Status of OPAL Boundary Geometry Feature and Surface Emission Models for Dark current and Multipacting Simulation

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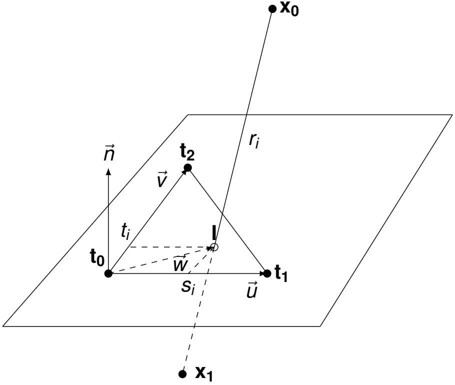
1. New geometry feature: particle-boundary collision test model
    - Basic idea: line segment-triangle intersection (LSTI) test
    - Early rejection strategy
2. Surface emission physics models
    - Field emission model
    - Secondary emission model
3. Current results
    - Dark current simulation with field emission model
    - Benchmark of secondary emission module
4. Plan for the next step

THE GOAL OF THE WORK

- Extend OPAL to handle the complex boundary.
- Provide field emission model and a reduced model with randomly generated electrons for dark current study (CTF3 gun, new gun...)
- Provide feasible multipacting model primarily for cyclotrons, including models of field emission, secondary emission...

Outline

LINE SEGMENT-TRIANGLE INTERSECTION TEST



- $\mathbf{x}_0, \mathbf{x}_1$ are position of a particle.
- Triangle $\mathbf{t}_0, \mathbf{t}_1, \mathbf{t}_2$ is one piece of triangulated boundary surface.
- Using [D.Sunday's] Line-Triangle intersect algorithm.
- Precomputed triangle normal.

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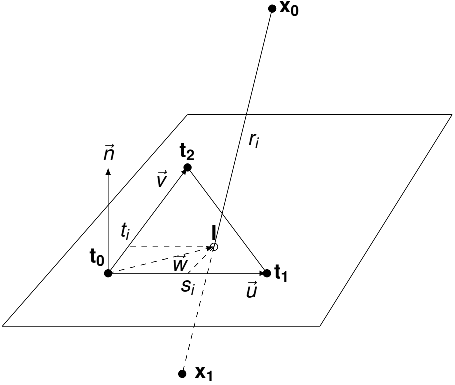

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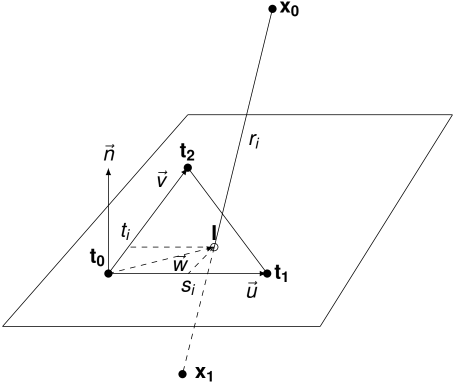

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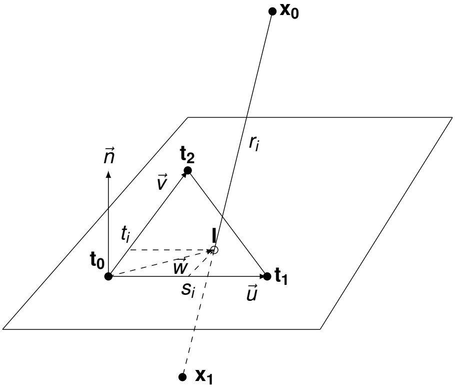

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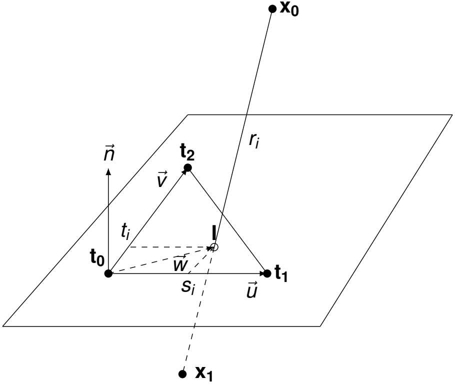

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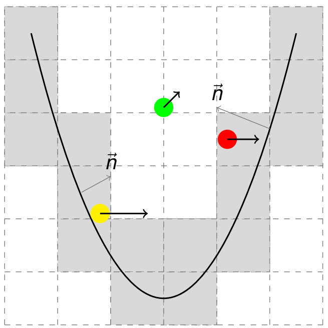

- Use uniformed boxes to facilitate the particle searching.
- Shield like boundary box.
- Direction of momentum and triangle normal are also evaluated.

