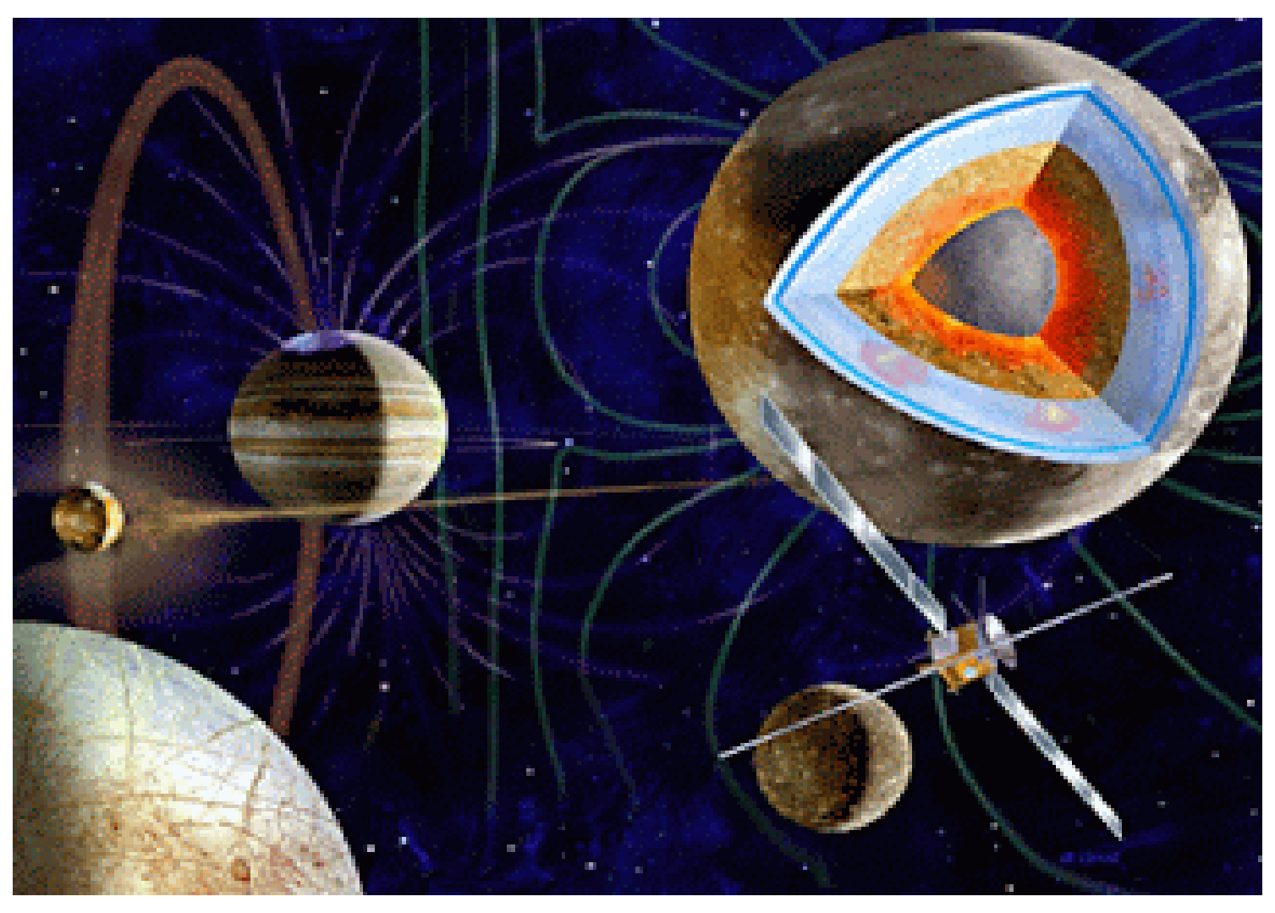

Monte-Carlo Internal Charging Too: MCICT

