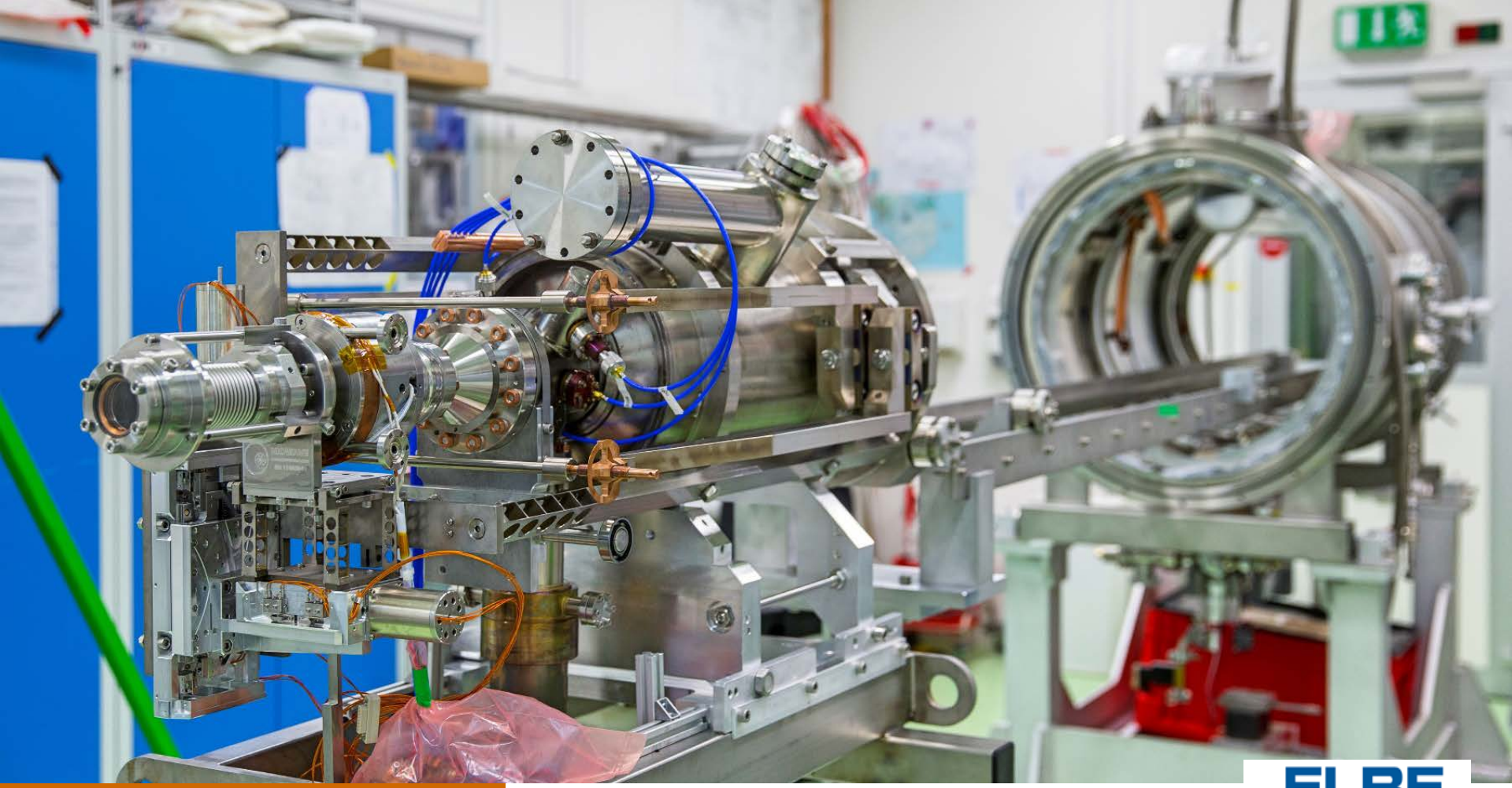

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Photocathodes for Photoinjectors

2015.12.04 Dresden

Photocathode transfer system for PCHB collaboration & photocathode activities at HZDR

Rong Xiang

on behalf of the SRF Gun Crew at ELBE

ELBE.

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Outline

1. Status of ELBE - SRF Gun
2. Status of Cs_2Te photocathode
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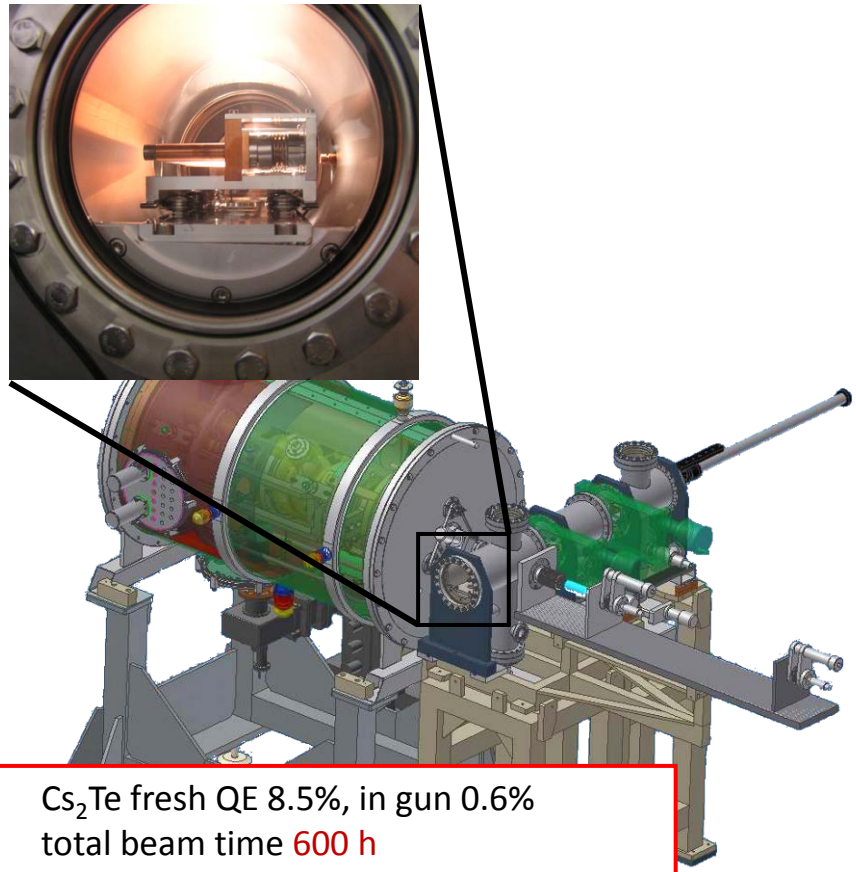
1. Status of ELBE - SRF Gun

ELBE SRF Gun I (2007-2014)



- Cs_2Te fresh QE 8.5%, in gun 0.6%
- total beam time 600 h
- extracted charge 264 C
- Max. CW beam current: 400 µA

- Cavity gradient limited by FE

  No cavity degradation during first 4 years
- Cs_2Te with long lifetime in SRF gun
- Multipacting suppression with DC Bias
- High dark current
- successful operation with ELBE

  Far-IR FEL operation, Compton-backscattering, Superradiant THz radiation, Slice emittance, Longitudinal phase space measurements

