Multivariate analysis for HaSpect

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Multivariate analysis

The work builds on ROOT TMVA and ties in with the HASPECT6 package.

Makes MVA easier to run:

- Specify the particles in the reaction
- Specify the variables to train on
- Specify the methods to be trained
- Train
- Specify the output variables (e.g. Missing mass)
- Apply

Variables

The MVA acts as another 'check', since it doesn't use variables such as missing mass.

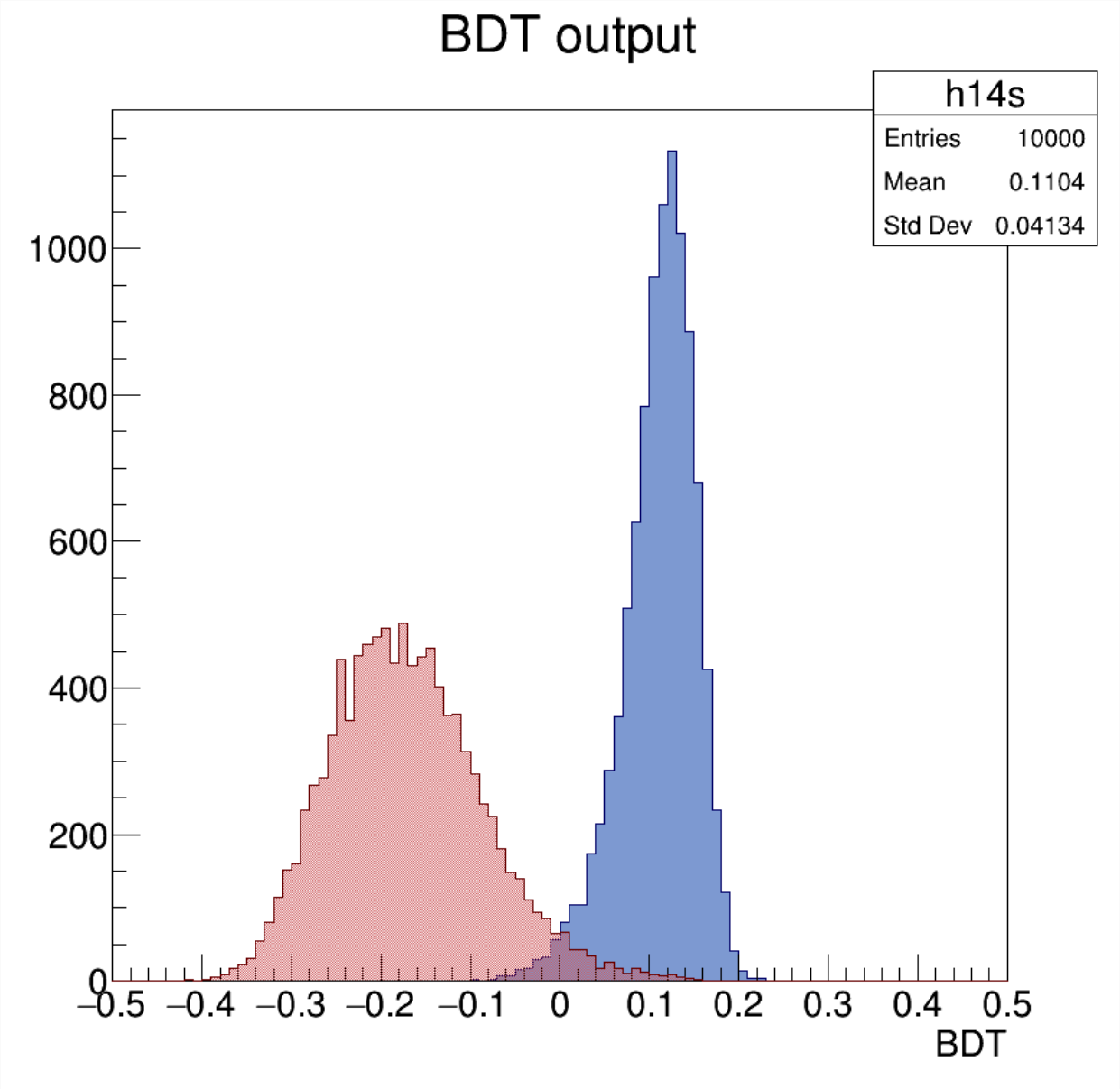
The following example will use:

- Momentum P
- Δt
- Energy deposited
- Angles θ and ϕ
- ΔE
- Vertex V_z

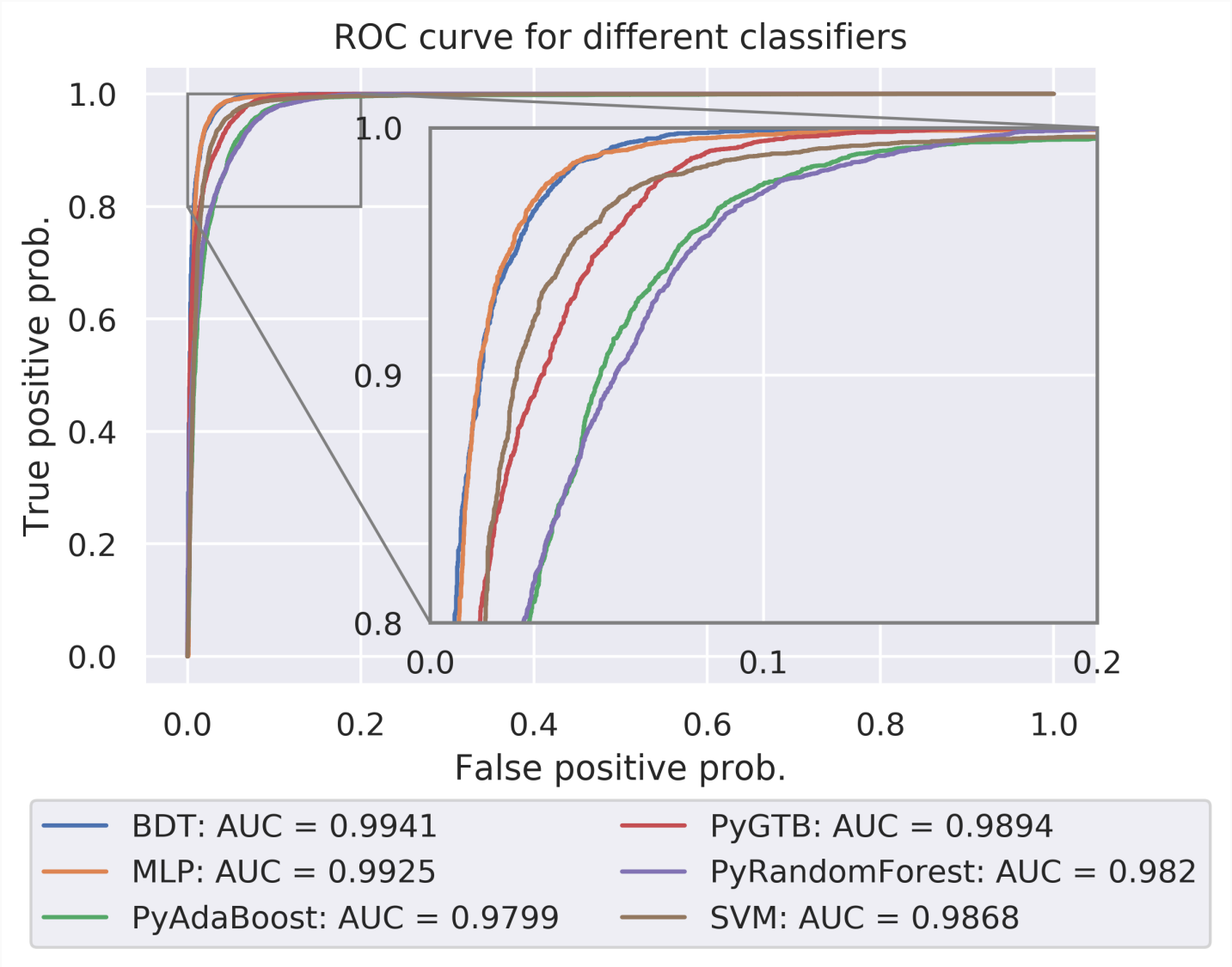
The data used is G13 data.

