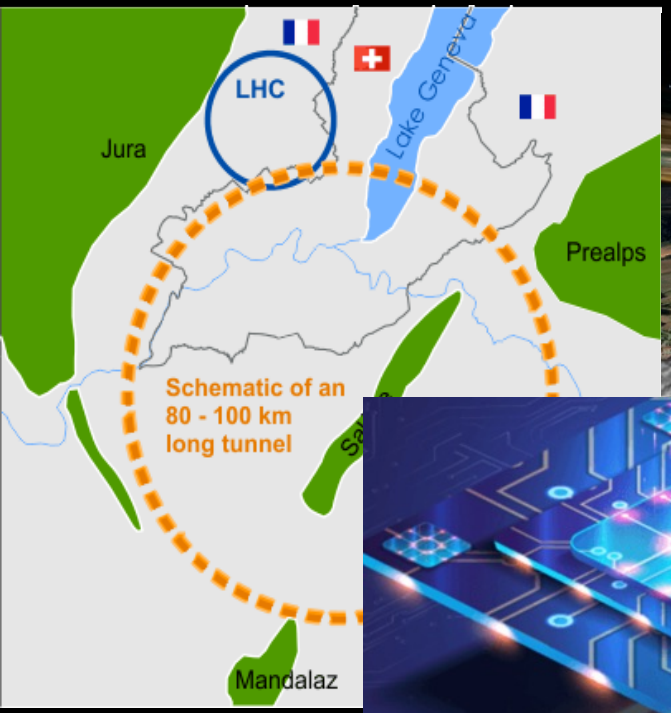
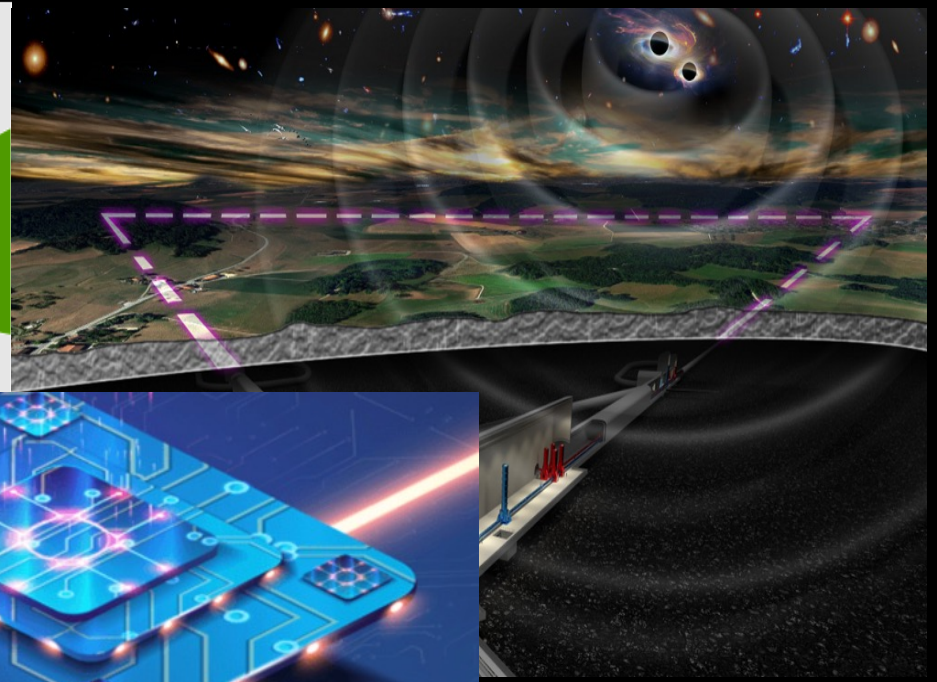
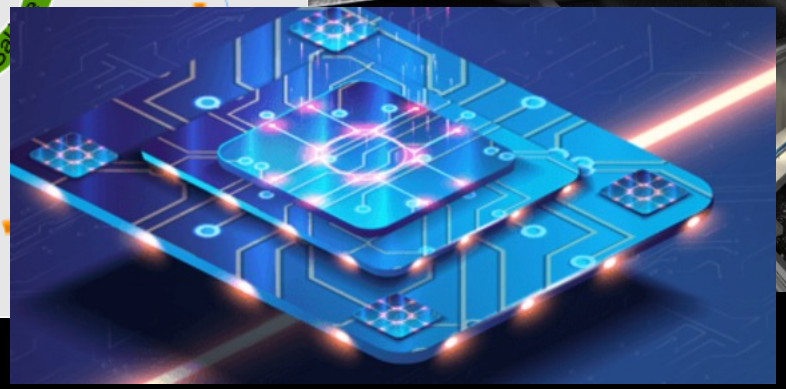
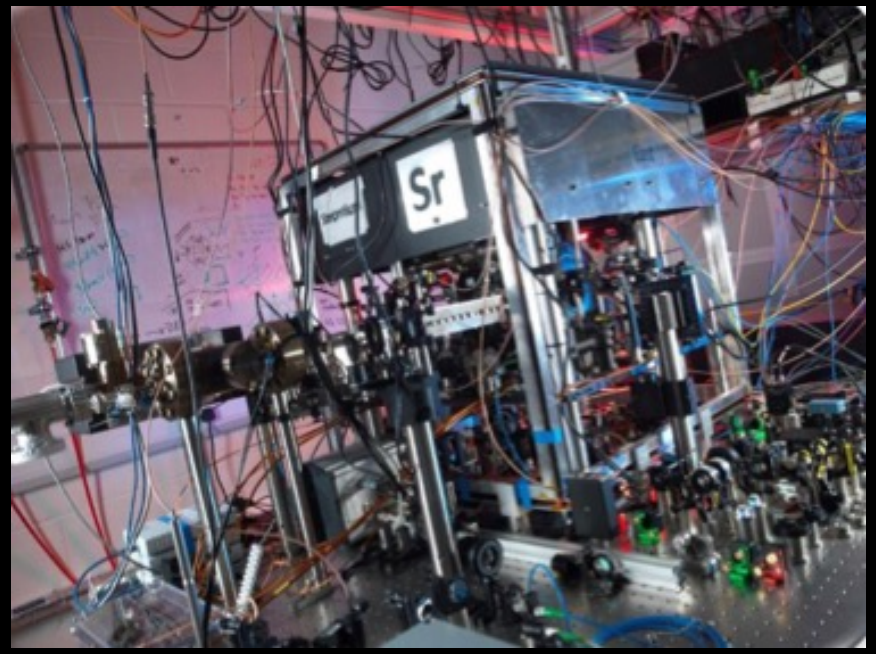
# Great Questions in Fundamental Physics and Detector Technologies to Address them via the ECFA Detector Roadmap and ECFA Detector R&D Collaborations








*Ian Shipsey,*
*Oxford University*
*(ECFA Roadmap co-coordinator )*

# Opportunities for Discovery

Many mysteries to date go unanswered including:

The mystery of the Higgs boson

The mystery of Neutrinos

The mystery of Dark Matter

They mystery of Dark Energy

The mystery of quarks and charged leptons

The mystery of Matter – anti-Matter asymmetry

The mystery of the Hierarchy Problem

The mystery of the Families of Particles

The mystery of  Inflation

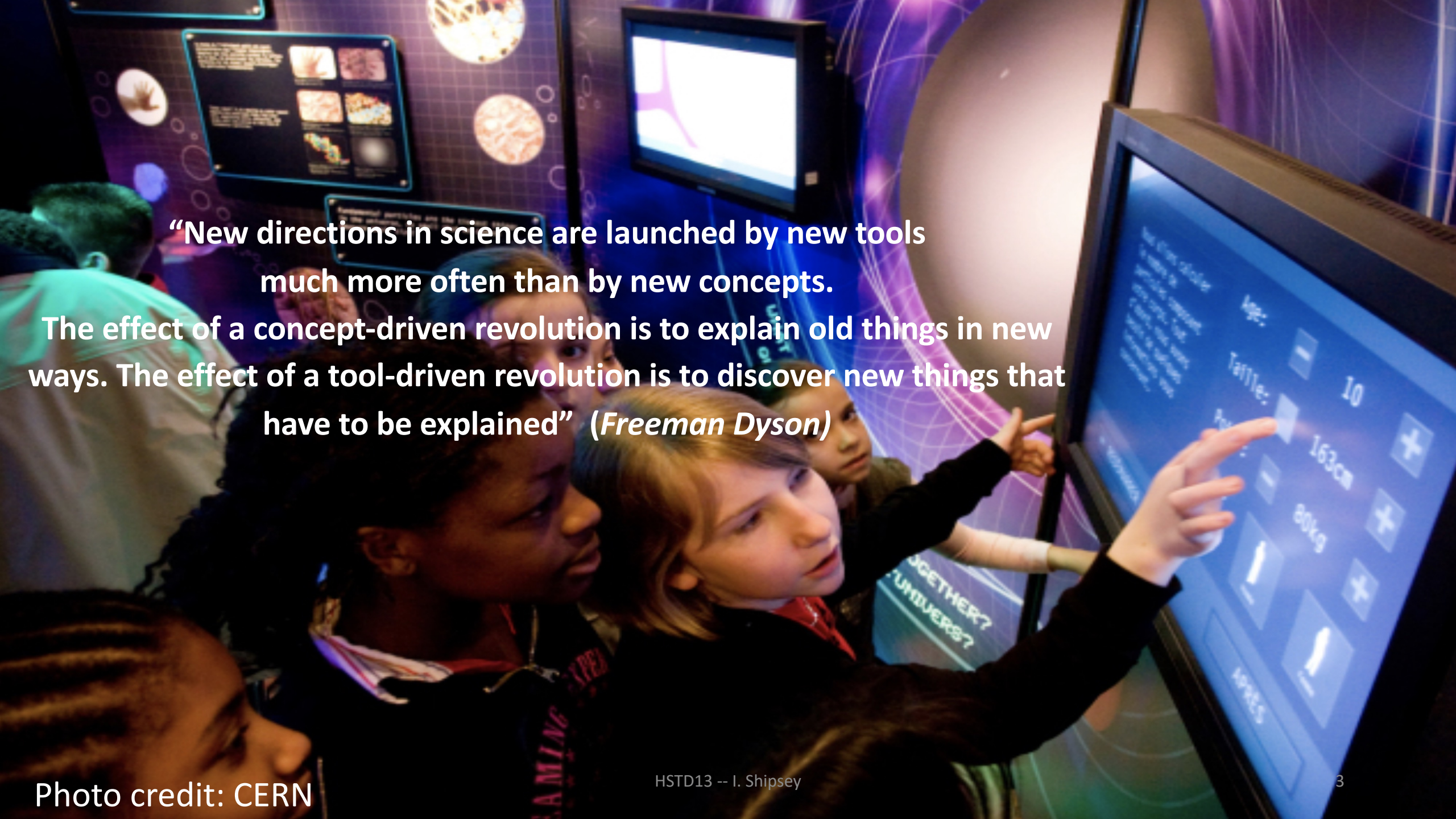
The mystery of Gravity

How do quarks and gluons give rise to the properties of nuclei

The mystery of the origin and engine of high energy cosmic particles

Multiple theoretical solutions – experiment must guide the way

**We are very much in a data driven era for which we need new tools!**



"New directions in science are launched by new tools much more often than by new concepts. The effect of a concept-driven revolution is to explain old things in new ways. The effect of a tool-driven revolution is to discover new things that have to be explained" (*Freeman Dyson)*

Photo credit: CERN


**“Measure what is measurable, and make measurable what is not so” (*Galileo Galilei)***

Photo credit: CERN

# Most recent European Strategies

## the large …

weblink


2017-2026 European Astroparticle Physics Strategy

## … the connection …

weblink


Long Range Plan 2017 Perspectives in Nuclear Physics

## … the small

weblink


2020 Update of the European Particle Physics Strategy

Are community driven strategies outlining our ambition to address compelling open questions

Guidance for funding authorities to develop resource-loaded research programmes

the update of the European Strategy for Particle Physics, recognizing the primacy of instrumentation, called on the community via ECFA to define a global detector R&D roadmap

