THE GEORGE WASHINGTON UNIVERSITY
WASHINGTON, DC

$K_L + p \rightarrow \pi^+ + \Lambda$

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HTTPS://WWW.LINKEDIN.COM/IN/MARSHALL-SCOTT-PH-D-17AB191B9

K LONG FACILITY

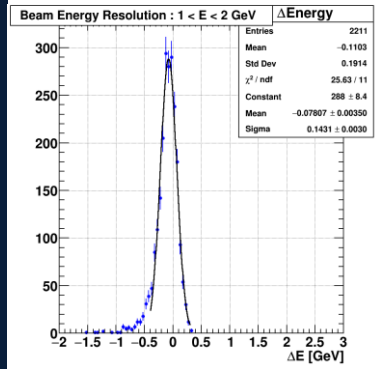
Jefferson Lab

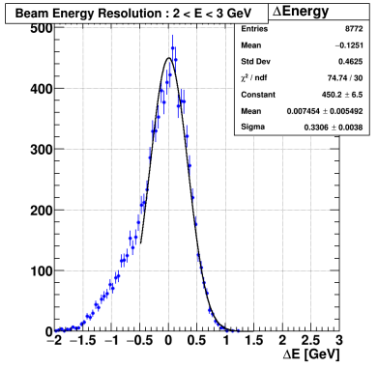
KL4 RXN AND GENERATING STEPS

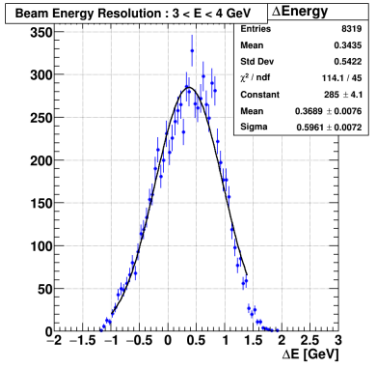
- Kl4 : $K^0_L + p \rightarrow \pi^+ + \Lambda$
  - $\Lambda \rightarrow p + \pi^-$ (63.9%) ; Current priority
  - $\Lambda \rightarrow n + \pi^0$ (35.8%)
- Backgrounds : (Primary) $K^0_L + p \rightarrow \pi^+ + \Sigma^0$, (Secondary) $K^0_L + p \rightarrow K^+ + \Xi^0$
- Generated histograms/root files (Monitoring Histograms, ReactionFilter, mcthrown_tree)
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=monitoring_hists foo_smeared.hddm
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=ReactionFilter –PReaction1=10_14__8_18 foo_smeared.hddm
  - hd_root --nthreads=8 -PPLUGINS=PEVENTRFBUNCH:USE_TAG=KLong -PVERTEX:USEWEIGHTEDAVERAGE=1 -PPLUGINS=mcthrown_tree foo_smeared.hddm

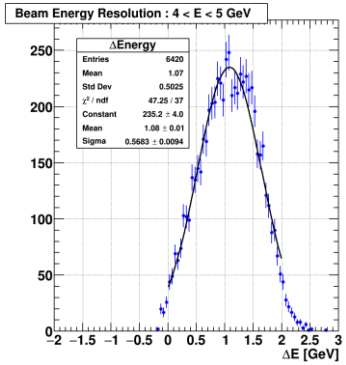
Beam Energy Resolution Issue Fixed

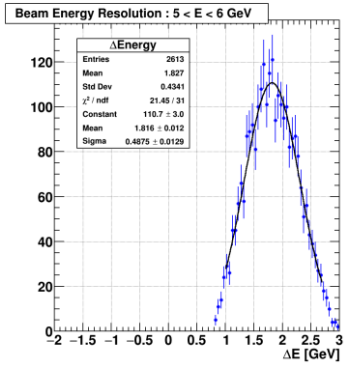
- The committee mentioned an issue that the mean of the resolution above E > 4 GeV was so large.
- Looking at the code the W < 3 GeV cut was only implemented for the reconstructed data, so there were events where the reconstructed event has W < 3 GeV, but not the thrown event, yielding large mean differences.
- This has been fixed.