For training only signals need to be simulated, the real data is pased as background

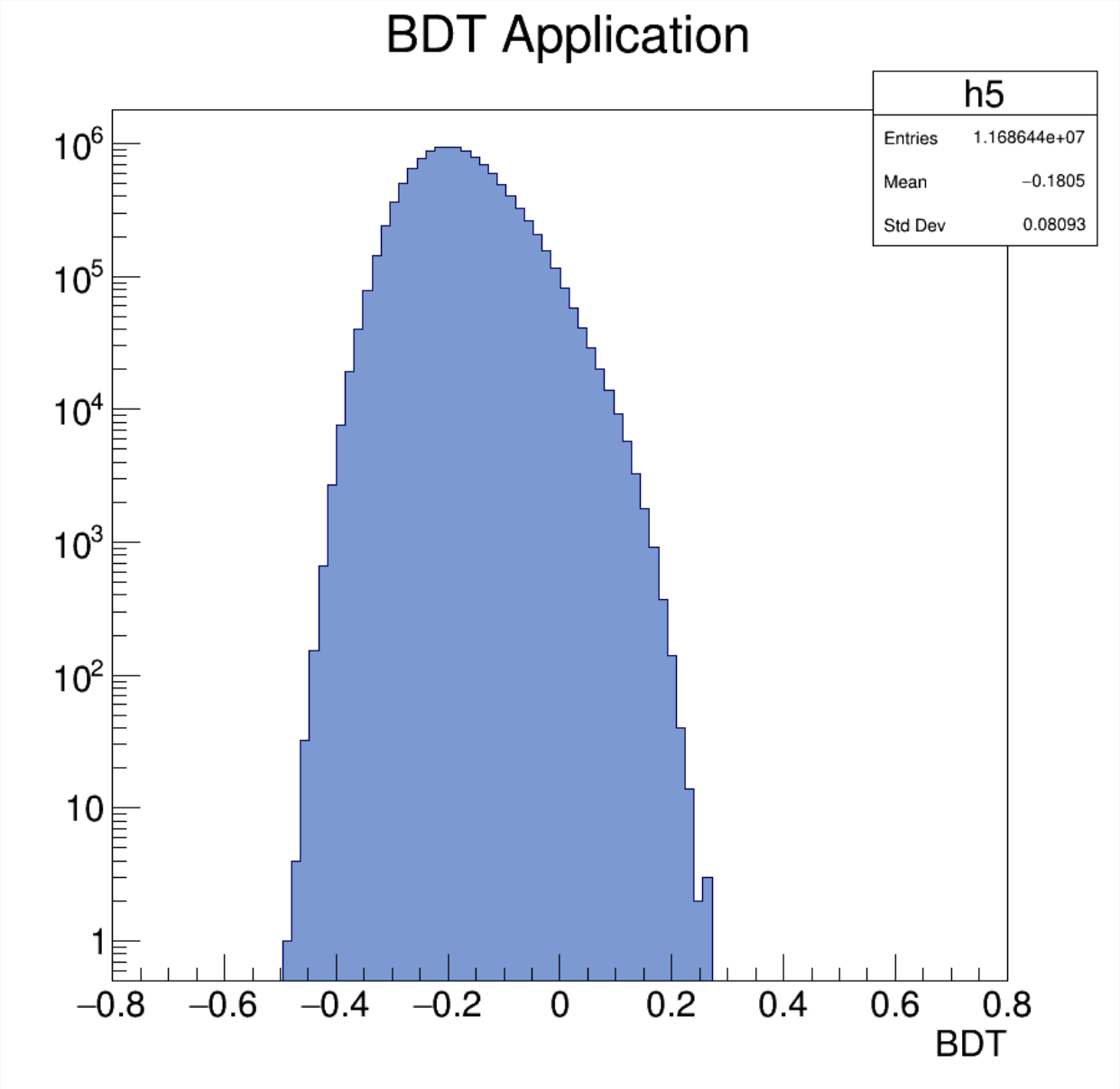
Training output



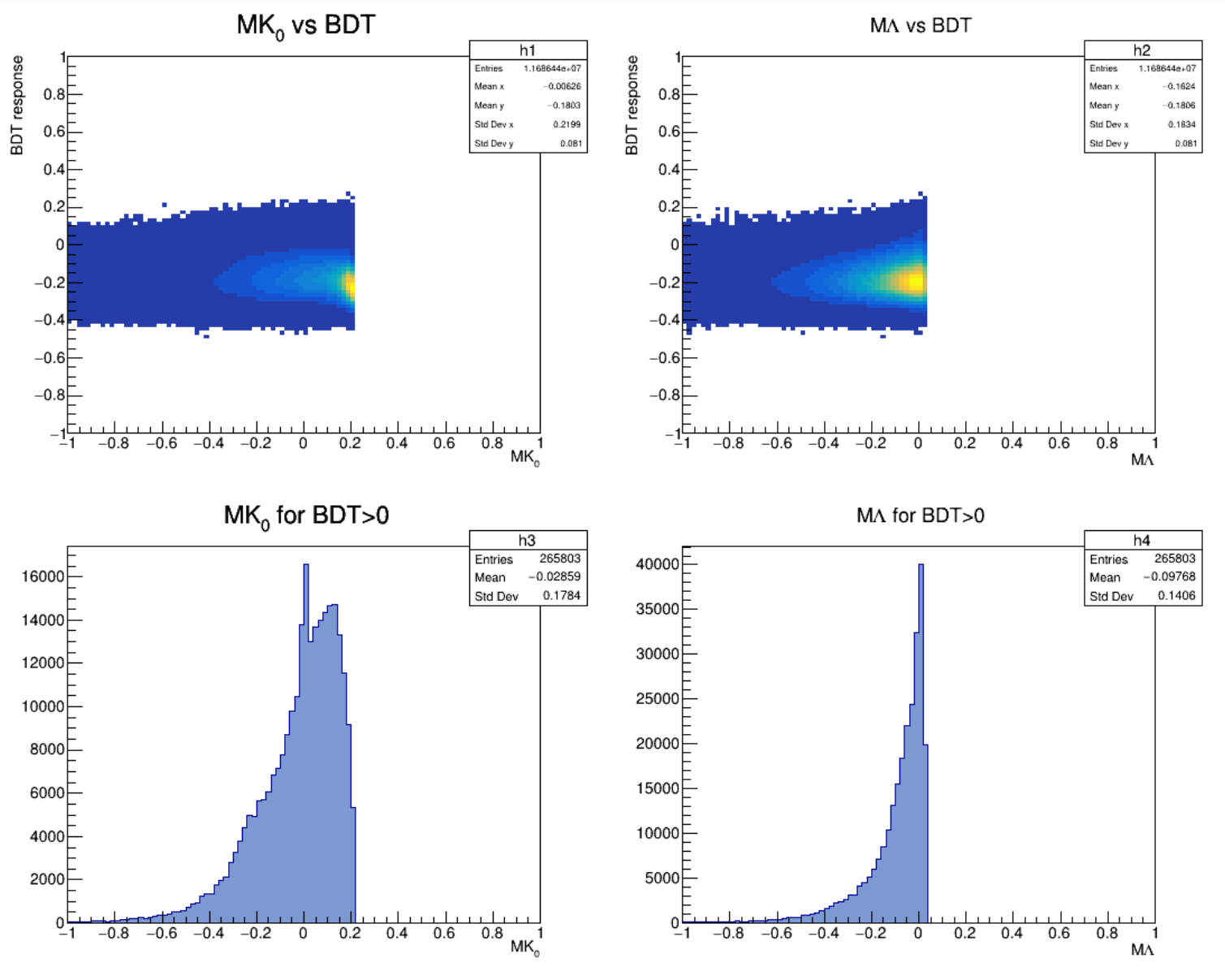
ROC curve


ROC curve for different classifiers
True positive prob.
False positive prob.
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
1.0
0.9
0.8
0.0
0.1
0.2
BDT: AUC = 0.9941
MLP: AUC = 0.9925
PyAdaBoost: AUC = 0.9799
PyGTB: AUC = 0.9894
PyRandomForest: AUC = 0.982
SVM: AUC = 0.9868

