Introduction to WG3: Gas and Material Studies

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DRD1 Collaboration Meeting at CERN
31st January 2024

Topics covered by the WG3: gas and material studies

Address common key issues related to gas and materials in the development of existing and future gaseous detectors

Gas
- Gas Properties (e.g. cross-section, chemical characterization, measurements)
- Eco-gases studies
- Light emission in gas

Systems
- Gas recuperation and recirculation systems
- Gas systems
- Sealed detectors and systems

Materials
- Resistive electrodes
- Solid converters
- Photocathodes (novel, aging, protection)
- Novel materials (e.g. nanomaterials)
- Material properties for detector and infrastructures
- Light (low material budget) materials
- Precise mechanics

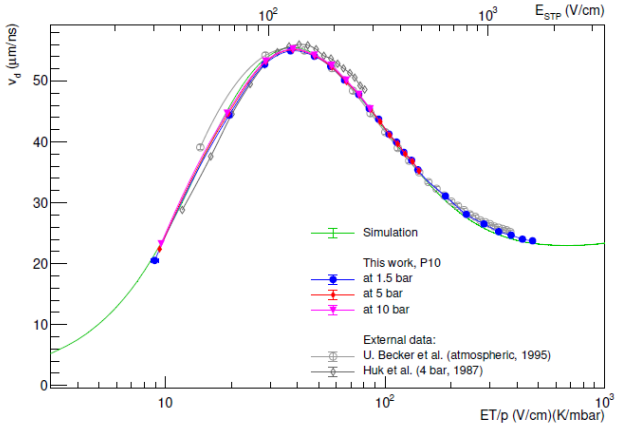
Long-term operation
- Ageing
- Outgassing
- Radiation hardness

Synergies and common aspects between technologies

Some topics have been identified as being of major interest for most of the gaseous detector communities, where synergies can also be found

Gas properties

- Common topic for all technologies
- Gas measurements (cross sections, drift velocity, diffusion for electrons and ions, etc.)
- Common database
- Gas simulation
- Gas analysis
- Eco-friendly gases



Eco gases

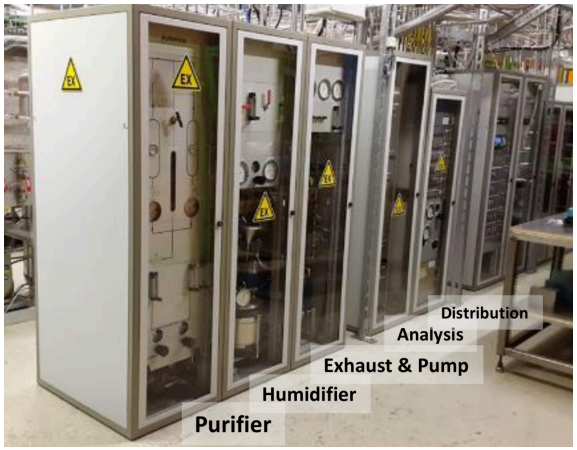
- Common topic for all technologies
- Studies on new gases
- Chemical characterisation
- Detector ageing

R134a
($C_2H_2F_4$)
GWP 1430

HFO-1234ze
($C_3H_2F_4$)
GWP 6

Gas systems

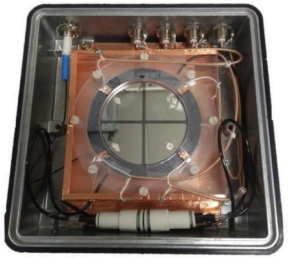
- Common topic for all technologies
- Gas recirculation systems
- Development of recuperation systems
- Development of small recirculation systems for laboratories, facilities, test-beam, etc.
- Gas purity



Synergies and common aspects between technologies

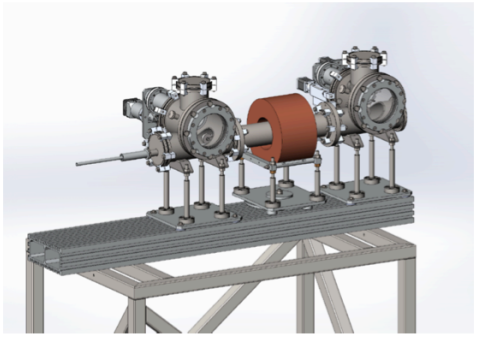
Resistive material

- Common topic for MPGD and RPC
- Common development of new materials
- Use of same tools/facilities to construct/test materials



