Updates on $\bar{p}p \to \bar{\Lambda}\Lambda$ Analysis with Extended Target

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Outline

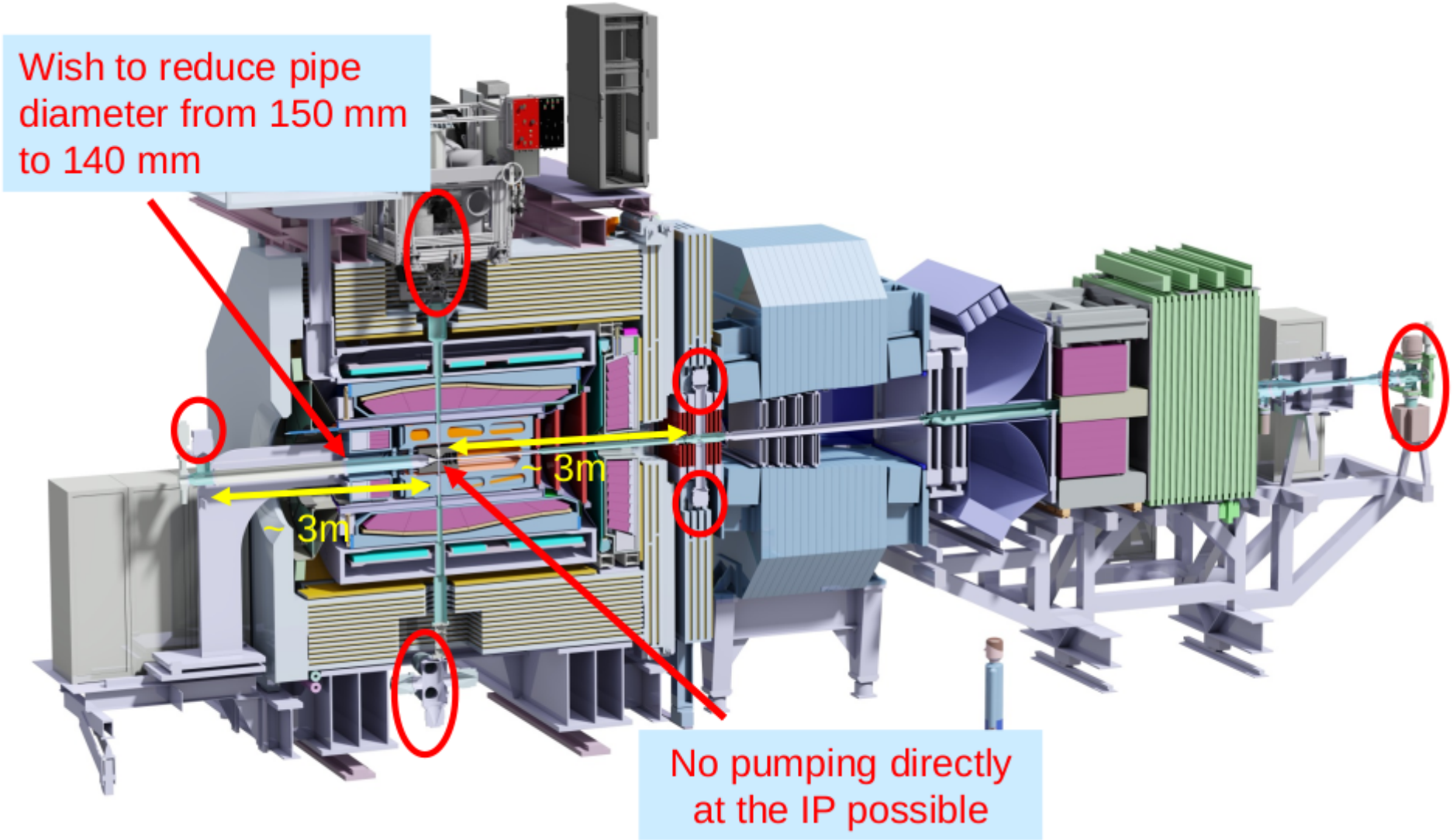
- Motivation
- Procedure
- $\bar{p}p \to \Lambda\bar{\Lambda}$ analysis for point-like and extended target
- Open Questions
- Summary
- Outlook

Motivation

- Presence of residual gas in the beam pipe
  - Effectively larger target
  - Vacuum simulations performed by Alfons Khoukaz (CM 20/1).
- $\bar{p}p \to \Lambda\bar{\Lambda}$ analysis as benchmark
  - Well studied channel
  - Displaced Vertices, similar situation of extended target
  - Expertise at Uppsala

- $\bar{p}p \to \Lambda\bar{\Lambda}$ analysis for extended target.

Position of Vacuum Pumps in Panda



Vacuum Studies

Four different scenarios are studied by Alfons Khoukaz (CM 20/1)

- NormalIP[1] (present study)
- NormalIP + Cryo Pumps
- BigIP
- BigIP + Cryo Pumps

As a starting point only the NormalIP used for IP sampling for this study.

[1] original IP geometry with 140mm upstream beam pipe

Reference Study

Study $\bar{p}p \to \Lambda\bar{\Lambda}$ analysis with

- $10,000$ events at $1.642\,\mathrm{GeV/c}$
- EvtGen as simulator (Signal and Non-resonant Bkg)
- Ideal Reco and Ideal PID algorithms
- Pre-selection & final selection criteria from Walter's doctoral thesis

Replicate $\bar{p}p \to \Lambda\bar{\Lambda}$ analysis for

- Extended Target

Software: FairSoft(jun19), FairRoot(18.2.0) & PandaRoot(oct19/dev)

Pre-selection Criteria

The following pre-selection criteria is used:

- Events with at least 4 charged tracks
- All possible combinations of $p\pi^-$ and $\bar{p}\pi^+$ are considered.
- Invariant mass of $p\pi^-$ fulfills $|m(\Lambda) - m(p\pi^-)| < 0.3$ GeV$/c^2$ + c.c.
- Vertex fit on all $\Lambda, \bar{\Lambda}$ candidates, reject those with $prob < 0.01$.
- For multiple $\Lambda/\bar{\Lambda}$ candidates, keep with smallest χ^2.
- $\Lambda, \bar{\Lambda}$ candidates are combined to reconstruct the $p\bar{p}$ system.
- A successful 4C-fit is required to reconstruct $\bar{p}p$.