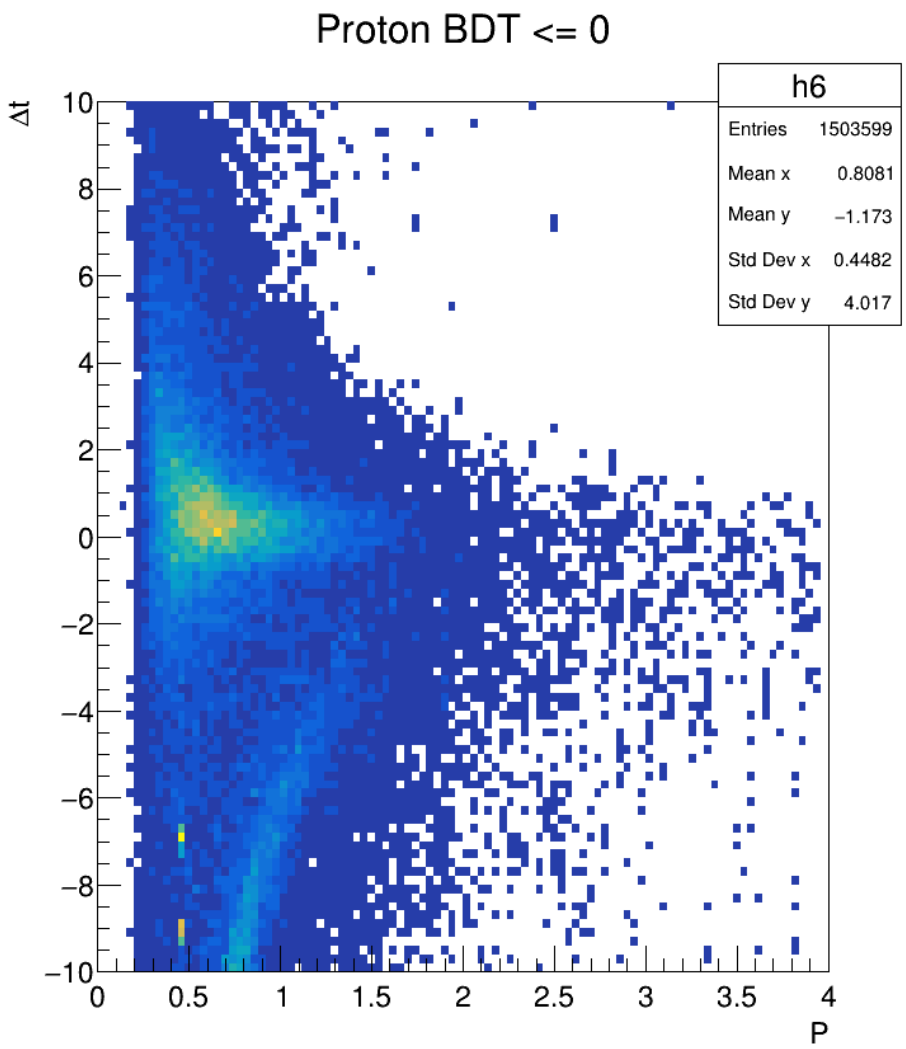
Application output

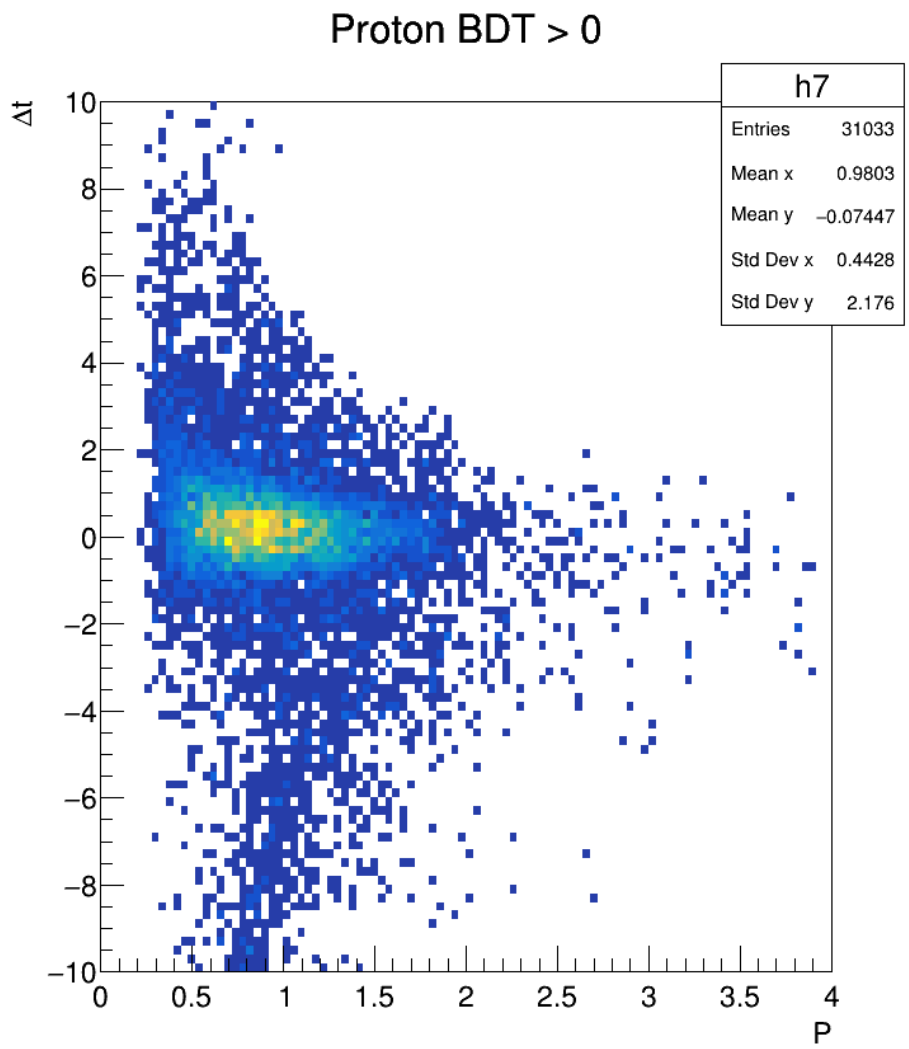


Missing mass

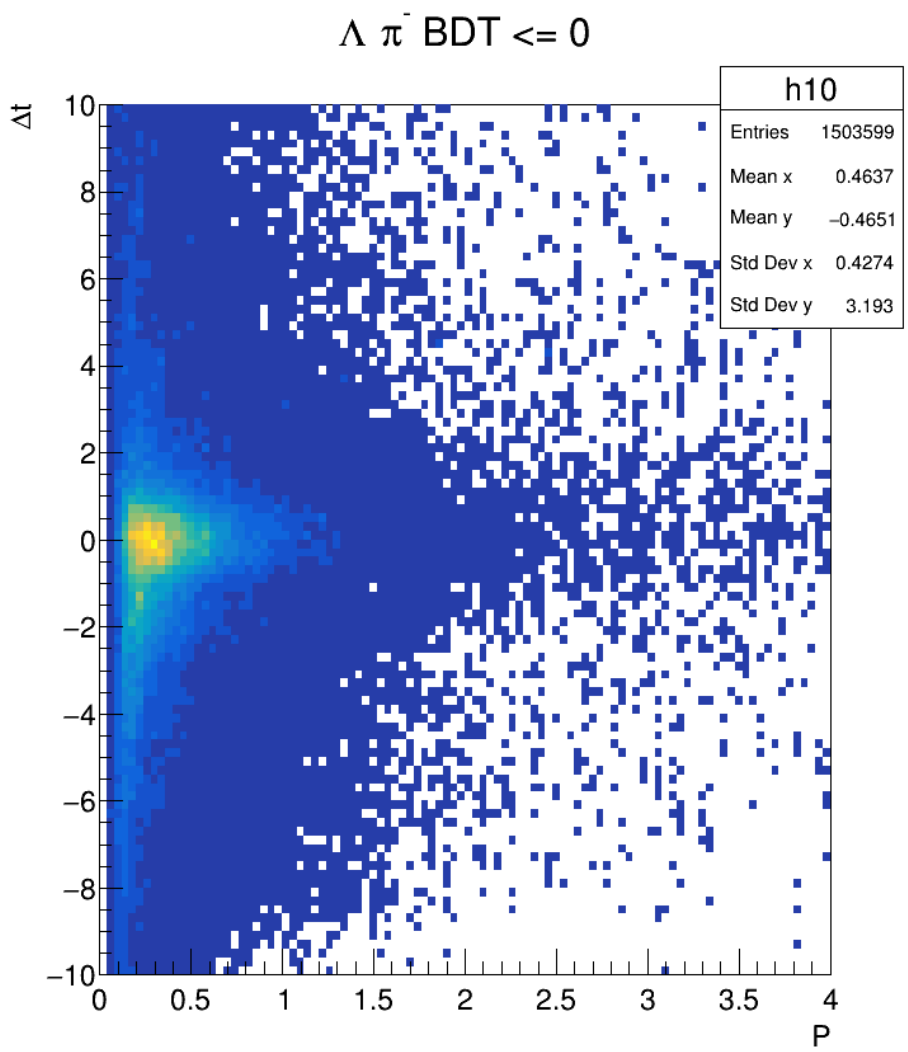


