DRD1 WG4 Simulation Studies Survey
Preliminary results

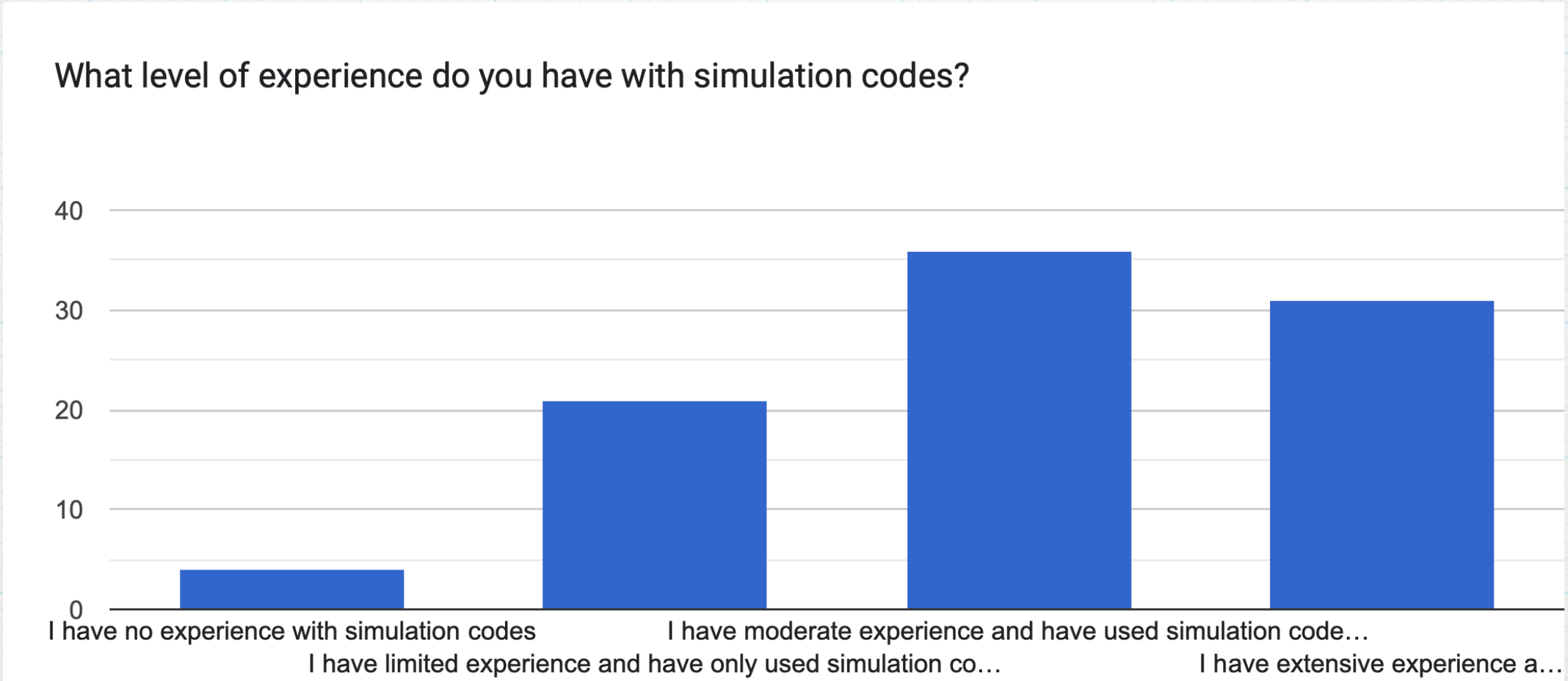
- **Aim:**
  - Get to know who already works on software & simulations
  - Get suggestions for future software developments
  - Understand priorities from the community

Thank you all for your active participation!

