EuCARD-SRF Annual Review 2011

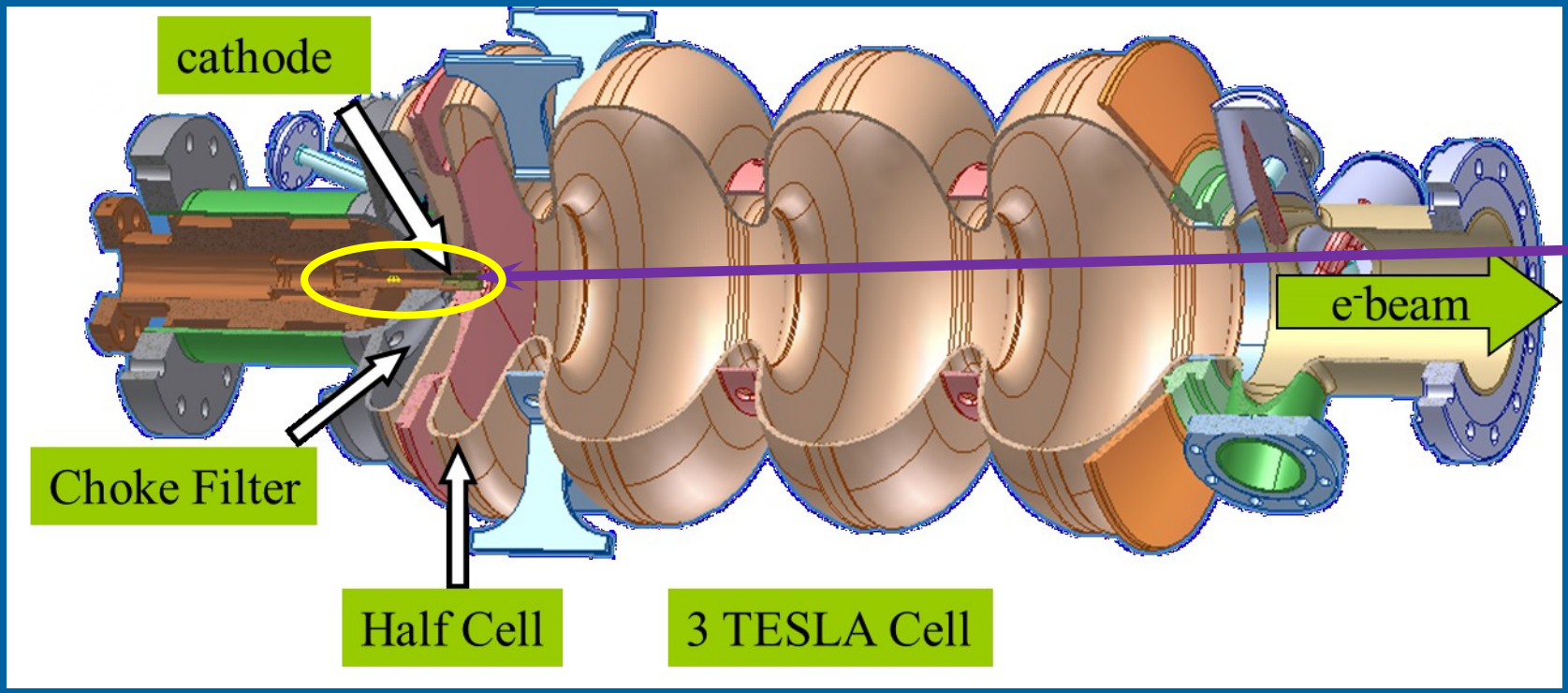
Task 10.7 "SCRF Gun at ELBE" Reports.

Plans and issues of the activities of GaAs for Rossendorf SRF injector

Rong Xiang

4 -5 May 2011 IPN Orsay

Photocathode in SRF gun



HZDR

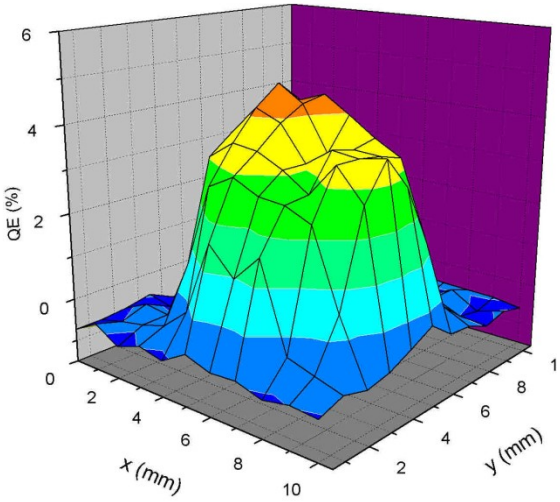
HELMHOLTZ ZENTRUM DRESDEN ROSSENDORF

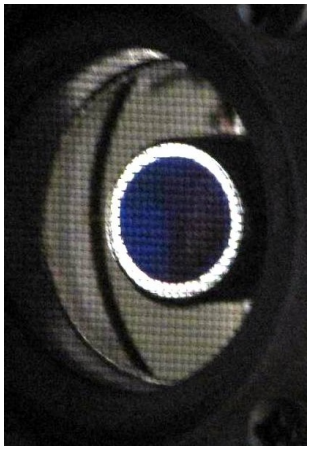
Outline

1. Status of the present Cs_2Te
2. The plans and test chamber of GaAs
3. The theoretical work about GaAs in SRF gun
4. Next steps

