Symposium Task Force 5: Quantum and Emerging Technologies

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12 April 2021

European Particle Physics Strategy Update

"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."

"Detector R&D activities require specialised infrastructures, tools and access to test facilities."

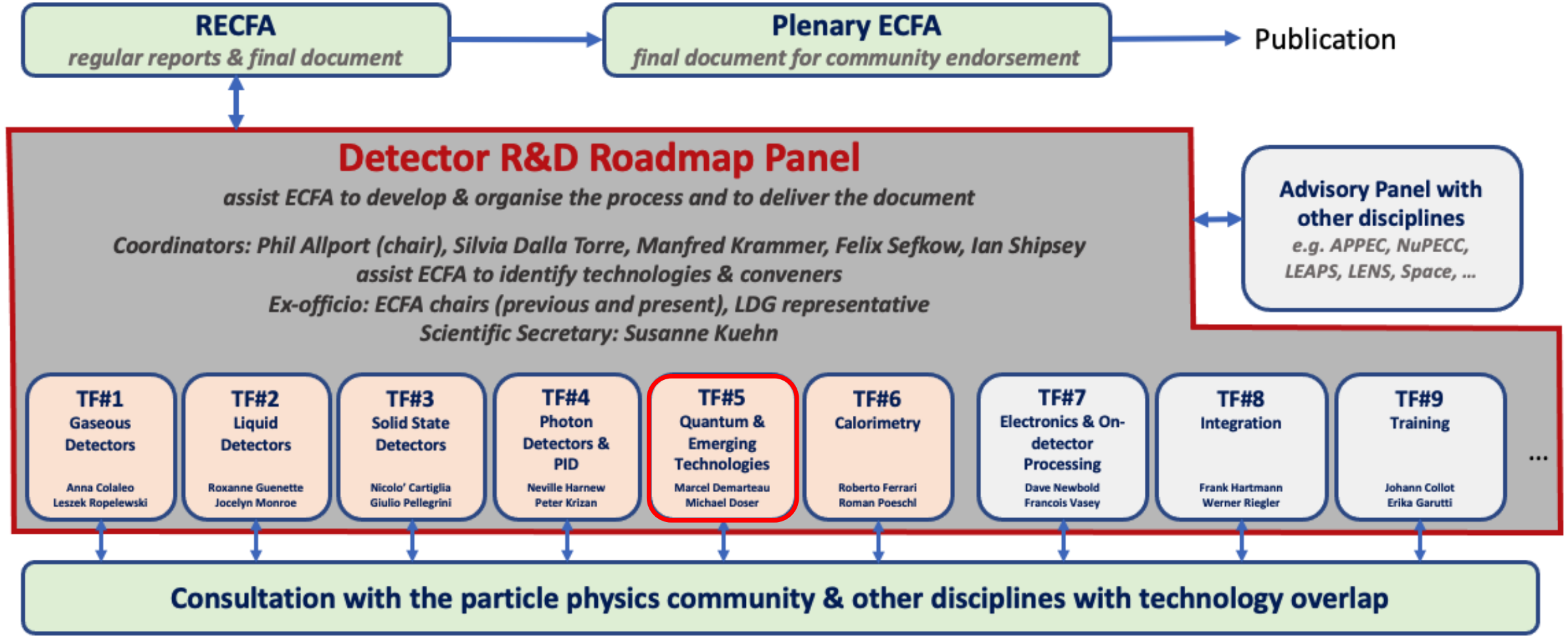
"**The community should define a global detector R&D roadmap that should be used to support proposals at the European and national levels**."

