



R&D for highly segmented multidimensional detectors for future experiments

Erika Garutti & Heiko Lacker

The High-D consortium

RWTH Aachen, HU Berlin, TU Darmstadt, U Freiburg, U Giessen, U Göttingen, U Frankfurt a. M., U Hamburg, DESY, U Heidelberg, JGU Mainz, MPI für Physik München, TU München, U Bonn, FZ Jülich, GSI

- Overview of detector development activities in Germany
- Stimulate cross-communities exchange & cooperation
- Conduct and develop concrete scientific projects
- Network building for young scientists

Aims of this meeting



At the end of this meeting it should be clear to us:

- What are High-D **highlights** from 09-2022 to 02-2023
- What are the **challenges** for 2023 (and beyond)

➔ BMBF reporting 2023:
we are asked to compile a consortium-wide report with 2022 achievements.

 High-D

Pages

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- Meetings
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 - › 4D Tracking
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 - CheapCal
 - Shower separation
 - Software Compensation
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5D Calorimetry

[Erika Garutti](#) posted on 11. Feb. 2022 09:49h – last edited by [Erika Garutti](#) on 17. Jan. 2023 16:11h

- [CheapCal](#)
- [WOM](#)
- [Software Compensation](#)
- [Shower separation](#)

List of Highlights:

- CheapCal: [Darkbox for prototype studies built and first prototype measurements performed](#)
- WOM-based LS detector: [1-cell prototype detector close to completion for DESY tesbeam measurement in October 2022](#)
- [Shower Separation](#) in Five Dimensions using Machine Learning
- [Software Compensation](#) in Five Dimensions using Machine Learning

Scientific results: Confluence page



<https://confluence.desy.de/display/HIGHD/High-D+Home>

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Software Compensation

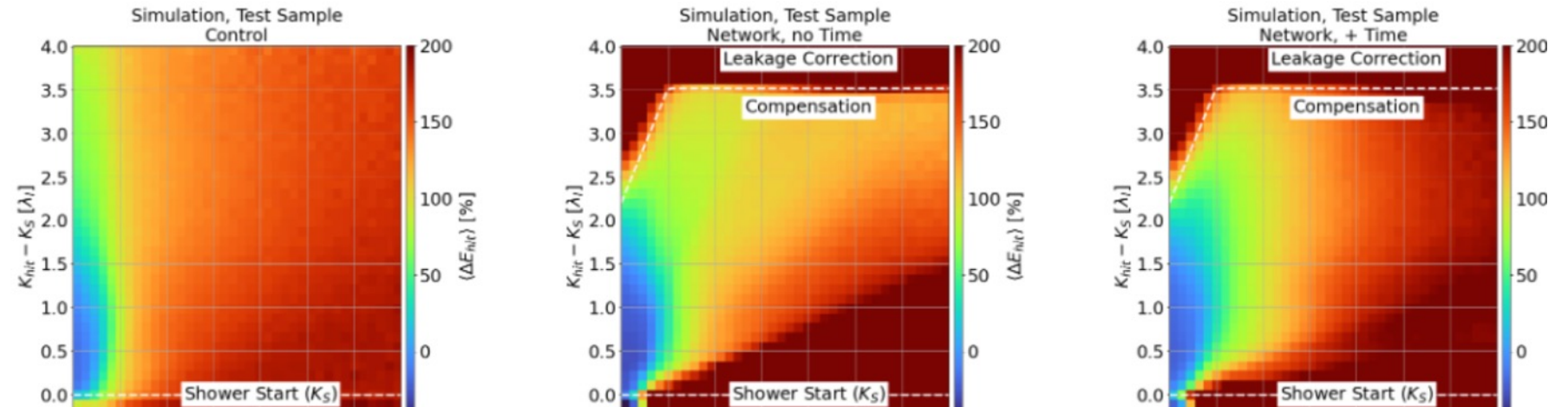
Erika Garutti posted on 17. Jan. 2023 13:23h - last edited by Erika Garutti on 17. Jan. 2023 16:08h

A neural network for software compensation was developed for the highly granular CALICE Analogue Hadronic Calorimeter (AHCAL).

The neural network uses spatial and temporal event information from the AHCAL and energy information, which is expected to improve sensitivity to shower development and the neutron fraction of the hadron shower.

The NN was designed to function using a local energy density estimate to overcome biasing effects on particle energies.

