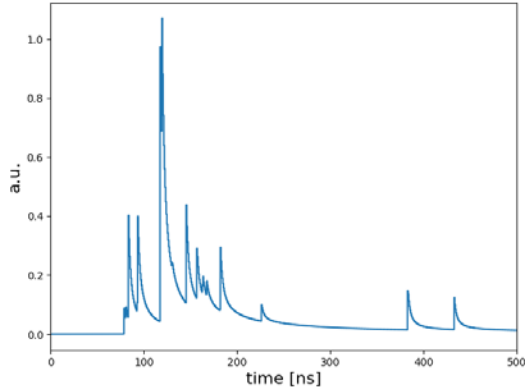


Key issues with dN/dx measurement

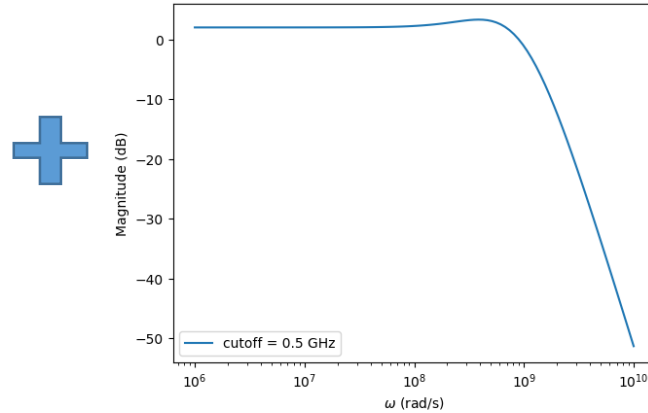
- Design optimization and performance study
 - Performance simulation
 - Thickness of the detector (inner and outer radius), cell size
 - Low drift velocity, low ionization density gas with low diffusion
 - Mechanics design and material
- Waveform tests
 - Fast and low noise electronics
- dN/dx reconstruction algorithm
 - Processing pile-up peaks of signal and reducing noise impacts
 - Identifying primary and secondary ionization signals
- Data suppression: need online data compression
- Total power & cooling scheme

Simulation

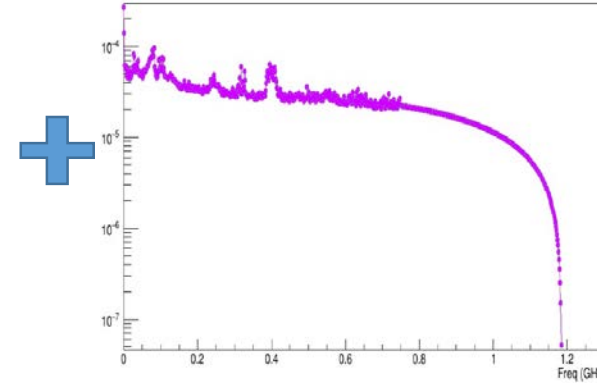
Induced signal
(Simulation)



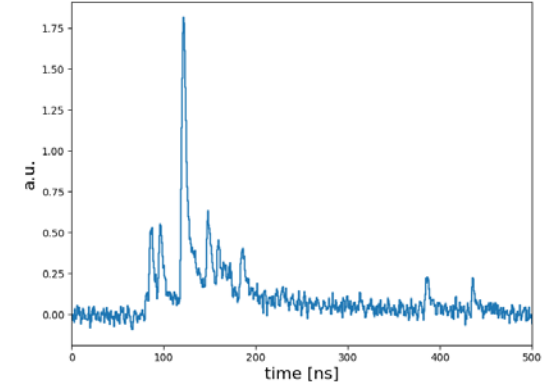
Electronics response
(beam test electronics)



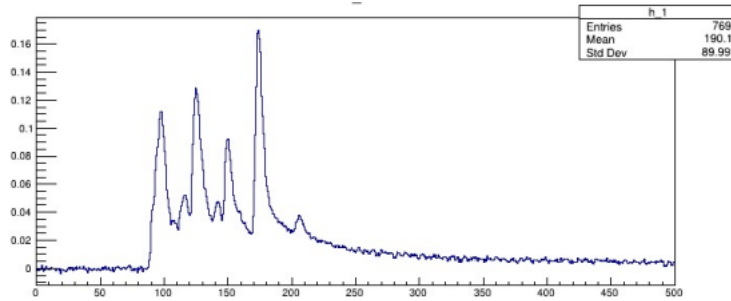
Noise
(beam test)



