Formazione delle nuove collaborazioni del CERN per R&D sui detector del futuro

Daniele del Re

EUROPEAN STRATEGY E R&D

Update of the European Strategy for Particle Physics

4. Other essential scientific activities for particle physics

…

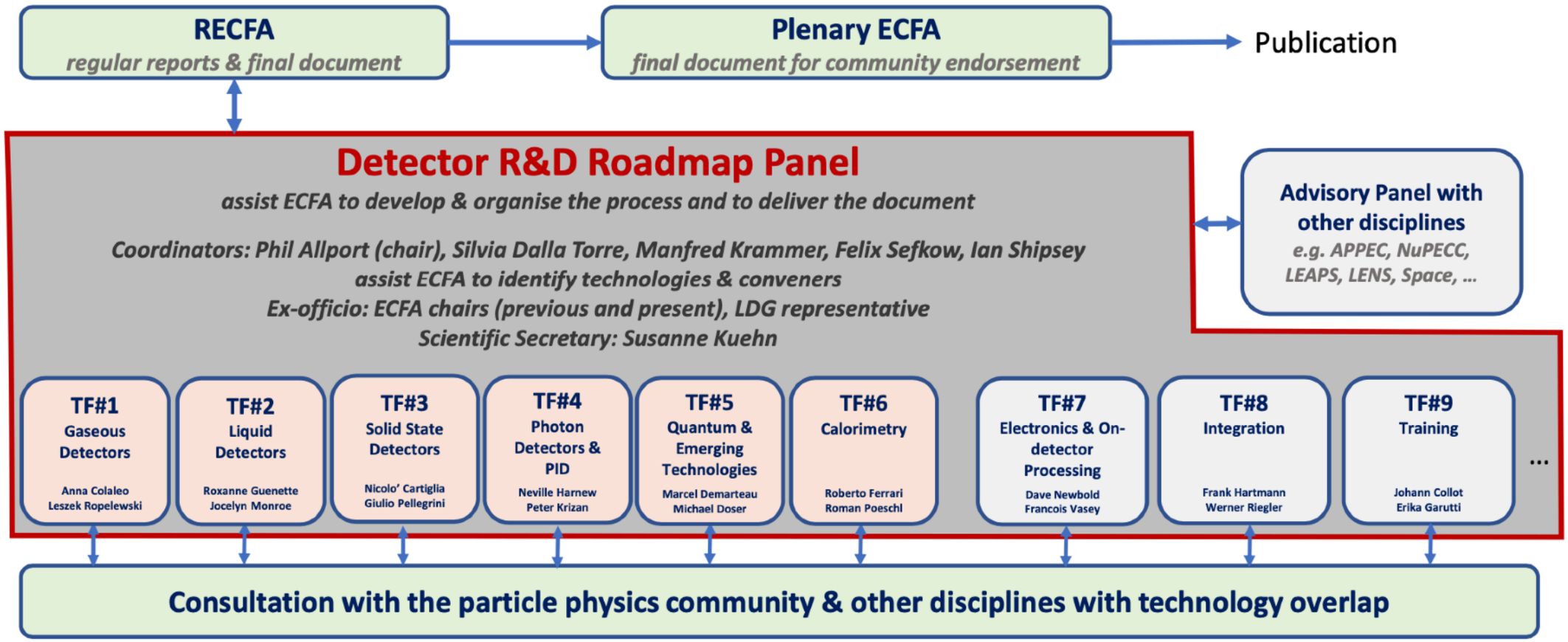
*c) The **success of particle physics experiments relies on innovative instrumentation and state-of-the-art infrastructures.** To prepare and realise future experimental research programmes, the community must **maintain a strong focus on instrumentation**. **Detector R&D programmes and associated infrastructures 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.***

