

# The New AIDAinnova Project and Detector R&D for Higgs Factories

Katja Krüger, based on slides by Felix Sefkow  
DESY



175th ILC project meeting | February 19th, 2021

# Outline



**AIDAInnova preparation**

**The proposal and project**

**Work Packages in view of R&D for Higgs factories**

**Next steps**

# EC-funded Detector R&D Projects



## PF6: EUDET: 2006-2010

- Detector development for linear collider

## FP7: AIDA: 2011-2014

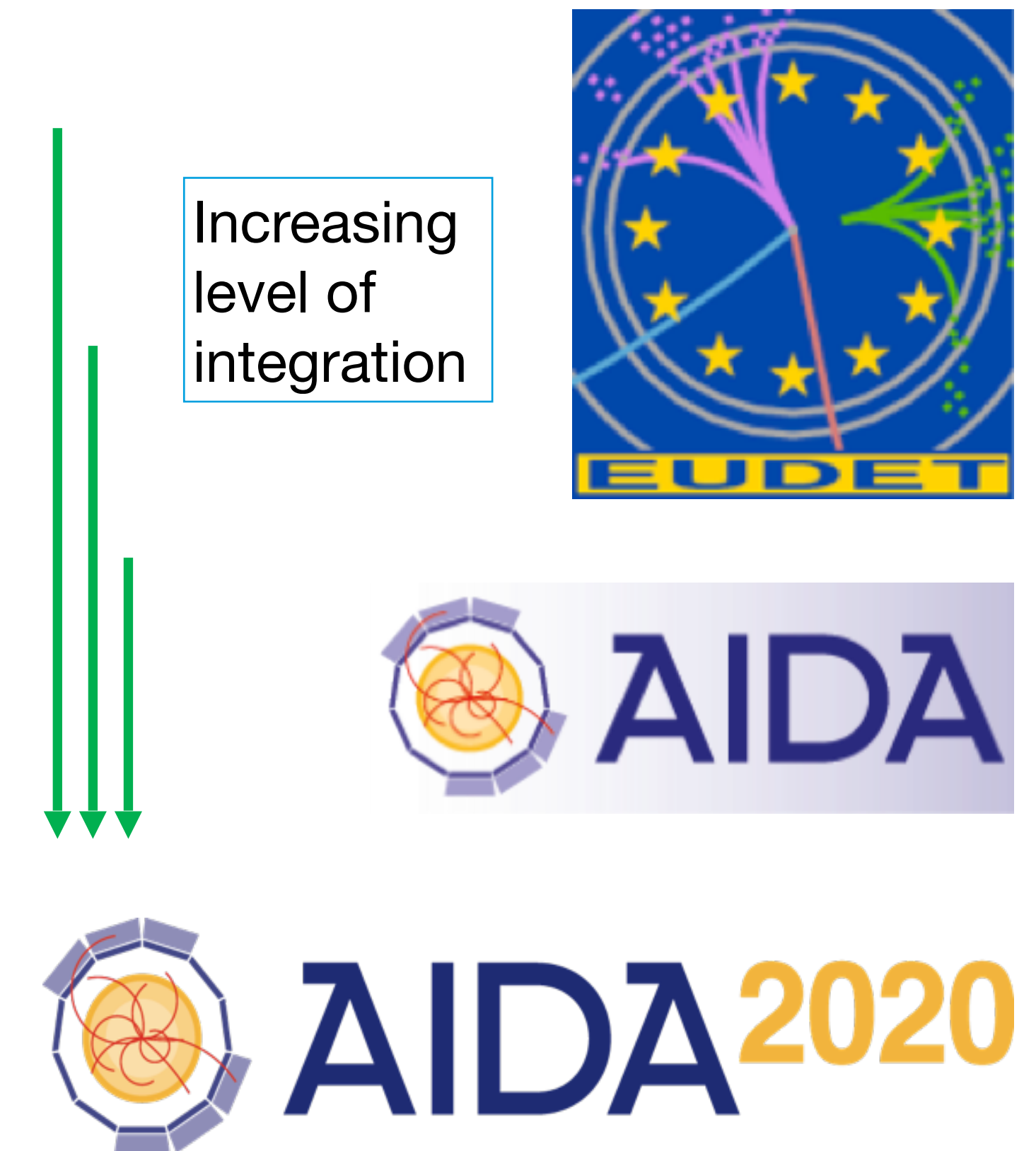
- Detector development for LHC upgrades and linear colliders
- Project-specific work packages

