Artificial Neural Network (ANN) for muon track candidate selection

Anna Senger

Outline

- Online Joint GlueX-EIC-PANDA Machine Learning Workshop link
- Simulation input
- ANN training
- Muon track candidates selected using ANN ID

What I learned from this Workshop ?

- Preselect input data to have good separation between signal and background
- Use parameters which are different (essentially) for background and signal
- Use parameters which are correlated with each other
- Use the same statistics for signal and background
- Use enough epochs (iterations), not too few (underfitting) and not too many (overfitting)

What I learned from this Workshop ?

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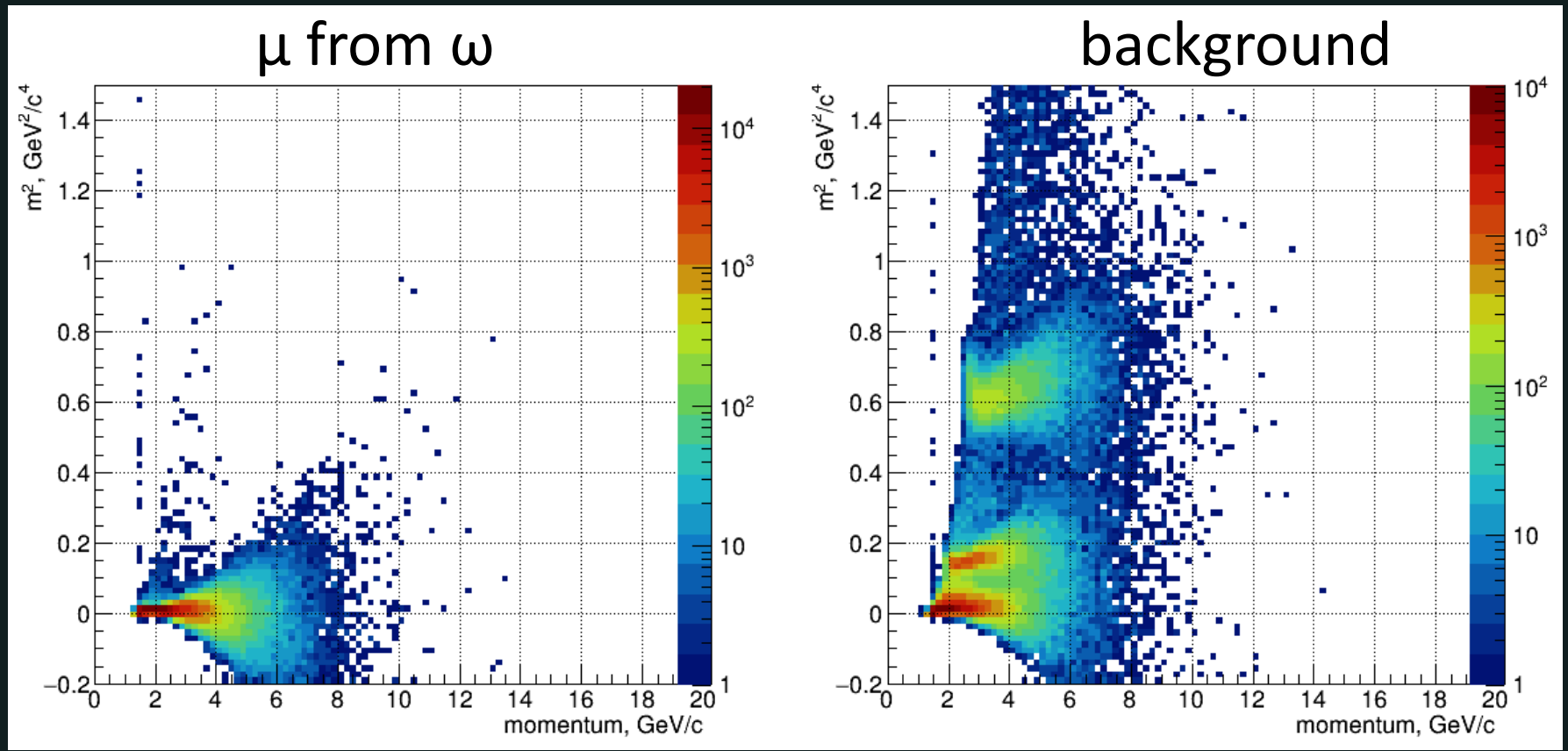
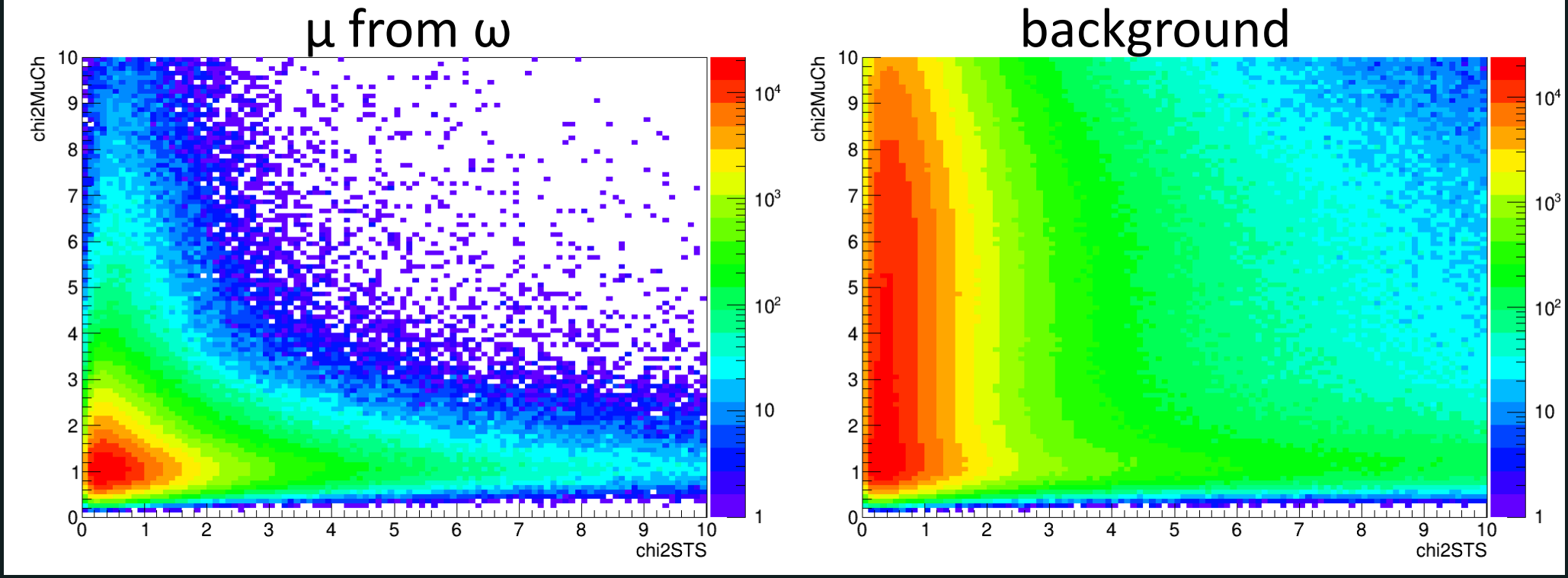
m^2 vs. momentum



