

Present status of the Rossendorf Superconducting RF Photo injector development

Jochen Teichert

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

CARE Collaboration Meeting @ CERN, Geneva, Nov. 23 – 25, 2005



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1

Outline

1. Motivation of SRF Gun Development
2. History
3. SRF Gun Parameters
4. Discussion of SRF Gun Components
 - 3 ½ cell Nb cavity
 - photo cathode cooling system
 - Cs₂Te cathode preparation & transfer
 - cavity tuner
 - He-Cryostat & transfer line
 - diagnostic beamline
5. Summary



High Brightness Photo-Injectors

DC-Photo-Injector

Medium to **high current**
low bunch charge
CW & High rep rate
medium emittance

normal conducting
RF-Photo-Injector

Low - medium current
high bunch charge
Low-medium duty factor
best emittance

SRF Gun

*delivers RF gun performance
with DC gun efficiency*



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3

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.
- It's not possible to do the emittance compensation like in a NC RF gun.



History of Superconducting RF Photo-Injectors

1988 first proposal published

*H. Piel et al., 10th FEL Conf.
Jerusalem, 1988*

Experimental Results:
Cool-down to 4.2 K, photoemission
 $E_{peak} = 5-7 \text{ MV/m}$, FE, dielectric losses

1991 first experimental setup – Univ. of Wuppertal

*A. Michalke, PhD Thesis, WUB-DIS 92-5
University of Wuppertal, 1992*

2002 first beam from a SRF gun – FZ Rossendorf

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



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5

Rossendorf SC 1/2 Cell Photo 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 isolated, LN_2 cooled



Gradient $E_{z,\max} = 22 \text{ MV/m}$.
At 4.2 K, no change of $Q_0 = 2 \times 10^8$
during operation period



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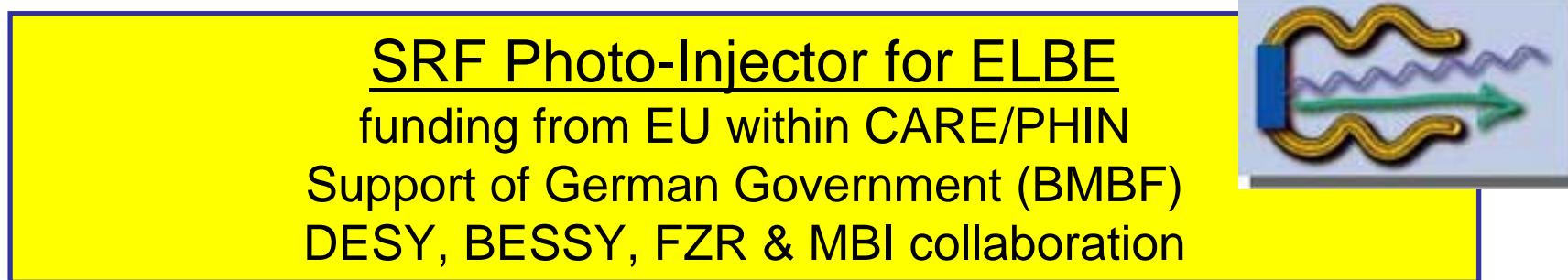
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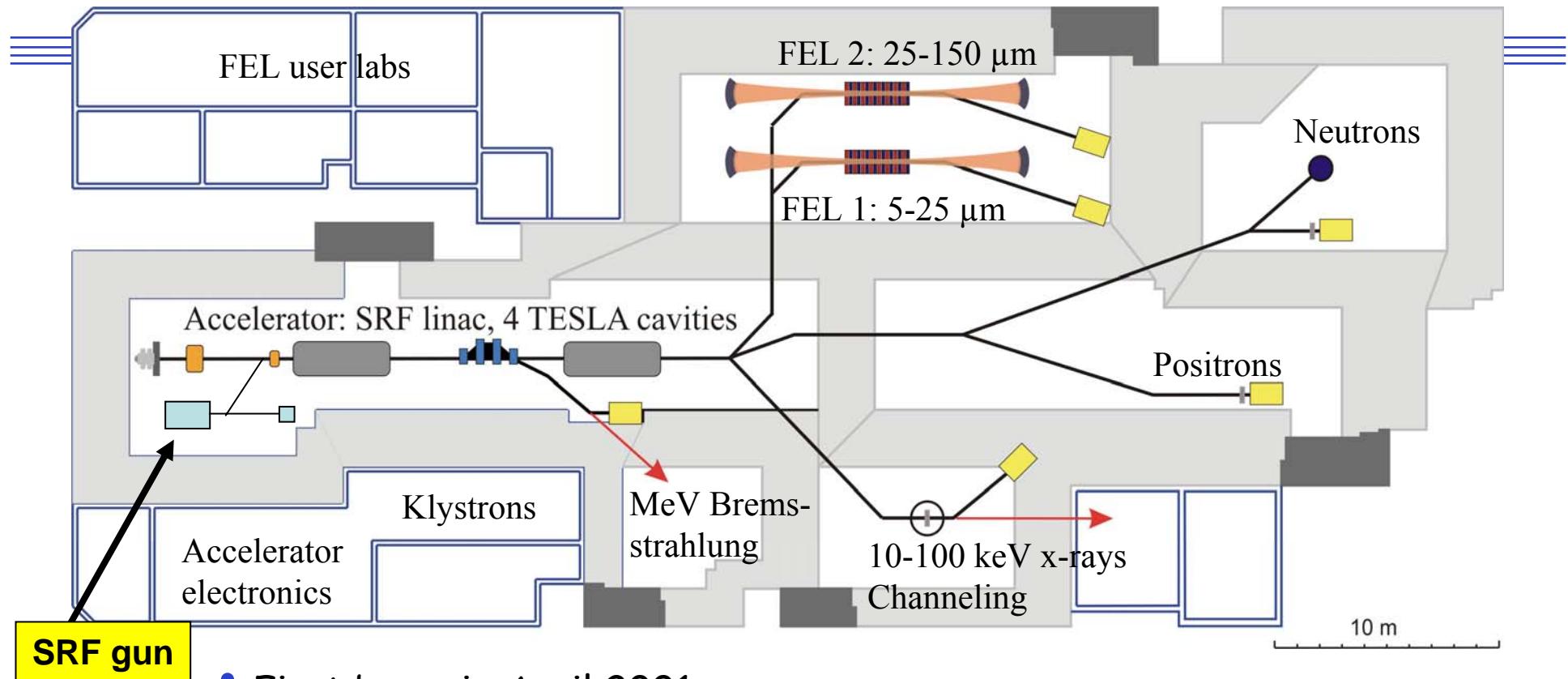
2002 first beam from a SRF gun – FZ Rossendorf

