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
- Feed down correction
- Outlook and to do

Correlation

Correlation may be defined as.

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

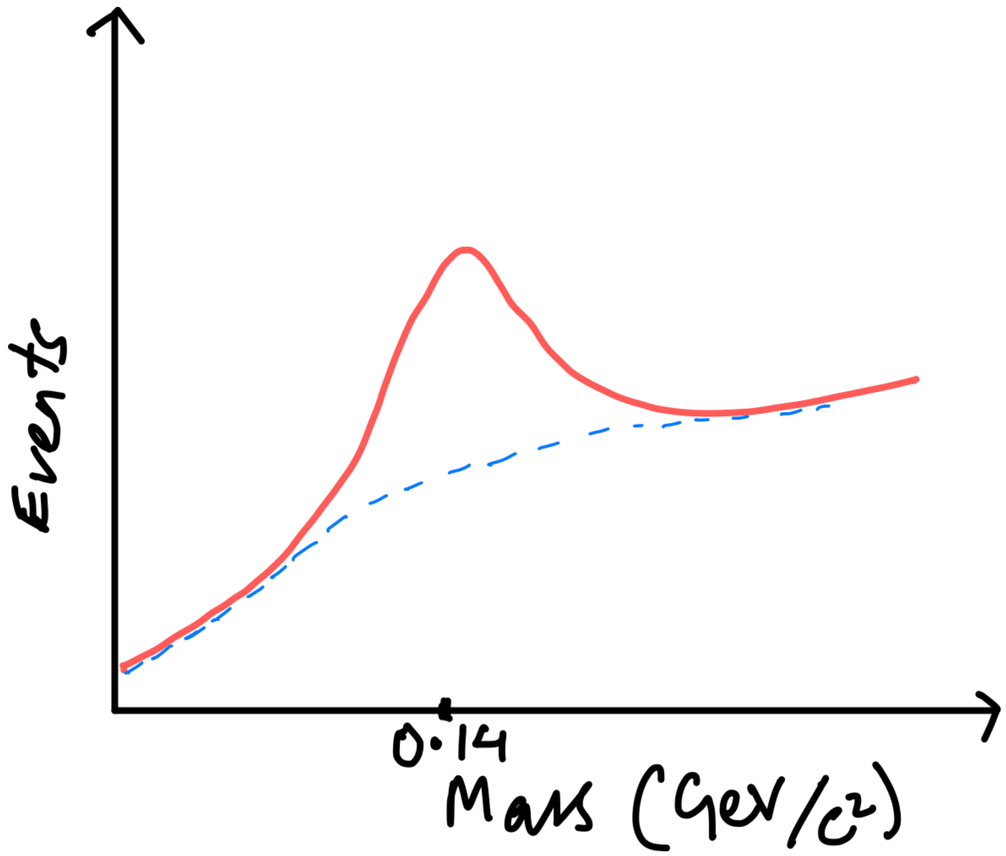
$\rho(x_1, x_2)$: conditional probability of finding the particle x_1 ,given the particle x_2 has been found.

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

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

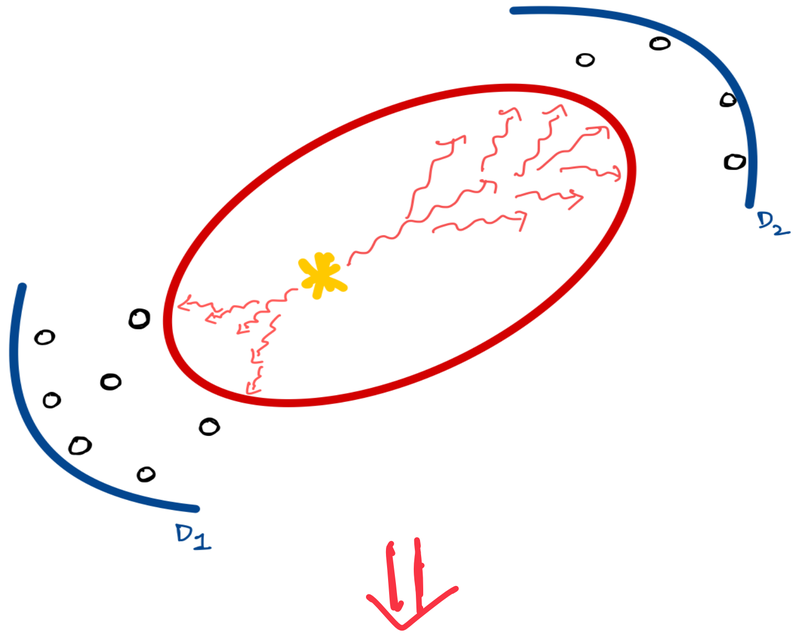
Physical processes generate correlation

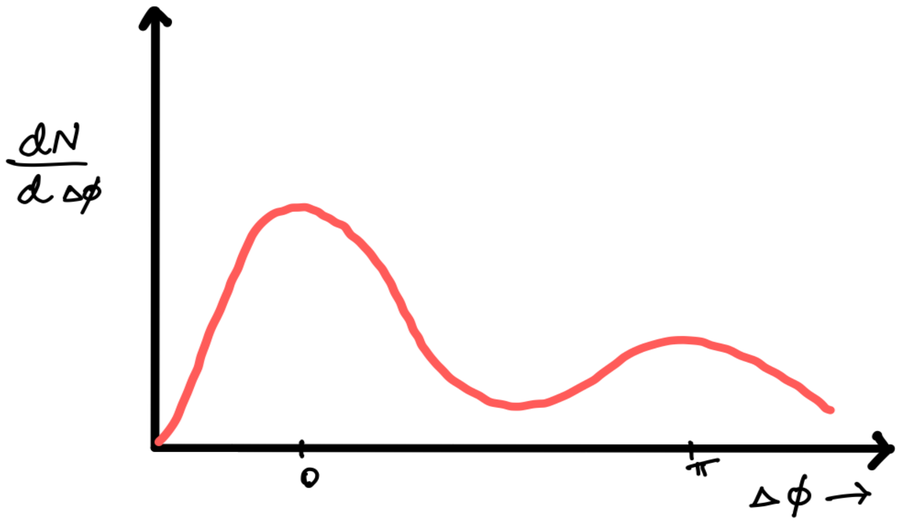
$$\pi^0 \rightarrow \gamma + \gamma$$

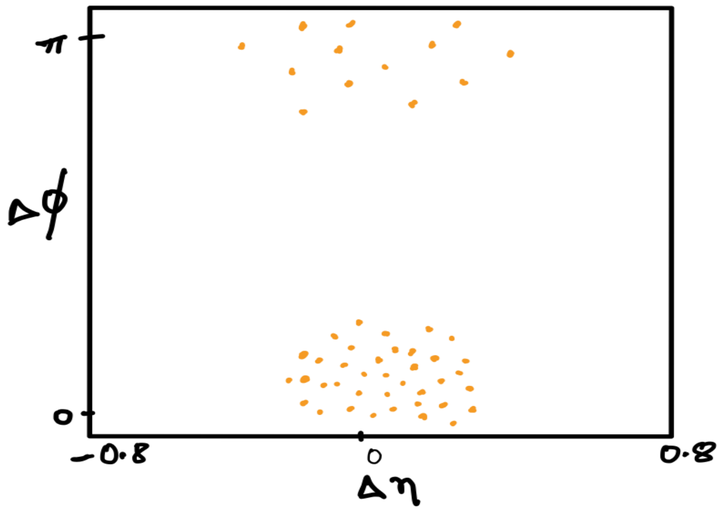


How correlation relevant in heavy ion collision:

- 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***).

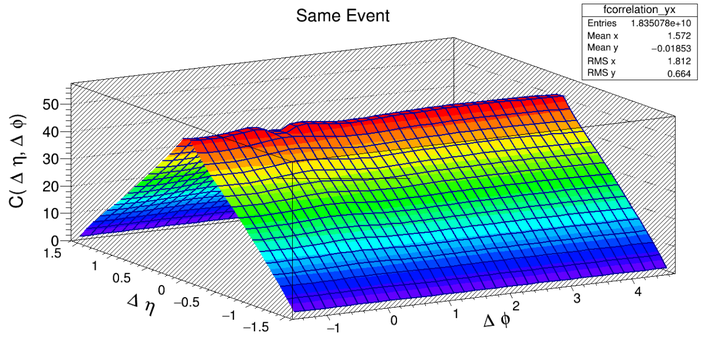
- Particles at intermediate p_T can be produced via two possible production mechanisms: **hard (fragmentation)** and **soft (recombination).**

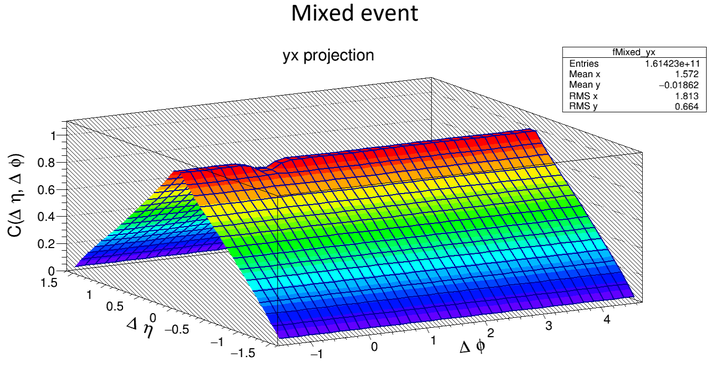
- Near side correlation yield using baryon or meson trigger may contain the possible signature of particle production mechanism.

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

Correlation Function:

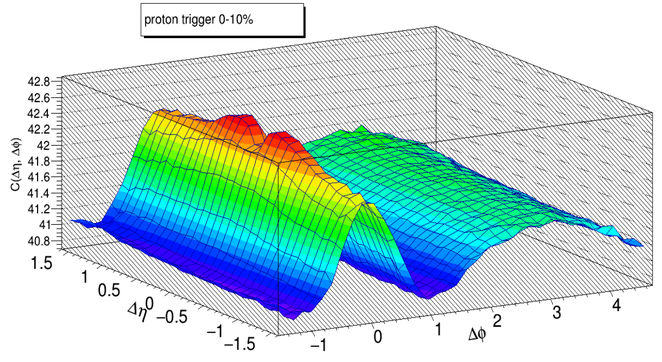
$$C(\Delta\eta,\Delta\phi) = \frac{1}{N_{trigg}} \frac{d^2 N_{asso}}{d\Delta\eta d\Delta\phi} = \alpha \frac{S(\Delta\eta,\Delta\phi)}{B(\Delta\eta,\Delta\phi)}$$





***S*(Δη, Δφ)** is the **signal**, constructed by taking triggers and associated particles from the same event.

B(Δη, Δφ) is the **background**, constructed by taking triggers and associated particles from different events(mixed event method).



Event selection cuts:

(The data set is **lhc15o** (pass2) and the corresponding MC is **lhc20j6a**)

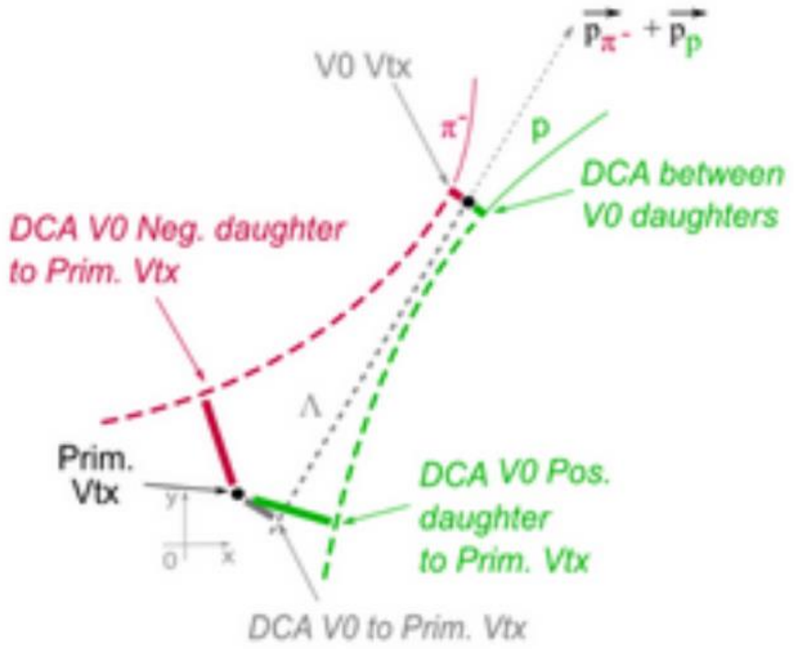
- kINT7 triggered events
- | Vz | < 10 cm
- Centrality 0-80%

Track selection cuts:

- | η | < 0.8
- Filterbit 768
- chi2 TPC per cluster < 2.5
- No. Of TPC clusters > 80

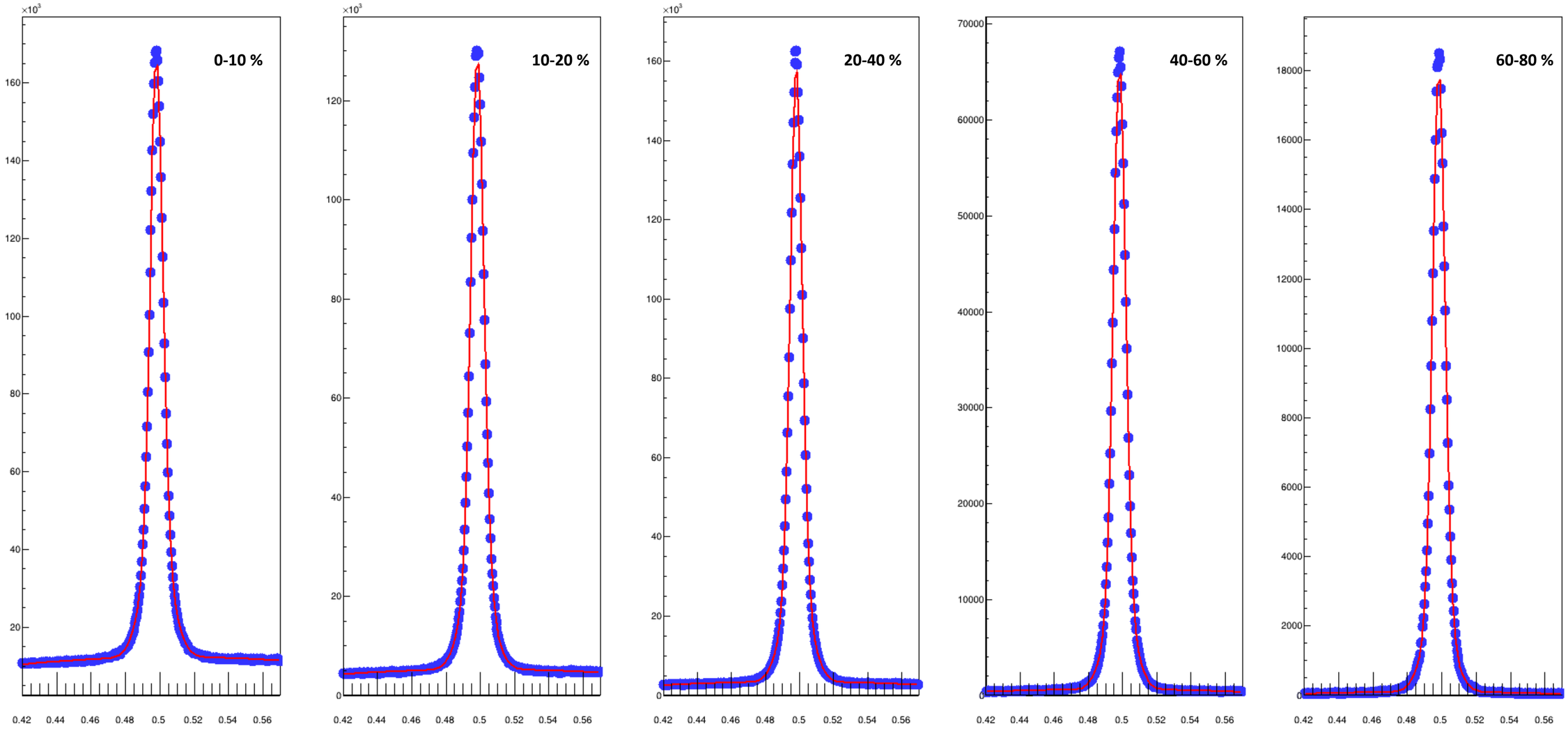
V0 selection cuts:

- 3< pT < 5 GeV/c
- $|\eta| < 0.5$
- 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, Λ) (0.98,0.995)
- Proper Life time (mL/p) (K^0_s, Λ) < (20., 25.) cm
- p_T^{arm} cut 0.2 $|\alpha|$

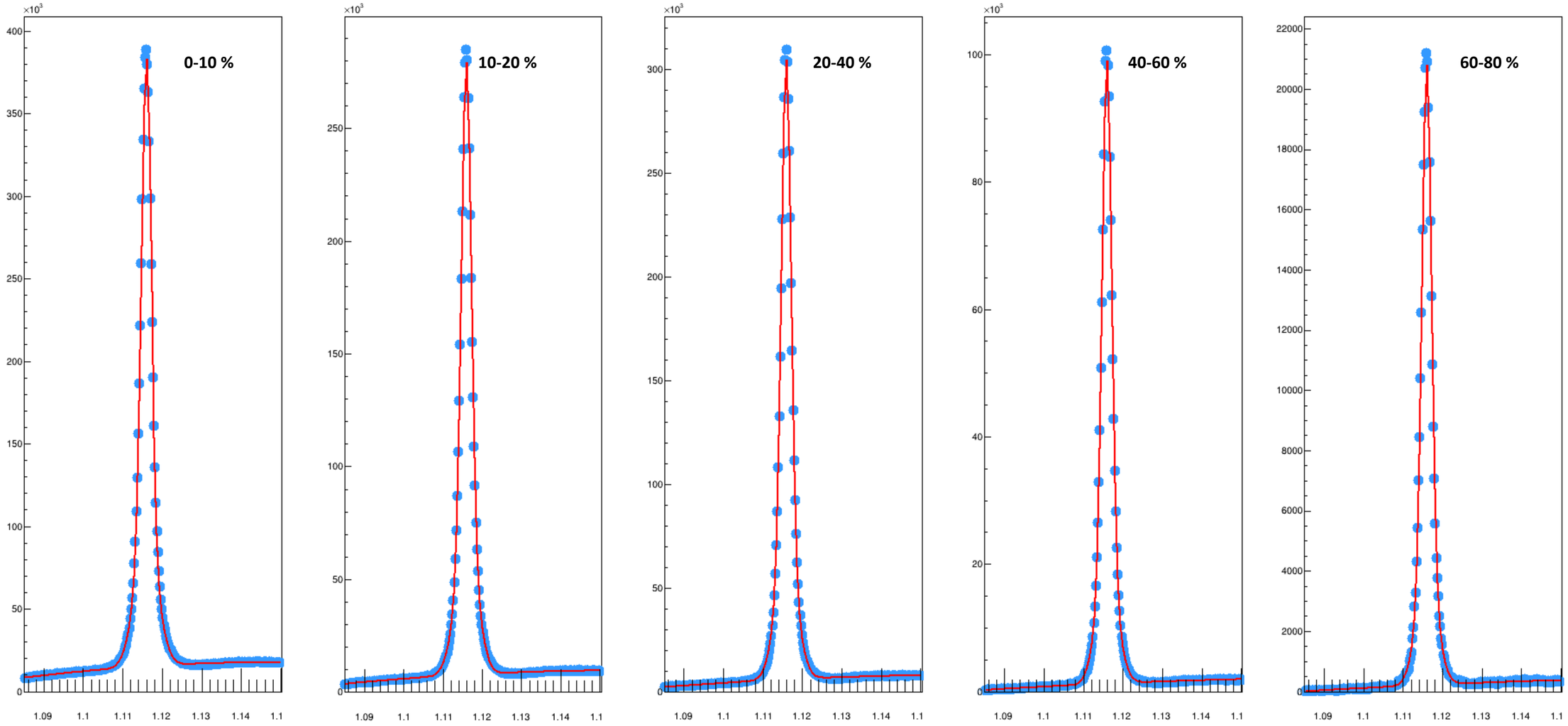


V0 daughters cut:

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

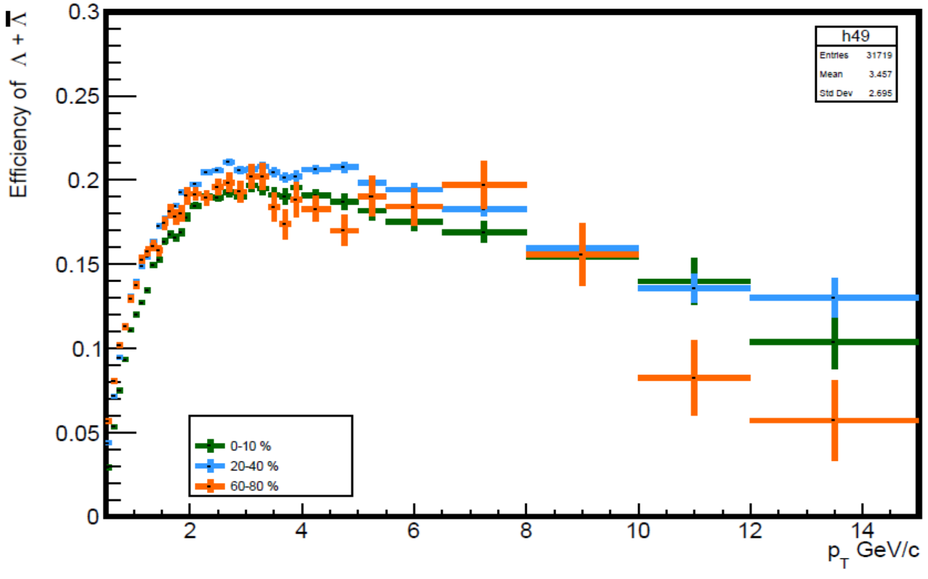


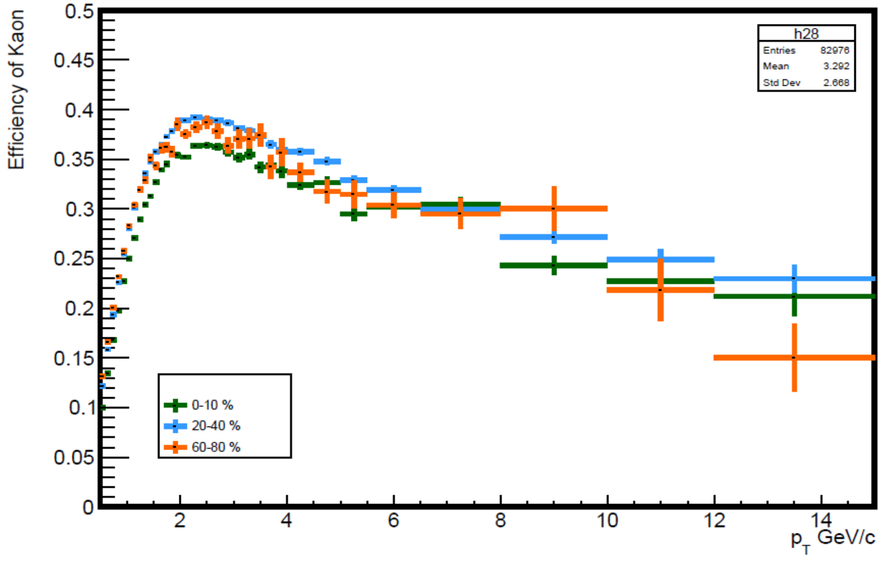
Invariant mass distribution for K_S^0



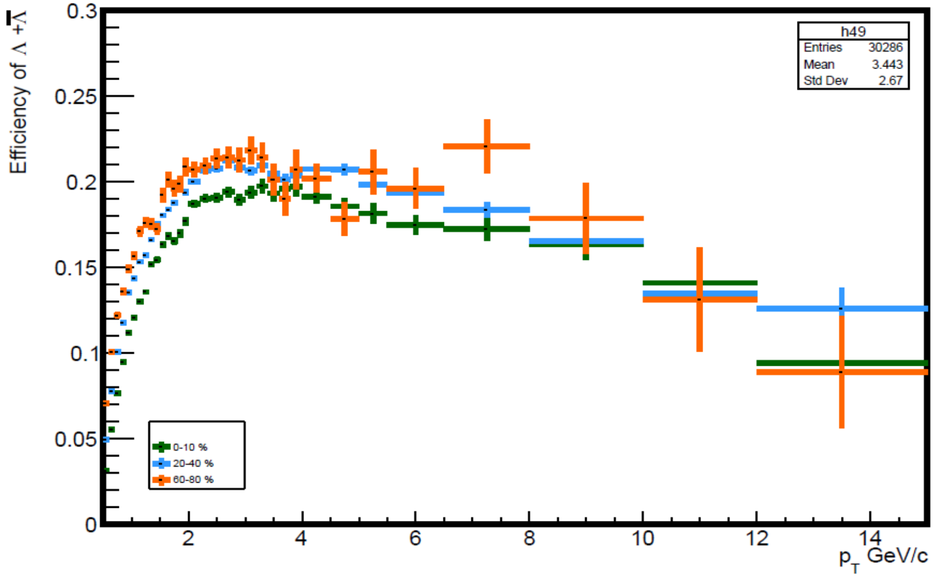
Invariant mass distribution for Λ

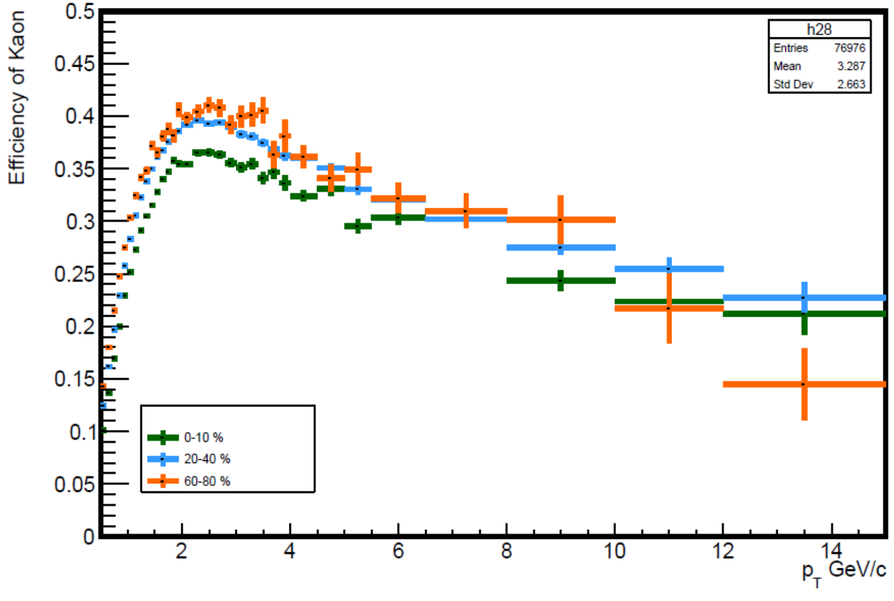
Efficiency of triggers



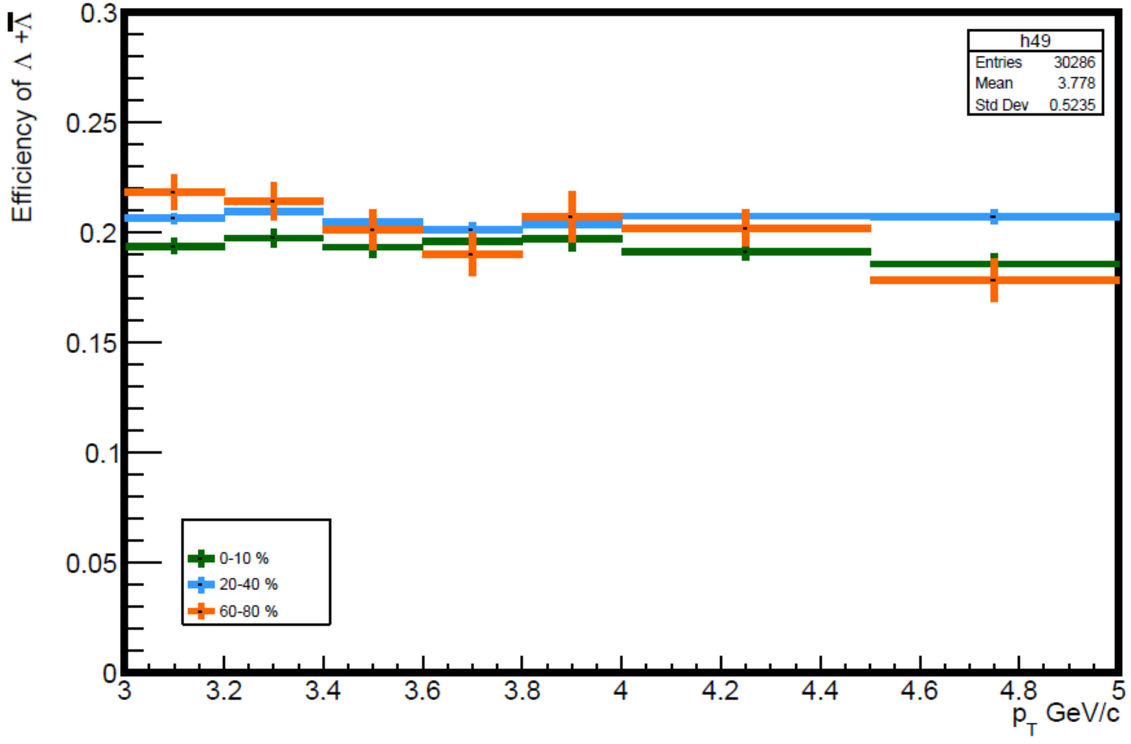


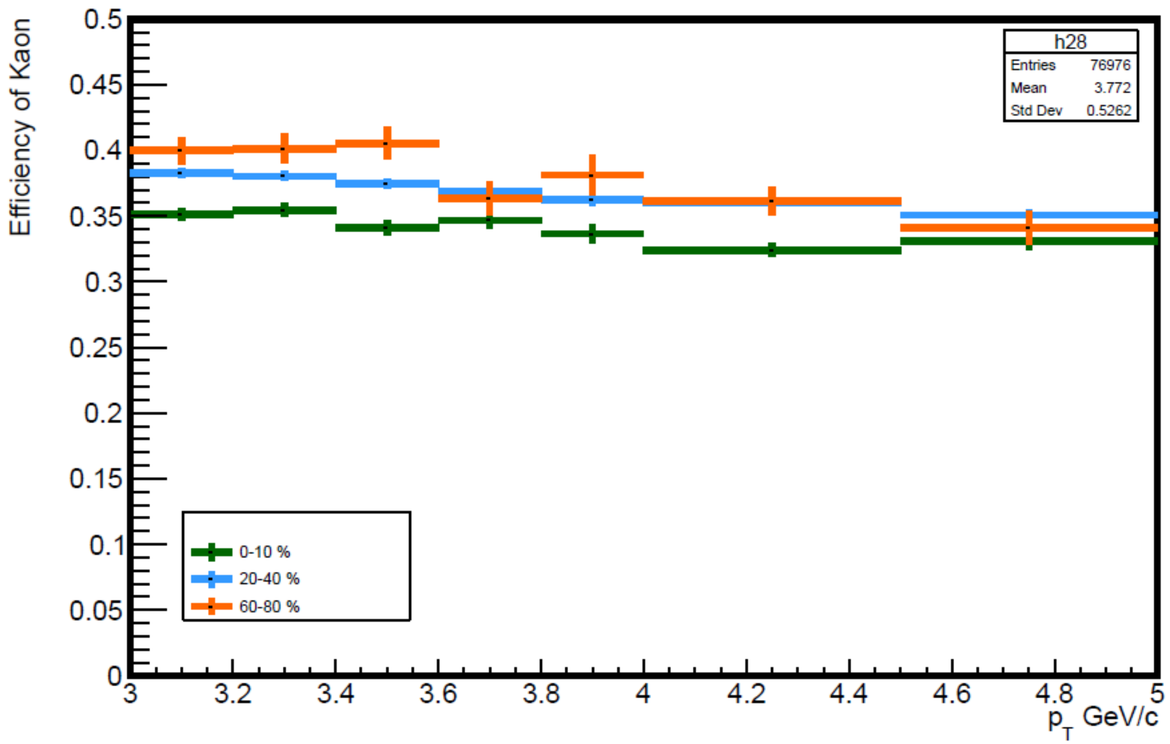
With TPC Nsigma cut <3.



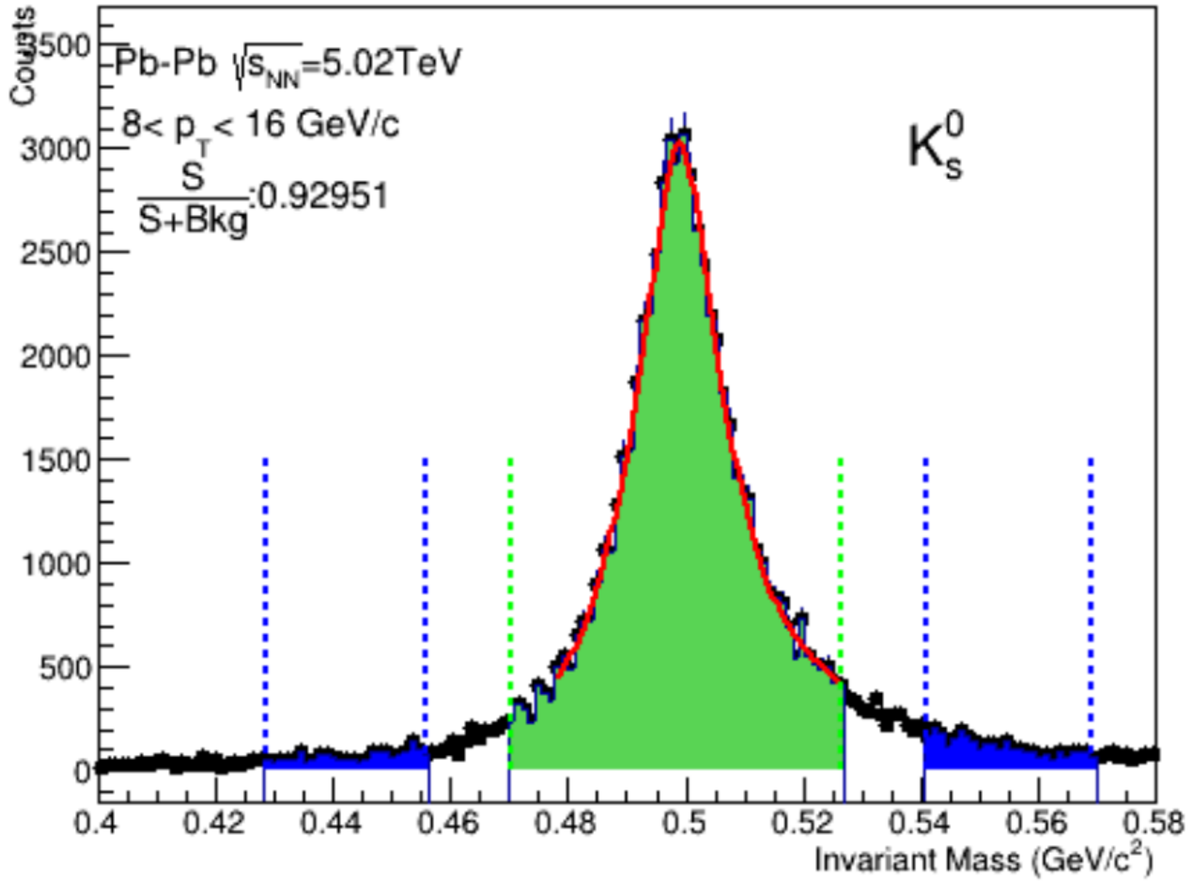


With TPC Nsigma cut <4.


Efficiency of $\Lambda + \bar{\Lambda}$
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

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

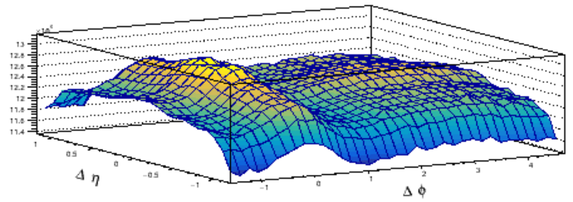


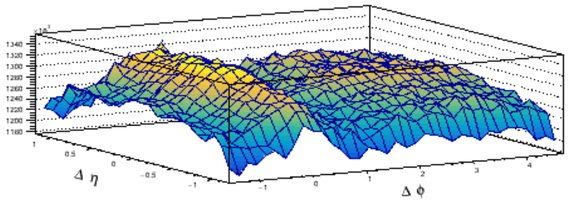
(From Mustafa Anaam's analysis note)

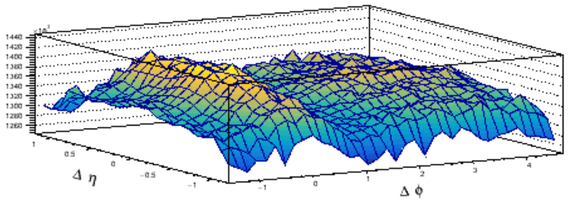
Peak region and side band regions for correlation function construction

K^0_s triggered

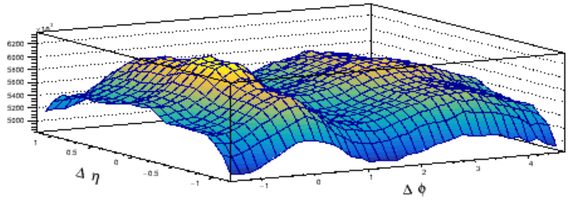
0-10 %

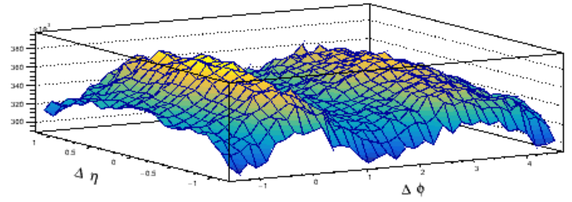


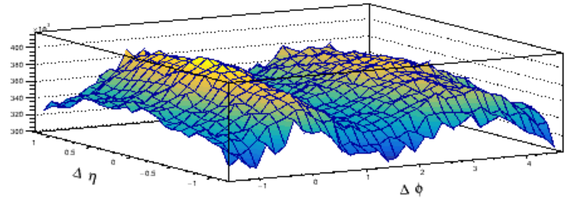




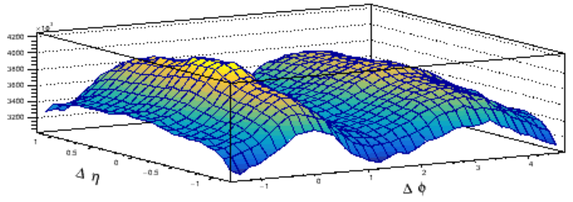
10-20 %

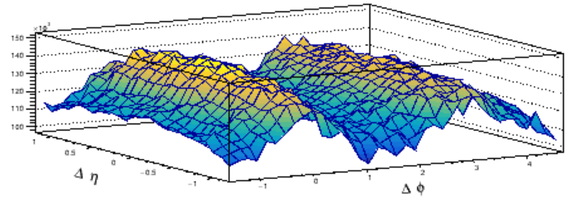


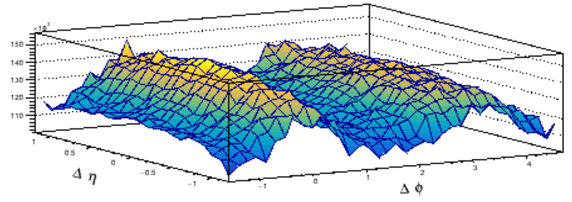




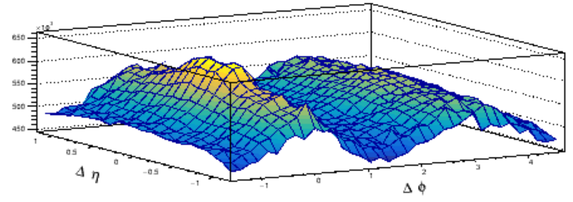
20-40 %

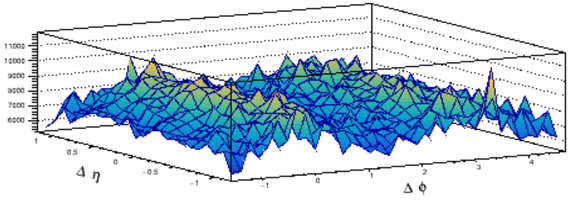


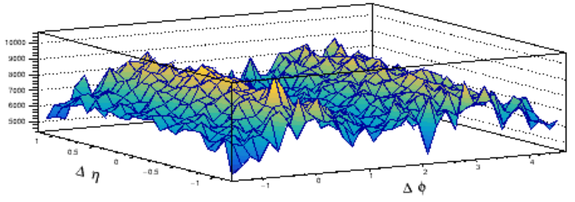




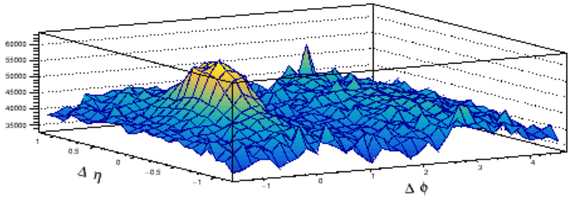
40-60 %

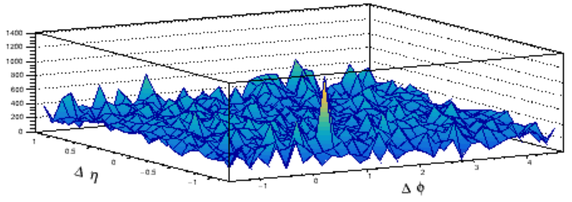


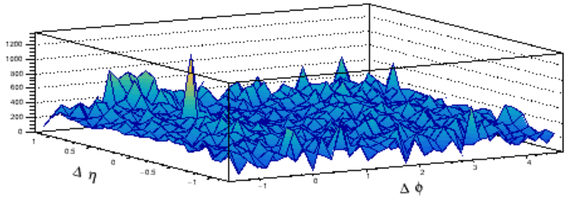




60-80 %







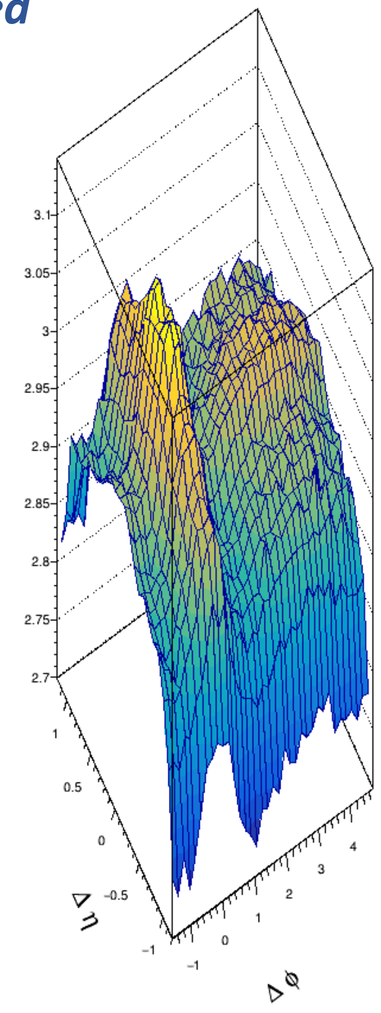
Peak region

Background left

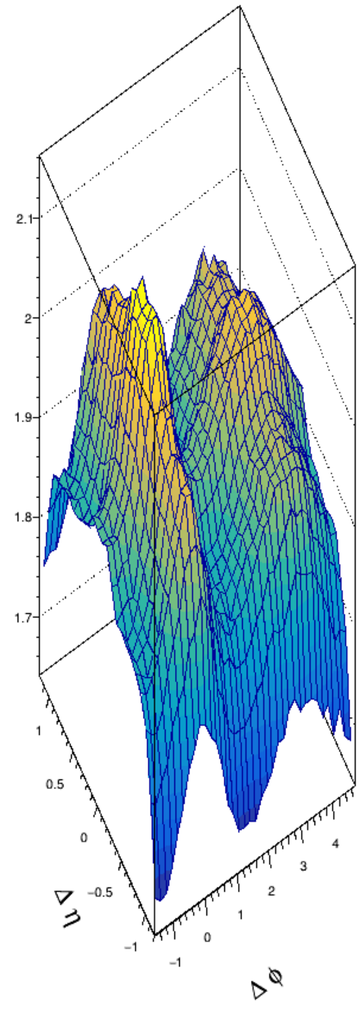
Background Right

K^0_s triggered

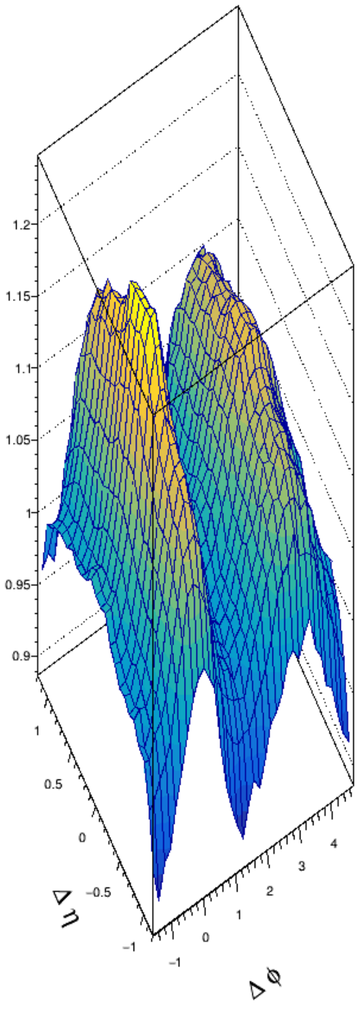
0-10 %



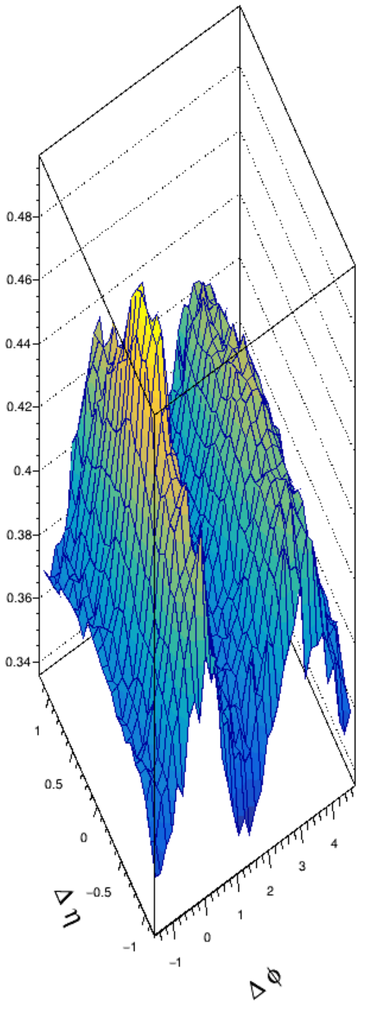
10-20 %



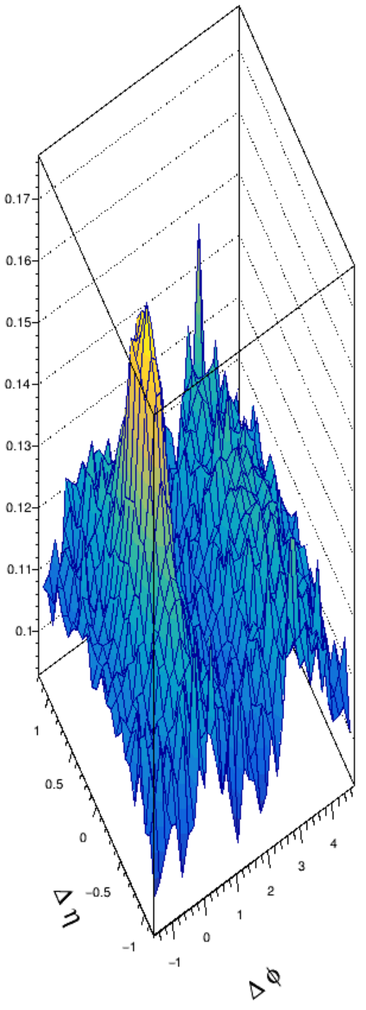
20-40 %



40-60 %

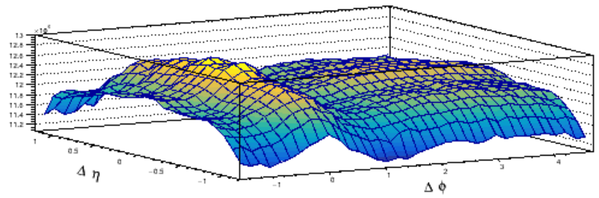
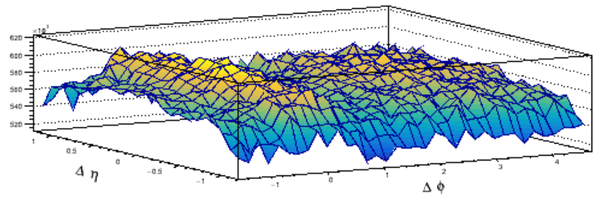
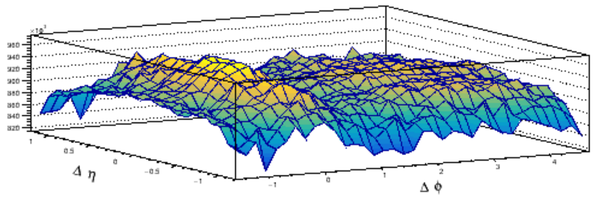


