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DRD3 – What?

ECFA Detector R&D Roadmap & Possible DESY Involvements

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Silicon Detector Interest Group Meeting

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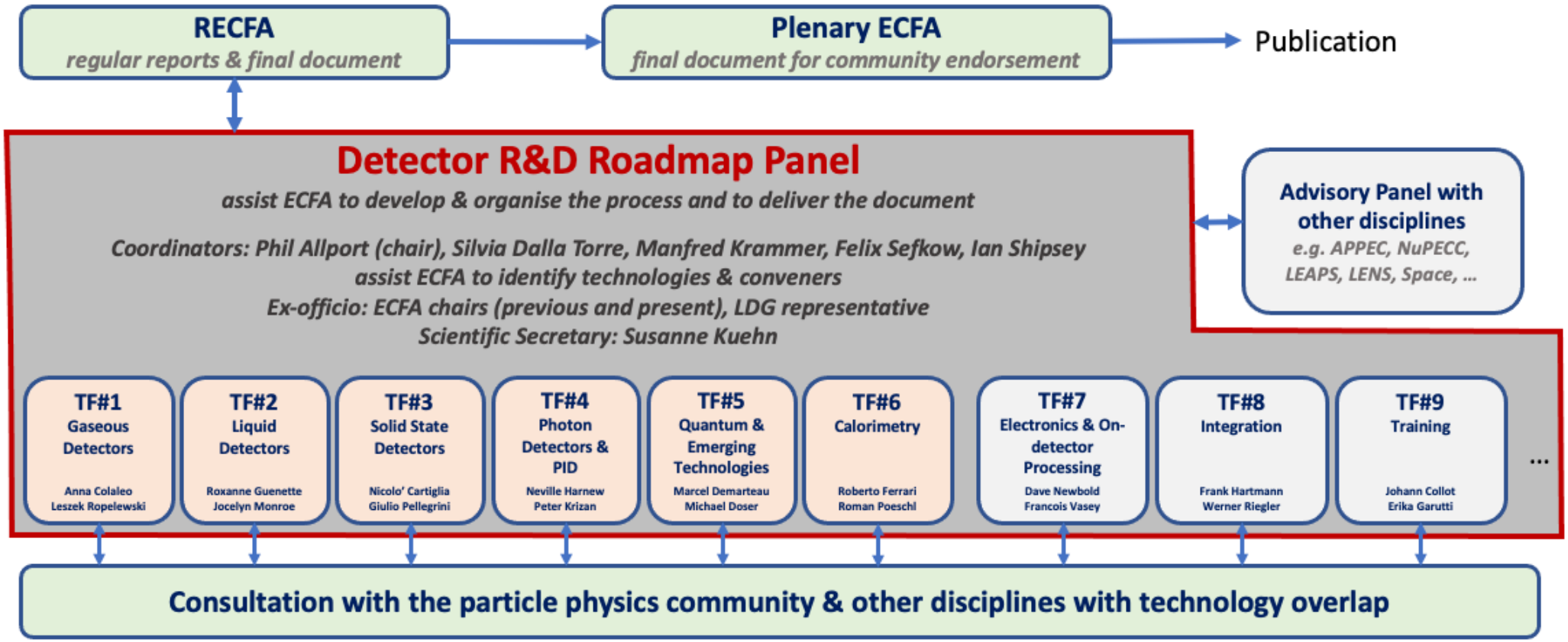
Goal of the ECFA Detector R&D Roadmap

"The [European Strategy for Particle Physics update] calls upon ECFA to develop a global detector R&D roadmap that should be used to support proposals at the European and national levels. That roadmap aims to define the backbone of detector R&D required to deploy the community's vision for both the near- and longer-term."

Overview by Felix
ECFA Roadmap Document @ CDS
DRD3 Workshop & Mailing List Registration

Organization to structure the consultation with the community



Overview Task Forces (and Conveners)

- TF1 Gaseous Detectors — Anna Colaleo (INFN Bari), Leszek Ropelewski (CERN)
- TF2 Liquid Detectors — Roxanne Guenette (Harvard), Jocely Monroe (RHUL)
- **TF3 Solid State Detectors** — Nicolo Cartiglia (INFN Turino), Giulio Pellegrini (IMB-CNM)
- TF4 Photon Detectors and PID — Neville Harnew (Oxford), Peter Krizan (Jozef Stefan Inst.)
- TF5 Quantum /Emerging Tech. — Marcel Demarteau (ORNL), Michael Doser (CERN)
- TF6 Calorimetry — Roberto Ferrari (INFN Pavia), Roman Poeschl (IN2P3-IJCLab)
- **TF7 Electronics / On-det. Proc.** — Dave Newbold (RAL), Francois Vasey (CERN)
- **TF8 Integration** — Frank Hartmann (KIT), Werner Riegler (CERN)
- TF9 Training — Johann Collot (IN2P3-LPSC), Erika Garutti (Hamburg)

