WP10 SRF
Task 7 SCRF Gun at ELBE
Subtask 7.3

Evaluation of Critical R&D Issues of SRF Guns

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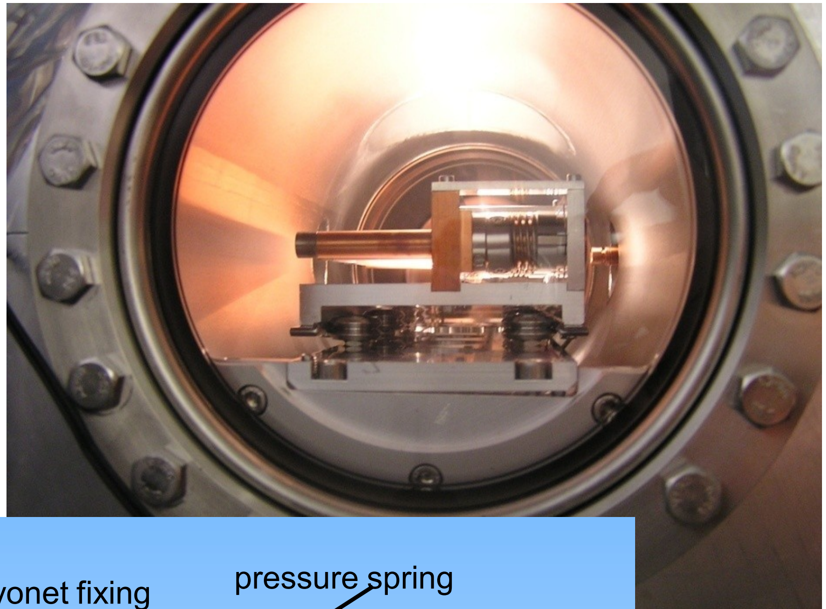
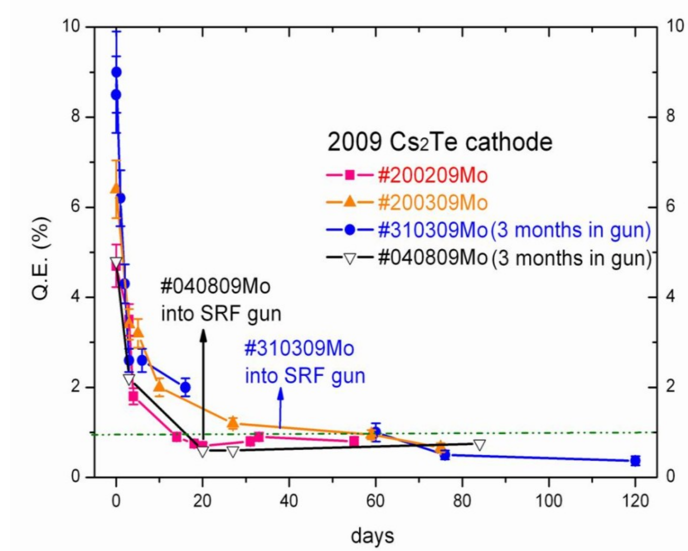
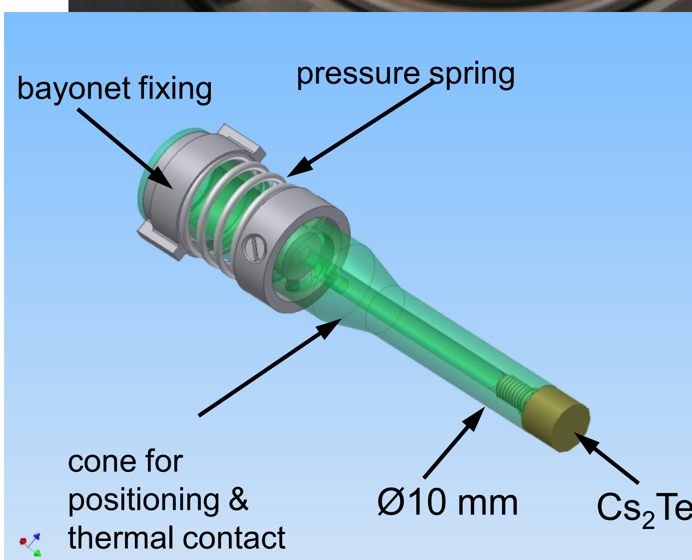
EuCard - SRF2011
Institute de Physique Nucleaire d´Orsay

Use of semiconductor photo cathodes like Cs_2Te requires a permanent vacuum of 10^{-9} mbar during preparation, transport, storage and operation







