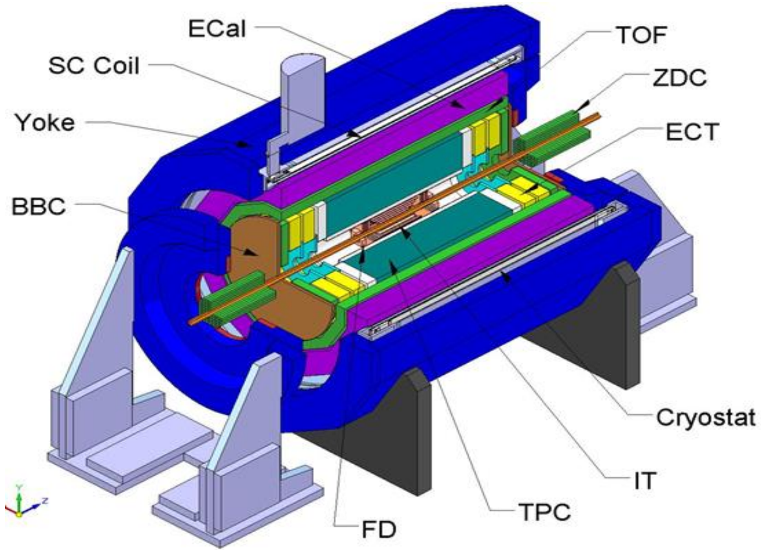
$\bar{\Lambda}$ reconstruction for the global polarization analysis

Raimbek Akhat

30.03.2021

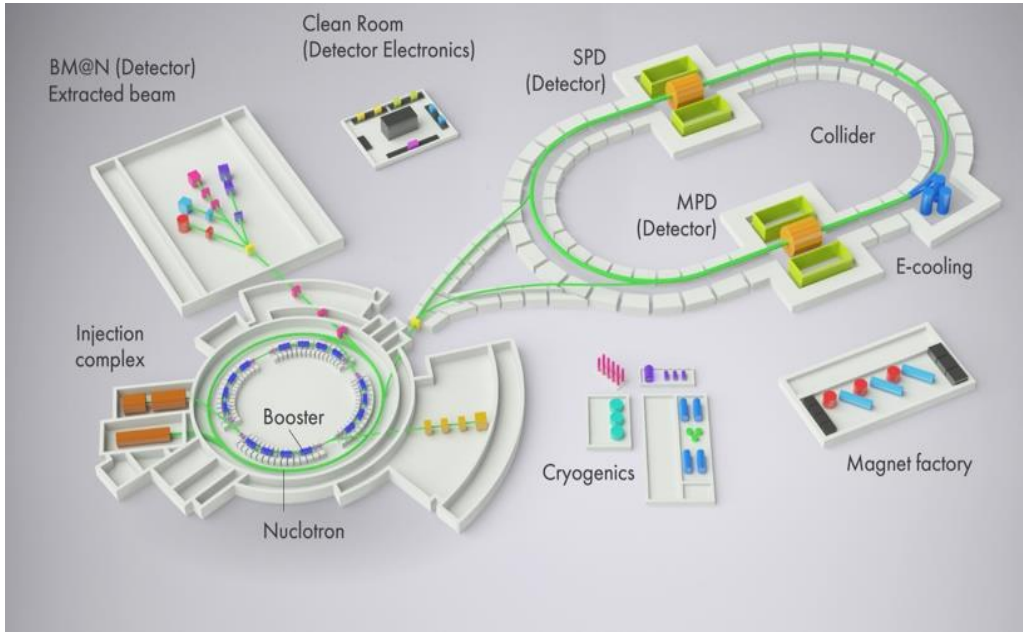
Motivation



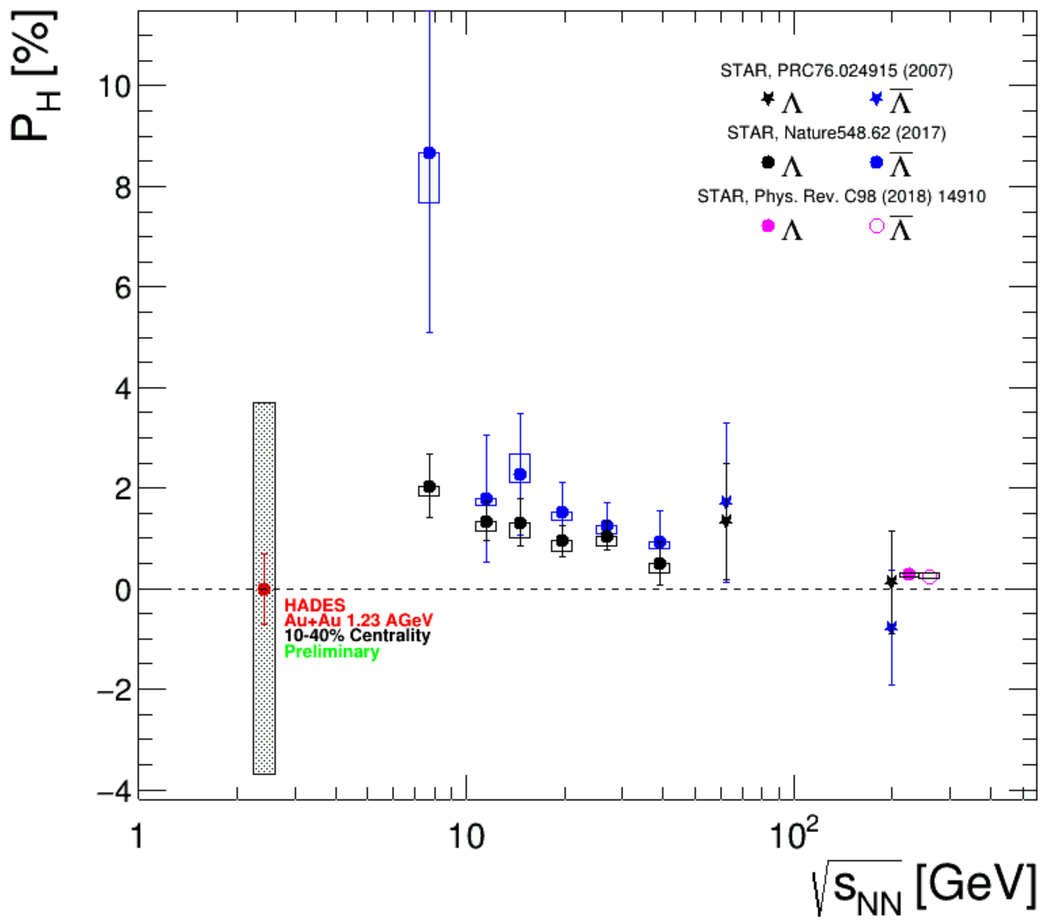
Hyperons can provide essential signatures of the hot and compressed baryonic matter

At NICA it is planned to study hyperons at MPD and BM@N setup.

In heavy ion collisions measurement of polarization strange hyperons allows to research properties of the QCD medium(vorticity, hydrodynamic helicity)



Motivation



Predicted[1] and observed[2] global polarization signals rise as the collision energy is reduced:

NICA energy range will provide new insight

Possible drop-off seen at in HADES[3] experiment reduced:

1. O. Rogachevsky, A. Sorin, O. Teryaev, Phys.Rev. C 82, 054910 (2010

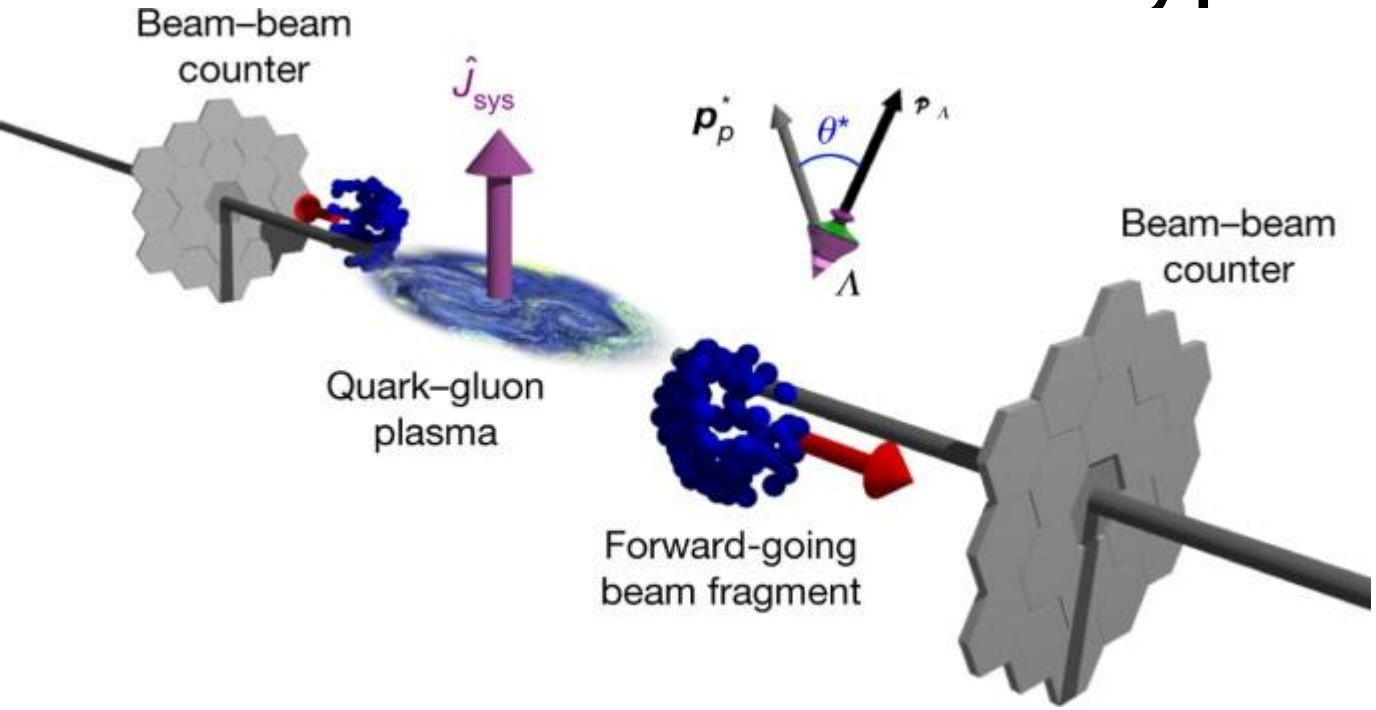
2. J. Adam et al. (STAR Collaboration), Phys. Rev. C 98, 014910 (2018)

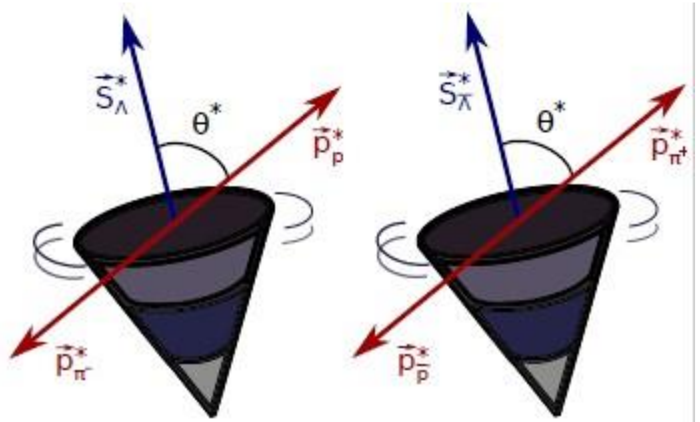
3. F. Kornas for the HADES Collaboration, SQM 2019, Bari, Italy (11.06.19)

Data

- 1 400 000 events for 0-5 %, 5-10%, 10-40%, 40-100% centrality
- PHSD for generation
- Au Au collision at 7.7 GeV

$\bar{\Lambda} - \Lambda$ hyperon polarization





Polarization can be measured through weak decay:

$$\Lambda \to p + \pi^-$$
$$\bar{\Lambda} \to \bar{p} + \pi^+$$

Angular distribution:

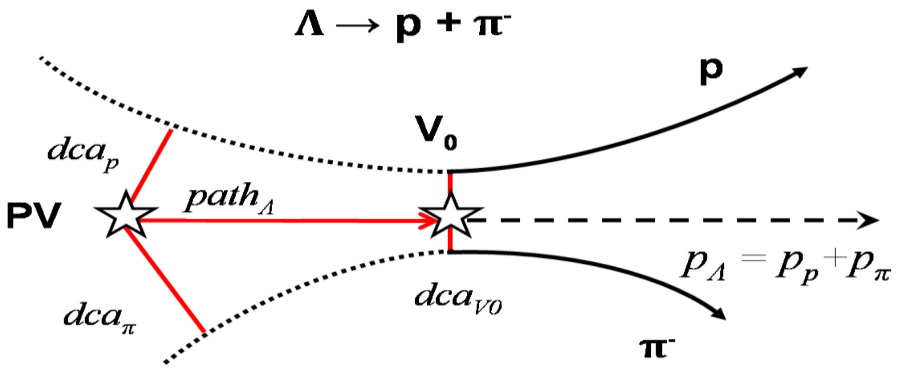
$$\frac{dN}{d\cos\theta} = 1 + \alpha_\Lambda P_\Lambda \cos\theta^*$$

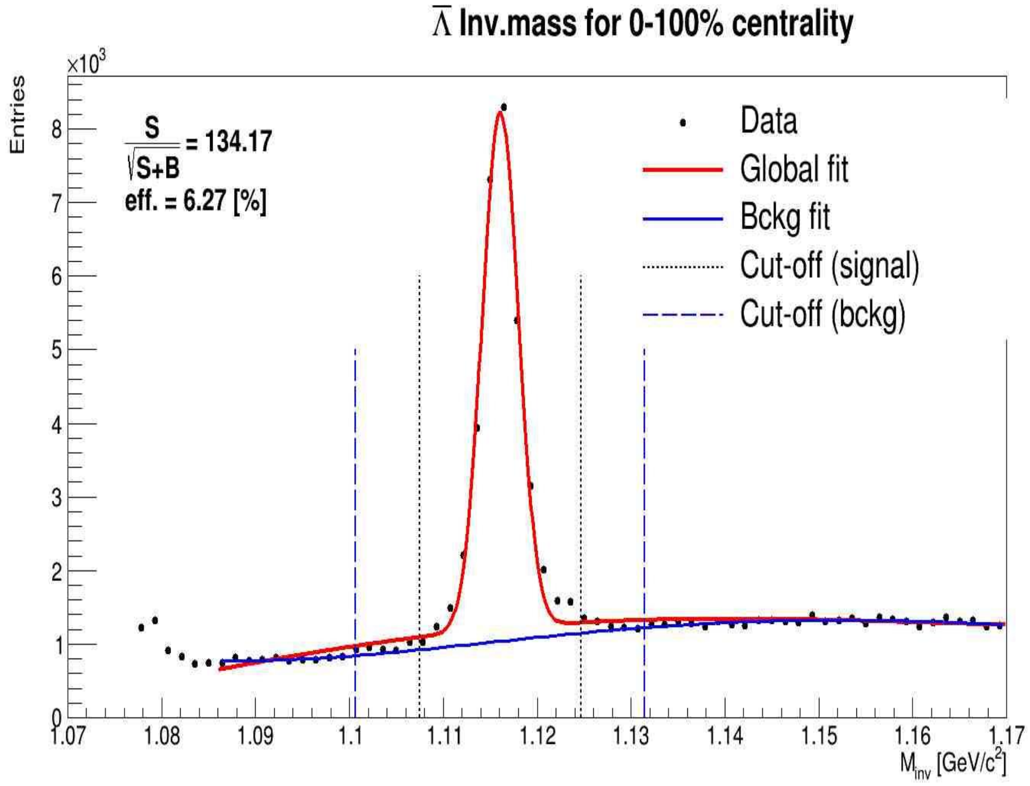
$\alpha_\Lambda = -\alpha_{\bar{\Lambda}} = 0.642$ decay parameter

Polarization can be measured: :

$$P_\Lambda = \frac{8}{\pi\alpha_\Lambda}\frac{1}{R_{EP}}\langle\sin(\Psi_{EP} - \theta^*)\rangle$$

$\bar{\Lambda} - \Lambda$ hyperon polarization analysis technique





PV – primary vertex
V_0 – vertex of hyperon decay
dca – distance of the closest approach
path – decay length

parameters for selection: $\varpi_1 = ln \dfrac{dca_\pi dca_p}{dca_\Lambda^2 + dca_{V_0}^2}$

All the parameters can also be normalized to their respective errors giving a set of χ^2

$$\varpi_2 = ln \frac{\sqrt{\chi_\pi^2 \chi_p^2}}{\chi_\Lambda^2 + \chi_{V_0}^2}$$

takes into account correlations of standard selection criteria taken in χ^2

Fitting function:
- **Gauss for signal**
- **Legendre polynoms (L_n) for**
- **background**
- **Cut-off <M_Λ>±4σ**
- **DCA and track-separation cuts**

$$f(x) = [0]\exp\left(\frac{(-0.5(x-[1]))^2}{[2]^2}\right) + [3](L_0 + [4]L_1 + [5]L_2$$

