ECFA
European Committee for Future Accelerators

Report from the DRDC: the DRD landscape

Inés Gil Botella (CIEMAT)

114th Plenary ECFA Meeting – Frascati, 5 July 2024

GOBIERNO DE ESPAÑA
MINISTERIO DE CIENCIA, INNOVACIÓN Y UNIVERSIDADES

Ciemat
Centro de Investigaciones Energéticas, Medioambientales y Tecnológicas

Slides thanks to Thomas Bergauer (DRDC Chair)

European Strategy on Particle Physics

Continuous process driven by the community

- First defined 2006
- **Update 2013** brought us HL-LHC decision
- **Update 2020** brought us decisions for post-HL-LHC times:
  - *Europe, together with its international partners, should investigate the technical and financial feasibility of a future hadr on collider at CERN with a centre-of-mass energy of at least 100 TeV and with an electron-positron Higgs and electroweak factory as a possible first stage.*
  - ***Detector R&D programmes** and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. **Synergies** between the needs of different scientific fields and **industry should be identified** and exploited to boost efficiency in the development process and increase opportunities for more **technology transfer benefiting society** at large. **Collaborative platforms and consortia** must be adequately supported to provide coherence in these R&D activities. The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels.*
  - *Europe should maintain its capability to perform innovative experiments at the boundary between particle and nuclear physics, and CERN should continue to **coordinate** with **NuPECC** on topics of mutual interest.*
  - ***Synergies** between particle and **astroparticle physics** should be strengthened through scientific exchanges and **technological cooperation** in areas of common interest and mutual benefit.*
- **Update 2026** on the horizon with input proposals by spring 2025

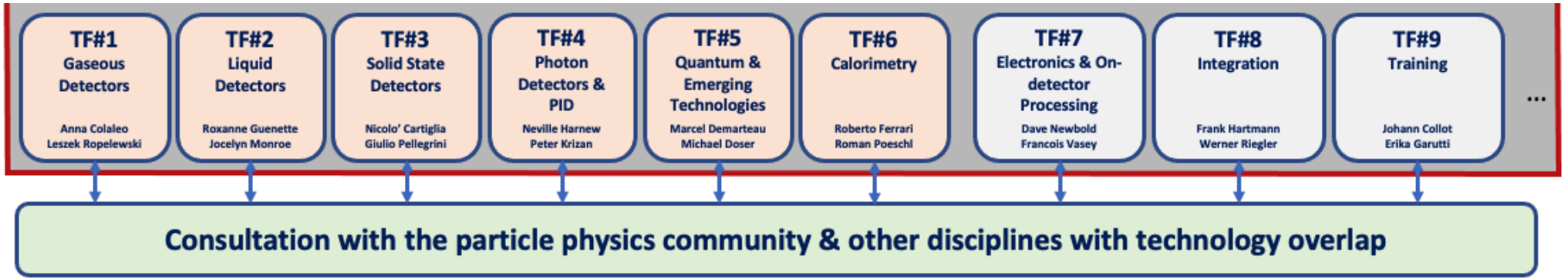
http://europeanstrategy.cern/

ECFA Detector Roadmap

European Committee for Future Accelerators (ECFA) released in 2021 a full document (200 pages) and synopsis (~10 pages) based on a community-driven effort

The full document can be referenced as DOI: 10.17181/CERN.XDPL.W2EX

- Overview of **future facilities** (EIC, ILC, CLIC, FCC-ee/hh, Muon collider) or major **upgrades** (ALICE, Belle-II, LHC-b,…) and their **timelines**
- Ten "**General Strategic Recommendations**" (full list in backup slides)
- **Nine Technology domains** with **Task Forces** areas
  - The **most urgent R&D topics** in each domain identified as **Detector R&D Themes** (DRDTs)



