

# The Cathode Preparation System

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## What we need ?

	Micro-Pulse	Cath.	SRF Gun		Laser necessary		Laser project	
		Q.E.	$Q_{\text{bunch}}$	$I_{\text{mean}}$	$P_{\text{mean}}$	$E_{\text{pulse}}$	$P_{\text{mean}}$	$E_{\text{pulse}}$
ELBE normal	13 MHz	1%	77pC	1mA	0.47 W	36 nJ	0.8 W	60 nJ
high charge	1 MHz	1%	1 nC	1mA	0.47 W	470 nJ	1.0 W	1 $\mu$ J
future goal	400kHz	2%	2.5 nC	1mA	0.24 W	590 nJ	1.0 W	1 $\mu$ J

# Cs<sub>2</sub>Te cathode

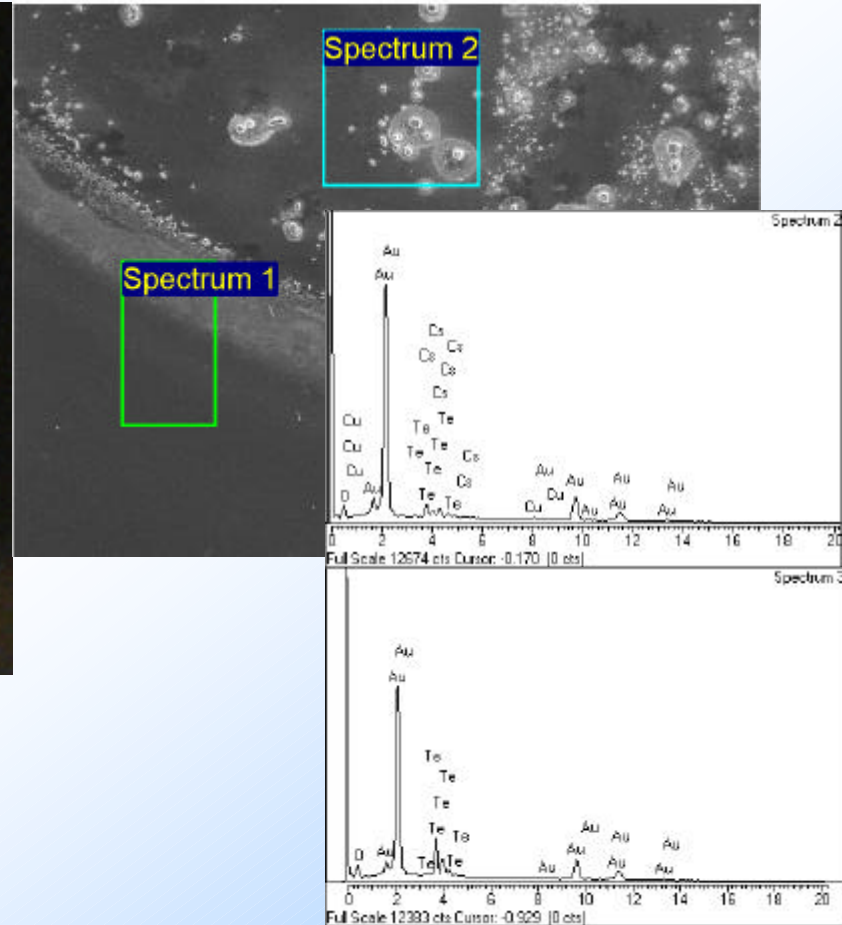
parameter	previously	necessary	international
Q.E.	0.2-0.5 %	>1 %	>4.5 %
Life time	?	1.2 kC 330 h @ 1mA (8 weeks)	1.2 kC 450 h @ 750 μA
Dark current	Small		Very small
average current density		32 mA/cm <sup>2</sup> @ r = 1 mm	21 mA/cm <sup>2</sup>
damage by Laser 263nm		32 W/cm <sup>2</sup> @ r = 1 mm	6 W/cm <sup>2</sup>
heat load		1 W	
electric field strength	22 MV/m	50 MV/m	125 MV/m

