The New AIDAinnova Project and the ECFA Detector Roadmap Process

Felix Sefkow
DESY

13th Terascale Detector Workshop | April 6, 2021

Outline

AIDAinnova overview

The Roadmap processes in ECFA and in AIDAinnova

Next steps

EC-funded Detector R&D Projects

PF6: EUDET: 2006-2010

- Detector development for linear collider

FP7: AIDA: 2011-2014

- Detector development for LHC upgrades and linear colliders
- Project-specific work packages

FP8: AIDA-2020: 2015-2020

- Common LC and LHC work packages
- New communities: large cryogenic neutrino experiments, new topics
- New innovation measures, with industry

Increasing level of integration

All had a strong leverage on matching funds from national sources typically factor 3

There is no other mechanism to provide coherence on European level

Context

The AIDA-2020 had been prepared in 2014

- following the European Strategy Update 2013
- clear emphasis on R&D for HL-LHC upgrades

AIDAinnova had to navigate in less well charted sea

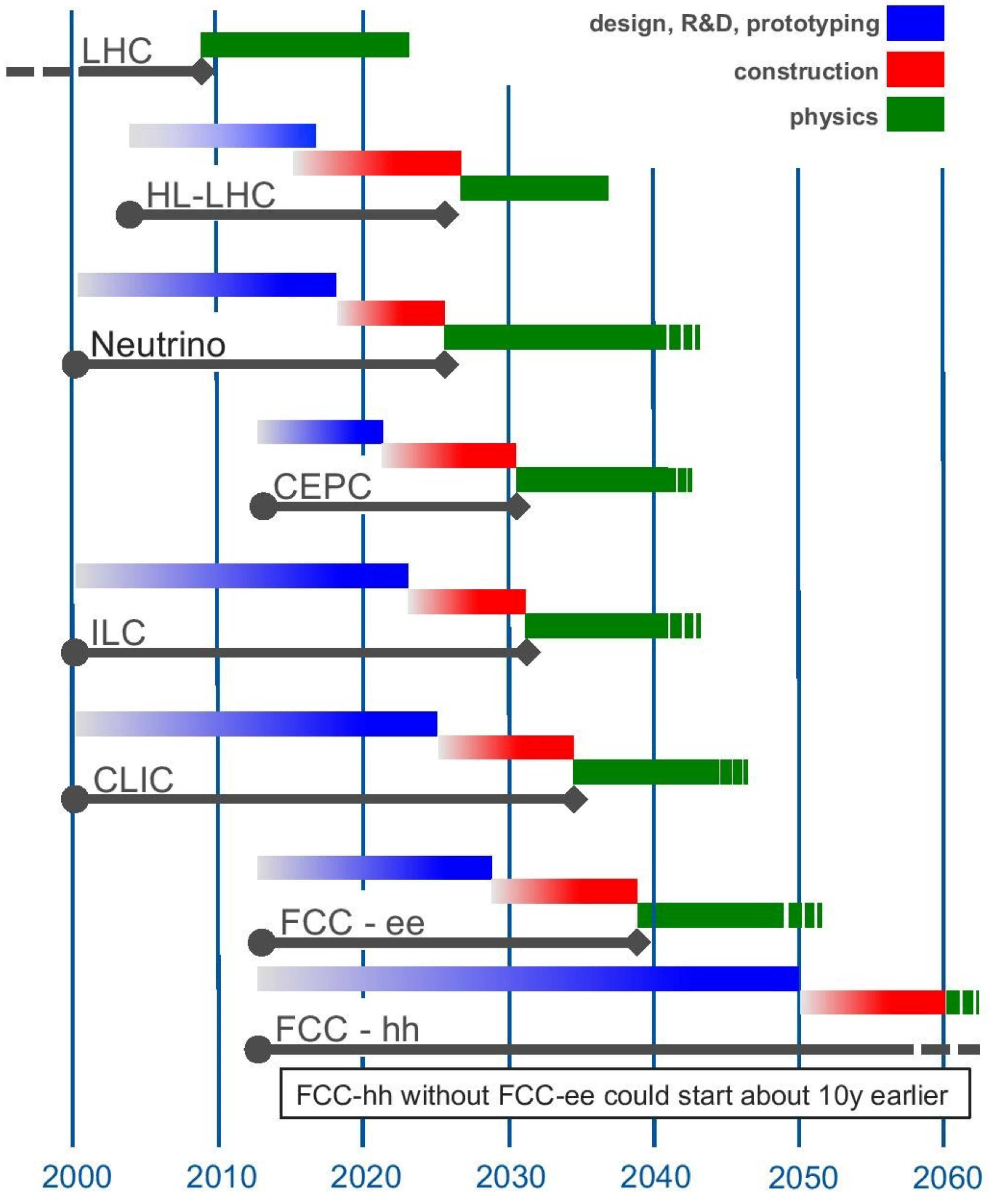
- more diverse range of target applications

Regardless of ongoing strategy process and funding uncertainties, projects have natural timelines

- e.g.: LHC < Higgs Factory < Future hadron collider

Emphasise common aspects and needs

- not exclusively, see later



Scope

AIDAinnova focusses on Strategic R&D in the pre-TDR phase

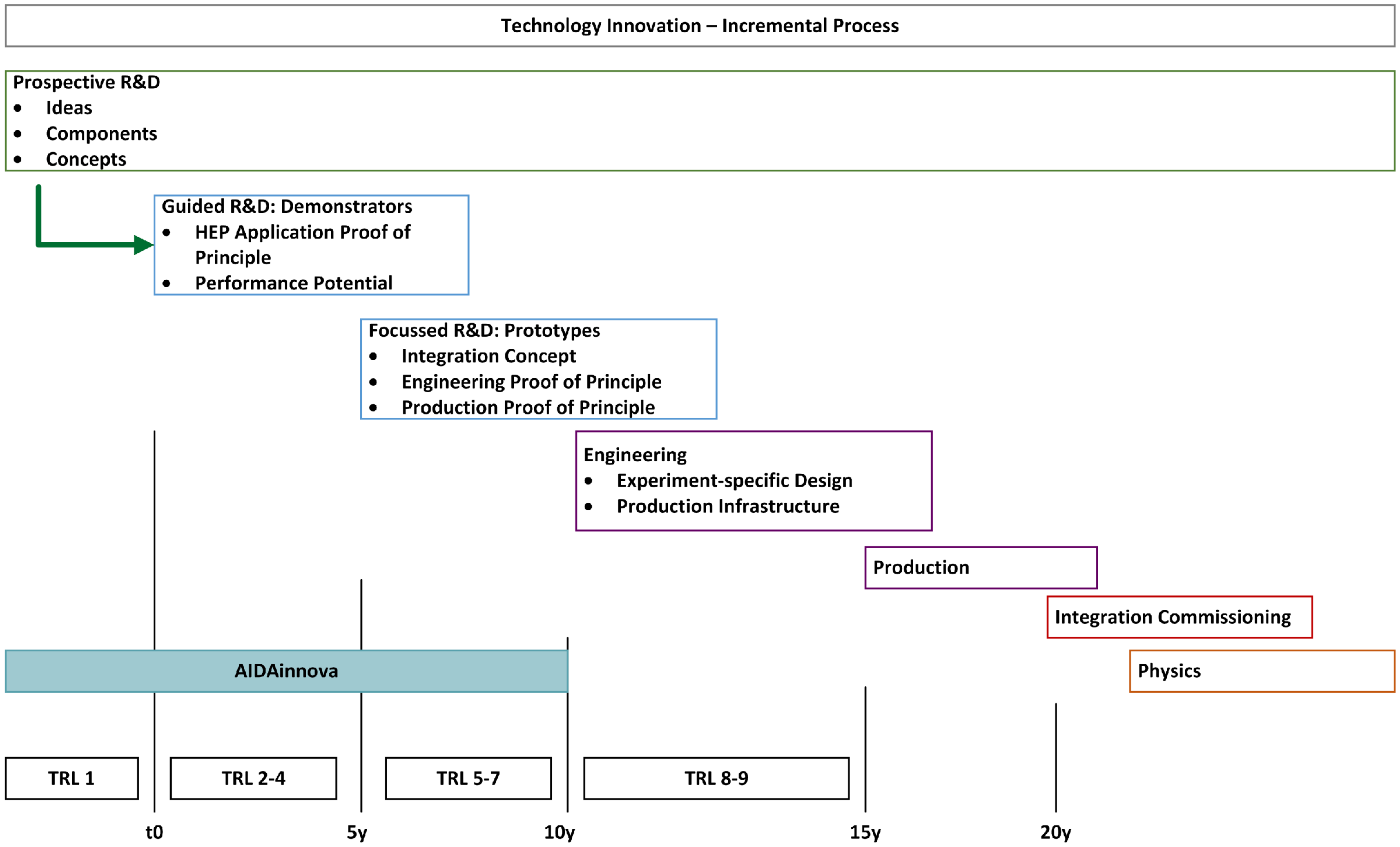
- Technology Readiness Levels 2-7
- Not yet experiment-specific: potential to unfold synergies

