# MPI Pulse Shape Simulation

## Outline:

- Motivation
- Pulse shape simulation: using 4-fold Segmented BEGe as an example
- Summary & outlook


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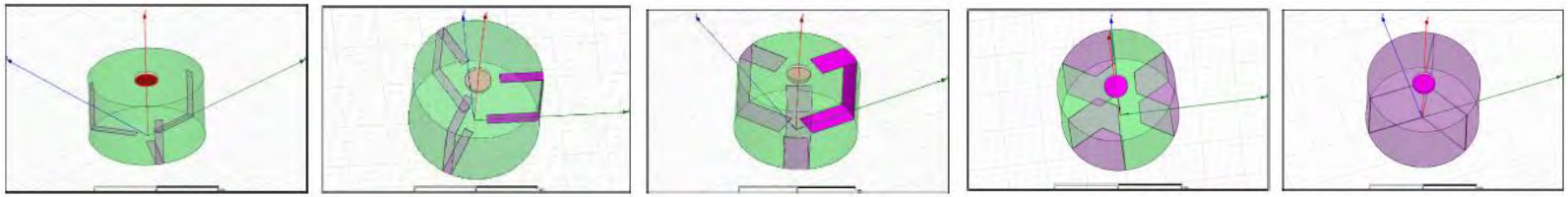
# Pulse Shape Simulation

## Why pulse shape simulation?

- **Improve the understanding of Ge detector**
  - impurity distribution
  - electron & hole mobility
  - charge trapping
  - charge collection efficiency

  } On the way we can learn
- **Sensitivity to event position**
- **Help on detector design**



➡ **Cost of HPGe detector >> cost of PSS**

- **Powerful tool for real data analysis**

# Framework of MPI Pulse Shape Simulation

**1 Physical process generation**
**[GEANT 4]**

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**Hits/Clustering**

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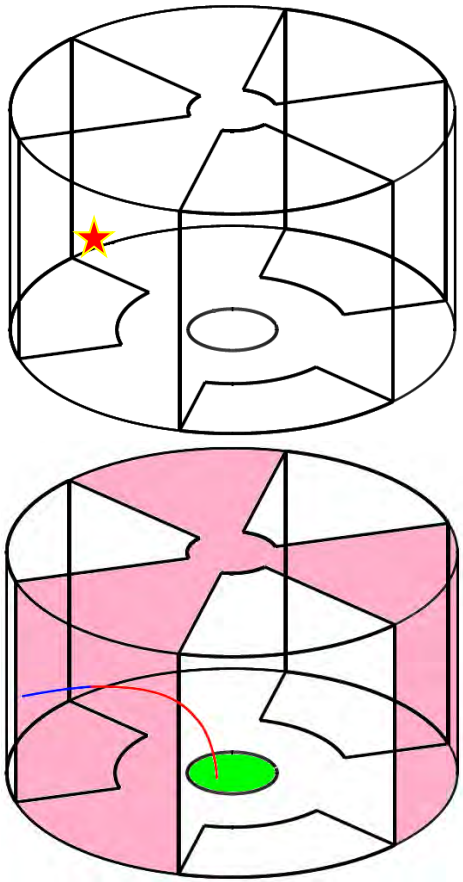
**2 Charge carriers drift in the bulk**
**[PSS in MaGe]**

