FRANZ – Frankfurt Neutron Source at Stern-Gerlach-Zentrum

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A Rebunching CH Cavity for Intense Proton Beams

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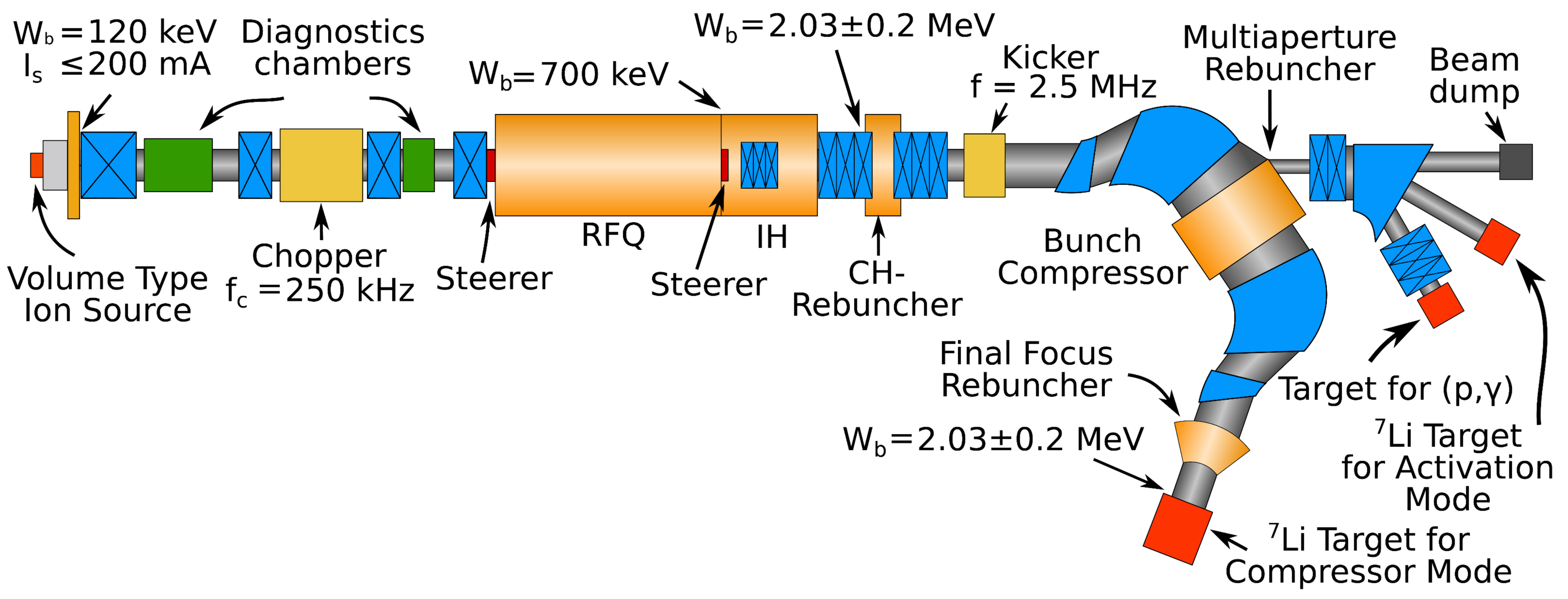
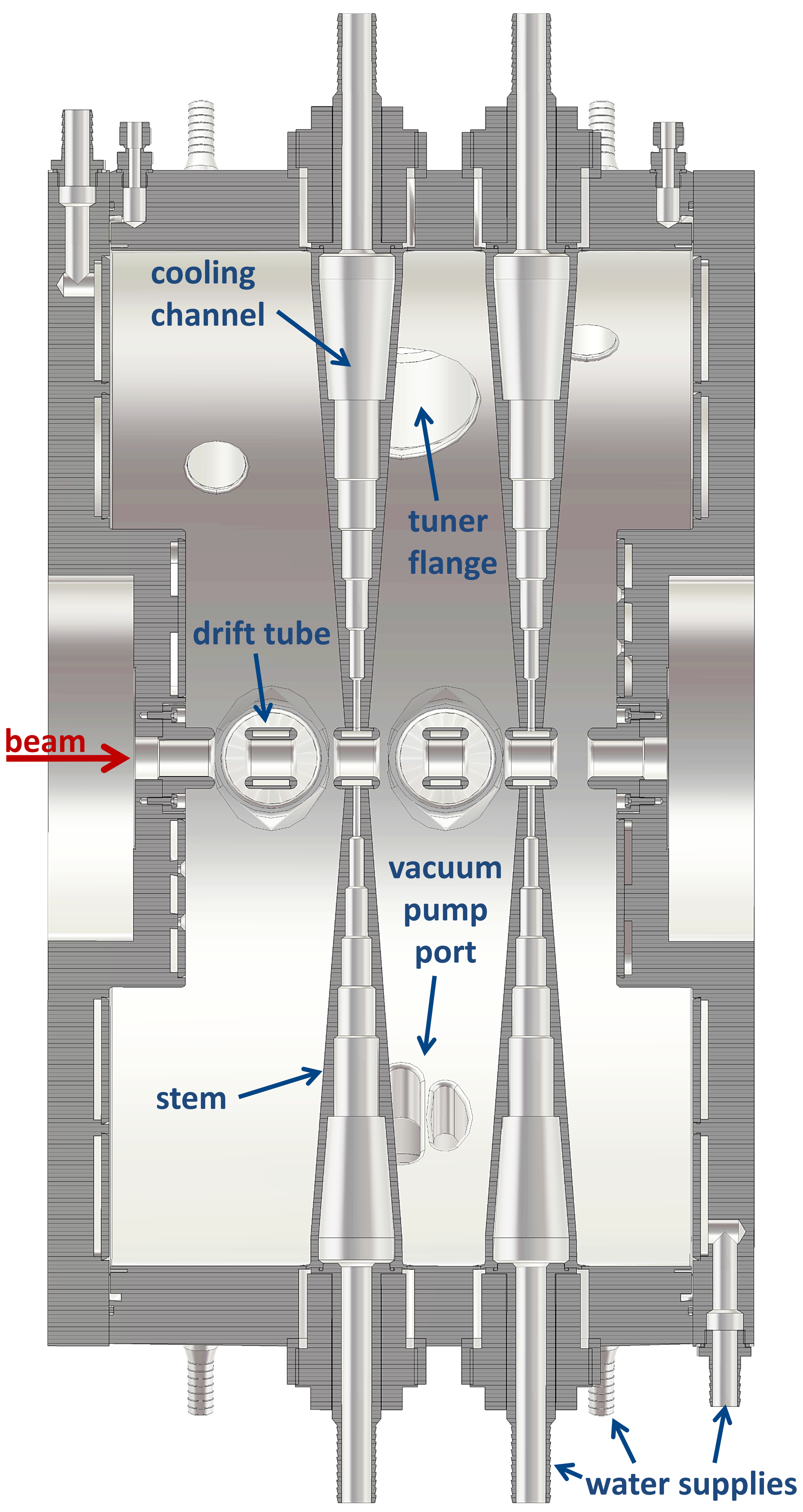
Abstract