## FP8: AIDA-2020: 2015-2020

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

**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**





# 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

Increased focus on industrial partners

No Transnational Access

Proposed funding 10 M€ for 4 years



# Proposal Preparation



## Consultation with the community

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

## 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)
- ...

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

## Deadline March 17, 2020 (postponed to May 14)

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

## 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

**Felix Sefkow (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



# 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

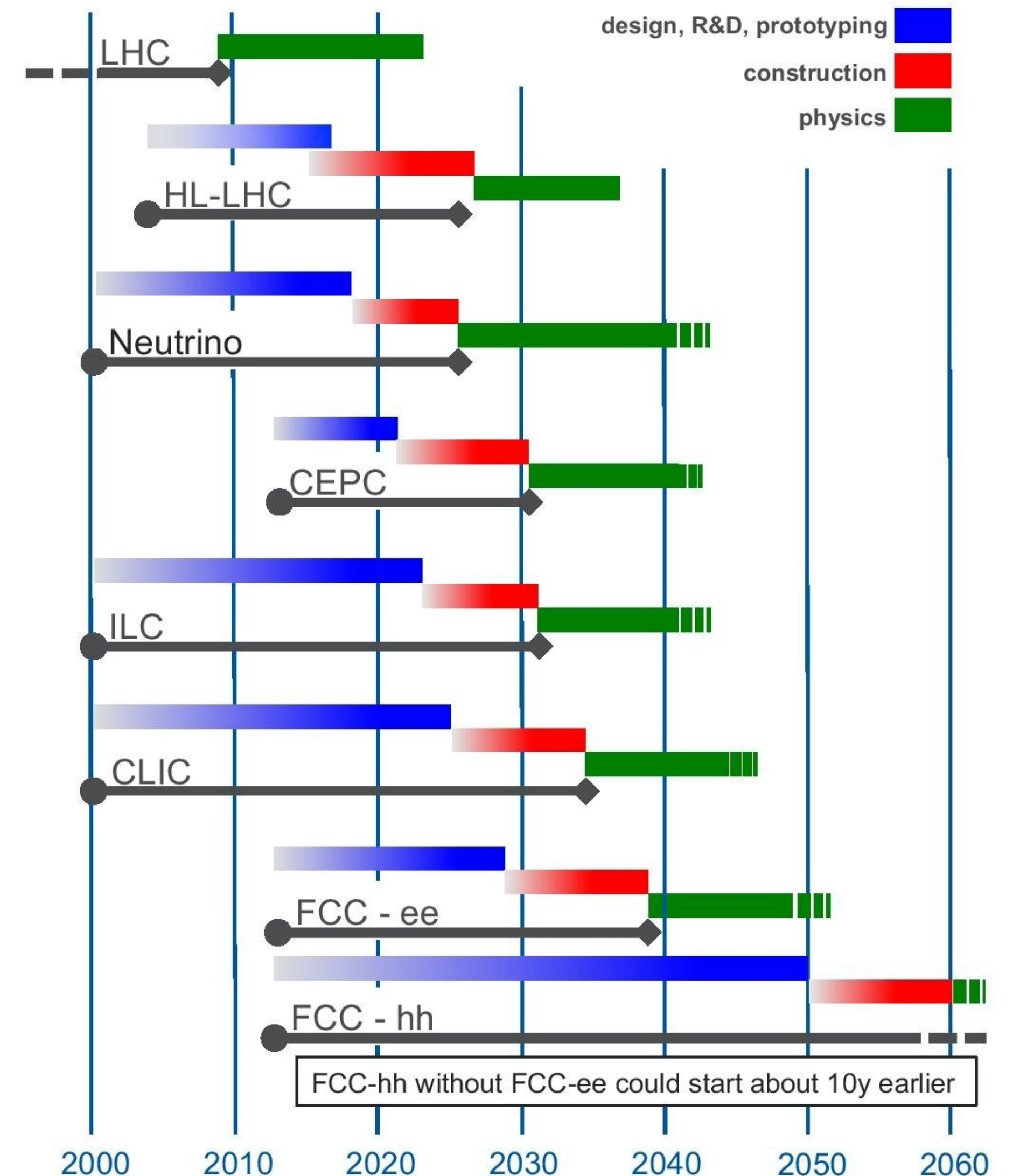
- more diverse range of target applications

## 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

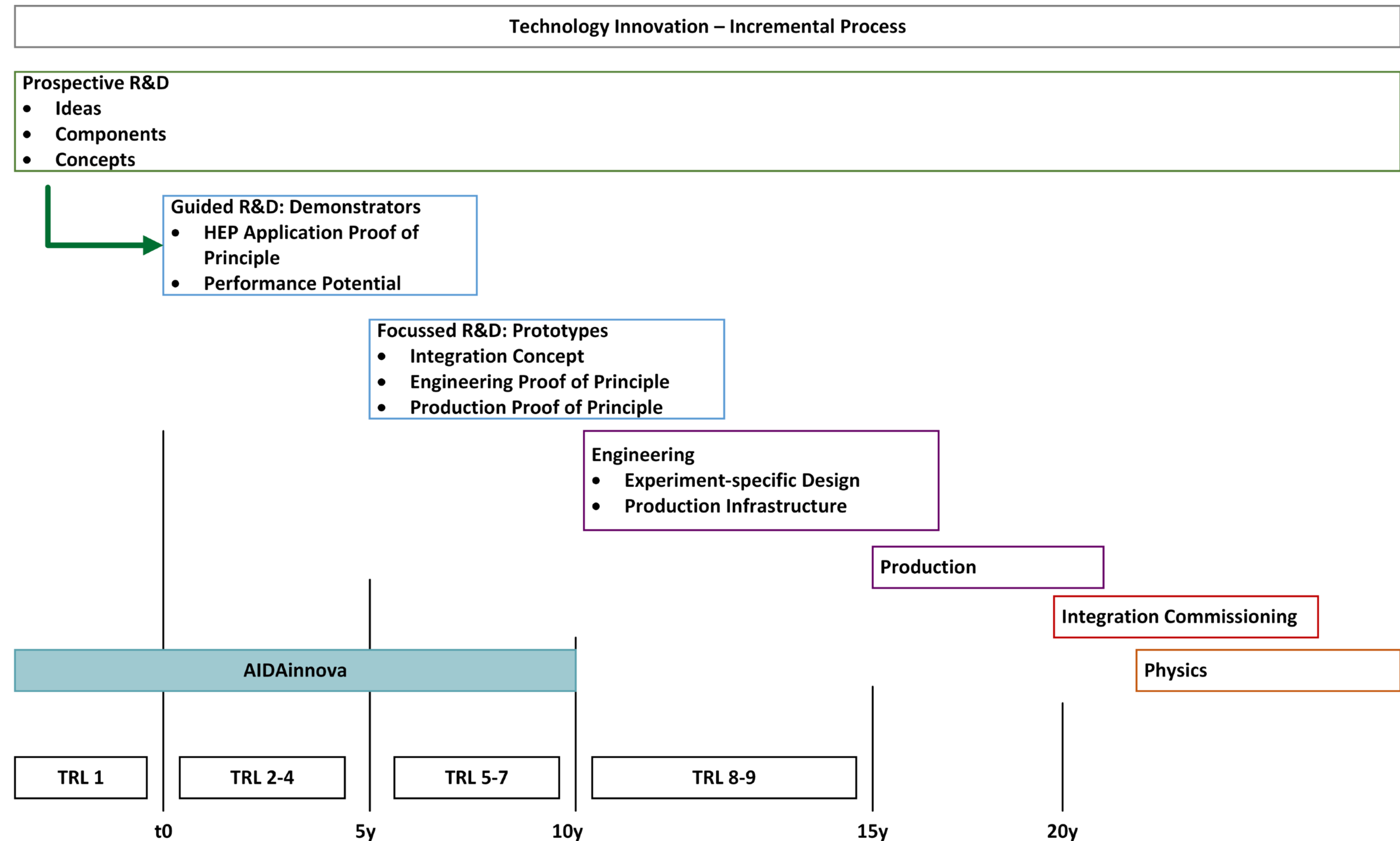
- Technology Readiness Levels 2-7
- Not yet experiment-specific: potential to unfold synergies

