# WG4 Updates & Discussion

20 June, 2024

Marco Mandurrino  ([marco.mandurrino@cern.ch](mailto:marco.mandurrino@cern.ch))

1st DRD3 Collaboration Meeting
CERN, 17–21 June, 2024

- Very precious contributions about Monte Carlo status and developments
  - **LGAD**, **SiPM**, **3D** sensor technologies are covered
  - **interaction particles/matter** module ($\rightarrow$GEANT4)
  - **signal digitization**
  - **time-dependent weighting field/potential** and **space-charge effects**
  - integration of **new material parameters**

| WG4 research goals <2027 | |
|---|---|
| | **Description** |
| **RG 4.1** | Flexible CMOS simulation adaptable to different technology nodes and development of connections between tools for device-level simulation and electronic circuit design/validation |
| **RG 4.2** | Implementation of newly measured semiconductor properties into TCAD and MC simulations tools |
| **RG 4.3** | Definition of benchmark for validating the radiation damage models with measurements and different benchmark models. |
| **RG 4.4** | Developing of bulk and surface model for $10^{16}\text{cm}^{-2} < \Phi_{eq} < 10^{17} \text{ cm}^{-2}$ |
| **RG 4.5** | Collate solutions from different MC tools and develop an algorithm to include adaptive electric and weighting fields |

# 1 – Feedback from the session(s)

- ## Other relevant feedback from this and other sessions

  - radiation damage models: M. Bomben, V. Subert - WG3, J. Burin & P. Gaggl - WP3 ⇒ **RG 4.3**, **4.4**

  - CMOS sensor simulation: H. Wennlöf ⇒ **RG 4.1**

  - front-end simulation: L. Tlustos ⇒ **RG 4.1**

  - simulations of new materials: J. Burin, S. Xiao ⇒ **RG 4.2**

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# 2 – Updates on WG4

**DRD3**
**– WG4 –**

- ## WG4 convener
  - **Håkan Wennlöf** (DESY) has accepted the role of **WG4 convener**

- ## Expressions of Interest
  - we received a new possible expression of interest from **Cambridge** (Sarah Williams) for a project involving WG4 and WG3 about **comparison of TCT measurements of irradiated sensors to TCAD simulation** $\Rightarrow$ **RG 4.3** (*definition of benchmark for validating the radiation damage models with measurements*)
  - the number of **participant Institutes** rises to **30**

- ## WG4 Structure and Organization
  - **Liaison Persons** (LP) survey
  - **General Meeting time slot** survey

  see next slide…

# 3 – WG4 Structure and Organization

**DRD3**
**– WG4 –**

- Liaisons Persons (LP). Very few questionnaires have been filled out. The outcome is that few people cover all the groups. Three possible approaches
  - **no LP**, due to the tight superposition of WG4 with other WGs and WPs
  - **LP only for "orthogonal" groups**: **WG7** (interconnections), **WG8**, **DRD7**
  - benefit from the work of **LP appointed by the other groups**

- General Meetings
  - **15 questionnaires** submitted, so far
  - the present consensus is on **Monday, 3pm – 4pm** (CERN time)
  - we would **wait for more submissions**: https://indico.cern.ch/event/1413316/surveys/5458
  - then, we will organize the **1st WG4 General Meeting**, indicatively in mid/late July (newdle-basis)
  - The task, at least at the very beginning, is to have a **complete view** of all the ongoing activities and search for **possible synergies** among sub-groups that **promote the achievement of RG**

# 4 – Topics for Discussion

**DRD3**
**– WG4 –**

- Any other ideas about the Liaisons Persons (LP) appointment?

- Content of the 1st WG4 General Meeting:
  - round-table?
  - focused presentations?
  - discuss "urgent" tasks related to selected projects?

- Are there topics not covered by our WG?

- AoB?

Just to remind you our Useful Links, in case of late comments:
- WG4 webpage: https://drd3.web.cern.ch/wg4
- WG4 e-group: drd3-wg4-simulations
- WG4 contact email: drd3-wg4-conveners@cern.ch
- DRD3 Scientific Proposal (v3.1): pdf

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# WG4 Research Goals (2024-2026)

**RG 4.1**  Flexible **CMOS simulation** adaptable to different technology nodes and development of **connections** between tools for **device-level simulation** and **electronic circuit design/validation**

**RG 4.2**  Implementation of **newly measured semiconductor properties** into TCAD and MC simulations tools

**RG 4.3**  Definition of **benchmark** for validating the **radiation damage models** with measurements and different benchmark models

**RG 4.4**  Developing of **bulk and surface model** for $10^{16} \text{ cm}^{-2} < \Phi_{eq} < 10^{17} \text{ cm}^{-2}$

**RG 4.5**  **Collate** solutions from **different MC tools** and develop an algorithm to **include adaptive electric and weighting fields**

# WG4 Activities 1/2 (2024-2026)

- **TCAD** activities will focus on providing **verification of tools** (mainly Silvaco and Synopsys, but also looking to other tools emerging) implementation of **new physics models** (impact ionization, mobility parametrization etc.), **exporting tools**, **communication with software companies** (e.g. implementation of WGs) and keeping the implementation of **common solutions to device simulations**.

- TCAD simulations will be complemented with **charge transport simulation tools** - **Monte Carlo tools** - allowing detailed studies of **complex sensor performance**. Different tools have been developed so far, but currently, the most supported and advanced tools are **Allpix Squared** and **Garfield++**, which will form the main/production framework, while other tools will continue to be used as verification and development tools. It is foreseen that **improvements in MC simulations will eventually be integrated into AllPix2 and Garfield++**. One obstacle for Monte-Carlo tools is currently the **lack of implementing adaptive/time-dependent weighting and electric fields** in induced current simulations.

- **Modeling of the radiation damage** in simulations has been evolving over the last two decades, but **there is not a general model** that, starting from the defect levels, comprehensively describes all the macroscopic properties of silicon, especially at extreme fluences (WG3). This is why it is important to define a **common framework for process simulation**, aimed at evaluating the **impact** of such model **on innovative devices**, **technologies** or **materials**.

# WG4 Activities 2/2 (2024-2026)

**DRD3**

- Development of **signal processing tools** that can be used with MC and TCAD tools and **general digitization models** for different sensors technologies.

- Owing to the emerging technology requirements of near future high-energy physics experiments, the present WG has to adopt long-term strategies to **promote/initiate discussion with designers of future experiments**, involved in the development of new detector concepts, to create a link between current expertise and next requirements.

- Last important item is – since the interdisciplinary nature of simulation – the establishment of a **cooperation framework among the different WGs and WPs**, as well as with other synergistic DRD collaborations.