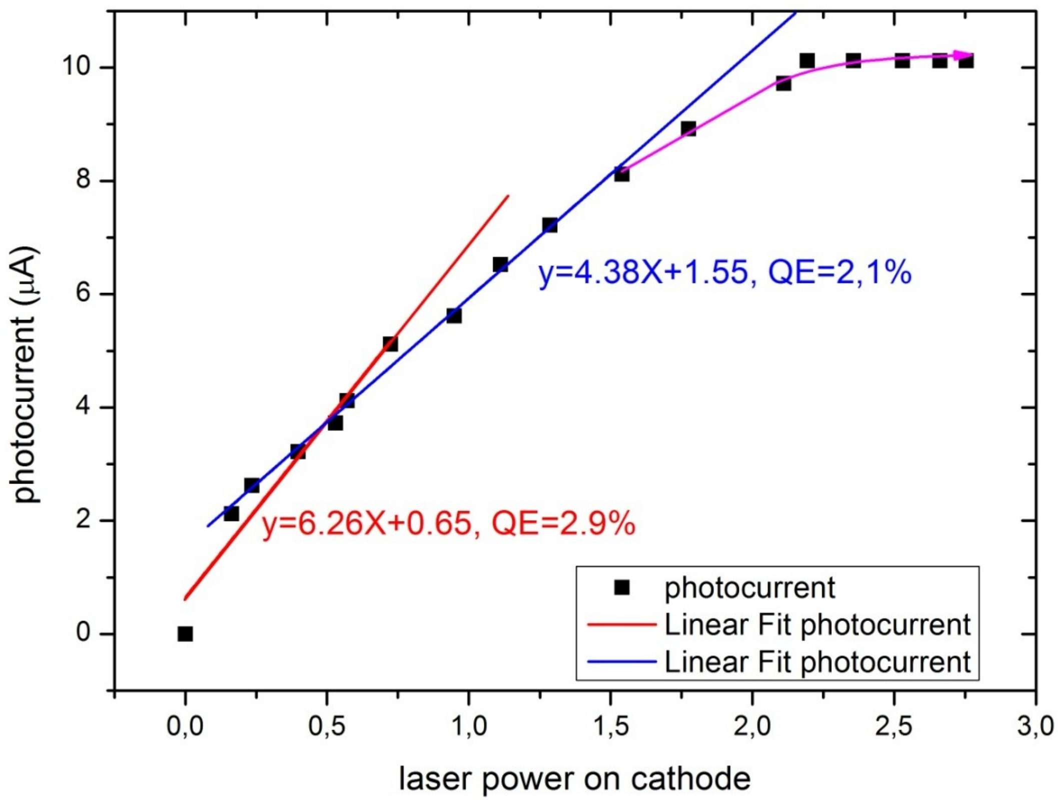
cathode #250310Mo: 25/5/2010 – in use

this cathode has until April 2011:
950 h beam time
35 C extracted charge

			...apping	operation (days)	charge (C)
			auto	123	1.1
23.2	9.6	normal	auto	195	1.7
72.1	9.2	BCP	auto	180	1.6
73.1	7.9	BCP	manual	114	1.0
78.1	7.7	EP	auto	62	0.5

FLASH/DESY
Proc. EPAC2006

Quantum efficiency measurement, cathode #250310Mo, April 2011, in SRF gun



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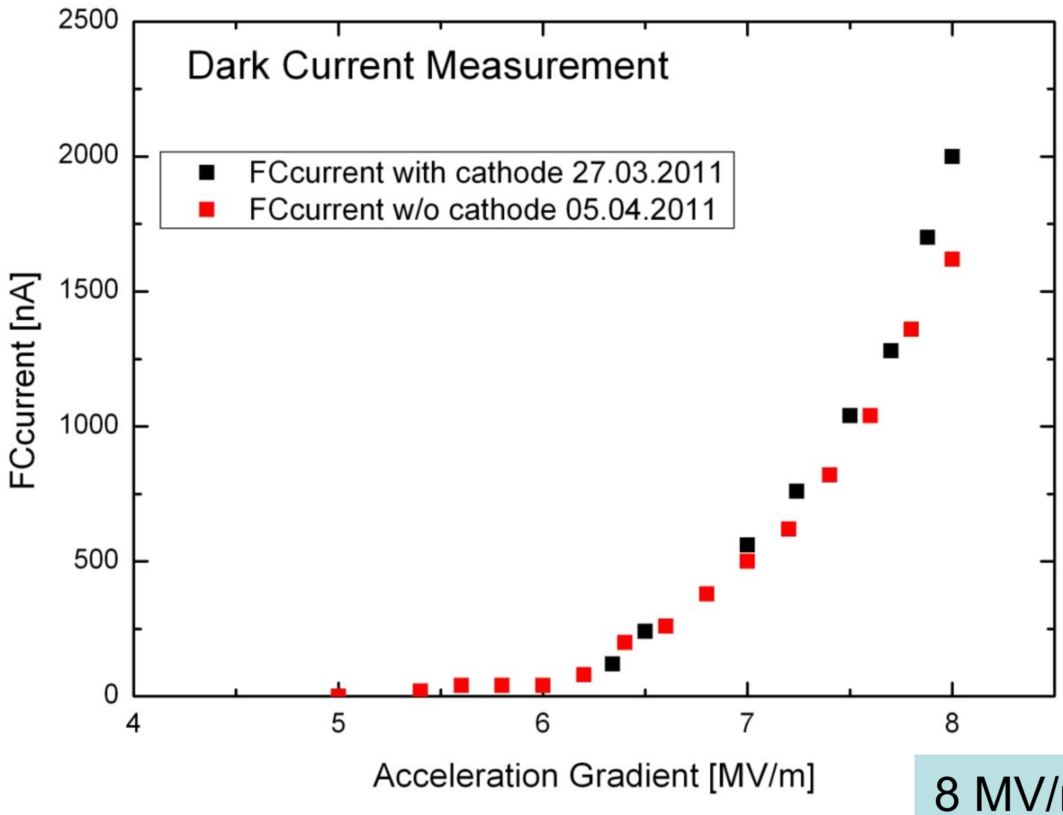
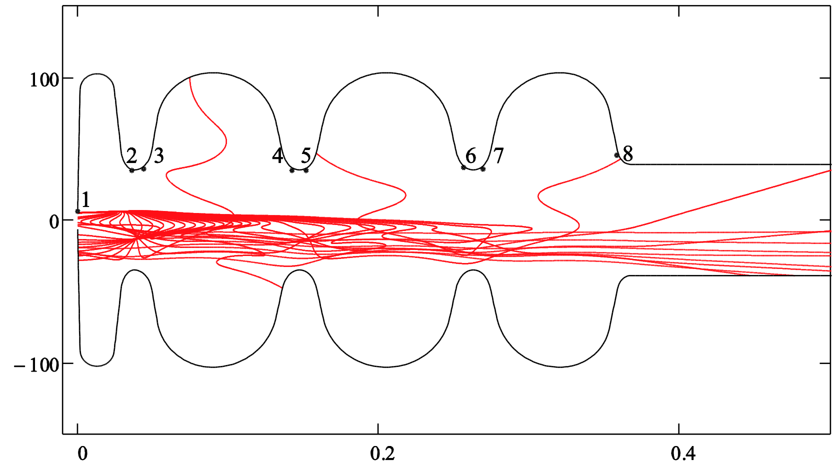
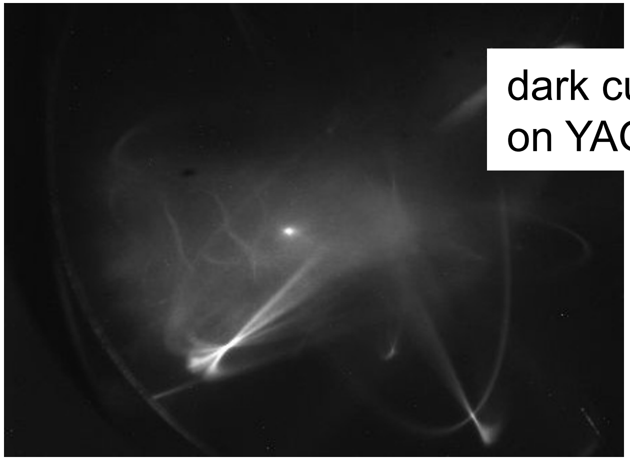
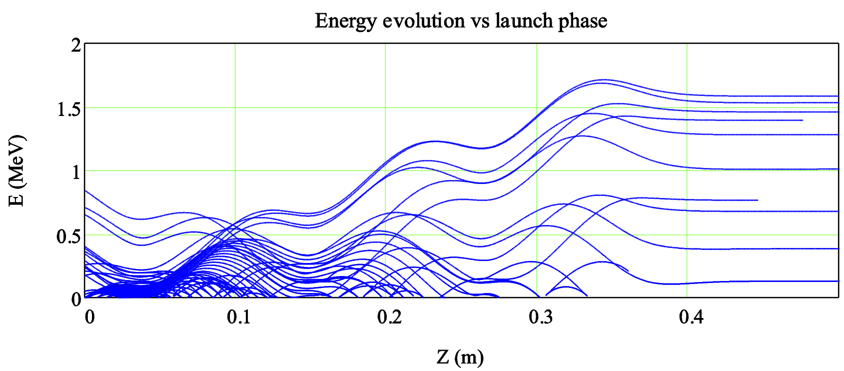
Dark current measured in Faraday cup 0.5 m in front of gun with pulsed RF, peak field until 21.6 MV/m