Include some prospective R&D

- competitive call at start of project
- “Blue Sky”, quantum sensors,…

Targeted applications

- Higgs Factories
- ATLAS, CMS LS4, ALICE, LHCb LS3 pre-TDR
- Accelerator-based neutrino experiments
- and others



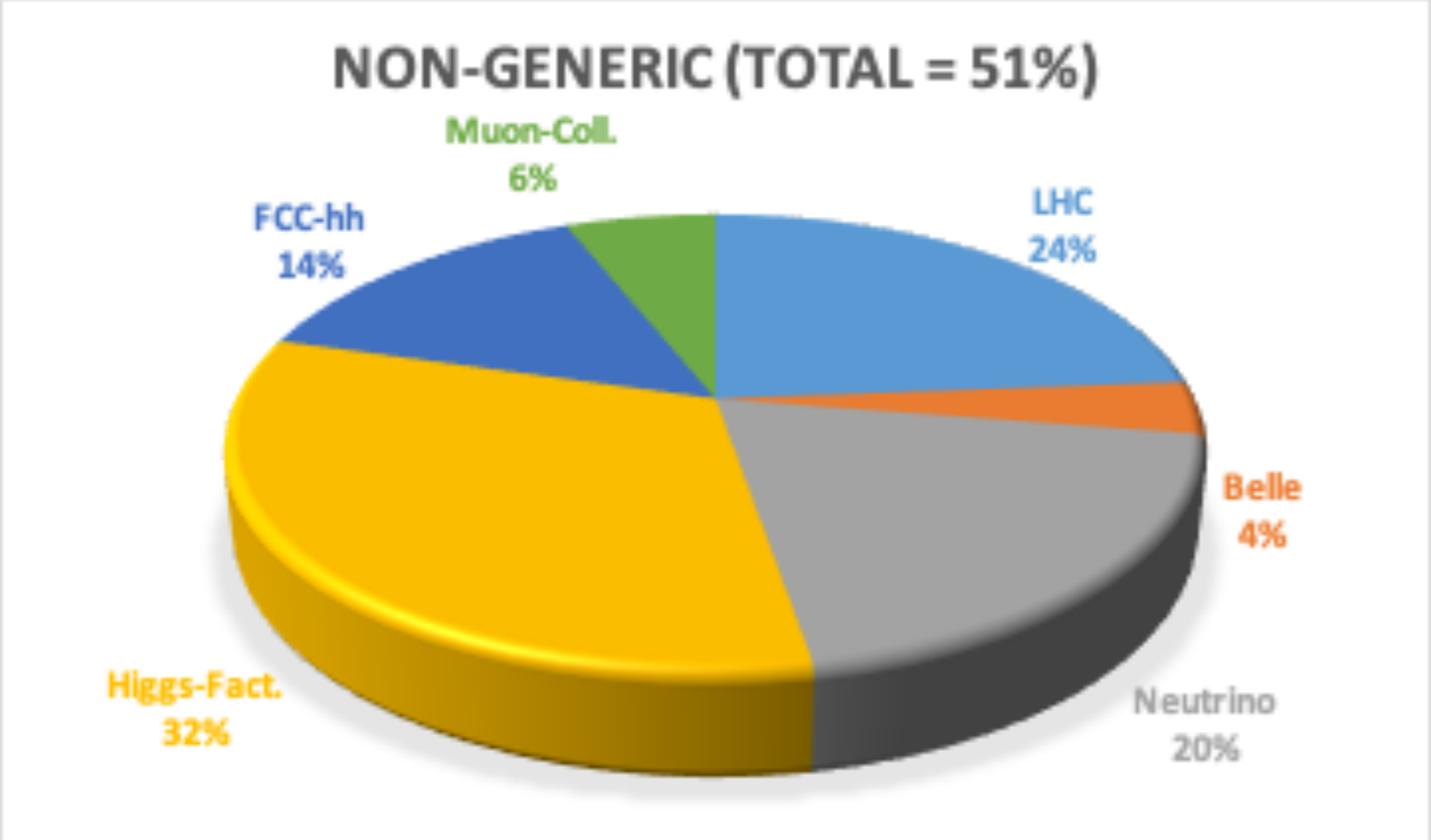
Budget

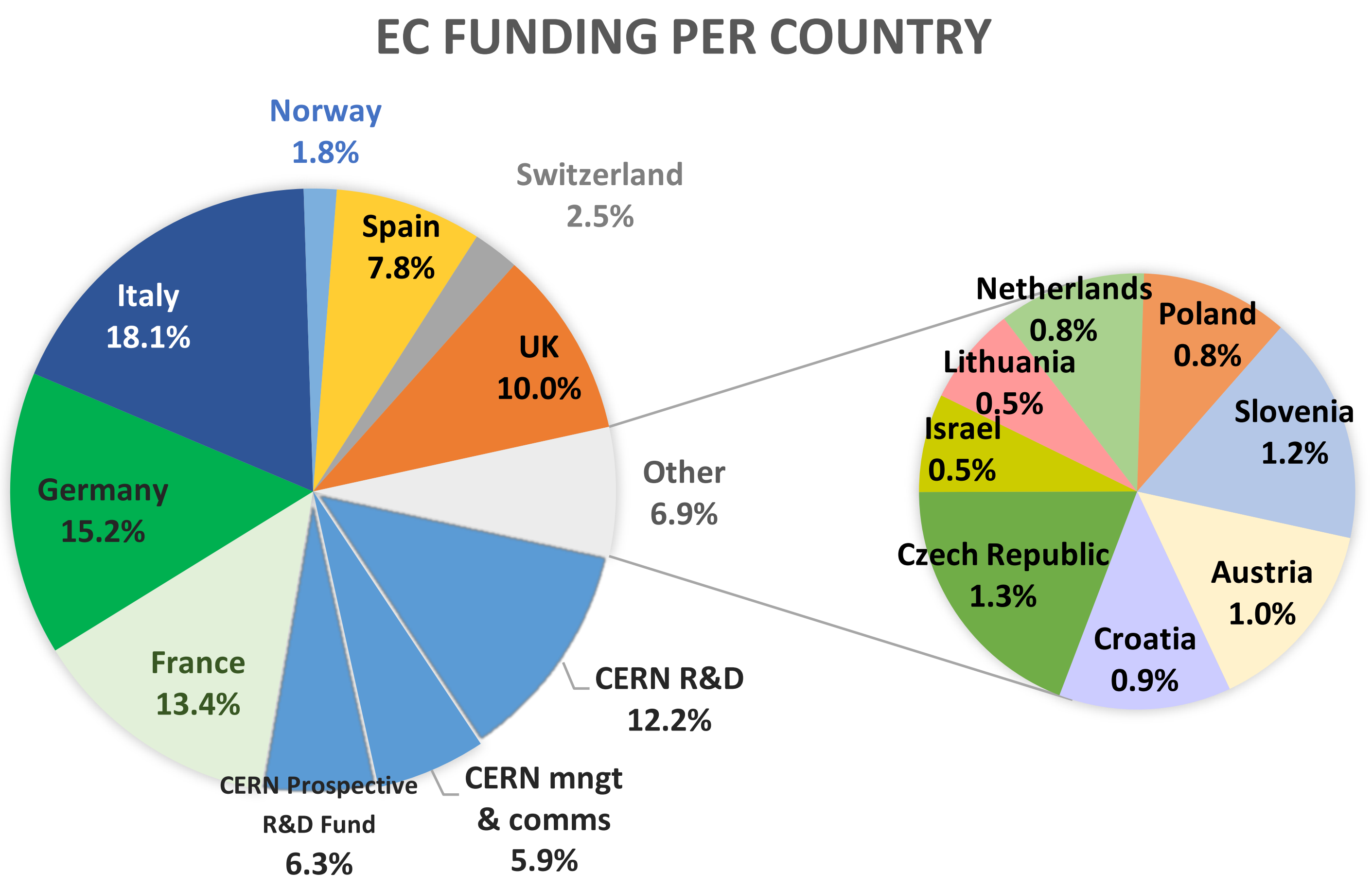
49% is "generic", beneficial for all future projects:

- Management, outreach and KT
- Testbeam and facility upgrades
- Mechanics and cooling, Software
- "Blue Sky" R&D plus some tasks in other WP

51% can be associated with 1 to 3 projects

- "Matrix" to be taken with a grain of salt…
- Sharing will influence generic part, too



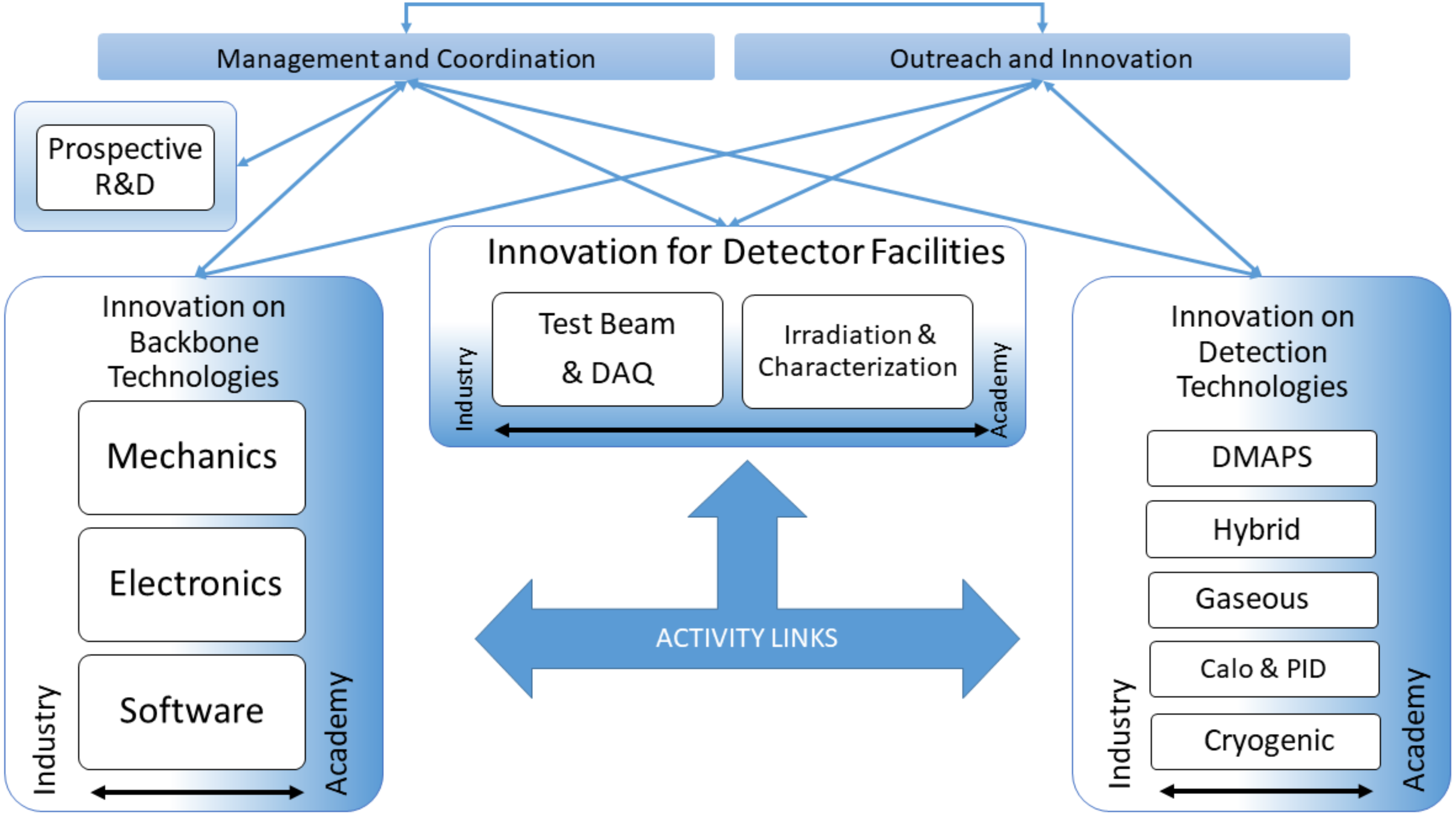


Total budget 22.5 M€

- academic partners match overhead-subtracted EC funds 2:1, commercial partners 1:1

10% of EC funds to non-academic partners

Work Packages



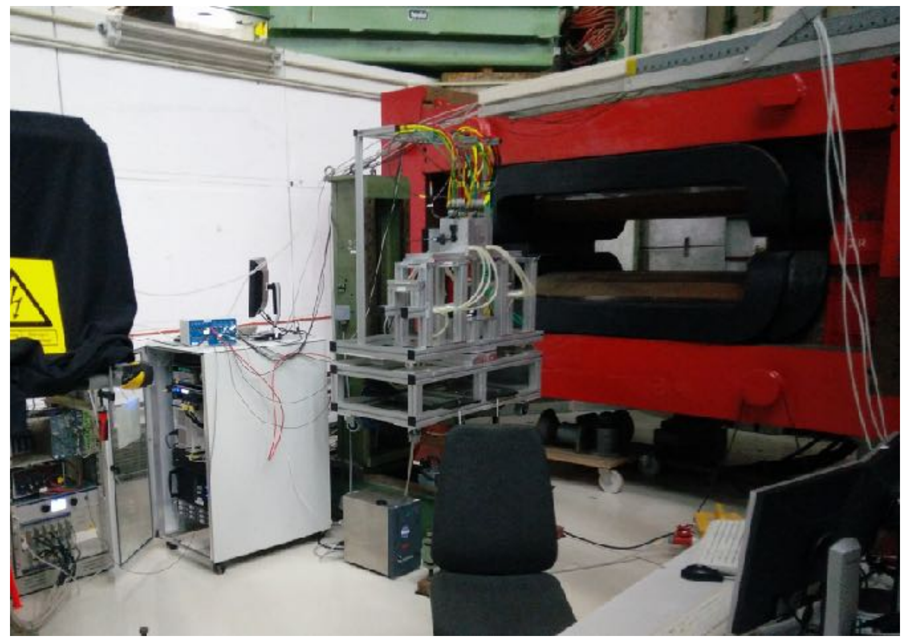
Similarities with
- AIDA-2020
- CERN Detector R&D
- ECFA Detector Roadmap

are purely accidental.

Telesopes Around The World

Contact:
Carsten Hast

CALADIUM @ SLAC in Stanford, USA



DATURA @ TB21

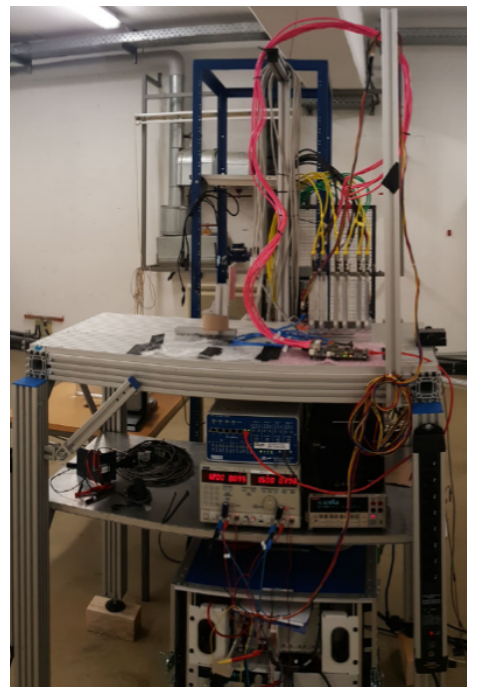
DURANTA @ *TB22*

TB contact:
Ralf Diener, Norbert Meyners, Marcel Stanitzki
Telescope contact:
Adrian Herkert

