

# Results from neural network study

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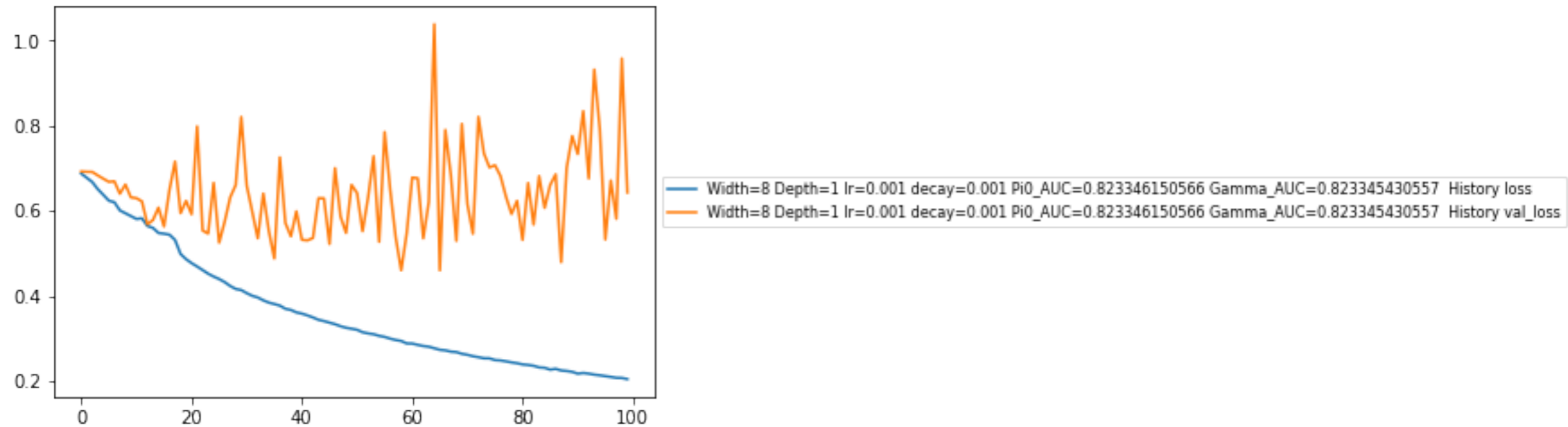
Model Name	optimizer	lr	decay	Pi0_AUC	Gamma_AUC
Width=8 Depth=1	'SGD'	0.0010	0.0100	0.4828	0.4828
Width=8 Depth=1	'RMSprop'	0.0100	0.0100	0.4991	0.4991
Width=8 Depth=1	'Adam'	0.0100	0.0010	0.5000	0.5000
Width=16 Depth=1	'RMSprop'	0.0100	0.0010	0.5000	0.5868
Width=64 Depth=1	'RMSprop'	0.0100	0.0100	0.5000	0.5911
Width=8 Depth=1	'RMSprop'	0.0100	0.0010	0.5036	0.5036
Width=8 Depth=1	'Adam'	0.0100	0.0100	0.5064	0.5064
Width=32 Depth=1	'RMSprop'	0.0100	0.0100	0.5122	0.5122
Width=8 Depth=1	'SGD'	0.0010	0.0010	0.5149	0.5149
Width=32 Depth=1	'Adam'	0.0100	0.0010	0.5345	0.5346
Width=32 Depth=1	'SGD'	0.0010	0.0100	0.5407	0.5407
Width=16 Depth=1	'SGD'	0.0010	0.0100	0.5523	0.5523
Width=32 Depth=1	'SGD'	0.0010	0.0010	0.5563	0.5563
Width=16 Depth=1	'SGD'	0.0100	0.0100	0.5748	0.5748
Width=8 Depth=1	'SGD'	0.0100	0.0010	0.5884	0.5884
Width=16 Depth=1	'RMSprop'	0.0100	0.0100	0.5950	0.5000
Width=16 Depth=1	'SGD'	0.0100	0.0010	0.5966	0.5966
Width=32 Depth=1	'SGD'	0.0100	0.0010	0.5976	0.5976
Width=64 Depth=1	'SGD'	0.0100	0.0100	0.5983	0.5983
Width=16 Depth=1	'RMSprop'	0.0010	0.0010	0.7029	0.7029
Width=32 Depth=1	'RMSprop'	0.0010	0.0010	0.7045	0.7045
Width=8 Depth=1	'Adam'	0.0010	0.0100	0.7057	0.7057
Width=64 Depth=1	'Adam'	0.0100	0.0100	0.7059	0.7059
Width=16 Depth=1	'Adam'	0.0010	0.0100	0.7352	0.7352
Width=32 Depth=1	'Adam'	0.0100	0.0100	0.7582	0.7582
Width=8 Depth=1	'Adam'	0.0010	0.0010	0.7619	0.7619
Width=8 Depth=1	'RMSprop'	0.0010	0.0100	0.7656	0.7656
Width=32 Depth=1	'RMSprop'	0.0010	0.0100	0.7677	0.7677
Width=64 Depth=1	'RMSprop'	0.0010	0.0100	0.7682	0.7682
Width=64 Depth=1	'Adam'	0.0010	0.0100	0.7889	0.7889
Width=16 Depth=1	'Adam'	0.0100	0.0100	0.8013	0.8013
Width=8 Depth=1	'RMSprop'	0.0010	0.0010	0.8233	0.8233
Width=16 Depth=1	'RMSprop'	0.0010	0.0100	0.8372	0.8372