Organised by ECFA, a roadmap should be developed by the community to balance the detector R&D efforts in Europe, taking into account progress with emerging technologies in adjacent fields. 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. …

da Karl Jacobs

La Roadmap



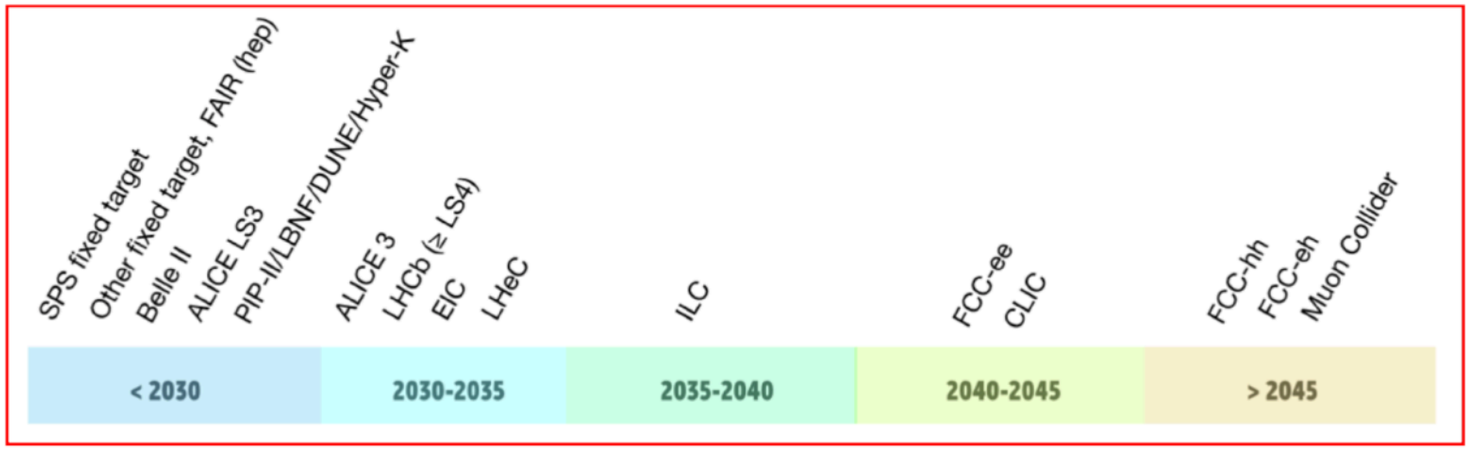
- ***Task forces*** *were composed of experts from the community covering key sub-topics in the relevant technology areas, including* ***two conveners*** *(who are part of the Roadmap Panel)*

- *Progress with emerging technologies in adjacent fields is provided through an* ***Advisory Panel with Other Disciplines*** *(→ expert contacts by Task Forces area)*

da Karl Jacobs

LA ROADMAP (II)

- Timeline of future accelerator facilities



The dates shown have deliberate low precision, and are intended to represent the **earliest 'feasible start date'** (where a schedule is not already defined), taking into account the necessary steps of approval, development and construction for machine and civil engineering.

- Task Forces have identified a set of detector R&D areas which are required if the physics programmes of experiments at these facilities are not to be compromised