## Include some prospective R&D

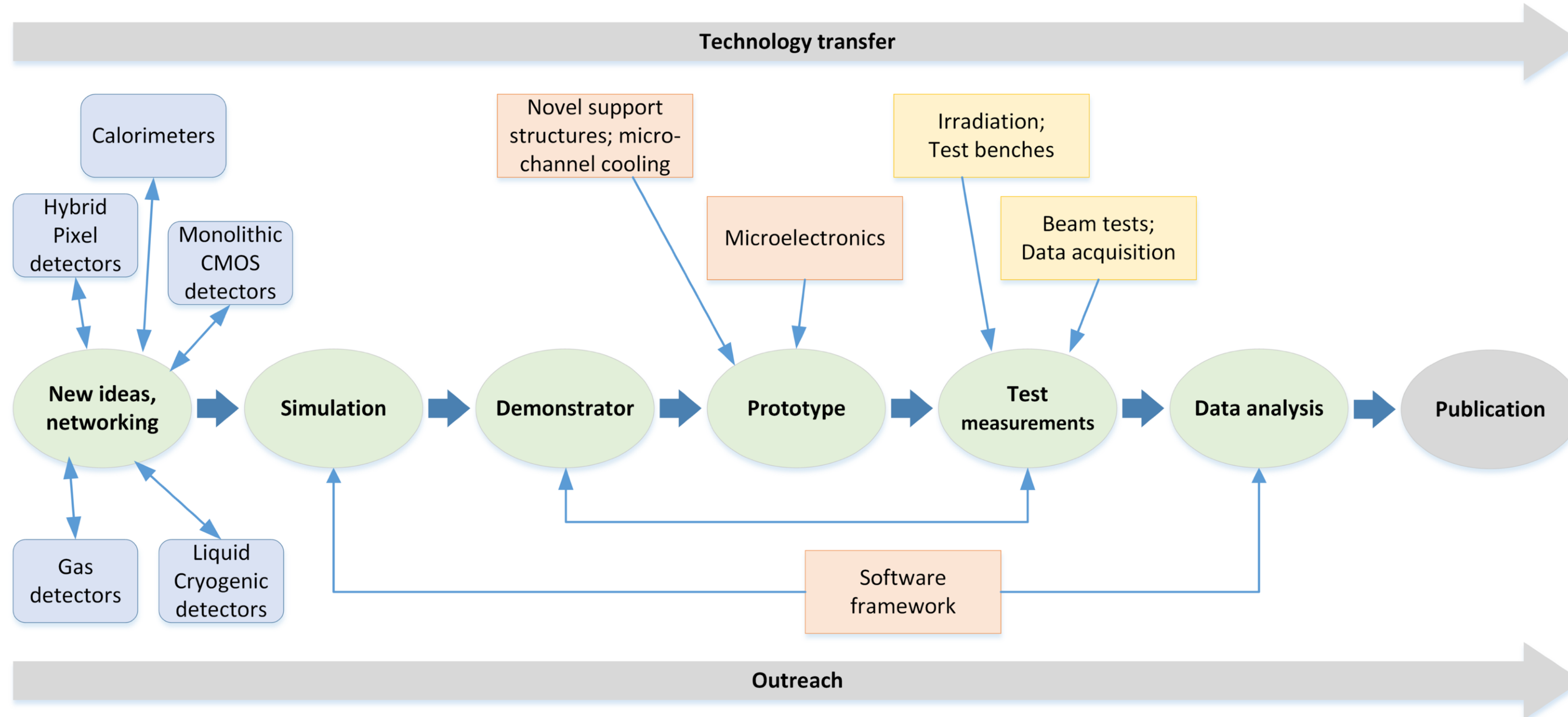
- competitive call at start of project
- “Blue Sky”, quantum sensors,...