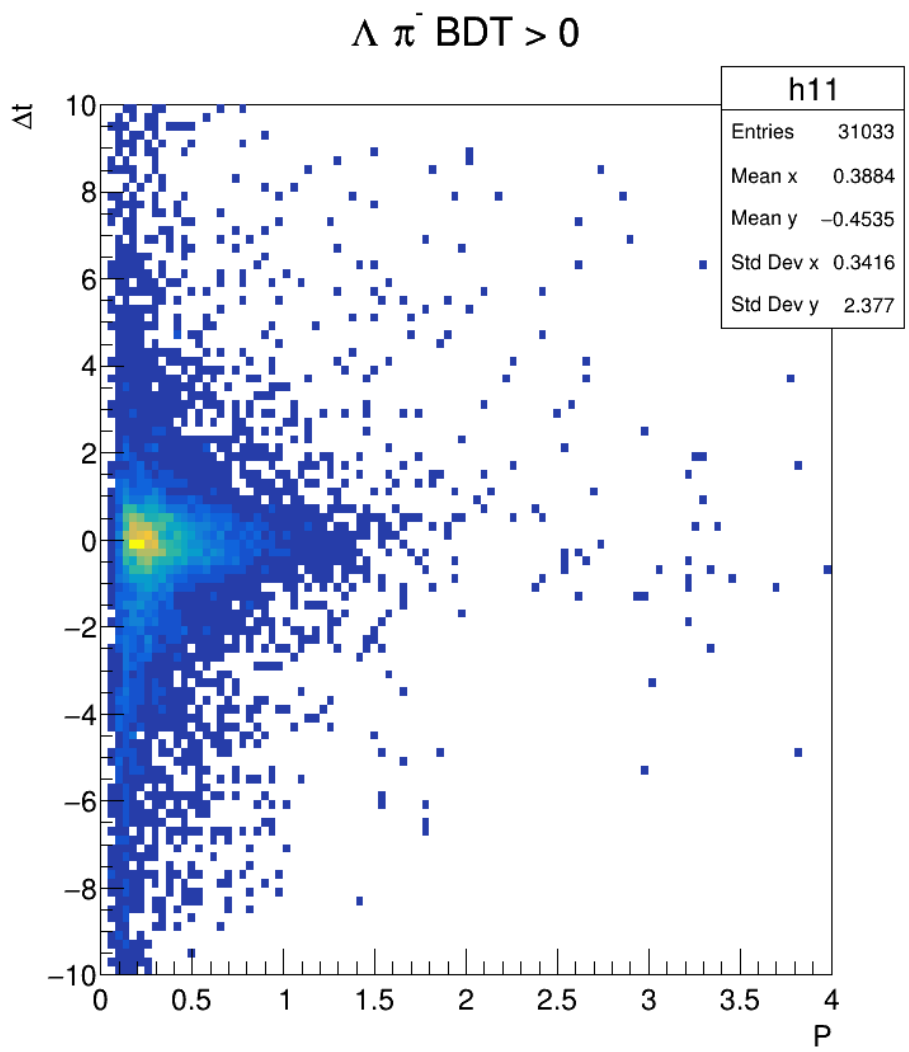
Proton


Proton BDT <= 0
h6
Entries 1503599
Mean x 0.8081
Mean y −1.173
Std Dev x 0.4482
Std Dev y 4.017
Δt
P

