中国科学技术大学
University of Science and Technology of China

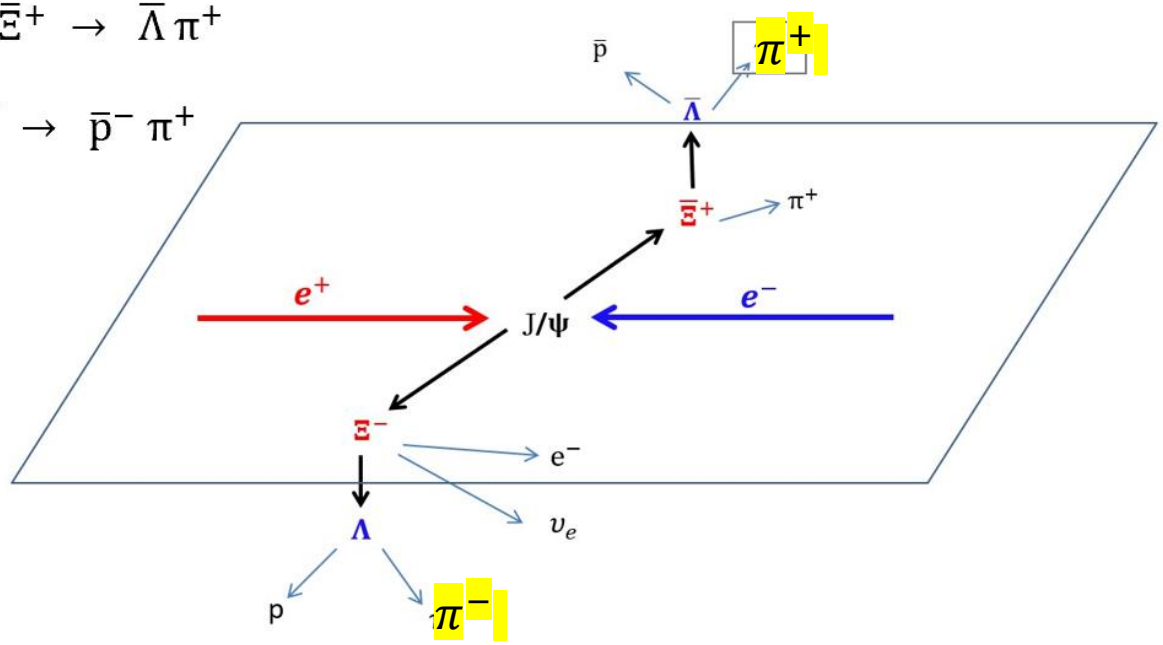
Measurements of the branching fraction for $\Xi^- \to \Lambda e^- \nu$

Data set

$J/\psi \rightarrow \Xi^- \bar{\Xi}^+$,

$\Xi^- \rightarrow \Lambda\, e^- \nu$, $\bar{\Xi}^+ \rightarrow \bar{\Lambda}\pi^+$

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



Here I chose $\Xi^- \rightarrow \Lambda\, e^- \nu$, $\bar{\Xi}^+ \rightarrow \bar{\Lambda}\pi^+$ as my data set.

Background analysis

Ξ^- DECAY MODES

	Mode	Fraction (Γ_i/Γ)	Confidence level
Γ_1	$\Lambda\pi^-$	(99.887 ± 0.035) %	
Γ_2	$\Sigma^-\gamma$	(1.27 ± 0.23) × 10^{-4}	
Γ_3	$\Lambda e^-\overline{\nu}_e$	(5.63 ± 0.31) × 10^{-4}	
Γ_4	$\Lambda\mu^-\overline{\nu}_\mu$	(3.5 $^{+3.5}_{-2.2}$) × 10^{-4}	
Γ_5	$\Sigma^0 e^-\overline{\nu}_e$	(8.7 ± 1.7) × 10^{-5}	
Γ_6	$\Sigma^0\mu^-\overline{\nu}_\mu$	< 8 × 10^{-4}	90%
Γ_7	$\Xi^0 e^-\overline{\nu}_e$	< 2.3 × 10^{-3}	90%

The main background should be $\Xi^- \rightarrow \Lambda\,\pi^-$

Data set

8000000 Background mc $\Xi^- \rightarrow \Lambda\, \pi^-$

1412000 signal mc $\Xi^- \rightarrow \Lambda\ e^-\ \nu$

Event selection

- Charged Tracks
  - ✓ No Vertex requirement; $|\cos\theta| < 0.93; \mathrm{n}charge\ positive \geq 2; ncharge\ negative \geq 1;$

- PID
  - ✓ Proton: p>0.32 GeV/c; $nproton^{-} \geq 1$
  - ✓ Pion: p<0.32 GeV/c; $npion^{+} \geq 2$

- Vertex fit for $\overline{\Lambda}, \overline{\Xi}^{+}$
  - ✓ For $\overline{\Lambda}, \overline{\Xi}^{+}$, primary and secondary vertex fit used for the $\bar{p}^{-}\pi^{+}$for $\overline{\Lambda}, \overline{\Lambda}\pi^{+}$for $\overline{\Xi}^{+}$.
    Loop all the pairs, select combination by minimizing $\chi^2 = \left(M(\bar{p}^{-}\pi^{+}) -\right.$

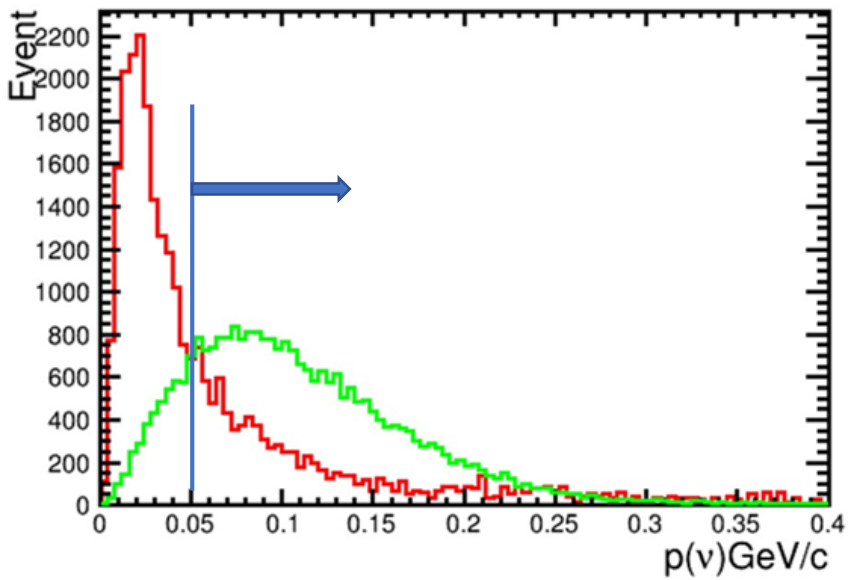
Event selection

- PID
  - ✓ $nproton^{+} \geq 1$, $npion^{-} \geq 2$
  - ✓ Electron: prob_e>prob_K && prob_e>prob_π; ie.size()==1;

