Measurements of ADC
& Energy of TPC using RNN

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2025 CENuM Workshop

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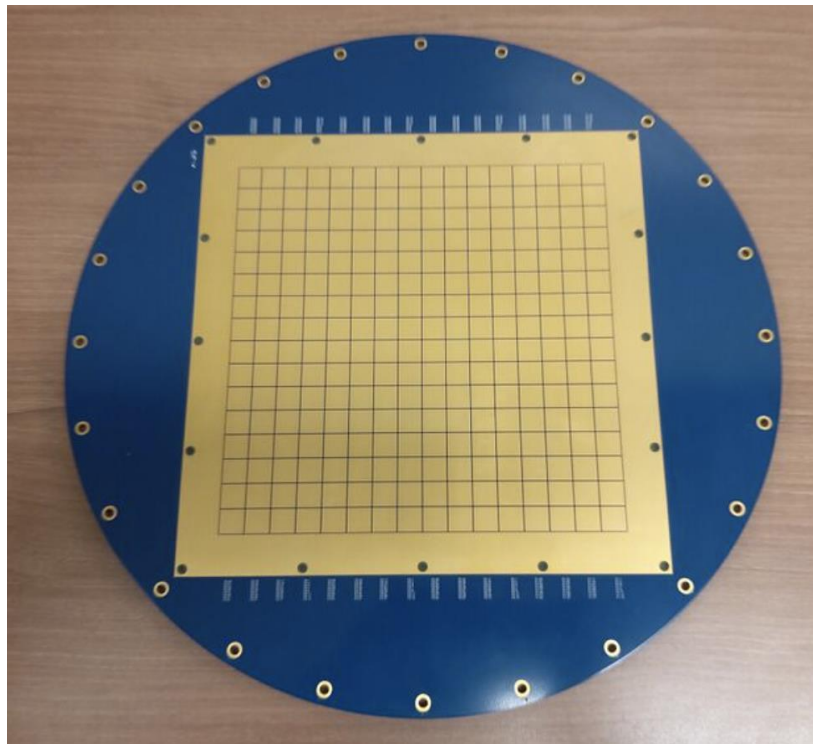2025 CENuM Workshop

1. Motivation

- **Final Goal**
Sejong TPC-DRUM

CsI(Ti) detector   Si detector

Field-cage
For AT-TPC

1. Motivation

(a) Proton data — GARFIELD++
TPC dE/dx [KeV/mm] vs Si+CsI energy [MeV]

