D Meson Detection at SPD

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Simulation Details

- A look at D meson detection at SPD using decays into pions and kaons
- $D0 \rightarrow \pi^+ K^-$
- $D^+ \rightarrow \pi^+ \pi^+ K^-$
- SpdRoot simulation
- Signal : 'gg2ccbar + qqbar2ccbar' : Pythia8
- Background : SoftQCD processes EXCEPT elastic : Pythia8
- SpdRoot version 4.1.3 : custom inner tracker with 4 layers MAPS only

Secopndary Vertex Reconstruction

- Vladimir Andreev's sample code for K0decay analysis was VERY useful
- SpdRCVerticesFinder for primary vertex ONLY
- SpdRCKFpartV0Finder for secondary vertex (parameters below)
- min *its* hits : 2, track sel : hard cut, prim vtx : reco
- min chi2 of daughter trk to PV : 0.1
- max chi2 between daughter trks : 20
- invariant mass range $1. \leq m_{inv} \leq 3.$ GeV$/c^2$

Constructing Random Background

- SpdRCKFpartV0Finder uses daughter pid to reconstruct vertex
- $v0\_finder->AddVertexCandidate(211, -321)$; $D0$ decay
- $v0\_finder->AddVertexCandidate(211, 211, -321)$; D^+ decay
- Combinations of pions, kaons and protons (and antiparticles) for both 2-particle decays and 3-particle decays were added to reproduce random background in real data analysis
- Caution : this *may* overestimate background that might be reduced in real data analysis, depending on the performance of the PID detector(s)

Differentiating Criteria

- Using MC info, tracks are traced back to mother particles
- For D : if daughter tracks have same D as mother : signal
- Otherwise background
- decay length, daughter chi2 to prim vtx, invariant candidate chi2 to prim vtx and sec vtx are plotted for signal and background separately to find distinguishing criteria
- The goal is to avoid peaks of background while retaining decent amount of signal
- Most often variables follow similar pattern for signal and background making it difficult

Comparing variables : Decay Length

Decay Length is more useful for D^+ for which $c\tau$ is roughly three times as high as that of the $D0$

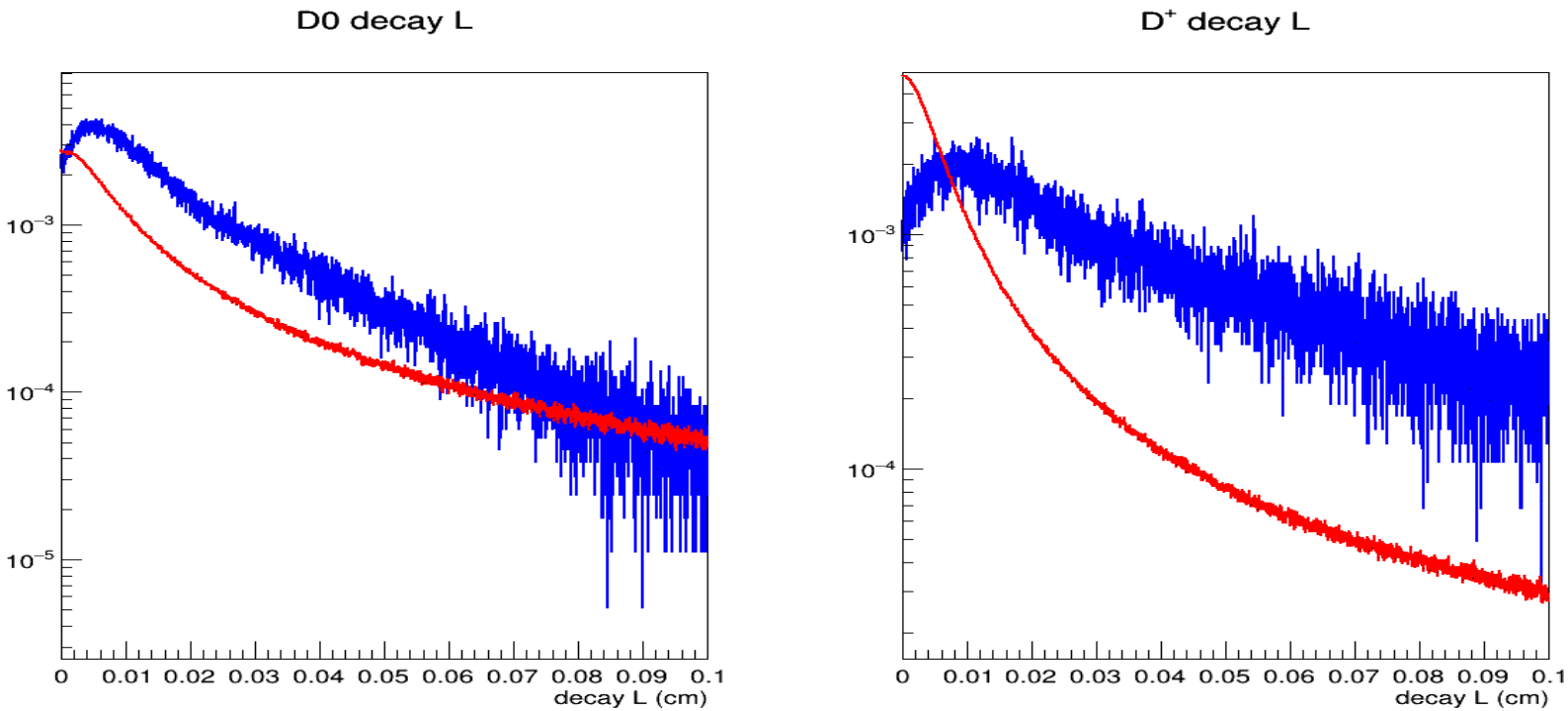


Figure 1: Decay length for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Decay Length/Error