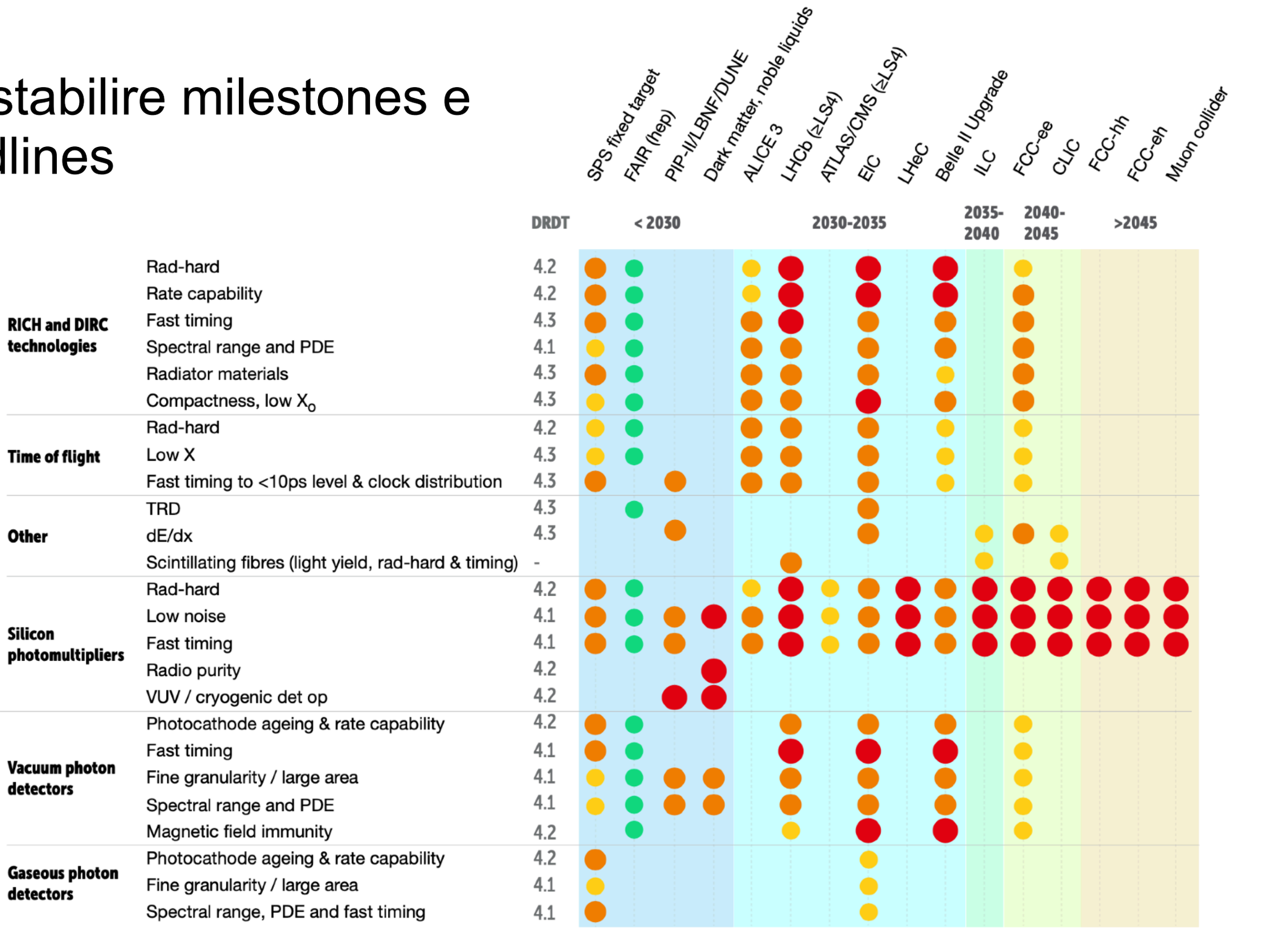
  The most important drivers for research in each technology area are defined as **"Detector R&D Themes" (DRDTs)**

- It is also noted that in many cases, the programme for a nearer-term facility helps enable the technologies needed for more demanding specifications later, providing **stepping stones** towards these

