Overview of the present status of the SRF gun design and construction

Jochen Teichert

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

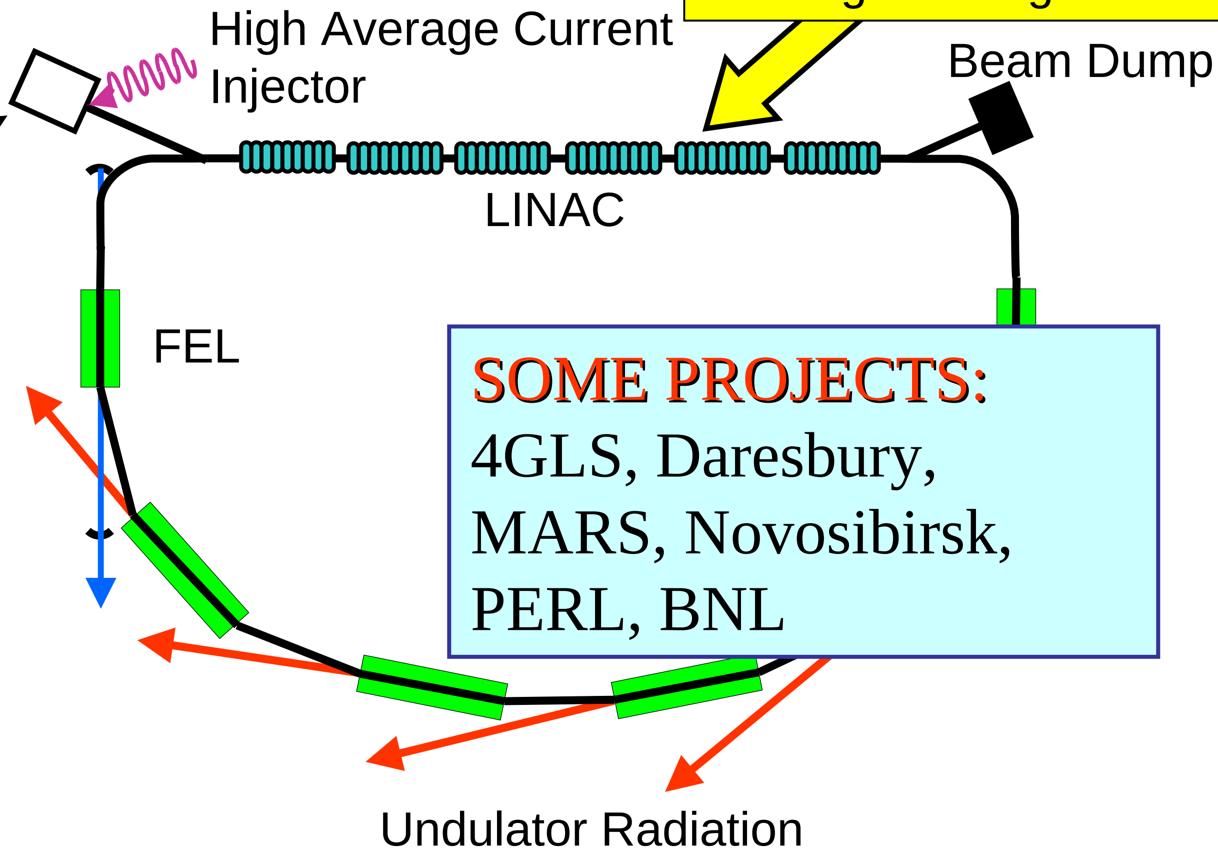
Motivation

4TH GENERATION LIGHT SOURCES

- high photon brightness
- short pulses
- high coherence

Energy recovery superconducting LINACs can provide the high quality e-beams with high average current

Photo-injectors
$\varepsilon_{t,n} \leq$ 2 mm mrad
with
cw – operation
SRF-Photoinjector ?