$L/|\delta L|$ a very useful distinguishing criterion. Significant background can be reduced by requiring $L/|\delta L| > 5$

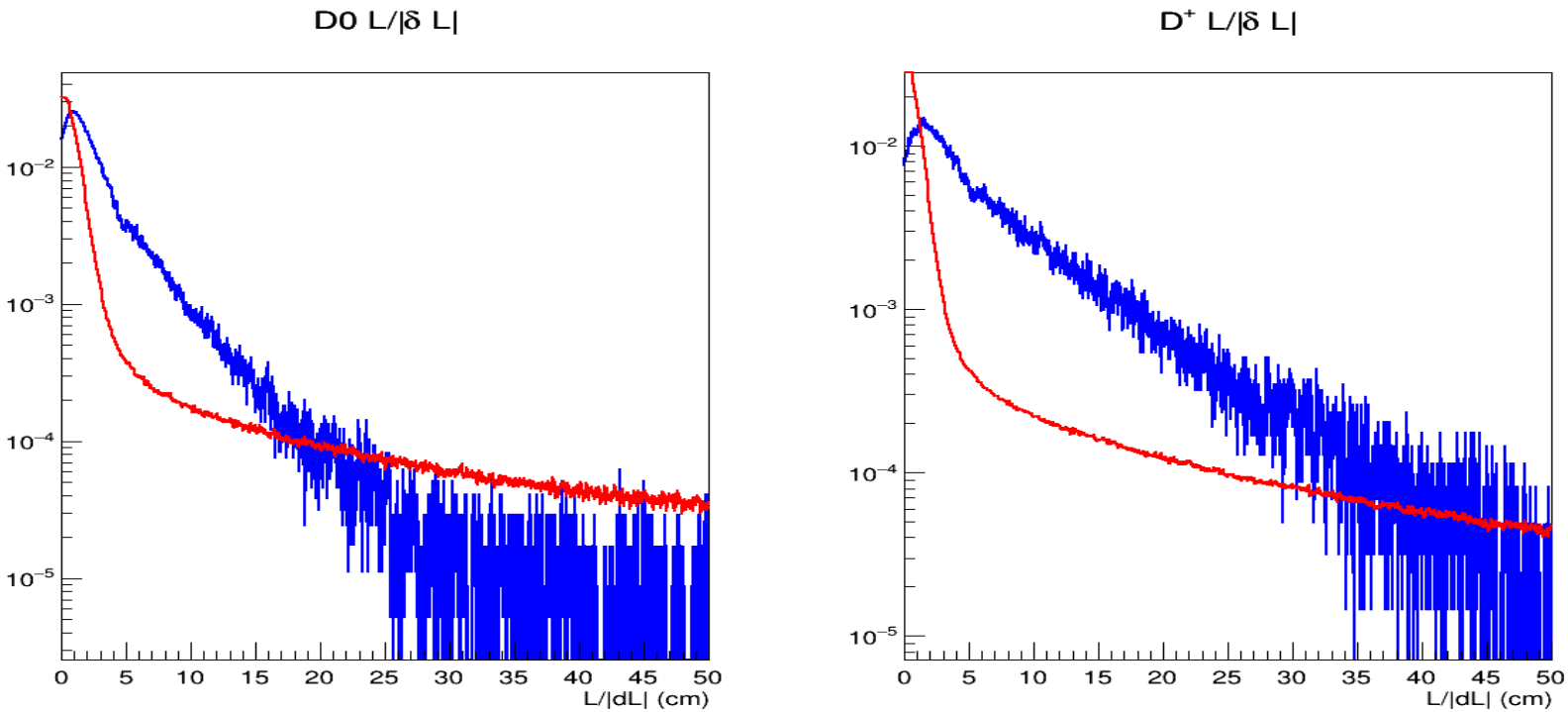


Figure 2: Decay length divided by error for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Daughter χ^2 to PV

