Study of inceasing CDC NN TRG Input

Yuxin Liu

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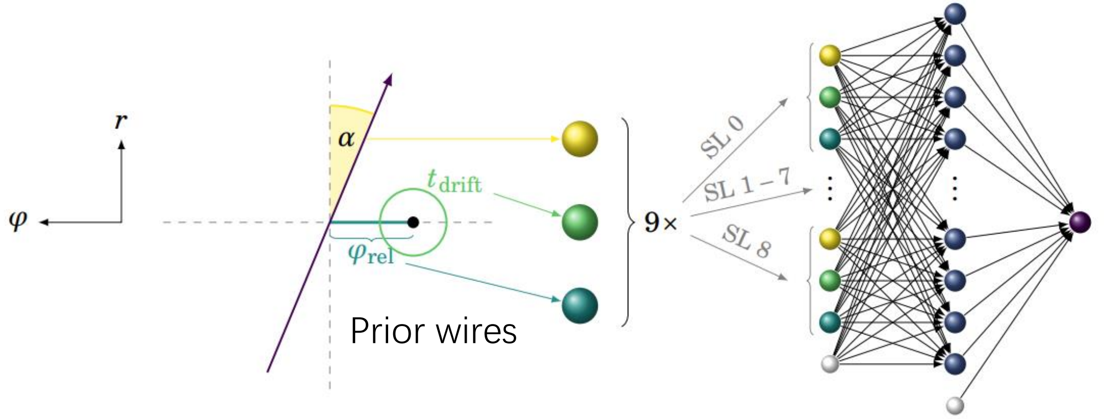
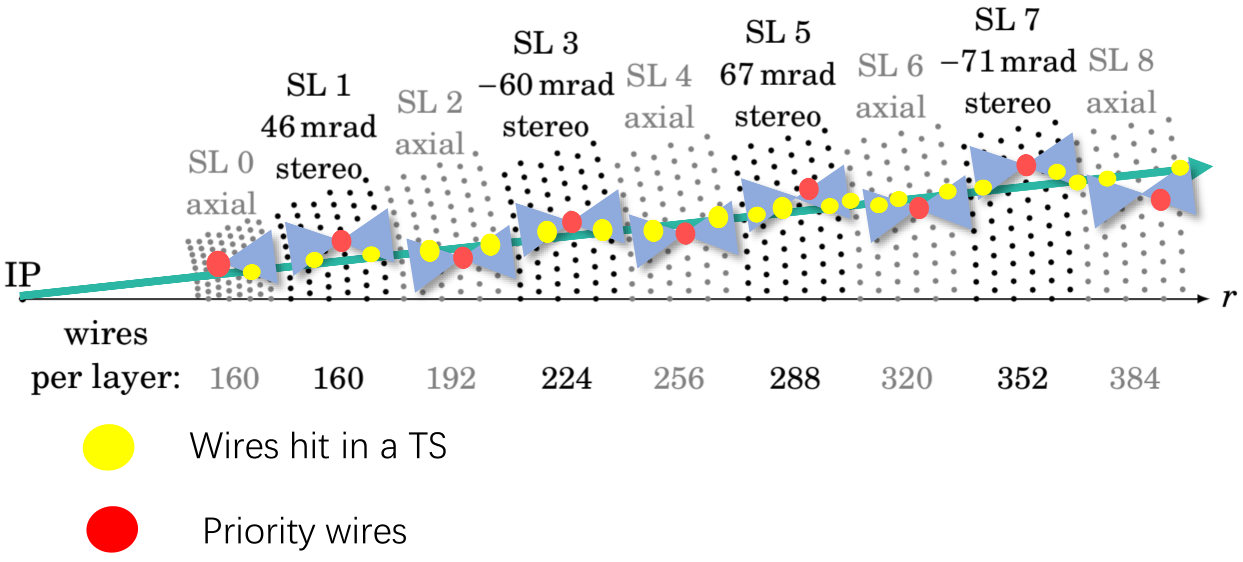
Motivation





Present 3D NN use only one prior wire per every Track Segment.

With UT4 Module, more input is possible for NN

For extra wire with $\boldsymbol{\sigma_{t_{drift}} \sim 32ns}$

$$z_0 = z_{cross} - \cot\theta_0 \frac{2\alpha}{\omega}$$

$$\Delta z_{cross} = \frac{r_{wire}}{\sin\psi}\sqrt{(\Delta\phi_{cross})^2 + (\Delta\phi_B)^2}$$

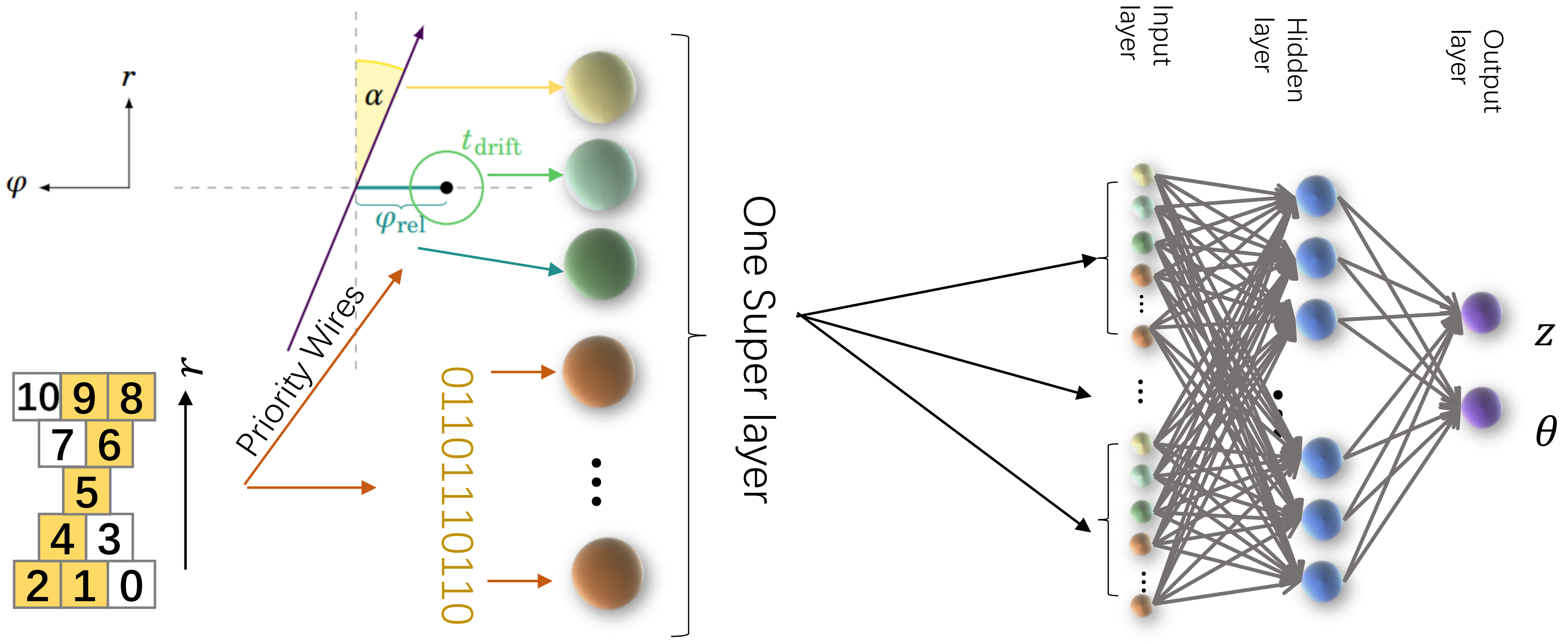
The Δz_{cross} calculated by a single wire is (at large $\boldsymbol{P_t}$)

$$\Delta z_{cross} \sim 2.0 \text{ cm to } 3.4 \text{ cm}$$

In the same order of prior wire (0.4cm to 1.4cm)

Could be used to improve the resolution of NN.

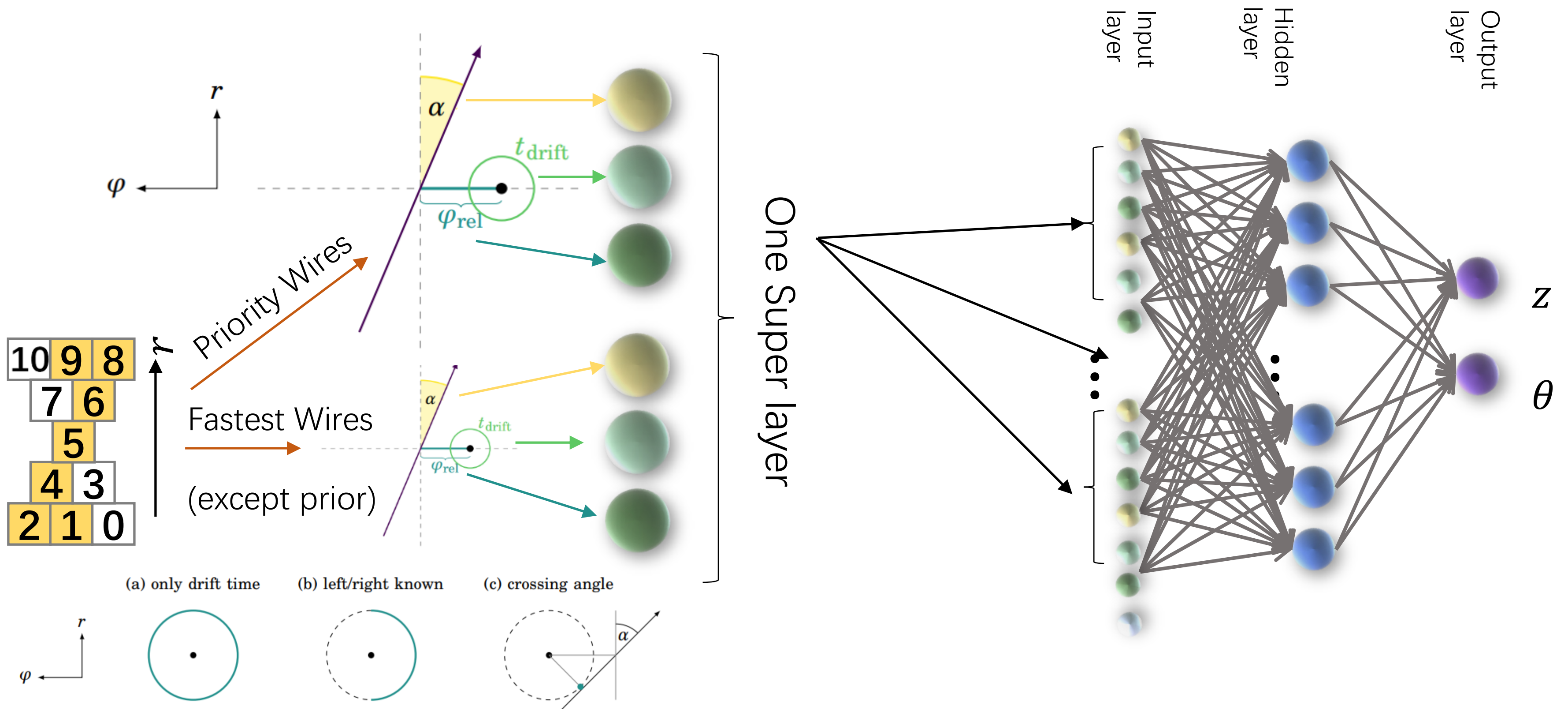
First attempt: Directly use TS pattern as input



Directly use 11/15 bits pattern as input

Since L/R information are got from pattern, hoping could replace L/R with it

Second attempt: Use extra wire(s) with full information



Using wires with no hit as input would decrease resolution significantly

Build up L/R look up table for every wires in TS

Choose the 1(2,3) wire(s) with fastest t_{drift} and with L/R know first (if applied)

MC Test

MC :

Train Sample

Particle gun:

muons;   single tracks;

Pt :[0.3 GeV,3 GeV], uniform;

Φ: [0, 360],uniform;

θ: [0,170], uniform;

Vertex z0: [-50, 50], uniform;

N events: 300k

Validation Sample:

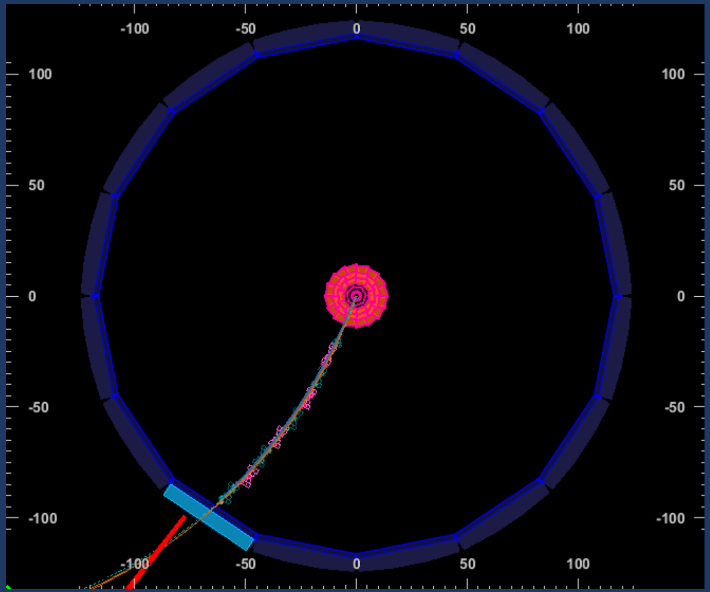
Same config;

