Feasibility Study for the Λ_c Reconstruction

Dariusch Deermann, PANDA Collaboration Meeting LIII, Uppsala, 8.6.2015

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

- Simulation Input
- Reconstruction of the Final State Particles
- Selection Criteria for the Λ Reconstruction
- Selection Criteria for the Λ_c Reconstruction
- Exclusive Reconstruction
- Background Considerations
- Estimated Beam Time Requirements

Simulation Input

- $\bar{\Lambda}_c \Lambda_c \rightarrow \bar{\Lambda} \pi^- \Lambda \pi^+ \rightarrow \bar{p} \pi^+ \pi^- p \pi^- \pi^+$

- BR=0.0107*0.639

- p_{beam}=10.2 GeV/c, $p_{threshold}$=10.16 GeV/c

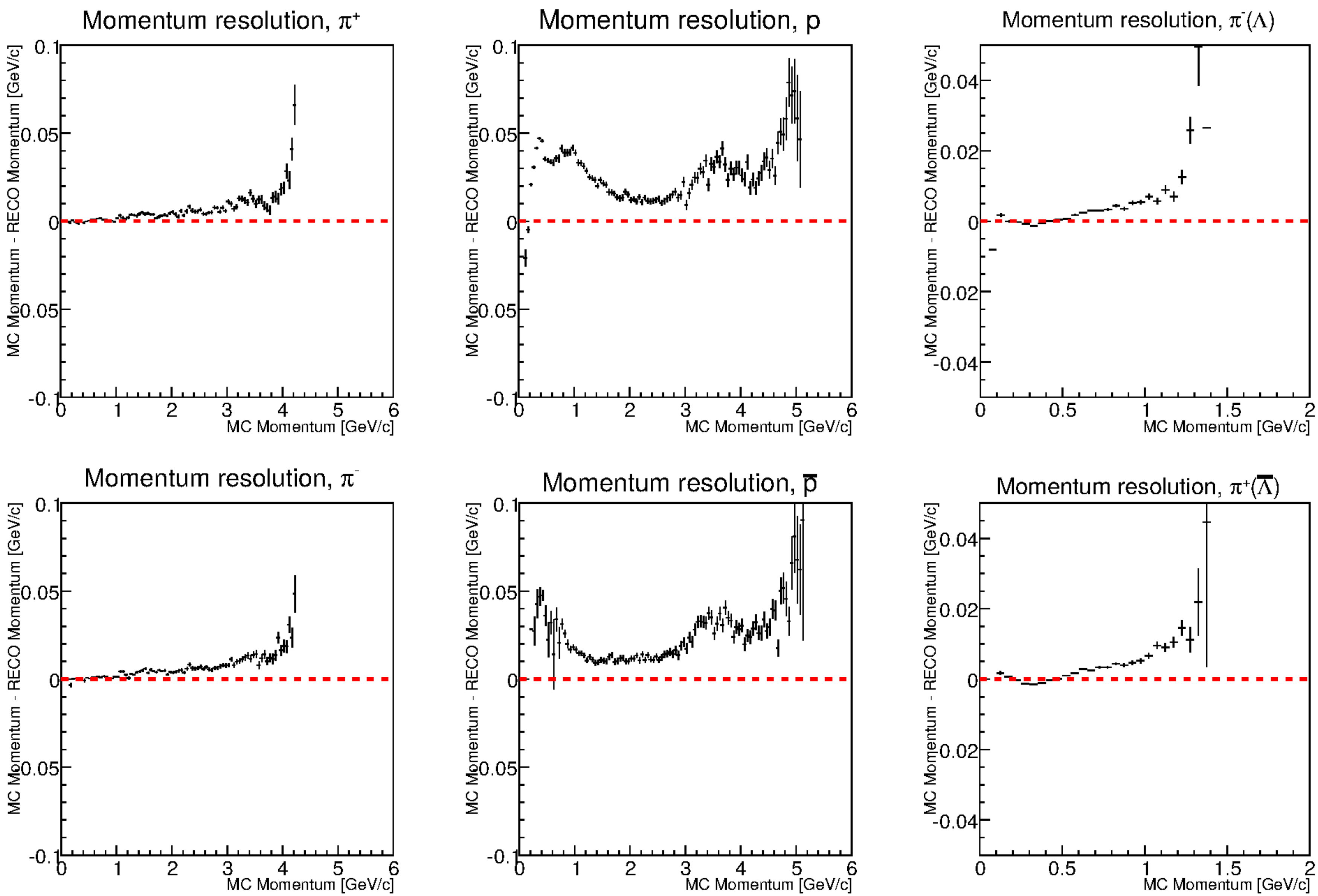
- Full detector setup

- Ideal pattern recognition and ideal PID

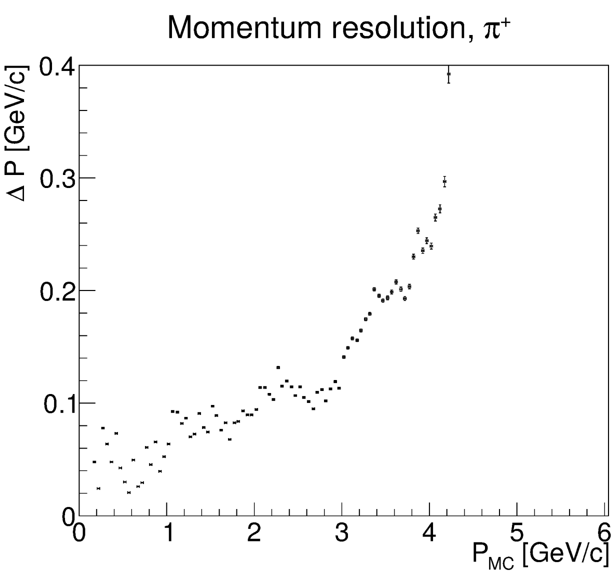
- Only tracks with >3 hits within the same subdetector were accepted

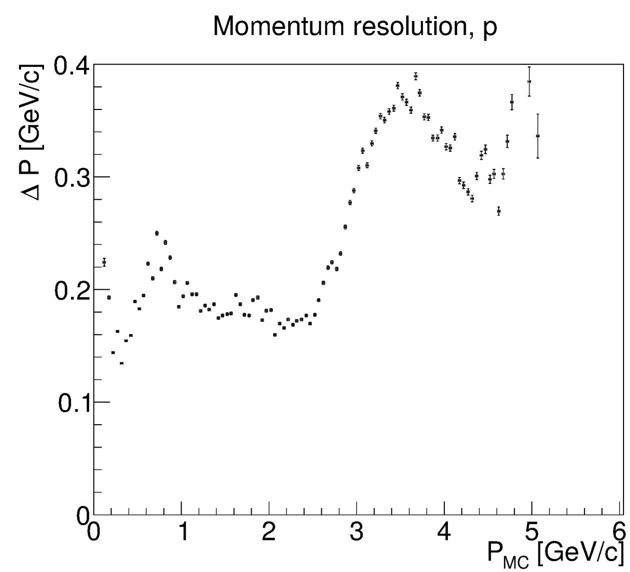
- 798000 signal events have been simulated (and 235M DPM events for the background study)

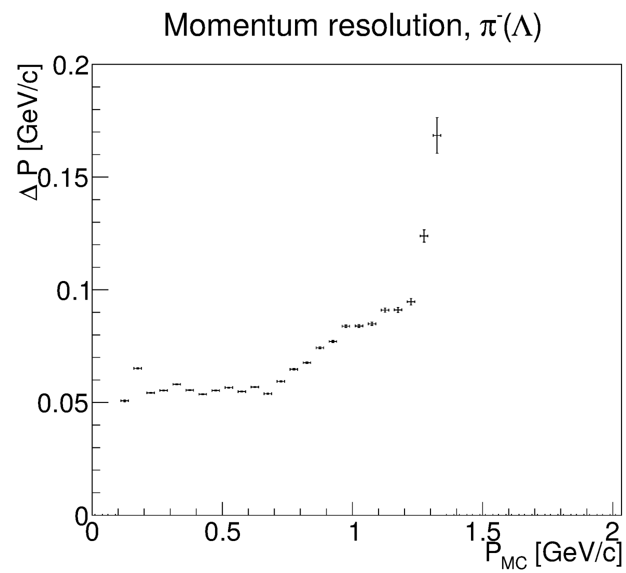
Systematic Offset in Momentum Reconstruction