Selection cuts for inv.mass Λ, $\bar{\Lambda}$

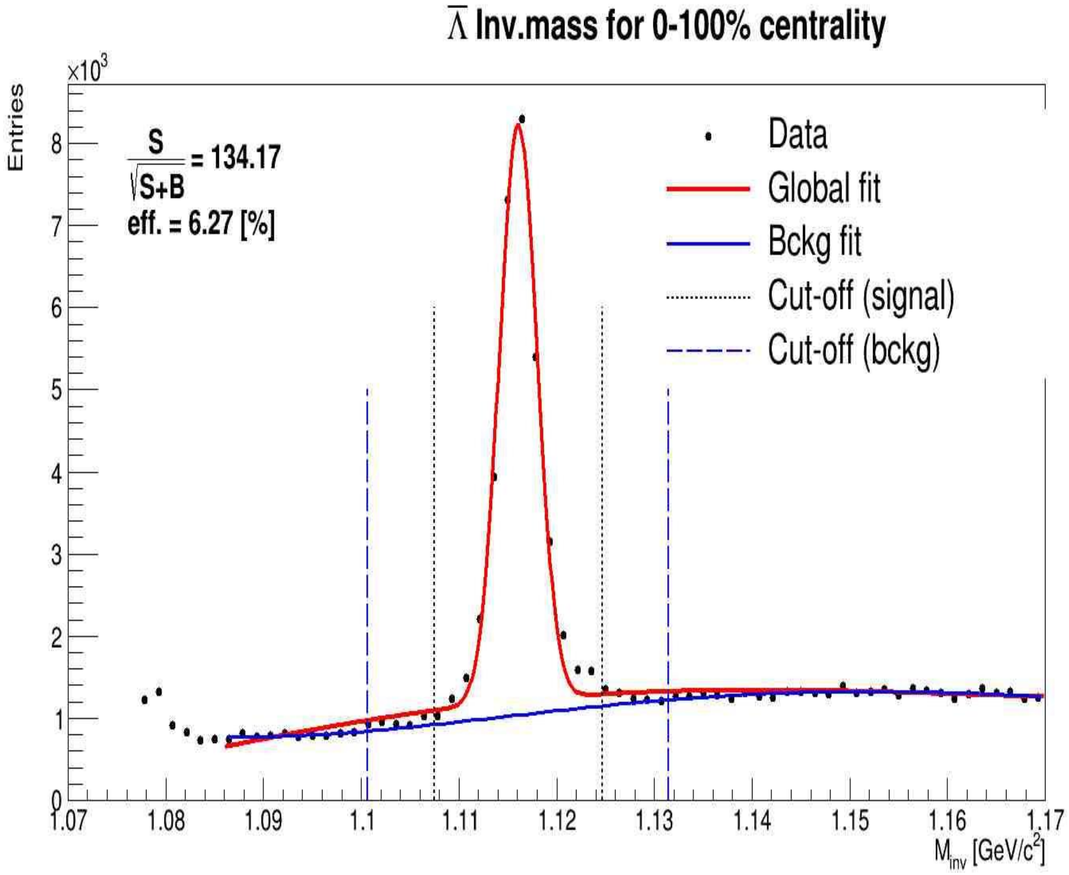
$\bar{\Lambda}$ hyperon

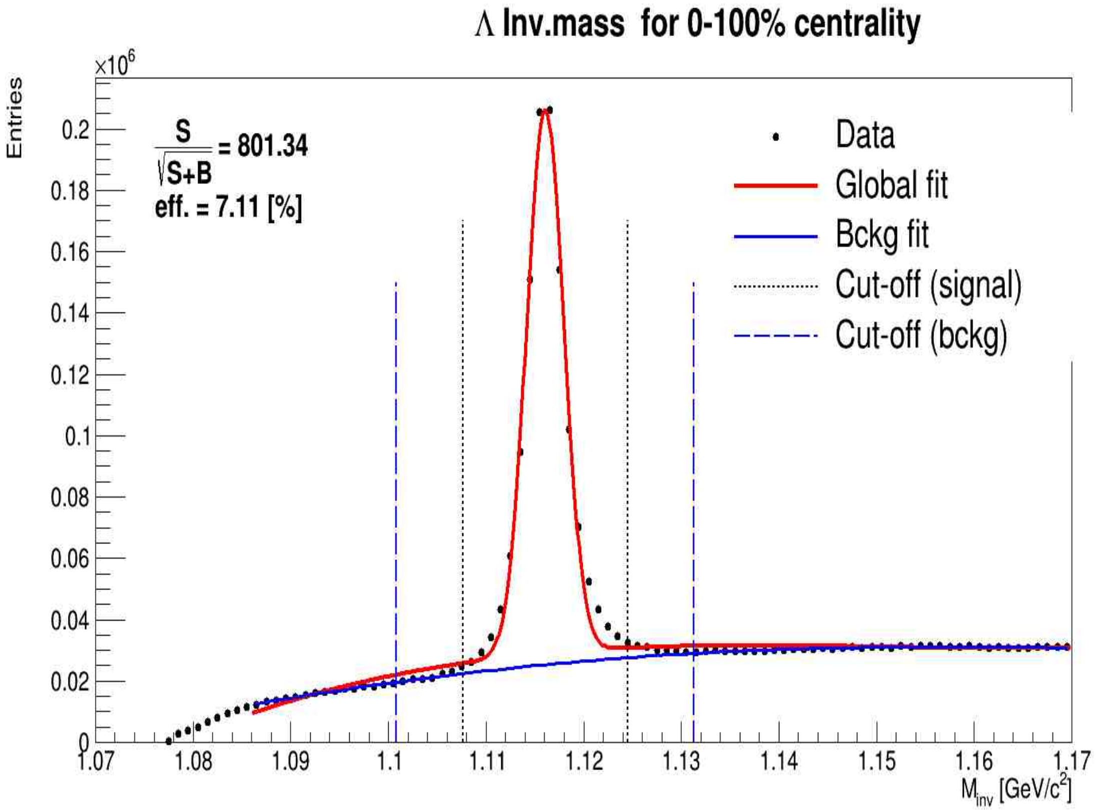
Centrality	Selection cut ϖ_2 at max.sign
0-5%	1.8
5-10%	1.6
10-40%	1.4
40-100%	0.8
0-100%	1.4

Λ hyperons

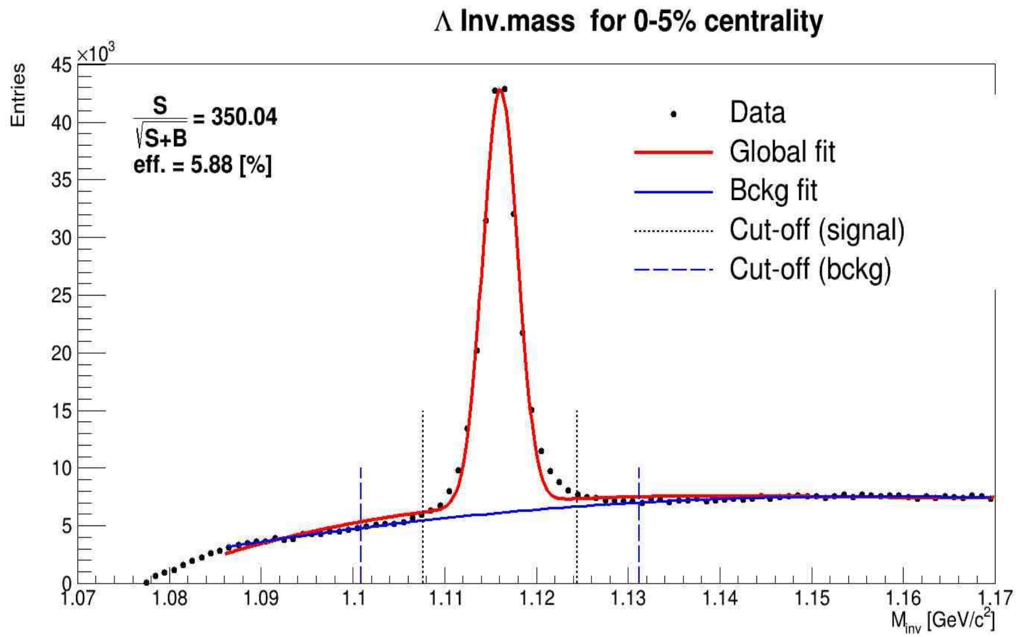
Centrality	Selection cut ϖ_2 at max.sign
0-5%	2.4
5-10%	2.2
10-40%	1.8
40-100%	1.2
0-100%	2.0