- Vertex fit for Λ, Ξ^{-}
  - ✓ For Λ, primary and secondary vertex fit used for the $p^{+}\pi^{-}$for Λ, Λ for Ξ^{-}.
  - ✓ For Ξ^{-}, primary vertex fit used for the Λe^{-} for Ξ^{-}.

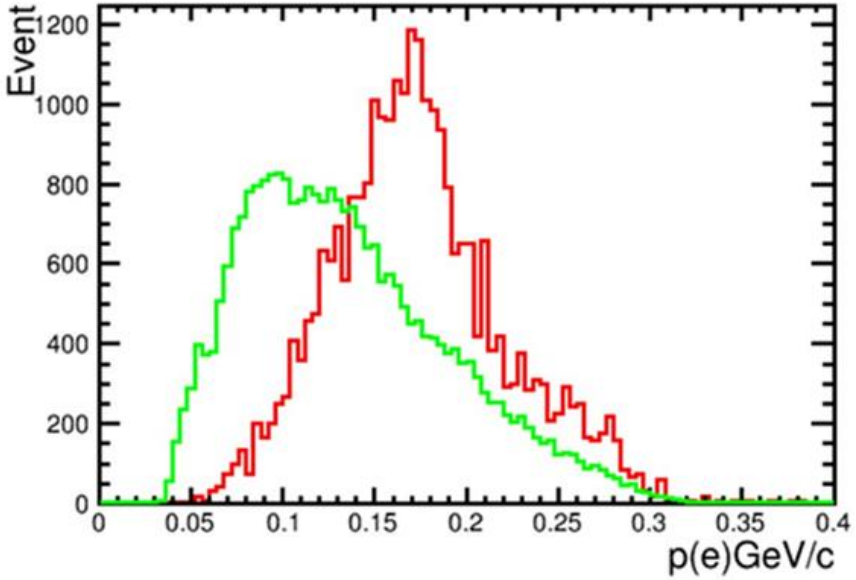
    Loop all the pairs, select combination by minimizing $\chi^2 = chisq_{p\pi^-} + chisq_{\Lambda} + chisq_{\Lambda e^-}$

Background analysis



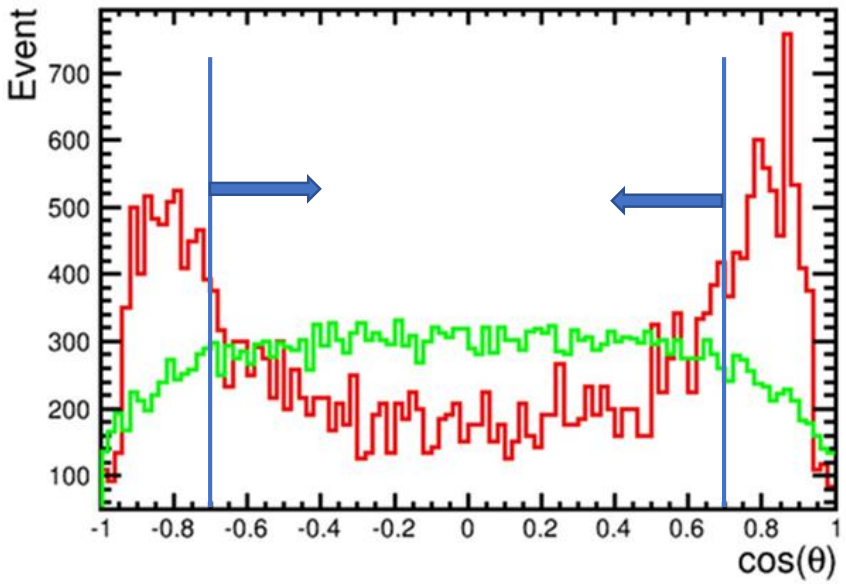
$\Xi^- \rightarrow \Lambda\ e^-\ \nu$

$\Xi^- \rightarrow \Lambda\ \pi^-$



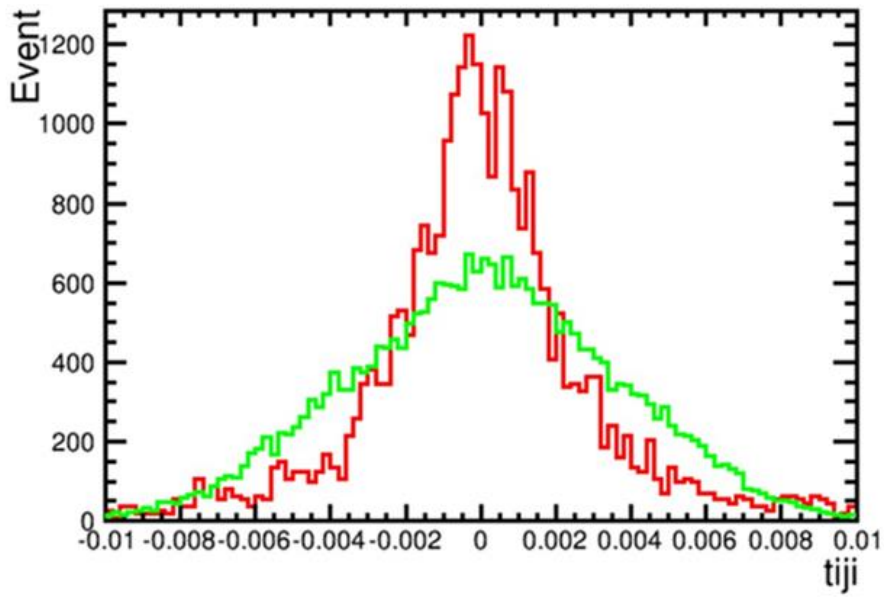
The momentum cut of neutrino should be
higher than 0.05

