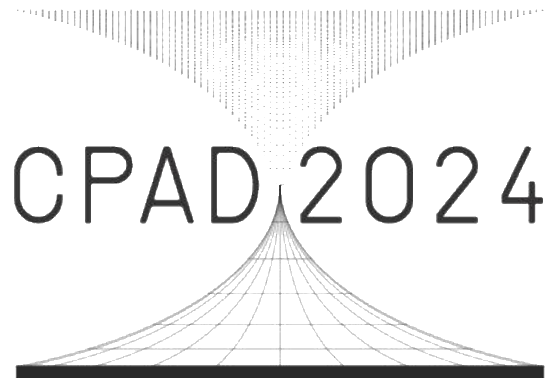


# Strategic R&D on gaseous detectors within DRD1 Work Packages



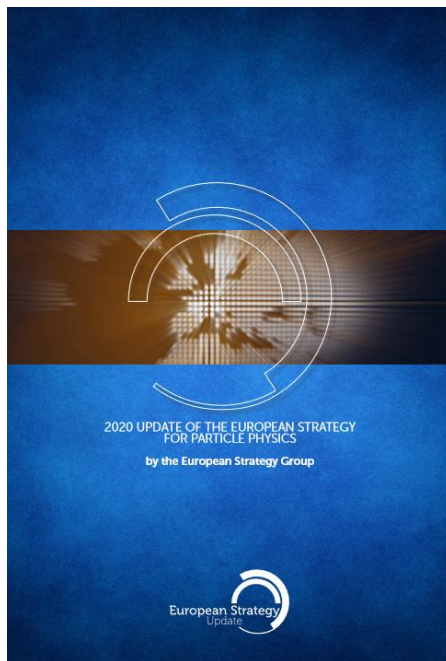
Piotr Gasik  
(GSI/FAIR & TU Darmstadt)

19.11.2024



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

Record created 2020-06-19, last modified 2021-11-11



<https://cds.cern.ch/record/2721370/files/CERN-ESU-015-2020%20Update%20European%20Strategy.pdf>

## 4

### Other essential scientific activities for particle physics

C. The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures. To prepare and realise future experimental research programmes, the community must maintain a strong focus on instrumentation. ***Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. Synergies between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large. Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.***

# ECFA Detector R&D Roadmap Document

October 2021

The links are here to the [Synopsis](#) and [Full Document](#) as presented to the Scientific Policy Committee and CERN Council in December 2021.

The Full Documents can be found on [10.17181/CERN.XDPL.W2EX](https://cds.cern.ch/record/2781181/files/ECFA-Detector-RD-Roadmap-2021.pdf)

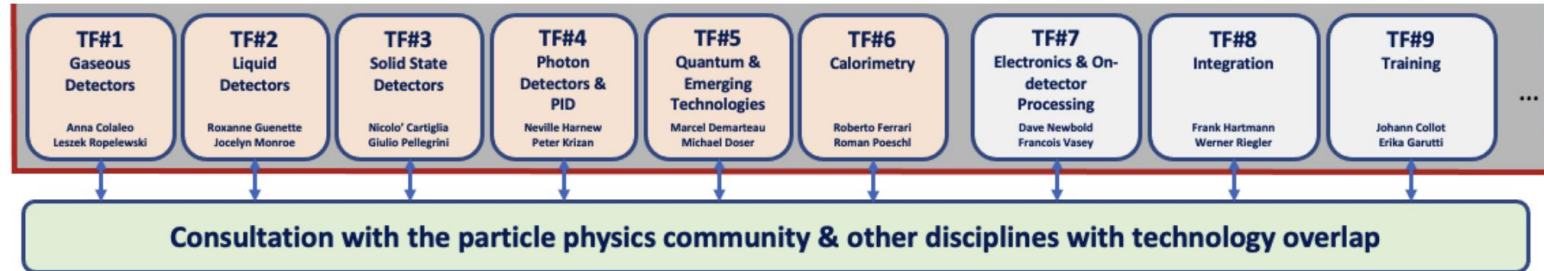


# ECFA Detector R&D Roadmap Document

© T. Bergauer (DRDC)

October 2021

- Overview of future facilities (EIC, ILC, CLIC, FCC-ee/hh, Muon collider) or major upgrades (ALICE, Belle-II, LHCb,...) and their timeline
- Ten “General Strategic Recommendations” (GSR)
- Nine Technology domains with Task Forces areas
  - The most urgent R&D topics in each domain identified as Detector R&D Themes (DRDTs)



# Roadmap implementation plan

© T. Bergauer (DRDC)

Fall 2022

- Approved by CERN SPC and Council in fall 2022 ([CERN/SPC/1190](https://cern.ch/CERN/SPC/1190) ; [CERN/3679](https://cern.ch/CERN/3679))

- CERN will host DRD collaborations

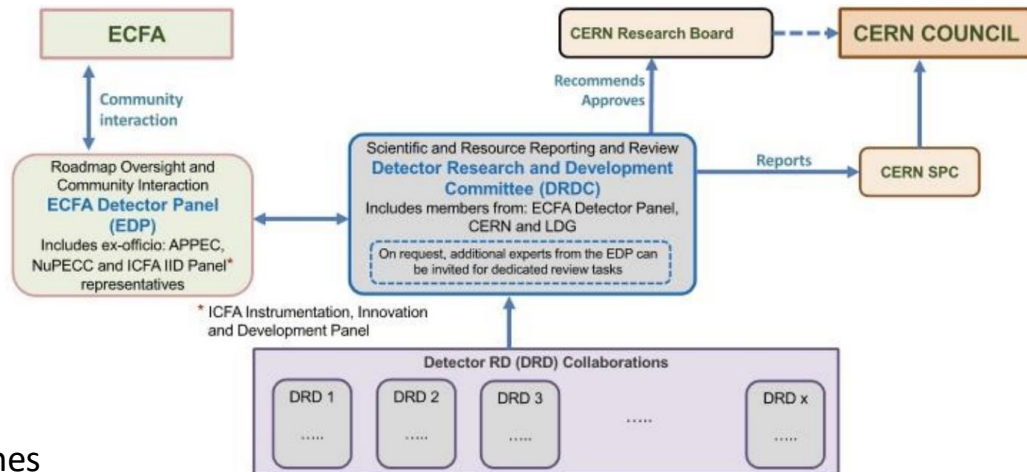
- Interaction between DRD collaborations and committees through DRDC
- Interface to ECFA via ECFA Detector panel