The NN method produced a **depth-dependent energy weighting and a time-dependent threshold** for enhancing energy deposits consistent with the timescale of evaporation neutrons and learning leakage correction effects.



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Upcoming training events



Events & training

[Erika Garutti](#) posted on 23. Aug. 2022 13:35h – last edited by [Erika Garutti](#) on 08. Feb. 2023 17:36h

Detector schools 2022:

- [European School of Instrumentation in Particle and Astroparticle Detectors \(ESIPAP\)](#)
- [EURIZON school on particle detector technologies](#), Kutaisi International University (KIU) in Kutaisi, Georgia, on **July 17-28, 2023** - The deadline for applications is March 28, 2023.
- [15th Terascale detector workshop](#) / Workshop "Simple FPGA-based Trigger System"

ECFA Detector R&D Roadmap



2020: Update on the European Strategy for Particle Physics

Timetable after approval by the European Lab Director Group:



Basic principle ECFA:
Project realisation
must not be delayed
by detectors

12/2021: ECFA Detector R&D Roadmap endorsed by CERN Council

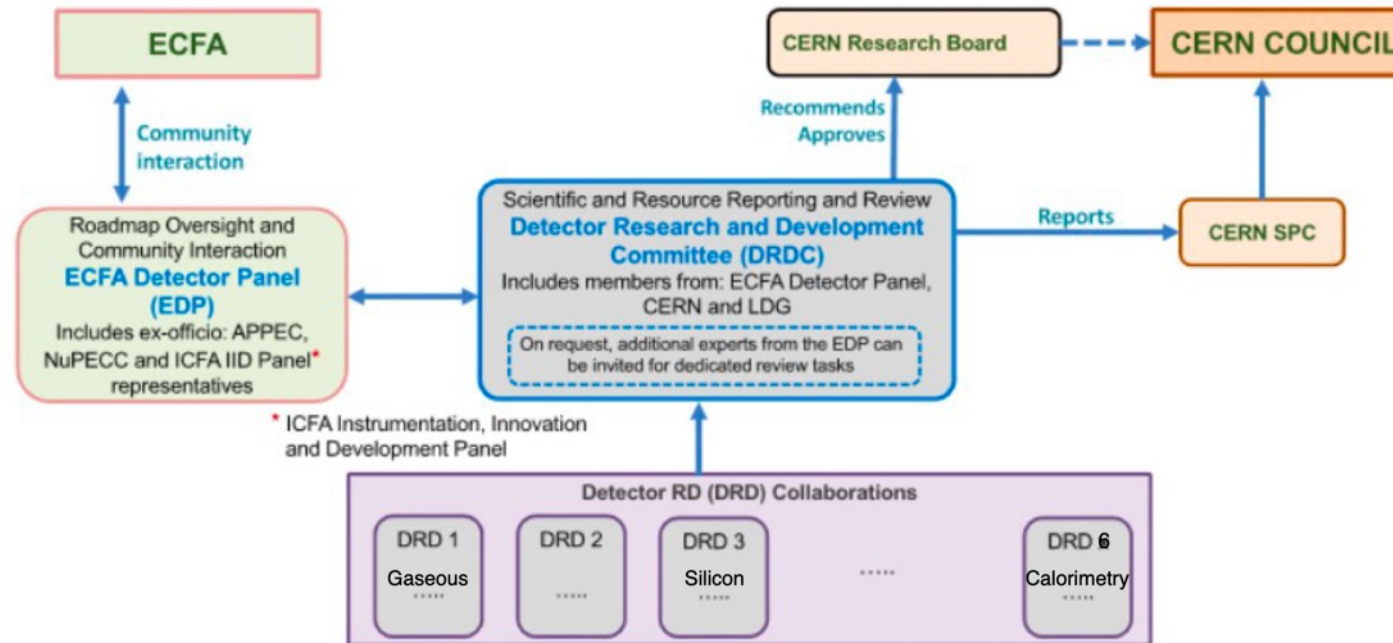
Overview and prioritisation of **required strategic R&D**

- Focused on future large-scale research facilities (ErUM area)
- Not experiment-specific (cross-cutting theme / Querschnittsthema)
- Not "blue sky"

ECFA Detector R&D Roadmap



Formation of new detector-R&D collaborations (DRD)