Background analysis



$\Xi^- \rightarrow \Lambda\ e^-\ \nu$

$\Xi^- \rightarrow \Lambda\ \pi^-$



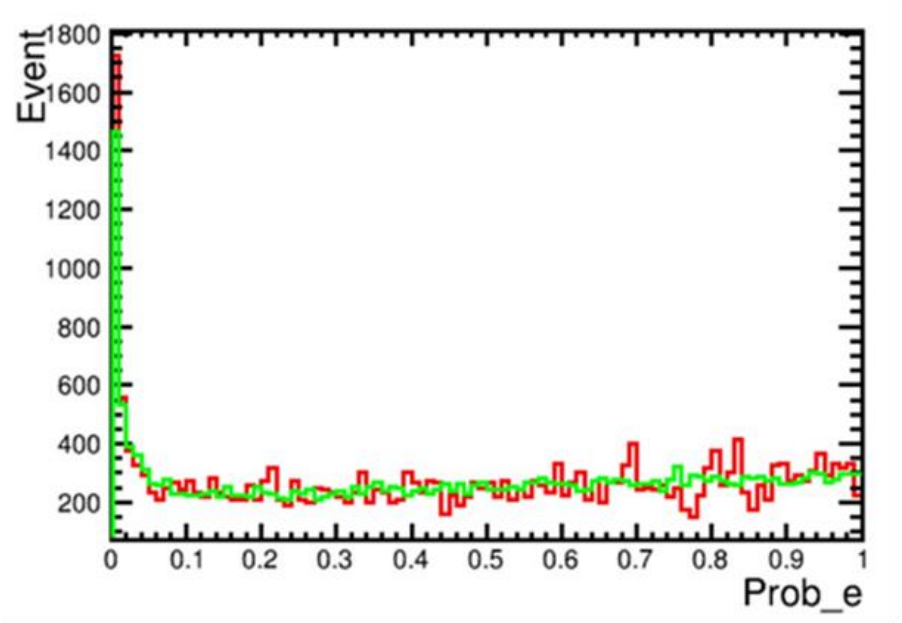
$$\vec{P}_\pi = \vec{P}_\Xi - \vec{P}_\Lambda$$

$$(\vec{p}_\Xi \times \vec{p}_\Lambda) \cdot \vec{p}_e$$

Here is the costheta of recoiling pion. We prefer the modulus of costheta is smaller than 0.7

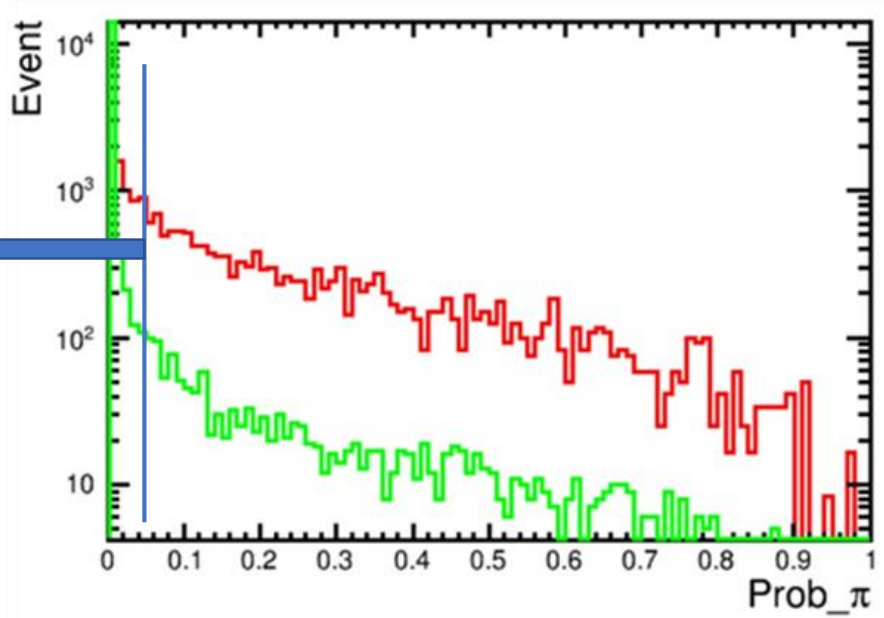
Because $\Xi \rightarrow \Lambda\ e\ \upsilon$ has 4 particles in this process and $\Xi \rightarrow \Lambda\ \pi$ only has 3. If we mistake π for electron, this result should be zero as for the background.