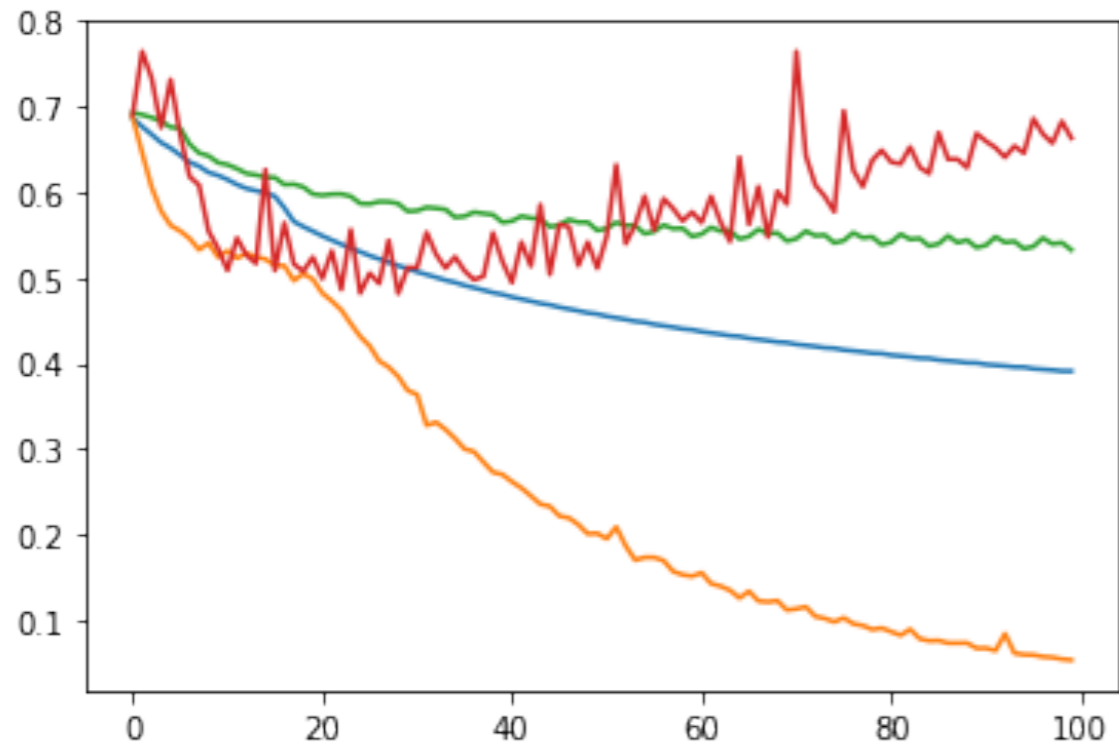
# AUC > 0.8

Number of Models: 3

Model Name	Pi0_AUC	Gamma_AUC	FinalScore[0]
Width=16 Depth=1 lr=0.01 decay=0.01 optimizer='Adam' HyperParamSet=13	0.8013	0.8013	0.6632
Width=8 Depth=1 lr=0.001 decay=0.001 optimizer='RMSprop' HyperParamSet=9	0.8233	0.8233	0.5611
Width=16 Depth=1 lr=0.001 decay=0.01 optimizer='RMSprop' HyperParamSet=15	0.8372	0.8372	0.5325

