Optimization of V^0-finding at a future Higgs factory

Final summer student presentations

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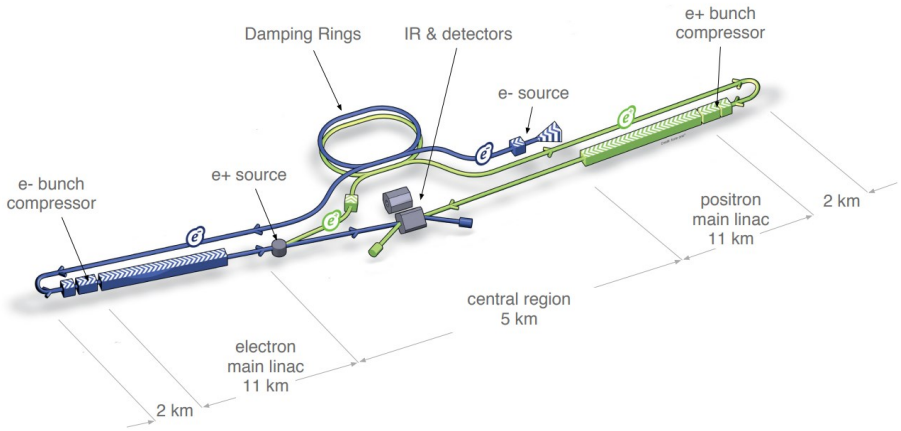
HELMHOLTZ

ILC and ILD

An overview

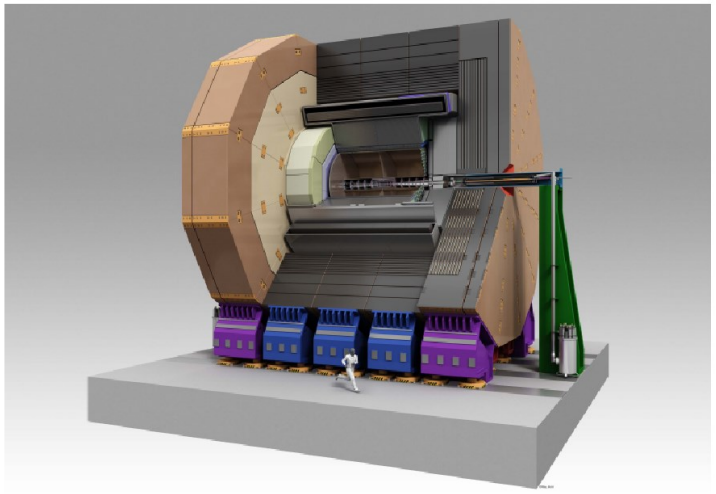
The International Linear Collider (ILC)

- Proposed linear accelerator under political consideration in Japan
- Center-of-mass energy: 250-500 GeV.
- Two proposed detectors: ILD and SiD



The International Large Detector (ILD)

- Multipurpose detector specialized on using Particle Flow Algorithms (PFA)
- Central tracker: time-projection chamber (TPC) which allows continuous tracking & measurement of the specific energy loss (dE/dx)



Physics Program at ILD

Motivation of my topic

Finding new physics with e.g.

- strange-Yukawa coupling ($H \rightarrow s\,\bar{s}$) (see https://arxiv.org/abs/2203.07535)
- W and Z hadronic branching fractions
- s-channel forward-backward asymmetry ($\mathrm{Z} \rightarrow s\,\bar{s}$) (see https://arxiv.org/abs/2306.11413)

ILD prerequisites:

→ high-performance jet tagging!

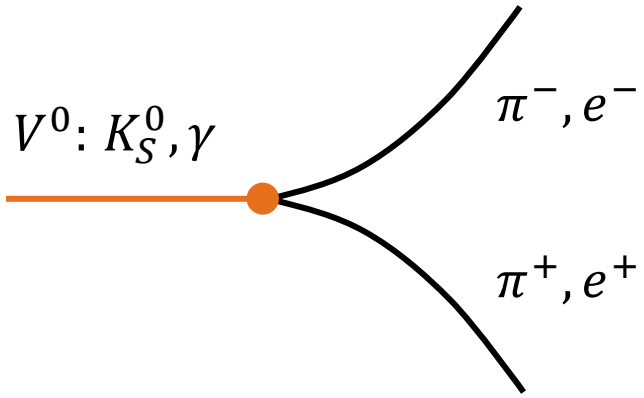
→ strange tagging requires identifaction of strange particles!

K_S^0 and Λ can be found via: **V0-finding**

Reconstruction of neutral particles V^0 at ILD

With iLCsoft

- Marlin processor: V^0- Finder
- For every track pair in tracking detectors: Calculation of point of closest approach between two tracks → V^0 candidate
- Determination of particle ID through testing rest mass hypotheses of different particles i ∈ $(\gamma, K_S^0, \Lambda, \overline{\Lambda})$ with **min($\Delta m = |m_{inv} - m_i|$)**



Analysis of the V^0- Finder

Research question

How well does the V^0-Finder perform?
Can we possibly improve it?

Investigations:

- Purity of the V^0- Finder
- Efficiency of the V^0- Finder
- PID condition

Purity and efficiency

Definitions

Efficiency

= Correctly identified reconstructed V^0 / all MC V^0

"How many MC V^0 are correctly identified?"

Purity

= Correctly identified reconstructed V^0 / all reconstructed V^0

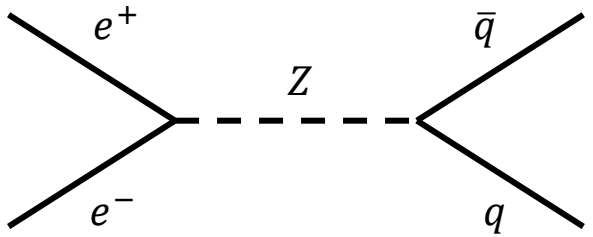
"How many reconstructed V^0 are coming from MC V^0 of the same kind?"

