```C++
// pt                          0,   1,   2,   3,   4,   5,   6,   7,   8,   9,  10,  11,  12
    double pTbin[14] = {0.2, 0.4, 0.6, 0.8, 1.0, 1.4, 1.8, 2.2, 2.8, 3.6, 4.6, 6.0, 7.0, 8.5};
// cent                     0,  1,   2,   3,   4
    int centBin[6] = {0, 20, 60, 100, 160, 200};
```

Samples

Data (HIMB4 RERECO)	`/HIMinimumBias4/qwang-V0Skim_v3-9d53152409b8a9b6fb15042030d9bf69/USER`
MC (Semi-private RECODEBUG)	`/MinBias_Hydjet_Drum5F_2018_5p02TeV/qwang-crab_HydjetDrum5F_RECODEBUG_V0Skim_v2-4fb2a1ba2f6b043399c08fb9db565e25/USER`
Data (HIMB19 RERECO WrongSign)	`/HIMinimumBias19/qwang-V0Skim_v3-5f932986cf38f9e8dbd6c3aea7f6c2b4/USER`

BDT

Training strategy

- Signal is from MC.
- Backgound is from either Data (WrongSign or SideBand) or MC.
  - WrongSign, two daughters with the same charge sign.
  - SideBand, for K_s with (mass<0.489 || mass>0.506), for Λ with (mass<1.1095 || mass>1.122).
- 250 DTs, Depth = 3, AdaptiveBoost.
  `H:!V:NTrees=250:MinNodeSize=2.5%:MaxDepth=3:BoostType=AdaBoost:AdaBoostBeta=0.5:UseBaggedBoost:BaggedSampleFraction=0.5:SeparationType=Gi`

Variables

Train Variable	description
pt	p_T
rapidity	y
vtxChi2	vertex Chi2
cosThetaXYZ	Cosine 3D pointing angle θ
Lxyz	3D decay length
vtxDecaySigXYZ	3D vertex significance
DCA	Distance of the closest approach
pTrkNHit	NHit of the positive daughter track
pTrkPt	p_T of the positive daughter track
pTrkPtError	p_T error of the positive daughter track
pTrkEta	η of the positive daughter track
pTrkNPxLayer	NPixel layer with hits of the positive daughter track
pTrkDCASigXY	transverse DCA significance of the positive daughter track
pTrkDCASigZ	longitudinal DCA significance of the positive daughter track
nTrkNHit	NHit of the negative daughter track
nTrkPt	p_T of the negative daughter track
nTrkPtError	p_T error of the negative daughter track
nTrkEta	η of the negative daughter track
nTrkNPxLayer	NPixel layer with hits of the negative daughter track
nTrkDCASigXY	transverse DCA significance of the negative daughter track
nTrkDCASigZ	longitudinal DCA significance of the negative daughter track
Cent	centrality bin

Spectator Variable	description
mass	V0 particle mass
eta	V0 particle η
phi	V0 particle ϕ
pdgId	V0 particle pdgId

Training sets

Name	Description
MCFull	MC signal + MC background, full eta range.
MCrap1	MC signal + MC background, limit V0 rapidity $\|\|y\|\| < 1.$.
DataWSrap1	MC signal + data wrong sign background, limit V0 rapidity $\|\|y\|\| < 1.$.
DataSBrap1	MC signal + data side-band background, limit V0 rapidity $\|\|y\|\| < 1.$.

Λ BDT Performance

Centrality 0-10%

	MCFull	MCrap1	DataWSrap1	DataSBrap1
$1.0 < p_T < 1.4$	NA	NA	NA	NA
$1.4 < p_T < 1.8$	almost NA	almost NA	almost NA 110/1,500	almost NA 105/1,500
$1.8 < p_T < 2.2$	120(NA)/30,000	108(NA)/40,000	115(13.58)/40,000	108(14.14)/40,000
$2.2 < p_T < 2.8$	110(17.38)/100,000	103(20.51)/100,000	109(19.64)/100,000	103(19.84)/100,000
$2.8 < p_T < 3.6$	104(17.18)/100,000	104(18.68)/100,000	104(18.44)/100,000	103(18.37)/100,000
$3.6 < p_T < 4.6$	108(11.11)/40,000	103(11.93)/40,000	106(11.65)/40,000	101(11.76)/40,000
$4.6 < p_T < 6.0$	109(5.42)/10,000	102(5.82)/10,000	108(5.66)/10,000	101(5.72)/10,000
$6.0 < p_T < 7.0$	110(1.86)/1,500	104(2.01)/1,400	111(1.88)/1,500	104(1.95)/1,300
$7.0 < p_T < 8.5$	110(1.37*)/600	103(1.23)/550	110(*)/600	103(1.23*)/600

Centrality 10-30%

	MCFull	MCrap1	DataWSrap1	DataSBrap1
$1.0 < p_T < 1.4$	NA	NA	NA	NA
$1.4 < p_T < 1.8$	almost NA	100(NA)/5,000	almost NA 110/4,200	almost NA 100/5,000
$1.8 < p_T < 2.2$	120(NA)/70,000	110(17.8*)/70,000	110(*)/90,000	107()/80,000
$2.2 < p_T < 2.8$	111(23.04)/180,000	107(25.21)/180,000	110(24.85)/170,000	109(24.95)/160,000
$2.8 < p_T < 3.6$	109(21.18)/150,000	105(22.32)/140,000	108(22.21)/140,000	105(22.19)/150,000
$3.6 < p_T < 4.6$	112(14.23)/65,000	105(14.82)/65,000	108(14.70)/65,000	105(14.73)/65,000
$4.6 < p_T < 6.0$	114(7.41)/20,000	104(7.69)/20,000	110(7.64)/19,000	103(7.68)/20,000
$6.0 < p_T < 7.0$	119(2.72)/2,600	108(2.83)/2,600	114(2.79)/2,800	104(2.81)/2,800
$7.0 < p_T < 8.5$	115(1.86)/1,300	109(1.82)/1,200	110(*)/1,300	109(1.82)/1,200

Centrality 30-50%

	MCFull	MCrap1	DataWSrap1	DataSBrap1
$1.0 < p_T < 1.4$	NA	NA	NA	NA
$1.4 < p_T < 1.8$	NA 120()/3,000	110()/1,800	117()/2,000	108()/2,000
$1.8 < p_T < 2.2$	120(12.24)/38,000	115(12.14)/34,000	110()/40,000	110()/40,000
$2.2 < p_T < 2.8$	115(16.79)/80,000	109(17.44)/80,000	111(17.33)/80,000	111(17.37)/80,000
$2.8 < p_T < 3.6$	114(16.29)/80,000	108(16.63)/80,000	108(16.60)/80,000	108(16.58)/80,000
$3.6 < p_T < 4.6$	115(11.29)/40,000	107(11.46)/40,000	109(11.44)/40,000	107(11.44)/40,000
$4.6 < p_T < 6.0$	116(6.32)/14,000	107(6.40)/14,000	109(6.39)/14,000	106(6.40)/14,000
$6.0 < p_T < 7.0$	116(2.54)/2,400	107(2.57)/2,400	114(2.56)/2,400	106(2.57)/2,400
$7.0 < p_T < 8.5$	122(1.69)/1,100	114(1.71)/1,100	117(1.71)/1,100	111(1.72)/1,200

Centrality 50-80%

	MCFull	MCrap1	DataWSrap1	DataSBrap1
$1.0 < p_T < 1.4$	NA	NA	NA	NA
$1.4 < p_T < 1.8$	NA 120()/900	100(2.09)/900	110(1.99)/700	100()/900
$1.8 < p_T < 2.2$	115()/11,000	107(6.85)/11,000	110(6.80)/11,000	108(6.82)/11,000
$2.2 < p_T < 2.8$	106(9.50)/24,000	98(9.60)/24,000	102(9.60)/24,000	101(9.58)/24,000
$2.8 < p_T < 3.6$	107(9.03)/24,000	97(9.09)/24,000	100(9.09)/24,000	98(9.08)/24,000
$3.6 < p_T < 4.6$	107(6.44)/13,000	97(6.48)/13,000	99(6.48)/13,000	99(6.48)/13,000
$4.6 < p_T < 6.0$	113(3.89)/5,000	99(3.90)/5,000	102(3.91)/5,000	102(3.91)/5,000
$6.0 < p_T < 7.0$	110(1.65)/1,000	104(1.65)/1,000	109(1.65)/1,000	101(1.65)/1,000
$7.0 < p_T < 8.5$	116(1.14)/500	110(1.14)/500	110(1.14)/500	109(1.16)/500

Optimization

The Λ selection is suggested to use MCFull at 110(BDT cut = 0.10).

