Thin film Pb/Nb photocathodes

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Świerk

EuCARD²

DESY

MS 80 Demonstrated operation of improved deposition system, Pb layers of 1 μm in thickness

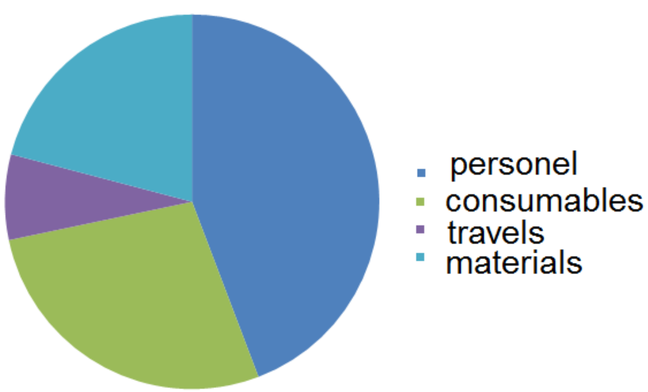
D12.8 Optimised procedure for microdorplets flattening with an UV laser

D12.8 Optimised procedure for preparation of flat, clean and adherent Pb/Nb films

Reason

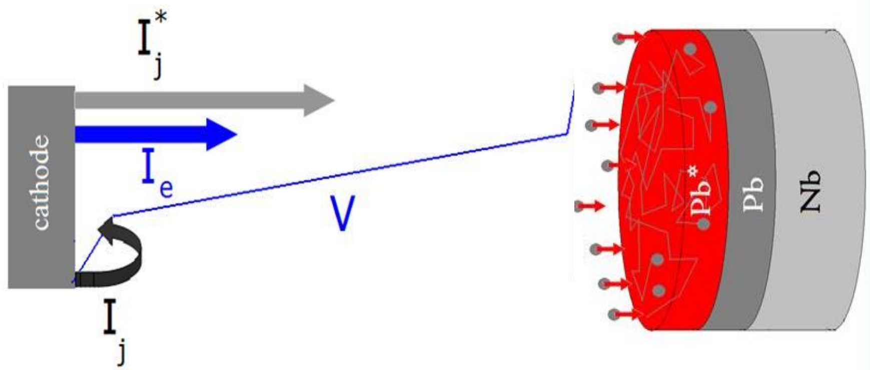
We found that plasma pulsed irradiation is more effective that the laser one. For plasma we learned how thick layer must be deposited to undergo a right change caused by energy deposition.

Beneficiary	Person* month	Personel cost per month	Personel direct	Personel indirect	Consumables	Travel direct	Materials and travels	Total direct	Total indirect	Total direc +indir	EC contribution
NCBJ	36	1927	69,389	41,634	69,000	18,500	52,500	156,889	94,134	251,023	98,134



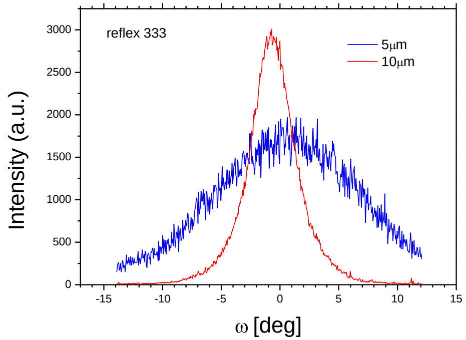
Cathodic arc

Explosive electron and Pb ions emission, ions accelerated in the pressure gradient and coupled to the electron flux



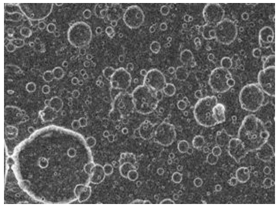
Consequences for the film:

- regular
- dense
- adherent
- texture (111)
- micro-droplets

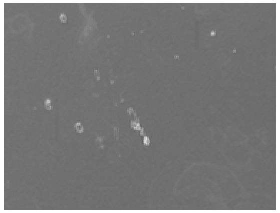


Growth

- Shallow inplantation
- diffusion with kinetic energy higher than displacement energy
- permanent ion exeed
- gradual cooling and condensation