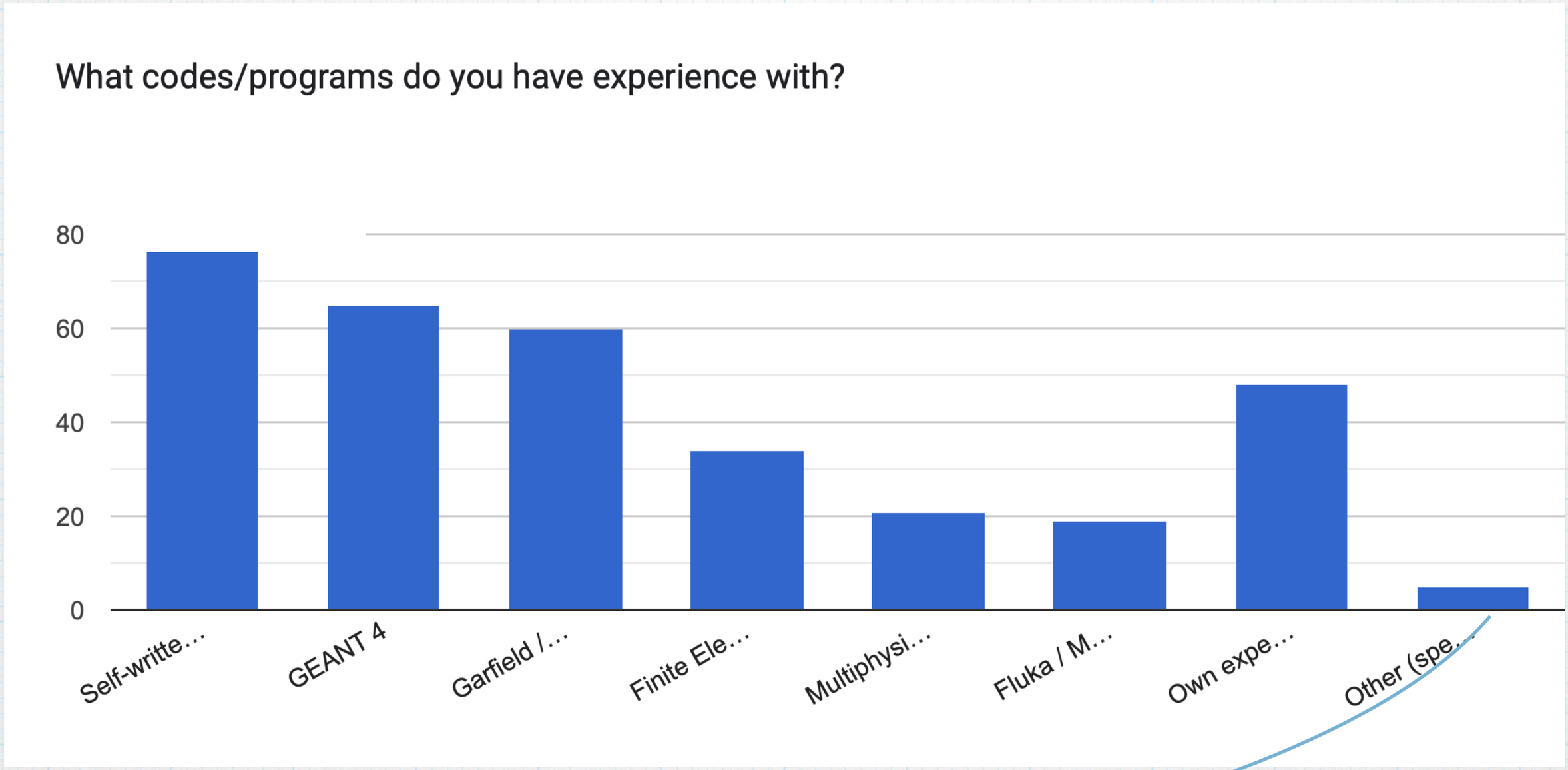
Maryna, on behalf of the WG4 team, 12/03/2024

Simulation & Modelling Experience

* 89 responses, some of them on behalf of the groups
* 74% have substantial experience in simulations

