# Near side Yield from two particle identified triggered correlation in Pb-Pb collisions at $\sqrt{s_{NN}} = 5.02 TeV$

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# Overview of this talk

- Correlation
- Motivation behind the Analysis
- Data set and Analysis cuts
- $K_s^0$ *and* $\Lambda$ triggered correlation function
- Outlook and to do

# Correlation

Correlation may be defined as.

$$R = \frac{\rho(x_1,x_2)}{\rho(x_1)\rho(x_2)}$$

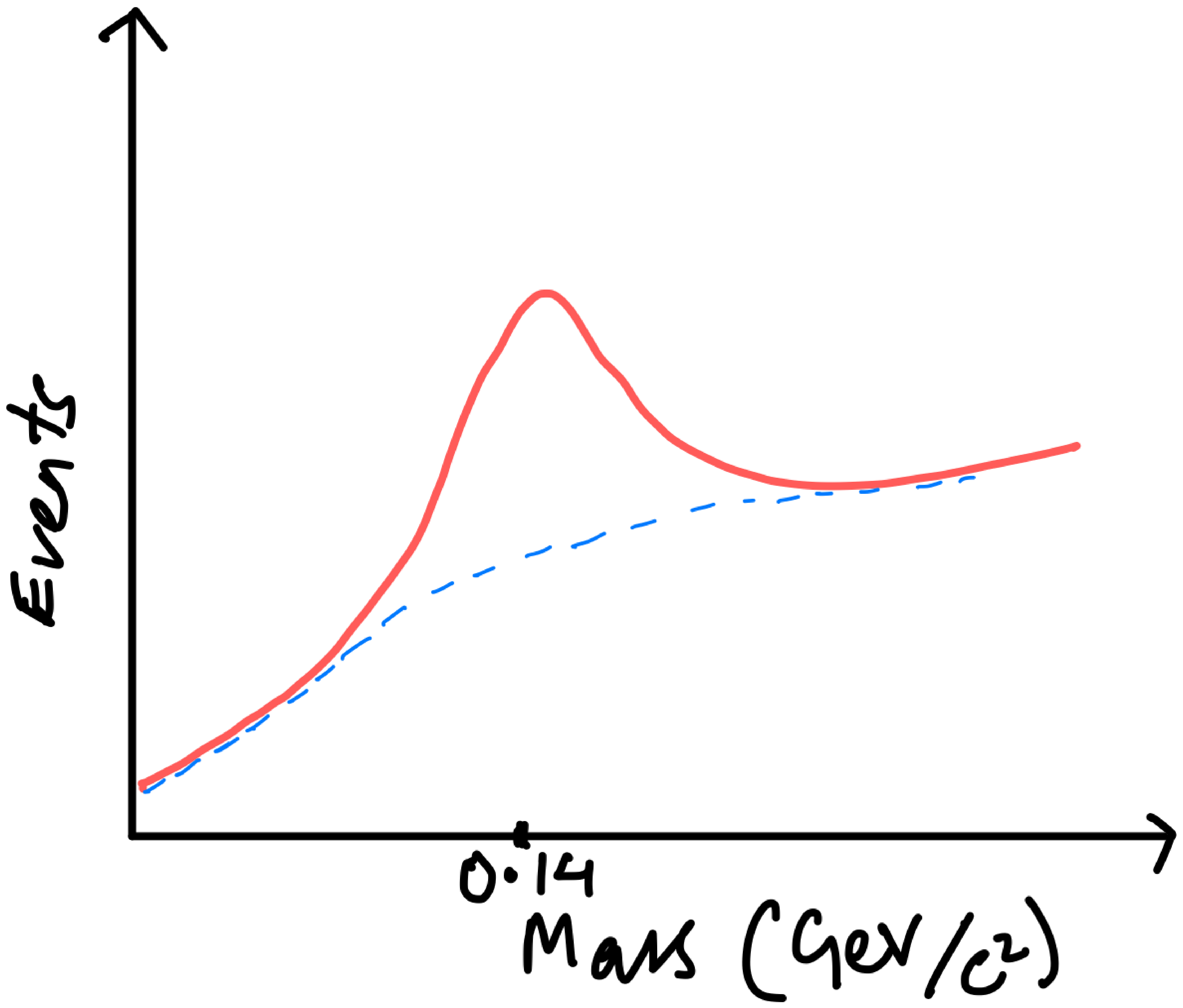
$\rho(x_1,x_2)$ : conditional probability of finding the particle $x_1$ ,given the particle $x_2$ has been found.

$\rho(x_1)$ : probability of find the particle $x_1$

$\rho(x_2)$ : probability of find the particle $x_2$

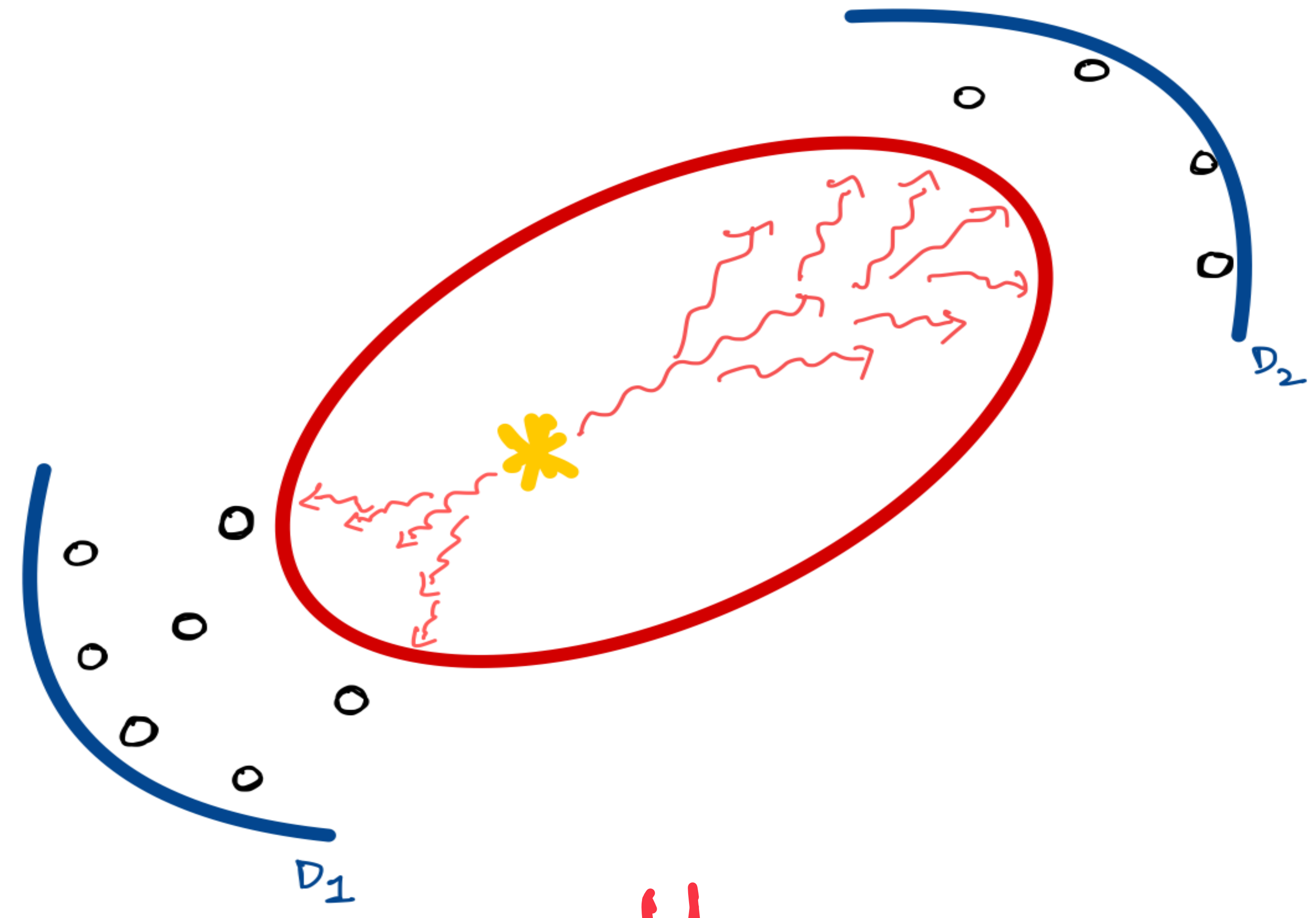
*Physical processes generate correlation*

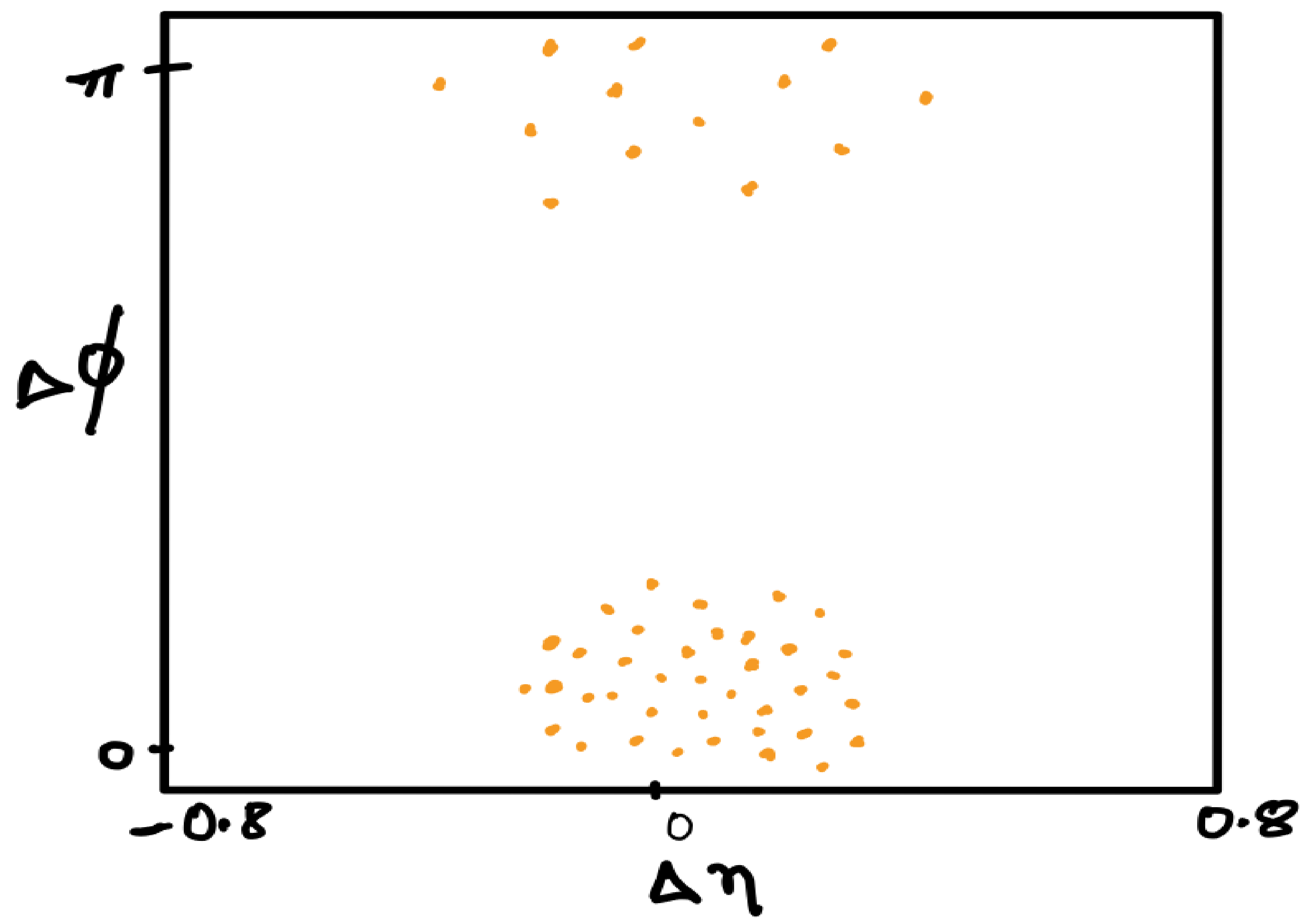
$$\pi^0 \rightarrow \gamma + \gamma$$

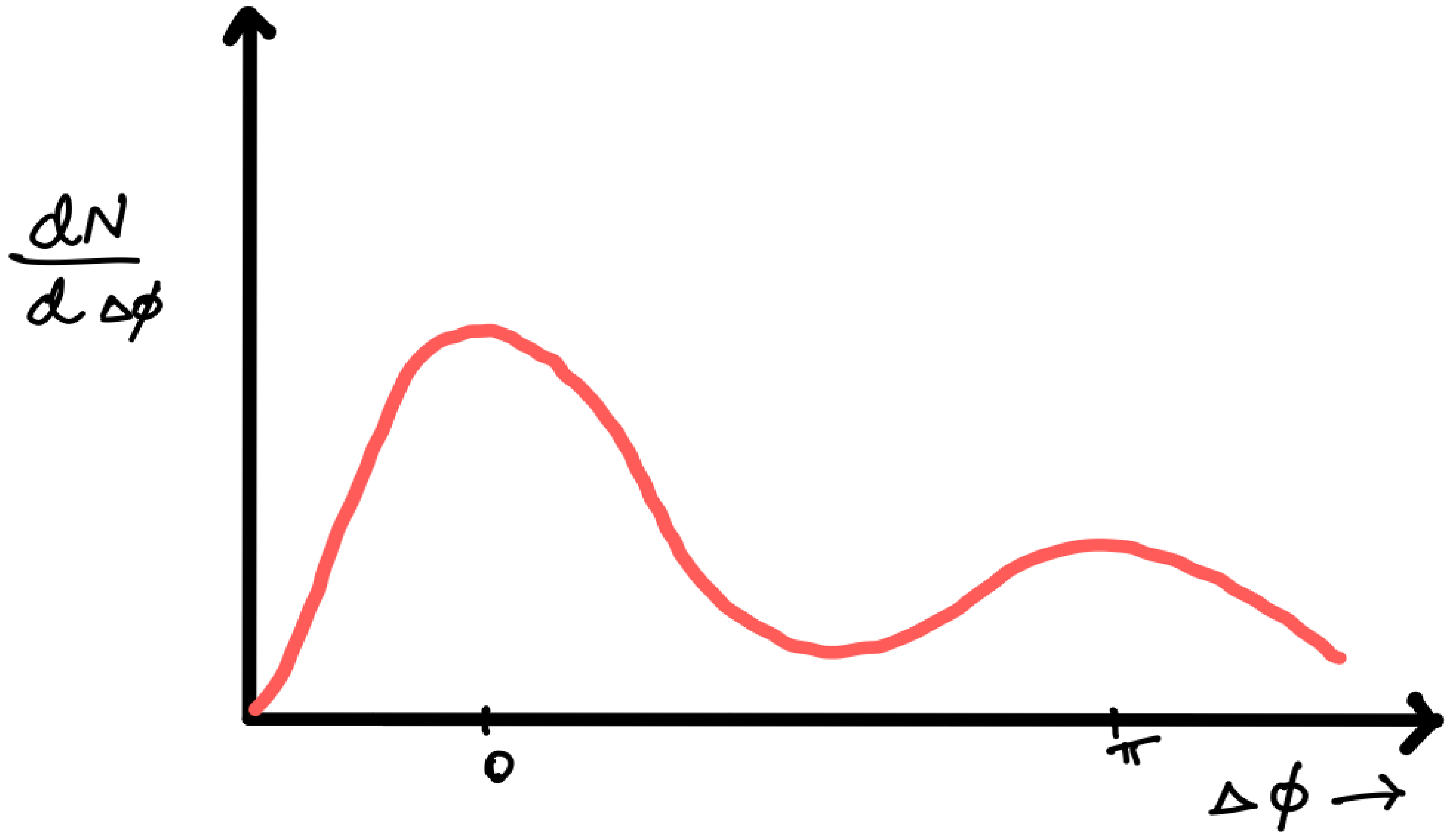


# How correlation relevant in heavy ion collision:

- Parton shower is created via fragmentation .
- Particles produced through such fragmentation are correlated.
- Correlation between Trigger particle & Associated particles with the trigger.



## Motivation:

- Baryon enhancement over mesons has been observed at intermediate $p_T$ $(2 < p_T < 4$ GeV/c) in both RHIC (***PHENIX Collaboration, Phys. Rev. Let. 91,172301(2003)***) and LHC(***ALICE Collaboration , Phys. Rev. Lett. C 90 (2014) 054901***).

- Particles at intermediate $p_T$ can be produced via two possible production mechanisms: **hard (fragmentation)** and **soft (recombination).**

- Near side correlation yield using baryon or meson trigger may contain the possible signature of particle production mechanism.

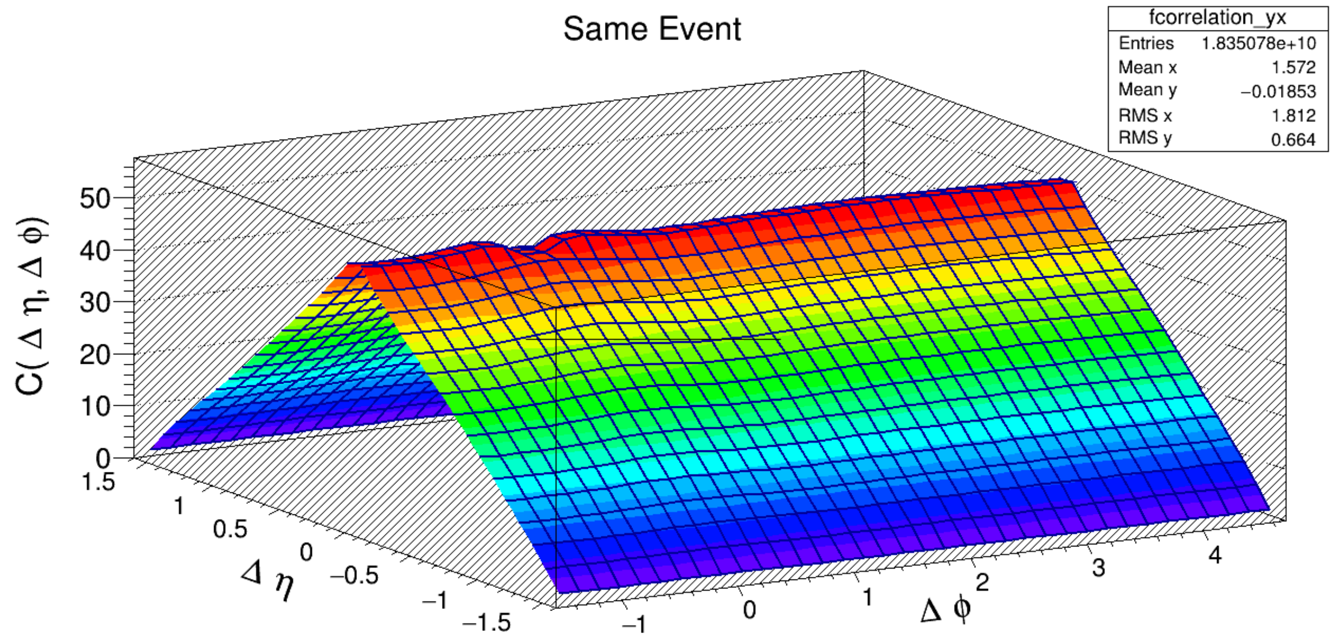
***Decrease in correlation could be the evidence about quark coalescence and also explain the baryon enhancement over mesons…***

# Correlation Function:

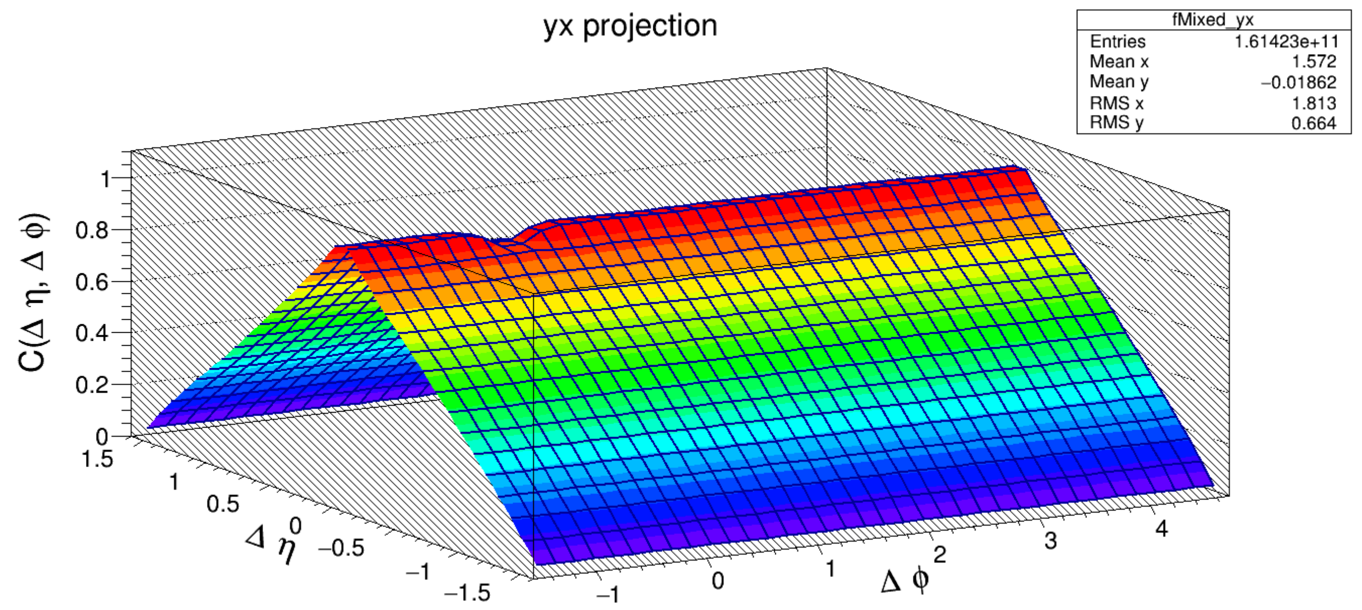
$$C(\Delta\eta, \Delta\phi) = \frac{1}{N_{trigg}} \frac{d^2 N_{asso}}{d\Delta\eta d\Delta\phi} = \alpha \frac{S(\Delta\eta, \Delta\phi)}{B(\Delta\eta, \Delta\phi)}$$

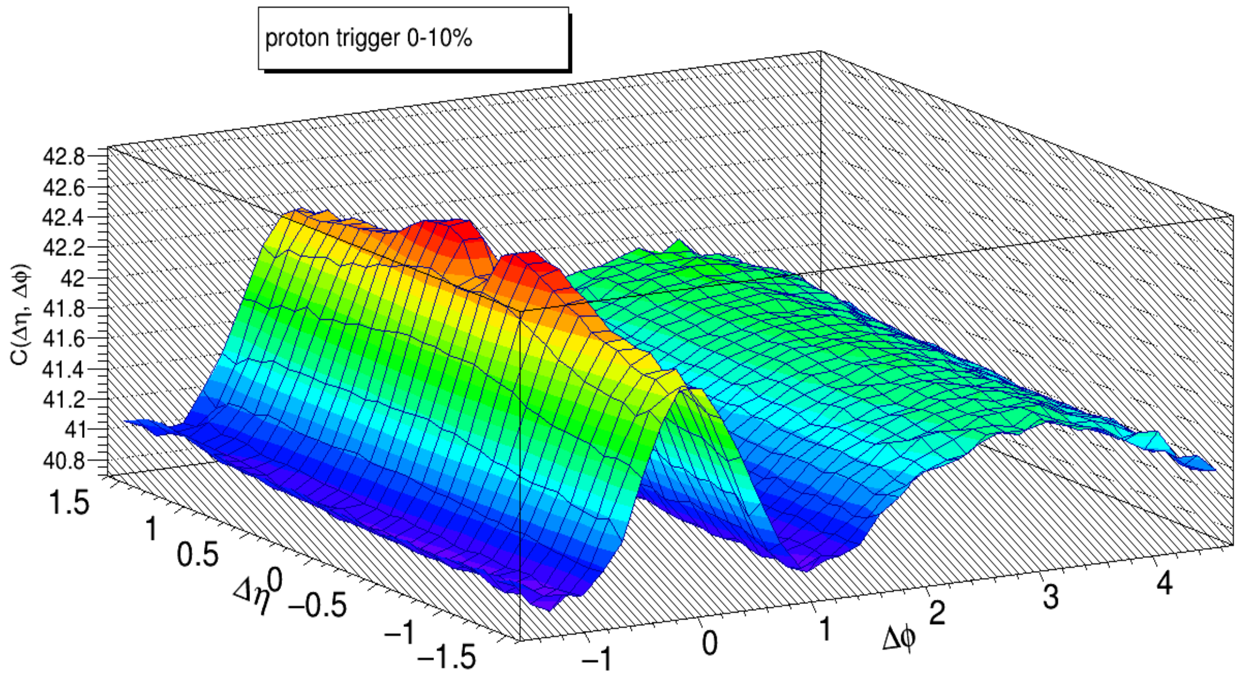
$\boldsymbol{S(\Delta\eta, \Delta\phi)}$ is the **signal**, constructed by taking triggers and associated particles from the same event.

$\mathbf{B(\Delta\eta, \Delta\phi)}$ is the **background**, constructed by taking triggers and associated particles from different events(mixed event method).




Mixed event



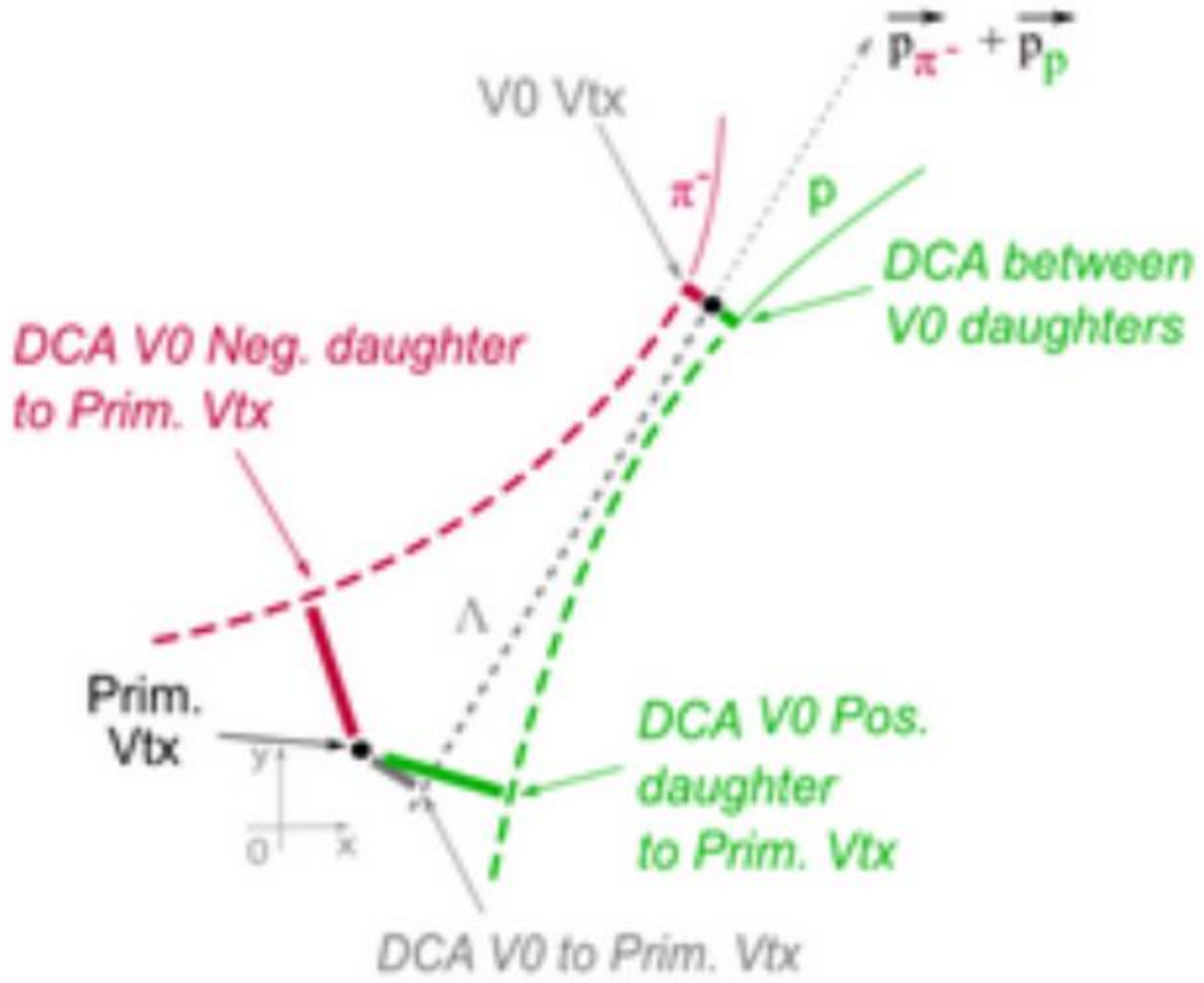



**Event selection cuts**: ( The data set is **lhc15o** (pass2) and the corresponding MC is **lhc20j6a**)
- kINT7 triggered events with Physics Selection have been used.
- | Vz | < 7 cm
- Centrality 0-80%

