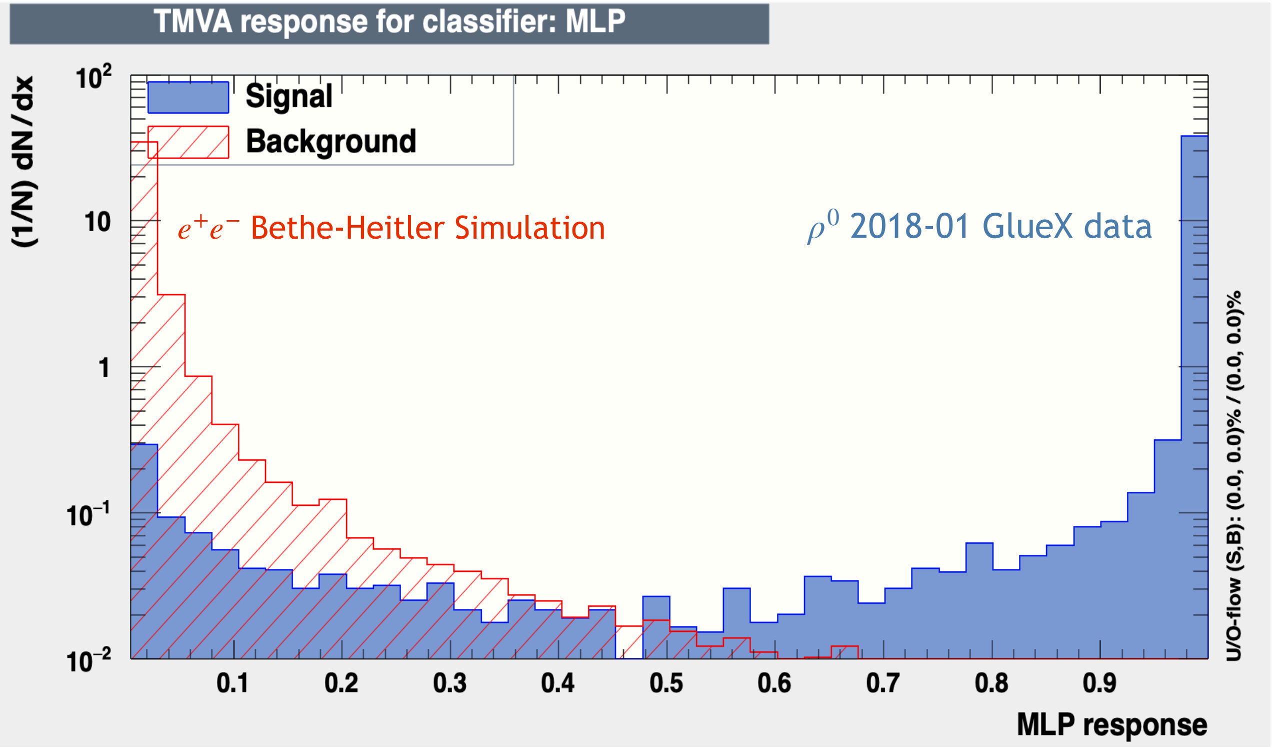
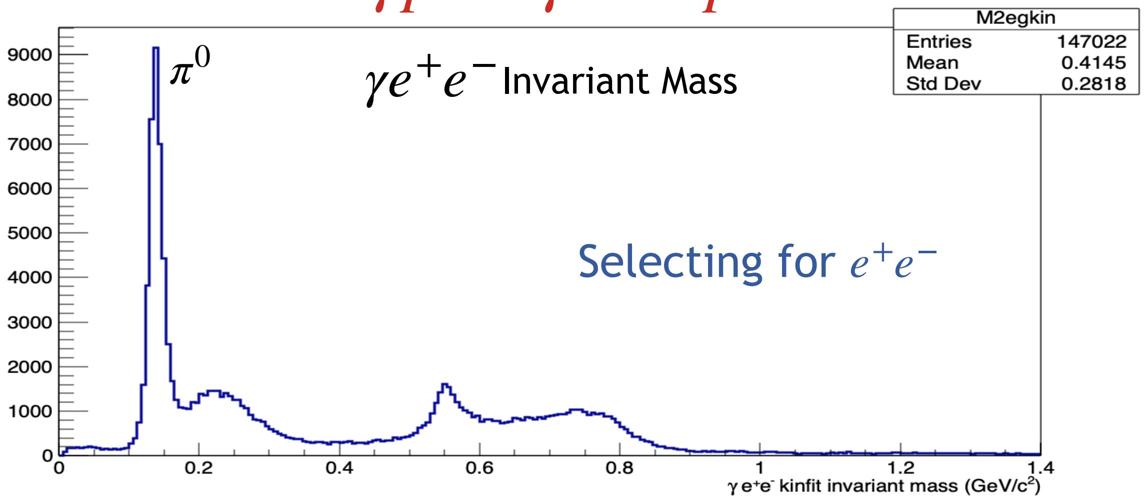
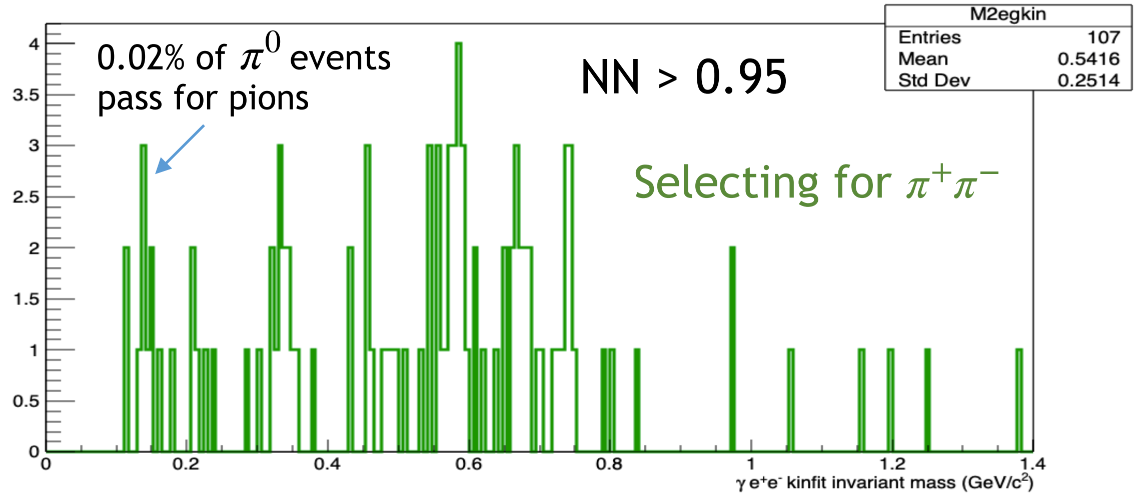
1. Reconciling the NN response plot from training with the classification of π^0 electrons *as pions* (bottom green plot).