What I learned from this Workshop ?

- Use parameters which are correlated with each other

χ^2/ndf_{MUCH} vs. χ^2/ndf_{STS}



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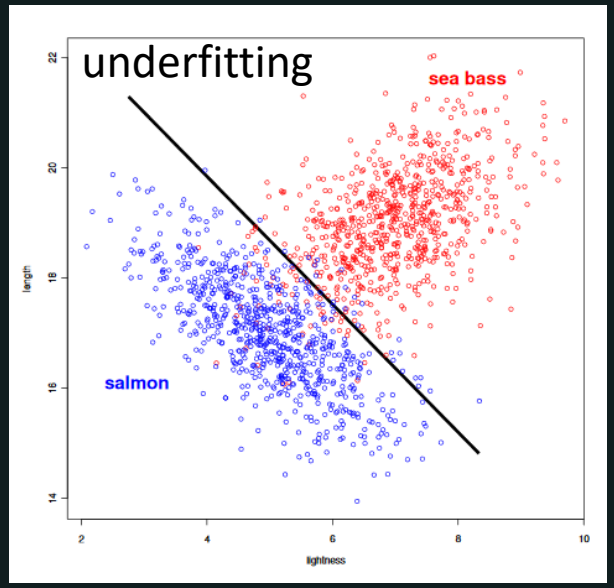
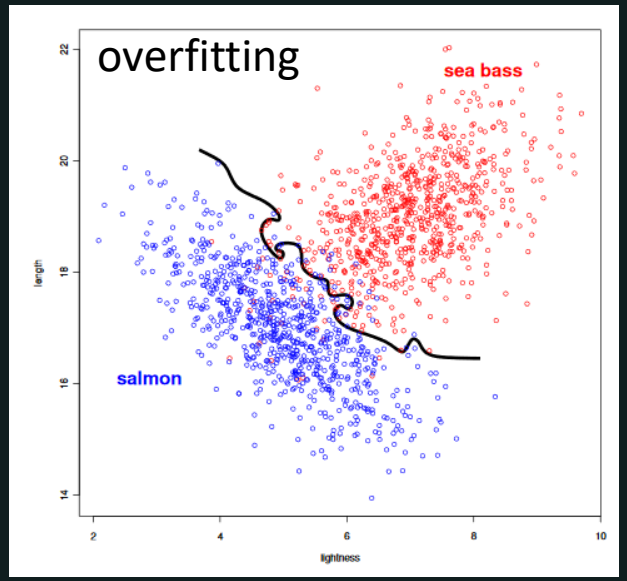
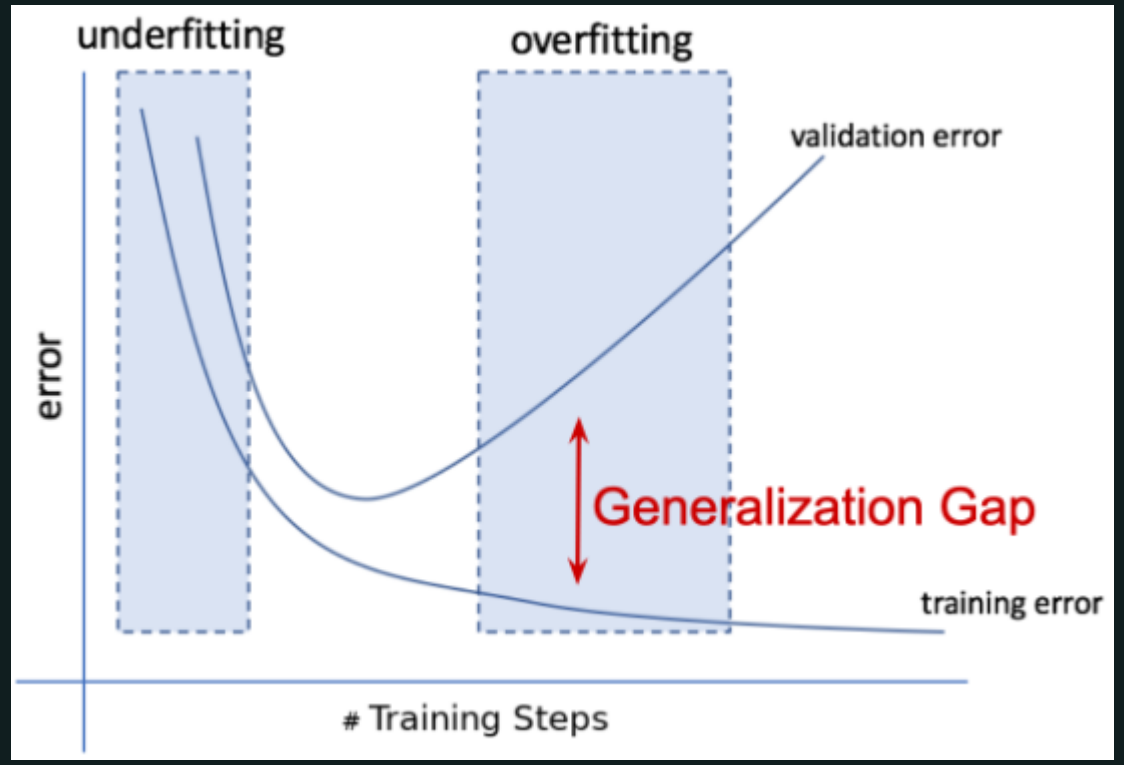




