

Kinematic Resolution Smearing

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PID Upgrade Meeting: 4.5.13



Hit Position Resolution Smearing

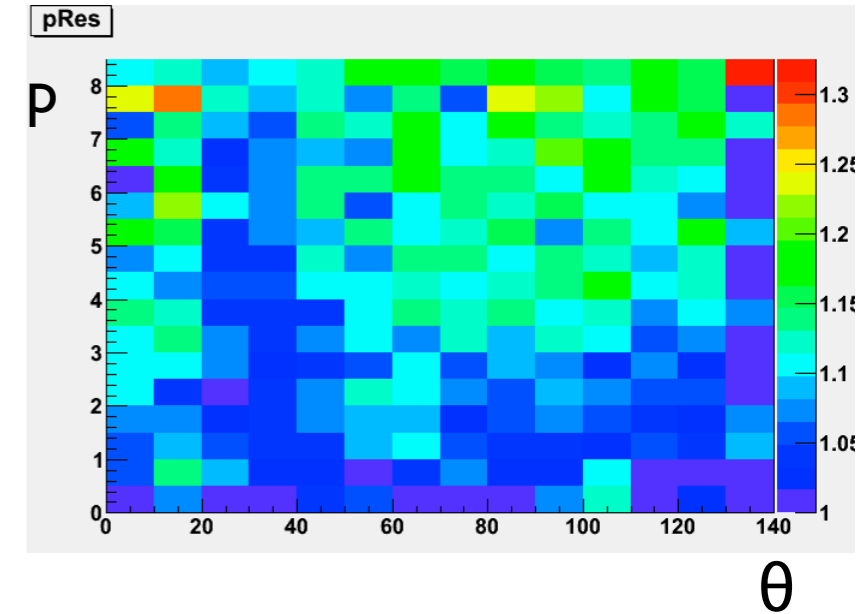
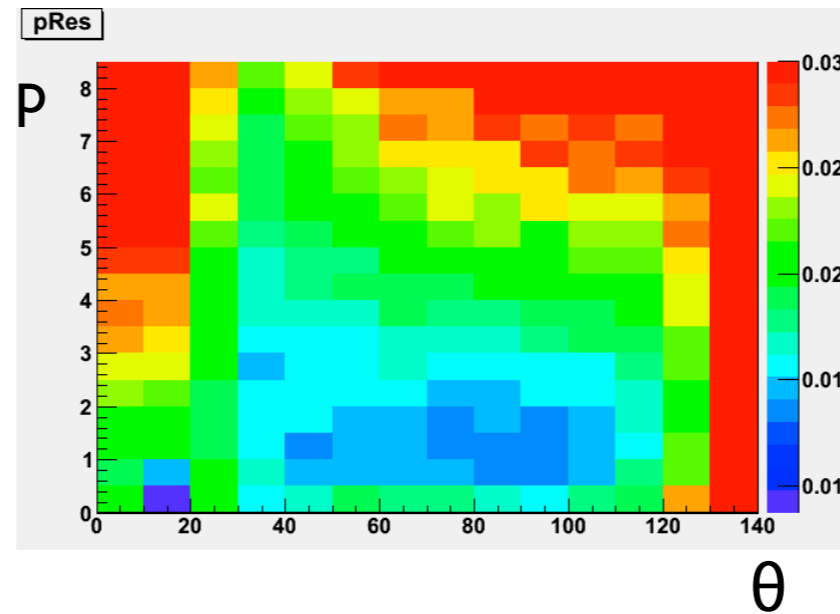
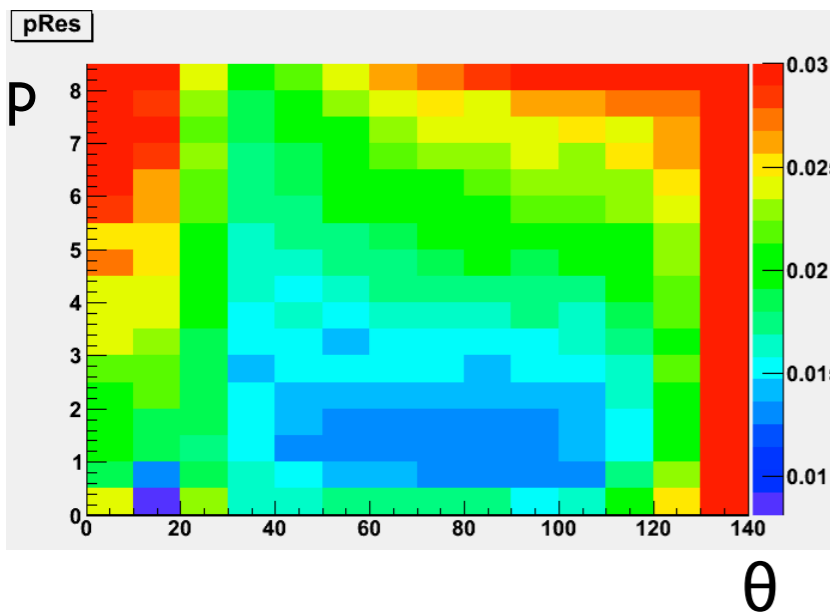
- Single π^+ thrown uniformly in hdgeant
- Use mcsmeas with parameters
 - -u4.23 (ie. ~50% worse CDC timing resolution)
 - -C225 (ie. ~50% worse FDC position resolution)
- Compare resolution in kinematic variables between these degraded position resolutions and nominal mcsmeas
- Goal: Find a map in p vs. θ for additional smearing to apply on a track-by-track basis to the data challenge data

Resolution Maps

No Smearing

~50% Position Smearing

Ratio



- Use resolution maps to apply ad-hoc smearing to kinematic quantities p_x , p_y , p_z , $\text{vertex}(x,y,z)$