Detector R&D Themes

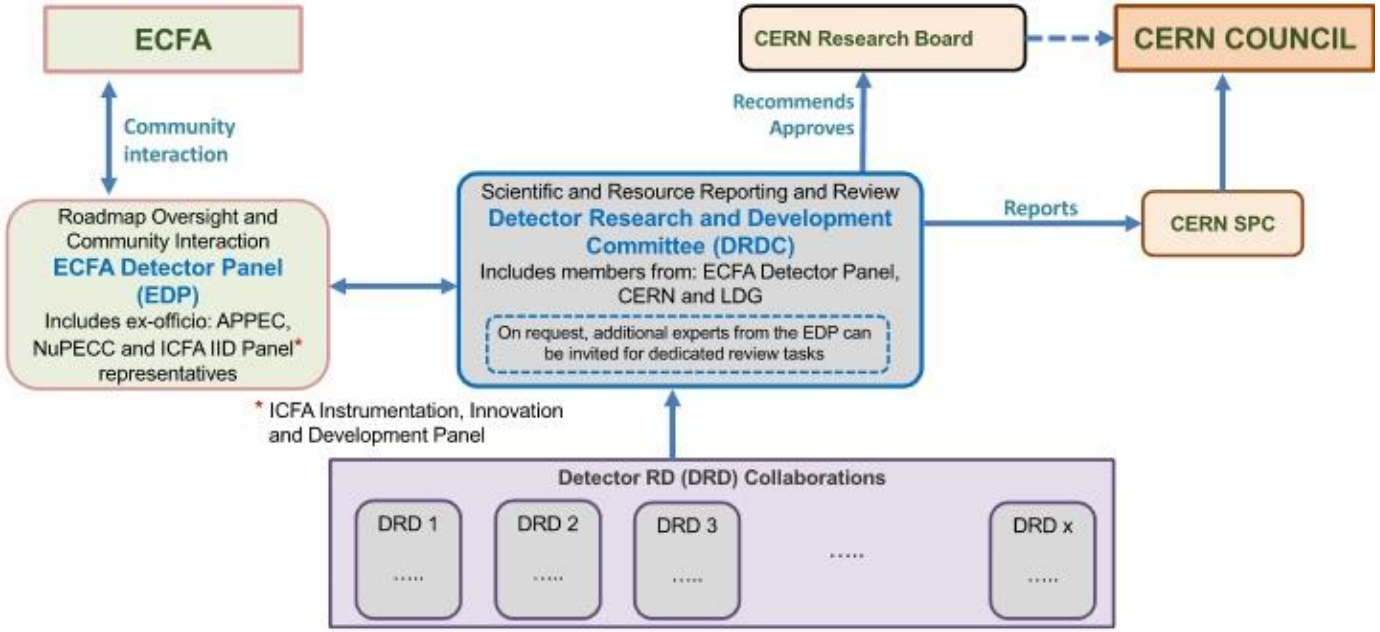
high-level deliverables

Detector Community Themes

Roadmap implementation plan

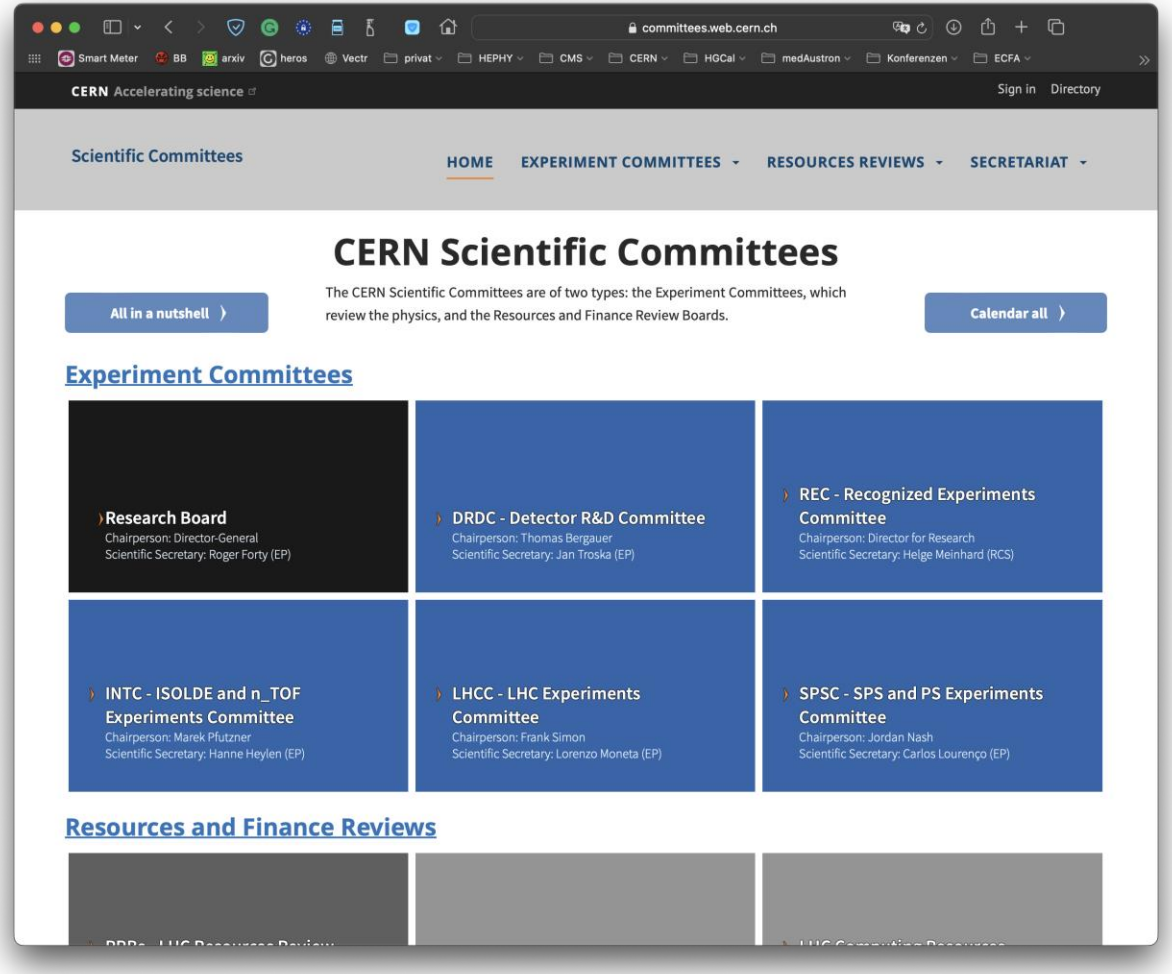
- Approved by CERN SPC and Council in fall 2022 (CERN/SPC/1190 ; CERN/3679)
- **CERN will host DRD collaborations**
  - ✦ Interaction between DRD collaborations and committees through DRDC
  - ✦ Interface to ECFA via ECFA Detector panel (EDP): https://ecfa-dp.desy.de

- Distinction between reviewing body (DRDC) and advisory body (EDP)
- **DRDC** reviews DRD progress, monitor milestones & deliverables, and reports to CERN Research Board
- **EDP** (full mandate to be found here) monitors ECFA Detector Roadmap, organizes "DRD managers forum" and provides input to the next Strategy update



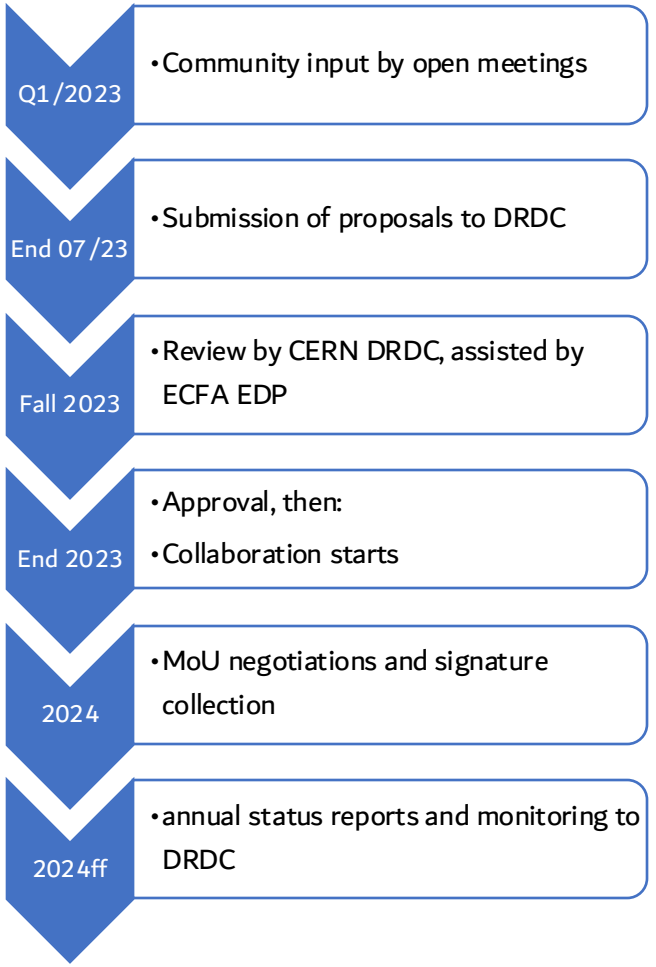
DRD Committee (DRDC)

- Detector R&D Committee is a new committee on the same level as SPSC and LHCC
  - ✦ Established in autumn 2023 following ECFA Detector Roadmap Process
  - ✦ http://committees.web.cern.ch/drdc
- Mandate of DRDC:
  - ✦ Reviews DRD proposals and suggests recommendations to CERN Research Board
  - ✦ Requests annual status reports of running DRD collaborations and conducts reviews of their progress
- DRDC meetings (Dec 23, Mar24, Jun24):
  - ✦ https://indico.cern.ch/category/17132/
  - ✦ Open and closed sessions

