A Few Thoughts on PFA Calorimetry at CEPC

- Focusing on the analog HCAL -

Frank Simon
Max-Planck-Institute for Physics

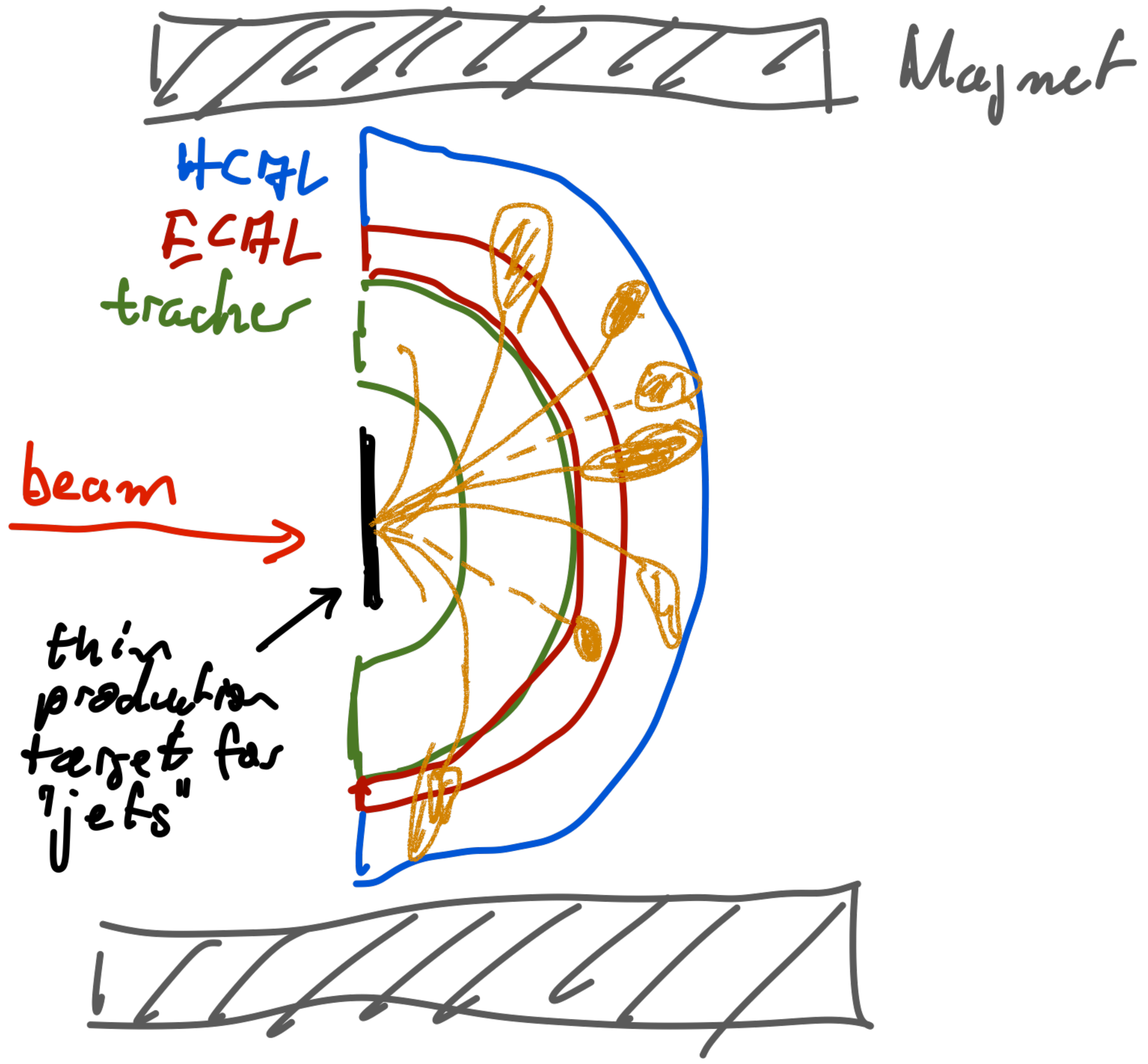
CEPC PFA Calorimetry Discussion
March 2019

Max-Planck-Institut für Physik
(Werner-Heisenberg-Institut)

Validating PFA Performance

Possible Approaches

- A fully realistic test of PFA in a test beam is (close to) impossible
  - requires "jets", tracking and momentum measurement & calorimetry covering all particles