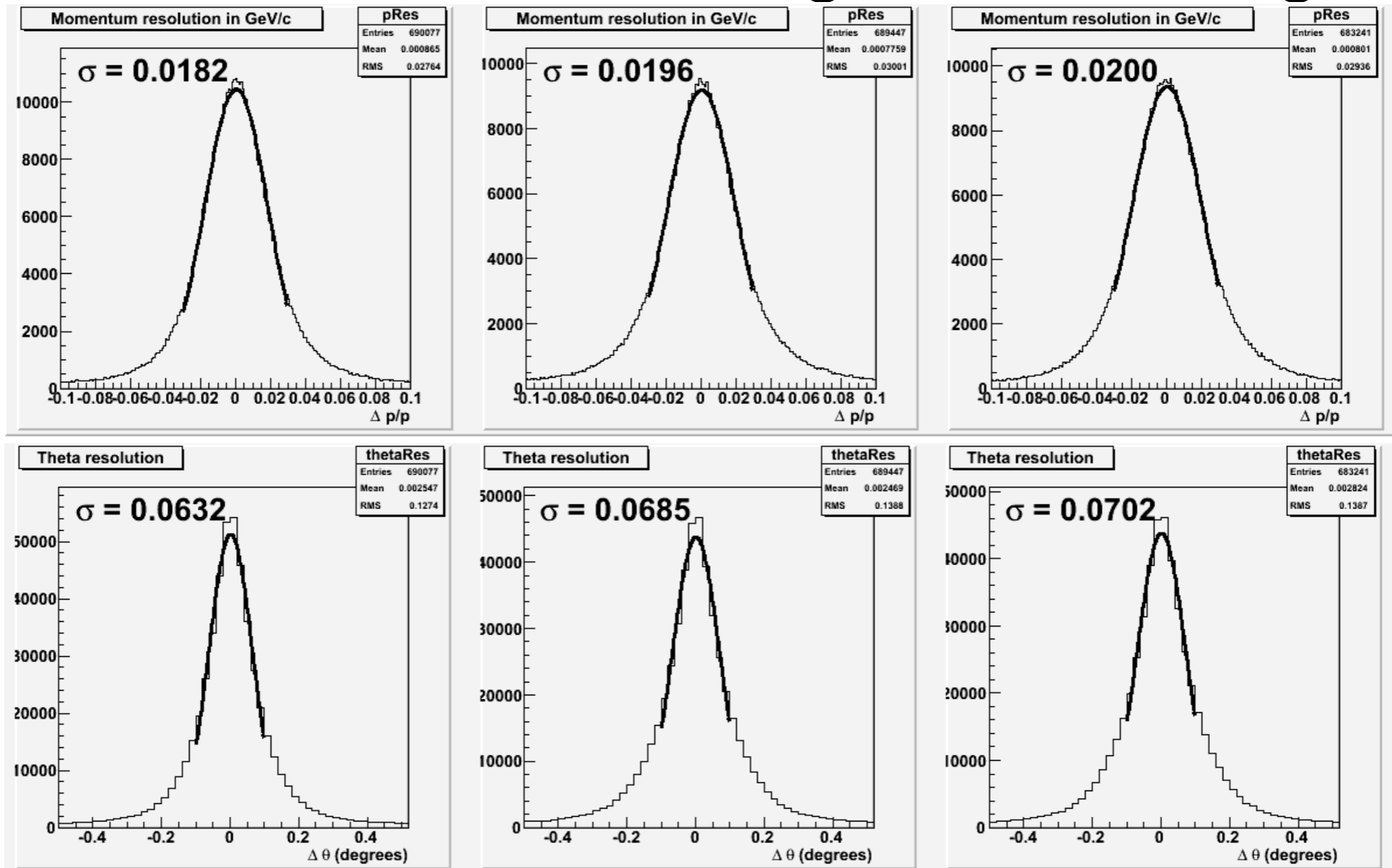
Kinematic Smearing

No Smearing

~50% Position Smearing

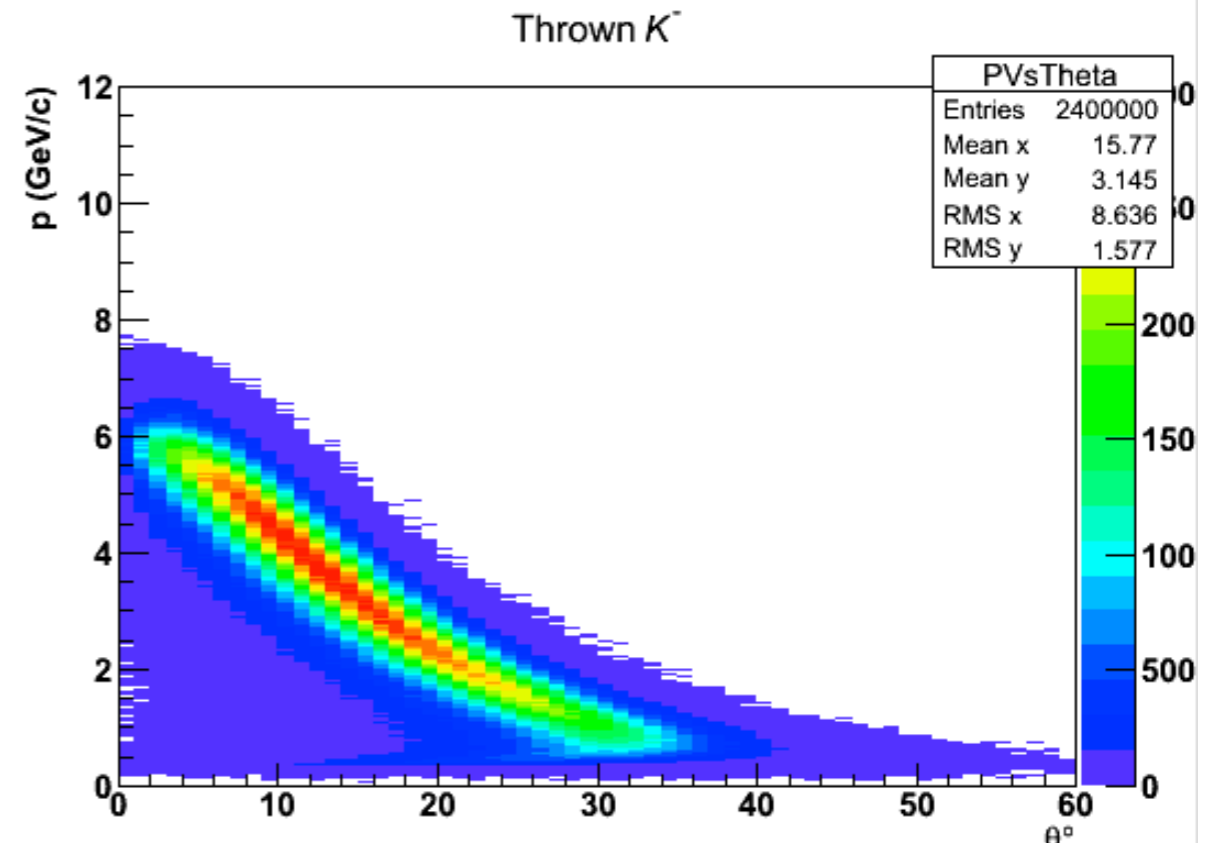
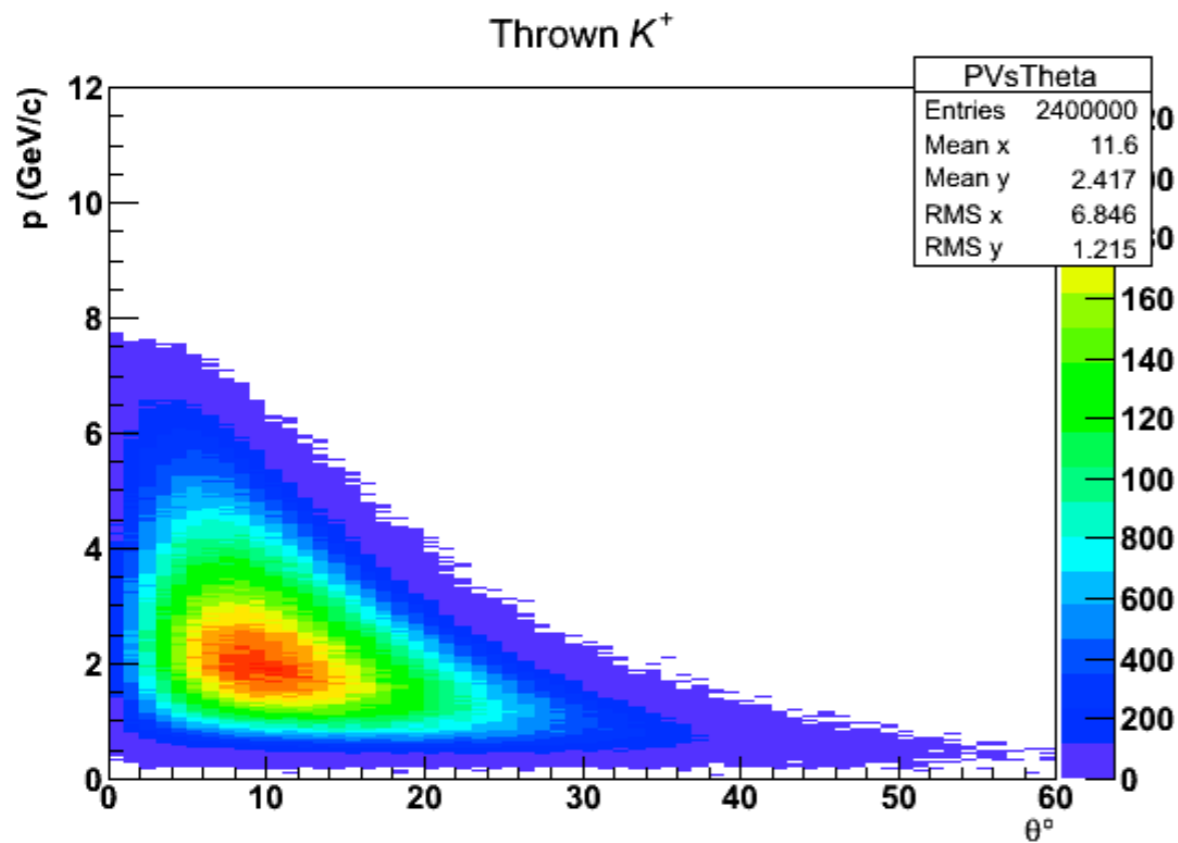
Ad-hoc Smearing

Use to smear data challenge reconstructed tracks



- Results in ~10% degradation in kinematic variable resolution

$h'(2600)$



- Data samples (data challenge bggen with $8.4 < E_\gamma < 9$ GeV):

$$\gamma p \rightarrow h'_2(2600)p$$

- Signal: Exclusive requirement on final state $p, K^+, K^-, \pi^+, \pi^-$

$$h'_2(2600) \rightarrow K_1(1400)^+ K^-$$

- Background: All bggen not satisfying signal requirement

$$K_1(1400)^+ \rightarrow K^*(892)^0 \pi^+$$

- All particle combinations are considered with **no cuts** applied before the decision tree