## Targeted applications

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



# Activities



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

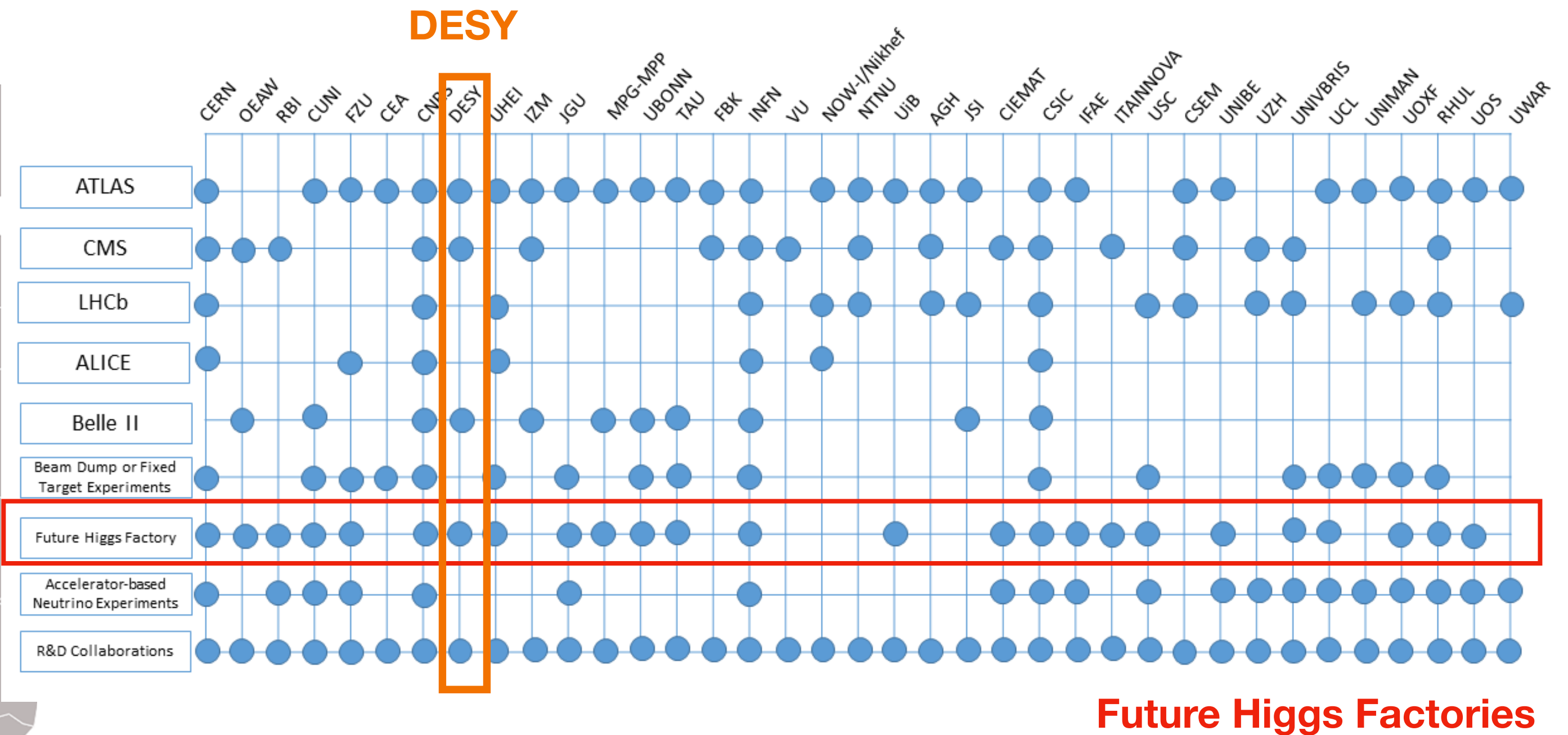
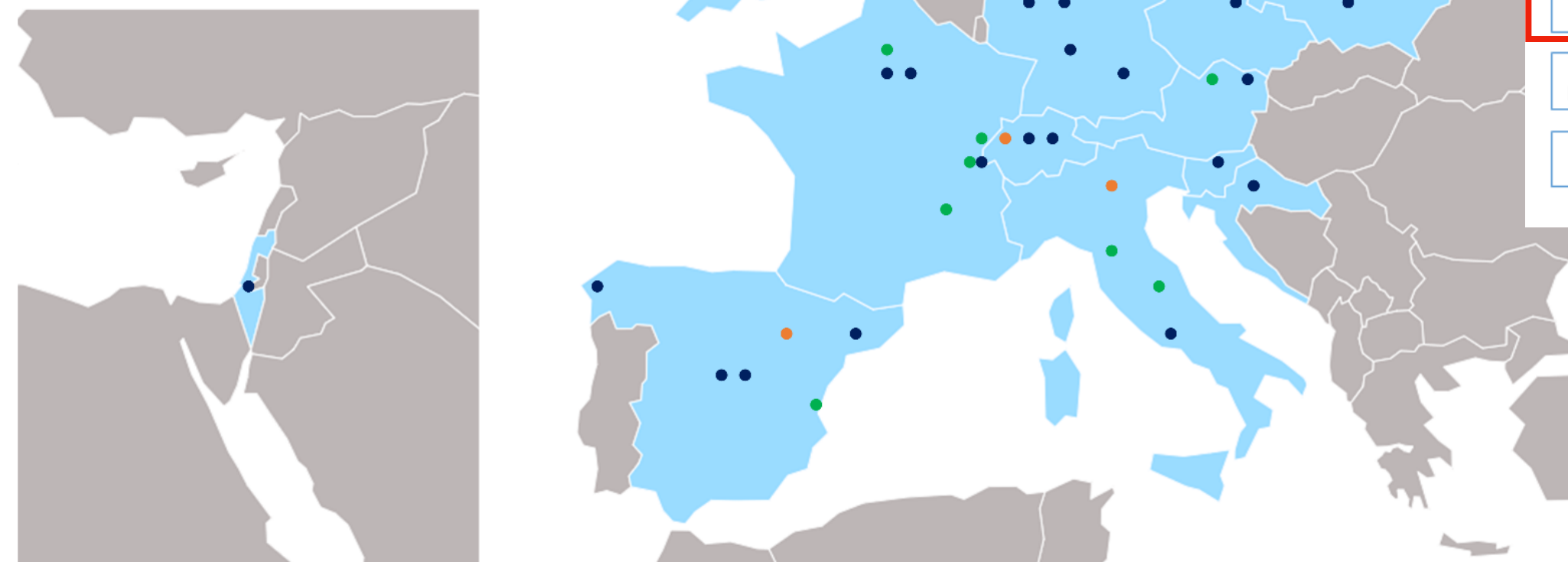