1. Status of ELBE - SRF Gun

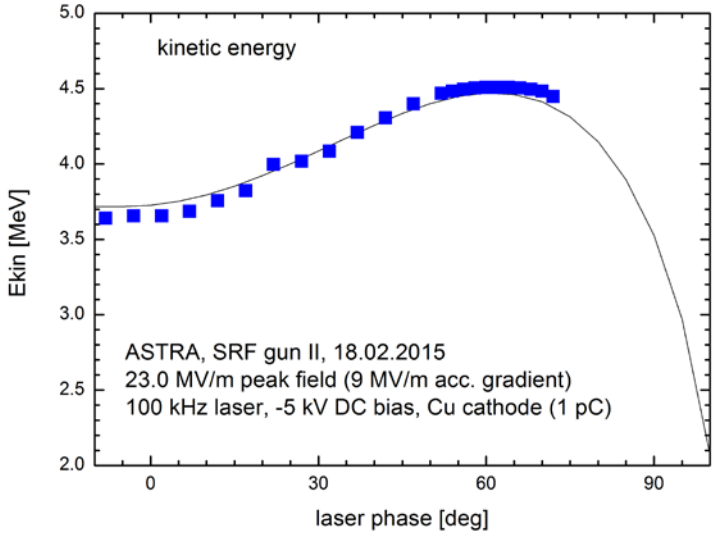
ELBE SRF Gun II

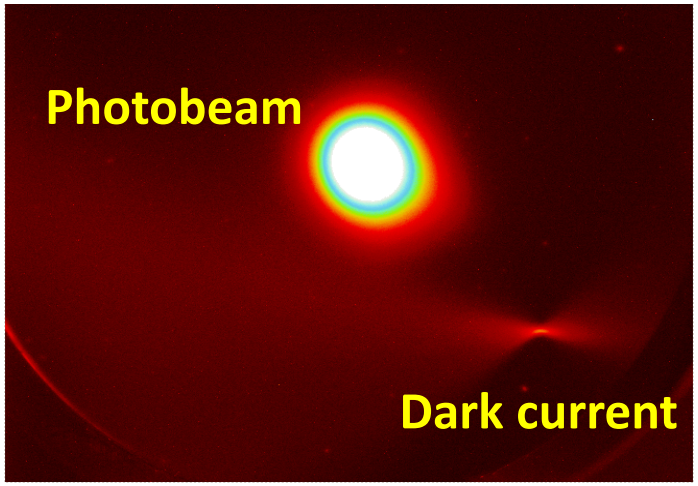
GUN

- E_{acc} = 8 MV/m CW (20.5 MV/m peak field)
- - 5 kV DC bias @ Cathode
- dark current in FC <100 nA @8 MV/m
- UV laser: 258 nm, 100 kHz, Gaussian 10 ps

PHOTO CATHODE

- Cu cathode 2 x 10^{-5} @ 258 nm
- 3 … 300 nA CW beam current (0.03- 3 pC @ 100 kHz rep. rate)
- the 1st experiment of Cs_2Te in gun failed





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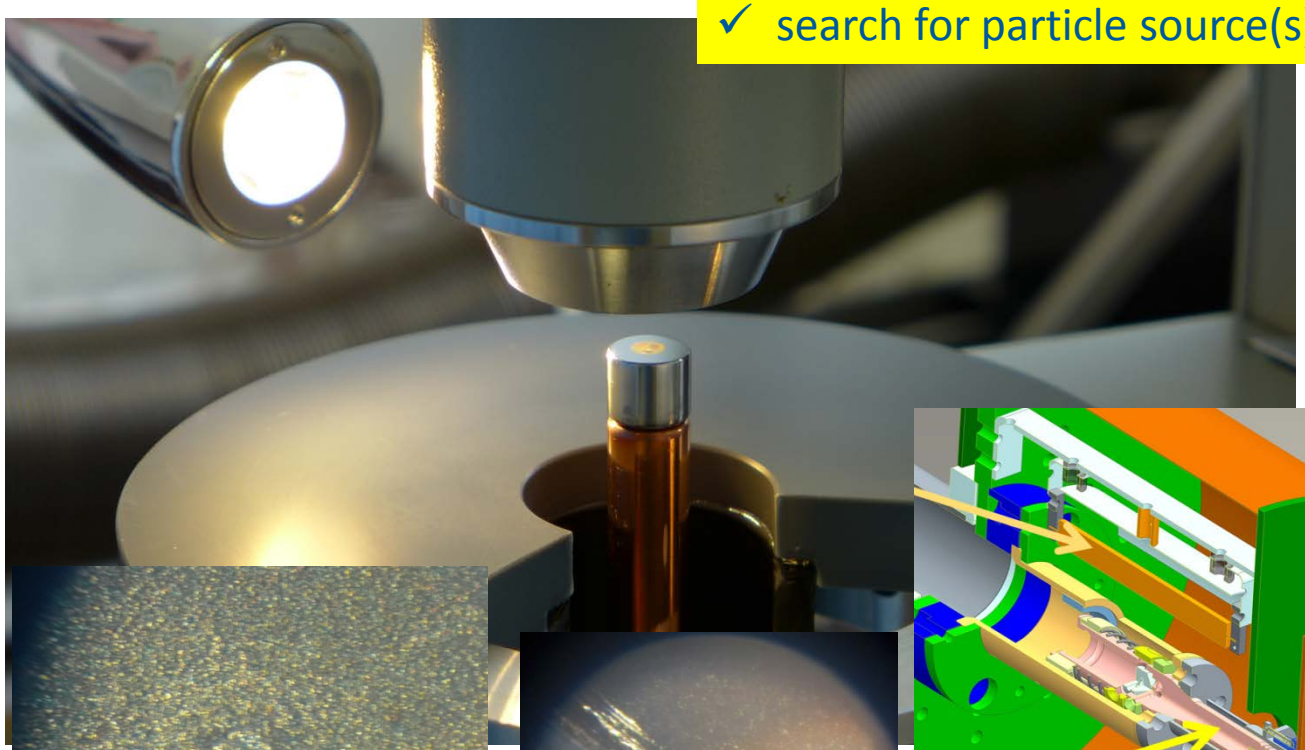
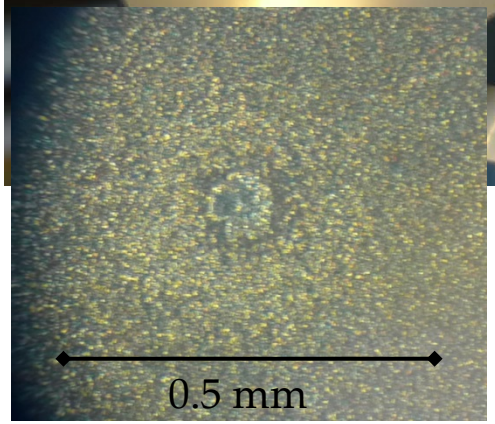
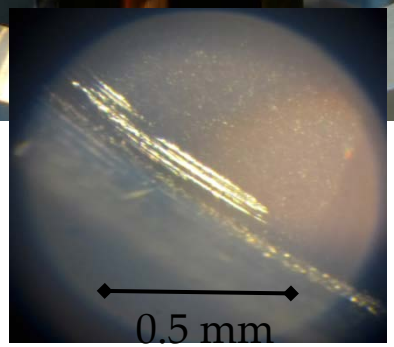
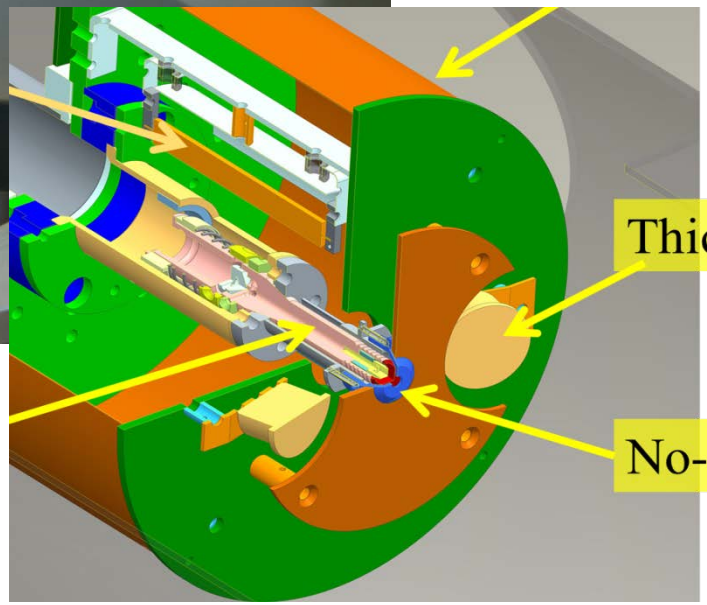
2. Status of Cs_2Te photocathode

