Karlsruher Institut für Technologie

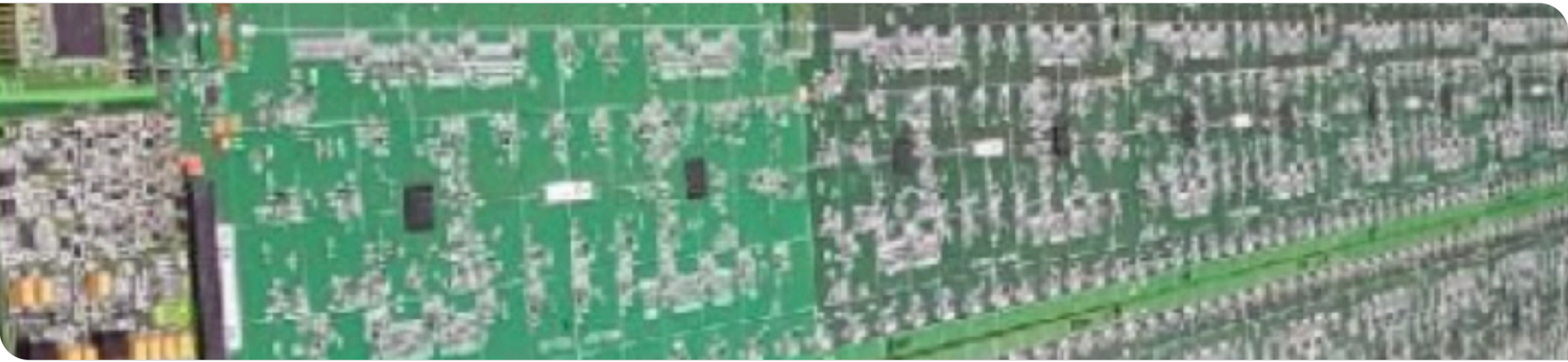
Institute for Data Processing and Electronics

Track 1

Input Proposals Overview & Main Directions

Frank Simon

DRD6 2nd Community Workshop, April 2023



Overview Input Proposals

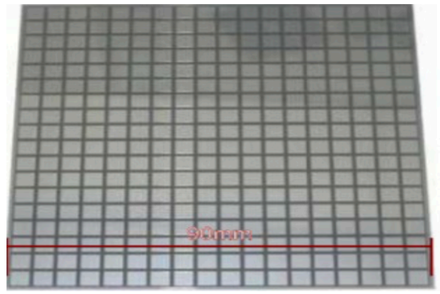
11 proposals submitted to Track 1

- Here: Overview of each proposal
  - Time scales taken as-is
    may need adjustments in proposal phase to bring all projects on an equal level or realism in assumptions
  - Some proposals considered for other tracks - see remarks, and upcoming presentations
    In the end: Will see when writing proposal which the best “alignment” is

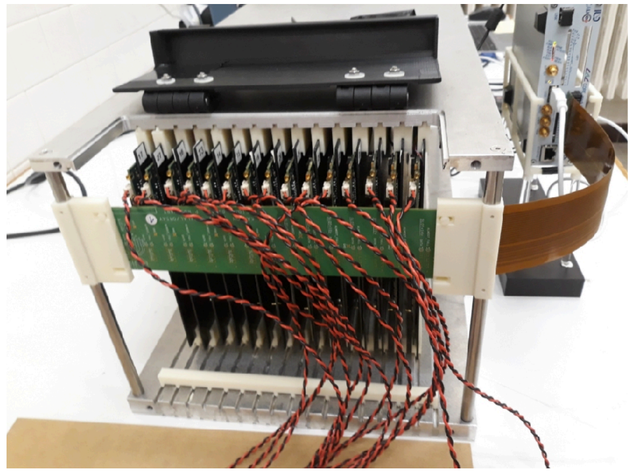
SiW ECAL

LLR, IJCLab, LPNHE, OMEGA, IFIC, Kyushu U, KEK, CERN

- Primary experimental context: Higgs Factories, possible near-term applications in LUXE and others
- A SiW-ECAL using silicon pad sensors with analog readout
  Builds on CALICE SiW ECAL technological prototype