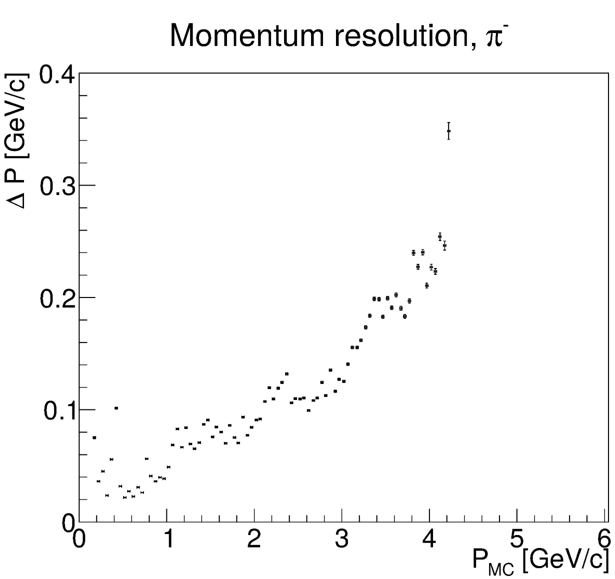


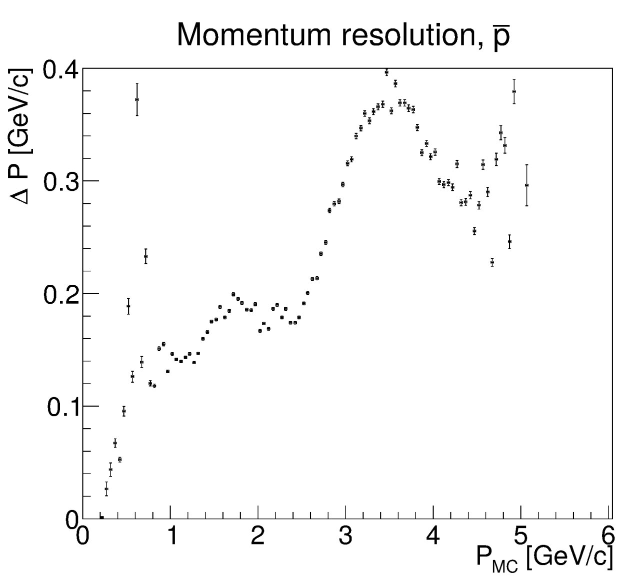
Momentum Resolution

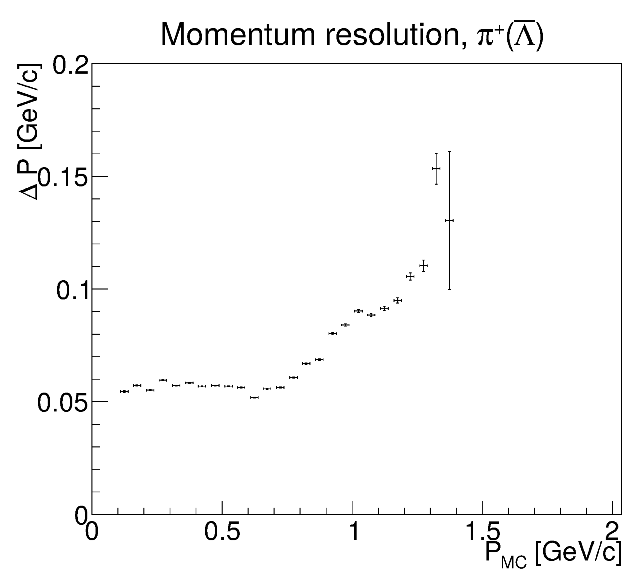












Reconstruction Efficiency

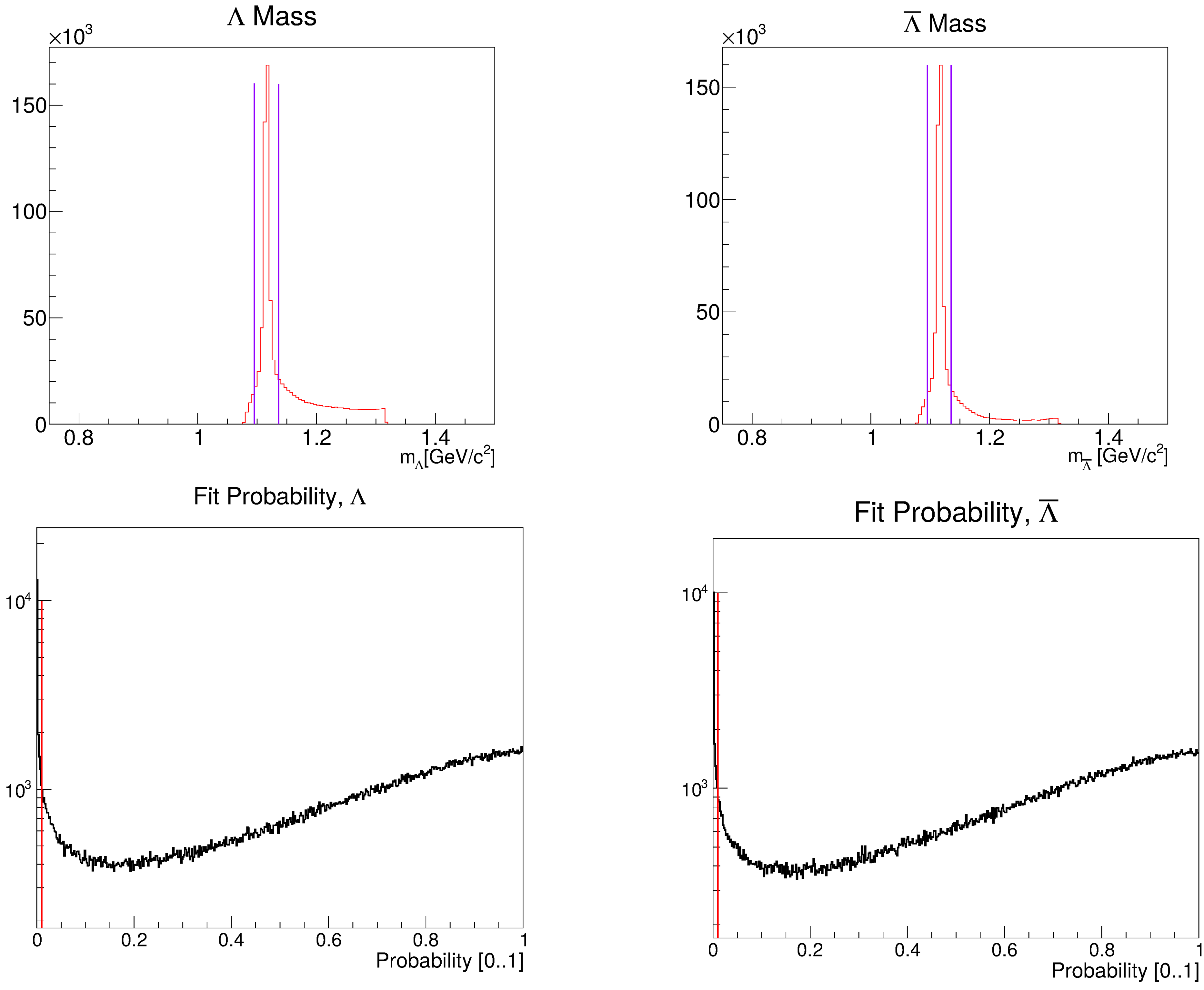
	ϵ
p	81.4 %
$\overline{p}$	79.9 %
$\pi^{+}(\Lambda_c)$	82.2 %
$\pi^{-}(\overline{\Lambda}_c)$	83.3 %
$\pi^{+}(\overline{\Lambda})$	75.4 %
$\pi^{-}(\Lambda)$	75.1 %

