



# Update on $Z \rightarrow e^+e^-$ cross section

Kalanand Mishra

*Fermilab*

*on behalf of Z Signal Extraction team:*

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*VBTF meeting*  
(Sept 3, 2010)

# Z→ee cross section using $\int L = 1.34 \text{ pb}^{-1}$



$$N_{\text{Selected}} = 463 \pm 21.5$$

$$N_{\text{Background}} = 4.6 \pm 5.5$$

Electron offline efficiency:

$$\epsilon_{\text{Reco}} = 1.0000 \pm 0.0060 \text{ (stat)} \pm 0.0055 \text{ (syst)}$$

$$\epsilon_{\text{Reco} \rightarrow \text{WP95}} = 0.9524 \pm 0.0100 \text{ (stat)} \pm 0.0101 \text{ (syst)}$$

$$\epsilon_{\text{WP95} \rightarrow \text{HLT}} = 0.9797 \pm 0.0047 \text{ (stat)} \pm 0.0131 \text{ (syst)}$$

$$\text{Dilepton efficiency} = 0.9067 \pm 0.0219 \text{ (stat)} \pm 0.0217 \text{ (syst)}$$

$$\text{Acceptance} = 0.4357 \pm 1.1\% \text{ (theory)} \pm 1\% \text{ (Energy scale)}$$

from  
MC

$$\sigma_{\gamma^*/Z} \times \text{BR}(Z \rightarrow ee) = 866.0 \pm 45.4 \text{ (stat)} \pm 33.8 \text{ (syst)} \pm 95.3 \text{ (lumi) pb}$$

$$\text{NLO prediction} = 970 \pm 20 \text{ pb}, \quad \text{NNLO prediction} = 972 \pm 39 \text{ pb}$$

Observed cross section is 10% lower than prediction !

The only MC ingredient now is acceptance. This will always remain so.

# Simultaneous fit for cross section & efficiency



Simultaneous fit to three samples: TT, TF(EBEB), TF(EBEE+EEEE)

NO.	NAME	VALUE	ERROR	
1	bkgGammaFailTF_BB	-1.59986e-02	1.17222e-02	} Exponential bkg. shape for the two low purity samples
2	bkgGammaFailTF_End	-9.98742e-03	9.24291e-03	
3	eff_B	9.44921e-01	2.50674e-02	} Electron offline efficiency in the barrel and endcaps
4	eff_E	9.45688e-01	4.64287e-02	
5	massShiftTF_BB	-1.11956e+00	5.14202e-01	} Mass shifts due to electron energy scale
6	massShiftTF_End	-1.46626e+00	1.07183e+00	
7	massShiftTT	-5.44216e-01	2.15923e-01	
8	nBkgTF_BB	2.90186e+01	7.50783e+00	} # background events in low purity sample
9	nBkgTF_End	4.40033e+01	8.51631e+00	
10	resoTF_BB	6.69634e-02	1.31782e-01	} Gaussian resolution widths
11	resoTF_End	1.64161e-01	2.90844e+00	
12	resoTT	2.18652e+00	3.11306e-01	
13	xsec	8.89085e+02	4.94679e+01	} Z signal cross section (contains ~1% residual bkg.)

