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DRD6 Collaboration Meeting

History, Status and Next Steps for setting up DRD Collaborations

Thomas Bergauer

9 April 2024

European Strategy on Particle Physics

<http://europeanstrategy.cern>

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 hadron 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. [... **The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels..**
 - Successful completion of High-Luminosity LHC must remain key focus
- **Update 2026** on the horizon with input proposals by spring 2025



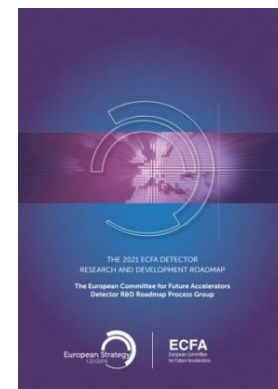
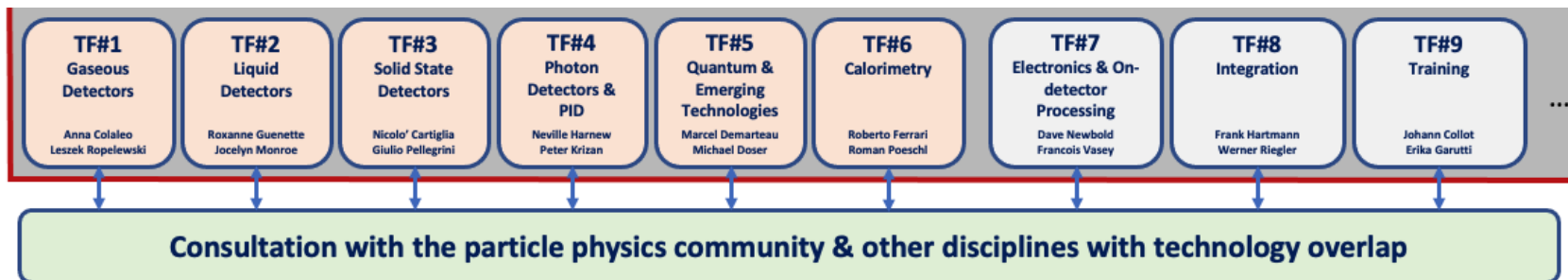
<http://dx.doi.org/10.17181/CERN.JSC6.W89E>

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

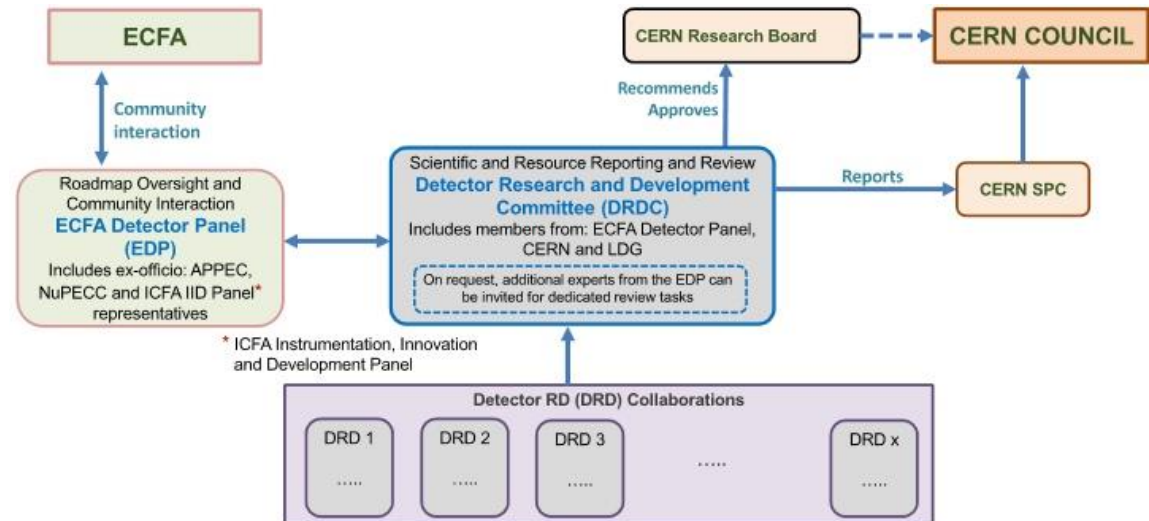
The full document can be referenced as DOI: 10.17181/CERN.XDPL.W2EX