8 MV/m acc. Gradient
= 21.6 MV/m peak field
= 4 MeV kinetic energy



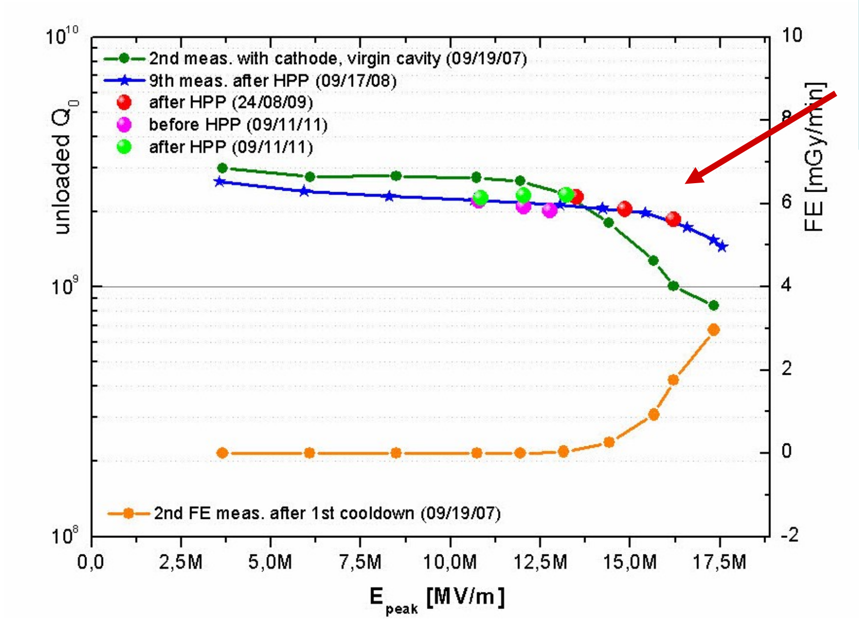




calculation of V. Volkov (HZB/BINP)

emission point	escape	E/E_{beam}	
		calculation	measured
1	yes	75 %	90-95 %
2	no	15 %	
3	no	20 %	
4	yes	60 %	81-87 %
5	no	45 %	
6	yes	30 %	
7	no	75 %	
8			

• SRF Gun cavity performance



Max. 16 MV/m peak field
= 6 MV/m acc. gradient
= 3 MeV beam energy

• Measurement of Q_0 versus E_{peak} since 2007
no degradation due to NC photo cathodes

• excellent life time of photo cathodes in SRF gun

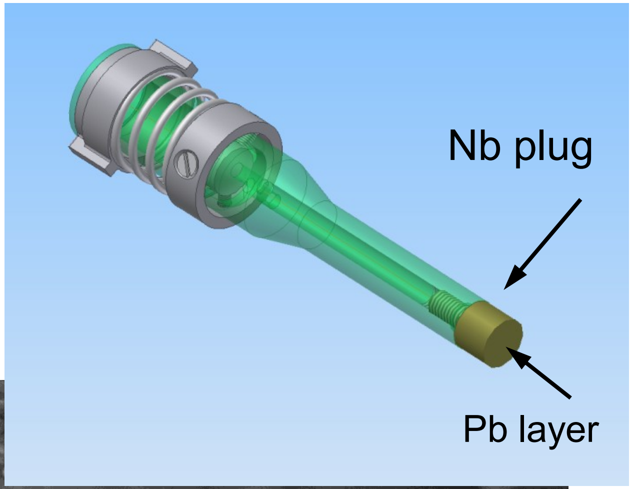
Test of superconducting Pb photo cathodes in the ELBE SRF gun

