

SRF Gun development at DESY.



Elmar Vogel⁵, Jacek Sekutowicz⁵, Serena Barbanotti⁵, Ingmar Hartl⁵, Kay Jensch⁵, Daniel Klinke⁵, Denis Kostin⁵, Wolf-Dietrich Moeller⁵, Manuela Schmoekel⁵, Sven Sievers⁵, Nicolai Steinhau-Kuehl⁵, Alexey Sulimov⁵, Jan-Hendrik Thie⁵, Birte van der Horst⁵, Hans Weise⁵, Lutz Winkelmann⁵, John Smedley¹, Jochen Teichert², Mateusz Wiencek³, Jerzy Andrzej Lorkiewicz⁴ and Robert Nietubyc⁴

Electron Beams for Continuous Wave (CW) FELs

photocathode gun technology providing high brightness beams

design beam parameters	CW SRF Gun for XFEL	APEX-1 Gun for LCLS II (NC)	pulsed NC XFEL Gun
bunch train duty cycle [%]	100	100	0.6
beam current [μA]	up to 25	up to 60	up to 27
bunch repetition rate [kHz]	1 000 to 100	620 to 100	up to 4 500
bunch charge [pC]	20 to 250	10 to 300	20 to 1 000
transverse emittance [μm]	0.4 to 0.8	0.2 to 0.6	0.2 to 1.0
beam energy at gun exit [MeV]	3	0.75	6.1
RF parameters			
operation frequency	1.3 GHz	186 MHz	1.3 GHz
accelerating gradient [MV/m]	21	19.5	31
electric peak (cathode) field [MV/m]	40	19.5	60
RF input power	750 W	~ 100 kW	~ 42 kW

The parameters of normal conducting (NC) pulsed guns can be met by superconducting (SC) guns operating continuous wave (CW).

All Superconducting Gun

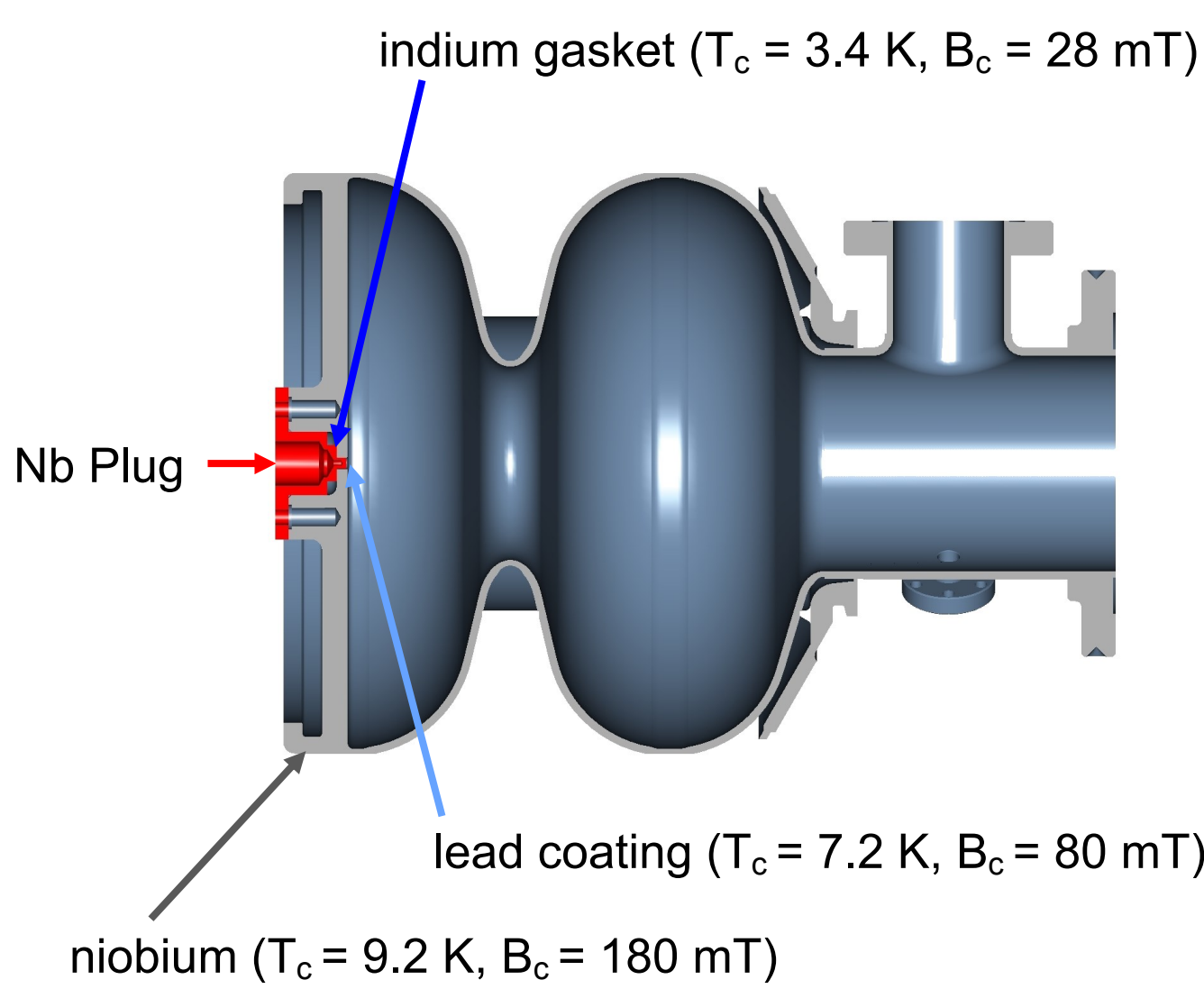
for optimal integration of cathodes in an ultra-clean SC cavity