- 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)**



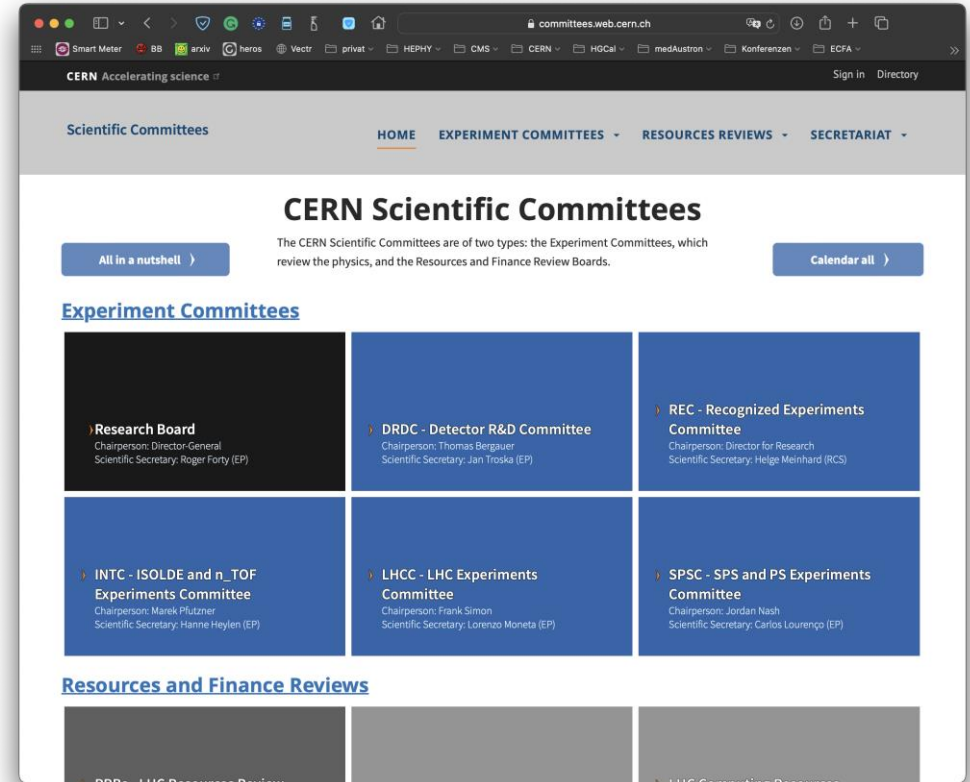
Roadmap implementation plan

- Approved by CERN SPC and Council in fall 2022 ([CERN/SPC/1190](https://cern.ch/spc/1190); [CERN/3679](https://cern.ch/council/3679))
- **CERN will host DRD collaborations**
 - Interaction between DRD collaborations and committees through DRDC
 - Interface to ECFA via ECFA Detector panel: <https://ecfa-dp.desy.de>
- Distinction between reviewing body (DRDC) and advising body (EDP)
- EDP also provides input to the next Strategy update



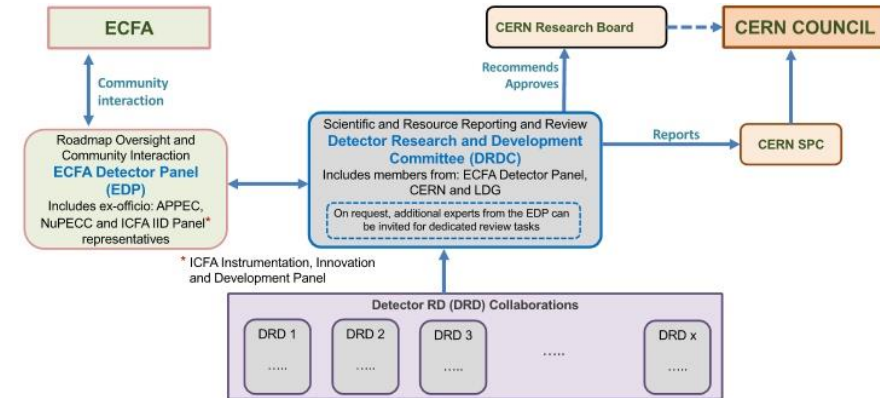
DRD Committee (DRDC)

- Detector R&D Committee is a new committee on the same level as SPSC and LHCC
 - Established 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



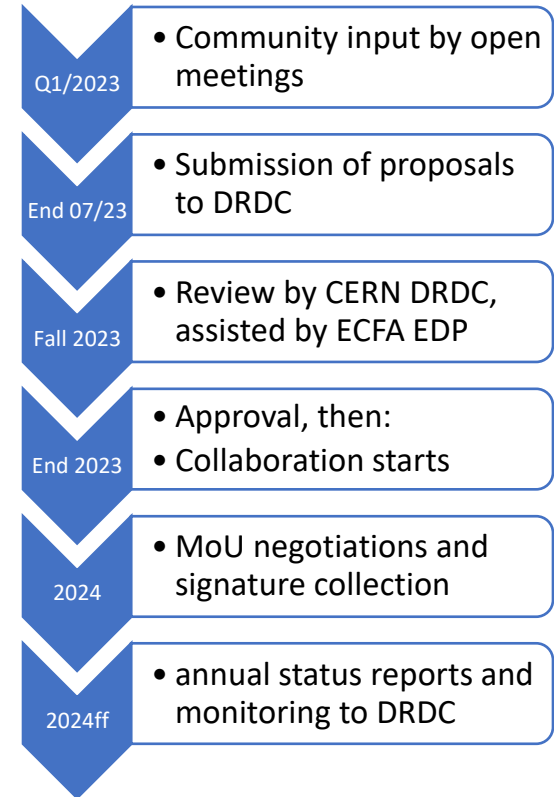
DRDC and ECFA EDP

- Detector R&D Committee (DRDC):
 - “Reviewing body”
 - Monitoring milestones and deliverables
 - Embedded in “CERN hierarchy”, reporting to RB
- ECFA Detector Panel (EDP):
 - “Advising body”, full mandate to be found [here](#)
 - Started to organize “DRD Managers Forum” recently
 - Organizing exchange across different DRDs
 - Define common terminology
 - Heritage from “full panel” meetings during proposal preparation
 - Providing input to European Strategy for Particle Physics Update 2026
 - Input proposals until 31 March 2025, “Granada” style meeting summer 2025



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



MoU Template

- CERN provides templates for the Memorandum of Understanding
 - 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 (previously called “lightweight”) is the only one which is physically/electronically signed by each institution; 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 Units** 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 finance committee meeting (with representatives of funding agencies)
- Status: First draft of MoU Template is available for CERN-internal review (legal service, DRC,...)