## PARAMETER CORRELATION COEFFICIENTS

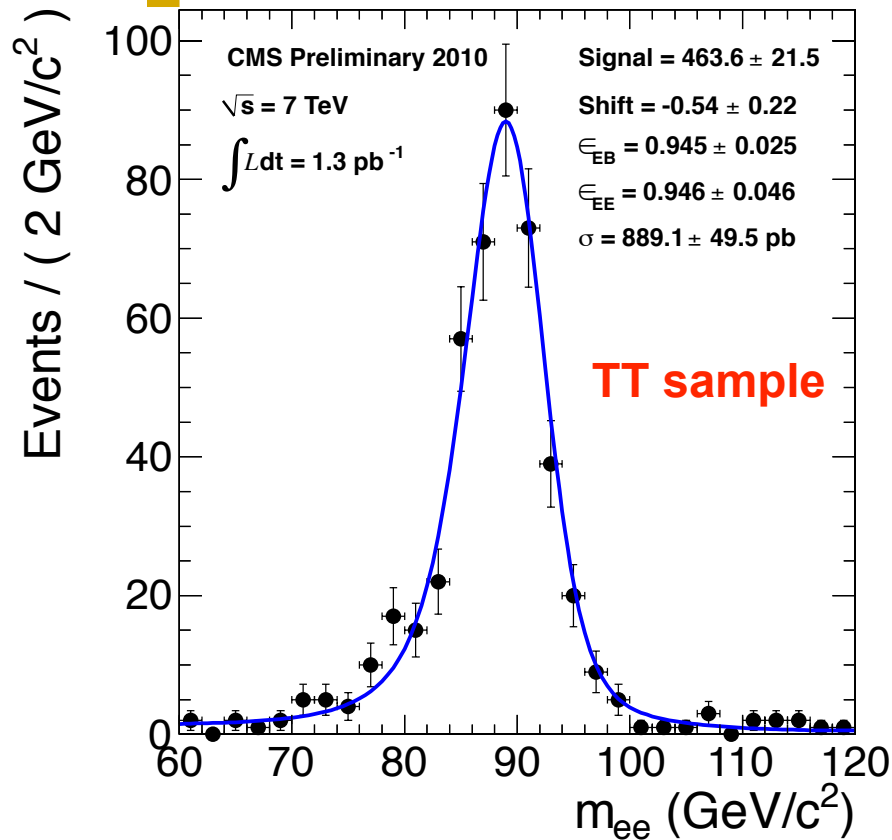
PARAMETER NO.	GLOBAL	1	2	3	4	5	6	7	8	9	10	11	12	13
1	0.04917	1.000	0.010	-0.043	-0.005	-0.008	-0.011	0.000	-0.034	-0.010	-0.001	-0.011	0.000	0.019
2	0.85772	0.010	1.000	-0.158	-0.751	0.001	-0.857	0.000	-0.073	-0.661	-0.000	-0.854	0.000	0.481
3	0.49232	-0.043	-0.158	1.000	0.028	-0.005	0.180	-0.000	0.318	0.155	0.000	0.179	-0.000	-0.293
4	0.88548	-0.005	-0.751	0.028	1.000	-0.001	0.856	-0.000	0.037	0.740	0.000	0.853	-0.000	-0.545
5	0.01047	-0.008	0.001	-0.005	-0.001	1.000	-0.001	0.000	-0.004	-0.001	-0.001	-0.001	0.000	0.002
6	0.99837	-0.011	-0.857	0.180	0.856	-0.001	1.000	-0.000	0.083	0.753	0.000	0.998	-0.000	-0.548
7	0.10532	0.000	0.000	-0.000	-0.000	0.000	-0.000	1.000	-0.000	-0.000	-0.000	-0.000	-0.105	0.000
8	0.32270	-0.034	-0.073	0.318	0.037	-0.004	0.083	-0.000	1.000	0.072	0.000	0.083	-0.000	-0.141
9	0.77851	-0.010	-0.661	0.155	0.740	-0.001	0.753	-0.000	0.072	1.000	0.000	0.750	-0.000	-0.474
10	0.00118	-0.001	-0.000	0.000	0.000	-0.001	0.000	-0.000	0.000	0.000	1.000	0.000	-0.000	-0.000
11	0.99830	-0.011	-0.854	0.179	0.853	-0.001	0.998	-0.000	0.083	0.750	0.000	1.000	-0.000	-0.547
12	0.10532	0.000	0.000	-0.000	-0.000	0.000	-0.000	-0.105	-0.000	-0.000	-0.000	-0.000	1.000	0.000
13	0.61874	0.019	0.481	-0.293	-0.545	0.002	-0.548	0.000	-0.141	-0.474	-0.000	-0.547	0.000	1.000

cross section after bkg subtraction

$\sigma = 880.3 \pm 49.5$  (stat)  $\pm 13.1$  (syst) pb

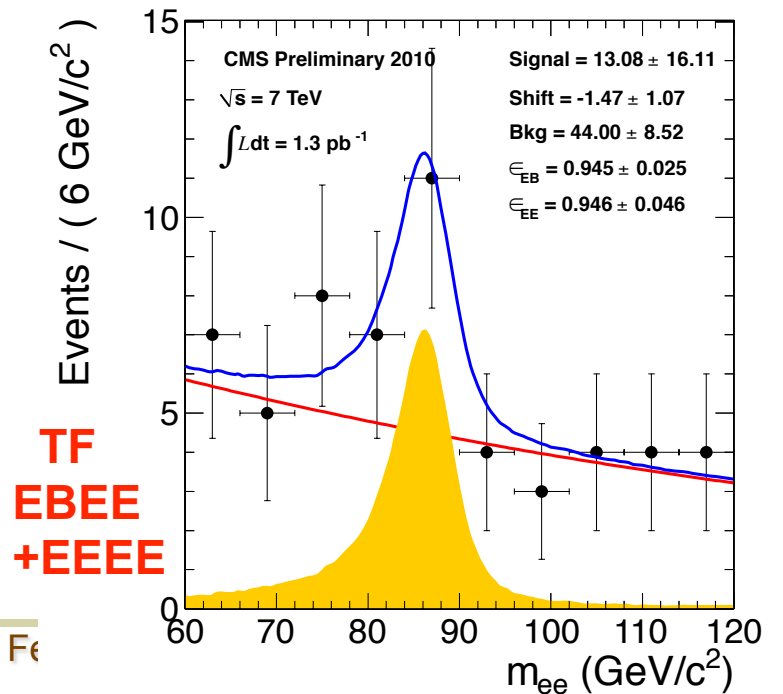
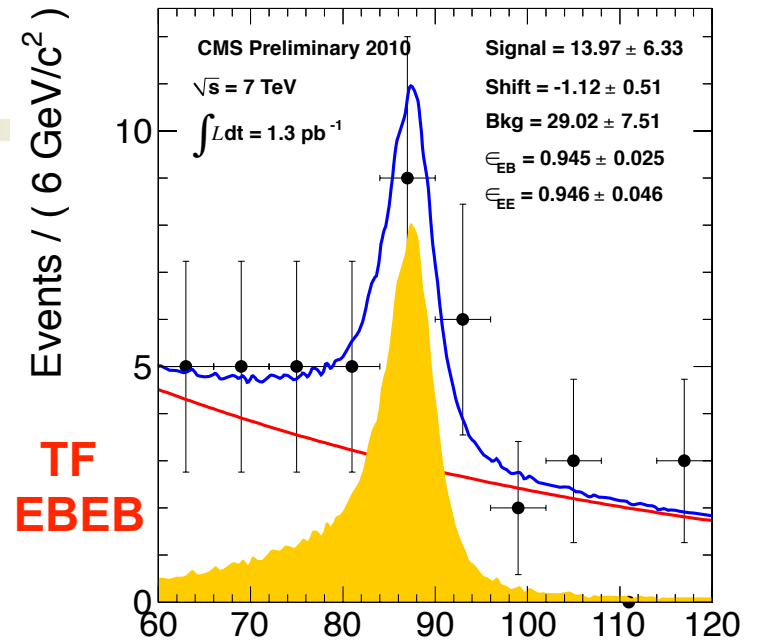
866.0  $\pm$  45.4  $\pm$  33.8 from simple counting

