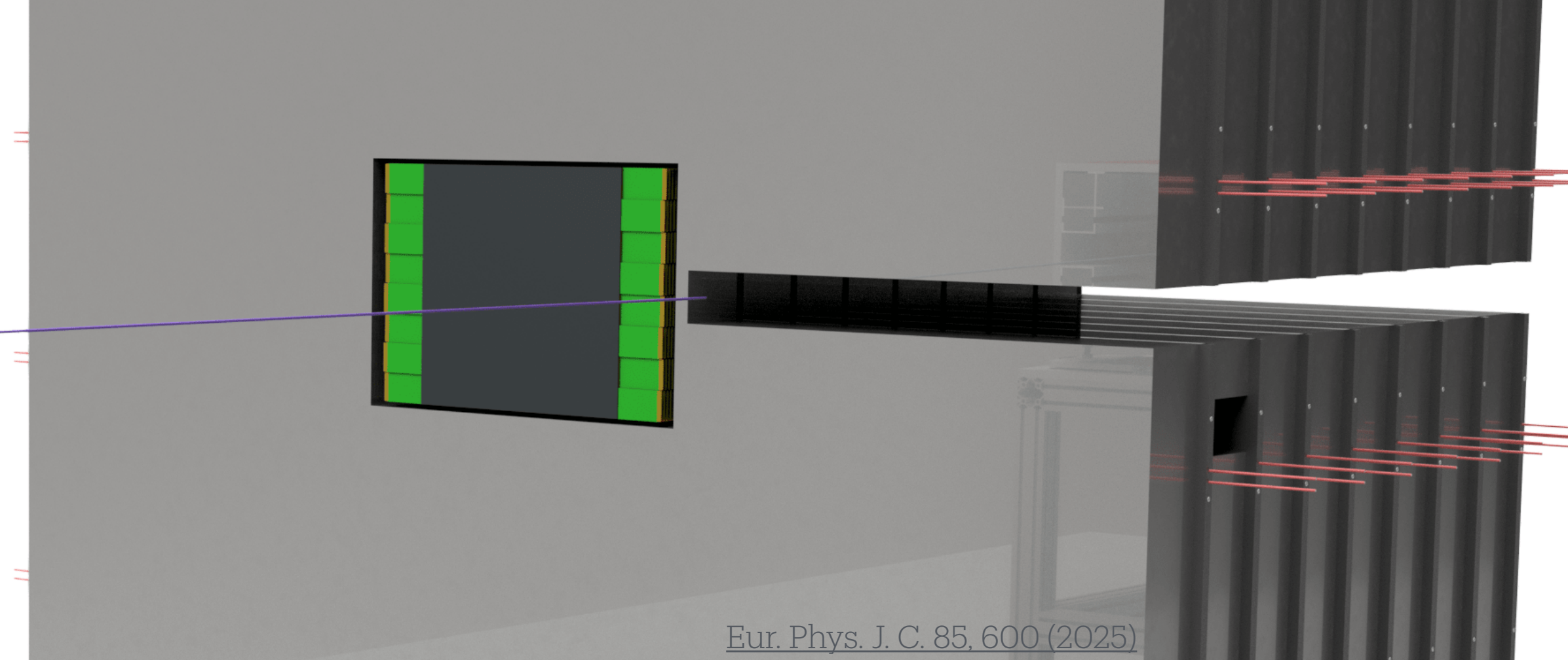
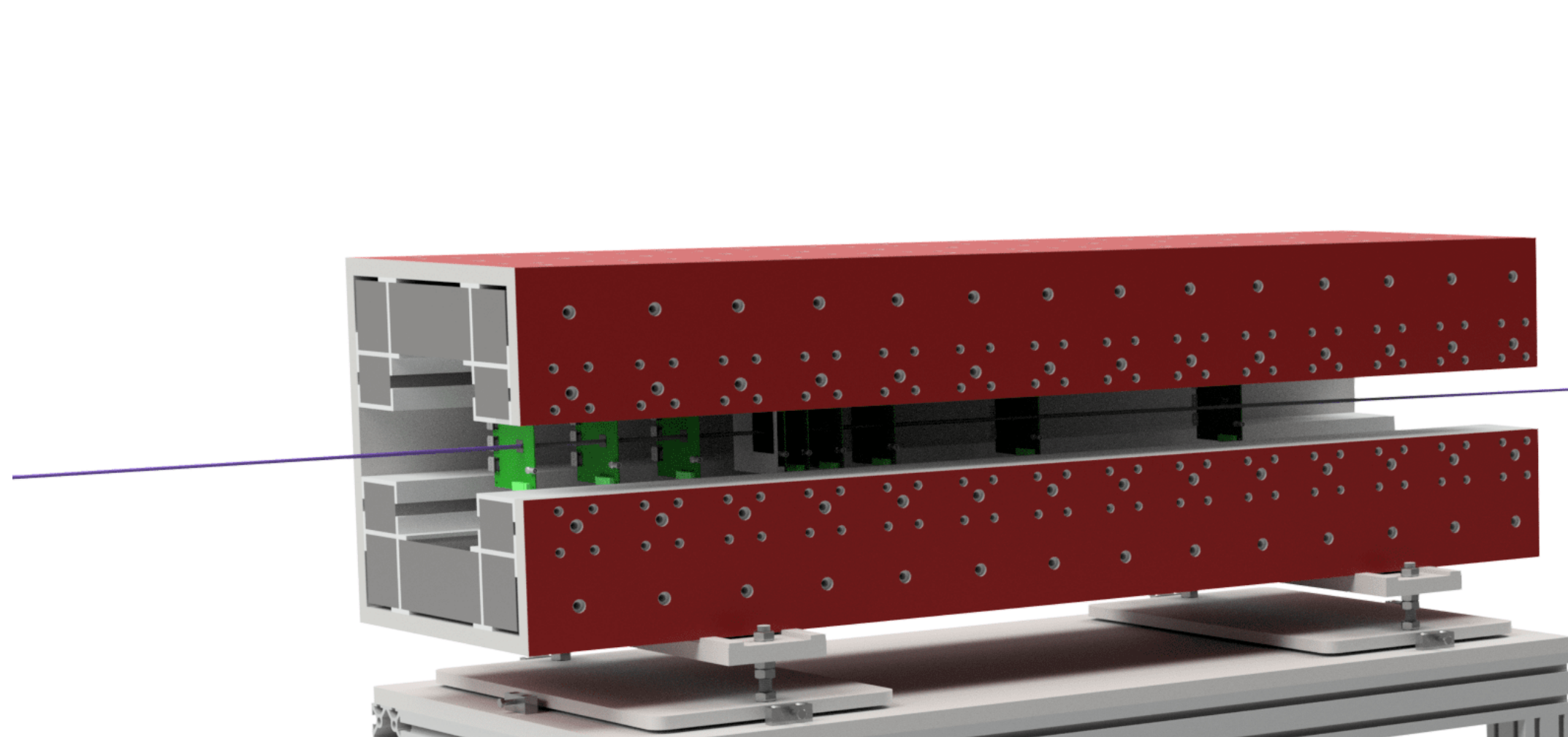


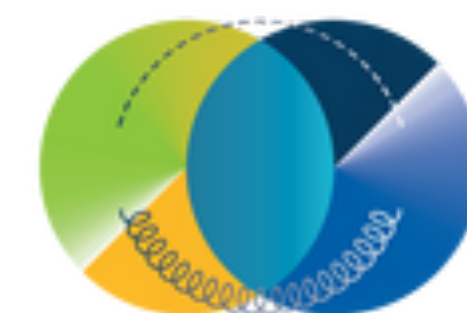


The Lohengrin Experiment

Cedric Breuning for the Lohengrin Study Group
01.10.2026 — LDM Workshop Bonn

Philip Bechtle¹, Christian Bepin¹, Dominique Breton², Cedric Breuning¹, Carlos Orero Canet⁴, Klaus Desch¹, Herbi Dreiner¹, Oliver Freyermuth¹, Rhorry Gauld^{1,3}, Markus Gruber¹, Cesar Blanch Gutierrez⁴, Hayem Hajjar¹, Matthias Hamer¹, Jan-Eric Heinrichs¹, Adrian Irles⁴, Jochen Kaminski¹, Laney Klippfahn¹, Nico Klein¹, Hans Krüger¹, Cemre Kurt, Michael Lupberger¹, Jihane Maalmi², Roman Pöschl², Dennis Proft¹, Leonie Richarz^{1,6}, Tobias Schiffer¹, Patrick Schwäbig¹, Martin Schürmann¹, Mika Thein¹, Emma Thier¹, Carla Vermöhlen¹, Dirk Zerwas⁵

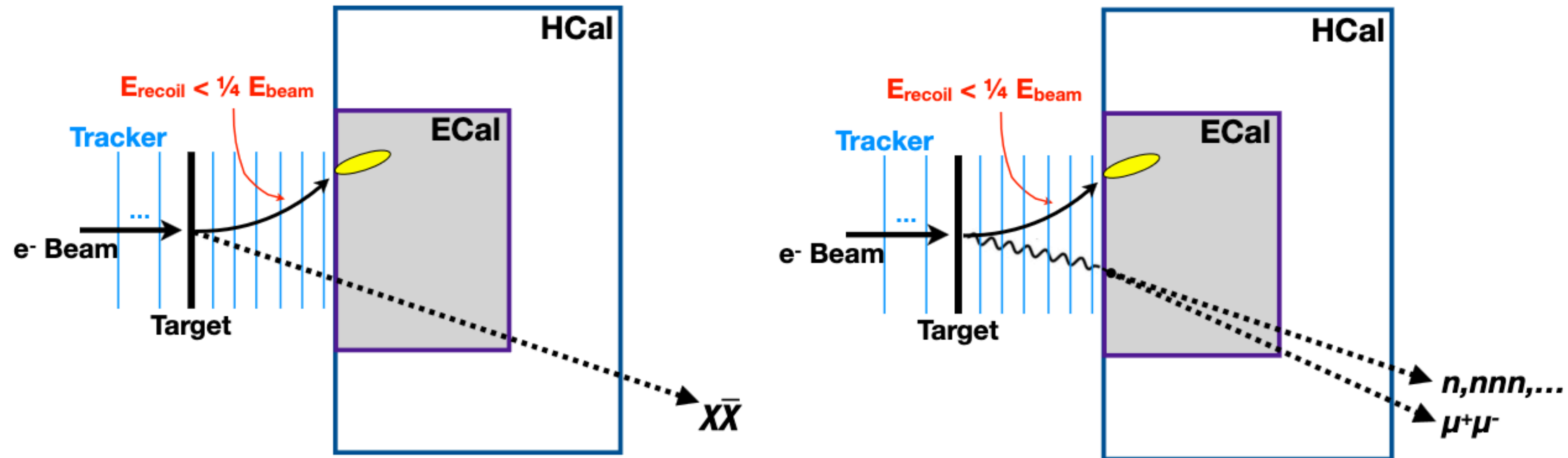
¹ Physikalisches Institut, University of Bonn | ² IJCLab Orsay | ³ Werner-Heisenberg-Institute, MPP Garching | ⁴ IFIC, Valencia | ⁵ DMLab, DESY/IN2P3/CNRS | ⁶ NTNU Norway



color meets flavor

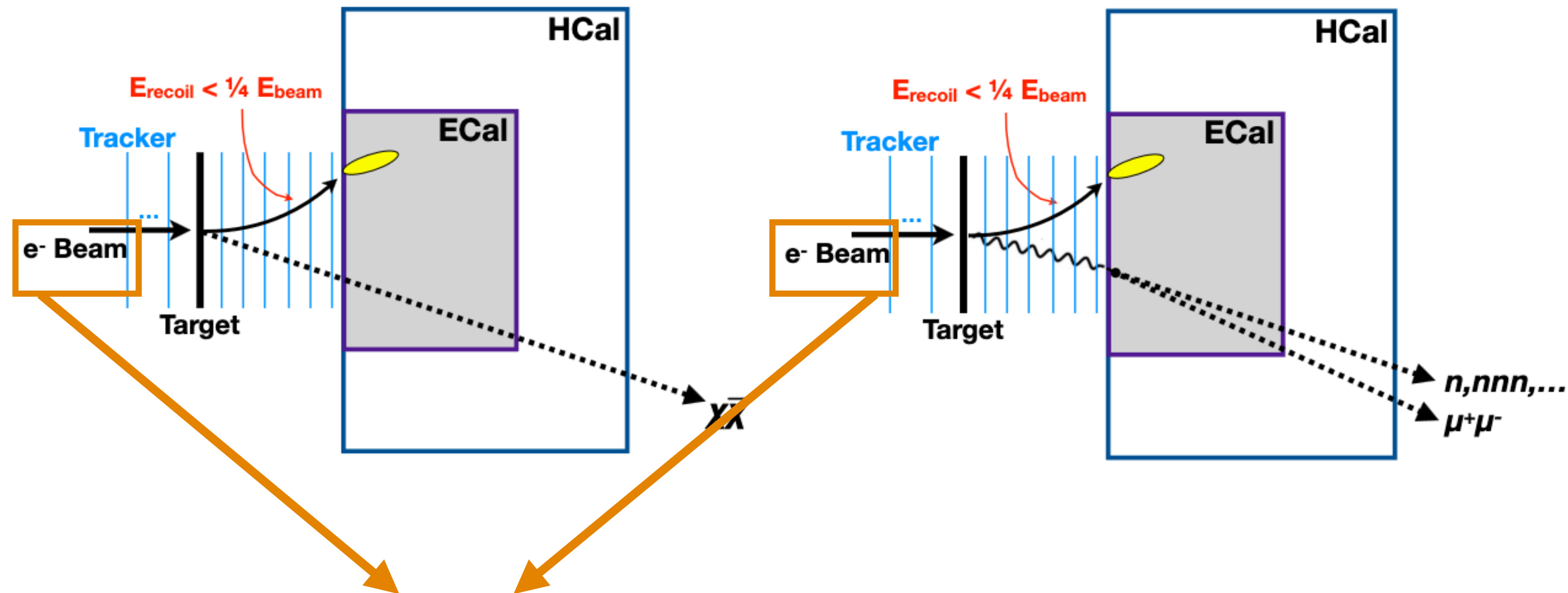
The idea

LDMX Proposal
[arXiv:2508.11833](https://arxiv.org/abs/2508.11833)



The idea

LDMX Proposal
[arXiv:2508.11833](https://arxiv.org/abs/2508.11833)



We also have something like that: **ELSA**

ELSA

$$\frac{\langle N_e \rangle}{\text{Event}} \leq 1$$

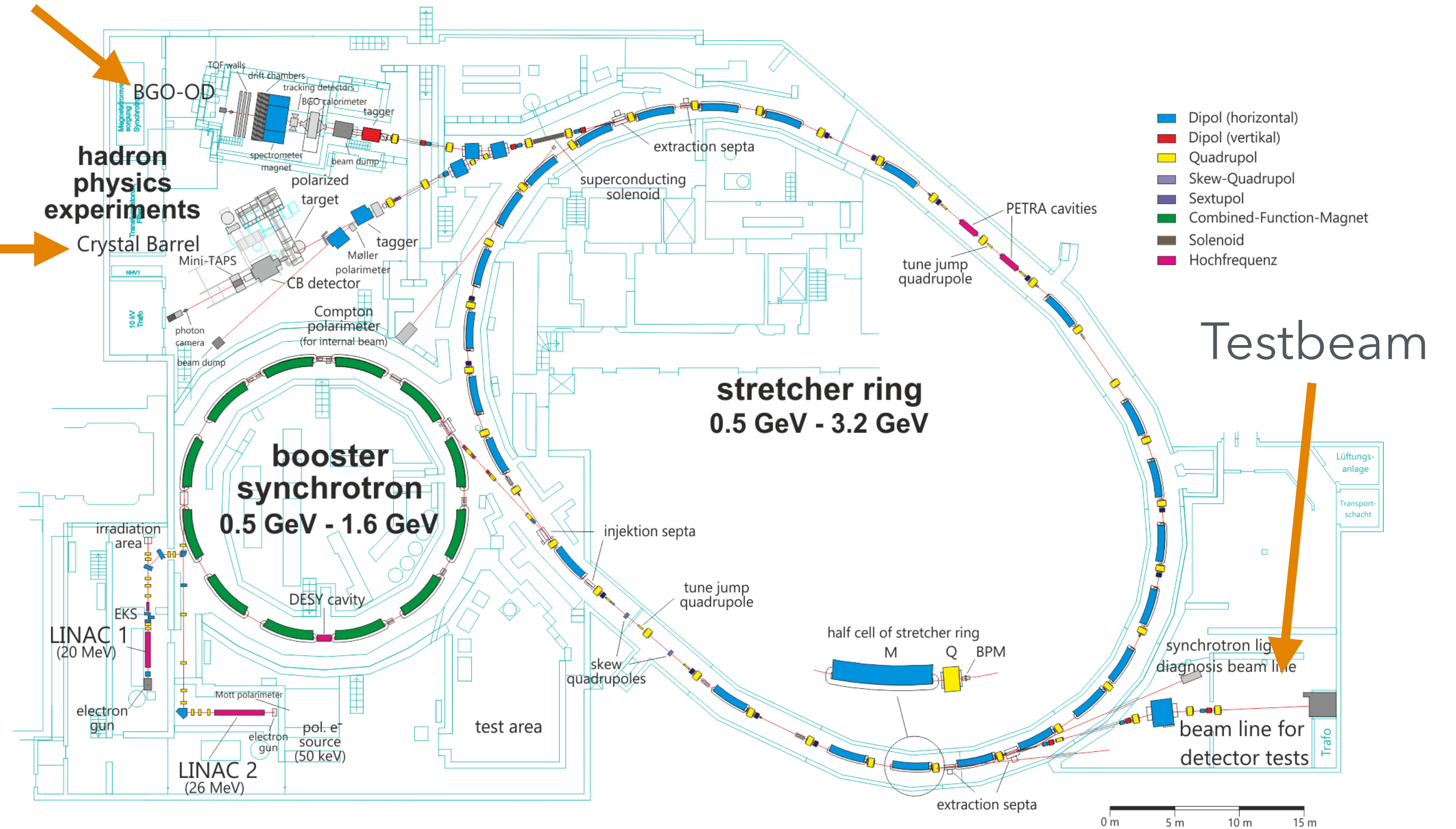
$$R_e = 500 \text{ MHz} \\ \rightarrow \frac{\langle N_e \rangle}{2 \text{ ns}} = 0.2$$

$$E_e \leq 3.2 \text{ GeV} \\ \sigma_E = 0.08 \%$$

Decomission

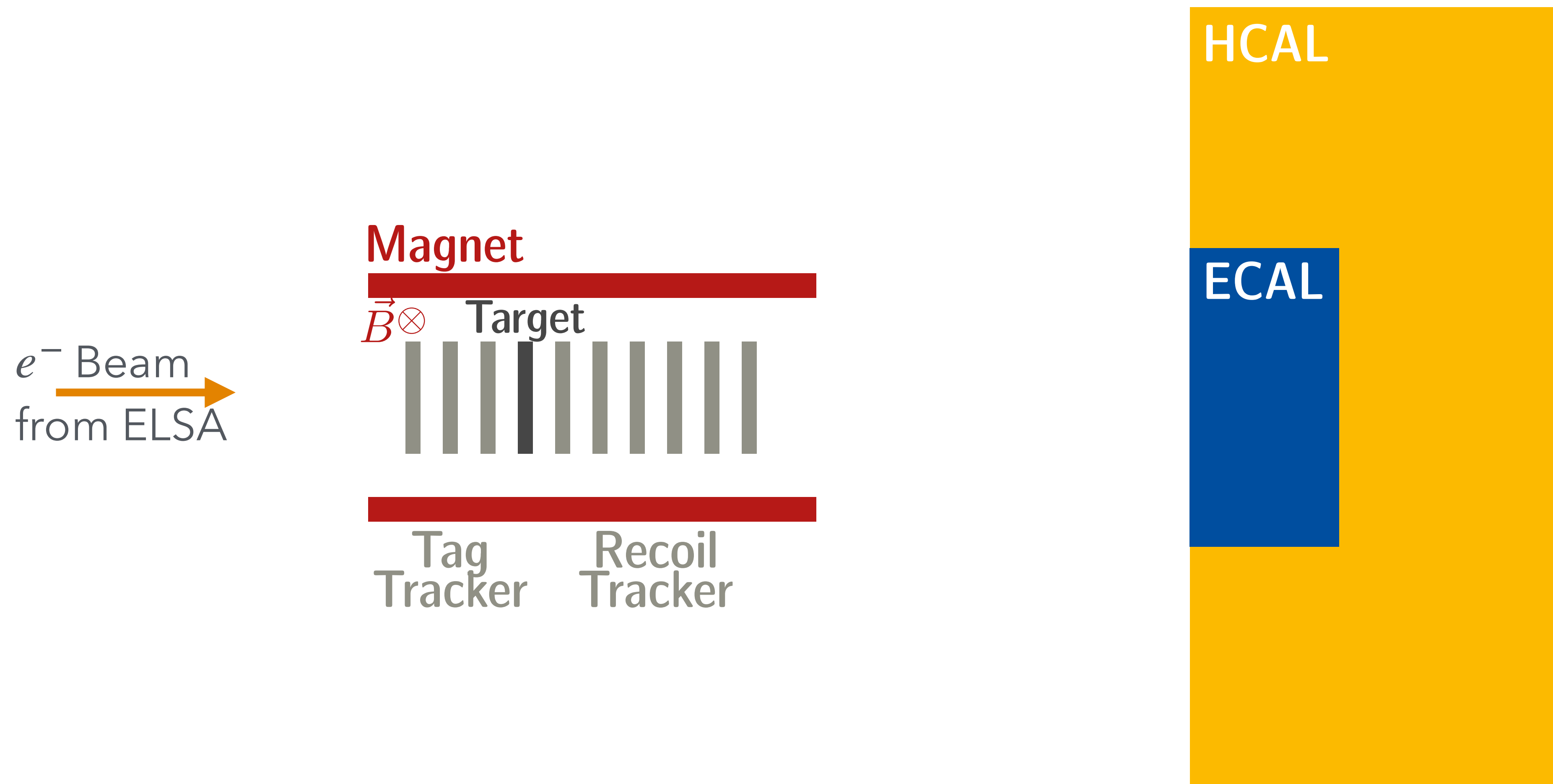
Insight
@ ELSA

Electron Stretcher Accelerator (ELSA)