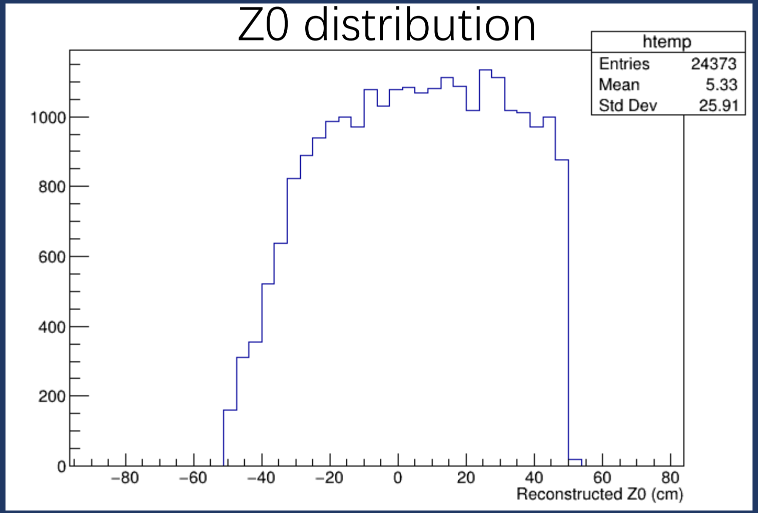
N events: 20k

Test Sample:

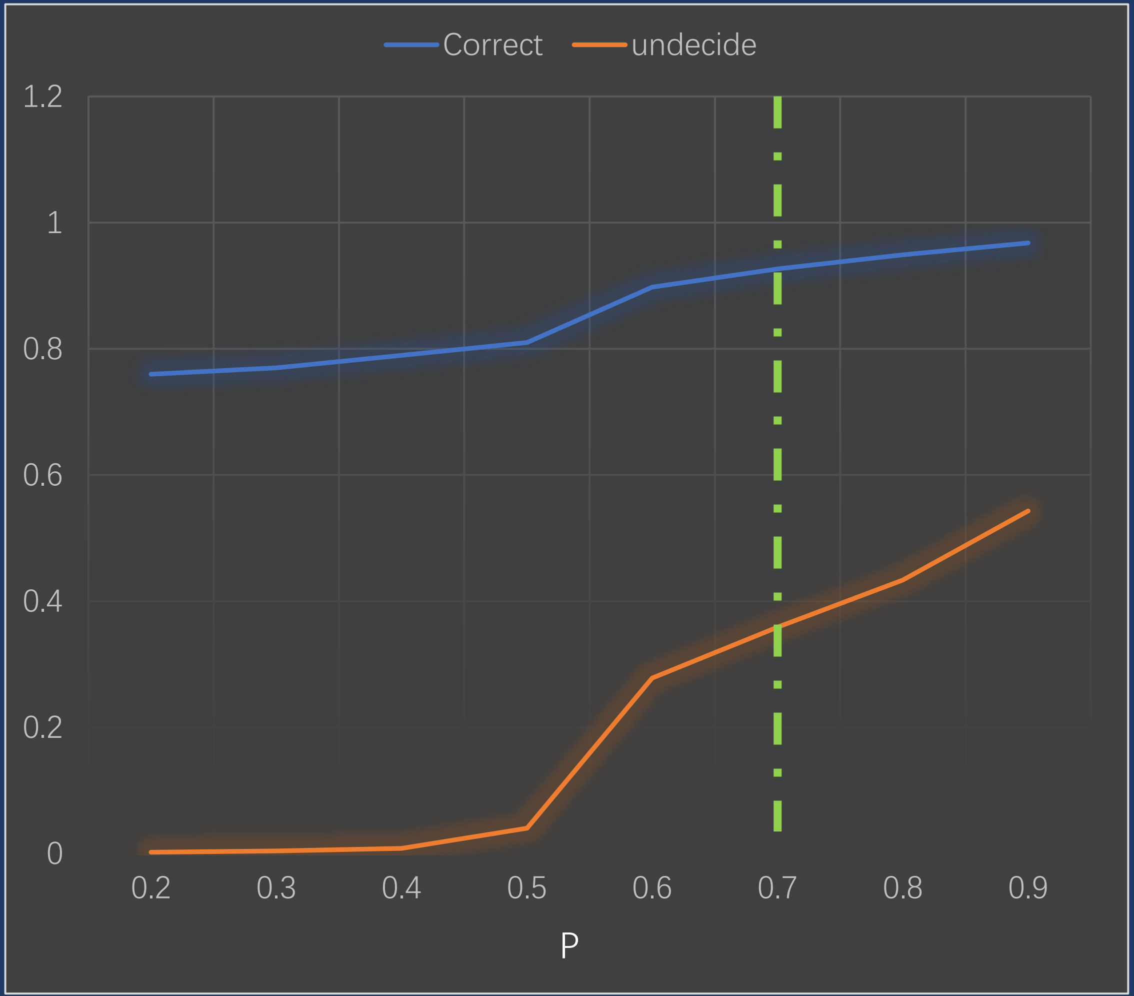
Same config;

N events: 50k





L/R information for every Wires in TS



Follow the old way to build up a LUT for **every wires in TS**

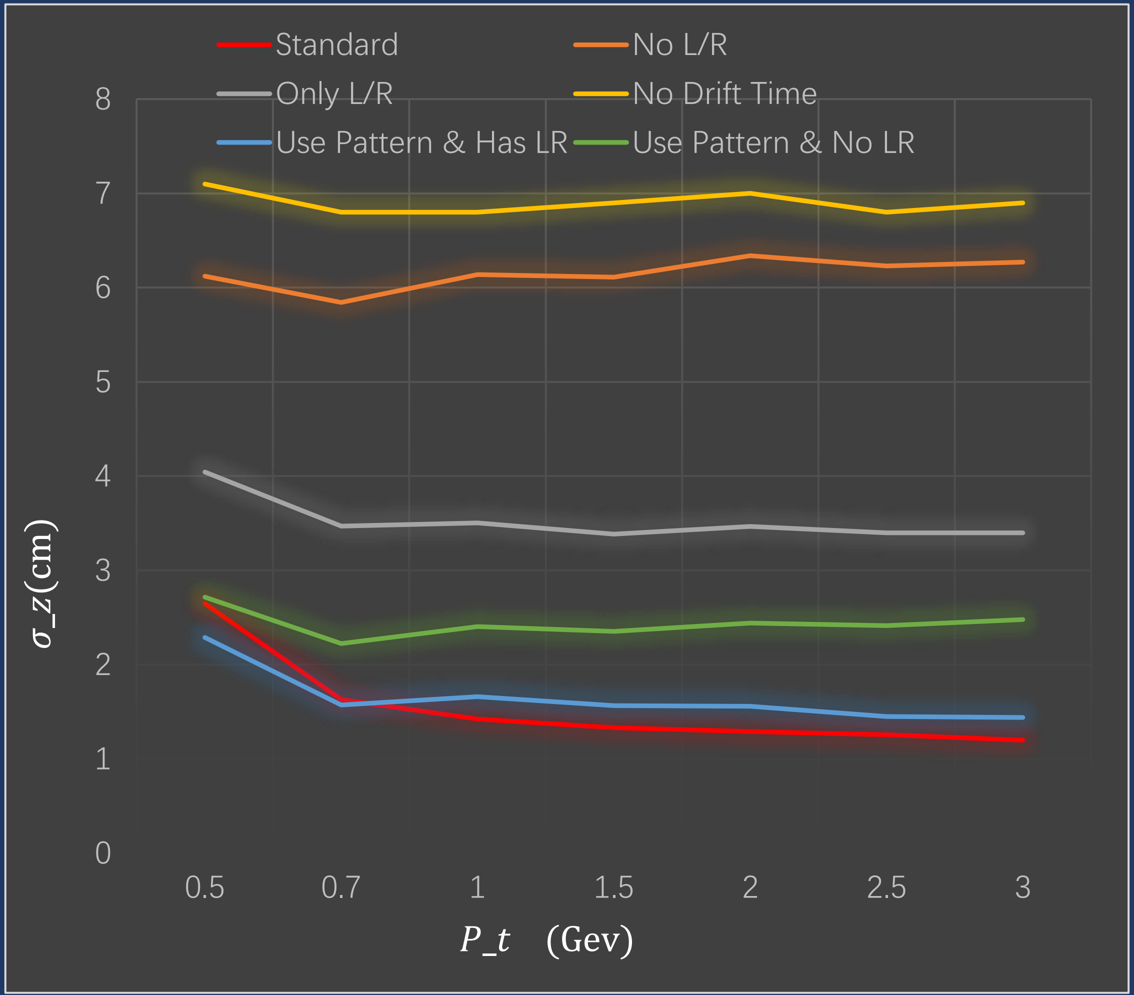
Use MC without Bkg first

$$L/R\ state = \begin{cases} left & if\ n_L > p(n_L + n_R) + 3\sigma \\ right & if\ n_R > p(n_L + n_R) + 3\sigma \\ undecide & otherwise \end{cases}$$

Choose P = 0.7 for LUT.

Since undetermined rate is high, when use LUT, only require one extra wire

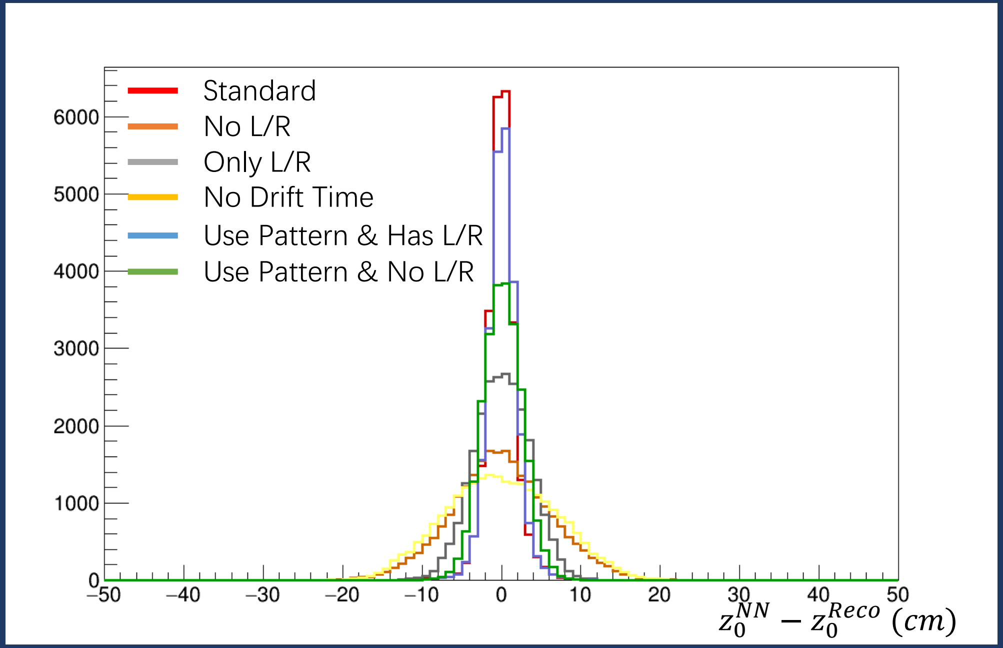
Use pattern to replace L/R



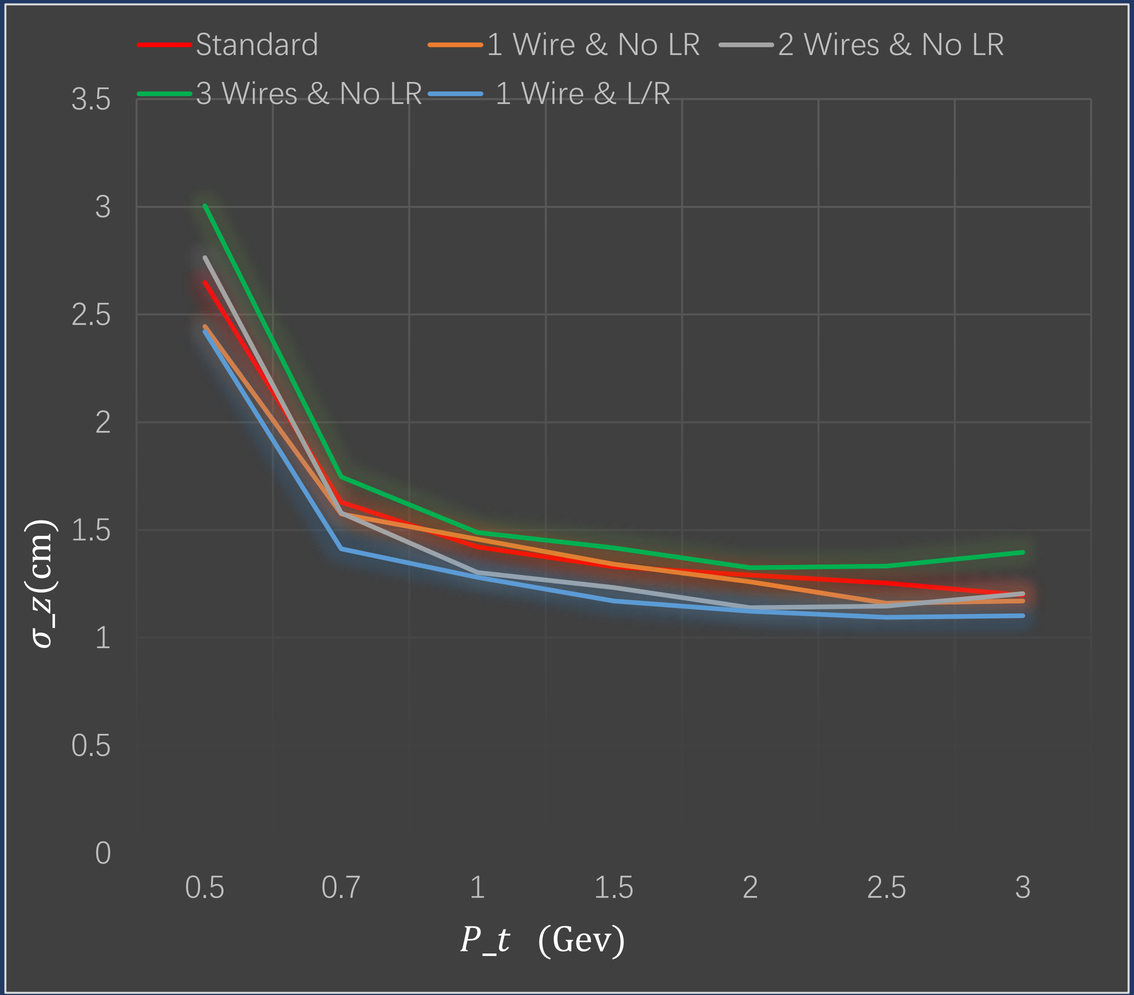
Trained NN based on MC

ETF : Set Event T0 as zero for precise t_{drift}

Pattern input can not fully replace L/R. Even with both pattern and L/R, no improvement for the standard model