# Simultaneous fit plots



- ◆ All three signal shapes taken from NLO (Powheg) MC + CMS simulation.
- ◆ Convolve using a Gaussian resolution.
- ◆ Let the energy scale float.

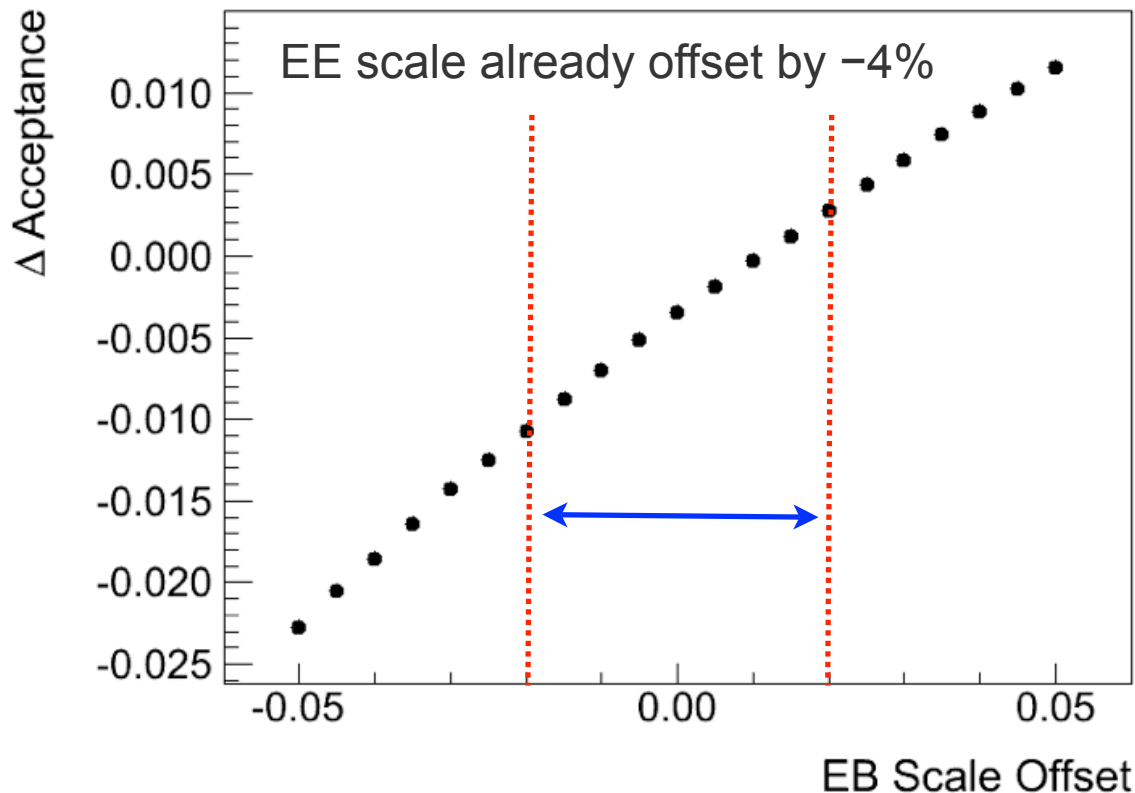
Kalanand Mishra, Fe



# Syst error in Z acceptance due to energy scale



- ◆ The impact of the energy scale on Z acceptance is small.
- ◆ The plot below shows the % change in acceptance vs the change in the EB energy scale when EE energy scale has already been shifted by -4%.
- ◆ We can safely assign a maximum syst. uncertainty of 1%.



If you look at the point where EB scale is shifted -2% and EE scale is shifted -4%, you see that the acceptance changes by about 1%. So this is the maximum systematic effect we could have.