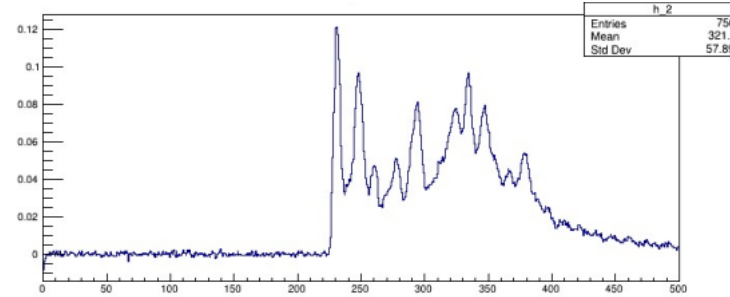
Waveform



Simulation



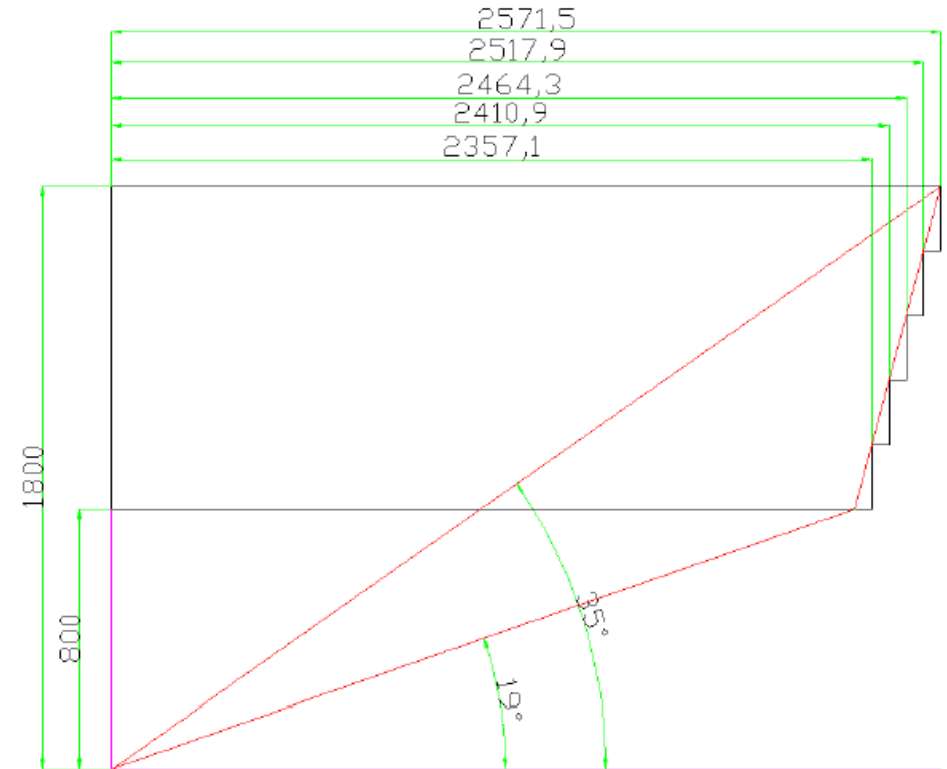
Beam test data



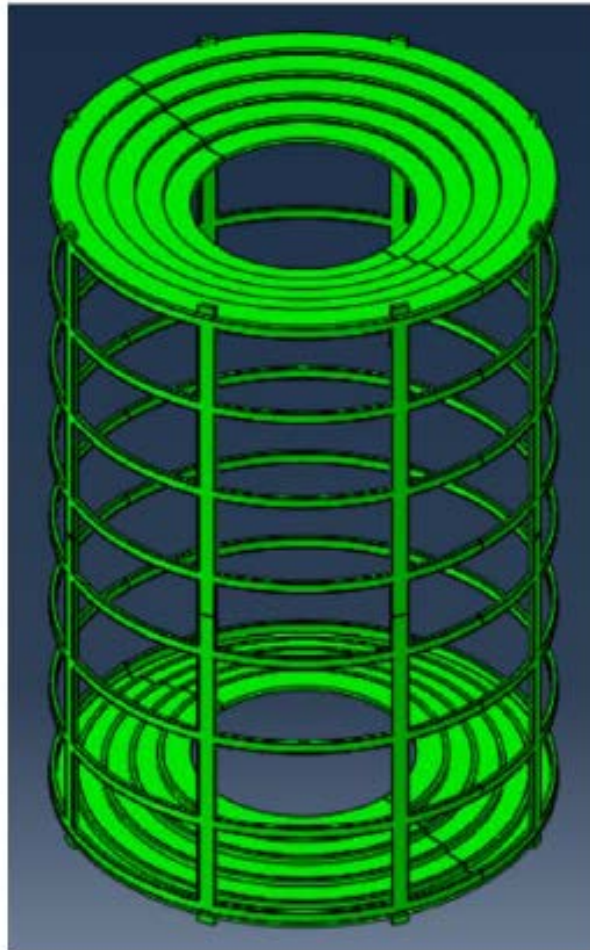
- A waveform based full simulation has been established for detector design and performance study

