Dark current measurements

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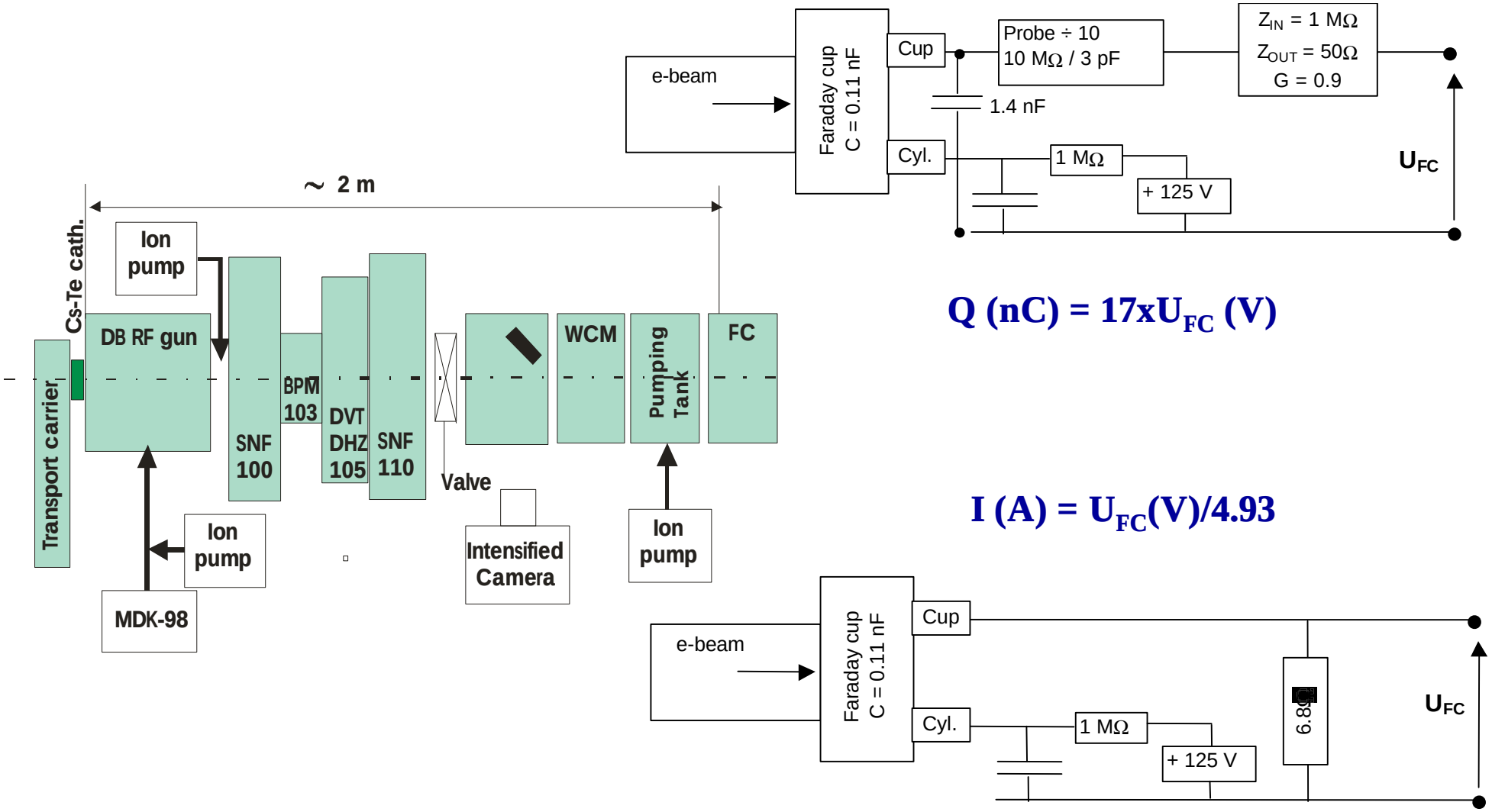
Main participants