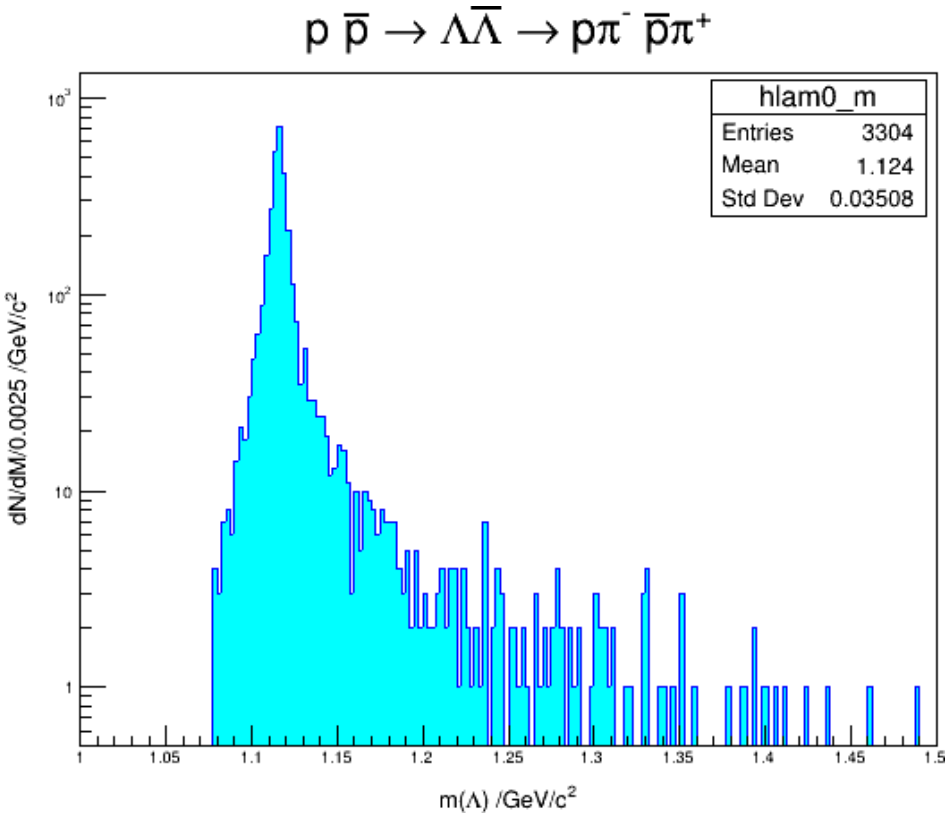
Final Selection Criteria

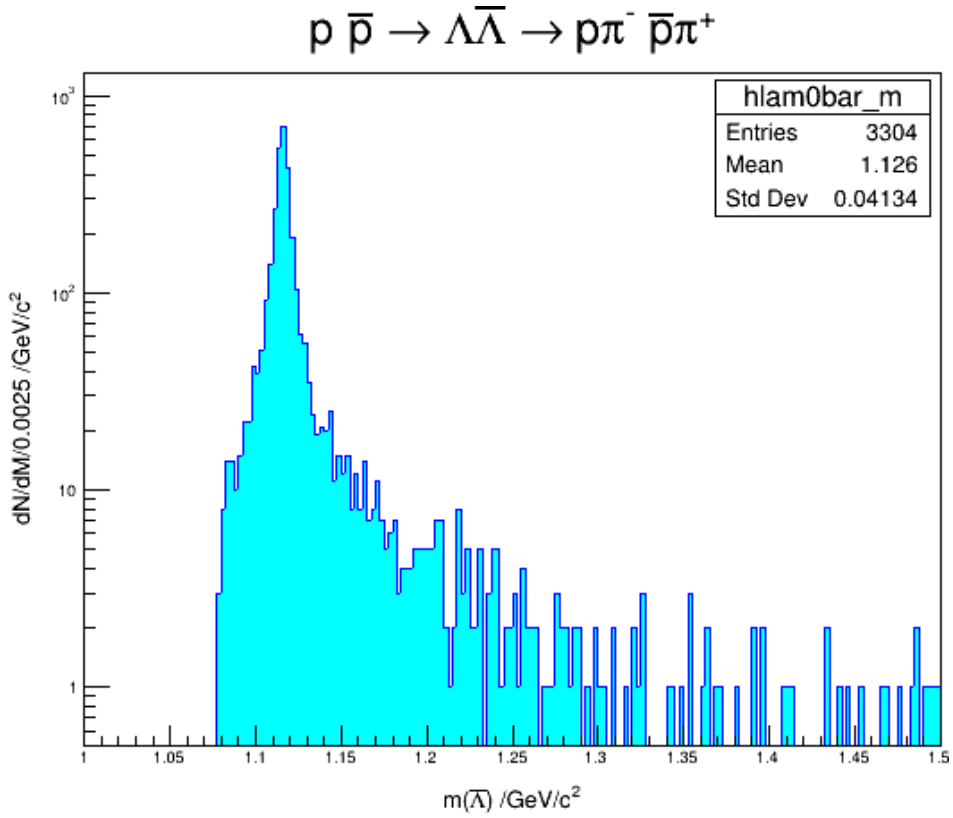
The following final selection is used:

- 4C fit quality:
  - $\chi^2_{4C} < 100$
- Mass criteria:
  - $|m_{fit}(p\pi^-) - m_{PDG}(p\pi^-)| < 5 \cdot \sigma_{m_{fit}}(p\pi^-)$ GeV/c^2
  - $|m_{fit}(\bar{p}\pi^+) - m_{PDG}(\bar{p}\pi^+)| < 5 \cdot \sigma_{m_{fit}}(\bar{p}\pi^+)$ GeV/c^2
- The z distance from IP (displaced decay vertex)
  - $z_{fit}(\Lambda) + z_{fit}(\bar{\Lambda}) > 2$cm

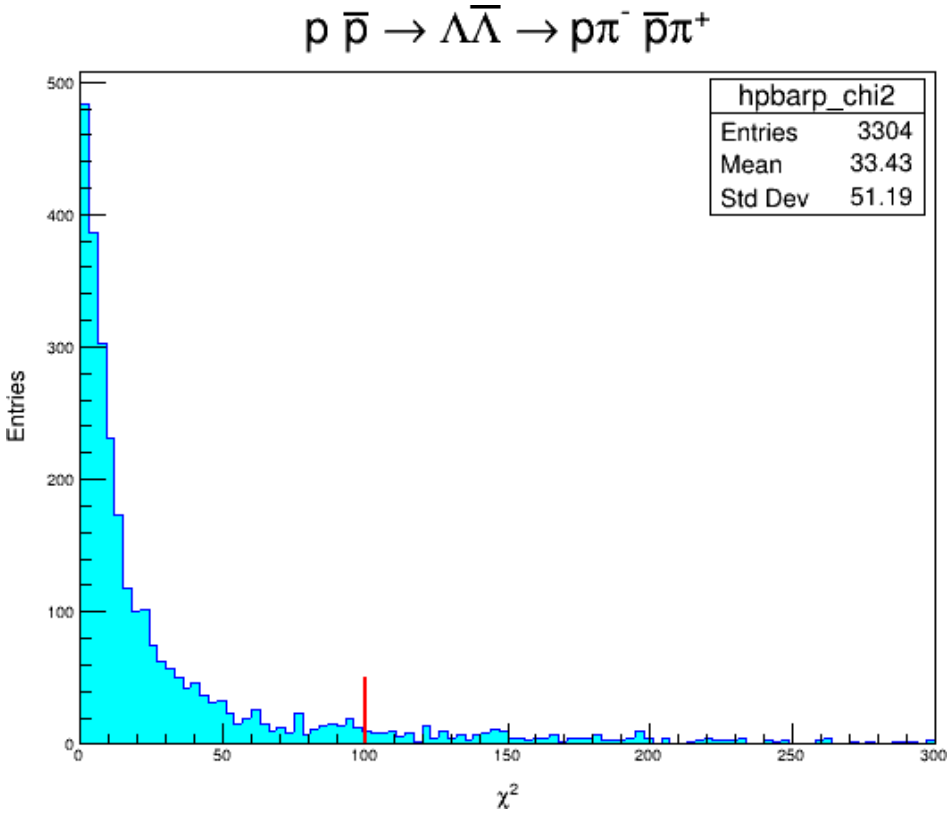
Upcoming: Point-like target, Signal (same procedure with background & extended target)