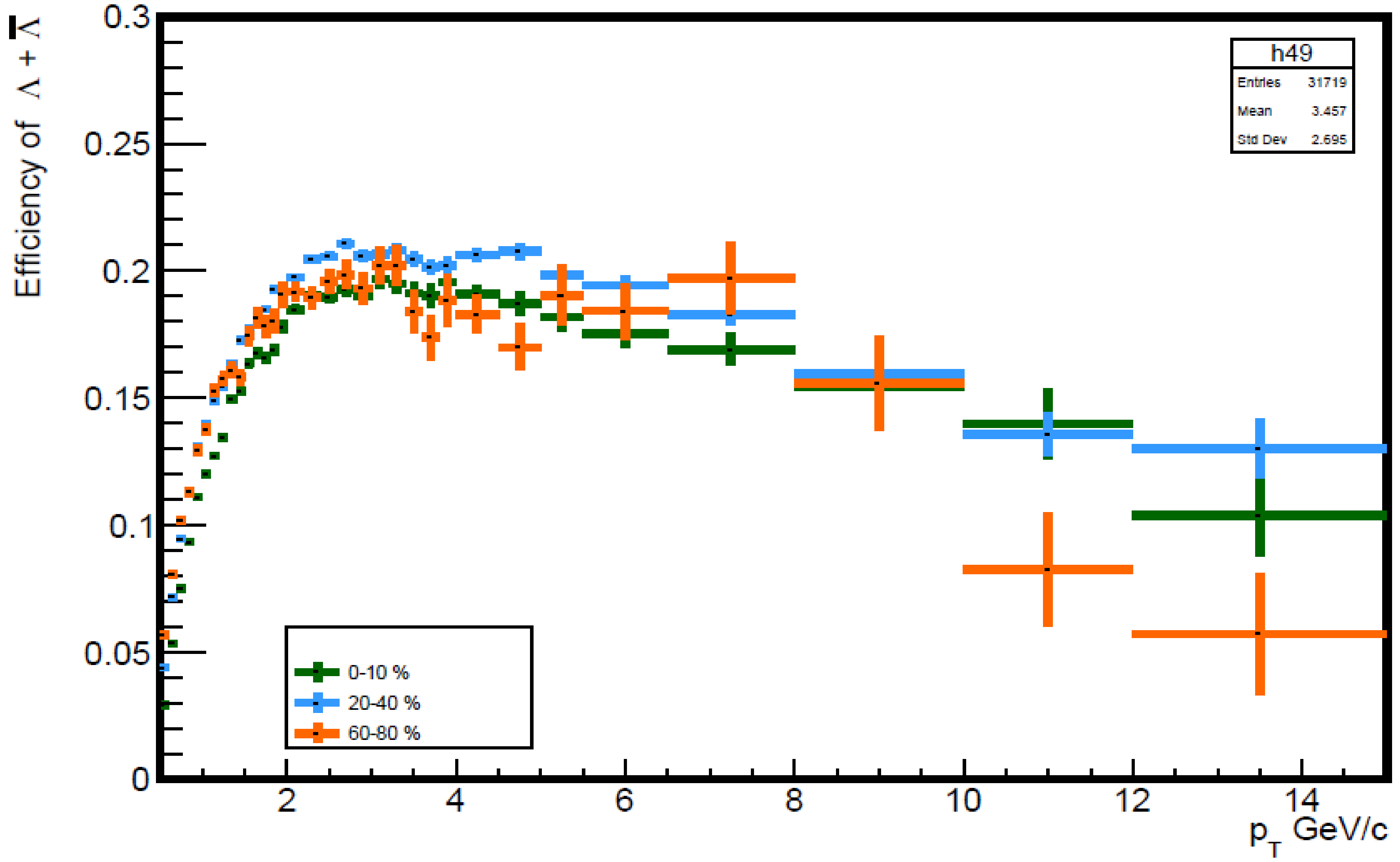
**Track selection cuts**:
- | $\eta$ | < 0.8
- Filterbit 768
- chi2 TPC per cluster < 2.5
- No. Of TPC clusters > 80

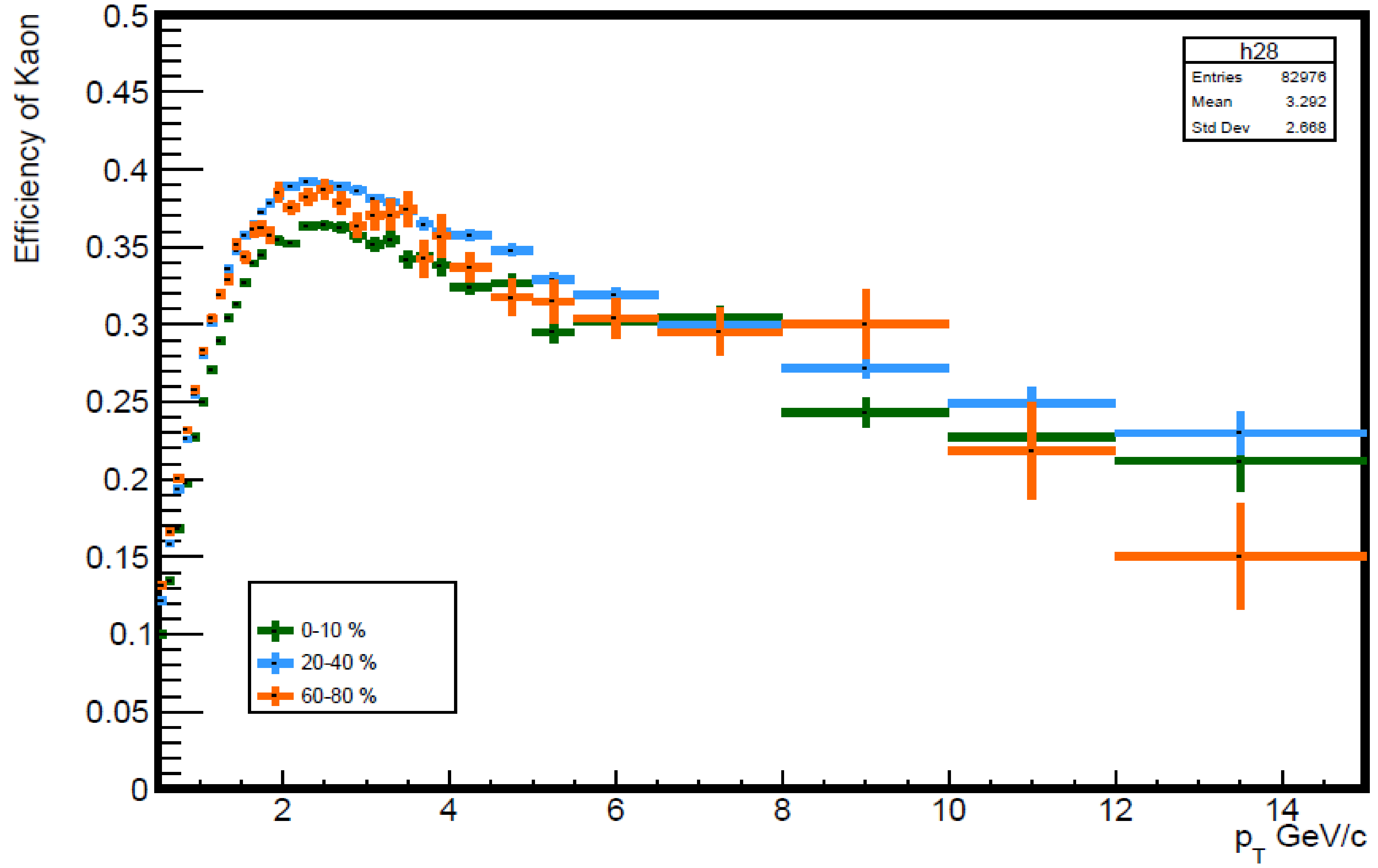
**V0 selection cuts**:
- 3< pT < 5 GeV/c
- $|\eta| < 0.6$
- Transverse decay radius > 5 cm
- DCA negative and primary track to Primary Vertex for $K^0_s$ > 0.1 cm
- DCA negative track to Primary vertex $(\Lambda, \bar{\Lambda})$ > (0.25, 0.1 ) cm
- DCA positive track to Primary vertex $(\Lambda, \bar{\Lambda})$ > (0.1, 0.25 ) cm
- V0 cos of pointing angle ($K^0_s$, $\Lambda$) (0.98,0.995)
- Proper Life time ( mL/p) ($K^0_s$, $\Lambda$) < (20., 25.) cm
- $p_T^{arm}$ cut 0.2 $|\alpha|$

**V0 daughters cut**:
- $|\eta| < 0.8$
- Nsigma TPC
- chi2 TPC per cluster < 2.5
- Ncrossedrows >60
- Ncorssedrows / Nfindable > 0.8
- The trigger particles are $K^0_s$ and $\Lambda$ with 3< pT < 5 GeV/c.
- Associated particles are all charged hadrons with 1< pT < 2 GeV/c.

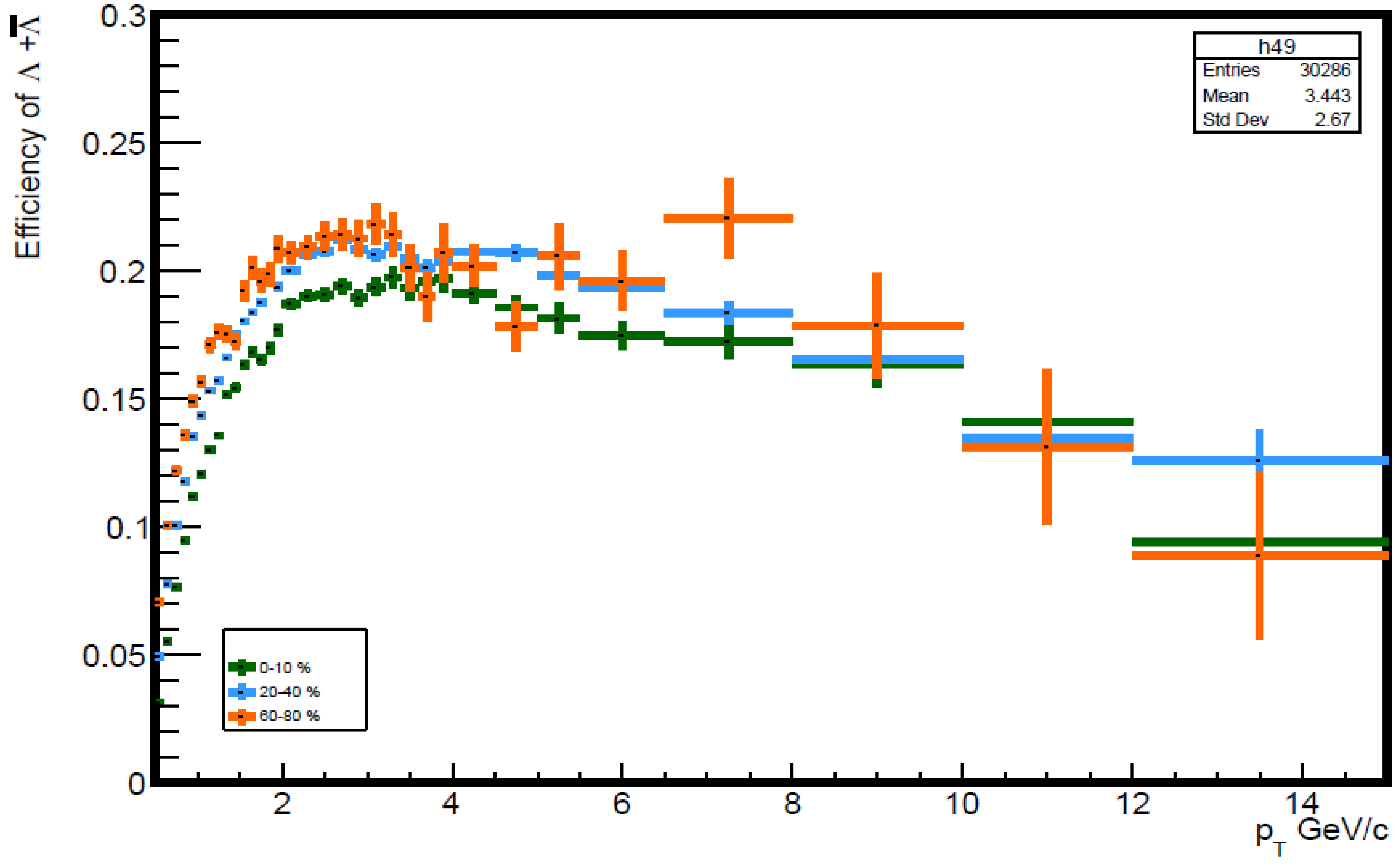


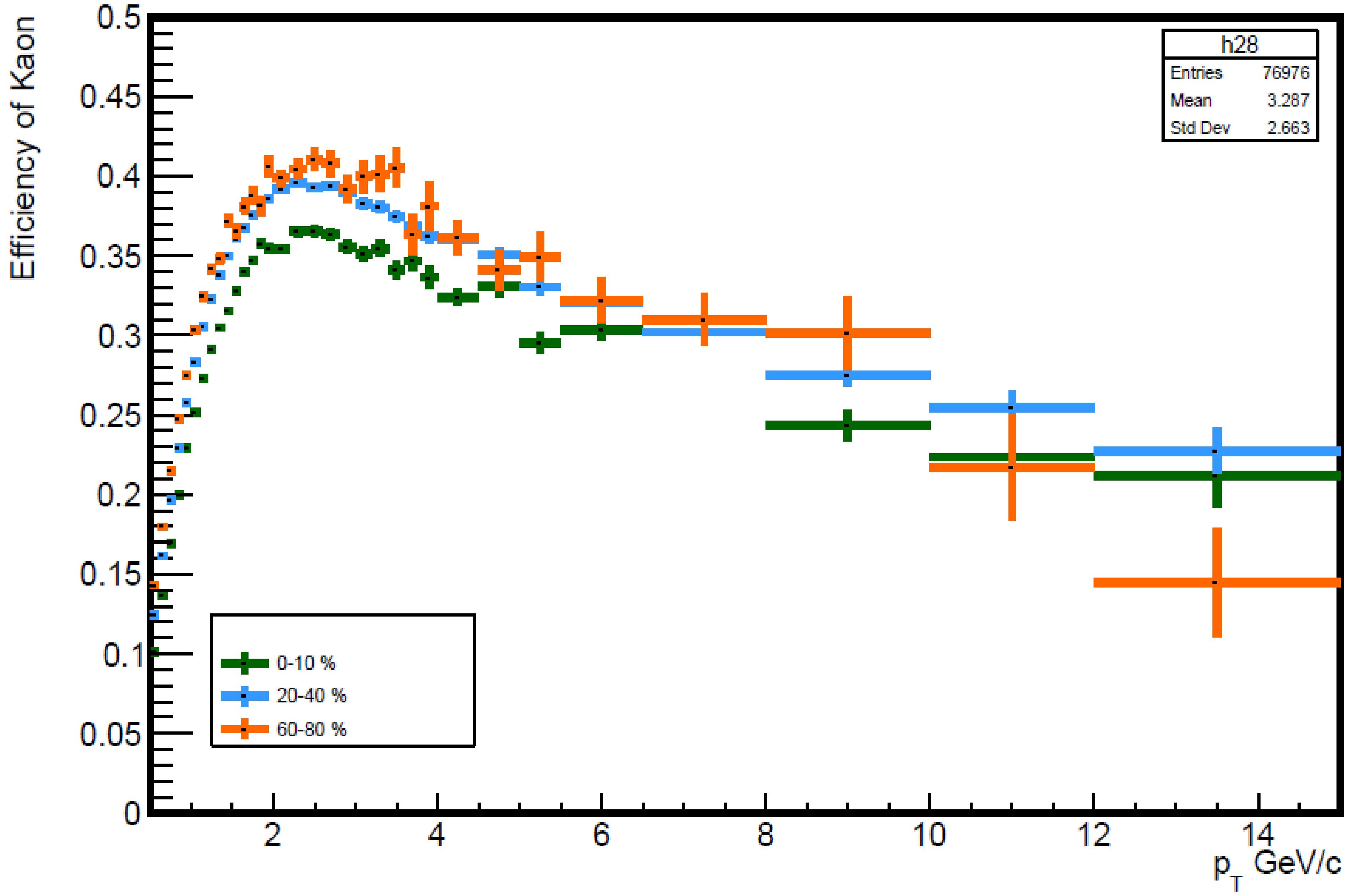
# Efficiency of triggers



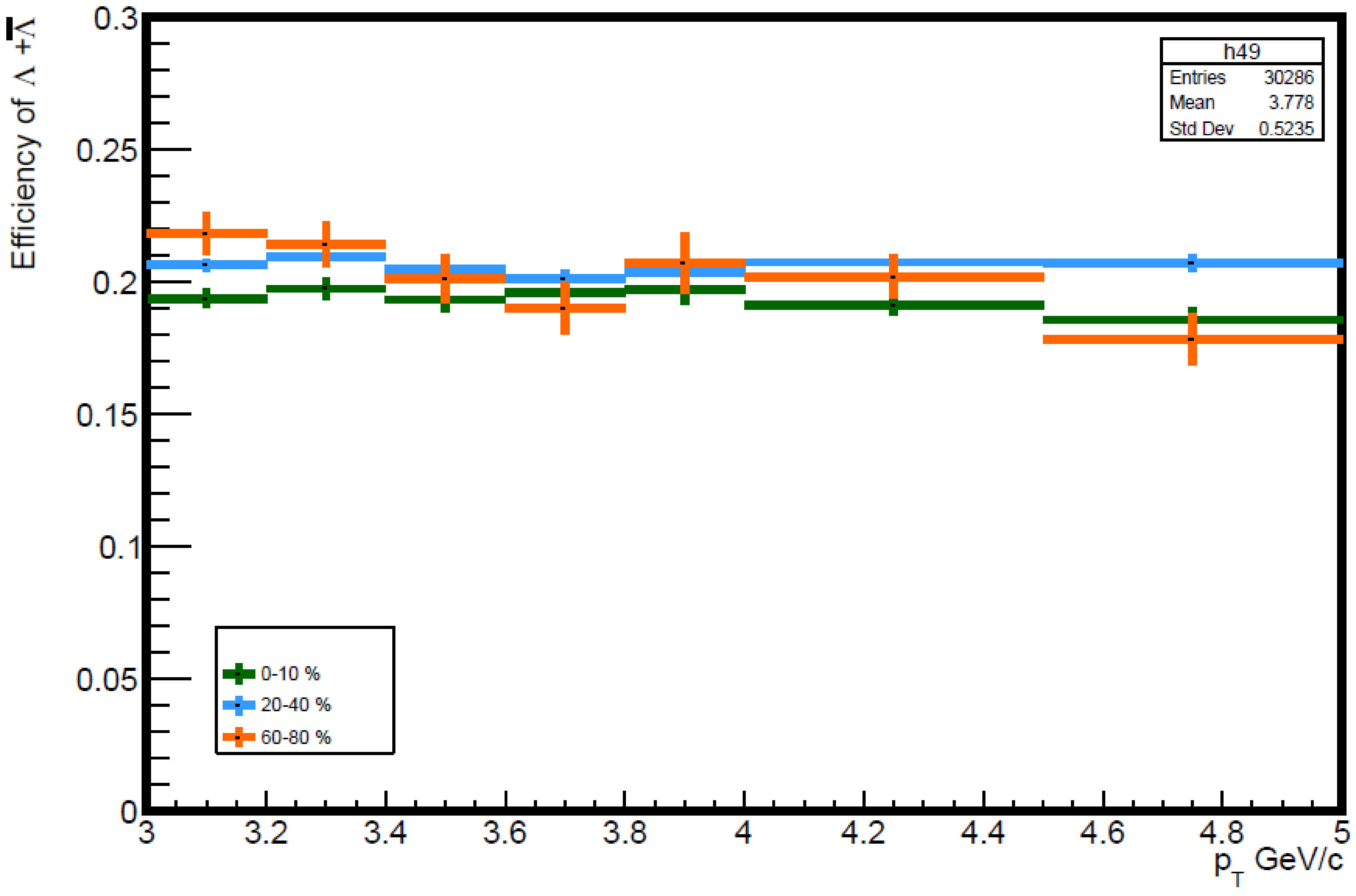



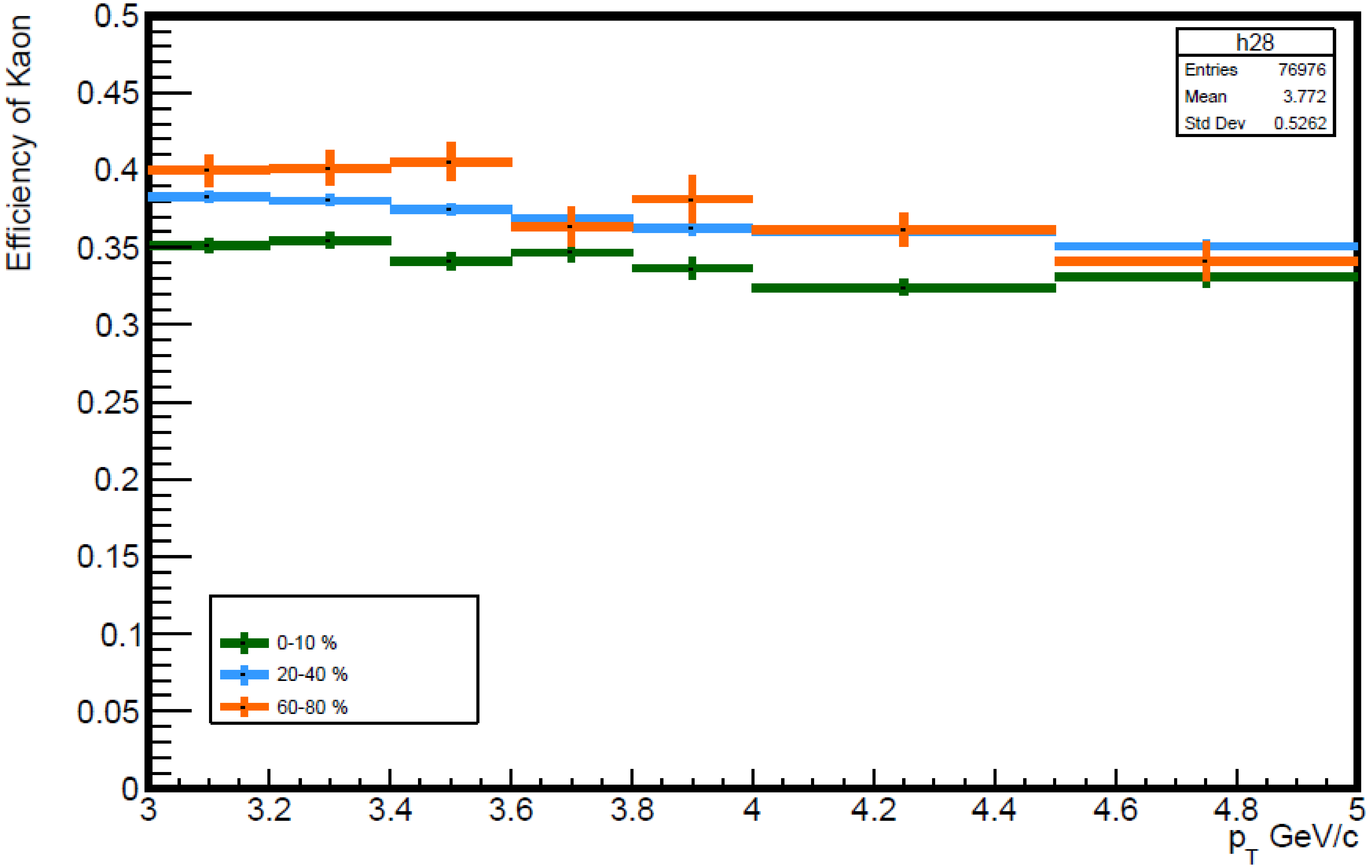

With TPC Nsigma cut <3.



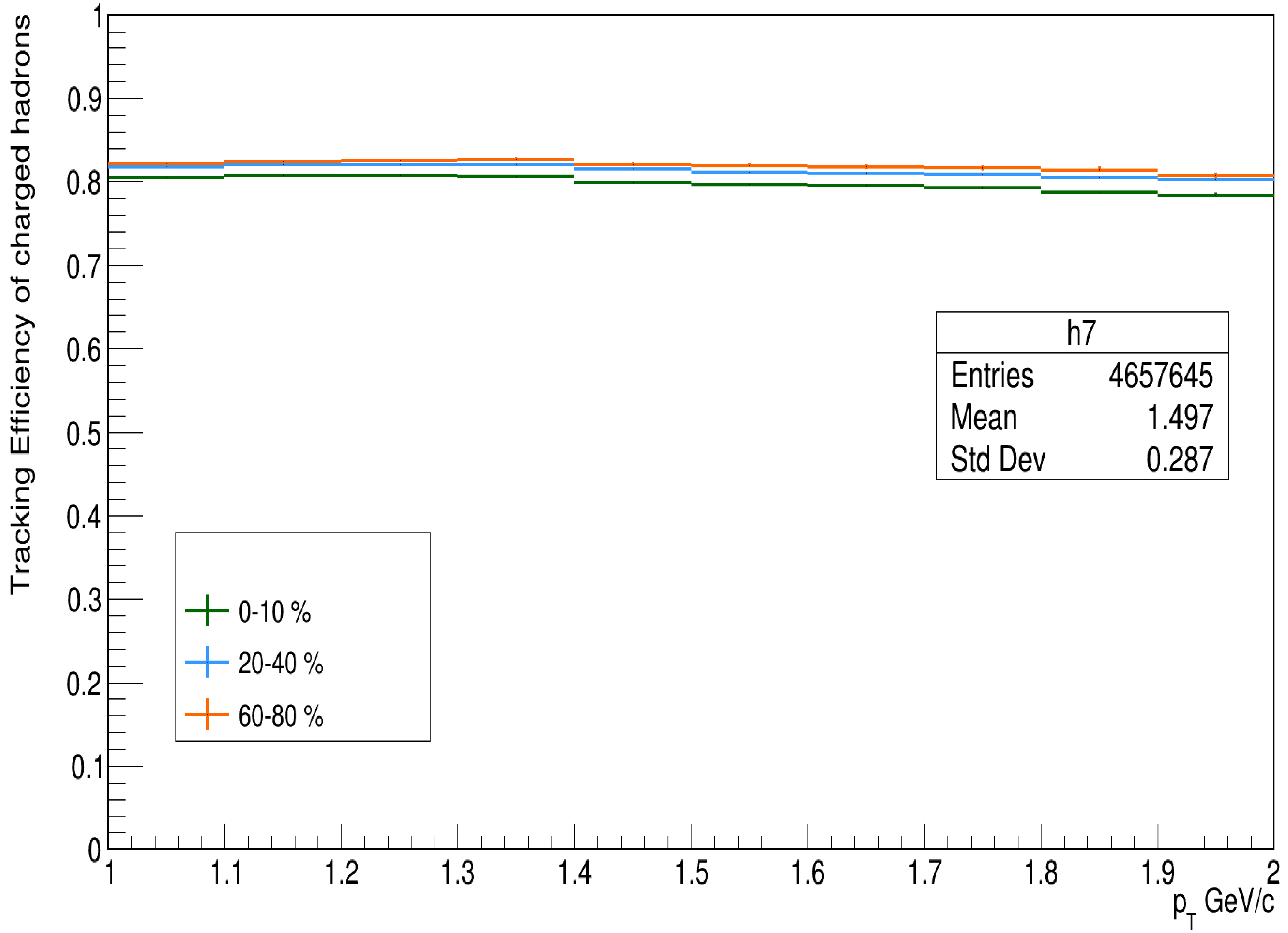



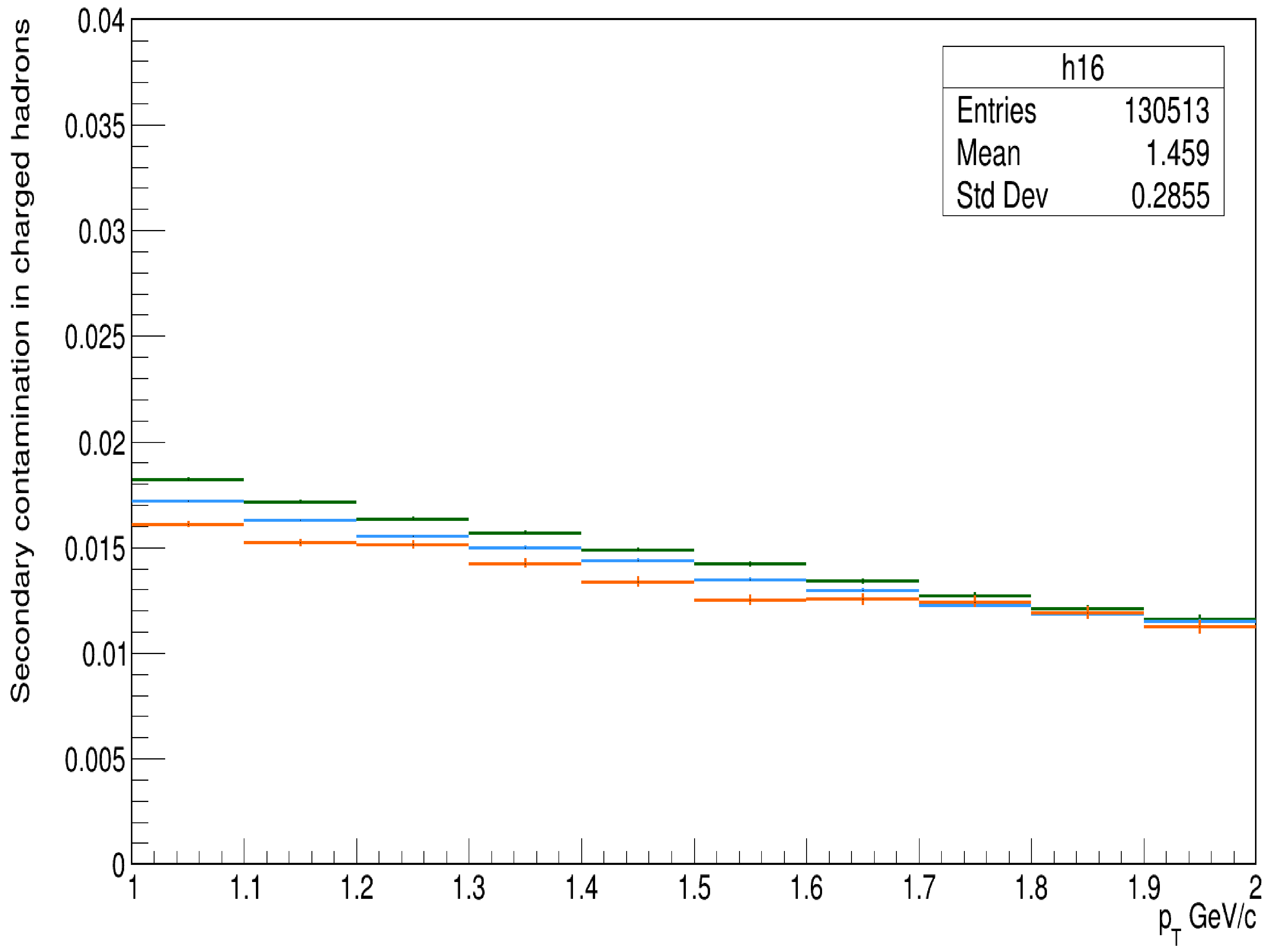

With TPC Nsigma cut <4.


