Review of the Status of SRF Photo-Injectors

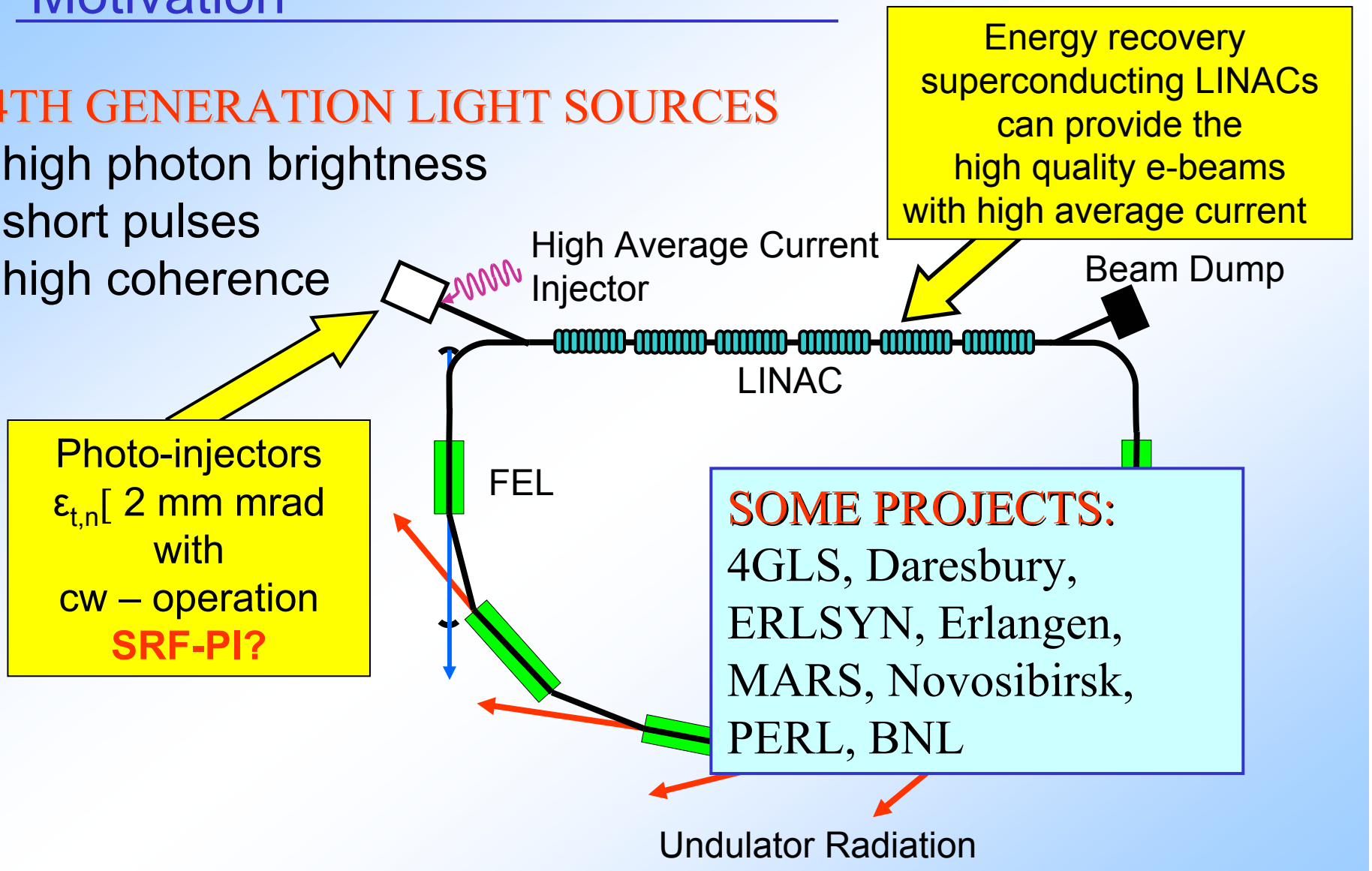
J. Teichert, H. Büttig, P. Evtushenko, D. Janssen,
U. Lehnert, P. Michel, Ch. Schneider

Forschungszentrum Rossendorf
Zentralabteilung Strahlungsquelle ELBE
PF 510119, 01314 Dresden
J.Teichert@fz-rossendorf.de