↓

**3 Induced charge on the electrode**
**[PSS in MaGe]**

↕

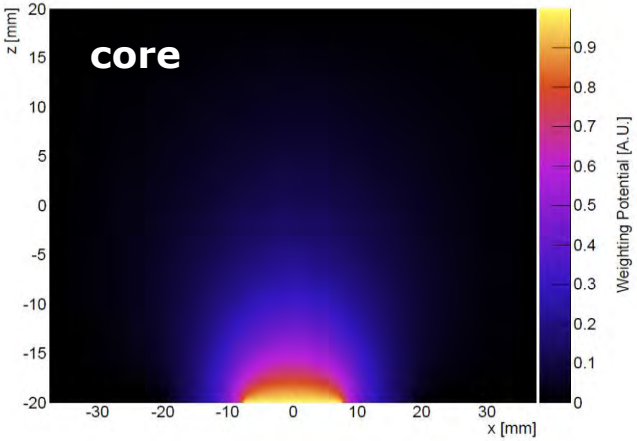
**Measurements**

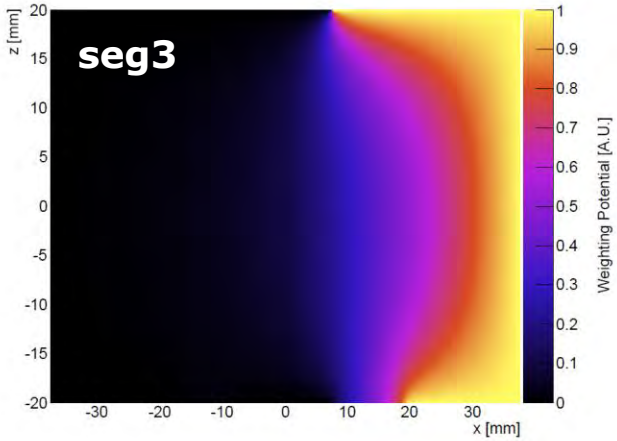


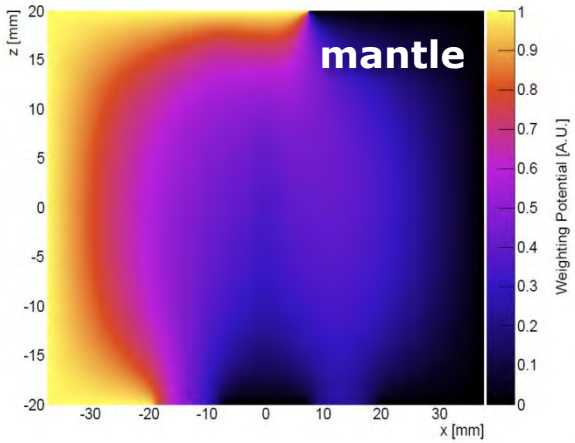

**Ramo-Shockley theorem**

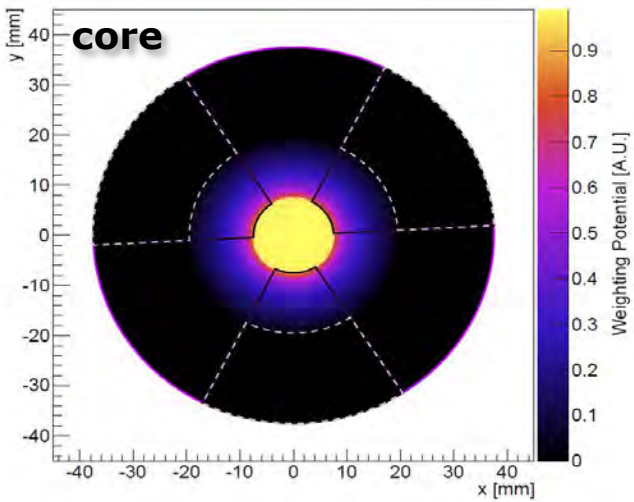
$$Q(t) = -q \times [\phi_w(\vec{r}_h(t)) - \phi_w(\vec{r}_e(t))]$$

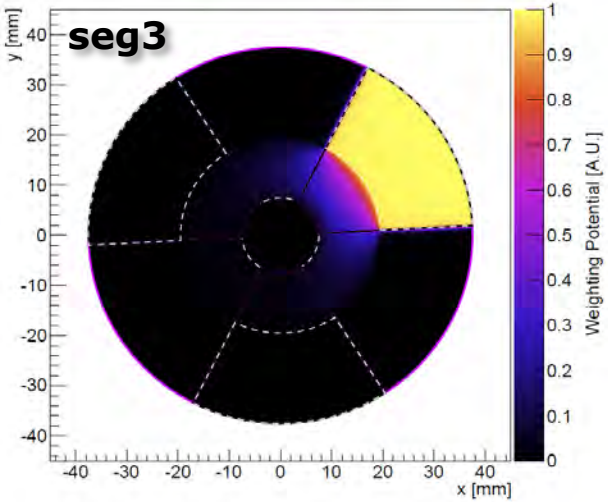
# Weighting Potentials of Segmented BEGe Detector

