

The DRD1 collaboration

The first three years of strategic R&D on gaseous detectors



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20.10.2026



Implementing the European Strategy for Particle Physics

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ESPPU 2020: "The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels."

- Bring together requirements of future particle physics projects and technology visions from the instrumentation field
 - community driven, including input from neighbouring fields
- Identify major detector R&D Themes (RDTs) and General Strategic Recommendations (GSR)

Implementation plan (requested by CERN Council) CERN/SPC/1190 ; CERN/3679

- Establish new review body DRDC and scheme
- Roadmap team supporting community-driven proposal process
- Approval of DRDs in 2023 and 2024 (for 3 years)
 - Update reports once per year

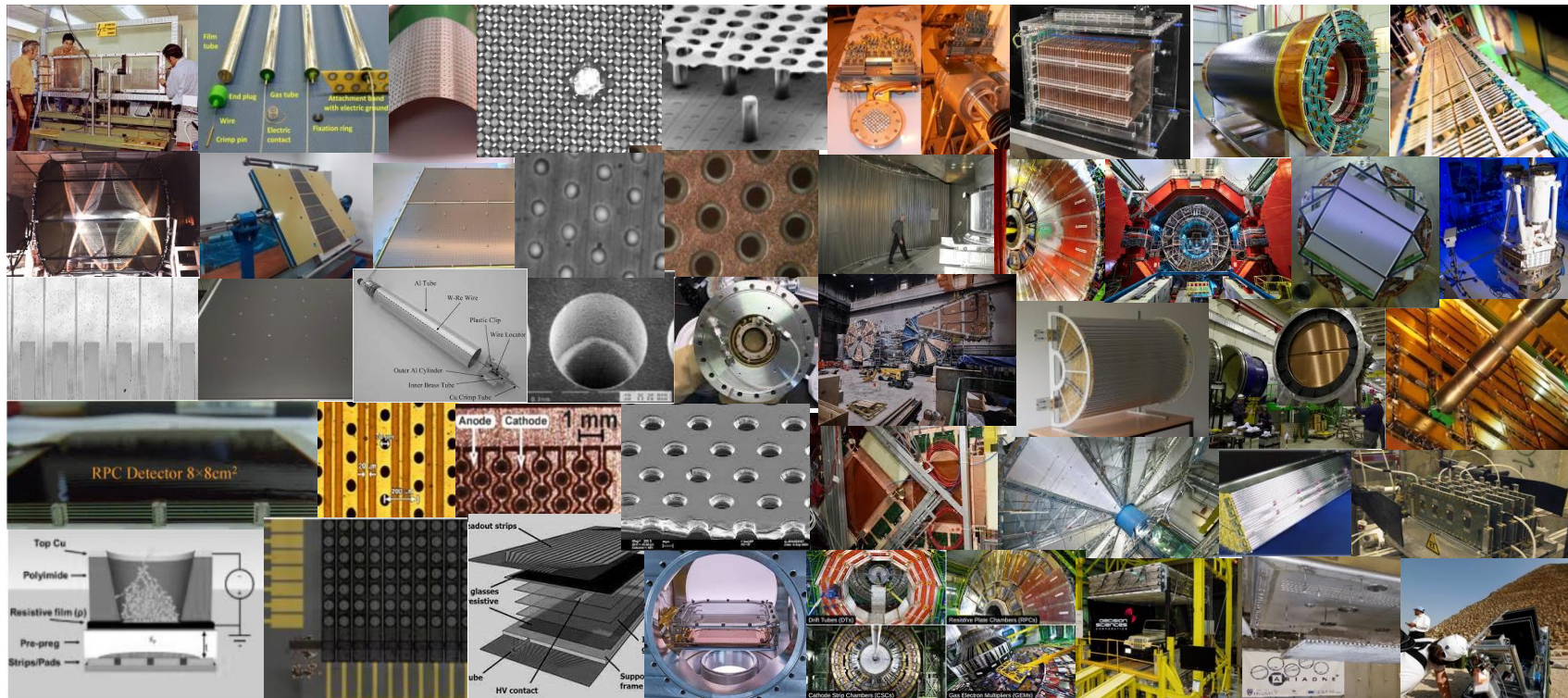


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DRD8: Mechanics

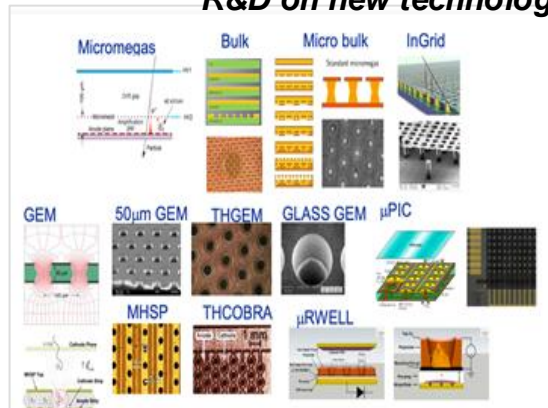
Ultra-thin beam pipes · CF foam and new materials · curved, retractable sensors · air & micro-channel cooling · eco-friendly cooling fluids · robots · augmented reality

The DRD1 Collaboration on gaseous detector technologies



DRD1: Gaseous Detector Technologies

R&D on new technologies, architectures, resistive materials, stability, upscaling, ...



Wire Chambers

Wire Chambers

- Ultra-thin ($< 15\mu\text{m}$) film tubes for lowest $X/X_0 \sim 0.02\%$
- Ultra-long ($\sim 5\text{m}$) and thin ($\sim 30\mu\text{m}$) film tubes
- "Smart" designs: self-stabilized straw modules, flex. mountings compensate relaxation
- Small straw diameter ($\sim 5\text{mm}$) for faster timing, less occupancy
- PID by dE/dx with "standard" time readout and time-over-thresh.
- 4D-measurement: 3D-space and (offline) track time

CSC/TCG

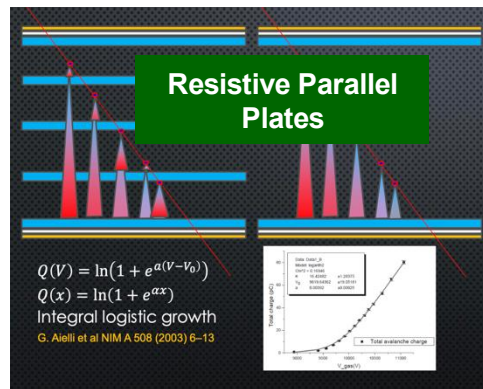
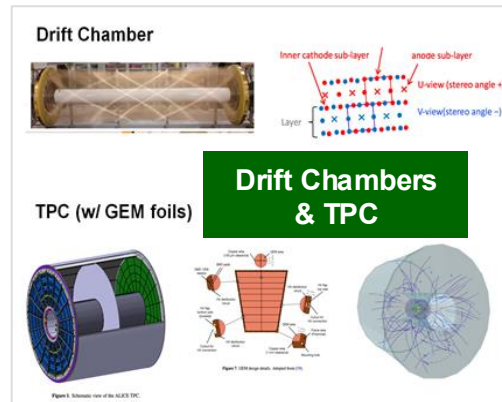
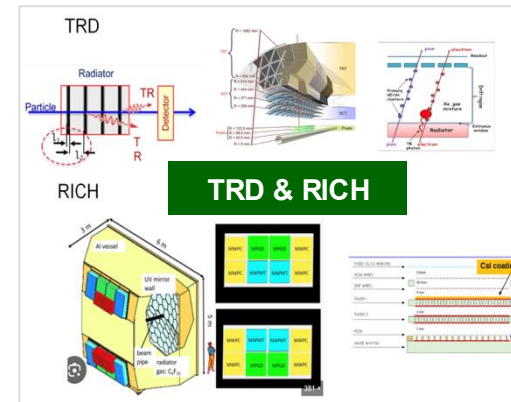
- Low X/X_0 TGC layers for central tracking regions?

Wires

- New wire materials new alloy, metallized carbon wire, ...
- Specific topic: wire corrosion, coating quality, ...

Wire Chambers

Picture from [15]



2024 - 2026: Seamless integration of ALL gaseous detector technologies into single collaborative effort

ECFA DETECTOR R&D ROADMAP CONTENT: TF1

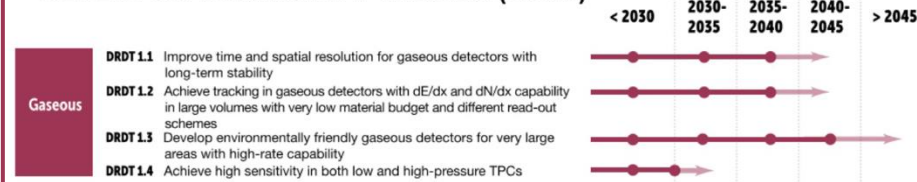
Performance targets and main drivers from facilities

Facility	Technologies	Challenges	Most challenging requirements at the experiment
HL-LHC	RPC, Multi-GEM, resistive-GEM, Micromegas, micro-pixel Micromegas, μ -RWELL, μ -PIC	Ageing and radiation hard, large area, rate capability, space and time resolution, miniaturisation of readout, eco-gases, spark-free, low cost	(LHCb): Max. rate: 900 kHz/cm ² Spatial resolution: ~ cm Time resolution: O(ns) Radiation hardness: ~ 2 C/cm ² (10 years)
Higgs-EW-Top Factories (ee) (ILC/FCC-ee/CepC/SCTF)	GEM, μ -RWELL, Micromegas, RPC	Stability, low cost, space resolution, large area, eco-gases	(IDEA): Max. rate: 10 kHz/cm ² Spatial resolution: ~60-80 μ m Time resolution: O(ns) Radiation hardness: <100 mC/cm ²
Muon collider	Triple-GEM, μ -RWELL, Micromegas, RPC, MRPC	High spatial resolution, fast/precise timing, large area, eco-gases, spark-free	Fluxes: > 2 MHz/cm ² (0-8 $^{\circ}$) < 2 kHz/cm ² (for 0-12 $^{\circ}$) Spatial resolution: ~100 μ m Time resolution: sub-ns Radiation hardness: < C/cm ²
Hadron physics (EIC, AMBER, PANDA/CMB@FAIR, NA60+)	Micromegas, GEM, RPC	High rate capability, good spatial resolution, radiation hard, eco-gases, self-triggered front-end electronics	(CBM@FAIR): Max rate: <500 kHz/cm ² Spatial resolution: < 1 mm Time resolution: ~ 15 ns Radiation hardness: 10 ¹³ neq/cm ² /year
FCC-hh (100 TeV hadron collider)	GEM, THGEM, μ -RWELL, Micromegas, RPC, FTM	Stability, ageing, large area, low cost, space resolution, eco-gases, spark-free, fast/precise timing	Max. rate 500 Hz/cm ² Spatial resolution = 50 μ m Angular resolution = 70 μ rad ($\eta=0$) to get $\Delta p/p \leq 10\%$ up to 20 TeV/c

