WP1 - Genuine trackers/hodoscopes

Large area muon systems, inner tracking/vertexing

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

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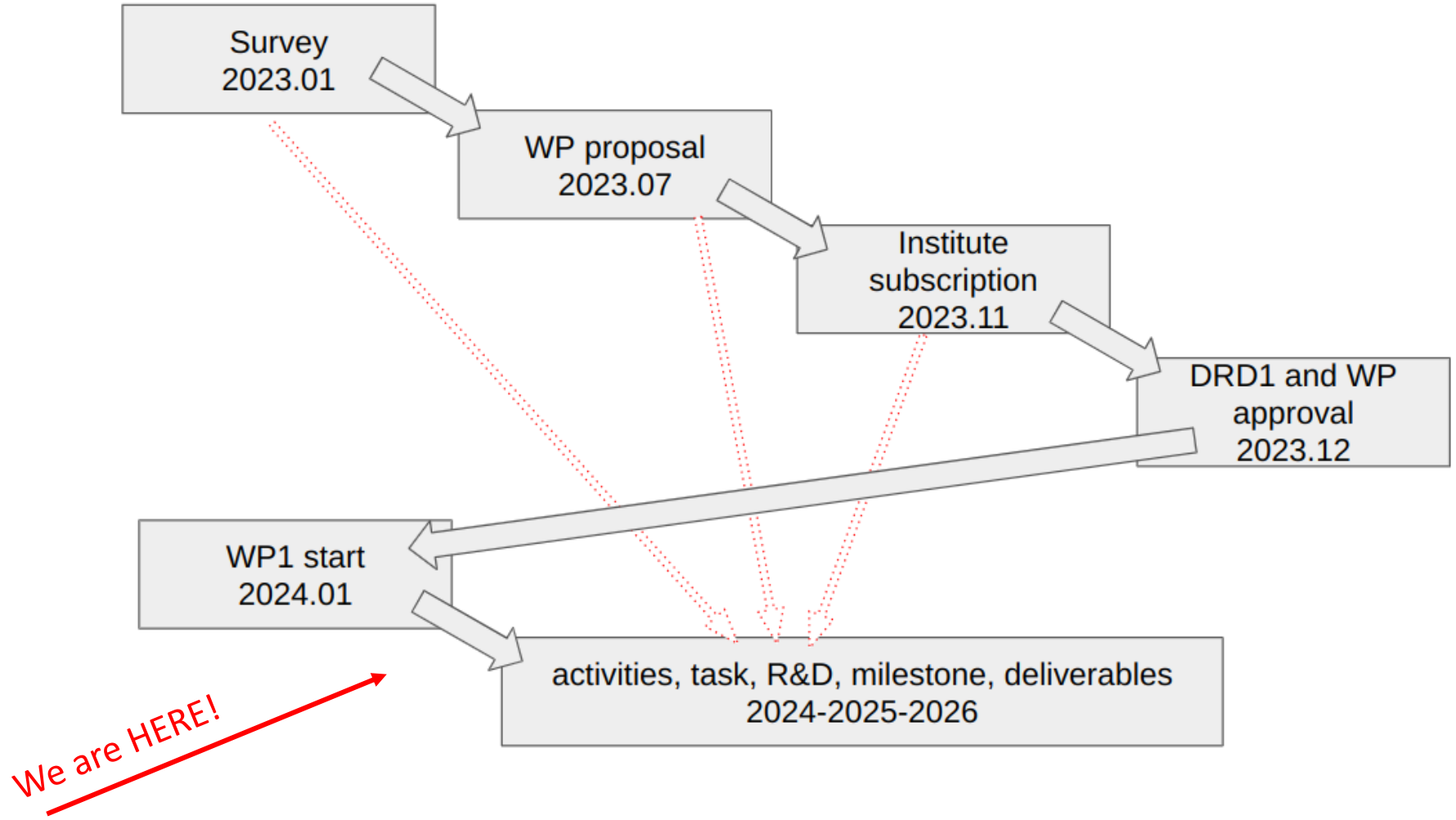
DRD1 Collaboration Meeting at CERN