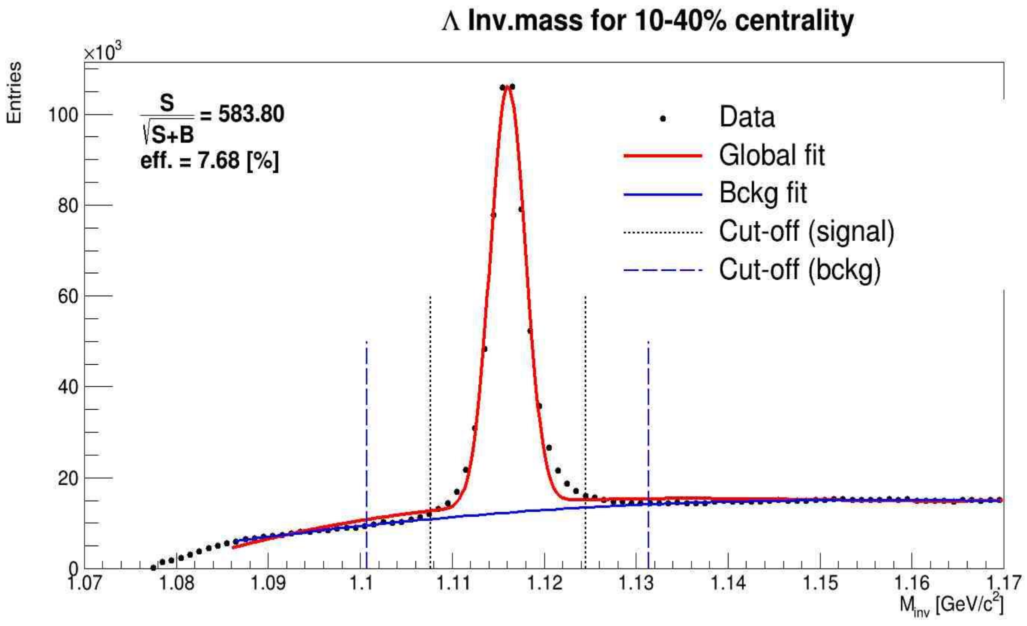
Invariant masses Λ, $\bar{\Lambda}$

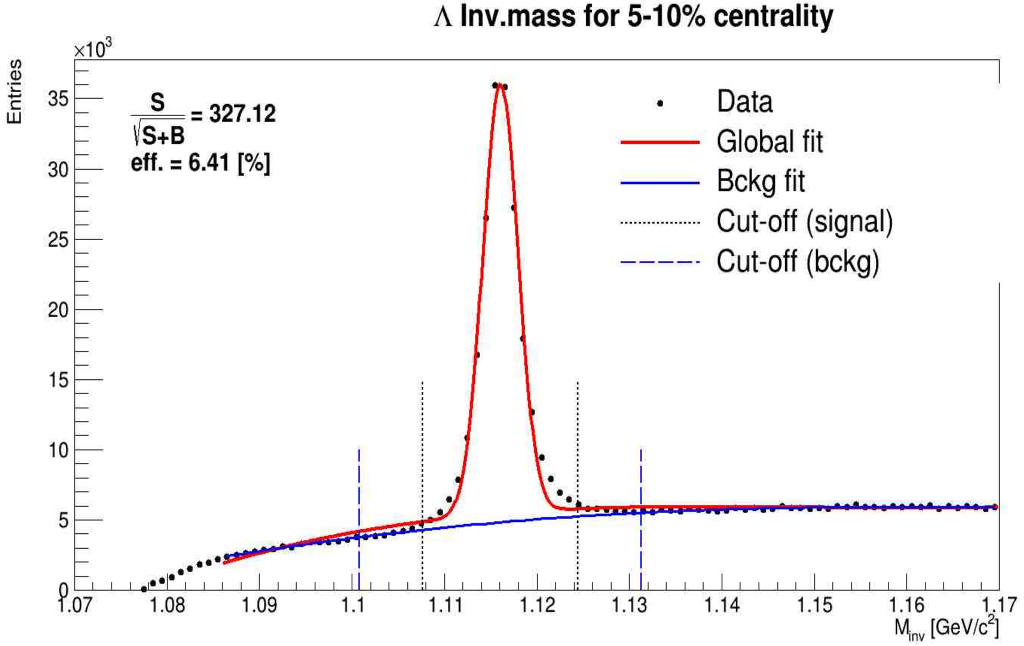


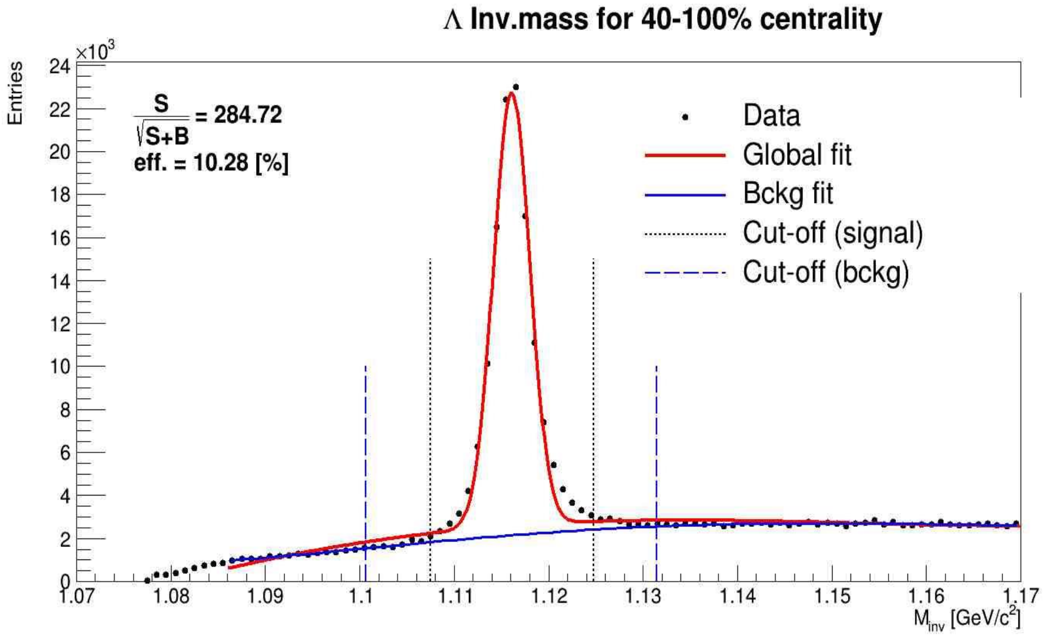


Invariant mass Λ for different centralities

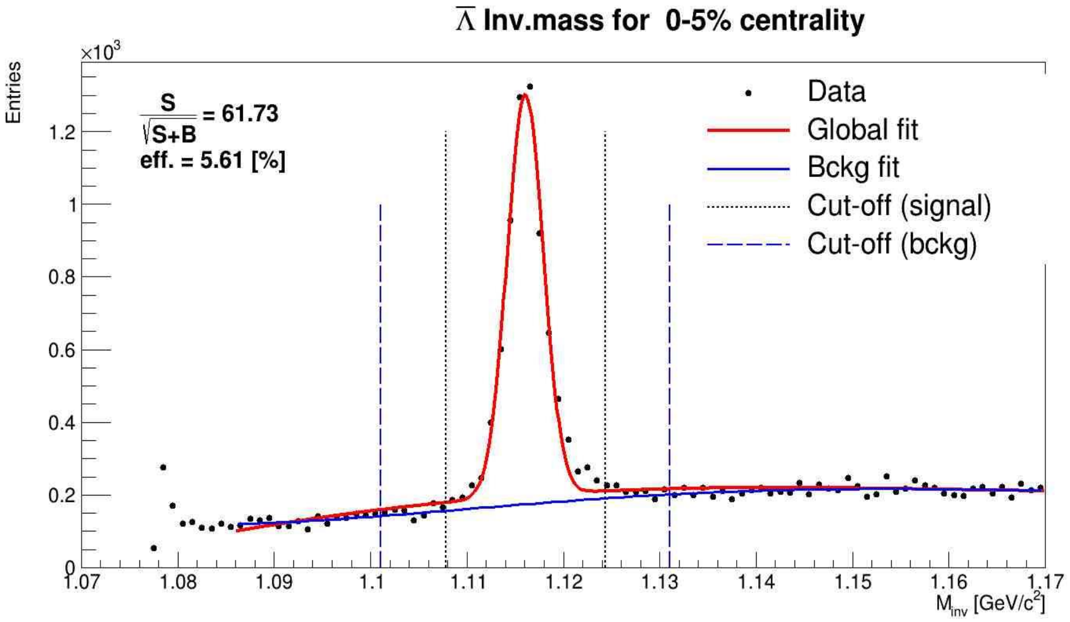


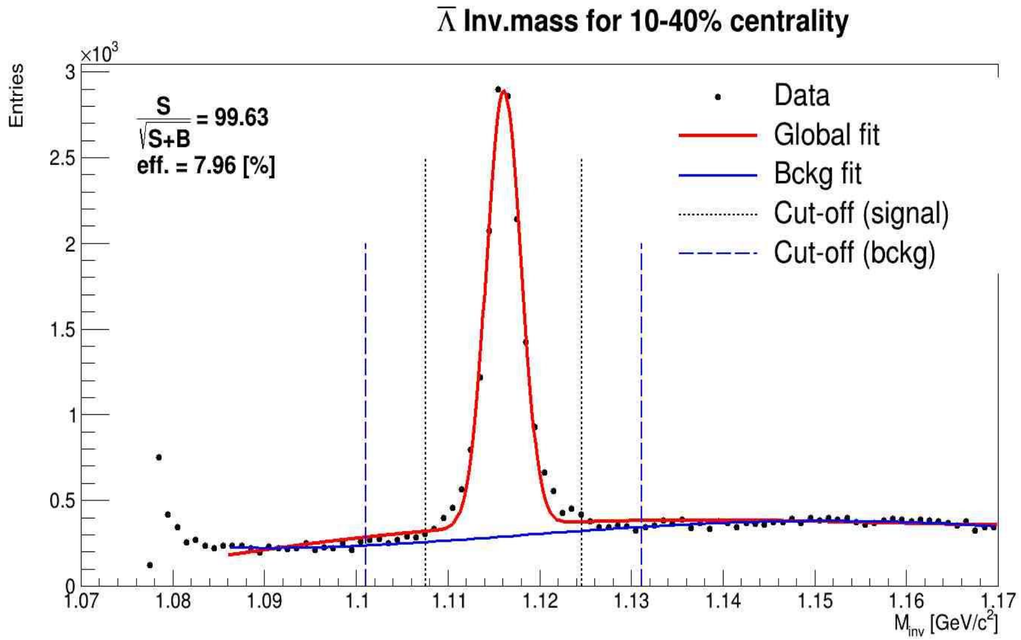


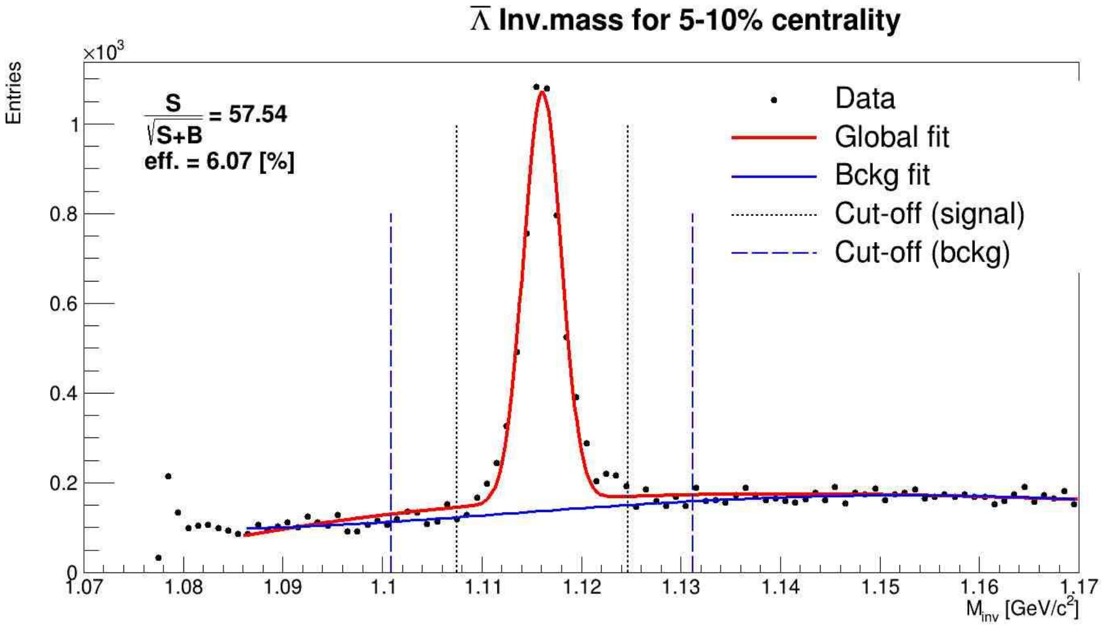