Extracted from the documents of 2020 EPPSU, https://europeanstrategyupdate.web.cern.ch/

For previous presentations on the Detector R&D Roadmap see Plenary ECFA: Jorgen D'Hondt (13/7/20) & Susanne Kuehn (20/11/20) (https://indico.cern.ch/event/933318/ & https://indico.cern.ch/event/966397/)

More roadmap process details at: https://indico.cern.ch/e/ECFADetectorRDRoadmap

Organization for Consultation of Relevant Communities



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

Organization for Consultation of Relevant Communities

- Focus on the technical aspects of detector R&D requirements given the EPPSU deliberation document listed "*High-priority future initiatives*" and "*Other essential scientific activities for particle physics*" as input and organise material by Task Force.
- Task Forces start from the future science programmes to identify main detector technology challenges to be met (both mandatory and highly desirable to optimise physics returns) to estimate the period over which the required detector R&D programmes may be expected to extend.
- Within each Task Force create a time-ordered technology requirements driven R&D roadmap in terms of capabilities not currently achievable.

Grouped targeted facilities/areas emerging from the EPPSU

1. **Detector requirements for full exploitation of the HL-LHC (R&D still needed for LS3 upgrades and for experiment upgrades beyond then) including studies of flavour physics and quark-gluon plasma (where the latter topic also interfaces with nuclear physics).**
2. **R&D for long baseline neutrino physics detectors (including aspects targeting astro-particle physics measurements) and supporting experiments such as those at the CERN Neutrino Platform.**
3. **Technology developments needed for detectors at e^+e^- EW-Higgs-Top factories in all possible accelerator manifestations including instantaneous luminosities at 91.2GeV of up to $5\times10^{36}cm^{-2}s^{-1}$.**
4. **The long-term R&D programme for detectors at a future 100 TeV hadron collider with integrated luminosities targeted up to $30ab^{-1}$ and 1000 pile-up for 25ns BCO.**
5. **Specific long-term detector technology R&D requirements of a muon collider operating at 10 TeV and with a luminosity of the order of $10^{35}\,cm^{-2}\,s^{-1}$.**

Broad Topic Areas

Grouped targeted facilities/areas emerging from the EPPSU

6. Detector developments for accelerator-based studies of rare processes, DM candidates and high precision measurements (including strong interaction physics) at both storage rings and fixed target facilities, interfacing also with atomic and nuclear physics.
7. R&D for optimal exploitation of dedicated collider experiments studying the partonic structure of the proton and nuclei as well as interface areas with nuclear physics.
8. The very broad detector R&D areas for non-accelerator-based experiments, including dark matter searches (including axion searches), reactor neutrino experiments, rare decay processes, neutrino observatories and other interface areas with astro-particle physics.

9. Facilities needed for detector evaluation, including test-beams and different types of irradiation sources, along with the advanced instrumentation required for these.
10. Infrastructures facilitating detector developments, including technological workshops and laboratories, as well as tools for the development of software and electronics.
11. Networking structures in order to ensure collaborative environments, to help in the education and training, for cross-fertilization between different technological communities, and in view of relations with industry.

12. Overlaps with neighbouring fields and key specifications required for exploitation in other application areas
13. Opportunities for industrial partnership and technical developments needed for potential commercialisation

ECFA
European Committee for Future Accelerators

Process and Timeline

Organisation

May 2020
EPPSU mandate to ECFA to develop a roadmap for detector R&D efforts in Europe

Sep 2020
Structure in place with **Detector R&D Roadmap Panel**

Dec 2020
Task Forces active

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

Expert & Community Consultation

Feb 2021
Collection of requirements of future facilities & projects

Feb/March 2021
Questionnaires of Task Forces to national contacts

Task Forces liaise with experts in
- ECFA countries
- adjacent disciplines
- industry

March-May 2021
Open Symposia

Drafting Roadmap & Feedback

May 2021
Task Forces collate input from symposia

25-28 May 2021 **Drafting sessions**
- opening session with all experts involved
- plenary & parallel sessions with Task Force members
- final session of Roadmap Panel

July 2021
Near final draft shared with RECFA*

30 July 2021
Presentation at Joint ECFA-EPS session

Until Sep 2021
Collect final community feedback*

Oct 2021
Detector R&D Roadmap Document submission to RECFA and afterwards to PECFA and Council