January 29, 2024

The DRD1-WP Journey

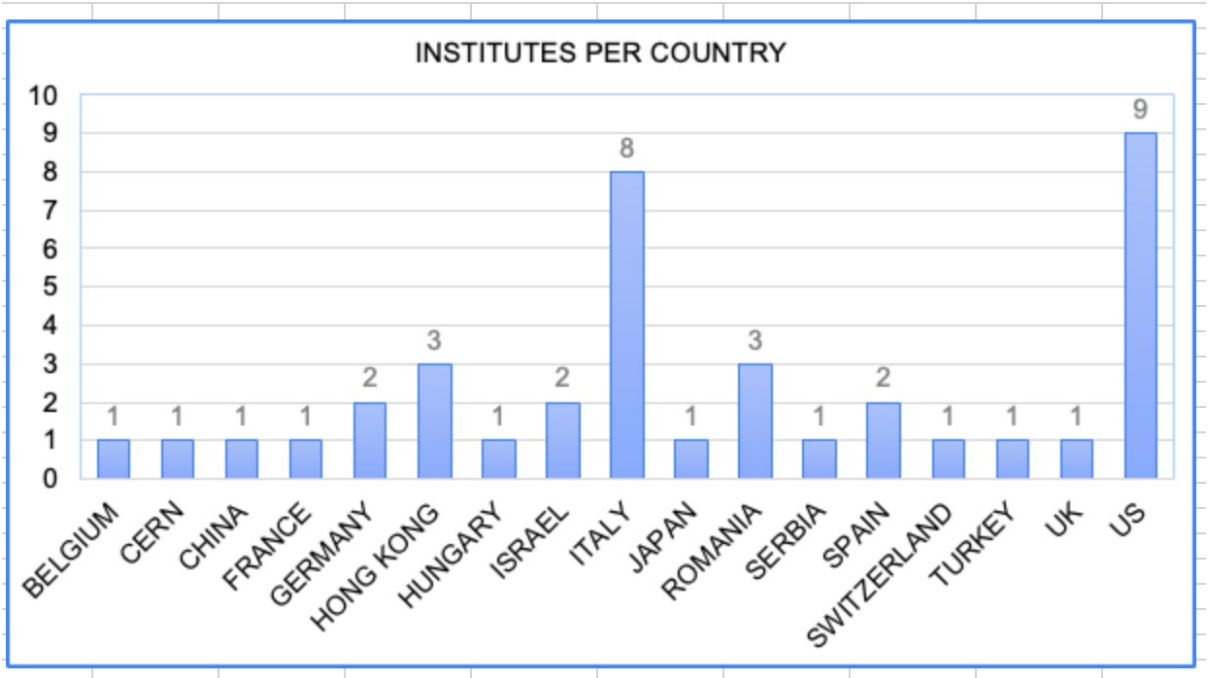


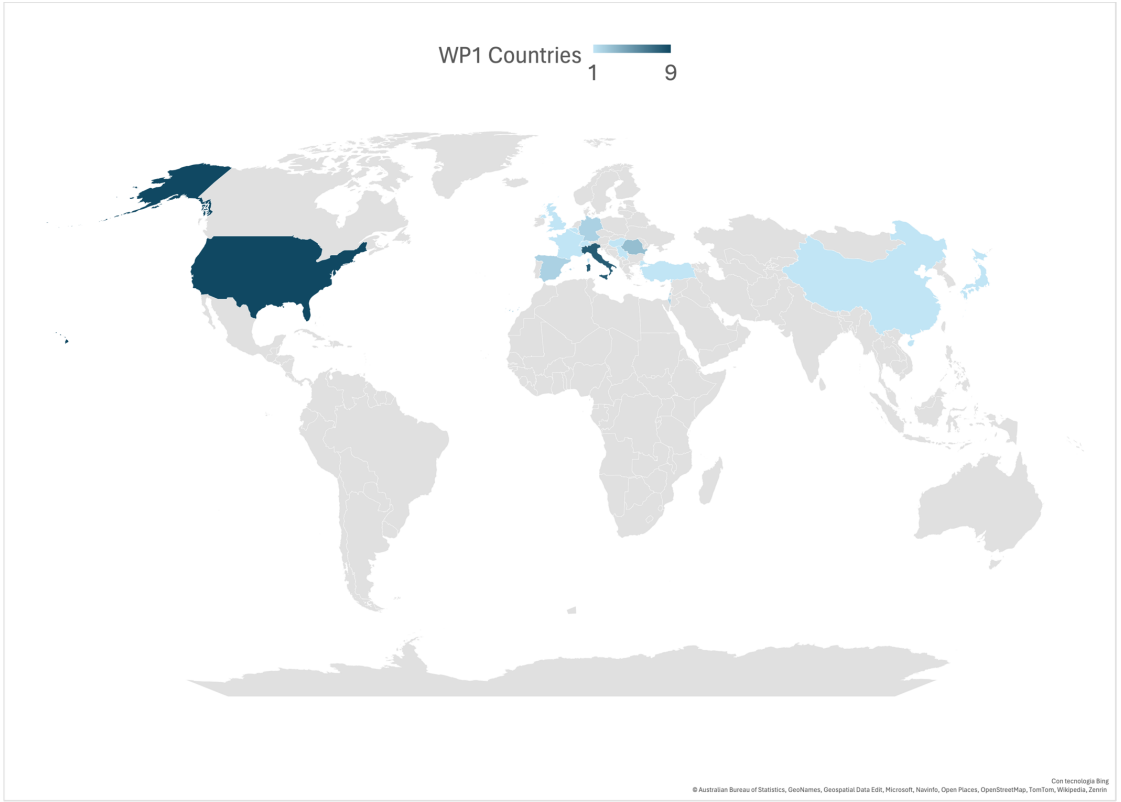
Participating Institutes in WP1 activities

CEA/Saclay IRFU, CERN, Centre for Energy Environmental and Technological Research (CIEMAT), Chinese University of Hong Kong (CUHK), Hong Kong University (HKU), Hong Kong University of Science and Technology (HKUST), INFN Bari, INFN Bologna, INFN Ferrara, INFN Laboratori Nazionali di Frascati, INFN Napoli, INFN Roma Tor Vergata, INFN Roma Tre, INFN Torino, IFIN-HH, Institute of General and Physical Chemistry (IGPC), Istinye University (ISU), Kobe University, Ludwig Maximilian University of Munich, Max Plank Institute for Physics, National University of Science and Technology Polytechnic Bucharest (UNSTPB), University of Cambridge, University of Geneva, University of Oviedo and ICTEA, University of Transylvania Brasov (UniTBv), University of Science and Technology of China (USTC), Vrije Universiteit Brussel (VUB), Weizmann Institute of Science, Wigner RCP, Brookhaven National Laboratory, Florida Institute of Technology, Jefferson Lab, Michigan State University, Tufts University, University of California Irvine, University of Florida, University of Massachusetts Amherst, University of Michigan, University of Wisconsin.

Tot: 39 Institutes

Participating Institutes in WP1 activities





Tot: 39 Institutes

Goals

Primary objective:

Strategically advance R&D in the domain of resistive gaseous detectors for applications as trackers, hodoscopes, and large-area muon systems **for new challenges at future facilities**.

- strengthen their stability, robustness, and long-term performance,
- Improve and consolidate construction/quality process
- optimize a cost-effective manufacturing together with industrial partners.

