From RD50 (and more) to DRD3

Solid state detectors

Giulio Pellegrini

Why this workshop? (my vision!)

- DRD´s are in phase of creation and this may be a **challenge** for the Spanish community but also a **risk** due to the change in the funding scheme.
- It can be useful to **remind** and explain the Roadmap to the community.
- **Detectors** are a very important part of all experiments, the **R&D** has a direct impact in many other activities. However, the Roadmap does **not cover** all the activity in R&D.
- A **discussion** is always useful, we will need to find synergies and new collaborations.
- A **critical mass** in the R&D may be necessary to achieve the objectives of the Roadmap. It is interesting and useful to understand the implication of Spanish institutes in the DRD´s.
- What is the role of **CSIC** in the DRD´s?
- Do we need a person **representing** each DRD in Spain?

The 2021 ECFA Detector R&D Roadmap

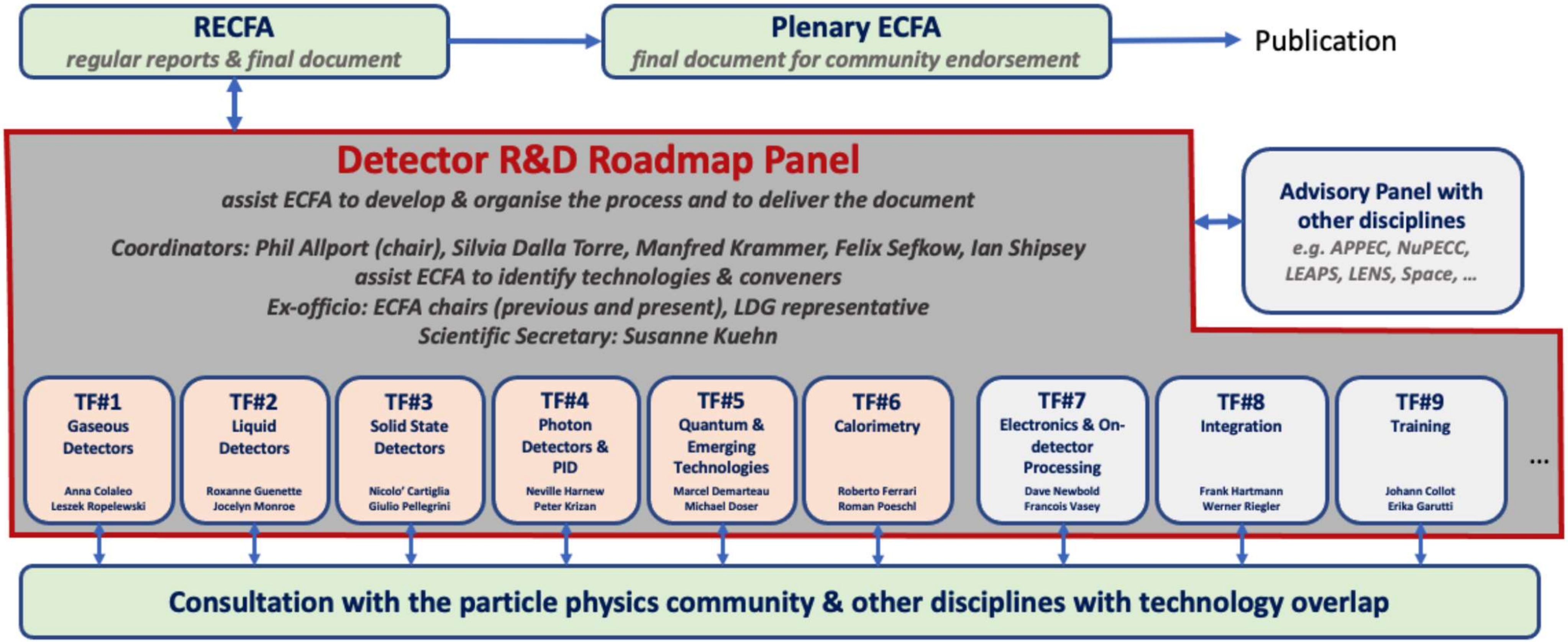
Organized by **ECFA** (The European Committee for Future Accelerators), the **roadmap** is developed by the community to balance the **detector R&D effort in Europe**, taking into account progress with **emerging technologies** in adjacent field.

The roadmap should **identify and describe a diversified detector R&D portfolio** that has the largest potential to **enhance** the performance of the particle physics programme in the near and long term.

- Roadmap developed in 2021, approved by Plenary ECFA on 18 Nov 2021
- Released in December 2021, after presentation to CERN Council
- Documents available: https://indico.cern.ch/event/957057/

The European Strategy of Particle Physics is reviewed and updated every five to ten years.

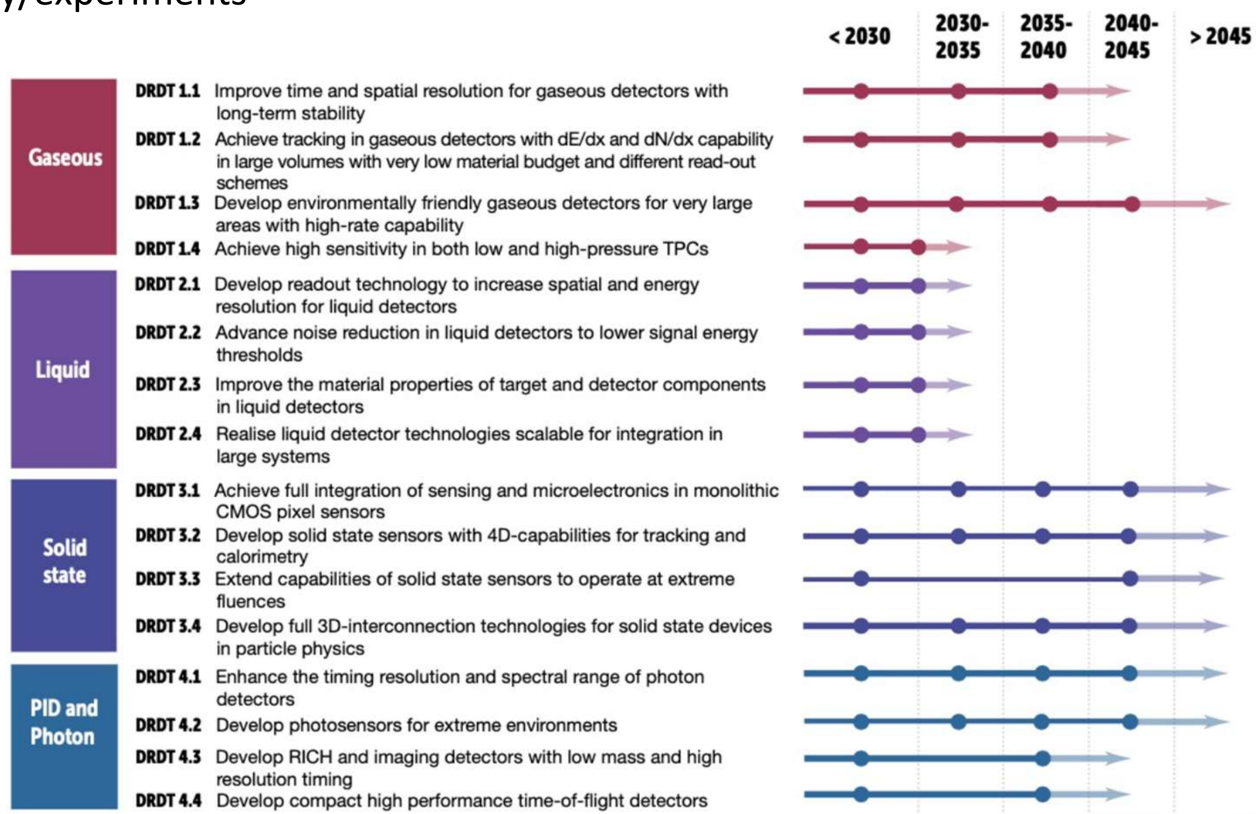
Panel Organisation



Detector Research and Development Themes

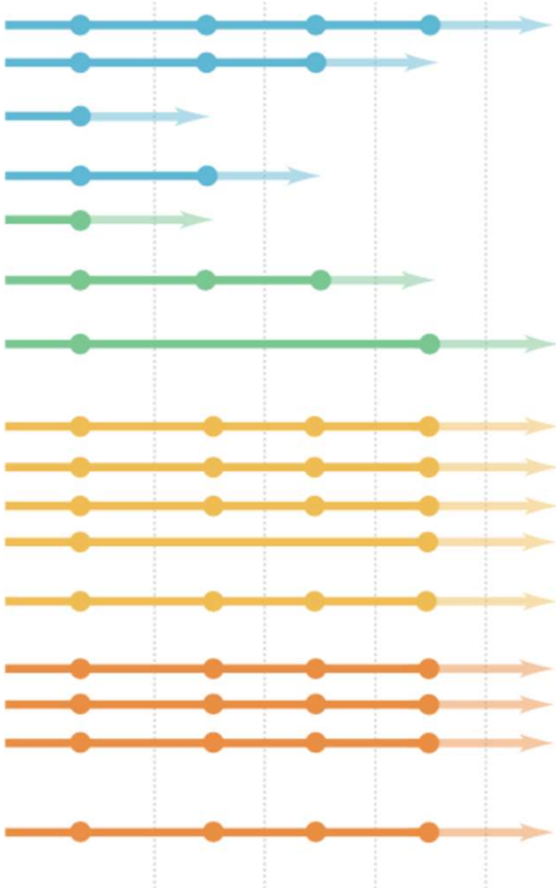
The summarizing timelines (in "Conclusions") are also based on the needs of the future facility/experiments

The faded region acknowledges the typical time needed between the completion of the R&D phase and the readiness of an experiment at a given facility



Detector Research and Development Themes

Quantum	DRDT 5.1	Promote the development of advanced quantum sensing technologies
	DRDT 5.2	Investigate and adapt state-of-the-art developments in quantum technologies to particle physics
	DRDT 5.3	Establish the necessary frameworks and mechanisms to allow exploration of emerging technologies
	DRDT 5.4	Develop and provide advanced enabling capabilities and infrastructure
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
Electronics	DRDT 7.1	Advance technologies to deal with greatly increased data density
	DRDT 7.2	Develop technologies for increased intelligence on the detector
	DRDT 7.3	Develop technologies in support of 4D- and 5D-techniques
	DRDT 7.4	Develop novel technologies to cope with extreme environments and required longevity
	DRDT 7.5	Evaluate and adapt to emerging electronics and data processing technologies
Integration	DRDT 8.1	Develop novel magnet systems
	DRDT 8.2	Develop improved technologies and systems for cooling
	DRDT 8.3	Adapt novel materials to achieve ultralight, stable and high precision mechanical structures. Develop Machine Detector Interfaces.
	DRDT 8.4	Adapt and advance state-of-the-art systems in monitoring including environmental, radiation and beam aspects



Detector R&D Roadmap: General Strategic Recommendations

GSR 1 - Supporting R&D facilities

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

*Aim: * Propose mechanisms to achieve a greater coherence across Europe to better streamline the local and national activities and make these more effective.*

** Give the area greater visibility and voice at a European level to make the case for the additional resources needed for Europe to maintain a leading role in particle physics with all the associated scientific and societal benefits that will flow from this.*

Compilation of the technology R&D needs and timeline for future solid state detectors.