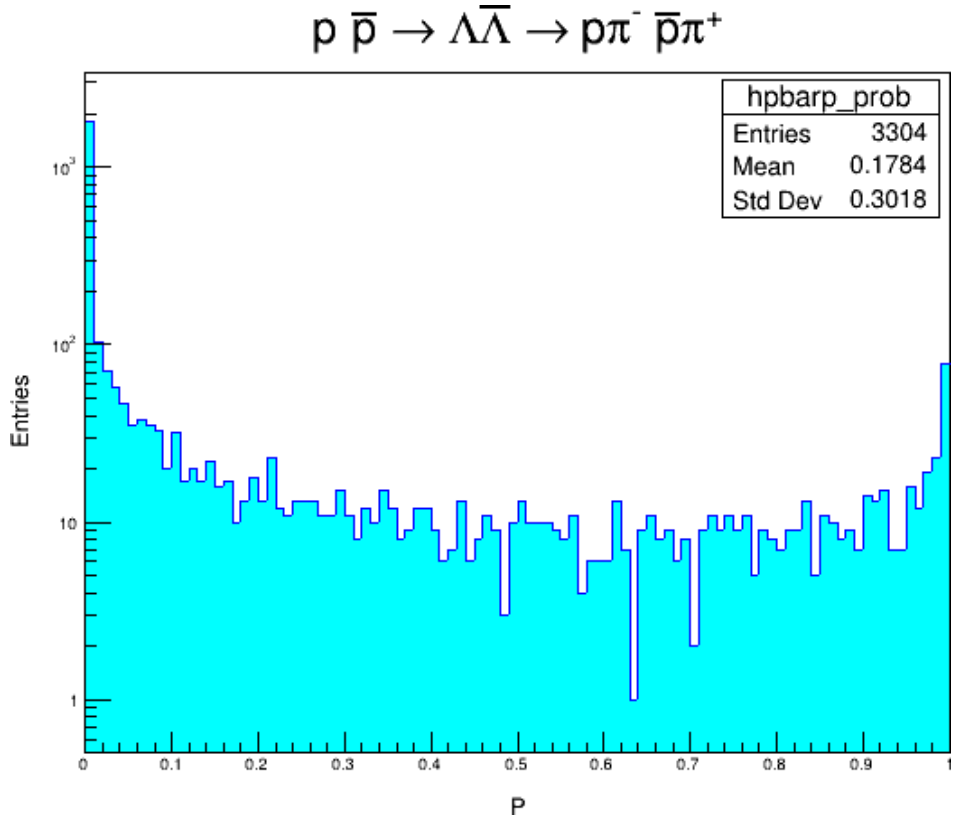
Pre-selection Cuts



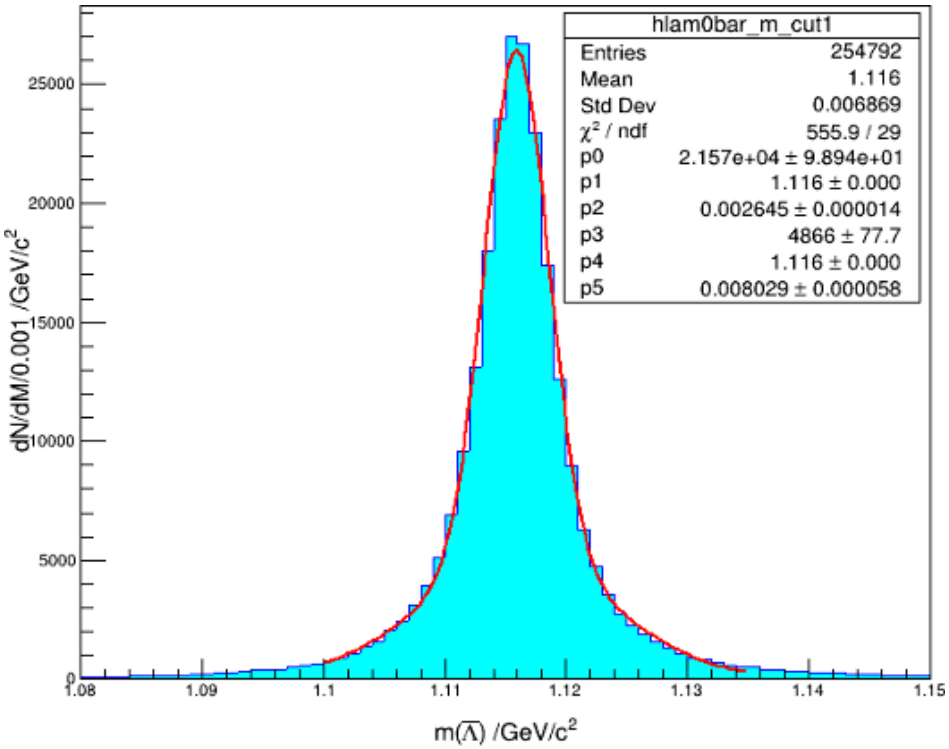


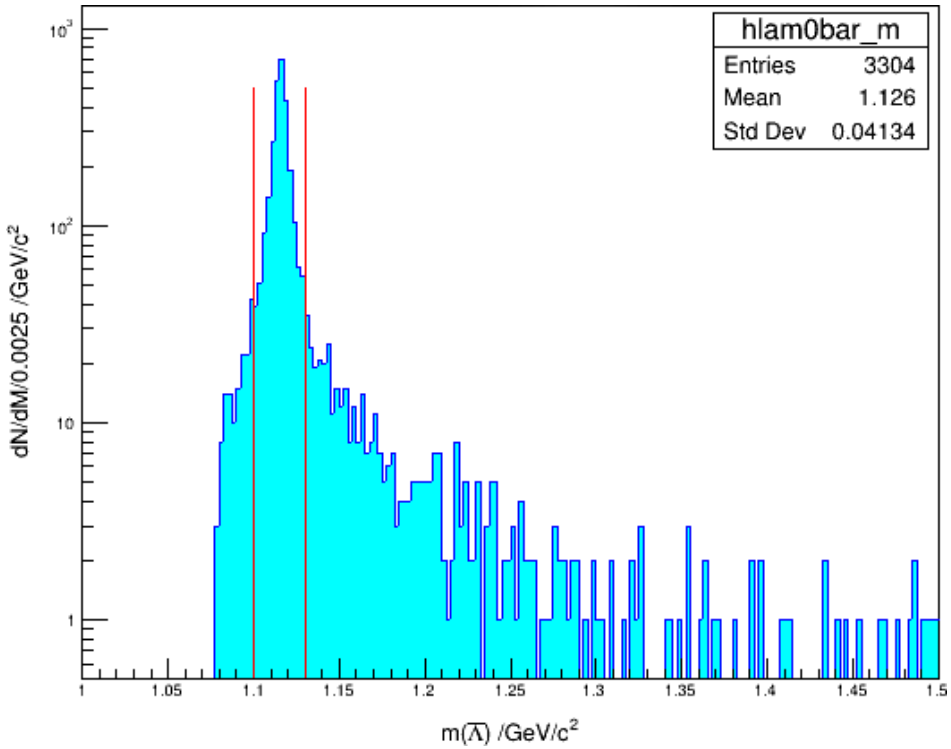
Final Selection: $\chi^2_{4c} < 100$





Final Selection: Mass Cut

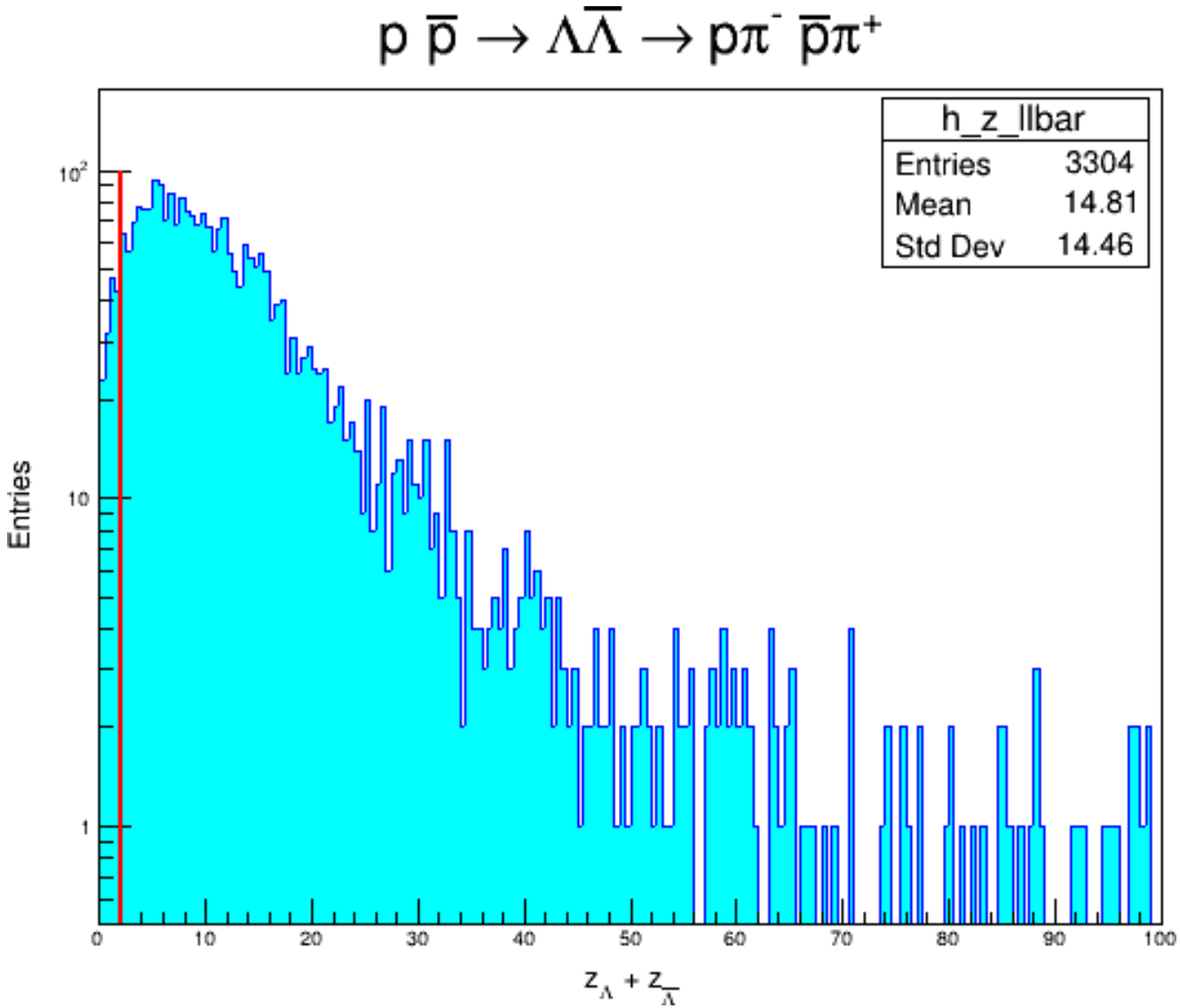




Double Gaussian Fit of Mass:

$\Rightarrow \sigma_{m_{fit}}(\bar{p}\pi^+) = 2.645 \cdot 10^{-3}\ \mathrm{GeV/c^2}$

Final Selection: $z_{\bar{\Lambda}} + z_{\Lambda} > 2$

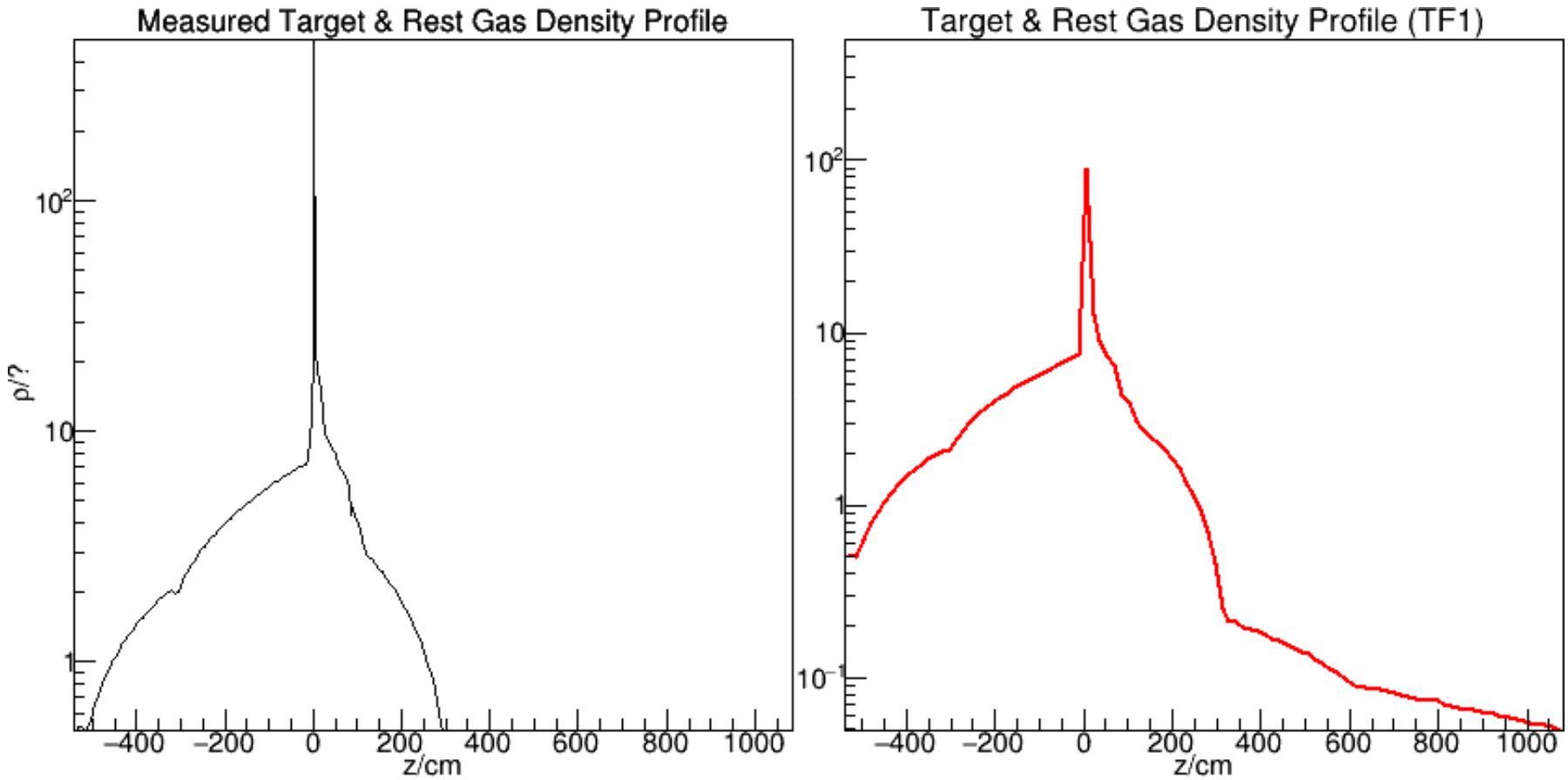


Final Efficiency (Point-like IP)

Channel	$p\bar{p} \to \bar{\Lambda}\Lambda$	$p\bar{p} \to \bar{p}\pi^+ p\pi^-$
Generated	10,000	10,000
Pre-selection	3304	3707
$\chi^2 < 100$	2585	3017
Mass cut	2239	284
$z_{\bar{\Lambda}} + z_{\Lambda} > 2$	2028	28
Efficiency %	20.28	0.28

$$R_{point} = \frac{\epsilon_{sig}}{\epsilon_{bkg}} = 72.43$$

Gas Density Profile (Case: NormalIP)



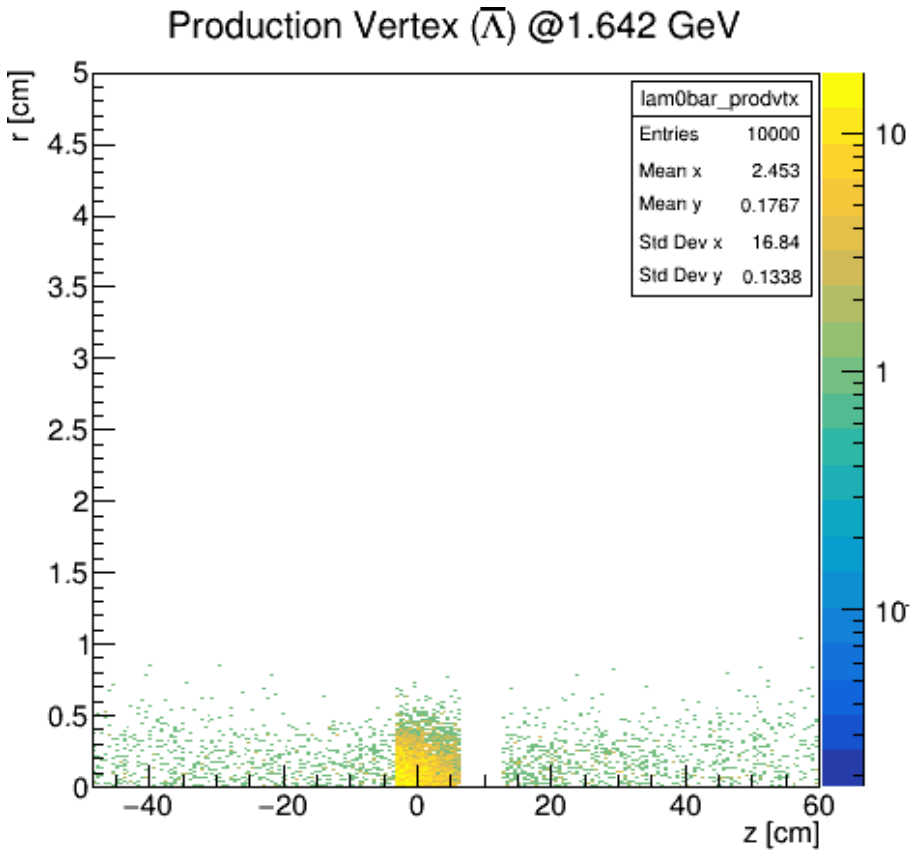
Final Efficiency (Extended)

