ÖAW AUSTRIAN ACADEMY OF SCIENCES

The European Strategy and Detector R&D Program

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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

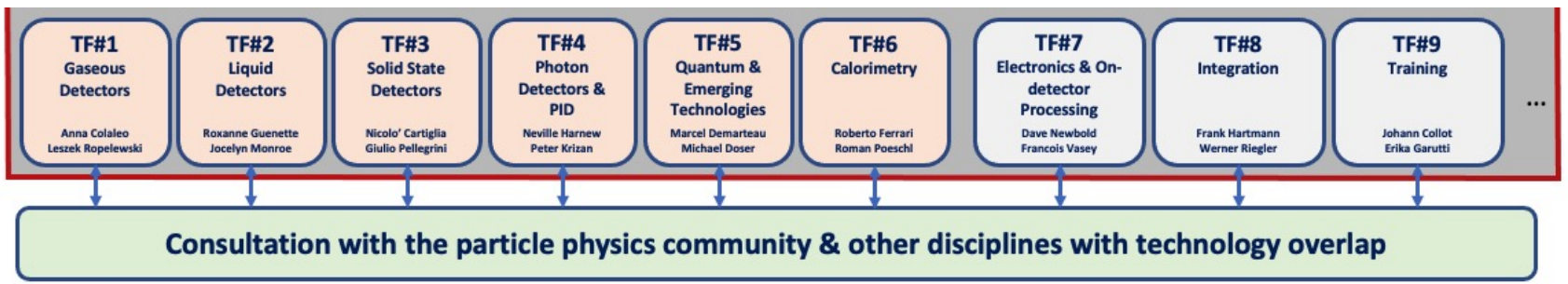
http://dx.doi.org/10.17181/CERN.JSC6.W89E

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

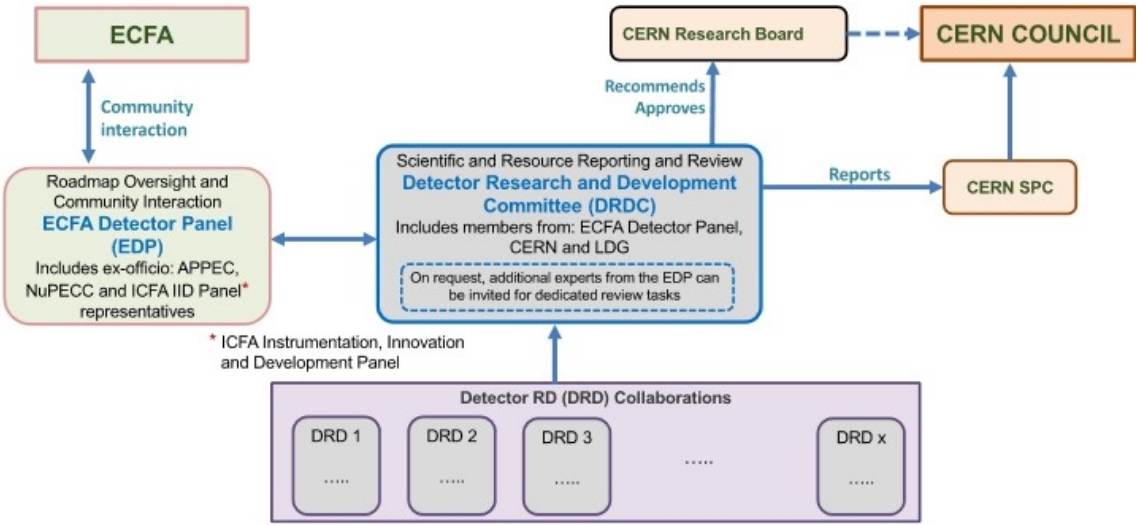
- Overview of **future facilities** (EIC, ILC, CLIC, FCC-ee/hh, Muon collider) or major **upgrades** (ALICE, Belle-II, LHC-b,…) and their **timelines**
- Ten "**General Strategic Recommendations**" (full list in backup slides)
- **Nine Technology domains** with **Task Forces** areas
  - The **most urgent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

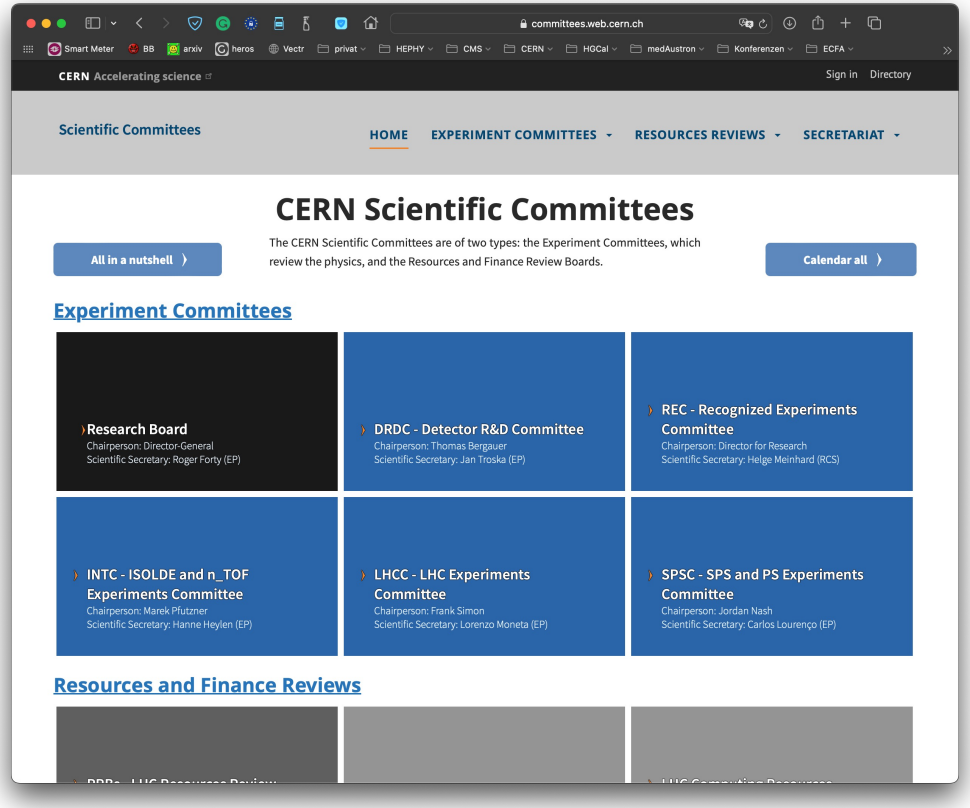
- Distinction between reviewing body (DRDC) and advising body (EDP)
- ECFA Detector Panel (EDP) interfaces to ECFA
  - Organizes "DRD managers forum"
  - provides input to the next Strategy update