Efficiency of Λ +Λ̄
h49
Entries 30286
Mean 3.778
Std Dev 0.5235
0-10 %
20-40 %
60-80 %
p_T GeV/c

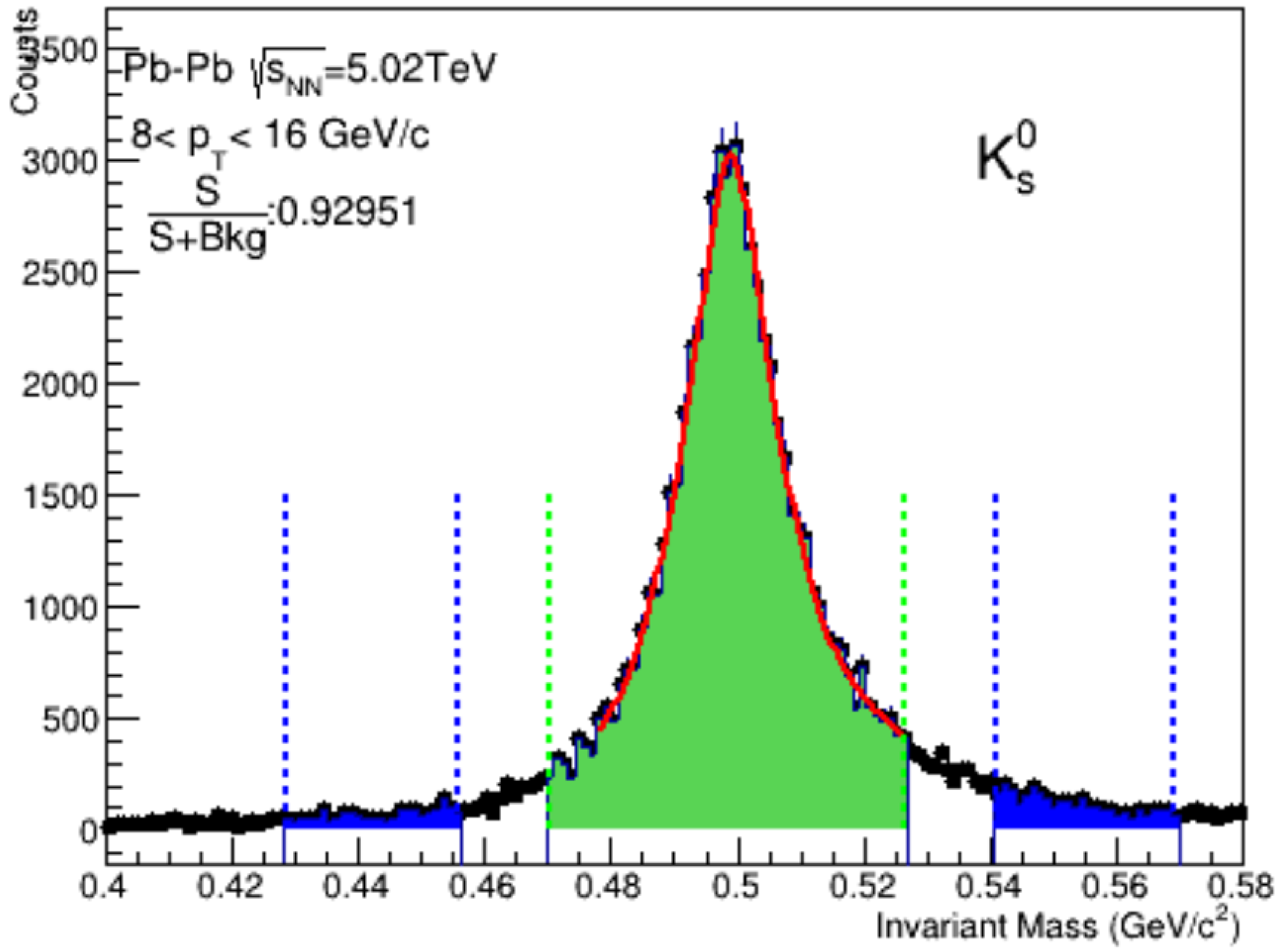

Efficiency of Kaon
h28
Entries 76976
Mean 3.772
Std Dev 0.5262
0-10 %
20-40 %
60-80 %
p_T GeV/c

# Efficiency of associated charged hadrons



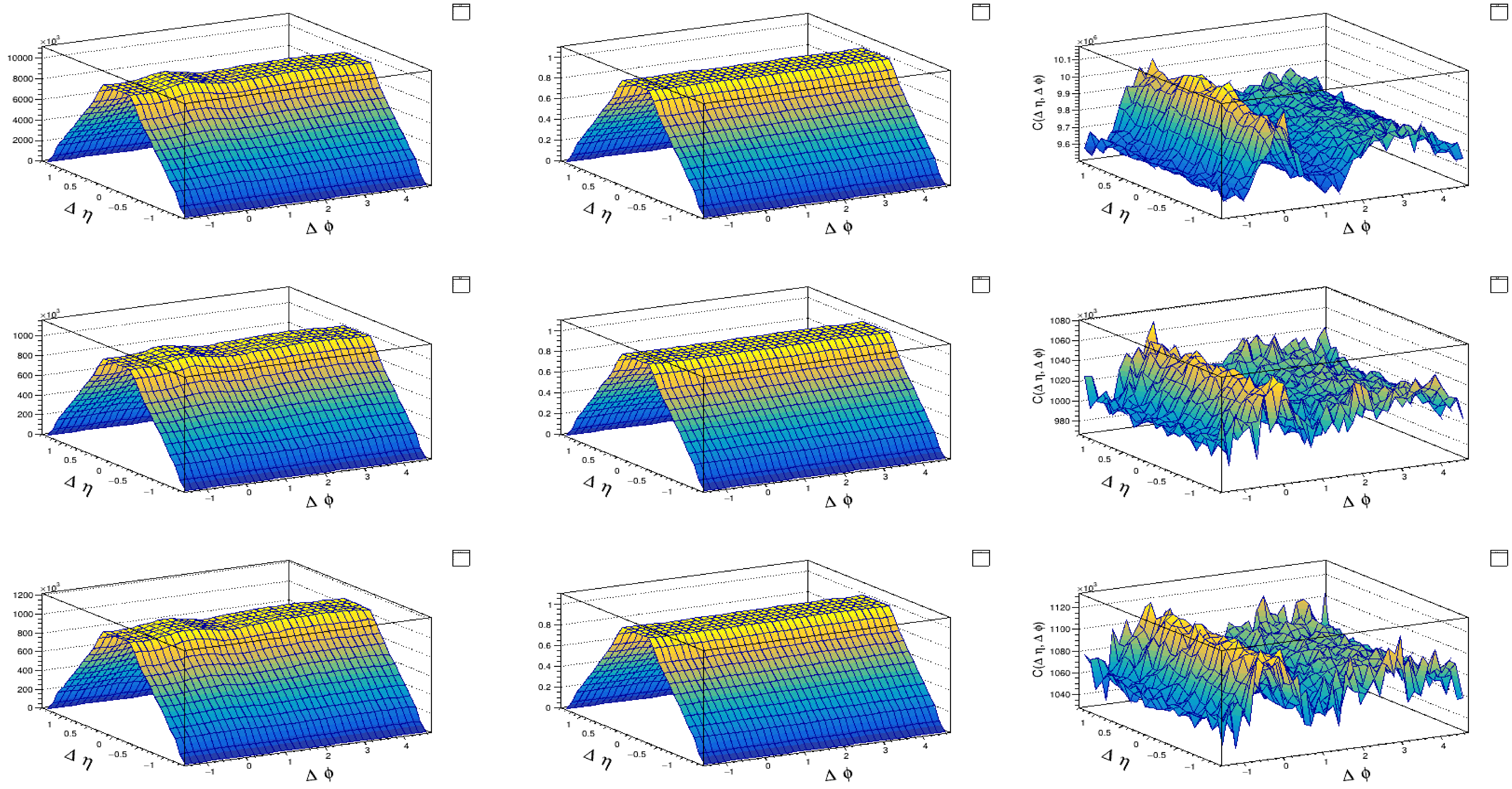
$$C(\Delta\varphi,\Delta\eta)_{fullcorr}(\Delta\varphi,\Delta\eta,p_{\mathrm{T,trig}}) = \frac{1}{N_{trig}^{fullcorr}}(p_{\mathrm{T,trig}})\left(\frac{d^2N_{sigpair}^{corr}}{d\Delta\varphi d\Delta\eta}(\Delta\varphi,\Delta\eta,p_{\mathrm{T,trig}}) - \frac{d^2N_{sidepair}^{corr}}{d\Delta\varphi d\Delta\eta}(\Delta\varphi,\Delta\eta,p_{\mathrm{T,trig}})\right),$$




(From Mustafa Anaam's analysis note)

Peak region and side band regions for correlation function construction

## *0 -10 % $K^0_s$ triggered*




**Peak region**

**Background left**

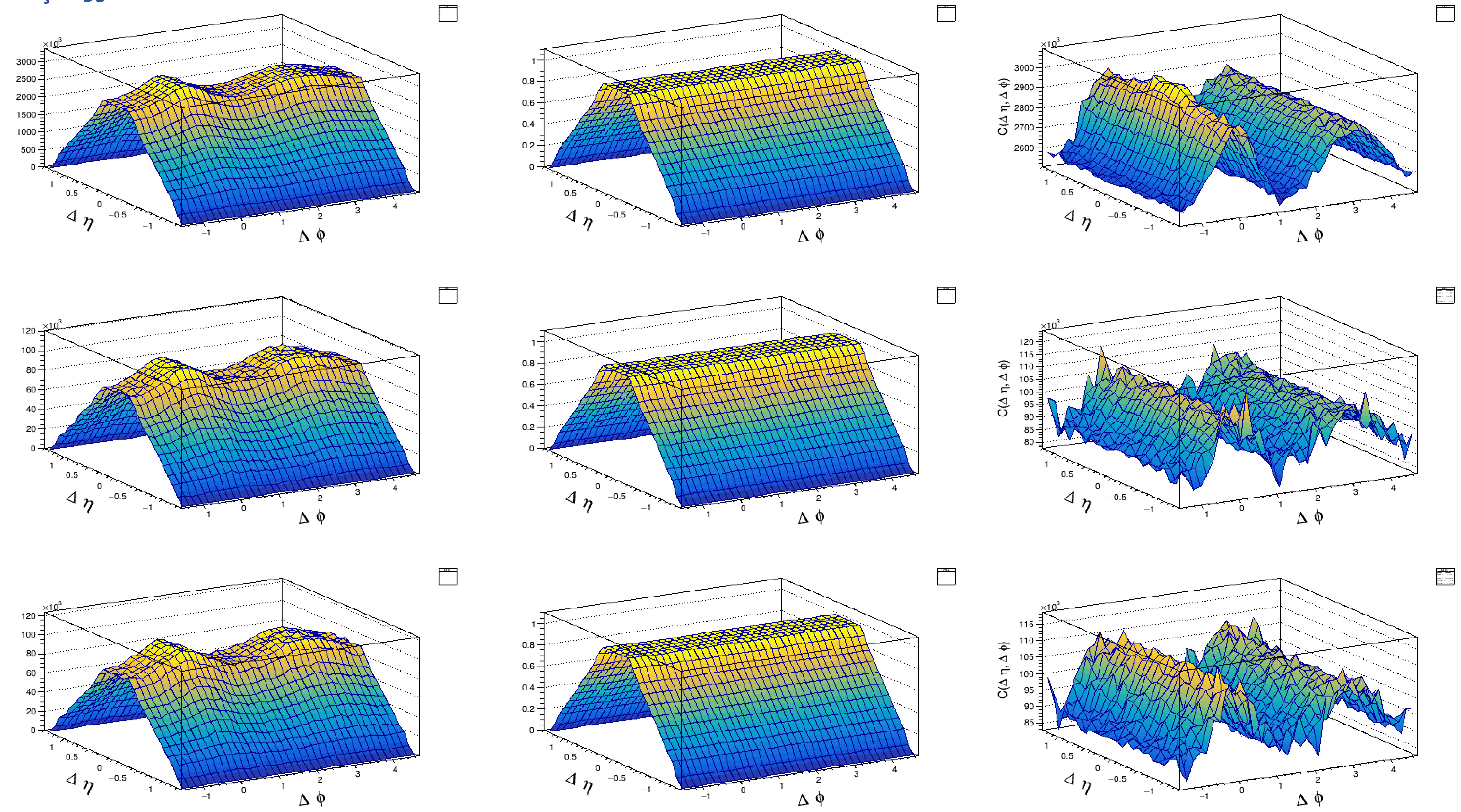
**Background Right**

**SAME EVENT**

**MIXED EVENT**

**SAME/MIXED**

## *20 -40 % $K^0_s$ triggered*




Peak region

Background left

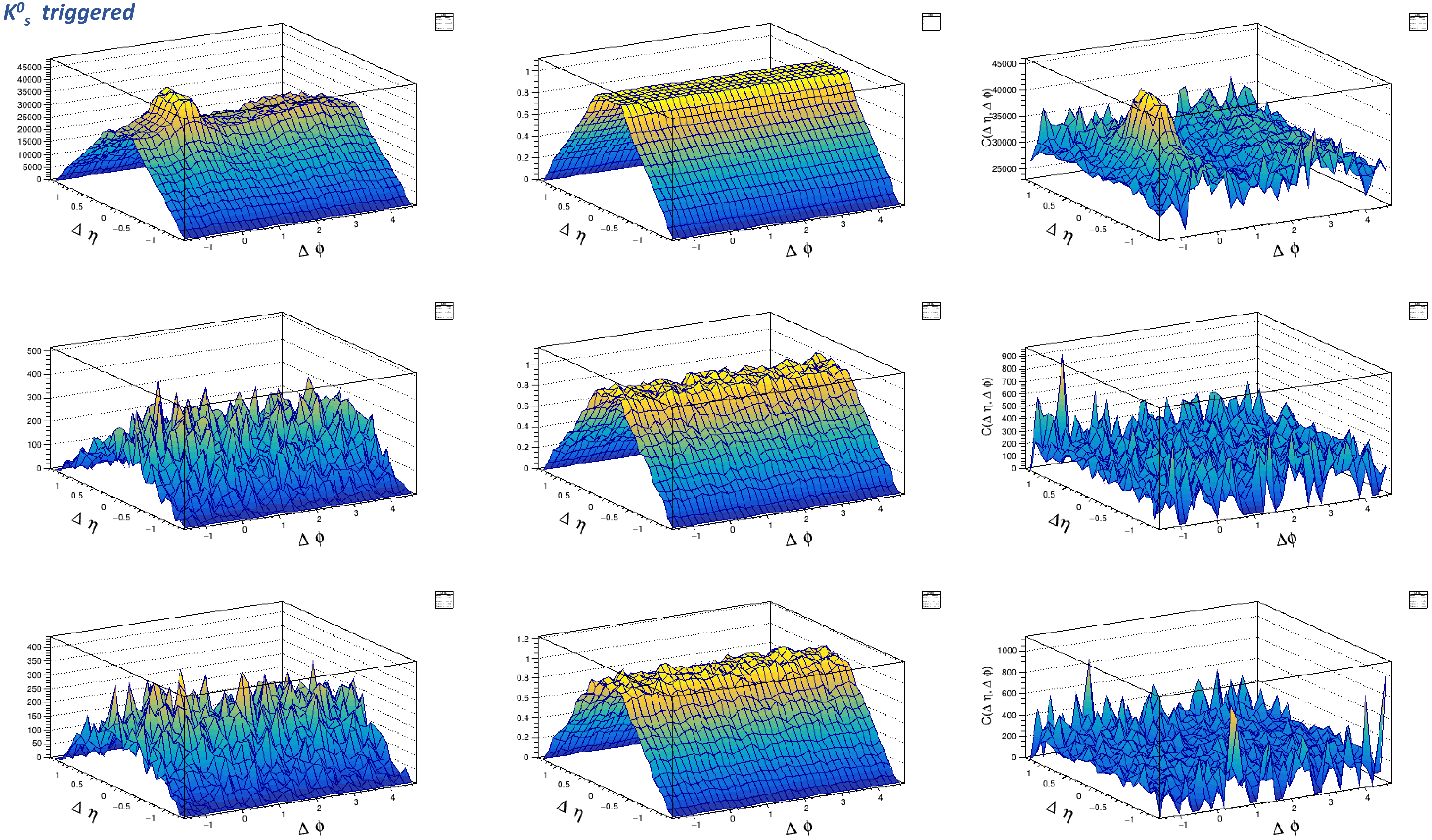
Background Right

SAME EVENT

MIXED EVENT

SAME/MIXED

*60 -80 % $K^0_s$ triggered*




Peak region

Background left

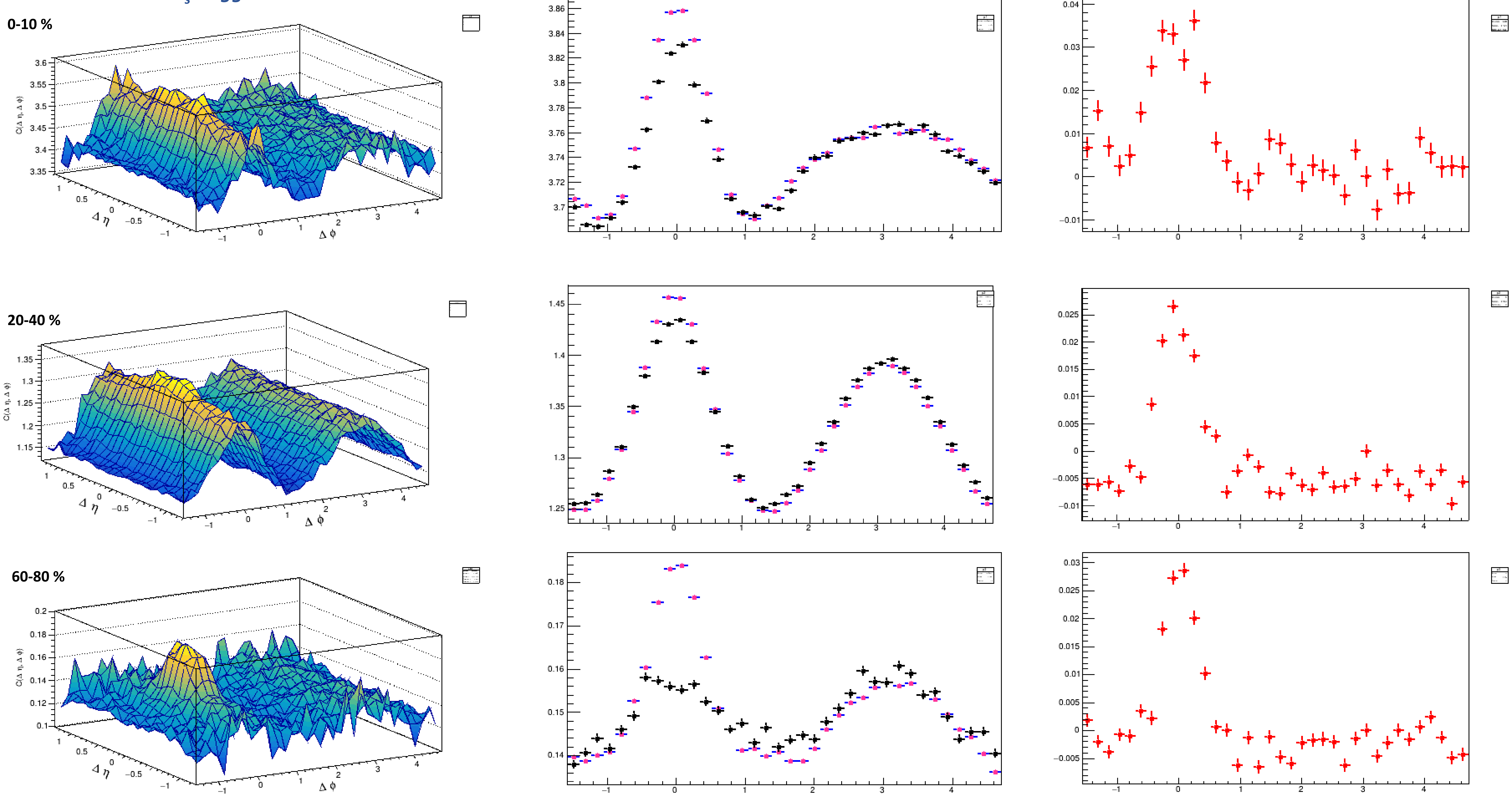
Background Right

SAME EVENT

MIXED EVENT

SAME/MIXED

## $K^0_s$ triggered

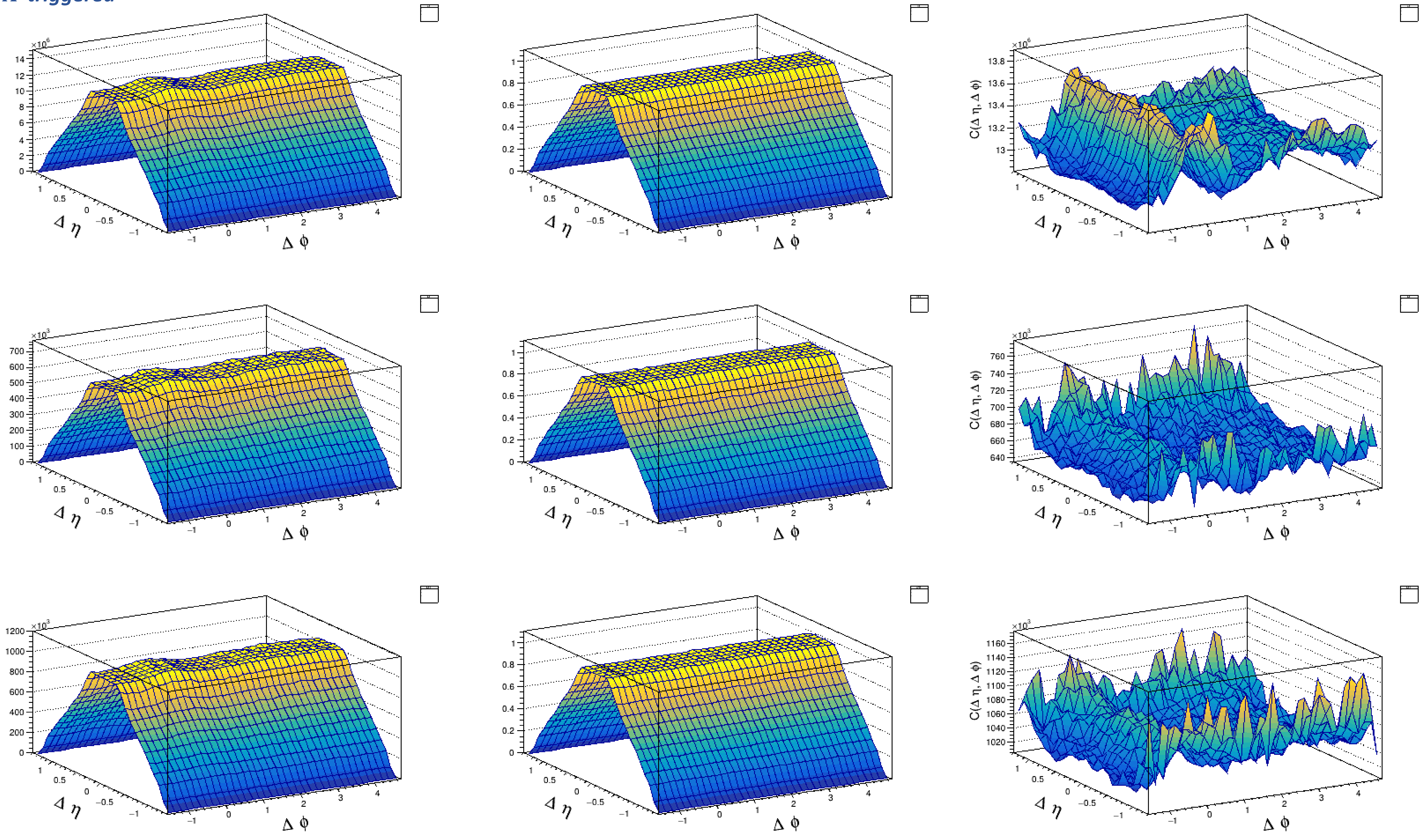



Per trigger Correlation function ( efficiency corrected)