# Most recent European Strategies

## the large …

weblink


2017-2026 European Astroparticle Physics Strategy

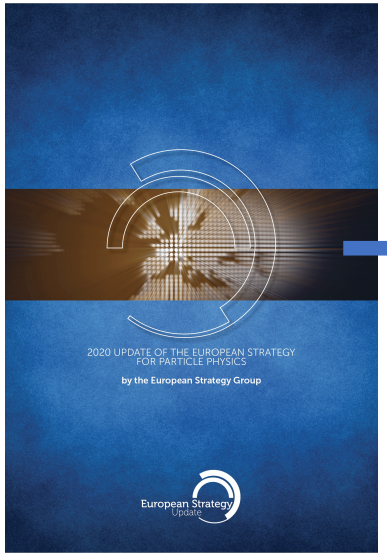
## … the connection …

weblink


Long Range Plan 2017 Perspectives in Nuclear Physics

## … the small

weblink

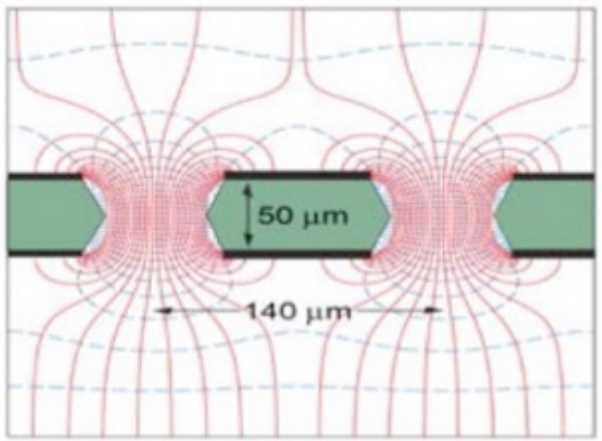



2020 Update of the European Particle Physics Strategy

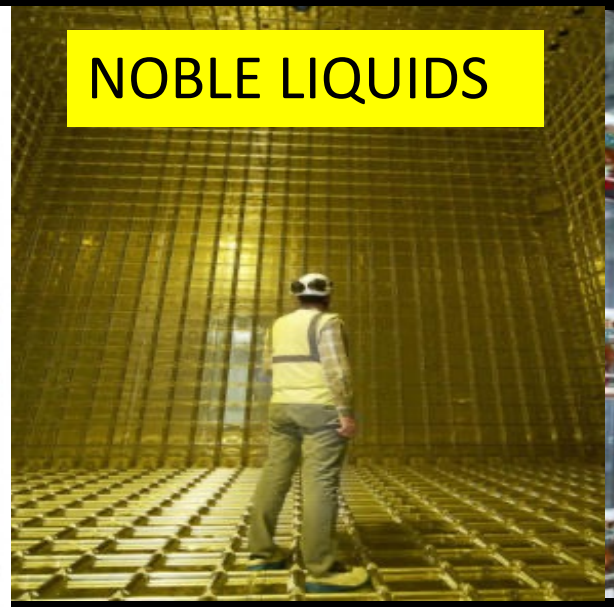

ECFA Detector R&D Roadmap

# Technology Classification for the ECFA R&D Roadmap

GASEOUS



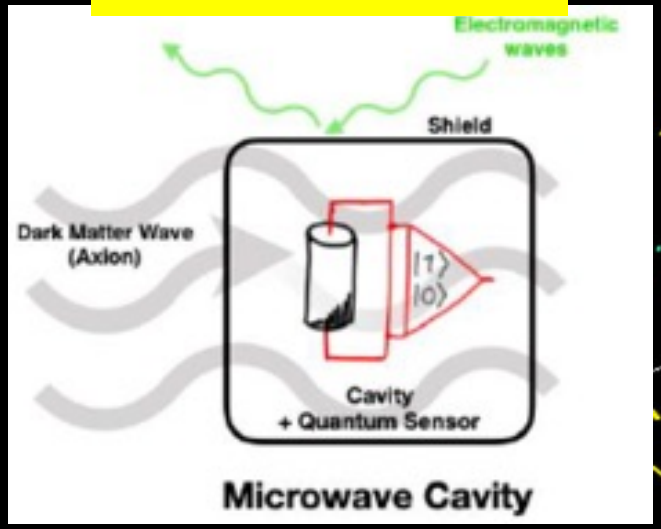

NOBLE LIQUIDS



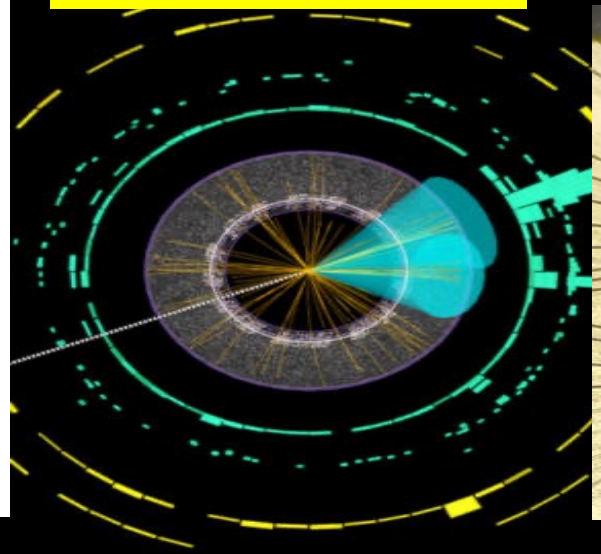
SOLID STATE

PHOTODETECTORS

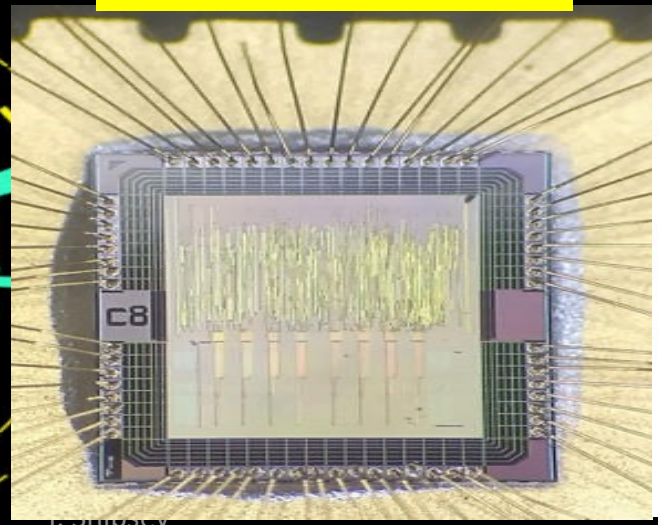
QUANTUM



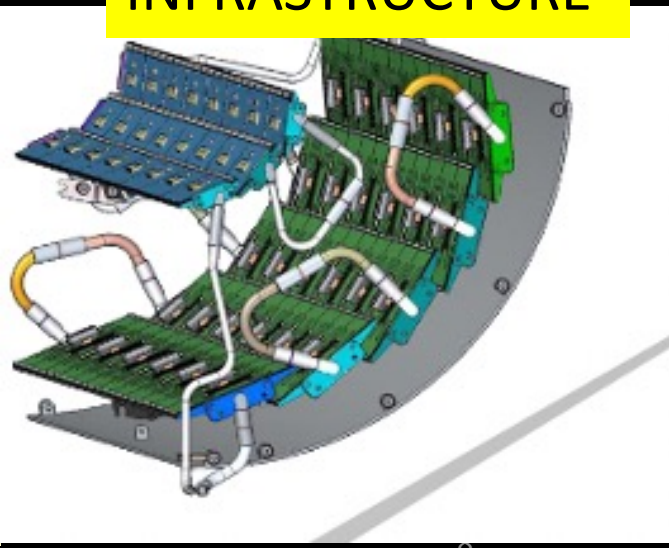

CALORIMETER



ELECTRONICS

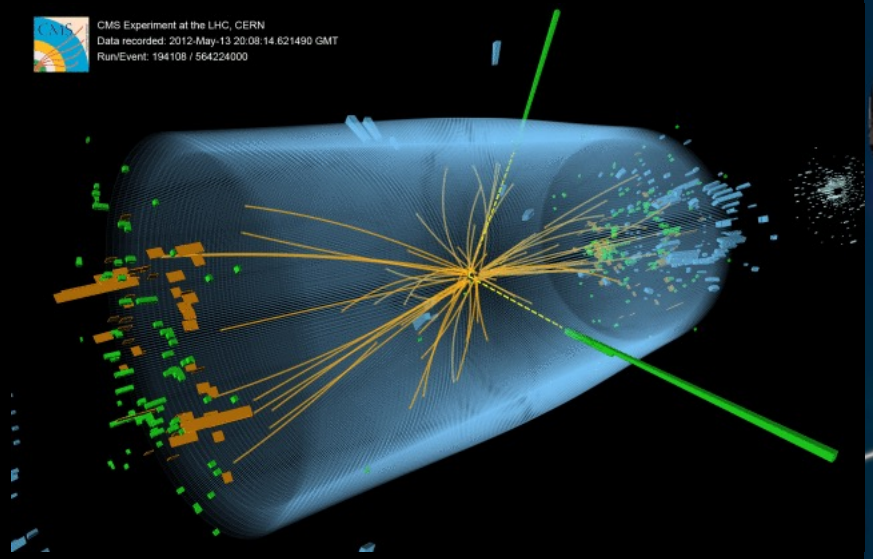


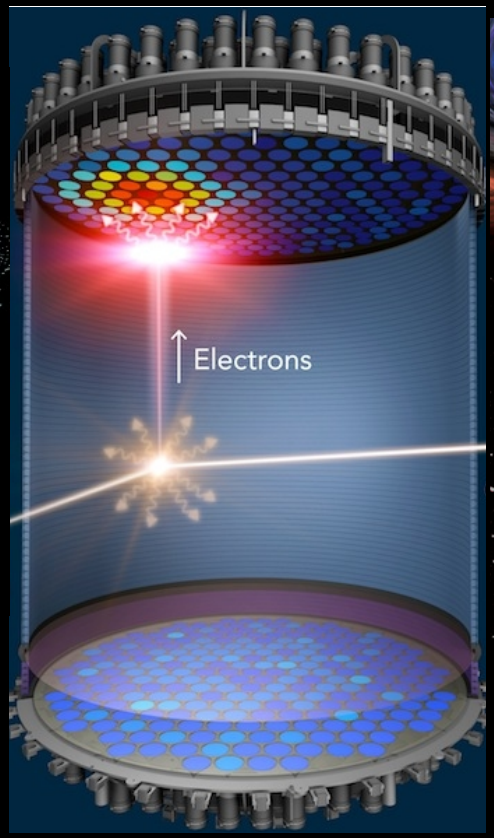

INFRASTRUCTURE

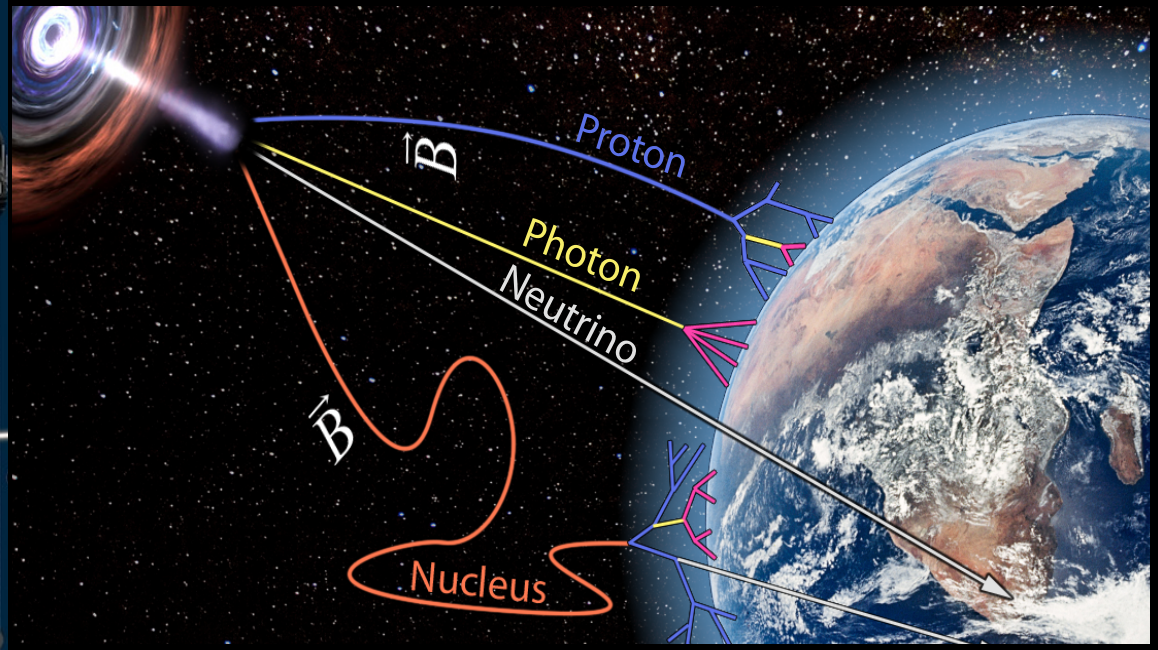


# Our Technologies: synergy & broad applicability

- The technologies we develop are broadly applicable across PP Nuclear Physics (NP)and Astro Particle Physics (APP) & synergistically developed



# ECFA Detector R&D Roadmap

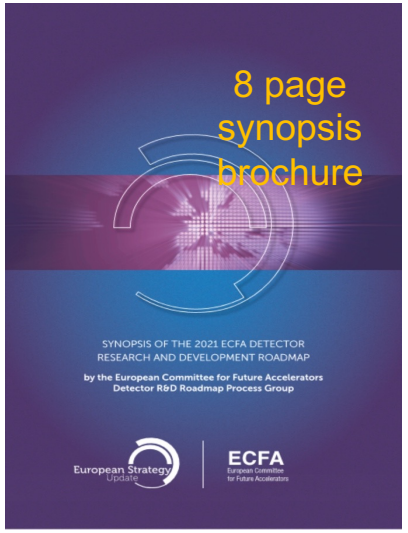
- Given the future physics programme, identify **the main technology R&D to be met so that detectors ar not the limiting factor for the timeline.**
- Detector context considered:

- Full exploitation of LHC
- Long baseline neutrinos
- Detectors for future Higgs-EW-Top factories (in all manifestations)
- Long term vision for 100 TeV hadron collider

- Future muon colliders
- Accelerator setup for rare decays/dark matter
- Experiments for precision QCD
- Non accelerator experiments (reactor neutrinos, double beta decay, dark matter)

Process organised by Panel and nine Task Forces with input sessions and open symposia with wide community consultation (1359 registrants)

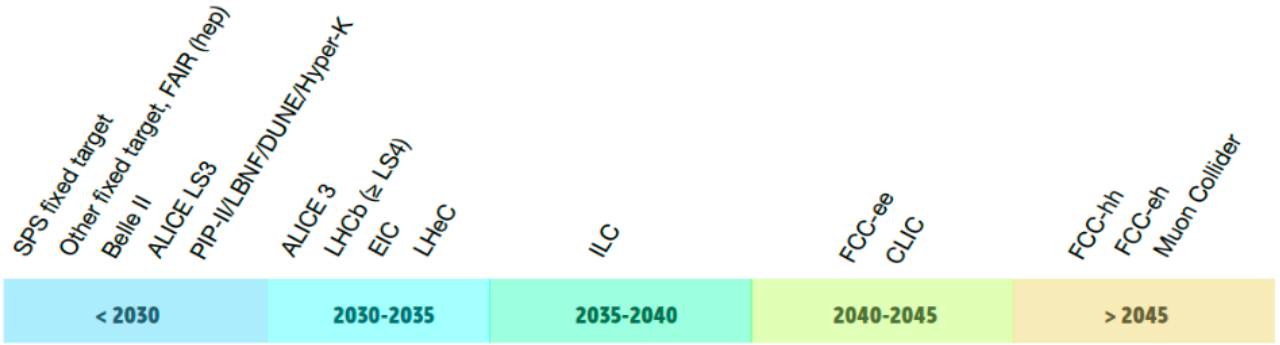
Main Document published (approval by RECFA at 19/11/21) and 8 page synopsis brochure prepared for less specialised audience

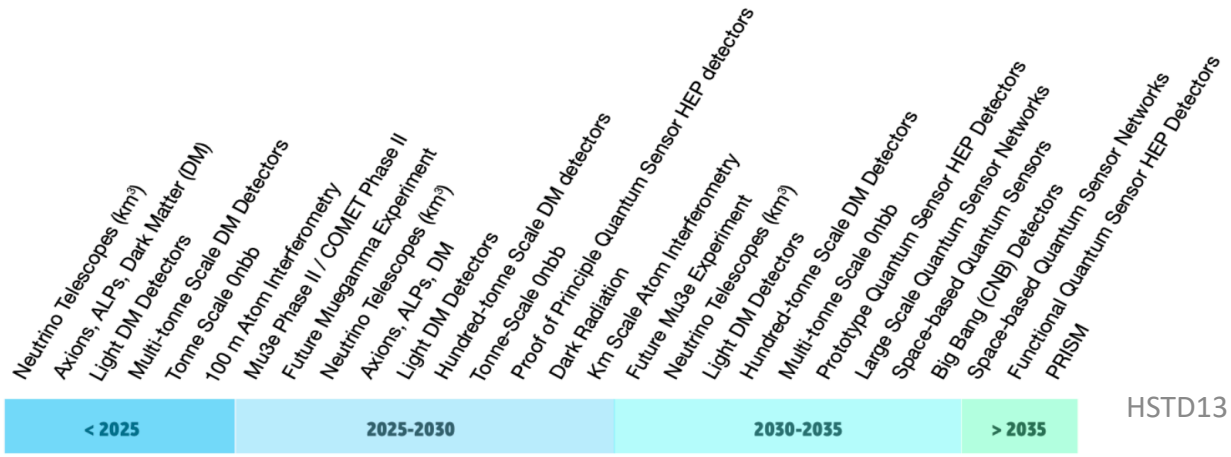



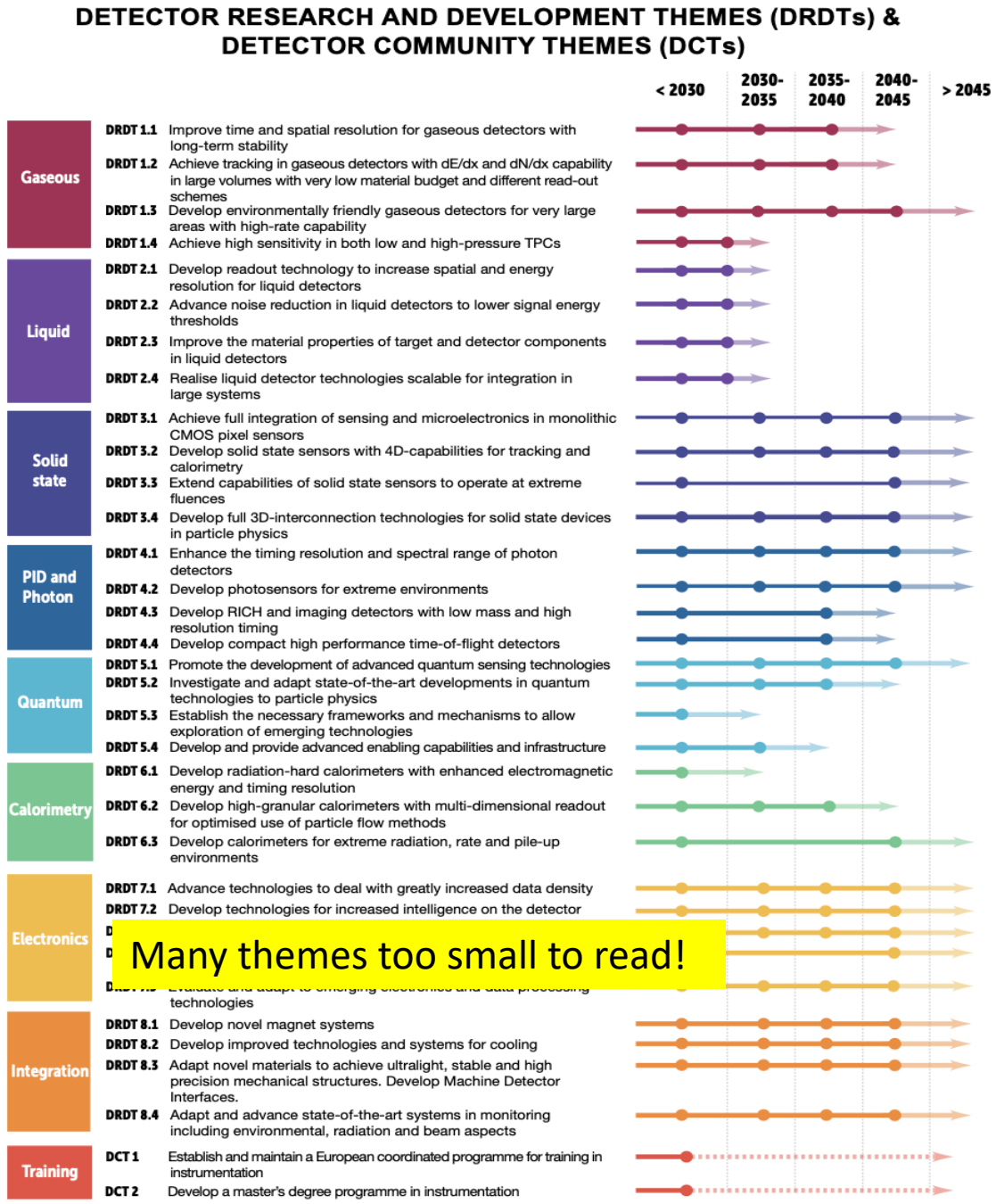

ECFA Detector R&D Roadmap Panel web pages at: https://indico.cern.ch/e/ECFADetectorRDRoadmap
Documents CERN-ESU-017: 10.17181/CERN.XDPL.W2EX

# Roadmap Document Structure

Within each Task Force (one for each technology area + training) the aim is to propose a time ordered detector R&D programme by Detector Research and Development Themes (DRDT) in terms of **capabilities not currently achievable**.