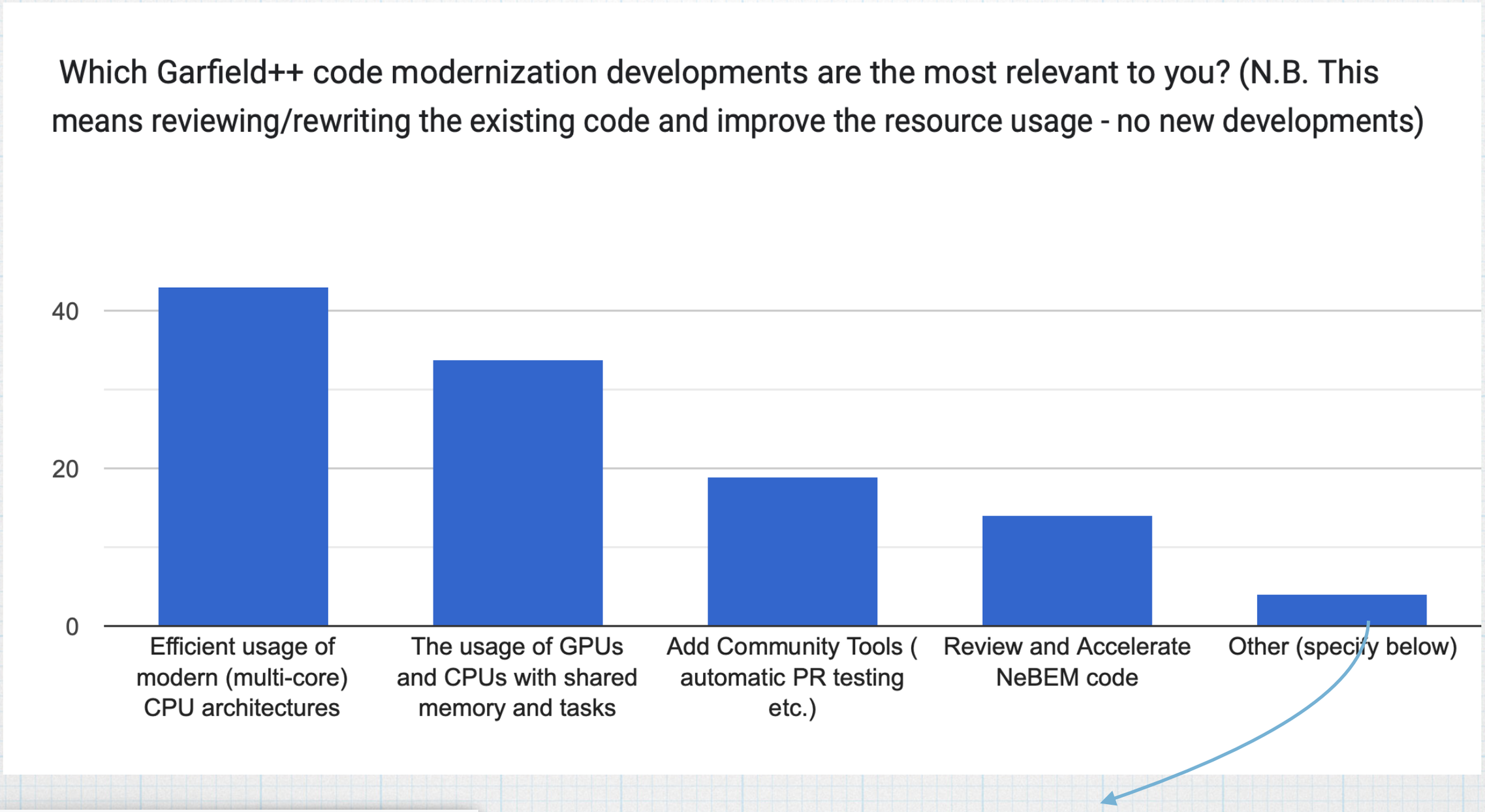


Simulation & Modelling Experience



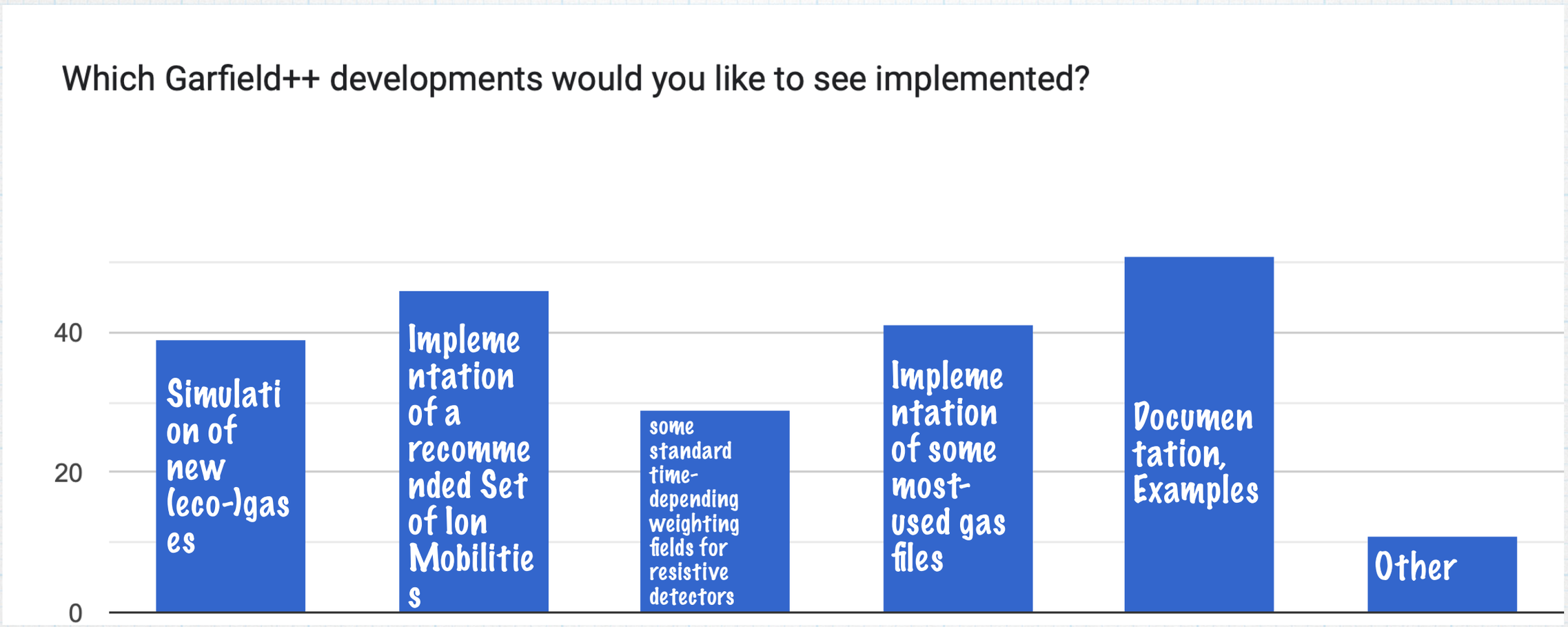
- C++ analysis and simulation frameworks, VMC, ...
- ROOT
- Rest-For-Physics
- SRIM/TRIM, LISE++
- Magboltz, Pyboltz, BetaBoltz
- MadGraph, Pythia, Delphes
- Gaussian 16, Orca 5.0

Garfield++ Code Modernization I



- Avalanche base class inheritance
- Distribution binaries, easy-to-use VMs or containers, web docs, easy integration with modern IDEs
- More suitable interface with COMSOL
- Fast simulation
- Further improvement of Garfield++ Python via pyROOT

Garfield++ Code Modernization II



- Space-charge effect depending on the geometry
- Correct Ion chemistry and mobility for relevant gases

- Standard example files, **compiled code for drift tube and drift cell**, which makes result comparisons between different groups easier.
- Code including **on/off switches for specific packages like ion drift, avalanches**
- **Further integration of TrackDegrad, support for non-uniform magnetic fields in ComponentFieldMap** and derived classes. Streamer development and charging up effect modeling.

