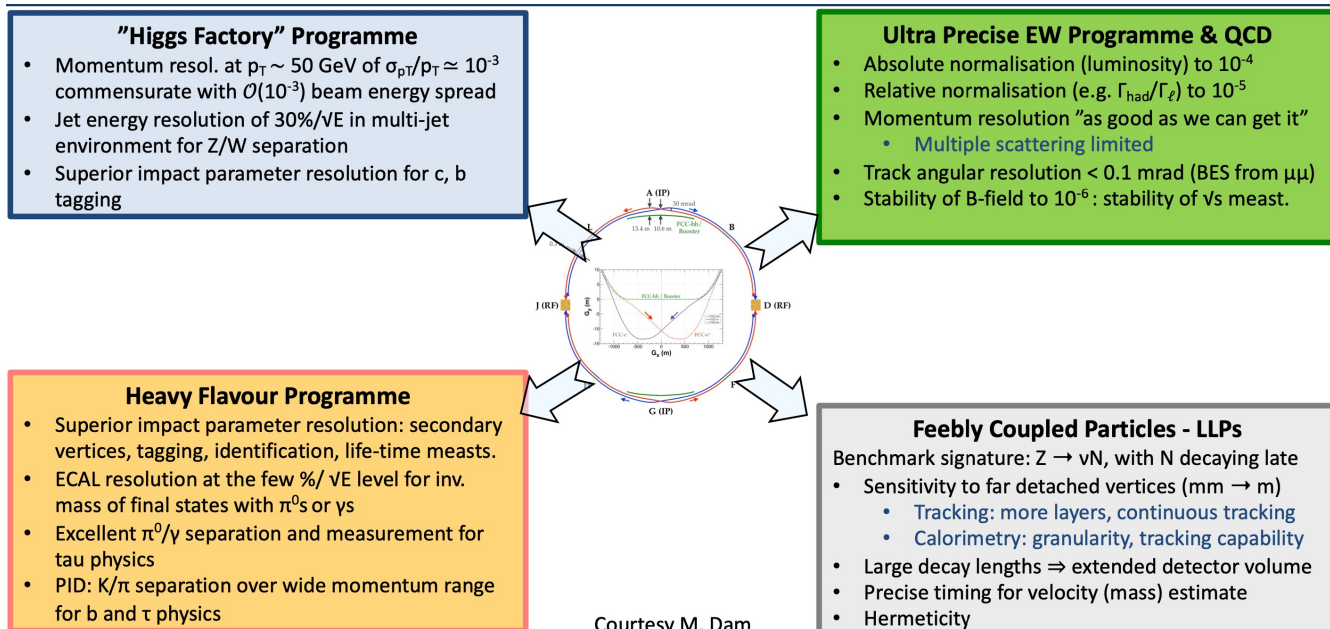# LHeC Technology Enabling a Higgs Factory
(Stepping stone for detector R&D towards Higgs factories)

CDR-Update detector concept is mostly an evolution of (HL)-LHC GPD detectors (ATLAS) + a more developed MAPS-based tracker concept

e+e- Higgs factory detectors have overlapping performance requirements to HL-LHC, but with less stringent environmental constraints
→ Much less stringent radiation hardness requirements
→ LHeC requirements have a lot in common with Higgs factories …
   can be used to test / refine / 'prototype' technologies & ideas.

"Higgs Factory" Programme
- Momentum resol. at $p_T \sim 50$ GeV of $\sigma_{p_T}/p_T \simeq 10^{-3}$ commensurate with $\mathcal{O}(10^{-3})$ beam energy spread
- Jet energy resolution of 30%/$\sqrt{E}$ in multi-jet environment for Z/W separation
- Superior impact parameter resolution for c, b tagging

Ultra Precise EW Programme & QCD
- Absolute normalisation (luminosity) to 10^{-4}
- Relative normalisation (e.g. Γ_{had}/Γ_ℓ) to 10^{-5}
- Momentum resolution "as good as we can get it"
  - Multiple scattering limited
- Track angular resolution < 0.1 mrad (BES from $\mu\mu$)
- Stability of B-field to 10^{-6} : stability of $\sqrt{s}$ meast.