Peak and bulk region $\Delta\phi$ projection

Bulk subtracted

*0 -10 %  Λ  triggered*




Peak region

Background left

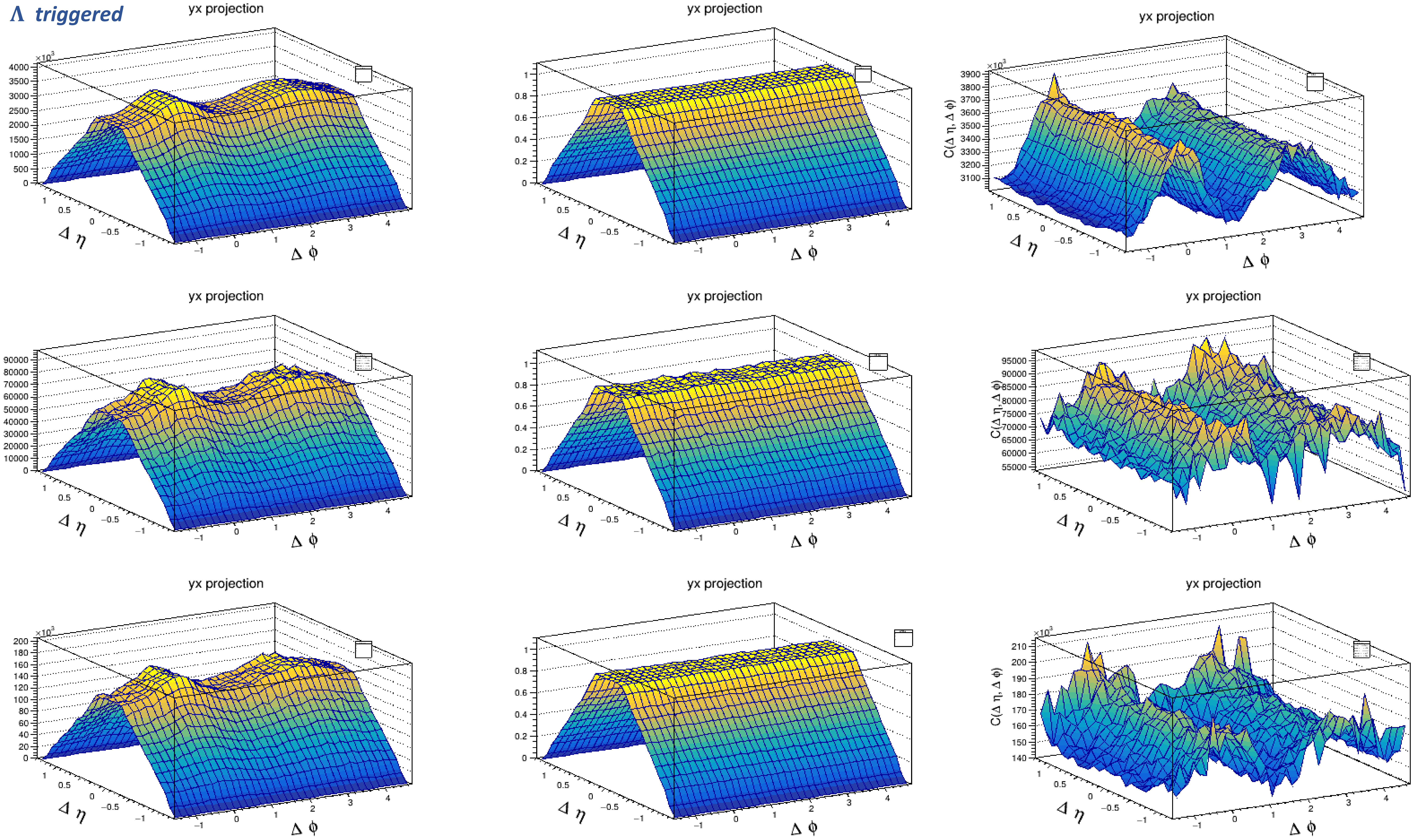
Background Right

SAME EVENT

MIXED EVENT

SAME/MIXED

## *20 -40 % Λ triggered*




Peak region

Background left

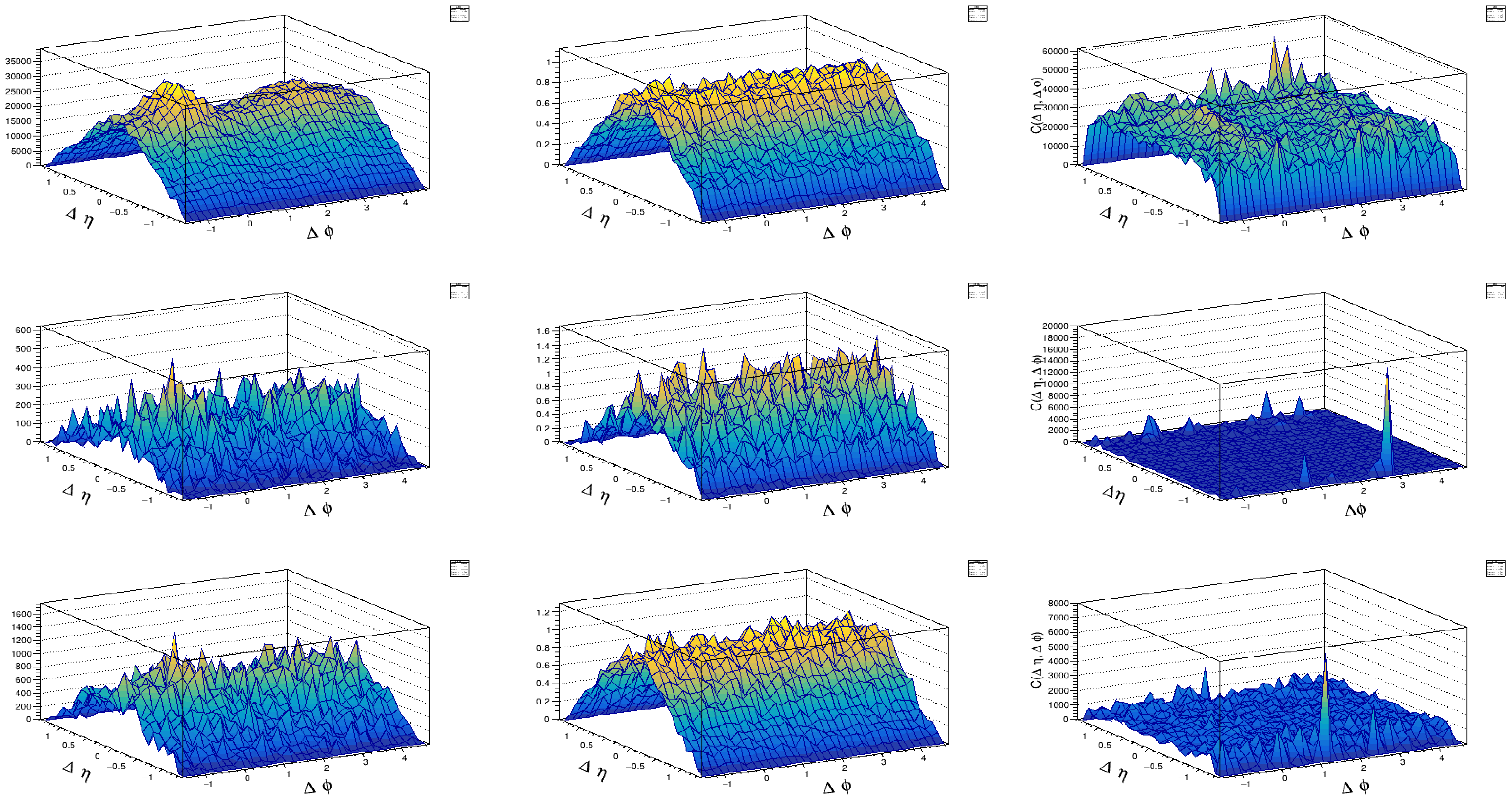
Background Right

SAME EVENT

MIXED EVENT

SAME/MIXED

## *60 -80 % Λ triggered*




Peak region

Background left

Background Right

SAME EVENT

MIXED EVENT

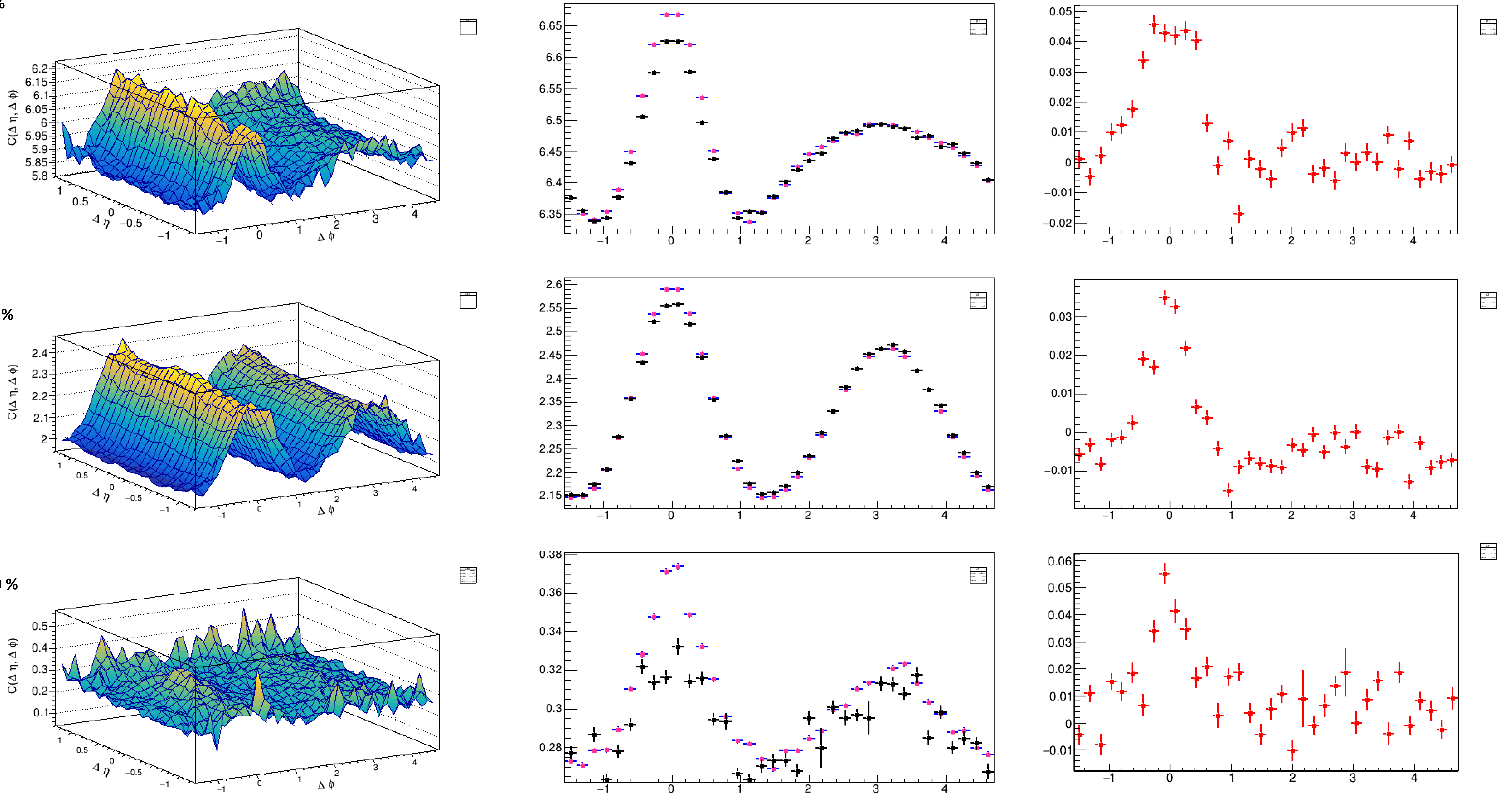
SAME/MIXED

***Λ triggered***

0-10 %

20-40 %

60-80 %

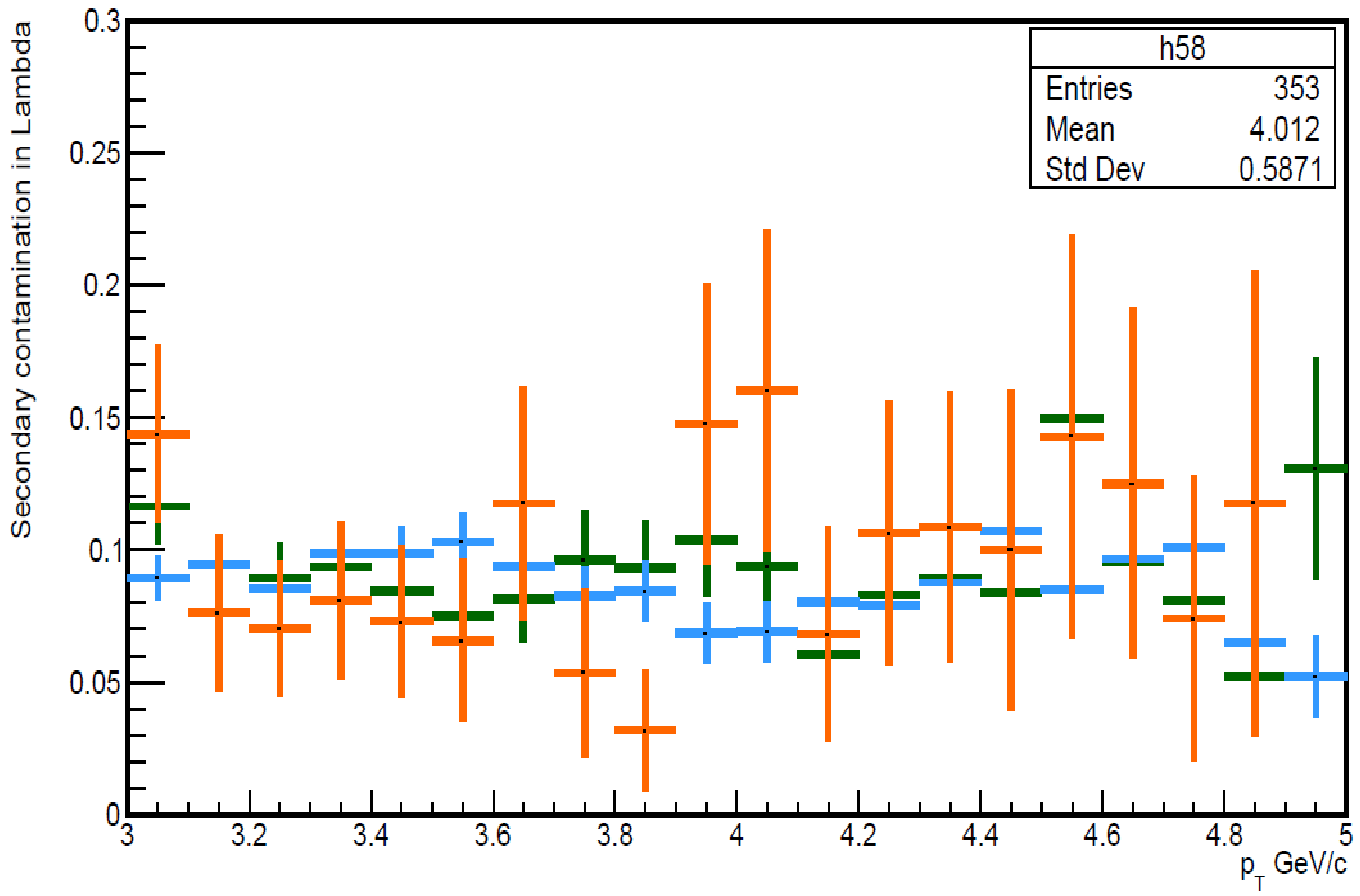


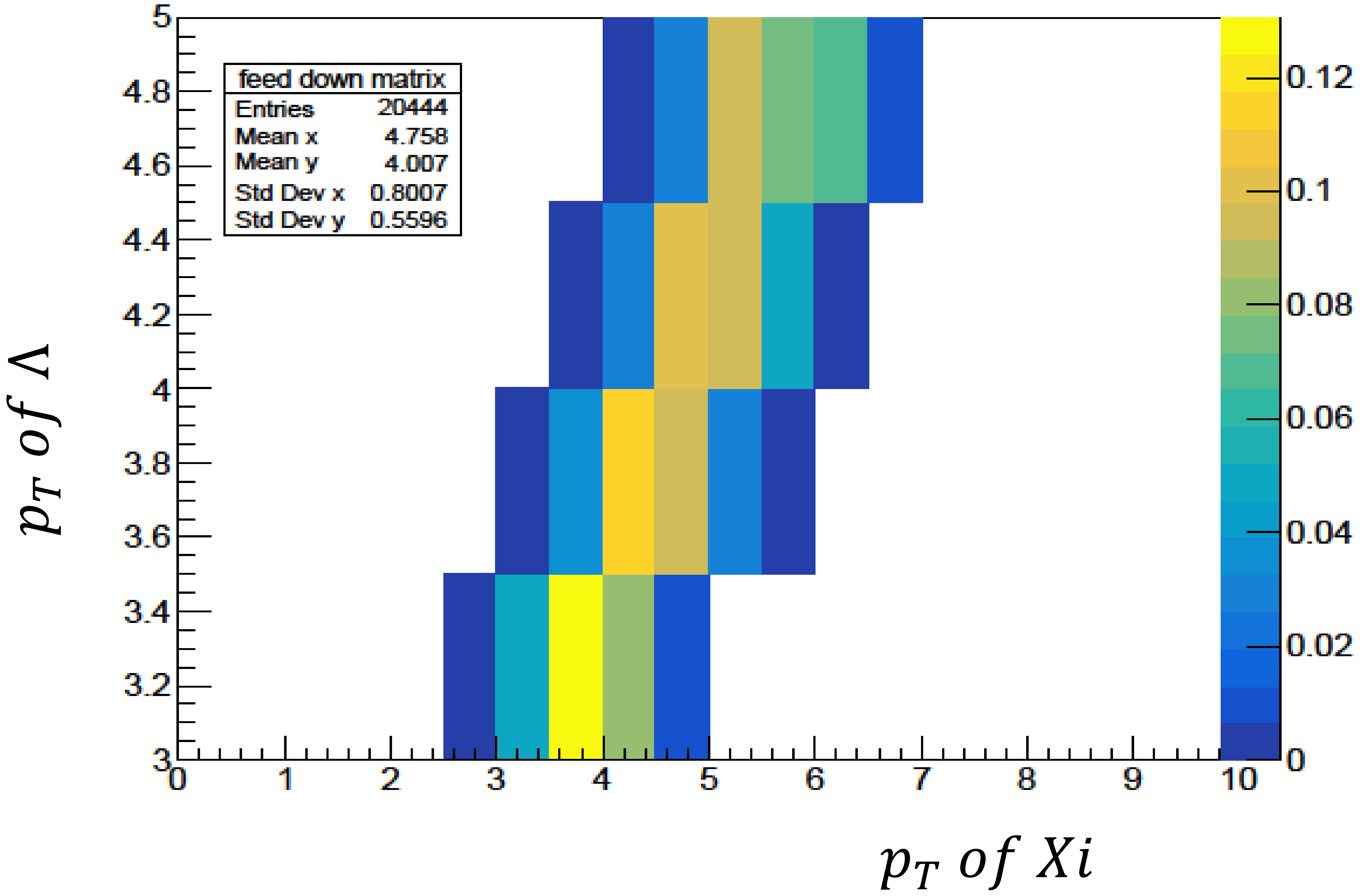

Per trigger Correlation function ( efficiency corrected)

Peak and bulk region $\Delta\phi$ projection

Bulk subtracted

# Contamination from feed down in Λ

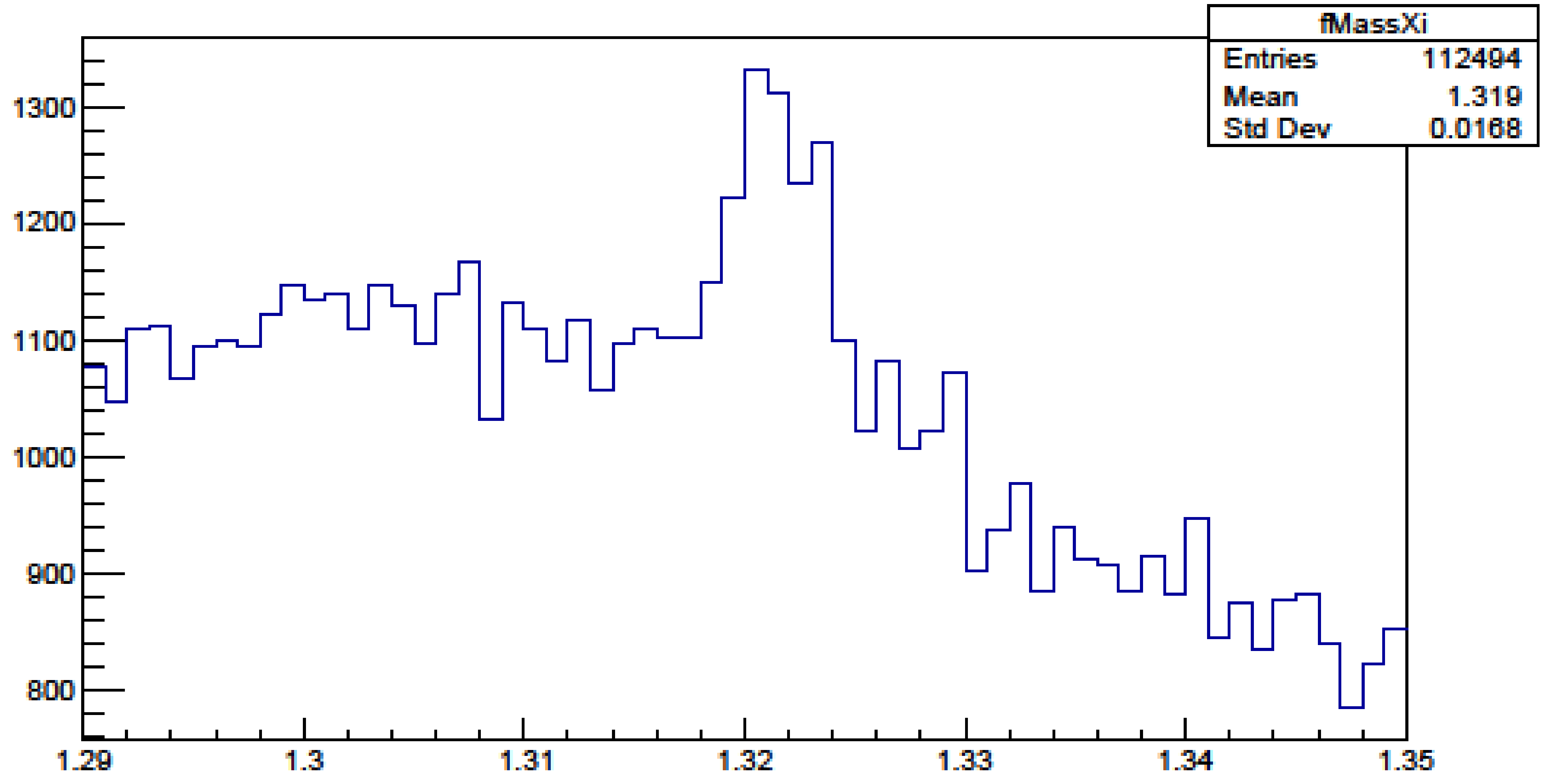



$$N^{final}_{trigg}(p_{\mathrm{T},i}) = C^{\Lambda}_{purity}(p_{\mathrm{T},i}) * (N^{measured}_{\Lambda}(p_{\mathrm{T},i}) - \frac{1}{\varepsilon_{\Lambda}}(p_{\mathrm{T},i}) \sum_{j} F_{ij} * C^{\Xi}_{purity}(p_{\mathrm{T},j}) * N^{measured}_{\Xi}(p_{\mathrm{T},j})) \quad (11)$$

$$N^{final}_{\Lambda-h}(p_{\mathrm{T},i}) = N^{measured}_{\Lambda-h}(p_{\mathrm{T},i}) - \frac{1}{\varepsilon_{\Lambda}}(p_{\mathrm{T},i}) \sum_{j} F_{ij} * (N^{measured}_{\Xi-h}(p_{\mathrm{T},j}) - N^{side-band}_{\Xi-h}(p_{\mathrm{T},j})) - N^{side-band}_{\Lambda-h}(p_{\mathrm{T},i}) \quad (12)$$

# Invariant mass Xi:




$3 < p_T < 7$ GeV/c

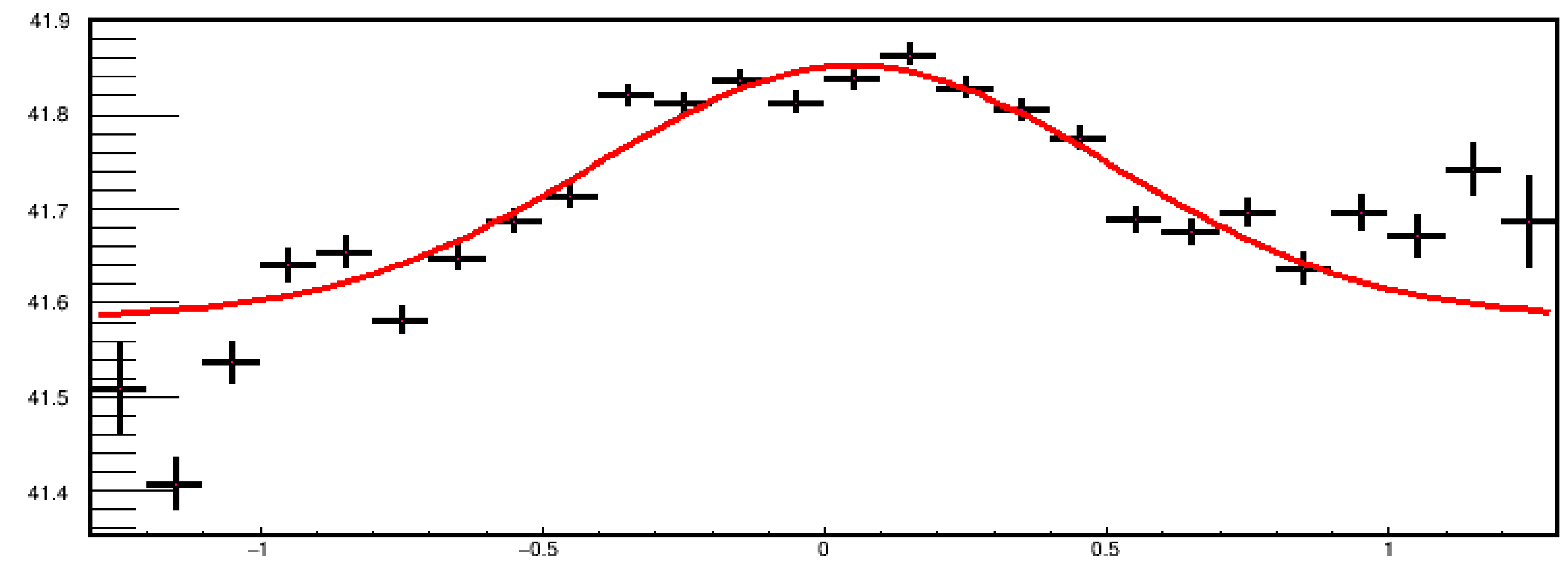
| Topological Variable | Value |
|---|---|
| Cascade transv. decay radius $R_{2D}$ (cm) | >0.6 |
| $V^0$ transv. decay radius (cm) | > 1.2 |
| DCA bachelor to PV (cm) | > 0.04 |
| DCA $V^0$ to PV (cm) | >0.06 |
| DCA meson $V^0$ track to PV (cm) | >0.04 |
| DCA baryon $V^0$ track to PV (cm) | >0.03 |
| DCA $V^0$ daughters ($\sigma$) | <1.5 |
| DCA bachelor to PV (cm ) | < 1.3 |
| Cascade $\cos(\theta_{PA})$ | >0.97 |
| $V^0$ $\cos(\theta_{PA})$ | >0.97 |
| Proper lifetime $K_S^0$ (cm) | <20 |
| $V^0$ invariant mass window (GeV/$c^2$) | ±0.008 |
| Maximum DCAz bachelor to PV (cm) | < 4 |
| **Selection** | **Value** |
| Rapidity $\|y\|$ | <0.5 |
| dE/dx (N$\sigma$) | <5 |
| Proper lifetime $mL/p$ | $< 3 \times c\tau$ |
| Tracking flags for daughters | kTPCrefit |
| Daughter Track $N_{TPCclusters}$ | > 70 |

0.995 used

Table 3: Selection criteria for charged Ξ candidates

# Summary and To Do

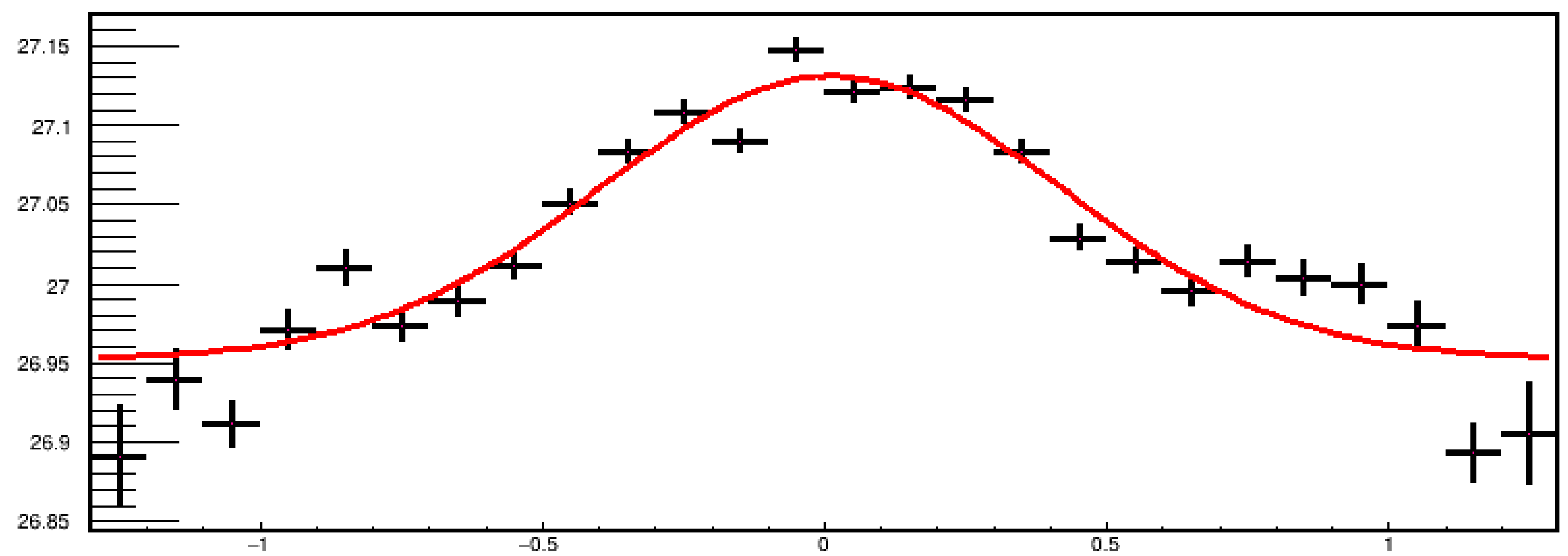
1. Efficiency corrected correlation function constructed for $\Lambda$ and $K_s^0$ triggers.
2. Separating the peak region and bulk region needs further analysis.
3. Yet to extract the yield by making away side zero.
4. Feed down correction in $\Lambda$ needs to be implemented after reducing the background.
5. Invariant mass fit is yet to be optimized.