Background analysis

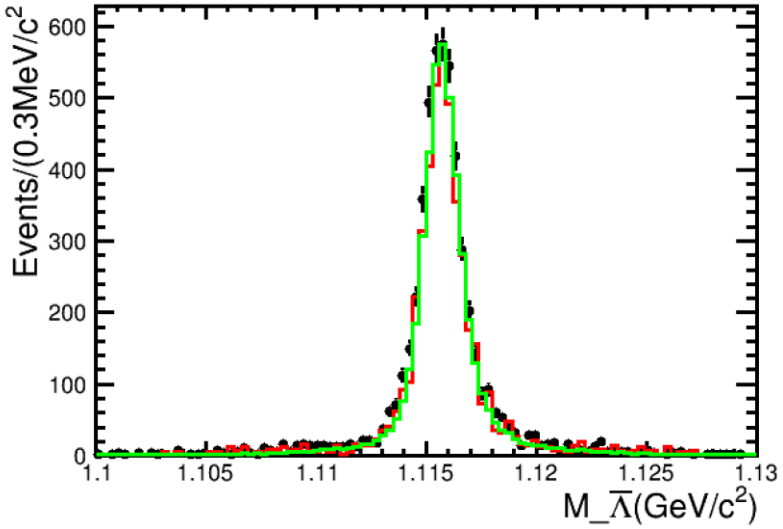


$\Xi^- \rightarrow \Lambda\ e^-\ \nu$

$\Xi^- \rightarrow \Lambda\ \pi^-$



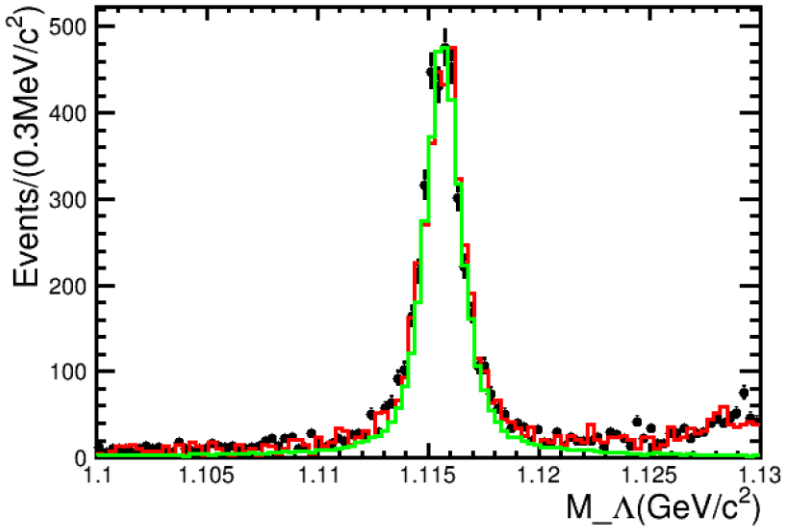
Event selection

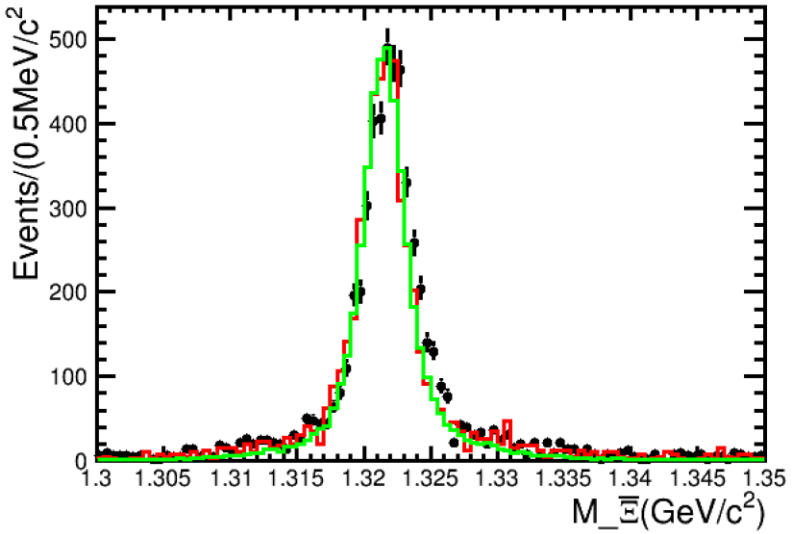


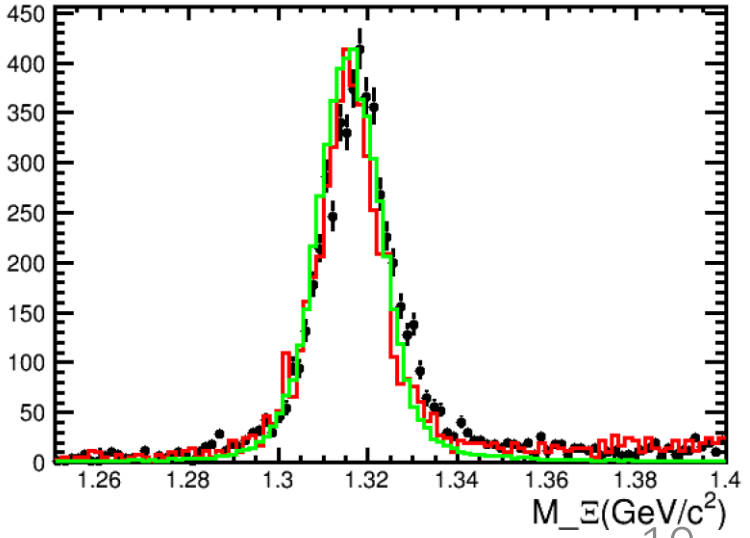
$\Xi^- \rightarrow \Lambda\ e^-\ \nu$

Inclusive MC

Jpsi data



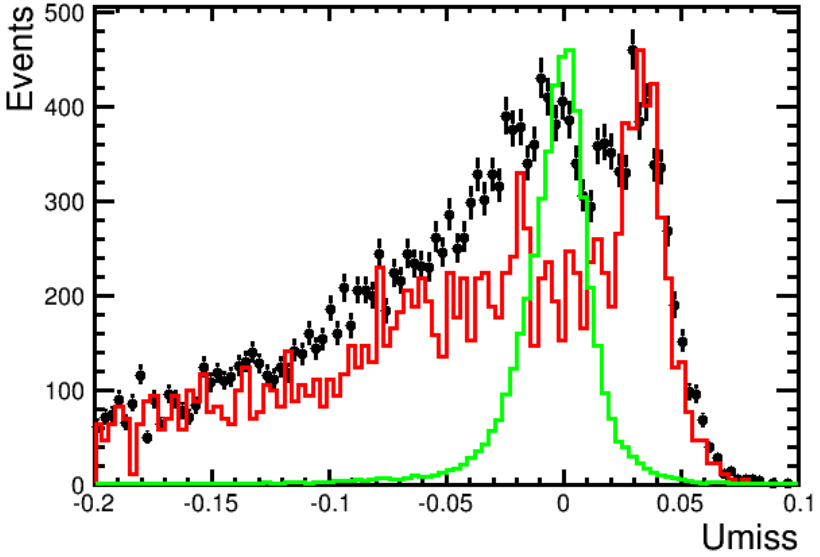


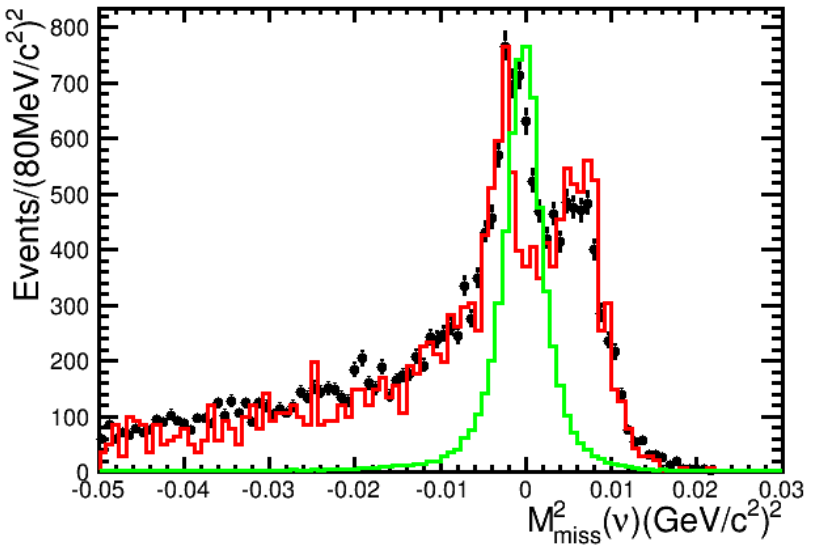


Variables

- Prob_e, Prob_pi, p_e
- Volume : $\vec{p}_{\Xi} \times \vec{p}_{\Lambda} \cdot \vec{p}_e$
- p_ν >0.05
- $|\cos\theta_{recoil\,\pi}|$<0.7