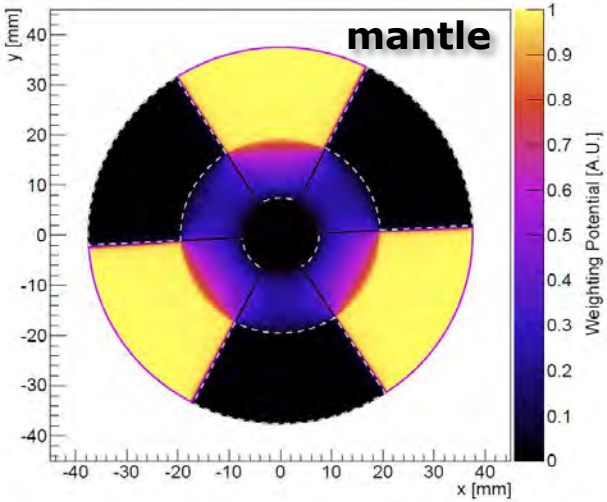


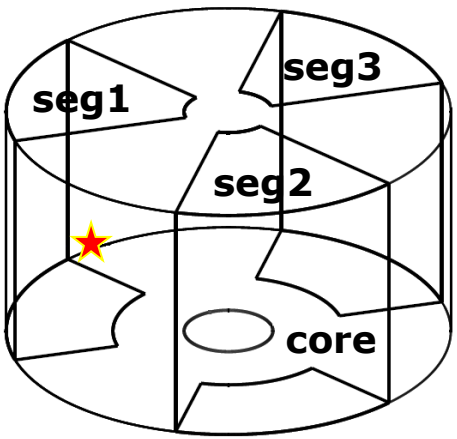



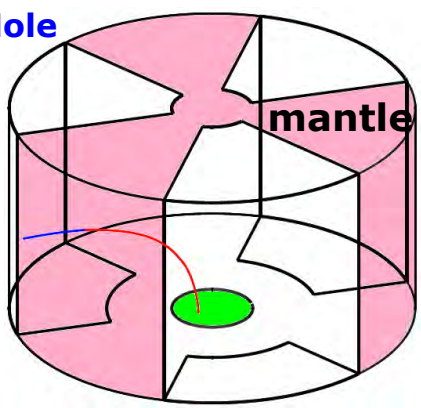



# Pulse Shape Simulation: An Example

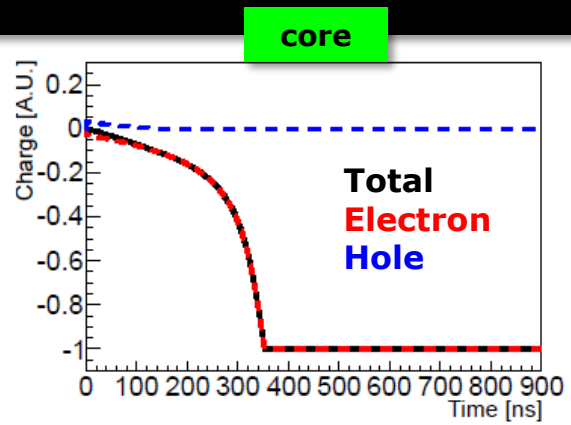


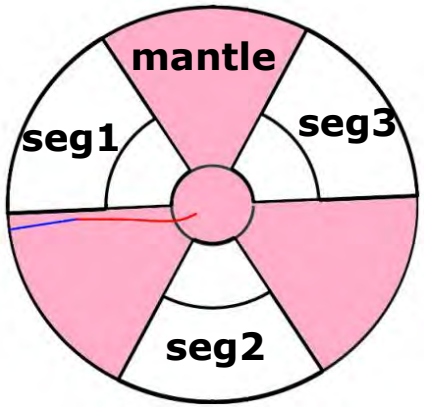

single hit in the bulk

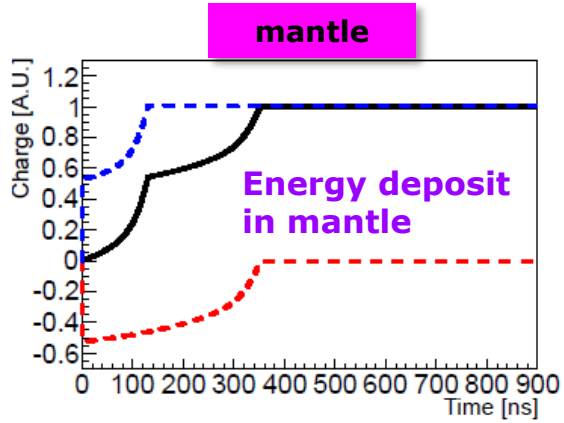
- Electron
- Hole

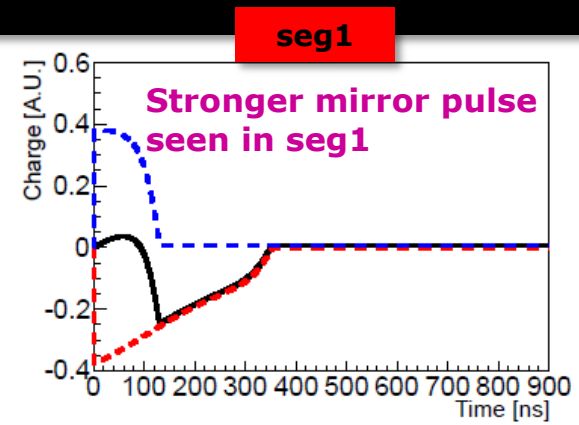


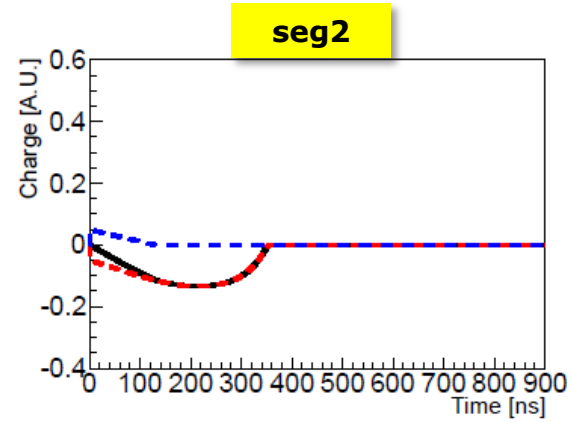