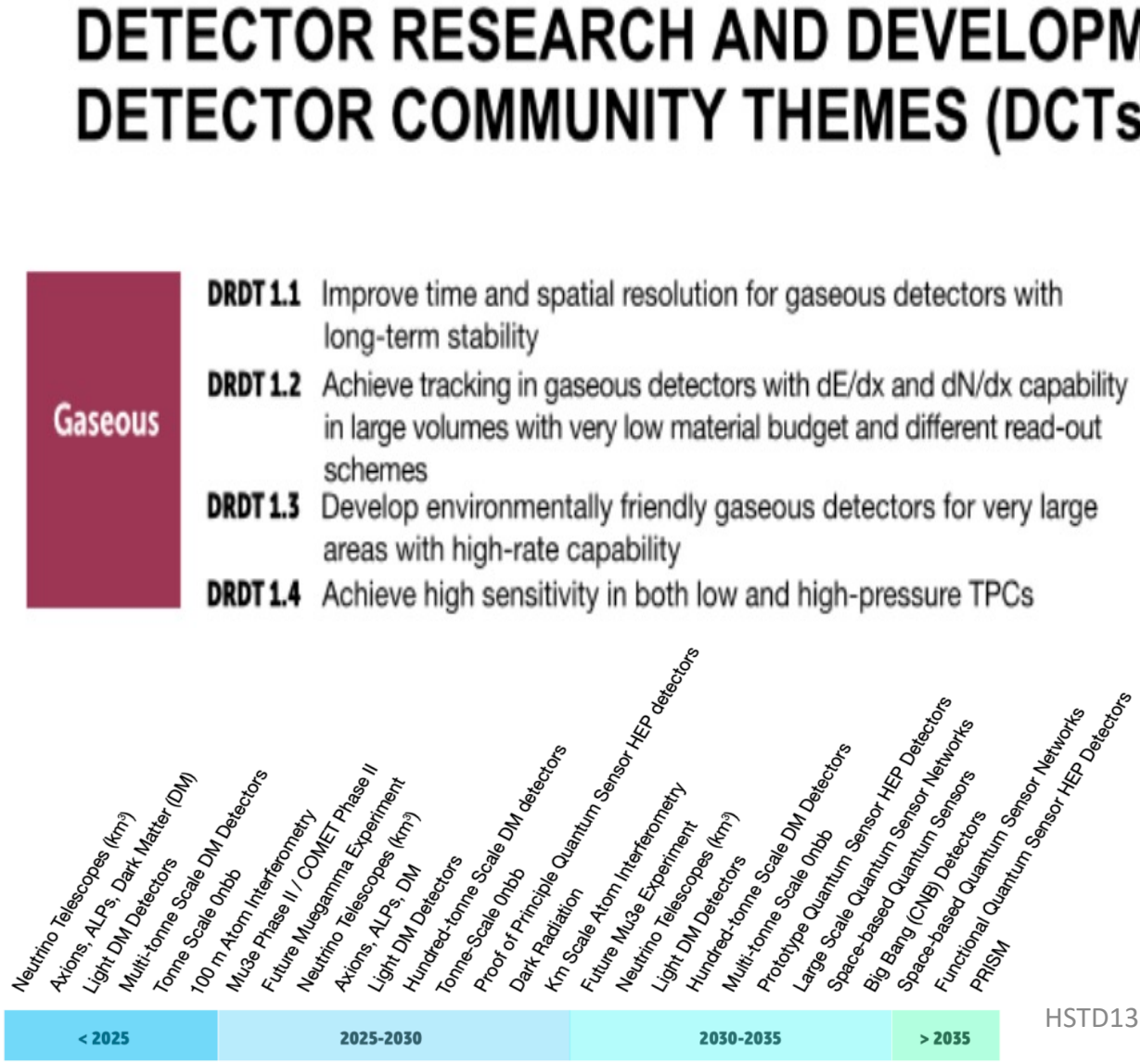



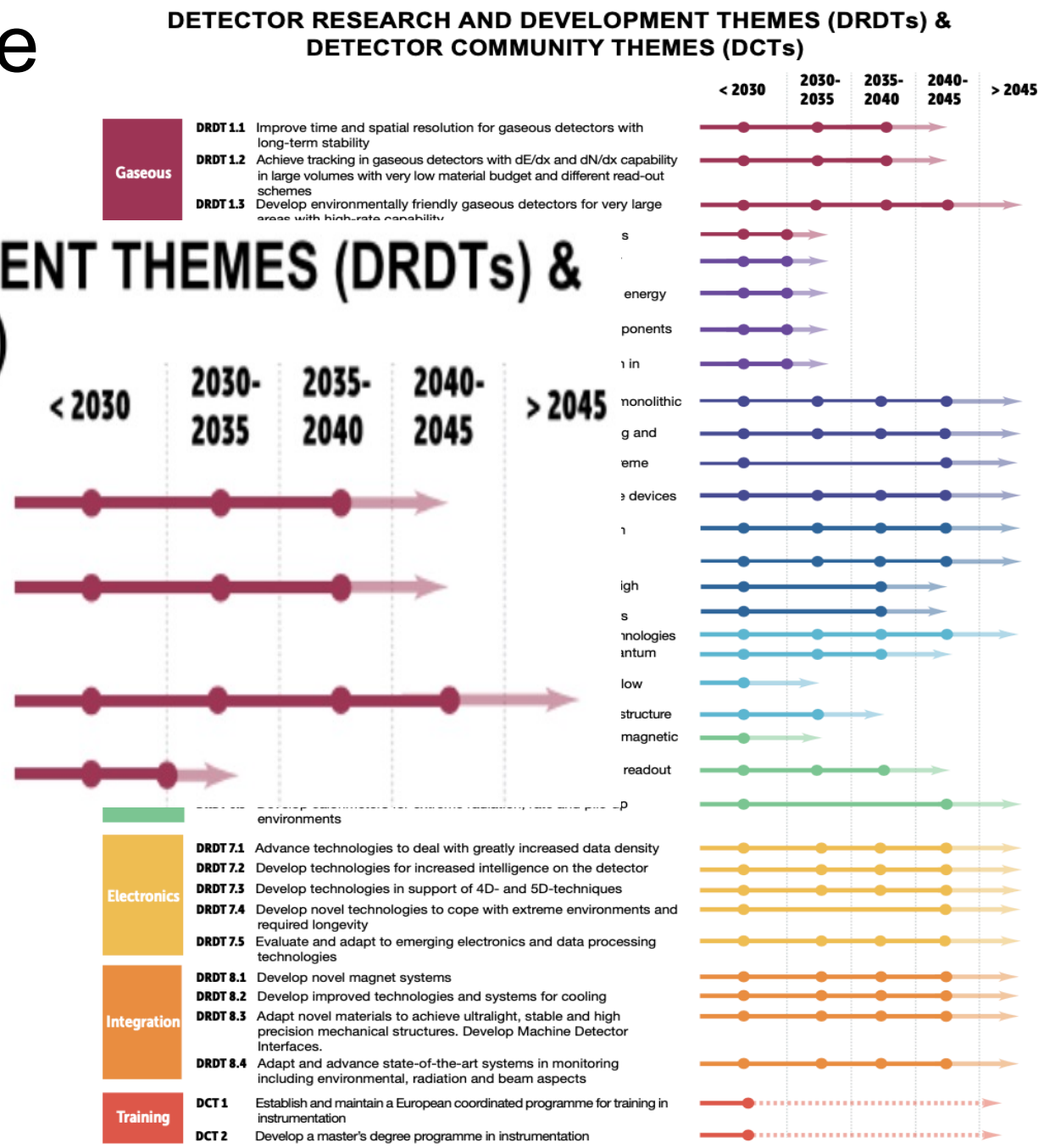




Many themes too small to read!

# Roadmap Document Structure

Within each Task Force the aim is to propose a time ordered detector R&D programme by



# Gaseous detectors

Are ubiquitous

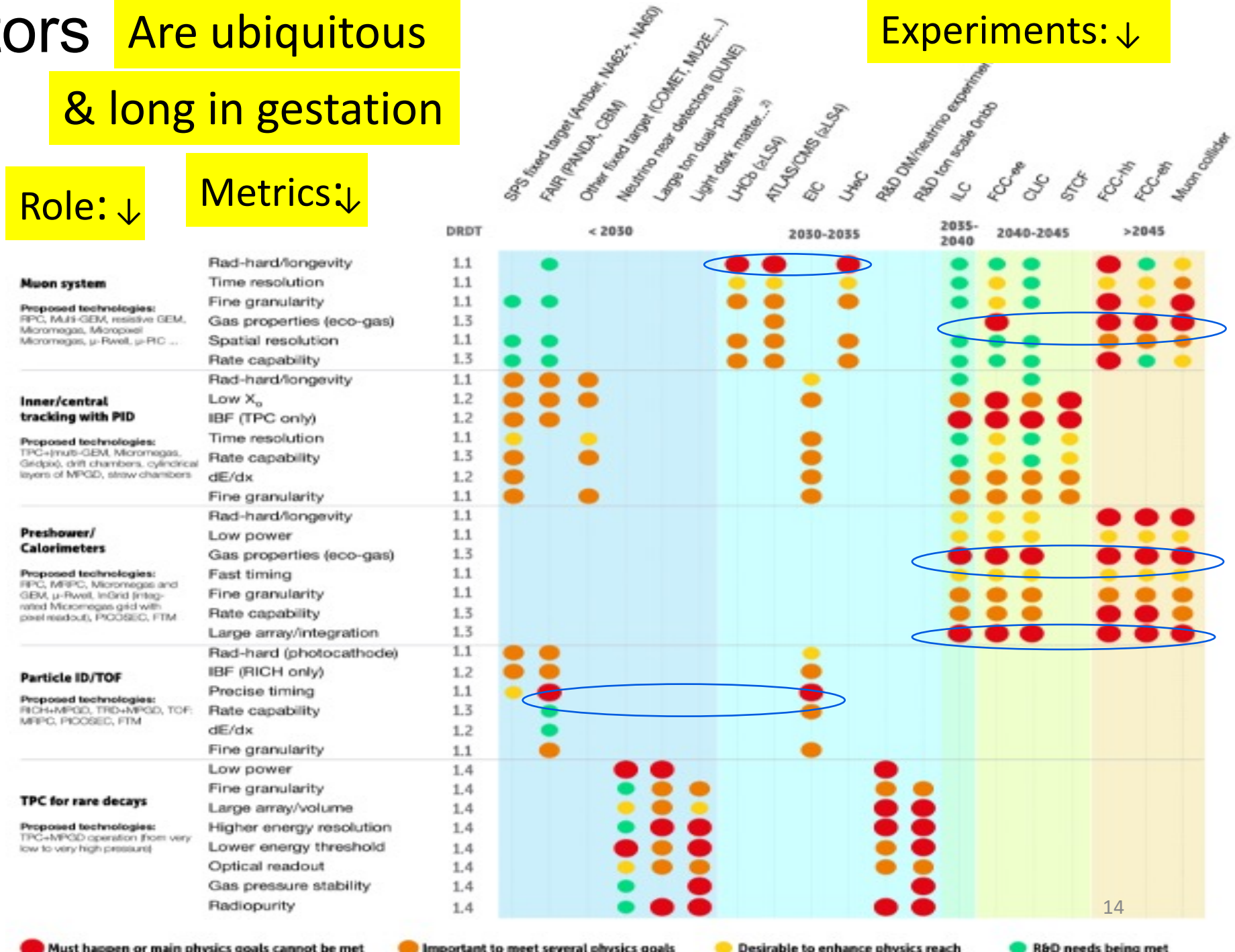
& long in gestation

Role: ↓

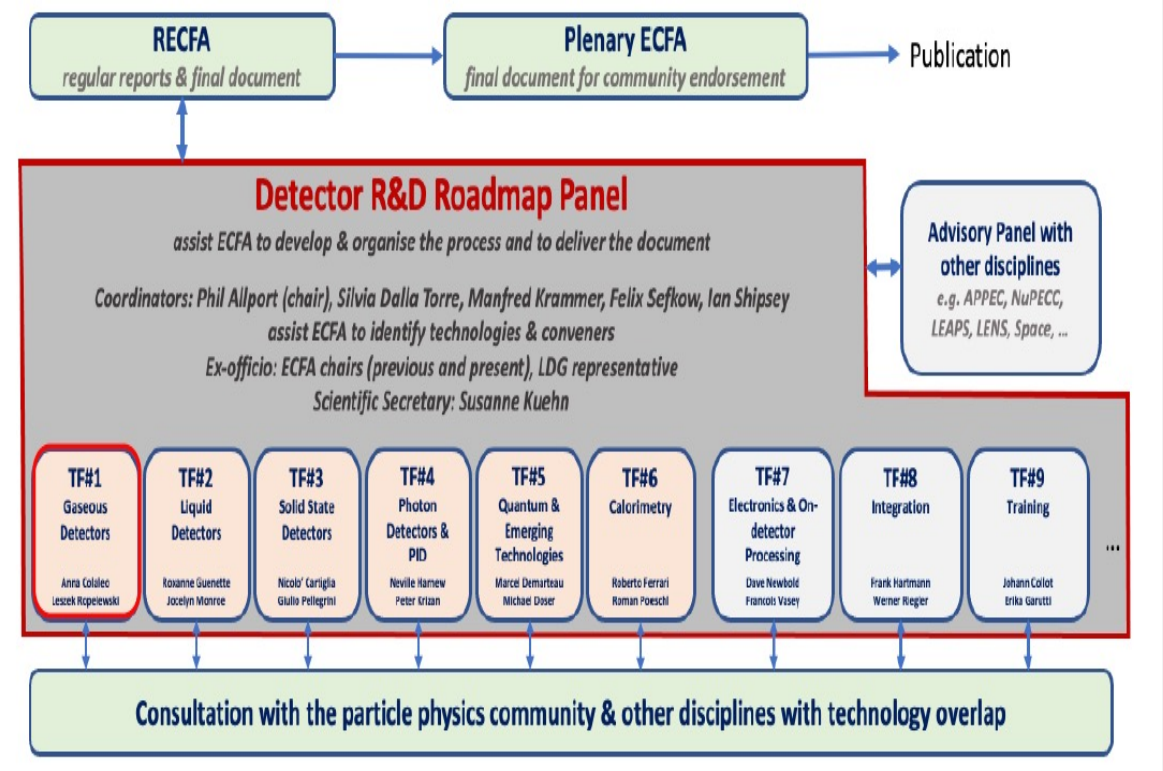
Metrics: ↓

Experiments: ↓

- **Detector Readiness Matrices of each Task Force chapter** focus on the extent to which the R&D topic is *mission critical* to the programme rather than the intensity of R&D required
  - Must happen or main physics goals cannot be met
  - Important to meet physics goals
  - Desirable to enhance physics reach
  - R&D need being met



# ECFA Detector R&D Roadmap Approval & Implementation




P. Allport chair - ex-officio ICFA-IIDP chair I. Shipsey

Roadmap was approved by Plenary ECFA in Nov. 2021

10 General Strategic Recommendations
GSR4: international coordination & organization of R&D activities
GSR6: establish long term strategic funding program