Heavy Flavour Programme
- Superior impact parameter resolution: secondary vertices, tagging, identification, life-time measts.
- ECAL resolution at the few %/ $\sqrt{E}$ level for inv. mass of final states with π^0s or γs
- Excellent π^0/γ separation and measurement for tau physics
- PID: K/π separation over wide momentum range for b and τ physics

Feebly Coupled Particles - LLPs
Benchmark signature: Z → νN, with N decaying late
- Sensitivity to far detached vertices (mm → m)
  - Tracking: more layers, continuous tracking
  - Calorimetry: granularity, tracking capability
- Large decay lengths ⇒ extended detector volume
- Precise timing for velocity (mass) estimate
- Hermeticity

Courtesy M. Dam

Input from EIC is a major opportunity
→ **Technology choices pointing the way for DIS and being tested**
→ **Current community contains lots of detector specialists solving similar problems to ours and needing future projects**
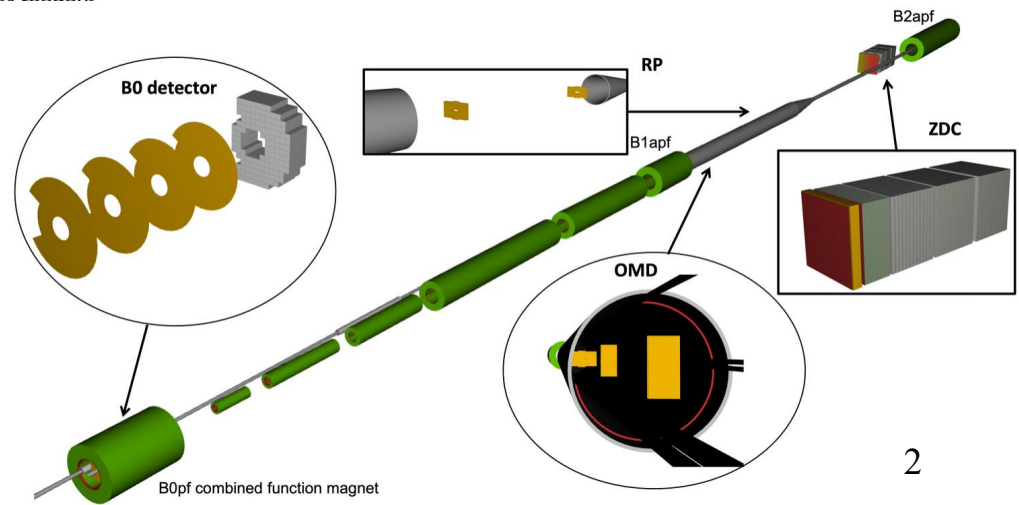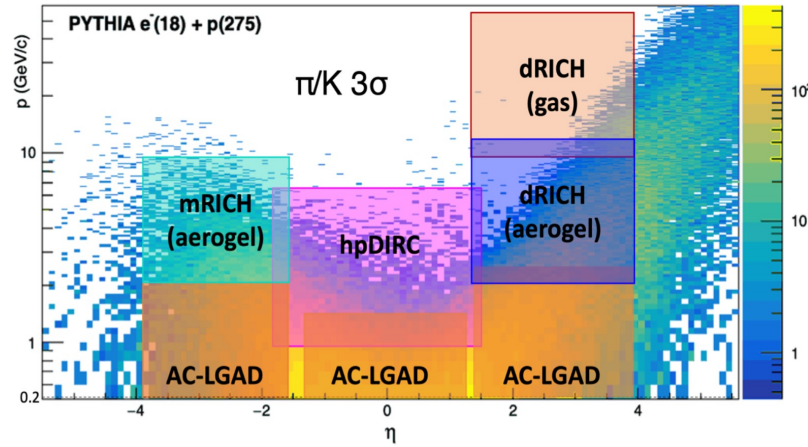
Imaging eCAL
Pb/SciFi sampling +
AstroPix
imaging
layers