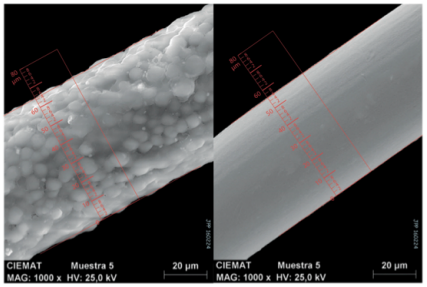
Precise mechanics and material properties

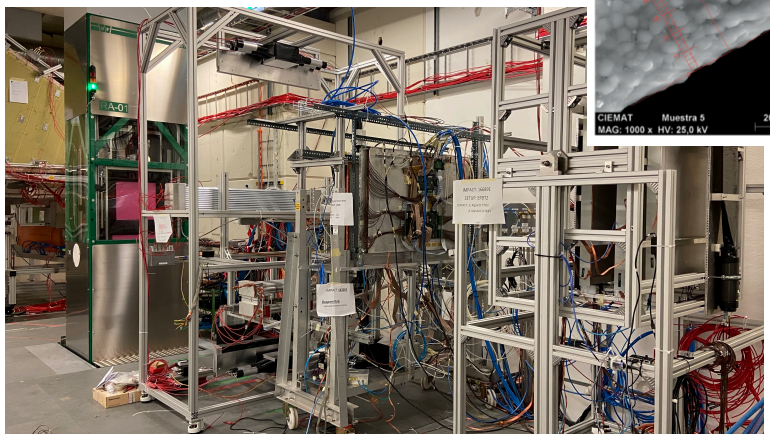
- Common topic for all technologies
- Mechanical tests
- Outgassing tests
- Radiation hardness



Ageing studies

- Common topic for all technologies
- Experience in common
- Material studies
- Radiation hardness studies
- Analysis: gas and material





Assets that the collaboration can support

It is fundamental to have common infrastructures and facilities, that would help in the execution of the projects in a more coherent and economical way as well as they would allow a better sharing of knowledge in the different fields

Gas properties

- simulation (support of software and training to the community): Garfield, Geant4, etc —> WG4
- database common for the different technologies