Charge carriers drift in the bulk

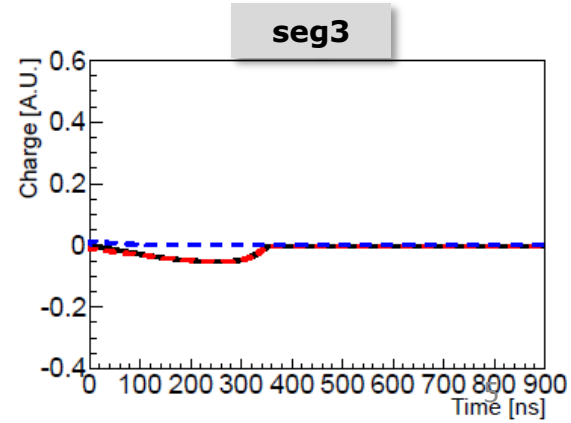


# Important parameters in Pulse Shape Simulation

## Parameters that affect trajectories

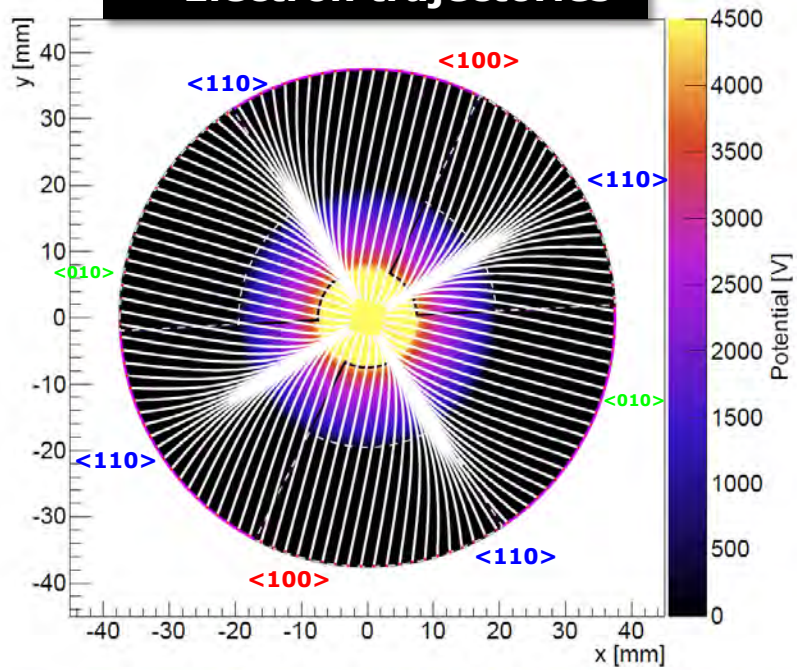
- Detector geometry
- Crystal axes orientation
- Impurity concentration (space charge)
- Carrier drift velocity
- Others:
  temperature, thermal diffusion, self repulsion, ...