↓

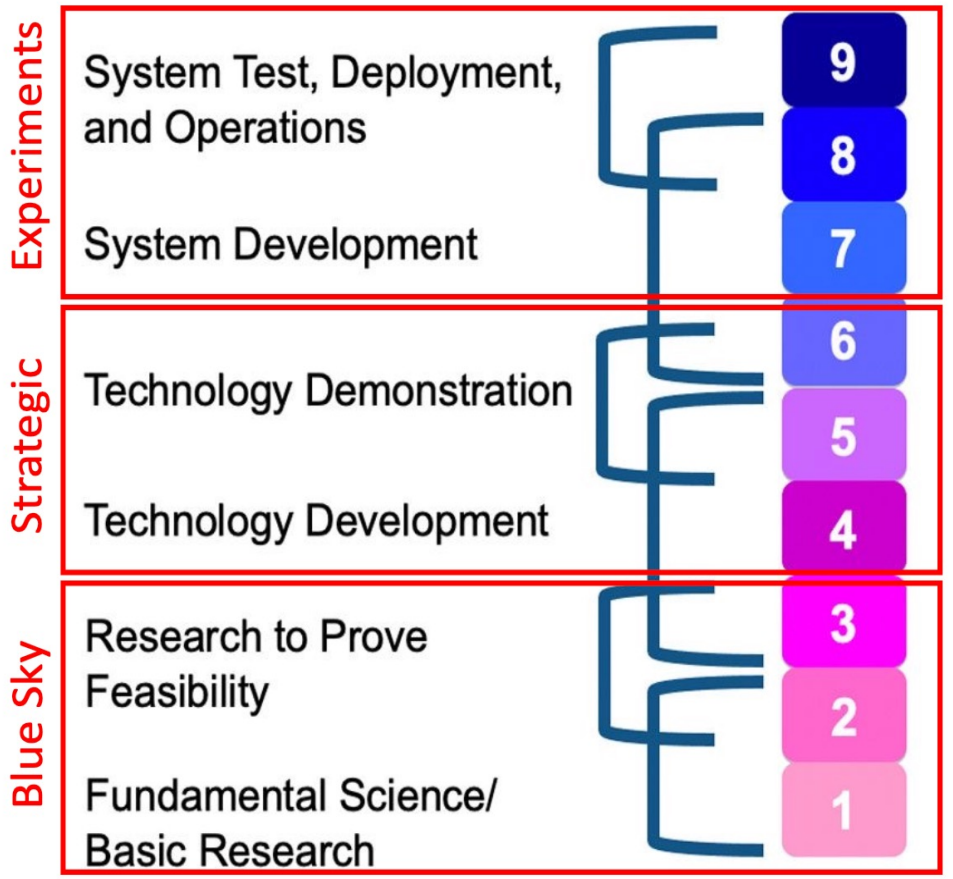
ECFA implementation proposal to form DRD collaborations hosted at CERN was endorsed by Council Sep. 2022
1 DRD for each technology led by the same large team that wrote the corresponding technology R&D plan in the Roadmap

# ECFA Detector Research & Development (DRD) Collaborations

**Strategic R&D** towards **necessary technologies to build future facilities** and experiments

- Addresses the DRDTs in ECFA roadmap by defining suitable deliverables and milestones
  - Technology Readiness Levels (TRL) 3-6
  - Backed up by **strategic funding**, agreed with funding agencies (MoUs)

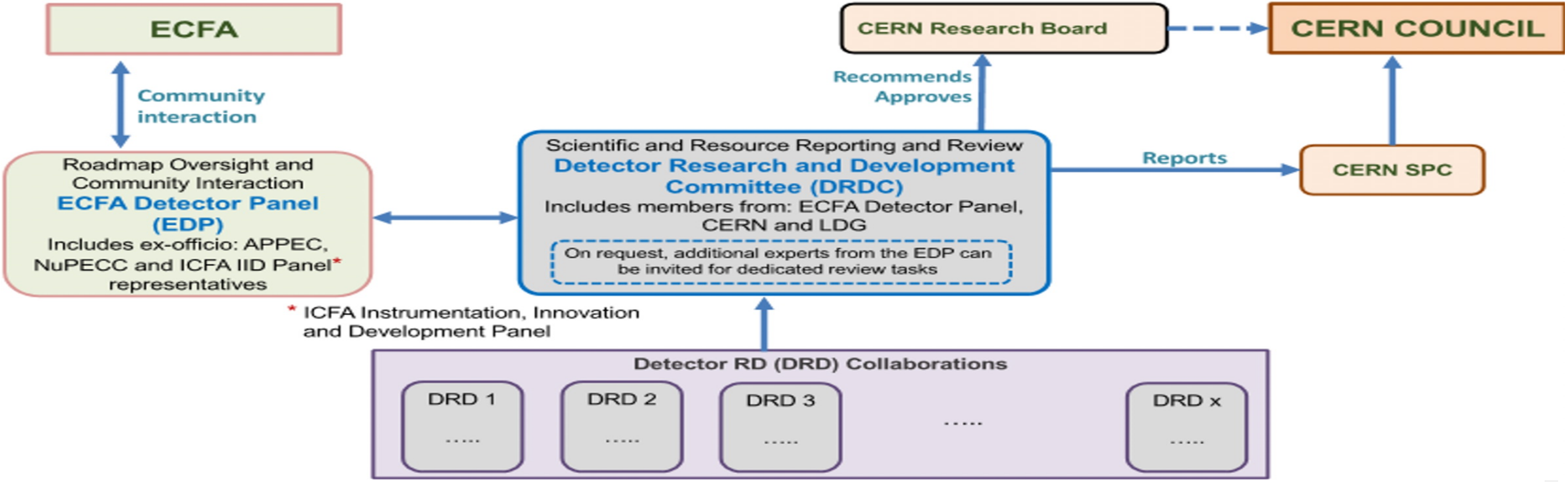
- DRD collaborations should also contain a small "**blue-sky**" section (TRL 1-3)
  - Allow new developments to emerge
  - Possibly financed by common fund + institute contributions (RD50/51 scheme)



# Framework for DRD collaborations

## similar to general conditions for execution of experiments at CERN

with a dedicated Detector R&D review Committee and MoU with Funding Agencies




EDP provides input on DRD proposals to the DRDC* in terms of roadmap priorities
it follows up achievements and evolution from experiment concept groups for update of the rodmap

* through its co-chairs, appointed members in the DRDC or via topic-specific experts in the conduct of the DRDC reviews

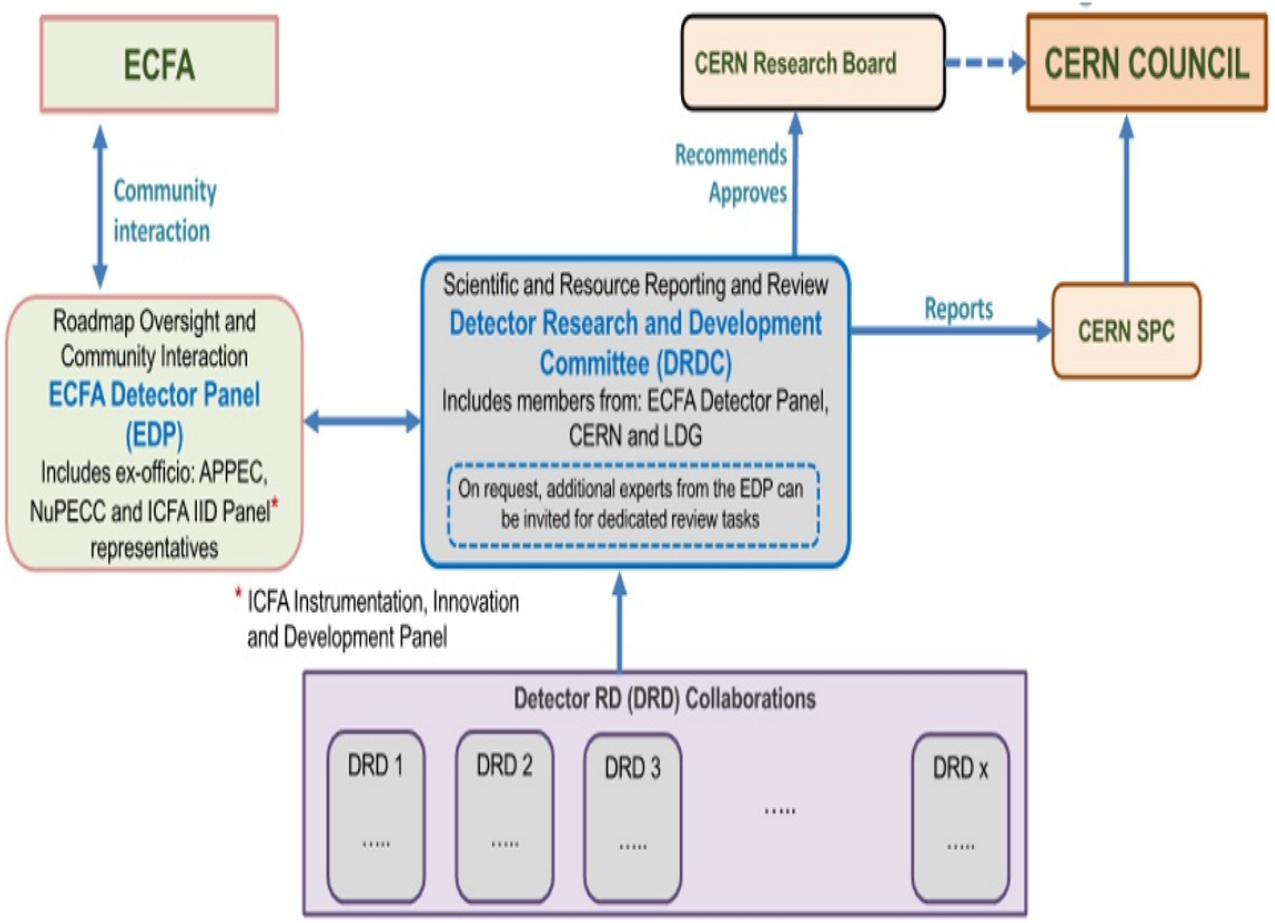
# Framework for DRD collaborations

## similar to general conditions for execution of experiments at CERN

with a dedicated Detector R&D review Committee and MoU with Funding Agencies

### 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 (Karl Jakobs), ICFA Detector Panel (Ian Shipsey), DRDC chair (**Thomas Bergauer**), APPEC & NuPECC observers*



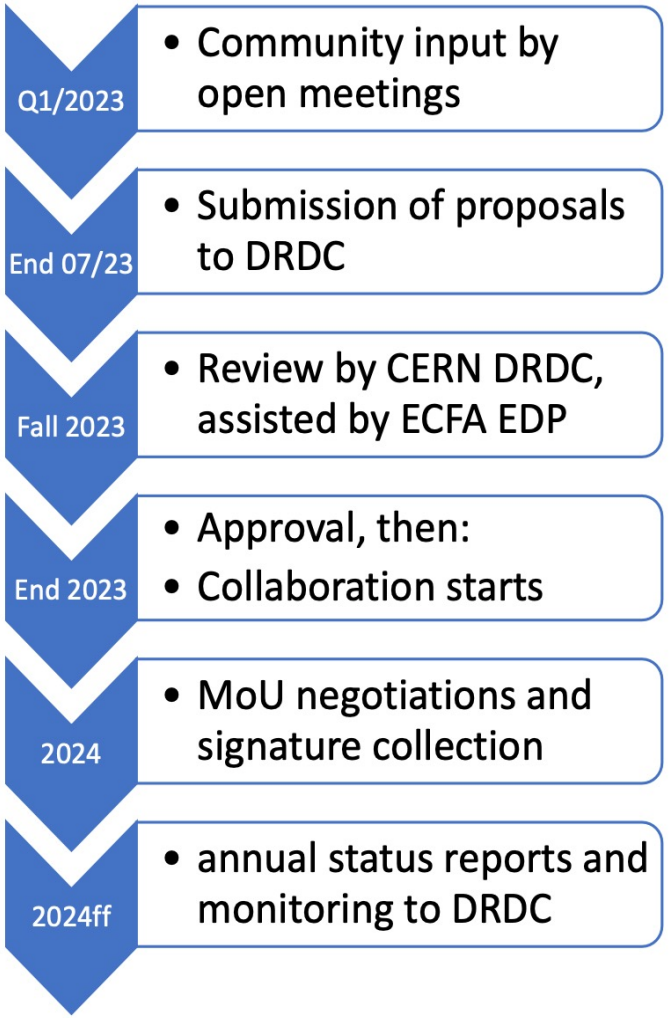

### Detector R&D Committee (DRDC):

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

# From ECFA Task forces and RD collaborations to DRD collaborations

**Timeline**:

- Review of DRD proposals by DRDC this fall:
  - Nine DRDC internal meetings so far discussing DRD proposals
  - Several meetings between DRDC and proponents of collabs.
  - Three iterations of each proposal received after suggestions from DRDC
- **Approval by the end of 2023**
  - 4th December: 1st official (but fully closed) DRDC meeting with presentations and discussions with each DRD proposal teams
  - 6th December: Official approval by CERN Research Board
- Once approved, DRD collaborations can start in 2024
  - Enables entry to CERN grey book, so that team leaders of each participating institute can be nominated and users registered
  - Collaborations will have kick-off meetings, elect spokespersons
  - MoU setup and collecting signatures from Funding Agencies
  - Later: Annual status reports to DRDC; monitoring of milestones and deliverables



Scientific Committees

HOME | EXPERIMENT COMMITTEES | RESOURCES REVIEWS | SECRETARIAT

# CERN Scientific Committees

All in a nutshell

The CERN Scientific Committees are of two types: the Experiment Committees, which review the physics, and the Resources and Finance Review Boards.

Calendar all

https://committees.web.cern.ch

## Experiment Committees

**Research Board**
Chairperson: Director-General
Scientific Secretary: Roger Forty (EP)

**DRDC - Detector R&D Committee**
Chairperson: Thomas Bergauer
Scientific Secretary: Jan Troska (EP)

**REC - Recognized Experiments Committee**
Chairperson: Director for Research
Scientific Secretary: Helge Meinhard (RCS)

**INTC - ISOLDE and n_TOF Experiments Committee**
Chairperson: Marek Pfutzner
Scientific Secretary: Hanne Heylen (EP)

**LHCC - LHC Experiments Committee**
Chairperson: Frank Simon
Scientific Secretary: Lorenzo Moneta (EP)

**SPSC - SPS and PS Experiments Committee**
Chairperson: Jordan Nash
Scientific Secretary: Carlos Lourenço (EP)

DRDC home

**COMMITTEE MEETINGS**

Agenda (Indico)
Minutes (CDS)
Members' List
Dates next meetings

**OFFICIAL DOCUMENTS**

Submit a proposal
Public Collection (CDS)
History - Archives

**DRDC REFEREES**

Internal site
*(protected)*

# Detector R&D Committee (DRDC)

The Detector Research and Development Committee (DRDC) receives proposals for new detector R&D experiments, evaluates them and decides whether to recommend approval. The DRDC reports to the CERN Director for Research and submits its recommendations to the Research Board. Once DRD collaborations are established, the Committee will request status reports and conduct reviews of their progress

*A first DRDC was set up in July 1990 and held its last meeting in January 1995. The role of reviewing the approved R&D experiments was taken over by the LHCC and the SPSC until end 2023. See the information in the CERN Archives website.*

**Chairperson**: Thomas Bergauer, HEPHY Vienna

**Scientific Secretary**: Jan Troska, EP Department

Next Meeting

MONDAY
**4 DEC**/23
10:00 - 17:35
(Europe/Zurich)

**1st meeting of the DRDC**

Event

https://committees.web.cern.ch/drdc

# 1st meeting of the DRDC

Monday 4 Dec 2023, 10:00 → 17:35 Europe/Zurich

61/1-009 - Room C (CERN)

Thomas Bergauer (Austrian Academy of Sciences (AT))

….was earlier today!

Description CERN-DRDC-2023-001, A-001

Videoconference DRDC meeting — Join

**10:00 → 10:05 Welcome** 5m

Speaker: Joachim Mnich

**10:05 → 10:15 Introduction** 10m

Speaker: Thomas Bergauer

2023-12-04_1stDRD...

**10:15 → 10:35 DRD1 Proposal: Development of Gaseous Detectors Technologies** 20m

Speakers: Anna Colaleo (Universita e INFN, Bari (IT)), Eraldo Oliveri (CERN), Leszek Ropelewski (CERN), Maksym Titov (IRFU, CEA Saclay, Université Paris-Saclay (FR)), Piotr Gasik (GSI - Helmholtzzentrum fur Schwerionenforschung GmbH (DE))

DRD1_DRDC_Mond... R_D_PROPOSAL__D...

**10:35 → 11:05 Discussion on DRD1 Proposal** 30m

**11:05 → 11:20 Coffee Break** 15m

**11:20 → 11:40 DRD6 Proposal: Calorimetry** 20m

Speakers: Gabriella Gaudio (INFN-Pavia), Roberto Ferrari (INFN Pavia (IT)), Roman Poeschl (Université Paris-Saclay (FR))

DRD6-proposal-v3.2...

**11:40 → 12:15 Discussion on DRD6 Proposal**

**12:15 → 12:35 DRD4 Proposal: Photon Detectors and Particle Identification Techniques**

Speakers: Christian Joram (CERN), Rok Pestotnik (Jozef Stefan Institute (SI))

DRD4 Proposal final... Presentation DRDC ... Presentation DRDC ...