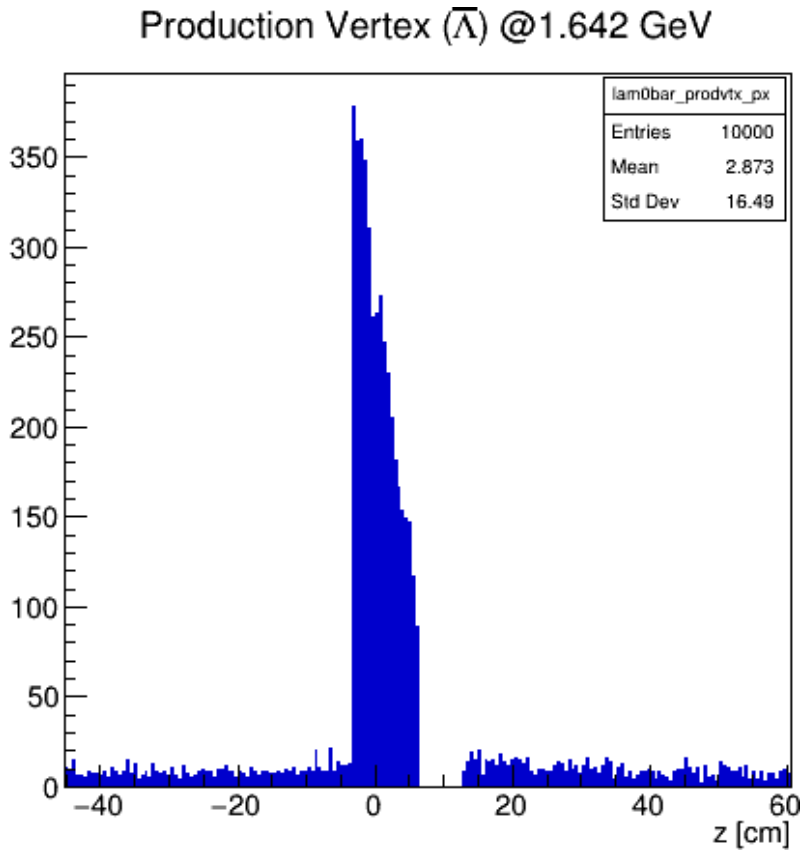
Channel	$p\bar{p} \to \bar{\Lambda}\Lambda$	$p\bar{p} \to \bar{p}\pi^+ p\pi^-$
Generated	10,000	10,000
Pre-selection	305	302
$\chi^2 < 100$	184	197
Mass cut	170	179
$z_{\bar{\Lambda}} + z_{\Lambda} > 2$	118	89
Efficiency %	1.18	0.89

$$R_{ext.} = \frac{\epsilon_{sig}}{\epsilon_{bkg}} = 1.33 \quad \Rightarrow \quad R_{point}(= 72.43) >> R_{ext.}$$

NOTE: To compare it with point-like target, one needs proper normalization.

z-Projection of PV (Signal/Extended/MC)





`mcTrack->GetStartVertex().Z()`

Summary

- Many open questions e.g. density distribution, normalization, etc
- More like Qualitative study rather than quantitative
- The "blank" region in MVD need to be investigated

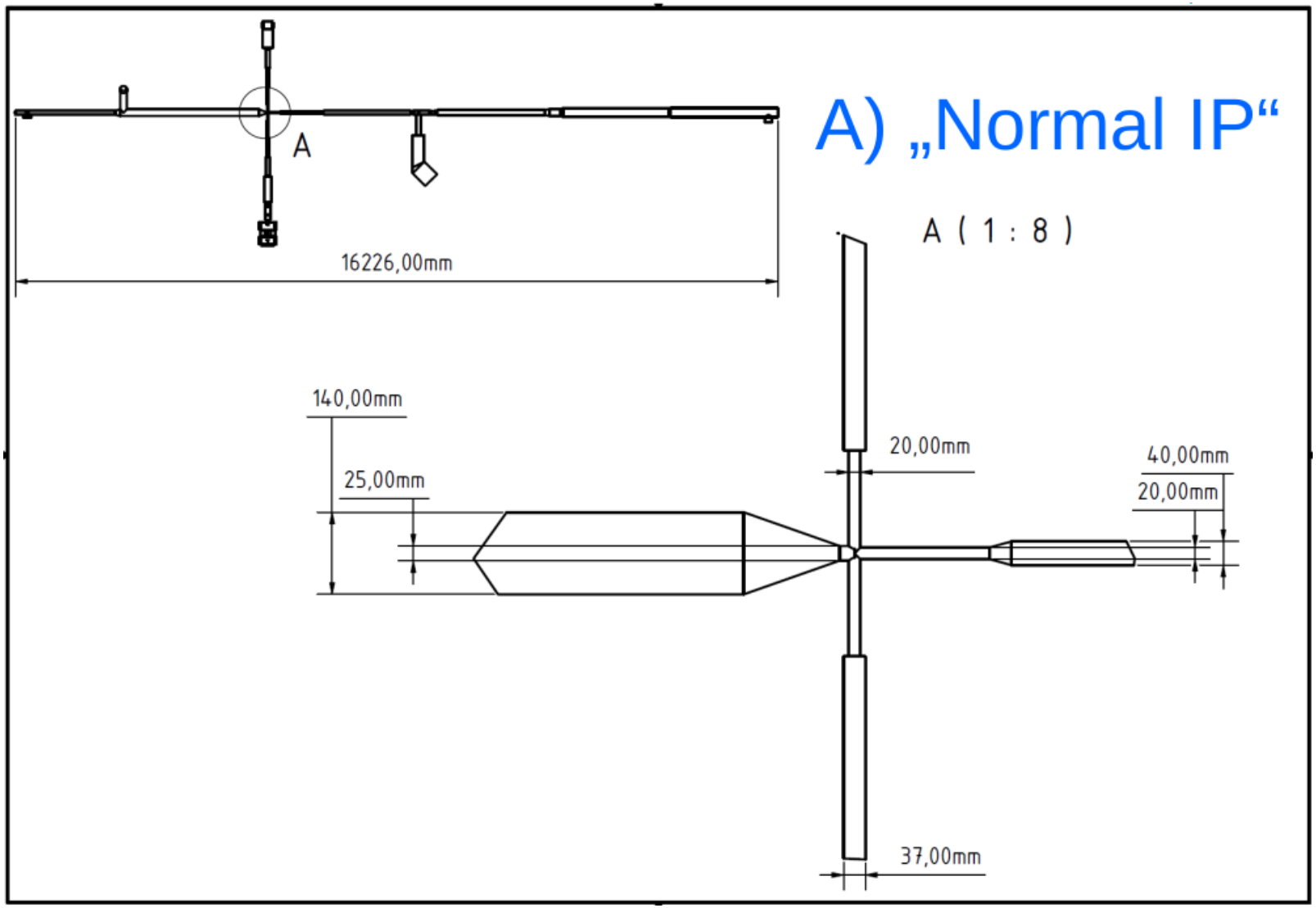
Outlook

- Optimized cuts
- Test different vacuum scenarios
- Investigate the "blank" region

