Possibilities of Measuring $\eta_C \to p\bar{p}$ at SPD

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PYTHIA Details

- $m_{\eta_C} = 2.984$ GeV$/c^2$, BR $(\eta_C \to p\bar{p})$: 1.45×10^{-3}
- PYTHIA does not hadronize η_c. *J/Ψ used instead for study*
- Only J/Ψ produced in $p + p$ collision : *Charmonium:gg2ccbar(3S1)[3S1(1)]g = on,off*
- $J/\Psi \to p\bar{p}$ decay forced : *443:oneChannel = 1 1 0 2212 -2212*
- Signal events normalized to 600K (expected events : SPD CDR) for one year of data at design luminosity
- MinBias (*SoftQCD:all = on)* studied for background
- Normalized to 39800B MinBias events (39.8 mb cross-section at $\sqrt{s} = 27$ GeV, 1 fb^{-1} integrated luminosity)
- Momentum resolution used : $\frac{\delta p}{p} = 0.02 + 0.002p$
- Basic selection criteria for $p, \bar{p}$: $p_T > 0.2$ GeV/c, $-3. \leq y \leq 3.$, more on cuts as we go

Daughter Multiplicity and Invariant Mass Distributions

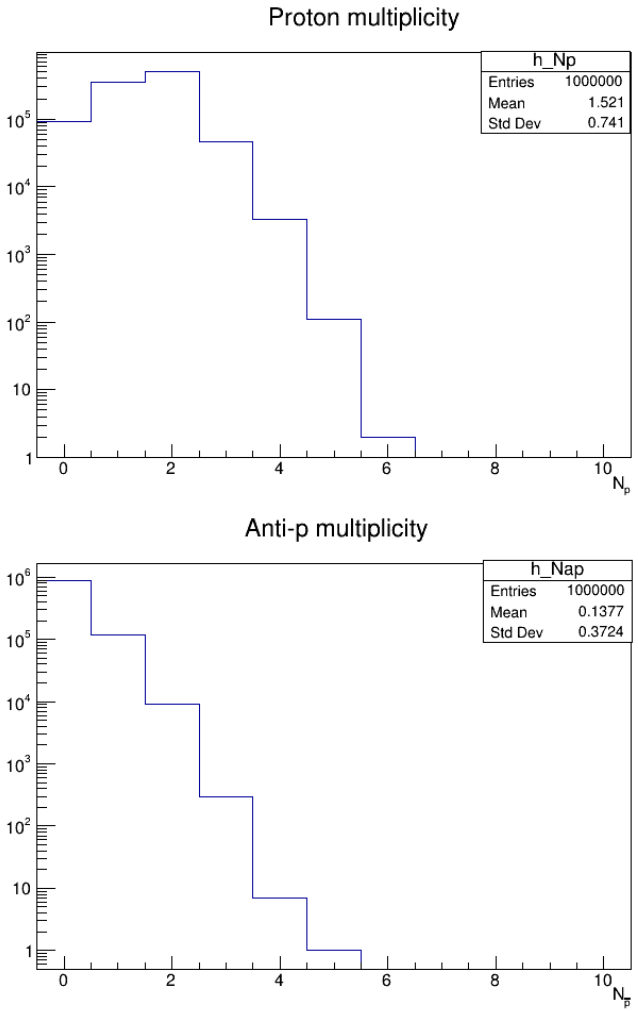


Figure 1: Multiplicities of protons (above) and antiprotons (below) in MinBias events (bkg)