Preliminary design parameters

DC Parameters	
Radius extension	800-1800 mm
Length of outermost wires ($\cos\theta=0.82$)	5143 mm
Thickness of inner CF cylinder	200 μm
Outer CF frame structure	Equivalent CF thickness: 1.63 mm
Thickness of end Al plate	35 mm
Cell size	18 mm \times 18 mm
# of cells	24766
Ratio of field wires to sense wires	3:1
Gas mixture	He/iC ₄ H ₁₀ =90:10



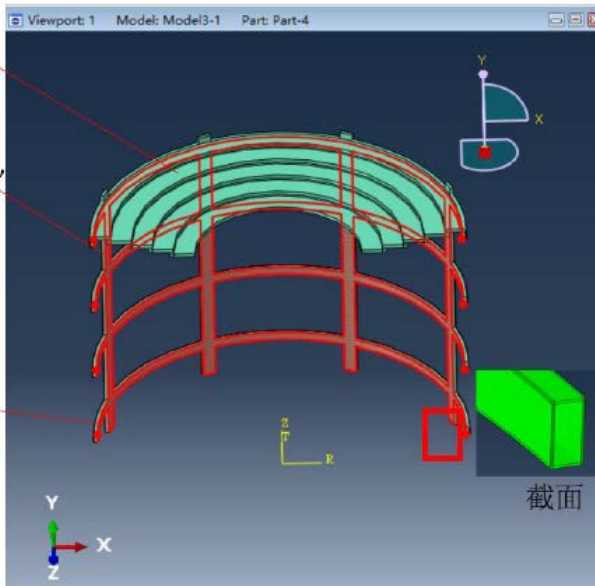
Preliminary mechanical structure



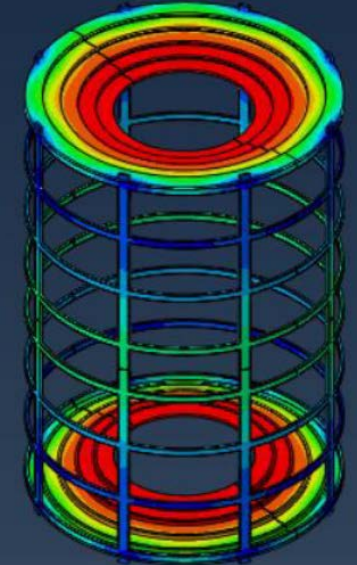
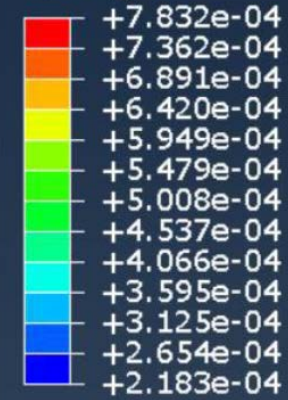
Al endplates :
35 mm