2018 GlueX data containing Dalitz decay. Select for pions and see how many e+e- pairs from π^0 get through.

$$\gamma p \rightarrow \gamma e^+ e^- p$$

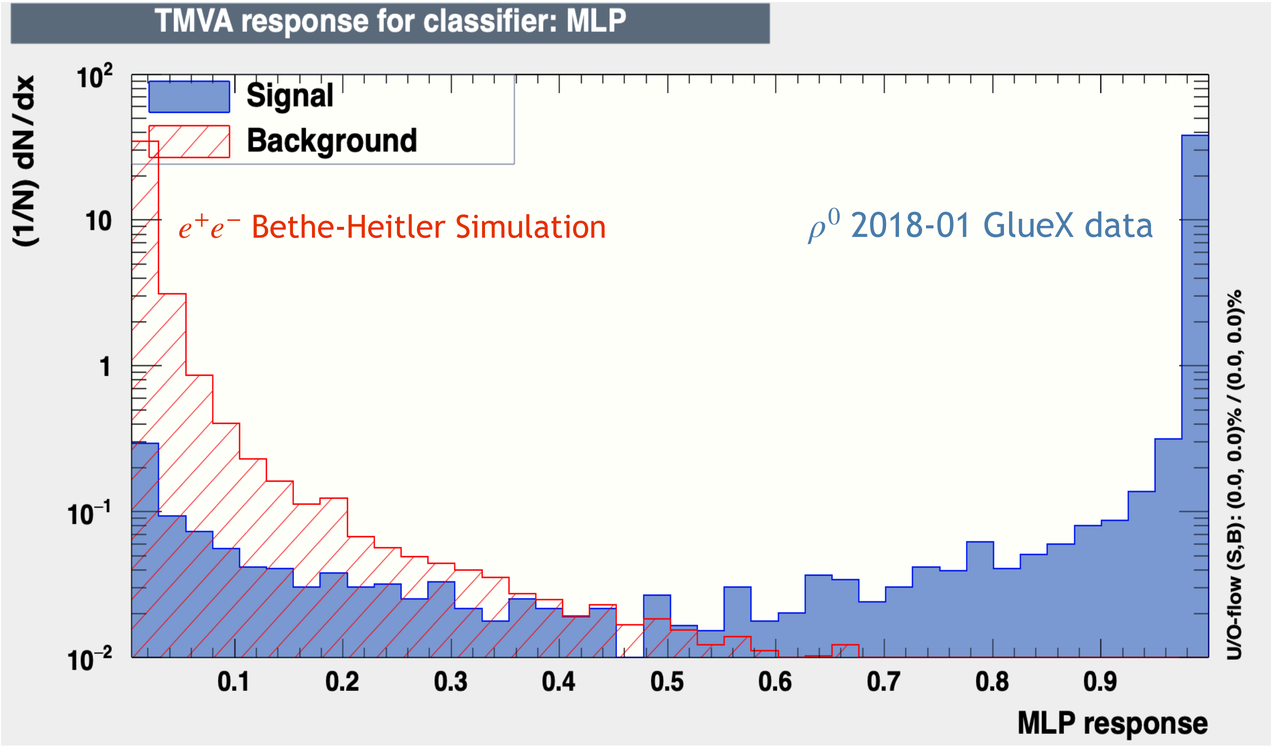




1. Reconciling the NN response plot from training with the classification of π^0 electrons *as pions* (bottom green plot).

Forget about these plots/numbers. They are from an old NN where the training pions had no strict cuts on the rho0 invariant mass—
the training sample was likely riddled with e+e- contamination.

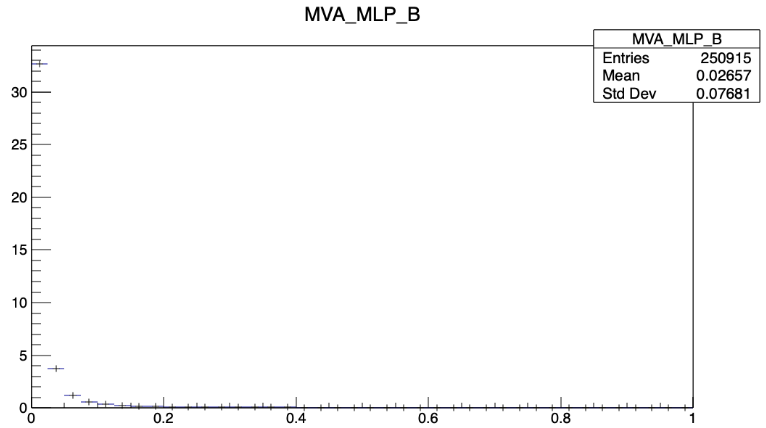
Let's do the study again with updated training!