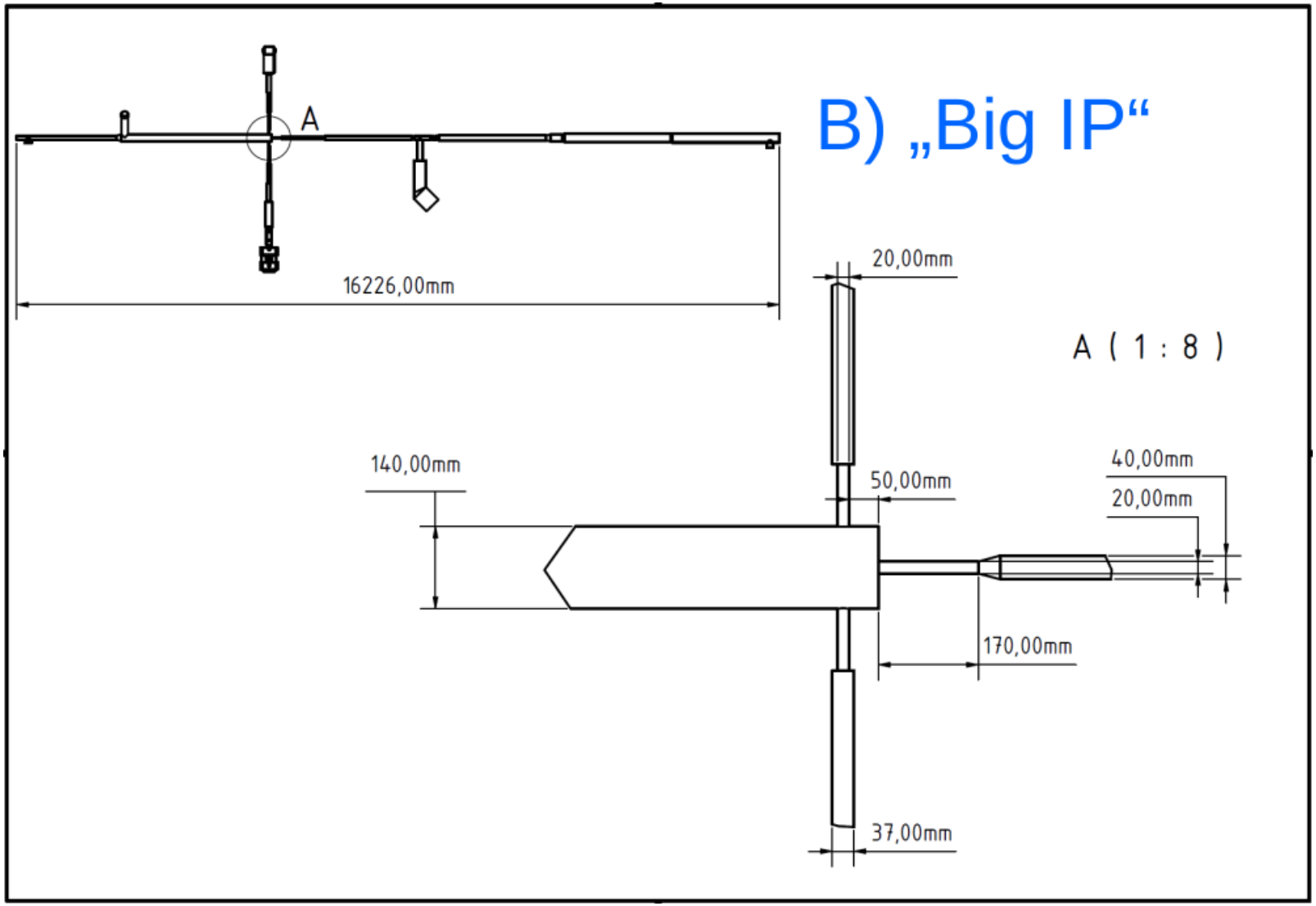
Questions?

Backup Slides

NormalIP


A
16226,00mm
A) „Normal IP“
A (1 : 8)
140,00mm
25,00mm
20,00mm
40,00mm
20,00mm
37,00mm

BigIP


A
16226,00mm
B) „Big IP“
20,00mm
A (1 : 8)
140,00mm
50,00mm
40,00mm
20,00mm
170,00mm
37,00mm

