The Reaction $\vec{\gamma} p \rightarrow \{\bar{\Lambda}\Lambda\} p$ Revealed with GlueX

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GlueX Production and Analysis Meeting

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GlueX Interest in $\vec{\gamma} p \rightarrow \{\bar{\Lambda}\Lambda\} p$

- An exercise, starting Summer 2017, to learn GlueX analysis software, and to see the "lay of the land" for $\Lambda\bar{\Lambda}$ production at GlueX energies
- This reaction has never before been seen: "discovery" exercise
- Work by undergraduate researcher Samuel Dai

Today: First Look at Data Quality

- Event selection
- Beam energy distribution
- Lambda angular distributions in C.M.
  - Forward-backward phenomenology
- Lifetime comparison

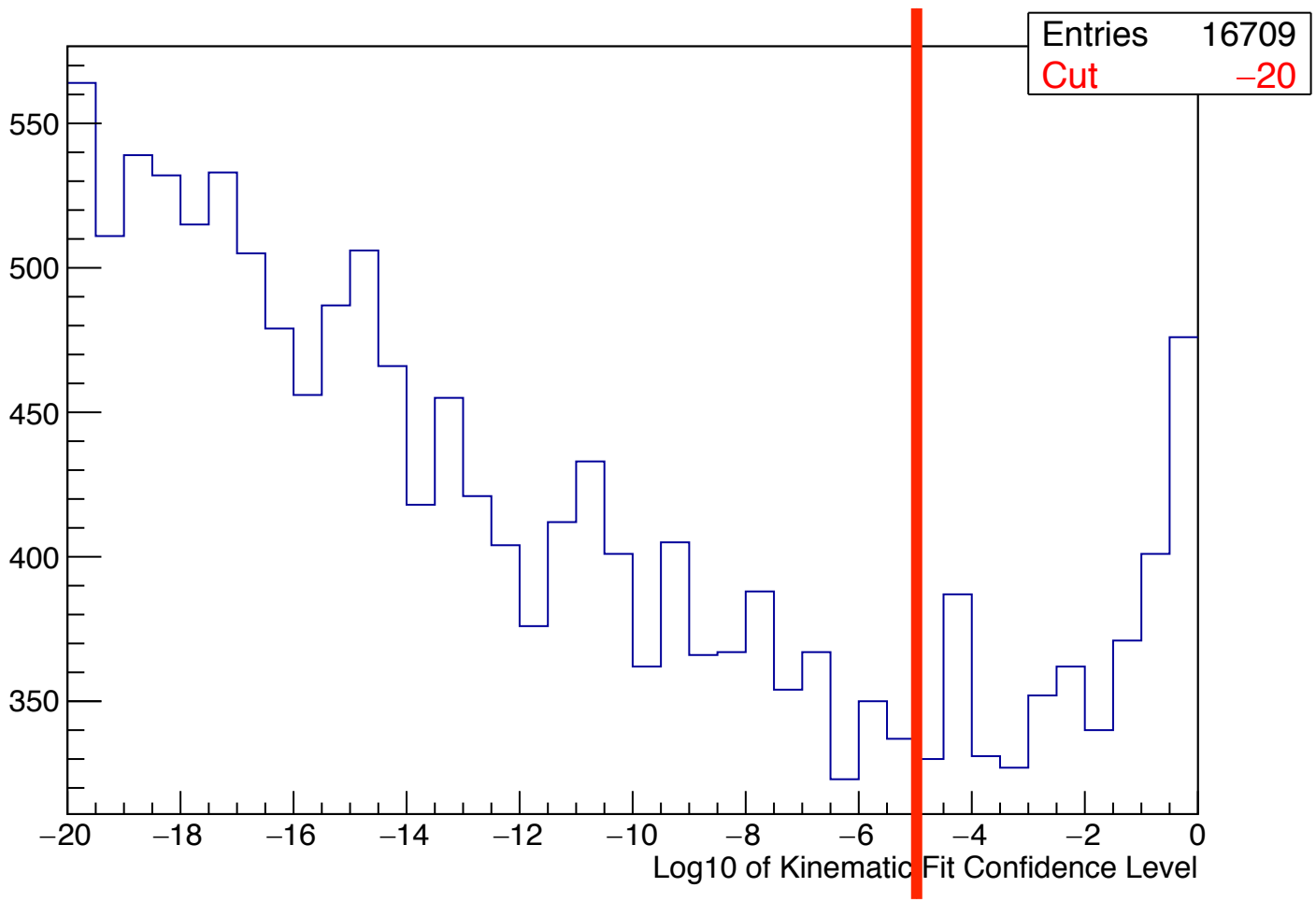
Data Selection

- Used Spring 2016 Runs 11366 to 11663
- JANA skim
  - Exclusive reaction: detect FIVE hadrons
  - Require kinematic fit to exclusive

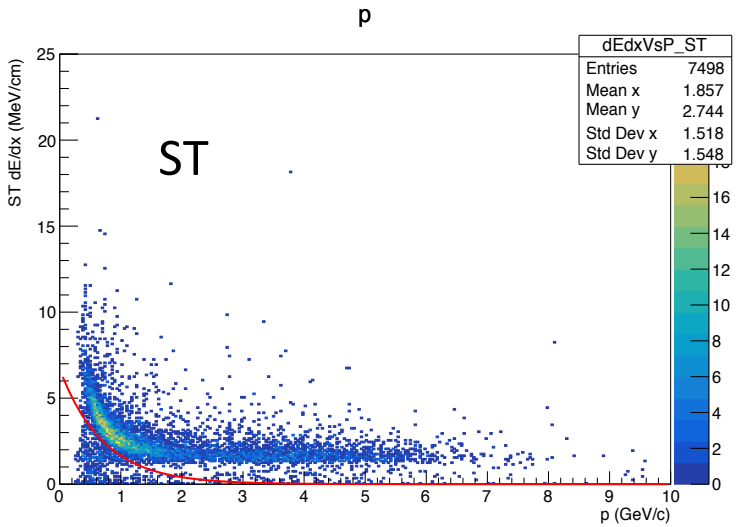
$$\gamma p \rightarrow p\bar{\Lambda}\Lambda \rightarrow p\pi^{+}\bar{p}\pi^{-}p$$

  - Detached vertices computed
  - Lambda masses constrained
- "standard" dE/dx and timing cuts