(b) Deuteron data — GARFIELD++
TPC dE/dx [KeV/mm] vs Si+CsI energy [MeV]
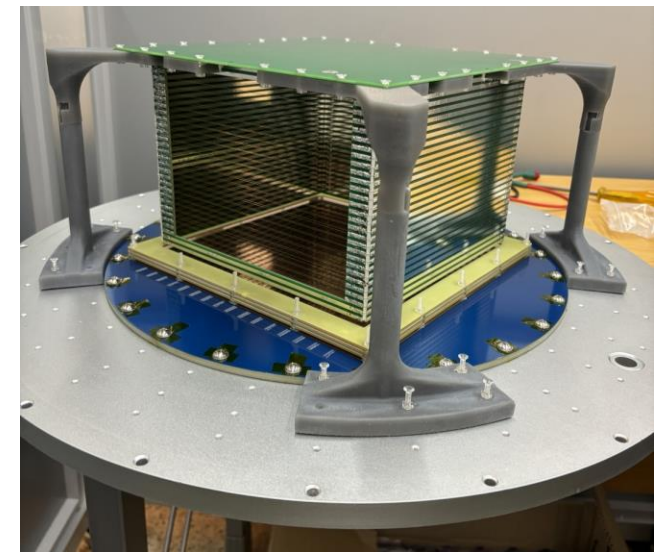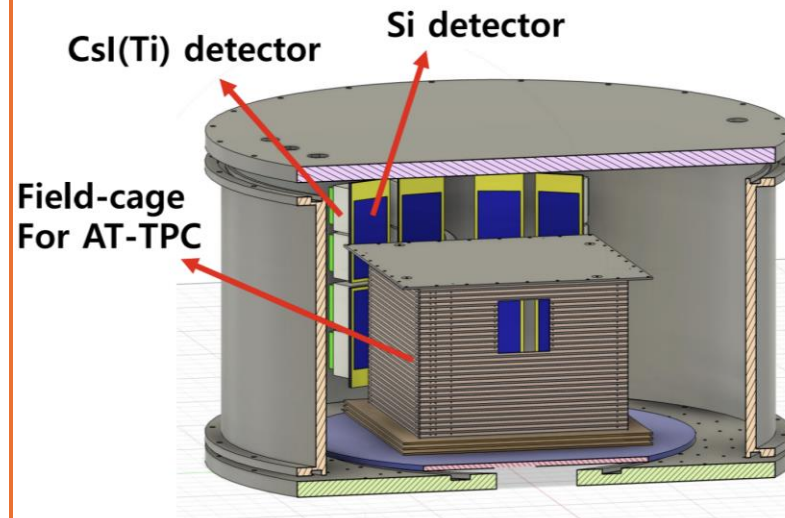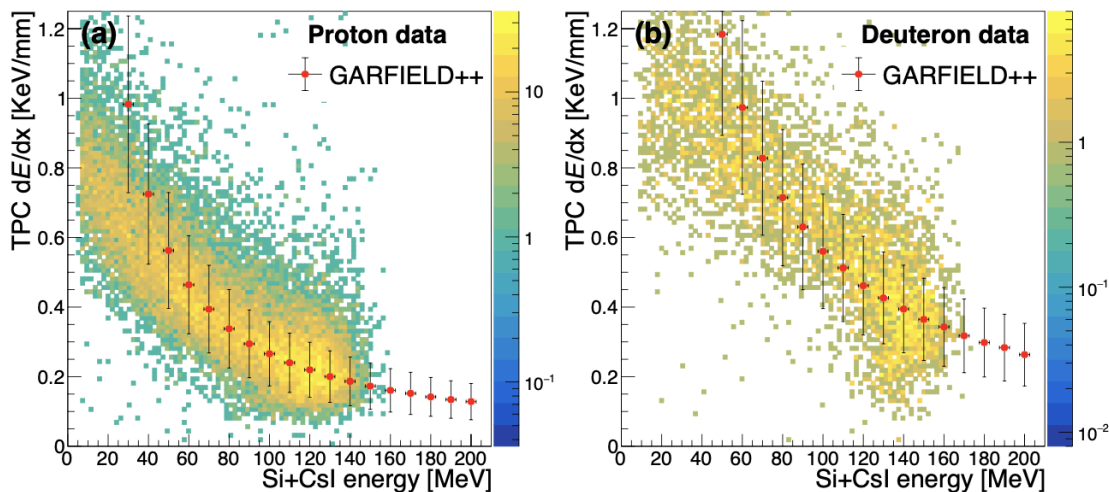
Yechan Cheon and Seunghwan Lee for the LAMPS Collaboration,
NIM A 1066, 169610 (2024)
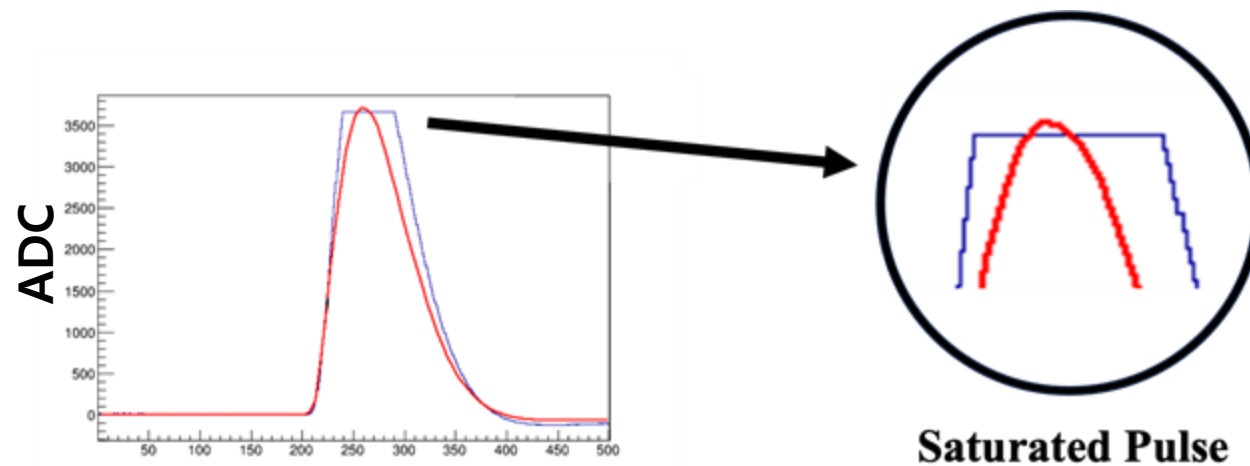
Saturated Pulse