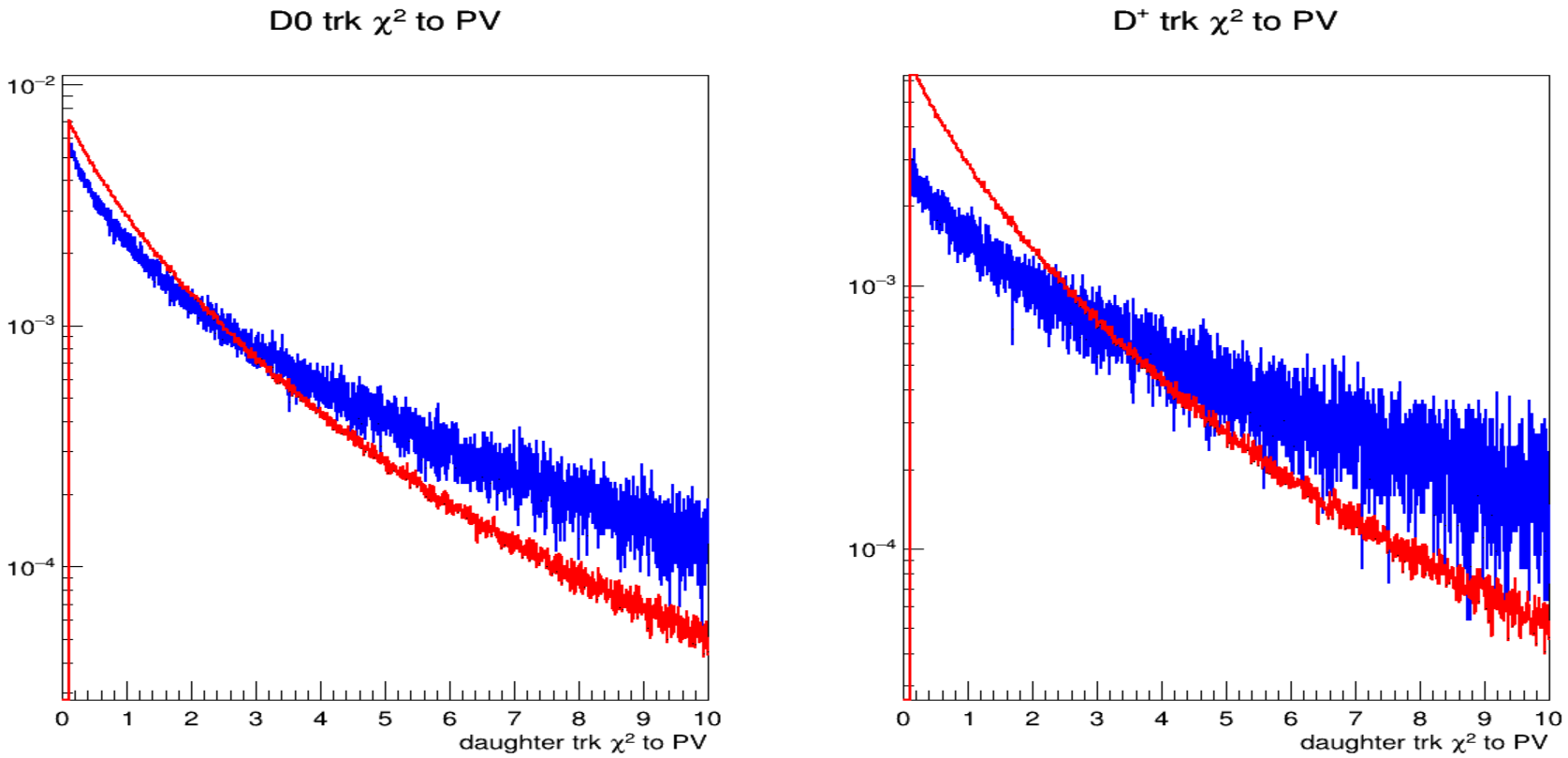


Figure 3: Daughter track χ^2 to primary vertex for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Mother χ^2 to PV