- Main R&D topics
  - Extension of current prototype based on power pulsing
    to continuous operations: reduction of power consumption,
    of cooling
  - Study of the addition of timing, either dedicated layers or volume timing

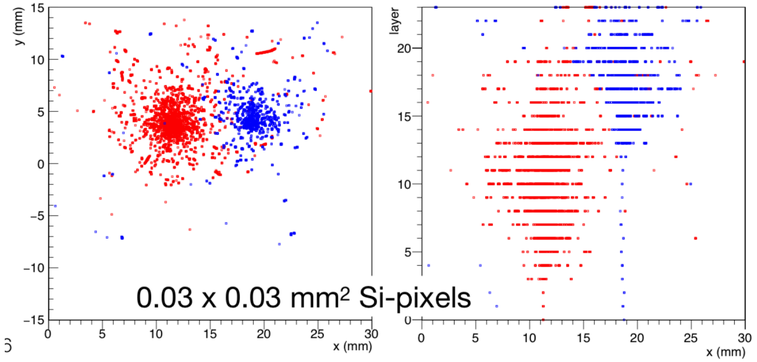


- 15 single-ASU prototype in beam in 2024
  current technology)
- Design for HF pilot module in 2025

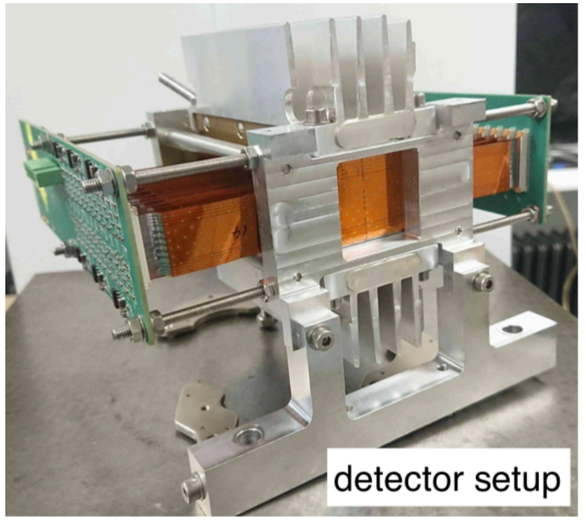
DECAL - Digital ECAL based on MAPS

HU Berlin, U B'ham, DESY-Z, HEPHY & NTU Athens, IC, Frankfurt, Rutherford, Sussex, Utrecht

- Primary experimental context: ALICE FOCAL, Higgs Factories
- A MAPS-based digital Silicon-Tungsten ECAL,
  building on current DECAL and EPICAL projects, partially integrated in CALICE



- Main R&D topics:
  - Full exploitation of existing EPICAL-2 prototype to evaluate performance
  - Establish requirements of a sensor dedicated for digital calorimetry
  - Design of next-generation sensor with calorimeter-specific optimisation (overlaps with DRDs 3, 7), and evaluation of sensor design
- Small-scale digital ECAL prototype in 2026, sensor submission early 2025



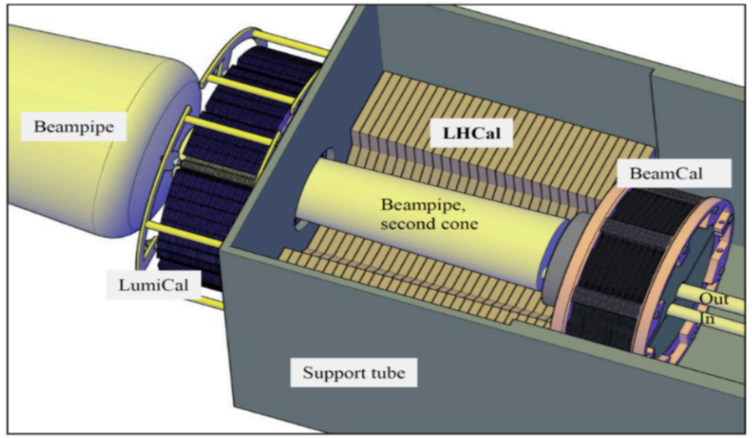
Note: Also relevant activities (and interest) at SLAC, U Oregon -
with connections to CERN

