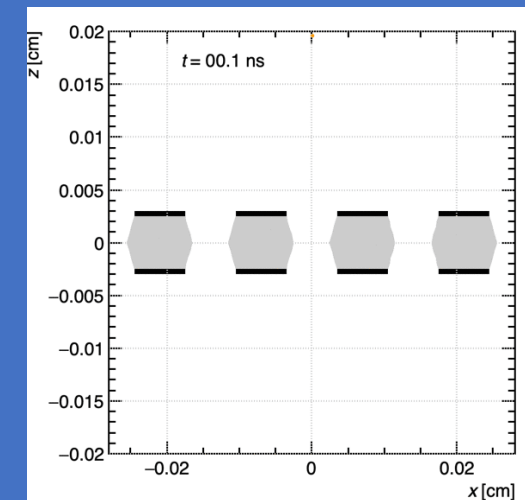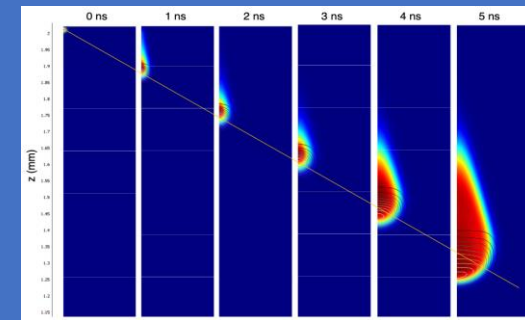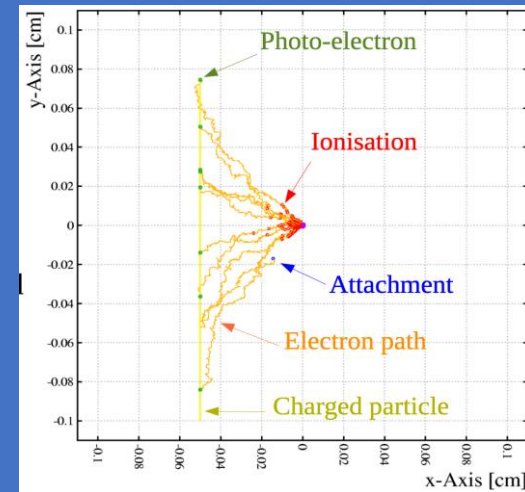# DRD1 - WG4

## Detector Physics, Simulations, and Software Tools

Marcello Abbrescia, Maryna Borysova, Paulo Fonte, Ozkan Sahin, Rob Veenhof, Piet Verwilligen
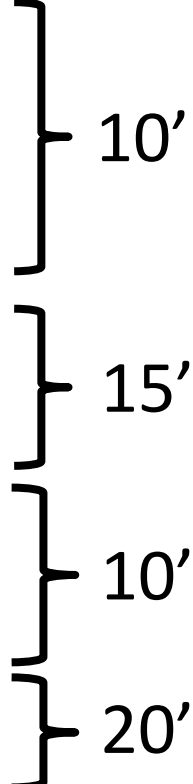
# Outline - WG4

*1h to discuss Detector physics, Simulations & Software Tools*

- ***Introduction*** *to the topics covered by WG4*
- ***Survey***
  - *Analysis and summary of the survey*
  - *Essential aspects from the Survey
    with relevance/impact in the context of DRD1 collab*

- ***Current State-of-the Art*** *in various technologies*
  - *Wires – TPC – RPC – MPGD*

- ***Potential Common Topics***
  - *Existing/Potential assets the collaboration can support*
  - *Synergies and common aspects between technologies*

- **Time for discussion**

*Fasten seatbelts!*

# Outline - WG4

*1h to discuss Detector physics, Simulations & Software Tools*

- ***Introduction*** *to the topics covered by WG4*
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    *with relevance/impact in the context of DRD1 collab*

  } 10'

- ***Current State-of-the Art*** *in various technologies*
  - *Wires – TPC – RPC – MPGD*

  } 15'

- ***Potential Common Topics***
  - *Existing/Potential assets the collaboration can support*
  - *Synergies and common aspects between technologies*

  } 10'

- **Time for discussion**

  } 20'

*Fasten seatbelts!*

# WG4 Detector Physics, Simulations & Software Tools

*Introduction to the topics covered by WG4*

- ## Detector Physics
  *simulation & modeling of physics processes that happen inside detectors:*
  *- basics: primary ionization; electron & ion drift; avalanches; signal induction*
  *- advanced: avalanche to streamer; discharges; rate-capability; clustering of ions ...*