SOME PROJECTS:
4GLS, Daresbury,
MARS, Novosibirsk,
PERL, BNL

Superconducting Photo-Injectors

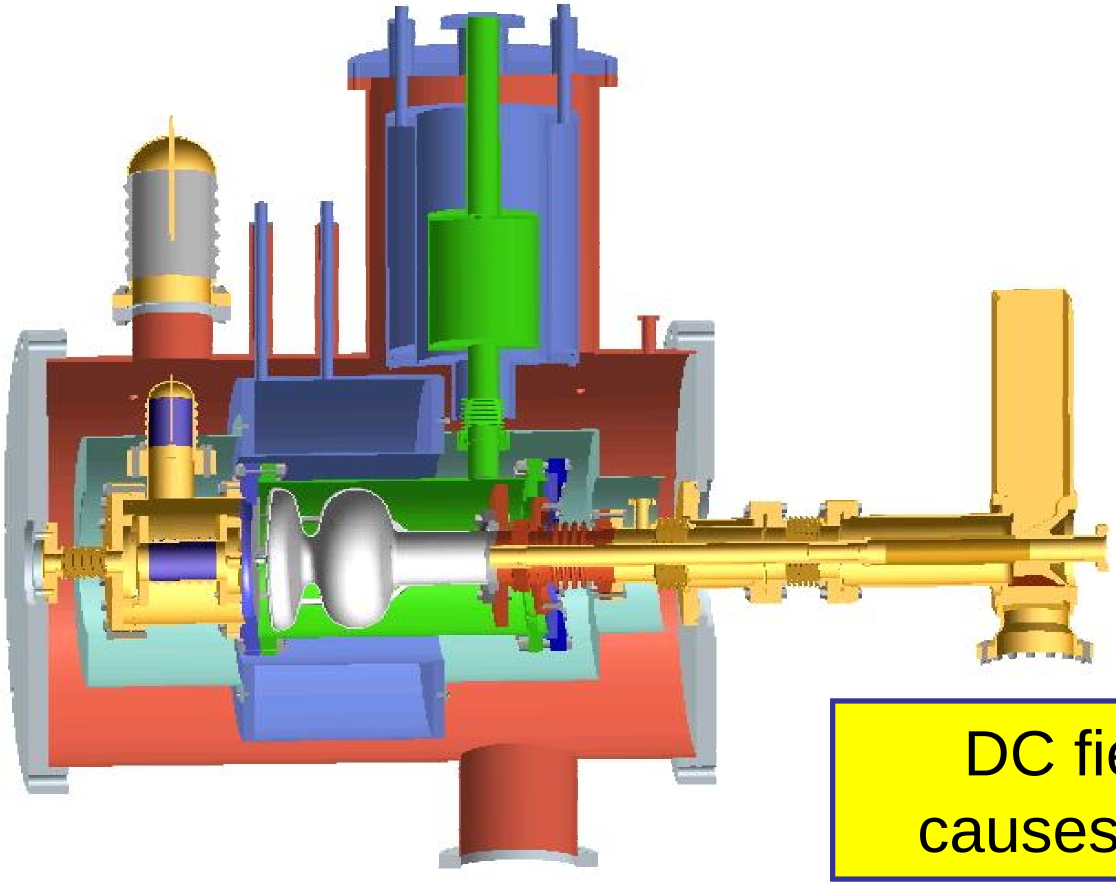
Main Advantage:

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.

Peking University 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

Courtesy of B. Zhang

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

BNL, AES Inc., JLAB collaboration

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

Courtesy of I. Ben-Zvi

AES SRF Photoinjector

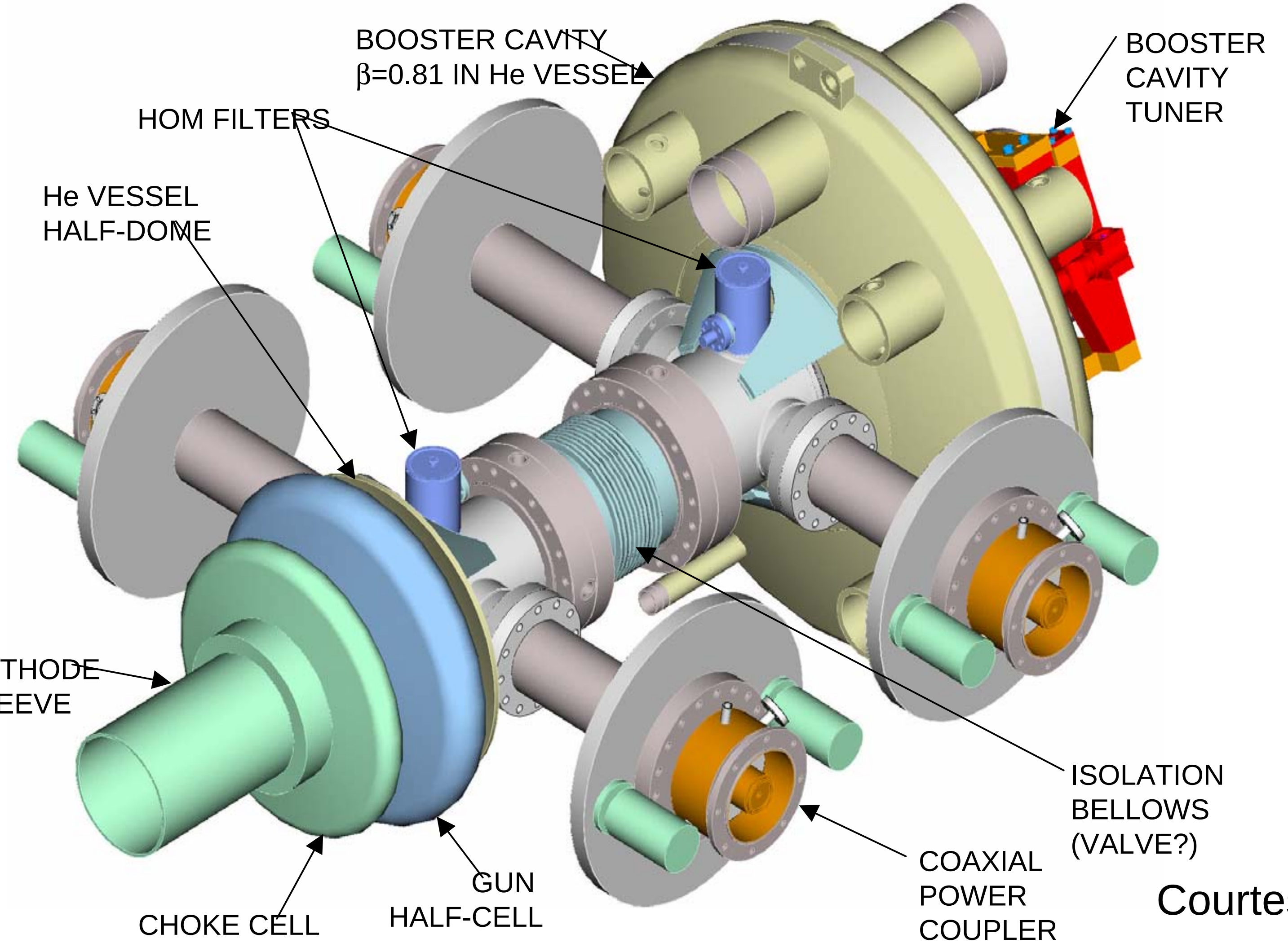
1.5 cell, 748.5 MHz
Energy: > 2 MeV
Emittance:
 transverse < 10 mm mrad (rms)
 longitudinal < 100 π keV ps (rms)
Beam current: 1A
Bunch charge: 1.3 nC

