Dönüştürücü Ağlar ve Sıvı Sinir Ağları ile B Kuark Jet Etiketleme

9’uncu Yüksek Enerji Fiziği İstanbul Çalıştayı

14-15 Ekim 2023

Asu Güvenli

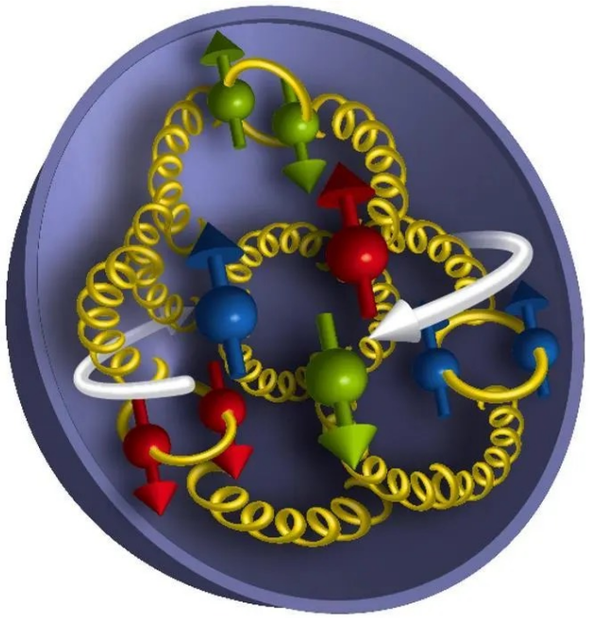
Fen Bilimleri Enstitüsü
Özyeğin Üniversitesi

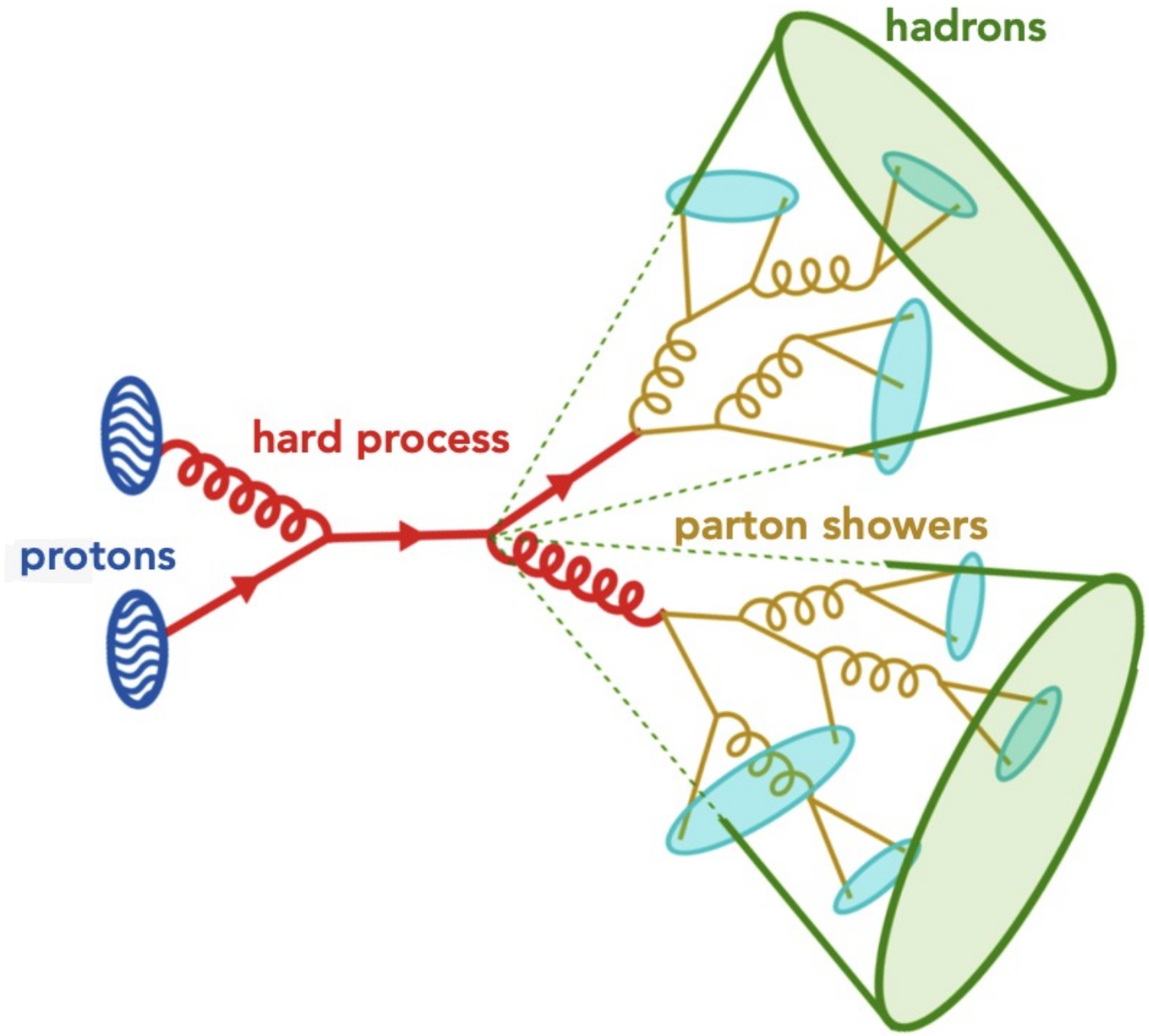
İçindekiler

- Jet Nedir?
- Neden B Kuark?
- Derin Öğrenme Modelleri
- Veri Seti
- Sonuçlar
- Yapılacak Geliştirmeler

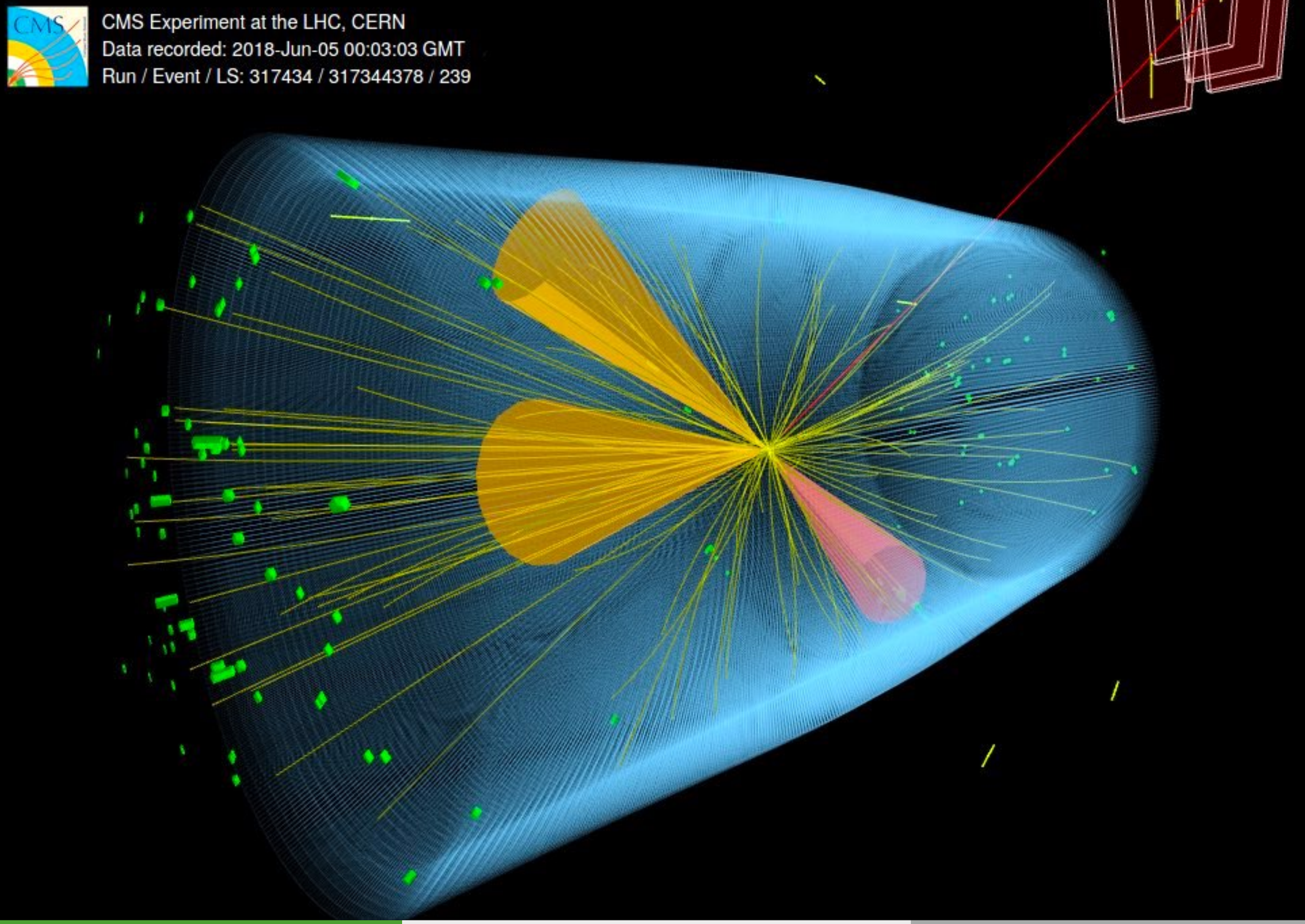
Jet Nedir ?