# Old $\text{Cs}_2\text{Te}$ cathode

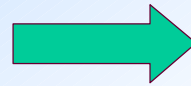


Eccentric position

Inhomogeneous



Former



New system

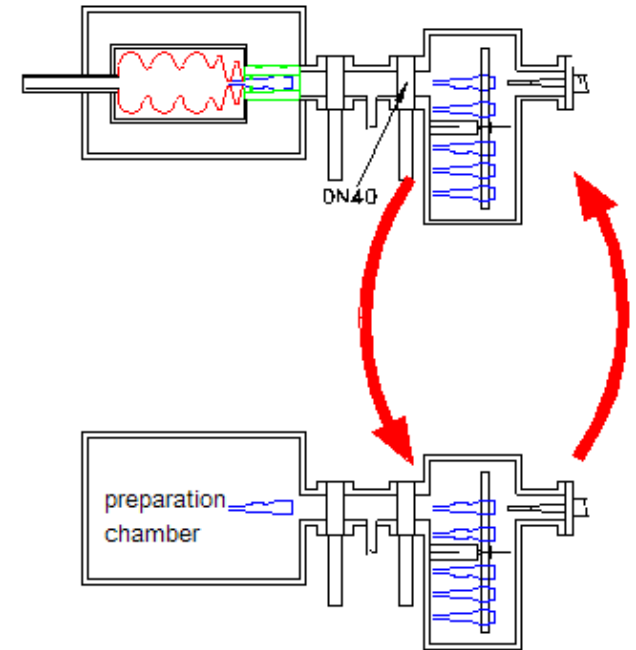
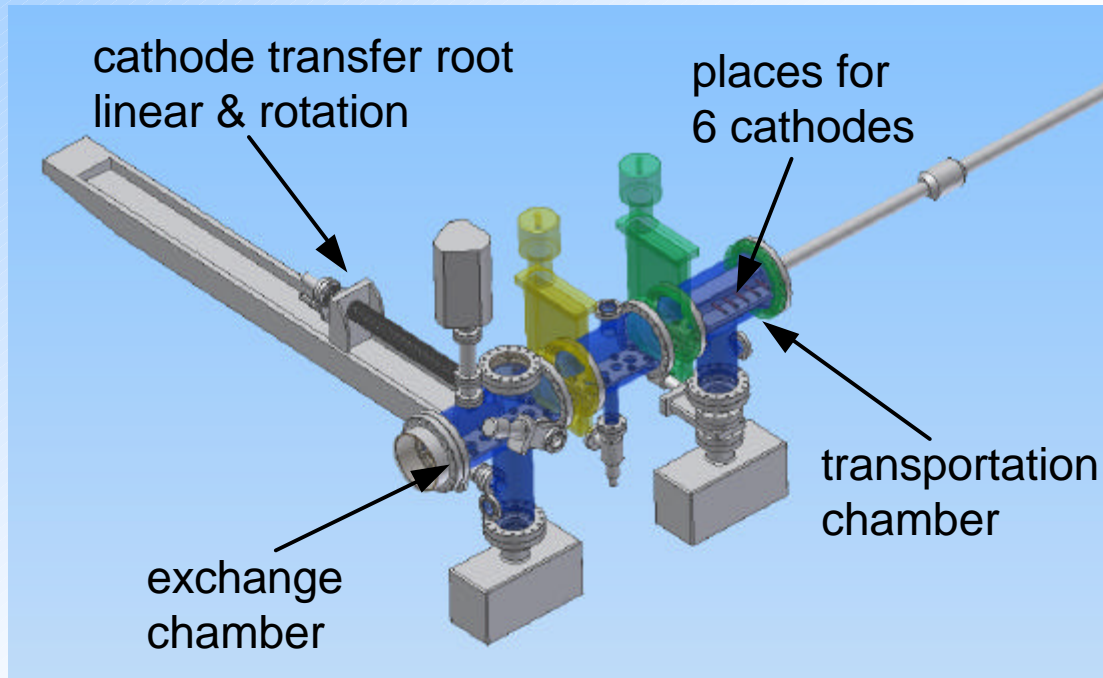
- Cathode transportation:  
only one cathode,  
bad adjustment
- Preparation chamber:  
bad vacuum
- Quality of cathodes:  
low Q.E.,  
inhomogeneous,  
Eccentric position