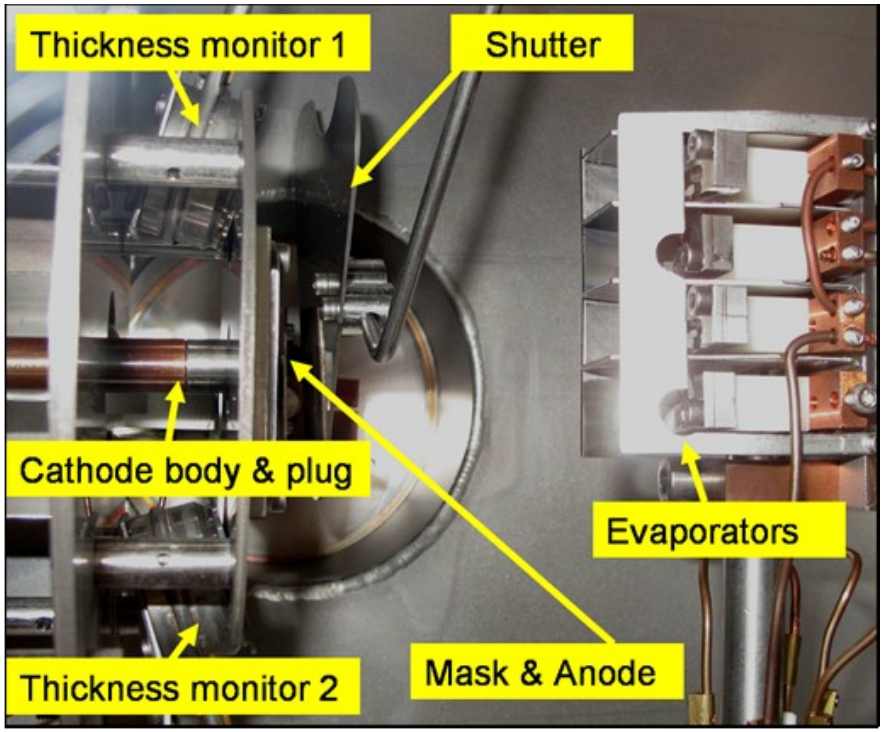
1. Status of the present Cs_2Te photocathode

The present Cs_2Te cathode serves in gun from May 2010, and provides totally 35 Coulombs





Cathode #250310Mo



Inside of preparation chamber

Proceedings of SRF2009, Berlin, Germany
Proceedings of FEL2010,Malmoe,Sweden
PhysRevSpecialTopics_13_043501

Outline

1. Status of the present Cs_2Te
2. The plans and test chamber of GaAs
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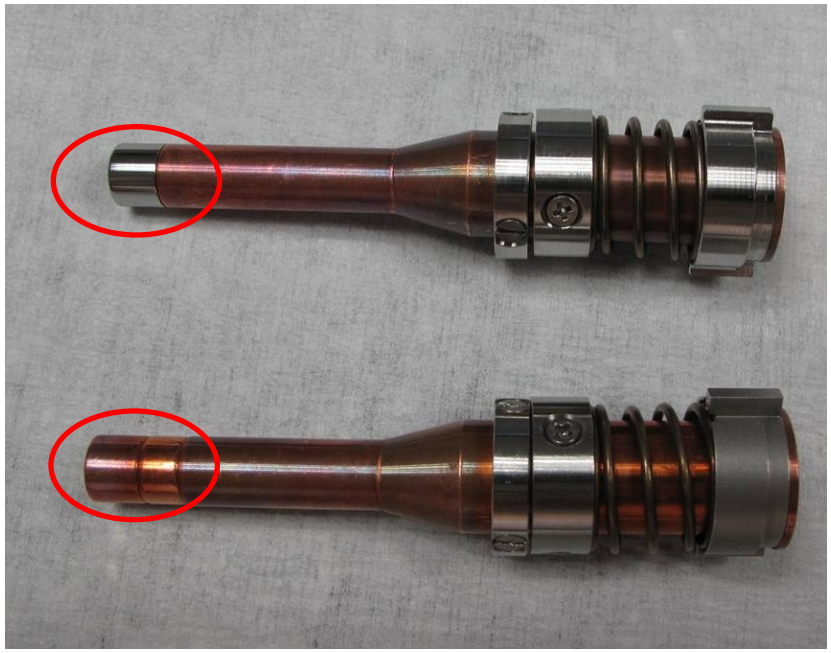
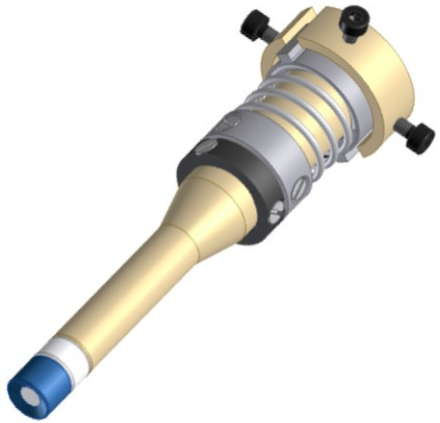
2. The plans and test chamber of GaAs for SRF gun