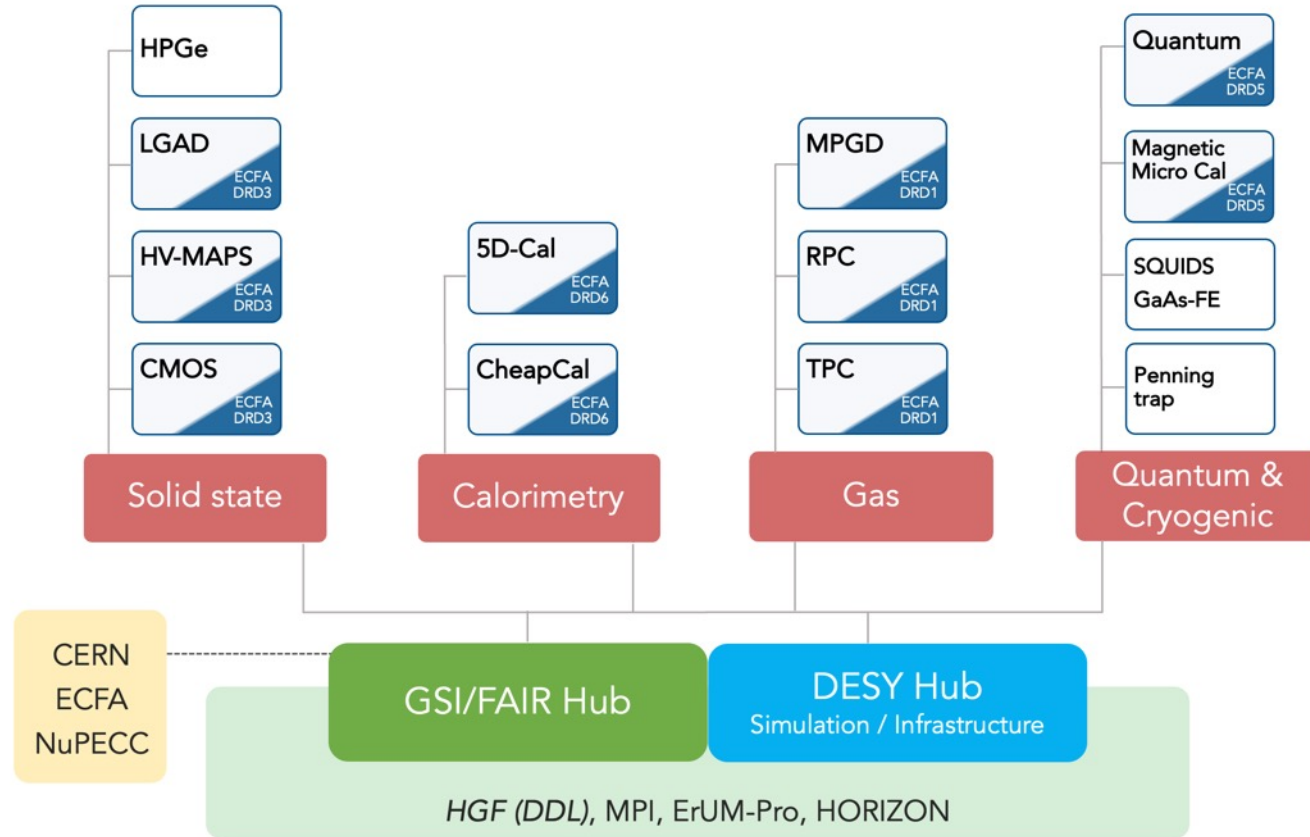
DRD 3: Silicon
Deadline for proposals 01.03.23

DRD 6: Calorimetry
Deadline for proposals 25.03.23
<https://indico.cern.ch/event/1213733/abstracts/>

Process underway, start of work from early **2024**.

Strong participation in the DRD collaborations is a prerequisite for playing a visible role in the next major projects