✓ search for particle source(s)

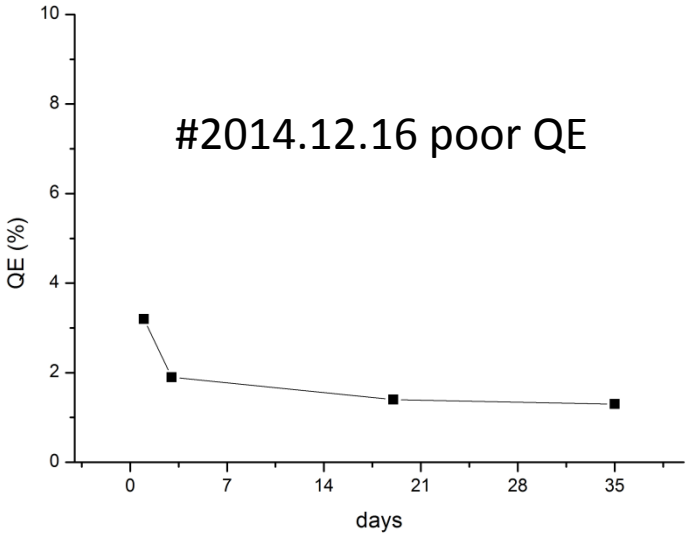


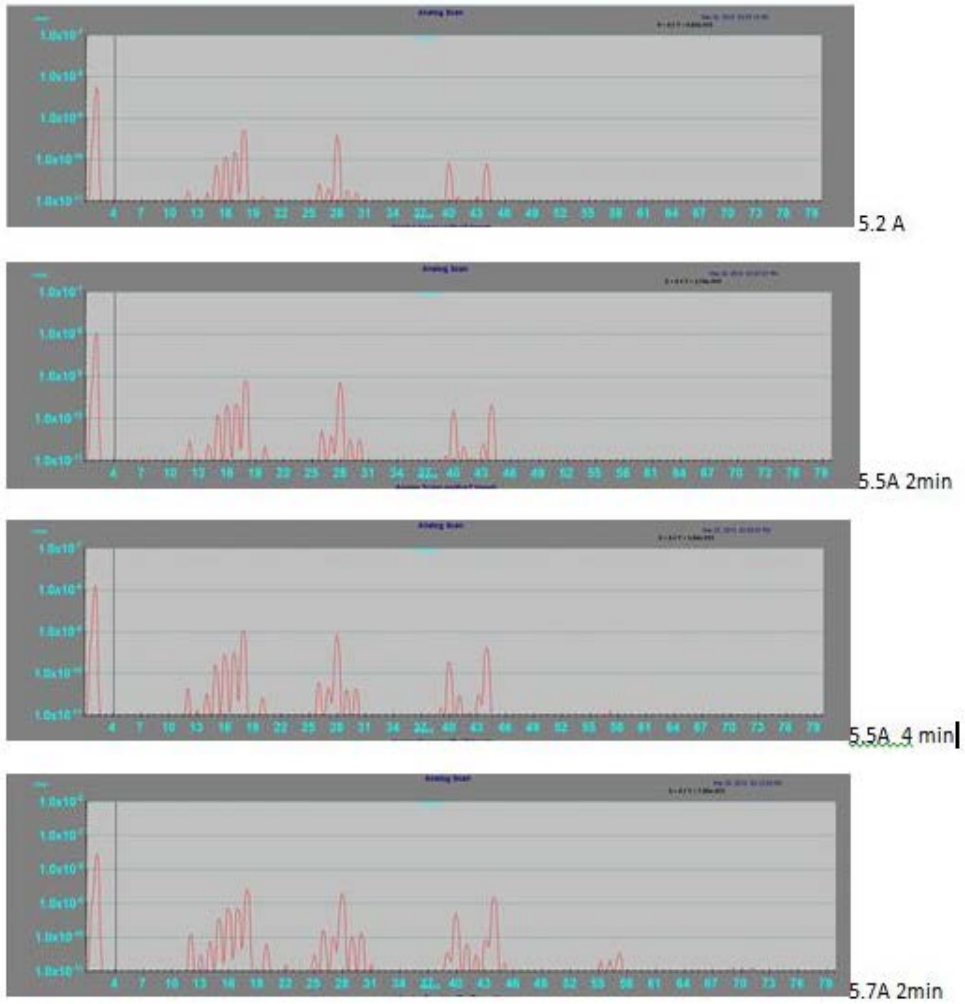






2. Status of Cs_2Te photocathode



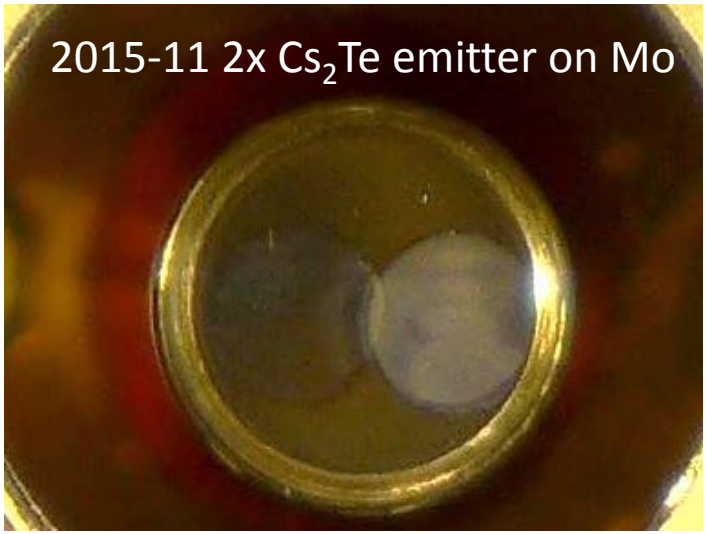


✓ search for carbohydrate source(s)