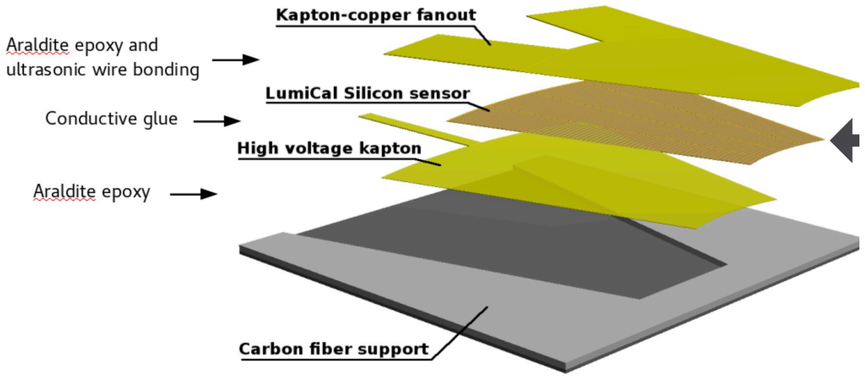
Highly Compact ECAL

TAU, AGH Cracow, U Warsaw, IFIC, ISS Romania

- Primary experimental context: Higgs Factories, possible near-term applications in LUXE
- Highly compact electromagnetic calorimeter with semiconductor sensors
  Builds on developments in FCAL
- Main R&D topics:
  - R&D on Si and GaAs sensors, including optimisation of readout integration
  - Development of thin conductive gluing
  - Development of readout electronics:
    - Readout of FLAME ASICs; development of FLAXE variant for LUXE
    - Wireless data transmission, joining WASAPT program
  - Mechanics with minimal tolerances
  - Simulation studies

- Design of prototype in 2024, construction & performance studies in 2026
- Design for HF calorimeter in 2026

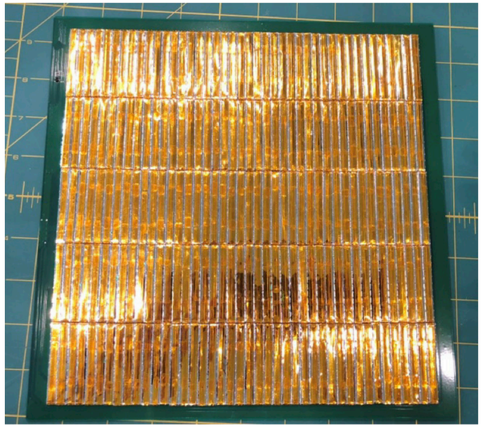




Highly Granular Scintillator-strip Calorimeter

U Tokyo, USTC, IHEP, Shinshu U, SJTU

- Primary experimental context: Higgs Factories
- A tungsten-scintillator-strip (with SiPM readout) calorimeter
  Building on CALICE technological prototype
- Main R&D goals for next period:
  - Engineering study for large-scale production
  - Timing performance - possibly by introducing dedicated timing layer(s)
  - Scintillator material - also extending to new ideas such as quantum dot material
  - Scintillator strip design
  - Active cooling system
  - Mechanical structure and services
  - Electronics - including low-power readout ASIC
  - Trigger-DAQ system - studied for Circular Colliders
- Construction of a new prototype as main deliverable



MPGD-based Hadronic Calorimeter

INFN & U Bari, Weizman Inst.

