Track3P

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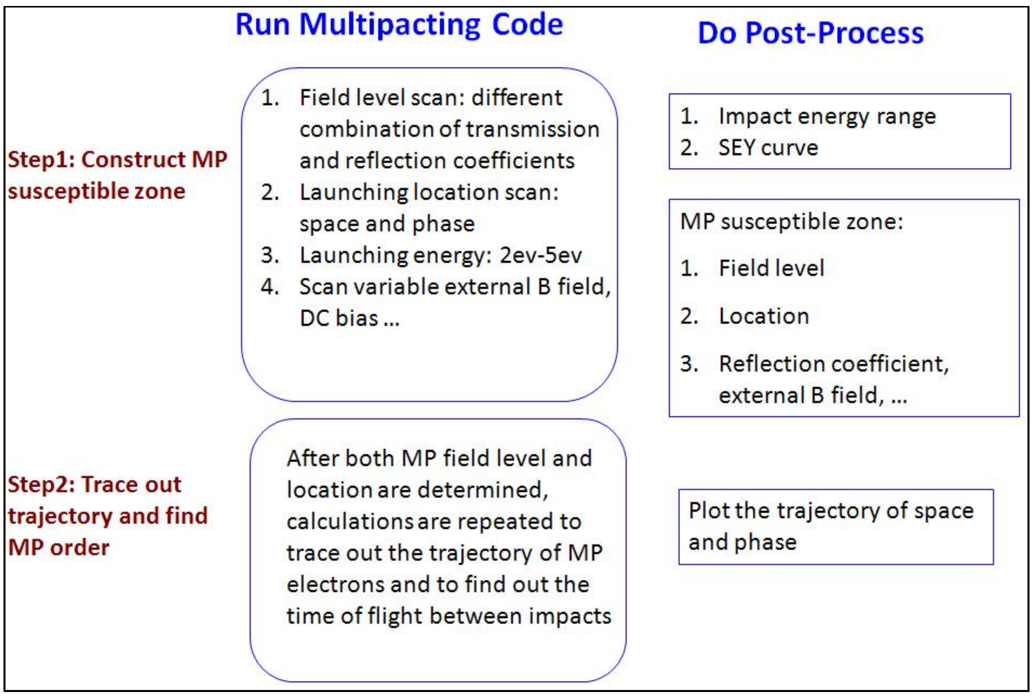
Table of Contents

Introduction

Track3P is a 3D parallel particle tracking code for multipacting and dark current simulations. Track3P provides unprecedented capabilities for modelling complex structures with fast turn-around times and has been successfully used to predict multipacting phenomena in many accelerator components such as the ILC ICHIRO cavities, TTFIII coupler and its components, SNS coupler and cavities,...

Multipacting procedure



Mathematical Modeling

Motion equations and Numerical scheme

$$\frac{d\vec{p}}{dt} = e\left(\vec{E} + \frac{1}{c}\left[\vec{v} \times \vec{B}\right]\right), \vec{p} = m\gamma\vec{v}, \gamma = \frac{1}{\sqrt{1 - v^2/c^2}}$$

$$\vec{r}_{n+1} = \vec{r}_1 + (\vec{v}_n + \vec{v}_{n+1})\frac{\Delta t}{2}, \vec{r}_1 = \vec{r}_n + \frac{1}{2}\vec{v}_n \Delta t$$

$$\vec{p}_{n+1} = \vec{p}_2 + \vec{E}(r_1, t_n)\Delta t \qquad f_2 = 2\frac{f_1}{1 + f_1^2\left|\vec{B}^2\right|}$$

$$\vec{p}_2 = \vec{p}_1 + f_2(\vec{p}^2 \times \vec{B}) \qquad f_1 = f_g \mathrm{tg} f_g^2\left|\vec{B}^2\right|$$

$$\vec{p}_1 = \vec{p}_n + \vec{E}(r_1, t_n)\Delta t \qquad f_g = \frac{ec\Delta t}{2\sqrt{\vec{p}^2 + mc^2}}$$

Omega3P fields interpretation

$$\overline{E}(x, y, z, t) = s\sum_i \overline{E}_i(x, y, z)\sin(w_i t + \psi_i)$$

$$\overline{B}(x, y, z, t) = \mu_0 s\sum_i \overline{H}_i(x, y, z)\cos(w_i t + \psi_i)$$

$\mathbf{E}_i$, $\mathbf{H}_i$ – Eigen modes

$\omega_i = 2\pi F_i$ – Eigen frequencies

ψ_i – Initial oscillation phases

$s = \frac{eU_{accel}}{\varepsilon_{stored}}$ - scale factor.

Field emission

Fowler-Nordheim law:

$$J(r,t) = 1.54 \times 10^{\left(-6 + \frac{4.52}{\sqrt{\varphi}}\right)} \frac{(\beta E)^2}{\varphi} e^{\left(\frac{-6.53 \times 10^9 \varphi^{1.5}}{\beta E}\right)}$$

$$v_0 = \sqrt{\frac{2|e|\varphi}{m}}$$

φ - Work function of the metal (i.e., 4.4 for Cu)

β - Field enhancement factor (300 typical)

E – Magnitude of external electric field

m – Mass of an individual particle

Secondary emission

$$I_{secondary} = I_{primary}\,\sigma(\varphi,\varepsilon),$$

$$\sigma = \delta + \eta + r,$$

where

δ - Coefficient of elastic scattering

η - Coefficient of non-elastic scattering

r – Coefficient for true secondary electrons

Past Accomplishments