6 cathodes  
Accurate adjustment

$10^{-11}$  mbar  $\sim$   $10^{-9}$  mbar

>1 %  
uniform

# Transportation Chamber

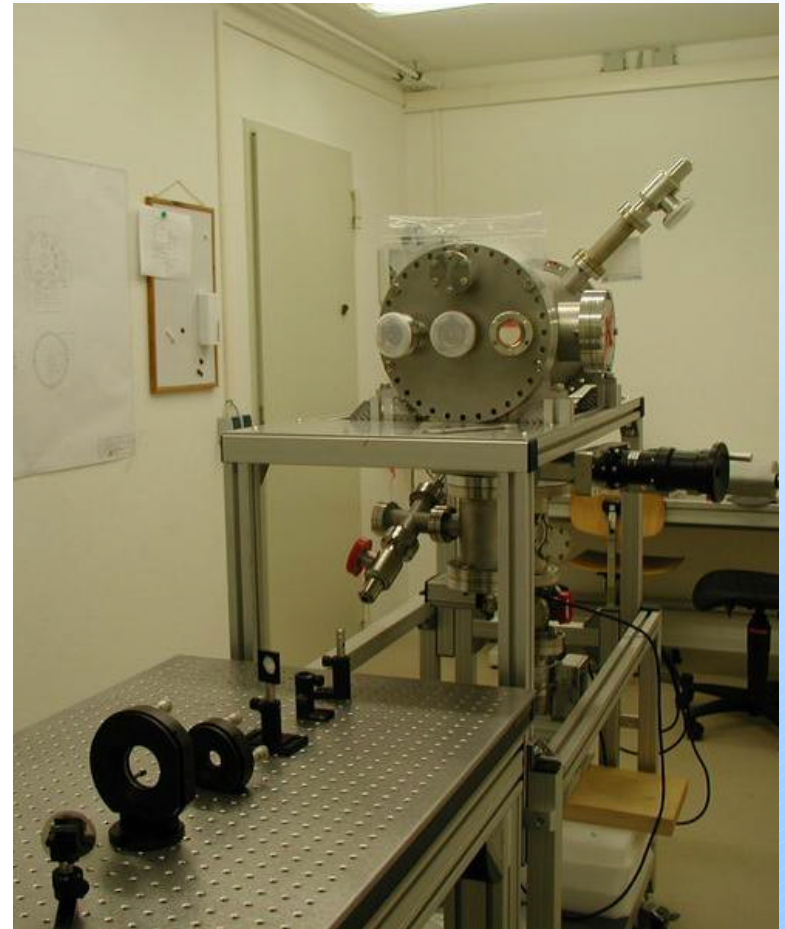
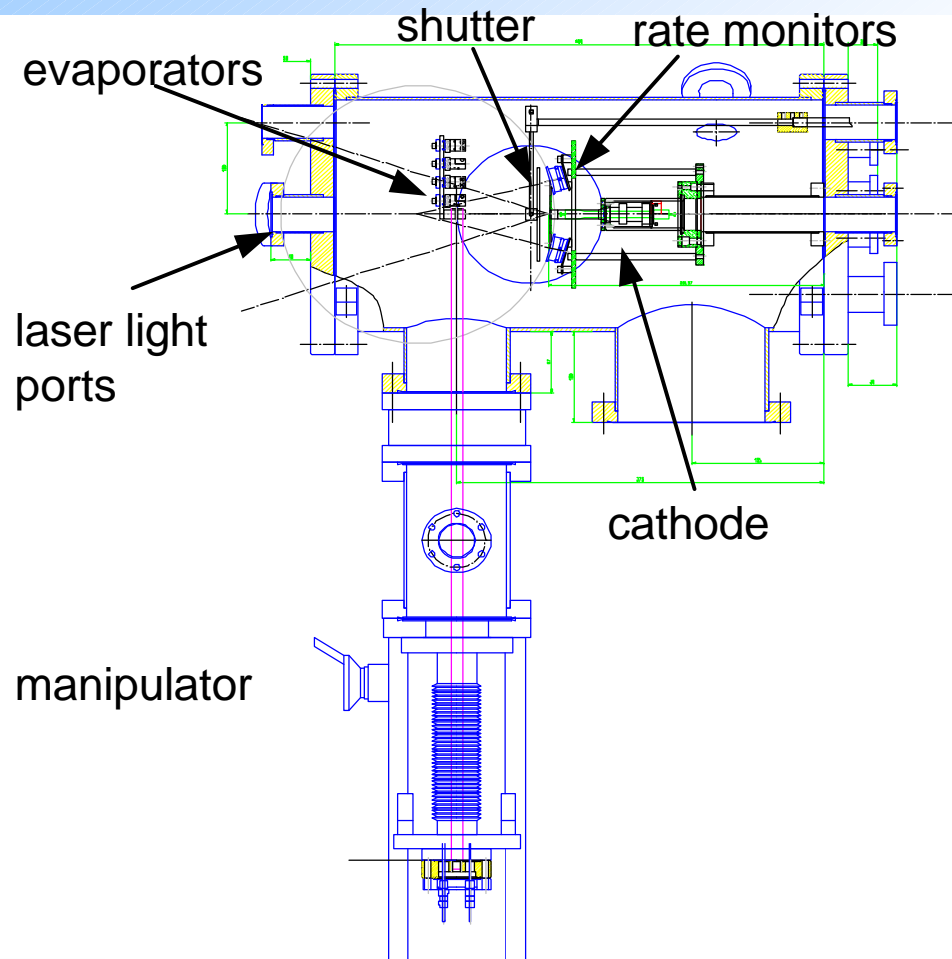