<https://ecfa-dp.desy.de>

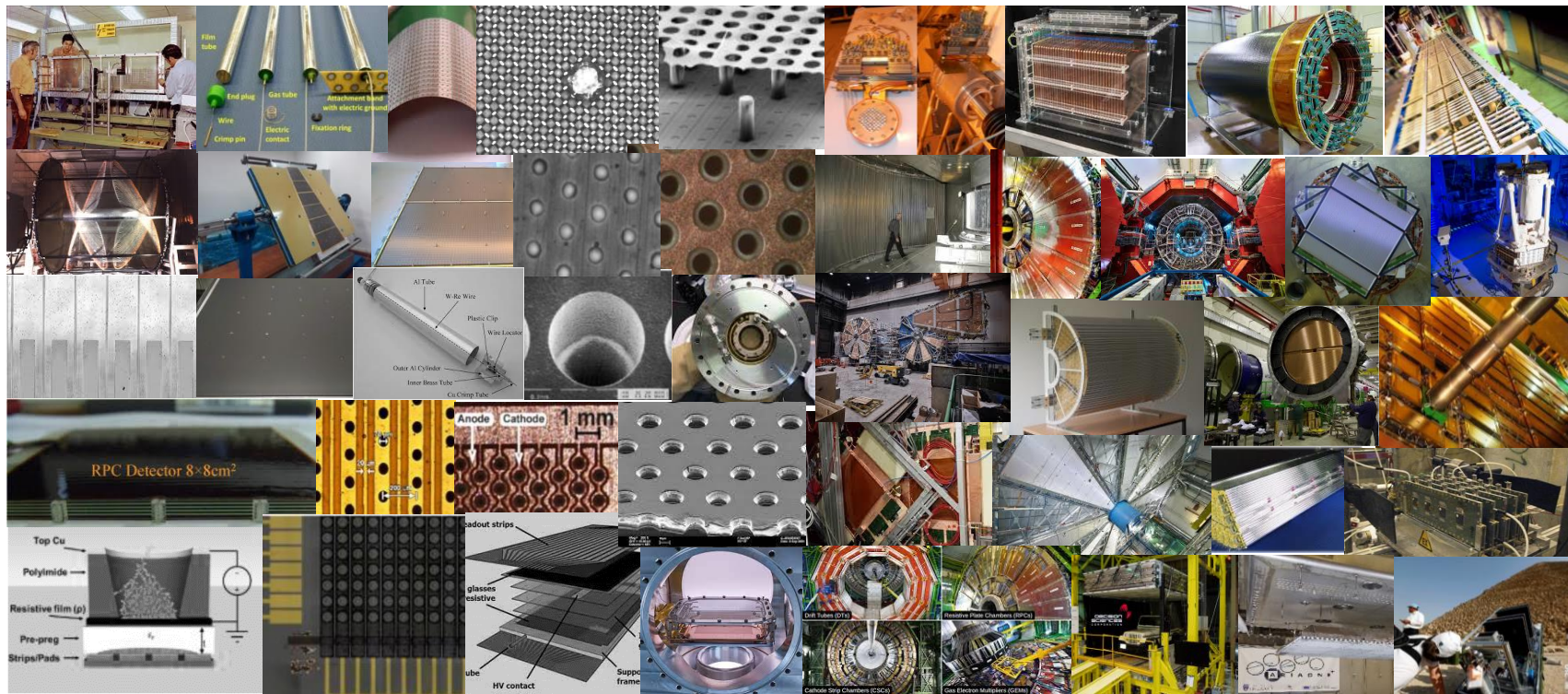
- Distinction between reviewing body (DRDC) and advising body (EDP)

- DRDC reviews DRD progress, monitor milestones and deliverables, and reports to CERN Research Board

- EDP monitor ECFA Detector Roadmap, and provides input to the next Strategy update



# The DRD1 Collaboration on gaseous detector technologies



# 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, $\mu$ -RWELL, $\mu$ -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 <sup>2</sup> Spatial resolution: ~ cm Time resolution: O(ns) Radiation hardness: ~ 2 C/cm <sup>2</sup> (10 years)
Higgs-EW-Top Factories (ee) (ILC/FCC-ee/CepC/SCTF)	GEM, $\mu$ -RWELL, Micromegas, RPC	Stability, low cost, space resolution, large area, eco-gases	(IDEA): Max. rate: 10 kHz/cm <sup>2</sup> Spatial resolution: ~60-80 $\mu$ m Time resolution: O(ns) Radiation hardness: <100 mC/cm <sup>2</sup>
Muon collider	Triple-GEM, $\mu$ -RWELL, Micromegas, RPC, MRPC	High spatial resolution, fast/precise timing, large area, eco-gases, spark-free	Fluxes: > 2 MHz/cm <sup>2</sup> (0-8 $\sigma$ ) < 2 kHz/cm <sup>2</sup> (for 0-12 $\sigma$ ) Spatial resolution: ~100 $\mu$ m Time resolution: sub-ns Radiation hardness: < C/cm <sup>2</sup>
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 <sup>2</sup> Spatial resolution: < 1 mm Time resolution: ~ 15 ns Radiation hardness: 10 <sup>9</sup> neq/cm <sup>2</sup> /year
FCC-hh (100 TeV hadron collider)	GEM, THGEM, $\mu$ -RWELL, Micromegas, RPC, FTM	Stability, ageing, large area, low cost, space resolution, eco-gases, spark-free, fast/precise timing	Max. rate 500 Hz/cm <sup>2</sup> Spatial resolution = 50 $\mu$ m Angular resolution = 70 $\mu$ 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)

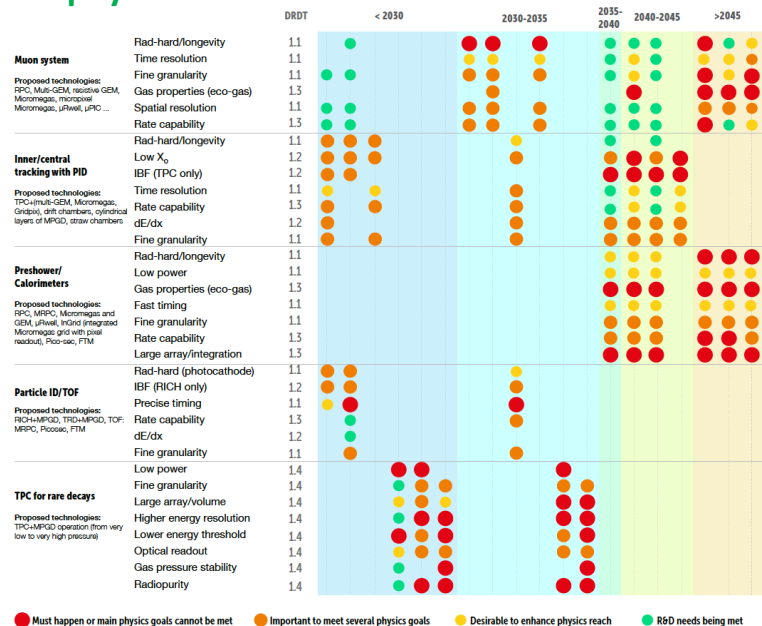
Gaseous

- 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

< 2030    2030-2035    2035-2040    2040-2045    > 2045



## Needs/benefits for physics reach



# Requirements for future experiments at future facilities

---

Rate Capabilities	Up to several MHz/cm <sup>2</sup>
Spatial Resolution	Down to 50 μm
Time Resolution	Down to few tens of ps
Radiation Hardness	up to 10 <sup>13</sup> n <sub>eq</sub> /cm <sup>2</sup> /y
Ageing	Up to C/cm <sup>2</sup>
Material Budget	<1% X/X <sub>0</sub>
Magnetic Field	Up to several Tesla
Gain	Larger than 10 <sup>5</sup> -10 <sup>6</sup>
dE/dx	Down to 10%

---

....