- **PS Operators**
- **Klystron Team**
- **Eric Chevallay**
- **Thibaut Lefèvre**
- **Guy Suberlucq**

Measurement set-up



Field enhancement factor and field emission area

- **For RF gun the field emission current could be approximated by : (1)**

$$\bar{I}_{FE} = \frac{5.7\times10^{-12}\times10^{4.52\times f^{-0.5}}\, Ae(bE)^{2.5}}{f^{1.75}}\times e^{\frac{-kf^{1.5}}{bE}}$$

- **The modified Fowler-Nordheim plot :** $\log(\frac{\bar{I}_{FE}}{E^{2.5}})$ **vs** $\frac{1}{E}$ **give :**

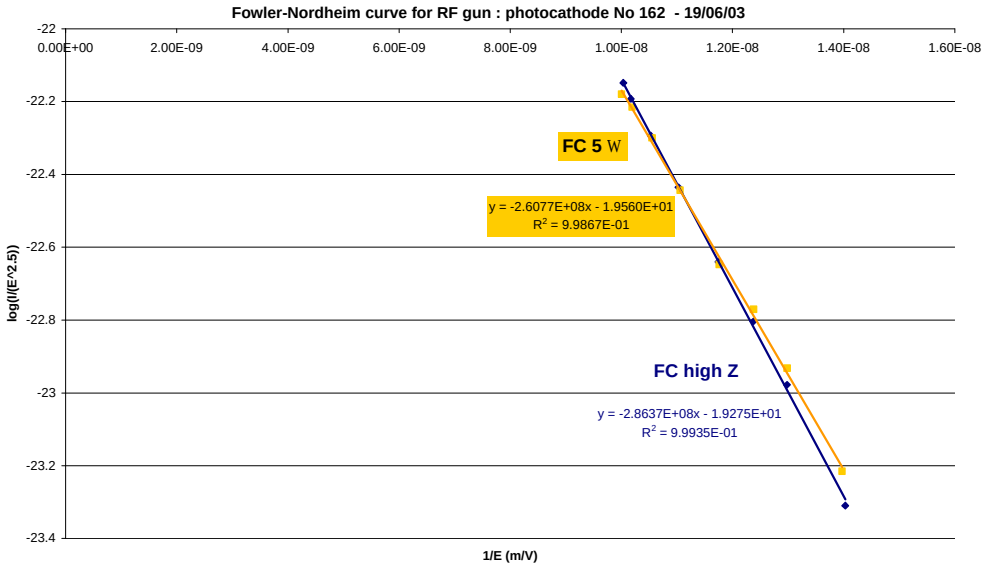
$$b = \frac{2.84\times10^{9} f^{1.5}}{\text{slope of the plot}}$$ **the field enhancement factor**

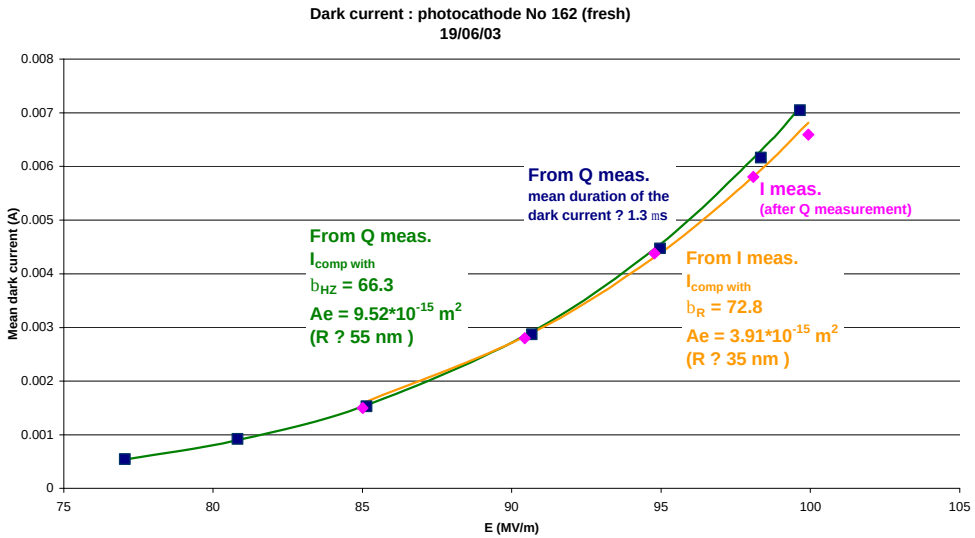
$$\log(Ae) = \log(\frac{\bar{I}_{FE}}{E^{2.5}})_{E\to\infty} - \log(5.7\times10^{-12}\times10^{4.52 f^{-0.5}}\, b^{2.5}) + \log(f^{1.75})$$