Challenges

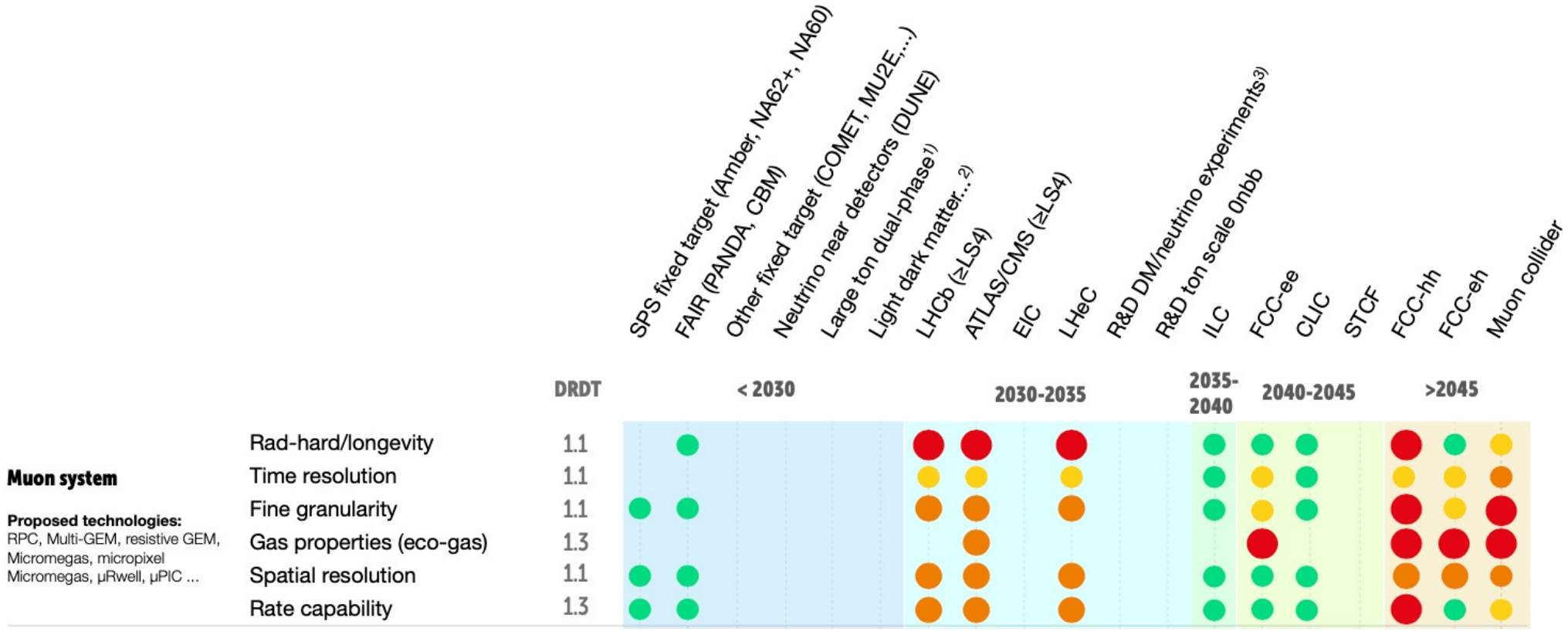
- Extending the state-of-the-art rate capability up to ~ 1-10 MHz/cm^2 with longevity compatible with decades of operation.

  →advancements in detector resistive configurations, new materials and geometries, low-noise electronics, and fine granularity readout to reduce occupancy.

- Addressing low/medium-rate applications involving muon tracking in HEP experiments like at FCCee, and exploring applications beyond HEP for large areas (in connection with WP9)
- Reliable and efficient operation with low-GWP (Global Warming Potential) gas mixtures.
- Improving time resolution at the level of nanosecond and achieving resolutions up to 10-100 ps for applications in high-rate collider experiments to mitigate pile-up effects.
- Establishing large-scale serial production and cost reduction measures.