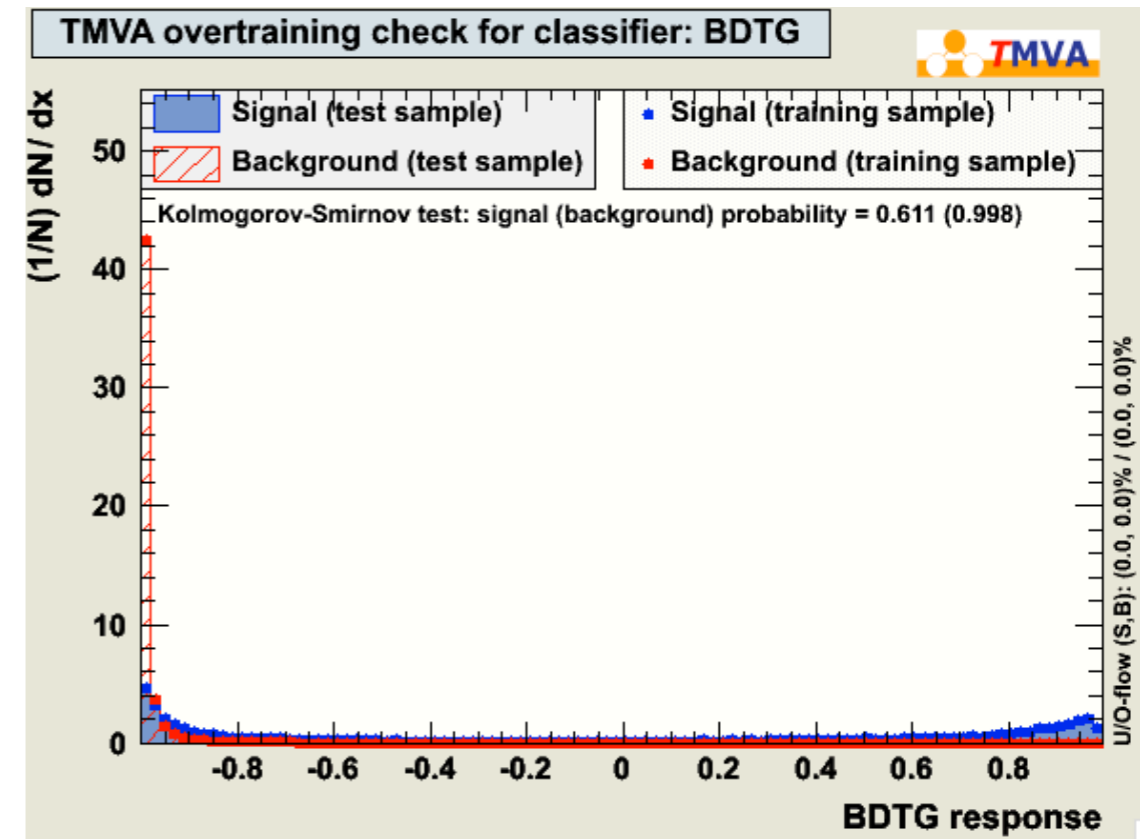
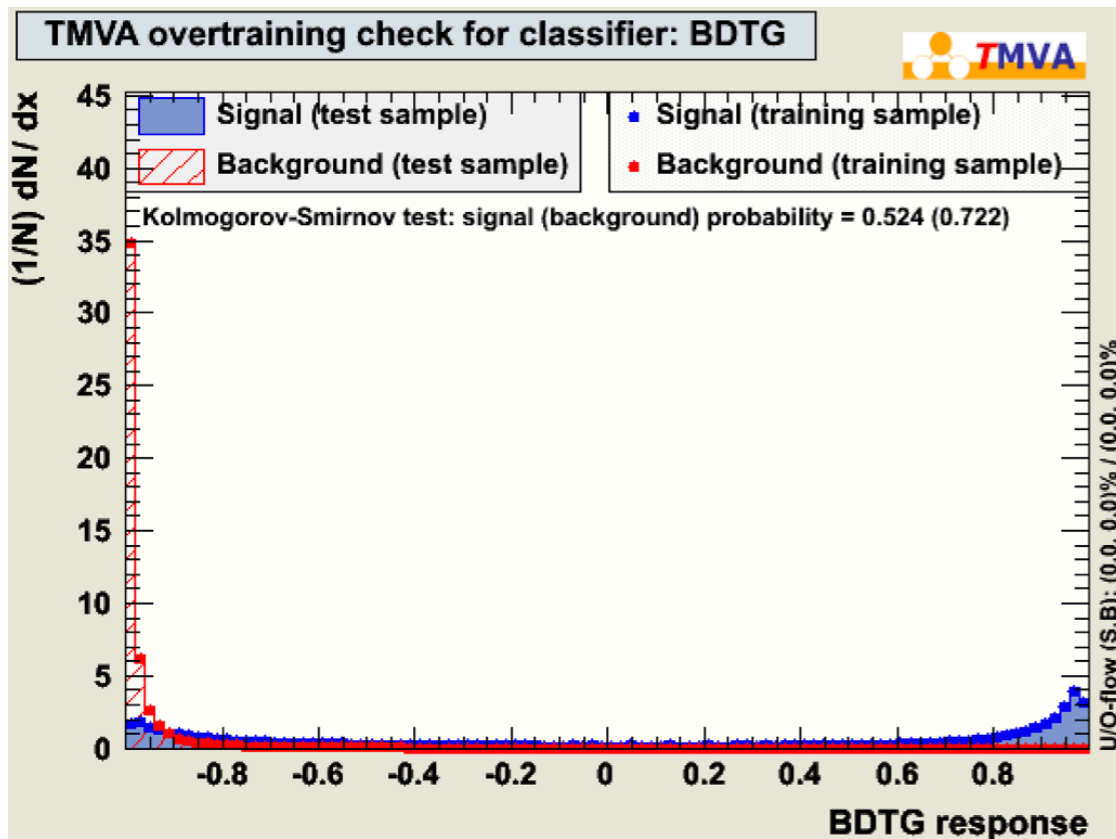
$$K^*(892)^0 \rightarrow K^+ \pi^-$$