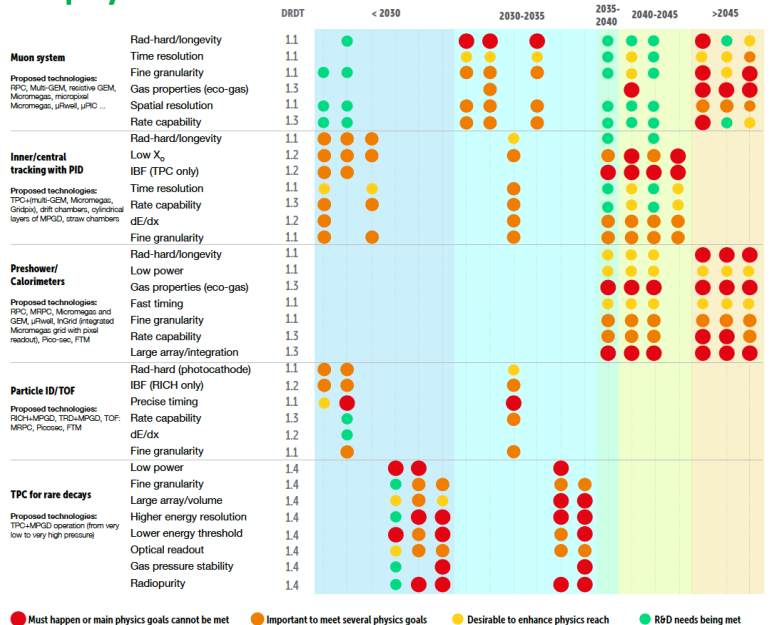
Example: Muon systems

Detector R&D themes

DETECTOR RESEARCH AND DEVELOPMENT THEMES (DRDTs) & DETECTOR COMMUNITY THEMES (DCTs)



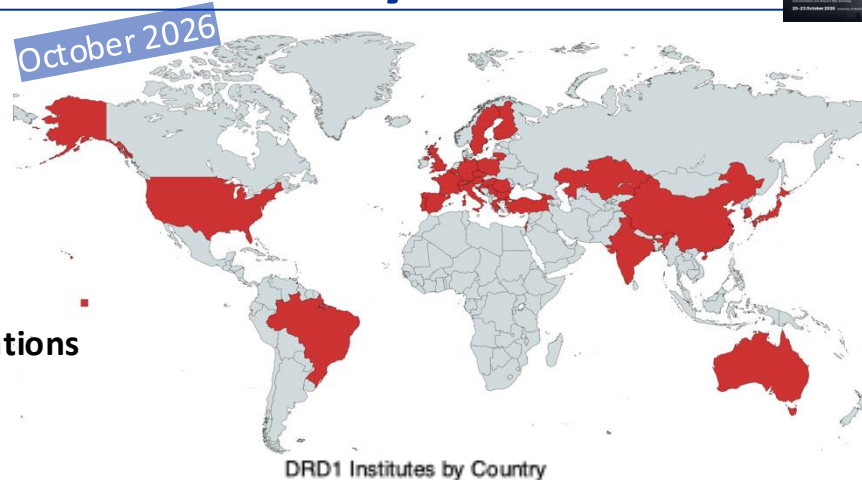
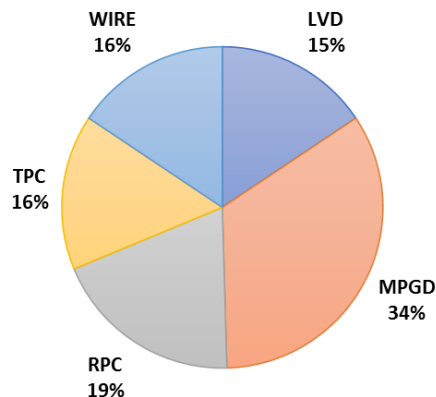
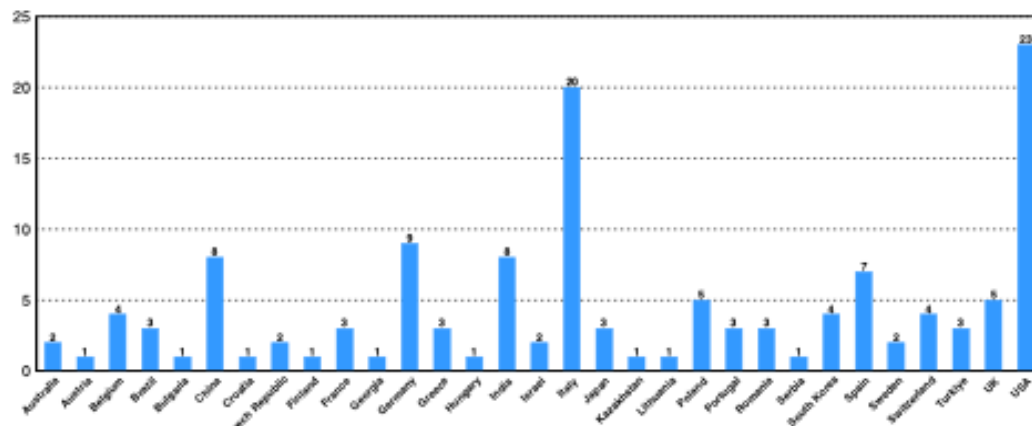
Needs/benefits for physics reach



DRD1: Large and diversified community

<https://drd1.web.cern.ch/>

- 135 Institutes
- 31 Countries
- More than 700 members
- 5 Industrial, Semi-Industrial and Research Foundations



DRD1 Collaboration proposal ([link](#)) approved by CERN Research Board in December '23

DRD1: Collaboration Organization and Management

Organizational structure of the DRD1

Collaboration is described in MoU Annex 4

DRD1 milestones:

- ✓ **Dec. 2023:** Approval of the DRD1 Collaboration Organizational Structure
- ✓ **Dec. 2023:** Elections of the Spokespersons, CB Chair/ Deputy for 2024-2025
- ✓ **Jun. 2024:** All DRD1 management positions are filled and approved by CB for 2-years term
- ✓ **Dec. 2025:** Elections of the CB Chair and DRD1 Spokespersons (2026-2027)
- ✓ **Jun. 2026:** Appointments for the new DRD1 management team for 2026-2028
- ✓ **Nov. 2026:** DRDC review for the DRD1 re-approval for the next 3-years term



Function	Name	Institution Code
Collaboration Board Chairperson	Anna Colaleo	IT-INFN.BA
Collaboration Board Deputy Chairperson	Leszek Ropelewski	CH-CERN
Collaboration Board Secretary	Margherita Primavera	IT-INFN.LE
CB Chair Advisory Group	Markus Ball	DE-UBONN
	Alberto Blanco Castro	PT-LIP
	Alan Bross	US-FERMILAB
	Mary Cruz Fouz	ES-CIEMAT
	Jianbei Liu	CN-USTC
Co-Spokespersons	Esther Ferrer Ribas	FR-IRFU-CEA
	Eraldo Oliveri	CH-CERN
Management Board Elected Members	Maxim Titov	FR-IRFU-CEA
	Markus Ball	DE-UBONN
	Alberto Blanco Castro	PT-LIP
	Amos Breskin	IL-WIS
	Gabriel Chares	FR-ICLAL
	Paul Colas	FR-IRFU-CEA
	Gianmaria Collazuol	IT-INFN.PD
	Nicola De Filippis	IT-INFN.BA
	Giuseppe Iaselli	IT-INFN.BA
	Jochen Kaminski	DE-UBONN
	Michael Tytgat	BE-VUB
	Piet Verwilligen	IT-INFN.BA
Management Board Members nominated by SPs	Peter Wintz	DE-FZJ-GSI-UBOCHUM
	Kondo Gnanvo	US-TINAF-ILAB
	Natsuki Tomida	JP-KYOTO-U
	Andy White	US-UTA
Working Groups Coordinator	Beatrice Mandelli	CH-CERN
Work Packages Coordinator	Hugo Ferreira Natal Da Luz	CZ-IEAP-CTU
Liaison Person with DRD2	Diego Gonzalez Diaz	ES-USC-IGFAE
Liaison Person with DRD4	Fulvio Tassarotto	IT-INFN.TS
Liaison Person with DRD5	Florian Maximilian Brunbauer	CH-CERN
Liaison Person with DRD6	Imad Laktineh	FR-ULYON1
Liaison Person with DRD7	Marco Bregant	BR-FAPESP-IFUSP
	Sorin Martoiu	RO-IFAJIN-HH

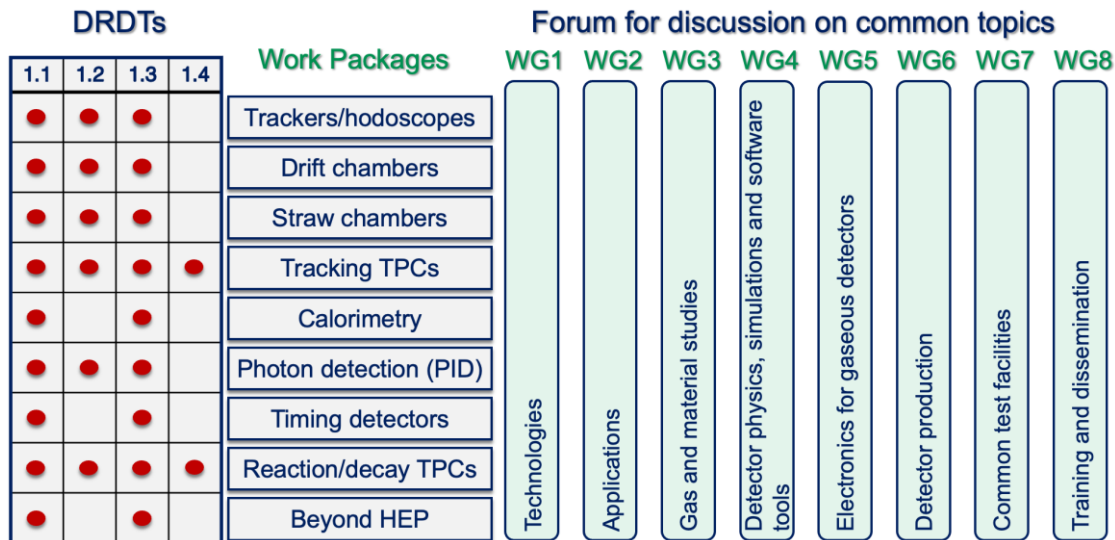
WG Conveners (around 40); WP (Project) Leaders (around 30))

Working Groups

The scientific organization is structured in eight Working Groups, the core of the scientific collaboration:

- supporting the development of novel technologies and the consolidation of existing ones,
- facilitating the exchange of ideas and fostering synergies between institutes,
- playing a crucial role in identifying, guiding, and supporting strategic detector R&D directions, facilitating the establishment of joint projects between institutes.