Motivation

4TH GENERATION LIGHT SOURCES

- high photon brightness
- short pulses
- high coherence



Superconducting Photo-Injectors

Main Advantage:

low RF power losses & cw operation

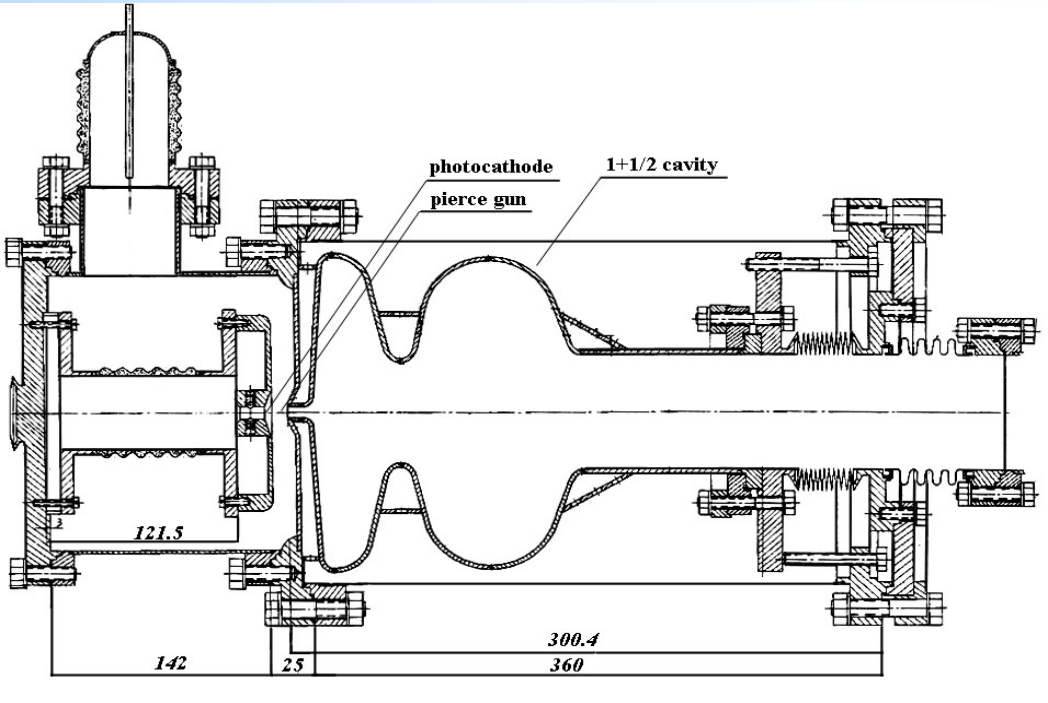
Problems and Open Questions:

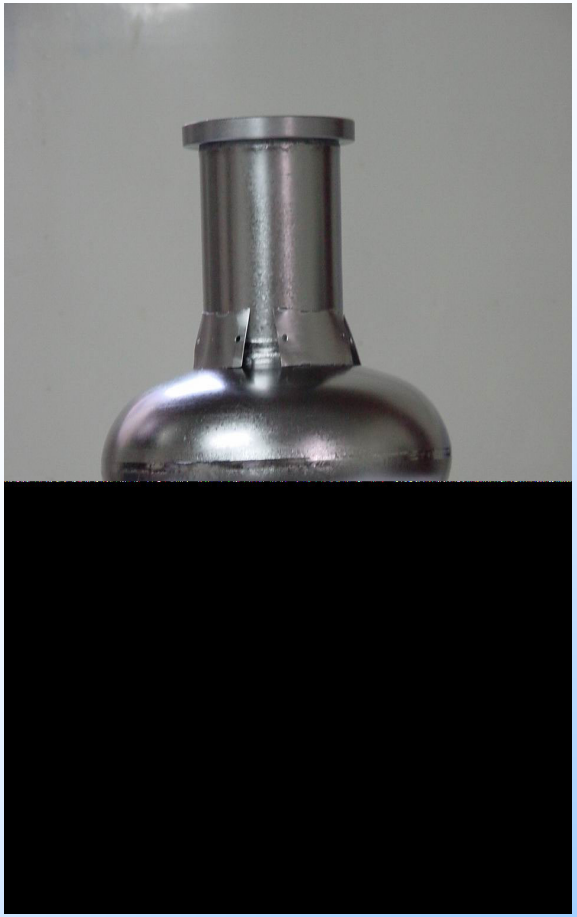
- Cavity contamination by particles sputtered from cathode (fast Q degradation, low gradient).
- Specific geometry of the SC cavity (cathode insert).Can we reach the high gradient?
- Operation of the photo cathode itself at cryogenic temperature.
- Not possible to do the emittance compensation like in a NC RF gun.