	"Technical" Start Date	< 2030			2030 - 2035		2035 - 2040	2040 - 2045		> 2045	
		ALICE LS3	Belle II CBM	NA62	LHCb, ATLAS, CMS (≳ LS4)[7]	ALICE 3 - EIC	ILC	FCC-ee	CLIC	FCC-hh	Muon Collider
MAPS	technology node[1]	65 nm - stitching	65 nm - stitching			28 nm		≲ 28 nm		≃ 10 nm	≲ 28 nm
MAPS	pitch	10 - 20 µm	10 - 20 µm			pitch ≲ 10 µm for σ_{hit} ≲ 3 µm in VD					
MAPS	pitch				Reduce z-granularity in TK - pad granularity in analog Cal.						
MAPS	wafer size[2]	12"	12"			12"					
MAPS	rate[3]		O(100) MHz/cm²						5 GHz/cm²	30 GHz/cm²	
MAPS	ultrafast timing[4]				σ_t ≲ 100 ps					σ_t ≲ 20 ps	
MAPS	radiation tolerance				3 x 10^{15} neq/cm²					$10^{18(16)}$ neq/cm² VD/Cal.(Trk)	
Planar/3D/Passive CMOS	technology node[1]				ASIC 28 nm	ASIC 28 nm		ASIC ≲ 28 nm		ASIC ≃ 10 nm	ASIC ≲ 28 nm
Planar/3D/Passive CMOS	pitch				≲ 25 µm in VD	≲ 10 µm for σ_{hit} ≲ 3 µm in VD					
Planar/3D/Passive CMOS	pitch				≲ 50 µm for σ_{hit} ≲ 10 µm in Trk						
Planar/3D/Passive CMOS	wafer size[2]					12"					
Planar/3D/Passive CMOS	rate[3]				6 GHz /cm²					30 GHz/cm²	
Planar/3D/Passive CMOS	ultrafast timing[4]			σ_t ≃ 50 - 100 ps		σ_t ≲ 100 ps				σ_t ≲ 20 ps	
Planar/3D/Passive CMOS	radiation tolerance				6 x 10^{16} neq/cm²					$10^{18(16)}$ neq/cm² VD/Cal.(Trk)	
LGADs	technology node[1]						ASIC 28 nm	ASIC ≲ 28 nm		ASIC ≃ 10 nm	
LGADs	pitch			≃ 300 µm (100% fill facor)	≲ 50 µm (100% fill facor)	same as for other technologies with ultimate pitch ≲ 10 µm for σ_{hit} ≲ 3 µm in VD					
LGADs	wafer size[2]				> 3"	12"					
LGADs	rate[3]				6 GHz /cm²					30 GHz/cm²	
LGADs	ultrafast timing[4]				σ_t ≲ 30 ps	σ_t ≃ 20 ps (PID)	σ_t ≲ 20 ps VD/Trk/Cal.	σ_t ≲ 10 ps PID	σ_t ≲ 20 ps VD/Trk/Cal.	σ_t ≲ 20 ps VD/Trk/Cal.	
LGADs	radiation tolerance				≳ 5 x 10^{15} neq/cm²					$10^{18(16)}$ neq/cm² VD/Cal.(Trk)	
backend processing	sensor thickness[5]	< 50 µm MAPS	< 50 µm MAPS		< 150 µm Plan/3D/Pas. < 50 µm LGADs	< 50 µm MAPS, Planar/3D/Passive CMOS, LGADs					
backend processing	3D integration[6]										

Schematic timeline of categories of experiments employing solid state sensors

"Technical" Start Date of Facility (This means, where the dates are not known, the earliest technically feasible start date is indicated - such that detector R&D readiness is not the delaying factor)				< 2030					2030-2035					2035 - 2040	2040-2045		> 2045		
				Panda 2025	CBM 2025	NA62/Klever 2025	Belle II 2026	ALICE LS3 [1]	ALICE 3	LHCb (≥LS4)[1]	ATLAS/CMS (≥ LS4)[1]	EIC	LHeC	ILC[2]	FCC-ee	CLIC[2]	FCC-hh	FCC-eh	Muon Collider
Vertex Detector[2]	MAPS Planar/3D/Passive CMOS LGADs	DRDT 3.1 DRDT 3.4	Position precision σ_{hit} (μm)		≃ 5		≲ 5	≃ 3	≲ 3	≲ 10	≲ 15	≲ 3	≃ 5	≲ 3	≲ 3	≲ 3	≃ 7	≃ 5	≲ 5
			X/X_0 (%/layer)	≲ 0.1	≃ 0.5	≃ 0.5	≲ 0.1	≃ 0.05	≃ 0.05	≃ 1		≃ 0.05	≲ 0.1	≃ 0.05	≃ 0.05	≲ 0.2	≃ 1	≲ 0.1	≲ 0.2
			Power (mW/cm²)		≃ 60			≃ 20	≃ 20			≃ 20		≃ 20	≃ 20	≃ 50			
			Rates (GHz/cm²)		≃ 0.1	≃ 1	≲ 0.1		≲ 0.1	≃ 6		≲ 0.1	≃ 0.1	≃ 0.05	≃ 0.05	≃ 5	≃ 30	≃ 0.1	
			Wafers area (")[4]					12	12			12			12		12		12
		DRDT 3.2	Timing precision σ_t (ns)[5]	10		≲ 0.05	100		25	≲ 0.05	≲ 0.05	25	25	500	25	≃ 5	≲ 0.02	25	≲ 0.02
		DRDT3.3	Radiation tolerance NIEL (x 10^{16} neq/cm²)							≃ 6	≃ 2						≃ 10^2		
			Radiation tolerance TID (Grad)							≃ 1	≃ 0.5						≃ 30		
Tracker[6]	MAPS Planar/3D/Passive CMOS LGADs	DRDT 3.1 DRDT 3.4	Position precision σ_{hit} (μm)						≃ 6	≃ 5		≃ 6	≃ 6	≃ 6	≃ 6	≃ 7	≈ 10	≃ 6	
			X/X_0 (%/layer)						≃ 1	≃ 1		≃ 1	≃ 1	≃ 1	≃ 1	≃ 1	≲ 2	≃ 1	
			Power (mW/cm²)						≲ 100	≃ 100		≲ 100		≲ 100	≲ 100	≲ 150			
			Rates (GHz/cm²)							≃ 0.16									
			Wafers area (")[4]						12			12		12	12	12	12		12
		DRDT 3.2	Timing precision σ_t (ns)[5]						25	≲ 25		25	25	≲ 0.1	≲ 0.1	≲ 0.1	≲ 0.02	25	≲ 0.02
		DRDT3.3	Radiation tolerance NIEL (x 10^{16} neq/cm²)							≃ 0.3							≲ 1		
			Radiation tolerance TID (Grad)							≃ 0.25							≲ 1		
Calorimeter[7]	MAPS Planar/3D/Passive CMOS LGADs	DRDT 3.2	Timing precision σ_t (ns)[5]											≲ 0.05	≲ 0.05	≲ 0.05	≲ 0.02		≲ 0.02
		DRDT 3.3	Radiation tolerance NIEL (x 10^{16} neq/cm²)														≳ 10^2		
			Radiation tolerance TID (Grad)														≃ 50		
Time of Flight[8]	MAPS Planar/3D/Passive CMOS LGADs	DRDT 3.2	Timing precision σ_t (ns)[5]				≃ 0.02		≃ 0.02		≲ 0.03	≃ 0.02	≃ 0.02		≲ 0.01		≲ 0.01	≃ 0.02	
		DRDT 3.3	Radiation tolerance NIEL (x 10^{16} neq/cm²)														≃ 10^2		
			Radiation tolerance TID (Grad)														≃ 30		

9

Detector R&D Themes (DRDT) identified by the ECFA Detector R&D Roadmap

Solid state detectors chapter 3

-3.1 - Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors

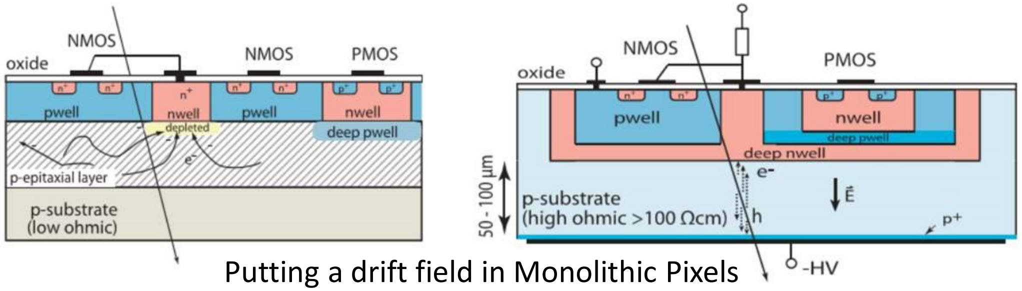
-3.2 - Develop solid state sensors with 4D-capabilities for tracking and calorimetry

-3.3 - Extend capabilities of solid state sensors to operate at extreme fluences

-3.4 -Develop full 3D-interconnection technologies for solid state devices in particle physics

Task Force 3 Solid State Detectors:
Nicolo Cartiglia, Giulio Pellegrini *(Conveners)*
Daniela Bortoletto, Didier Contardo, Ingrid-Maria Gregor; Gregor Kramberger, Heinz Pernegger (*Expert Members*)

3.1 Achieve full integration of sensing and microelectronics in monolithic CMOS pixel sensors



Putting a drift field in Monolithic Pixels

In **HV-CMOS** a deep n-well surrounds the electronics of every pixel.

