The Field Emission Simulator (FES) Current Status

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June 2, 2014

Introduction

There are currently several simulations offering solutions to modelling the phenomena of field emissions and dark current propagation.

The FES (Field Emission Simulator) was built as a high statistics, dark current tracking code, with planned interfaces to Beamline modelling tools - most notably is MAUS.

Originally desgined to be a "quick and dirty" dark current spectrum producer - it has since grown and expanded to improve the accuracy

FES

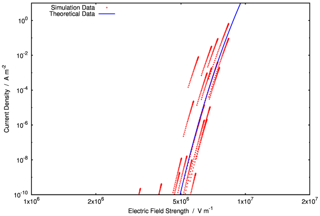
Some details on the simulation:

Simulation Program	C++
Analysis Library	Python
Configuration	XML
Equation of Motions	Runge-Kutta Order 4
Output Formats	Text file, VRML and a compressed data fomat

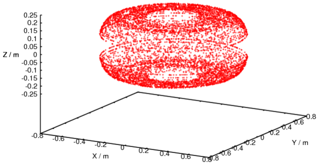
Driven by well known relativsitc mechanics, electromagnetic fields, and ionisation energy losses. The weak point is how we configure the Fowler-Nordheim Emitters.

Capabilities

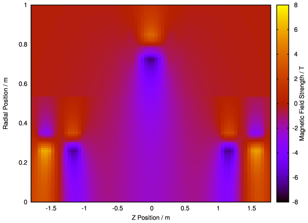
- Field map reader and simulation
- Accurate cavity construction from surface maps
- Fowler-Nordheim Simulation
- High satistics - typically ∼1-10 million
- Tunable emitter distributions
- (Part-finished space charge simulation)



Comparison between simulated Fowler Nordheim Emitters and the Theory



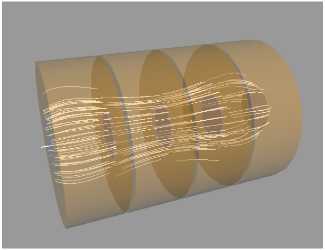
Locations of emitters in a single cavity



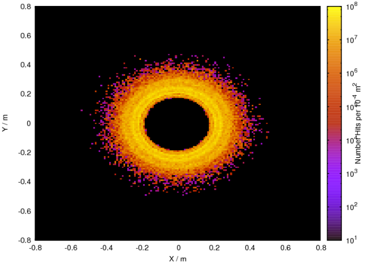
An example field map for an RFCC

An Example RFCC Simulation

Left Image: Particle tracking working well
Right Image Beginnings of the breakdown & cavity heating studies has started



An example geomtry with some electron tracks included



Cross section of all electron-cavity impacts

Planned Improvements

There are two ways to significantly improve the results of the simulations - improving/expanding the physics models used and tuning/changing the configuration.

Improving the physics models:

- Finish the space charge module
- Finish the cavity heating analysis to predict possible breakdown sites
- Full X-ray simulation from electron-cavity interactions
- Look at time varying enhancement factors and dynamic emitter creation & destruction

Improving the configuration:

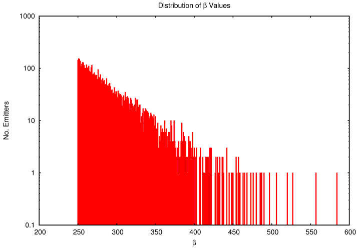
For that we need some data!

Improvements from Data

Configuration Improvements Measurements

- Enhancement factors and emitter site properties
- The distributions of enhancement factors and work functions across the emitters
- How emitters change with time - creation or destruction of emitters due to multipacting

All these parameters require physical studies of emitter sites in high gradient electric fields.
Improving the knowledge of them would improve the simulation



Currently used distribution of enhacement factors

Improvements from Data

Tuning Improvements Measurements

- Measurements of dark current flux at large and small (ideally ∼ns) timescales
- Distrbution of dark current accross the cavity window aperture
- X-ray and dark current angular distrbutions through the windows
- Energy spectra of any measured dark currents or X-rays

These measurements would not directly affect the configuration of the simulation, however algorithms could be used to adjust the configuration to better match the data.

Benefits from MTA Results

Any direct measurements of emitter site parameters before and/or after tests would be useful.

Measurements of dark current leaving cavities would be useful in simulation tuning

Any other external detector measurements could be used for tuning. Simple detectors are currently part of the simulation!

Conclusions

So far - so good.
The basics are in and we've passed all the sanity checks.

No significant physics improvements left to make - but plenty of room to tune and correct the simulation with data

Very interested in looking at breakdown studies and dynamic emitters to advance the simulation.