60-80 %

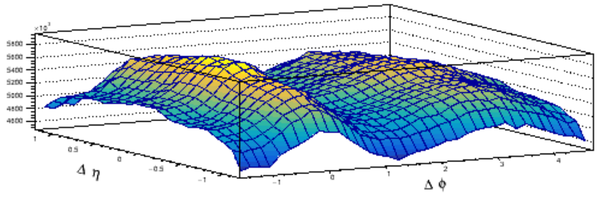
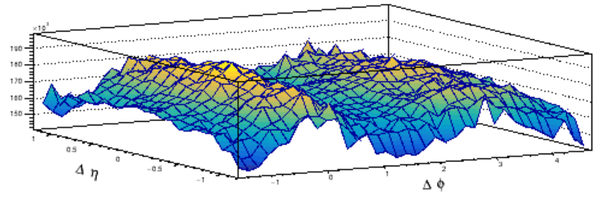
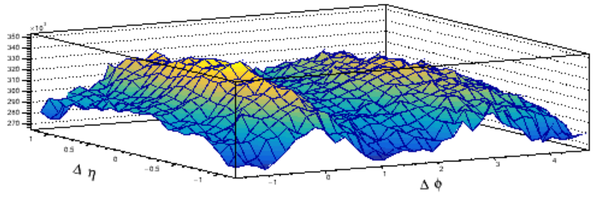


Λ triggered

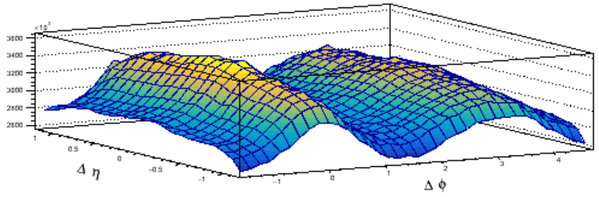
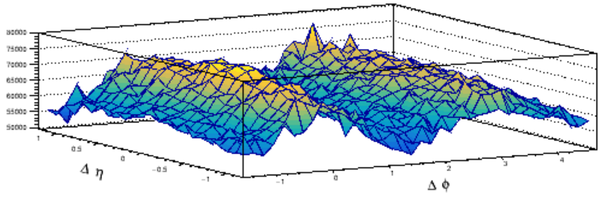
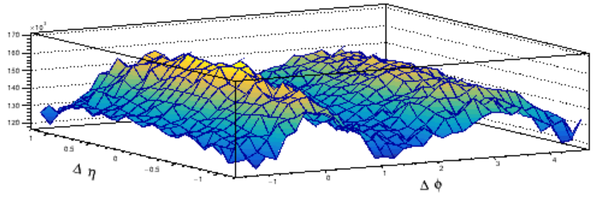
0-10 %

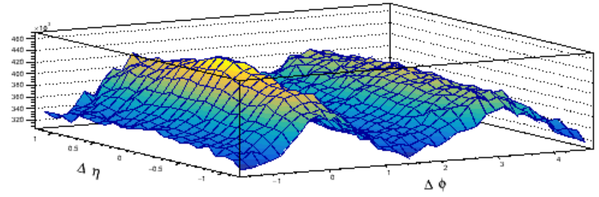
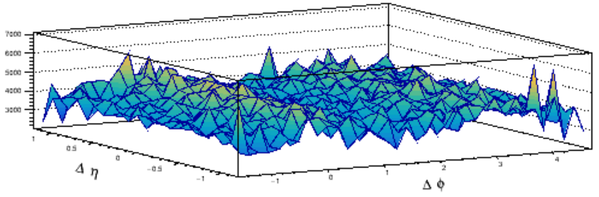
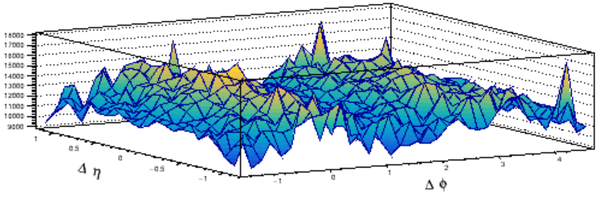
10-20 %

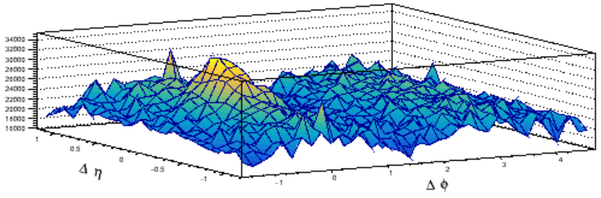
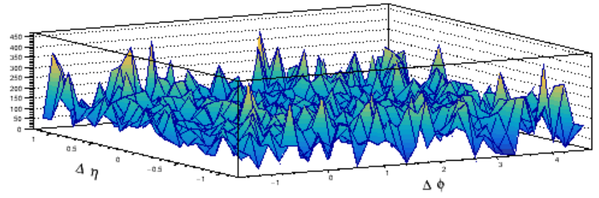
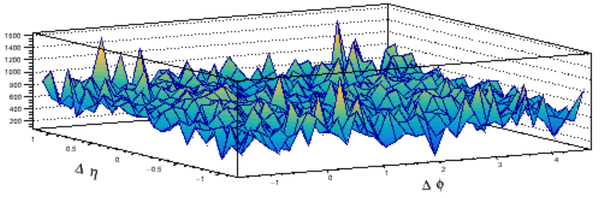
20-40 %

40-60 %

60-80 %

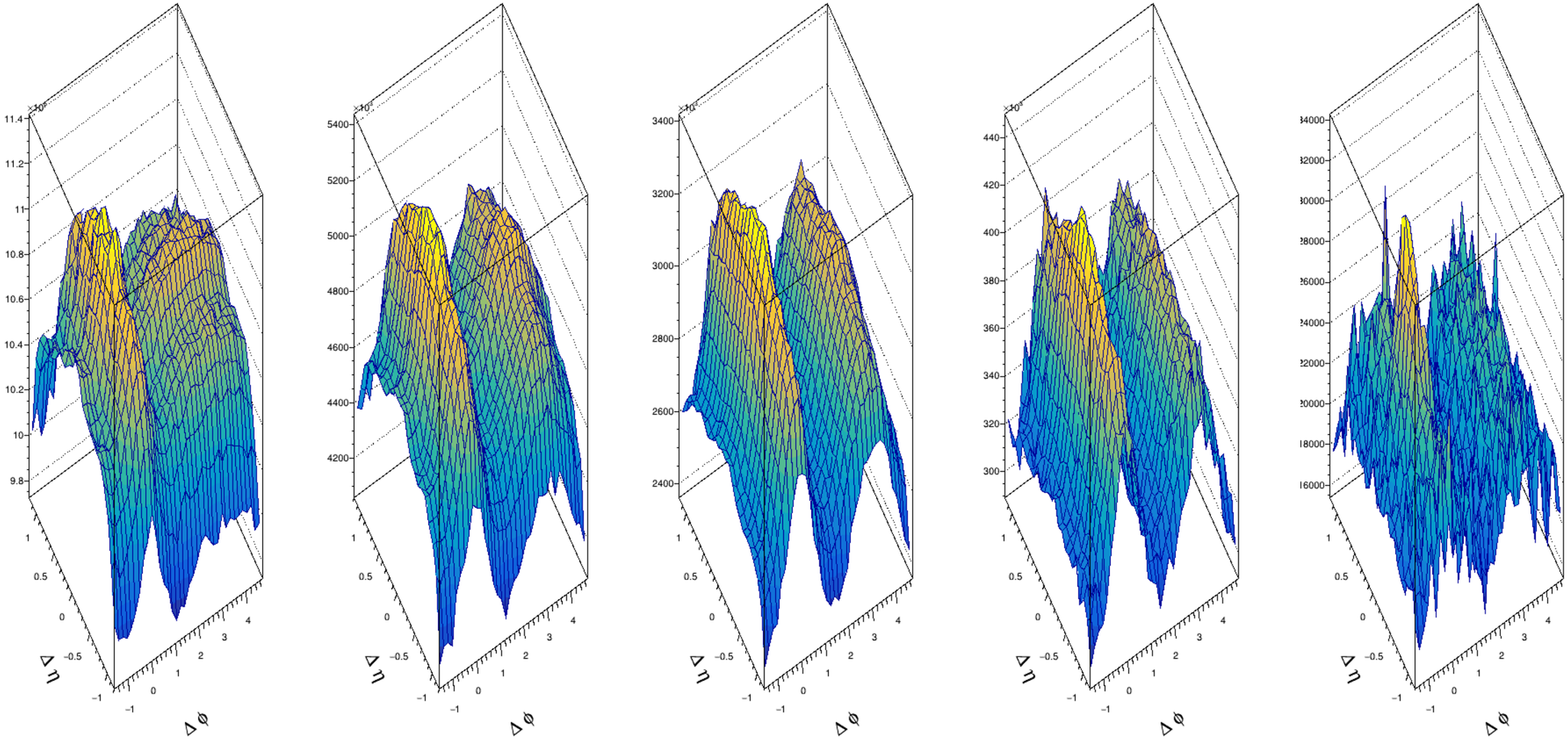
Peak region

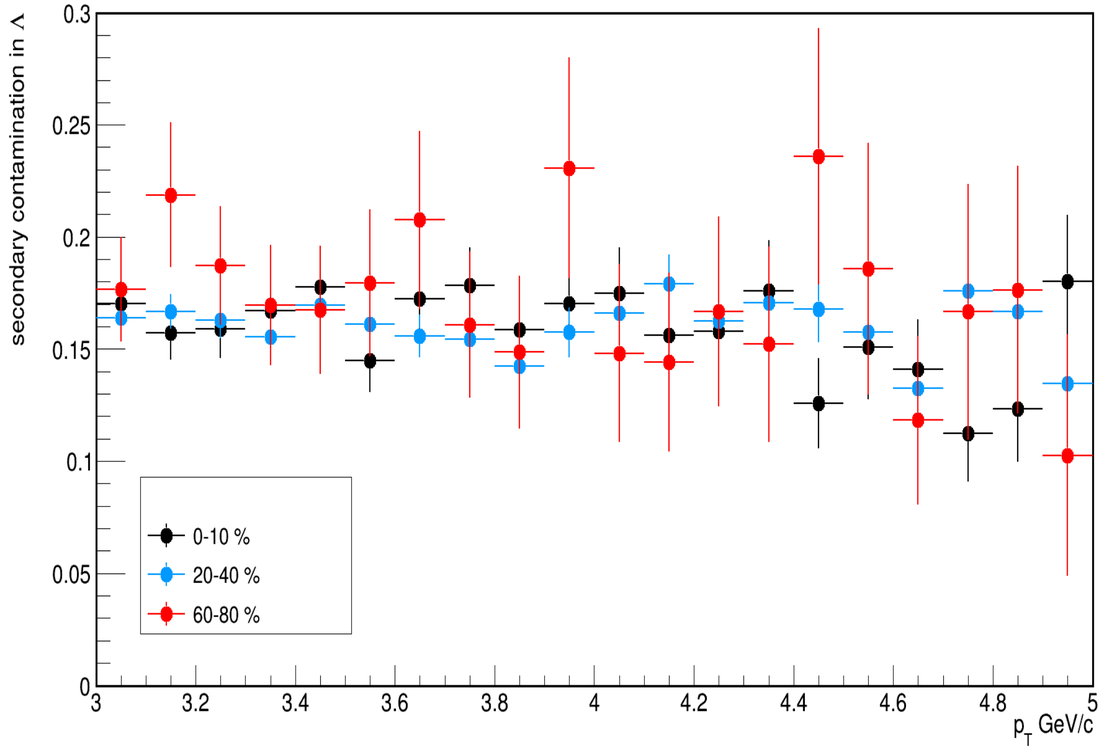
Background left

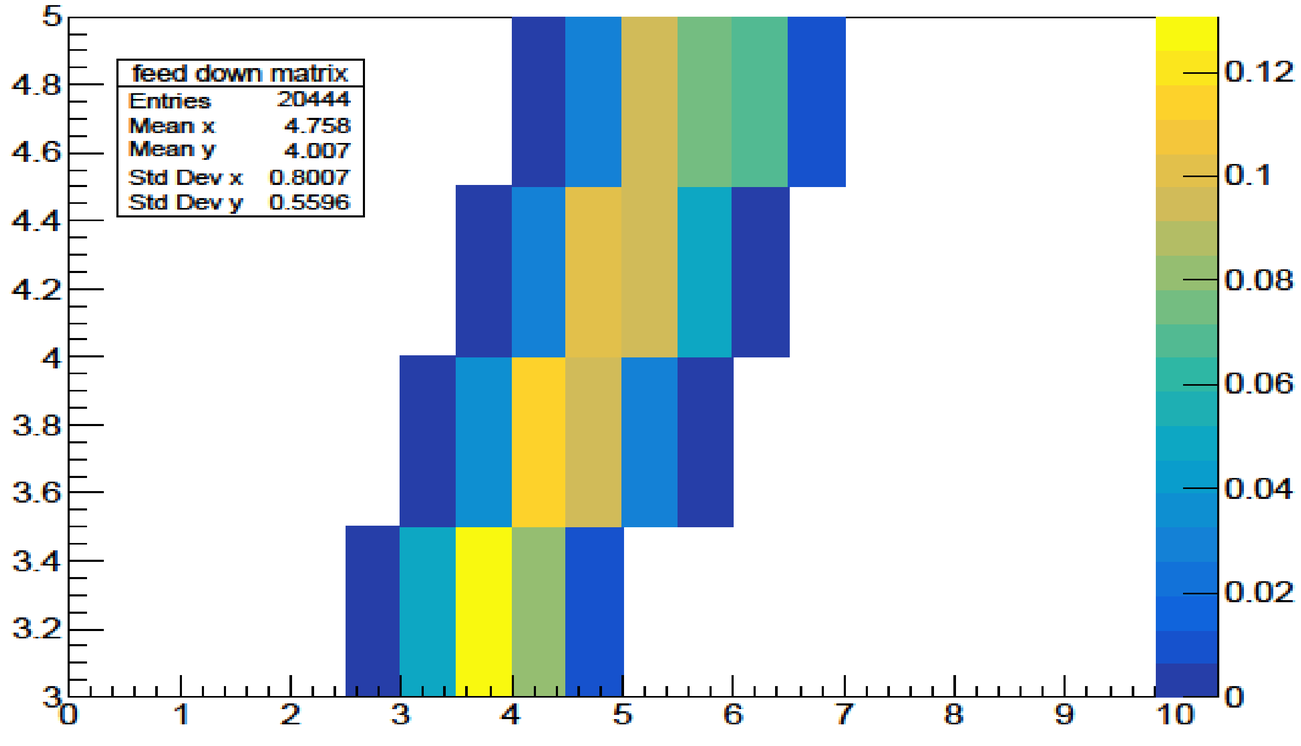
Background Right

0-10 % **10-20 %** **20-40 %** **40-60 %** **60-80 %**

Λ triggered



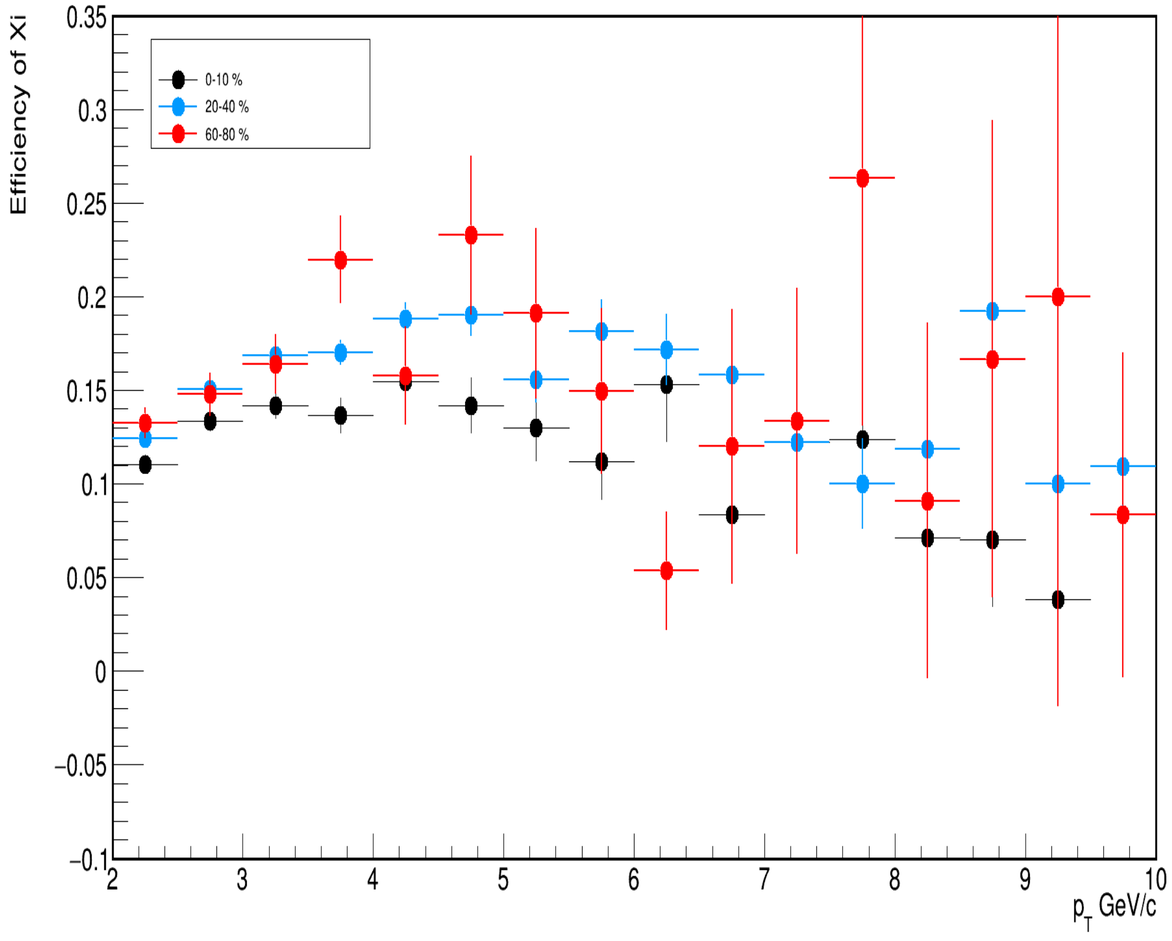


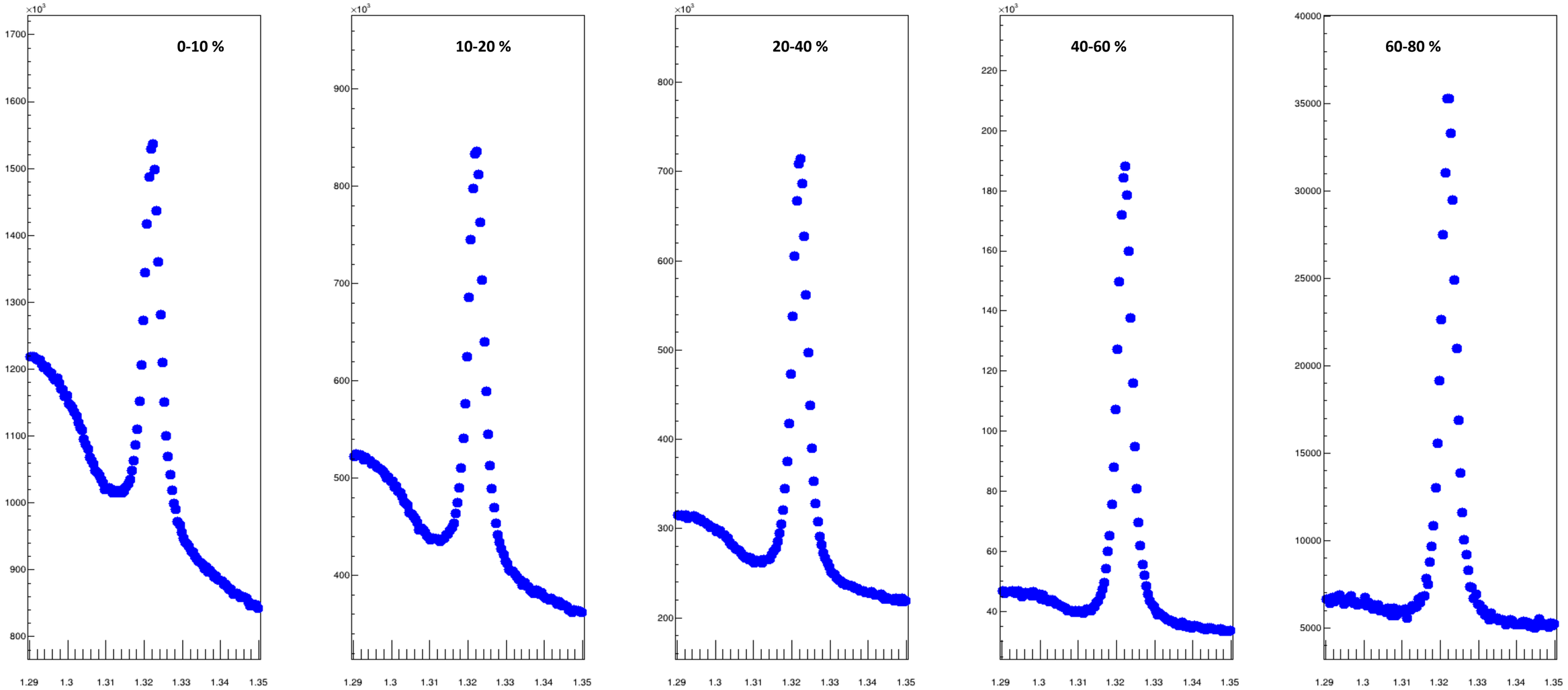


$$N^{final}_{trigg}(p_{T,i}) = C^{\Lambda}_{purity}(p_{T,i}) * (N^{measured}_{\Lambda}(p_{T,i}) - \frac{1}{\varepsilon_{\Lambda}}(p_{T,i}) \sum_j F_{ij} * C^{\Xi}_{purity}(p_{T,j}) * N^{measured}_{\Xi}(p_{T,j})) \quad (11)$$

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

Variable	Selection	
	Ξ	Ω
$\cos\theta_{\mathrm{pa}}$	> 0.99	> 0.99
V0 $\cos\theta_{\mathrm{pa}}$	> 0.99	> 0.99
bachelor–baryon $\cos(\theta_{\mathrm{pa}})$	$< 0.999999^{*}$	$< 0.999999^{*}$
R (cm)	> 1	> 1
V0 R (cm)	$> 3, < 85$	$> 3, < 85$
DCA V0–PV (cm)	> 0.1	> 0.1
DCA bachelor–PV (cm)	> 0.1	> 0.1
DCA V0 daughters–PV (cm)	> 0.2	> 0.2
DCA bachelor–V0 (cm)	< 1	< 1
DCA V0 daughters (σ)	< 1	< 1
Proper lifetime ($c\tau$)	< 3.0	< 3.0
V0 mass window (MeV/c^2)	5	5
Competing mass rejection (MeV/c^2)	—	8
$\lvert y\rvert$	< 0.5	< 0.5
daughters' $\lvert\eta\rvert$	< 0.8	< 0.8
TPC clusters	≥ 80	≥ 80
TPC clusters over findable	≥ 0.8	≥ 0.8
χ^2 per TPC cluster	≤ 2.5	≤ 2.5
TPC n_σ	≤ 5	≤ 5
TPC refit	true	true
Track quality for Pb–Pb	true	true





