# Updates on D0 Reconstruction Study

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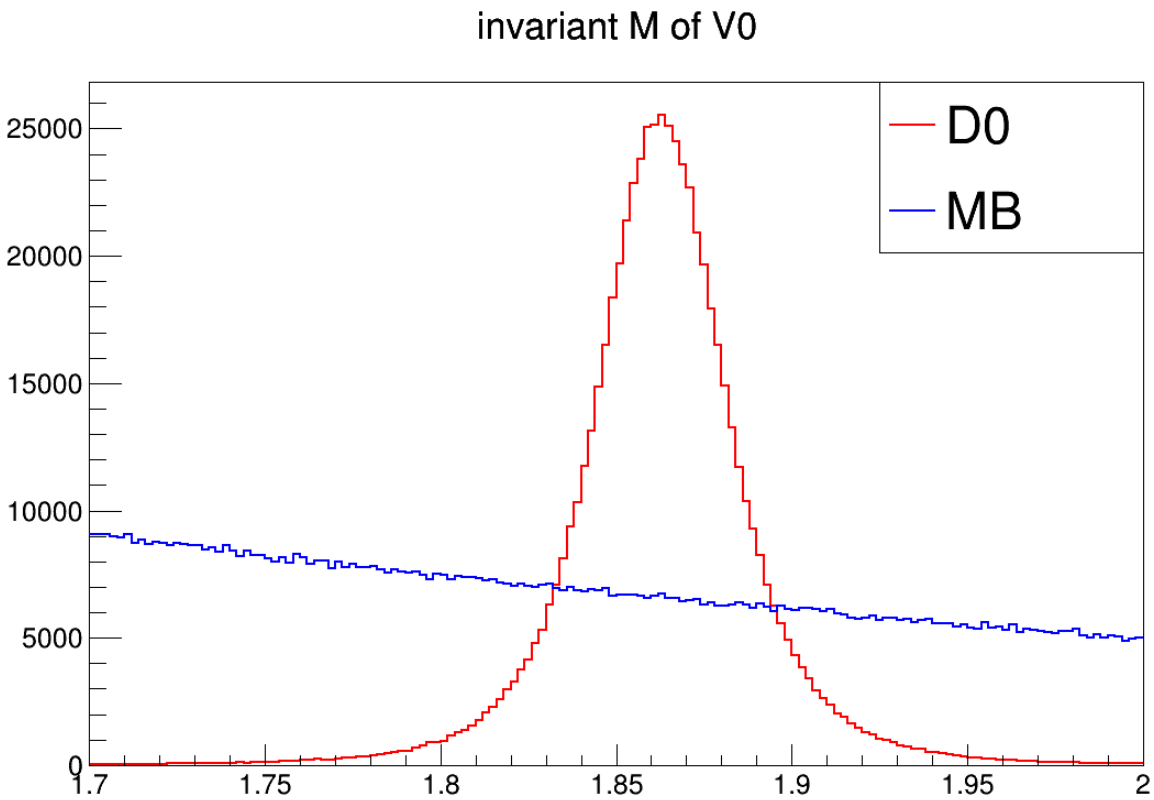
# Simulation Details

- Subsystems : Beam-pipe, Inner Tracker, Straw Tracker, Magnet
- Magnetic field : Bz = 1 T in box geometry
- Silicon Inner Tracker : MAPS, 4 layers, no end-cap
- Event vertex (0,0,0), no smearing applied
- Minimum bias (except elastic) for background study and opencharm channels for signal (D0)
- $D^0 \rightarrow \pi^+ K^-$ channel forced to enhance statistics in simulation (original branching ratio 3.89%)

# Analysis Details

- V0 reconstuction with KFParticle package, constrained to primary vertex
- Require at least 3 SVD hits for daughter $(\pi, K)$ track candidates
- SpdVertexCombiFinder used to reconstruct all possible combinations of ($\pi$,K) in minbias event
- Mass window cut (1.7 - 2.0 GeV/$c^2$) applied for all cases for both signal D0 and random background from MB
- 4 M open-charm events generated, $D^0 \rightarrow \pi^+ K^-$ forced
- 40 M MB (except elastic) events generated

# Starting Point



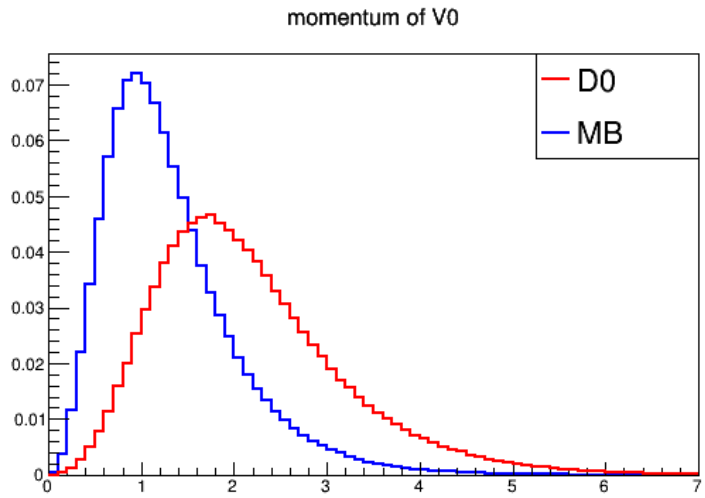

Generated : 4 M D0, 40 M MB

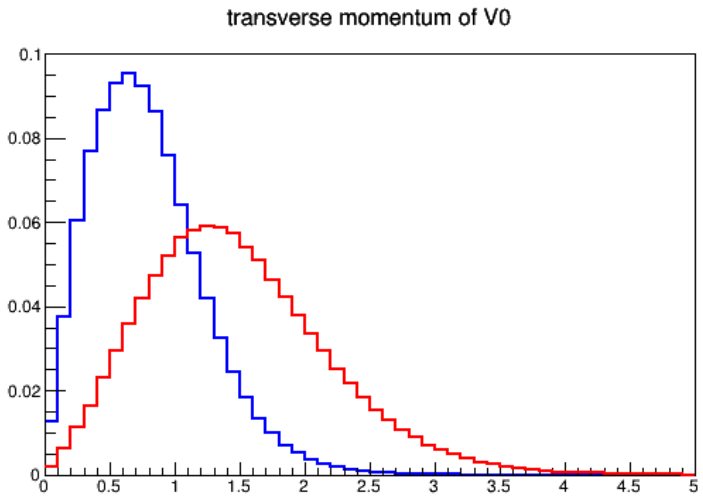
Detected : 633533 D0, $1.02634 \times 10^6$ MB

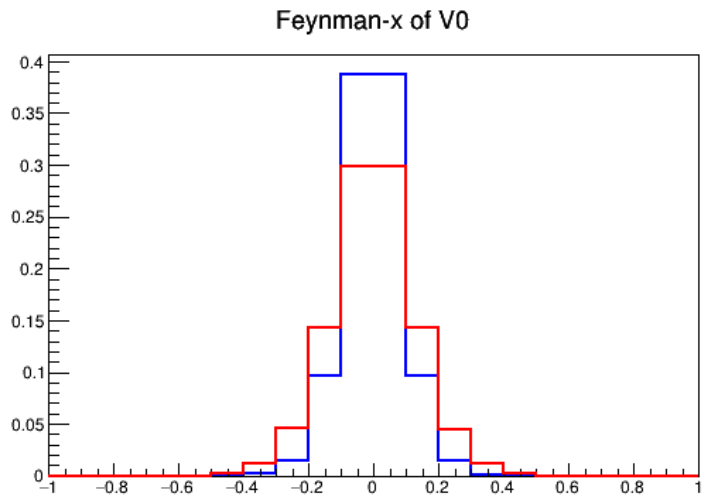
# About Cuts

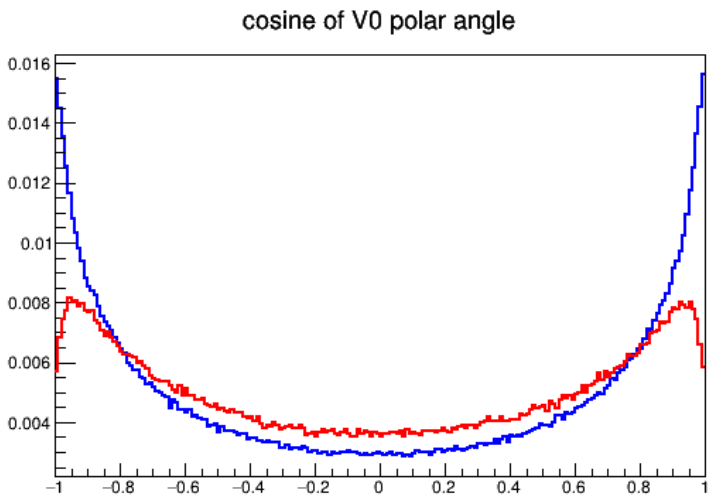
- As a first choice, wanted to avoid cuts on kinematic variables to avoid artiticial bias in distribution
- Polar angle cuts can take off precious staistics in the high $x_F$ regions
- Momentum cuts can adversely affect our already limited PID capability
- Cuts based on only reconstruction related variables so far (can always introduce kinematic variable based cuts if needed)