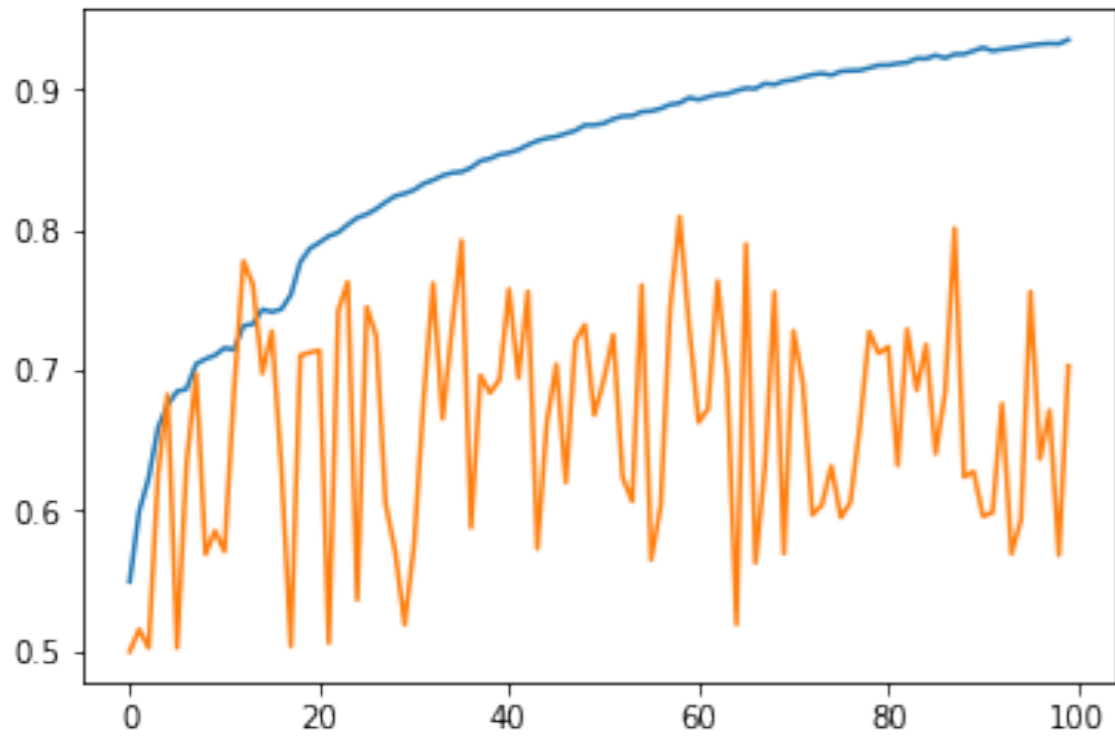
## Loss vs. Epoch



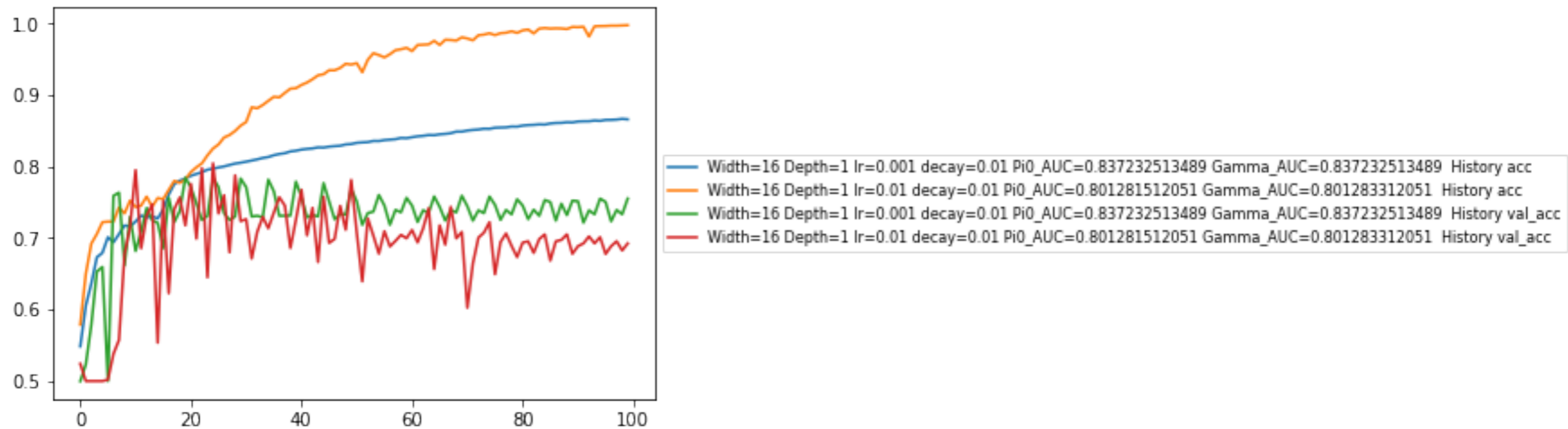


Width=16 Depth=1 lr=0.001 decay=0.01 Pi0\_AUC=0.837232513489 Gamma\_AUC=0.837232513489 History loss  
 Width=16 Depth=1 lr=0.01 decay=0.01 Pi0\_AUC=0.801281512051 Gamma\_AUC=0.801283312051 History loss  
 Width=16 Depth=1 lr=0.001 decay=0.01 Pi0\_AUC=0.837232513489 Gamma\_AUC=0.837232513489 History val\_loss  
 Width=16 Depth=1 lr=0.01 decay=0.01 Pi0\_AUC=0.801281512051 Gamma\_AUC=0.801283312051 History val\_loss

## Accuracy vs. Epoch



Width=8 Depth=1 lr=0.001 decay=0.001 Pi0\_AUC=0.823346150566 Gamma\_AUC=0.823345430557 History acc  
 Width=8 Depth=1 lr=0.001 decay=0.001 Pi0\_AUC=0.823346150566 Gamma\_AUC=0.823345430557 History val\_acc



# 3D Convolutional Neural Network

Input (Batchsize, 25, 25, 25, 1) + (Batchsize, 5, 5, 60, 1)

Activation = ReLU and Batch Normalization

3D Conv, Kernel = (5, 5, 5), Strides=(2, 2, 2), Activation = ReLU

Batch Normalization

AveragePooling3D, pool\_size=(5, 5, 5) for ECAL and (1, 1, 5)  
for HCAL

Flatten, Batch Normalization, Dropout (0.5)