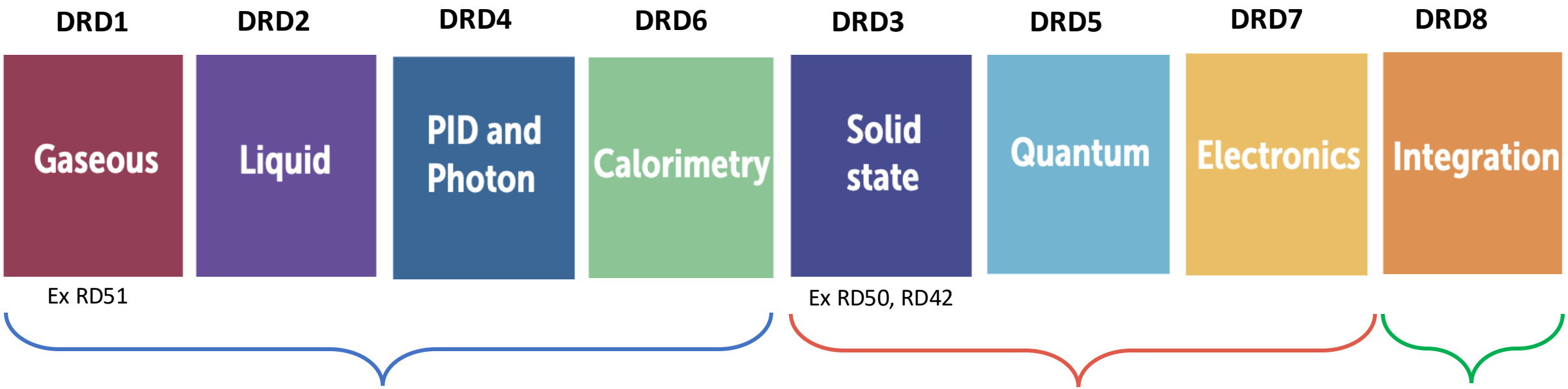


From ECFA Task Forces to DRD Collaborations

- Chapters convenors (Task Force) from ECFA Roadmap became part of Proposal Writing Teams for new DRD collaborations
- Collected input from the communities in open meetings happening in the beginning of 2023
- **Summer 2023: Submission deadline of DRD proposals**
  - ✦ The DRDC (DRD Committee) was appointed at the same time only
  - ✦ Review of first DRD proposals by DRDC in autumn 2023
  - ✦ Intense phase of work as also DRDC mandate and tasks had to be defined first
- **Approval of first DRD collaborations in December 2023 RB**
- Once approved, DRD collaborations started in 2024
  - ✦ Collaborations have kick-off meetings, elect management positions,…
  - ✦ Setting up MoU and collecting signatures from Funding Agencies
- **Approval of second set of DRD collaborations in June 2024 RB**



Status of DRD collaborations



DRD reports & proposals

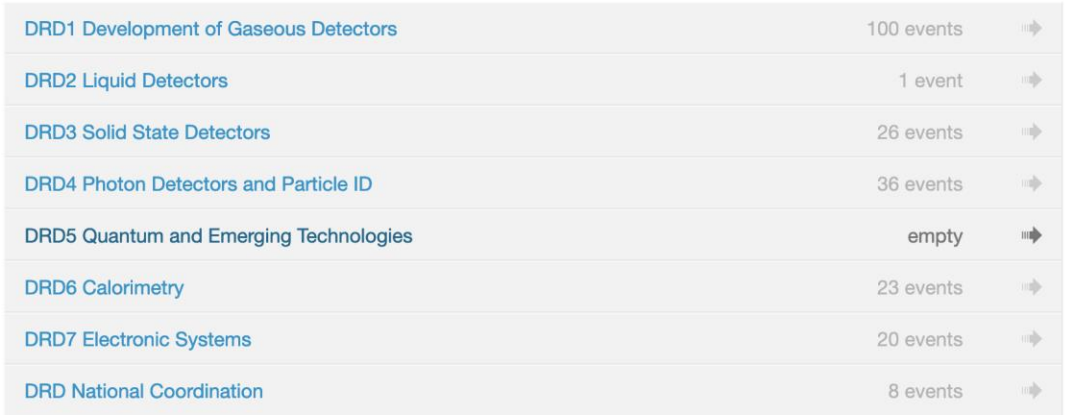
- DRD **reports** at open session of DRDC meeting:

  https://indico.cern.ch/event/1356910/

- **Indico**: Category “Experiments / R&D”

  https://indico.cern.ch/category/6805/

- Full DRD **proposals** in CERN CDS
  - ✦ Proposal by DRD8 to be written by the end of this year
  - ✦ They contain **strategic R&D** needs and definition of work packages, milestones & deliverables
  - ✦ **Strategic funding** to be agreed with funding agencies/institutions
  - ✦ **Progress** tracked by annual DRDC review
- **Next step** is to prepare and sign DRD **MoUs**



MoU template

- CERN has recently provided a **template** for the Memorandum of Understanding between all institutes of each DRD collaboration (and CERN)
  - ✦ To be in agreement with CERN's *General Conditions for the execution of experiments*, legal service, KT office
  - ✦ Should be almost identical for all DRD collaborations
- **Main MoU** is the only one which is physically/electronically **signed by each collaborating institution/Funding Agencies**; Contains: Obligations of CERN as host laboratory, industrial involvements, common fund, definitions:
  - ✦ **Working Groups** shall reflect the internal structure of the Collaboration. They are expected to be long-lasting
  - ✦ **Work Packages** shall reflect time-limited resource-loaded activities with clearly defined **objectives** and **deliverables**
- **Annexes**: everything that can change over time
  - ✦ Does not necessarily need a physical signature by funding agencies, but agreement/vote at Resource Board (with representatives of funding agencies)
- **Status**: First draft of MoU template is under discussion with management of DRD collaborations

- Annex 1: Collaborating Institutions and their Contact Persons
- Annex 2: Funding Agencies and their Representatives
- Annex 3: Organisational Structure of the Collaboration
- Annex 4: Financial Participation of the Funding Agencies
- Annex 5: Working Groups
- Annex 6: Work Packages and deliverables
- Annex 7: Background IP
- Annex 8: CERN General Conditions Applicable to Experiments

Status in the US

- Result from US Snowmass process: recommendation to create Detector R&D collaborations in the US
  - ✦ Organized by CPAD (Coordinating Panel for Advanced Detectors) of the APS/DPF
  - ✦ They created 11 RDCs (R&D Collaborations) and appointed coordinators (see https://cpad-dpf.org/?page_id=1549)
  - ✦ Recently started to reach out to the community and work on detailed planning at CPAD workshop 7-10 Nov 2023
- DRD collaborations are open for US participation
  - ✦ No concurrency, but synergy
  - ✦ Overlap to DRDs through people/groups involved in both and liaisons

RDC#	TOPIC
1	Noble Element Detectors
2	Photodetectors
3	Solid State Tracking
4	Readout and ASICs
5	Trigger and DAQ
6	Gaseous Detectors
7	Low-Background Detectors
8	Quantum and Superconducting Sensors
9	Calorimetry
10	Detector Mechanics
11	Fast Timing