Material studies and development

- Common tools/facilities to develop and prepare materials —> WG6

few examples

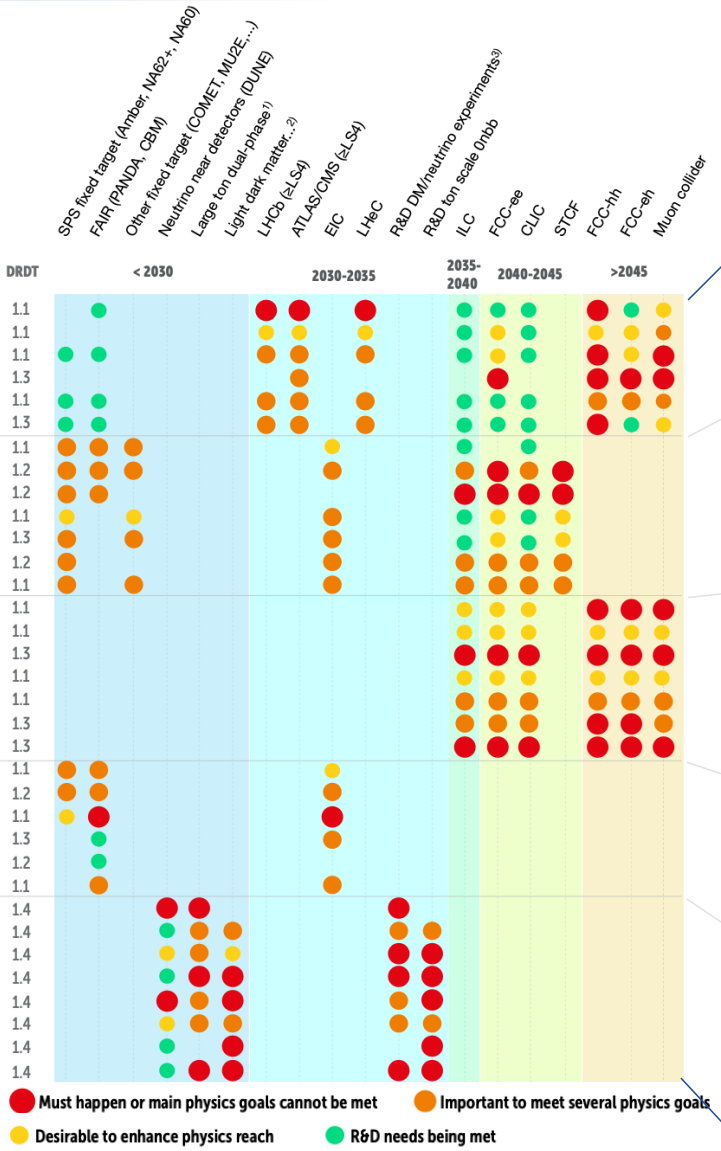
Ageing studies

- facilities needed to perform ageing studies (for example GIF++) —> WG7
- infrastructure necessary to run the test (for example trigger system, etc) —> WG7

Outgassing, radiation hardness and material studies

- common facilities can be useful for all technologies —> WG7

ECFA challenges and links with WG3 topics



DRDT 1.1 Improve time and spatial resolution for gaseous detectors with long-term stability

DRDT 1.2 Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out schemes

DRDT 1.3 Develop environmentally friendly gaseous detectors for very large areas with high-rate capability

DRDT 1.4 Achieve high sensitivity in both low and high-pressure TPCs

Muon system

Proposed technologies:
RPC, Multi-GEM, resistive GEM, Micromegas, micropixel Micromegas, μRwell, μPIC ...

- Rad-hard/longevity
- Time resolution
- Fine granularity
- Gas properties (eco-gas)
- Spatial resolution
- Rate capability

Inner/central tracking with PID

Proposed technologies:
TPC+(multi-GEM, Micromegas, Gridpix), drift chambers, cylindrical layers of MPGD, straw chambers

- Rad-hard/longevity
- Low X_0
- IBF (TPC only)
- Time resolution
- Rate capability
- dE/dx
- Fine granularity

Preshower/ Calorimeters

Proposed technologies:
RPC, MRPC, Micromegas and GEM, μRwell, InGrid (integrated Micromegas grid with pixel readout), Pico-sec, FTM

- Rad-hard/longevity
- Low power
- Gas properties (eco-gas)
- Fast timing
- Fine granularity
- Rate capability
- Large array/integration

Particle ID/TOF

Proposed technologies:
RICH+MPGD, TRD+MPGD, TOF: MRPC, Picosec, FTM

- Rad-hard (photocathode)
- IBF (RICH only)
- Precise timing
- Rate capability
- dE/dx
- Fine granularity

TPC for rare decays

Proposed technologies:
TPC+MPGD operation (from very low to very high pressure)

- Low power
- Fine granularity
- Large array/volume
- Higher energy resolution
- Lower energy threshold
- Optical readout
- Gas pressure stability
- Radiopurity

- Gas Properties
- Eco-gases studies
- Light emission in gas
- Gas recuperation and recirculation systems
- Gas systems
- Sealed detectors and systems
- Resistive electrodes
- Solid converters
- Photocathodes
- Novel materials
- Material properties for detector and infrastructures
- Light (low material budget) materials
- Precise mechanics
- Ageing
- Outgassing
- Radiation hardness

Common objectives for WG3

Reference	Description	Common Objective
D3.1.1	Gas properties: drift velocity, diffusion for e- and ions, gain measurements, light emission, attachment, etc.	Common gas properties database
D3.2.1	Characterisation of new eco-friendly gases: gas properties, cross-section, etc.	New data for the integration in Magboltz and Garfield++ (collaboration with WG4)
D3.3.1	Longevity and ageing studies for different technologies	Report for a common approach
D3.3.2	Characterisation of material for the construction of detectors: material properties, compatibility, outgassing, etc.	Common construction material database
D3.4.1	Development of gas recirculation and recuperation systems	New design and knowledge transfer
D3.5.1	Resistive material: characterisation of different materials	Common resistive material database and procedures
D3.6.1	Mechanics: compression, rigidity, machining precision, etc.	Common approach for the different technologies