Longitudinal beam,
Cross section:
 $122 \times 40\text{mm}$

Annular beam,
Cross section:
 $80 \times 40\text{mm}$



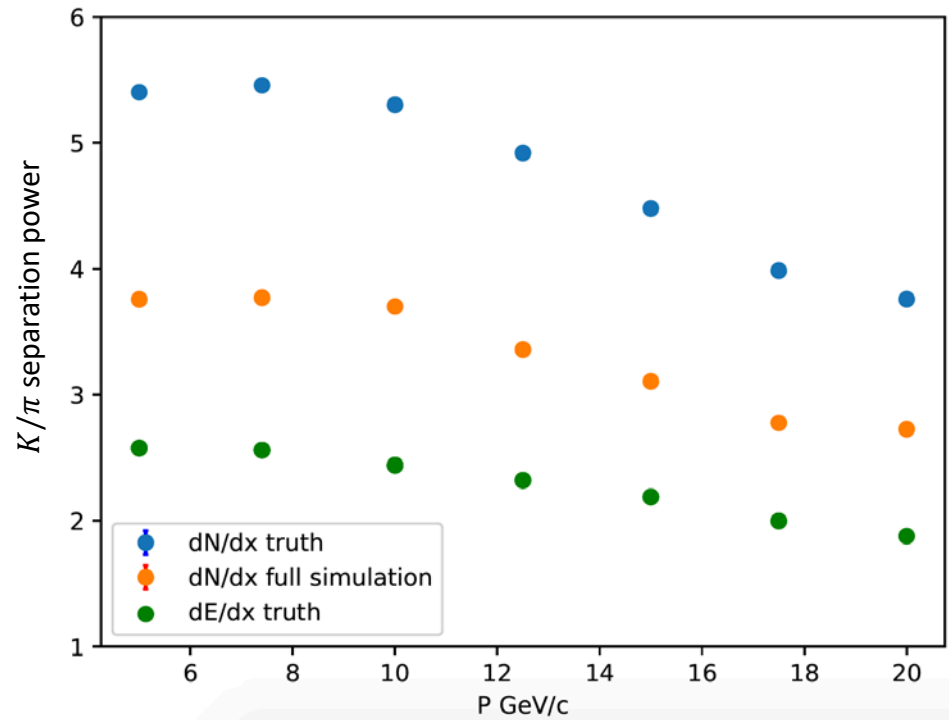
U, Magnitude



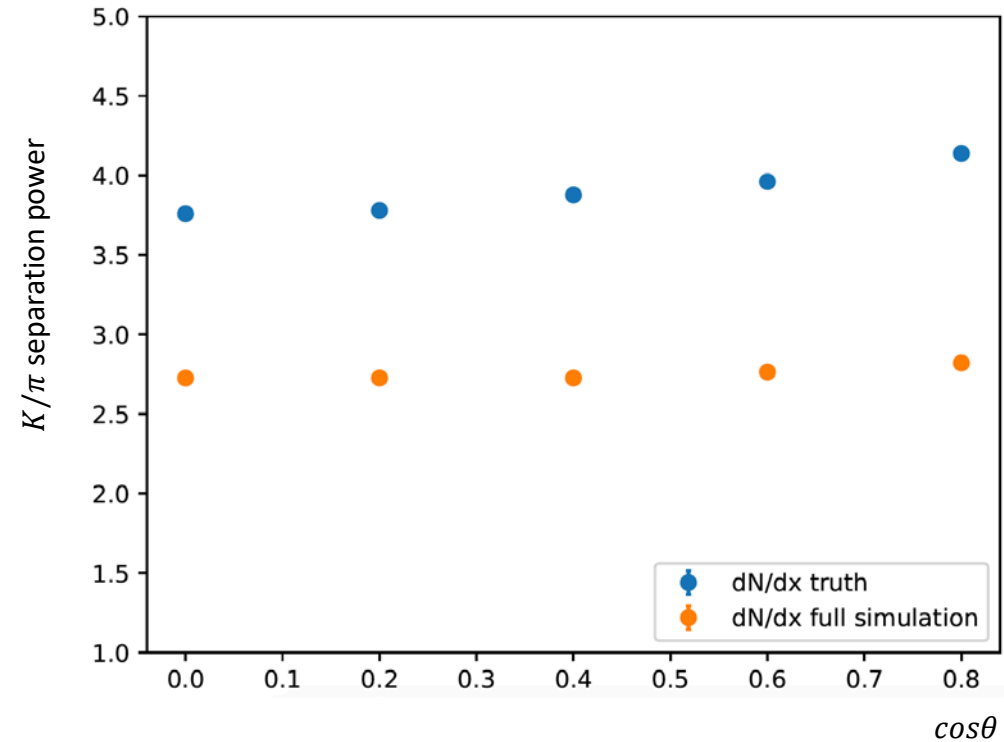
- Carbon fiber frame structure, including 8 longitudinal hollow beams and 8 annular hollow beams
- Thickness of inner CF cylinder: $200\mu\text{m}/\text{layer}$
- Effective outer CF frame structure: 1.63 mm
- Thickness of end Al plate: 35 mm ($0.39 X_0$)

PID performance

K/π separation power vs
P (1m track length, $\cos\theta=0$)