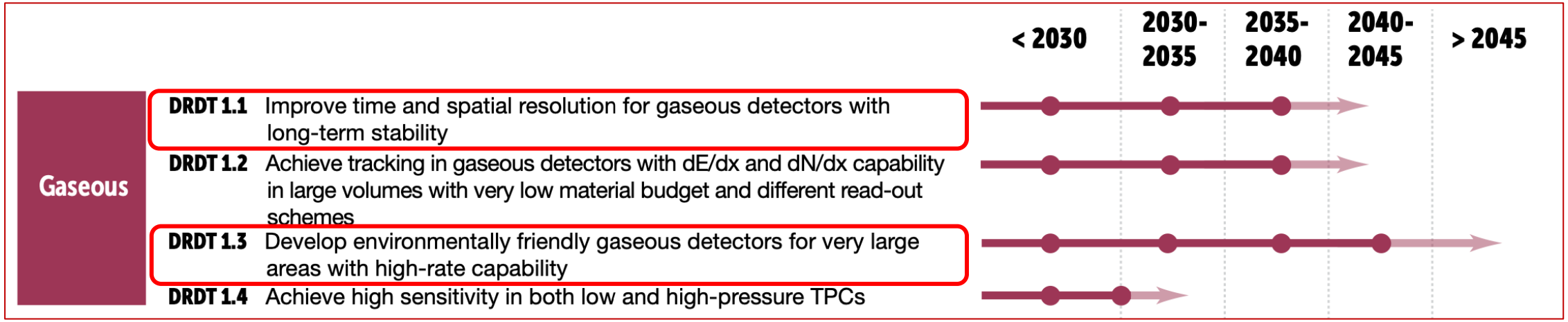
Main Challenges for Large Area Muon System

Schematic timeline of the R&D needs for next generation experiments



Connection with ECFA R&D Themes - DRDT

Schematic timeline of the R&D needs for next generation experiments



TASKS and Performance Goals

TASKS	PERFORMANCE GOALS
T1: New RPC Structures	Achieve RPCs with a high-rate capability (ranging from 10kHz/cm2 to 1MHz/cm2) and/or improved timing resolution (reaching sub-ns to ps levels) using new resistive materials and fine structure.
T2: New Resistive MPGD Structures	Development of large area resistive MPGD capable of efficient and stable operation under conditions of high rates (D2.1) as well as low/medium rates (D2.2)
T3: New Front-end electronics	Frontend operation up to 0.1-1 GHz; High density channel; Radiation hardness; time resolution (< 10 ps); local zero suppression; higher FE gain amplification
T4: Optimization of scalable multichannel readout systems	Development of novel Scalable Readout Systems for Gaseous Detectors. Development of new FPGA-based readout system that matches the data throughput of the electronics
T5: Eco-friendly gases	Reduce the GHG emission from the detectors and define new ecological gas mixture that keeps similar performance of the current gas mixture
T6: Manufacturing	Constructing and exploring cost-effective methods for producing high-quality, high-performance large area resistive MPGD suitable for low to medium rates with industrial production.
T7: Longevity on large detector areas	Ensure operation of gaseous detectors without ageing effects with optimal and/or eco-friendly gas mixtures up to integrated charges in the order of C/cm^2
T8: New detector structures	Develop new detector structure and hybrid system exploiting new ideas and established technologies to explore new frontiers in gaseous detectors

Milestones and Deliverables (in the Executive Summary)

DELIVERABLE 1 (Month 36)	DELIVERABLE 2 (Month 36)
Large areea RPC and MPGD prototypes: Design, construction, and test of RPC and MPGD-based prototypes **[T1, T2]** with advanced solutions for extensive surface coverage **[T6]**, optimized for medium-high flow rates (range tens kHz/cm2 – few MHz/cm2), precise tracking (100 μm) and timing (few ns). This includes considerations for the compatibility of eco-friendly gases. **[T5, T7]**	**New frontend and DAQ systems:** Completion of the innovative ASICs' final design; compilation of comprehensive production documentation; if applicable, initiation of the engineering run for the first chip, should it be in an advanced stage **[T3].** DAQ system prototyping for gaseous detectors, aiming to push the boundaries in terms of timing, radiation resistance, multi-channel high rate acquisition and performance, for large systems **[T4].**

