Status and future of DRD1 international collaboration

Eraldo Oliveri (CERN) and Maxim Titov (IRFU, CEA Saclay, U Paris-Saclay) on behalf of the DRD1 Collaboration

Outline

Chronology and Context

The DRD1 Collaboration

Scientific Activities

- Work Packages
- Working Groups
- Common Projects

The Role of the Chinese Community in DRD1

Summary and outlook

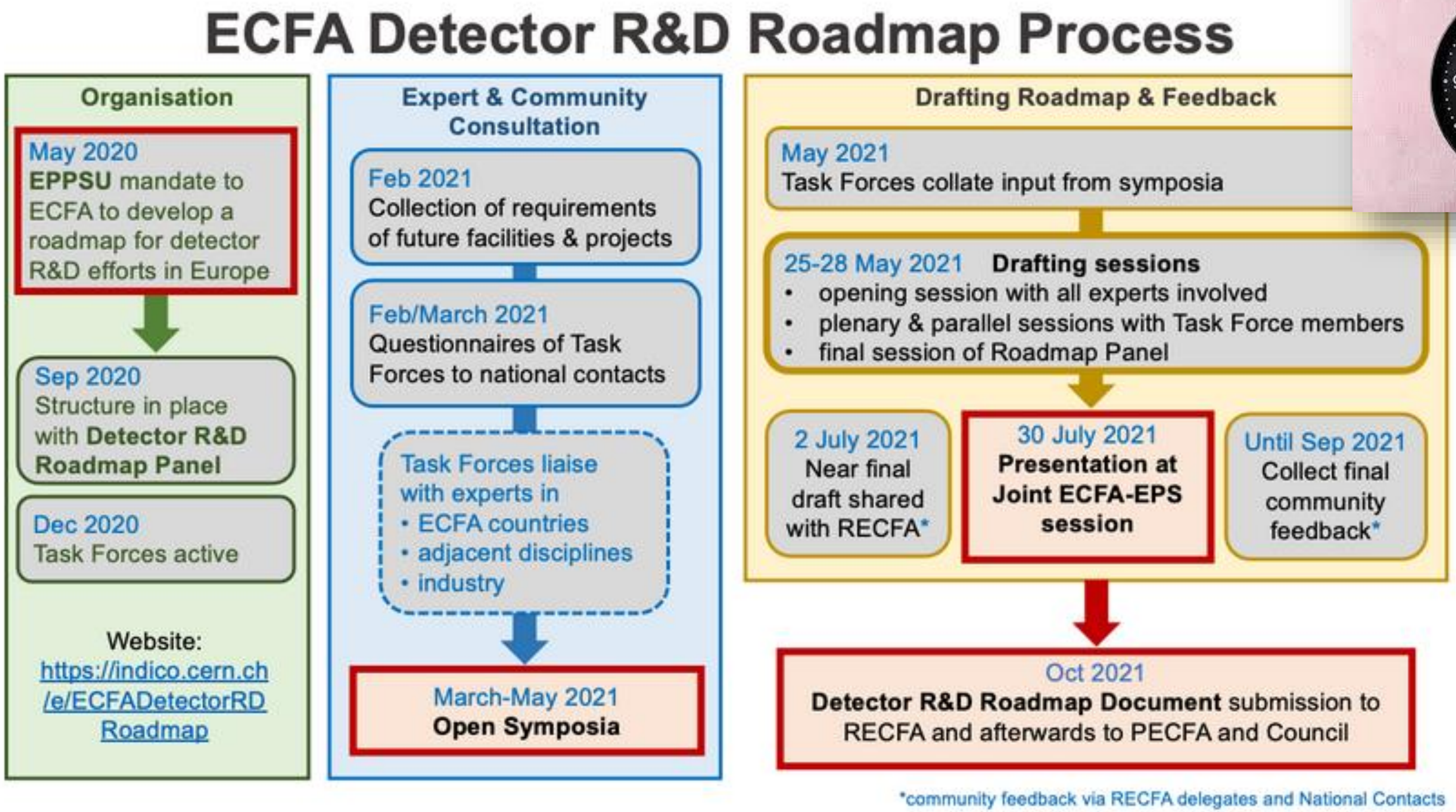
Chronology: European Strategy Update for Particle Physics (2020)

- **European Strategy Update for Particle Physics (2020)**
  - community is first invited to submit proposals (also called inputs) for projects that it would like to see realised in the near-term, mid-term and longer-term future
  - inputs are then reviewed by the Physics Preparatory Group
  - results of these discussions are then concisely summarised in this Briefing Book

- **Physics Briefing Book**
  (Input for the European Strategy Update for Particle Physics)
  - https://doi.org/10.48550/arXiv.1910.11775

- **Mandate for the Preparation of the Roadmap**
  - https://indico.cern.ch/event/957057/page/21633-mandate-for-the-preparation-of-the-roadmap

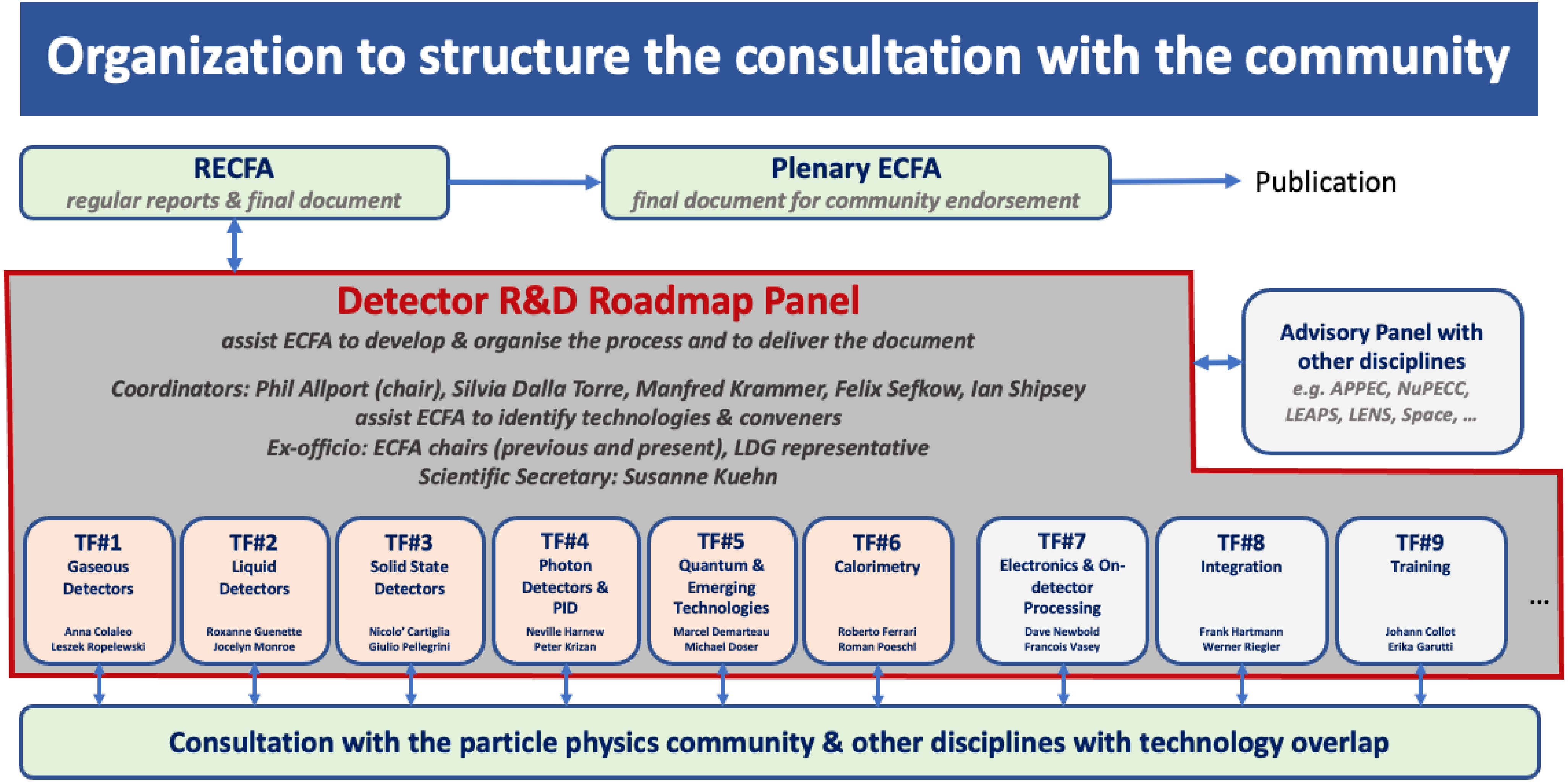
ECFA Detector R&D Roadmap Process - Timeline



https://indico.cern.ch/event/957057/page/21803-timeline-of-the-roadmap-process

Panel members and Task Forces (EP-DT)