Activity started after discussion at the Daresbury meeting April 2010

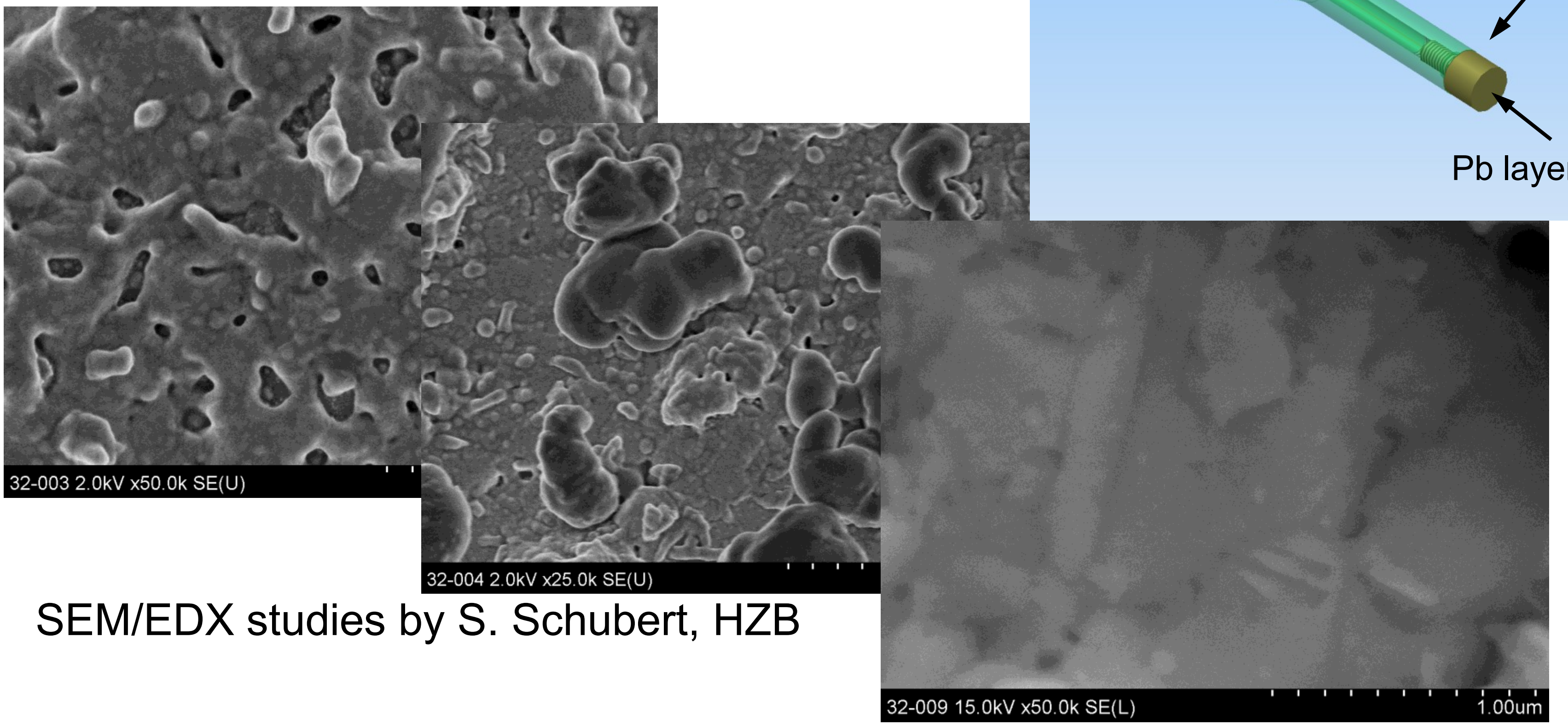
J. Teichert (HZDR), S. Schubert, T. Kamps (HZB), R. Nietubyc (IPJ Swierk)

- Fabrication of Niobium plugs at FZD (3 samples) and polishing,
- Inspection at HZB and polishing of one plug (34) @ Pilz Optics
- deposition of Pb layer at IPJ
- Inspection at HZB – with SEM/EDX for layer homogeneity and pollution
- QE measurements and QE maps at HZDR (in preparation system)
- Test of Pb cathodes in SRF gun at HZDR
- Inspection after use at HZB

Status:



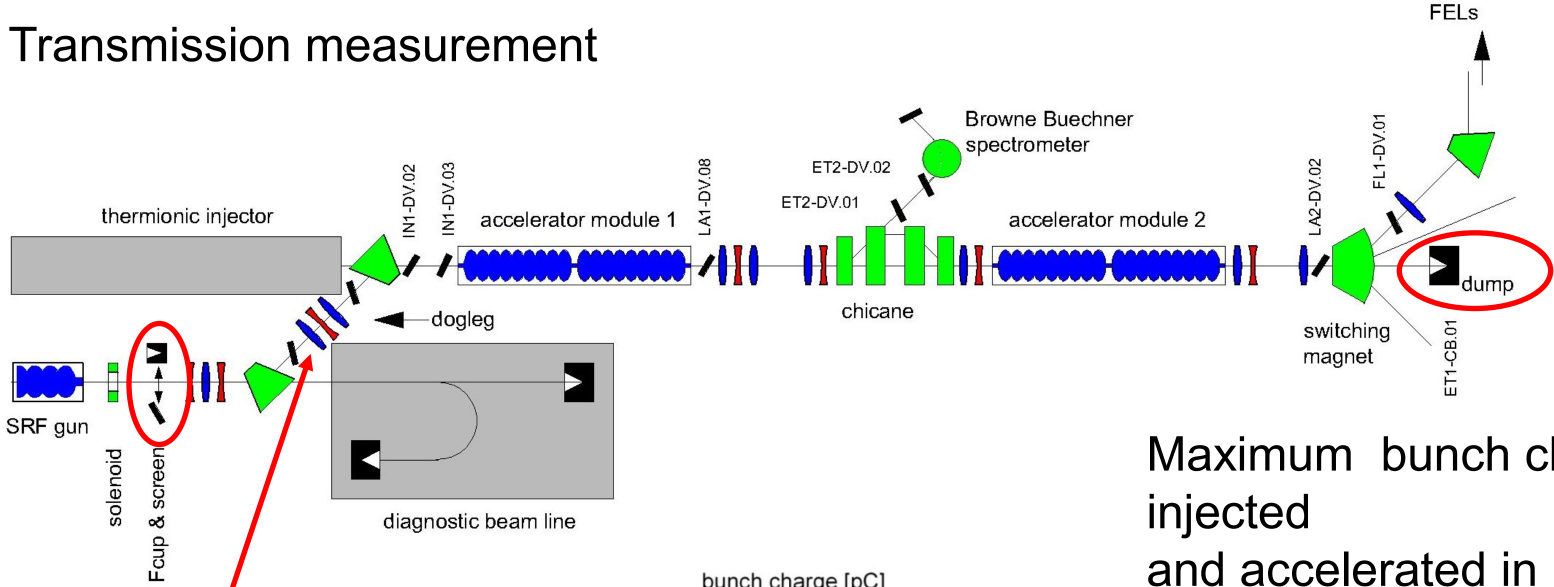
SEM images of Pb layer on cathode 32



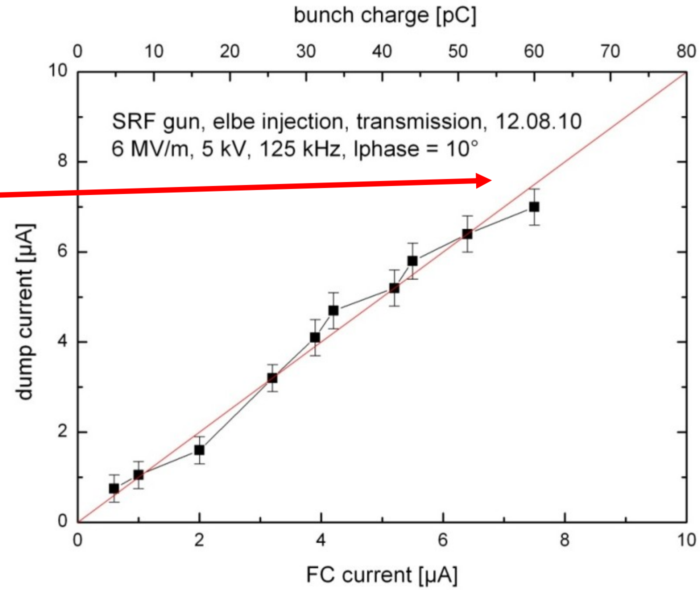
SEM/EDX studies by S. Schubert, HZB

next: load into the transport chamber with the next set of photo cathodes

Transmission measurement



beam loss > 2.5 %
in dogleg
(beam loss monitor)



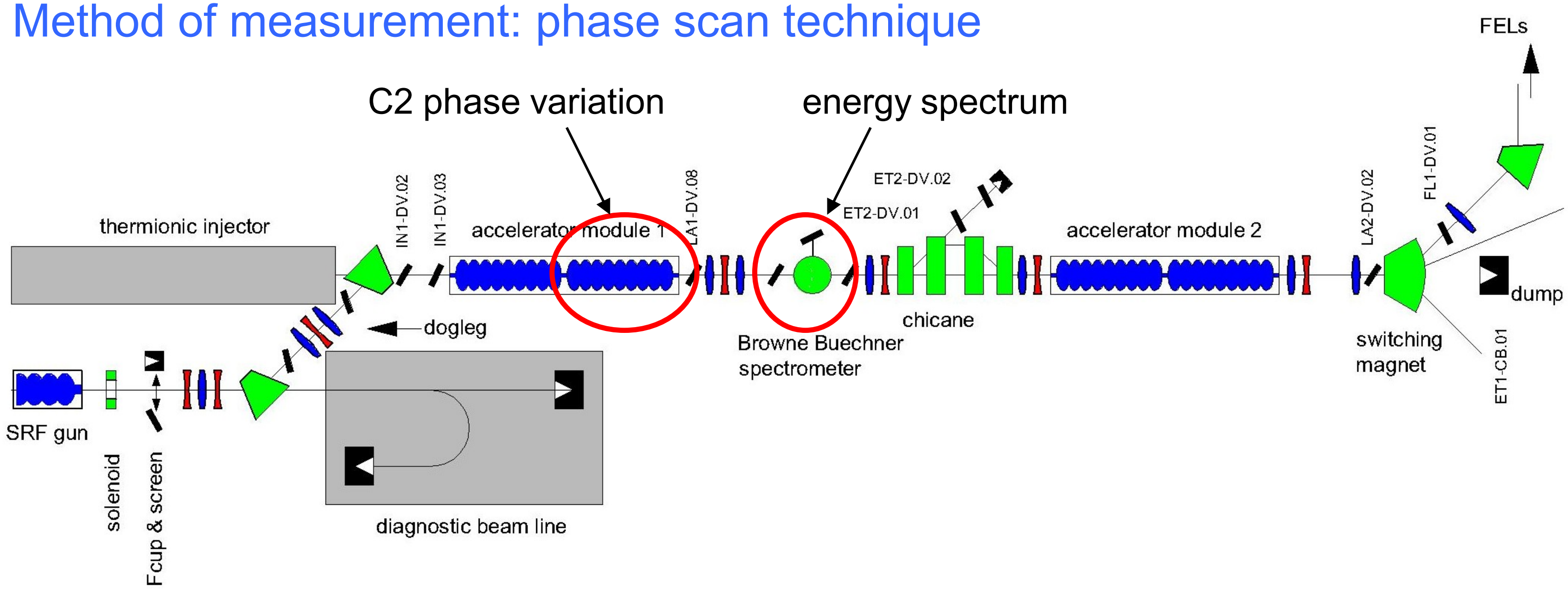
Maximum bunch charge injected
and accelerated in ELBE:
120 pC @ 50 kHz (6 µA);
with 100% transmission:
60 pC @ 125 kHz