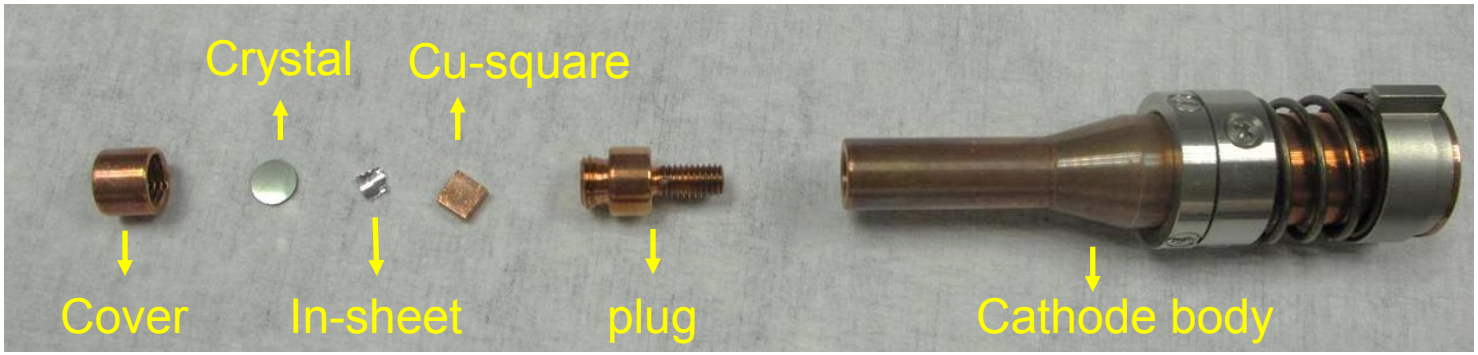


Cathode (9.8cm)
designed for Cs_2Te

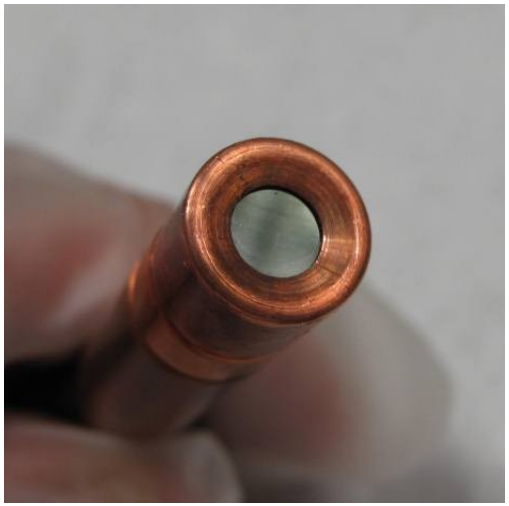
Cathode (9.8cm)
designed for GaAs



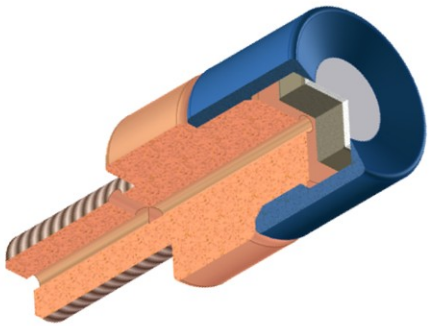
2. The plans and test chamber of GaAs for SRF gun



The structure of cathode plug



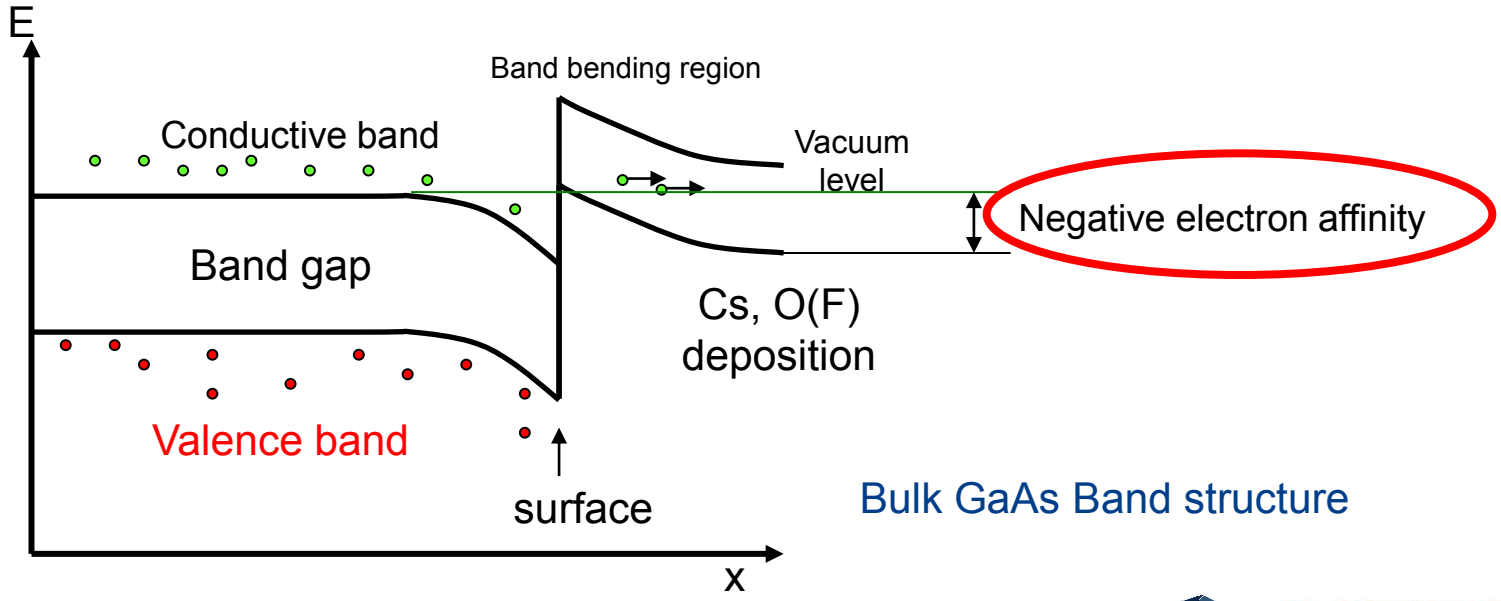
With Pierce cone
Inside ϕ 4.75 mm
Outside ϕ 10 mm