SRF-PI: Peking Univ. DC-SC Photo-Injector

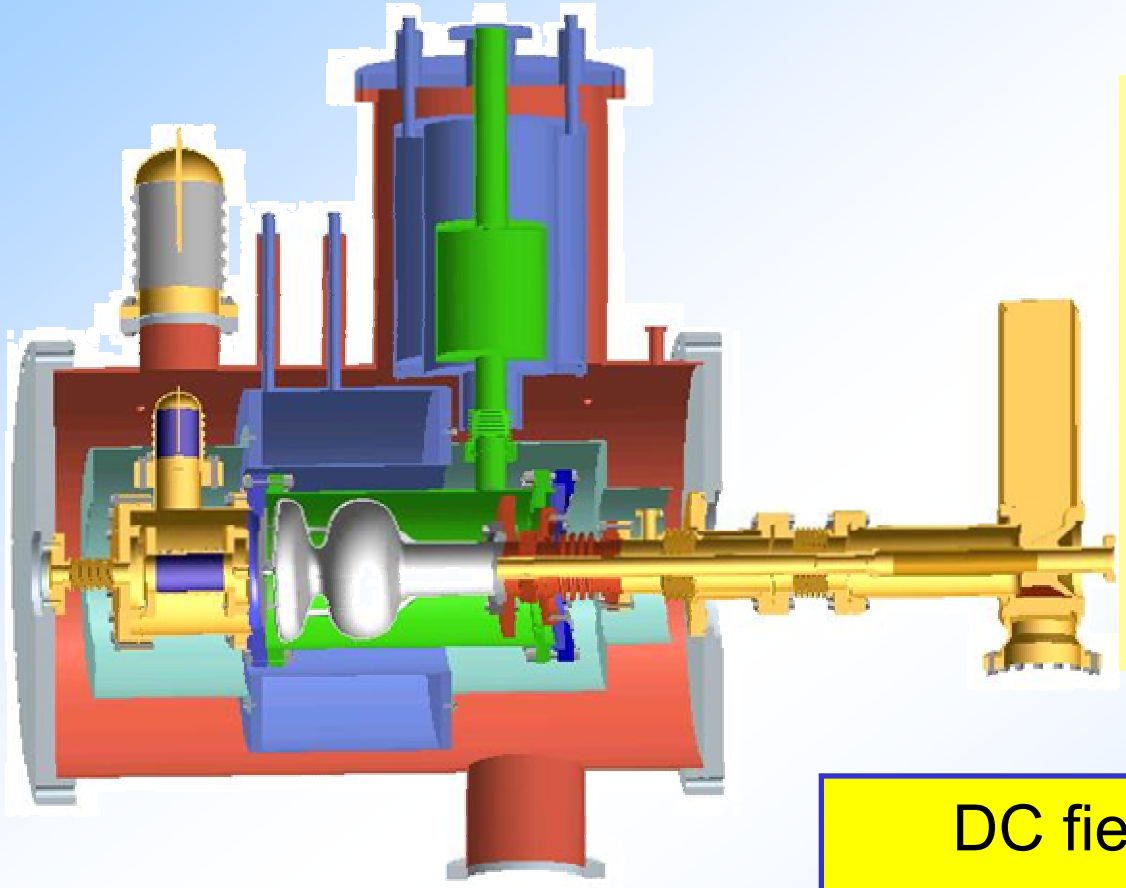
Photocathode outside the cavity

No compatibility problems





SRF-PI: Peking Univ. DC-SC Photo-Injector



1.5 cell, 1.3 GHz
Field: 15 MV/m (5 kW)
DC voltage: 70 kV
DC gap: 15 mm
Charge: 60 pC
Simulation:
Energy: 2.6 MeV
Trans. emittance:
12.5 mm mrad