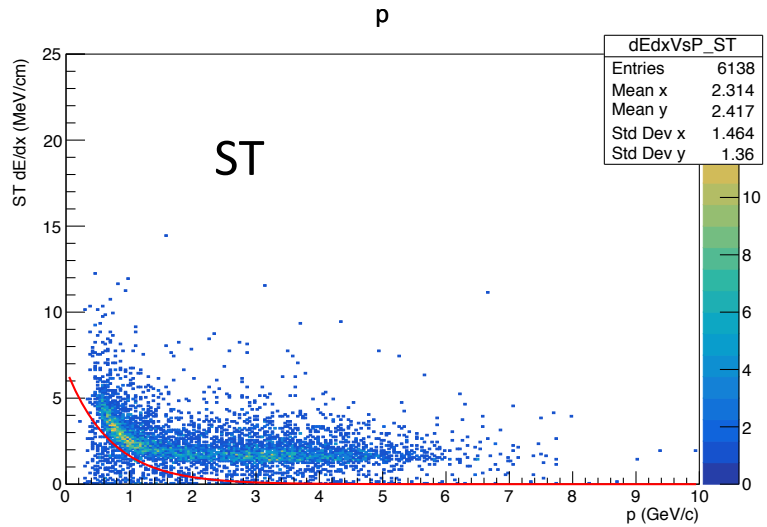
Kinematic Fit Confidence Level



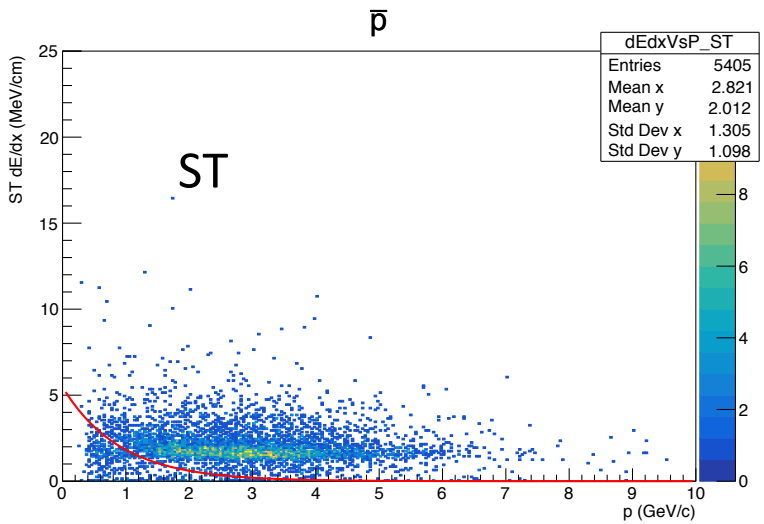
Pre-dE/dx Cut



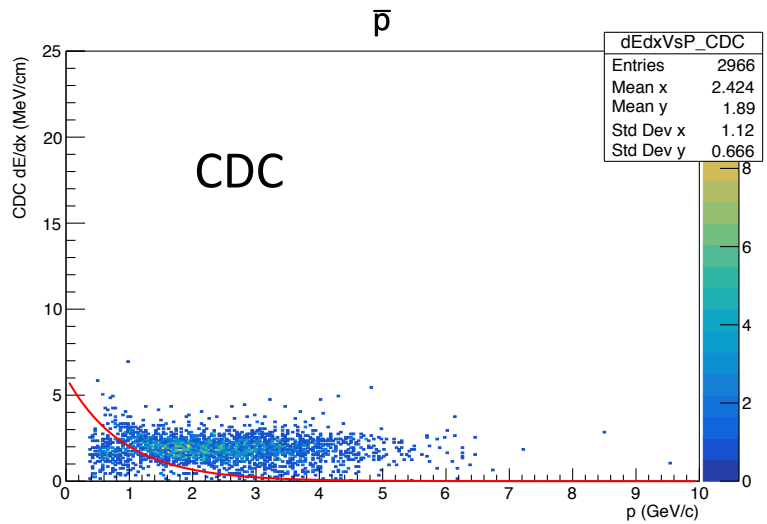
Recoiling Target Proton



Lambda Decay Proton

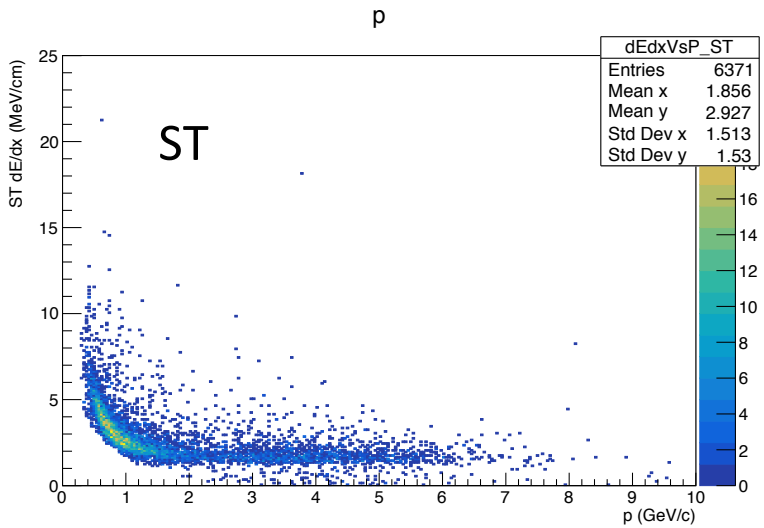


AntiLambda Decay AntiProton

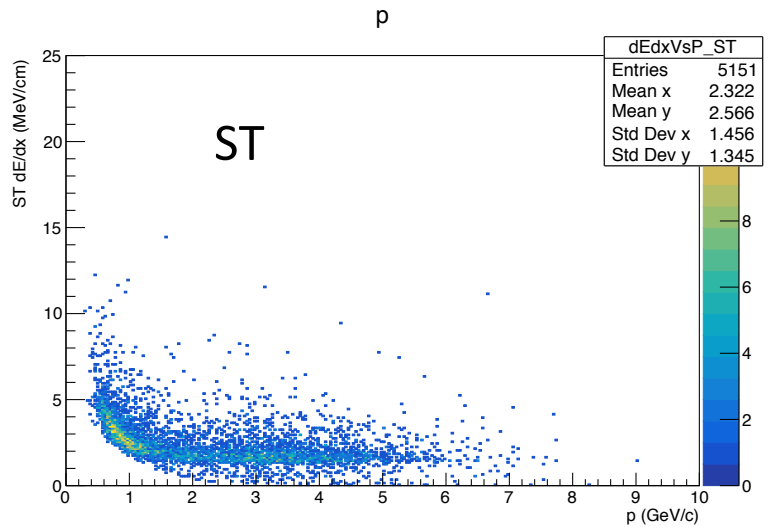


AntiLambda Decay AntiProton

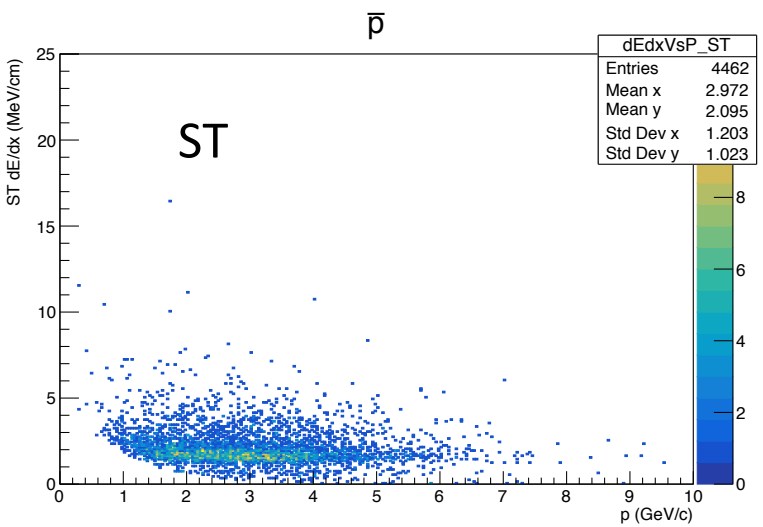
Post-dE/dx Cut



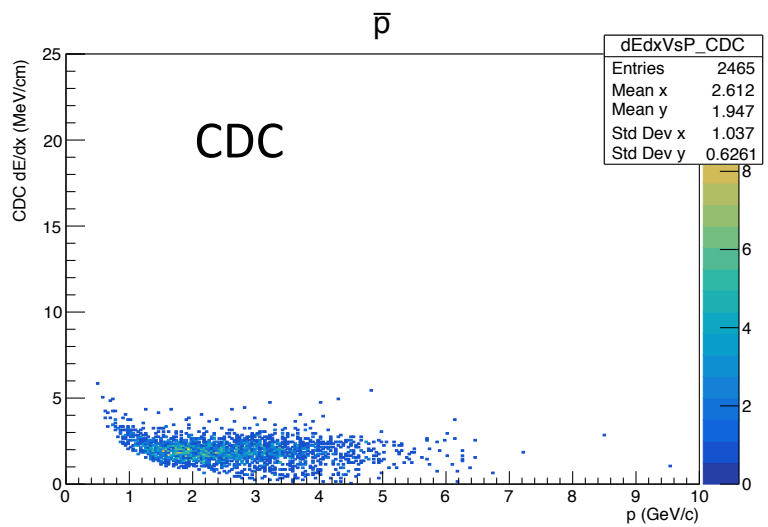
