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

Jiajun Tang

University of Science and Technology of China

Oct 21, 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

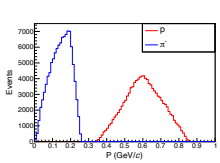
Measurements of decay asymmetry for $\Xi^0 \to \Sigma\gamma$

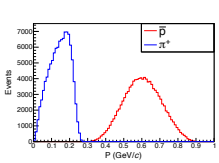
Experiments	BR/10^{-3}	α	Events
1989 SPEC	$3.56 \pm 0.42 \pm 0.10$	$+0.20 \pm 0.32 \pm 0.05$	85
2000 NA48	$3.16 \pm 0.76 \pm 0.32$	–	17
2001 KTEV	$3.34 \pm 0.05 \pm 0.09$	$-0.63 \pm 0.08 \pm 0.05$	4045
2010 NA48	–	$-0.729 \pm 0.030 \pm 0.076$	15k

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: $N_p, N_{\pi^-}, N_{\bar{p}}, N_{\pi^+} \geq 1$



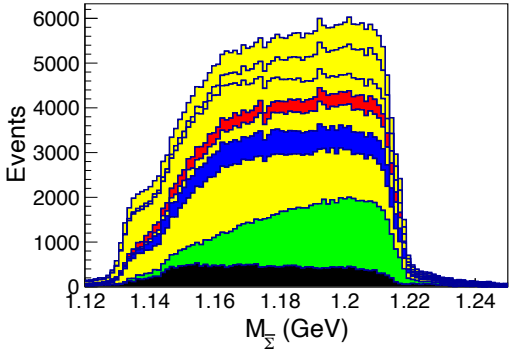


- Neutral Tracks: $N_\gamma \geq 2$
- $\Lambda\&\bar{\Lambda}$: Loop $p\pi^-(\bar{p}\pi^+)$ pairs to find the best
- Kinematics Fit
  - Constrain m_{π^0} & $m_{\bar{\Xi}}$
  - Loop $\gamma\gamma$ pairs to optimize

BDT – BKG Components

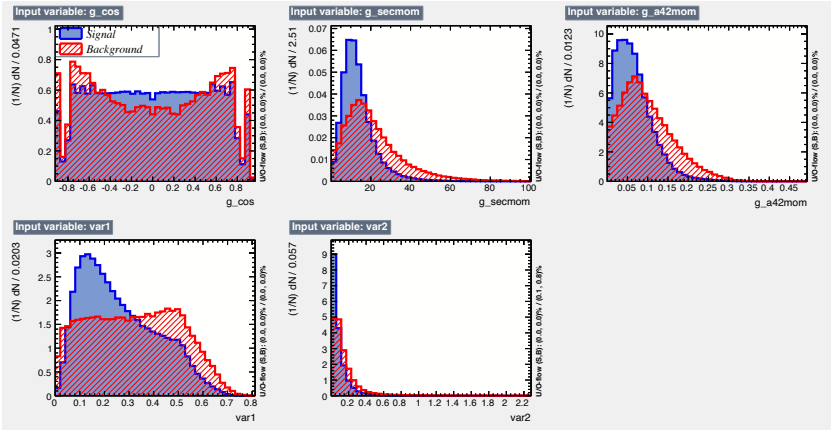
Apply truth match to 2 photons
Get a set of match angles:
$(\theta_{\gamma_1 \text{with} \pi^0},\ \theta_{\gamma_1 \text{with missing} \pi^0},\ \theta_{\gamma_2 \text{with} \pi^0},\ \theta_{\gamma_2 \text{with missing} \pi^0})$
Classify BKG as

- 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

BDT – Input

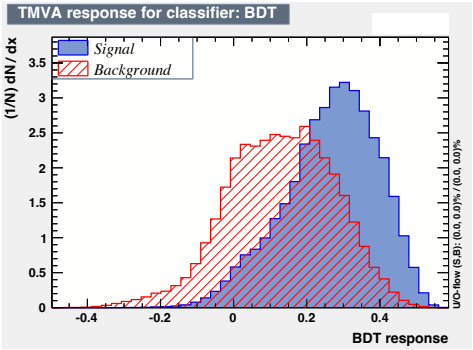


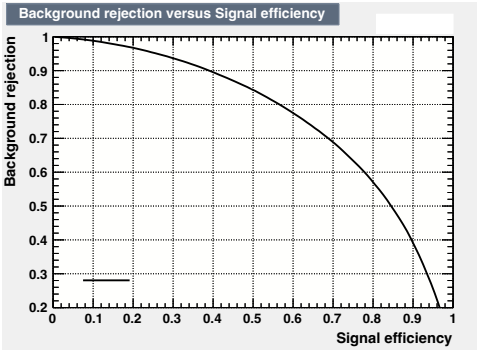
- Bkg sample: each match angle is larger than 15°
- Signal sample: one of the angles is less than 10°