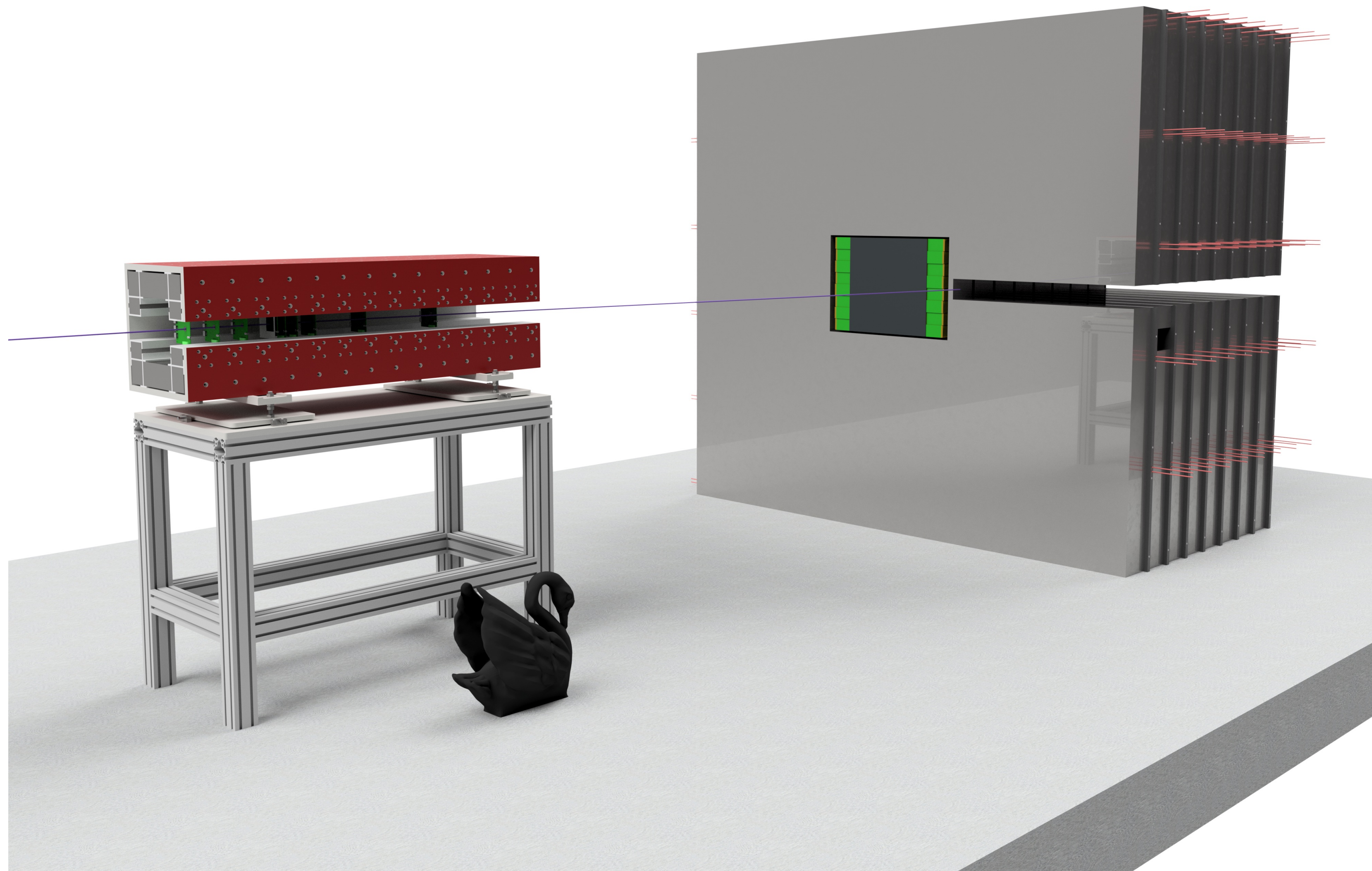
The Lohengrin Experiment

Sketch



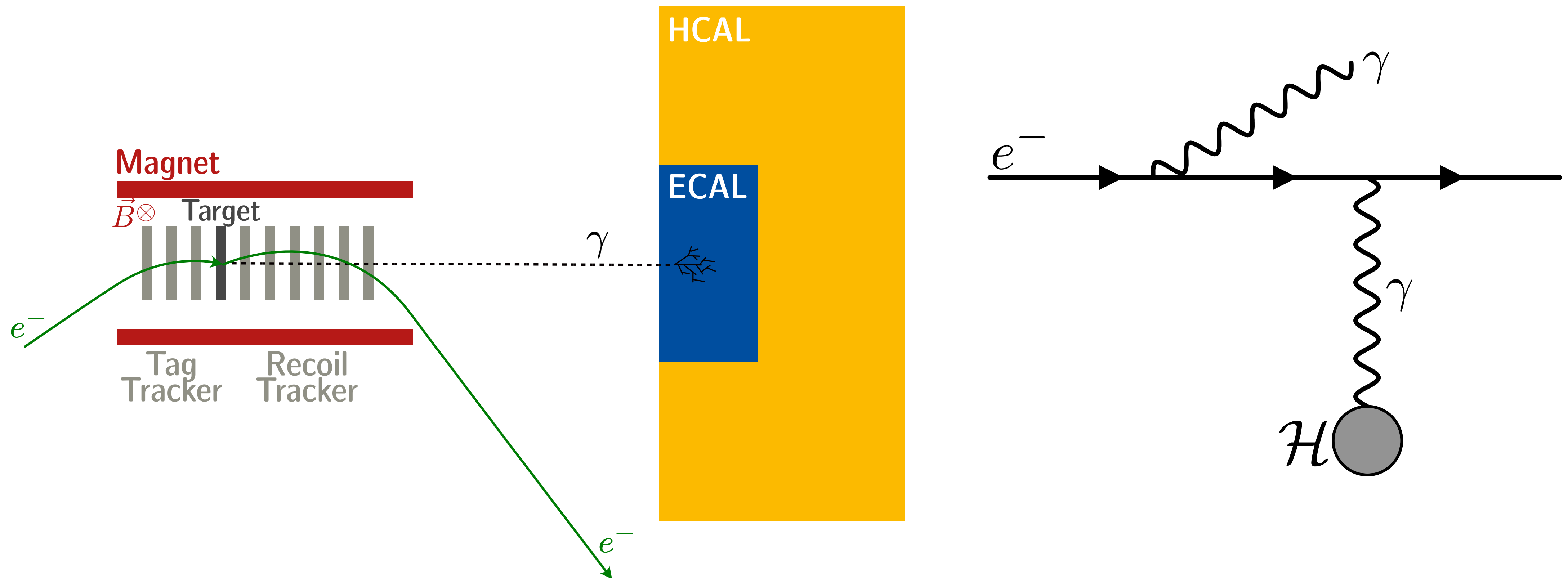
The Lohengrin Experiment

Render



Lohengrin Experiment Concept

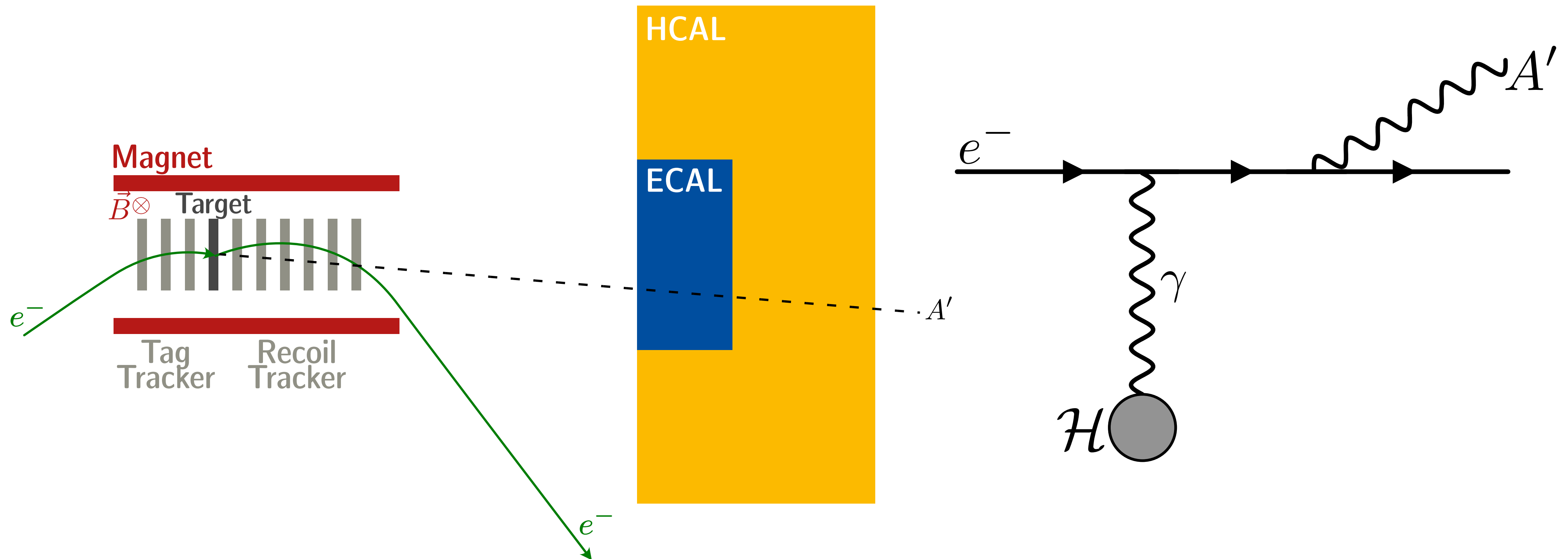
QED Bremsstrahlung



→ Low energetic recoil electron + ECAL Signal

Lohengrin Experiment Concept

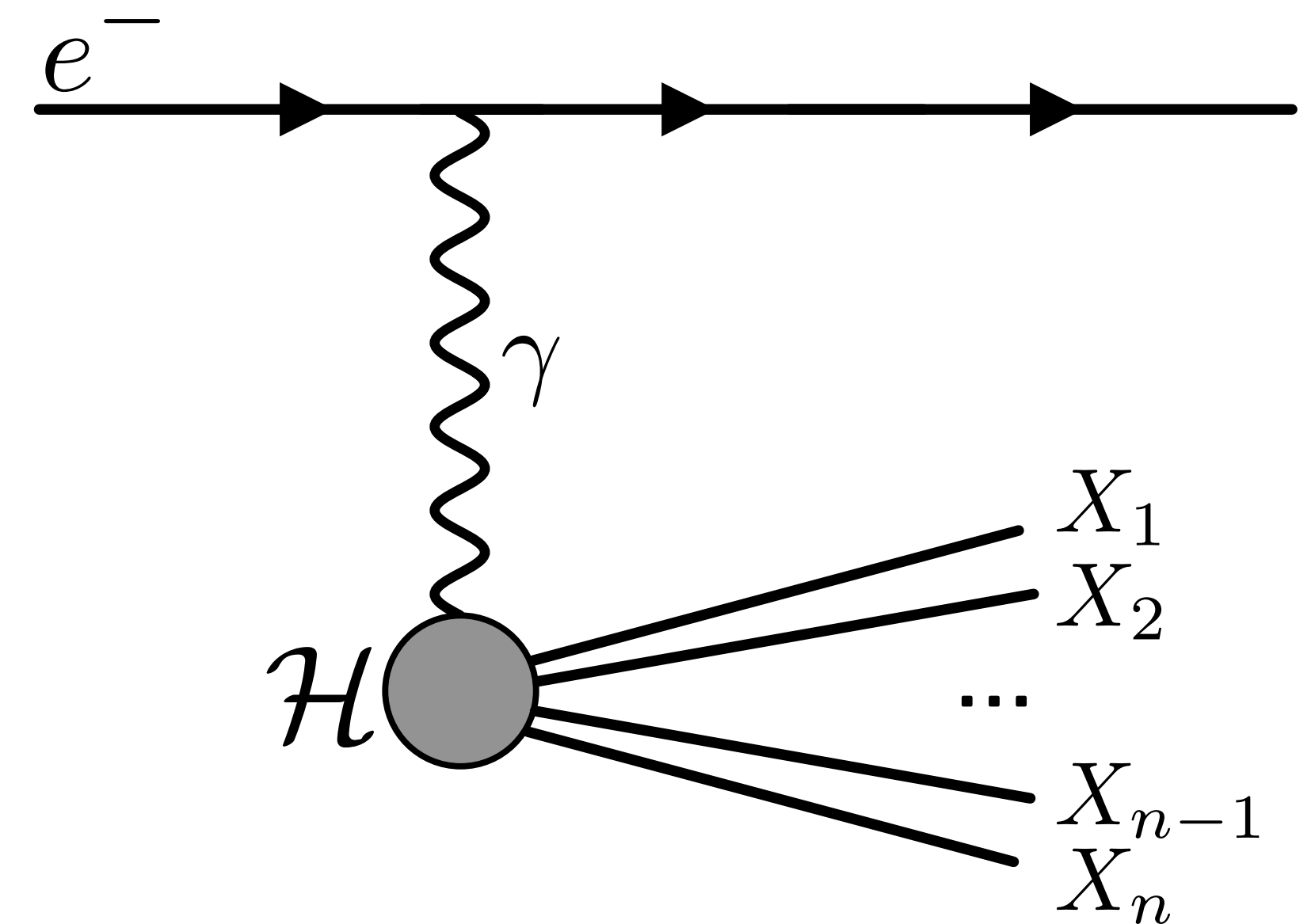
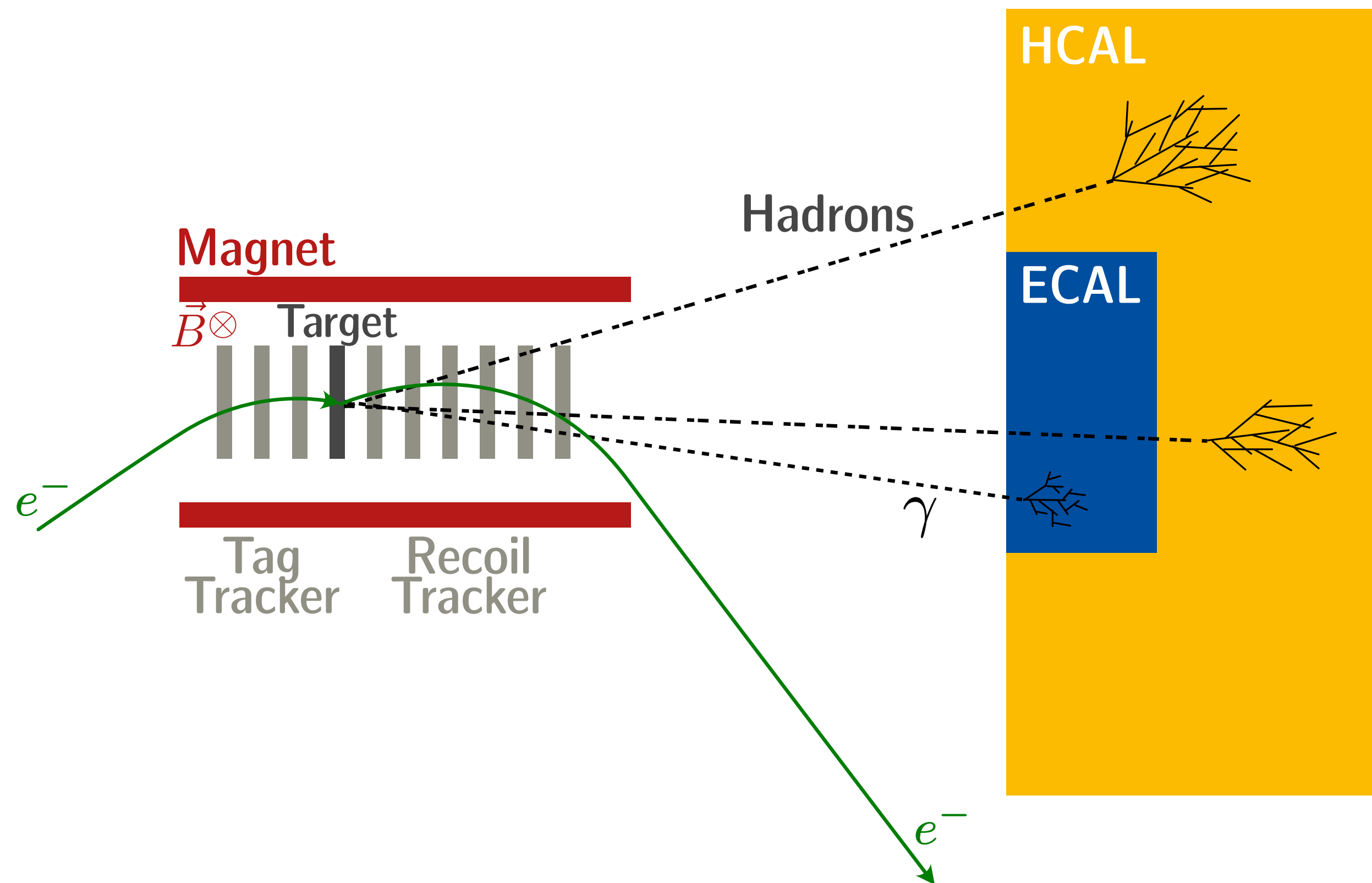
Dark Bremsstrahlung



→ Low energetic recoil electron

Lohengrin Experiment Concept

Electro Nuclear Reactions

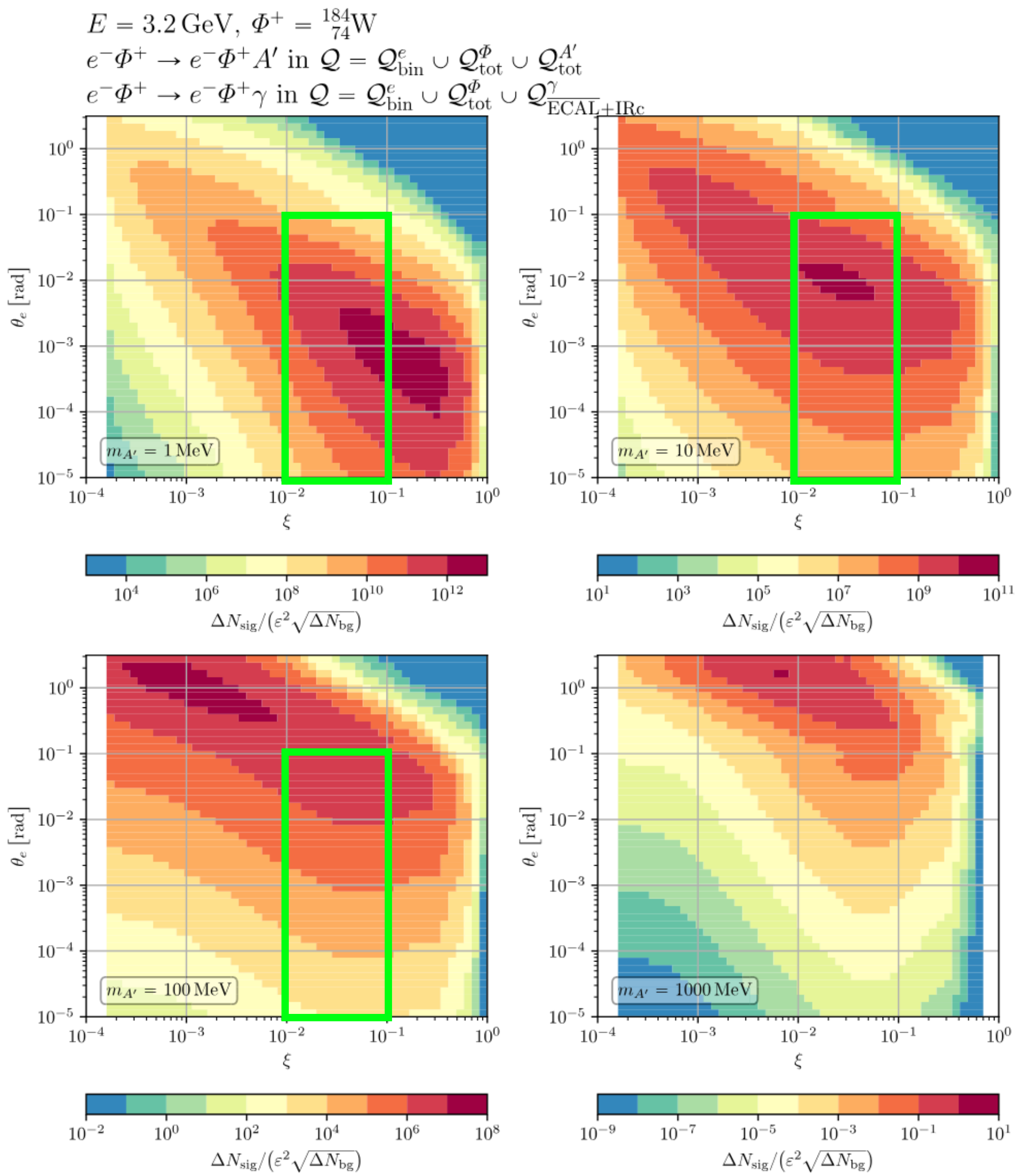


→ Low energetic recoil electron + ECAL/HCAL Signal

Where are we looking



Recoil e^- polar angle



Assuming a perfect detector...

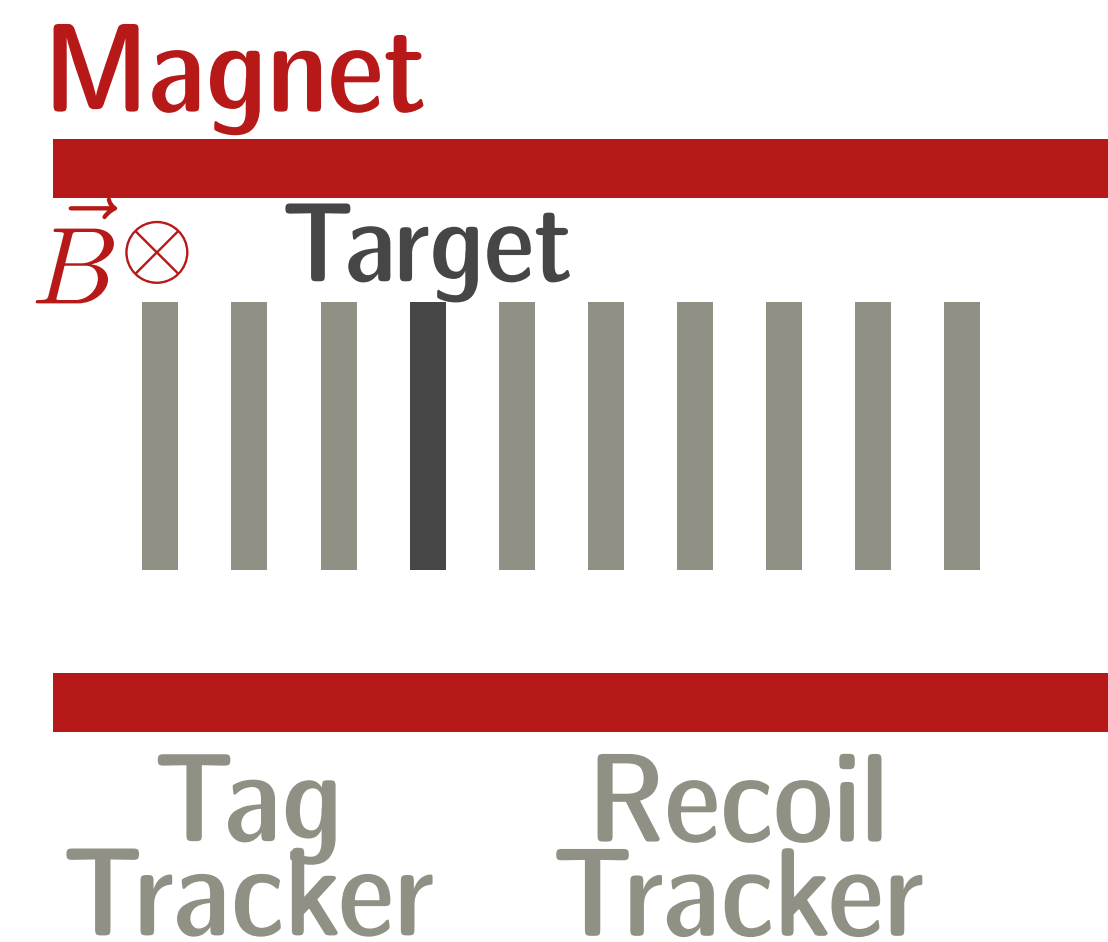
Green Area: promising for $m_{A'} \in [1,100] \text{ MeV}$

A' Mass [MeV]	ε^2	Run Days to produce 100 A'
4.5	$O(10^{-11})$	$O(10^2) - O(10^3)$
10	$O(10^{-10})$	$O(10^2) - O(10^3)$
100	$O(10^{-8})$	$O(10^2) - O(10^3)$
1000	$O(10^{-7})$	$O(10^8) - O(10^9)$