# V0 Kinematic Variables

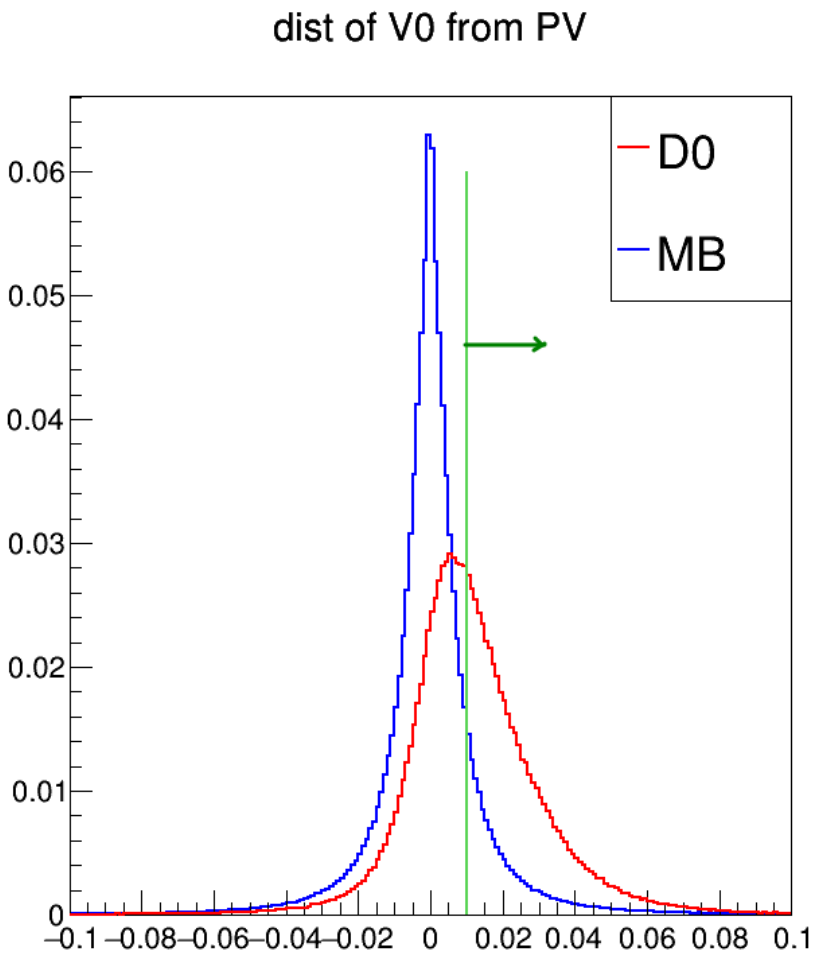


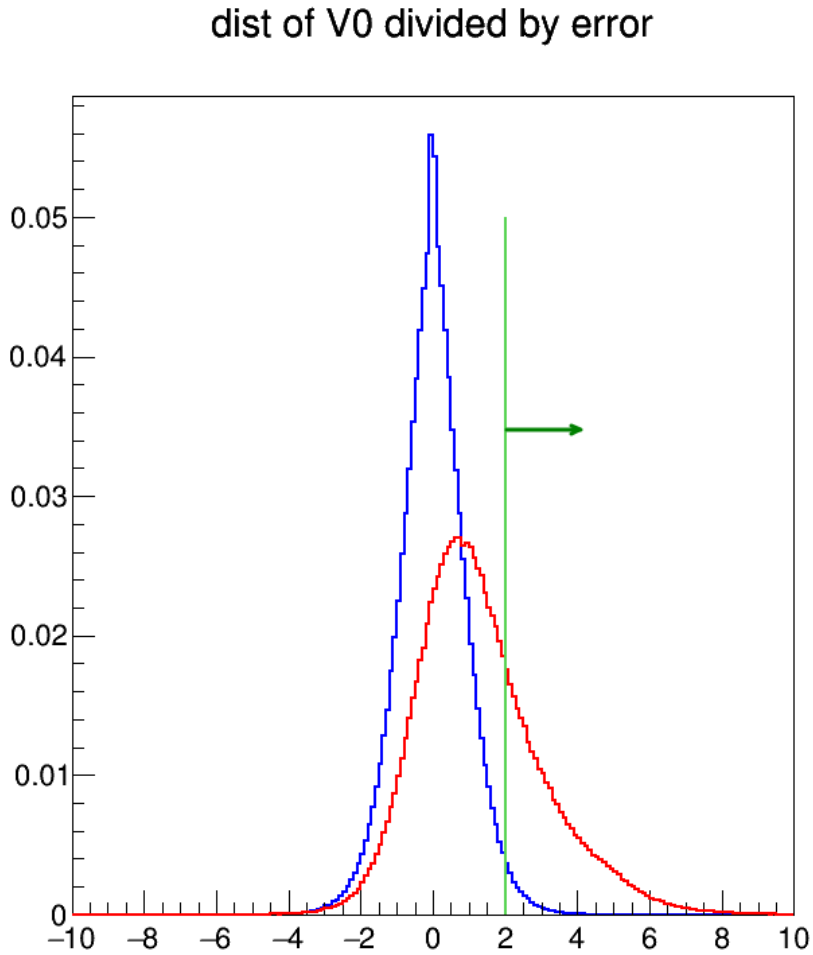



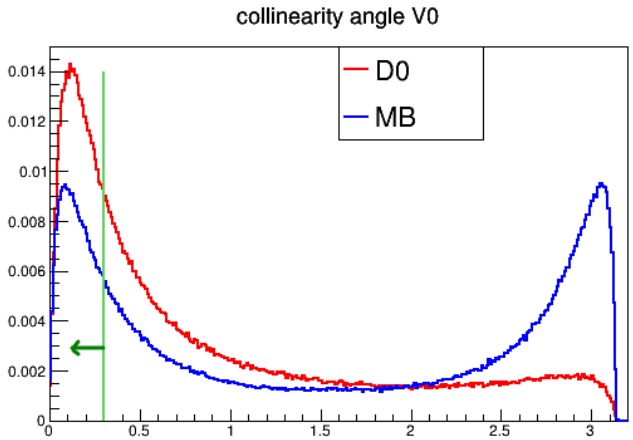
# V0 Decay Length and Uncertainty

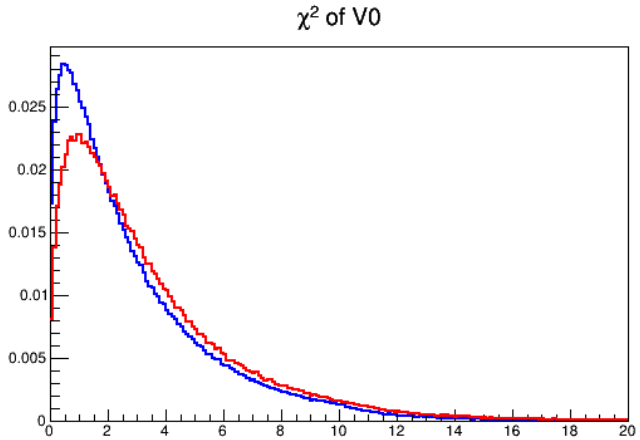


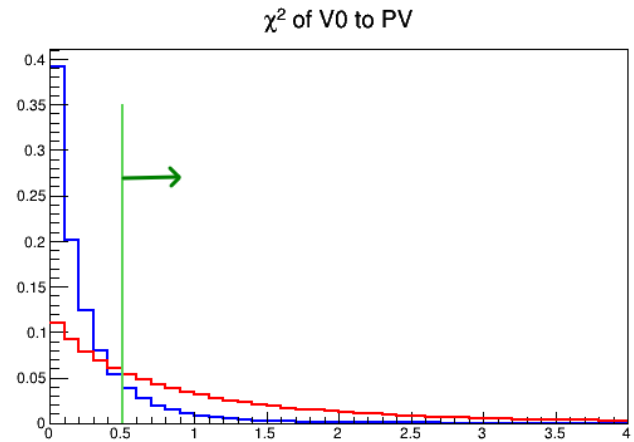



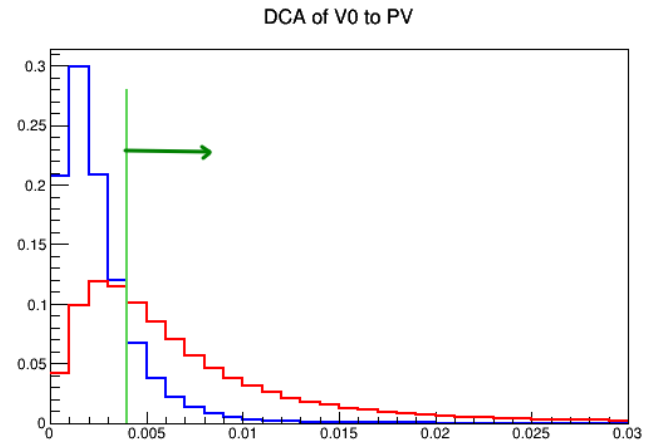

accept above the cuts

# V0 Reconstruction Variables



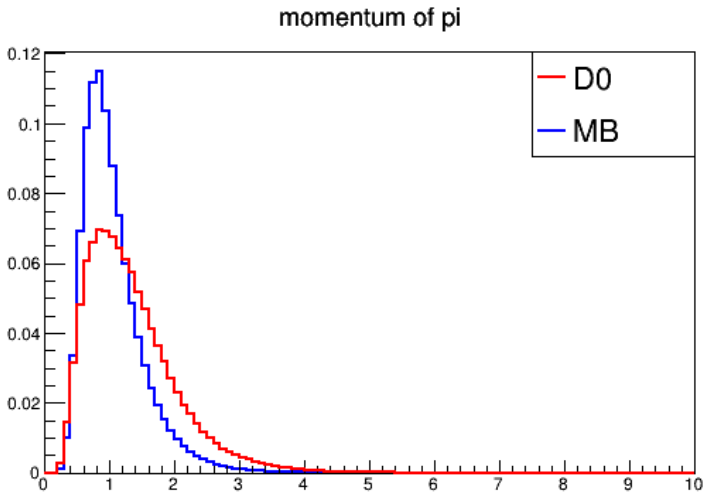



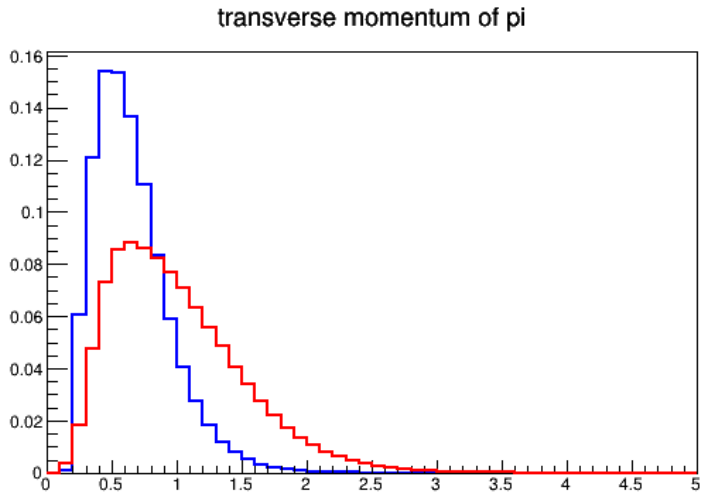



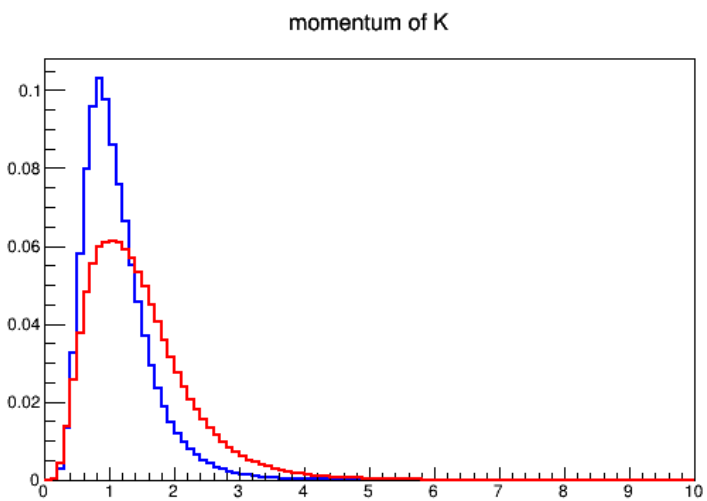