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2005 up to now 7 SRF gun projects, currently 4 projects are running
(FZ Rossendorf, Peking Univ., AES/BNL, INFN Frascati)



The radiation source ELBE – 40 MeV, 1 mA, cw linac



- First beam in April 2001
- Nuclear physics experiments are running since January 2002
- Channeling radiation since September 2003
- FEL 1 since May 2004
- FEL 2, neutron & positron beamlines planned for 2006



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Rossendorf SRF Photo Gun Parameters

Normal-conducting cathode inside SC cavity

Cavity:	Niobium 3+½ cell (TESLA Geometry) Choke filter
Operation:	T = 1.8 K
HF frequency:	1.3 GHz
HF power:	10 kW
Electron energy:	9.5 MeV
Average current:	1 mA
Cathode:	Cs_2Te thermally isolated, LN_2 cooled
Laser:	262 nm, 1W

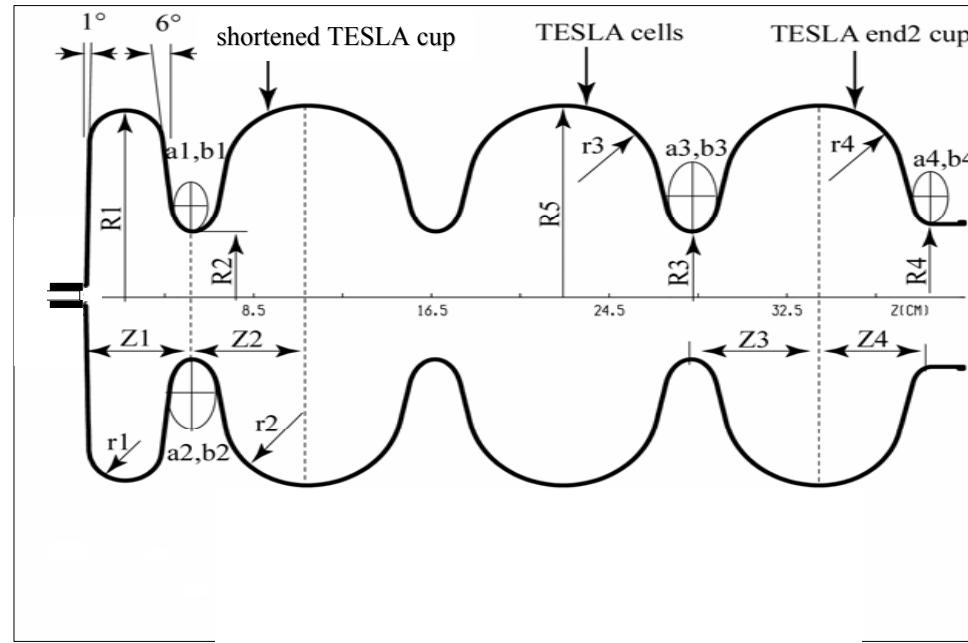
Rossendorf SRF Photo Gun Parameters

Planned Operation Modes and Beam Parameters

	ELBE	High Charge	BESSY-FEL
Pulse Frequency (CW)	13 MHz	\leq 1 MHz	1 kHz
Bunch Charge	77 pC	1 nC	2.5 nC
Bunch Length (FWHM)	5 ps	20 ps	50 ps
Peak Current	15.4 A	50 A	125 A
Average Current	1.0 mA	\leq 1 mA	2.5 μ A
Norm trans. Emittance _N (rms)	1.5 μ m	2.5 μ m	3 μ m

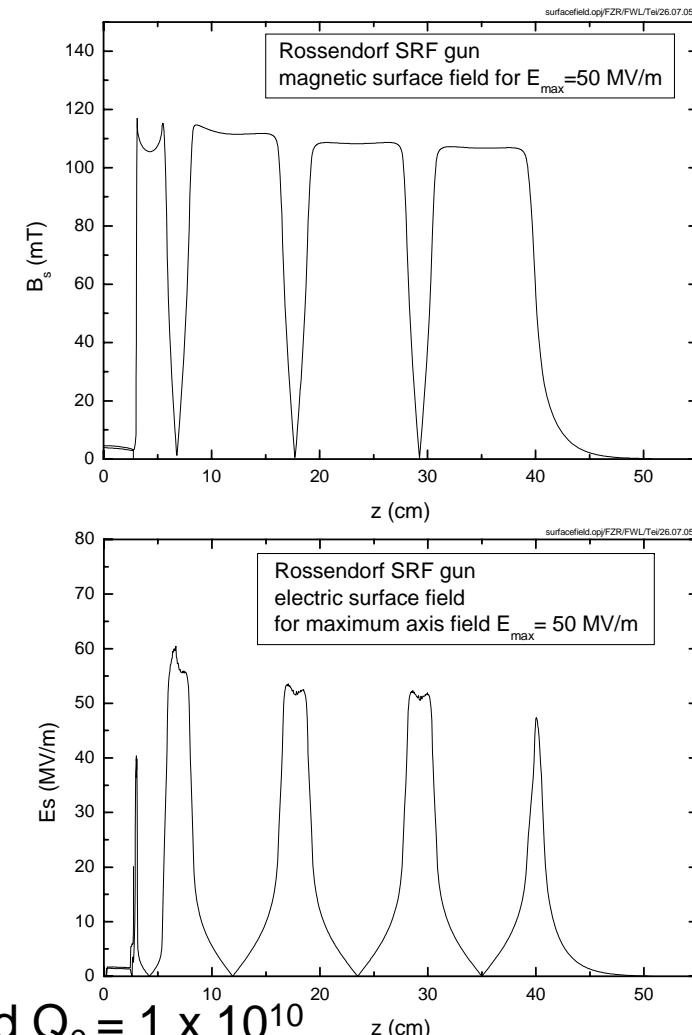


Rossendorf SRF Photogun – 3 ½ Cell Cavity Design



1. 3 GHz, 10 kW
optimized half cell & 3 TESLA cells
 $E_{z,\max} = 50 \text{ MV/m}$ (T cells)
 $= 33 \text{ MV/m}$ (1/2 cell)

TESLA 500 specification, i.e. $E_{\text{acc}} = 25 \text{ MV/m}$ and $Q_0 = 1 \times 10^{10}$