NOT useful

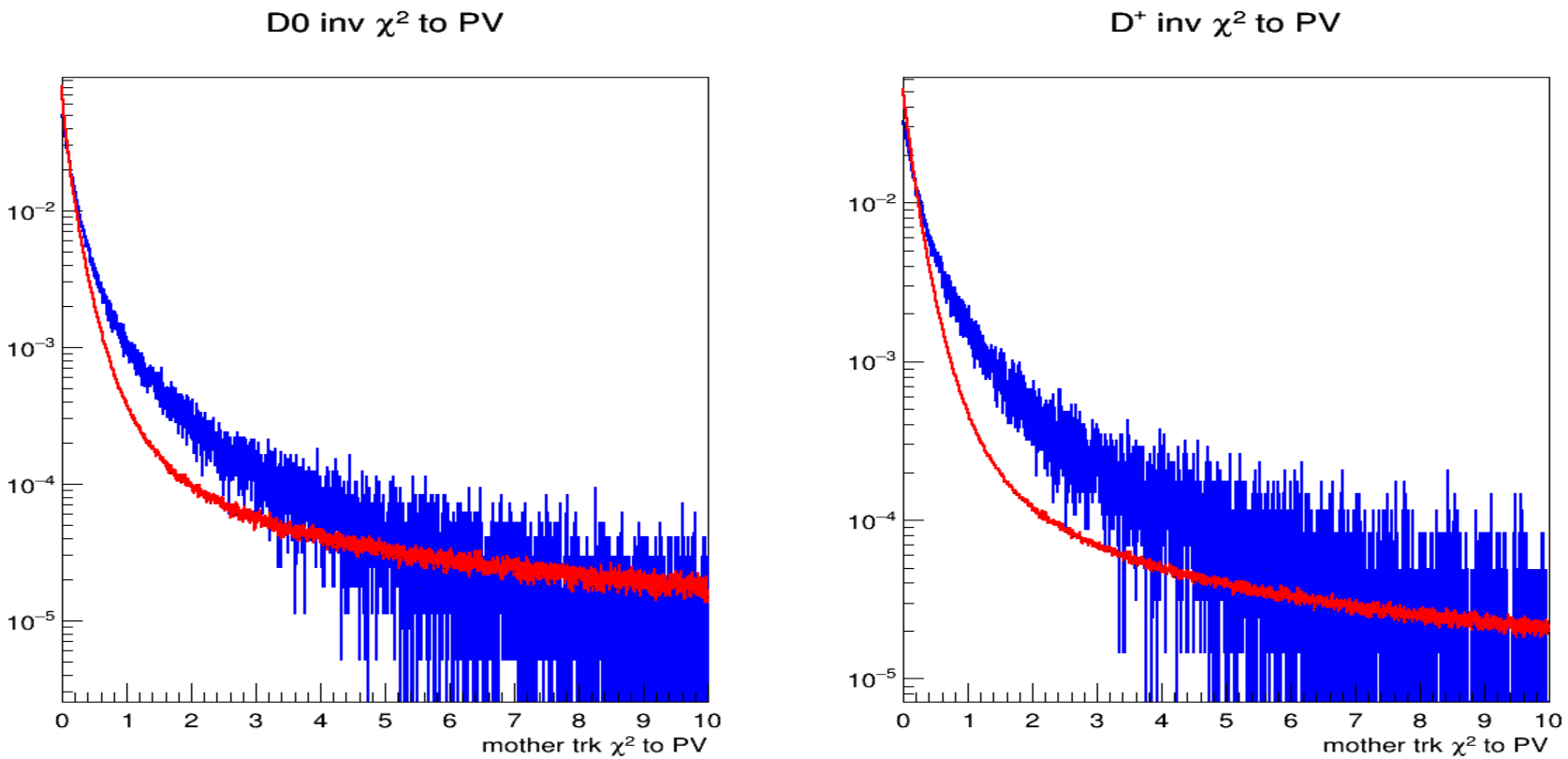


Figure 4: Invariant candidate χ^2 to primary vertex for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Mother χ^2 to SV

NOT useful

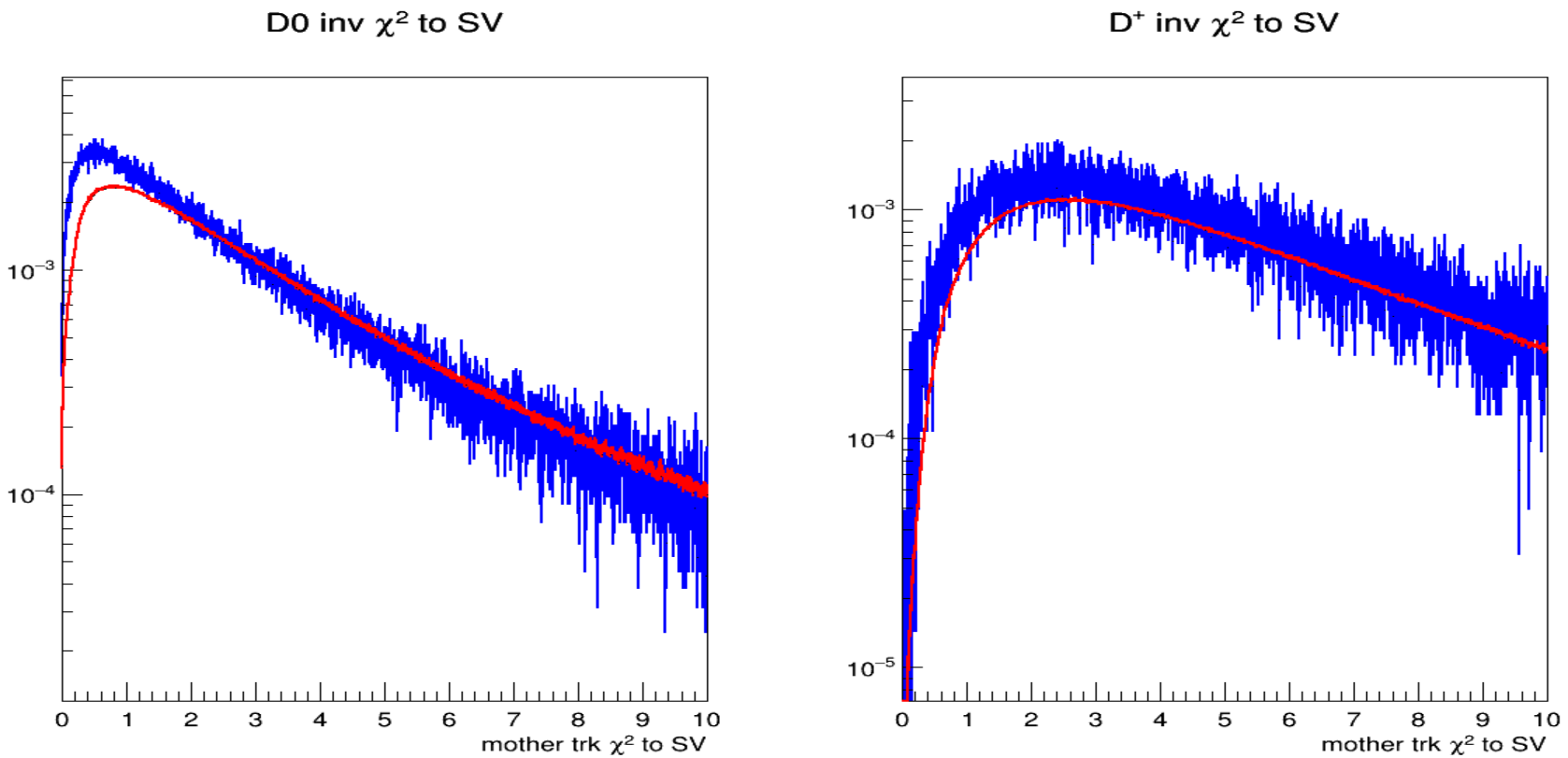


Figure 5: Invariant candidate χ^2 to secondary vertex for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Mother Polar Angle

Apparently useful to reduce background, but ...