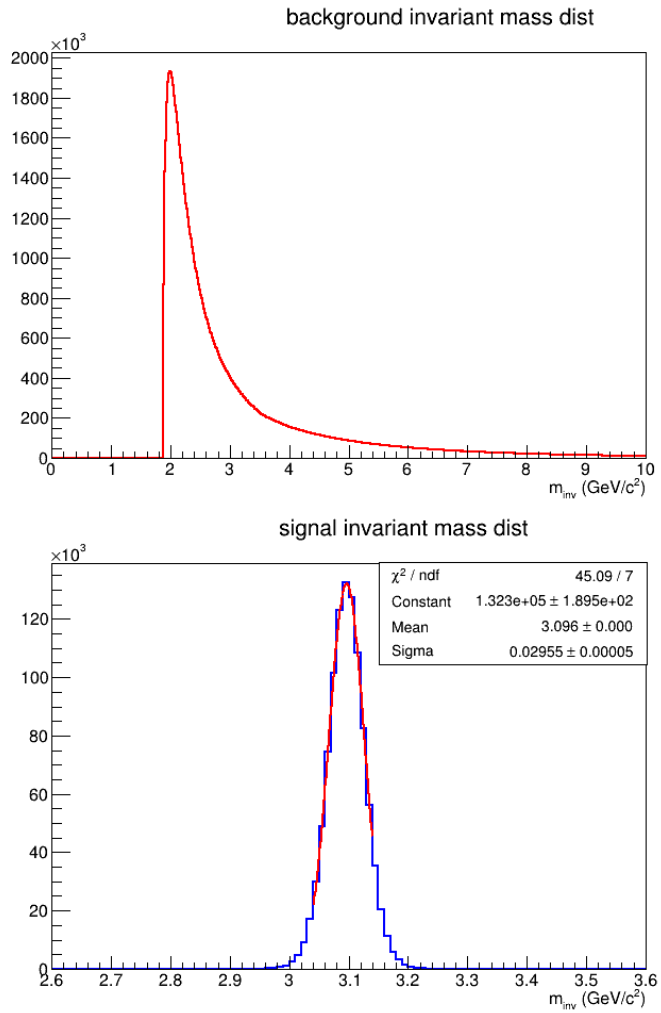


Figure 2: Overall invariant mass distribution of background (above) and signal (below)

Four Sets of Cuts for Comparison of Variables

- To clear multiple/other decays, events with single anti-protons are considered only
- $p, \bar{p}$: $p_T > 0.2$ GeV, $-3. < y < 3.$ (basic cut for tracker and SPD acceptance)
- $y \sim 3.$ corresponds to $2 - 5$ degrees depending on particle and momenta
- $p, \bar{p}$: $p_T > 0.2$ GeV, $-3. < y < 3.$, $cos(\theta) < 0.9$
- $cos(\theta) < 0.9$ correspond to ~ 26 degrees, roughly restricts daughter particles to barrel only
- $p, \bar{p}$: $p_T > 1.0$ GeV, $-3. < y < 3.$, $cos(\theta) < 0.9$
- $p, \bar{p}$: $p_T > 2.0$ GeV, $-3. < y < 3.$, $cos(\theta) < 0.9$

