SIMULATION STUDIES FOR DARK CURRENT SIGNATURE FROM DLS RF GUN

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Introduction and work objective

- **System**: Delhi light source (DLS) at IUAC: Compact THz facility based on pre-bunched FEL under commissioning (THz range: ~0.2 – 3 THz).
- [*Proceedings of this conference; ID: TUPAB106, WEPAB131*]
- **Present status** : RF gun conditioning done upto ~ 1 MW, to be done at higher powers.
- **Objective:** Simulation study of dark current expected during RF conditioning.

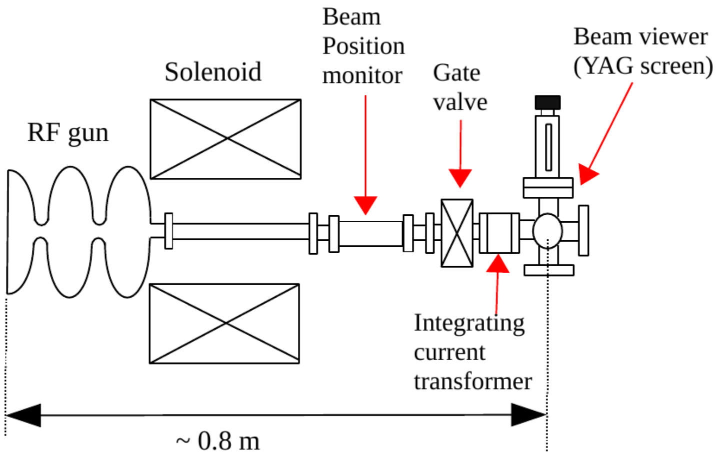
RF gun:

- 2860 MHz,
- 2.6 cell Cu cavity.

Photocathode:
Cu plug.

Max peak field:
115 MV/m

Energy range:
4 – 8 MeV

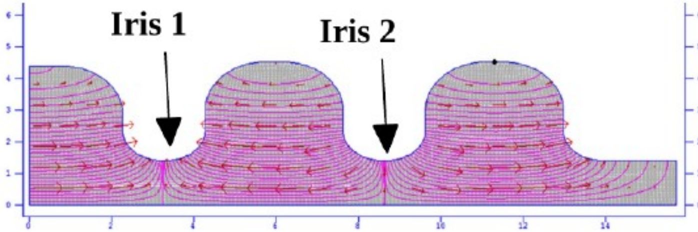


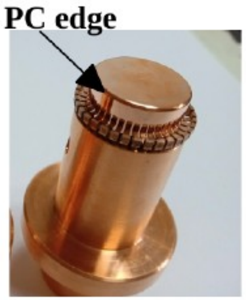
Beam line schematic for dark current detection

Identifying dark current source

Dark Current (dc) :
Unwanted field emission electron current that travels down the beam line.

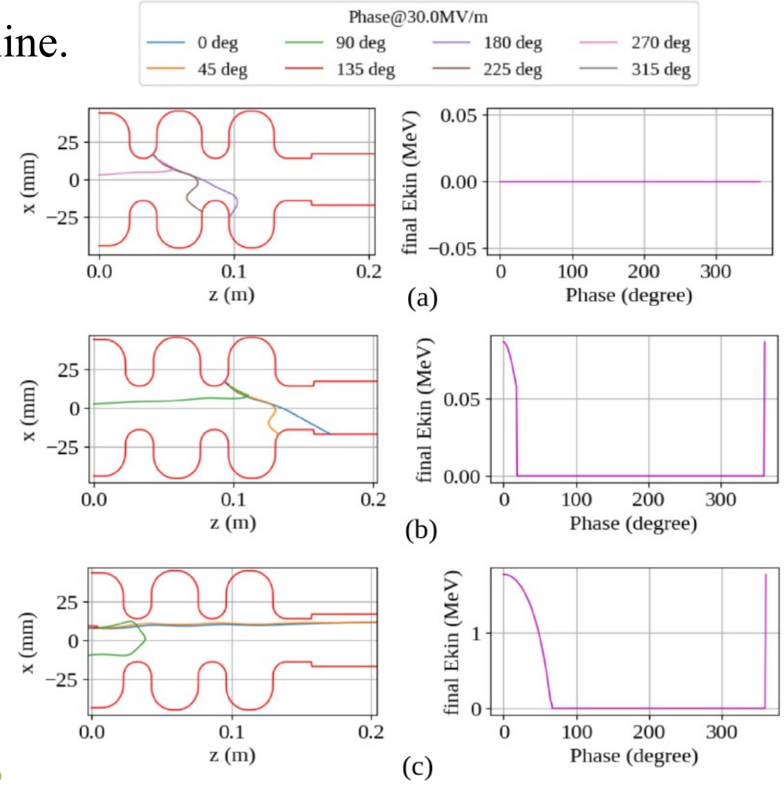
Field emission sources: Irises, PC edge, any scratch on PC.