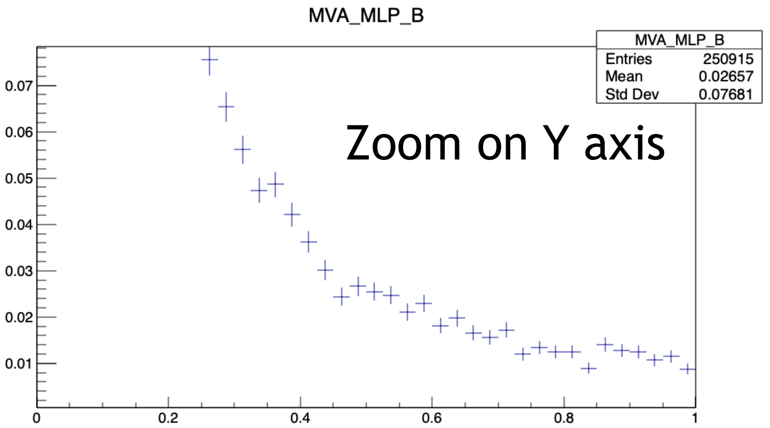


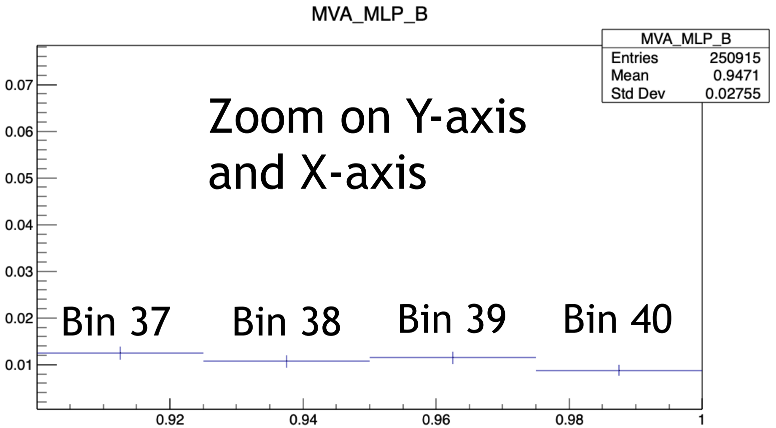
Suppose we wanted to only look at pions with a NN response above 0.9.
In the training sample, do we have perfect separation from electrons?

If we were to do the pi0 study again, where we classify the pi0->ge+e- peak, selecting for pions, how many misclassified electrons could we expect to see above 0.9?

Simulated **electrons** (used in training) MLP Neural net response values.







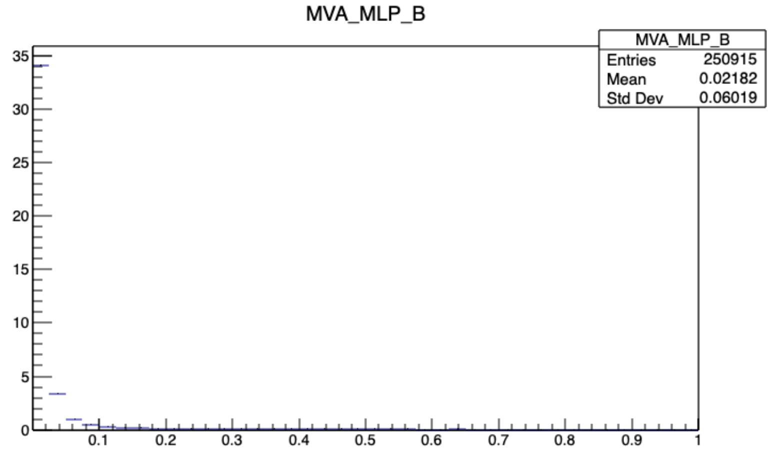
There are 40 bins total.

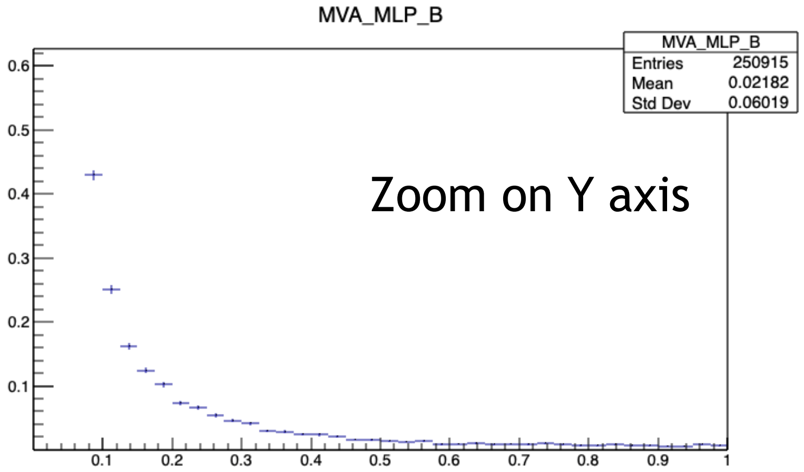
$$\int_{1}^{40} N_{BH}(x)dx = 39.999664$$

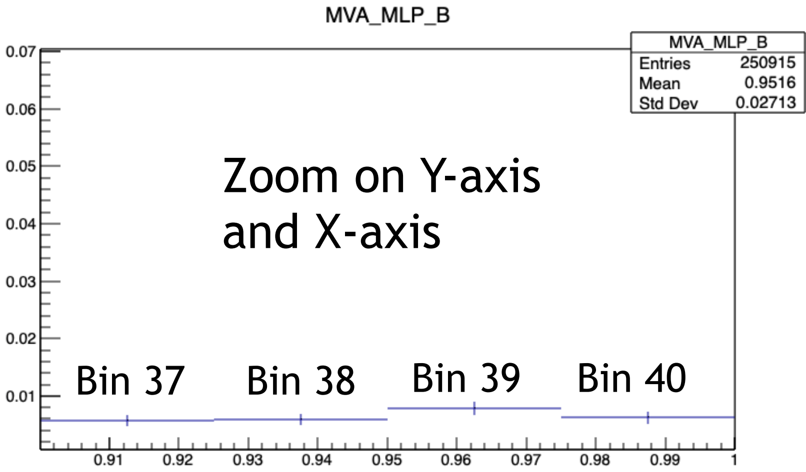
Likelihood of e- track getting misclassified as π- = 0.1%

$$\frac{\int_{37}^{40} N_{BH}(x)dx}{\int_{1}^{40} N_{BH}(x)dx} = \frac{0.030926548}{39.999664} = 0.0010840325$$

Simulated **positrons** (used in training) MLP Neural net response values.