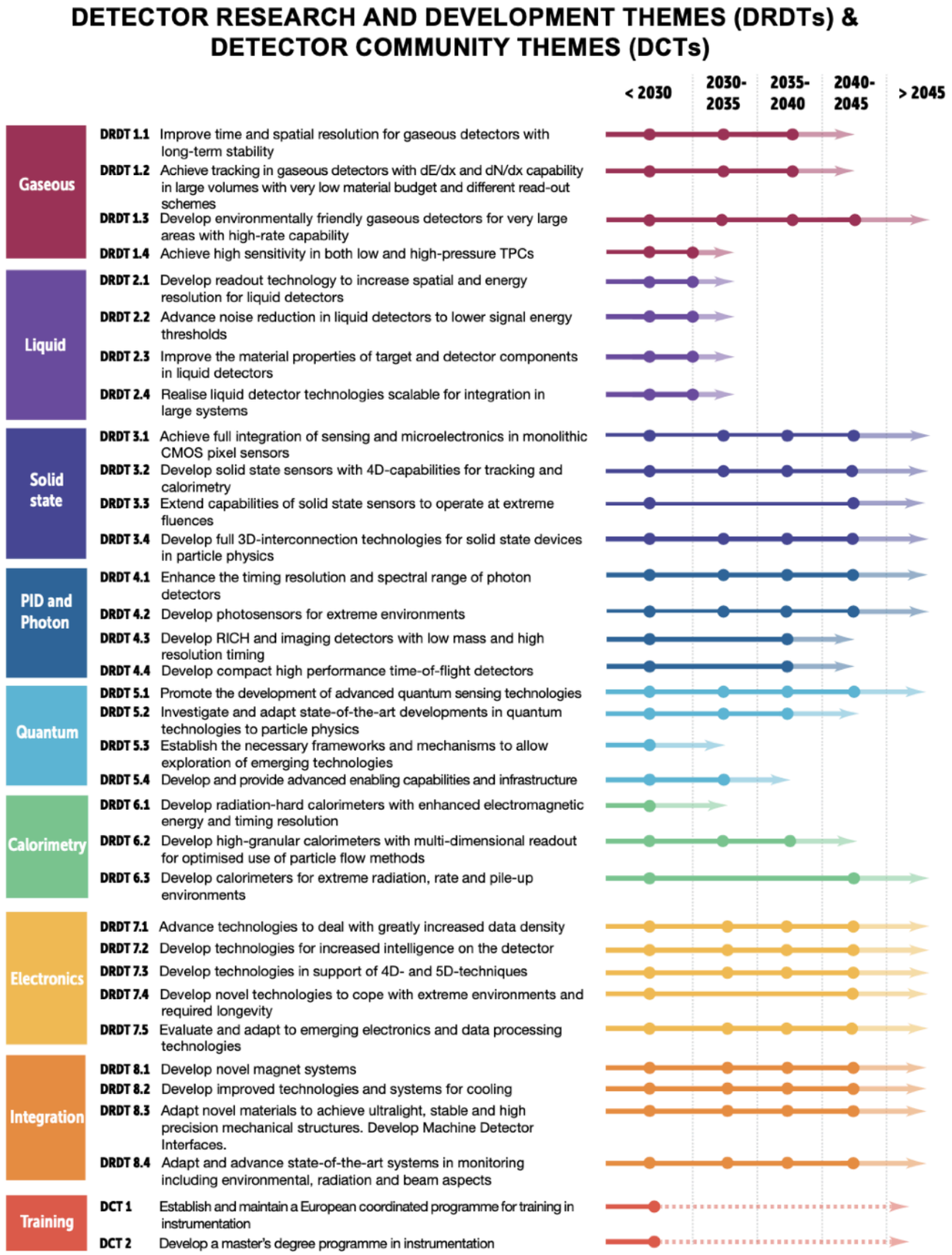
- In addition to the Detector R&D Themes **General Strategic Recommendations** are made

ESEMPIO PER I DETECTOR PID

Per stabilire milestones e deadlines



TEMI DI RICERCA E DEADLINES



Freccia: target per completamento
Palline: stepping stone intermedia

STRATEGIC RECOMMENDATIONS

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

see backup slides for details

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.

da Karl Jacobs

DOCUMENTO DI SINOSSI

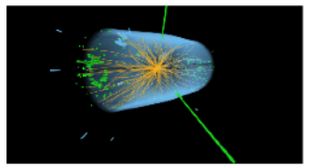
- **Documento** che contiene ciò che vi ho detto finora:
  - https://cds.cern.ch/record/2784893

_Building the Foundations

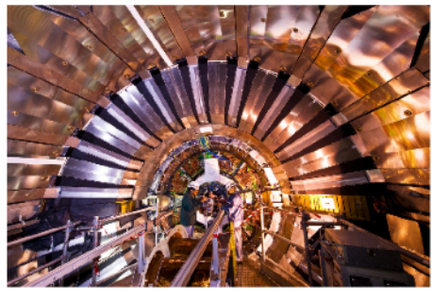
"Strong planning and appropriate investments in Research and Development (R&D) in relevant technologies are essential for the full potential, in terms of novel capabilities and discoveries, to be realised."

The field of particle physics builds on the major scientific revolutions of the 20th century, particularly on the experimental discoveries and theoretical developments which culminated in the Nobel Prize-winning discovery of the Higgs boson at CERN in 2012. The ambitions for the field going forward are set out from a European perspective in a global context in the European Strategy for Particle Physics (ESPP) which was updated in 2020. This strategy lays down a vision for the coming half-century, with a science programme which, in exploring matter and forces at the smallest scales and the Universe at earliest times, will continue to provide answers to questions once thought only to be amenable to philosophical speculation, and has the potential to reveal fundamentally new phenomena or forms of matter never observed before.