TIME information ➢ **TIME BUCKET**
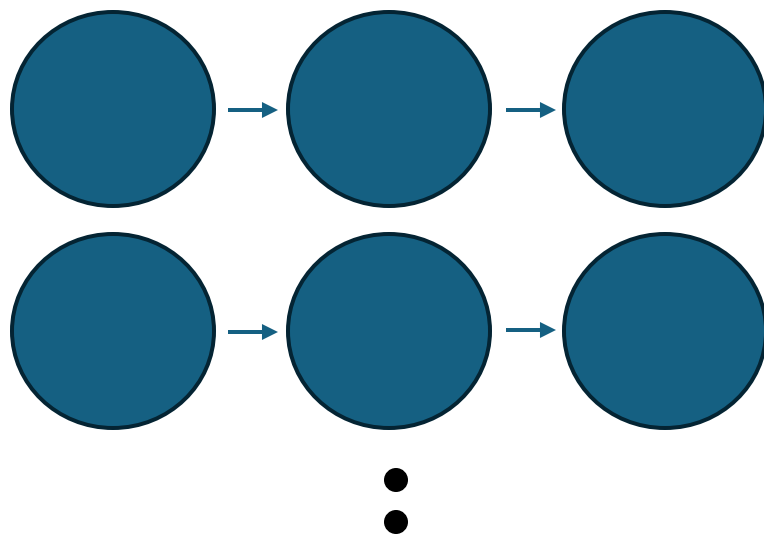ENERGY information ➢ **ADC**

It is essential to obtain the **precise maximum of the saturated pulse**

off-peak ➢ input
in-peak ➢ output

2. Finding the Accurate ADC using RNN (1) What is RNN?
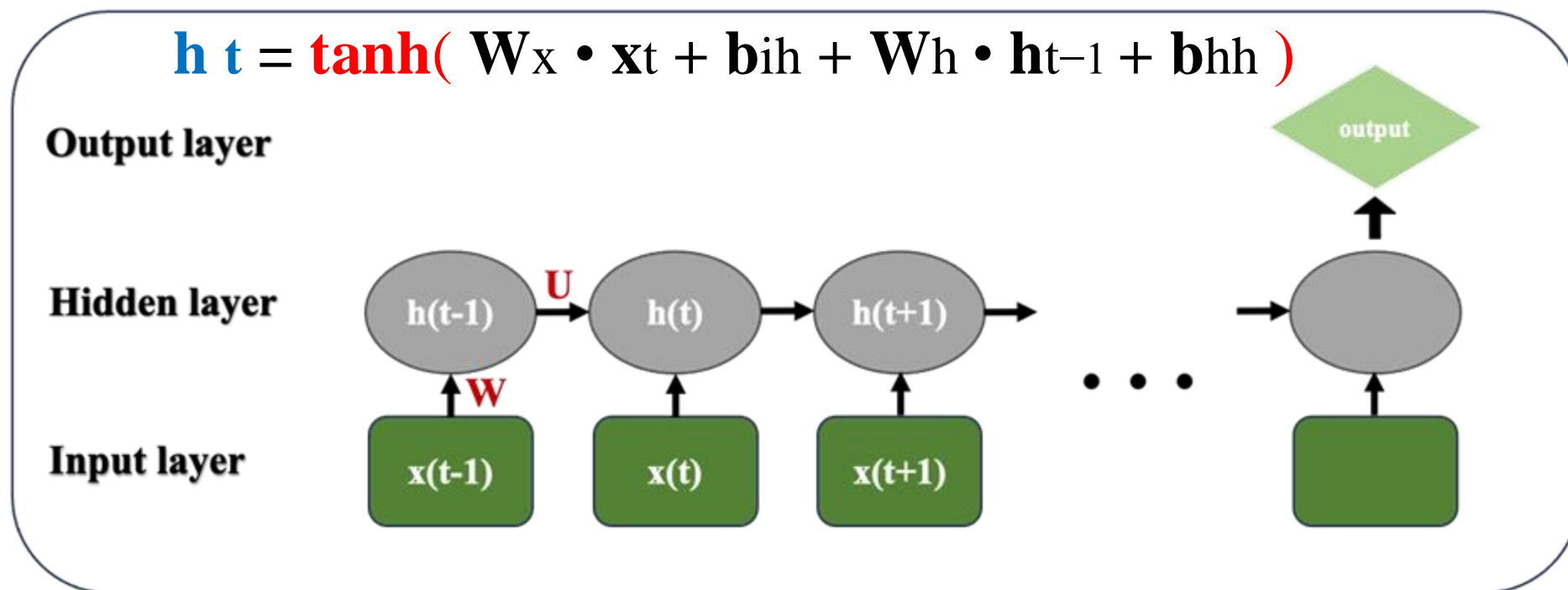
Feedforward **N**eural **N**etwork