- 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 their sub-units (“work units”)
- Annex 7: Background IP
- Annex 8: CERN General Conditions Applicable to Experiments

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.

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
 - DRDC member Petra Merkel (FNAL) was CPAD co-chair until recently
 - Now Jonathan Asaadi (Texas) involved in DRD2
 - They created 11 RDCs (R&D Collaborations) and appointed coordinators (see https://cpad-dpf.org/?page_id=1549)
 - Calorimetry coordinators: Marina Artuso, Minfang Yeh
 - 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

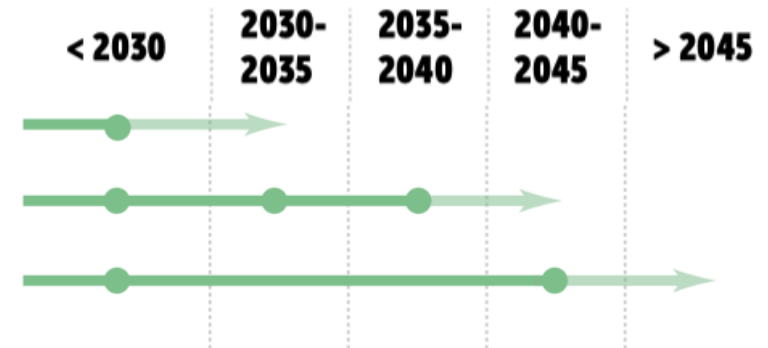
RDC#	TOPIC
1	Noble Element Detectors
2	Photodetectors
3	Solid State Tracking
4	Readout and ASICs
5	Trigger and DAQ
6	Gaseous Detectors
7	Low-Background Detectors
8	Quantum and Superconducting Sensors
9	Calorimetry
10	Detector Mechanics
11	Fast Timing

R&D Topics in ECFA Roadmap

- The most urgent R&D topics in each Task Force area are identified by **Detector Readiness Matrix**
- **Detector R&D Themes (DRDTs)** were formulated as high-level deliverables

Calorimetry

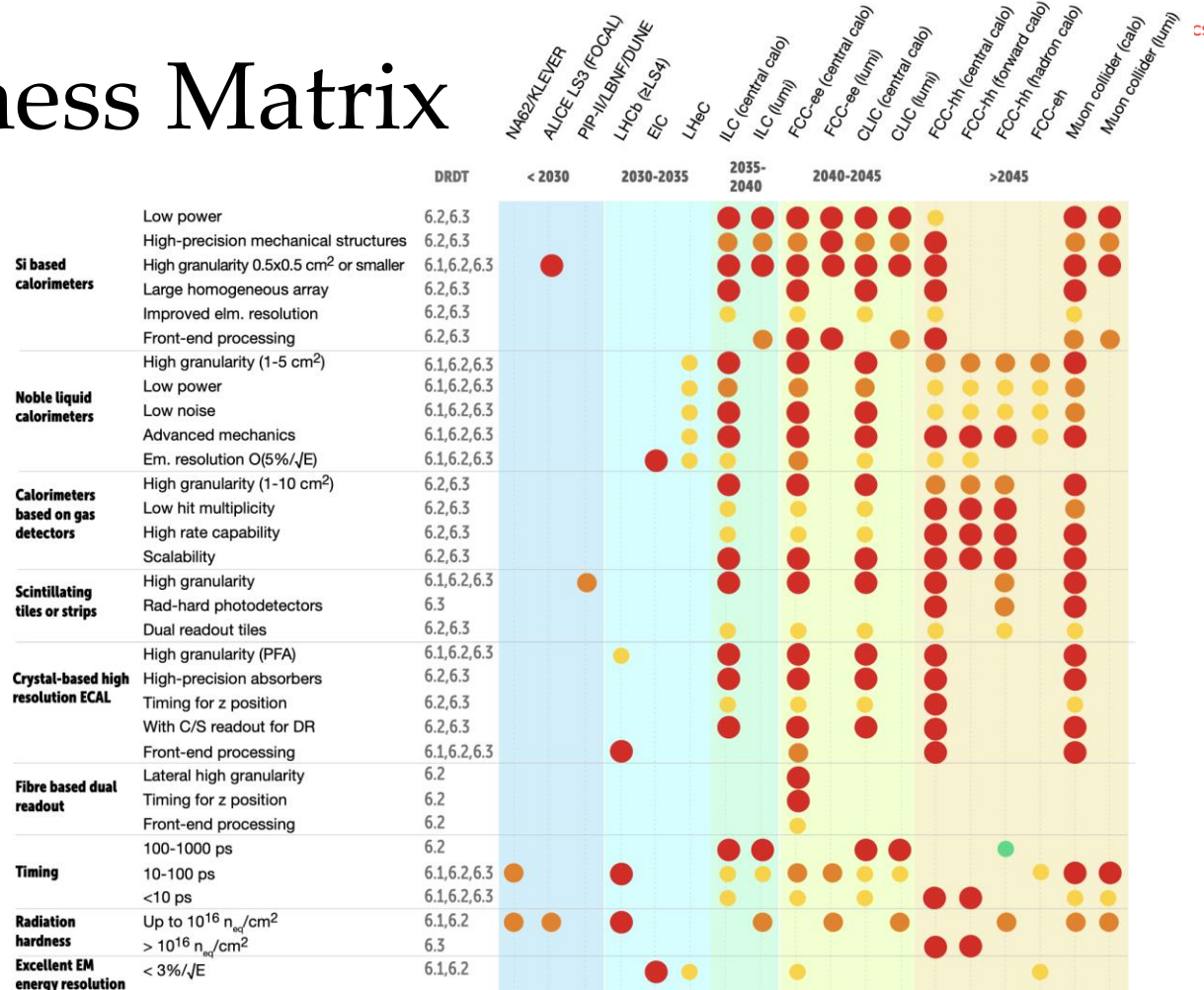
- DRDT 6.1** Develop radiation-hard calorimeters with enhanced electromagnetic **energy and timing resolution**
- DRDT 6.2** Develop high-granular calorimeters with multi-dimensional readout for optimised use of **particle flow methods**
- DRDT 6.3** Develop calorimeters for **extreme radiation, rate and pile-up environments**