Detector R&D Collaborations

DRD1: Gaseous Detectors

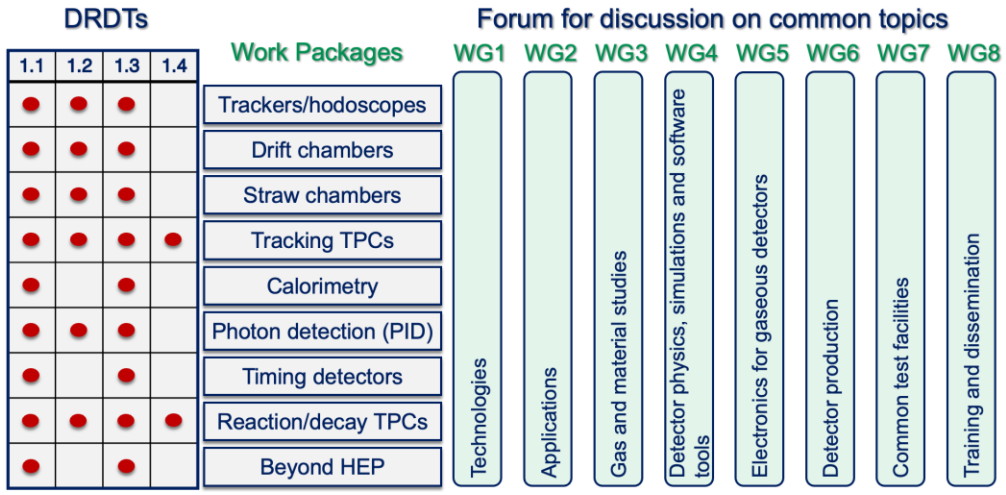
Gaseous

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

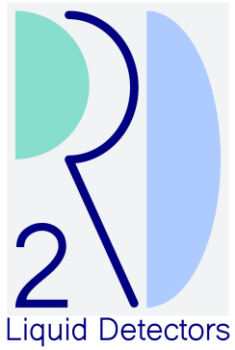
DRDT 1.4 Achieve high sensitivity in both low and high-pressure TPCs

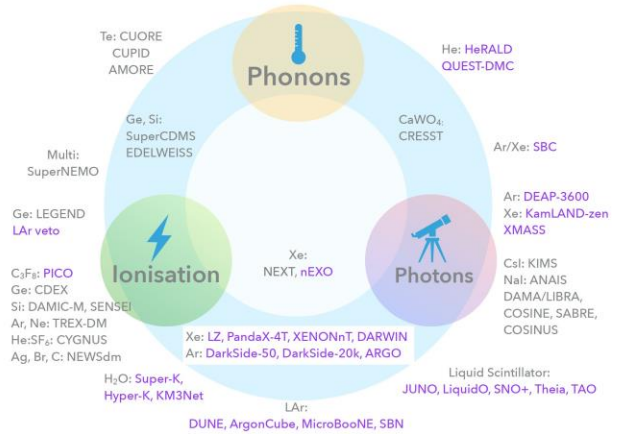


- Organized in
  - ✦ **Working Groups:** serving as the backbone of R&D
  - ✦ **Work Packages:** will reflect the DRDTs,
  - ✦ and **Common Projects** (blue sky) financed by fixed yearly fee (Common Fund)
- Large community of 170 institutes, 700 members, 33 countries
- Anticipated budget: 3 MCHF/y existing, additional 3 MCHF/y requested, 270/100 FTE
- Complete DRD1 management structure in place - CB board chair: Anna Colaleo, CB deputy: Leszek Ropelewski; Spokespersons: Eraldo Oliveri, Maxim Titov + MB + WG & WP leaders
- Collaboration website: https://drd1.web.cern.ch
- **DRD1 collaboration meetings**: Jan 29 –Feb 2, 2024 link, 2nd Collaboration Meeting June 17-21, 2024 link + regular WG meetings
- Started to work on MoU based on RD51 MoU, and started discussion with CERN
- Requested six weeks of beamtime at CERN SPS

DRD2: Liquid Detectors

- Covers **Dark Matter** and **Neutrino** experiments, accelerator and non-accelerator-based
- Several large-scale and many small-scale experiments running or foreseen with liquid detectors
- Technology: Noble Liquids (e.g. DUNE), Water Cherenkov (e.g. Super/Hyper-K) and Liquid Scintillator with light and ionization readout
- Underground Dark Matter Experiments – small and rare signals R&D for multi-ton scale noble liquids:
  - ✦ Target doping and purification
  - ✦ Detector components radiopurity and background mitigation
- **Feb. 5-7, '24: inaugural DRD2 Collaboration Meeting at CERN** https://indico.cern.ch/event/1367848/
  - ✦ Exciting scientific programme! 156 participants, 91 contributed talks, from 71 institutes in 15 countries
  - ✦ Governance working group plan for definition of Collaboration Board (CB) and call for CB chair nominations
- CB Board chair election 1 March 2024: W. Bonivento; spokespersons election on June 2024: G. Fiorillo & R. Guenette. Election of WP/WG leaders in July.





[ECFA roadmap, Modified from L.Baudis]

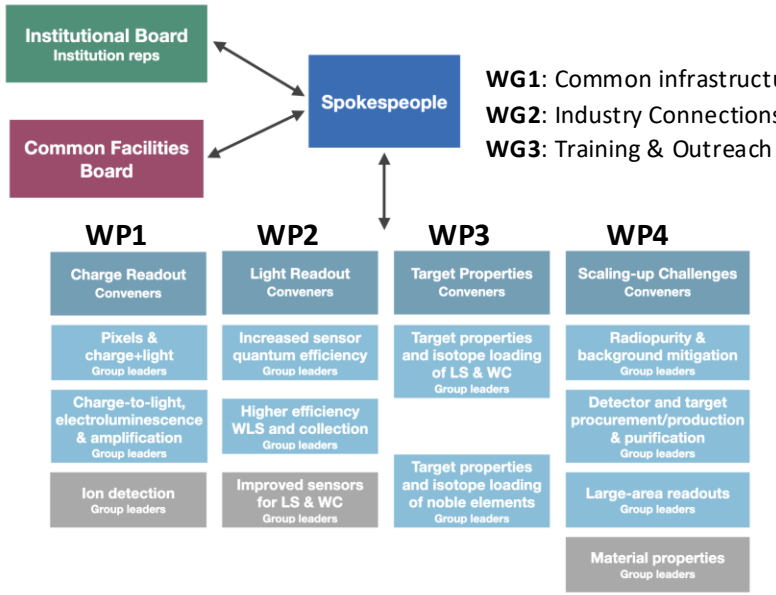
Liquid

DRDT 2.1 Develop readout technology to increase spatial and energy resolution for liquid detectors

DRDT 2.2 Advance noise reduction in liquid detectors to lower signal energy thresholds