Recoil e^- energy fraction

The Lohengrin Experiment

Simulation

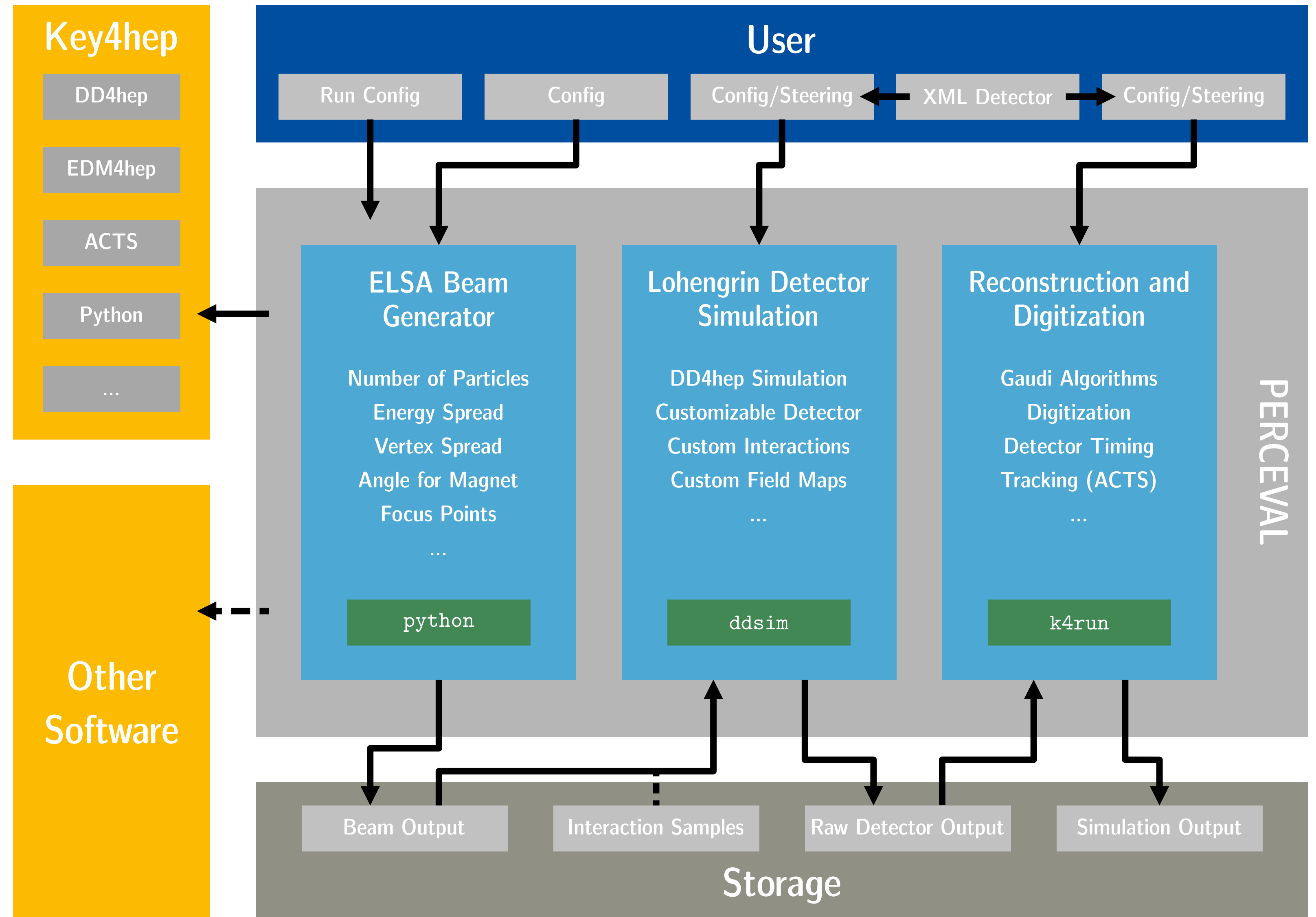


PERCEVAL

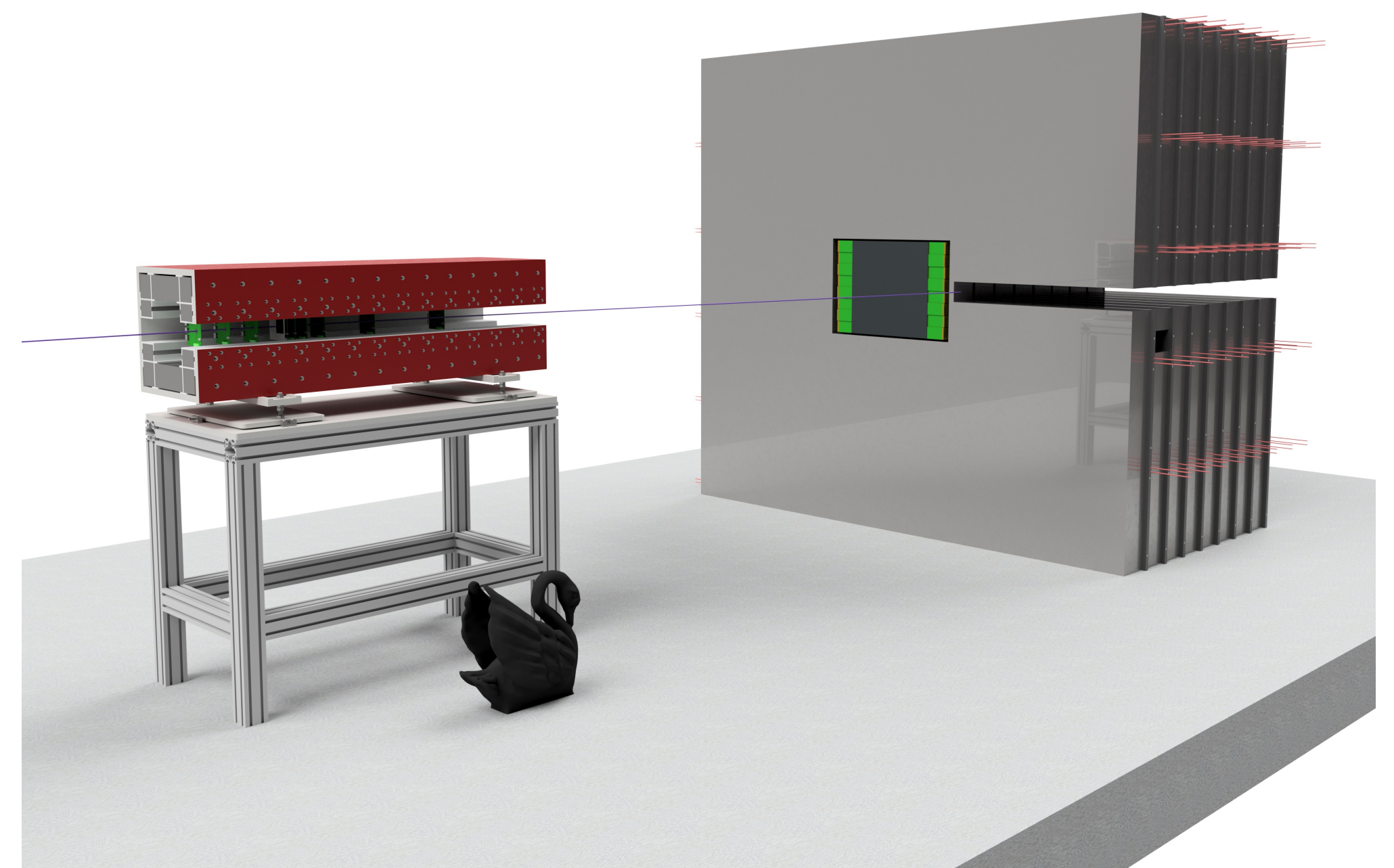
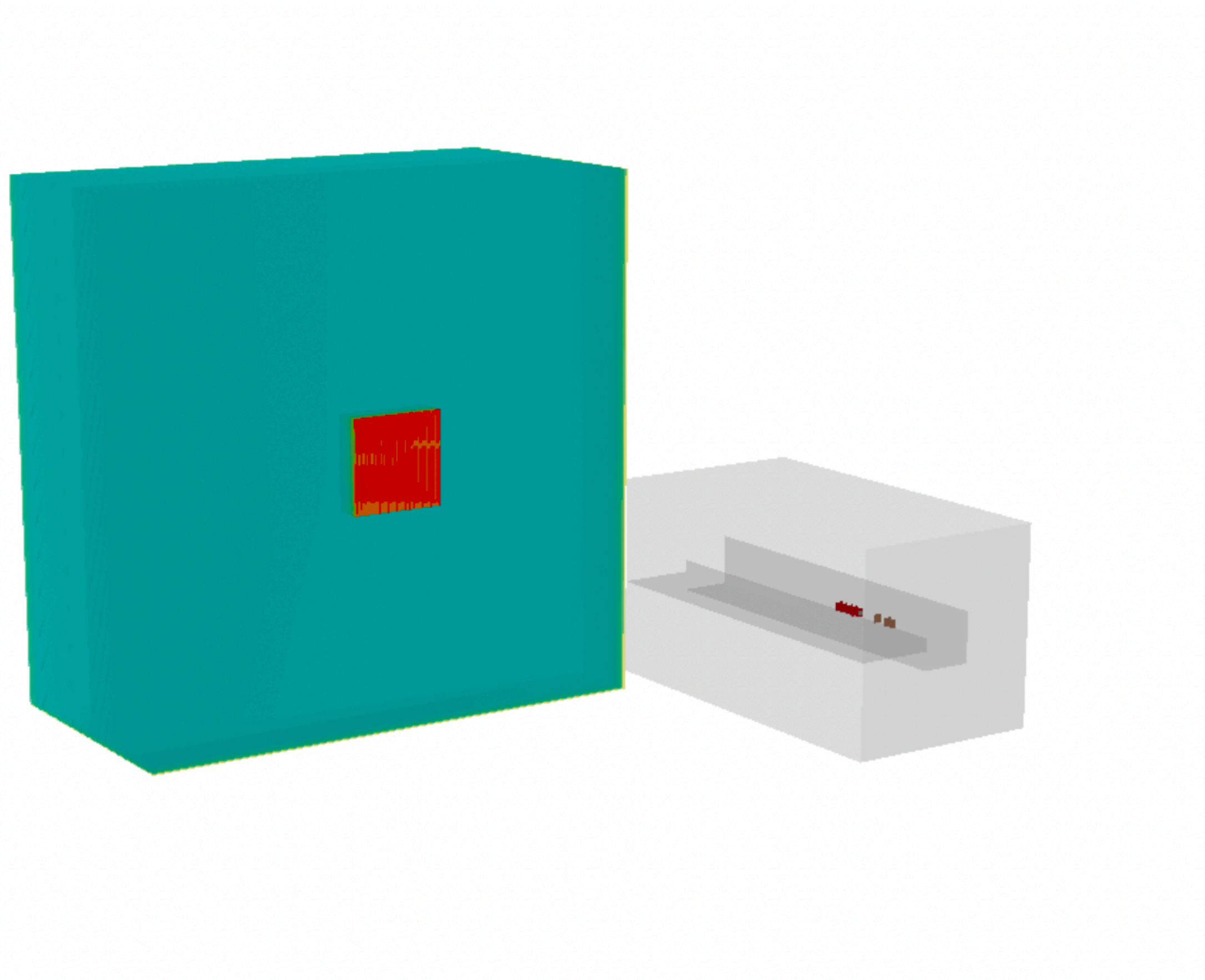
Requirements:

- Use existing solutions where possible
- Allow flexible changes in the setup
- Plugin custom interactions
- ...

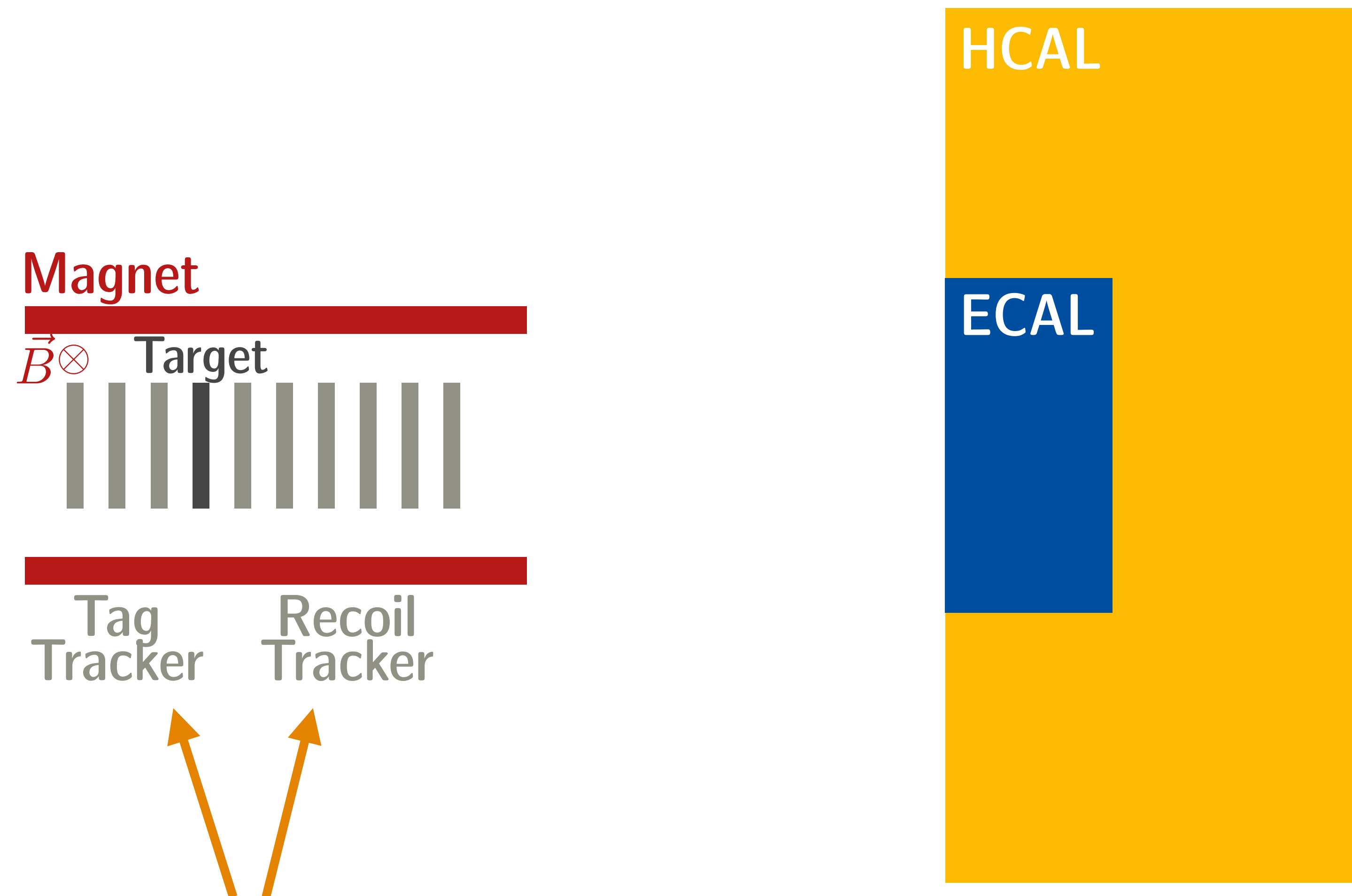
→ Key4hep, ACTS,...



DD4hep setup

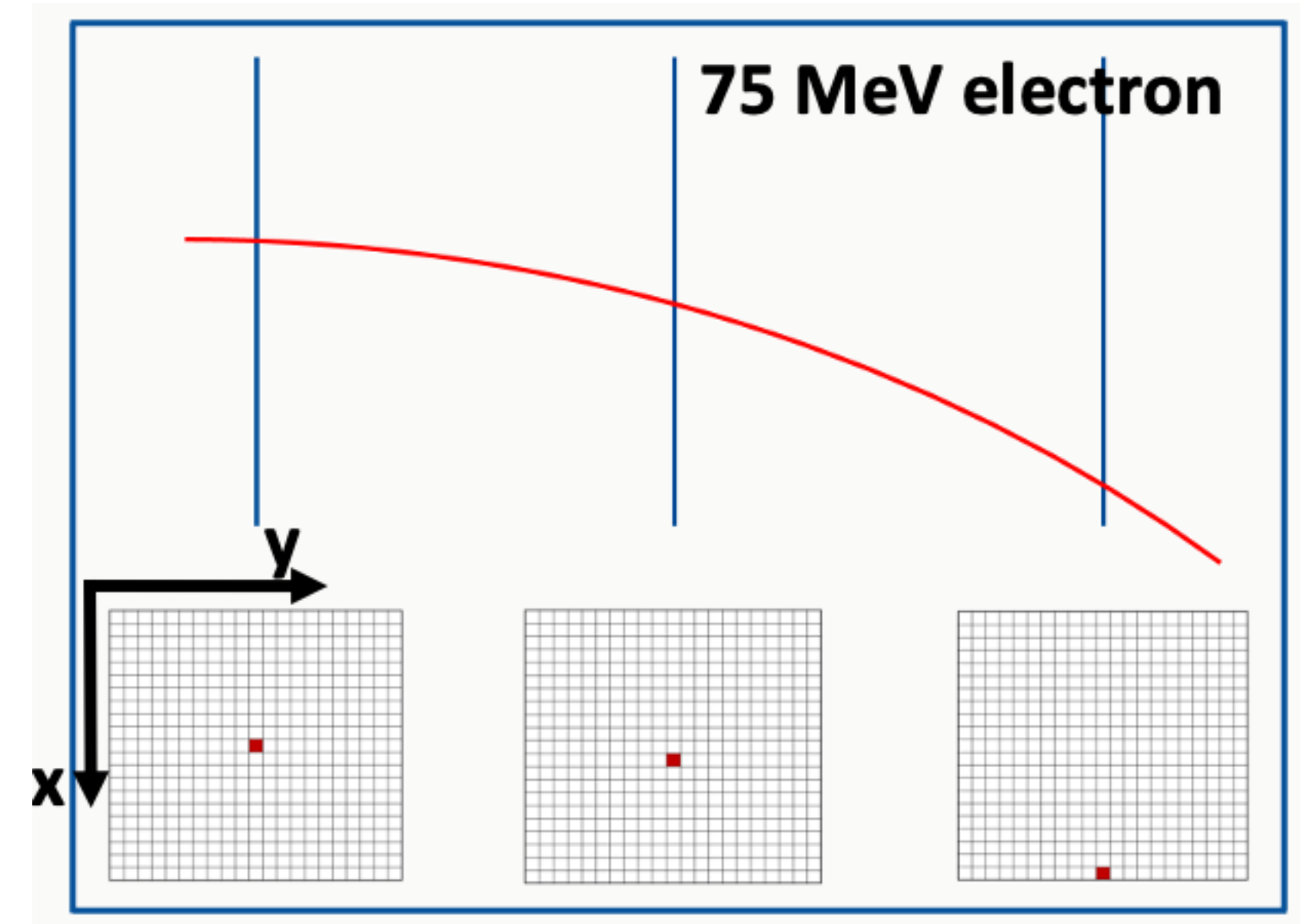
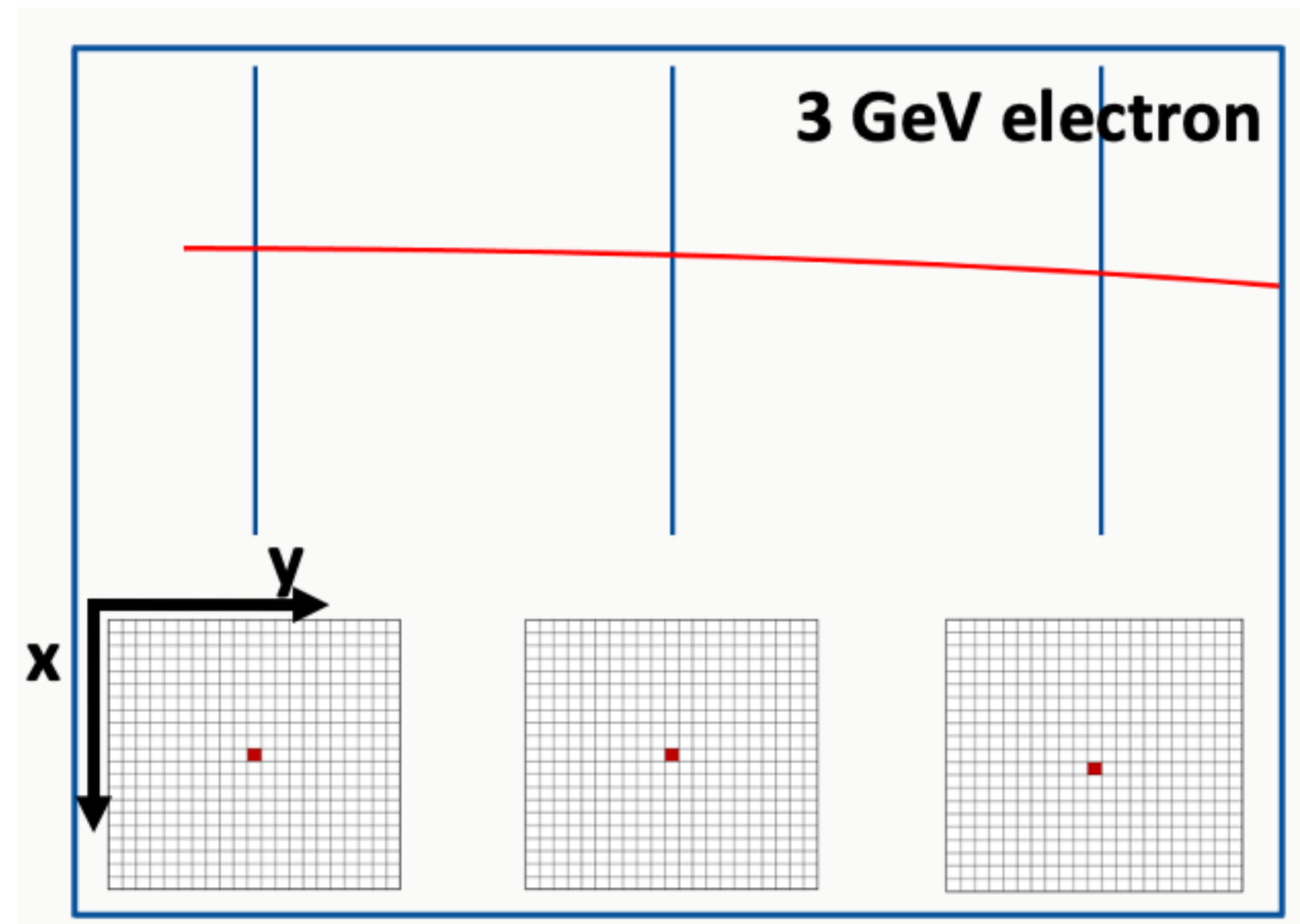