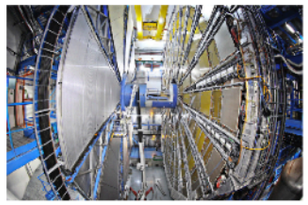
The ESPP recognises the huge advances in accelerator and detector technologies since the world's first hadron collider, the Intersecting Storage Rings, started operation at CERN 50 years ago. These advances have not only supported, and in turn benefited from, numerous other scientific disciplines but have spawned huge societal benefits through developments such as the World Wide Web, Magnetic Resonance Imaging, Positron Emission Tomography and 3D X-ray imaging.



Event display of a candidate Higgs boson decaying into two photons as recorded by the CMS experiment. (© CERN)



Installation of the CMS Central Tracking Detector with 10 million read-out channels and using silicon detectors covering an area of over 200 m². (© CERN)



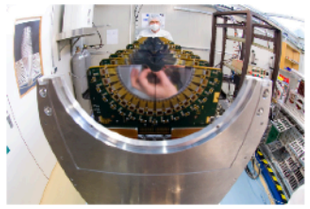
ATLAS gas detector based muon spectrometer, which covers a total area the size of a football field and measures the paths of the muons that pass through it to an accuracy of better than a tenth of a millimetre. (© CERN)

The far-reaching plans of the ESPP require similar progress over the coming decades in accelerator and detector capabilities to deliver its rich science programme. Strong planning and appropriate investments in Research and Development (R&D) on relevant technologies are essential for the full potential, in terms of novel capabilities and discoveries, to be realised.

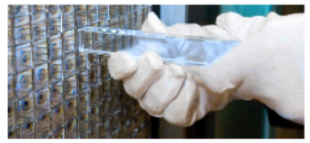
The 2020 update of the ESPP called on the European Committee for Future Accelerators (ECFA) to develop a global Detector R&D Roadmap defining the backbone of detector R&D required to deploy the community's vision. This Roadmap aims to cover the needs of both the near-term and longer-term programme, working in synergy with neighbouring fields and with a view to potential industrial applications.

_Setting the Priorities

"To fully explore the properties of the Higgs boson and study many of the other deepest questions in physics necessitates the development of a roadmap for the required detector technologies."



Vertex Locator (VELO) of the LHCb experiment allowing short lived particle lifetimes to be measured with precision of a twentieth of a picosecond. (© CERN)



Insertion of lead-tungstate crystals (over three times the density of conventional glasses) into the high granularity electromagnetic calorimeter of the ALICE detector giving percent scale energy measurements. (© CERN)

ProtoDUNE: three hundred cubic metre volume prototype Liquid Argon Neutrino Detector being constructed at CERN. (© CERN)

The highest priority laid down by the updated ESPP is for a future Higgs factory to thoroughly explore the properties of this completely new type of particle, which is seen as a key to a much deeper understanding of how the Universe works. Until the discovery of the Higgs boson, every known particle was either a "matter" or a "force" particle, describing the world in terms of fundamental entities and their interactions without being able to accommodate the fact that particles also have mass. In the ESPP, the vision for the future facilities to fully explore the properties of the Higgs boson and study many of the other deepest questions in physics necessitates the development of a roadmap for the required detector technologies (in much the same way as the LHC and its upgrades significantly guided R&D planning for previous decades). The ECFA Detector R&D Roadmap addresses this need whilst highlighting synergies with other projects on nearer timescales and showing how they are also embedded in the longer-term context.

In the area of detector development, it is vital to build on Europe's world-leading capabilities in sensor technologies for particle detection, using gas and liquid-based or solid-state detectors, as well as energy measurement and particle identification. Also required are cutting-edge developments in bespoke microelectronics solutions, real-time data processing and advanced engineering. Adequate resourcing for such technology developments represents a vital component for future progress in experimental particle physics. Talented and committed people are another absolutely core requirement. They need to be enthused, engaged, educated, empowered and employed. The ECFA Detector R&D Roadmap brings forward concrete proposals for nurturing the scientists, engineers and technicians who will build the future facilities and for incentivising them by offering appropriate and rewarding career opportunities.