AZALEA @ PS, T10
Currently at DESY TB24

AIDA @
SPS, H6B

ACONITE @ SPS, H6A



ANEMONE @
BONN / ELSA

TB contact:
Daniel Elsner
Telescope contact:
David-Leon Pohl

SPS/PS contact:
Henric Wilkens
Telescope contact:
André Rummler

Marcel Stanitzki

German Participation WP 3, 12

WP3: Testbeam and DAQ Infrastructure

- ***Marcel Stanitzki (DESY)****, Mathew Wing (UCL)*
- Upgrade of EUDET **telescopes** with ALPIDE sensors, standard **Cold Box**
- **Fast timing support**, ps timing in TLU
- **Timepix integration**, LGAD plane
- DAQ software **EUDAQ2**
- DAQ hardware for silicon (**Caribou**) and gas detectors (VMM3)
- Incorporate new sensors from CMOS WP

WP12: Software for Future Detectors

- ***Frank Gaede (DESY)****, Graeme Stewart (CERN)**
- **Turnkey software stack**
- **Machine learning for fast simulation**
- **Tracking algorithms**
- Particle flow reconstruction

German Participation WP 5, 6

WP5: Depleted Monolithic Active Pixel Sensors

- *Sebastian Grinstein (IFAE),*
  David-Leon Pohl (Bonn)
- **High granularity DMAPS** for e+e- colliders
  - Low mass, low power: ALICE, Belle, HiggsF
- **Radiation-hard DMAPS**
- Both: Design, fabrication at different foundries, readout, irradiation, test

WP6: Hybrid Pixel Sensors for 4D Tracking and Interconnection Technologies

- *Anna Macchiolo (UZH),*
  Claudia Gemme (INFN)
- **3D and LGAD sensors:**
  - **simulation software** (***DESY***)
  - design and common submissions
  - characterisation, process optimisation
- **Interconnection technologies** for ultra-thin structures (***Bonn, DESY, IZM***):
  - Anisotropic Conductive Films
  - **Wafer-to-wafer bonding**

German Participation WP8

WP8: Calorimeters and Particle Identification Detectors

- *Roberto Ferrari (INFN), **Katja Krüger (DESY)**, Roman Poeschl (CNRS)*
- **High Granularity**
  - **Integration aspects Si, SiPM, compact interfaces and structures (DESY, Mainz)**
  - LAr read-out PCB prototyping
- **Optical readout**
  - Crystals for fast timing
  - **Large area scintillators**; granularity and timing **(DESY, Mainz, MPP Munich)**
- SiPMs for calorimeters and particle ID
- Dual readout fibre calorimeter, read-out system

German Participation WP 10, 11

WP10: Advanced Mechanics for Tracking and Vertex detectors

- *Paolo Petagna (CERN), Marcel Vos (CSIC)*
- **Optimised cooling substrates**
  - **Micro-channels**, 3D printed cold plates, ultra-light composites **(MPG-HLL Munich)**
- Micro-connectivity
- Super-critical CO2
- Characterisation facility for ultra-light structures

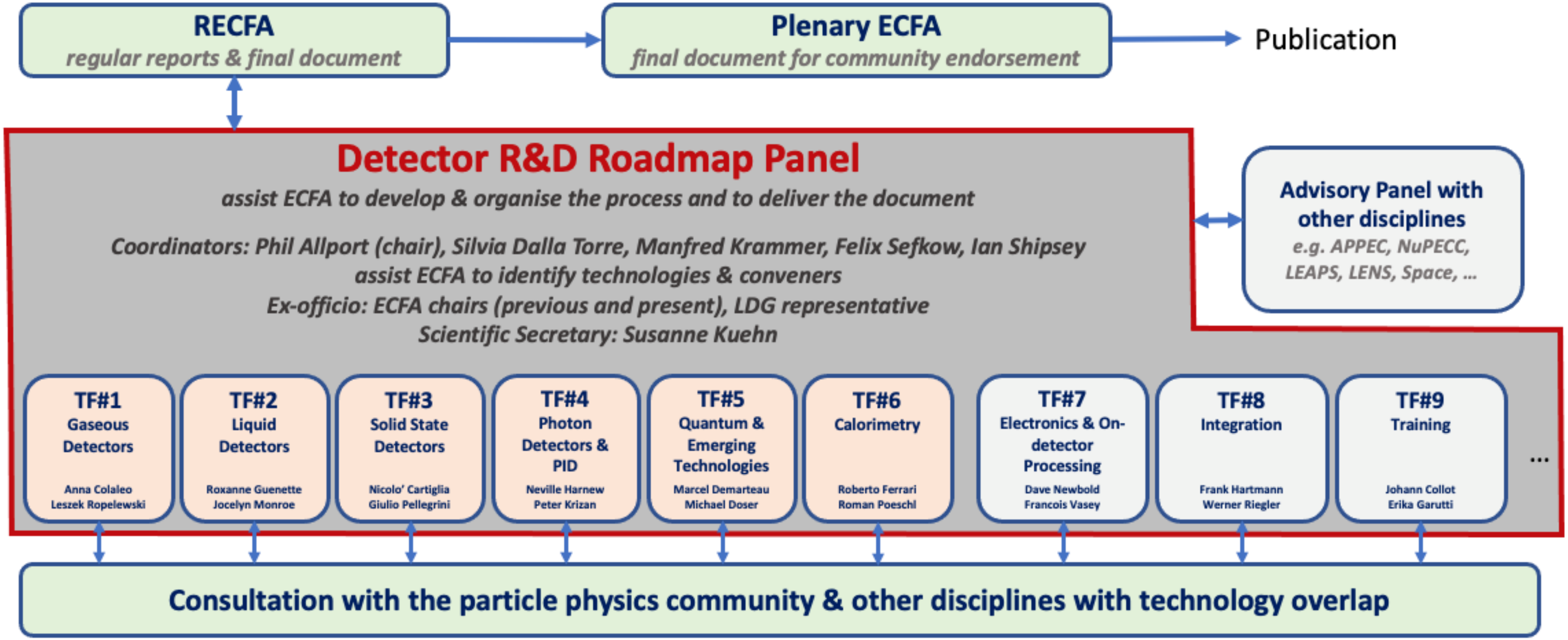
WP11: Microelectronics

- *Christophe de La Taille (CNRS), Angelo Rivetti (INFN)*
- **Explore 28 nm** CMOS **(Bonn)**
- **ASIC network** for MPW runs
  - MPGDs, Si, SiPM, cold LAr readout **(DESY, Heidelberg)**

AIDAinnova Summary and Next Steps

- EC-funded detector initiatives are a **unique forum** to exchange knowhow, unfold synergies and enhance coherence in European detector R&D
- AIDAinnova started on April 1, 2021
- **10 M€** of fresh resources and leverages a total budget of 22.5 M€ (4 years)
- Largest share is dedicated to **Higgs factory targeted R&D**
- A **kick-off meeting** will be held **April 13-16, online**
  - most WPs had pre-kick-off meetings already
  - well prepared to set up the work programme and get started!

Organization for Consultation of Relevant Communities



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

The ECFA Detector Roadmap Process

- EC requires AIDAinnova to follow or to develop a roadmap
- ECFA initiated a Roadmap process with the EPPSU https://indico.cern.ch/event/957057/
  - AIDA will adopt the ECFA roadmap and explain how its programme fits in
- ECFA Roadmap builds on the **EPPSU as a starting point**
  - Future projects, priorities and timelines
  - Physics programme and resulting detector requirements (Briefing Book)
- **Consulting the Community in Open Symposia** (1 day per topical Task Force)
  - This week: Noble Liquid Detectors 9.4.
  - Others still to come: Quantum & Emerging 12.4., Silicon 23.4., Gas 29.4., Training 30.4. Photodetectors 6.5., Calorimetry 7.5.