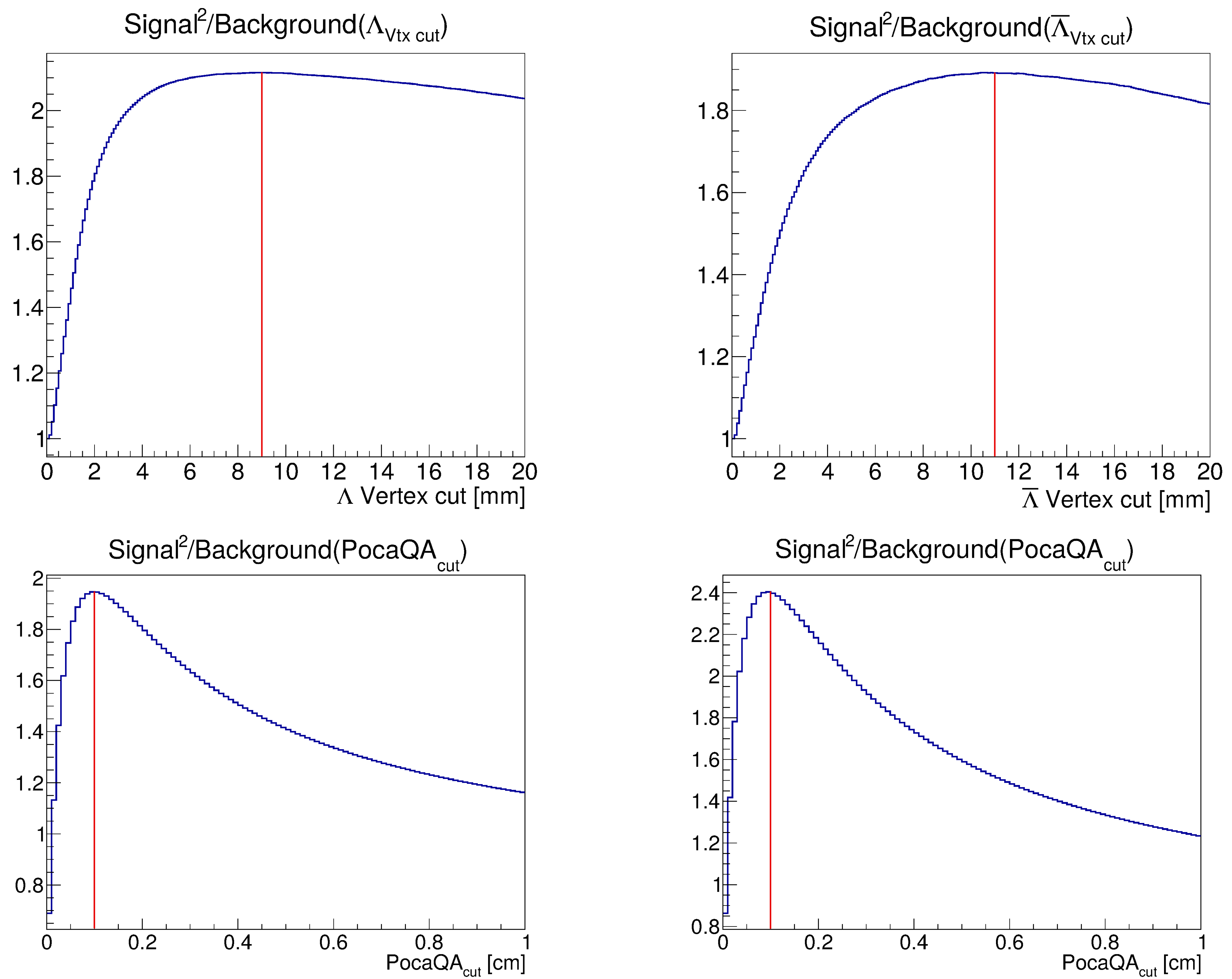
Λ efficiency: 62.3%

$\overline{\Lambda}$ efficiency: 61.4%

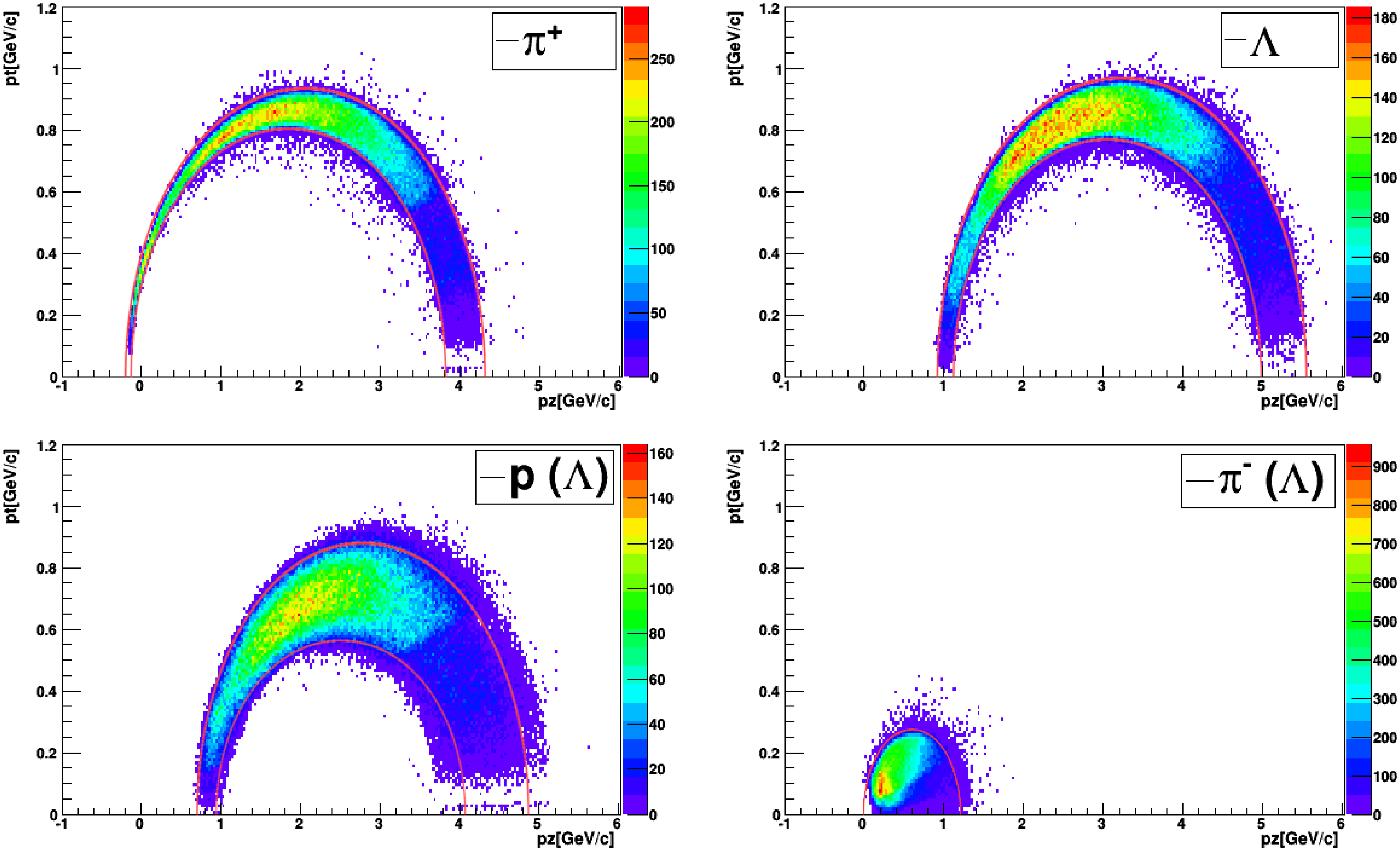
Λ Reconstruction

- π^- and p are combined to Λ (and charge conjugated)
- A kinematic fit with a mass constraint was applied on the candidates
- Vertex reconstruction has been performed via the Point of Closest Approach (POCA)
- The following cuts have been applied:
  - Cut on the unfitted mass
  - Cut on the fit probability (P>0.01)
  - Cut on the decay vertex position (difference in Vtx distribution between signal and background)
  - Cut on PocaQA value


Λ Mass
×10^3
150
100
50
0
0.8
1
1.2
1.4
m_Λ[GeV/c^2]
Λ̄ Mass
×10^3
150
100
50
0
0.8
1
1.2
1.4
m_Λ̄ [GeV/c^2]
Fit Probability, Λ
10^4
10^3
0
0.2
0.4
0.6
0.8
1
Probability [0..1]
Fit Probability, Λ̄
10^4
10^3
0
0.2
0.4
0.6
0.8
1
Probability [0..1]