0-10 % $K_s^0$ *triggered*

$\chi^2/ndf$ = 7.9

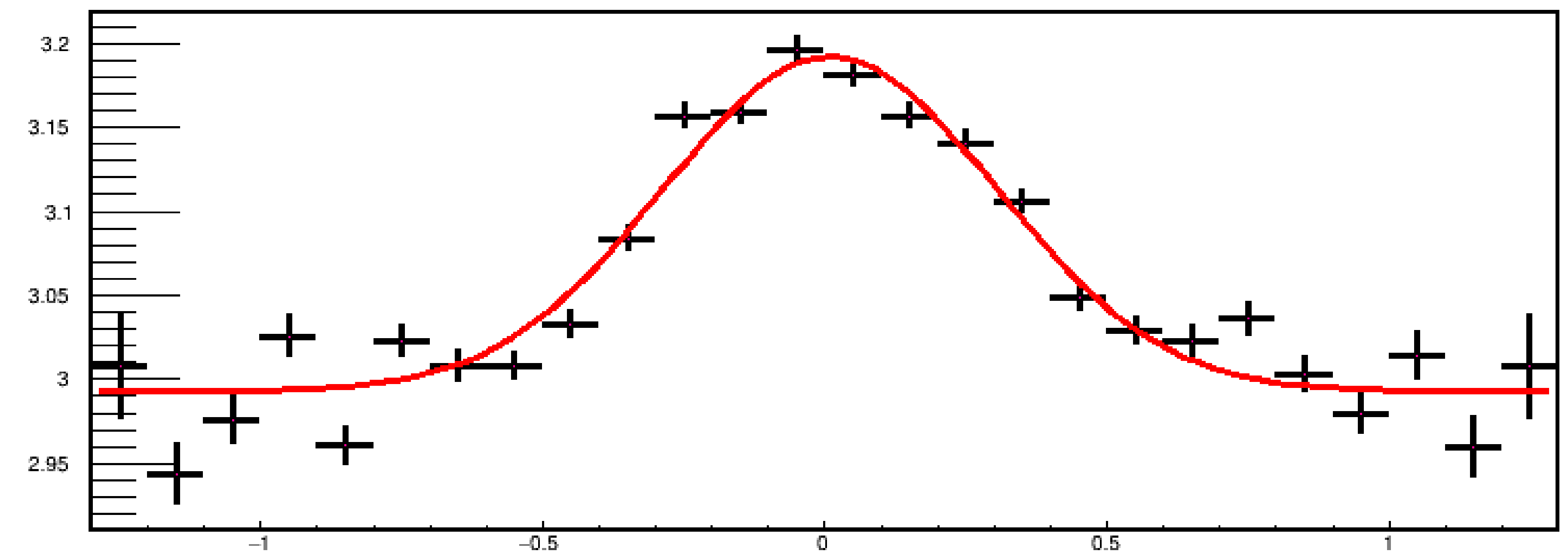
$\sigma = 0.45$




40-60 % $K_s^0$ *triggered*

$\chi^2/ndf$ = 4.55

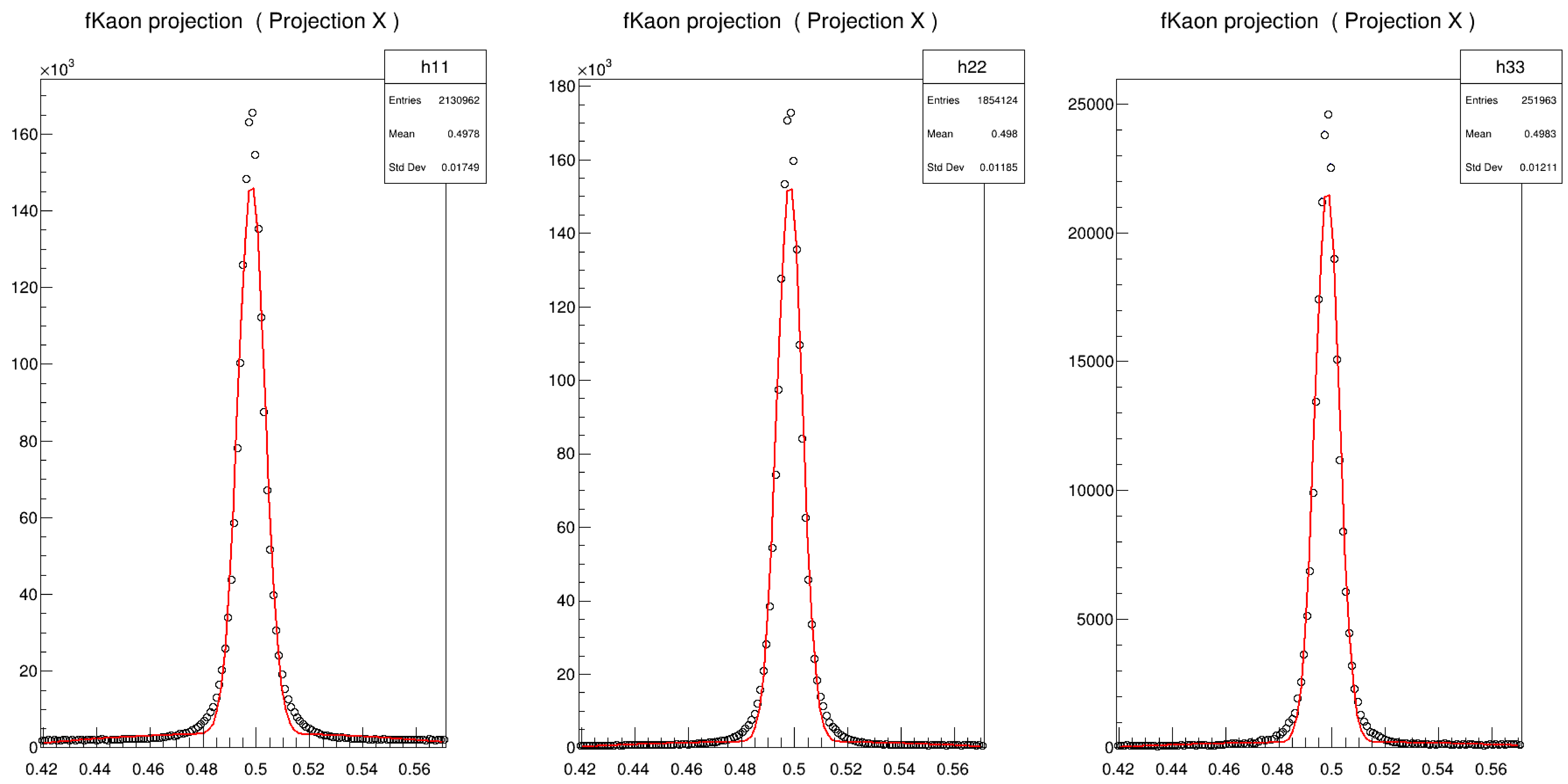
$\sigma = 0.40$



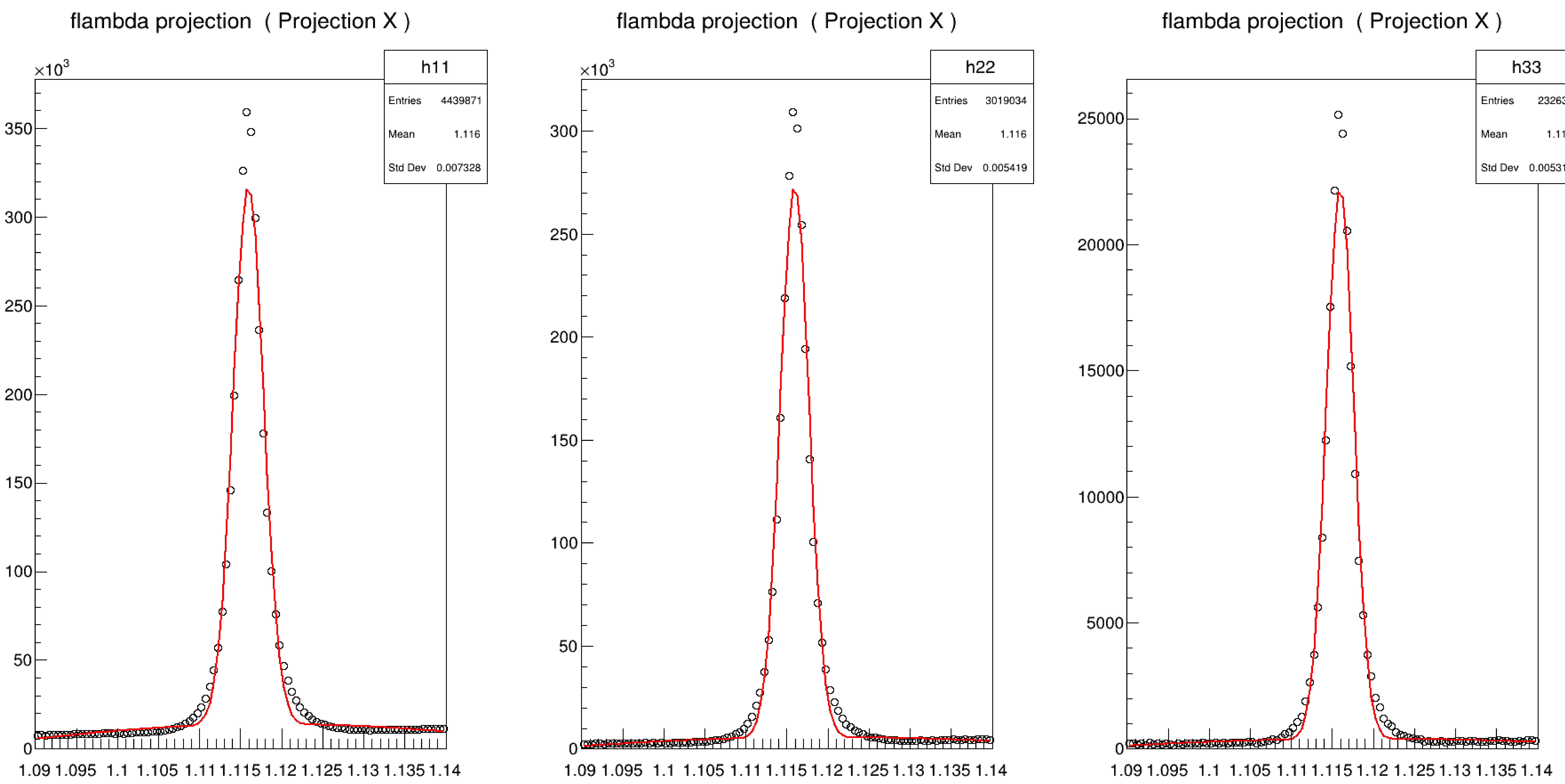

60-80 % $K_s^0$ *triggered*

$\chi^2/ndf$ = 3.69

$\sigma = 0.29$

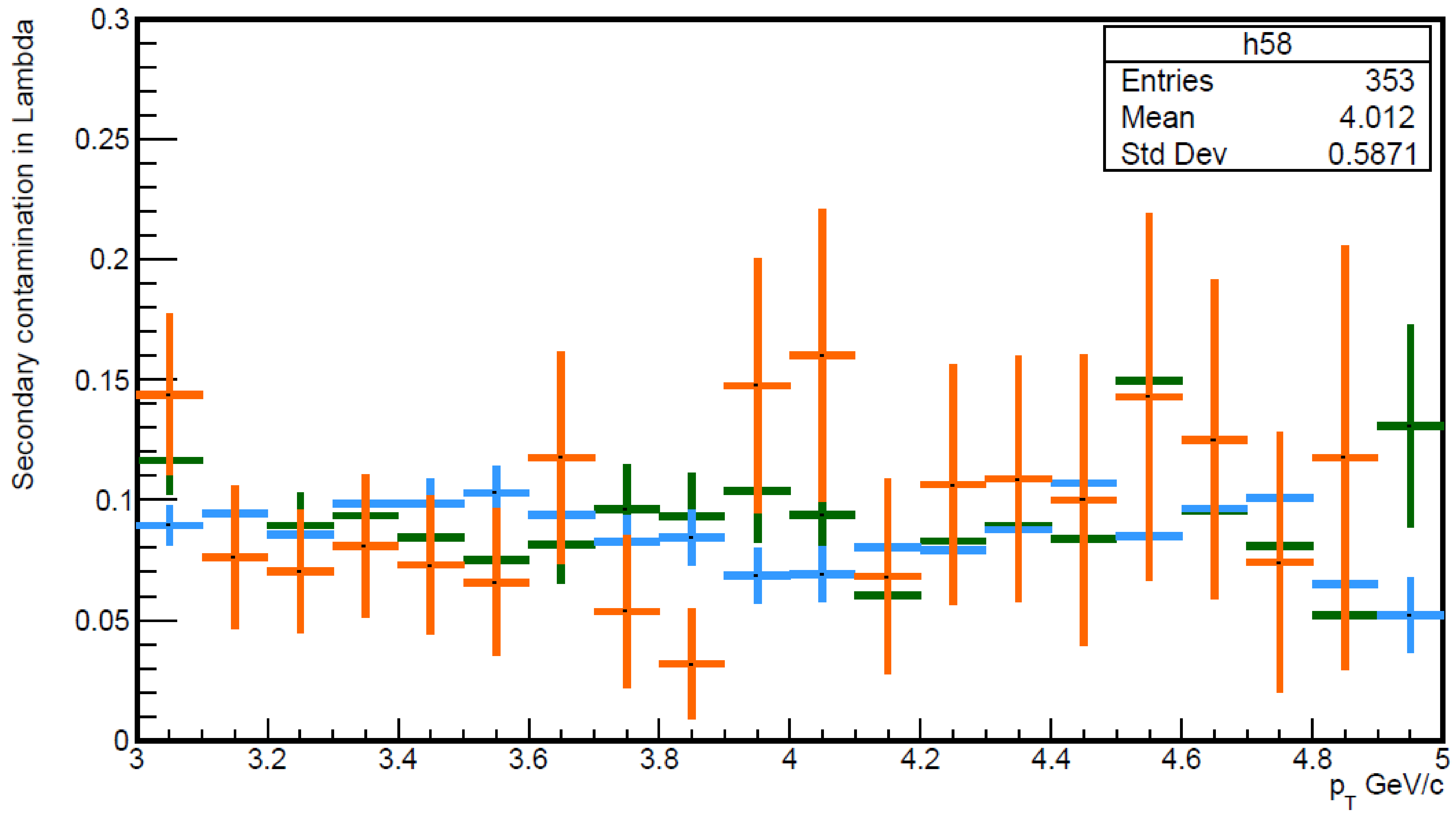


fKaon projection ( Projection X )
h11
Entries 2130962
Mean 0.4978
Std Dev 0.01749
×10^3
0
20
40
60
80
100
120
140
160
0.42 0.44 0.46 0.48 0.5 0.52 0.54 0.56
fKaon projection ( Projection X )
h22
Entries 1854124
Mean 0.498
Std Dev 0.01185
×10^3
0
20
40
60
80
100
120
140
160
180
0.42 0.44 0.46 0.48 0.5 0.52 0.54 0.56
fKaon projection ( Projection X )
h33
Entries 251963
Mean 0.4983
Std Dev 0.01211
0
5000
10000
15000
20000
25000
0.42 0.44 0.46 0.48 0.5 0.52 0.54 0.56

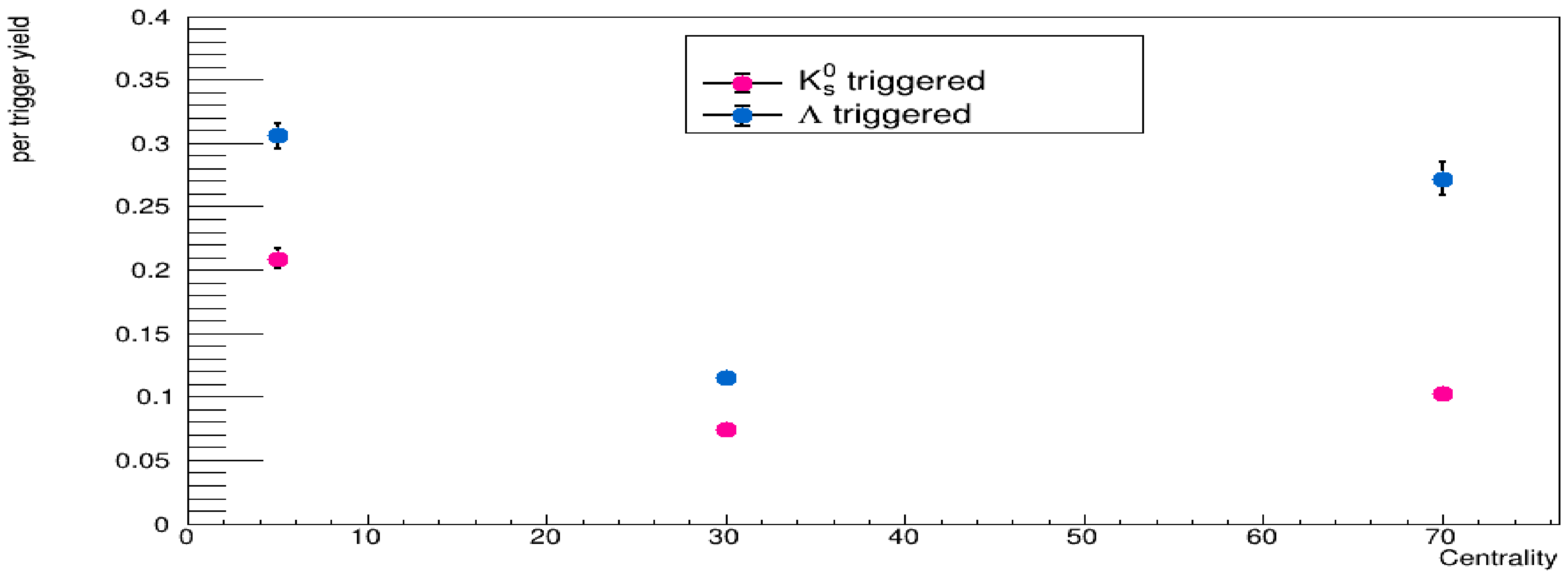


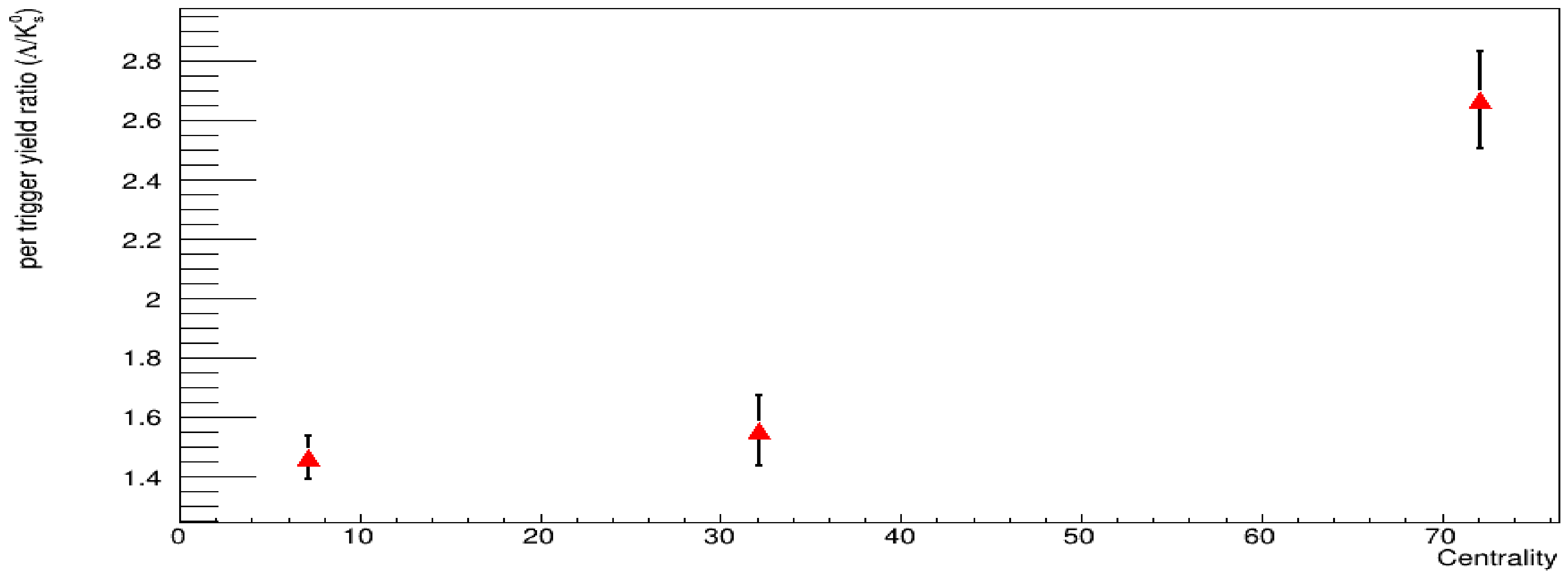
flambda projection ( Projection X )
h11
Entries 4439871
Mean 1.116
Std Dev 0.007328
×10^3
0
50
100
150
200
250
300
350
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14
flambda projection ( Projection X )
h22
Entries 3019034
Mean 1.116
Std Dev 0.005419
×10^3
0
50
100
150
200
250
300
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14
flambda projection ( Projection X )
h33
Entries 232636
Mean 1.116
Std Dev 0.005317
0
5000
10000
15000
20000
25000
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14

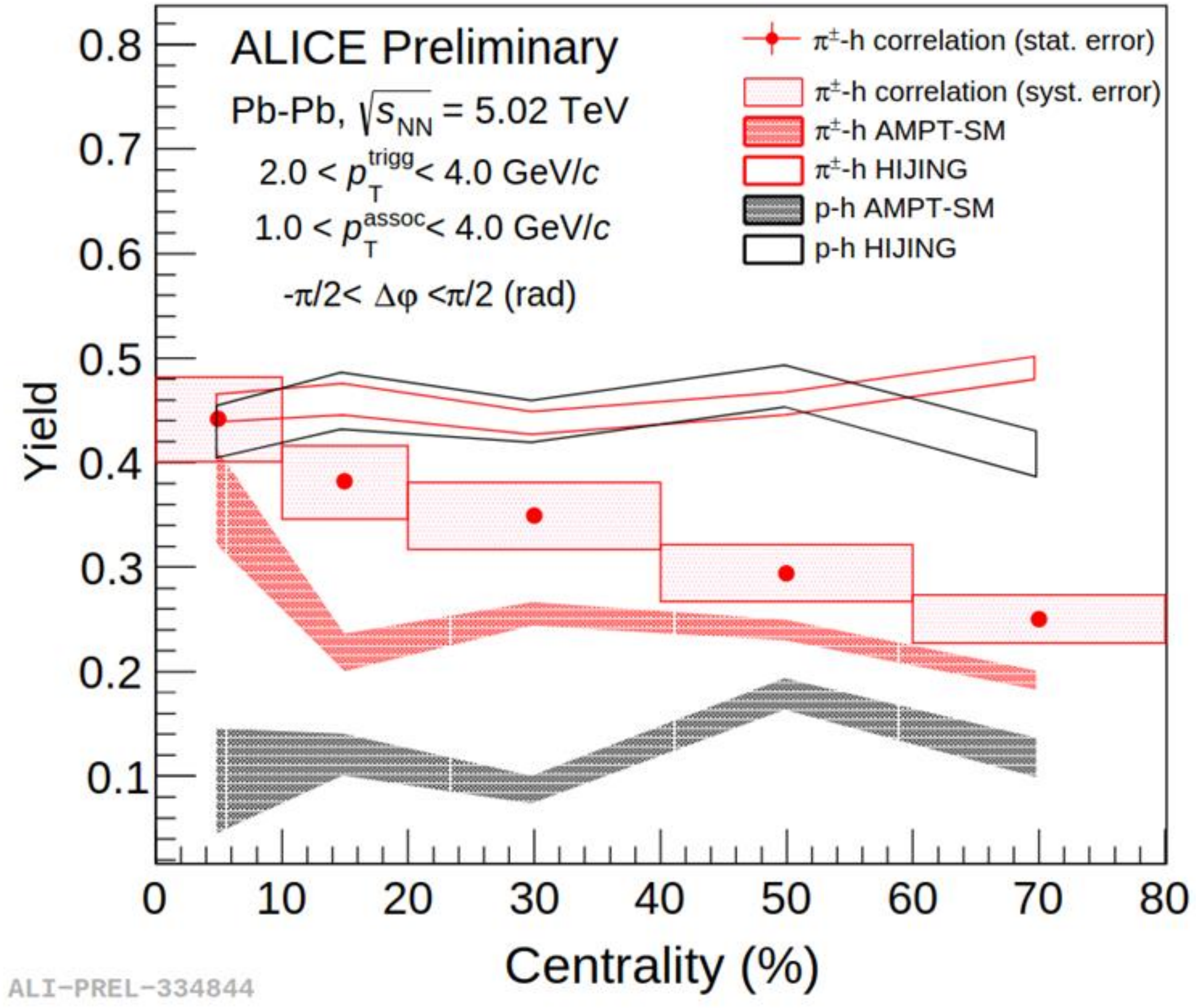
# BACKUP Plots



```
for (Int_t iXi = 0; iXi < nXiTot; iXi++)
 {
   AliAODcascade *Xi=fAOD->GetCascade(iXi);
    if (!Xi) continue;

   AliAODMCParticle* recoMCXi = static_cast<AliAODMCParticle*>(fArrayMC->At(TMath::Abs(Xi->GetLabel())));
     if(!recoMCXi) continue;

      Int_t pdgCode=((AliAODMCParticle*)recoMCXi)->GetPdgCode();

       if( Xi->Pt()< 2.5) continue;
       if (Xi->Pt()> 7.)continue;

      Double_t yXi = Xi->RapXi();

     if(TMath::Abs(yXi)>0.5) continue;

      if(Xi->CosPointingAngle(fBestPrimaryVtxPos)< 0.97) continue;


      AliAODTrack *pitrack = (AliAODTrack *) ( Xi->GetDecayVertexXi()->GetDaughter(0) );
      if(pitrack->Charge()==0) continue;

      Double_t nclus_pi =pitrack->GetTPCNcls();
         if(nclus_pi<70.) continue;

   AliAODMCParticle* recoMCpi = static_cast<AliAODMCParticle*>(fArrayMC->At(TMath::Abs(pitrack->GetLabel())));

   Int_t pdgcode=((AliAODMCParticle*)recoMCpi)->GetPdgCode();

   cout<<"the bachelor track is "<<pdgcode<<endl;

   AliAODTrack *V0track = (AliAODTrack *) ( Xi->GetDecayVertexXi()->GetDaughter(1) );

   //       AliAODMCParticle* recoMCv0 = static_cast<AliAODMCParticle*>(fArrayMC->At(TMath::Abs(V0track->GetLabel())));

   //      Int_t pdgcodee=((AliAODMCParticle*)recoMCv0)->GetPdgCode();

   cout<<"the v0 track is "<<V0track->Charge()<<endl;


 }
```

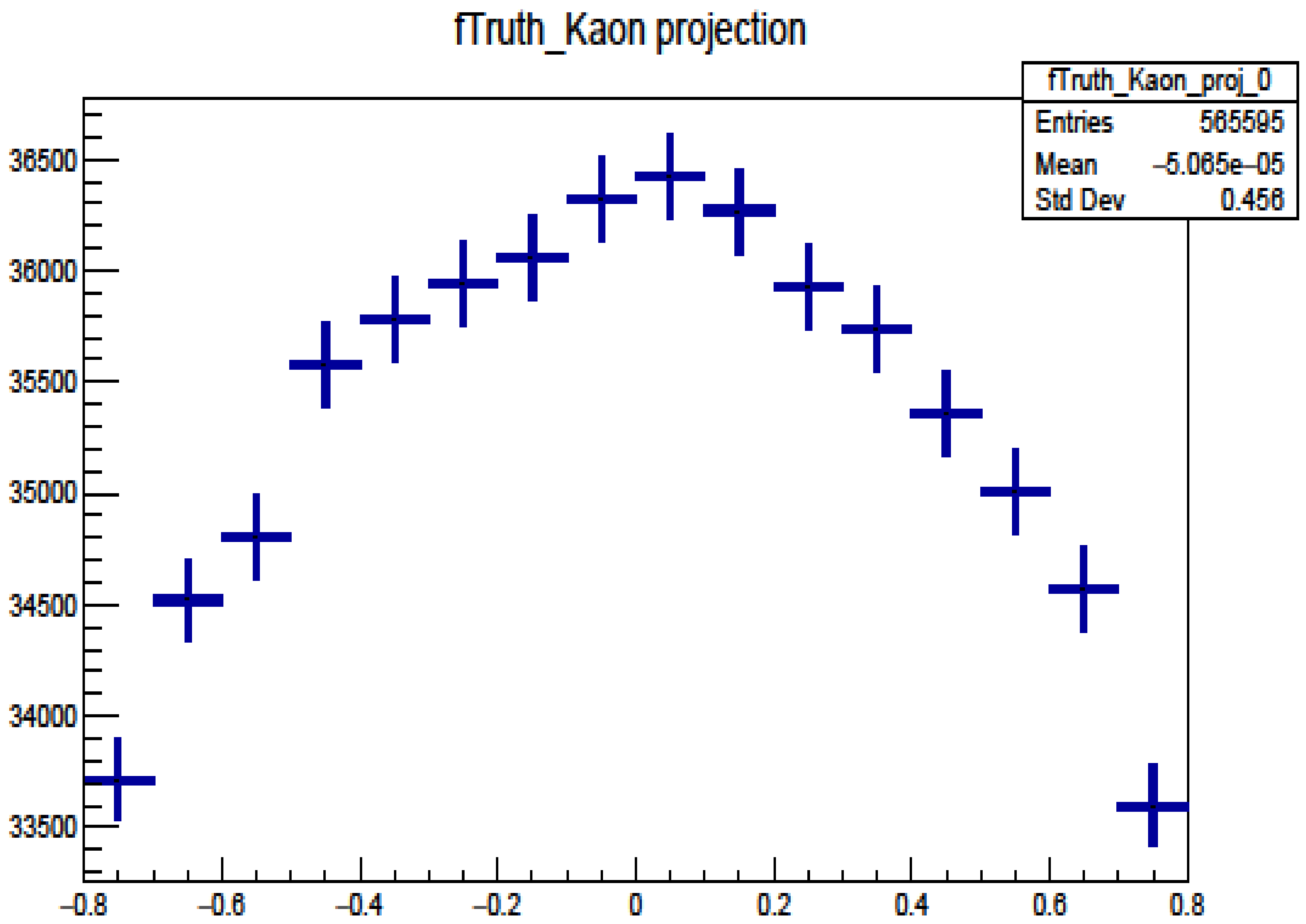


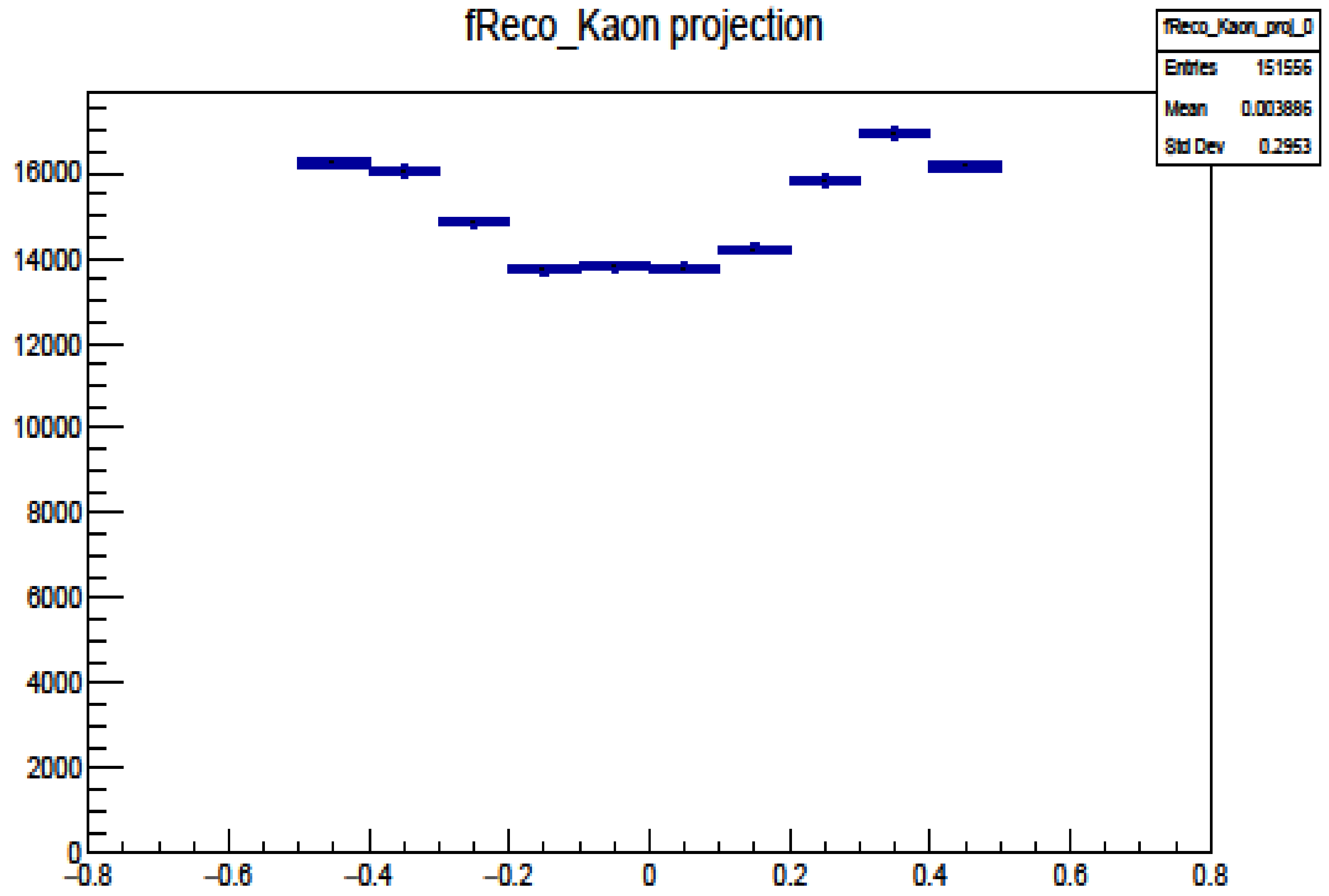



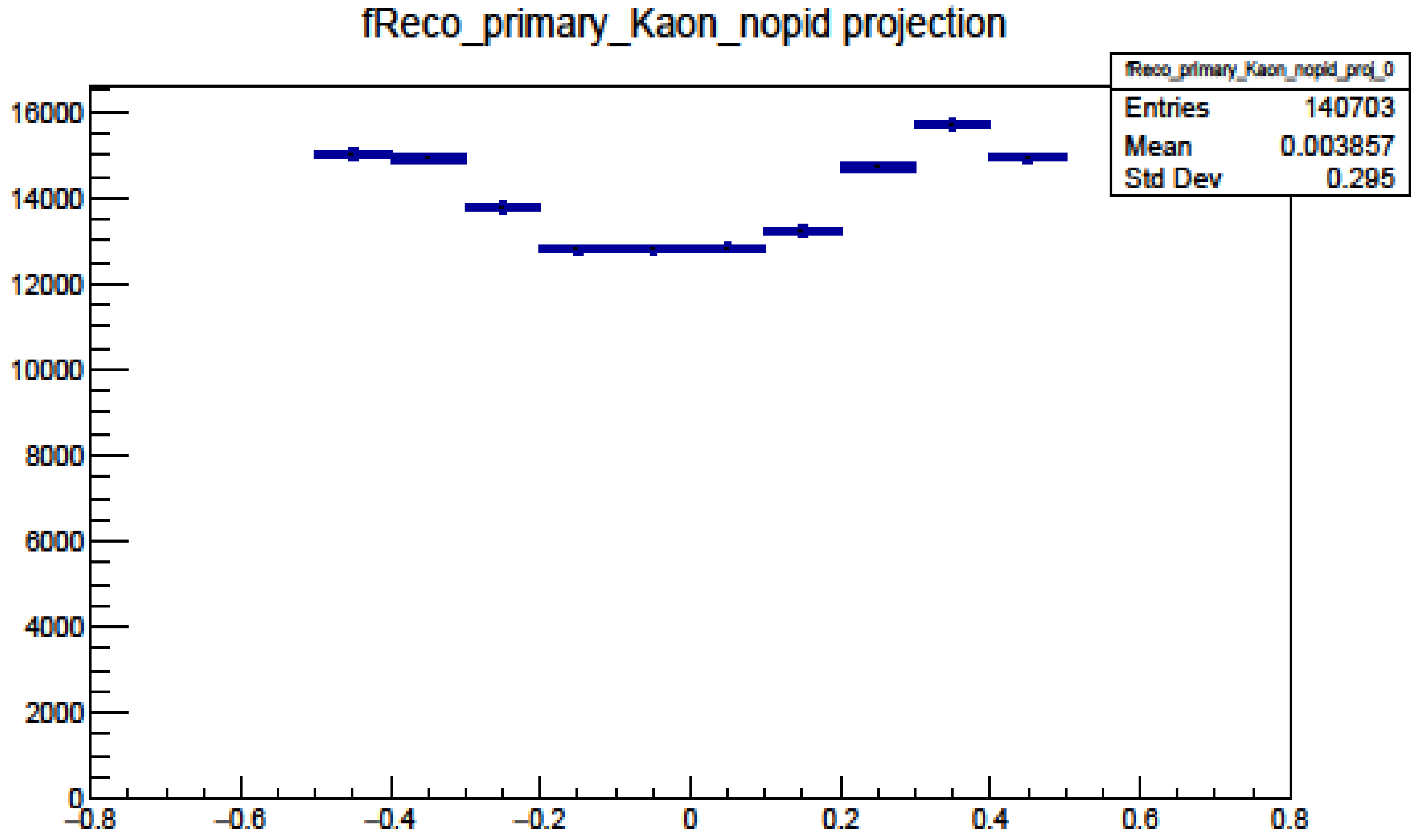




1. Dilution in yield ratio with centrality is observed but the baryon triggered yield is more than the meson triggered yield ??
2. Yet to extract the yield by making away side zero.
3. There are more no. of lambda triggers in 0-10 % and 20-40 % than Kaon triggers??
4. Invariant mass fit is yet to be optimized.