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

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

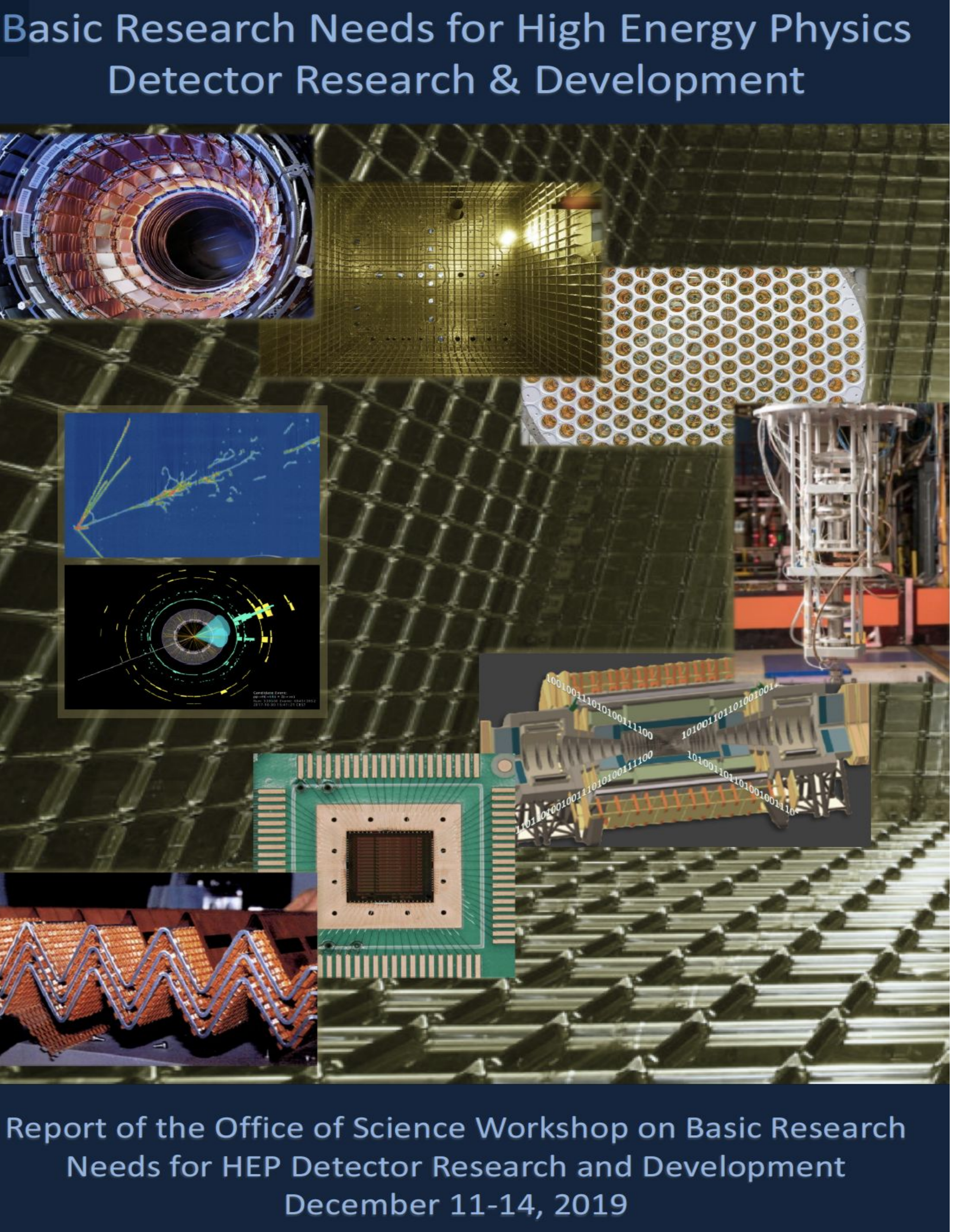
July 2021
Near final draft shared with RECFA*

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



DOE Basic Research Needs Study on Instrumentation

(Report to HEPAP - final draft)

Bonnie Fleming
Ian Shipsey
(on behalf of the BRN Panel)

Physics to Technologies

Physics to Technologies

Calorimetry

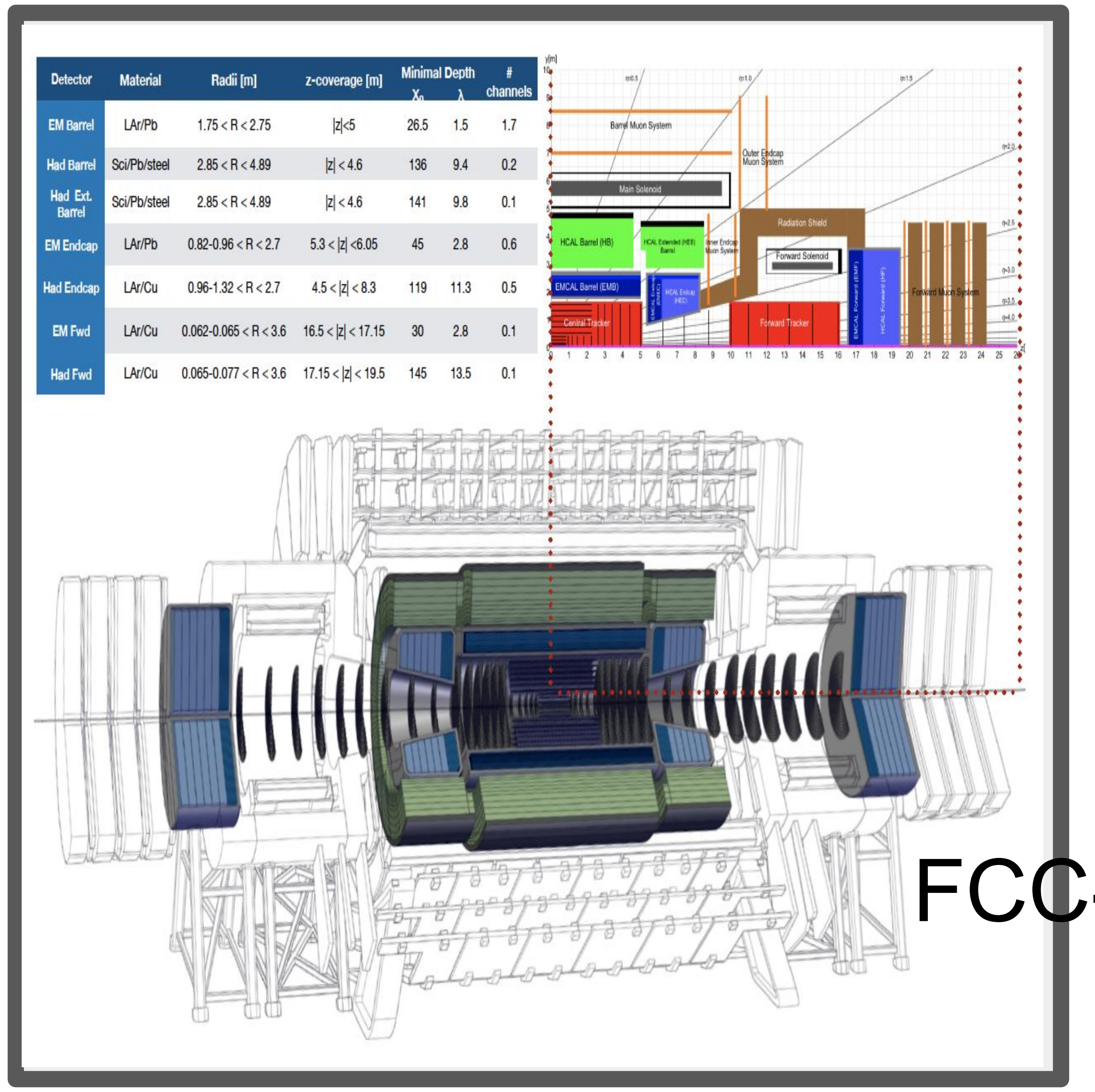
Priority Research Direction	Technical Requirements
PRD 1: Enhance calorimetry energy resolution for precision electroweak mass and missing-energy measurements	TR 1.3, TR 1.4, TR 5.1, TR 5.5, TR 5.10
PRD 2: Advance calorimetry with spatial and timing resolution and radiation hardness to master high-rate environments	TR 1.4, TR 5.7
PRD 3: Develop ultrafast media to improve background rejection in calorimeters and improve particle identification	TR 1.3, TR 1.4, TR 5.7

Connections outside of HEP:

- The detection of photons, electrons, and hadrons beyond HEP. Eg: experiments at EIC
- Development of organic scintillators for medicine and national security

Facilities and Capabilities (existing and needed)

- Detailed, reliable simulation studies (GEANT4)
- Irradiation facilities to qualify materials, test beams
- Characterizing precision timing systems.
- Studies of data rate, rad tolerance, improved or alternate power delivery systems.
- Expertise: Research scientists at universities



FCC-hh

Francesco Lanni Roger Rusack (leads)
Nural Akchurin Sarah Eno Paolo Rumerio Ren-Yuan Zhu