DC field at cathode causes high emittance

B.C. Zhang et al., SRF Workshop 2001

SRF-PI: BNL All-Niobium SC Gun

No contamination from cathode particles

1/2 cell, 1.3 GHz
Maximum Field: 45 MV/m

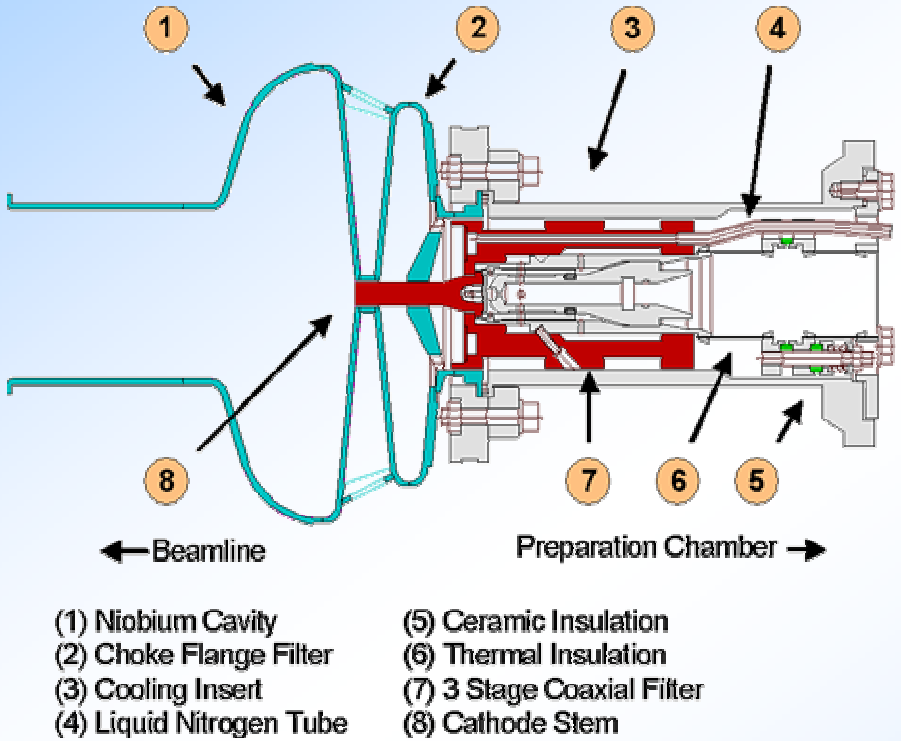
Q.E. of Niobium @ 248 nm
with laser cleaning
before: 2×10^{-7}
after: 5×10^{-5}