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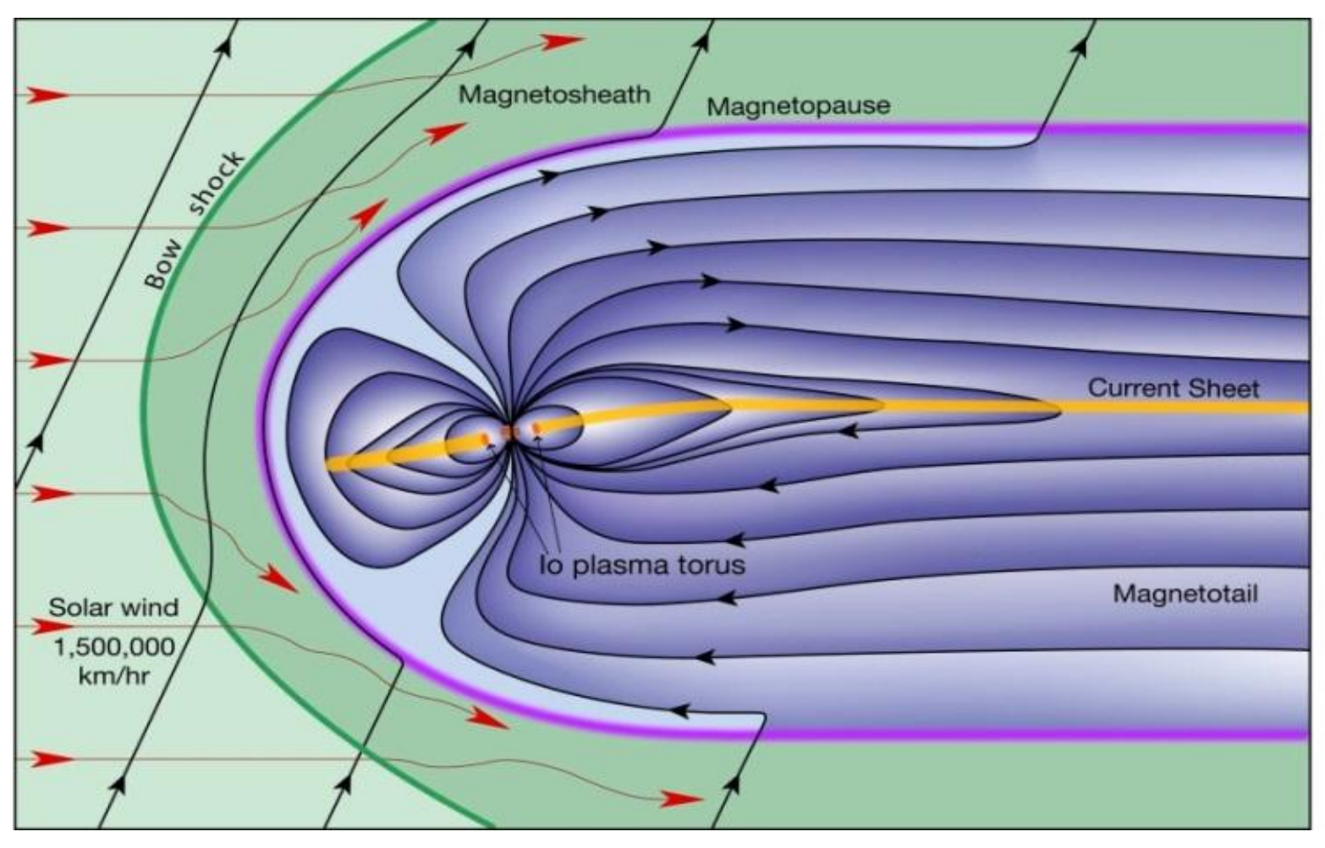
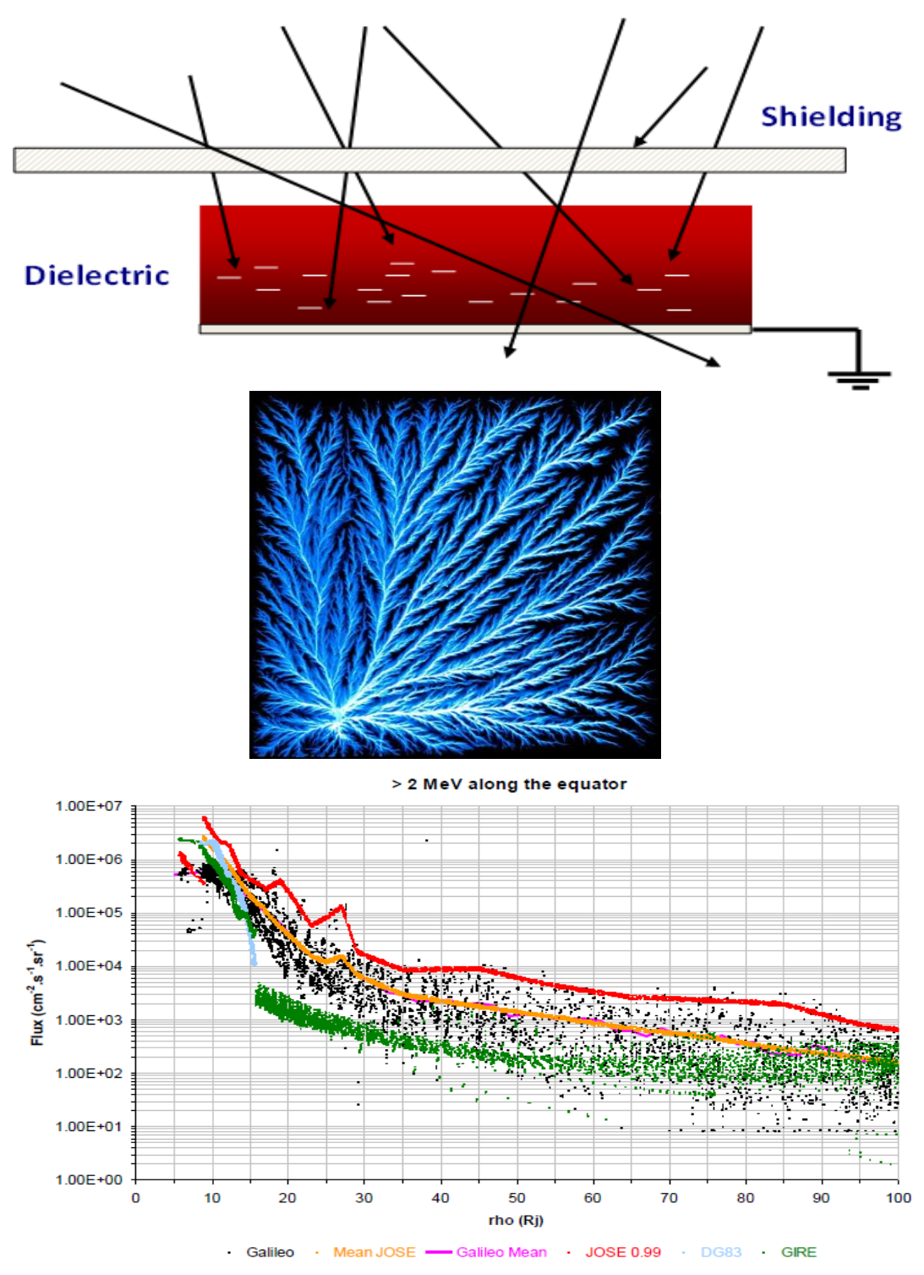