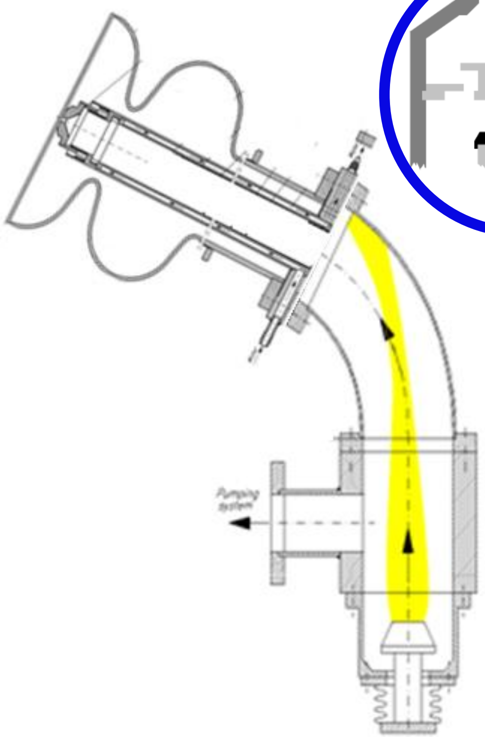


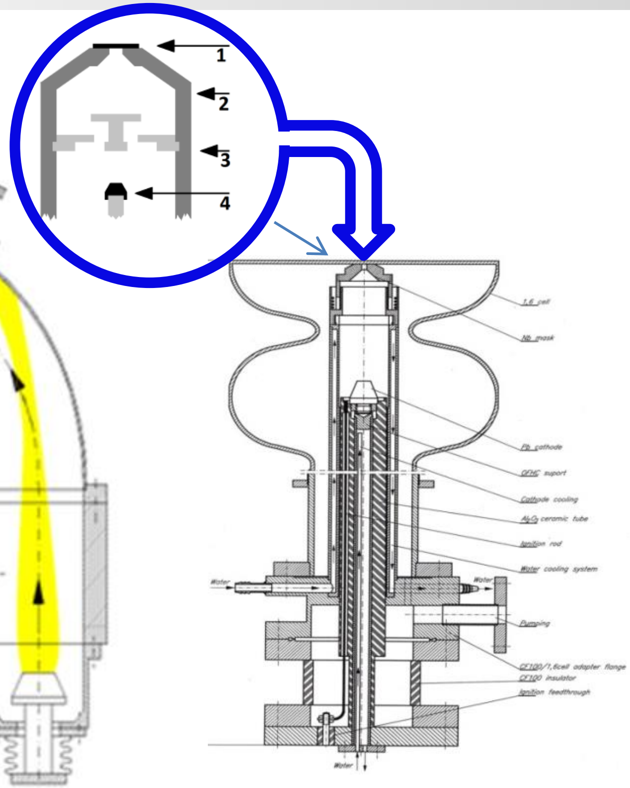
unfiltered

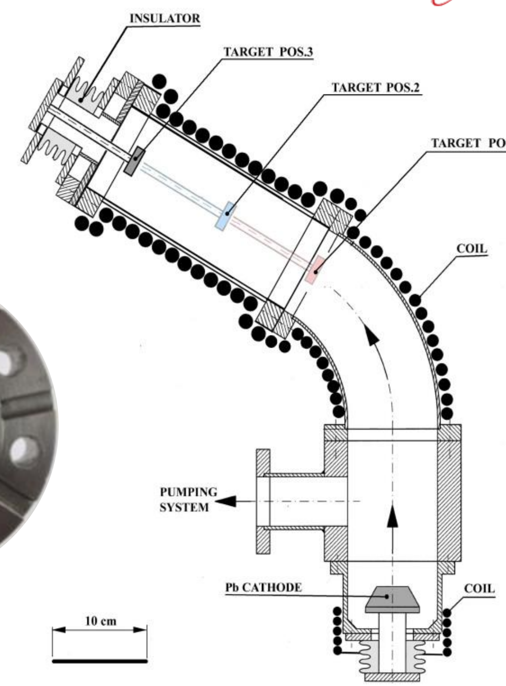


filtered

Filtering







Knee-like magnetic filter, deposition directly onto cavity back wall

Low througput long time, debrees

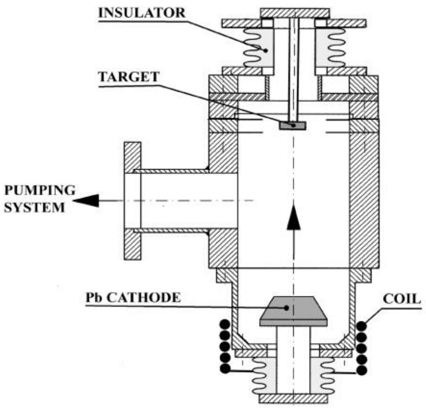
Short distance – short time

still debrees

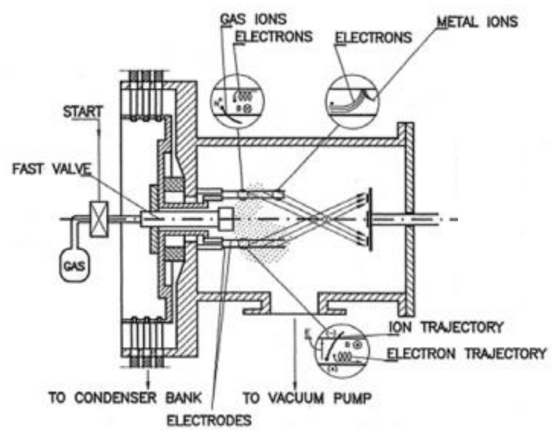
Detachable plug, treatment of which is separated from the e-gun cavity. Performance has been tested vs the plasm channel length