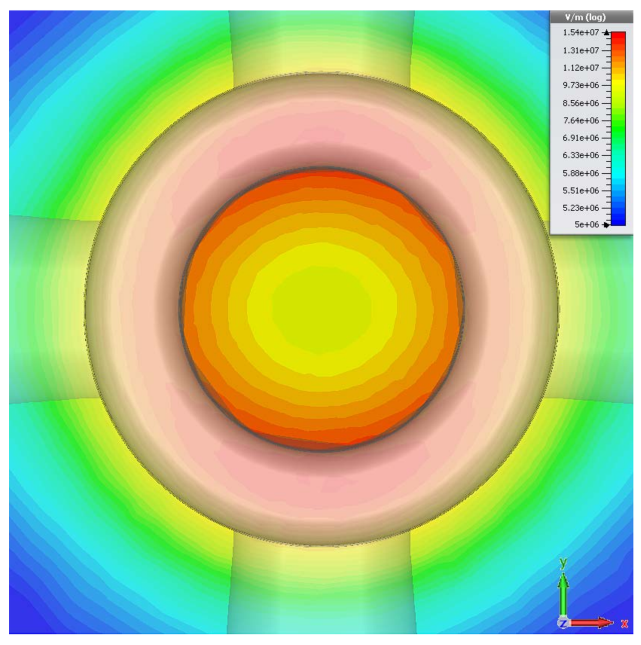
The Frankfurt Neutron Source at the Stern-Gerlach-Zentrum (FRANZ) will provide ultra-short neutron pulses at high intensities and repetition rates. The facility is currently under construction at the Goethe-University in Frankfurt am Main (Germany). A 5-gap CH rebuncher is installed behind a coupled RFQ/IH-DTL combination at the end of the LINAC section between two magnetic quadrupole triplets. It will be used for varying the final proton energy around 2 MeV as well as for focusing the bunch longitudinally to compensate huge space charge forces at currents up to 200 mA at the final stage of extension. High current beam dynamic simulations have been performed. They include benchmarking of different beam dynamic codes like LORASR and TraceWin, as well as validating the results by measurements. Detailed examination of multipole field impact, due to the cavity's geometry, together with error tolerance studies and thermal simulations are also performed. Furthermore, this CH rebuncher serves as a prototype for rt CH cavities at MYRRHA, an Accelerator Driven System in Belgium for transmutation of high level nuclear waste. After copper plating the cavity, RF conditioning will start soon.
In the following, the results regarding the electric quadrupole components will be presented.