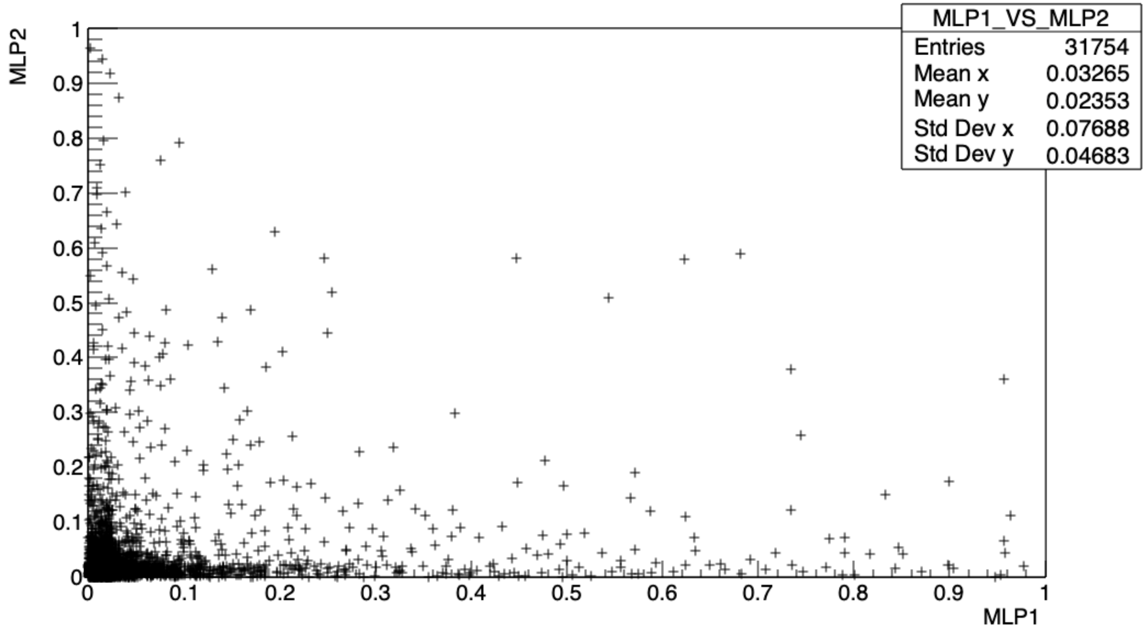
$$\frac{\int_{37}^{40} N_{BH}(x)dx}{\int_{1}^{40} N_{BH}(x)dx} = \frac{0.025666261}{40.000309} = 0.00064165652$$

Likelihood of e- track getting misclassified as π- = 0.1%

Likelihood of e+ track getting misclassified as π+ = 0.06%

$$0.1\% \times 0.06\,\% = 0.006\,\%$$

Classifying pi0->ge+e-



Selecting for Pions		
NN cut	omega->pi0pi+pi- (%)	pi0->ge+e- (%)
NN > 0.9	89.27888272	0
NN > 0.6	92.98702496	0
NN > 0.55	93.35576502	0.006298419097
NN > 0.4	94.32370768	0.01259683819

LIKELIHOOD OF MISCLASSIFICATION AT NN > 0.9 WAS

$$0.1\% \times 0.06\,\% = 0.006\,\%$$

ZERO PI0 events surviving does not contradict this prediction.

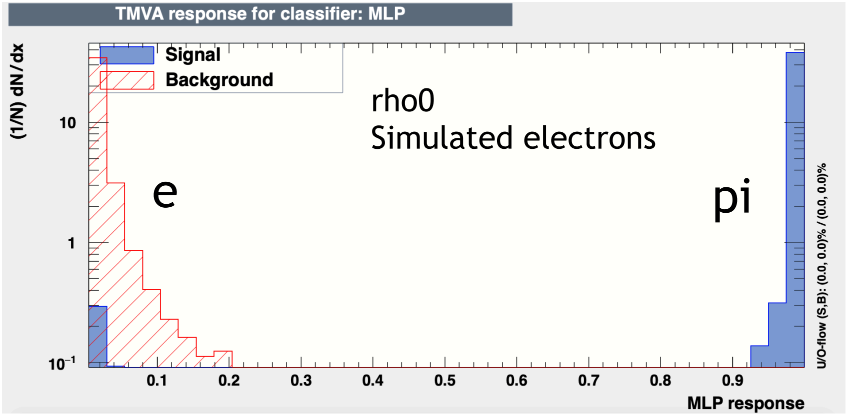
Can actually set NN response cut for pions much lower than I originally thought.