- ## Detector Performance
  *modeling and simulation of detection efficiency, spatial resolution, time resolution, track reconstruction, two-track separation, ...*

  *- stand-alone (e.g. Garfield++)*
  *- integrated in big experiment (e.g. GEANT4 & custom C++ digitizers)*

- ## Software development and maintenance
  *people working on SW integrated in their experiments – private code*
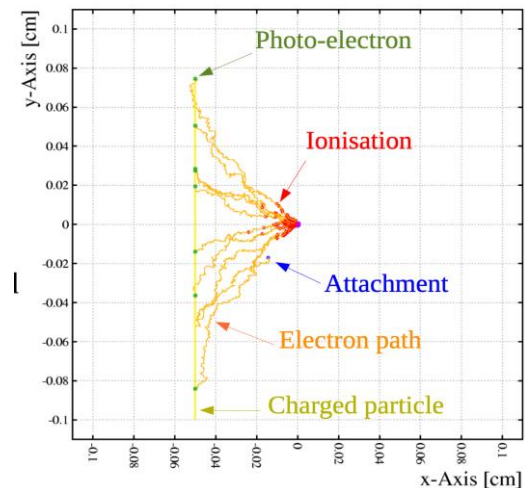  *Stand-alone or re-usable code available to everyone (e.g. Garfield++)*

- ## Gas Properties Databases (e.g. cross-sections)
  *Measurements - Extraction of cross-sections from data*
  *Upload in DB – Implementation in SW Tools (e.g. Magboltz)*

- ## Detector design
  *Specific software used for detector design ...*
  *of course we need this but ... commercial ... no R&D in our community*

4

# Survey for WG4

*Disclaimer* – *only 69 institutes have filled in the survey within the deadline*
*Several institutes involved in Physics Modelling & Simulation of MPGD or RPC are missing*
*including institutes with key contributions to common software:*
   *e.g. neBEM; GEANT4-Garfield interface, Magoltz, PyBoltz,*
*or heavy-duty users of simulation:*
   *e.g. charging up in Triple-GEMs and Thick GEMs, RPC simulation with Ecogas, …*

# 4. Detector physics, simulations, and software tools

**Research interests and activities**

**Answered: 69** — Please select the activities of interest for your group and specify in the comments if the interest is as user and/or developer

**A. Detector Physics (modelling and simulations)**: 50

**B. Detector Performance Studies (modelling and simulations)**: 46

**C. Software development and maintenance**: 22

**D. Gas Properties Databases (e.g. cross-sections) - Use and/or Maintenance**: 21

**E. Detector design** : 48

*Ambiguous … can be:*
*(1) technical design software: Solidworks, Catia, PCB-software, …*
*(2) Performance simulations to modify design big experiments…*

Chart:
- A: 72.5%
- B: 66.7%
- C: 31.9%
- D: 30.4%
- E: 69.6%
- F

Y-axis: Answers
X-axis: # of times chosen (0, 5, 10, 15, 20, 25, 30, 35, 40, 45)
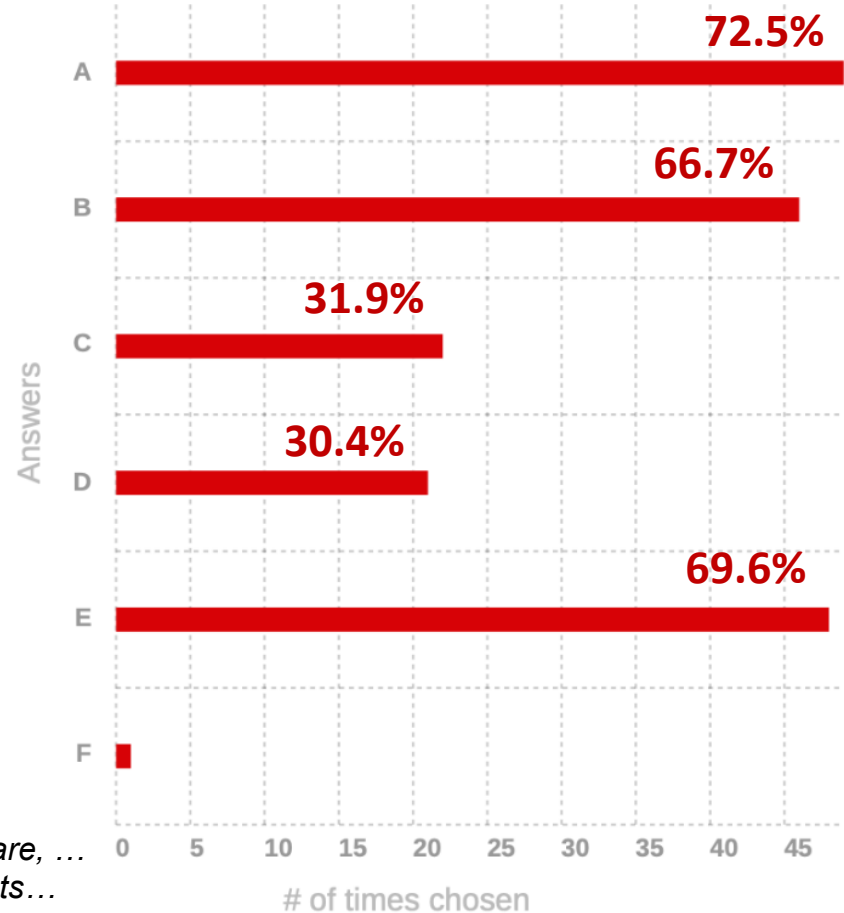
- **> 2/3 is Interested in Detector Physics & Detector Performance Simulations**
- **30% is interested in software development | 70% is interested in detector design**