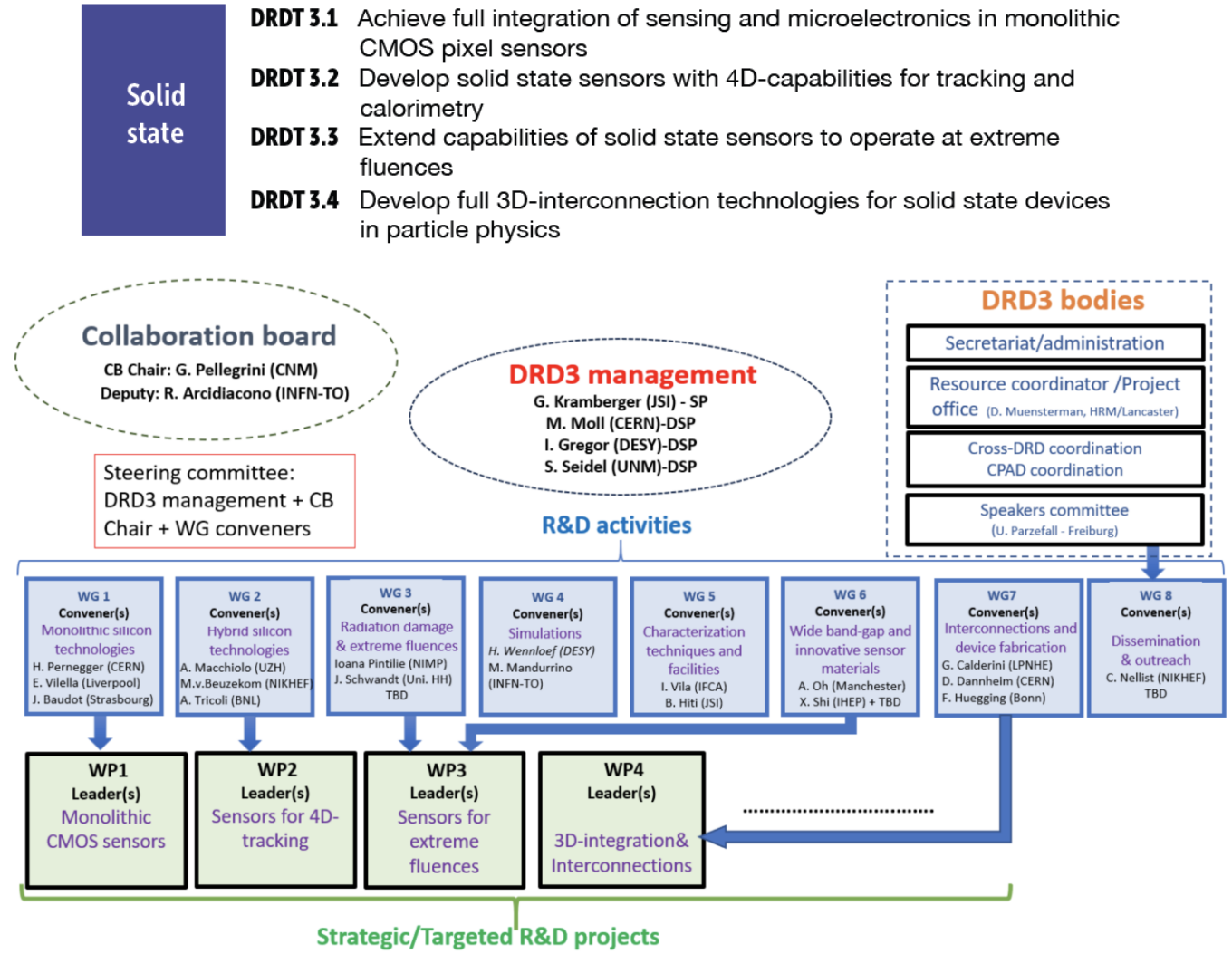
DRDT 2.3 Improve the material properties of target and detector components in liquid detectors

DRDT 2.4 Realise liquid detector technologies scalable for integration in large systems



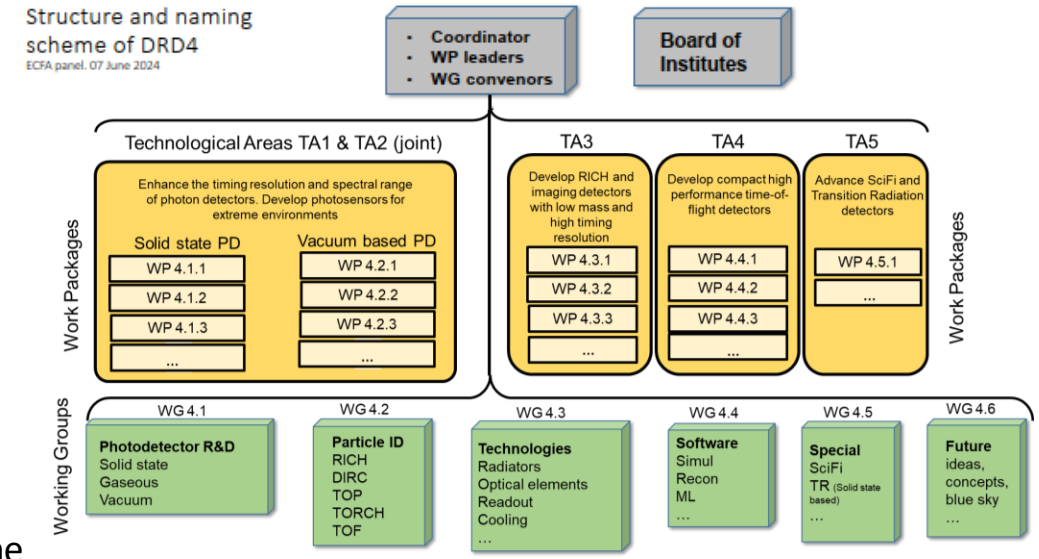
DRD3: Solid State Detectors

- DRD3 benefits from existing RD50 collaboration
  - ✦ Extended by diamonds (RD42) and 3D integration
  - ✦ Large interest in CMOS (DMAPS) sensors
- Large Collaboration: 143 institutes, 28 countries, ~900 interested people
  - ✦ ~ 70% are from Europe, 15% from North America,
  - ✦ Compare: RD50: 65 institutes and 434 members
- Budget:
  - ✦ ~5 MCHF/y (existing), ~8 MCHF/y (requested)
  - ✦ 327 FTE (existing), 170 FTE (requested)
- Collaboration website: https://drd3.web.cern.ch
- CB Board chair elected: Giulio Pellegrini (CNM Spain), deputy Roberta Arcidiacono (INFN Torino); Spokesperson elected: Gregor Kramberger (JSI Slovenia)
- Most of the WG conveners have been elected
- **1st Collaboration meeting**: 17-21 June 2024 at CERN https://indico.cern.ch/event/1402825/



DRD4: Photon Detectors & Particle ID

- Developments on PMTs, MCP-PMTs, SiPMs, APD, HPD, quantum devices, SciFi
  - ✦ Challenges for example for SiPMs: rad hard, dark rate, timing
- Applications in Ring Imaging Cherenkov Detectors (RICH), Time-of-Flight (ToF), TRD
- Connection to almost every other DRD collab. (gas, Silicon, Calo, electronics, SiPM at cryogenic temp.)
- Collaboration: 74 institutes from 19 countries, 7 (semi-) industrial partners
- Collaboration website: https://drd4.web.cern.ch
- **DRD4 constitutional meeting** happened at CERN (23-24 January 2024): https://indico.cern.ch/event/1349233/; 2nd collaboration meeting on 17-20 June 2024 at CERN: https://indico.cern.ch/event/1403486/
  - ✦ CB board chair: Guy Wilkinson
  - ✦ Spokesperson: Massimiliano Fiorini
  - ✦ WP/WG chairs elected