- $|M_{\bar{\Xi}} - 1.32171| < 0.011$
- $|M_{\bar{\Lambda}} - 1.115683| < 0.0115$
- $|M_{\Lambda} - 1.115683| < 0.0115$
- $|M_{\Xi} - 1.32171| < 0.03$

Apply selection to data





$$Umiss = E_\nu - |\vec{p}_\nu|$$

$$M^2_{miss} = E^2_\nu - |\vec{p}_\nu|^2$$

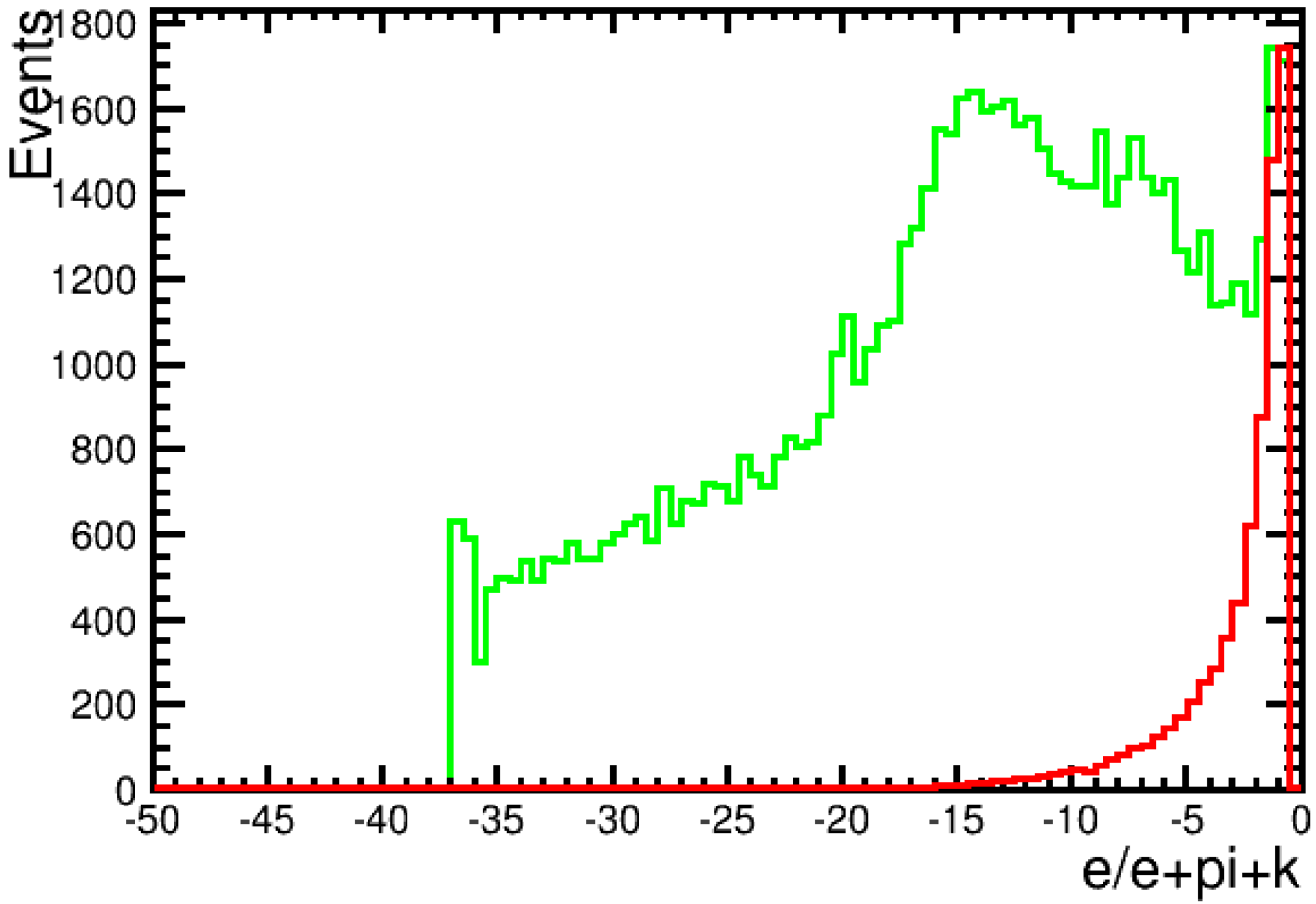
$$E_\nu = E_{beam} - E_\Lambda - E_e$$

$$\vec{p}_\nu = \vec{p}_{all} - \vec{p}_{\bar{\Xi}} - \vec{p}_\Lambda - \vec{p}_e$$

$$\vec{p}_{\bar{\Xi}} = \hat{p}_{tag}\sqrt{E^2_{beam} - m^2_{\bar{\Xi}}}$$

Event selection

$$\ln(1 - \frac{prob_e}{prob_e + prob_{pi} + pron_{kaon}})$$



TMVA

Variables :