The Lohengrin Experiment



Lohengrin L0-Trigger

L0-Trigger: Event reduction by factor 10-20

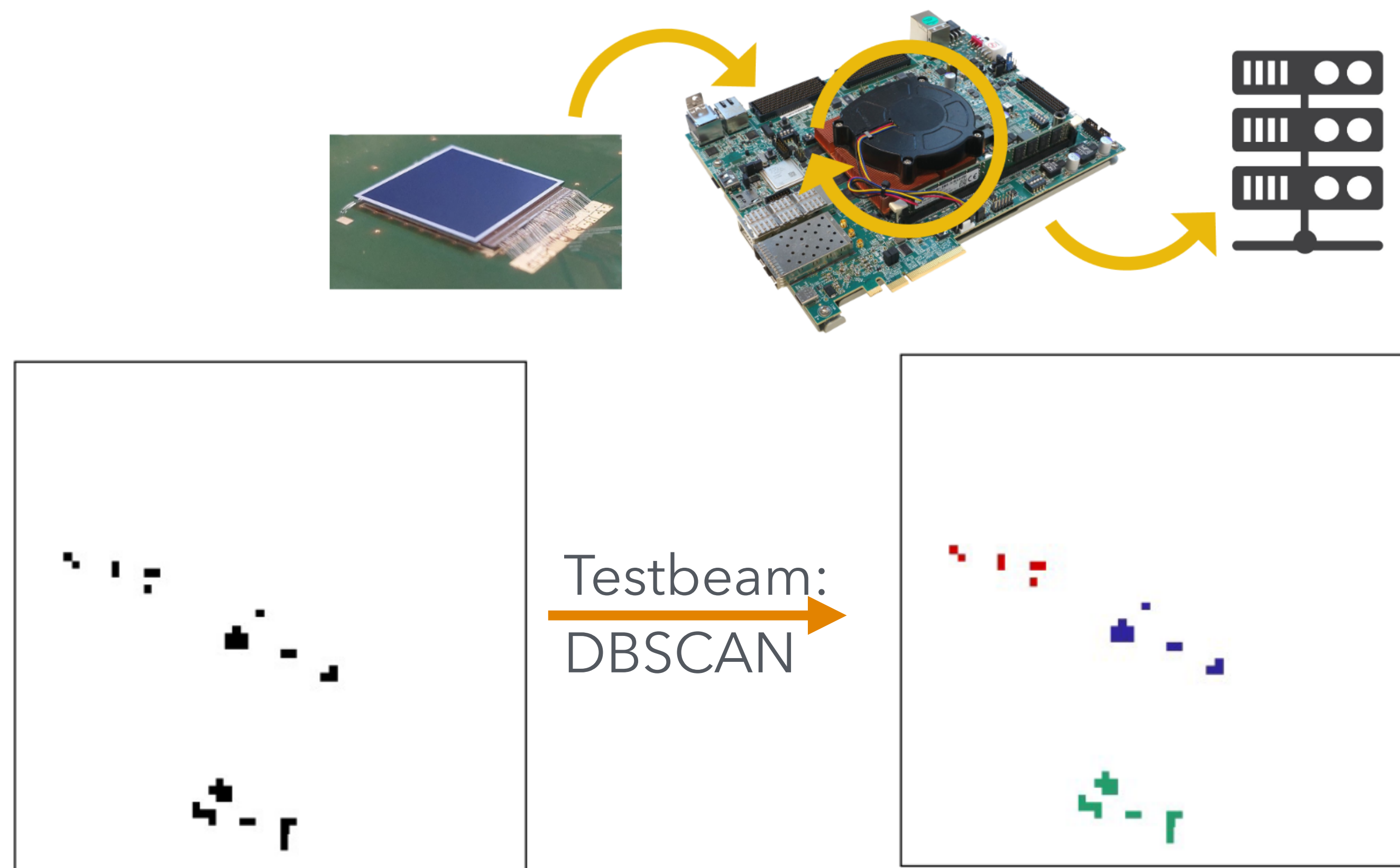


Column	Rows	chip0 → chip1	chip1 → chip0
5	400, 200	29.89 ns	21.68 ns
100	329, 160	23.59 ns	19.71 ns
219	480, 48	62.63 ns	54.31 ns
220	128, 124	2.54 ns	-0.36 ns

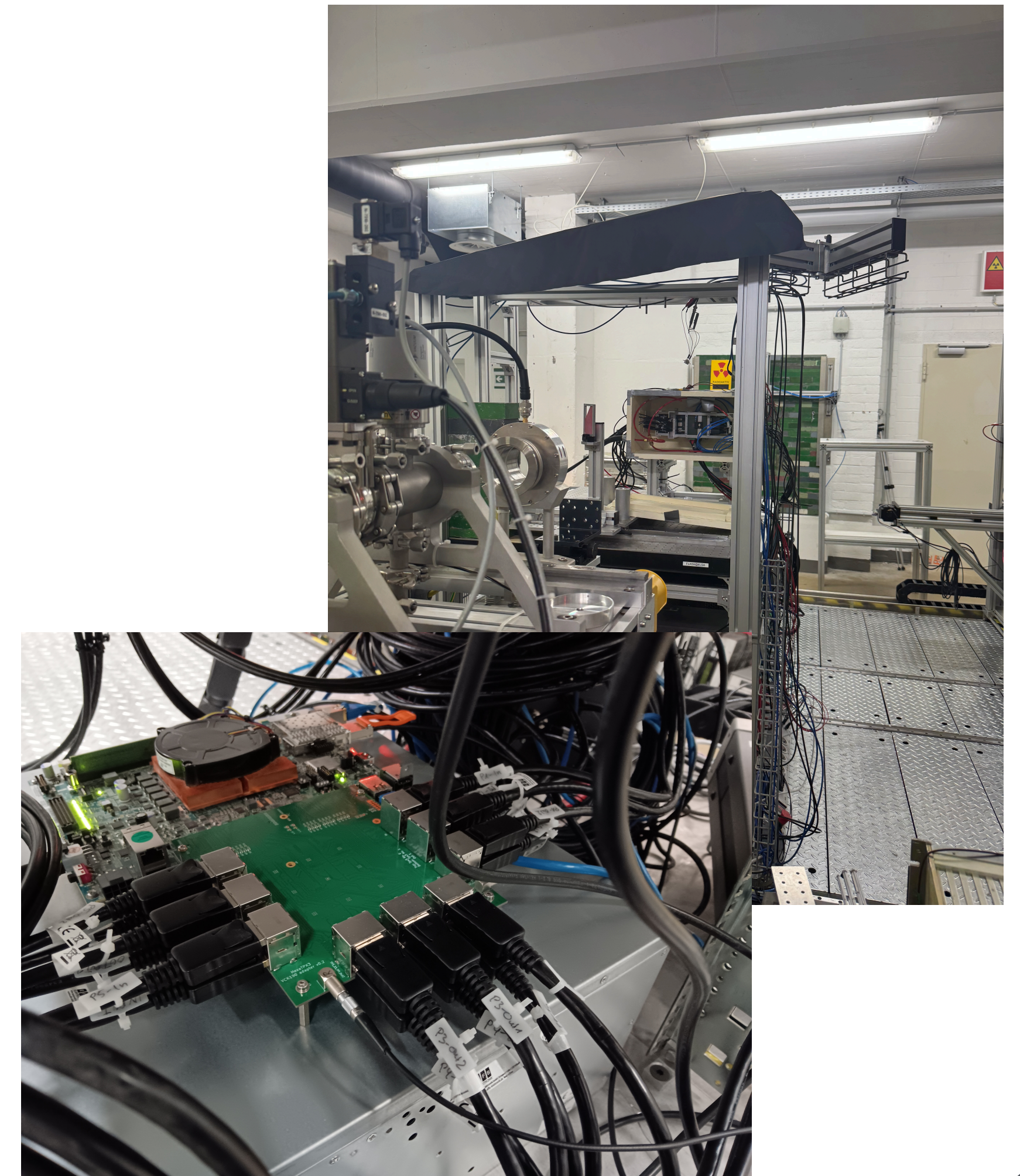
→ Difference between multiple chips (Hit-Or) needs improvement (here: TJ-Monopix2)

AI engine driven track trigger

2 successful testbeams in 2025



Goal: Graph Neural Network with coarse track fit



Lohengrin Tracker

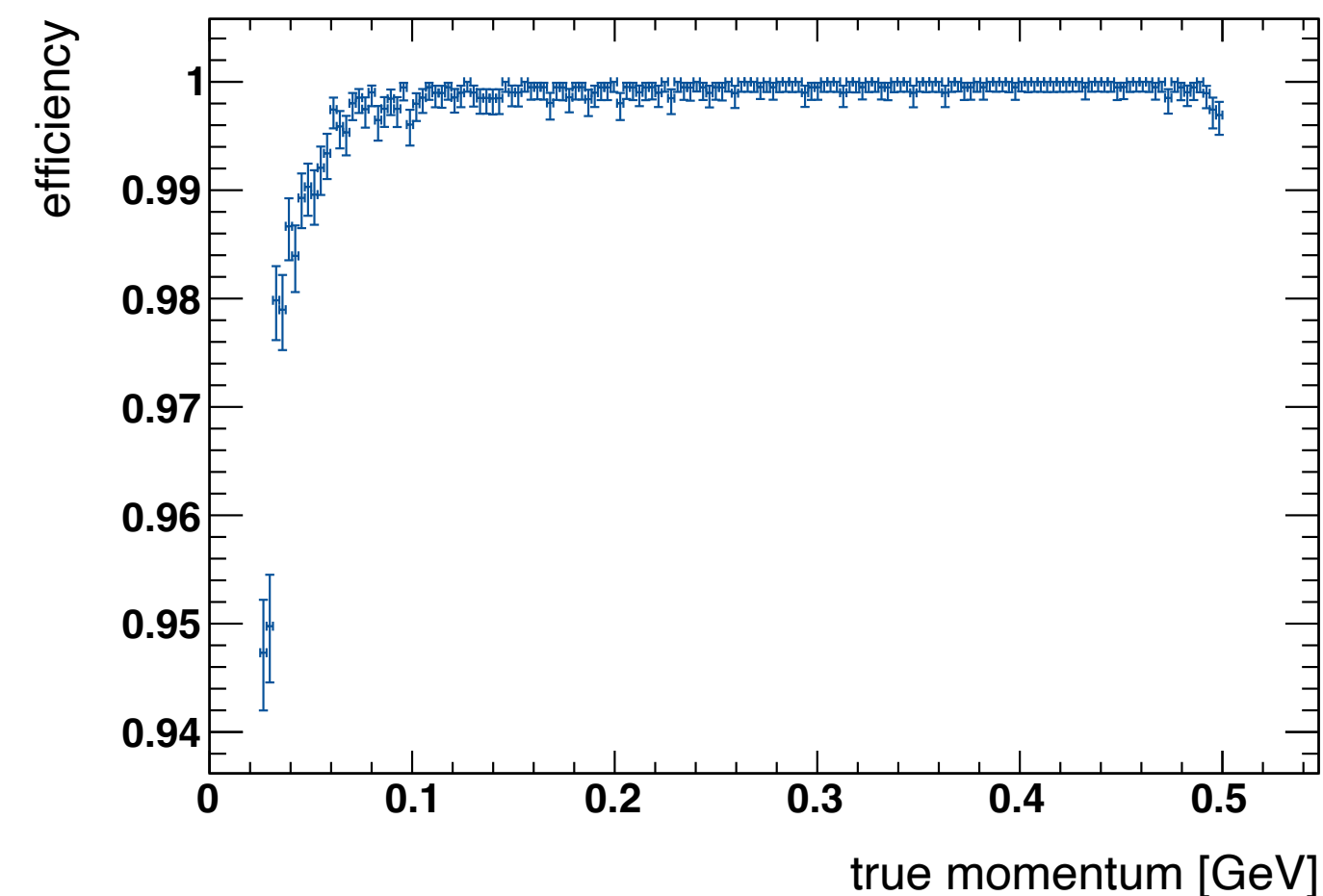
Requirements:

Reasonable hit rate per pixel
Low material budget

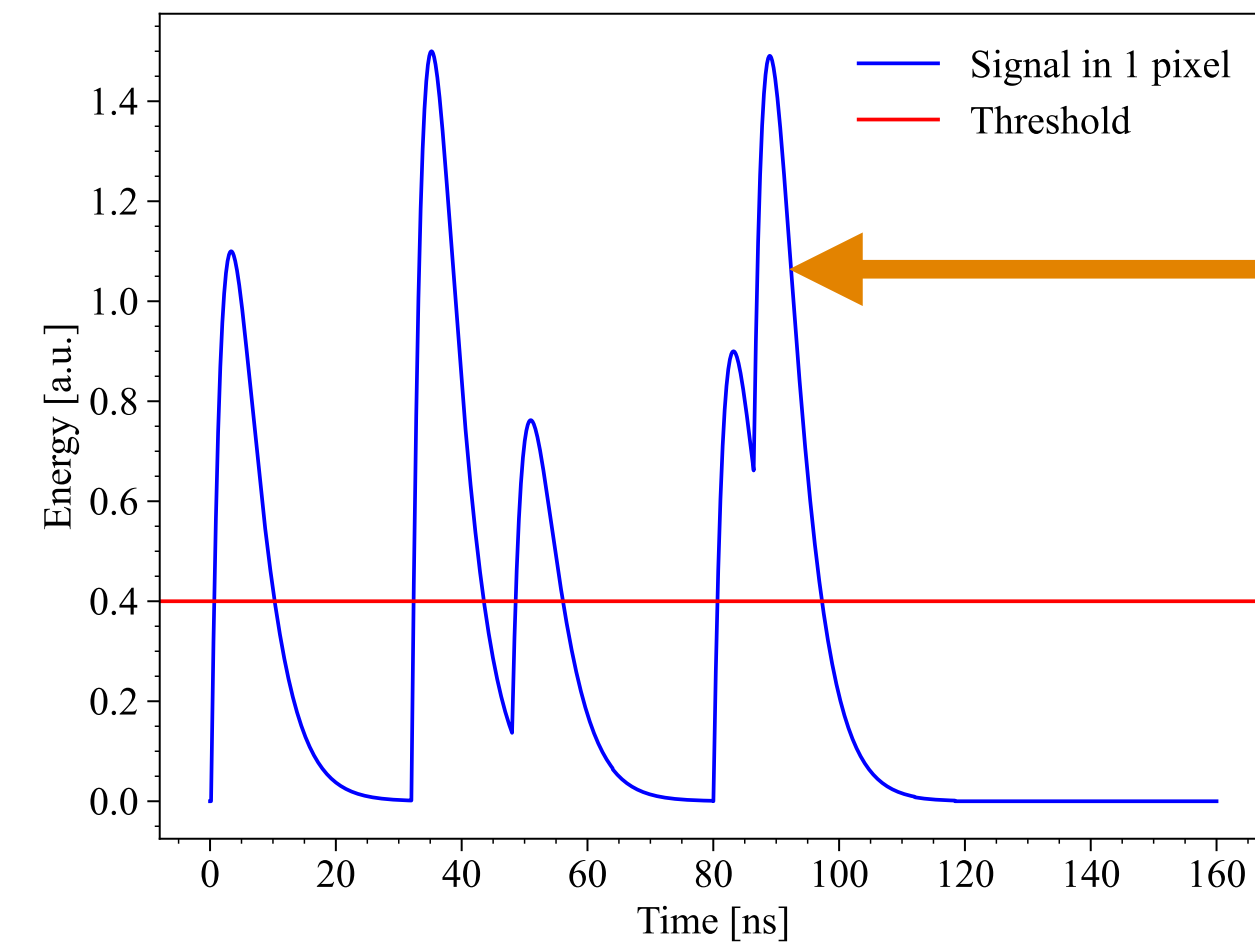
Current Studies:

TJ Monopix, Obelix like tracking ASICs

Need good tracking to low momenta



Need a fast tracker

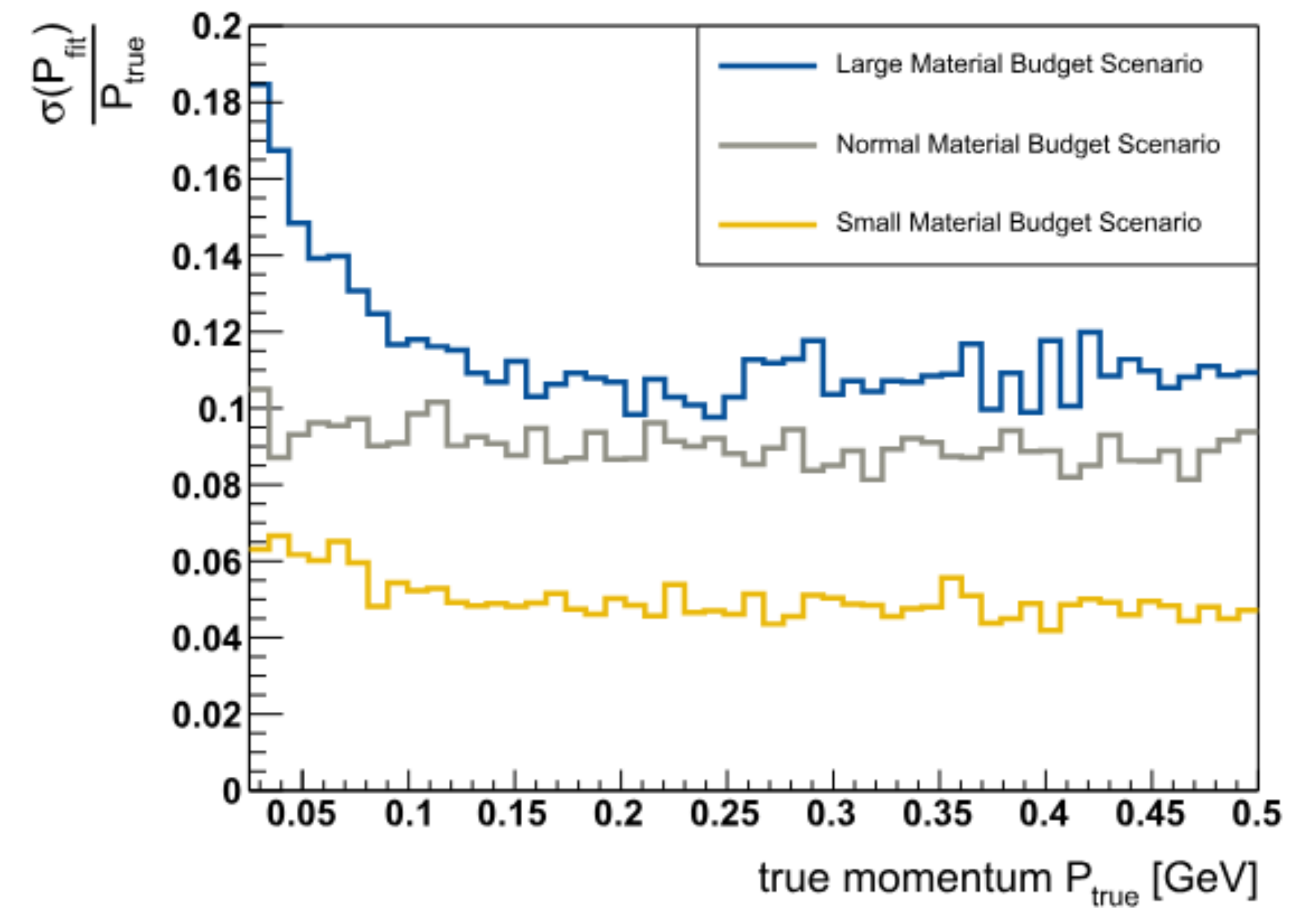
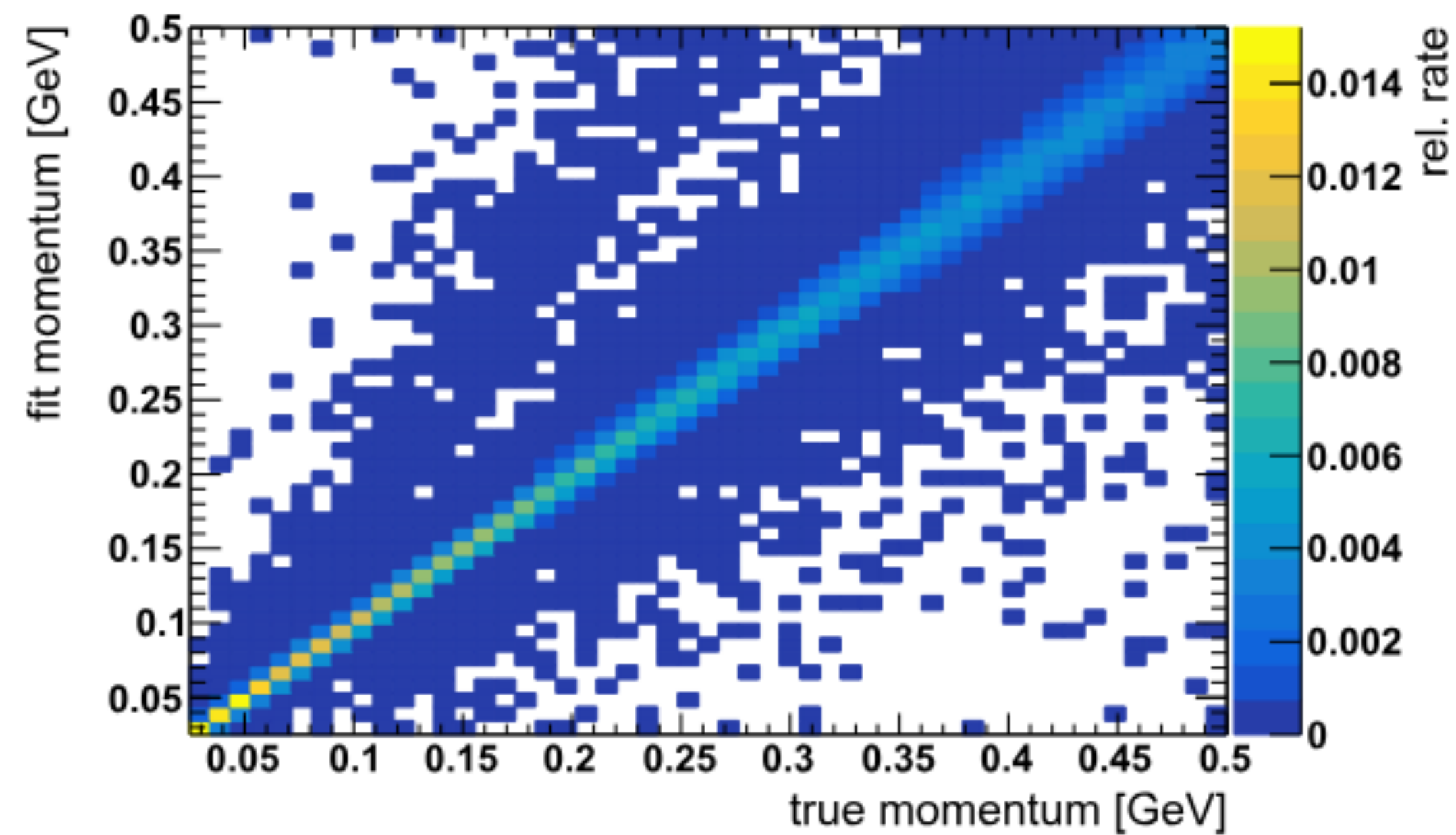