½ + 1 – cell split type design
Cathode problem: Rossendorf solution
normal conducting cathode
with thermal + electrical insulation,
and choke filter

ADVANCED ENERGY SYSTEMS, INC.

Courtesy of M. Cole

AES SRF Photoinjector



Courtesy of M. Cole

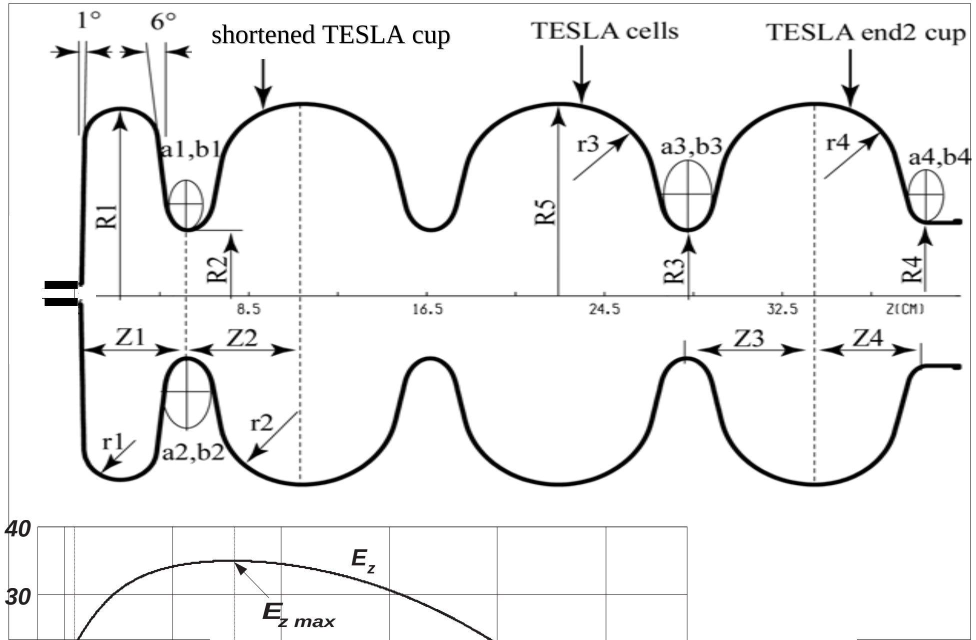
ELBE SRF Photogun – Basic Design

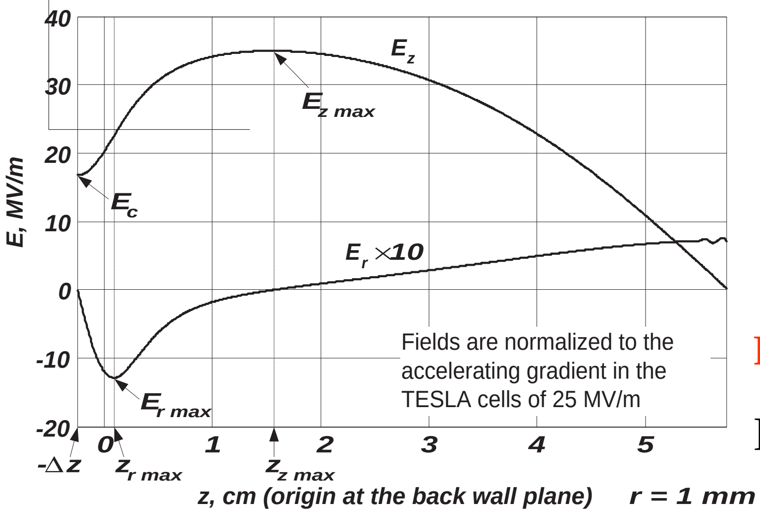
Normal-conducting cathode inside SC cavity

Successful Proof of Principle Experiment, D. Janssen et al., NIM A507(2003)314

Cavity:	Niobium 3+½ cell (TESLA Geometry)
	Choke filter
Operation:	T = 1.8 K
Frequency:	1.3 GHz
HF power:	10 kW
Electron energy:	10 MeV
Average current:	1 mA
Cathode:	Cs_2Te
	thermally insulated, LN_2 cooled
Laser:	262 nm, 1W
Pulse frequency:	13 MHz & < 1 MHz
Bunch charge:	77 pC & 1 nC