ASTRA Simulations with single e$^-$ at 8 phases of RF (45^o apart) from the irises and PC edge.

Main dc source: PC edge & PC surface scratches



Single e$^-$ simulations @ 30 MV/m

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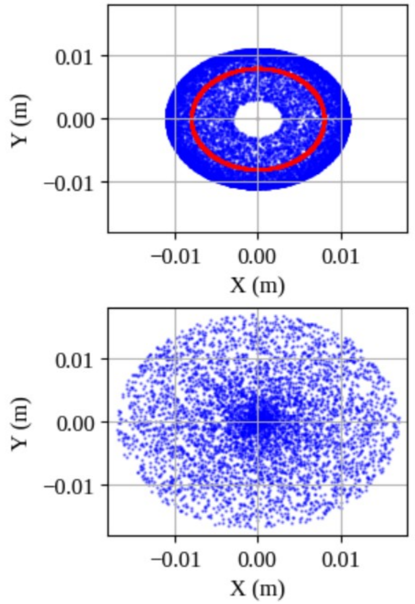
Multi particle simulation from PC edge

Input Parameters:
β ~ 150,
Φ = 4.5 eV
Ea = 29 MV/m
emitter ar ~ 3x10^{-8} mm^2.

Total current in RF cycle ~ 0.21 mA
Typical dc emission time ~ 1 fs
[*J. H. Han, DESY THESIS 2005-045*]
Total charge in a RF cycle ~ 0.21 atto-C

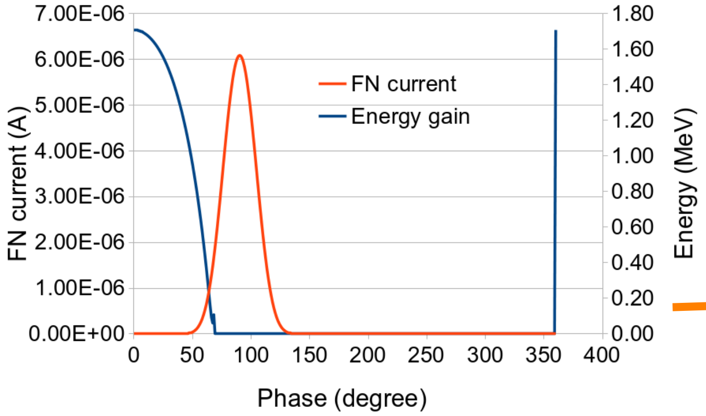
Assuming all points on PC edge emits
Charge of ring of 16mm dia ~ 35 pC
FWHM of FN distribution: ~ 31 ps
(*RF period =350 ps*)



Ring distribution @ (LEFT) PC, cavity exit, (RIGHT) YAG screen.

Fowler Nordheim Equation

$$I_{FN} = \frac{1.54\times10^{-6}\times10^{4.52/\sqrt{\Phi}}A_e(\beta E\sin\theta)^2}{\phi} \times \exp\left(-\frac{6.53\times10^{9}\phi^{1.5}}{\beta E\sin\theta}\right)$$



The FN and energy scan plot :

- The phase overlap region decides the energies in the dark current.
- At higher fields the overlap is higher
- At 29 MV/m the phase overlap ~ 55°-69° with energy range ~ 0.73 MeV to 0.00 MeV.