Garfield++ Code Modernization II cont.

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- Inclusion of charge exchange processes (low energy ions in low-density gas) based on energy-dependent microscopic cross-sections
- **Possibility to work with both electric and magnetic fields imported from an open-source FEM software**. Re-calculate electric field distortions due to space-charge distribution. New developments to work with open-source software and complex structures for semiconductors.

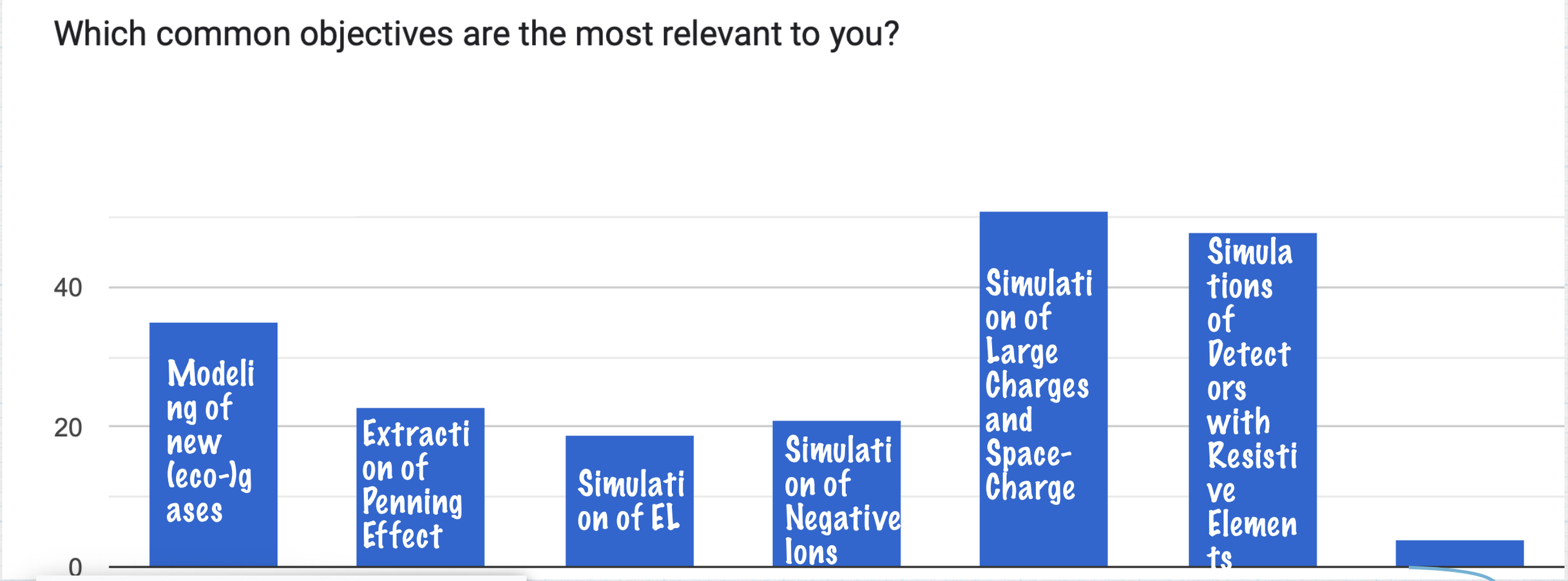
- It seems that G**arfield/Garfield++ is not fully functional at very low pressures <10 mbar**

- Quenching effects in nucleus-gas interactions, **avalanche modeling at low gas pressures**

- The ability **to simulate signal transmission on large structures**. This will set the limits to timing, signal integrity, noise mitigation and large area readouts as detectors become faster. At the moment, this part is still done old-style, with a mix of simple concepts (impedance matching, x-talk), and following an experimental approach. Building efficient readouts of fast detectors such as delay-line (as for MCPs) or multi-strip will never truly catch ground without this type of simulations. This know-how has already been developed in the framework of MRPCs and is not particularly difficult to implement.