Recurrent **N**eural **N**etwork
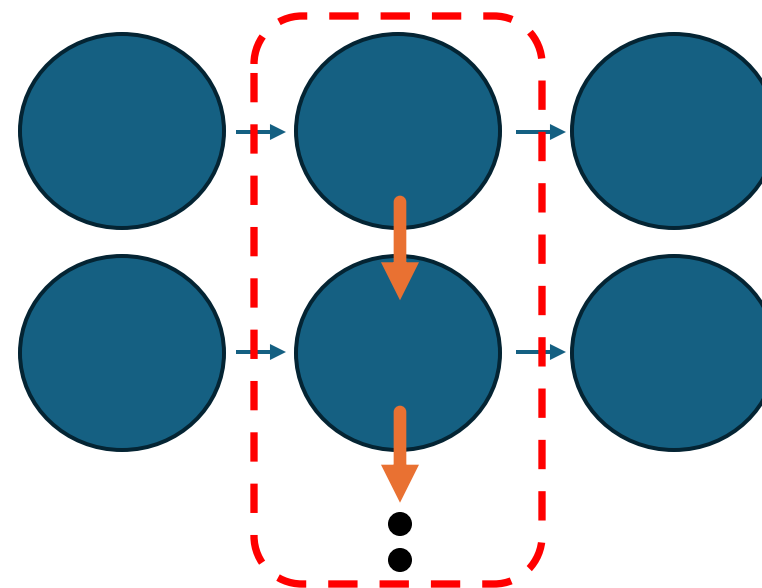
2. Finding the Accurate ADC using RNN
(1) What is RNN?