# Consortium



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

Legend:  
● Academia  
● Industry  
● RTOs



Future Higgs Factories

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

# 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

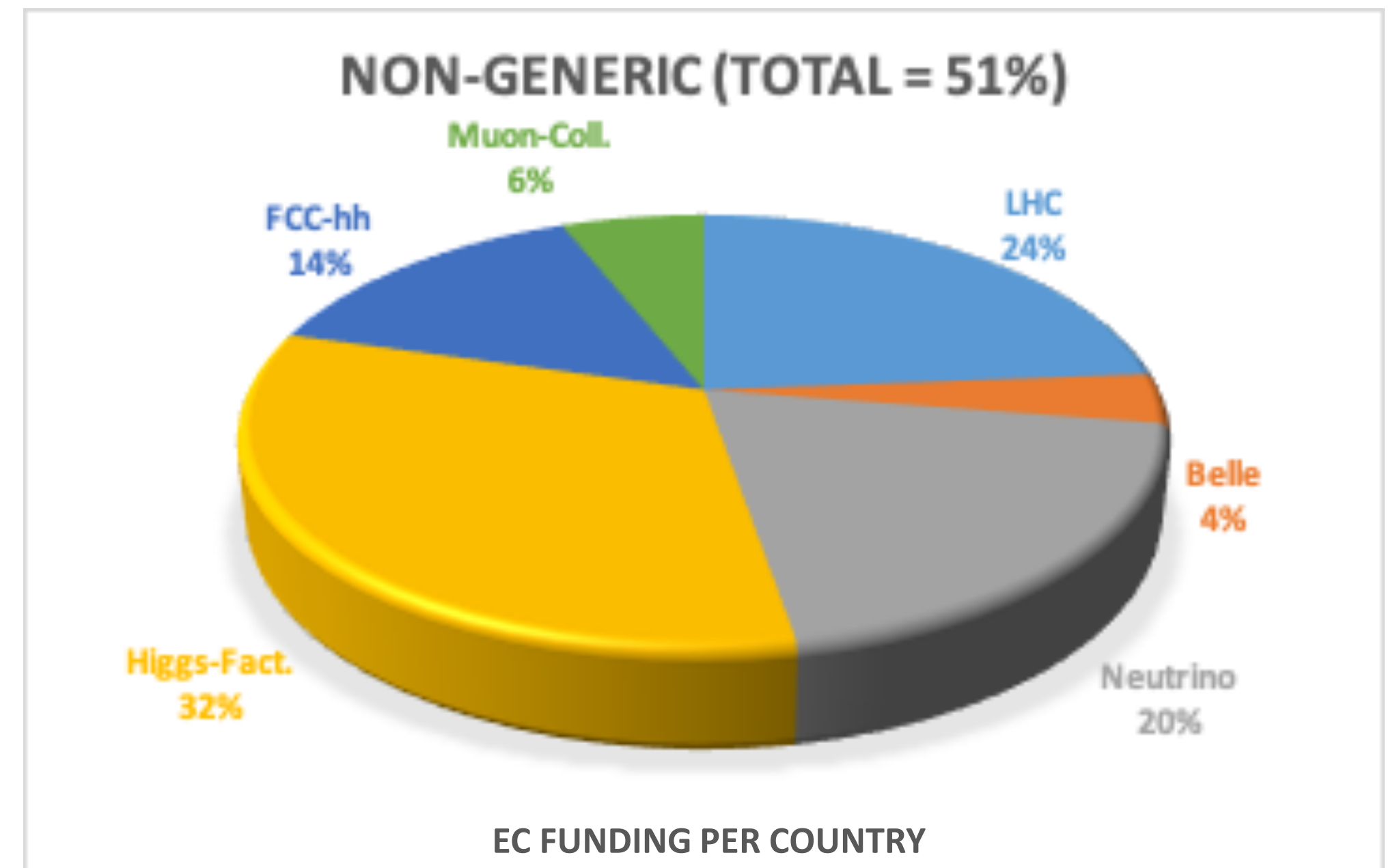
**51% can be associated with 1 to 3 projects**

- “Matrix” to be taken with a grain of salt...
- Sharing will influence generic part, too