No trade off between droplets removal efficency and surface cleanliness has been found

Unfiltered deposition followed with a separatated flattening

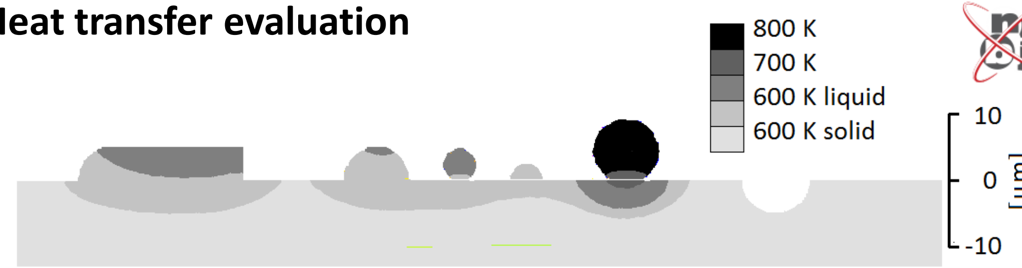


Direct deposition several μm

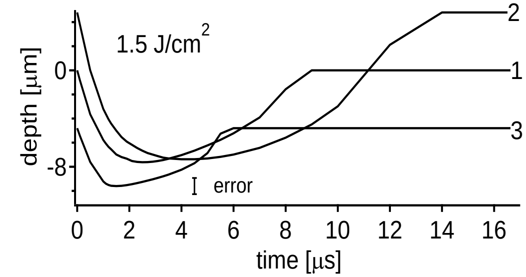


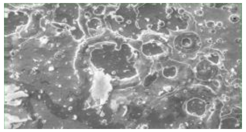
Melting and flattening with
Rod Plasma Injector
1J/cm^2 , 1 μs Ar^+ pulses

Heat transfer evaluation

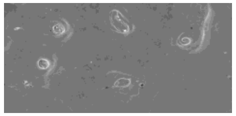


- Film molten down to 9 μm during 6 - 14 μs
- Interface remains solid
- Droplets stay liquid the longest time