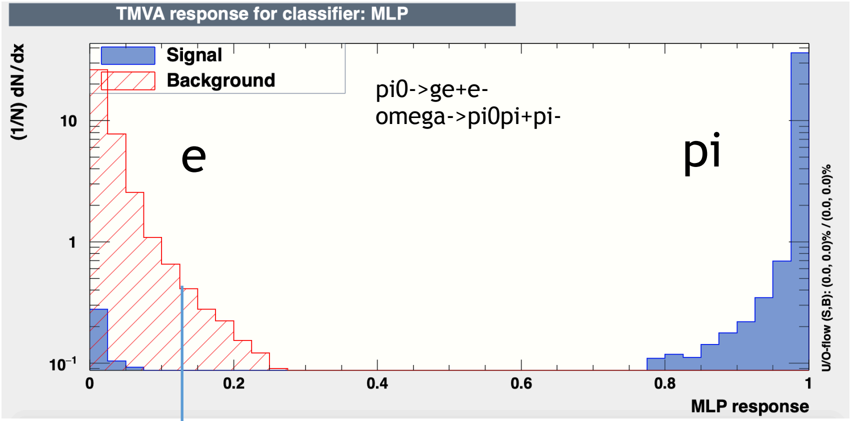
2. Low NN response PIONS

Pions have a pileup under electron peak in two separate training sample sources
(BH MC/rho vs omega/pi0)

a.) Are the number of events of the low NN response pions the same between the two training sample sources?

b.)
Contamination?
Physics?





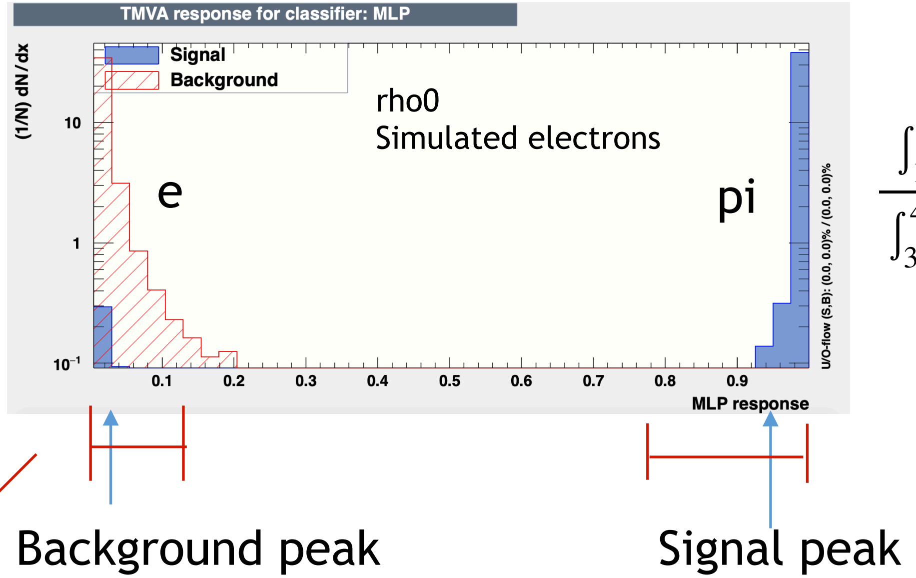
LET'S CALL EVERYTHING BELOW BIN 5 THE "LOW NN RESPONSE REGION" OR NNR = 0.12

a.) Are the number of events of the low NN response pions the same between the two training sample sources?

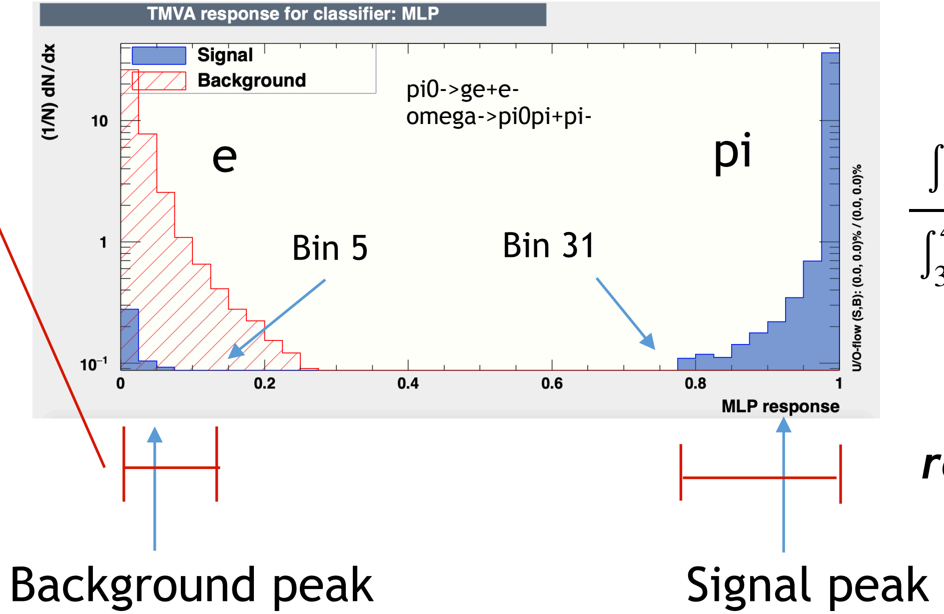
Integral procedure:
MVA response histograms have **40 bins.**

Background peak integral: bins 1 to 5
Signal peak integral: bins 31 to 40

I keep the bounds of integration the same for both rho0 and omega(782)



$$\frac{\int_1^5 N_{\rho_0}(x)dx}{\int_{31}^{40} N_{\rho_0}(x)dx} = \frac{0.76404053}{39.046492} = 0.019567456$$



$$\frac{\int_1^5 N_{\omega(782)}(x)dx}{\int_{31}^{40} N_{\omega(782)}(x)dx} = \frac{0.67999367}{38.519641} = 0.017653167$$