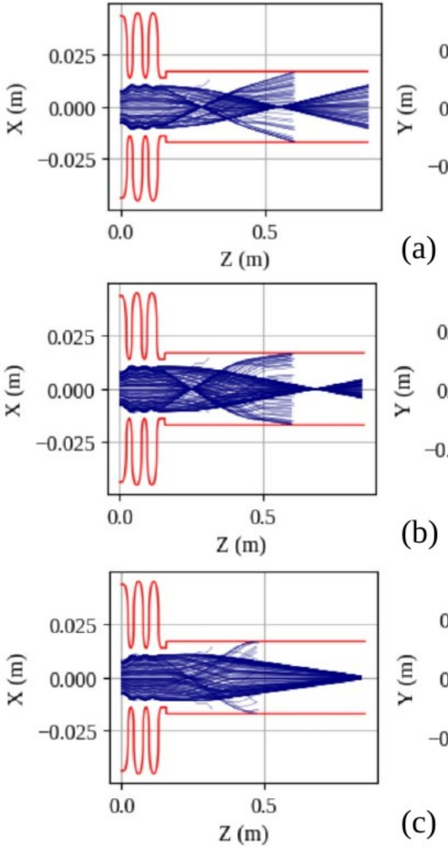
Multi particle simulation from PC edge

Simulation results:

- energy range of dc : 0.003 MeV to 0.7 MeV @ 29 MV/m.
- Analysed three energies (within 5%) viz. 0.06 MeV, 0.12 MeV & 0.18 MeV at a fixed solenoid field (0.0352 T)
- Traced the particle trajectories & distribution in screen for each energy.

Outcome

- Tuning the solenoid – tunes different distribution of the energies
- At a given cavity & solenoid field - dominant dc energies can be studied



0.06 MeV

0.12 MeV

0.18 MeV

Dark current detection at DLS

RF Conditioning :

RF pulse width: 4 μs,

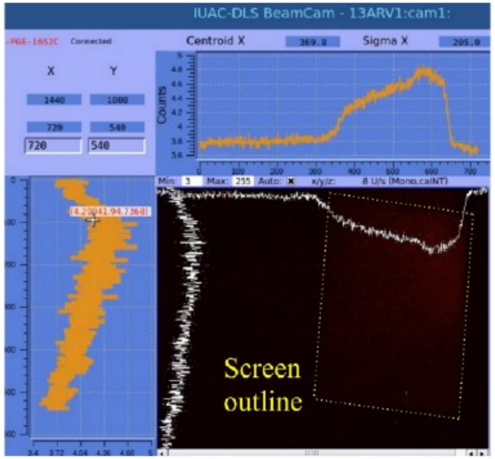
Pulse rep. Rate: 30 Hz

P_{fwd} into cavity increased from low level

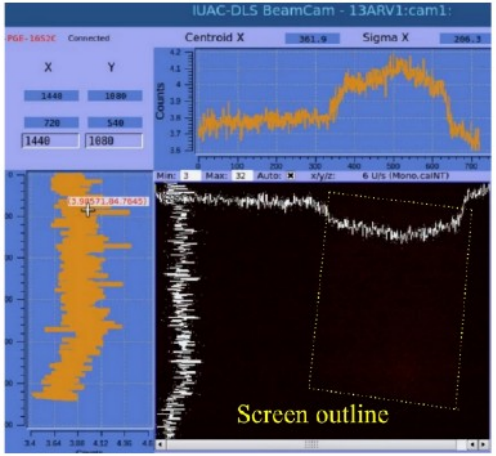
max P_{fwd} ~ 1 MW so far.

Observations:

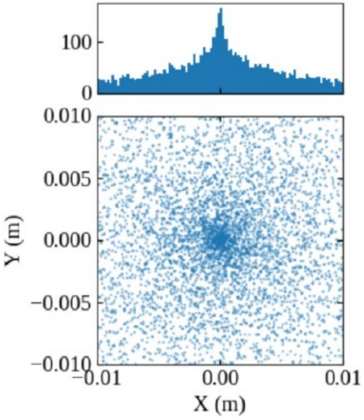
- A persistent dc background + occassional random bright spots.
- The dc background pattern changed with solenoid current.
- At higher solenoid currents the background intensity dropped. Same observed in simulation

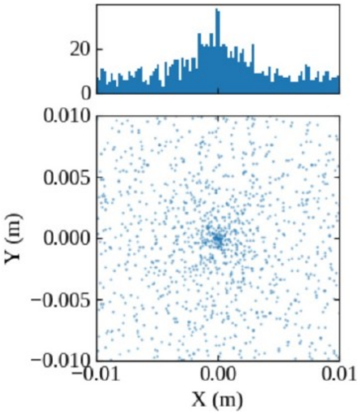


B_sol: 0.035 T



B_sol: 0.095 T





Future scope: Further study when conditioned at higher powers

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Ms Madhuri Aggarwal
Mr. Ashish Sharma

Thank You