- Jet, yüksek enerjili partonların büyük bir hızla bir araya gelmesi sonucu oluşan yoğun ve odaklanmış bir parçacık akışıdır.
- Jetler, temel parçacıkların çekirdek etkileşimleri sonucu meydana gelir.

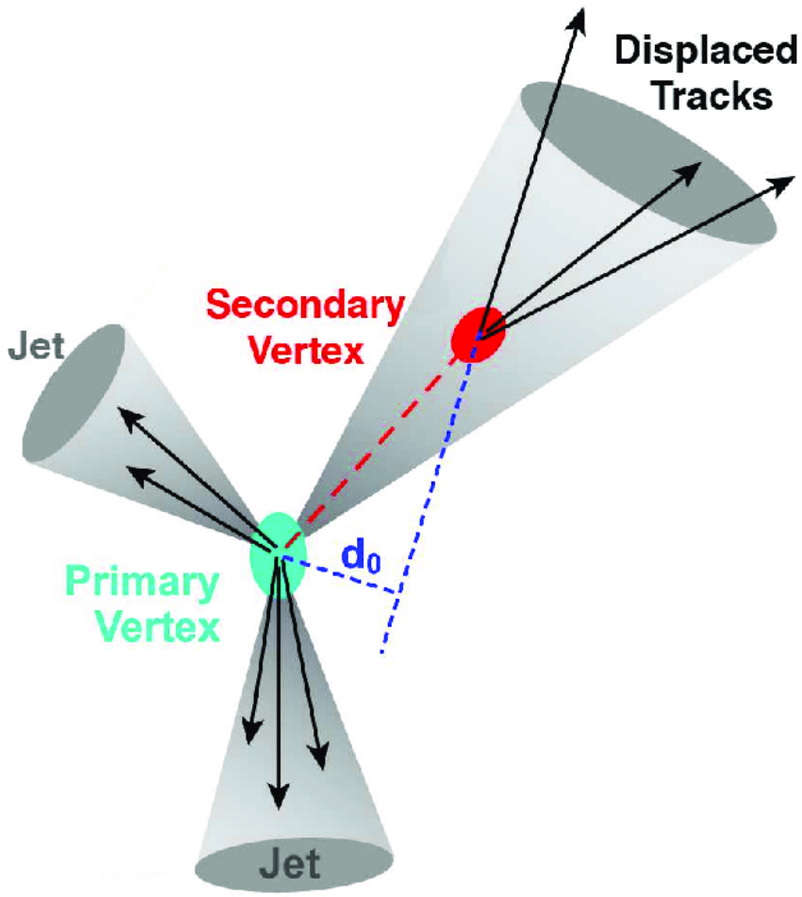




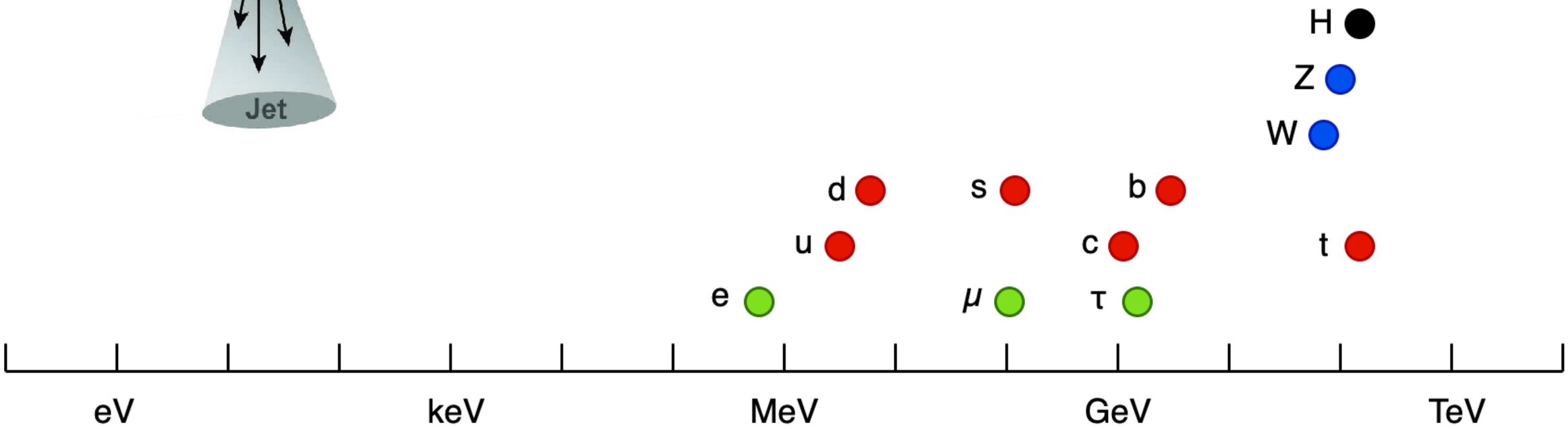
Jet Nedir ?


CMS Experiment at the LHC, CERN
Data recorded: 2018-Jun-05 00:03:03 GMT
Run / Event / LS: 317434 / 317344378 / 239

Neden B Kuark?

