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Charged Particle Identification in Delphes

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CEPC Tracker Layout Working Hour
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Outline

- **Introduction**
- **Goals**
- **Method**
- **The current progress**
- **Summary**

Introduction

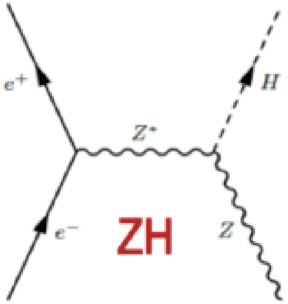
Physical background

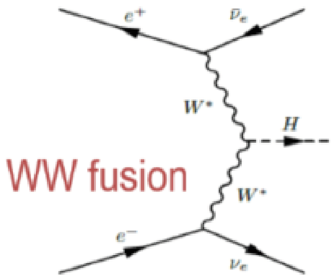
- The Standard Model (SM)
  - It describes the **strong**, **weak** and **electromagnetic** interactions. (under the framework of quantum gauge field theory)
  - The theoretical predictions of SM are in excellent agreement with the past experimental measurements.
- Higgs boson
  - Helps to our understanding of the origin of mass of subatomic particles.
  - Was recently discovered of the predicted fundamental particle, by the ATLAS and CMS experiments
  - Its discovery confirmed the Higgs Mechanism.

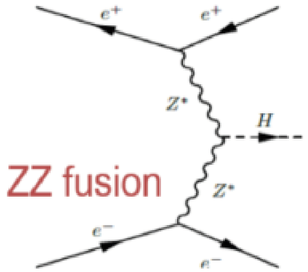
Introduction

CEPC's physical goals

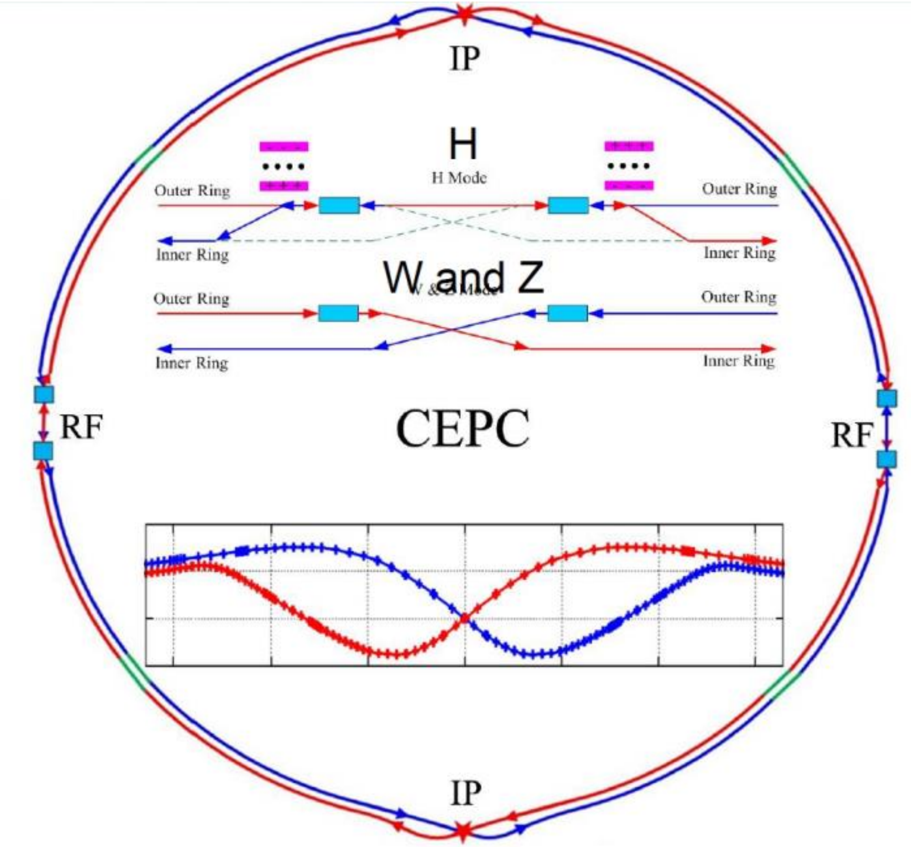
- to measure properties of Higgs boson as precise as possible
  - Higgs Factory
  - Properties: mass, spin, CP nature, couplings, and etc.
- Be upgraded to a proton-proton collider
  - Reach unprecedented high energy and discover New Physics
- three different modes
  - H ($e^+ e^- \to ZH$) (240 GeV)
  - W ($e^+ e^- \to W^+ W^-$) (160 GeV)
  - Z ($e^+ e^- \to Z$) (91 GeV)