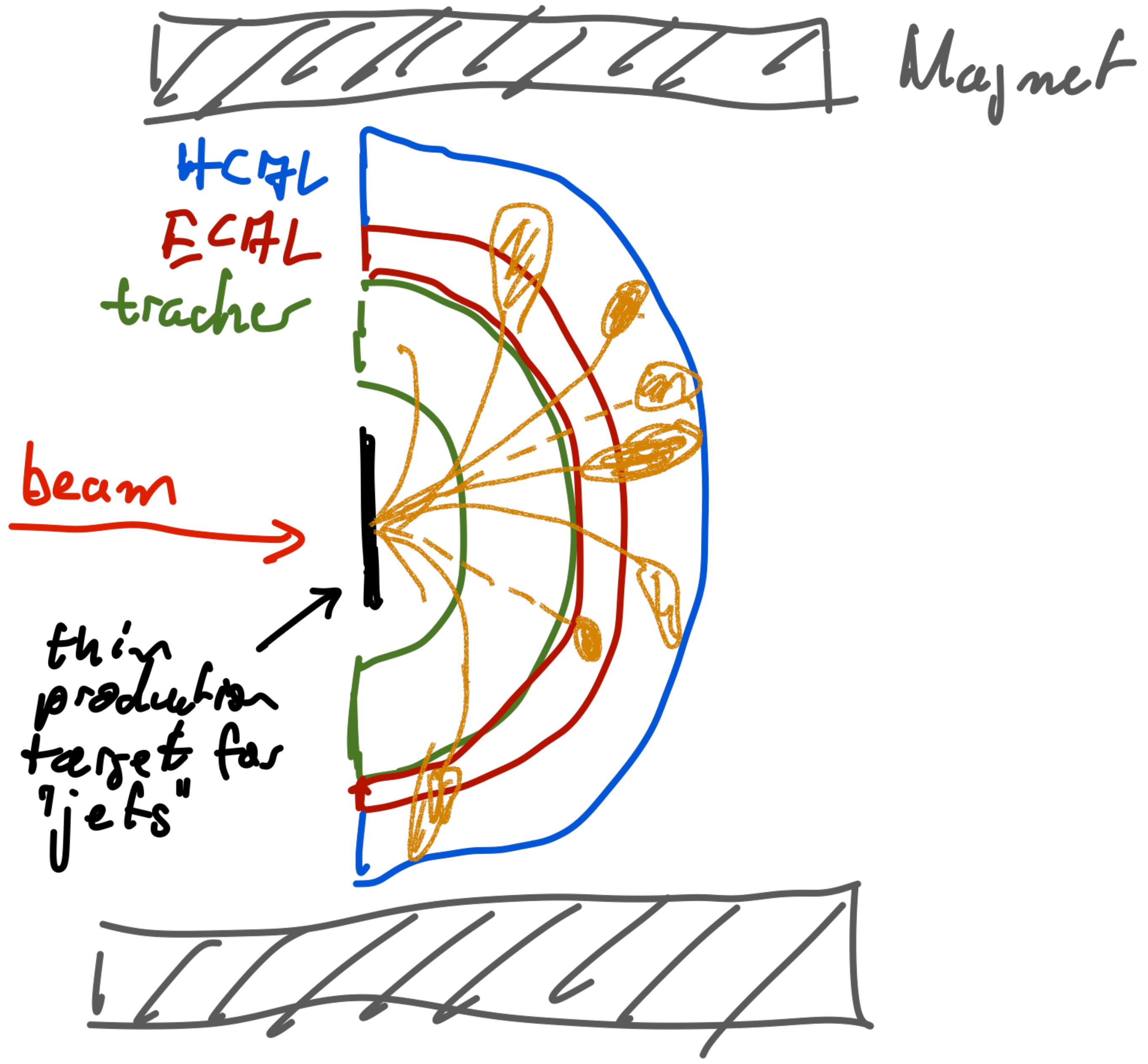


… and even with such a setup there are limitations:
jet energy not very well defined, particle composition, …

