



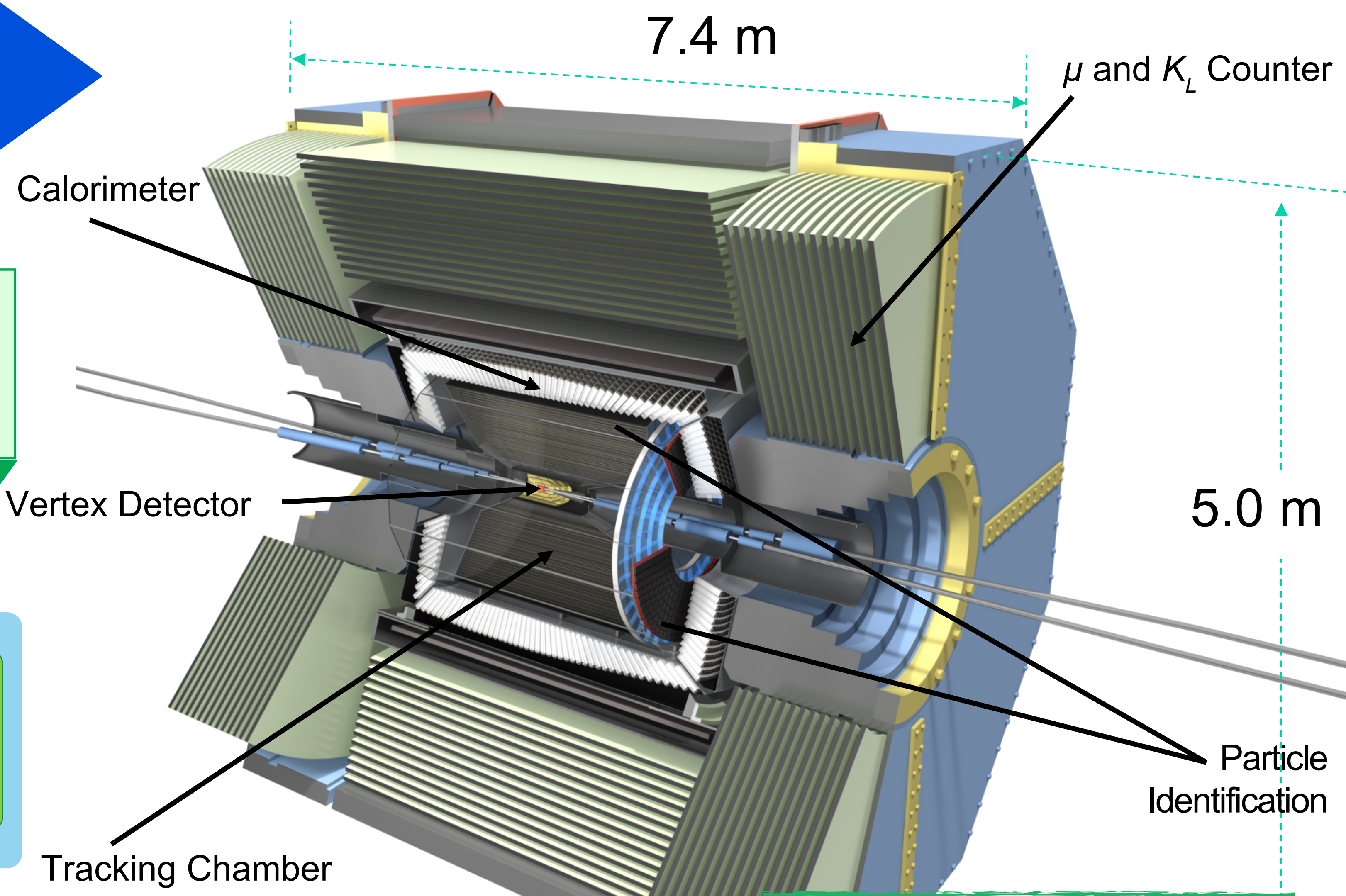
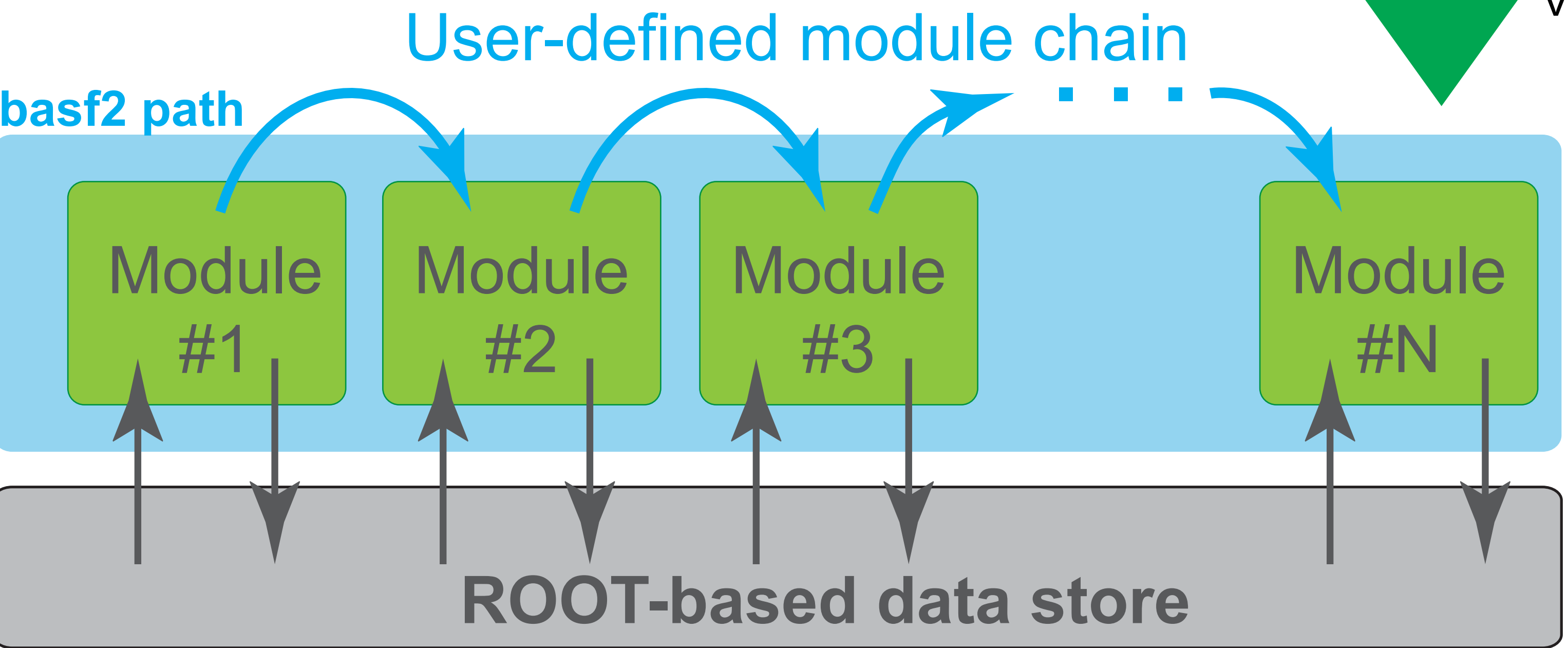
Track Extrapolation and Muon Identification in Belle II Event Reconstruction