Simulated Data

ILD Large MC production (GEANT4-based)

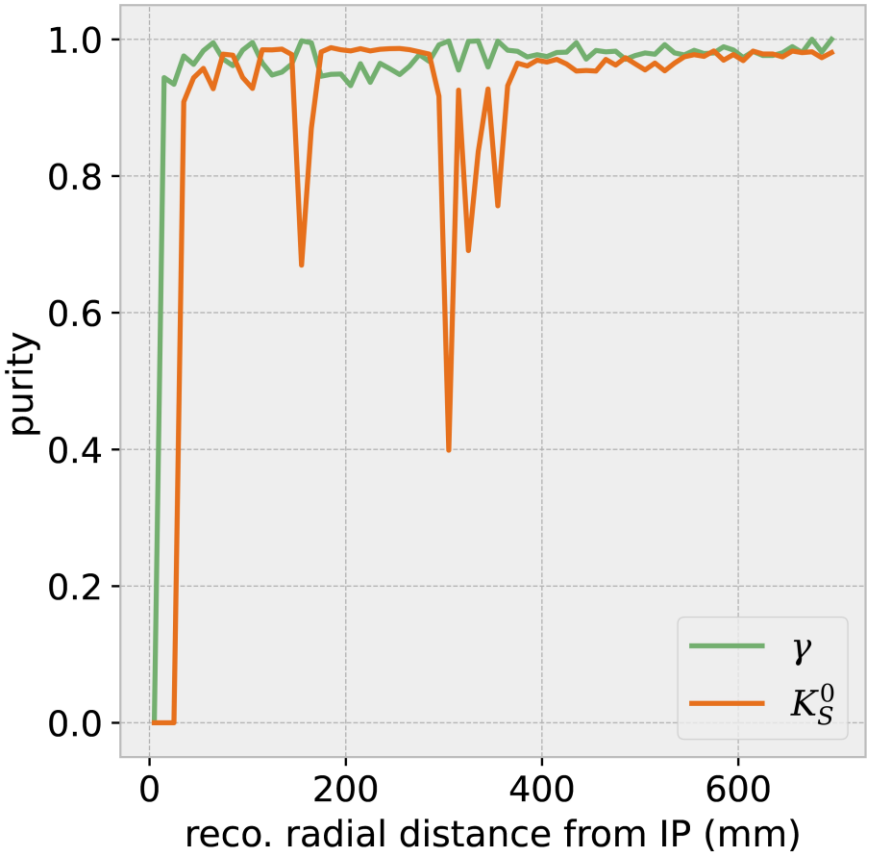
s-channel $q\bar{q}$ process (2-fermion-Z-hadronic)