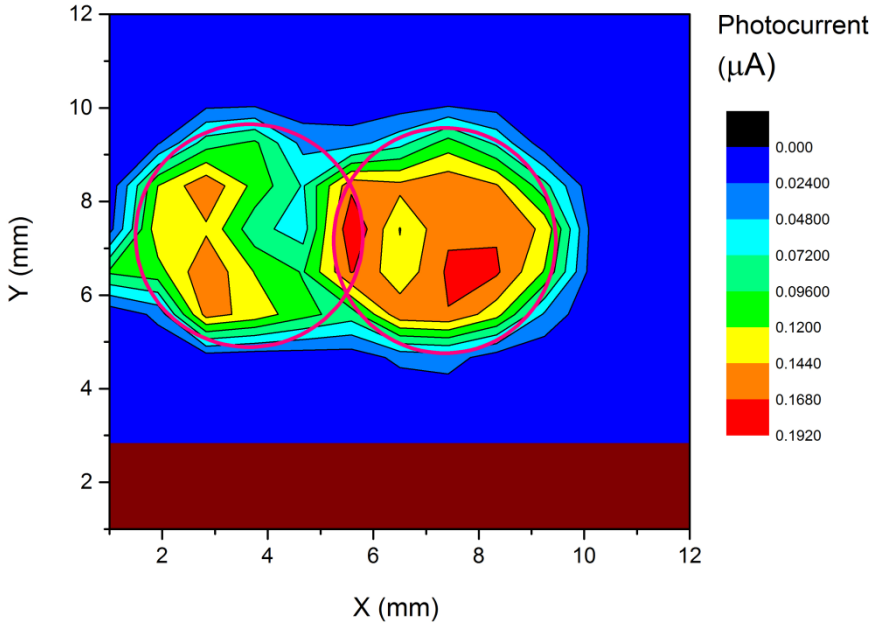
- in evaporator holder
- cesium dispenser (from the same tin)

RGA spectra during evaporation of a cesium dispenser

2. Status of Cs_2Te photocathode



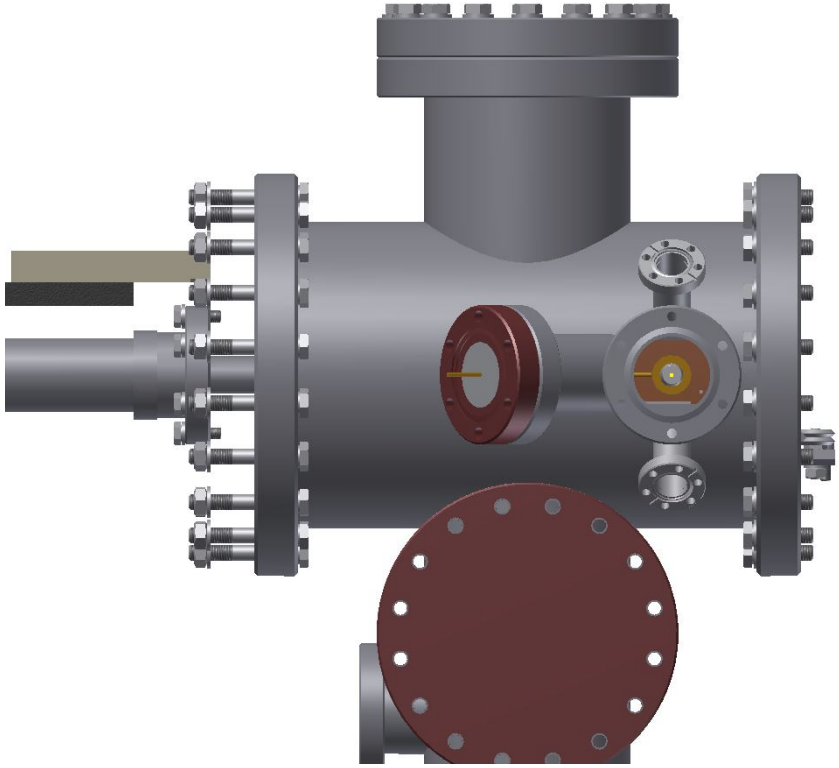
stable QE 0.7% in 1x10^{-8} mbar



QE distribution with roughness of 20%

- remove all pollution sources **(√)**
- calibrate cathode heating **(√)**
- new evaporator unit and test **(√)**
- bake for XHV in prep. chamber in December 2015
- prepare new Cs_2Te series
- transport to gun in 2016

2. Status of Cs_2Te photocathode



Modification of transport camber **(√)**

- Visual inspection
- QE measurement
- Particle detect
- RGA

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3. Laser cleaning for Mg photocathode

Motivation: to search for a „Clean“ (Cs-free) cathode for SRF gun

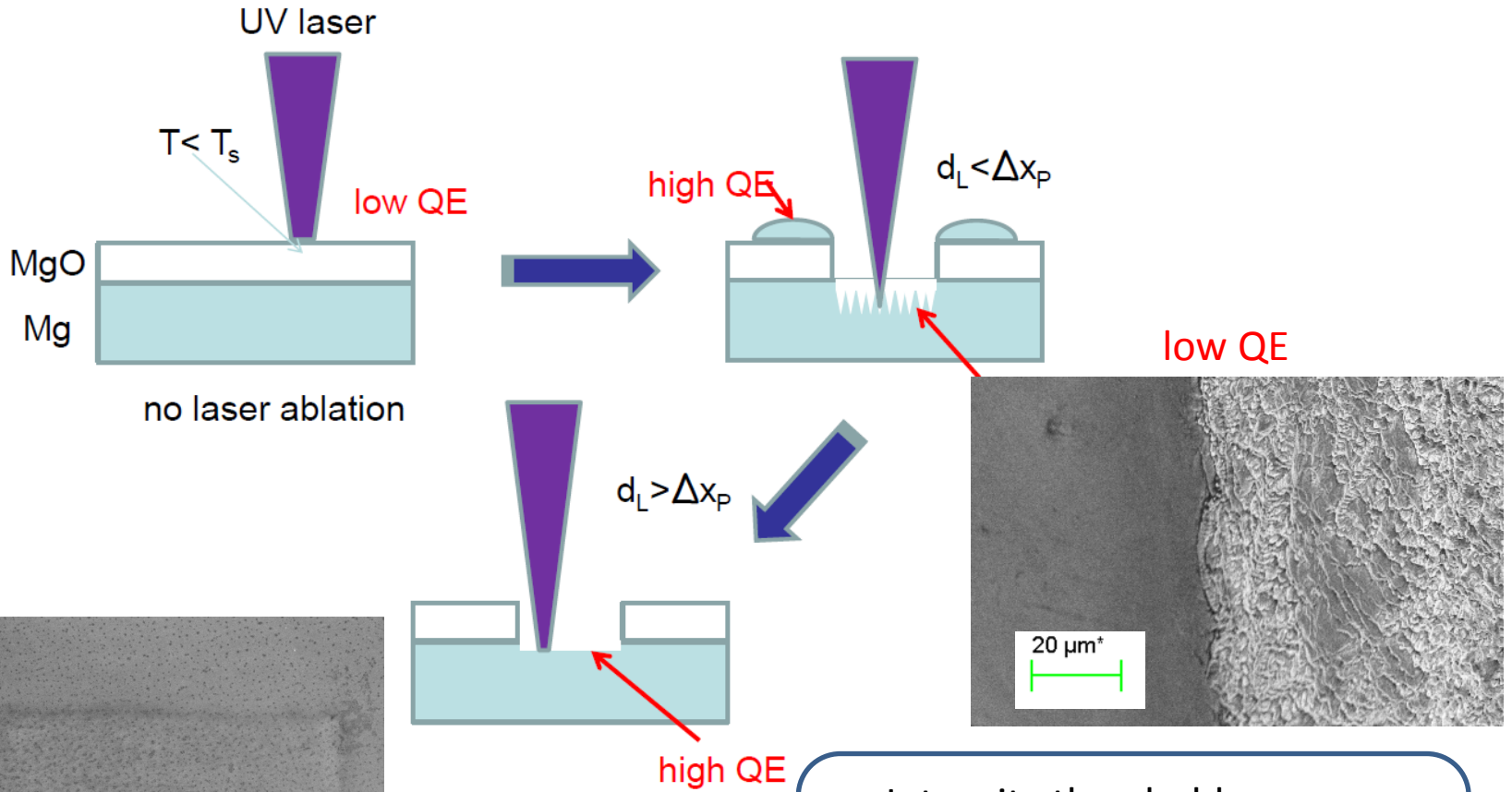
Metal	QE (%)	XPS for sample surface(%) O 1s	C 1s	Work Function (eV)
Al				
Received	9.5E-6	36.8	38.3	4.0
Ar^+ sputter	2.2E-5	13.4	17.4	4.9
Ag				
Rece				
Ar^+ s				
Cu				
Rece				
Ar^+ s				
Mg				
Received	6.0E-6	35.2	52.3	3.4
Ar^+ sputter	**1.7E-3**	40.0	0	3.4
Mo				
Received	1.47E-7	24.2	64.9	5.1
Ar^+ sputter	2.48E-6	7.8	17.8	5.2