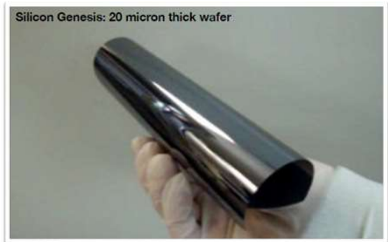
- The deep n-wells isolate the pixel electronics from the p-type substrate.
- The substrate can be **reverse biased** with no influence on the transistors.
- A **depletion zone** in the volume around the n-wells is formed.
- The n-wells collect electrons mainly by **drift**.
- Depending on the technology (or Foundry) used **many improvement** are possible

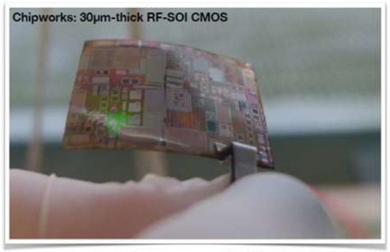
Monolithic Active Pixel Sensors (MAPS) sensors are successfully employed on large scale in HEP
-MIMOSA28 (ULTIMATE) in STAR. First MAPS system in HEP
-Latest instalment, ALICE ITS2 (10 m2, TowerJazz 180 nm), is taking data at LHC

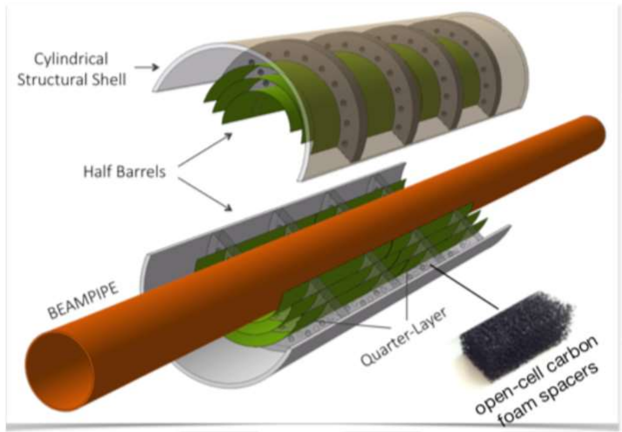
Monolithic sensors combining sensing and readout elements

CMOS MAPS for ALICE ITS3 (Run 4): (LOI: CERN-LHCC-2019-018, M. Mager)

- Three fully cylindrical, wafer-sized layers based on curved ultra-thin sensors (20-40 µm), air flow cooling.
- Deeper sub-micron technology node (65 nm vs. 180 nm) allows for larger wafers (300 mm vs. 200 mm) with higher integration density
- The CMOS manufacturing process allows to produce wafer-scale chips
- Very low mass (IB), < 0.02-0.04% per layer
- **successful in-beam verification of bent MAPS**







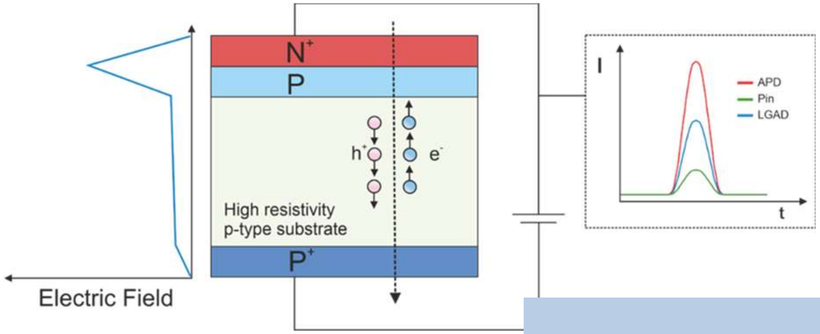
Maurice Garcia-Sciveres and Norbert Wermes 2018 Rep. Prog. Phys. 81 066101
Peric I 2007 , Nucl. Instrum. Methods A 582 876–85

3.2 Sensors with 4D-capabilities for tracking and calorimetry

By "**4D tracking**" we mean the process of assigning a space and a time coordinate to a hit.

Time information hugely beneficial to supress **pile-up in pp-collisions** -> new physics may also be possible

Design innovation: Low Gain Avalanche Diode (LGAD)



- **LGAD** technology is based on the APD concept.
- Multiplication layer less doped to reach a **linear** and **moderate gain** (10-30) in a high operating voltage.

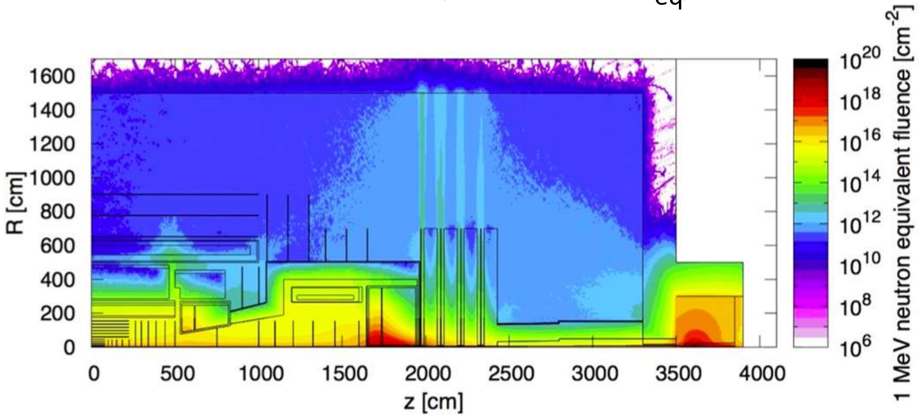
Tens of ps!
Combined to fine (tens of μm) spatial resolution

[1] G. Pellegrini et al., NIM A765 (2014) 12
[2] H.-W. Sadrozinski et al., arXiv: 1704.08666

3.3 Extend capabilities of solid state sensors to operate at extreme fluences

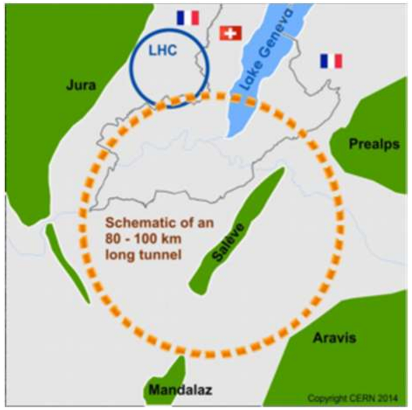
What is extreme presently?

FCC-hh 30/ab 1 MeV n_{eq}/cm^2



- ✓ Central Tracker: First IB layer (2.5cm) **: 5-6 10^{17} cm^{-2}**
- ✓ Forward calorimeters: HAD-calo and **EM5 10^{18} cm^{-2}**
- ✓ The detectors will require time resolution of **tens of ps**.

	LHC	FCC
Perimeter (km)	27	80-100
pp collision (TeV)	14	100
Fluence (10^{15} n_{eq}/cm^2)	6 (IBL)	600



Physics of silicon is not well understood, more studies are needed R&D in progress.

New materials may be necessary to work in this harsh conditions.

3.4 Interconection: Detectors with Electronics

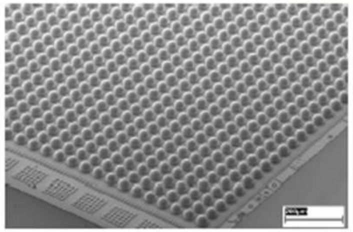
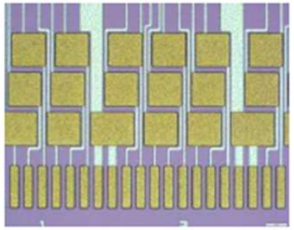
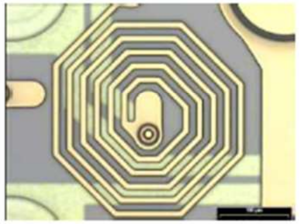
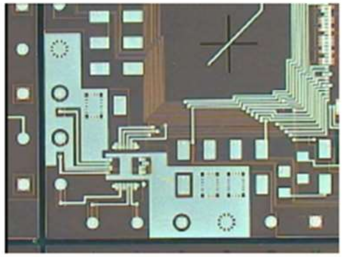
Fraunhofer IZM

Wafer Level Post-Processing Technologies

2D Wafer Level Packaging

Fine Pitch Bumping and Interconnects

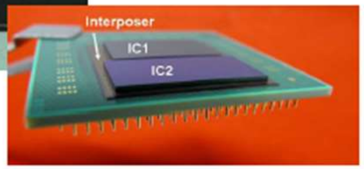
Redistribution Layer with Integrated Passives

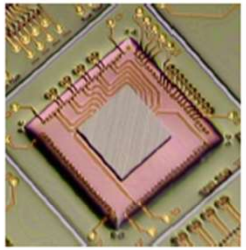
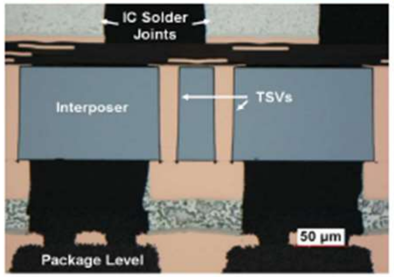





2.5D System Integration

Chip on Chip Thin Chip Integration (TCI)

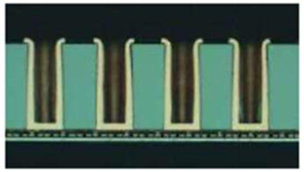
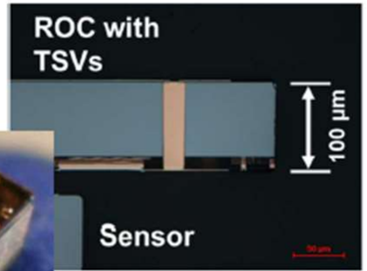
TSV Silicon Interposer

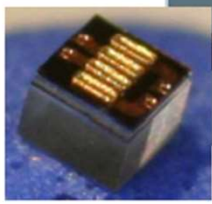



3D System Integration

TSV in active IC



Complexity / Functionality / Integration

The success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures. To prepare and realise future experimental research programmes, the community must maintain a **strong focus on instrumentation**. Detector R&D programmes and associated infrastructures should be supported at CERN, national institutes, laboratories and universities. **Synergies** between the needs of different scientific fields and industry should be identified and exploited to boost efficiency in the development process and increase opportunities for more technology transfer benefiting society at large.

Collaborative platforms and consortia must be adequately supported to provide coherence in these R&D activities. **The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels**.

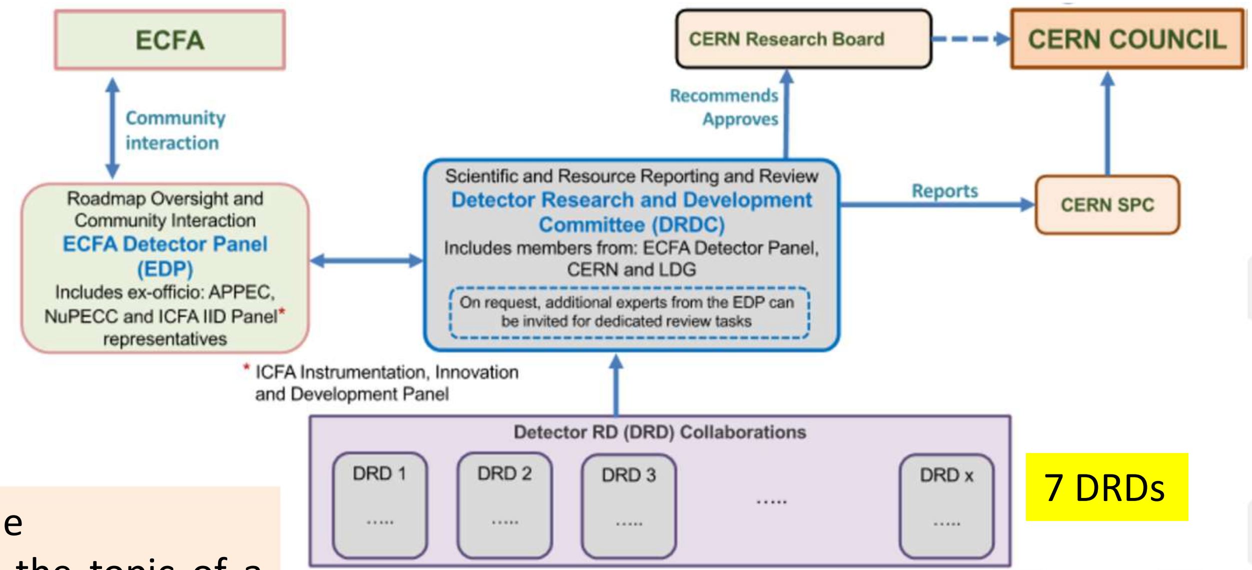
Implementation plan

CERN Council has mandated ECFA to work out a detailed implementation plan (in close collaboration with the SPC, the funding agencies and the relevant research organisations in Europe and beyond).