DRD Committee (DRDC) at CERN

- 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

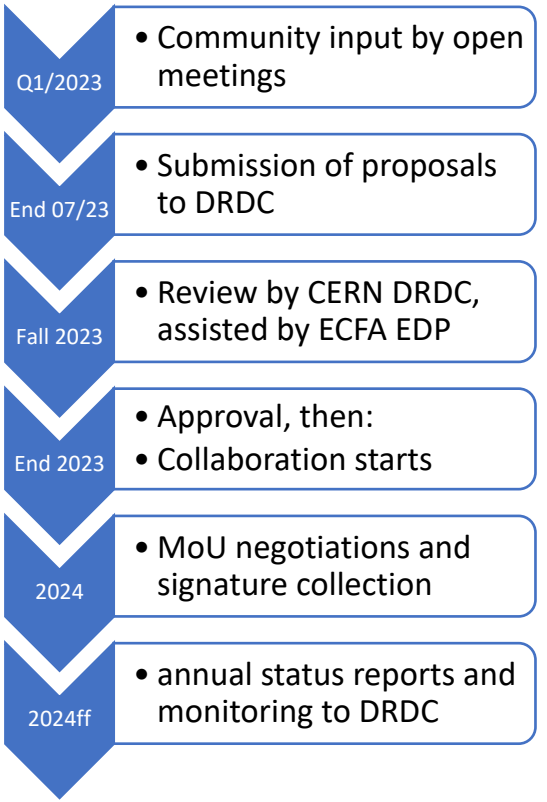


From ECFA Task forces to DRD collaborations

- 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 by CERN

- CERN will provide a template for the **Memorandum of Understanding between all institutes of each DRD collaboration (and CERN)**
  - To agree with CERN's *General Conditions for the execution of experiments*, legal service, KT office,…
- **Main MoU** is the only one that is physically/electronically signed by each institution; Contains: Obligations of CERN as host laboratory, industrial involvements, common fund, definitions of work packages, working groups. Meant to be unchanged during the whole collab. lifetime
- **Annexes**: everything that can change over time
  - Do 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,…)

- Note: DRD proposals are no funding applications
  - However, in some countries , it might help when funding applications are backed up by CERN-approved collaborations

- Annex 1: Collaborating Institutions and their Contact Persons
- Annex 2: Funding Agencies and their Representatives
- Annex 3: Organizational Structure of the Collaboration ("bylaws")
- Annex 4: Financial Participation of the Funding Agencies
- Annex 5: Working Groups
- Annex 6: Work Packages and sub-units (down to deliverable)
- Annex 7: Background IP
- Annex 8: CERN General Conditions Applicable to Experiments

R&D Topics in ECFA Roadmap

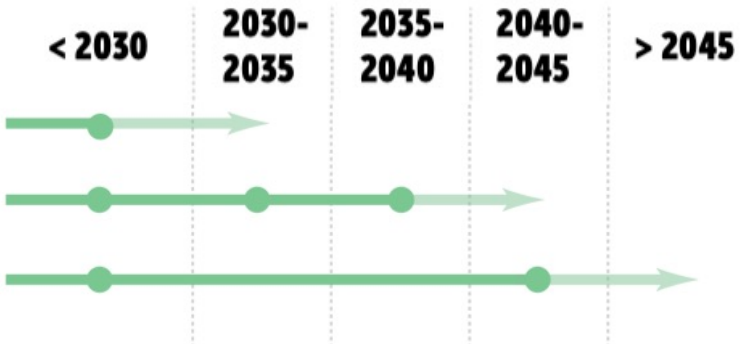
- **Detector R&D Themes (DRDTs)** were formulated as high-level deliverables
  - DRD 6 (calorimetry) shown as example here:

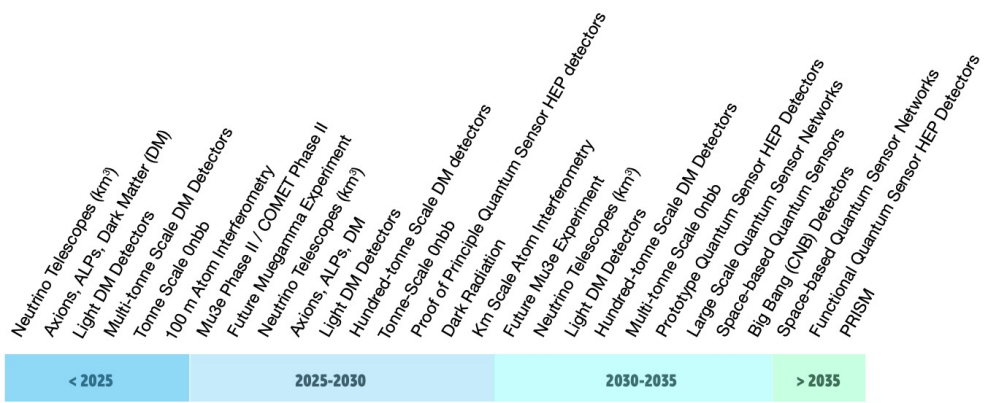
Calorimetry

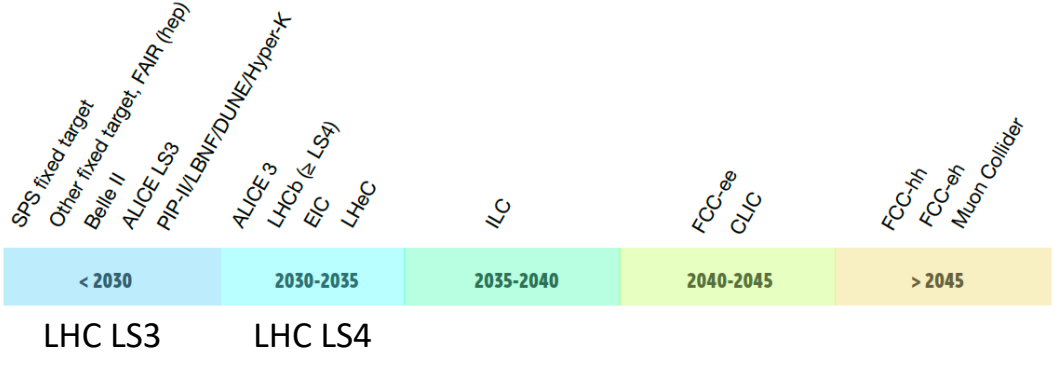
DRDT 6.1 Develop radiation-hard calorimeters with enhanced electromagnetic energy and timing resolution