Extracted by ECFA Detector R&D Roadmap  
[10.17181/CERN.XDPL.W2EX](https://cds.cern.ch/record/10.17181/CERN.XDPL.W2EX)

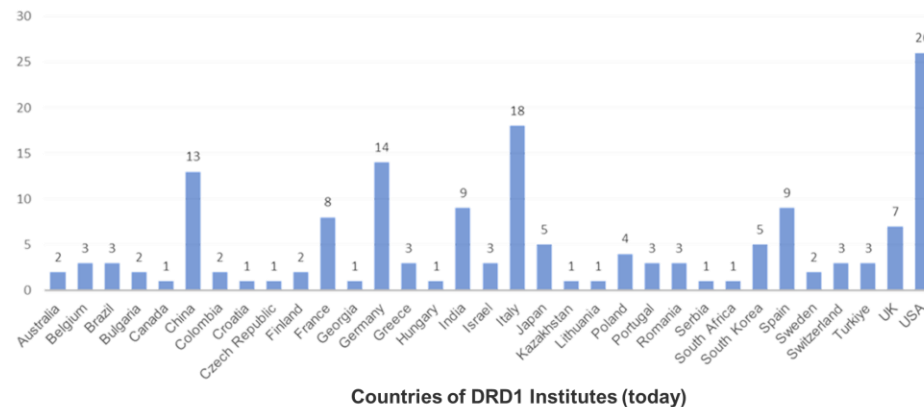
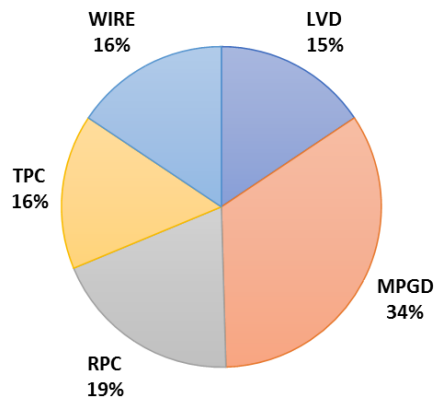
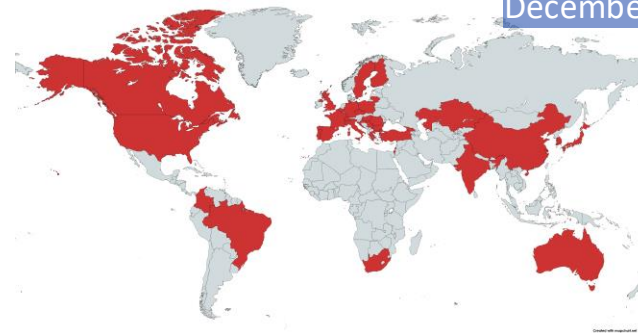
- **Muon Systems** (HL-LHC, ILC/FCC-ee/CepC/SCTF, Muon Collider, Hadron Physics, FCC-hh),
- **Inner and Central Tracking** (HL-LHC, ILC/FCC-ee/CepC/SCTF, Rare/Atomic/Nuclear Physics, Hadron Physics),
- **Preshower/Calorimeters** (ILC/FCC-ee/CepC/SCTF, Muon Collider, Hadron Physics),
- **Particle ID/TOF: RICH and TRD** (Hadron and Nuclear Physics, FCC-ee/CepC), **TOF** (Hadron and Nuclear Physics),
- **TPC for Rare Decays** (WIMP, Solar Axions, Nuclear Physics, Neutrino and neutrino-less double beta decay, DM)

# DRD1: Large and diversified community

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

December 2023

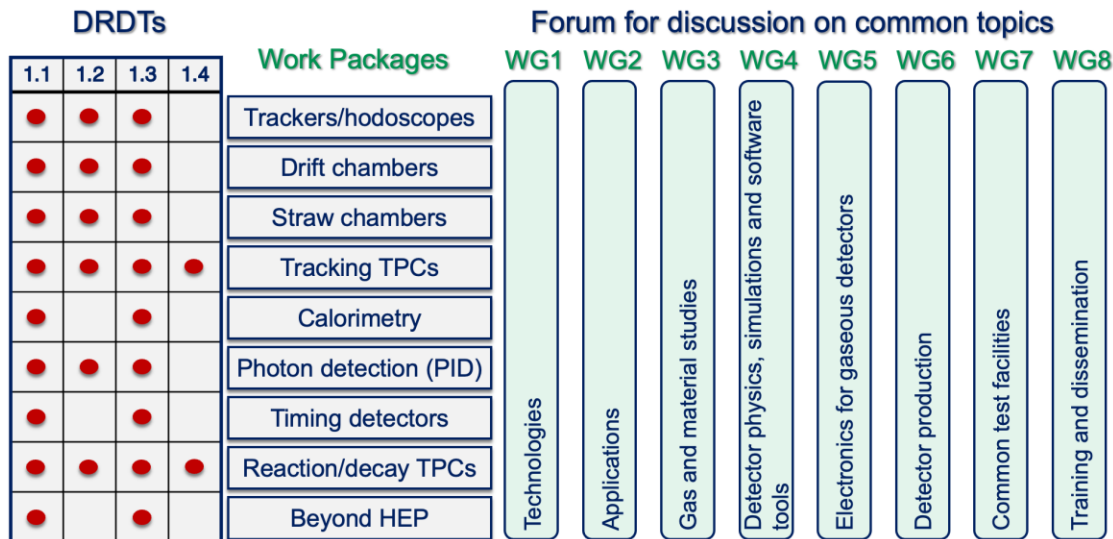
- More than 160 Institutes
- More than 30 Countries
- More than 700 members
- 5 Industrial, Semi-Industrial and Research Foundations



