Design Upgrades of the Next Superconducting RF Gun for ELBE

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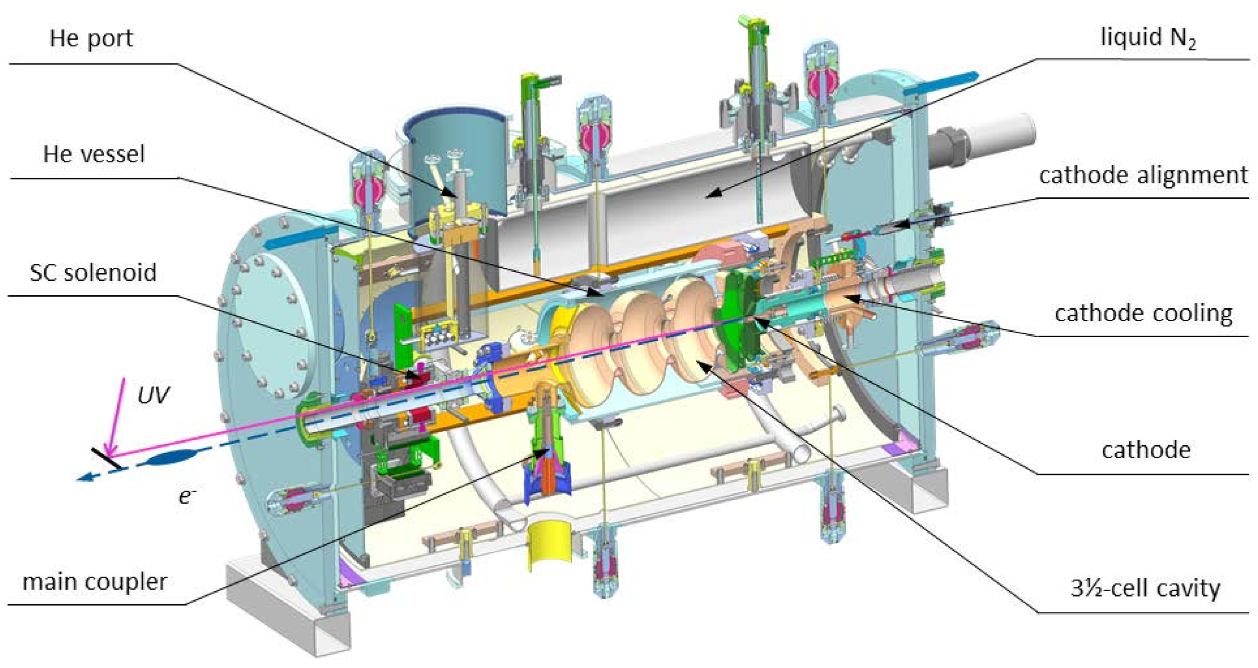
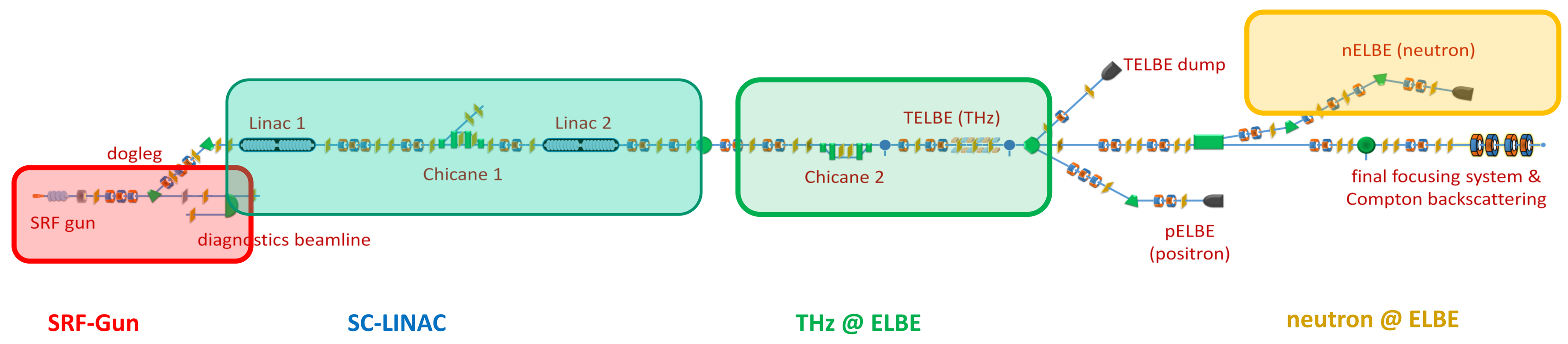
SRF Photoinjector