Minimum particle generation during exchange  
Six cathodes can be stored and transferred  
Accurate adjustment

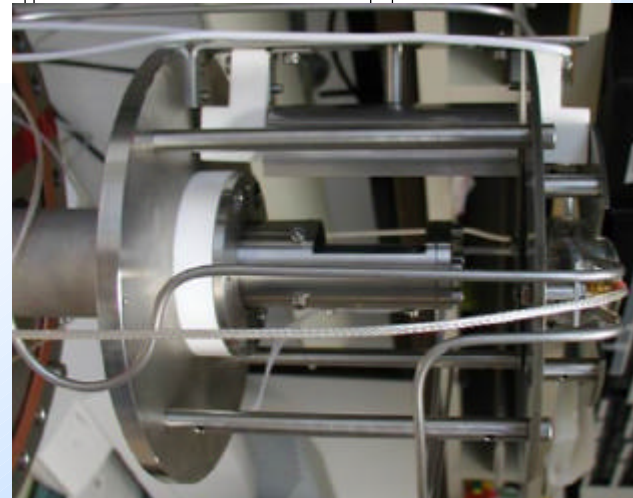
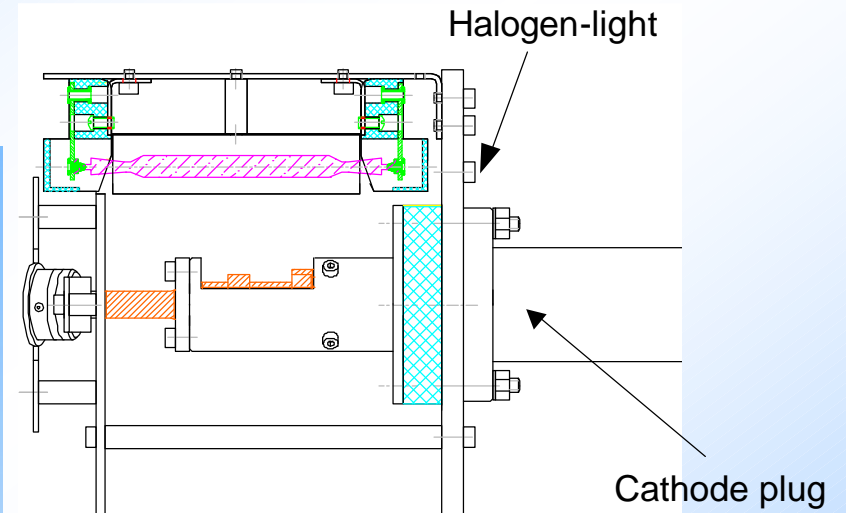
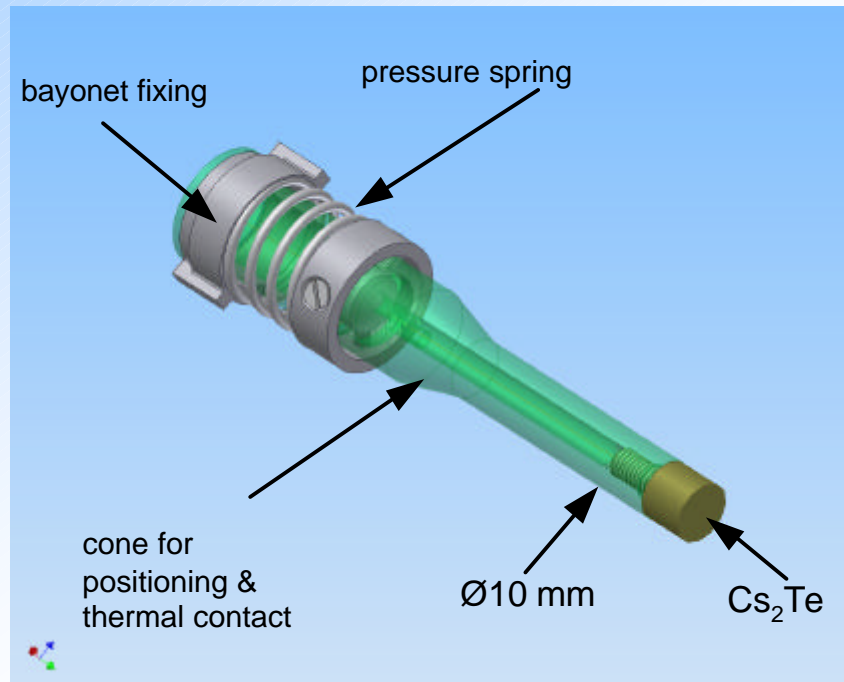
# Preparation Chamber Functions