Introduction

- Charging environment presents important risk to Jupiter missions
  - Internal (deep dielectric) charging from electrons >100 keV
  - Surface charging from lower-energy plasma
- Numerous incidents of charging events for Voyager and Galileo
- Requirements for better engineering model for internal charging
  - Gap between DICTAT engineering tool and more detailed models (SPIS)

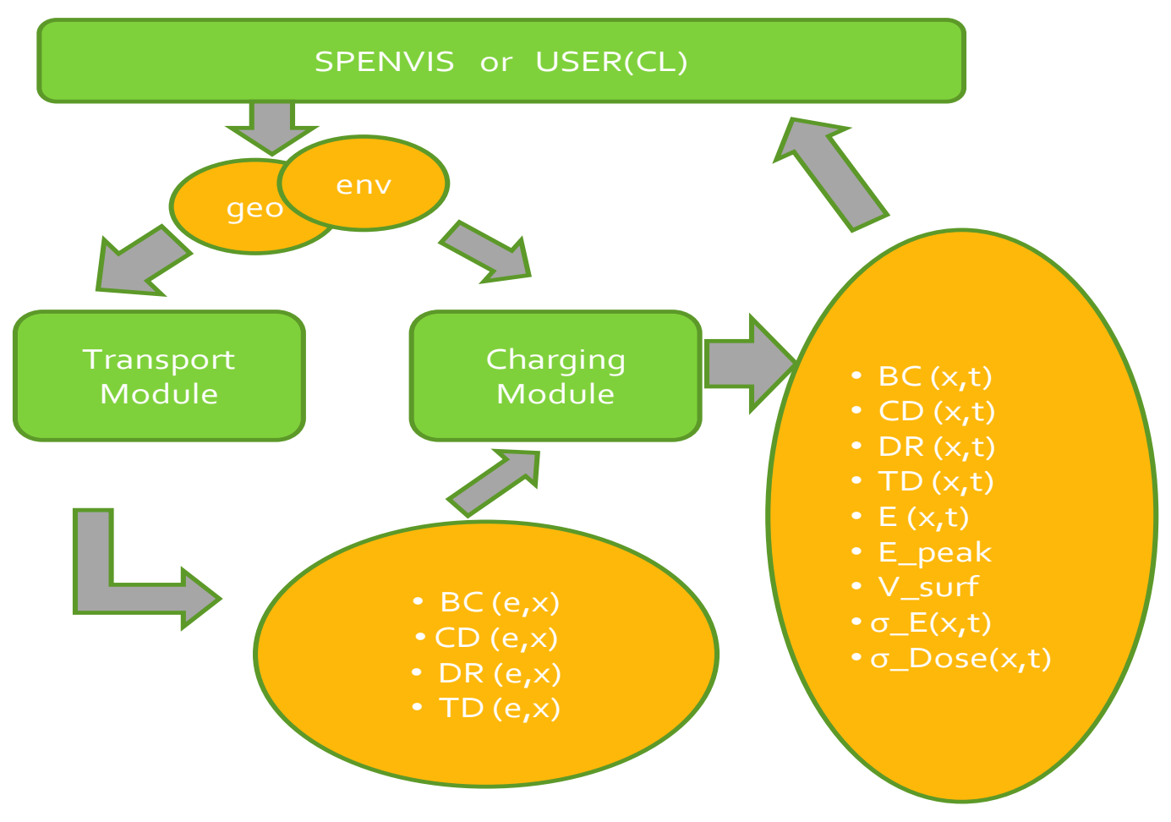
DICTAT (Dielectric Internal Charging Threat Assessment Tool) is a widely used ESA-developed simulation tool for performing simple 1-d internal charging analyses in an engineering context. Since most spacecraft that are subject to significant internal charging effects are found in geostationary orbit, the DICTAT code was originally focused on typical geostationary environments and typical materials used in geostationary spacecraft. The analytical current transport equations are valid for electrons up to 10MeV and for the common low-Z materials used in spacecraft, including the common aluminium and carbon-fibre structural materials and plastics where charge often accumulates



MCICT – Monte Carlo Internal Charging Tool

- A New 1D Internal Charging Tool, for the JUICE mission
  - Multi-layered structure, in slab or cylindrical shape
  - User defined dielectric, shielding, grounding material definition
- Geant4 Monte Carlo based particle transport
  - For both electron and proton environment
  - Variable environment, spectral and temporal
- Fast field solver based on Ohm's law
- Build-in visualization plotting features
- Python and C++ implementation
- Stand alone package available for both Windows and Linux platforms
- Also available on SPENVIS

MCICT – Code Overview



- Transport Module
  - Updated GRAS
  - Slab/Cylindrical geometry – arbitrary layers of shields and dielectrics
  - Per layer based tallies - > Response Functionss
- Charging Module
  - Convolution of the RFs and the Envs.
  - Field solver – Omh's law
  - Plotting
- Execution:
  - Controlled via a simple ASCII input file