Thermal analysis:
maximum laser power of 1 W/cm^2
& low Q.E. limit current

T. Srinivasan-Rao et al., PAC 2003
I. Ben-Zvi, Proc. Int. Workshop, Erlangen, 2002

SRF-PI: Rossendorf SC ½ Cell Gun

normal-conducting cathode inside SC cavity

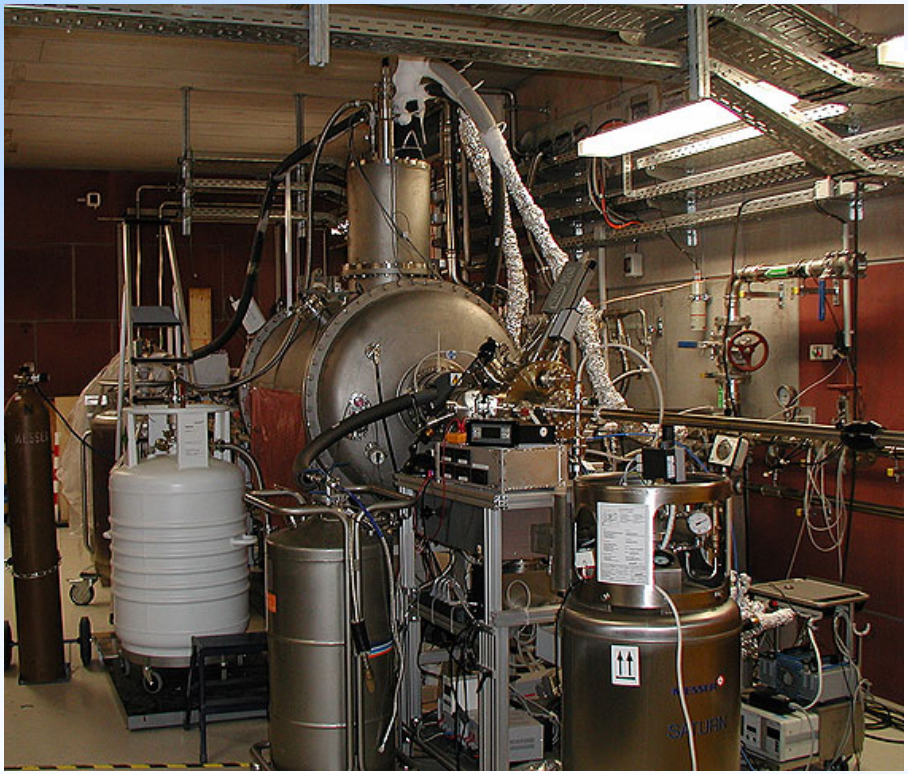


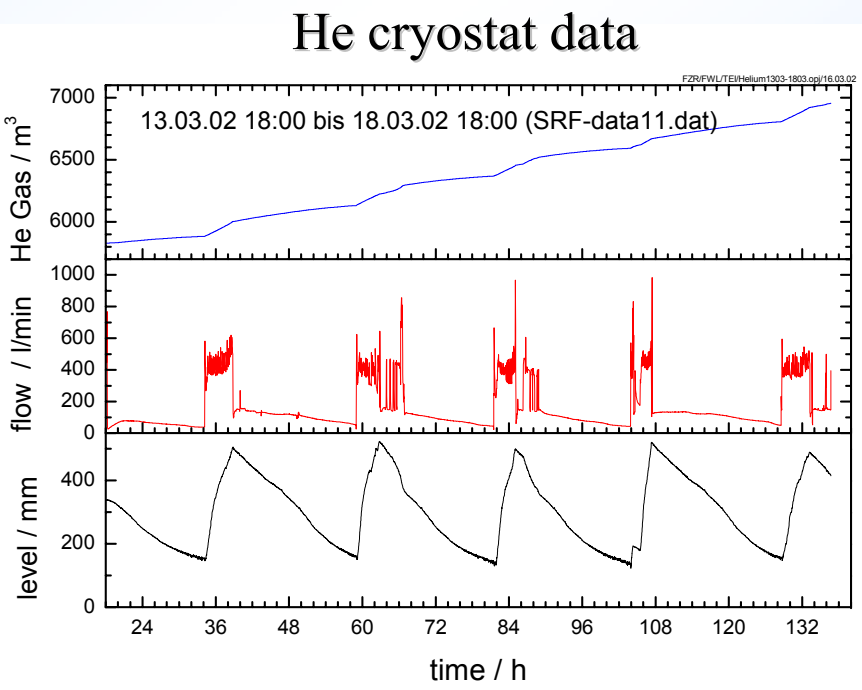
Cavity:
Niobium ½ cell, TESLA Geometry
1.3 GHz
Cathode:
Cs_2Te (262 nm, 1 W laser)
thermally insulated, LN_2 cooled

