DRD4 Collaboration Proposal

Abstract
This document describes a proposal for joint research and development work in the fields of photodetectors and particle identification techniques in high energy physics. For this purpose, university groups and research centres propose to form an international collaboration in the framework of the ECFA Detector R&D Roadmap, called DRD4. The collaboration is organised in Working Groups and a set of Joint Projects. The formal aspects of the DRD4 collaboration are defined in a Memorandum of Understanding. Topics, planning, resources and sharing of the Joint Projects are described in separate Memoranda of Agreement annexed to the MoU.
The joint research work is primarily focused on technologies that are needed to upgrade the current or build the next generation of high energy physics experiments. The outcome will be proofs of principle, prototypes and reduced-scale demonstrators. R&D needed to adapt detectors to the specific needs of an experiment as well as integration and industrialisation are in general not part of DRD4 and shall remain under the full responsibility of the experiment.

Introduction (objectives of the DRD4 collaboration)

(at present: intro of the TF4 chapter in the RD Roadmap, to be shortened)
Photon detectors are at the heart of most experiments in particle physics. Moreover, they are also finding applications in scientific fields as distant as chemistry and biology and are ubiquitous in society in general. As we encounter new environments where we need to collect the light, we require both advances in existing technology and transformative, novel ideas to meet the demanding requirements. Advancement in photon detector technology is therefore essential to address all the science drivers of future high energy physics experiments.

Reliable particle identification (PID) methods have become an indispensable experimental tool, in particular for the physics of heavy flavours, in studies of heavy-ion collisions, and in electron-hadron experiments. PID has significantly contributed to our present understanding of elementary particles and their interactions and will continue to be an essential ingredient in several of the planned experiments. The continuous advances in the development of pixelated single photosensors and fast and low-noise read-out electronics have pushed PID detectors, in particular Ring Imaging Cherenkov (RICH) counters, to

unprecedented levels of performance. This has allowed a very efficient identification of charged particles and an outstanding background rejection in a vast momentum range from a few 100MeV/c up to several 100GeV/c. However, the ever-growing demands of the future physics programme, from underground facilities to high luminosity colliders, require mastering a novel generation of PID detectors with high separation power over four to five orders of magnitude in momentum.

As discussed in the RD Roadmap in great detail, four main lines of R&D will be pursued in this area: DRDT 4.1 - Enhance timing resolution and spectral range of photon detectors; DRDT 4.2 - Develop photosensors for extreme environments; DRDT 4.3 - Develop RICH and imaging detectors with low mass and high-resolution timing; DRDT 4.4 - Develop compact high-performance time-of-flight detectors.

Scope of the DRD4 Research Work

DRD4 shall cover the following photodetector technologies: PMT incl. MA-PMT, MCP PMT, SiPM incl. digital, APD, and HPD, as well as any new (quantum) sensor promising to be compatible with size, cost, and radiation constraints of a particle physics experiment. In most cases the primary application is the detection of single photons in PID detectors. DRD4 is also interested in other applications of these technologies such as Calorimetry (readout of fibres, crystals, organic scintillators) - DRD6, as well as medical imaging and industrial application (automotive).

DRD4 shall cover the following PID technologies: RICH, DIRC, TOF, TOP, TORCH.
*** Add SciFi trackers ***
DRD4 is also interested in other PID technologies and will maintain contacts with the corresponding DRDs: dE/dx (usually implemented with gaseous detectors, DRD1), Transition Radiation detector – TRD (usually implemented with gaseous detectors, DRD1).

DRD4 shall cover the following technologies related to PID and photodetectors Cherenkov radiators (solid, liquid, gaseous, aerogel, low GWP): optical components (mirrors, windows,..), readout ASICs for PD testing, and any other auxiliary equipment (operation, testing and characterisation). DRD4 shall cover analysis and simulation techniques related to PID detectors, fast photon tracking incl. GPU, pattern recognition incl. neural networks.

Planning technology area 1: DRDT 4.1 - Enhance timing resolution and spectral range of photon detectors
(including a task/deliverable synoptic, resources and list of contributing institutes)

This is needed for fast timing in Cherenkov and time of flight detectors, for operation with high particle fluxes and pile-up, and in extending the wavelength coverage of scintillation photons from noble gases and Cherenkov photons.
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Planning technology area 2: DRDT 4.2 - Develop photosensors for extreme environments:
(including a task/deliverable synoptic, resources and list of contributing institutes)

This being essential for operation in the high-radiation environments at the HL-LHC, Belle II upgrade, EIC and FCC-hh; and similarly for cryogenic operation.
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Planning technology area 3: DRDT 4.3 - Develop RICH and imaging detectors with low mass and high resolution timing.
(including a task/deliverable synoptic, resources and list of contributing institutes)