Leo Pilonen, Virginia Tech (for the Belle II Collaboration's Software Group)

#35
Track 2
Offline computing

The Belle II experiment at the SuperKEKB colliding-beam $e^+ e^-$ accelerator in Tsukuba, Japan, studies the behaviour and symmetry properties of heavy quarks and leptons.

The Belle II software framework basf2 has a modular design with Python steering of on-demand dynamically-loaded C++ modules and inherent event-based parallel-processing capability.



GEANT4E:
Error propagation for track reconstruction inside the GEANT4 framework

Pedro Arce (CIEMAT)

CHEP 2006, Mumbai, 13-17th February 2006

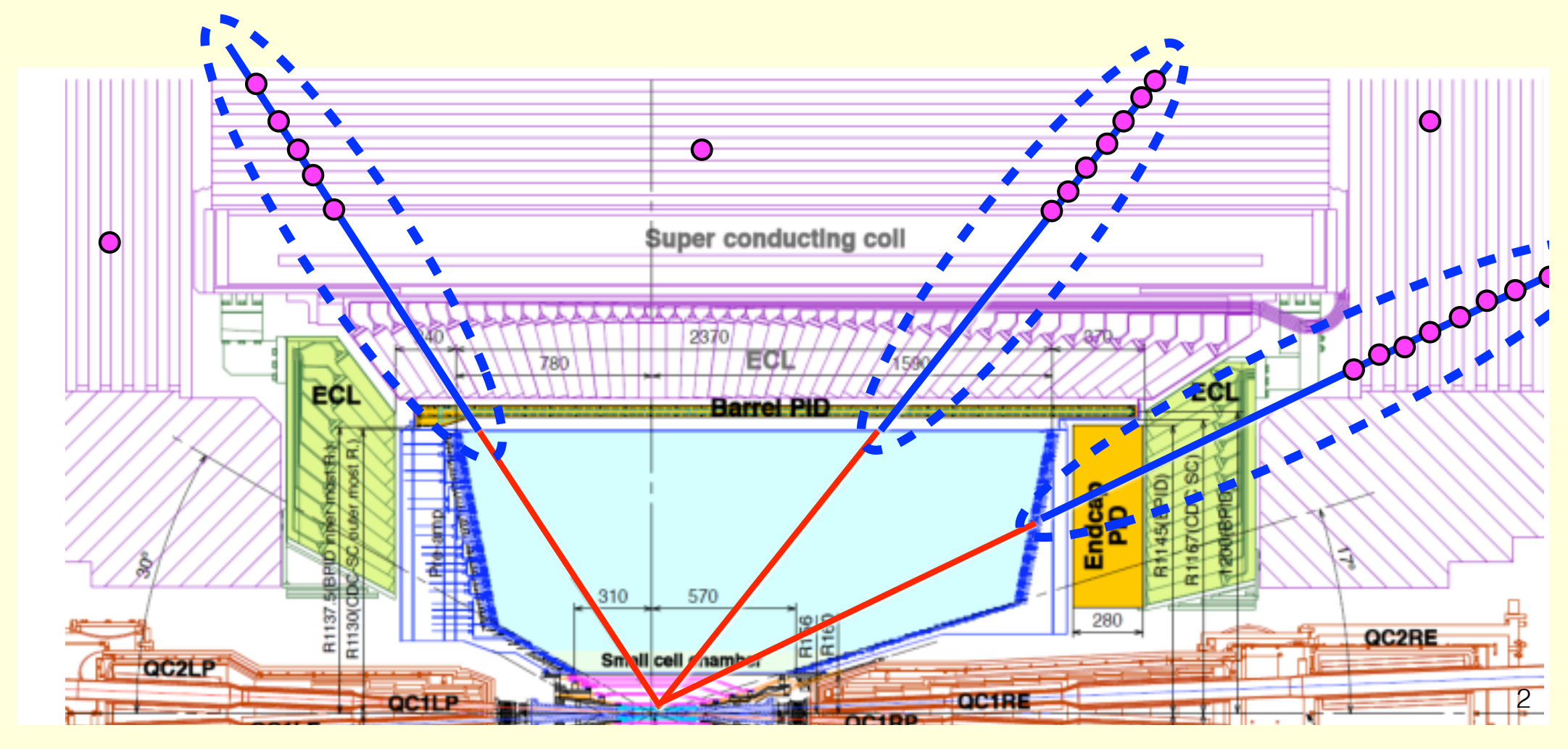
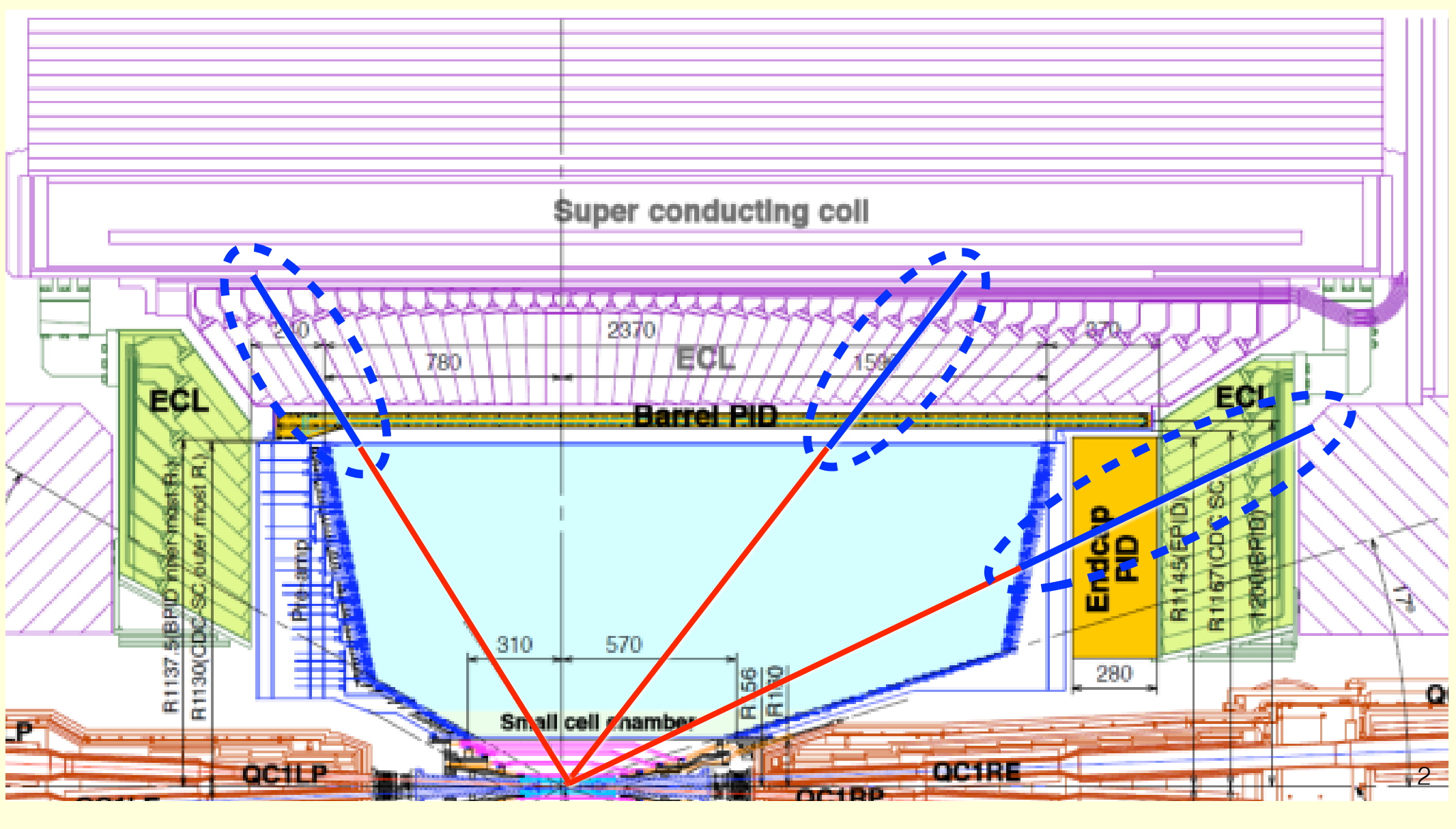
Two basf2 event-reconstruction modules for particle ID using GEANT4E