Prob_e ——— probability of electron in ParticleID

Prob_pi ——— probability of pion in ParticleID

Prob_k ——— probability of kaon in ParticleID

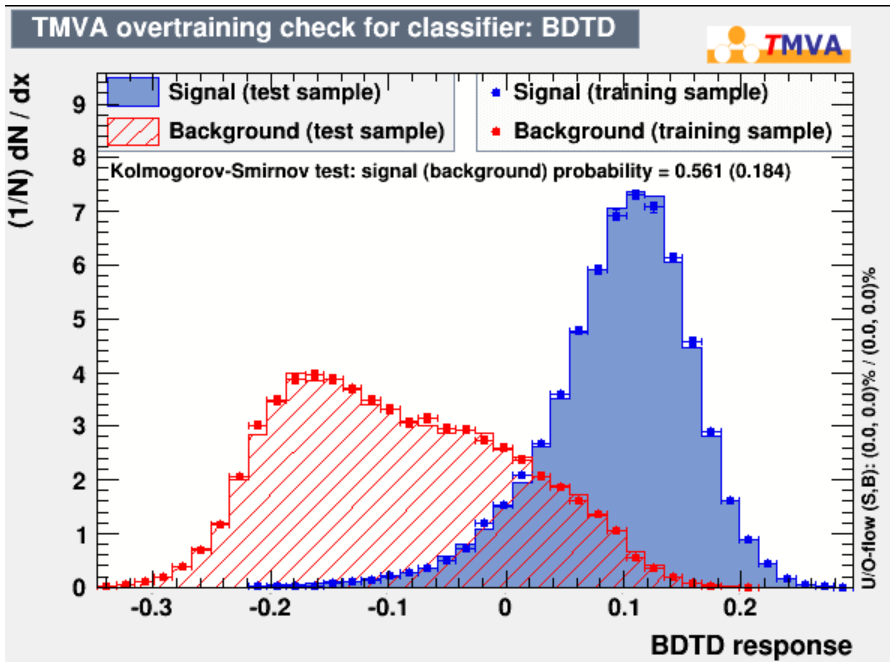
P_e ——— momentum of electron

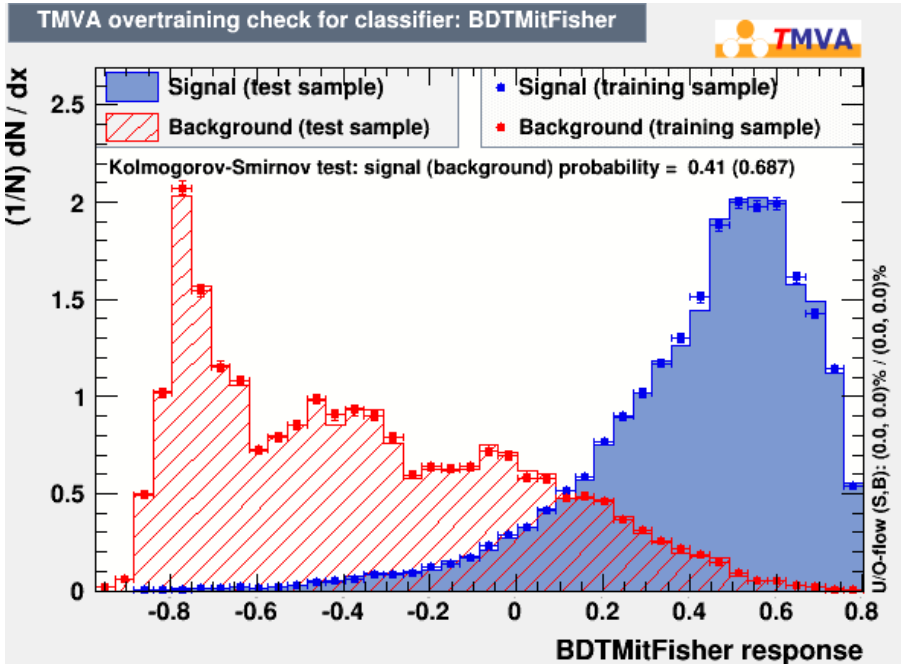
P_ν ——— momentum of neutrino

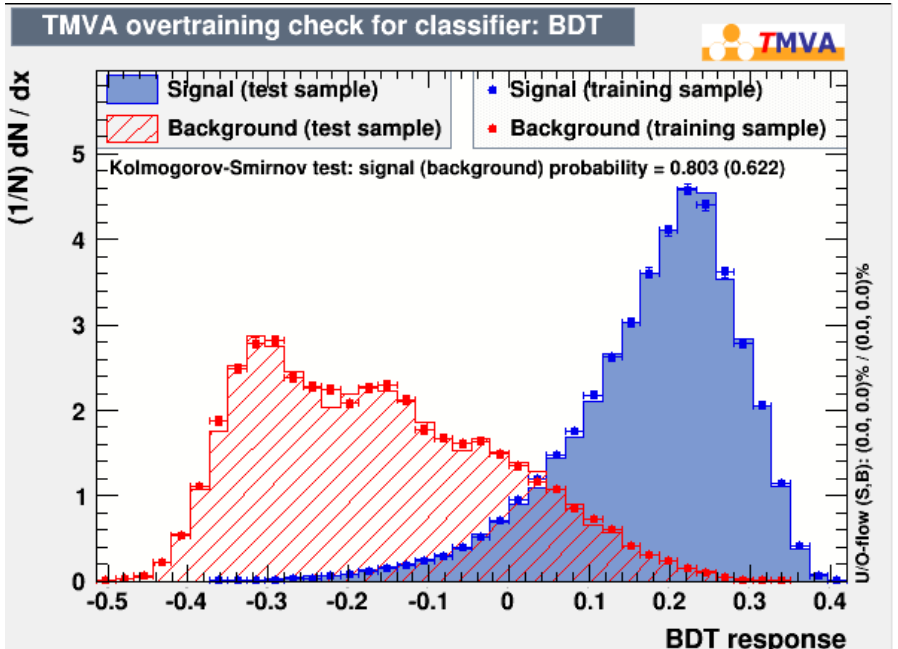
$\cos\theta_{recoil\,\pi}$ ——— cos(θ) of recoil pion