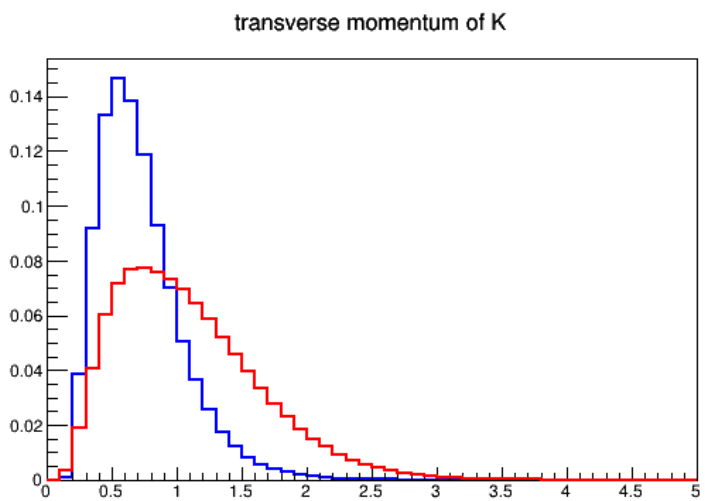

accept below angle cut and above $\chi^2$,DCA cuts

# Daughter Track Kinematic Variables

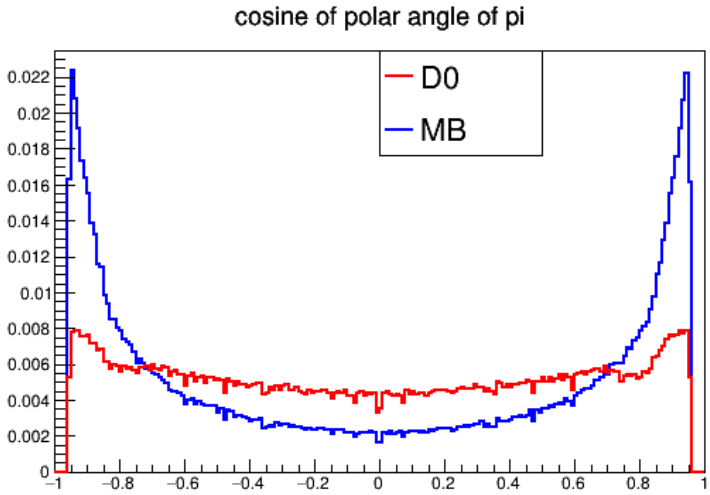


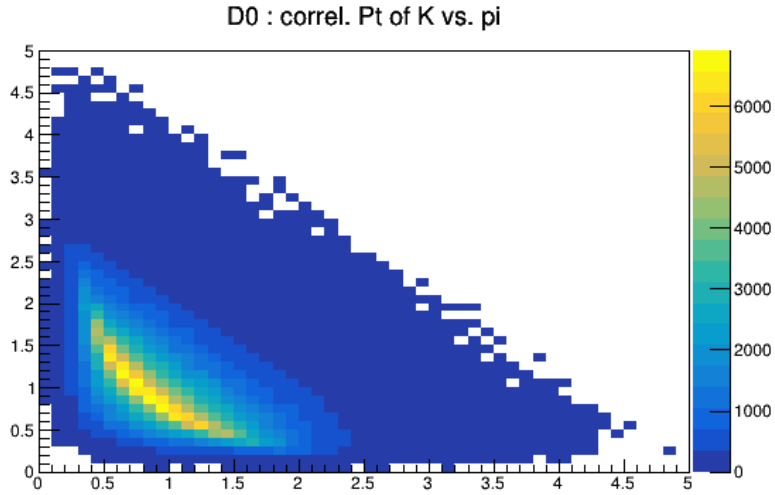



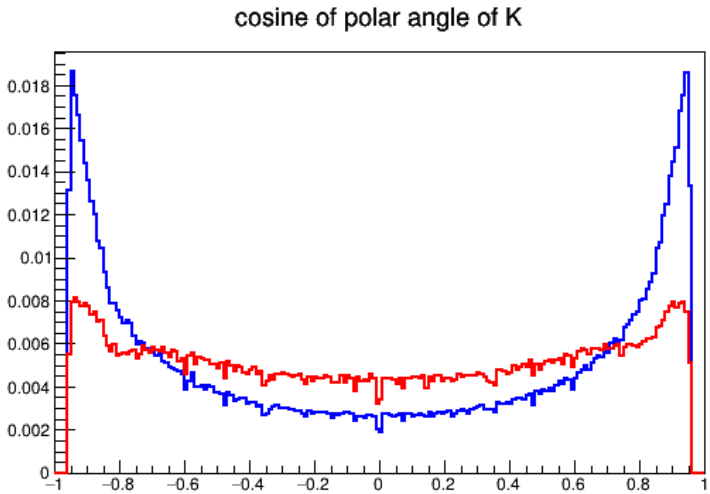



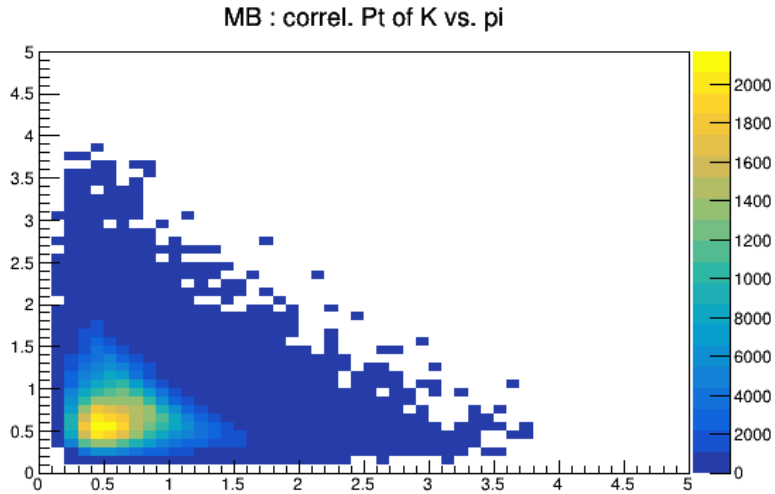



# Daughter Track Kinematic Variables

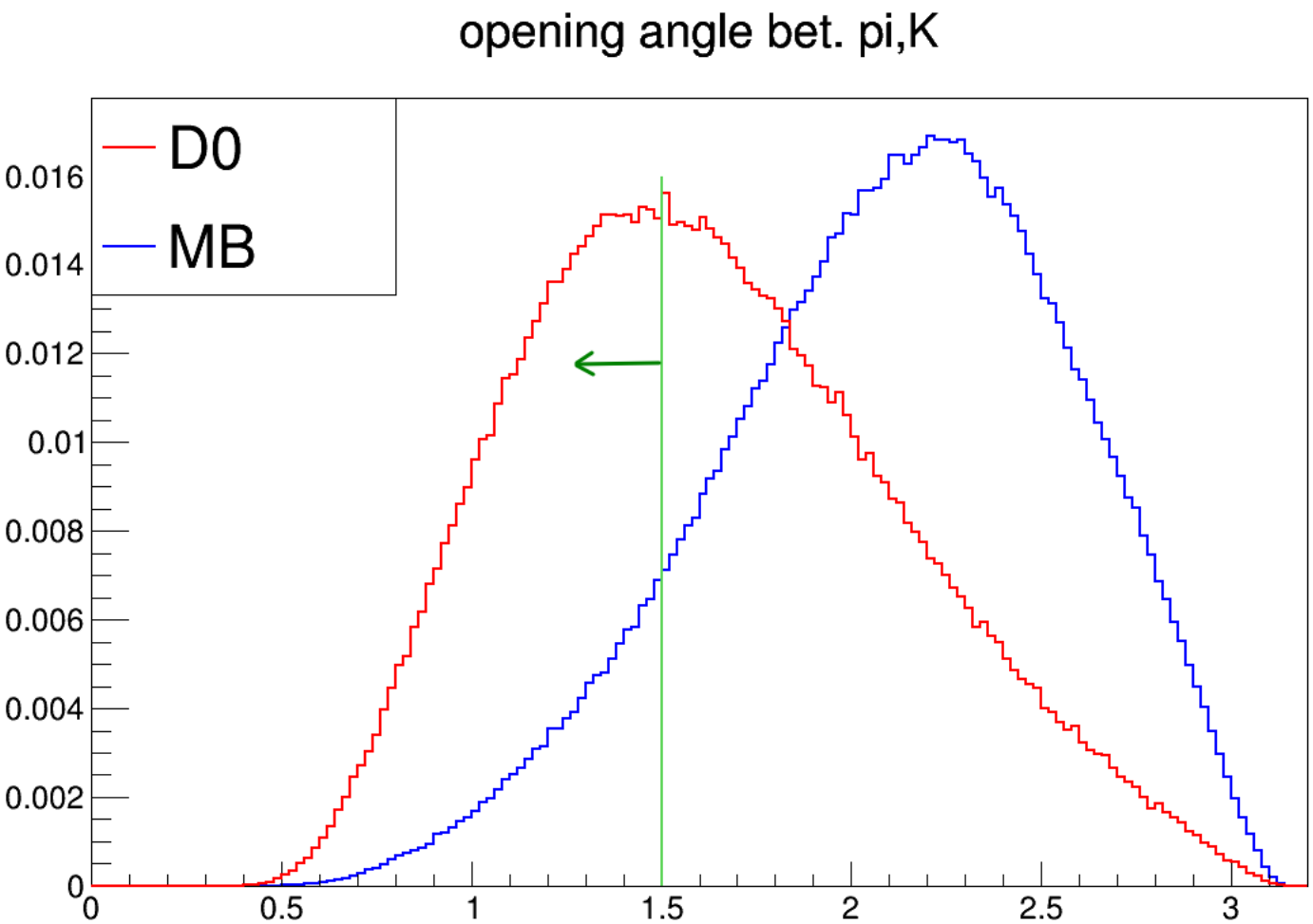


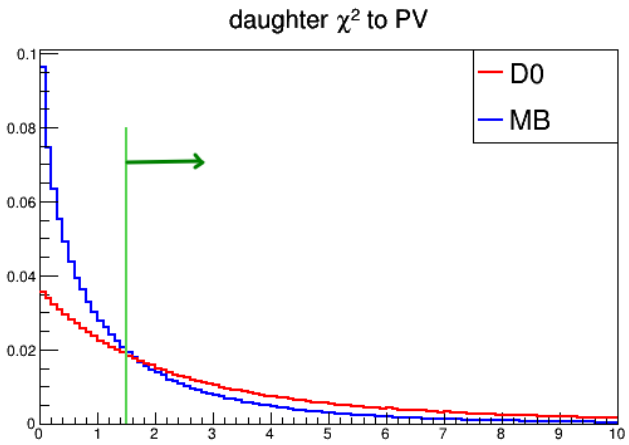



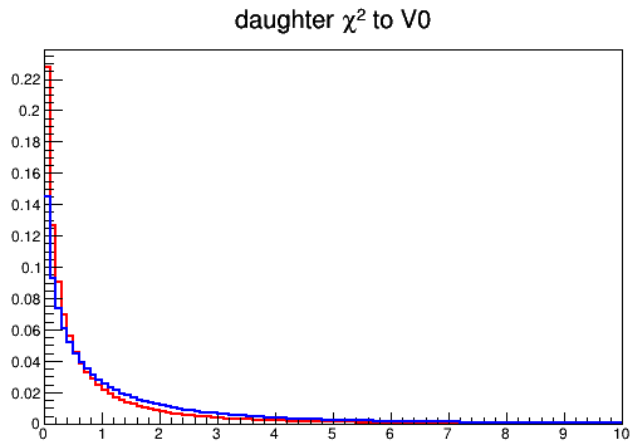