Detector Readiness Matrix

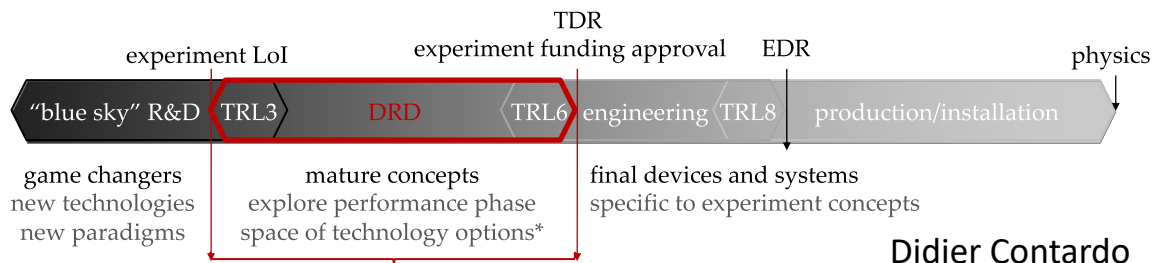
- Looks like no short-term deliverables exist
 - Many goals for ILC and FCC-ee
- DRD6 proposal has several deliverables and milestones within next three years
 - Necessary to track progress by DRDC



Strategic R&D

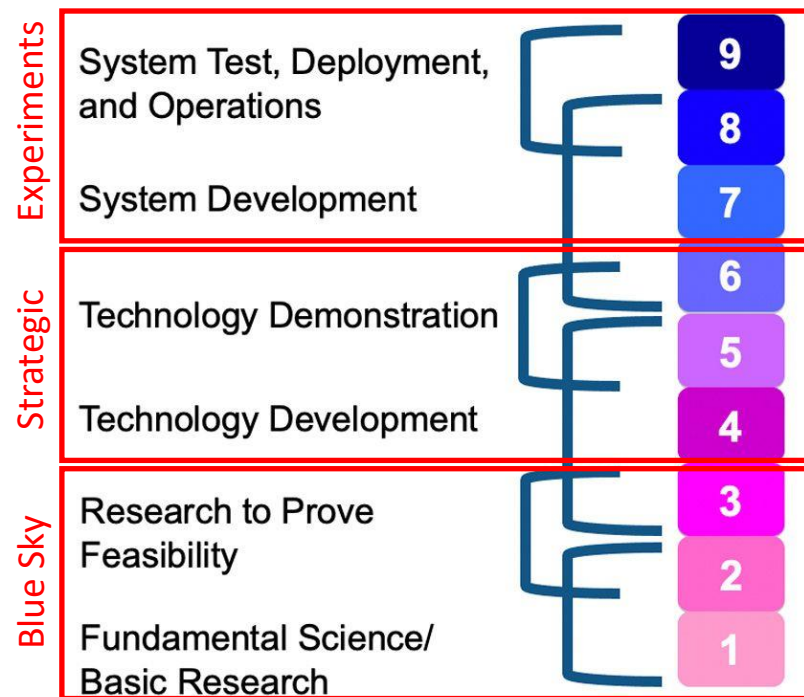
Strategic R&D bridges the gap between the idea (“blue sky research”, TRL 1-3) and the **deployment and use in a HEP experiment** (TRL 8-9)

- 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



Didier Contardo

Technology Readiness Levels (TRLs) 1-9:
Method for estimating the maturity of technologies



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 (Three in silicon community *)!
- **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

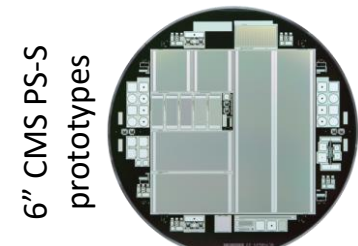
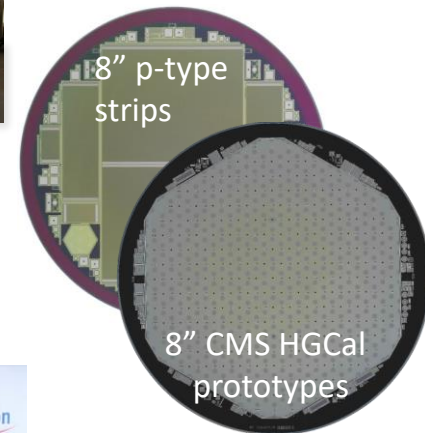
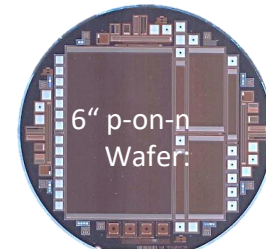
Example for the need of strategic R&D