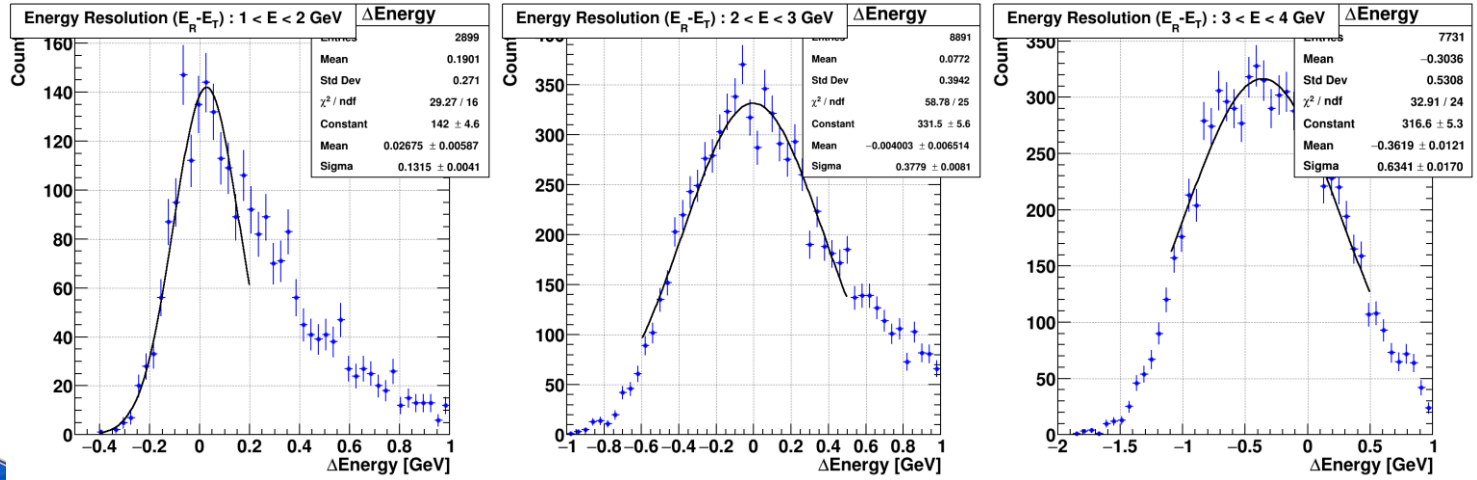






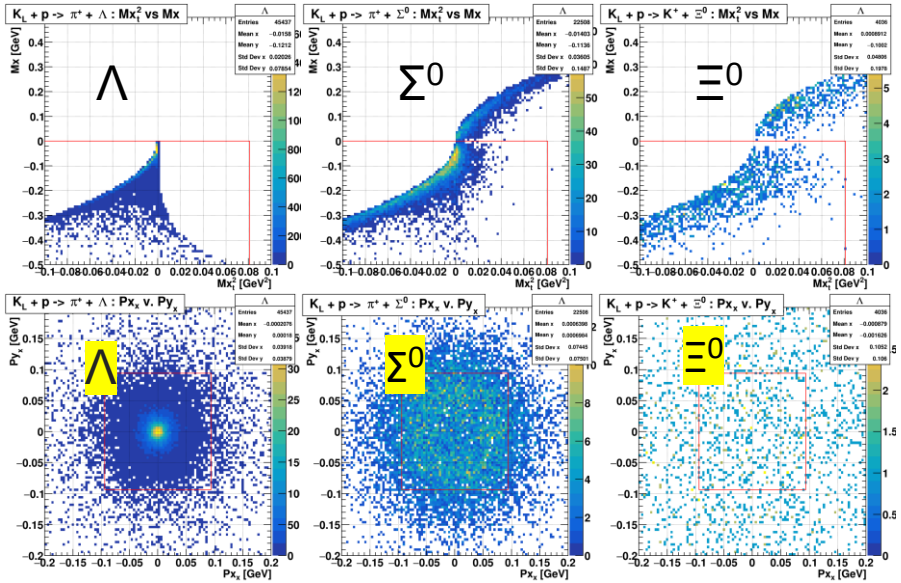
Beam Energy Resolution new results

- Below are the updated results.
- The last two energy bins, i.e. 4 < E < 5 GeV and 5 < E < 6 GeV, no longer exist.
- Widths of the surviving bins are comparable to the previous ones.