Recoiling Target Proton



Decaying Lambda Proton

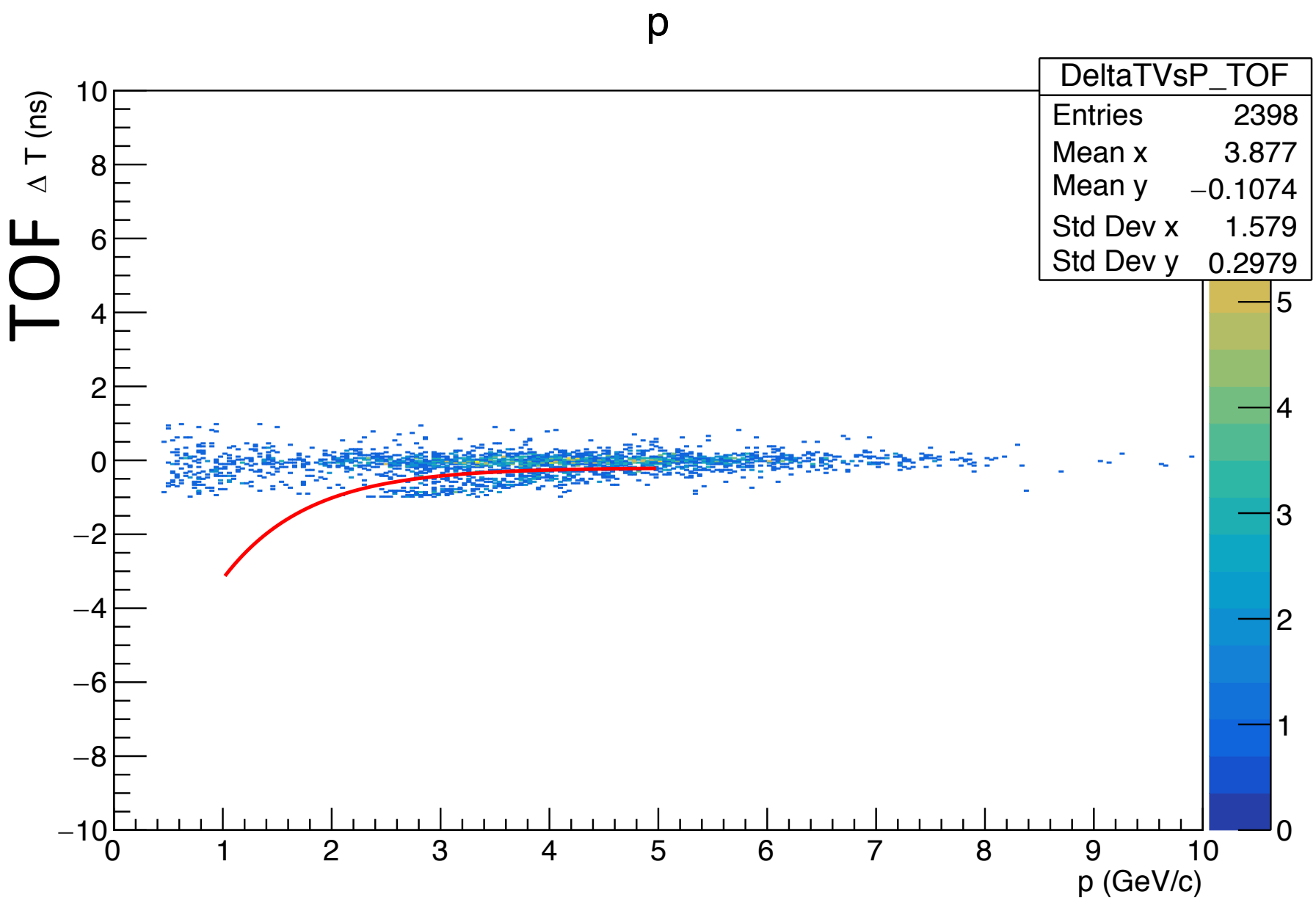


Decaying AntiLambda AntiProton

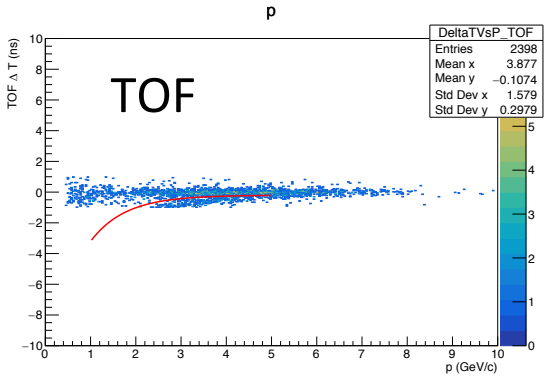


Decaying AntiLambda AntiProton

Pre-dE/dx Cut


p
DeltaTVsP_TOF
Entries 2398
Mean x 3.877
Mean y −0.1074
Std Dev x 1.579
Std Dev y 0.2979
TOF Δ T (ns)
p (GeV/c)

Pre-ΔT Cut



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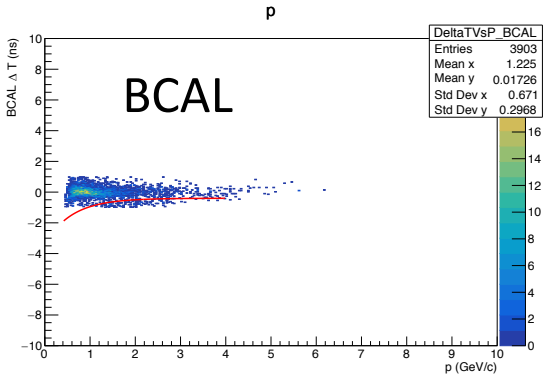