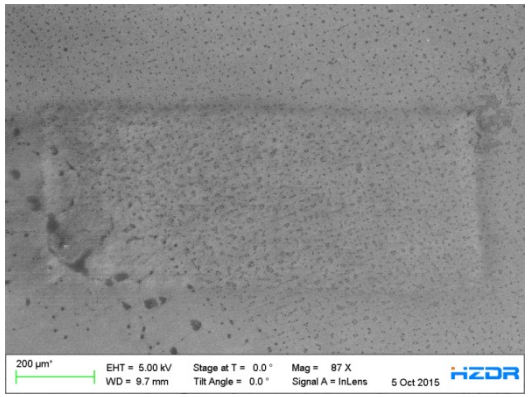
S. Mistry et.al. 2015 ASTeC Daresbury Results of Ar^+ sputter cleaning of metal PC

- highest QE 0.2 % @ 260 nm
- MgO layer removal in-situ
  - laser cleaning
  - ion beam sputtering
- long life time in UHV (<$1e^{-9}$ mbar)
- high e-current up to 100 µA and up to 500 pC
- No cavity contamination from alkali material

Also: successful experience of Alpha-X RF gun NIM A 797 (2015) 222

3. Laser cleaning for Mg photocathode



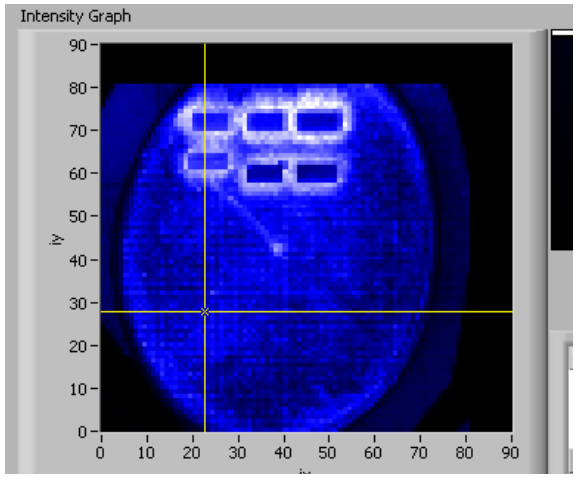


- Intensity threshold
- Illuminating duration
- Surface roughness of sample
- Mono-crystal or poly- Mg

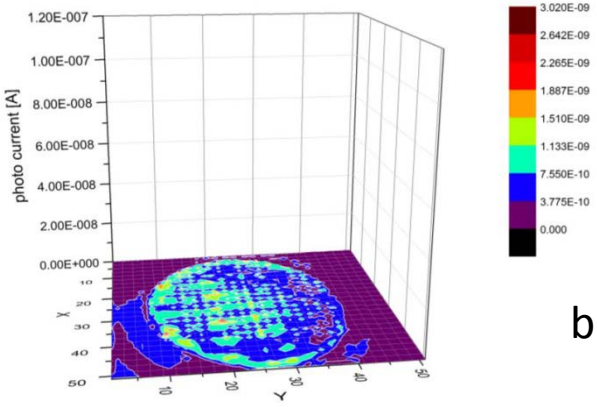
J. Teichert, HOPE Meeting Mainz, Oct. 23, 2015

3. Laser cleaning for Mg photocathode

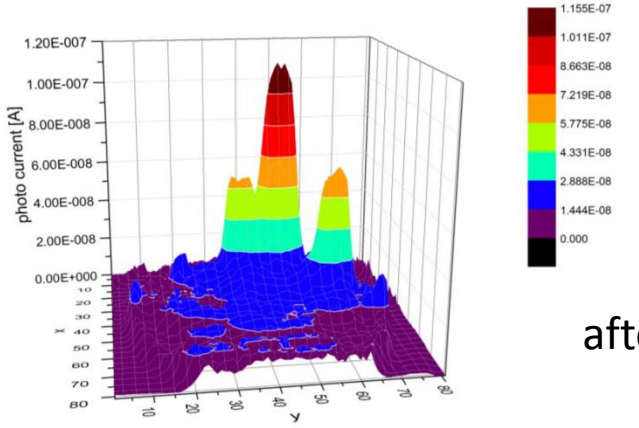
SEM



QE scan



before cleaning



after cleaning

photo current @ 1 mW		QE		improvement
fresh Mg/MgO	after treatment	fresh Mg/MgO	after treatment	
1 (+-0.4) nA	115 nA	5 x 10^{-6}	> 6 x 10^{-4}	100