Pre-selection Cuts

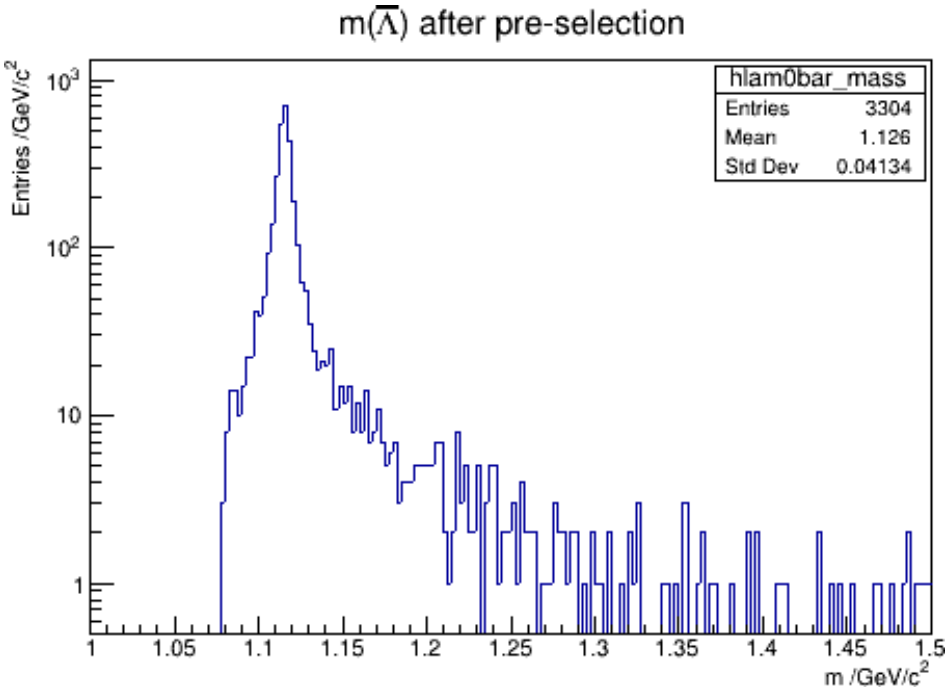


Figure: $\bar{p}p \to \bar{\Lambda}\Lambda \to \bar{p}\pi^+ p\pi^-$

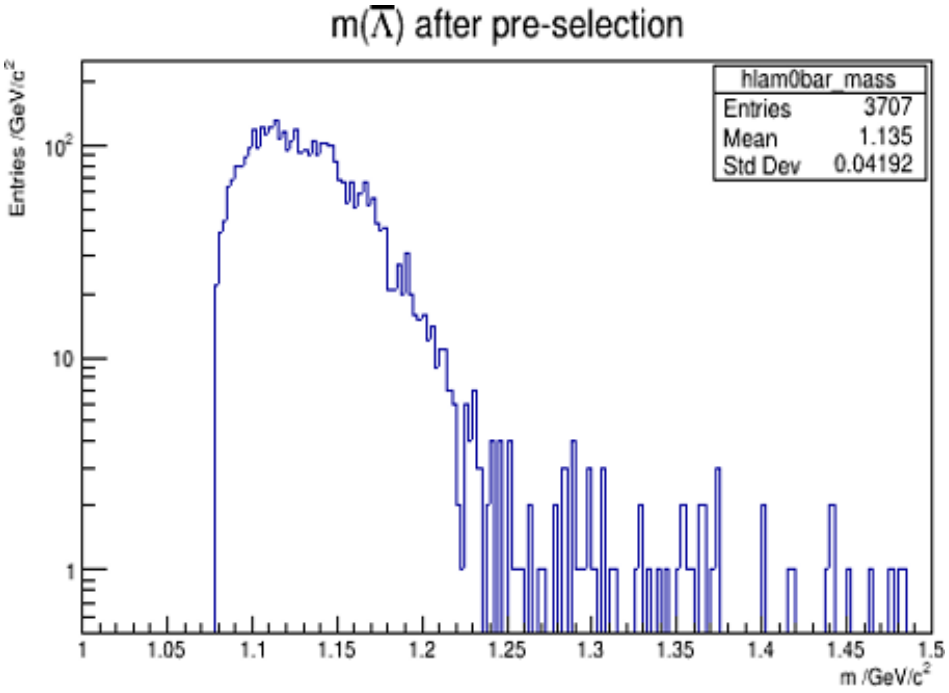


Figure: $\bar{p}p \to \bar{p}\pi^+ p\pi^-$

Final Selection: $\chi^2_{4c} < 100$

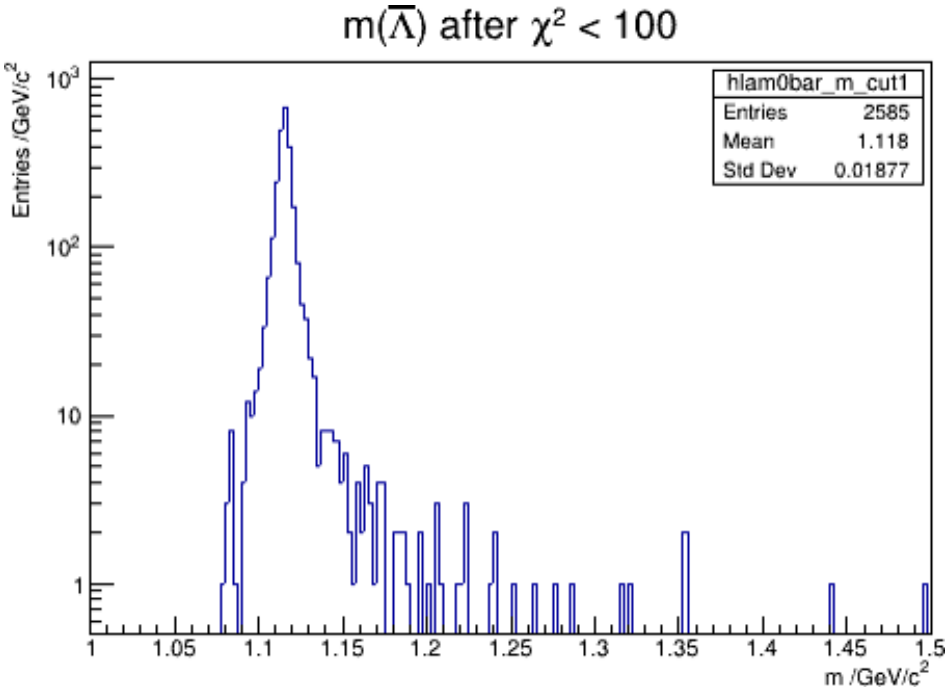


Figure: $\bar{p}p \to \bar{\Lambda}\Lambda \to \bar{p}\pi^+ p\pi^-$

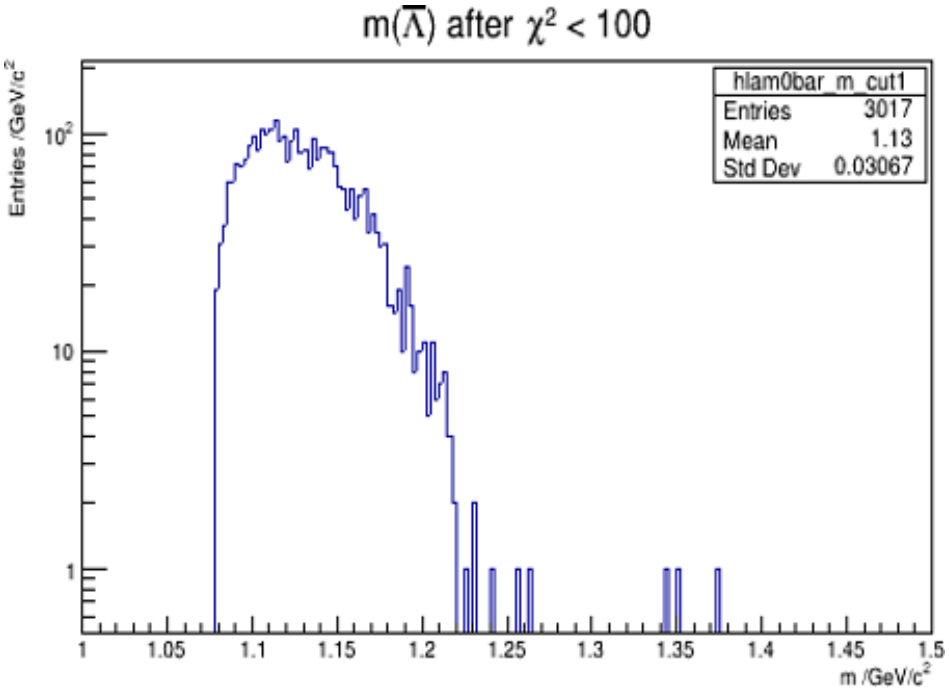


Figure: $\bar{p}p \to \bar{p}\pi^+ p\pi^-$

Final Selection: Mass Cut

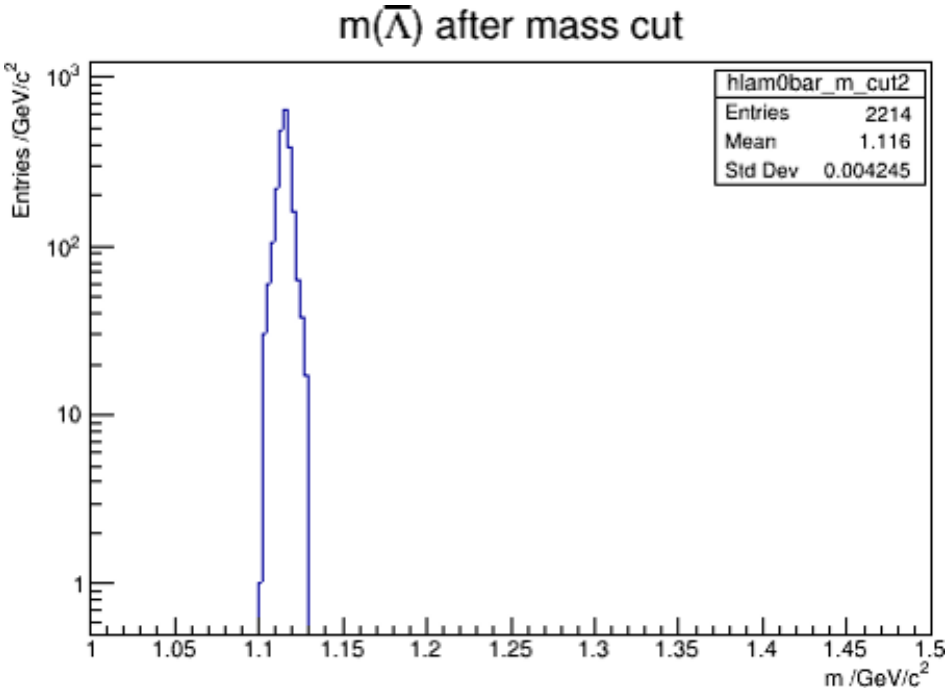


Figure: $\bar{p}p \rightarrow \bar{\Lambda}\Lambda \rightarrow \bar{p}\pi^+p\pi^-$