# 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.



# 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
<b>Technologies</b>	<b>Applications</b>	<b>Gas and material studies</b>	<b>Detector physics, simulations, and software tools</b>	<b>Electronics</b>	<b>Detector production</b>	<b>Common test facilities</b>	<b>Training and dissemination</b>
Large Volume Detectors (Drift chambers, TPCs)	Trackers/Hodoscope	Measurement of Gas Properties	Garfield++	Front-End Electronics for Gaseous Detectors	Common Production Facilities and Equipments	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	QA/QC	Test Beam Common Facilities	Training and Dissemination Initiatives
RPCs, MRPCs	Calorimetry	Ageing and Outgassing studies	Simulation of Detectors with Resistive Elements	Modernised Readout Systems (DAQ); FE Integration	Collaboration with Industrial Partner	Irradiation Common Facilities	Career Promotion
TPC	Photon Detector (PID)	Gas systems	Modelling and Simulation of Eco-friendly Mixtures	Modernised Readout Systems (DAQ): portability	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 (nano material) - new material for wire - new converter	Optimization of Simulations (time, hw/sw resources)	Instrumentation ( e.g. HV, LV, monitoring )		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					

# 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

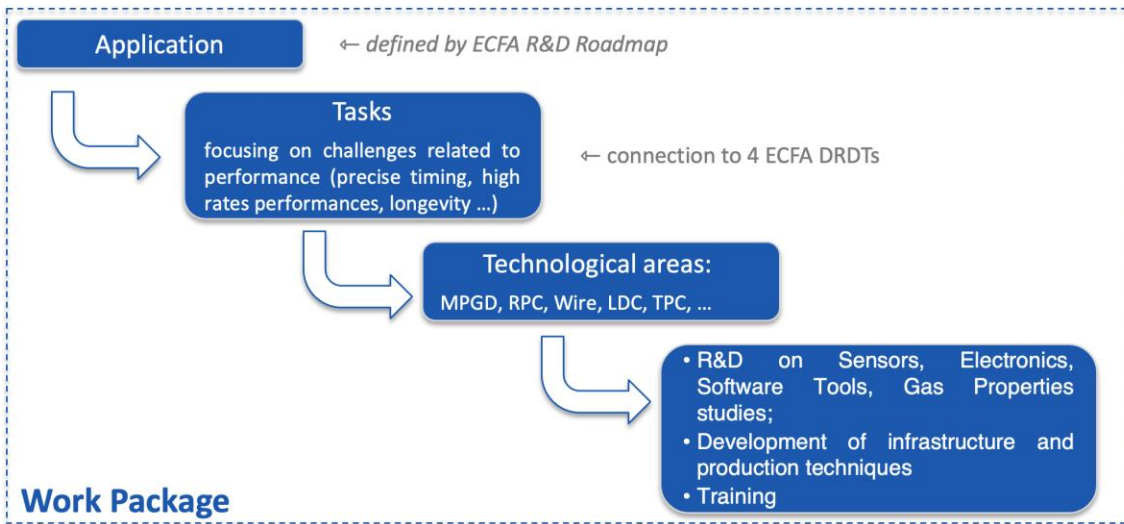
**For low-TRL (blue sky) R&D, or other short term generic projects**

## Work Packages

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

**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**



# 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

- High bandwidth, high gain, low power consumption, low mass

## T2: Development of a scalable multichannel DAQ board

- High sampling rate, Dead-time-less, DSP and filtering ability, Event time stamping, for Track triggering

## T3: Mechanics: new wiring procedures and new endplate concepts

- Feed-through-less wiring procedures, more transparent endplates (< 5%  $X_0$ )

## T4: Increase rate capability and granularity

- Smaller cell size, shorter drift time and higher field-to-sense ratio

## T5: Consolidation of new wire materials and wire metal coating

- Wires with high yield strength, low mass, low Z, high conductivity; metal coated C wires

## T6: Study ageing phenomena for new wire types

- Establish charge collection limits

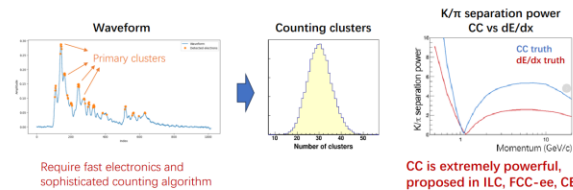
## T7: Optimization of gas mixing, recuperation, purification and recirculation

- Performance of hydrocarbon-free gas mixtures with high quenching power

## Cluster counting measurement (CC)

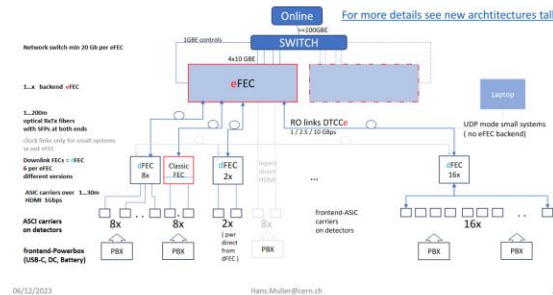
### Alternatively, counting primary clusters

- Poisson distribution → Get rid of the secondary ionizations
- Small fluctuation → Potentially, a factor of 2 better resolution than  $dE/dx$



[https://indico.cern.ch/event/1360282/contributions/5773675/attachments/2789695/4864602/DRD1\\_240130\\_CEPC\\_DC.pdf](https://indico.cern.ch/event/1360282/contributions/5773675/attachments/2789695/4864602/DRD1_240130_CEPC_DC.pdf)

## the full plan: Scalable Readout Architecture



[https://indico.cern.ch/event/1360282/contributions/5786568/attachments/2790914/4867304/Scalable\\_ReadoutSystemfor\\_DRD1.pdf](https://indico.cern.ch/event/1360282/contributions/5786568/attachments/2790914/4867304/Scalable_ReadoutSystemfor_DRD1.pdf)

# WP3: Inner and central tracking with PID (Straw Chambers)

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

## T1: Optimize straw materials and straw production technologies

- Thin fil, walls (20-30  $\mu\text{m}$  and below), robust metallization, low cross-talk and resistance to ageing

## T2: Improve straw tube designs

- Small diameter straws (5mm) with fast timing ( $< 100$  ns).
- Ultra-thin straws with tube walls  $< 20$   $\mu\text{m}$  ( $X/X_0 < 0.02\%$ ).
- Ultra-long straws with thin walls ( $\sim 30$   $\mu\text{m}$ ) and 4 m length

## T3: Optimize the detector mechanical system

- self-supporting straw modules, control of material relaxation with precise alignment

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

- Leading- and trailing-edge time readout, charge readout down to sub-ns precision