PID and Photon

DRDT 4.1 Enhance the 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

DRD5: Quantum Sensors

Quantum

- **DRDT 5.1** Promote the development of advanced quantum sensing technologies
- **DRDT 5.2** Investigate and adapt state-of-the-art developments in quantum technologies to particle physics
- **DRDT 5.3** Establish the necessary frameworks and mechanisms to allow exploration of emerging technologies
- **DRDT 5.4** Develop and provide advanced enabling capabilities and infrastructure

- Quantum Technologies are a rapidly emerging area of technology development to study fundamental physics
  - ✦ development of HEP detectors on the long term
- Full proposal developed in the last year
  - ✦ Effort driven by Michael Doser (CERN) and Marcel Demarteau (Oak Ridge)
  - ✦ Two community workshops [link]
- Re-structured the Roadmap topics into WPs
  - ✦ Many reports and documents as deliverables, but this is in the nature of this proposal (early TRL)
- Draft proposal was submitted to DRDC end of February 2024 and sent to interested institutions; 96 groups, 344 participants
  - ✦ **Approved in June 2024**

Roadmap topics

Proposal WP's

Sensor family → / Work Package ↓	clocks & clock networks	superconduct-ing & spin-based sensors	kinetic detectors	atoms / ions / molecules & atom interferometry	opto-mechanical sensors	nano-engineered / low-dimensional / materials
WP1 *Atomic, Nuclear and Molecular Systems in traps & beams*	X			X	(X)	
WP2 *Quantum Materials (0-, 1-, 2-D)*		(X)	(X)		X	X
WP3 *Quantum super-conducting devices*		X				(X)
WP4 *Scaled-up massive ensembles* (spin-sensitive devices, hybrid devices, mechanical sensors)		X	(X)	X	(X)	X
WP5 *Quantum Techniques for Sensing*	X	X	X	X	X	
WP6 *Capacity expansion*	X	X	X	X	X	X

WP-2 (0-,1- and 2-D materials)

WP-2a	→ characterization protocol	→ database definition	→	populated db
(application-specific tailoring)	*protocol*	*Database prototype*		*Functional database*
WP-2ab	→ workshop/conference	→ device designs	→	novel hybrid devices
(extended functionalities)	*Device concepts*	*Prototype devices*		*Functional devices*
WP-2c	→ status & desiderata	→ prototype model	→	benchmarked simulations
(simulations)	*Report*	*Simulation SW designs*		*Validation report*

DRD6: Calorimetry

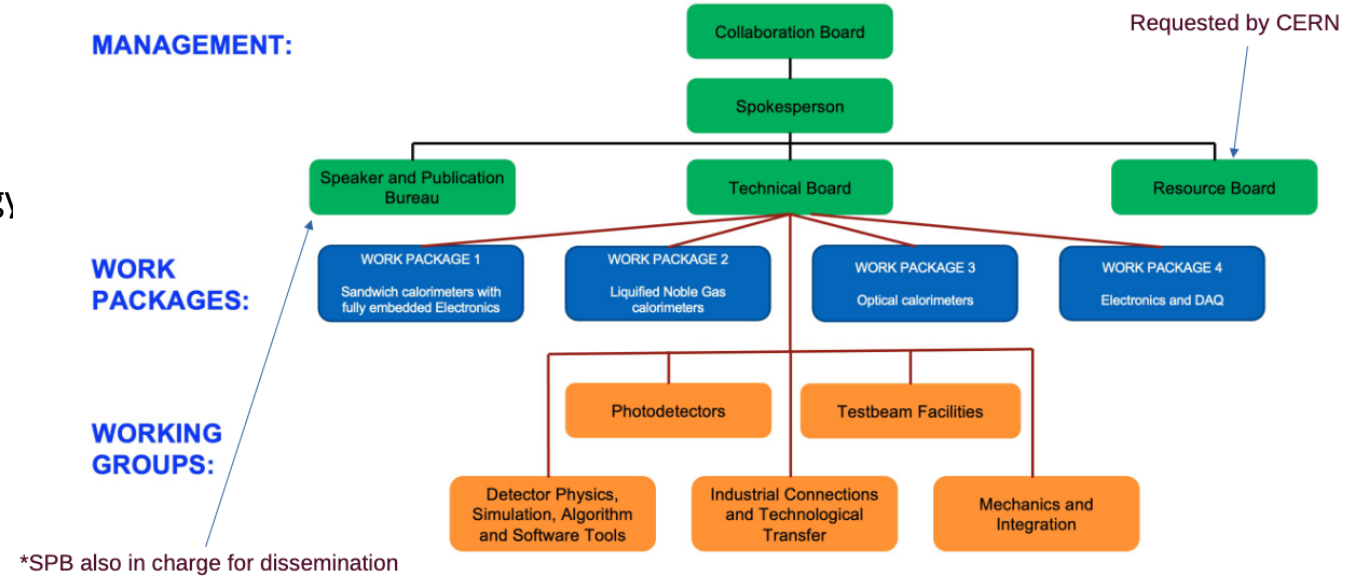
- Collaboration emerged from several collaborations like CALICE and CrystalClear (RD18)
- 131 institutions; CB chair: Roberto Ferrari; Spokesperson: Roman Poeschl
- Targets: high granularity, timing resolution, hadronic energy resolution
- 1st Community Meeting 12/1/23 https://indico.cern.ch/event/1212696/
- Input proposals collected until 1st of April 2023
- 2nd Community Meeting 20th April 2023 https://indico.cern.ch/event/1246381/
- Input proposals have been condensed into a DRD final version proposal, submitted to DRDC on November 15th
- DRD-on-Calorimetry approved by CERN Research Board on December 6th to start on January 1st 2024
- **DRD6 Collaboration Meeting at CERN** (9-11 April 2024)
  - ✦ https://indico.cern.ch/event/1368231/