ELBE SRF Photogun – Cavity Design Parameter



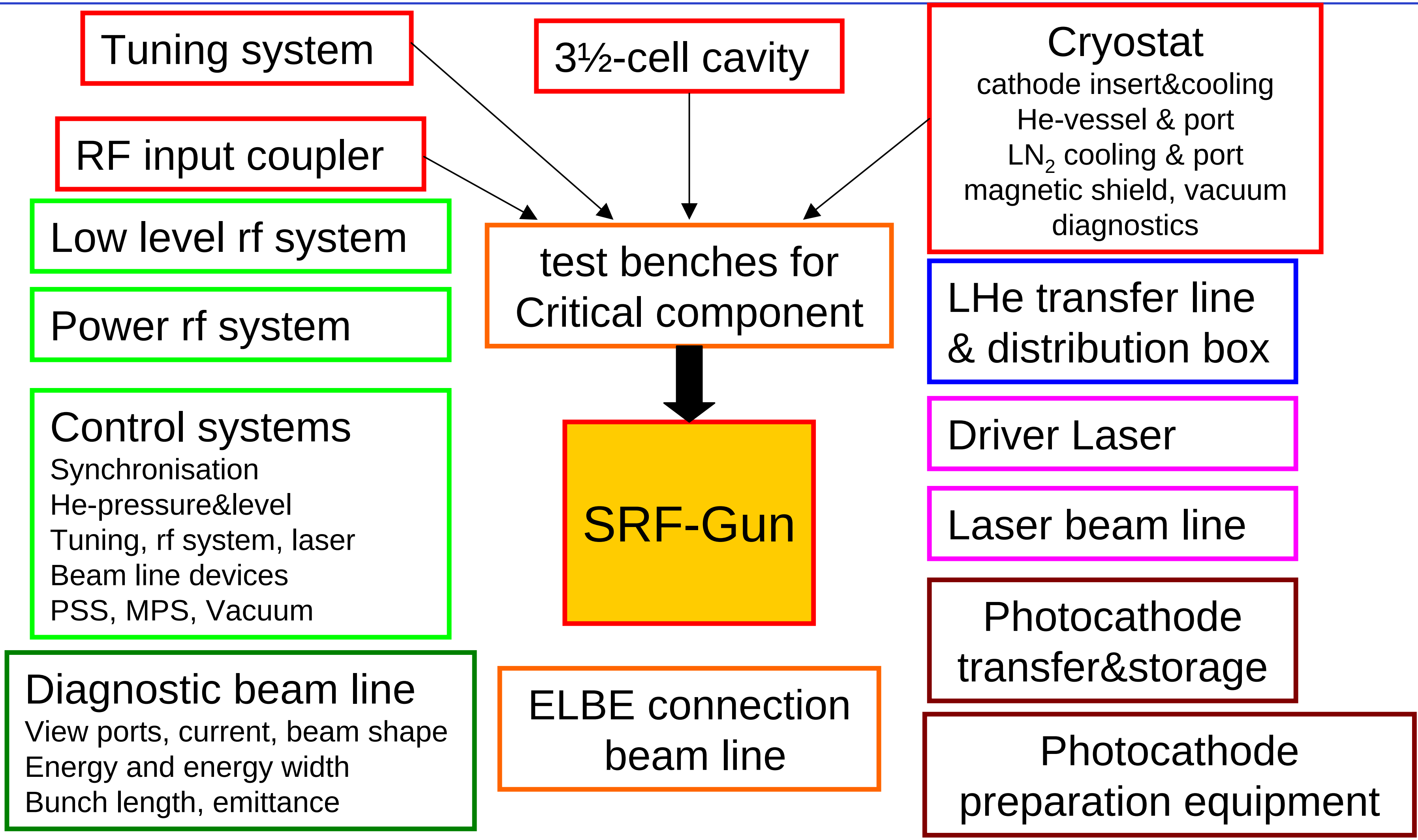


1. 3 GHz, 10 kW optimized half cell & 3 TESLA cells $E_{z,max}$= 50 MV/m (T cells) = 33 MV/m (1/2 cell)	
77 pC	1 nC
I_{av}= 1 mA	
E = 9.5 MeV	
0.5 mm mrad	2.5 mm mrad