# Opening Angle Between Daughter Tracks

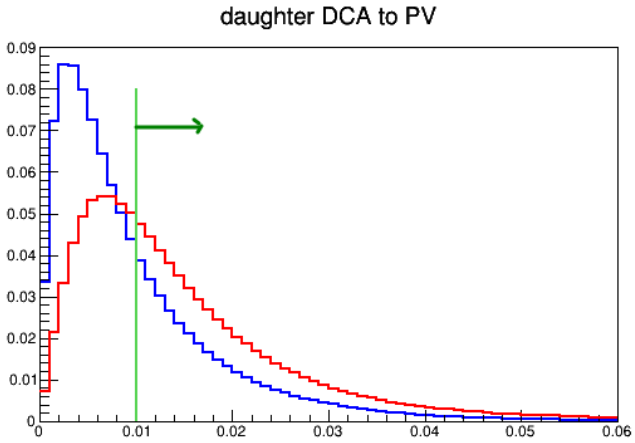


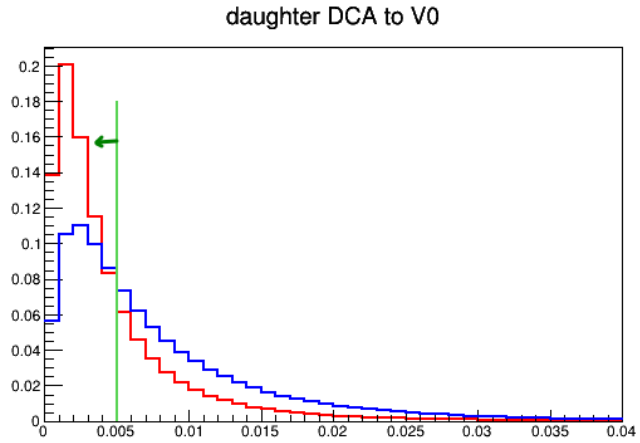

accept below the cut

# Daughter Track Reconstruction Variables



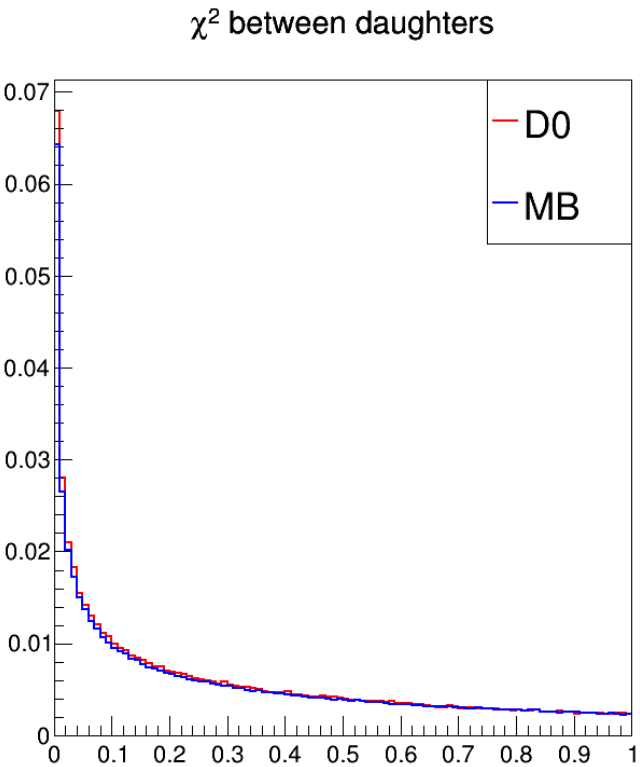



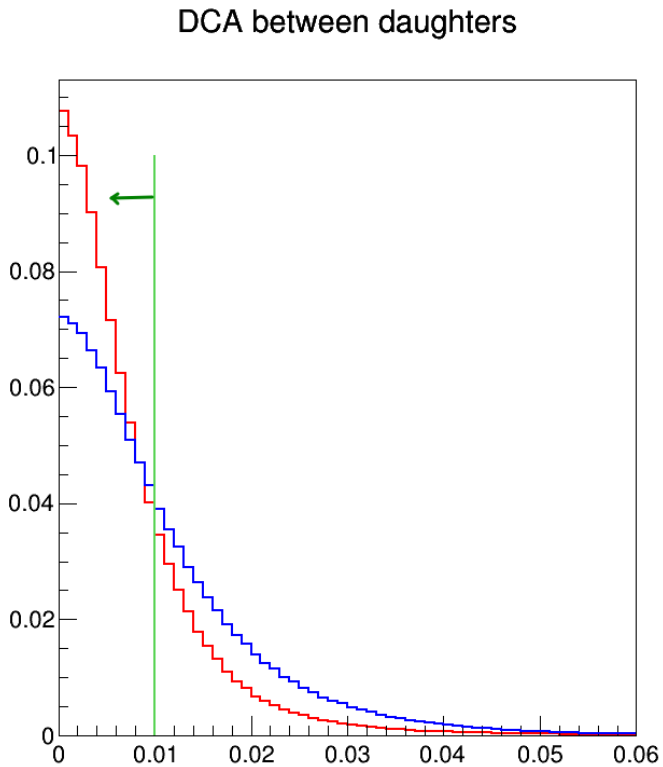




accept above the cuts related to PV and below DCA to V0

# Daughter Track Reconstruction Variables



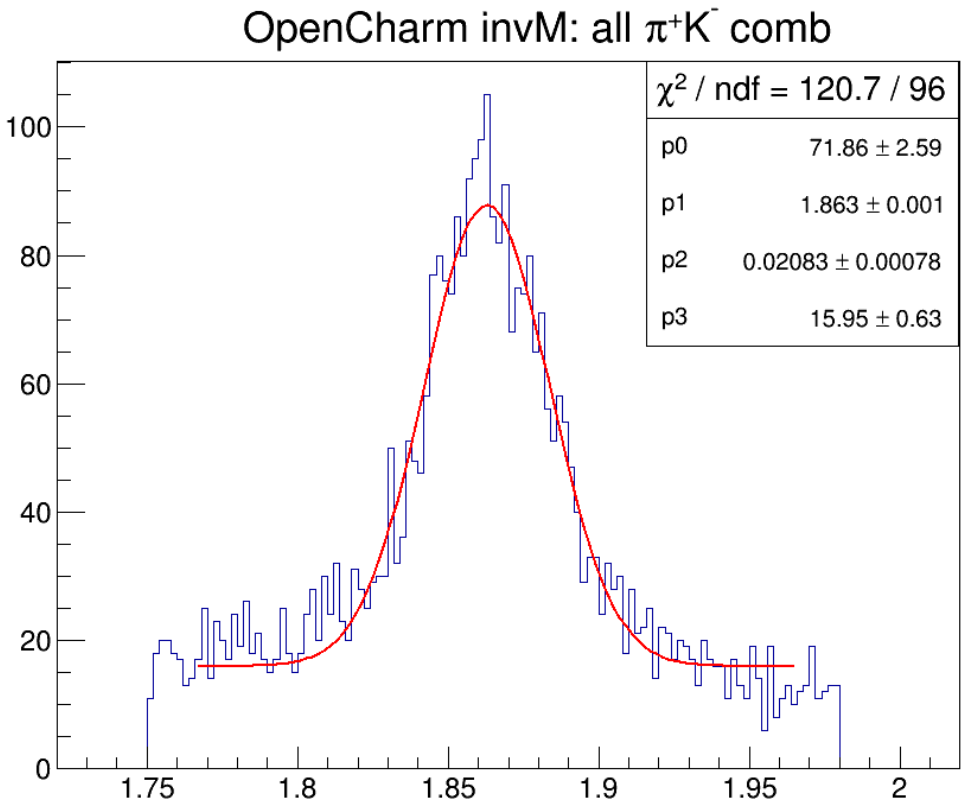

accept below the cut

# Cuts to Suppress MB Background

- Decay length : $L > 0.008$ cm, $L/dL > 2$.