# Big picture on systematic uncertainty



- Red numbers re-evaluated

## muons

## electrons

Source	W channel (%)	Z channel (%)	Source	W channel (%)	Z channel (%)
Muon reco/ID/iso	1.3	2.2	Electron reco/ID/iso	3.6	2.7
Trigger efficiency	1.4	0.2	Trigger efficiency	0.5	0.1
Momentum scale and resolution	1.0	0.5	Momentum scale and resolution	1.9	1.0
MET scale and resolution	1.0	/	MET scale and resolution	1.6	/
Background subtraction	<3.0	/	Background subtraction	1.5	1.5
PDF uncertainty	1.1	1.2	PDF uncertainty	0.8	1.1
Other theoretical uncertainties	1.4	1.6	Other theoretical uncertainties	1.6	1.3
Total (without lumi)	4.2	3.1	Total (without lumi)	4.8	3.7
Luminosity	11.0	11.0	Luminosity	11.0	11.0
Statistical uncertainty	1.3	4.6	Statistical uncertainty	1.4	4.8

[ computed for Pieter's jamboree talk

Our largest syst uncertainty and focus of our current effort

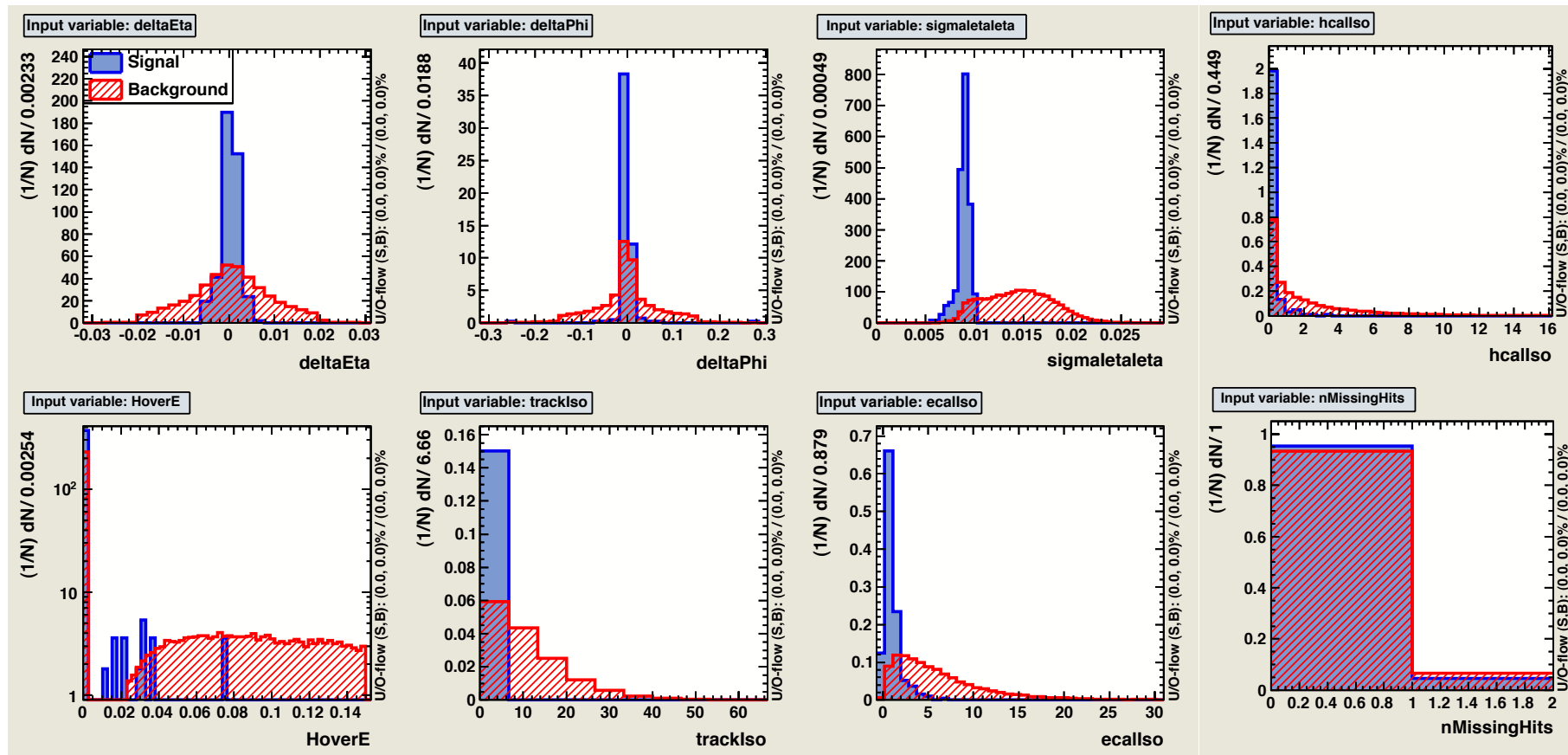
# Efforts at improving electron selection