Extra wire as input

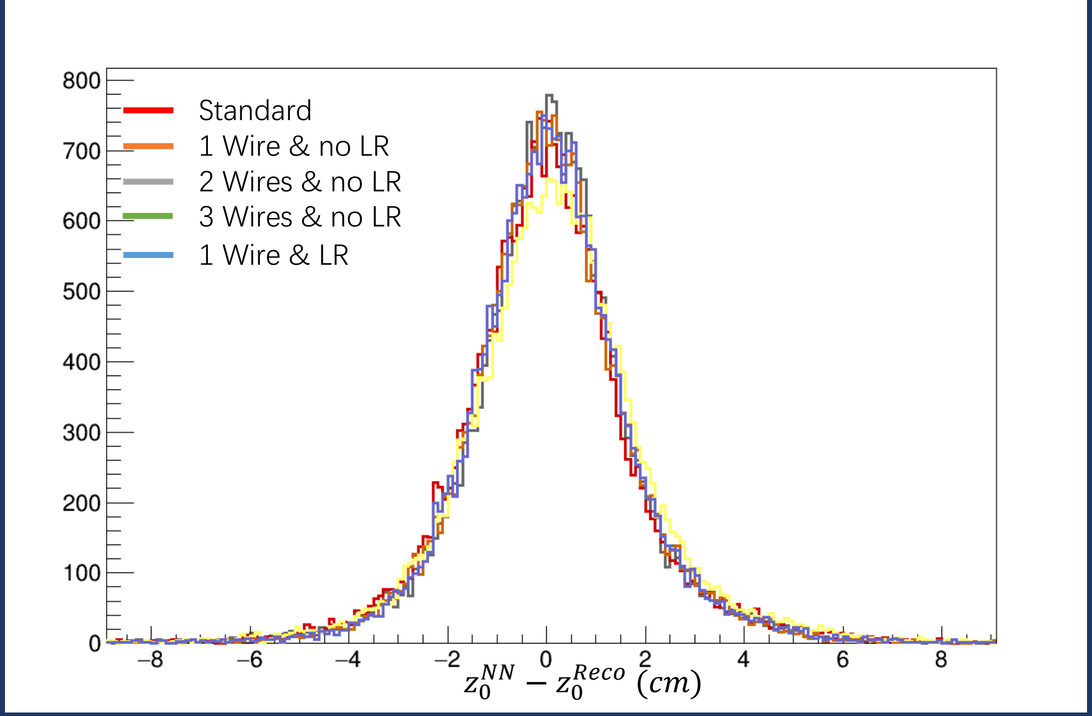


Trained NN based on MC

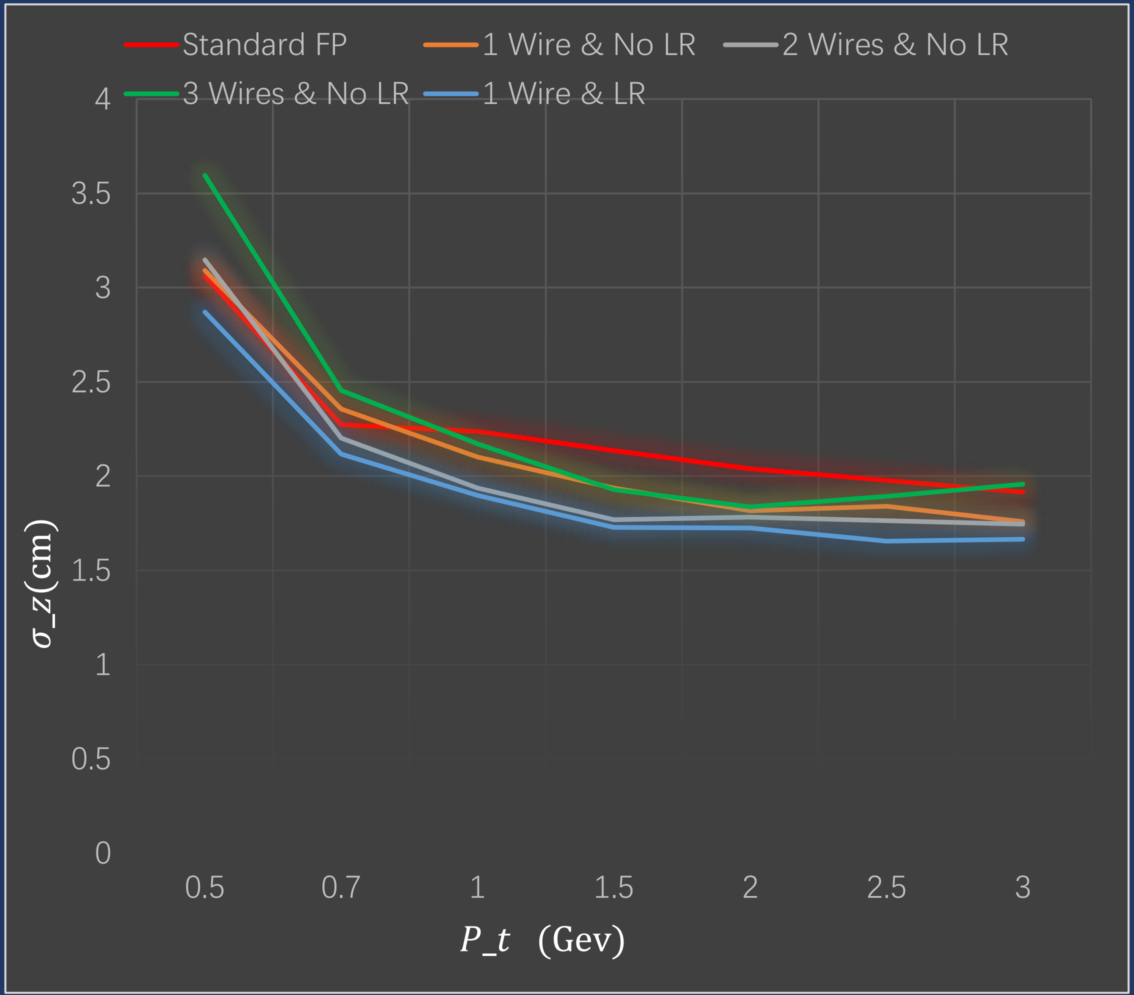
ETF : Set Event T0 as zero for precise t_{drift}

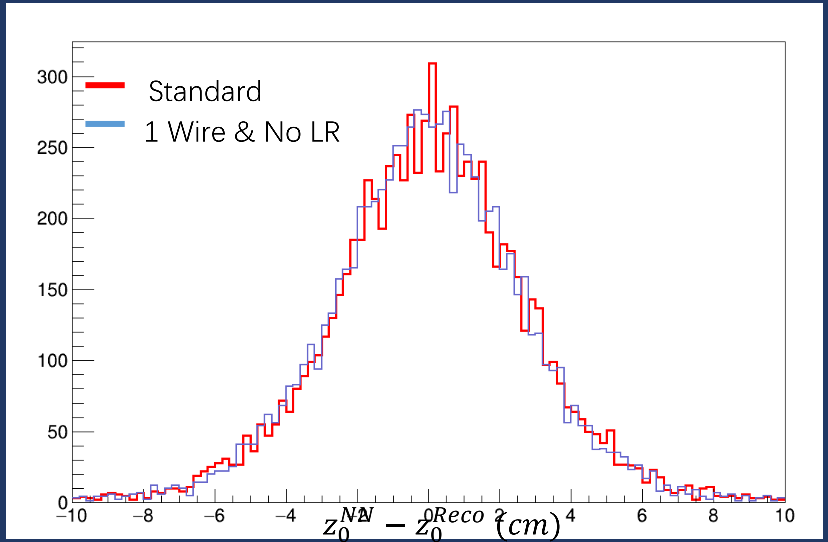
Add More wires without L/R make little improvement

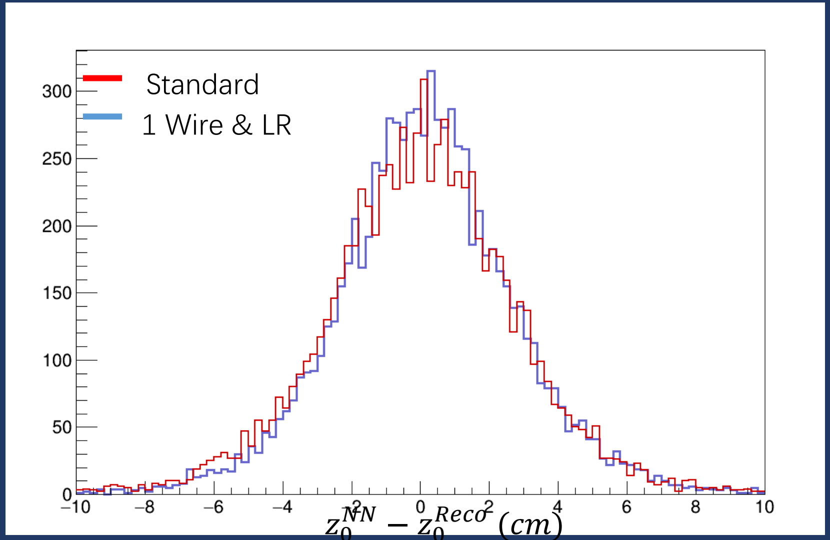
Add wire with L/R could make slightly difference in MC