ECFA **Roadmap Coordination Group** worked out a proposal to organise long-term R&D efforts into:
newly established Detector R&D (DRD) Collaborations anchored at CERN.

Three areas of Detector R&D:

1. **Strategic R&D via DRD Collaborations** (long-term strategic R&D lines) (address the high-priority items defined in the Roadmap via the DRDTs)
2. **Experiment-specific R&D** (with very well defined detector specifications) (funded outside of DRD programme, via experiments)
3. **"Blue-sky" R&D** (competitive, short-term responsive grants, nationally organised)



7 DRDs

DRD9 is taken care of by a new ECFA Training Panel while
DRD8 felt their area is too experiment specific to be the topic of a "Strategic R&D" bid.

https://cds.cern.ch/record/2838406?ln=en

Timeline for Establishing DRD Collaborations

Q4 2022

- Identify **key players and stakeholders** from the wider international community.
- Where current relevant detector R&D collaborations exist, their **managements** need to be fully involved from the beginning of this process.
- **DRD proposal teams**, to lead the preparation of the more detailed DRD proposals in each area, should be identified as a result of this process.

Q1 2023:

- Outcomes of **community workshops** are collated and each DRD proposal team calls for expressions of interest from institutes.
- DRDC **mandate formally defined and agreed with the CERN Management**; DRDC membership appointments begin; EDP mandate plus membership updated to reflect additional roles .

Q2 2023:

- **Develop the new DRD proposals** based of the detector roadmap and community interest in participation, and ramp up to a steady state in 2026.
- “Strategic R&D” proposals (**materials and total FTE**). The primary aim is to create a dedicated funding line for *Strategic R&D*.
- Mechanisms **agreed with funding agencies** for structuring country-specific DRD collaboration funding requests.

Timeline for Establishing DRD Collaborations

Q3 2023

- **The DRD proposal teams submit full DRD proposals** , indicating estimates of the resources needed (including both those requested and those that are already available, as well as details of who covers what, i.e. pledges by institutes/ funding agencies).

Q4 2023:

- Following the review and revision (if required) of proposals, the DRDC recommends the formal establishment of the DRD collaborations.
- Formal **approval** is given by the CERN Research Board

2024

Collection of MoU signatures. The areas of interest per institute and the expected support for the long-term commitments involved should be specified in the MoUs.

Formal start of the DRD collaborations (01/01/2024).

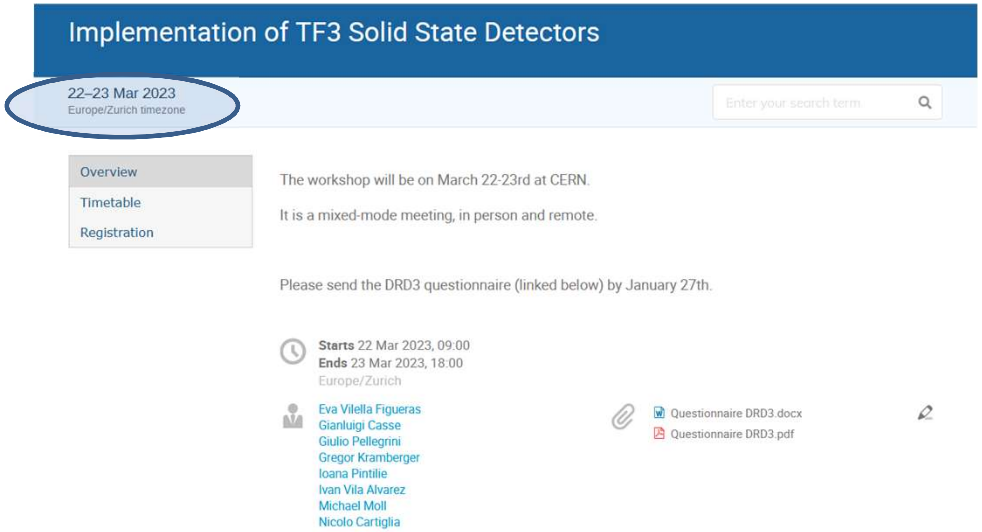
Work to do!

For each DRDT, we should highlight the following:

- Technologies to be studied and performances to be expected with respect of the set goals
- Key R&D deliverables in the coming three years
- Estimated costing
- List of institutes
- Resources available:
  - Manpower (FTE)
  - Committed budget
  - Additional budget

RD50 -> DRD3

RD50 DRD Proposal team:
Giulio Pellegrini & , Nicolo Cartiglia -> assigned by ECFA to coordinate the implementation of the Detector Roadmap of DRD3 .
Michael Moll , Gianluigi Casse, Ioana Pintilie , Eva Vilella, Gregor Kramberger. + many more for each specific tasks.

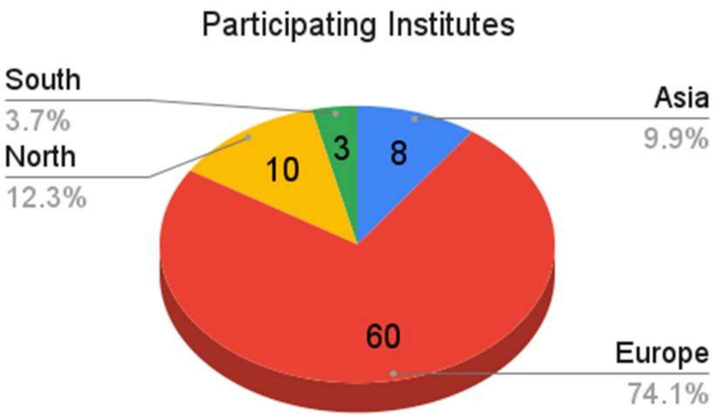


https://indico.cern.ch/event/1214410/

410 people registered!!!!

83 Expression of Interest

3 Continents



Country	Institutes [#]	Institutes [names]
Austria	1	HEPHY
Brazil	1	USP
Canada	3	Carleton/NRC (Ottawa) , SFU, TRIUMF
Chile	2	UNAB/SAPHIR, UTFSM
China	3	IHEP, Jilin Univ., USTC
Czech Republic	3	Charles Univ.Prague, FNSPE CTU, FZU Czech Academy
Finland	2	Helsinki-HIP, LUT University of Technology
France	7	APC, cppm.in2p3., IJCLab, IP2I, IPHC, Irfu CEA, LPNHE Paris
Germany	9	Bonn, CIS, Dortmund, Freiburg, GSI, HU Berlin, MPG HLL, MPP Munich, UHH University of Hamburg, IZM
Greece	1	Demokritos
India	1	IITM
Israel	2	Tel Aviv, WIS
Italy	9	FBK, INFN Ba, INFN CNR Perugia, INFN Fi, INFN Pisa, INFN To, UniFi, UniMi, UniPavia
Japan	1	KEK
Lithuania	1	Vilnius University
Montenegro	1	University of Montenegro
Netherlands	2	NiKhef, PARTREC
Poland	1	AGHKrakow
Romania	1	NIMP
Slovenia	1	JSI
Spain	**8**	**CNA, GIE_ETSI-Sevilla, IFAE, IFCA-Santander, IFIC- Valencia, IGFAE-USC, IMB-CNM-CSIC, ITAINNOVA**
Switzerland	5	CERN, ETH, PSI, UNIGE, UZH
Türkiye	1	Istanbul Univ.
UK	8	BILPA-Birmingham, Bristol, Brunel Univ, Manchester, Oxford, QMUL, RAL, STFC-RAL
USA	7	BNL, FNAL, Los Alamos, SCIPP, Univ. of Illinois, Chicago, Univ. of new Mexico, UTK

New Work Program/Structure (DRD3)

Preliminary!!!

Co-Spokespersons (2)

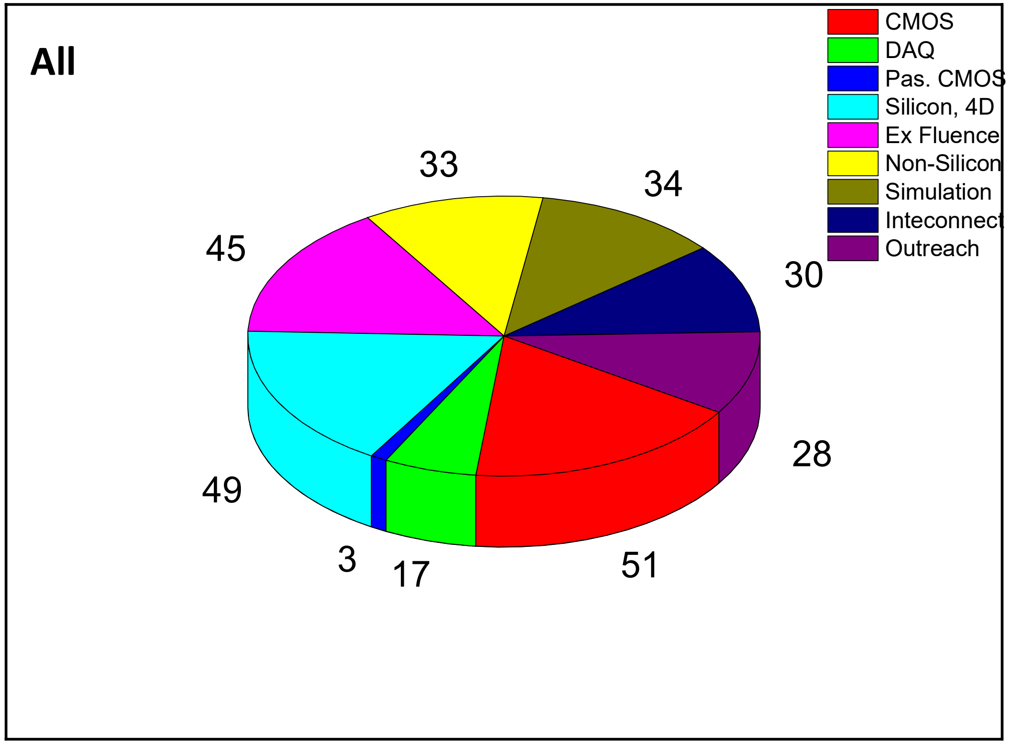
- **WP1: Monolithic CMOS sensors**
- **WP2: Hybrid sensors for tracking and calorimetry with space, time and/or energy resolution**
- **WP3: Radiation damage & ultra-high fluences**
- **WP4: Simulation**
- **WP5: New characterization techniques and facilities of common interest**
- **WP6: Non-silicon semiconductor and other material studies**
- **WP7: Interconnect and device fabrication technologies**
- **WP8: Dissemination and outreach**