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

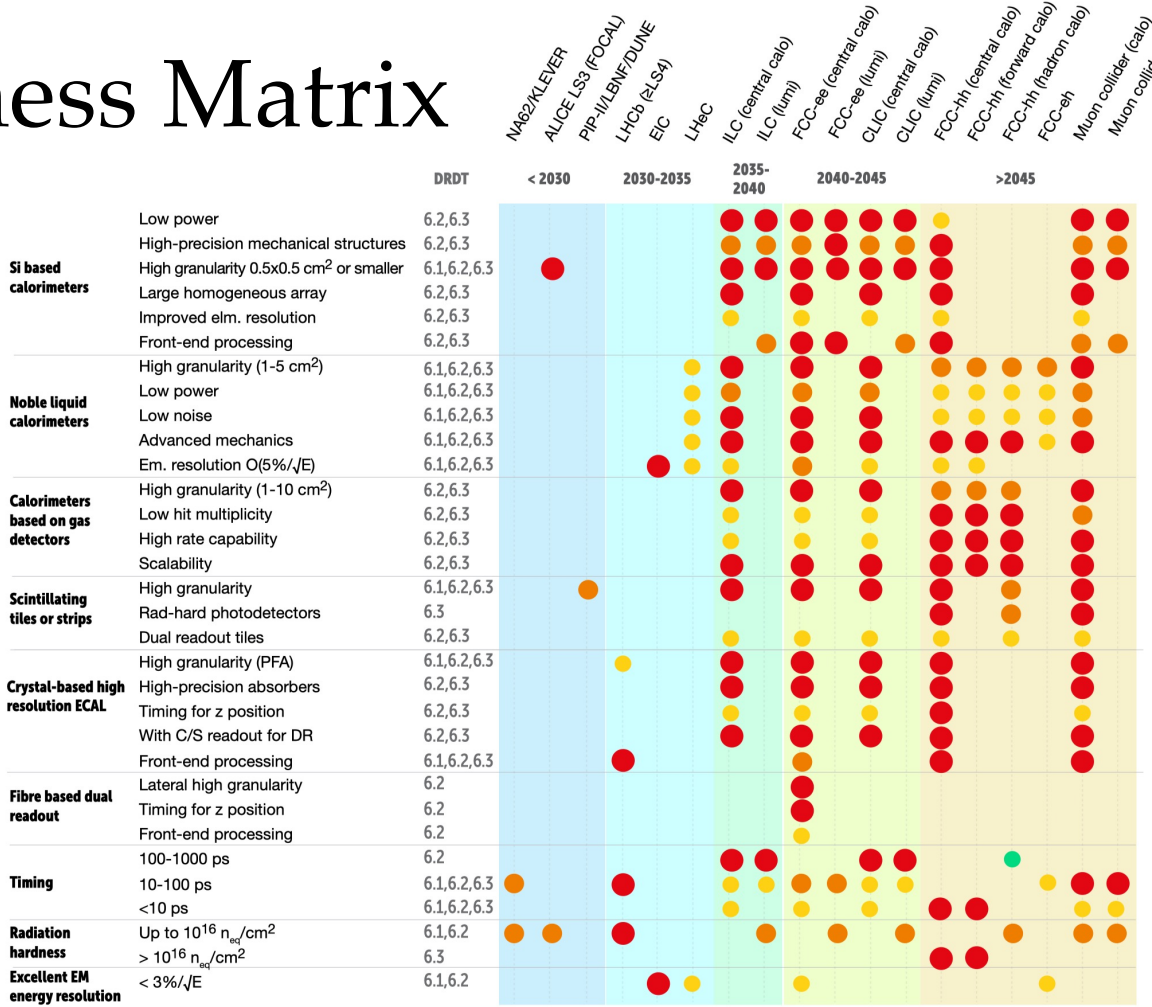






Detector Readiness Matrix

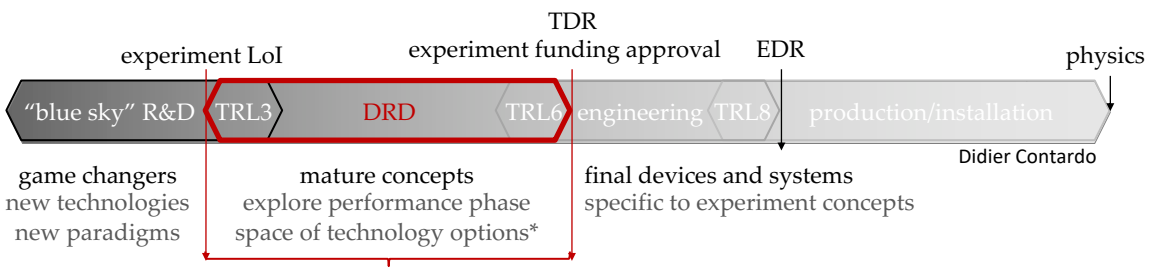
- Lists the **strategic R&D needs** of different topics in a traffic-light style system
- Used to define work packages, projects, deliverables in proposals written by proto-collaboration
  - Submitted for review to DRDC and approval by CERN RB
  - Progress tracked by annual DRDC review



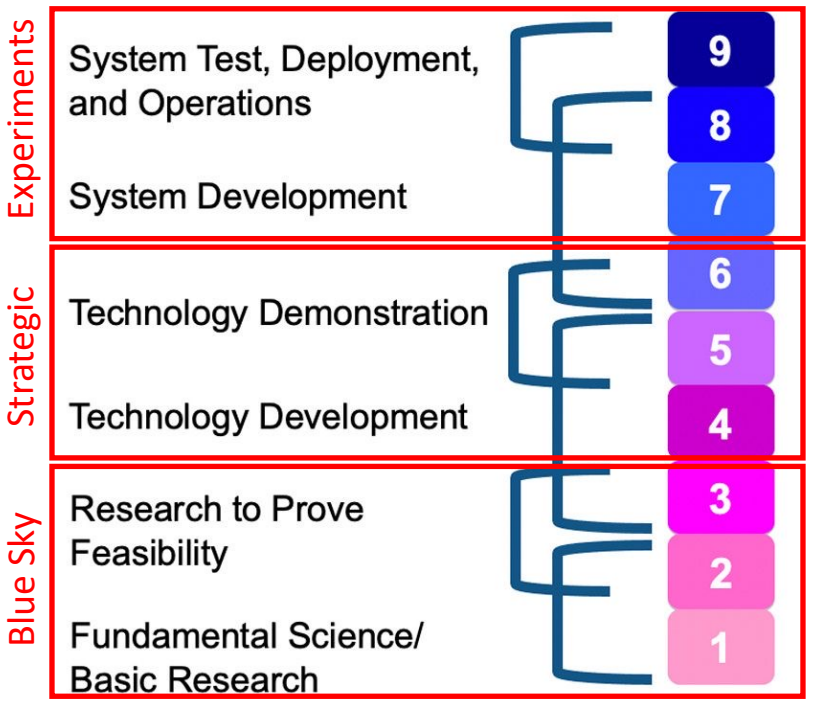
Strategic R&D

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



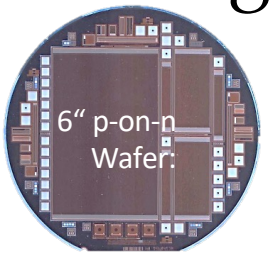
Blue Sky R&D

- Blue Sky R&D is basic research where "real-world" applications are not immediately apparent.
  - Covers very low TRLs (Technology Readiness Levels)
  - Starting point of development
- **EU-funded and national 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

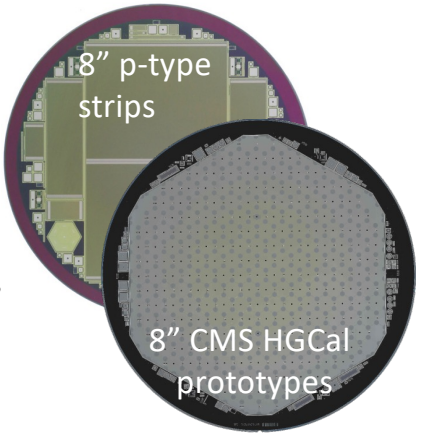
Example for the need of strategic R&D

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**

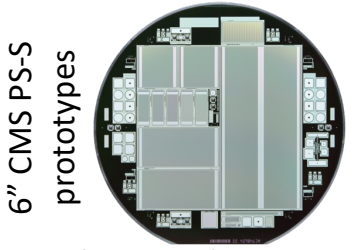



Infineon CEO together with HEPHY and CERN representatives



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



Similar effort driven by INFN with STMicroelectronics quite some time ago for planar sensors of LHC ("Phase-0")