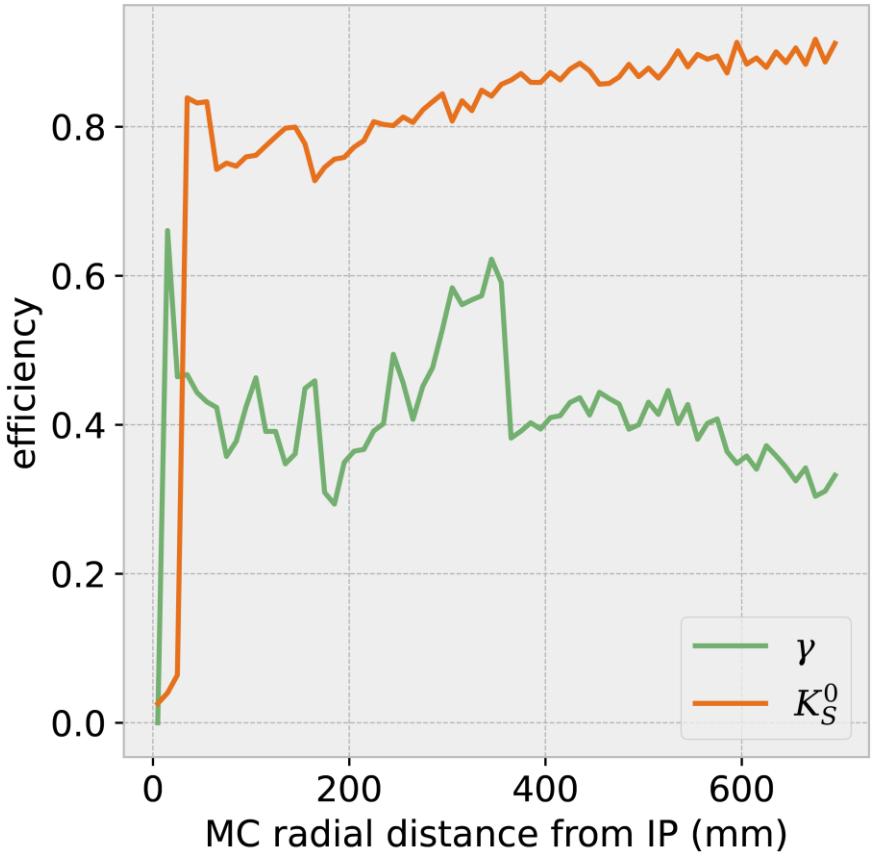
~ 200 000 V^0



Purity and efficiency

Status quo



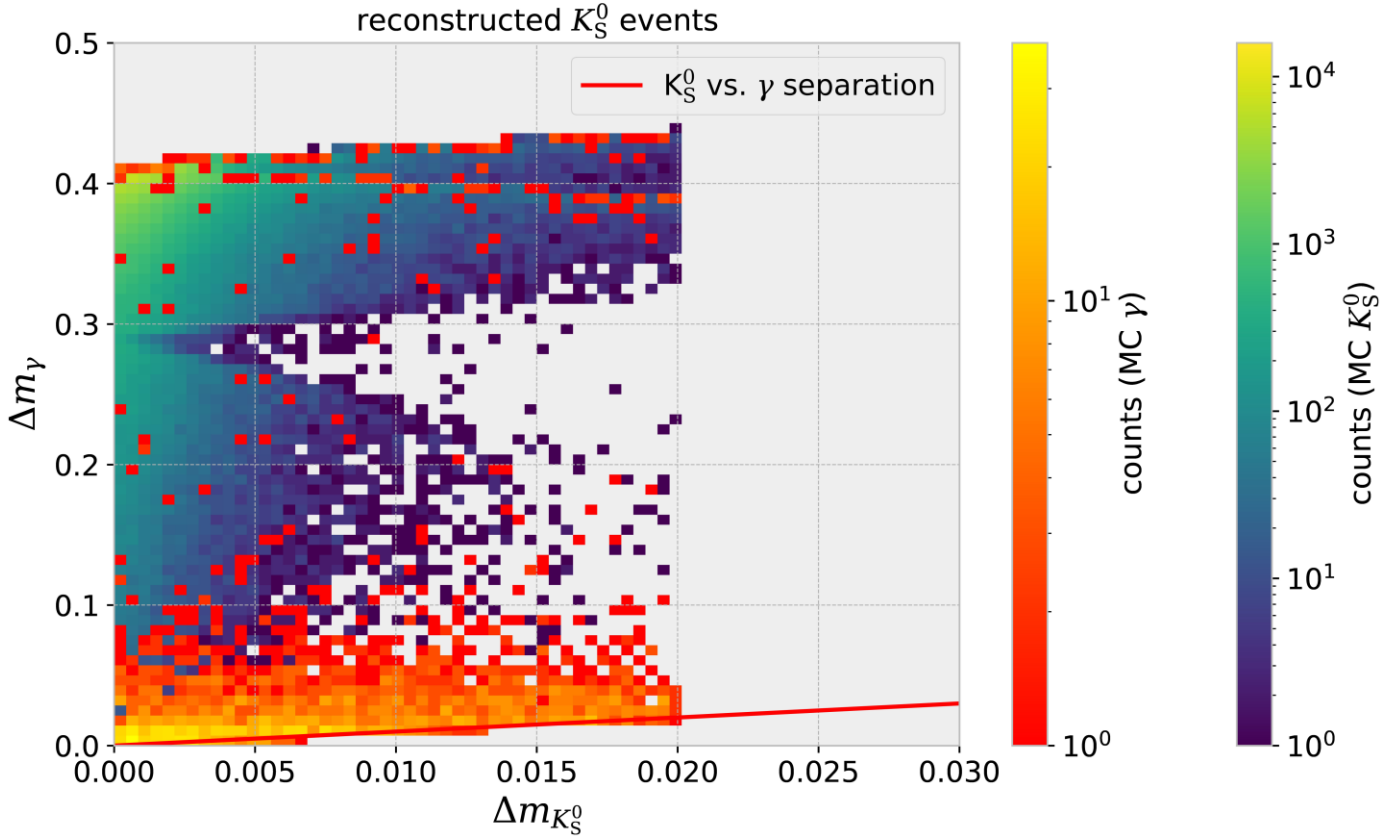


Observation: There are MC Photons among reconstructed K_S^0 ! (0.986%)

PID via mass condition

Reconstructed K_S^0: K_S^0 vs. γ separation

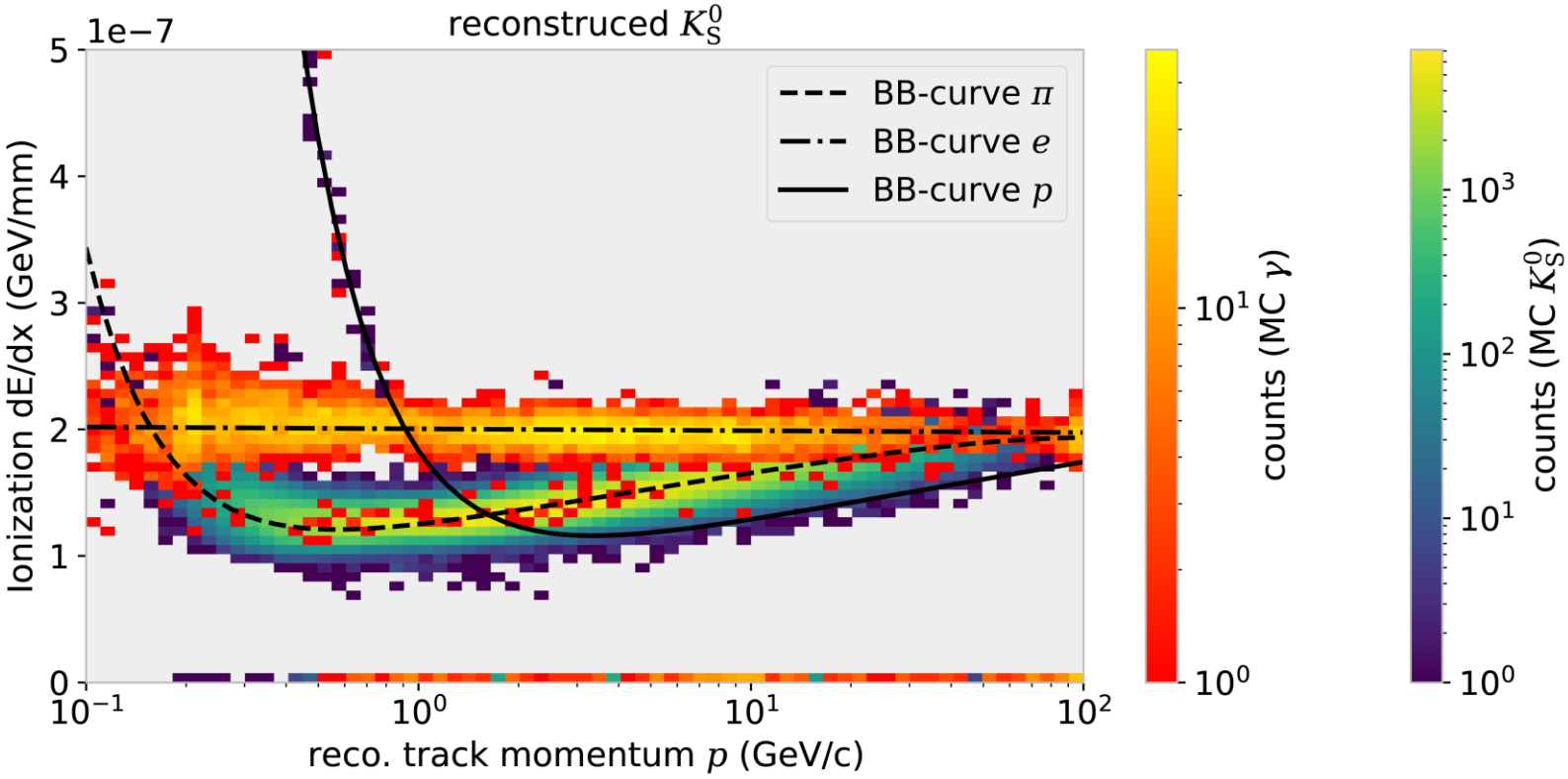
- Distinction between K_S^0 and γ through test of invariant masses
- If $\left|m_{inv} - m_{K_S^0}\right| = \Delta m_{K_S^0} < \Delta m_\gamma$, V^0 is identified as K_S^0 and vice versa