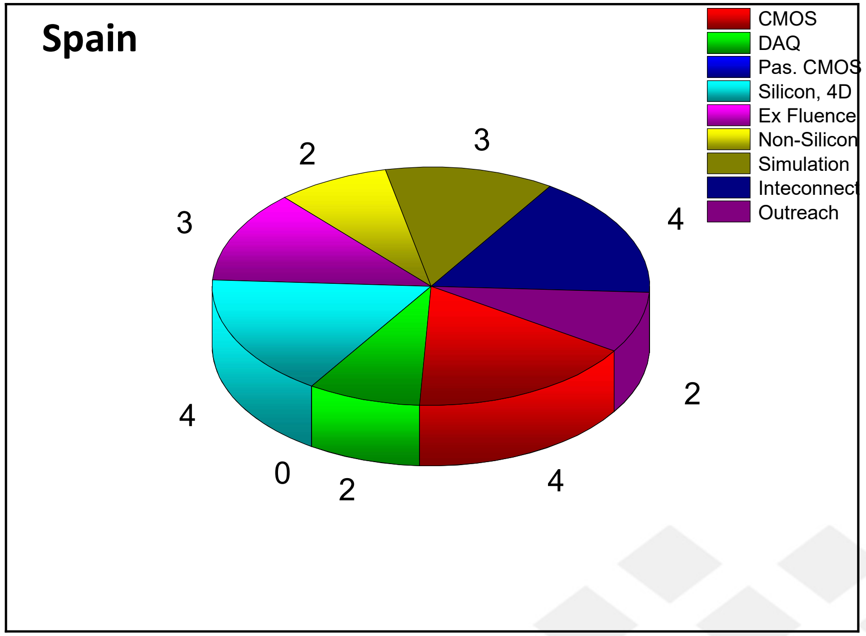
Milestones

- Understand the limit of WBG semiconductors at high fluences.
- Study innovative materials

Collaboration Board Chair & Deputy

Technological areas of interest within the DRD3





Technological areas defined according to the Detector Research and Development Themes but more detailed.

FTE analysis

		FTE/year:	FTE(sum):
HV-CMOS	[Fix]	37.1	80
	[Temp]	42.7	34%
Hybrid Sensors	[Fix]	21.7	54
	[Temp]	32.6	23%
Rad Hard.	[Fix]	13.7	35
	[Temp]	21.6	15%
Tech	[Fix]	10.6	26
	[Temp]	15.0	11%
WBG	[Fix]	8.9	23
	[Temp]	14.1	10%
Connect	[Fix]	4.7	12
	[Temp]	7.2	5%
Outreach	[Fix]	2.5	7
	[Temp]	4.5	3%
Sum	[Fix]	99.1	
	[Temp]	137.5	
Sum	[All]	236.5	

No data for Spain, working on the script to understand why

Funding (Ideal)

In each country / laboratory the DRD proposal process has to be discussed with the respective funding agencies;

GSR 6 -Establish long-term strategic funding programmes

Establish, additional to short-term funding programmes for the early proof of principle phase of R&D, also long-term strategic funding programmes to sustain both research and development of the multi-decade DRDTs in order for the technology to mature and to be able to deliver the experimental requirements. Beyond capital investments of single funding agencies, international collaboration and support at the EU level should be established. In general, the cost for R&D has increased, which further strengthens the vital need to make concerted investments.

GSR 7 –"Blue-sky" R&D

It is essential that adequate resources be provided to support more speculative R&D which can be riskier in terms of immediate benefits but can bring significant and potentially transformational returns if successful both to particle physics: unlocking new physicsmay only be possible by unlocking novel technologies in instrumentation, and to society. Innovative instrumentation research is one of the defining characteristics of the field of particle physics. "Blue-sky" developments in particle physics have often been of broader application and had immense societal benefit. Examples include: the development of the World Wide Web, Magnetic Resonance Imaging, Positron EmissionTomography and X-ray imaging for photon science.

Operation funding in Spain to support the R&D (2024-2028). No personnel!

	Institute 1	Institute 2	Institute 3	Institute 4	Institute 5	Institute 6	Institute 7	Institute 8
HV-CMOS		25000		25000			10000	
Hybrid Sensors				25000		20000	25000	
Rad Hard.	10000	3000		25000		20000	25000	
Tech	10000			25000		20000	10000	35000
WBG	10000			25000			50000	
Connect				25000			10000	
Outreach		3000		25000		10000	5000	
Sum (/year)	30000	31000	0	175000	0	70000	135000	35000

Total Spain: 476,000.00 €/year
Average per institute 59.000 €/year

Total : 9.645.814 €/year
Average per institute 116.215 €

What DRD3 might bring in addition to the present situation

- Support to young students (travel scholarships? I think this would be very useful, maybe paying 50% of the accommodation, not all students have the possibility to travel abroad)
- More interchange with other fields of applications
- Funding -> commitments for long term (5 years?) from national funding agencies.
- Possibility to finance large projects (presently too expensive).
- Administrative support (the support for the RD50 administration 5% of a staff person, clearly not enough)
- Coordination to participate in international projects (for instance: EU but any other idea is welcome)
- Contact companies interested in R&D on sensors.

Thank you for your attention

Campus Univ. Autónoma de Barcelona (UAB)
08193 Cerdanyola del Vallès (Bellaterra)
Barcelona · Spain

Giulio Pellegrini

@imb_cnm

www.imb-cnm.csic.es

Backup slides

Finance Review Committees (FCR)

- DRD3 will have to find/appoint a resource coordinator for DRD3 that is ready to spend significant fraction of his/her time to prepare reports in accordance with the CERN Finance classification schemes for finance categories; and detailed reports on all money transactions as well as handle the budget in a way that regular reporting to funding agencies can be provided
- (GC) CERN rep as chair, one rep per funding agency or institution (as the case may be – check MoU signatories), experiment resource coordinator (all with voting rights) (invited experts) Spokesperson(s), scientific secretary, … (no voting rights)
- FRCs are meant to be at least as much of a help as a burdenInformation channel with funding agencies and CERN Management
- Incentive to funding agencies to pay contributions :-)

30

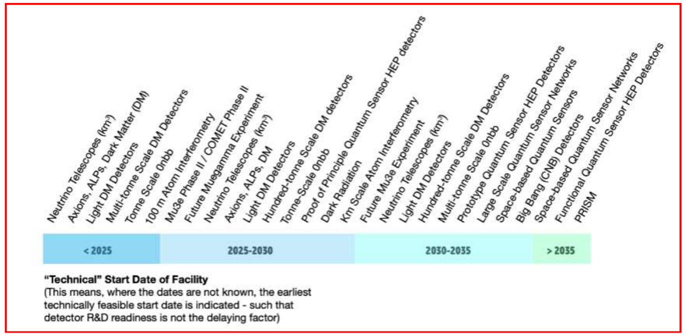
Detector R&D Roadmap

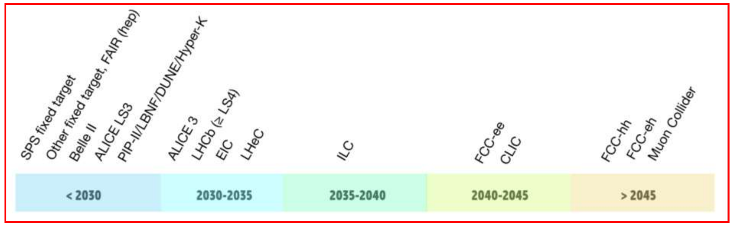
248 page report and 8 page synopsis document identifying the most urgent R&D topics or activities for meeting the EPPSU listed programme in each of the 9 TF Areas.

Topic urgency identified through the requirement that, given the earliest reasonable start date for an EPPSU supported possible future facility/experiment, the detector R&D should not be the time-limiting factor.

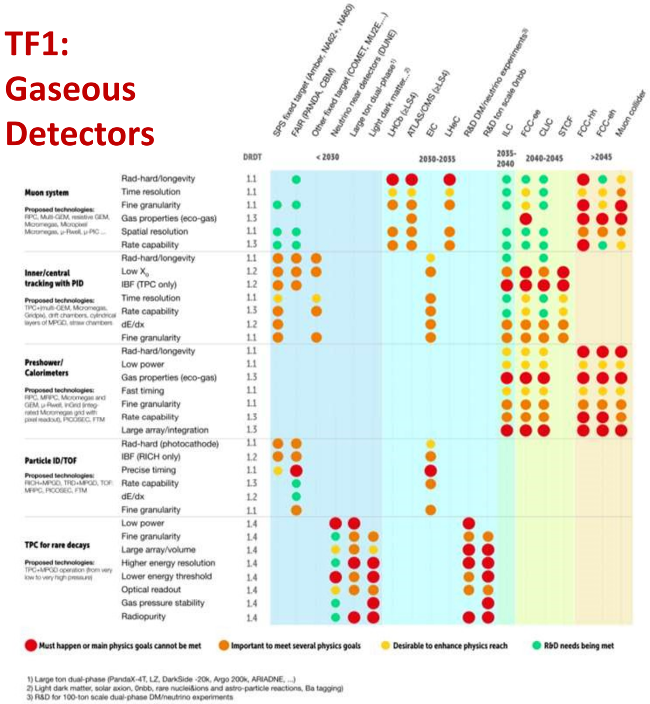
(https://cds.cern.ch/record/2784893)

Example non-accelerator dates (not complete)