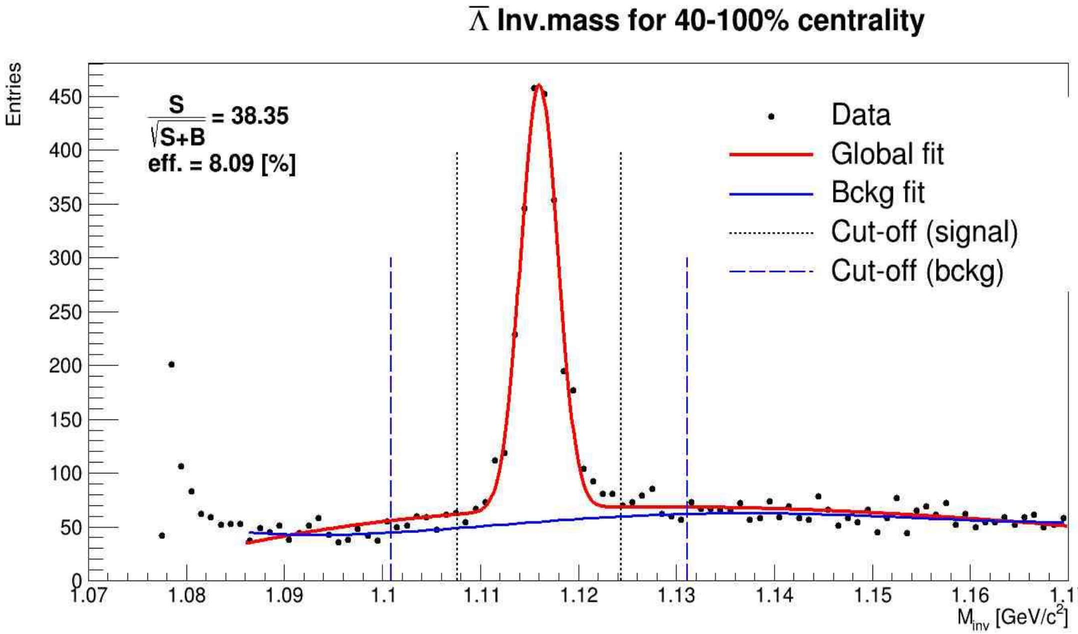


Invariant mass $\overline{\Lambda}$ for different centralities

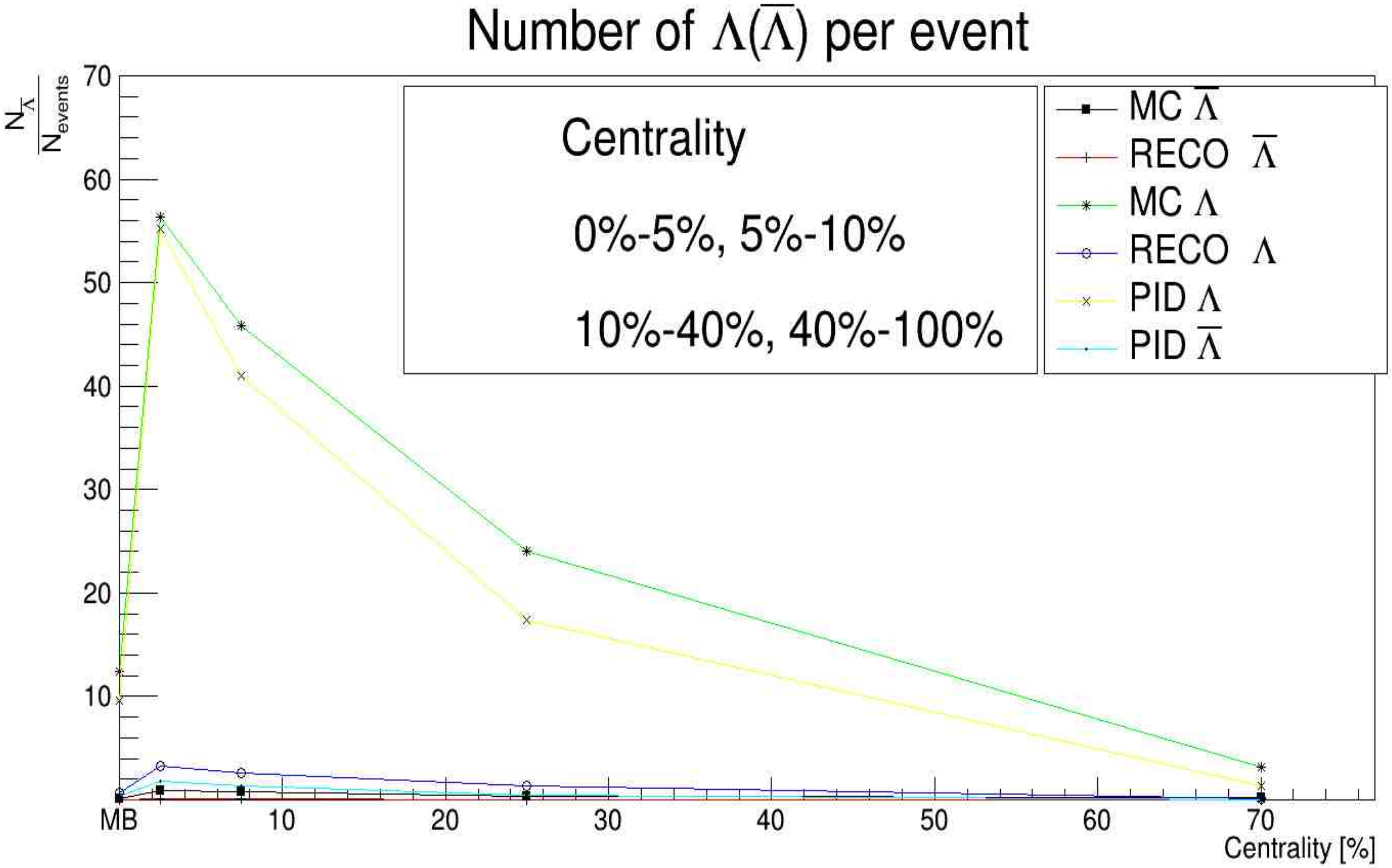




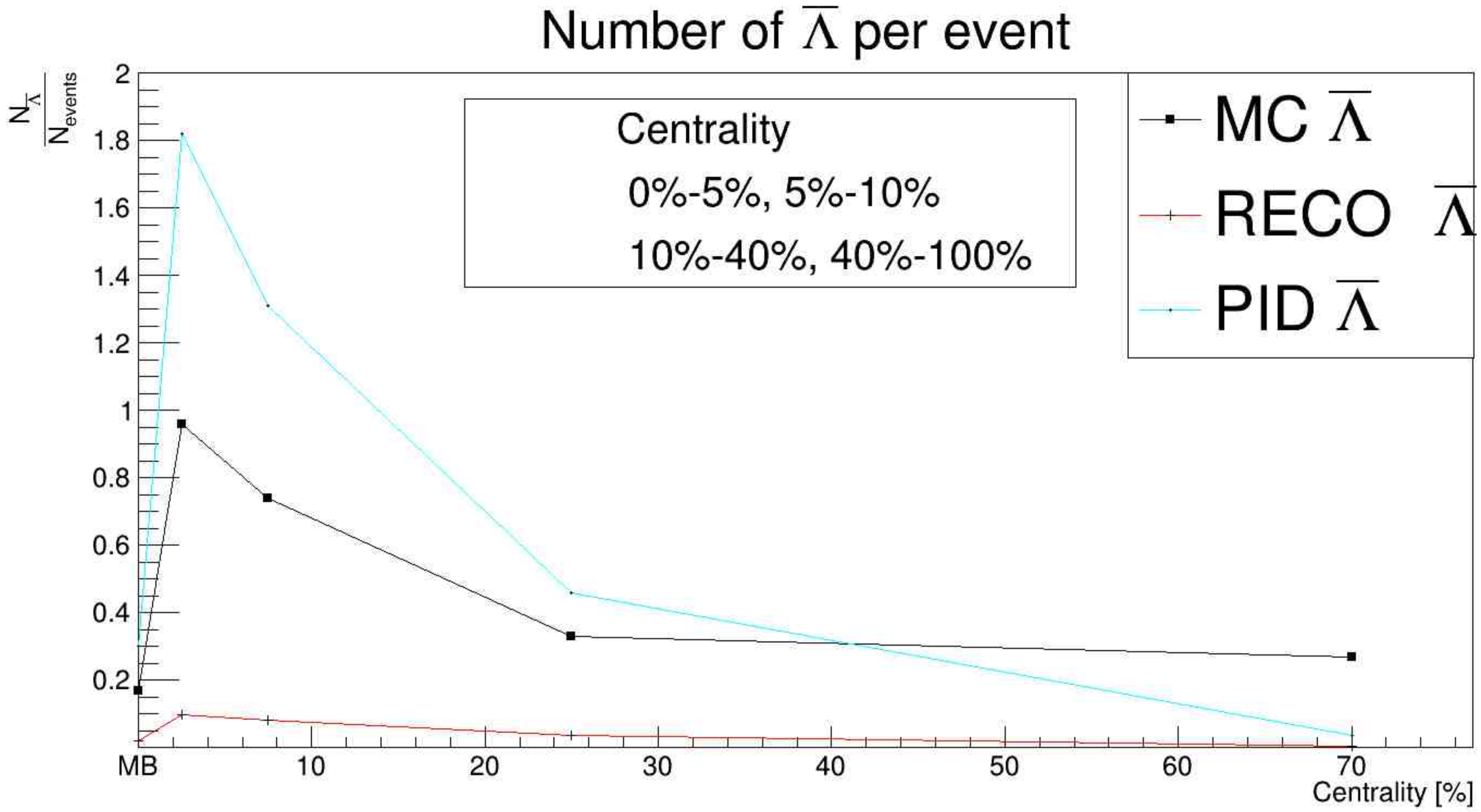




Number of $\overline{\Lambda} - \Lambda$ per event for different centralities



Number of $\overline{\Lambda}$ per event for different centralities



$\bar{\Lambda} - \Lambda$ hyperons yield

MC Λ hyperons

Centrality	Number
0-5%	3 338 380
5-10%	2 851 102
10-40%	8 845 462
40-100%	2 306 016
0-100%	17 372 000

PID Λ hyperons

Centrality	Number	Number with selection cut ω_2
0-5%	62 107 649	3 273 203
5-10%	79 497 683	2 550 396
10-40%	43 758 171	6 421 057
40-100%	64 718 671	1 065 843