- Primary experimental context: Muon Collider
- Inspired by CALICE DHCAL & SDHCAL
- Using MPGDs (examples uRWELL, resistive Micromegas) for higher-rate environments
- Already ongoing activities: testing of detectors, test of a small calorimeter prototype with up to 6 GeV pions in 2023
- Main R&D topics
  - Simulation for HCAL design definition
  - Construction of a prototype with 50 x 50 cm^2 active layers, further extensions
  - Test beam campaigns

- NB: At the moment prototypes do not have integrated electronics: R/O at detector edges

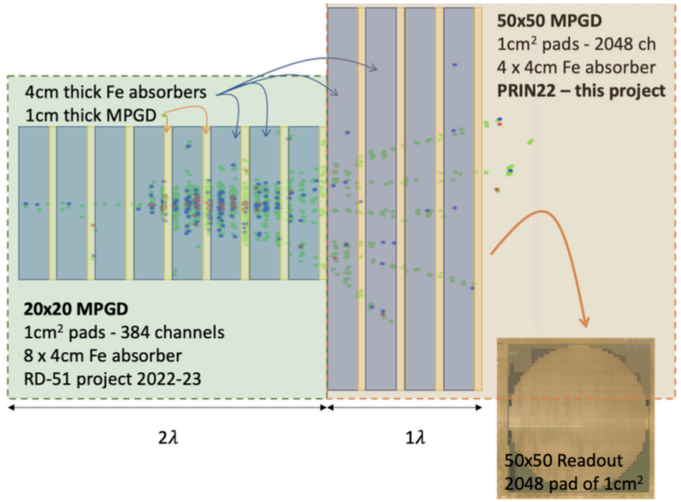
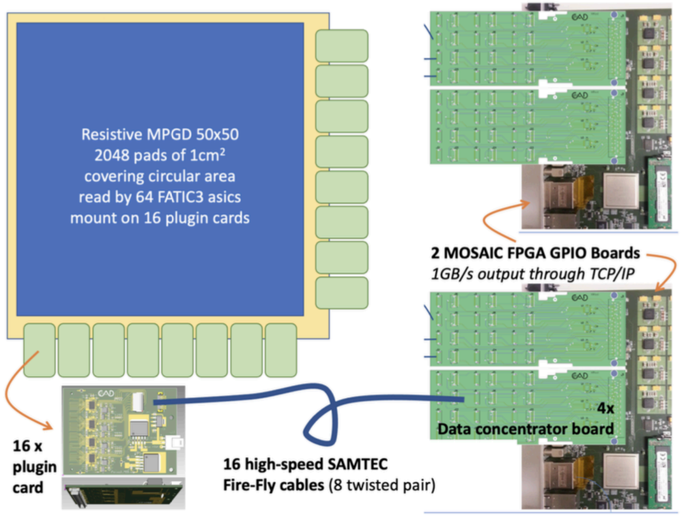


Fig. 2.4: Layout of the HCAL prototype with 3λ depth. The first 2λ is made of the 20x20cm² prototype developed in the RD-51 project in 2022, while the last λ necessary to contain longitudinally (95%) protons and pions of 1-6 GeV is made of 50x50cm² detectors developed in this project.