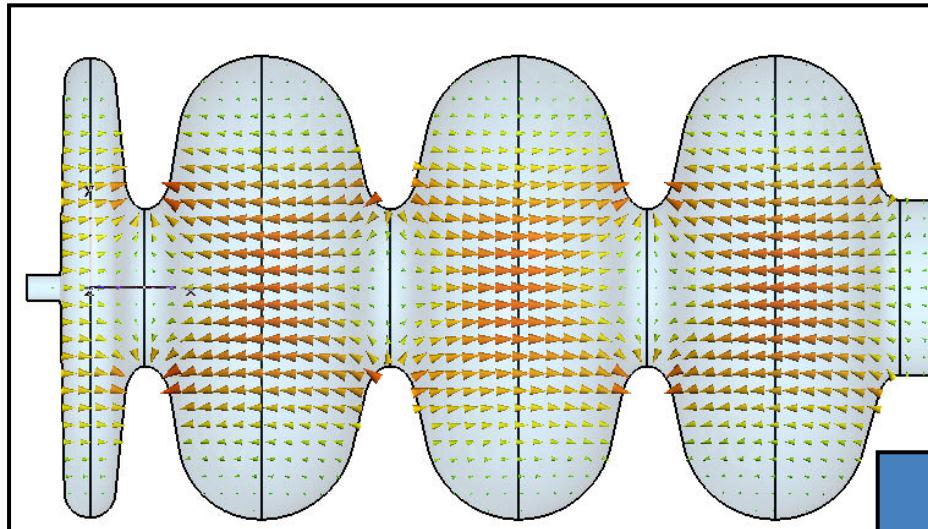


Rossendorf SRF Gun - 3½ Cell Niobium Cavity

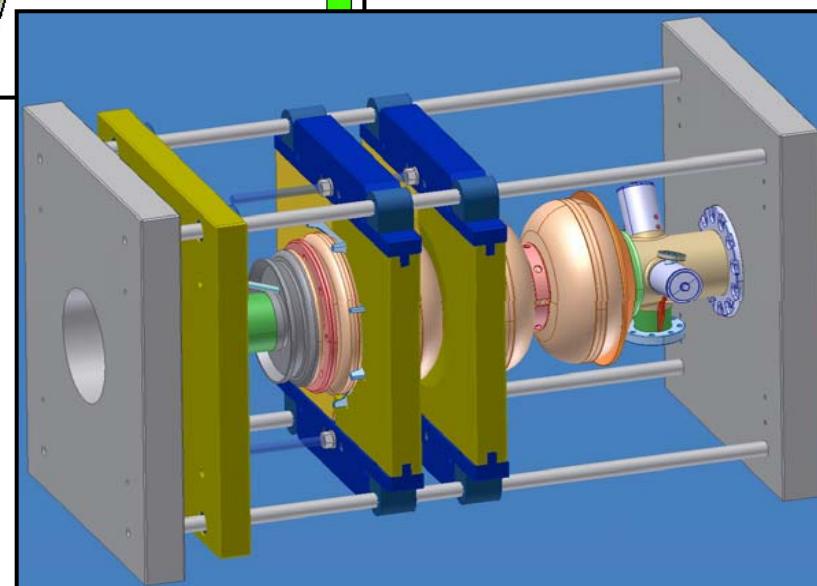
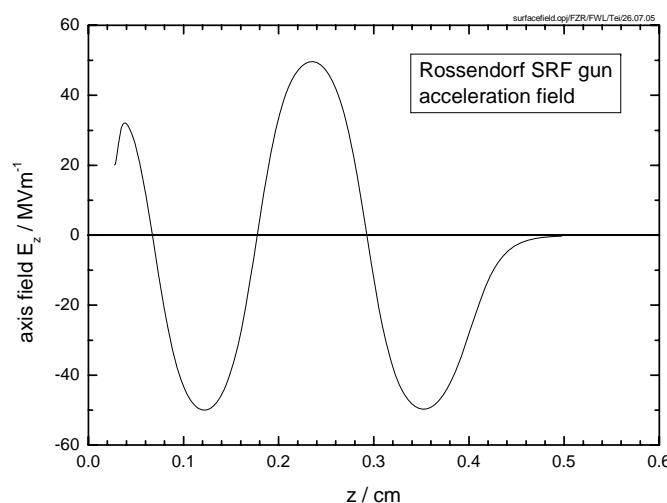
Niobium RRR 300 (RRR 40)
NbTi flanges
3 TESLA shape cells
cathode half-cell with 12 mm hole
beam tube:
flange for 10 kW power coupler
2 HOM couplers (TESLA type)
1 pick-up
cathode side:
choke filter with pick-up



