

The state-of-the-art quantum technology

Applications to High Energy Physics problems

Abdualazem Fadol Mohammed

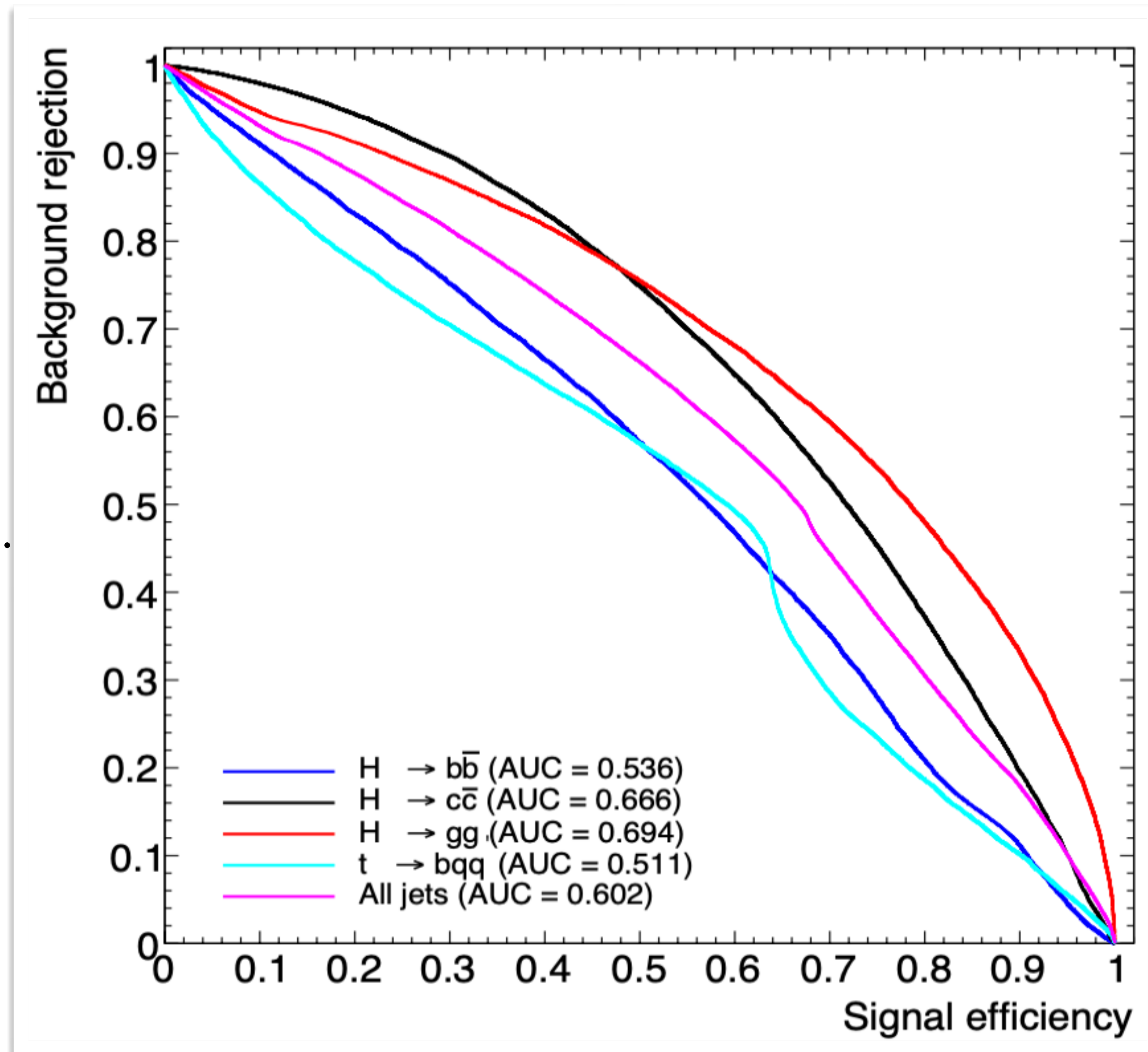


August 26, 2024