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

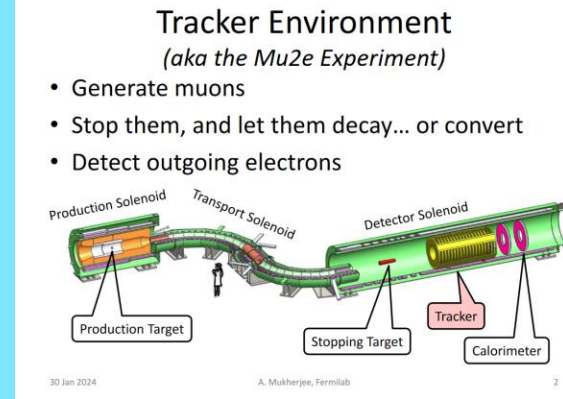
- spatial resolutions  $< 150$   $\mu\text{m}$ ,  $t_0$  extraction of  $\mathcal{O}(\text{ns})$  resolution and  $dE/dx$  resolution better than 10%

## T6: Enhance the longevity of the detector

- Ageing resistance of  $\mathcal{O}(1$  C/cm) for thin-wall straws

## T7: Optimize the online-/offline software

- Straw tube and electronics simulations, calibration, pattern recognition, tracking, PID and alignment



<https://indico.cern.ch/event/1360282/contributions/5776334/attachments/2789666/4864549/CeMDRD1.pdf>



### Aluminum wires



Al wires are a problem

- Only one manufacturer and not European friendly
- Small players can not talk with manufacturers

Ask for meetings with manufacturers from a CERN collaboration is easier: two manufacturers contacted and meetings planned

One already happened with many openings also on C wires!

We reached out Luma Metal and Jacques Allemann companies. Anyother ideas?

Gabriel CHARLES
01/2024 DRD1 Collaboration Meeting

[https://indico.cern.ch/event/1360282/contributions/5780934/attachments/2792445/4870101/2024-01\\_DRD1\\_NewCollab.pdf](https://indico.cern.ch/event/1360282/contributions/5780934/attachments/2792445/4870101/2024-01_DRD1_NewCollab.pdf)

# WP3: Inner and central tracking with PID (Straw Chambers)

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

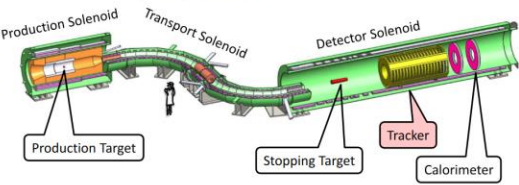
The work package is organized in work projects, which address certain R&D aspects for the respective application, but also the formation of collaborating sub-groups and common project description for funding application:

- **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

Each project contains a detailed R&D description, list of dedicated tasks, deliverables and timelines.

## Tracker Environment (aka the Mu2e Experiment)

- Generate muons
- Stop them, and let them decay... or convert
- Detect outgoing electrons



30 Jan 2024 A. Mukherjee, Fermilab 2

<https://indico.cern.ch/event/1360282/contributions/5776334/attachments/2789666/4864549/CeMDRD1.pdf>

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

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

## T1: IBF reduction

- Reduce IBF in gated and ungated operation

## T2: pixel TPC development

- Pixelised readout technologies, evaluate  $dE/dx$  with prototypes

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

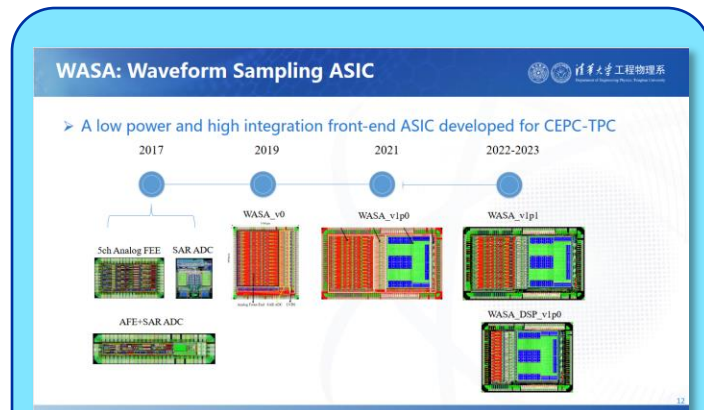
- -Reduce material budget of FCs, endcaps and cooling infrastructure

## T4: FEE for TPCs

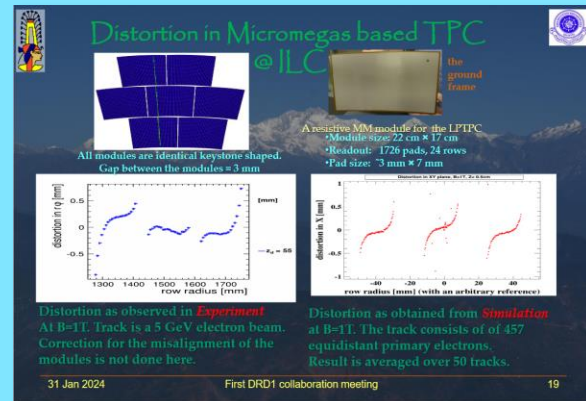
- Low-power ASICs, implementation in SRS, increase SRS R-O rate for TPCs

## T5: Gas mixture

- Low diffusion, low wt gases, eco-gases



<https://indico.cern.ch/event/1360282/contributions/5786540/attachments/2790669/4866569/Development%20of%20front-end%20ASIC%20for%20gas%20detectors%20v1.pdf>



<https://indico.cern.ch/event/1360282/contributions/5767287/attachments/2791017/4867261/OverviewW3.pdf>

# WP5: Calorimetry

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

## T1 : Construction of large gaseous detectors for granular calorimeters

- Uniform response in terms of efficiency and particle cluster size
- Development of precise mechanical structures and gas distribution systems

## T2 : Timing performance of gaseous detectors for calorimeters

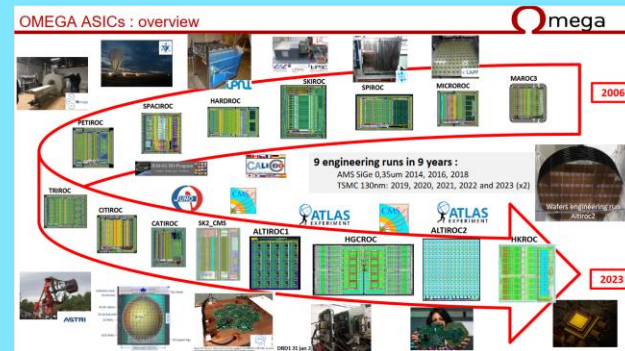
- Good uniformity of time performance for close-by shower separation and contribution of delayed neutrons

## T3 : Readout electronics for calorimeter gaseous detectors

- Good uniformity of time performance

## T4 : High-rate capability gaseous detectors for circular collider calorimeters

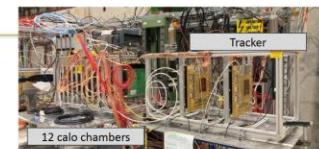
- Scalable Readout Systems development. New FPGA-based readout system that matches the data throughput of the electronics.