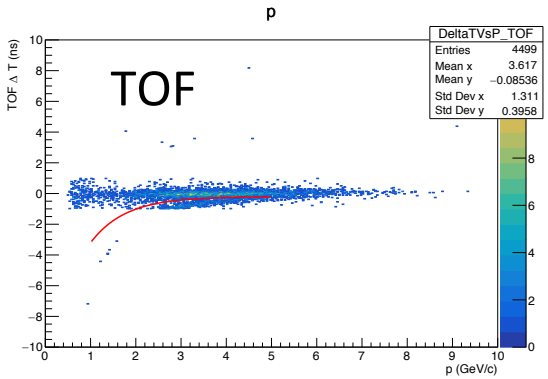

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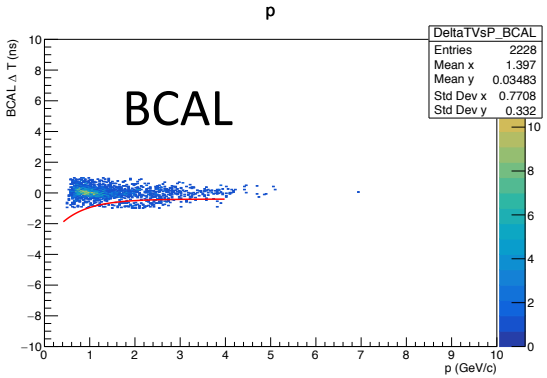
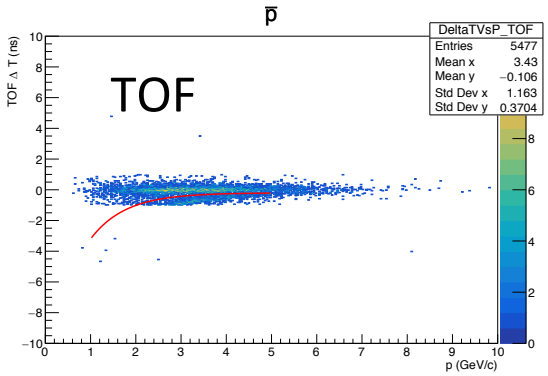
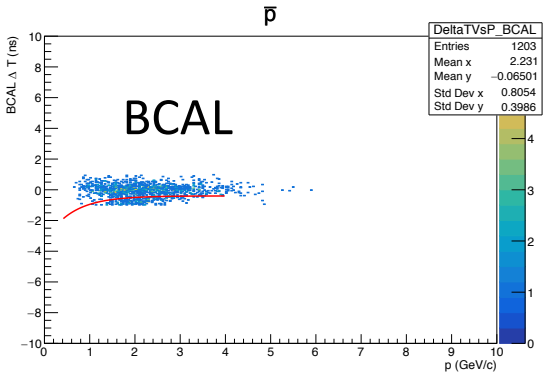
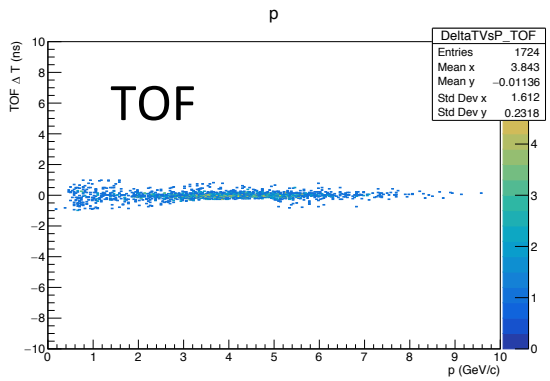




Decaying AntiLambda AntiProton



Post-ΔT Cut



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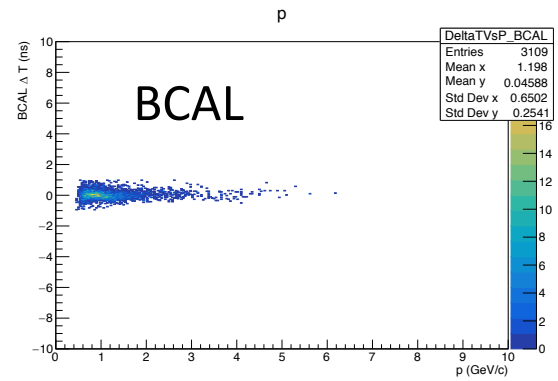

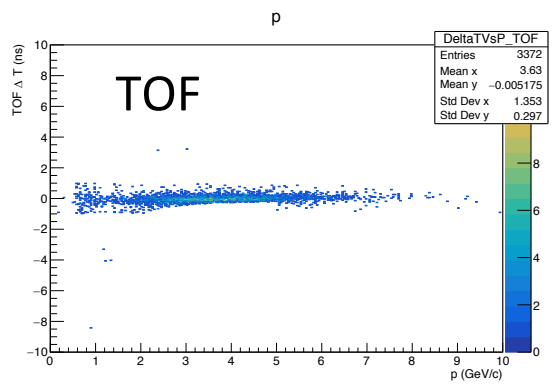

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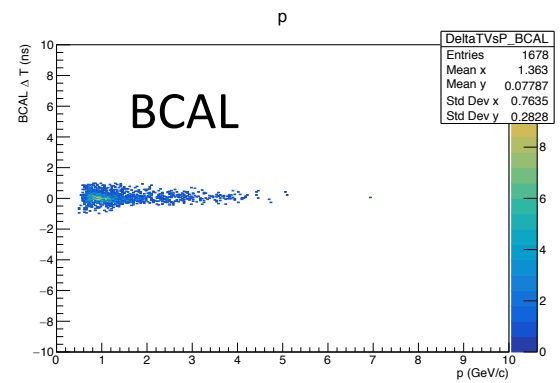
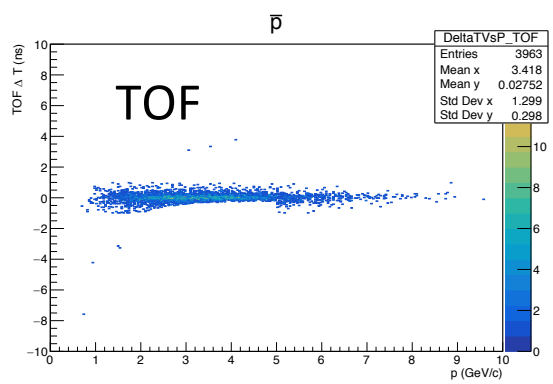
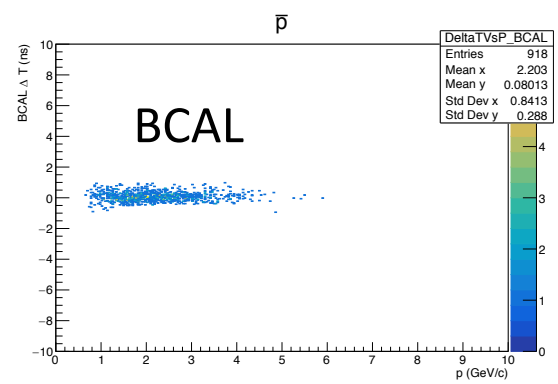