An example of MCICT input file

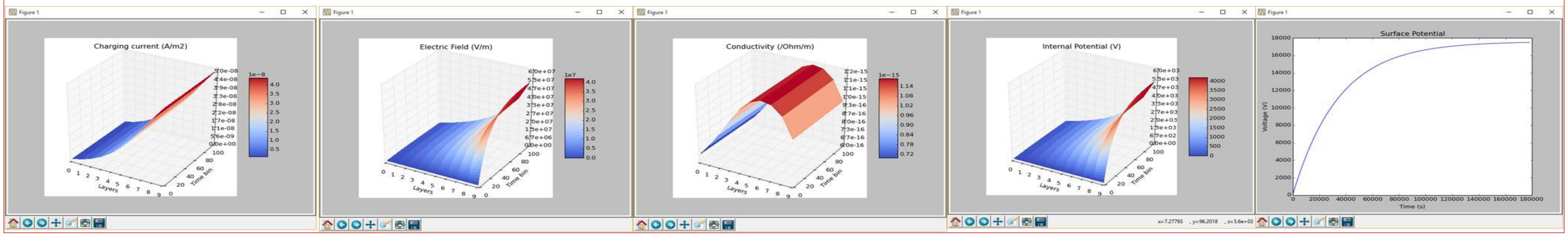
```
___Env___
# 9 options are available
e-, MeV, /cm2/s, iso
Pow, -0.5, 0.5, 5.
0., 1e6
100., 1e7
1800.,1e5
___Geo___
# slab/cylinder
cylinder
# the first layer is at the outer most!
# layer_name, thickness, material, temp, D/G/F, n-sub
# (thickness in mm, temp in K, D: dielectric; G: ground; F: floating
#  metal)
L1 , 0.1,  G4_Al , 110,  G , 1
L2 , 0.2,  G4_MYLAR , 110,  D , 20
L3 , 0.1,  G4_Cu , 110,  F ,1
L4 , 0.2,  G4_TEFLON , 110,  D , 20
L5 , 0.1,  MyAl , 110,  G , 1
```

```
___Mat___
# MULASSIS format
MyAl Al 2.0

___Die___
# name, permitivity, dark_conductivity, kp, delta, ea
#(see README for definition and units)
G4_MYLAR , 2.31, 9.31e-16, 4.0e-15, 0.61, 0.81
G4_TEFLON , 2.31, 9.31e-16, 4.0e-15, 0.61, 0.81

___Obs___
#step/table
# step, start time, end time, nr of steps (time in seconds)
step, 60, 3600, 60
# plotting (true) or not (false)
batch, false
#
# events, output_mod, number of events, true/false - run GRAS?
events, 100000, 100000, true
```

MCICT – Results



Comparison with other codes – NUMIT2 & DICTAT4.1: 1 mm PMMA, 0.5 MeV e-

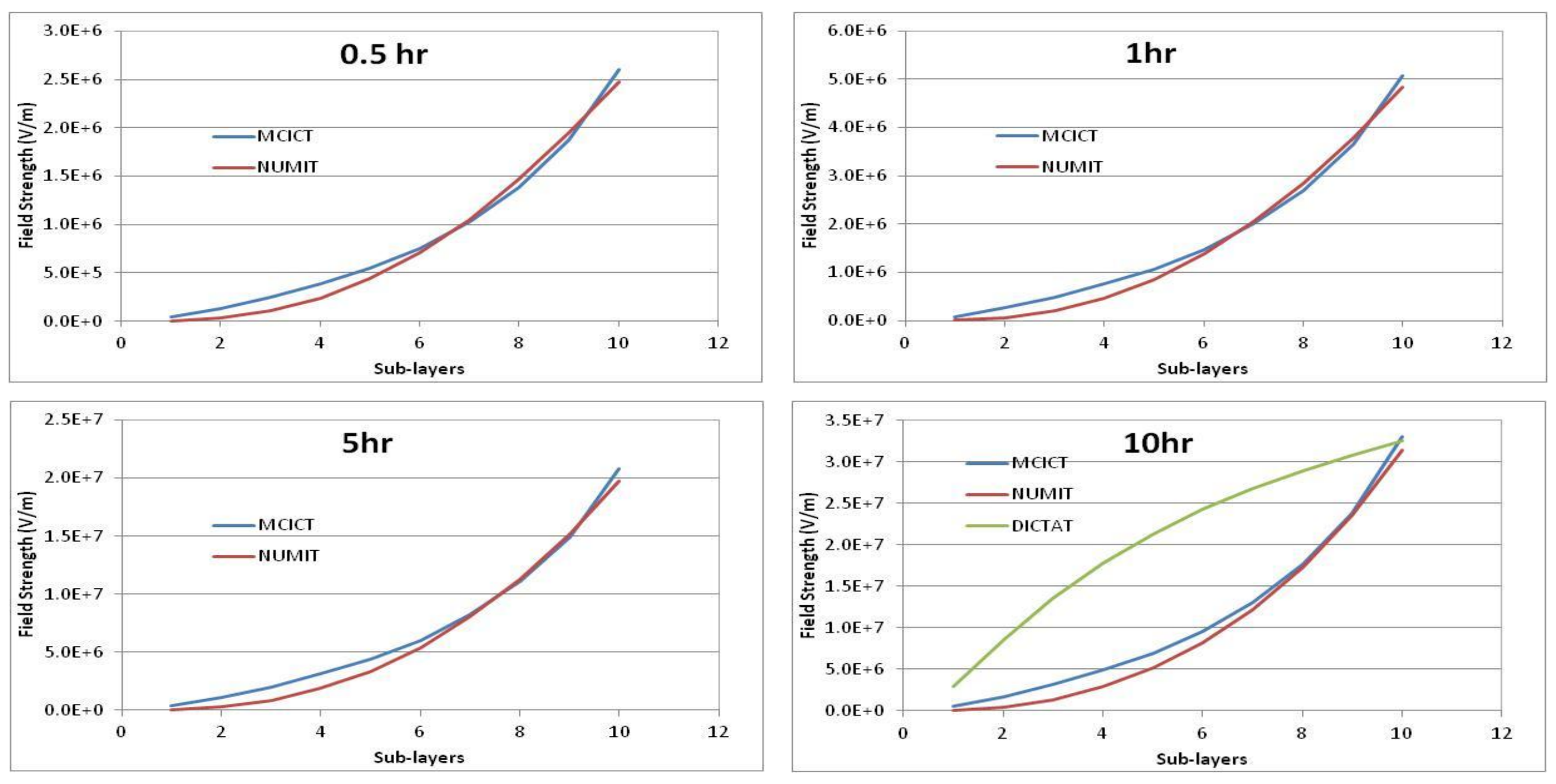
- Setup
  - 1 mm PMMA, grounded on the back side only
  - Conditions and material parameters are outlined in the table below, plus Δ=1.0
  - PMMA divided into 10 sub-layer

