Study of HWRD process $\Xi^0 \to \Sigma^0\gamma$

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Nov 18, 2022

Motivation

Hara theorem
In hyperon weak radiative decay(HWRD):
B^{PV} should vanish under SU(3) limit $\rightarrow \alpha_\gamma = 0$
Take the weak breaking of SU(3) symmetry into consideration $\alpha_\gamma \sim \pm 0.2$

$$\alpha_\gamma = \frac{2\mathrm{Re}(A^{PC} * B^{PV})}{|A^{PC}|^2 + |B^{PV}|^2}$$

- α_γ: decay asymmetry
- A^{PC}: parity conserving amplitude
- B^{PV}: parity violating amplitude

Motivation

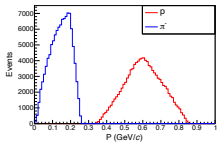
Measurements of decay asymmetry for $\Xi^0 \to \Sigma\gamma$

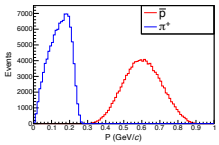
Experiments	BR$/10^{-3}$	α	Events
1989 SPEC	$3.56 \pm 0.42 \pm 0.10$	$+0.20 \pm 0.32 \pm 0.05$	85
2000 NA48	$3.16 \pm 0.76 \pm 0.32$	–	17
2001 KTEV	$3.34 \pm 0.05 \pm 0.09$	$-0.63 \pm 0.08 \pm 0.05$	4045
2010 NA48	–	$-0.729 \pm 0.030 \pm 0.076$	15k

Analysis Strategy

$$J/\psi \to \Xi^0\bar{\Xi}^0,\ \bar{\Xi}^0 \to \bar{\Sigma}^0\gamma,\ \Xi^0 \to \Lambda\pi^0, \bar{\Sigma}^0 \to \bar{\Lambda}\gamma$$

- Reconstruction: missing π^0
- Charged Tracks
  - $N \geq 4$
  - after pid: $N_p, N_{\pi^-}, N_{\bar{p}}, N_{\pi^+} \geq 1$





- Neutral Tracks: $N_\gamma \geq 2$
- $\Lambda\&\bar{\Lambda}$: Loop $p\pi^-(\bar{p}\pi^+)$ pairs to find the best
- Kinematics Fit
  - Constrain m_{π^0} & $m_{\bar{\Xi}}$
  - Loop $\gamma\gamma$ pairs to optimize

BDT – BKG Components

- Main bkg process:

$$J/\psi \to \Xi^0\bar{\Xi}^0,\ \bar{\Xi}^0 \to \bar{\Lambda}^0\pi^0,\ \Xi^0 \to \Lambda\pi^0$$

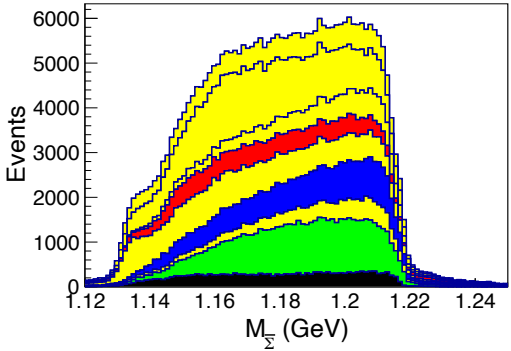
- Final state particles:

$$\mathrm{p\bar{p}}\pi^+\pi^-\gamma\gamma\gamma\gamma$$

BDT – BKG Components

Apply truth match to 2 photons
Get a set of match angles:
$(\theta_{\gamma_1 \text{with} \pi^0},\ \theta_{\gamma_1 \text{with missing} \pi^0},\ \theta_{\gamma_2 \text{with} \pi^0},\ \theta_{\gamma_2 \text{with missing} \pi^0})$
Classify BKG as