https://indico.cern.ch/event/957057/page/20875-panel-members-and-task-forces

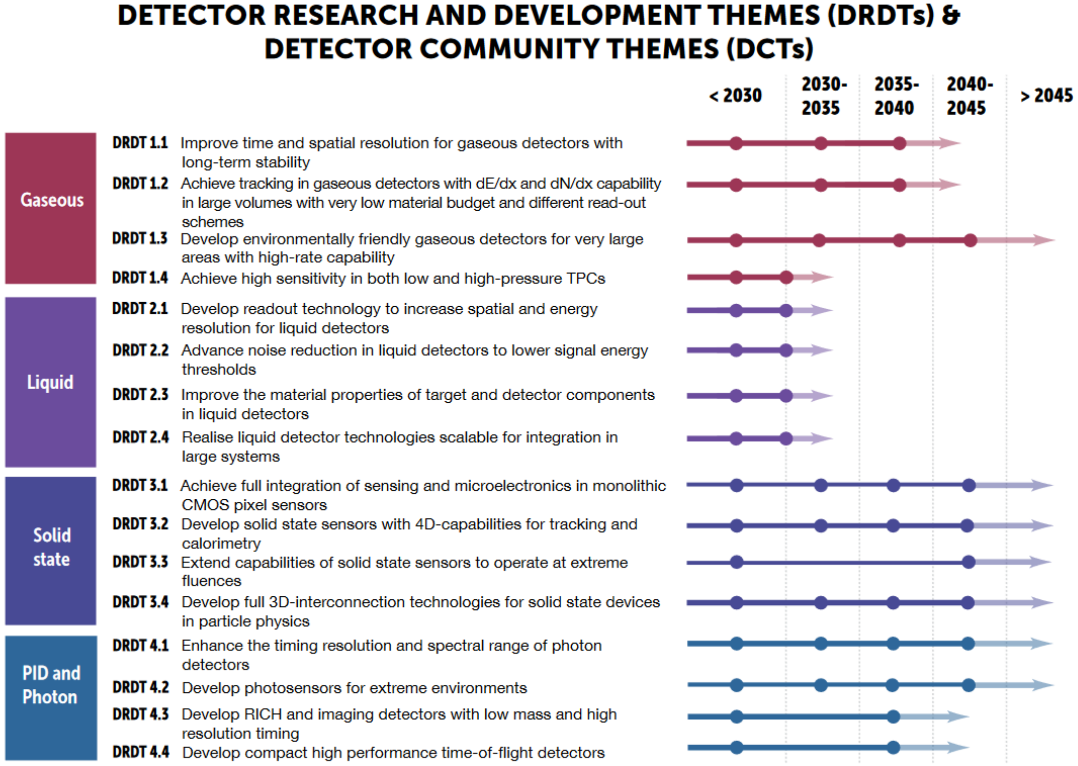


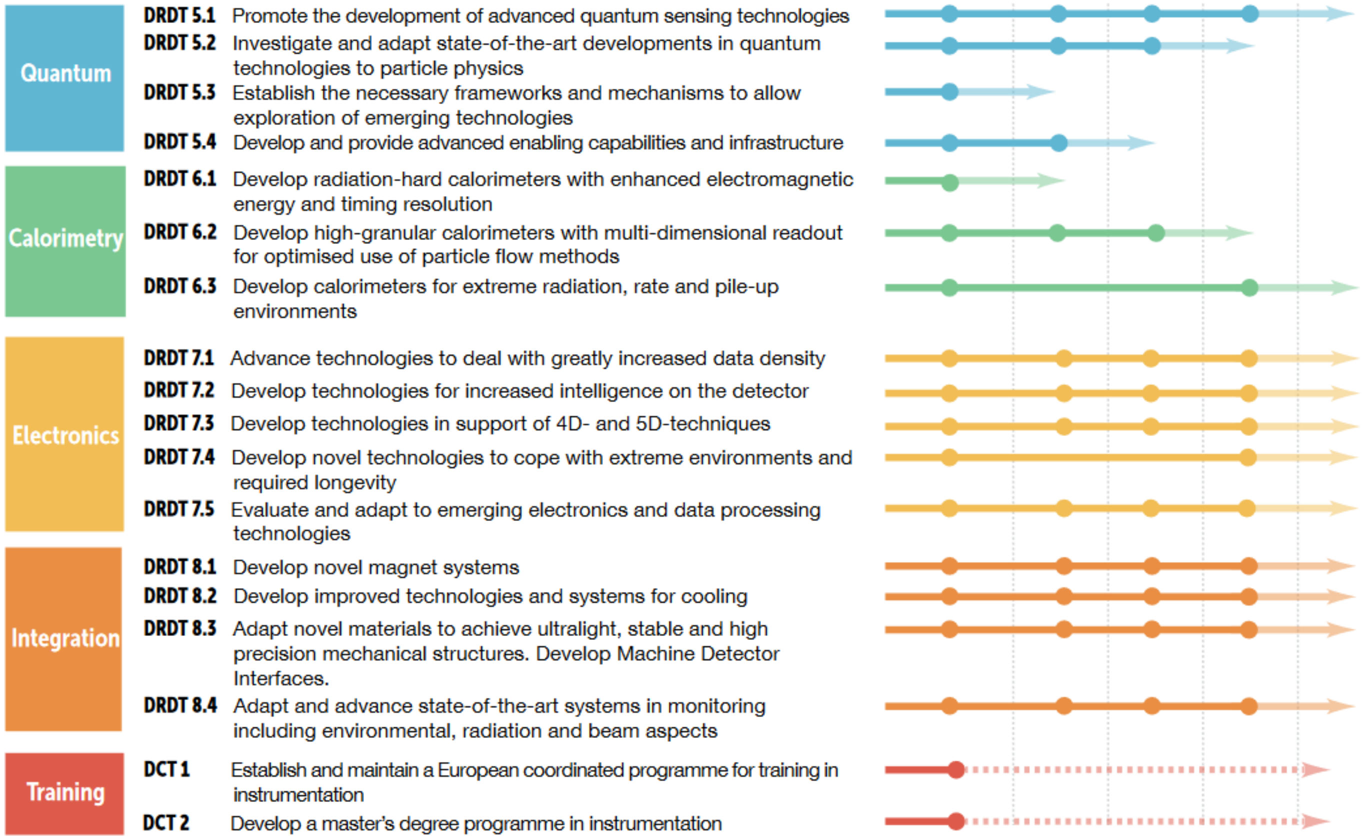
ECFA Detector R&D Roadmap Document

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

ECFA Detector R&D Roadmap Document

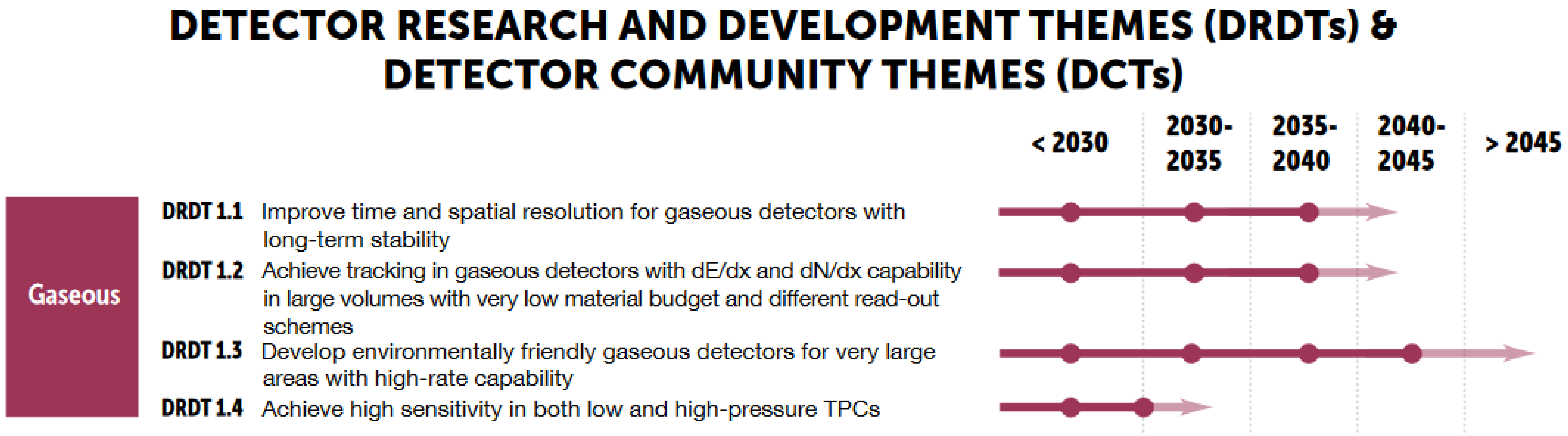




https://cds.cern.ch/record/2784893/files/Synopsis%20of%20the%20ECFA%20Detector%20R&D%20Roadmap.pdf

ECFA Detector R&D Roadmap Document

October 2021



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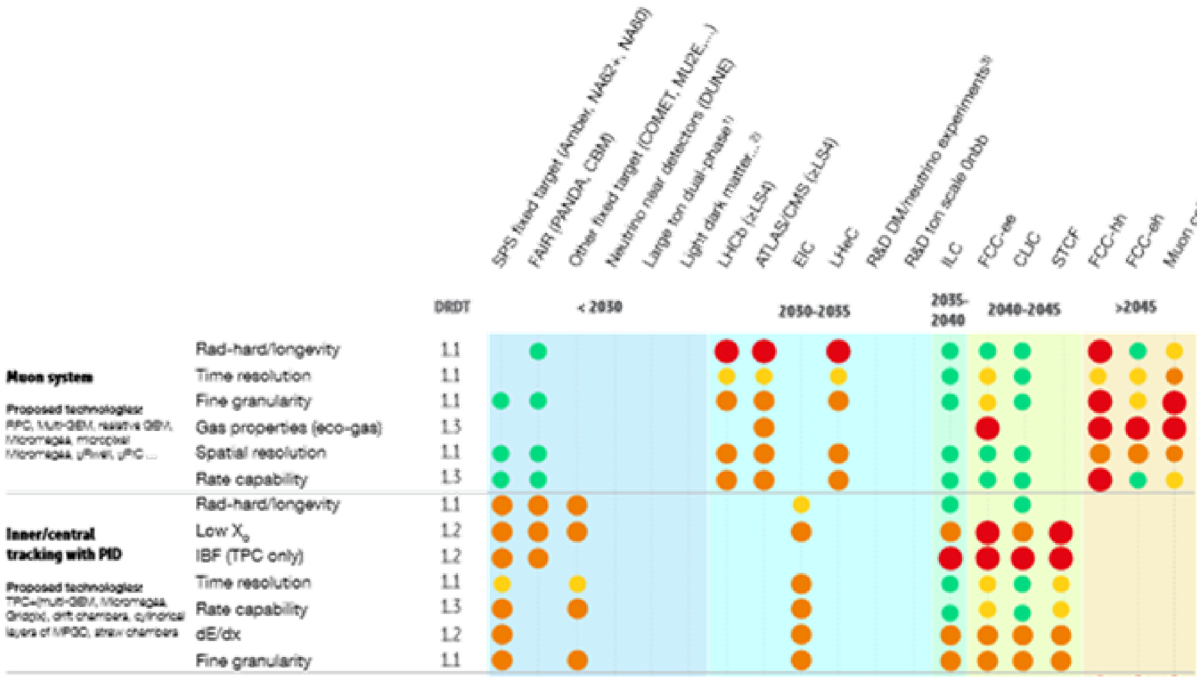
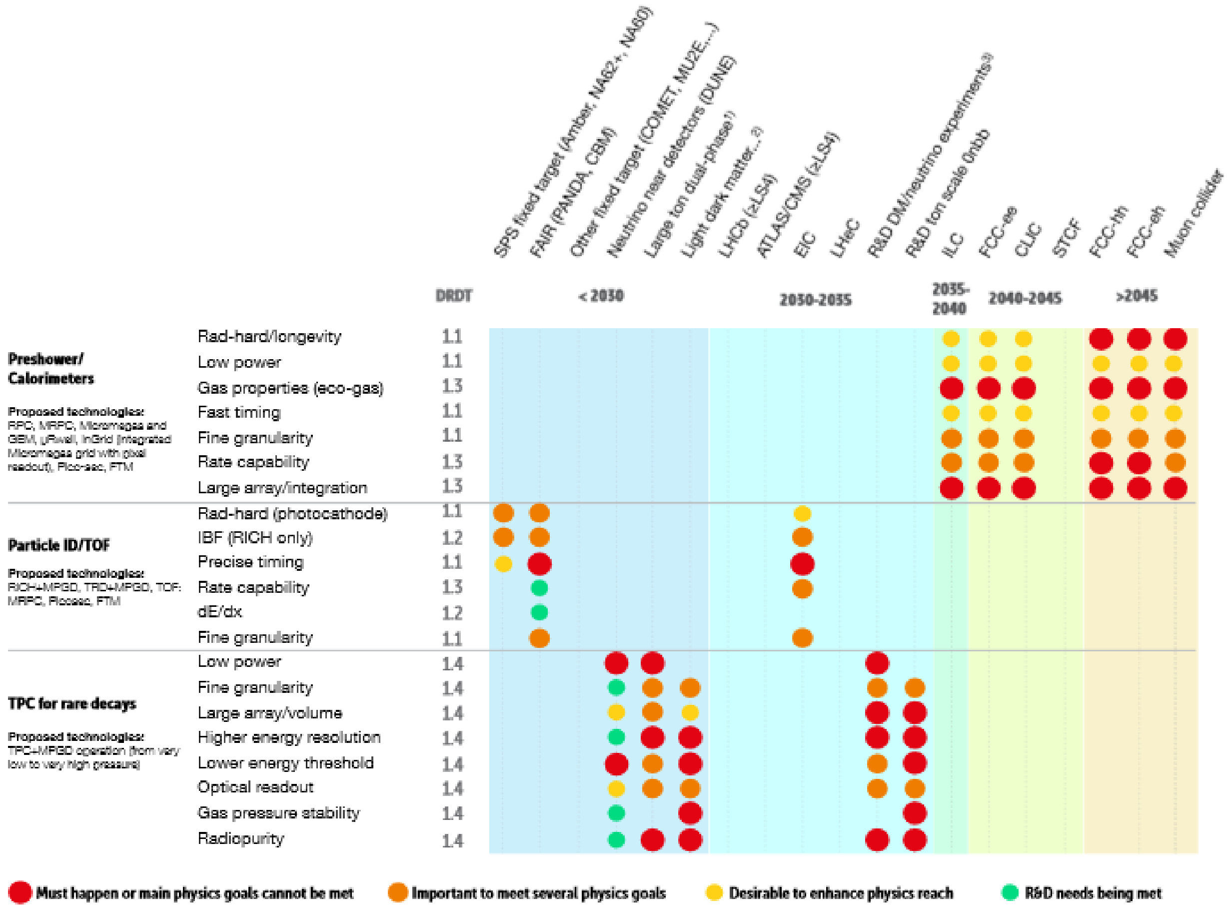
Detector R&D Themes and Requirements from future experiments





Must happen or main physics goals cannot be met | Important to meet several physics goals | Desirable to enhance physics reach | R&D needs being met

https://cds.cern.ch/record/2784893/files/ECFA%20Detector%20R&D%20Roadmap.pdf

General Strategic Recommendation

The report concludes with ten "General Strategic Recommendations" (GSRs). The aim of these is to propose mechanisms to achieve a greater coherence in detector R&D across Europe through better streamlining of local and national activities. Greater coordination will reduce duplication, improve effectiveness and give the area greater visibility. It will also give the field a greater voice at a European level to make the case for the additional resources needed for Europe to maintain a leading role in particle physics, with all the associated scientific and societal benefits that will flow from this.

The GSR topics covered by the detailed recommendations in the report are:

GSR 1 - Supporting R&D facilities
GSR 2 - Engineering support for detector R&D
GSR 3 - Specific software for instrumentation
GSR 4 - International coordination and organisation of R&D activities
GSR 5 - Distributed R&D activities with centralised facilities
GSR 6 - Establish long-term strategic funding programmes
GSR 7 - "Blue-sky" R&D
GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts
GSR 9 - Industrial partnerships
GSR 10 - Open Science

GSR 4 - International coordination and organisation of R&D activities

In some, but not all, areas of generic detector R&D, community-led collaborations provide vital fora for exchange of ideas and pooling of resources, thereby minimising duplication of effort. This ecosystem, which originally sprung from a CERN initiative around the challenges of detectors for the LHC and has evolved over three decades, has proved to be very effective and has also spawned a number of collaborations not linked to the original CERN structures. Within GSR 4, it is proposed to significantly refresh the structures and processes for the creation and peer-reviewing of such R&D collaborations, encouraging CERN and the other national laboratories to actively assist in catalysing this transformation

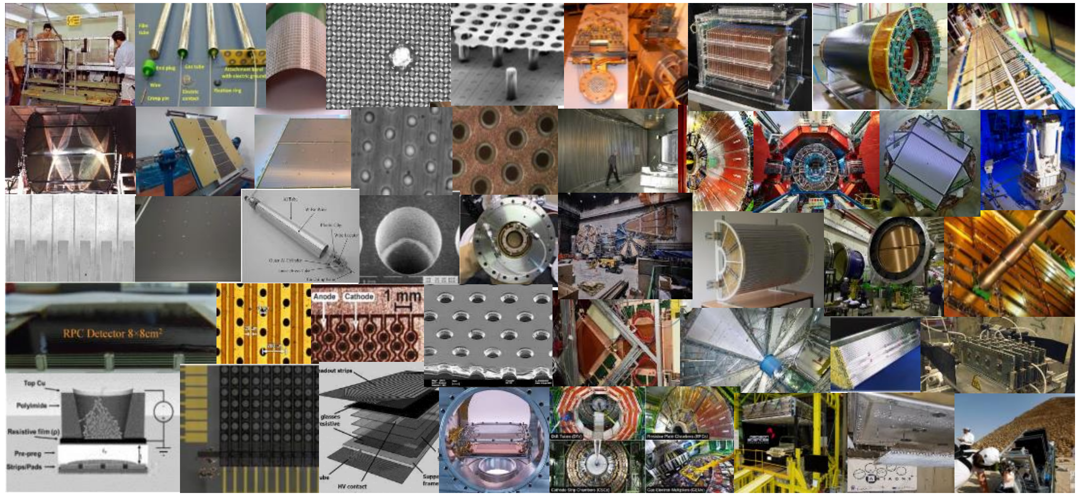
GSR 5 – Distributed R&D Activities with Centralized Facilities