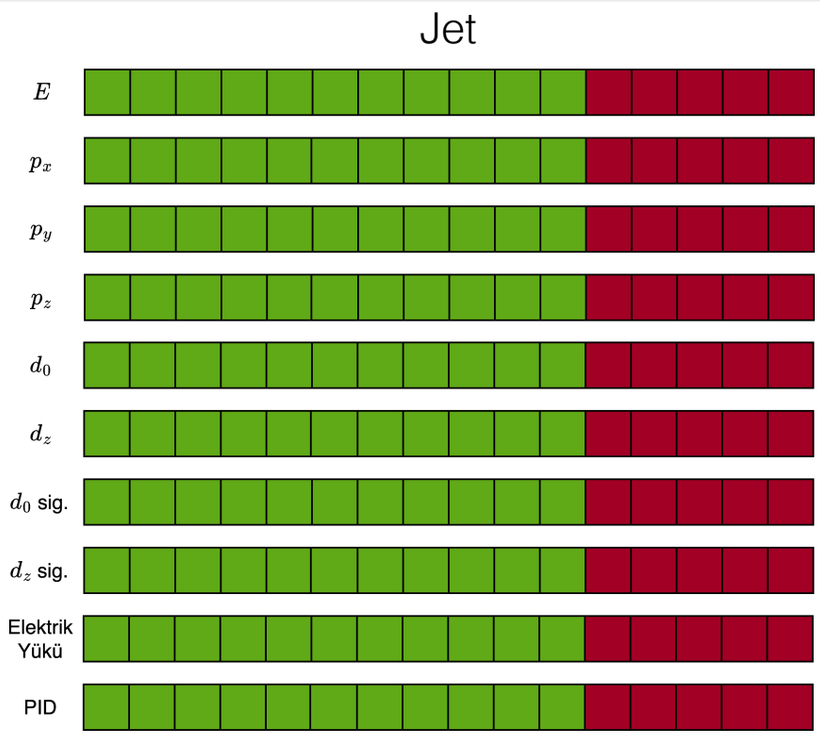


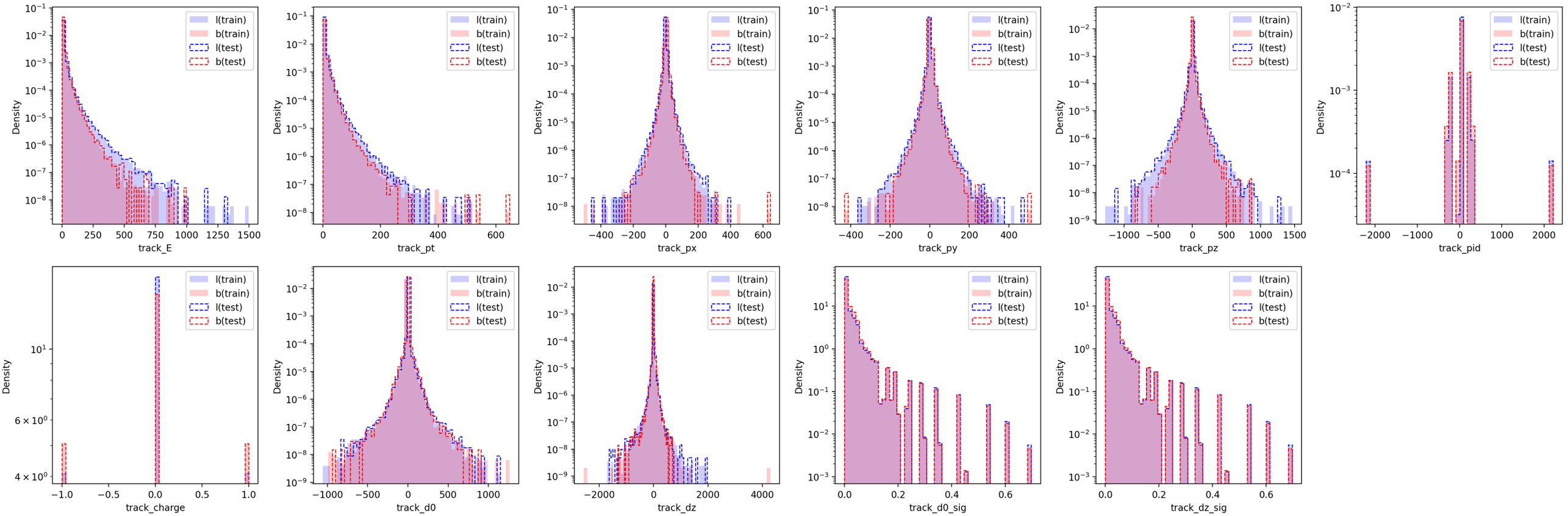
- Bazı önemli yüksek kütleli parçacıklar, genellikle bottom kuarklara bozunurlar.
- B kuark'ın göreceli uzun ömrü detektörde tespit edilmesine olanak sağlar.



Veri Seti

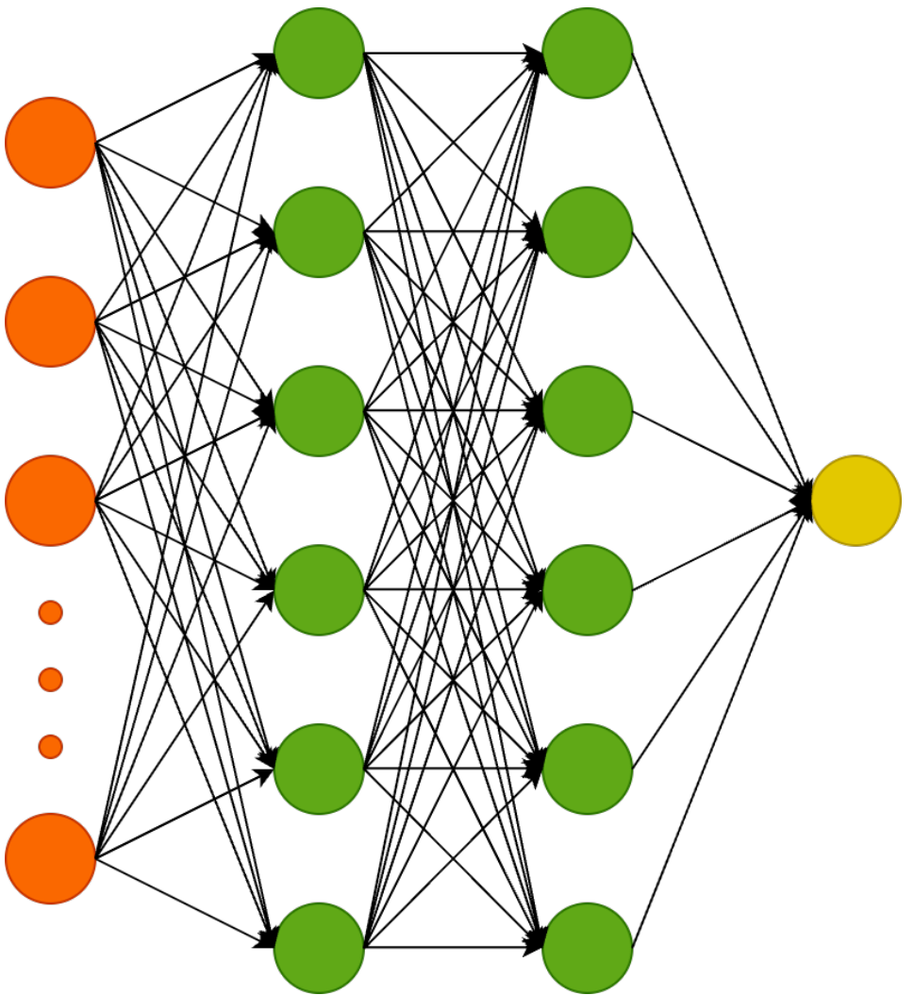
- MG5 > Pythia8 > Delphes
- pp > tt~ , antikT, $\Delta R = 0.4$
- 1.5 milyon jet, 0.35 b kuark jet, 0.65 udsc kuark ve gluon jet
- Pedleme, kesme ve azalan p_T'ye göre sıralama
- Temel *"Track"* özellikleri