- 1 Both come from *signal* π^0
- *Only* $\gamma 1$ *is from signal*
  - *2* $\gamma 2$ *comes from missing* π^0
  - *3* $\gamma 2$ *is noise*
- *Only* $\gamma 2$ *is from signal*
  - *4* $\gamma 1$ *comes from missing* π^0
  - *5* $\gamma 1$ *is noise*
- *Both aren't from signal*
  - *6 Both come from missing* π^0
  - *7* $\gamma 1$ *from missing* π^0 & $\gamma 2$ *is noise*
  - *8* $\gamma 2$ *from missing* π^0 & $\gamma 1$ *is noise*
  - *9 Both are noise*



Bottom-up corresponds to case 1-9
Yellow Part: containing noisy photons

Independence of Process

3 samples of different processes:

- Red:

$$J/\psi \to \Xi^0\bar{\Xi^0},\ \bar{\Xi^0} \to \bar{\Lambda}^0\pi^0,\ \Xi^0 \to \Lambda\pi^0$$

- Blue:

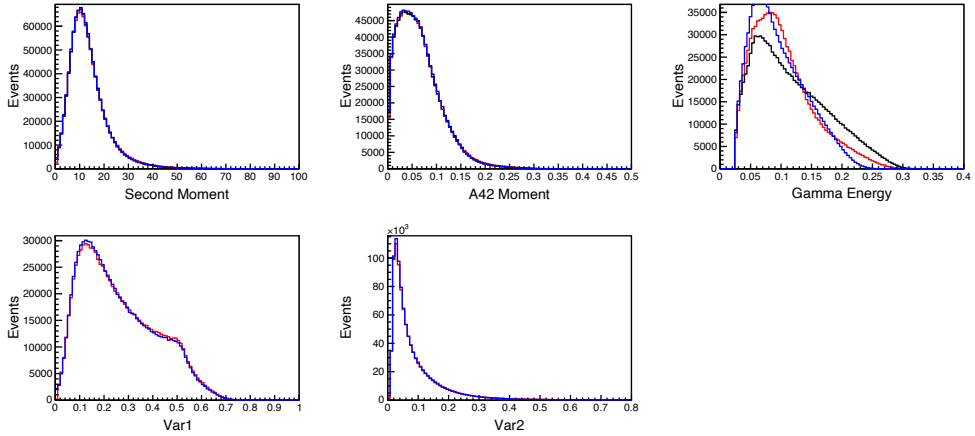
$$J/\psi \to \bar{\Xi}^+\Xi^-,\ \bar{\Xi}^+ \to \bar{\Lambda}\pi^+,\ \Xi^- \to \Lambda\pi^-,\ \bar{\Lambda} \to \bar{\mathrm{n}}\pi^0,\ \Lambda \to \mathrm{p}\pi^-$$

- Black:

$$J/\psi \to \Lambda\bar{\Lambda},\ \bar{\Lambda} \to \bar{\mathrm{n}}\pi^0,\ \Lambda \to \mathrm{p}\pi^-$$

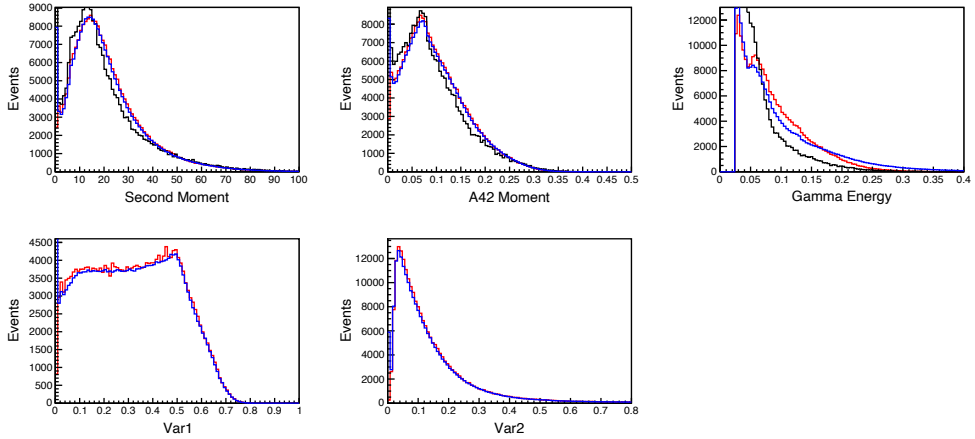
Independence of Process – Distribution of energy-weigthed input variables