Validating PFA Performance

Possible Approaches

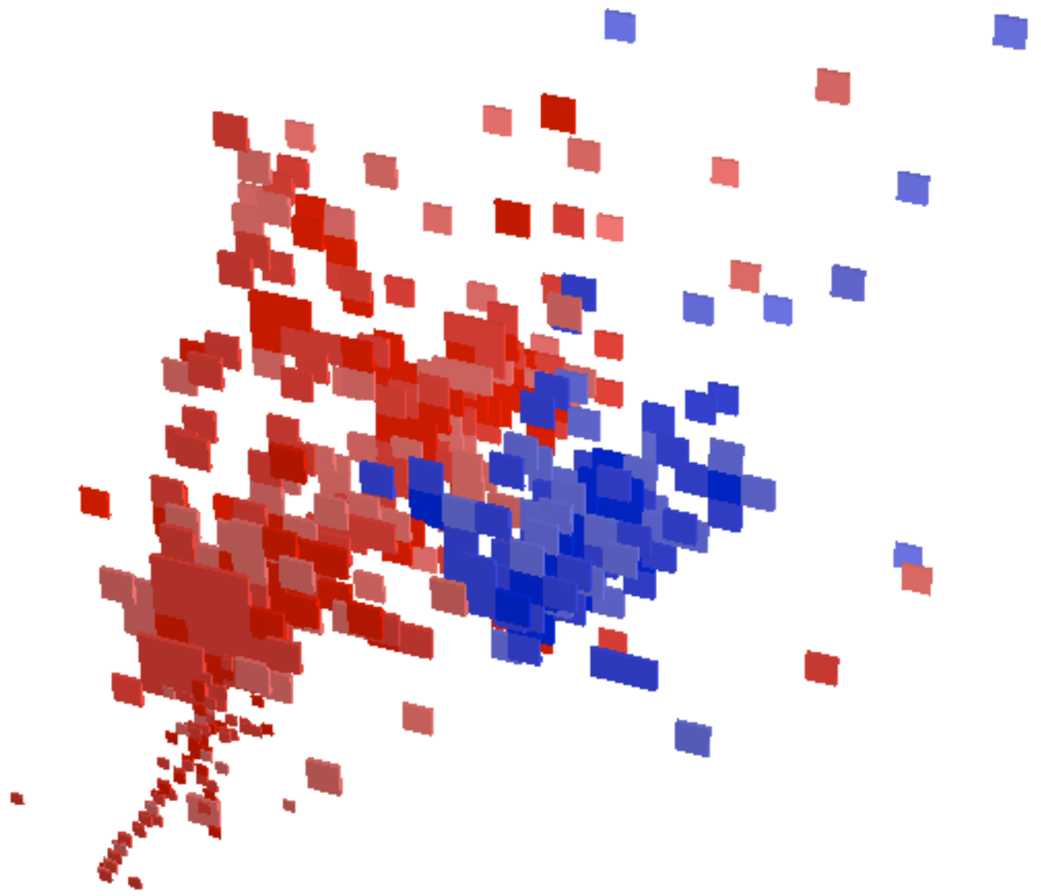
- A fully realistic test of PFA in a test beam is (close to) impossible
  - requires “jets”, tracking and momentum measurement & calorimetry covering all particles