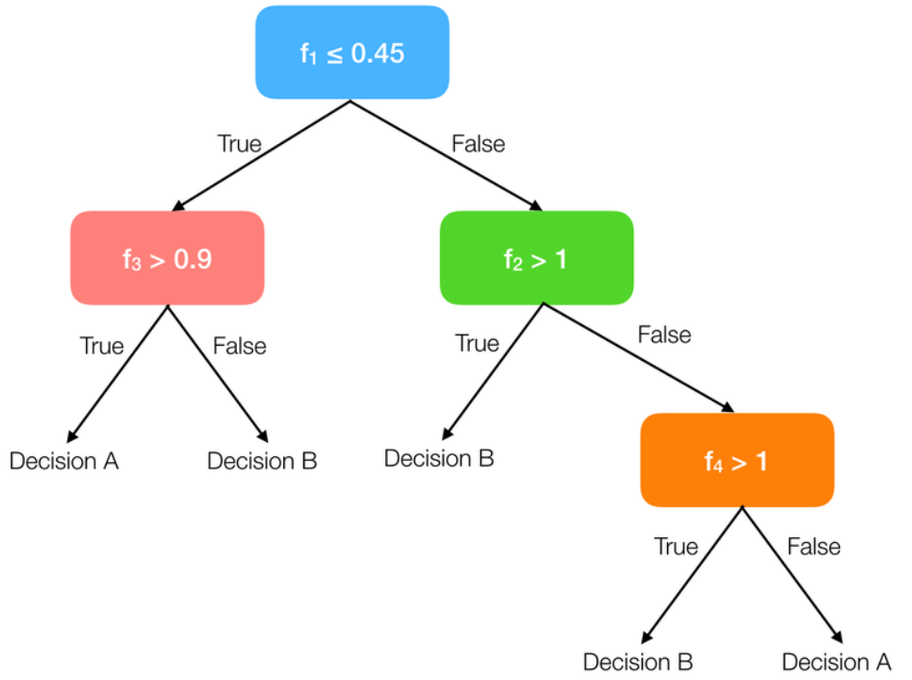
Derin Öğrenme Modelleri

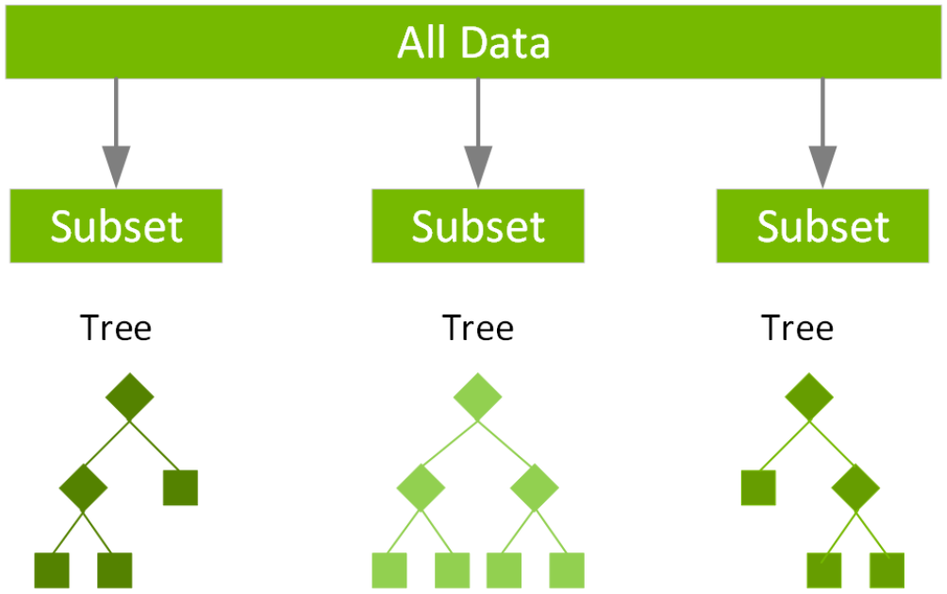
Fully-Connected



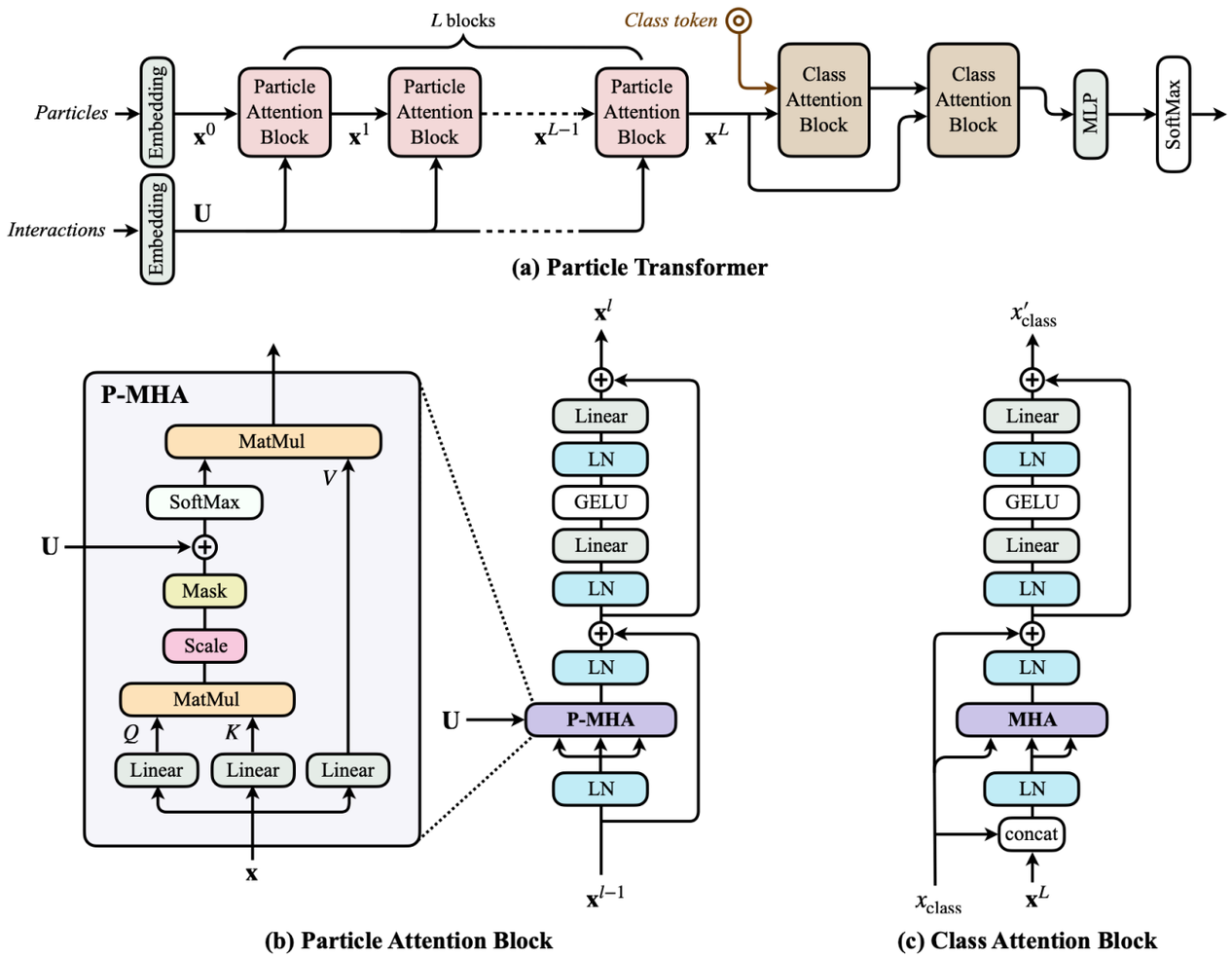
- Veri, 2 model için de uç uca eklendi.