MILESTONES for D1	MILESTONES for D2
M1.1 - Month12: Review of Detector Prototypes - Examining the current status and future prospects of innovative resistive materials, novel structures, and challenges in hybridizing Resistive Plate Chambers (RPC) and Micro-Pattern Gas Detectors (MPGD). This evaluation includes compiling of a comprehensive report highlighting comparative performance, along with the respective advantages and disadvantages of available technologies **[T1, T2, T5, T6, T7, T8]**	**M2.1 - Month 12:** Review of the status of the art of ASICs and DAQ systems, and definition of requirements for next generation large area muon systems **[T3, T4]**
M1.2 Month 24: Detector Prototypes Enhancement - Building upon the insights from M1.1. Proof of rate capability above 100 kHz/cm2, assessing the status and potential improvements of RPC and MPGD detectors, informed by feedback from the previous phase. **[T1, T2, T5, T6, T7, T8]**	**M2.2 - Month 24:** Design and Simulation studies of new ASICs building blocks for MPGD and RPC and technical note(s) about the chips expected performance **[T3]**
	M2.3 - Month 24: Design of novel Scalable Readout Systems for Gaseous Detectors - assessment of performance achievements based on DAQ modeling **[T4]**

The detailed list of deliverables is in BACKUP and at WP1

Preliminary estimates of resources for the years 2024-2026

(to be confirmed by the funding agencies)

Existing Resources - SUMMARY					
FTE			Material (kCHF)		
2024	2025	2026	2024	2025	2026
47	**51**	**51**	**651**	**516**	**501**

Proposed New Resources - SUMMARY					
FTE			Material (kCHF)		
2024	2025	2026	2024	2025	2026
22	**24**	**24**	**716**	**1040**	**670**

Starting WP1 Activities within a Shared and Collaborative Approach

WP1 Meetings and Workshops – a PROPOSAL

Schedule regular meetings and mini-workshops as opportunities to meet, track progress, and share updates

- WP1 one-day Workshops
- Theme-based Meetings

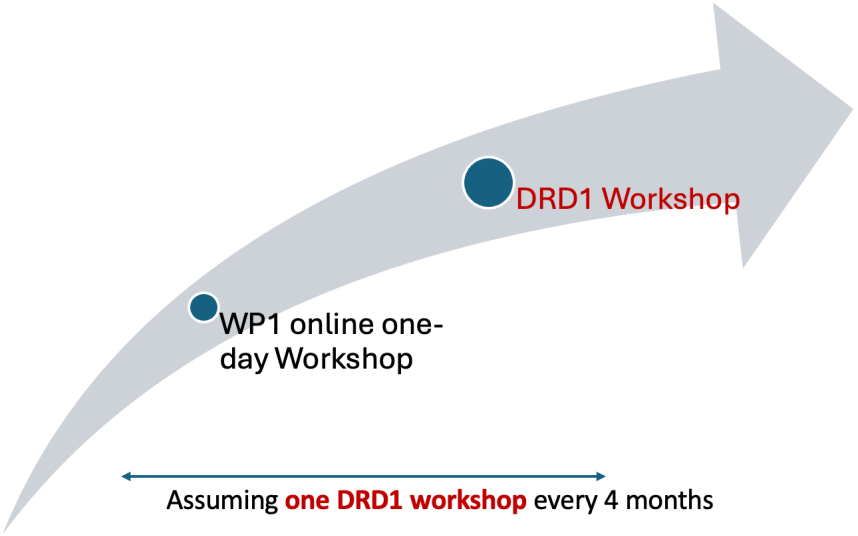
WP1 one-day Workshop (schedule and structure) - PROPOSAL