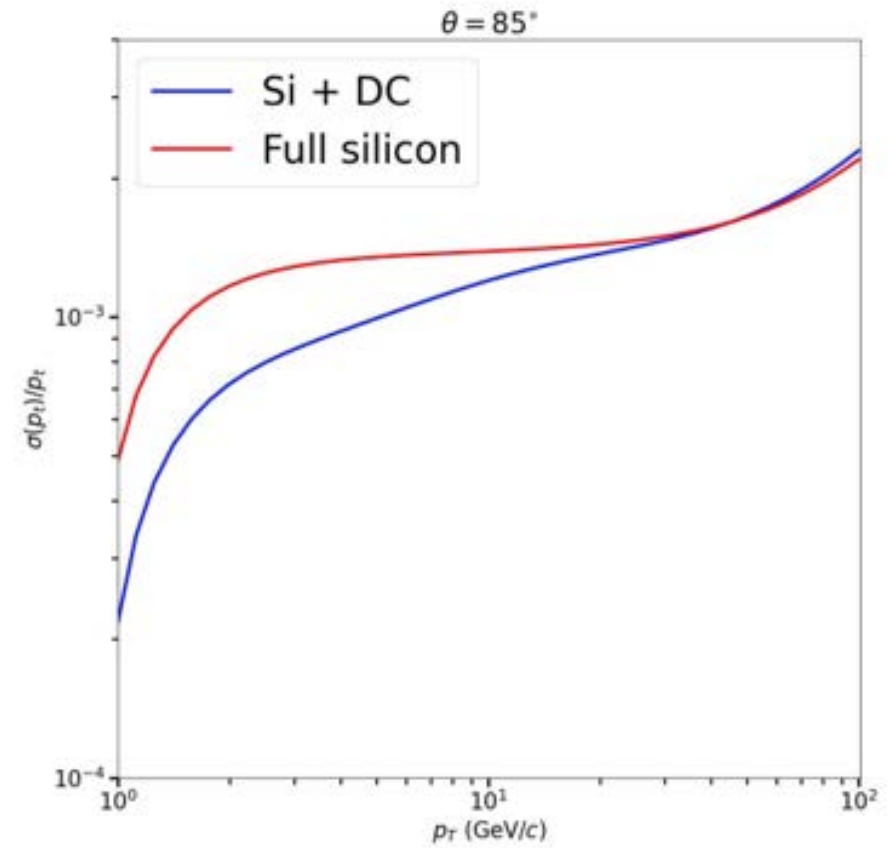
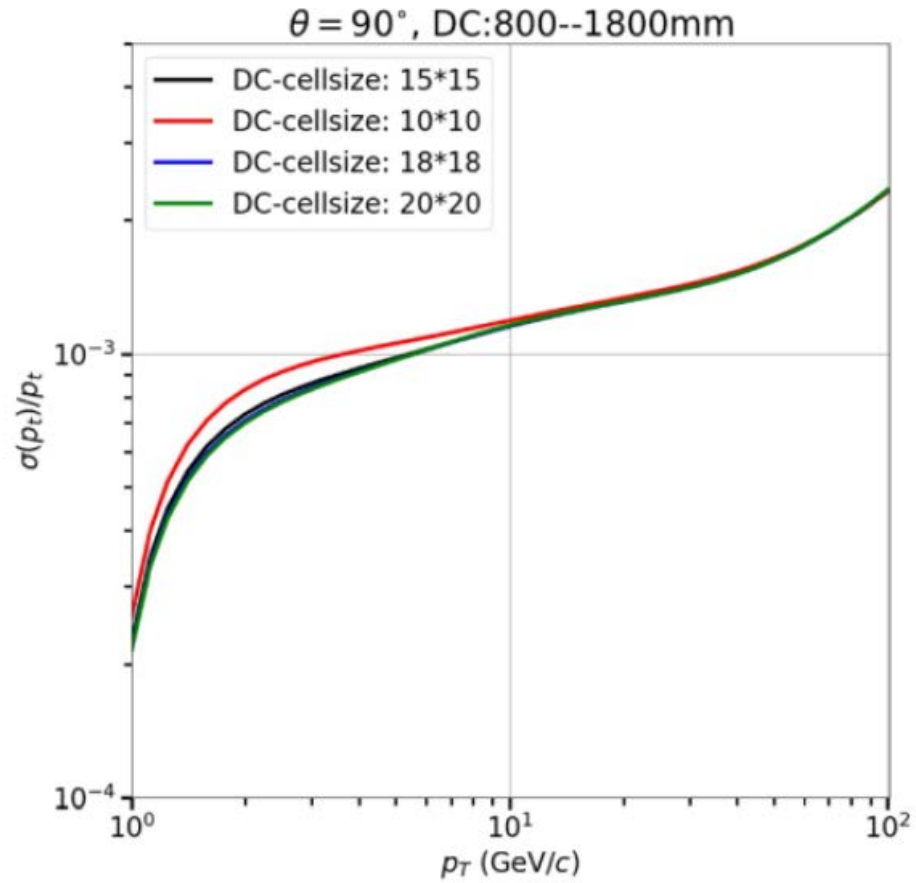


K/π separation power vs
 $\cos\theta$ (P= 20 GeV/c)