Hit not
registered

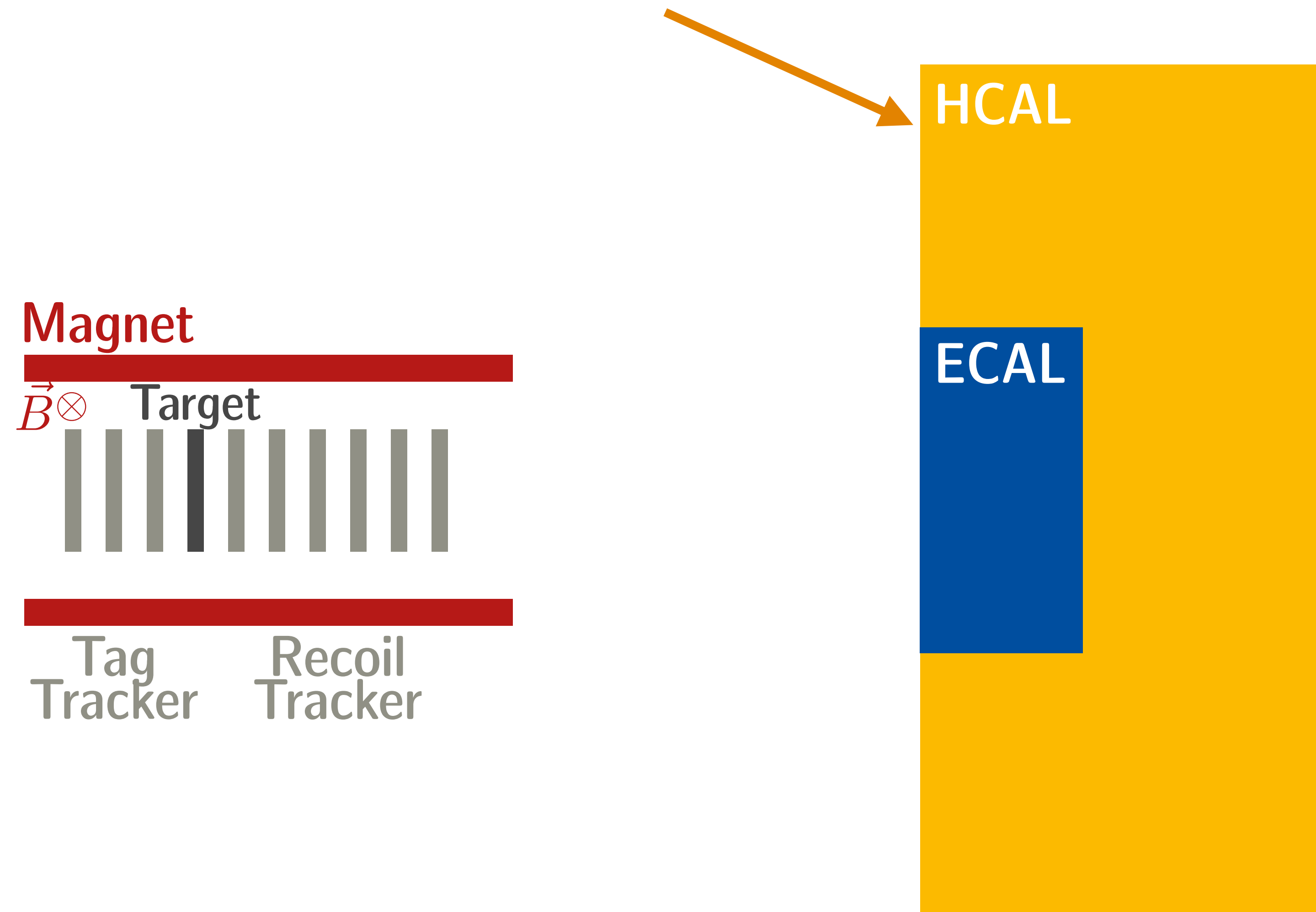
Chips themselves need to be fast

Tracking

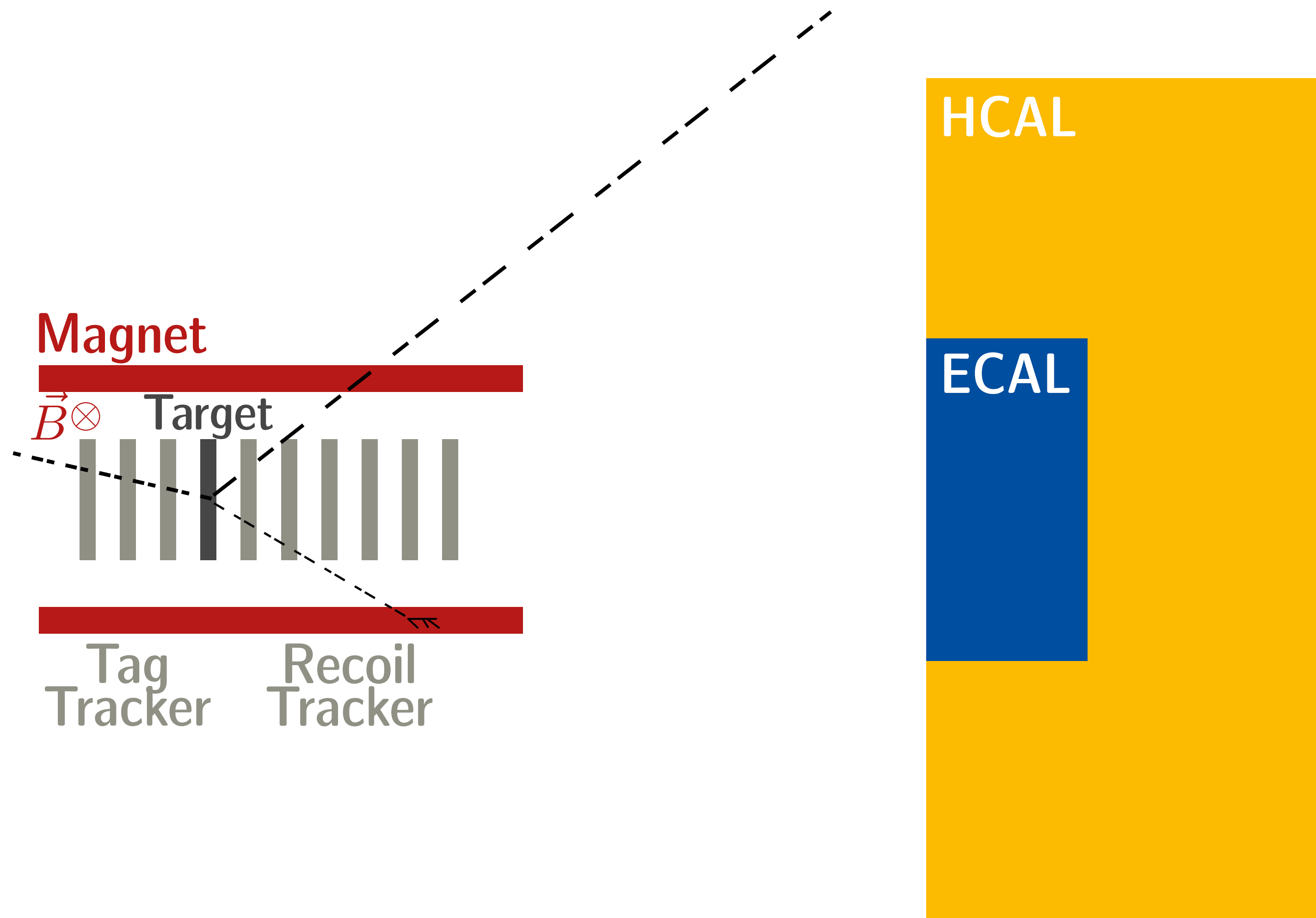
Whitepaper Simulations, ACTS



The Lohengrin Experiment



Problematic Hadronic Backgrounds



How problematic is this?

Signal: $10^2 - \mathcal{O}(10^3)$

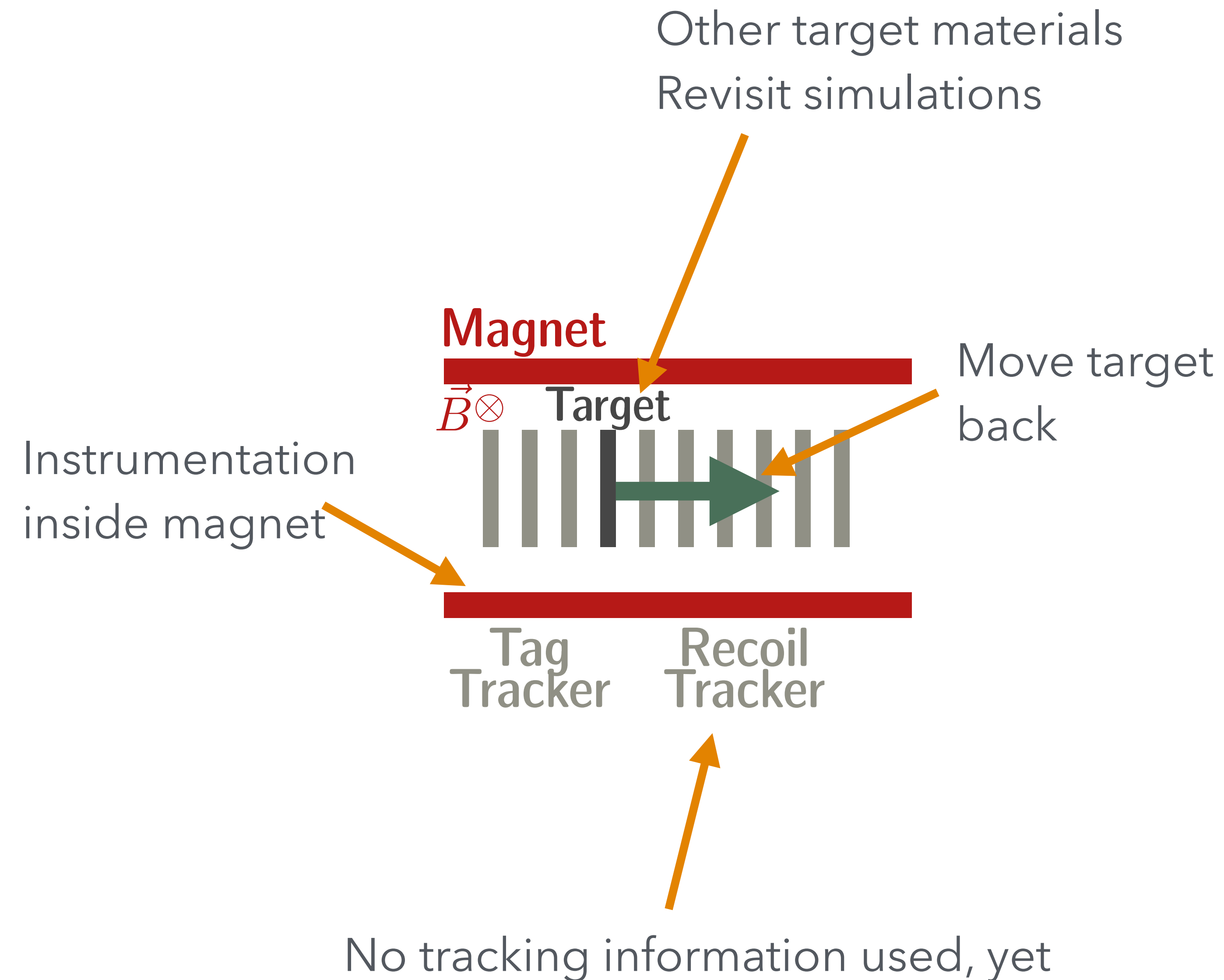
Background

Only geometric: $\mathcal{O}(10^3) - \mathcal{O}(10^4)$

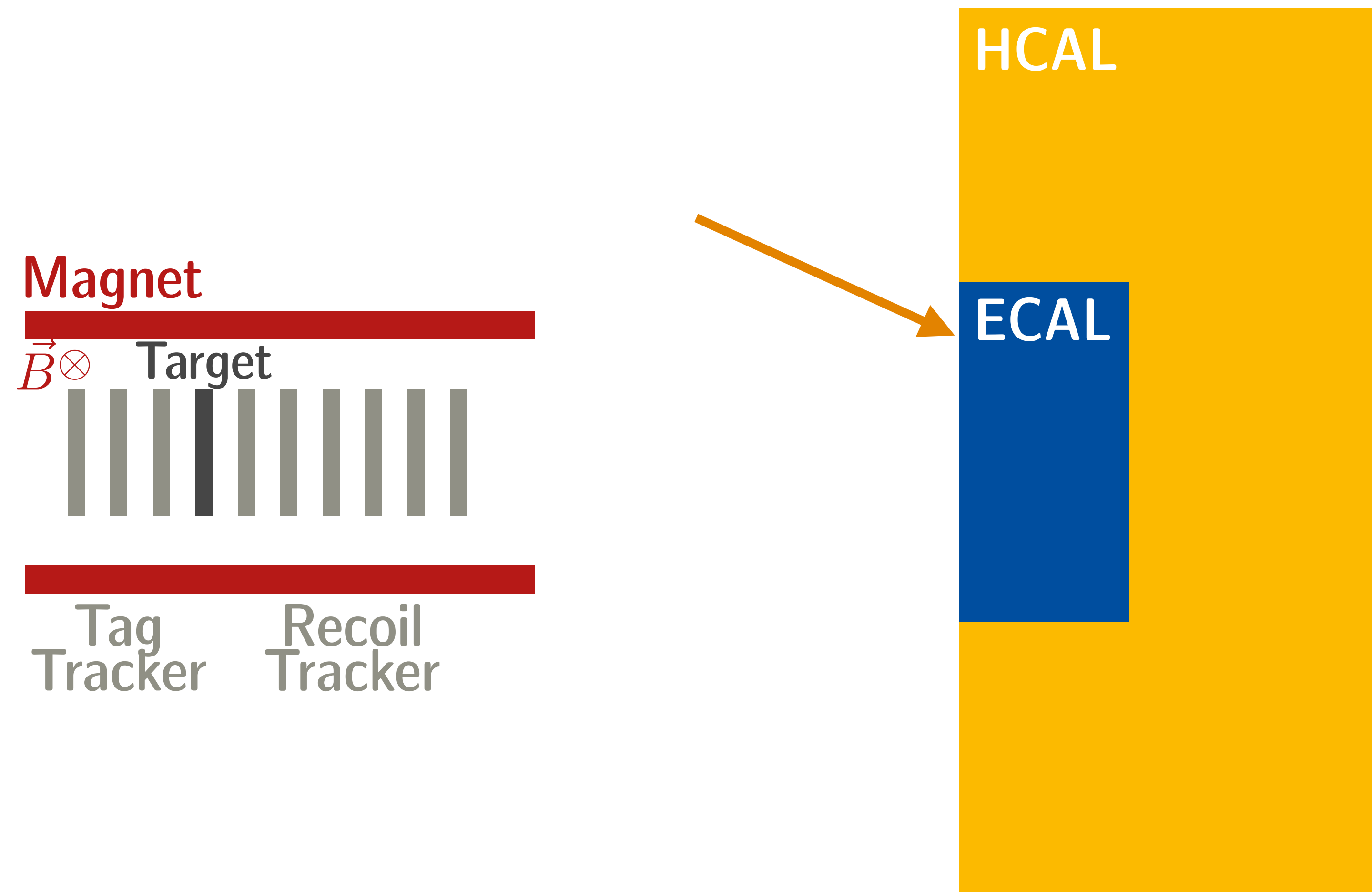
Incl. components: $\mathcal{O}(10^6)$

For more details: Laney's talk this afternoon!

How to solve these background problems

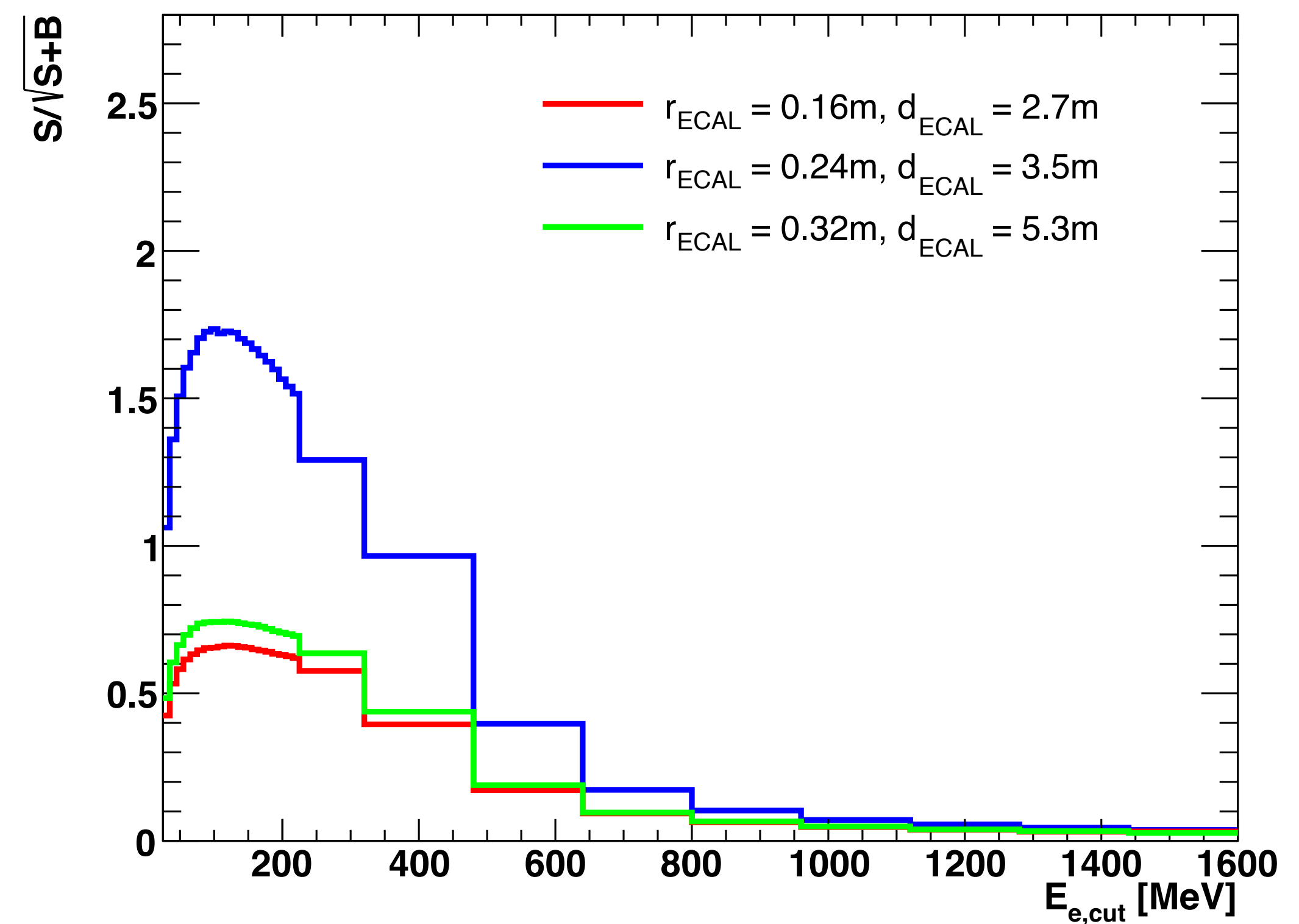
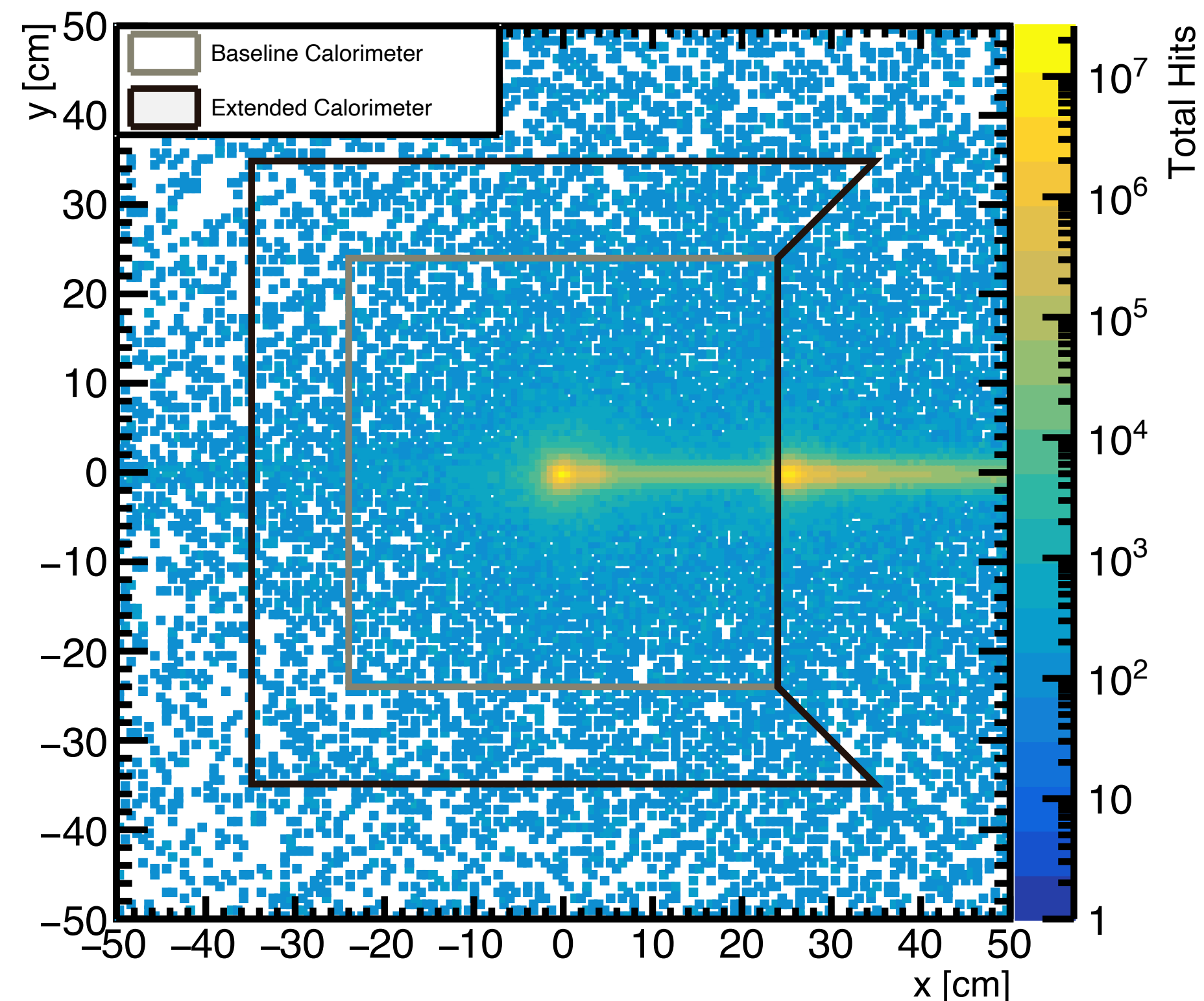


The Lohengrin Experiment



Whitepaper ECAL Setup

CALICE SiW ECAL → sampling calorimeter with 30 layers of Si and W



→ Bend e^- out of ECAL, find high energetic γ on top of low energy QED background

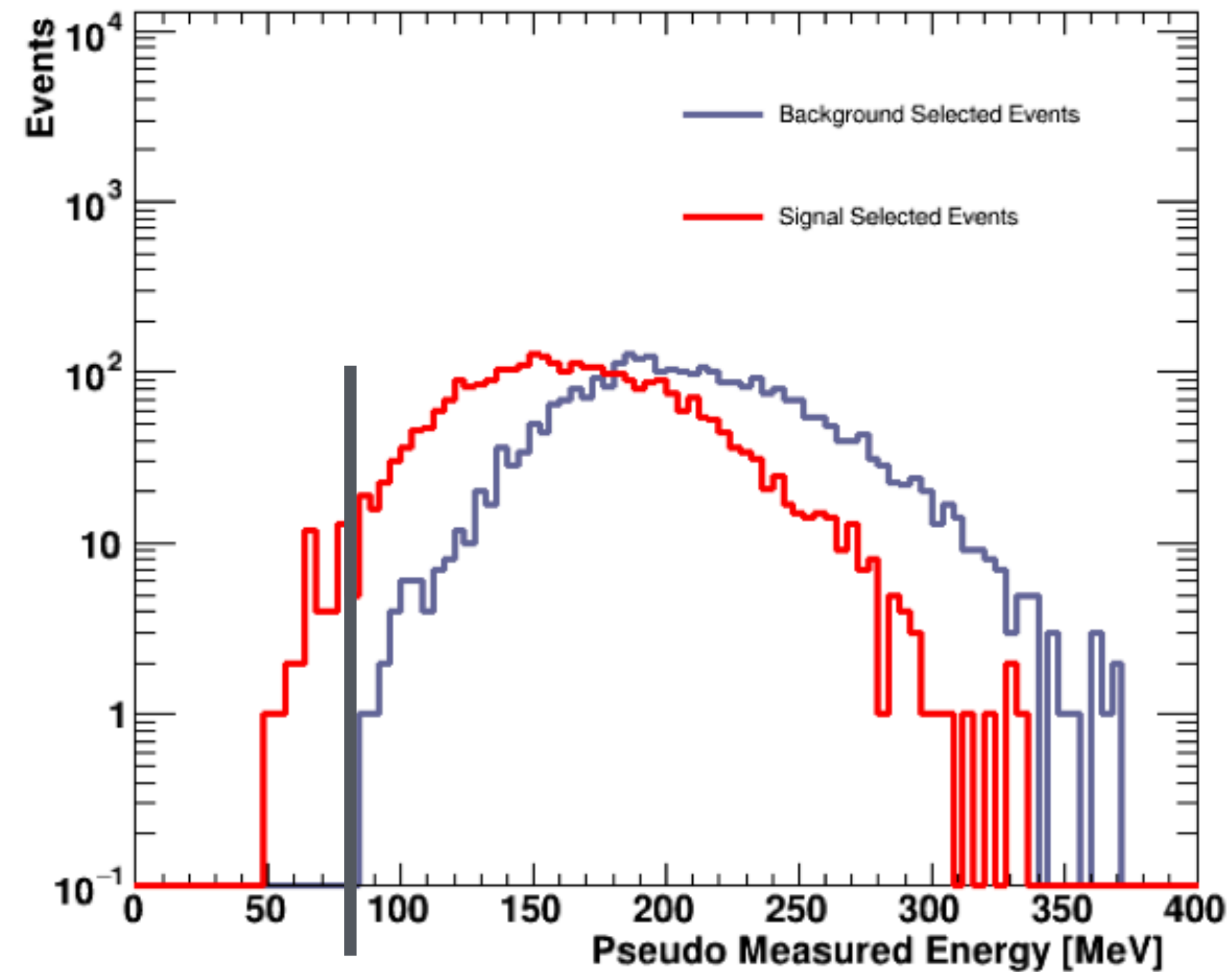
→ Most sensitive for $E_e \leq 100\text{ MeV}$