One-Day mini-Workshop: **to ensure Global and efficient Participation**

- **Frequency**: 3 in a year, (synchronized with DRD1 workshop)
- **Agenda**: 2-3 hours in the morning and 2-3 hours in the afternoon with the objective of facilitating participation from diverse time zones
- **Areas:** cover all Tasks in a comprehensive approach

➢ Objective:

- Track group activities
- Monitor the progress of the milestones and deliverables
- Facilitate collaboration between institutes and identify potential common projects.
- Prepare WP1 reports for the DRD1 Collaboration



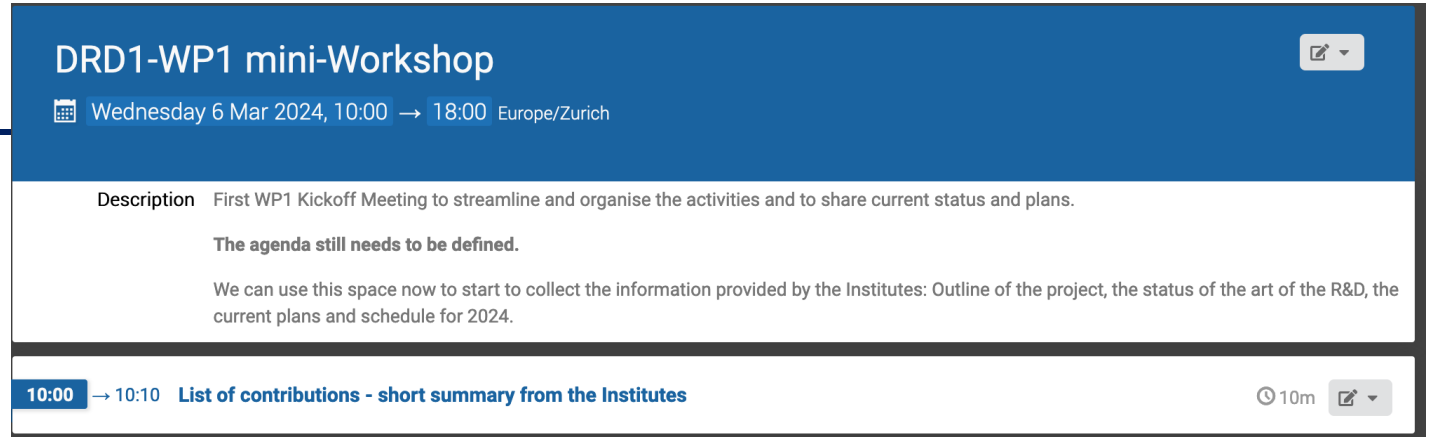
Theme-Based Meetings - PROPOSAL

Theme-Based Meetings: Enhancing a collaborative approach

➢ **Objective:**

- Focus discussions on specific themes (e.g., new RPC structures, resistive MPGD structures, analysis tools/methods).
- Group institutes with shared technologies or deliverables.
- Share experiences and build common activities.
- Monitor the progress of deliverables.

First One-Day mini-Workshop



First WP1 One-Day mini-Workshop on March 6, 2024 (tentatively)

- Goal: **Scientific Activities Overview**

- Objective:
  - Collect ongoing and planned scientific activities for this year from each group in WP1
  - Build-up the Scientific Collaboration / Facilitate collaboration with new institutes
  - Identify potential common projects

- Preparation:
  - Requested short summaries include R&D status, current plans, and schedule for 2024
  - Email request sent to all Institute contacts
  - Requested short summaries (slides). Include R&D status, current plans, and schedule for 2024
  - Submission deadline by the end of February

Communication Tools - General Info and useful links

WP1 web page direct link: https://drd1.web.cern.ch/wp/wp1

Mailing Lists: (for all drd1 mailing lists see: https://drd1.web.cern.ch/egroups)

- drd1-WP1-contact: Coordinators of WP1
- drd1-WP1: Participants of DRD1 WP1 (to be filled / self-added members allowed)

WP1 Indico Category:

- https://indico.cern.ch/category/17059/

  WP1 meetings and repository of the material
  (i.e. talks, plots, etc.)