2. The plans and test chamber of GaAs for SRF gun

Bulk GaAs(Zn-doped) crystal 400μm thick

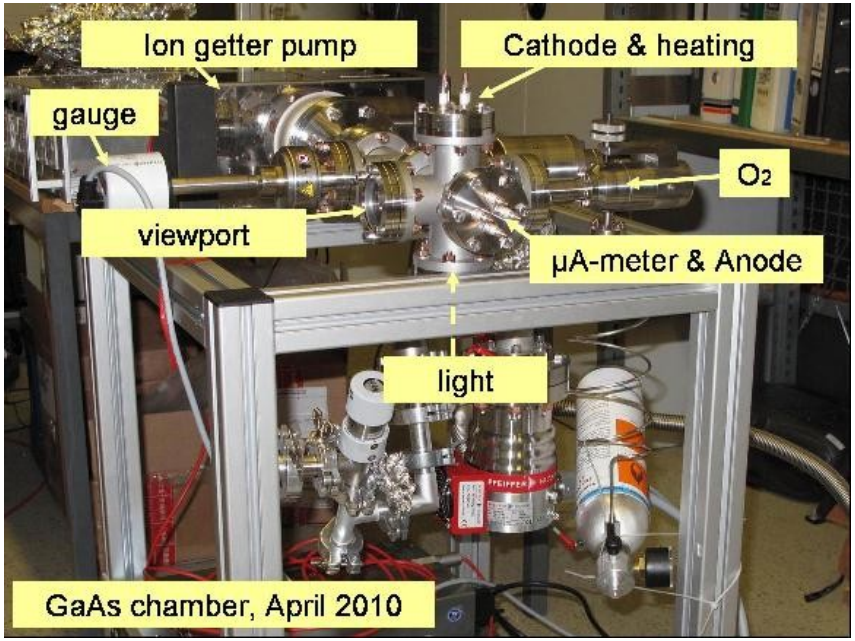
- (100)
- high doped 10^{18}~10^{19}cm^{-3}