Figure: Signal samples

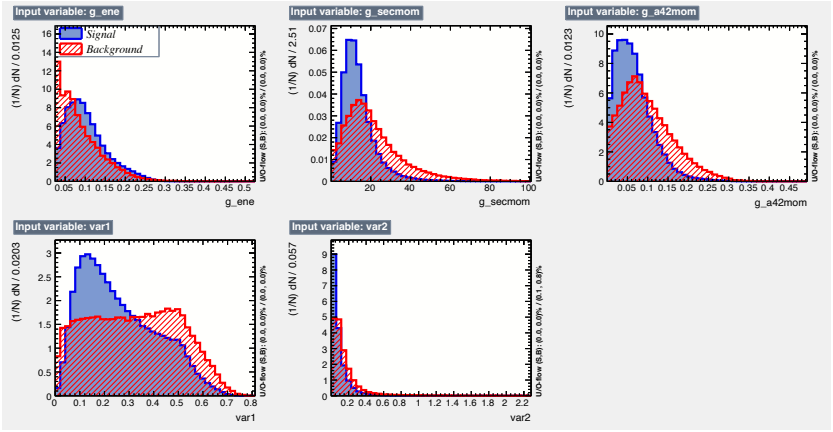


Independence of Process – Distribution of energy-weigthed input variables

Figure: Bkg samples



BDT – Input

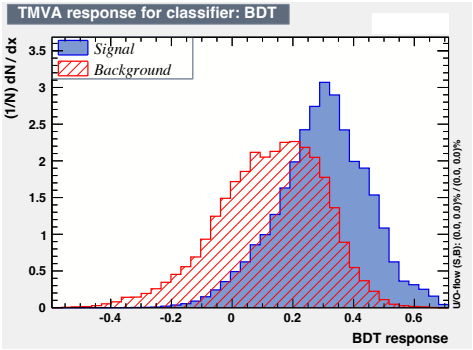


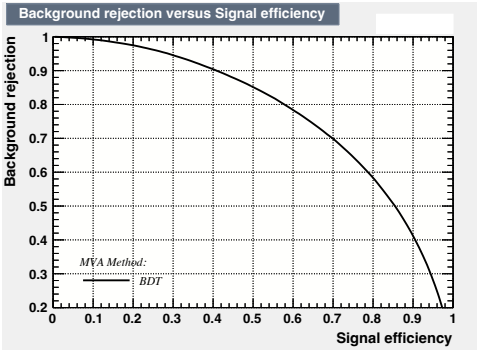
- Bkg sample: each match angle is larger than 15°
- Signal sample: one of the angles is less than 10°

$$\mathrm{var1} = \frac{e3\times3 - eSeed}{e3\times3}$$

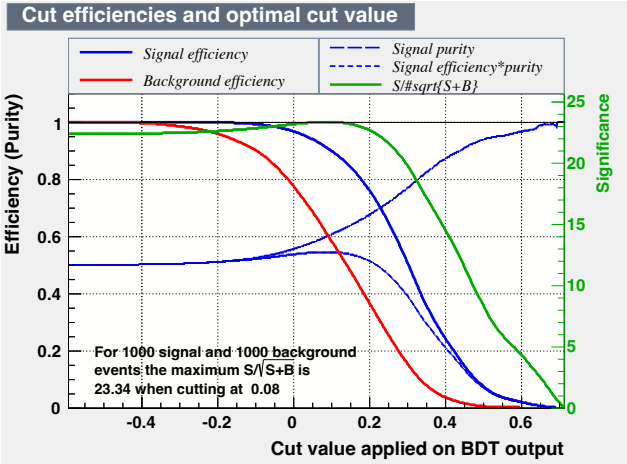
$$\mathrm{var2} = \frac{E - eSeed}{(Hits-1)\times eSeed}$$