*community feedback via RECFA delegates and National Contacts

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Process and Timeline

Input session of Future Facilities I
Friday 19 Feb 2021, 13:00 → 18:00 Europe/Zurich

- 13:00 → 13:30 **Detector R&D requirements for HL-LHC**
  Speaker: Chris Parkes (University of Manchester (GB))
  ECFA_RD_Parkes_1...
- 13:30 → 14:00 **Detector R&D requirements for strong interaction experiments at future colliders**
  Speaker: Luciano Musa (CERN)
  MUSA_ECFA_IS_20...
- 14:00 → 14:30 **Detector R&D requirements for strong interaction experiments at future fixed target facilities**
  Speaker: Johannes Bernhard (CERN)
  Detector R&D requir...
- 14:30 → 14:45 Coffee-Tea Break
- 14:45 → 15:15 **Detector R&D requirements for future linear high energy e+e- machines**
  Speaker: Frank Simon (Max-Planck-Institut fuer Physik)
  LC_DetRoadmapInp...
- 15:15 → 15:45 **Detector R&D requirements for future circular high energy e+e- machines**
  Speaker: Mogens Dam (University of Copenhagen (DK))
  ECFA_Detector_R&D...
- 15:45 → 16:15 **Detector R&D requirements for future high-energy hadron colliders**
  Speaker: Martin Aleksa (CERN)
  20210219-ECFA-Det...
- 16:15 → 16:35 **Detector R&D requirements for muon colliders**
  Speaker: Nadia Pastrone (Universita e INFN Torino (IT))
  MuonColliders_Dete...

Input session of Future Facilities II
Monday 22 Feb 2021, 14:00 → 18:00 Europe/Zurich

- 14:00 → 14:30 **Detector R&D requirements for future short and long baseline neutrino experiments**
  Speaker: Marzio Nessi (CERN)
  21-02-22-ECFA-Neut... 21-02-22-ECFA-Neut...
- 14:30 → 15:00 **Detector R&D requirements for future astro-particle neutrino experiments**
  Speaker: Maarten De Jong (Nikhef National Institute for subatomic physics (NL))
  ECFA - Maarten de ... ECFA - Maarten de ...
- 15:00 → 15:30 **Detector R&D requirements for future dark matter experiments**
  Speaker: Laura Baudis (University of Zurich)
  baudis_ecfa_feb21....
- 15:30 → 15:40 Coffee-Tea Break
- 15:40 → 16:10 **Detector R&D requirements for future rare decay processes experiments**
  Speakers: Cristina Lazzeroni (University of Birmingham (GB)) , Cristina Lazzeroni (University of Birmingham (GB))
  ECFA_Lazzeroni.pdf
- 16:10 → 16:40 **Detector R&D requirements for future low energy experiments**
  Speaker: Dr Alexandre Obertelli (TU Darmstadt)
  ECFA_LowEnergyFa...

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March-May 2021
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May 2021

- 07 May ECFA Detector R&D Roadmap Symposium of Task Force 6 Calorimetry
- 06 May ECFA Detector R&D Roadmap Symposium of Task Force 4 Photon Detectors and Particle Identification Detectors

April 2021

- 30 Apr ECFA Detector R&D Roadmap Symposium of Task Force 9 Training
- 29 Apr ECFA Detector R&D Roadmap Symposium of Task Force 1 Gaseous Detectors
- 23 Apr ECFA Detector R&D Roadmap Symposium of Task Force 3 Solid State Detectors
- 12 Apr ECFA Detector R&D Roadmap Symposium of Task Force 5 Quantum and Emerging Technologies
- 09 Apr ECFA Detector R&D Roadmap Symposium of Task Force 2 Liquid Detectors

March 2021

- 31 Mar ECFA Detector R&D Roadmap Symposium of Task Force 8 Integration
- 25 Mar ECFA Detector R&D Roadmap Symposium of Task Force 7 Electronics and On-detector Processing