existing cathode insertion systems still face challenges

- w.r.t. multipacting, field emission, cathode heating, cathode lifetime, etc.
- R&D still required and ongoing
- e.g. performed at HZDR and HZB

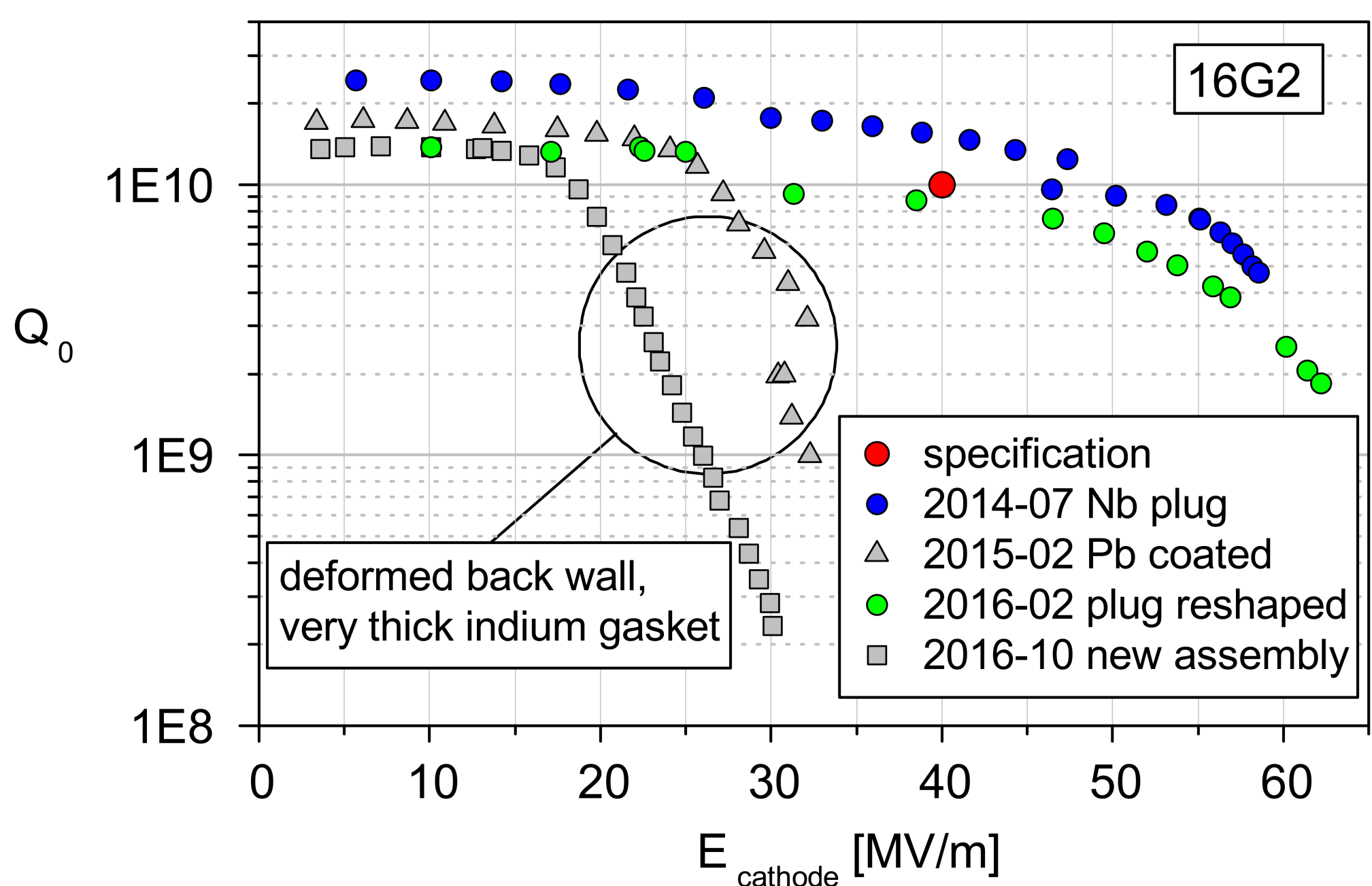
DESY approach: superconducting (sc) cathode attached to the cavity backside