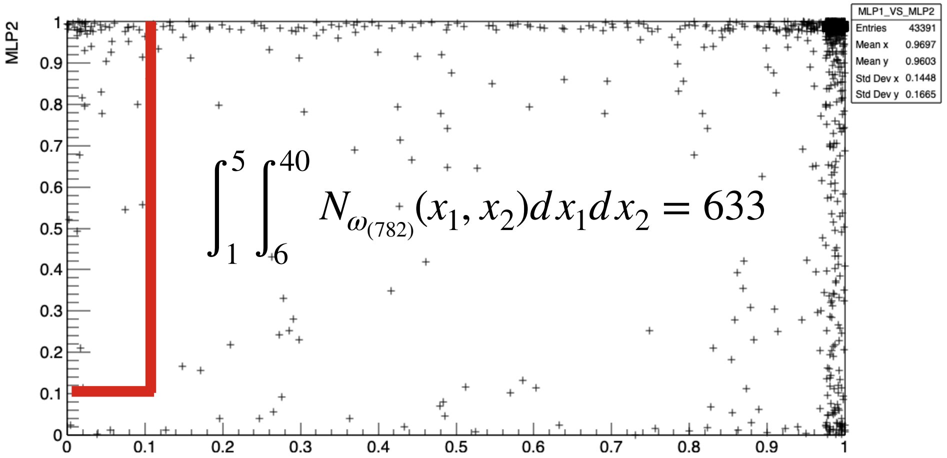
roughly 2% in both training methods

LET'S CALL EVERYTHING BELOW BIN 5 THE "LOW NN RESPONSE REGION" OR NNR = 0.12

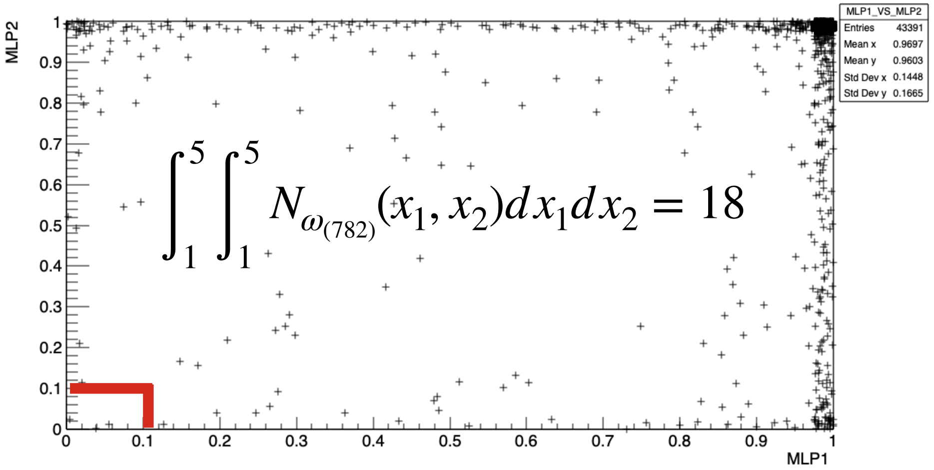
Integration of 3 complementary regions: *how many pion events have at least 1 track in the extreme e+e- NN response territory?*

Trained on simulated BH pairs and $\rho^0 \rightarrow \pi^+\pi^-$ events

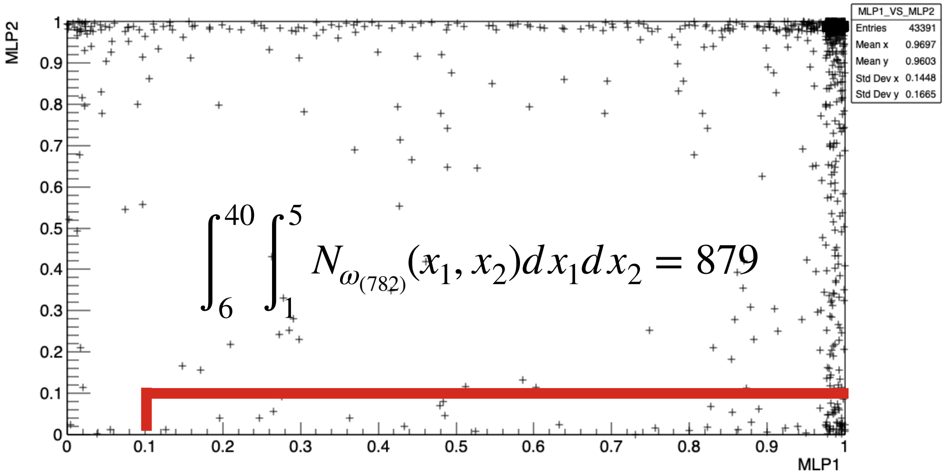
Classifing $\omega(782) \rightarrow \pi^0\pi^+\pi^-$ events



$$\int_1^5 \int_6^{40} N_{\omega(782)}(x_1, x_2)dx_1dx_2 = 633$$



$$\int_1^5 \int_1^5 N_{\omega(782)}(x_1, x_2)dx_1dx_2 = 18$$



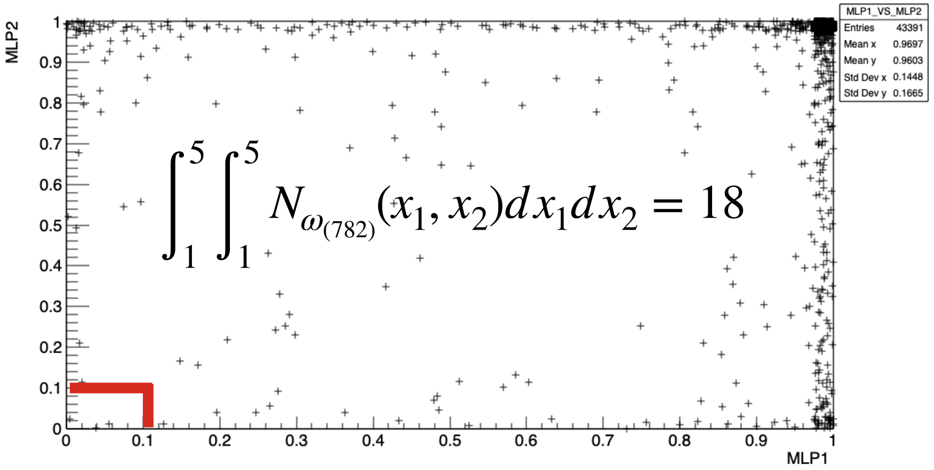
$$\int_6^{40} \int_1^5 N_{\omega(782)}(x_1, x_2)dx_1dx_2 = 879$$

$$\frac{18 + 633 + 879}{43391} = \frac{1530}{43391} = 0.035$$

3.5% of events ***need to be accounted for.***

3.5% of events ***need to be accounted for***.