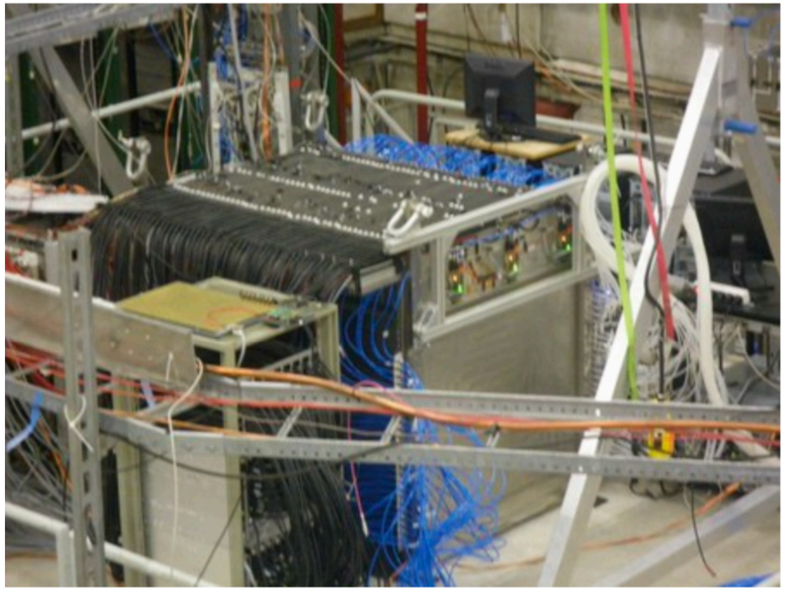


T-SDHCAL

IP2I Lyon, CIEMAT; VUB, OMEGA, U Cordoba, Yonsei Cancer Center, GWNU, SJTU, U Tunis El Manar

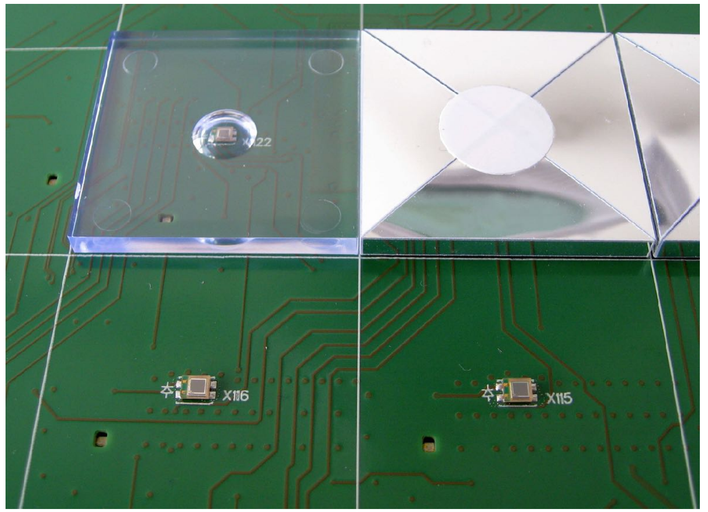
- Primary experimental context: Higgs Factories
- A RPC-based semi-digital HCAL with timing capability
  Builds on CALICE SDHCAL technological prototype
- Main R&D directions
  - Simulation studies extending to time information
  - Study and development of cooling and cassette concepts
  - Fast timing electronics
  - Development of DAQ system
  - Construction of detector units, validation in beam tests

- Until 2026: Complete initial R&D steps to propose T-SDHCAL concept for circular HF



SiPM-on-Tile AHCAL

DESY, U Göttingen, U Hamburg, U Heidelberg, KIT, U Mainz, FZU Prague, OMEGA



- Main experimental context: Higgs Factories
- SiPM-on-tile / steel HCAL
  Builds on CALICE AHCAL Technological Prototype

- Main R&D topics:
  - Extension of current detector concept to circular colliders with continuous readout
    - evaluate consequences of higher data rate
    - re-evaluate need for cooling
    - re-optimisation of detector to ensure optimal performance while respecting new constraints
- Corresponding hardware development: ASICs (KLAuS, OMEGA), HBU and interfaces, mechanical and thermal design; scintillator geometry

- First layers for new system design in 2026, EM stack with ~15 layers ~ 2029

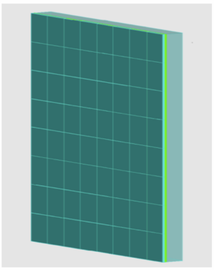
Frank Simon (frank.simon@kit.edu)

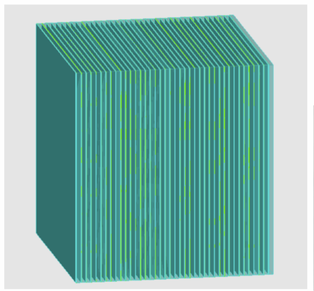
Highly Granular HCAL with Glass Scintillator Tiles