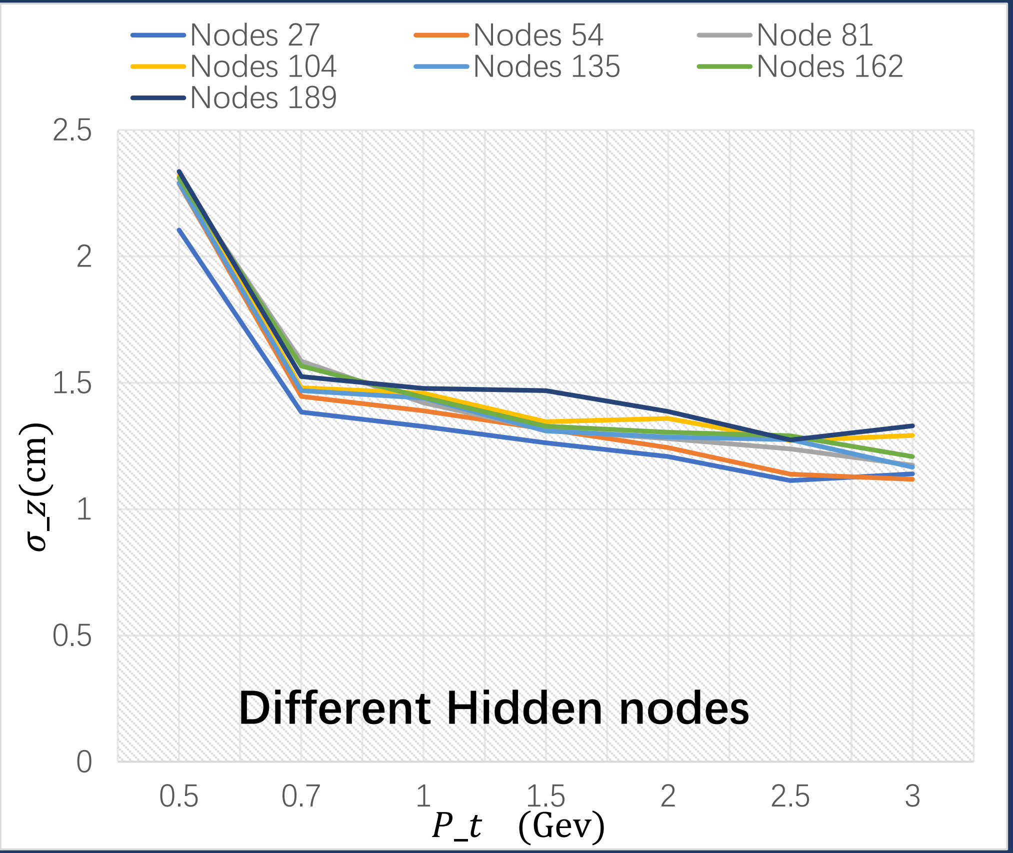
Extra wire as input -- fastpriority

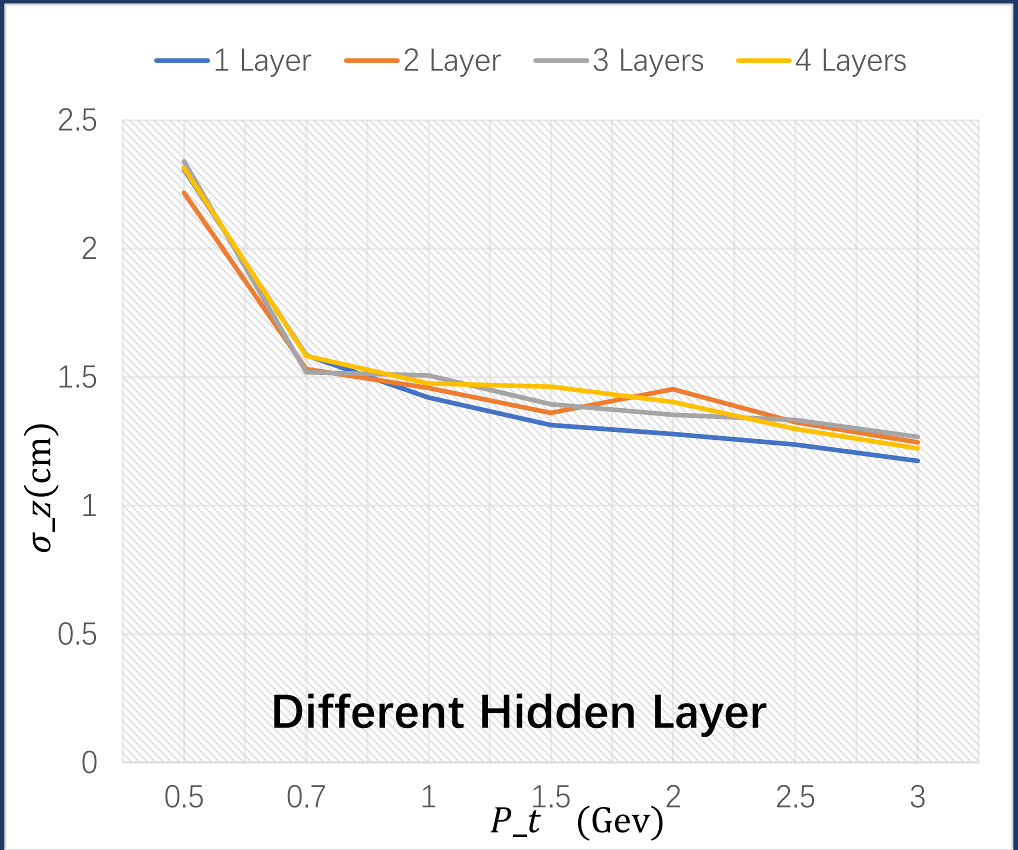






Hidden Layer



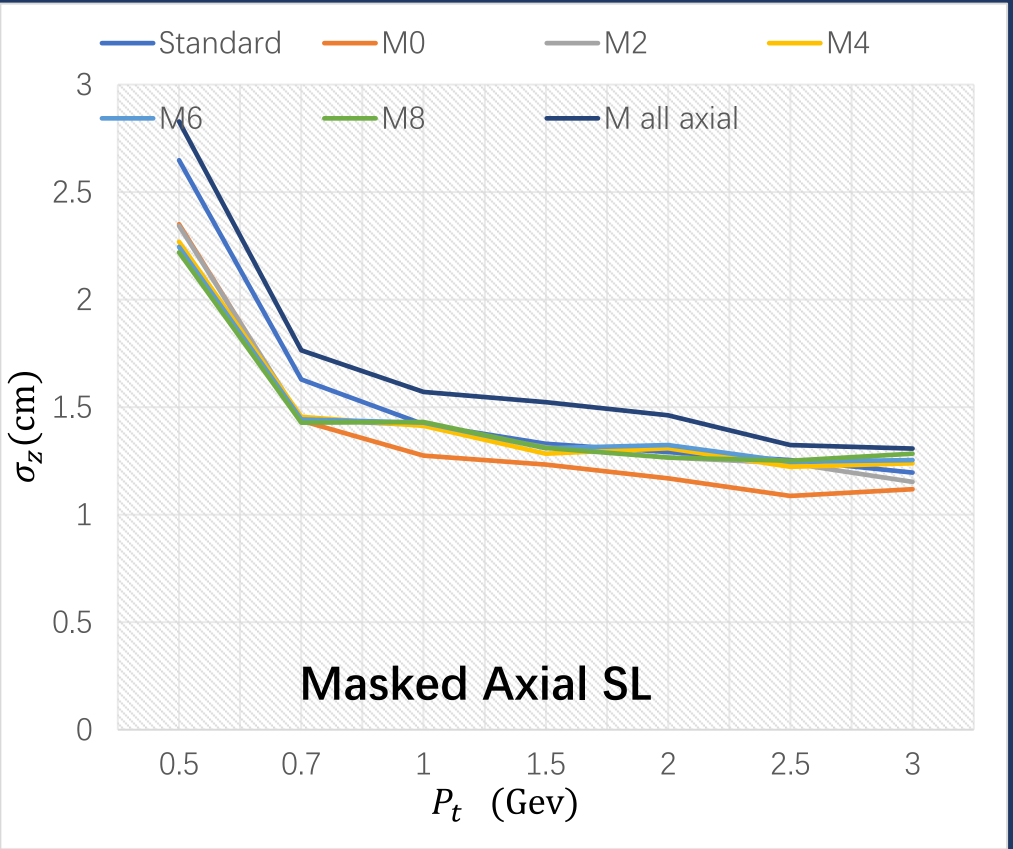


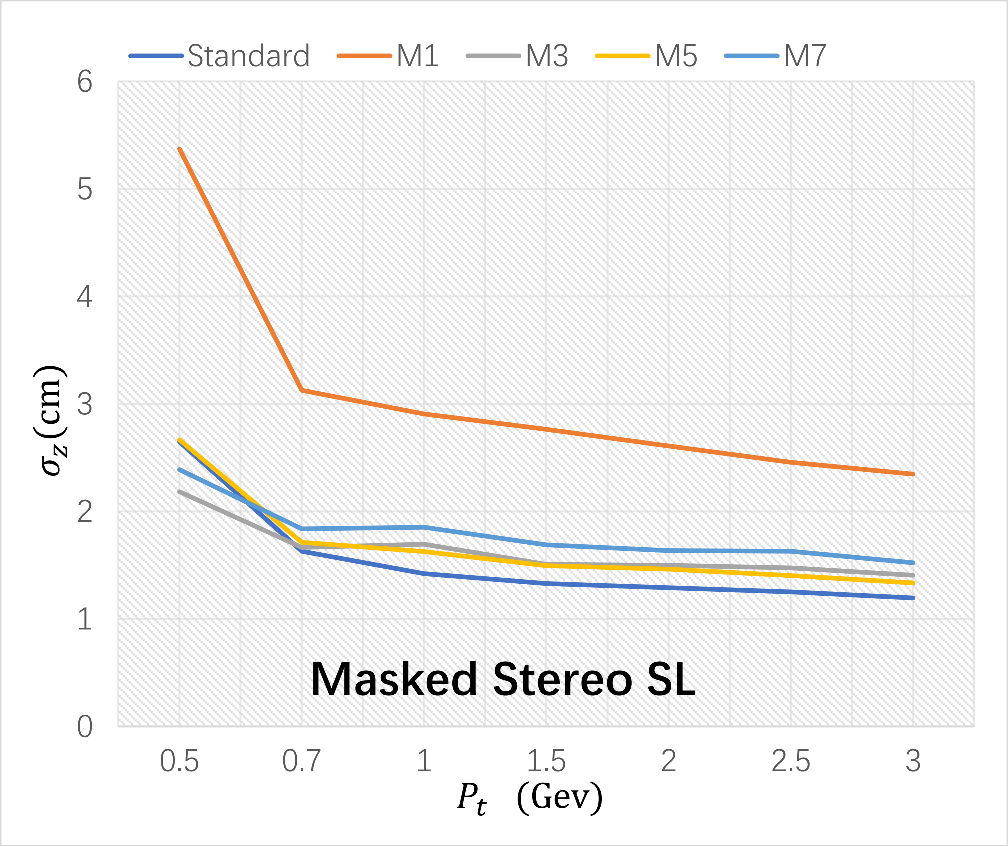
Trained with MC, event t0 =0.

Different hidden Layers / nodes do not make large difference in standard model

Add more wires do not induce other relationship, keep hidden layer as before.

Masked Super Layer

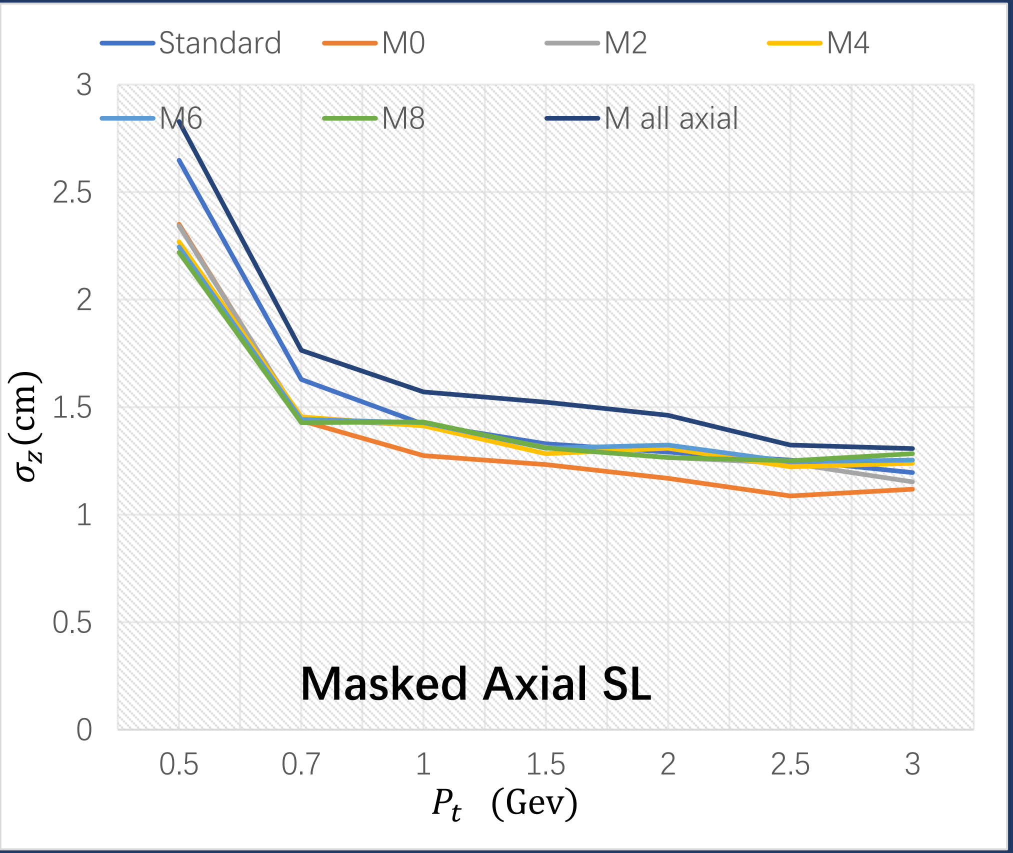


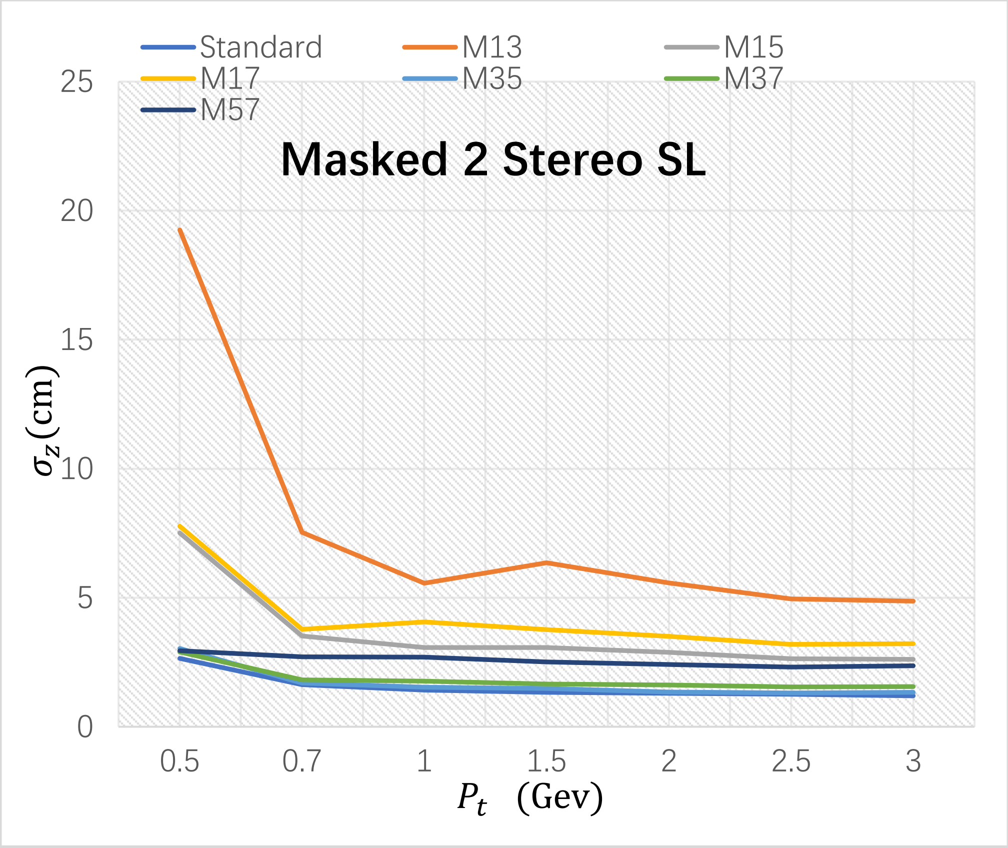


To see the importance of each super layer, masked each one for the training & testing for NN.

Axial layer contribute little to the NN, even masked all, resolution decrease little

Masked Super Layer





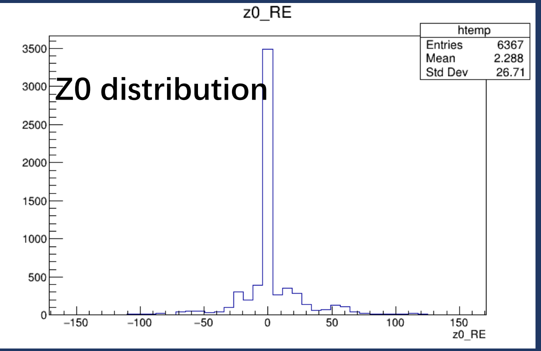
To see the importance of each super layer, masked each one for the training & testing for NN.