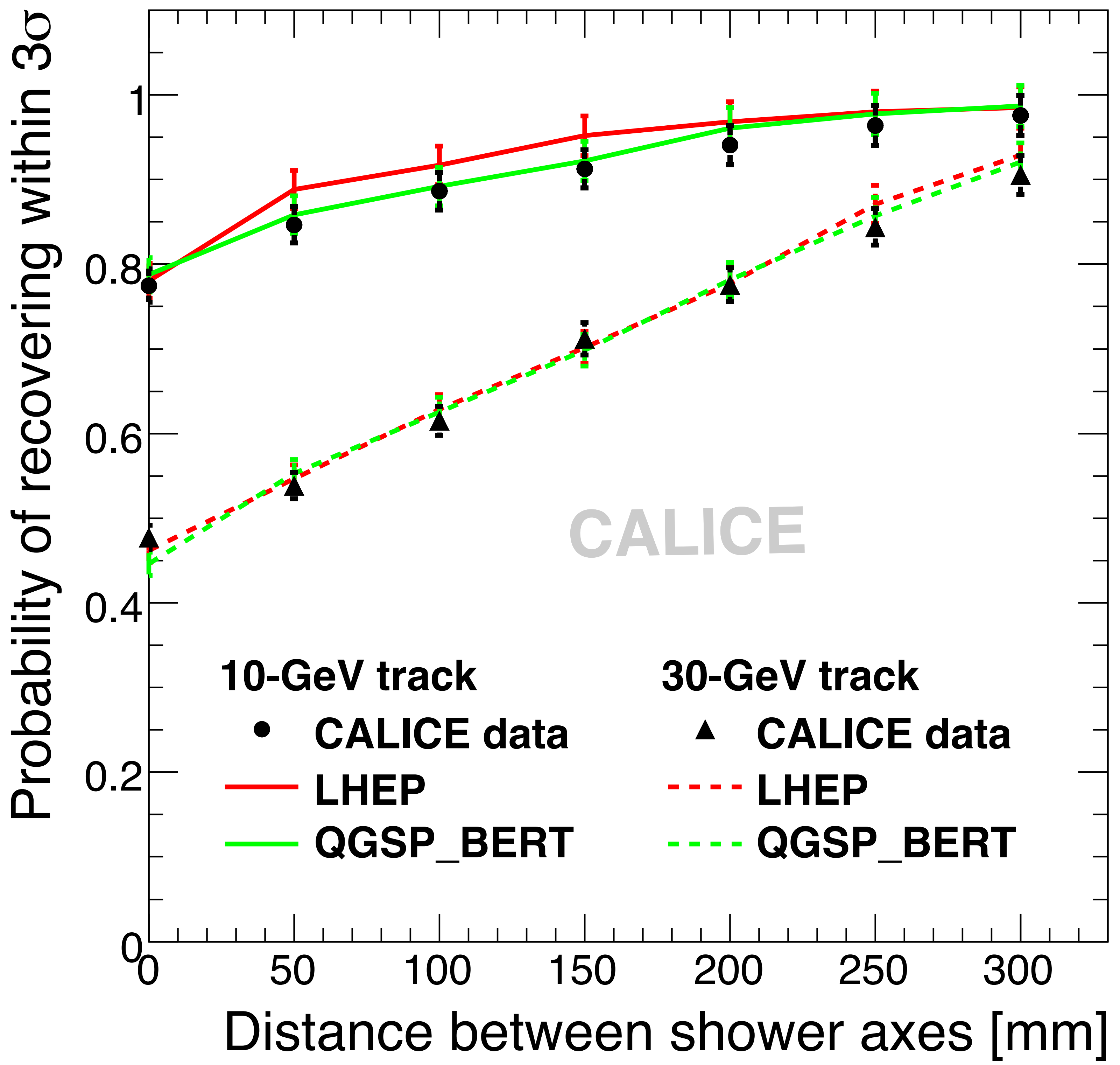


… and even with such a setup there are limitations:
jet energy not very well defined, particle composition, …

➯ The CALICE approach: Factorize the problem: Full PFA in simulations, test individual ingredients in beams

For calorimeters: Energy reconstruction, resolution and two-particle separation



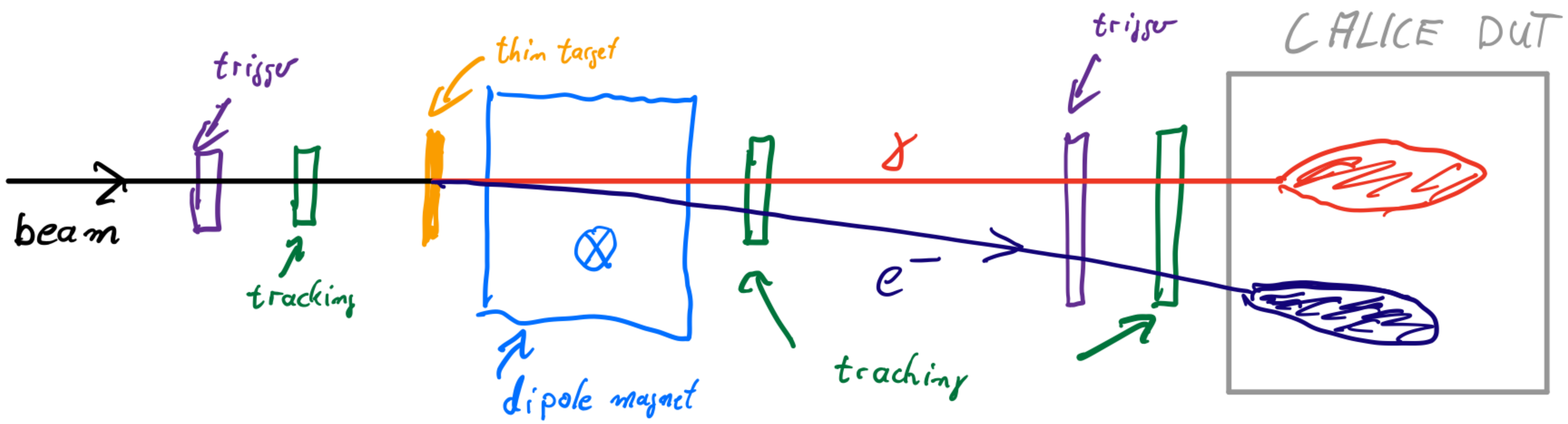


Validating PFA Performance

Possible Approaches

- Still, combined measurements of tracking and calorimetry remain interesting - and in some cases this can also be done with reasonable effort in beam tests:

- One example: Tagged photons - can be used to test electron / photon separation, bremsstrahlung recovery, …



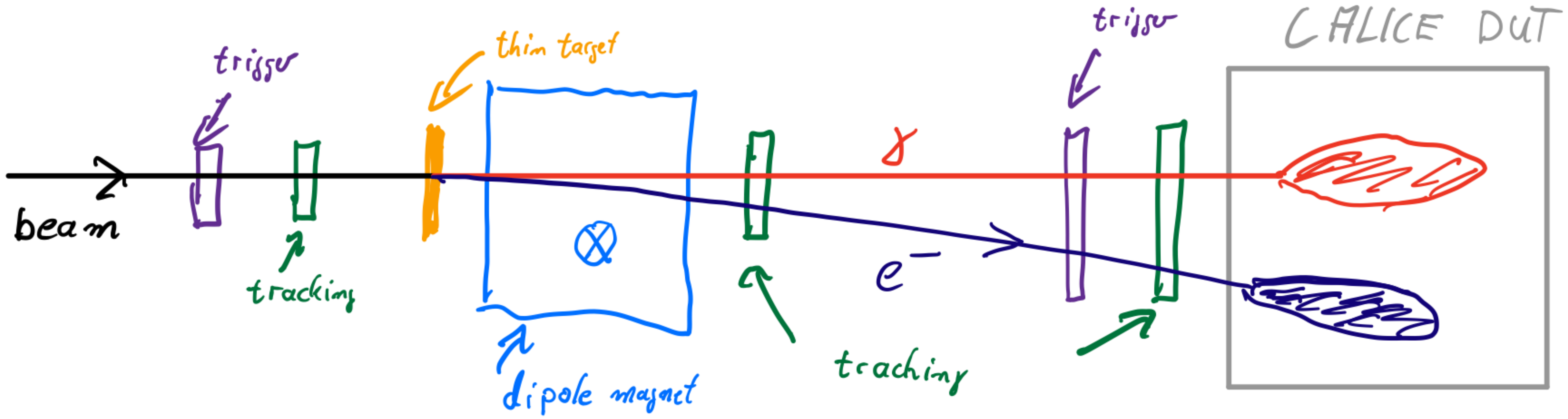
… has for example been used to study a very compact SiW ECAL for luminosity measurements at Linear Colliders

Validating PFA Performance

Possible Approaches

- Still, combined measurements of tracking and calorimetry remain interesting - and in some cases this can also be done with reasonable effort in beam tests:

- One example: Tagged photons - can be used to test electron / photon separation, bremsstrahlung recovery, …



… has for example been used to study a very compact SiW ECAL for luminosity measurements at Linear Colliders

- For hadrons this is much more difficult - impossible to tag neutral hadron energy in that way…: Combined measurements of tracking and calorimetry with a target can be made, but there is very little control - unlikely to yield quantitative performance results, but useful as an integration exercise

A Note on Occupancies

Very naive ballpark numbers

- In a AHCAL with 3 x 3 cm^2 cells: Typically ~ 10 cells / GeV hadronic energy: At most a few 1000 active cells for a typical hadronic event at CEPC

➫ Backgrounds will be a (the?) key occupancy and data volume driver

A Few Thoughts on Cost

Based on AHCAL estimates for ILD, mainly

- General cost structure of the system:
  - ~ 22% fixed costs (services, high level interfaces, …)
  - ~ 22% scale with the volume of the detector (primarily absorber cost)
  - ~ 33% scale with the area covered by active layers (PCBs, scintillator)
  - ~ 22% scale with the number of channels (SiPMs, ASICs)

- Looking at the costs of a scintillator cell:
  - 74% SiPM
  - 15% Scintillator
  - 11% Reflector foil

~ 25% of total cost

- ASIC costs are ~ 25% of the cell + SiPM costs

- Looking at the PCB costs:
  - Fully assembled ~ 115% of corresponding cell + SiPM costs (almost as much as cell + SiPM + ASIC)

➪ a key cost driver!

A Few Thoughts on Power

All based on power pulsing

- Detector elements:
  - ASICs ~ 25 μW / channel (with a 1% duty cycle - target values, current prototypes ~ 5x higher)
  - SiPMs ~ 15 μW / channel
- On-detector electronics:
  - Interfaces per layer (and module) ~ 10 W (current numbers, with PP)
  - Data concentrators per module ~ 20 W

Key challenges for CEPC:

- ASIC power consumption - and need for cooling in active layers
- Also relevant: layer-wise interfaces