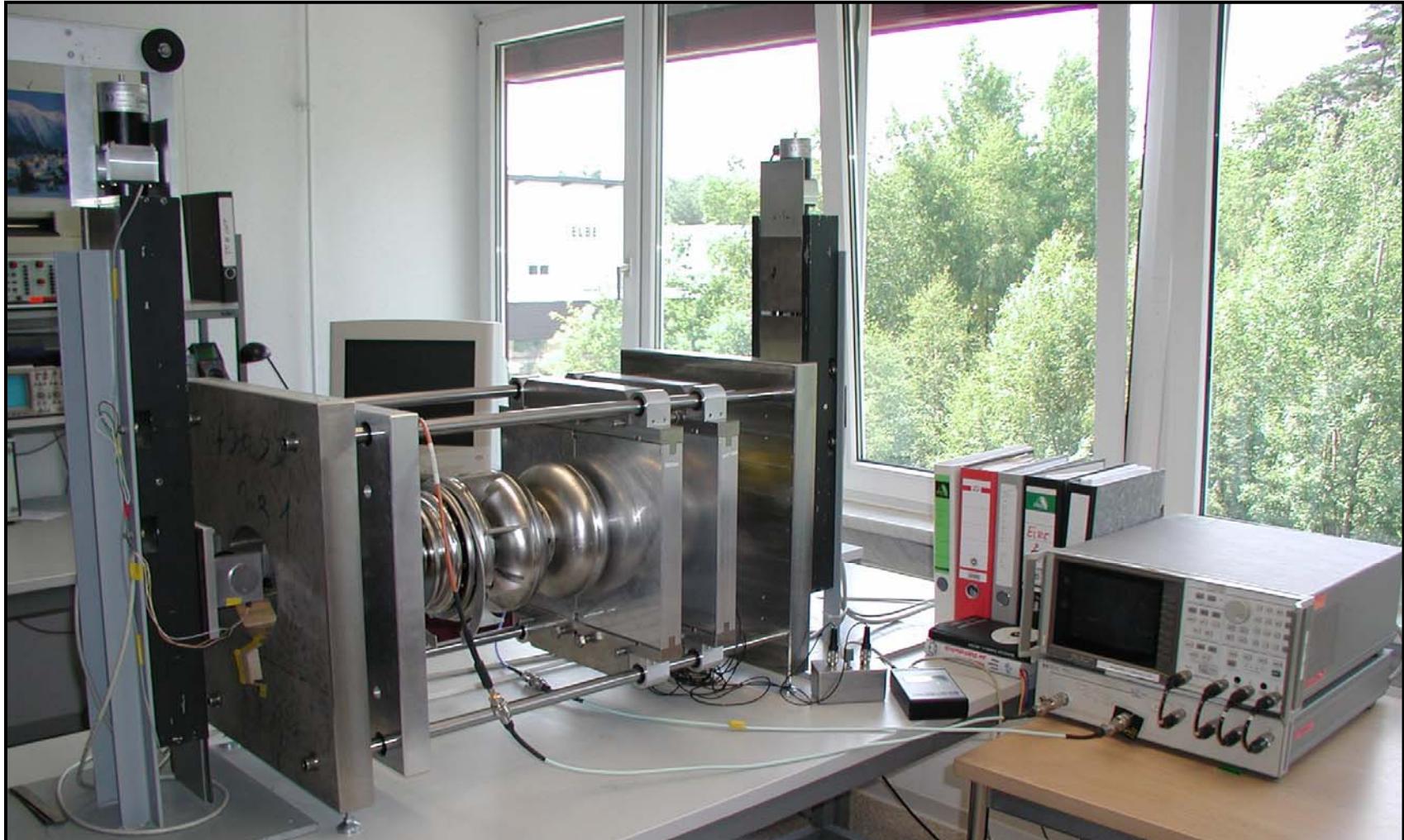
Rossendorf SRF Gun – Cavity warm tuning



for “field flatness” tuning
a bead-pull machine and
a warm tuning apparatus was built



Rossendorf SRF Gun – Cavity warm tuning



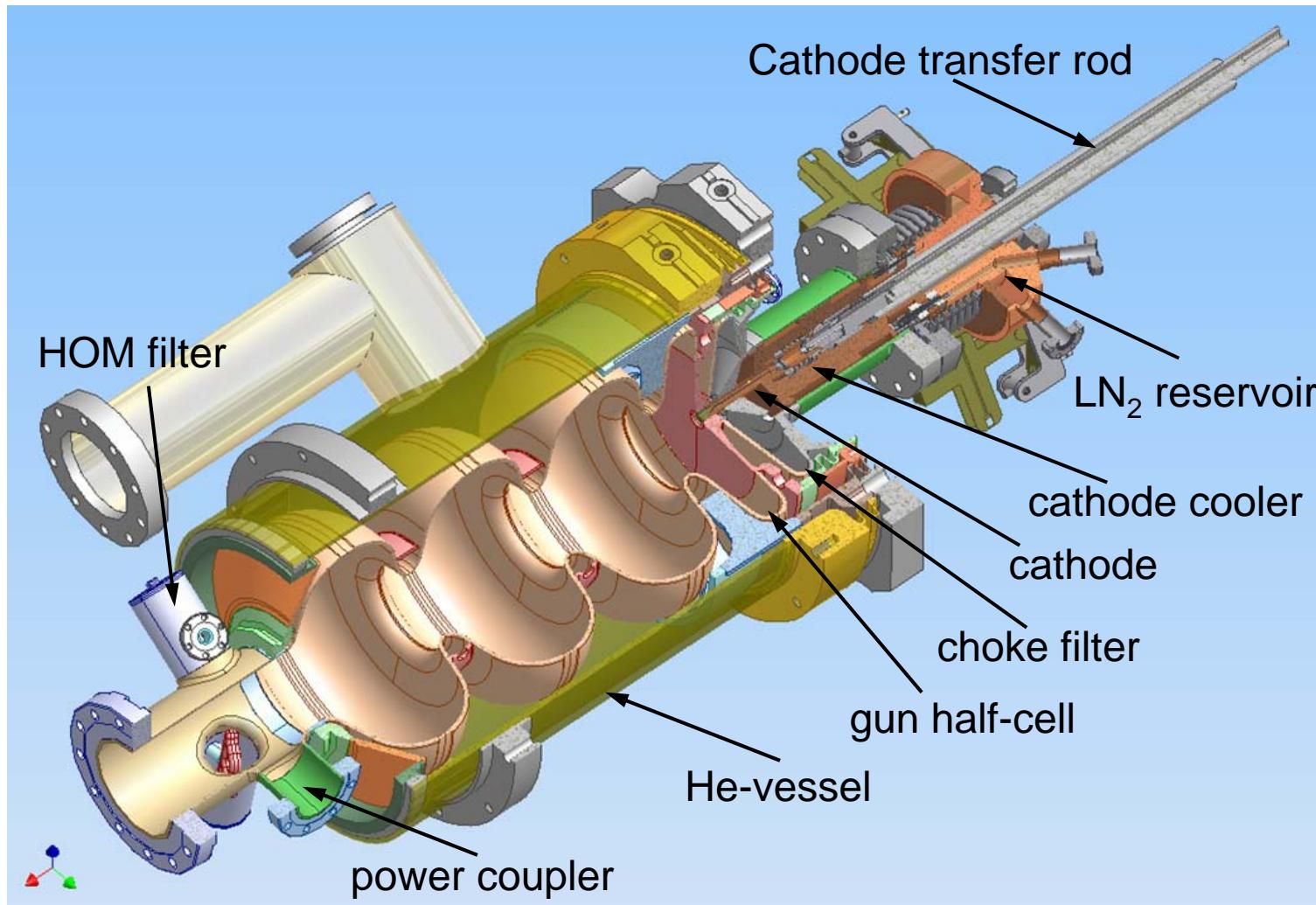
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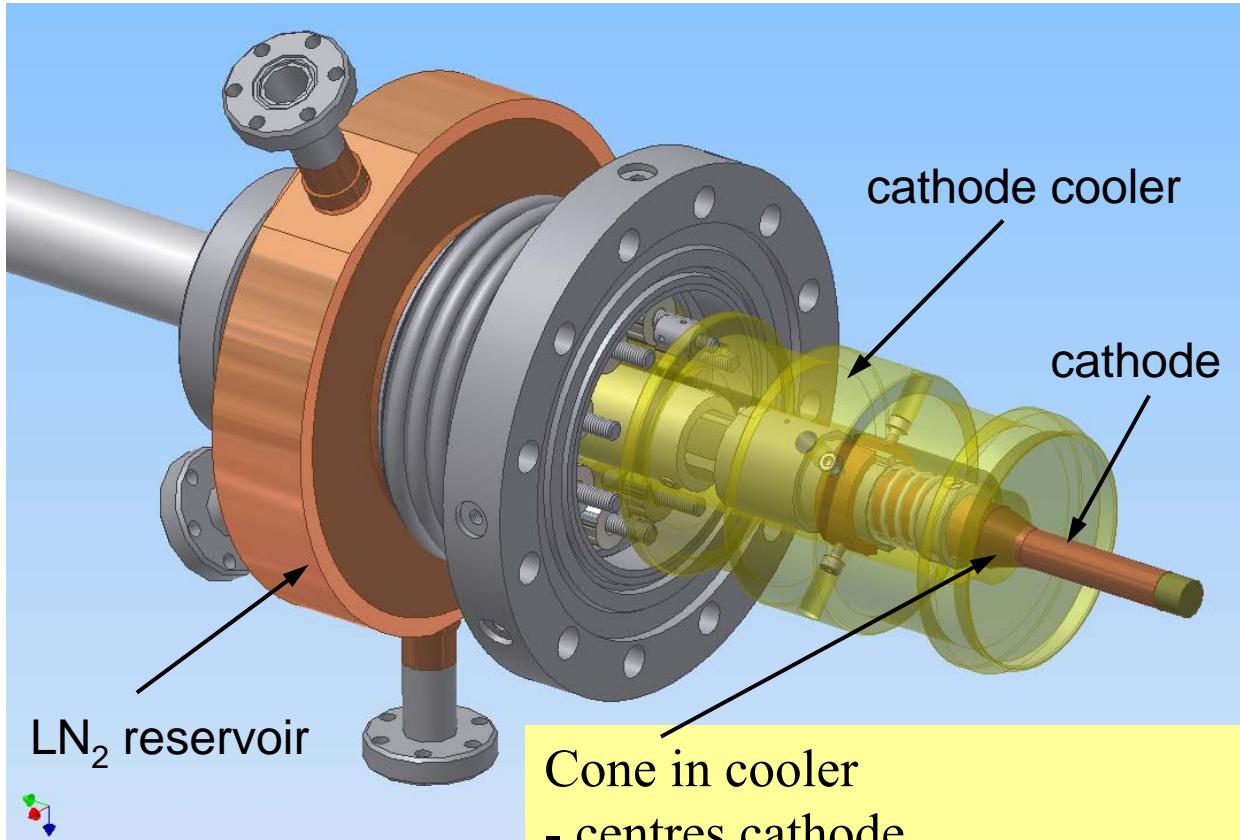
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14