01/03/2023

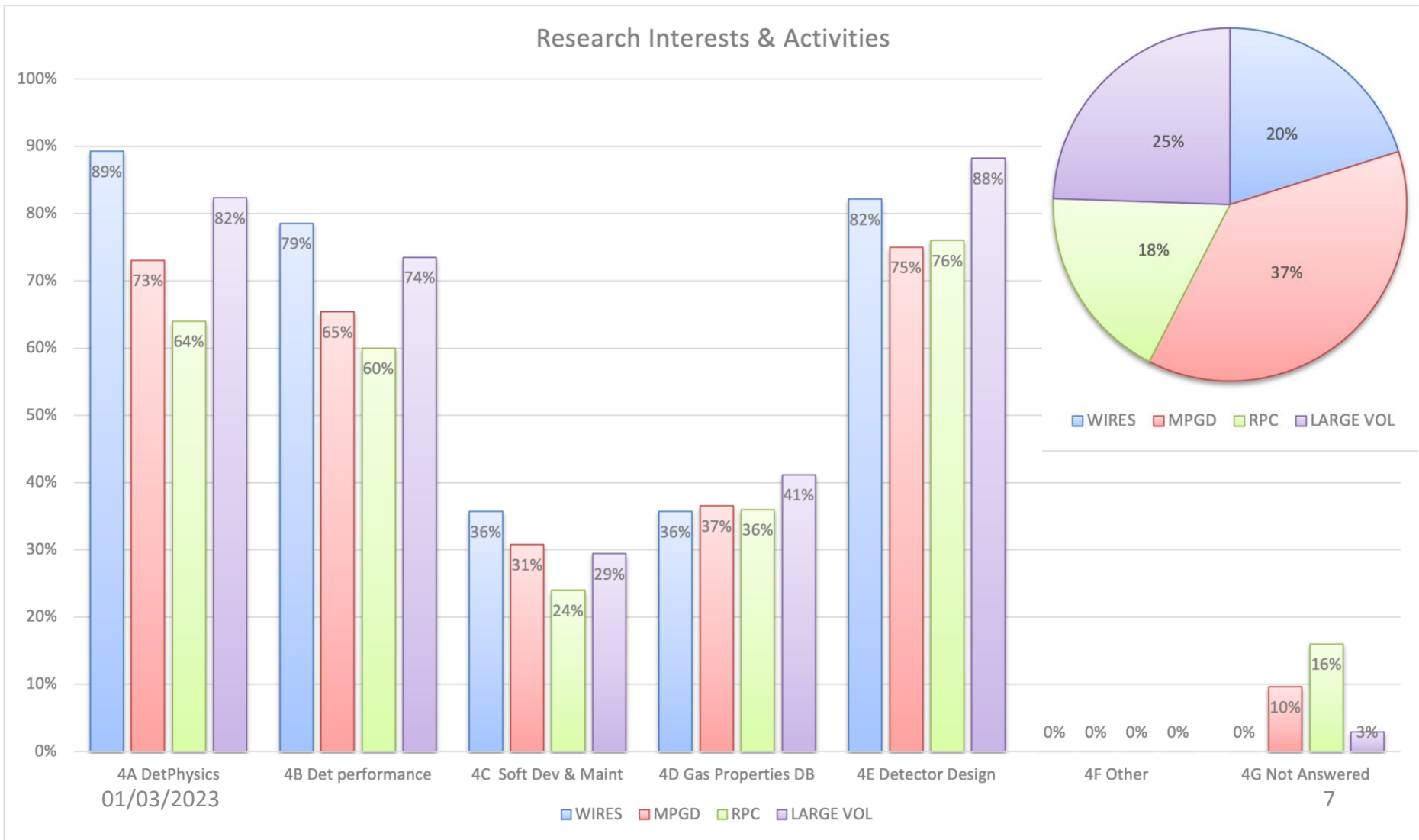# Detector Physics, Simulations & Software Tools: *research interests*

*No clear distinction between various technologies - homogeneous*

## Is your team involved in Software Development

Is your team involved in software development?
If the answer is yes, please specify in the comments section the activity and the number of involved people.