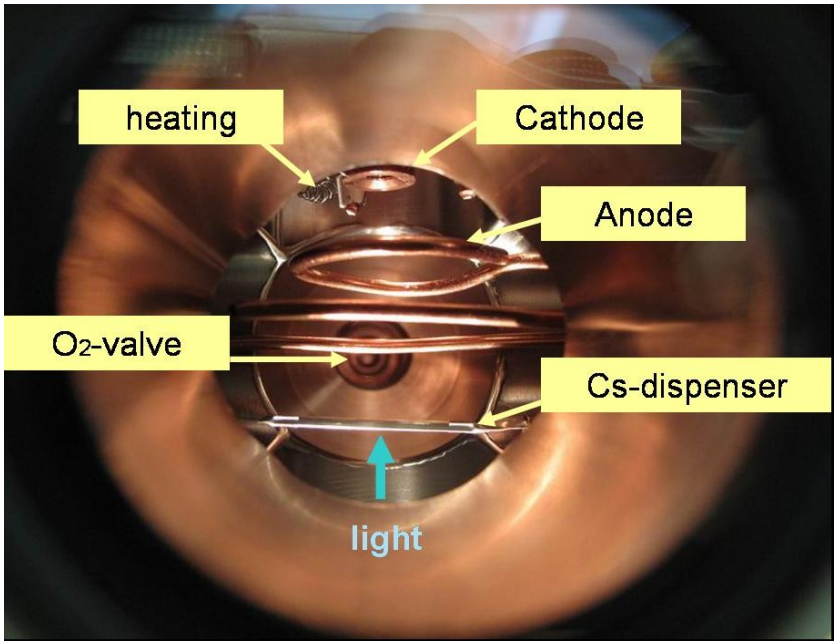


Bulk GaAs Band structure

2. The plans and test chamber of GaAs for SRF gun

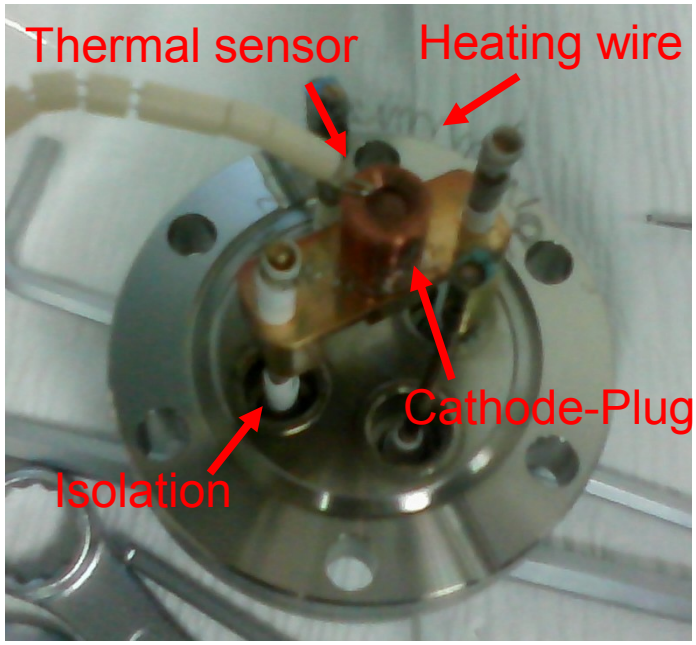
GaAs preparation test – going on



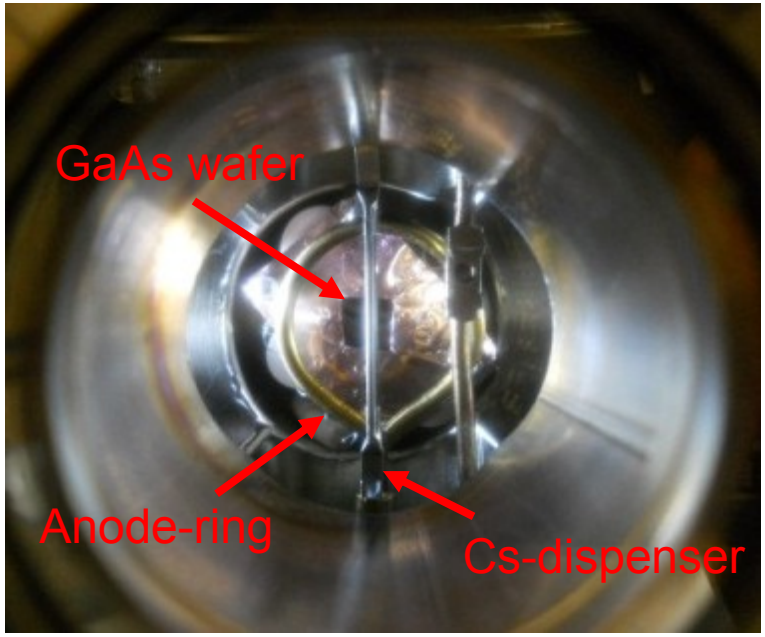


2. The plans and test chamber of GaAs for SRF gun

GaAs preparation test – going on



1. Test with the plug



2. Test with the wafer

2. The plans and test chamber of GaAs for SRF gun

GaAs preparation test – going on

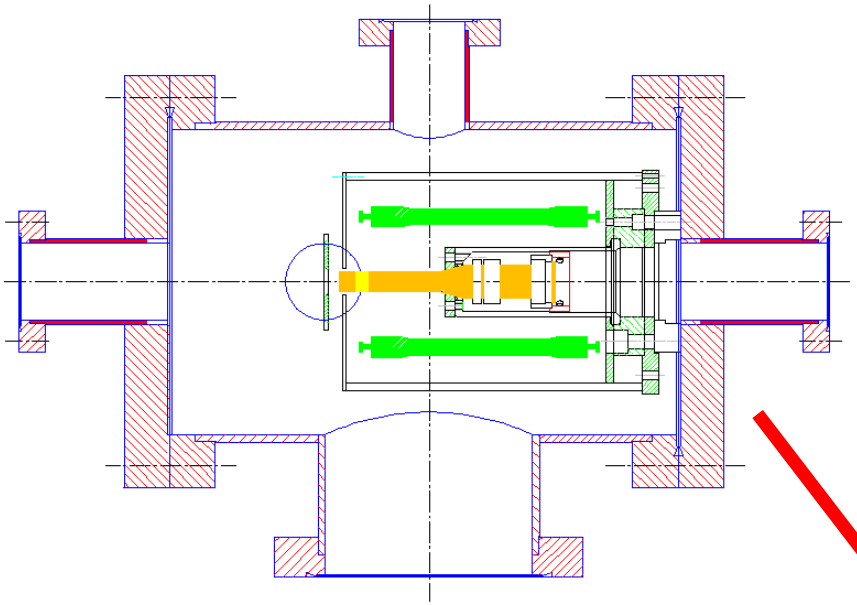
1. Sample treatment:

- Chemical etching with 4:1:1 of concentrated H_2SO_4, 30% H_2O_2 and H_2O
- Rinsing
- Blowing with N2

2. Heating in Vacuum

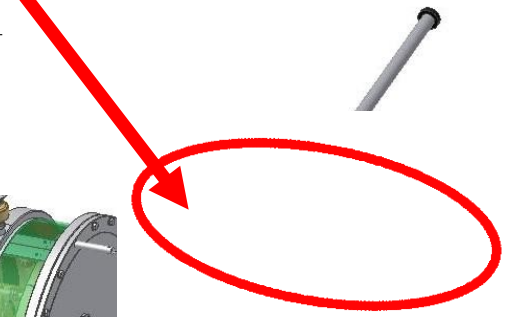
- Vacuum chamber $1x10^{-9}$mbar (must be better)
- Heated to 570^{o}C for 5 min (Vacuum $1x10^{-7}$mbar, must be better)
- Cs-tube is heated with 2.7A current