## Comparison of signal and background for electrons in EB

Signal  $\equiv$  electrons in Z events chosen randomly

Background  $\equiv$  fake electrons from Jet30 triggered events

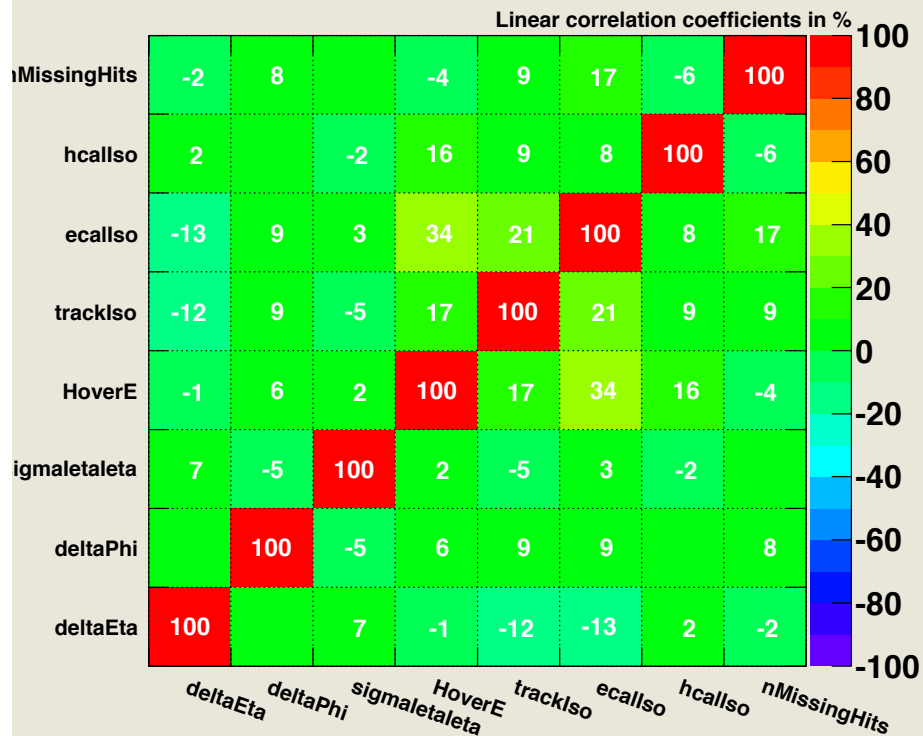


Correlation among these variables on the next slide ➤

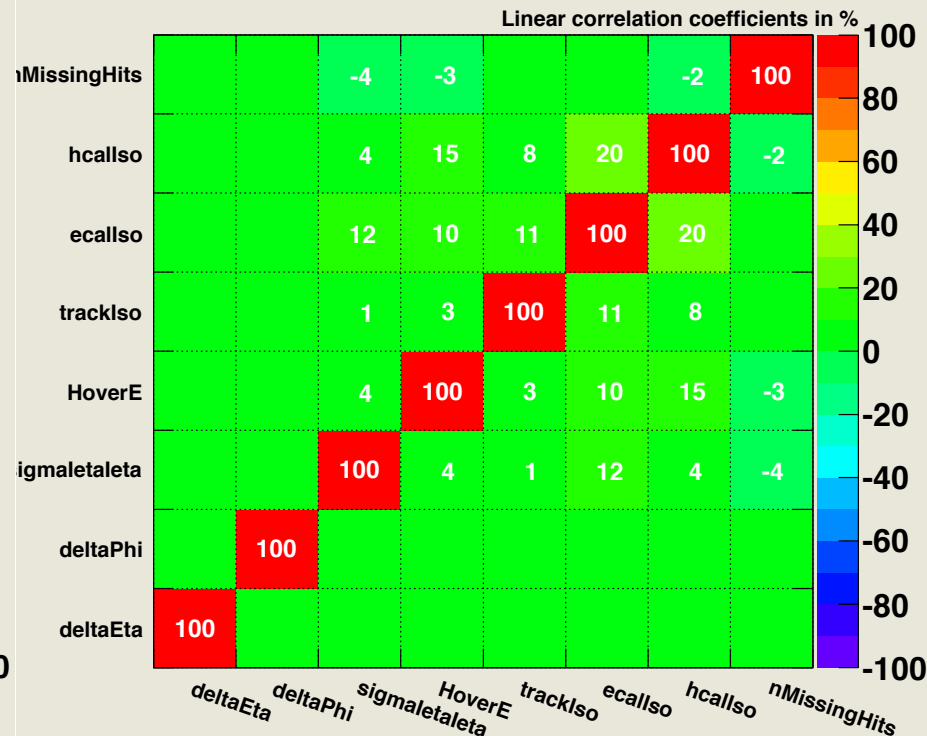
# EB: variable correlations



Correlation Matrix (signal)



Correlation Matrix (background)



Iso variables are quite correlated – H/E is correlated with calo iso.