**A. Yes**: 28 (40.58%)

**B. No**: 41 (59.42%)

**40% involved in Software Development**

Yes

No

## Would you be willing to contribute or support common developments in the context of the DRD1 collaboration?

Ans
wer
ed:

69

If the answer is yes, please add more information in the comments section if your team can take charge of specific tasks, or if members of your team are willing to supervise common developments or if members of your team are willing to take part in ongoing efforts.

**A. Yes**: 39 (56.52%)

**B. No**: 30 (43.48%)

**55% willing to *contribute* or to *support* Software R&D in DRD1**

Yes

No

01/03/2023

> **50% is Interested in supporting common developments in DRD1**

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# Involvement in SW development

*No clear distinction between various technologies - homogeneous*
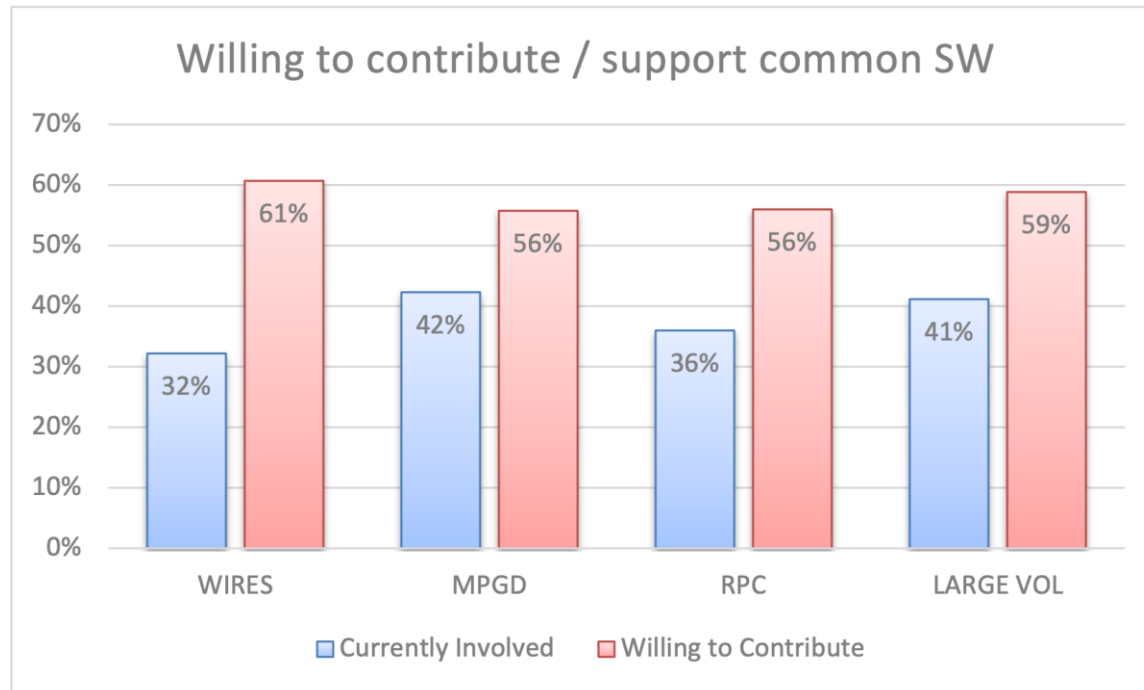


- Makes me very optimistic ☺
- But many are currently involved in "own" software – whether for their own group of own experiment
- => Hopefully we can work together on "common" software, accessible and adaptable for everyone

**Answer** Which software/simulation development do you consider necessary on a term of 5-10 years
ed: (34) to improve your work or, as users, to make progress in the field?