**12:35 → 13:10 Discussion on DRD4 Proposal**

**13:10 → 14:00 Lunch**

Special arrangement for DRDC Members

**14:00 → 14:20 DRD2 Proposal: Liquid Detectors**

Speakers: Jocelyn Monroe (University of London (GB)), Roxanne Guenette

ECFA_TF2_Proposal...

**14:20 → 14:55 Discussion on DRD2 Proposal**

**15:00 → 15:20 DRD3 Proposal: Solid State Detectors**

Speakers: Giulio Pellegrini (Centro Nacional de Microelectrónica (IMB-CNM-CSIC)), Giulio Pellegrini (Universidad de Valen

DRD3_proposa_v3.p... DRD3_proposa_v3.p... DRD3___Silicon_Det...

**15:20 → 16:00 Discussion on DRD3 Proposal**

**16:00 → 16:15 Coffee Break**

https://indico.cern.ch/event/1328078/

# Memorandum of Understanding

- All institutes of one DRD collaboration sign a “light-weight” MoU
  - Does not contain commitments on strategic funds
  - Defines Common Fund, if agreed by the respective DRD Collaboration
  - Covers IP topics, how to handle involvement of industr

  (In that case very similar as the current existing MoUs of RD50/51)
  - MoU Template will be provided by CERN (currently being negotiated with legal office, KT, DRC,..)
- Strategic funding will be agreed upon in annexes to this light-weight MoU
  - One Annex per Work Package, signed by the FAs of the institutes involved in the respective WP

# Proposed
# Detector R&D collaborations

Highlights of scientific programs, organization and community contributions

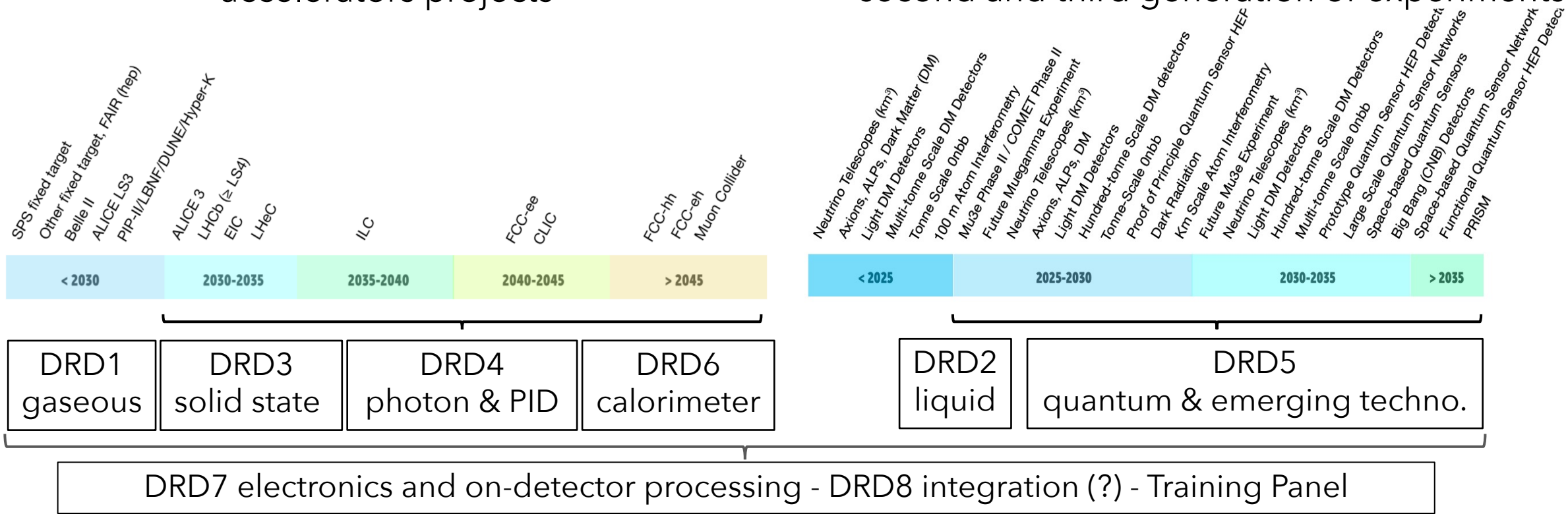
# Status of Proposed DRD Collaborations

| Collab. | Topic | Initial Proposal Submission | Seeking approval | comment |
|---|---|---|---|---|
| DRD 1 | Development of Gaseous Detectors | July 2023 | Dec. 2023 | Former RD51 |
| DRD 2 | Liquid Detectors | July 2023 | Dec. 2023 | |
| DRD 3 | Solid State Detectors | 3 Oct. 2023 | Dec. 2023 | Former RD50 |
| DRD 4 | Photon Detectors and Particle Identification Techniques | July 2023 | Dec. 2023 | |
| DRD 6 | Calorimetry | July 2023 | Dec. 2023 | CALICE, CrystalClear |
| DRD 5 | Quantum and Emerging Technologies | | later | |
| DRD 7 | R&D Collaboration for Electronic Systems | LoI submitted | later | |
| TF 8 | Integration | - | later | Workshop on 6$^{th}$ Dec. |

# Context of HEP projects for Detector Research & Development

upgrades and future large accelerators projects

small accelerators, nuclear reactors, cosmic rays second and third generation of experiments




*Planning of projects is for physics start at the time of the roadmap, end of strategic R&D must consider project engin., constr. and instal. time*

# DRD1: Gaseous Detectors

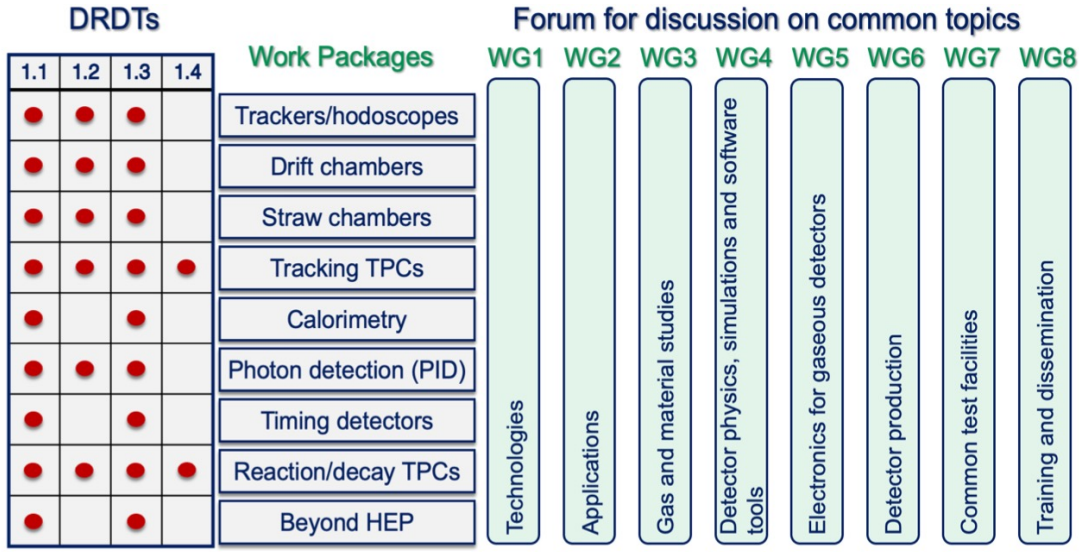
**Gaseous**

**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

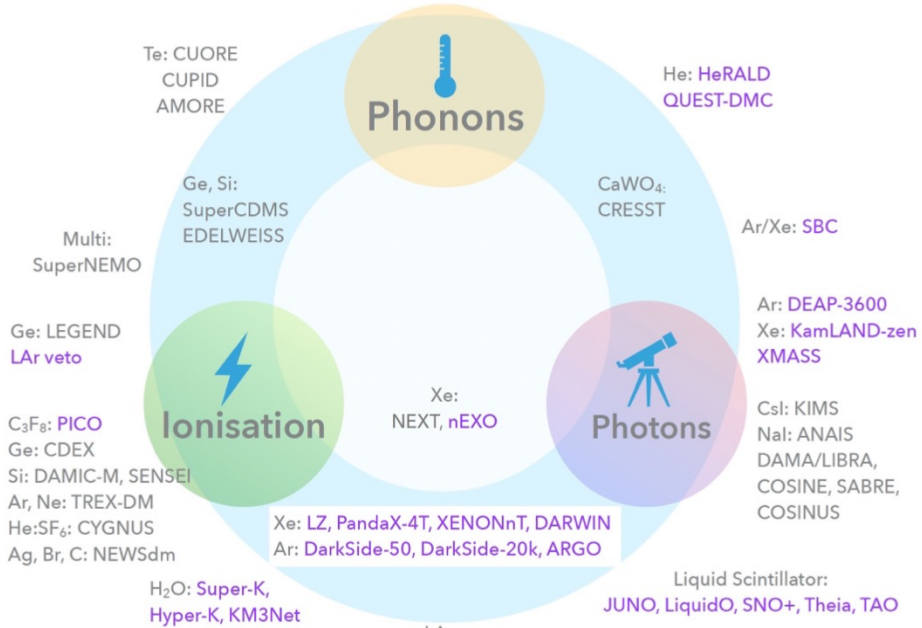
**DRDT 1.4** Achieve high sensitivity in both low and high-pressure TPCs



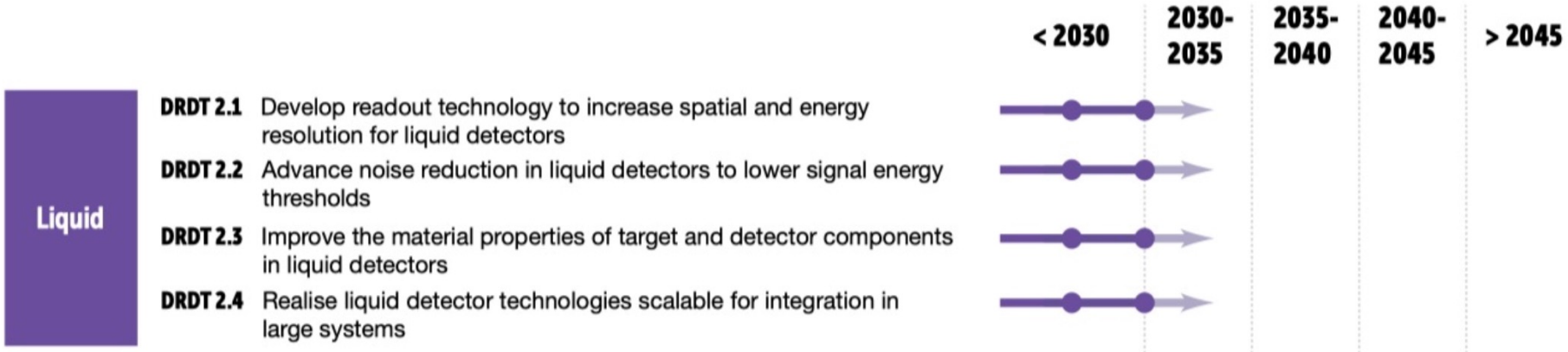

- Organized in
  - **Working Groups:** serving as the backbone of the proposed R&D environment and framework
  - **Work Packages:** will consolidate the activities of institutes with shared research interests in specific areas,
  - and **Common Projects** (blue sky) financed by fixed yearly fee (Common Fund)
- Large community of 160 institutes
- Budget: 3 MCHF/y existing, additional 3 MCHF/y requested, 270/100 FTE
- Community meeting: most recent June 23;
  next tentatively scheduled for Dec. 2023; DRD1 Kick-off meeting Jan-Feb 2024
- Web page: https://drd1.web.cern.ch/ (with proposal v1.4)

# DRD2: Liquid detectors

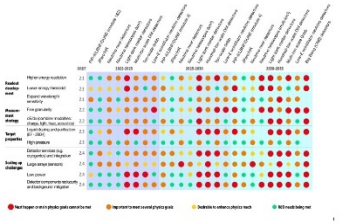
- Covers Dark Matter and Neutrino experiments, accelerator and non-accelerator-based
- Several large-scale and many small-scale experiments running or foreseen with liquid detectors
- Technology: Noble Liquids (e.g. DUNE), Water Cherenkov (e.g. Super/Hyper-K) and Liquid Scintillator with light and ionization 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




[ECFA roadmap, Modified from L.Baudis]



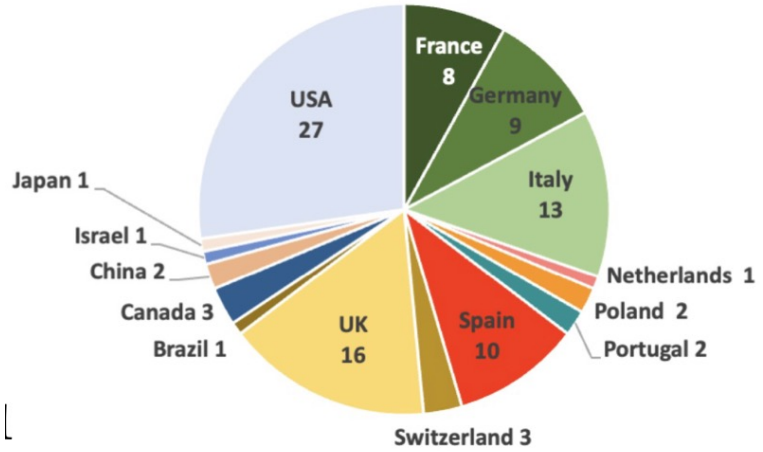

Note: Developments in this field are rapid and it is not possible today to reasonably estimate the dates for projects requiring longer-term R&D



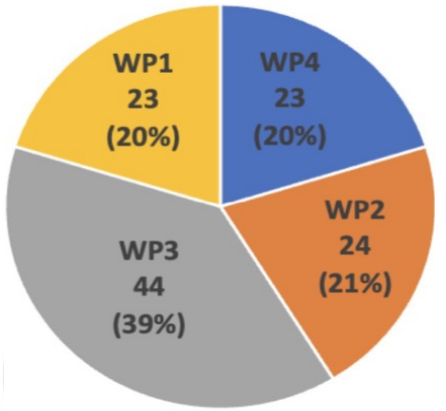
# DRD2: Liquid detectors

- DRD2 is divided in four WPs
  - Aligned but not identical to DRDTs
  - Based on 51 bottom-up projects
  - 150 participants in community meeting
  - Conveners: Roxanne Guenette, Jocelyn Monroe + contributors
- DRD2 Collaboration from 114 institutes in 15 countries
  - Significant US contribution (>25%)
  - Nominated liaisons to DRD1,4 and 7
- Budget:
  - 2.6 / 7.8 M€/y (available / required)
  - 148.4/ 305.6 (available/required) FTE

