DRD1 Proposal

DRD1 document in preparation

https://cernbox.cern.ch/s/BKQsu6oiuhPWDaa

Structure of the document:

First 30 pages :

- Scientific organization of DRD1 Collaboration
- Collaboration organization
- Resource and infrastructures

From page 31

- Research topics and Work plan
  - 8 sections: one per Working Group
  - WorkPackages described in 7.2

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DRD1 EXTENDED R&D PROPOSAL

Development of Gaseous Detectors Technologies

Abstract

The document provides an overview of the state of the art and challenges for various detectors concepts and technologies, as well as a detailed list of R&D tasks grouped into Work Packages (WPs) that related to the strategic R&D programs to which funding agencies might commit, with related infrastructures and tools necessary to advance the technological goals, as outlined in the ECFA R&D roadmap. The main DRD1 document is structured into chapters, each describing the activity planned by the eight Working Groups (WG), which are the core of the future scientific organization. The current DRD1 proposal concentrates on the collaborative research program for the next 3 years.

On-line version: `https://cernbox.cern.ch/s/BKQsu6oiuhPWDaa`

Geneva, Switzerland

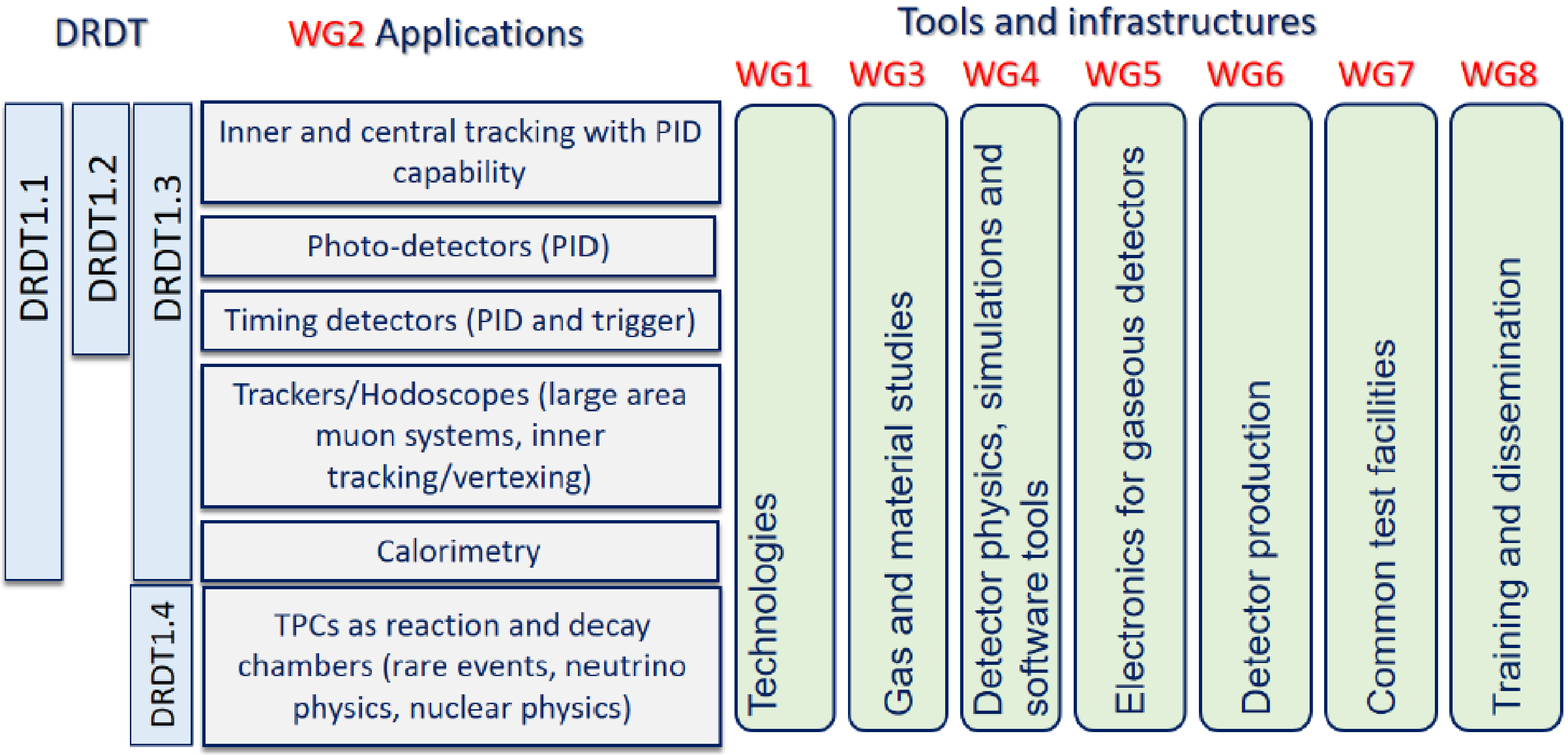
July 12, 2023

111 institutions in 4 continents expressed interest to join the DRD1 Collaboration

See more information at DRD1 2nd workshop [link]

DRD1 Scientific organization: Working groups

- **Structure in Working Groups, forum for scientific discussions, coordinated by <u>conveners</u>:**
  - aligned with the scientific program of the ECFA roadmap through the applications related to future facilities challenges, outlined by R&D Themes (DRDTs*), but also to the GSRs



Note: Applications Beyond HEP recently added

Working groups description in the proposal

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Working groups description in the proposal

2.1.1 Working Groups

The Collaboration will be organized into Working Groups (WGs), serving as the backbone of the proposed R&D environment and framework. WGs will support the development of novel technologies and the consolidation of existing ones. They will facilitate the exchange of ideas and foster synergies between institutes, serving as a knowledge and technology hub. Additionally, they will be recognized as a scientific reference for the community. The proposed WGs are as follows:

- WG1: Technological Aspects and Developments of New Detector Structures, Common Characterization and Physics Issues
- WG2: Applications
- WG3: Gas and Material Studies, and link to Novel Technologies
- WG4: Detector Physics, Modelling and Simulation frameworks
- WG5: Electronics for Gaseous Detectors
- WG6: Production and Technology Transfer
- WG7: Common Test Facilities and Infrastructures
- WG8: Knowledge Transfer, Training and Career

These Working Groups will guide new developments and provide support for the research activities of Collaboration members.

Working groups description in the proposal

Detailed (60 pages) description in section 7

"Detailed Description of Research Topics and Work Plan"

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

Table 12: WG3 - Common Objectives

Reference	Description	Deliverable Nature
D4.1.1	Garfield++ Modernization: Review Core Code (Multi-Thread, Heterogeneous Arch)	Core Code
D4.1.2	Garfield++ Modernization: Add Community Tools (Automatic Builds etc)	Software Tools
D4.1.3	Garfield++ Modernization: Review & Accelerate neBEM Code	New Release
D4.2.1	Garfield++ Framework Improvement: Recommended Set of Ion Mobilities	New Release
D4.2.2	Garfield++ Framework Improvement: Long-Term Solution for Magboltz	New Release
D4.2.3	Garfield++ Framework Improvement: Displays, Documentation, Examples	New Release

Table 13: WG4 - Objectives 4.1-4.2: Overview

Reference	Description	Deliverable Nature
D5.2.1	SRSe WP1-8	eFEC
D5.2.2	SRSe WP1-8	VMM software and firmware migration
D5.2.3	SRSe - WP1-8	DAQ and reconstruction software
D5.2.4	SRSe	Testing and integration
D5.2.5	Common DAQ/SRS WP1,4	SAMPA implementation
D5.2.6	Common DAQ/SRS - WP4	Timepix3 implementation
D5.2.7	Common DAQ/SRS	*RPC front-end implementation(tbd)*
D5.2.8	SRS upgrades	2.5 Gbit Ethernet and L0 trigger ß
D5.2.9	Portable, Connected μSRS nodes	readout of distributed, small detectors over long distance

Table 16: WG5 - Objective 5.2: Modernised Readout System

- a set of objectives identified for each WG
- While asking the confirmation of being part of the collaboration, requiring to express intention on contributing in the listed objectives

Contributions of DRD1 Institutes

Here tables summarizing Institute Participation in the DRD1 Working Group activities and expression of interest for DRD1 Work Packages