Dogleg acceptance needs low energy spread,

Correlated energy spread can be
compensated in module 1

Optimum Gun Parameters?

- Method of measurement: phase scan technique



longitudinal beam ellipse

$$\tau = \begin{pmatrix} \tau_{11} & \tau_{12} \\ \tau_{12} & \tau_{22} \end{pmatrix}$$

$$\sqrt{\tau_{11}} = \sigma_t \; rms\ bunch\ length\ (ps)$$

$$\sqrt{\tau_{22}} = \sigma_E \; rms\ energy\ spread\ (keV)$$

$$\tau(1) = R_{C2}\tau(0)R_{C2}^T$$

cavity transport matrix

$$R_{C2} = \begin{pmatrix} 1 & 0 \\ -\omega_{RF} V_{C2} \sin(\varphi_{C2}) & 1 \end{pmatrix}$$

cavity energy boost:

$$V_{C2}\cos(\varphi_{C2})$$

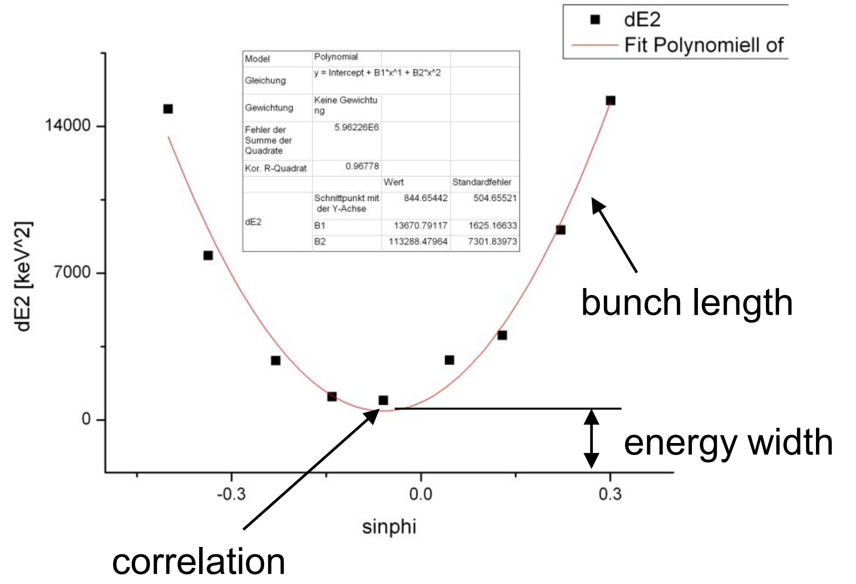
Longitudinal phase space measurement

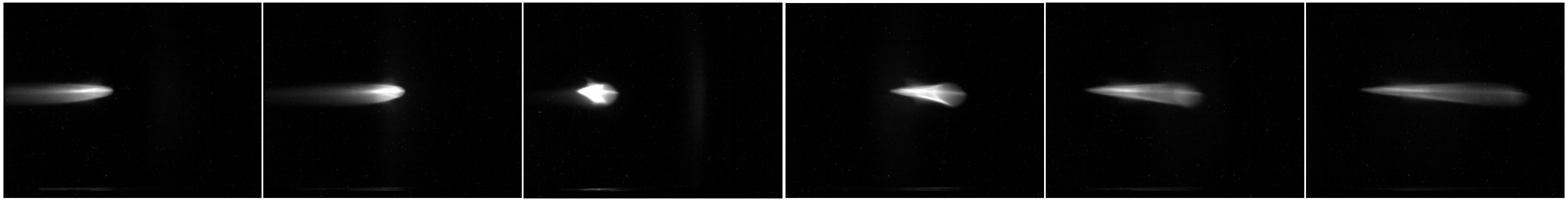
$$\sigma_E^2(1) = \tau_{22}(0) - 2\tau_{12}(0)V_{C2}\sin(\varphi_{C2}) + \tau_{11}(0)(V_{C2}\sin(\varphi_{C2}))^2$$