Invariant mass distribution for Xi

$\Xi^{\pm}$ *triggered*

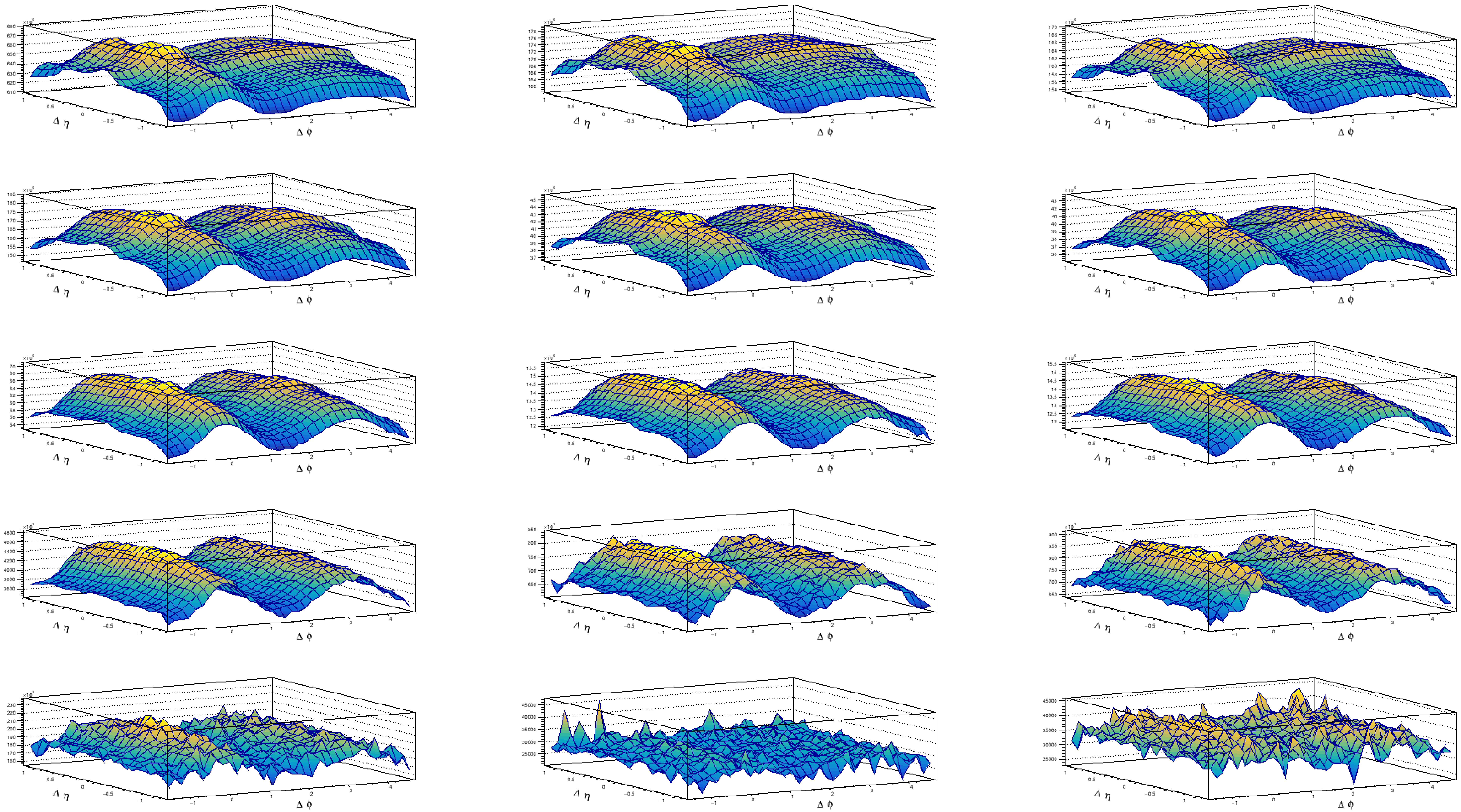
0-10 %

10-20 %

20-40 %

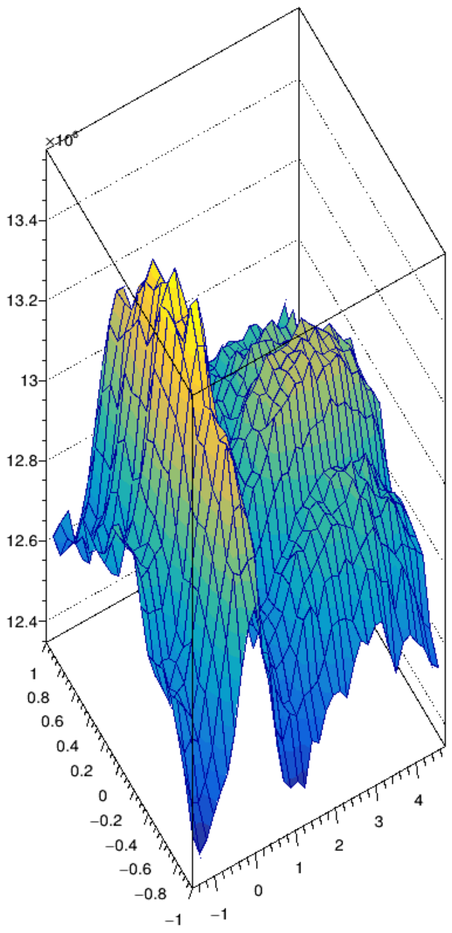
40-60 %

60-80 %

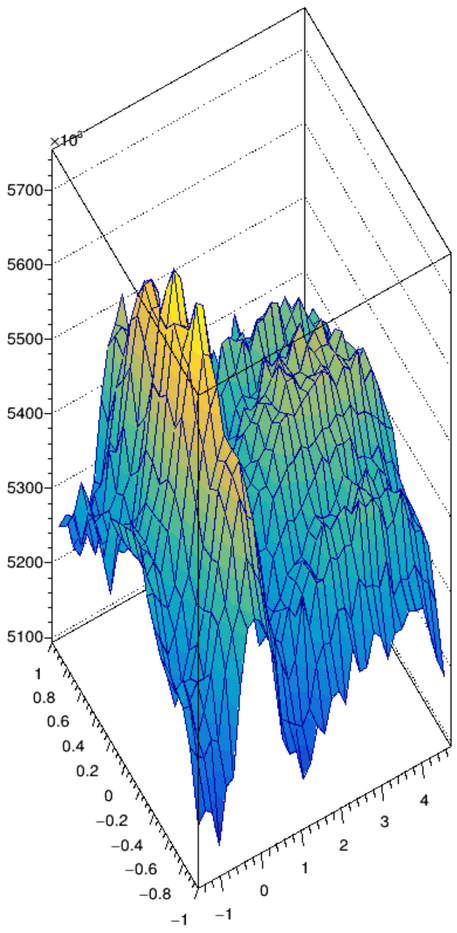


Peak region **Background left** **Background Right**

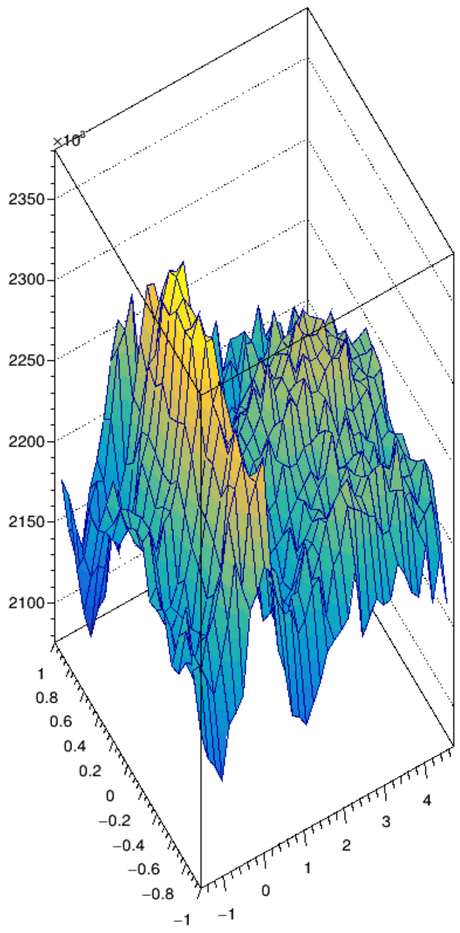
2 < p_T < 2.5 GeV/c



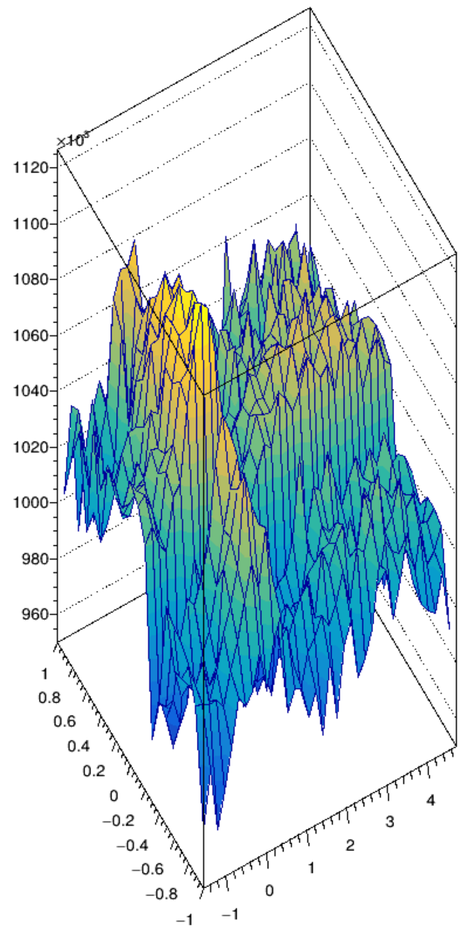
2.5 < p_T < 3 GeV/c



3 < p_T < 3.5 GeV/c



23.5< p_T < 4 GeV/c

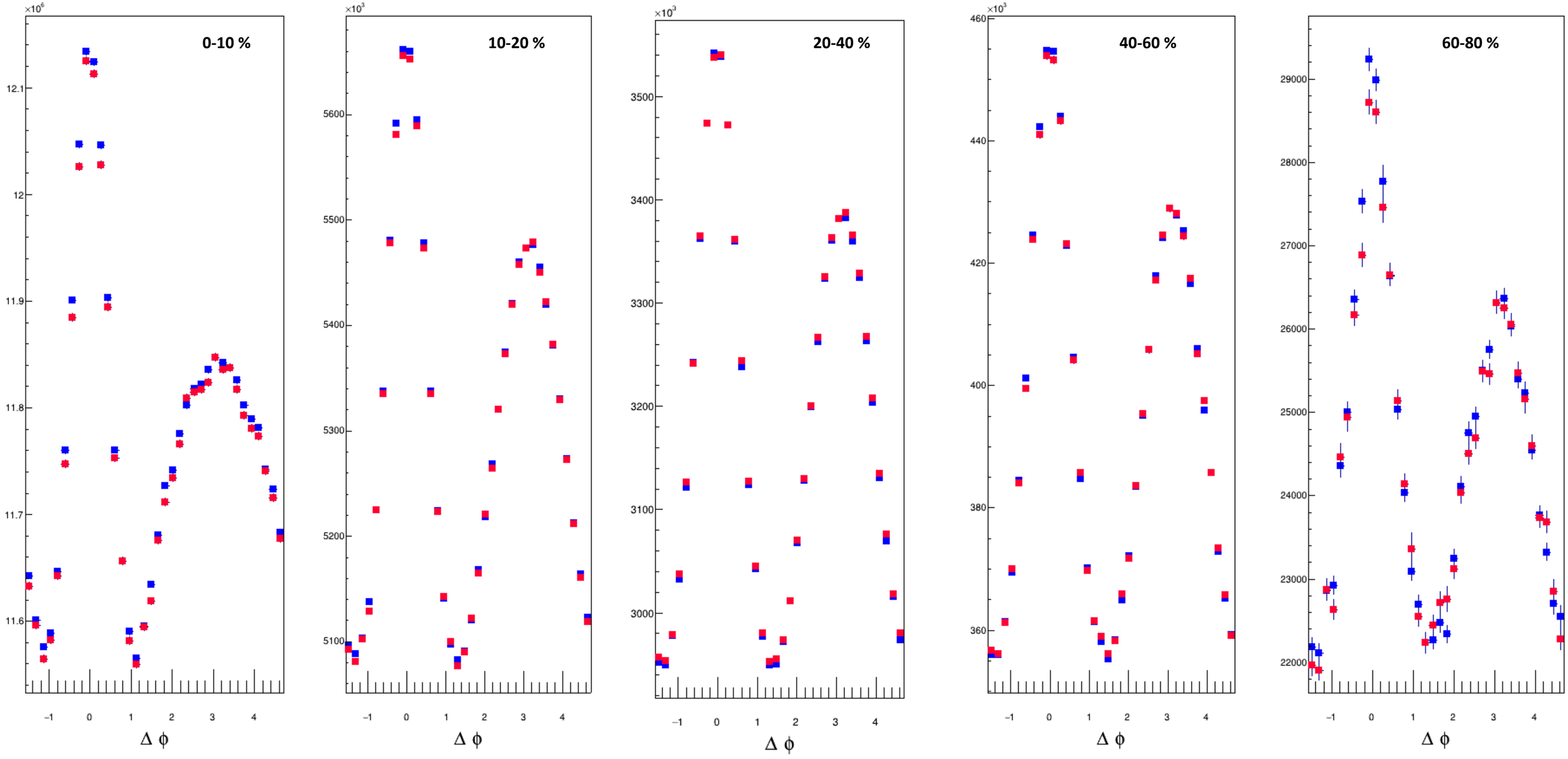


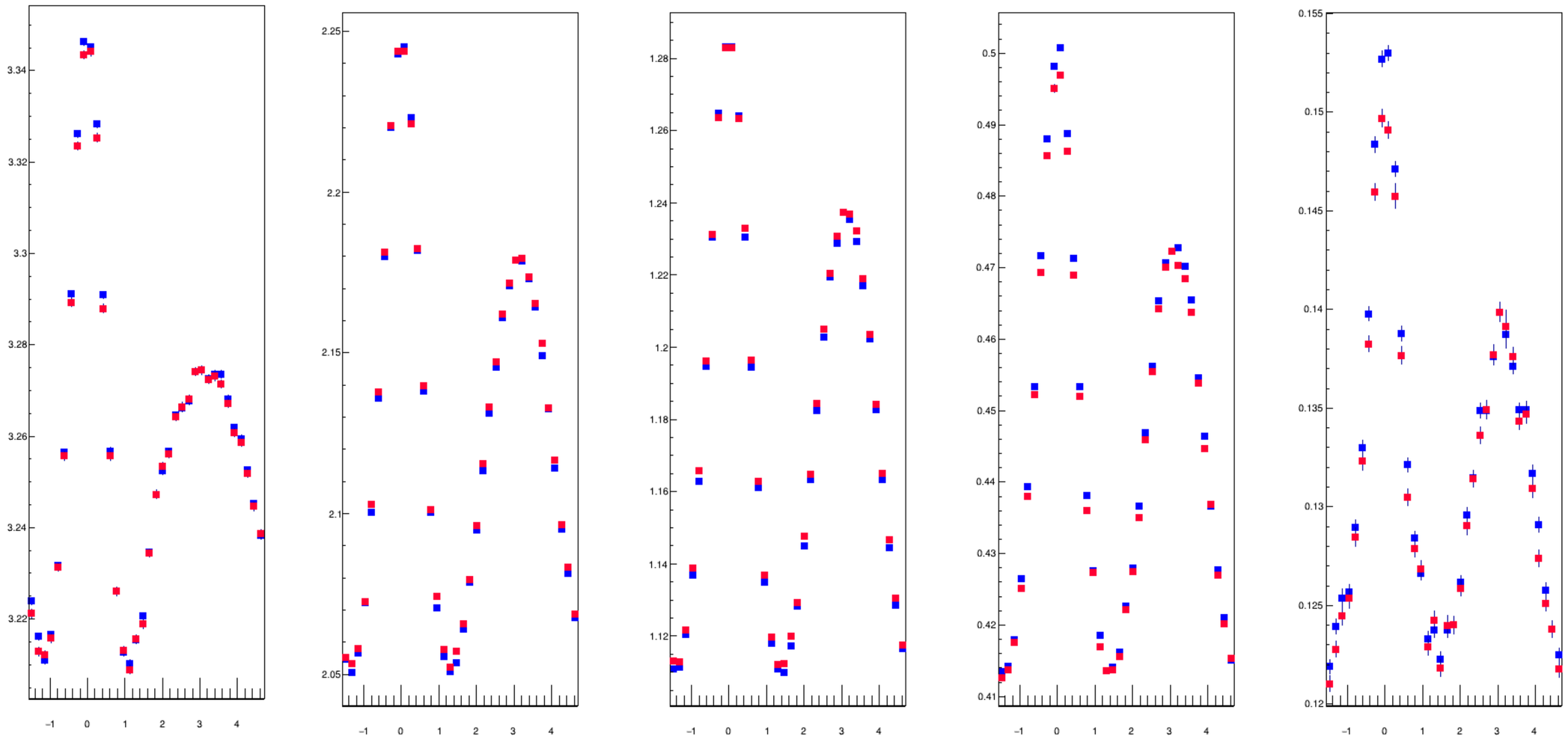
Λ triggered (0-10 %) correlation functions in pt bins, corrected for feed down

Summary and To Do

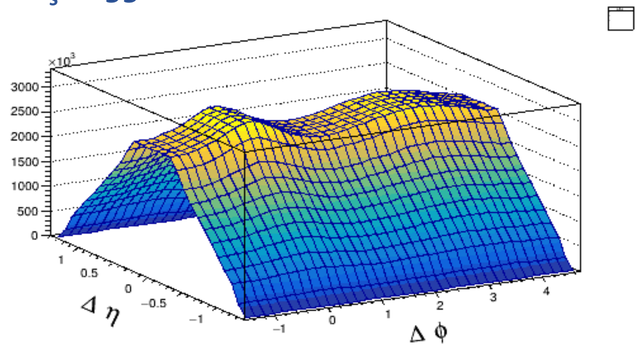
1. Efficiency corrected correlation function constructed for Λ and K_s^0 triggers.
2. Feed down correction in Λ implemented.
3. Separating the peak region and bulk region needs further investigation.
4. Next step would be take $\Delta\phi$ projections and extract near side yield.

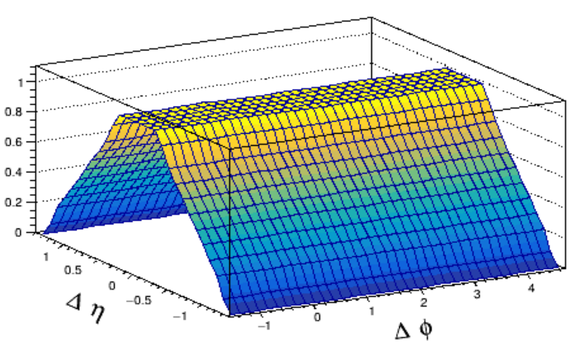
BAckups

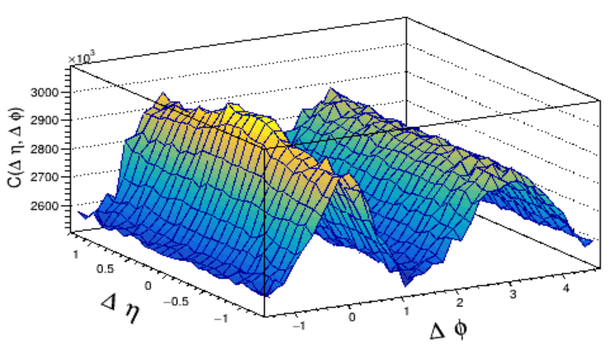



3.34
3.32
3.3
3.28
3.26
3.24
3.22
2.25
2.2
2.15
2.1
2.05
1.28
1.26
1.24
1.22
1.2
1.18
1.16
1.14
1.12
0.5
0.49
0.48
0.47
0.46
0.45
0.44
0.43
0.42
0.41
0.155
0.15
0.145
0.14
0.135
0.13
0.125
0.12
−1
0
1
2
3
4

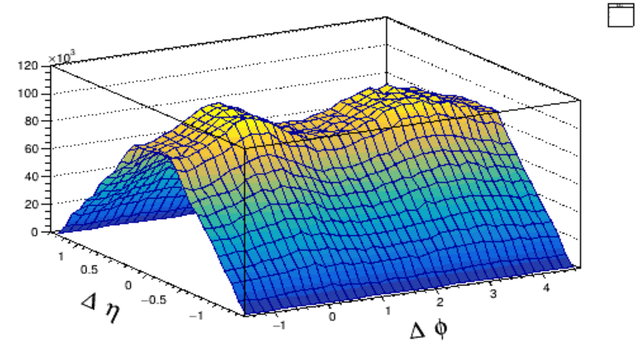
20 -40 % K^0_s triggered

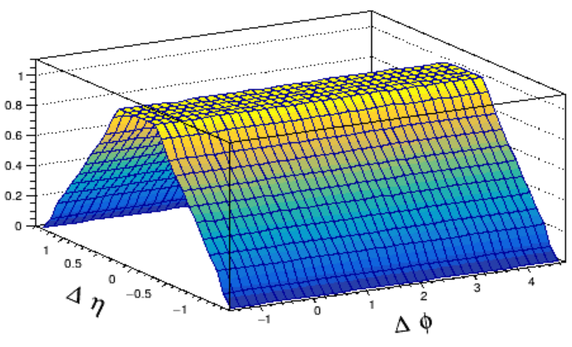


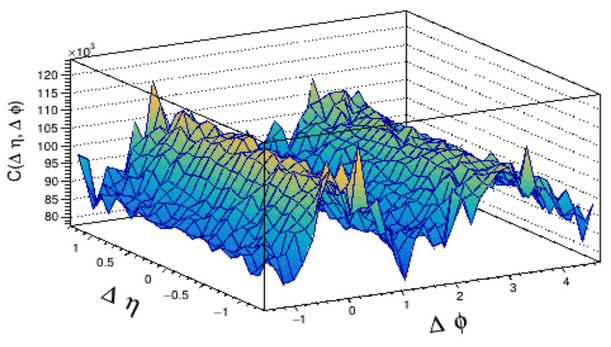




Peak region







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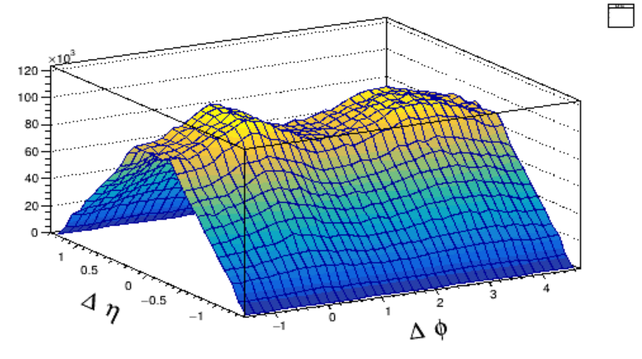
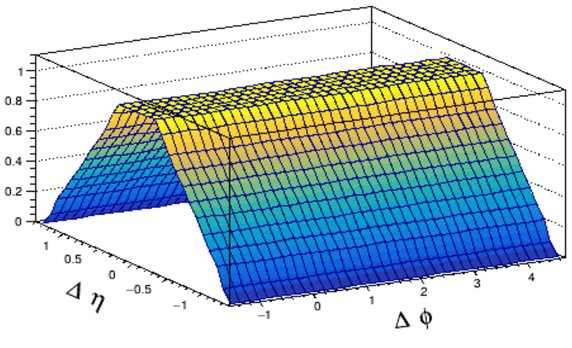
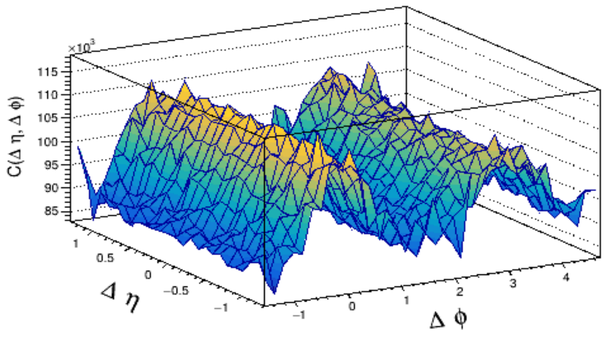