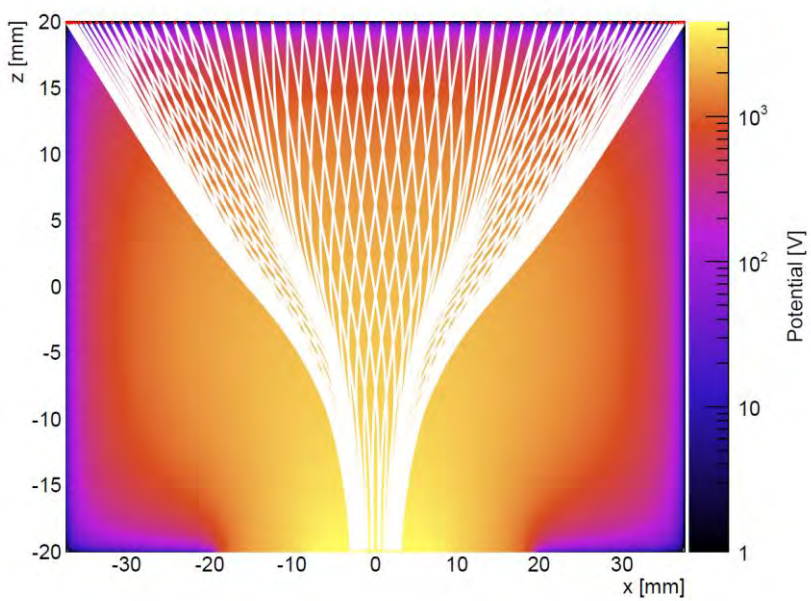
## Parameters of electronics

- Bandwidth, decay time of the signal, noise, response function of electronics, ...
  [ref: Eur. Phys. J. C (2010) 68: 609-618]