Polar Angle : Protons

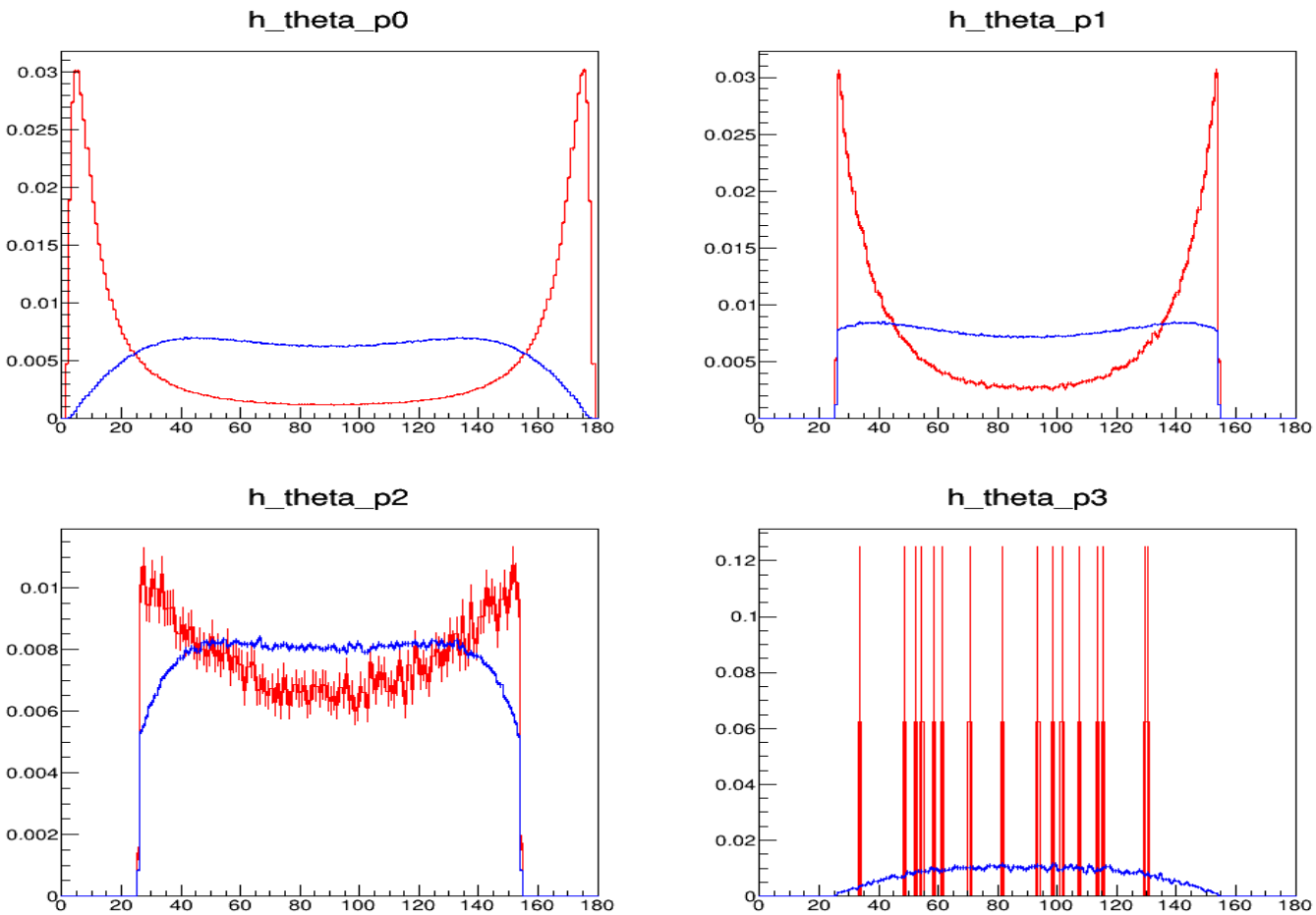
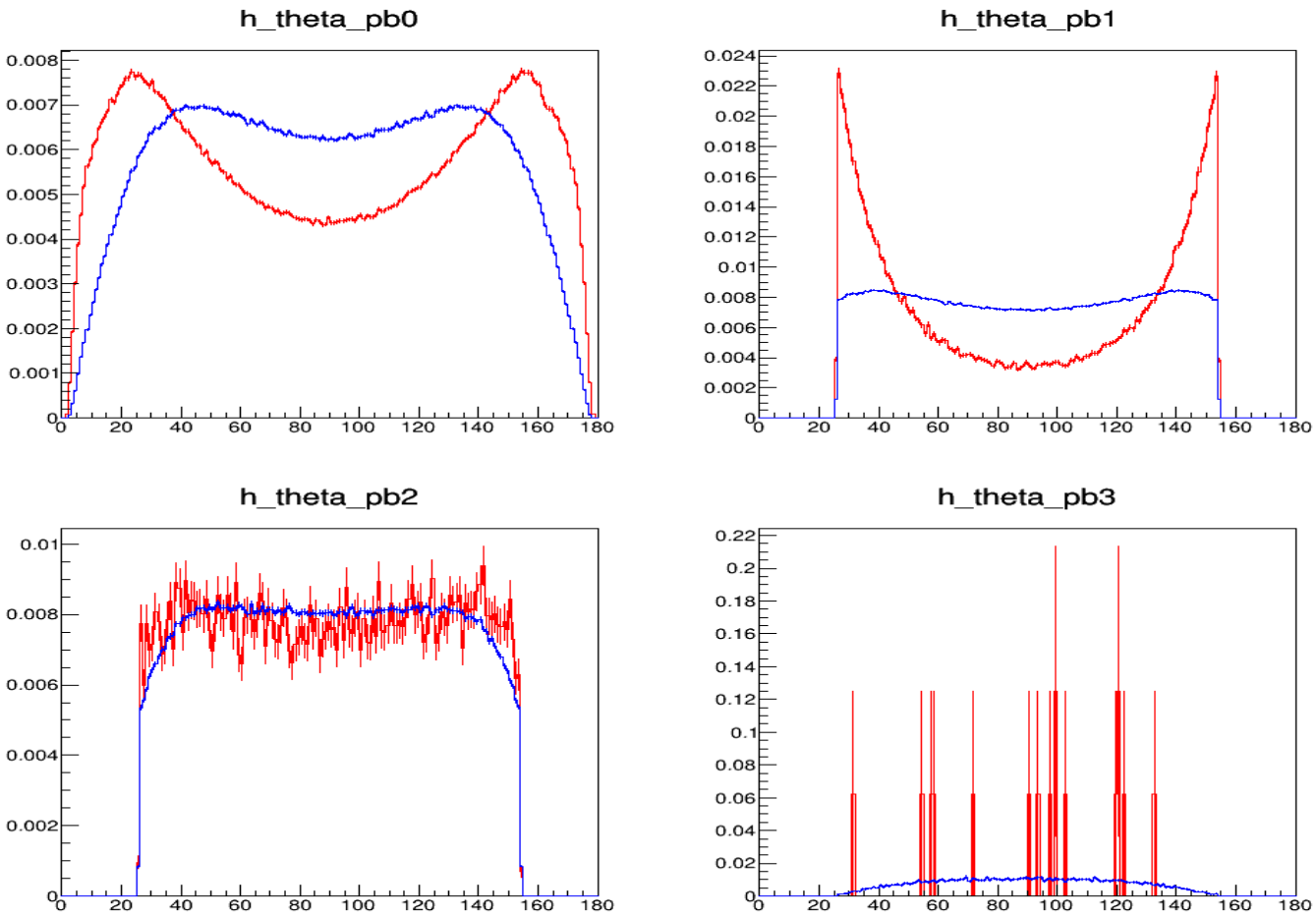