Reconstructed Λ hyperons

Centrality	Number
0-5%	191 649
5-10%	162 863
10-40%	491 715
40-100%	109 312

MC $\bar{\Lambda}$ hyperons

Centrality	Number
0-5%	57 334
5-10%	46 308
10-40%	123 330
40-100%	19 935

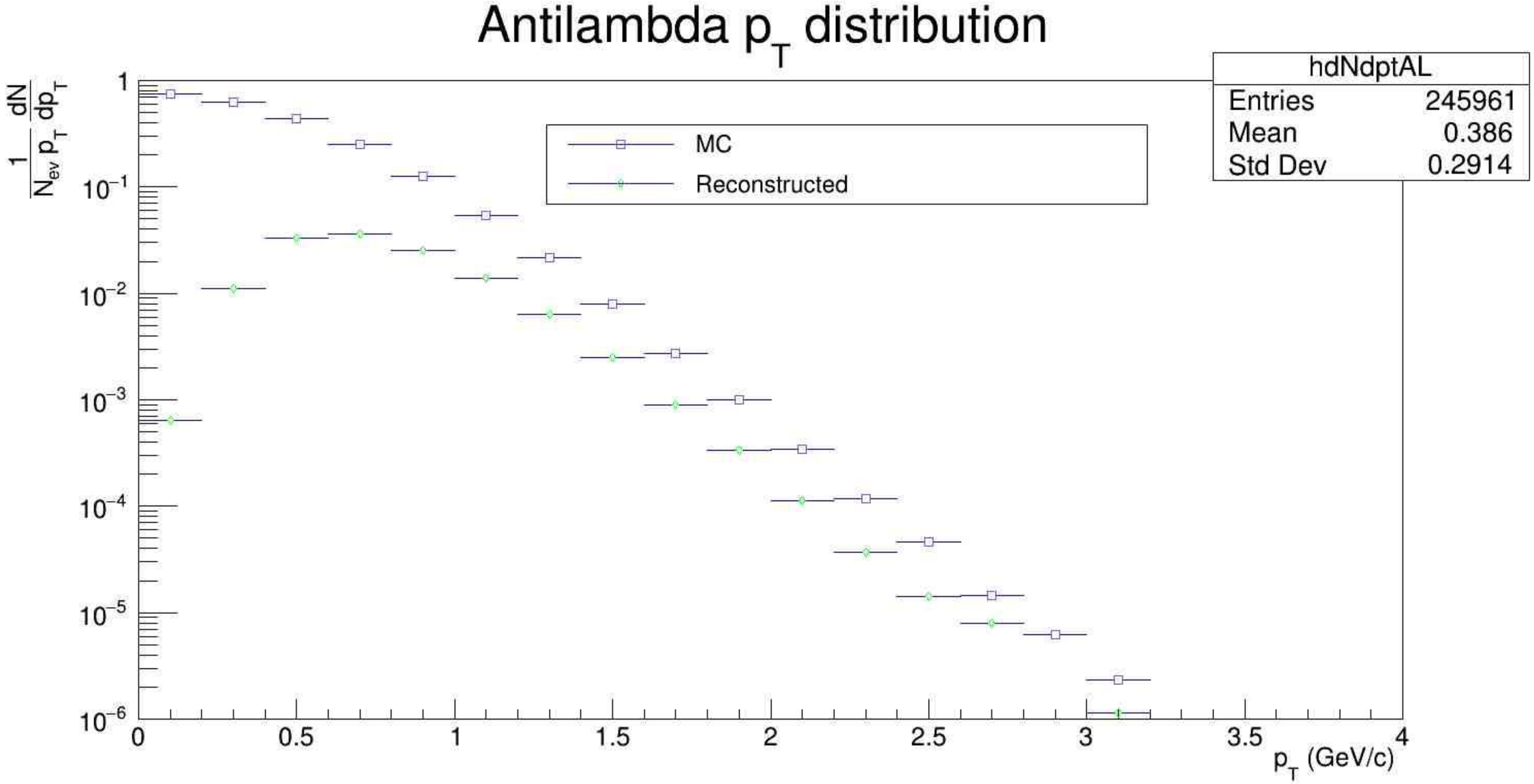
PID $\bar{\Lambda}$ hyperons

Centrality	Number	Number with selection cut ω_2
0-5%	1 367 159	108 132
5-10%	8 823 384	81 623
10-40%	1 454 977	172 069
40-100%	87 294	26 507

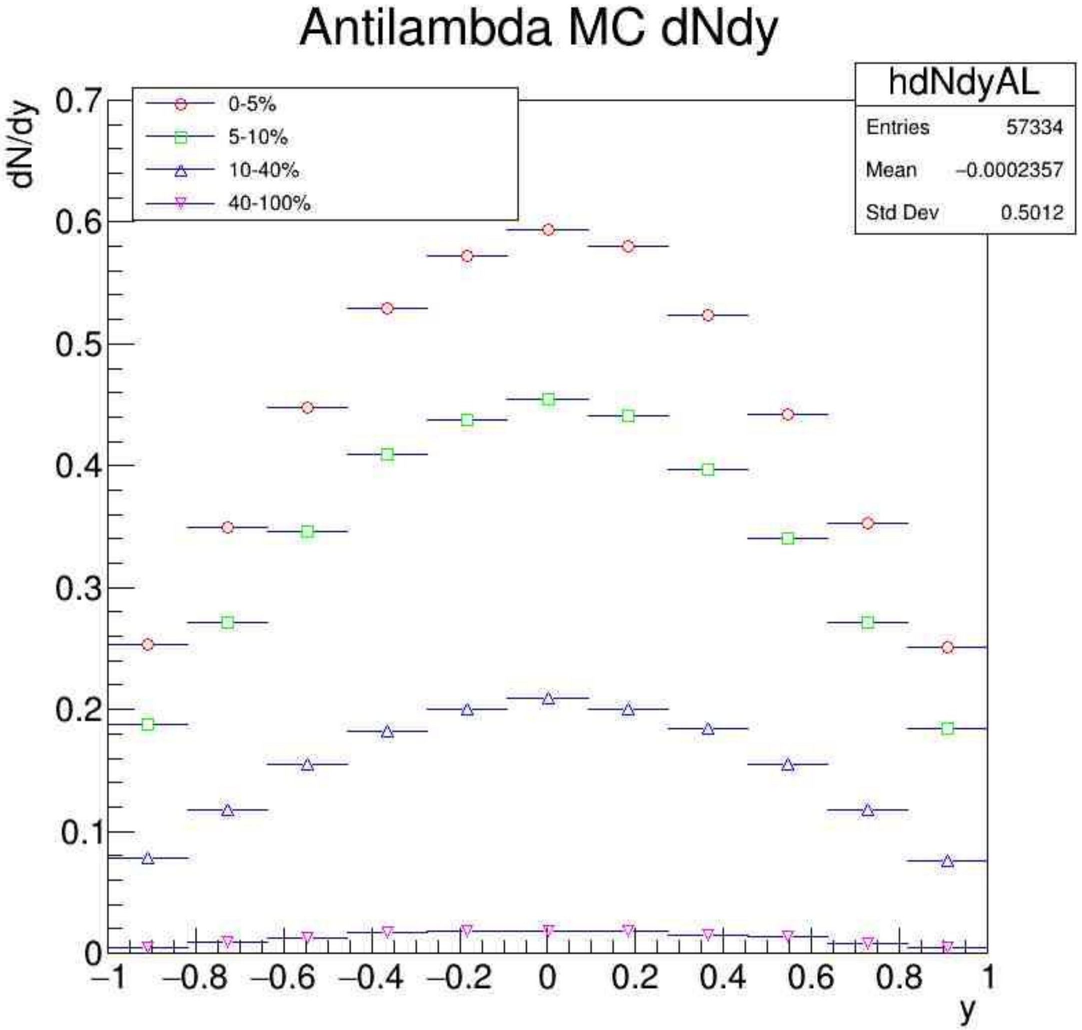
Reconstructed $\bar{\Lambda}$ hyperons

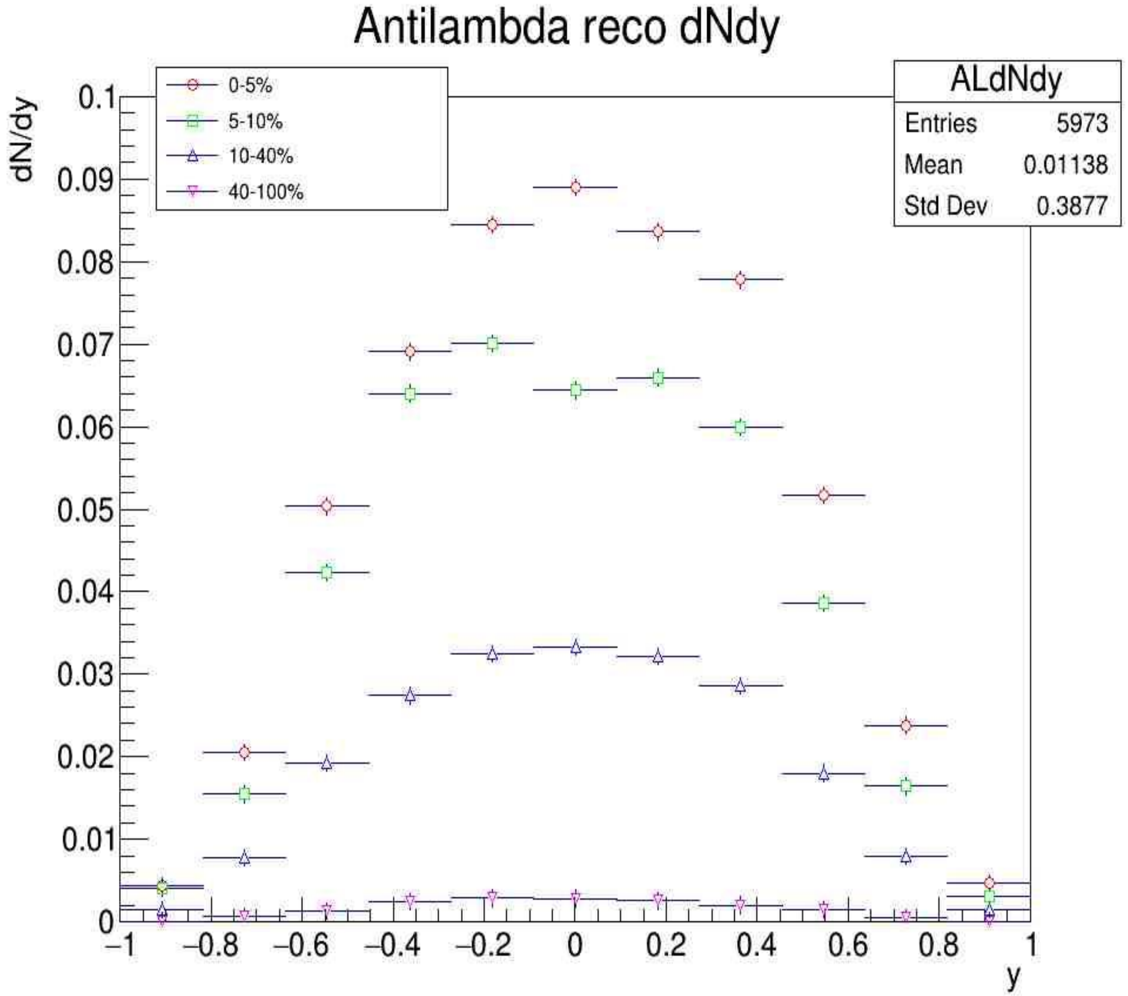
Centrality	Number
0-5%	5861
5-10%	5000
10-40%	13698
40-100%	2132

