

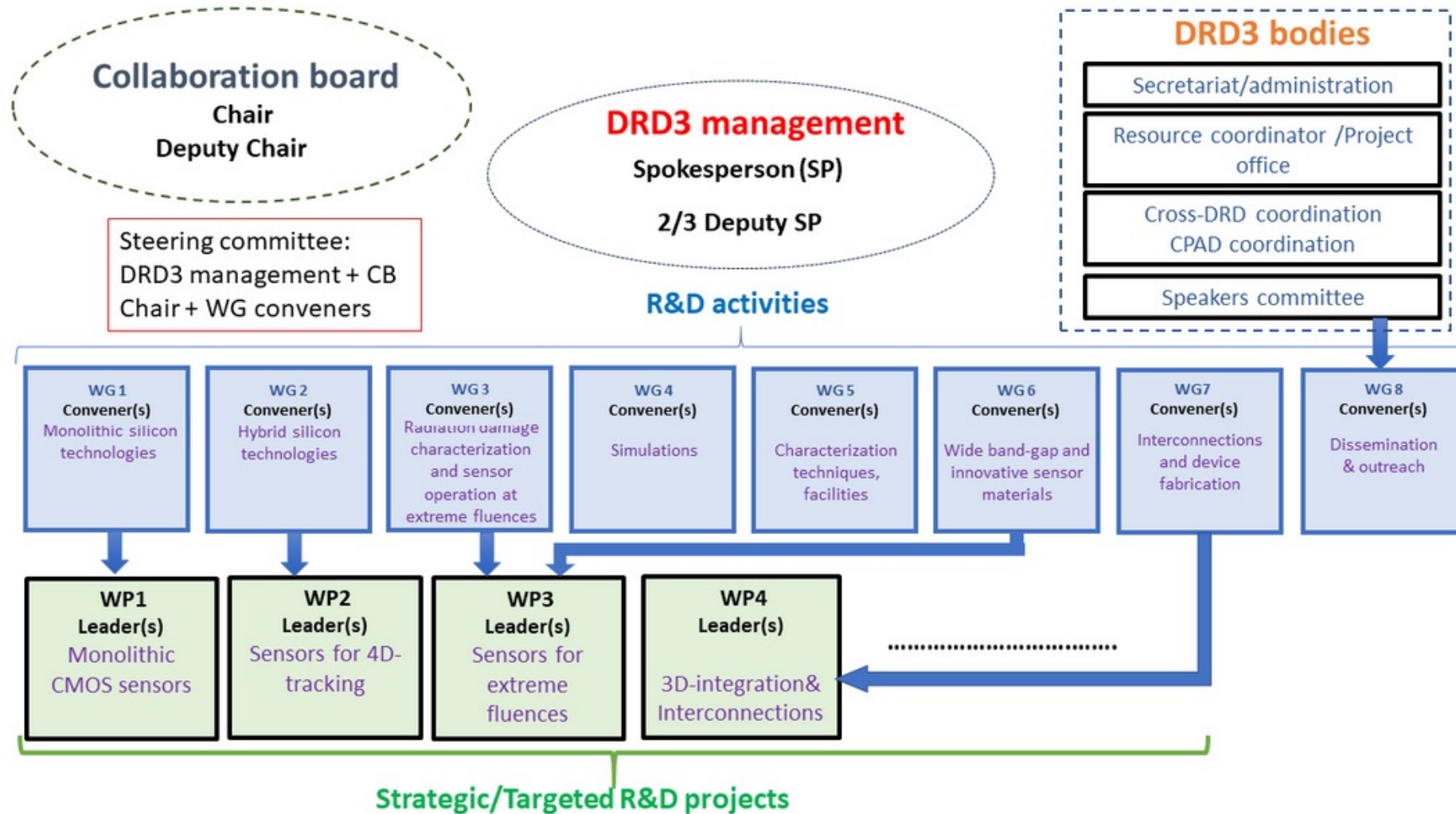
1st WG4 Scientific Preparatory Meeting

3 June, 2024

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- 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](#)

DRD3 Organization



source: <https://drd3.web.cern.ch/>

Scientific Proposal - WG4

DRD3
- WG4 -

« The simulation work 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 (with particle and Transient Current Technique, TCT) benefiting from much faster code and integration of other software packages e.g. GEANT4.