from parabola fit

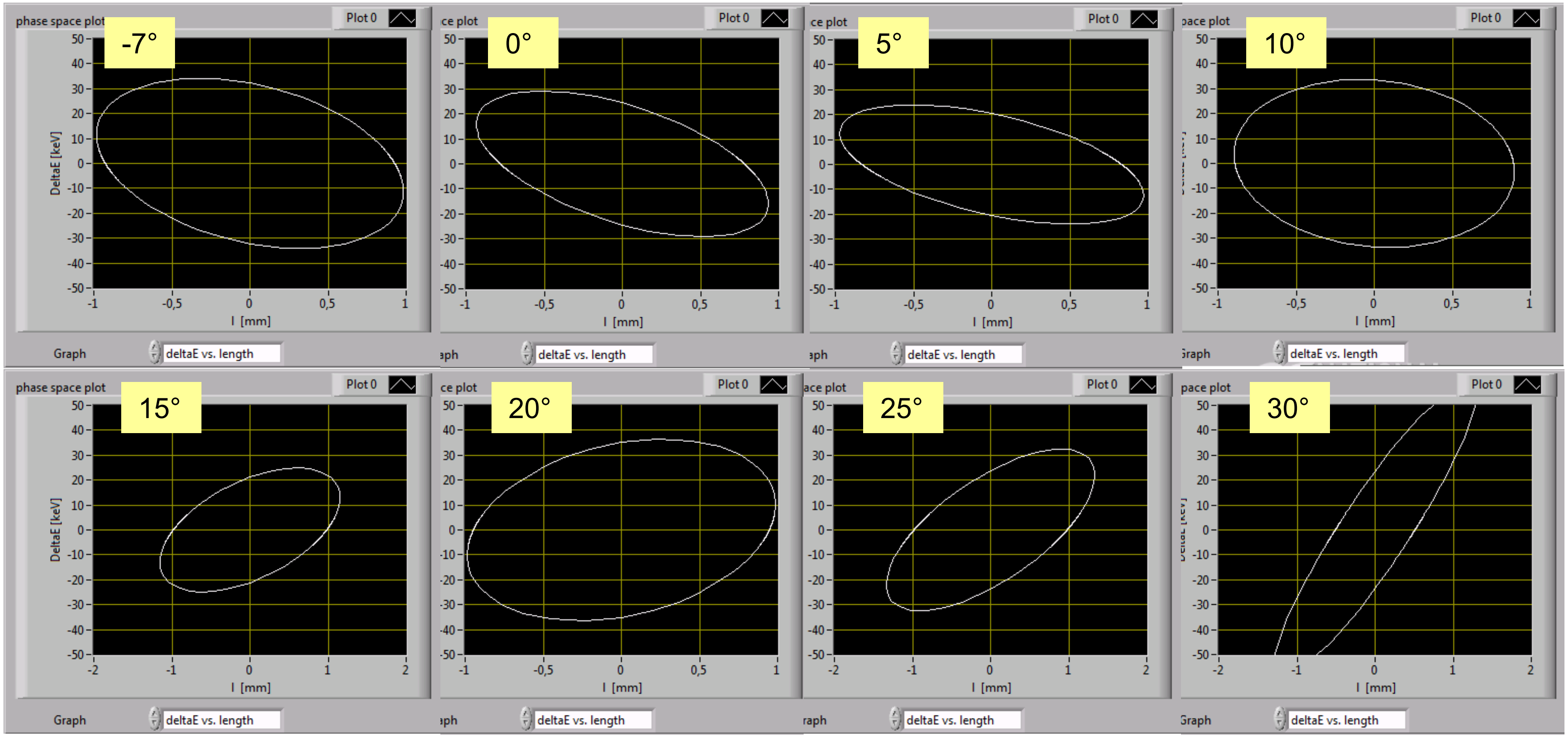
rms longitudinal emittance

$$\varepsilon_{long} = \sqrt{\tau_{11}\tau_{22} - \tau_{12}^2}$$



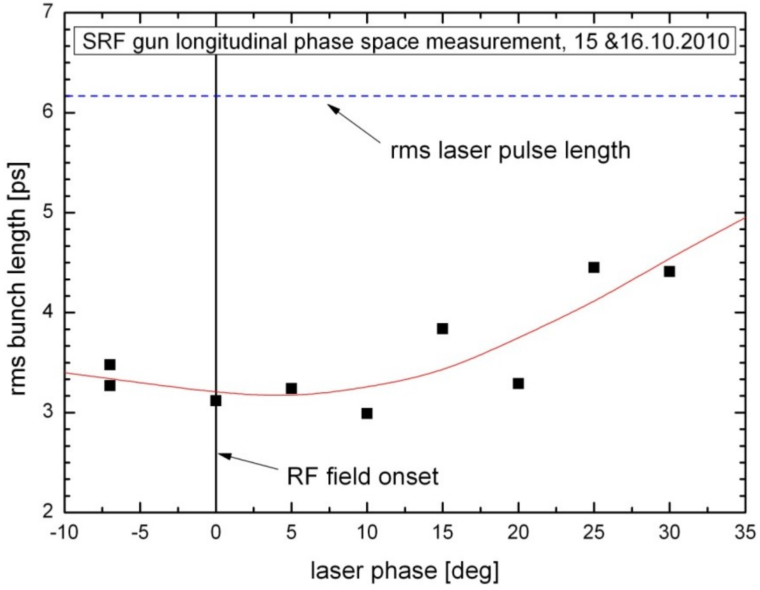


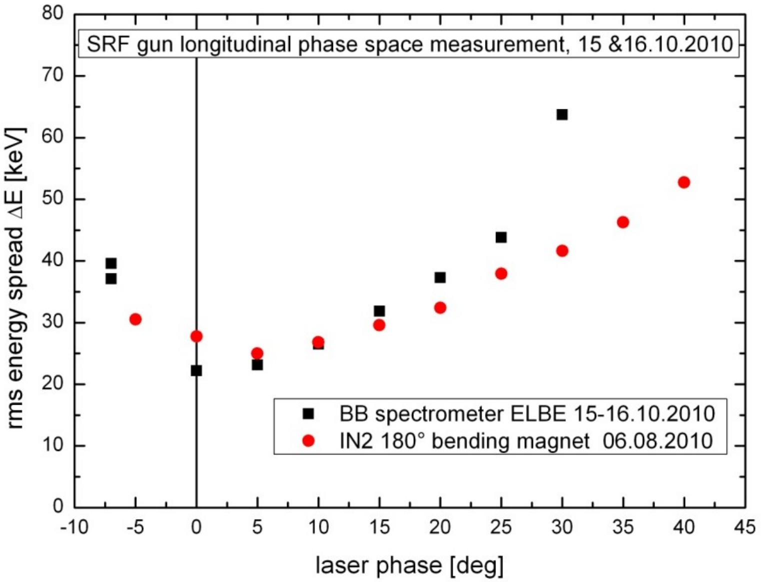
Phase space measured at cavity C2 as function of SRF gun laser phase