My group worked for almost a decade with European semiconductor industry to find a “second source” for large-area planar Si sensors (targeting Phase-II Upgrades)

- Attracted a lot of attention
- Pushed HPK into developing 8” process
→ now being used for CMS HGCal
- Milestones:
 - 2009: re-produce 6” p-on-n strip sensors
 - 2015: First AC-coupled strip sensors on 8” wafers
 - 2016/17: production of first 8” hexagonal HGCal sensors
 - 2018: **program stopped due to economic reasons**

Reason for termination of program before series production:

- O(10) more wafer runs (~150k€ each) would have been necessary to mature the technology
- Strategic R&D funding for R&D costs → reduction of series production costs



Detector R&D collaborations

Highlights of organization and structure

Status DRD Collaborations

Fully Approved for an
initial period of 3 years
by CERN Research Board
in December 2023

- Gaseous Detectors (DRD1) [ex RD51]
- Liquid Detectors (DRD2)
- Photodetectors & Particle ID (DRD4)
- Calorimetry (DRD6)

Reports at open session of DRDC meeting: <https://indico.cern.ch/event/1356910/>
Full Proposals in [CERN CDS](#)

Conditionally approved

- Semiconductor Detectors (DRD3) [ex RD50, RD42,..]

Full proposals submitted
last week for review

- Quantum Sensors (DRD5)
- Electronics (DRD7)

Both aim for approval in June

Letter of Intent submitted

- Integration (DRD8)

Full Proposal to be written
by the end of this year

DRD1: Gaseous Detectors

Gaseous

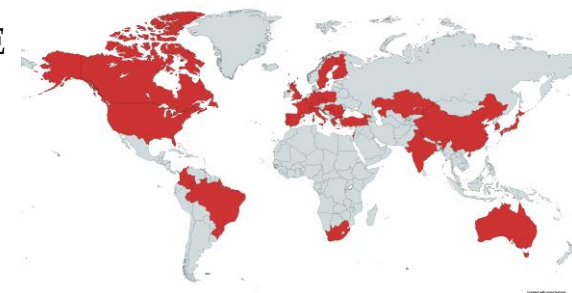
- DRDT 1.1** Improve time and spatial resolution for gaseous detectors with long-term stability
- DRDT 1.2** Achieve tracking in gaseous detectors with dE/dx and dN/dx capability in large volumes with very low material budget and different read-out schemes
- DRDT 1.3** Develop environmentally friendly 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 161 institutes, 700 members, 33 countries
- Anticipated budget: 3 MCHF/y existing, additional 3 MCHF/y requested, 270/100 FTE
- Elections Mid-December resulted in CB board chair : Anna Colaleo; Spokespersons : Eraldo Oliveri, Maxim Titov
- A collaboration website exists: <https://drd1.web.cern.ch>
- Collaboration meetings: 29.1. to 2.2.2024: [link](#), 2nd Collaboration Meeting June 17-21; 3rd Collaboration Meeting December (tbc) + 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

DRDTs

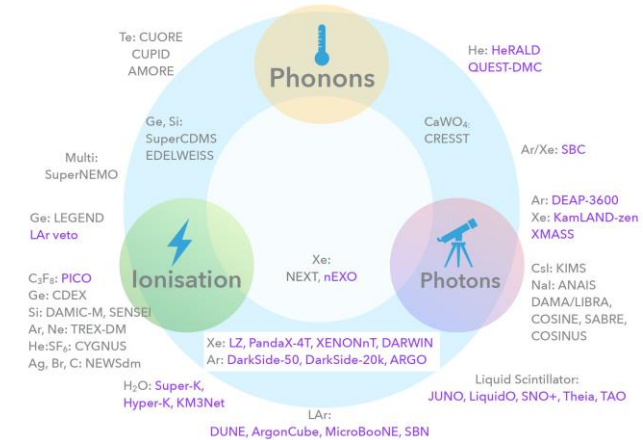
1.1	1.2	1.3	1.4	Work Packages
●	●	●		Trackers/hodoscopes
●	●	●		Drift chambers
●	●	●		Straw chambers
●	●	●	●	Tracking TPCs
●		●		Calorimetry
●	●	●		Photon detection (PID)
●		●		Timing detectors
●	●	●	●	Reaction/decay TPCs
●		●		Beyond HEP

Forum for discussion on common topics



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 resulted in CB board chair W. Bonivento



[ECFA roadmap,
[Modified from L.Baudis](#)]

Note: Developments in this field are rapid and it is not possible today to reasonably estimate the dates for projects requiring longer-term R&D