Introduction



CEPC collider ring (100km)

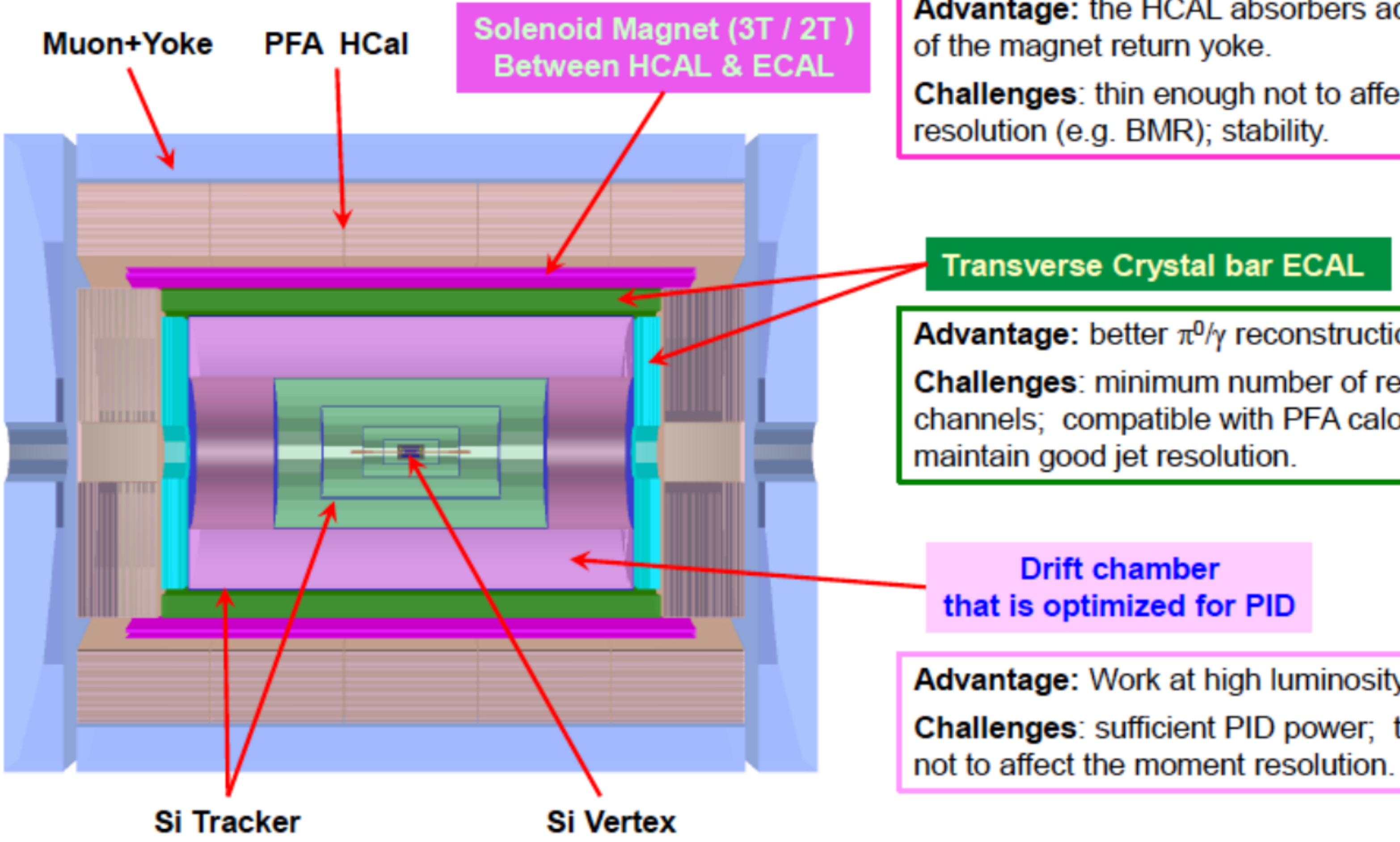
CEPC event generate

- **Luminosity**
- **quantity**

Operation mode	Z factory	W threshold scan	Higgs factory
Ecm (GeV)	~91.2	158 – 172	240
$L(10^{34}cm^{-2}s^{-1})$	17 – 32	10	3
Running time (years)	2	1	7
Integrated luminosity (ab^{-1})	8 – 16	2.6	5.6
Higgs yield	-	-	10^6
W yield	-	10^7	10^8
Z yield	10^{11-12}	10^9	10^9