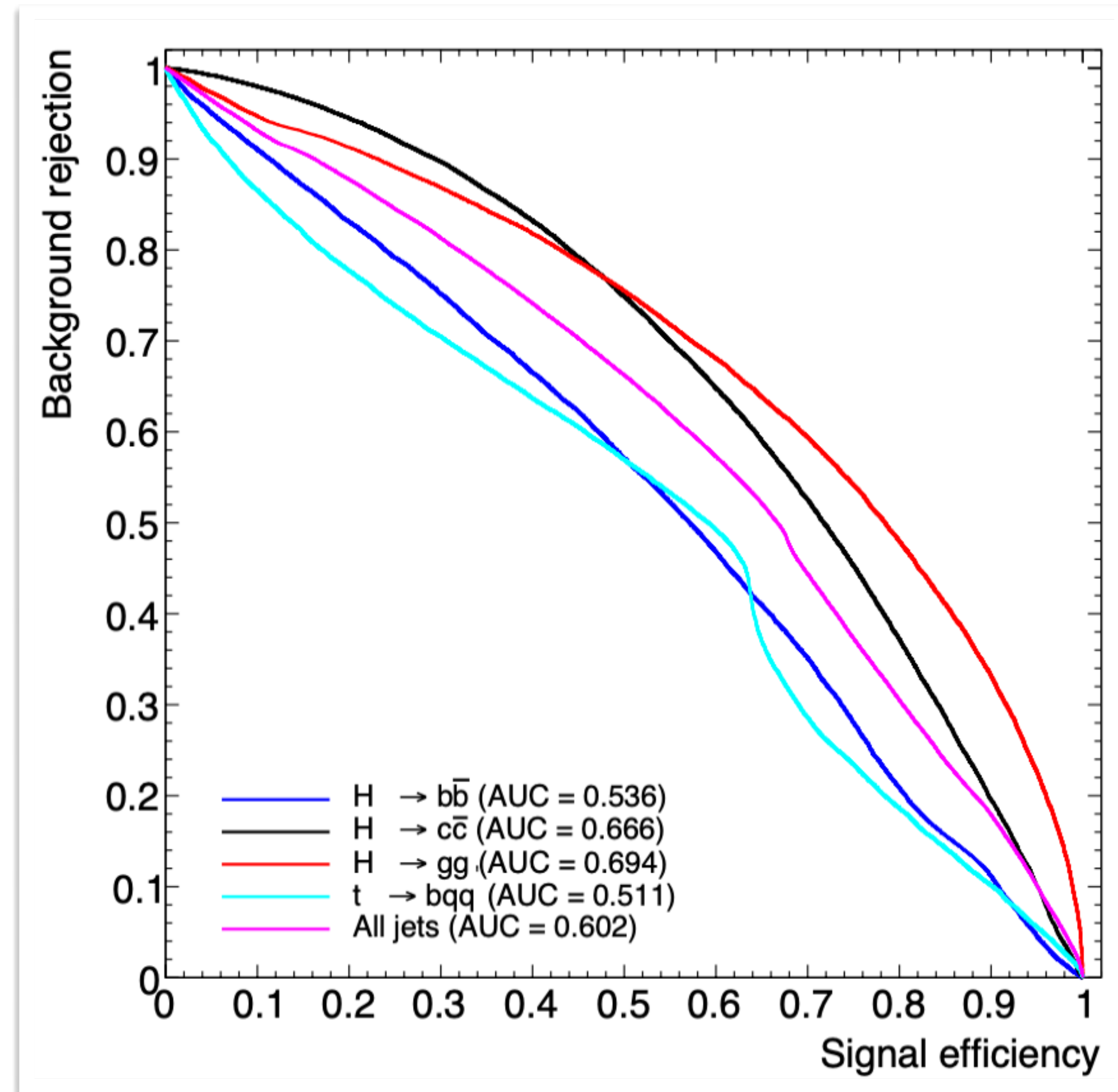
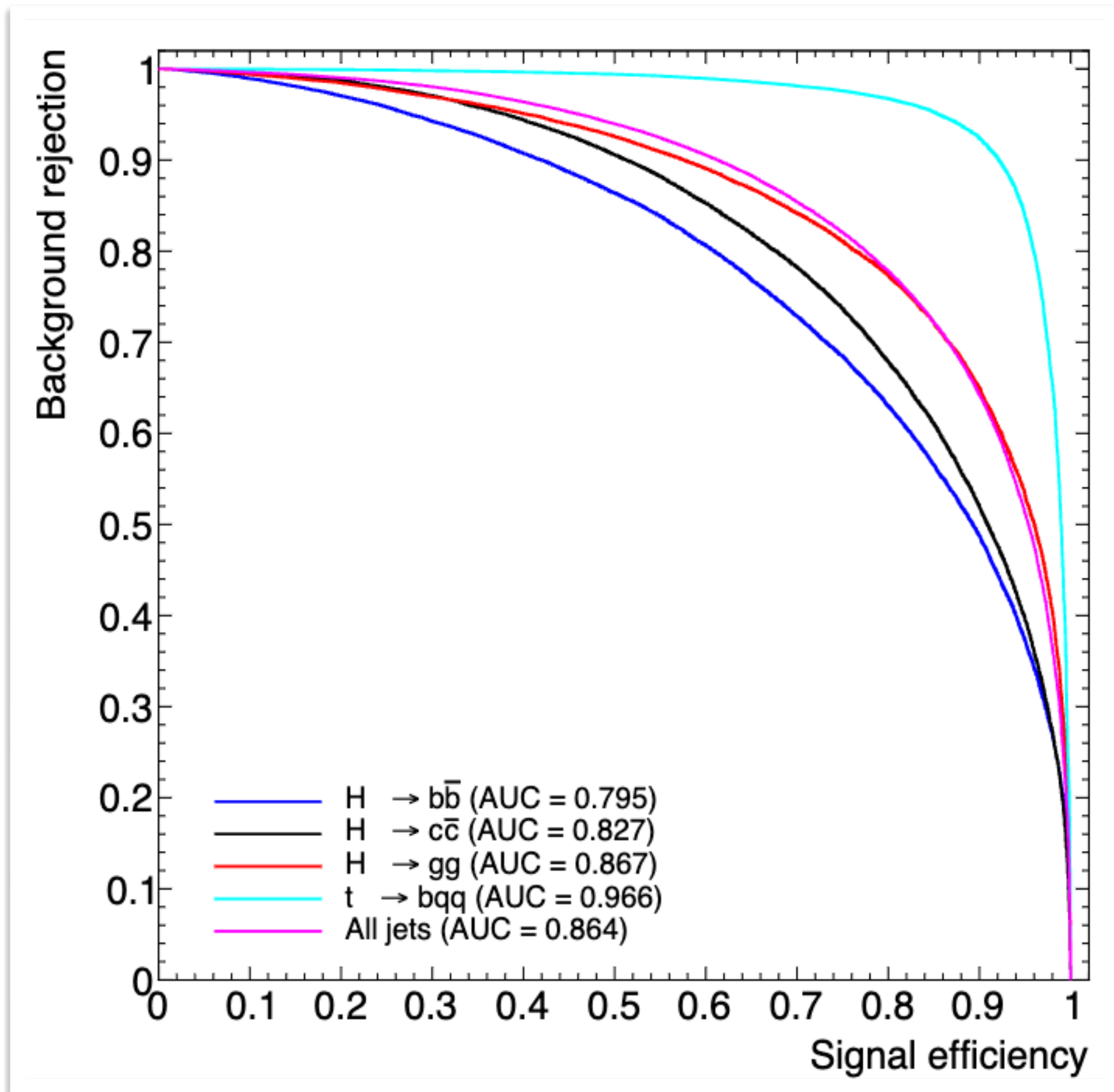