XGBoost

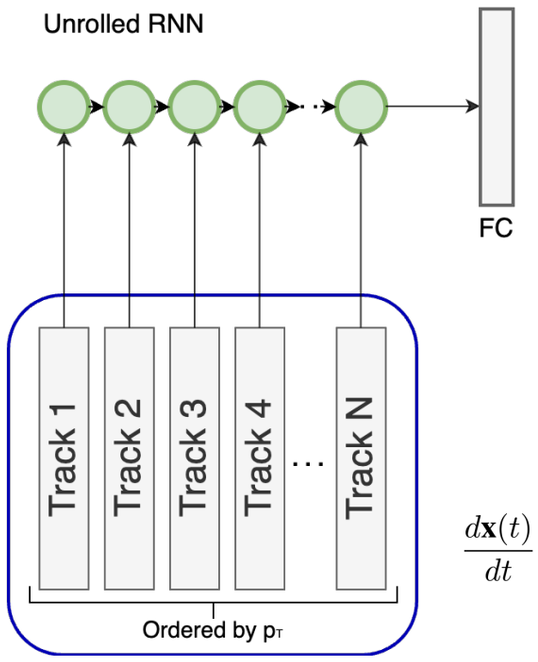


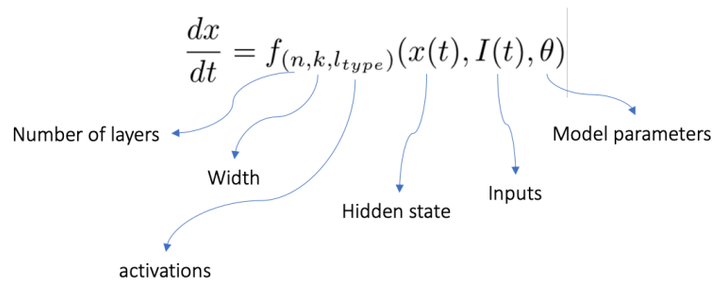


Parçacık Dönüştürücü



Sıvı Sinir Ağları



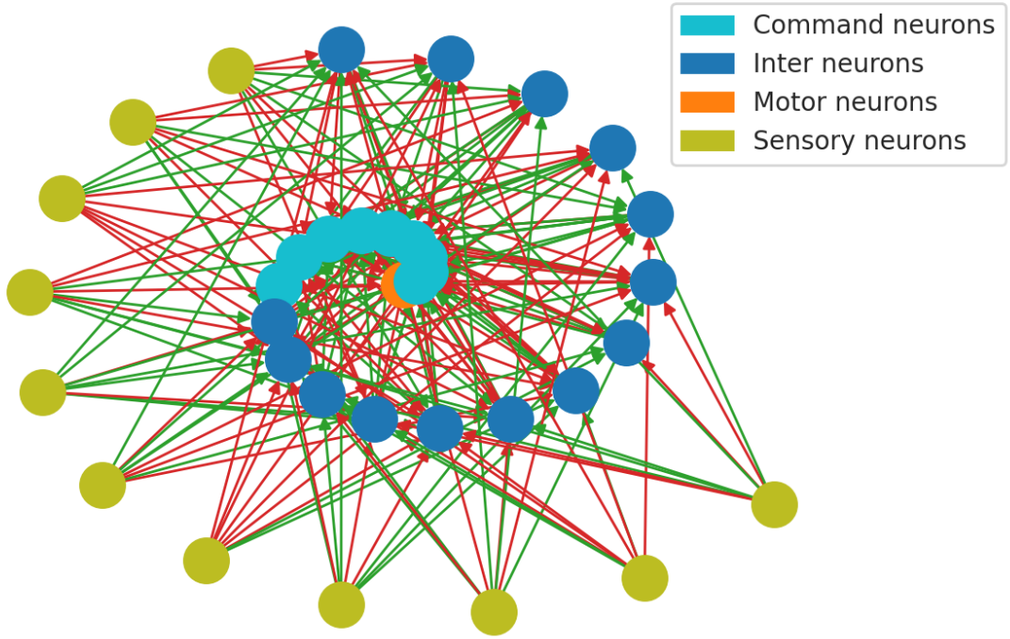


$$d\mathbf{x}(t)/dt = -\mathbf{x}(t)/\tau + \mathbf{S}(t) \qquad \mathbf{S}(t) \in \mathbb{R}^M$$

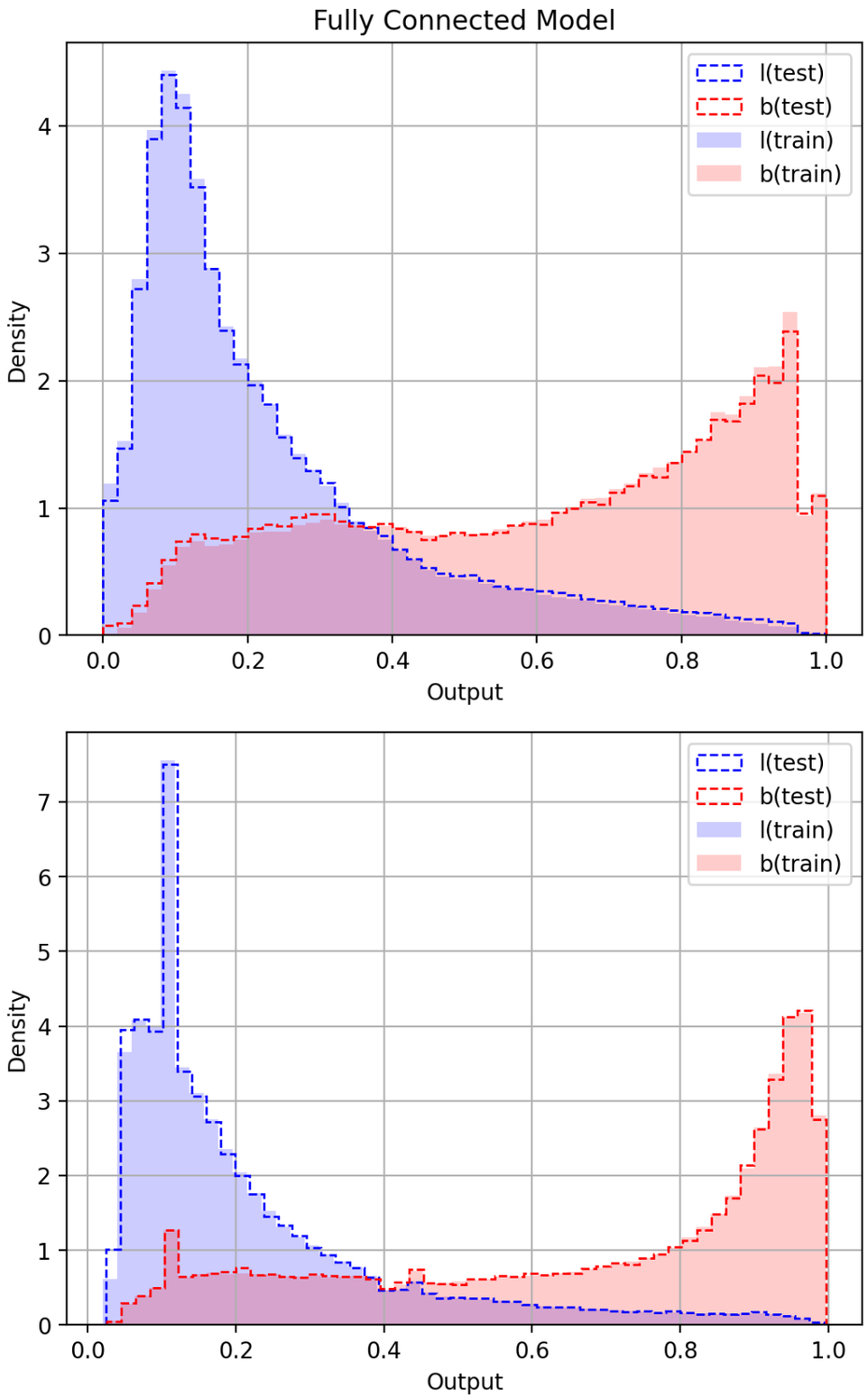
$$\mathbf{S}(t) = f(\mathbf{x}(t), \mathbf{I}(t), t, \theta)(A - \mathbf{x}(t))$$

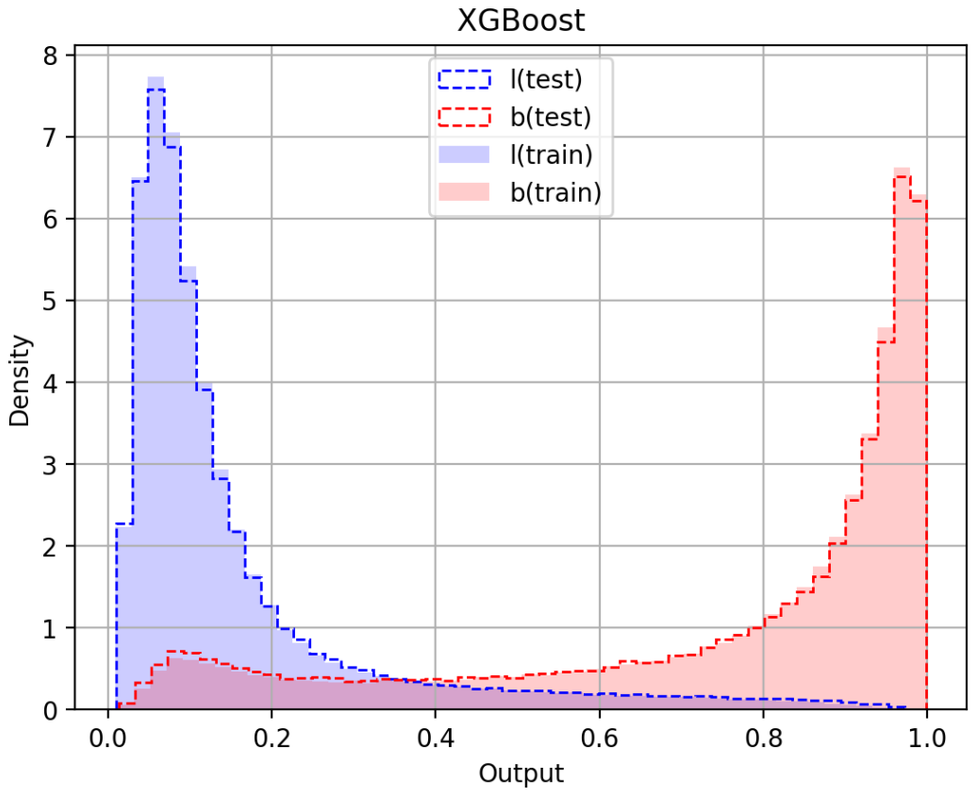
$$\frac{d\mathbf{x}(t)}{dt} = -\left[\frac{1}{\tau} + f(\mathbf{x}(t), \mathbf{I}(t), t, \theta)\right]\mathbf{x}(t) + f(\mathbf{x}(t), \mathbf{I}(t), t, \theta)A$$