$$h_t = \tanh(W_x \cdot x_t + b_{ih} + W_h \cdot h_{t-1} + b_{hh})$$

2. Finding the Accurate ADC using RNN
(2) RNN with Pulse Simulation data

LILAK Simulation data
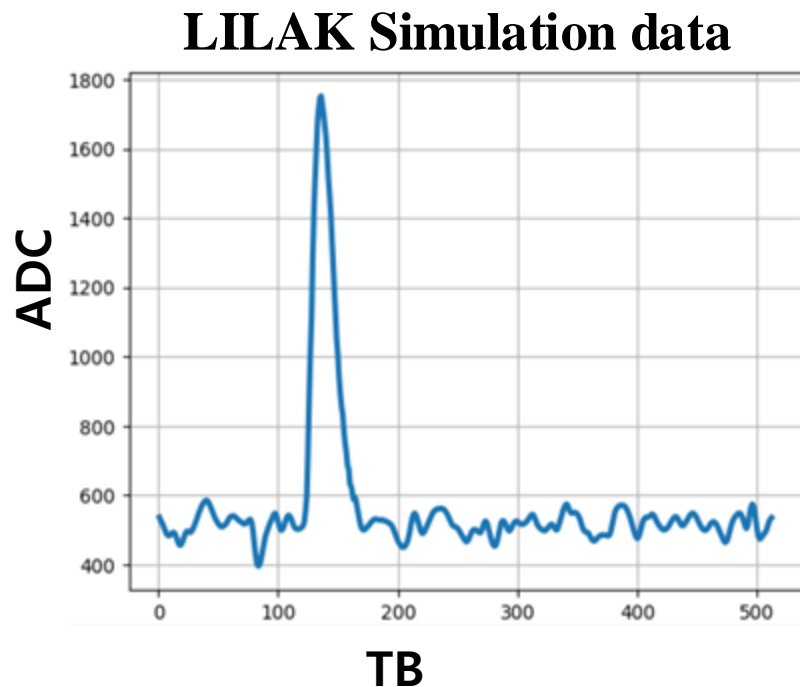
Data Information

 CENS LILAK project Simulation data

ADC according to the TIME BUCKET ➢ **Input**
MAX ADC ➢ **Output**

Peak Information

 ADC : (1000,3000) Random
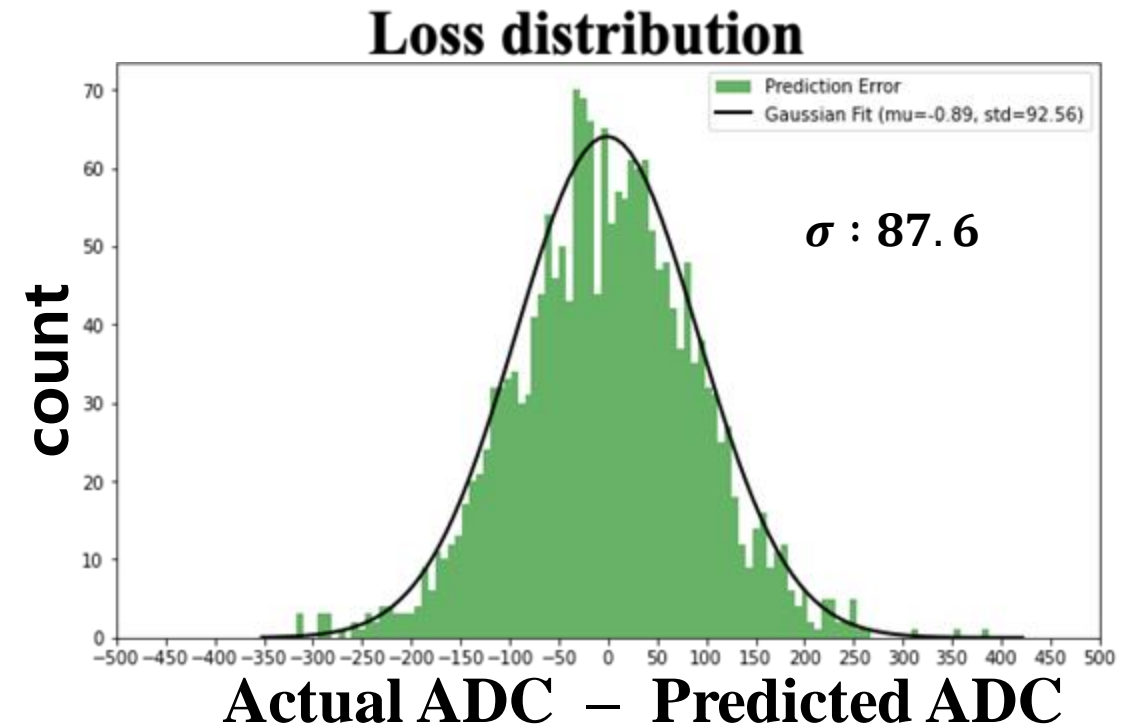
 TB : (100,300) Random

2. Finding the Accurate ADC using RNN (2) RNN with Pulse Simulation data

Data x 10000

Label x 8000

Test x 2000

RNN Model Definition

Hyperparameter Tuning

Result

Hidden size: 249
Learning rate: 0.0049613
batch size: 128

Loss distribution

Prediction Error
Gaussian Fit (mu=-0.89, std=92.56)