BACKUP

TASKS and Deliverables (T1-T4)

TASK 1	TASK 2	TASK 3	TASK 4
New RPC Structures	**New Resistive MPGD Structures**	**New Front-end electronics**	**Optimization of scalable multichannel readout systems**
D1.1: Design, construction, and tests of single/multi-gap surface resistivity RPC with DLC electrodes.	**D2.1:** Large area (approximately 50cm x 50cm) prototypes based on resistive elements and novel MPGD architectures for high particle rates (range 100 kHz/cm2 – few MHz/cm2) particle rates, 2D readout, <100um space resolution, about 10ns timing resolution, high gain (above 104) to ensure stability and providing a good margin for nominal working point	**D3.1:** Design, production and validation of a new ASIC chip for MPGDs based on new architecture for next MPGD and a technical note about the chip expected performance.	**D4.1**: Design, implementation, and optimization of novel Scalable Readout Systems for Gaseous Detectors
D1.2: Design, construction, and test of innovative RPC structures with current (HPL, glass) and novel resistive materials (phenolic glass, GaAs, etc.) working comfortably up to 100 kHz/ cm2	**D2.2:** Large area MPGD prototypes for low/medium rates (few-100 kHz/cm2) for large surface coverage O(1000 m2), optimized in terms of performance (precise tracking – below 100 um and timing – few ns) and overall cost	**D3.2:** Integration and performance assessment of a Bi-CMOS SiGe heterojunction technology FE ASIC, with various detectors technologies, and Design of an increased performance ASIC with ultimate time resolution (< 10 ps) and possibility of local zero suppression and daisy chaining	**D4.2**: Development of scalable high-speed processing and interface FPGA IP blocks for the DAQ ecosystem.
D1.3: Design, construction, and test of prototypes of RPC trackers structures (made of multiple independent gas gaps and readout electrodes) suitable for 3D space-time tracking, with millimetric space resolution and up to 100 ps time resolution.	**D2.3:** Support and update of the modelling and simulation framework for the study of induced signals in detectors with resistive elements	**D3.3:** Development of a radiation hard multichannel TDC board and integration in a detector setup	**D4.3**: Development of scalable DAQ software for high-speed data transport.

TASKS and Deliverables (T5-T8)

TASK 5	TASK 6	TASK 7	TASK 8
Eco-friendly gases	**Manufacturing**	**Longevity on large detector areas**	**New Detector Structures**
D5.1 Test and characterization of RPCs operated with low-GWP (HFO) and new eco-gas mixtures.	**D6.1:** DLC production with C.I.D (CERN-INFN DLC machine)	**D7.1** Studying the impact of integrated current and unknown gas-induced ageing effect on the long-term performance of the detector. Studies with eco-gas mixtures.	**D8.1:** Design, construction, and test of prototypes (area of 30x10 cm2) composed of Resistive Cylindrical Chamber (RCC), with different resistive materials and read-out electrodes.
D5.2 Compatibility of the new eco-gases with gas system components	**D6.2**: Industrial co-production of MPGD (micro-RWELL, Micromegas)	**D7.2** Development and test of gaseous detectors operated with new recuperation and recirculation systems.	**D8.2:** Hybridization of an RCC with a drift tube, and performance study
	D6.3: MWPC- and GEM-based chamber production using industry-standard printed circuit boards with option of integrated electronics.	**D7.3**: Characterization of detectors constructed from industry-standard production methods in terms of ageing, environmental robustness (humidity, temperature cycling), mechanical stability (vibration, stress load) and gamma irradiation.	**D8.3**: Construction and test of a curved micro-RWELL prototypes with cylindrical and tubular shapes