FRANZ Schematic Layout

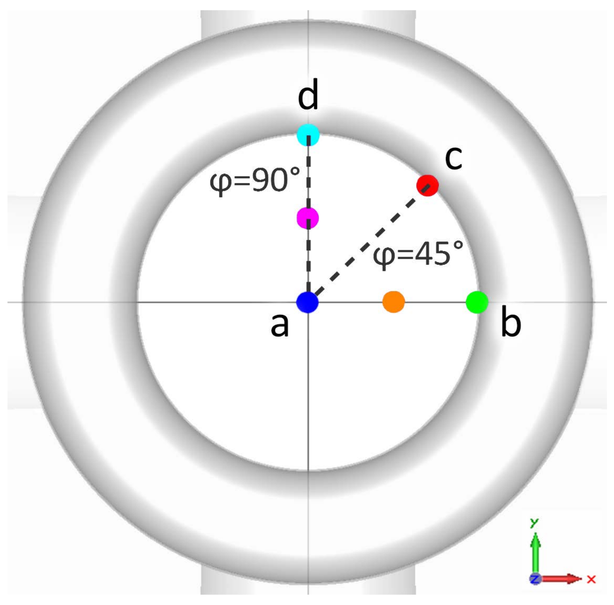


Sectional Side View

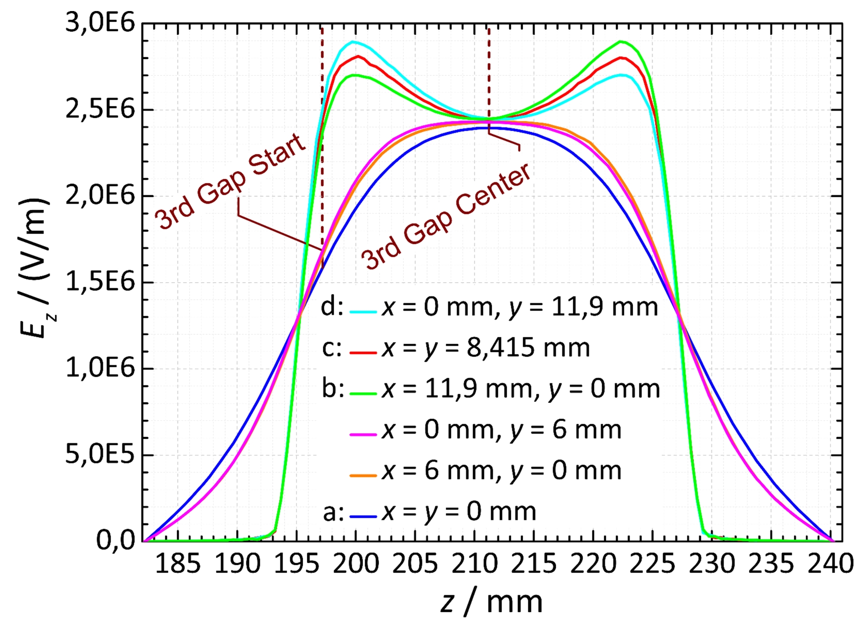




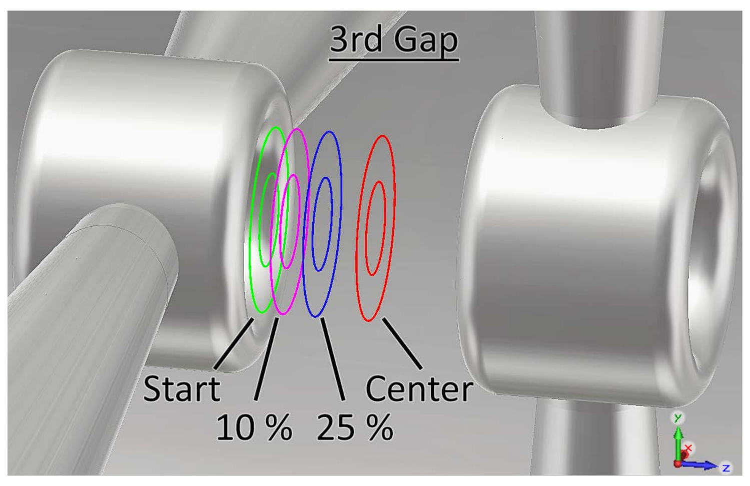
E_z false color plot: NO perfect circle!