Signal^2/Background($\Lambda_{Vtx\ cut}$)
Λ Vertex cut [mm]
Signal^2/Background($\overline{\Lambda}_{Vtx\ cut}$)
$\overline{\Lambda}$ Vertex cut [mm]
Signal^2/Background($PocaQA_{cut}$)
$PocaQA_{cut}$ [cm]
Signal^2/Background($PocaQA_{cut}$)
$PocaQA_{cut}$ [cm]

Cuts on p_t vs p_z

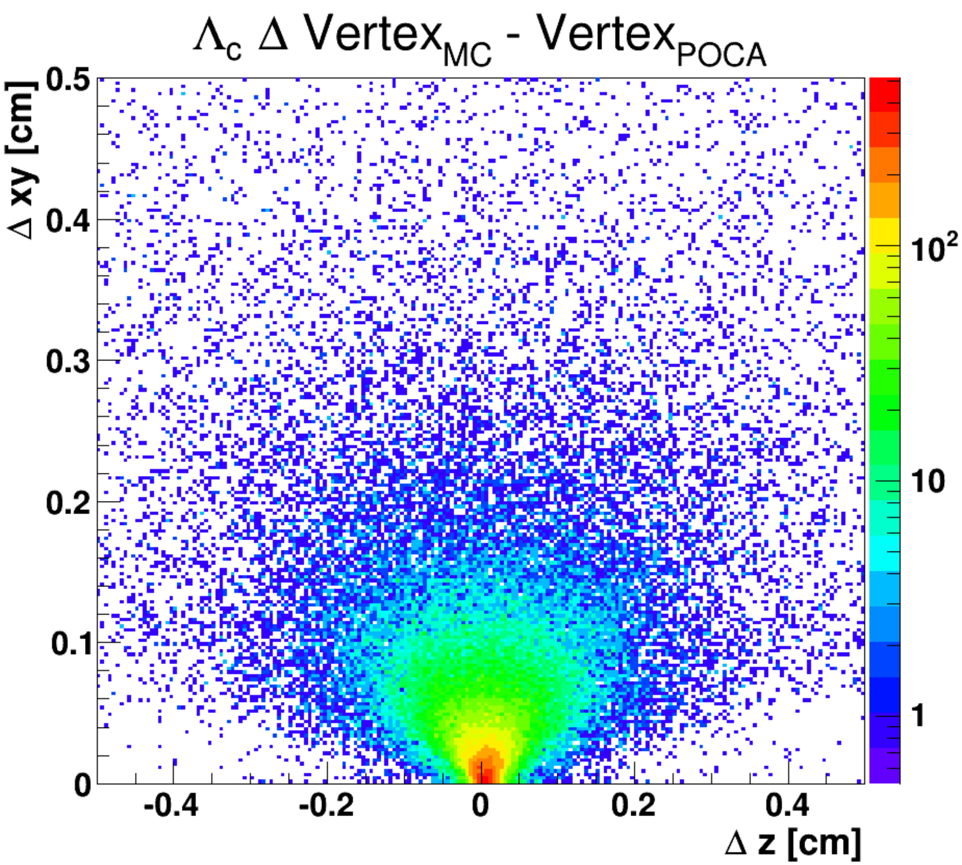


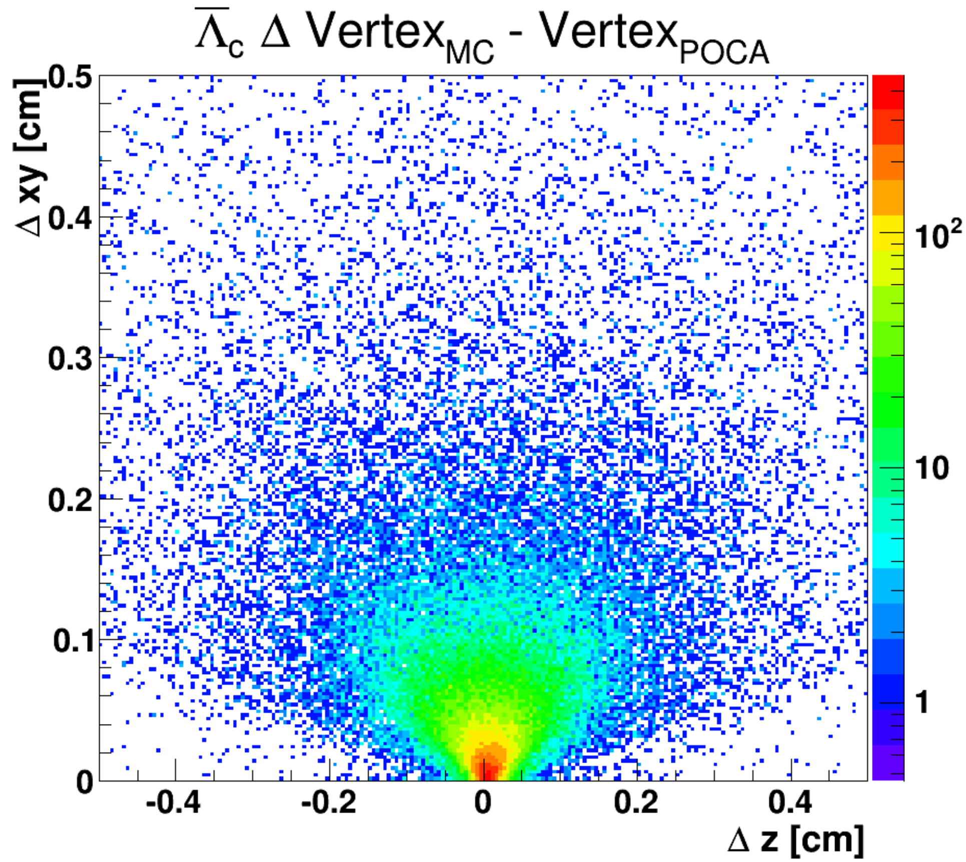
Λ_c Reconstruction

- Combined π^+ and Λ form the Λ_c candidates (π^- and $\overline{\Lambda}$ for $\overline{\Lambda}_c$)
- A mass constraint fit is used to discard ambiguities
- A cut on the fit probability was applied (P>0.01)

Λ_c Reconstruction

Combined π^+ and Λ form the Λ_c candidates (π^- and $\overline{\Lambda}$ for $\overline{\Lambda}_c$)