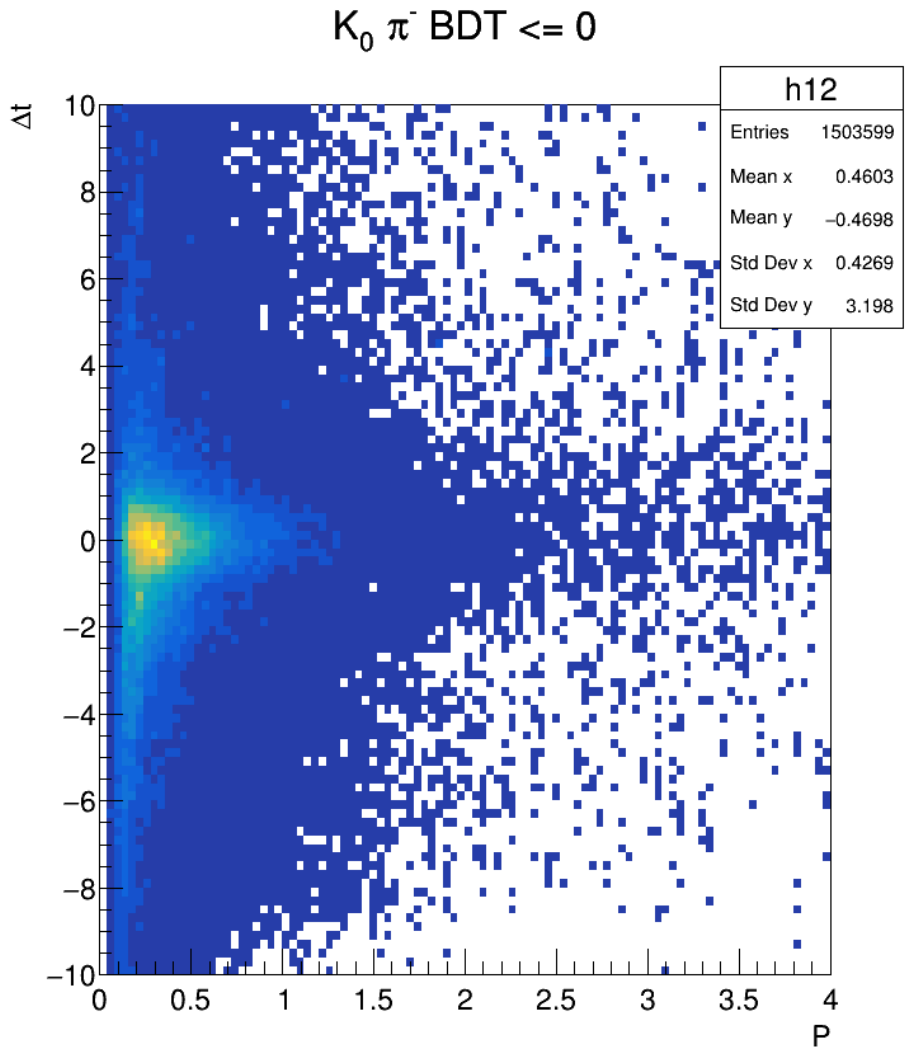

Proton BDT > 0
h7
Entries 31033
Mean x 0.9803
Mean y −0.07447
Std Dev x 0.4428
Std Dev y 2.176
Δt
P