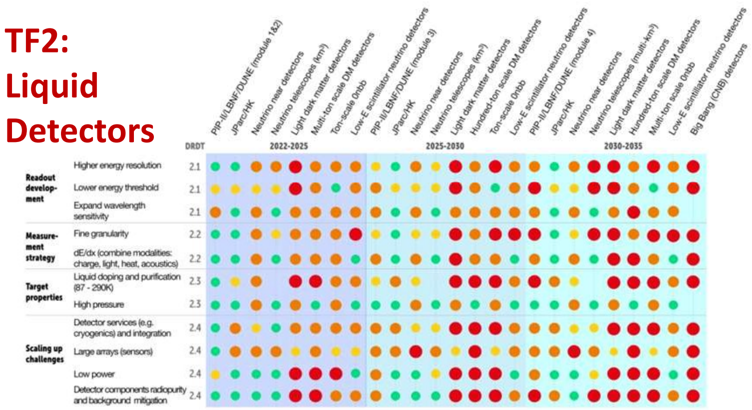




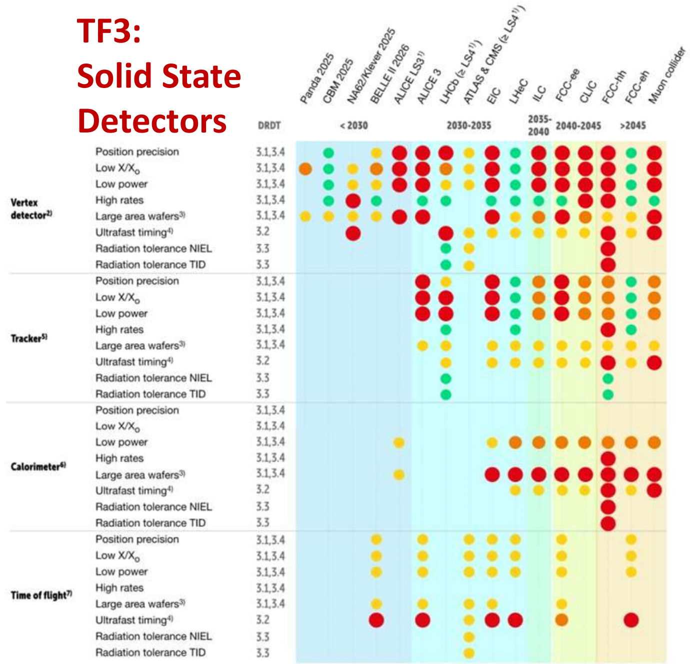
TF1: Gaseous Detectors



TF2: Liquid Detectors



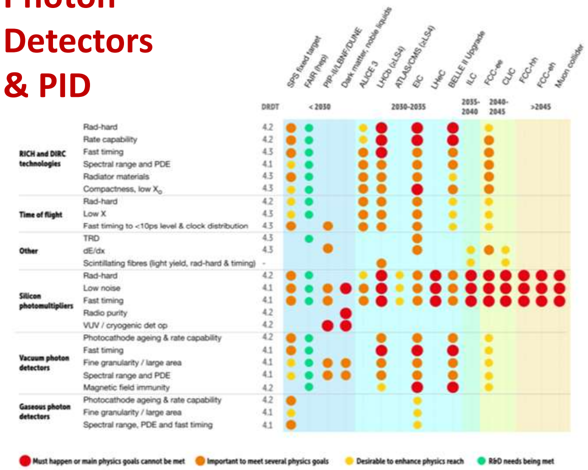
TF3: Solid State Detectors



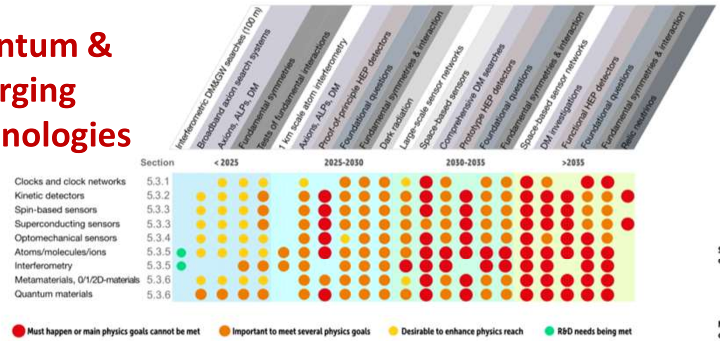
Must happen or main physics goals cannot be met — Important to meet several physics goals — Desirable to enhance physics reach — R&D needs being met

Detector R&D Roadmap

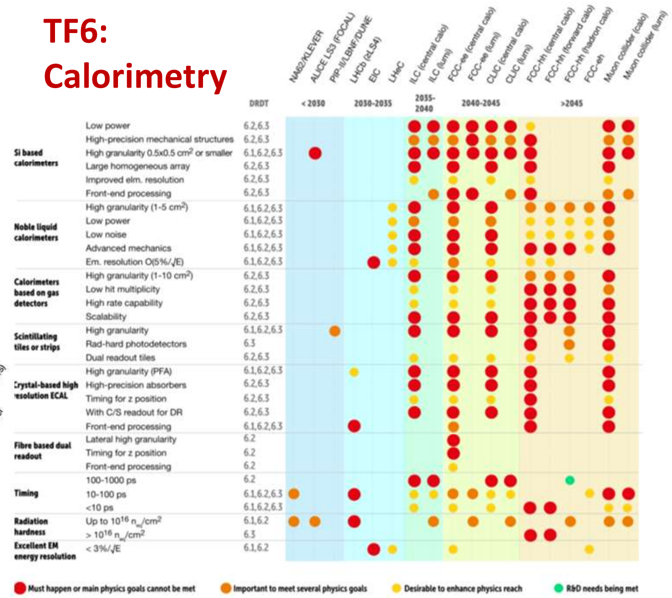
TF4: Photon Detectors & PID



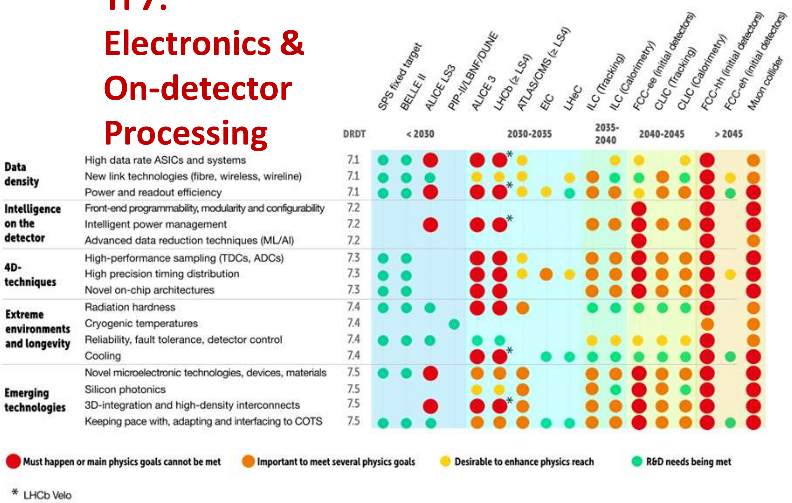
TF5: Quantum & Emerging Technologies



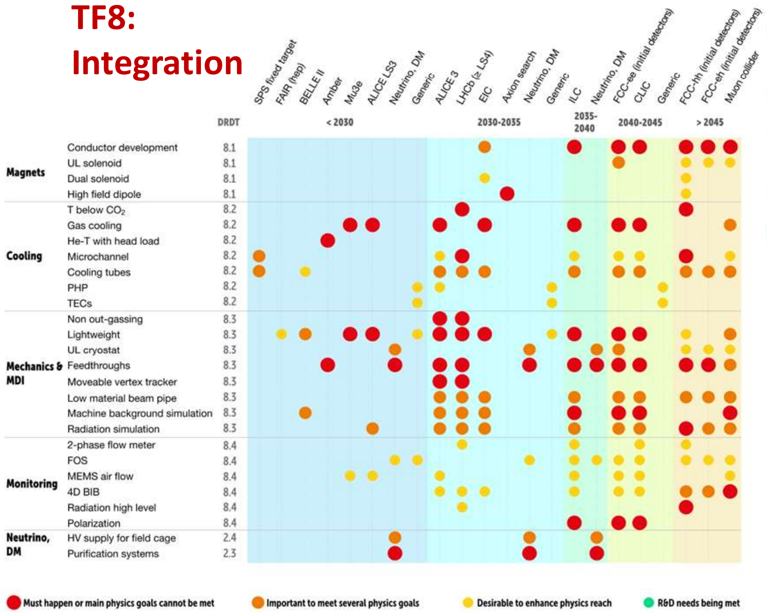
TF6: Calorimetry



TF7: Electronics & On-detector Processing



TF8: Integration



(https://cds.cern.ch/record/2784893)

Detector R&D Themes

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

Liquid

- **DRDT 2.1** Develop readout technology to increase spatial and energy resolution for liquid detectors
- **DRDT 2.2** Advance noise reduction in liquid detectors to lower signal energy thresholds
- **DRDT 2.3** Improve the material properties of target and detector components in liquid detectors
- **DRDT 2.4** Realise liquid detector technologies scalable for integration in large systems

Solid state

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

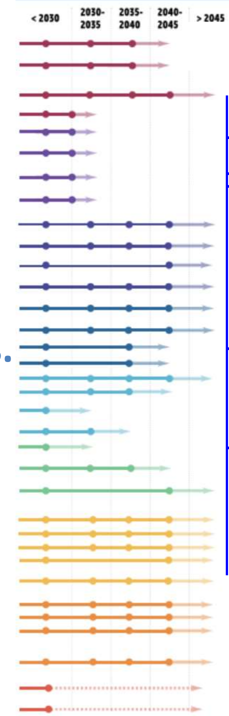
PID and Photon

- **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

Quantum

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

- The most urgent R&D topics in each Task Force area are identified as **D**etector **R**&**D** **T**hemes.
- The **timeframe** illustration for requirements in each **DRDT** area, in both the brochure and the main document, are based on the more detailed information and charts in the individual chapters.



https://cds.cern.ch/record/2784893

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

Electronics

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

Integration

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

Training

- **DCT 1** Establish and maintain a European coordinated programme for training in instrumentation
- **DCT 2** Develop a master's degree programme in instrumentation

In addition to the Detector R&D Themes described above and discussed in each chapter the following General Strategic Recommendations were made under the following headings.

GSR 1 - Supporting R&D facilities

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

GSR 1 - Supporting R&D facilities

It is recommended that the structures to provide Europe-wide coordinated infrastructure in the areas of: test beams, large scale generic prototyping and irradiation be consolidated and enhanced to meet the needs of next generation experiments with adequate centralised investment to avoid less cost-effective, more widely distributed, solutions, and to maintain a network structure for existing distributed facilities, e.g. for irradiation

GSR 2 - Engineering support for detector R&D

In response to ever more integrated detector concepts, requiring holistic design approaches and large component counts, the R&D should be supported with adequate mechanical and electronics engineering resources, to bring in expertise in state-of-the-art microelectronics as well as advanced materials and manufacturing techniques, to tackle generic integration challenges, and to maintain scalability of production and quality control from the earliest stages.

GSR 3 - Specific software for instrumentation

Across DRDTs and through adequate capital investments, the availability to the community of state-of-the-art R&D-specific software packages must be maintained and continuously updated. The expert development of these packages - for core software frameworks, but also for commonly used simulation and reconstruction tools - should continue to be highly recognised and valued and the community effort to support these needs to be organised at a European level.

GSR 4 - International coordination and organisation of R&D activities

With a view to creating a vibrant ecosystem for R&D, connecting and involving all partners, there is a need to refresh the CERN RD programme structure and encourage new programmes for next generation detectors, where CERN and the other national laboratories can assist as major catalysers for these. It is also recommended to revisit and streamline the process of creating and reviewing these programmes, with an extended framework to help share the associated load and increase involvement, while enhancing the visibility of the detector R&D community and easing communication with neighbouring disciplines, for example in cooperation with the ICFA Instrumentation Panel.

GSR 5 - Distributed R&D activities with centralised facilities

Establish in the relevant R&D areas a distributed yet connected and supportive tier-ed system for R&D efforts across Europe. Keeping in mind the growing complexity, the specialisation required, the learning curve and the increased cost, consider more focused investment for those themes where leverage can be reached through centralisation at large institutions, while addressing the challenge that distributed resources remain accessible to researchers across Europe and through them also be available to help provide enhanced training opportunities.

GSR 6 - Establish long-term strategic funding programmes

Establish, additional to short-term funding programmes for the early proof of principle phase of R&D, also long-term strategic funding programmes to sustain both research and development of the multi-decade DRDTs in order for the technology to mature and to be able to deliver the experimental requirements. Beyond capital investments of single funding agencies, international collaboration and support at the EU level should be established. In general, the cost for R&D has increased, which further strengthens the vital need to make concerted investments.