Output 2 units

# AUC > 0.85

Number of Models: 4

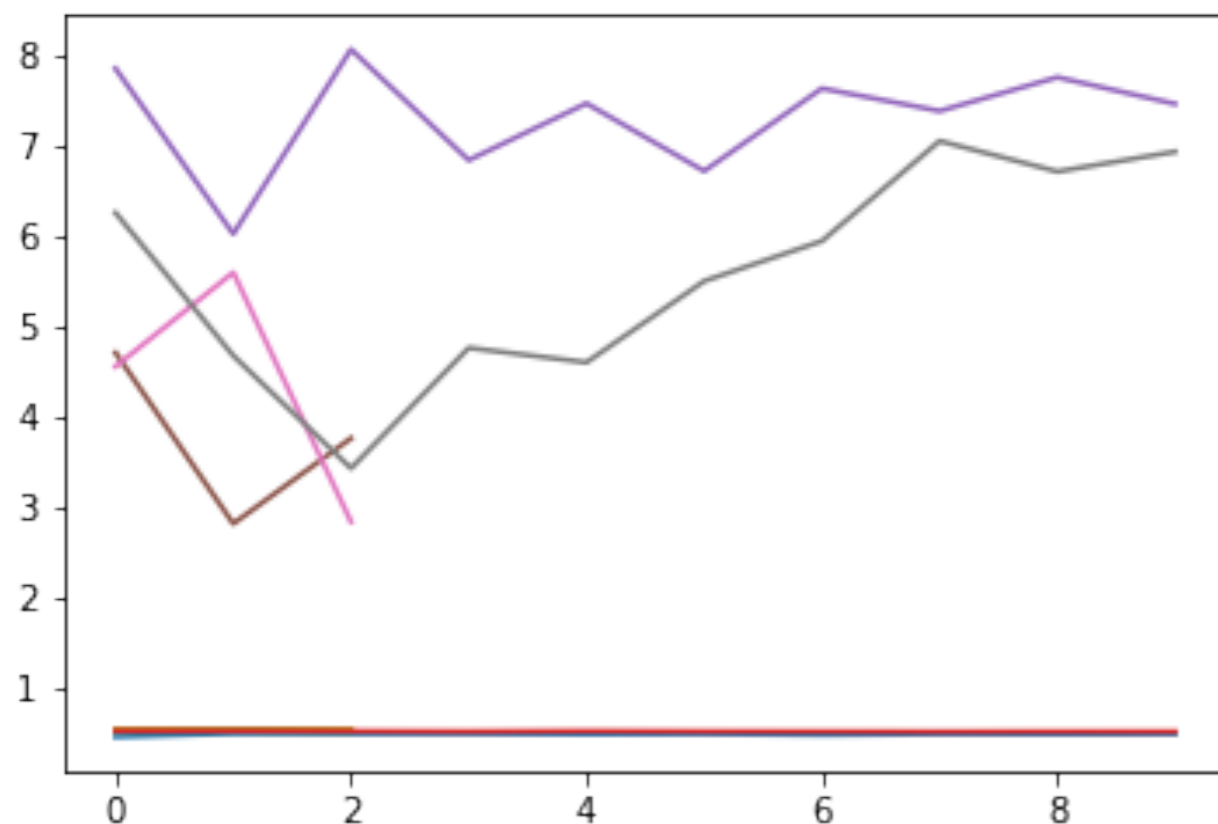
Model Name

FinalScore[0]

