

# Report on WG4 activities

13 November, 2025

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Marco Mandurrino

4th DRD3 Collaboration Week  
CERN, 10–14 November, 2025

## WG 4 - Simulation

The simulation working group will be dedicated to the development of common simulation packages, tools, and radiation models. There will be two lines of activities that will be pursued: TCAD tools and so-called Monte Carlo (MC) tools. While the former is commonly used in sensor design, process simulation, and radiation damage modeling the latter are extensively tested in sensor performance evaluation benefiting from much faster code and integration of other software packages.

Another important activity in WG4 will be the continuation of radiation hardness (bulk and surface) modeling, starting from the defect level using mainly TCAD, but also MC tools. Radiation hardness models for wide bandgap semiconductors (WBS) will be explored and developed. The WG4 will be an important part of many working groups and work packages: it will contribute to the simulations of sensor development and performance in WG1 and WG2, it will collaborate with WG3 to incorporate in the simulation the latest understanding of radiation damage, it will be used to optimize the developments of common tools (WG5), and will facilitate the use of WBS (WG6) by incorporating their properties in the simulation package.

### Conveners:

Marco Mandurrino ([marco.mandurrino@cern.ch](mailto:marco.mandurrino@cern.ch))  
Håkan Wennlöf ([h.wennlof@cern.ch](mailto:h.wennlof@cern.ch))

### Upcoming Events

7th Allpix Squared User Workshop, MBI (Vienna), April 28-30, 2026: [Indico Agenda](#)  
4th DRD3 Collaboration Week (in person), CERN, Nov 10-14, 2025: [Indico Agenda](#)

### Past Events

WG4 General Meeting #16 (online), Oct 13, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
SIMDET 2025, 6th school on silicon detector simulation, LPNHE, Paris, Oct 1-3, 2025: [Indico Agenda](#)  
basic course on TCAD simulations at the 2nd DRD3 TCT School, CERN, Sep 23-25, 2025: [Indico Agenda](#) | [Contribution](#) | [Lecture Recording](#)  
WG4 General Meeting #15 (online), Sep 15, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #14 (online), Jul 28, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
3rd DRD3 Collaboration Week (in person), Nikhef (Amsterdam), Jun 2-6, 2025: [Indico Agenda](#)  
WG4 General Meeting #13 (online), May 12, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
6th Allpix Squared User Workshop, Nikhef (Amsterdam), May 7-9, 2025: [Indico Agenda](#)  
WG4 General Meeting #12 (online), Apr 28, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #11 (online), Apr 14, 2025, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
CERN Detector Seminar on simulation of signal induction with resistive elements, Mar 28, 2025, 11:00 (CET): [Event Page](#)  
WG4 General Meeting #10 (online), Mar 17, 2025, 15:00 (CET): [Indico Agenda](#) | [Meeting Recording](#)  
basic course on TCAD simulations at the DRD3 AIDAInnova TCT School, CERN, Mar 4-6, 2025: [Indico Agenda](#) | [Contribution](#) | [Lecture Recording](#)  
WG4 General Meeting #09 (online), Mar 3, 2025, 15:00 (CET): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #08 (online), Feb 10, 2025, 15:00 (CET): [Indico Agenda](#) | [Meeting Recording](#)  
2nd DRD3 Collaboration Week (in person), CERN, Dec 2-6, 2024: [Indico Agenda](#)  
WG4 General Meeting #07 (online), Nov 11, 2024, 15:00 (CET): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #06 (online), Oct 21, 2024, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #05 (online), Oct 7, 2024, 15:00 (CEST): [Indico Agenda](#) | [Meeting Recording](#)  
WG4 General Meeting #04 (online), Sep 16, 2024, 15:00 (CEST): [Indico Agenda](#)  
WG4 General Meeting #03 (online), Sep 2, 2024, 15:00 (CEST): [Indico Agenda](#)  
WG4 General Meeting #02 (online), Aug 5, 2024, 15:00 (CEST): [Indico Agenda](#)  
WG4 General Meeting #01 (online), Jul 22, 2024, 15:00 (CEST): [Indico Agenda](#)  
1st DRD3 Collaboration Week (in person), CERN, Jun 17-21, 2024: [Indico Agenda](#)  
1st WG4 Scientific Preparatory Meeting (online), Jun 3, 2024, 10:00 AM (CEST): [Indico Agenda](#)  
5th Allpix Squared User Workshop, May 22-24, 2024: [Indico Agenda](#)

## Research Results

Literature review on 4H-SiC TCAD parameters (J. Burin *et al.* from HEPHY, Austria):

- [ch.1](#) (permittivity)
- [ch.2](#) (impact ionization)
- [ch.3](#) (incomplete ionization)
- [ch.4](#) (DOS mass)
- [ch.5](#) (bandgap)
- [ch.6](#) (recombination)
- [ch.7](#) (mobility)

Paper on a technology-independent simulation approach for CMOS sensors (DESY, CERN, University of Campinas):

<https://doi.org/10.1016/j.nima.2025.170227>

## Open Positions

two-year "Scientist for Device Simulation" postdoc position at DESY (expired on Sep 8, 2024)

## Useful Links and Tools

WG4 contact email: [drd3-wg4-conveners](mailto:drd3-wg4-conveners)

WG4 meetings: [Indico Page](#)

WG4 e-group (self subscription with admin approval): [drd3-wg4-simulations](mailto:drd3-wg4-simulations)

WG4 Mattermost channel: [link](#)

Complete review of 4H-SiC TCAD parameters (J. Burin, HEPHY)

WG4 involved in the 7th Allpix Squared User Workshop and 2nd DRD3-AIDAInnova TCT School