Figure 3: Polar angle (θ) of p in degrees: signal, background

- Mostly fwd and bkwd protons
- Cuts down as we require higher p_T
- More bkg protons as we move from mid-rapidity
- Decision : require $45^0 \leq \theta \leq 135^0$ to cut on background and keep most of signal

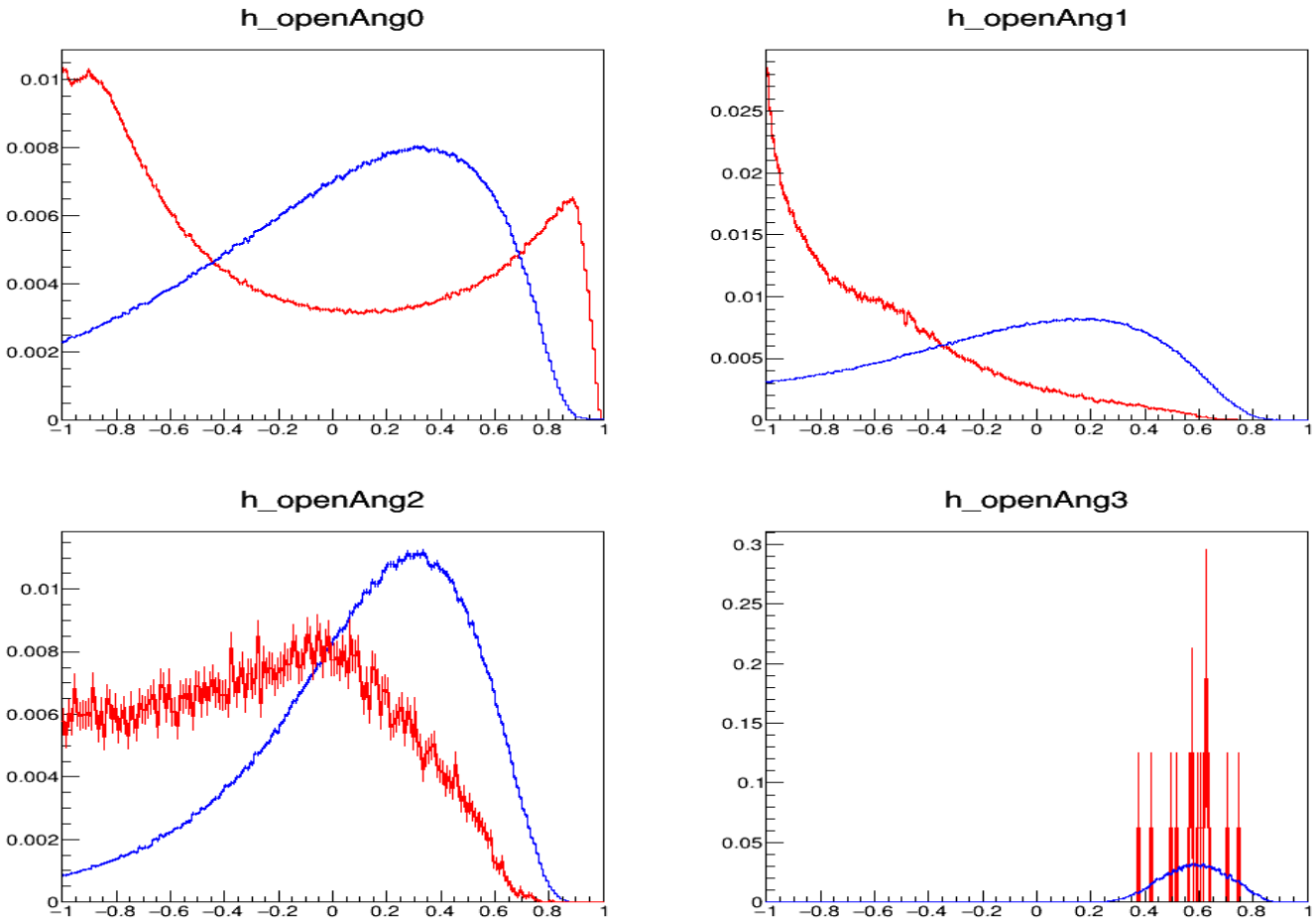
Polar Angle : Antirotons



- Similar pattern as for protons
- Similar cut introduced

Figure 4: Polar angle (θ) of $\bar{p}$ in degrees : signal, background

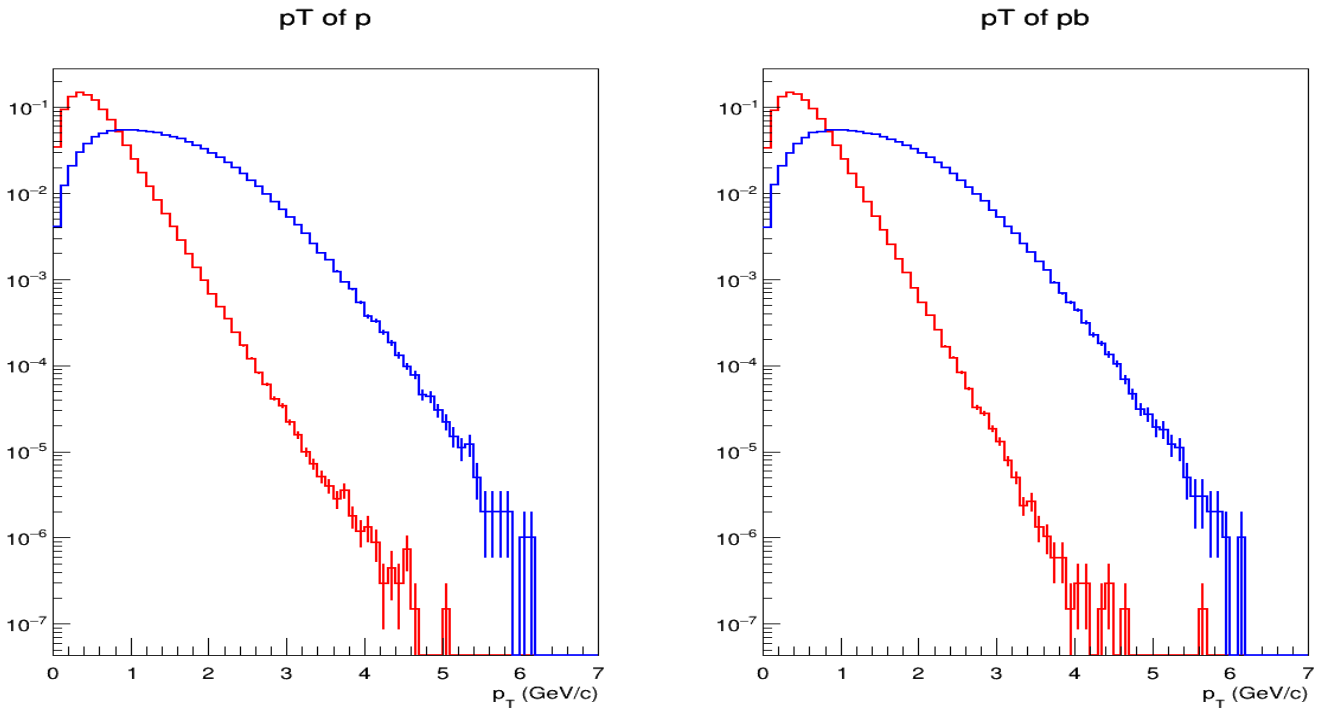
Opening Angle



- Many back to back combinations to start with
- Clear pattern for large angles for bkg
- Decision : require $cos(\alpha) > 0$.

Figure 5: Cosine of opening angle : signal, background

Daughter Particle p_T



- Bkg dominated by low pT particles
- Decision : try various p_T cuts, $p_T > 1$ GeV/c seems a natural cut