The future of Detector R&D in Germany HIGH-D

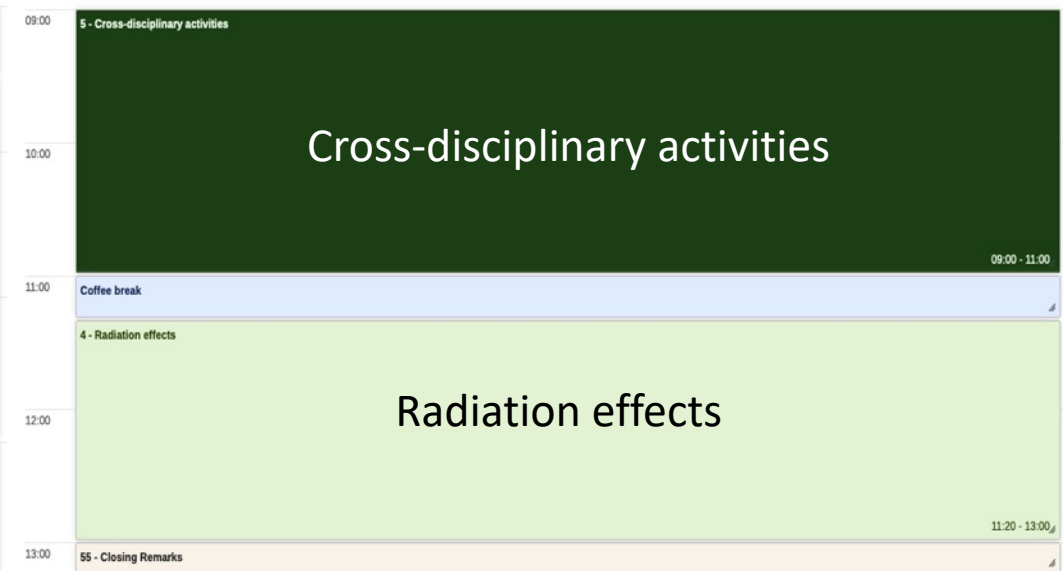


Develop a structure with a clear link to the relevant DRD collaborations.

Membership of the emerging DRD collaborations should not be a prerequisite for participation in a consortium, so that other R&D topics can also be mapped.

The R&D activities of the KET and KHuK communities have a large thematic overlap
→ cooperation makes a lot of sense

Schedule



Do not miss!!!

Pls meeting

Concluding remarks



High-D

is a consortium to coordinate the effort on detector development in HEP and Hadron&Nuclear Physics

It needs your input & participation to become a success !

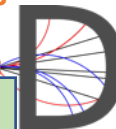
Let us talk science now ...

BACKUP

High-granular Multi-dimensional detectors

Receive BMBF funds

Receive other funds



AP1: 4D tracking

Garutti

AP2: 5D calorimetry

Lacker

AP3: Cross-disciplinary activities

AP3.1 Reconstruction algorithms for Md detectors (ML)
Garutti, Paul, Sefkow, Simon

AP3.3 Scintillating-Fiber-Tracker
Aumann, Paul

AP3.2 Digital ECAL
Issever, Worm

AP3.6 High-throughput DAQ
Fischer, Paul, Schumann

AP3.5 Multi-purpose ASIC receiver chain
van Waasen, Bretz

AP3.4 New Materials
Brinkmann

AP3.7 SiPM research
Bretz, Garutti

Scint. / Cherenkov

AP2.1-3 WOM – LS
Bretz, Lacker, van Waasen, Fischer, Schumann, Wurm

AP2.4 CheapCal
Lacker, Issever, Brinkmann, Büscher, Wanke, Paul

AP2.5 SplitCal
Büscher, Wanke

AP4: Radiation effects

AP1.5 CPS response to ions
Masciocchi, Stachel

AP4.1 Simulation and measurements of N_{eff} CPS, LGAD, SiPM
Deveaux, Garutti, Stroth

AP4.2 Measuring SEE in CPS and Optical transceiver
Deveaux, Stroth

Fast timing layers

AP1.1 Highly segmented sensors
Galatyuk, Quadt

AP1.2 Timing layer application
Garutti, Gregor

AP1.3 Ultimate time resolution
Galatyuk, Gregor, Hofmann

High-D web page



- Static web page with mandate and structure of consortium:

<https://www.physik.hu-berlin.de/de/eephys/genericdetectorrnd/rnd2>

- Living web page updated from Consortium members

<https://confluence.desy.de/display/HIGHD/High-D+Home>

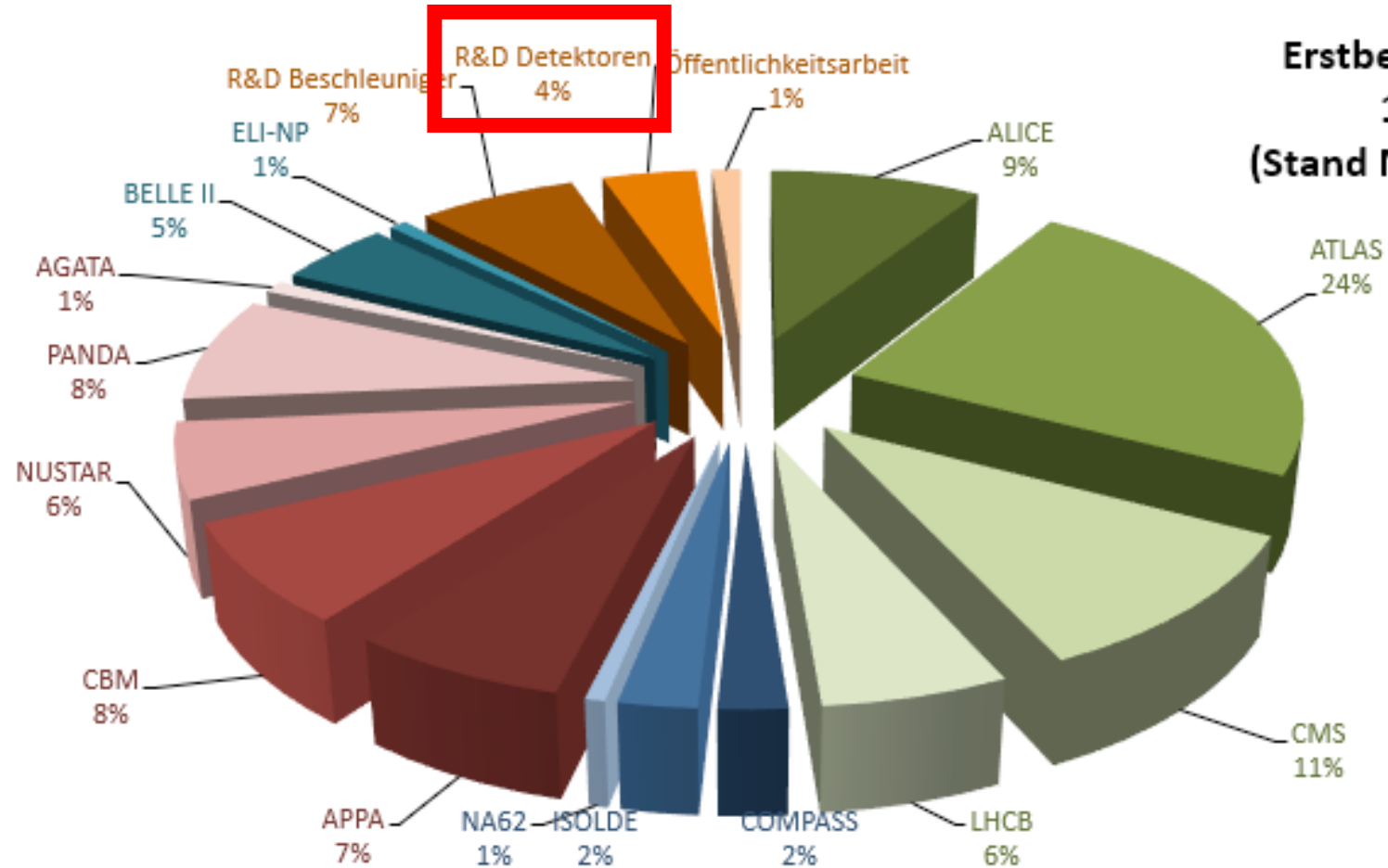
BMBF funding 2021 -2024

„Physik der kleinsten Teilchen“ FP 2021-2024

Total R&D Detektoren
~4,5 Mill.
15 projects

High-D:
~1,5 Mill.
7 projects

Erstbewilligung:
105 Mio. €
(Stand Nov. 2021)



The High-D consortium



First large scale coordinated effort on detector development in High-Energy and Hadron&Nuclear Physics

Mandate:

- Research on new generation **high-precision detectors** with unprecedented spatial, temporal, and energetic resolution, **for applications at** future accelerator-based experiments at both the **Energy Frontier** as well as the **Intensity Frontier**

Members:

10 universities + 4 research centers in Germany

Program:

Fundamental research on 5D detectors with **extreme granularity** and on **novel reconstruction techniques**

The High-D research overview

Higher segmentation is achieved by:

- novel microelectronic technologies
- novel semiconductor designs
- new segmentation concepts
- novel readout electronics

to ensure optimal reconstruction precision these must be accompanied by:

- novel algorithms that effectively utilize 5D information
- integration of all components of a detector system (“particle flow” approach)

Consortium divided in 4 interconnected work packages:



- Two main pillars: **4D tracking** and **5D calorimetry**
- Two cross-linking packages