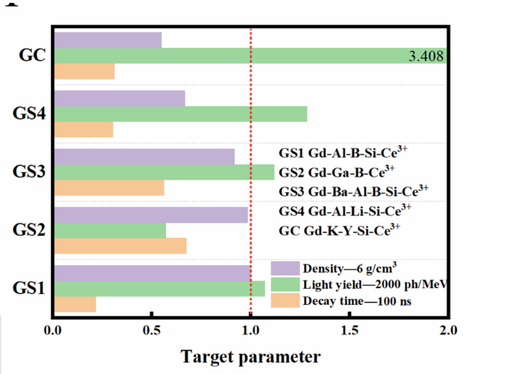
IHEP, Glass Scintillator Collaboration (CN institutes, universities)

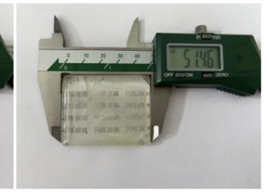
- Primary experimental context: Higgs Factories
- A variation of the CALICE AHCAL concept: Using glass scintillator tiles instead of plastic
  - Increased sampling fraction - with the potential for improved energy resolution

- Main R&D directions:
  - R&D of scintillator material - main targets: high density, high light yield, low cost
  - Simulation studies of hadronic performance: single particles, jets
  - Development of modules:
    - setup for characterization,
    - EM prototype ~2025
    - HCAL prototype ~ 2027







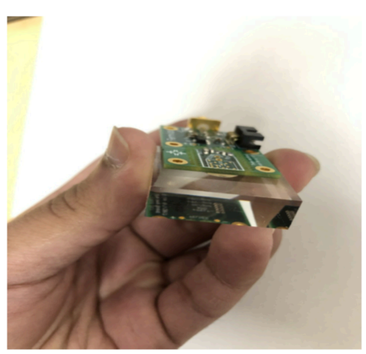


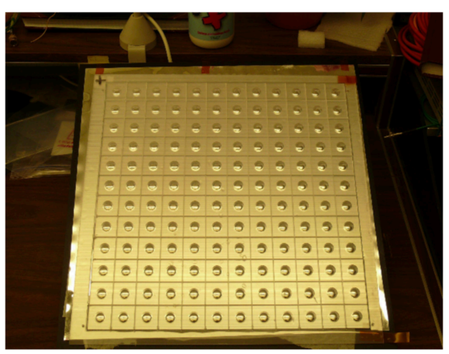
ADRIANO3 - Triple Readout Calorimeter

Beykent, U Iowa, NIU, INFN; ANL, Fairfield U, U Tokyo, Fermilab, Shinshu U, U Kansas

- Primary experimental context: REDTOP
- Extension of ADRIANO2 (fully active granular dual readout calorimeter) to three readout modes to achieve 5D shower measurement, disentangling the neutron component of the shower. Technologies:
  - High-density glass as Cherenkov Medium (and absorber)
  - Plastic scintillator tiles
  - RPCs with cm^2 pad readout
- Key R&D goals
  - optimization of the construction technique in terms of:
  - light yield, RPC efficiency, timing resolution, and cost
  - Test layers in 2024, small-scale prototype 2025
  - Larger-scale prototype 2026-2027
- Plans to use ultrafast ASICs for RPC readout Source (DRD7) may need discussion

Initial focus on optical materials and RPCs:
Track 3 as home?