D. Janssen et al., NIM-A, Vol. 507(2003)314

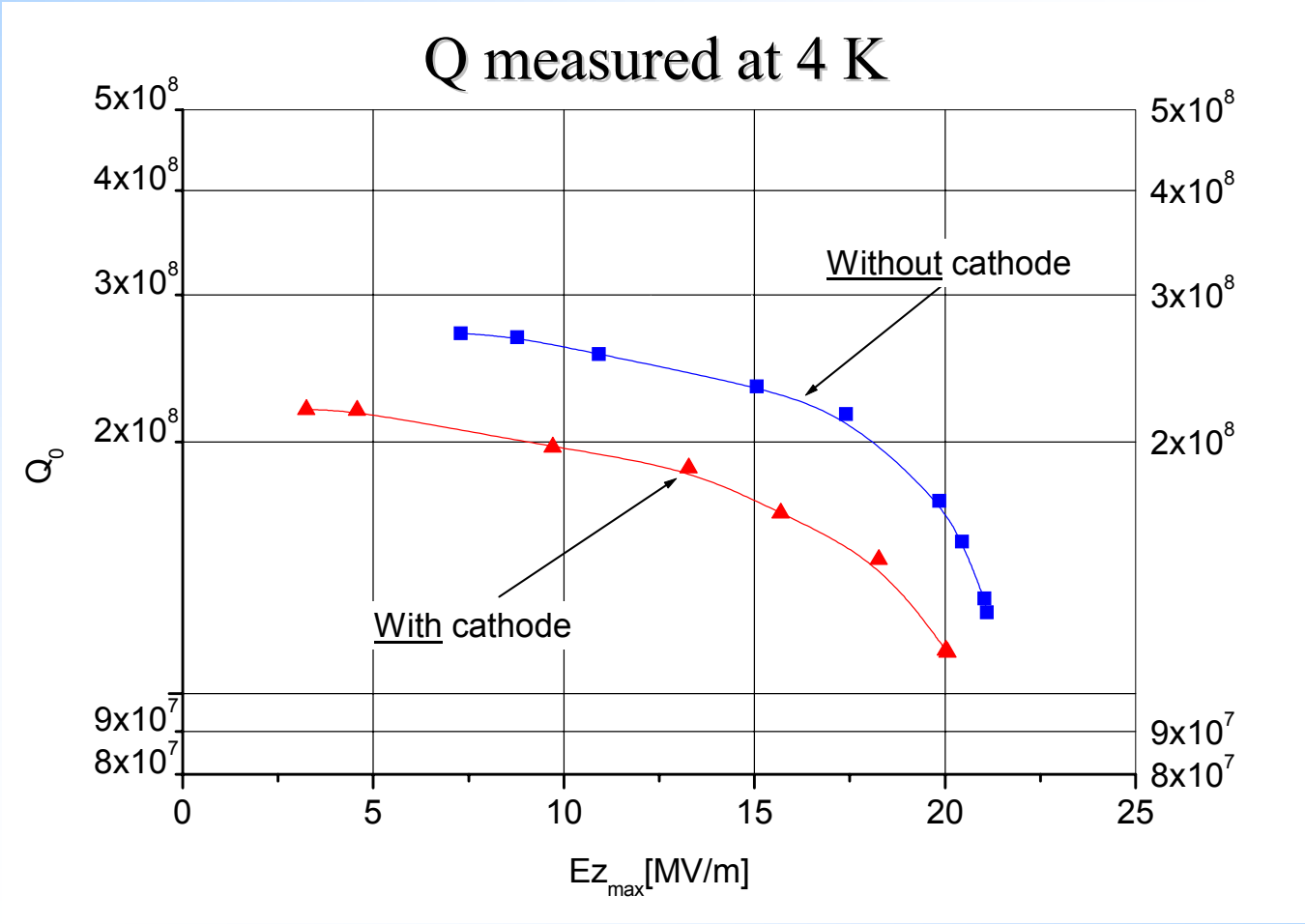
SRF-PI: Rossendorf ½ Cell SRF Gun

Cool down to 4 K and operation of the SRF gun over 7 weeks in 2002



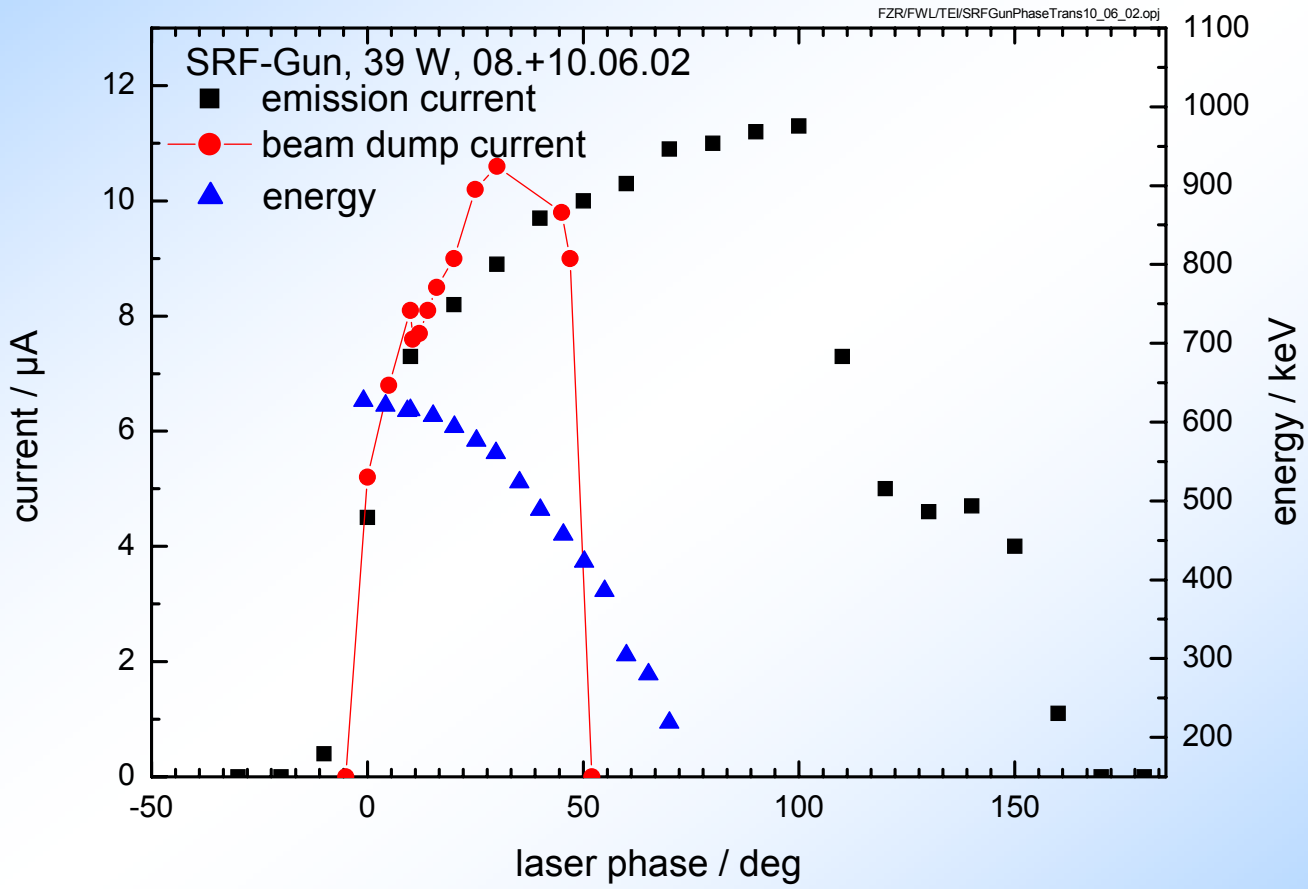


SRF-PI: Rossendorf ½ Cell SC Gun



SRF-PI: Rossendorf ½ Cell SC Gun

Electron beam parameters



SRF-PI: Rossendorf ½ Cell SC Gun

Summary of experimental results

Stable operation of the SRF Gun over 7 weeks 5h/day was demonstrated.