Ae = area of a single dominant emitter or
area of a collection of emitters of similar strengths

(1) J.W. Wang, PhD Thesis, Stanford University (1989)

Dark current measurement on Cs_2Te photocathode





Main results from dark current measurements (1)

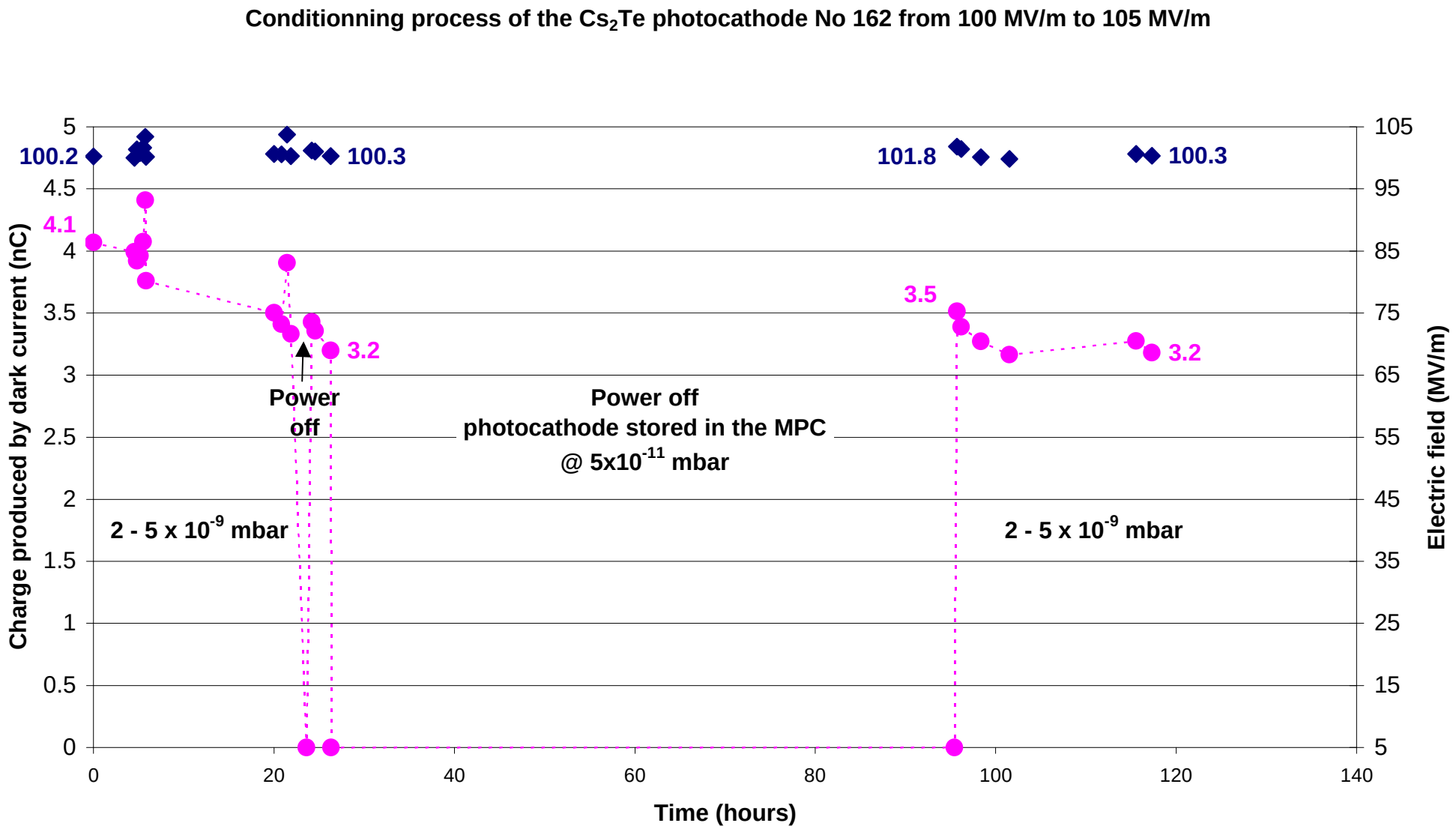
- **Standard conditioning process:**

  Slow increase of the klystron output power by minimizing break-downs, until 18MW nominal power, corresponding to 100 MV / m. After more than 10 minutes without breakdown, the cathode is considered as conditioned.