INPUTS TO NUMIT FOR THE SAMPLE PROBLEM

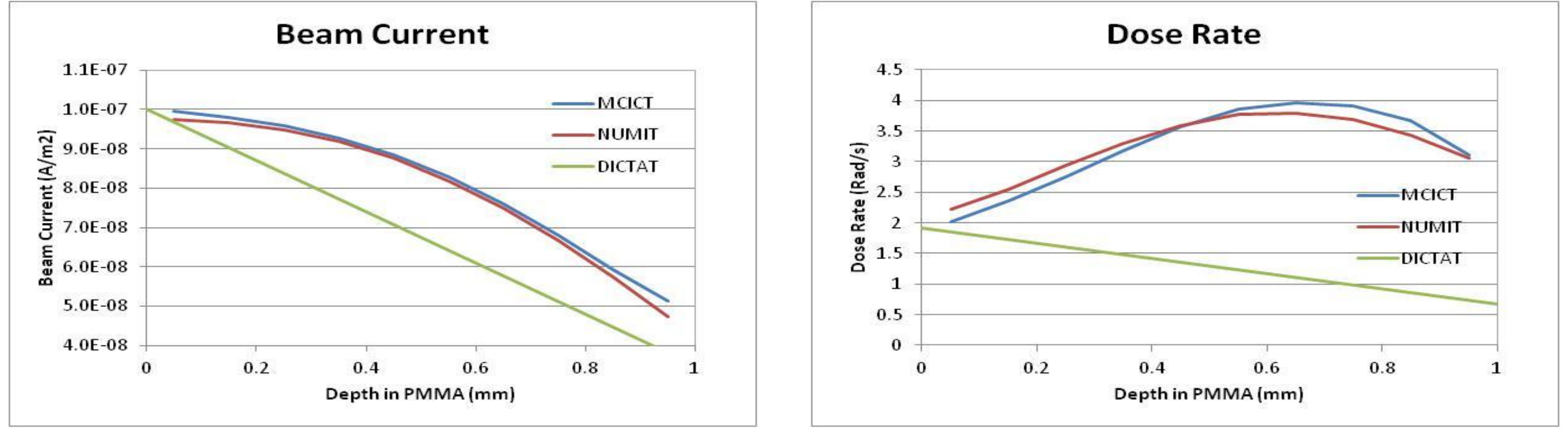
J_{inc}	electron beam current	-1.0×10^{-7}	A/m^2
T_0	electron beam energy	0.5	MeV
d	dielectric thickness	0.001	m
Z_{eff}	effective atomic number of the dielectric	6	
A_{eff}	effective atomic mass of the dielectric	12	
ε	dielectric permittivity at 300°K	3.28×10^{-11}	F/m (κ = 3.71)
ρ	dielectric's density	1.19	g/cm^3
g_{dark}	dark conductivity	1.0×10^{-16}	$ohm^{-1}\ m^{-1}$
g_{rad}	radiation induced conductivity	2.76×10^{-16}	$sec\ ohm^{-1}\ m^{-1}\ rad^{-1}$