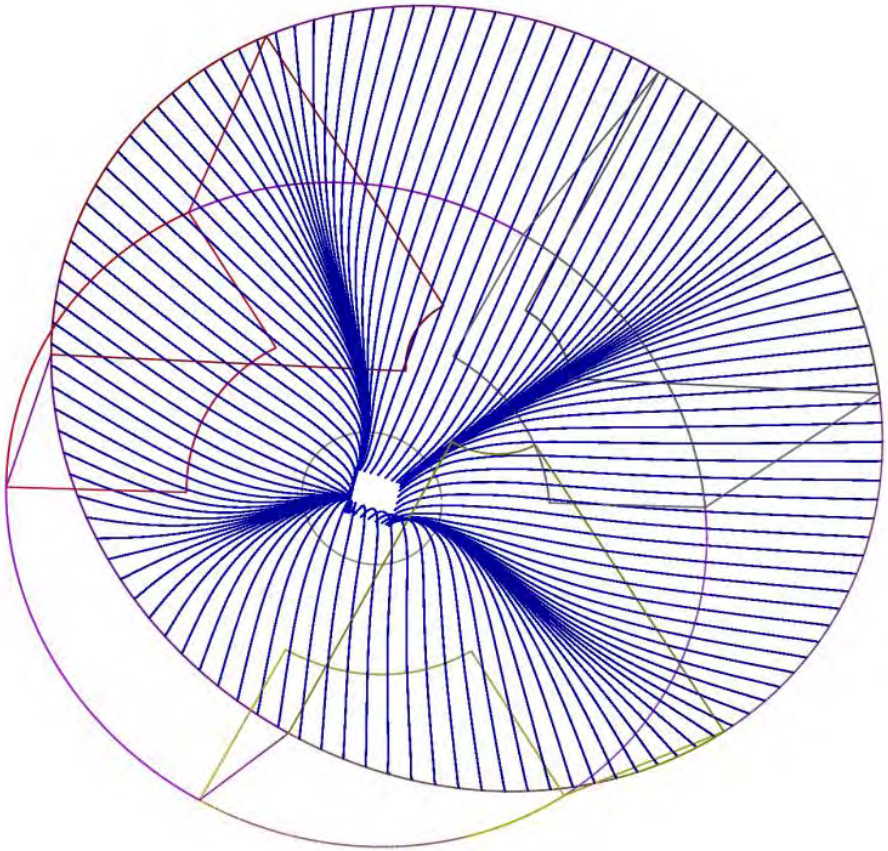
# Crystal Axes Orientation

- **Electron trajectories**



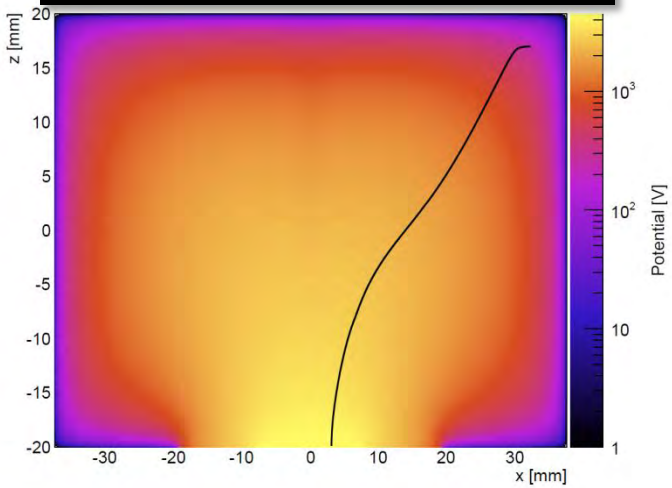




## Electron trajectories

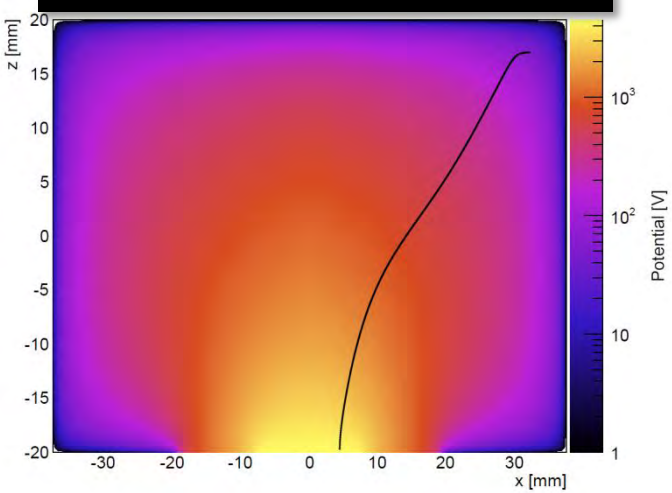


# Effect of Changing Impurities in PSS

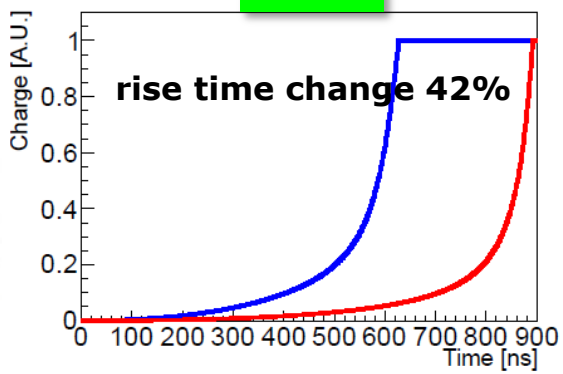
**ρ(top-bot): (0.95-1.30)x10$^{10}$ 1/cm$^3$**