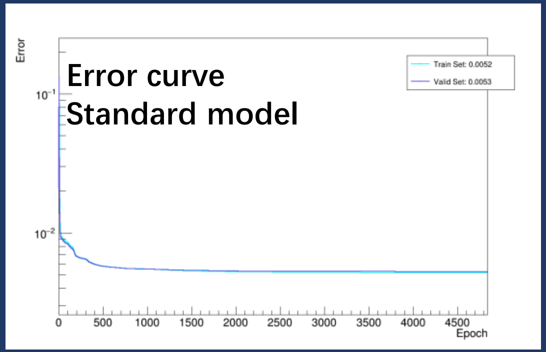
Axial layer contribute little to the NN, even masked all, resolution decrease little

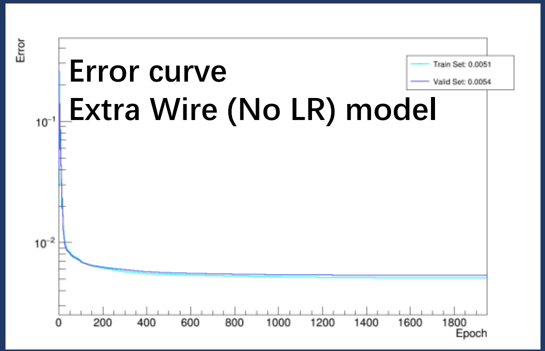
Train with real data

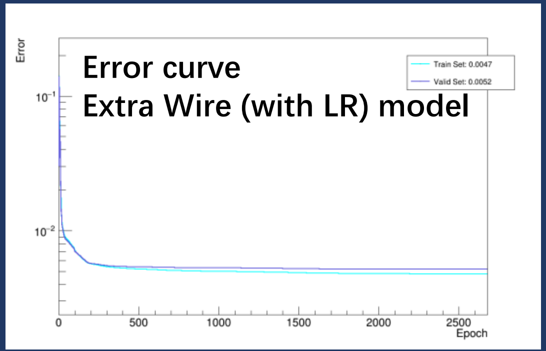
Train Standard model and one extra wire model (with/without LR) with exp26 run1771 & exp26 run1762; beam-reco-monitor.