	Fresh Cs_2Te photo-cath.	Used Cs_2Te photo-cath	Chemically cleaned copper plug	ICE cleaned copper plug	ICE cleaned used Cs_2Te photo-cath.
f (eV)	3.55	3.55	4.6	4.6	4.6
b From - to	73 - 66	77 - 53	104 - 70	94 - 49	102 - 100
Eq.Radius (nm)	35 - 55	27 - 165	38 - 269	55 - 2616	31 - 37
I_{mean} (mA) at 100MV/m	7.3 – 6.9	6.9 – 6.5	5.2 – 4.8	4.3 – 3.8	3.2

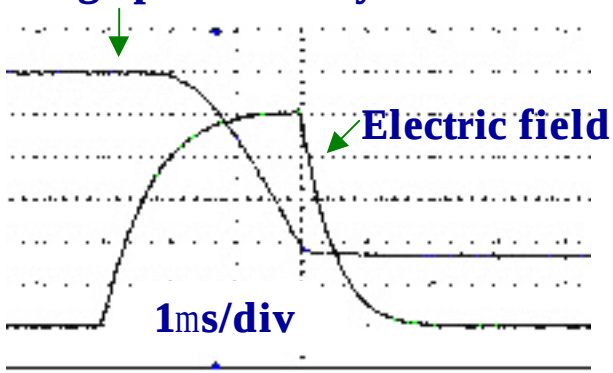
ICE : Argon ion bombardment at $5x10^{-2}$ mbar eq. N_2

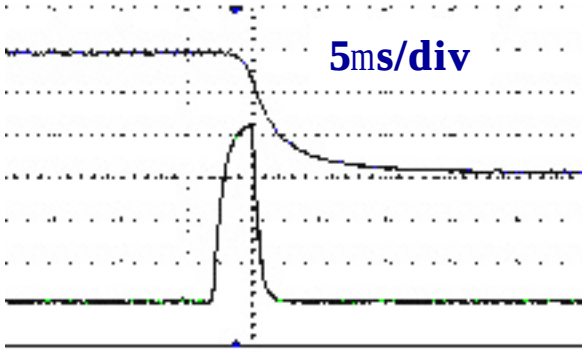
Main results from dark current measurements (2)