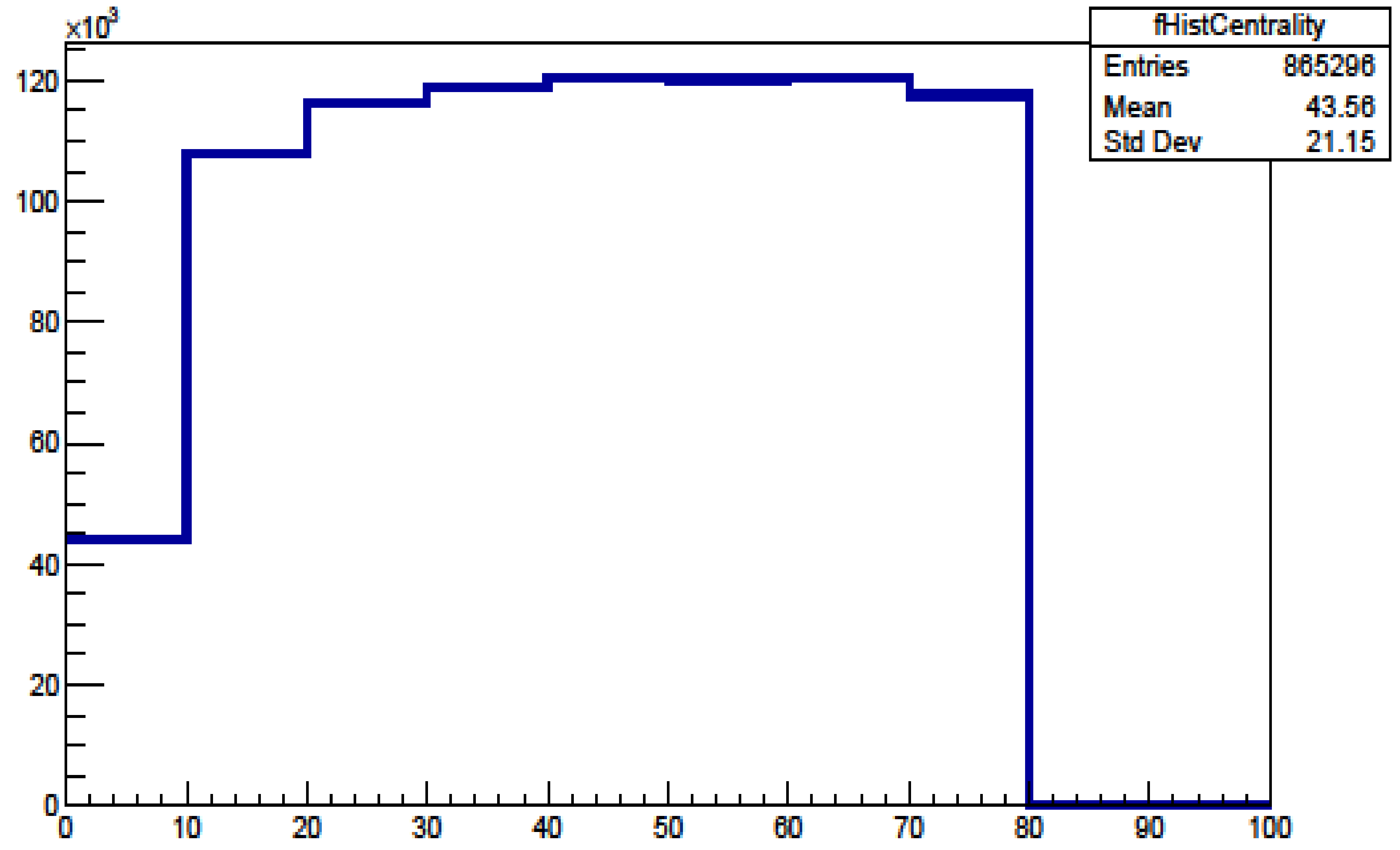
## BACKUP Plots

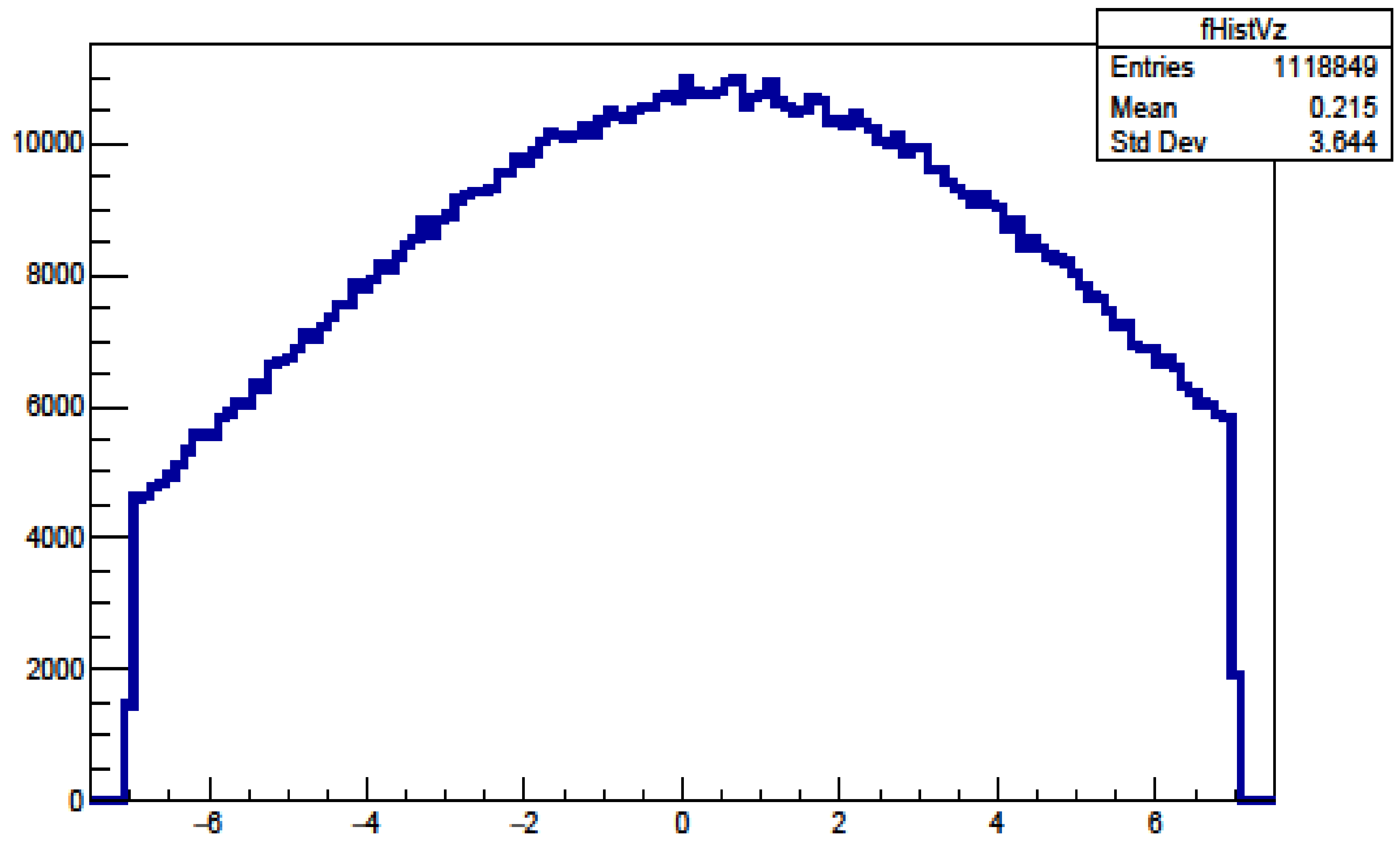


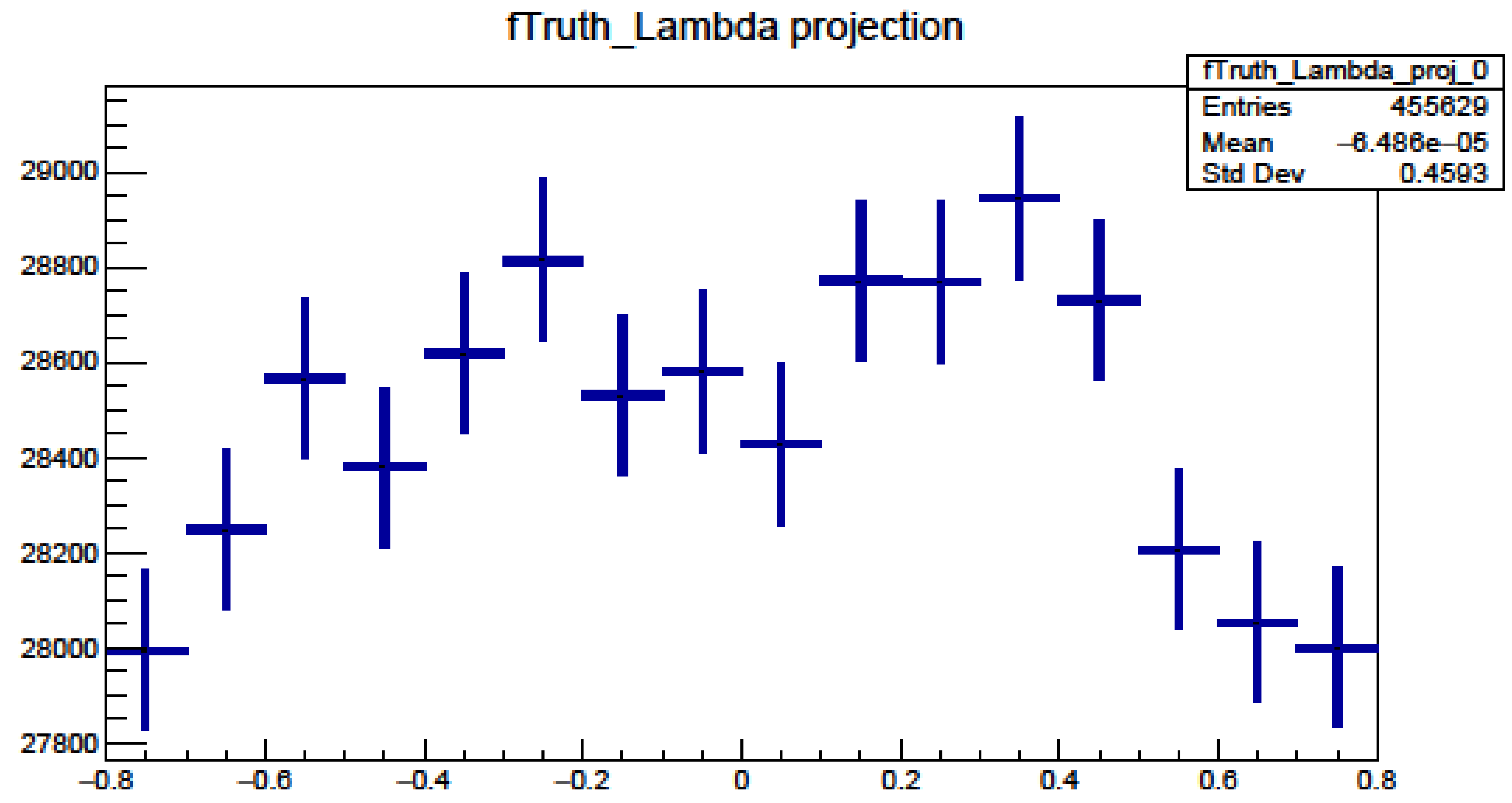



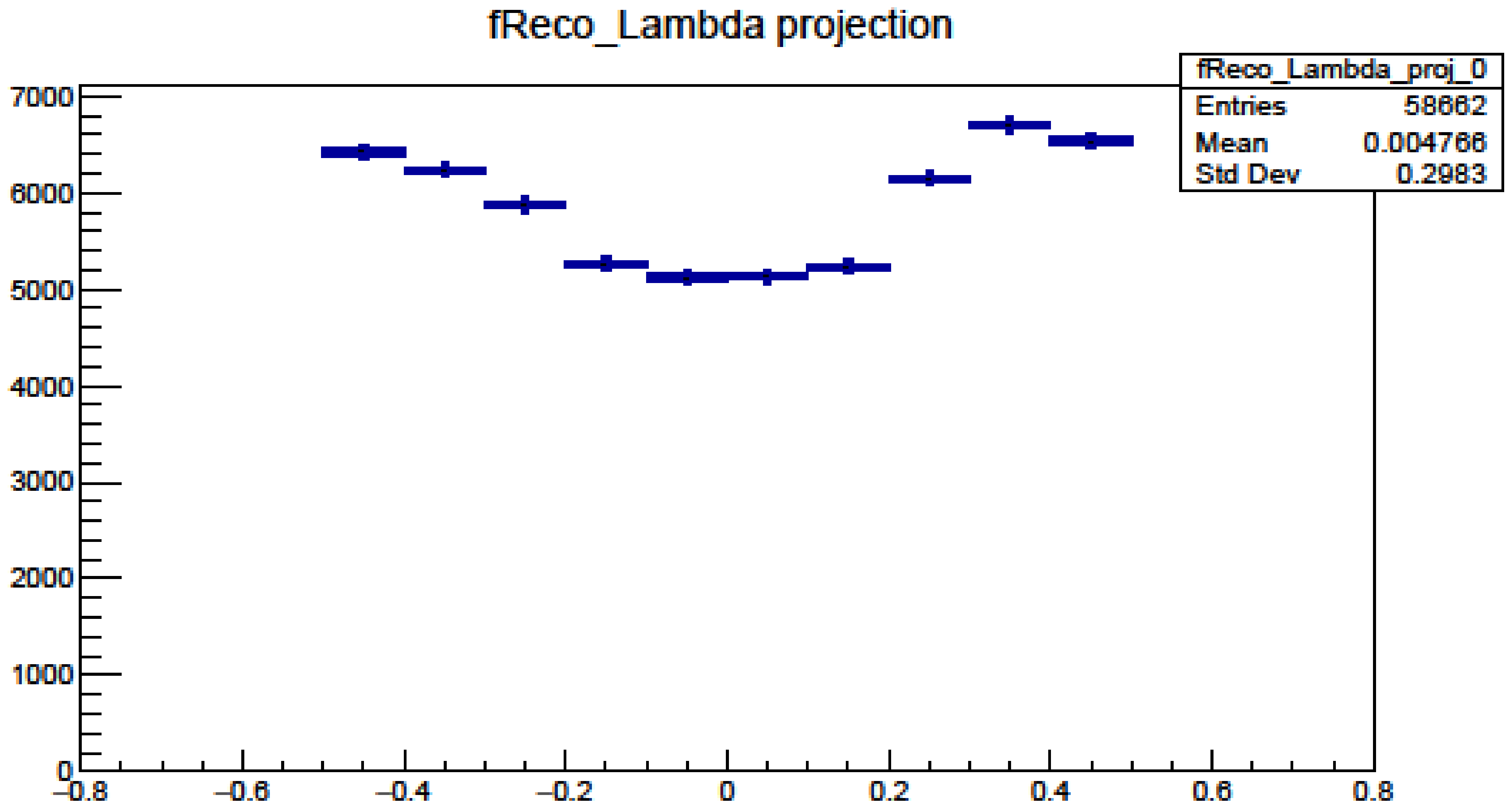
## BACKUP Plots

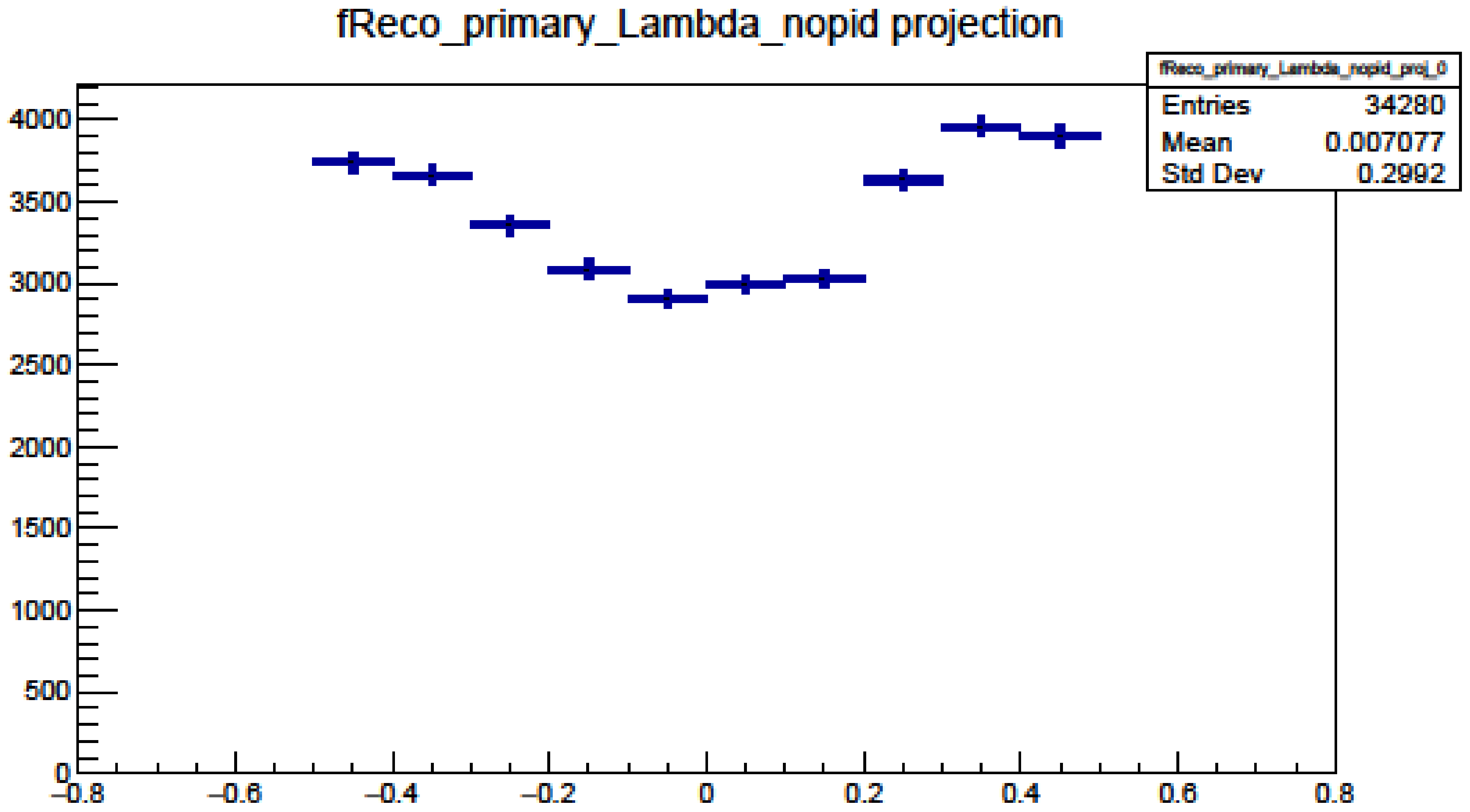


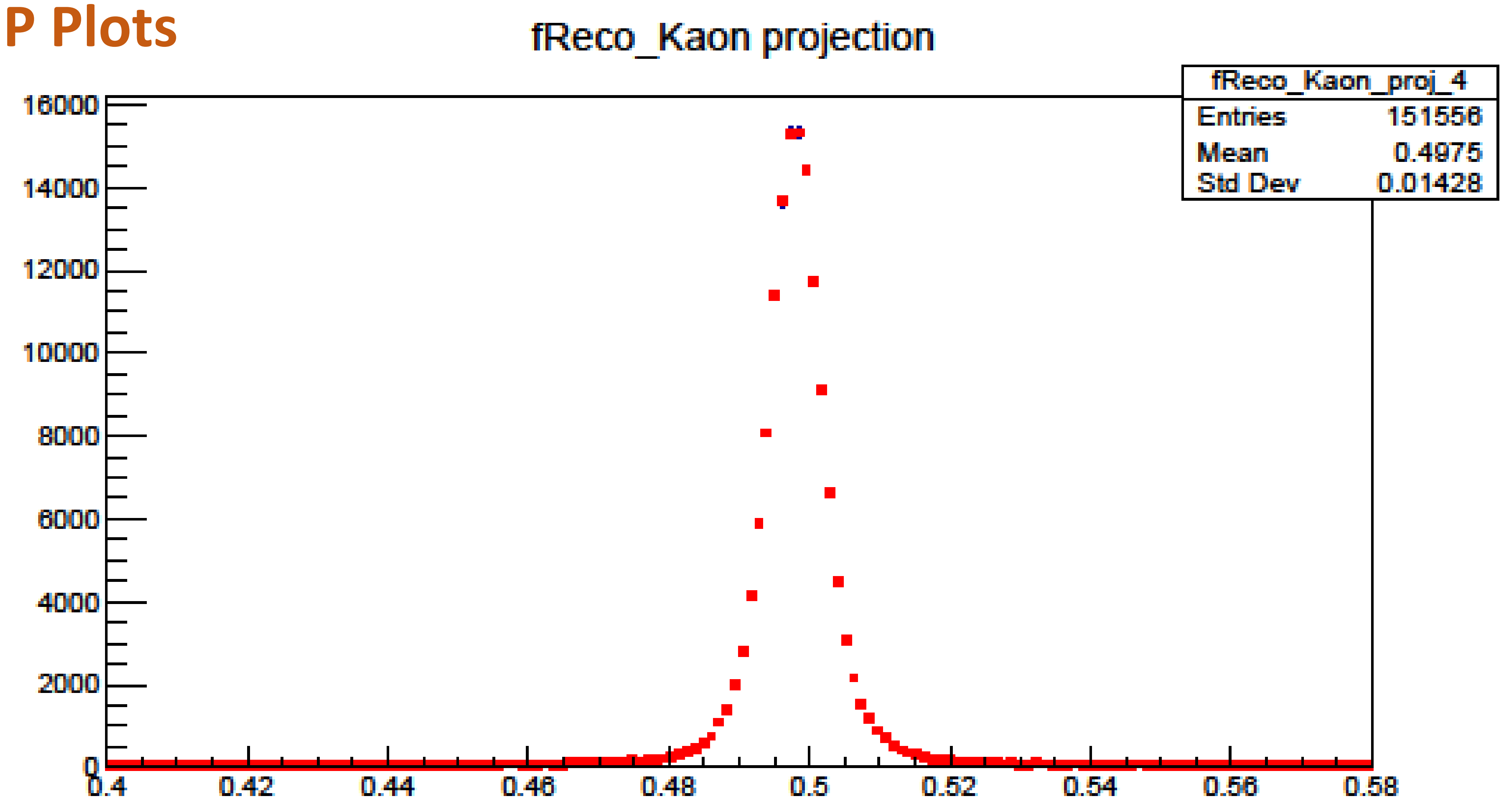
## BACKUP Plots

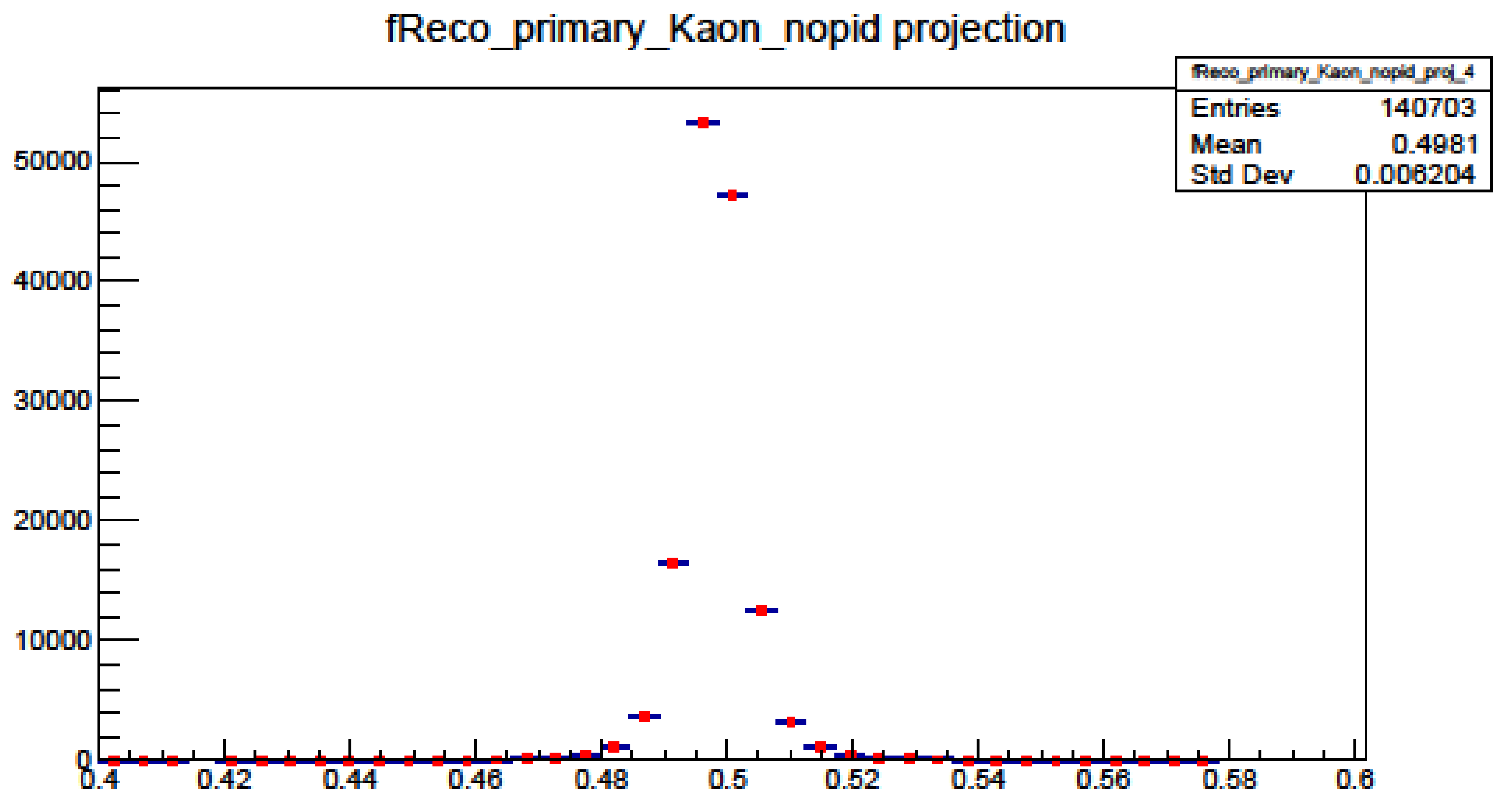


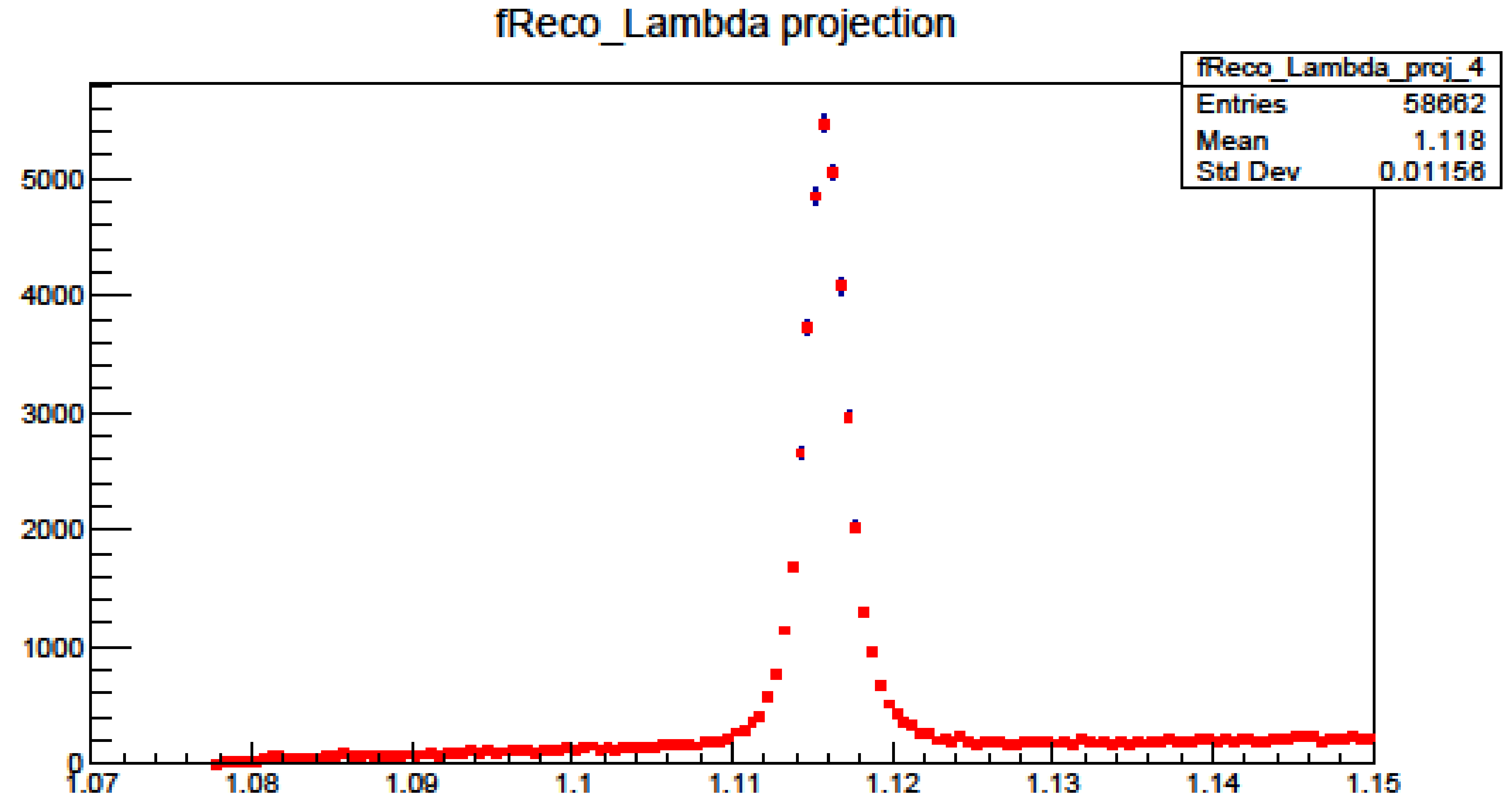



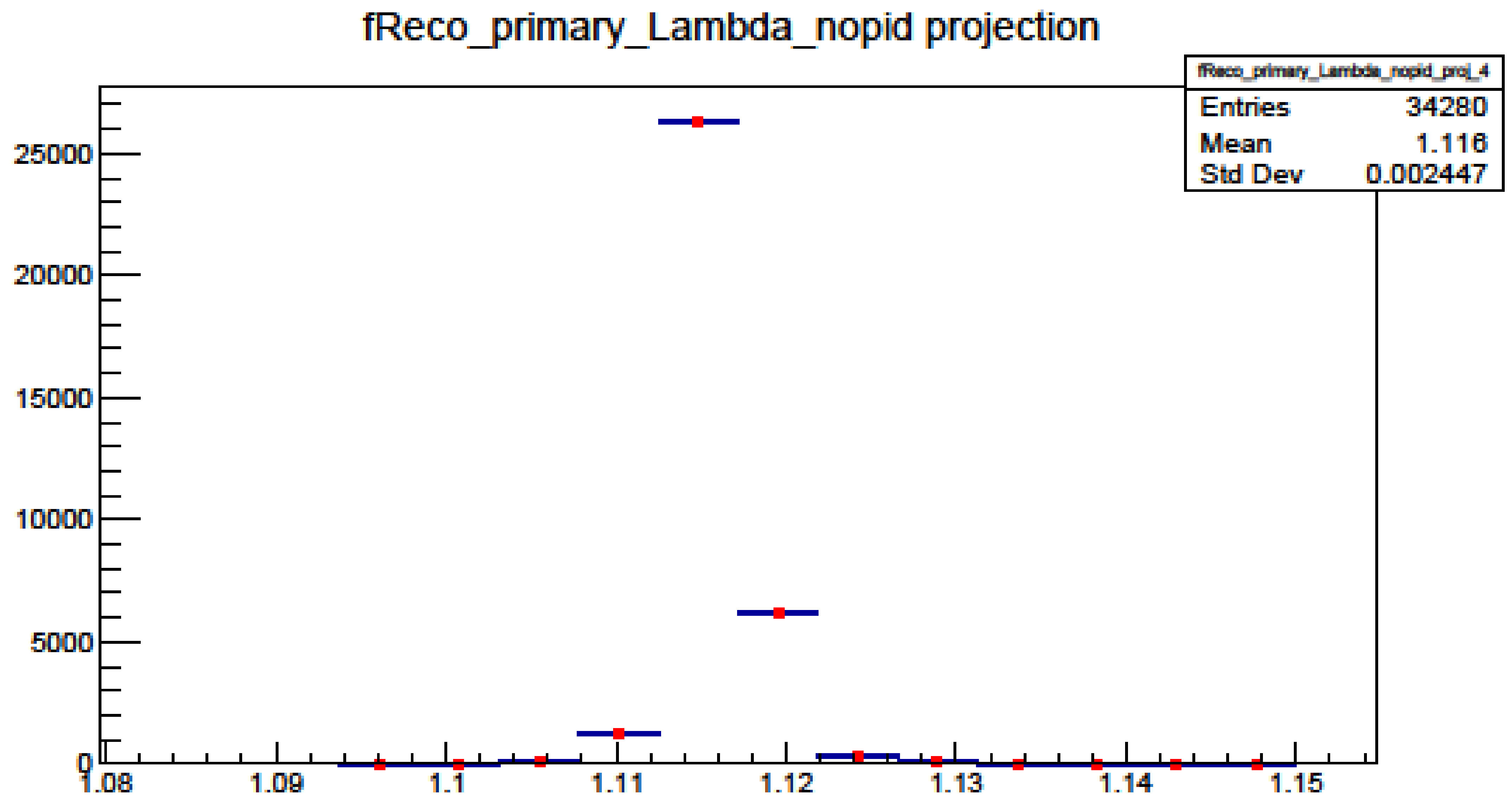