Detector R&D collaborations

Highlights of organization and structure

DRD1: Gaseous Detectors

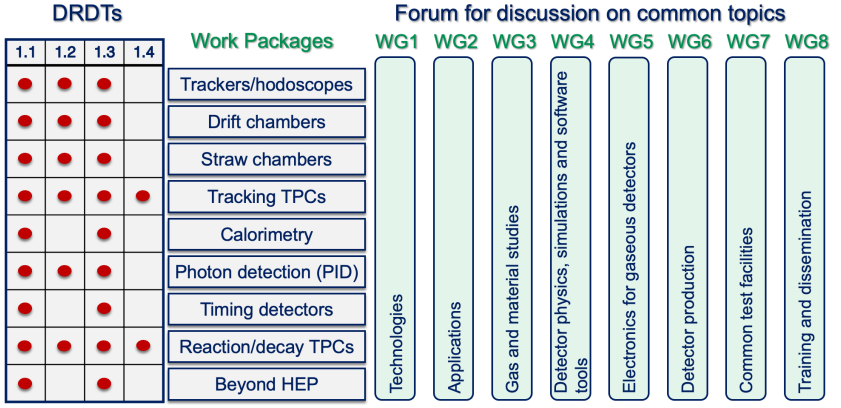
Gaseous

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

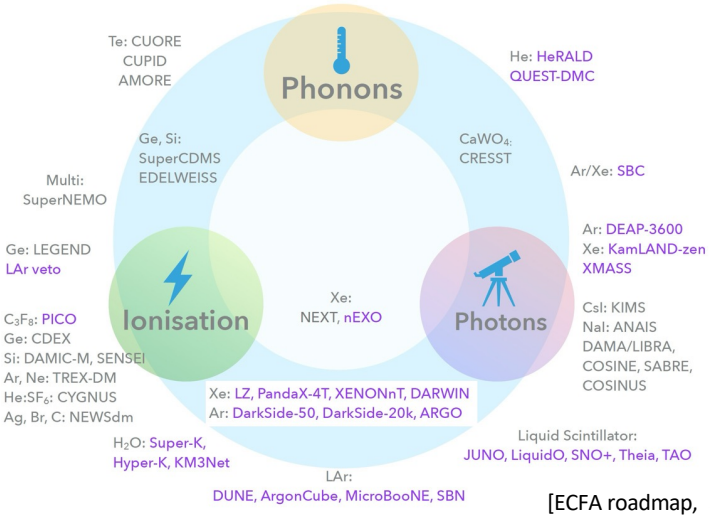
DRDT 1.4 Achieve high sensitivity in both low and high-pressure TPCs



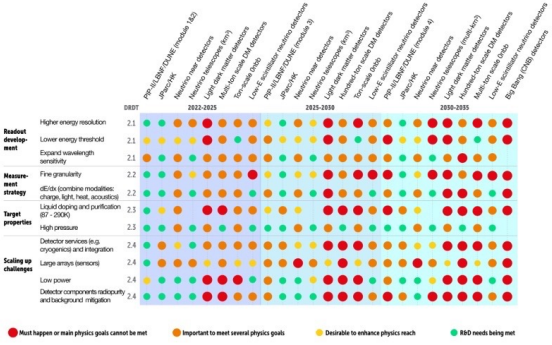
- Organized in
  - **Working Groups:** serving as the backbone of R&D
  - **Work Packages:** will reflect the DRDTs,
  - and **Common Projects** (blue sky) financed by fixed yearly fee (Common Fund)
- Large community of 161 institutes, 700 members, 33 countries based on previous RD51 collab.
- Anticipated budget: 3 MCHF/y existing, additional 3 MCHF/y needed, 270/100 FTE
- 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
- Requested six weeks of beamtime at CERN SPS for 2024 already

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
  - Underground Dark Matter Experiments: small and rare signals
- Technology: **Noble Liquids** (e.g. DUNE), **Water Cherenkov** (e.g. Super/Hyper-K) and **Liquid Scintillator** with light and ionization readout
- 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/
  - 156 participants, 91 contributed talks, from 71 institutes in 15 countries
- CB Board chair election 1 March 2024 resulted in CB board chair W. Bonivento
- Developments in this field are rapid and it is not possible today to reasonably estimate the dates for projects requiring longer-term R&D

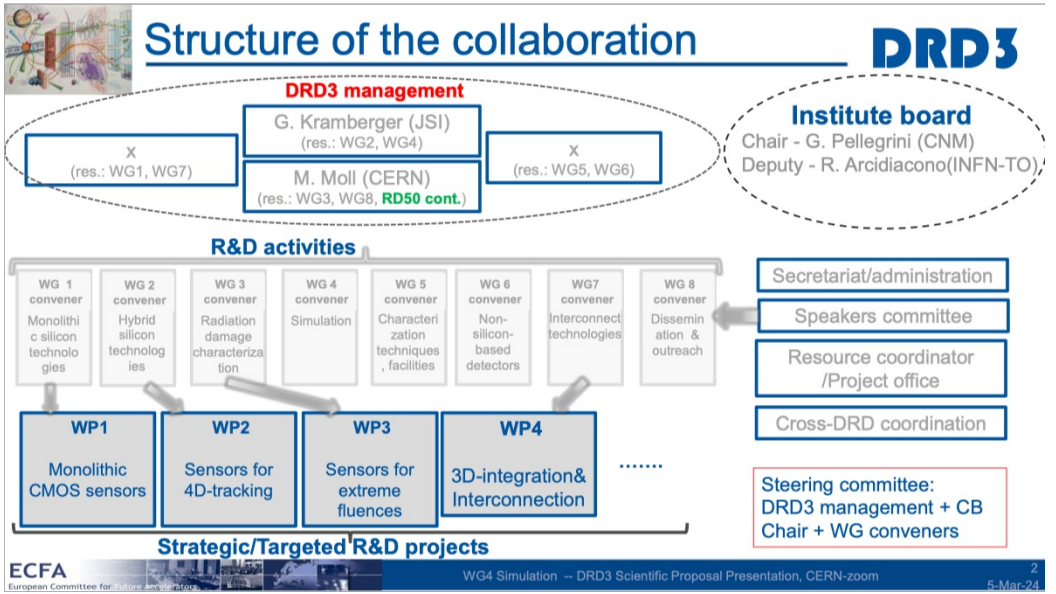


[ECFA roadmap, Modified from L.Baudis]



DRD3: Semiconductor Detectors

- DRD3 benefits from existing RD50 collaboration, extended by diamonds (RD42) and 3D integration
  - Focus widened from pure radiation hardness (HL-LHC Ph-2 upgrades) to lepton collider needs
  - Large interest in CMOS (DMAPS) sensors
- Large Collaboration: 132 institutes from 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 (additional needed)
  - 327/170 FTE (existing / additional needed)