3. Activation (not finished)

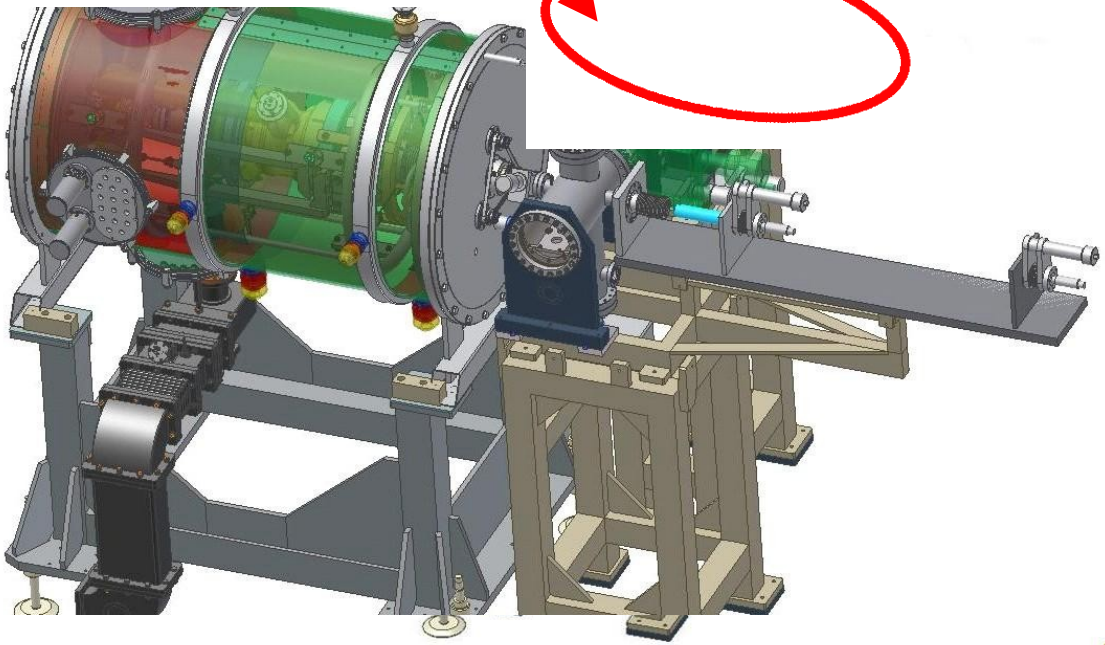


tion chamber

Vacuum problem from the big cathode body?



SRF gun &
Cathode transport system



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3.1 The heat load on GaAs

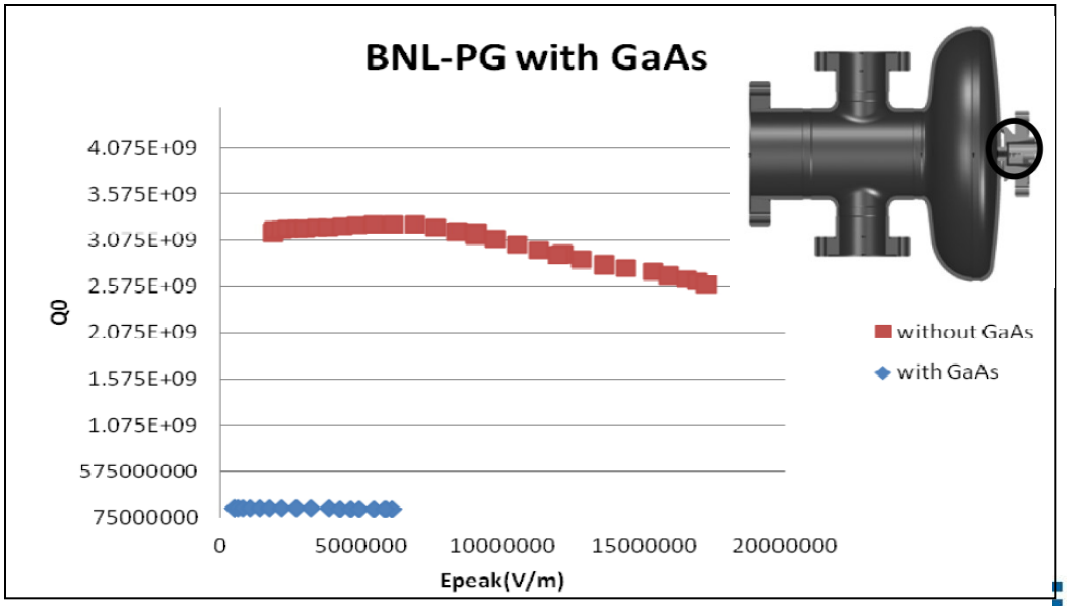
The problem of the NC material in SRF gun:

1.Bulk GaAs with resistance

$$P_c = \frac{1}{2} R_s \int_s |H|^2 \, \mathrm{d}s \, .$$

2.GaAs is dielectric material

$$P = E^2 \omega A d \varepsilon_r \varepsilon_0 \cdot tg\delta$$

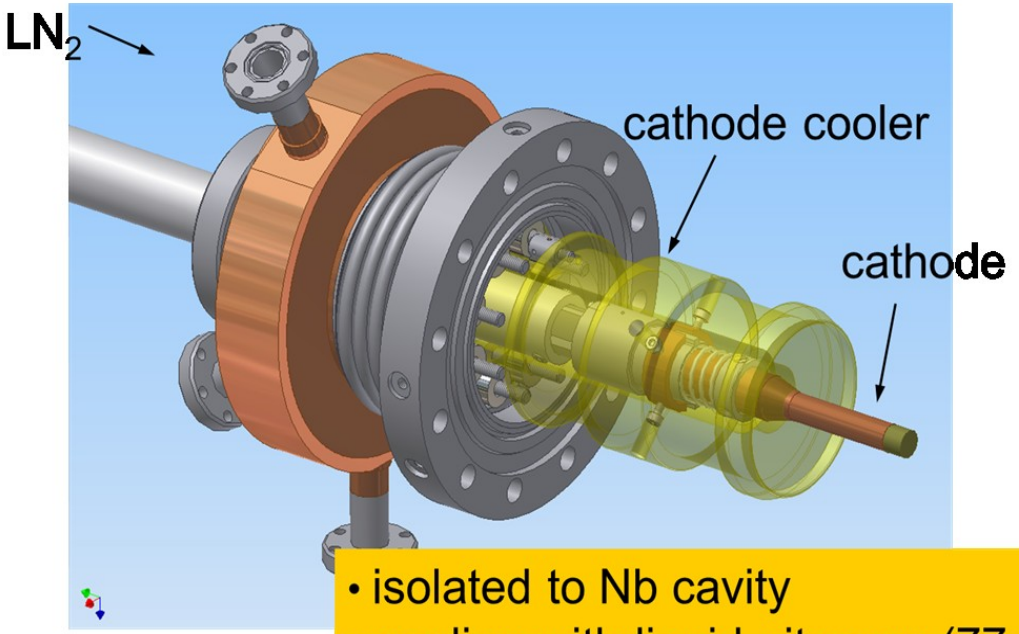


E.Wang, J. Kewisch, et al., IPAC10, Kyoto, Japan

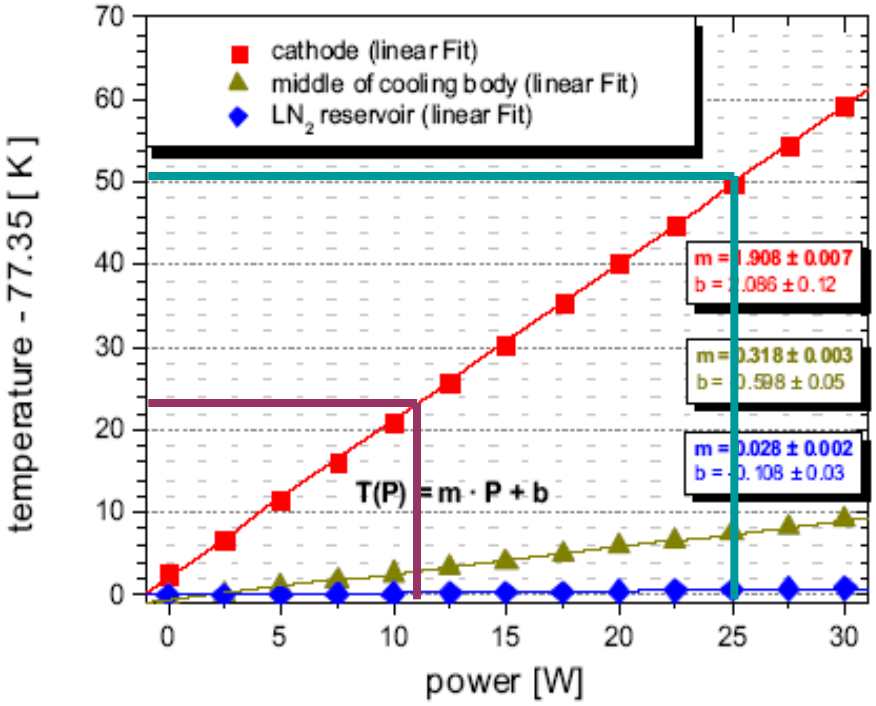
3.1 The heat load on GaAs

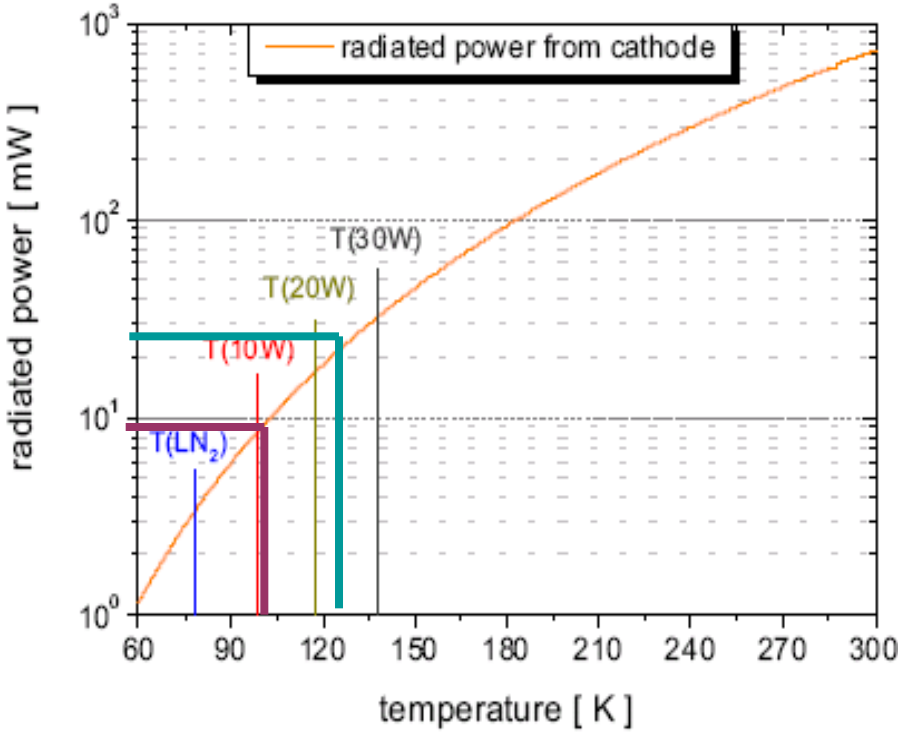
Thickness (μm)	Diameter (mm)	$E_{cathode}$ (MV/m)	Power loss (W)
350	5	20	102
350	5	10	25.5
350	5	6.5	10.7

special support and cooling system



- isolated to Nb cavity
- cooling with liquid nitrogen (77 K)





Thickness (μm)	Diameter (mm)	$E_{cathode}$ (MV/m)	Power loss (W)	Radiation to cavity (mW)
350	5	20	102	450
350	5	10	25.5	25
350	5	6.5	10.7	