[https://indico.cern.ch/event/1360282/contributions/5786550/attachments/2790728/4866705/CdLT\\_DRD1\\_31Jan24.pdf](https://indico.cern.ch/event/1360282/contributions/5786550/attachments/2790728/4866705/CdLT_DRD1_31Jan24.pdf)

## MPGD-HCAL setup

- **2 supporting structures:**
  - "calo structure" hosting up to 12 MPGD chambers where we can easily integrated iron slabs:
    - to be upgraded for hosting 50x50cm<sup>2</sup> chambers
  - "tracker structure" (60x60x120cm<sup>3</sup>):
    - 2 scintillators
    - 2 Tmm (X&Y readout)
    - 1 GEM (X&Y readout)



- **Electronics:**
  - APV25
  - FEC+ADC
  - preliminary measurements with  $\mu$ RWELL/RPWELL coupled to VMM3a done
- **Gas:**
  - (Ar:CO<sub>2</sub>:iso); (93:5:2) for MM & RPWELL
  - (Ar:CO<sub>2</sub>:CF<sub>4</sub>); (45:15:40) for  $\mu$ RWELL

[https://indico.cern.ch/event/1360282/contributions/5768394/attachments/2791972/4869090/DRD1\\_HCal\\_test\\_beam.pdf](https://indico.cern.ch/event/1360282/contributions/5768394/attachments/2791972/4869090/DRD1_HCal_test_beam.pdf)

# 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/cm<sup>2</sup>

## 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  $10^{11}$  n<sub>e,q</sub>/cm<sup>2</sup>, 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

- $\sigma_x < 1$  mm

## T6: Time resolution

- $\sigma_t < 100$  ps

## T7: Modelling and simulation of gaseous photon detectors

- IB, gain, stability

## T8: Large area coverage

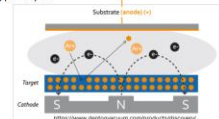
- Gain and QE variation  $\leq$  10% over 1 m<sup>2</sup> area with  $\leq$  10% dead area

## T9: Readout electronics for single photon signals

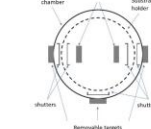
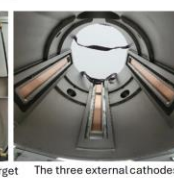
- New frontend ASIC chip with 64 channels, ENC 0.5 fC at 20pF

### 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://indi.cern.ch/event/1360282/contributions/5768339/attachments/2790602/4866455/Resistive%20Electrodes.pdf>

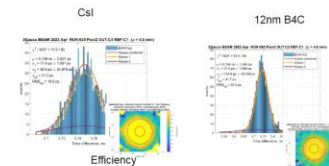
### 2024 test beam campaign

#### 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 MP7 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://indi.cern.ch/event/1360282/contributions/5768339/attachments/2791408/4868879/Picoset\\_estoem-DRD11Jan2024.pdf](https://indi.cern.ch/event/1360282/contributions/5768339/attachments/2791408/4868879/Picoset_estoem-DRD11Jan2024.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  $30 \text{ kHz/cm}^2$ )

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

T4: Spatial resolution and readout granularity

- Spatial resolution of mm with low number of readout channels

T5: Stability, robustness and longevity

- IBF  $< 1\%$  with  $< 100 \text{ ps}$  time resolution for single photoelectrons, Stable, high-gain operation

T6: Material studies (Radiation-hardness, longevity)

T7: Gas studies for precise timing applications

- Eco-friendly, recuperation, ageing mitigation,  $\text{CO}_2$ -based mixture with geometrical quenching

T8: Modelling and simulation of timing detectors

T9: Readout electronics for precise timing

- Low-noise FEE, High input C, Large dynamic range, Fast rise time, sensitivity to small Q

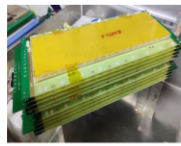
T10: Precision mechanics and construction techniques

- Precise mechanics ( $\mu = \text{m}$ ) over relatively large active areas (hundreds of  $\text{cm}^2$ )

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

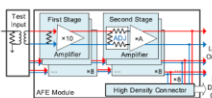
- Test bench for precise timing studies

A prototype of 20ps MRPC

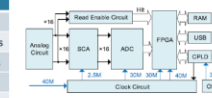


MRPC prototype	
gas gap thickness	128 $\mu\text{m}$
number of gas gaps	4 chambers $\times$ 8 gaps
glass material	low resistivity glass
glass thickness	400
readout strips	5 mm in width (2 mm clearance)


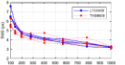
Total material:  $< 0.1X_0$



Fast amplifier  
Bandwidth=1.4GHz



Waveform sampling  
Based on DR54  
Sampling freq=5 GS/s

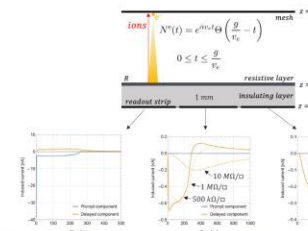



Wang Yi, Tsinghua University
1st DRD1 Collaboration Meeting, 2024.1.29-2
29

<https://indico.cern.ch/event/1360282/contributions/5768593/attachments/7289689/4864817/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/7290842/486696>

# WP7: Gaseous timing detectors

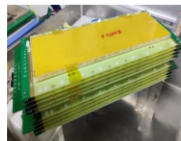
<https://drd1.web.cern.ch/wp/wp7>

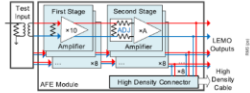
This work package contains two projects:

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

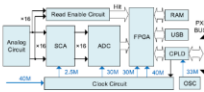
Each project contains a detailed R&D description, list of dedicated tasks, deliverables and timelines

## A prototype of 20ps MRPC

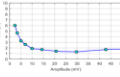
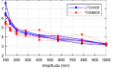




**Fast amplifier**  
Bandwidth=1.4GHz



**Waveform sampling**  
Based on DR54  
Sampling freq=5 GS/s

	MRPC prototype
gas gap thickness	128 μm
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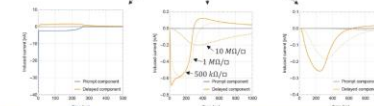
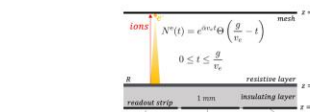
Total material: <math><0.1X\_0</math>

Wang Yi, Tsinghua University
1st DRD1 Collaboration Meeting, 2024.1.29-2.2
29

<https://indico.cern.ch/event/1360282/contributions/5768593/attachments/7789689/4864817/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.