Rossendorf 3½ Cell SRF Gun – Cavity & Cathode Cooling



ELBE SRF Photogun – Liquid N₂ Cathode Cooling



Test bench

thermal
conductance
measurements,
cathode
temperature?
&
test of the
cathode transfer
system

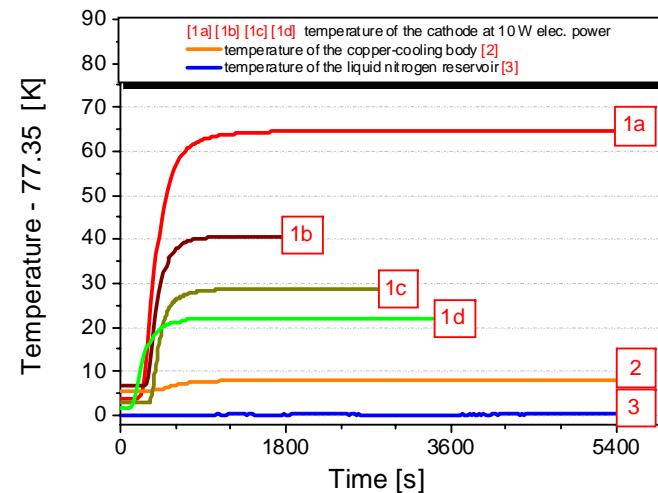
- Cone in cooler
- centres cathode
 - cathode is pressed in by spring
 - **thermal contact of cone surface ?**



Rossendorf 3½ Cell SRF Gun – Liquid N₂ Cathode Cooling



Test bench
for
thermal conductance
measurements,
cathode temperature?



30 W power input to the photo cathode
burdens the cavity with **only 31 mW**.



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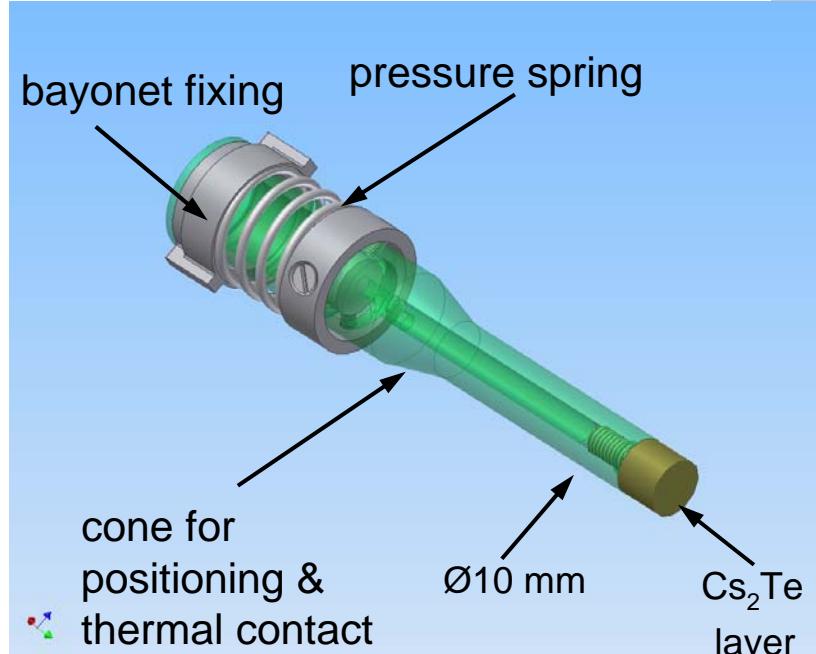
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Rossendorf 3½ Cell SRF Gun– Cathode Preparation