K_S^0 vs. γ separation

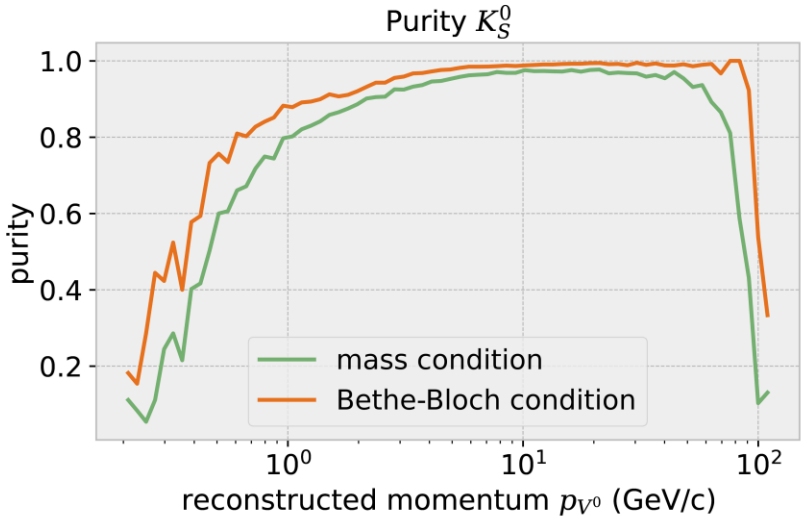
An other approach: Bethe-Bloch

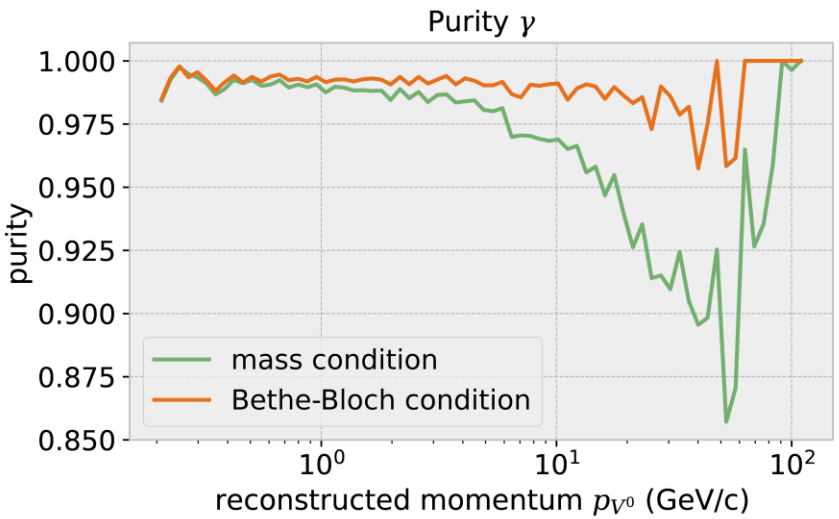
- Distinction between K_S^0 and γ through amount of ionisation of the decay products in TPC (dE/dx)
- Description via Bethe-Bloch formula → Improvement of V^0-Finder?