- Calculation and evaluation of cross-sections (rate constants) for new and existing gas reactions and mixtures

Common Objectives in Simulation and Physics Modelling

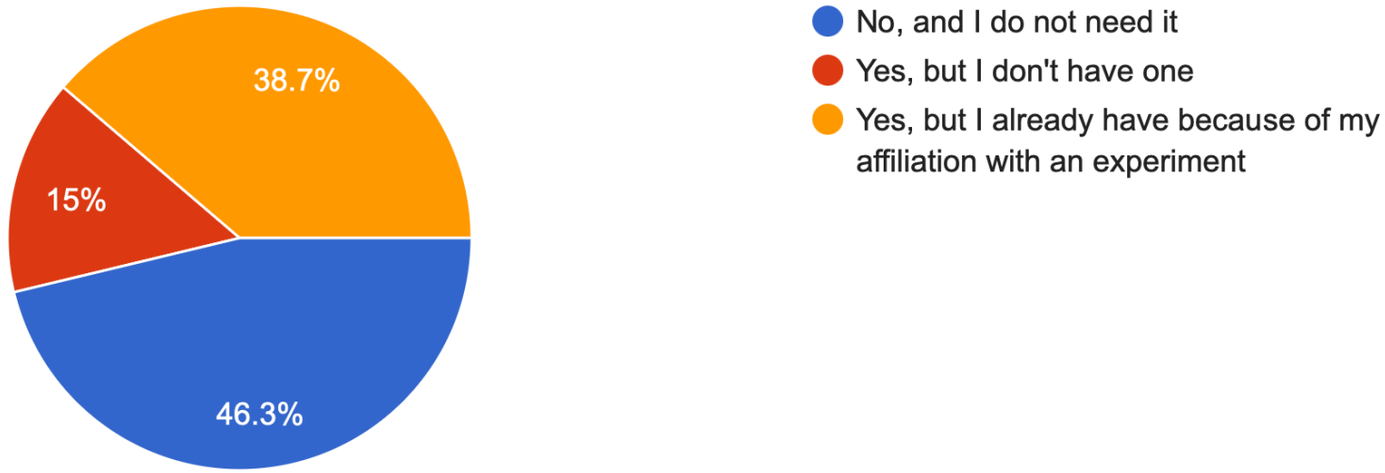


- simulation/**modelling of time response**
- Simulation **of signal induction**
- Raw **charge signal (charge vs time)**
- Developments to the **semiconductor part of Garfield++.** Also a dedicated feature to calculate a complex geometry/electric field/magnetic field within Garfield. This output could be later export to a file to be used as the input for the transport simulation.
- GEM and solid state detectors
- Simulation **at low gas pressures**
- simulation of after pulsing, predefined/improved examples of 'standard' detectors/detector components (eg. Micromegas, GEMs, **implementation of more realistic micromeshes**, etc.), better interfacing between different programs (eg. Ansys -> Geant4 -> Garfield++)
- **drift chamber and TPC readout** development
- **Ion interaction at low energy** (<100 keV)
- feasibility studies for **combining Garfield++ and chemical simulation approaches for the prediction of properties of new gases**
- Electron and ion dynamics, recombination