Figure 6: Transverse momentum of p (left) and $\bar{p}$ (right) : signal, background

Cuts For Sig/Bkg Study

- To clear multiple/other decays, events with single anti-protons are considered only
- $p, \bar{p}$: $p_T > 0.2$ GeV, $-3. < y < 3.$ (basic cut for tracker and SPD acceptance)
- $p, \bar{p}$: $p_T > 0.2$ GeV, $-3. < y < 3.$, $45^0 < \theta_{p,\bar{p}} < 135^0$
- $p, \bar{p}$: $p_T > 0.2$ GeV, $-3. < y < 3.$, $45^0 < \theta_{p,\bar{p}} < 135^0$, $cos(\alpha) > 0.$
- $p, \bar{p}$: $p_T > 0.5$ GeV, $-3. < y < 3.$, $45^0 < \theta_{p,\bar{p}} < 135^0$, $cos(\alpha) > 0.$
- $p, \bar{p}$: $p_T > 1.0$ GeV, $-3. < y < 3.$, $45^0 < \theta_{p,\bar{p}} < 135^0$, $cos(\alpha) > 0.$
- $p, \bar{p}$: $p_T > 2.0$ GeV, $-3. < y < 3.$, $45^0 < \theta_{p,\bar{p}} < 135^0$, $cos(\alpha) > 0.$