ECAL Timing

Current technology

$$\tau = 180 \text{ ns}$$

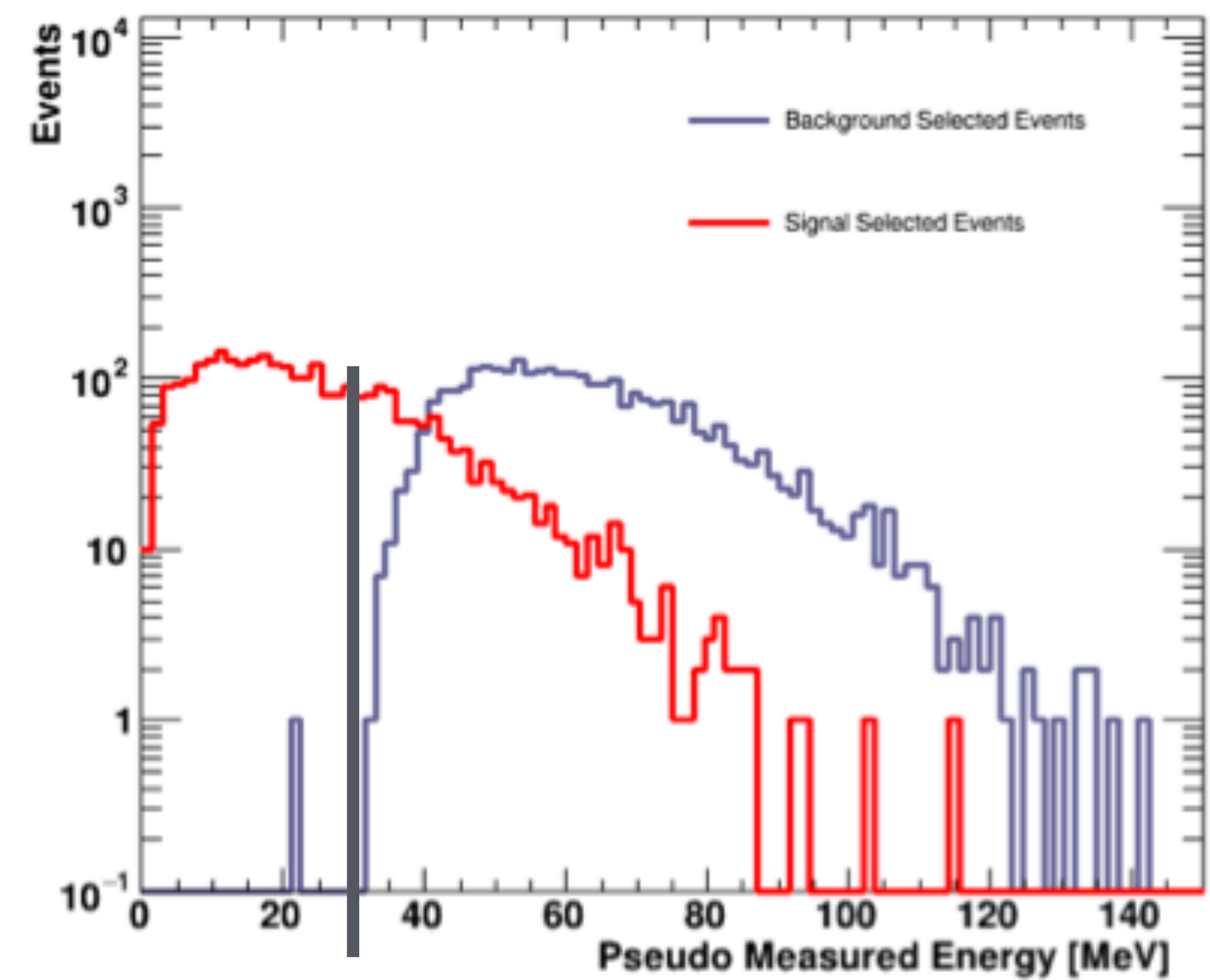
Signal efficiency $\rightarrow 0 \%$



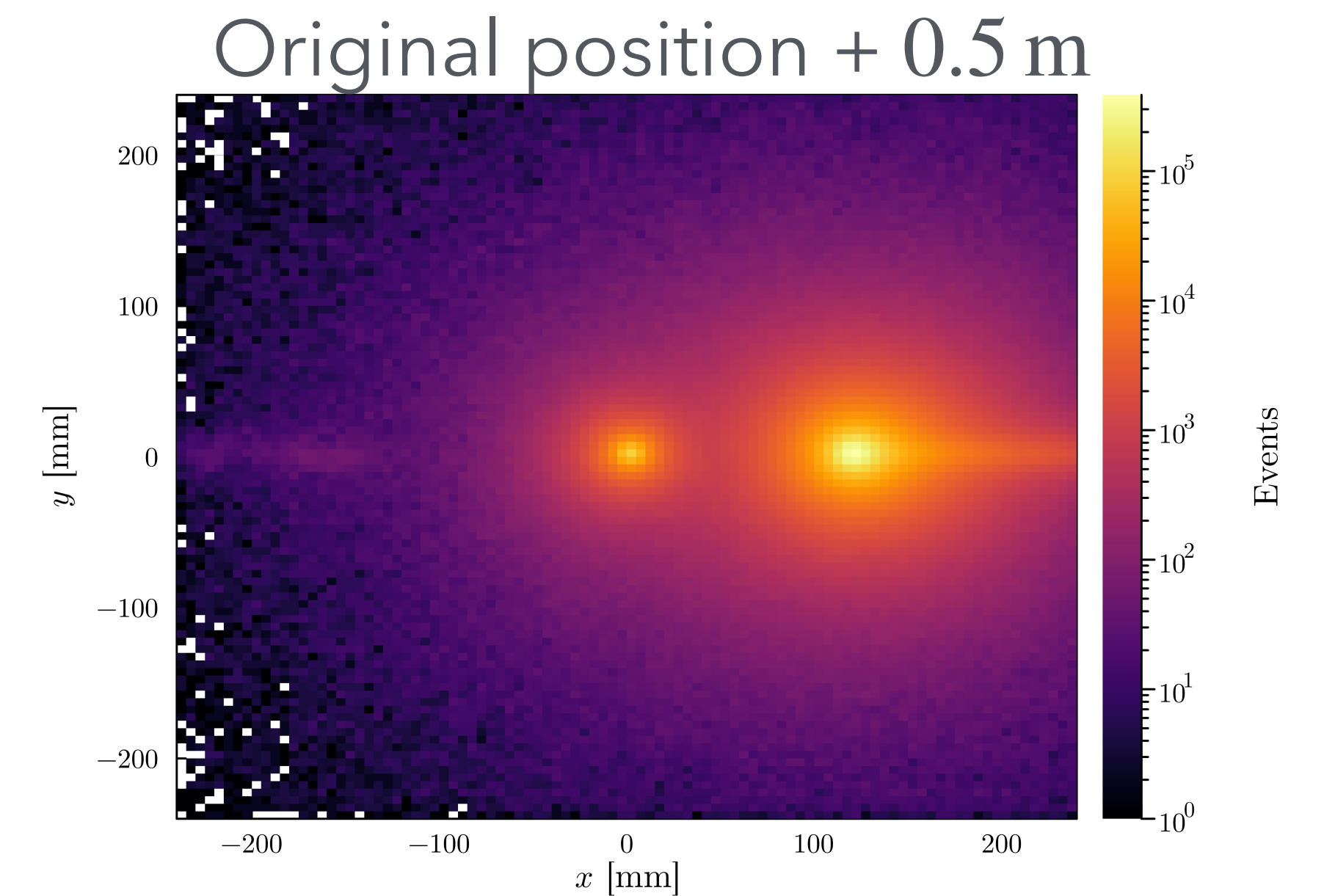
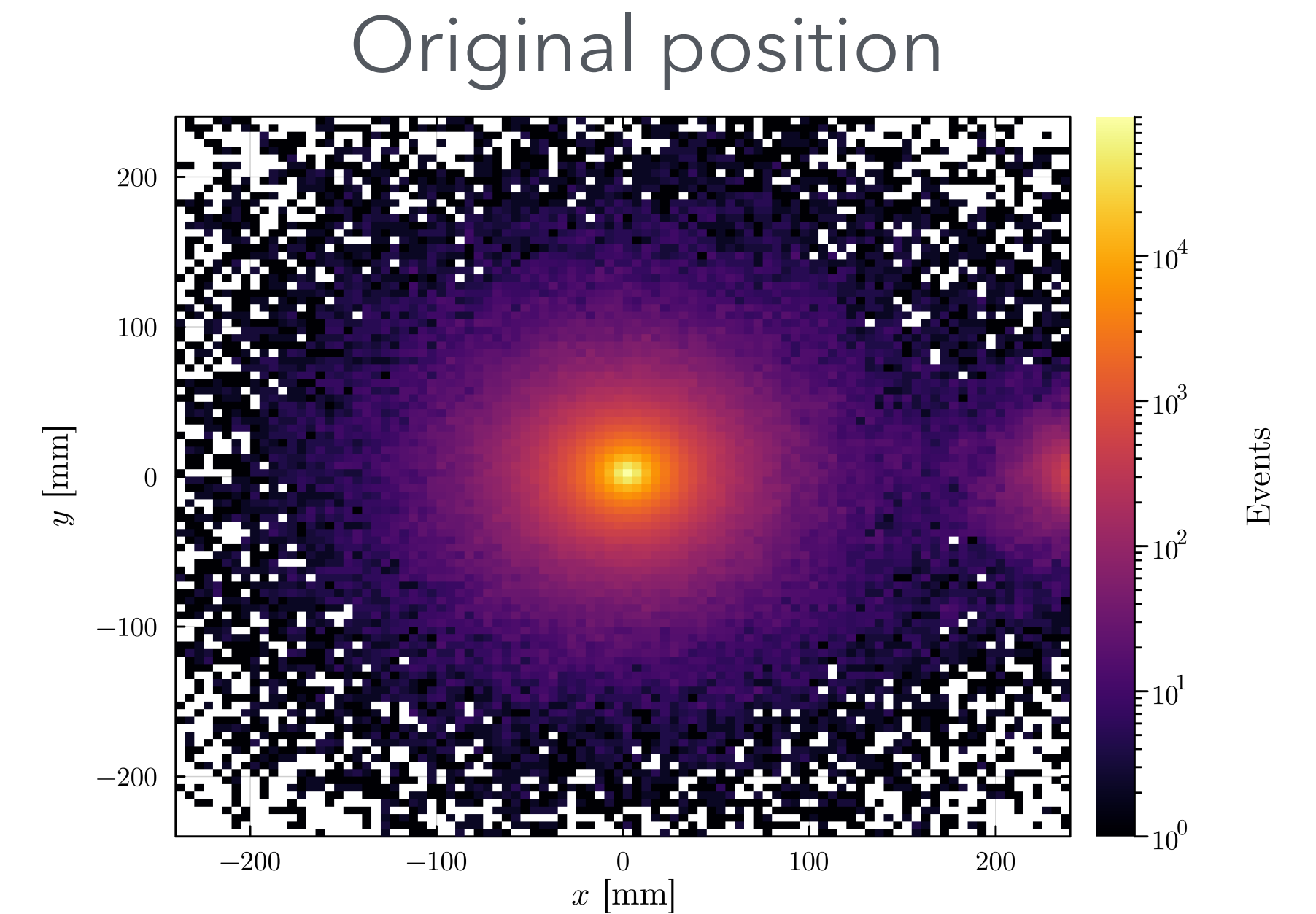
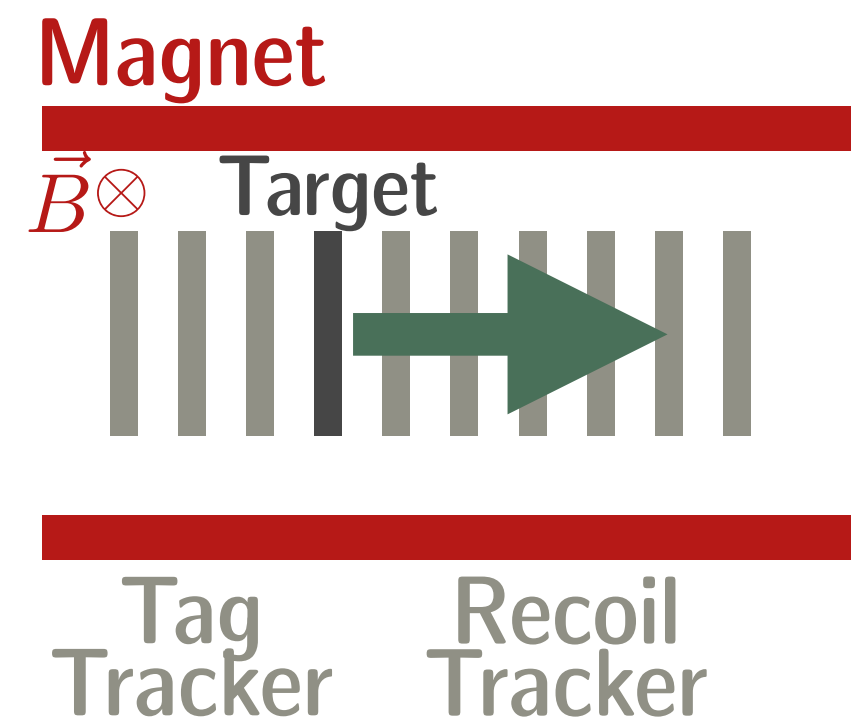
Faster ECAL

$$\tau = 30 \text{ ns}$$

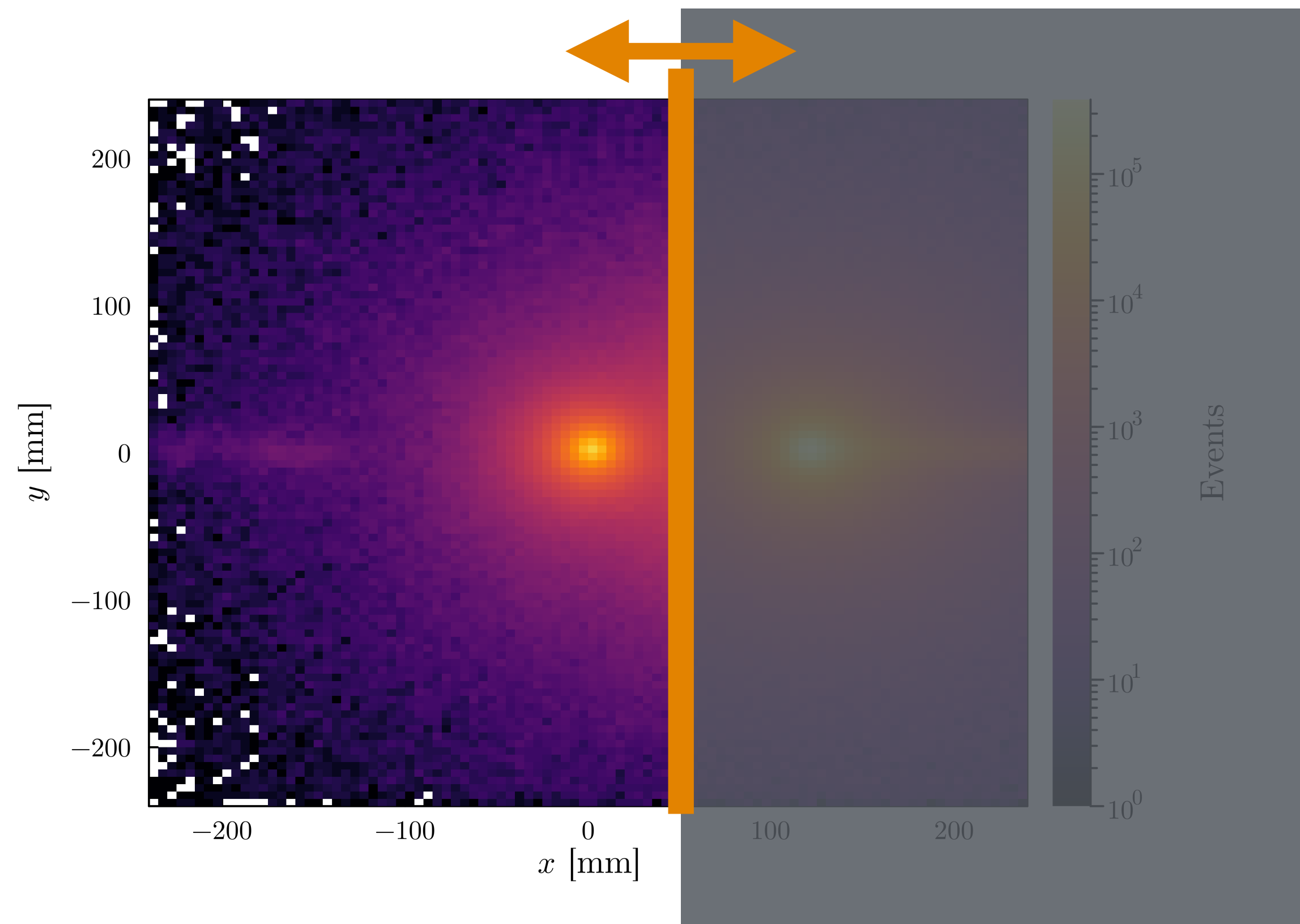
Signal efficiency $\rightarrow 68 \%$



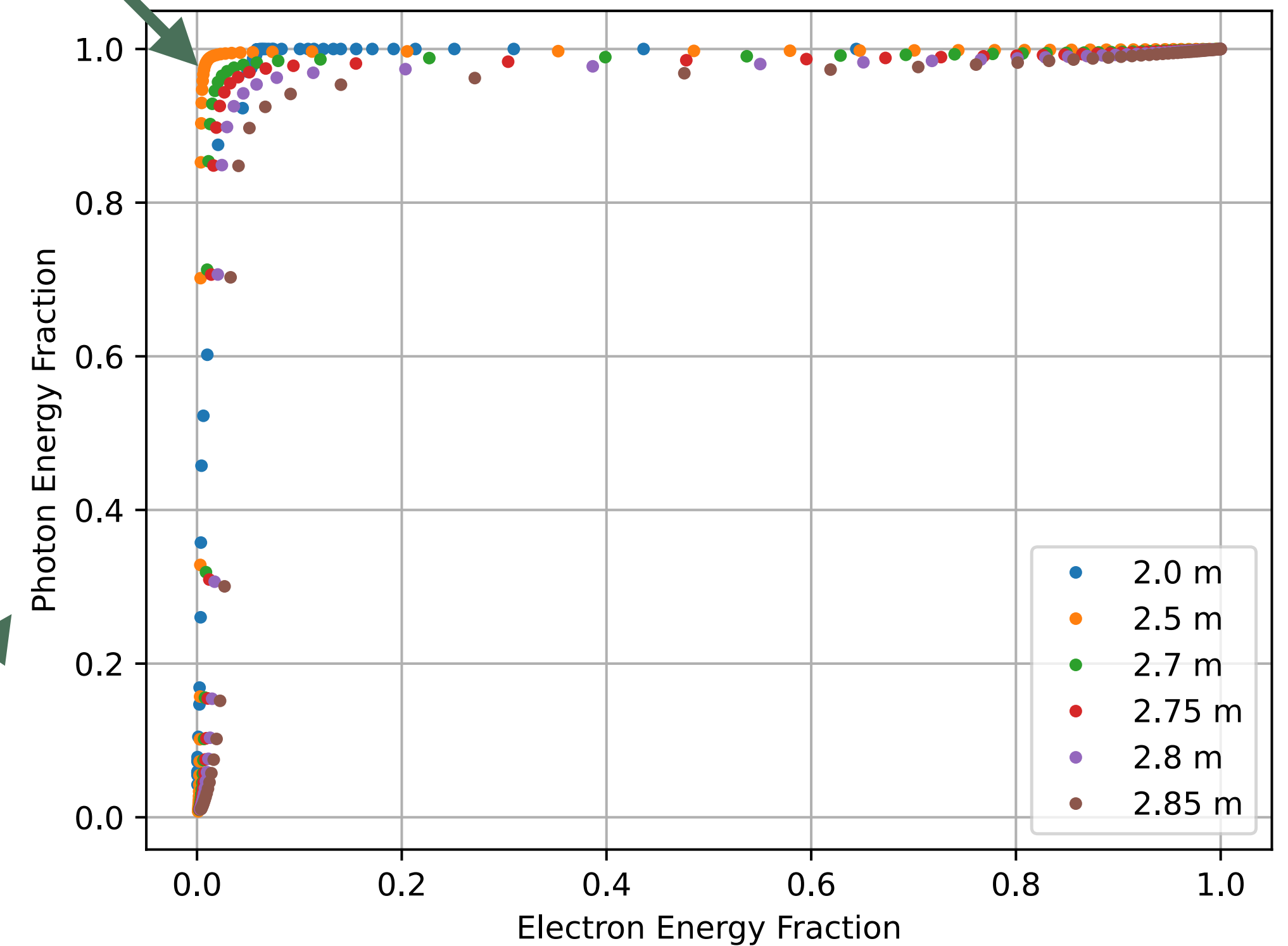
Moving the target back



Removing electrons in the ECAL



Choose Working Point

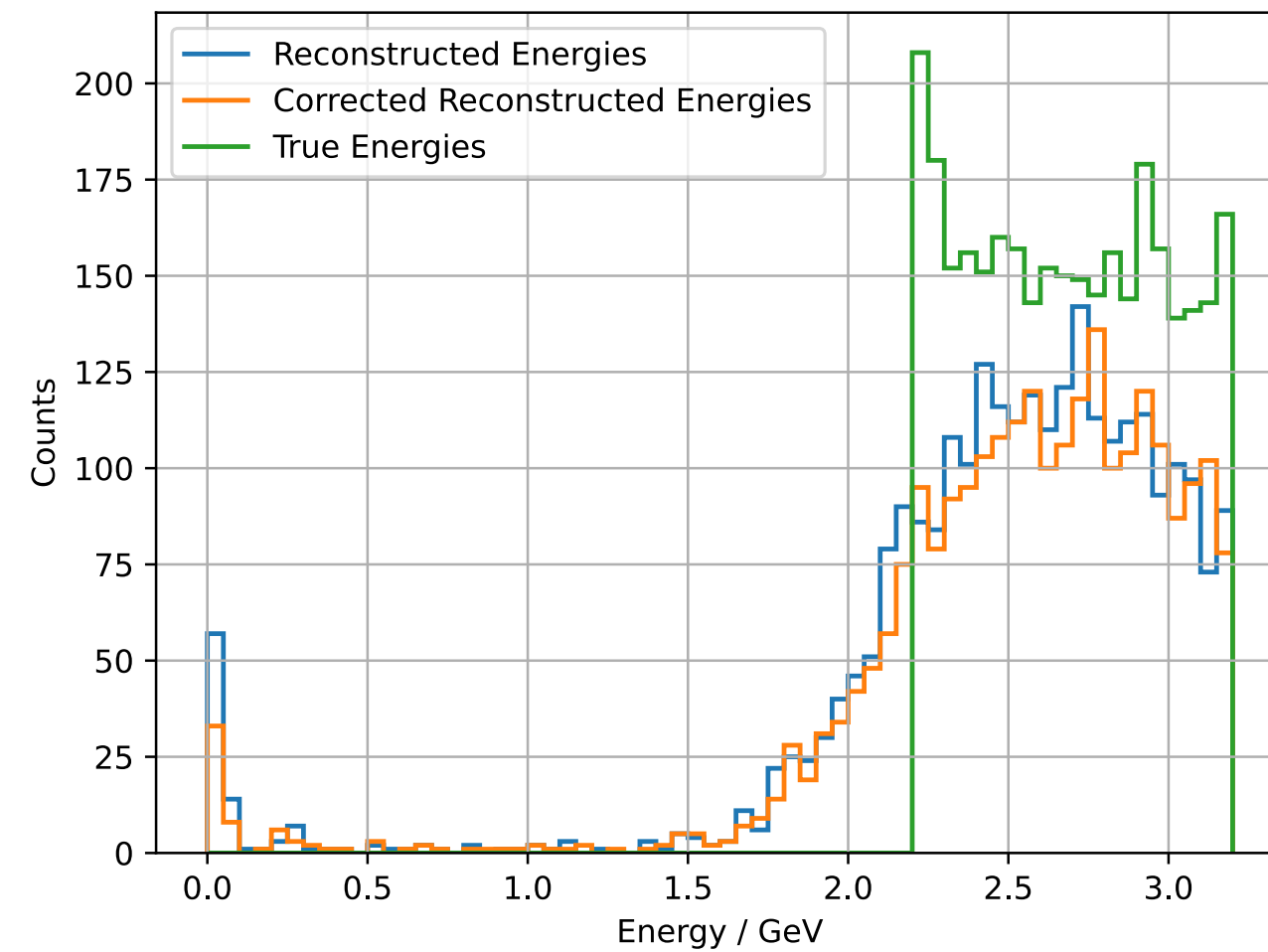


Photon Energy Fraction: $\langle E_{\gamma,\text{left}}/E_{\gamma,\text{total}} \rangle$ for E in ECAL