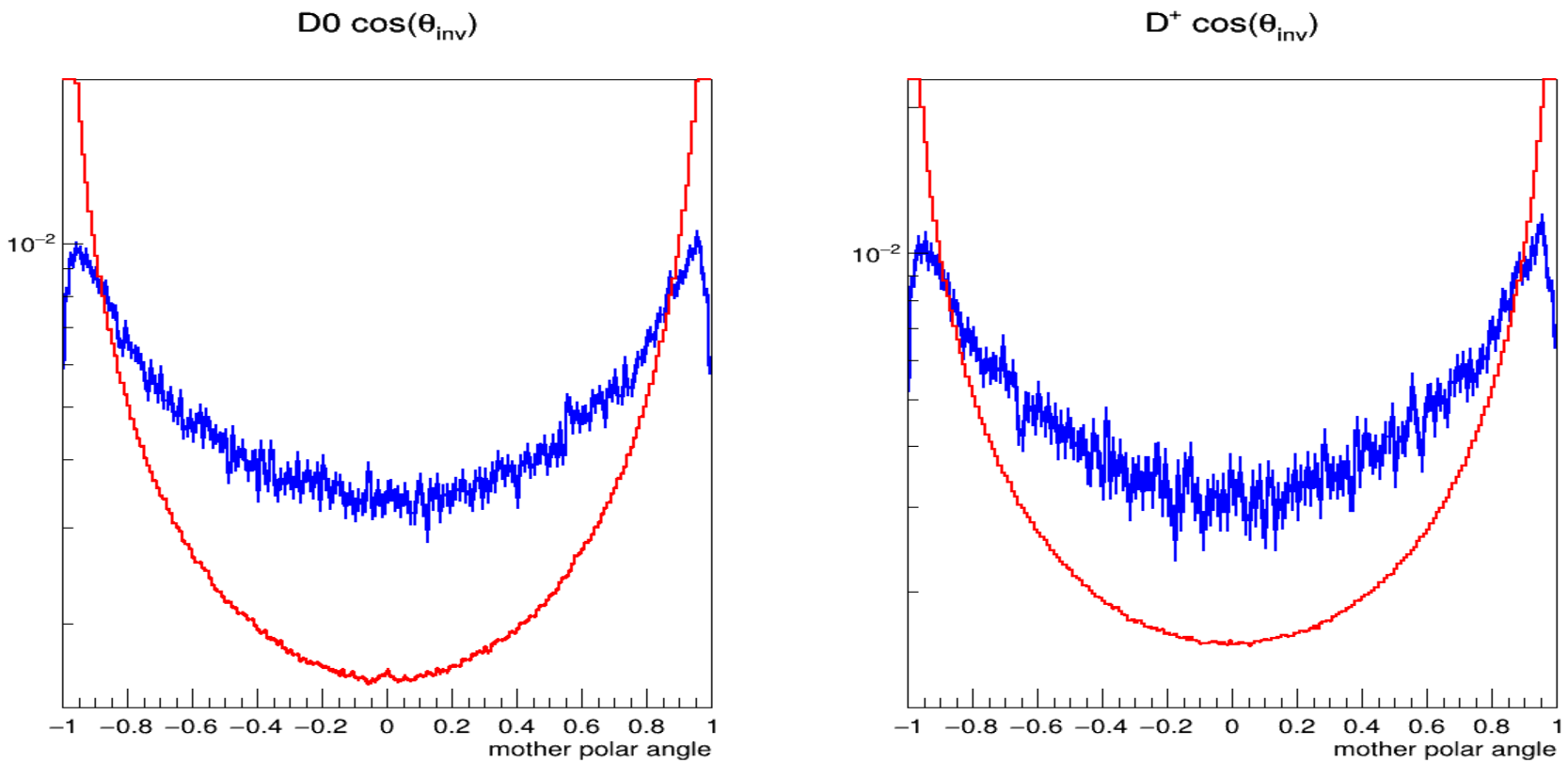


Figure 6: Invariant candidate polar angle for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Mother x_F

For asymmetry analysis, only $x_F > 0.2$ is relevant, so ...