Comprehensive Particle ID
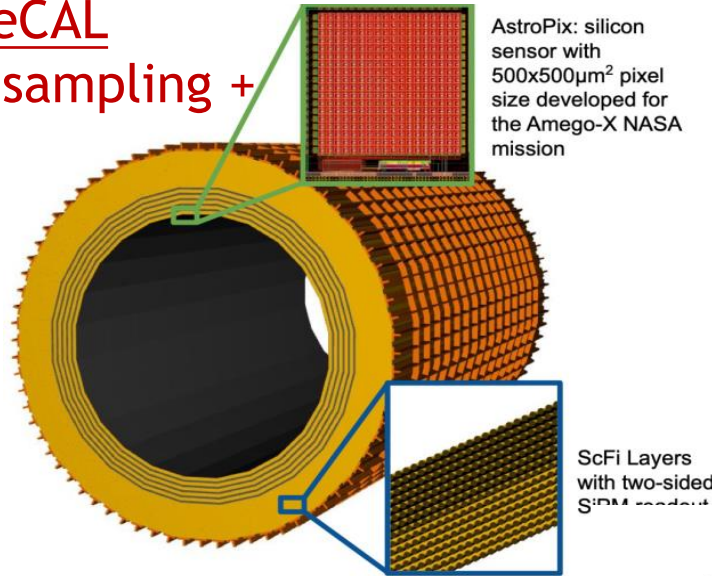
- Forward protons inside and outside beampipe ($0.45 < E_p'/E_p < 1$)
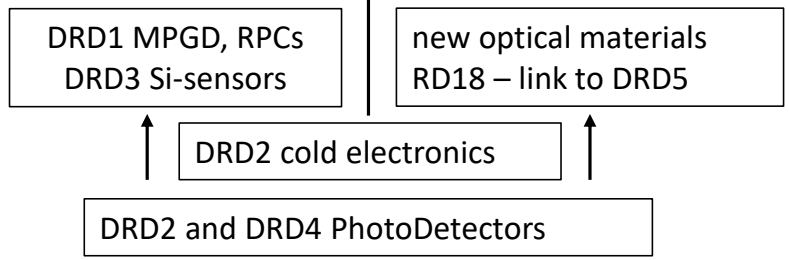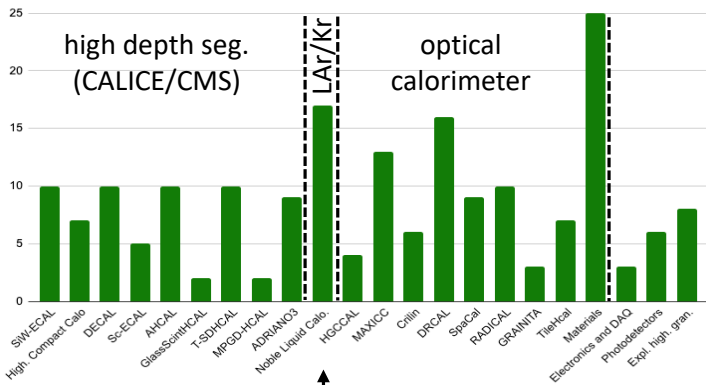
- Forward neutrons with ALICE FOCAL-like ZDC

2

Other inputs / pathways:
- **HL-LHC Upgrades (ALICE for silicon, LHCb for PID)**
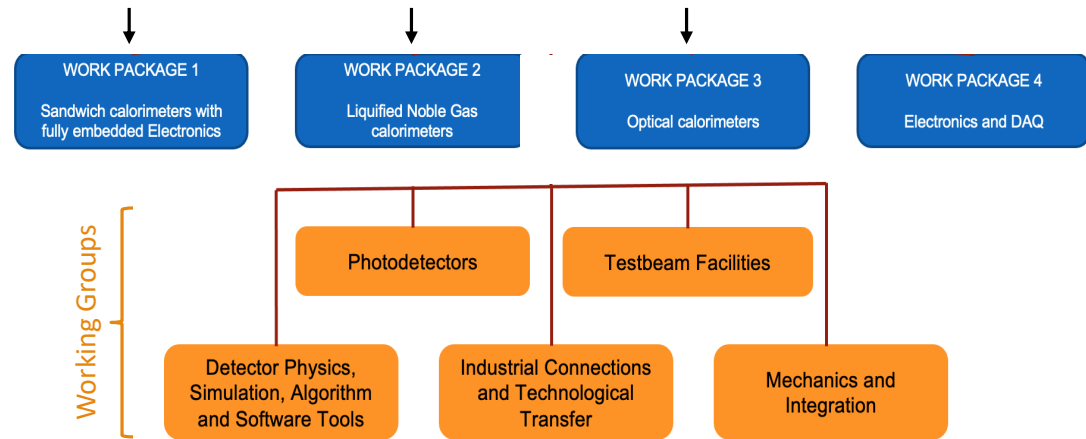- **DRD R&D Collaborations provide a generic framework for technology development**

DRD6: Calorimetry

[Didier Contardo]