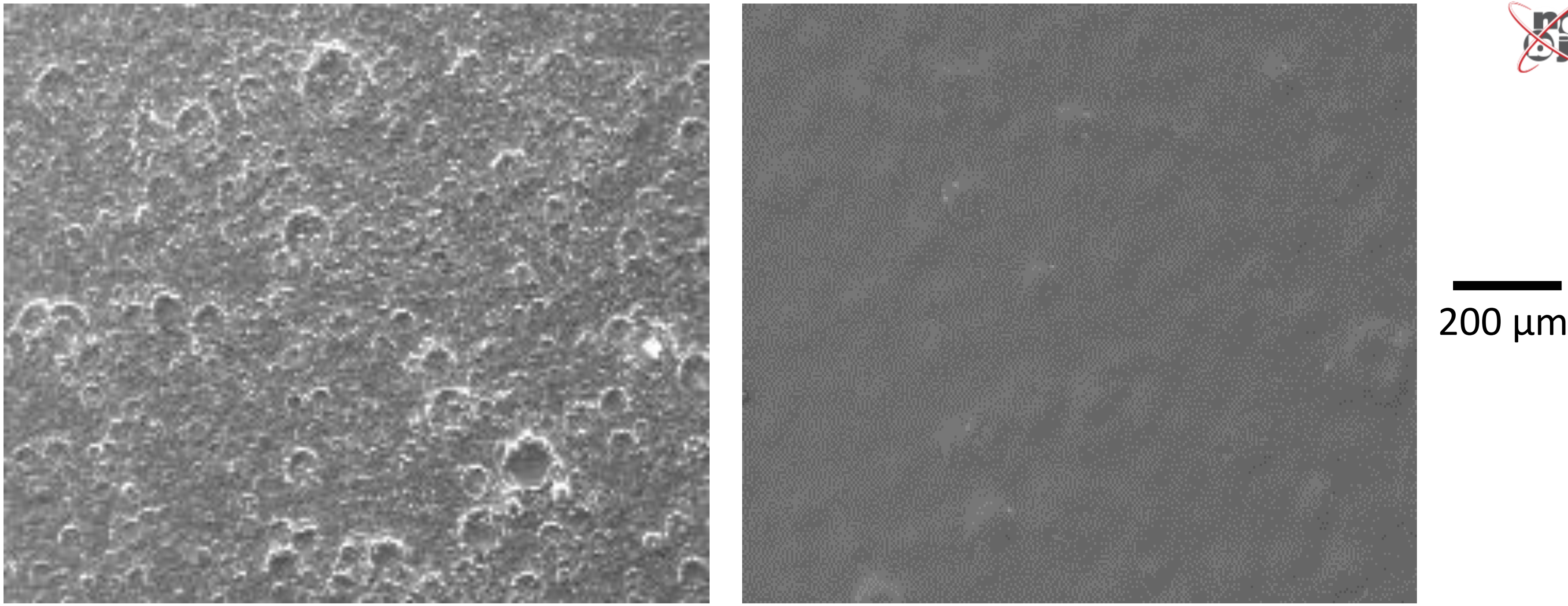
8 μm heavily damaged with 1.8 J/cm^2



12 μm accidentally perforated with 3 ×1.5 J/cm^2

20 μm,
6 × 1.5 J/cm^2

Achieved performance

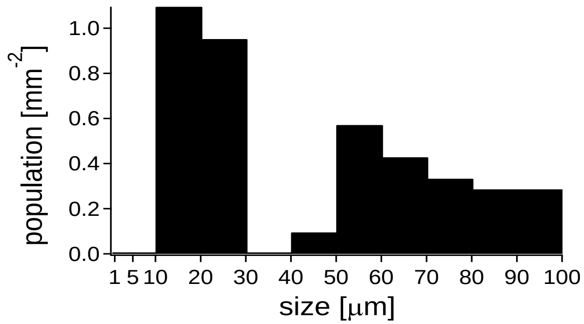


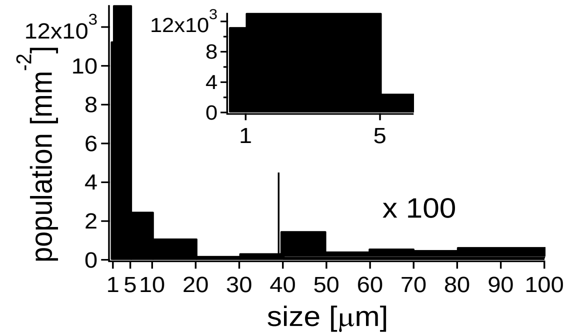
Applied treatment resulted in a continuous and uniform layer.

population	$3 \cdot 10^4$ mm^{-1}	5 mm^{-1}
droplets coverage	0.85	0.01
altitude difference	50 μm	1 μm (5 μm)
lateral correlation length	1 μm	100 μm

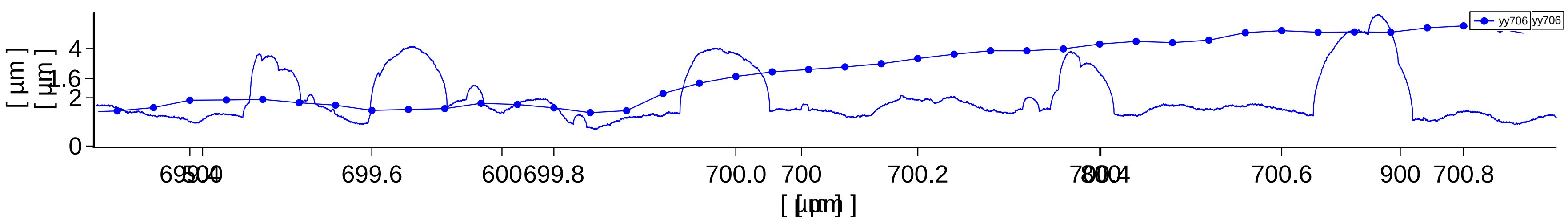
20 μm,
6 × 1.5 J/cm^2

Surface models





- 0.4 × 4 mm² model areas were populated with droplets ensembles of radii distributions found with SEM inspection for as deposited and flattened samples, respectively
- Centres locations of hemispherical extrusions have been randomly chosen on the model areas in the grids of 40 nm resolving mesh
- Surface cross sectons profiles along randomly chosen 4 mm long streight lines have been calculated



- Distributions of fragments normals inclination angles to the overall surface normal has been calculated
- Electric field was calculated in the surface vicinity by applying a voltage beteween that surface and the plane in the infinity, which corresonds to 40 MV/m at the ideally flat surface

Morphology improvement

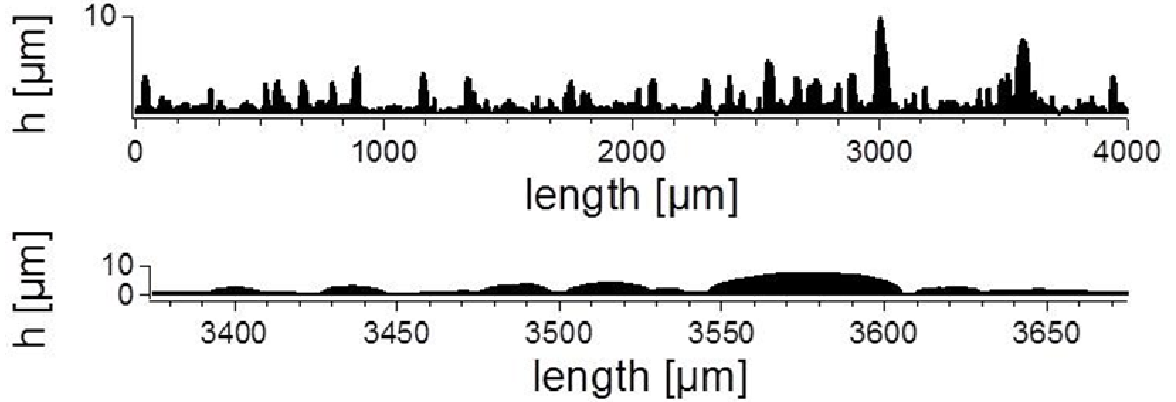


Fig. 8. Modelled surface profile for the as deposited sample. a. – entire model surface, the vertical dimension is 40 times magnified; b. - a specific region drawn in natural aspect ratio