The Beijing Super Cloud Computing Center

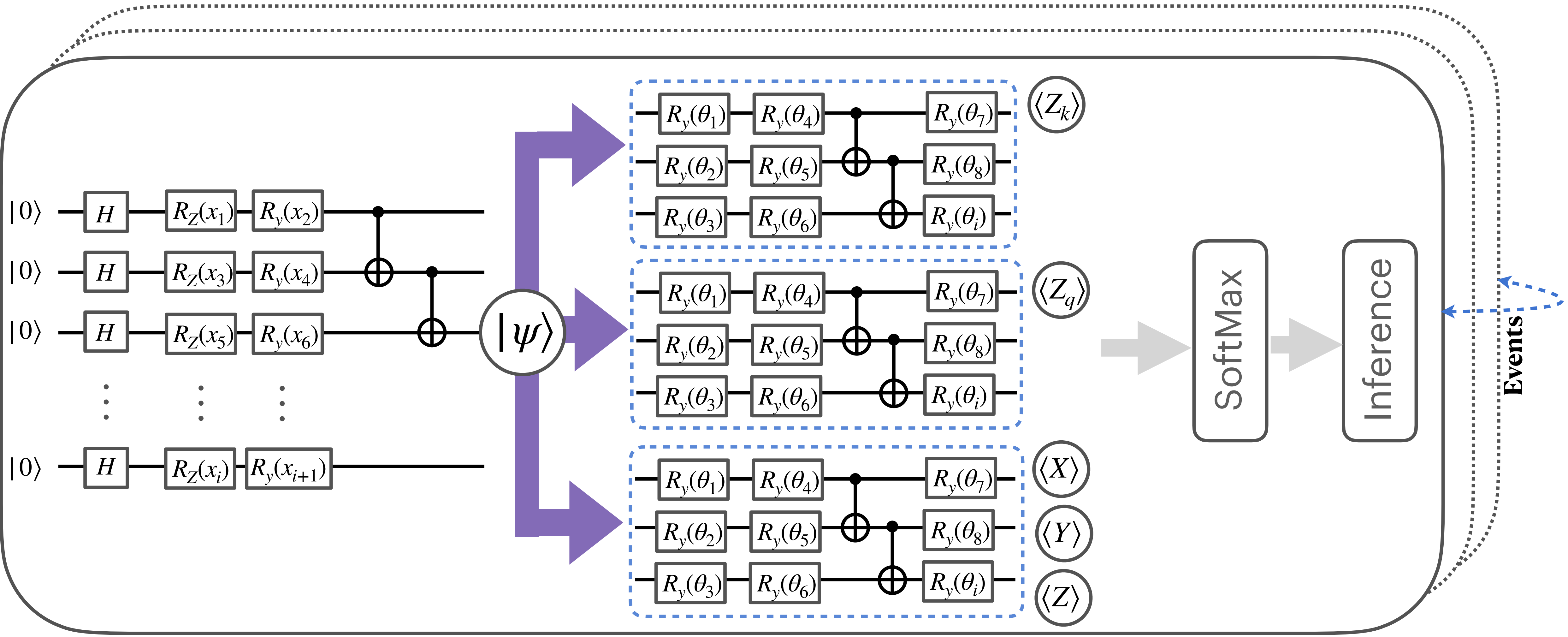
- We got two free accounts for testing:
 - NC-N40: GeForce RTX 4090 (Spent)
 - BSCC-N32-E: problem installing packages
- The test was done using four jet types:
 - $H \rightarrow b\bar{b}$, $H \rightarrow c\bar{c}$, $H \rightarrow gg$, and $t \rightarrow bqq'$
- Each class has 100k events: 20%
- The default configuration for the network was used.
- Running time for 50 epochs: 2d, 3h, 20m for QParT.



The Beijing Super Cloud Computing Center



Quantum Transformer



□ This is still experimental work towards building a pure-quantum transformer inspired by [ArXiv: 2205.05625](https://arxiv.org/abs/2205.05625).