Signal and Background : One Year of Data

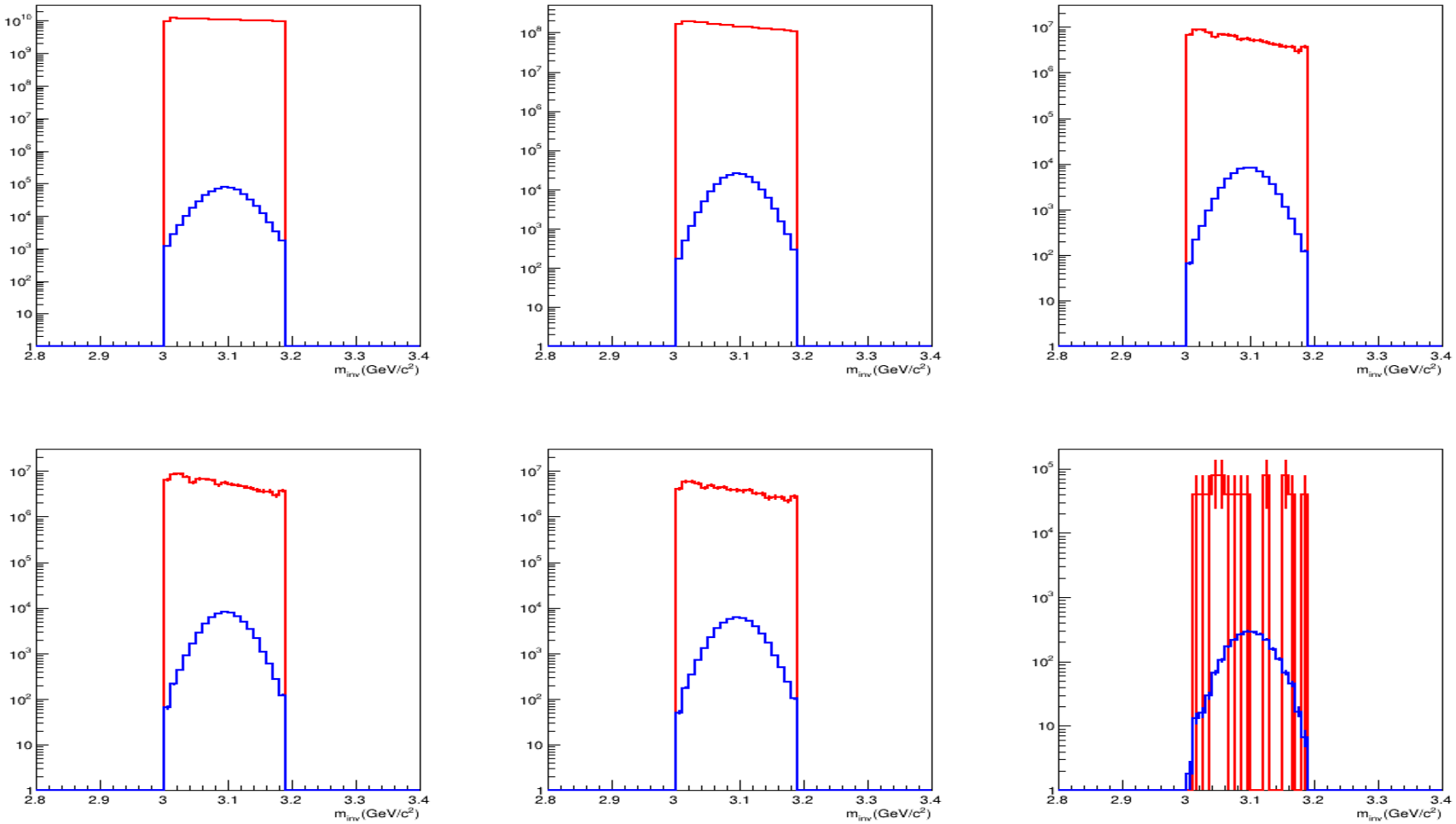


Figure 7: Invariant mass (within 3σ window of signal peak) for six different cut sets : signal, background