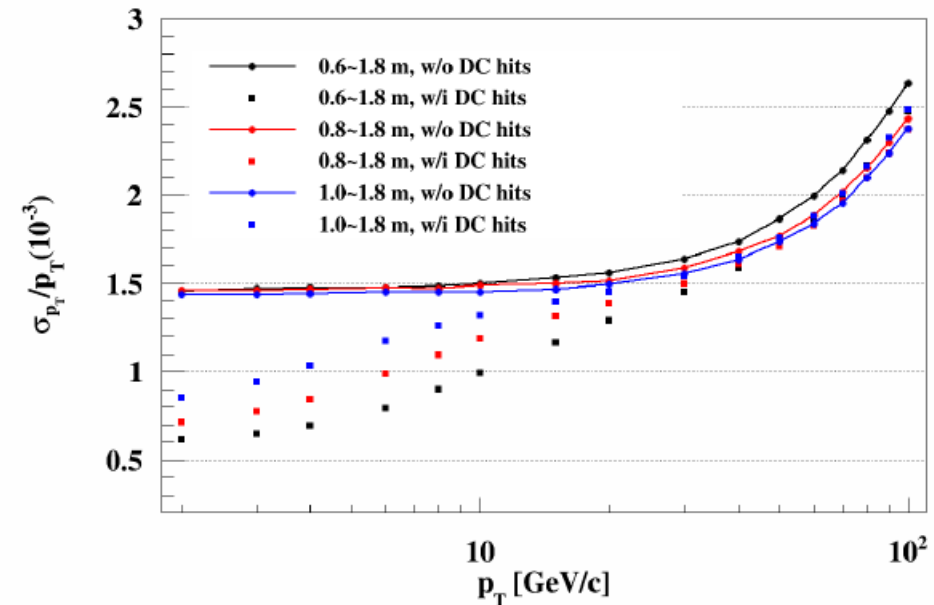
$$S = \frac{|(\frac{dN}{dx})_{\pi} - (\frac{dN}{dx})_K|}{(\sigma_{\pi} + \sigma_K)/2}$$