Photolayer: Cs₂Te



Technology:
Co-evaporation process

from CERN, Trautner, Suberlucq, Chevallay



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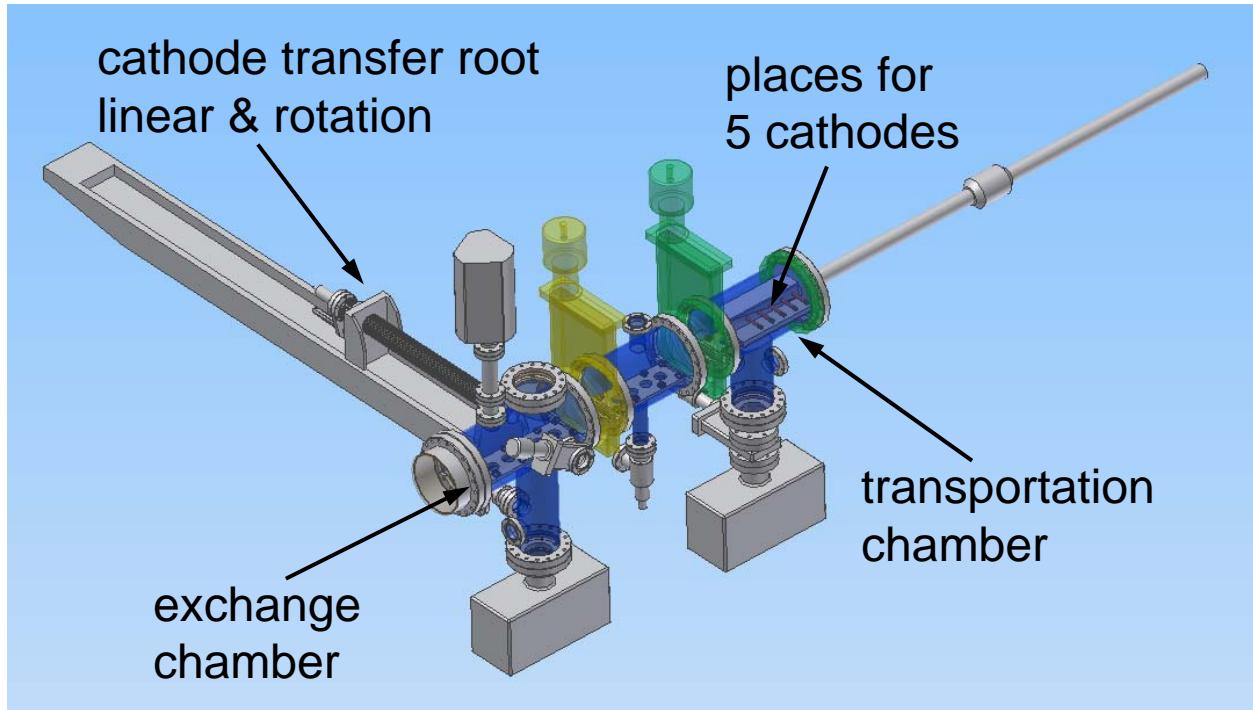
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18

Rossendorf 3½ Cell SRF Gun – Cathode Exchange



accurate adjustment of the cathode;
minimum particle generation
during exchange

**2 identical
systems**

at the SRF-gun
(accelerator hall)
&
at the cathode
preparation
chamber
(preparation lab)

transportation
chambers allow
cathode transport
in vacuum



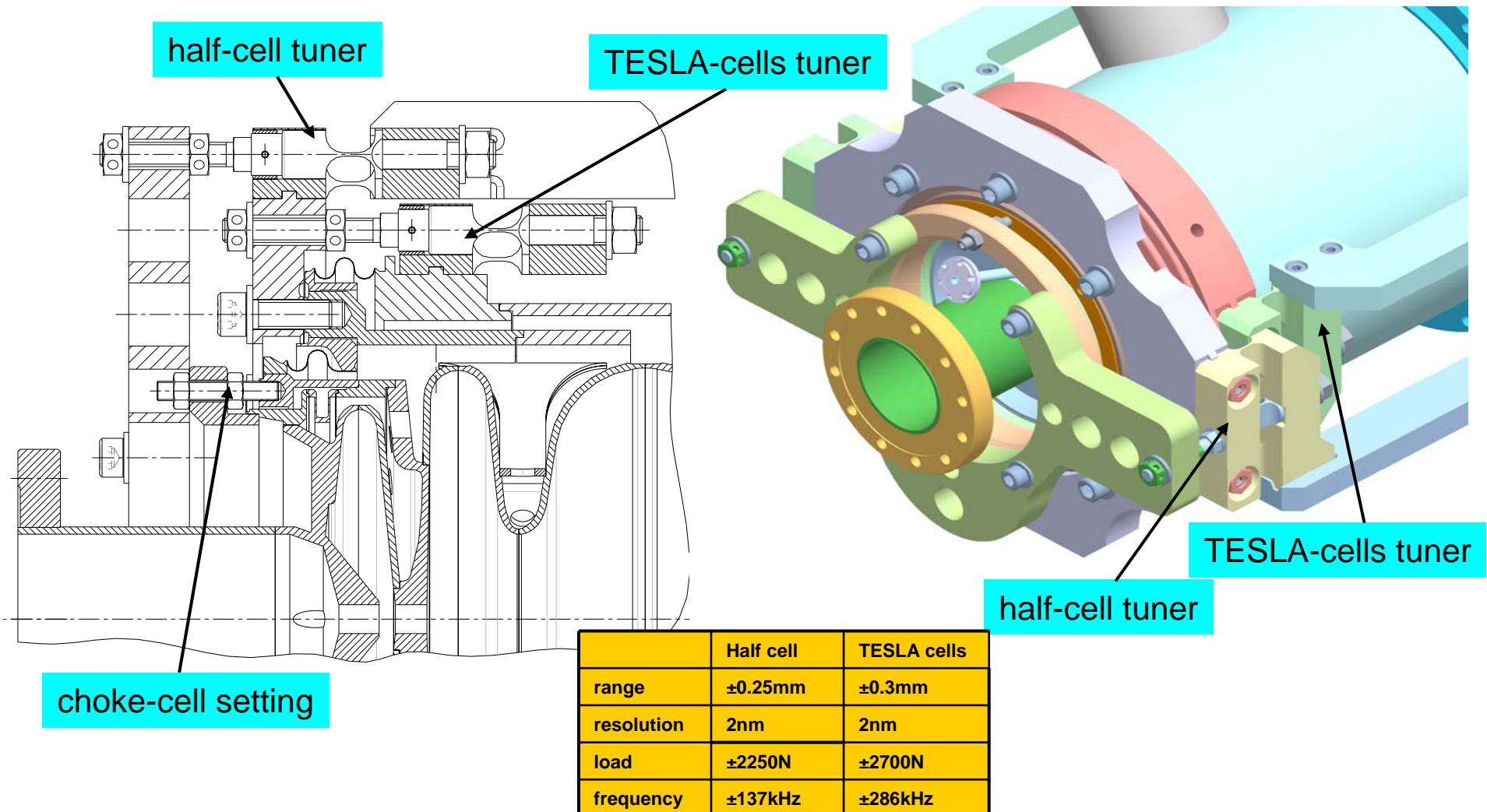
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19