Signal and Background : One Year of Data

	Signal (S)	Background (B)	S/B
cut 0	576839	2.059×10^{11}	2.802×10^{-6}
cut 1	183674	2.836×10^{9}	6.476×10^{-5}
cut 2	61342	1.063×10^{8}	5.773×10^{-4}
cut 3	59491	1.032×10^{8}	5.767×10^{-4}
cut 4	46180	1.032×10^{7}	6.292×10^{-4}
cut 5	2353	6.766×10^{5}	3.477×10^{-3}

Table 1: For one year of data at design luminosity, signal and background counts from $\eta_c \rightarrow p\bar{p}$. cut 4 represent daughter $pT > 1$ GeV/c cut. Higher pT cut drastically reduces signal but also improves S/B ratio

Outlook

- Analysis very similar to Nikita Trunovs work
- Somewhat stricter cut on polar angle and opening angle compared to his
- Still too high backgrounds for extraction of signal from fit
- Shall report again if I find something that improves S/B
- From transverse momentum distributions, it is clear we can further reduce background at the cost of signal too
- Not feasible for any asymmetry study, but cross-section measurements at high $p_T > 3\ GeV/c$ bins can be quite possible, especially, with data collected over multiple years
- More ideas for background suppression are welcome

Thank You

Invariant p_T

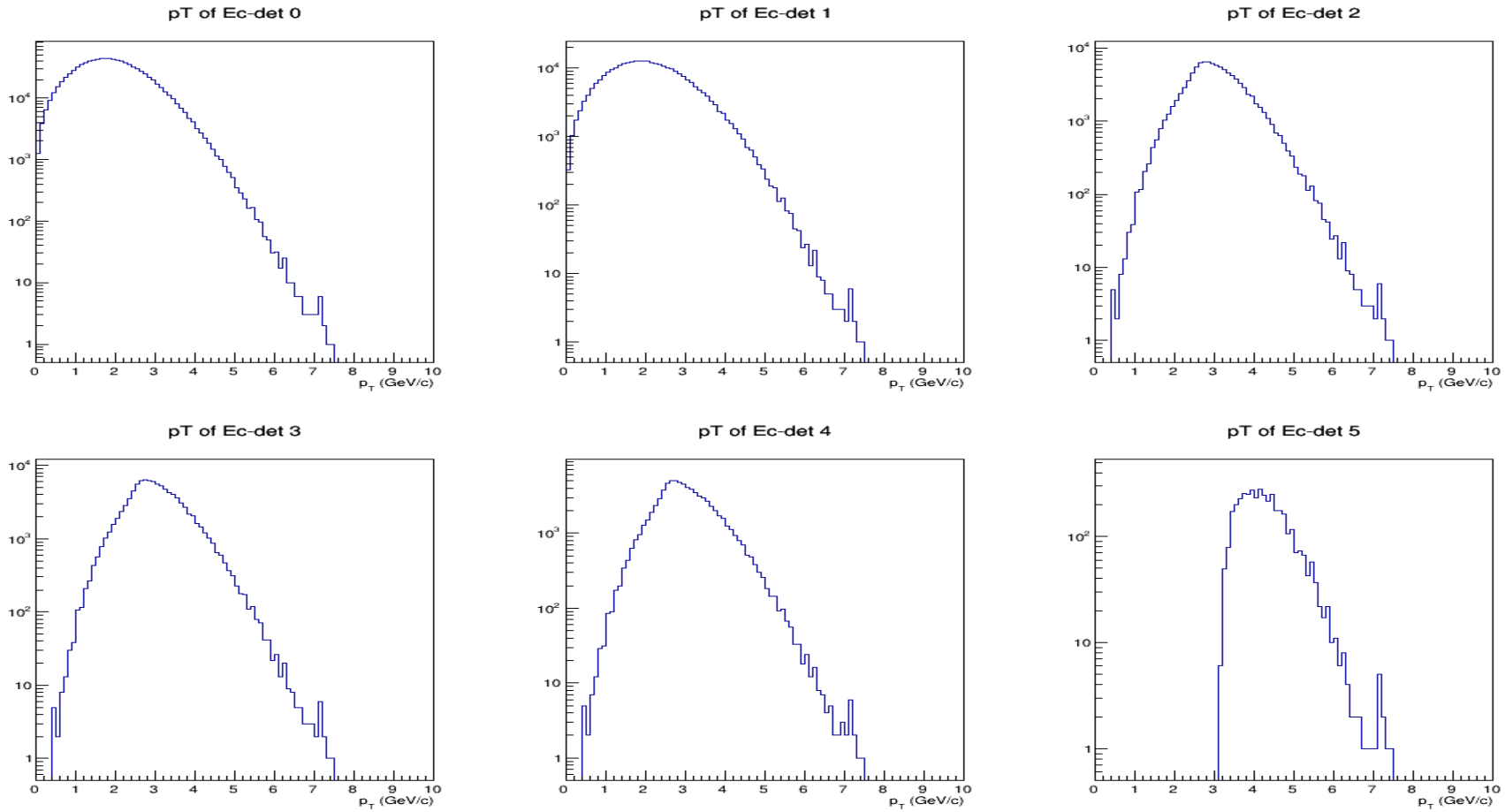


Figure 8: Invariant transverse momentum of signal particle

Invariant x_F

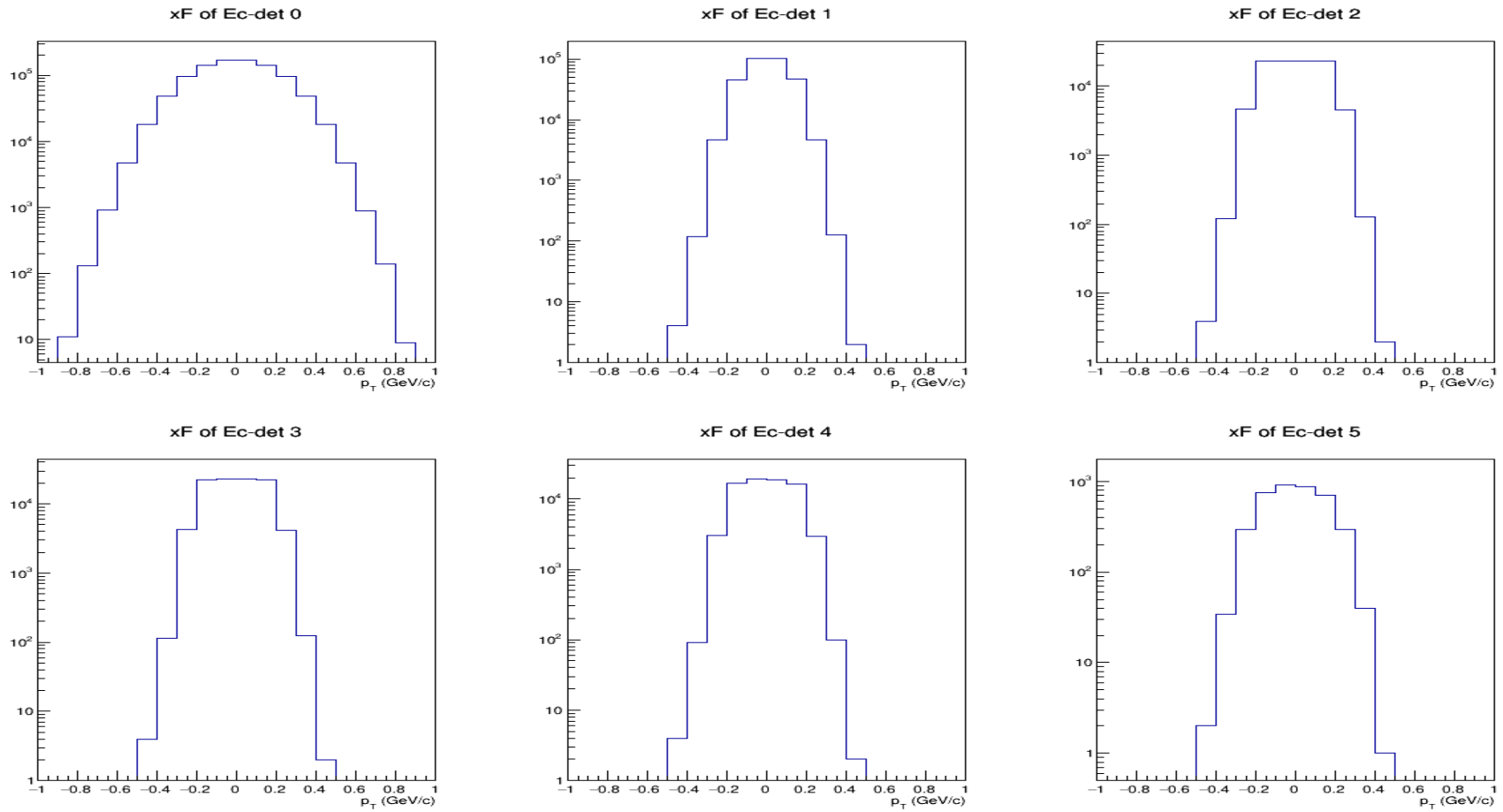


Figure 9: Feynman x of signal particle