Momentum resolution

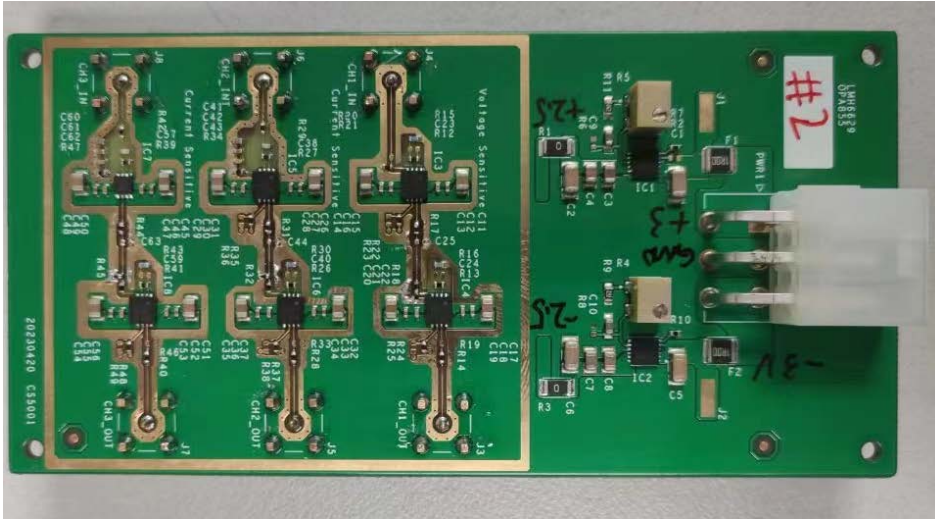


Optimization consideration

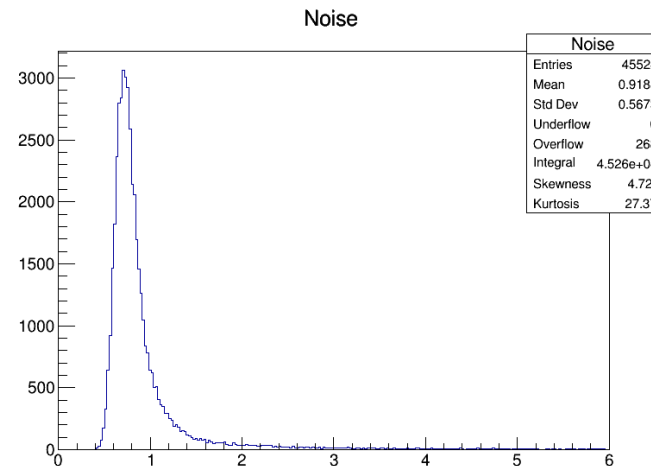
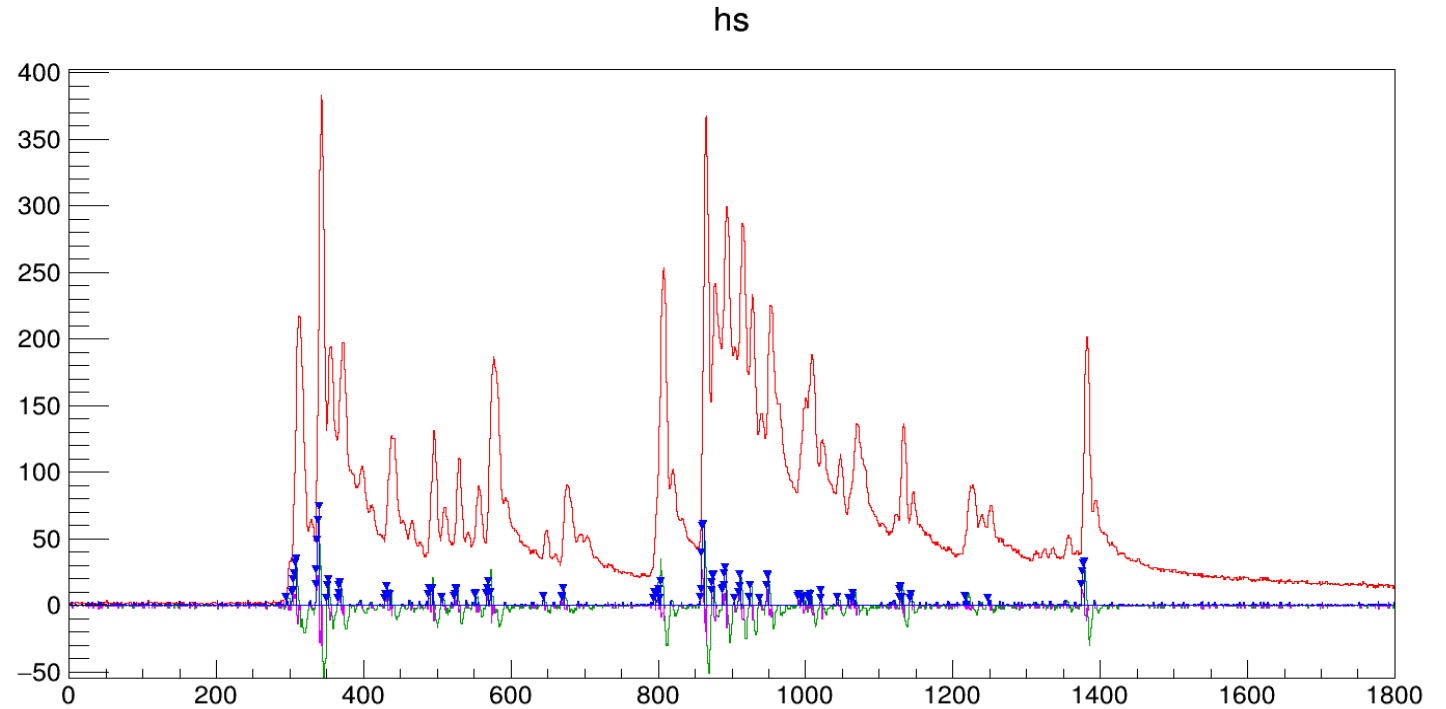
- Inner radius
 - Inner radius: 800mm \rightarrow 600mm or even smaller
 - Track length: 1m \rightarrow 1.2m , better dN/dx resolution
 - K/ π separation power: $2.8\sigma \rightarrow 3.1\sigma$ or even better@20GeV
- Cell size
 - Reduce the cell size of the first 10 layers to achieve stable operation at high counting rates and minimize aging effects



Fast electronics and prototype tests



- Low noise and high bandwidth preamplifiers have been developed and tested with drift chamber prototypes



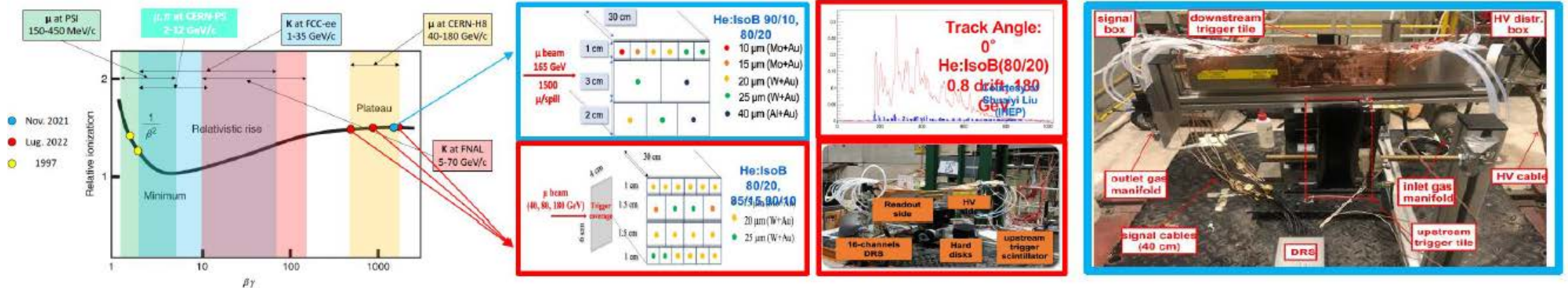
Beam test with detector prototype

Beam tests organized by INFN group:

- Two muon beam tests performed at CERN-H8 ($\beta\gamma > 400$) in Nov. 2021 and July 2022.
- A muon beam test (from 4 to 12 GeV/c) in 2023 performed at CERN.
- Ultimate test at FNAL-MT6 in 2024 with π and K ($\beta\gamma = 10-14$) to fully exploit the relativistic rise.