Introduction

The 4th conceptual detector design



Advantage: the HCAL absorbers act as part of the magnet return yoke.

Challenges: thin enough not to affect the jet resolution (e.g. BMR); stability.

Advantage: better π^0/γ reconstruction.

Challenges: minimum number of readout channels; compatible with PFA calorimeter; maintain good jet resolution.

Advantage: Work at high luminosity Z runs

Challenges: sufficient PID power; thin enough not to affect the moment resolution.

From center away：

- **Vertex Detector**
- **Silicon Tracker**
- **Drift Chamber**
- **Calorimeter**
- **Superconducting magnets**
- **Muon Detector**

Goals

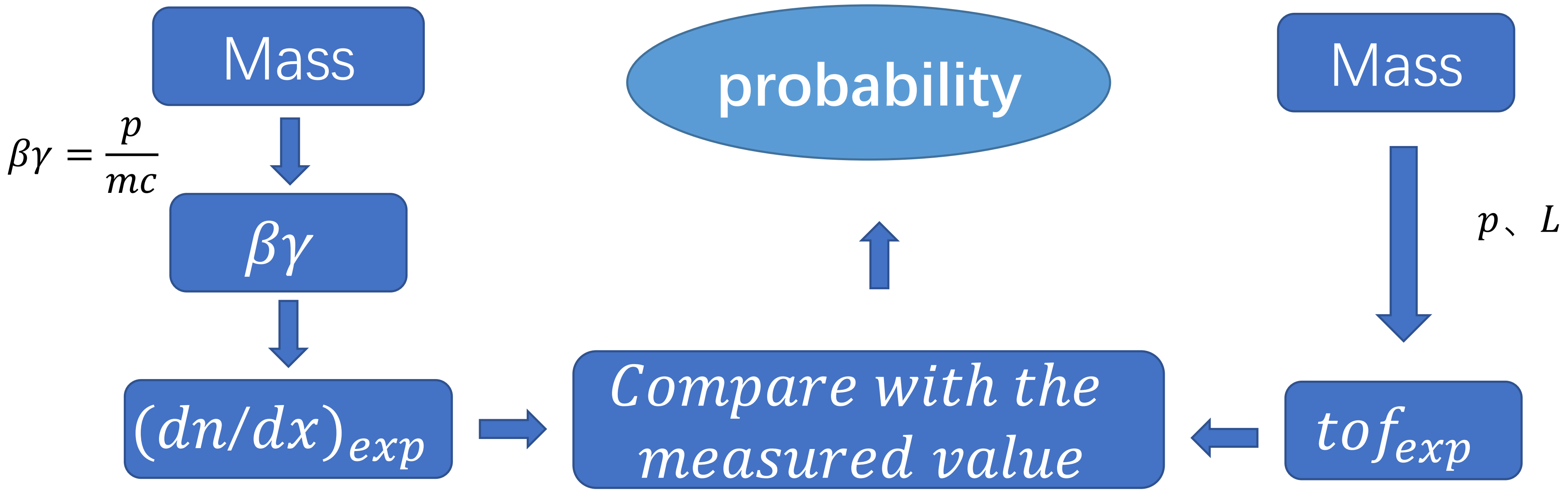
- Delphes (a detector response simulation framework)
  - Input
    - A monte-carlo event file
    - A configfiguration card (.tcl)
  - Output
    - A root file
- CEPC detector simulation
  - Charged particle： Momentum， impact parameter
  - Neutral particle： energy
  - Jet： perform jet-clustering with the charged and neutral particle as input
  - But PID ability is not available.
- This work is to add PID ability by combining dn/dx and tof.