DRD3: Semiconductor Detectors

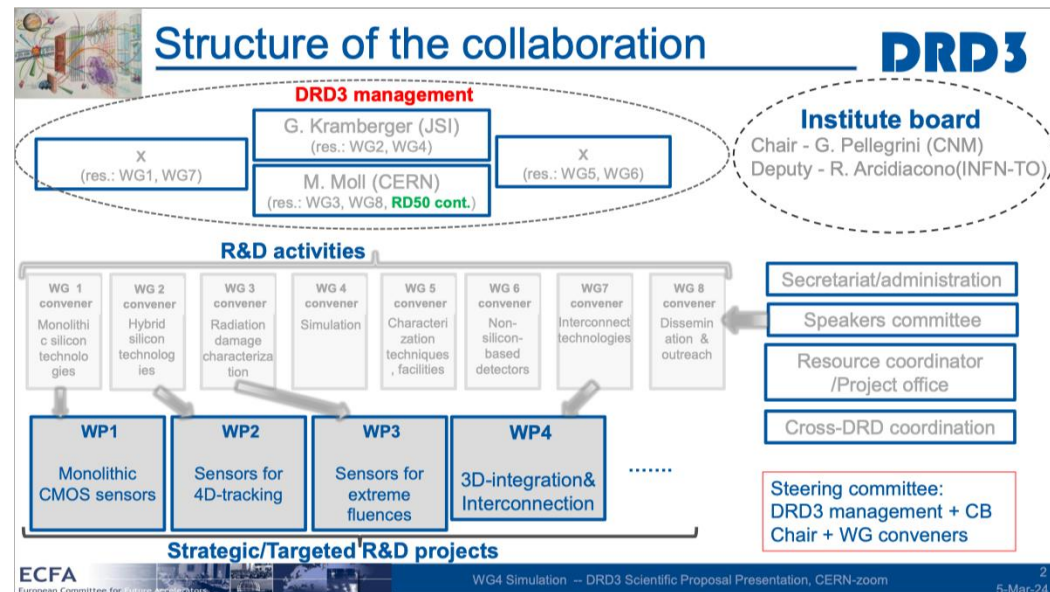
- DRD3 benefits from existing [RD50](#) collaboration
 - Extended by diamonds ([RD42](#)) and 3D integration
 - Large interest in CMOS (DMAPS) sensors

- Large Collaboration: 132 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)

- CB Board chair elected: Giulio Pellegrini (CNM Spain), deputy Roberta Arcidiacono (INFN Torino) nominated
- Spokesperson elected: Gregor Kramberger (JSI Slovenia)

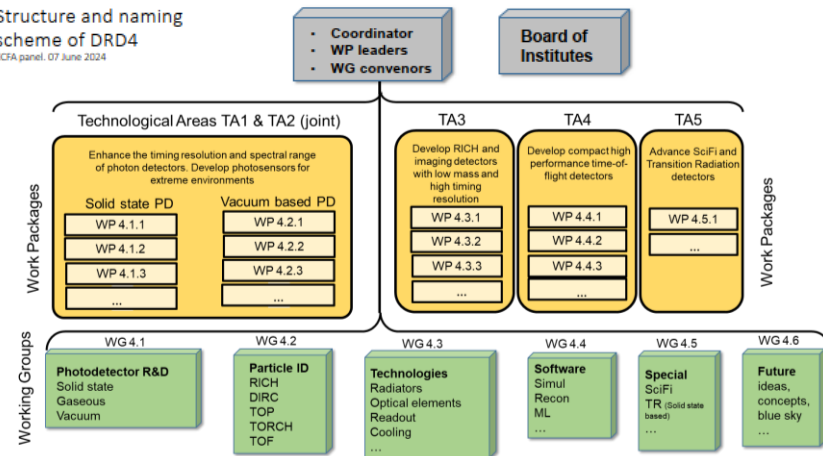
- Main work is planned to be performed in Working Groups, WP not yet well integrated, but they plan to call for WP projects



DRD4: Photodetectors & 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
- **DRD4 constitutional meeting** happened at CERN (23-24 January): <https://indico.cern.ch/event/1349233/>
 - CB board chair: Guy Wilkinson
 - Spokespersons: Massimiliano Fiorini
 - Most WP/WG chairs were elected as well

Structure and naming scheme of DRD4
ECFA panel, 07 June 2024



PID and Photon	DRDT 4.1	DRDT 4.2	DRDT 4.3	DRDT 4.4
	Enhance the timing resolution and spectral range of photon detectors	Develop photosensors for extreme environments	Develop RICH and imaging detectors with low mass and high resolution timing	Develop compact high performance time-of-flight detectors

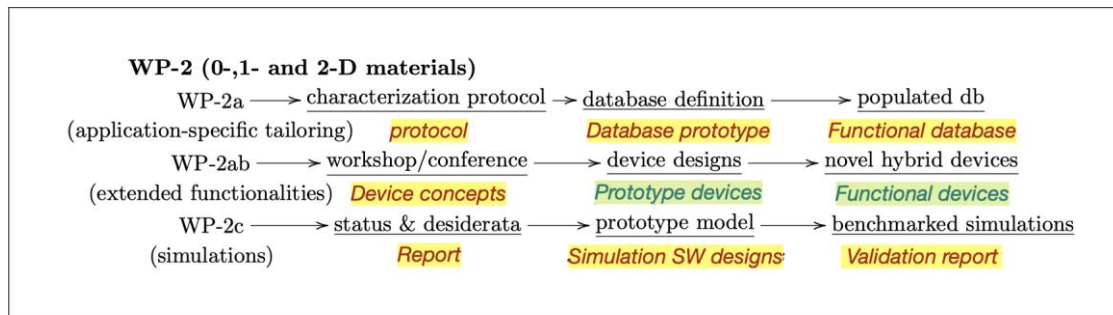
DRD5: Quantum Sensors

- 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; 67 signed up within two weeks
 - Aim to be approved in June**