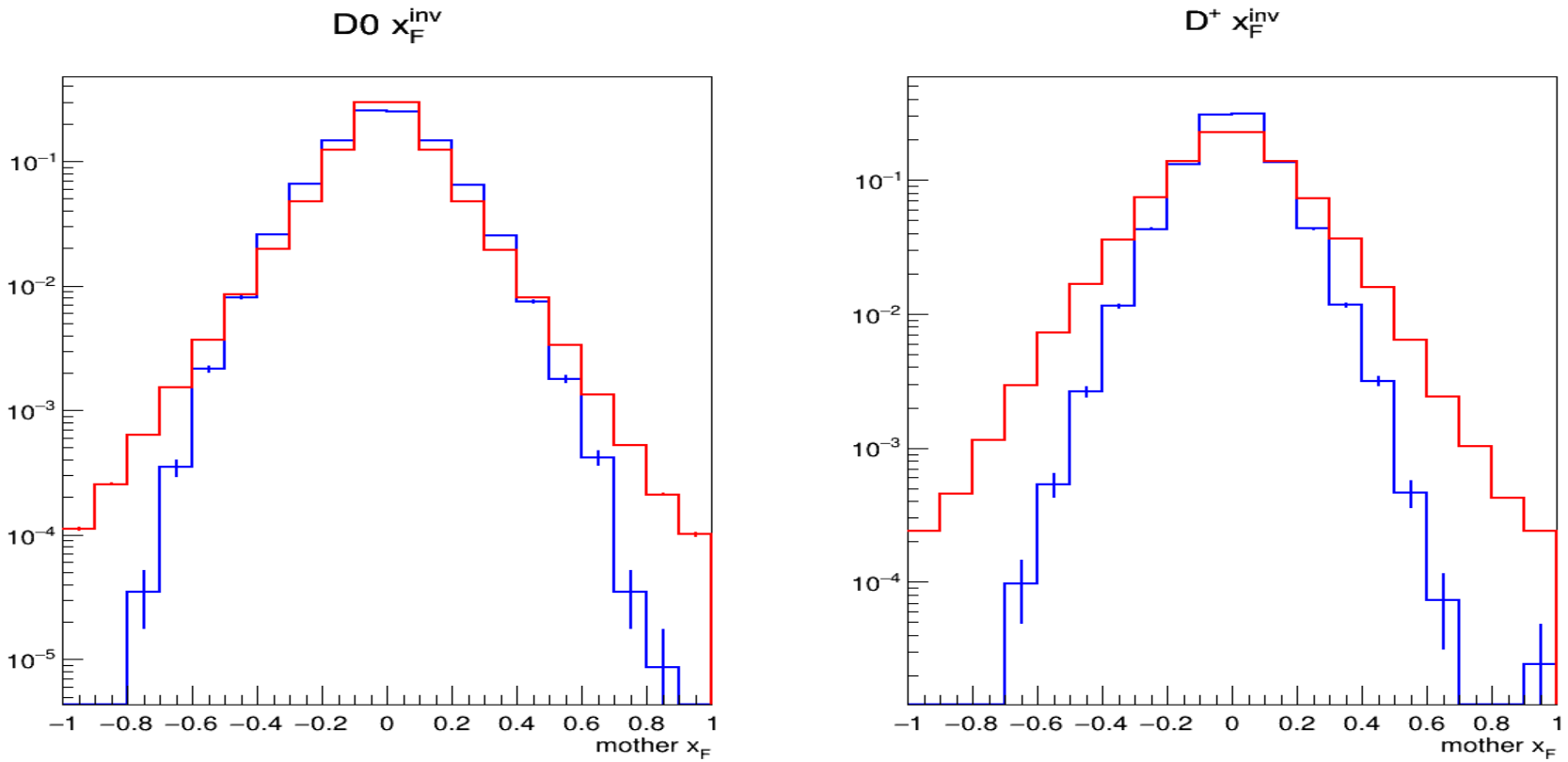
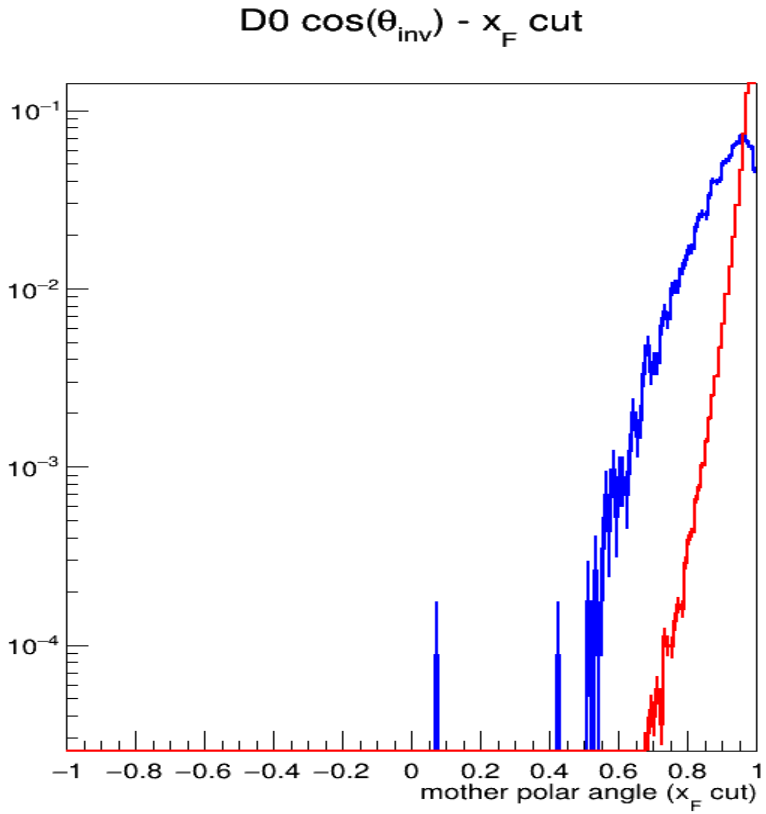


Figure 7: Invariant candidate x_F for $D0$ (left) and D^+ (right) : signal, background

Comparing variables : Mother Polar Angle After x_F Cut

Not so useful anymore (please ignore the background on right)