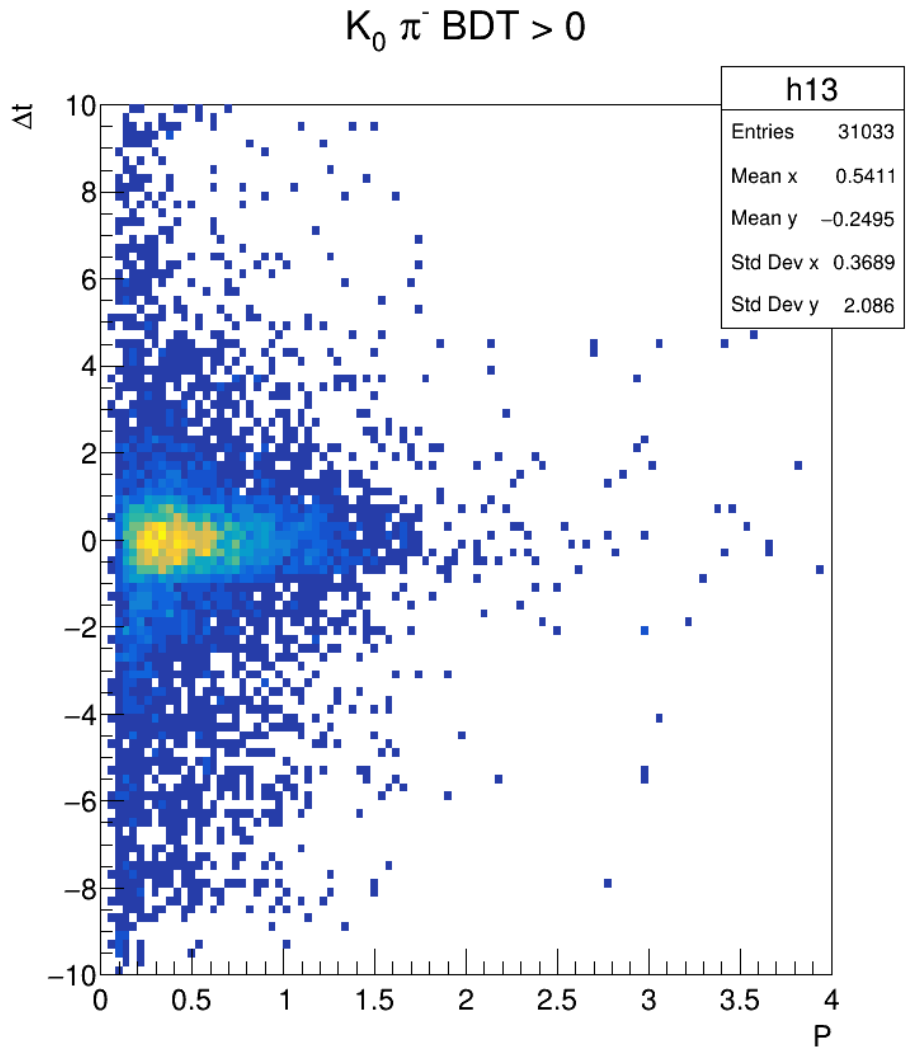
π^- from Λ



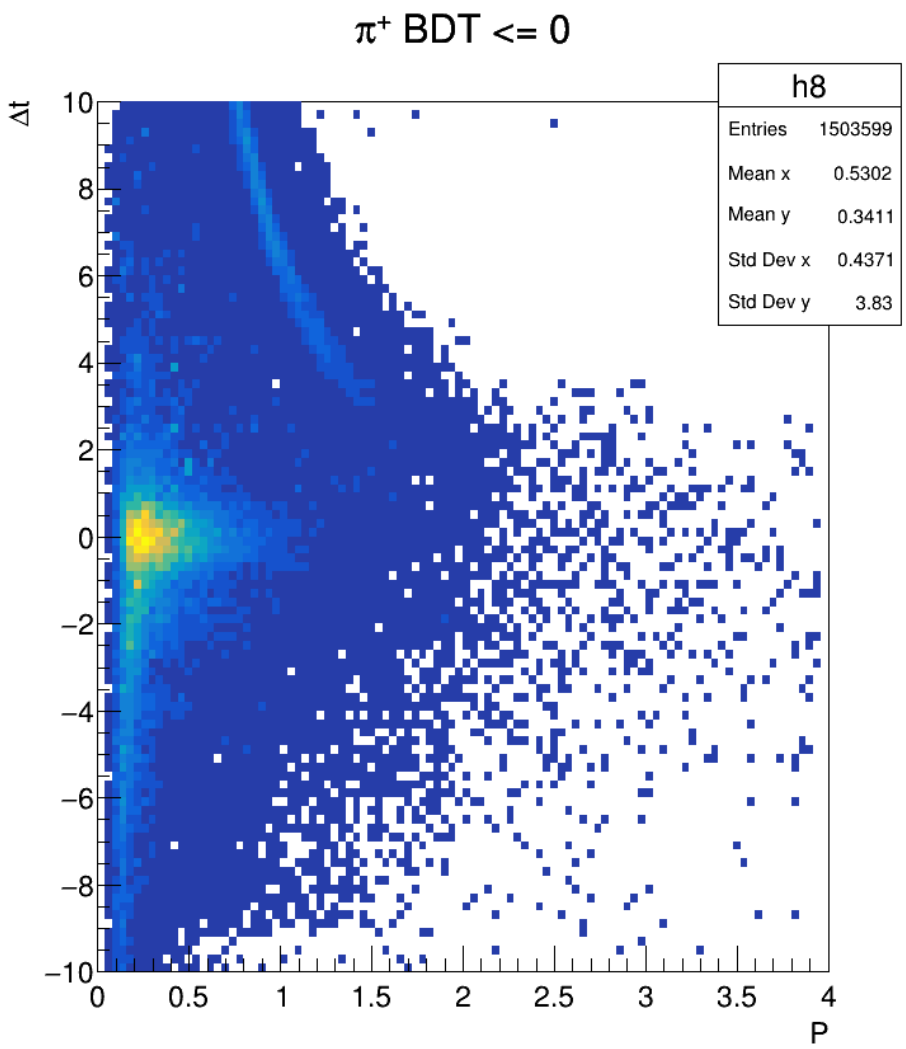


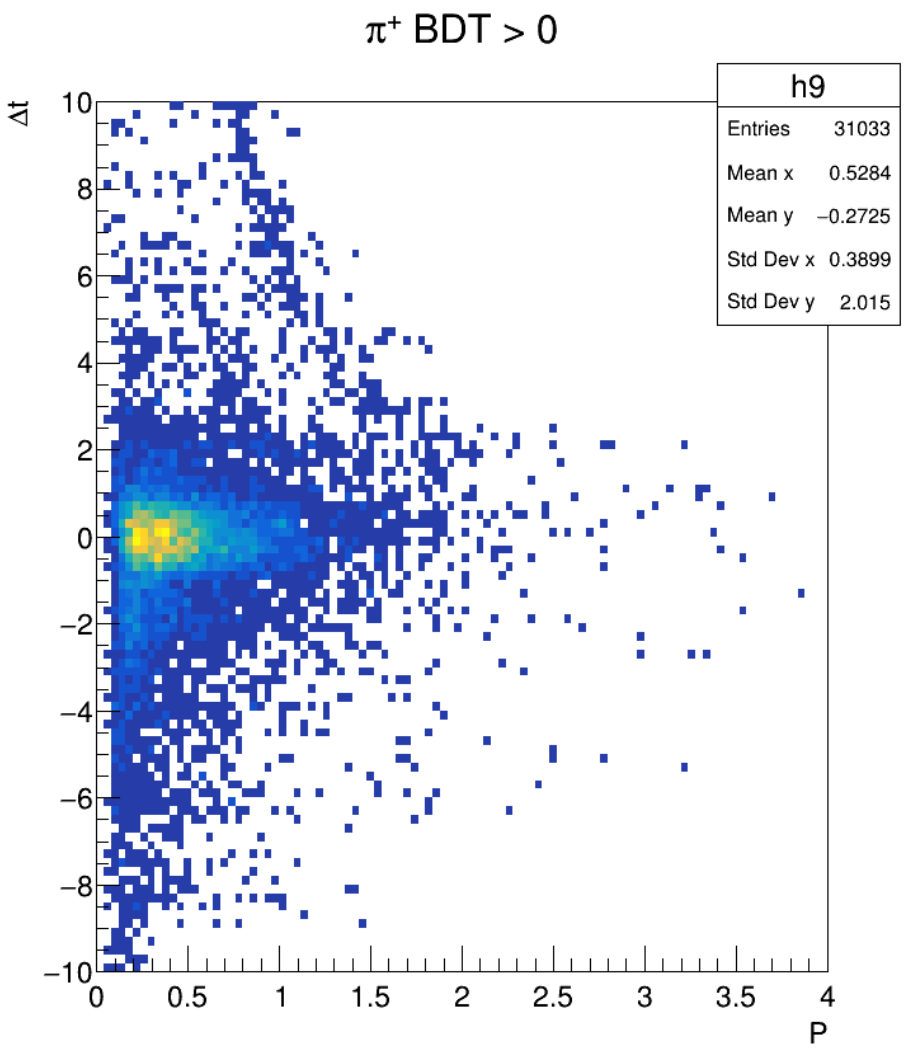
π^- from K_0

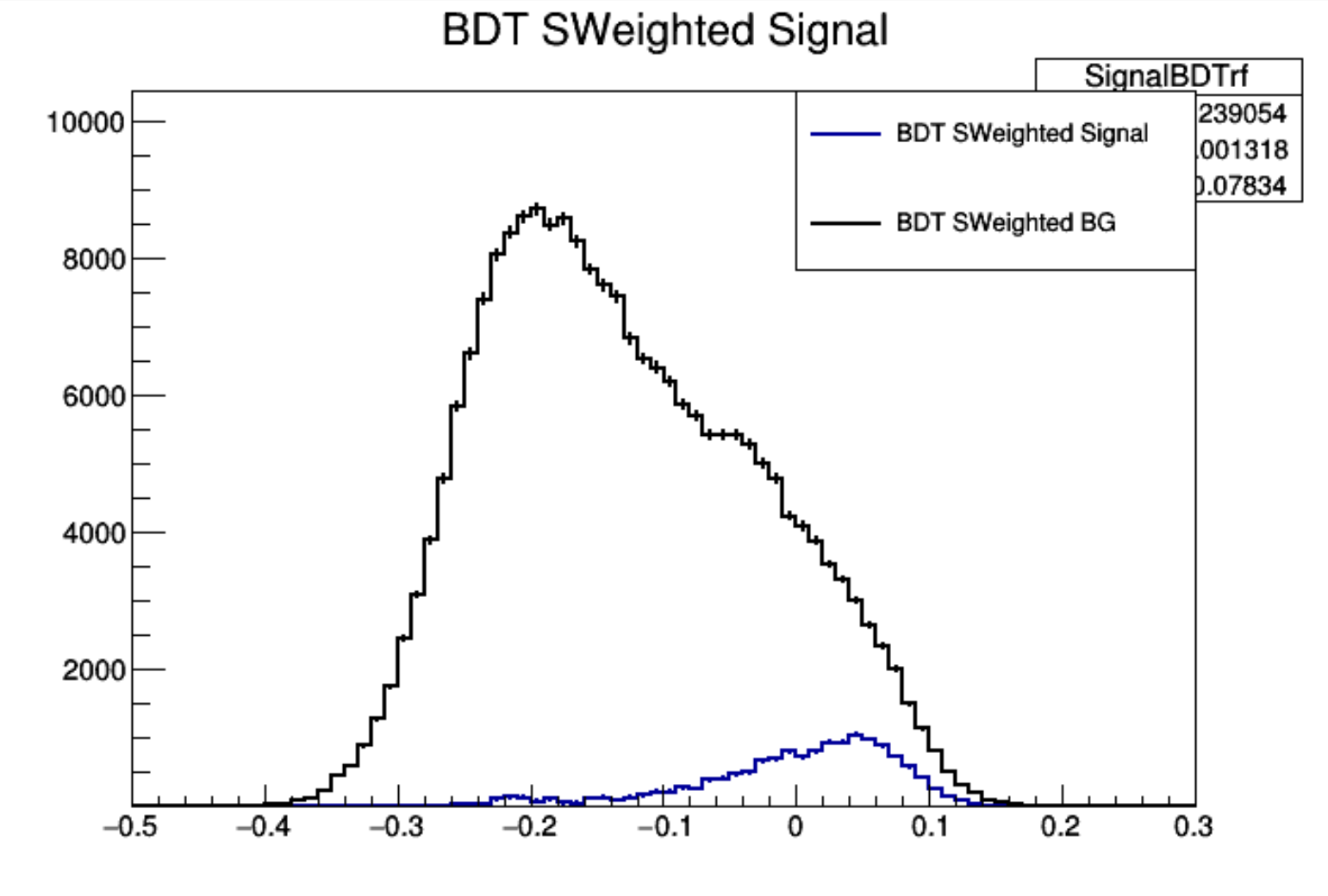

K0 π- BDT <= 0
h12