- Only reconstructed proton considered

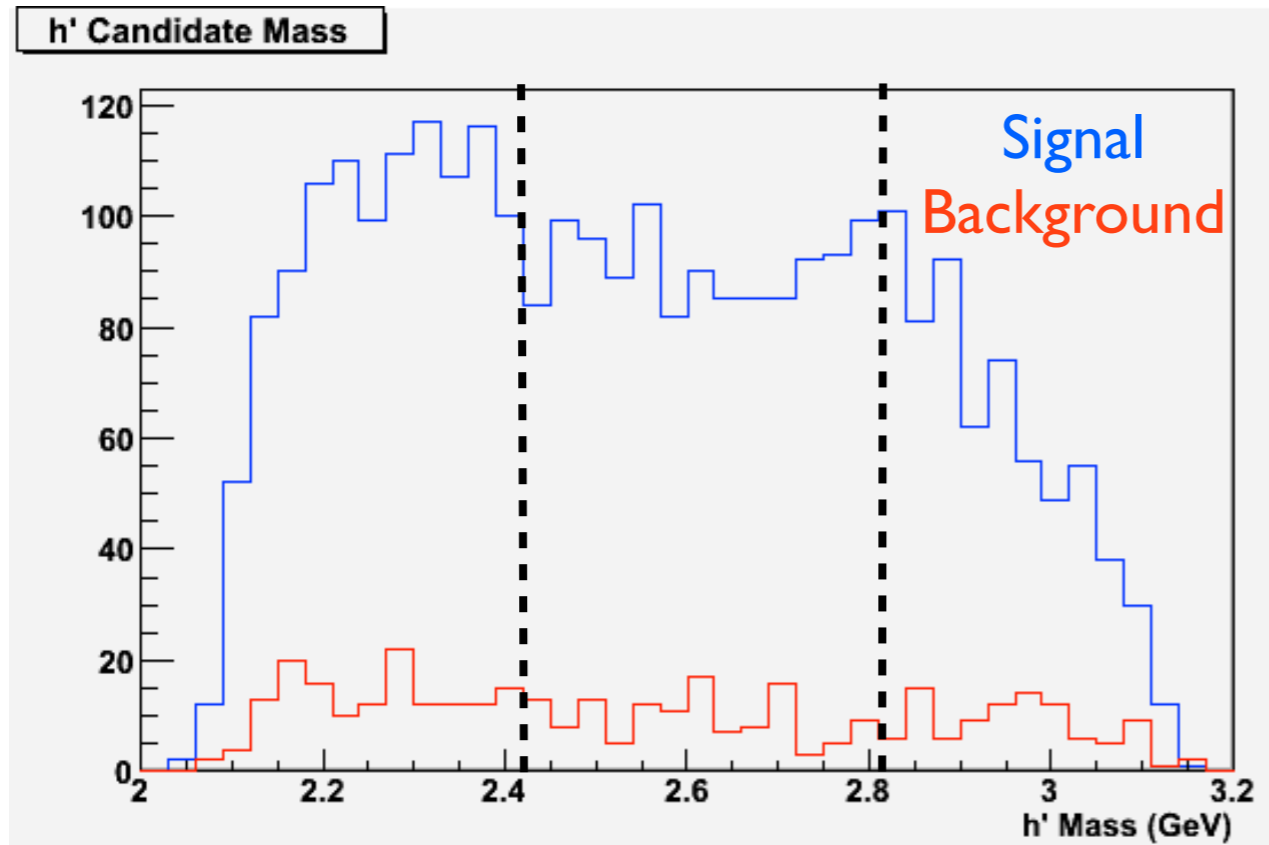
Kinematic Smearing w/o CKOV

No Smearing

Ad-hoc Smearing



$h'(2600)$ w/o CKOV

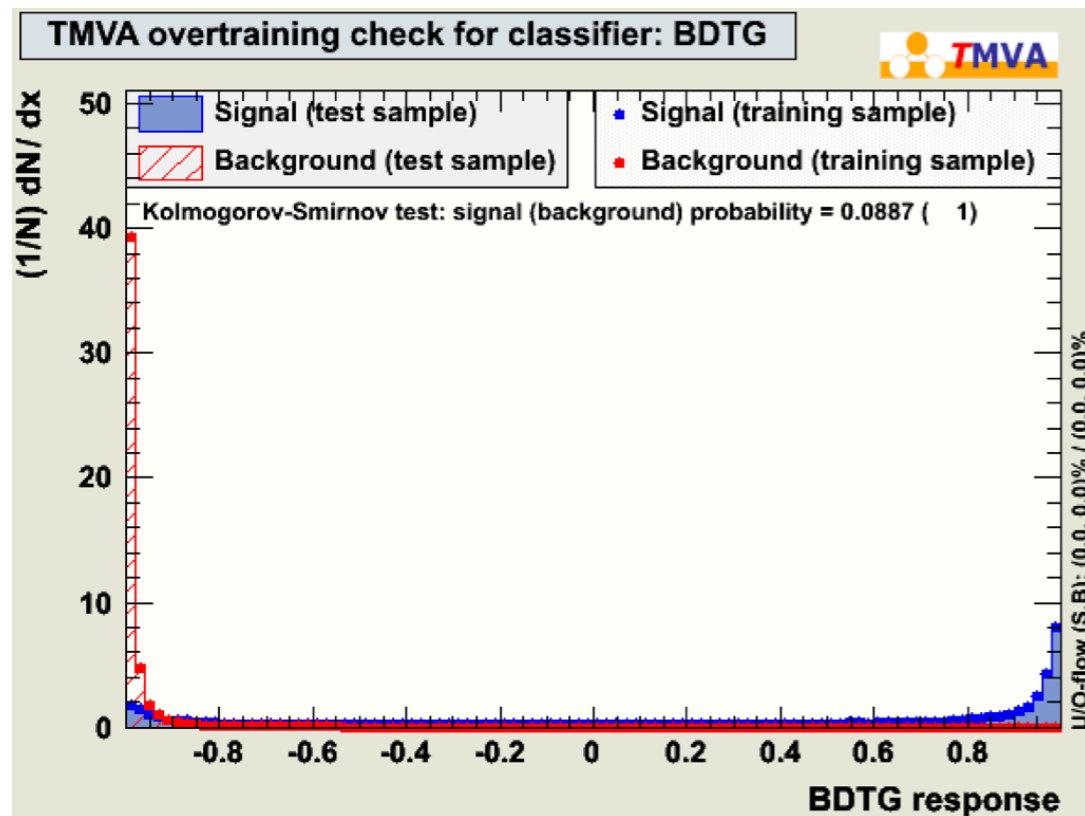


BDT Cut and
 $\pm 1.5 \Gamma$ cut on K_L, K^* and h' masses
 For cuts-based adjusted KinFit CL cut to
 achieve purity = 0.9

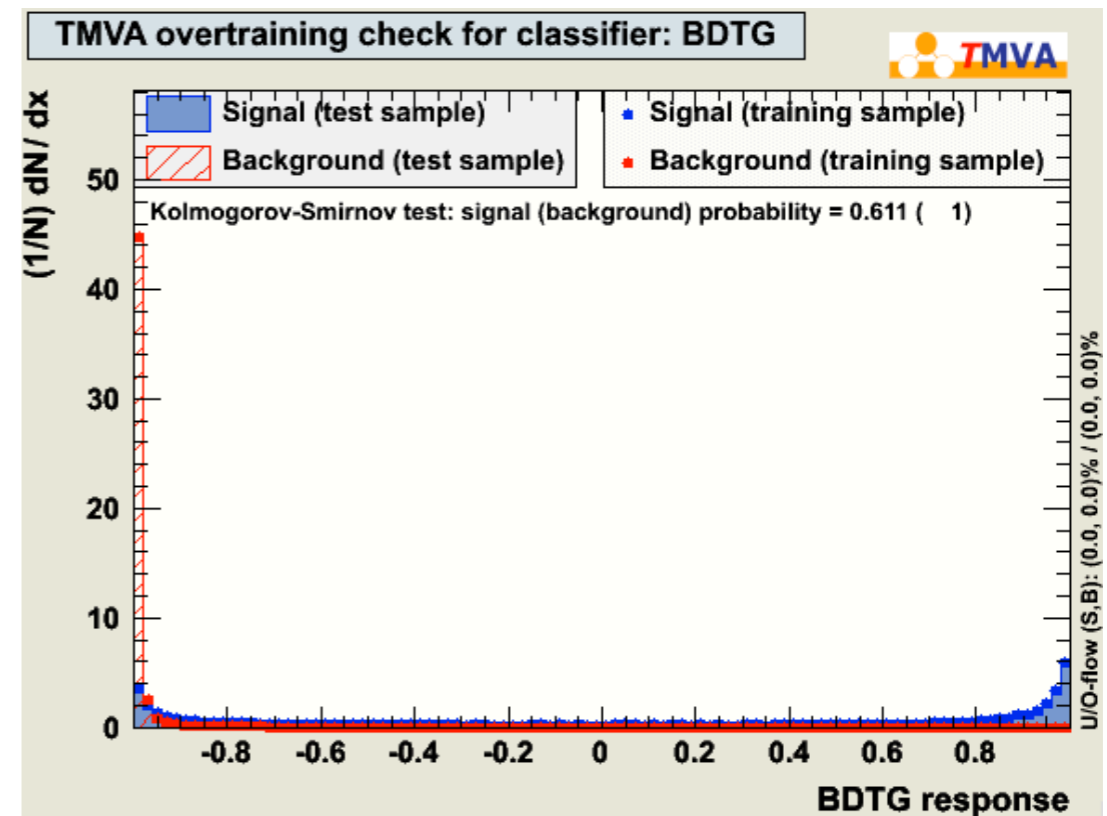
Analysis	Selection Efficiency	Purity
Cuts (w/o CKOV)	0.06	0.90
BDT (w/o CKOV)	0.29	0.90
BDT (w/o CKOV)	0.12	0.95
BDT Smear (w/o CKOV)	0.23	0.90