Solid state

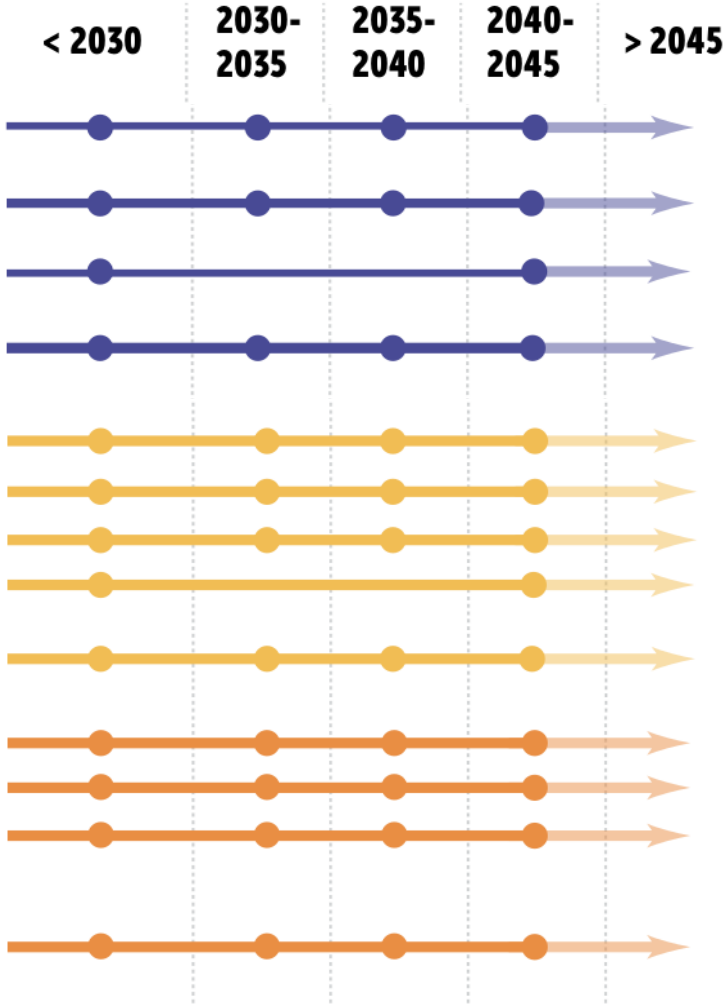
- **DRDT 3.1** Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors
- **DRDT 3.2** Develop solid state sensors with 4D-capabilities for tracking and calorimetry
- **DRDT 3.3** Extend capabilities of solid state sensors to operate at extreme fluences
- **DRDT 3.4** Develop full 3D-interconnection technologies for solid state devices in particle physics

Electronics

- **DRDT 7.1** Advance technologies to deal with greatly increased data density
- **DRDT 7.2** Develop technologies for increased intelligence on the detector
- **DRDT 7.3** Develop technologies in support of 4D- and 5D-techniques
- **DRDT 7.4** Develop novel technologies to cope with extreme environments and required longevity
- **DRDT 7.5** Evaluate and adapt to emerging electronics and data processing technologies

Integration

- **DRDT 8.1** Develop novel magnet systems
- **DRDT 8.2** Develop improved technologies and systems for cooling
- **DRDT 8.3** Adapt novel materials to achieve ultralight, stable and high precision mechanical structures. Develop Machine Detector Interfaces.
- **DRDT 8.4** Adapt and advance state-of-the-art systems in monitoring including environmental, radiation and beam aspects



Suggested Implementation Timeline

Through 2023, mechanisms will need to be agreed with funding agencies in parallel to the process below for country specific DRD collaboration funding requests for Strategic R&D and for developing the associated MoUs.

Q4 2022	Outline structure and review mechanisms agreed by CERN Council. Detector R&D Roadmap Task Forces organise **community meetings** to establish the scope and scale of community wishing to participate in the corresponding new DRD activity. (Where the broad R&D topic area has one or more DRDTs already covered by existing CERN RDs or other international collaborations these need to be fully involved from the very beginning and may be best placed to help bring the community together around the proposed programmes.)
Q1 2023	**DRDC mandate formally defined** and agreed with CERN management; Core DRDC membership appointed; and EDP mandate plus membership updated to reflect additional roles.
Q1-Q2 2023	**Develop the new DRD proposals** based of the detector roadmap and community interest in participation, including light-weight organisational structures and resource-loaded work plan for R&D programme start in 2024 and ramp up to a steady state in 2026.
Q3 2023	**Review of proposals by DRDC** leading to recommendations for formal establishment of the DRD collaborations.
Q4 2023	DRD Collaborations receive formal **approval from CERN Research Board**.
Q1 2024	New structures operational for ongoing review of DRDs and R&D programmes underway.