Thomas Stibor



Daniel Lersch

Simulation input

- CBMROOT release APR20
- central Au+Au @ 8 *A* GeV/c (UrQMD) events
- ω generated using PLUTO
- LMVM setup
- MC PID for efficiency and S/B ratio calculations
- statistics 10^6 events

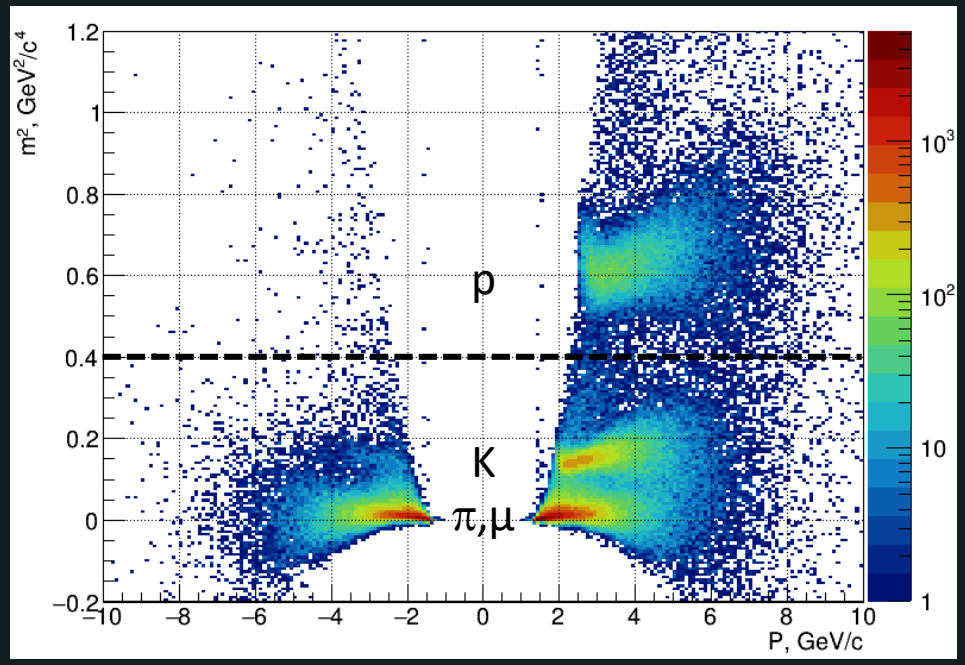
ANN training I

- Track parameters for training:
  - χ^2/ndf
    - in primary vertex
    - in STS
    - in MUCH
    - in TRD
  - number of hits
    - in STS
    - in MUCH
    - in TRD
  - momentum
  - mass calculated from time measurements in TOF
  - particle ID: 0 – background, 1 – muon from ω

- Preselection data:
  - χ^2/ndf
    - in primary vertex < 10
    - in STS < 10
    - in MUCH < 10
    - in TRD < 10
  - number of hits
    - in STS > 5
    - in MUCH > 8
    - in TRD > 0
    - in TOF > 0
  - mass < 0.4 GeV^2/c^4