Kinematic Smearing w/ CKOV

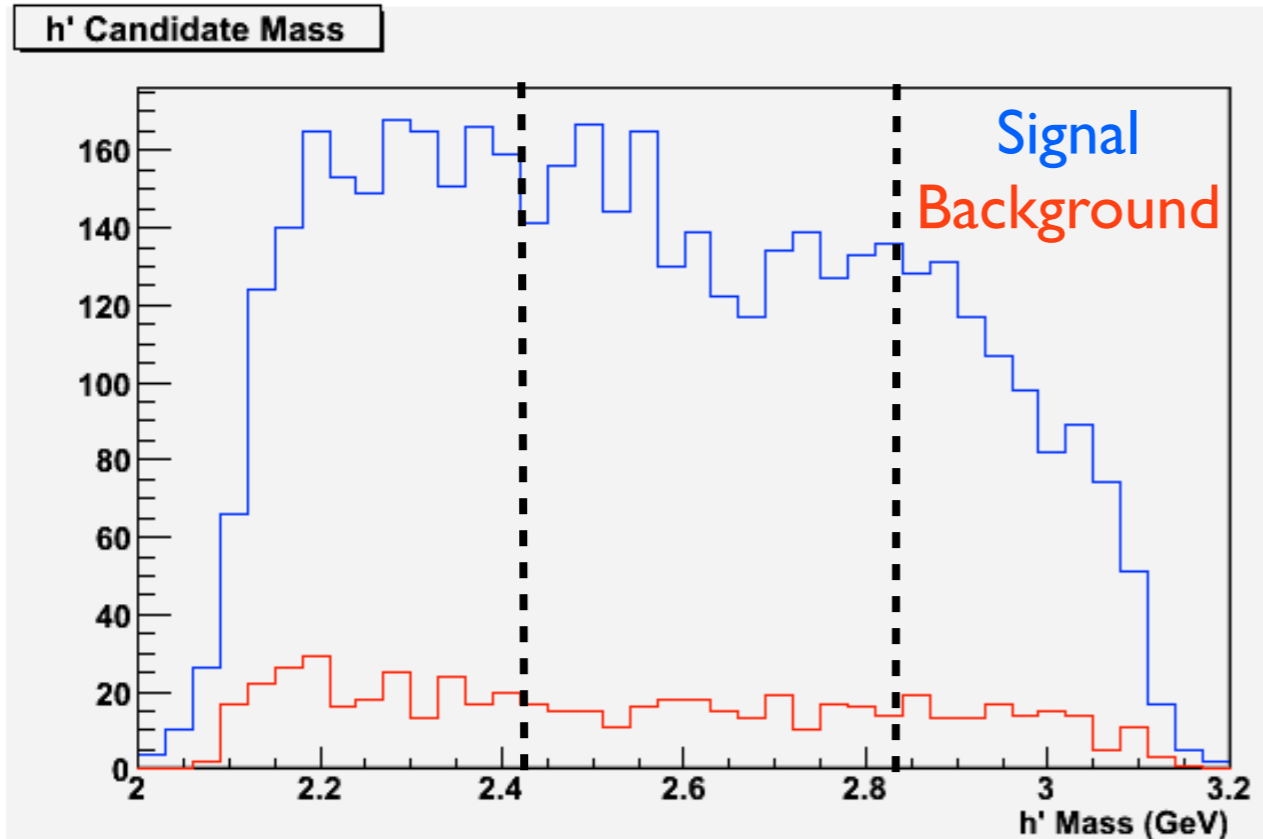
No Smearing



Ad-hoc Smearing



$h'(2600)$ w/ CKOV

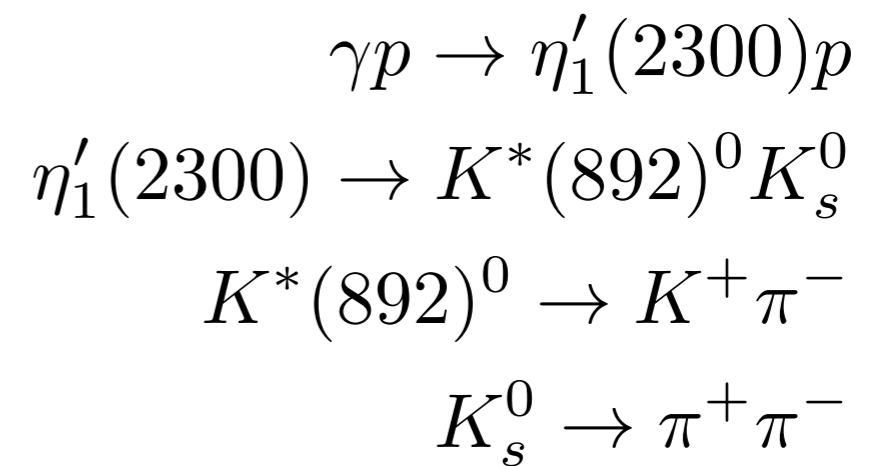
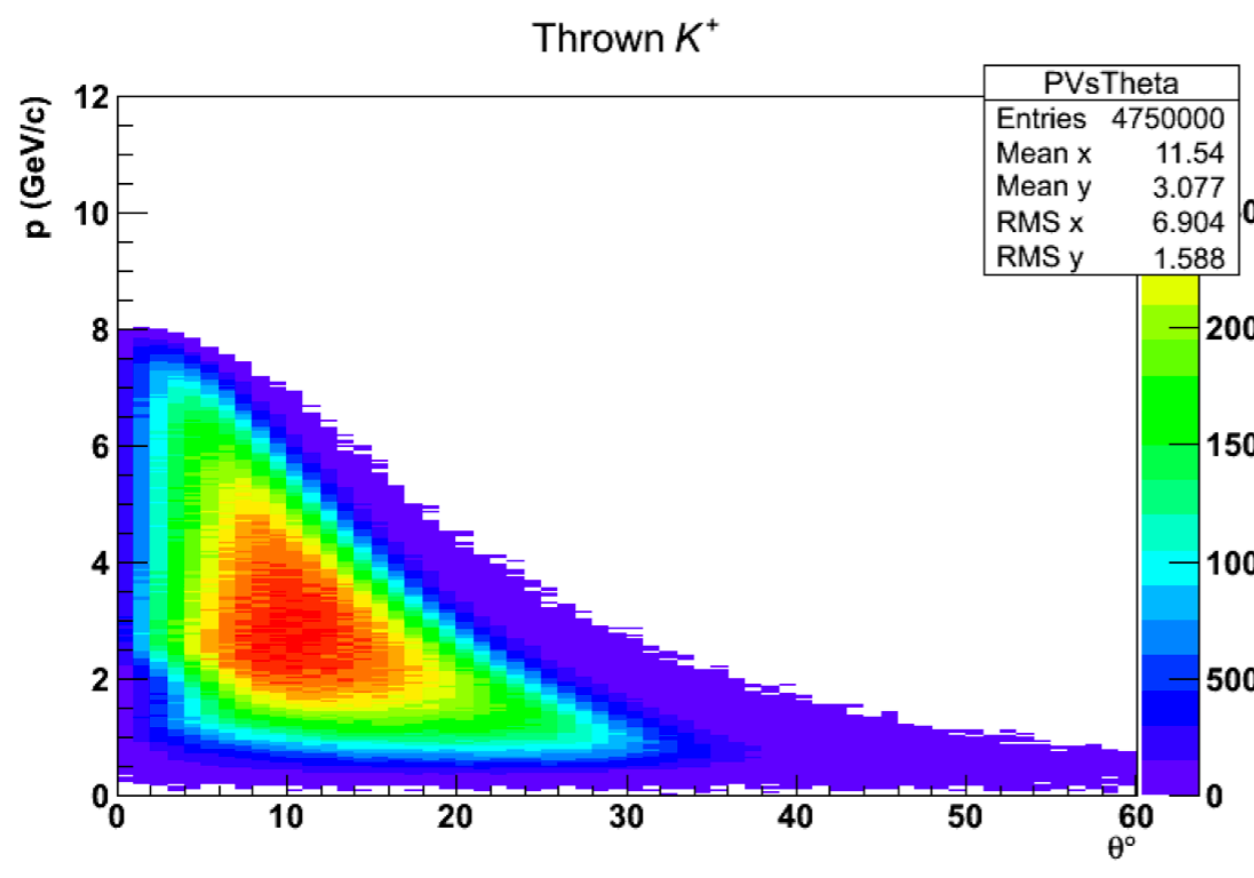


BDT Cut and
 $\pm 1.5 \Gamma$ cut on K_1, K^* and h' masses

Remaining background:
 5% True PID but not exclusive
 10% Correct topology but Proton \leftrightarrow K^+
 50% Correct topology but $\pi^+ \leftrightarrow K^+$
 15% Correct topology but $\pi^- \leftrightarrow K^-$

Analysis	Selection Efficiency	Purity
BDT (w/o CKOV)	0.29	0.90
BDT (w/o CKOV)	0.12	0.95
BDT (w/ CKOV)	0.38	0.90
BDT (w/ CKOV)	0.21	0.95
BDT Smear (w/ CKOV)	0.35	0.90

$\eta'(2300)$



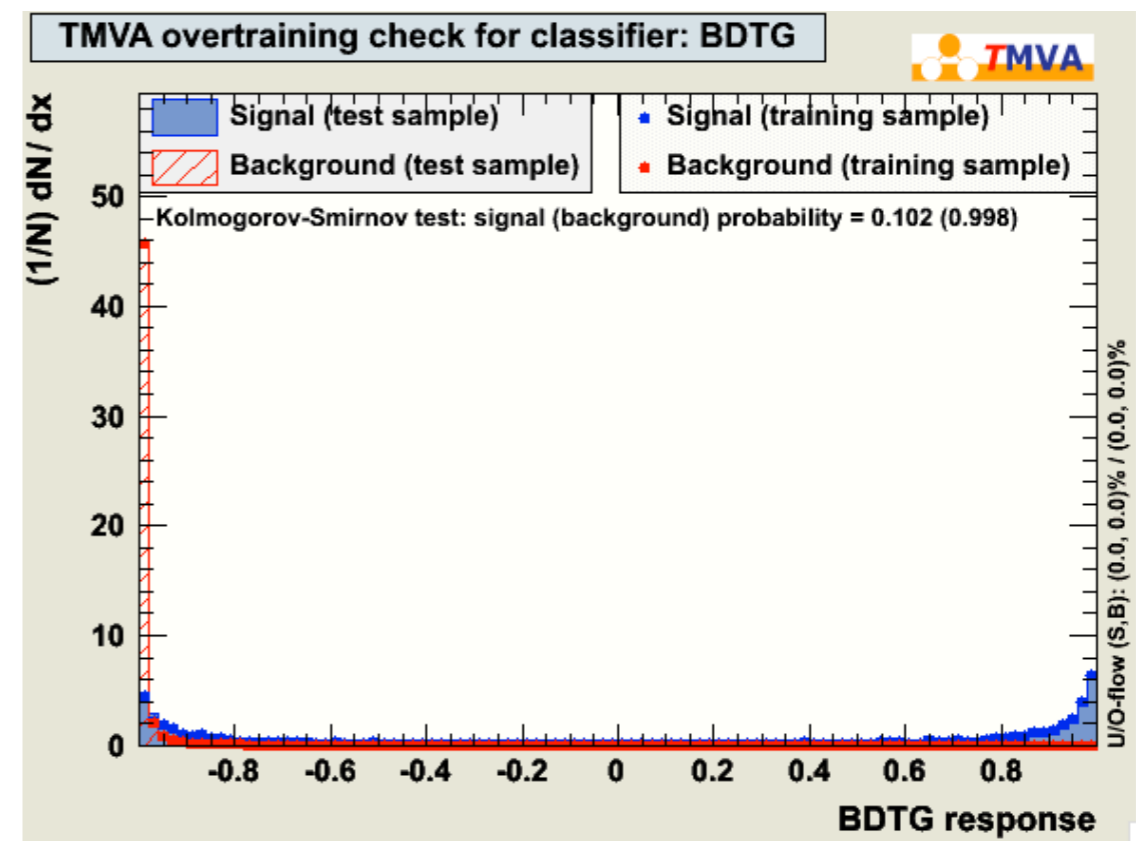
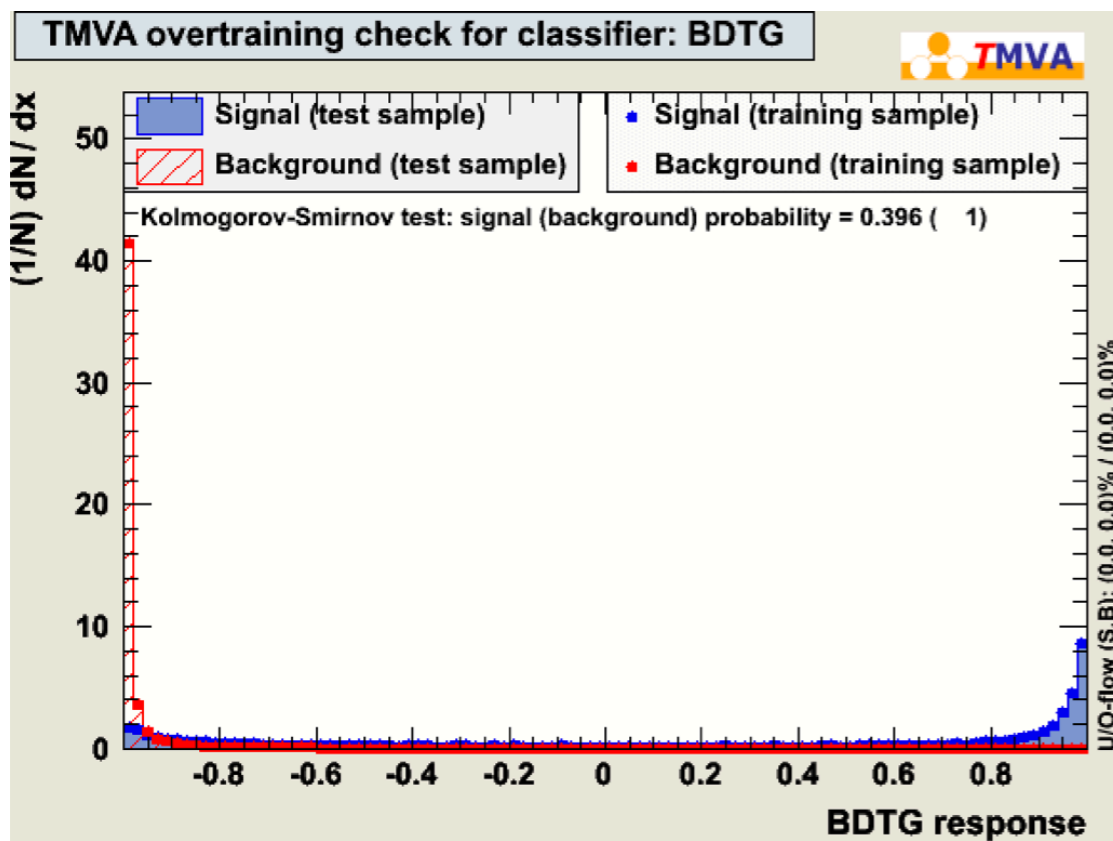
- Data samples (data challenge bggen with $8.4 < E_\gamma < 9$ GeV):
 - Signal: Exclusive requirement on final state $p, K^+, \pi^-, K_s \rightarrow \pi^+ \pi^-$
 - Background: All bggen not satisfying signal requirement
- All particle combinations are considered with **no cuts** applied before the decision tree
- Only reconstructed proton considered