- Ultra high vacuum ( $10^{-11}$  mbar ~  $10^{-9}$  mbar )
- Cathode holding
  - Halogen-light heating
  - Ion-beam cleaning (in design)
- Evaporation of Te and Cs
- Measurement of quantum efficiency
  - QE during deposition
  - Life time
  - Distribution scan

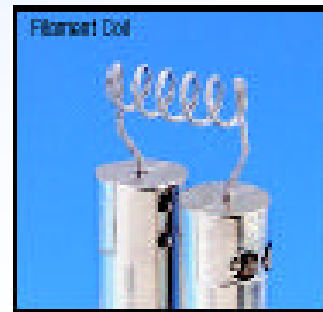
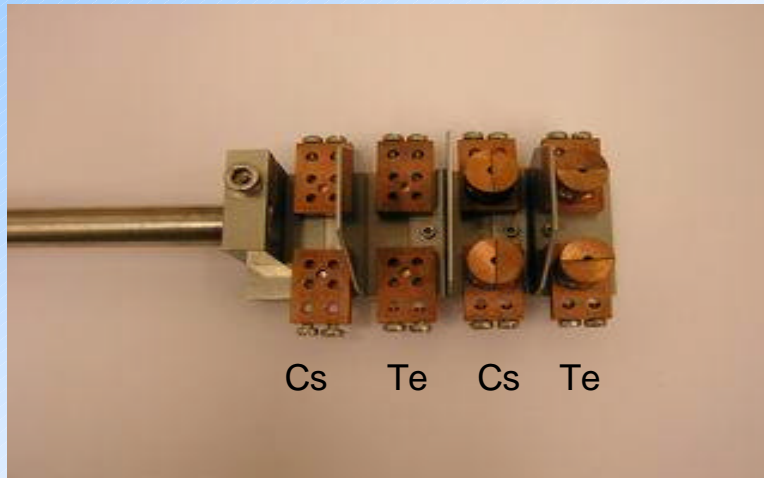
# New preparation Chamber



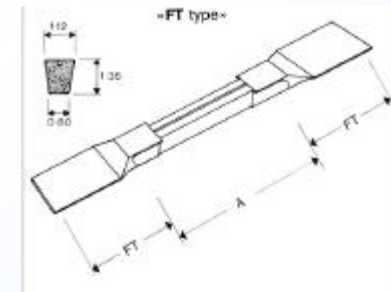
# Cathode & holder



# Evaporators & shutter

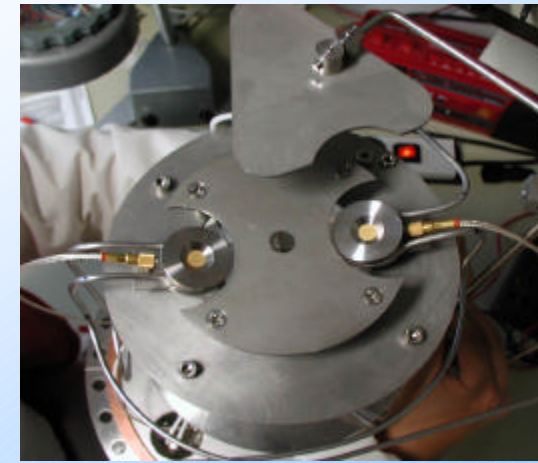
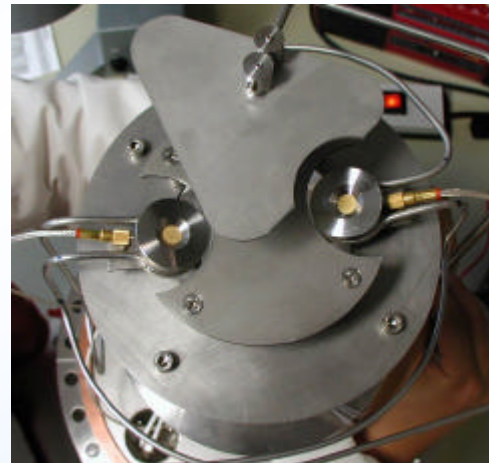
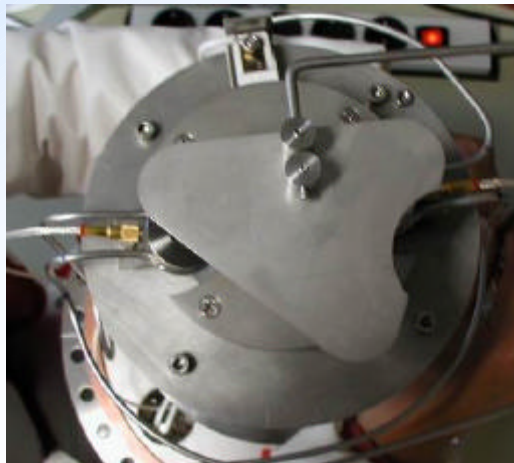