Volume ——— $\vec{p}_\Xi \times \vec{p}_\Lambda \cdot \vec{p}_e$

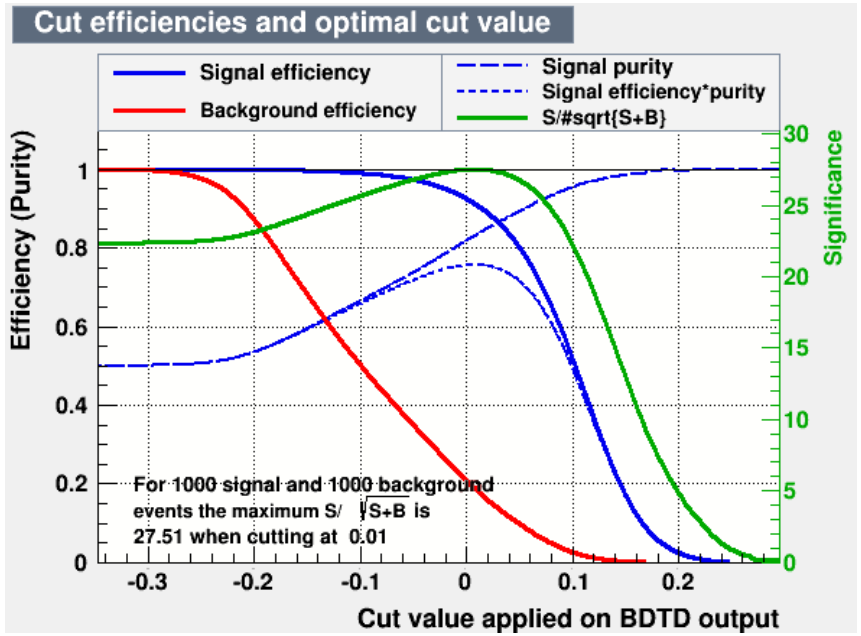
TMVA

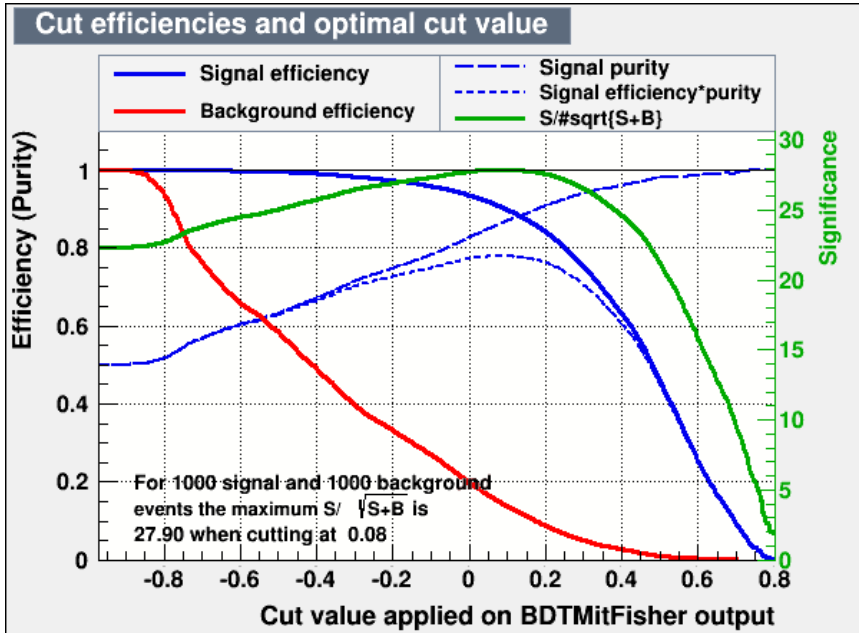

TMVA overtraining check for classifier: BDTD
TMVA
Signal (test sample)
Signal (training sample)
Background (test sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.561 (0.184)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDTD response

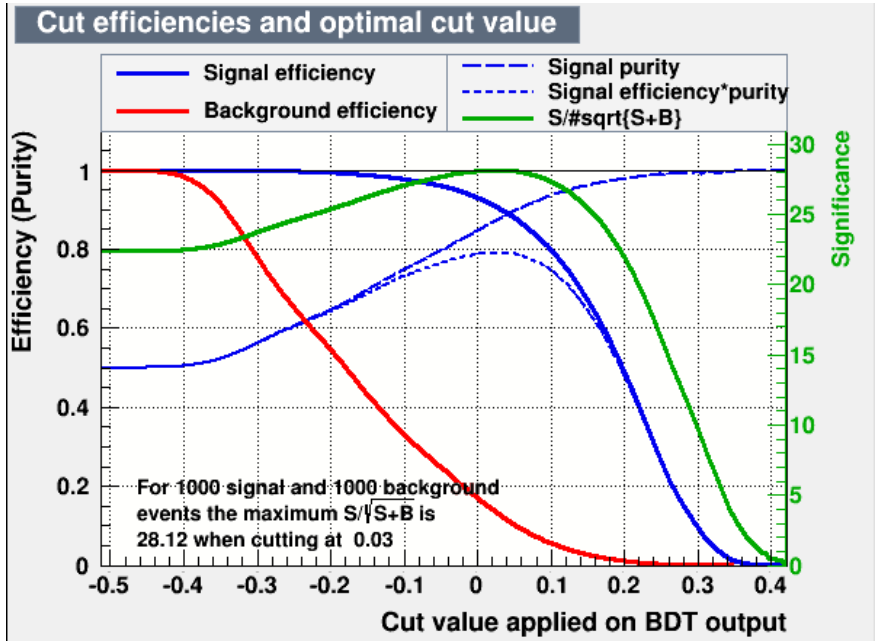

TMVA overtraining check for classifier: BDTMitFisher
TMVA
Signal (test sample)
Signal (training sample)
Background (test sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.41 (0.687)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDTMitFisher response


TMVA overtraining check for classifier: BDT
TMVA
Signal (test sample)
Signal (training sample)
Background (test sample)
Background (training sample)
Kolmogorov-Smirnov test: signal (background) probability = 0.803 (0.622)
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDT response

TMVA


Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/#sqrt{S+B}
Efficiency (Purity)
Significance
For 1000 signal and 1000 background
events the maximum S/√S+B is
27.51 when cutting at 0.01
Cut value applied on BDTD output