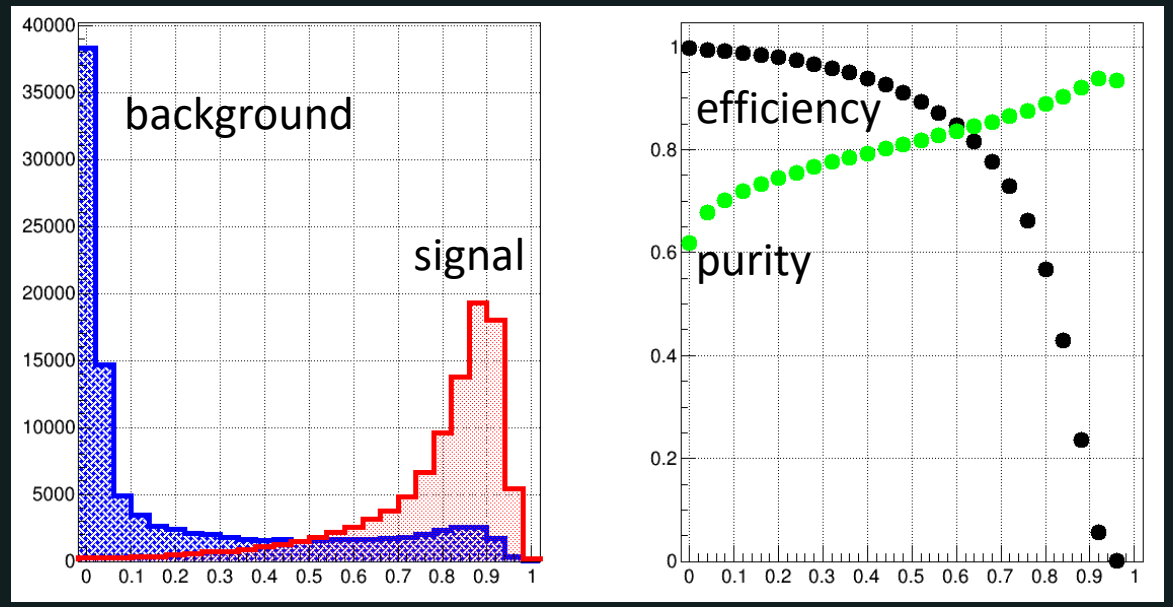
ANN training II

- Use normalized data (0÷1)
- 1000 epochs
- Train positive and negative tracks separately: different cocktail of positive and negative background tracks
  - more or less the same number of π+ and π-
  - more K+ than K-
  - almost all p ($\bar{p}$?) could be cut after condition mass < 0.4 GeV^2/c^4