K_s^0 BDT Performance

Centrality 0-10%

	MCFull
$0.2 < p_T < 0.4$	NA
$0.4 < p_T < 0.6$	NA
$0.6 < p_T < 0.8$	115(1.62)/170
$0.8 < p_T < 1.0$	106(5.37)/5,000
$1.0 < p_T < 1.4$	103(25.01)/90,000
$1.4 < p_T < 1.8$	102(37.46)/200,000
$1.8 < p_T < 2.2$	105(38.67)/200,000
$2.2 < p_T < 2.8$	105(35.61)/170,000
$2.8 < p_T < 3.6$	104(23.62)/80,000
$3.6 < p_T < 4.6$	105(12.72)/22,000
$4.6 < p_T < 6.0$	112(6.51)/6,000
$6.0 < p_T < 7.0$	116(2.82)/1,200
$7.0 < p_T < 8.5$	118(2.12)/700

Centrality 10-30%

	MCFull
$0.2 < p_T < 0.4$	NA
$0.4 < p_T < 0.6$	NA
$0.6 < p_T < 0.8$	117(1.64)/300
$0.8 < p_T < 1.0$	112(8.26)/9,000
$1.0 < p_T < 1.4$	106(33.84)/160,000
$1.4 < p_T < 1.8$	108(47.87)/300,000
$1.8 < p_T < 2.2$	109(49.30)/320,000
$2.2 < p_T < 2.8$	110(45.71)/290,000
$2.8 < p_T < 3.6$	108(31.00)/140,000
$3.6 < p_T < 4.6$	109(17.49)/44,000
$4.6 < p_T < 6.0$	112(9.73)/13,000
$6.0 < p_T < 7.0$	114(4.41)/3,000
$7.0 < p_T < 8.5$	116(3.32)/1,700

Centrality 30-50%

	MCFull
$0.2 < p_T < 0.4$	NA
$0.4 < p_T < 0.6$	NA
$0.6 < p_T < 0.8$	115(1.27)/200
$0.8 < p_T < 1.0$	118(6.35)/5,000
$1.0 < p_T < 1.4$	113(25.57)/90,000
$1.4 < p_T < 1.8$	117(37.71)/190,000
$1.8 < p_T < 2.2$	115(37.55)/200,000
$2.2 < p_T < 2.8$	114(34.87)/170,000
$2.8 < p_T < 3.6$	113(24.98)/90,000
$3.6 < p_T < 4.6$	110(15.55)/34,000
$4.6 < p_T < 6.0$	105(10.12)/15,000
$6.0 < p_T < 7.0$	100(5.03)/3,600
$7.0 < p_T < 8.5$	99(3.95)/2,200

Centrality 50-80%

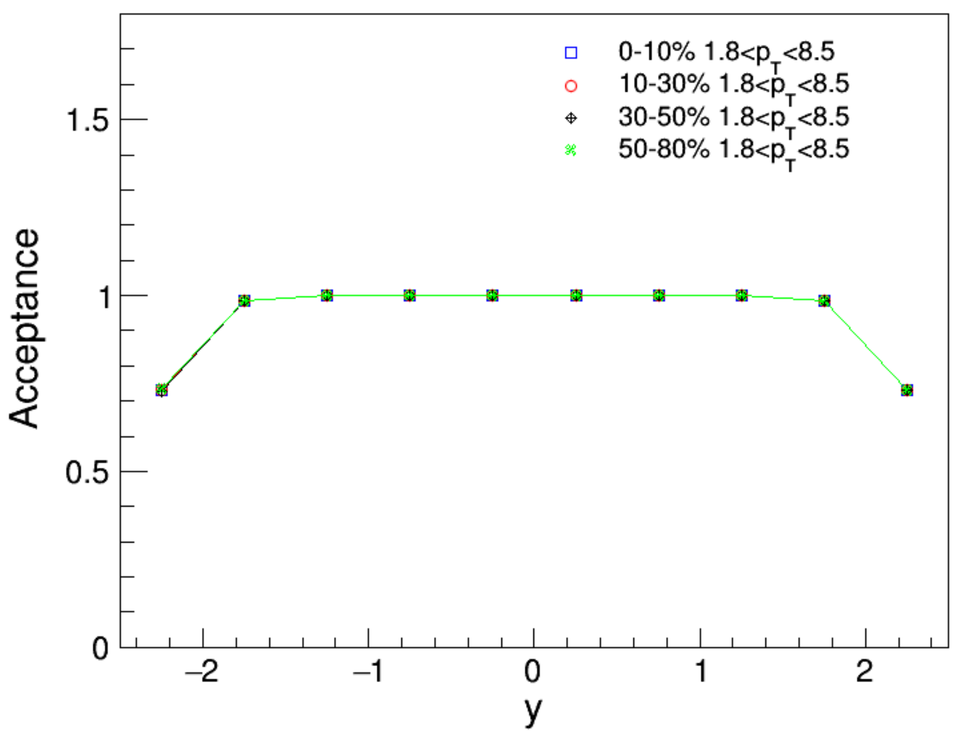
	MCFull
$0.2 < p_T < 0.4$	NA
$0.4 < p_T < 0.6$	NA
$0.6 < p_T < 0.8$	110(*)/80
$0.8 < p_T < 1.0$	115(3.93)/2,000
$1.0 < p_T < 1.4$	113(15.46)/30,000
$1.4 < p_T < 1.8$	112(22.48)/50,000
$1.8 < p_T < 2.2$	112(22.14)/65,000
$2.2 < p_T < 2.8$	110(20.82)/60,000
$2.8 < p_T < 3.6$	107(15.56)/34,000
$3.6 < p_T < 4.6$	111(10.27)/15,000
$4.6 < p_T < 6.0$	95(7.18)/7,000
$6.0 < p_T < 7.0$	94(3.64)/1,700
$7.0 < p_T < 8.5$	87(2.85)/1,000

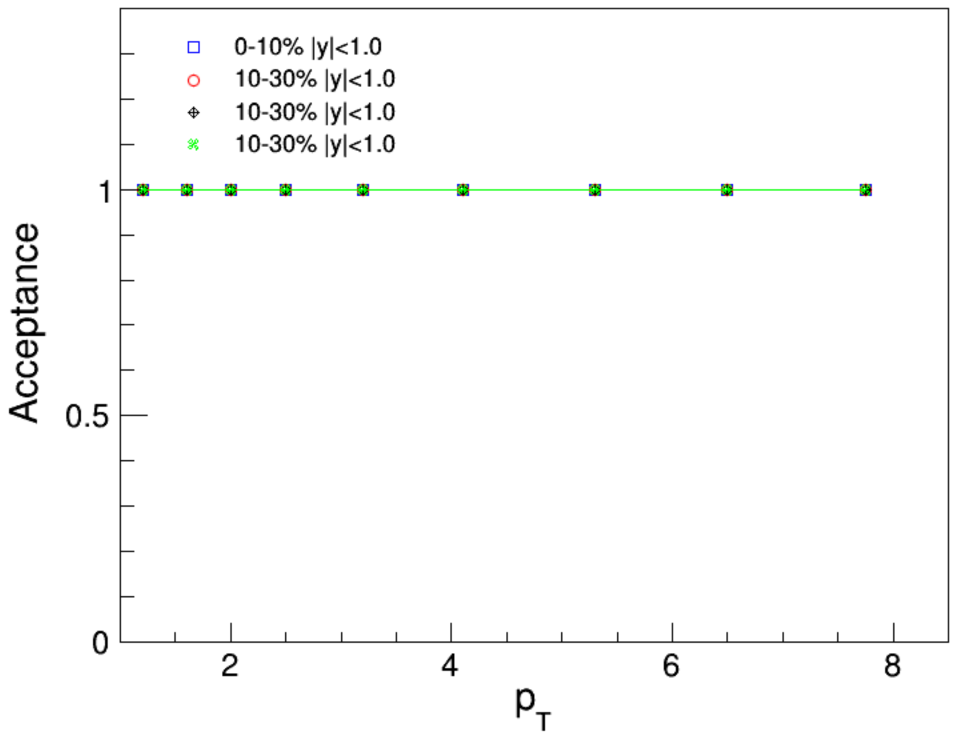
Optimization

The K_S^0 selection is suggested to use MCFull at 110 (BDT cut = 0.10).