1. Double low NN response



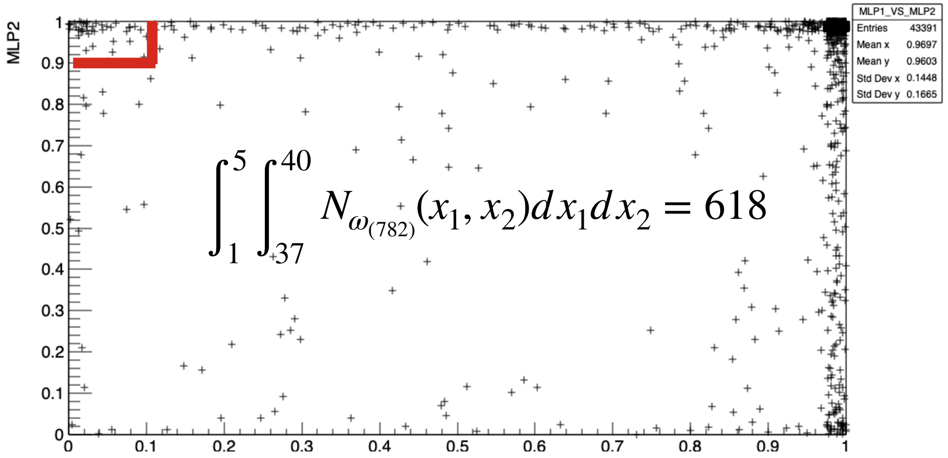
$$\int_1^5 \int_1^5 N_{\omega(782)}(x_1, x_2) dx_1 dx_2 = 18$$

$0.04\,\%$ of $\omega(782) \rightarrow \pi^0\pi^+\pi^-$ events have both tracks with low NN response values.

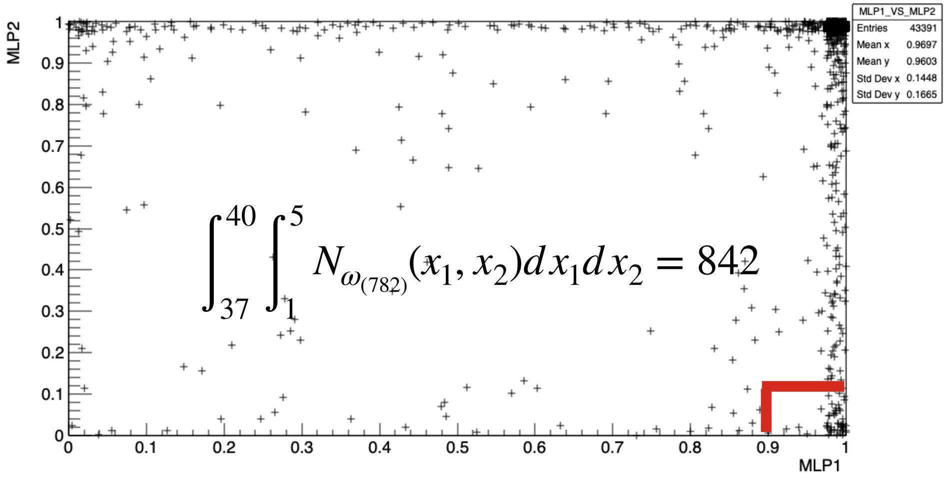
Let's assume (for no good reason other than playing a game)
that this is contamination. Now 3.46% events need to be accounted for.

3.46% of events ***need to be accounted for.***

2. One high NN response, one low. (NN1 > 0.9, NN2 < 0.12)



$$\int_{1}^{5}\int_{37}^{40} N_{\omega(782)}(x_1, x_2)dx_1dx_2 = 618$$



$$\int_{37}^{40}\int_{1}^{5} N_{\omega(782)}(x_1, x_2)dx_1dx_2 = 842$$

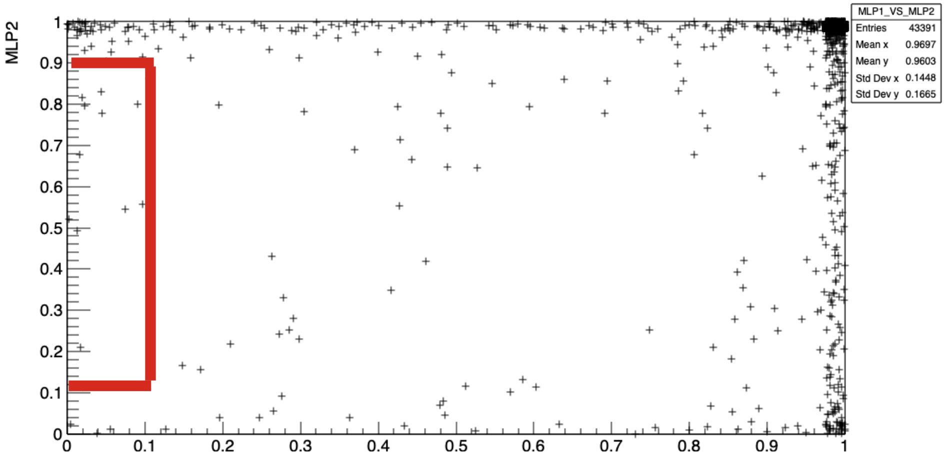
$$\frac{618 + 842}{43391} = 0.033647531$$