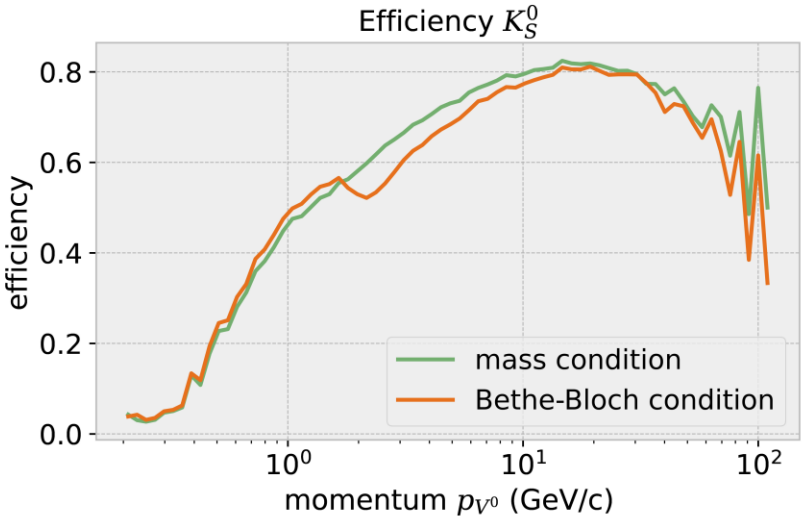


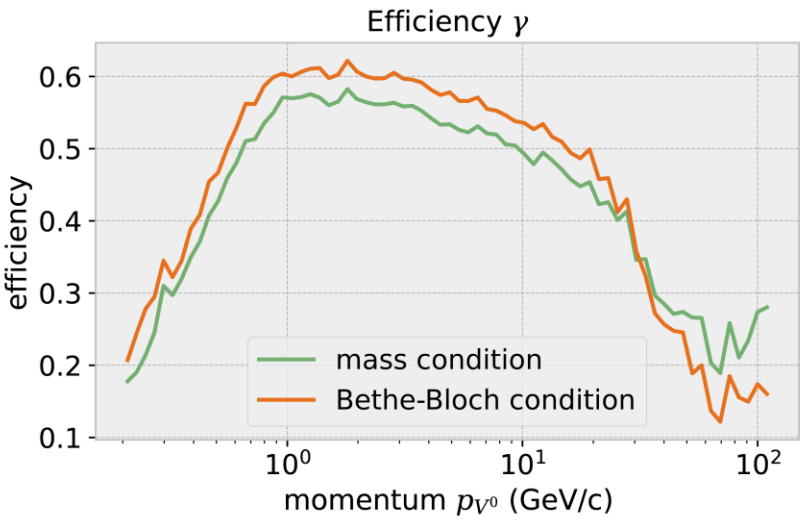
Purity and efficiency

PID via Bethe-Bloch



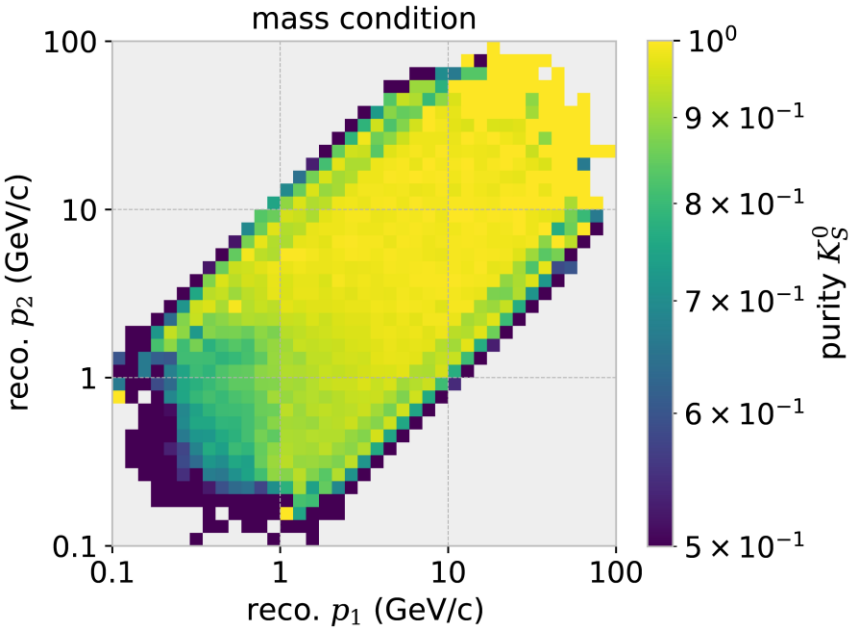


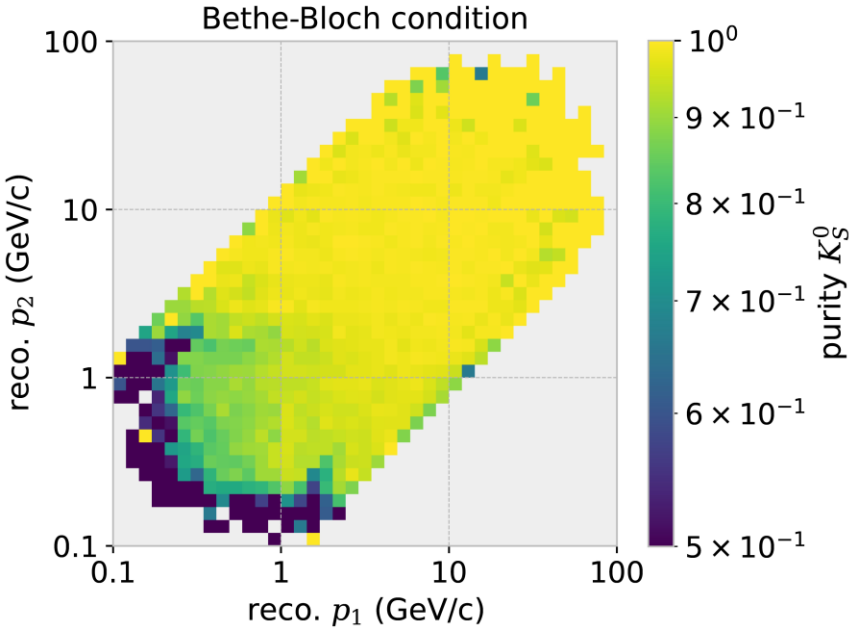