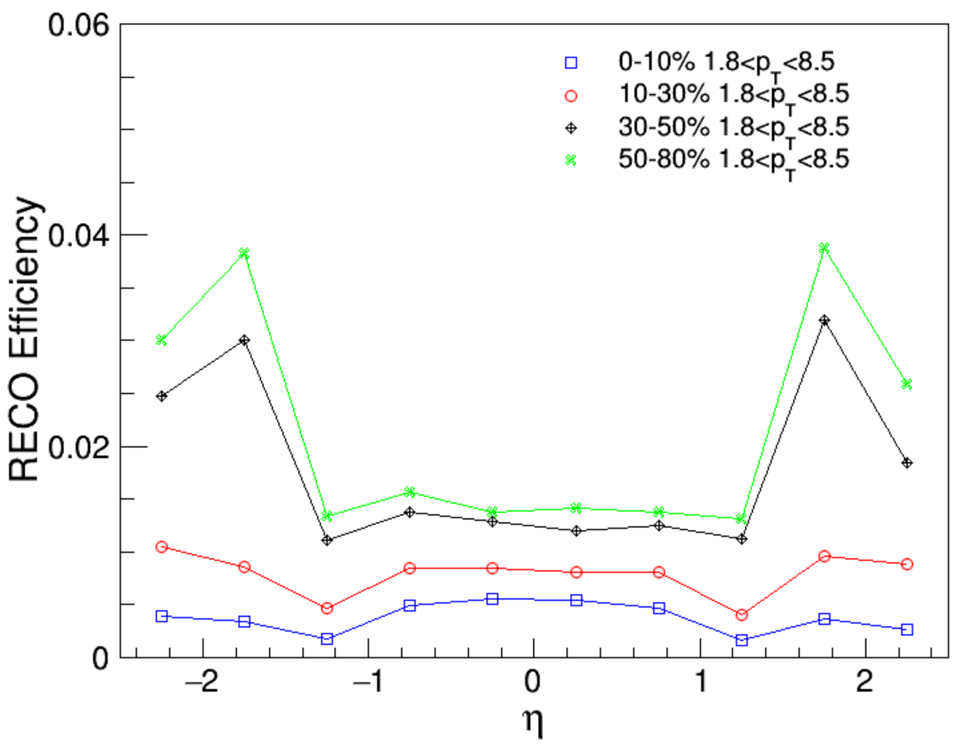
Λ Efficiencies and fake rates

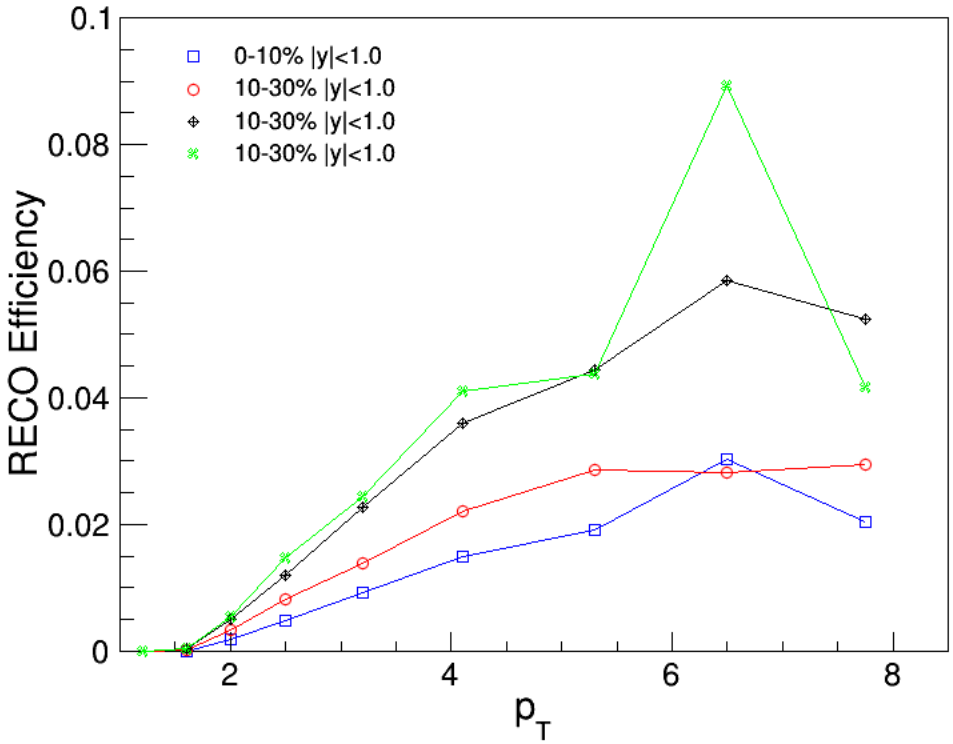
Λ acceptance



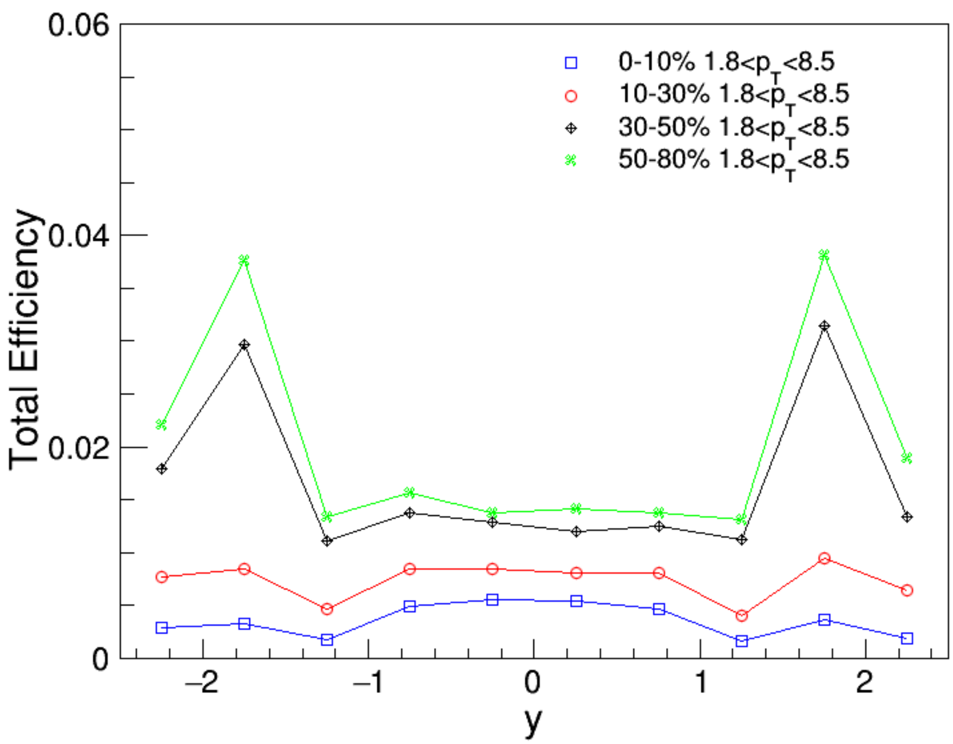


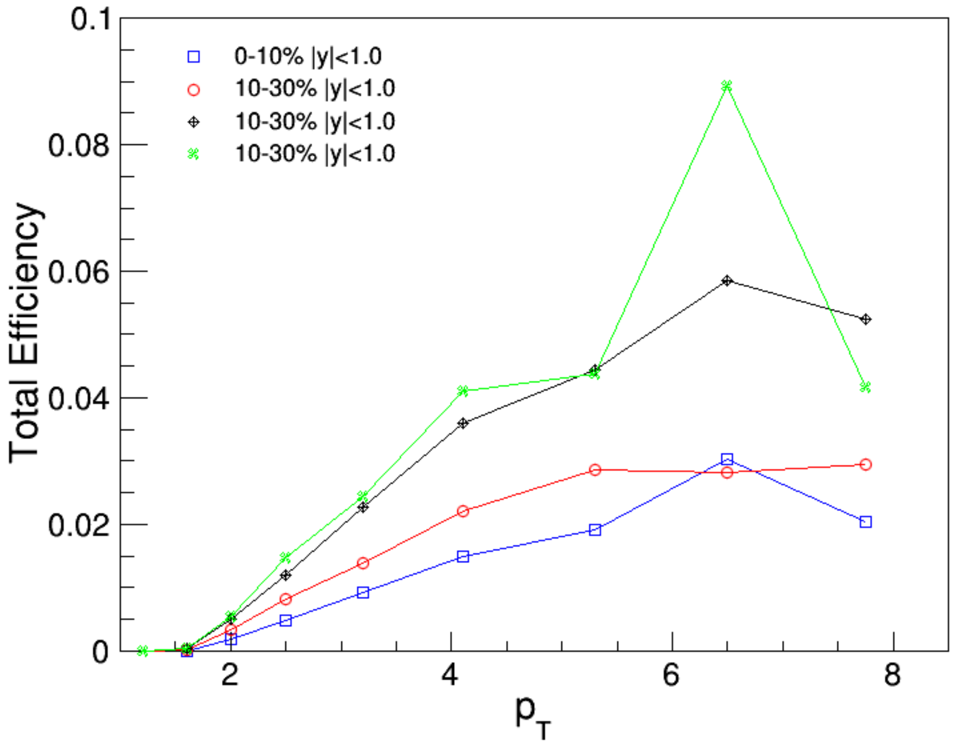
Λ **RECO efficiency**



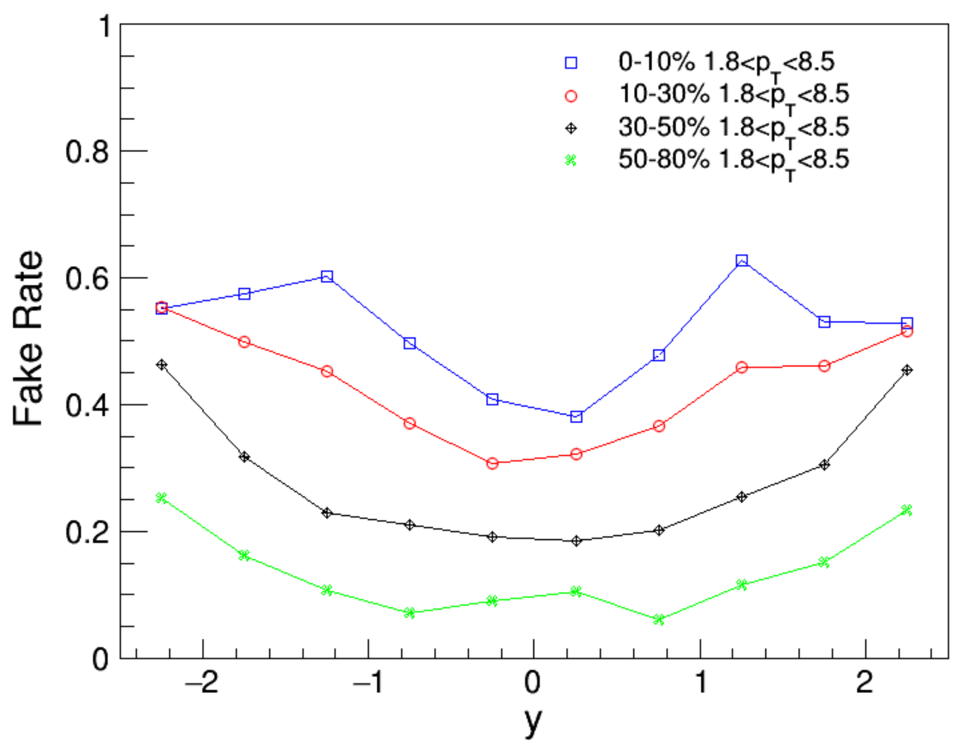


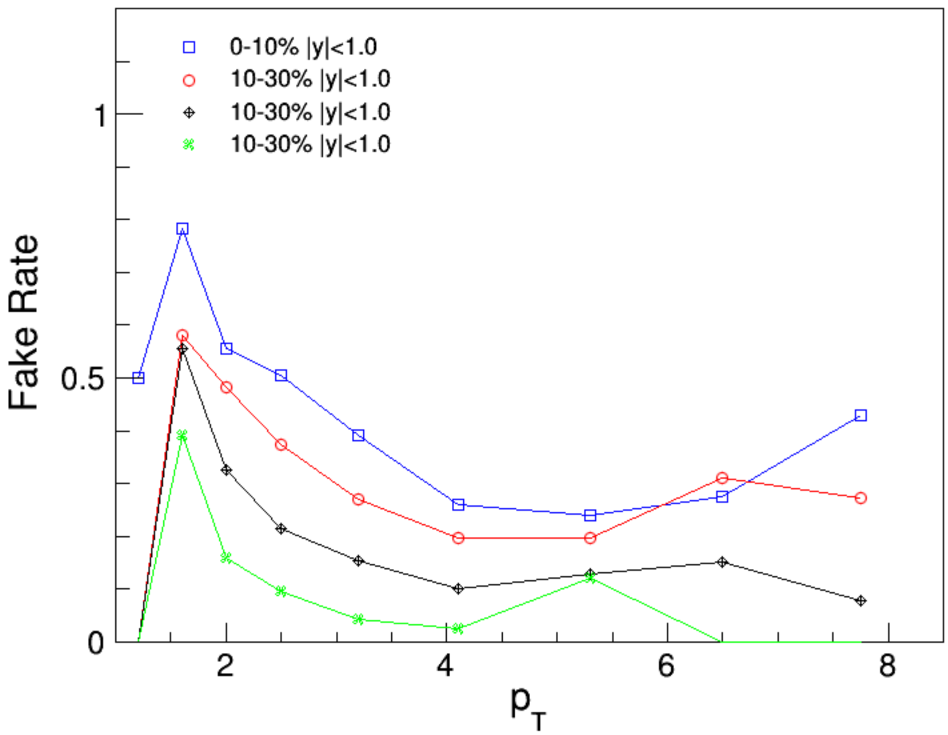
Λ **total efficiency**





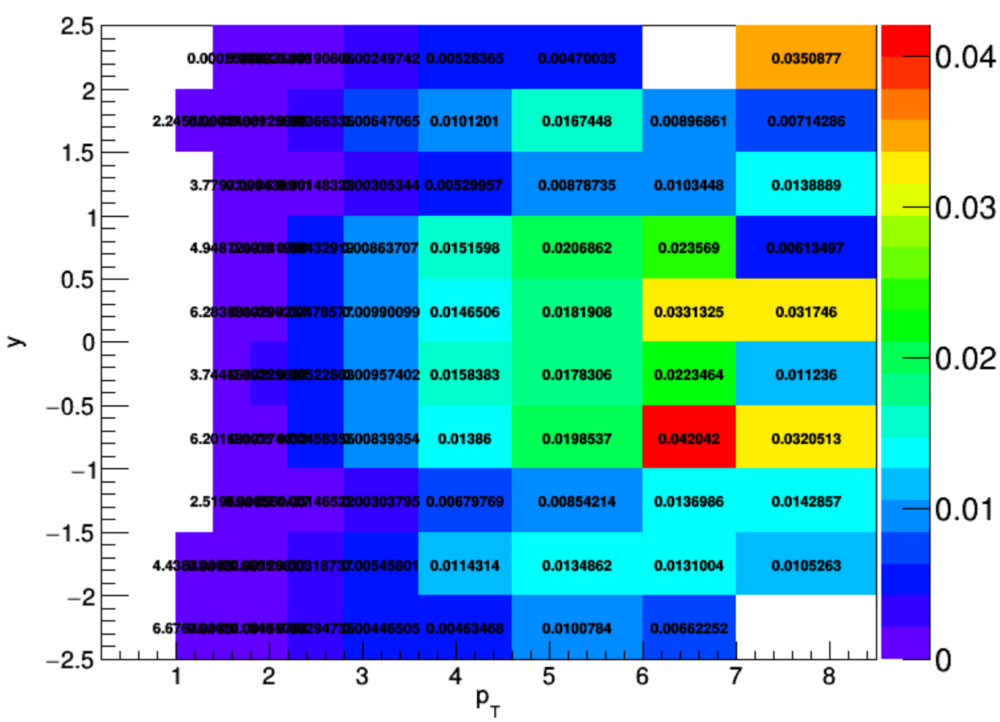
Λ **fake rate**