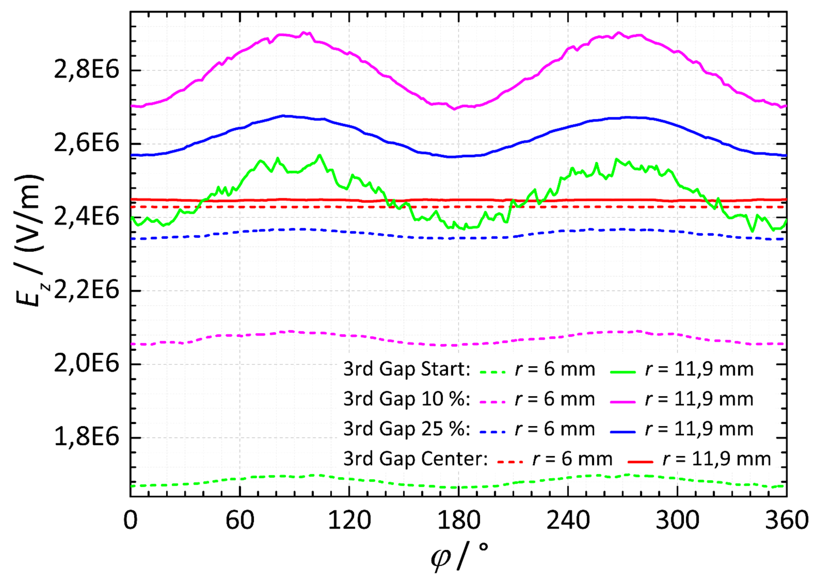
Straight lines parallel to z

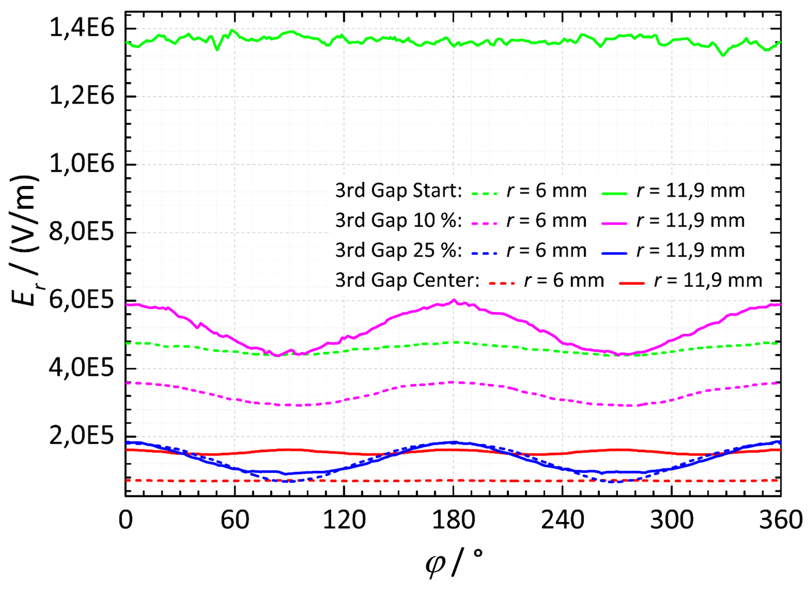


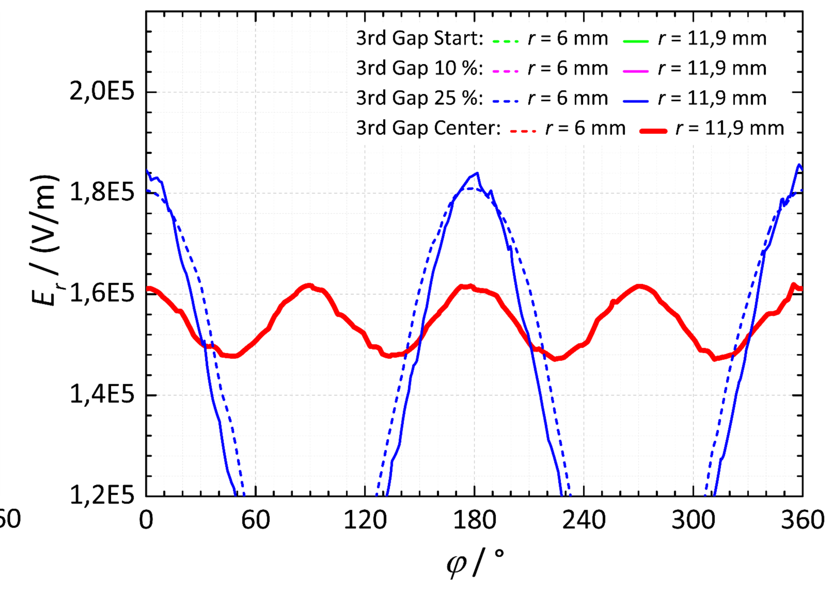
$E_{z,b}$ vs. $E_{z,d}$ reveals multipole component

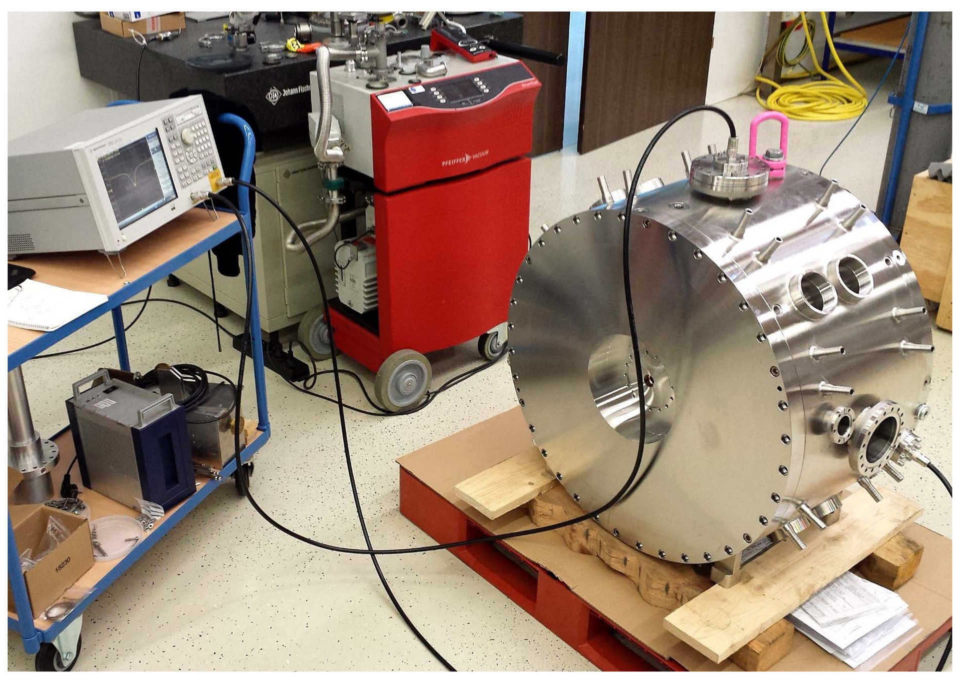


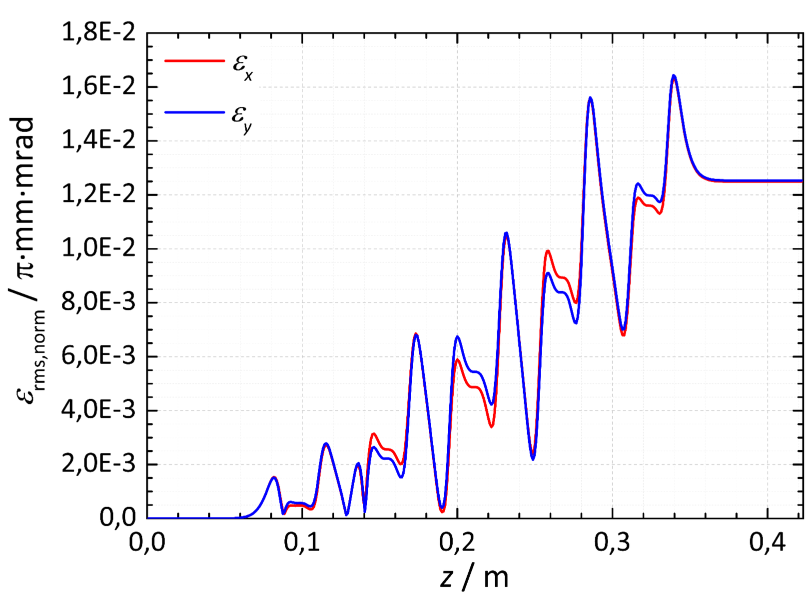
- Crossed neighbouring stems lead to an azimuthal dependence of the *E*-field.
- *E*-field component analysis on circular paths reveal the quadrupole modulation.
- The longitudinal *E*-field varies by up to ±4 %, the radial even by up to ±15 % with φ.
- In the gap center, *E* in dependence of φ is fairly uniform, but an octupole pattern is visible (arises when two quadrupoles are placed side by side but twisted by 90° to each other).