Number of institutions by nation



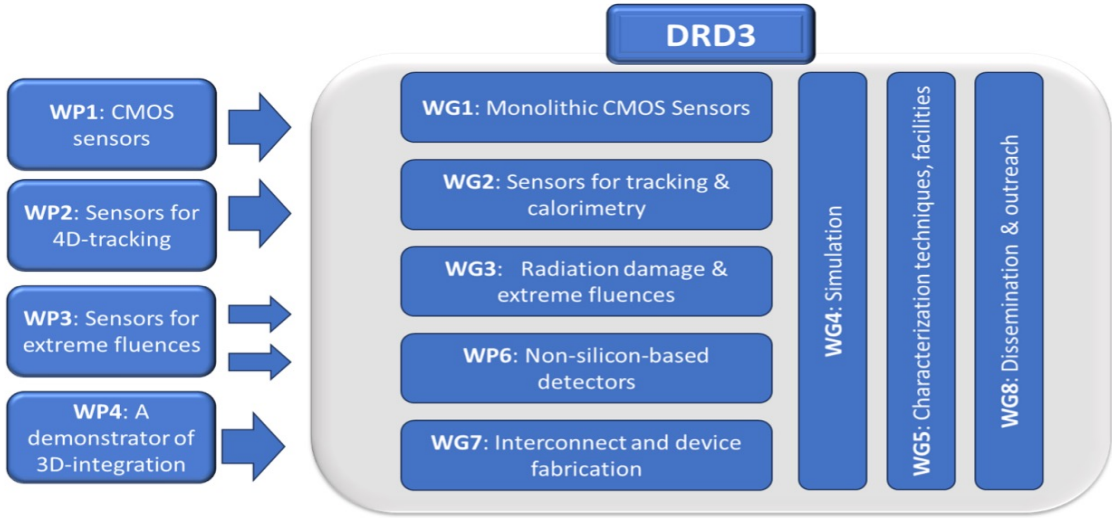

Number of institutions by WP



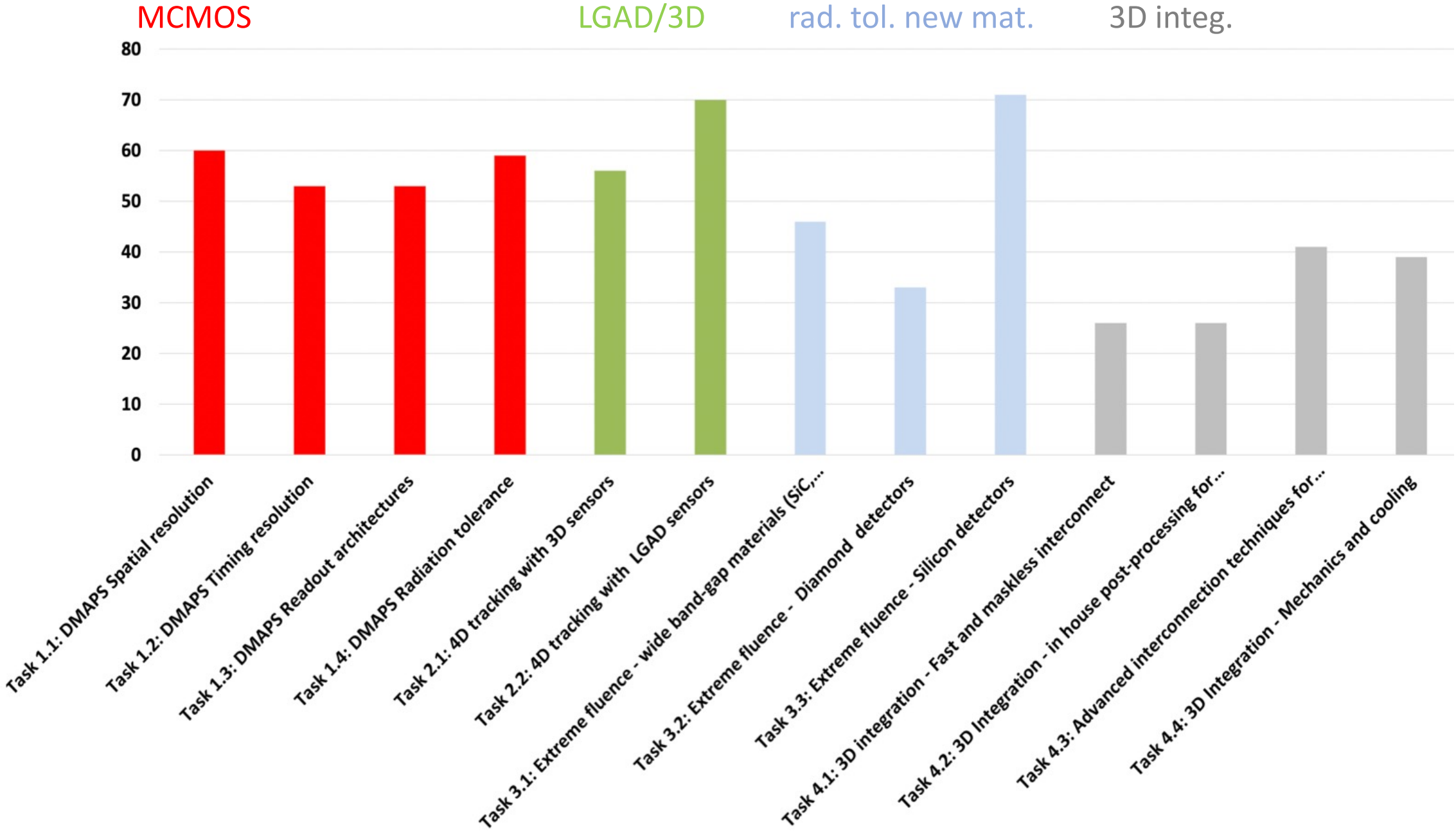

| WP1 | WP2 | WP3 | WP4 |
|---|---|---|---|
| Charge Readout Conveners | Light Readout Conveners | Target Properties Conveners | Scaling-up Challenges Conveners |
| Pixels & charge+light Group leaders | Increased sensor quantum efficiency Group leaders | Target properties and isotope loading of LS & WC Group leaders | Radiopurity & background mitigation Group leaders |
| Charge-to-light, electroluminescence & amplification Group leaders | Higher efficiency WLS and collection Group leaders | | Detector and target procurement/production & purification Group leaders |
| Ion detection Group leaders | Improved sensors for LS & WC Group leaders | Target properties and isotope loading of noble elements Group leaders | Large-area readouts Group leaders |
| | | | Material properties Group leaders |
| DRDT 2.1, 2.2 | DRDT 2.1, 2.2 | DRDT 2.3 | DRDT 2.3, 2.4 |

# DRD3: Semiconductor Detectors

- DRD3 benefits from existing RD50 collaboratior
  - Extended by diamonds (RD42) and 3D integration
- Organized in
  - Work Packages identical to DRDTs
  - Working Groups very similar to current RD50
  - Common projects (for blue-sky)
    (many still running from RD50)
- Large Collaboration: 129 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)




| WP | Task | Title |
|---|---|---|
| 1 | 1.1 | DMAPS: spatial resolution |
| 1 | 1.2 | DMAPS: timing resolution |
| 1 | 1.3 | DMAPS: read-out architectures |
| 1 | 1.4 | DMAPS: radiation tolerance |
| 2 | 2.1 | 4D tracking: 3D sensors |
| 2 | 2.2 | 4D tracking: LGAD |
| 3 | 3.1 | Extreme fluence: wide band-gap materials (SiC, GaN) |
| 3 | 3.2 | Extreme fluence: diamond-based detectors |
| 3 | 3.3 | Extreme fluence: silicon detectors |
| 4 | 4.1 | 3D Integration: fast and maskless interconnect |
| 4 | 4.2 | 3D Integration: in house post-processing for hybridization |
| 4 | 4.3 | 3D Integration: advanced interconnection techniques for detectors |
| 4 | 4.4 | 3D Integration: mechanics and cooling |

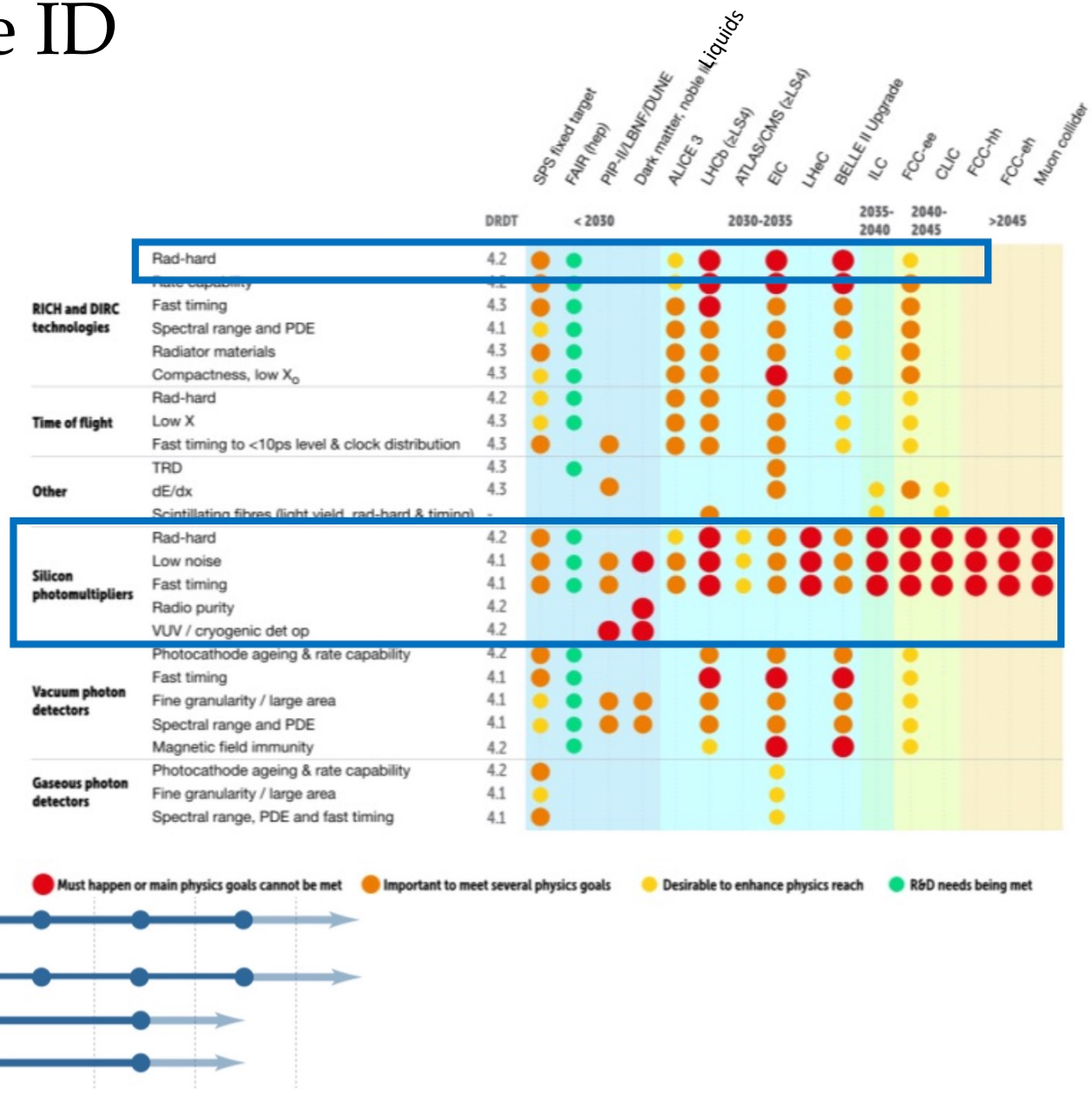

MCMOS
LGAD/3D
rad. tol. new mat.
3D integ.
80
70
60
50
40
30
20
10
0
Task 1.1: DMAPS Spatial resolution
Task 1.2: DMAPS Timing resolution
Task 1.3: DMAPS Readout architectures
Task 1.4: DMAPS Radiation tolerance
Task 2.1: 4D tracking with 3D sensors
Task 2.2: 4D tracking with LGAD sensors
Task 3.1: Extreme fluence - wide band-gap materials (SiC,...
Task 3.2: Extreme fluence - Diamond detectors
Task 3.3: Extreme fluence - Silicon detectors
Task 4.1: 3D integration - Fast and maskless interconnect
Task 4.2: 3D Integration - in house post-processing for...
Task 4.3: Advanced interconnection techniques for...
Task 4.4: 3D Integration - Mechanics and cooling

# DRD4: Photodetectors & Particle ID

- Particle Identification (PID) essential to identify decays when heavy flavor are present

- **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.)




**PID and Photon**

**DRDT 4.1** Enhance the timing resolution and spectral range of photon detectors

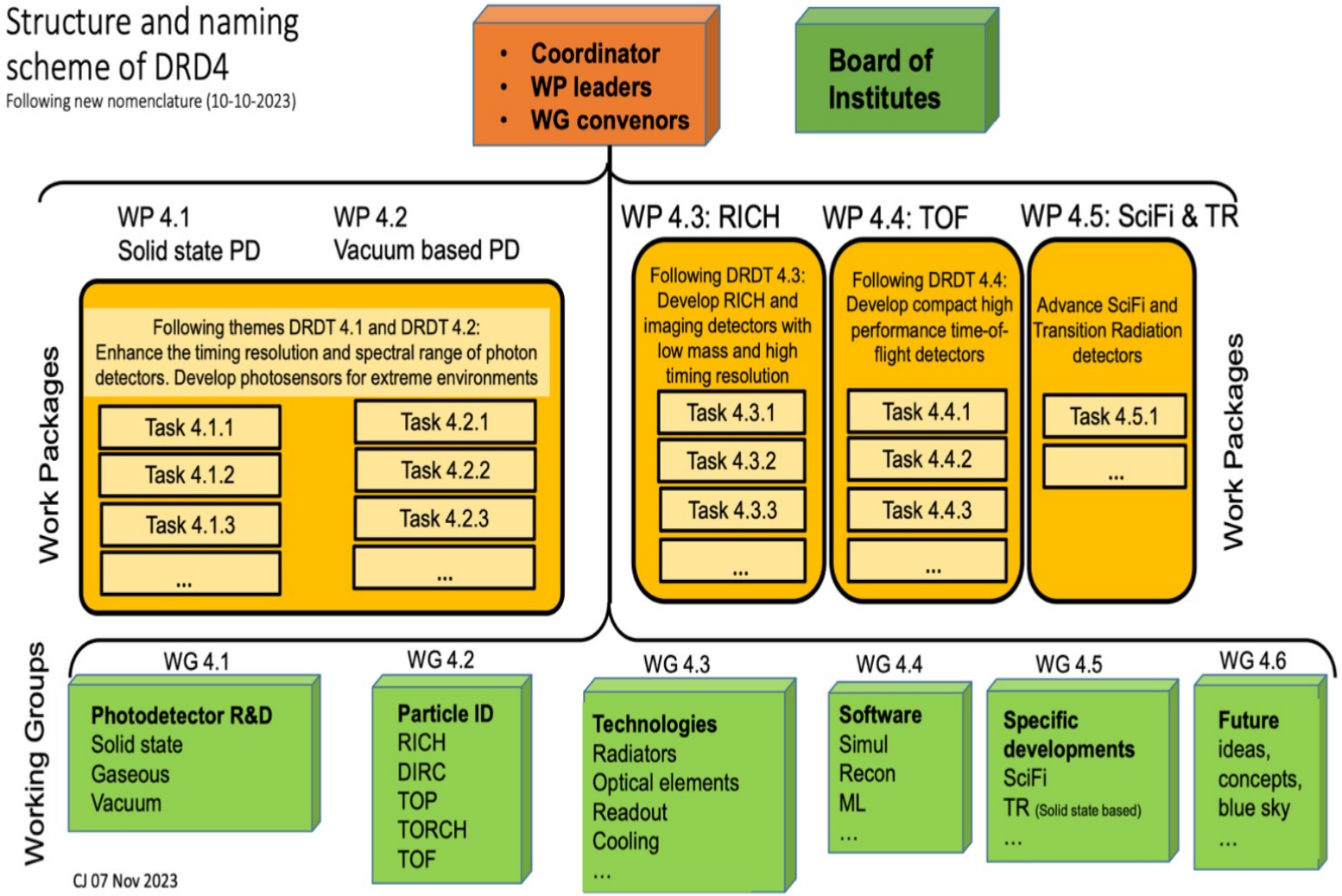
**DRDT 4.2** Develop photosensors for extreme environments

**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

# DRD4: Photodetectors & Particle ID

- Collaboration currently led by Christian Joram (CERN) + Peter Krizan (Ljubljana) + team of 12 others
  - election of management when collaboration officially constituted in 2024
- 67 institutes + 7 industrial partners
  - EU + 6 US, 2 China, 2 Japan, 2 Australia, 1 S.Korea, 1 Armenia
- Budget
  - 100 FTE/y (avail), ~60 FTE/y (additional)
  - 1.5MCHF/y (avail.), 1.8MCHF/y (additional)



# DRD6 Calorimetry

- Collaboration emerged from CALICE and CrystalClear (RD18)
  - 23 input proposals were collected from existing collaborations, boiled down to four WPs and five Working Groups
  - 110 institutes; 183 FTE/y (existing), 100 FTE/y requested
  - Budget ~3.2M€/y existing, ~1.4 to 2.4M€/y requested (2024-2026)