GSR 7 – "Blue-sky" R&D

It is essential that adequate resources be provided to support more speculative R&D which can be riskier in terms of immediate benefits but can bring significant and potentially transformational returns if successful both to particle physics: unlocking new physics may only be possible by unlocking novel technologies in instrumentation, and to society. Innovative instrumentation research is one of the defining characteristics of the field of particle physics. "Blue-sky" developments in particle physics have often been of broader application and had immense societal benefit. Examples include: the development of the World Wide Web, Magnetic Resonance Imaging, Positron Emission Tomography and X-ray imaging for photon science.

GSR 8 - Attract, nurture, recognise and sustain the careers of R&D experts

Innovation in instrumentation is essential to make progress in particle physics, and R&D experts are essential for innovation. It is recommended that ECFA, with the involvement and support of its Detector R&D Panel, continues the study of recognition with a view to consolidate the route to an adequate number of positions with a sustained career in instrumentation R&D to realise the strategic aspirations expressed in the EPPSU. It is suggested that ECFA should explore mechanisms to develop concrete proposals in this area and to find mechanisms to follow up on these in terms of their implementation. Consideration needs to be given to creating sufficiently attractive remuneration packages to retain those with key skills which typically command much higher salaries outside academic research. It should be emphasised that, in parallel, society benefits from the training particle physics provides because the knowledge and skills acquired are in high demand by industries in high-technology economies.

GSR 9 - Industrial partnerships

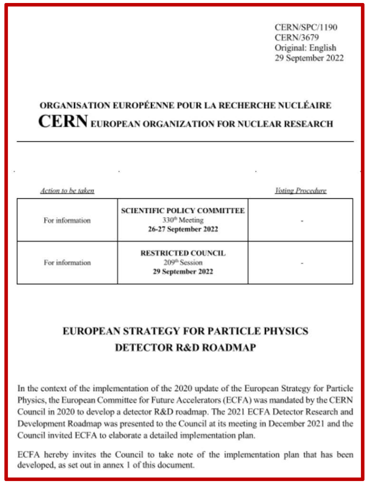
It is recommended to identify promising areas for close collaboration between academic and industrial partners, to create international frameworks for exchange on academic and industrial trends, drivers and needs, and to establish strategic and resources-loaded cooperation schemes on a European scale to intensify the collaboration with industry, in particular for developments in solid state sensors and micro-electronics.

GSR 10 – Open Science

It is recommended that the concept of Open Science be explicitly supported in the context of instrumentation, taking account of the constraints of commercial confidentiality where these apply due to partnerships with industry. Specifically, for publicly-funded research the default, wherever possible, should be open access publication of results and it is proposed that the Sponsoring Consortium for Open Access Publishing in Particle Physics (SCOAP^3) should explore ensuring similar access is available to instrumentation journals (including for conference proceedings) as to other particle physics publications.

Roadmap Implementation Brief History

- **CERN Council charged ECFA with developing an implementation plan for the Detector R&D Roadmap recommendations.**
- **Initial proposals, worked out by the Roadmap Coordination Group, were presented and discussed in the Rome RECFA meeting in March 2022, followed by extensive discussions with Funding Agencies and further refinement of the proposals.**
- **The proposed Detector and Accelerator implementation plans were presented to all Funding Agencies at the April 2022 Plenary RRB https://indico.cern.ch/event/1133070/timetable/ by ECFA and LDG Chairs (Karl Jakobs and Dave Newbold).**
  - **Given the diverse funding and costing models for different Funding Agencies it was decided to utilise the existing understood framework for funding long-term investments in particle physics experiments at CERN as the basis for supporting Detector R&D (DRD) Collaborations to deliver the multi-decadal Strategic R&D programmes to meet requirements identified by the DRDTs in the Roadmap documents.**
  - **The clear need for "strategic" R&D was emphasised as separate from, but additional to, that for "blue-sky" and "experiment-specific" activities.**
- **Slightly updated implementation proposals were then presented during June 2022 Council Week and at Plenary ECFA on 22nd July 2022. (See also Plenary ECFA 18th November 2022.)**
- **Further refinements of the implementation plan for the Detector R&D Roadmap were discussed over the summer with the Roadmap Panel, CERN management plus RD50, RD51 and CALICE representation.**
- **These led to the September 2022 SPC and Council approved implementation plan: CERN/SPC/1190.**


CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For information	SCIENTIFIC POLICY COMMITTEE 330th Meeting 26-27 September 2022	-
For information	RESTRICTED COUNCIL 209th Session 29 September 2022	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

GSR 4 - International coordination and organisation of R&D activities

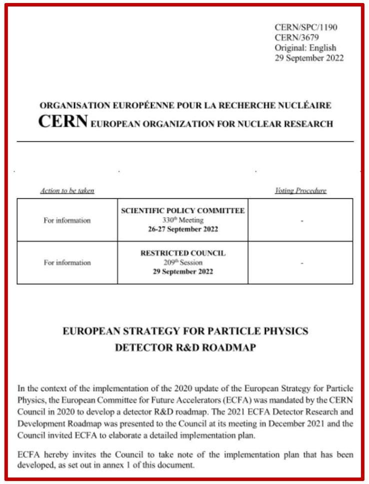
With a view to creating a vibrant ecosystem for R&D, connecting and involving all partners, there is a need to refresh the CERN RD programme structure and encourage new programmes for next generation detectors, where CERN and the other national laboratories can assist as major catalysers for these. It is also recommended to revisit and streamline the process of creating and reviewing these programmes, with an extended framework to help share the associated load and increase involvement, while enhancing the visibility of the detector R&D community and easing communication with neighbouring disciplines, for example in cooperation with the ICFA Instrumentation Panel.

GSR 6 - Establish long-term strategic funding programmes

Establish, additional to short-term funding programmes for the early proof of principle phase of R&D, also long-term strategic funding programmes to sustain both research and development of the multi-decade DRDTs in order for the technology to mature and to be able to deliver the experimental requirements. Beyond capital investments of single funding agencies, international collaboration and support at the EU level should be established. In general, the cost for R&D has increased, which further strengthens the vital need to make concerted investments.

→ **New DRD Collaborations - main focus of September 2022 implementation plan**

- **Other GSRs are not forgotten and are being either addressed by the new ECFA Training Panel, the ECFA-LDG R&D Taskforce or other initiatives by ECFA in consultation with key stakeholders.**
- **The emphasis of the current activities of the EDP and Roadmap Panel are to establish the new Detector R&D (DRD) collaborations needed in support of "strategic" R&D and to put in place the required reviewing processes. (This should be emphasised again as being separate from, and additional to, that for "blue-sky" and "experiment-specific" activities.)**


CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For information	SCIENTIFIC POLICY COMMITTEE 330th Meeting 26-27 September 2022	-
For information	RESTRICTED COUNCIL 209th Session 29 September 2022	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

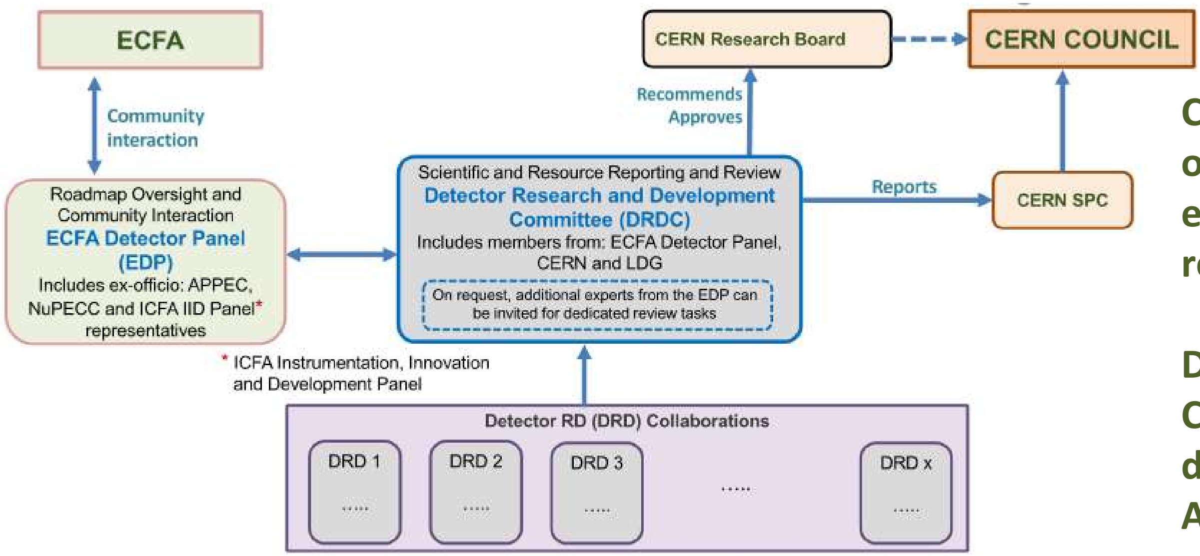
ECFA
European Committee for Future Accelerators

Reviewing Organisation

(CERN/SPC/1190)

ECFA (through RECFA and PECFA) maintains broad links to the wider scientific community.

EDP engages with other scientific disciplines and also communities outside Europe through close links with the ICFA IID Panel.



CERN provides rigorous oversight through well-established and respected reviewing structures.

DRDs able to benefit from CERN recognition in dealings with Funding Agencies and corporations.

EDP:

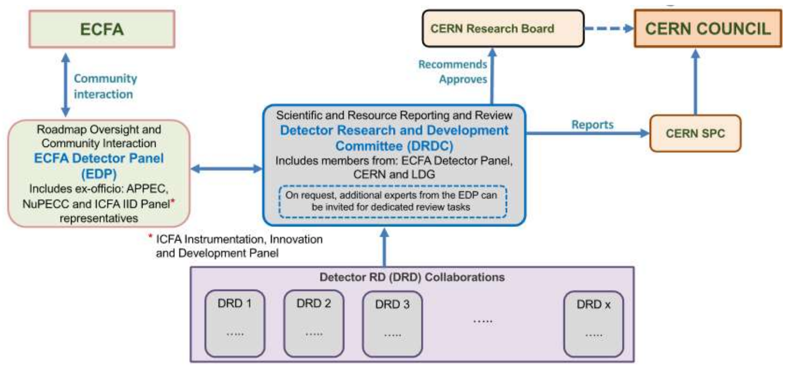
- provides direct input, through appointed members to the DRDC, on DRD proposals in terms of Roadmap R&D priorities (DRDTs);
- assists, particularly via topic-specific expert members, with annually updated DRDC scientific progress reviews of DRDs;
- monitors overall implementation of ECFA detector roadmap/DRDTs;
- follows targets and achievements in light of evolving specifications from experiment concept groups as well as proto-collaborations for future facilities;
- helps plan for future updates to the Detector R&D Roadmap.

DRDC:

- provides financial, strategic and (with EDP) scientific oversight;
- evaluates initial DRD resources request with focus on required effort matching to pledges by participating institutes (including justification, given existing staff, infrastructures and funding streams);
- decides on recommending approval;
- conducts progress reviews on DRDs and produces a concise annual scientific summary encompassing the full detector R&D programme;
- be the single body that interacts for approvals, reporting etc with the existing CERN committee structure.