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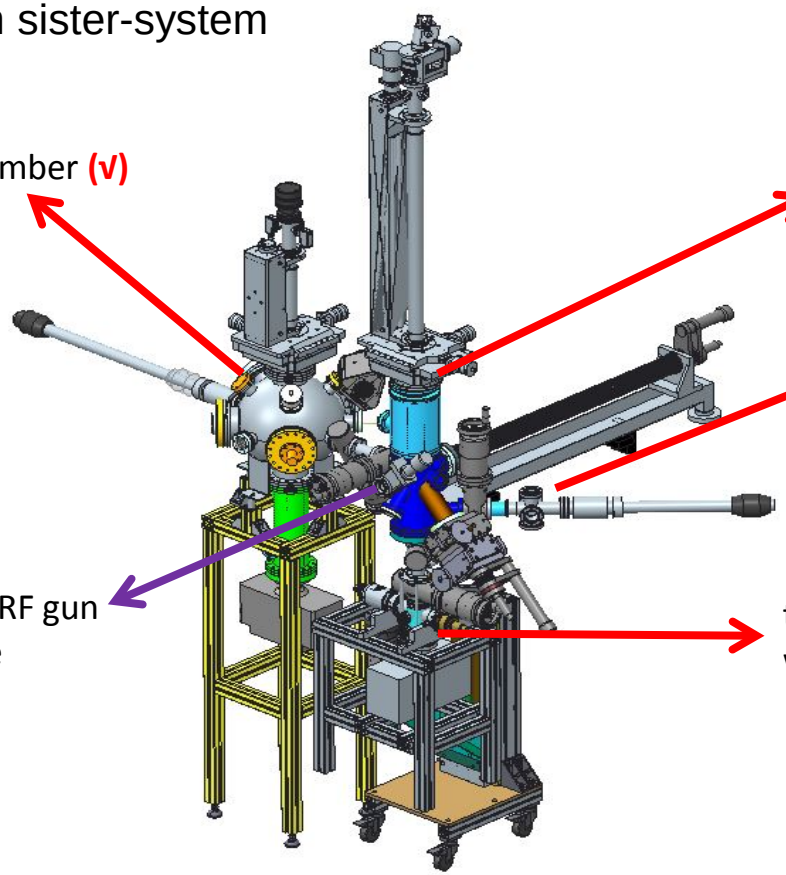
4. Transfer system for PCHB collaboration

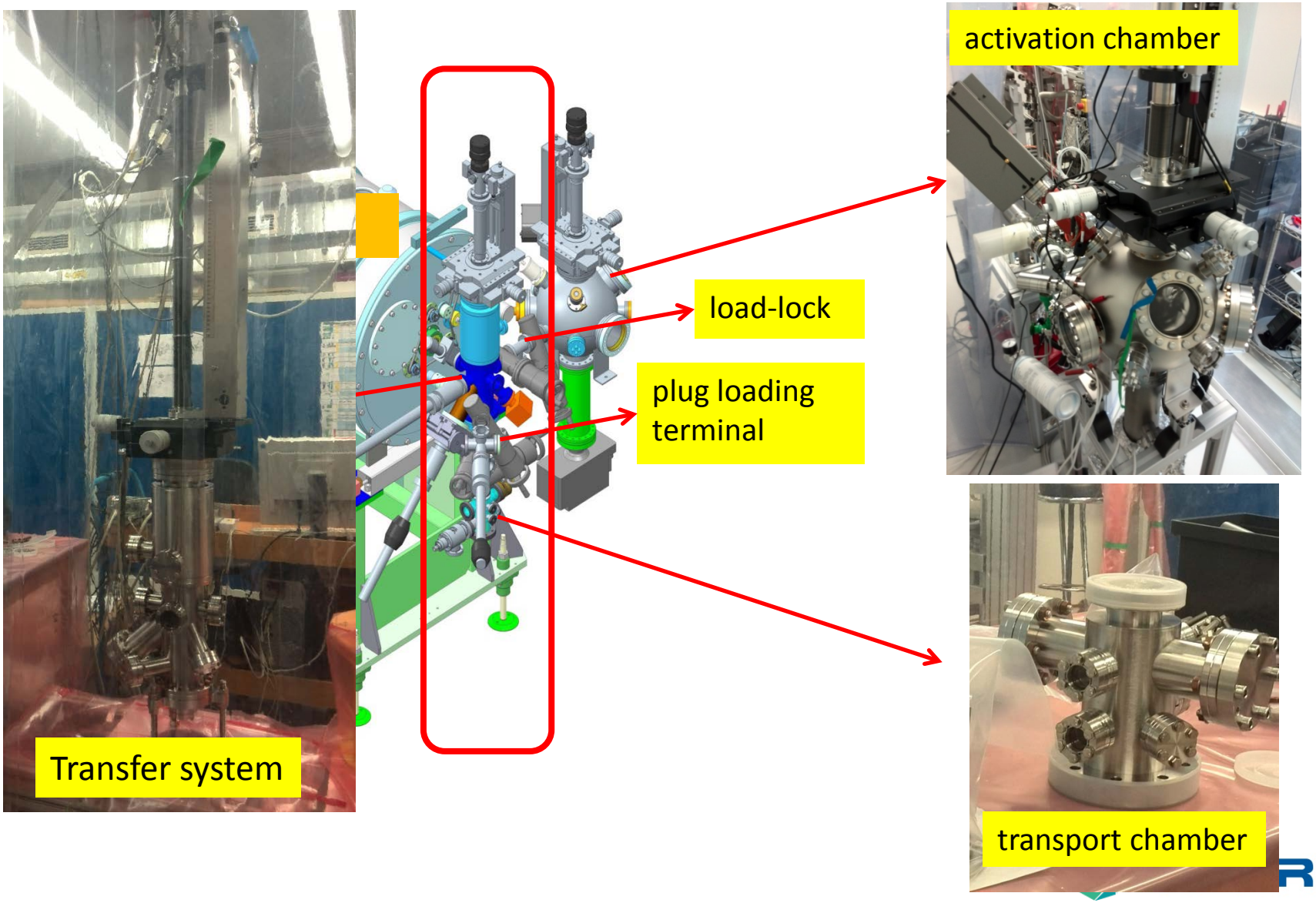
Motivation: Net-working between different preparation and analysis systems

At HZDR for SRF gun

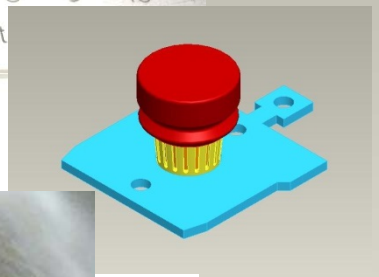
- GaAs (Cs, O), GaN(Cs) in-situ activated
- Transport cathode quickly into SRF gun
- XHV ~ 1×10^{-11} mbar is required
- to test cathodes from sister-system in SRF gun