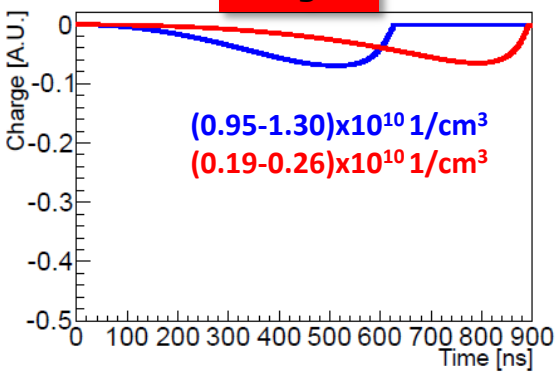

**ρ(top-bot): (0.19-0.26)x10$^{10}$ 1/cm$^3$**

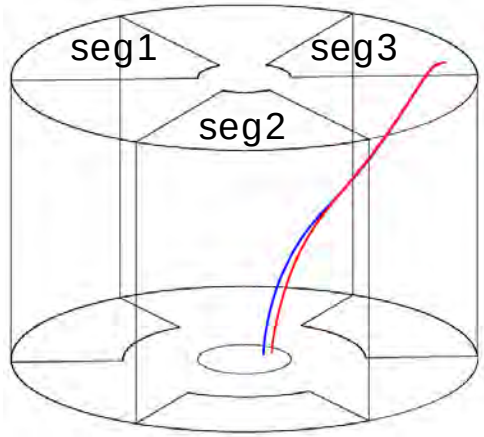



**core**

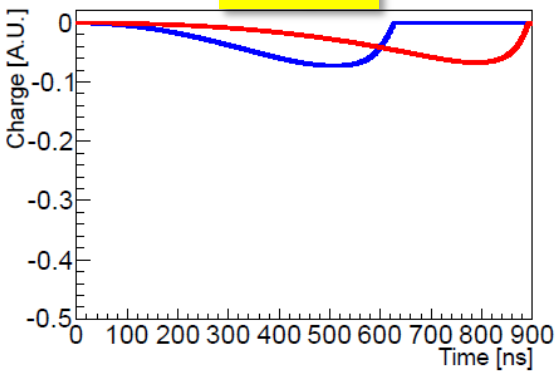



**seg1**

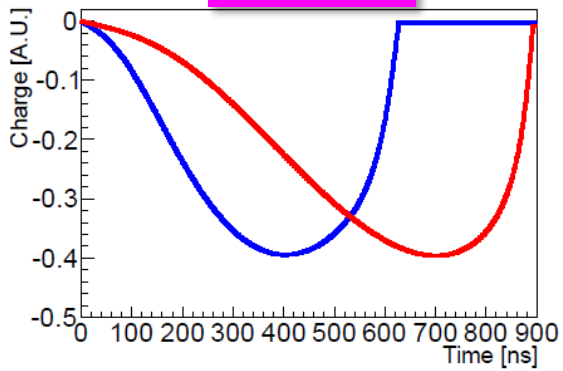


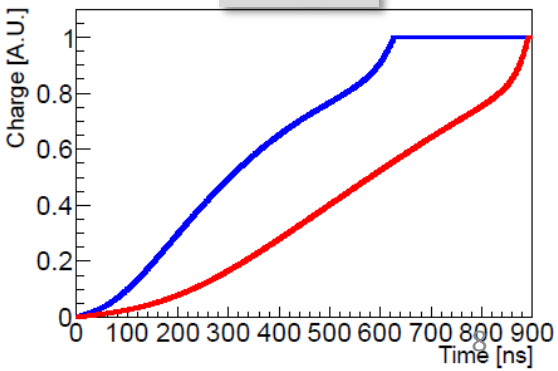

**seg2**




**mantle**




**seg3**

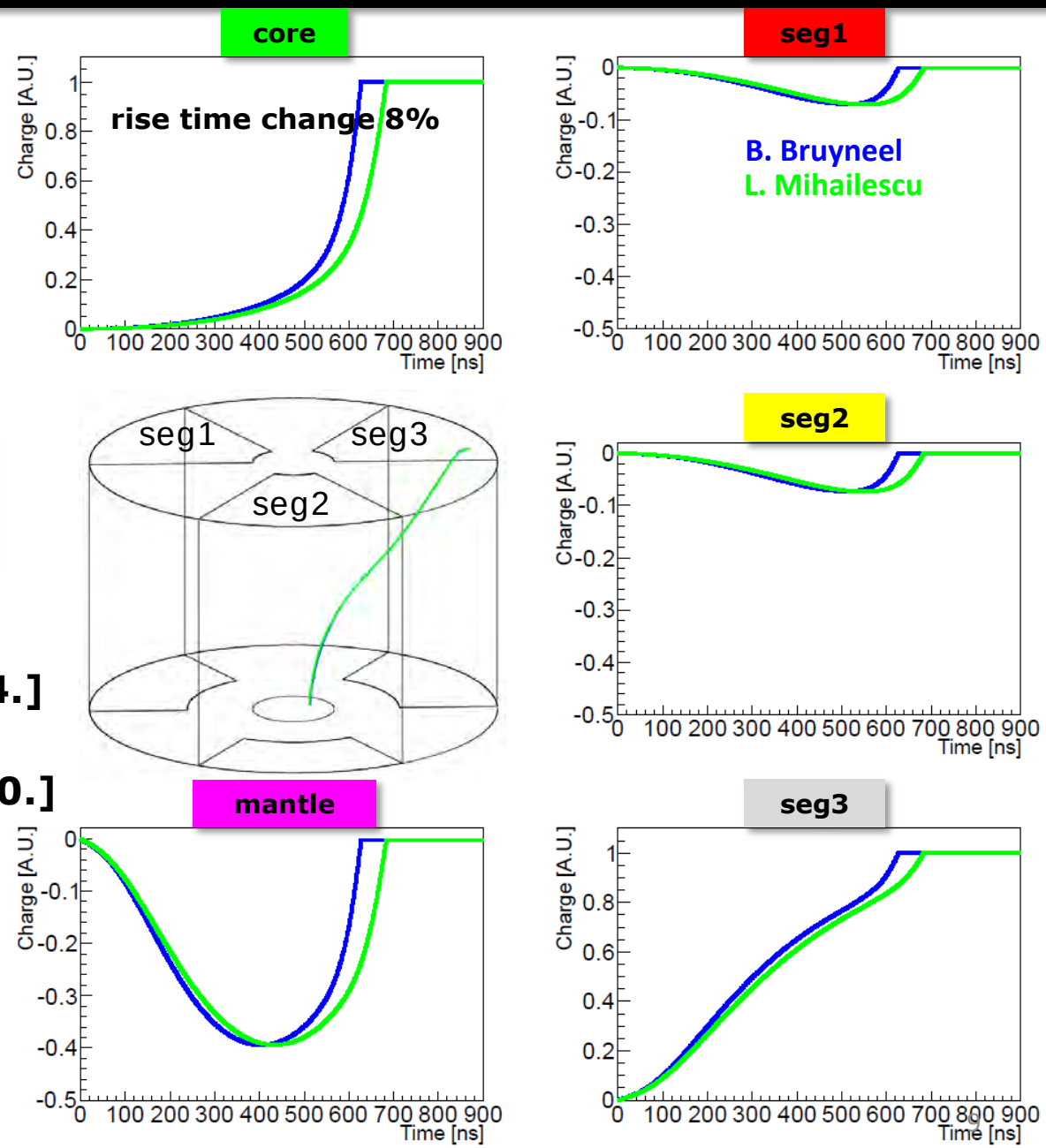


# Effect of Changing Charge Carrier Mobilities

- **Two papers with different mobility parametrizations:**

$$v = \frac{\mu_0 E}{[1 + (\frac{E}{E_0})^{\beta}]^{1/\beta}} - \mu_n E$$

- **B. Bruyneel et al., [NIMA 569 (2006) 764.]**
- **L. Mihailescu et al., [NIM A 447 (2000) 350.]**