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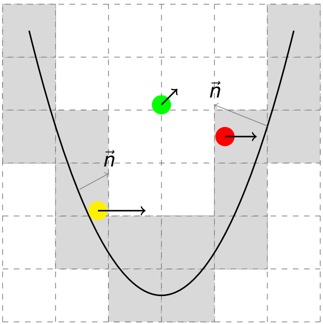

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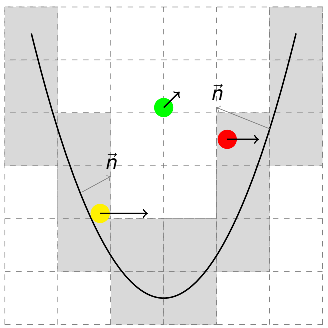

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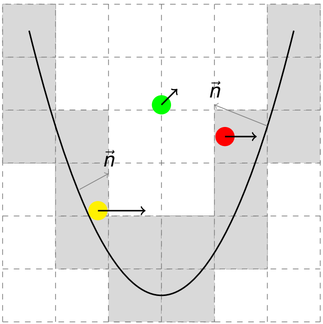

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- Fowler-Nordheim formula induced by [R. H. Fowler, L. Nordheim] and implemented for dark current simulation by [J. H. Han]:
  $J(\mathbf{r}, t) = \frac{A(\beta E)^2}{\varphi t(y)^2} \exp\left(\frac{-Bv(y)\varphi^{3/2}}{\beta E}\right)$
- $J(\mathbf{r}, t)$: current density in position $\mathbf{r}$ and time t; φ: work function; β: field enhancement factor; E: electric field in the normal direction of surface; A and B are empirical constants;
- Functions $v(y)$ and $t(y)$ represents the image charge effects, detailed in [Y. Feng and J. P. Verboncoeur's paper] with: $y = \sqrt{\frac{e^3}{4\pi\varepsilon}}\frac{\sqrt{\beta E}}{\varphi} = 3.795 \times 10^{-5}\frac{\sqrt{\beta E}}{\varphi}$.

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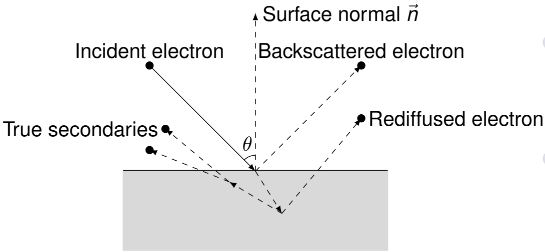

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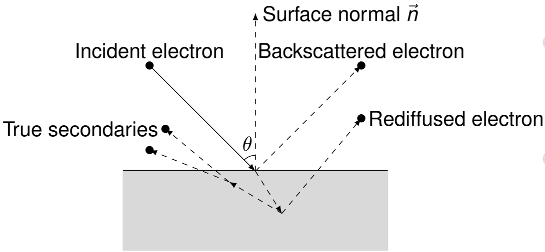

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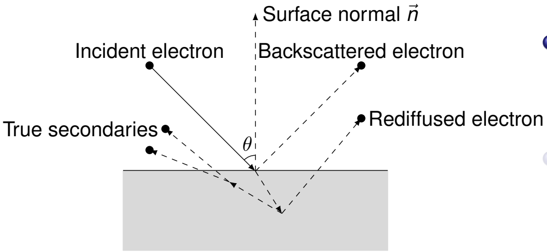

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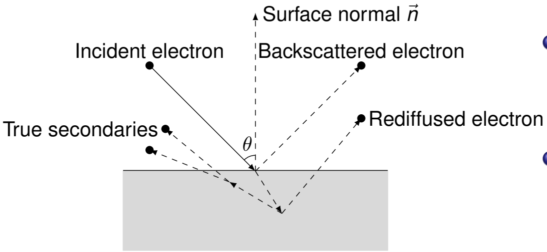