Another important activity in WG4 will be the continuation of **radiation hardness modeling**, bulk, and surface, starting from the defect level using mainly TCAD, but also MC tools. Radiation hardness models for WBS [wide bandgap semiconductors] will be explored and developed.

The WG4 will be an **important part of many working group 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 ».

From the DRD3 Scientific Proposal

- **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**.

Scientific Proposal - WG4 Activities 2/2

DRD3
– WG4 –

- 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.

Scientific Proposal - WG4 Goals

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**

Scientific Proposal - RG/WP links

Work Package		3.1 Monolithic CMOS sensors				3.2 4D Tracking		3.3 Extreme Fluence			3.4 Intercon.			
		Spatial resolution	Temporal resolution	Read-out architecture	Radiation Tolerance	3D sensors	LGAD	Wide band-gap materials	Diamond	Silicon	maskless interconnect	in house post-processing	advanced interconnect	mechanics and cooling
RG Description														
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	X	X	X	X									
4.2	Implementation of newly measured semiconductor properties into TCAD and MC simulations tools	X	X	X	X	X	X	X	X	X				
4.3	Definition of benchmark for validating the radiation damage models with measurements and different benchmark models.	X	X			X	X	X	X	X				
4.4	Developing of bulk and surface model for $10^{16} \text{cm}^{-2} < \Phi_{eq} < 10^{17} \text{cm}^{-2}$							X	X	X				
4.5	Collate solutions from different MC tools and develop an algorithm to include adaptive electric and weighting fields	X	X			X	X							

source: DRD3 Scientific Proposal

Scientific Proposal - WG4 Resources

DRD3 - WG4 -

Period 2024–2026:

source: DRD3 Scientific Proposal

Resources available to the DRD3					
	Present situation			Strategic R&D	
	Permanent [FTE/y]	Non Permanent [FTE/y]	Budget [kCHF/y]	Non Permanent [FTE/y]	Budget [kCHF/y]
Total	170.7	156.3	5070.2	170.9	7898.5

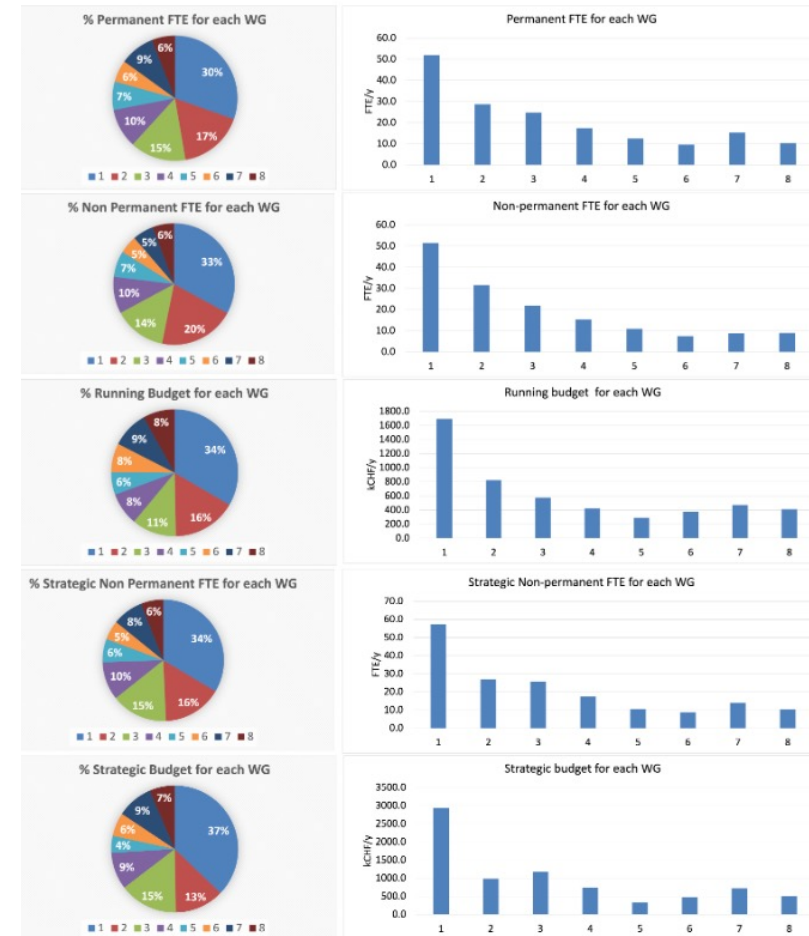
4.1	3.7	2.9	82.1	3.4	178.4
4.2	5.6	5.6	114.2	6.0	299.9
4.3	2.1	1.7	54.9	2.6	89.1
4.4	4.4	3.3	144.8	3.8	137.6
4.5	1.7	1.8	28.2	1.7	38.7
Total	17.4	15.3	424.2	17.5	743.6