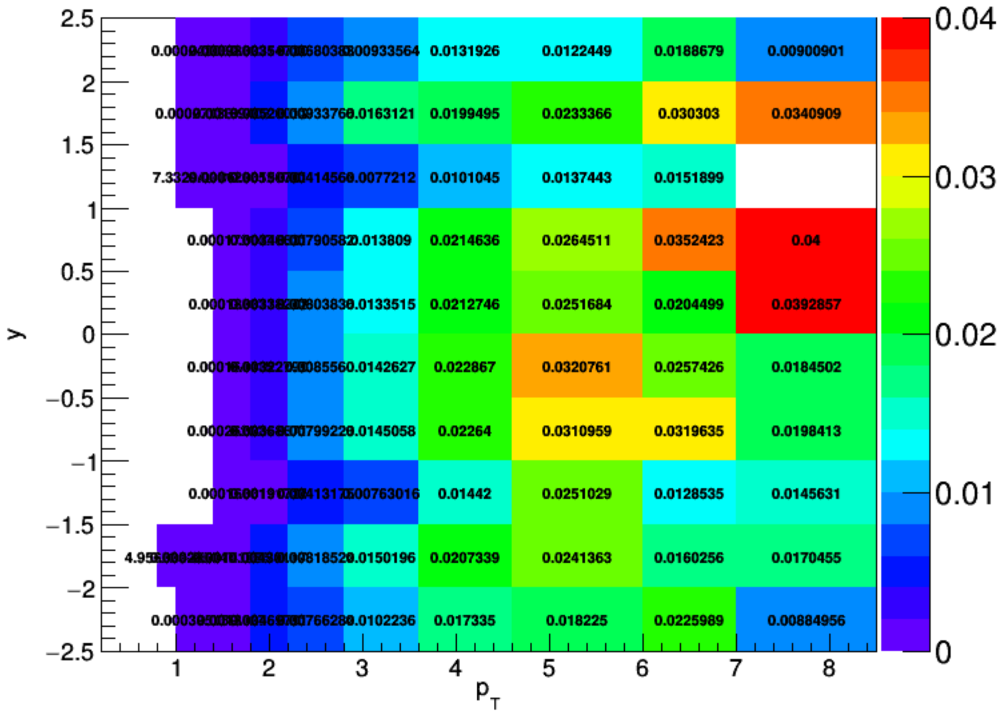


Λ 2D total efficiency

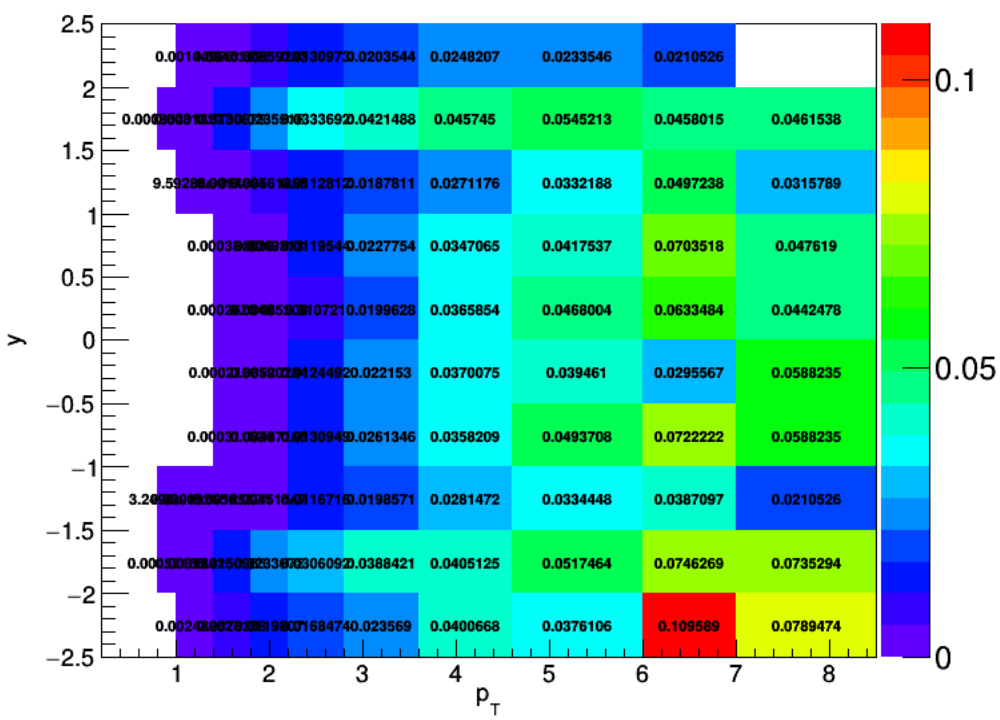
- 0-10%



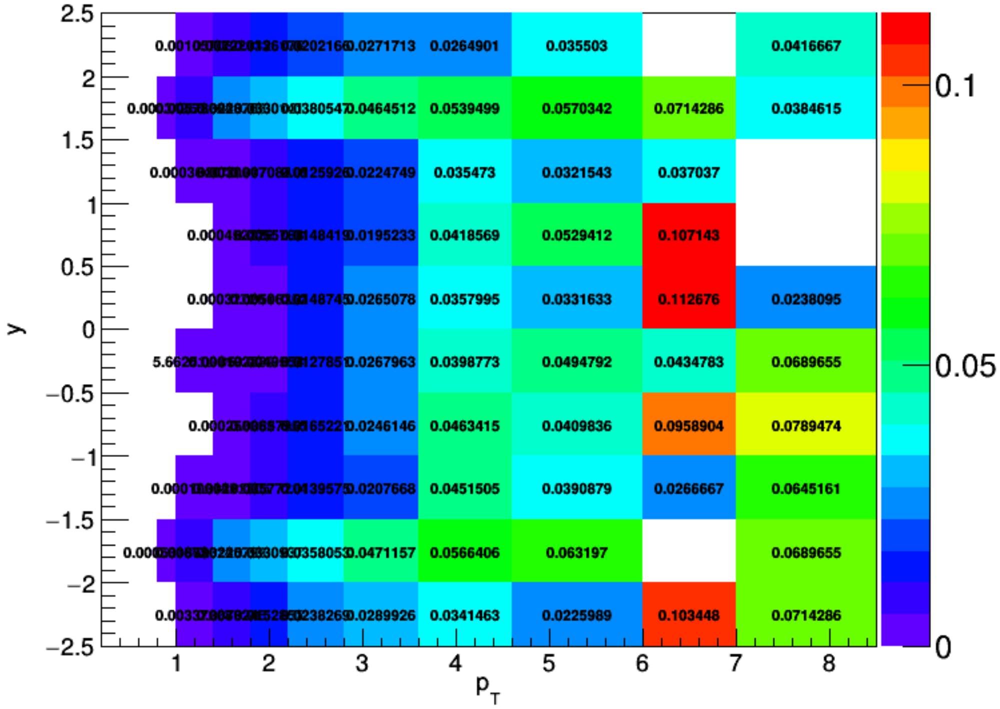
- 10-30%



- 30-50%

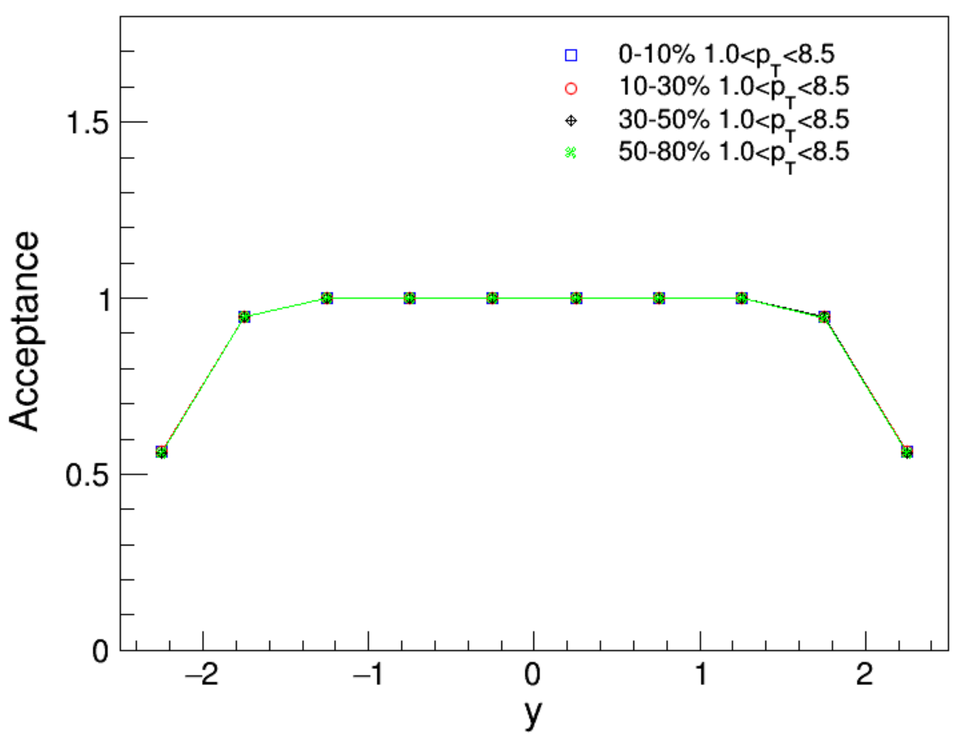


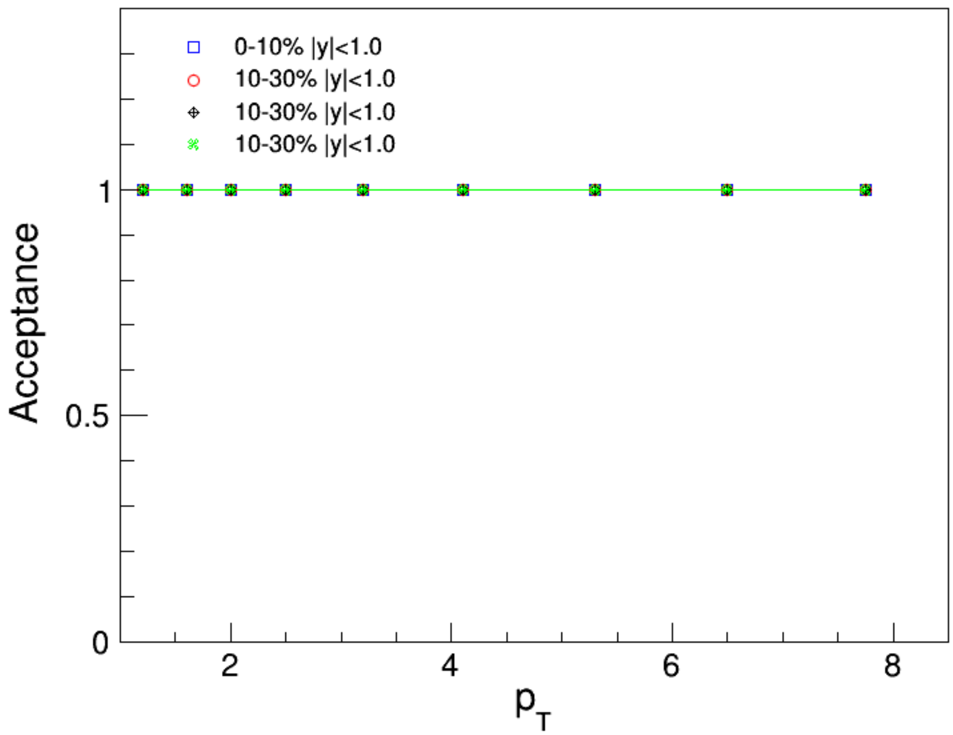
- 50-80%



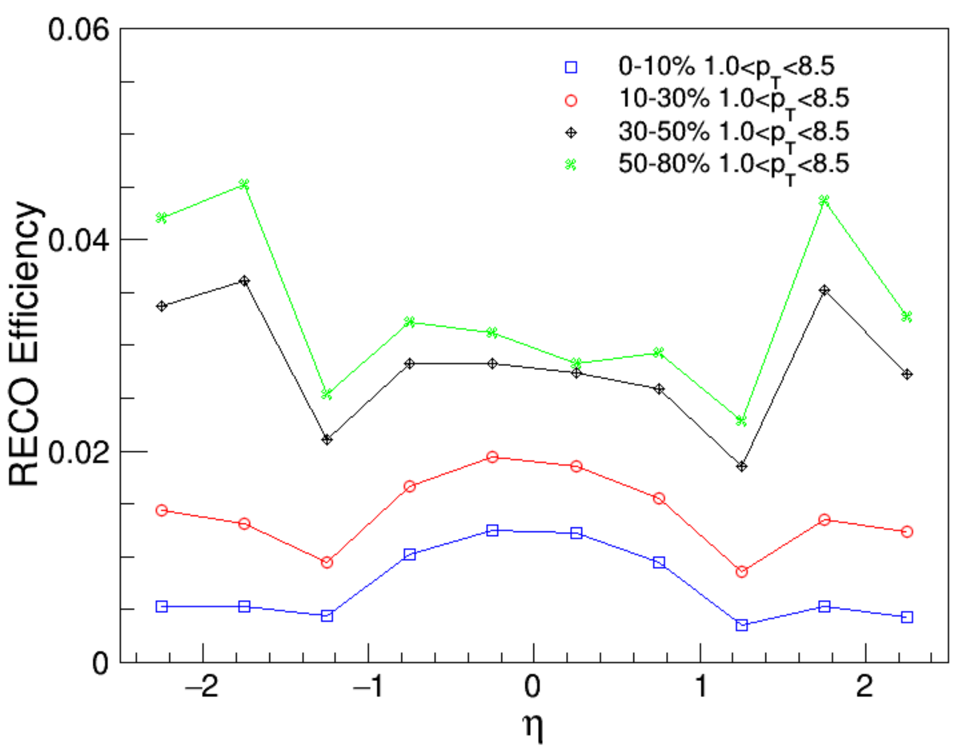
K_S^0 Efficiencies and fake rates

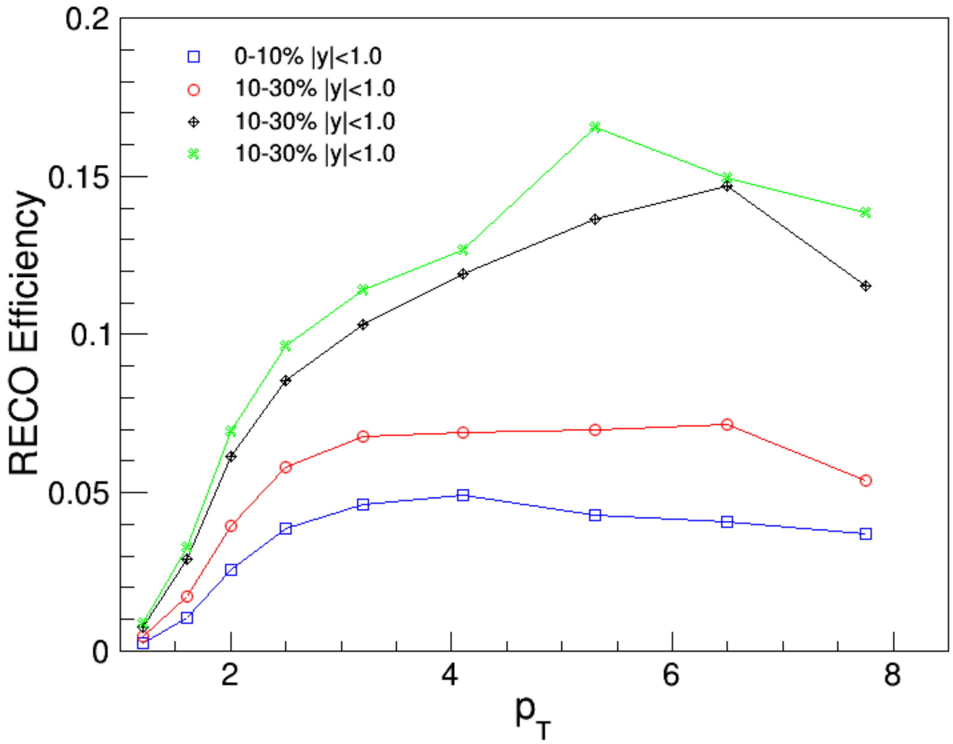
K_S^0 acceptance