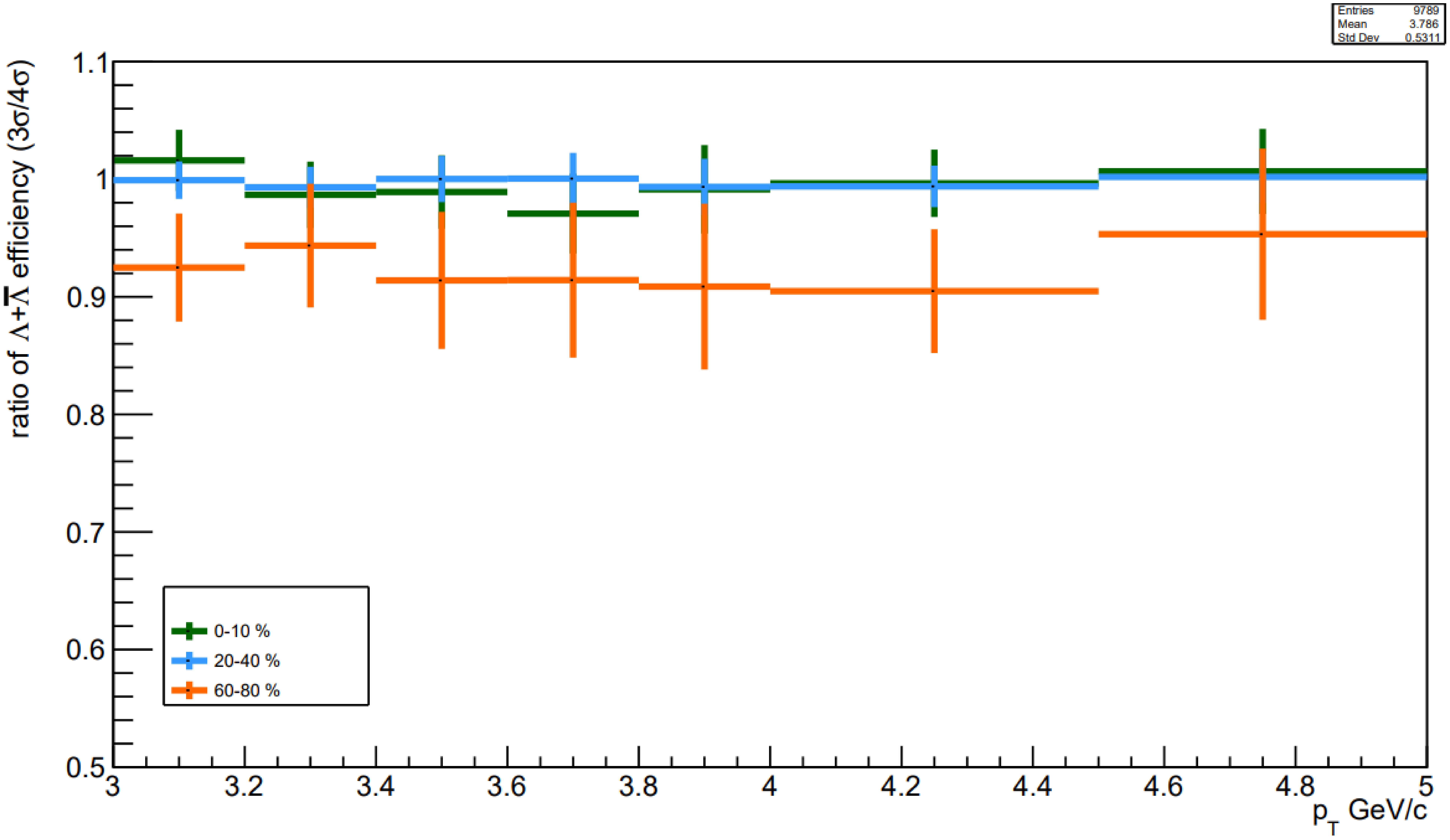
# BACKUP Plots

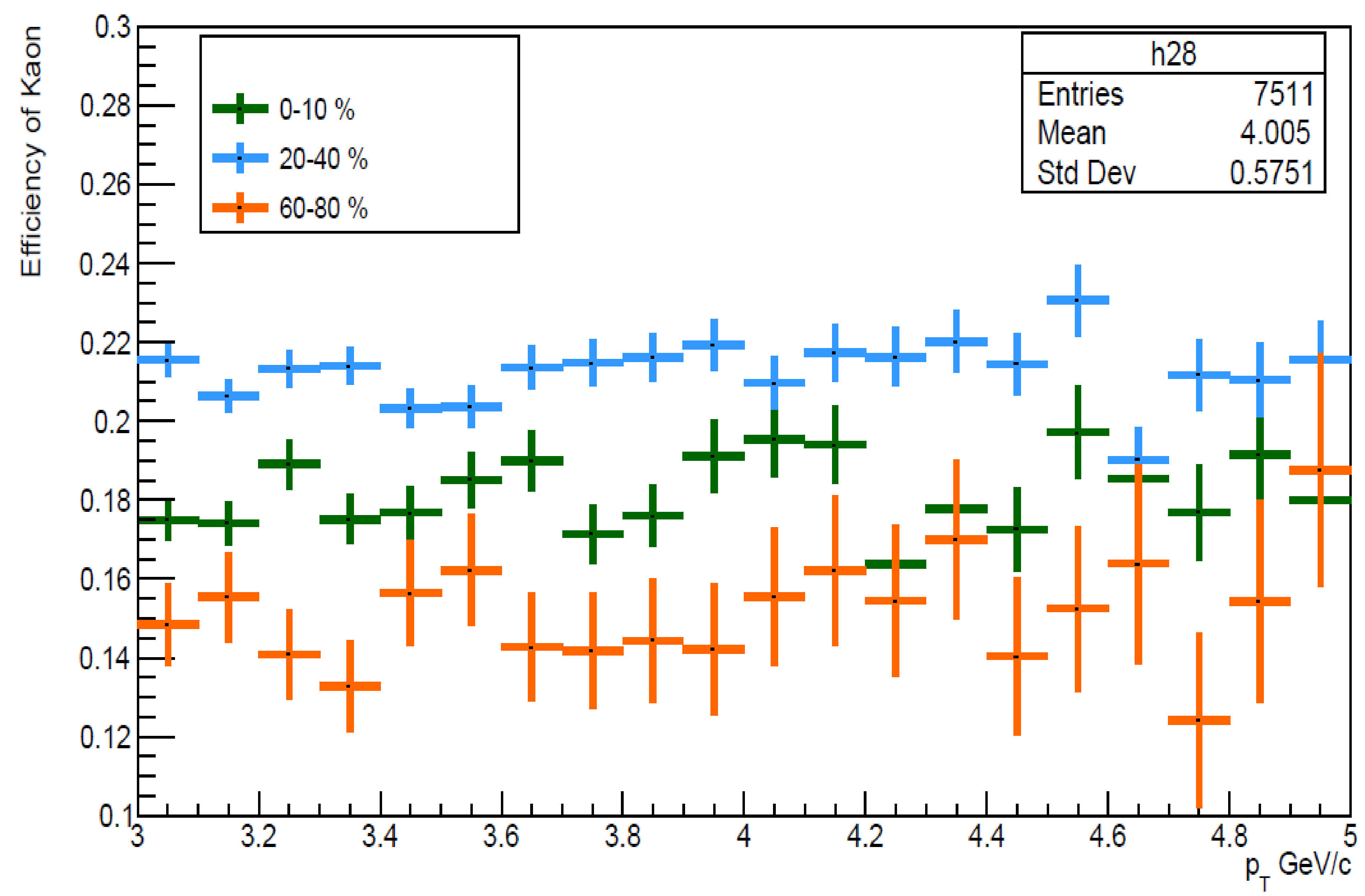


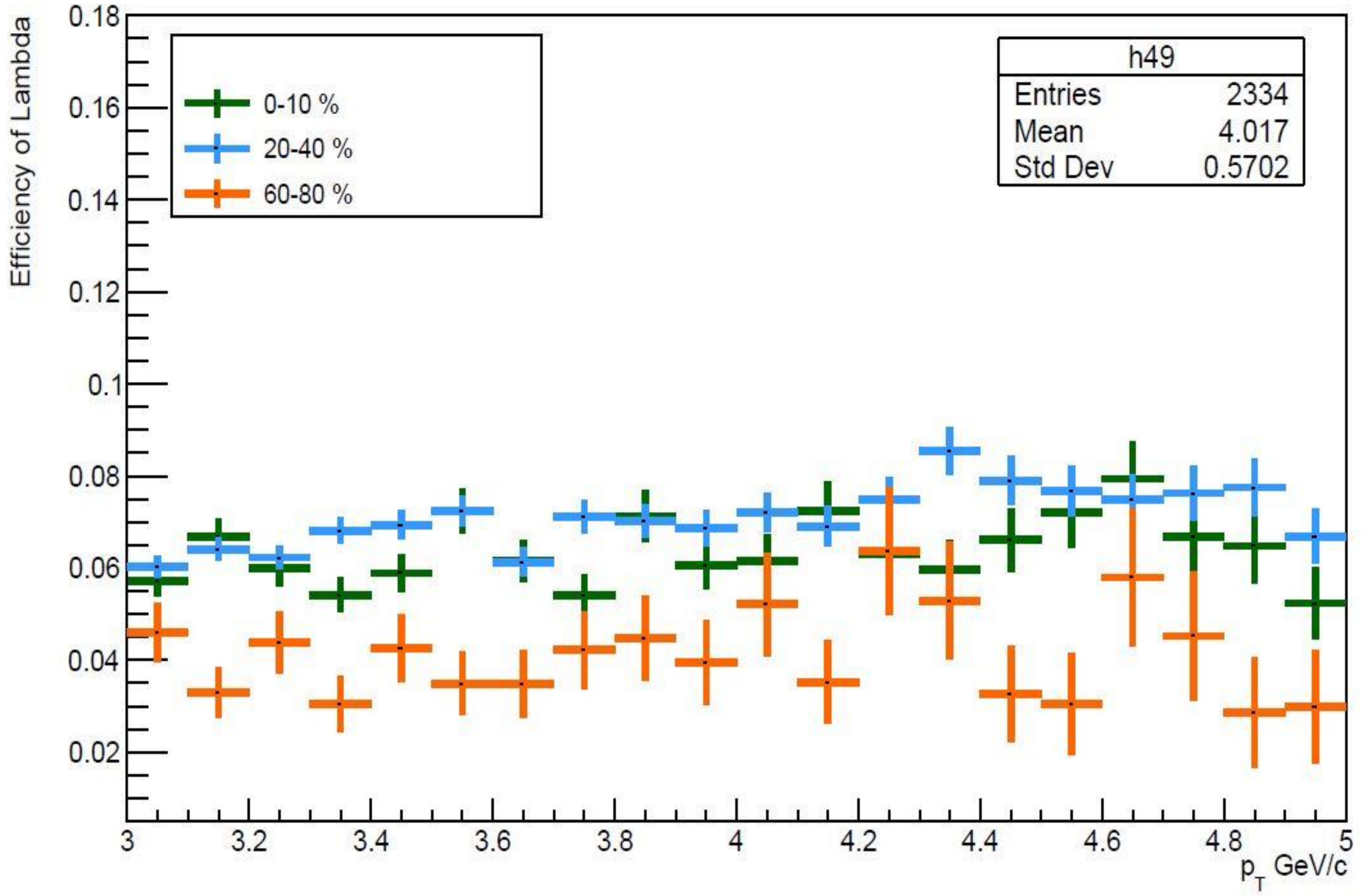



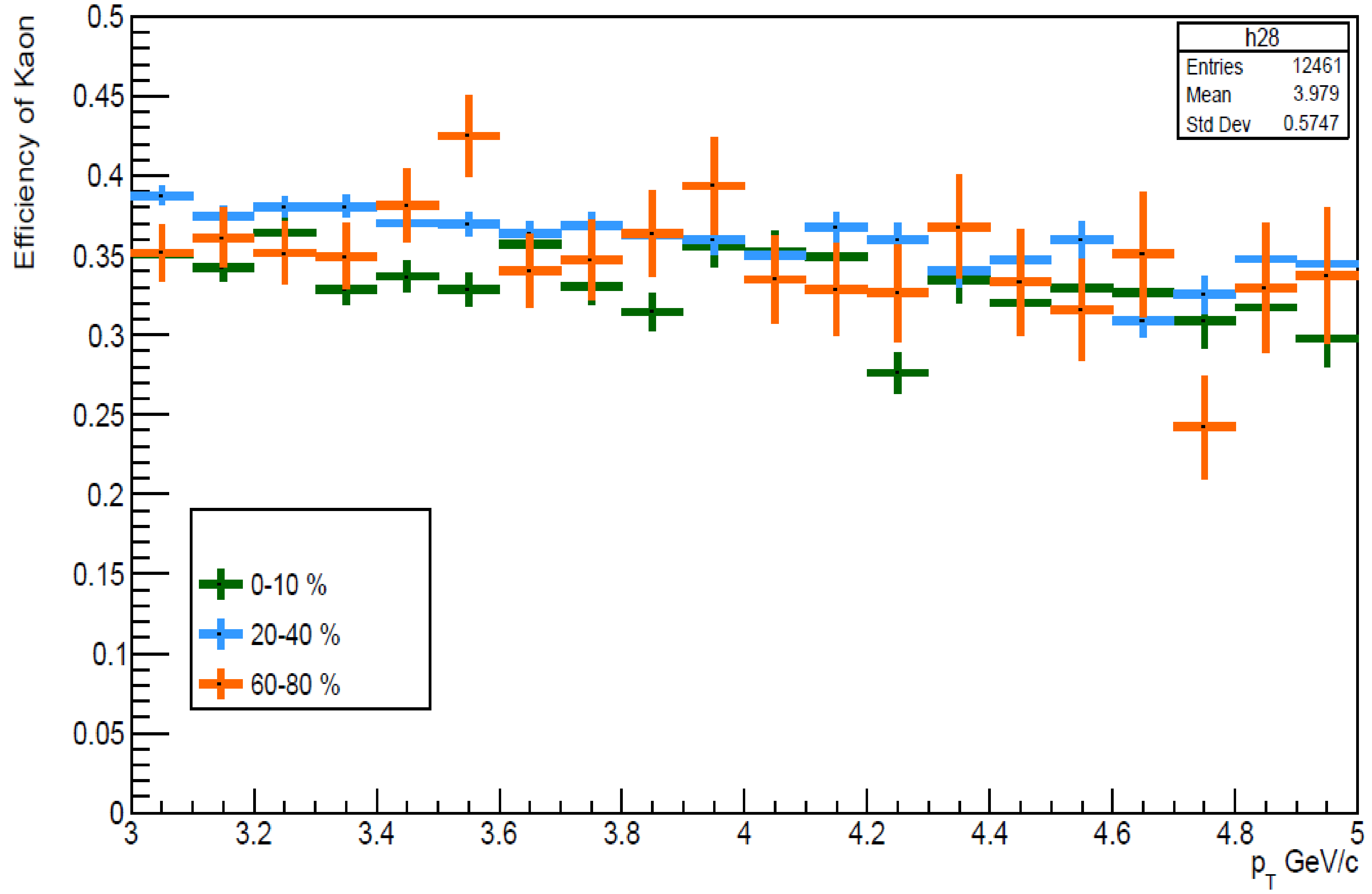



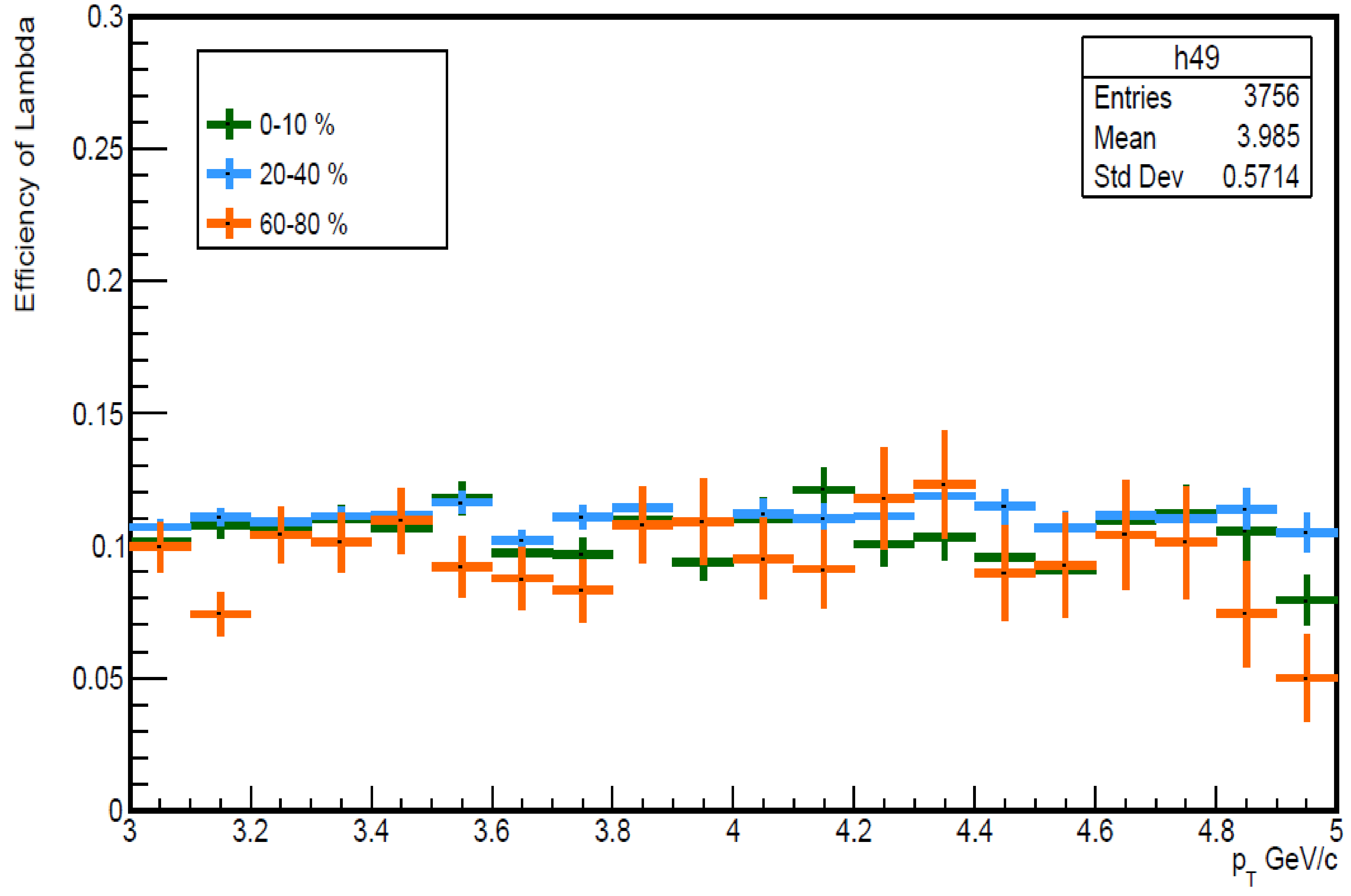

Entries 9789
Mean 3.786
Std Dev 0.5311
ratio of $\Lambda+\bar{\Lambda}$ efficiency (3σ/4σ)
1.1
1
0.9
0.8
0.7
0.6
0.5
3
3.2
3.4
3.6
3.8
4
4.2
4.4
4.6
4.8
5
$p_T$ GeV/c
0-10 %
20-40 %
60-80 %