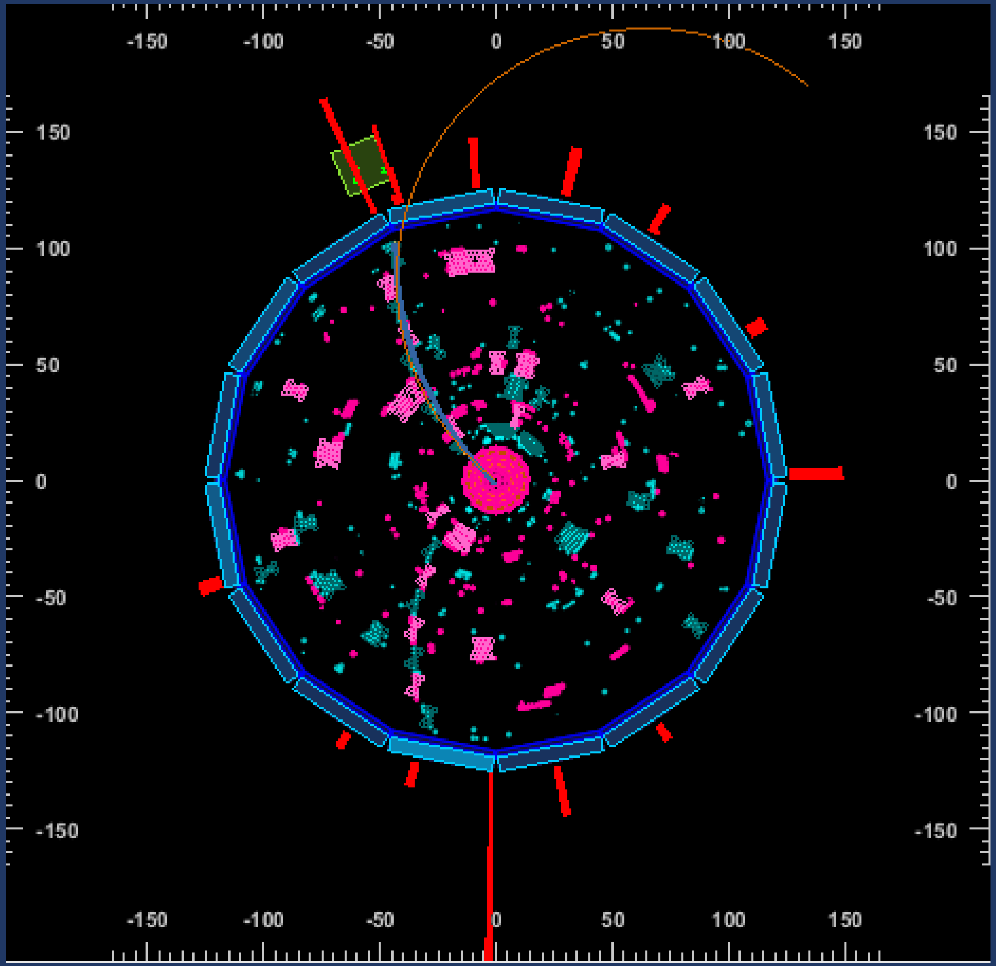
ETF option :fastpriority





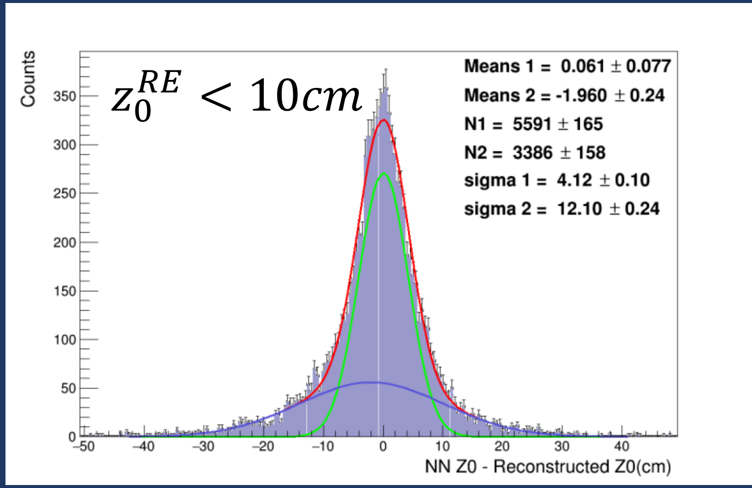


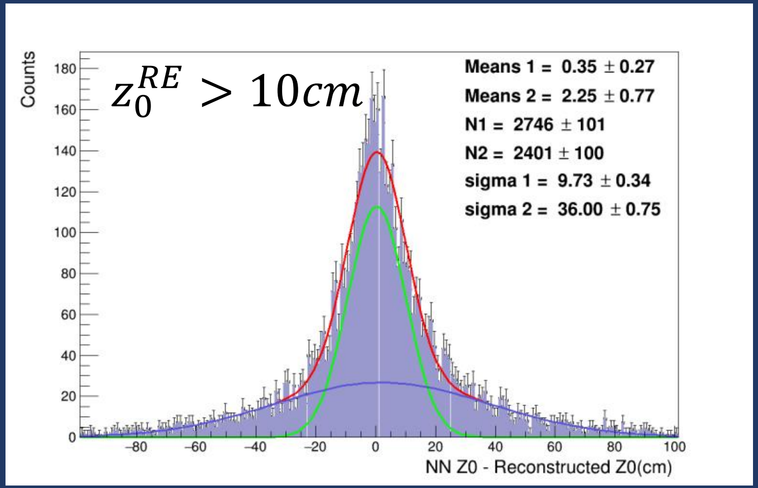




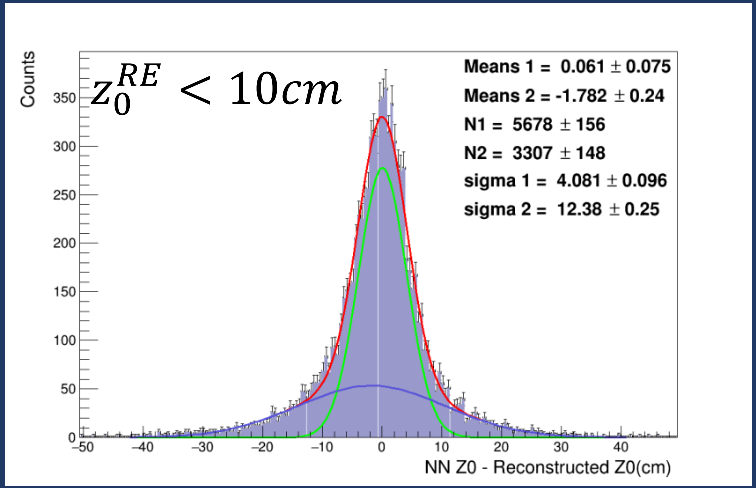
Test with real data exp26 run1771

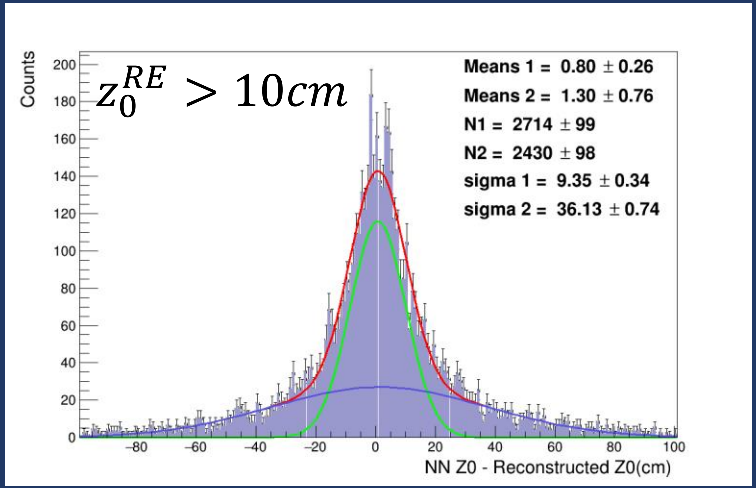
Standard Model



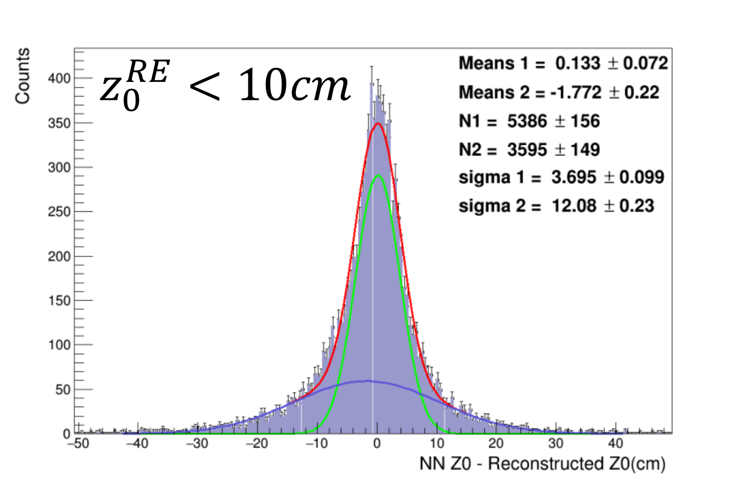


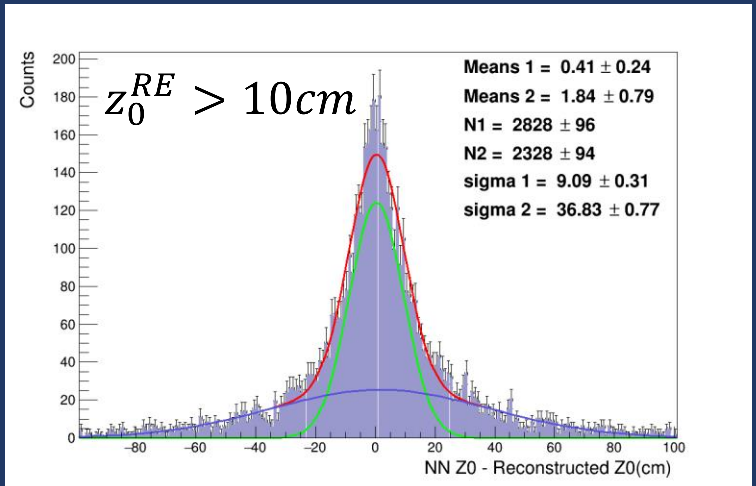
Extra Wire 1 No L/R





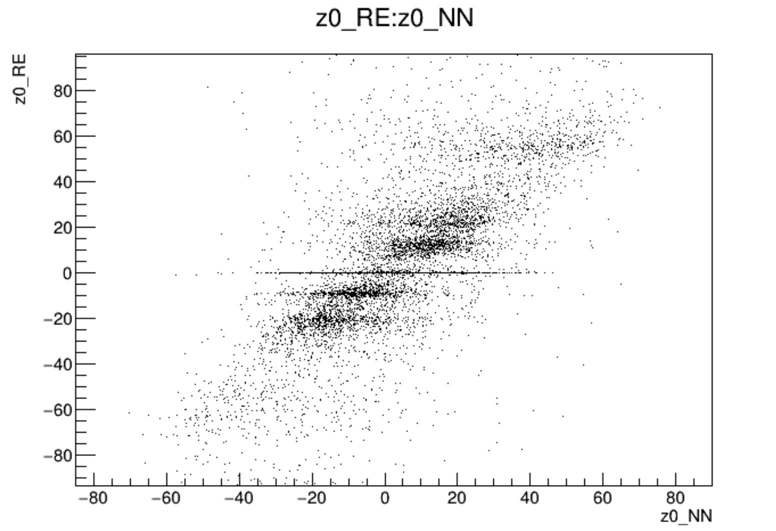
Extra Wire 1 with L/R



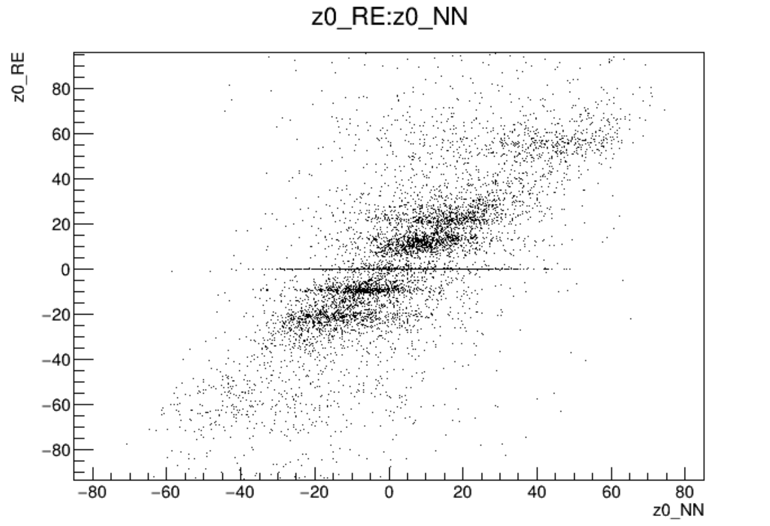


Test with real data exp26 run1771

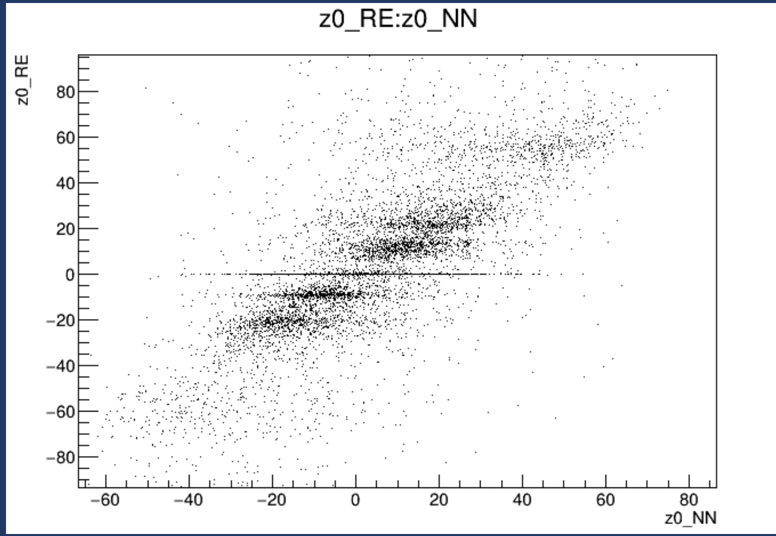
Standard Model



Extra Wire 1 No L/R



Extra Wire 1 with L/R



Training still need to be improved.

Summary & Plan

Summary

a) Add extra wires with L/R could improve the resolution of NN

b) Hidden layer has little influence of NN

c) Directly use pattern as input can hardly improve performance under current structure.

Plan

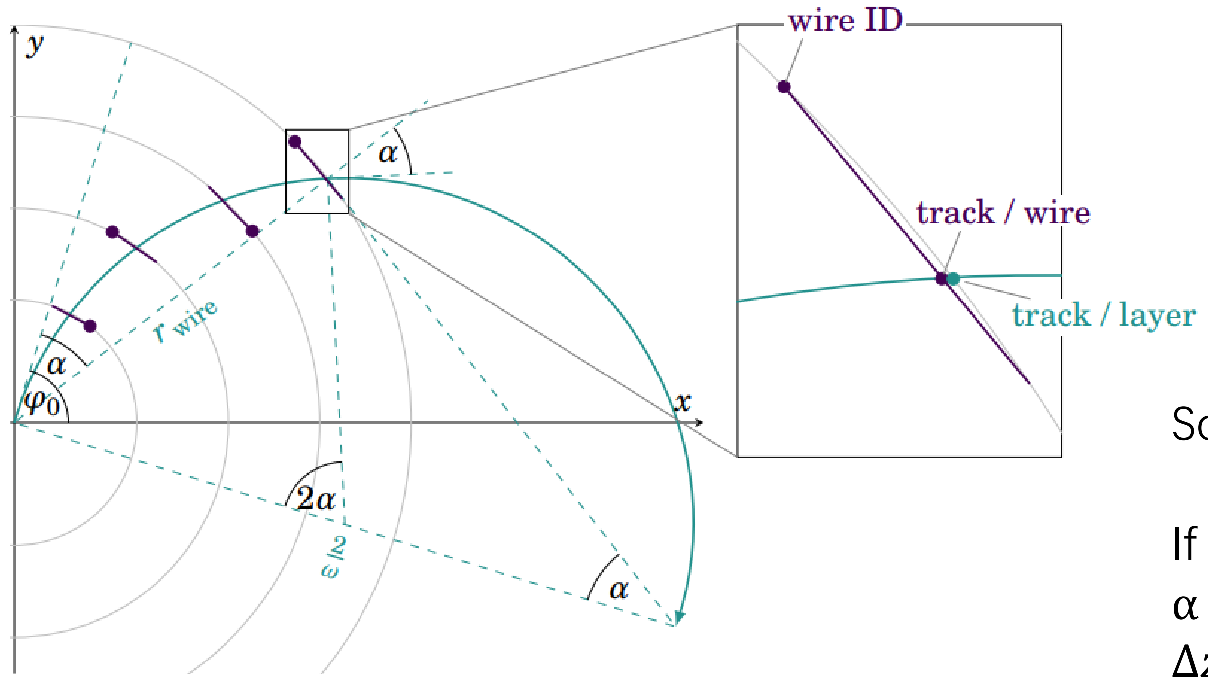
a) Switch training method to pytorch

b) Enlarge the real data training set

c) Generate a better LUT for all wires with real data

BACK UP

How to calculate out z0&z0 uncertainty



With direct cross stereo wire:

$$\phi_{cross} \sim \phi_0 - \arcsin\left(\frac{1}{2} r_{wire}\omega\right) \equiv \phi_0 - \alpha(r,\omega)$$

$$\frac{z_{cross} - z_B}{Z_F - Z_B} = \frac{\phi_{cross} - \phi_B}{\phi_F - \phi_B}$$

$$z_0 = z_{cross} - \cot\theta_0 \frac{2\alpha}{\omega}$$

Drift time would influence:

$$\phi_{hit} = \phi_{wire} \pm \arcsin\left(\frac{v_{drift}t_{drift}cos\alpha}{r_{wire}}\right)$$

$$r_{hit} = r_{wire} \pm v_{drift}t_{drift}sin\alpha$$

So the δt_{drift} would influence ϕ_{cross} $and\ r_{wire}$

If we ignore r_{wire} comparing with δt_{drift}, (with small α and large P_t)
Δz_0 could be consist of Δz_{cross} (from 3D Fitter /NN)
And $\Delta(\cot\theta_0 \frac{2}{\omega})$ (From 2D track)

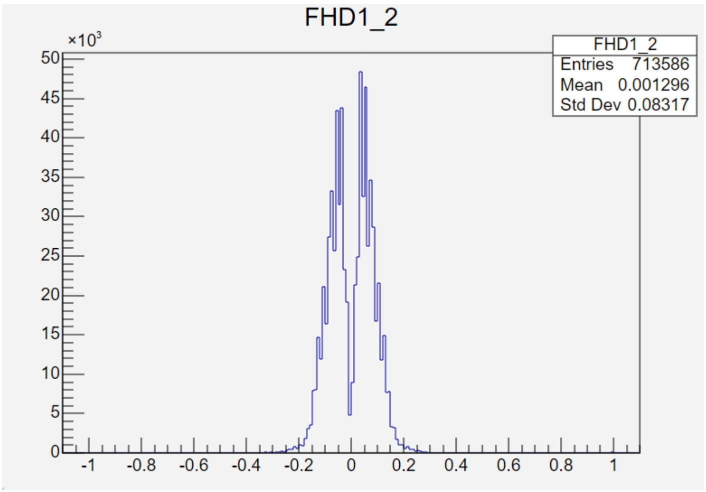
And: $$\Delta z_{cross} = \frac{r_{wire}}{\sin\psi}\sqrt{(\Delta\phi_{cross})^2 + (\Delta\phi_B)^2}$$

Still, ignore r_{wire} comparing with δt_{drift},

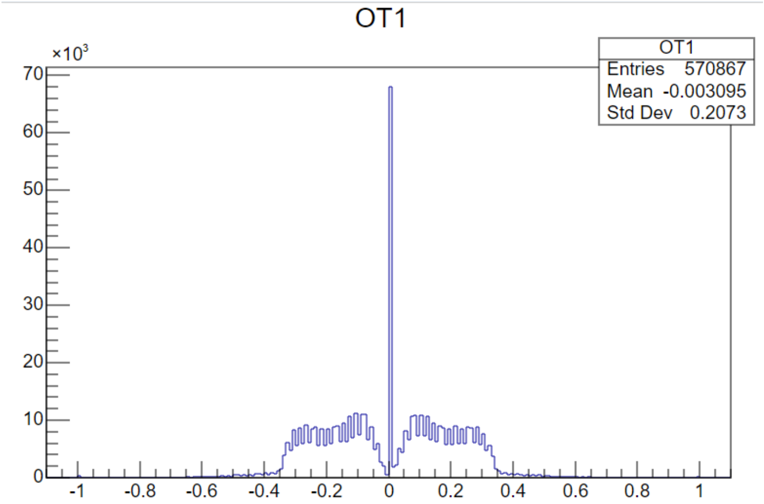
$$\Delta\phi_{cross} \times \sim 0.03° - 0.08° \ (varied\ from\ r_{wire})$$