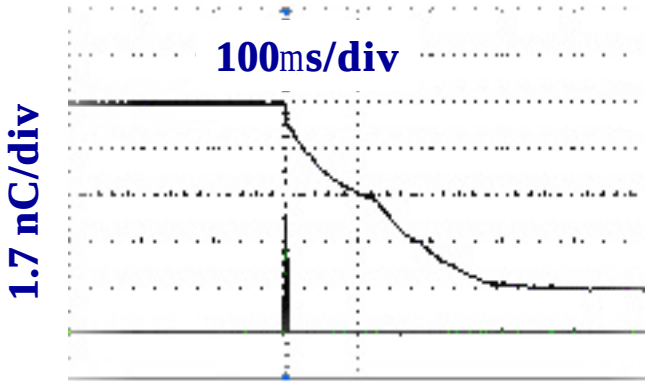


Strange phenomena

charge produced by dark current



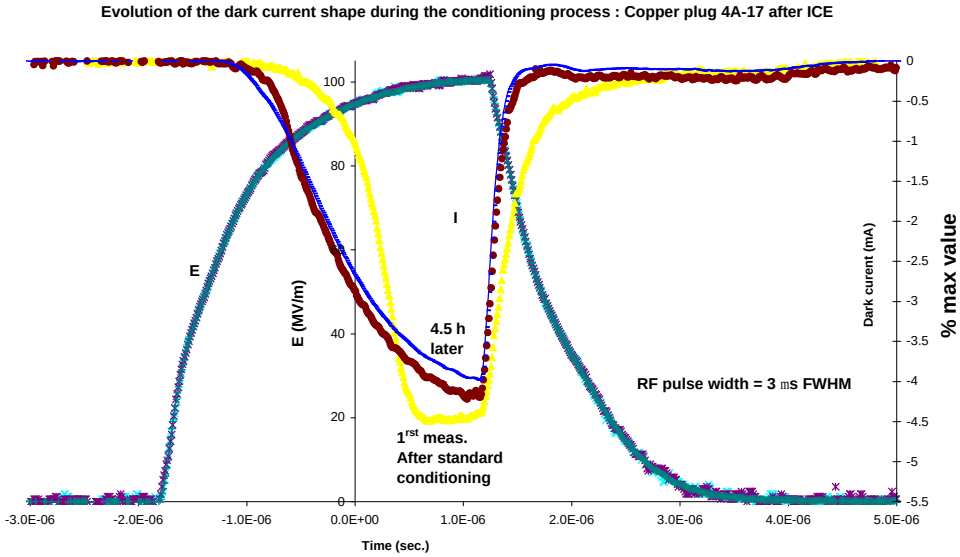


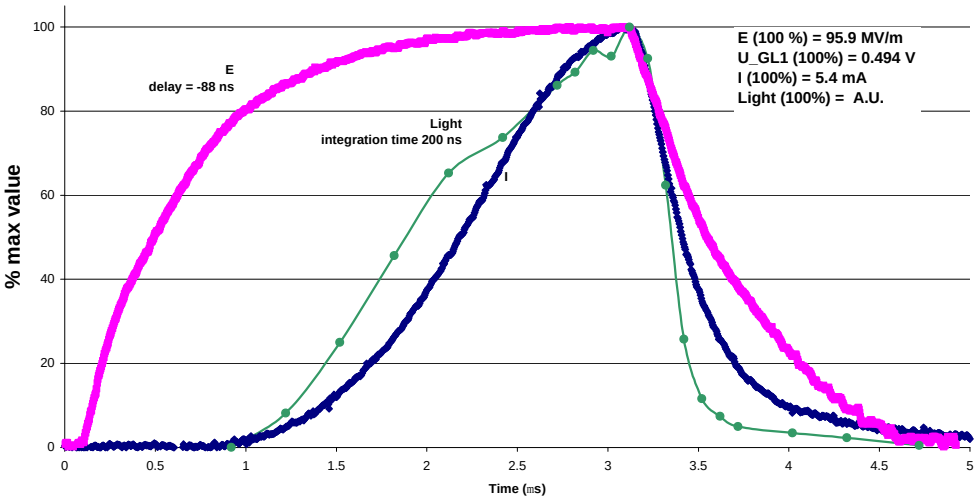


Nominal shape

Long tail shape sometime during conditioning process

often just before an RF breakdown. Confirmed by light measurements





Conclusion

- No major difference between Cs_2Te photo-cathodes and copper plugs in term of dark current up to 100 MV / m
- Cleaning by argon ion bombardment (ICE) helps to reduce dark current
- Conditioning process of the copper plug, with or without ICE, before Cs_2Te cathode preparation, helps for the photo-cathode conditioning.
- The long tail of the charge produced by dark current during the conditioning process should come from ions which can potentially destroy the photo-cathode.

  More investigations should be done.