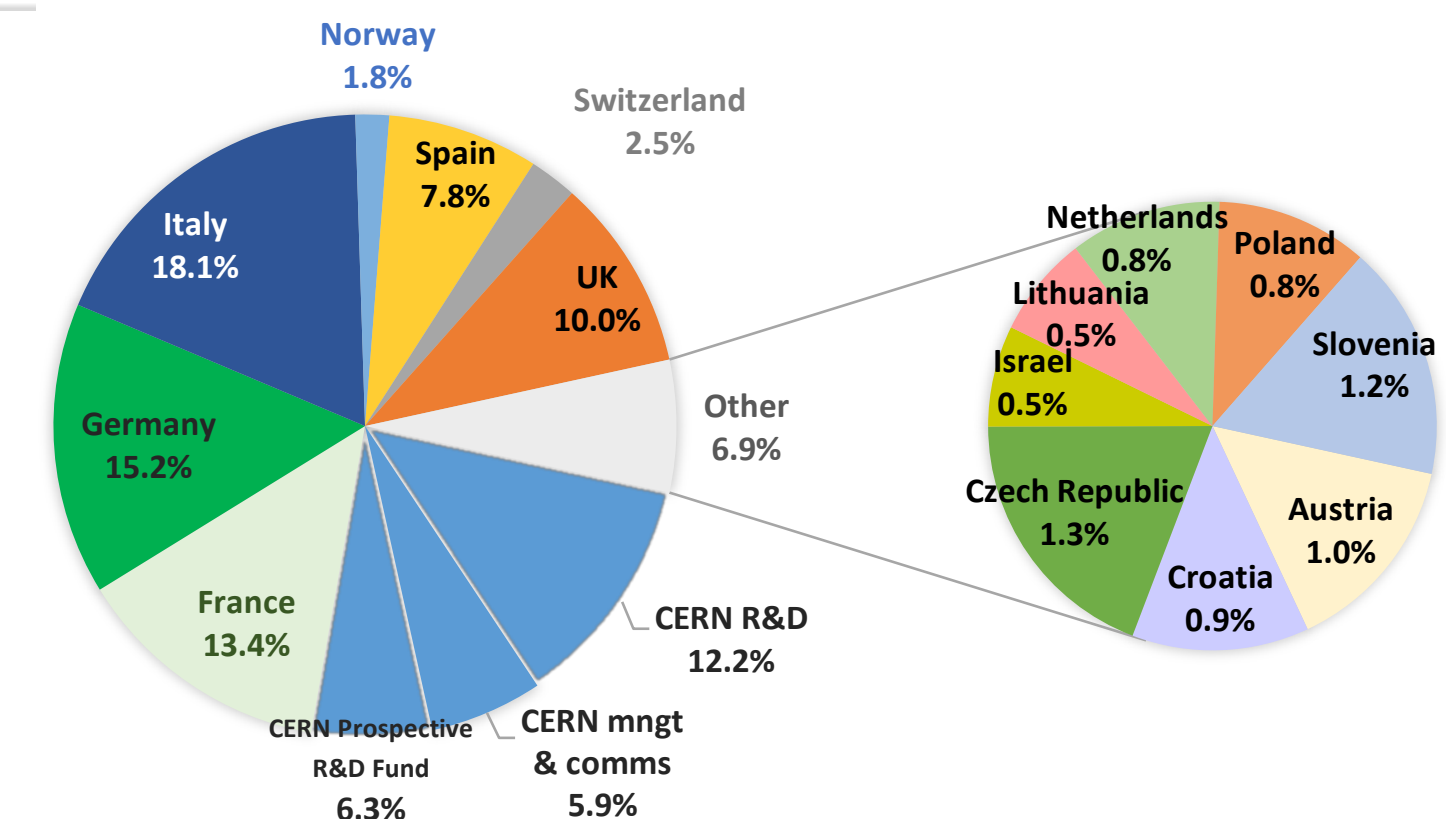
**Total budget 22.5 M€**

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

**10% of EC funds to non-academic partners**



EC FUNDING PER COUNTRY



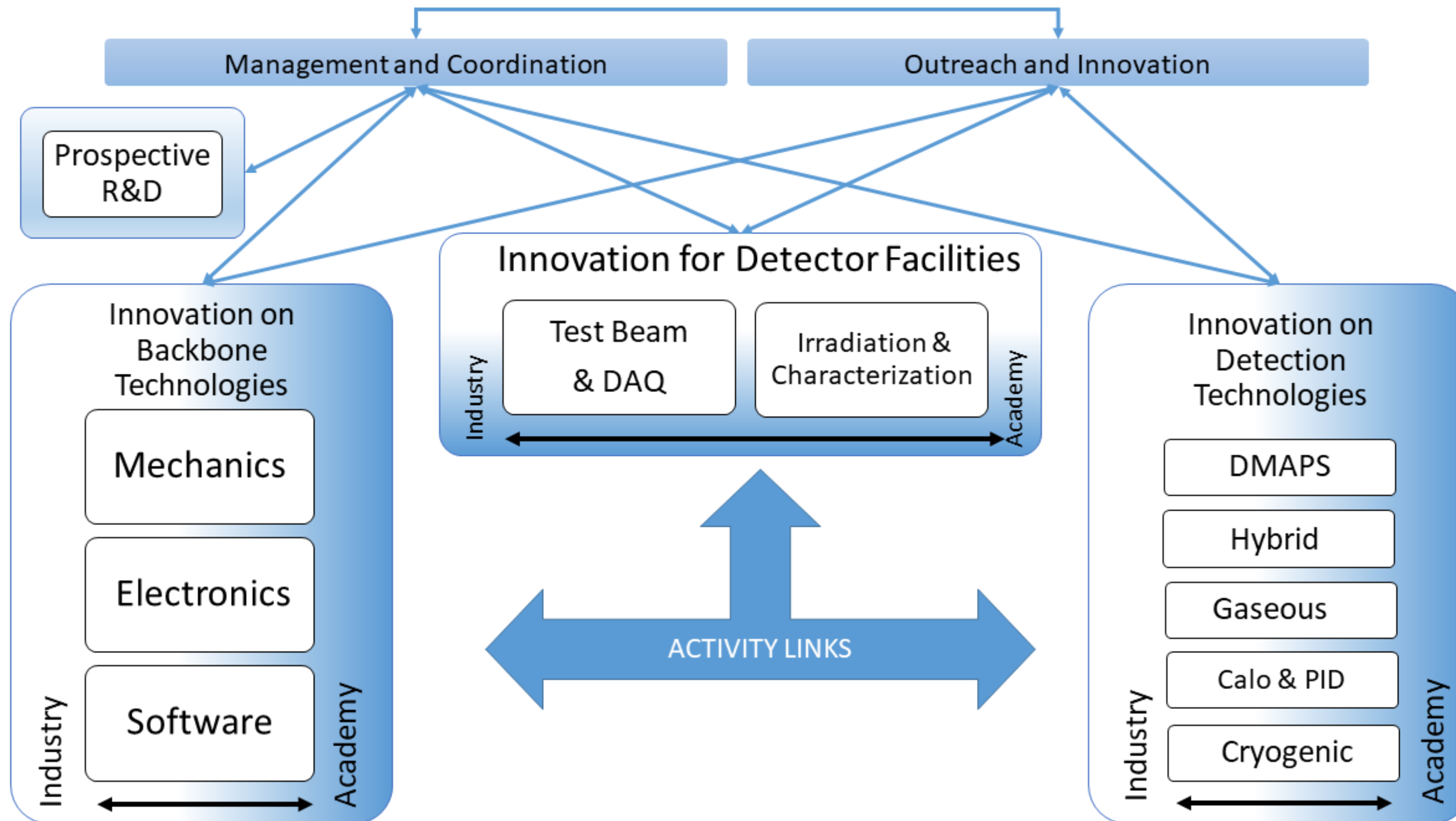
# Higgs Factory Detector R&D



Detector Technology	Linear & Circular Colliders common R&D	Differences
<b>All</b>	test infrastructure prototype electronics software for reconstruction and optimisation	readout rates power and cooling requirements
<b>Silicon Vertex and Track Detectors</b>	highest granularity and resolution, timing ultra-thin sensors and interconnects simulation and design tools low-mass support structures cooling micro-structures	emphasis on timing (background) and position resolution
<b>Gaseous Trackers and Muon Chambers</b>	ultra-light structures for large volumes industrialisation for large area instrumentation eco-friendly gases	DC and TPC presently considered only at some colliders
<b>Calorimeters and Particle ID</b>	highly compact structures and interfaces advanced photo-sensors and optical materials ps timing sensors and electronics	emphasis on granularity and stability DR and LAr presently only considered for circular



# Work Packages



Similarities with

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

are purely accidental.

# Management and Related



## WP1: Project Management and Coordination

- *Felix Sefkow (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

\* Proposed Work Package Coordinators, to be endorsed by Governance Board

# 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/>
  - AIDAInnova 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)
- Before the start of the series of symposia:
  - representatives from future projects are invited to present to the panel an update / reminder of their requirements and views on most important developments
  - material will be made accessible to Task Force Members and Symposium Speakers



# 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

## WP4: Upgrade of Irradiation and Characterisation Facilities

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

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# Telescope History: EUDET - AIDA - AIDA-2020

	EUDET FP6	AIDA FP7	AIDA2020 Horizon2020
<b>Telescope</b>	EUDET Style Pixel Telescopes Design & Commissioning	EUDET Style Pixel Telescopes Operation & Improvements	“Telescopes around the world” Further enhancements Lycoris- Large Area Telescope
<b>DAQ Hardware</b>	EUDET TLU	EUDET TLU AIDA Mini TLU	AIDA TLU EUDET TLU (legacy)
<b>DAQ Software</b>	EUDAQ		EUDAQ2 EUDAQ (legacy)