As required for particle identification at HL-LHC, Belle II upgrade, EIC, and FCC-ee.
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Planning technology area 4: DRDT 4.4 - Develop compact high performance time-of-fight detectors.
(including a task/deliverable synoptic, resources and list of contributing institutes)

As a complementary approach for particle identification at HL-LHC, EIC and FCC-ee.
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Common simulation tools and test facilities

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Partnerships (industrial, other research areas, other applications)

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Networking and training

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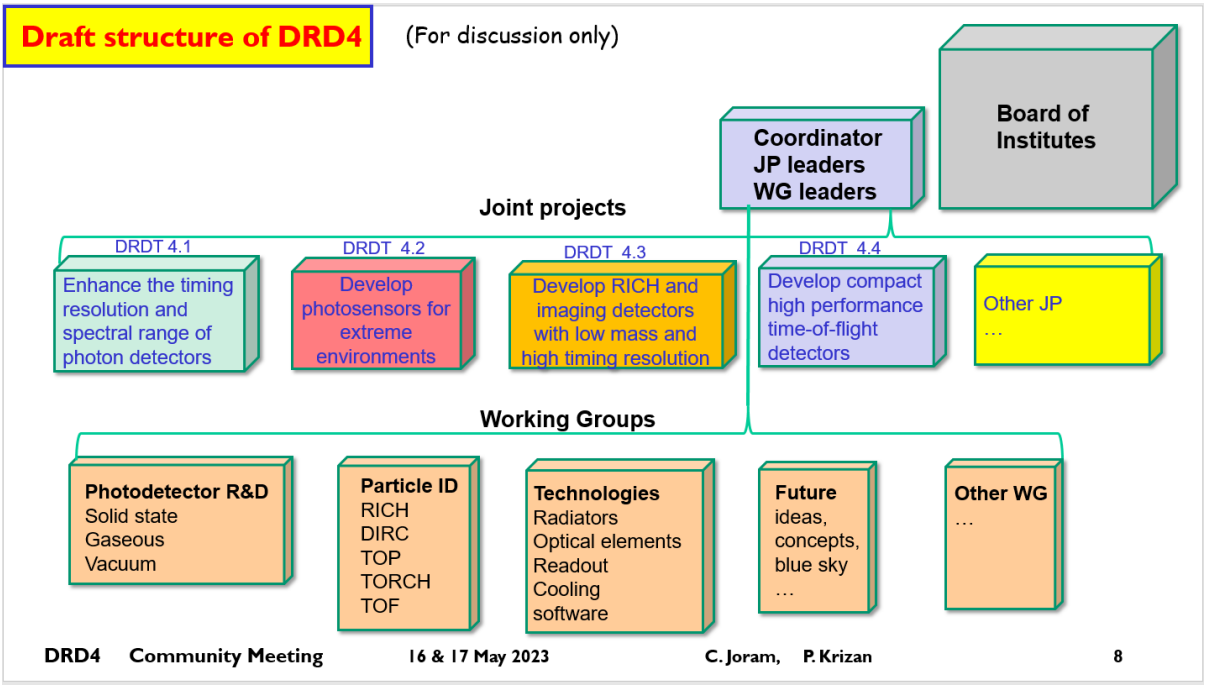
Proposal for the collaboration structure

DRD4 shall be subdivided into thematic fields (working groups). These could be Photodetectors, Particle ID, Tools/technologies, Future. Collaboration members belong to one or several working groups. A WG is led by an expert who organises dedicated meetings during the DRD4 collaboration meetings. In these meetings, members exchange information, expose problems, ask for advice, agree on standards. The WG leader preferably selects talks addressing the goals of the roadmap.

Members working on related topics, but in different experiments, can propose Joint Projects or join existing ones. Joint Projects have agreed goals, milestones, and resource sharing. These common projects shall address the main goals of the roadmap or new topics of high relevance. At present the following Joint Projects are foreseen: Enhance timing resolution and spectral range of photon detectors (DRD4.1), Develop photosensors for extreme environments (DRD4.2), Develop RICH and imaging detectors with low mass and high-resolution timing (DRD4.3), Develop compact high-performance time-of-flight detectors (DRD4.4). More Joint Projects can be considered according to the needs of the Collaboration.

The collaboration is managed by a Coordinator who is elected from the team of WG and JP leaders. The Coordinator reports to the Board of Institutes.



Resources - existing and anticipated

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Summary (high level planning synoptic by DRDT broken-down to sub-areas)

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