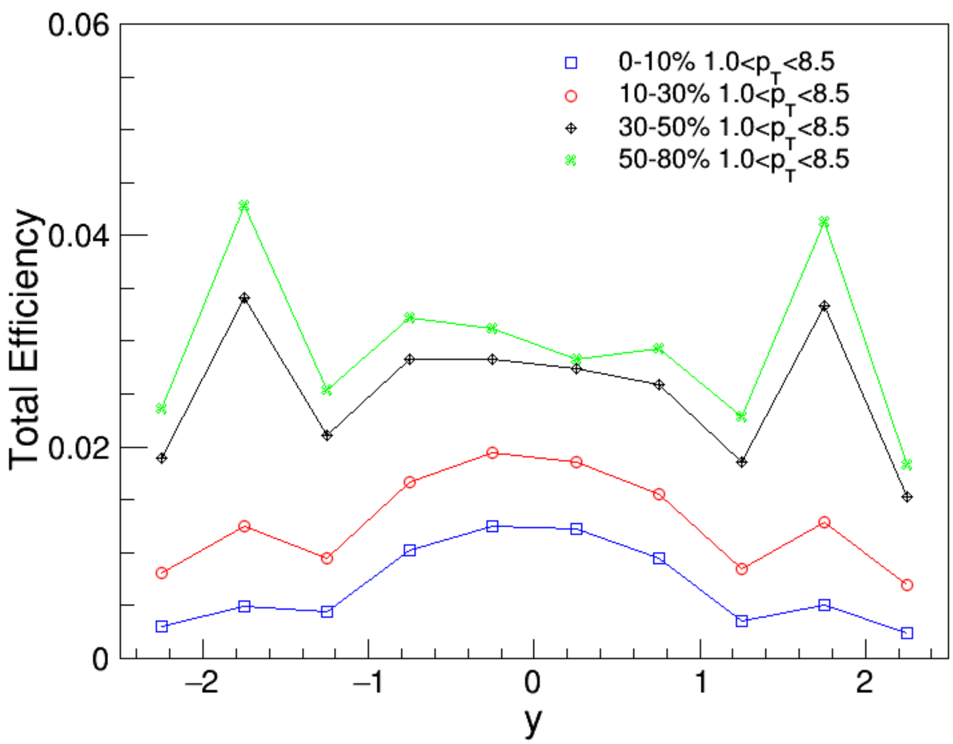


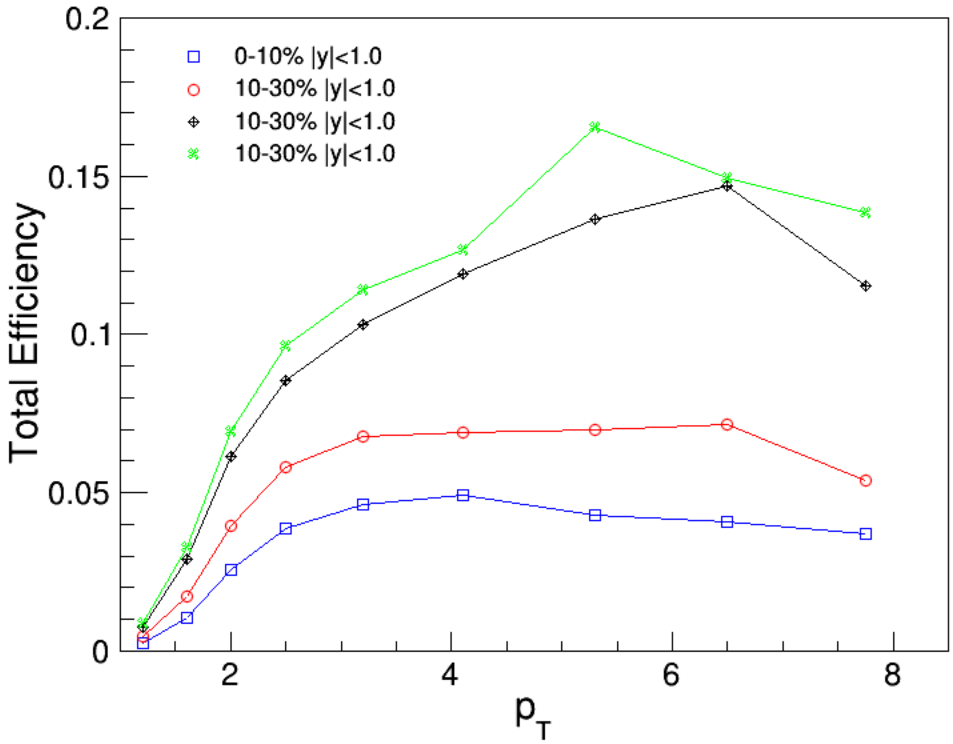
K_S^0 **RECO efficiency**



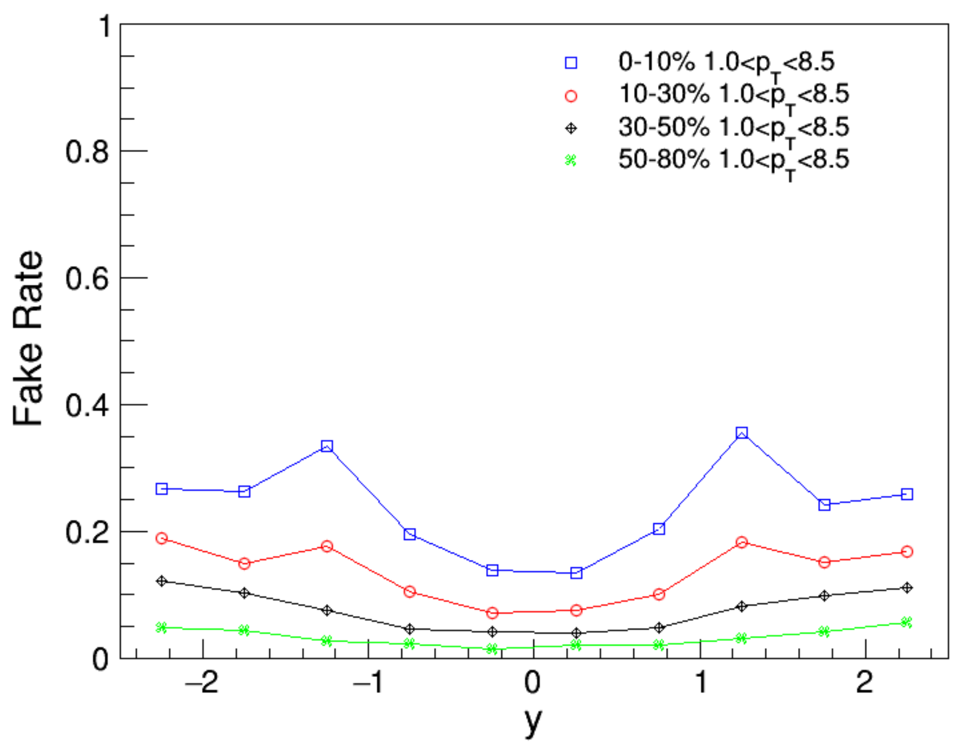


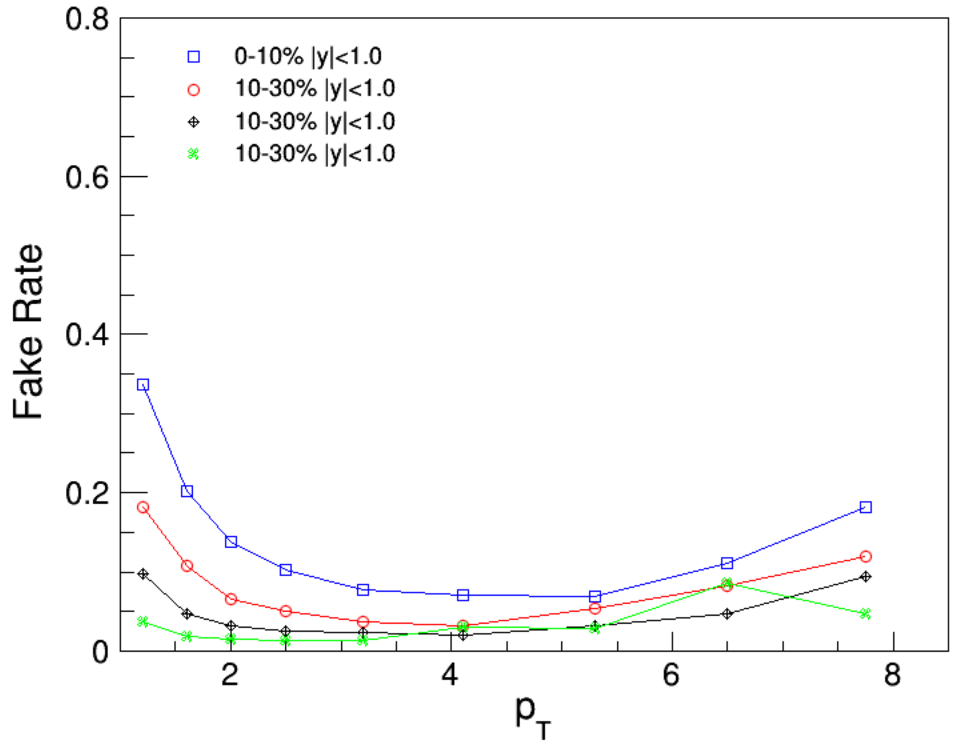
K_S^0 **total efficiency**





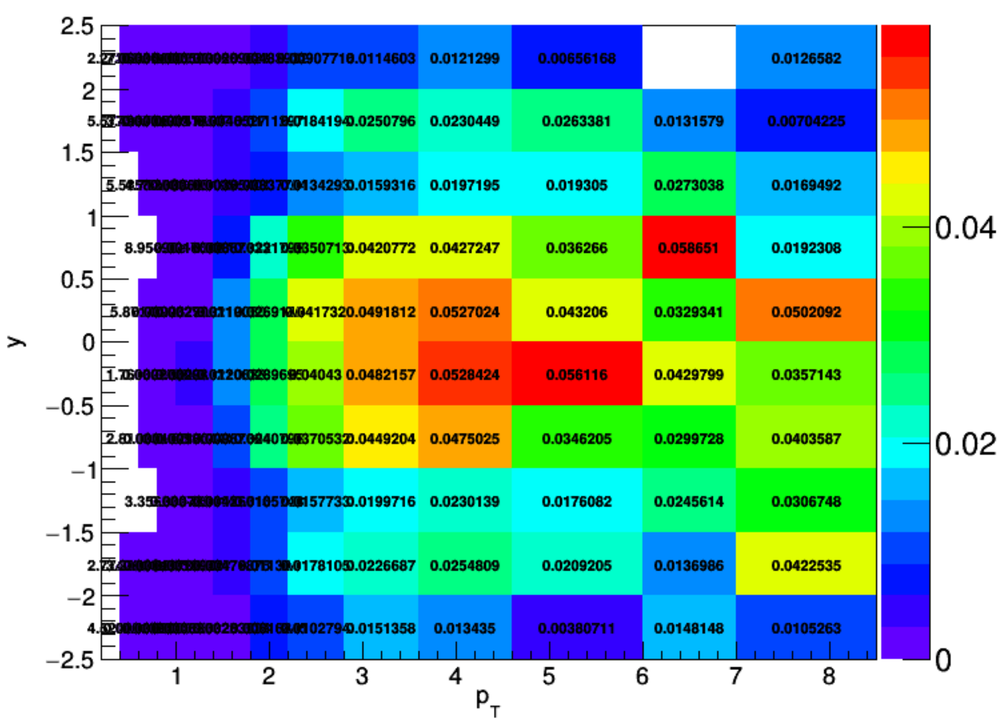
K_S^0 **fake rate**



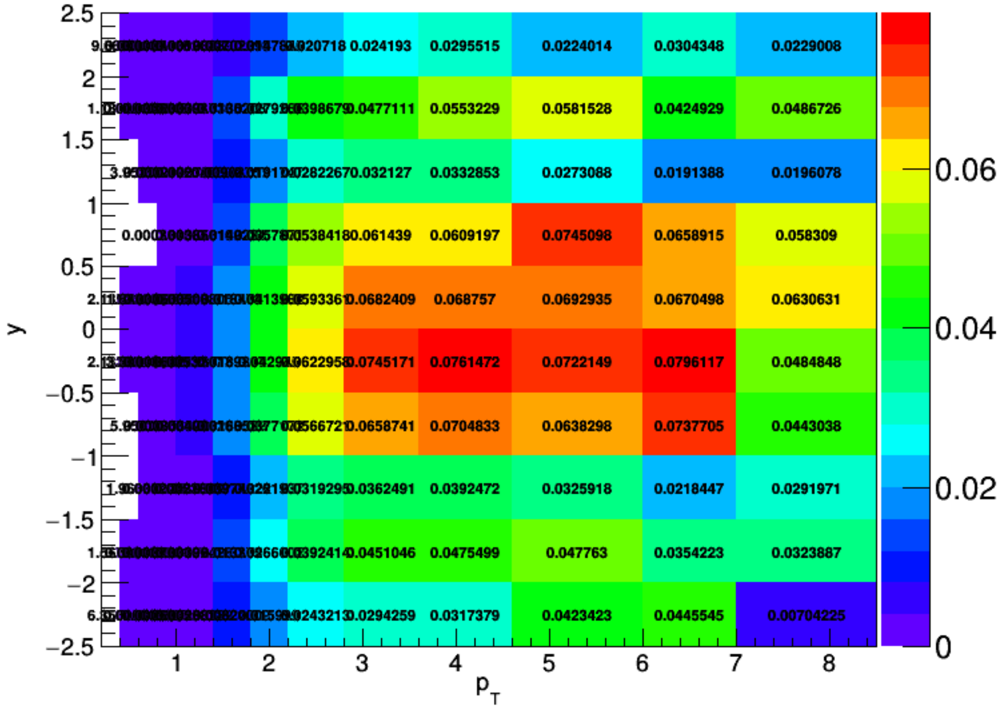


K_S^0 2D total efficiency

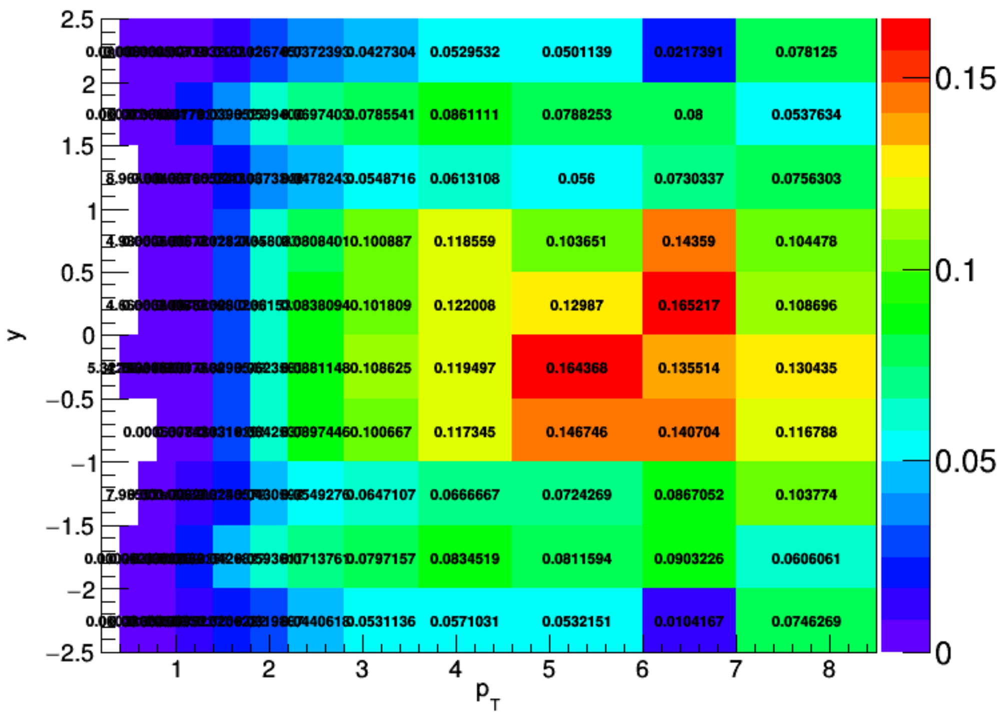