"Liquid" = variable

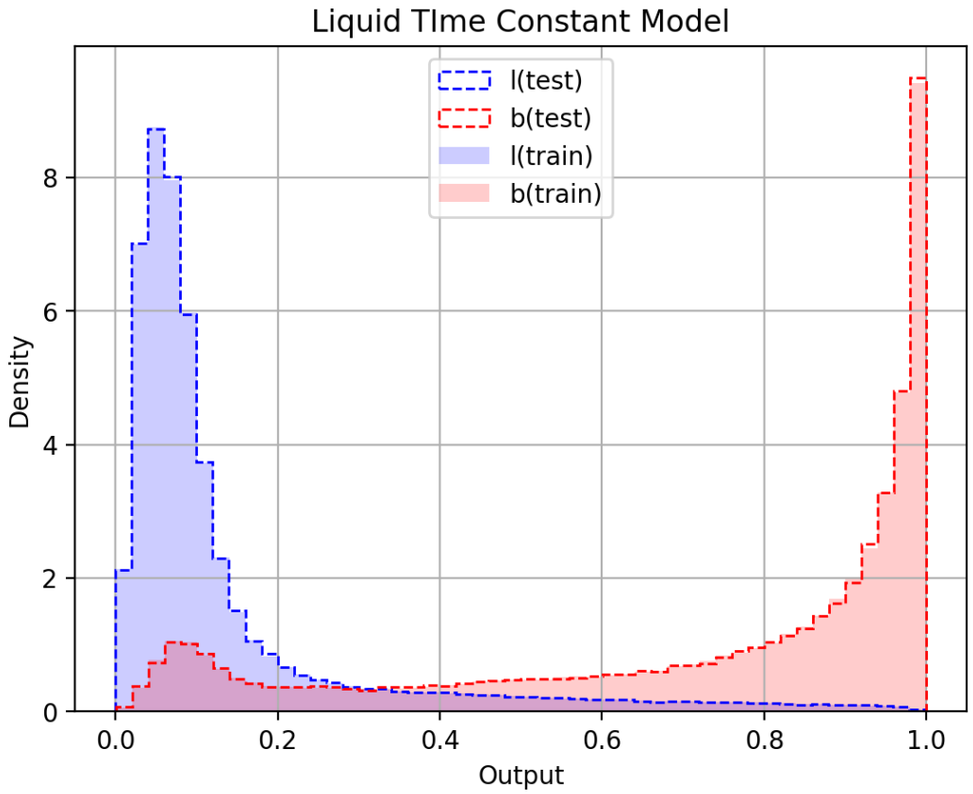


Sonuçlar

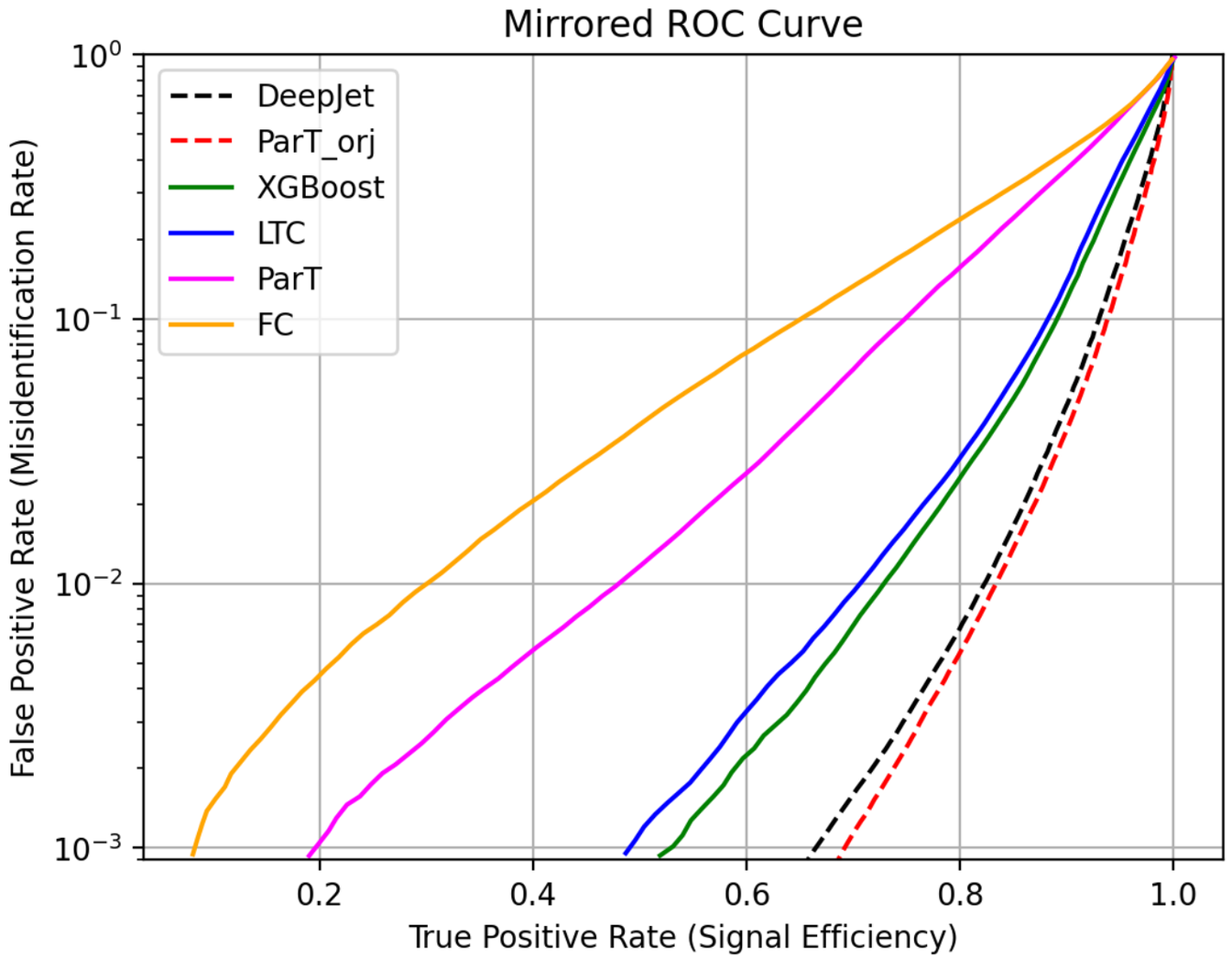

Fully Connected Model
l(test)
b(test)
l(train)
b(train)
Density
Output


XGBoost
l(test)
b(test)
l(train)
b(train)
Density
Output

l(test)
b(test)
l(train)
b(train)
Density
Output


Liquid TIme Constant Model
l(test)
b(test)
l(train)
b(train)
Density
Output

Sonuçlar



	Accuracy (%)	AUC	F1 Skoru
Fully-Connected	78,791	0,851	0,716
XGBoost	87,531	0,932	0,830
Particle Transformer	81,503	0,870	0,744
Liquid Time Constant	86,875	0,925	0,826

Yapılacak Geliştirmeler

- Yüksek seviyeli Jet özelliklerinin eklenmesi.
- Ayrım gücü yüksek Track özelliklerinin eklenmesi.
- Jet özellikleri ve Track özellikleri için 2 kademeli bir model geliştirilmesi.
- Daha büyük bir veri seti ile eğitimler yapılacak.

