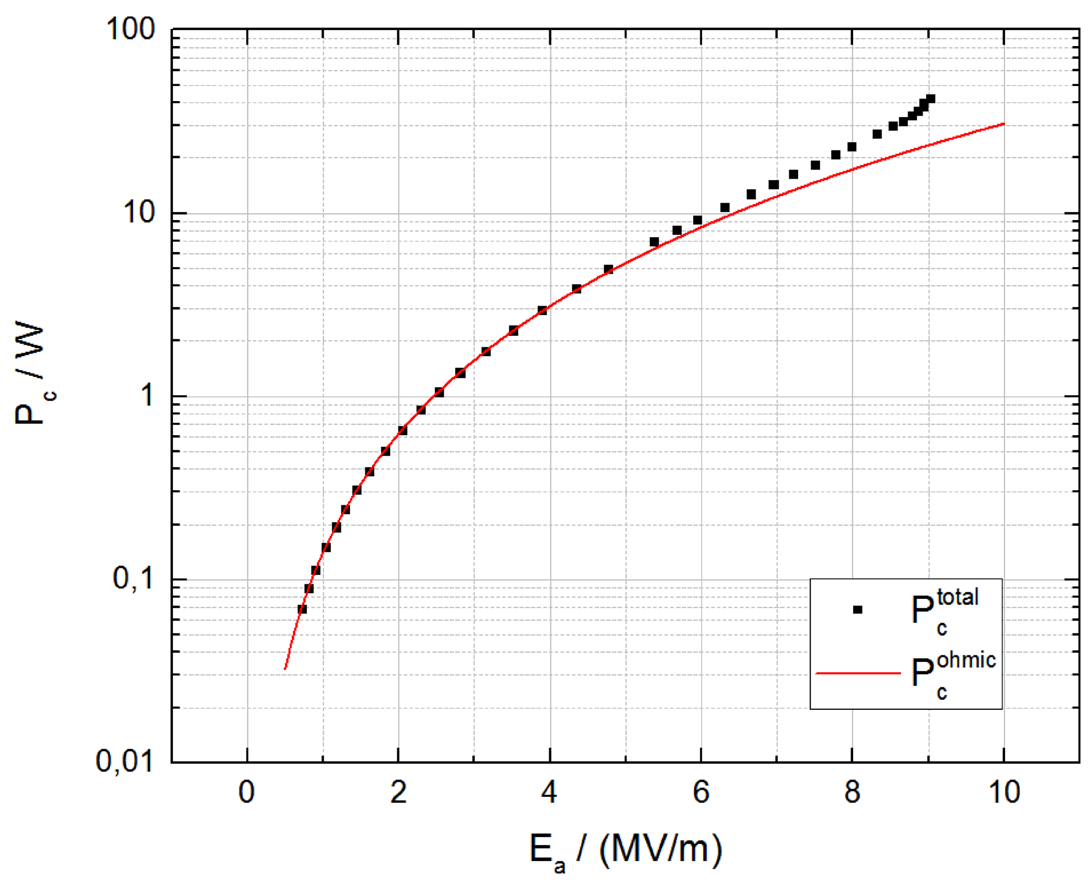


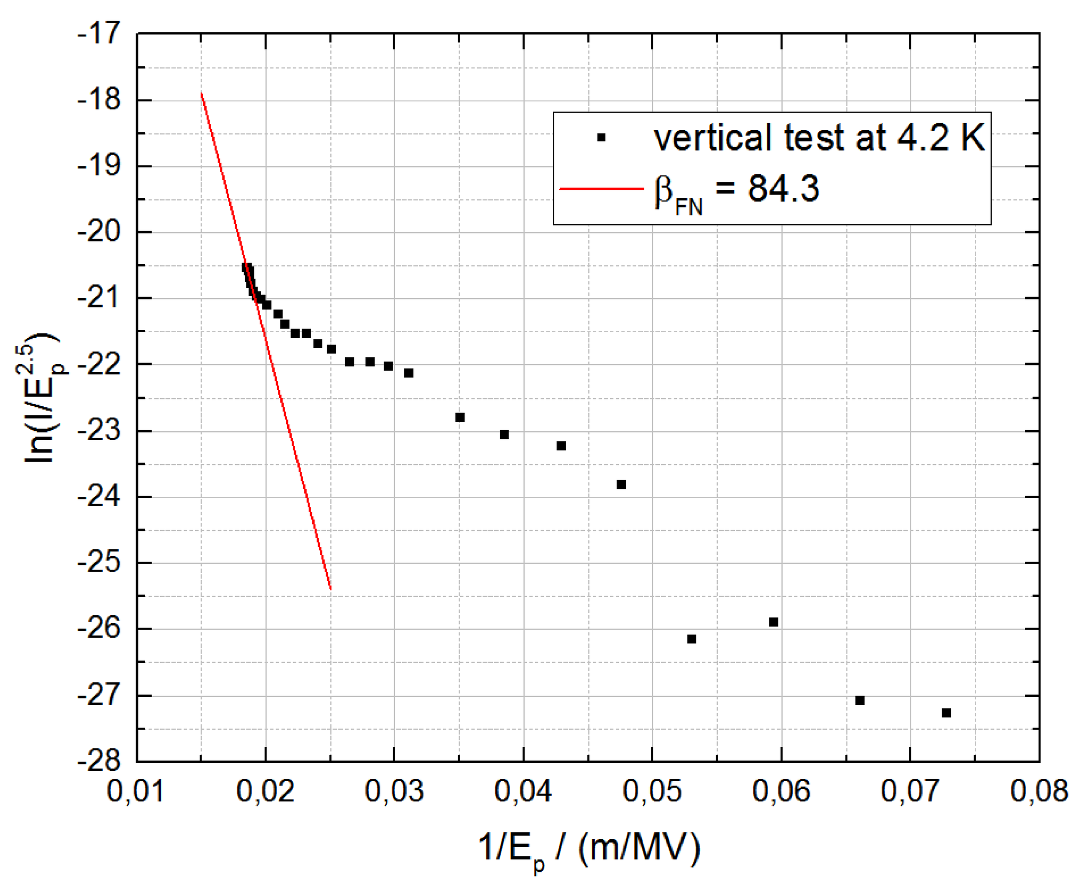
Parameter	Unit	Value
Q_0^{low}		$1.02 \cdot 10^9$
Q_e^{low}		$1.68 \cdot 10^8$
R_s	nΩ	48.4
R_{BCS}	nΩ	12.6
R_{mag}	nΩ	9.78
R_0	nΩ	26.02
E_a	MV/m	9
U_{eff}	MV	3.32
Q_0^{High}		$2.43 \cdot 10^8$
Q_e^{low}		$1.68 \cdot 10^8$

Field emission analysis

- Due to technical limitations High Pressure Rinsing (HPR) was possible only along the beam axis resulting in a higher risk of field emitters on the inner surface
- By plotting the total losses inside the cavity as well as the ohmic and non-ohmic losses depending on E_a, field emission is visible from approx. E_a = 5 MV/m due to increased non-ohmic losses
- The corresponding Fowler-Nordheim-Plot illustrates the enhancement factor **β_{FN} = 84.3** of the electric fields on the field emitter surface







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