# 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

- Ionization energy threshold  $\sim 10$  keV in 0.01-10 bar range with a scalable concept
- Stable operation over a broad dynamic range ( $10^4$ ) to enable sub-mm reconstruction
- IBF suppression (T2 only)

T3: Enhanced operation of pure or trace-amount doped noble gases

- $m^2$ -scale and 0.1-1.0 t scale detectors with single- $e^-$  sensitivity and near-Fano level energy resolution

T4: Ultra-low-energy reconstruction of highly ionizing tracks (incl. negative-ion readout)

- Tracking of  $\sim 10$ keV nuclear tracks in a concept scalable to  $m^2$  and beyond

T5: Determination of the interaction time ( $T_0$ )

- Achieve a viable timing signal while keeping low electron diffusion and high amplification

T6: Microscopic gas properties and gas handling

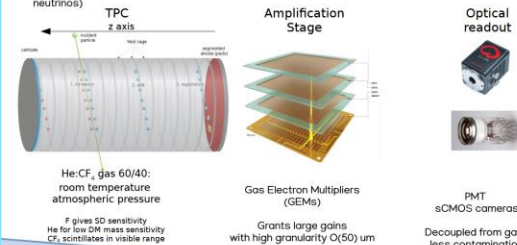
- New gas mixtures operated in conditions of high purity

T7: Radiopurity

- Improve manufacturing process and purification as well as material-selection standards

## CYGN0 EXPERIMENT

- CYGN0 project aims to construct a large directional detector,  $O(10-100)$  m<sup>2</sup>, for rare event searches (DM, Solar neutrinos)



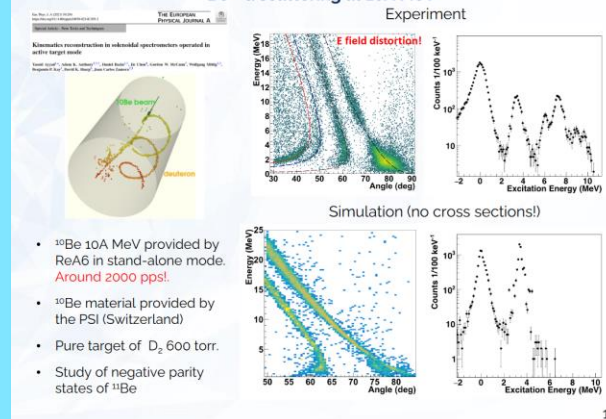
G.Dho

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30/01/2024

[https://indico.cern.ch/event/1360282/contributions/5776328/attachments/2790142/4866164/Sli-de\\_CYGN0.pdf](https://indico.cern.ch/event/1360282/contributions/5776328/attachments/2790142/4866164/Sli-de_CYGN0.pdf)

## <sup>10</sup>Be + d scattering at 10A MeV



[https://indico.cern.ch/event/1360282/contributions/5767288/attachments/2790902/4867067/Avvad\\_DRD1\\_Jan2024\\_final.pdf](https://indico.cern.ch/event/1360282/contributions/5767288/attachments/2790902/4867067/Avvad_DRD1_Jan2024_final.pdf)

# WP8 - TPCs as reaction and decay chambers

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

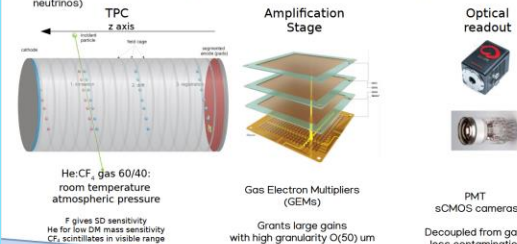
This work package contains four projects:

- **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.

Each project contains a detailed R&D description, list of dedicated tasks, deliverables and timelines.

## CYGN0 EXPERIMENT

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G.Dho

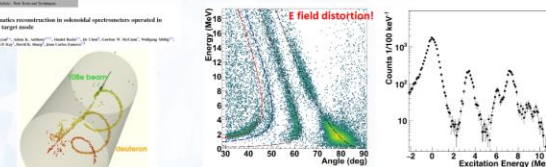
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30/01/2024

[https://indico.cern.ch/event/1360282/contributions/5776328/attachments/2790142/4866164/Sli\\_de\\_CYGN0.pdf](https://indico.cern.ch/event/1360282/contributions/5776328/attachments/2790142/4866164/Sli_de_CYGN0.pdf)

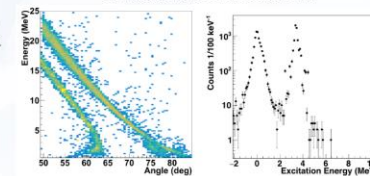
## <sup>10</sup>Be + d scattering at 10A MeV

Experiment



Simulation (no cross sections!)

- <sup>10</sup>Be 10A MeV provided by ReA6 in stand-alone mode. Around 2000 pps!
- <sup>10</sup>Be material provided by the PSI (Switzerland)
- Pure target of D<sub>2</sub> 600 torr.
- Study of negative parity states of <sup>11</sup>Be



10

[https://indico.cern.ch/event/1360282/contributions/5767288/attachments/2790902/4867067/Avvad\\_DRD1\\_Jan2024\\_final.pdf](https://indico.cern.ch/event/1360282/contributions/5767288/attachments/2790902/4867067/Avvad_DRD1_Jan2024_final.pdf)

# 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

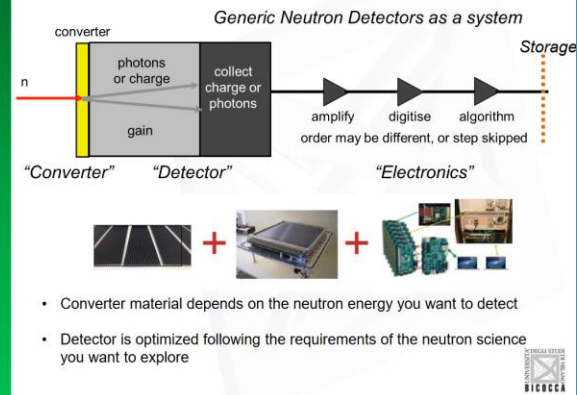
T9: Beam monitors with high temporal resolution for ion beam therapy and space radiation simulation

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/Croci-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



Muon system for pyramids by CEA, D. Attié



CEE telescope installation, D. De Giustola

Gianluca Rigoletti

[https://indico.cern.ch/event/1360282/contributions/5768838/attachments/2790631/4866507/Gas%20systems%20for%20gaseous%20detector%20-%20DRD1%20meeting%20\(1\).pdf](https://indico.cern.ch/event/1360282/contributions/5768838/attachments/2790631/4866507/Gas%20systems%20for%20gaseous%20detector%20-%20DRD1%20meeting%20(1).pdf)

# DRD1 MoU & Annexes

November 2024

- Completed DRD1 MoU+Annexes submitted to CERN Management;
- Green light to initiate the MoU signature process as soon as possible!