$$\mathrm{var1} = \frac{e3{\times}3 - eSeed}{e3{\times}3}$$

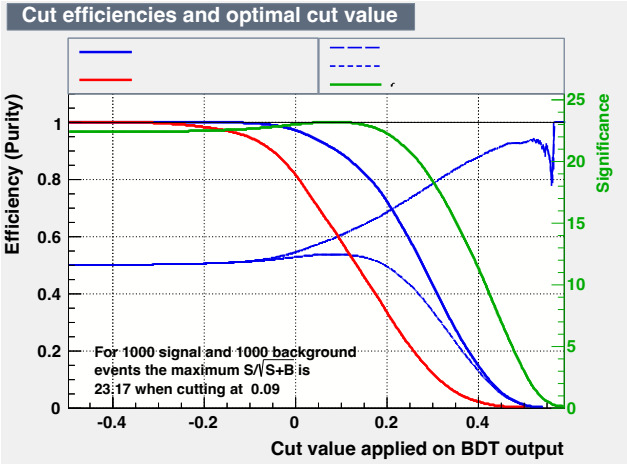
$$\mathrm{var2} = \frac{E - eSeed}{(Hits - 1){\times}eSeed}$$

BDT – Results

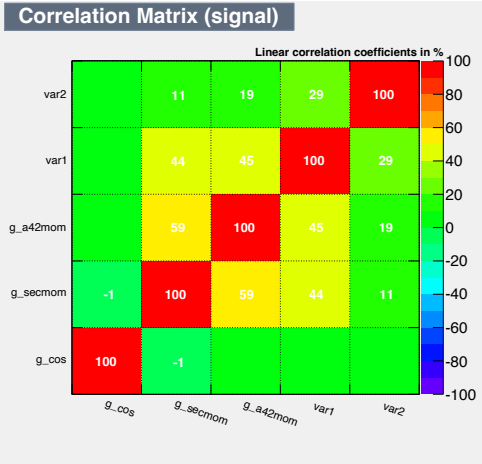

TMVA response for classifier: BDT
Signal
Background
(1/N) dN / dx
3.5
3
2.5
2
1.5
1
0.5
0
-0.4
-0.2
0
0.2
0.4
BDT response
U/O-flow (S,B): (0.0, 0.0)% / (0.0, 0.0)%

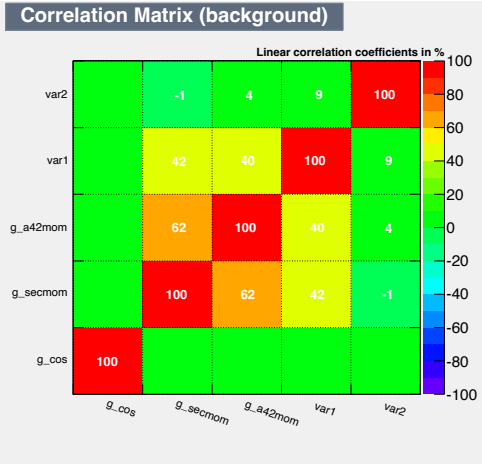

Background rejection versus Signal efficiency
Background rejection
1
0.9
0.8
0.7
0.6
0.5
0.4
0.3
0.2
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
1
Signal efficiency

BDT – Results


Cut efficiencies and optimal cut value
Efficiency (Purity)
Significance
Cut value applied on BDT output
For 1000 signal and 1000 background
events the maximum S/√S+B is
23.17 when cutting at 0.09
1
0.8
0.6
0.4
0.2
0
25
20
15
10
5
0
-0.4
-0.2
0
0.2
0.4

BDT – Results


Correlation Matrix (signal)
Linear correlation coefficients in %
var2
var1
g_a42mom
g_secmom
g_cos
11
19
29
100
44
45
100
29
59
100
45
19
-1
100
59
44
11
100
-1
g_cos
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_cos
-1
4
9
100
42
40
100
9
62
100
40
4
100
62
42
-1
100
g_cos
g_secmom
g_a42mom
var1
var2
100
80
60
40
20
0
-20
-40
-60
-80
-100