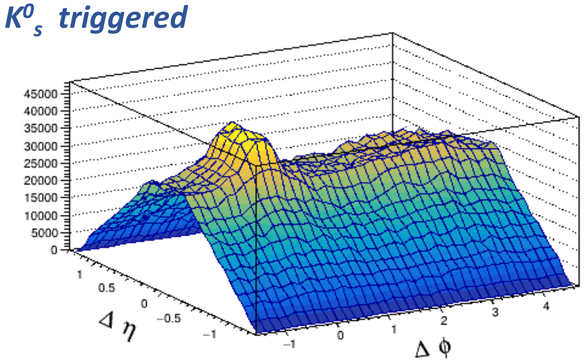
Background Right

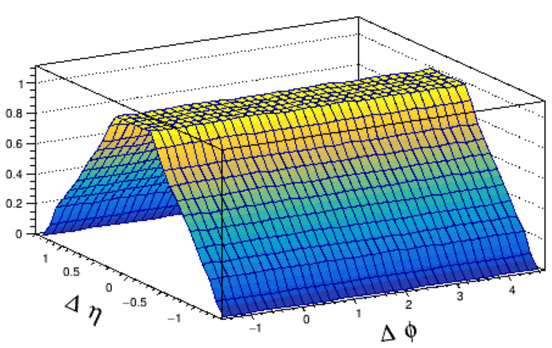
SAME EVENT

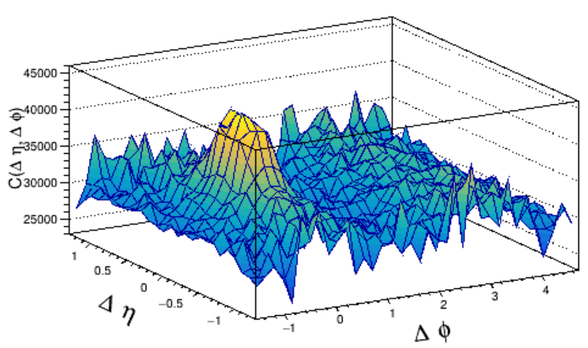
MIXED EVENT

SAME/MIXED

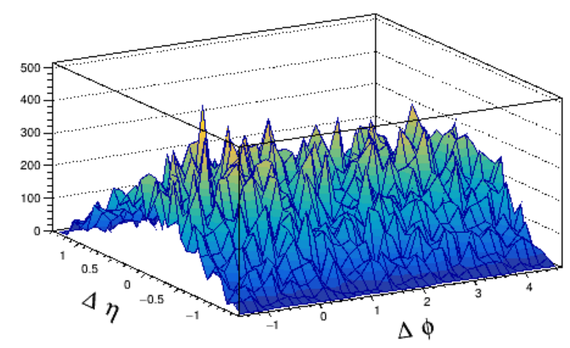
60 -80 % K^0_s triggered

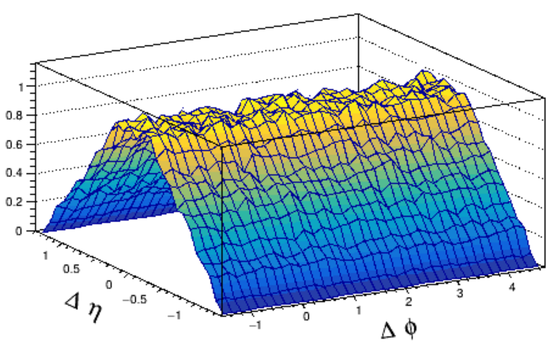


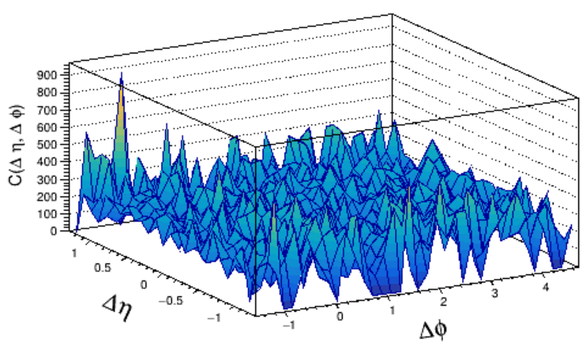




Peak region







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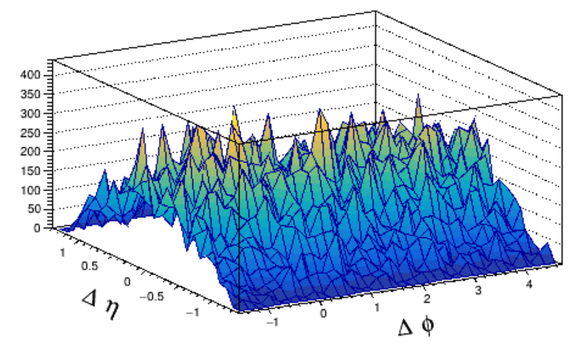
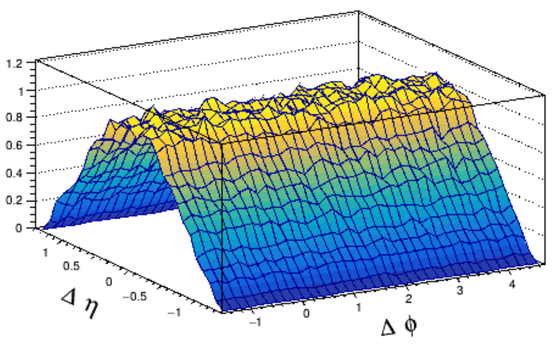
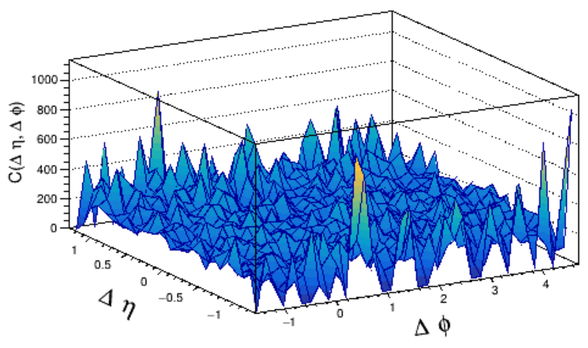






Background Right

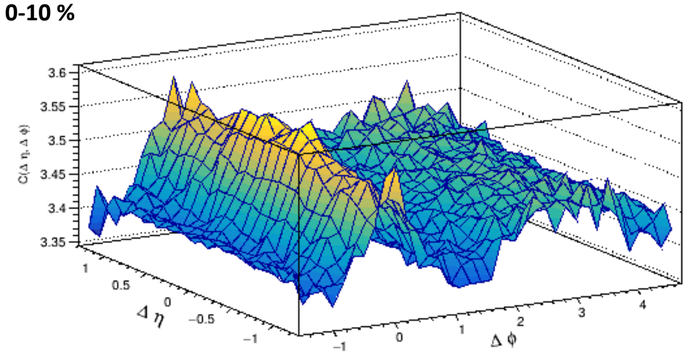
SAME EVENT

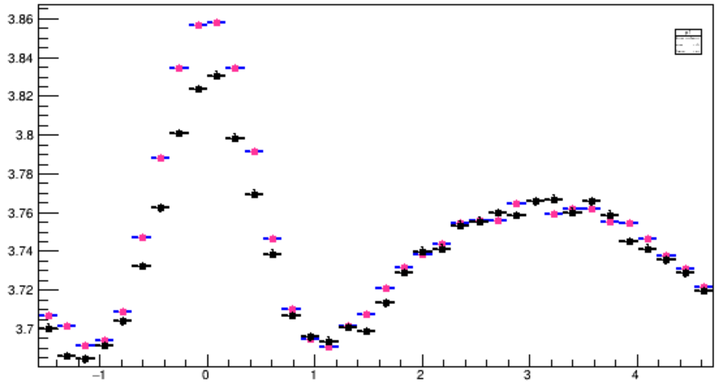
MIXED EVENT

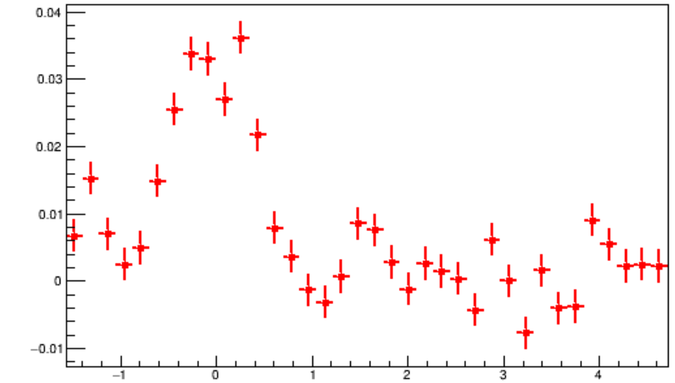
SAME/MIXED

K^0_s triggered

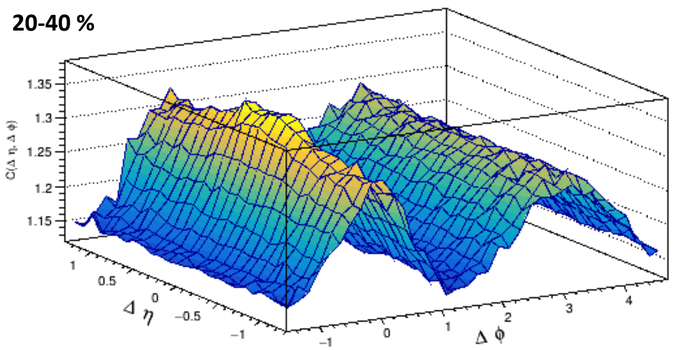
0-10 %

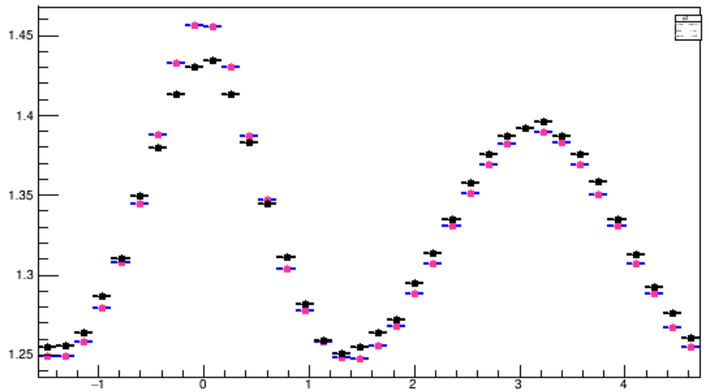


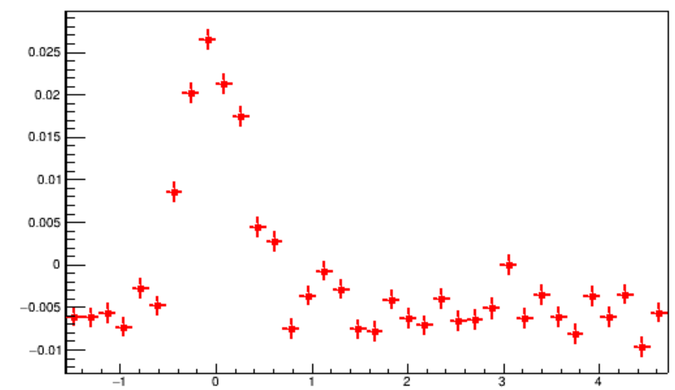




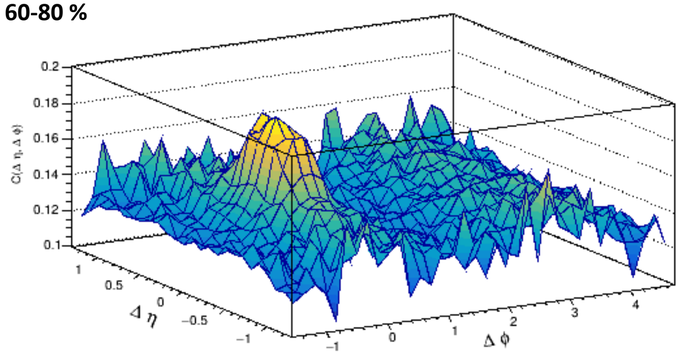
20-40 %

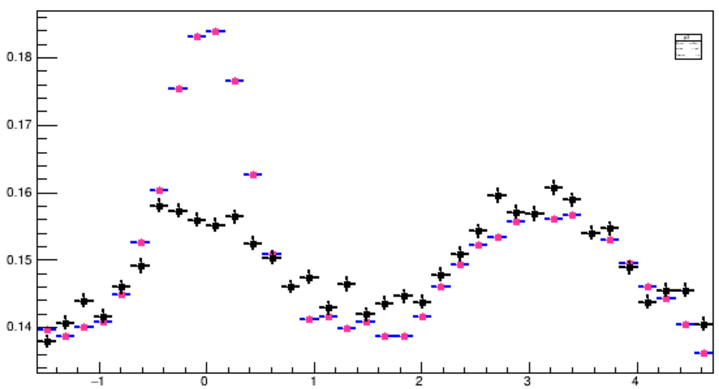


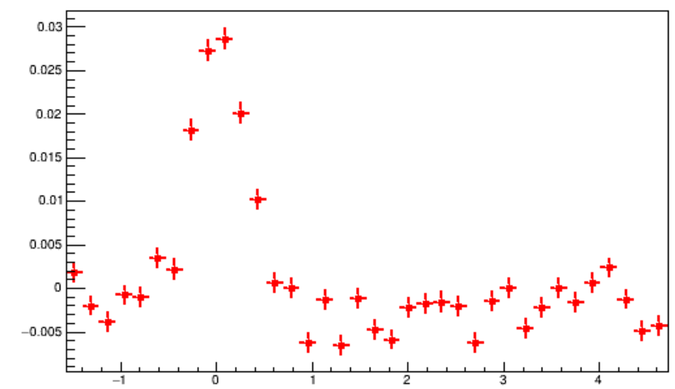




60-80 %





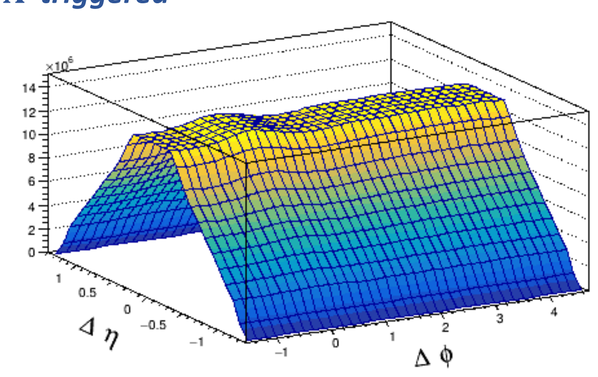


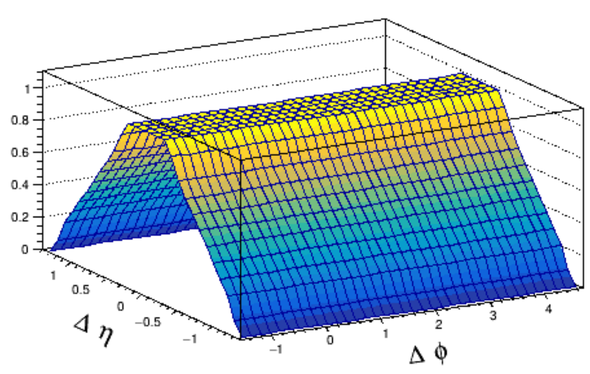
Per trigger Correlation function (efficiency corrected)

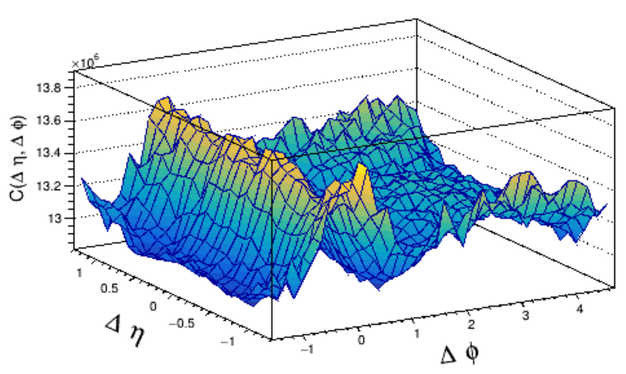
Peak and bulk region $\Delta\phi$ projection

Bulk subtracted

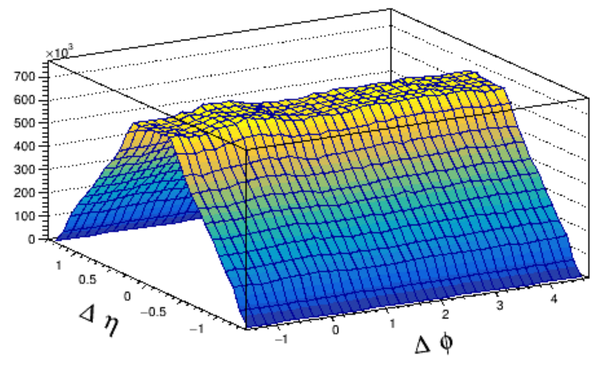
0 -10 % Λ triggered

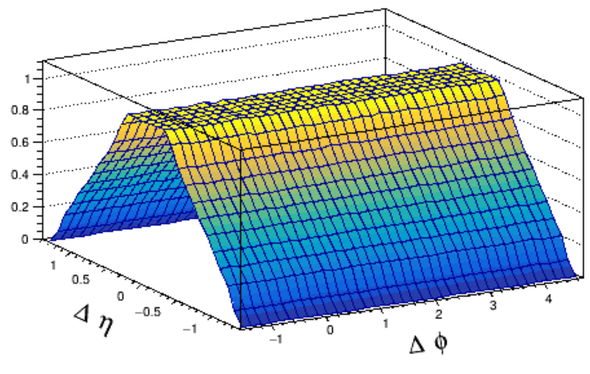


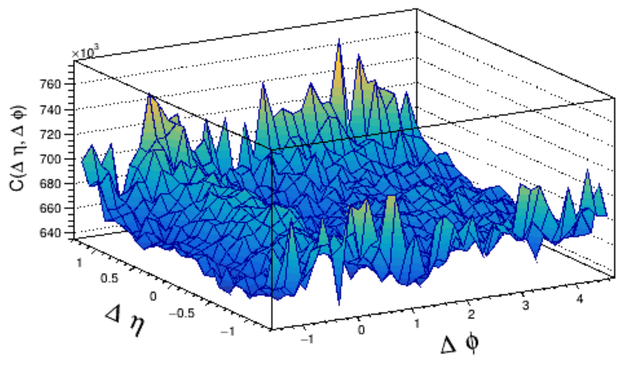




Peak region







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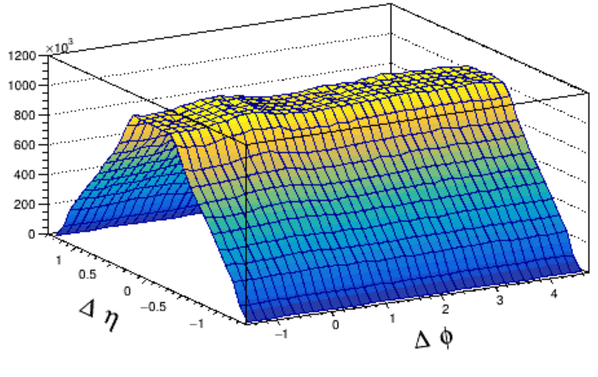
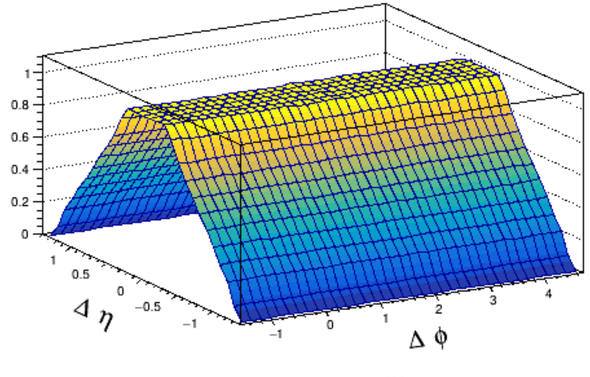
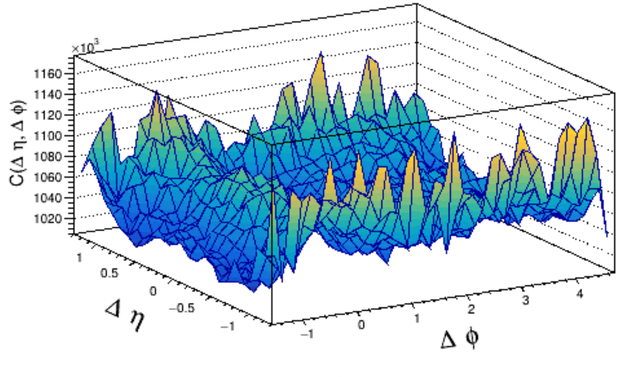