Roadmap topics

Proposal WP's

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



DRD7: Electronics

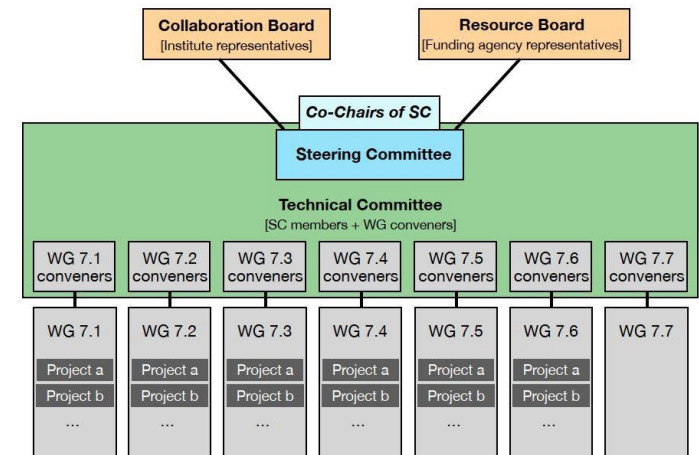
- Full proposal received by 29 February 2024; **aiming approval in June 2024**
- Objectives: Carry out strategic R&D in electronics, fulfilling DRDTs, Coordinate cross-European access to technologies, tools and knowledge, Interface with other DRDs
- Organization:
 - 19 countries, 68 institutes
 - Somehow CERN-centric at present, e.g. 9/19 WG conveners
 - [1st workshop](#) happened in March, [2nd workshop](#) 25-27 September 2023

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



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
- 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 FTE at the moment

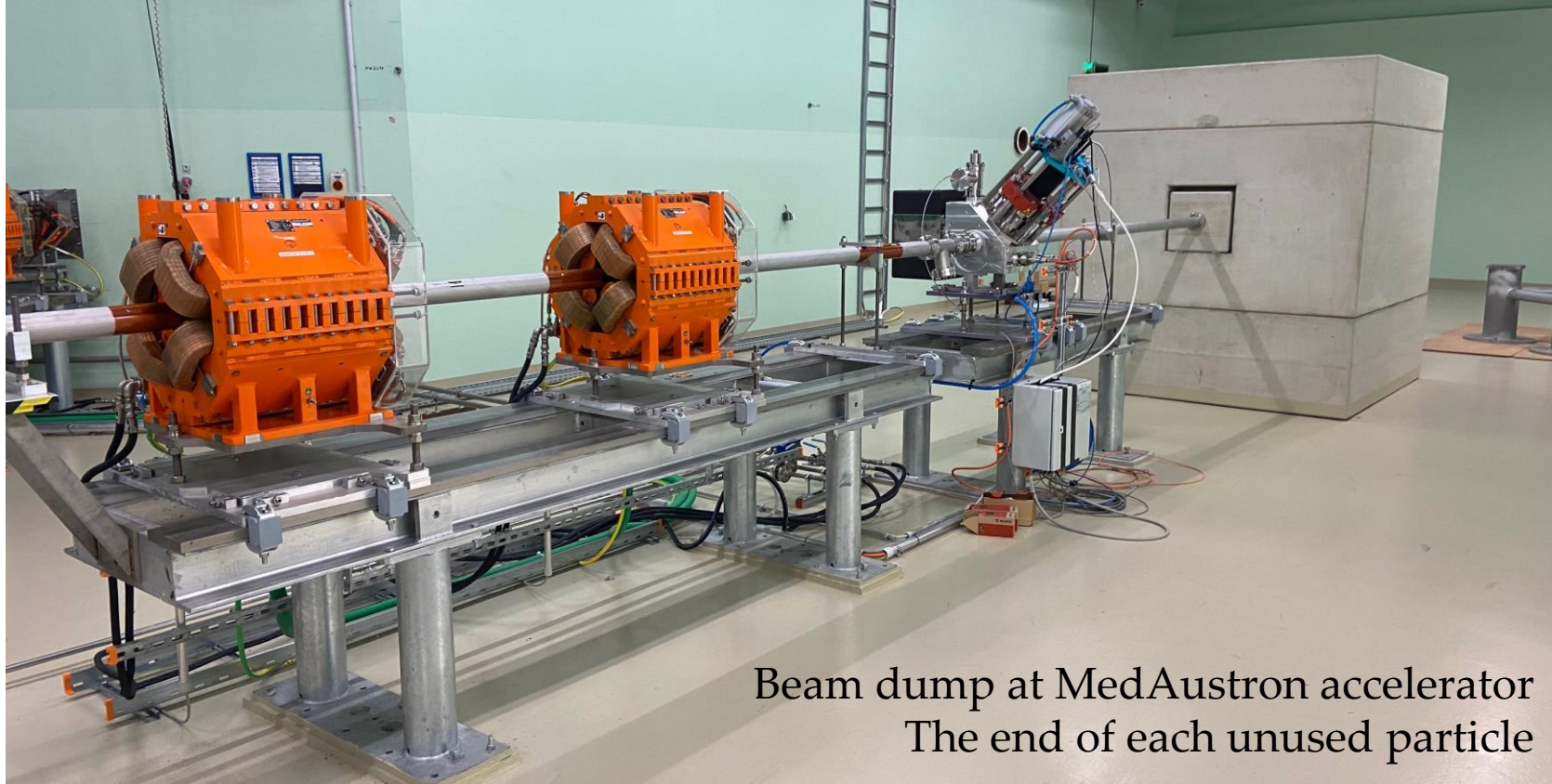
Integration

- 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

Summary

- **Instrumentation must not be the limiting factor to meeting the needs of the long-term European particle physics program**
- New Detector R&D (DRD) collaborations are currently being set up following ECFA Detector roadmap to pave the way for the next decades.
 - Collaborations are CERN-hosted
- We are on good track, having the 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

The End.