- CB Board chair : Giulio Pellegrini (CNM Spain)
- Spokesperson: Gregor Kramberger (JSI Slovenia) with deputies (Sally Seidel, Michael Moll, n.n.)
- Webpage: https://drd3.web.cern.ch/

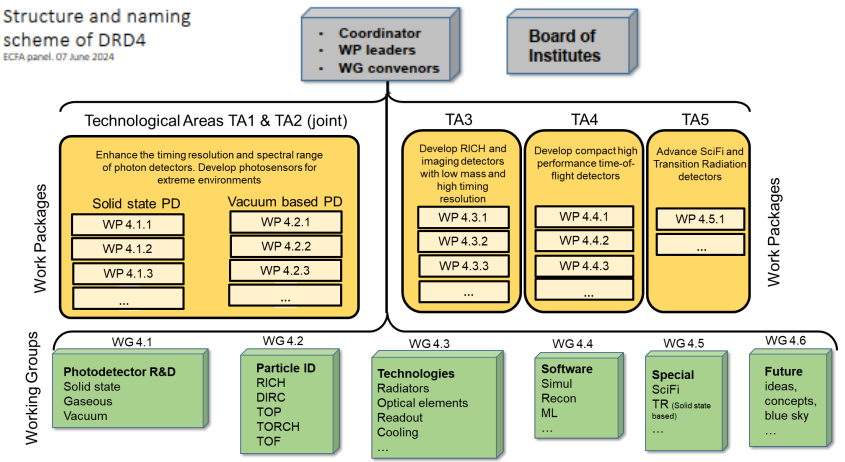
- Recently started with WG/WP meetings to organize work towards 1st DRD3 collaboration meeting (17-21 June 2024)

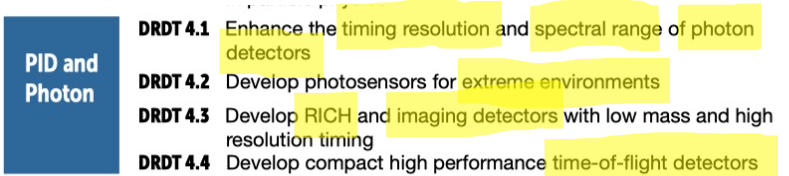
DRD4: Photodetectors & Particle ID

- **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** 23-24 January: https://indico.cern.ch/event/1349233/
  - CB board chair: Guy Wilkinson
  - Spokespersons: Massimiliano Fiorini
  - WP/WG chairs elected as well
- Next meetings 17-21 June 2024 ; 21-25 October 2024





DRD5: Quantum Sensors

- Quantum Technologies are a rapidly emerging area of technology development to study fundamental physics
  - Targeting a lower TRL than the other DRDs
  - 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)
- Signed by 94 institutions, 338 persons, with (rough estimate of 20 FTE per WP)

- Final proposal was submitted to DRDC last week **Aim to be approved in June**

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)

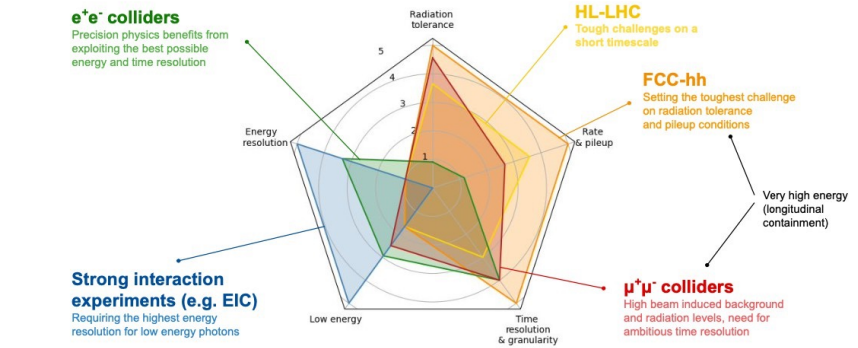
WP-2a (application-specific tailoring)	characterization protocol *protocol*	database definition *Database prototype*	populated db *Functional database*
WP-2ab (extended functionalities)	workshop/conference *Device concepts*	device designs *Prototype devices*	novel hybrid devices *Functional devices*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

DRD6: Calorimetry

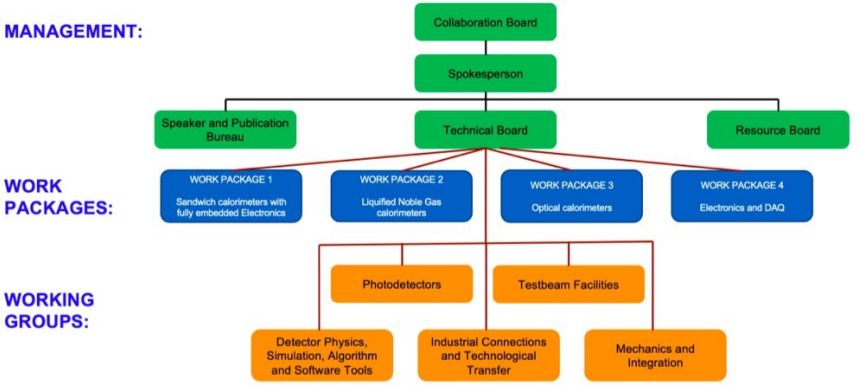
- R&D in calorimetry has a particularly long lead-time
  - Many technology developments (gas, scintillator or Silicon-based readout) done in other DRDs
  - Large and challenging prototype setups even in early stages
  - Dedicated calorimeter test beam line at SPS requested (H8?)