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



Working group tasks

The collaborative structure of DRD1 keeps RD51 structure in Working Groups

Working-group conveners coordinate R&D tasks of the respective working groups. Two coordinators elected through a nomination process, approved by MB and CB

WG 1	WG 2	WG 3	WG 4	WG 5	WG 6	WG 7	WG 8
Technologies	Applications	Gas and material studies	Detector physics, simulations, and software tools	Electronics	Detector production	Common test facilities	Training and dissemination
Large Volume Detectors (Drift chambers, TPCs)	Trackers/Hodoscope	Measurement of Gas Properties	Garfield++	Front-End Electronics for Gaseous Detectors	Common Production Facilities and Equipment	Detector Laboratories Network	Knowledge Exchange and Facilitating Scientific Collaborations
MPGDs	Inner and Central Tracking with PID Capabilities: - Drift Chambers - Straw tubes - TPC	Studies on Eco-friendly Mixtures	Simulation of Large Charges and Space Charge	Modernised Readout Systems (DAQ): - high performances - FE Integration - portability	QA/QC	Test Beam Common Facilities	Training and Dissemination Initiatives
RPCs, MRPCs	Calorimetry	Ageing and Outgassing studies	Simulation of Detectors with Resistive Elements		Collaboration with Industrial Partner	Irradiation Common Facilities	Career Promotion
TPC	Photon Detector (PID)	Gas systems	Modelling and Simulation of Eco-friendly Mixtures	Instrumentation (e.g. HV, LV, monitoring)	Gaseous Detector FORUM (know-how)	Specialized Laboratories (outgassing/ageing, gas analysers, photocathodes)	Outreach and Education
Straw tubes, TGC, CSC, drift chambers, and other wire detectors	Timing Detectors (PID & Trigger)	Materials studies: - novel material (nanomaterial) - new material for wire - new converter	Optimization of Simulations (time, hw/sw resources)			Common instrumentation and software	
New amplifying structures	TPC as reaction and decay chambers	Photocathodes	Specific Processes (e.g. Electroluminescence)				
	Beyond HEP - Medical Application - Neutron Science - Muography - Space Applications - Other (Dosimetry, Beam Monitoring, Cultural Heritage, Homeland Security,...)	Precision Mechanics					

WG1 Technological Aspects and New Detector Structures

Forum for Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issues. Promotes innovation in gaseous detector architectures, supporting the development of new detector concepts across wire chambers, RPCs, MPGDs, and large-volume gaseous systems.

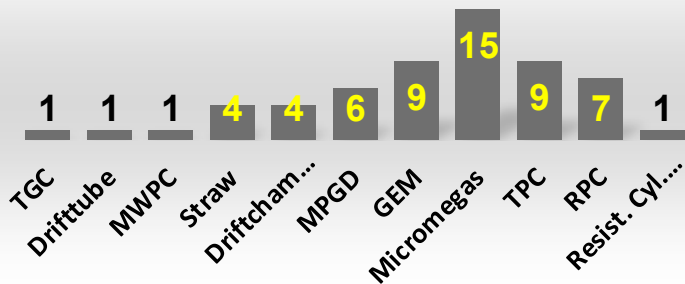
R&D in the focus of the WG

- **Monitor and share** detector performance progress and **new concepts**
- **Gather experience** from running or completed experiments
- Keep in contact with groups in the world-wide DRD1 community
- Select presentations for the WG1 session in DRD1 collaboration meetings
- Contact and invite relevant R&D reports from non-DRD1 groups

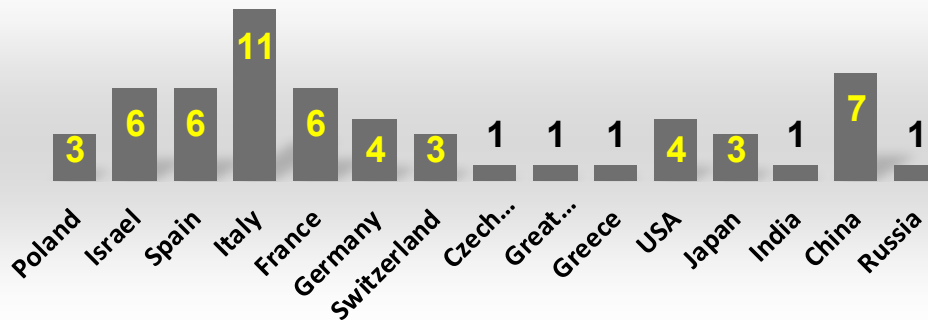
Common Activities in 2024-2026

- Organization of WG1 session for the DRD1 collaboration meetings
- 8 sessions with 58 presentations covering 11 detector technologies
- Topical workshop together with WG2 on Technologies and Applications of Gaseous Detectors at FCC (<https://indico.cern.ch/event/1675383/>) , 13 technology talks during the 1-day workshop

Talks per Detector Technology



Contributions from 15 Countries



WG2 — Applications

Connecting detector R&D activities with present and future applications.

R&D in the focus of the WG

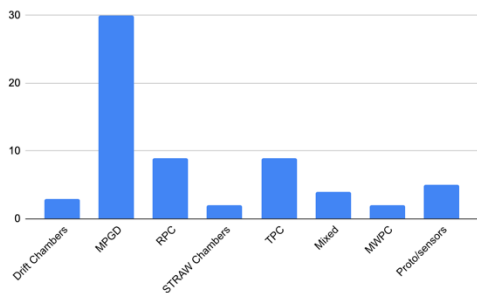
- **Application-driven gaseous detector R&D**: identifying the detector performance and technology developments required by current and future experiments and applications.
- **Bridging applications and detector development**: translating application needs into R&D priorities, fostering interactions between users and developers, and promoting technology transfer across scientific domains.

Common Activities in 2024-2026

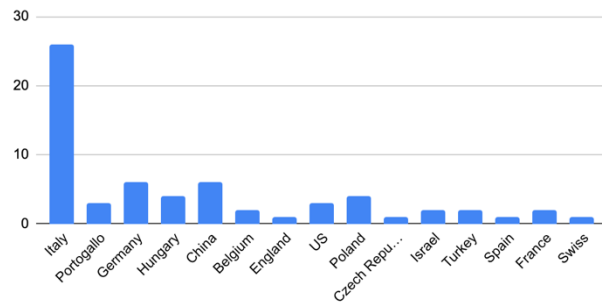
- **8 WG2 sessions** organized during the DRD1 Collaboration Meetings
- **Topical workshop** on *Technologies and Applications of Gaseous Detectors at FCC (WG1 & WG2)*
- **51 talks presented** across WG2 sessions and workshop

Statistical overview of the WG2 activities

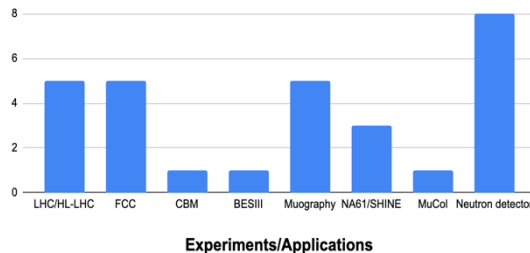
Technology coverage



Country participation



Applications and experiments



WG3 — Materials and Gas Mixtures

Develops **new materials** and **eco-friendly gas mixtures** to enhance detector performance and longevity, addressing **ageing and sustainability** for high-performance, low-impact detectors

R&D in the focus of the WG

- Facilitate contacts and exchange of expertise between different groups at Collaboration Meetings or dedicated ones,
- organizing topical Workshops,
- supporting the identification, proposal and realization of common activities.

Grafana for lab monitoring: a hands-on workshop

Indico event: <https://indico.cern.ch/e/gw2025>

hybrid format for remote participation ≈ 50 participants



<https://indico.cern.ch/event/1543925/sessions/604114/#20250618>

Common Activities in 2024-2026

- Gas Properties and Studies of New Mixtures (syn. WG4)
- Ageing and Outgassing
- Recirculation and Recuperation Systems (syn. WG7)
- Material studies involving wires and resistive materials (syn. WG6)
- Mechanics (syn. DRD8)

Topical Workshops: Towards Sustainable Gas Mixtures for Future Detectors 2025

- **Regulatory landscape**, interdisciplinary and industrial perspectives
- **Gas Recovery, Recycling, and Closed-loop Systems**
- **Gas Replacement Strategies**: Physics and Performance

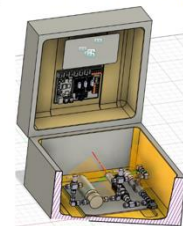
Workshop 1: Regulatory landscape, interdisciplinary and industrial perspectives	Workshop 2: Gas Recovery, Recycling, and Closed-loop Systems	Workshop 3: Gas Replacement Strategies: Physics and Performance
1.1.1. Introduction to the regulatory landscape	2.1.1. Introduction to gas recovery and recycling	3.1.1. Introduction to gas replacement strategies
1.1.2. Regulatory requirements for gas mixtures	2.1.2. Gas recovery and recycling systems	3.1.2. Gas replacement strategies for different detector types
1.1.3. Regulatory requirements for gas mixtures	2.1.3. Gas recovery and recycling systems	3.1.3. Gas replacement strategies for different detector types
1.1.4. Regulatory requirements for gas mixtures	2.1.4. Gas recovery and recycling systems	3.1.4. Gas replacement strategies for different detector types
1.1.5. Regulatory requirements for gas mixtures	2.1.5. Gas recovery and recycling systems	3.1.5. Gas replacement strategies for different detector types
1.1.6. Regulatory requirements for gas mixtures	2.1.6. Gas recovery and recycling systems	3.1.6. Gas replacement strategies for different detector types
1.1.7. Regulatory requirements for gas mixtures	2.1.7. Gas recovery and recycling systems	3.1.7. Gas replacement strategies for different detector types
1.1.8. Regulatory requirements for gas mixtures	2.1.8. Gas recovery and recycling systems	3.1.8. Gas replacement strategies for different detector types
1.1.9. Regulatory requirements for gas mixtures	2.1.9. Gas recovery and recycling systems	3.1.9. Gas replacement strategies for different detector types
1.1.10. Regulatory requirements for gas mixtures	2.1.10. Gas recovery and recycling systems	3.1.10. Gas replacement strategies for different detector types

Gas monitoring sensors and real-time visualisation

Plug-and-play real time monitoring system for gas detectors in R&D environment in lab and test beam