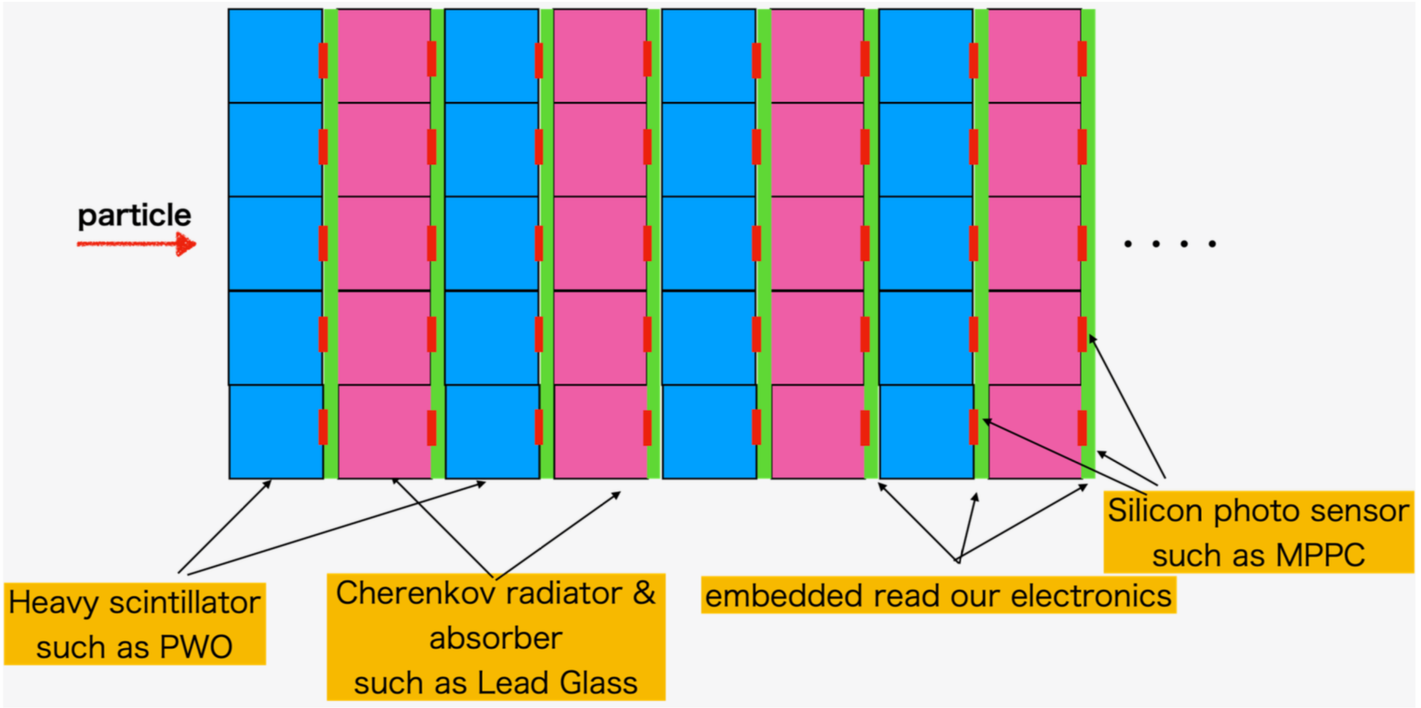




Double Readout Sandwich Calorimeter

Shinshu U

- Primary experimental context: Higgs Factories
- A concept for an (almost) fully active hadron calorimeter
  - Alternating layers of heavy scintillator (PWO) and Cherenkov medium (lead glass)
    Each read out by embedded SiPMs
- Currently studied in simulations only on the system level, studies of individual prototype cells in progress
- Goal: construction of up to 5 layers in 2024, a 20 layer prototype in 2026



Initial focus on optical materials and RPCs:
Track 3 as home?

Calorimeter ASICs

OMEGA, AGH Krakow, CEA IRFU

- An overarching proposal for the further development of the ASIC family currently in use in highly granular calorimeters. Not just Track 1, but clearly highly relevant here.
  - Builds on the experience in CALICE

- The goal is to develop ASICs than can serve most different input elements in use in DRD6:
  Silicon, gas detectors, scintillators (crystals, tiles, fibers -> SiPM readout), liquid Argon
  - A central goal: reduction of power consumption by ~ 1 order of magnitude compared to HGCROC as current state-of-the-art

NB: Proponents (and project-specific developments) in part also included in other input proposals.