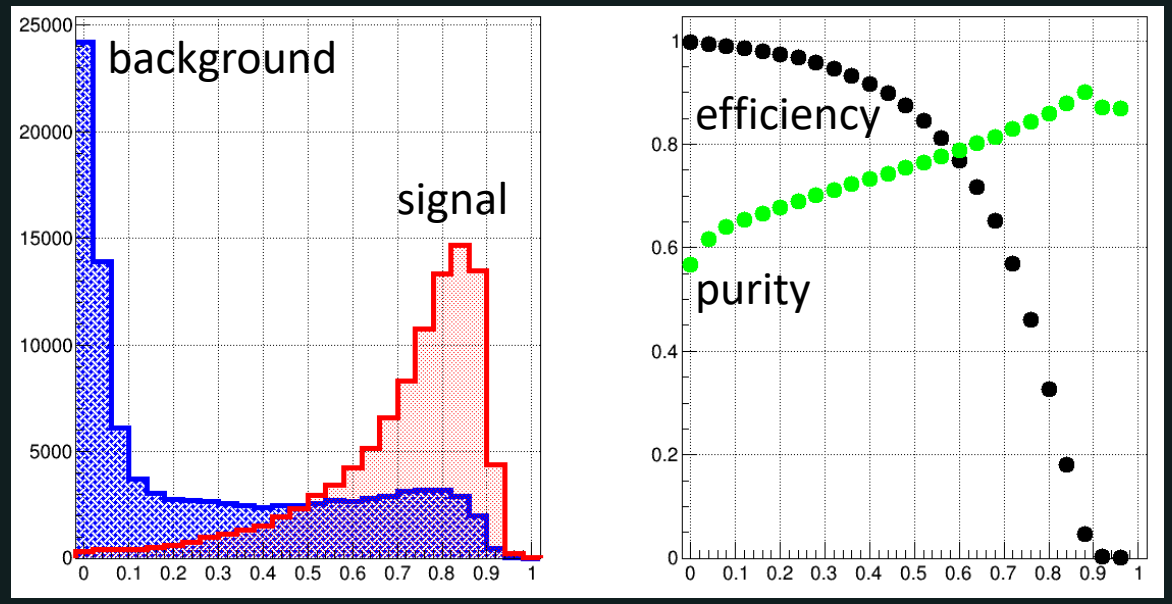


ANN output

Positive tracks

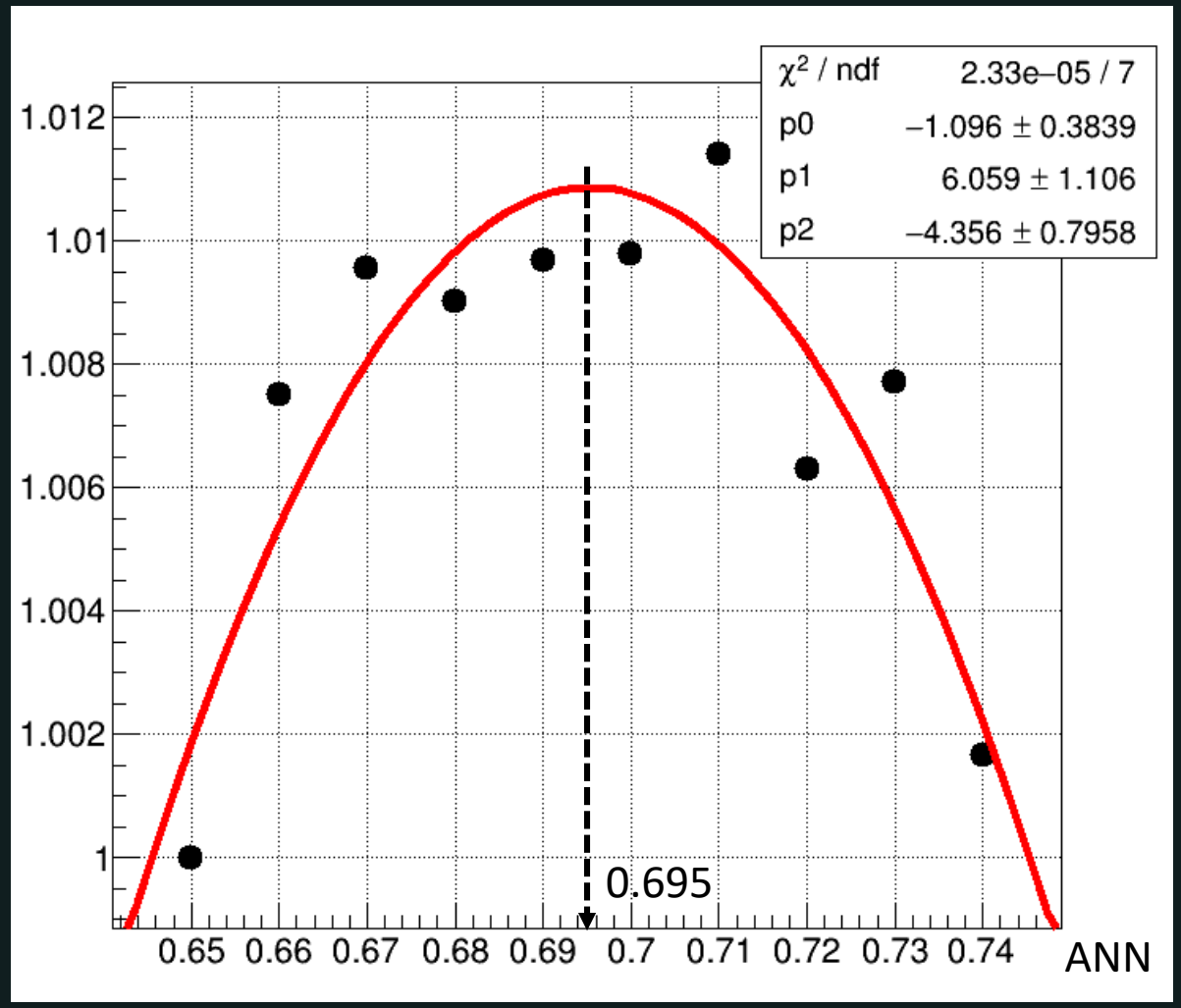


Negative tracks



efficiency = signal passing ANN cut / total signal
purity = signal passing ANN cut / (signal+background passing ANN cut)