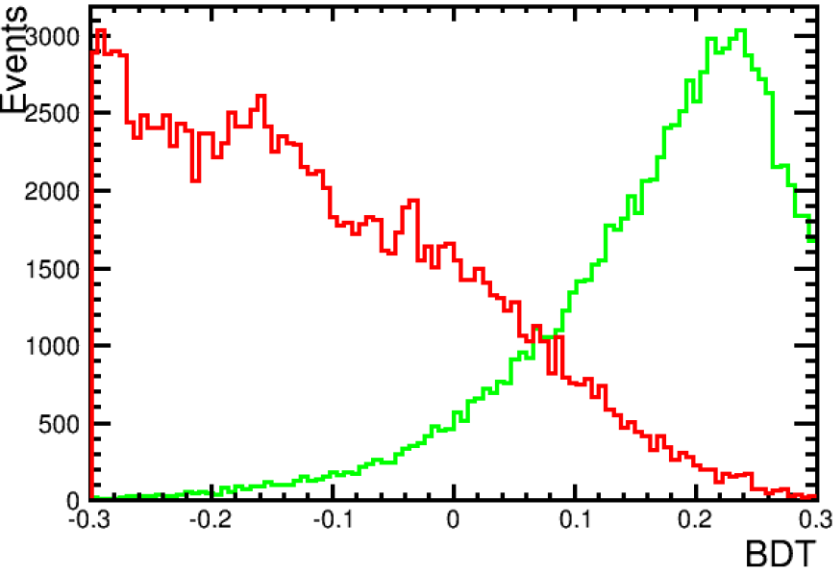

Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/#sqrt{S+B}
Efficiency (Purity)
Significance
For 1000 signal and 1000 background
events the maximum S/√S+B is
27.90 when cutting at 0.08
Cut value applied on BDTMitFisher output

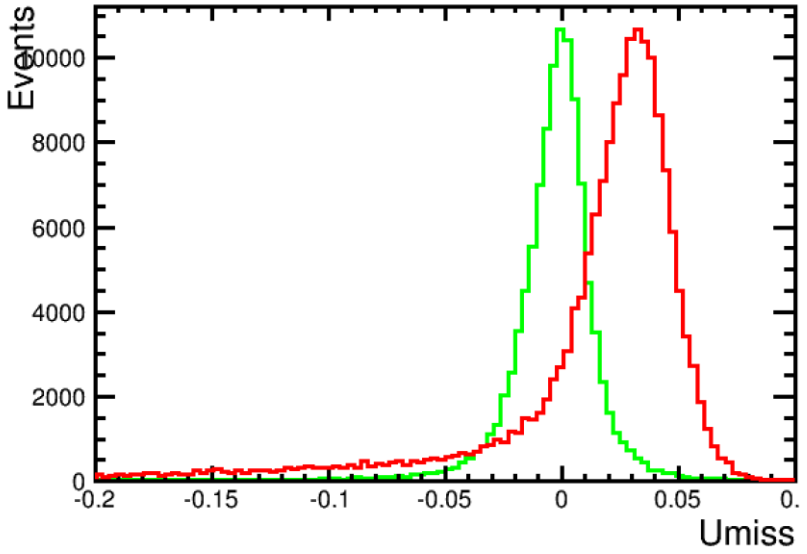

Cut efficiencies and optimal cut value
Signal efficiency
Background efficiency
Signal purity
Signal efficiency*purity
S/#sqrt{S+B}
Efficiency (Purity)
Significance
For 1000 signal and 1000 background
events the maximum S/√S+B is
28.12 when cutting at 0.03
Cut value applied on BDT output

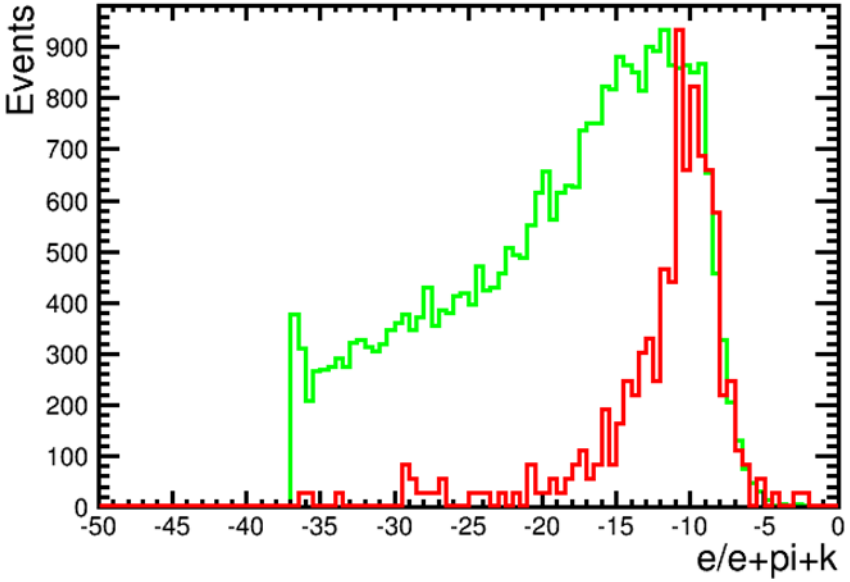
TMVA

Variables : Prob_e, Prob_pi, Prob_k, P_e, P_ν, $\cos\theta_{recoil\,\pi}$, volume

BDT>0.2 and $\mathbf{ln}(1-\frac{prob_e}{prob_e+prob_{pi}+prob_{kaon}})$**<-14**







TMVA

I chose BDT method.

BDT>0.2 and $\mathbf{ln}(\mathbf{1}-\frac{\boldsymbol{prob_e}}{\boldsymbol{prob_e}+\boldsymbol{prob_{pi}}+\boldsymbol{prob_{kaon}}})$**<-14**

Background efficiency=206/8000000= 2.575×10^(-5)

signal efficiency=41568/1412000=0.03

$$\frac{\textbf{sig efficiency}\times\textbf{sig fraction}}{\textbf{bkg efficiency}\times\textbf{bkg fraction}}=\frac{\mathbf{0.03\times 5.63\times 10^{-4}}}{\mathbf{2.575\times 10^{-5}}}=\mathbf{0.655}$$

TMVA

BDT_out>0.2 and $\mathbf{ln}(1-\frac{prob_e}{prob_e+prob_{pi}+prob_{kaon}})$**<-14**

11822M jpsi data (I misused 5911M twice)

154 events are left