- ☺ cleaning after cathode insertion in a clean room
 - ☺ cathode particles (lead) should not heat and quench the cavity
 - ☹ exchanging the cathode
- ⇒ only reasonable with cathode lifetimes above 100 days



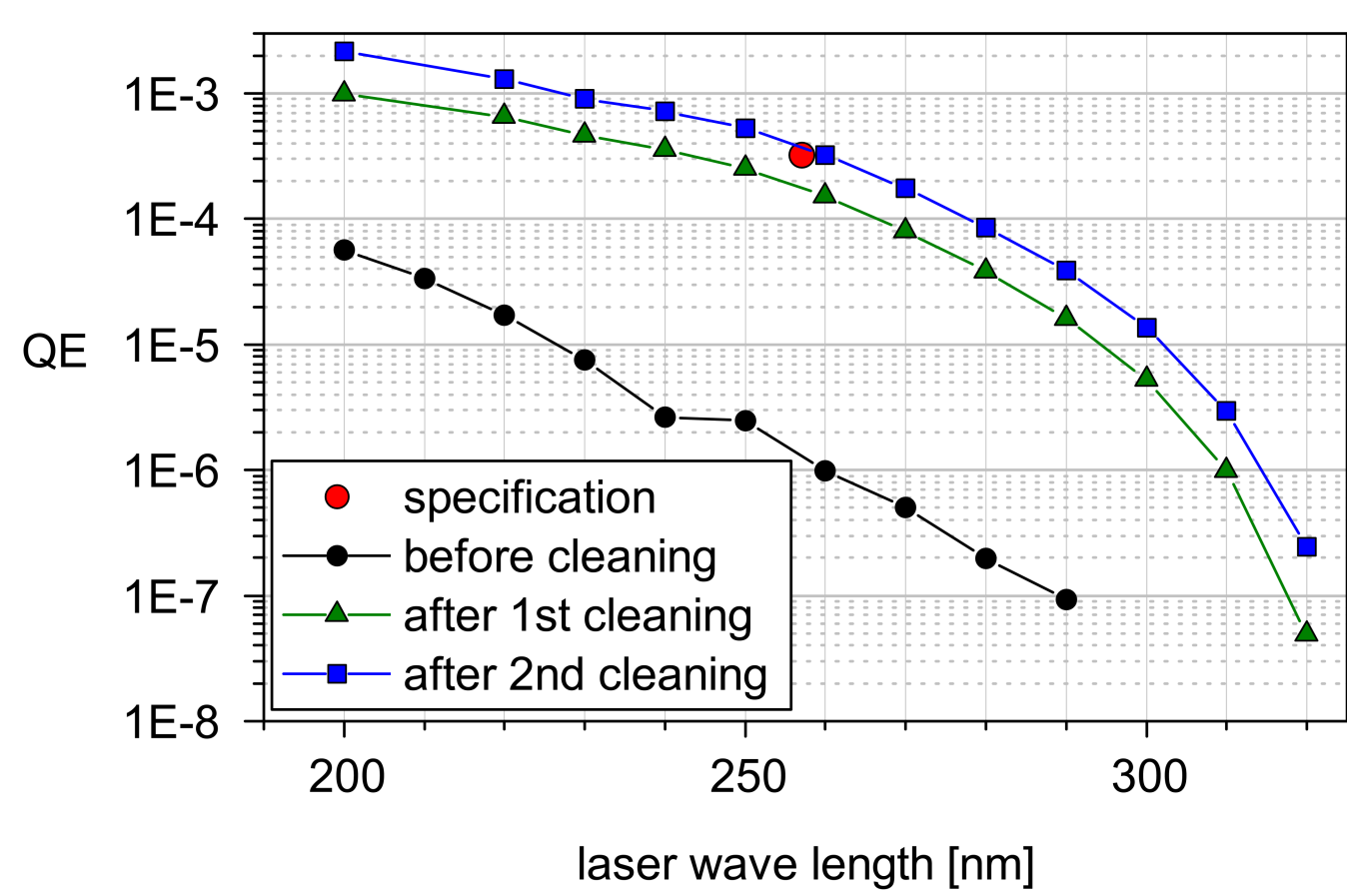
We Achieve the Required Gradients