Rossendorf 3½ Cell SRF Gun - Tuning System

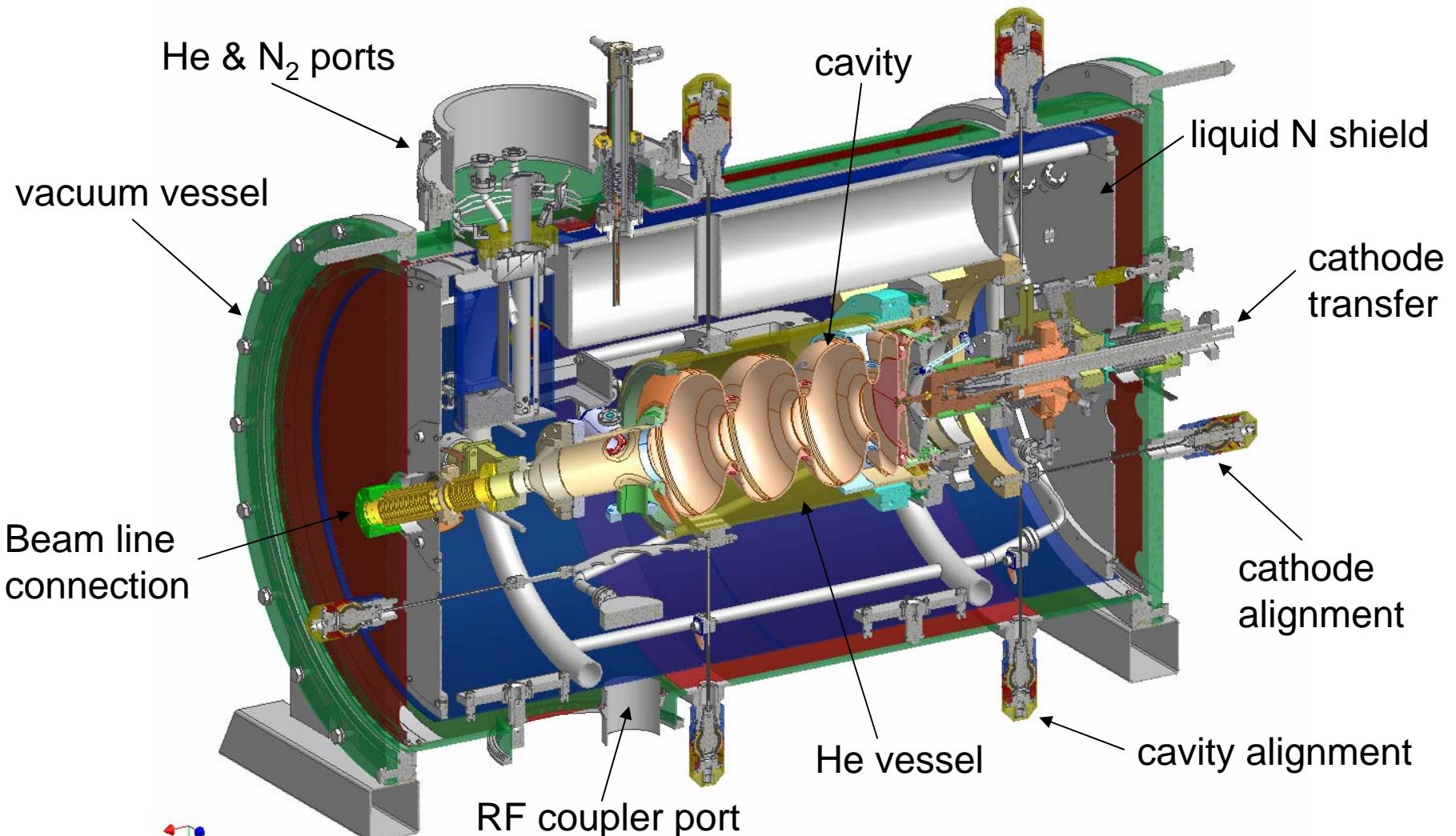


Rossendorf 3½ Cell SRF Gun - Tuning System

Tuner test bench
Operation at cryogenic temperature (liquid N₂)
Cavity is simulated by a spring