- Collinearity angle : $Acol < 0.3$ rad
- V0 properties : $\chi^2_{V0-PV} > 0.5$, $DCA_{V0-PV} > 0.004$ cm
- Daughter track properties :
- $DCA_{\pi-K} < 0.01$ cm, opening angle $OA < 1.5$ rad
- Daughter to PV : $\chi^2_{d-PV} > 1.5$, $DCA_{d-PV} > 0.01$ cm
- Daughter to V0 : $DCA_{d-V0} < 0.005$ cm
- Invariant mass window 1.7-2.0 GeV/$c^2$
- $|x_F| > 0.2$ for asymmetry measurements

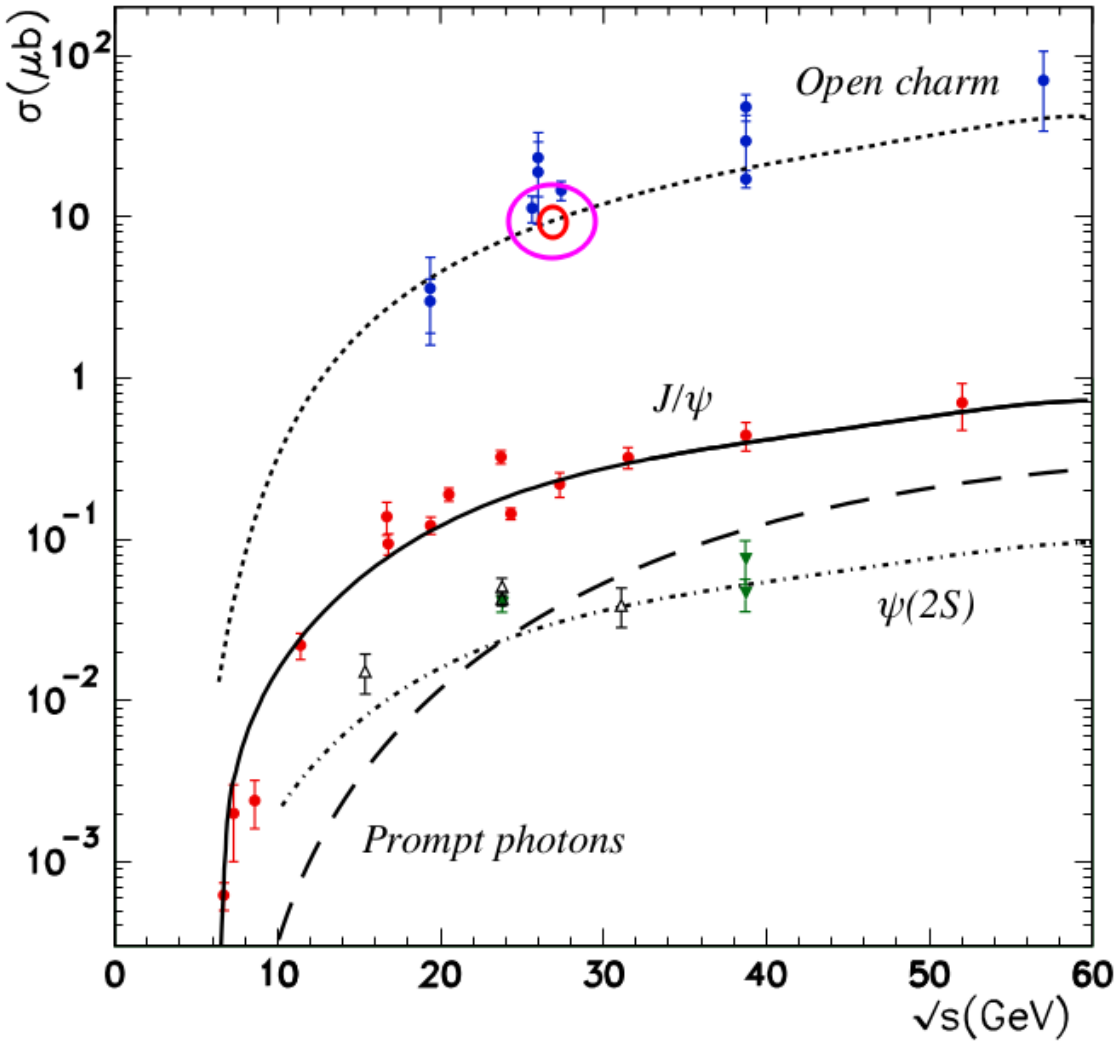
Before we look at the effect of the cuts ... a couple of comments