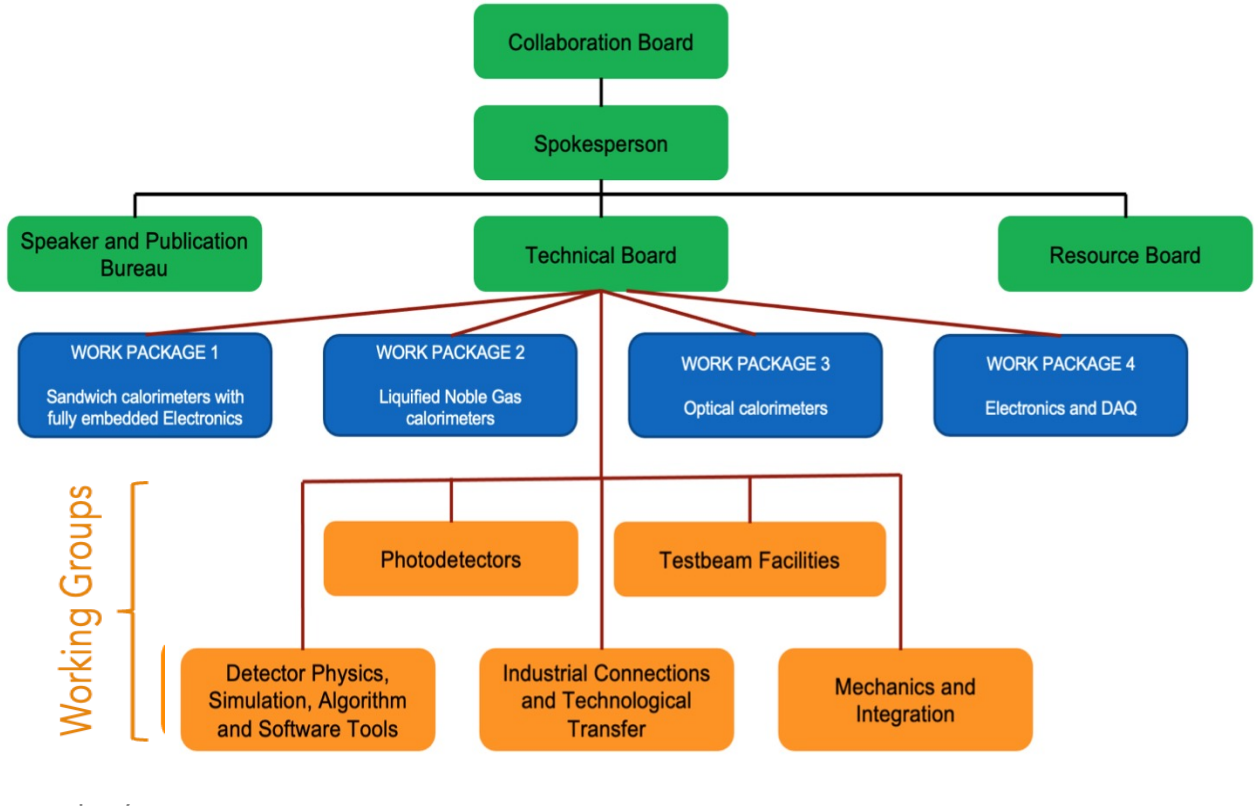
- R&D in calorimetry has a particularly long lead-time due
  - Many technology developments (gas, scintillator or Silicon-based readout) done in other DRDs
  - Large and challenging prototype setups even in early stages
  - Dedicated calorimeter test beam line requested

**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

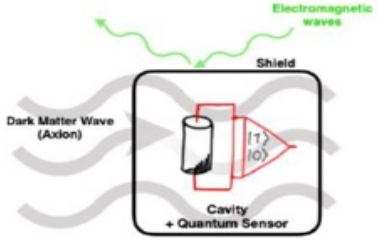
**DRDT 6.3** Develop calorimeters for extreme radiation, rate and pile-up environments



# DRD5 : Quantum sensors and emerging technologies

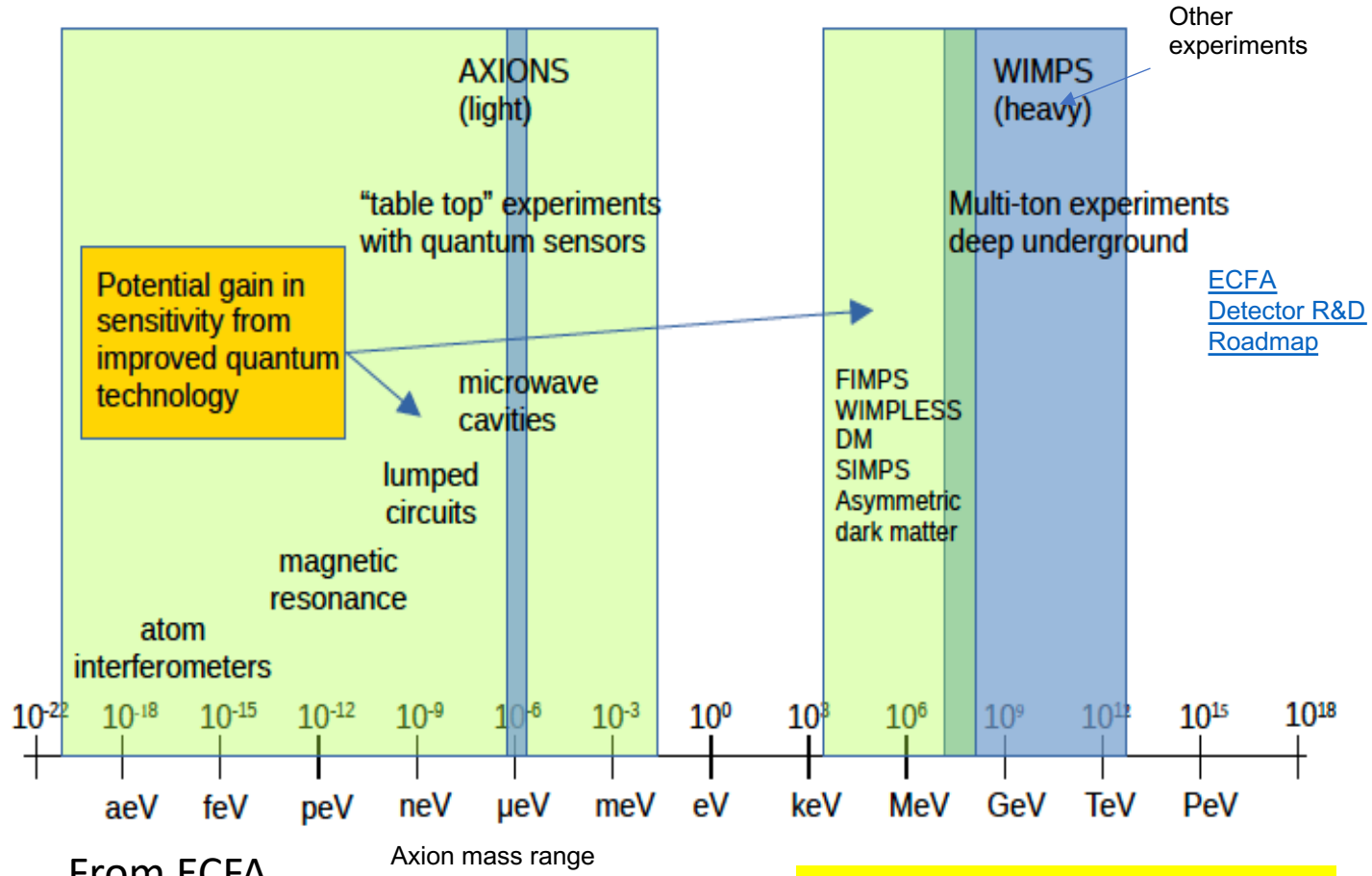
- **Quantum Technologies are a rapidly emerging area** of technology development to study fundamental physics: Dark Matter, neutrino mass, gravity, new forces, EDMs
- The ability to engineer quantum systems to improve on the measurement sensitivity holds great promise
- **Many different sensor and technologies being investigated**: clocks and clock networks, spin-based, superconducting, optomechanical sensors, atoms/molecules/ions, atom interferometry,
- Several initiatives started at CERN, DESY, FNAL, US, UK, Japan, India…


- Development of HEP detectors long term
- Nano/meta/heterogenous materials




S. Golawa

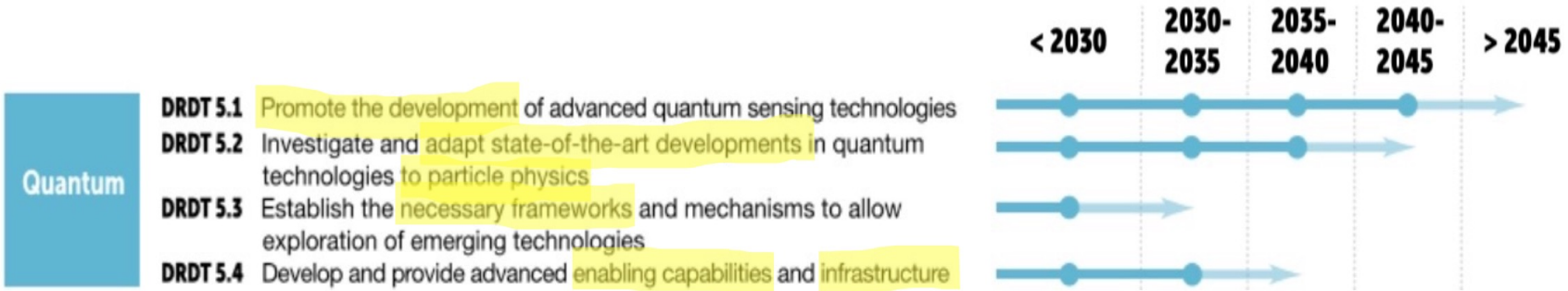
Example: potential mass ranges that quantum sensing approaches open up for Axion searches & other light particles

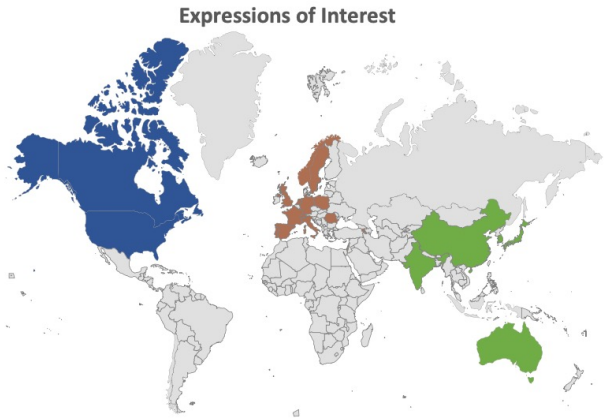



From ECFA Roadmap

Blue: now
Light green: with quantum

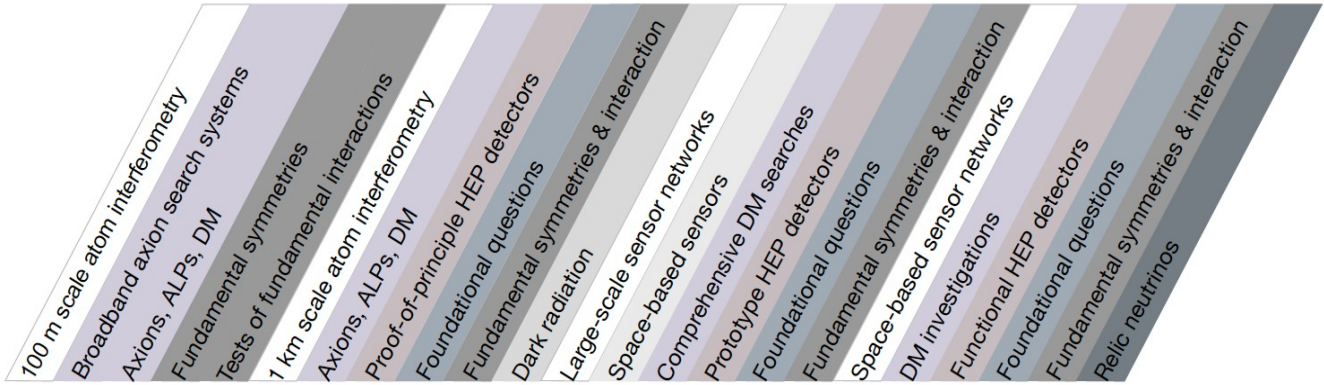
# DRD5 Collaboration



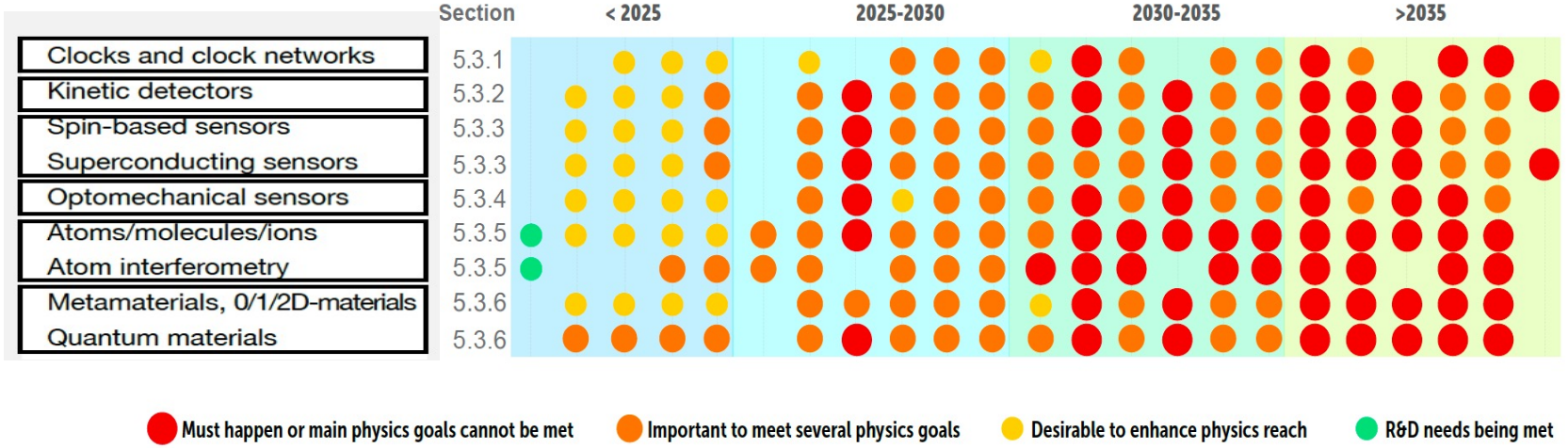




- 40 institutes in 15 countries
- 25 proposed contributions
- conveners: Marcel Demarteau, Michael Doser
- White Paper / LoI being submitted to DRDC
  - Information on personal web page of M. Doser

A workshop to prepare the proposal for submission by year end to place Oct. 2-4



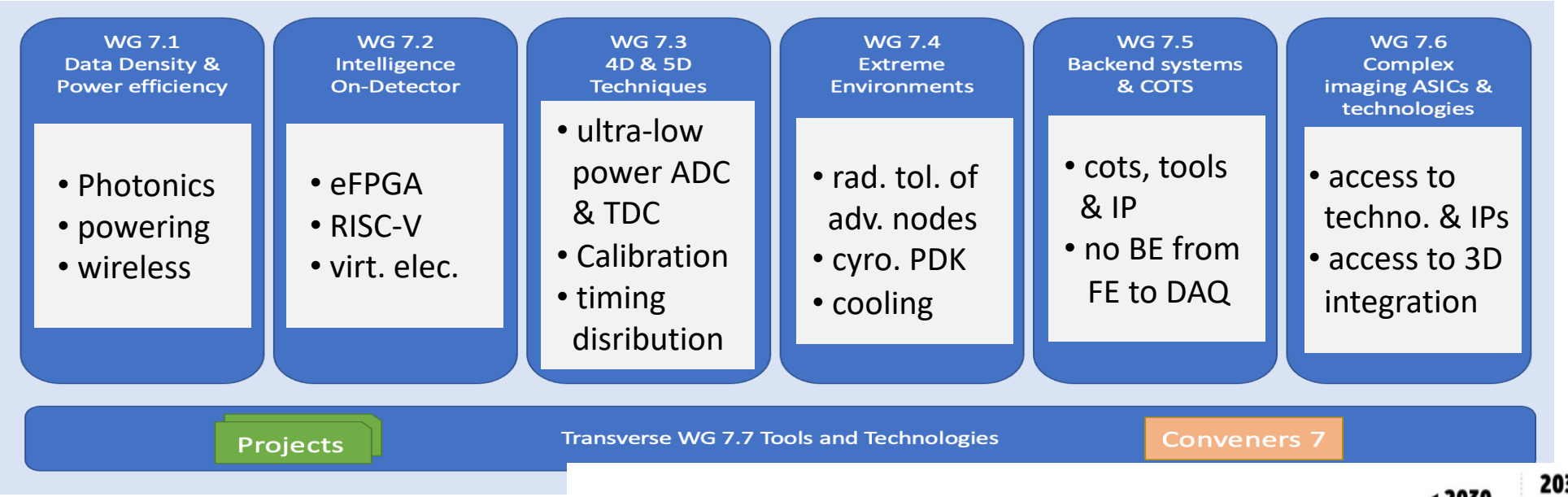

Technology areas
sensor families



# DRD7: Electronic systems

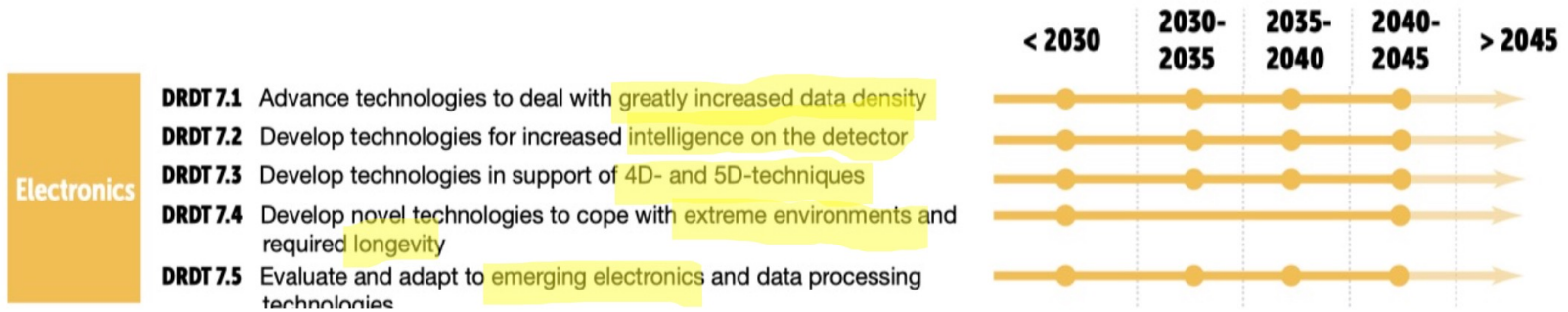
Letter of Intent exists full proposal by end of year