Analysis results: normalized significance



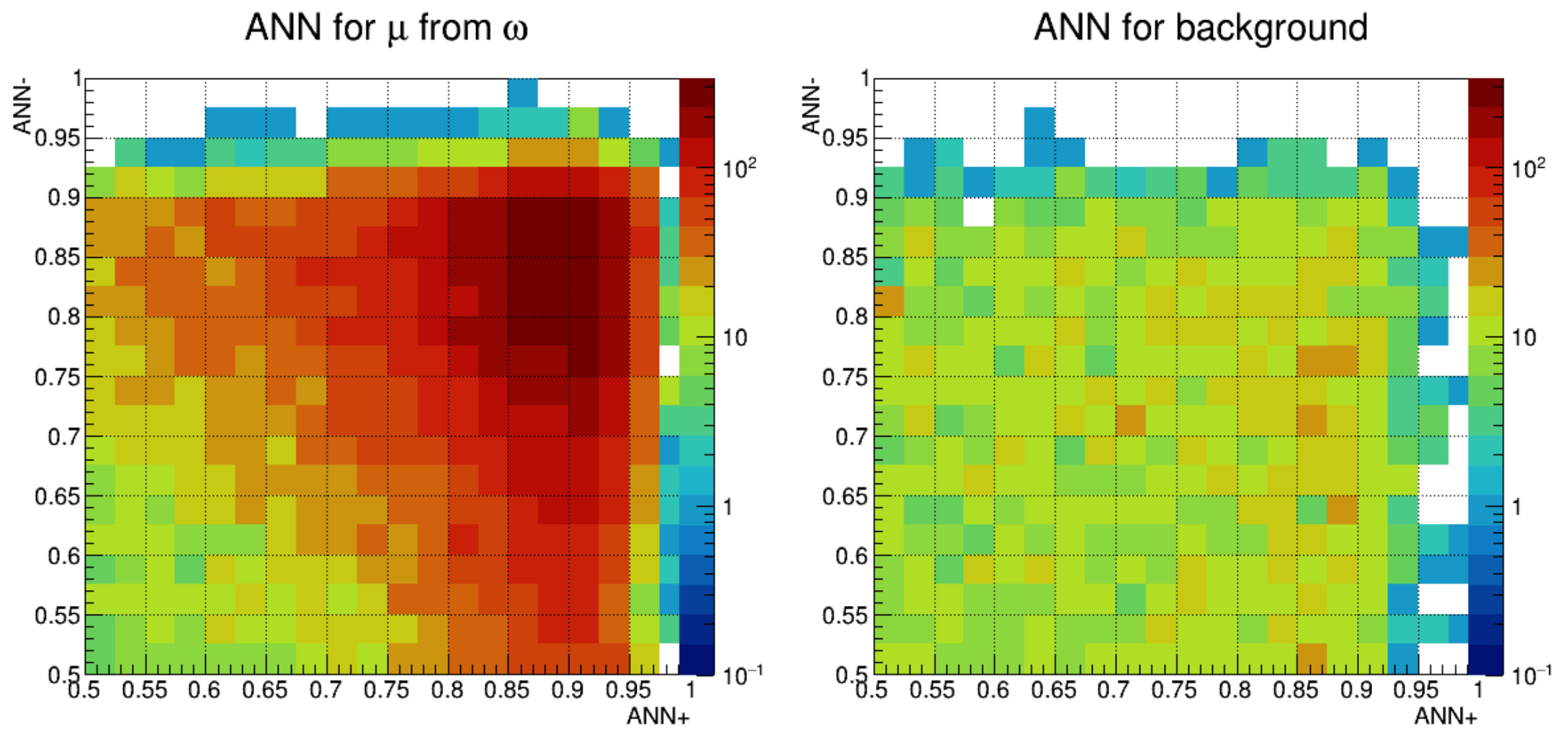
the same ANN cut for + and - particles

ANN > 0.695:

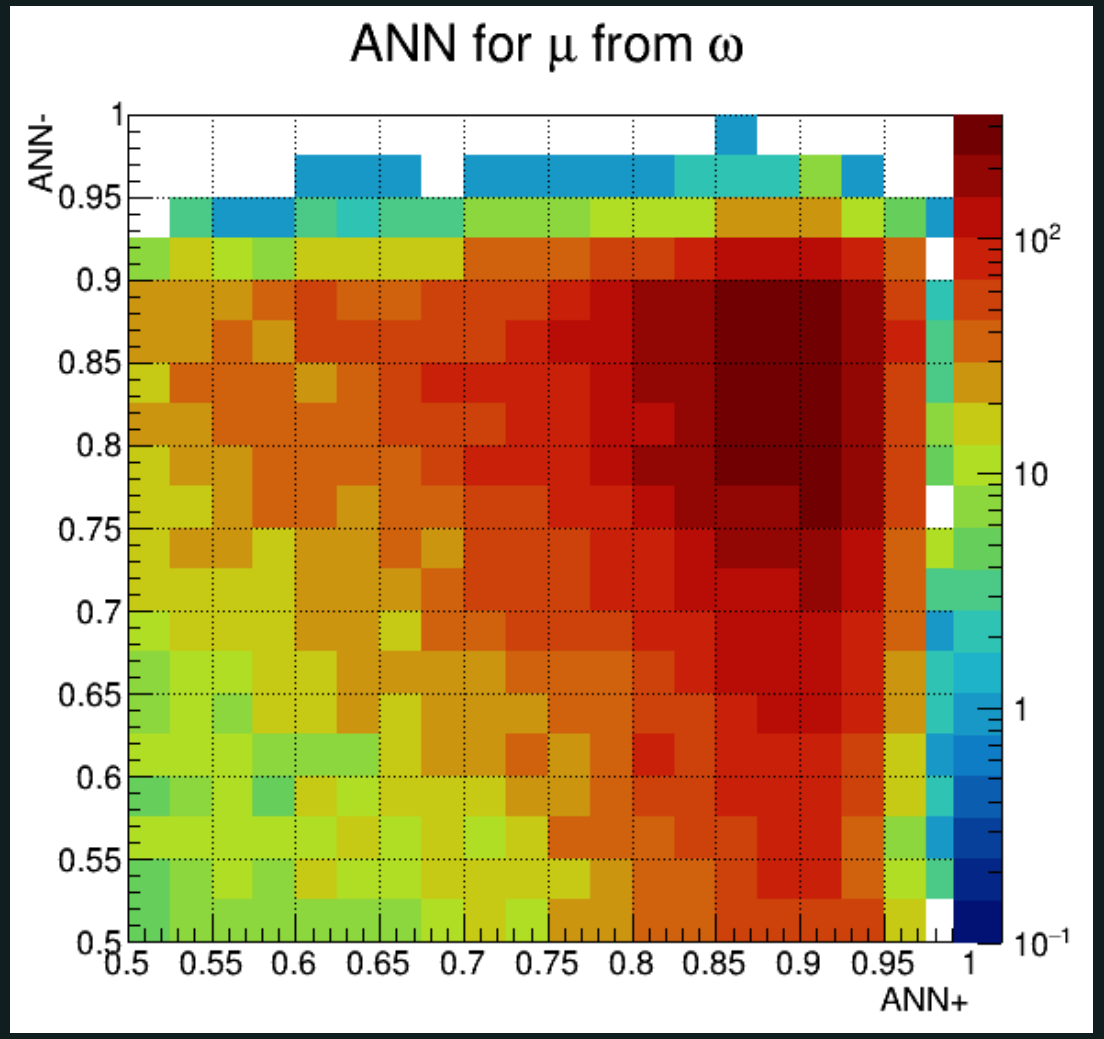
ω/B ratio = 0.04

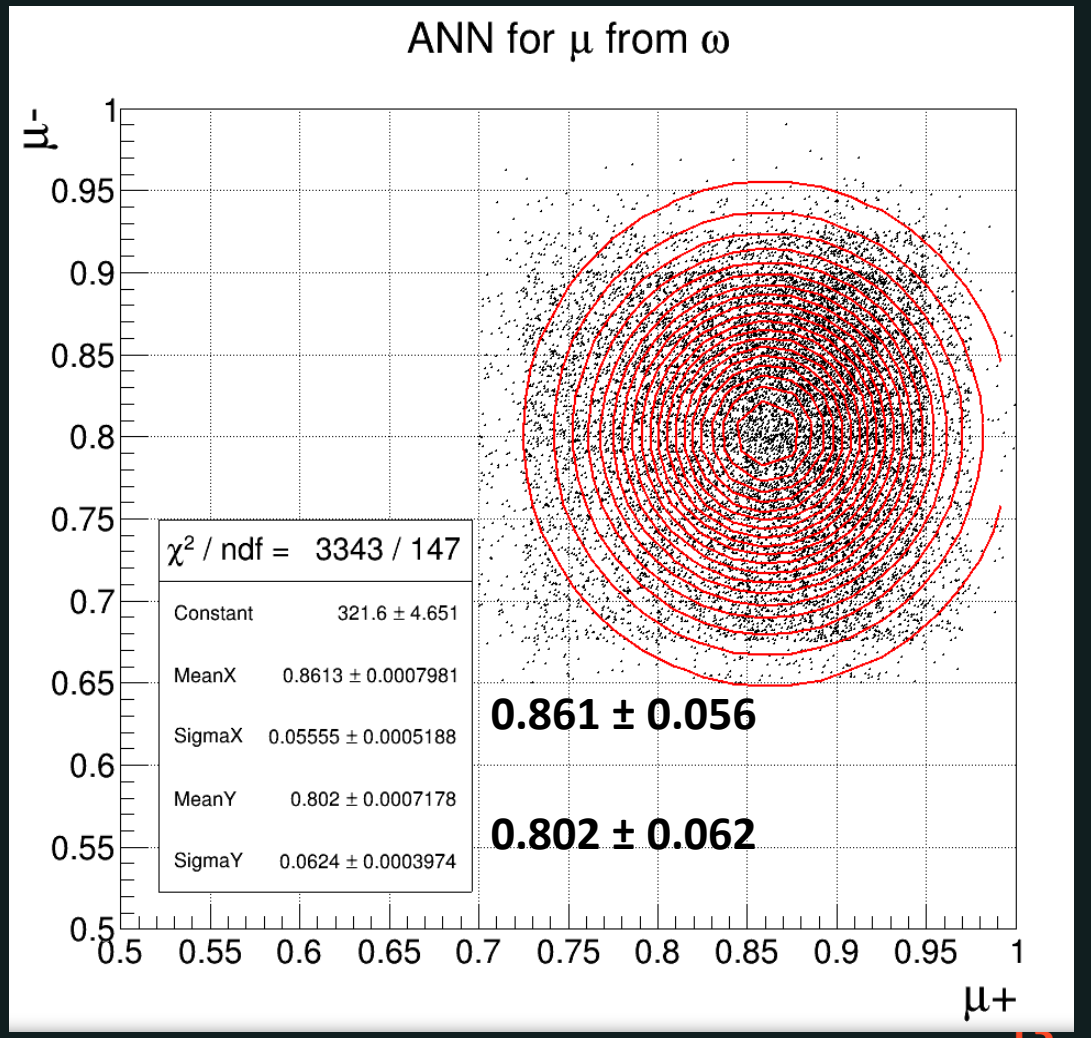
ε_{ω} = 1.33 %

ANN for positive and negative tracks



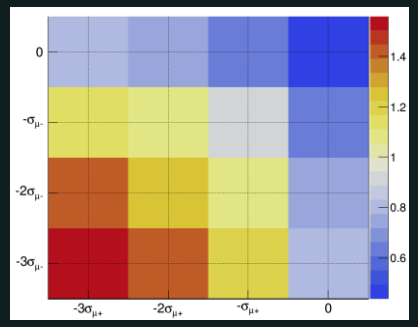
ANN for positive and negative tracks



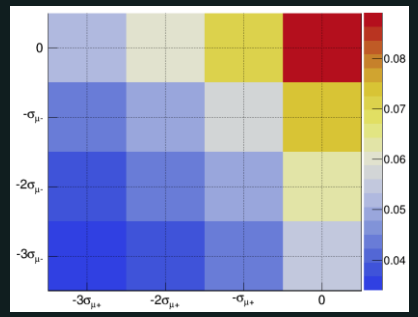


Analysis results using ANN PID

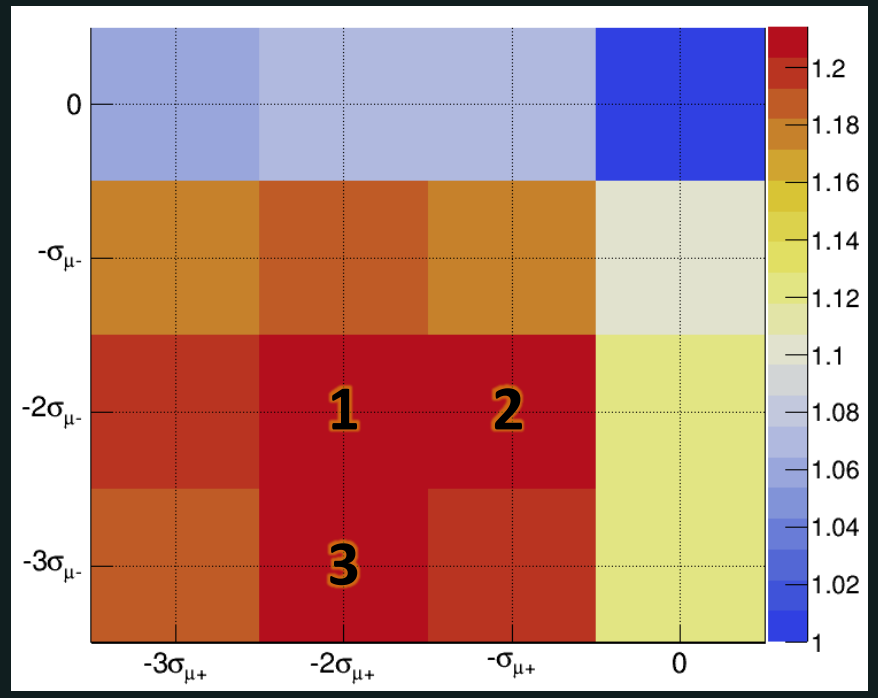
Efficiency



ω/background ratio



Normalized significance



μ+: ANN=0.861, σ=0.056

μ-: ANN=0.802, σ=0.062

cut combination	ε_ω %	ω/background ratio
1	**1.27**	**0.043**
2	**1.09**	**0.050**
3	**1.42**	**0.038**