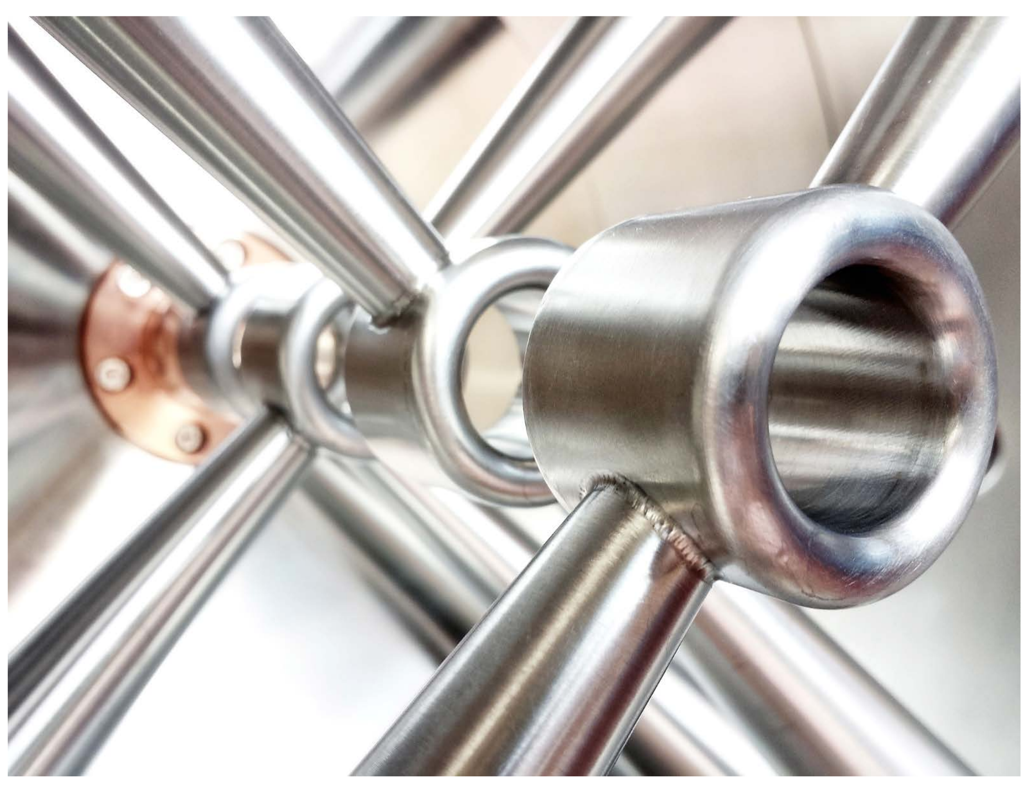








- Beam dynamics simulations with TraceWin showed that the overall influence of the azimuthal dependence is very small.
- Modifications of the beam at the gap entrance are inverted when the beam exits the gap, du to the crossed stems.
- Nevertheless a "pencil beam" reacts very sensitive and reveals the field asymmetry.



Parameter	Unit	Value
Particle		Proton
β		0.065
f	MHz	175
E_{in}	MeV	2.03
E_{out}	MeV	1.8–2.2
Gaps	#	5
Total length	mm	462
Cavity inner diam.	mm	332
Aperture diam.	mm	24
Wall thickness	mm	40–52
Cooling channels	#	29
Dynamic tuner	#	1
Static tuner	#	1
U	kV	295
U_{eff}	kV	245
Z_{eff}[1]	MΩ/m	58
Q_0[1]		13500
P[1]	kW	2.9

[1] simulated CST MWS value, normalized with the desired voltage.

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