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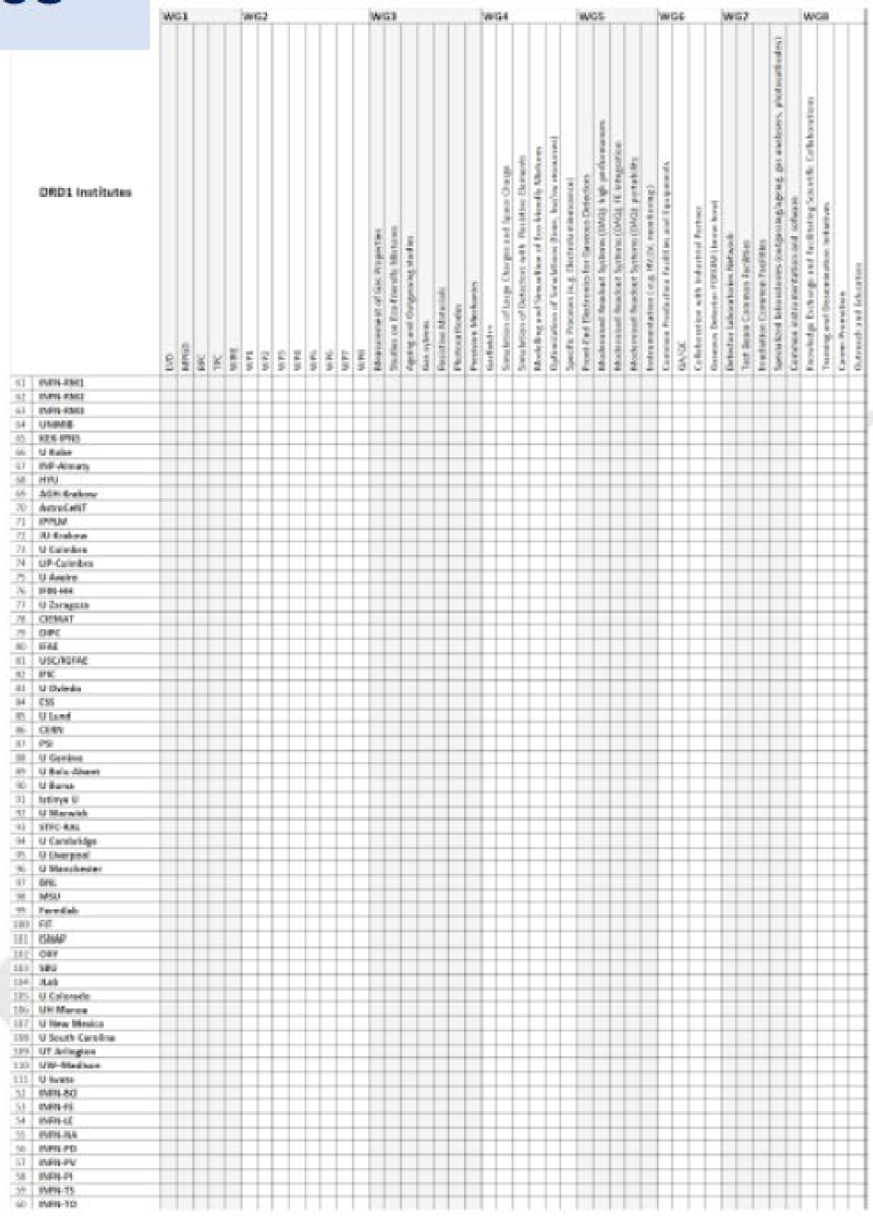

Figure 5: Institute Participation in the DRD1 Working Group Collaboration activities and expression of interest for DRD1 Work Packages (Part 2).