results from cavity '16G2'



Quantum Efficiency (QE) and Cathode Lifetimes

the QE of the lead cathodes



lifetime of the lead cathodes

long time test

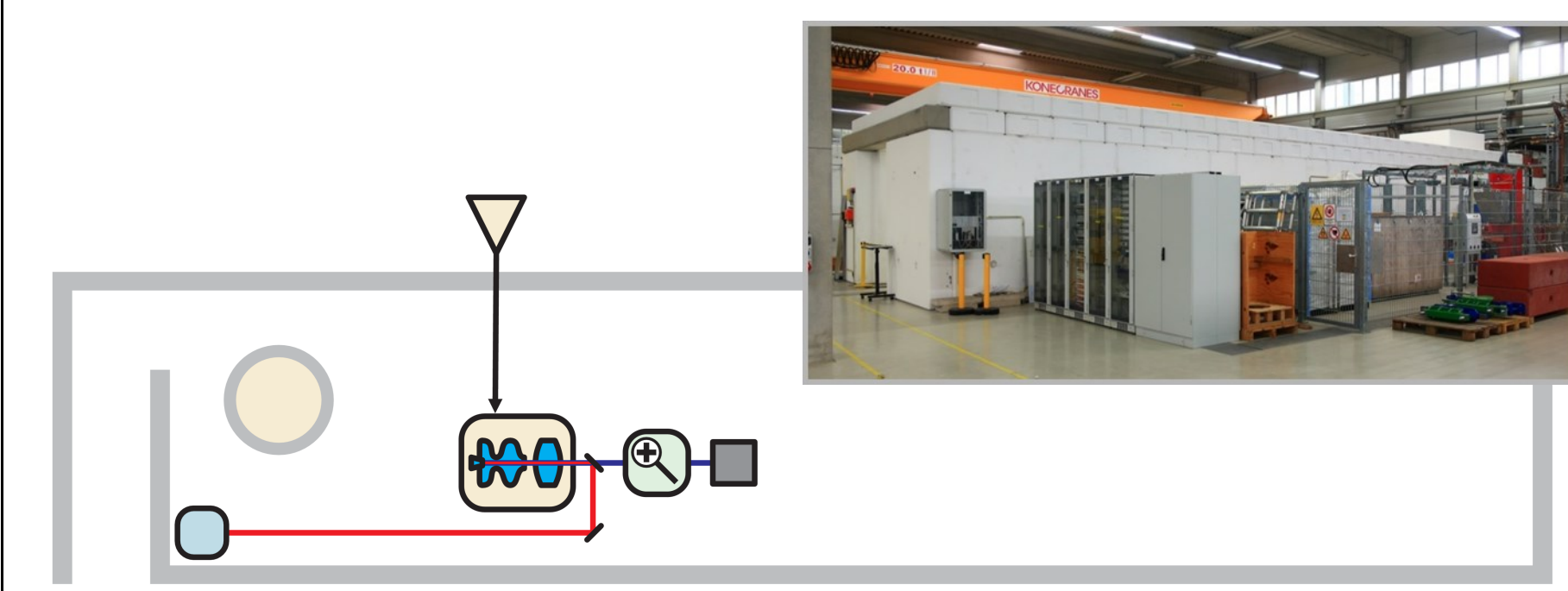
- 550 hours of irradiation
- ⇒ only small QE variations