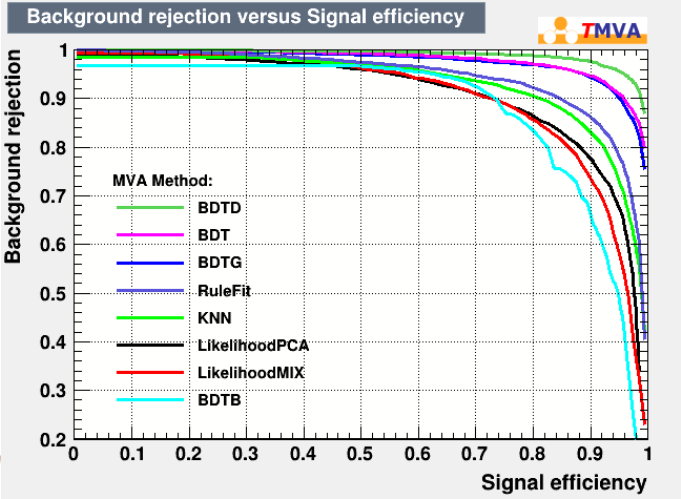
Selection Cuts

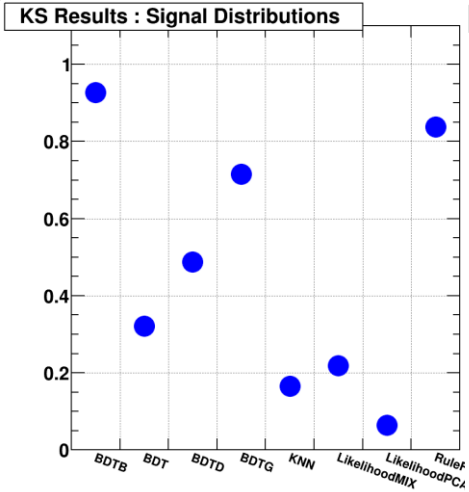
- Previous Cuts
  - $M_x < 0$ GeV : $[M_x = |K_L + p - \Lambda - \pi|]$
  - $M_{xt}^2 < 0.081$ GeV^2 : $[M_{xt}^2 = E_x^2 - p_{xz}^2]$
  - $P_{xx}, P_{xy} < 0.094$ GeV
- These cut signal by 10%, while removing the Σ and Ξ backgrounds by 50 and 90%, respectively.
- Studied some machine learning to see if I could improve on the cuts.
- I did an 80/20 train/test split using the $\Lambda\pi^+$ distributions as signal and the $\Sigma\pi^+$ as background.
- A list of the training variables is in the backup slides.

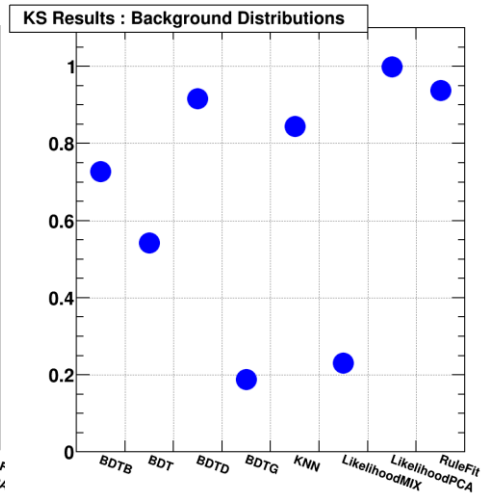


Machine Learning for Background Removal

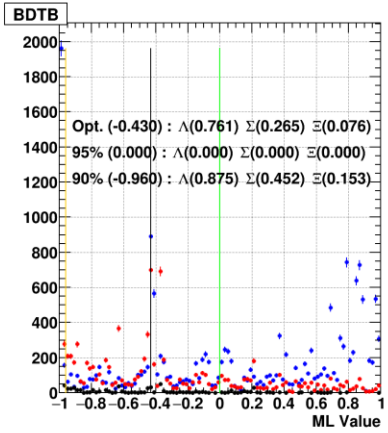
- ROC curve shown on the left depicts how well the ML model is at discriminating signal from background, with larger areas reflecting better discrimination.
- The KS (Kolmogorov Smirnov) tests below reflect how comparable the testing and training distributions are in terms of the ML values. A higher percentage reflect more compatibility and therefore less overtraining (p >0.05 is considered fine).