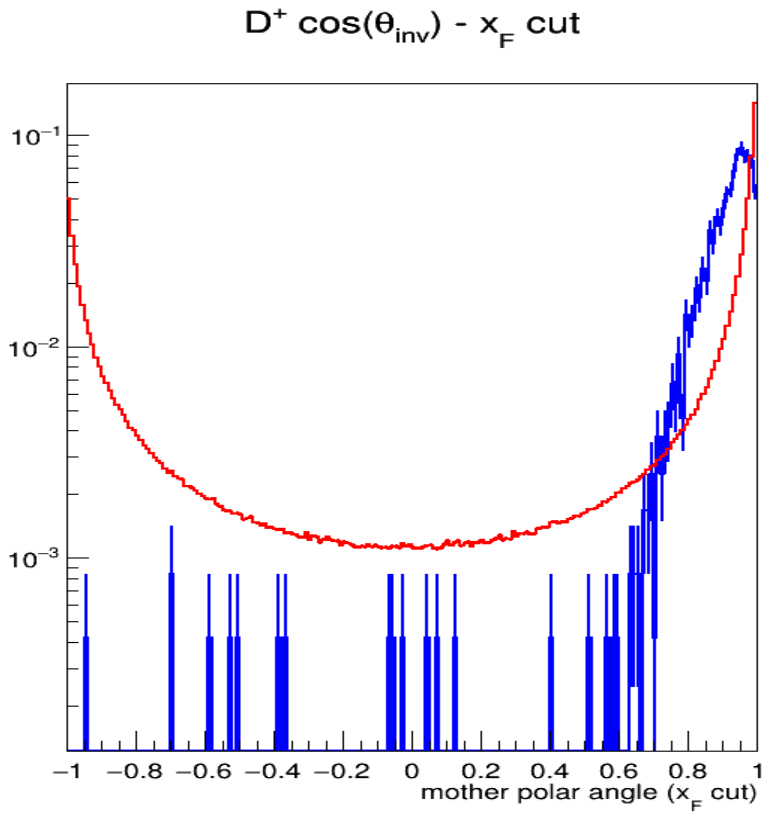


Figure 8: Invariant candidate polar angle after x_F cut for $D0$ (left) and D^+ (right) : signal, background

Invariant Mass Distributions

From **same number** of signal, background events :

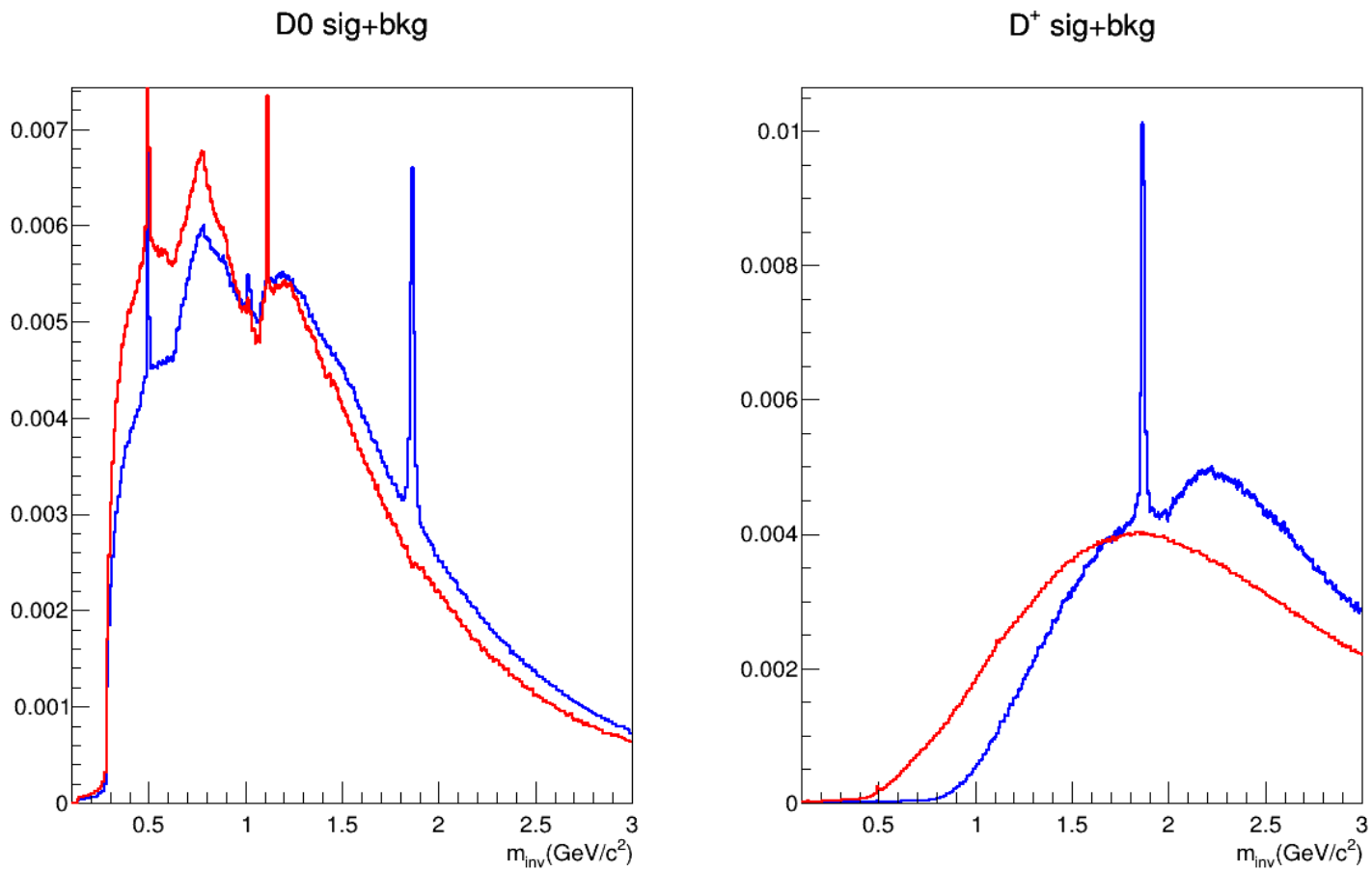


Figure 9: Invariant mass distributions for $D0$ (left) and D^+ (right) : signal, background