# (1) Background From Open-Charm Events




Neglecting this backgorund for now

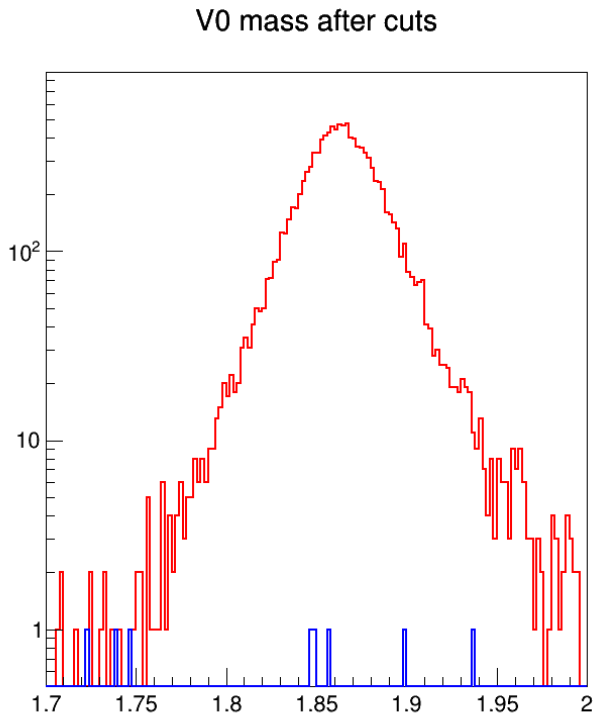
# (2) Process Cross-section

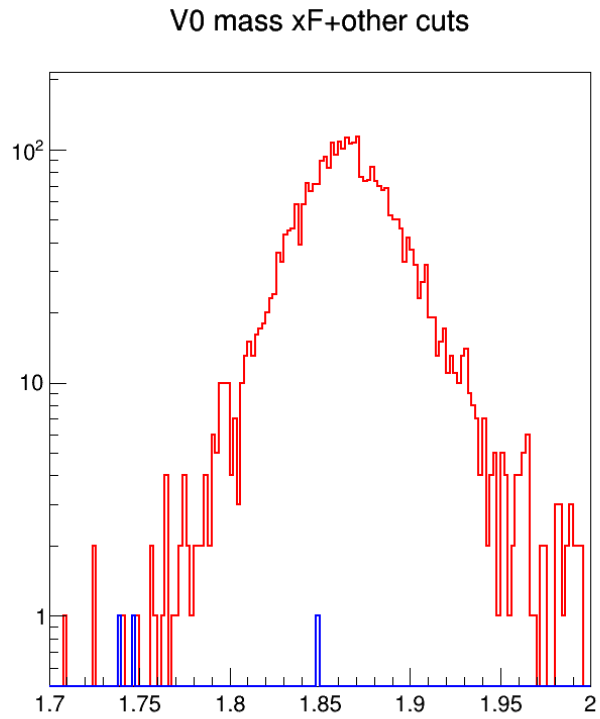


# (2) Some Relevant Numbers

- CDR plot gives open-charm cross-section $\sim 9.4\ \mu b$ (on the fitted curve) at $\sqrt{s} = 27$ GeV (there is some wiggle room - nearest data $\sim 14\ \mu b$)
- PYTHIA gives open-charm cross-section $\sim 1.5\ \mu b$ at $\hat{p_T}_{min} = 1$ GeV
- $D^0$ is produced in $\sim 49\%$ open-charm events
- Considering $D^0 \rightarrow \pi^+ K^-$ branching ratio (3.89%), process cross-section $\sim 180\ nb$
- CDR estimate table suggests twice this (360 nb)
- In 1 year's data (integrated luminosity 1 $fb^-$), events produced with $D^0 \rightarrow \pi^+ K^-$ process : 180-360 Million. Let's say 240 M

# After Cuts




started with : 633533 D0, $1.02634 \times 10^6$ MB

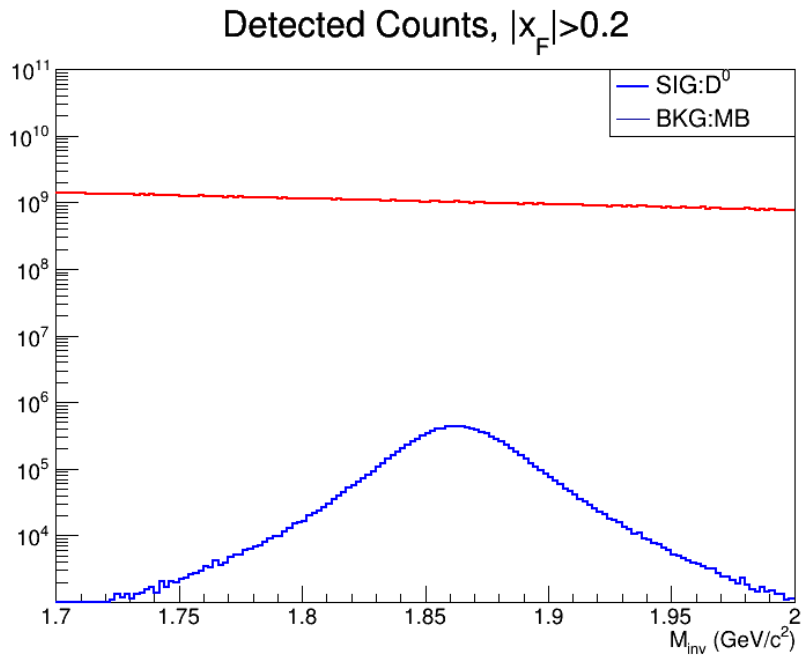
before $x_F$ cut : 11456 D0, 8 MB

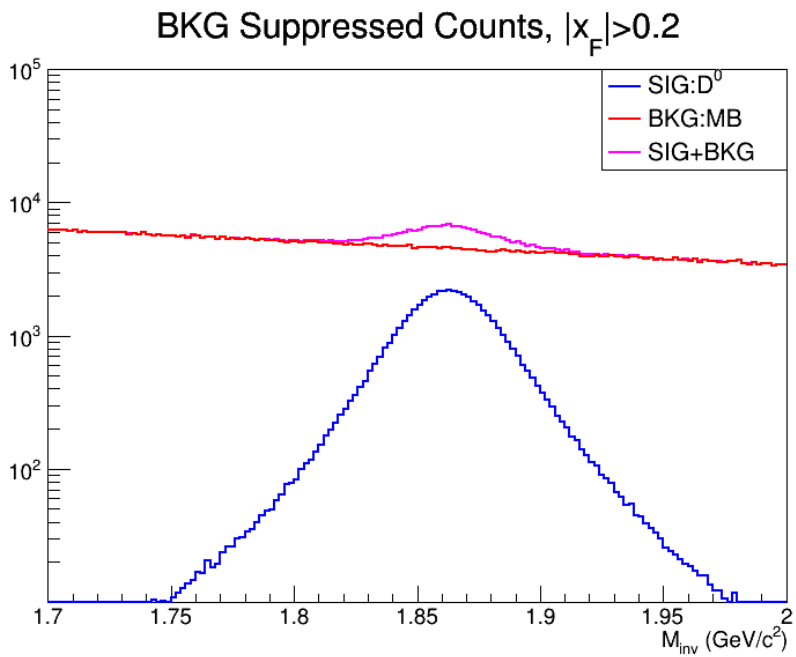
after $x_F$ cut : 3279 D0, 3 MB

# Cut Effects

- D0 : after-cuts/detected : $3279/633533 = 5.2 \times 10^{-3}$
- MB : after-cuts/detected : $3/1.026 \times 10^{6} = 2.9 \times 10^{-6}$
- After cuts, S/B = 1093 (*generated* event ratio $N_S/N_B = 1/10$)
- Accounting for proper D0 branching ratio, S/B = 42.5
- Assuming 32.8 mb for MB and 9.4 $\mu b$ for open-charm, real data *produced* event ratio $N_S/N_B = \sigma_S/\sigma_B = 1/3489$
- **since Pythia gives an order of mag lower open-charm cross-sec, I underestimated this factor in my earlier presentations
- Expected from data, S/B $\sim 1/8$, for now
- There is room for experimentation with cuts
- background counts after cut statisticlaly not reliable yet