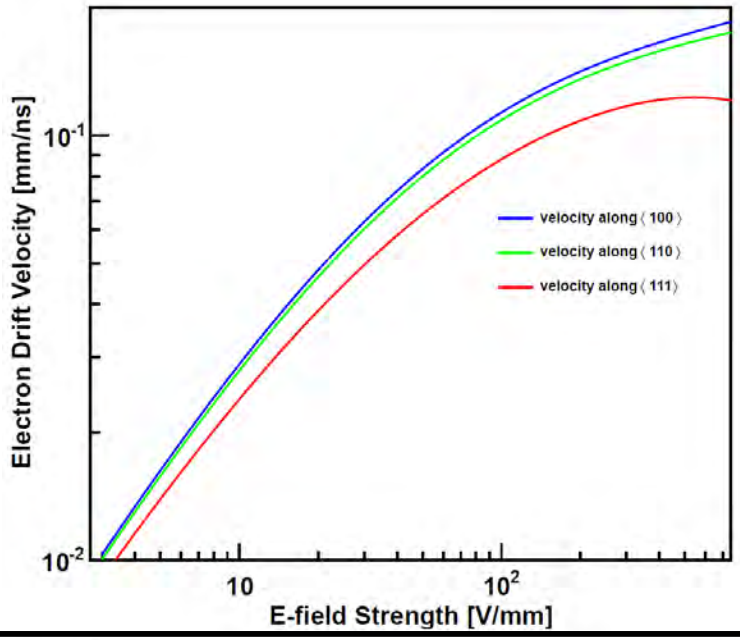
# Summary & Outlook

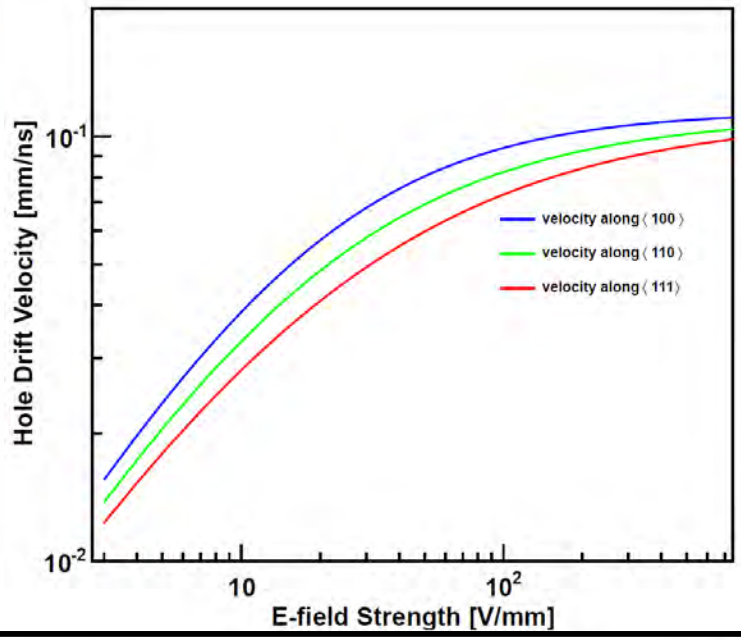
- **MPI simulation packages:**
  - **Physics process generation using GEANT4**
  - **Pulse shape simulation using MPI PSS implemented in MaGe**
- **Validation of PSS:**
  - **Compare to measurements**
  - **Fine tuning input parameters in PSS**
- **Development of PSS tools to study event topologies of the 4-fold segmented BEGe detector ongoing**
- **Extract MPI PSS from MaGe**
- **PSS event library: Cover full volume**
- **Add T dep., flex. Mob., diffusion, self repulsion**


FREE BONUS!

# Mobilities

**B. Bruyneel et al.**




**L. Mihailescu et al.**