MMS prototype



MMS final design

WG4 — Detector Physics, Simulation and Software

Detector physics, simulations & software tools

R&D in the focus of the WG

- Understanding and **modelling the fundamental physical processes** governing the operation of gaseous detectors.
- Development, maintenance, support, and dissemination of **common simulation tools** to reproduce these processes and predict detector performance.
- Benchmarking and validation of simulation models through systematic comparison with experimental measurements.
- Providing **guidelines** and best practices for the **design and optimization** of the next generation of gaseous detectors

Community Building

- Organization of working meetings (10 events) on relevant topics, including:
 - Simulation of Resistive Detectors
 - Large Avalanches Topical Meeting
 - Low Pressure Simulation & Measurements
- Organization of WG4 session at Collaboration Meetings (60 Contributions)
- **Contribution to the DRD1 schools through lectures and tutoring.**
- **Organization of the first Simulation school 2026 in Bari (34 participant students)**

Working Meeting

- Topical working meetings: 10 events since January 2024, typically 30–50 participants, multiple contributions:
- Simulation of resistive detectors (Apr 2024)
- Modelling of non-equilibrium effects and low pressure (Feb & Apr 2024)
- Simulation of large avalanches and space-charge (Jun 2024, Apr 2025)
- Modelling of electroluminescence
- Modelling of eco-gases

Common Activities in 2024-2026

- Modernisation and improvement of the Garfield++ framework
- Simulation of signals and rate capability in detectors with resistive elements
- Modelling of electroluminescence
- Modelling of eco-friendly gases and extraction of their cross sections
- Modelling of non-equilibrium effects and low-pressure operation

Development & Support of Common Software Tools

- Garfield++
 - Magboltz
 - Degrad
 - Heed
 - neBEM
- (See next slide)

Garfield++ (garfieldweb.cern.ch • gitlab.cern.ch/garfield)

- Physics & accuracy: improved low-pressure e^- tracking, SWEATERS-based deexcitation & radiation-trapping upgrades, recombination process, AvalancheMC improvements
- Performance & scalability: GPU support for AvalancheMicroscopic, CPU multi-threading AvalancheMicroscopic and AvalancheMC, super-charge clustering for large avalanches
- Starting the inclusion of dynamic space-charge field update using a semi-analytical method
- Signal induction for resistive detectors (ELMER, COMSOL)

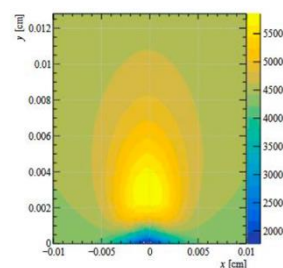
Magboltz & Degrad (magboltz.web.cern.ch)

- Magboltz 11.19: new gas-table format and updated cross sections
- Eco-gas cross sections (CERN–ETH Zürich effort) implemented in Magboltz
- Magboltz++: first working C++ transcript as long-term solution
- New Degrad interface (beta) for primary ionization by electrons

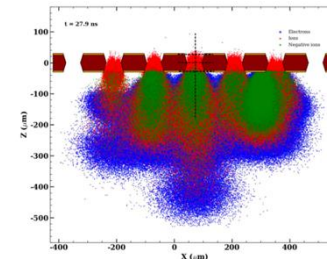
neBEM (gitlab.cern.ch/garfield)

- Addition to parallel computing capabilities: CUDA / OpenMP acceleration
- Starting the inclusion of dynamic space-charge field update for large-avalanche simulation

Space Charge Effects in MPGDs (CERN Summer Student; neBEM)

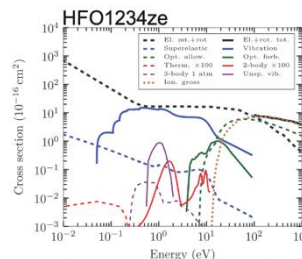


<https://repository.cern/records/fpfqg-hc985>

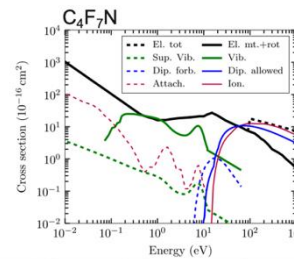


<https://indi.to/KY3Gw>

Inclusion of new cross-section to Magboltz (CERN-ETH Zürich)



DOI 10.1088/1361-6463/ae6871



DOI 10.1088/1361-6463/ae6871

WG5 — Electronics for Gas Detectors

Coordinates developments in front-end electronics and data acquisition systems, addressing the requirements of future detectors in terms of rate capability, noise performance, timing precision, and integration.

R&D in the focus of the WG

Innovating front-end electronics and data acquisition systems for gaseous detectors.

WG5 is key to managing high-rate, low-noise, and precise signal processing.

The group's efforts ensure that the electronic components are well integrated with detector systems to support the demanding requirements of modern experiments.

VMM3a-SRS integration into new detector technologies

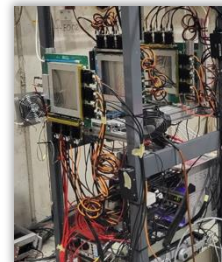


- Detector characterization
- Students mentoring
- System's debugging and optimization

Common Activities in 2024-2026

- Topical Workshop on Electronics for Gaseous Detectors.
- **Scalable Readout System:** upgrade of the current system towards a new and more powerful version, the eSRS. Consolidation of the existing system and integration into different detector technologies (MPGD, wire, RPC). Support for the DRD1 test-beam campaign and tracking/timing telescopes (two DRD1 telescopes, several DUTs, and support for external groups).
- FE ASIC for Gaseous Detectors: survey of future needs and evaluation of a potential common activity on novel FE ASIC prototyping.

- **SRS is present in some experiments in the US,**
- **VMM3a has been developed in BNL,**
- **SALSA will serve as FE ASIC in ePIC.**



Support at DRD1 test-beam

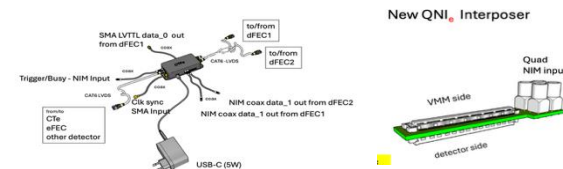
- Deployment of two DRD1 telescopes with several DUTs
- On-site support to external groups

VMM3a-SRS online documentation

<https://vmm-srs.docs.cern.ch/>

Upcoming

- Development of a new FE ASIC for DRD1
- Development of discrete electronics within the CERN summer studentship program.
- New design of RO architectures for SRSe.



WG6 — Production and Technology Transfer

Supporting the transition of detector concepts from laboratory prototypes to industrial-scale production.

R&D in the focus of the WG

- **Scale up** gaseous detector technologies, optimize costs, and **support the transition** from prototypes to **industrial manufacturing**.
- **Strengthen strategic CERN support for the MPT** workshop and enhance the use of existing manufacturing facilities across the community.
- Facilitate the establishment of new production facilities at DRD1 institutions and research laboratories.
- Develop **new detector concepts** and layouts suitable for large-scale and industrial production.
- **Collaborate with companies**

Production Facilities

- CERN MPT Workshop
- New MPGD and RPC workshops under development
- Support for CEA and XX workshops.
- Collaboration with LUMA and other external partners.

Common Activities in 2024-2026

- Detector manufacturing & production: manufacturing technologies, mass production, quality control, and cost-effective large-volume production.
- Production facilities: development and maintenance of shared infrastructures, optimization of existing facilities, and establishment of new manufacturing facilities.
- Industrialization: building partnerships with industrial partners and spin-offs to transition successful academic prototypes into commercial technologies.
- Production for experiments and projects: supporting detector production for DRD1 and other projects.
- 2025 Topical Workshop on Detector Manufacturing, including a visit to the CERN MPT Workshop.

Survey of Existing Facilities & Upcoming Production

Survey on existing facilities and upcoming gaseous detector production.

The survey includes a few questions on production plans, capabilities, and future needs.



DRD1
Gaseous Detector Technologies

Production needs
2026-2029

The aim of this document is to gather as much information as possible about production **planned** for the next three years of gaseous detectors. It should be updated every year. Older versions should be kept together. This document is here to help sharing knowledge among the community.

There is a long collaboration of US institutes with the MPT workshop – both in production and support to production.

WG7 — Common Test Facilities and Infrastructures

Supports access to shared infrastructures, including test-beam and irradiation facilities, enabling common validation and benchmarking of detector prototypes across DRD1 activities.

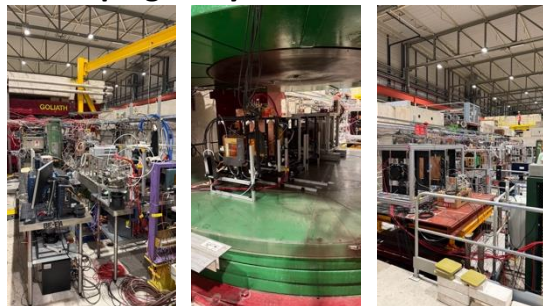
R&D in the focus of the WG

- Detector Laboratories Network
- Common Instrumentation and infrastructures for Test Beam and Irradiation Facilities
- Outgassing and Ageing
- Gas monitoring
- Thin Film Deposition Facilities
- Standard and customised laboratory instrumentation and software
- Facilities Database

Common Activities in 2024–2026

- **Shared laboratory:** gas studies, detector characterization and common electronics integration.
- **SPS/H4 test beams:** coordination, infrastructure, local support and CERN interfaces for DRD1 groups.
- **Common test-beam infrastructure:** tracking/timing telescopes, triggers, electronics, gas systems, DCS and environmental monitoring.
- **GIF++:** participation of several DRD1 groups in parallel irradiation campaigns.
- **Gas systems:** development of a small recirculation system for laboratory and test-beam use (in synergy with WG3).

TB campaign July 2026



SPS Test Beam Campaigns

- 2024: 3 DRD1 TB campaigns (8/8/5 setups)
- 2025: 2 DRD1 TB campaigns (13 /17 setups)
- 2026: 2 DRD1 TB campaigns (9 /16 setups)

Indico pages of TB campaigns

- Sep. '24 <https://indico.cern.ch/event/1462069/>
- July '25 <https://indico.cern.ch/event/1578401/>
- Nov. '25 <https://indico.cern.ch/event/1599108/>
- May '26 <https://indico.cern.ch/event/1647512/>
- July '26 <https://indico.cern.ch/event/1647848/>

JLAB/UVA took part in test beam activities, together with other groups (CEA/SACLAY, INFN Roma 2) involved in ePIC/EIC experiment.

WG8 — Training and Dissemination

Education, knowledge transfer, and career development.

Focus of the WG

- Recognizing the importance of knowledge exchange, training opportunities and promoting researcher careers in a collaborative framework,
- Training and Dissemination aims at facilitating scientific exchanges in the gaseous detector community and educating as well as retaining experts in the field of gaseous detector development.