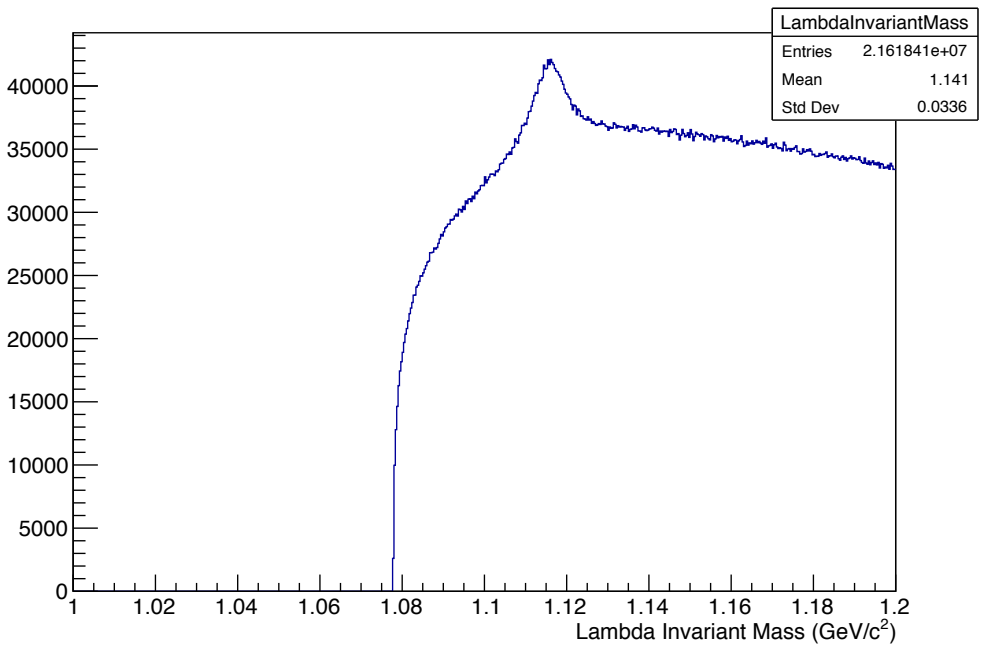


Decaying AntiLambda AntiProton

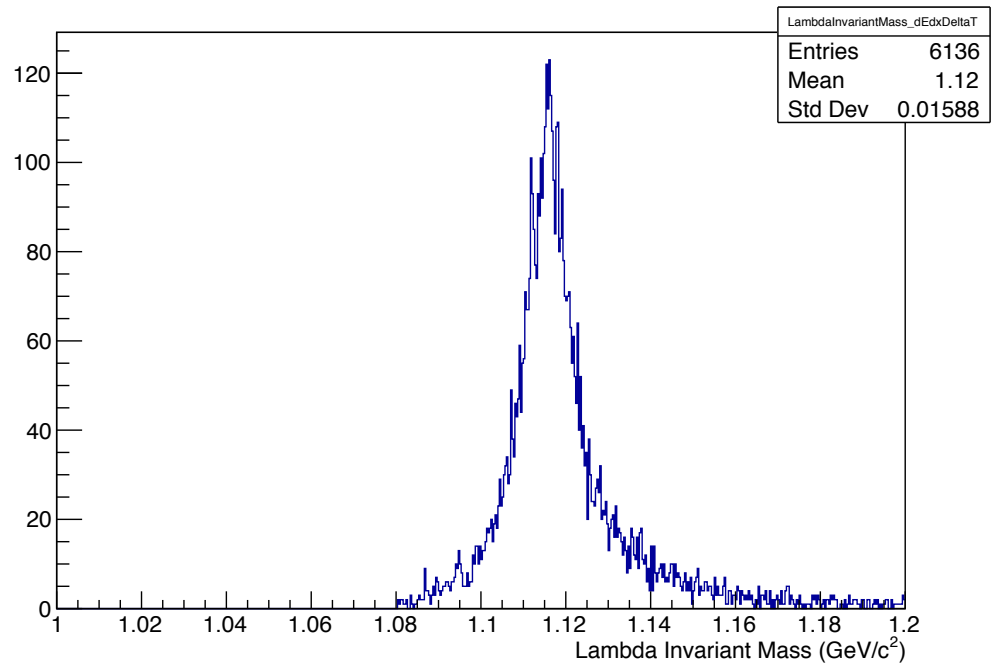


Lambda Invariant Mass

Before All Cuts

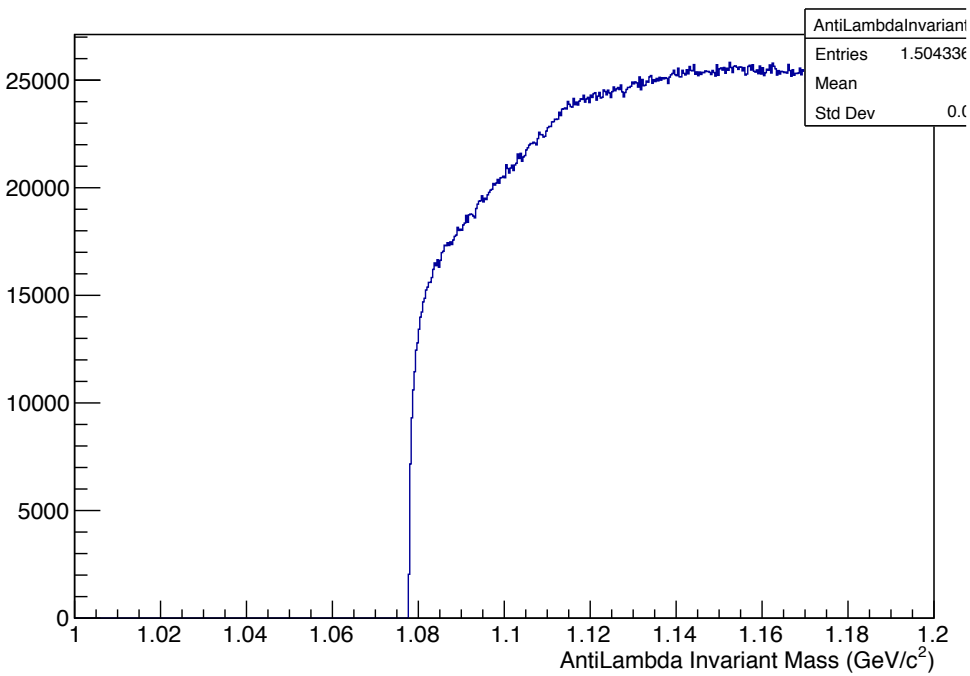


After All Cuts

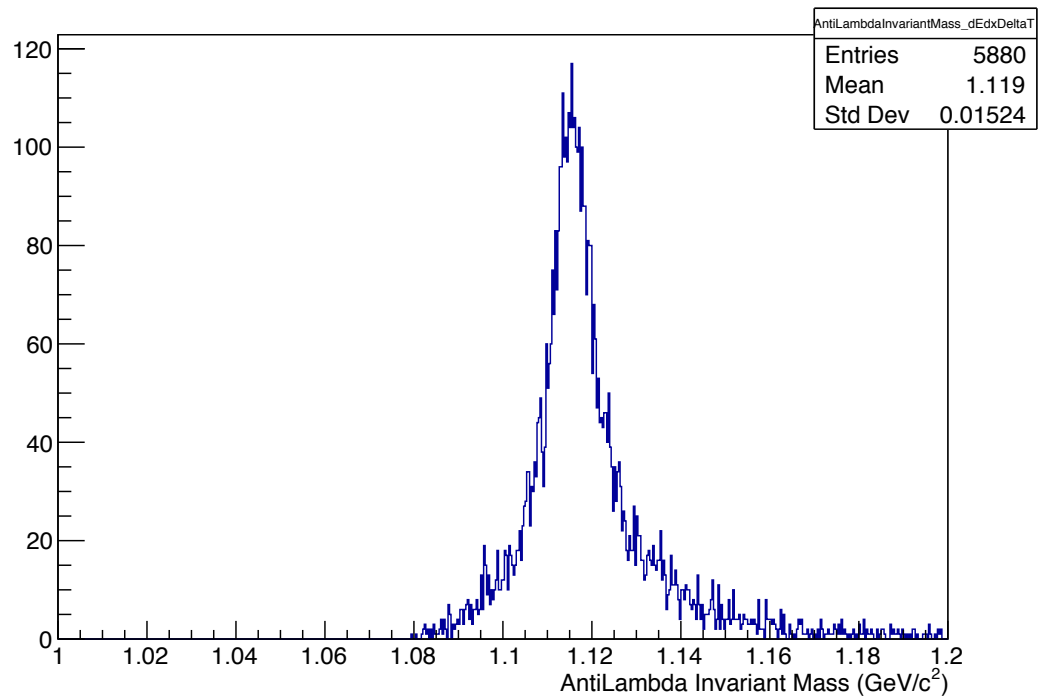


AntiLambda Invariant Mass

Before Cuts

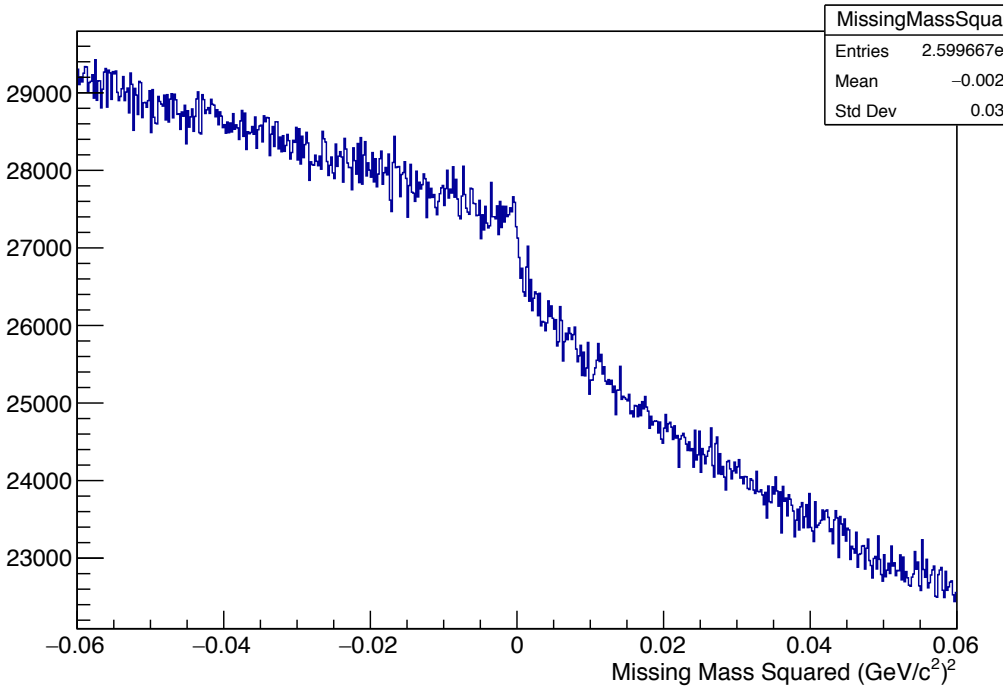


After Cuts

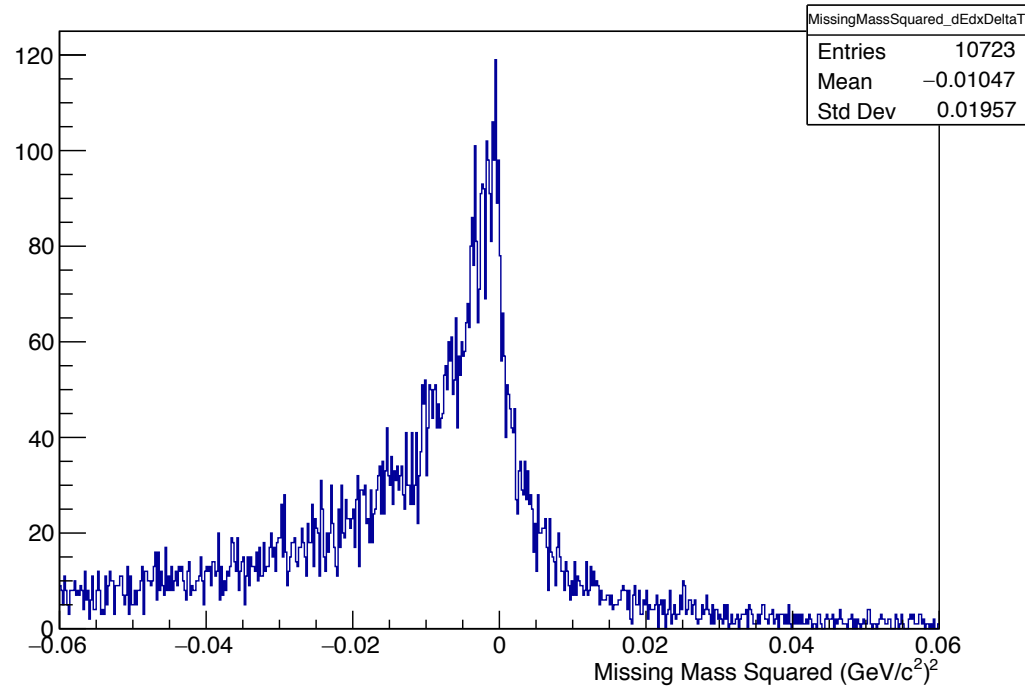


Missing Mass Squared

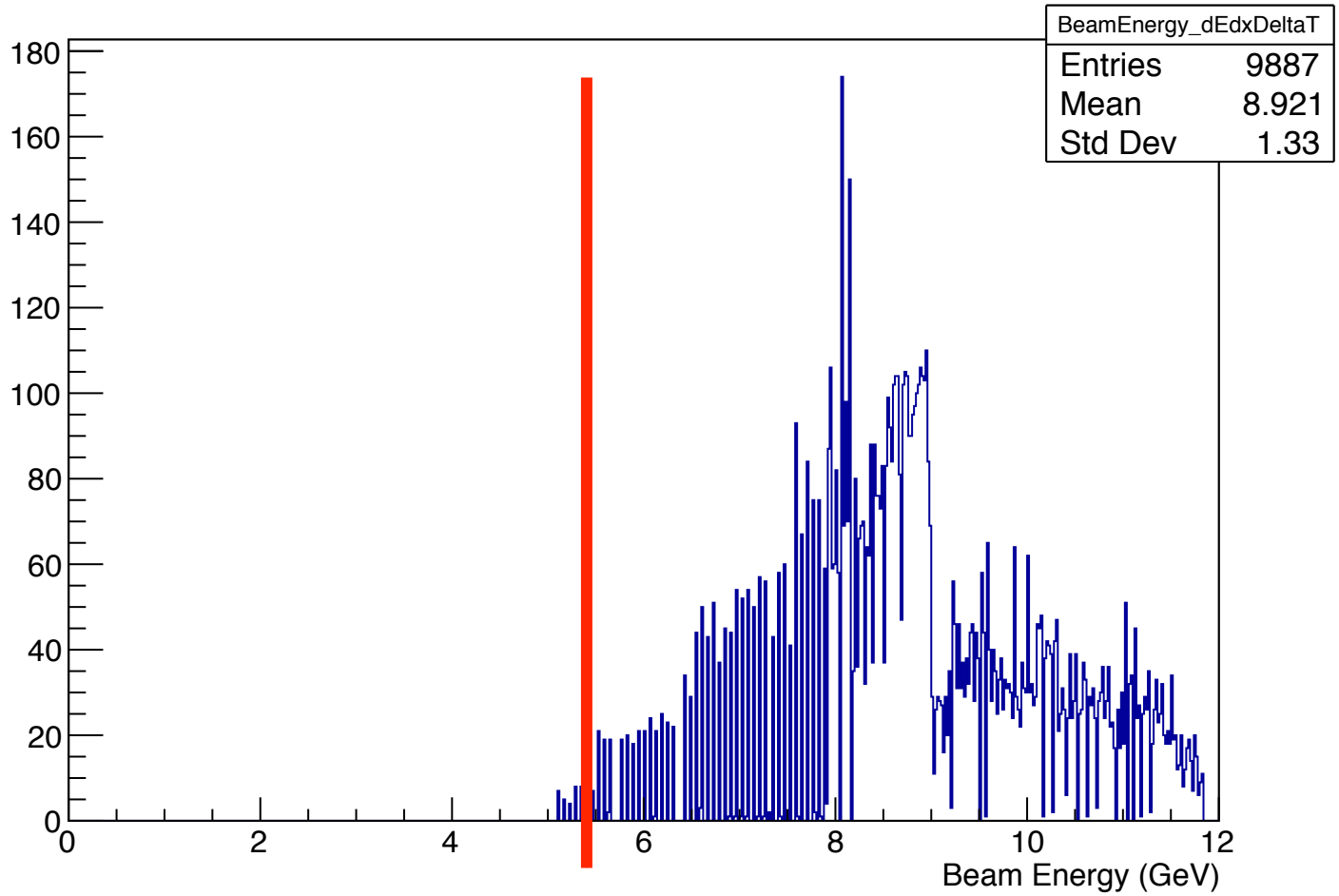
Before Cuts



After Cuts

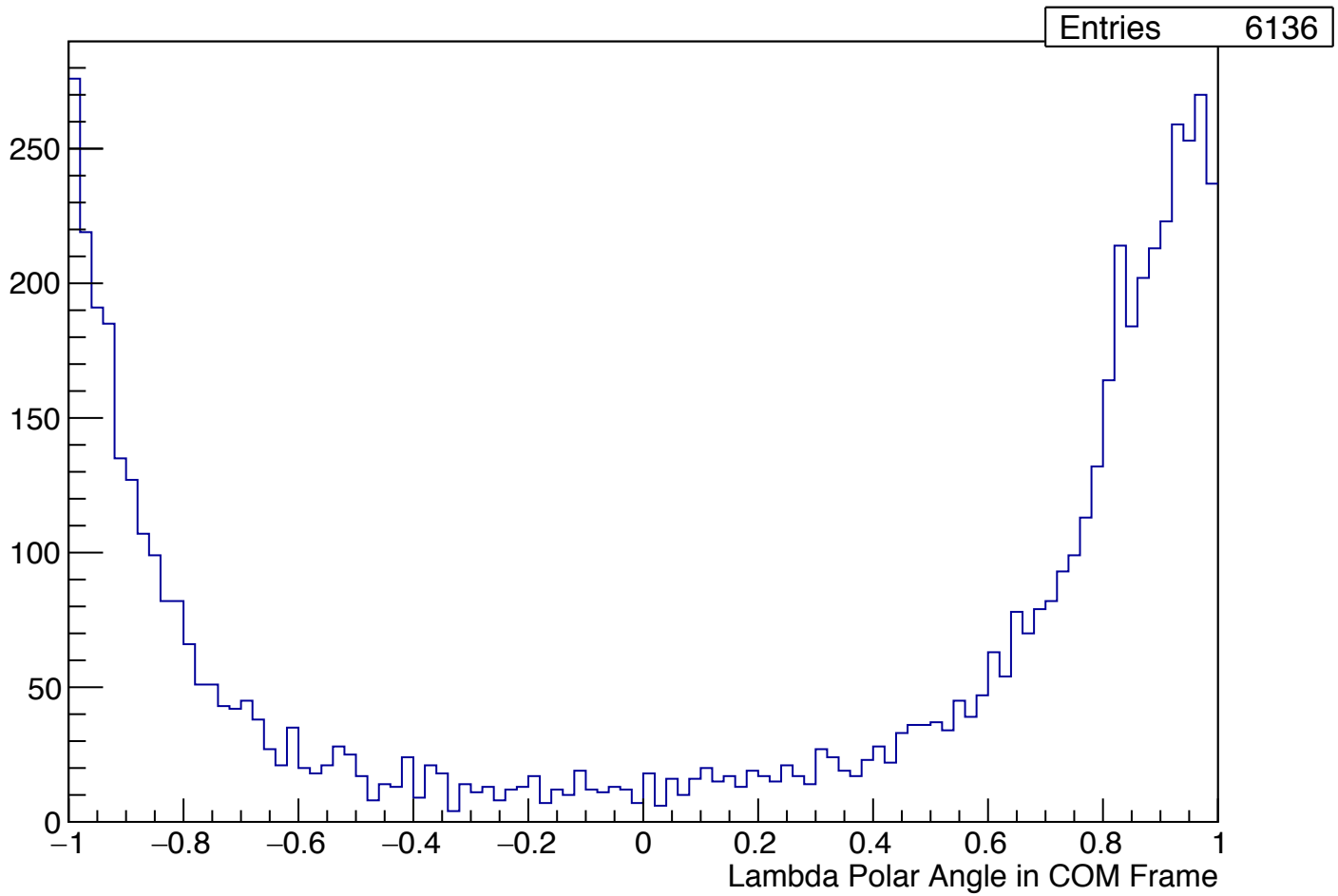


Beam Energy Distribution