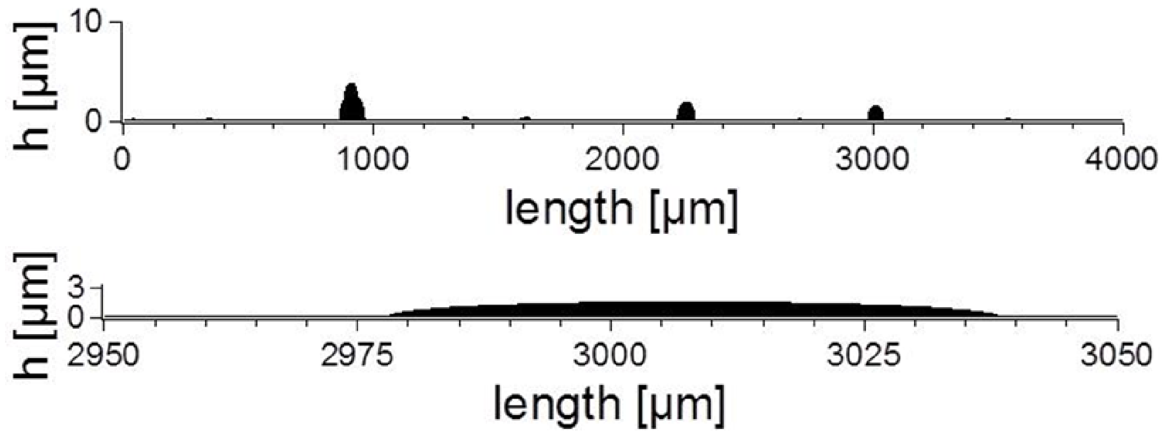
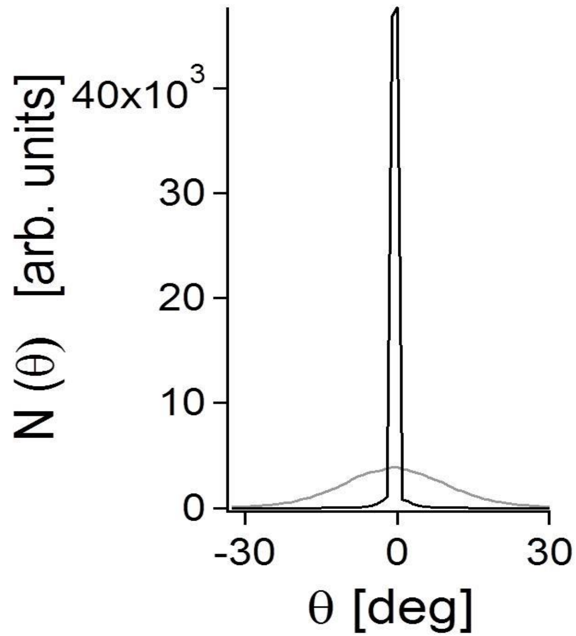


Fig. 9. Modelled surface profile for the flattened sample. a. – entire model surface, the vertical dimension is 40 times magnified; b. - a specific region drawn in natural aspect ratio



A fraction of 0.96 the surface inclined within angular ranges:

fs deposited: ±25°
flattened: ±5°

Electric field improvement

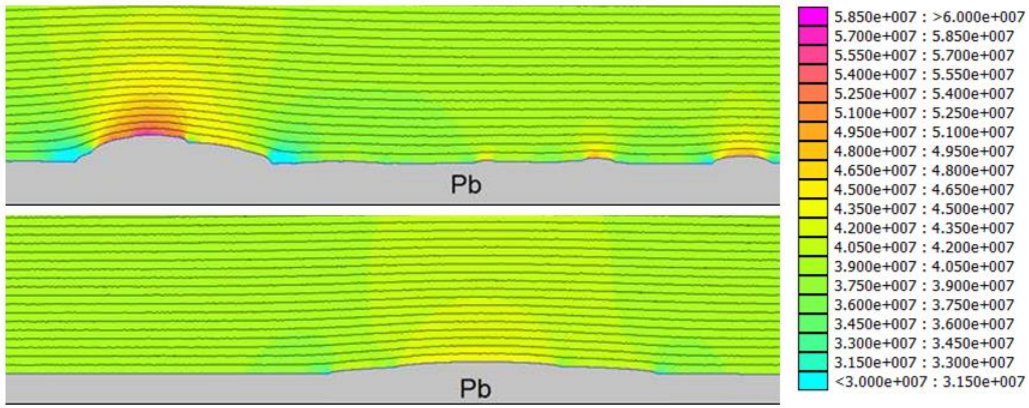


Fig. 11. Maps of electric field in the vicinity of modelled surface. a. – as deposited sample; b. – flattened sample