Maximum beam energy was 900 keV, corresponds to $E_{z,max}$=22 MV/m.

No significant change of Q without and with cathode.

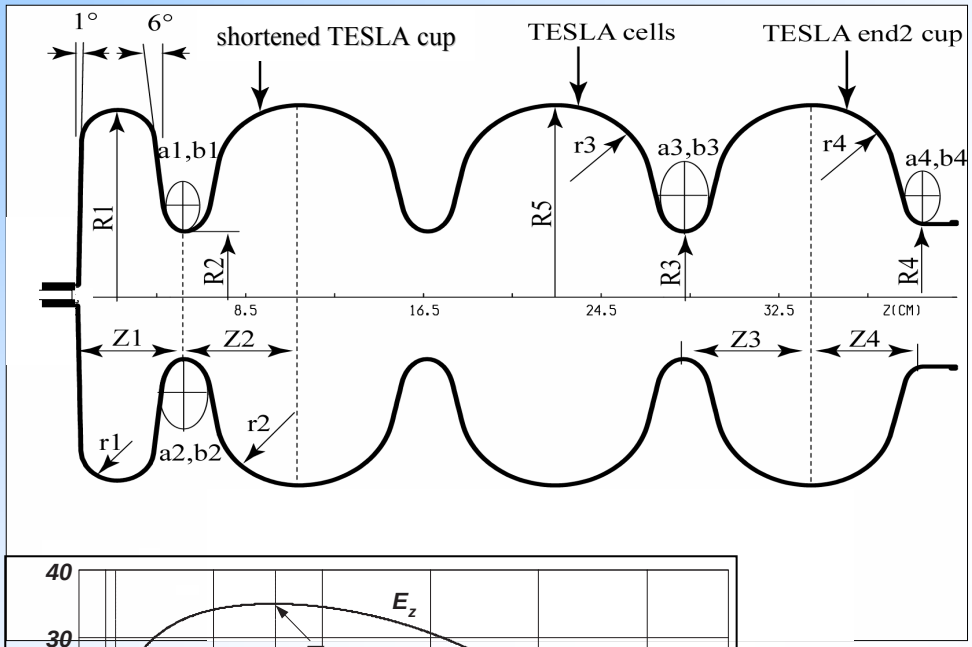
For low bunch charge the beam parameters were measured.

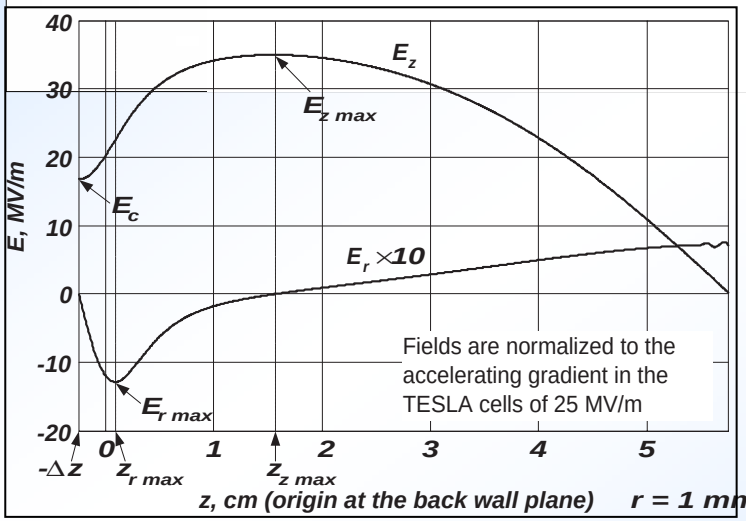
Proof-of-Principle Experiment

At 4.2 K, we did not find any changes of Q = 2×10^8 during the whole operation.