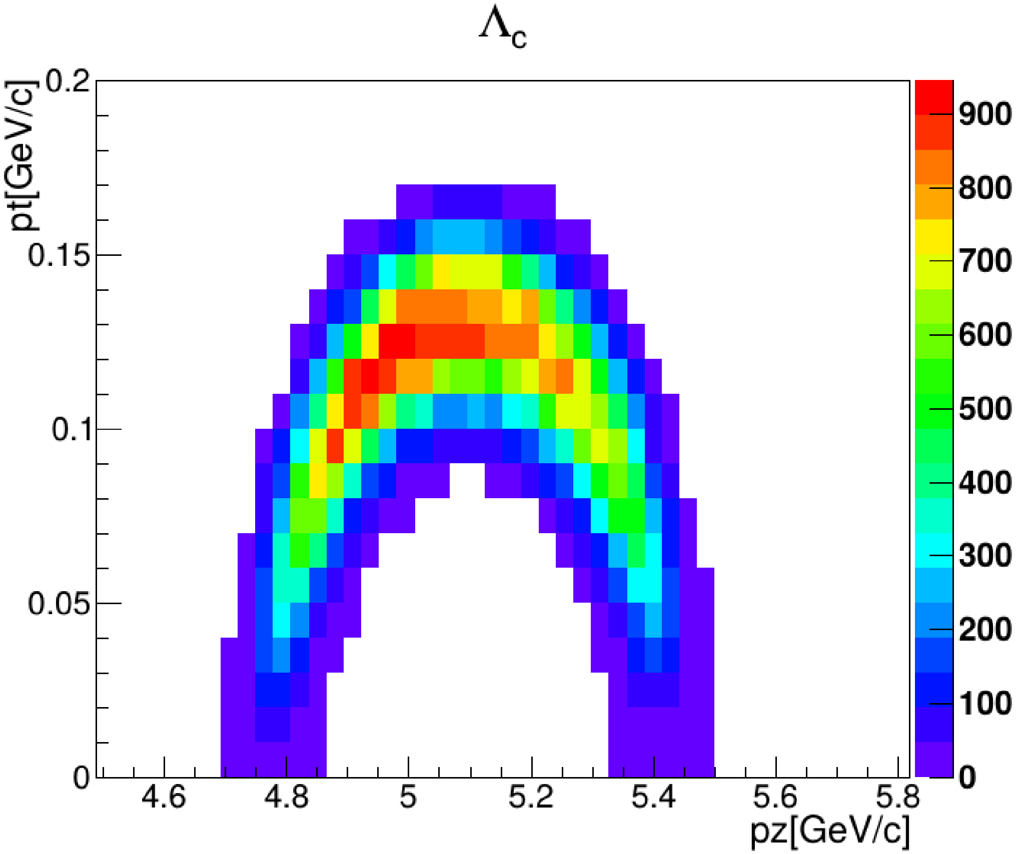


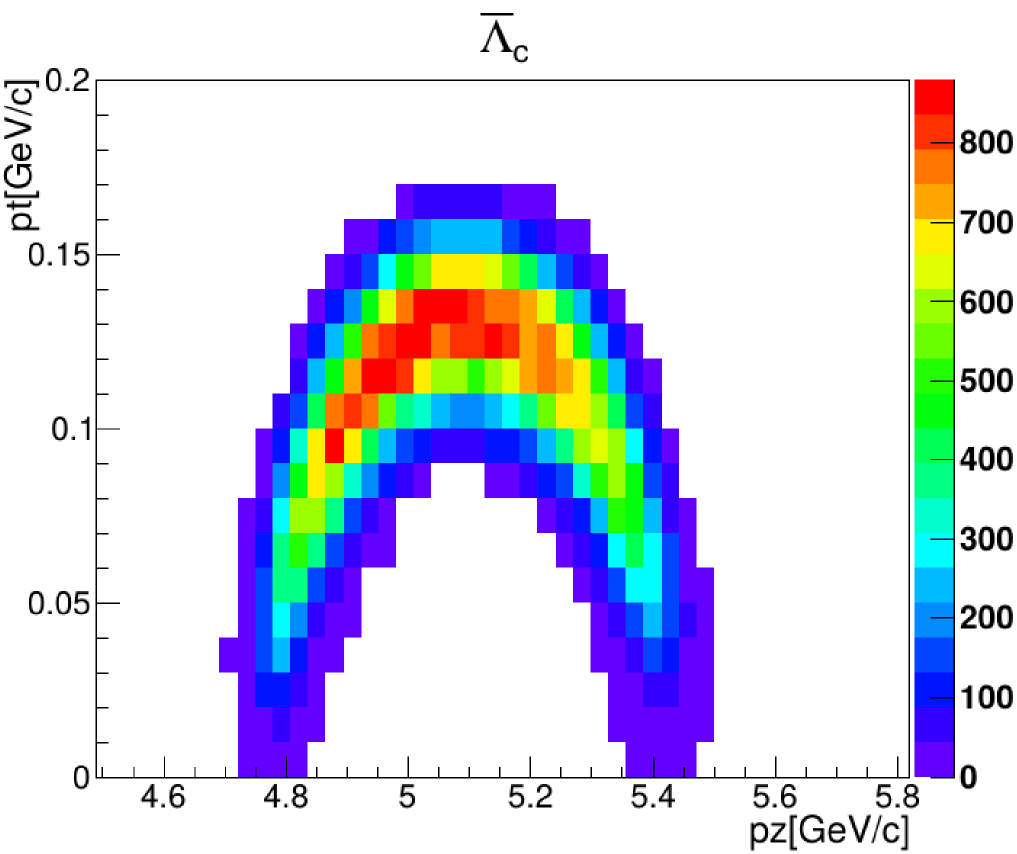


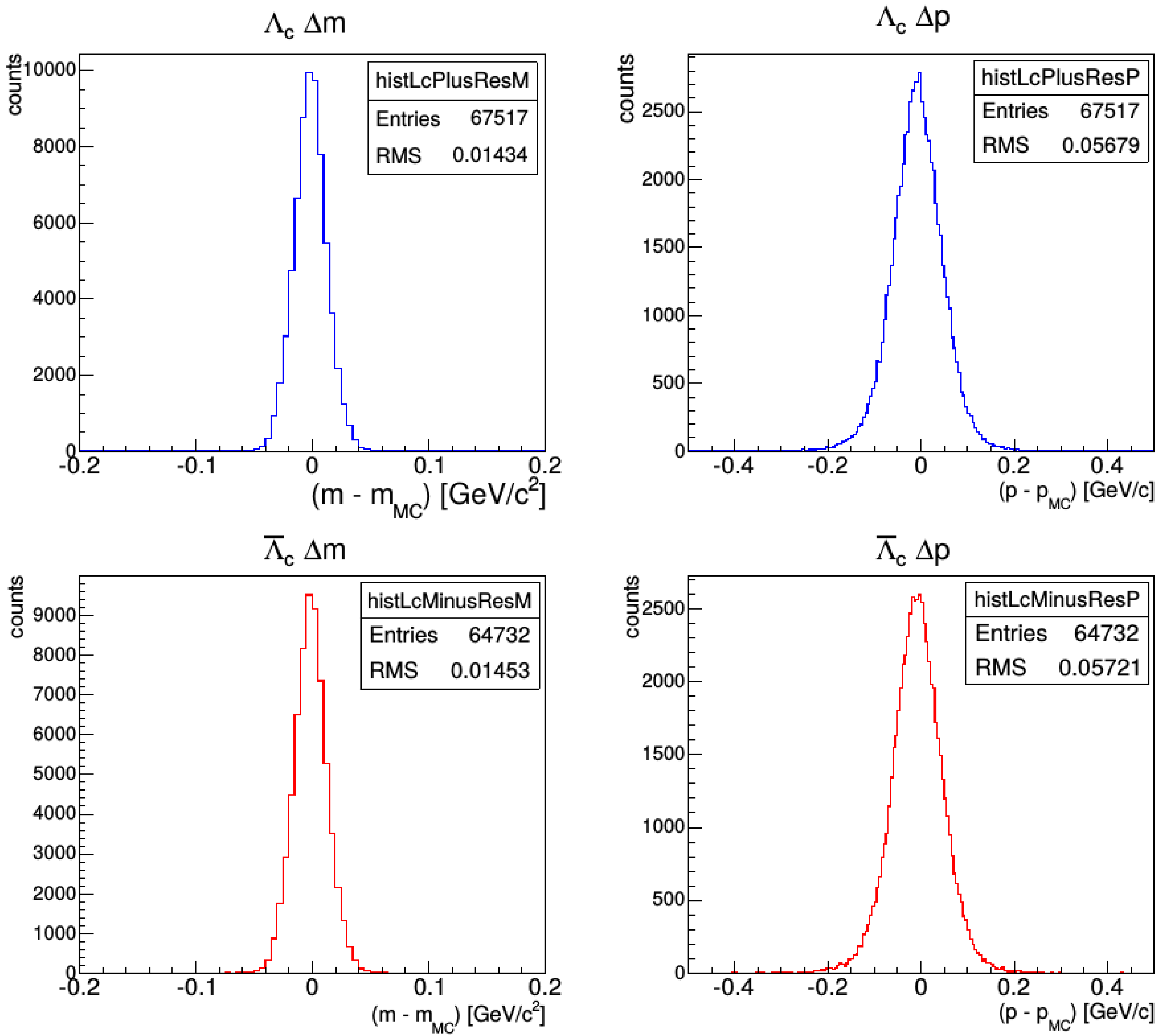
Cut on vertex position:

$$\frac{(z_{POCA} - 135\,\mu\mathrm{m})^2}{(2\,\mathrm{mm})^2} + \frac{R_{POCA}^2}{(1.75\,\mathrm{mm})^2} \leq 1$$

p_t vs p_z distribution







	ϵ	$\mathrm{RMS_m}$	$\mathrm{RMS_p}$
Λ_c	8.5 %	14.3 MeV/c^2	56.8 MeV/c
$\overline{\Lambda}_c$	8.1 %	14.5 MeV/c^2	57.2 MeV/c