Access to computing resources

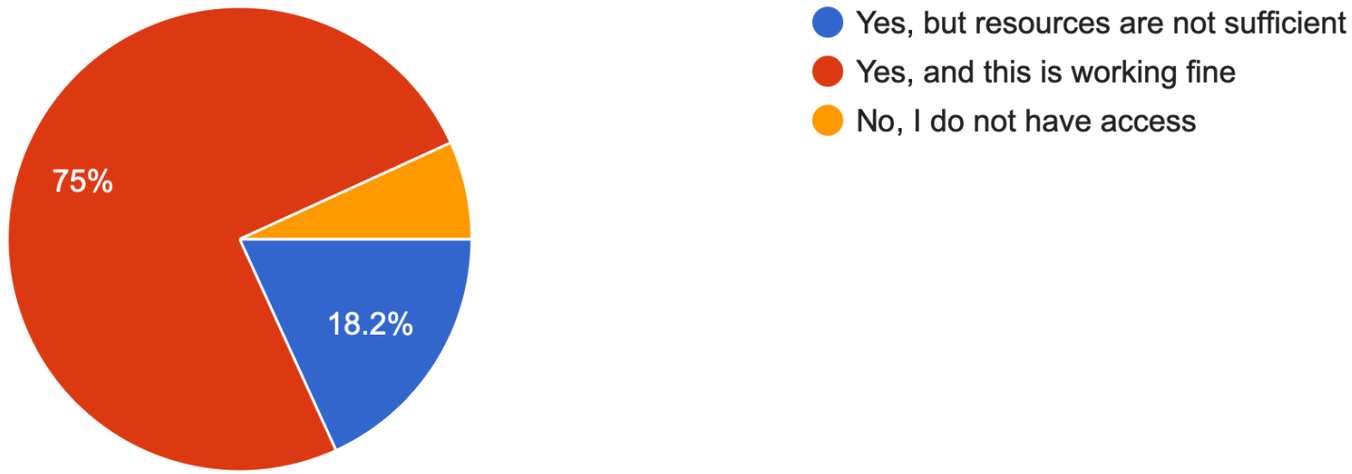
Do you need lxplus account for your simulation activities?

80 responses



Do you have access to local computing resources?

88 responses



How can DRD1 WG4 give you the best support to help you start your simulation?

* 25 responses asking for better documentation

* Beginner tutorials and examples
* Better documentation
* A masterclass for beginners?
* Make Garfield REALLY easy to install and use
* Short course/workshop on the simulation of resistive element detectors
* Documentation
* The **online material and code that was prepared for MPGD detector school is a good starting point**
* Give a common starting point with properly defined environments and libraries. Also, some basic examples can be shared with students.
* Code shar
* Already ge
* Simulation
* A primer m
* setup/mak
  detector c
  homogeniz
  used funct
* Short cour
* Tutorials, t
* Help start
* The knowl
* Lectures and hands-on in Garfield
* To offer the best support for initiating a simulation, DRD1 WG4 could c and provide exhaustive examples.
* I have students who could be involved so any supporting documentati
* By providing a set of standard validated plots. So that one can confirm
* I think that beginners have some trouble to build the simulation enviro s with the minimum necessary external dependencies possible can make the bu k.
* Example, guides
* An online course at the beginner level can be organized.

https://garfieldpp.web.cern.ch/garfieldpp/

Getting started

- Installation
- Examples
- Documentation (User Guide, Doxygen, FAQ)

Support

- If you have any questions, please send a mail to garfield-support@cern.ch (or contact Heinrich Schindler or Rob Veenhof directly).
- To receive (infrequent) announcements about updates of the code, please subscribe to the mailing list `garfield-users@cern.ch` on E-Groups.
- Issues can be reported on GitLab.