Resource and infrastructures

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Here tables summarizing for each WP - main deliverables – istitutions involved/overall FTE (comulative informations)

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Details on the WP are in section 7, (details on resource in extended WP for annex Mou -see Piotr's slides)

Detailed Description of Research Topics and Work Plan

#	Task	Performance Goal	DRD1 WGs	ECFA DRDT	Comments	Deliv. next 3y	Interested Institutes
T1	IBF reduction	- Gain × IBF ≈ 1-2 - IBF optimization together with energy resolution and discharge stability	WG4, WG7 (7.1-2,5)	1.2	- Hybrid stacks - Gating GEM - Distortion corrections - Space-charge monitoring - Development of simulation tools - Operation in magnetic fields	- Provide a large-area prototype with a uniform IBF distribution of G*IBF≤5 keeping the energy resolution at a tolerable level - Present a structure with stable settings for G×IBF of 1-2 - Determine the ion blocking power of a GEM-based gate - Provide systematic studies and simulations of IBF performance for the most common structures in (high) magnetic fields - Introduce an IBF calculator (Garfield-based) for optimization of the HV parameters	IFUSP, GSI, U Bonn, IRFU/CEA, USTC, KEK-IPNS, DESY, GANIL, RWTH Aachen, INFN-PD, IPPLM, CERN, PSI, U Bursa, SBU, WIS, U Coimbra, U Aveiro, Wigner, SINP Kolkata
T2	Pixel-TPC development	- Produce 30000-60000 GridPixes to read out a full TPC - Achieve dN/dx counting-resolution < 4%	WG3, WG7 (7.1-2,5)	1.1	- InGrids (grouping of channels) - Low-power FEE - Optimization of pixel size (>200 µm) or cost reduction	- Provide a large-area pixel-based (InGrid) readout module - Measuring IBF for GridPix. Reduction with double-mesh - Present dN/dx measurements in beam - Small area prototypes of MPGD/TimePix hybridisation	U Bonn, U Carleton, WIS, CERN
T3	Optimization of the amplification stage and its mechanical structure, and development of low X/X_0 field cages (FC)	- Uniform response across a readout unit-area. - Keep $\sigma_{dE/dx} \simeq 4\%$ - Point resolution of <100 µm - Minimize static distortions by reducing insensitive areas - Minimize $E \times B$ - Achieve E-field homogeneity at $\sim 10^{-4}$ level	WG1, WG4, WG6, WG7 (7.1-2,5)	1.1 1.2	**Minimization of static distortions:** - Algorithms for distortion corrections - Field shaping wires - Minimize GEM frame area (use thicker GEMs) - Laser systems **Main ampl. stages:** - Encapsulated resistive-anode MMG - Multiple GEM - GridPix - Hybrids **FC:** - high-quality strips, suspended strips - module flatness	- Provide a solution for a large-volume TPC with $\mathcal{O}(10^6)$ pad-readout by means of pre-production of several readout modules of comparable quality	IRFU/CEA, U Bonn, IHEP CAS, USTC, GANIL, CNRS-IN2P3/IJCLab, GSI, RWTH Aachen, INFN-RM1, INFN-PD, INFN-BA, IPPLM, PSI, U Bursa, SBU, BNL, WIS, IPAE
T4	Low-power FEE	- <5 mW/ch for >10^6 pad TPC - ASIC development in 65 nm CMOS	WG5	1.3	- Continuous vs. pulsed	- Present stable operation of a multi-channel TPC prototype with a low-power ASIC	IHEP CAS
T5	FEE cooling	- Operate 10^6 channels per end-plate	WG5	1.2	- Two-phase CO_2 cooling - Micro-channel cooling with 300 µm pipes in carbon fiber tubes - 3D printing: complex structures, performance optimization, material selection	- Present a prototype of a cooling system for the 10^6 pad TPC option	IRFU/CEA, U Lund, INFN-PI, INFN-LE, INFN-PD
T6	Gas mixture	Optimize: - Longevity - Ageing - Discharge probability - Drift velocity - Ion mobility	WG1, WG3 (3.1D, 3.2A, 3.2B), WG4, WG7 (7.1-3,5)	1.1	- Discharge probability, ageing, gas properties - Optimization of the HV working point - Optimization wrt. the expected resolution (aim for <100 µm) - Cluster ions	- Lower the discharge probability of readout units by 1-2 orders of magnitude down to $\sim 10^{-11}$ per hadron - Avoid secondary discharges in MPGD stacks	CERN, IFUSP, GSI, TUM, IHEP CAS, GANIL, USTC, CNRS-IN2P3/IJCLab, IRFU/CEA, CNRS-LSBB, RWTH Aachen, U Bonn, Bose, INFN-RM1, INFN-LE, INFN-PD, INFN-BA, IPPLM, USC/IGFAE, U Bursa, SBU, U Warwick, U Aveiro, U Bolu-Abant

Currently 8 WPs: for each of them we have descriotion of activities and challenges with detailed tables

Example Work Package 4: Inner and central tracking

Challenges for the TPC at colliders

- Good dE/dx resolution, partly driven by a good gain uniformity;
- very low (gain x Ion Back Flow) to drastically reduce space charge distortions;
- high readout granularity to cope with the particle multiplicity;
- electronics with low power dissipation to meet the increased density of readout channels.
- large area coverage at reduced low cost, relying on lightweight mechanical structures based on composite materials.