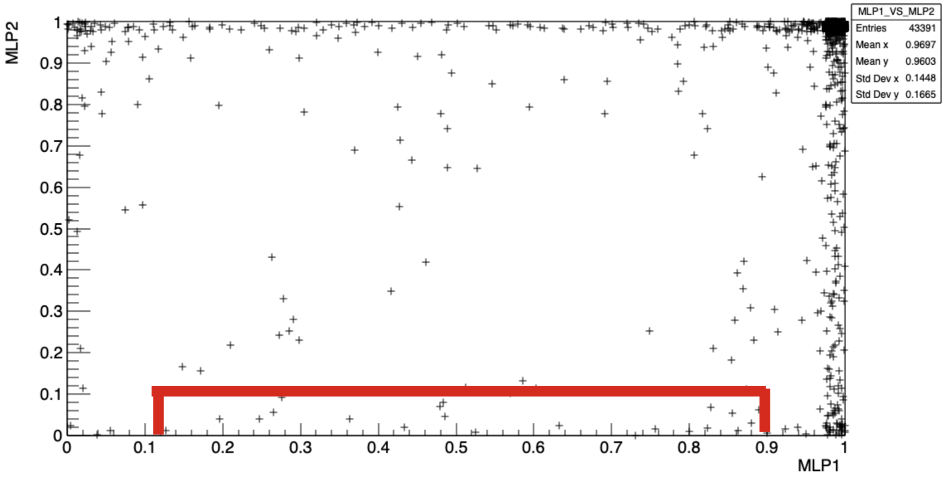
Let's assume (again, for no good reason)
3.3% of events have charge exchange reaction (π+ or π-)

Now 0.16% of events need to be accounted for.

This leaves 0.16% of events left populating “no man’s land”

2. “No man’s land”



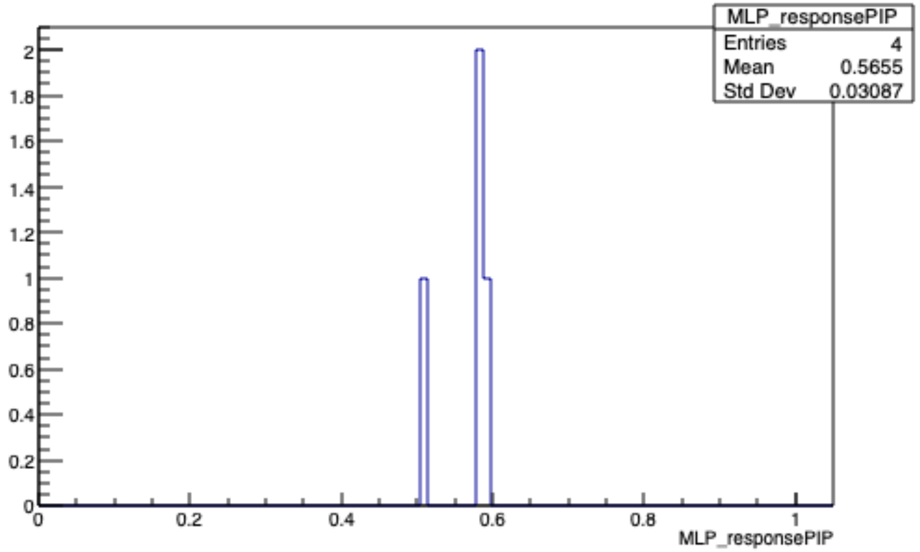


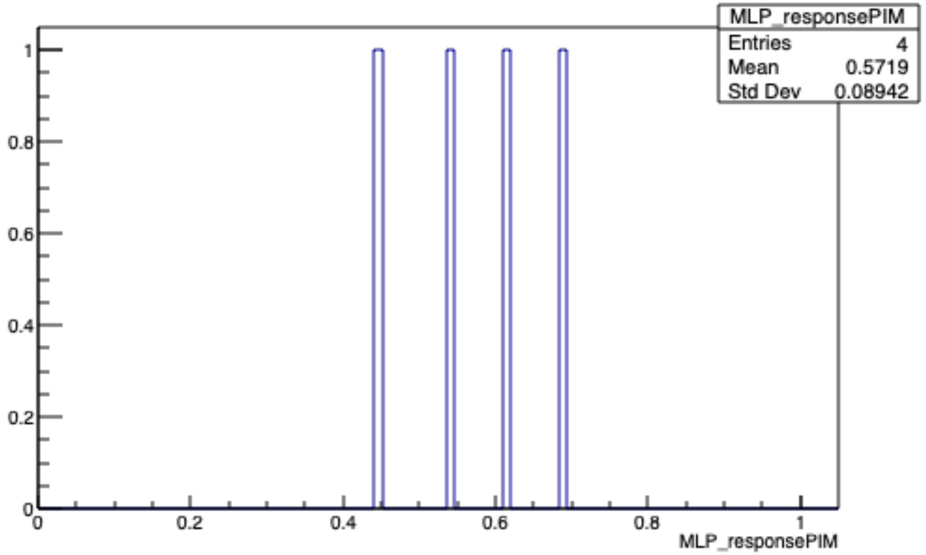
Actually let’s pair 0.16% with the 0.04% that we called contamination into a 0.2% group

Is it reasonable?

3.3% total charge exchange reaction (π+ and π-)
0.2% contamination/unknown

Selecting for Electrons		
NN cut	omega->pi0pi+pi- (%)	pi0->ge+e- (%)
NN < 0.1	0.03917863151	89.98866285
NN < 0.05	0.03456938075	78.32713989
NN < 0.025	0.0276555046	57.59904264
NN < 0.005	0.009218501533	5.375700699


MLP_responsePIP
Entries 4
Mean 0.5655
Std Dev 0.03087
MLP_responsePIP


MLP_responsePIM
Entries 4
Mean 0.5719
Std Dev 0.08942
MLP_responsePIM