- 0-10%



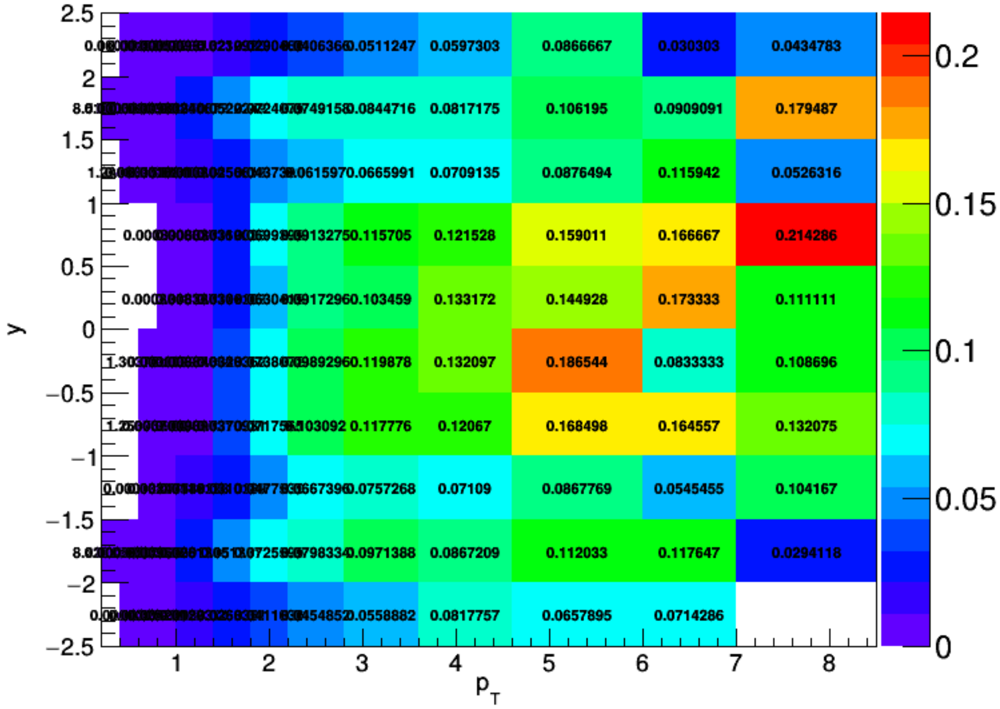
- 10-30%


2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
y
1
2
3
4
5
6
7
8
p_T
0.06
0.04
0.02
0
0.024193 0.0295515 0.0224014 0.0304348 0.0229008
0.0477111 0.0553229 0.0581528 0.0424929 0.0486726
0.032127 0.0332853 0.0273088 0.0191388 0.0196078
0.061439 0.0609197 0.0745098 0.0658915 0.058309
0.0682409 0.068757 0.0692935 0.0670498 0.0630631