$\bar{\Lambda}$ hyperon yield vs p_T



$\bar{\Lambda}$ hyperon yield vs rapidity





Factors affecting $\overline{\Lambda}$ reconstruction efficiency.

0-5 % centrality

Factor	Efficiency, %
Branching ratio: $\overline{\Lambda} \rightarrow \bar{p} + \pi^+$	61.9
$\bar{p}$ and π^+at $\|\eta\|$<1.3	35.6
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.05 GeV/c	33.2
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.1 GeV/c	24.4
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.2 GeV/c	7.3
Reconstructed $\bar{p}$ and π^+at $\|\eta\|$<1.3	22.7
Maximum significance	10.4

10-40 % centrality

Factor	Efficiency, %
Branching ratio: $\overline{\Lambda} \rightarrow \bar{p} + \pi^+$	62
$\bar{p}$ and π^+at $\|\eta\|$<1.3	35.8
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.05 GeV/c	33.3
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.1 GeV/c	24.4
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.2 GeV/c	7.1
Reconstructed $\bar{p}$ and π^+at $\|\eta\|$<1.3	23.1
Maximum significance	11.4

5-10 % centrality

Factor	Efficiency, %
Branching ratio: $\overline{\Lambda} \rightarrow \bar{p} + \pi^+$	62
$\bar{p}$ and π^+at $\|\eta\|$<1.3	35.7
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.05 GeV/c	33.2
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.1 GeV/c	24.7
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.2 GeV/c	7.3
Reconstructed $\bar{p}$ and π^+at $\|\eta\|$<1.3	22.9
Maximum significance	11

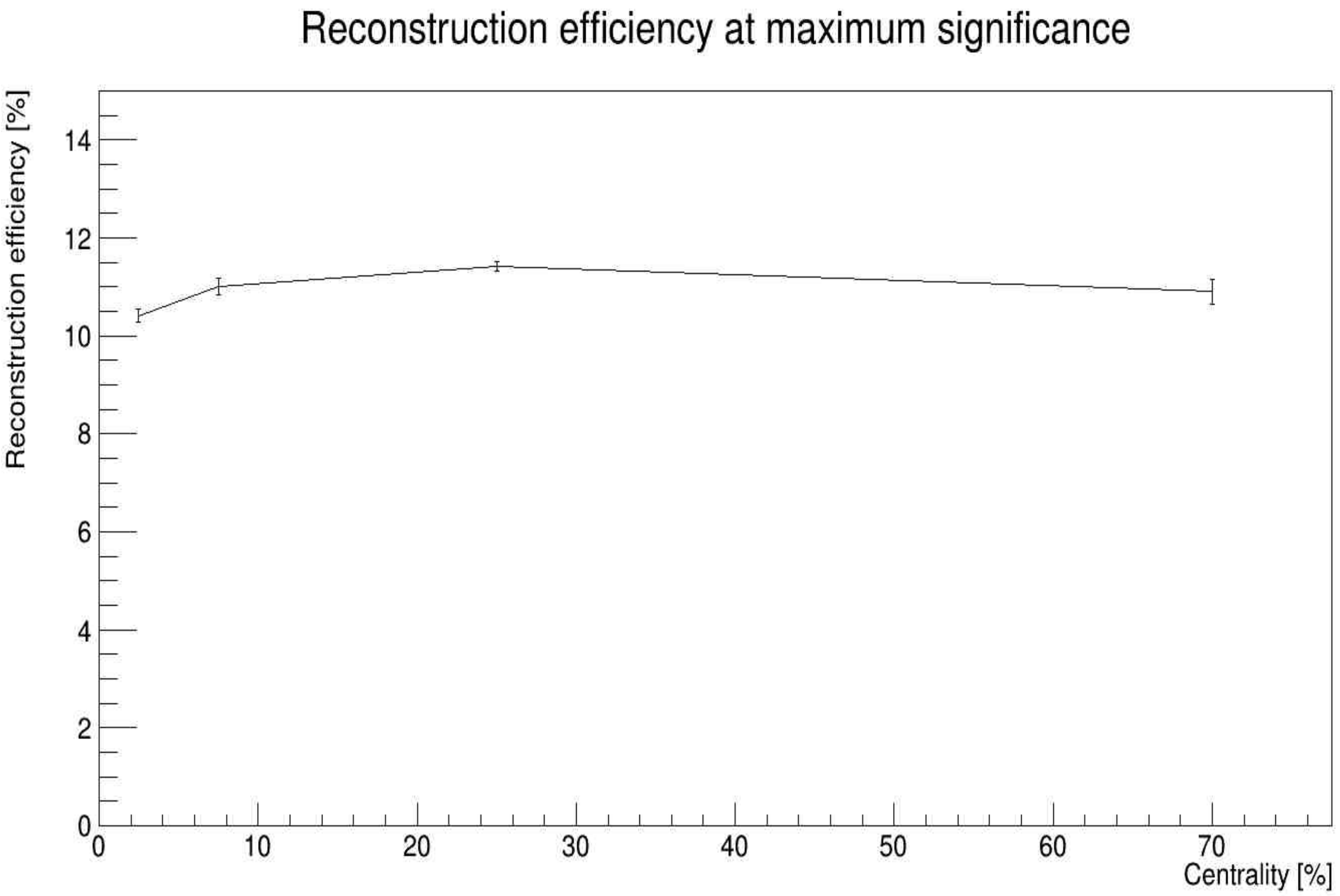
40-100 % centrality

Factor	Efficiency, %
Branching ratio: $\overline{\Lambda} \rightarrow \bar{p} + \pi^+$	62.2
$\bar{p}$ and π^+at $\|\eta\|$<1.3	36.3
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.05 GeV/c	33.6
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.1 GeV/c	23.3
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.2 GeV/c	5.8
Reconstructed $\bar{p}$ and π^+at $\|\eta\|$<1.3	22.2
Maximum significance	10.9

Factors affecting $\overline{\Lambda}$ reconstruction efficiency.

AuAu 0-100 % centrality

Factor	Efficiency, %
Branching ratio: $\overline{\Lambda} \rightarrow \bar{p} + \pi^+$	62
$\bar{p}$ and π^+at $\|\eta\|$<1.3	35.8
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.05 GeV/c	33.3
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.1 GeV/c	24.3
$\bar{p}$ and π^+at $\|\eta\|$<1.3 and p_T>0.2 GeV/c	7
Reconstructed $\bar{p}$ and π^+at $\|\eta\|$<1.3	22.9
Maximum significance	11.2


Reconstruction efficiency at maximum significance
Reconstruction efficiency [%]
14
12
10
8
6
4
2
0
0
10
20
30
40
50
60
70
Centrality [%]

Conclusion

- Comparison of the number of hyperons produced MC, PID, and reconstructed
- We show the preliminary invariant mass distribution for reconstructed hyperons for different sets of centrality.
- We got Factors affecting $\overline{\Lambda}$ reconstruction efficiency

Thank you for attention your attention