- Collaboration emerged from several collaborations like CALICE and CrystalClear (RD18)
  - 23 input proposals were collected from existing collaborations, boiled down to four WPs and five Working Groups
- Size : 131 institutes;
  - 183 FTE/y (existing), 100 FTE/y additional needed
  - Anticipated Budget ~3.2M€/y existing, ~1.4 to 2.4M€/y additional needed (2024-2026)
  - Little (extra) need at the beginning (2024-2026)

- 1st Collaboration Meeting happened 9-11 April and marked the end of the transition phase



Inspired from https://indico.cern.ch/event/994685/



DRD7: Electronics

- Full proposal received by 21 May 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
  - No orthogonal "Service-Provider" for other DRDs
- Organization:
  - 19 countries, 68 institutes
  - 1st workshop in March, 2nd workshop in Sept. 2023; 1st collaboration meeting planned 9-10 Sept 2024

Electronics

DRDT 7.1 Advance technologies to deal with greatly increased data density

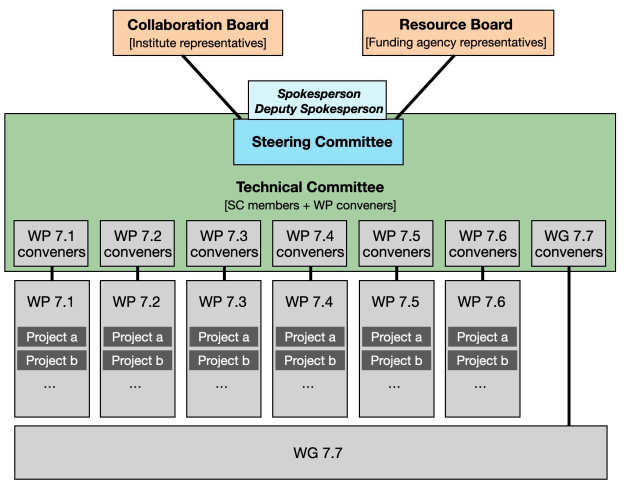
DRDT 7.2 Develop technologies for increased intelligence on the detector

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

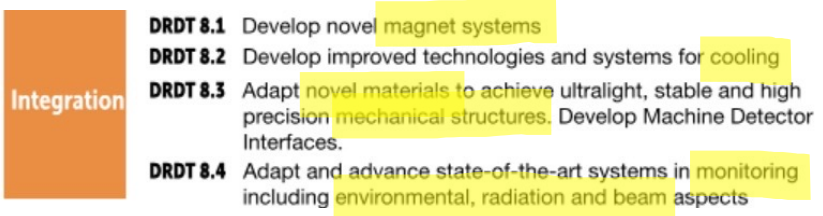
WP 7.6 Complex imaging ASICs and technologies
WG 7.7. Transversal Tools and Technologies



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
  - Burkhard Schmidt (CERN) and Andreas Mussgiller (DESY)

- Community survey resulted in 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



Overview 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 March open DRDC session: https://indico.cern.ch/event/1356910/
Full Proposals in CERN CDS

Conditionally approved

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

Final proposals submitted last week

- Quantum Sensors (DRD5)
- Electronics (DRD7)

Both aim for approval in June
Talks at open session June 3rd

Letter of Intent submitted

- Integration (DRD8)

Full Proposal to be written by the end of 2024

Summary

- New CERN-hosted Detector R&D (DRD) collaborations are currently being set up following ECFA Detector roadmap
  - 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, re-defining deliverables and work packages towards MoU, start working
  - to pave the way for the next decades and address the future instrumentation needs

- I invite everybody interested in detector R&D to get in touch and eventually join a DRD collaboration
  - There are still certain topics defined in the ECFA roadmap not covered in DRD collabs.
  - Next chance: 3rd June to hear about quantum sensors (DRD5) and electronics (DRD7)
  - 17-21 June: collaboration meetings of DRD1, DRD3 and DRD4 at CERN


on 2024 Imaging workshop
ÖAW HEPHY Institut für Hochenergiephysik TU WIEN
5th Ion Imaging Workshop
21-22 October 2024 in Vienna, Austria
https://ionimaging2024.sciencesconf.org/
Scientific Topics:
➢Ion imaging systems
➢Reconstruction methods
➢Clinical applications
➢Treatment monitoring
➢Related topics
Deadline for abstracts:
5 July 2024
Organising Committee
• Hirtl Albert, TU Wien (Austria)
• Bergauer Thomas, HEPHY, Austrian Academy of Sciences (Austria)
• Dedes George, LMU Munich, Department of Medical Physics (Germany)
• Krah Nils, University of Lyon, CNRS, CREATIS lab (France)
• Landry Guillaume, LMU Munich, University Hospital (Germany)
• Rit Simon, University of Lyon, CNRS, CREATIS lab, (France)
• Simard Mikaël, University College London (United Kingdom)
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VCI
VIENNA CONFERENCE ON INSTRUMENTATION
SCIENTIFIC TOPICS
New Detector Developments in
> Particle Physics
> Astro-particle Physics
> Nuclear Physics
> Quantum Sensing
> Medicine and Biology
Associated detector electronics and detector specific software
THE 17th VIENNA CONFERENCE ON INSTRUMENTATION
17 – 21 FEBRUARY 2025
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ABSTRACT SUBMISSION DEADLINE
6 October 2024
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The End.