A major concern for the future of several sensor R&D areas (particularly those linked to solid-state devices, microelectronics and on-detector data handling) is that R&D costs to exploit, adapt and further develop cutting-edge technologies are rising much faster than the rate of inflation. Although addressing the niche specifications of particle physics can provide an important vehicle for product development, the field remains by commercial standards a low volume market making it expensive. Increasingly, costs can only be met through a significant pooling of resources, particularly given the growing complexity and degree of specialisation required of those involved in the device design and the need to negotiate as a larger-scale organisation. GSR 5 proposes a solution to achieving the required critical mass through a network of national hubs which, while improving focus and cost-effectiveness, would still allow a vibrant research base in individual smaller institutes and university departments

GSR 6 – Establish long-term strategic funding programs

Linked to rising R&D costs, the need for a critical mass and the decadal timescales for strategic R&D investments needed for the ESPP programmes, there is an urgent need to augment the short-term funding mechanisms, suited for exploratory stages of the R&D cycle, with funding mechanisms better suited to long-term programmes as outlined in GSR 6. The scale of the technical challenges, the long planning horizons and the need to build serious relationships with industrial partners make sustained strategic investment a must, particularly if matching resources are to be leverage

DRD1: A very large and diversified set of technologies and solution, a very large and diversified community



GSR 4 - International coordination and organisation of R&D activities

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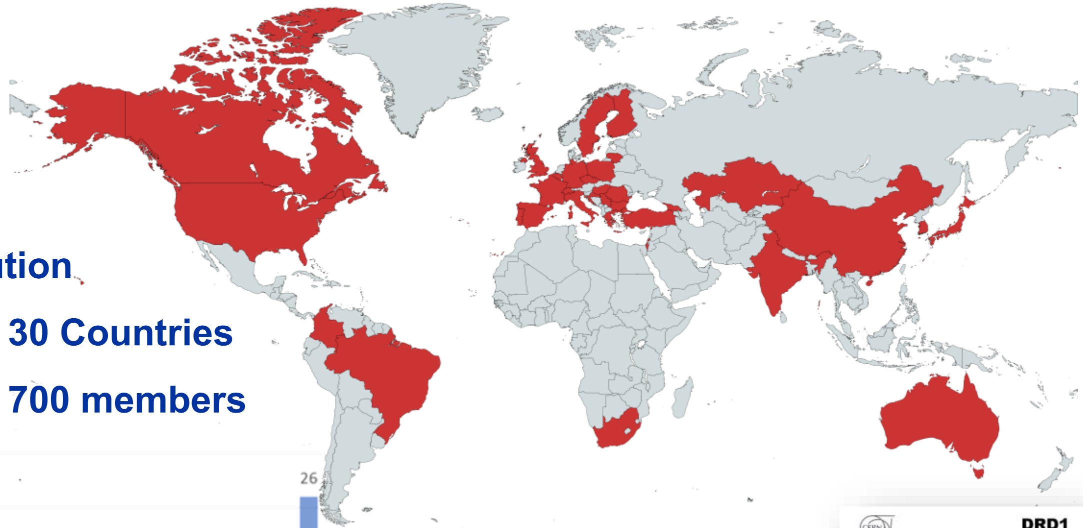
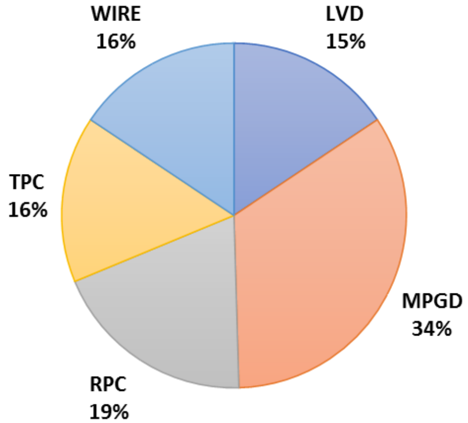
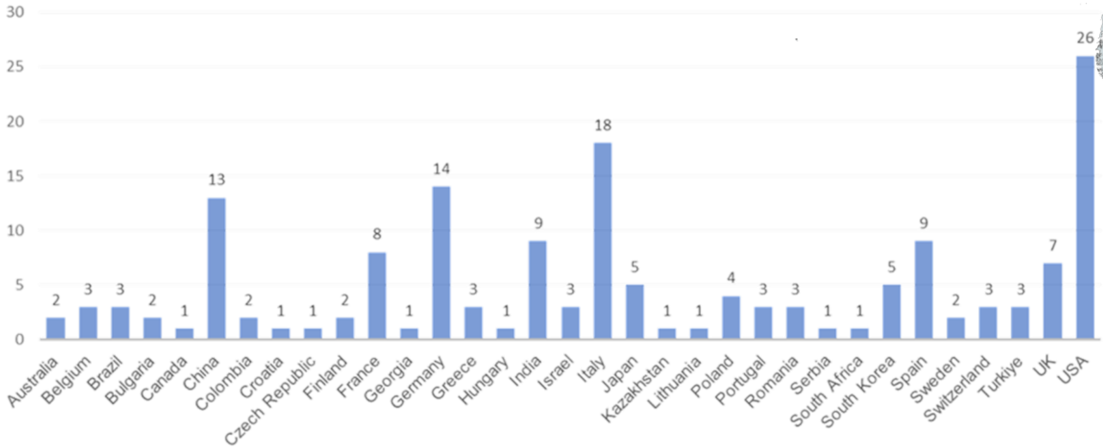


- **133 Institution**
- **More than 30 Countries**
- **More than 700 members**

Technologies at the time of the proposal



Institutions at the time of the proposal



DRD1 Extended R&D Proposal (December 2023)

https://cds.cern.ch/record/2885937

DRD1 Scientific Organization

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

DRDTs

1.1	1.2	1.3	1.4	Work Packages
●		●		Trackers/hodoscopes
●	●	●		Drift chambers
●	●	●		Straw chambers
●	●	●	●	Tracking TPCs
●		●		Calorimetry
●	●	●		Photon detection (PID)
●		●		Timing detectors
●	●	●	●	Reaction/decay TPCs
●		●		Beyond HEP

WG1	WG2	WG3	WG4	WG5	WG6	WG7	WG8
Technologies	Applications	Gas and material studies	Detector physics, simulations and software tools	Electronics for gaseous detectors	Detector production	Common test facilities	Training and dissemination

DRD Themes

Work Packages (Strategic R&D)

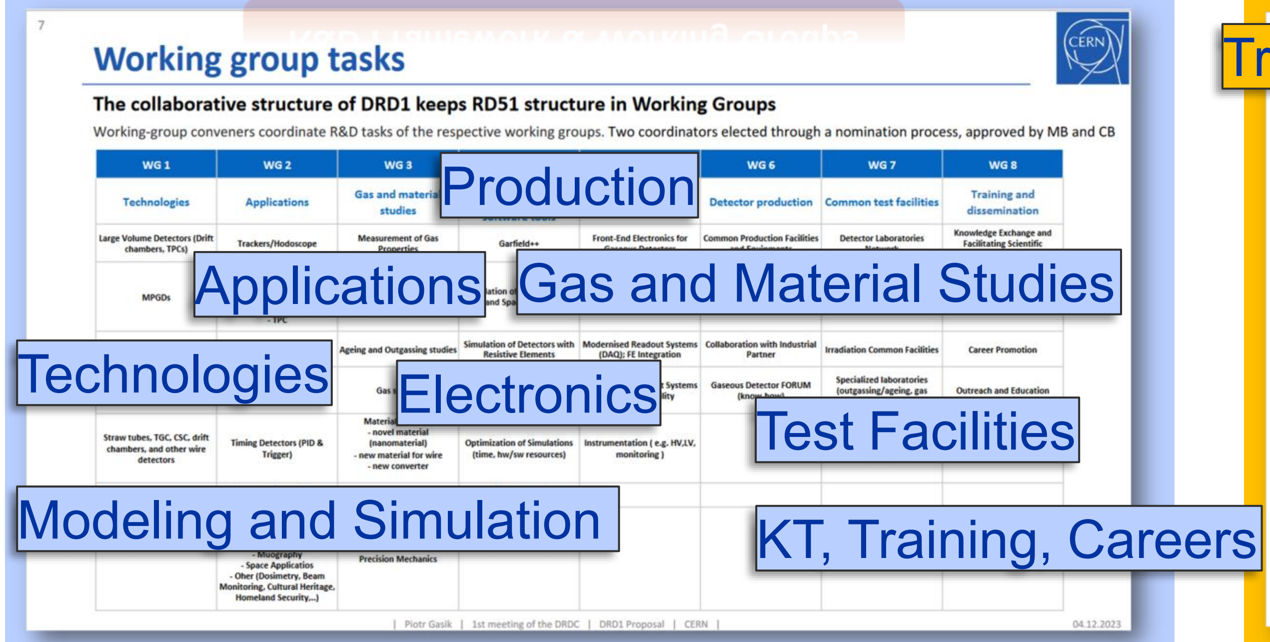
Working Groups (R&D Framework)

Main goal: present how DRD1 is addressing the general recommendations (I)

GSR 5 – Distributed R&D Activities with Centralized Facilities

A major concern for the future of several sensor R&D areas (particularly those linked to solid-state devices, microelectronics and on-detector data handling) is that R&D costs to exploit, adapt and further develop cutting-edge technologies are rising much faster than the rate of inflation. Although addressing the niche specifications of particle physics can provide an important vehicle for product development, the field remains by commercial standards a low volume market making it expensive. Increasingly, costs can only be met through a significant pooling of resources, particularly given the growing complexity and degree of specialisation required of those involved in the device design and the need to negotiate as a larger-scale organisation. GSR 5 proposes a solution to achieving the required critical mass through a network of national hubs which, while improving focus and cost-effectiveness, would still allow a vibrant research base in individual smaller institutes and university departments

R&D Framework & Working Groups



P. Gasik, DRD1 Proposal: Development of Gaseous Detectors Technologies, **1st meeting of the DRDC** 4 Dec 2023, CERN

R&D FRAMEWORK

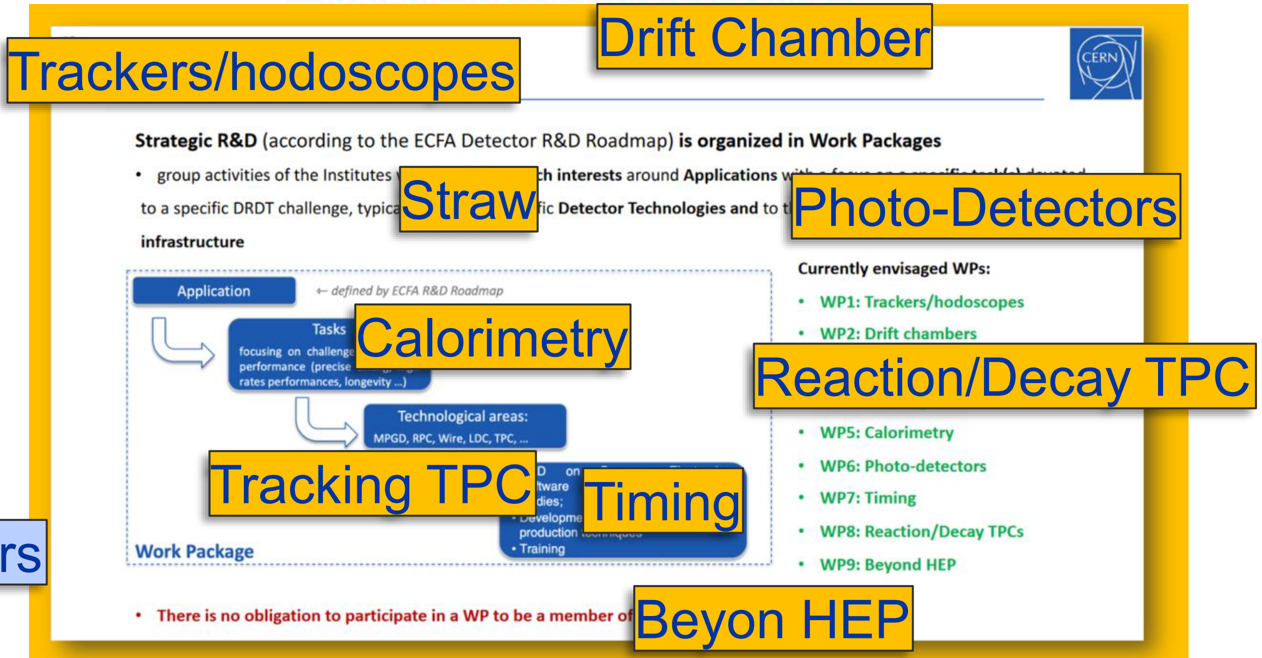
https://drd1.web.cern.ch/working-groups

Main goal: present how DRD1 is addressing the general recommendations (II)

GSR 6 – Establish long-term strategic funding programs

Linked to rising R&D costs, the need for a critical mass and the decadal timescales for strategic R&D investments needed for the ESPP programmes, there is an urgent need to augment the short-term funding mechanisms, suited for exploratory stages of the R&D cycle, with funding mechanisms better suited to long-term programmes as outlined in GSR 6. The scale of the technical challenges, the long planning horizons and the need to build serious relationships with industrial partners make sustained strategic investment a must, particularly if matching resources are to be leverage

Strategic R&D & Work Packages



P. Gasik, DRD1 Proposal: Development of Gaseous Detectors Technologies, **1st meeting of the DRDC** 4 Dec 2023, CERN

STRATEGIC R&D PROJECTS

https://drd1.web.cern.ch/wp

a simplified vision, reality is slightly more complex and mixed

DRD1 Scientific Activities (I) Work Packages

Strategic R&D

DRD1 Work Packages

WP ID	Title
WP1	Trackers, hodoscopes, large area muon systems
WP2	Drift chambers
WP3	Straws and drift tubes
WP4	Tracking TPCs
WP5	Gaseous calorimeters
WP6	Gaseous photon detectors
WP7	Timing detectors
WP8	Reaction/decay TPCs
WP9	BHEP applications

Work Package 1

Advances resistive gaseous detectors for muon systems and inner tracking, focusing on innovative materials, optimized geometries, and enhanced electronics for precise, high-rate tracking and long-term stability.