github.com/asugu

Kullanılan Metrikler

Doğruluk (Accuracy)

$$\frac{TP + TN}{TP + FP + TN + FN}$$

AUC

ROC eğrisi altında kalan alan
ROC Eğrisi : TPR vs. FPR

F1 Skoru

$$Precision = \frac{TP}{TP + FP}$$

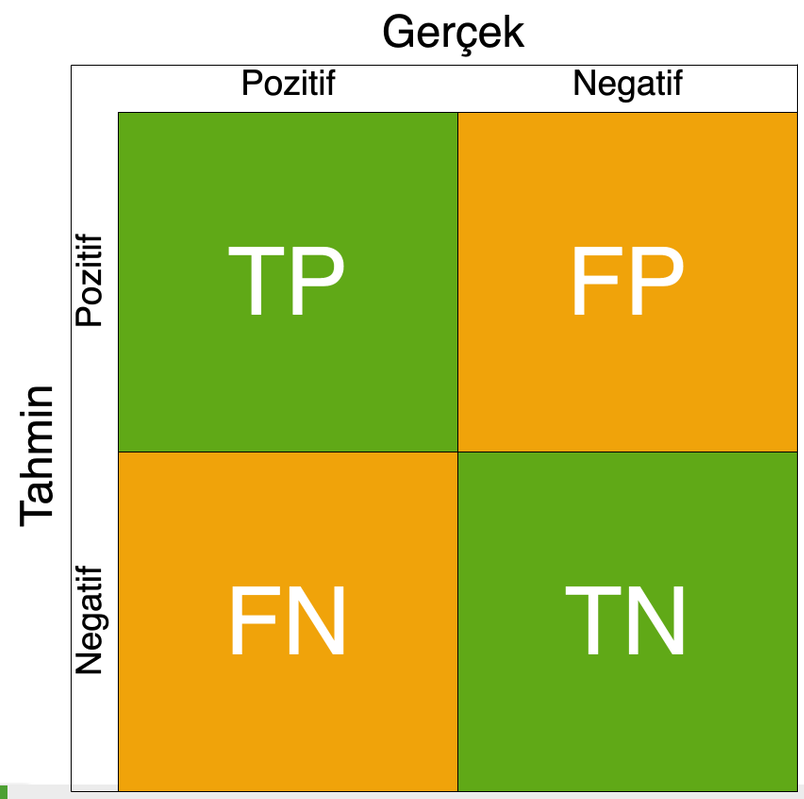
Sinyal Verimliliği

$$TPR = \frac{TP}{TP + FN}$$

$$Recall = \frac{TP}{TP + FN}$$

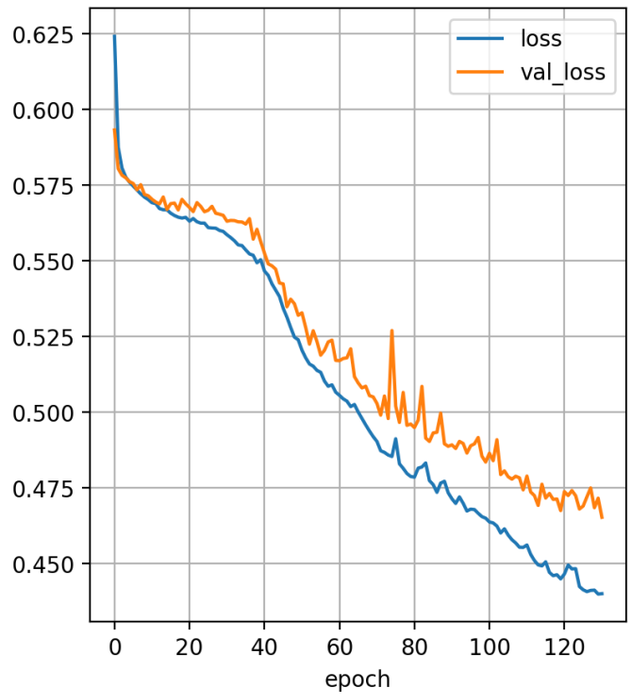
Arkaplan Reddi

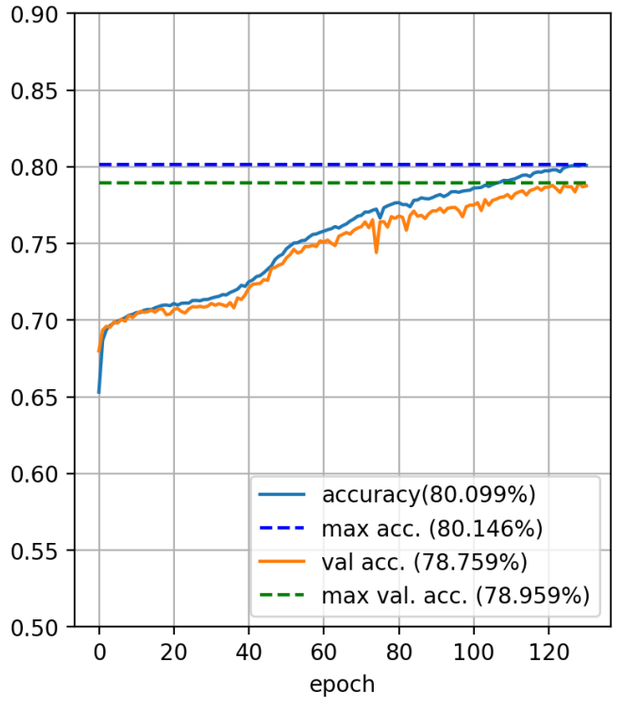
$$FPR = \frac{FP}{FP + TN}$$

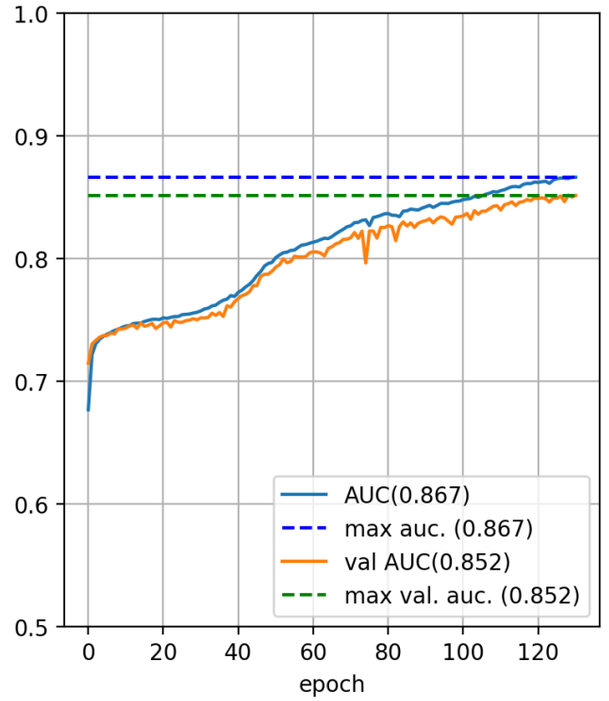


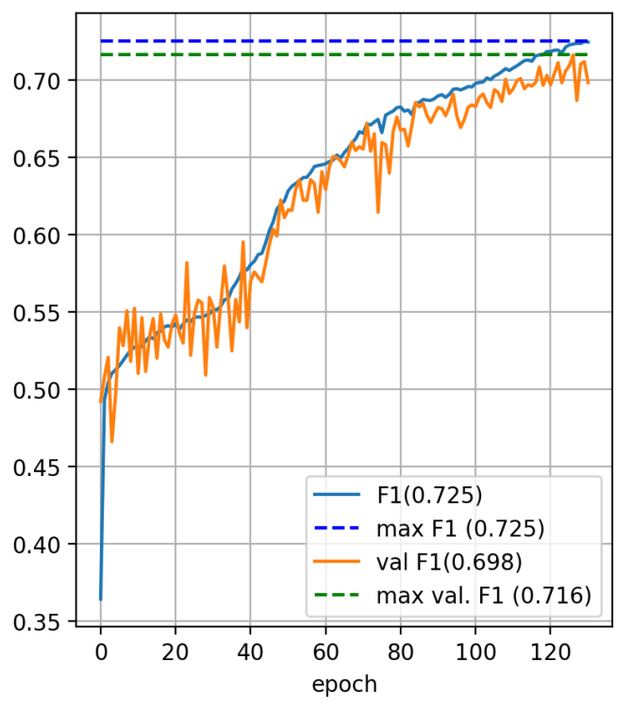
$$F1 = \frac{2Precision * Recall}{Precision + Recall}$$

