Field emitters are poised as next-generation cathodes capable of operating at high frequencies and high peak power: compact and naturally suited for shaped and patterned beam production. We developed a computational toolbox to realistically model the particle dynamics in field emitter cathode systems. The algorithm can account for field emission technology beyond the Fowler Nordheim law

- Nonplanar geometries
- Semiconductors (Straton-Baskin-Lvov-Fursey)
- Temperature dependent emission (Murphy-Good)
- Compatible with ASTRA, Impact-T, and GPT

**FEgen Capabilities**

- FEgen provides capabilities for both RF and DC/pulse power environments
- Allows for emission patterns consisting of one emitter, emitter grid, or custom emitter pattern
- Pulse power/DC option assumes a flat top current is used to create a time-uniform charge distribution Q=I*t
- RF environment uses the Fowler Nordheim equation in RF field
- Inputs experimental data for charge collected over a pulse: Q_E = \frac{Q}{t}
- Simulates different cathode dimensions to optimize design: Q_E = Q (\frac{R_{\text{master}}}{R})^2
- Can be used for a single RF cycle for different cathode radii and pulse lengths
- Emission period, initial energy spread, local field, and work function can be varied to simulate a wide variety of experimental settings and different emission physics
- Output files can be directly imported into ASTRA, GPT, or Impact-T for beam tracking simulations
- Flags are set to -1 as the particles are generated at the cathode surface

FEgen is an open-source freeware software. Ongoing improvements include potential barriers for nonplanar geometries and temperature dependence.

**Application Example: Modeling of Patterned Beam Using Field Emitter Array**

- Field emission arrays produce transversely patterned beams without complex laser schemes of masking or holography
- Transversely shaped electron beam can be converted into longitudinally shaped beam by emittance exchange or a similar schematic
- In this example, the beam is produced by an array of diamond pyramids
- 8 diamond pyramids were emitting as shown on a YAG screen 2.54m downstream
- FEgen uses GPT and the exact solenoid settings to produce the correct gradient patterned beam at the right location with the same local field, effective emission area, work function, and charge
- FEgen coupled with GPT demonstrates time dependent simulations with extremely high resolution and accuracy not found in ASTRA or Impact-T

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