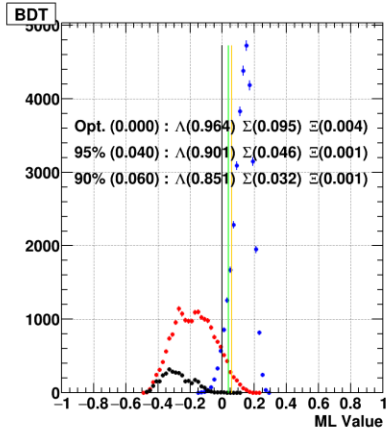


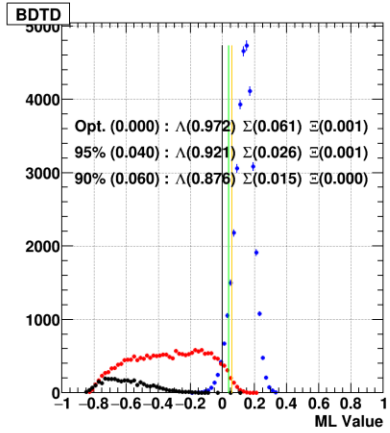


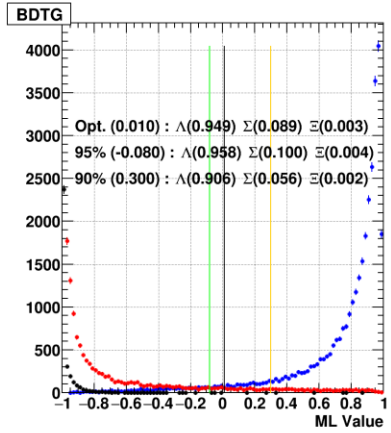


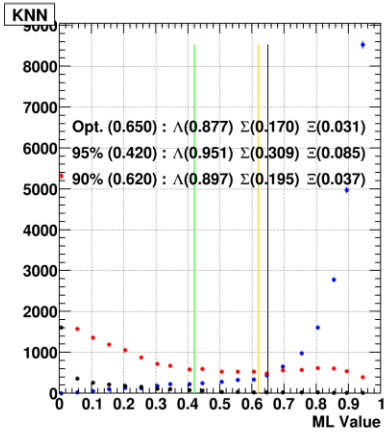
ML RESULTS

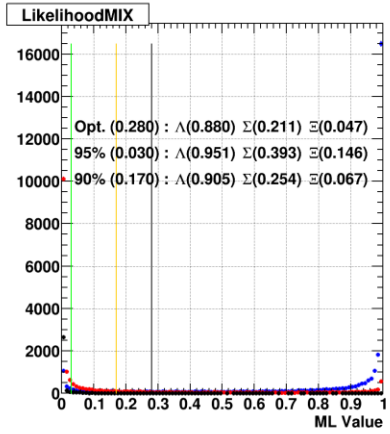

BDTB
Opt. (-0.430) : Λ(0.761) Σ(0.265) Ξ(0.076)
95% (0.000) : Λ(0.000) Σ(0.000) Ξ(0.000)
90% (-0.960) : Λ(0.875) Σ(0.452) Ξ(0.153)
ML Value

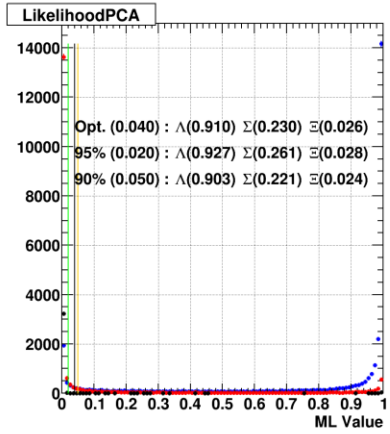

BDT
Opt. (0.000) : Λ(0.964) Σ(0.095) Ξ(0.004)
95% (0.040) : Λ(0.901) Σ(0.046) Ξ(0.001)
90% (0.060) : Λ(0.851) Σ(0.032) Ξ(0.001)
ML Value

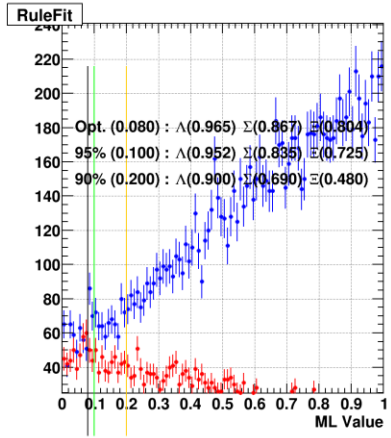

BDTD
Opt. (0.000) : Λ(0.972) Σ(0.061) Ξ(0.001)
95% (0.040) : Λ(0.921) Σ(0.026) Ξ(0.001)
90% (0.060) : Λ(0.876) Σ(0.015) Ξ(0.000)
ML Value


BDTG
Opt. (0.010) : Λ(0.949) Σ(0.089) Ξ(0.003)
95% (-0.080) : Λ(0.958) Σ(0.100) Ξ(0.004)
90% (0.300) : Λ(0.906) Σ(0.056) Ξ(0.002)
ML Value


KNN
Opt. (0.650) : Λ(0.877) Σ(0.170) Ξ(0.031)
95% (0.420) : Λ(0.951) Σ(0.309) Ξ(0.085)
90% (0.620) : Λ(0.897) Σ(0.195) Ξ(0.037)
ML Value