• ext

- extrapolates each reconstructed charged track outward
- assumes 6 particle-type hypotheses (e, μ, π, K, p, d) per track
- records crossings at each GEANT4 sensitive-volume boundary
- record time, position, momentum and 6x6 covariance matrix

• muid

- extrapolates each track through the K_L -muon detector (KLM)
- assumes only the muon hypothesis
- applies a Kalman filter at each layer crossing; adjust the extrapolated-track properties based on matching-hit location
- assigns particle-identification likelihood based on KLM's measured-vs-extrapolated range + transverse scattering



GEANT4 and GEANT4E coexistence in basf2

GEANT4E, as distributed, **cannot be used with GEANT4:**

- ☒ incompatible particle lists
- ☒ incompatible physics processes
- ☒ conflicting usage of sensitive-detector geometry
- ☒ distinct states when calling RunManager
- ☒ distinct step-by-step Navigators
- ☒ incompatible user actions (SteppingAction etc)

GEANT4E, as distributed, **is limited:**

- ☒ propagates only electrons, positrons and photons

We have resolved these issues and limitations. All mods are done **outside** the geant4(e) code base.

Define a combined (and extended) PhysicsList that incorporates **both** geant4 and geant4e functionality.

```

Our modified ConstructParticle() defines
gamma e+ e- mu+ mu- pi+ pi- pi0 kaon+
kaon- kaon0 kaon0L kaon0S proton anti_proton
neutron anti_neutron geantino chargedgeantino
opticalphoton etc for use by GEANT4 only

& g4e_gamma g4e_e+ g4e_e- g4e_mu+ g4e_mu
g4e_pi+ g4e_pi- g4e_kaon+ g4e_kaon- g4e_proton
g4e_antiproton g4e_deuteron g4e_antideuteron
(all with PIDcode = 0) for use by GEANT4E only

```

- ☒ Avoids the problem that standard GEANT4E PhysicsList defines only three particles (gamma e+ e-) and these conflict with GEANT4 usage during simulation

- ☒ During GEANT4 simulation, G4SteppingManager calls user code to process steps through "sensitive" detector volumes and record the hits therein.

- ☒ During GEANT4E extrapolation, our custom version of StepLengthLimitProcess() disables this behaviour:

```

G4ParticleChange aParticleChange;
G4VParticleChange*
ExtStepLengthLimitProcess::PostStepDoIt( const G4Track& track,
const G4Step& e )
{
aParticleChange.Initialize( track );
aParticleChange.ProposeSteppingControl( AvoidHitInvocation );
return &aParticleChange;
}

```

- ☒ Avoid the special G4ErrorPropagationNavigator in GEANT4E. Instead, use the standard G4Navigator defined in GEANT4.