The SRF gun produces high-brightness electron beams (low emittance, high bunch charge) in CW operation (MHz pulse repetition rate)



- 3.5 cell elliptical niobium cavity, 1.3 GHz [1],
- normal-conducting photocathode, cooled with liquid N_2,
- SC solenoid integrated in cryo-module,
- exchange system for photocathodes,
- superconducting cell RFchoke filter,
- two tuners, one for half-cell and one for three TESLA cells
- HOM couplers, TESLA type, pick-up for dLLRF control
- main coupler, liquid N_2 cooled, warm and cold window

ELBE Accelerator Facility



- Drossel gun (1/2 cell cavity) by D. Janssen [2]: First SRF gun produced an electron beam.
- ELBE SRF Gun I (3.5 cell cavity): first SRF gun at an accelerator, IR-FEL operation [3].
- ELBE SRF Gun II: installed in 2014, since 2018 in regular operation for user runs, THz radiation with 200 pC @ 100 kHz CW (20 µA) applying a Mg photocathode (0.1 – 0.3 % QE) [4]

Planned use of SRF Gun III
TELBE – superradiant THz production
500 pC increase of pulse energy 5 µJ -> 40 µJ (4 W @ 100 kHz CW)

nELBE – neutrons and pELBE – positrons
≤ 500 pC and higher average current up to 500 µA

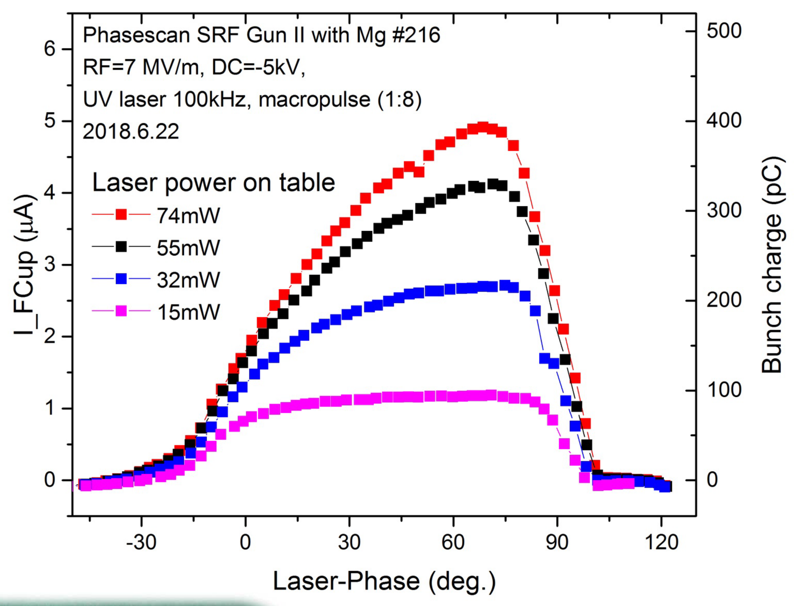
application of Cs_2Te photocathodes with QE >1 %

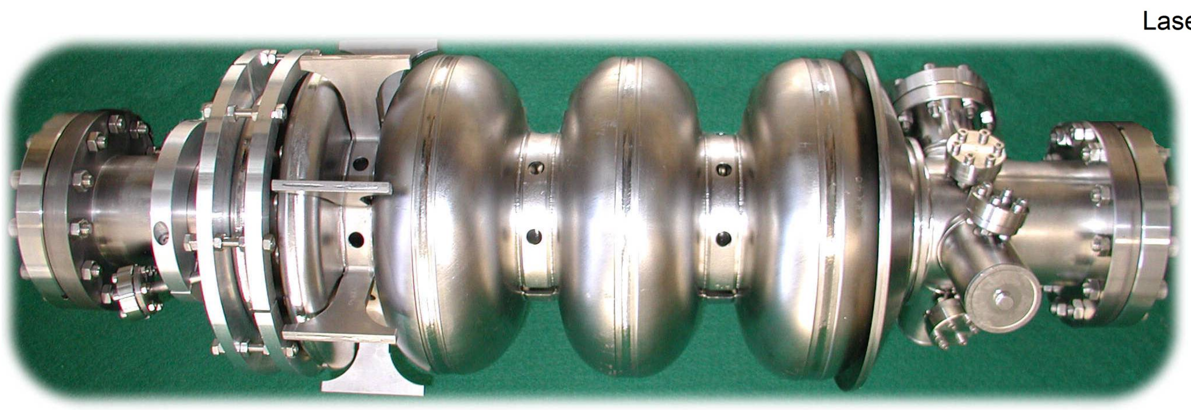
ELBE SRF Gun III – Pushing Gradient Limit

Parameter	SRF Gun II	SRF Gun III
Gradient	8 MV/m	12 MV/m
Peak field on axis	20.5 MV/m	**31 MV/m**
Kinetic energy	4 MeV	6 MeV
Bunch charge	300 pC	**500 pC**
Beam current	30 µA	50 µA [1)], 500 µA [2)]
CW pulse repetition rate	100 - 500 kHz [1)] 13 MHz [2)]	25 kHz – 1 MHz [1)] 13 MHz [2)]
Photo cathode / QE	Mg / 0.2 – 0.3 % Cs_2Te / >1 %	Mg/ 0.2 %, Cs_2Te / >1 %
Dark current	30 nA	<50 nA

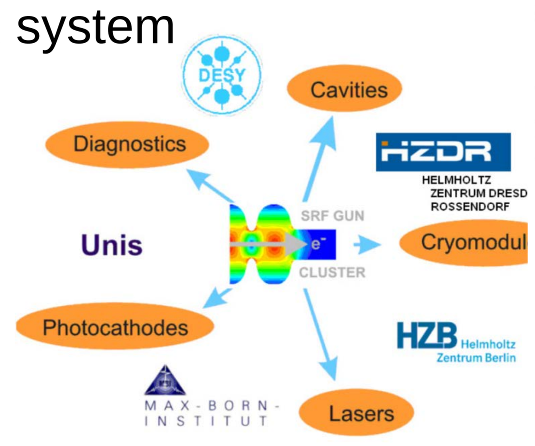
[1)] Mg cathode, [2)] Cs_2Te cathode

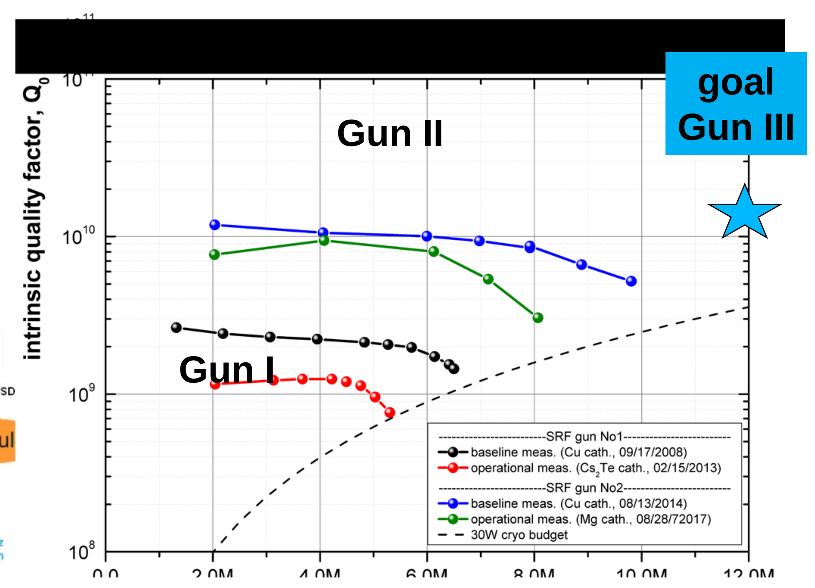
The higher gradient improves beam quality (transverse and longitudinal emittance) and shifts the space charge limit towards higher bunch charges up to 500 pC.