LikelihoodMIX
Opt. (0.280) : Λ(0.880) Σ(0.211) Ξ(0.047)
95% (0.030) : Λ(0.951) Σ(0.393) Ξ(0.146)
90% (0.170) : Λ(0.905) Σ(0.254) Ξ(0.067)
ML Value


LikelihoodPCA
Opt. (0.040) : Λ(0.910) Σ(0.230) Ξ(0.026)
95% (0.020) : Λ(0.927) Σ(0.261) Ξ(0.028)
90% (0.050) : Λ(0.903) Σ(0.221) Ξ(0.024)
ML Value


RuleFit
Opt. (0.080) : Λ(0.965) Σ(0.867) Ξ(0.804)
95% (0.100) : Λ(0.952) Σ(0.835) Ξ(0.725)
90% (0.200) : Λ(0.900) Σ(0.690) Ξ(0.480)
ML Value

Future work

- Improve Λ fit, especially on the right side of the distribution
- Λ polarization
- Λ vertexing for background removal
- Studies on misidentified proton/π^+

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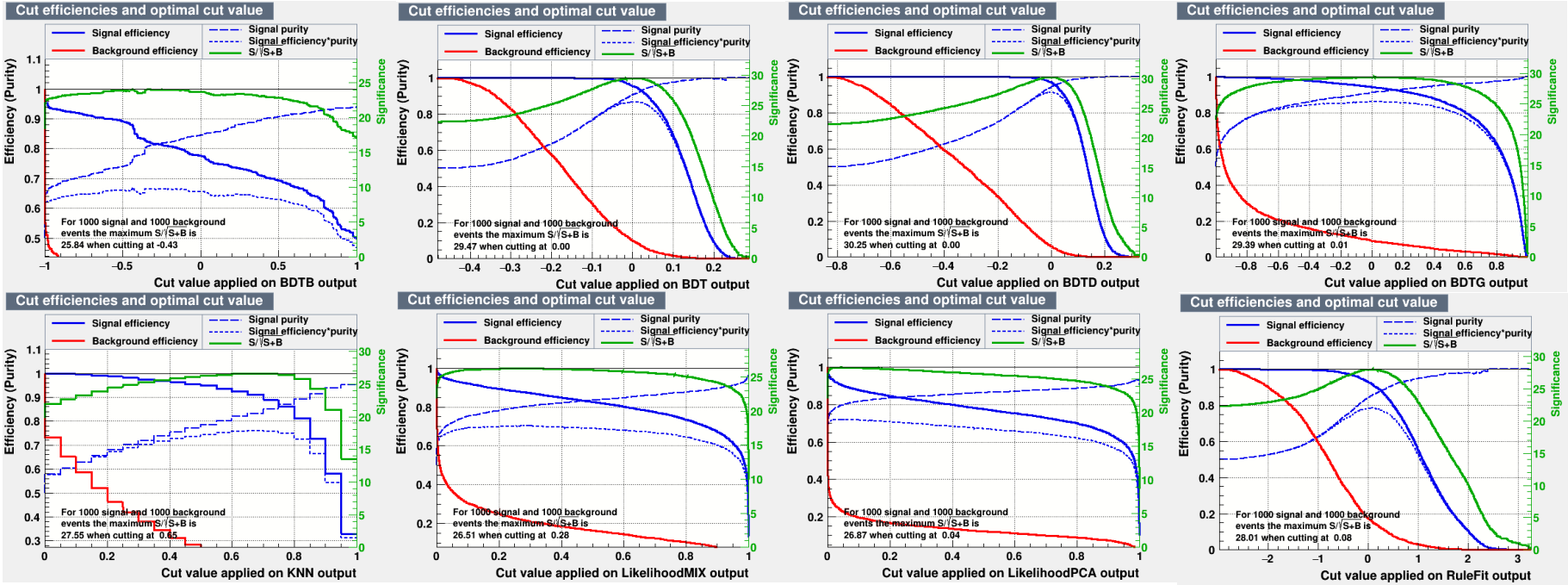
Backup Slides

ML Variables

- Proton : p_x, p_y, p_z, E
- π^- : p_x, p_y, p_z, E
- π^+ : p_x, p_y, p_z, E
- Λ : p_x, p_y, p_z, E, m_T^2, p_T, E_T^2
- x : p_x, p_y, p_z, E, m, m_T^2, p_T, E_T^2

ML Cut efficiencies



M. B. C. Scott

Λ Distributions