BDT – Results

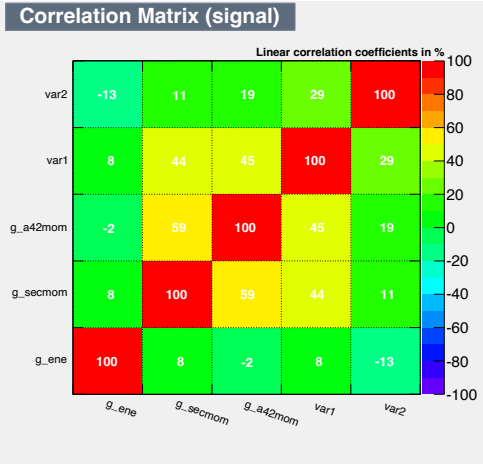

TMVA response for classifier: BDT
Signal
Background
(1/N) dN / dx
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%
BDT response

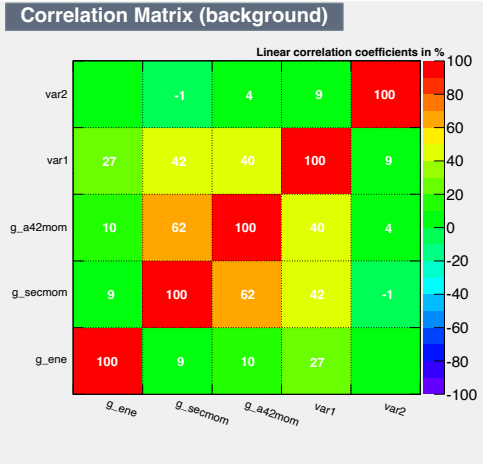

Background rejection versus Signal efficiency
Background rejection
MVA Method:
BDT
Signal efficiency

BDT – Results


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
23.34 when cutting at 0.08
Cut value applied on BDT output

BDT – Results


Correlation Matrix (signal)
Linear correlation coefficients in %
var2
var1
g_a42mom
g_secmom
g_ene
-13
11
19
29
100
8
44
45
100
29
-2
59
100
45
19
8
100
59
44
11
100
8
-2
8
-13
g_ene
g_secmom
g_a42mom
var1
var2
100
80
60
40
20
0
-20
-40
-60
-80
-100


Correlation Matrix (background)
Linear correlation coefficients in %
var2
var1
g_a42mom
g_secmom
g_ene
-1
4
9
100
27
42
40
100
9
10
62
100
40
4
9
100
62
42
-1
100
9
10
27
g_ene
g_secmom
g_a42mom
var1
var2
100
80
60
40
20
0
-20
-40
-60
-80
-100

BDT – Results

Figure: Before BDT

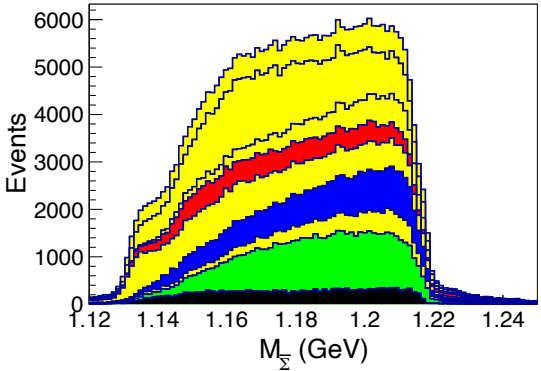


Figure: After BDT