$\sigma : 87.6$

Actual ADC – Predicted ADC
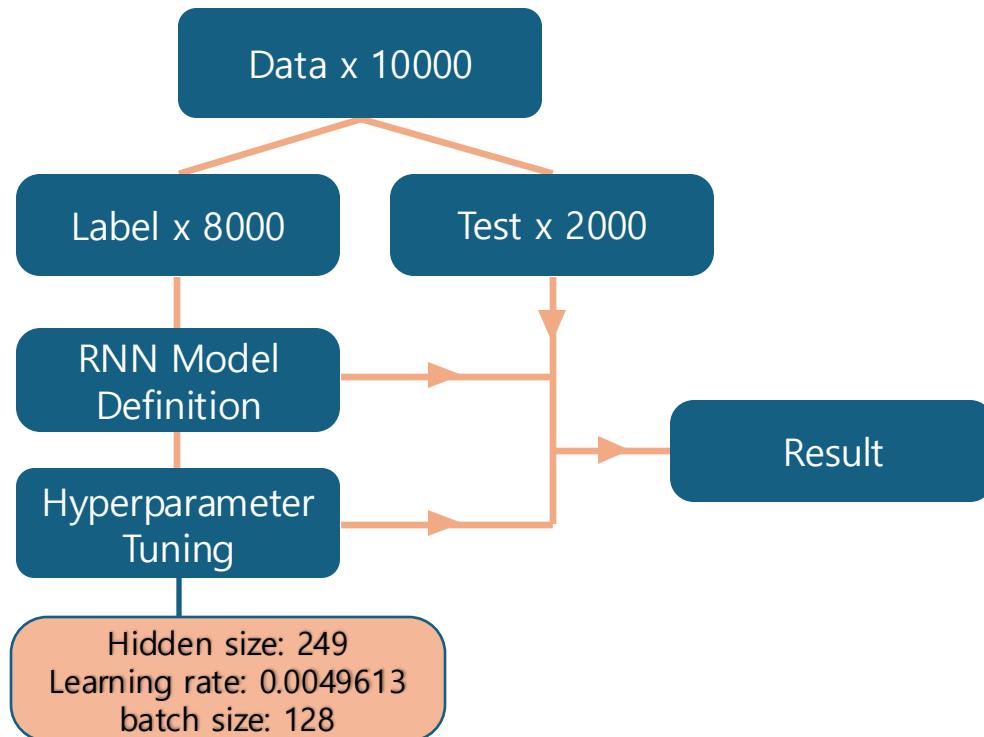
Mean Absolute Error (MAE): 72.9 (ADC)
R² Score: 0.974