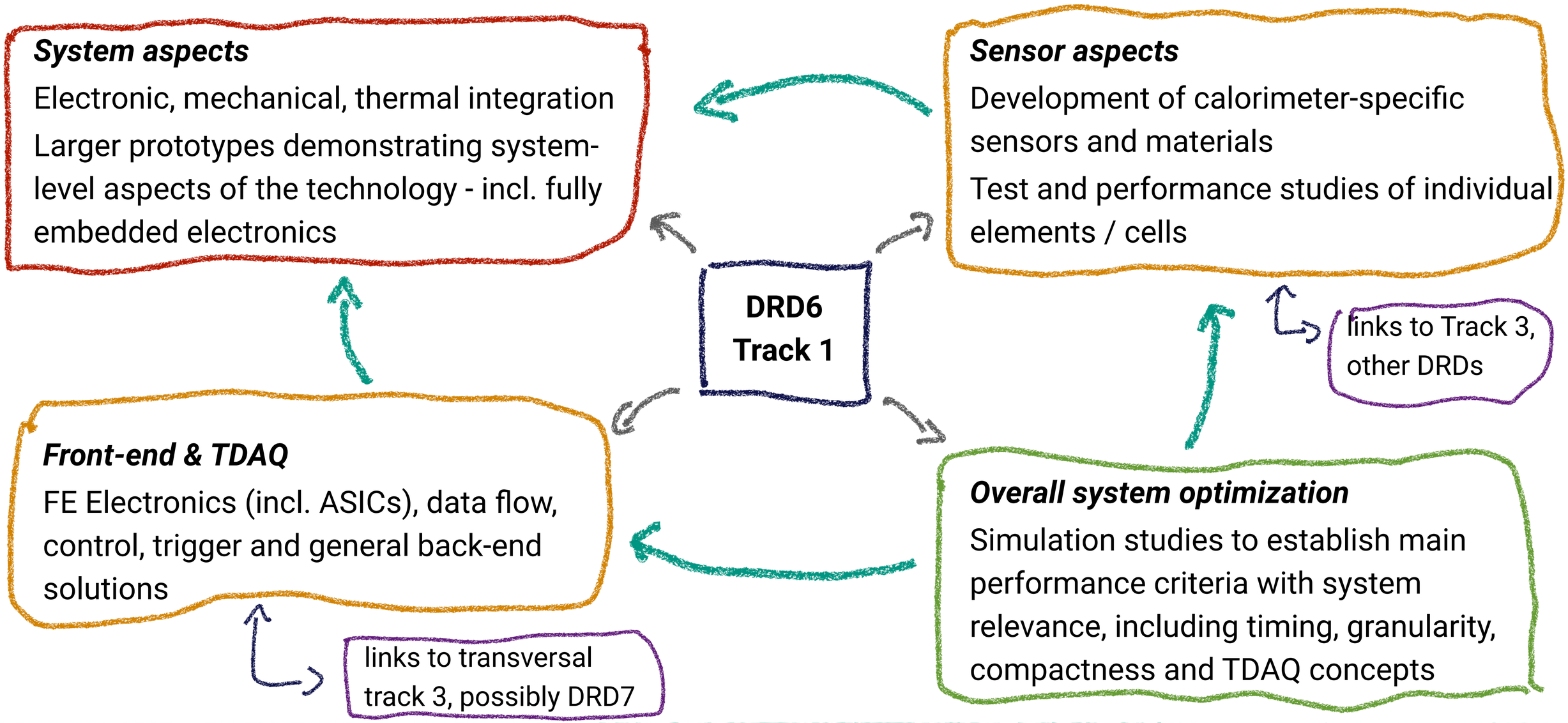
Not in Track 1, but as a transversal activity!

The Emerging Picture

A first attempt to identify main activities that characterize Track 1

Main R&D Directions

Defining Track 1



First thoughts moving forward

Track 1 as part of a collaboration

- By construction, the input proposals typically present self-contained projects
  Many are growing out if existing projects, with already established (or at least plausible) solutions for electronics, readout and other system aspects.

- Identifying synergies, and possibilities for common solutions will be critical:
  - Reduce resource needs for parallel development
  - Enable common operation of prototypes in future tests
  - Possibly set standards for future full detector systems