Marcel Stanitzki



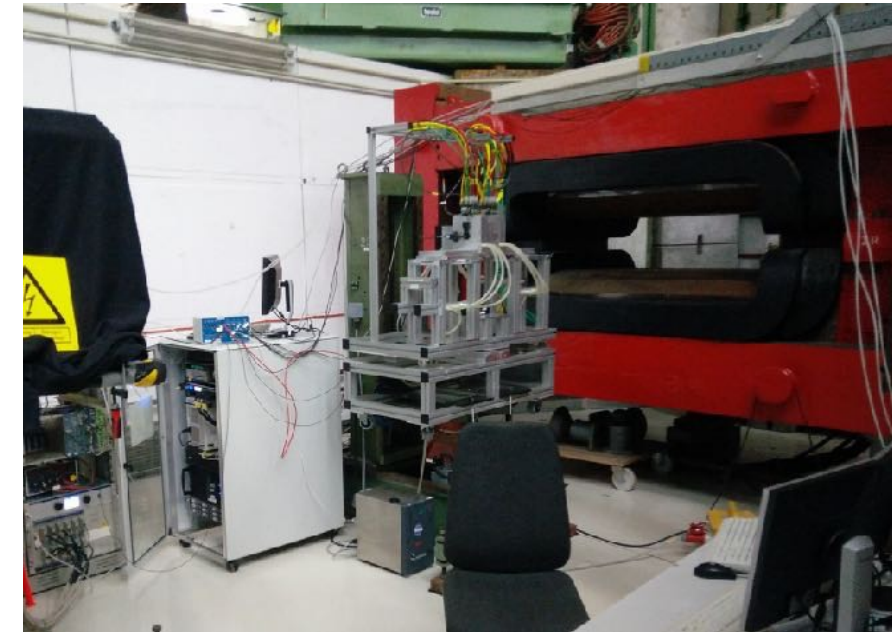
# Telescopes Around The World



Contact:  
Carsten Hast



**CALADIUM** @ SLAC in Stanford, USA



**DATURA** @ TB21

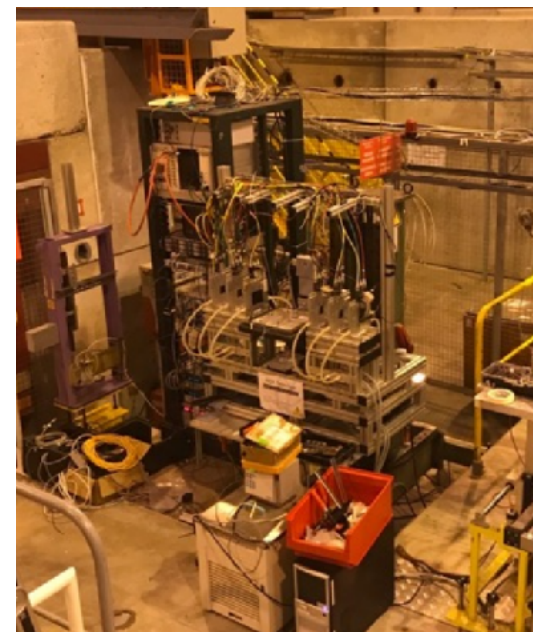


**DURANTA**  
@ TB22

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



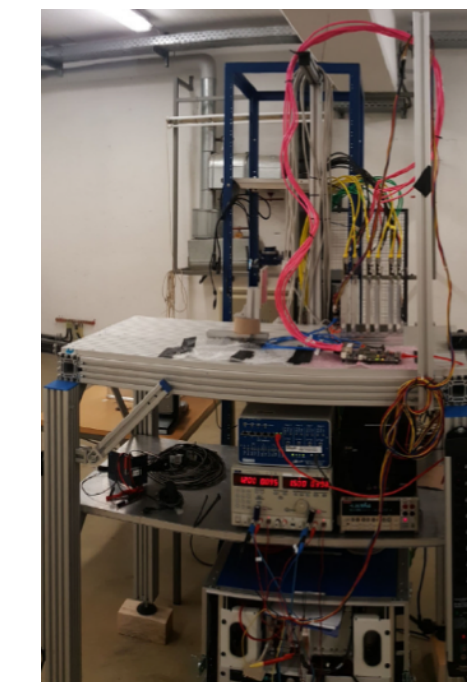
**AZALEA** @ PS, T10  
Currently at DESY TB24