RF focusing in SC gun cavities

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

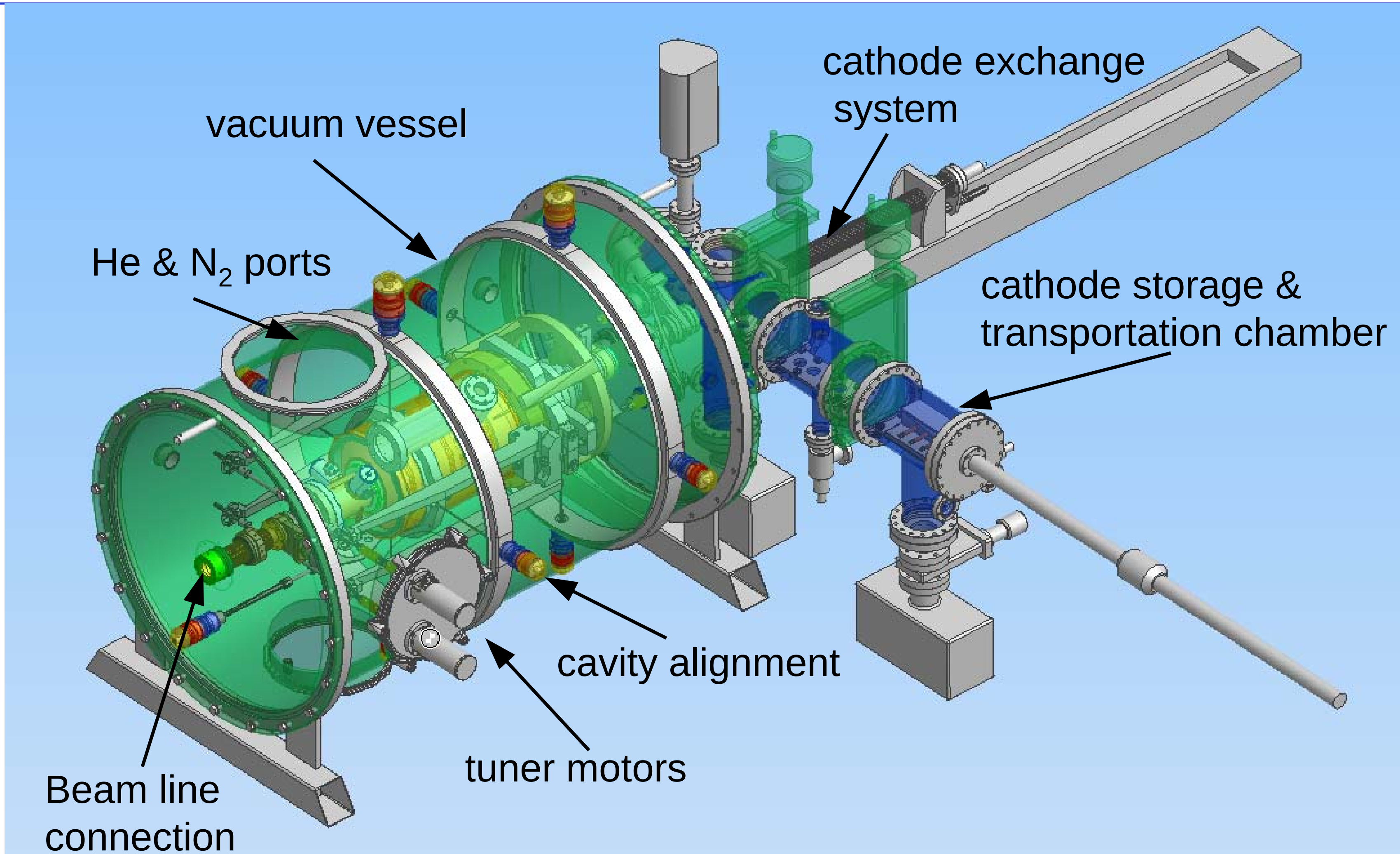
Main Components of the ELBE SRF Photogun