Beam dump at MedAustron accelerator
The end of each unused particle

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**

Future Large Experiments

- Five Time periods defined

(HL-)LHC timeline:



SPS fixed target
 Other fixed target, FAIR (hep)
 Belle II
 ALICE LS3
 PIP-II/LBNF/DUNE/Hyper-K
 ALICE 3
 LHCb (\geq LS4)
 EIC
 LHeC

ILC

FCC-ee
 CLIC

FCC-hh
 FCC-eh
 Muon Collider

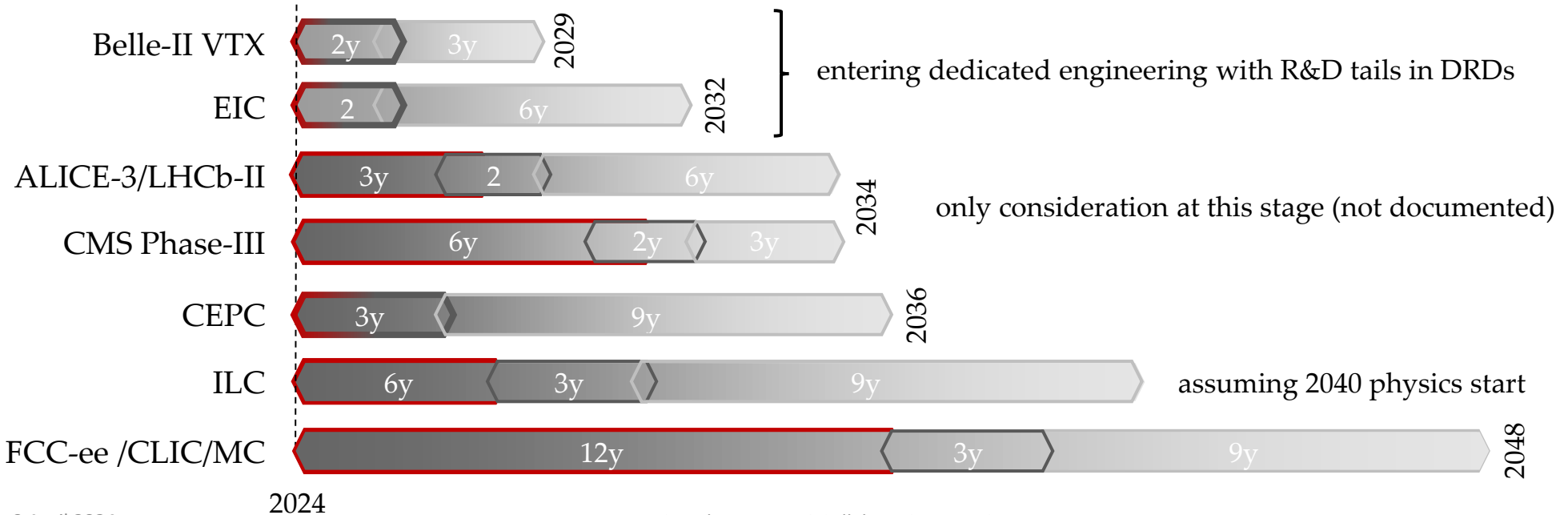
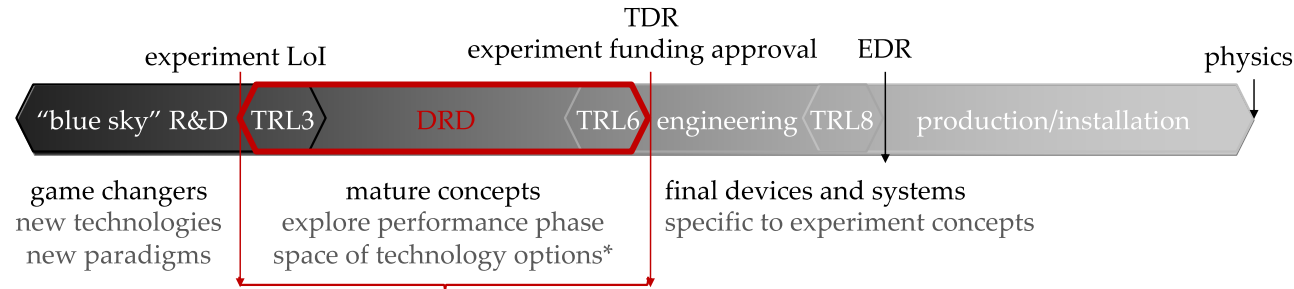


LHC LS3

LHC LS4

Broad timelines for future HEP Projects

Didier Contardo



Committee Members

ECFA Detector Panel (EDP):

- Co-chairs: **Phil Allport** (Birmingham), **Didier Contardo** (Lyon)
- 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