Gas

Materials

Materials

Long-term operation

Systems

Table 13: WG3 - Common Objectives

WG3 communication channels and activities

Contact email: drd1-wg3-convenors@cern.ch

Mailing list: drd1-wg3@cern.ch

E-group link to subscribe: DRD1-WG3

- WG3 conveners will organise dedicated meetings to discuss specific topics: please send to us feedback about possible needs, interests or ideas

- Well-defined common objectives in the DRD1 Proposal: community is welcome to start contributing. Several aspects to take into accounts (know-how on R&D hardware, database, software, etc.). Need several and versatile expertises in the WG3

Summary

- The DRD1 WG3 aims to address key issues, related to gas and material studies, common to all gaseous detector technologies under development for future applications
- The WG3 main research topics are well linked with the ECFA themes and strongly connected to several tasks currently foreseen for the DRD1 Working Packages
- Shared resources, facilities and expertise will be key ingredients to achieve the WG3 common objectives which will also take advantage of synergies with other DRD1 WGs
- Today's session is a starting point for a collaborative discussion on topics and synergies of the WG3 within the DRD1 and especially within the different technologies

09:20 **Gas properties database**
Speaker: Nick Thamm (Rheinisch Westfaelische Tech. Hoch. (DE))

09:40 **Eco-gas studies**
Speaker: Marcello Abbrescia (Bari Physics Department and INFN)

10:00 **Gas systems for gaseous detectors**
Speaker: Gianluca Rigoletti (CERN)

10:20 **Resistive electrodes**
Speaker: Gianfranco Morello (INFN e Laboratori Nazionali di Frascati (IT))

10:40 **New Wires with CHANGE**
Speaker: Gabriel Charles (Université Paris-Saclay (FR))

11:00 **Long-term and aging studies: the example of CMS Muon system**
Speaker: Katerina Kuznetsova (University of Florida (US))

Back-up slides

Impacts of some topics in the Physics roadmap

few examples

Use of F-gases for future particle detectors

- European Union F-gas regulation is aiming to phase out most of F-gases in the coming years
- Implementation of several strategies to reduce the GHG emissions in particle detection

Gas recirculation
Gas recuperation
Eco-gas studies
Gas Properties
Sealed detectors and systems

Muon systems
Calorimetry
Photon detection
Particle ID/TOF

Longevity of the detectors

- In future accelerators, the accumulated charge will reach also hundreds of C/cm^2
- Fundamental to validate detectors in these harsh environments

Material properties
Ageing studies
Outgassing
Radiation hardness

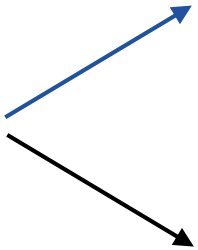
Muon systems
Inner/central tracking
Calorimetry
Particle/IDTOF

Impacts of some topics in the Physics roadmap

few examples

Improve in rate capability and time resolution

- Rate capability: operation at flows up to ~10 MHz/cm^2 (especially muon and inner/central tracking)
- Time resolution: depending on the application we can go down to less than hundreds ps

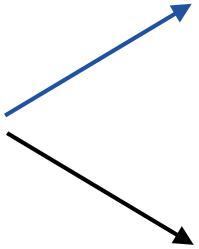


Gas properties
Resistive electrodes
Solid converters
Photocathodes
Novel materials

Muon systems
Inner/central tracking
Calorimetry
Particle ID/TOF

Construction of new detector systems

- Very large detector systems are foreseen for new experiments
- The design and construction are fundamental for the good success of the experiment
- Both manufacturing on an industrial scale and optimisation of the design will be necessary



Gas systems
Material properties for detector and infrastructures
Light (low material budget) materials
Precise mechanics

All detector systems