Combining mass and Bethe-Bloch condition

Method





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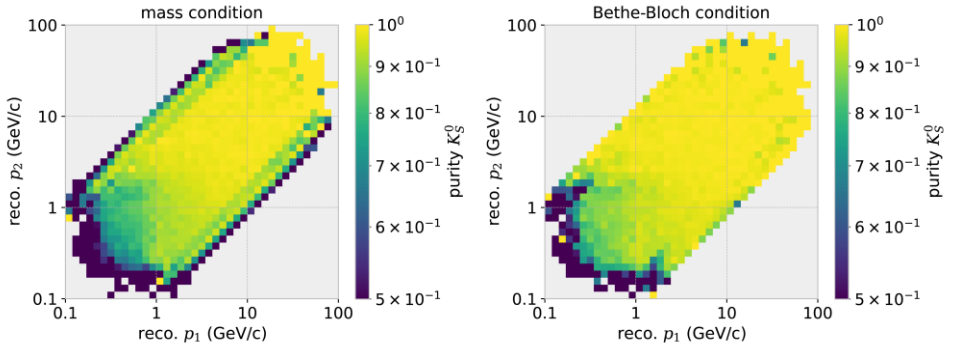
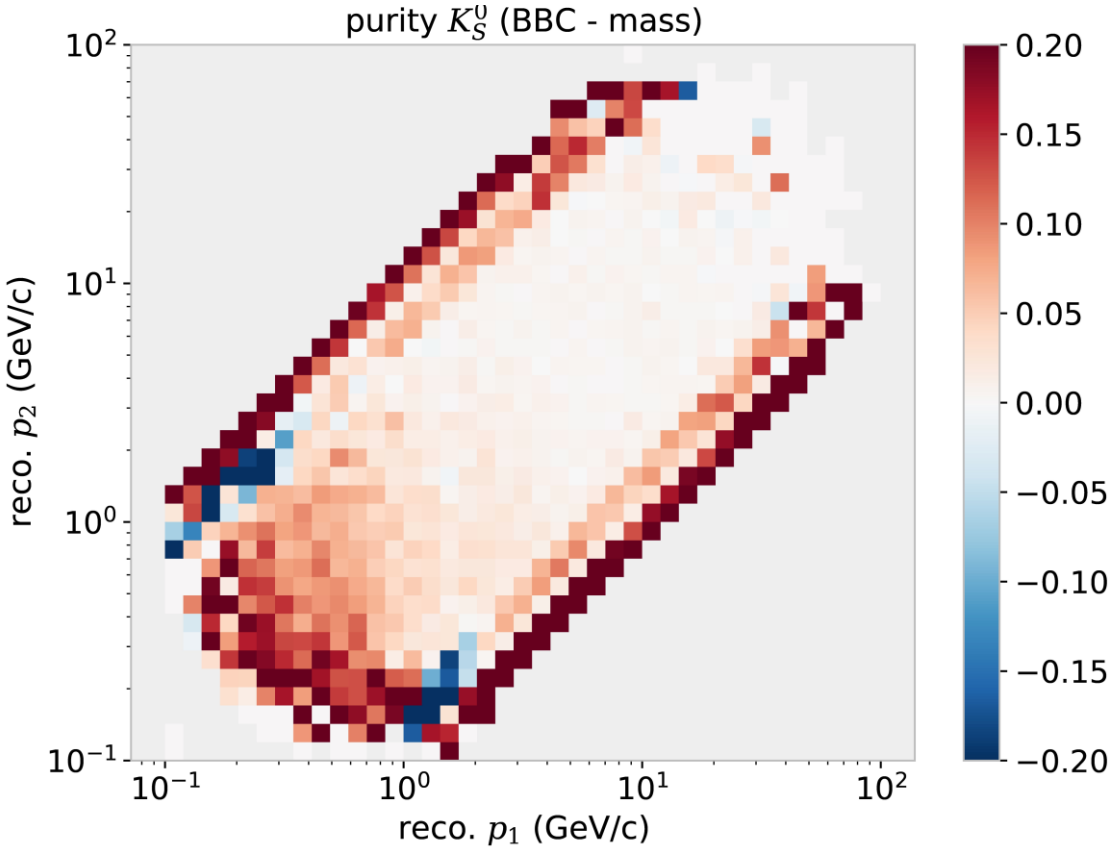