Science	Measurement	Technical Requirement	PRD
Higgs properties with sub-percent precision Higgs self-coupling with 5% precision	TR 1.1: Tracking for e^+e^-	TR 1.1.1: p_T resolution: $\sigma_{p_\mathrm{T}}/p_\mathrm{T} = 0.2\%$ for central tracks with $p_\mathrm{T} < 100$ GeV, $\sigma_{p_\mathrm{T}}/p^2_\mathrm{T} = 2 \times 10^{-5}$/GeV for central tracks with $p_\mathrm{T} > 100$ GeV TR 1.1.2: Impact parameter resolution: $\sigma_{r\phi} = 5 \bigoplus 15\ (p\ [\mathrm{GeV}] \sin^{\frac{3}{2}}\theta)^{-1}\ \mu$m TR 1.1.3: Granularity : $25 \times 50\ \mu\mathrm{m}^2$ pixels TR 1.1.4: 5 μm single hit resolution TR 1.1.5: Per track timing resolution of 10 ps	18, 19, 20, 23
Higgs connection to dark matter	TR 1.2: Tracking for 100 TeV pp	Generally same as e^+e- (TR 1.1) except TR 1.2.1: Radiation tolerant to 300 MGy and $8 \times 10^{17}\ \mathrm{n_{eq}/cm^2}$ TR 1.2.2: $\sigma_{p_\mathrm{T}}/p_\mathrm{T} = 0.5\%$ for tracks with $p_\mathrm{T} < 100$ GeV TR 1.2.3: Per track timing resolution of 5 ps rejection and particle identification	16, 17, 18, 19, 20, 23, 26
New particles and phenomena at multi-TeV scale	TR 1.3: Calorimetry for e^+e^-	TR 1.3.1: Jet resolution: 4% particle flow jet energy resolution TR 1.3.2: High granularity: EM cells of $0.5 \times 0.5\ \mathrm{cm}^2$, hadronic cells of $1 \times 1\ \mathrm{cm}^2$ TR 1.3.3: EM resolution : $\sigma_E/E = 10\%/\sqrt{E} \bigoplus 1\%$ TR 1.3.4: Per shower timing resolution of 10 ps	1, 3, 7, 10, 11, 23
	TR 1.4: Calorimetry for 100 TeV pp	Generally same as e^+e- (TR 1.3) except TR 1.4.1: Radiation tolerant to 4 (5000) MGy and $3 \times 10^{16}\ (5 \times 10^{18})\ \mathrm{n_{eq}/cm^2}$ in endcap (forward) electromagnetic calorimeter TR 1.4.2: Per shower timing resolution of 5 ps	1, 2, 3, 7, 9, 10, 11, 16, 17, 23, 26
	TR 1.5: Trigger and readout	TR 1.5.1: Logic and transmitters with radiation tolerance to 300 MGy and $8 \times 10^{17}\ \mathrm{n_{eq}/cm^2}$ TR 1.5.2: Total throughput of 1 exabyte per second at 100 TeV pp collider	16, 17, 21, 26

Science	Timescale	Technical Requirement	PRD
Search for new physics though rare flavor interactions	medium term	TR 5.1: Timing resolution at the level of $10-30$ ps per hit in the silicon-pixel vertex detectors and $10-30$ ps per track for both PID detectors (RICH, TORCH) and electromagnetic calorimeters	2, 10, 18
	medium term	TR 5.2: Development of radiation-hard, fast and cost-effective photosensors for TORCH and RICH detectors and tracking systems with optical readout	9, 11
	medium term	TR 5.3: Development of the next generation ASICS to extract the large data rate (and possibly pre-process it) out of inner pixel layer detectors in a very challenging radiation environment	16, 17
Tests of the CKM quark mixing matrix description	medium term	TR 5.4: Radiation-hard silicon pixel detectors (fluences of $5 \times 10^{16}\ \mathrm{n_{eq}/cm^2}$)	18, 20
	medium term	TR 5.5: Cost-effective electromagnetic calorimeter with granularity of typically $2 \times 2\ \mathrm{cm}^2$, resolution of $\frac{\sigma(E)}{E} \sim \frac{10\%}{\sqrt{E}} \oplus 1\%$ and timing resolution of a few tens of ps; total radiation dose of ~ 200 Mrad	1
	medium term	TR 5.6: Real-time processing of large amount of data (400-500 Tb/sec) and development of radiation-hard, high-rate optical links, with tight constraints of low-power consumption and low mass	16, 17, 21, 22
	long term	TR 5.7: Fast-timing resolution at the level of 1 ps per track for $\pi/K/p$ separation up to 50 GeV	3, 10
Studies of Lepton Flavor Universality	long term	TR 5.8: Further ASICS development to extract and pre-process on detector the large data rate of inner layers detectors in an extreme radiation environment	16, 17
	long term	TR 5.9: Radiation-hard, ultra-fast silicon pixel detectors (fluences of $10^{18}\ \mathrm{n_{eq}/cm^2}$)	18, 19, 20
	long term	TR 5.10: Very high granularity calorimeters preserving an energy resolution of $\frac{\sigma(E)}{E} \sim \frac{10\%}{\sqrt{E}}$	1, 2, 7, 9
	long term	TR 5.11: Real-time processing of large amount of data (1Exabytes/sec) and development of radiation-hard, high-rate optical links, with tight constraints of low-power consumption and low mass	16, 17, 21, 22, 23

Roadmap Summary

- A “European Strategy for Detectors”
  - can be very helpful if done well
  - aligning the community after major HL-LHC effort
  - good connection between US and European process
  - German community well represented (NC: Lutz Feld)
- Series of high-level symposia just started
  - main path for community consultation
- Goal: Present a draft at EPS in July

Backup

The AIDAinnova Call

Another call in FP8 was not obvious

- Followed intensive discussions with EC, incl. actions by the CERN directorate

Targeted Call INFRAINNOV-04-2020: Innovation pilots

- Advanced Integrated Activities (i.e. the AIDA-2020 community)
- which have reached a high level of integration and can focus on joint research: **collaborative**

Objectives

- Support research **infrastructure** networks developing and implementing a **common strategy/ roadmap** including technological development required for improving their services through **partnership with industry**
- Support **incremental innovation** and cooperation with industry

Complementarity to ATTRACT (compoeritive, disruptive)

Increased focus on industrial partners

No Transnational Access

infrastructure: common interest

Proposed funding 10 M€ for 4 years

Proposal Preparation

Consultation with the community

- Call for Expressions of Interest in May 2019
- Overwhelming response: 162 EoIs

Structuring the Input: Topic Convenors*

- Reports at 1st Open Meeting September 4, 2019

Proposal Structure, Work Package definition

- Presented at 2nd Open Meeting October 23, 2019
- Nominate Work Package Contacts
- (Budget, WP Tasks)
- (Letters of Commitment, Institutes,…)
- (Proof-reading)
- …

Deadline March 17, 2020 (postponed to May 14)

- proposal was submitted within deadline, and resubmitted with minor touch-up

Hard and intense work by many people: Thank you to all of them!

CERN-EU Office:

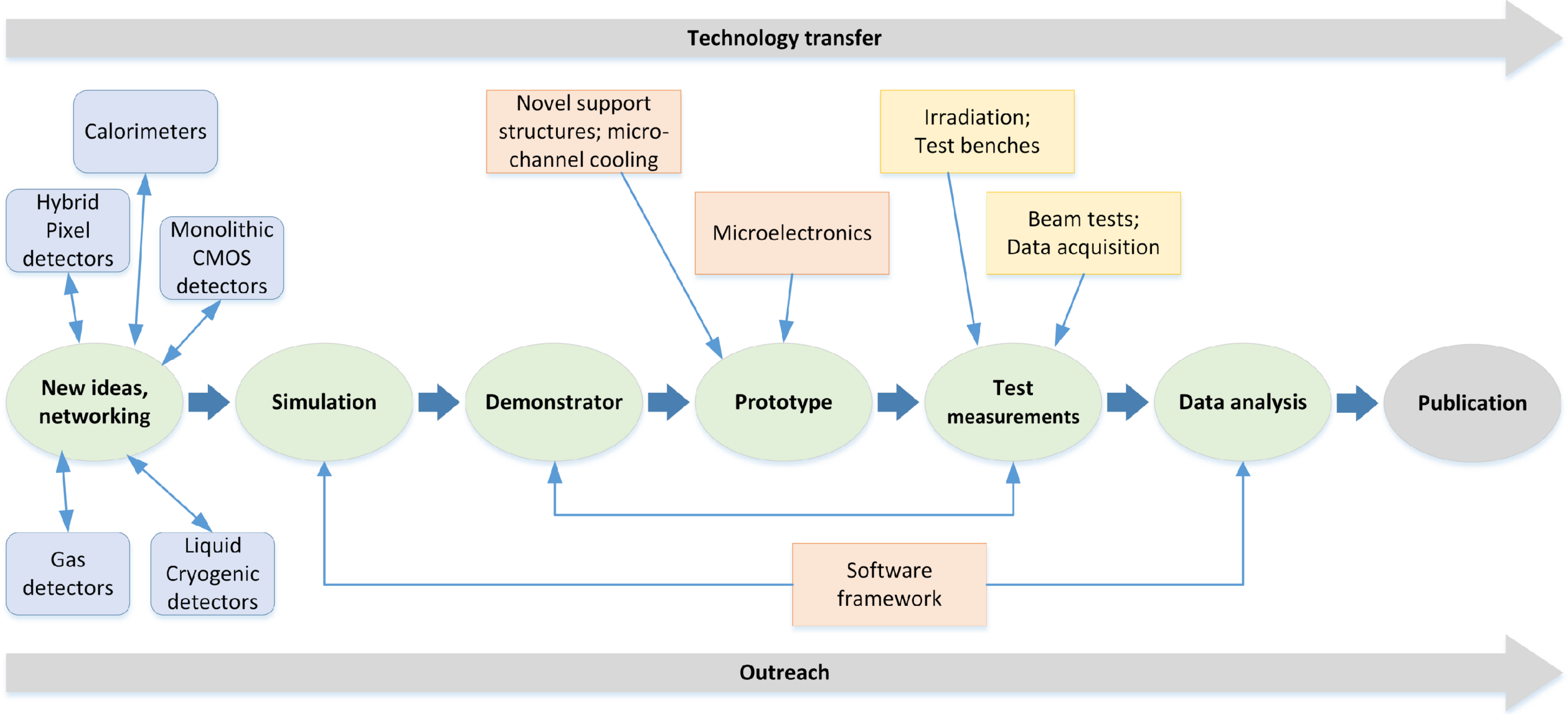
Livia Lapadatescu
Sabrina El Jacoubi
Coralie Hunsicker
Laëtitia Veyrat

Proposal Preparation Team:

Daniela Bortoletto (U Oxford)
AIDA-2020 Deputy Coordinator
Giovanni Calderini (LPNHE Paris)
AIDA-2020 Governance Board Chair
Paolo Giacomelli (Bologna)
AIDA-2020 Deputy Coordinator
FS (DESY)
AIDA-2020 Scientific Coordinator
Svetlomir Stavrev (CERN)
AIDA-2020 Administrative Coord.
Anne Dabrowski (CERN)
CERN representative in the PPT
Thomas Bergauer (HEPHY Vienna)
Lucie Linssen (CERN)
Ivan Vila Alvarez (CSIC Santander)
Morgan Wascko (IC London)