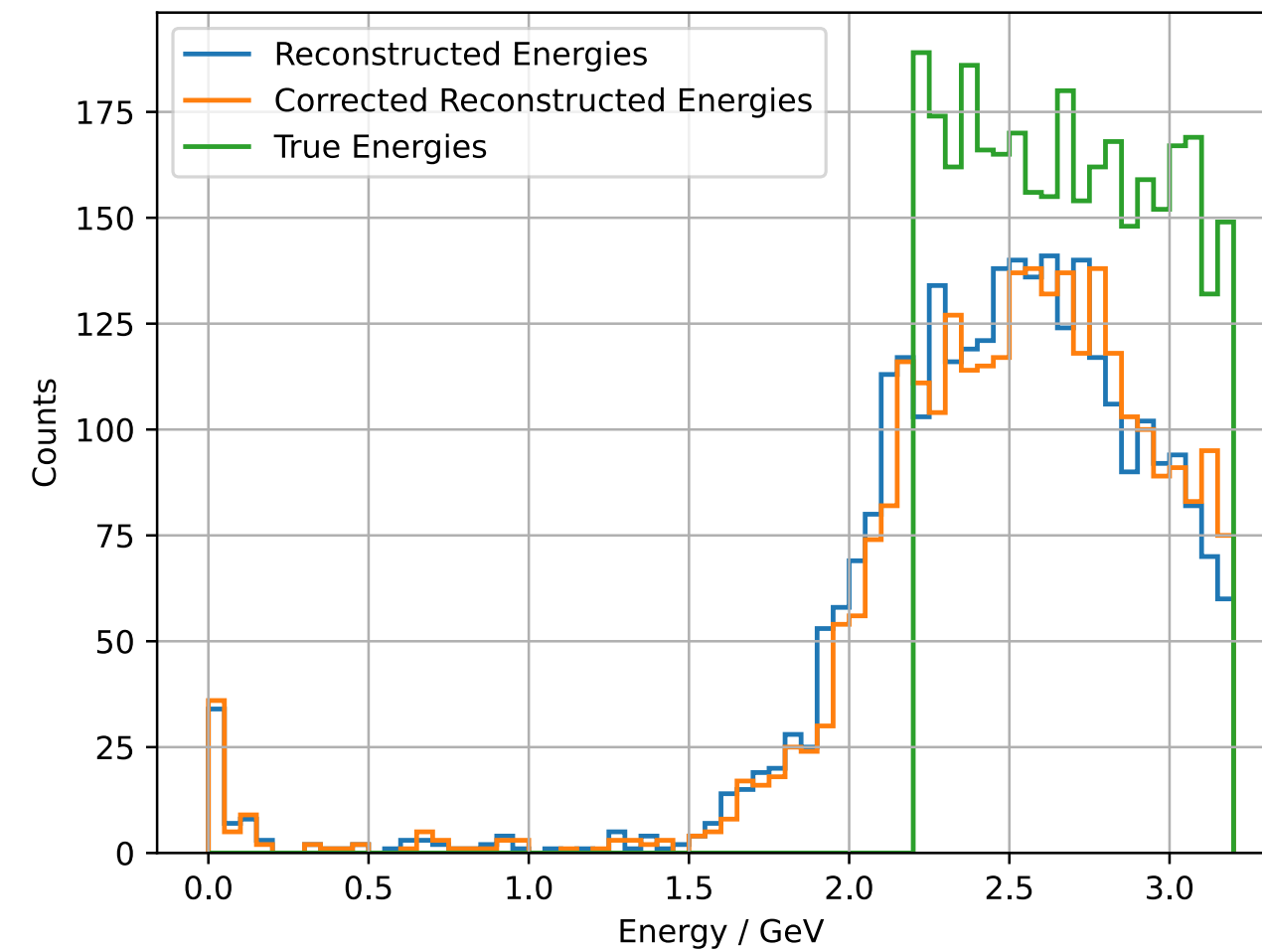
Recoil Electron Energy Fraction: $\langle E_{e',\text{left}}/E_{e',\text{total}} \rangle$ for E in ECAL

Photon reconstruction in the ECAL

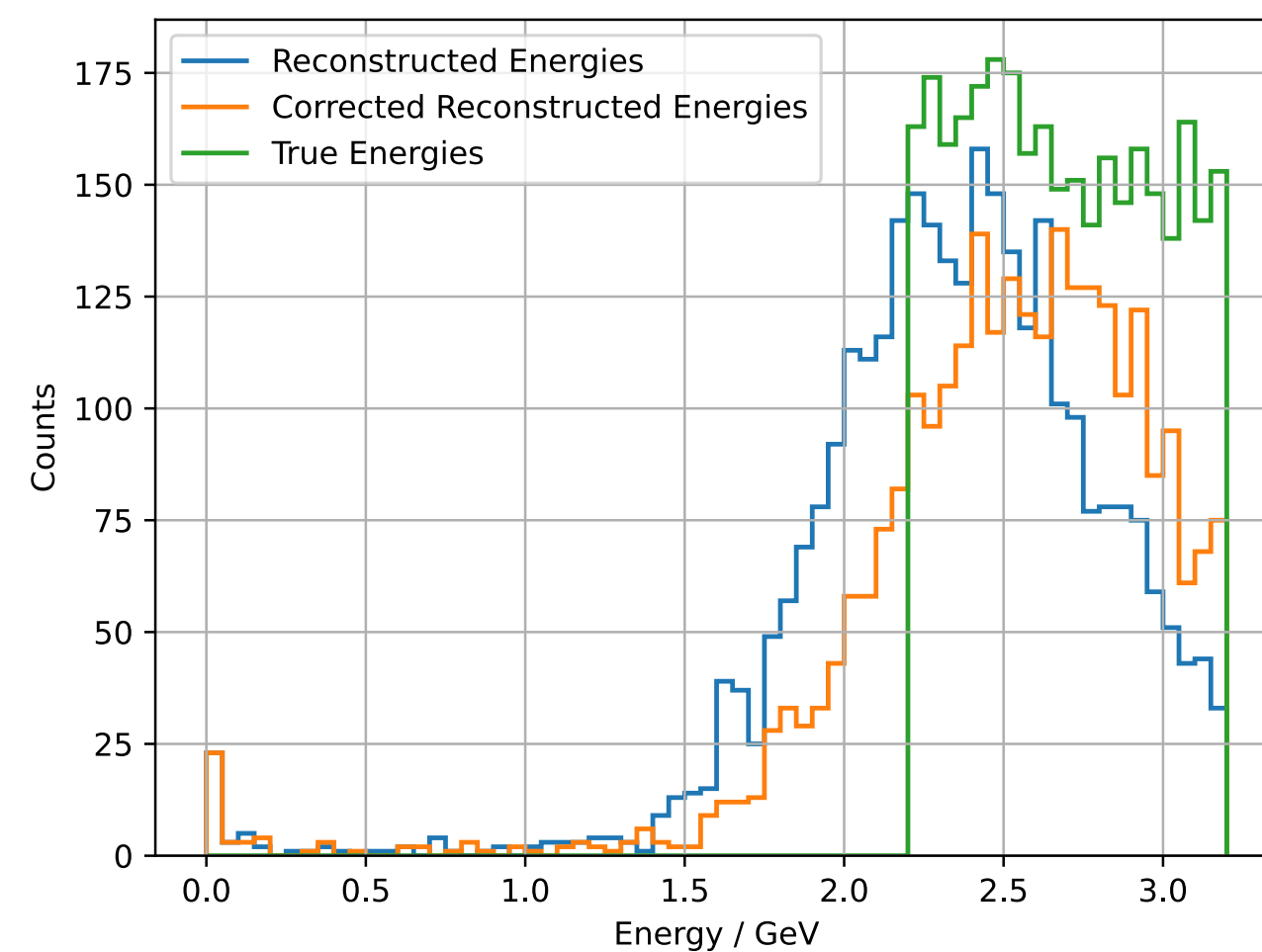
$z_t = 2 \text{ m}$



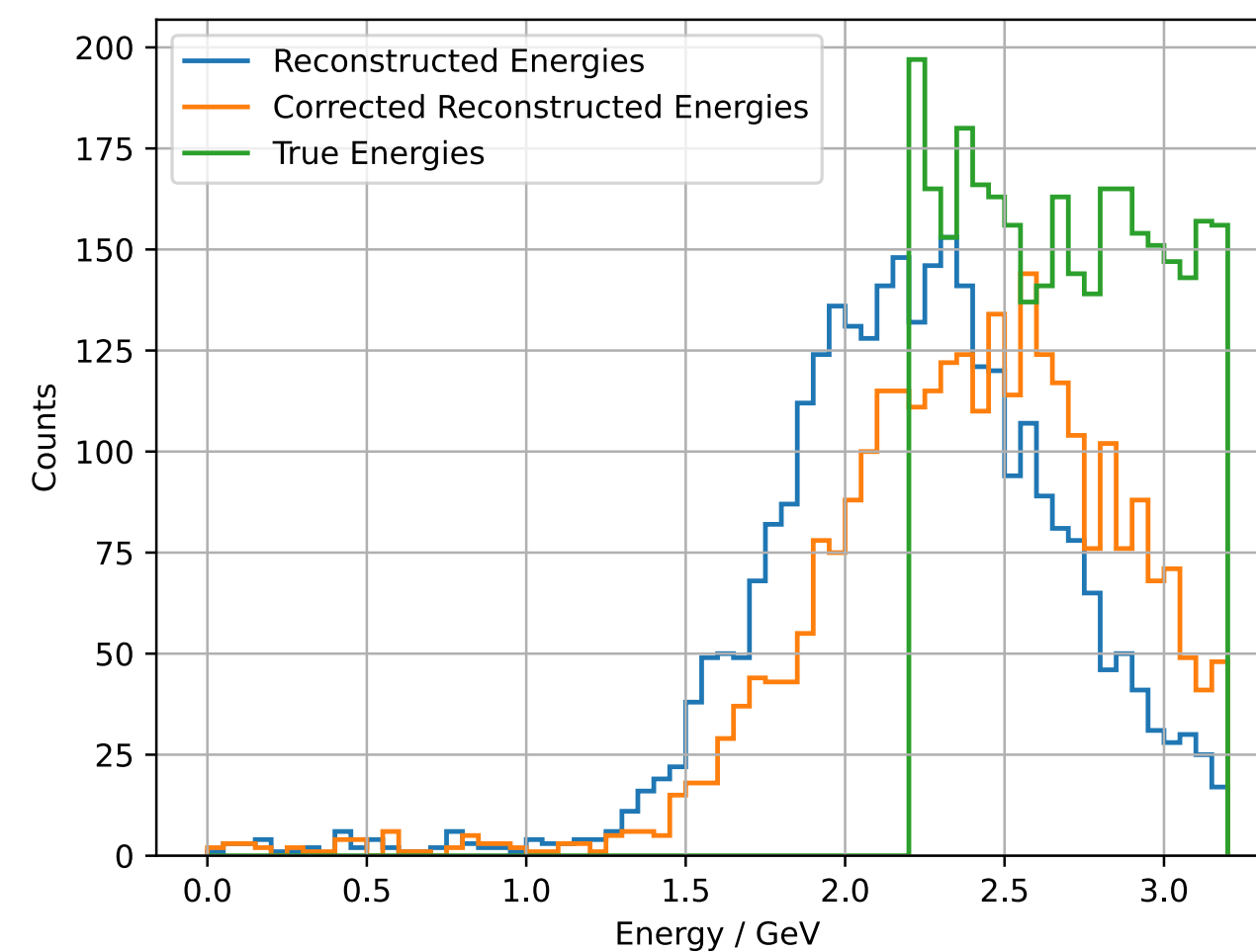
$z_t = 2.5 \text{ m}$



$z_t = 2.7 \text{ m}$



$z_t = 2.85 \text{ m}$



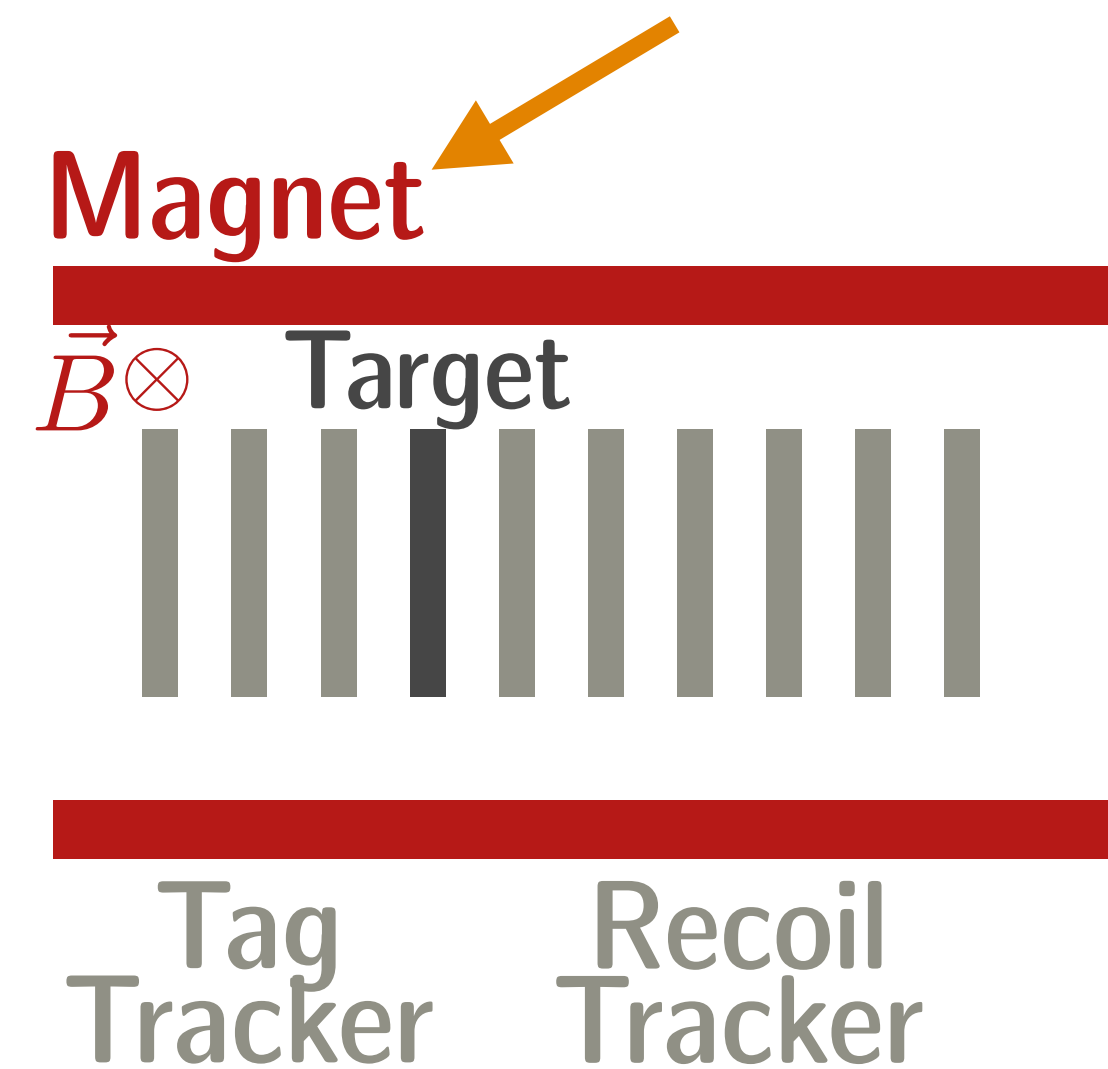
From Working Point

$$E_{\text{det}} = f_{\gamma} E_{\gamma} + f_e E_e$$

Track Info

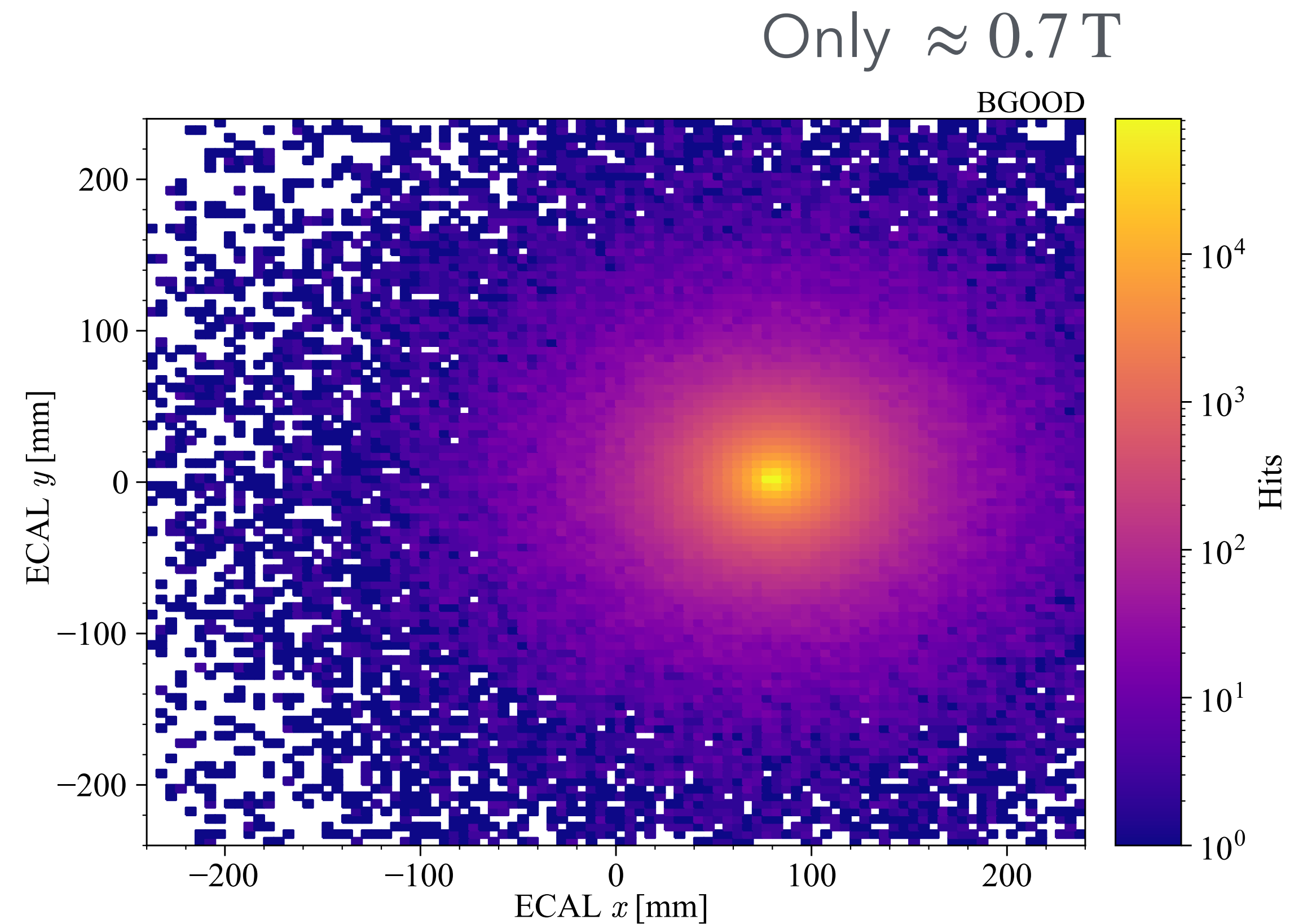
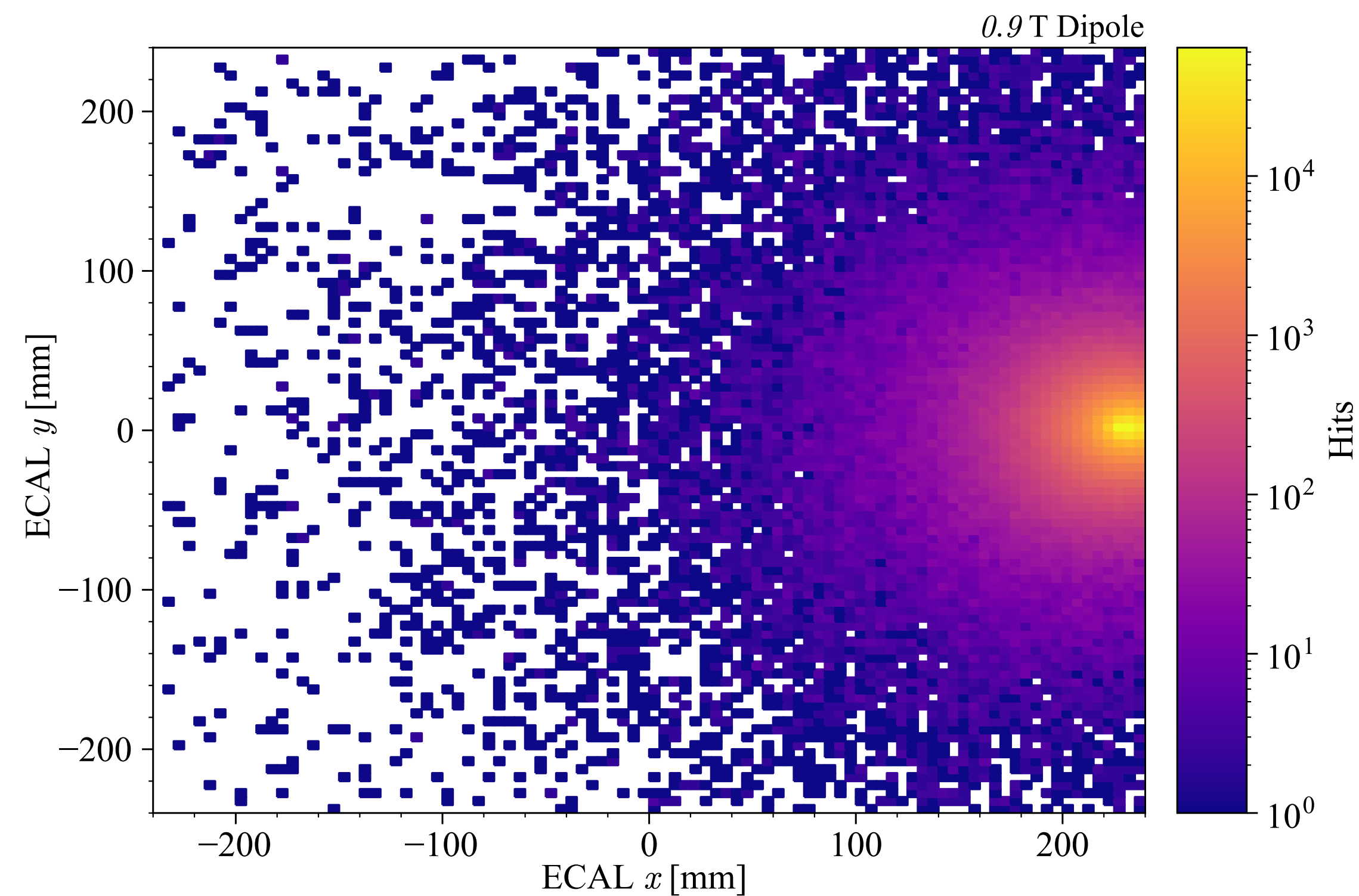
$$E_{\gamma} = \frac{E_{\text{det}} - f_e E_e}{f_{\gamma}}$$