$$\Delta\phi_B \sim \frac{v_{drfit}cos\alpha}{r_{wire}}\Delta t_{drift}$$

Input Parameters

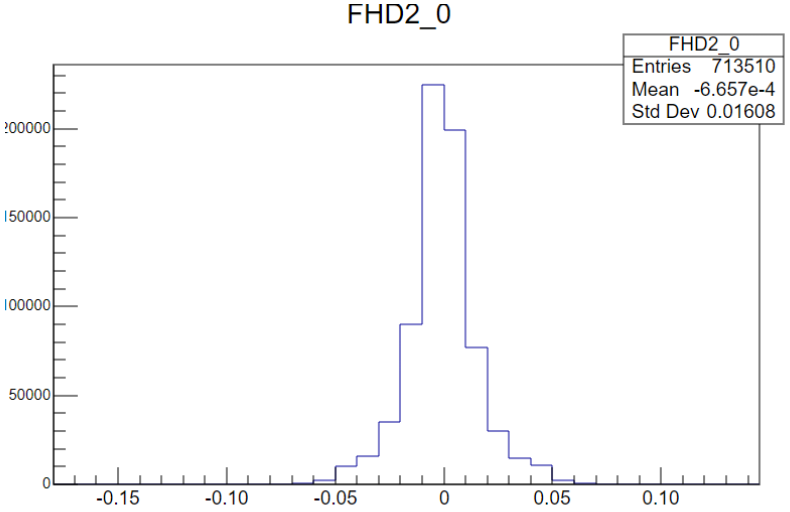


Extra T

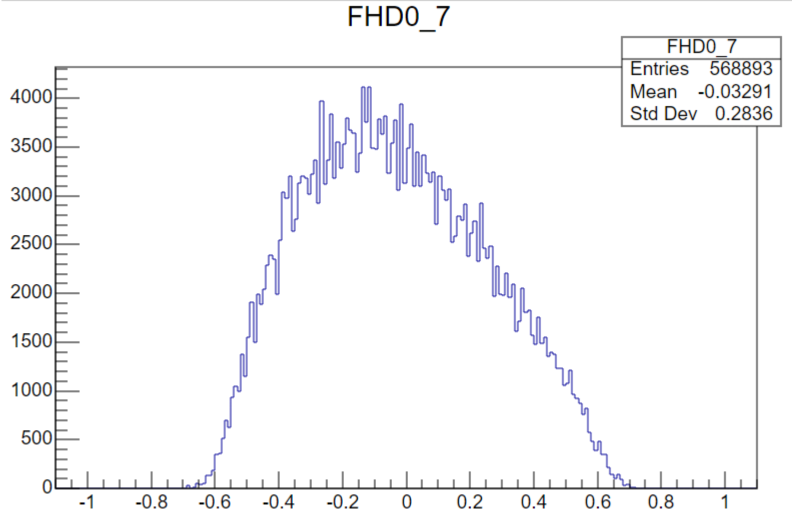


Origin T

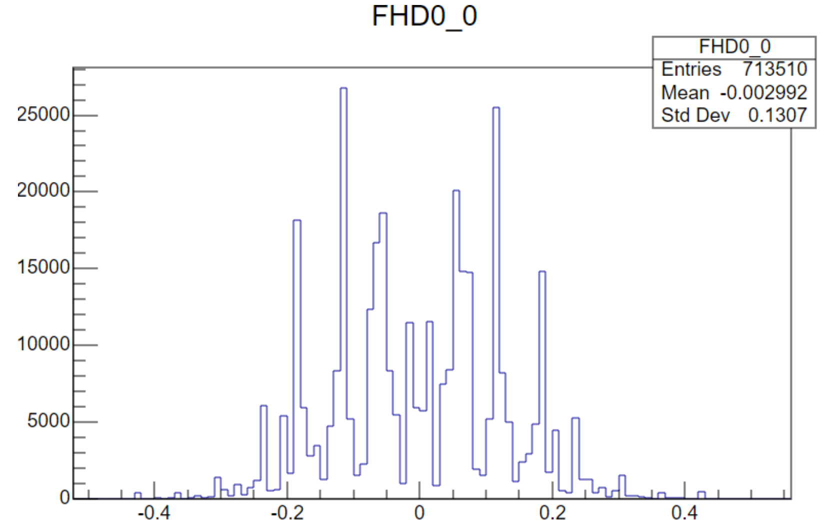
For exp26run1771



Extra α



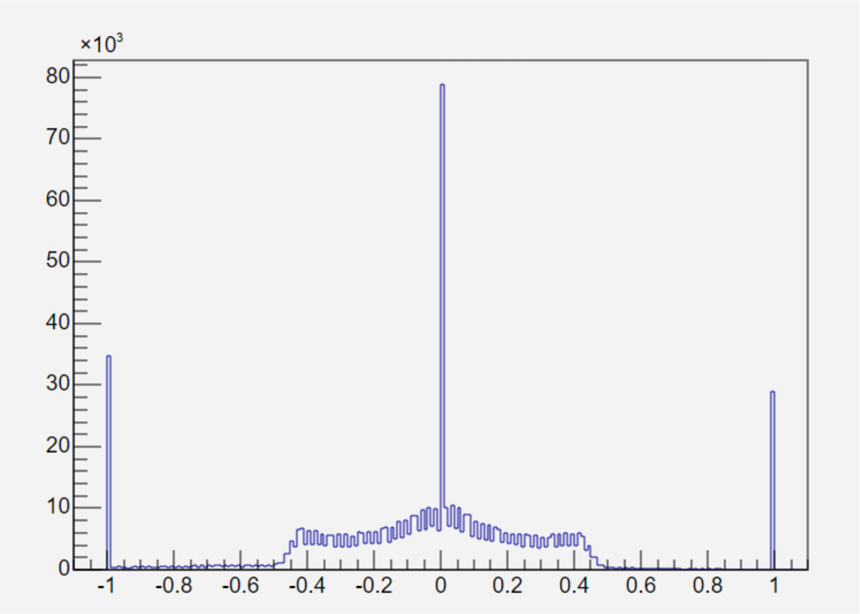
Extra ϕ Stereo

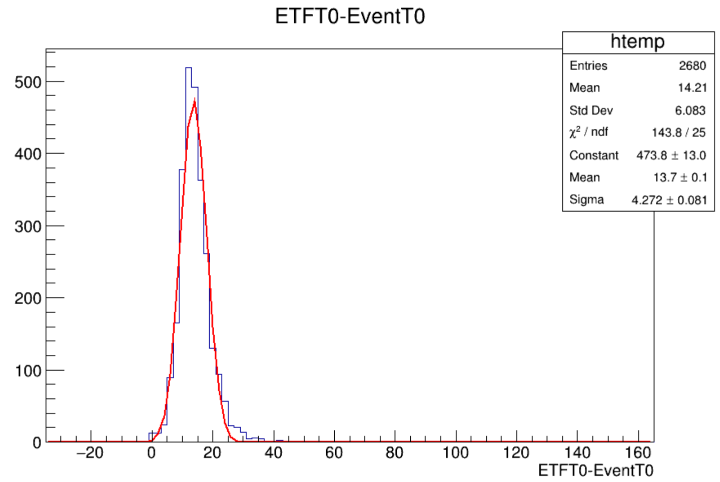


Extra ϕ Axial

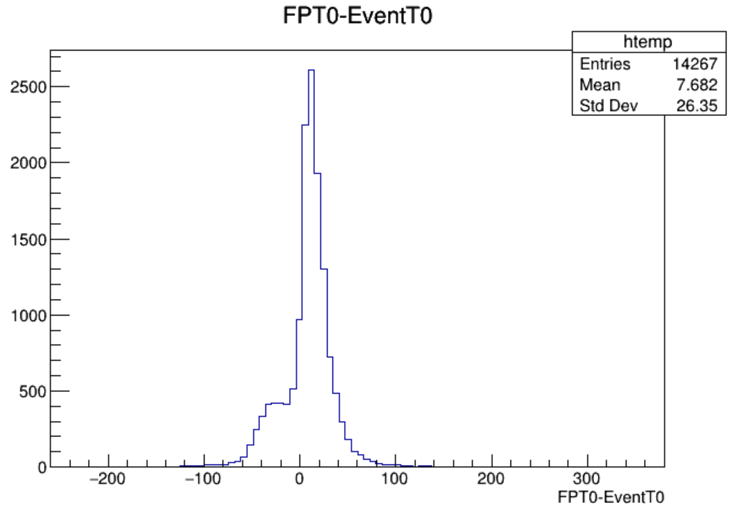
For ETF Hough

Exp24 run 2004





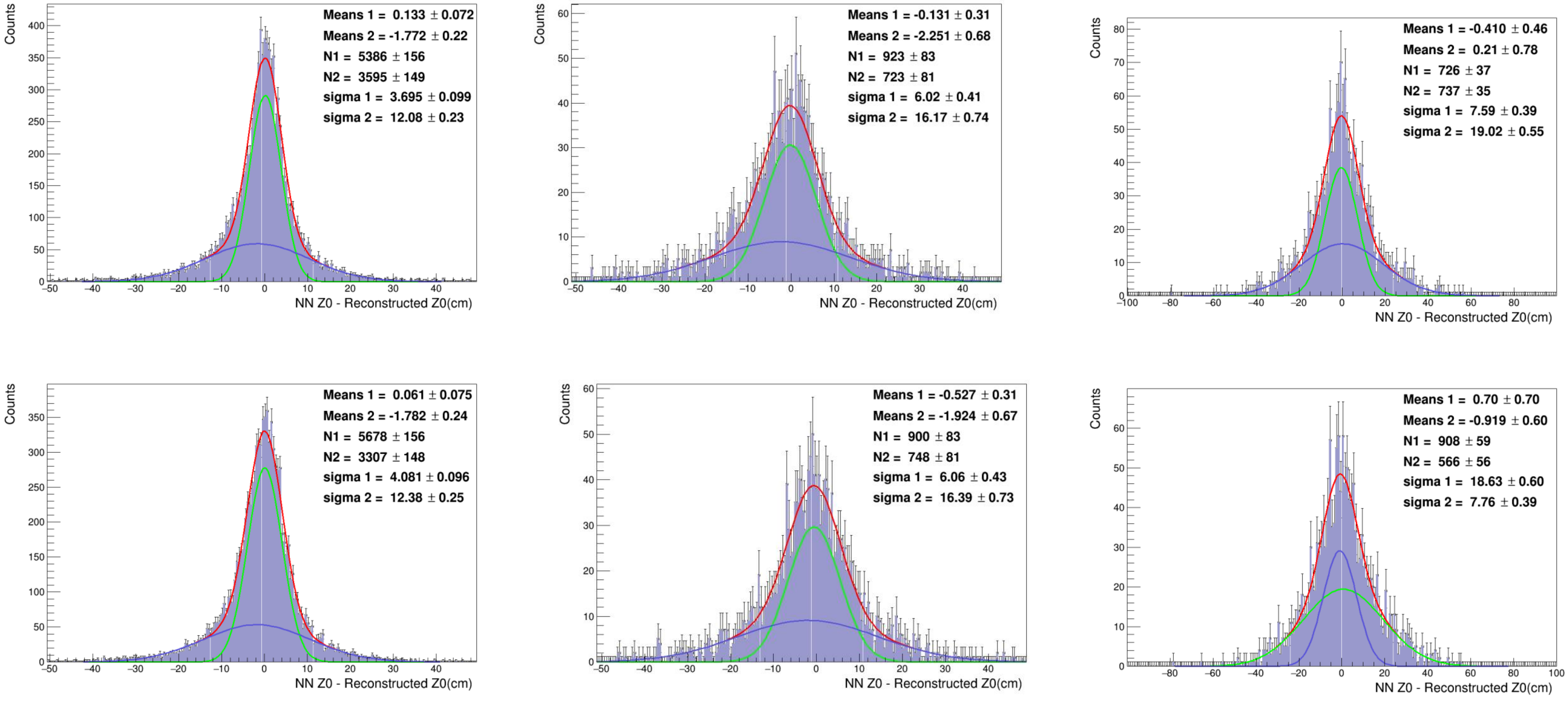
+-1 → t_drift <t_event_time in ETF Hough



Old dealing method, if t_drift < 0 → Set t_Drift == t_max…

ETF T0 ↑ FP T0 ↓

Detail result compare with z0



Wire1

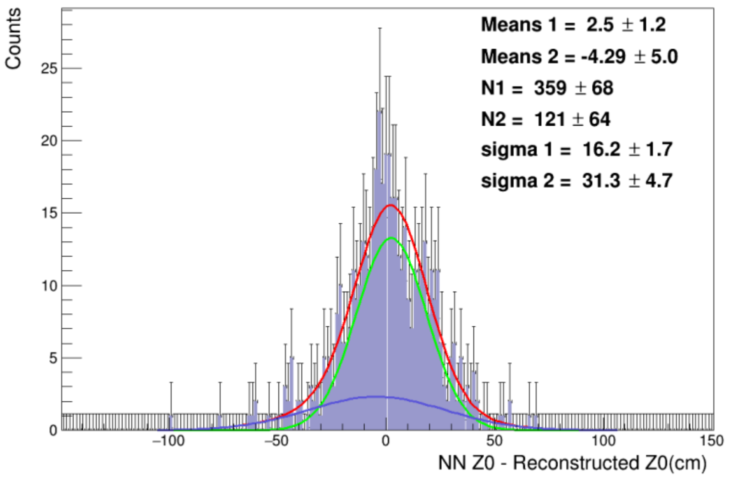
Standard

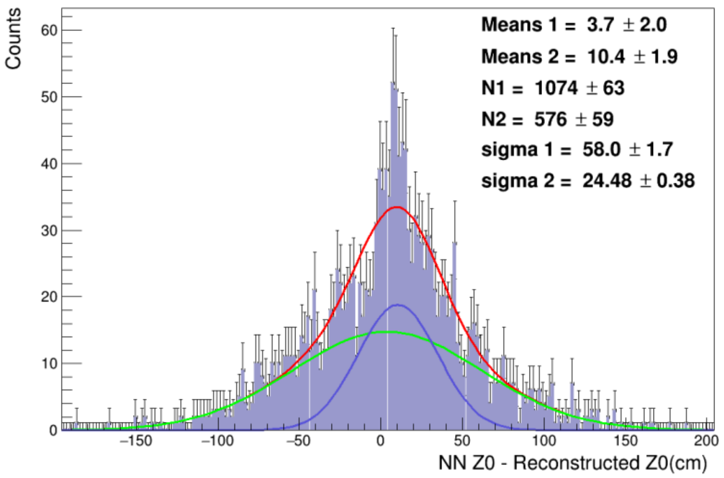
0-10

10-20

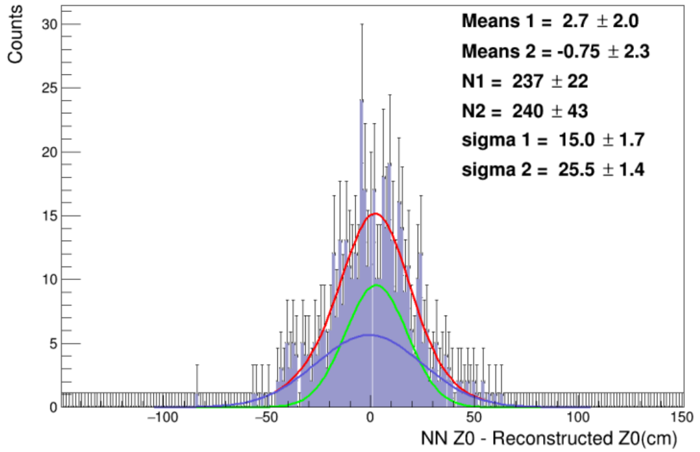
20-30

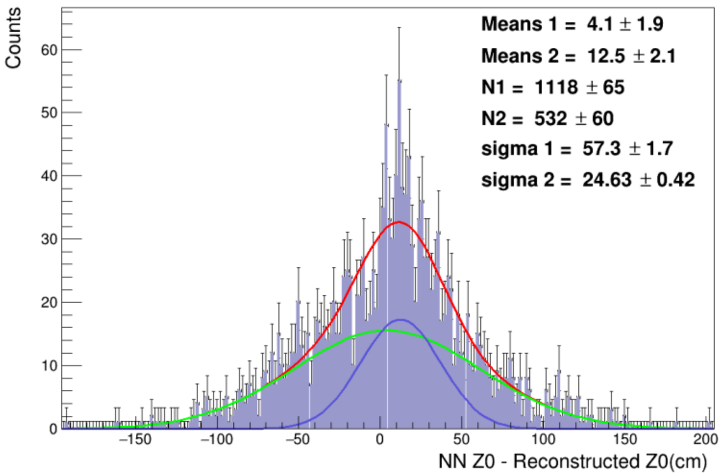
Detail result compare with z0





Wire1





Standard

30-40

40+

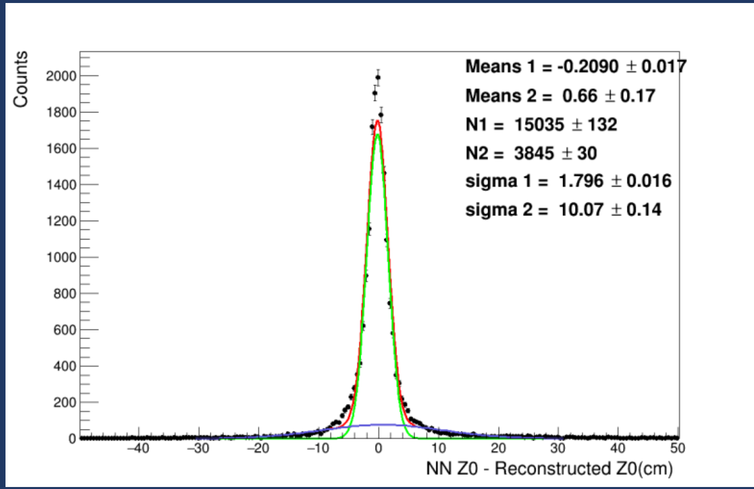
Real data test –Train with exp24 run 2004