Tungsten-Spirale for Te



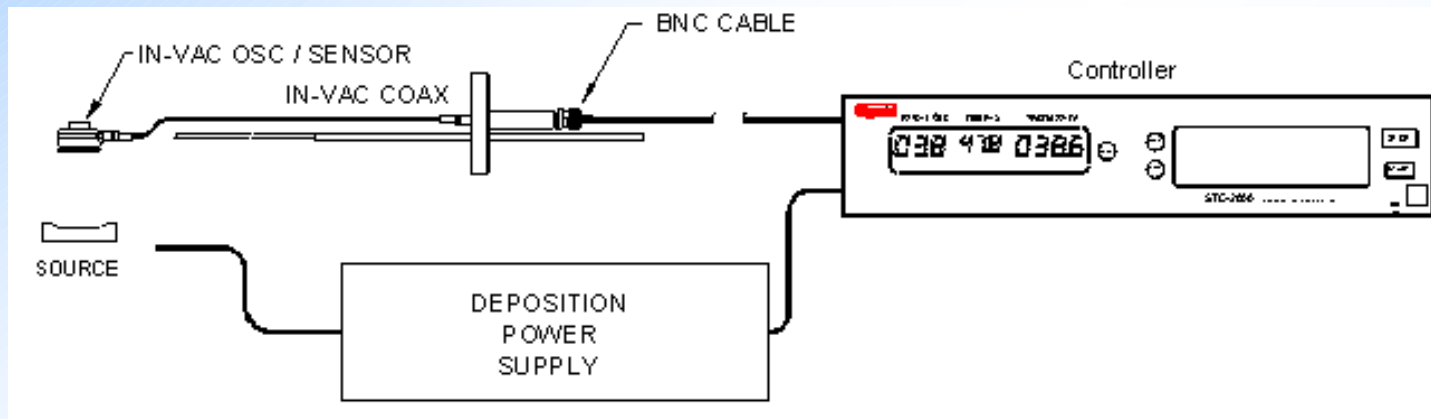
Getter for Cs

( $\text{Cs}_2\text{CrO}_4$  and Zr 84%-Al 16%)



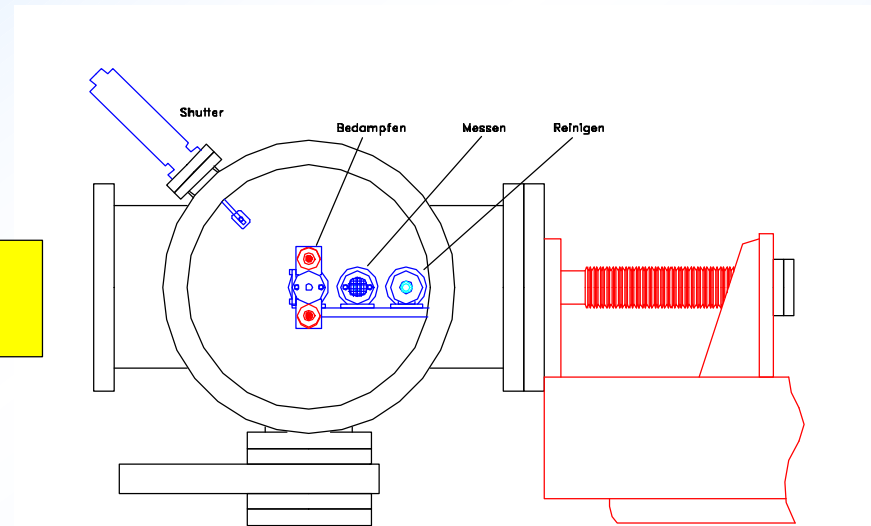
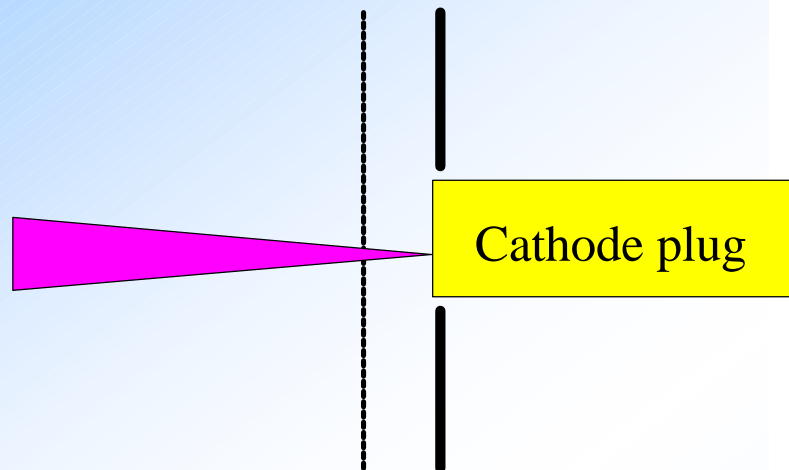
# Deposition rate monitors