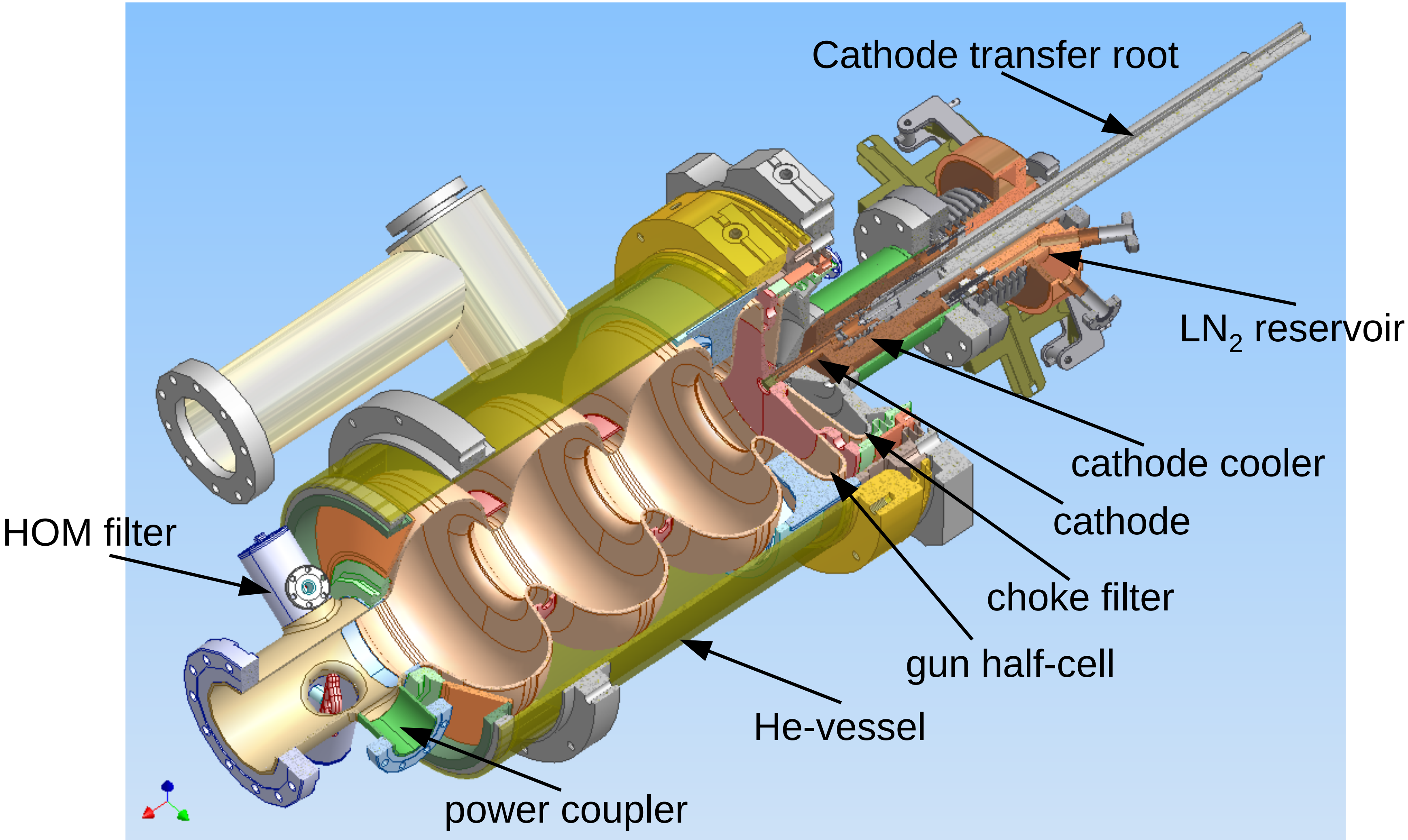
ELBE SRF Photogun – Present Status

Cavity:	**Design finished**
	Fabrication of 2 (RRR 40 & 300) cavities at ACCEL GmbH and a third cavity by Peking University
Cavity tuners:	**Fabrication finished**
	tests necessary
Cathode cooling system:	
	Design finished, in fabrication
Cathode transfer system:	
	Design finished
Cathode preparation chamber:	
	Design finished, in the work-shop
Cryomodule:	Design will be finished in July