Implementation Plan

Proposed implementation plan

- It is proposed to organise long-term R&D efforts into **newly established Detector R&D (DRD) Collaborations**

  Detector technology areas: larger DRD collaborations should be considered
  (one for each of the six areas and an additional similar structure for some of the transversal topics)

- **DRD Collaborations should be anchored at CERN** → CERN recognition, DRD label

- **Taking full account of existing, well-managed and successful ongoing R&D collaborations and other existing activities**
  (RD50, RD51, …, CERN EP R&D programme, EU-funded initiatives, collaborations exploring particular technology areas for future colliders)

- The **formation of new DRD collaborations** should adopt a **community-driven approach**
  Supported by existing ECFA Detector R&D Roadmap Task Forces, with involvement of managements of existing R&D collaborations

- Aim for proposals in July 2023; New structure in place in January 2024;
  Ramp-up of resources during 2024/25, reaching a steady state in 2026

da Karl Jacobs

Implementation Timeline

Through 2023, mechanisms will need to be agreed with funding agencies in parallel to the process below for country specific DRD collaboration funding requests for Strategic R&D and for developing the associated MoUs.

Q4 2022	Outline structure and review mechanisms agreed by CERN Council. Detector R&D Roadmap Task Forces organise **community meetings** to establish the scope and scale of community wishing to participate in the corresponding new DRD activity. (Where the broad R&D topic area has one or more DRDTs already covered by existing CERN RDs or other international collaborations these need to be fully involved from the very beginning and may be best placed to help bring the community together around the proposed programmes.)
Q1 2023	**DRDC mandate formally defined** and agreed with CERN management; Core DRDC membership appointed; and EDP mandate plus membership updated to reflect additional roles.
Q1-Q2 2023	**Develop the new DRD proposals** based of the detector roadmap and community interest in participation, including light-weight organisational structures and resource-loaded work plan for R&D programme start in 2024 and ramp up to a steady state in 2026.
Q3 2023	**Review of proposals by DRDC** leading to recommendations for formal establishment of the DRD collaborations.
Q4 2023	DRD Collaborations receive formal **approval from CERN Research Board**.
Q1 2024	New structures operational for ongoing review of DRDs and R&D programmes underway.

da Karl Jacobs

ESEMPIO DI PRIMA RIUNIONE: TF 6 (I)

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ECFA Detector R&D Roadmap Task Force 6: Calorimetry Community Meeting

Thursday, 12 January 2023 - *09:00*
CERN (222/R-001)