Materials from past Symposia, Input Sessions and other components of the ECFA Detector R&D Roadmap Process can be found at https://indico.cern.ch/e/ECFADetectorRDRoadmap

Links for Roadmap Process

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

https://indico.cern.ch/event/957057/page/21633-mandate (Panel Mandate document)

https://home.cern/resources/brochure/cern/european-strategy-particle-physics

https://arxiv.org/abs/1910.11775 (Briefing Book)

https://science.osti.gov/-/media/hep/pdf/Reports/2020/DOE_Basic_Research_Needs_Study_on_High_Energy_Physics.pdf

https://ep-dep.web.cern.ch/rd-experimental-technologies (CERN EP R&D)

http://aida2020.web.cern.ch/aida2020/ (linking research infrastructures in detector development and testing)

https://attract-eu.com/ (ATTRACT: linking to industry on detection and imaging technologies)

https://ecfa-dp.desy.de/public_documents/ (Some useful documents from the ECFA Detector Panel)

TF5: Quantum and Emerging Technologies

< Today

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TF5: Quantum and Emerging Technologies, Welcome!

- Quantum Technologies are a rapidly emerging area of technology development to study fundamental physics. The ability to engineer quantum systems to improve on the measurement sensitivity holds great promise.
- One of the goals of this task force is to provide an overview of the various nascent quantum methodologies and present a pathway for their development into the implementation of particle physics experiments.
- Given the tremendous advances in quantum technologies and the interest at the highest level of government, we expect the audience for this symposium to be very large.
- The development of quantum-enhanced sensing capabilities for particle physics is relatively new and the symposium is structured accordingly.
- Full symposium is recorded

TF5 Symposium Today

The symposium today has been structured as follows:

- Science targets - Overview and Landscape
  - Overview of the key open science questions where quantum technologies could have a huge impact
- Experimental methods and techniques - Overview and Landscape
  - Overview of the currently used quantum methodologies and their implementation
- Experimental methods and techniques - New Developments
  - Overview of some of the new developments
- Experimental and technological challenges
  - Exposé of some key barriers to be overcome
- Discussion

Many, many thanks to all the speakers!!

Many thanks for your participation!

Every talk leaves plenty of time for discussion; we expect lively interactions.

Logistics for Today / real-time feedback:

- Each presentation consists of a talk of 20 minutes, and is followed by a 10 minute discussion period.
- Discussion session at 17:45 - 18:30
- There is a live google doc to enter questions and answers real time
  https://docs.google.com/document/d/1uU8tGtK4rA7Qe-3Pqf1FvAYbdLMAKGZ4PnQHWovJE5o/edit
  This link is also at the top of the TF5 symposium webpage: https://indico.cern.ch/event/999818/
  Please use this extensively, since it will also form a basis of input for the report.
- The Q&A feature can also be used to ask questions online and provide feedback.
- email the Task Force (email contacts are in the google doc)
- This meeting is run in 'seminar format', that is, everyone can mute and unmute him/herself. Please observe proper protocol and mute. If you have a question, "raise your hand" and we will invite you to comment.

After Today

- This symposium is not the end of the consultation, but just the beginning of the process. Additional feedback is welcome until the last symposium on 7 May.
- The two main ways to provide feedback are:
  - The google doc, which will be left open until the end of the month.
    https://docs.google.com/document/d/1uU8tGtK4rA7Qe-3Pqf1FvAYbdLMAKGZ4PnQHWovJE5o/edit
    Everyone is invited to participate and provide input.
  - By email to:
    ECFA-DetectorRDRoadmap-TF5QuantumDetectors-Input@cern.ch
    Please try to provide input before May 7, the date for the last symposium.
- A drafting session is planned for May 24—27

- **Note: Your participation today and your input are essential!**

Many thanks for your participation,
please join the discussions
and provide feedback;

ENJOY the symposium