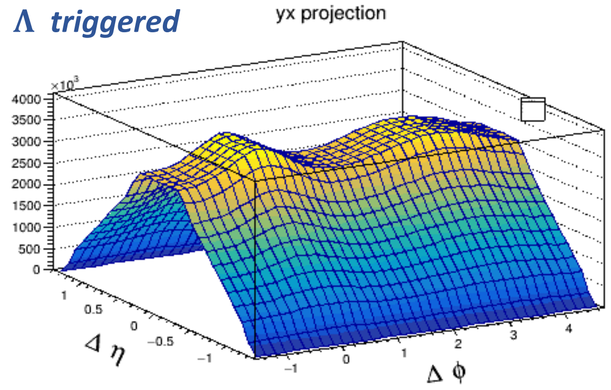


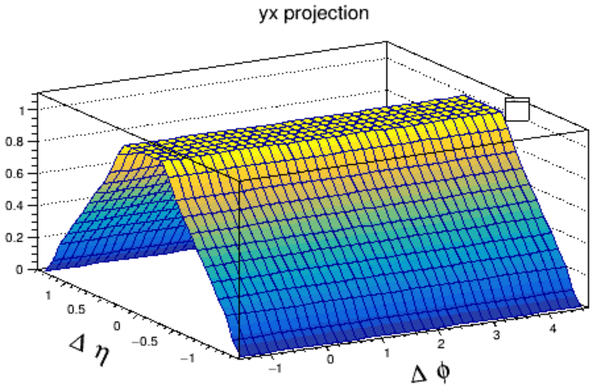


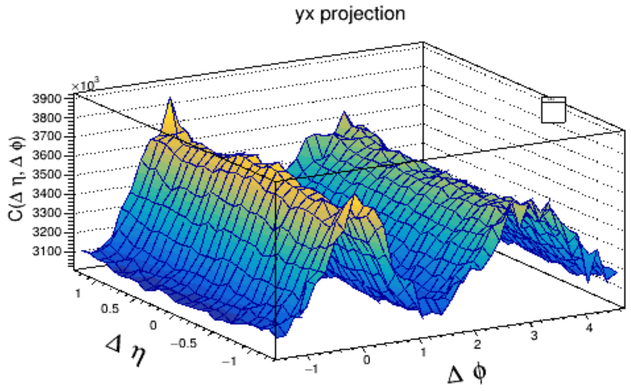
Background Right

SAME EVENT **MIXED EVENT** **SAME/MIXED**

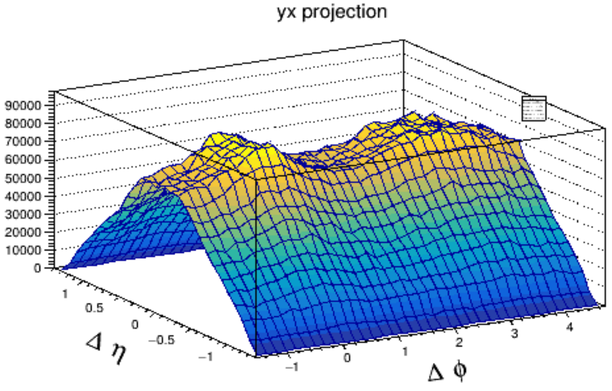
20 -40 % Λ triggered

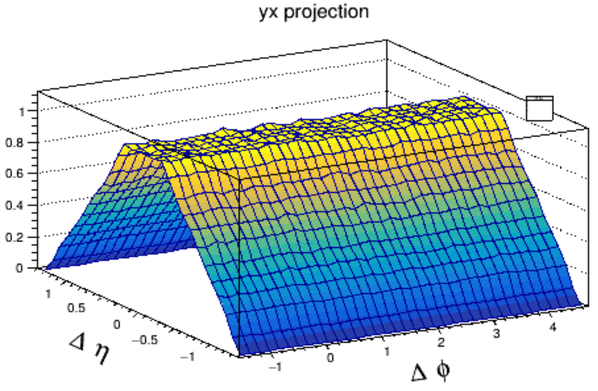


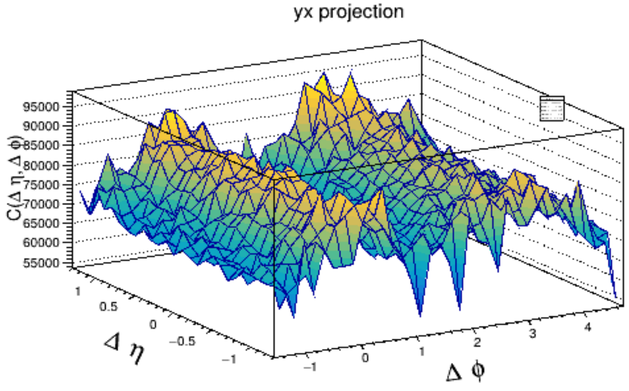




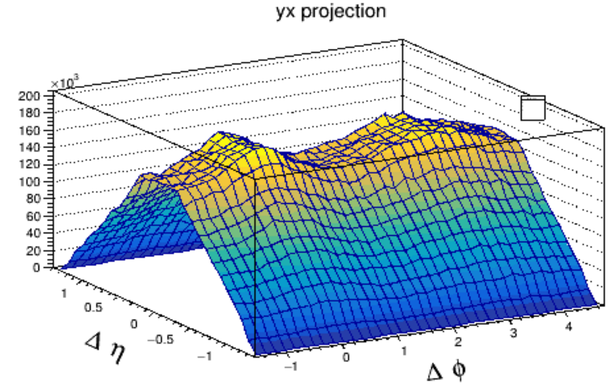
Peak region

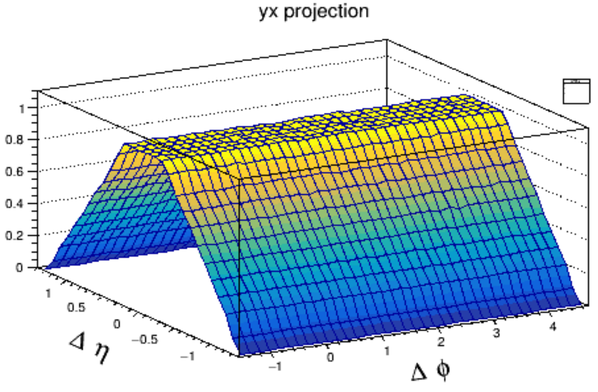


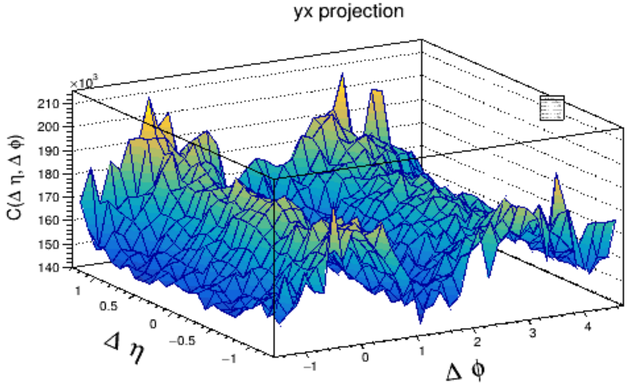




Background left



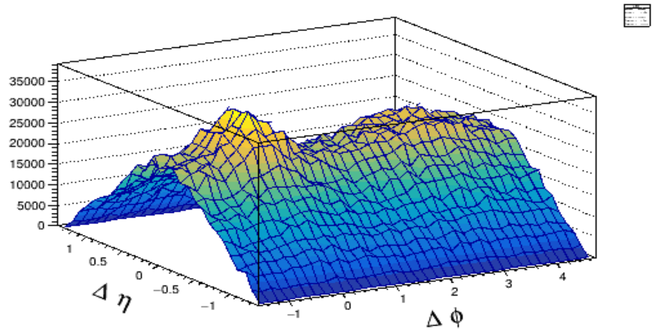


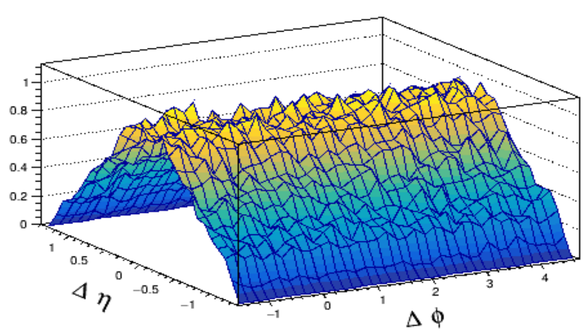


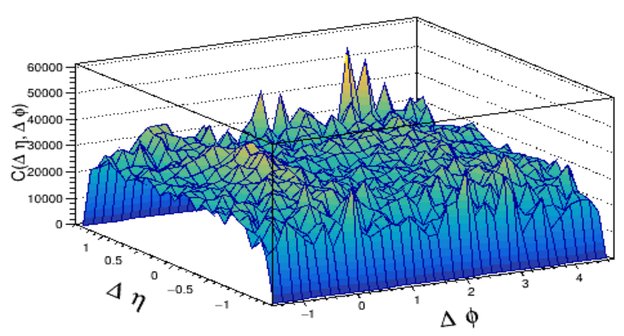
Background Right

SAME EVENT **MIXED EVENT** **SAME/MIXED**

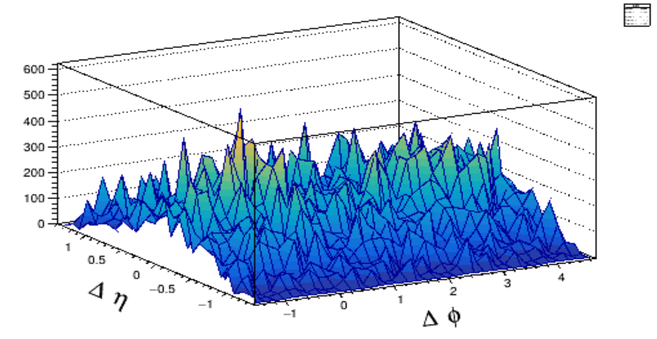
60 -80 % Λ triggered

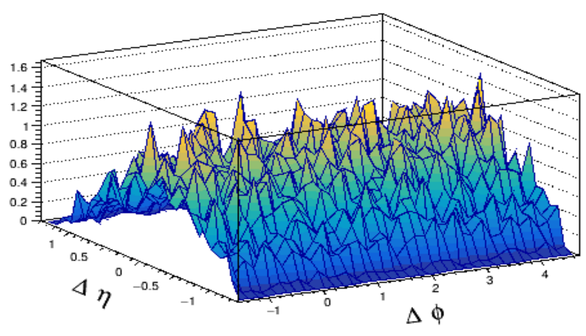


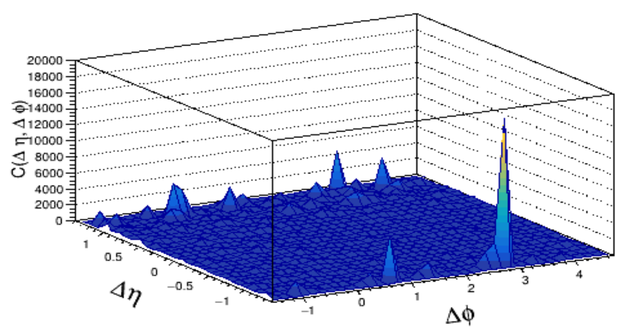




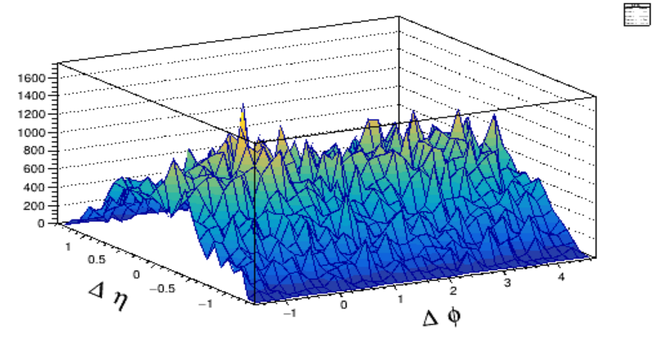
Peak region

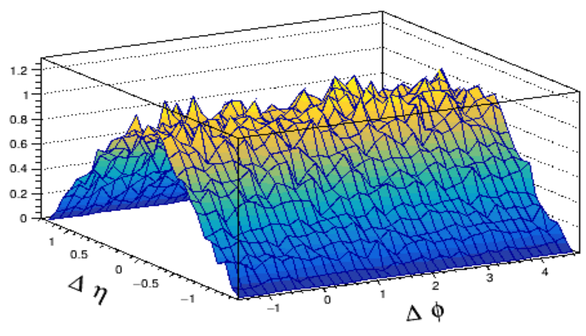


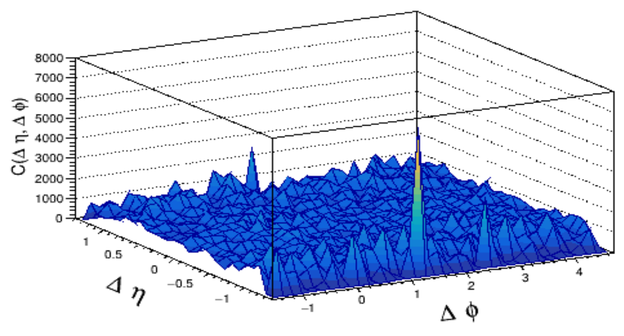




Background left





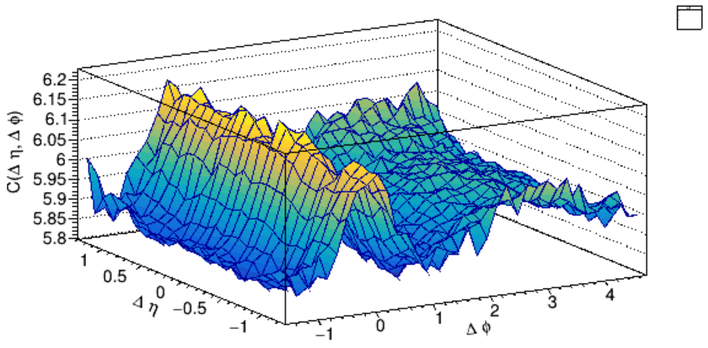


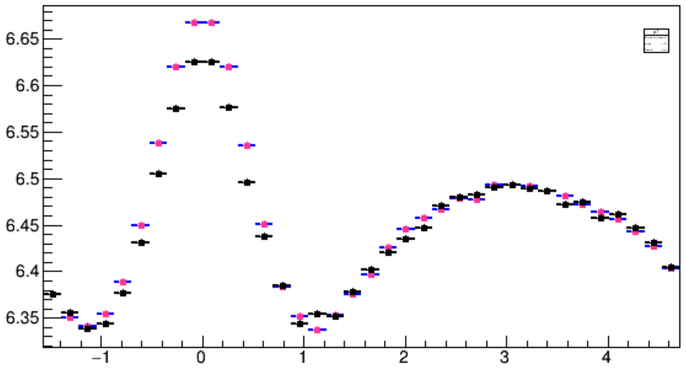
Background Right

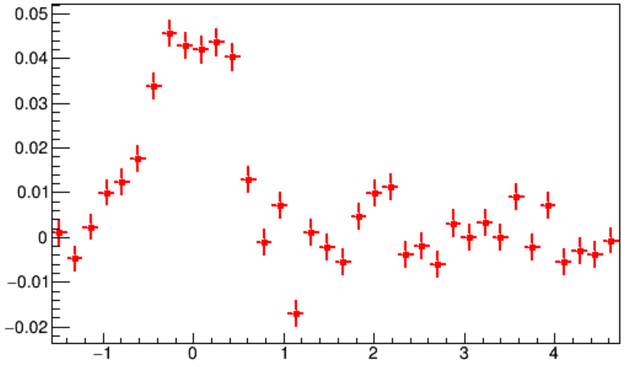
SAME EVENT **MIXED EVENT** **SAME/MIXED**

Λ *triggered*

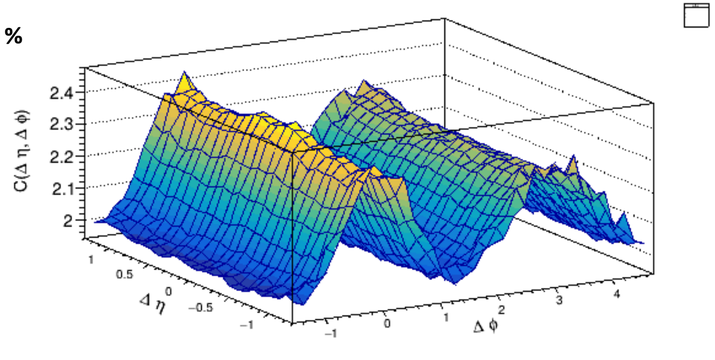
0-10 %

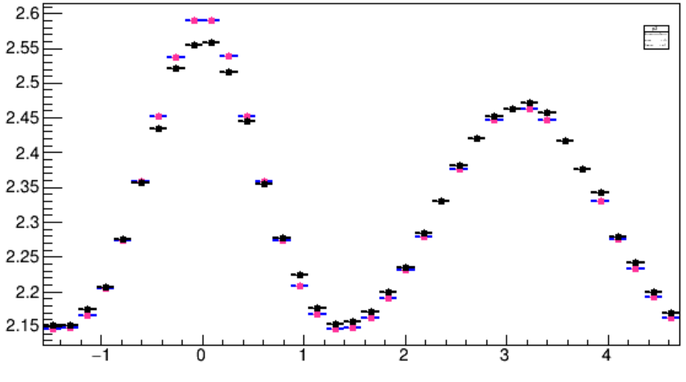


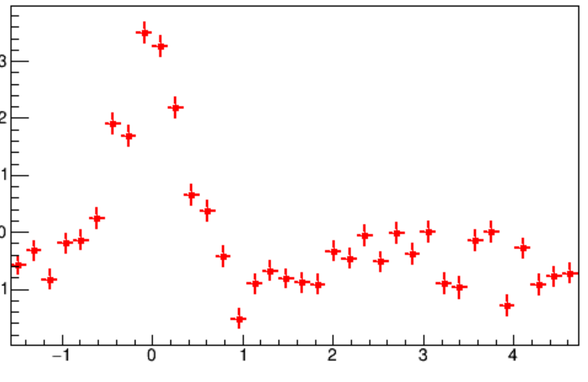




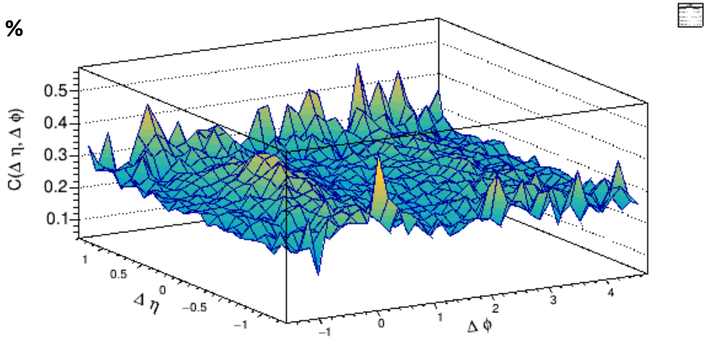
20-40 %

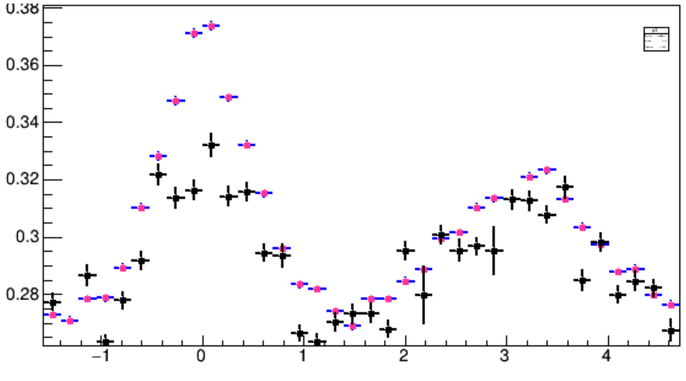


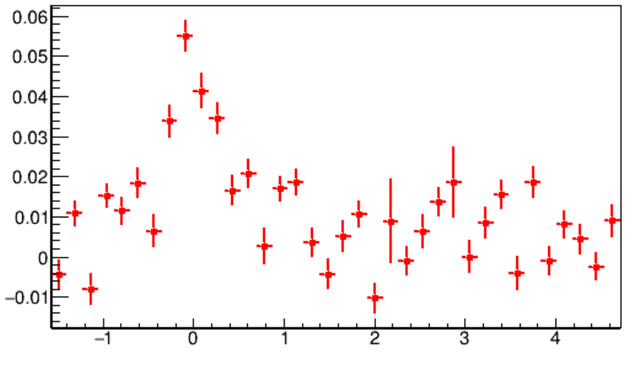




60-80 %





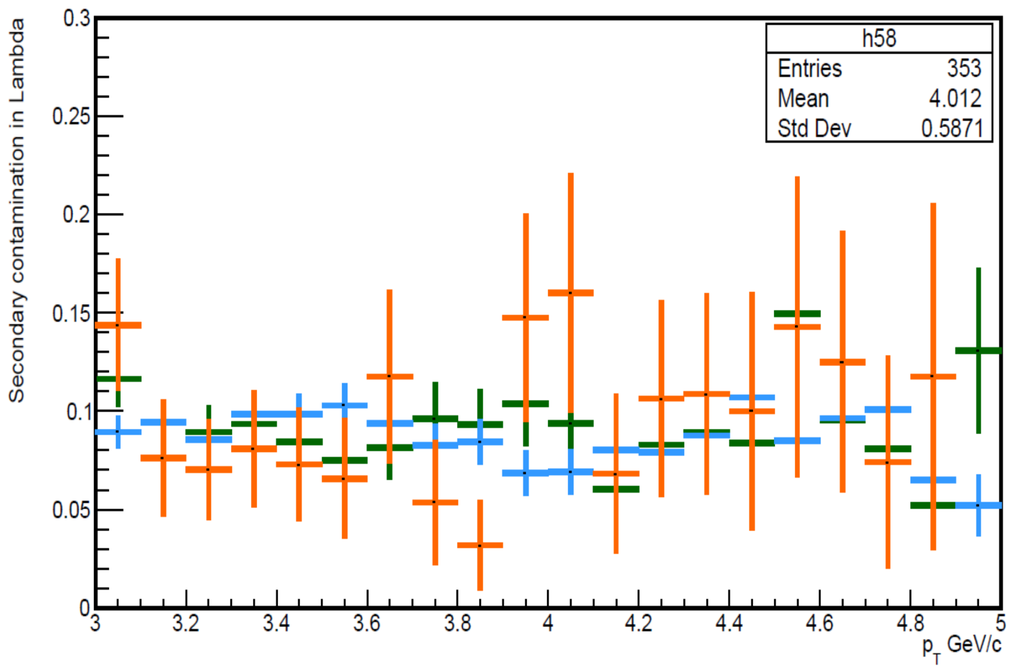


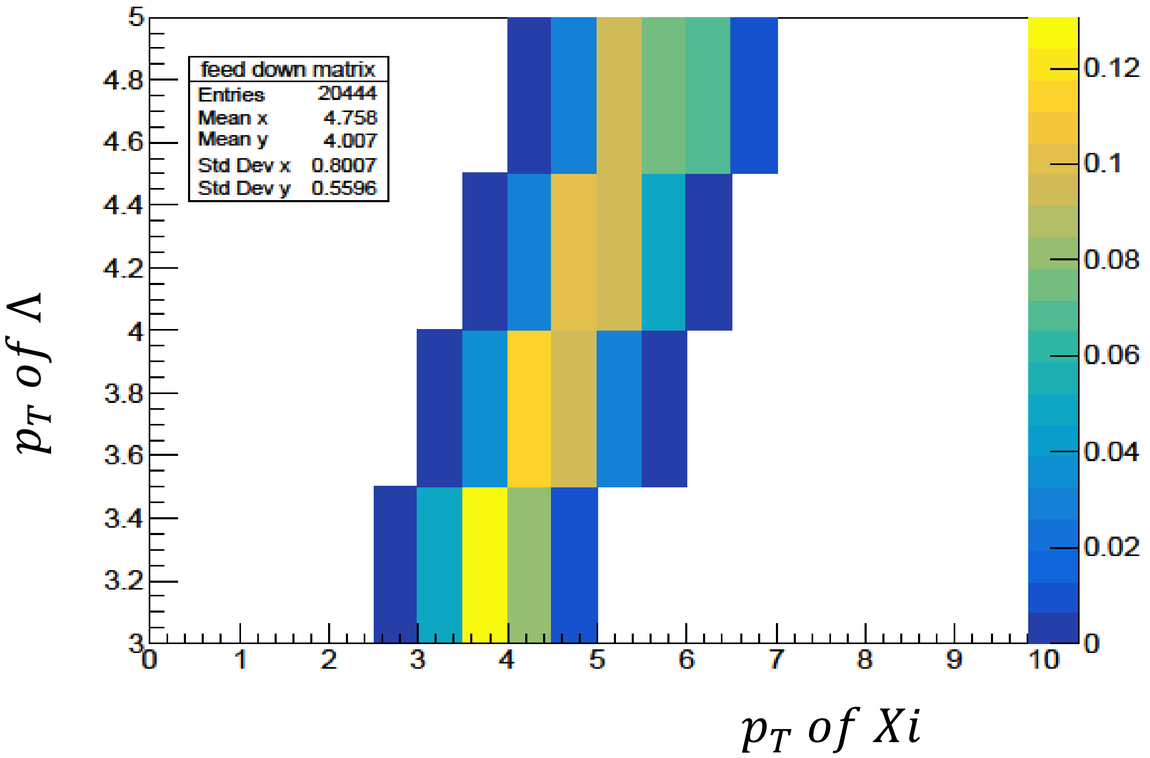
Per trigger Correlation function (efficiency corrected)