2. Finding the Accurate ADC using RNN (2) RNN with Pulse Simulation data

Saturated Simulation data

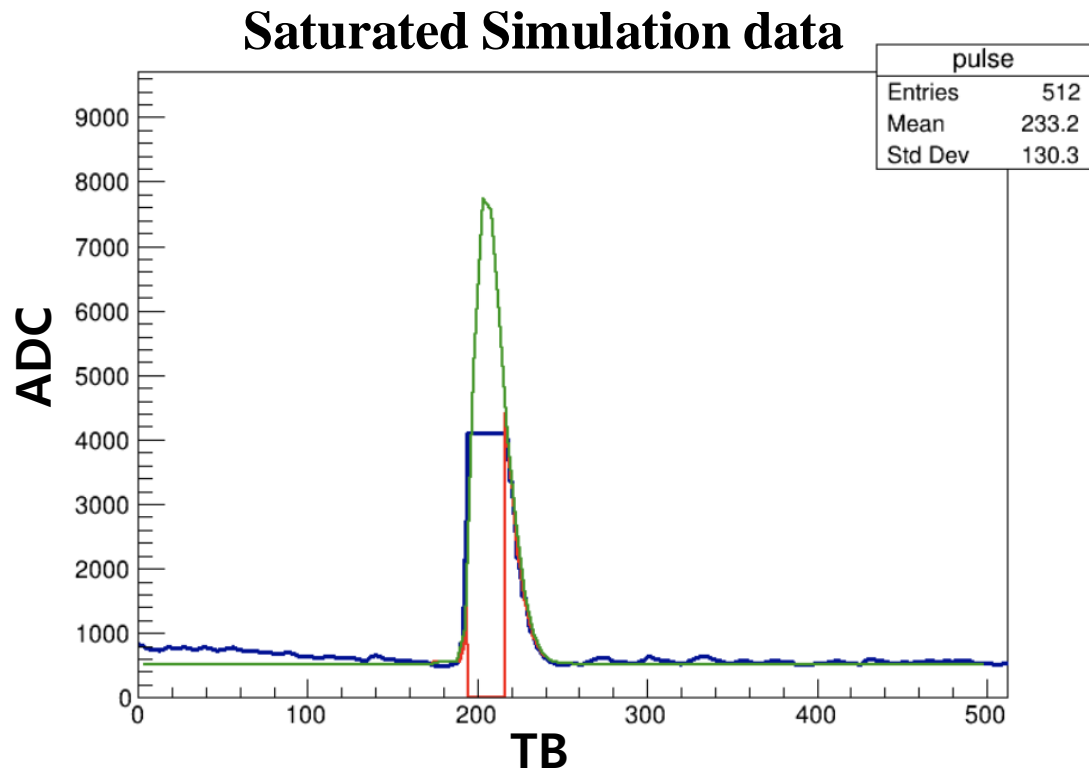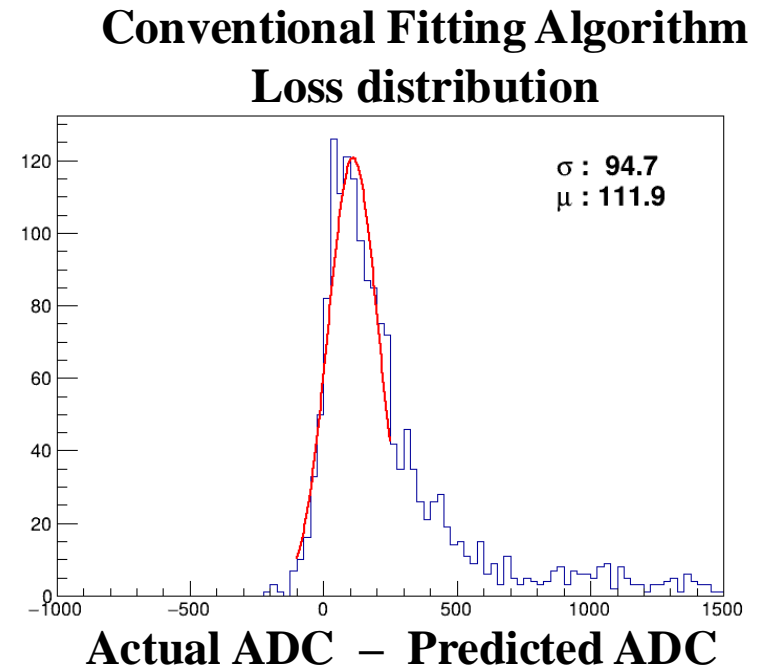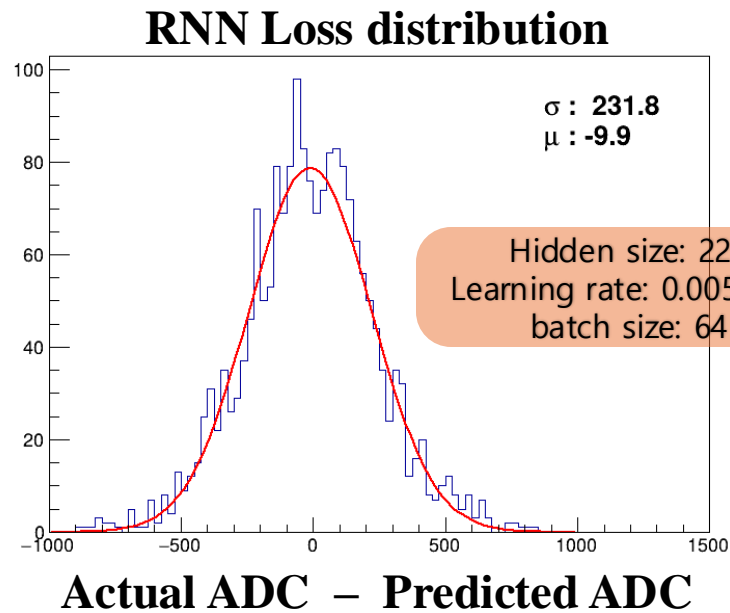| pulse	
Entries	512
Mean	233.2
Std Dev	130.3

ADC (0 , 4096) ➢ **Input**

TRUE MAX ADC (4096 , 10000) ➢ **Output**

2. Finding the Accurate ADC using RNN (2) RNN with Pulse Simulation data

RNN Loss distribution

σ : 231.8
μ : -9.9

Hidden size: 224
Learning rate: 0.0050649
batch size: 64

Actual ADC – Predicted ADC

Conventional Fitting Algorithm Loss distribution

σ : 94.7
μ : 111.9

Actual ADC – Predicted ADC

The RNN increases the width compared to conventional methods.
Better accuracy in predicting uncertainty due to its symmetry.

3. Summary

1. Attempted to estimate the Max ADC of saturated pulse using RNN.

2. There is an advantage in predicting uncertainty more accurately, but the width needs to be reduced.

3. **Future Plan**: Use the RNN tool with data obtained from HIMAC.

Thank you