existing funding lines

(resources that are **expected to be available** on existing budget lines or through **very likely to be received** future resources)

from funding requests

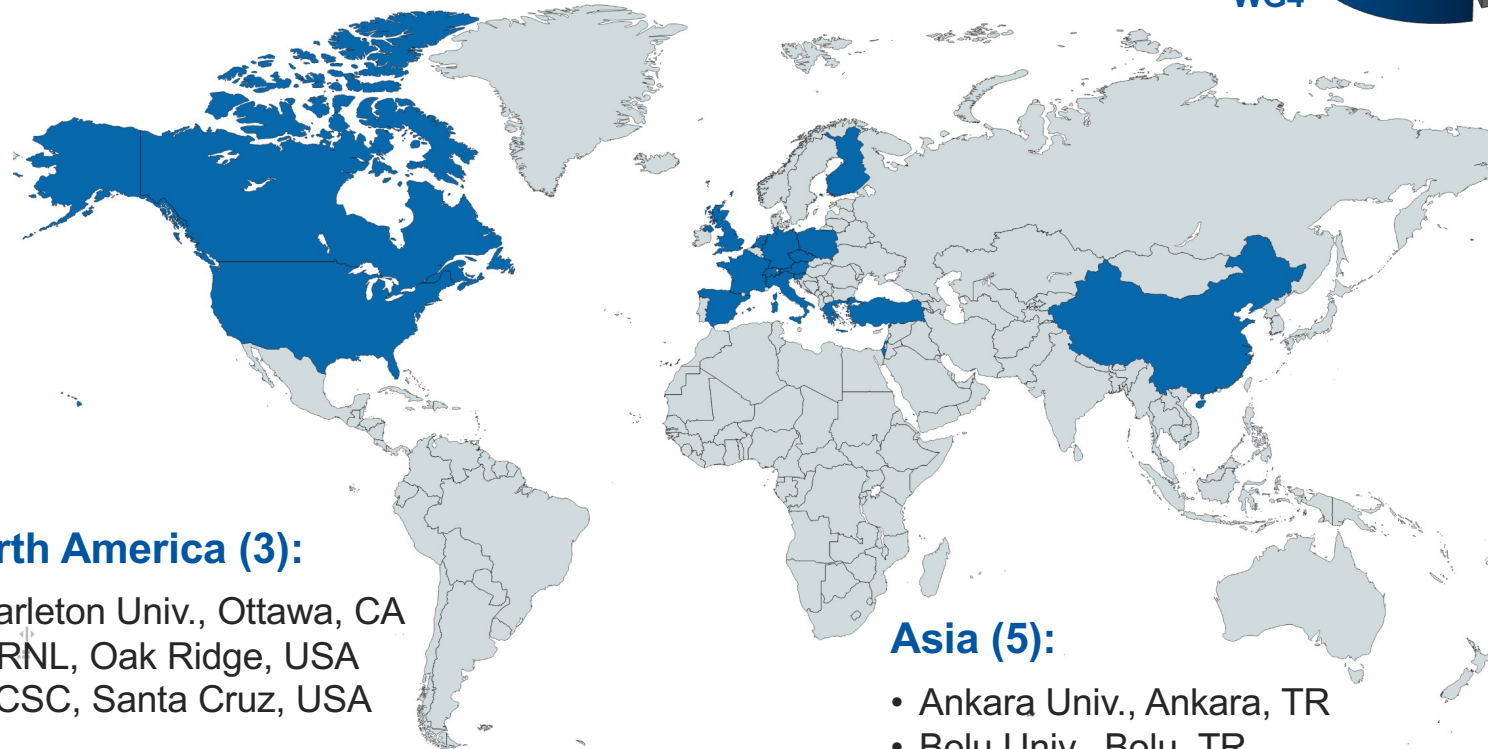
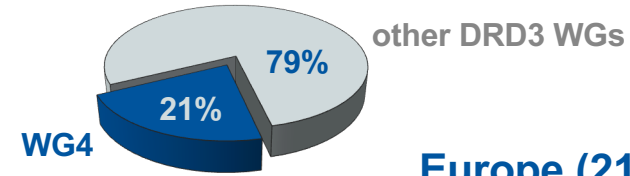
(required to fulfill the complete strategic R&D work program, mainly coming from national agencies)