Thank you for your attention

General Strategic Recommendations

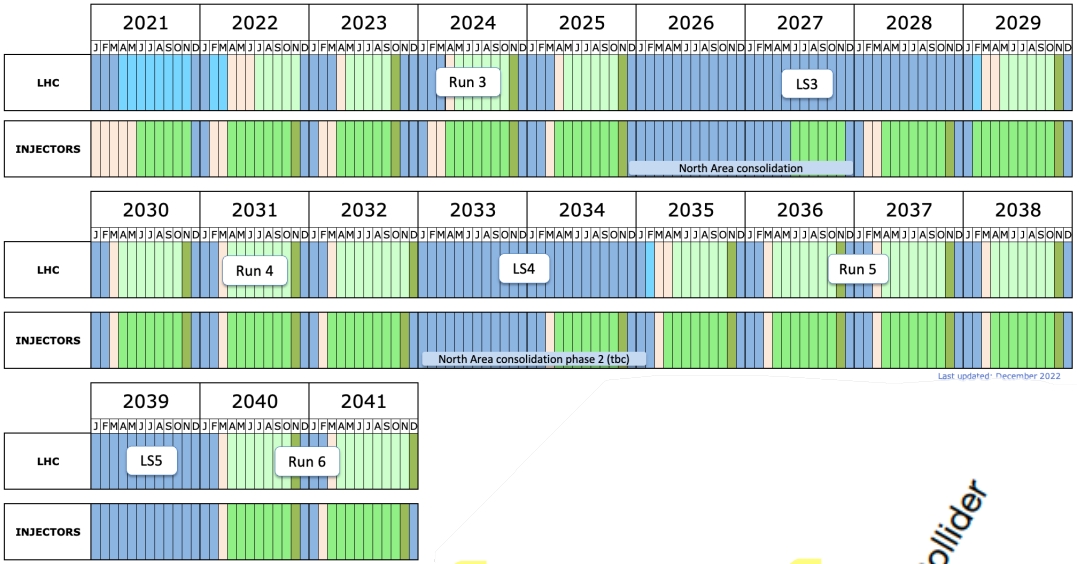
The General Strategic Recommendations (GSR) topics are:

- 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**

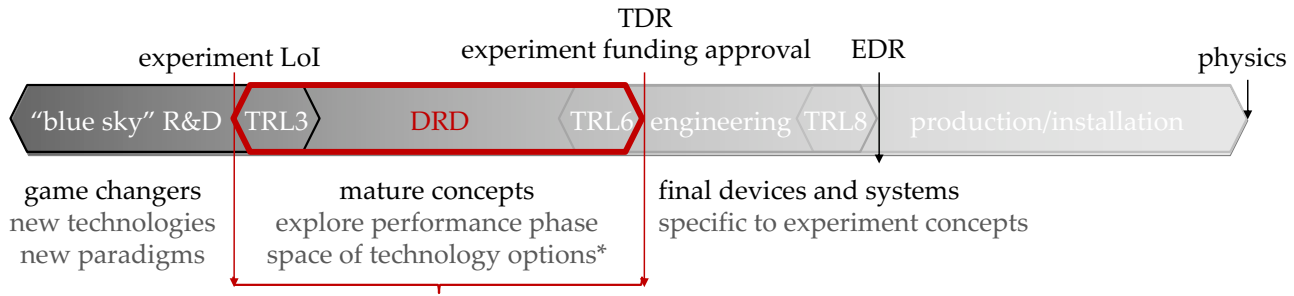
Future Large Experiments

- Five Time periods defined

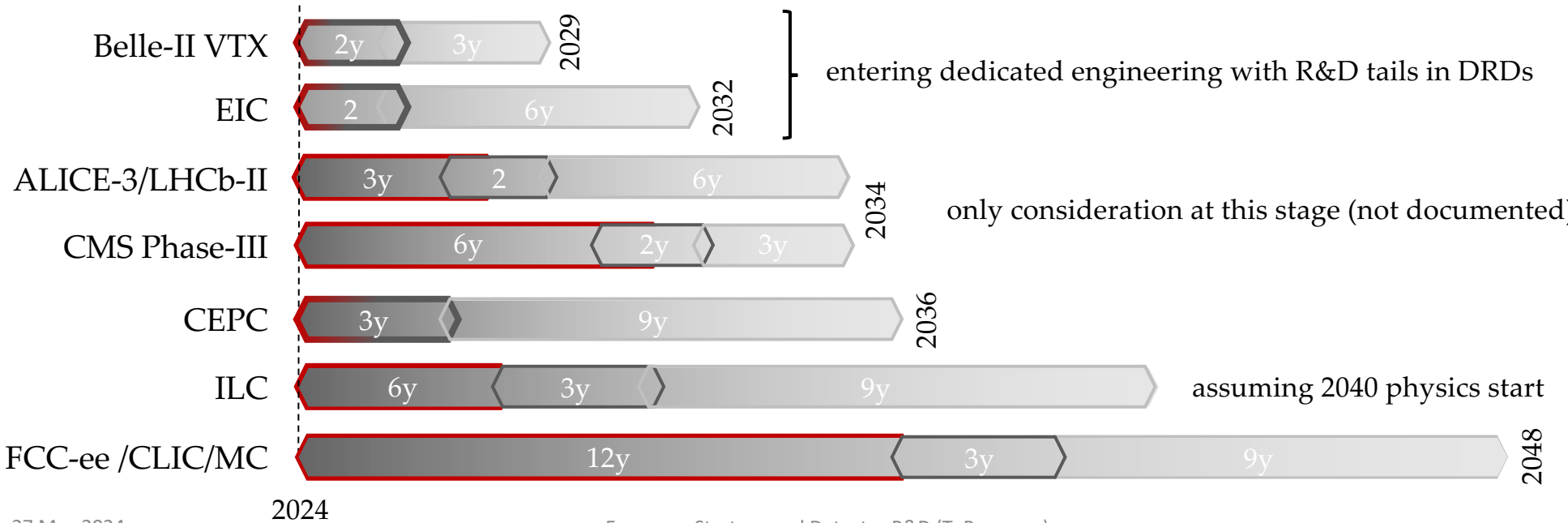
(HL-)LHC timeline:



Broad timelines for future HEP Projects



Didier Contardo



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- Liquid Detectors: ***Inés Gil Botella*** *(CIEMAT)*
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Names in bold in both committees