Trackers, hodoscopes, large area muon systems:

- Developing trackers, hodoscopes, and large-area muon systems.
- Aligned with ECFA Detector R&D Roadmap (DRDT 1.1 & 1.3).
- Leptonic Colliders: Focus on large gaseous detectors and eco-friendly gases.
- Hadronic Colliders: Developing detectors for rates up to 10 MHz/cm².

Progress:

Main Deliverables: Prototypes (large-area) and new Front-End/DAQ systems.

- New resistive designs: GEM- µRWELL, µRGROOVE
- Capacitive sharing readout under development
- Optimized RP materials for tens kHz/cm² rates
- RPCs validated with eco-gas mixtures
- ASICs: progress on SALSA, VMM3, TORA

Notes

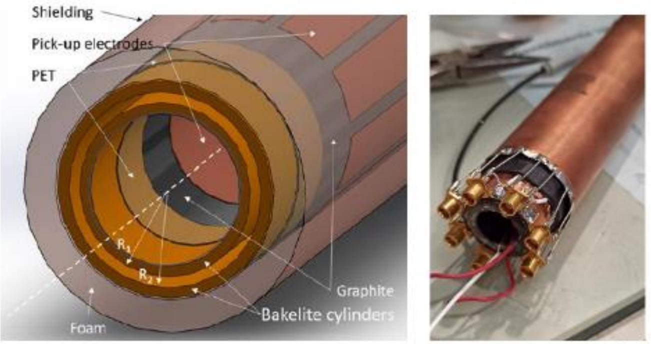
Future Challenge: Manufacturing of large-area detectors through the crucial technology **transfer of these cutting-edge methodologies to industry**, while rigorously maintaining the performance specifications demonstrated by the laboratory prototypes.

Multiple technologies are investigated simultaneously (cross-fertilization, new ideas, diversified approaches)

Manufacturing

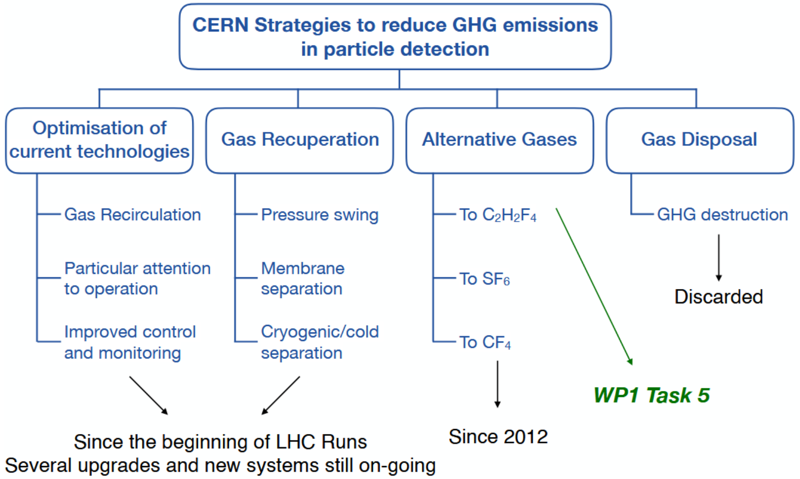
CERN-INFN DLC (CID) sputtering machine

New Detector Structures



Resistive Cylindrical Chamber: RCC
https://doi.org/10.1016/j.nima.2023.168822

Eco-Friendly Gases



CERN strategies for GHG reduction

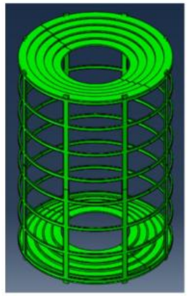
Work Package 2

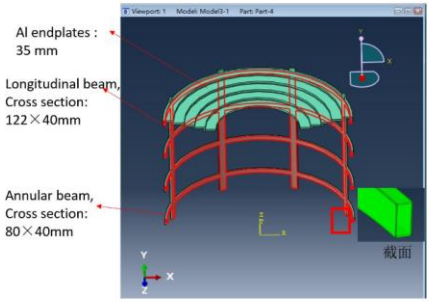
Large-volume drift chambers for tracking and particle ID at future lepton colliders (FCC-ee, CEPC) and flavor factories (SCTF). Offer precise tracking at low p_T and excellent particle ID via cluster counting. Key R&D challenges involve mechanics, electronics, and gas mixture

Drift chambers:

- Cluster Counting FE and DAQ (T1, T2)
- New wire materials and metal coating (T5) and new wiring procedures and new endplate concepts (T3) for Large Volume, High Granularity, low material budget
- Increase rate capability and granularity (T4)
- Ageing phenomena for new wire types (T6)
- Optimization of gas mixing, purification, and recirculation systems (T7)

Mechanics (CEPC DC)





- Carbon fiber frame structure, including 8 longitudinal hollow beams and 8 annular hollow beams
- Thickness of inner CF cylinder: 200 µm/layer
- Effective outer CF frame structure: 1.63 mm
- Thickness of end Al plate: 35 mm

- Mises stress: 70 MPa
- Principal stress: 33 Mpa
- Deformation: 0.8 mm
- Buckling coefficient: 17.2

Preliminary calculation shows stable

Progress:

- Advanced (T3), In progress (T1, T2, T4), Started (T5), Not started (T6, T7 – awaiting further input and contributions from the community)
- Electronics design for Tasks 1 and 2 ongoing; different solutions under study
- Significant progress on Tasks 3 and 5; prototypes under development

Wires Studies

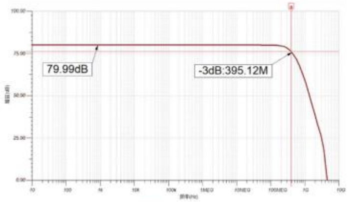
- Tungsten and molybdenum gold-coated, carbon monofilaments tested.
- Aluminium wires to be characterized.

Carbon monofilaments

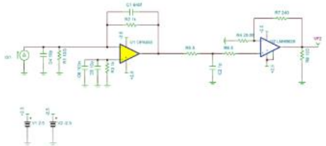
Specimen number	Tensile Strength - UTS (GPa)	Young module (Gpa)	R^2	Effective test time (s)	Total wire elongation (mm)	Elongation (%)
21	1.445	103.413	0.9997	28.350	0.567	1.418
22	1.732	102.886	0.9996	33.725	0.675	1.686
23	2.120	103.973	0.9999	41.375	0.828	2.069
24	2.247	98.236	0.9986	45.650	0.913	2.283
25	2.247	107.915	0.9996	41.425	0.829	2.071
Average Set	1.958	103.284	0.999	38.105	0.762	1.905

Cluster Counting Electronics

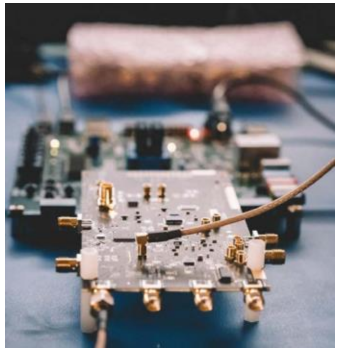
Electronics development



- High bandwidth current sensitive preamplifiers based on LMH6629 have been designed and developed
- Tested with detector prototype and digitizer (DT5751) with 1 GHz sampling rate



An 8-channel prototype frontend board made with COTS, read out using an oscilloscope



NALU SCIENTIFIC Waveform Digitizers

Work Package 3

Optimizes straw and drift tube technologies to minimize material while maintaining excellent timing and spatial resolution, using self-supporting structures and high-granularity electronics.

Straws and drift tubes:

Covers a broad range of applications (FCC-ee/hh, hadron and neutrino physics, Dark Sector) optimizing straw materials, production technologies, and readout electronics.

Next generation of straw technologies:

- Large volumes with low material budget
- Enhanced measurements and resolutions
- Enhanced longevity
- Thin-film straws and large area in vacuum

Progress:

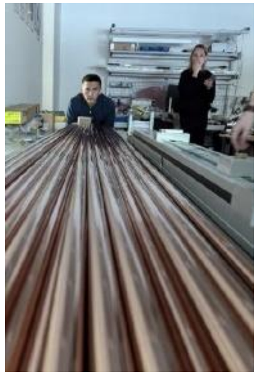
- FCC-ee central straw tracker: low-mass, PID-capable; implemented in simulation and prototypes tested in beam.
- Central self-supporting straw tracker prototype in progress (~600 straws) with electronics ready.
- Neutrino target-tracker: long (4m), thin-wall straws; labs, tools, and supply chains set; frame prototypes in progress.
- Production : ultrasonic straw welding line in preparation;
- Electronics ToRA ASIC prototype produced, performance tests upcoming.

Straw tracker for hadron physics

Self-supporting Straw module (PANDA-STT)

Ultrasonic Welding Technique

USW procedure for double side alu-metalized films



Readout Electronics (TORA)

Readout for trackers with PID: Simultaneous Time–at-Threshold and charge

Detector	MM	Straw	
Channels/ASIC	64	64	
Power/channel	≤ 20	≤10	mW
Input capacitance	≤550	20-100	pF
Input charge	1-100	1-1000	fC
Input impedance	≤50 Ω	*tbd*	Ω
Max rate	≤ 0.5	≤0.18	MHz
Peaking time	150-500	25-150	ns
Time resolution	1-2	≤1	ns
Charge resolution	8	10	bits
Gain	10-20	2	mV/fC
ENC @10 pF	500-1000		e^-
ENC @150 pF	1000-2000		e^-
ENC @60 pF		3000	e^-
Threshold range	*tbd*	0-15	fC
Clock frequency	200	200	MHz

TOrino **R**eadout (for) **A**MBER ASIC

Work Package 4

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.

Tracking TPCs:

Main R&D Topics:
- IBF reduction,
- Pixelated readout,
- optimized amplification
- low-X/X_0 field cages
- dedicated TPC front-end electronics
- gas mixture studies.

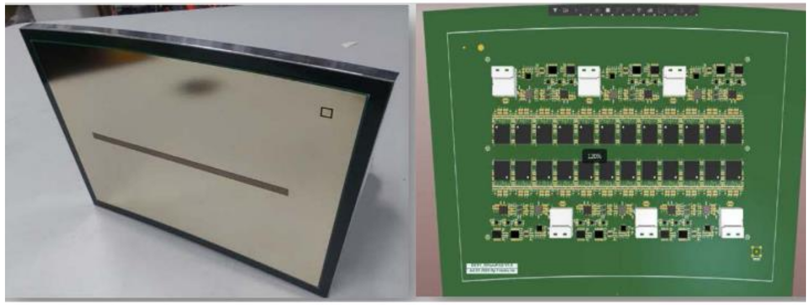
Progress:

- Activities ongoing at Institution level.
- Most efforts focused on high rate, high-granularity (pixel) readout for various applications.

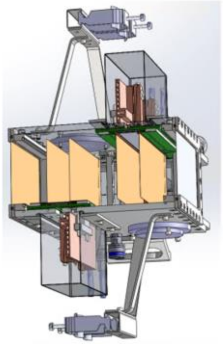
Notes

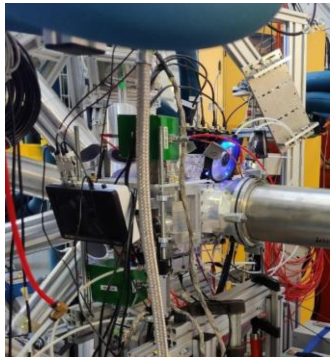
Wide range of activities has reached a critical mass to pursue endorsement by the collaboration.

Pixelated TPC readout for CEPC

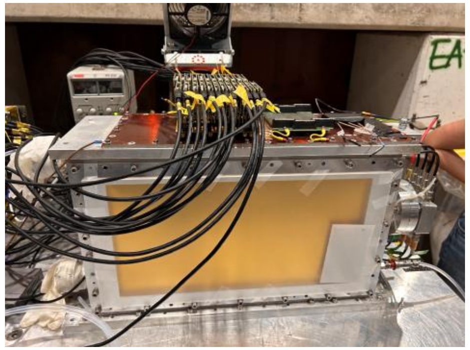


Ultra-Low Material Budget, High-rate GEM based TPC for Super-FRS @ FAIR and MIXE @ PSI



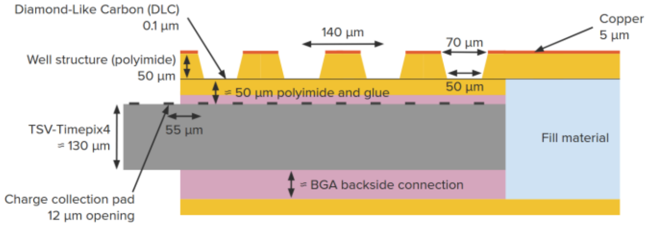


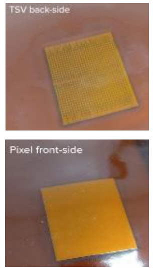
High-Rate Tracking (HYDRA)



HYDRA pion tracker, GEM+MM TPC with VMM3a readout

Timepix4 Embedding in uRWELL/MM





Work Package 5

Develops thin, highly granular sampling calorimeters with uniform performance, robust timing, and cost-effectiveness, supporting particle flow algorithms.

Gaseous calorimeters:

Conception, construction and characterization of large sampling elements for calorimeters

Timing performance of gaseous detectors for calorimeters

Readout electronics for calorimeter gaseous detectors

Progress:

Scientific work is ongoing

Regular WP5 scientific meetings organized

Working closely with the program proposed in DRD6.

Units developed in DRD1/WP5 will later be used in the gaseous calorimeters proposed in DRD6. Electronics readout and mechanical constraints are considered in the detector design.