The Lohengrin Experiment



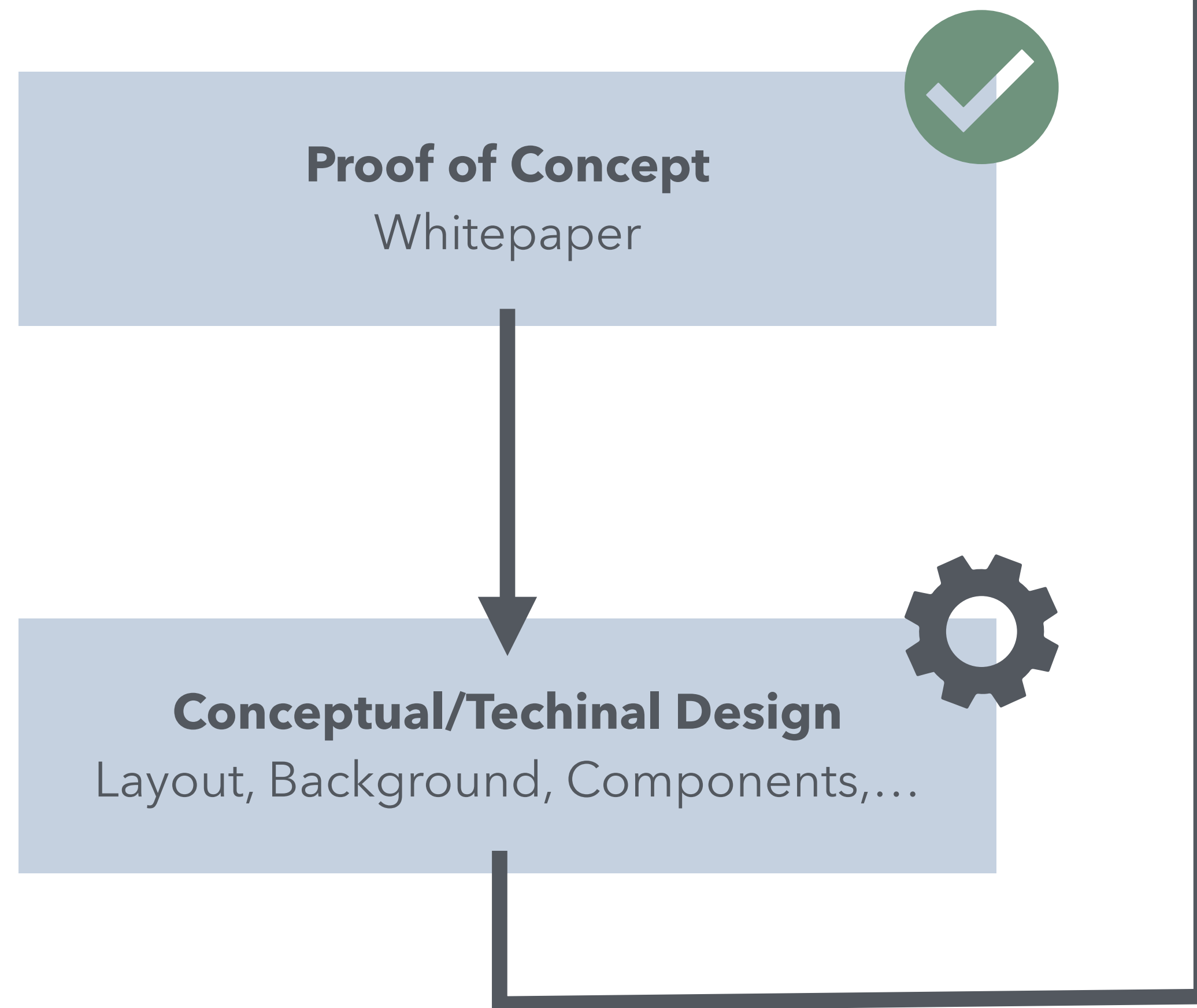
Existing magnets

Simulation: Electron gun + magnet + ECAL

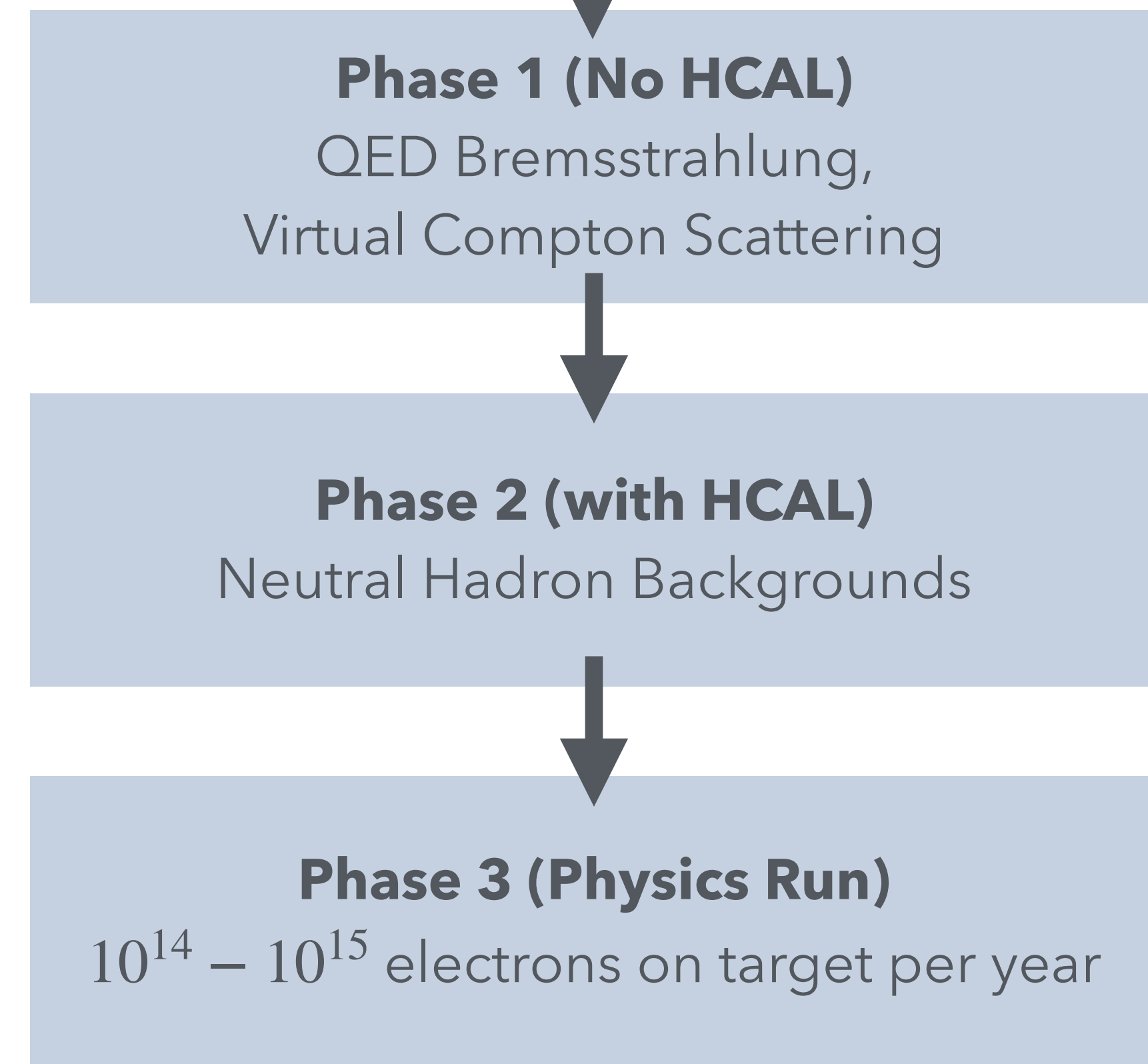


→ resolving the electron in the ECAL would become necessary anyways

Roadmap

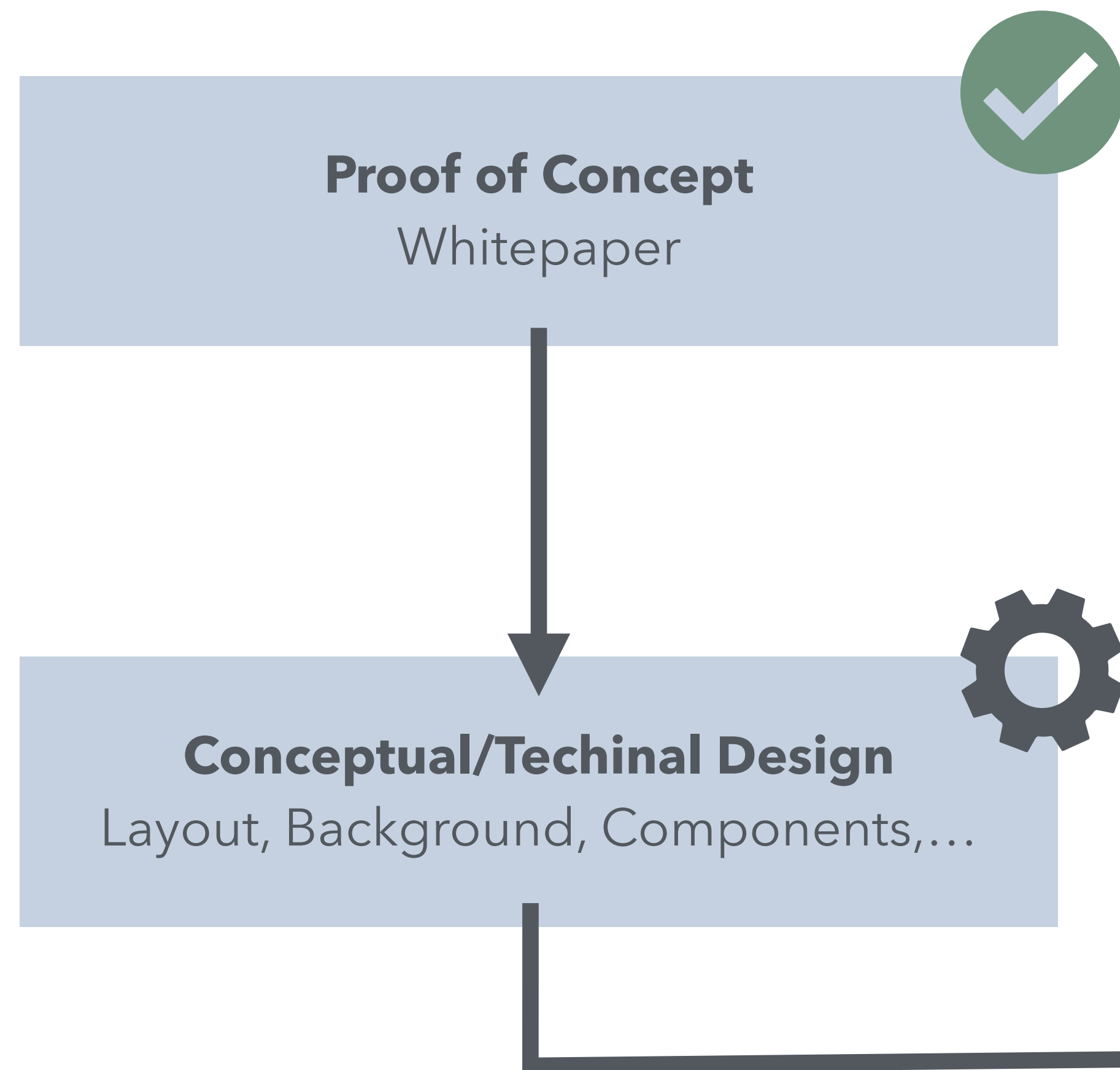


Conceptual Studies



Experimental Phases

Roadmap



Conceptual Studies

Phase 0 (No HCAL, with/without ECAL)
Electron Scattering Measurements

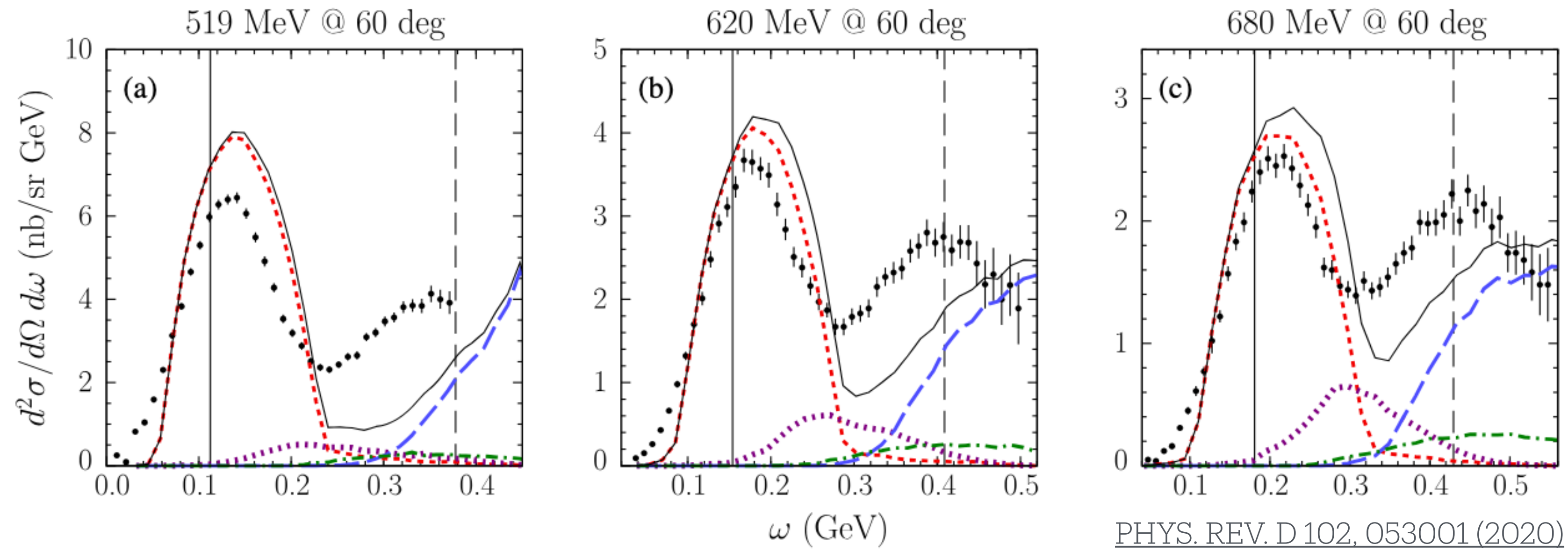
Phase 1 (No HCAL)
QED Bremsstrahlung,
Virtual Compton Scattering

Phase 2 (with HCAL)
Neutral Hadron Backgrounds

Phase 3 (Physics Run)
 $10^{14} - 10^{15}$ electrons on target per year

Experimental Phases

Electron Nucleus Scattering Cross Section



- MC Generators not accurate enough
- No data available at low angles
- Important for ν scattering (e.g. DUNE)
- We can cover part of that!

What do we need?

Tracker 

→ TJ-Monopix2/Timepix3

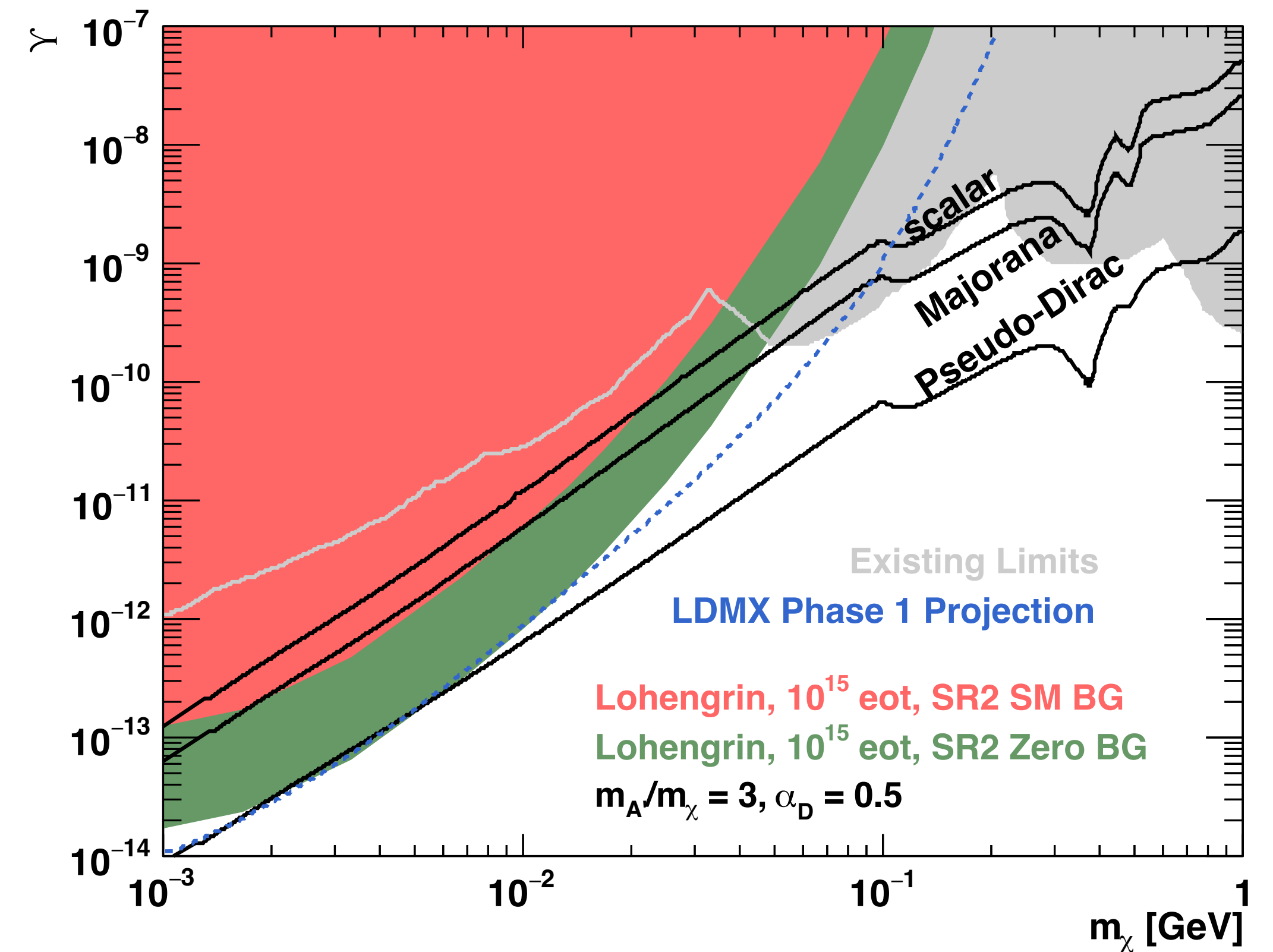
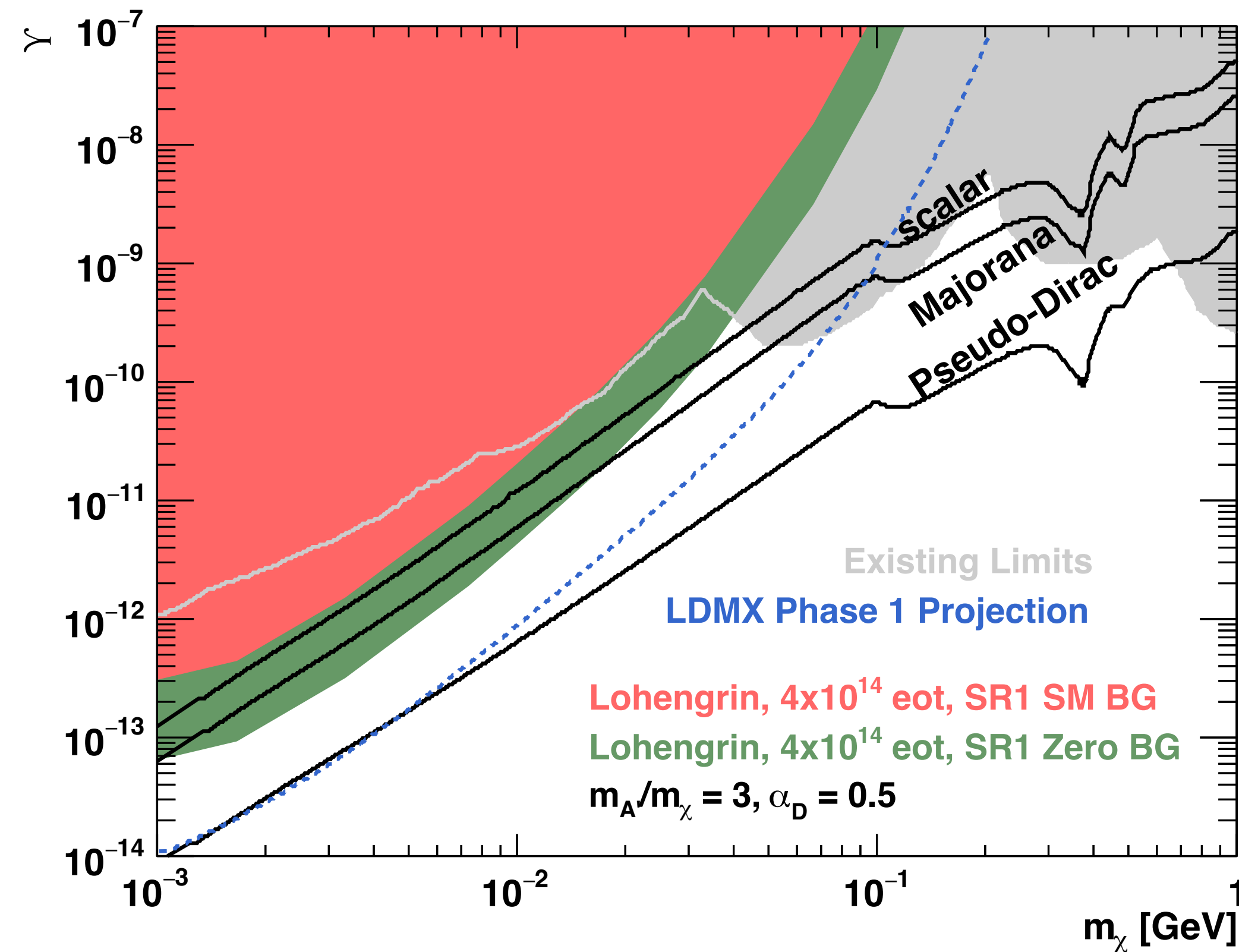
Target 

Magnet 

→ BGOOD

(ECAL) 

The goal



More aggressive SR, more eot
Lower E_e threshold can be lowered