Quantum Efficiency (QE)

- ⇒ sufficient for the specified bunch charge using an industry built cathode laser
- ⇒ so far no degradation over time

Laser cleaning (at 248nm):
1st 1000 shots with 0.06 mJ/mm²
2nd 10000 shots with 0.06 mJ/mm²

Next Step: Putting It All Together



Goal: Demonstration of a sufficiently long lifetime of the cathode irradiated with a laser in a cavity operating at the design gradient and generating electron bunches with charge up to 250 pC.

The New Cavities 16G3 and 16G4

built in spring 2017 together with industry

improved mechanical design

- backside reinforced
- titanium thread inserts
- improved cathode plug
- design validation by a mechanical model
- new auxiliaries like cavity handling frames



Cathode Laser

we are purchasing an industry built laser (Pharos), similar to the ones already used at DESY



laser parameter	specification
wavelengths	1030 nm / 515 nm / 257 nm
pulse length (FWHM)	300 fs – 15 ps (UV)
repetition rate	single-shot – 1.1285 MHz
average power in UV	1 W @ 100 kHz 2 W @ 100 kHz (short period)
max. pulse energy in UV	10 μJ @ 100 kHz (short term 20 μJ)
special features	output from oscillator for synchronization, actuator to stabilize laser oscillator, spare parts for fast harmonic module exchange