- NUMIT 2:
  - Need to inset a 1m air gap between the front electrode and the PMMA layer
  - PMMA sliced into 10 layers, and the derived parameters per layer are the average at front and back boundaries
- DICTAT 4.1:
  - Dose-rate, beam current calculated from formula

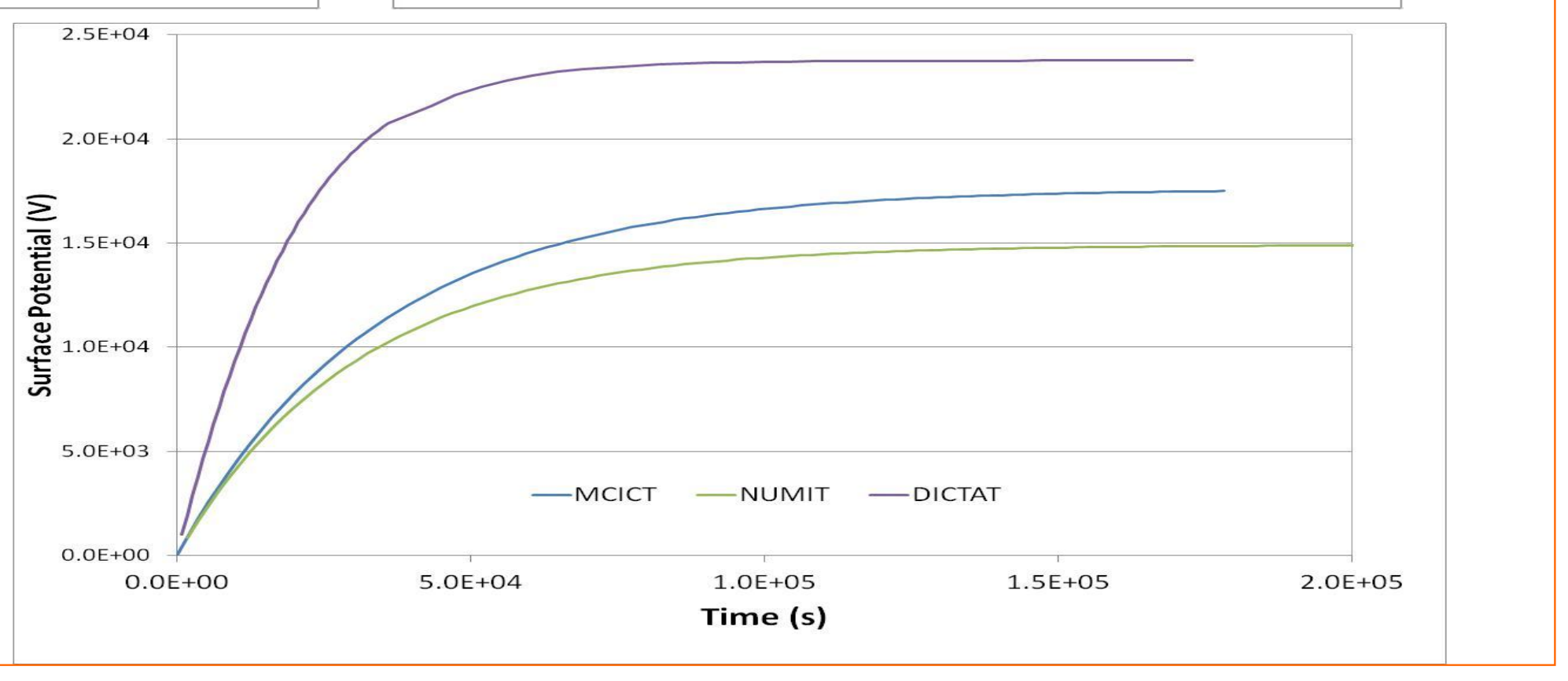
Electrical Fields



Initial dose rate and charging current



Surface Potential



Future Work:

- Validation with experiment data
- Comparison with CIRSOS/SPIS-IC
- Improved charging physics model
- Alternative field solver

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