Effects of the Cuts on the Efficiency

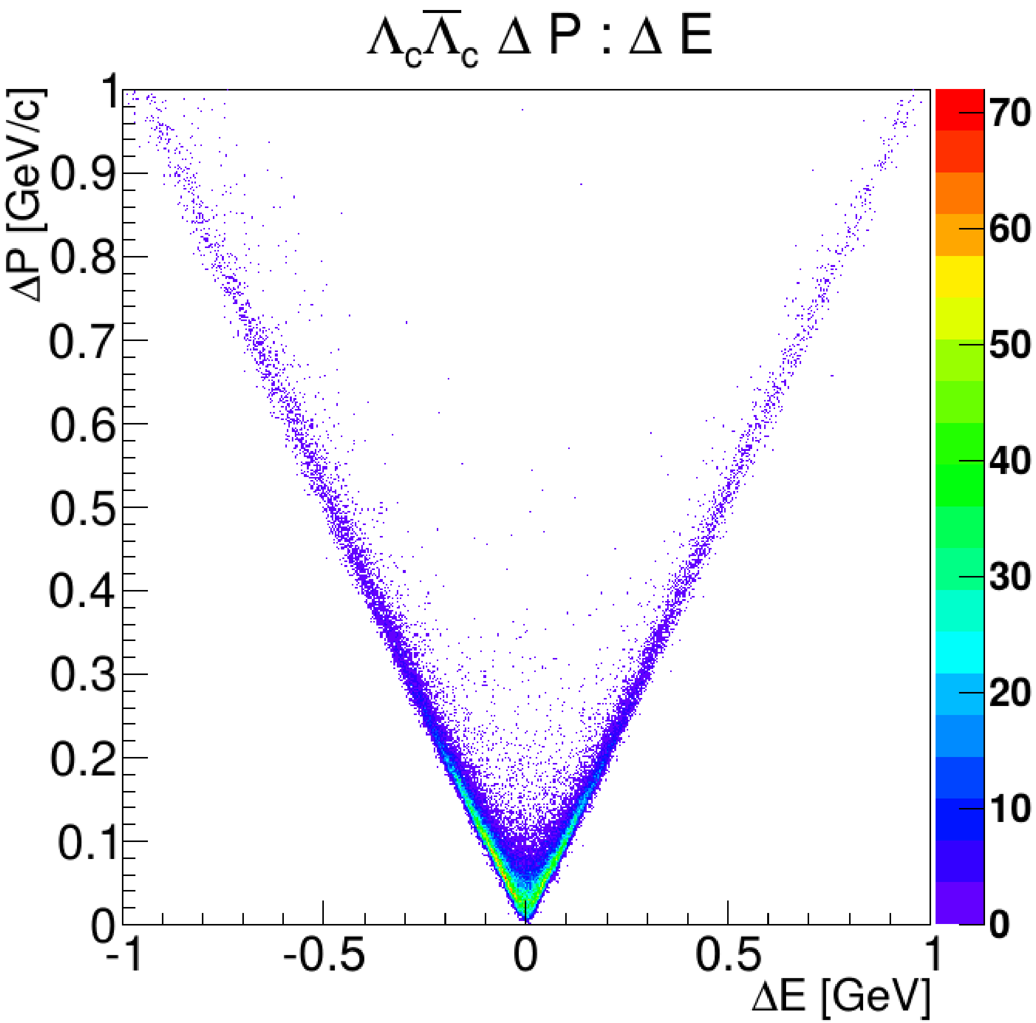
cut	-	$\Lambda(\overline{\Lambda})$ PocaQA	$\Lambda(\overline{\Lambda})$ mass	$\Lambda(\overline{\Lambda})$ origin	$\Lambda_c(\overline{\Lambda}_c)$ origin	p_t vs p_l
ϵ_{Λ_c}	48.4 %	17.6 %	40.5 %	46.6 %	31.9 %	25.0 %
$\epsilon_{\overline{\Lambda}_c}$	49.6 %	17.9 %	40.3 %	47.4 %	32.8 %	25.2 %

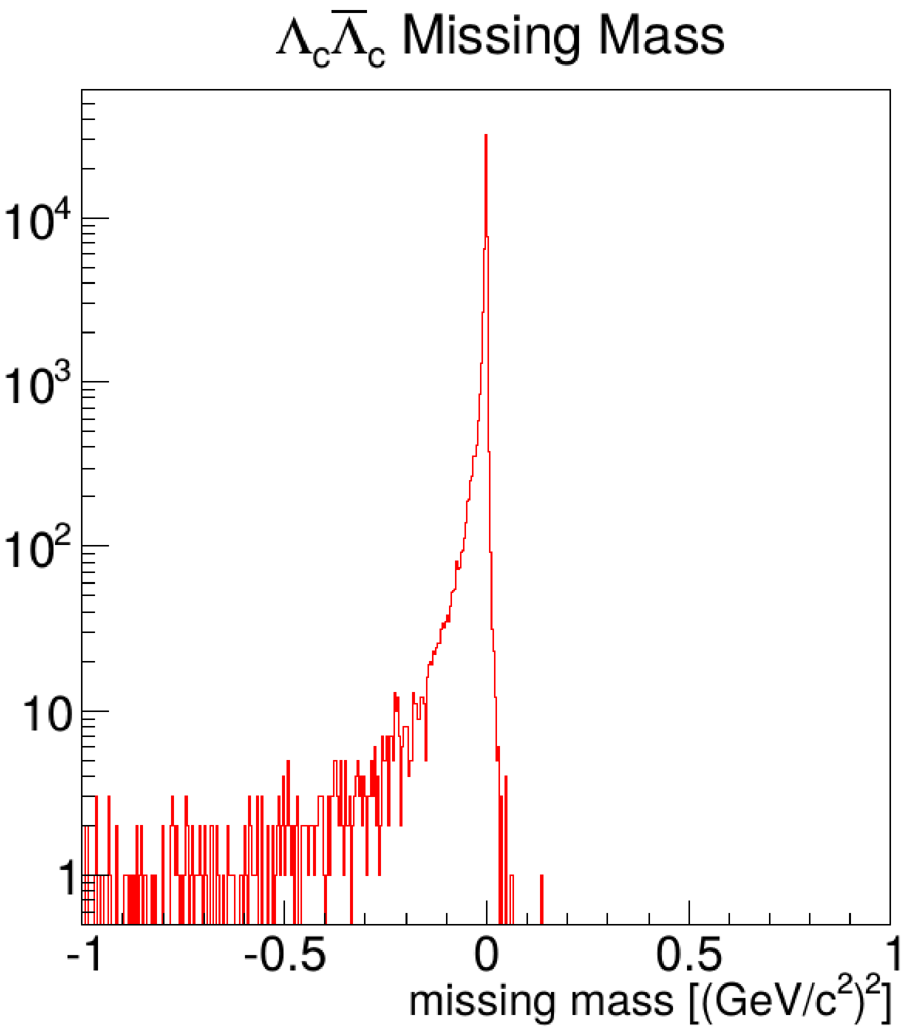
$(prob > 0.01)$ and	-	$\Lambda(\overline{\Lambda})$ PocaQA	$\Lambda(\overline{\Lambda})$ mass	$\Lambda(\overline{\Lambda})$ origin	$\Lambda_c(\overline{\Lambda}_c)$ origin	p_t vs p_l
ϵ_{Λ_c}	42.7 %	17.8 %	36.6 %	40.9 %	28.6 %	24.0 %
$\epsilon_{\overline{\Lambda}_c}$	42.8 %	17.6 %	36.3 %	40.6 %	28.8 %	23.8 %