0.0745171 0.0761472 0.0722149 0.0796117 0.0484848
0.0658741 0.0704833 0.0638298 0.0737705 0.0443038
0.0362491 0.0392472 0.0325918 0.0218447 0.0291971
0.0451046 0.0475499 0.047763 0.0354223 0.0323887
0.0294259 0.0317379 0.0423423 0.0445545 0.00704225

- 30-50%


2.5
2
1.5
1
0.5
0
−0.5
−1
−1.5
−2
−2.5
y
1
2
3
4
5
6
7
8
p_T
0.15
0.1
0.05
0
0.0427304 0.0529532 0.0501139 0.0217391 0.078125
0.0785541 0.0861111 0.0788253 0.08 0.0537634
0.0548716 0.0613108 0.056 0.0730337 0.0756303
0.100887 0.118559 0.103651 0.14359 0.104478
0.101809 0.122008 0.12987 0.165217 0.108696
0.108625 0.119497 0.164368 0.135514 0.130435
0.100667 0.117345 0.146746 0.140704 0.116788
0.0647107 0.0666667 0.0724269 0.0867052 0.103774
0.0797157 0.0834519 0.0811594 0.0903226 0.0606061
0.0531136 0.0571031 0.0532151 0.0104167 0.0746269

- 50-80%



y
p_T