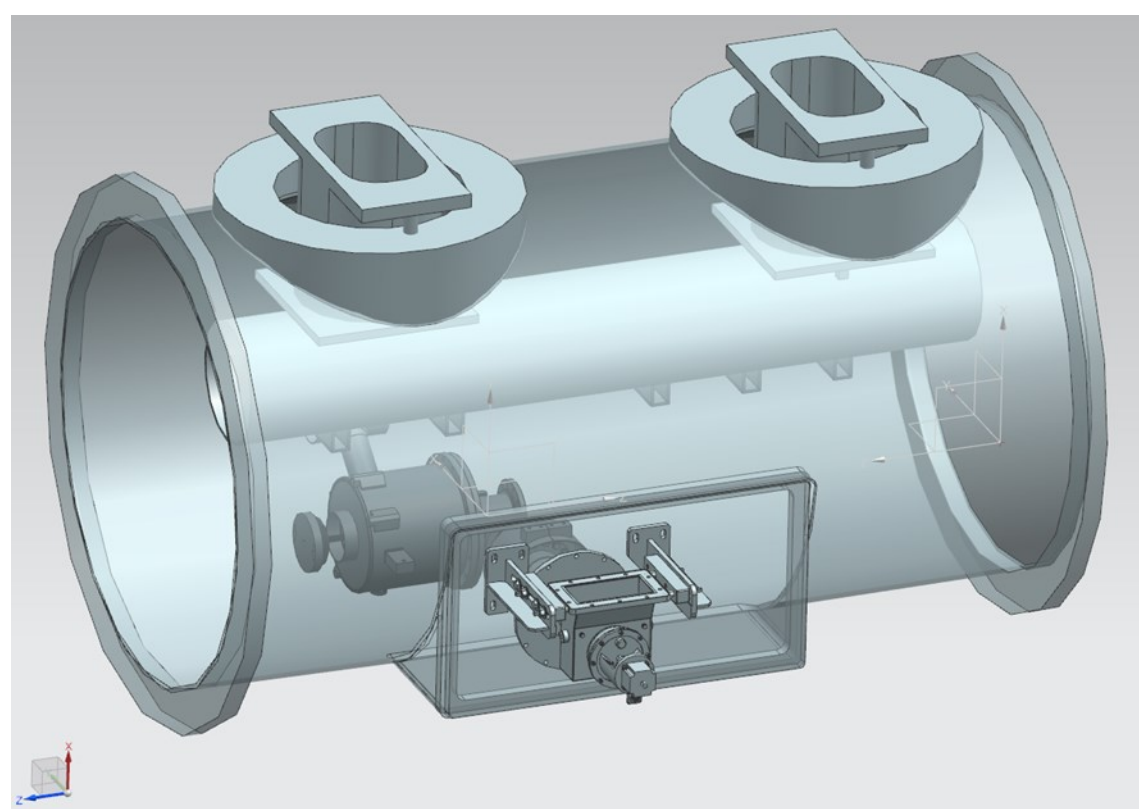
SRF Gun Cryomodule

development and construction of the cryomodule

- for future flexibility, HZDR and HZB gun cavities should also fit
- special features: ability to align the beam line when the module is cold, likewise the (cold) solenoid

there is a common interest from HZDR, HZB and DESY

- first meeting in November 2017 at HZB
- copies of this module may later be used at all three laboratories



first draft of the SRF gun cryomodule

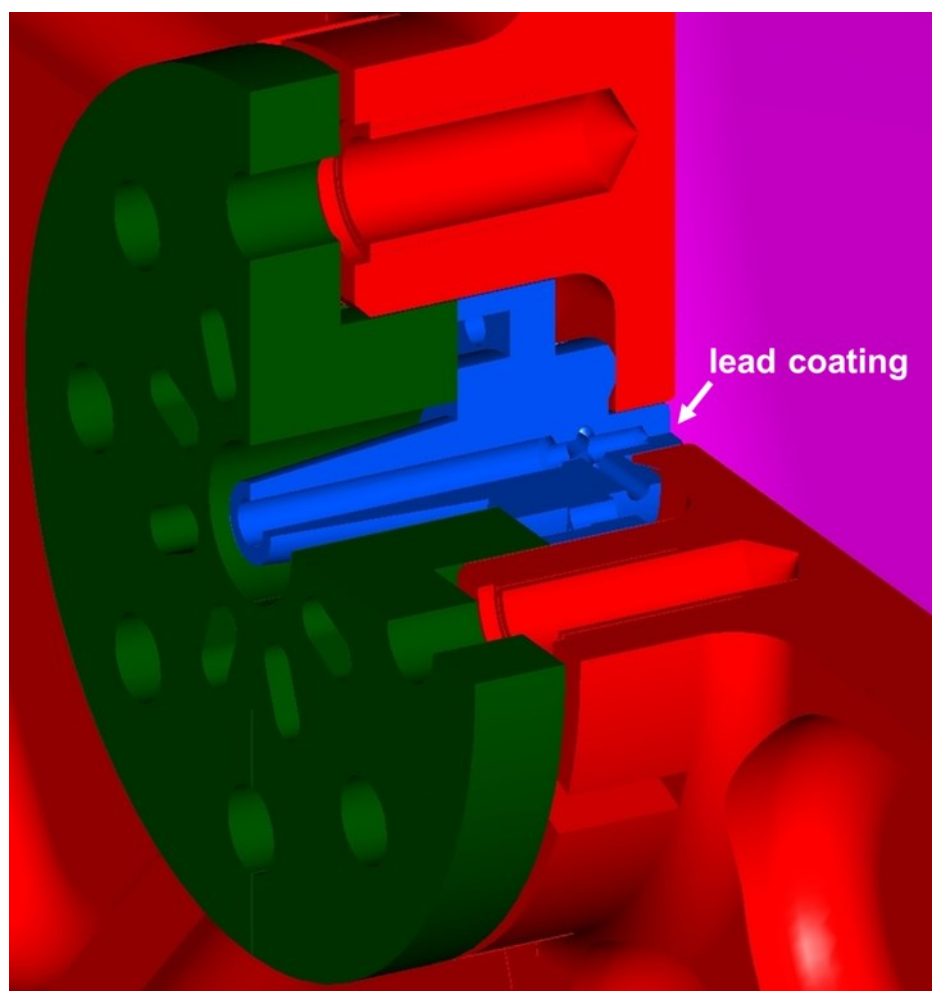
Cathodes and Preparation

three types under investigation

- lead coated Nb plug
- bulk lead disc on Nb plug
- bulk lead plug

focus of R&D

- preparation of niobium plugs before coating
- lead coating (by NCBJ, Poland)
- clean room compatibility



niobium plug (blue) screwed to cavity backside

References

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