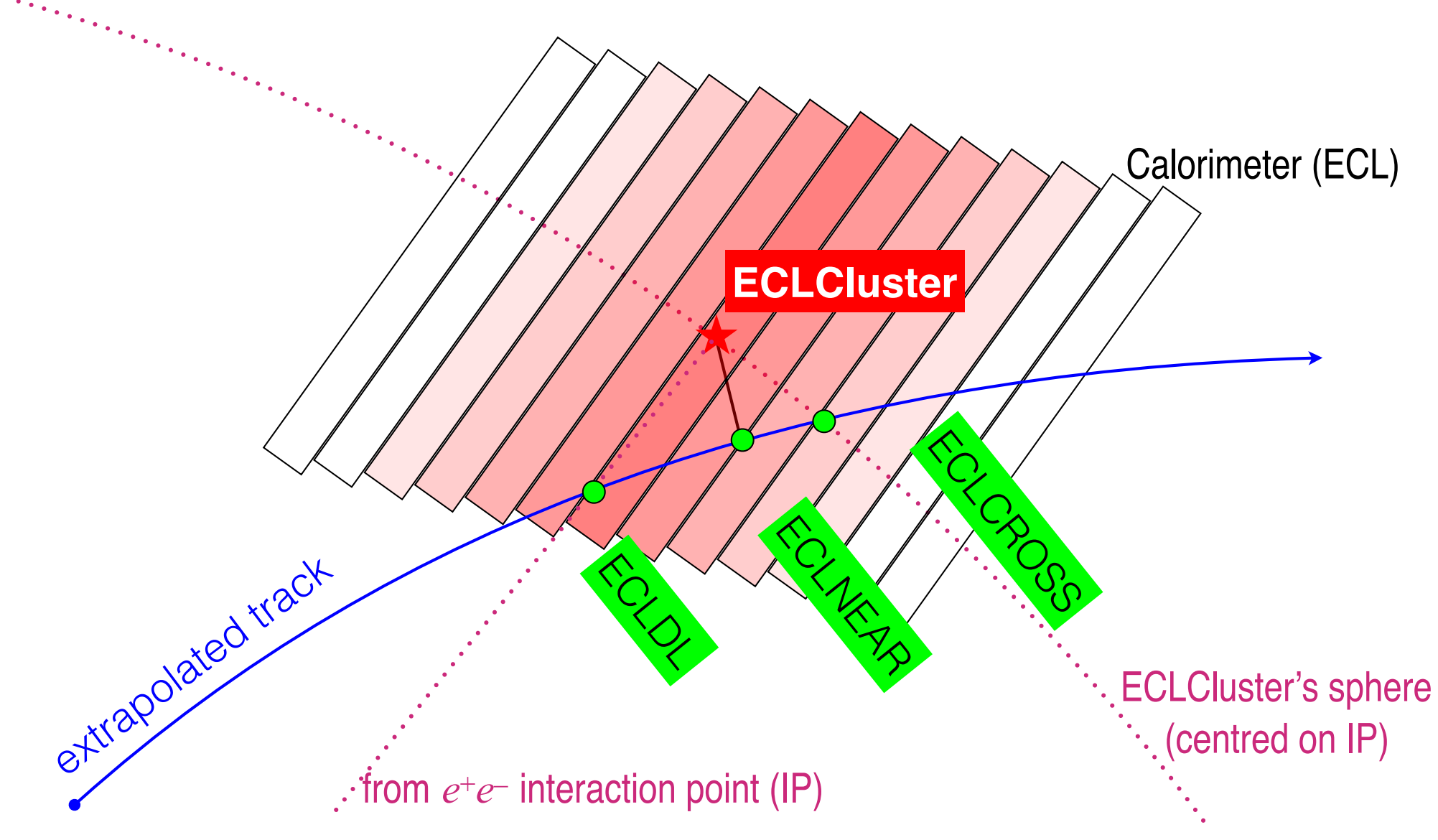
- ☒ GEANT4E requires a **target surface** (G4ErrorCylSurfaceTarget is an infinite-length cylinder). After each GEANT4E step, G4ErrorPropagationNavigator would have checked if track crossed this surface. Our steering code does this check.

- ☒ Our custom version of G4ErrorCylSurfaceTarget is a closed finite-length cylinder that includes the endcap surfaces.

- ☒ The distributed MagFieldLimitProcess in GEANT4E assumes that the magnetic field is along the z axis. Our custom MagFieldLimitProcess removes this assumption.

- ☒ The distributed G4EnergyLossForExtrapolator defines energy-loss processes for electrons and positrons only. Our custom G4EnergyLossForExtrapolator extends these processes to μ, π, K, p and d (and their anti-particles).

Track-cluster matching in the calorimeter:



Muon identification and hadron mis-ID:

