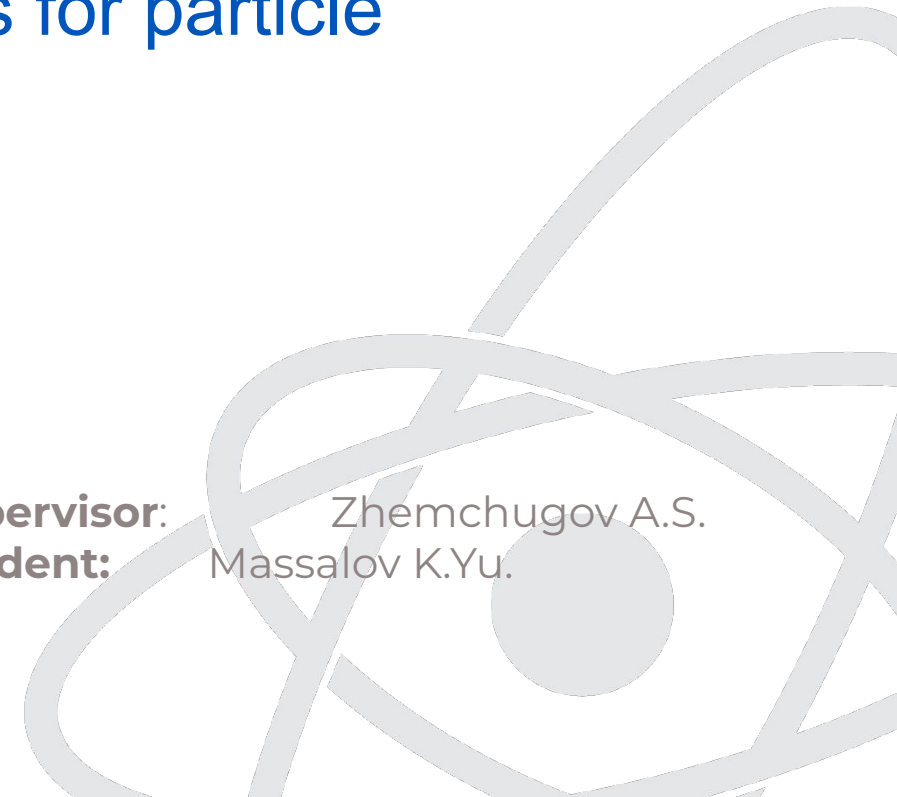


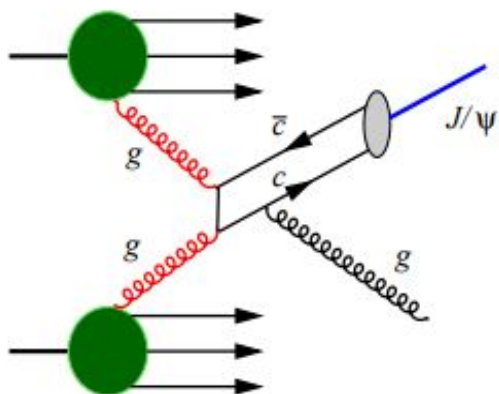
National Research Nuclear University MEPhI
Institute of Nuclear Physics and Engineering
Department of "Elementary Particle Physics" N°40

Application of artificial intelligence methods for particle identification in the FARICH SPD detector

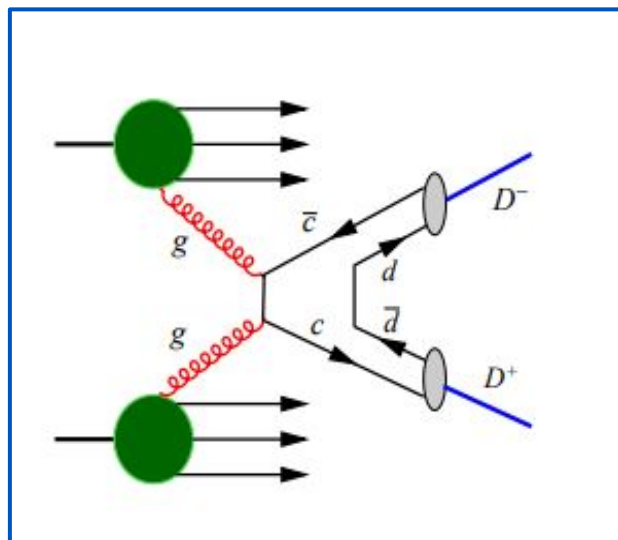
Supervisor: Zhemchugov A.S.
Student: Massalov K.Yu.

Moscow 2024

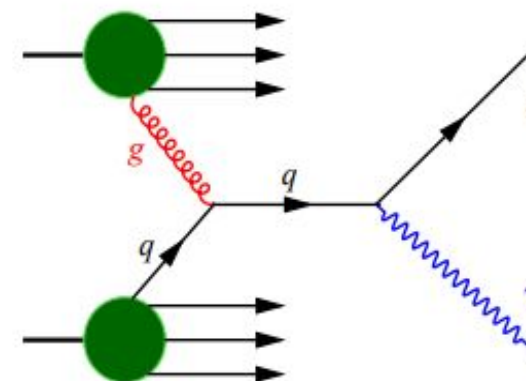




inclusive production of charmonia



open charm



prompt photons

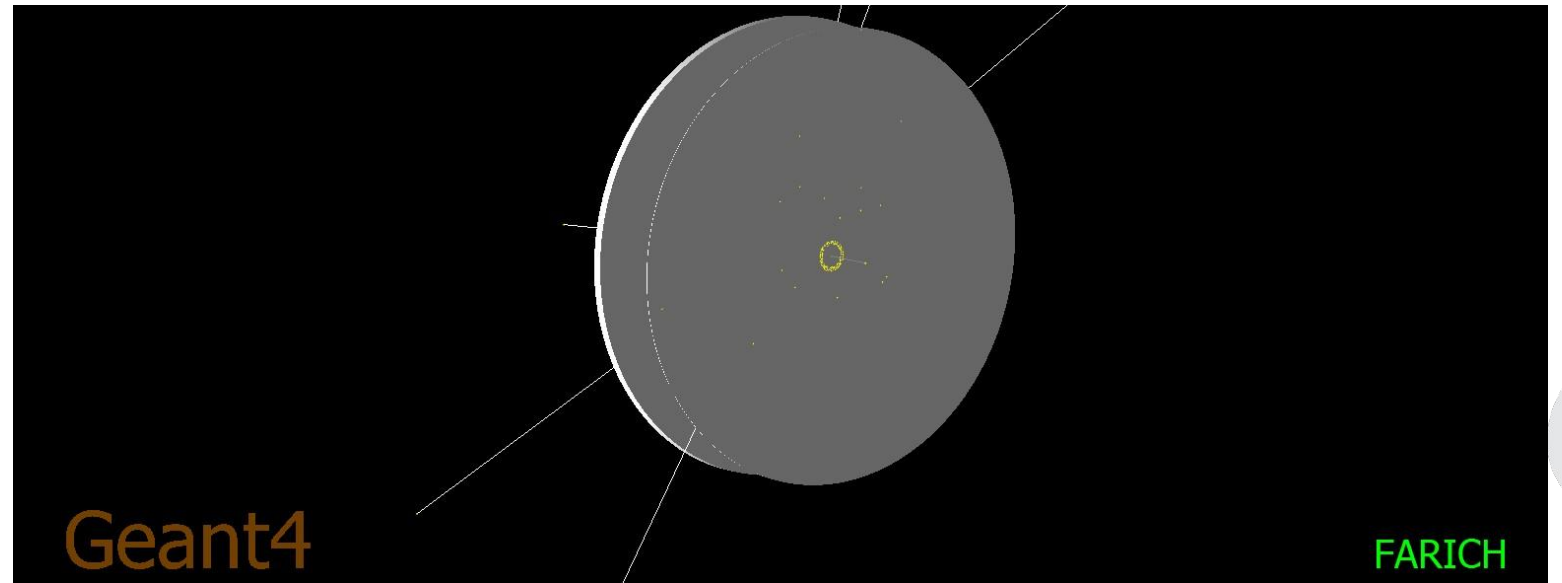
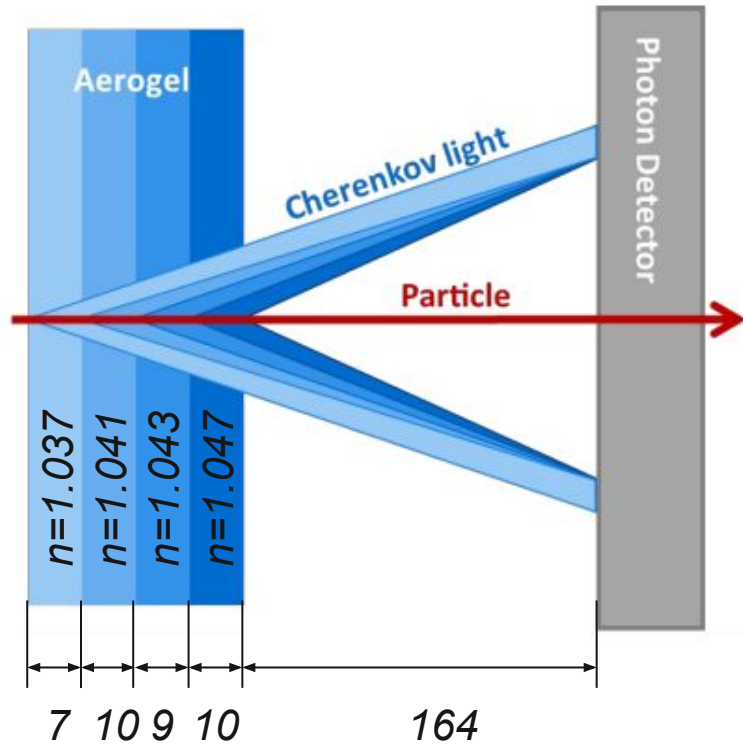
Decay modes of **D-meson**:

$$D^0 \rightarrow K^- \pi^+$$

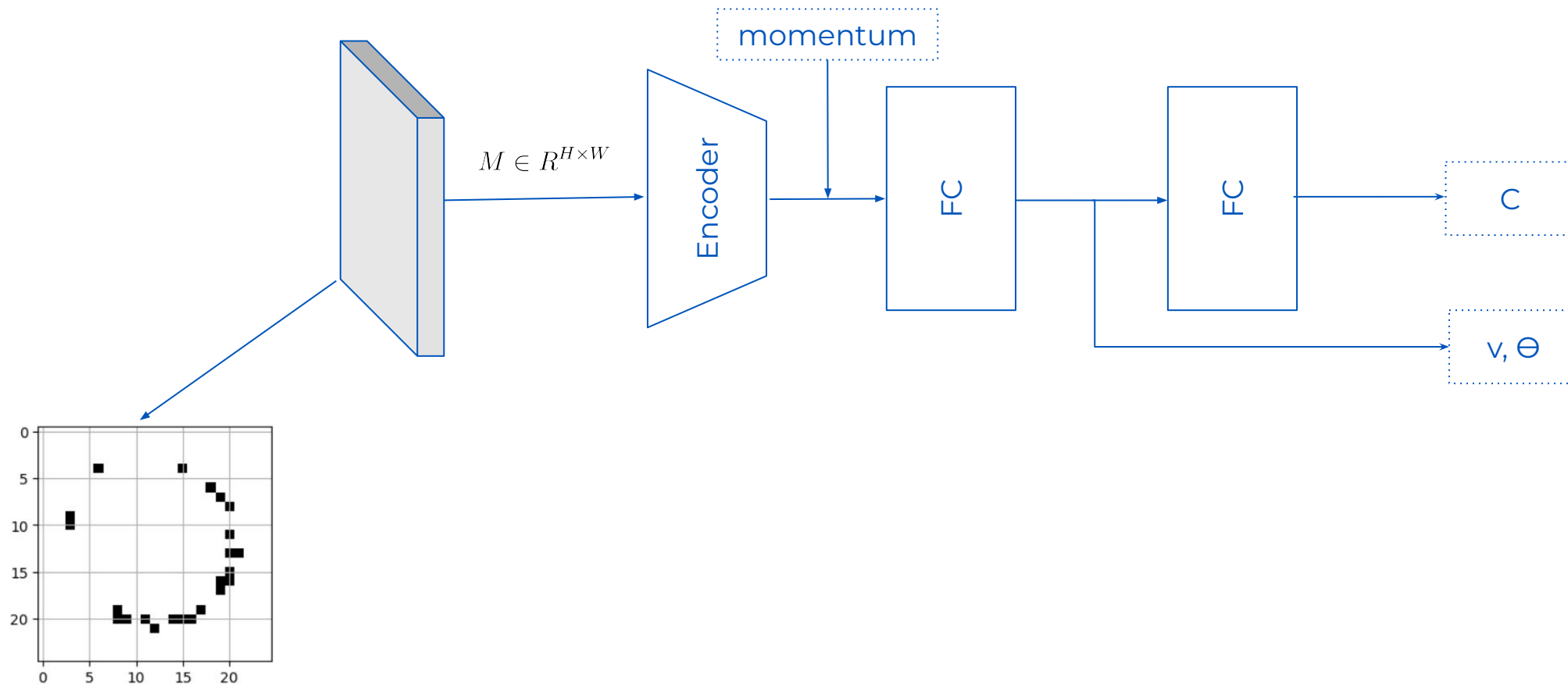
$$D^+ \rightarrow K^- \pi^+ \pi^+$$

1. Creation of neural network methods for reconstructing signals from the FARICH detector
2. Studying their characteristics and comparing them with classical approaches

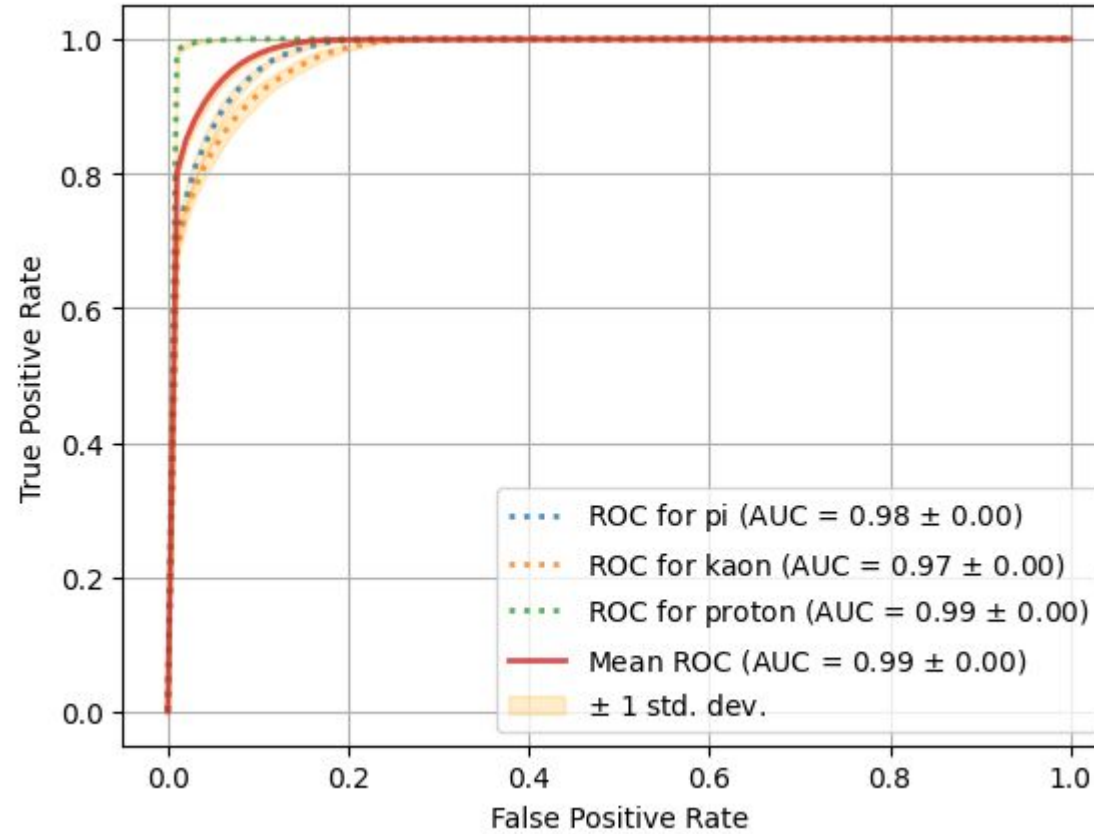
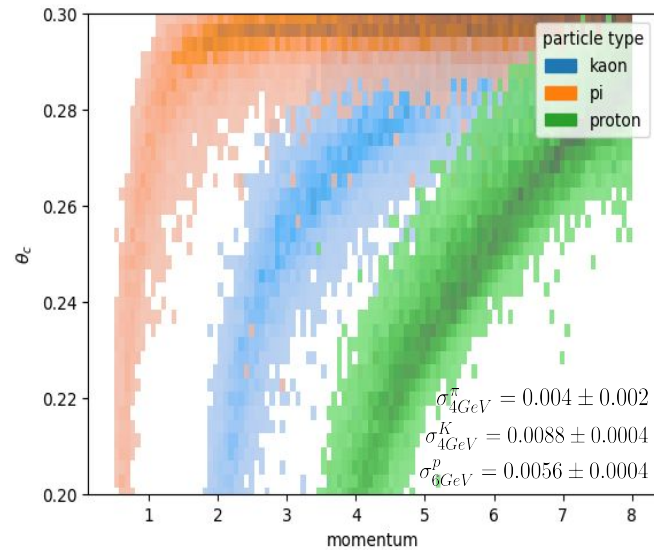
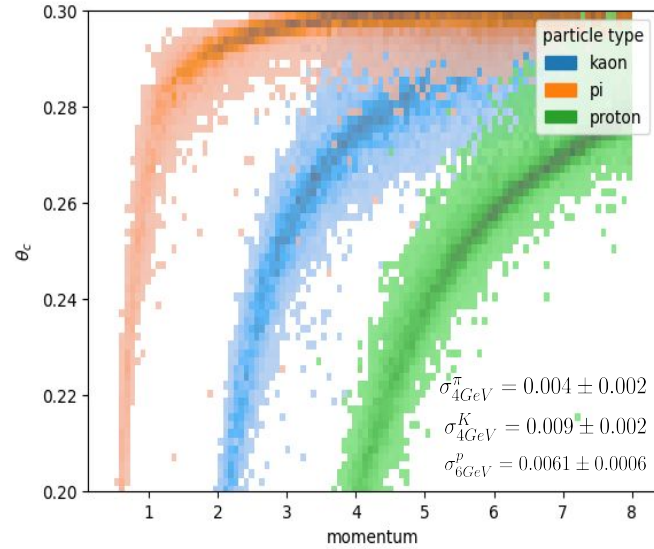
Modeling of the FARICH detector



First approach

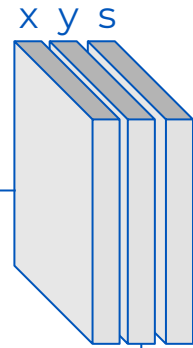


First approach



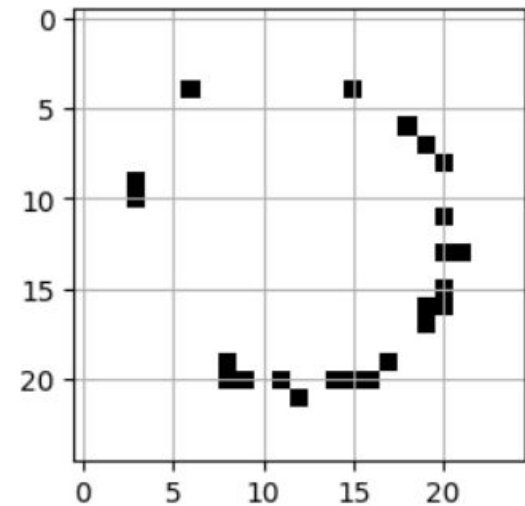
- $AUC = 0.987 \pm 0.002$
- $MAE_v = 0.0016 \pm 0.0001$
- $MAE_{\Theta} = 0.0041 \pm 0.0006$

Coordinate grid

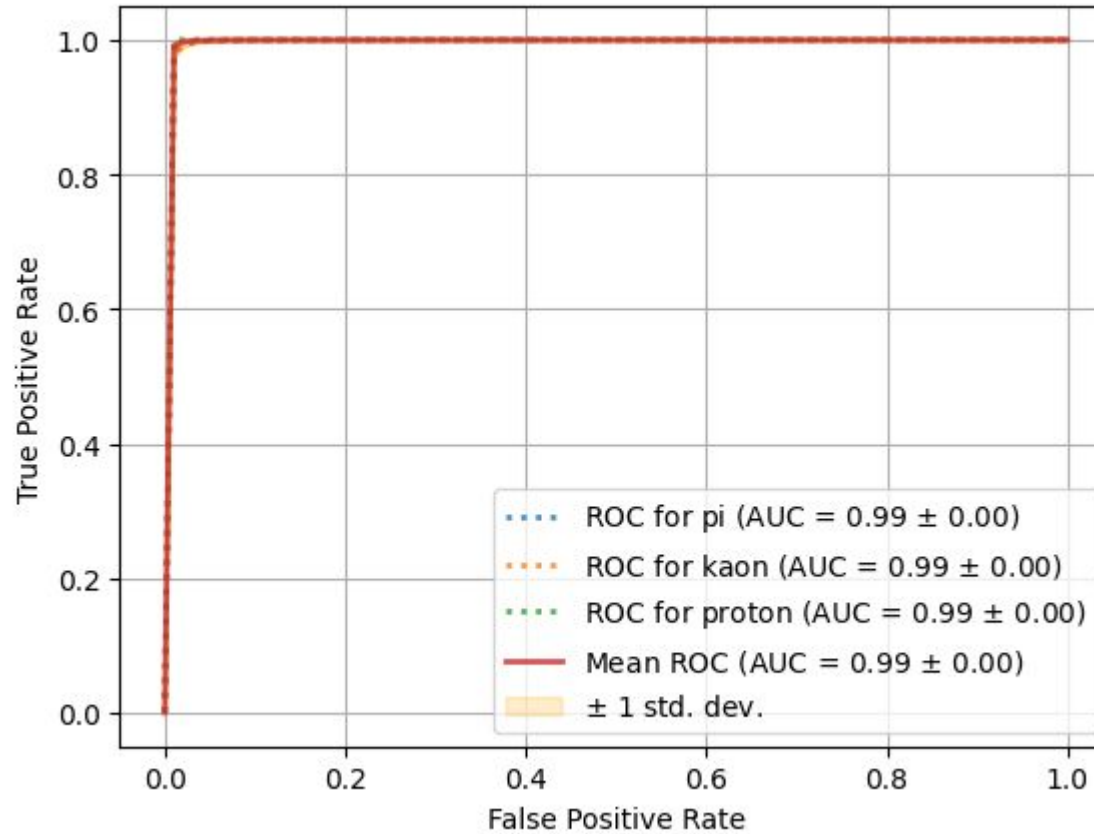
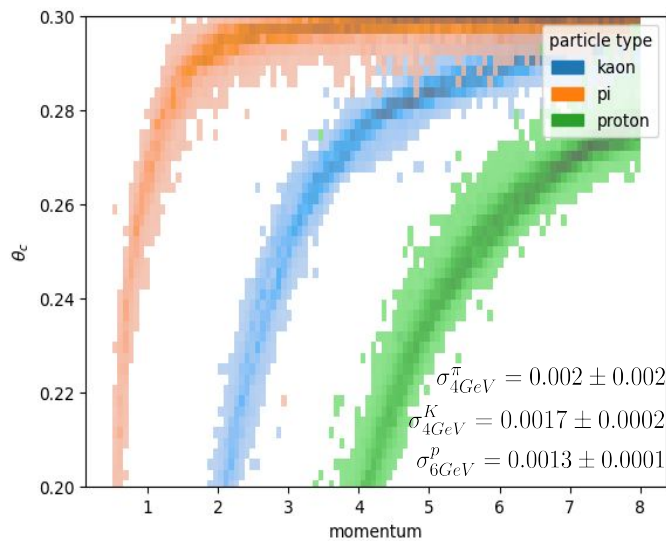
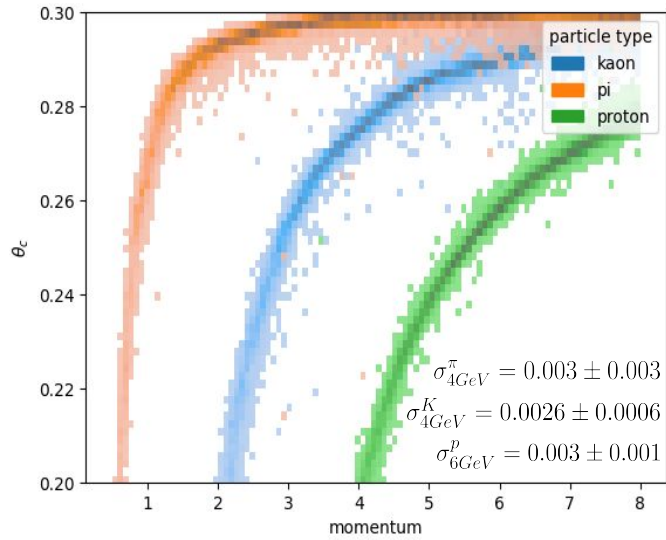


102	102	102	...	102	102
103	103	103	...	103	103
104	104	104	...	104	104
...					
124	124	124	...	124	124
125	125	125	...	125	125
126	126	126	...	126	126

46	47	48	...	69	70
46	47	48	...	69	70
46	47	48	...	69	70
...					
46	47	48	...	69	70
46	47	48	...	69	70
46	47	48	...	69	70



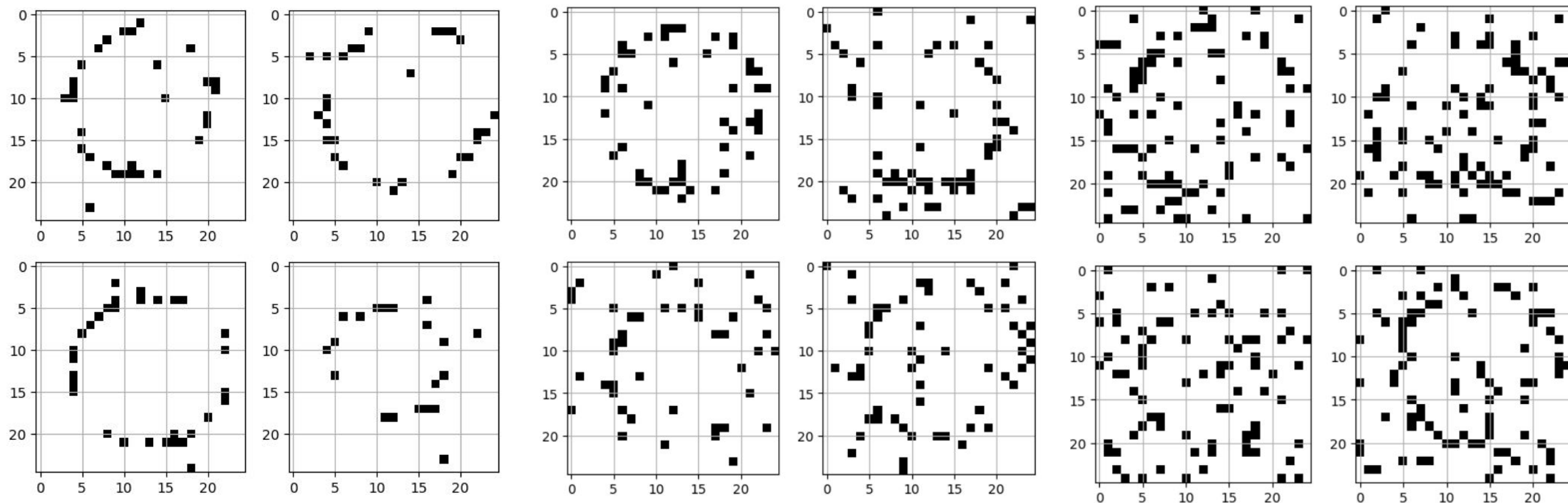
Coordinate grid



- $AUC = 0.9994 \pm 0.0001$
- $MAE_v = 0.0007 \pm 0.0001$
- $MAE_{\Theta} = 0.0017 \pm 0.0002$

Noise resistance

Levels of noise



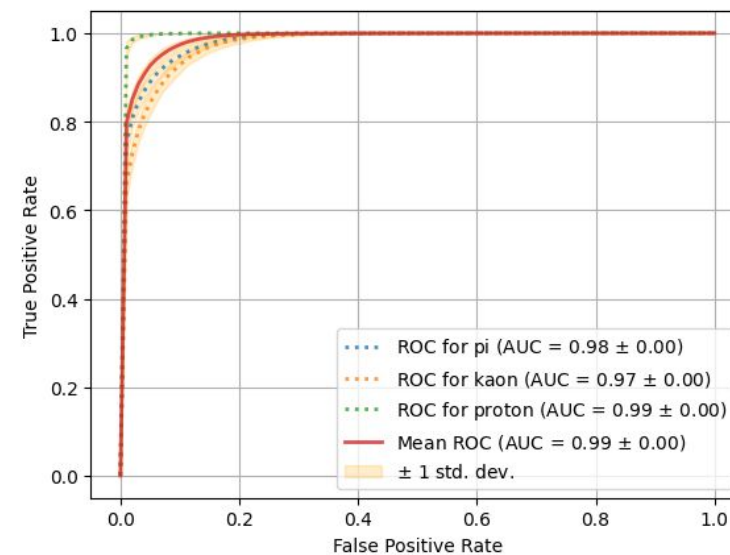
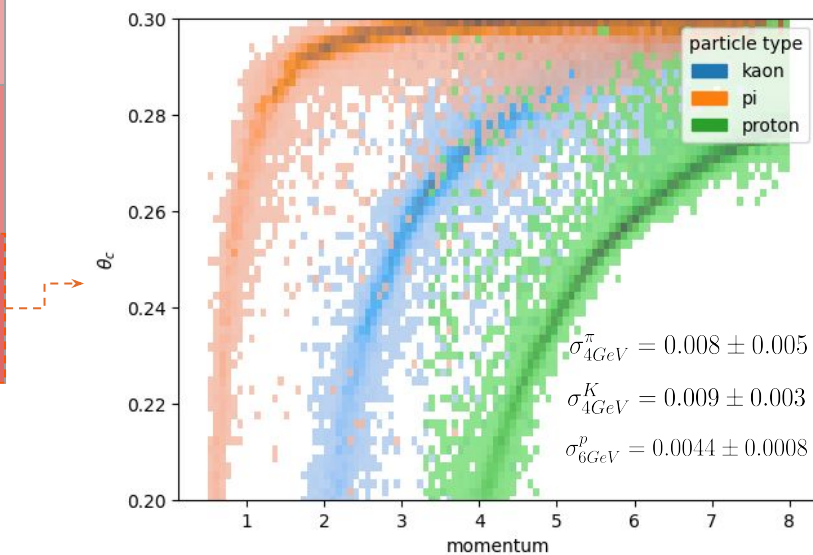
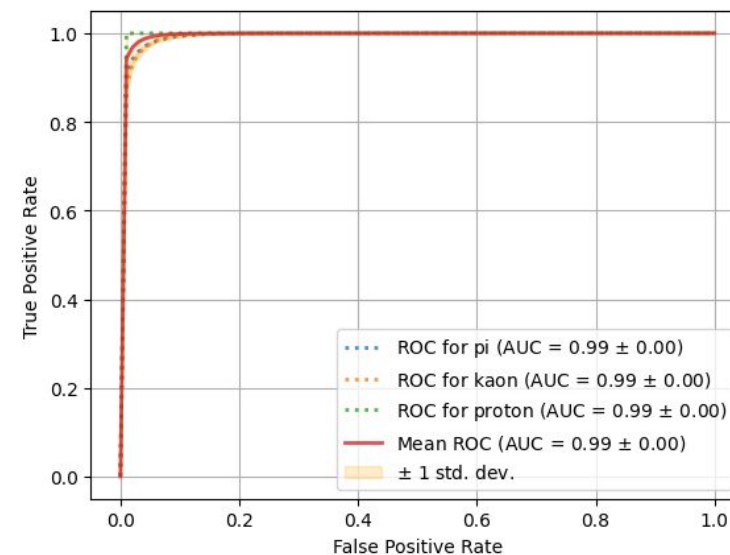
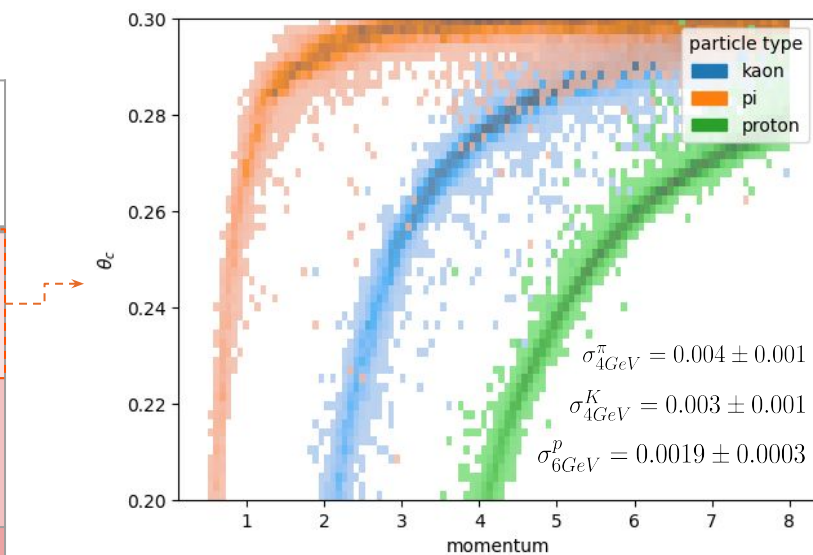
Bernoulli(0.01)

Bernoulli(0.05)

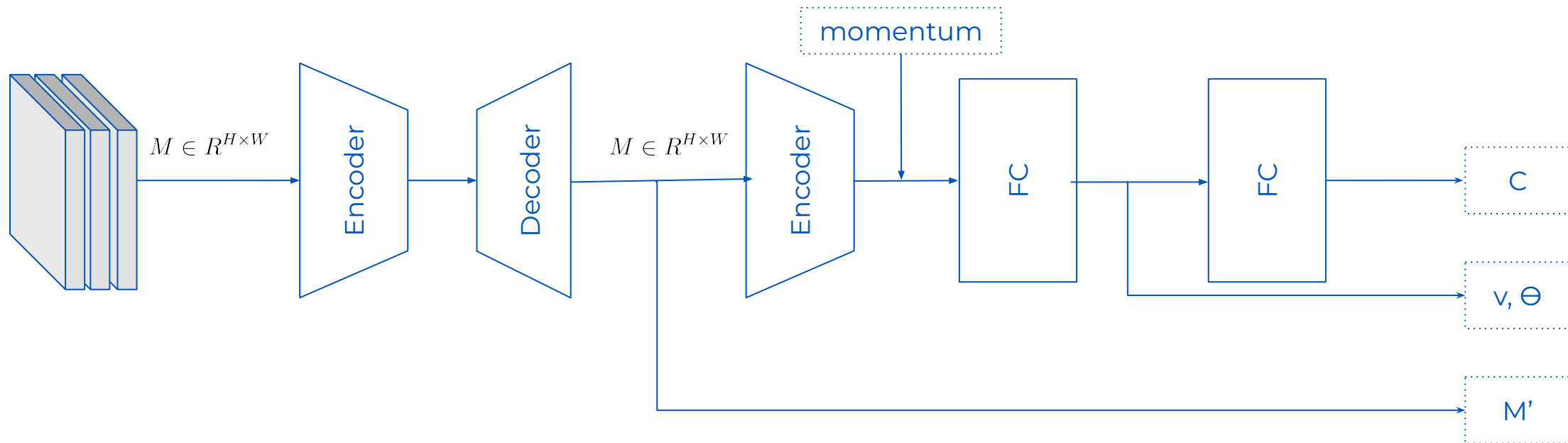
Bernoulli(0.1)

Without denoising

noise level	ROC AUC	MAE
0.01-0.02	0.9972 ±0.0005	0.0026 ±0.0003
0.03-0.04	0.995± 0.001	0.0029± 0.0002
0.05-0.06	0.991± 0.002	0.0034± 0.0003
0.07-0.08	0.989± 0.002	0.0038± 0.0004
0.09-0.10	0.985± 0.003	0.0041± 0.0004



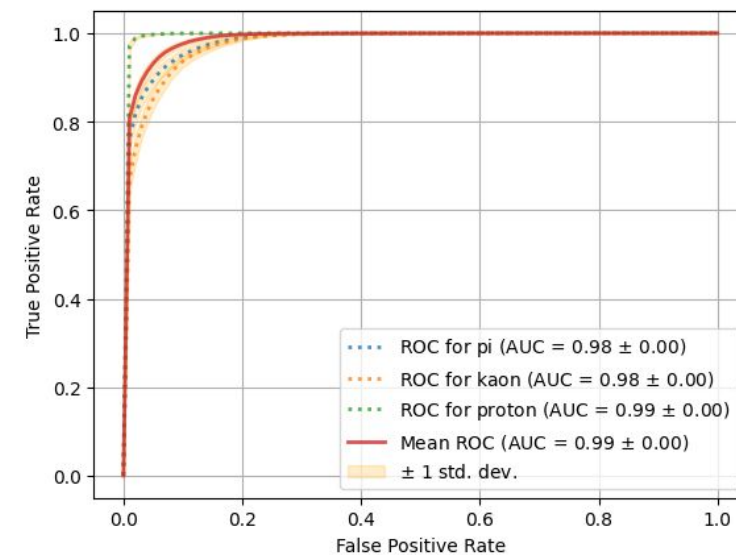
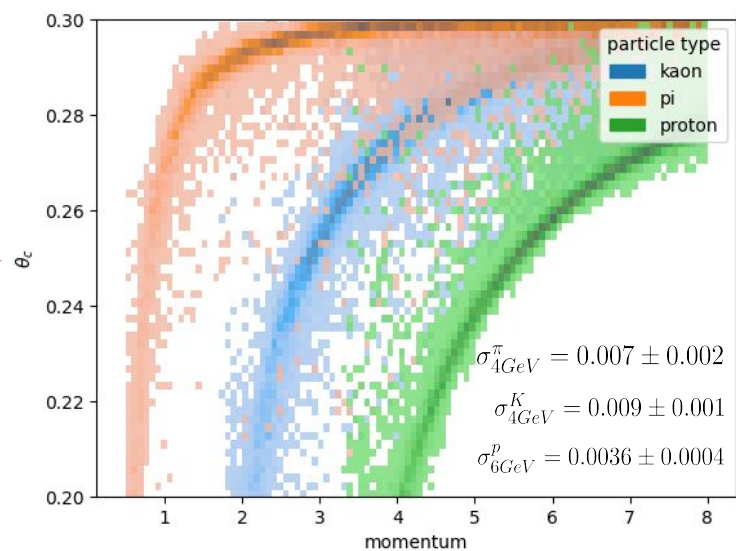
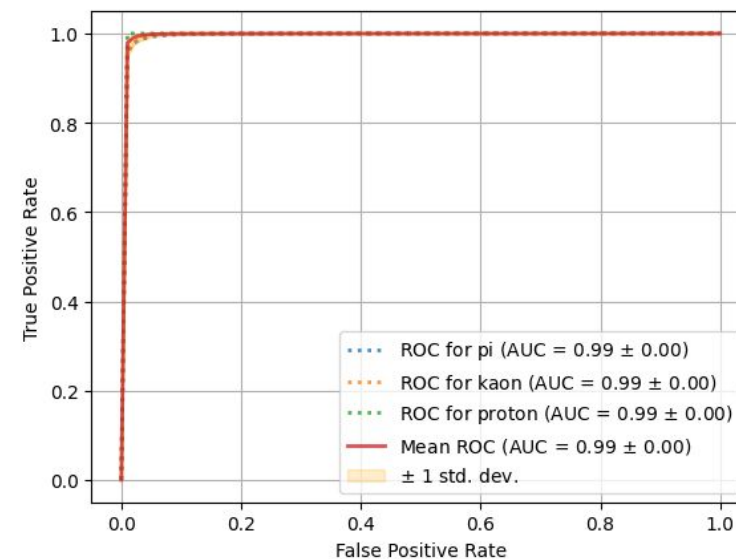
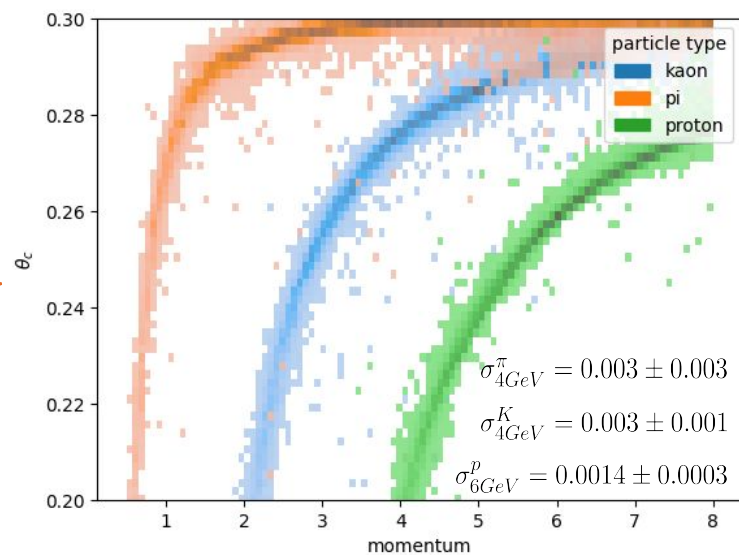
With denoising



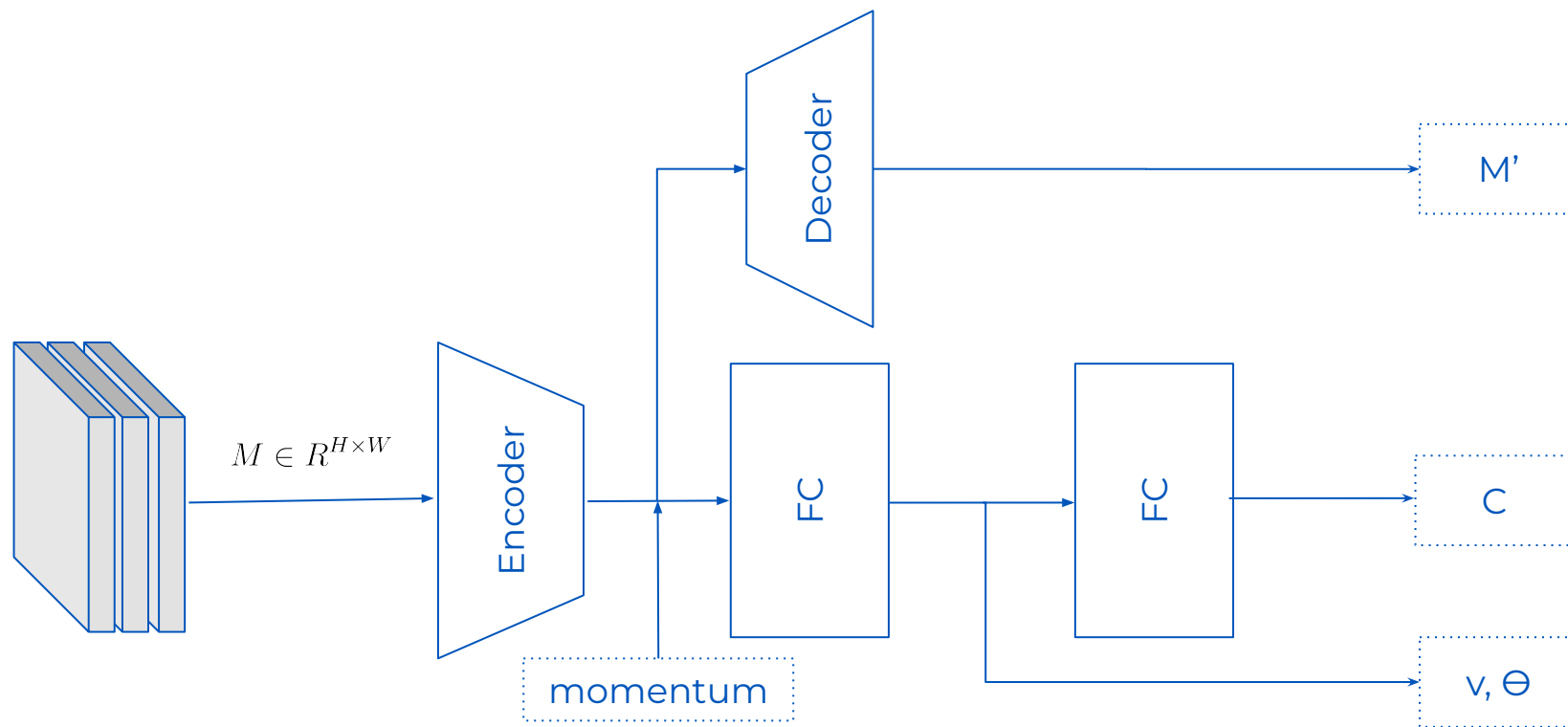
* M' - denoised image

With denoising

noise level	ROC AUC	MAE
0.01-0.02	0.9988 ± 0.0002	0.0021 ± 0.0004
0.03-0.04	0.9979 \pm 0.0004	0.0022 \pm 0.0003
0.05-0.06	0.9967 \pm 0.0007	0.0025 \pm 0.0001
0.07-0.08	0.994 \pm 0.001	0.0027 \pm 0.0002
0.09-0.10	0.986 \pm 0.002	0.0039 \pm 0.0002

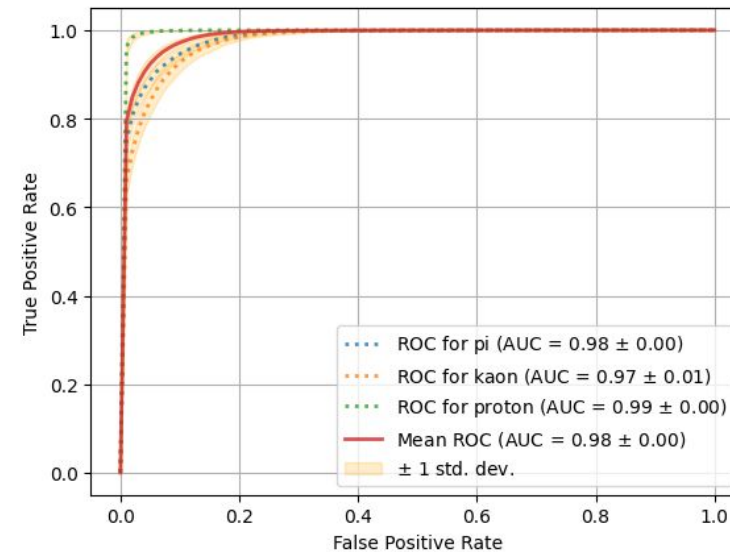
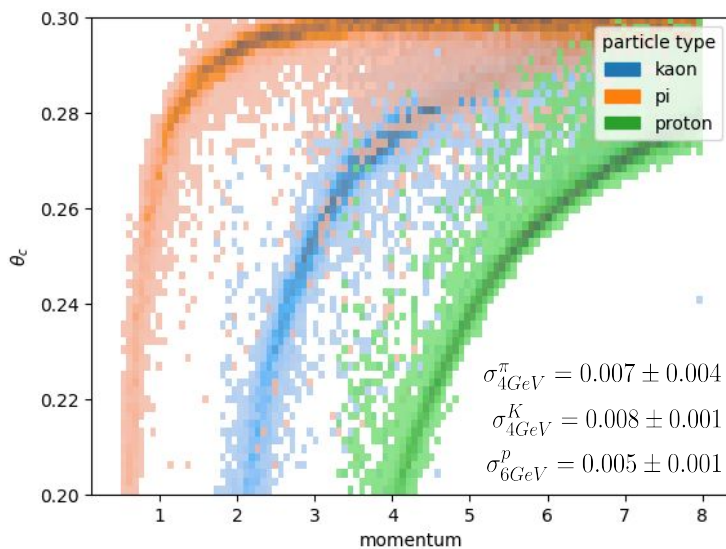
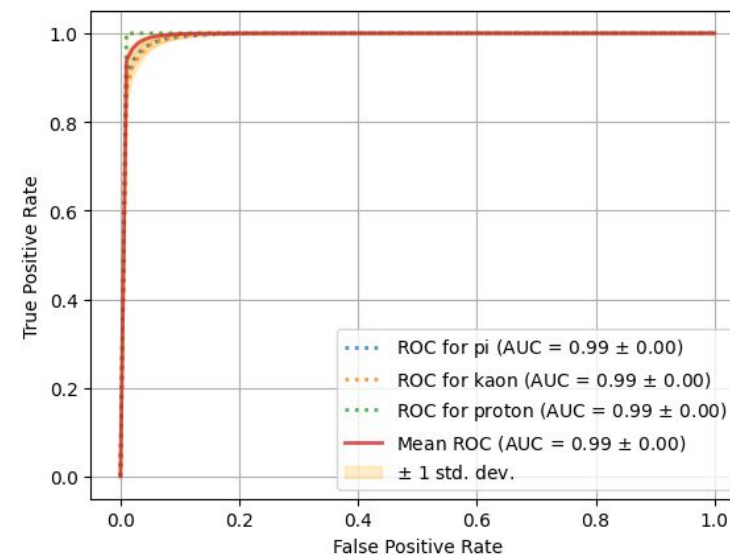
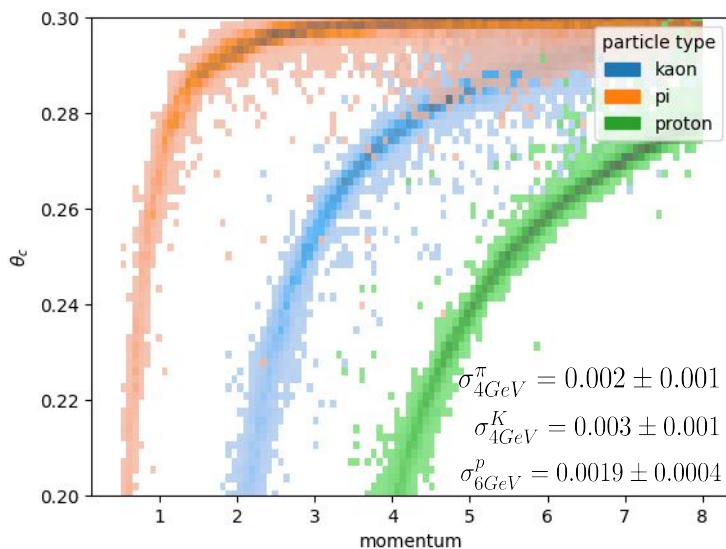


Size reduction

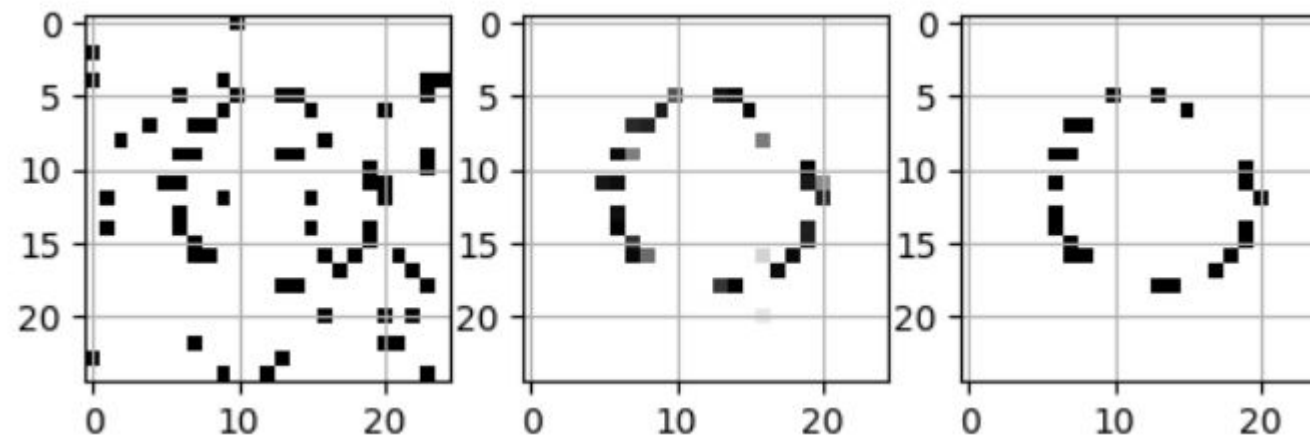


Size reduction

noise level	ROC AUC	MAE
0.01-0.02	0.997±0.001	0.0025±0.0004
0.03-0.04	0.995±0.001	0.0027±0.0003
0.05-0.06	0.992±0.001	0.0032±0.0005
0.07-0.08	0.989±0.002	0.0034±0.0004
0.09-0.10	0.985±0.004	0.0039±0.0005



Denoising result



Noisy

Cleared

Target

Final comparison (for noise level 0.00 - 0.05)

	AUC	MAE(v)	MAE(θ)	Inference time (batch, 1000 samples)
v1	0.9966±0.0009	0.0010±0.0001	0.0029±0.0003	(12.50±0.02) ms
v2	0.9978±0.0004	0.00087±0.00006	0.0021±0.0002	(73.80±0.02) ms
v3	0.996±0.001	0.009±0.0001	0.0026±0.0003	(53.50±0.08) ms

- *best time*

- *best performance*

A neural network was developed to recognize particles and find their speed. The model's resistance to noise was studied.

In the future it is planned:

- to compare NN models with classic methods
- adding circles intersections
- build the pipeline for particle identification.

**Thank you for
your attention**