Area of application: future electron colliders (ILC, FCC-ee, CEPC). Timeline: 2035-2040, most of the R&D goals should be reached by 2030 to allow for timely construction.

Work Packages description in the proposal

Resource and Participation Tables presented in the proposal as cumulative data (as in Didier's guidelines here]

Currently we have 8 WPs: cumulative information about available resources

WP	Description	Material (2024)	Material (2025)	Material (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Tracking/Vertexing)	#	#	#	#	#	#
WP2	Inner and Central Tracking with Particle Identification Capability (Drift)	#	#	#	#	#	#
WP3	Inner and Central Tracking with Particle Identification Capability(Straw)	#	#	#	#	#	#
WP4	Inner and Central Tracking with Particle Identification (TPC)	#	#	#	#	#	#
WP5	Calorimetry	#	#	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#	#	#

Table 1: DRD1 Workpackages, cumulative resources (Material[kCHF] and FTE) available in existing funding lines covering the ECFA strategic R&D for the years 2024, 2025, 2026

Proposed table

Work Packages description in the proposal

Cumulative information about additional resource

WP	Description	Material (2024)	Material (2025)	Material (2026)	FTE (2024)	FTE (2025)	FTE (2026)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Tracking/Vertexing)	#	#	#	#	#	#
WP2	Inner and Central Tracking with Particle Identification Capability (Drift)	#	#	#	#	#	#
WP3	Inner and Central Tracking with Particle Identification Capability(Straw)	#	#	#	#	#	#
WP4	Inner and Central Tracking with Particle Identification (TPC)	#	#	#	#	#	#
WP5	Calorimetry	#	#	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#	#	#

Table 2: DRD1 Workpackages, additional (not existing) funding request to cover the ECFA strategic R&D for the years 2024, 2025, 2026

Proposed table

Work Packages description in the proposal

Cumulative information about resource for material and FTE, projection >2027

WP	Description	Material (2027-2029)	Material (≥2030)	FTE (2027-2029)	FTE (≥2030)
WP1	Trackers & Hodoscopes (Large Area Muon Systems, Inner Tracking/Vertexing)	#	#	#	#
WP2	Inner and Central Tracking with Particle Identification Capability (Drift)	#	#	#	#
WP3	Inner and Central Tracking with Particle Identification Capability(Straw)	#	#	#	#
WP4	Inner and Central Tracking with Particle Identification (TPC)	#	#	#	#
WP5	Calorimetry	#	#	#	#
WP6	Photo-Detectors (PID)	#	#	#	#
WP7	Timing Detectors (PID and Trigger)	#	#	#	#
WP8	TPCs as Reaction and Decay Chambers (Rare Events, Neutrino Physics, Nuclear Physics)	#	#	#	#

Table 3: DRD1 Workpackages, resources projections for the years 2027-2029, ≥2030.

Proposed table

Here the table summarizing list of the available facilities in the DRD1 Institutes