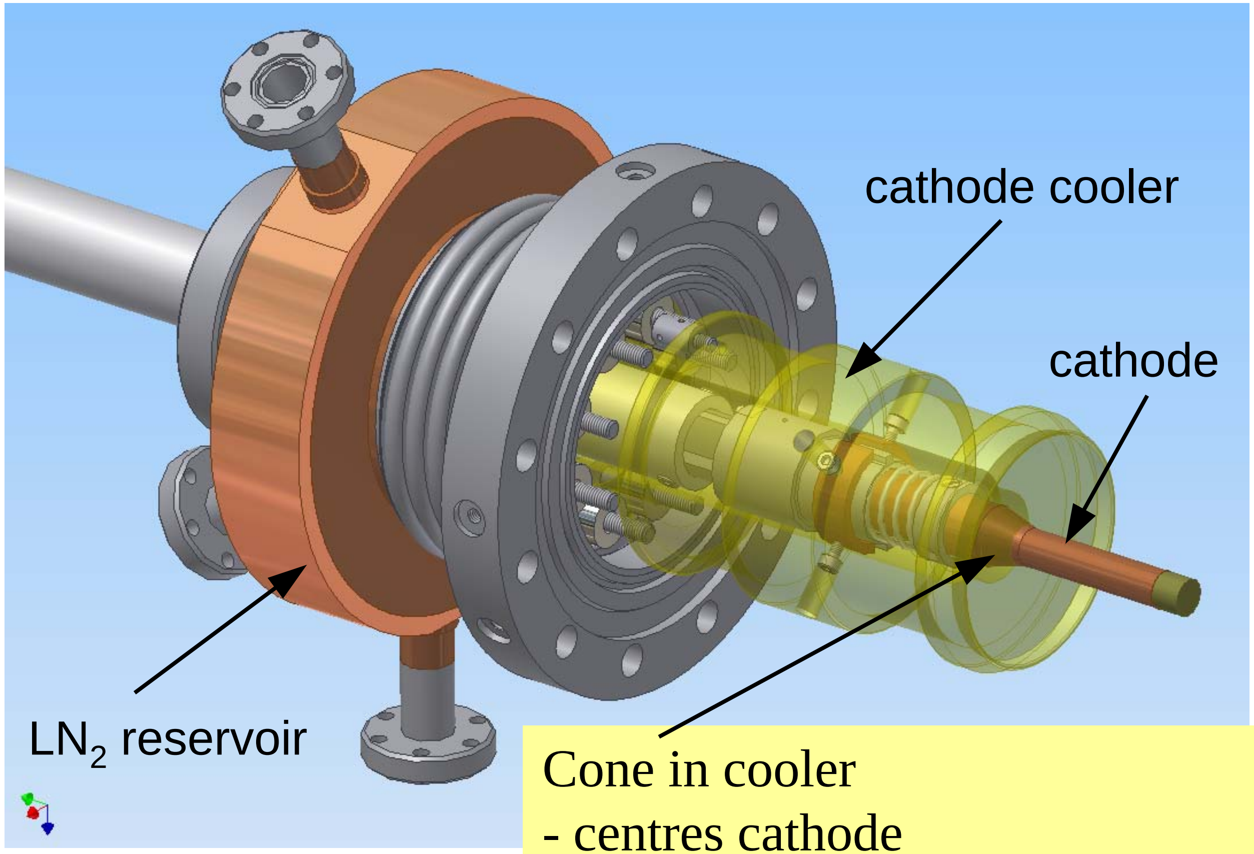
ELBE SRF Photogun – Cryomodule design



ELBE SRF Photogun – Cavity design



ELBE SRF Photogun – Liquid N_2 Cathode Cooling

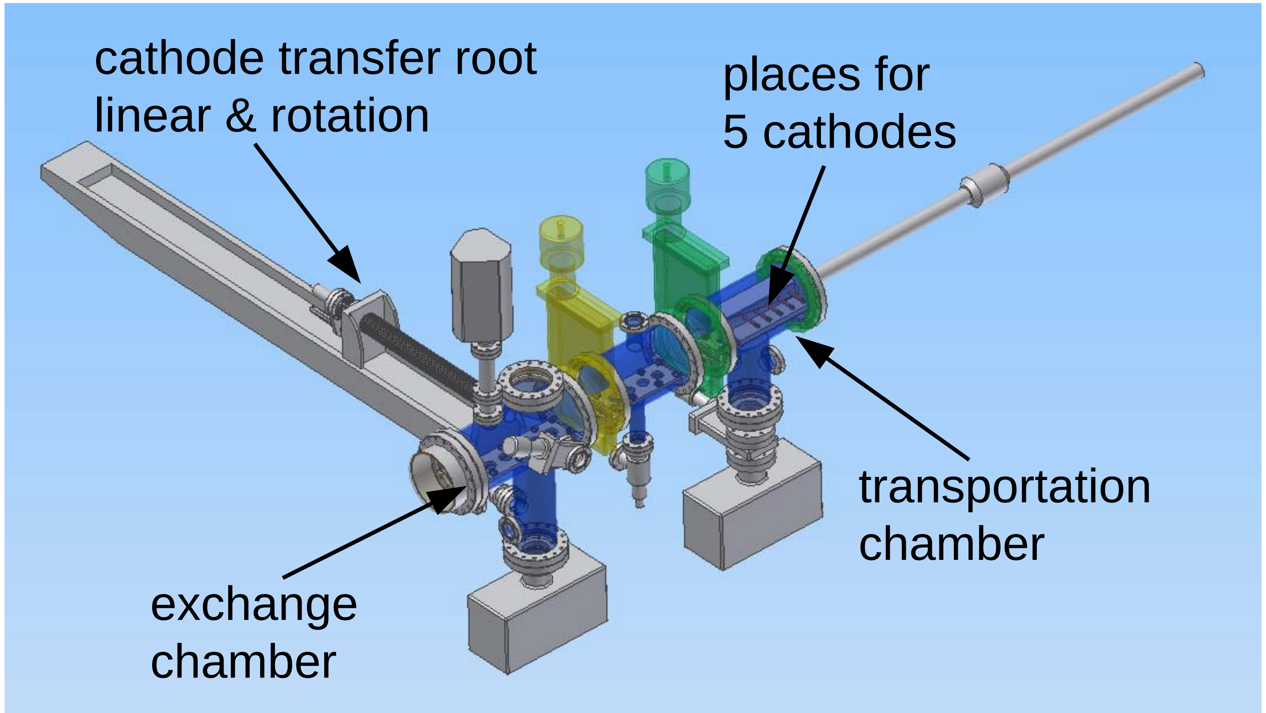


Cone in cooler
- centres cathode
- cathode is pressed in by spring
- **thermal contact of cone surface ?**