---- Quartz oscillators



Rate resolution:  
0.1 Å/s  
Temperature  
~20°C

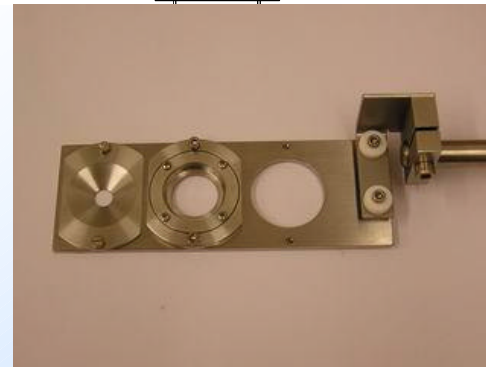
# Scanner of Q.E.



Molybdenum mesh

nominal Aperture: 0.44mm

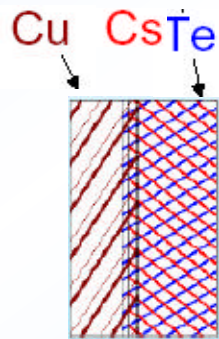
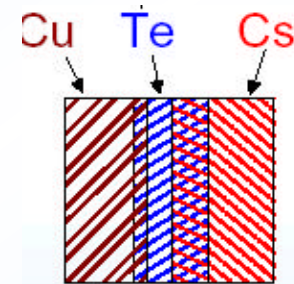
wire diameter: 0.07mm



# Preparation technology

## Former: standard

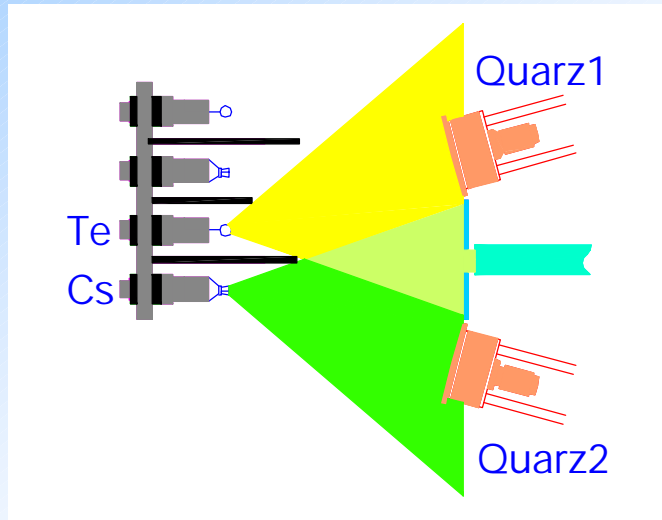
first Te evaporation, ca. 20 nm  
then Cs activated up to maximum photo current  
sometimes result in the failure of uniformity



## New: co-evaporation

Te and Cs simultaneously

# Co-evaporation



Stoichiometric

$$R = \frac{N_{\text{Cs}}}{N_{\text{Te}}} = \frac{2}{1}$$

## Calibration

Te, Cs separate

$$f_1^{\text{Te}} = \frac{s_1^{\text{Te}}}{s_c^{\text{Te}}}, \quad f_2^{\text{Te}} = \frac{s_2^{\text{Te}}}{s_c^{\text{Te}}}$$

$$f_1^{\text{Cs}} = \frac{s_1^{\text{Cs}}}{s_c^{\text{Cs}}}, \quad f_2^{\text{Cs}} = \frac{s_2^{\text{Cs}}}{s_c^{\text{Cs}}}$$

## Preparation

$$\mathbf{h}_{\text{Te}} = \frac{1}{D} (\mathbf{h}_1 f_2^{\text{Cs}} - \mathbf{h}_2 f_1^{\text{Cs}})$$