Train NN with exp24 run2004 and exp26r1968

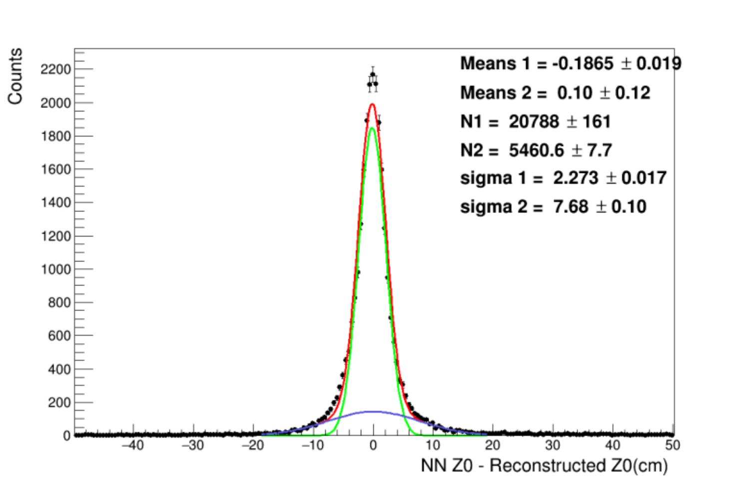
Test with exp24 run2004(sorry not unpacked another one for test)
And exp26 run 1777 (which use for trigger study with z0 in any range)

exp24 run2004

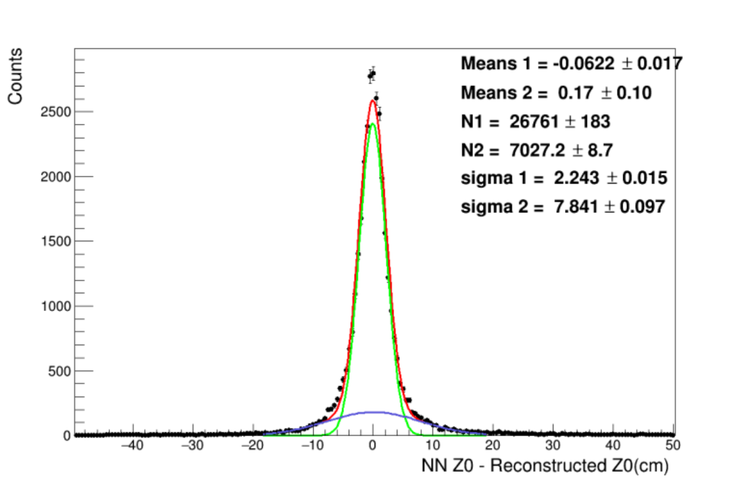
Origin with ETFHough



Wire 1 with ETFHough



Wire 2 with ETFHough



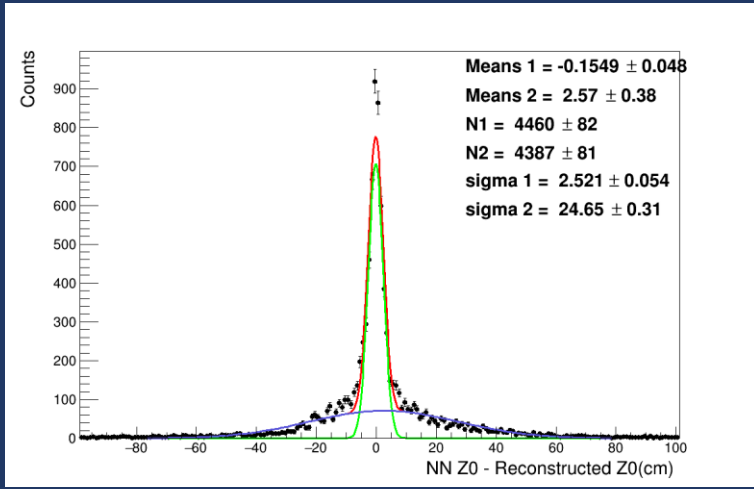
Real data test –Train with exp24 run 2004

Train NN with exp24 run2004 and exp26r1968

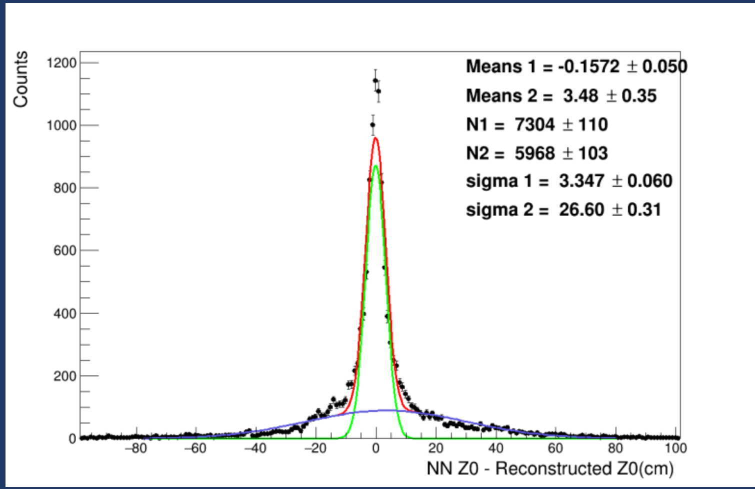
Test with exp24 run2004(sorry not unpacked another one for test)
And exp26 run 1777 (which use for trigger study with z0 in any range)

exp26 run 1777

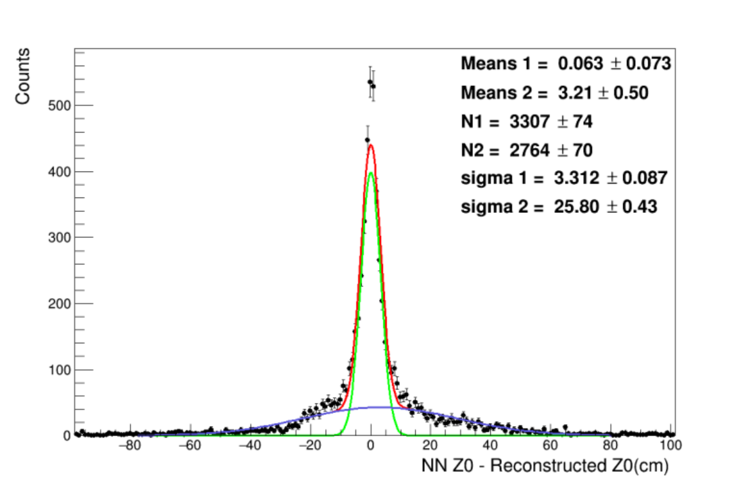
Origin with ETFHough



Wire 1 with ETFHough

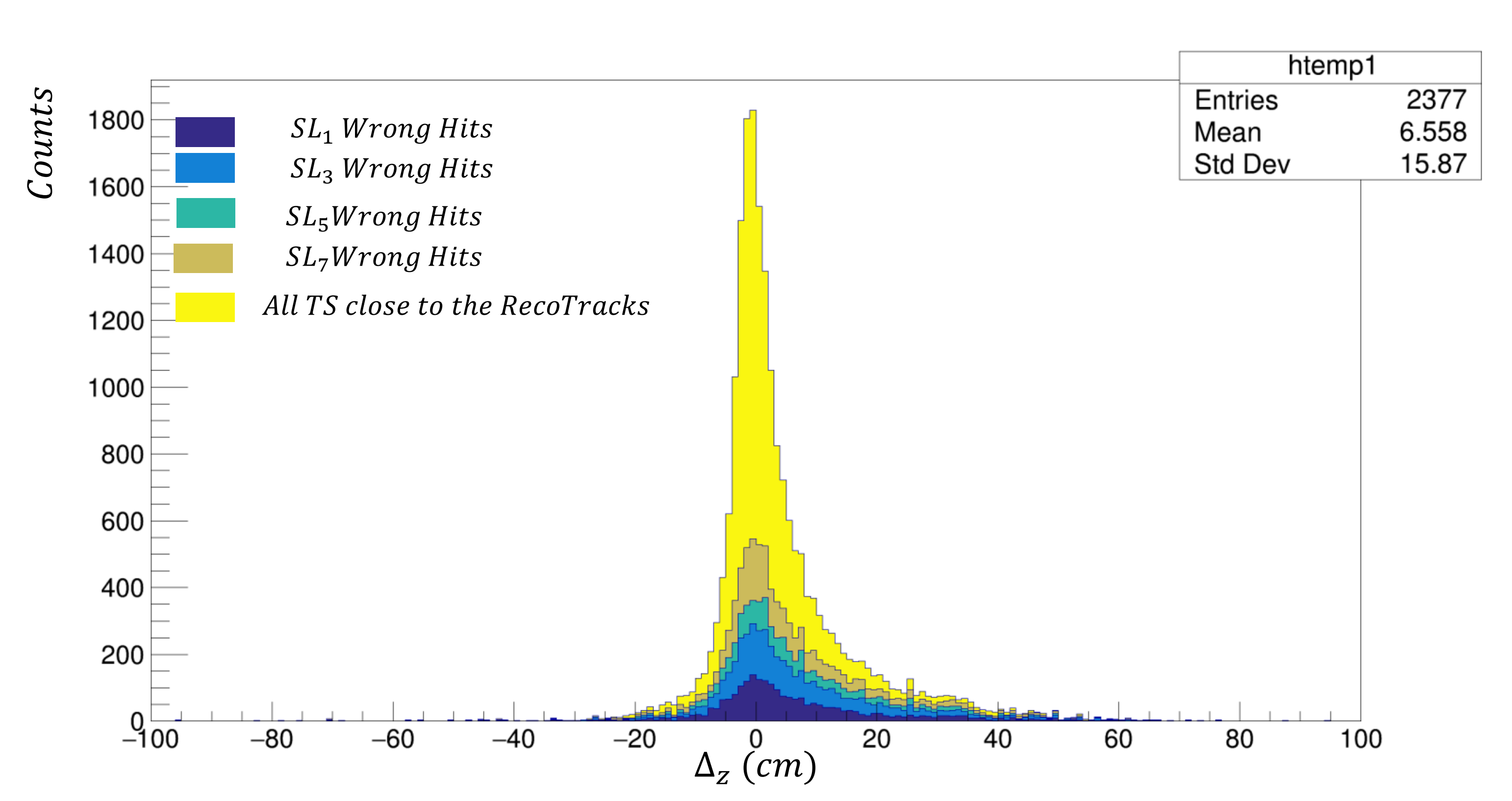


Wire 2 with ETFHough



Track Segment ID

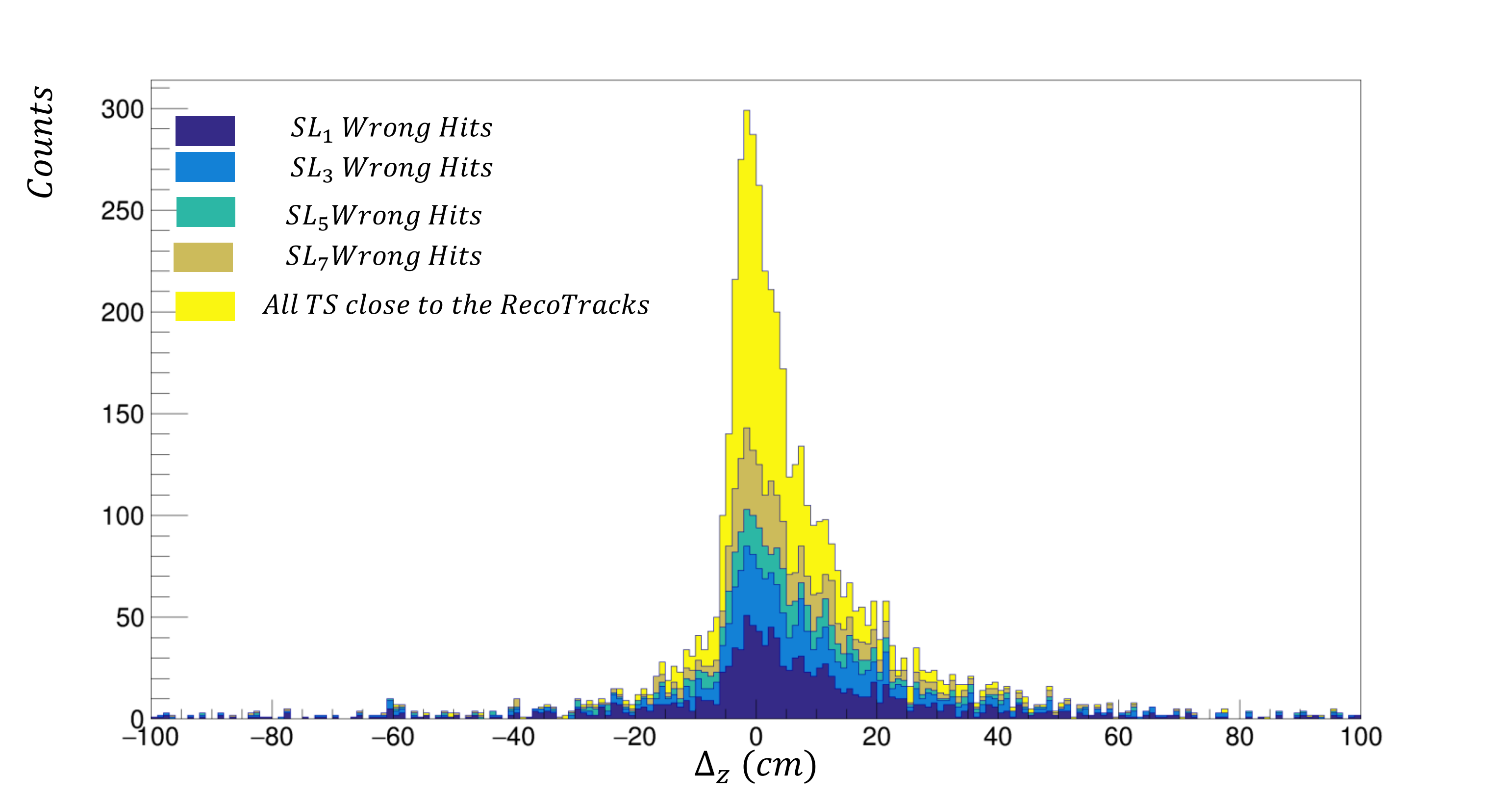
Consider the Delta Z distribution of those NN choose wrong hit



exp024run2004

Track Segment ID

Consider the Delta Z distribution of those NN choose wrong hit



exp026run1777