Pi0\_AUC

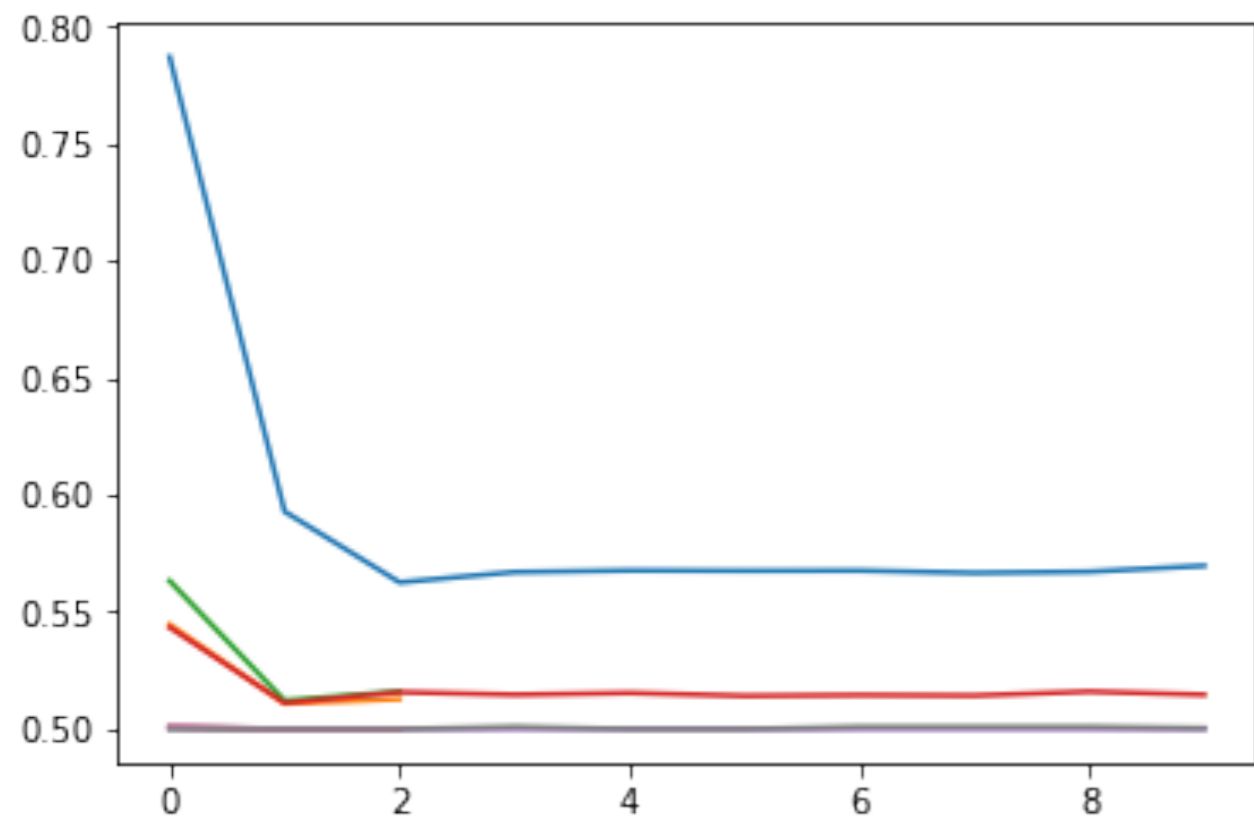
Gamma\_AUC

Model Name	Pi0_AUC	Gamma_AUC
lr=0.001 decay=0.01 optimizer='Adam' HyperParamSet=4 6.9140	0.8522	0.8547
lr=0.001 decay=0.01 optimizer='Adam' HyperParamSet=4 2.8605	0.8595	0.8595
lr=0.001 decay=0.01 optimizer='Adam' HyperParamSet=4 3.7577	0.8687	0.8687
lr=0.001 decay=0.01 optimizer='Adam' HyperParamSet=4 7.4557	0.8824	0.8996



Legend for the graph:

- lr=0.001 decay=0.01 Pi0\_AUC=0.882390917661 Gamma\_AUC=0.89955580384 History loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.868654555939 Gamma\_AUC=0.868650975937 History loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.859526750097 Gamma\_AUC=0.8595316701 History loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.852242285435 Gamma\_AUC=0.854677306993 History loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.882390917661 Gamma\_AUC=0.89955580384 History val\_loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.868654555939 Gamma\_AUC=0.868650975937 History val\_loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.859526750097 Gamma\_AUC=0.8595316701 History val\_loss
- lr=0.001 decay=0.01 Pi0\_AUC=0.852242285435 Gamma\_AUC=0.854677306993 History val\_loss



- Ir=0.001 decay=0.01 Pi0\_AUC=0.882390917661 Gamma\_AUC=0.89955580384 History acc
- Ir=0.001 decay=0.01 Pi0\_AUC=0.868654555939 Gamma\_AUC=0.868650975937 History acc
- Ir=0.001 decay=0.01 Pi0\_AUC=0.859526750097 Gamma\_AUC=0.8595316701 History acc
- Ir=0.001 decay=0.01 Pi0\_AUC=0.852242285435 Gamma\_AUC=0.854677306993 History acc
- Ir=0.001 decay=0.01 Pi0\_AUC=0.882390917661 Gamma\_AUC=0.89955580384 History val\_acc
- Ir=0.001 decay=0.01 Pi0\_AUC=0.868654555939 Gamma\_AUC=0.868650975937 History val\_acc
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