ECFA
European Committee for Future Accelerators

Detector Panel Membership



The membership of the EDP reflects the needs to provide expertise in each of the key detector areas identified in the Roadmap: Gaseous Detectors; Liquid Detectors; Solid-State Detectors; Photon Detectors and Particle Identification; Quantum and Emerging Technologies; Calorimetry; Electronics and On-detector Processing; and Integration.

- **The EDP is proposed to have two Co-chairs (as worked well for the Roadmap TFs) who could also be permanent members of the DRDC to advise and regularly report on EDP deliberations.**
- **It is proposed that the terms of the Co-chairs be defined as three years with periods in office to run eighteen months out of phase with each other to provide continuity. The mandate of each Co-chair can be renewed once, for a maximum period of six years.**
- **It is proposed that the positions of Scientific Secretary and Member have terms of three years, renewable once, but also staggered in time to ensure reasonable overlaps of experience when terms come to an end.**
- **The updated membership includes the current EDP augmented with the following new members:**
  - **Co-chairs: Phil Allport (Birmingham) and Didier Contardo (IP2I Lyon)**
  - **Scientific Secretary: Doris Eckstein (DESY) Solid State Detectors**
  - **Silvia Dalla Torre (INFN Trieste) Gaseous Detectors; Inés Gil Botella (CIEMAT) Liquid Detectors; Roger Forty (CERN) PID and Photon Detectors; Steven Hoekstra (Groningen) Quantum and Emerging Technologies; Laurent Serin (Orsay LAL) Calorimetry; Electronics; Valerio Re (Bergamo) Electronics;**
  - **Karl Jakobs (Freiburg) ex-officio (ECFA Chair); Ian Shipsey (Oxford) ex-officio ICFA IIDP Chair;**
  - **APPEC and NuPECC appointed Observers: Aldo Ianni (INFN, LNGS) and Eugenio Nappi (INFN, Bari).**

Implementation Timelines

- **Assuming the new DRDs need to come into existence by the start of 2024, the call was sent on 25th October 2022 to the communities wishing to participate in the corresponding new DRD activities with sign up for the different Task Force areas at https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap.**
- **Given the timeline presented in CERN/SPC/1190, work on draft guidelines for DRD proposals was initiated last Autumn and circulated to those leading international proposal preparation.**

Overview
Implementation of the ECFA Detector R&D Roadmap
Mandate for the Preparation of the Roadmap
The Roadmap Document
Panel members and Task Forces
Input from future facilities
Symposia
Registration to the symposia
ECFA Detector R&D Roadmap Process
Timeline of the Roadmap process
Questionnaires
Relevant documents
Internal

Implementation of the ECFA Detector R&D Roadmap

After the publication of the ECFA Detector R&D Roadmap, CERN Council requested ECFA to develop the plan for its implementation.

The document approved by the SPC and CERN Council in September 2022 can be found at https://indico.cern.ch/event/1197445/contributions/5034860/attachments/2517863/4329123/spc-e-1190-c-e-3679-Implementation_Detector_Roadmap.pdf.

As proposed in the document, topic specific community meetings will now be held in the course of the coming months. To sign up for these and to register your interest in participating on the corresponding R&D Collaborations being developed please see the links below.

- TF1 Gaseous Detectors https://indico.cern.ch/event/1214405/
- TF2 Liquid Detectors https://indico.cern.ch/event/1214404/
- TF3 Solid State Detectors https://indico.cern.ch/event/1214410/
- TF4 Photon Detectors and PID https://indico.cern.ch/event/1214407/
- TF5 Quantum and Emerging Technologies https://indico.cern.ch/event/1214411/
- TF6 Calorimetry https://indico.cern.ch/event/1213733/
- TF7 Electronics and On-detector Processing https://indico.cern.ch/event/1214423/
- TF8 Integration https://indico.cern.ch/event/1214428/
- TF9 Training https://indico.cern.ch/event/1214429/

https://indico.cern.ch/e/ECFADetectorRDRoadmap

3. Timeline for Establishing DRD Collaborations

The proposed timeline takes into account the fact that current R&D collaborations at CERN would need to seek an extension for continuation beyond the end of 2023 and that the most labour-intensive aspects of the general-purpose detectors for the HL-LHC deliverables should be completed by the end of 2025, allowing a significant number of experts to become available for new initiatives. This suggests that DRD collaborations need to come into existence in 2023, and requests for new resources would typically anticipate a ramp-up of requirements through 2024/25 before a reasonably steady state is reached in 2026.

It is proposed that this could be achieved according to the following timeline:

Q4 2022:

- Through the ECFA roadmap task forces identify key players and stakeholders from the wider international community who are interested in pursuing the DRDT topics identified in the ECFA roadmap. Where current relevant detector R&D collaborations exist, their managements need to be fully involved from the beginning of this process.

CERN/SPC/1190

CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For information	**SCIENTIFIC POLICY COMMITTEE** 330th Meeting **26-27 September 2022**	-
For information	**RESTRICTED COUNCIL** 209th Session **29 September 2022**	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

Implementation Timelines

- The stakeholders to be contacted in each area covered by one of the task forces should also include:
  - representatives of those involved in nearer-term facilities where these are clear "stepping stones" towards the longer-term ambitions;
  - those engaged in establishing detector concepts for the longer-term experimental programmes identified as "high-priority future initiatives" in the European Strategy for Particle Physics;
  - proponents of activities beyond the immediate horizon that are advocated as "other essential scientific activities for particle physics" in the European Strategy;
  - where relevant, the primary contact persons for other existing funded international detector R&D programmes (including activities supported by the EU and CERN).

- With the help of this wider group, one or more community workshops should be organised to gather input on how the relevant communities consider that a strategic R&D programme should be organised and to discuss the proposed structure with the ECFA R&D roadmap coordinators.

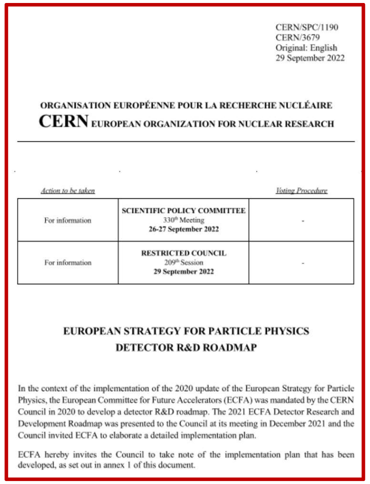
- **DRD proposal teams,** to lead the preparation of the more detailed DRD proposals in each area, should be identified as a result of this process.

Q1 2023:

- Outcomes of community workshops are collated and each **DRD proposal team** calls for expressions of interest from institutes (or groups of institutes) wishing to bid for strategic R&D in the corresponding areas identified in the DRDTs. These institutes would also need to organise themselves nationally to initiate discussions with their corresponding funding agencies.

- *DRDC mandate formally defined and agreed with the CERN Management; DRDC membership appointments begin; EDP mandate plus membership updated to reflect additional roles.*

CERN/SPC/1190



CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For information	**SCIENTIFIC POLICY COMMITTEE** 330th Meeting **26-27 September 2022**	-
For information	**RESTRICTED COUNCIL** 209th Session **29 September 2022**	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.

Implementation Timelines

Q2 2023:

- Through the **DRD proposal teams**, and based on the input from the community consultation, coordinate community-led bids for bottom-up roughly costed "strategic R&D" proposals (materials and **total** FTE), from consortia around technologies that can address one or more of the DRDTs, identifying the required materials costs and effort going forward. For the latter, it would be necessary to further separate existing staff or possible in-kind contributions from posts requiring additional resources. Funded activities in the context of supported experiments should be reported where potentially relevant (as stepping stones), but the resources included as in-kind contributions should focus on R&D that is not specific to individual approved experiments. As explained above, the primary aim is to create a dedicated funding line for *Strategic R&D*. The general case and motivation for such long-term strategic R&D can be found in the GSRs of the published Roadmap document.

- Proposals specific to the sub-areas should be evaluated for their relevance to DRDTs and possible overlaps or gaps with respect to them, and resources should then be matched to the stated goals. Each **DRD proposal team** should formulate a lightweight DRD organisational structure to accommodate the ambitions of the community, with appropriate sub-structures where they consider this necessary.

- *Mechanisms agreed with funding agencies for structuring country-specific DRD collaboration funding requests.*

Q3 2023:

- The **DRD proposal teams** submit full DRD proposals at the start of Q3 (July 2023), indicating estimates of the resources needed (including both those requested and those that are already available, as well as details of who covers what, i.e. pledges by institutes/ funding agencies).

- *The DRDC reviews proposals in terms of their scientific scope, milestones and technical feasibility, with the help of topic-specific experts from the EDP, and critically examines all financial aspects of the strategic R&D part of the DRD programme.*

Q4 2023:

- Where part of the new DRDs already has resources allocated for particular R&D deliverables (for example, through a pre-existing R&D collaboration covering a significant fraction of the DRD topic areas), mechanisms to carry funding and activities forward into the new DRD context need to be established.

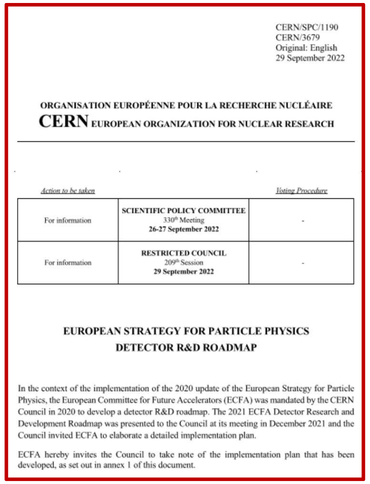
- *Following the review and revision (if required) of proposals, the DRDC recommends the formal establishment of the DRD collaborations.*

- *Formal approval is given by the CERN Research Board.*

2024:

- Collection of MoU signatures. The areas of interest per institute and the expected support for the long-term commitments involved should be specified in the MoUs.

Note: suggested proposal lengths are ~20 pages (case for R&D provided by the Roadmap itself) and the request is for *reasonable estimates informed by discussions with the Funding Agencies*.



CERN/SPC/1190
CERN/3679
Original: English
29 September 2022

ORGANISATION EUROPÉENNE POUR LA RECHERCHE NUCLÉAIRE
CERN EUROPEAN ORGANIZATION FOR NUCLEAR RESEARCH

Action to be taken		Voting Procedure
For information	**SCIENTIFIC POLICY COMMITTEE** 330th Meeting **26-27 September 2022**	-
For information	**RESTRICTED COUNCIL** 209th Session **29 September 2022**	-

EUROPEAN STRATEGY FOR PARTICLE PHYSICS
DETECTOR R&D ROADMAP

In the context of the implementation of the 2020 update of the European Strategy for Particle Physics, the European Committee for Future Accelerators (ECFA) was mandated by the CERN Council in 2020 to develop a detector R&D roadmap. The 2021 ECFA Detector Research and Development Roadmap was presented to the Council at its meeting in December 2021 and the Council invited ECFA to elaborate a detailed implementation plan.

ECFA hereby invites the Council to take note of the implementation plan that has been developed, as set out in annex 1 of this document.