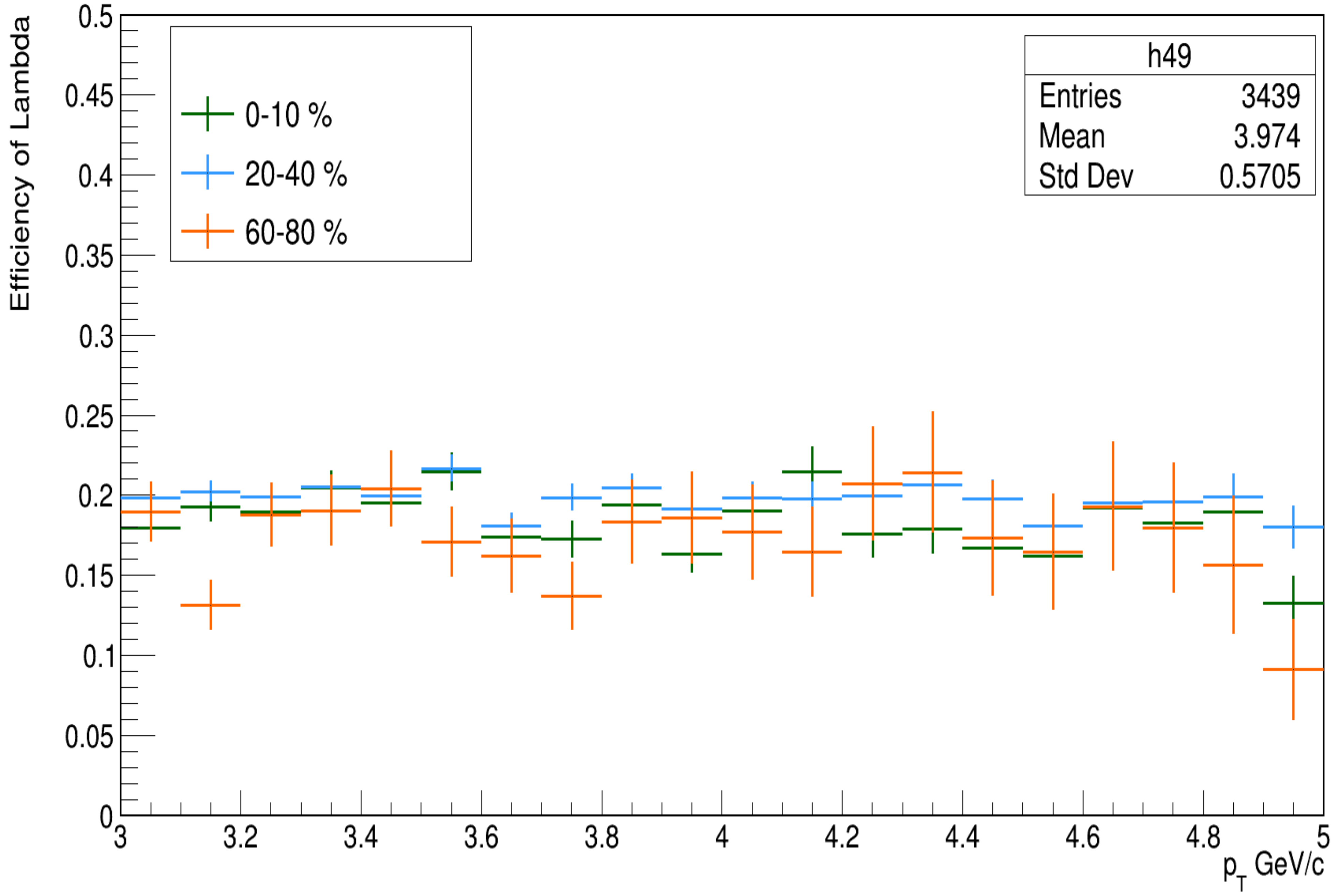



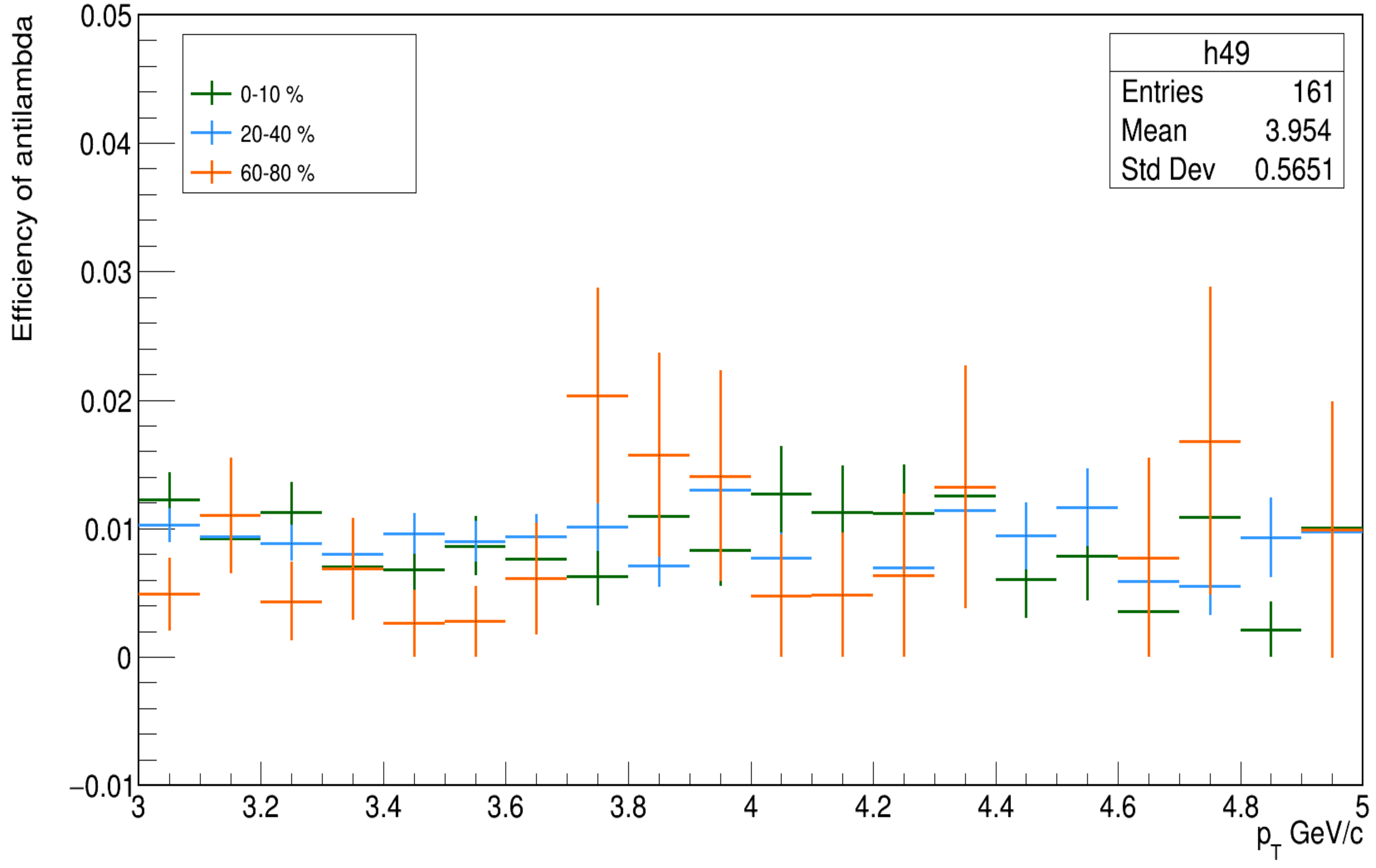

**With combined Nsigma<2 cut ( TPC+ TOF)**



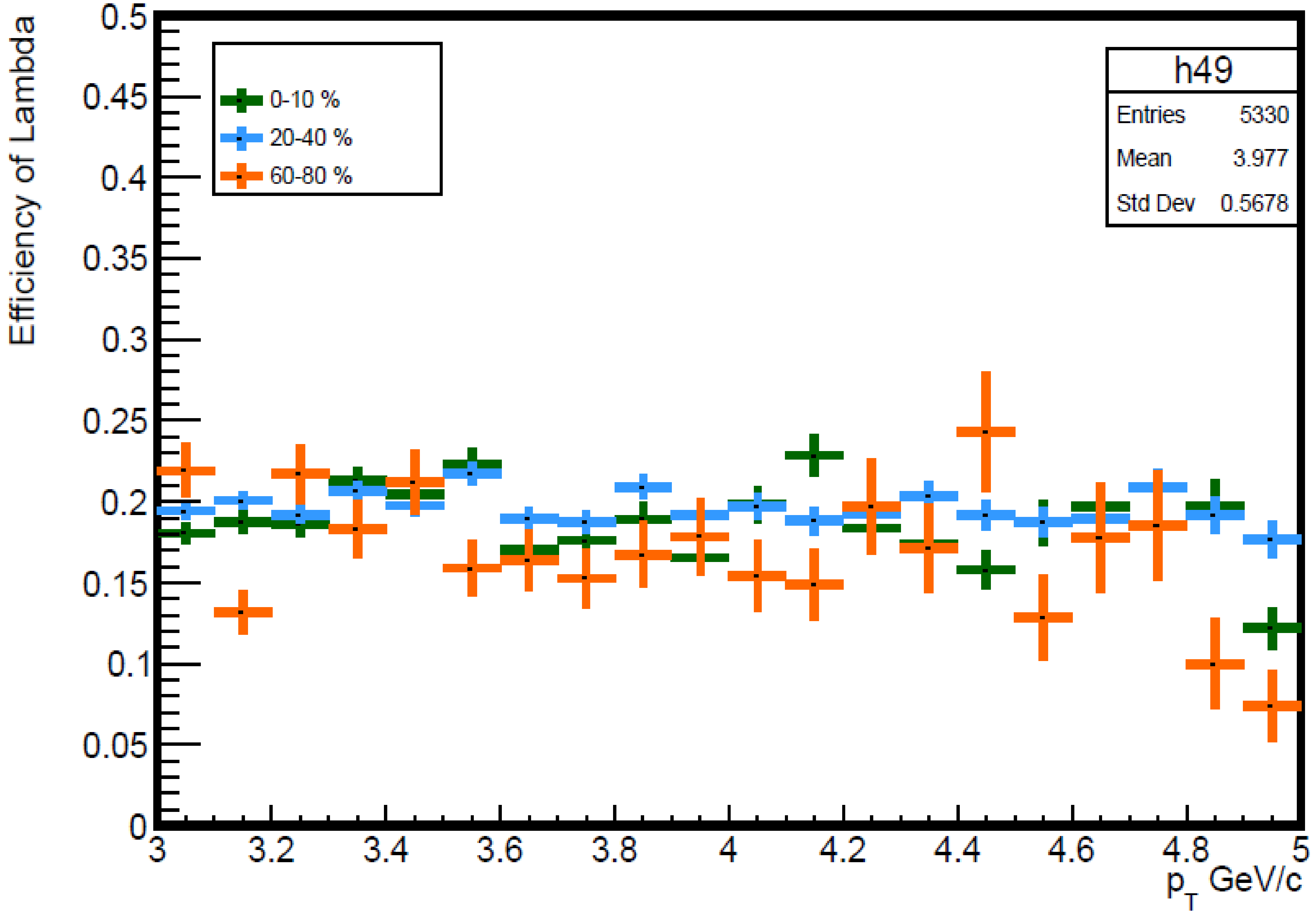



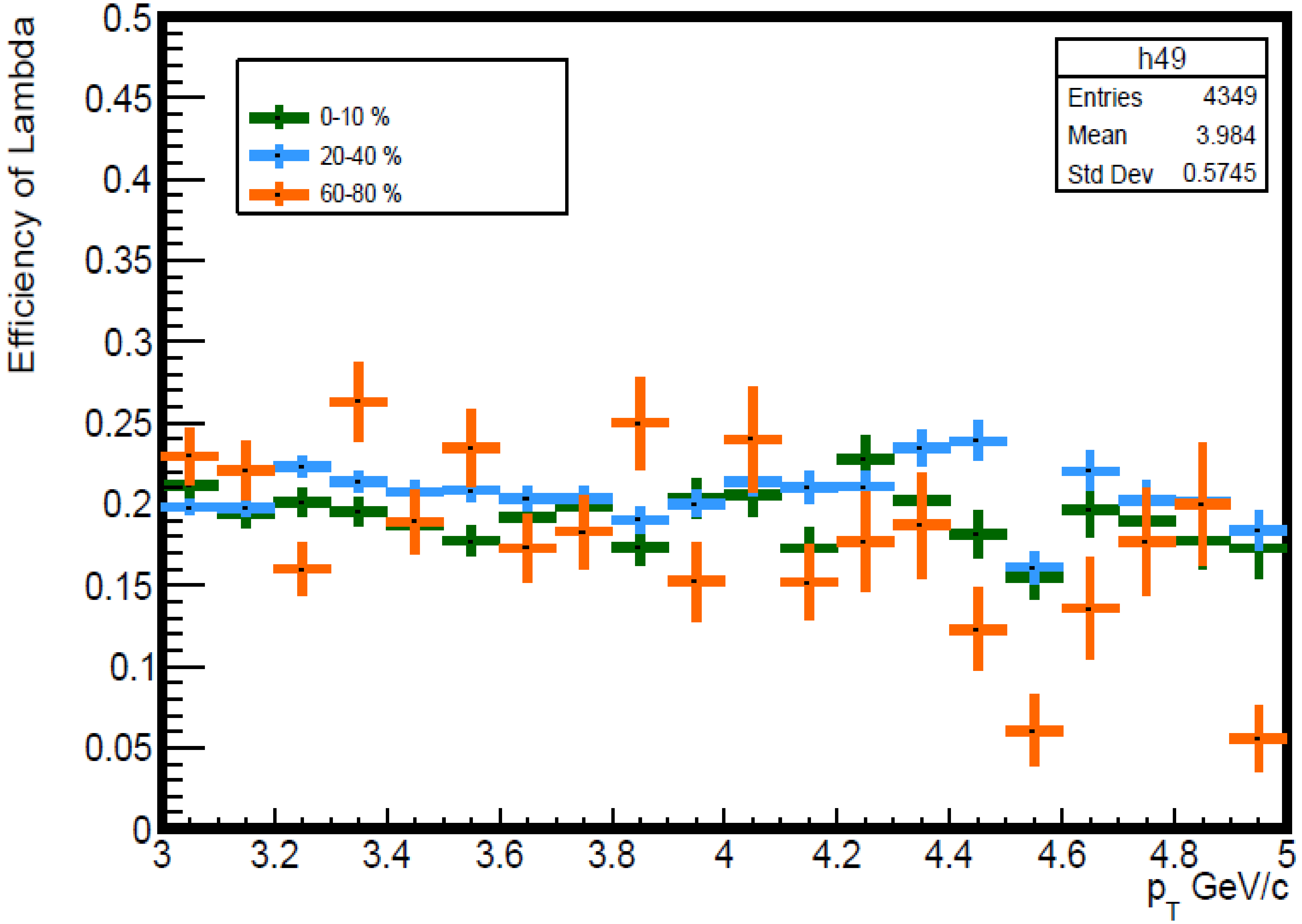

**With NsigmaTPC<3 cut**




**(With NsigmaTPC<3 cut )**




**Lambda and antiLambda efficiency are in similar range now**

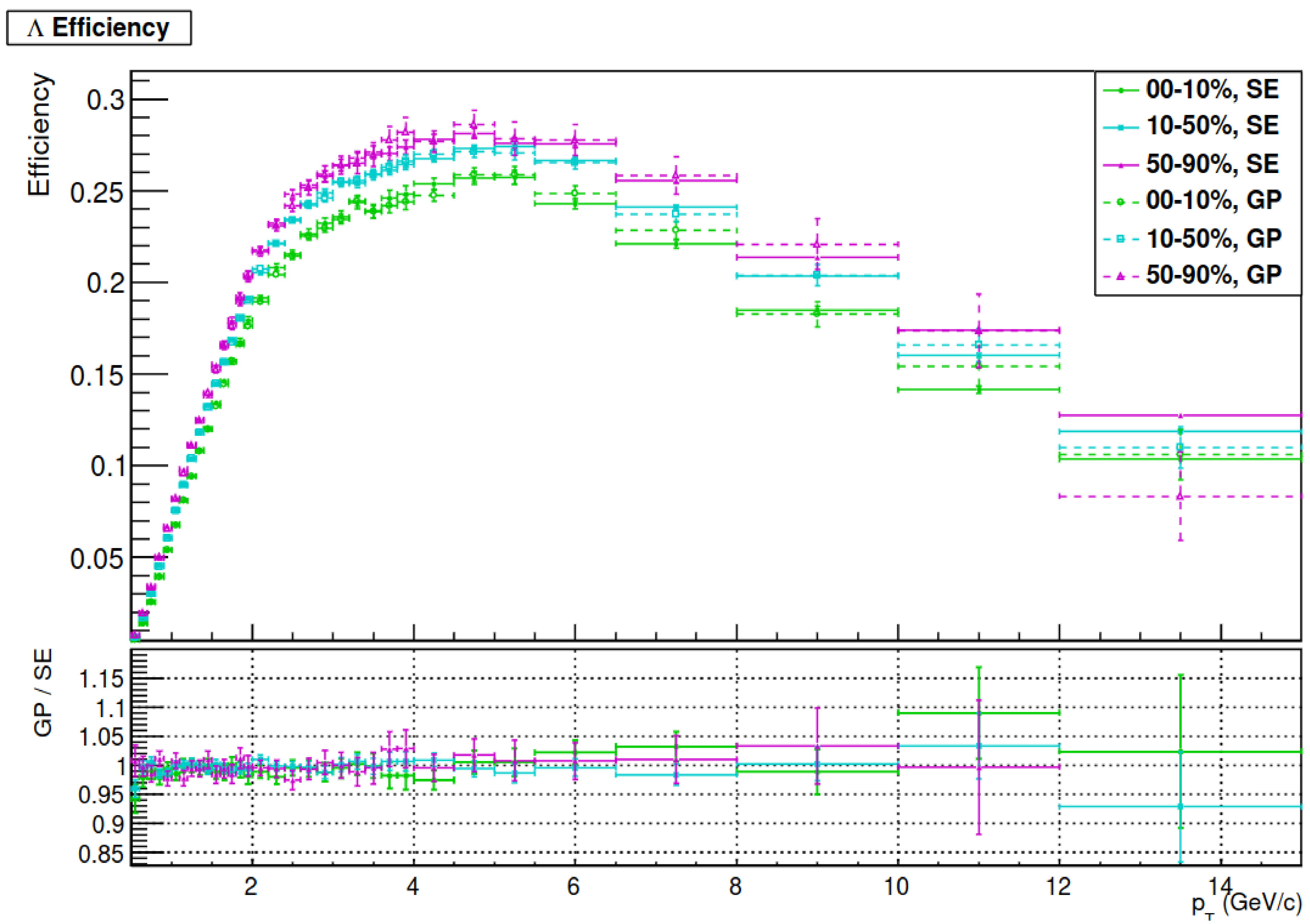
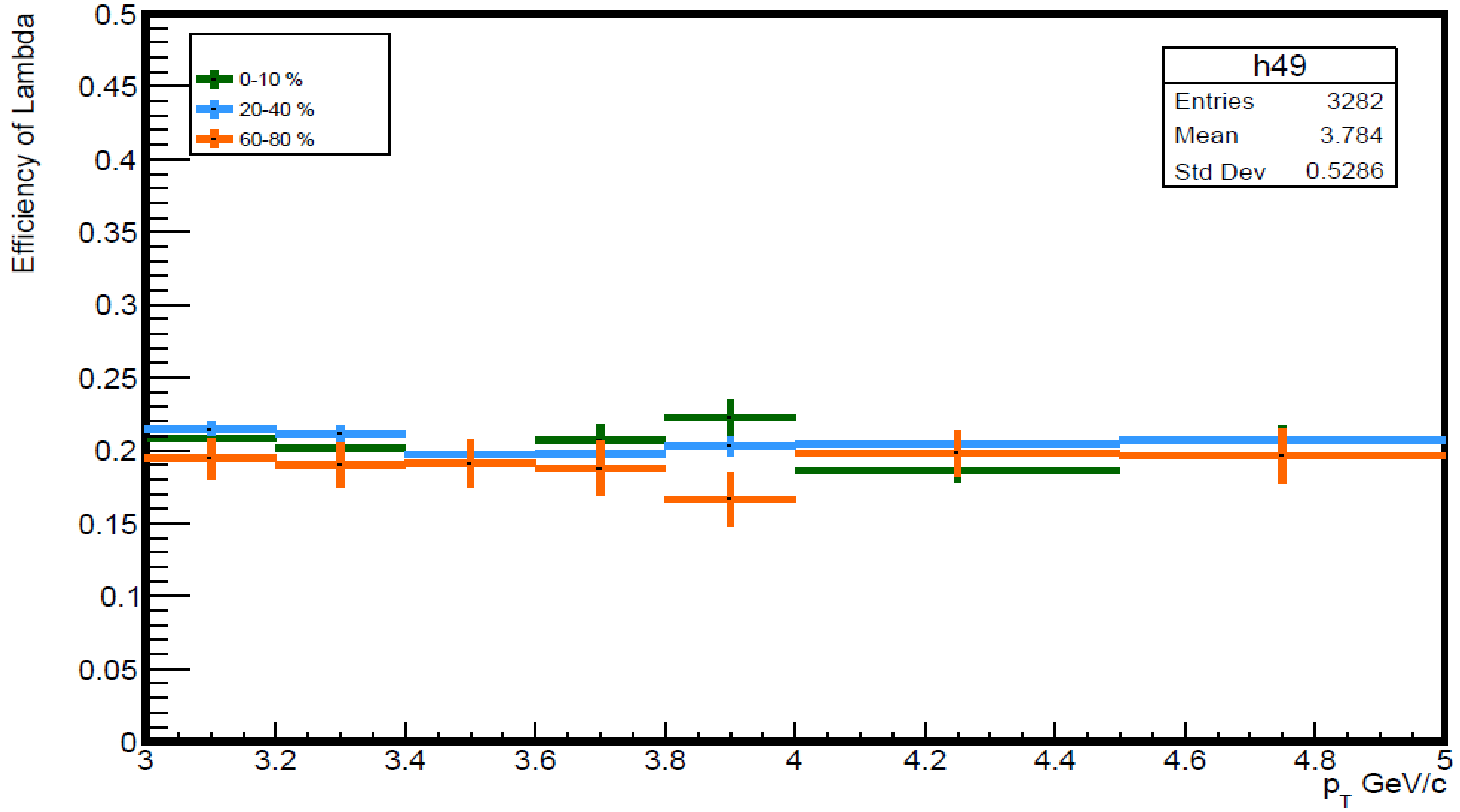
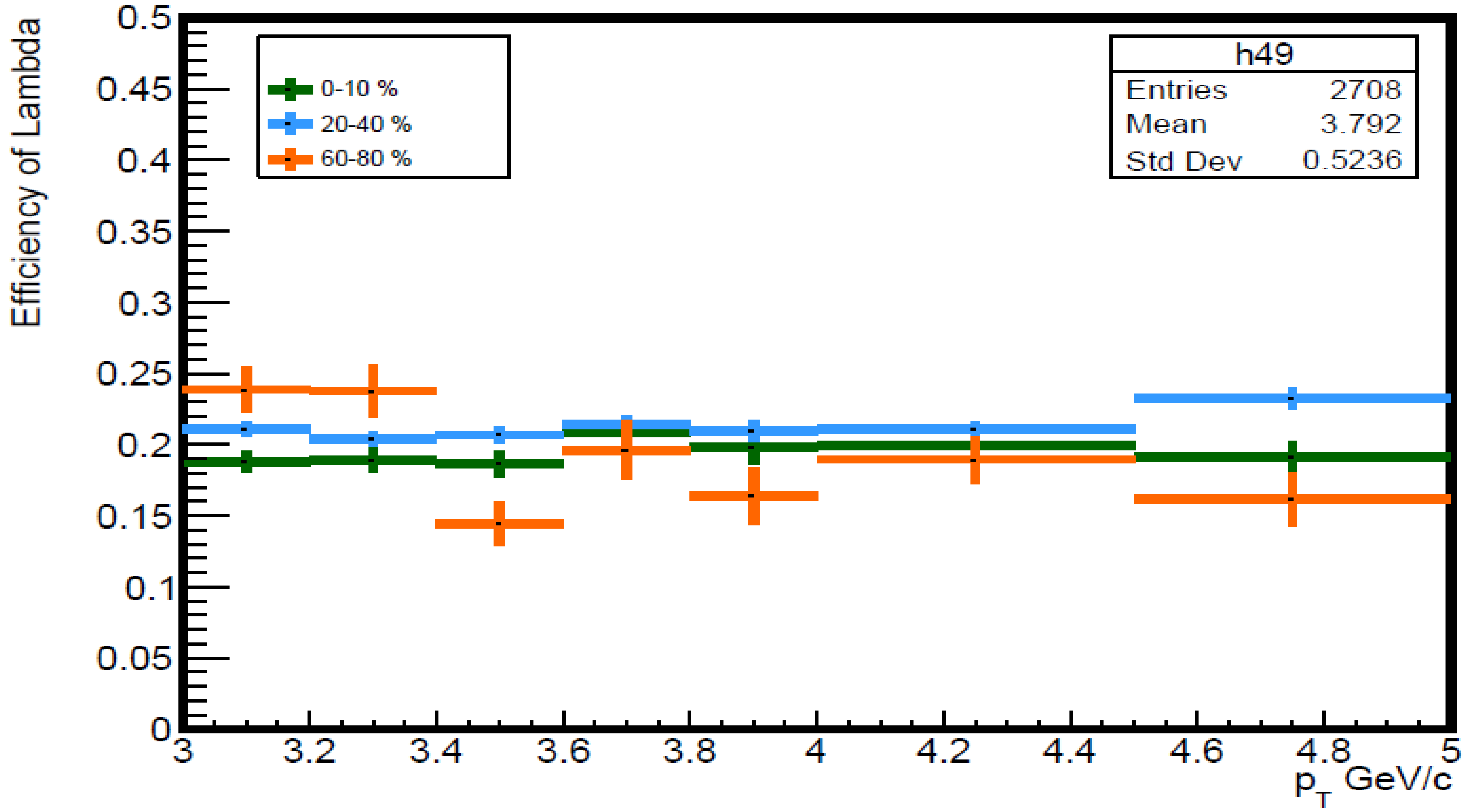
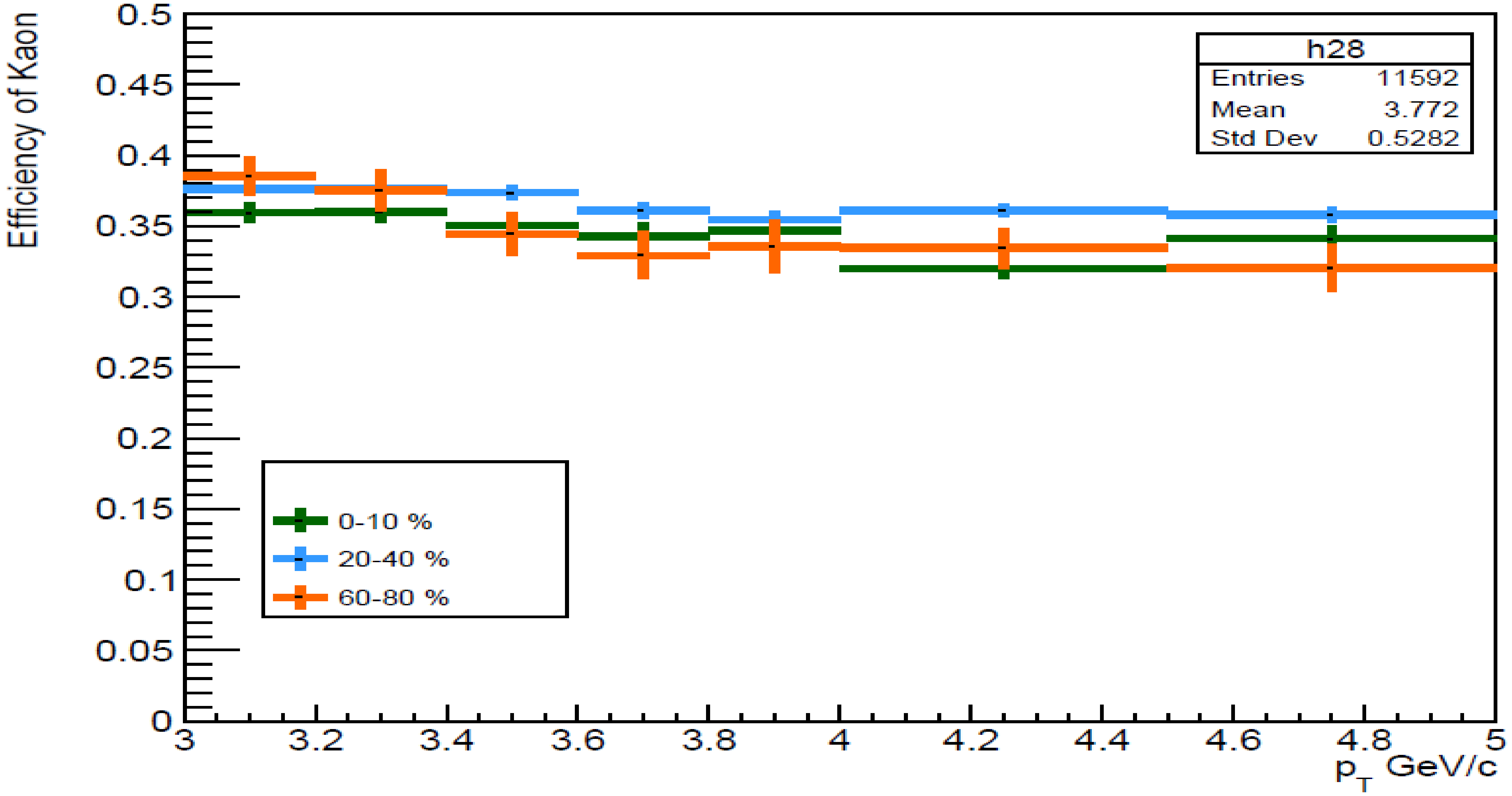


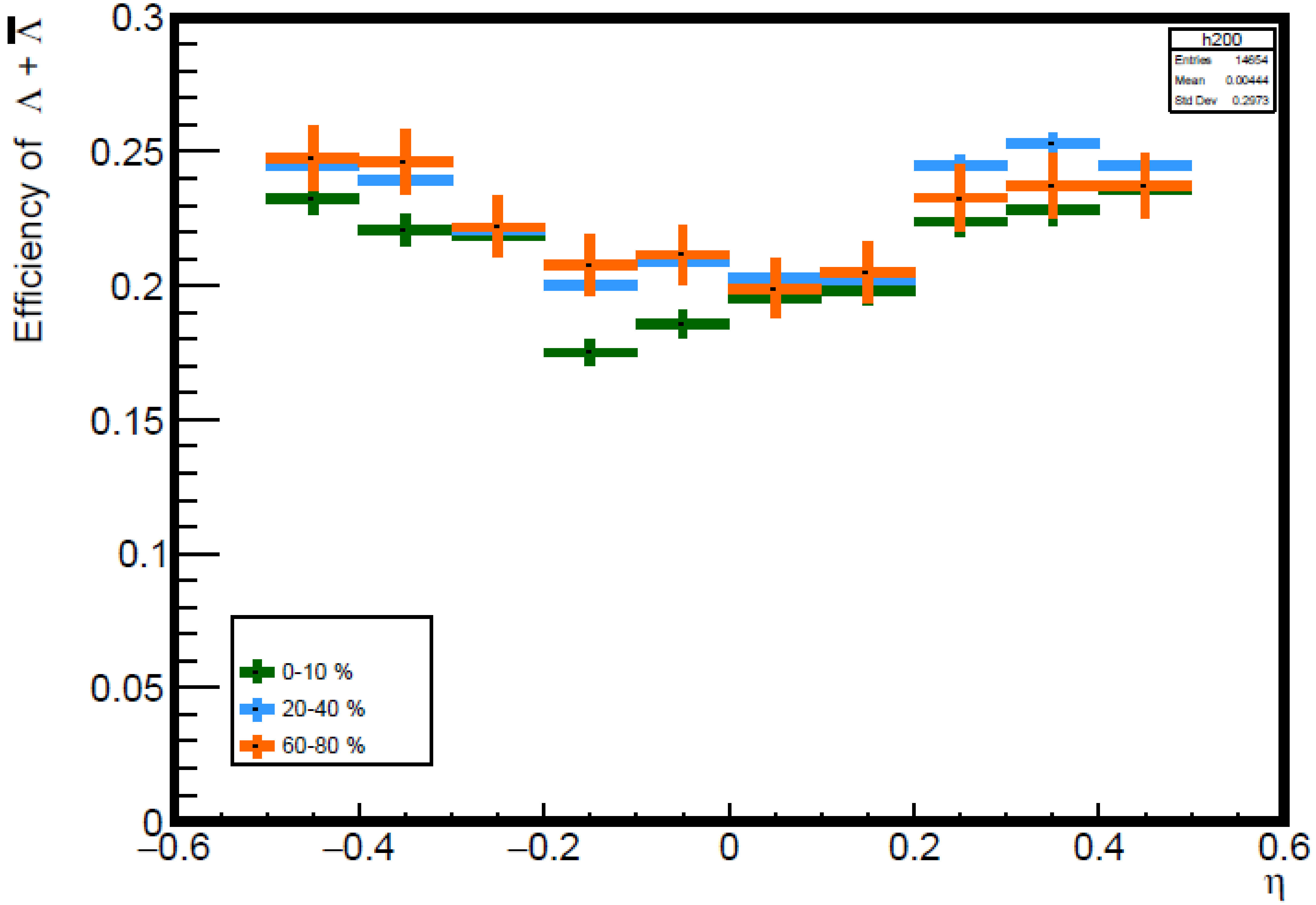

**Fig. 13:** Λ reconstruction efficiency as a function of $p_{\mathrm{T}}$ in the rapidity range $|y| < 0.5$ for SE (strangeness enriched) and GP (general purpose) Monte Carlo datasets.

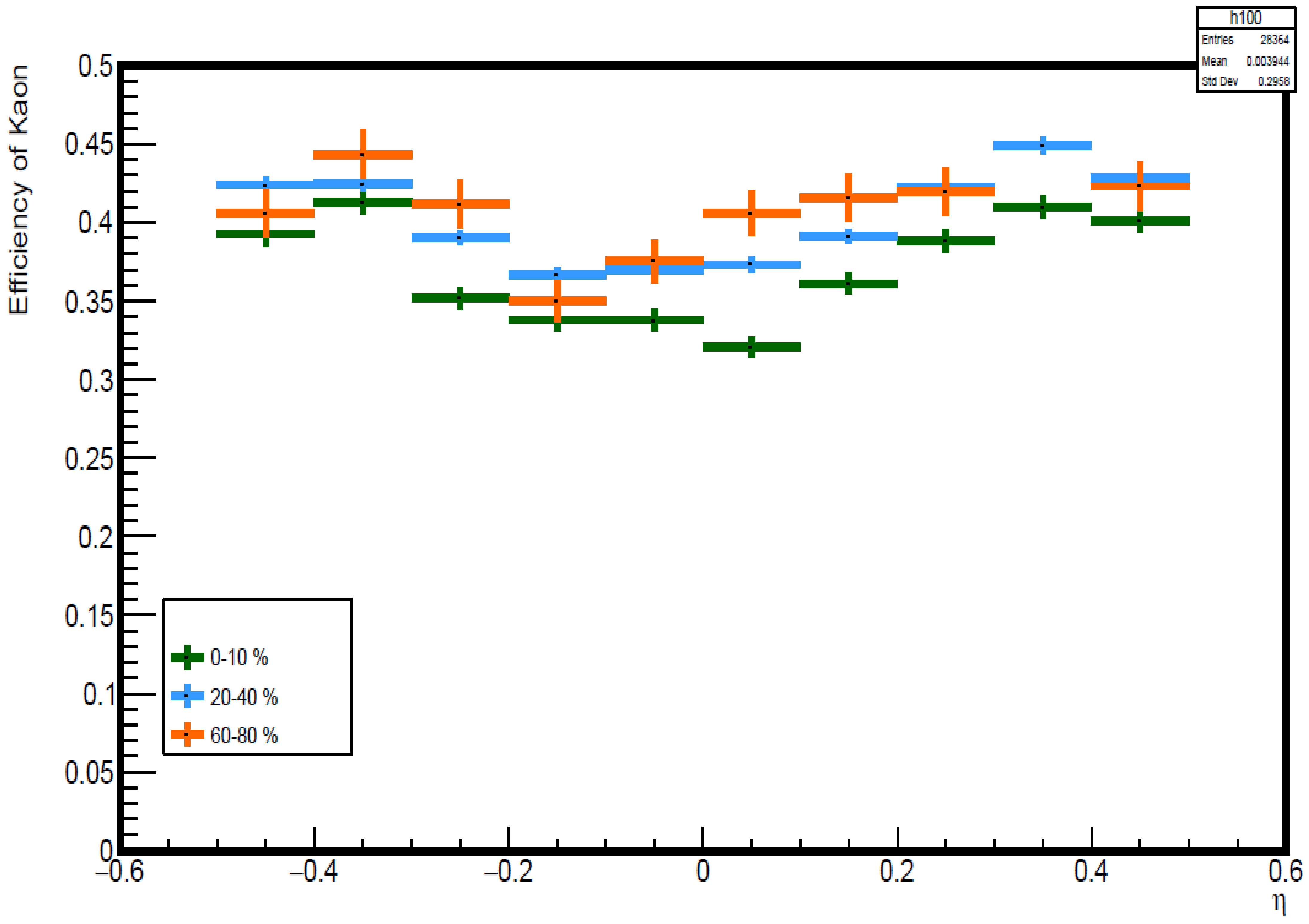



**Now Lambda and antiLambda efficiency are similar**




h200
Entries 14654
Mean 0.00444
Std Dev 0.2973
Efficiency of $\Lambda + \bar{\Lambda}$
0-10 %
20-40 %
60-80 %
η


h100
Entries 28364
Mean 0.003944
Std Dev 0.2958
Efficiency of Kaon
0-10 %
20-40 %
60-80 %
η

# How to apply the secondary contamination correction?

1. Do I need to plot $C(\Delta\eta, \Delta\phi, centrality, p_T)$ ?
2. Xi-h correlation function should be corrected for efficiency of Xi?