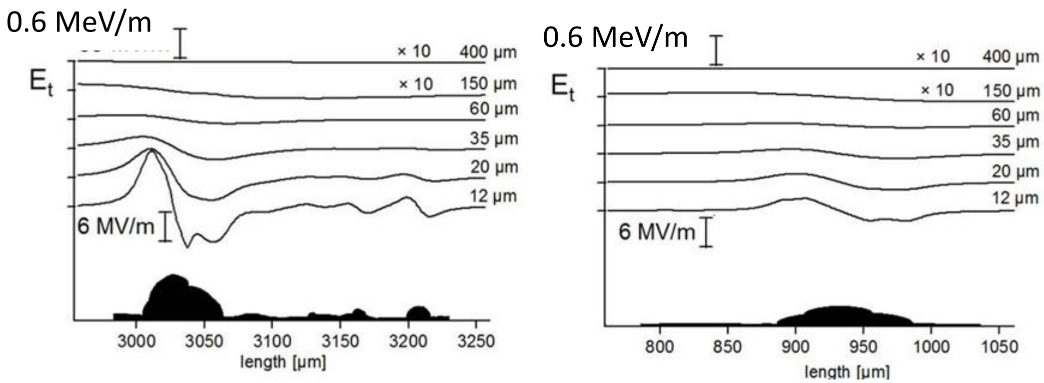


Fig. 12. Transverse contribution of the electric field calculated for the model surface for the regions containing the highest protrusions. a. – as deposited sample; b. – flattened sample

Electric field inhomogeneity :

as deposited: 20 - 60 MV/m

flattened: 37 – 46 MV/m

- after flattening a transverse field is 5 times weaker
- no transverse field beyond 400 µm

Accelerator performance

$E_{cathode}$	40 MV/m
QE at 266 nm	$1.8 \cdot 10^{-4}$
Bunch rep. rate	100-250 kHz
Bunch charge	250-100 pC
P of irradiating laser at 266nm	1 W
Normalized emittance for 250pC	<0.5 µm rad

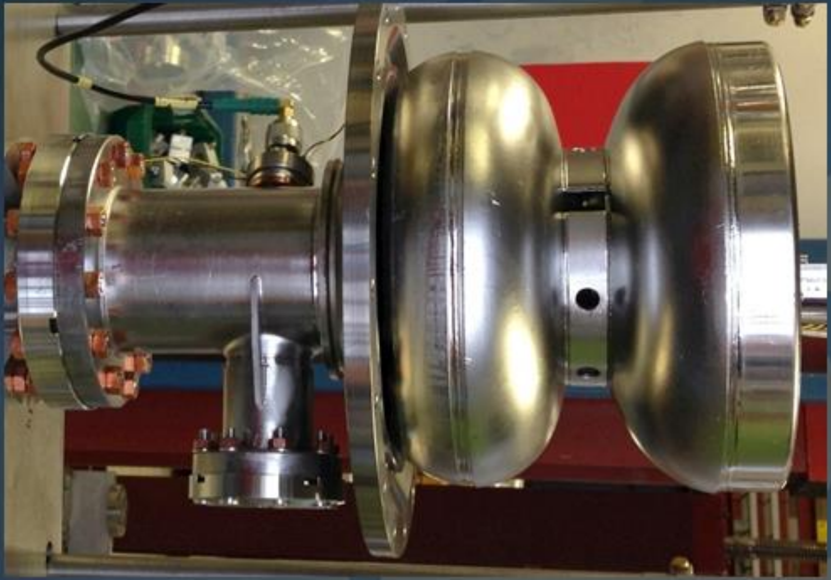
266 nm, 10 µJ , 5 ps, 100 kHz

380 pC, 38 µA

Long term stability is being tested at HZDR

- Dark current modelling base on breakdown current measurements with pulsed E field
- Beam dynamics calculation – emittance evaluation

The 1.5-cell gun cavity prototype was built at TJNAF. The present plug version has very effective cooling of the cathode.