Exclusive Reconstruction

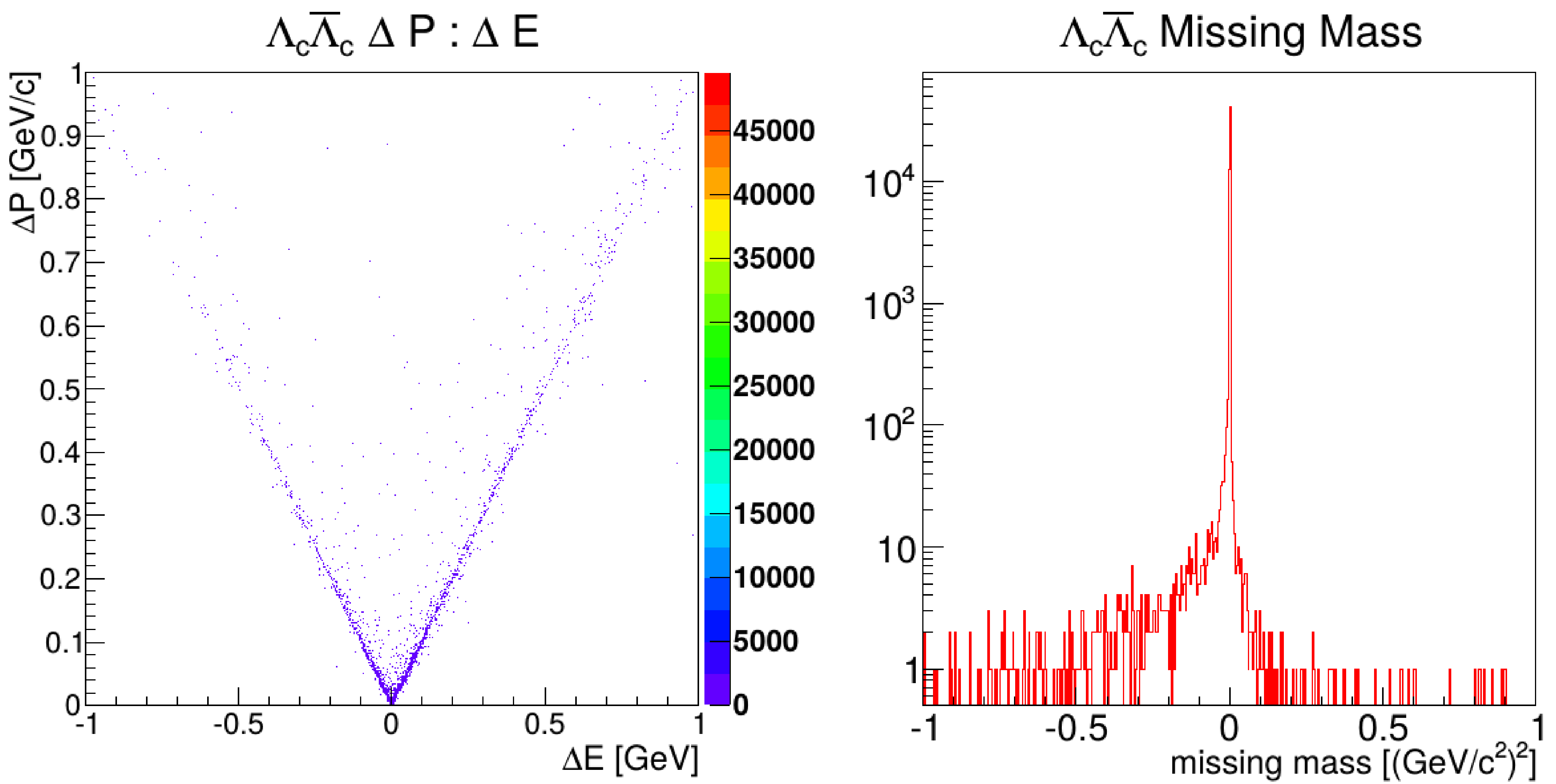
- Looser selection criteria are possible as background is surpressed by both candidates:
  - PocaQA cut at 5 cm
  - no cuts on p_t vs p_z distributions
  - no cut on the Λ and Λ vertices
- Efficiency of the exclusive measurement with those selection criteria is 6.9 %.
- Four constraint fits are possible.

Momentum and Energy Resolution and Missing Mass





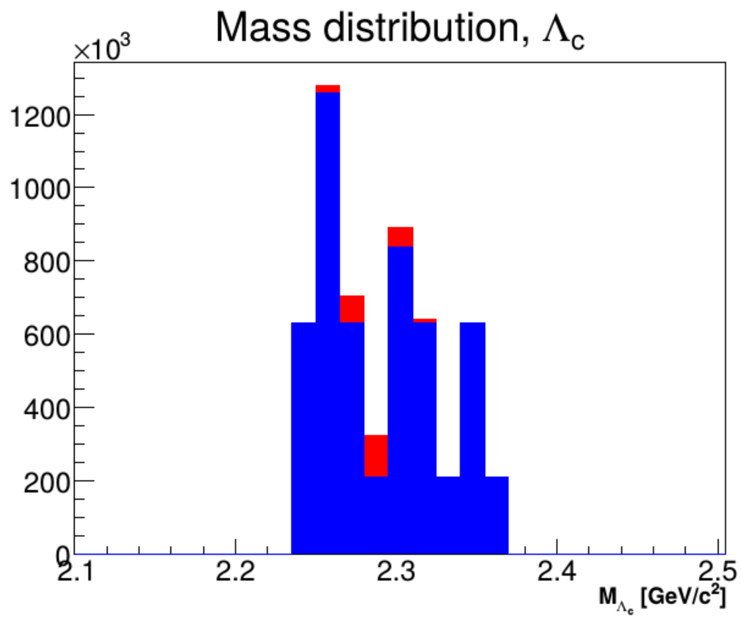
With Pnd4CFitter Applied



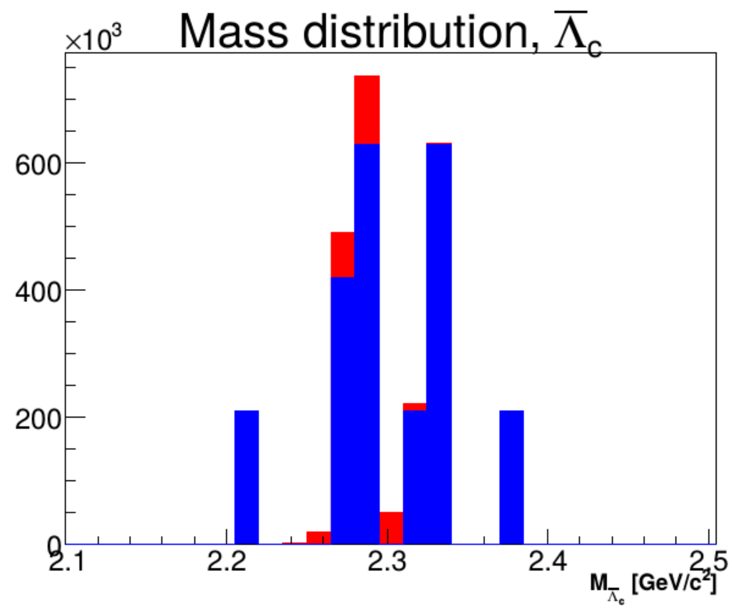
Background Considerations

- Cross section predictions for $\bar{p}p \rightarrow \bar{\Lambda}_c \Lambda_c$ range from a few nb to ~10μb.
- 235 million DPM events have been simulated with Prometeus.
- With the selection criteria shown above, 25 Λ_c and 11 $\bar{\Lambda}_c$ candidates have been reconstructed.
- None of the DPM events has been reconstructed as an exclusive event.