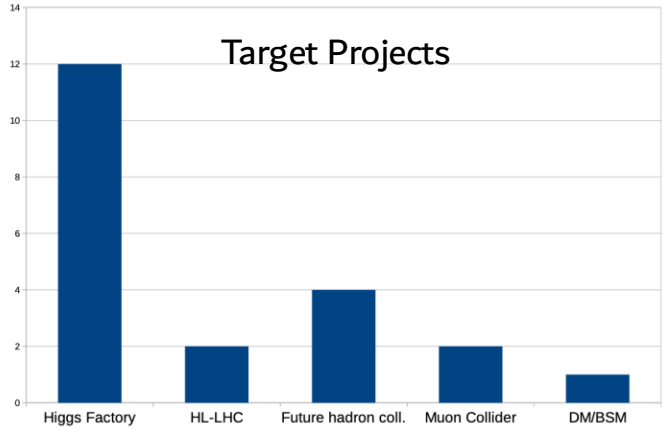
Calorimetry

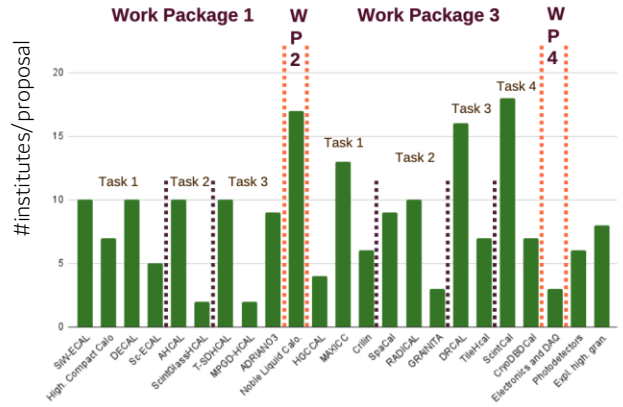
DRDT 6.1 Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution

DRDT 6.2 Develop high-granular calorimeters with multi-dimensional readout for optimised use of particle flow methods

DRDT 6.3 Develop calorimeters for extreme radiation, rate and pile-up environments







DRD7: Electronics

- Full proposal received by 29 February 2024; **approved in June 2024**
- Objectives: Carry out strategic R&D in electronics, fulfilling DRDTs, Coordinate cross-European access to technologies, tools and knowledge, Interface with other DRDs (No orthogonal “Service-Provider” for other DRDs)
- Organization: 19 countries, 68 institutes
  - ✦ Somehow CERN-centric at present, e.g. 9/19 WG conveners
  - ✦ 1st workshop happened in March, 2nd workshop 25-27 Sept 2023, 1st collaboration meeting planned 9-10 Sept 2024

Electronics

DRDT 7.1 Advance technologies to deal with greatly increased data density

DRDT 7.2 Develop technologies for increased intelligence on the detector

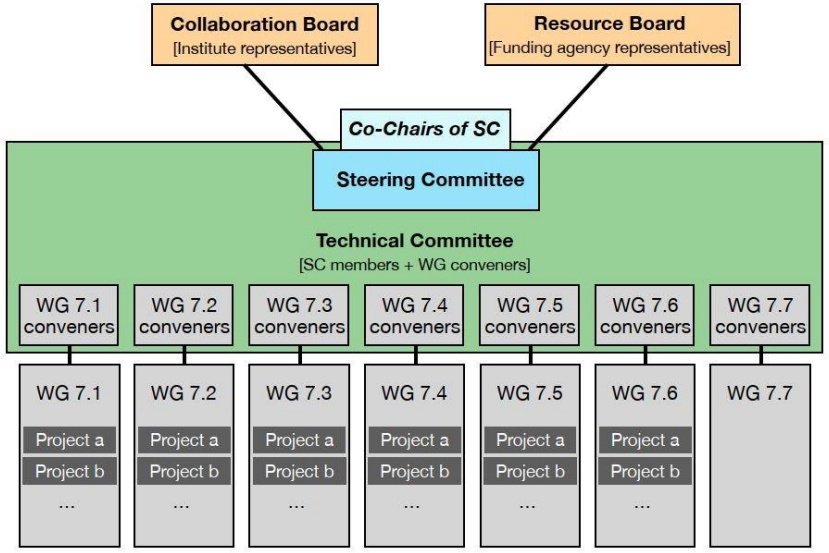
DRDT 7.3 Develop technologies in support of 4D- and 5D-techniques

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

WG 7.6 Complex imaging ASICs and technologies

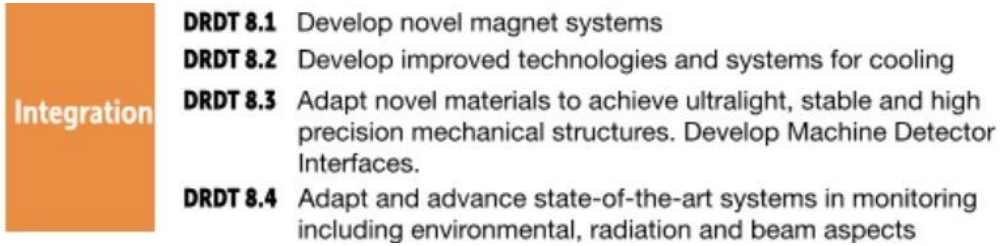
WG 7.7. Transversal Tools and Technologies



Nomenclature to be adapted

DRD8: Integration

- Initial TF convenors did not continue as proposal preparation team
- New proponents had to be searched for, which were found by the group around the “Forum on Tracker Mechanics” workshop organizers
  - ✦ Burkhard Schmidt (CERN) and Andreas Mussgiller (DESY)
- Community survey replied that there is an interest in going forward
- Community Meeting on December 6, 2023
- LoI received by end of February 2024 with the aim to write a full proposal by the end of this year
  - ✦ LoI does not cover all DRDTs, as they are quite diverse
  - ✦ Focus on vertex detector mechanics and cooling
  - ✦ 22 institutes in 7 countries, 32 FTEs at the moment



Summary

- New CERN-hosted Detector R&D (DRD) collaborations are currently being set up following ECFA Detector roadmap to pave the way for the next decades and address the future instrumentation needs.
  - ✦ First DRD collaborations already starting up, and the others following soon.
- **Next steps** of the collaborations: completing organization structure, electing and endorsing convenors, re-defining deliverables, MoU writing, getting financial commitments from funding agencies, and start working together
- DRDC will review the progress of DRDs
  - ✦ DRDC 13-14 Nov 2024: DRD1, 2, 4 & 6 status reports after one year
  - ✦ DRDC 24-25 Feb 2025: DRD3, 5 & 7 status reports

General Strategic Recommendations

The General Strategic Recommendations (GSR) topics are:

- GSR 1: Supporting R&D facilities (**test beams, large-scale generic prototyping and irradiation)**
- 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**

Committee Members

ECFA Detector Panel (EDP):

- Co-chairs: ***Phil Allport*** *(Birmingham),* ***Didier Contardo*** *(Lyon), Felix Sefkow*
- Scientific secretary: *Doris Eckstein (DESY)*
- Gaseous Detectors: *Silvia Dalla Torre (Torino)*
- Liquid Detectors: ***Inés Gil Botella*** *(CIEMAT)*
- Solid State Detectors: *Doris Eckstein, Phil Allport*
- PID & Photon Detectors: ***Roger Forty*** *(CERN)*
- Quantum and emerging Technologies: *Steven Hoekstra (Groningen)*
- Calorimetry: ***Laurent Serin*** *(IJCLab)*
- Electronics: *Valerio Re (Bergamo)*
- Ex Officio: *ECFA Chair (Paris Sphicas), ICFA Detector Panel (Ian Shipsey), DRDC chair (**Thomas Bergauer**), APPEC & NuPECC observers*

Detector R&D Committee (DRDC):