https://root-forum.cern.ch/c/garfieldxx/25

Garfield++

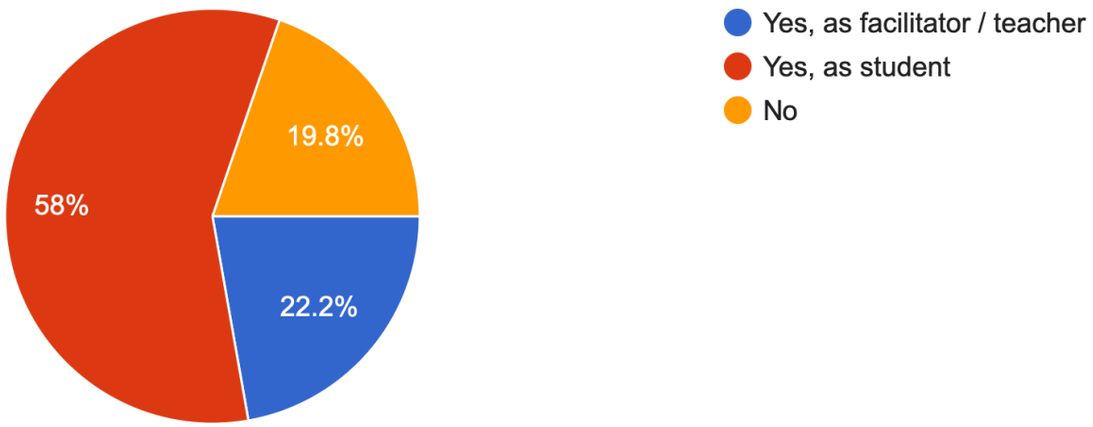
Discuss Garfield-related problems here!

https://root-forum.cern.ch

Simulation school

Would you like to participate in the simulation school if we will organize this in the future?

81 responses



What are your expectations for the simulation school ? E.g. What would you like to learn? Other expectations? —> 35 responses

- Basics of popular simulation tools and how to choose the right tool, **From Basics to advanced simulations**. (14 persons suggested)
- I would like to **have a better understanding of gaseous detectors** and gaseous detector simulations (3 persons suggested)
- Most recent developments in gaseous detector simulations, an **overview of current challenges** in simulation developments (3 persons suggested)
- The opportunity **to participate remotely** would be very welcome.

- **Quantum chemistry** calculations
- Contribute to activities related to l**ow-energy nuclear physics**
- I would like to **learn how to use different geometries and doping substrates to simulate semiconductors**.

Simulation school, cont.

- I want to **learn GPU computing to accelerate avalanche process** .
- I would like to see some **edge case modelling** i.e. not well known principles rather about resistive elements (maybe even with lossy permitivity) or space-charge effects, penning modelling, photo modelling etc.
- to get acquainted with: Ansys, Magboltz, garfield++, Geant4, COMSOL, etc.

- new ideas to improve simulations, new capabilities of existing tools...
- Simulation of GEMs and MicroMegas
- Running Garfield++ on concrete problem

Other suggestions

- Can we get proper open source licensing conditions on Garfield++? Could follow example of ROOT https://root.cern/about/license/ or Geant4 https://geant4.org/download/license.
- License Data Analysis Framework
- I would like to see more examples and integrations with Python in the docs
- I think it is a good idea to keep some long-term support versioning of the Garfield++ code. Maybe keeping a dev branch and a master, with the master stable, may help students not break their simulation codes in a fresh install.

Outlook

- We have collected substantial feedback from our community, and it will guide us in setting the priorities

For the nearest future:

- To do an inventory of what examples one can find in the Garfield++ website and link it to the DRD1 website
- To think of better ways of the diffusion of information to the community
- To make a Jupiter notebook to show the drift velocity for gas mixtures and link it to DRD1 webpage / Garfiel webpage
- To collect examples on reconstruction code / Kalman Filter / and share

For the school preparation might need a 2-prong approach:

- school and exercises for students ….
- an alternative approach for faculty scientists who also do not know the details but have no time for schools or other discussions

For the near future:

- Implementation of i) scintillation, ii) negative ions, iii) implementation of Penning transfers at the microscopic level iv) spark development and quenching

For the future:

- To make the Ph.D. in detector physics simulation recognizable

Please do not hesitate to contact us if you would like to provide additional comments/suggestions (drd1-wg4-conveners@cern.ch).