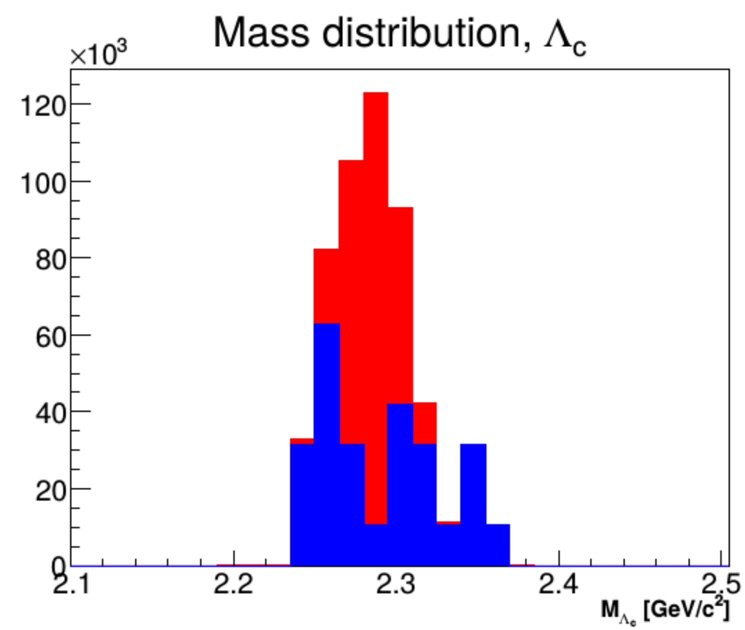
Signal to Background Comparison



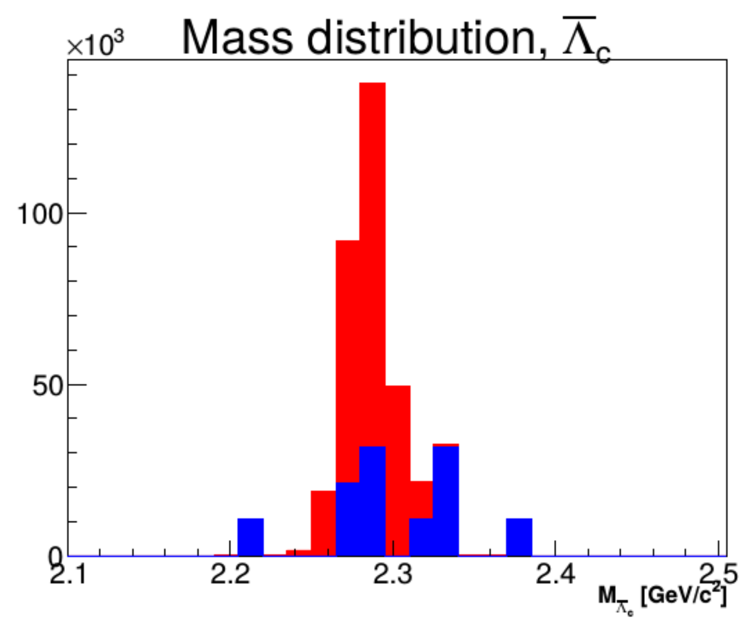
$\Lambda_c, \sigma_{tot} = 100\,\text{nb}$



$\overline{\Lambda}_c, \sigma_{tot} = 100\,\text{nb}$



$\Lambda_c, \sigma_{tot} = 2\,\mu\text{b}$



$\overline{\Lambda}_c, \sigma_{tot} = 2\,\mu\text{b}$

Beam Time Requirements

$$t_b \cdot \mathcal{L} \cdot \sigma_{p\bar{p}\to\Lambda_c\bar{\Lambda}_c} \cdot \epsilon_{\Lambda_c} \cdot \mathrm{BR} > 3 \cdot \sqrt{\mathcal{L} \cdot \sigma_{tot.} \epsilon_{bg} \cdot t}$$

$$\Leftrightarrow t_b > \frac{9 \cdot \sigma_{tot} \cdot \epsilon_{bg}}{\mathcal{L} \cdot \sigma^2_{p\bar{p}\to\Lambda_c\bar{\Lambda}_c} \cdot \epsilon^2_{\Lambda_c} \cdot \mathrm{BR}^2}$$

- Full luminosity is assumed $\mathcal{L} = 2 \cdot 10^{32}\,\mathrm{cm}^{-2}\mathrm{s}^{-1}$
- BR is the product of the $\Lambda_c \to \pi^+ \Lambda$ and the $\Lambda \to p\pi^-$ BRs.

Estimated Beam Time Requirement

	$\sigma_{\overline{p}p\to\overline{\Lambda}_c\Lambda_c}$	$N_{\text{true}} > 3\sqrt{N_{\text{false}}}$	$N_{\Lambda_c,\overline{\Lambda}_c} = 1000$
Λ_c	5 nb	277 d	19.9 d
$\overline{\Lambda}_c$	5 nb	134 d	20.9 d
Λ_c	100 nb	16.6 h	1 d
$\overline{\Lambda}_c$	100 nb	8.1 h	1 d
Λ_c	500 nb	39.8 min	4.8 h
$\overline{\Lambda}_c$	500 nb	19.3 min	5 h
Λ_c	2 μb	150 s	71.7 min
$\overline{\Lambda}_c$	2 μb	73 s	75.2 min

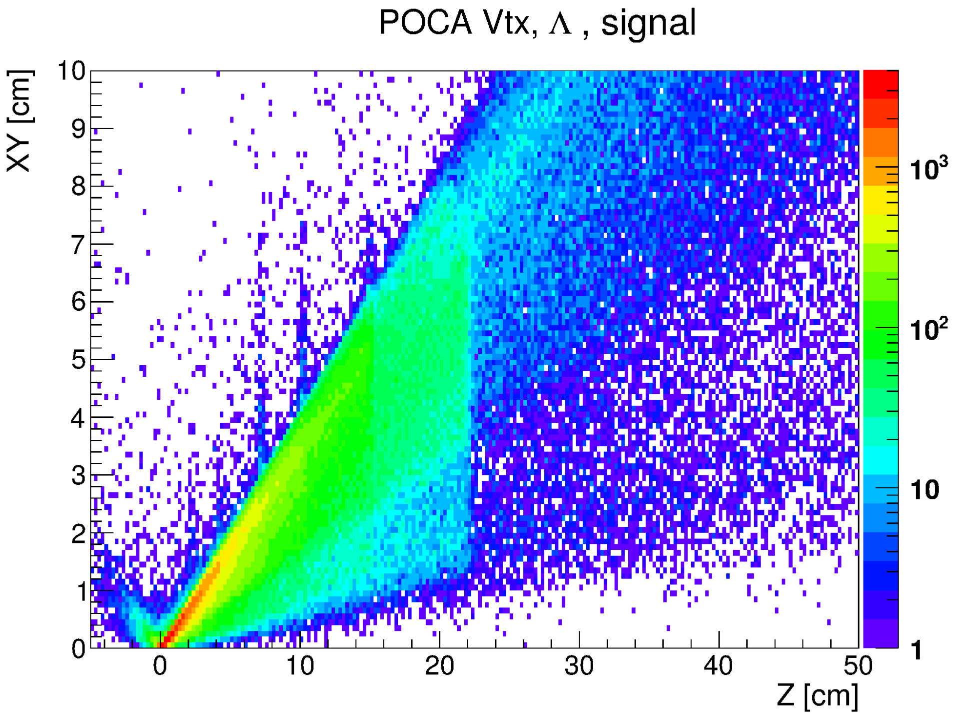
The exclusive measurement ranges from 1event/3days to >100/day.

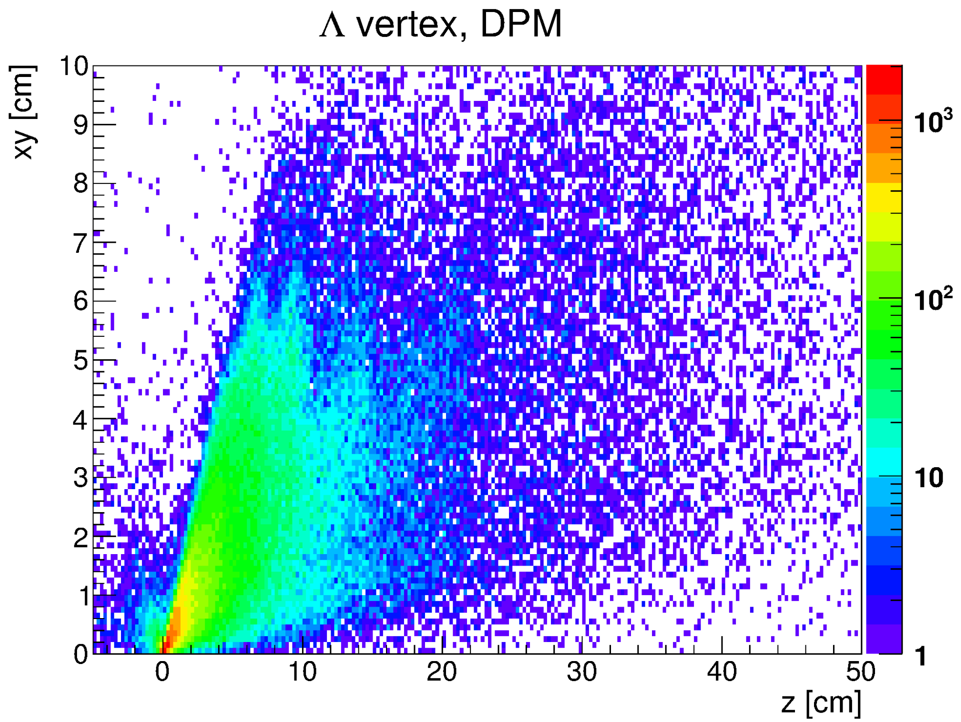
Summary

- Reconstruction of the channel is possible

- Depending on the reaction's cross section, the required beam time for a reasonable amount of statistics ranges from hours to months.

Thank you for your attention!


POCA Vtx, Λ , signal
XY [cm]
Z [cm]
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
1
10
10^2
10^3


Λ vertex, DPM
xy [cm]
z [cm]
0
10
20
30
40
50
1
2
3
4
5
6
7
8
9
10
1
10
10^2
10^3