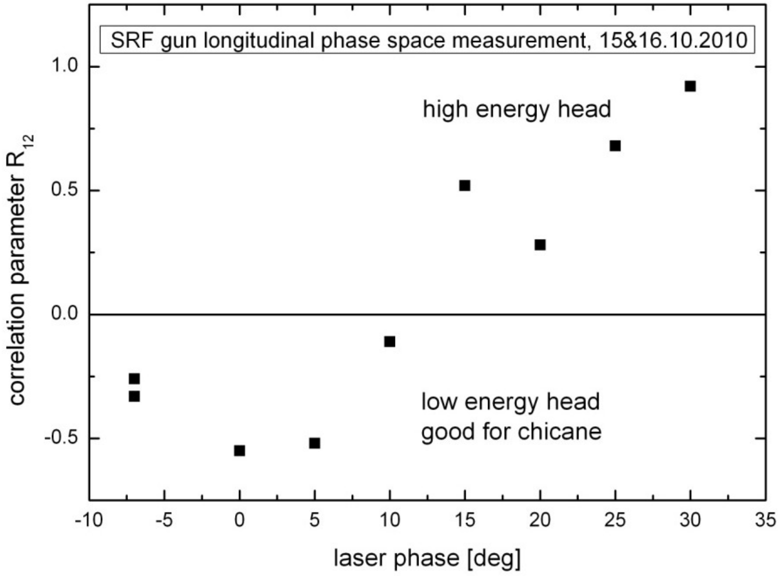


Beam energy (pc): 18.6 MeV, Gradient C1: 6.8 MV/m, gradient C: 8.4 MV/m
Gun gradient: 6.0 MV/m, Ekin = 3 MeV
Reprate: 125 kHz CW, 1.3 µA average current, bunch charge: 10 pC

Subtask 7.3 Longitudinal phase space measurement







Overview on superconducting photoinjectors

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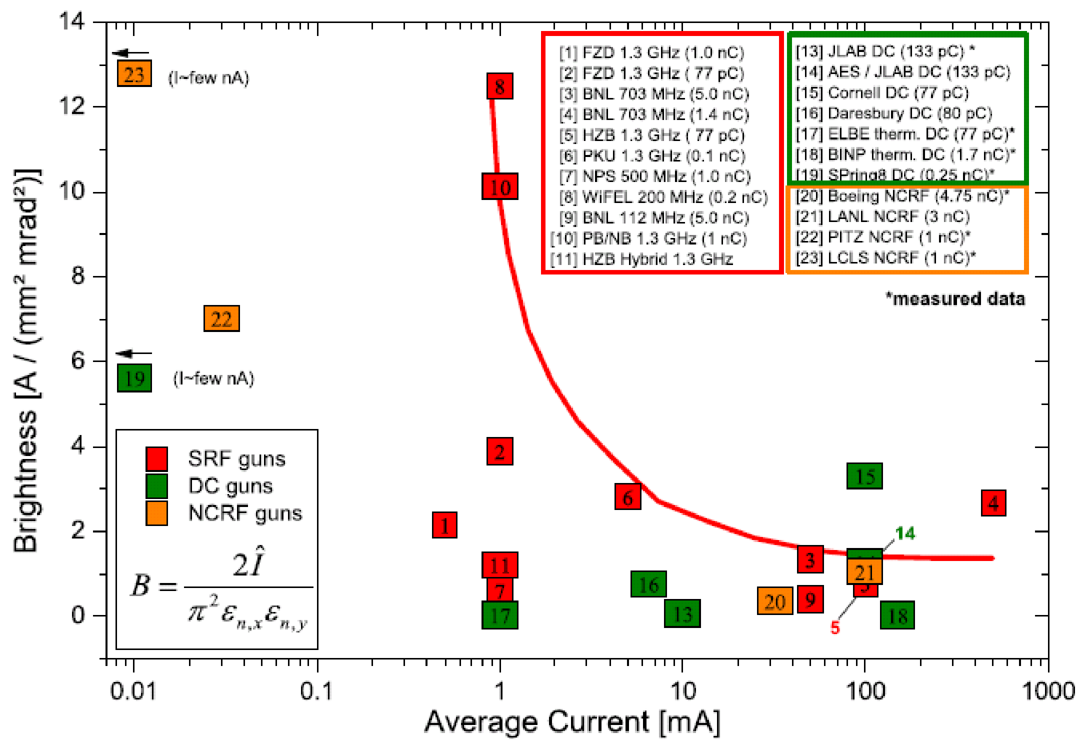
The success of most of the proposed energy recovery linac (ERL) based electron accelerator projects for future storage ring replacements (SRR) and high power IR–free-electron lasers (FELs) largely depends on the development of an appr
Proc. SPIE Int. Soc. Opt. Eng
high brightness, low emittance
elegant way to create a beam o
photoinjector with the superco
gun). SRF gun R&D programs
institutes and companies (AE
Wisconsin University). Substa
was demonstrated at FZD [R.
Conference (FEL 09), Liverp
near future SRF guns are expe
we will review the concepts, t

DOI: 10.1103/PhysRevSTAB.14.(



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Summary

- Demonstration of succesfull operation and long lifetime of normal conducting photo cathodes in SC RF guns
- First successful measurements using the ELBE accelerator
  - slice emittance measurements
  - longitudinal phase space
- Start the collaboration work in photo cathodes with Pb-cathodes
  comparison of results
  exchange for characterization
  standard design for SRF gun cathodes at HZB and HZDR

- Next work
  - continuation of dark current studies
  - after 13 MHz laser upgrade: high average current operation (1mA)
  - publication