Note: Displaced vertex!

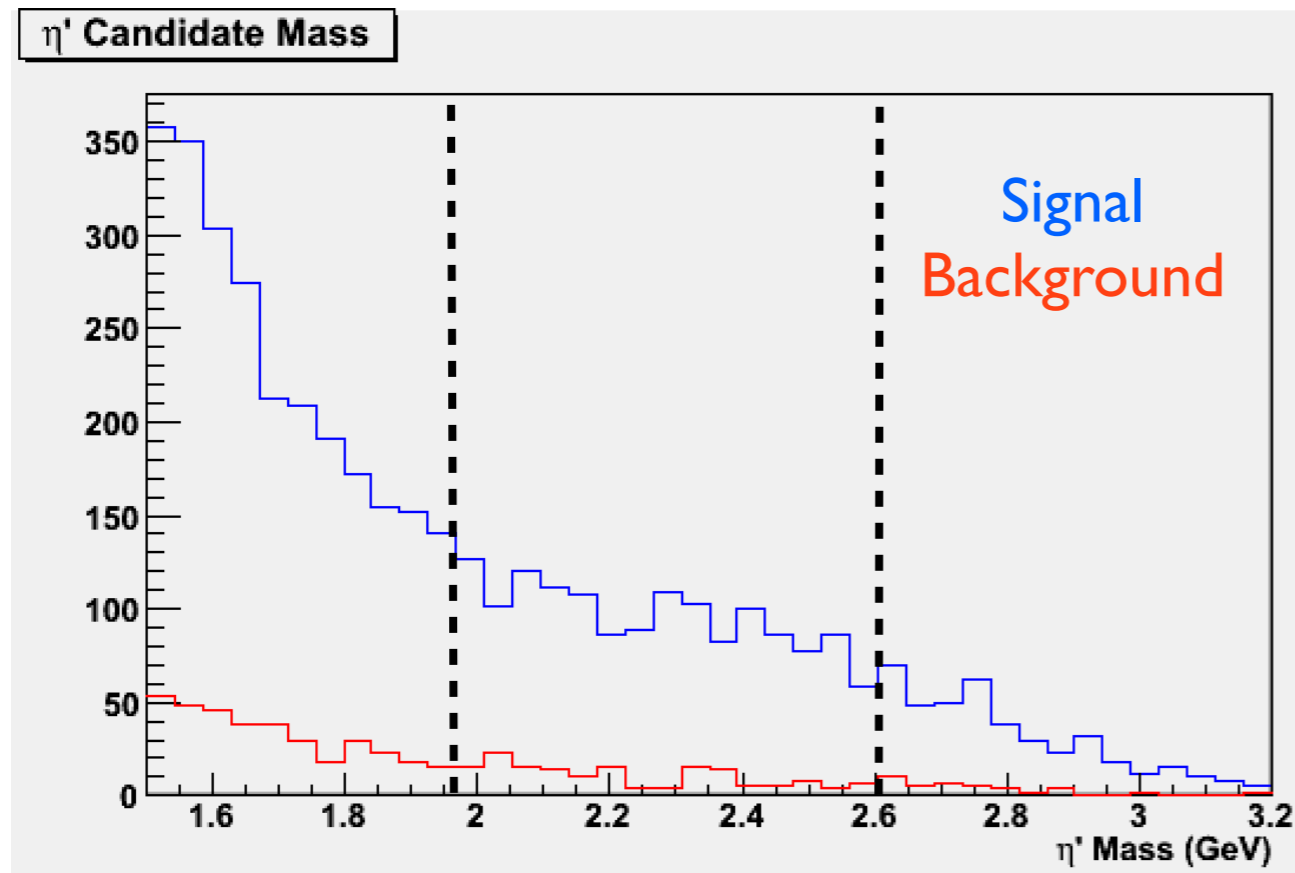
Kinematic Smearing w/ CKOV

No Smearing

Ad-hoc Smearing



$\eta'(2300)$ w/o CKOV



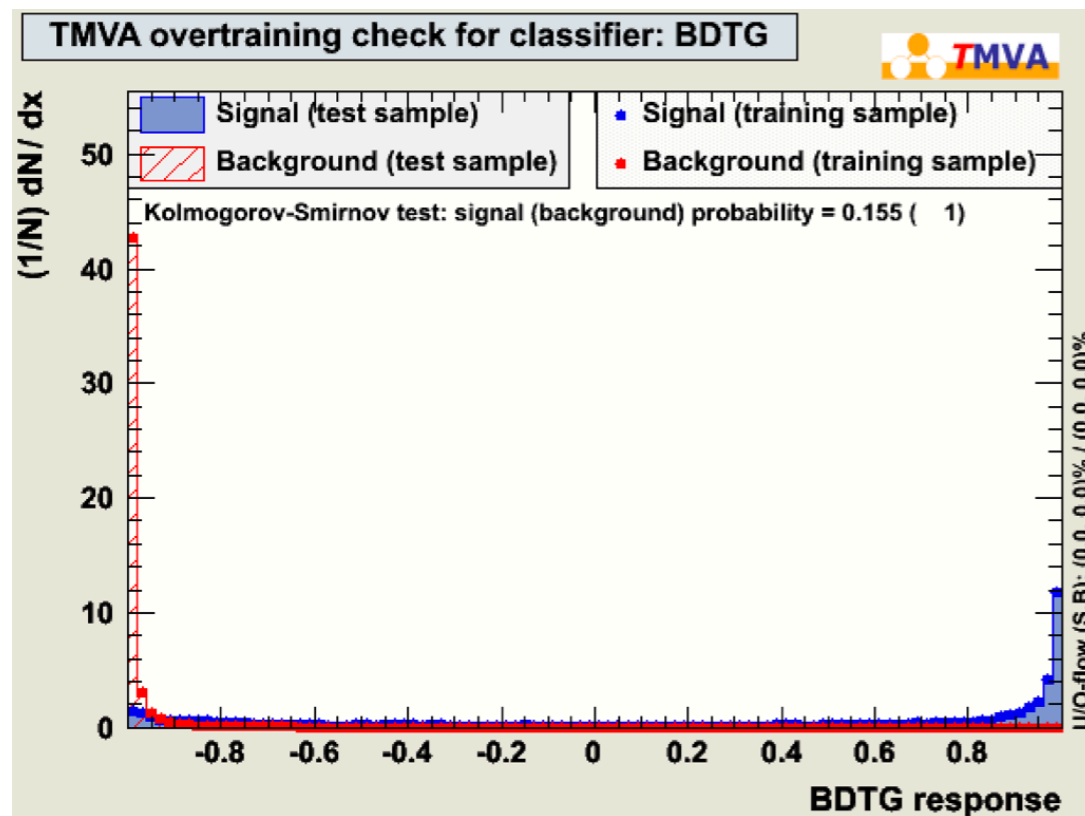
BDT Cut and
 $\pm 1.5 \Gamma$ cut on K^* and η' masses