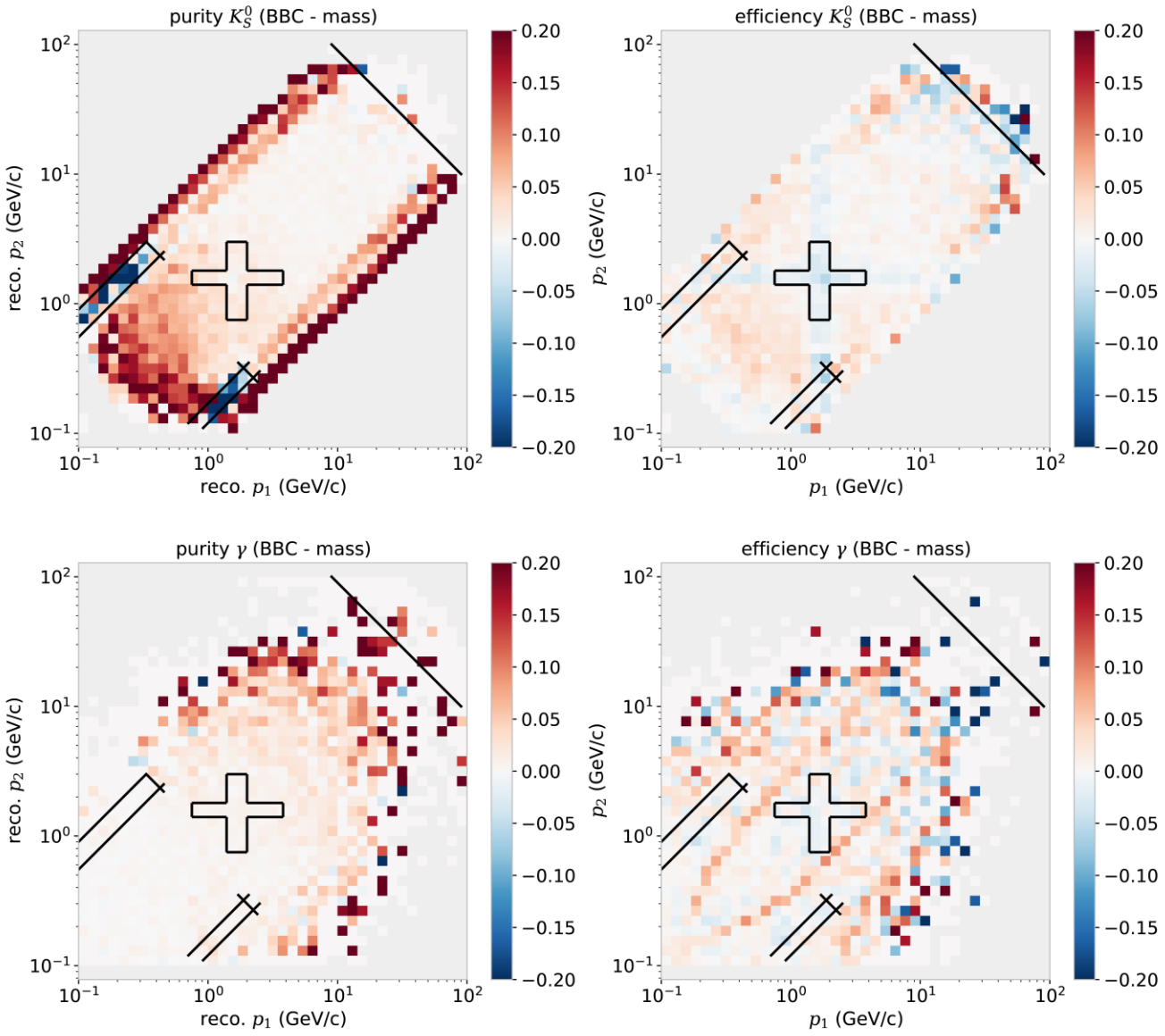


Combining mass and Bethe-Bloch condition

Method: the cut

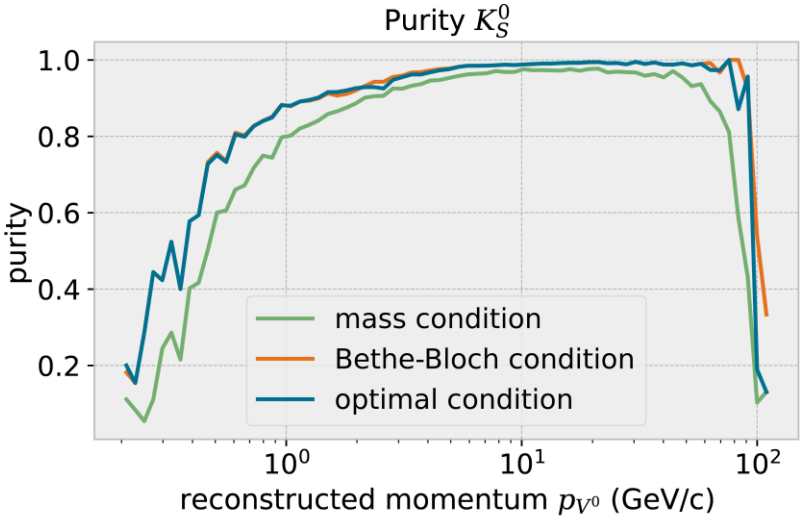
- **Red regions**: Bethe-Bloch condition better
- **Blue regions**: mass condition better

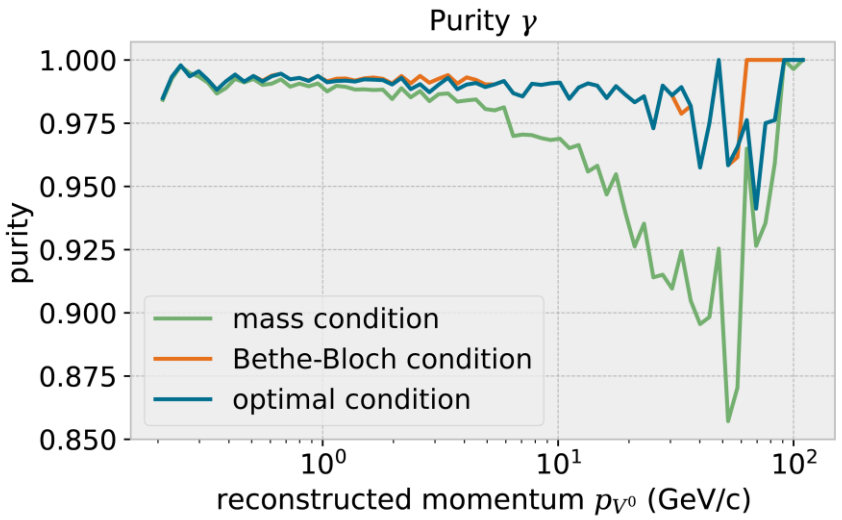
→ **Cut**: Use mass condtion in blue areas, Bethe-Bloch condition otherwise!