: Sessions / : Talks : Breaks

		12 Jan 2023	
AM	09:00	Introduction to community meeting - Roman Poeschl (Université Paris-Saclay (FR)) Roberto Ferrari (INFN Pavia (IT)) Roberto Ferrari (222/R-001)	talk120123-v5.pdf
	09:45	**Sandwich calorimeters with fully embedded electronics** - Frank Simon (Max-Planck-Institut fuer Physik) David Barney (CERN) (until 10:50) (222/R-001)	
	09:45	Electromagnetic section - Adrian Irles (IFIC CSIC/UV) (222/R-001)	TF6_20230112_Irles_v4.pdf
	10:20	Hadronic section - Katja Kruger (Deutsches Elektronen-Synchrotron (DE)) Katja Kruger (Deutsches Elektronen-Synchrotron (DE)) (222/R-001)	CaloDRD_hadronic_Krueger.pdf
	10:50	--- Coffee Break ---	
	11:05	**Sandwich calorimeters with fully embedded electronics** - Frank Simon (Max-Planck-Institut fuer Physik) David Barney (CERN) (until 12:00) (222/R-001)	
	11:05	Calorimeters based on MAPS sensors - Thomas Peitzmann (Nikhef National institute for subatomic physics (NL)) (222/R-001)	epical-2-drd-meeting.pdf
	11:20	Forward Calorimeters - Yan Benhammou (Tel Aviv University (IL)) (222/R-001)	forward.pdf
	11:40	Spillover and discussion (222/R-001)	
PM	12:00	--- Lunch break ---	
	13:30	**Liquid Noble Gas Calorimeters** - Tommaso Tabarelli de Fatis (Universita & INFN, Milano-Bicocca (IT)) Martin Aleksa (CERN) (until 14:30) (222/R-001)	
	13:30	Current status of Noble-Liquid Calorimetry R&D - Brieuc Francois (CERN) (222/R-001)	20230112_Brieuc_Francois_Noble_Liquid_Calorimetry_ECFA_TF6_CommunityMeeting.pdf
	14:00	Future Plans & Goals for Noble-Liquid Calorimetry for Future Collider Experiments - Nicolas Morange (Université Paris-Saclay (FR)) (222/R-001)	NobleLiquidCaloPlans.pdf
	14:30	**Optical Calorimeters: Scintillating based, sampling and homogeneous calorimeters** - Etiennette Auffray Hillemanns (CERN) Gabriella Gaudio (Dipartimento di Fisica Nucleare e Teorica) Gabriella Gaudio (INFN-Pavia) (until 15:30) (222/R-001)	
	14:30	Introduction - Etiennette Auffray Hillemanns (CERN) Gabriella Gaudio (INFN-Pavia) (222/R-001)	20230112_DRD_Calo_Optical_Intro_1.pdf
	14:40	Homogeneous Calorimeters - Marco Toliman Lucchini (Università & INFN, Milano-Bicocca (IT)) (222/R-001)	23_01_12_HomogeneousCalorimetry_DRD_TF6_CERN.pdf
	15:05	Picosecond Scintillating sampling electromagnetic calorimeters - Philipp Roloff (CERN) (222/R-001)	tf06_calorimetry_community_meeting_12_01_2023_roloff_version4.pdf
	15:30	--- Coffee Break ---	
	15:50	**Optical Calorimeters: Scintillating based, sampling and homogeneous calorimeters** - Etiennette Auffray Hillemanns (CERN) Gabriella Gaudio (INFN-Pavia) Gabriella Gaudio (Dipartimento di Fisica Nucleare e Teorica) (until 17:15) (222/R-001)	
	15:50	Tile Calorimeters - Henric Wilkens (CERN) (222/R-001)	TF6-Tilecal.pdf
	16:15	Dual Readout Fiber Calorimeters - Romualdo Santoro (Insubria University and INFN - MI) (222/R-001)	santoro_ECFA_Jan2023.pdf
	16:40	Recent development on scintillators - Etiennette Auffray Hillemanns (CERN) (222/R-001)	

ESEMPIO DI PRIMA RIUNIONE: TF 6 (II)

ECFA

very short wrap-up (2)

European Strategy Update

The interest of the community looks excellent! More than 100 people participating

Way toward proposal:

2nd Community Meeting around mid April with focus on concrete proposals

TF6+ will contact stakeholders and will inform about progresses

In any case contact us directly or use Q&A File if you have questions/ideas

some (possible) driving lines

learn from (i.e. build on top of) existing experiences of collaborative R&D

think about building light and flexible MoU

each collaboration will decide its own structure!

We should be able to formulate common goals and synergies

nothing is fixed

must find the right way to combine/cope with national projects

must find the right way to combine/cope with existing collaborations or activities

but all is up to us -> we drive the process

once more: please provide critical input

AZIONI

- **Andare alle pagine**
  - 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/

e aggiungere il proprio nominativo (registrazione) all'argomento di interesse

BACKUP

Discussione in Commissione 1

- **Presentazione di Karl Jacobs** in commissione 1 a novembre
  - https://agenda.infn.it/event/33170/contributions/183514/attachments/99276/137650/ECFA_Roadmap_INFN_2022.11.15.pdf
- Durante discussione **alcune perplessità sollevate,** e.g.:
  - Sostituiscono sigle su R&D CERN già presenti, come RD51
  - Accentrare tutte le attività R&D al CERN con budget comune potrebbe limitare le nuove idee e la competizione
  - Si possono davvero finanziare e promuovere le attività R&D Blue Sky?
  - ….
- Nonostante le perplessità, **generale consenso** affinché i **ricercatori di ciascuna sezione segnalino interesse nelle diverse linee di ricerca**
  - https://indico.cern.ch/event/957057/page/27294-implementation-of-the-ecfa-detector-rd-roadmap
  - **più saremo, più avremo voce in capitolo** nel plasmare queste nuove realtà con cui avremo a che fare in futuro

STRATEGIC RECOMMENDATION (I)

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.

STRATEGIC RECOMMENDATION (II)

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.

STRATEGIC RECOMMENDATION (III)

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.