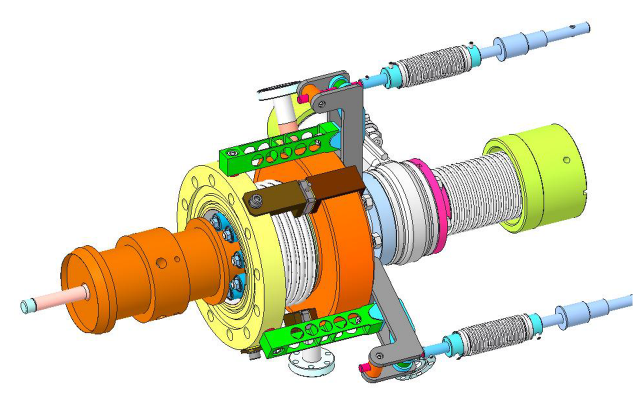


3.5 cell cavity of Gun I, produced by RI, is under refurbishment at DESY
- electro polishing
- modified HPR system

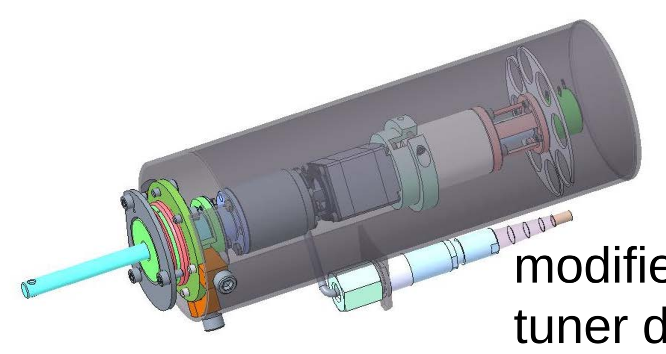




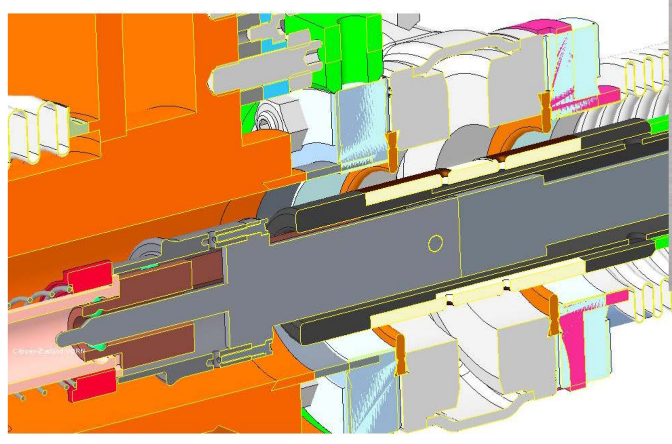
Gun III Cryomodule Improvements



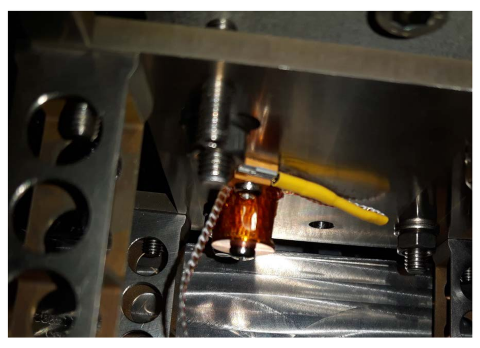
Cathode cooling & positioning system
additional capacitive position sensors



Tuning
modified hysteresis-free tuner drives



Cathode exchange
Touch sensors for safety and computer-aided alignment of cathode transfer rod



Temperature Sensors
cernox from LAKESHORE

Retaining Cavity Performance

Critical for the cavity are the cleanness, the particle-free movement, and a safe operation of photocathodes

- dry ice cleaning of PC bodies
- inspection of PC with respect to scratches, particle pollution, etc.
- quality check, no Cs contamination (multipacting)
- check of the PC cooling

References

[1] A. Arnold et al., Nucl. Instr. and Meth. A577 (2007) 440.
[2] D. Janssen et al. Nucl. Instr. and Meth. A 507 (2003) 314.
[3] J. Teichert et al., Nucl. Instr. and Meth. A 743 (2014) 114
[4] J. Teichert et al., IPAC 2018, Vancouver, Canada, April 29 – May 4, 2018

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