Entries 1503599
Mean x 0.4603
Mean y −0.4698
Std Dev x 0.4269
Std Dev y 3.198
Δt
P

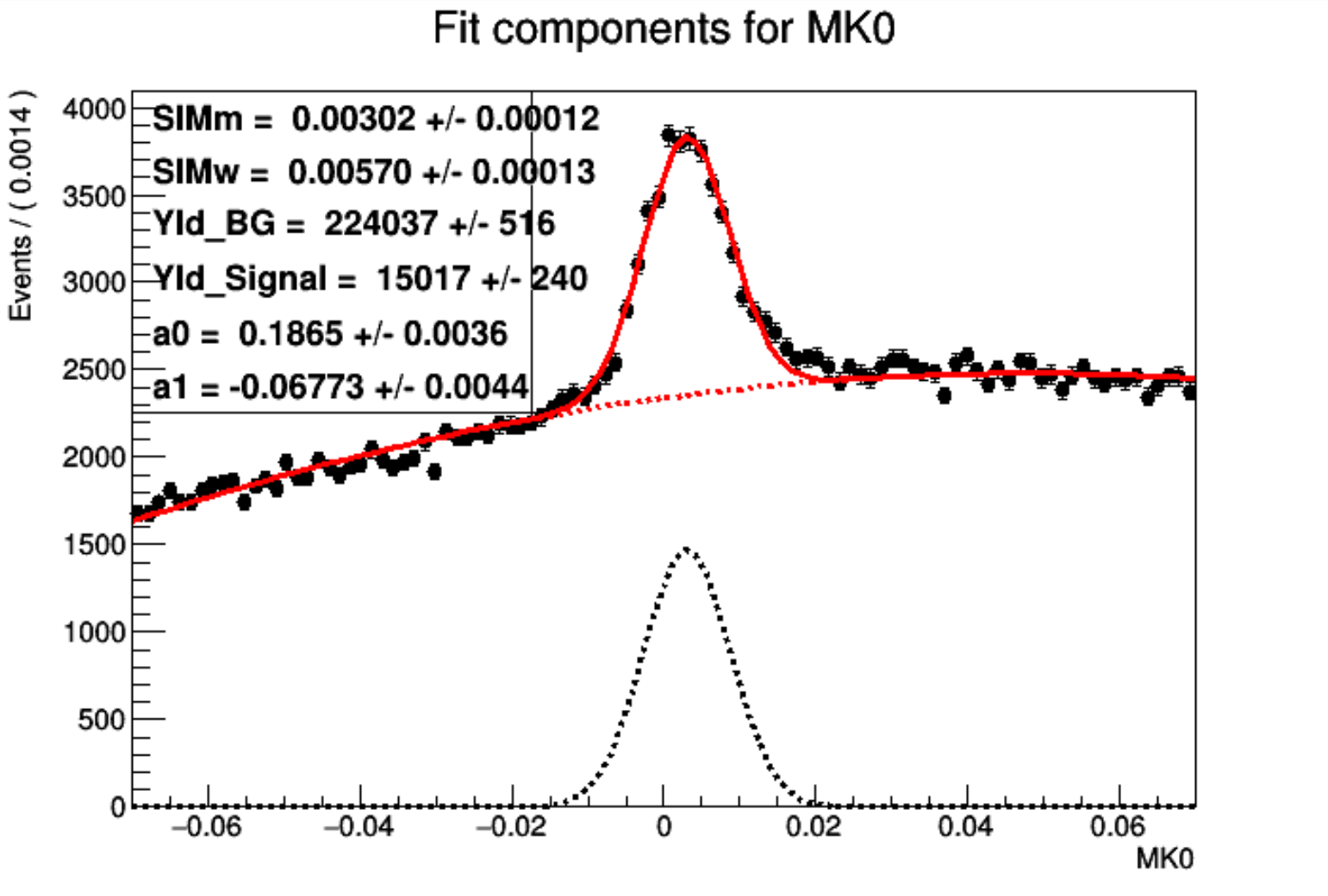

K0 π- BDT > 0
h13
Entries 31033
Mean x 0.5411
Mean y −0.2495
Std Dev x 0.3689
Std Dev y 2.086
Δt
P