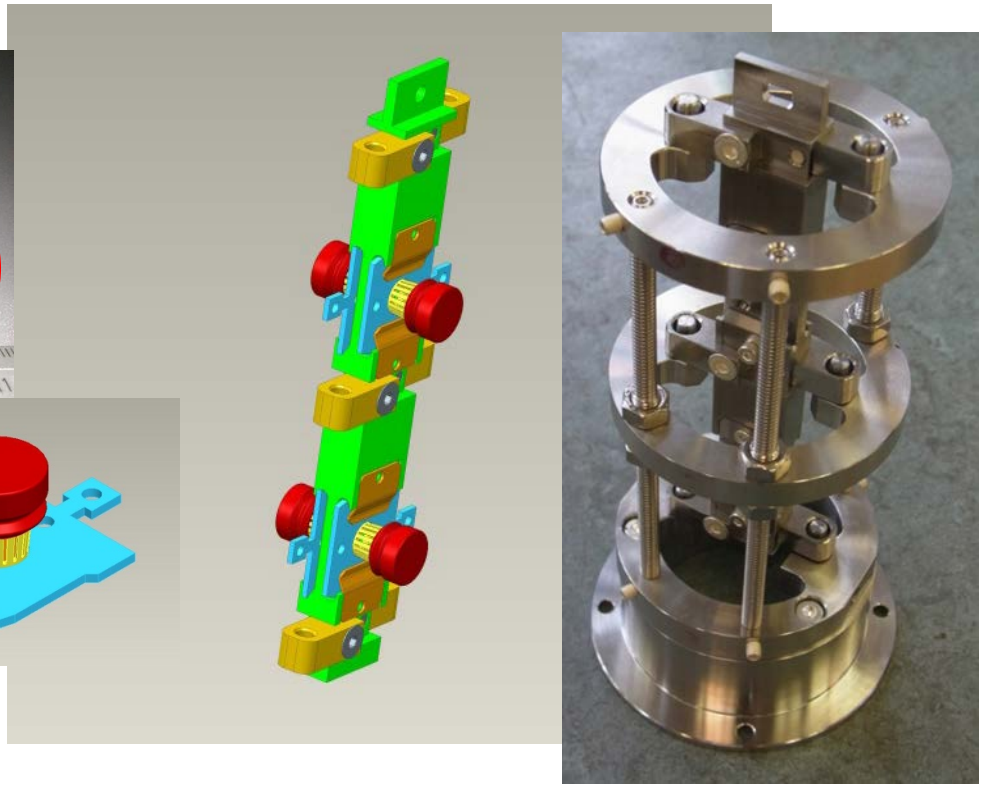


4. Transfer system for PCHB collaboration



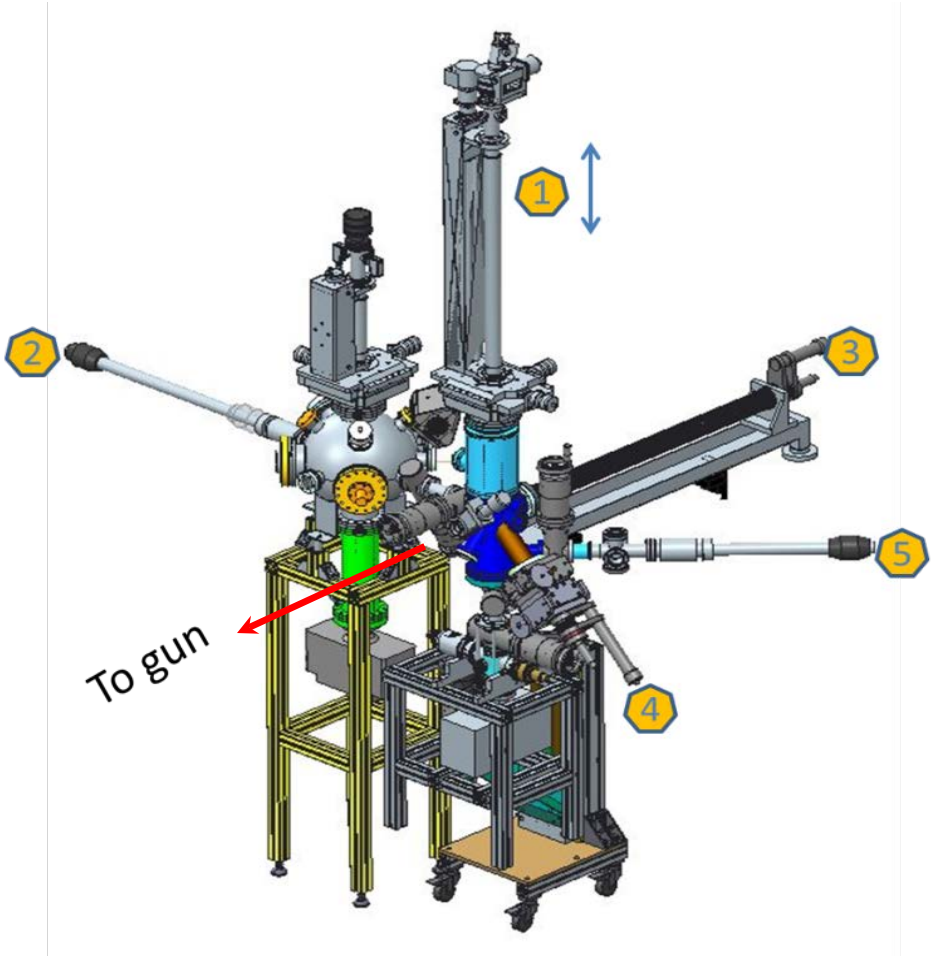
4. Transfer system for PCHB collaboration





- exchangeable plugs
- plugs fixed with CuBe springs (in yellow) on the flags.
- flags hold by the carrier (green) in transport chamber
- flags manipulated with jaws in chambers

4. Transfer system for PCHB collaboration



GaAs cathode preparation & transfer system (in commissioning).

1. **move wagen with jaws (√)**
   - z =610mm movement
   - 360° Rotation
   - X,Y table ± 12.5 mm
   - 2nd inner-Z movement 12mm

2. **(Magnetic) move one chip with jaws (√)**
   - Movement 600mm

3. **move cathode body into gun**
   - original ELBE SRF Gun manipulator (√)

4. **(Magnetic) move puck (plug) with finger**
   - 300 mm movement
   - X-Y table ± 7.5 mm (√)

5. **(Magnetic) insert one chip with jaws**
   - Movement 330 mm (√)

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5. Summary

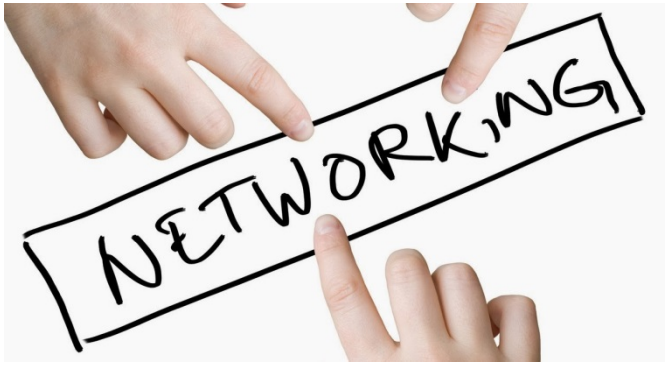
- SRF gun with photocathode is promising but very challenging …
  rich experiences
  a lot of patience

- Metallic photocathodes are safe for cavity.
  Cu for the gun commissioning and low bunch charge measurement
  Mg will be tested in SRF gun in December 2015.