# EB: optimization using linear discriminant



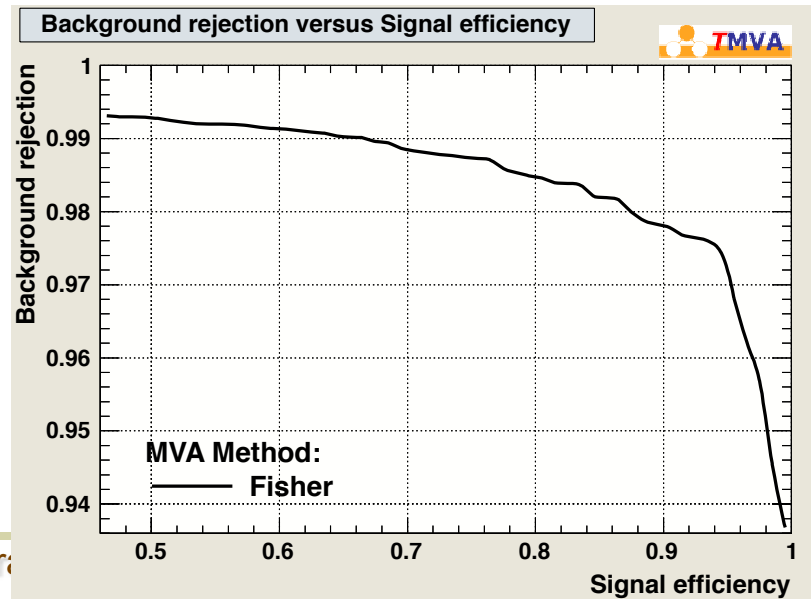
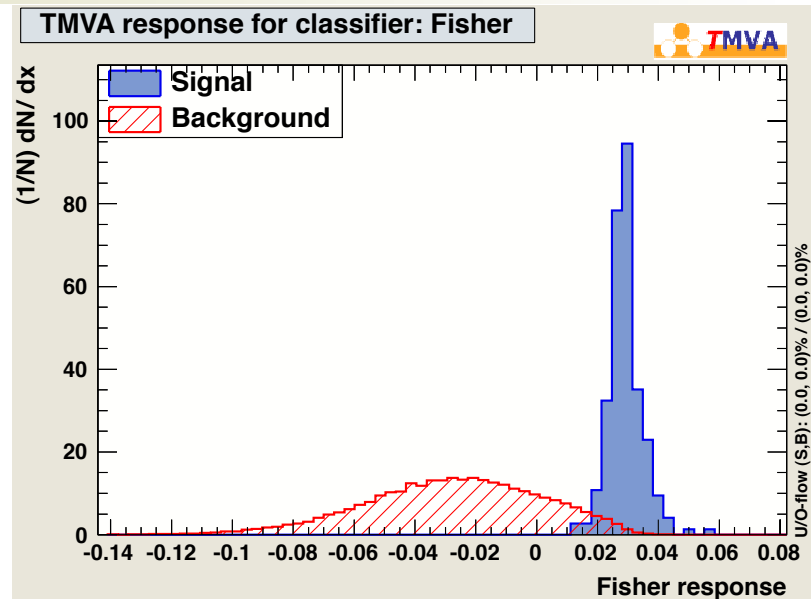
## Results for Fisher coefficients

Variable:	Coefficient
deltaEta:	-0.031
deltaPhi:	+0.004
sigmaletaleta:	-6.617
HoverE:	-0.160
trackIso:	-0.000
ecallso:	-0.002
hcallso:	-0.002
nMissingHits:	-0.011
(offset):	+0.089

can use as a template variable instead

Ranking result (top variable is best ranked)

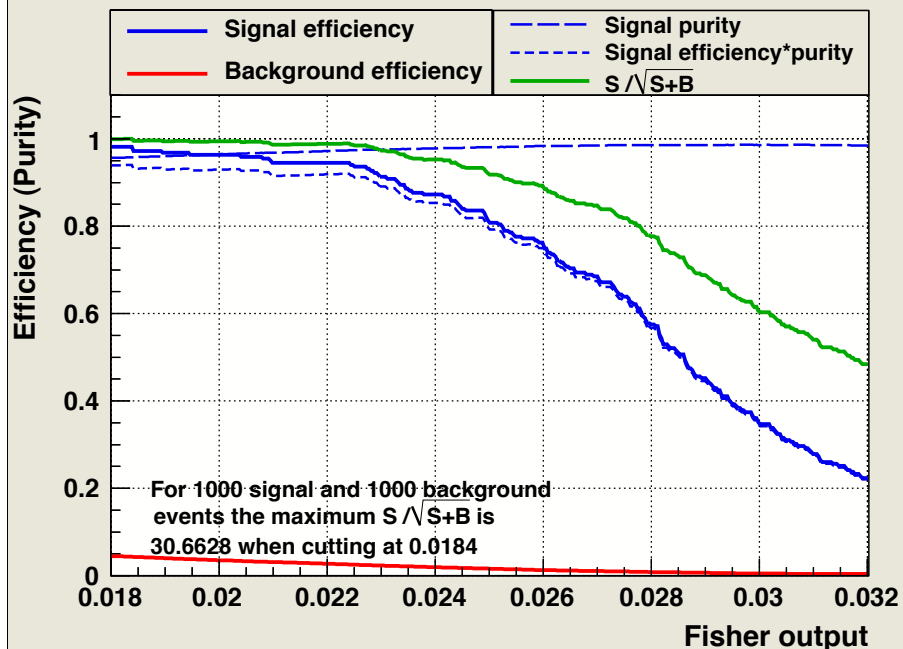
Rank	Variable	Discr. power
1	sigmaletaleta	3.648e-03
2	ecallso	2.387e-03
3	HoverE	1.689e-03
4	hcallso	1.556e-03
5	trackIso	2.624e-04
6	nMissingHits	3.260e-05
7	deltaEta	3.672e-07
8	deltaPhi	1.453e-08