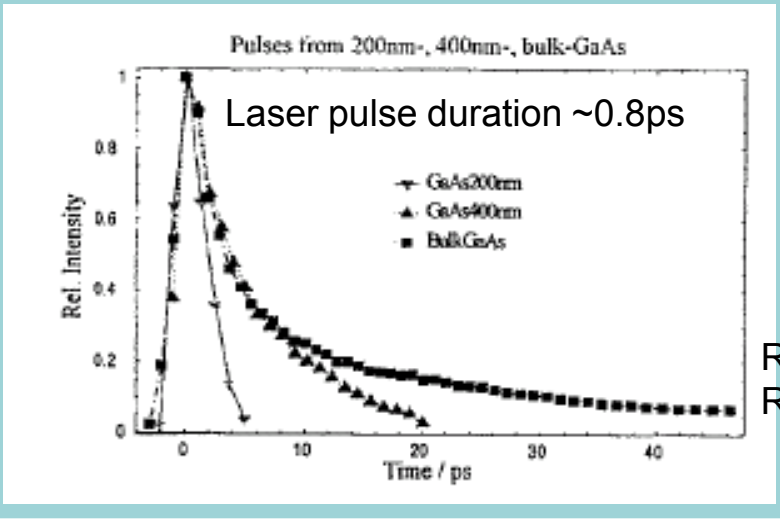
The next step

Test an unactivated GaAs crystal (ϕ 5mm) in SRF gun

- 1. Nb-cavity quality
- 2. L-He consumption
- 3. field emisstion

3.2 Response time of bulk GaAs in RF field

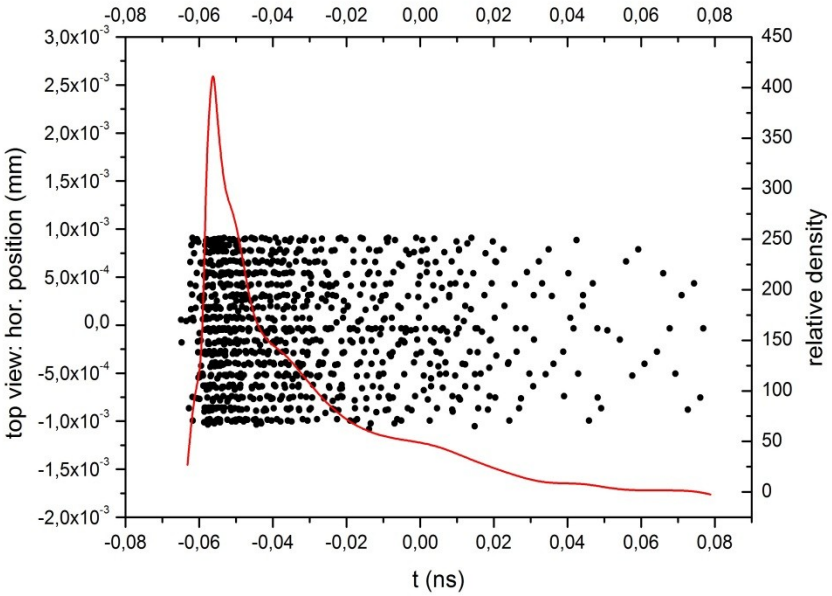
1. In DC field, bulk GaAs shows slow response time, long tail pulse

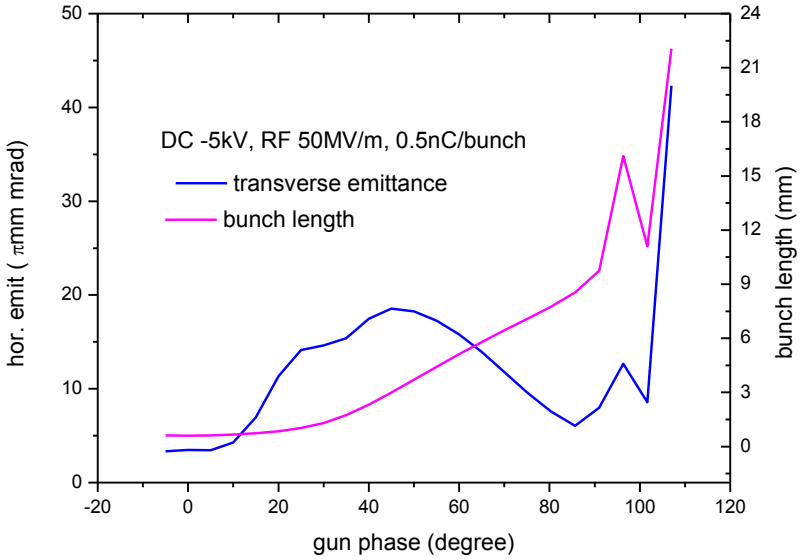


Ref 1: J. Schuler, SPIN2000
Ref 2: K. Aulenbacher, J. Appl. Phys. **92**, 7536 (2002)

2. In RF field, Sub-ps electron bunch is possible, because the penetrated rf field can speed up the electrons in the crystal.

Ref 2:E. Wang, et al., IPAC'10





The simulation for long bunch length case.
If the pulse shape is with long tail like ref.1, the large emittance appears.
So the short response time of ps level is important. But how to measure it?

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Next steps

- Finish the test on GaAs activation
- Finish the new preparation chamber connected to cathode transfer system
  - vacuum ~10^{-11} mbar, with NEG pumps
  - match to the transfer system
- Improve vacuum in cathode transfer system
- Test unactivated bulk GaAs in the SRF gun
- New laser (600nm~800nm) and optical beam line
- GaAs cathode photoemission

Thank you!

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