SRF Photo-Injector for ELBE

SRF-PI: Rossendorf 3½ Cell Gun Project





Cavity design

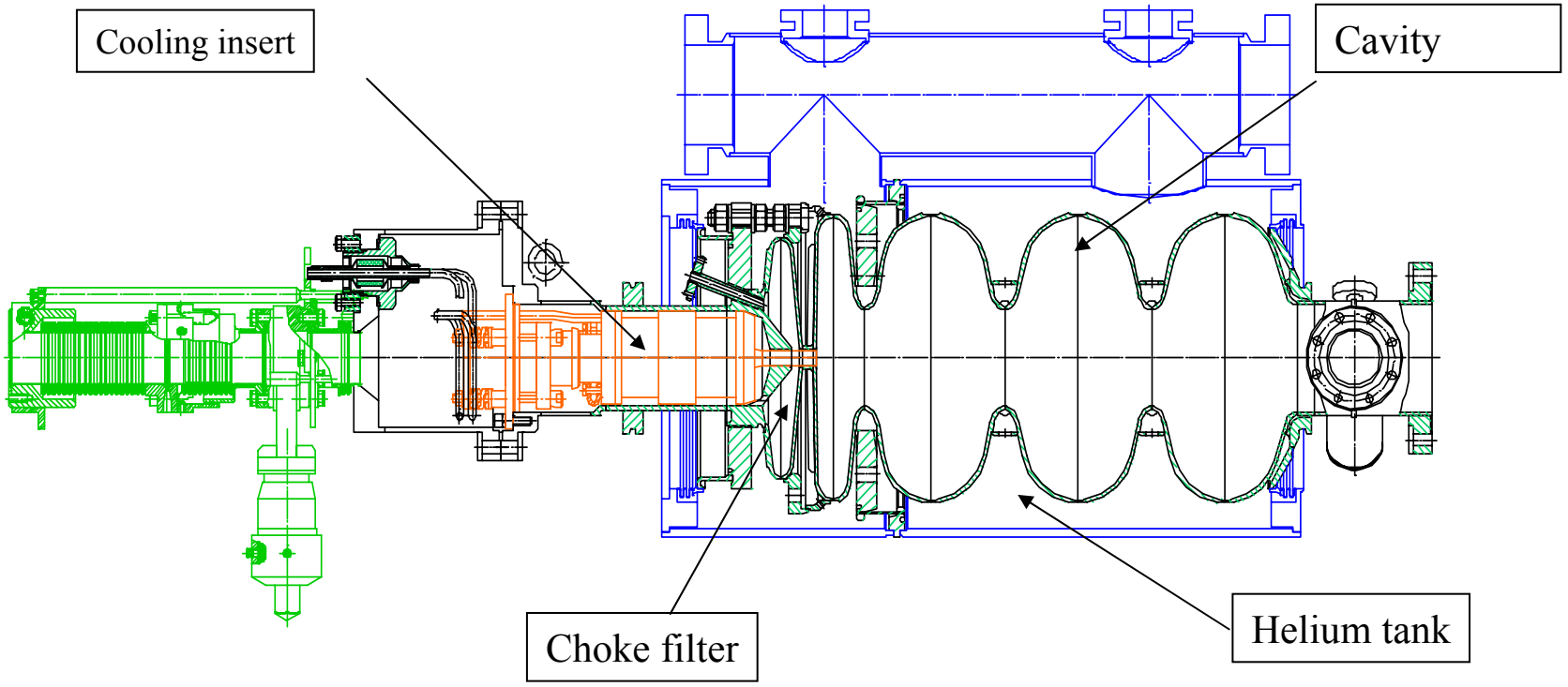
1. 3 GHz, 10 kW optimized half cell & 3 TESLA $E_{z,max}$= 50 MV/m (T cells) = 33 MV/m (1/2 cell)	
77 pC	1 nC
I_{av}= 1 mA	
E = 9.5 MeV	
0.5 mm mrad	2.5 mm mrad

RF focusing in SC gun cavities

D. Janssen, V.Volkov, NIM A452(2000)34

SRF-PI: Rossendorf 3½ Cell Gun Project

J.Stephan, D. Janssen, FZR, S.Kruchkov BINP



Summary

Overview of the SRF-PI Projects

	Peking Univ.	BNL	Rossendorf	
Type	DC-SC Gun	All Niobium	NC Cathode in SC Cavity	
Cell	1+1/2	1/2	1/2	3+1/2
Cathode	Cs_2Te	Laser-cleaned Nb	Cs_2Te	Cs_2Te
Q.E. @262 nm	0.01	$5x10^{-5}$	0.0025	0.05
Contamination	no	no	not found	?
transv. emittance	bad	good	good	best
Status	cool down to 4 K	Q measured at 4 K	**operated at 4 K**	Project started (cavity design)

Collaboration:

BESSY, Berlin
Max-Born-Institut, Berlin
TJNAF, Newport News
University of Peking
BINP, Novosibirsk
DESY, Hamburg
ACCEL, Bergisch Gladbach
Technische Universität, Dresden

The ELBE crew

(visiting the cool-down of the ELBE river source, Spindleruv Mlyn, Czech Republic, April 2003)