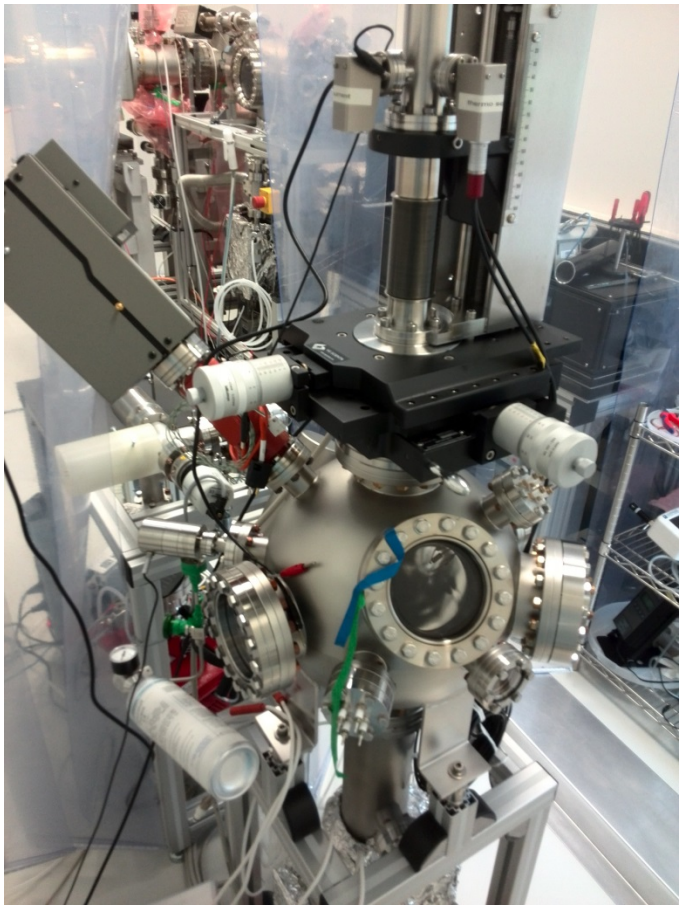
- Semiconductor photocathodes needs more studies
  Cs_2Te will be back in SRF gun in 2016
  GaAs (Cs,O), GaN(Cs) have been considered as candidates (HOPE2)
  Cs_2KSb from HZB

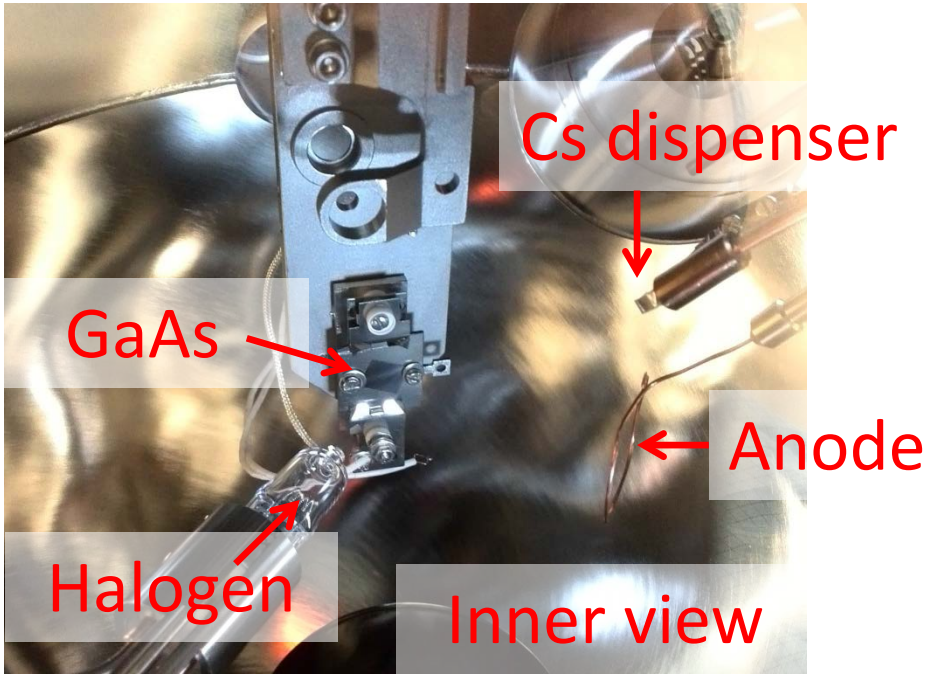
- Sister-Transfer-systems have been produced for close cooperation between labs (supported by PCHB).

Thank you for your attention !

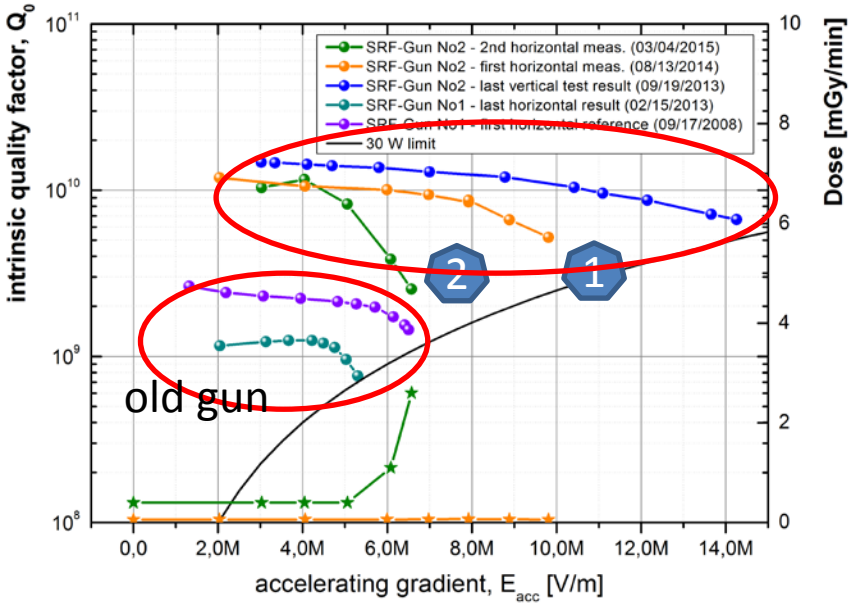


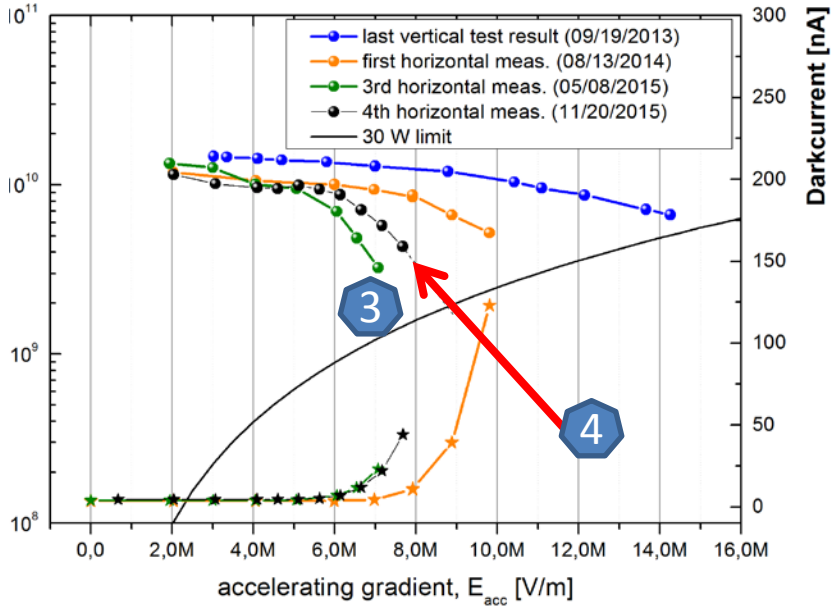
GaAs / GaN activation chamber





Vacuum 4×10^{-11}mbar.





Gradient of gun cavity degraded strongly after the first Cs_2Te test, and then heal slowly.