source: DRD3 Scientific Proposal

WG4 Expressions of Interest 1/4

Involved Institutes (29) and Countries (18)



North America (3):

- Carleton Univ., Ottawa, CA
- ORNL, Oak Ridge, USA
- UCSC, Santa Cruz, USA

Asia (5):

- Ankara Univ., Ankara, TR
- Bolu Univ., Bolu, TR
- JLU, Changchun, CN
- Tel Aviv Univ., Tel Aviv, IL
- USTC, Langfang, CN

Europe (21):

- AET-NKUA, Athens, GR
- AGH, Krakow, PL
- APC, Paris, FR
- BHAM, Birmingham, UK
- CERN, Geneva, CH
- Charles Univ., Prague, CZ
- CNM, Barcelona, ES
- DESY, Hamburg, DE
- GIE-ETSI, Sevilla, ES
- Hamburg Univ., Hamburg, DE
- HEPHY, Vienna, AT
- HIP, Helsinki, FI
- IEAP, Prague, CZ
- INFN, Padova/Perugia/Torino, IT
- IPHC, Strasbourg, FR
- JSI, Ljubljana, SI
- Manchester Univ., Manchester, UK
- NIKHEF, Amsterdam, NL
- TU Dortmund, Dortmund, DE

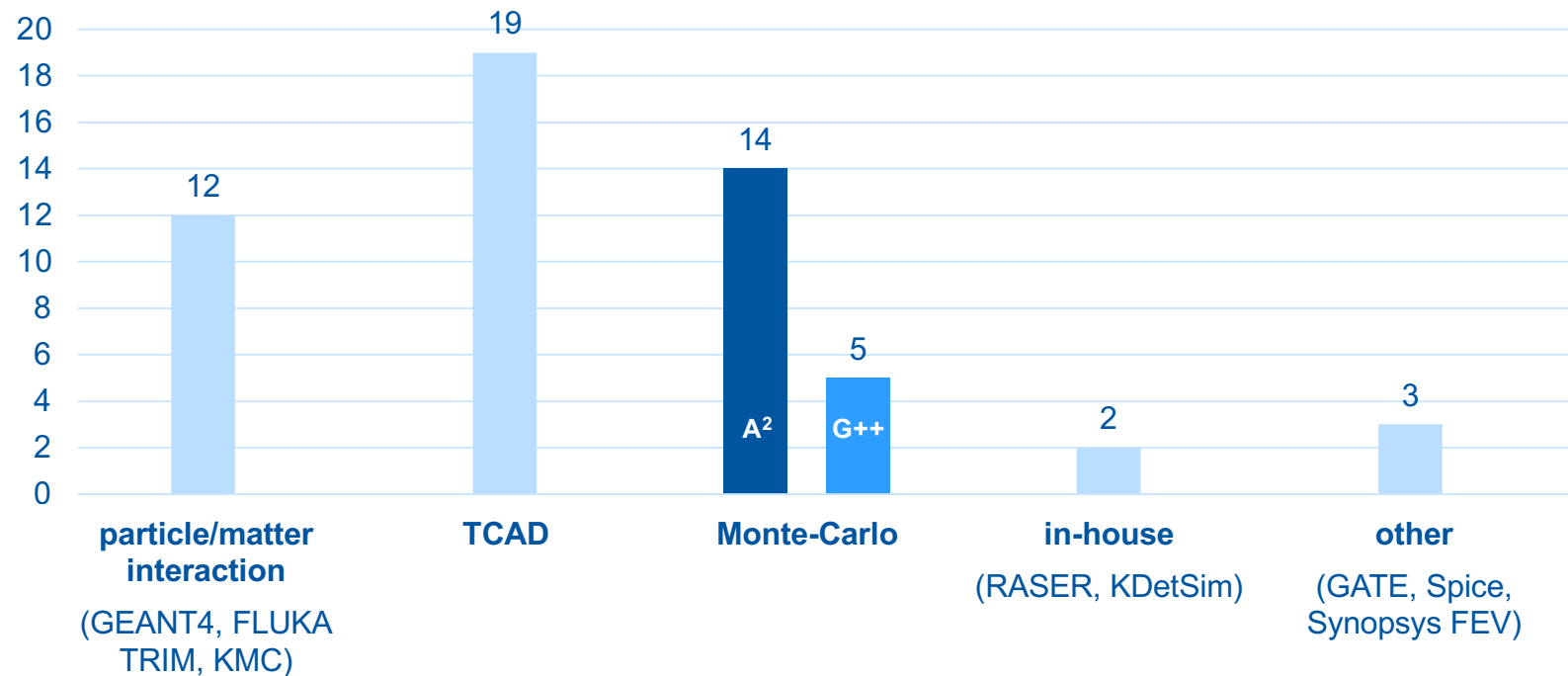
WG4 Expressions of Interest 2/4

Scientific Interests and Potential WGs / WPs / DRD Connections



WG4 Expressions of Interest 3/4

Simulation Tools



General Considerations

- The TCAD category includes different tools, whose solutions need to be self-consistently optimized
 - Synopsys TCAD Sentaurus
 - Silvaco TCAD
 - other commercial and in-house tools
- Further relevant ongoing activities
 - **adaptive fields** in MC simulations (JSI Ljubljana)
 - signal formation in correspondence of **resistive electrodes** (CERN)
 - **collate solutions** from **different MC** tools (INFN Torino)
 - develop connections between **device-** and **circuit-level design** tools (DESY, INFN Perugia and Torino)
 - **process** simulations (Hamburg Univ., INFN Torino)
- Estimated Total FTEs: ~27 (approx. 1 FTE / Institute) compared to 32.7 declared in the Scientific Proposal

1st DRD3 Collaboration Meeting

DRD3
- WG4 -

WEDNESDAY, JUNE 19	
9:00 AM → 10:35 AM	WG3/WP3 - Extreme fluence and radiation damage characterization: WP3 project proposals Conveners: Ioana Pintilie (National Inst. of Materials Physics (RO)), Dr Joern Schwandt (Hamburg University (DE))