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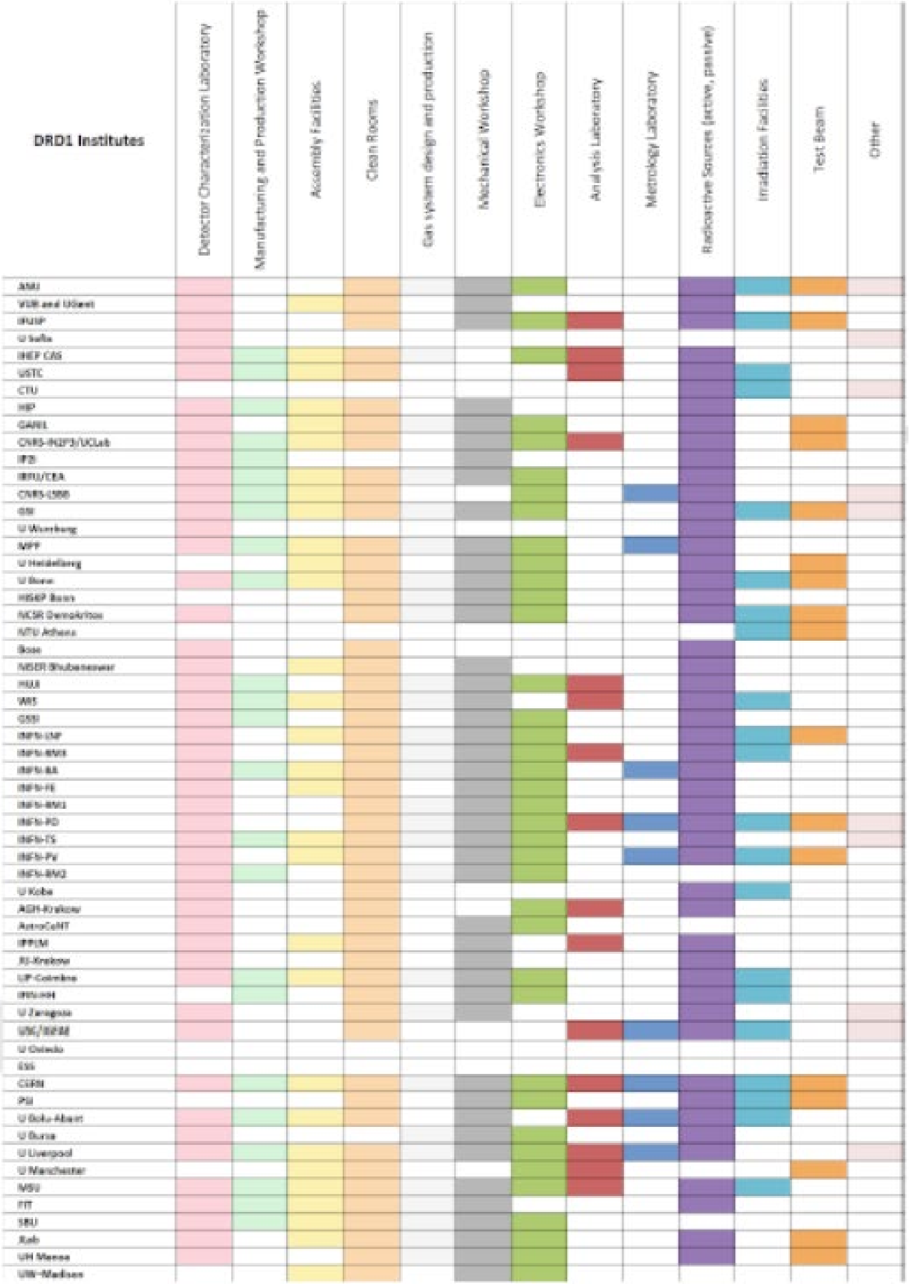

Figure 6: List of the available facilities in the DRD1 Institutes. The shown information have been collected during the first DRD1 survey and needs to be updated to include all the interested institutes

Synergies with other DRDs

Contents

DRD1 proposal finalization timeline
To be agreed with DRDC chair

- **March- 5 May**: **draft document** preparation including a preliminary definition of Work Package
- **15 May:** Start the community consultation. **1st Draft** shared with Institute Contacts.
- **15 May - 1 June**: Proposal Team works on the draft document within working groups, implementing the feedback from the community and preparation of the preliminary version of the Executive Summary with WP tables.
- **1 June:** End of the community feedback about the first draft
- **16 June:** Approval of the document for the community-wide discussion and release to the **2nd draft** whole community.
- **22-23 June: DRD1 Community workshop** - wide discussions during the community workshop
- **June- July: -** Definition of the required resources for the outlined programme need (split into personel effort (FTEs) and material plus services (non-FTE) costs. – institute's inputs
- **End-July:** Submission of the proposal without resource information (to be agreed with DRDC chair)
- **Sept/October:** Resource table included, although with no guarantee at this stage that the figures appearing can be committed (date to be agreed with DRDC chair)