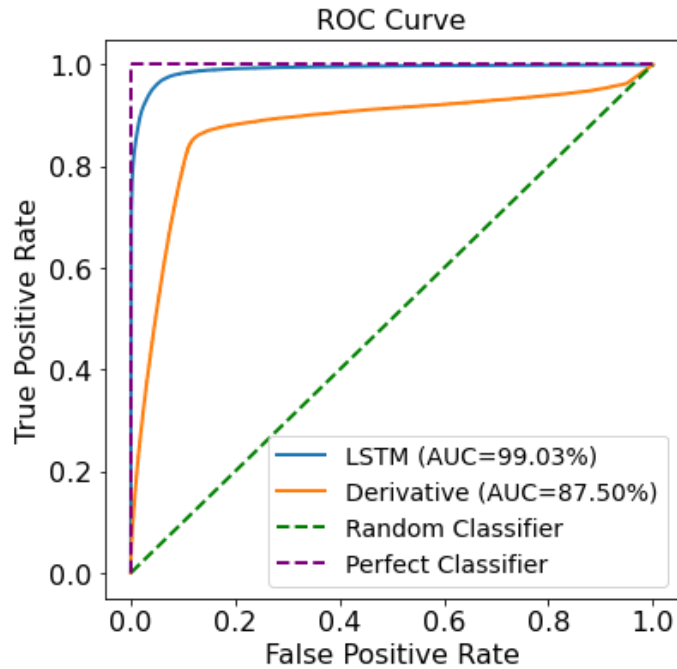
Contributions from IHEP group:

- Participate data taking and collaboratively analyze the test beam data
- Develop the machine learning reconstruction algorithm**

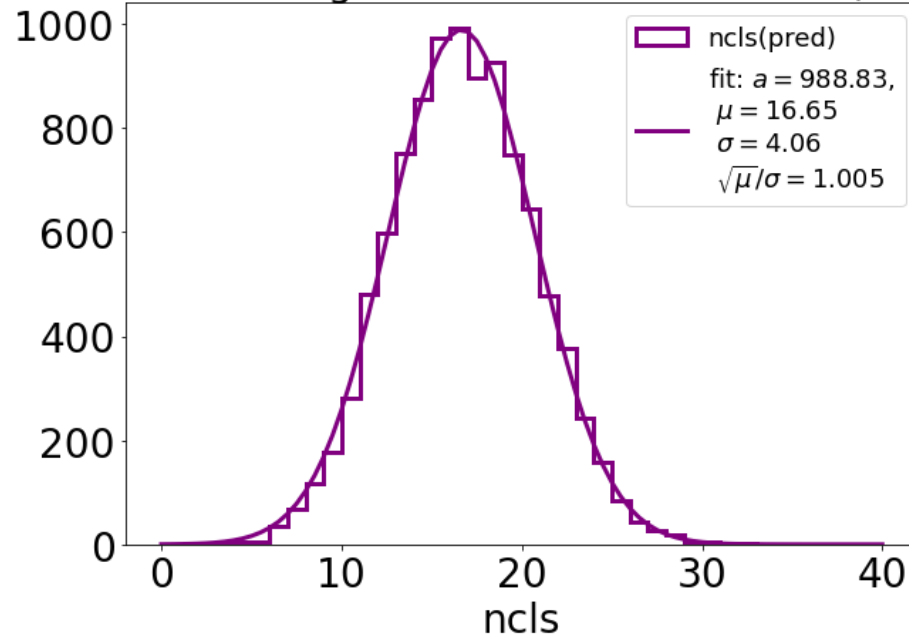


See Nicola De Filippis's talk at the CEPC Workshop for details

Performance with deep learning based algorithm



LSTM Peak Finding + DGCNN Classification (thr=0.61)



Cluster counting reconstruction based on one cell waveform

Clusterization Method	μ	σ	σ/μ
MC truth	16.53	3.93	23.8%
Classical algorithm	18.67	4.60	24.6%
Deep learning	16.65	4.06	24.4%

Closer to MC truth N_{cls} distribution

Towards TDR

- Clarify the geometry design based on overall requirement and design
 - Total power & cooling scheme
 - Mechanics
 - Endcap material
- Hit density and data suppression based on background study

- Deep learning reconstruction
- Physics benchmarks
- Fast electronics developments and experiments
- Prototype study with test beam
- Mechanics test

Geometry	Radius extension	
	Length ($\cos\theta$)	
Performance	Momentum resolution	
	K/ π separation power (20 GeV/c)	
Endcap Material	Total Power	
	Cooling scheme	
	Endcap material	
Data suppression and transmission	Number of channel	
	Data size	
Wire tension		