DRD1 Gaseous Detector School

Annual DRD1 Gaseous Detector School

- CERN in 2024,
- FTD, University of Bonn, Germany in 2025,
- **FRIB, MSU, USA in 2026.**

The school covers MPGD, wire-based and RPC detectors and features lectures as well as hands-on exercises over 5-10 days.



DRD1 Awards

Annual prizes in 2 categories:

- PhD thesis award
- early-career scientist award.

The third category for exceptional contributions to the collaboration is not awarded each year.

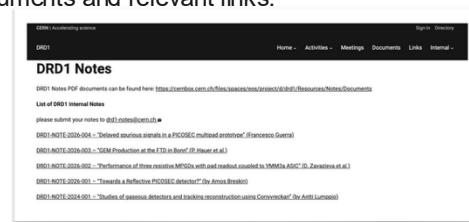
Common Activities in 2024-2026

- Organisation of the DRD1 Gaseous Detector School
- Support of the simulation school organised by WG4,
- Initiation of DRD1 Awards,
- Fostering knowledge sharing activities,
- Maintaining web resources,
- Sharing news and announcements with a bulletin.

DRD1 website

A central collection of information including but not limited to:

- upcoming and previous meetings,
- conferences and workshops,
- job opportunities,
- DRD1 notes,
- software resources,
- information concerning registration, mailing lists and e-groups,
- documents and relevant links.



Organization of the collaboration activities

Following the indication of ECFA Detector Panel two areas of Detector R&D :

- “Blue-sky” R&D (competitive, short-term responsive grants, nationally organised)
- Strategic R&D via DRD Collaborations (long-term strategic R&D lines) (address the high-priority items defined in the Roadmap via the DRDTs)

Two types of DRD1 joint projects implemented:

Common projects

For low-TRL (blue sky) R&D, or other short term generic projects

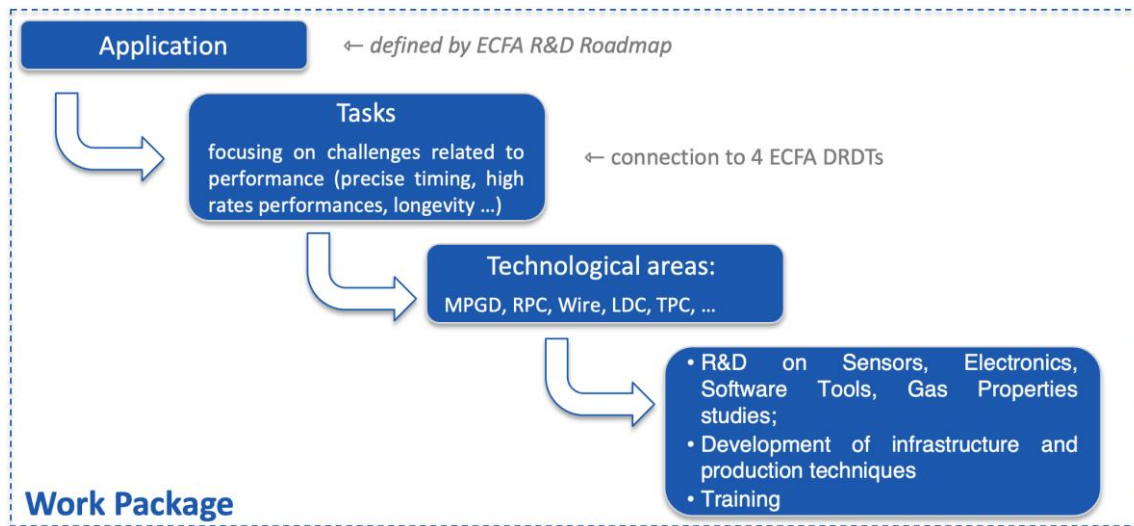
Work Packages

Strategic R&D targeting the priority programmes outlined in the updated European Strategy for Particle Physics

Work Packages

Strategic R&D (according to the ECFA Detector R&D Roadmap) **is organized in Work Packages**

- group activities of the Institutes with **shared research interests** around **Applications** with a focus on a **specific task(s)** devoted to a specific DRDT challenge, typically related to specific **Detector Technologies** and to the development of **specific tools or infrastructure**



Currently established WPs:

- **WP1: Trackers/hodoscopes**
- **WP2: Drift chambers**
- **WP3: Straw chambers**
- **WP4: Tracking TPCs**
- **WP5: Calorimetry**
- **WP6: Photo-detectors**
- **WP7: Timing**
- **WP8: Reaction/Decay TPCs**
- **WP9: Beyond HEP**

DRDTs

1.1	1.2	1.3	1.4
•	•	•	
•	•	•	
•	•	•	
•	•	•	•
•		•	
•	•	•	
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- 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

WP1: Trackers, Hodoscopes, Large area muon systems

T1: New RPC Structures

T2: New Resistive MPGD Structures

T3: New Front-end electronics

T4: Optimization of scalable multichannel readout systems

T5: Eco-friendly gases

T6: Manufacturing

T7: Longevity on large detector areas

T8: New detector structures

<https://drd1.web.cern.ch/wp/wp1>

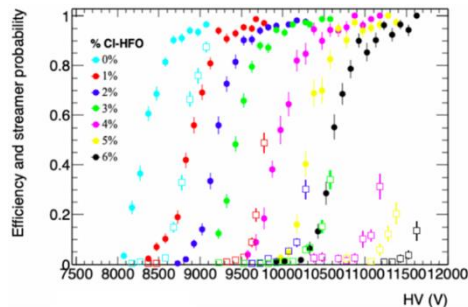
Activities in 2024-2026

- **Development of new electrode materials**, such as GaAs, DLC or RCC for RPC.
- **Novel MPGD layouts**, like the PEP-DOT and hybrid GEM-uRWELL; new layering of MM.
- On the **electronics front**, progress is marked by the development of specialized ASICs (such as VMM3, TIGER, TORA, and SALSA).
- In **environmental sustainability**, with the validation of low-GWP eco-gas mixtures and extensive long-term aging campaigns.
- **Industrialization** efforts are enabling large-scale manufacturing for MPGD such as MM and μ -RWELL

Goals

Development of large-area gaseous detector systems, including **Resistive Plate Chambers (RPCs)** and **Micro-Pattern Gaseous Detectors (MPGDs)**, for muon systems, triggering, tracking, and precision timing applications.

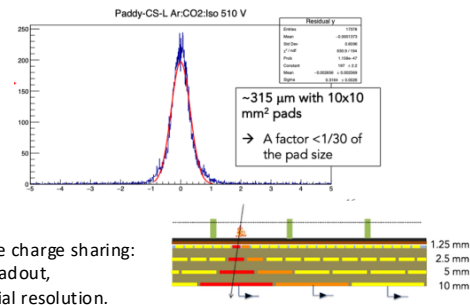
Eco-gas studies for RPC



Sputtering machine for new material deposition



New Structures and Layout



WP2: Inner and central tracking with PID (Drift Chambers)

<https://drd1.web.cern.ch/wp/wp2>

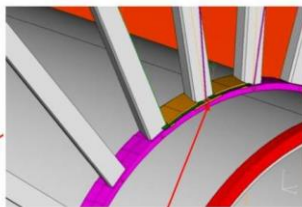
- T1: Development of front-end ASIC for cluster counting
- T2: Development of a scalable multichannel DAQ board
- T3: Mechanics: new wiring procedures and new endplate concepts
- T4: Increase rate capability and granularity
- T5: Consolidation of new wire materials and wire metal coating
- T6: Study ageing phenomena for new wire types
- T7: Optimization of gas mixing, recuperation, purification and recirculation

Goals

Large-volume drift chambers for tracking and particle ID at future lepton colliders (FCC-ee, CEPC) and flavor factories (SCTF).

Precise tracking at low pT and excellent particle ID via cluster counting. Key R&D challenges involve mechanics, electronics, and gas mixture

New wiring procedures and new endplate concepts



Spacers (yellow) and PCBs (green) are inserted between the spokes. The spacers have holes for the distribution of the gas

The edge of the PCB acts as a stop on the spoke, providing a reference.

The supporting cables are anchored to some spacers appropriately shaped

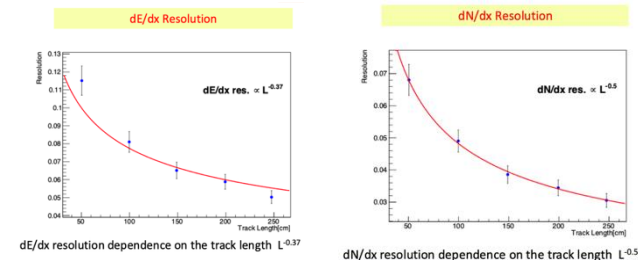
Carbon foam core 6x lighter than aluminum – FOAM ROHACELL® 35 HTC

IDEA DCH

Wires Studies

- Tungsten and molybdenum gold-coated, carbon monofilaments tested.
- Aluminium wires to be characterized
- Ageing tests going to start

Cluster Counting: dn/dx resolution



~ 2 times improvement in the resolution using dN/dx method

WP3: Inner and central tracking with PID (Straw and Drift Tubes)

<https://drd1.web.cern.ch/wp/wp3>

T1: Optimize straw materials and straw production technologies

T2: Improve straw tube designs

T3: Optimize the detector mechanical system

T4: Optimize the front-end electronics (ASIC) and read-out system

T5: Enhance the tracker measurement information (3D, t_0 , dE/dx)

T6: Enhance the longevity of the detector

T7: Optimize the online-/offline software

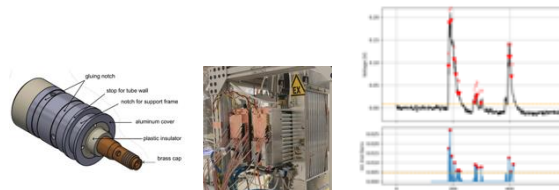
- **Project A** - Drift tube developments for new high-rate applications
- **Project B** - Straw chamber technologies for hadron physics applications
- **Project C** - Large area straw detector for Dark Sector applications
- **Project D** - Straw chamber technologies for neutrino physics applications
- **Project E** - Optimization of straw materials and production technologies
- **Project F** - Optimization of electronic readout

Activities in 2024-2026

- Straw productions for various straw diameters, lengths, thin-film tubes and metallization started and in progress
- New laboratory production line for up to 5m long straws by technique of ultrasonic film tube welding set up and on track
- First prototypes of straws and electronic readout for cluster counting (dN/dx) produced and beam tests started
- ToRA ASIC prototype for signal readout with simultaneous Time-at-Threshold and charge measurement produced, and performance tests started
- Prototypes of tracking and target modules for neutrino physics, development of integrated readout, preparation for assembly of full-scale 3.9 m "Module 0"