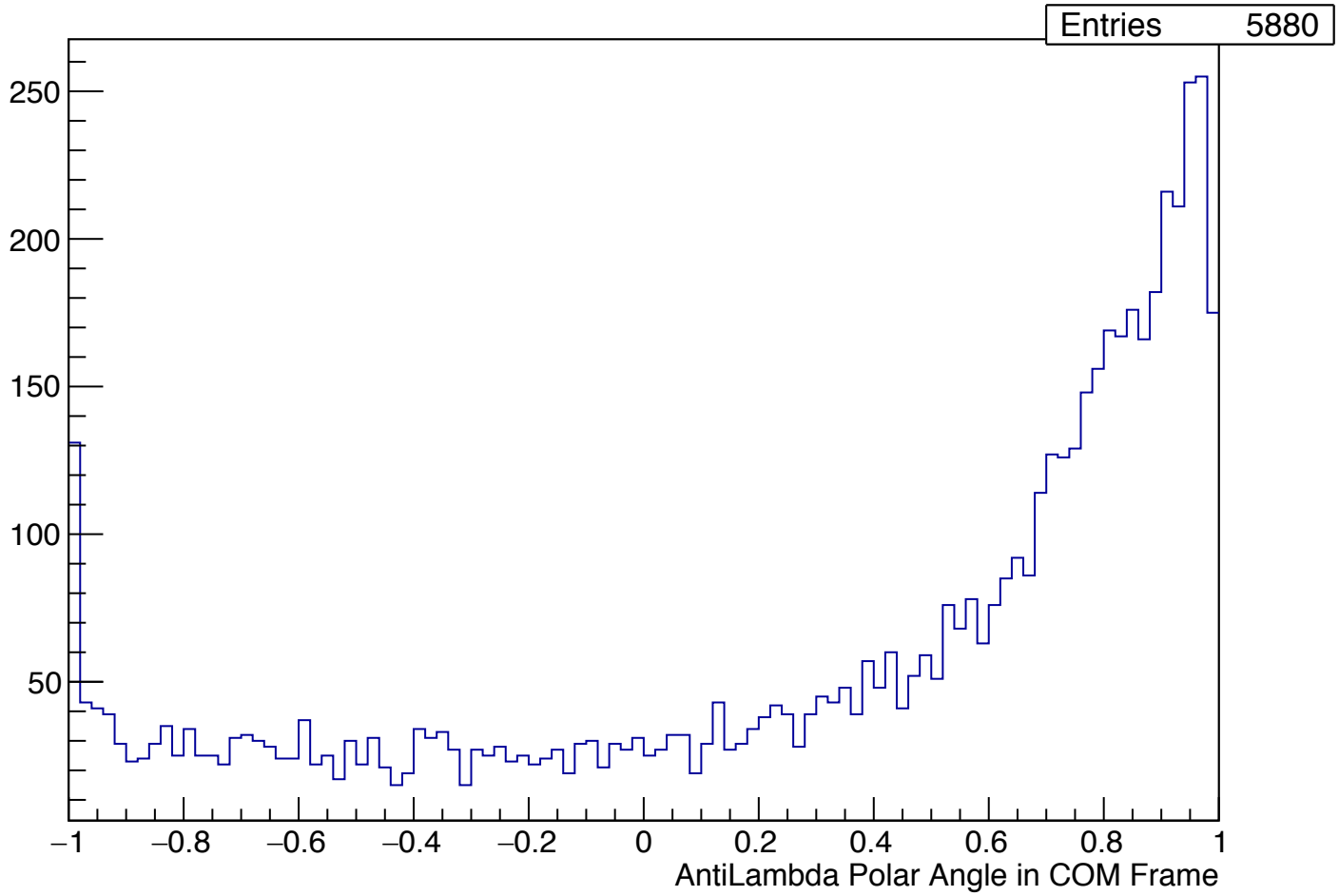


- Now, how would you guess that the Lambda particles are distributed in CM angle?
  - uniformly?
  - forward?
  - backward?

Lambda Polar Angle in CM



AntiLambda Polar Angle in CM



Reaction Mechanism

- The anti-Lambda is always forward
- The Lambda can be forward or backward
- Two t-channel amplitudes:
  - Nonstrange: recoil proton goes backward
    - Pomeron or pion exchange
  - Strange: recoiling Lambda goes backward
    - Kaon exchange

CPT Invariance Test

- Lifetimes for particle and anti-particle must be the same:

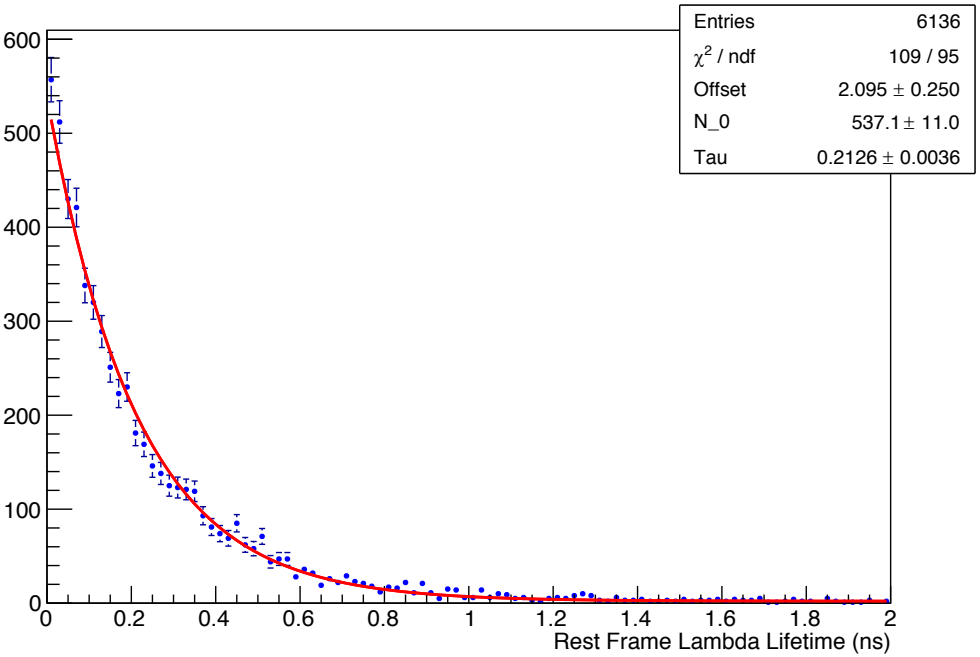
$$\tau_{\Lambda} = \tau_{\bar{\Lambda}} \quad \text{(by CPT)}$$

$$\tau_{\Lambda} = 263.2 \pm 2.0\, ps$$

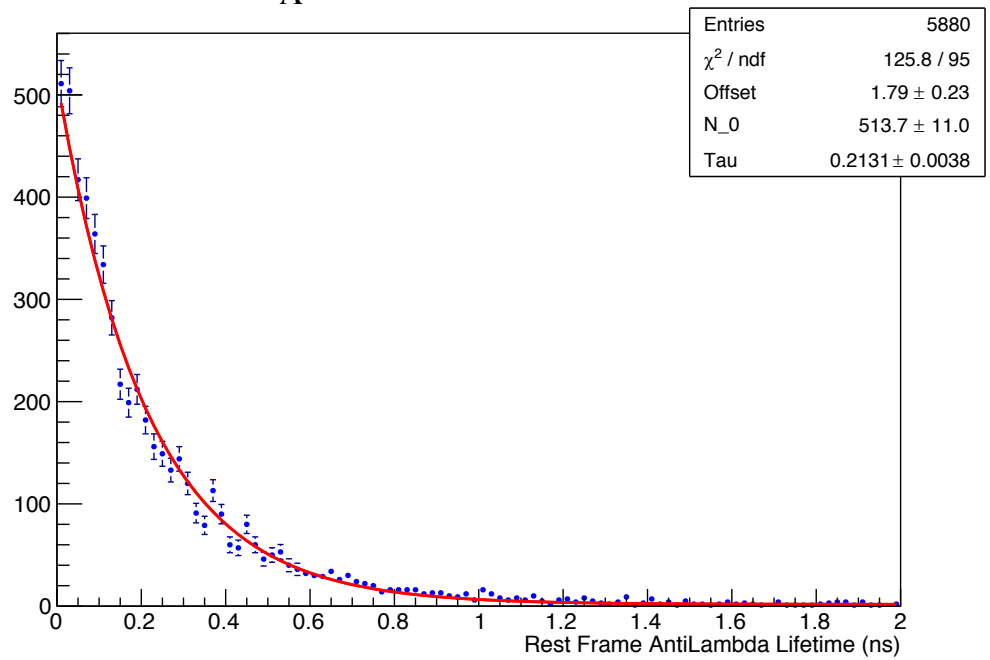
$$\left(\tau_{\Lambda} - \tau_{\bar{\Lambda}}\right) / \tau_{\Lambda} = -0.001 \pm 0.009 \text{ (PDG)}$$

Reconstructed Lifetimes

$$\tau_{\Lambda} = 212.6 \pm 3.6\,ps$$



$$\tau_{\bar{\Lambda}} = 213.1 \pm 3.8\,ps$$



NO acceptance corrections have been made.

Summary

- We see the reaction!
  - CL distribution looks poor; what to do?
- PID cuts are mild, but some background remains (probably)
- Interesting angular distributions seen
- Lifetimes are too short: need to test & correct with Monte Carlo
- Have ~x2.5 statistics from 2017 run
- (Defer showing other physics observations to another meeting)

Supplemental Slides

Research Outline re $\vec{\gamma} p \rightarrow \{\bar{\Lambda}\Lambda\} p$

- Study the reaction mechanism
  - Compare to $\bar{p}p$
  - Cross section measurements
- Hunt for continuum resonances in $p\bar{\Lambda}$ and $\Lambda\bar{\Lambda}$ "baryonium states"
- Spin correlations
  - Singlet fraction
- CP violation test
- CPT test