Method

Charged Particle Identification

- Using dN/dx and tof
  - Get the probabilities of particles to be assuming as five types of particles.
    - e, μ, π, K, p

- **The most likely assumption is taken**



Method

The calculation of the probability

$$\chi_1 = \frac{(dN/dx)_{meas} - (dN/dx)_{exp}}{\sigma}$$ 2.3% $(dndx)_{exp}$

$$\chi_2 = \frac{tof_{meas} - tof_{exp}}{\sigma}$$ 50ps

$(dN/dx)_{exp}$: the corresponding dn/dx from $\beta\gamma$ calculated from the masses of different particles

tof_{exp}: $tof_{exp} = \frac{L}{v} = \frac{L}{\beta c}$ $\beta = \frac{p}{\sqrt{p^2 + m^2}}$

$\chi^2 = {\chi_1}^2 + {\chi_2}^2$ (It follows a Chi-square distribution of 2 degrees of freedom)

→ get five chi-squared values for five particles → five probabilities

The most likely assumption is taken

The current progress

PID efficiency

the preliminary average identification results are shown in the table below :

$(conciderate\ all\ five\ particles)$

$\text{Probability} > 0.1\%$

	truth number	correct number	accuracy
e	862	354	0.410673
u	4646	2391	0.514636
pion	31454	22612	0.718891
kaon	4774	4338	0.908672
p	1765	1661	0.941076