Good! 34/69 = 50%

- **Institutes indicate the <u>currently existing tools</u>:**
    - *GEANT, Garfield(++), ROOT, SRIM, Degrad, Magboltz, Heed, Ansys, Comsol, Fluka, Elmer, Mathematica, Matlab, NeBEM, Spice, Catia, Solidworks, …*
    - *Several running custom code as final step*
    - *Some (generic) experimental framework: ILCSoft/Marlin, Key4HEP, Rest-for-Physics,…*
    - *Institutes forgot about Database for Gaseous processes*
    - Some SW is free, some is proprietary and require the payment of licenses
    - <u>Need to foresee continued maintenance</u>
      for **established** free software developed within our own community:
        - *Garfield(++), Magboltz, Heed*       **=> SW maintained & supported by RD51**
        - *Think about future / maintainability … e.g. Pyboltz*
    - People want easy interfaces, better integration, …
    - GitLab to collect all existing codes / routines?
- **Institutes request for <u>extension</u> of existing tools / develop new features:**
    - Simulation of systems with resistive layers with Garfield
    - Physics modelling of systems with resistive layers & detector stability
    - Integration of simulation tools into the engineering tools (*alla TCAD*)
    - Integration of negative Ion Drift
    - Fast simulation of large Gain / large charge / space charge
    - Dynamical effects due to space-charge, accuracy of gain simulations
    - Correct implementation of Ion drift, Ion clusters, …
    - Microscopic description of scintillation & photon transport (optical readout)

## Development of and access to simulation and software

**Answe** List, if any, relevant problems you experienced or you would expect on **red:** _11_ doing software work with your team, both as developers and as users..

Somewhat OK 11/69 = 15%

- **Problems experienced** *(+ some comments)*
  - Software not well integrated / complicated integration (e.g. Garfield & GEANT)
  - Version compatibility between different software codes: COMSOL & Garfield
  - **Need skilled training for people running simulations**
    - i.e. steep learning curve – dedication required on medium-long term
    - Need skilled persons to adapt / write from scratch code for GPU
  - Difficulty to have funding for simulation dedicated person
    - Difficulty to have scientific proposals accepted based only/mostly on SW
  - Costly licenses
  - Storage issues
  - Limited Computing power
    *But also: tendency to use SW as user and cannot afford big investments such as done by big experiments to make code run Parallel or to use upcoming technology such as GPU => here we should act as a global community!*
  - Poor quality documentation … *even though GEANT & Garfield++ are excellent examples*
  - Continuity in the activity for software development
    *And this is again linked to the difficulty to obtain funding for dedicated persons …*
  - Missing data (ionization cross sections, Penning Transfers, Feedback)
    *=> means we should perform the measurements!*

# Institutes willing to put manpower on development of common code!

*2 people from our team will work on software development.* *Our team is willing to take part in ongoing efforts also we can take charge of specific tasks*

*We co-developed Pyboltz (a Python-version of Magboltz) together with UTA and Steve Biagi. Using this framework, we managed to simulate recently neutral bremstrahlung emission in scintillation-based noble-element detectors, and published in Phys. Rev. X. We use Pyboltz regularly for detector optimization. Concerning our support to the community: given the academic nature of our center and the way research is funded in Spain,* *we can generally provide support if an equal amount of matching manpower exists.*

*We do custom Monte Carlo software development according to our needs to improve or anticipate detector's performance – 2 person involved* *Our team would be willing to take charge of specific tasks, supervising common developments* *or taking part in ongoing efforts. We have developed a* *photon transport simulation software ANTS2,* *useful for development of detectors with optical readout (gaseous and liquid).*

*Involved in custom software development for modelling RPC and MRPC behaviour -* *1 people Interested in taking part in common development* *or supervising tasks in modelling RPC and MRPC performance.*

*Our team is currently working on the CMS RPC simulation.* *If needed we could participate in a development of electronic avalanche simulation software* *(with and without using GPUs).*

# Essential Aspects with *relevance/impact* in DRD1

- **ECFA General Strategic Recommendations**
  - [GSR-3] Specific Software for Instrumentation
  - [GSR-8] Attract, nurture, recognise & sustain the careers of R&D experts
  - [GSR-9] Industrial partnerships
    *-> might become crucial for additional funding (EU)*

- **Main Take-home messages:**
  - Users indicate existing software tools & *want better tools*
    - *=> need to continue maintenance & development*
    - *=> we have the expertise … need to pass on to Future Generations*
  - Users indicate they want *extension of existing tools* to cover better/more
  - 2/3 of our community is interested in detector physics through being able to simulate and model physics processes and by simulating the detector performance
  - *2/3 interested in Detector design software*
  - 1/3 of our community is interested in *Software development*
  - 1/3 of our community is interested in *(using) Gas properties DB*
  - Response is uniform among various gaseous detection technologies