10:35 AM → 12:20 PM	WG4 - Simulations: WG4 talks Convener: Marco Mandurrino (Universita e INFN Torino (IT))
1:00 PM → 3:05 PM	WG7/WP4 - Interconnect technologies: WG7 talks Conveners: Dominik Dannheim (CERN), Fabian Huegging (University of Bonn (DE)), Giovanni Calderini (LPNHE-Paris, Centre National de la Recherche Scientifique (FR))
3:05 PM → 6:00 PM	WG7/WP4 - Interconnect technologies: WP7 project proposals Conveners: Dominik Dannheim (CERN), Fabian Huegging (University of Bonn (DE)), Giovanni Calderini (LPNHE-Paris, Centre National de la Recherche Scientifique (FR))

~2-hour session:

- **2** out of 29 institutes expressed the **interest** to present a contribution during the collaboration meeting
- **1 abstract** already **submitted**
- other **2** contributions were reserved by the convener for **MC tools developers**

- Possible presentation of the WG4 Structure
- Abstract submission open until **6 June!!!** ⇒ <https://indico.cern.ch/event/1402825/abstracts/>

Closing Considerations

Final WG4 Structure (to be shaped in the next two weeks):

- Complete list of involved **institutes**, with **contact persons** and **FTEs**
- Complete list of available **computational infrastructures / software**
- Overview and classification of the **activities**:
 - **optimize the efforts**
 - check **coverage** of the **activities / goals**, with possible **call for uncovered areas**
- Nomination of **Liaison Persons** for each of the other WGs / WPs / DRDs

About the WG4 Organization:

- **General meetings** open to all the DRD3 Community: **monthly-** or **biweekly-**based (tbd)
- **Focused meetings**: depending on the needs
- We will most likely need a **repository / platform** to share data and information
- Any other suggestions from the Management / Participants

Time for discussion...