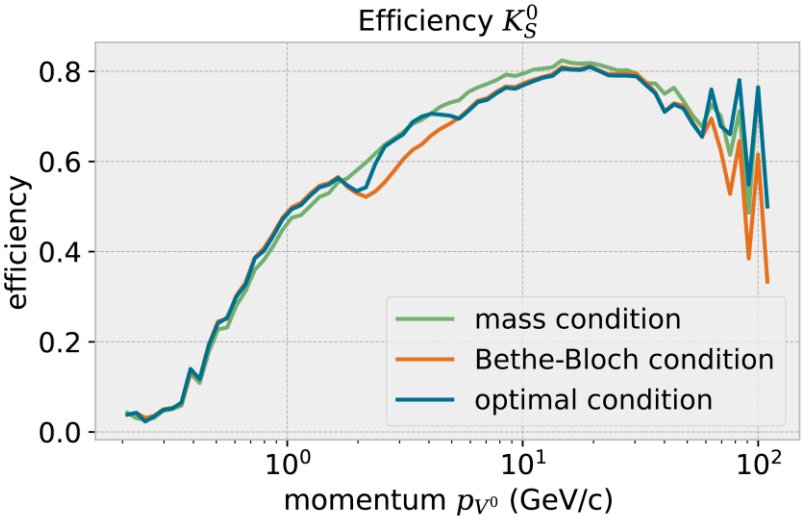


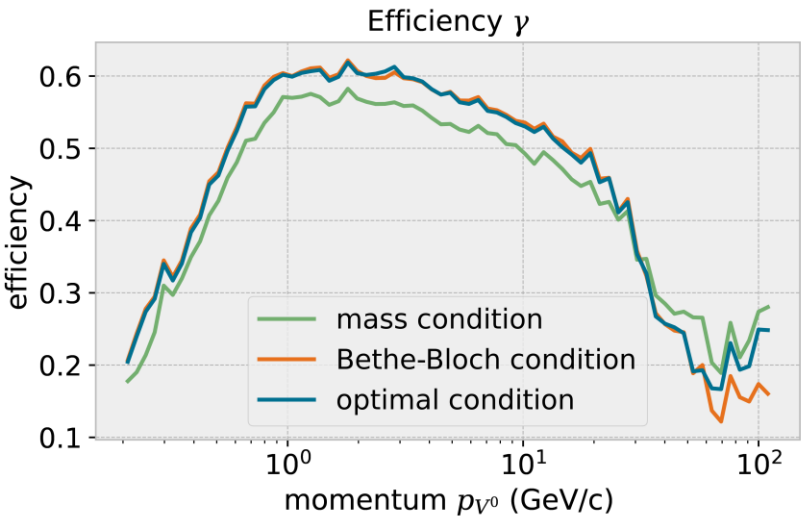
Purity and efficiency

PID via mass and Bethe-Bloch conditions

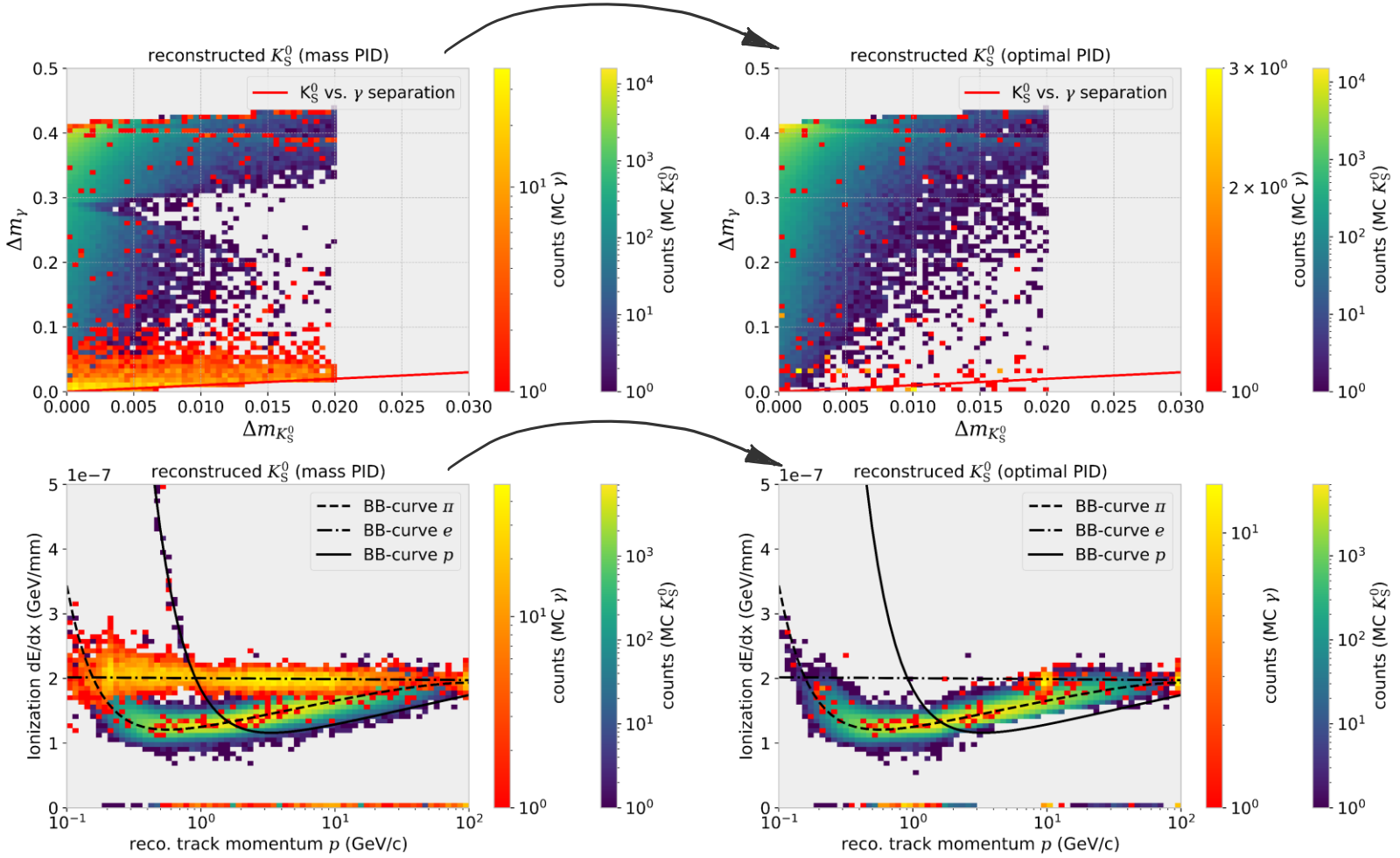








Back to the motivation: K_S^0 purity



0.986% MC photons of reco. K_S^0

0.072% MC photons of reco. K_S^0

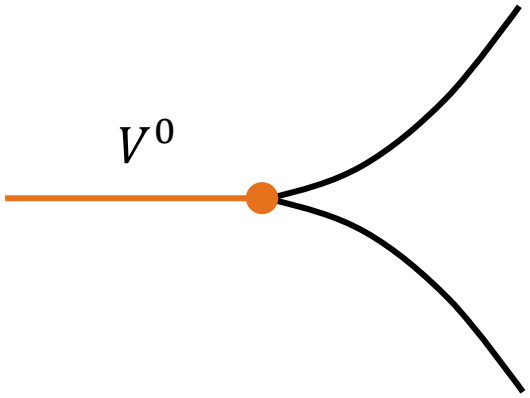
→ **Improvement: Factor of 13.6**

Conclusion

In the middle of the journey…

Summary

- Two new PID methods implemented into Marlin V^0-Finder, which are **ready to use**
- Improvement of purity **and** efficiency of V^0-Finder
- Personal highlight: Improvement of K_S^0 purity regarding photons by a **factor of 13.6**



Outlook

- Other combinations of using mass and Bethe-Bloch condition
- Boosted Descicion Tree (BDT)?
- Investigating Λ and $\overline{\Lambda}$

Thank you

Any questions?

Contact

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Why not using calorimeter information?

Insights to reconstruction at ILD

- Tracking reconstruction happens before calometry
- No particle flow objects yet
- V^0 are input to the particle flow alogrithm (Pandora)

Future consideration: Implemention of V^0 - finding in Pandora

→ *much* work needed

Let‘s build ILC first ;)

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K_S^0 purity

Investigation of the detector geometry