Rossendorf 3½ Cell SRF Gun – Cryomodule design

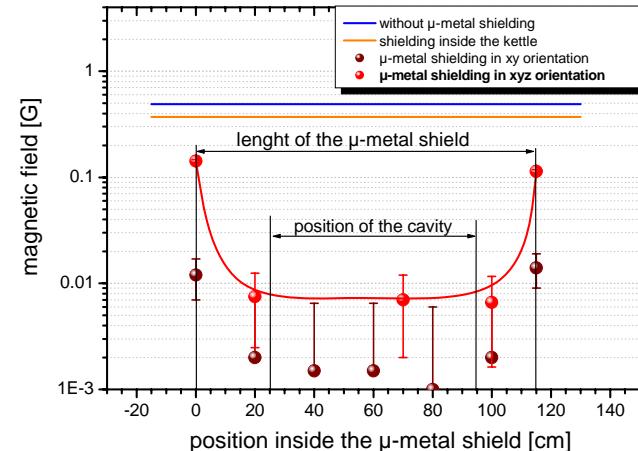


Rossendorf 3½ Cell SRF Gun – Cryomodule

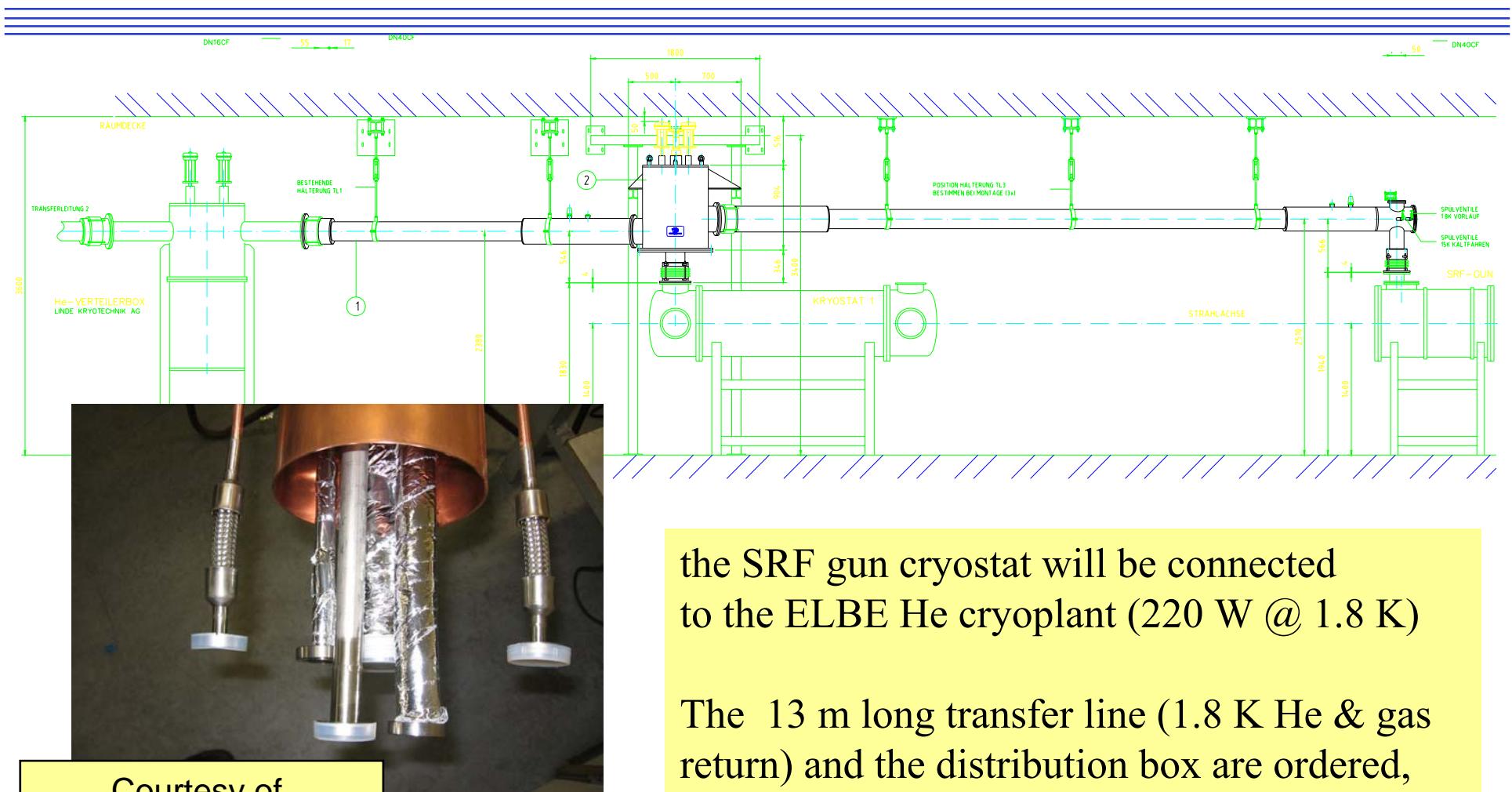


Main parts have been delivered:

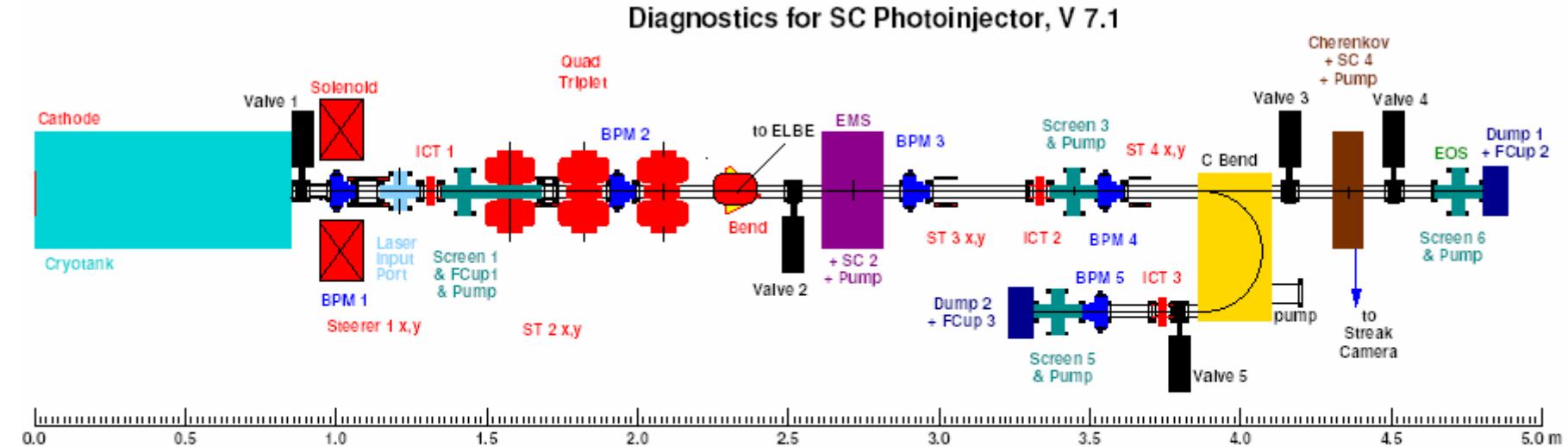
- vacuum vessel
- magnetic shield
- liquid N₂ shield



Helium Transfer Line and Distribution Box



Rossendorf 3½ Cell SRF Gun – Diagnostic Beamline



Current: Faraday cups & ICTs
Energy & energy spread: C bent magnet
Transverse emittance: slit mask
Bunch length: Cherenkov radiator + streak camera
electro-optical sampling

Courtesy of
Dirk Lipka, BESSY



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25

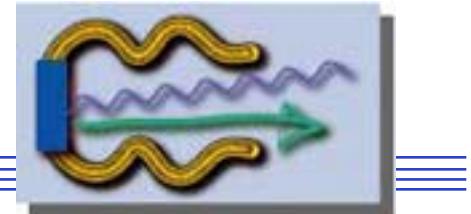
Summary

1. Design phase is concluded.
2. Tests of critical components are finished or running (cavity)
3. Most of the parts are fabricated and delivered
4. Next work: installation of the He-transferline
 & cathode preparation system in clean-room
 vertical test of cavity (Q_0 over E) @ DESY
In 2006 assembling of the gun (deliverable)





Thank you for YOUR attention



Collaboration:

BESSY, Berlin

DESY, Hamburg & Zeuthen

Max-Born-Institut, Berlin

TJNAF, Newport News

University of Peking

BINP, Novosibirsk

CERN, Geneva

INFN, Frascati

ACCEL GmbH, Bergisch Gladbach

Technische Universität Dresden

IfE-Automatisierung GmbH, Dresden

Ingenieurkontor Stephan, Dresden



The ELBE crew

(in the Radebeul vineyards,
near Dresden)



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27