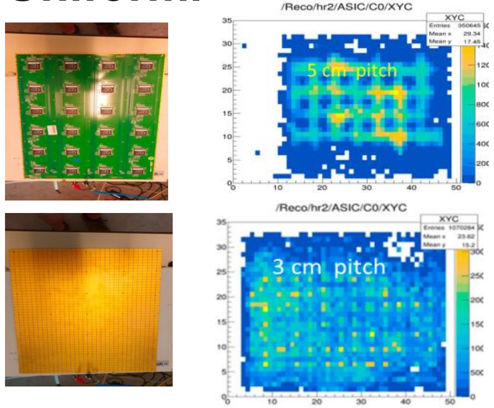
Notes (Plans, Issues,..):

Future activities

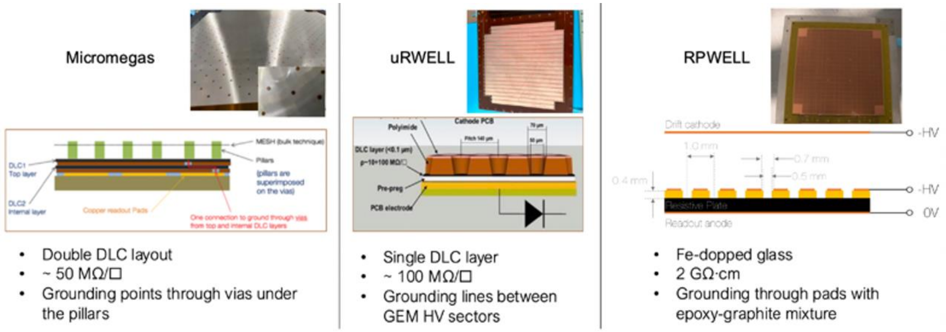
- Study of time-response homogeneity (MRPC)
- Design of large-area detectors (MPGD)
- Precision mechanics (Common)
- Electronics: use of variants of CALOROC ASIC

developed by OMEGA within DRD6

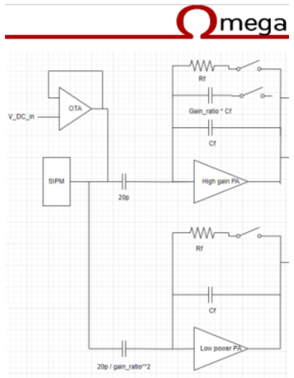
MRPC (50cm x 33cm) Uniformity Studies



MPGD-HCAL Comparative studies



Front End Electronics



CALOROC

FATIC

Work Package 6

Advances RICH photon detectors with robust UV/visible-sensitive photocathodes, low-noise electronics, and minimized ion backflow for accurate photon detection.

Gaseous photon detectors:

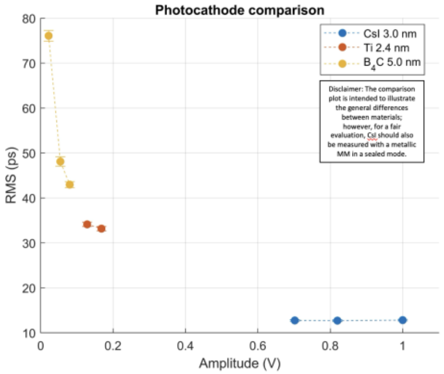
Used in particle and astrophysics experiments, Cherenkov and scintillation imaging, and large-area photon detectors for medical and other fields.

R&D focuses on:
- Robust and efficient UV photoconverter
- Visible-light photoconverter
- IBF suppression
- Enhanced time and spatial resolution
- Single-photon readout electronics

Progress:

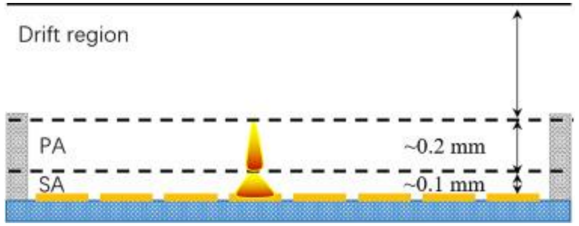
- Scientific activities on innovative photocathodes and detector performance improvement are ongoing at Institute level
- **Existing link with DRD4 on common activities** (optical properties and environmental impact of gases)

Alternatives to CsI Photocathodes (PICOSEC)



Nanodiamond Coating on THGEM

Low IBF Double Mesh Micromegas for photon detection



Work Package 7

Focuses on sub-nanosecond timing detectors using RPCs and MPGD-based Cherenkov sensors, minimizing electronic jitter and scaling up prototypes for large areas.

Timing detectors

(A:MPGD, B:RPC):

Crucial for future detectors:
- enabling accurate 4D tracking,
- effective pile-up suppression,
- enhanced particle identification.

This technology is essential for key systems, including calorimeters and muon detectors, and enables new precision measurements.

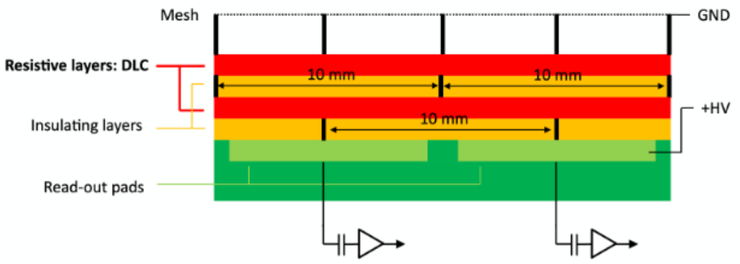
Progress:

- Different manufacturing/assembly techniques tested.
- MPGD Prototypes for high-rate and high-granularity applications produced and tested, confirming good time resolution.
- (More/RPC or totally/MPGD) Eco-friendly, non-flammable gas mixtures tested, showing good time resolution.
- Electronics: multichannel ASICs candidates considered.

Notes

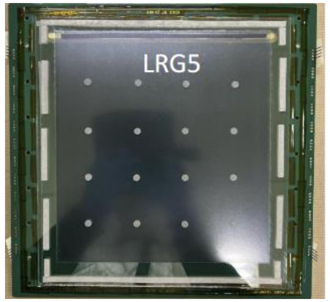
- **New manufacturing approaches** towards tillable, large-area detectors.
- **Photocathode** efficiency and robustness remains a challenge; metallic & carbon-based options promising.
- **Multi-channel readout electronics** for precise timing

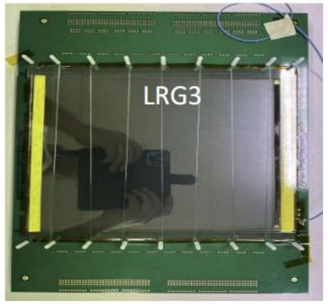
High Rate PICOSEC Micromegas



PICOSEC Double DLC Layer Micromegas for vertical charge evacuation and high-rate application.

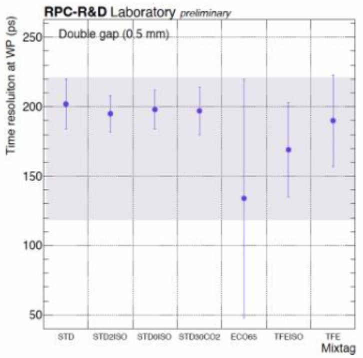
Construction Methods Comparison (Glass RPC)

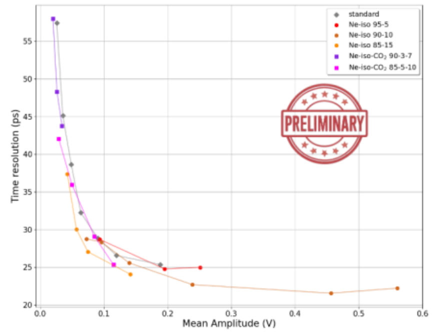




RPC Detectors with low-resistivity glass and two different construction methods (fishing lines and spacers) tested and compared

(ECO) Gas Mixtures Studies





Assess timing performance using standard gas mixture and new eco-friendly gases(left: RPC, right: PICOSEC)

Work Package 8

Optimizes TPCs for rare-event and nuclear/neutrino studies, enhancing low-energy sensitivity, reducing backgrounds, and integrating advanced simulations.

Reaction/decay TPCs:

- High-pressure TPCs for precision studies of **neutrino** interactions (A)
- TPCs for low-energy **nuclear physics** (B)
- Electroluminescence-based TPCs for **rare-event searches** and other R&D on pure noble-gas amplification (C)
- **Radiopure and/or low-energy TPCs** for precise track imaging and/or calorimetry with avalanche-based readouts (D)

Progress:

Research activities progressing at different speed in the four projects.

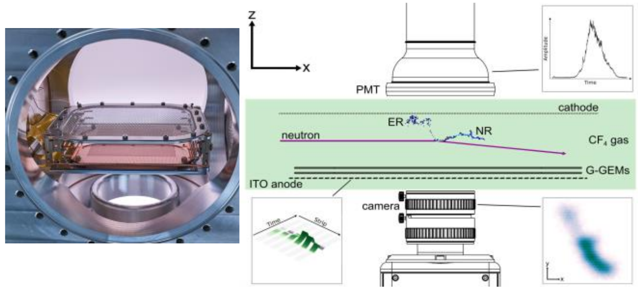
Common main deliverable is TPC commissioning and proof of principle demonstration.

Teams are all advancing toward larger detectors with better energy thresholds and tracking,

Notes

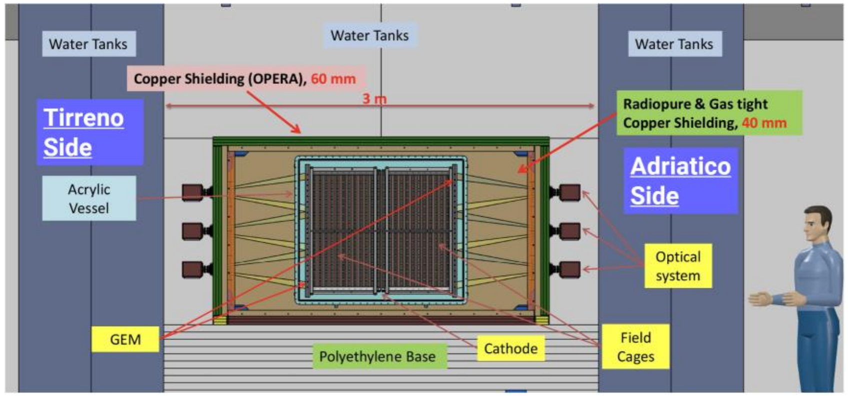
Groups with different physics goals but a shared technology, enabling knowledge exchange and joint progress.

3D Imaging: MIGDAL (RAL)



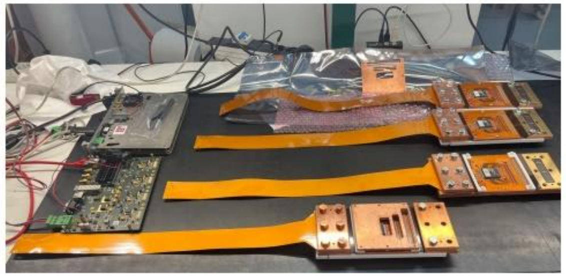
Low-pressure CF_4 TPC for Migdal effect –optical (2D camera) and charge readout (orthogonal ITO strips).

Big and Radiopure: CYGNO (GSSI, INFN)



0.4 m³ demonstrator nearing completion – 80 × 50 cm² readout, two back-to-back 50 cm drifts.

Radiopure: IAXO (CAPA)



Development of new radiopure frontend to be placed inside the shielding (lower noise)

Work Package 9

Adapts gaseous detectors for muography, medical imaging, and neutron detection, emphasizing robust, low-power, cost-effective designs and technology transfer.

BHEP applications:

Muography, **Medical physics** and **Neutron sciences** with strong interconnections.

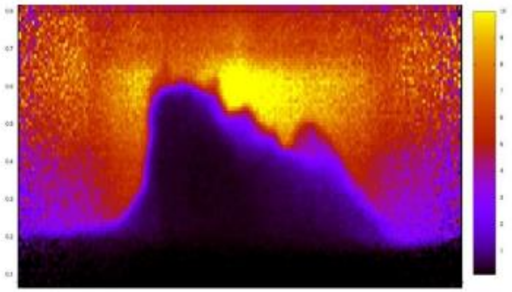
Hostile or extreme conditions, very low level of maintenance, or strong requirements on operational stability, safety, gas emissions or structural stability.

Progress:

All involved groups are progressing very well toward detector performance evaluation (main common deliverable).

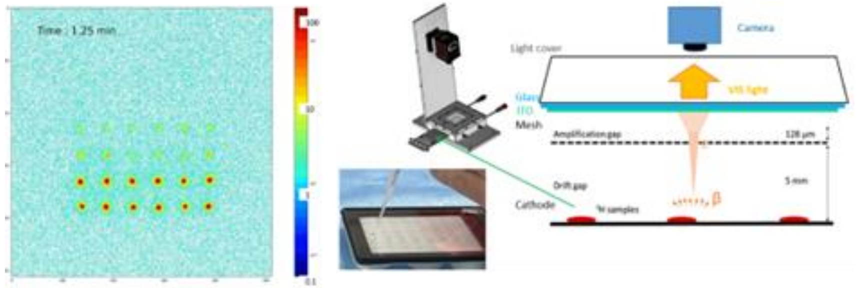
All proposed tasks are covered by ongoing activities. In a few tasks, the three main research lines (Muography, Medical and Neutron) overlap and share efforts.

Muon imaging and extreme environment conditions



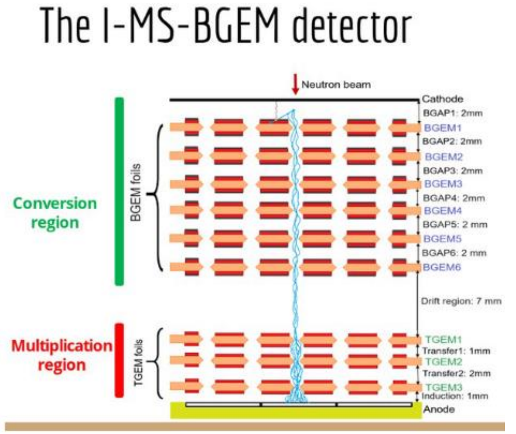
Sealed mode operation demonstrated for over 6 months for RPCs and MWPCs.