* see Back-up slides

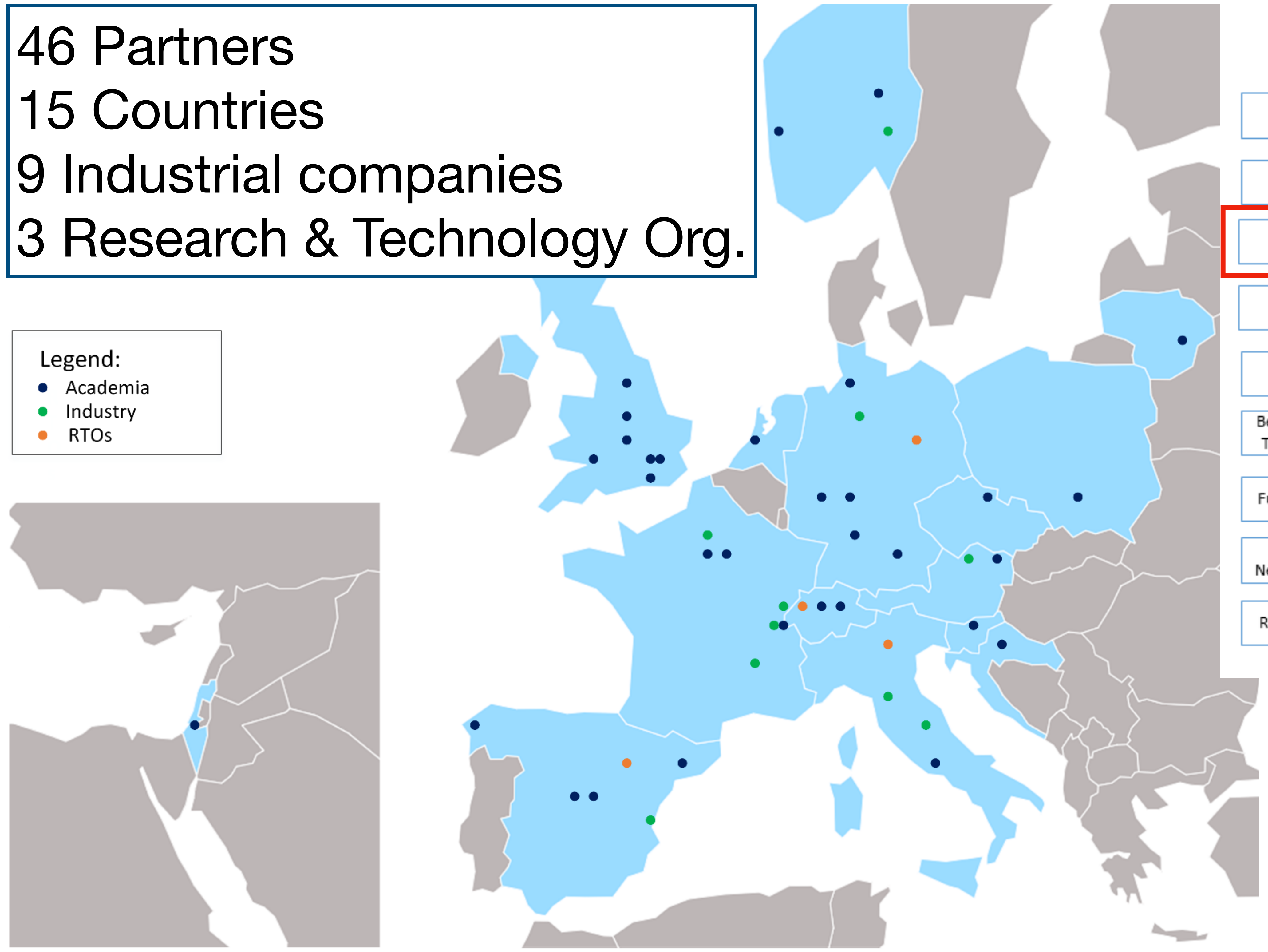
Activities

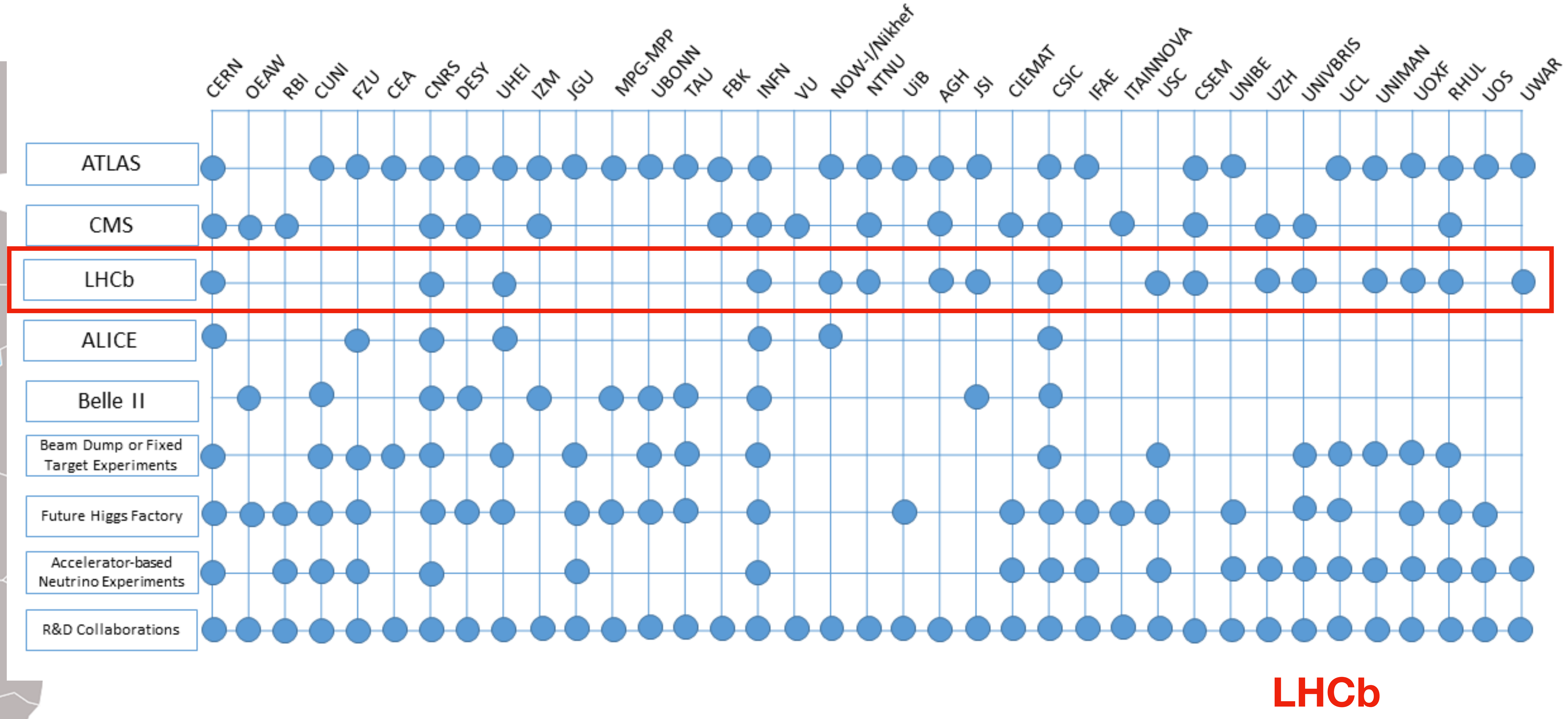


- Technology transfer to and from industrial partners happens throughout the development cycle
- Same is true for outreach

Consortium

46 Partners
15 Countries
9 Industrial companies
3 Research & Technology Org.





- Good regional and community coverage
- Industrial partners fully embedded
- CERN acts as Coordinating Institute

Relation with Collaborations

- AIDA relies on the established and well functioning organisational structures of our community and does not duplicate them
  - Activities typically embedded in collaborative efforts (ATLAS, CMS, CALICE, RDxx,…)
  - Majority of funding is matching resources
- We have Milestones and Deliverables, so some follow-up is necessary
  - take a light-weight, lean management approach
  - 5 Steering Meetings (3h) / year, WPs report at every other meeting
  - One annual meeting / year: Forum for exchange across projects
- This approach needs a functioning transmission mechanism for guidance and feed-back
  - conceptual studies of the physics potential and overall detector requirements and optimisation
  - technology R&D and prototyping

Management and Related

WP1: Project Management and Coordination

- *FS (DESY), Svet Stavrev (CERN)*
- Scientific, administrative, financial coordination and reporting
- Relation with other Innovation Pilots and the EC
- **Establish a European Roadmap for Detector R&D**
- proposed to do that **in close liaison with ECFA**

WP2: Communication, Outreach and Knowledge Transfer

- *Daniela Antonio, Aurelie Pezous (CERN)*
- Web-site, newsletter, wider audiences
- academia meets industry, impact analysis
- Training and visibility for young instrumentation scientists' careers

WP13: Prospective and Technology-driven Detector R&D

- *Peter Krizan (JSI)*
- Define a **competitive call**, follow up projects
- Topics such as detectors for extreme conditions (very high radiation levels, cryogenic environments), ultimate accuracy, or novel materials or technologies, quantum sensors etc

Gaseous and Large Cryogenic Detectors

WP7: Gaseous detectors

- *Silvia Dalla Torre (INFN), Burkhard Schmidt (CERN)*
- Multi-gap RPCs for fast timing
- Eco-friendly gases
- MPGDs, industrialisation
  - μR-WELL technology
- Large gaseous detectors:
  - Cluster-counting electronics for ultra-light drift chambers
  - High-pressure TPC readout
- MPGD-based photo-detection for Cherenkov PID

WP9: Cryogenic Neutrino Detectors

- *Dario Autiero (CNRS), Andrzej Szelc (Manchester)*
- Single phase TPC pixel charge read-out
- Dual-phase TPC readout
- Optical readout of LAr scintillation light

Detector Facilities

WP3: Testbeam and DAQ Infrastructure

- *Marcel Stanitzki (DESY), Mathew Wing (UCL)**
- Upgrade of EUDET **telescopes** with ALPIDE sensors, standard **Cold Box**
- **Fast timing support**, ps timing in TLU
- **Timepix integration**, LGAD plane
- DAQ software **EUDAQ2**
- DAQ hardware for silicon (**Caribou**) and gas detectors (VMM3)
- Incorporate new sensors from CMOS WP

Evolution:
Maintain and support existing infrastructure
Stable interfaces: protect user investments
User support remains central

WP4: Upgrade of Irradiation and Characterisation Facilities

- *Fernando Arteche (ITAINNOVA), Federico Ravotti (CERN)**
- **Micro-Ion-Beam upgrade at RBI**
- TPA-TCT baded sensor characterisation system
- Upgrade of Electromagnetic Compatibility (EMC) test infrastructure

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

- 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 $10^{35}\,cm^{-2}\,s^{-1}$.**

Requirmemnts talk given
by Frank Simon

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 technologically 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

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)

Four Grand Challenges encompass this Instrumentation revolution

- **Advancing HEP detectors to new regimes of sensitivity**: *To make the unmeasurable measurable will require the development of sensors with exquisite sensitivity with the ability to distinguish signal from noise…. Research will be needed to develop these sensors with maximal coupling to the quanta to be sensed and push their sensitivities to ultimate limits.*

- **Using Integration to enable scalability for HEP sensors:** *Future HEP detectors for certain classes of experiments will require massive increases in scalability to search for and study rare phenomena ... A key enabler of scalability is integration of many functions on, and extraction of multidimensional information from, these innovative sensors.*

- **Building next-generation HEP detectors with novel materials & advanced techniques**: *Future HEP detectors will have requirements beyond what is possible with the materials and techniques which we know. This requires identifying novel materials … that provide new properties or capabilities and adapting them & exploiting advanced techniques for design & manufacturing.*

- **Mastering extreme environments and data rates in HEP experiments**: *Future HEP detectors will involve extreme environments and exponential increases in data rates to explore elusive phenomena. ... To do so requires the intimate integration of intelligent computing with sensor technology.*

Topic Convenors

- Test beam Facilities & DAQ:
  - **M.Stanitzki (DESY), M.Wing (UCL), H. Wilkens(CERN)**
- Irradiation & Characterisation Facilities
  - **F.Ravotti (CERN), F.Arteche (Zaragosa), G.Kramberger (JSI)**
- Mechanics & Cooling
  - **P.Petagna (CERN), C. Gargiulo (CERN), G. *Viehhauser* (Oxford)**
- Microelectronics & Interconnections
  - ***C. De La Taille (Palaiseau), A.Rivetti (Torino), A Marchioro (CERN)***
- CMOS detectors
  - **S. Grinstein (Barcelona), M. *Caccia* (Como), P. *Riedler* (CERN), T. *Hempernek* (Bonn)**
- Hybrid silicon detectors
  - **A. Macchiolo (Zurich) G.Pellegrini (CSIC), C. Gemme (Genova)**
- Calorimeters
  - **R. Poeschl (LAL), K. Krüger (DESY), R.Ferrari (Pavia)**

Topic Convenors

- Particle ID
  - **G.Wilkinson (Oxfrd), E.Auffray (CERN)**
- MPGD & RPC
  - **S. Della Torre (Trieste),** M.Tytgat (Ghent), **B. Mandelli (CERN)**
- Large Volume Gas Detectors
  - **B. Schmidt (CERN), F. Grancagnolo (Lecce)**
- Neutrino Detectors
  - **D. Autiero (Lyon), E. Rondio (Warsaw), G. Catanesi (Bari)**
- Software
  - **F. Gaede (DESY), G.Stewart (CERN)**
- Knowledge Transfer & Outreach
  - **A. Pezous (CERN)**

(Speakers)