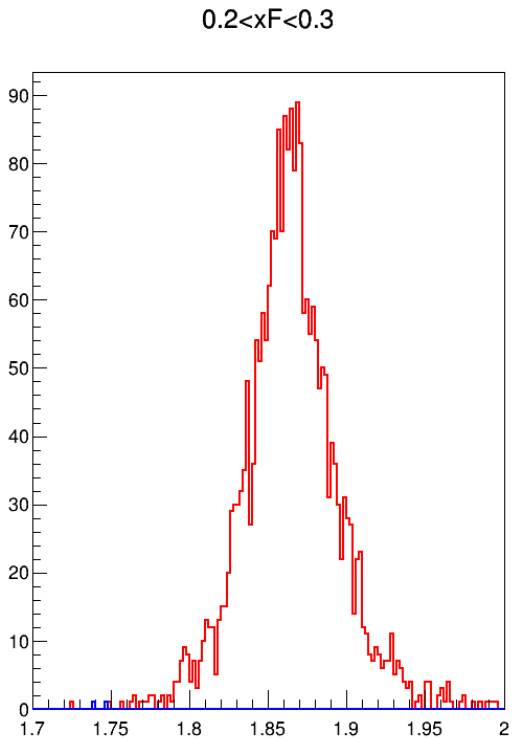
# After Cuts Effect : Scaled Versions

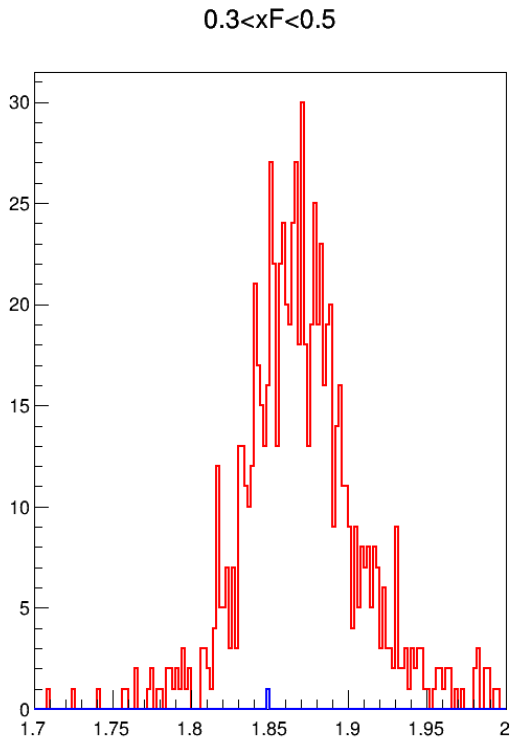


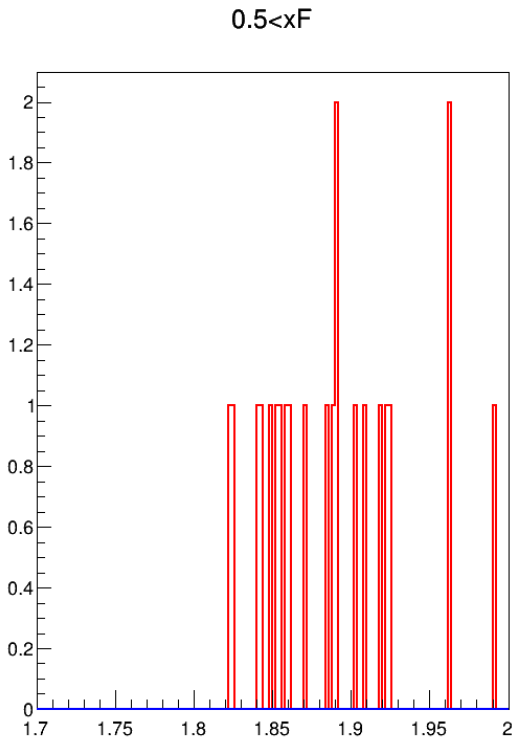




IFF all data from a one year run were recorded, this is how it would look : before (left) and after (right) cuts to reduce background

# In Feynman-x Bins



# Estimated Statistical Uncertainty of Asymmetry

- 4M of $D^0 \rightarrow \pi^+ K^-$ process (forced decay) produces counts :
  1. xF: 0.2-0.3 : 2416
  2. xF: 0.3-0.5 : 841
  3. xF: 0.5- : 22
- Statistical uncertainty of $A_N$ will crucially depend on software event selection - how many D0 events will be retained?
- Assume 240 M process events produced and we keep 50% of them (total of 120 M D0 decay recorded : factor of 30 gain)
- Accounting for proper branching ratio, uncertainty $(\frac{1}{\sqrt{N}})$ in xF bins :
  1. xF: 0.2-0.3 : 0.019
  2. xF: 0.3-0.5 : 0.032
  3. xF: 0.5- : 0.19

# In the Context of Asymmetry

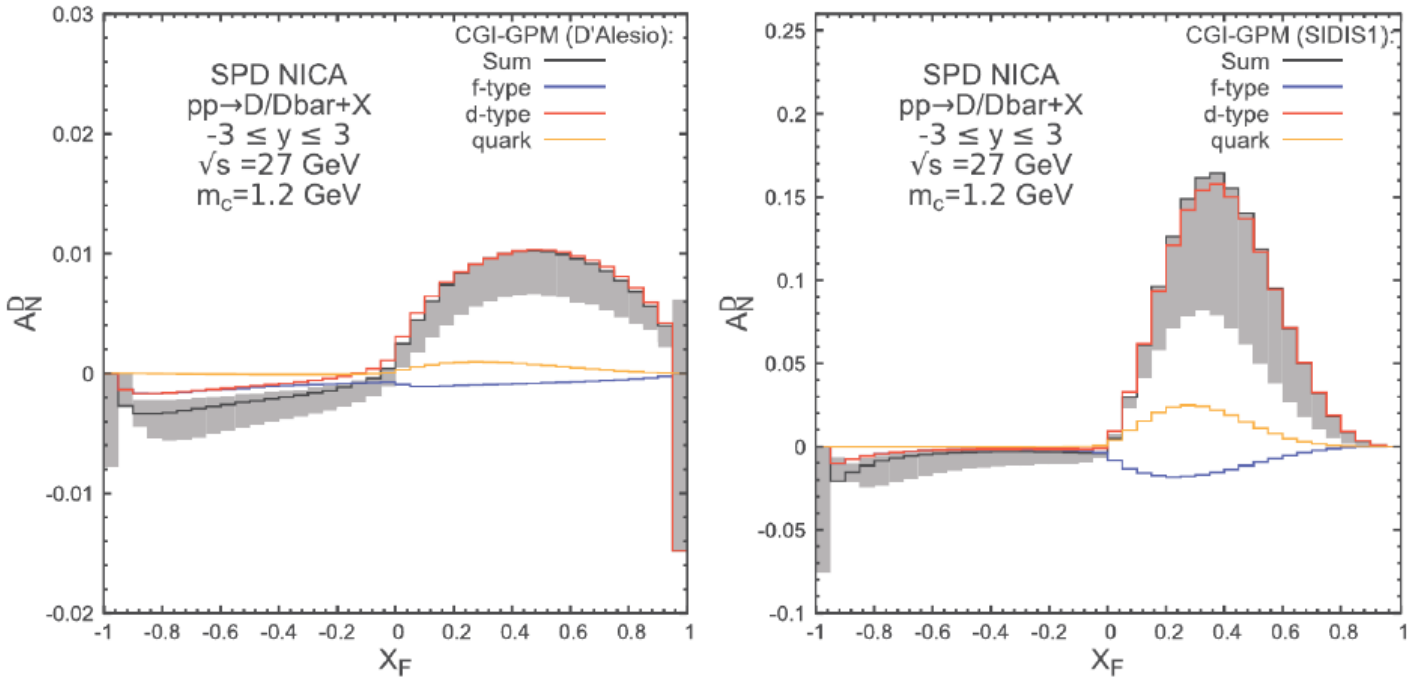
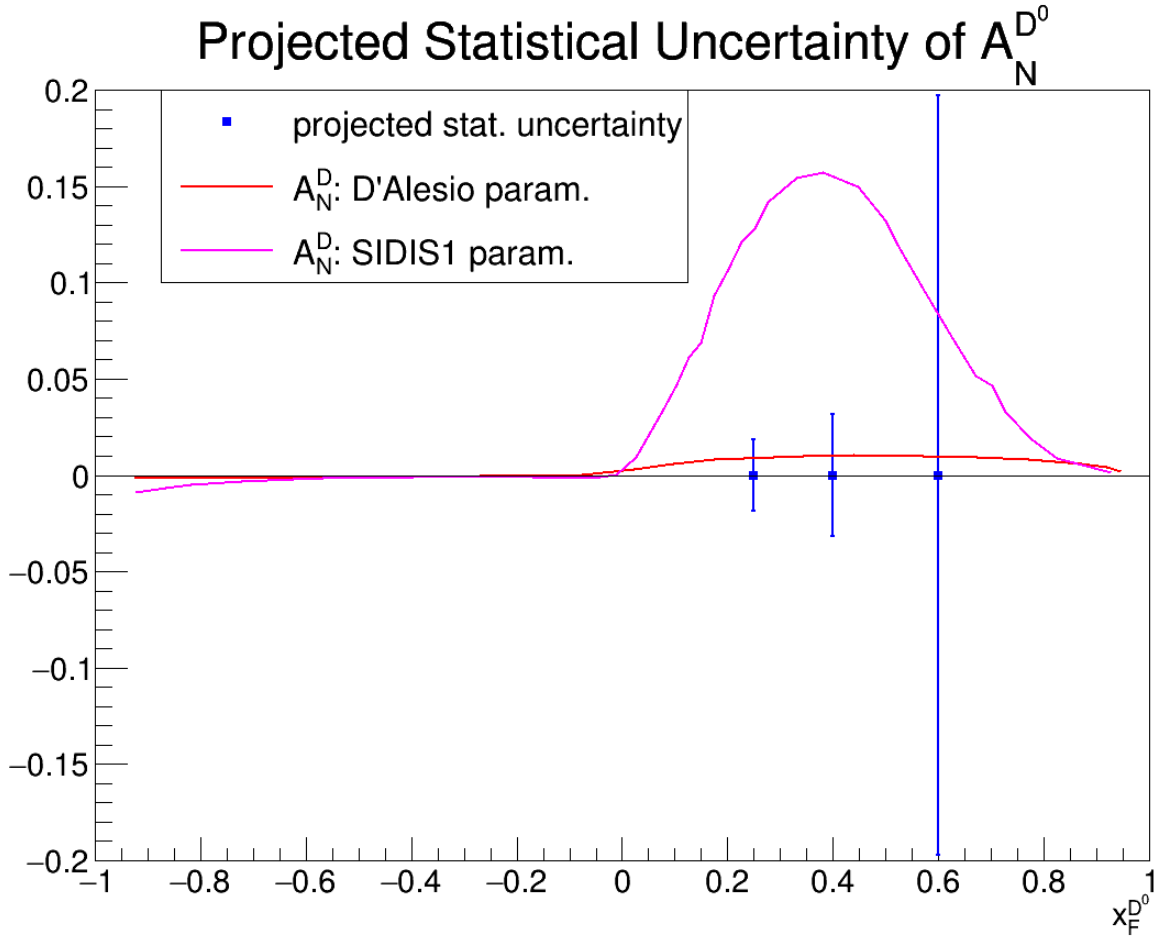