Beta Imaging for medical research



Optically readout micromegas for beta imaging and activity measurement on cell level

Innovative neutron converter geometries



in combination with gaseous amplifying structures for high-rate, efficient, low background detectors

DRD1 Scientific Activities (II) Working Groups

R&D Framework

DRD1 Working Groups

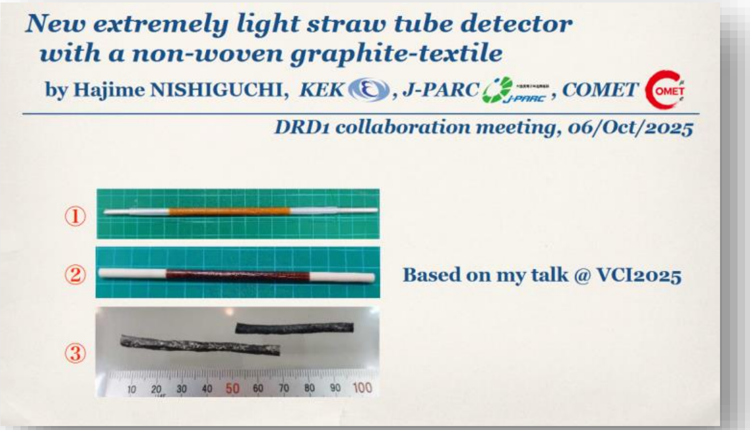
Working Group	Description
WG1	Technological aspects and developments of new detector structures, common characterization and physics issues
WG2	Applications
WG3	Gas and materials
WG4	Modelling and simulations
WG5	Electronics for gaseous detectors
WG6	Production and technology transfer
WG7	Collaboration laboratories and facilities
WG8	Knowledge transfer, training, career promotion

Working Group 1

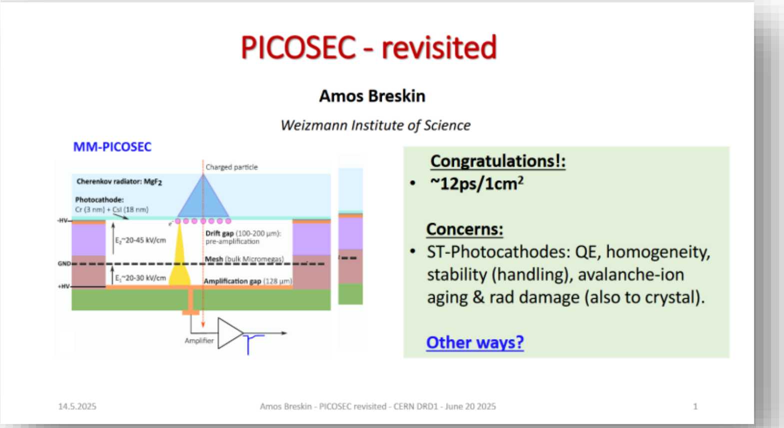
Advances the design and development of innovative detector architectures, including wire-based systems, RPCs, MPGDs, and large-volume detectors, ensuring robust, scalable, and adaptable solutions for future experiments.

Support efficient scientific exchange, with proper peer review and discussion within the community, focusing on relevant aspects and keeping track of all **Technological aspects and developments of new detector structures, common characterization and physics issues** of interest for the he full DRD1 community

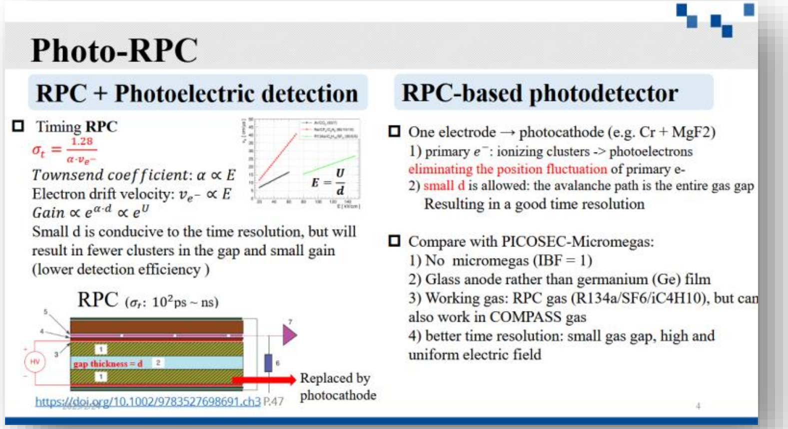
Wire



MPGD



RPC

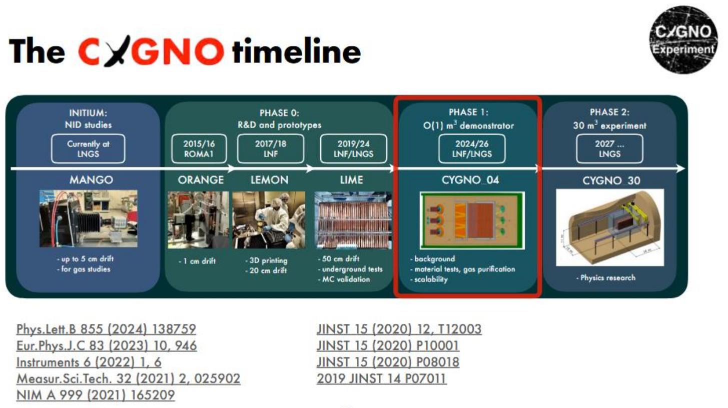


Working Group 2

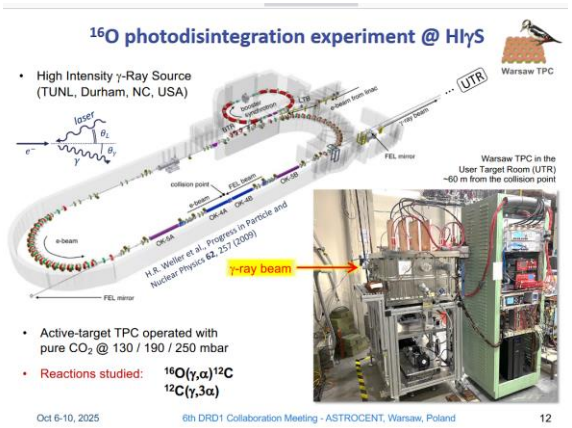
Bridges fundamental R&D and practical applications, identifying performance needs and promoting technological breakthroughs for particle physics and other fields.

Support efficient scientific exchange with proper peer review and discussion within the community, focusing on relevant aspects and keeping track of all **Applications** covered by the full DRD1 community.

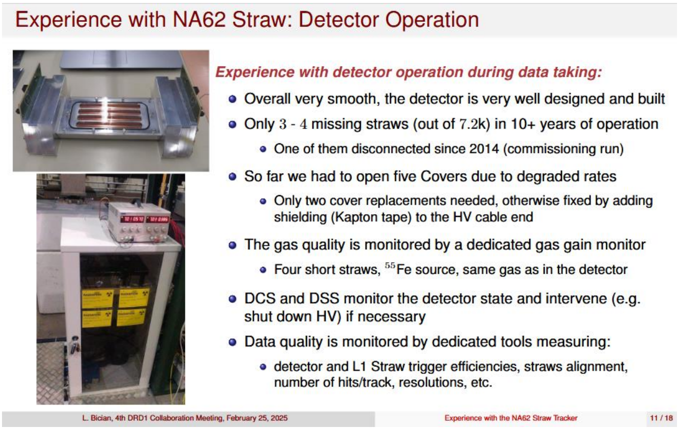
Cygno Experiment



Active Target TPC @ HIγS



NA62 Straw



Working Group 3

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

WG3: Gas and Materials

Facilitate contacts and exchange between different groups and expertise at Collaboration or Dedicated Meeting, supporting topical workshops, proposing common activities

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

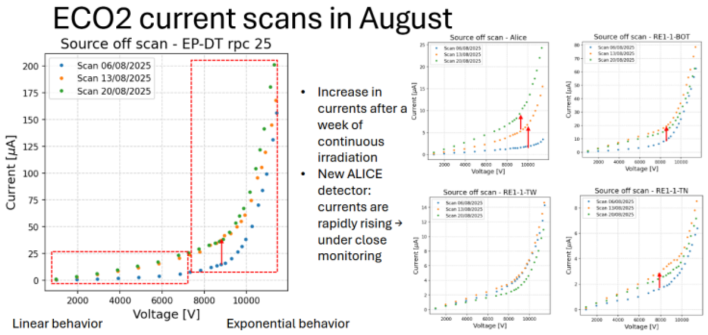
Planned Common Activities:

- Gas Properties and Studies of New Mixtures (syn. WG4)
- Ageing and Outgassing
- Recirculation and Recuperation Systems (syn. WG7)
- Resistive Materials (syn. WG6)
- Mechanics (syn. DRD8)

OTELLO:

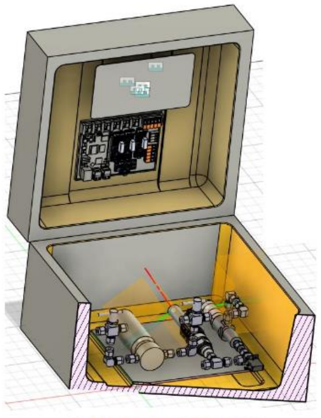
Project proposal focused on the development of sustainable and high-performance gas mixtures for next-generation gaseous detectors

Long-term performance studies of RPC detectors operated with eco-friendly gas mixtures at the CERN GIF++ facility (CERN Summer Student)

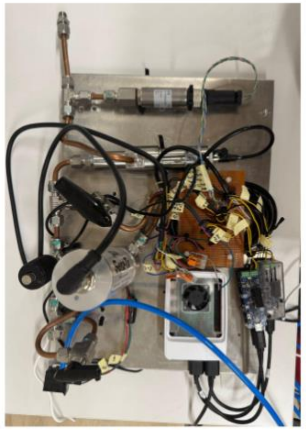


https://tinyurl.com/drd1ecocss25

Gas monitoring sensors and real-time visualisation (CERN Summer Student)



MMS final design



MMS prototype

https://tinyurl.com/3cm2s22n

Working Group 4

Advances simulation tools and modelling techniques to predict detector behaviour, optimize performance, and guide the design of future detectors.

WG4: Modelling and Simulation

Active contribution to the **DRD1 schools** (2024 and 2025) through lectures and tutoring.

Organization of **WG4 session** at Collaboration Meetings (**34 Contributions**)

Organization of **working meetings (9 events, 53 contribution)** on relevant topics:
- Simulation of Resistive Detectors
- Large Avalanches Topical Meeting
- Low Pressure Simulation & Measurements

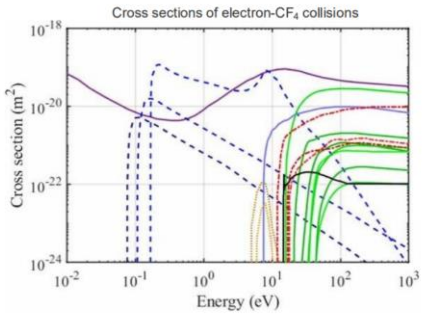
WG4 Mailing list with almost 200 subscription

Upcoming:

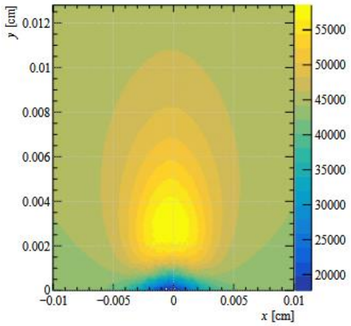
Organization of a dedicated simulation school in Bari (18–22 May 2026).

Planned Common Activities:
- GARFIELD++ and MAGBOLTZ consolidation
- Simulation of Large avalanches
- Study of the transition to streamer operation mode
- Study of Timing properties
- Electroluminescence
- Techniques for fast simulations

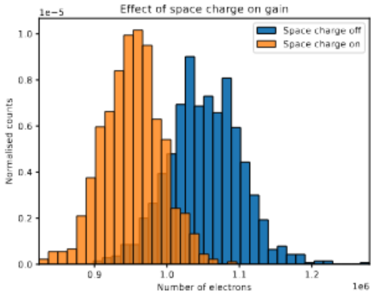
Cross-Sections & MAGBOLTZ



Space Charge Effects in Simulations of Large Avalanche Dynamics (CERN Summer Student)



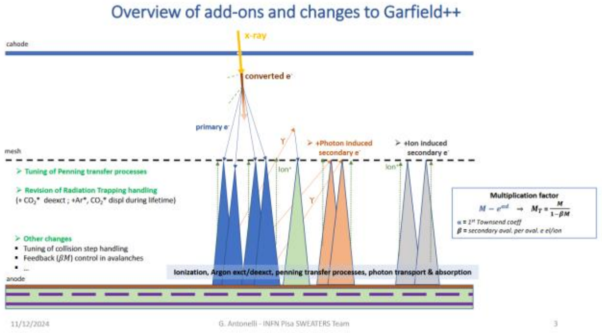
(b) 1.5×10^6 ionisations



(b) 200 starting electrons, 540V

https://repository.cern/records/fpfgq-hc985

Garfield++ @ Low Pressure (SWEATERS)



Working Group 5

Innovates front-end electronics and data acquisition systems, ensuring high-rate, low-noise, precise signal processing integrated with detector systems for modern experiments.