Through 2024, collection of MoU signatures

Brainstorming – DRD3 topics @ DESY

No	Topic	DESY Interest	Comment
1	**Monolithic CMOS sensors** ASIC design, TCAD, testing, off-chip electronics (PCB, FPGA), modeling, …	Yes	Obvious
2	**Sensors for tracking and calorimetry with space, time and/or energy resolution** 4D, 3D, trench detectors, modeling, simulation,	Yes	Covers kind of everything
3	**Radiation damage & ultrahigh fluences** Defect characterization, TCAD / damage simulations, irradiation tests	No	
4	**New characterization techniques, common facilities** Irradiation and test beam facilities, IBIC, laser testing, …	Yes	Part of role as national lab, Overlap with AIDAXXX ?
5	**Interconnect and device fabrication technologies** **3D integration, TSV, reduction of pitches, wafer bonding..**	yes	Is this a “service task” or will there be real R&D too?
6	**Non-silicon semiconductor and other materials** Diamond, SiC, GaN, WBG, ..	Maybe	If we had additional resources to commit ..
7	**Dissemination and outreach** Mobility programs, publications, conferences, training, links to other fields & industry, IP, website, collaboration admin, ...	Willing to help at some level	Most activities covered by the host lab

Brainstorming – DRD7 topics @ DESY

No	Topic	DESY Interest	Comment
1	**Advance technologies to deal with greatly increased data density** High data rate ASICs and systems, New link technologies, Power and readout efficiency	Yes	28nm, 65nm, power efficient MAPS FE,
2	**Develop technologies for increased intelligence on the detector** Front-end programmability, modularity and configurability, Intelligent power management, Advanced data reduction techniques (ML/AI)	Yes	Data reduction
3	**Develop technologies in support of 4D-and 5D-techniques** High-performance sampling (TDC, ADC), High-precision timing distribution, Novel on-chip architectures	yes	Low-power readout architectures for MAPS
4	**Develop novel technologies to cope with extreme environments and required longevity** Radiation-hardness, Cryogenic conditions, Reliability, fault tolerance, detector control, Cooling	no	General interest
5	**Evaluate and adapt to emerging electronics and data processing technologies** Novel microelectronic technologies, devices, materials; Silicon photonics; 3D integration and high density interconnects; Keeping pace with, adapting, and interfacing with COTS	yes	Si photonics links, 3D interconnects

The DRD Workshops

- Workshop held at CERN (in hybrid mode) for every DRD to discuss community input & ideas
- Rough structure of working groups (WG) already defined by DRD coordinators
  - DRD7 Workshop: 14/15.03.2023 @ CERN
    https://indico.cern.ch/event/1214423/
  - DRD3 Workshop: 22/23.03.2023 @ CERN
    https://indico.cern.ch/event/1214410/
- (Very short) presentations from the different WGs (DRD3) or topics (DRD7)
- Next steps: collate discussions, additional input received during workshops, write DRD proposal – separate proposals for each

DESY input to DRD3

- Documents: https://confluence.desy.de/display/TTD/DRD+3%3A+Solid+State+Detectors
- Main focus on Monolithic Active Pixel Sensors
- Additional activities of interest:
  - Fast timing detectors for 4D tracking
  - Characterization techniques (beam telescopes)
  - Silicon photonics (DRD7)
- Technological areas of interest (tools):
  - Testbeam facility
  - Corryvreckan Test-beam Reconstruction Framework
  - Allpix Squared Semiconductor Simulation Framework
  - Caribou DAQ Framework

Monte Carlo Simulations in DRD3 – Allpix Squared

- Complexity of detectors increases, many technologies, different approaches combined (e.g. monolithic + LGAD)
  - Necessity of MC simulations growing
  - Some sensors / setups impractical to simulate in TCAD (time limitation, stochastics)
  - Community needs common flexible, tested & supported MC simulation tools

- Proposal in DRD3 / WG4 (Simulations) to establish Allpix Squared as commonly maintained MC simulation software
  - Development & extension of flexible, universal framework for semiconductor MC simulations
  - Model building for adaptive electric fields
    - Plasma effects - high local charge densities, heavy ions, high gamma fluxes
    - Dynamic trapping/de-trapping models
  - Time-weighted simulation approach - dynamic weighting field
  - Development of commonly-used front-end circuit models, interface to SPICE simulators
  - Continue documentation & training effort: User workshops & tutorials / trainings, reference manual

DRD3 Common Project Proposal

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“Fine-pitch CMOS pixel sensors with precision timing for vertex detectors at future Lepton-Collider experiments”

- Proposal together with APC Paris, CERN, IPHC Strasbourg, UOxford, UZurich
- Development and evaluation of monolithic fine-pitch pixel sensors implemented in advanced CMOS imaging processes, targeting the LC requirements as outlined in the ECFA detector roadmap.
- Key development targets include ~3 µm single-point resolution, down to ~5 ns time resolution as required for some of the LC proposals, thinning to below 100 µm, an average power consumption below 50 mW/cm2, a minimal inactive periphery area, and a sensor architecture scalable to a large-area detector system.
- It is foreseen to develop high-resolution beam-telescope sensors as an intermediate target in a first R&D phase.


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