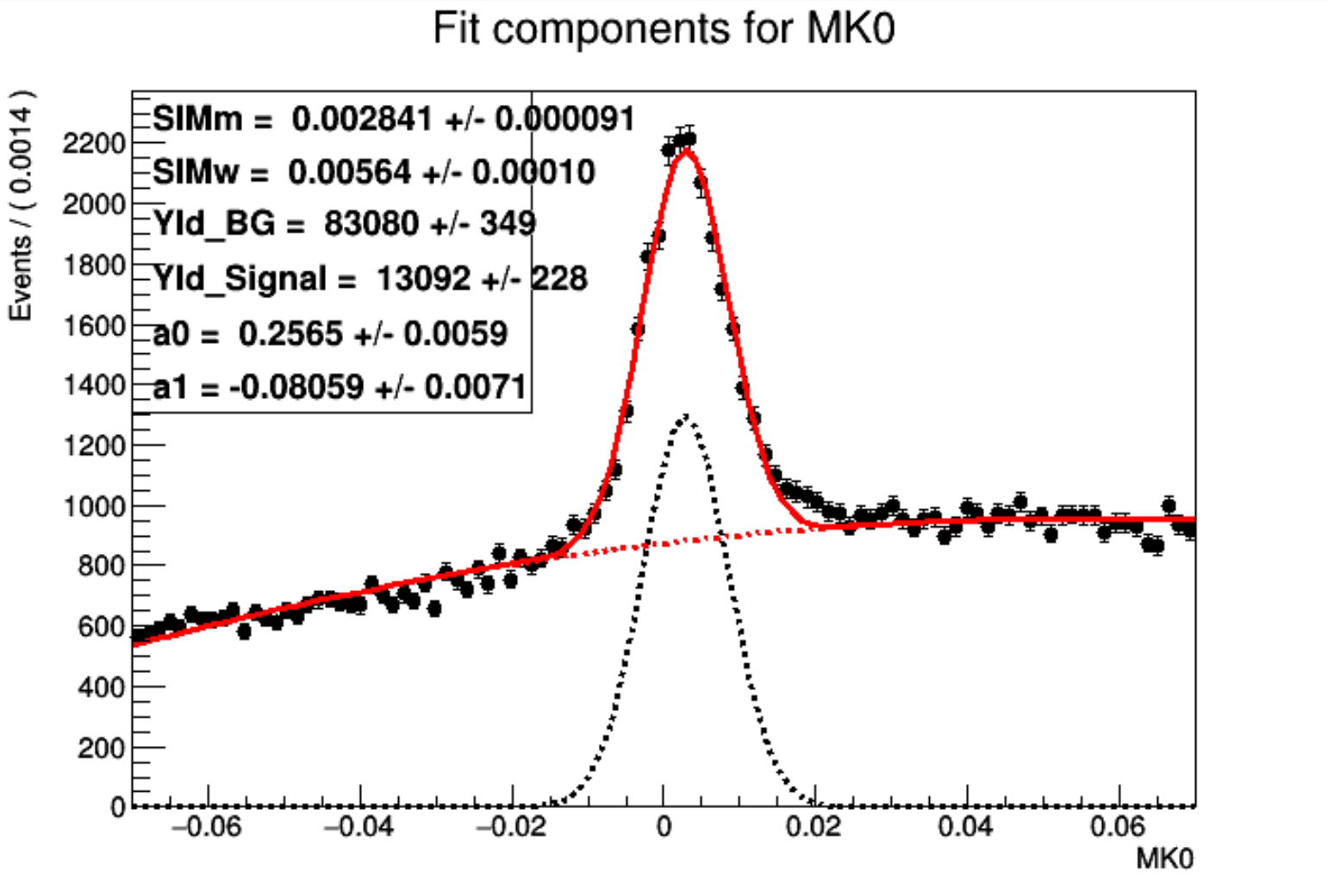
π^+

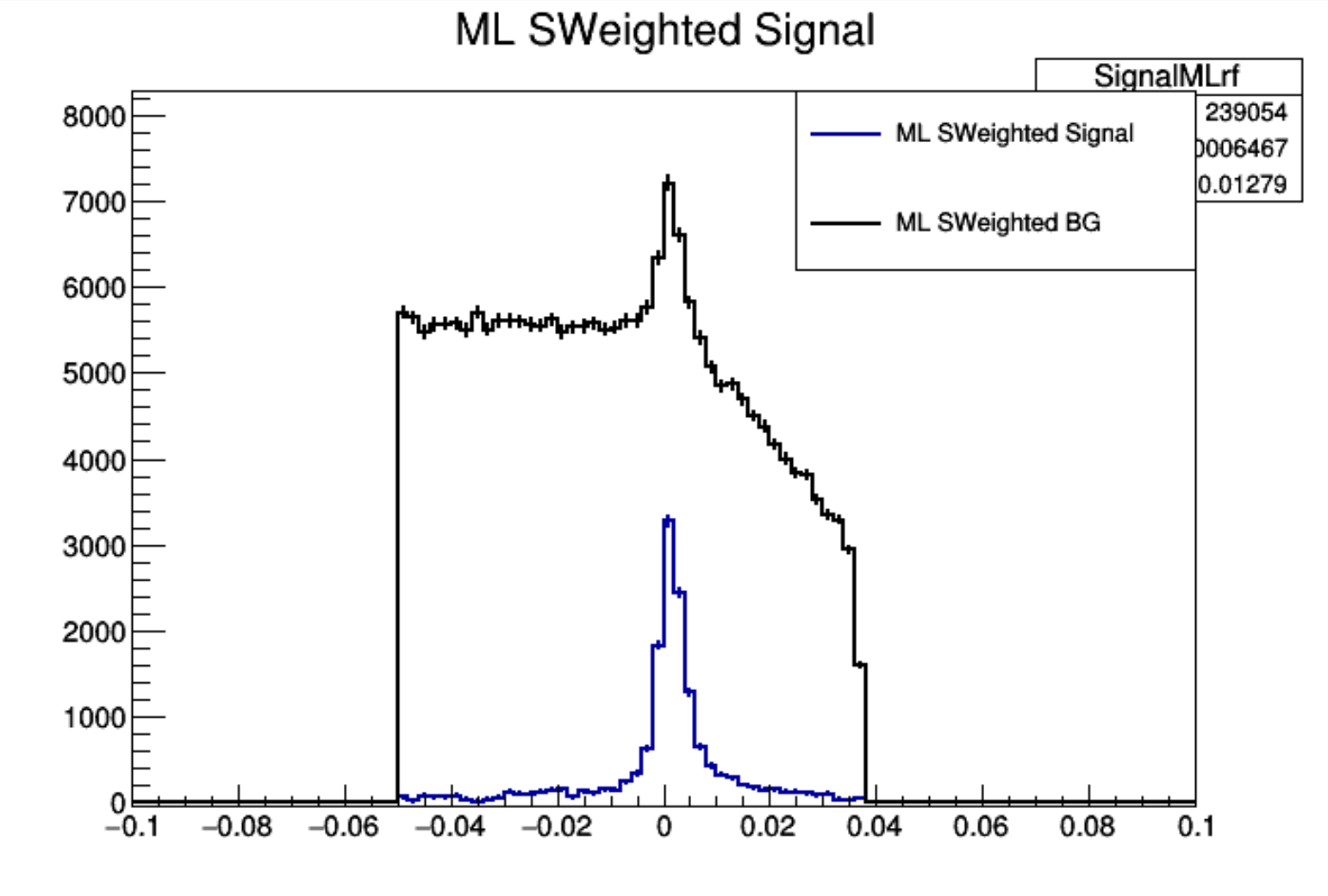

π⁺ BDT <= 0
h8
Entries 1503599
Mean x 0.5302
Mean y 0.3411
Std Dev x 0.4371
Std Dev y 3.83
Δt
P


π⁺ BDT > 0
h9
Entries 31033
Mean x 0.5284
Mean y −0.2725
Std Dev x 0.3899
Std Dev y 2.015
Δt
P


BDT SWeighted Signal
SignalBDTrf
239054
001318
0.07834
BDT SWeighted Signal
BDT SWeighted BG
10000
8000
6000
4000
2000
−0.5
−0.4
−0.3
−0.2
−0.1
0
0.1
0.2
0.3


Fit components for MK0
SIMm = 0.00302 +/- 0.00012
SIMw = 0.00570 +/- 0.00013
Yld_BG = 224037 +/- 516
Yld_Signal = 15017 +/- 240
a0 = 0.1865 +/- 0.0036
a1 = -0.06773 +/- 0.0044
Events / (0.0014)
4000
3500
3000
2500
2000
1500
1000
500
0
−0.06
−0.04
−0.02
0
0.02
0.04
0.06
MK0


Fit components for MK0
SIMm = 0.002841 +/- 0.000091
SIMw = 0.00564 +/- 0.00010
Yld_BG = 83080 +/- 349
Yld_Signal = 13092 +/- 228
a0 = 0.2565 +/- 0.0059
a1 = -0.08059 +/- 0.0071
Events / (0.0014)
2200
2000
1800
1600
1400
1200
1000
800
600
400
200
0
−0.06
−0.04
−0.02
0
0.02
0.04
0.06
MK0


ML SWeighted Signal
SignalMLrf
239054
0006467
0.01279
ML SWeighted Signal
ML SWeighted BG
8000
7000
6000
5000
4000
3000
2000
1000
0
−0.1
−0.08
−0.06
−0.04
−0.02
0
0.02
0.04
0.06
0.08
0.1