Fully-Connected

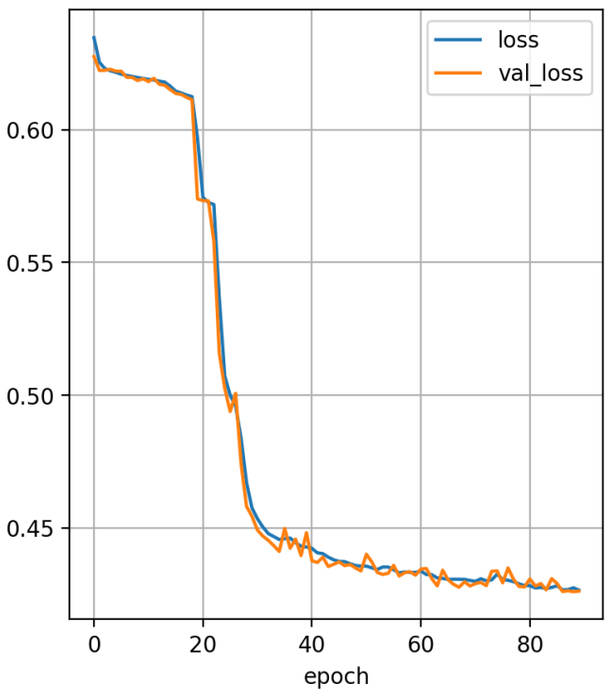


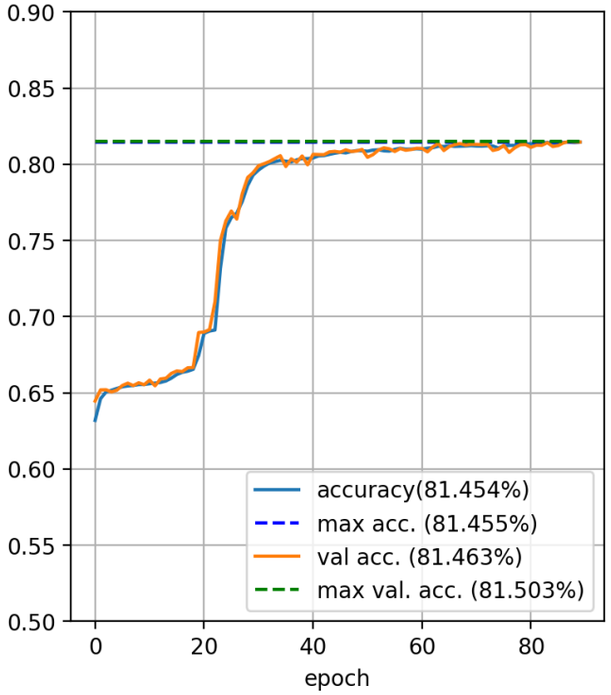


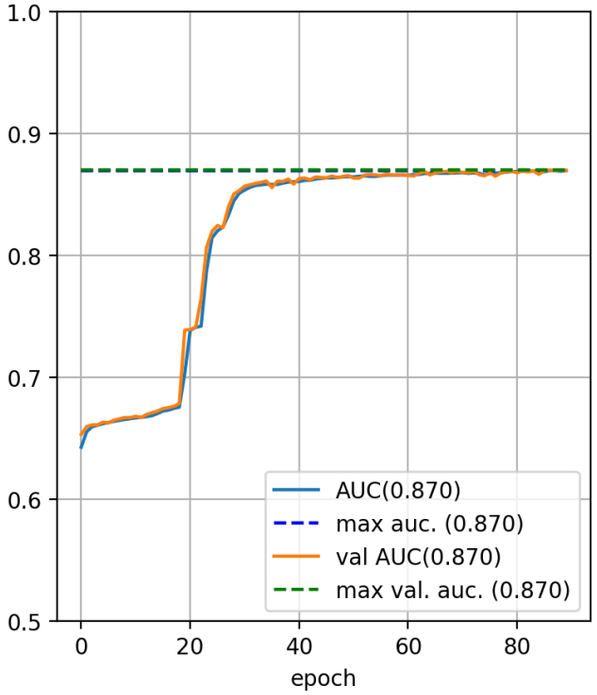


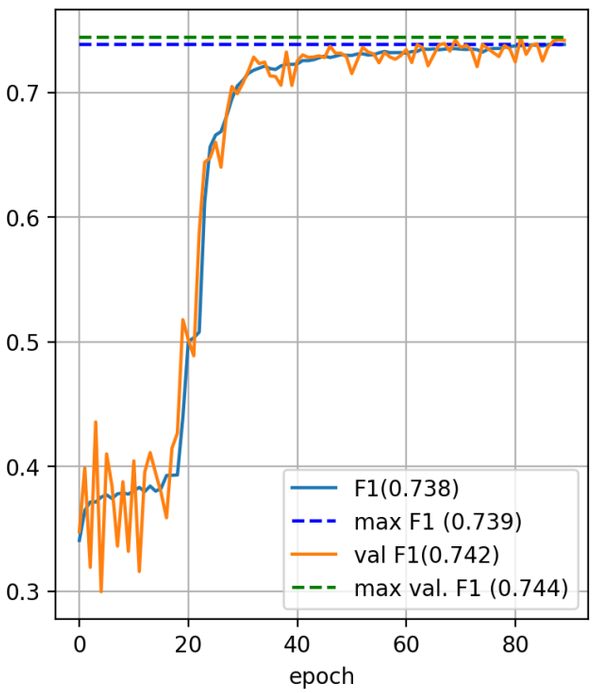


Particle Transformer

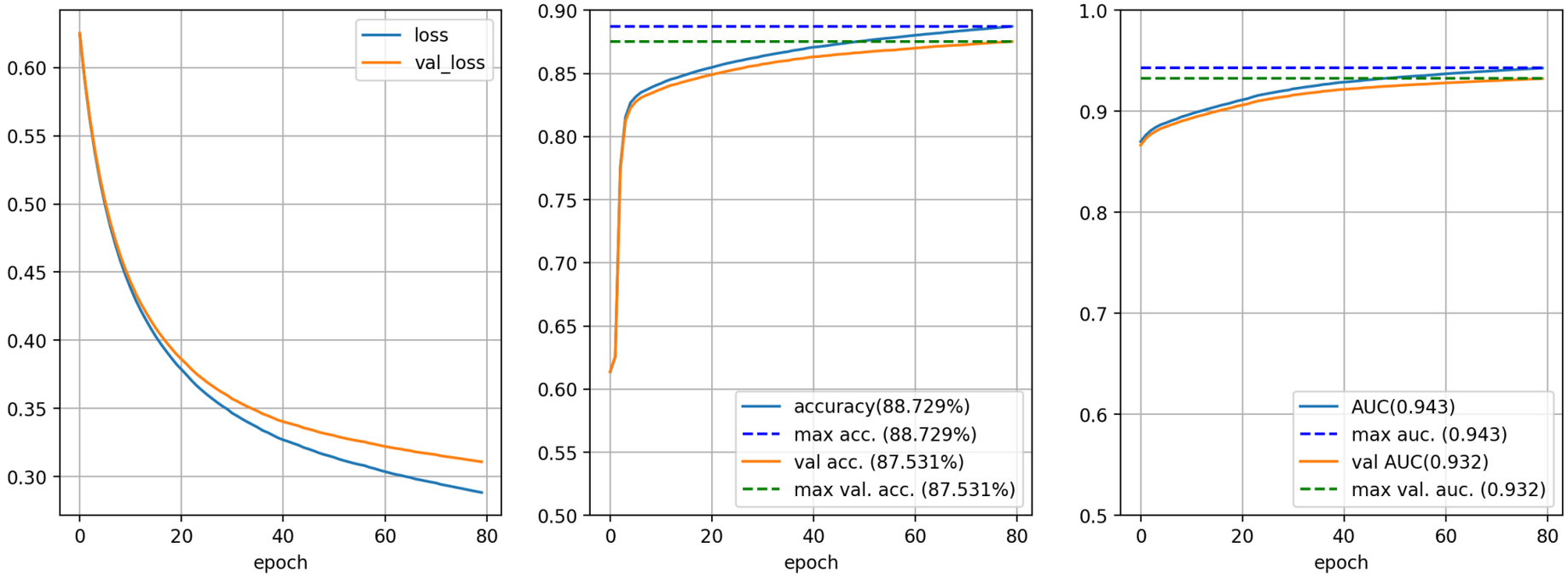








XGBoost



Liquid Time Constant