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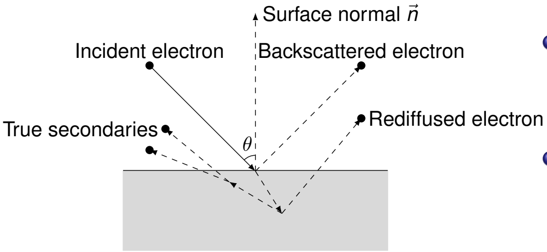

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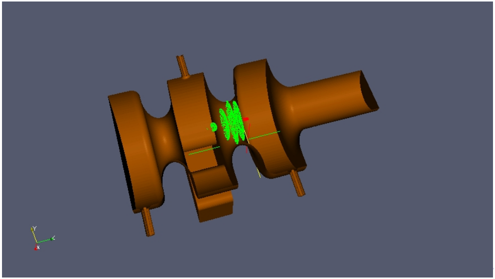
- We add a post processing feature which shows the origin positions and phase of dark current particles which are alive beyond user specified positions.
- Animation of CTF3 gun
- Dark current of the new gun.



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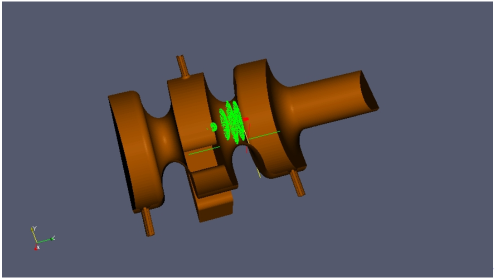

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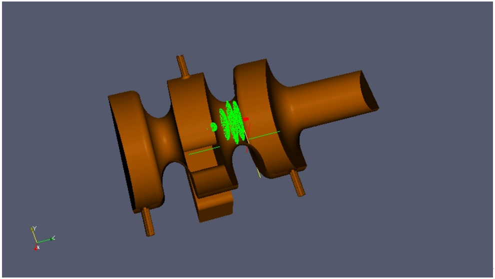

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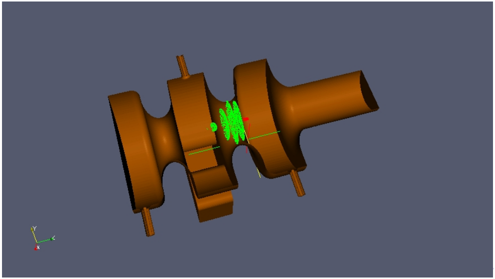

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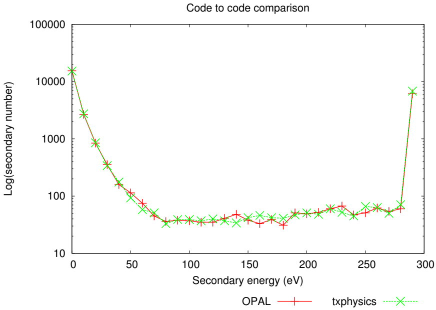

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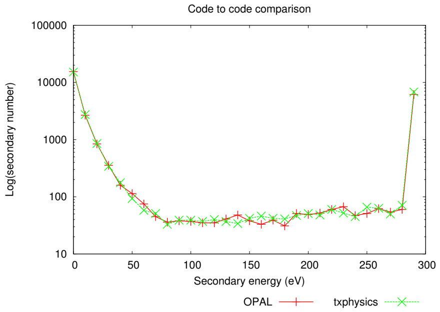

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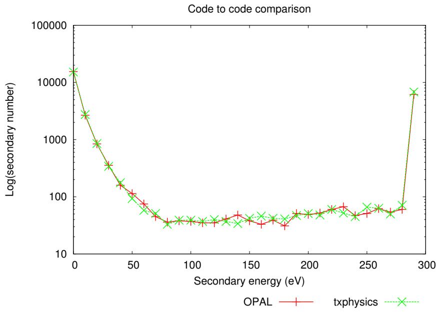

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REFERENCES

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