Quantum Transformer

- Wrapping the quantum self-attention with the following class

```
import torch
import torch.nn as nn
import numpy as np
from Modules.QuantumSelfAttention import QuantumSelfAttention

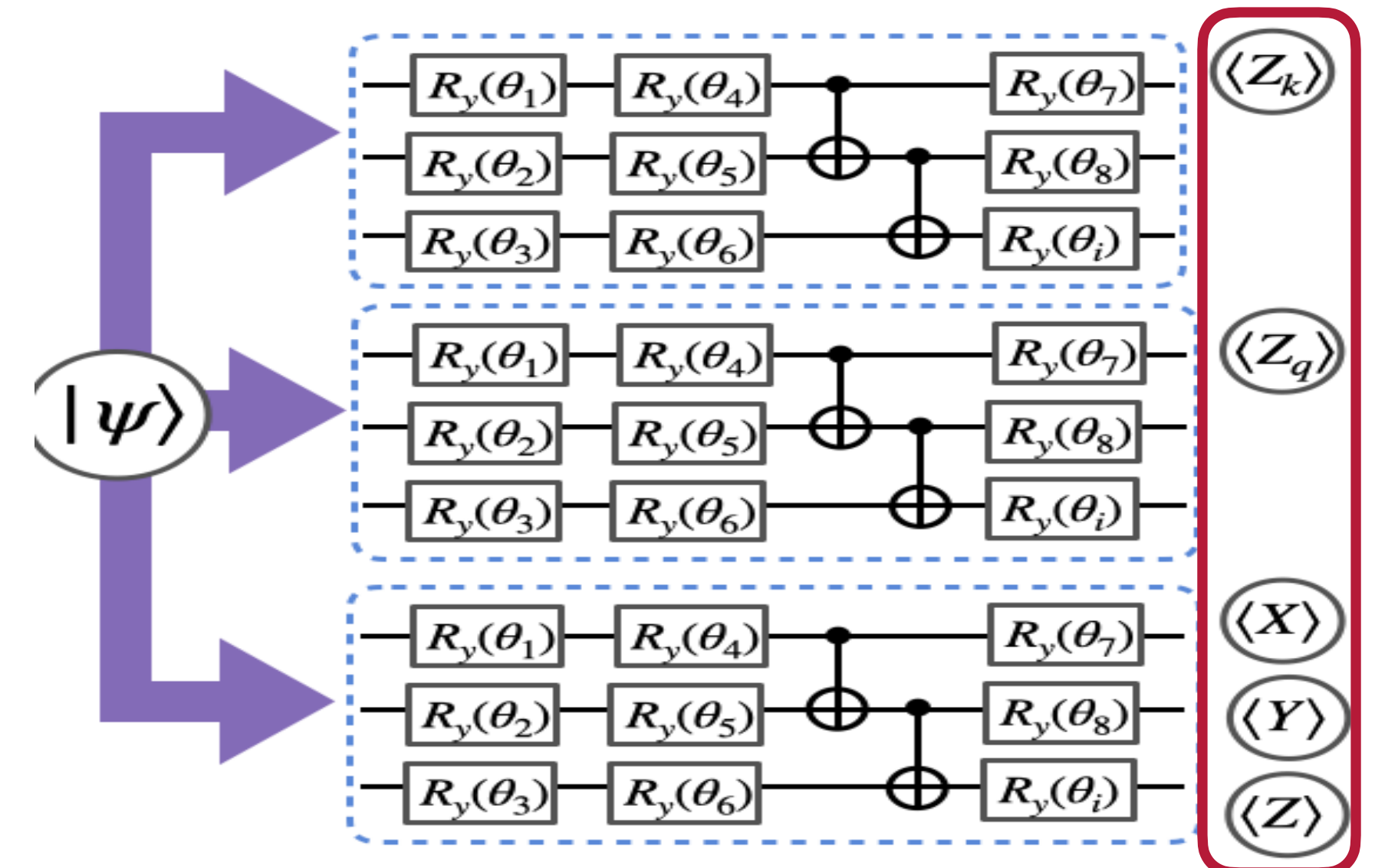
You, 7 days ago | 1 author (You)
class BinaryClassifier(nn.Module):
    def __init__(self, input_dim):
        super(BinaryClassifier, self).__init__()
        self.n_qubits = input_dim // 2
        self.fc = nn.Linear(self.n_qubits * 3, self.n_qubits * 3, bias=True)
        #self.sigmoid = nn.Sigmoid()
        You, 7 days ago • Uncommitted changes

    def forward(self, x):
        output = self.fc(x)
        #output = self.sigmoid(output)
        output = output.view(x.size(0), -1)
        return output

You, 3 weeks ago | 1 author (You)
class CombinedModel(nn.Module):
    def __init__(self, input_dim, seed, shots, device="cpu", L=1):
        super(CombinedModel, self).__init__()
        self.attention = QuantumSelfAttention(input_dim, seed, shots, device, L)
        self.classifier = BinaryClassifier(input_dim)

    def forward(self, x):
        attention_scores = self.attention(x)
        output = self.classifier(attention_scores)
        return output
```

- This was tested using the CEPC data.
- However, the performance is not good.
- The reason might be from:



- We need to refine the wrapper.

PennyLane package

- I heard that PennyLane is faster than Qiskit packages in simulation.
- We re-write the quantum self-attention using the PennyLane package.
- However, the performance is worse for now than for Qiskit.
- The time difference between the two packages is not big. Both are a round three days for 100 epochs.