WG5 : Electronics for Gaseous Detectors

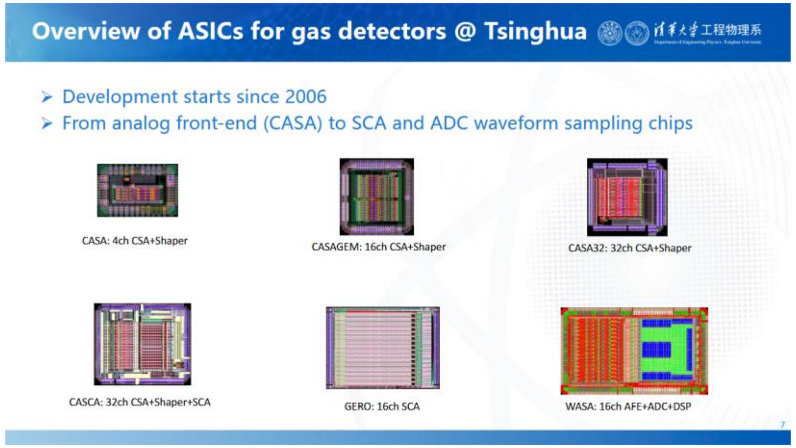
Common Development of FE, DAQ and Instrumentation.

WG session at CM and regular meetings with developers.

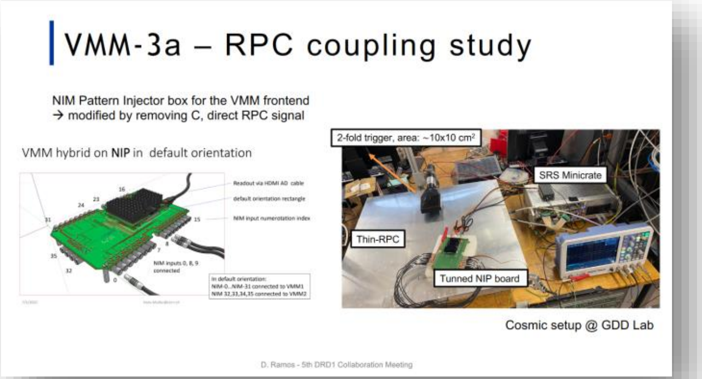
Planned Common Activities:

- Front-End ASICs
- Common and Scalable DAQ
- Custom Instrumentation (Powering and Monitoring)

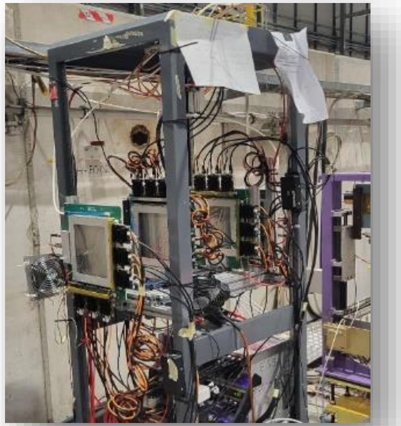
Follow up on ASICs developments



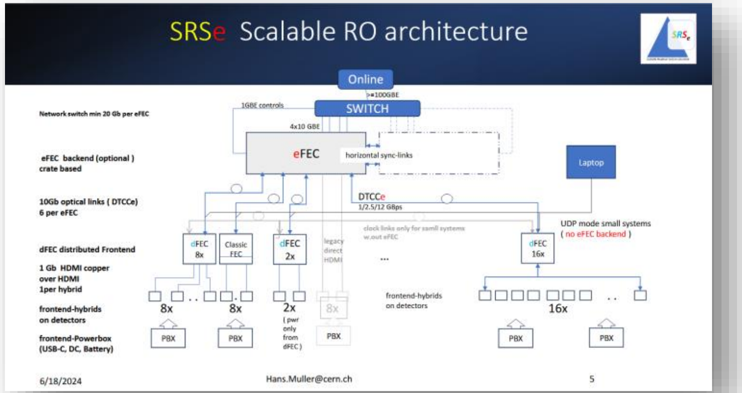
Integration of Common Electronics (VMM3a) into different Detector Technologies (RPC)



FE & DAQ for Test Beam



New design of RO Architectures based on SRS: SRSe



Working Group 6

Streamlines manufacturing and quality control, facilitating the transition of advanced detector technologies from lab research to industrial production, ensuring economic viability and accessibility.

WG6: Production and Technology Transfer

2025 Topical Workshops: Detector Manufacturing and Production

- Manufacturing Technologies
- New Manufacturing and Production Facilities
- Industrial Partners and Spin-Offs
- Existing Manufacturing and Production Facilities
- Production for Experiments and Projects (Lessons Learned)
- Visit to the CERN MPT Workshop

Planned Common Activities:

- Survey of production Needs and Capabilities and strategic guidelines in manufacturing and production facilities.
- QA/QC protocols and Instrumentation
- Technology transfer checklist and database (projects and Industrial Partners)
- Establishment of a Forum for sharing and knowledge transfer

Production and Manufacturing – crucial for Strategic R&D (DRD1) and future experiments – Fundamental to keep and improve manufacturing capability and capacity.

- **Strengthen strategic CERN support for the MPT workshop**
- **Facilitate and enhance the use of existing manufacturing facilities in the community**
- **Facilitate the establishment of new facilities at DRD1 institutions or research laboratories**
- **Support technology transfer to industry**
- **Proper Human Resources Considerations in terms of training and dissemination**

Working Group 7

Provides shared access to test-beam and irradiation facilities for validation and benchmarking of detector prototypes, ensuring all technologies meet rigorous performance standards.

WG7: Collaboration Laboratories and Facilities

- Detector Laboratories Network
- Common Instrumentation and infrastructures for Test Beam and Irradiation Facilities
- Outgassing and Ageing (Syn. WG3)
- Gas monitoring (Syn. WG3)
- Thin Film Deposition Facilities (Syn. WG6)
- Standard and customized laboratory instrumentation and software
- Facilities Database

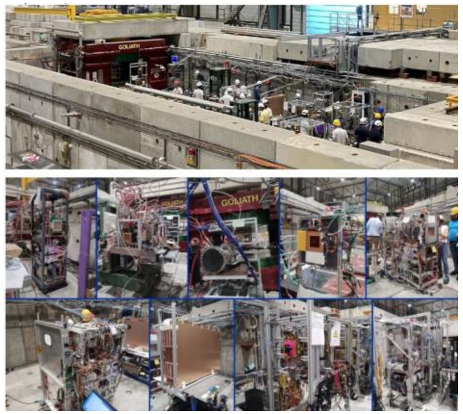
Collaboration laboratories and facilities at CERN:

- Laboratory: GDD (CERN, EP-DT-GD), EHN1 887/R-Q1
- DRD1 Test Beam campaigns at EHN1/SPS Semi-permanent installation (H4) – Coordinated by DRD1
- GIF++ (Irradiation and Beam) – Coordinated by CERN

During LS3, WG7 will:

- Facilitate access to other facilities whenever possible.
- Seek assistance from local DRD1 teams.
- Provide support with common hardware and software.
- Informative session to present all available alternatives in 2026.

H4(PPE134) Test Beam



DRD1 Beam telescopes

DRD1 Teams in GIF++

SPS/H4 DRD1 Test Beam Campaign

2024: 3 DRD1 test-beam campaigns **(8/8/5 setups)**

2025: 2 DRD1 test-beam campaigns **(13 /17 setups)**

2026: essential to hold 2 test-beam campaigns

Working Group 8

Supports education, mentorship, and outreach for emerging detector experts through DRD1 schools, workshops, and resources such as the DRD1 Bulletin, Forum, and Website (https://drd1.web.cern.ch), fostering a sustainable research community.

WG8: Knowledge Transfer, Training, Career Promotion

- Topical Workshop and DRD1 Internal Notes
- Schools and Trainings
- Support to Young Researchers (job opportunities, awards, participation promotion)
- Education and Outreach

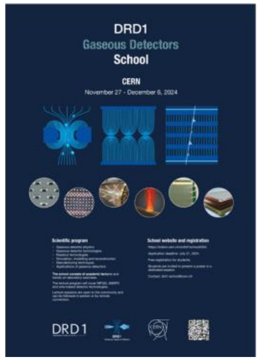
2025 Highlights

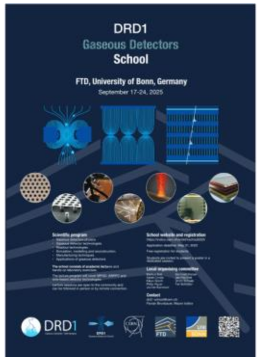
- DRD1 **School** at FTD, Bonn University, Germany with 24 students and >40 lectures and tutors from DRD1
- Opening of call for **DRD1 Awards** (thesis award and Early Career Scientist Award
- Regular **DRD1 bulletin** with timely information on collaboration activities, job opportunities and conferences
- DRD1 Gaseous **Detector Seminar** series: organization of regular seminars and discussions

Outlook for 2026

- DRD1 School at FRIB, MSU, USA in July with 32 students, local organizing team formed and starting preparations
- Continuation of **regular communications** and highlighting **career opportunities**
- DRD1 Gaseous **Detector Seminar** series: Focus on societal applications

DRD1 Gaseous Detector Schools





- First Edition at CERN
- This year in Bonn
- Next in US at FRIB/MSU

2025 School @ Bonn: 24 students from 12 countries (18h of lectures and 8 different labs exercises) with almost 50 lecturers and tutors from DRD1 institutes

Lab exercises

FTD at Bonn University hosting the school was a unique opportunity to include lab exercises on the **manufacturing and assembly** of GEMs in the in-house cleanroom facilities as well as the readout of a small TPC with **GridPix** detectors.

6

[2nd DRD1 Gaseous Detectors School,](#) FTD, University of Bonn, Germany from September 17-24, 2024
[1st DRD1 Gaseous Detectors School,](#) CERN from November 27th to December 6th, 2024

DRD1 Scientific Activities (III) Common Projects

Common Projects

Description

Common Projects address shared interests within the DRD1 community, including:

- **Blue-sky & Generic R&D**: High-risk, long-term, or exploratory research with potential for major future impact.
- **Detector Physics R&D**: Measurements and simulations to advance detector understanding, introduce new concepts, or improve existing solutions.
- **Novel Applications:** Development of gaseous detectors for new uses.
- **Technology R&D**: Advancing techniques, characterization methods, and tools of common interest.
- **Industry Transfer**: Promoting the adoption of gaseous detector technologies in industry.

2025 Common Project Call

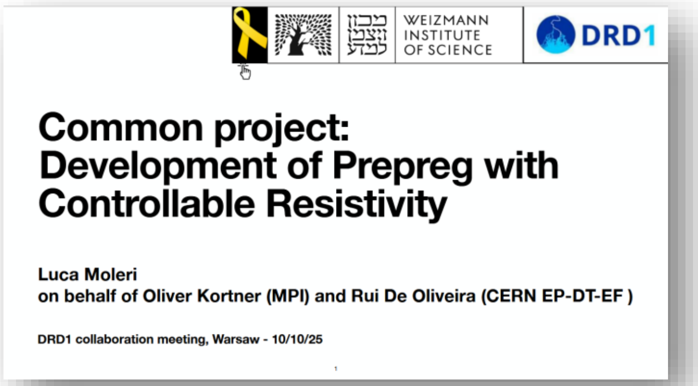
First Call opened from March 12 till May 31.

5 Project received and due to limited available resources, only one approved.

Next Common Project Call

Opening of the call in December 2025, with results expected for June/July 2026.

Approved Common Project



https://events.camk.edu.pl/event/124/contributions/1244/attachments/838/2227/251010_Resistive_prepreg_common_project_DRD1-collaboraton-meeting.pdf

Current resistive electrodes for gaseous detectors

A. Resistive layer
- Thin layer of film
- surface resistivity
  100 kΩ/□ - GΩ/□

B. Resistive plate
- o(mm) thick
- Bulk resistivity
  $10^9 - 10^{11}\ \Omega \cdot \mathrm{cm}$

R&D development: prepreg with tuneable resistivity

Prepreg (pre-impregnated composite fiber): fibers (e.g., carbon, glass, aramid) pre-impregnated with a partially cured resin (e.g., epoxy, phenolic, thermoplastic).