- Advance the state-of-the-art in performance of electronics and data processing
- Improve and develop further common standards, methodologies, and IP
- Build expertise, increase efficiency and decrease duplication of effort
- Provide facilities and tools for R&D in the community, with long-term continuity
- Common point of contact to foundries




Six (Seven) Development areas (WPs) 50 Institutes, 18 nations
Steering committee: J. Baudot, M. French, A. Rivetti, F. Simon, F. Vasey
+ 20 WP coordinators
1st workshop happened March, 2nd workshop 25-27 September 2023

16 projects received from 50 institutes in 18 countries



# Task Force 8: Integration

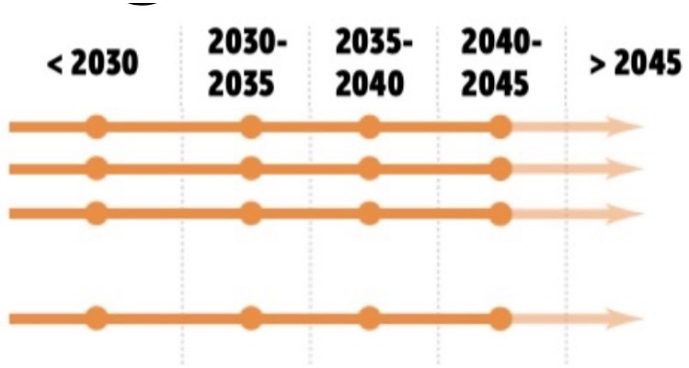
**Integration**

**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



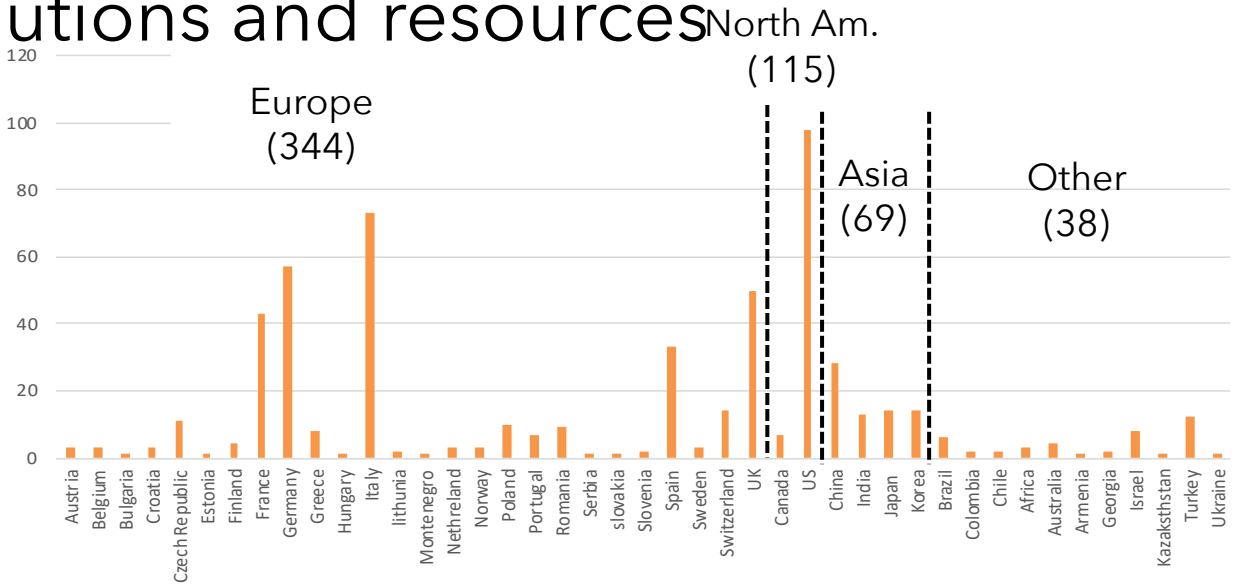

- Target: Mechanical support and structures, cooling, magnets and management of radiation environment
  - DRDTs are quite diverse
  - Some topics are very closely connected to the genuine DRDs, where the technology is developed (e.g. DRDT 8.3)
- **No DRD collaboration has been proposed yet, but 16 institutions replied favourably to a community survey**
  - **Community Meeting on December 6, 2023**

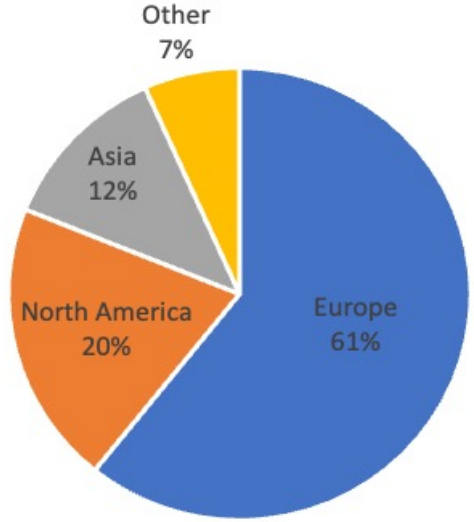
**Topics:**

- Gas cooling development
- Single- and two-phase liquid cooling R&D
- Humidity control
- Temperature control
- Thermal management
- Thermal performance verification
- Thermal interface materials and expansion differences
- Pipe materials, pipe connection techniques and fittings
- Choices and characterisation of construction materials
- 3D printing
- Radiation and mechanics: Materials and issues like access constraints
- FEA and its comparison to real objects
- Structure design and optimisation
- Application of machine learning for design issues

# Summary of contributions and resources

566 institutes sum of participating insitutes in DRD1-2-3-4-6 (intstitutes can contribute to different DRDs)

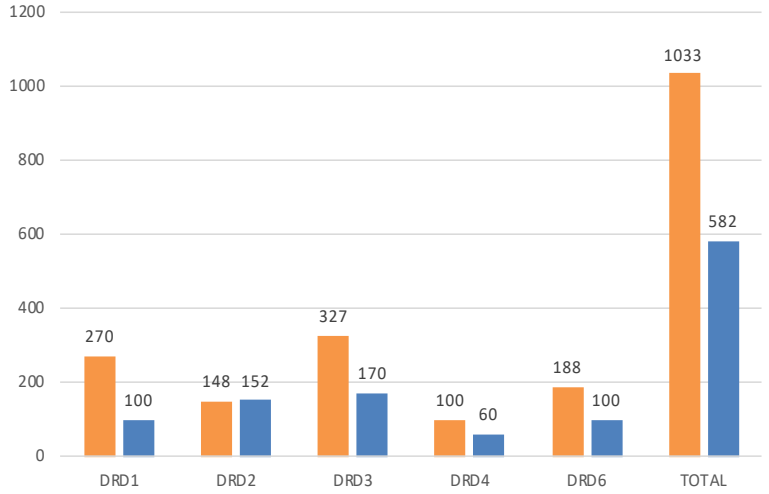


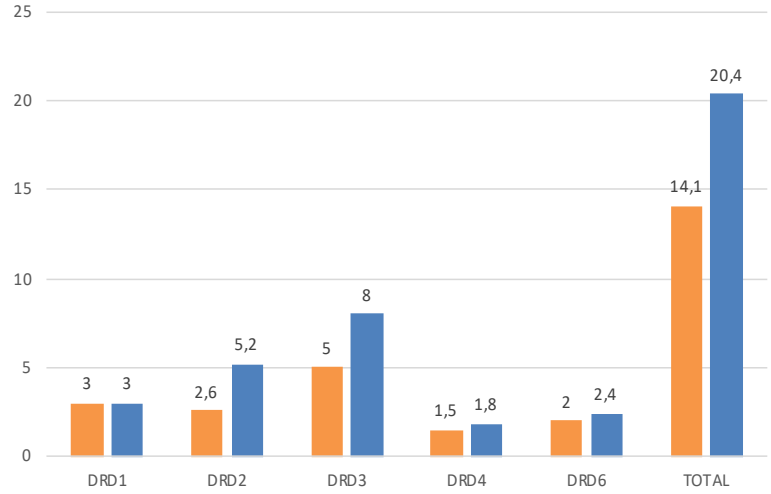

preliminary

Expected FTE/y & funding/y
≃ average over 3 first years
available ≃ current funding
additional ≃ requested to fulfil progr.
based on a survey
(non-uniform answers from institutes)
not a commitment
need consolidation for MoUs

FTE/y available/additional




funding/y available/additional (MCHF)



# Summary Part 1

- **New Detector R&D (DRD) collaborations are being set up following the ECFA Detector roadmap to pave the way for the next decades.**
  - Main Goal: Instrumentation is not the limiting factor to meet the needs of the long-term particle physics program
  - Collaboration-building for communities that have not worked together before

- Submitted, currently being reviewed by DRDC: **Gas detectors** (DRD1), **liquid detectors** (DRD2), **semiconductor detectors** (DRD3), **photodetectors & particle ID** (DRD4), **calorimetry** (DRD6)
  - DRDC and CERN research board approval meetings 4$^{th}$ and 6$^{th}$ of December
  - The proposals will then be publicly accessible in the CERN CDS
- Proposal Submission later:
  - **Quantum sensors** (DRD5), **Electronics** (DRD7)
  - **Integration** (DRD8) to be decided

# Summary Part 2

Through preparation of new DRD proposals important progress has been made to :

- build new communities
  - large world- wide contributions
- prepare a global scientific programme to execute the ECFA roadmap
- assess resource needs and availability

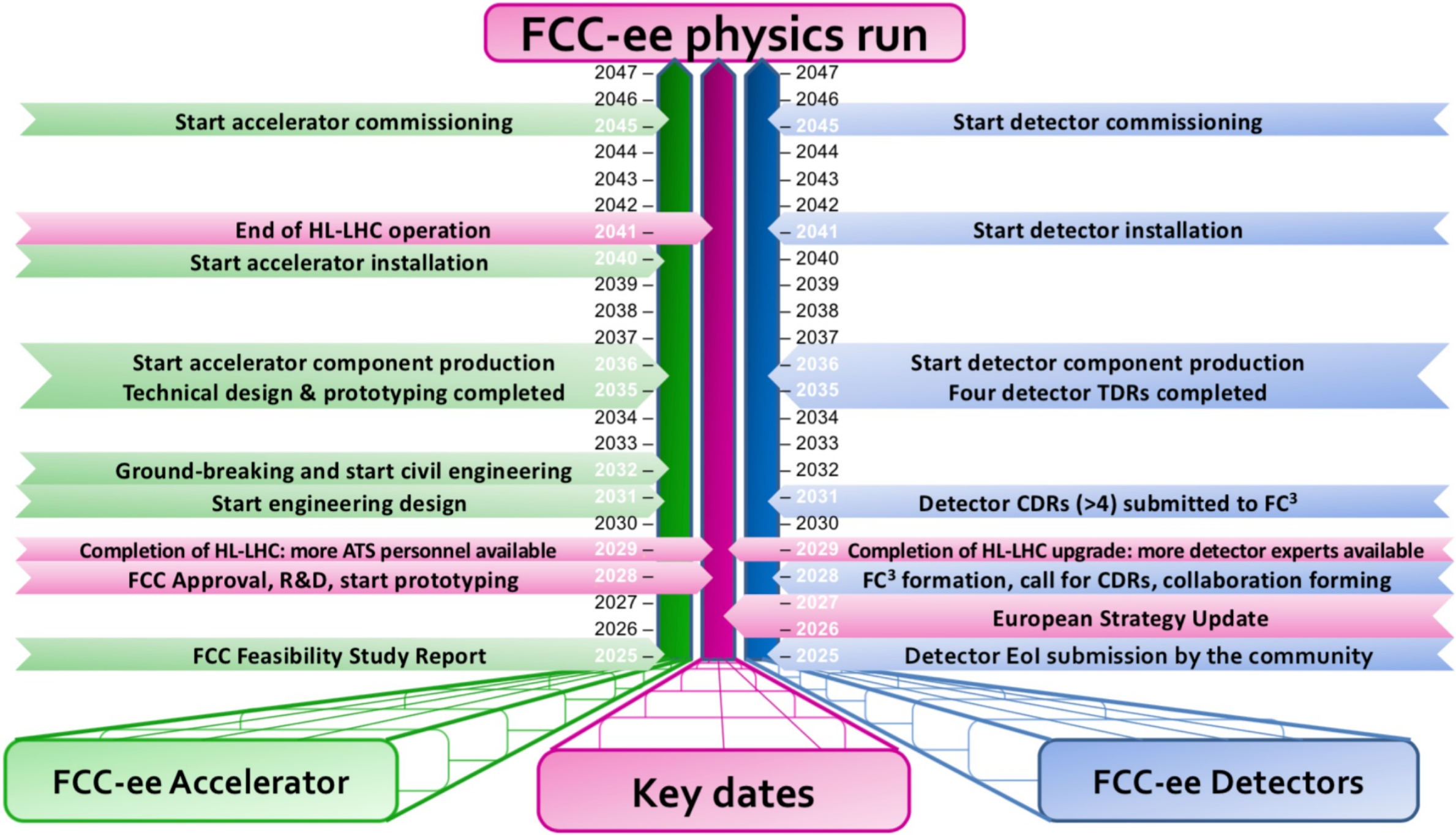
The DRD collaborations will soon become active to :

- Implement their organizational structure
- consolidate the scientific programme and the resource needs in preparation for MoUs with National Funding Agencies
  - substantial ramp-up of resources is needed
- common work on availability of infrastructure and beam test facilities is on-going with the Lab Directors Group
- fields outside HEP can join the collaborations as full members or partners
- rules for industrial/semi-public partnerships are being prepared for MoUs with CERN guidance

A new ECFA training panel has been established to create a Europe-wide MSc Instr. and other enhanced training opportunities

*thanks especially to Thomas Bergauer DRDC Chair, P. Allport ECFA Roadmap Panel Chair and K. Jakobs ECFA chair and ECFA Roadmap Co-ordinators S. Della Torre, M.Krammer, S.Kuehn, F. Sefkow, I.Shipsey*
*A. Colaleo, L. Ropeleweski (DRD1); R. Guenette, J. Monroe (DRD2); N. Cartiglia, G. Pellegrini (DRD3); C. Joram , P. Krizan (DRD4); M. Demarteau, M. Doser (DRD5); R. Ferrari, R. Poeschl (DRD6); D. Newbold, F. Simon, F. Vasey (DRD7)*

# Additional Material


FCC-ee physics run
2047
2046
Start accelerator commissioning
2045
2044
2043
2042
End of HL-LHC operation
2041
Start accelerator installation
2040
2039
2038
2037
Start accelerator component production
Technical design & prototyping completed
2036
2035
2034
2033
Ground-breaking and start civil engineering
Start engineering design
2032
2031
2030
Completion of HL-LHC: more ATS personnel available
2029
FCC Approval, R&D, start prototyping
2028
2027
2026
FCC Feasibility Study Report
2025
2047
2046
Start detector commissioning
2045
2044
2043
2042
Start detector installation
2041
2040
2039
2038
2037
Start detector component production
Four detector TDRs completed
2036
2035
2034
2033
2032
Detector CDRs (>4) submitted to FC3
2031
2030
2029
Completion of HL-LHC upgrade: more detector experts available
2028
FC3 formation, call for CDRs, collaboration forming
2027
European Strategy Update
2026
2025
Detector EoI submission by the community
FCC-ee Accelerator
Key dates
FCC-ee Detectors