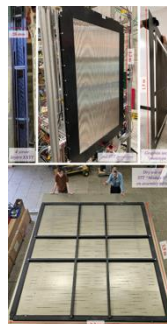
Straw Tracker for FCCee

- Detector concept based on simulation of detector under FCCee operating conditions, prototyping and in-beam tests
- First prototypes produced at Michigan and MPI Munich
- New FE amplifier, DAQ with waveform digitization for dN/dx
- Prototype in-beam tests started (e- and mixed hadron beams)



Integrated V-Target/Straw Tracker for DUNE

- Completion and test of 2nd 1.2m prototype of tracking module with final components
- Completion and test of 1.5 m graphite target prototype
- Development of integrated readout and test beam validation
- Established industrial supply chain and tooling for final components
- QC procedures and sample validation
- Preparation for the assembly of full-scale 3.9 m x 3.3 m tracking "Module 0"



Straw Production Technologies

- Thin-film ultrasonic tube welding technique, various tube diameters 5-20mm, and tube lengths up to 4-5m
- Thin-film metallization: Cu/Au or Al single/double-sided
- New production line installed at INP Almaty (KZ) and commissioned, personnel training & first productions ongoing
- Straw samples inspection by CERN-MM-MME



WP4: Inner and central tracking with PID (Tracking TPCs)

T1: IBF reduction

T2: pixel TPC development

T3: Optimization of the amplification stage and its mechanical structure, and development of low X/X0 field cages

T4: FEE for TPCs

T5: Gas mixture

<https://drd1.web.cern.ch/wp/wp4>

Goals

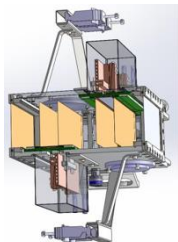
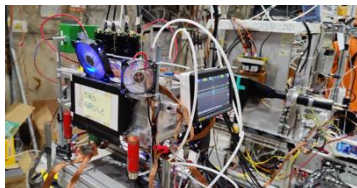
Enhances TPC performance in high-rate, high-multiplicity environments, introducing advanced readout, gating strategies, and optimized gas mixtures to reduce ion backflow and improve dE/dx measurements.

Activities in 2024-2026

- Implementation of VMM3 into Twin TPC
- Operation of TPC with reduced material budget, using He-CO₂
- SAMPA SRS hybrids available for testing
- Test TPCs that can be adapted to test selected components.
- TPC with GEMPix3 readout tested in beam
- Integration of Tpx4 with GEM and uRWELL

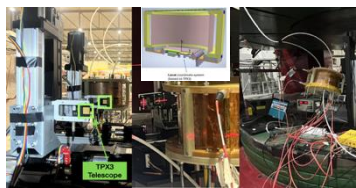
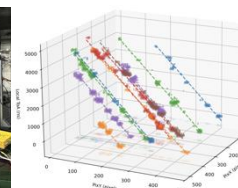
Twin TPC with VMM3 readout

Test beams performed at PSI and CERN SPS



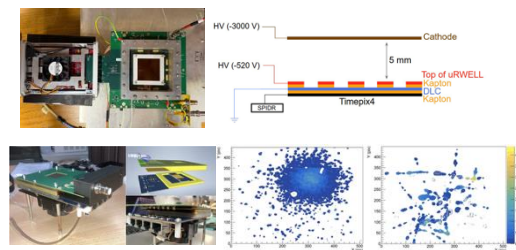
TPC with GEMPix3 readout

First test beam results under analysis



TPX4 integration with MPGD

Prototypes with uRWELL at CERN GDD (top) and GEMPix4 at IEAP CTU (bottom)



WP5: Calorimetry

<https://drd1.web.cern.ch/wp/wp5>

- T1 : Construction of large gaseous detectors for granular calorimeters
- T2 : Timing performance of gaseous detectors for calorimeters
- T3 : Readout electronics for calorimeter gaseous detectors
- T4 : High-rate capability gaseous detectors for circular collider calorimeters

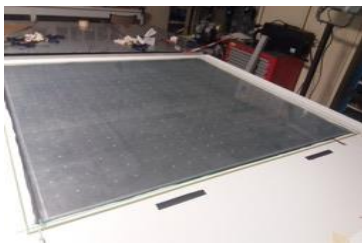
Goals

- Develop and characterize large gaseous detectors to equip future highly granular calorimeter proposed for future colliders like FCCee and muon collider.
- Several technologies are developed: (M)RPC, Micromegas and μ WeELL. High efficiency and homogeneity over large area are the key elements of this WP.
- Timing performance and high-rate capabilities with new eco-friendly gases are also looked for.
- Readout electronics system with very large number of electronic channels is one of the important features to be developed.

Activities in 2024-2026

- Development of new method to build large MRPC. Results show excellent efficiency and homogeneity.-
- Construction of 50 cm x 50 cm MPGD detectors of different kinds: Micromegas, μ Well, μ PWELL with high efficiencies. They were successfully tested in a hadronic prototype
- Realisation of large (100 cm x 50 cm) board hosting on one side PETIROC ASICs and on the other side 2cm x 2cm pickup pads.

New techniques to build MRPC



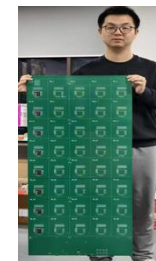
Spacers made of double-face tape

First prototypes with MPGD



Results agree with the simulation

Large Active Unit Sensor



Large ASU equipped with PETIROC ASICs

WP6: Gaseous photon detectors

<https://drd1.web.cern.ch/wp/wp6>

T1: New robust UV PC for gaseous photon detectors

- < 20% deterioration of quantum efficiency for 100 mC/cm²

T2: Increase photon detection efficiency

- Photoelectron efficiency in gas $\geq 75\%$ of that under vacuum

T3: Suppression of IBF to the photocathode, increase of stability and longevity

- Stable operation for $G > 10^5$ in harsh environment of $10^{11} \text{ n}_{\text{eq}}/\text{cm}^2$, IBF down to 10^{-4} ,

T4: Gaseous photon detectors sensitive to visible light

- Sustained photosensitivity to visible light in gaseous photon detector

T5: Spatial resolution and readout granularity

- $\sigma_x < 1 \text{ mm}$

T6: Time resolution

- $\sigma_t < 100 \text{ ps}$

T7: Modelling and simulation of gaseous photon detectors

- IBF, gain, stability

T8: Large area coverage

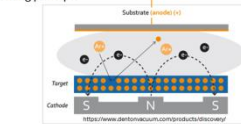
- Gain and QE variation $\leq 10\%$ over 1 m^2 area with $\leq 10\%$ dead area

T9: Readout electronics for single photon signals

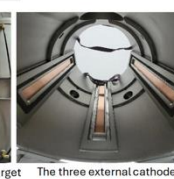
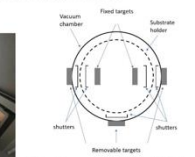
- New frontend ASIC chip with 64 channels, ENC 0.5 fC at 20pF

The magnetron sputtering machine

Working principle



- The field creates ion-electron pairs in the plasma
- The electrons are accelerated and further ionize the plasma generating new ions
- A magnetic field concentrate the ions in a peculiar region of the target (speed track)
- The ions drift towards the target and by collision the material is extracted flying all over the vacuum chamber



Machine co-funded by CERN and INFN. R&D led by INFN LNF, Roma3 and Na

<https://indico.cern.ch/event/1360282/contributions/5768339/attachments/2790602/4866455/Resistive%20Electrodes.pdf>

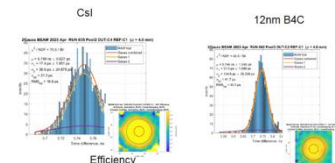
2024 test beam campaign

Photocathodes

- CsI
- B4C
- DLC
- Nanodiamonds

- B4C and DLC depositions at USTC before beam
- B4C depositions (1inch) at Saclay before beam
- DLC samples prepared at CERN MPT workshop
- CsI depositions at CERN: 1inch and 10x10cm
- Nanodiamond samples existing to be tested

- Groups purchase/prepare substrates
- Shared depositions
- Sharing photocathode samples (1inch) to evaluate in different prototypes



<https://indico.cern.ch/event/1360282/contributions/5768339/attachments/2791408/4868879/Picoset-test-beam-DRD1Jan2024.pdf>

WP7: Gaseous timing detectors

<https://drd1.web.cern.ch/wp/wp7>

T1: Optimize the amplification technology towards large-area detectors ($> \text{m}^2$)

T2: Enhance timing performance ($\sigma_t < 50 \text{ ps}$ up to 30 kHz/cm^2)

T3: Enhance rate capability ($\sigma_t < 200 \text{ ps}$ up to $100\text{-}150 \text{ kHz/cm}^2$)

T4: Spatial resolution and readout granularity

T5: Stability, robustness and longevity

T6: Material studies (Radiation-hardness, longevity)

T7: Gas studies for precise timing applications

T8: Modelling and simulation of timing detectors

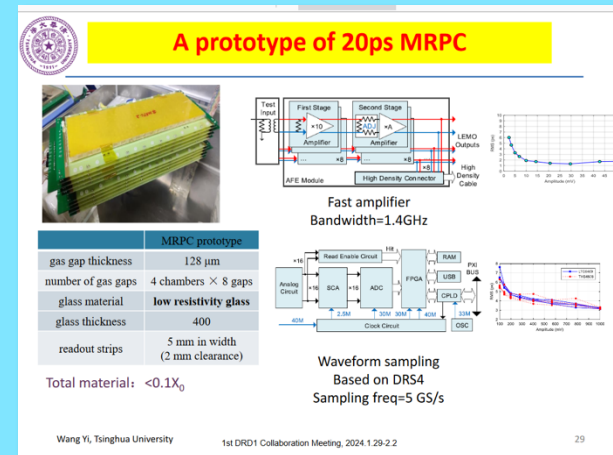
T9: Readout electronics for precise timing

T10: Precision mechanics and construction techniques

T11: Common framework and test facilities for precise timing R&D

This work package contains two projects:

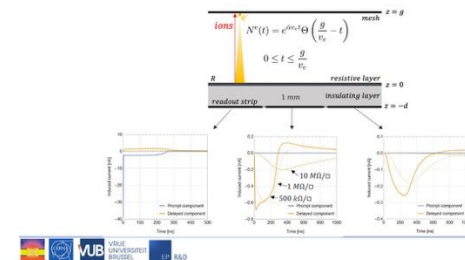
- **WP7 Project A** - High-rate, high-granularity precise timing with MPGDs
- **WP7 Project B** - High-rate, large, precise timing (M)RPC



<https://indico.cern.ch/event/1360282/contributions/5768593/attachments/2789689/4864817/Newest%20development%20of%20MRPC.pdf>

Signal 'spreading' in a thin resistive layer

Let us examine a Townsend avalanche occurring within the amplification gap of a MicroMegas detector, resulting in a signal being generated on the readout strips.