For cuts-based adjusted KinFit CL
cut to achieve purity = 0.9

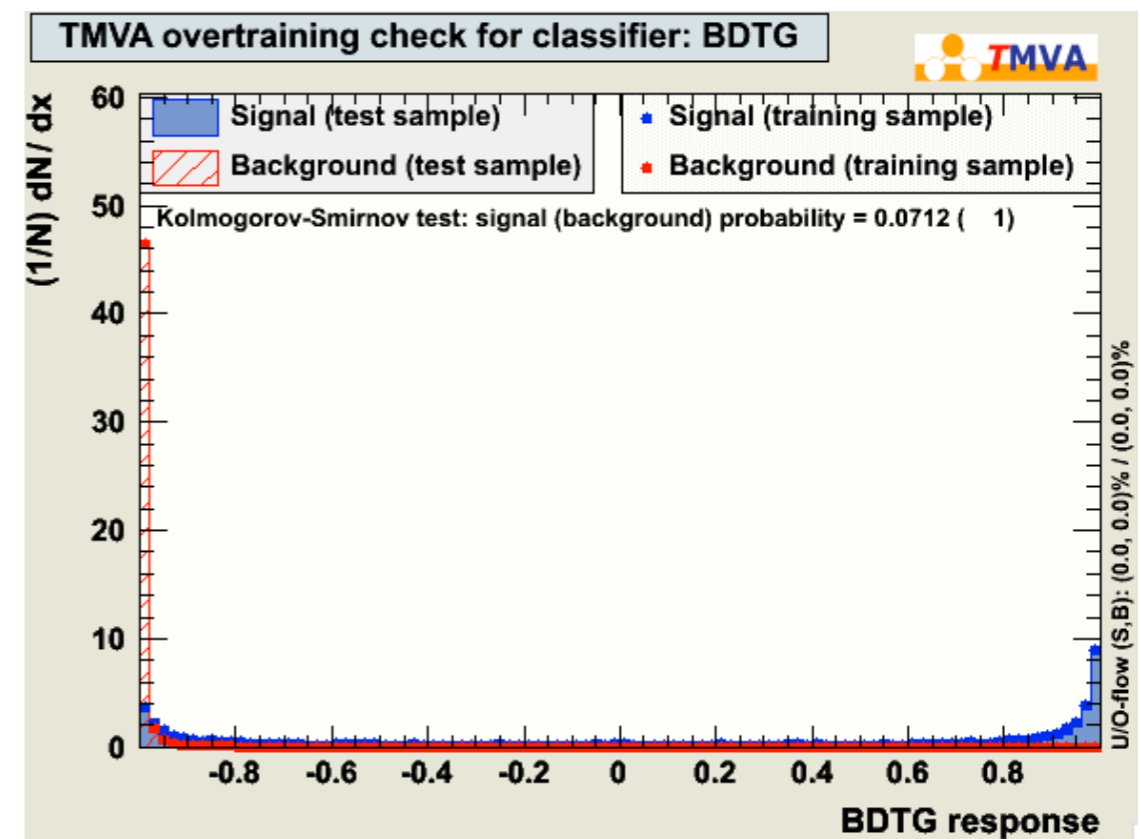
Analysis	Selection Efficiency	Purity
Cuts (w/o CKOV)	0.08	0.90
BDT (w/o CKOV)	0.28	0.90
BDT (w/o CKOV)	0.11	0.95
BDT Smear (w/o CKOV)	0.23	0.90

Kinematic Smearing w/ CKOV

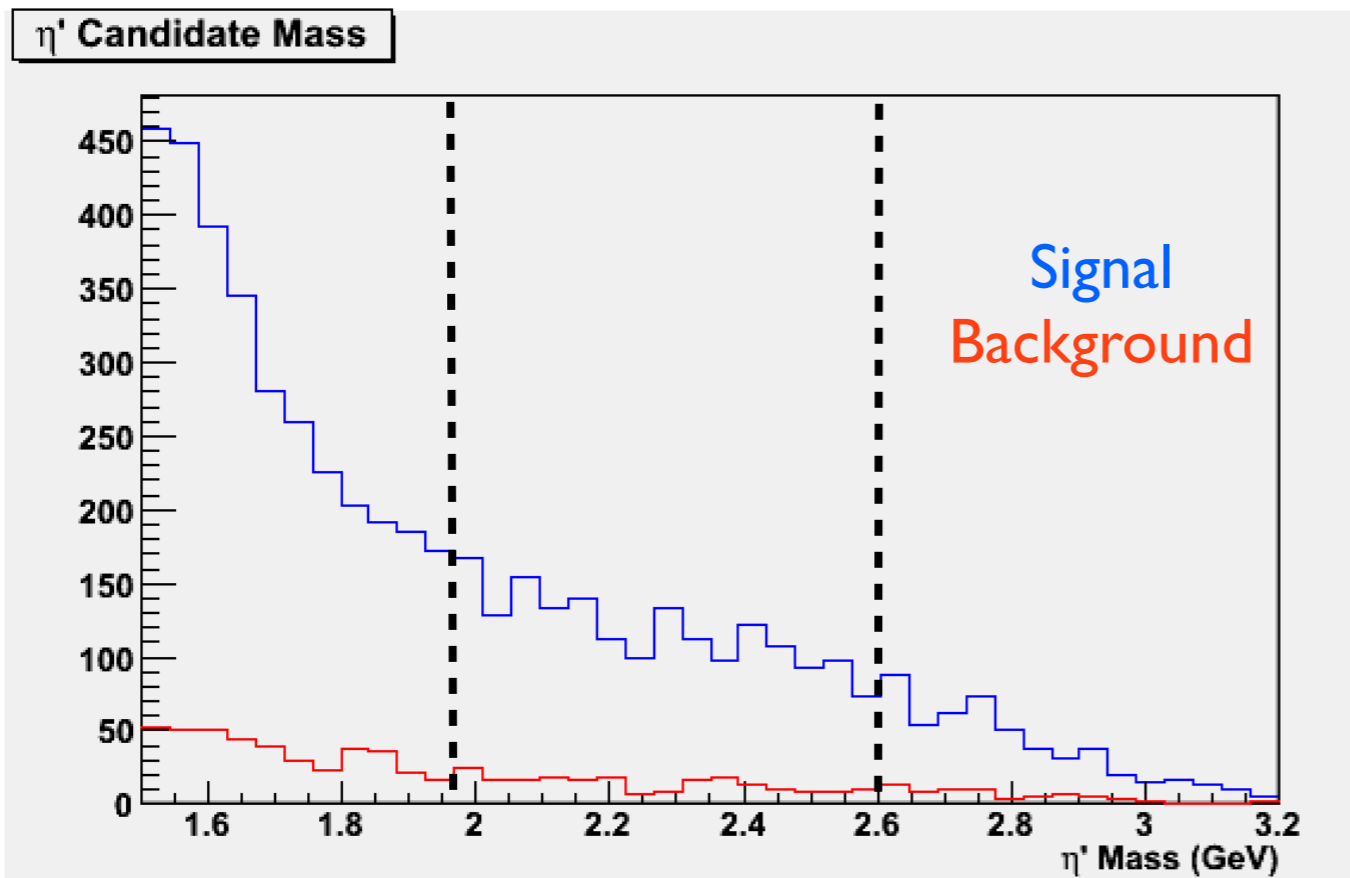
No Smearing



Ad-hoc Smearing



$\eta'(2300)$ w/ CKOV



BDT Cut and
 $\pm 1.5 \Gamma$ cut on K^* and η' masses

Remaining background:
10% True PID but not exclusive
10% Correct topology but Proton \leftrightarrow K^+
80% $K^- \pi^+ K_s$ (really signal with \bar{K}^*)

Analysis	Selection Efficiency	Purity
BDT (w/o CKOV)	0.28	0.90
BDT (w/o CKOV)	0.11	0.95
BDT (w/ CKOV)	0.41	0.90
BDT (w/ CKOV)	0.29	0.95
BDT Smear (w/ CKOV)	0.33	0.90

Smearing Summary

- Degraded resolution of kinematic variables to simulate ~50% worse position resolution
- Efficiencies are reduced to maintain 90% purity

	No Smear Efficiency		Ad-hoc Smear Efficiency	
	w/o CKOV	w/ CKOV	w/o CKOV	w/ CKOV
$h'(2600)$	0.29	0.38	0.23	0.35
$\eta'(2300)$	0.28	0.41	0.23	0.33

Higher Purity Performance

	Selection efficiency		Expected Yield ($\times 10^6$)	
	w/o CKOV	w/ CKOV	w/o CKOV	w/ CKOV
$h'(2600)$ 90% Purity	0.29	0.38	2.97	3.84
$h'(2600)$ 95% Purity	0.12	0.21	1.22	2.12
$\eta'(2300)$ 90% Purity	0.28	0.41	0.66	0.97
$\eta'(2300)$ 95% Purity	0.11	0.29	0.26	0.69