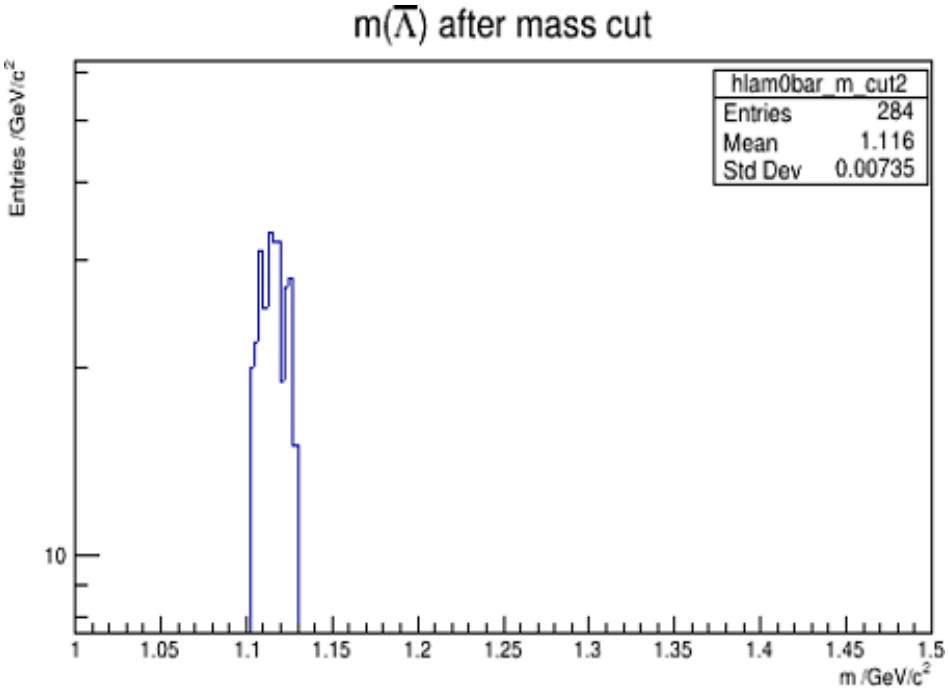


Figure: $\bar{p}p \rightarrow \bar{p}\pi^+p\pi^-$

Final Selection: $z_{\bar{\Lambda}} + z_{\Lambda} > 2$

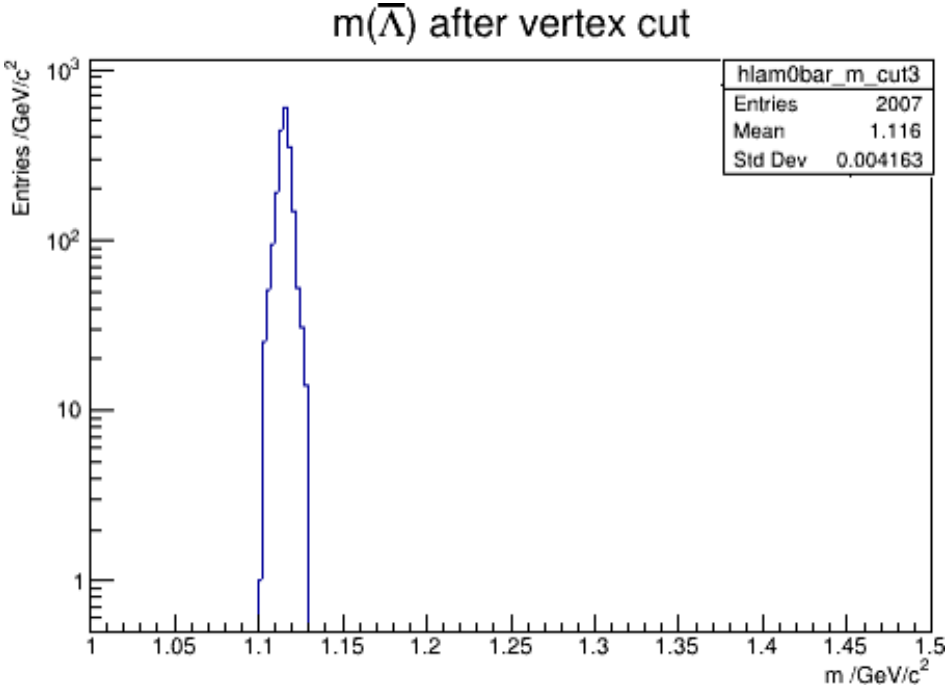


Figure: $\bar{p}p \to \bar{\Lambda}\Lambda \to \bar{p}\pi^+ p\pi^-$

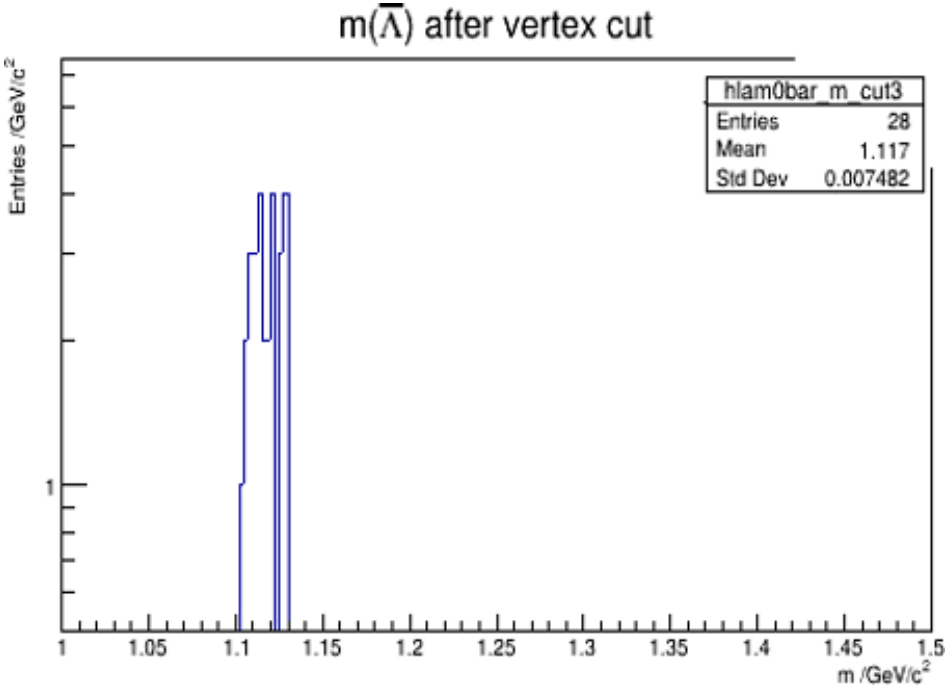


Figure: $\bar{p}p \to \bar{p}\pi^+ p\pi^-$

Final Selection: Displaced Vertex Distribution

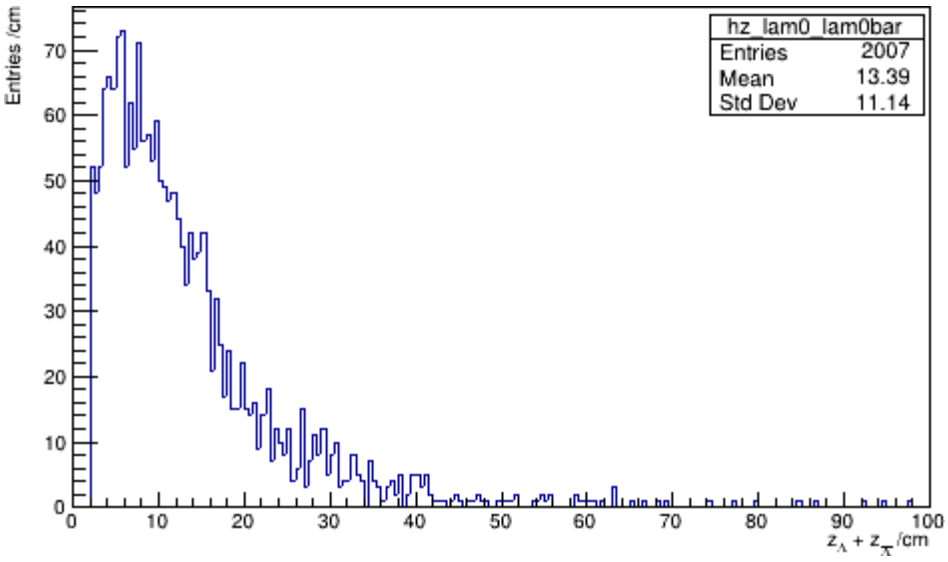


Figure: $\bar{p}p \to \bar{\Lambda}\Lambda \to \bar{p}\pi^+ p\pi^-$

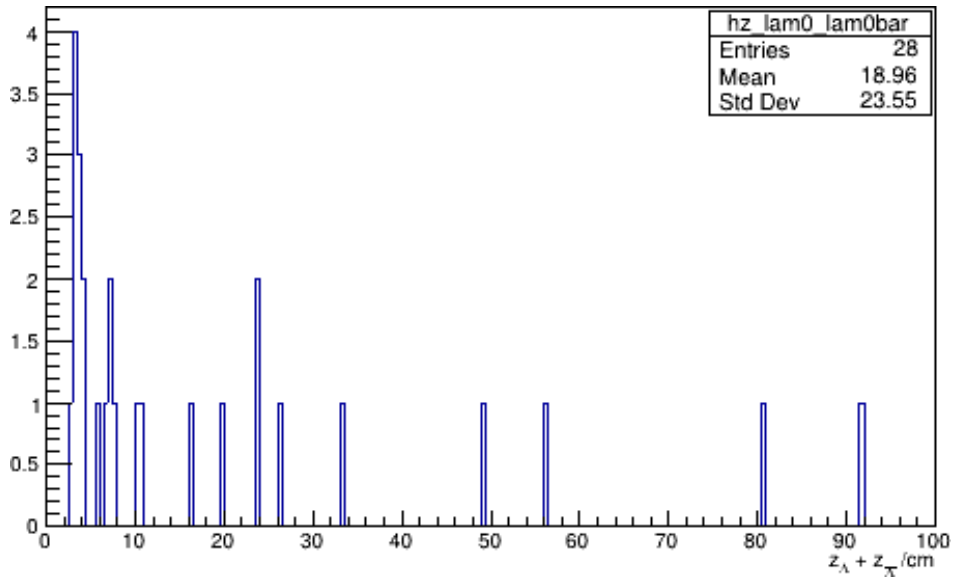


Figure: $\bar{p}p \to \bar{p}\pi^+ p\pi^-$