18 prototype projects to cover options
in configurations of electromagnetic and hadronic
segments in all technology options

mostly driven by interest for future e-e colliders
particle flow in all concepts evolving to 5D
pre-existing communities in the 3 main class of calorimeters

DRD1 MPGD, RPCs
DRD3 Si-sensors

new optical materials
RD18 – link to DRD5

DRD2 cold electronics

DRD2 and DRD4 PhotoDetectors

new concepts digital MCMOS/RPC, opaque scint., depth seg. with prec. timing, homogenous HCAL, Quantum Dots

# Homework → Investigate detector concepts for Higgs Factories in detail

CLD

IDEA

CDR

ALLEGRO (Noble Liquid ECAL based)

new
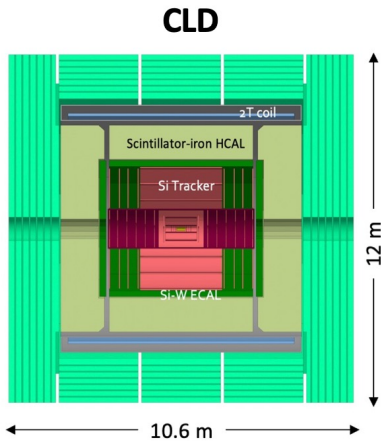
CLD
- Well established design
  - ILC -> CLIC detector -> CLD
- Full Si vtx + tracker;
- CALICE-like calorimetry;
- Large coil, muon system
- Engineering still needed for operation with continuous beam (no power pulsing)
  - Cooling of Si-sensors & calorimeters
- Possible detector optimizations
  - σ_p/p, σ_E/E
  - PID ($\mathcal{O}$(10 ps) timing and/or RICH)?
  - ...
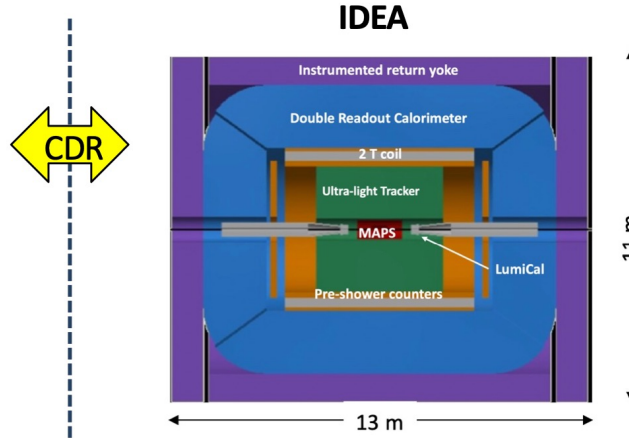
IDEA
- A bit less established design
  - But still ~15y history
- Si vtx detector; ultra light drift chamber w powerful PID; compact, light coil;
- Monolithic dual readout calorimeter;
  - Possibly augmented by crystal ECAL
- Muon system
- Very active community
  - Prototype designs, test beam campaigns, ...

FCC-ee CDR: https://link.springer.com/article/10.1140/epjst/e2019-900045-4
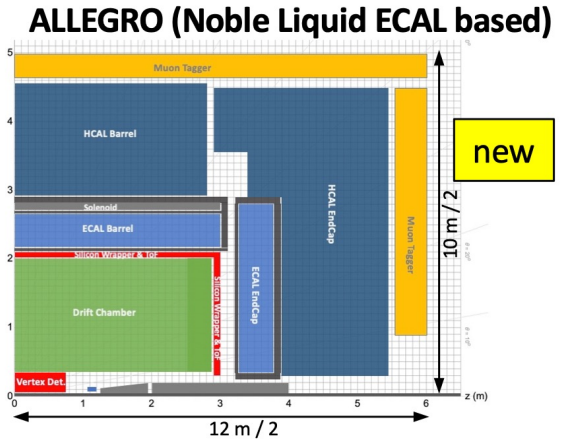
ALLEGRO
- A design in its infancy
- Si vtx det., ultra light drift chamber (or Si)
- High granularity Noble Liquid ECAL as core
  - Pb/W+LAr (or denser W+LKr)
- CALICE-like or TileCal-like HCAL;
- Coil inside same cryostat as LAr, outside ECAL
- Muon system.
- Very active Noble Liquid R&D team
  - Readout electrodes, feed-throughs, electronics, light cryostat, ...
  - Software & performance studies

To be resolved → Interface of this section with 'Detector Readiness' (Yuji)