Test bench

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

ELBE SRF Photogun – Cathode Exchange & Transport



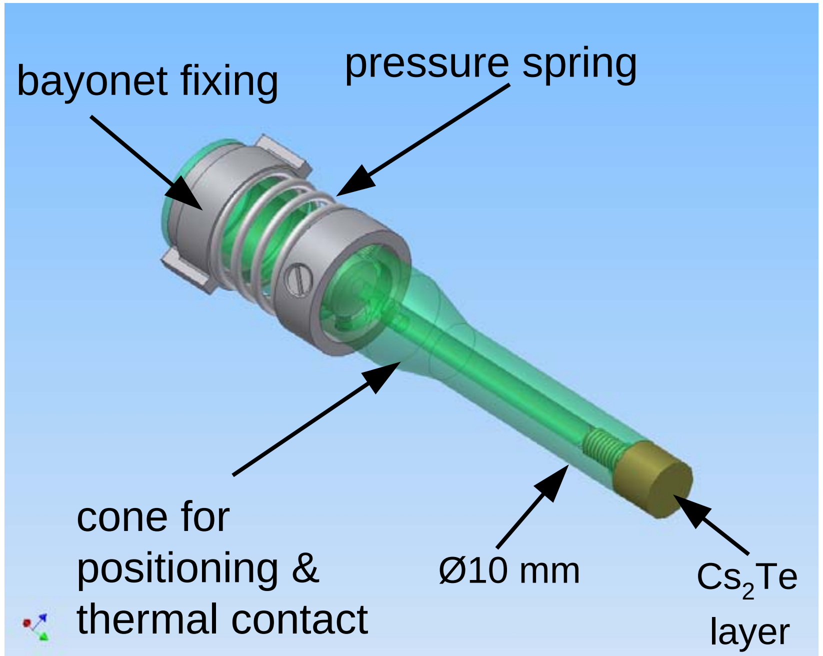
2 identical systems

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

transportation chambers allow cathode transport in vacuum

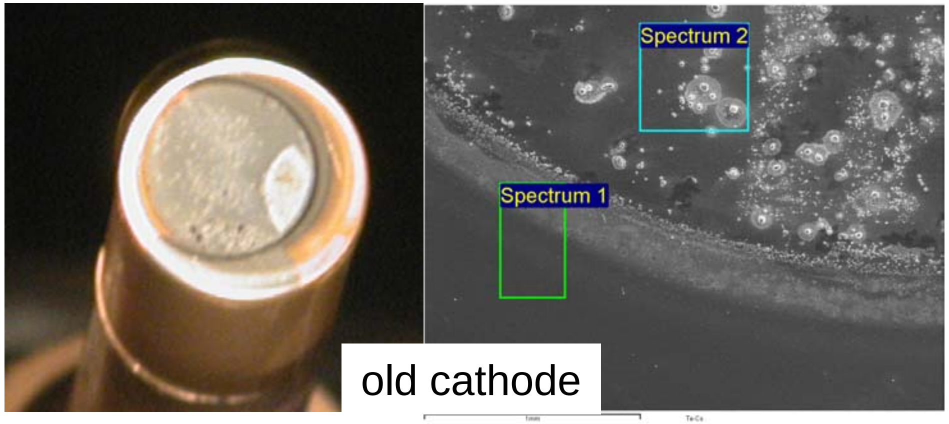
accurate adjustment of the cathode;
minimum particle generation
during exchange

ELBE SRF Photogun – Cathode preparation

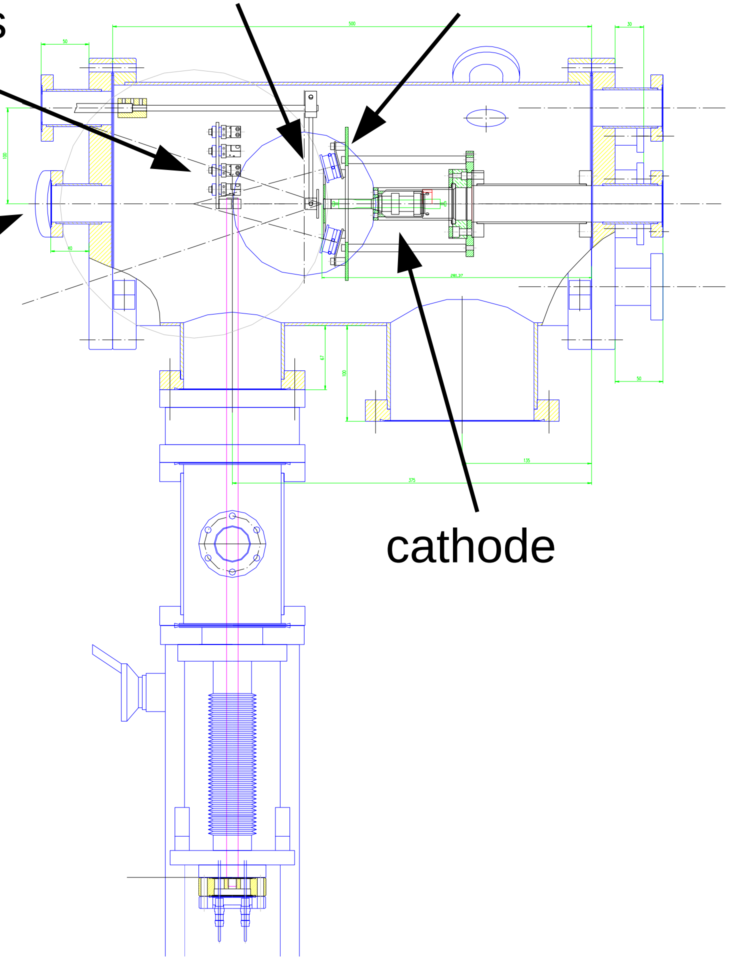


Photolayer: Cs_2Te

Pulse rate	mean current	bunch charge	Laser		
			Q.E.	P_{mean}	E_{pulse}
13 MHz	1 mA	77 pC	1 %	0.8 W	60 nJ
1 MHz		1 nC		1 W	1 µJ



ELBE SRF Photogun – Cathode preparation chamber



Technology:

Co-evaporation process

from CERN

Trautner, Suberlucq, Chevallay, 2001

4 evaporators with
- tellurium
- Cs_2CrO_4 (saes getters)

2 deposition rate monitors
- separate measurements for Te and Cs
- control of 1 : 2 ratio

cathode heating

cathode cleaning (ion sputtering)

Q.E. measuring with 262 nm, 10 mW laser
- during deposition
- aging
- distribution (laser spot scan)

ELBE SRF Photogun – Next steps & problems

Next work in Rossendorf:

assembling of new cathode preparation chamber
assembling of cathode cooling test bench
2 PostDoc positions from CARE
beginning in May resp. July

Collaboration:

co-evaporation technology know-how from CERN

Infrastructure:

new lab for cathode preparation & gun assembling ready;
FZR will give money for the LHe-plant modification
(distribution box and transfer line)

Financial support of BMBF:

proposal with BESSY, DESY, MBI
evaluated positively,
but we are still waiting for the money

Thank you for YOUR attention

The ELBE crew
(visiting the ELBE river source, Spindleruv Mlyn, Czech Republic, April 2003)

Collaboration:
BESSY, Berlin
Max-Born-Institut, Berlin
TJNAF, Newport News
University of Peking
BINP, Novosibirsk
DESY, Hamburg & Zeuthen
ACCEL GmbH, Bergisch Gladbach
Technische Universität, Dresden
IfE-Automatisierung GmbH, Dresden
Ingenieurkontor Stephan, Dresden