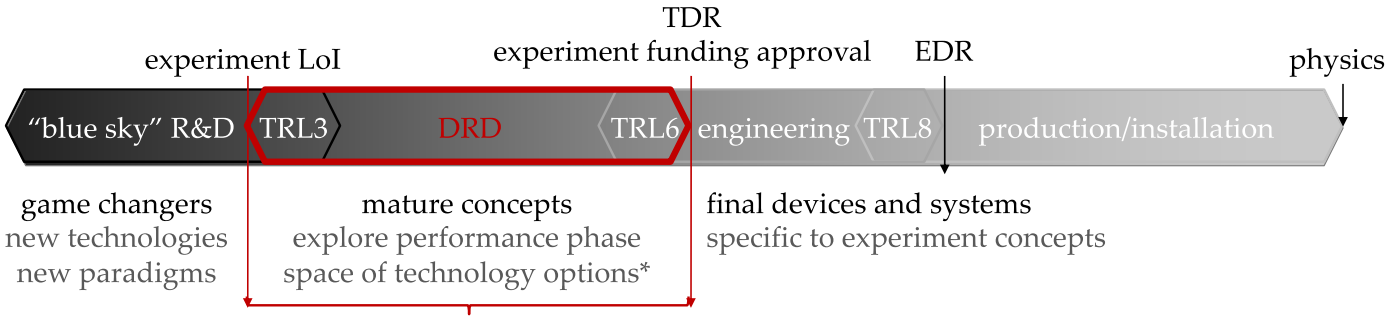
- ***Thomas Bergauer*** (HEPHY Vienna), Chairperson
- *Jan Troska* (CERN), scientific secretary
- *Stan Bentvelsen* (NIKHEF; LDG contact)
- *Shikma Bressler* (Weizmann)
- *Dimitry Budker* (Mainz)
- ***Roger Forty*** (CERN; RB contact)
- *Claudia Gemme* (INFN and U. Genoa)
- ***Inés Gil Botella*** (CIEMAT)
- *Petra Merkel* (Fermilab; US contact)
- *Mark Pesaresi* (Imperial College)
- ***Laurent Serin*** (IJCLab)
- Ex-officio: **P. Allport, D. Contardo** (EDP)

Names in bold in both committees

Strategic R&D

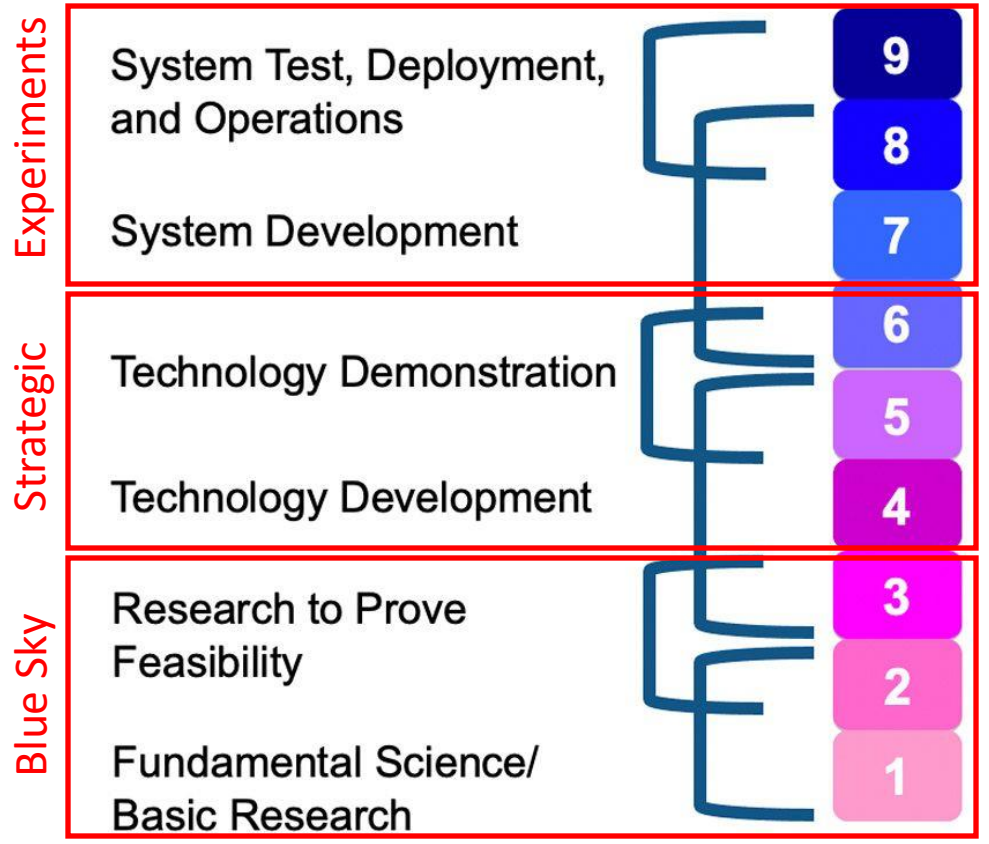
Strategic R&D bridges the gap between the idea ("**blue sky research**", TRL 1-3) and the **deployment and use in a HEP experiment** (TRL 8-9)

- Detector R&D Collaboration should address TRLs from 3 to 7, before experiment-specific engineering takes over
- Covers the development and maturing of technologies, e.g.
  - ✦ Iterating different options
  - ✦ Improving radiation hardness
  - ✦ Scaling up detector area, number of layers,..
- Backed up by **strategic funding**, agreed with funding agencies



Technology Readiness Levels (TRLs) 1-9:

Method for estimating the maturity of technologies



Didier Contardo

Blue Sky R&D

- Blue Sky R&D is basic research where "real-world" applications are not immediately apparent.
  - ✦ Covers very low Technology Readiness Levels
  - ✦ Starting point of development

- **EU-funded programs** play an important role in enabling and supporting generic R&Ds in Europe: AIDA/2020/innova, ATTRACT, ERC grants
  - ✦ Not existing in other parts of the world to this extent
  - ✦ Successor to AIDAinnova planned

- **Common fund** of RD50/RD51 was used to fund “common projects” which can be seen as blue sky
  - ✦ RD50 rules: minimum 3 institutes; financial contribution is doubled by RD50
  - ✦ MoU has a paragraph about common fund; can or cannot be used by DRD collaborations, but allows to start collecting money by simple CB vote, without having formal update of MoU

Resources Board

- Collaboration Board as (scientific and technical) representation of collaborating institutions
- Resources Board as a representation of funding agencies
  - ✦ Definition of a Funding agency:
    - Collaborating institutions themselves, if they have the authority for the committed funds
    - or a body acting on behalf of one or several institutions in the conclusion of the MoU (e.g. INFN)
- Creation (and termination?) of working groups and work packages require approval by CB and RB
  - ✦ No funding agency involved must object
- There have been suggestions that the RB meetings of all DRD collaborations should happen in a common way, similar to what happens for LHC RRB
  - ✦ Common plenary session for all four LHC experiments, then more detailed individual meetings for each of the four over two days.