Comparison of cuts

ANN cuts	ε_ω %	ω/background ratio	norm. significance
first step*	**1.09**	**0.033**	**1**
new ANN ±	**1.09**	**0.050**	**1.22**

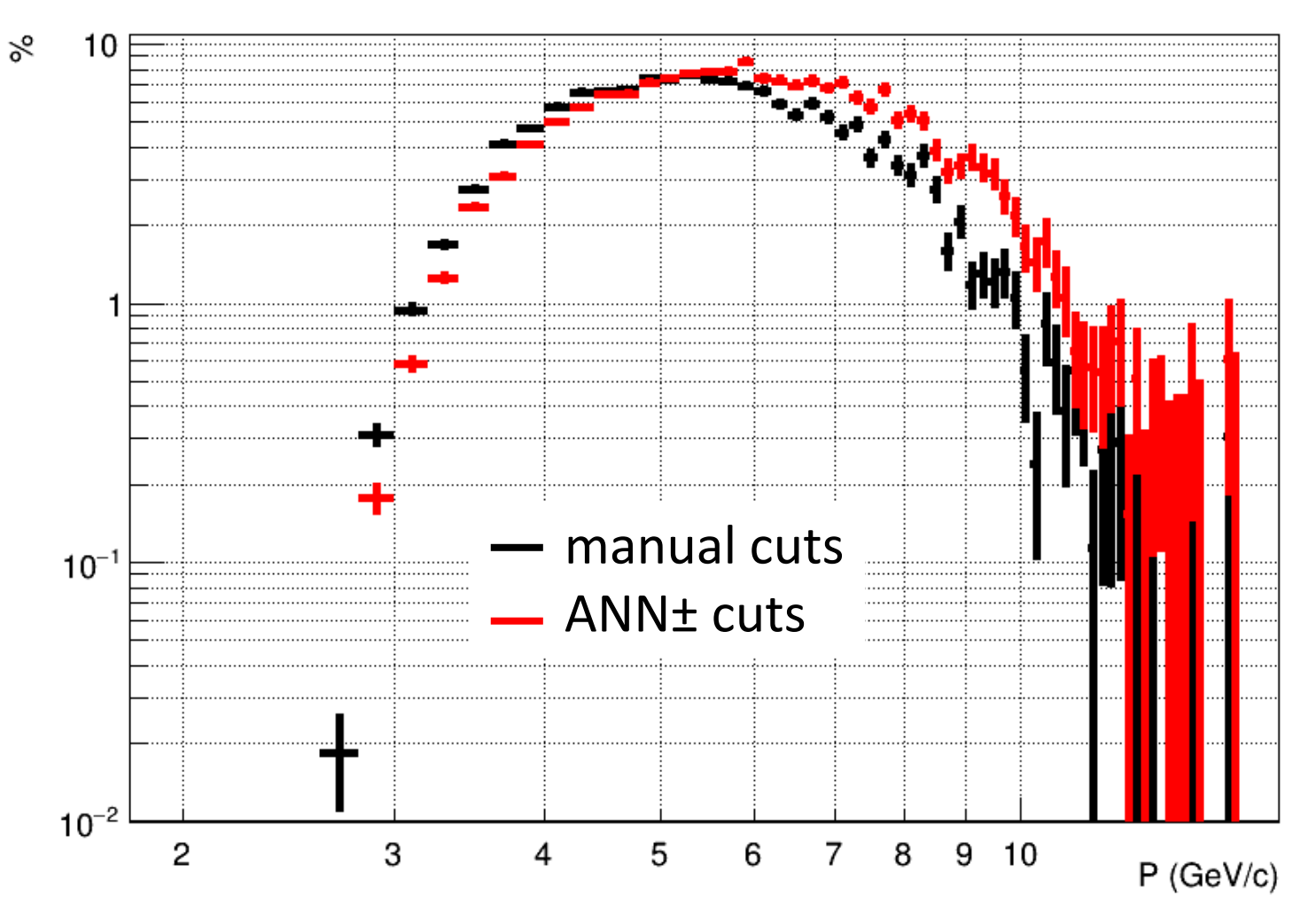
* CBM PWG Di-Lepton meeting, Sep.4 2020 link

Comparison of cuts

cut combination	ε_ω %	ω/background ratio	norm. significance
manual cuts*	**1.27**	**0.012**	**1**
new ANN ±	**1.27**	**0.043**	**1.85**

* $\chi^2_{Vertex}<3$, $\chi^2_{STS}<3$, $\chi^2_{MUCH}<3.2$
STS>6, MUCH>9, TRD
$\sigma_{TOF}=4$

Comparison of cuts: ω 4π-efficiency vs. P



Comparison of cuts: P_t vs. Y

ANN± cuts (1) manual cuts (2) 1-2