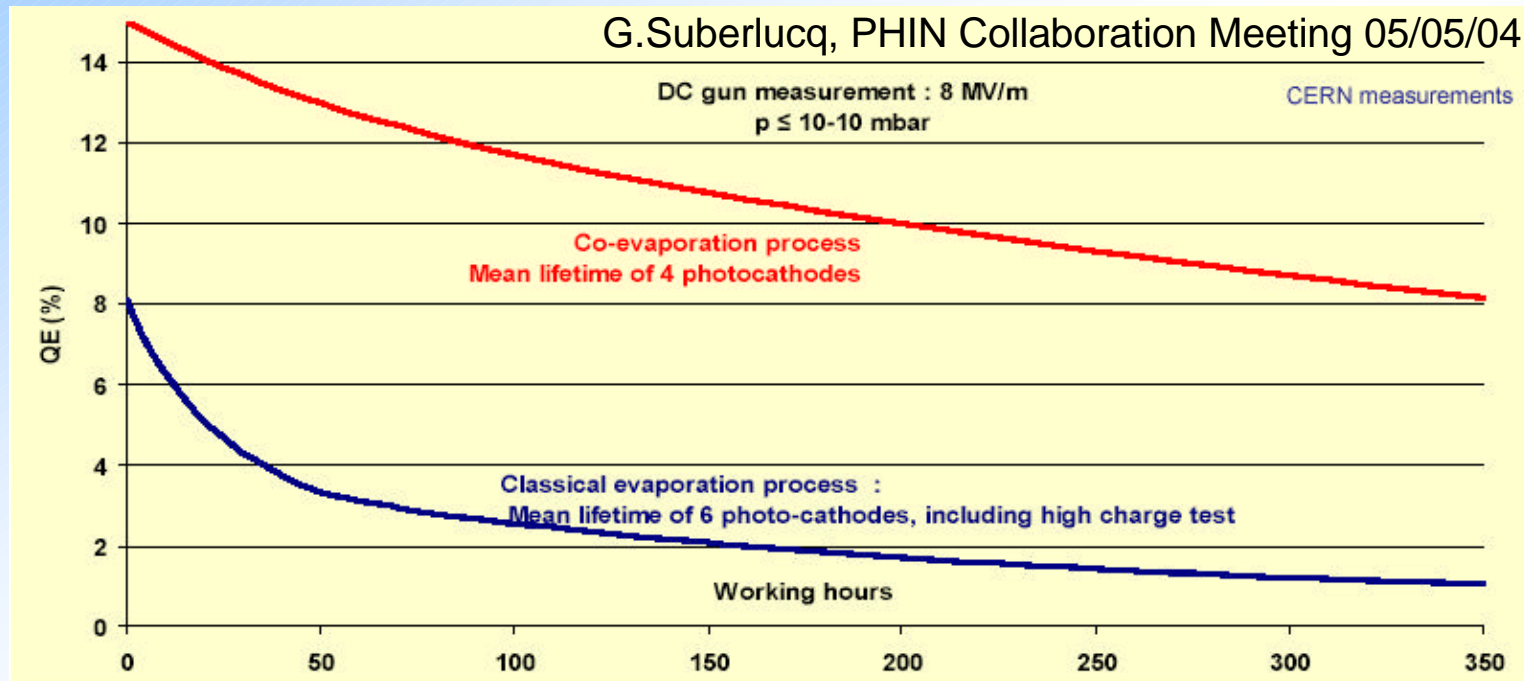
$$\mathbf{h}_{\text{Cs}} = \frac{1}{D} (\mathbf{h}_2 f_1^{\text{Te}} - \mathbf{h}_1 f_2^{\text{Te}})$$

$$D = f_1^{\text{Te}} f_2^{\text{Cs}} - f_2^{\text{Te}} f_1^{\text{Cs}}$$

$$R = \frac{N_{\text{Cs}}}{N_{\text{Te}}} = \frac{M_{\text{Te}} \mathbf{h}_{\text{Cs}}}{M_{\text{Cs}} \mathbf{h}_{\text{Te}}}$$

$$s = \frac{1}{r_{\text{Cs}2\text{Te}}} \int dt (\mathbf{h}_{\text{Te}} + \mathbf{h}_{\text{Cs}})$$

# Co-evaporation in CERN



- Dramatic improvement of QE and lifetime can be attained by using the co-evaporation process
- Know-how in technology (stoichiometric ratio)

# Next work

- Continue the assembling of new preparation chamber
  - Mechanical
  - Cleaning
  - Vacuum
- Finish the construction of control system
- Set up the optical system
  - Diagnose of QE
  - Scan beam
- Begin the test of co-evaporation process
  - Stoichiometric ratio measurement
  - Evaporation rate control