**AIDA** @  
SPS, H6B



**ACONITE** @ SPS, H6A



**ANEMONE** @  
BONN / ELSA



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



**SPS/PS contact:**  
Eva Barbara Holzer  
**Telescope contact:**  
André Rummler

Marcel Stanitzki



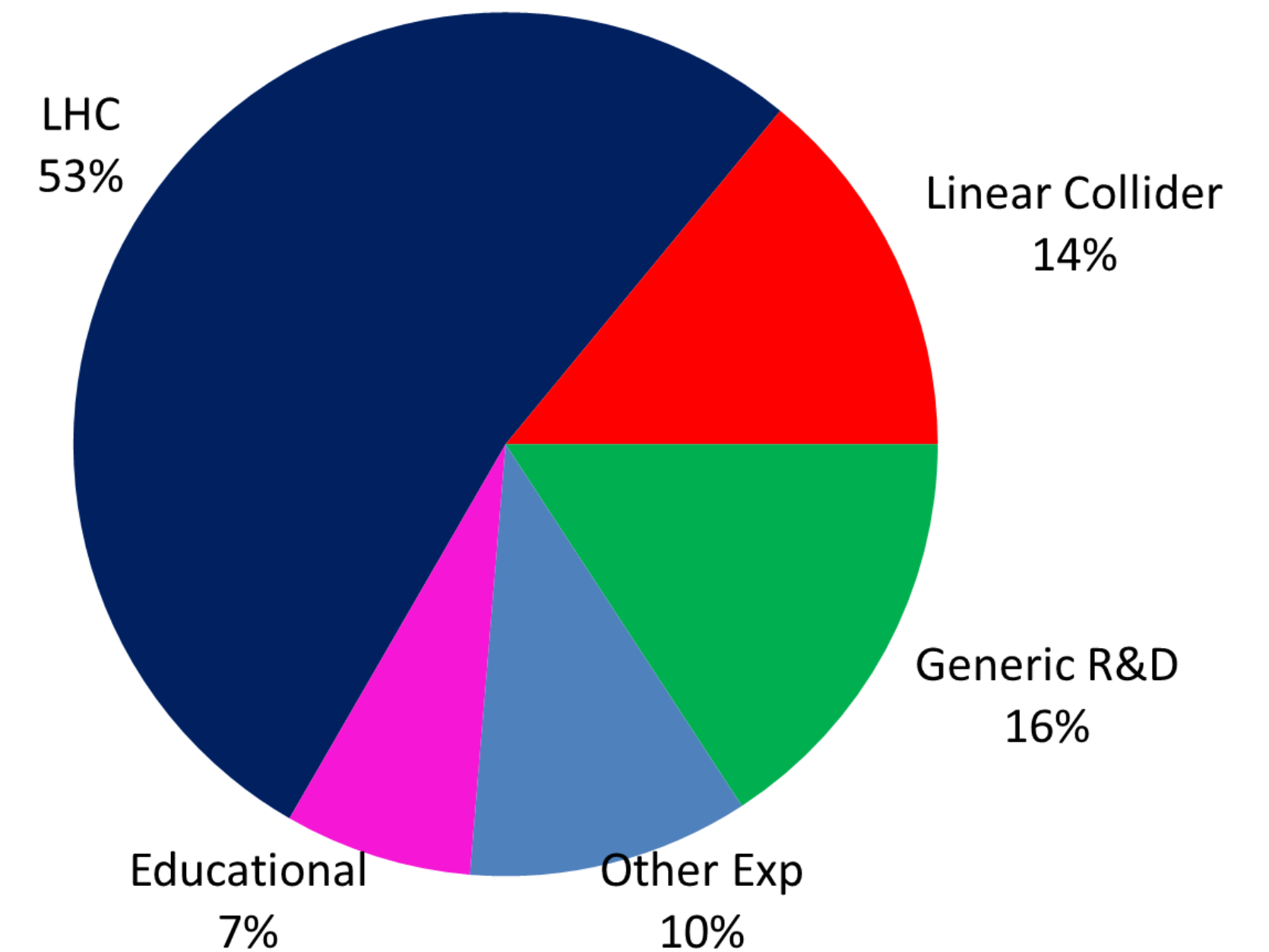
# Telescope Usage



## Key Ingredients:

- One package for your test beam needs
- Continuous User support (since 15 years)
- No focus on single experiment, user community or beam line
- One-time integration effort, then “seamlessly” move between CERN, DESY, ELSA, SLAC
- Unmatched pointing resolution
- Thanks to 18 x18  $\mu\text{m}$  pixels of MIMOSA26

Telescope Usage 2019



Marcel Stanitzki

# Silicon Detectors



## 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

\* Proposed Work Package Coordinators, to be endorsed by Governance Board

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

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

# 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
  - $\mu$ R-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

\* Proposed Work Package Coordinators, to be endorsed by Governance Board



# Calorimeters & Particle ID



## 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
  - **LAr read-out** PCB prototyping
- **Optical readout**
  - **Crystals** for fast timing
  - Large area **scintillators**; granularity and timing
- **SiPMs** for calorimeters and particle ID
- **Dual readout fibre** calorimeter, read-out system

\* Proposed Work Package Coordinators, to be endorsed by Governance Board

# Backbone Technologies



## 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
- **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
- **ASIC network for MPW runs**
  - **MPGDs, Si, SiPM, cold LAr readout**

## WP12: Software for Future Detectors

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

\* Proposed Work Package Coordinators, to be endorsed by Governance Board

# DESY in AIDAInnova



## **WP1: Project Management and Coordination**

## **WP2: Communication, Outreach and Knowledge Transfer**

## **WP3: Testbeam and DAQ Infrastructure**

- Alpide upgrade
- TLU for ps timing
- LGAD timing layer
- EUDAQ enhancements
- Caribou

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

- Simulation and processing of common 3D and LGAD sensors
- Development of interconnection technologies for future pixel detectors

## **WP8: Highly granular calorimeters and PiD detectors**

- Integration aspects of highly granular calorimeters

## **WP11: Microelectronics**

- Networking & ASICs for other work packages

## **WP12: Software for Future Detectors**

- Turnkey software stack
- PODIO
- Machine Learning Calo and G4 Integration
- Advanced Tracking

Scientific Contact: Katja Krüger

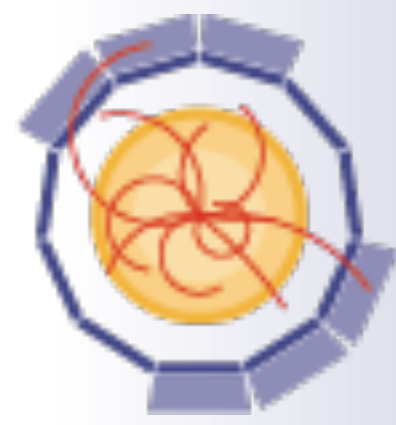


# Summary and Next Steps



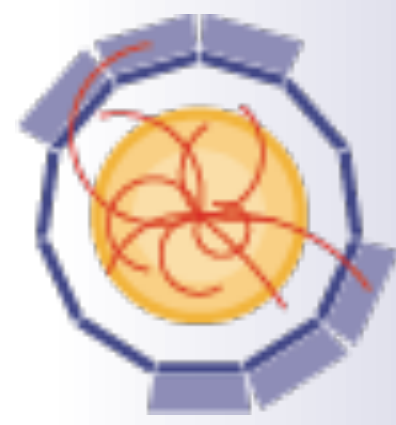
- EC-funded detector initiatives are a **unique forum** to exchange knowhow, unfold synergies and enhance coherence in European detector R&D
- AIDAInnova was **approved** on Nov 3, project will start on April 1, 2021
- **10 M€** of fresh resources and leverages a total budget of 22.5 M€ (4 years)
- Largest non—generic share is dedicated to **Higgs factory oriented R&D**
- A **kick-off meeting** has tentatively been scheduled for the week **April 13-16**
  - 4 days, zoom
  - set up the work programme and get started!

Backup



- 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)





- 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)