Peak and bulk region $\Delta\phi$ projection

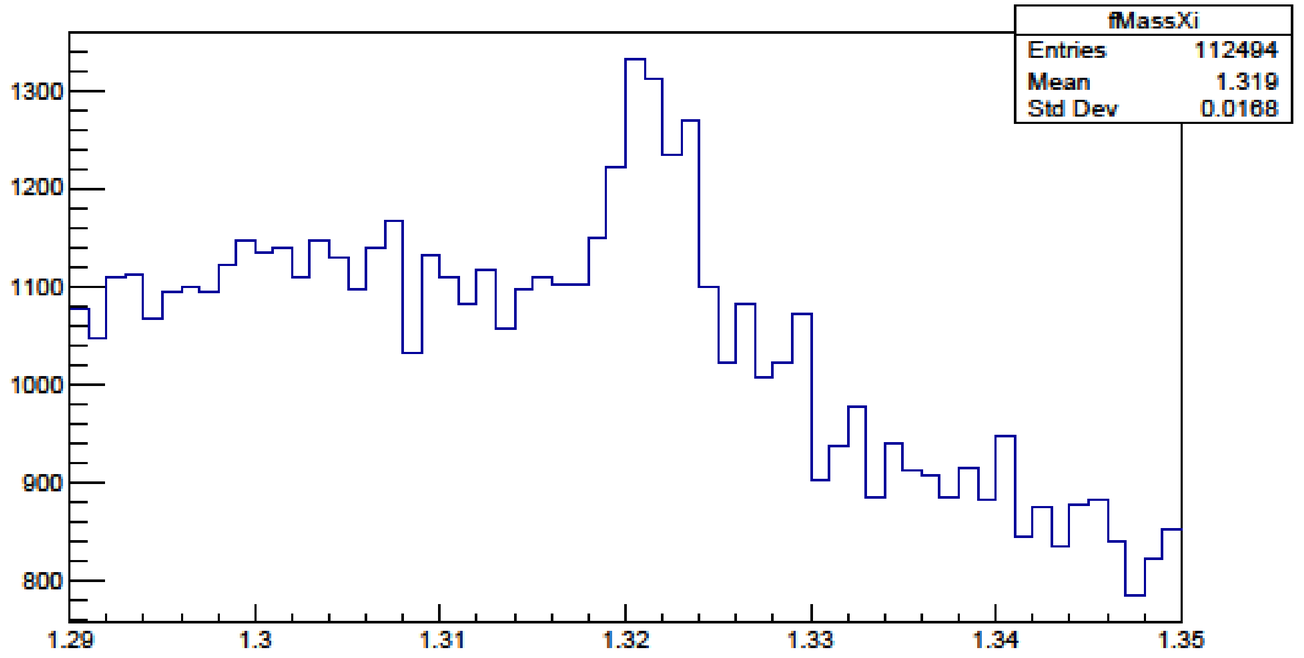
Bulk subtracted

Contamination from feed down in Λ





Invariant mass Xi:



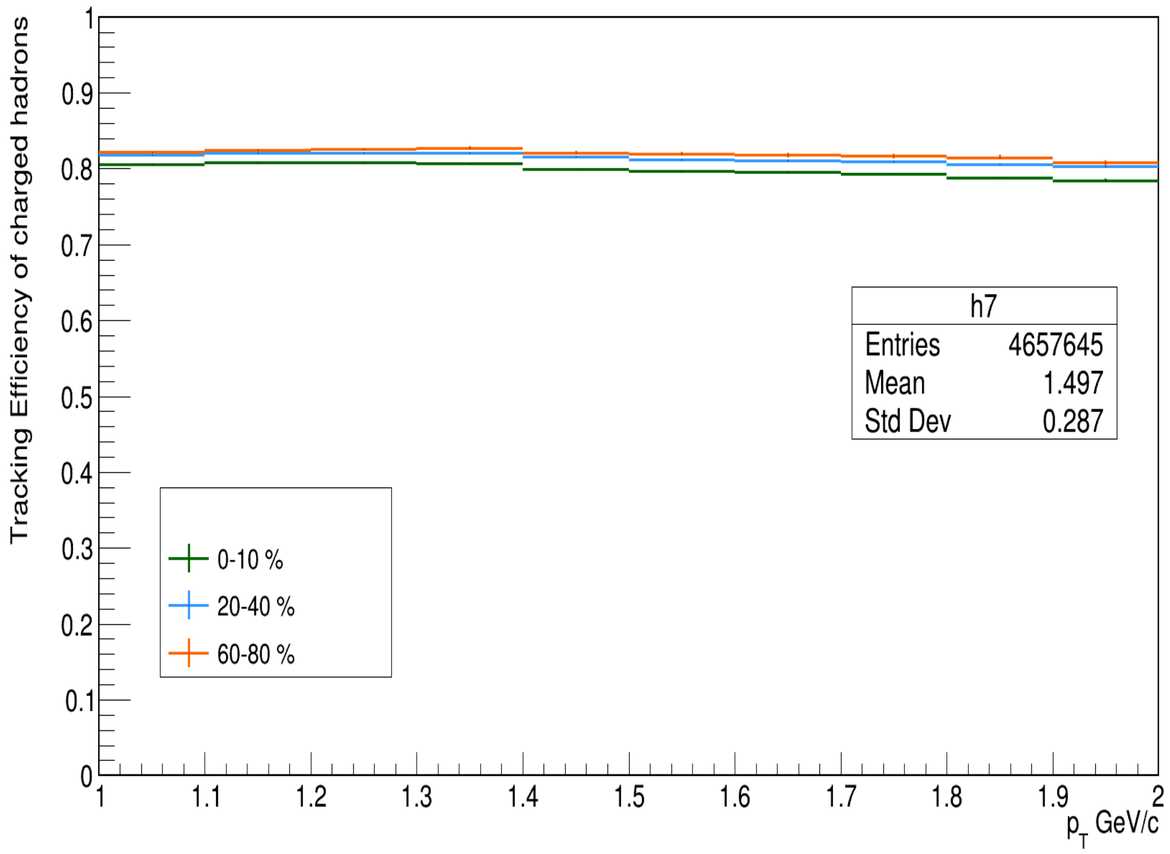
3 <p_T< 7 GeV/c

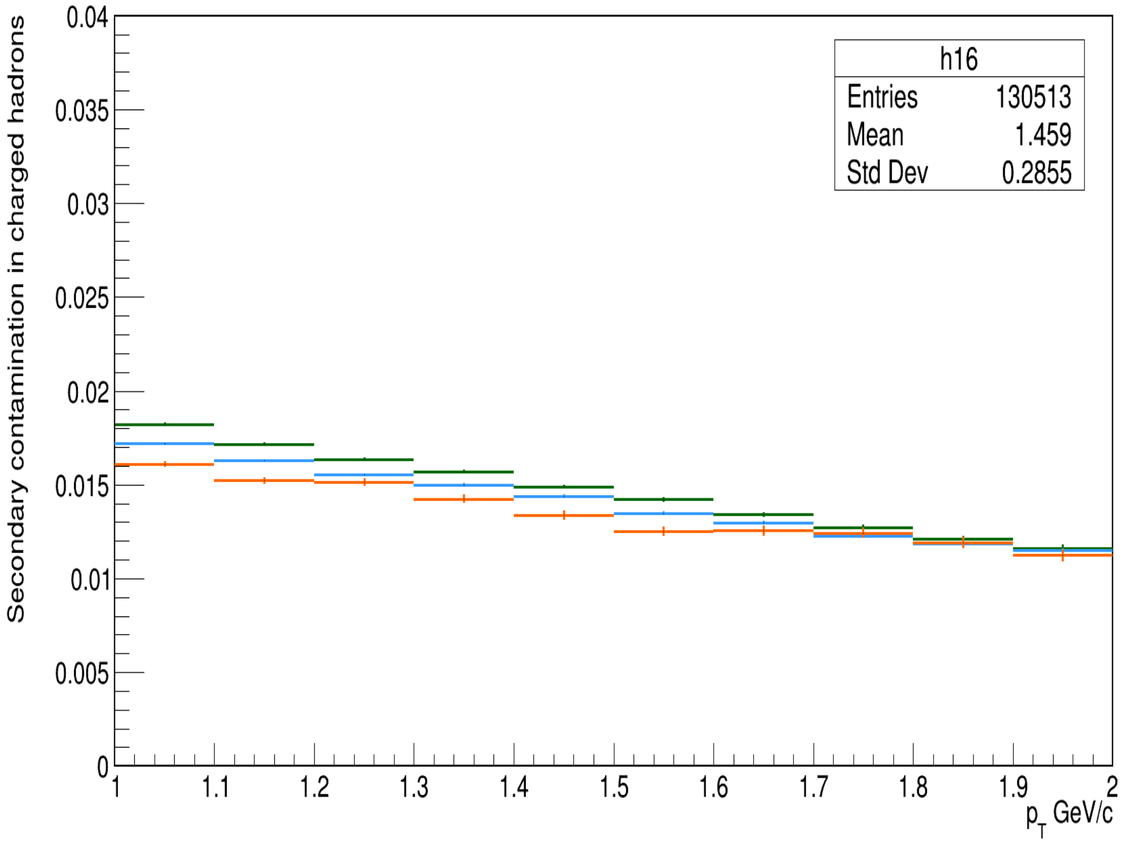
Topological Variable	Value
Cascade transv. decay radius R_{2D} (cm)	>0.6
V^0 transv. decay radius (cm)	> 1.2
DCA bachelor to PV (cm)	> 0.04
DCA V^0 to PV (cm)	>0.06
DCA meson V^0 track to PV (cm)	>0.04
DCA baryon V^0 track to PV (cm)	>0.03
DCA V^0 daughters (σ)	<1.5
DCA bachelor to PV (cm)	< 1.3
Cascade cos(θ_{PA})	>0.97
V^0 cos(θ_{PA})	>0.97
Proper lifetime K^0_S (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 (Nσ)	<5
Proper lifetime mL/p	$< 3 \times c\tau$
Tracking flags for daughters	kTPCrefit
Daughter Track $N_{TPCclusters}$	> 70