- Adjust BDT cut to give higher purity of 0.95 and 0.90

Backup

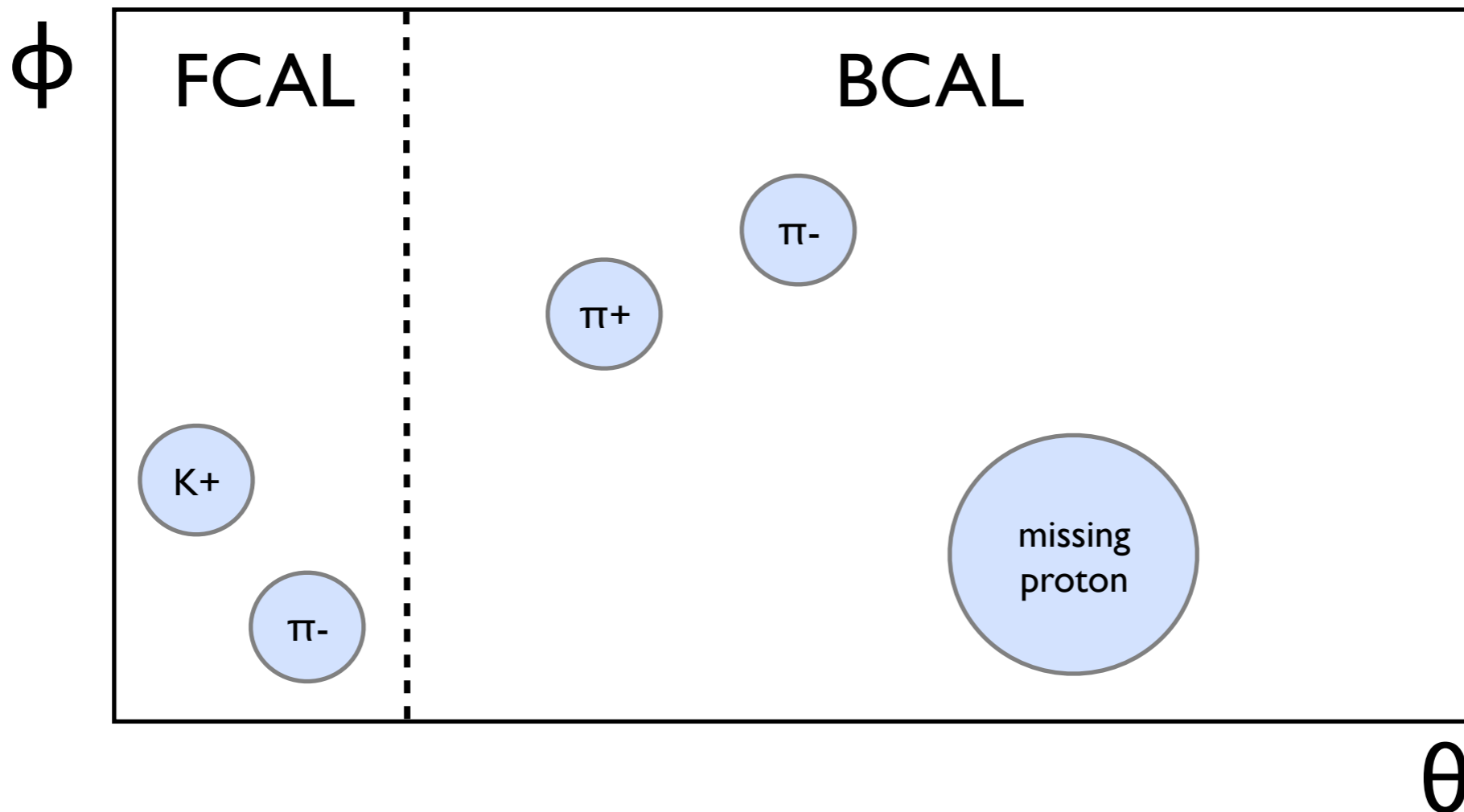
Selection Efficiency

- My signal condition for PYTHIA events only requires final state particles to be correctly identified but not intermediate resonance (eg. $K^* \rightarrow K\pi$)
- Place cuts on intermediate resonance masses separate from BDT cut
- Previous presentations:
 - Selection efficiency was the fraction of reconstructed signal events which passed the invariant mass cuts and the BDT cut
 - Not real signal efficiency because some events removed by invariant mass cuts, which made these too low
- This presentation (and future):
 - Selection efficiency is for the BDT cut only
 - No impact to purity numbers or expected yields

Reminder of variables included in the BDT

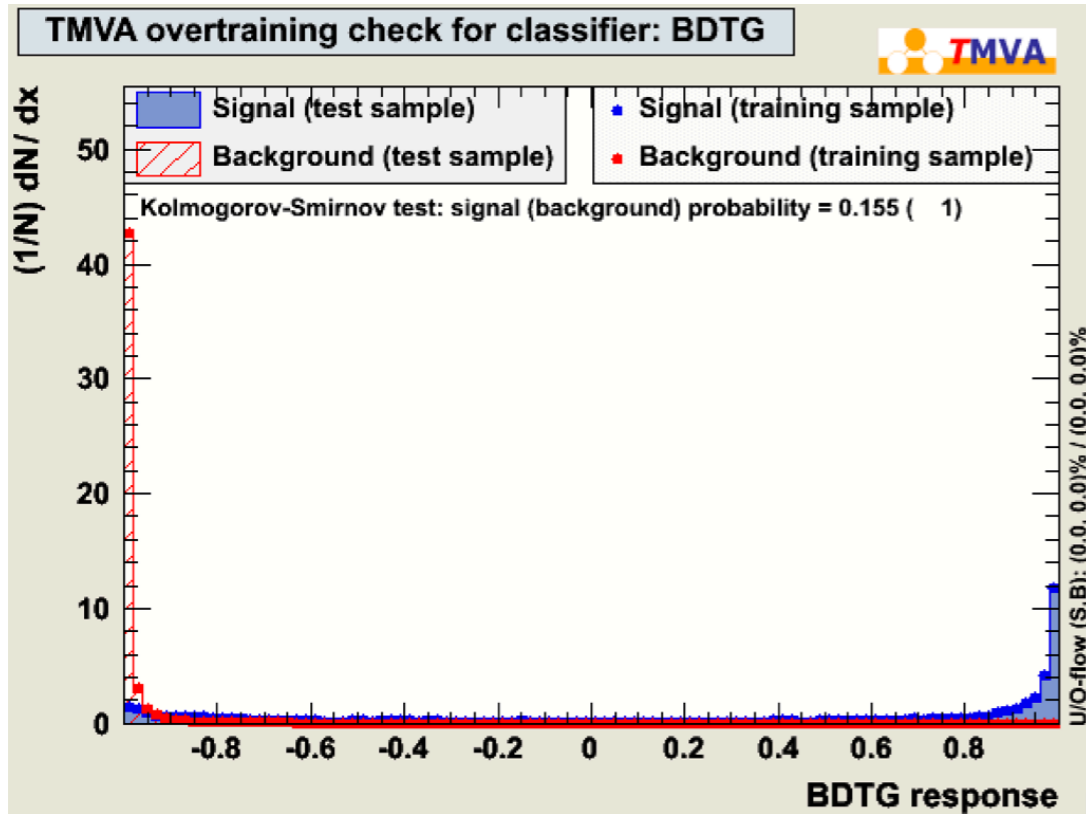
- Kinematic Fit CL
- Primary vertex χ^2 : Quality of $K_s K^+ \pi^-$ from a single point
- Secondary vertex χ^2 : Quality of $\pi^+ \pi^-$ from a single point
- K_s flight distance significance in R and Z (separately)
- K_s impact parameter χ^2 : Change in PV χ^2 when particle removed from PV
- Isolation sums for track momenta, BCAL and FCAL energy
- For each track use:
 - χ^2 from track fit
 - Time of flight CL
 - Track energy loss dE/dx CL
 - Impact parameter χ^2 : Change in PV χ^2 when particle removed from PV

Isolation Variables



- Motivation: identify backgrounds with extra charged track or neutral outside of the desired topology
- Use covariance matrices for reconstructed tracks to identify a “cone” around each track which we exclude ECAL showers within

η' (2300) w/ CKOV



Highest ranked variables:

Kinematic Fit
 Secondary vertex
 displacement
 PID information
 χ^2 variables

Particle codes:

p1 = π^+ (Ks)
 p2 = π^- (Ks)
 p3 = K^+ (K*)
 p4 = π^- (K*)
 p5 = proton

Rank	Variable	Variable Importance
1	SV_flightSignificanceDelZ	2.475e-01
2	isolatedBCALSumE	1.201e-01
3	kinFitCL	1.052e-01
4	p3_ckovFOM	6.740e-02
5	SV_ChiSq	4.182e-02
6	p2_ckovFOM	4.144e-02
7	p3_timeFOM	3.915e-02
8	PV_r	3.861e-02
9	p1_ckovFOM	3.348e-02
10	SV_flightSignificanceDelR	2.977e-02
11	p5_ChiSq	2.854e-02
12	p4_dEdxFOM	2.714e-02
13	p1_timeFOM	2.209e-02
14	p3_dEdxFOM	1.713e-02
15	p5_dEdxFOM	1.604e-02
16	p4_timeFOM	1.601e-02
17	SV_ChiSqIP	1.339e-02
18	p2_dEdxFOM	1.323e-02
19	p1_dEdxFOM	1.229e-02
20	p5_timeFOM	1.143e-02
21	p4_ckovFOM	9.079e-03
22	p4_ChiSq	8.729e-03
23	isolatedFCALSumE	8.360e-03
24	p2_timeFOM	7.071e-03
25	PV_ChiSq	6.105e-03
26	p3_ChiSq	6.055e-03
27	isolatedTrackSumP	5.687e-03
28	p2_ChiSq	4.487e-03
29	p4_ChiSqIP	2.574e-03
30	p1_ChiSq	0.000e+00
31	p3_ChiSqIP	0.000e+00
32	p5_ChiSqIP	0.000e+00
33	p5_ckovFOM	0.000e+00

Momentum Asymmetry

Analysis	Selection Efficiency	Purity
BDT (w/o CKOV)	0.29	0.90
Mom Asym (w/o CKOV)	0.31	0.90
BDT (w/ CKOV)	0.38	0.90
Mom Asym (w/ CKOV)	0.41	0.90
BDT (w/o CKOV)	0.12	0.95
Mom Asym (w/o CKOV)	0.14	0.95
BDT (w/ CKOV)	0.21	0.95
Mom Asym (w/ CKOV)	0.27	0.95