Invariant Mass Distributions : Comments

Signal : OpenCharm PYTHIA events include some background from random combinations
Background : MinBias events produce purly random background
Mass peaks at $M_{inv} = 0.497$ GeV$/c^2$ and $M_{inv} = 1.115$ GeV$/c^2$ are respectively $K^0 \to \pi^+\pi^-$ and $\Lambda^0 \to p\pi^-$

Histograms for next slide represent :

- no cuts
- $x_F > 0.2$
- $x_F > 0.2$, $L/|\delta L| > 5.$
- $x_F > 0.2$, $L/|\delta L| > 5.$, Trk $\chi^2 > 1.$

Invariant Mass Distributions for $D0$

From **same number** of signal, background events :

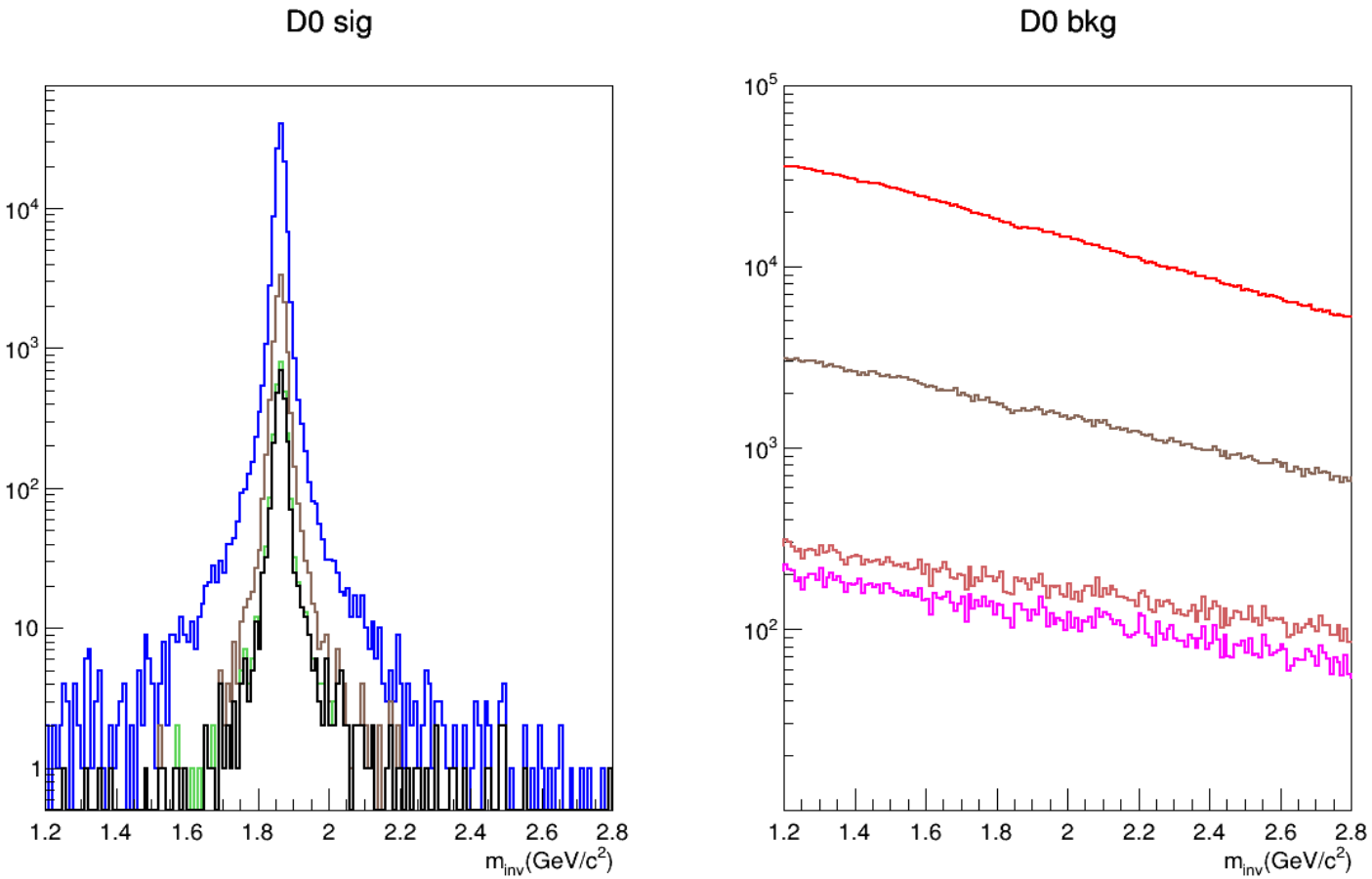


Figure 10: Invariant mass distributions of $D0$ signal (left) and combinatorial background (right)

About S/B

- Open charm production process cross-section : 2.593×10^{-3} mb
- MinBias non-elastic cross-section : 32.835 mb
- $D0 \rightarrow K^{-}\pi^{+}$ BR : 3.89%
- $D^{+} \rightarrow \pi^{+}K^{-}\pi^{+}$ BR : 9.22%
- All info combined gives ratio of background to signal events in a given data sample $\sim 1.6 * 10^{5}$
- Playing with the cut sets SO FAR : for $D0$ mesons, $S/B = 1.4* \sim 10^{-4}$

Outlook

- Need to fix some bug in the charged D meson part of the code
- Need to estimate D counts as function of p_T after cuts
- Concern : SpdRCKFpartV0Finder requires pid for reconstruction of secondary vertex. How will it work for real data
- Comment : Invarinat mass resolution $\sim$ 15 MeV, is that realistic with MAPS?
- With new SpdRoot build will test with other Inner Tracker configurations

Thank You