<https://indico.cern.ch/event/1360282/contributions/5767284/attachments/2790842/486696/WDRD1-January-2024-TijmesJanssens.pdf>

WP7A Fast-Timing Gaseous Detectors (MPGD)

Goals

- Development of MPGDs optimized for high time resolution of tens of ps.
- Evaluation of achievable timing resolution with environmentally friendly gas mixtures.
- Robustness, scalability and suitable readout electronics are developed to match precise timing MPGDs.
- The long-term plans of this work package aim to provide precise timing detectors to match the requirements of future experiments.

Activities in 2024-2026

- Detector scaling up,
- detector and photocathode robustness,
- readout electronics,
- gas studies.

Common test beam campaigns have been the focus of performance studies of different detector configurations.

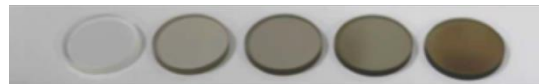
Scalability and readout electronics

Multipad detector prototypes are being characterized in view of achievable timing resolution and spatial resolution. 10x10 cm² and a first 20x20 cm² prototypes have been developed. Custom frontend electronics are implemented.



Photocathodes and robustness

Studies of photocathode materials are being pursued to improve robustness against ion backflow. Carbon-based materials (DLC, B4C) are characterized. Resistive Micromegas are implemented and show good timing response.



Studies of alternative gas mixtures

Alternative gas mixtures have been characterized to evaluate the achievable timing response with different binary or tertiary gas mixtures. Options include mixtures which use less expensive and greenhouse friendly gases such as Ne, He and admixtures of isobutane. High gain and good timing resolution has been achieved while the baseline mixture of Ne-CF₄-ethane continues to provide the best results.

WP7B Fast-Timing Gaseous Detectors (RPC)

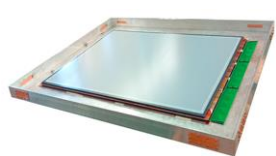
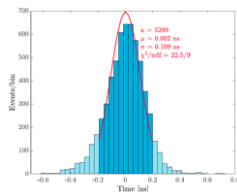
Goals

- Development of (M)RPC with excellent time resolution in all possible configurations:
 - 200 ps for double RPC,
 - 100 ps for 4 gap RPC,
 - < 60 ps for double stack 4 gap RPC.
- Different readout systems are studied (strips, pads) with different readout electronics.
- Provide timing detectors for triggers, ToF and T-SHCAL applications.
- Replacement of the current gas mixture by eco-friendly ones that maintain the excellent timing performances.

Activities in 2024-2026

- Double 4-6-gap stack of medium and large size were produced. Pickup strips with existing electronics (nino, etc...). Time resolution better than 100 ps was achieved.
- Pad-based readout boards and large single 4-gap stack are produced and will be tested soon.
- Double large RPC is also produced: Timing resolution is under study

Time resolution with mRPC@Coimbra



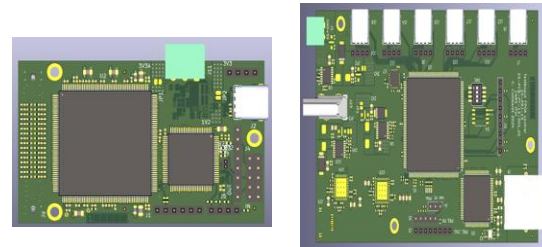
130 cm x 90 cm

100ps, 1mm resolution obtained with 2x6-gap
Better timing obtained with more gaaps@Tsinghua

Bi-RPC construction@ and tests @Bari



Electronics readout@Lyon



Boards with 1PETIROC and DAQ boards to deal with 6 PETIROC boards

WP8 - TPCs as reaction and decay chambers

<https://drd1.web.cern.ch/wp/wp8>

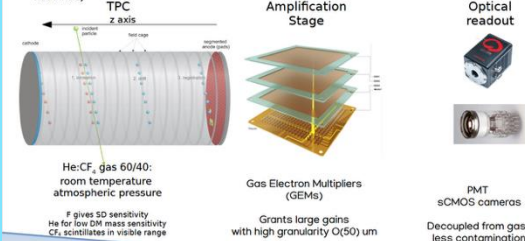
- T1: Enhanced operation of optical readout across gas densities
- T2: Enhanced operation of charge readout across gas densities
- T3: Enhanced operation of pure or trace-amount doped noble gases
- T4: Ultra-low-energy reconstruction of highly ionizing tracks (incl. negative-ion readout)
- T5: Determination of the interaction time (T_0)
- T6: Microscopic gas properties and gas handling
- T7: Radiopurity

This work package contains four projects:

- **WP8 Project A** - High Pressure TPCs for precision studies of neutrino interactions.
- **WP8 Project B** - TPCs for low-energy nuclear physics.
- **WP8 Project C** - Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification.
- **WP8 Project D** - Radiopure and/or low-energy TPCs for precise track imaging and/or calorimetry with avalanche-based readouts.

CYGN0 EXPERIMENT

- CYGN0 project aims to construct a large directional detector, $Q(10-100) \text{ m}^2$, for rare event searches (DM, Solar neutrinos)



G.Dho

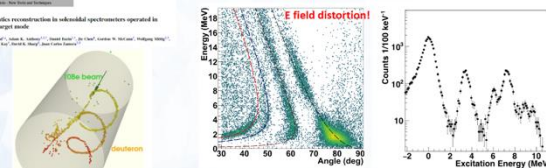
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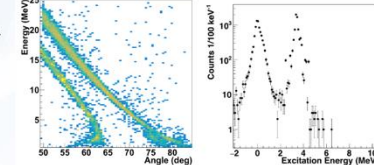
$^{10}\text{Be} + d$ scattering at 10 MeV

Experiment



Simulation (no cross sections!)

- ^{10}Be 10A MeV provided by ReA6 in stand-alone mode. Around 2000 pps!
- ^{10}Be material provided by the PSI (Switzerland)
- Pure target of D_2 600 torr.
- Study of negative parity states of ^{10}Be



https://indico.cern.ch/event/1360282/contributions/5767288/attachments/2790902/4867067/Awad_DRD1_jan2024_final.pdf

WP8 TPCs as Reaction and Decay Chambers

Optimization of the TPC detection technique for active targets in nuclear, neutrino and dark matter physics from 20mbar to 60bar

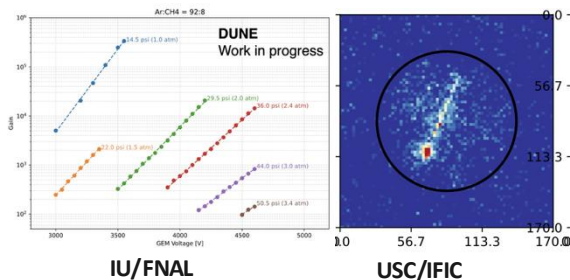
Goals

- High-pressure Ar-based TPCs with pixelated readout for full-3D reconstruction of neutrino-interaction final states.
- Near-Fano energy resolution / single electron detection in noble-gas TPCs via electroluminescence, for $0\nu\beta\beta$, CEvNS and low-mass dark matter.
- Radiopure DM-TPCs for event reconstruction below 1keV.

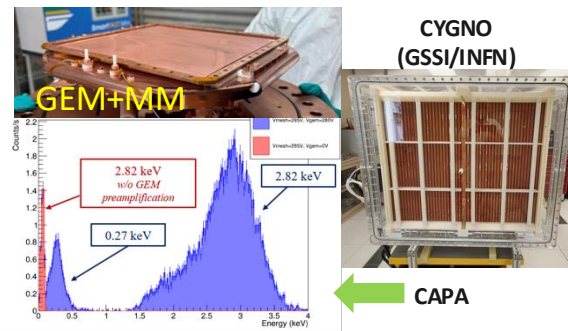
Activities in 2024-2026

- New large DM-TPCs under commissioning (50L, 400L...). Sub-keV thresholds achieved!.
- First-ever gain measurements at high-pressure with triple GEM and triple th-GEM setups (4-8bar).
- Comprehensive characterization of tracking performance for optical readout of ν -TPCs.
- Large EL structures operating at 10x10 cm at 10 bar of pure argon.

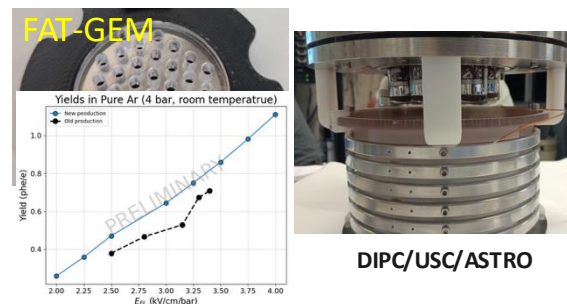
ν -oscillation TPC demonstrators



DM TPC demonstrators



EL technology demonstrators



WP Leaders: Esther Ferrer Ribas (FR-IRFU-CEA), Diego Gonzalez Diaz (ES-USC-IGFAE), Alan Bross (US-FERMI LAB), Marco Cortesi (US-FRIB-MSU), Ayyad Limonge Francesc Yasid (ES-USC-IGFAE), Francesc Monrabal (ES-DIPIC), Giorgio Dho (IT-INFN.LNF)

WP9: Beyond HEP

<https://drd1.web.cern.ch/wp/wp9>

T1: Cost-efficient outdoor detector design and construction

T2: Mechanical and environmental stability under outdoor and extreme conditions

T3: Detector portability and low maintenance

T4: Low power long-lived cost-efficient readout, performance of electronics under neutron and gamma irradiation

T5: Optimization and simulation methods for muon imaging, neutron and medical detectors

T6: Benchmarking infrastructures and knowledge transfer

T7: Optical readout MPGDs for biomarker imaging and beam characterization in ion beam therapy

T8: Gaseous photon detectors for in-beam monitoring for ion beam therapy and imaging

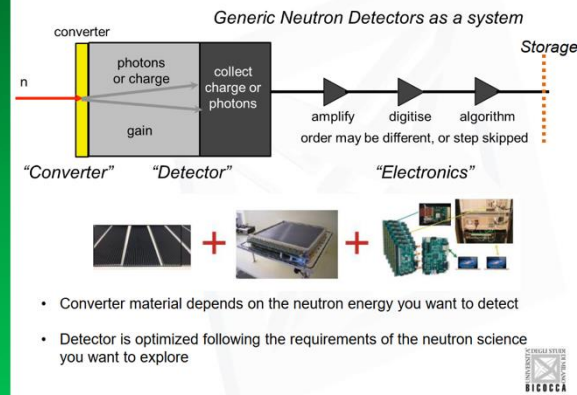
T9: Beam monitors with high temporal resolution for ion beam therapy and space radiation simulation