Figure 1: $A_N$ estimations for D mesons (not just $D^0$)

Percent level uncertainty can already distinguish between model dependence of calculation (which is order of magnitude different)

# Projected Asymmetry of $A_N^{D^0}$



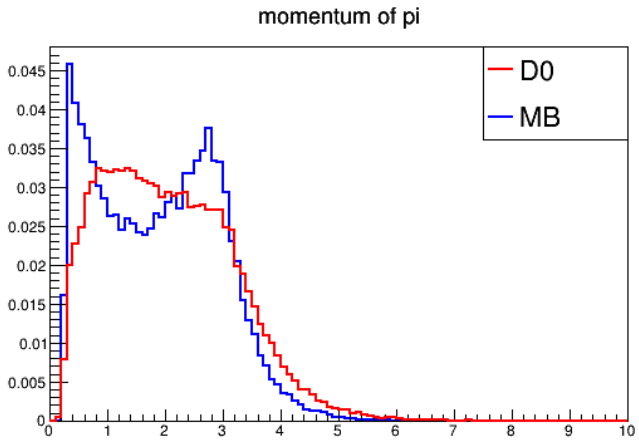

d-type $A_N^D$ for theroretical estimation shown here

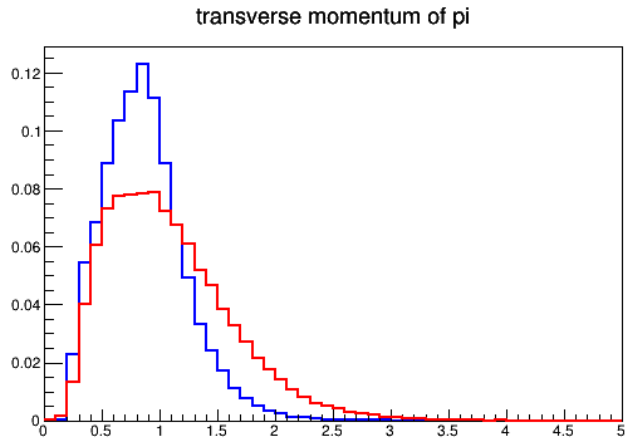
# Summary

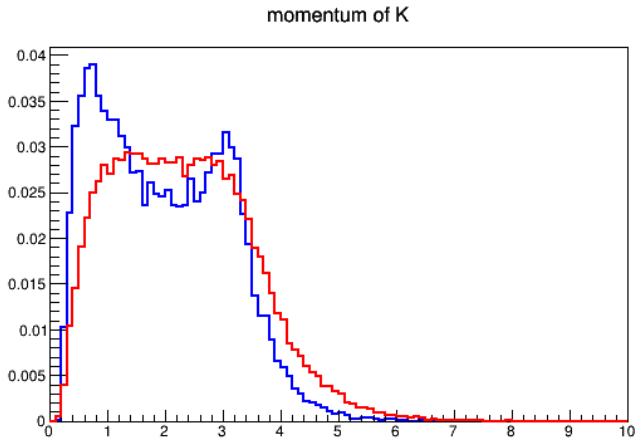
- Background suppression seems on the right tracks
- Statistically not meaningful to put a number yet
- Still need a large MC data set sitting at EOS from our software team
- This is in many ways 'ideal'
- Vertex smearing and real PID usage will make things worse
- Event selection criteria will also most probably create a different $N_S/N_B$ in recorded data, giving more flexibility in analysis to keep more of signal events
- I'll reiterate, software event selection is crucial for our statistics and therefore, uncertainty

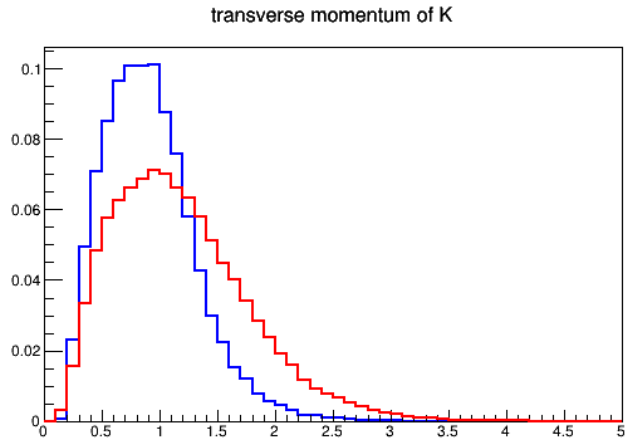
# Backup

# Daughter Comparisons With $x_F$ Cut



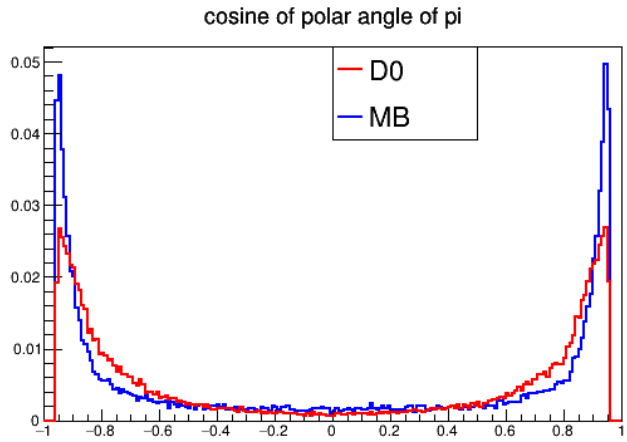



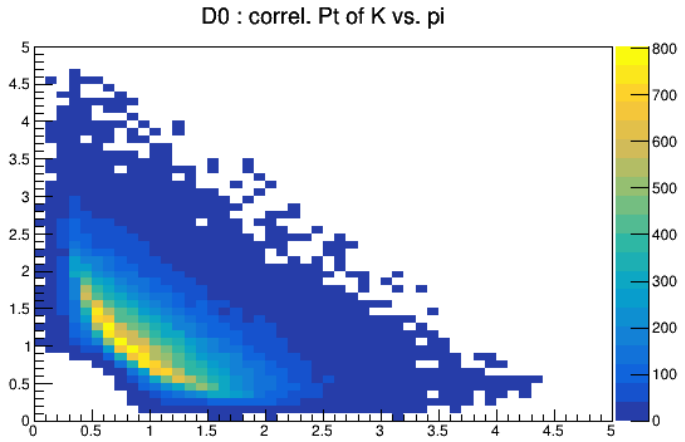



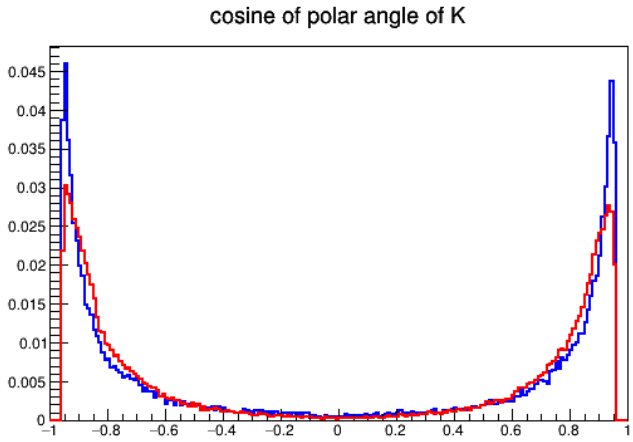



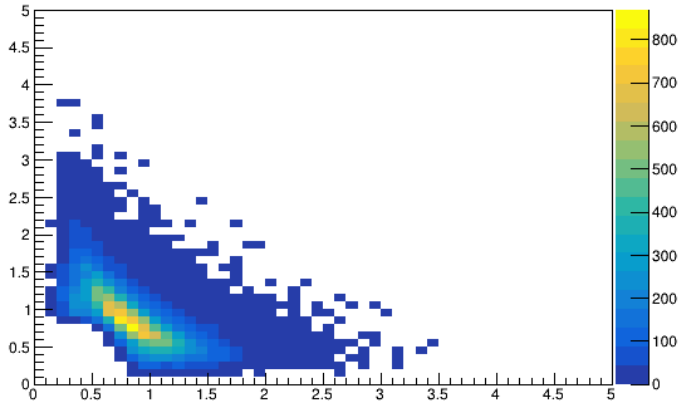

to compare with V. Andreev's plots

# Daughter Comparisons With $x_F$ Cut




to compare with V. Andreev's plots