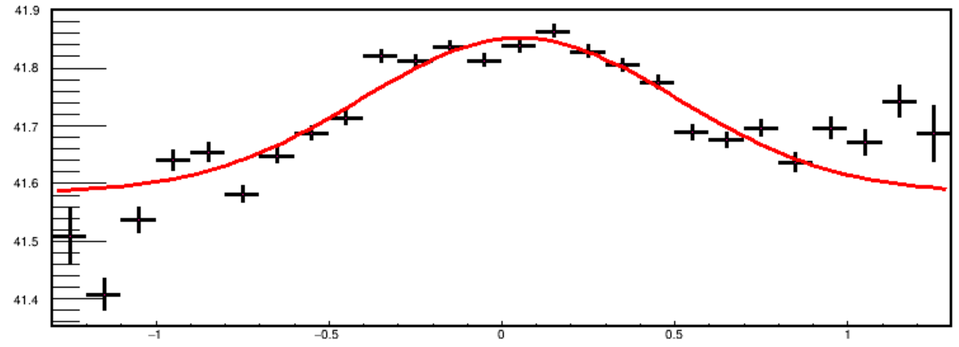
0.995 used

Table 3: Selection criteria for charged Ξ candidates

Efficiency of associated charged hadrons



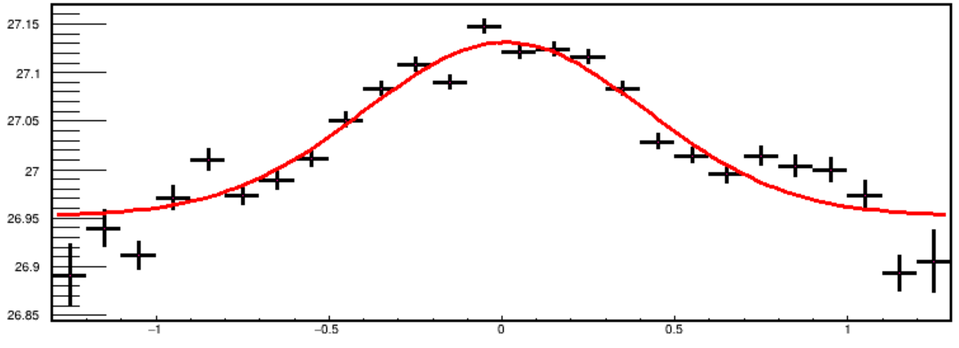




0-10 % K_s^0 *triggered*

χ^2 /ndf = 7.9

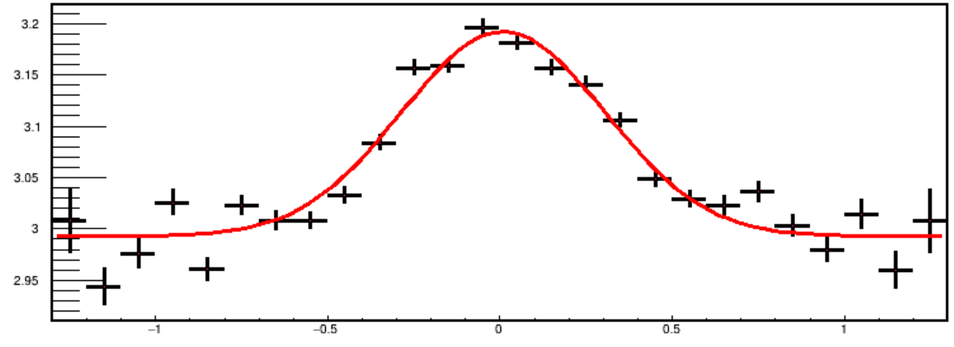
$\sigma = 0.45$



40-60 % K_s^0 *triggered*

χ^2 /ndf = 4.55

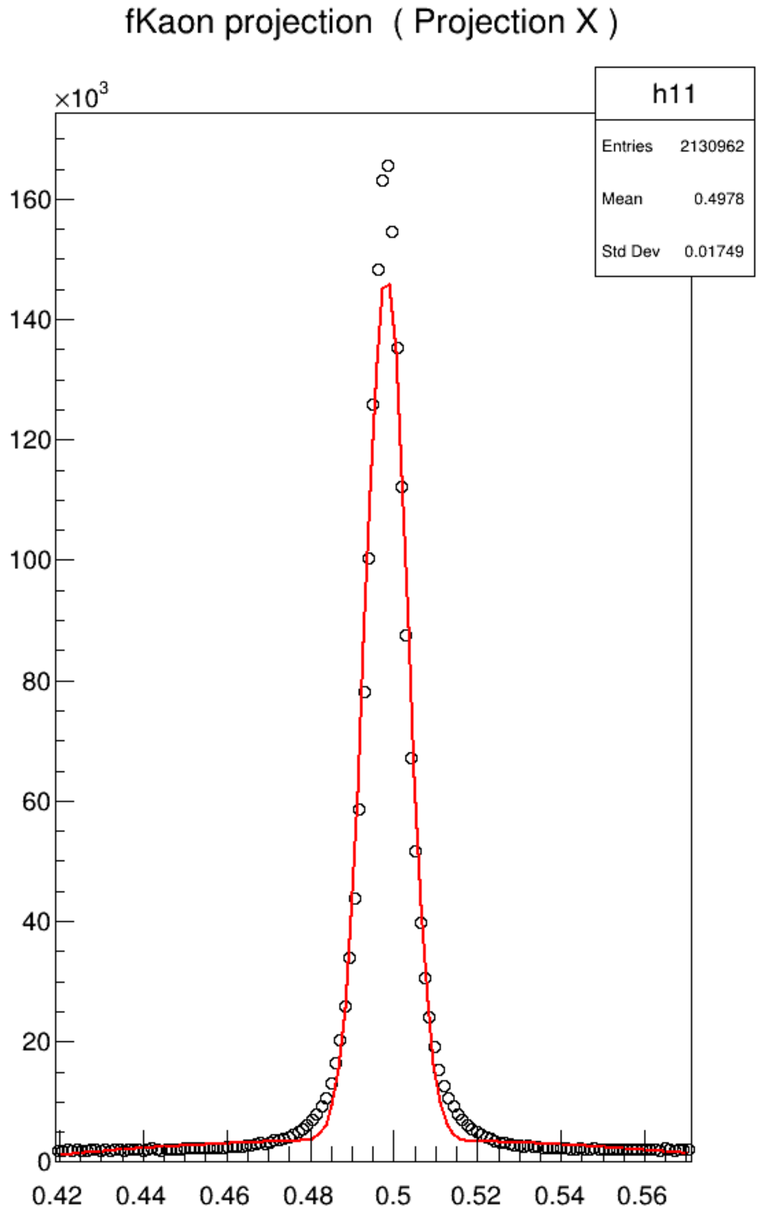
$\sigma = 0.40$

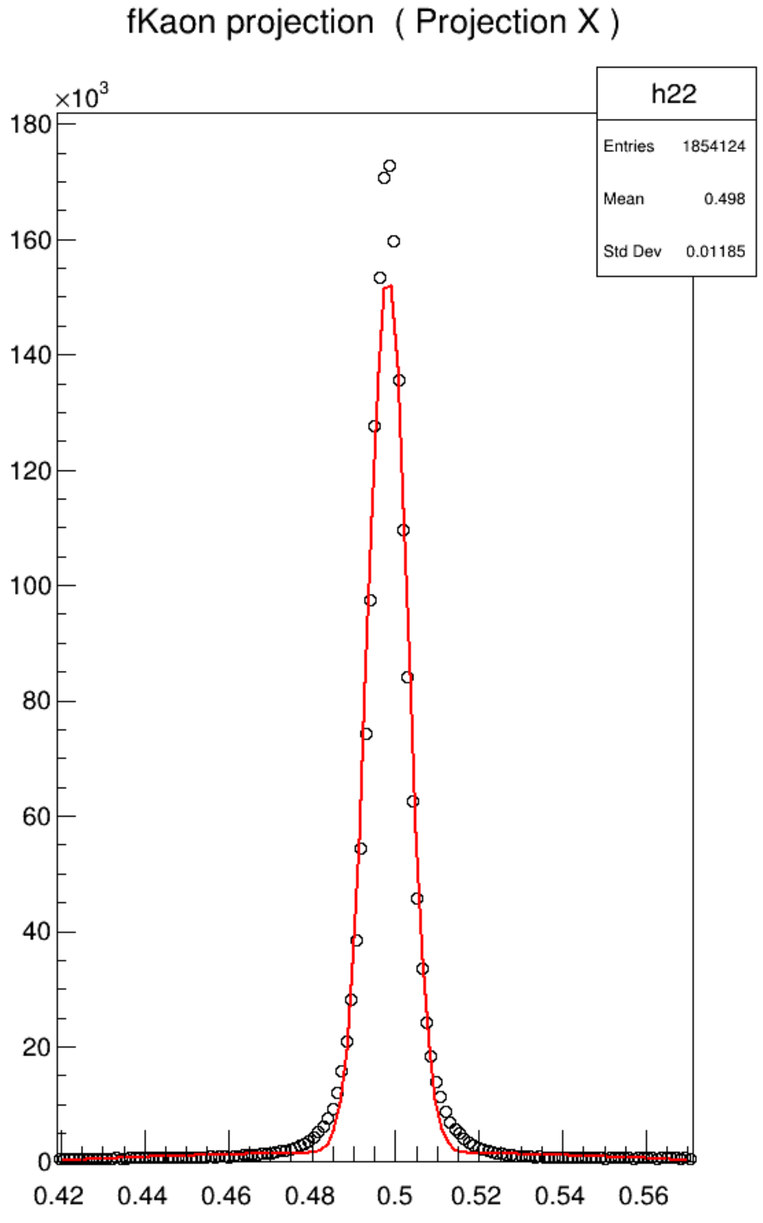


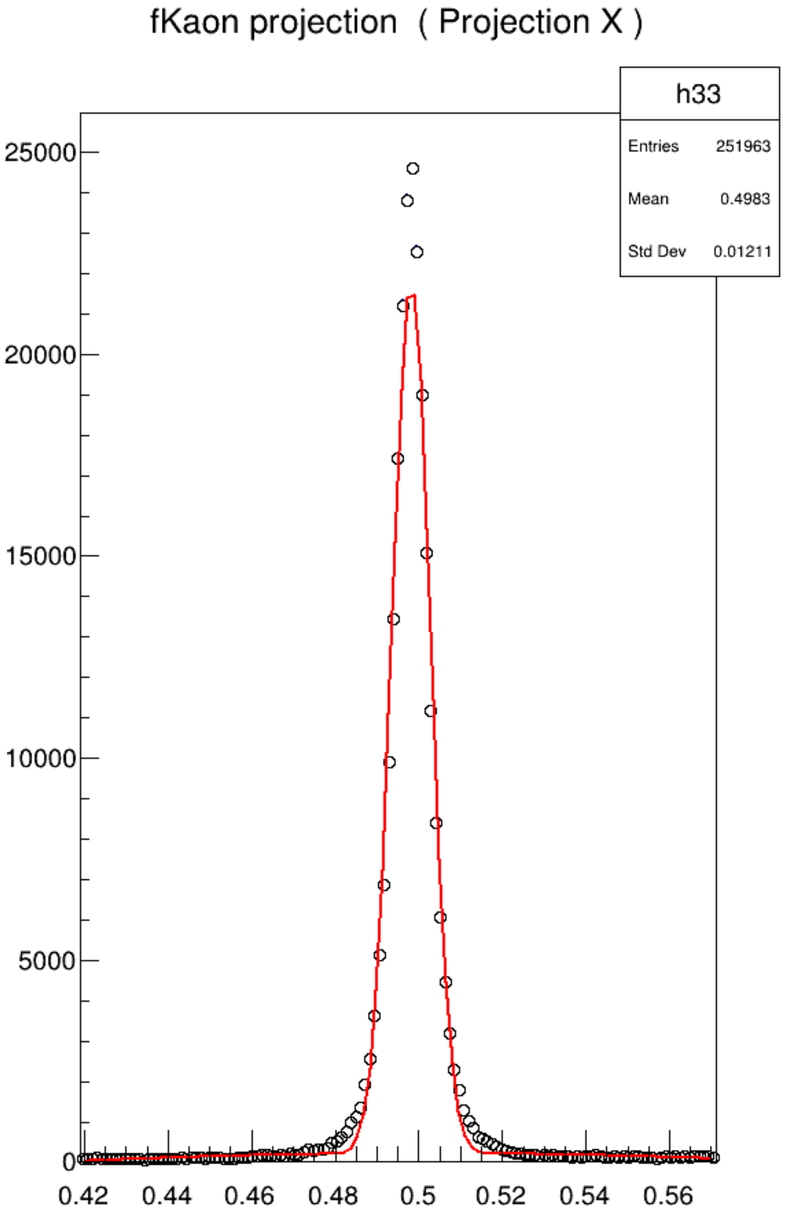
60-80 % K_s^0 *triggered*

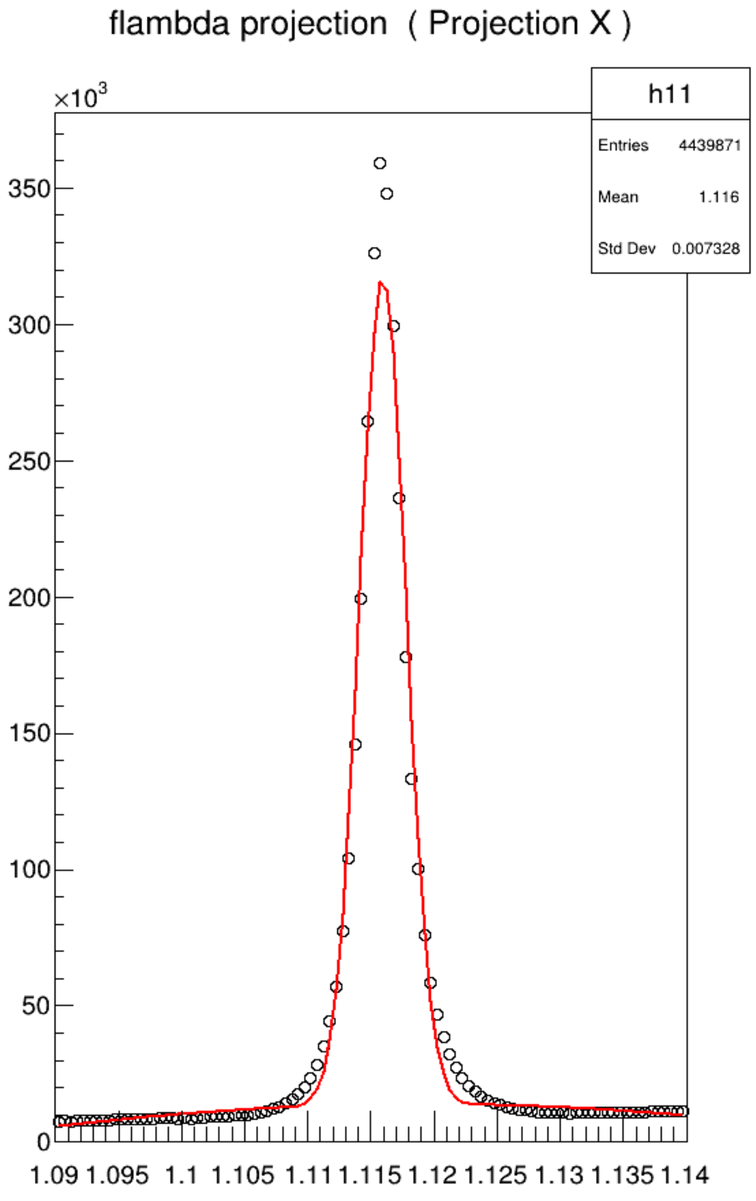
χ^2 /ndf = 3.69

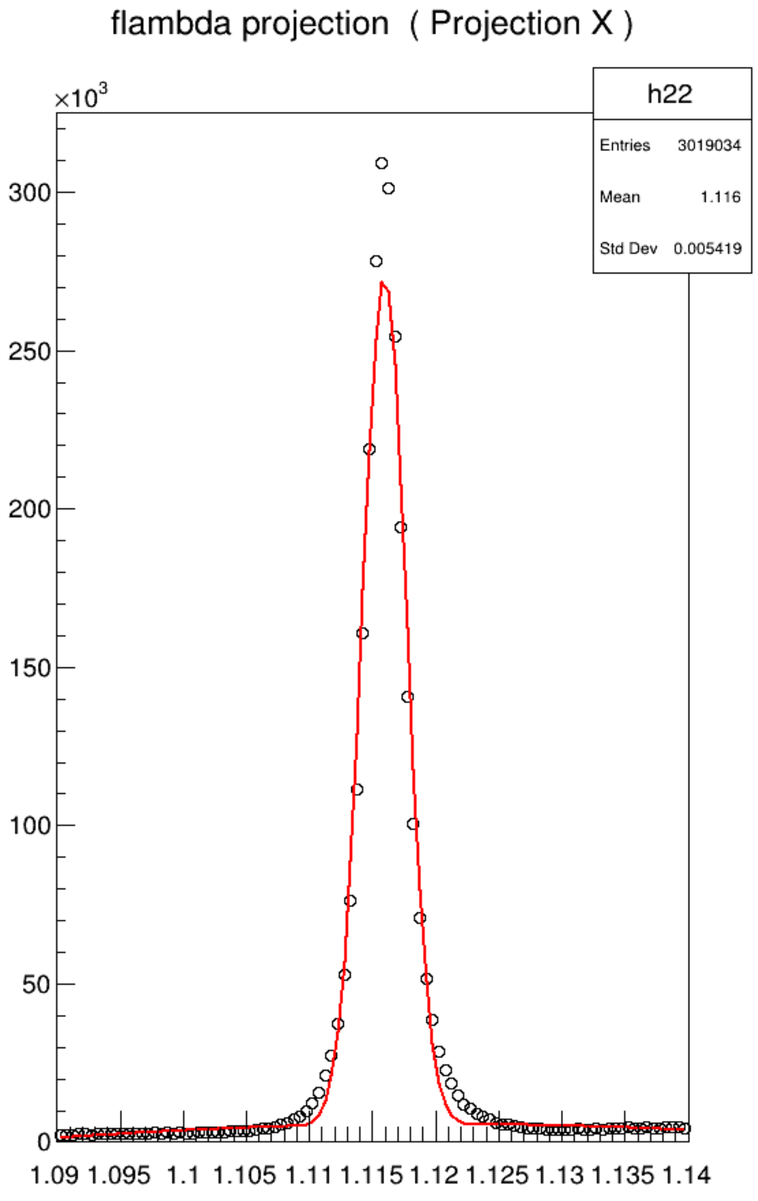
$\sigma = 0.29$

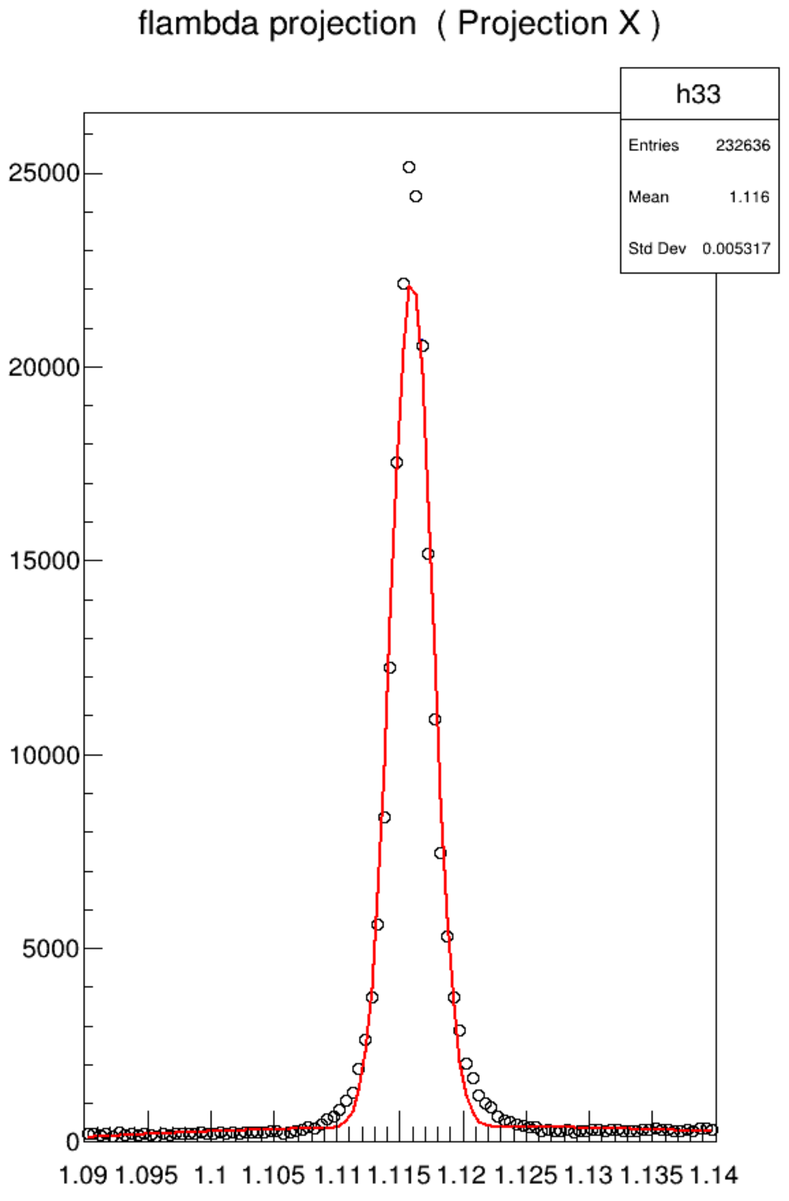

fKaon projection (Projection X)
h11
Entries 2130962
Mean 0.4978
Std Dev 0.01749
×10^3
160
140
120
100
80
60
40
20
0
0.42
0.44
0.46
0.48
0.5
0.52
0.54
0.56


fKaon projection (Projection X)
h22
Entries 1854124
Mean 0.498
Std Dev 0.01185
×10^3
180
160
140
120
100
80
60
40
20
0
0.42
0.44
0.46
0.48
0.5
0.52
0.54
0.56

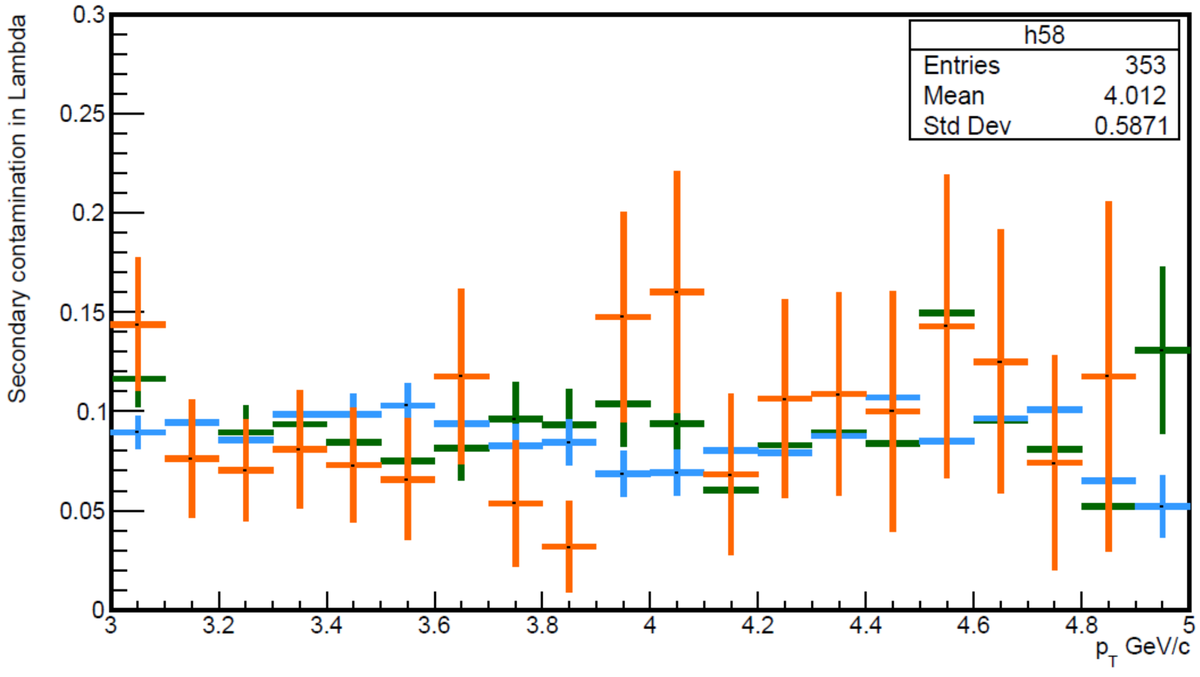

fKaon projection (Projection X)
h33
Entries 251963
Mean 0.4983
Std Dev 0.01211
25000
20000
15000
10000
5000
0
0.42
0.44
0.46
0.48
0.5
0.52
0.54
0.56


flambda projection (Projection X)
h11
Entries 4439871
Mean 1.116
Std Dev 0.007328
×10^3
350
300
250
200
150
100
50
0
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14

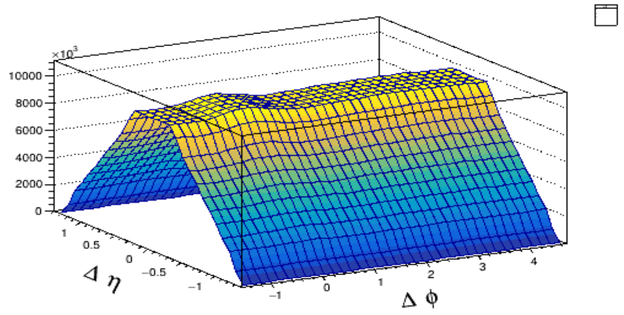

flambda projection (Projection X)
h22
Entries 3019034
Mean 1.116
Std Dev 0.005419
×10^3
300
250
200
150
100
50
0
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14

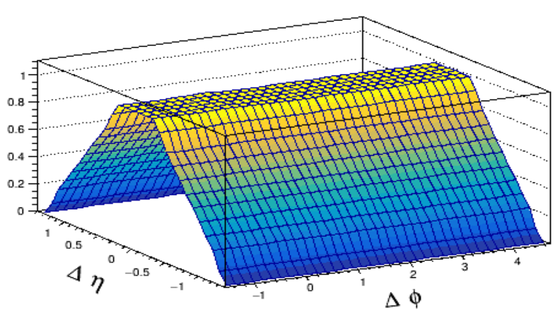

flambda projection (Projection X)
h33
Entries 232636
Mean 1.116
Std Dev 0.005317
25000
20000
15000
10000
5000
0
1.09 1.095 1.1 1.105 1.11 1.115 1.12 1.125 1.13 1.135 1.14

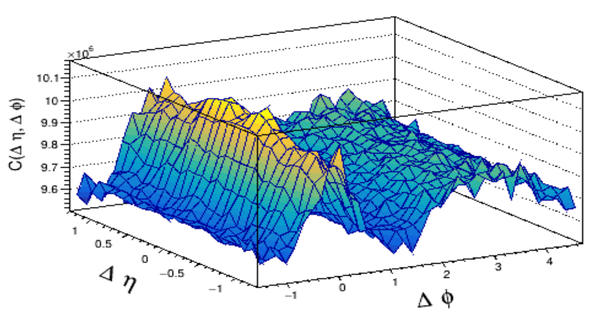
BACKUP Plots



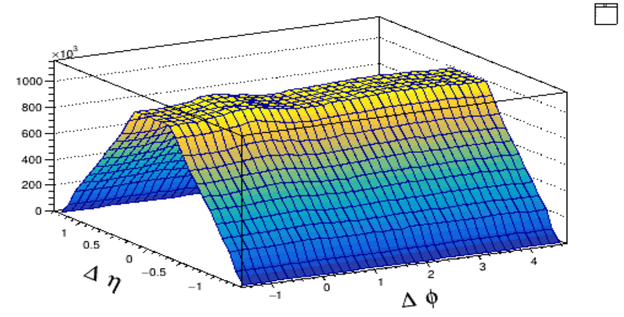
0 -10 % K^0_s triggered

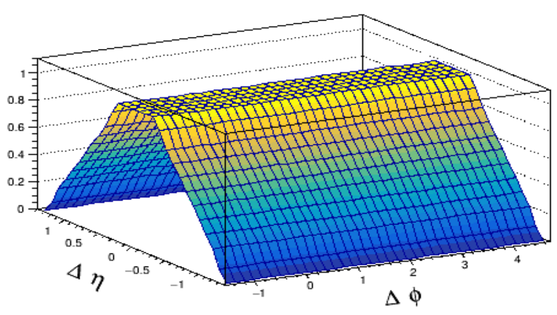


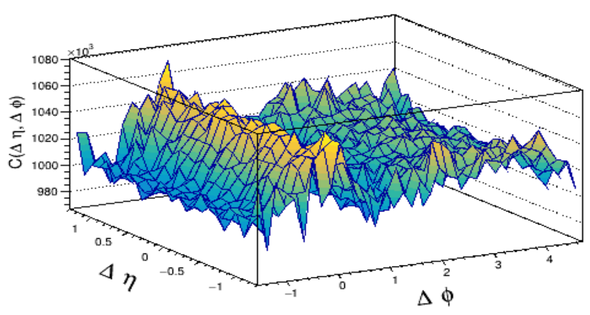




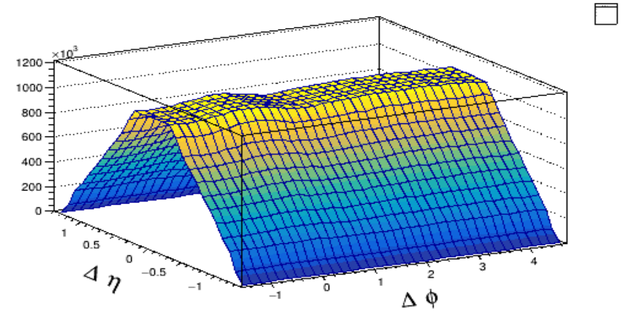
Peak region

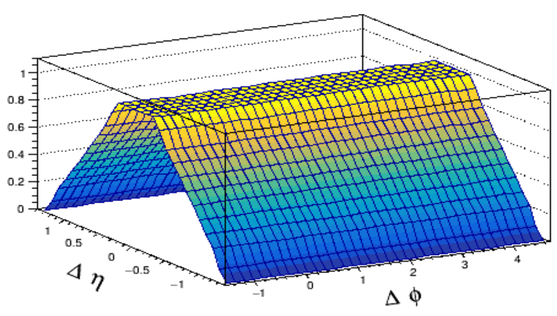


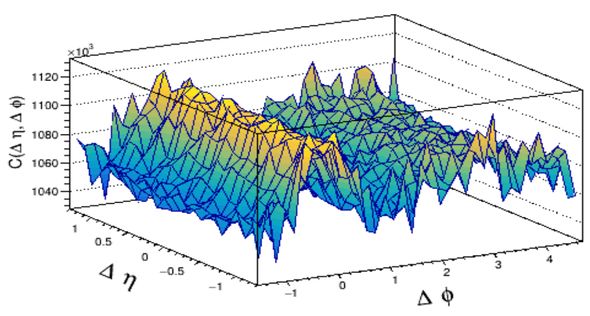




Background left





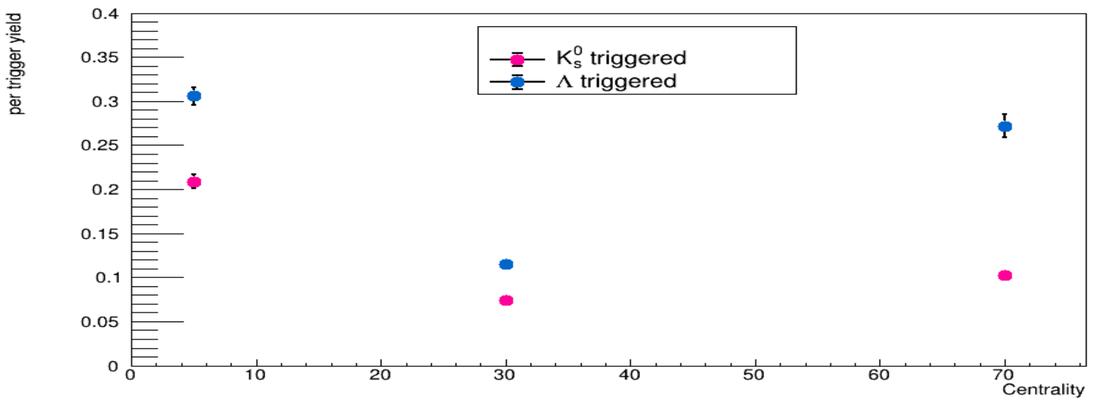


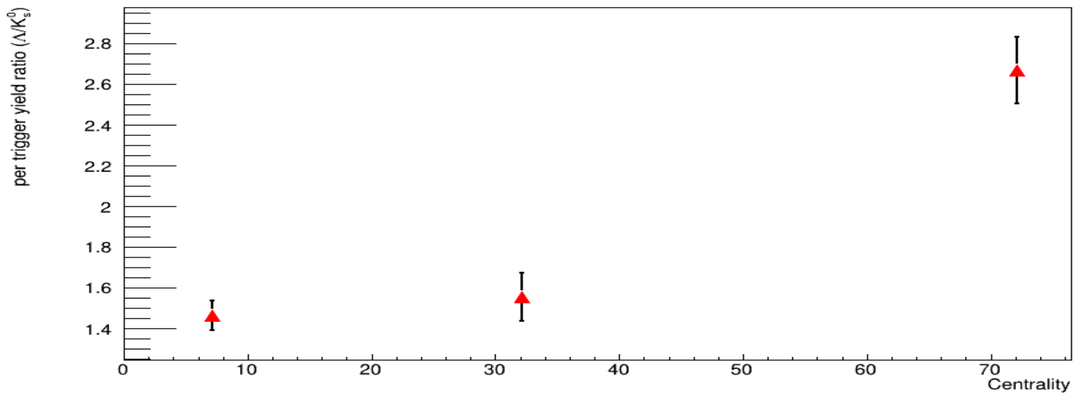
Background Right

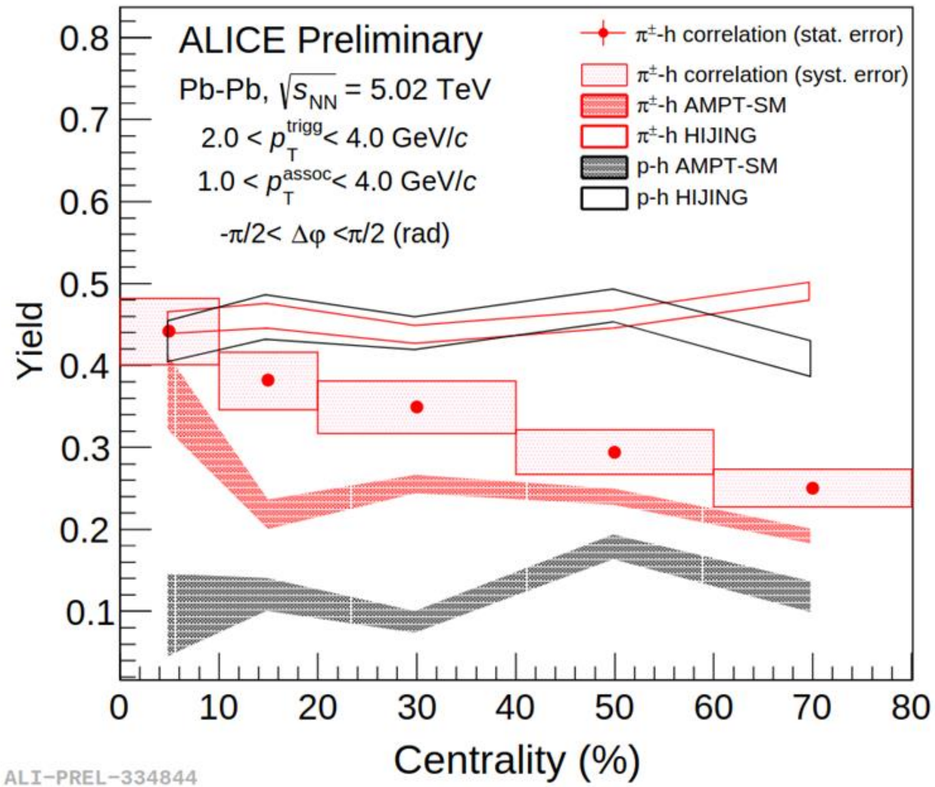
SAME EVENT

MIXED EVENT

SAME/MIXED







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.

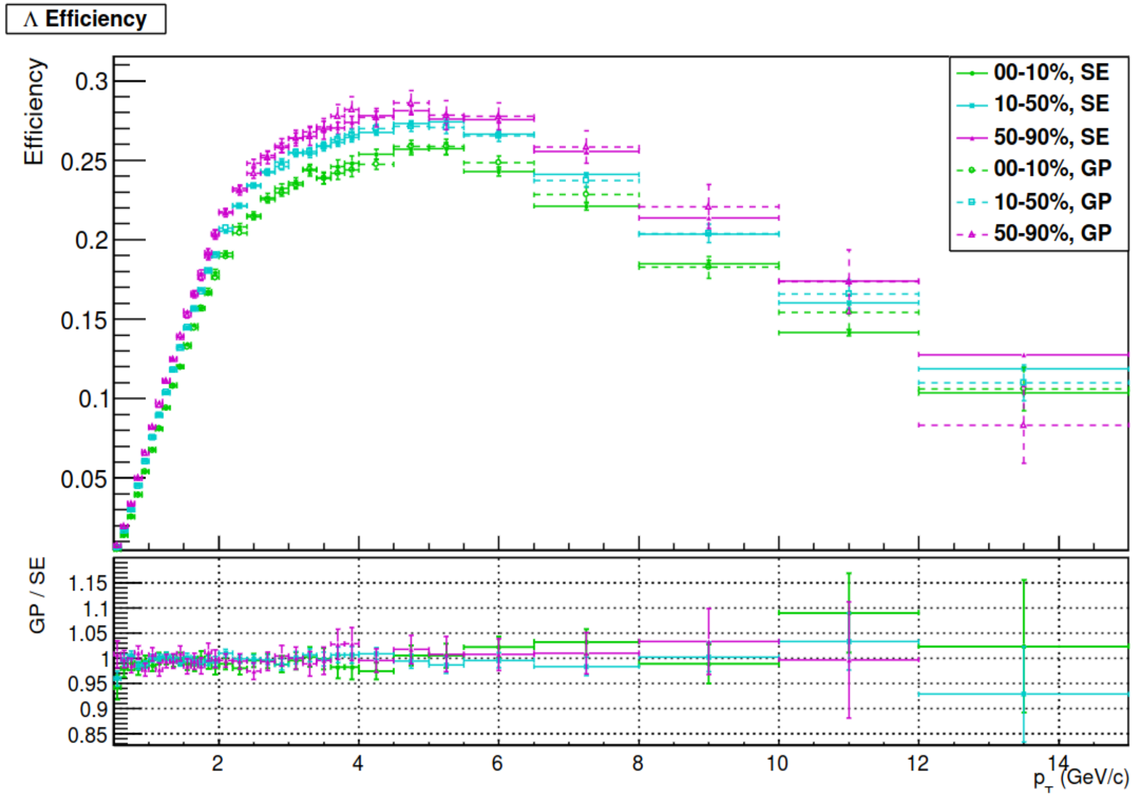


Fig. 13: Λ reconstruction efficiency as a function of p_{T} in the rapidity range $|y| < 0.5$ for SE (strangeness enriched) and GP (general purpose) Monte Carlo datasets.