T10: Innovative neutron converter geometries in combination with gaseous amplifying structures for high-rate, efficient, low-background detectors

T11: Spatial resolution, readout granularity and rate capability impact on neutron imaging and dosimetry

T12: Study of Gamma Ray sensitivity and neutron discharge probability

Basic principle to realize a neutron detector



<https://indico.cern.ch/event/1360282/contributions/5776333/attachments/2789713/4864634/Crocini-WP9-DRD1-Neutron.pdf>

Mini recirculating gas systems

Mini to micro recirculating gas systems

- Required for specific applications (harsh environment, safety rules)
- Could be used to save expensive or greenhouse gases also for small laboratories

Differences from medium-to-large gas systems

- Size of the gas systems: as small as possible
- Price of the components: should be reduced as much as possible for accessibility
- Alternatives to industrial controllers and components might be needed to reduce costs
- Components should be validated for their use with gaseous detectors

Ongoing design and development from different groups

- Targeting different detectors types and different applications
- Ongoing collaboration between CEA Saclay and CERN EP-DT to develop new systems → knowledge sharing



Gianluca Rigoletti

<https://indico.cern.ch/event/1360282/contributions/5776338/attachments/2790631/4866507/Gas%20systems%20for%20gaseous%20detectors%20-%20DRD1%20meeting%2011.pdf>

WP9 Beyond High-Energy Physics

Goals

Adapt, optimize, and transfer gaseous detector technologies developed within HEP to applications Beyond HEP,

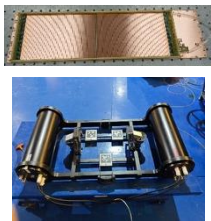
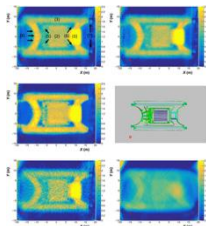
- muography,
- medical applications,
- neutron science.

Develop robust, reliable, cost-effective, and field-ready detector systems for challenging operational environments:

- large-area tracking for cosmic-muon imaging,
- ultrafast and real-time beam monitoring for medical and space-radiation applications,
- high-rate, low-background neutron detection and beam monitoring as alternatives to ^3He -based technologies.

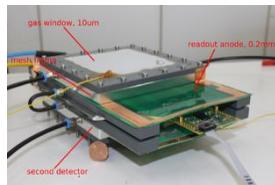
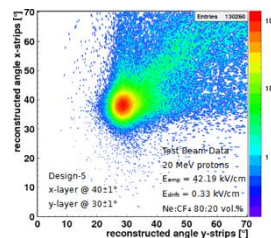
Muography

Sealed mode operation beyond 1 year (MWPC, RPC); 3D image reconstruction (Micromegas)



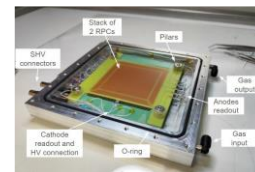
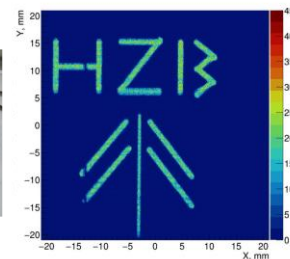
Medical applications

Floating strips Micromegas proton beam monitor



Neutron science

RPC neutron detectors



Activities in 2024-2026

Development of robust, portable and low-maintenance RPC and Micromegas detectors for muography, including low- and zero-flow operation.

Optical-readout MPGDs and fast GEM-based beam monitors for medical and space-radiation applications, reaching MHz-rate operation and sub-mm spatial resolution.

For neutron science, development of novel B-, Gd- and N-based converters coupled to GEM, Micromegas and RPC detectors, with progress in high-rate neutron imaging, detection efficiency, background suppression and operation in intense neutron and gamma fields.

DRD1 Work Package resources

- All the resources are used exclusively by the institutes,
- Each institute decides where its activities are carried out and where its deliverables will be used,
- All institutes are welcome to participate in Work Packages in their own terms and using the resources they find appropriate.
- There is room for participation of institutes from the USA in DRD1 under the framework of HL-LHC and/or the Electron-Ion Collider (EIC):
 - DRD1 is prepared to adapt at Collaboration- and Work Package-level to ensure compatibility with the requirements of the DOE.

November 2024

Country	Collaborating Institution	Town	Institution Code	Contact
Belgium	Vrije Universiteit Brussel	Brussel	BE-VUB	M. Tytgat
China	University of Science and Technology of China	Hefei	CN-USTC	J. Liu
China	Chinese University of Hong Kong	Hong Kong	CN-CUHK	Y. Tu
China	Hong Kong University	Hong Kong	CN-HKU	Y. Tu
China	Hong Kong University of Science and Technology	Hong Kong	CN-HKUST	Y. Tu
France	Institute of research into the fundamental laws of the Universe, CEA, Université Paris-Saclay	Gif-sur-Yvette	FR-IRFU-CEA	M. Vandenbroecke
Germany	Ludwig-Maximilians-University of Munich	Munich	DE-LMU	O. Biebel
Germany	Max-Planck-Institut für Physik, Munich	Munich	DE-MPG	O. Kortner
Hungary	HUN-REN Wigner Centre for Physics	Budapest	HU-HUN-REN	D. Varga
Israel	Weizmann Institute of Science	Rehovot	IL-WIS	S. Bressler
Italy	INFN Sezione di Bari, University and Politecnico di Bari	Bari	IT-INFN.BA	A. Pastore
Italy	INFN Sezione di Bologna	Bologna	IT-INFN.BO	P. Giacomelli
Italy	INFN Sezione di Ferrara	Ferrara	IT-INFN.FE	G. Cibinetto, R. Farinelli
Italy	INFN Laboratori Nazionali di Frascati	Frascati	IT-INFN.LNF	G. Benvenuti, M. Poli Lener, D. Piccolo, A. Paoloni
Italy	INFN Sezione di Napoli, University of Napoli	Napoli	IT-INFN.NA	M. Della Pietra
Italy	INFN Sezione di Roma Tor Vergata, University of Roma Tor Vergata	Roma	IT-INFN.RM2	P. Camarri
Italy	INFN Sezione di Roma Tre	Roma	IT-INFN.RM3	M. Iodice
Italy	INFN Sezione di Torino, University of Torino	Torino	IT-INFN.TO	M. Greco

The Work Package starts on start date and ends on end date.

The deliverables, time scales and contributing institutions are indicated in the table below.

Number	Title	Description	Start date	End date	Institutions
D1.1	Large area and MPGD prototypes	Design, construction, and test of RPC and MPGD-based prototypes [T1, T2] with advanced solutions for extensive surface coverage [T6], optimized for medium-high flow rates (range tens kHz/cm ² – few MHz/cm ²), precise tracking (100 μm) and timing (few ns). This includes considerations for the compatibility with noble gases.	0	36M	BE-VUB, CN-USTC, CN-CUHK, CN-HKU, CN-HKUST, FR-IRFU, CEA, DE-LMU, DE-MPP, HU-HUN-REN, IL-WIS, IT-INFN.BA, IT-INFN.BO, IT-INFN.FE, IT-INFN.LNF, IT-INFN.NA, IT-INFN.RM2, IT-INFN.RM3, JP-KOBE-U, RO-UNSTPB, RO-IFIN-HH, RS-IOFH-BG, CH-CERN, CH-UNIG, TR-ISTINYE, UK-PHY-CAM, e+e-US Cluster
M1.1.1	Review of Detector Prototypes	Examining the status and future prospects of innovative resistive materials, novel structures, and challenges in hybridizing Resistive Plate Chambers (RPC) and Micro-Pattern Gas Detectors (MPGD). This evaluation includes compiling of a comprehensive report highlighting comparative performance, along with the respective advantages and disadvantages of available	0	12M	

Resources and List of FA's to be complemented only after DRD1 MoU signature & WP endorsement process

[illegible]

2026: Work Packages Endorsement

WP ID	Title		No. Institutes	No. Countries
WP1	Trackers, Hodoscopes, Large area muon systems		30	15
WP2	Drift Chamber		13	6
WP3	Optimization of Tracking Technologies	Project A: Drift tube developments for very high-rate applications	7	2
		Project B: Straw chamber technologies for hadron physics applications	4	3
		Project C: Mini drift cells/wires for Dark Sector applications	2	2
		Project D: Silicon chamber technologies for neutrino physics applications	8	4
		Project E: Optimization of straw materials and production technologies	2	2
		Project F: Optimization of electronic readout	3	3
WP4	Tracking TPCs		9	6
WP5	Gaseous calorimeters		10	8
WP6	Gaseous photon detectors		11	10
WP7	Timing detectors	Project A: High-rate, high-granularity precise timing with MPGD	9	9
		Project B: High-rate, precise timing with (M)RPC	20	11
WP8	Reaction/Decay TPCs	Project A: High-rate, large, precise timing (MPGD)	20	11
		Project B: High Pressure TPCs for precise studies of exotic resonances	16	7
		Project C: TPCs for low-energy nuclear physics	10	8
		Project D: Electroluminescence-based TPCs for Rare Event Searches and other R&D on pure noble gas (direction)	9	4
		Project E: Radiopure and/or cryogenic TPCs for precise track imaging and/or calorimetry with photosensor	15	11
WP9	R&D applications		17	12

WP endorsement process already started:

- WP4 – endorsement completed
- WP 1, 2, 7A under internal reviewing

- WP Endorsement rules are included in the MoU Annexes 6.2-6.3
- The detailed WP Endorsement procedure is currently being prepared for evaluation and approval of the Collaboration Board

Scientific Endorsement objectives

- Alignment with relevant ECFA themes, referencing the ECFA Detector R&D Roadmap document.
- Progress in the scientific program and its objectives.
- A detailed list of milestones and expected deliverables.
- Collaboration and interaction with Working Groups (WGs), other Work Packages, and other DRDs.

Resources Endorsement objectives

- Resource requirements and allocation. All relevant WP Funding Agencies (WP-FA) listed in the Work Package Annexes (7.4.x) will be invited (+Management Board)
- Confirmations from the WP-FA to ensure that the proposed resource table accurately reflects their allocated funding and support.

Summary

- ☐ **DRD1, a community-driven collaboration**, covers a large set of different technologies, different applications and a **large and diversified community**; it **promotes the clustering** of different **research teams**, acting as a seed for long-term collaborations and activities

- ☐ DRD1 aims to offer a proper R&D framework (WGs & WPs) to support both **strategic and generic, blue-sky, and technology-driven R&D**

- ☐ **WP Endorsement process** is ongoing

- ☐ **The activities** described in most of the **Work packages are advancing** independently of their endorsement status

- ☐ DRD1 **is looking forward** to more advanced **collaboration with the US** community
 - ☐ **Join us** with your intermediate **generic R&D** and **technological projects!**