Annex 1: Collaborating Institutions and their Contact Persons

Annex 2: Funding Agencies and their Representatives

Annex 3: Equipment Structure and Technical Participation of the Collaborating Institutions

Annex 4: The Organisational Structure of the Collaboration

Annex 5: Overview of the Financial Participation of the Funding Agencies

Annex 6: Specific Obligations and Responsibilities of CERN as the Host Laboratory of the DRDn Collaboration

**Annex 7: Work Packages**

Annex 8: Working Groups

Annex 9: Other work Entities (Common Project, Common Investment)

Annex 10: Included Background IP

Annex 11: Conflict of Interest Disclosure Form

Annex 12: CERN General Conditions Applicable to Experiments

Annex 1 Collaborating Institutions and their Contact Persons

Country	Collaborating Institution	Town	Institution Code	Contact
Australia	Australian National University	Canberra	AU-ANU	Lindsey Bignell
Australia	University of Melbourne	Melbourne	AU-UMELBOURNE	Martin Sevier
Belgium	Université libre de Bruxelles	Brussel	BE-ULB	Gilles De Lentdecker
Belgium	Vrije Universiteit Brussel	Brussel	BE-VUB	Michael Tytgat
Belgium	Ghent University	Ghent	BE-UGENT	Didar Dobur
Belgium	UCLouvain, Université catholique de Louvain	Louvain-la-Neuve	BE-UCLouvain	Andrea Giammanco
Brazil	Centro Brasileiro de Pesquisas Físicas	Rio de Janeiro	BR-RIO-CBPF	Gilvan Augusto Alves
Brazil	Universidade do Estado do Rio de Janeiro	Rio de Janeiro	BR-UERJ	Helio Nogima
Brazil	Instituto de Física da Universidade de São Paulo	São Paulo	BR-IFUSP	Marco Bregant
Bulgaria	Institute for Nuclear Research and Nuclear Energy - Sofia	Sofia	BG-INRNE	Plamen Stoianov Iaydjiev
Bulgaria	Sofia University St. Kliment Ohridski	Sofia	BG-USOFIA	Leandar Litov
Canada	Carleton University, Ottawa	Ottawa	CA-UCARLETON	Jesse A. Heilman
China	Institute of High Energy Physics, CAS	Beijing	CN-IHEP-CAS	Huirong Qi
China	Tsinghua University	Beijing	CN-UTSINGHUA	Yi Wang
China	Jiling University	Changchun	CN-UJILING	Weimin Song
China	University of Science and Technology of China	Hefei	CN-USTC	Jianbei Liu
China	Chinese University of Hong Kong	Hong Kong	CN-CUHK	YanJun Tu

Annex 2 Funding Agencies and their Representatives

Country	Funding Agency	Funding Agency Code	Representative	Institution(s) represented*
Australia	Australian National University	AU-ANU	Lindsey Bignell	
Australia	University of Melbourne	AU-UMELBOURNE	Martin Sevier	
Belgium	Université libre de Bruxelles	BE-ULB	Gilles De Lentdecker	
Belgium	Vrije Universiteit Brussel	BE-VUB	Michael Tytgat	
Belgium	Ghent University	BE-UGENT	Didar Dobur	
Belgium	UCLouvain, Université catholique de Louvain	BE-UCLouvain	Andrea Giammanco	
Brazil	Centro Brasileiro de Pesquisas Físicas	BR-RIO-CBPF	Gilvan Augusto Alves	
Brazil	Universidade do Estado do Rio de Janeiro	BR-UERJ	Helio Nogima	
Brazil	Instituto de Física da Universidade de São Paulo	BR-IFUSP	Marco Bregant	
Bulgaria	Institute for Nuclear Research and Nuclear Energy - Sofia	BG-INRNE	Plamen Stoianov Iaydjiev	
Bulgaria	Sofia University St. Kliment Ohridski	BG-USOFIA	Leandar Litov	
Canada	Carleton University, Ottawa	CA-UCARLETON	Jesse A. Heilman	
China	Institute of High Energy Physics, CAS	CN-IHEP-CAS	Huirong Qi	
China	Tsinghua University	CN-UTSINGHUA	Yi Wang	
China	Jiling University	CN-UJILING	Weimin Song	
China	University of Science and Technology of China	CN-USTC	Jianbei Liu	

FA signing the MoU are not necessarily the same as the FA listed in the WPs



# 2024: Work Packages Endorsement

WP ID	Title	No. Institutes*	No. Countries	
WP1	Trackers, Hodoscopes, Large area muon systems	30	15	
WP2	Drift Chamber	13	5	
WP3	Optimization of Straw Tracker Technologies	Project A: Drift tube developments for new high-rate applications	7	2
		Project B: Straw chamber technologies for hadron physics applications	4	3
		Project C: Large area straw detector for Dark Sector applications	2	2
		Project D: Straw 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	16	10	
WP5	Gaseous calorimeters	10	8	
WP6	Gaseous photon detectors	11	10	
WP7	Timing detectors	Project A: High-rate, high-granularity precise timing with MPGDs	9	9
		Project B: High-rate, large, precise timing (MJRPC)	20	11
WP8	Reaction/Decay TPCs	Project A: High Pressure TPCs for precision studies of neutrino interactions	16	7
		Project B: TPCs for low-energy nuclear physics	10	8
		Project C: Electroluminescence-based TPCs for Rare-Event Searches and other R&D on pure noble-gas amplification	9	4
		Project D: Radiopure and/or low-energy TPCs for precise track imaging and/or calorimetry with avalanche-based readouts	15	11
WP9	BHEP Applications	17	12	

## Future Steps:

- **Approve WP endorsement procedure** at the DRD1 CB meeting in Dec. 2024
- **Initiate WP endorsement** process **after MoU signature start**

- WP Endorsement rules are included in the MoU Annexes 7.2-7.3
- 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**
- ✓ Despite formal aspect for DRD1 still to be completed (MoU), the activities started in 2024. Prompt actions are required to **preserve and enhance the current momentum in the community**
- ✓ **DRD1 MoU Annexes** has been completed and are **up-to-date**; **the green light to initiate the signing of the MoU received!**

## Next steps:

- **Circulate the MoU+Annexes to receive the last feedback (names/data/information connected to the group)**
  - **Apply changes (if any)**
  - **Share the final MoU with CERN management**
  - **CERN management initiates the signature process**
- ✓ **WP Endorsement process** is being finalized and can be initiated after **MoU signature is started**