Meeting Recordings and Minutes available for the last 12 WG4 General Meetings

## 7th Allpix<sup>2</sup> User Workshop

28 - 30 April 2026

MBI-ÖAW, Vienna, Austria

Abstract Deadline: 23 March 2026

Registration Deadline: 15 April 2026



### Organisers

Brigitte De Monte  
Håkan Wennlöf  
Paul Schütze  
Sebastian Onder  
Roberto Russo  
Simon Spannagel  
Thomas Bergauer  
[allpix-squared-workshop@cern.ch](mailto:allpix-squared-workshop@cern.ch)

<https://indico.cern.ch/e/apsqws7>



- **Strategies to boost participation**
  - **Regular General Meetings** (~1 meeting per month, on average excluding summer break)
  - **Standard update talks**
  - **Invited talks** on a **relevant topic** from 8th WG4 General Meeting onwards (Feb 10, 2025)
  - General meeting presentations frequently lead to **useful discussions**
- **Main updates since 3rd DRD3 week**
  - Simulations of the Monolithic Active Pixel Sensors for the OCTOPUS Project ⇒ 15th General Meeting (September 15)
  - Study of Irradiation-Induced Defects in LGADs ⇒ 16th General Meeting (October 13)
- **New groups joining WG4**
  - Taiyuan University of Technology
  - Xiamen University Malaysia

# WG4 Research Goals (2024-2026)

DRD3  
- WG4 -

- 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  $10^{16} \text{ cm}^{-2} < \Phi_{\text{eq}} < 10^{17} \text{ cm}^{-2}$
- RG 4.5 **Collate** solutions from **different MC tools** and develop an algorithm to **include adaptive electric and weighting fields**

# WG4 at the 4th DRD3 Week

- **5 talks** directly in the WG4 session
- Simulations **mentioned across a lot of the talks** in different sessions as well
  - Fewer talks than last time in the WG4 session, but simulations are an obvious important part of DRD3
- **Significant work** carried out and presented well-aligned with the research goals

09:00	<b>RASER simulation of 4D tracking detectors</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Chenxi Fu</i> 09:00 - 09:20
	<b>Multiscale Simulation of Irradiation-Induced Defect Evolution in EPI silicon LGADs</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Wei Li</i> 09:20 - 09:40
	<b>Garfield++: New Features and Ongoing Development</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Djunes Janssens</i> 09:40 - 10:00
10:00	<b>A TCAD Simulation Framework for DLTS-based Defect Characterisation in Solid-State Particle Detectors</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Tommaso Croci</i> 10:00 - 10:20
	<b>Simulations of the Monolithic Active Pixel Sensors for the OCTOPUS Project</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Anastasiia Velyka</i> 10:20 - 10:40
	<b>WG4 - Updates and Discussion</b> 6/2-024 - BE Auditorium Meyrin, CERN	<i>Håkan Wennlöf et al.</i> 10:40 - 11:00

# WG4 at the 4th DRD3 Week

- Simulations mentioned across a lot of the **talks** in different sessions
  - Great to see! So much going on
- Please consider attending and presenting in the **WG4 meetings**
  - Also front-end electronics simulations and its interplays
  - Work-in-progress presentations are **encouraged**
    - no need for final polished results
- It is a **gathering point** of simulations experts, and presentations frequently lead to fruitful discussions

First results of COFFEE3, a small prototype for 55nm HVCMOS validation	Zijun Xu	6/2-024 - BE Auditorium Meyrin, CERN	14:15 - 14:35
Development of sensors with intrinsic gain in LFoundry 150 nm technology	Prof. Philippe Schwemling	6/2-024 - BE Auditorium Meyrin, CERN	15:15 - 15:35
The OCTOPUS project: optimizing monolithic active pixel sensors for the next generation of lepton collider experiments	Roberto Russo		
Status of the MANTA project	Michael Deveaux	6/2-024 - BE Auditorium Meyrin, CERN	17:25 - 17:45
Development of 3D silicon pixel sensors at USTC	Kuo Ma	6/2-024 - BE Auditorium Meyrin, CERN	09:41 - 09:57
Development of 3D Pixel Sensors via an 8-inch CMOS-Compatible Process	Huimin Ji	6/2-024 - BE Auditorium Meyrin, CERN	10:35 - 10:51
Results from iLGAD sensors bump bonded to Timepix4	Daan Jasper Oppenheim	6/2-024 - BE Auditorium Meyrin, CERN	11:59 - 12:15
Observation of charge multiplication in a SiEM	Victor Coco	6/2-024 - BE Auditorium Meyrin, CERN	12:17 - 12:33
Advancements in Low-Gain Avalanche Diodes (LGADs) for the ALICE 3 timing layers	Francesca Carnesecchi	6/2-024 - BE Auditorium Meyrin, CERN	17:10 - 17:26
Studies of surface radiation damage with CMS HGCAL test diodes	Eva Fialova	6/2-024 - BE Auditorium Meyrin, CERN	15:50 - 16:10
Edge Silicon Sensors Fabricated with Edge Ion Implantation And Microwave Anneal Activation	David Gentry		
Leakage current evolution in LHCb VELO sensors during Run 1-2 LHC data taking period.	Agnieszka Oblakowska-Mucha		
iLGAD sensors from FBK	Marco Ferrero	Auditorium Meyrin, CERN	17:46 - 18:02
Technological development and performance of Low Gain Avalanche Detectors with and without carbon co-doping at I.	Florent Dougados		

# WG4 useful links

- WG4 contact email: [drd3-wg4-conveners](mailto:drd3-wg4-conveners)
- WG4 meetings: [Indico Page](#)
- WG4 e-group (self subscription with admin approval):  
[drd3-wg4-simulations](#)
  - Sign up here to receive meeting notifications and similar
- WG4 Mattermost channel: [link](#)

# Backup

# 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)

- 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.