The **resin** may contain additives (e.g., carbon black, CNTs, graphene, metal particles) **to control electrical conductivity or static dissipation.**

The Role of the Chinese Community in DRD1

DRD1 Institutions

Institute of High Energy Physics, CAS	Beijing
Tsinghua University	Beijing
College of Physics, Jilin University	Changchun
University of Science and Technology of China	Hefei
Institute of Modern Physics, Chinese Academy of Sciences	Lanzhou
Nanjing University of Aeronautics and Astronautics	Nanjing
Shanghai Jiao Tong University	Shanghai
Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences	Shenzhen
Wuhan University	Wuhan

Expression of Interest in DRD1 WPs

Work Package 1: Trackers, Hodoscopes, Large Area Muon Systems

University of Science and Technology of China, Hefei

Work Package 2: Drift Chambers

Institute of High Energy Physics, CAS, Beijing

Tsinghua University, Beijing

College of Physics, Jilin University, Changchun

University of Science and Technology of China, Hefei

Institute of Modern Physics, Chinese Academy of Sciences, Lanzhou

Wuhan University, Wuhan

Work Package 4: Tracking TPCs

Institute of High Energy Physics, Beijing

Tsinghua University, Beijing

Work Package 5: Gaseous Calorimeters

Shanghai Jiao Tong University, Shanghai

Work Package 6: Gaseous Photon Detectors

University of Science and Technology of China, Hefei

Work Package 7: Timing detectors

University of Science and Technology of China, Hefei

Tsinghua University, Beijing

Shanghai Jiao Tong University, Shanghai

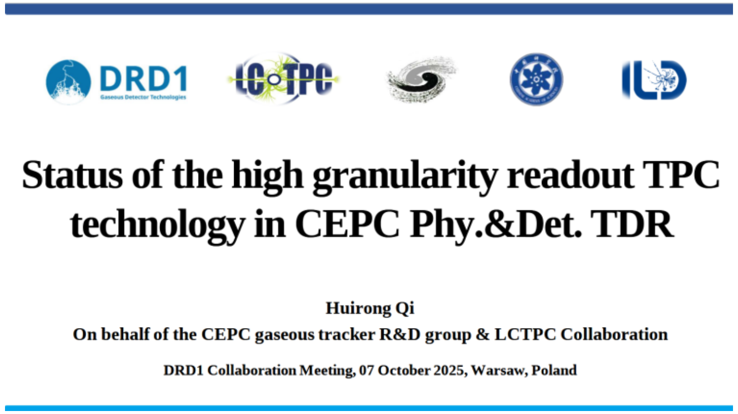
Shenzhen Institute of Advanced Technology, Chinese Academy of Sciences, Shenzhen

Work Package 9: BHEP Applications

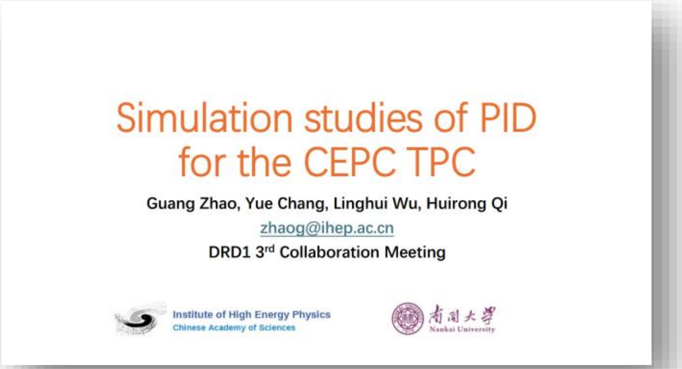
Nanjing University of Aeronautics and Astronautics, Nanjing

Very important Interest and potential contribution from the Chinese DRD1 Community towards the strategic R&D oriented Work Packages

Examples of Scientific Activities within the Chinese Community of high relevance to DRD1



https://events.camk.edu.pl/event/124/contributions/1226



https://indico.cern.ch/event/1442324/contributions/6262871

https://indico.cern.ch/event/1360282/contributions/5773675/attachments/2789695/4864602/DRD1_240130_CEPC_DC.pdf

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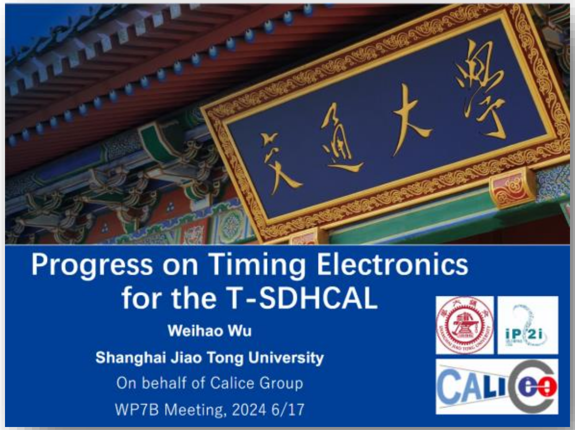

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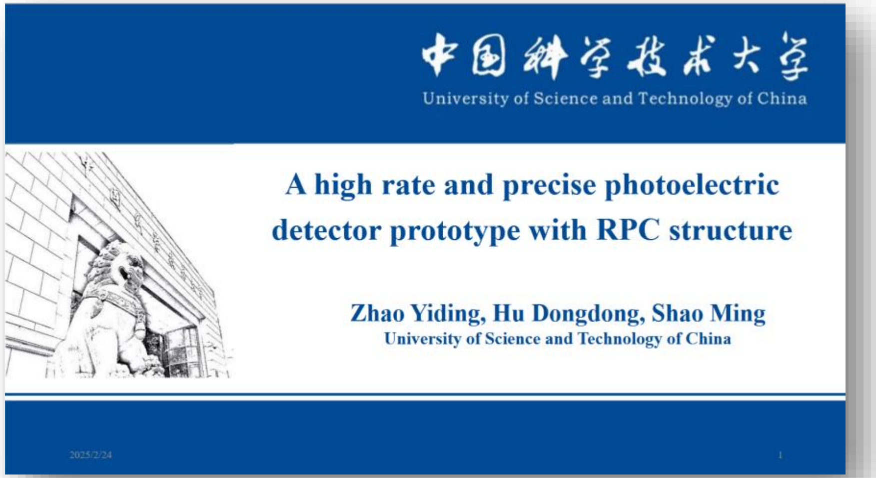
These are just some examples; others exist

Examples of Scientific Activities within the Chinese Community of high relevance to DRD1



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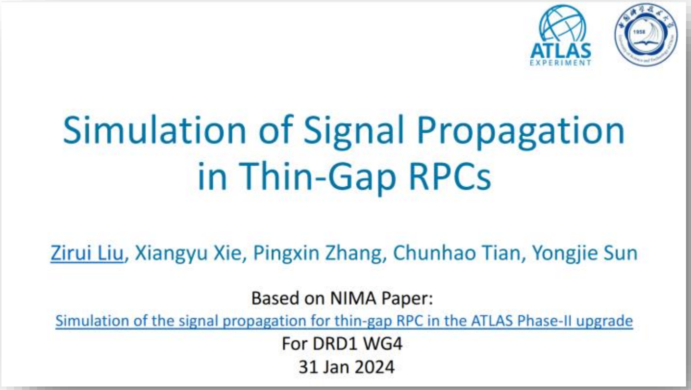

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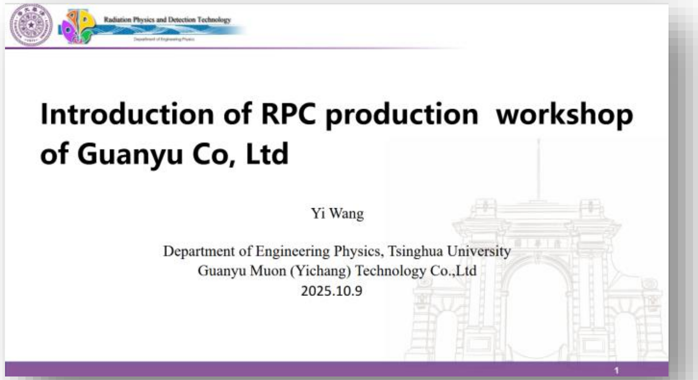
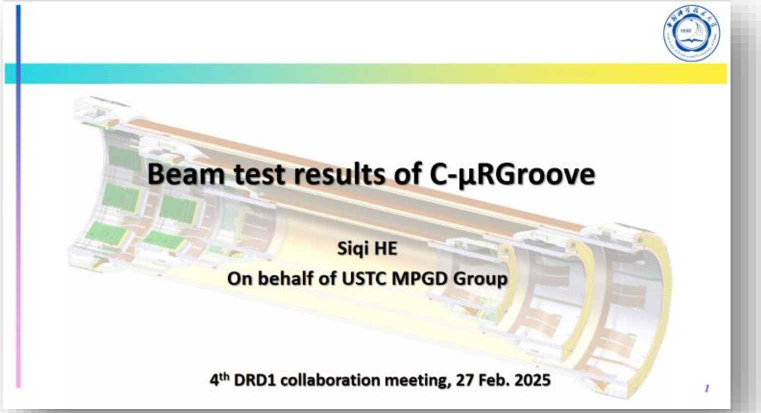


https://events.camk.edu.pl/event/124/contributions/1206

These are just some examples; others exist

Examples of Scientific Activities within the Chinese Community of high relevance to DRD1

https://indico.cern.ch/event/1509323/contributions/6351321



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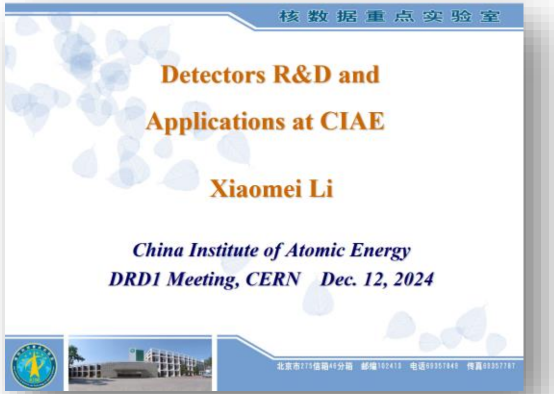

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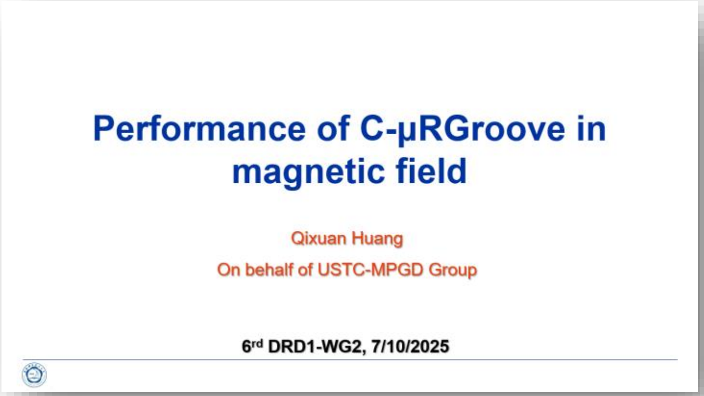
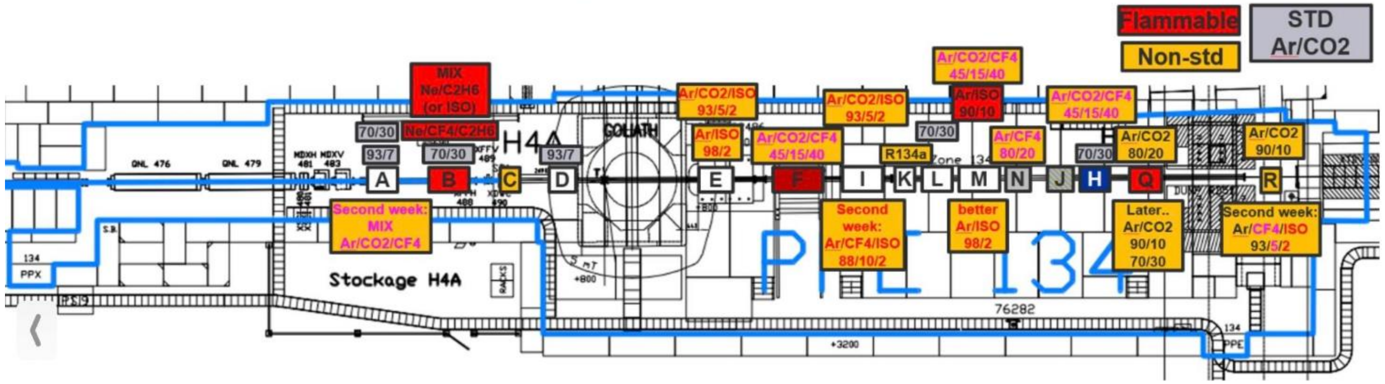


https://events.camk.edu.pl/event/124/contributions/1219/

These are just some examples; others exist

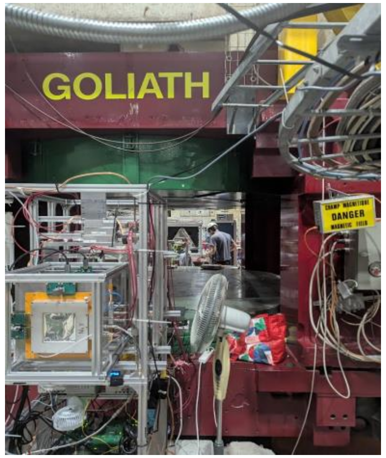
Now@CERN – DRD1 Test Beam at CERN/SPS

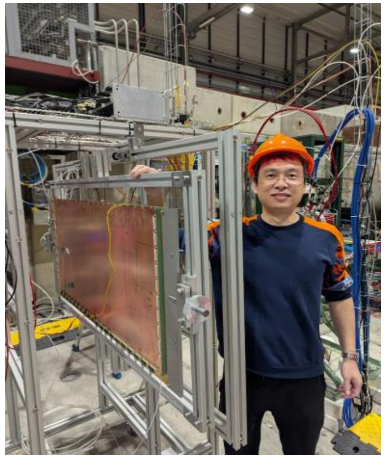
BEAM H4, PPE134 – Updated gas (DRD1, Nov 5th)



A:	DRD1 telescope B 150cm	J:	*LMU MM 130cm* Bleu-Orange
B:	PICOSEC 200cm Desy	K:	INFN Bari RPC group <100cm
C:	PARASITIC: minicatus <100cm XSCA	L:	DRD1 telescope A 150cm
D:	USTC RICH 130cm	M:	USTC (uRGroove) 200cm
E:	ePIC CEA Saclay 170cm	N:	Optical Readout 120cm Table Alu
F:	ePIC INFN Roma Tor Vergata 250cm BIG RED	Q:	Tandem-GEM-TPC 160cm Desy
H:	FCC uRWELL 150cm LAPP	R:	HYDRA tracker (TU Darmstadt) 100cm XSCA
I:	INFN Roma Tre & Nap 200cm		

USTC RICH and USTC uGroove Teams





Summary and outlook

DRD1 has successfully established **a community-driven collaboration** that unites a **wide range** of gaseous detector technologies, applications, and expertise. It fosters **long-term partnerships** and provides a **coherent R&D framework** (*Working Groups & Work Packages*) *to support strategic, exploratory, and technology-driven innovation.*

Future Steps

Boost the DRD1 research program and common activities within the Working Group framework.
Several initiatives are already underway (some presented today), with more in preparation.

Strengthen international recognition and support for the Work Packages
Advance strategic R&D more efficiently and synergistically, enhancing the WPs visibility within the scientific community and with funding agencies.

Deepen collaboration across the full DRD1 community
Chinese teams are at the forefront of DRD1-relevant R&D and play a key role in shaping the collaboration’s future.

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