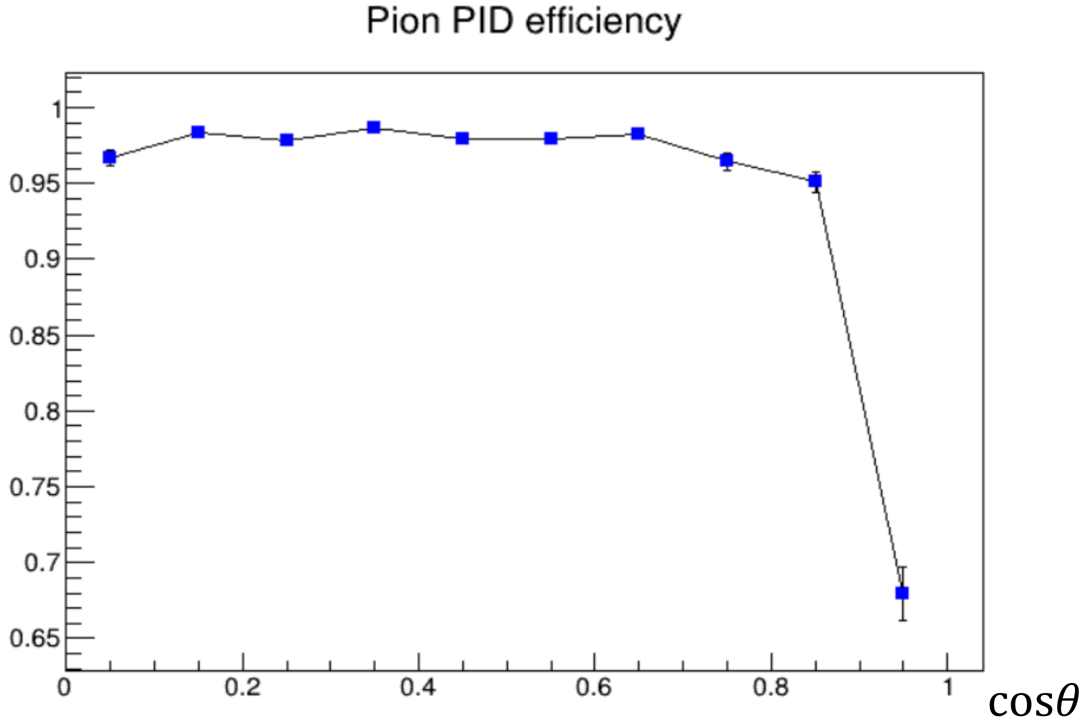
increasing

- **The probability is roughly within reasonable bounds**

The current progress

PID efficiency dependence on $\cos\theta$

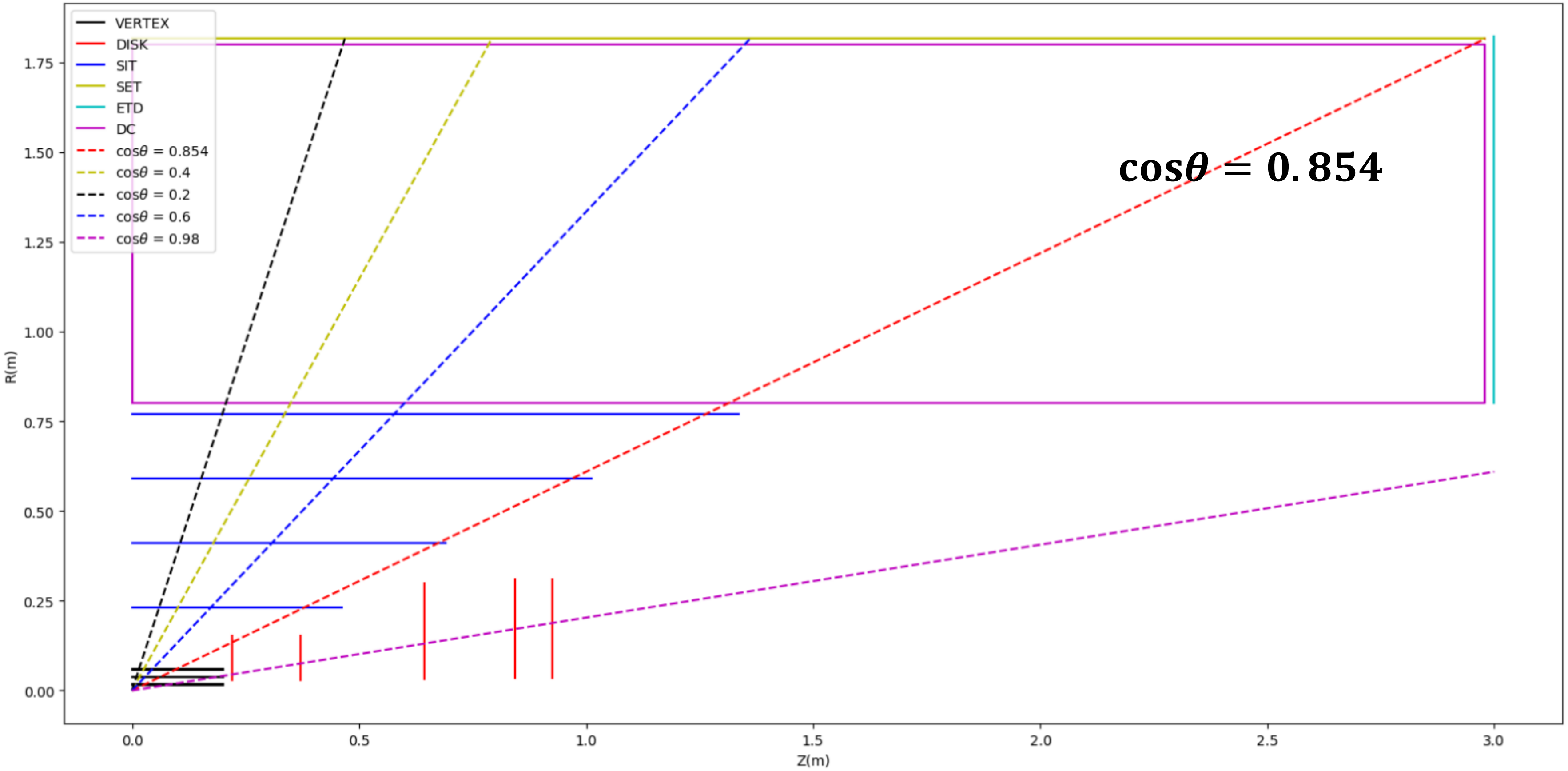
Considering π and μ are easily confused, we only identify 3 particles: π, K, p
(the quality of π is close to μ's) Probability $> 0.1\%$



- **When $\cos\theta < 0.8$, The PID performance is better.**
- **It is consistent with the expectation of CEPC (shown on the next page)**

The current progress

The distribution of particle angles in the detector:



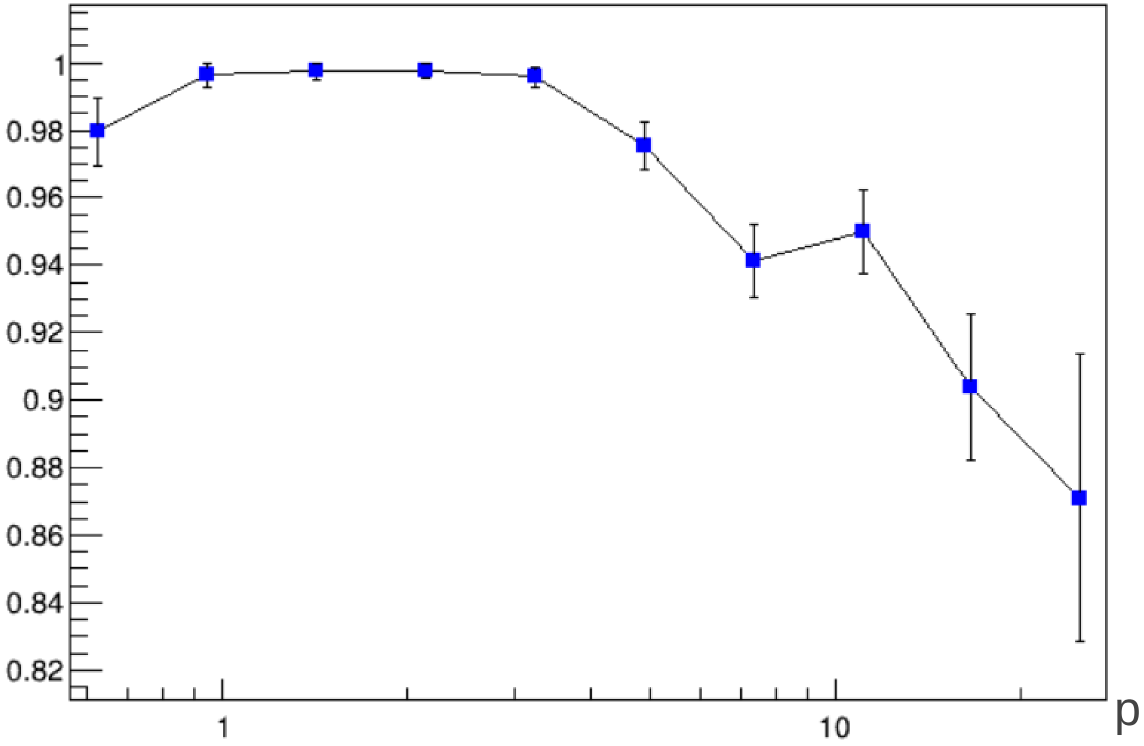
- **About $\cos\theta < 0.854$, All the particles hit the detector.**

(This result comes from the study by Youhi Yun et al)

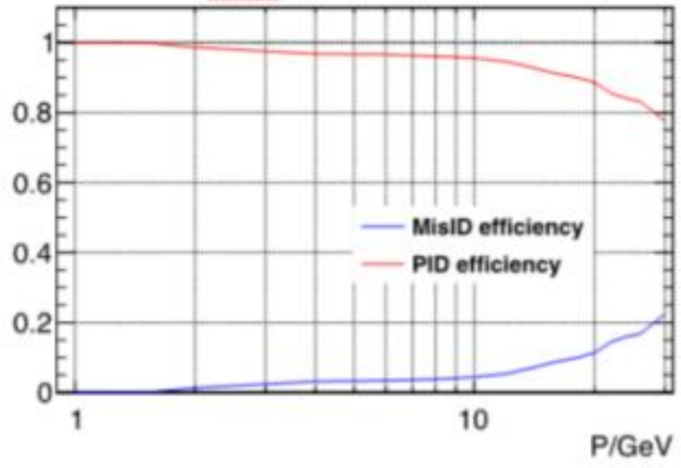
The current progress

Kaon PID efficiency dependence on momentum

only identify 3 particles: π, K, p (Probability > 0.1%, cosθ <0.8)



Reference:



- The general trend is consistent

Summary

- **Summary**
  - After many previous tests, the framework of PID part is in place.
  - But there are still many details that need to be revised to be more realistic.
    - The resolution of dN/dx and tof
    - Criterion for the identification of particles
    - Etc.
- **Next to do**
  - More validations
  - Demonstrate the significance of PID on physics study.

Thanks!