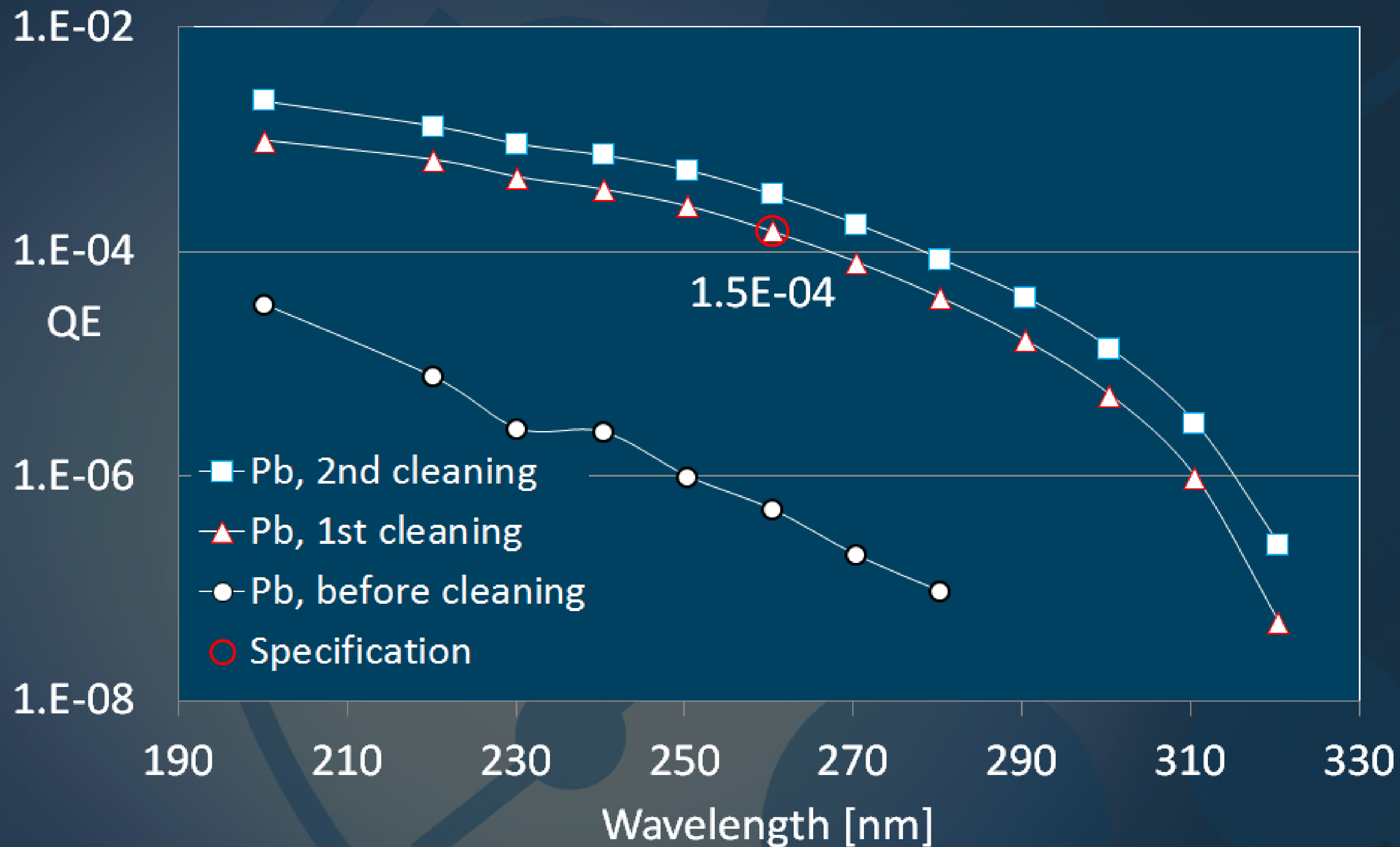


1.5-cell , 1.3 GHz gun cavity

New plug with LHe channels

Nb/Pb cathode

Recent QE test at BNL of the Pb coating on new plug

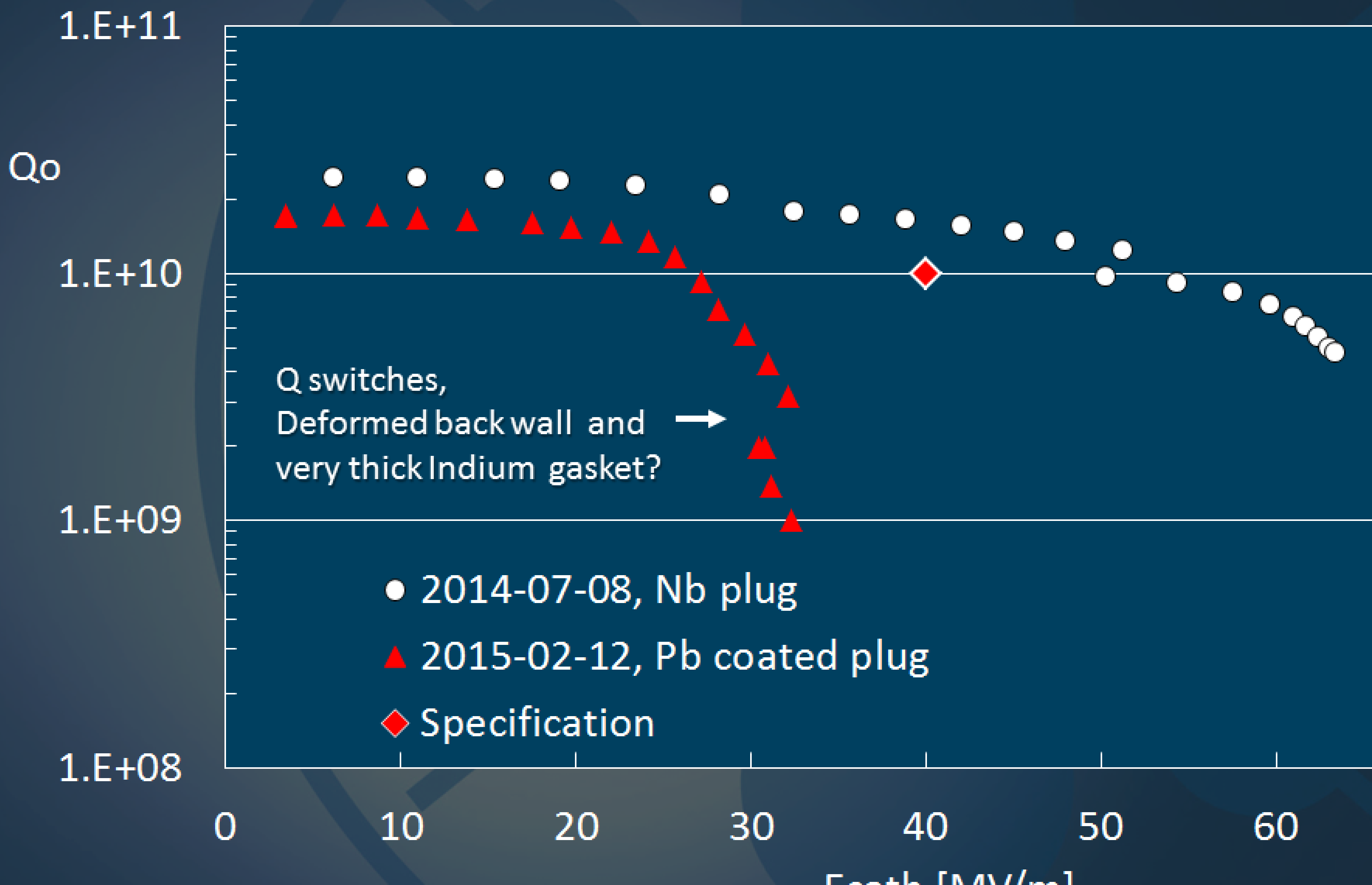


Courtesy J. Smedley, J. Sinsheimer, M. Gaowei and V. Gofron

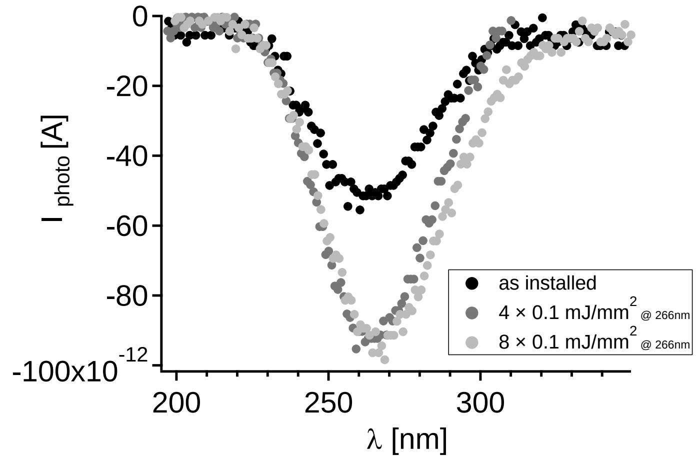
Laser cleaning: 1st 1000 shots with 0.06 mJ/mm^2,
2nd 10000 shots with 0.06 mJ/mm^2, all at 248nm

R&D at DESY

The test results of 1.5-cell gun cavity with Nb and Pb-coated catho



Instruments developement



Pb/Nb Sample ex-situ prepared with 200 pulses of 0.5 mJ/mm^2 at 532 nm then treated with
8 × 0.1 mJ/mm^2 at 266 with .
QE= $6 \cdot 10^{-4} \pm 5 \cdot 10^{-4}$ (*preliminary results)*

Built since 2014:

150 W Xe lamp + monochromator +fiber optical path+ picoamperometer

255 nm 1 W diodes

Nd YAG +IV harmonics generator 30 μJ, 10 ns, 20 Hz + collimation

Pulser 12.5 kV + 50 μm precise manipulators: 1. sample holder, 2. Farady cup

Conclusions

MS 80 Demonstrated operation of improved deposition system, Pb layers of 1 μm in thickness

Direct arc deposition

D12.8 Optimised procedure for microdorplets flattening with an UV laser

Pulsed plasma flattening

Thanks for the attention

Thanks for the collaboration on photocathodes and innovative RF technologies