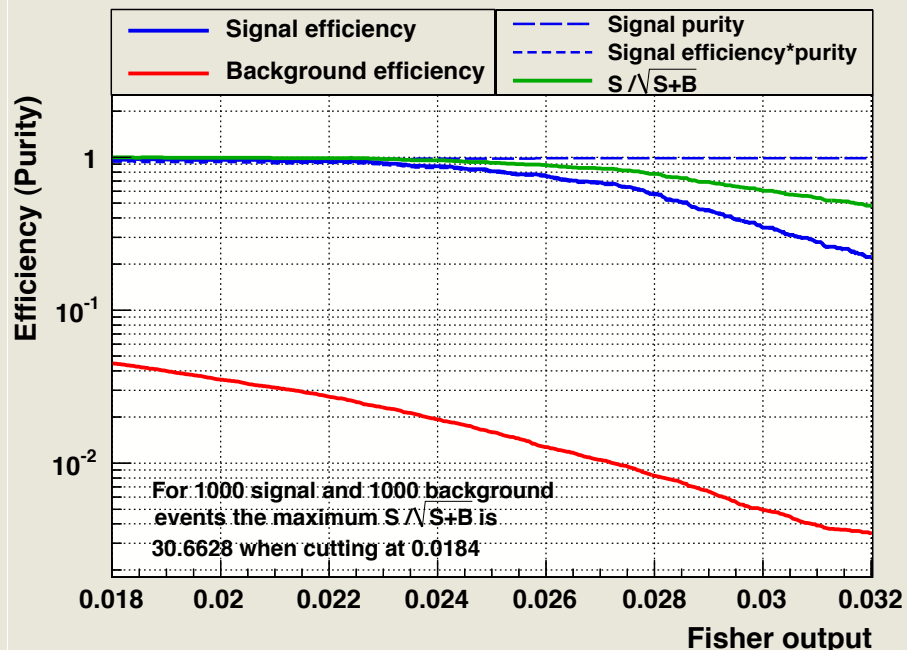


# EB: optimized performance

Cut efficiencies and optimal cut value



Cut efficiencies and optimal cut value



Y-axis scaled linear

Y-axis scaled logarithmic

Possible to achieve 98% purity for 80% efficiency point using an optimal cut.

Correlations between input variables and MVA response:

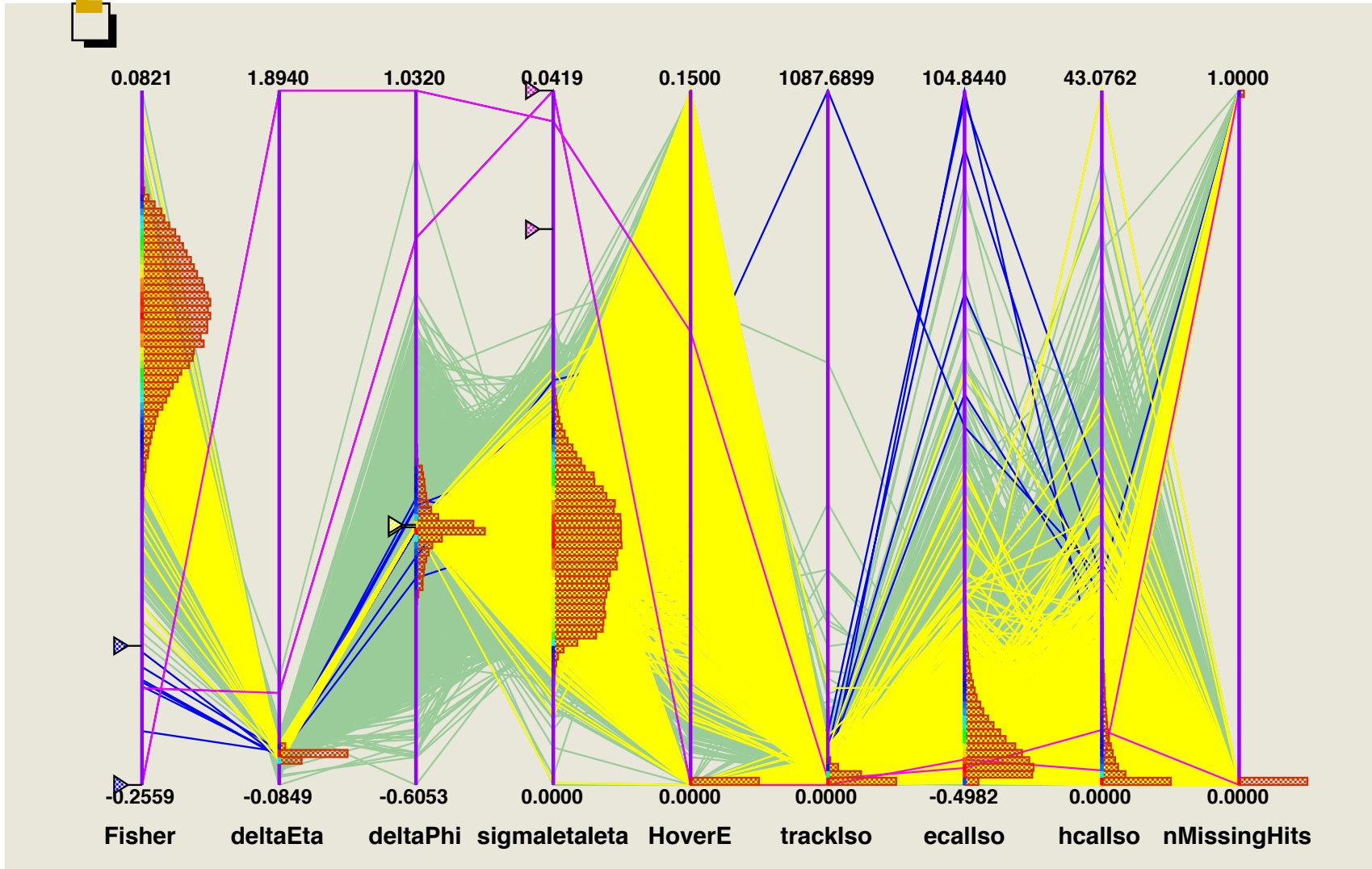
Sig

	Fisher
deltaEta:	-0.026
deltaPhi:	-0.187
sigmaletaleta:	-0.894
HoverE:	-0.265
trackIso:	-0.005
ecallIso:	-0.347
hcallIso:	-0.202
nMissingHits:	-0.233

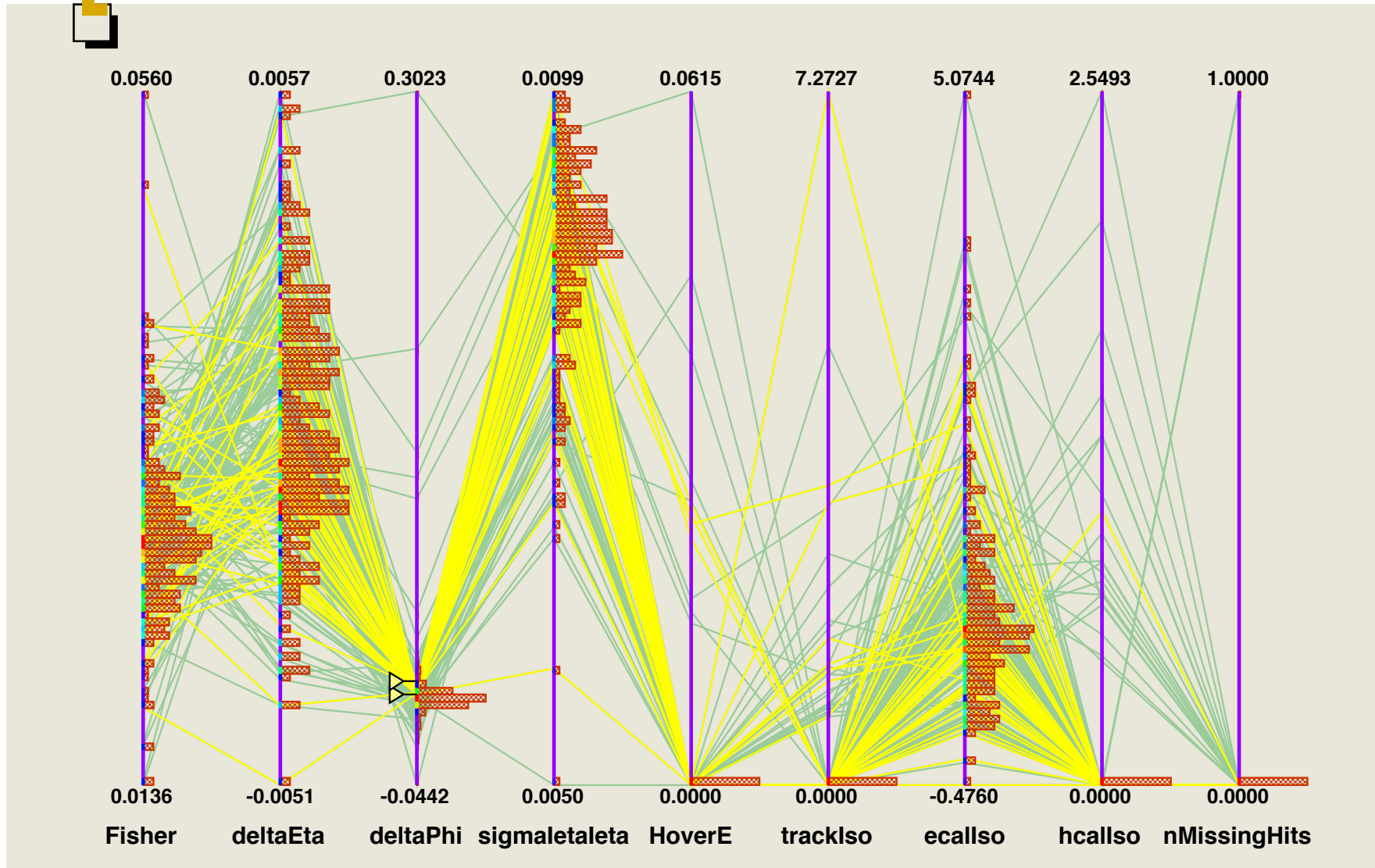
Bkg

	Fisher
deltaEta:	-0.034
deltaPhi:	+0.014
sigmaletaleta:	-0.840
HoverE:	-0.357
trackIso:	-0.305
ecallIso:	-0.499
hcallIso:	-0.350
nMissingHits:	-0.042

# EB: parallel visualization of variables (signal)



# EB: parallel visualization of variables (backgrd)



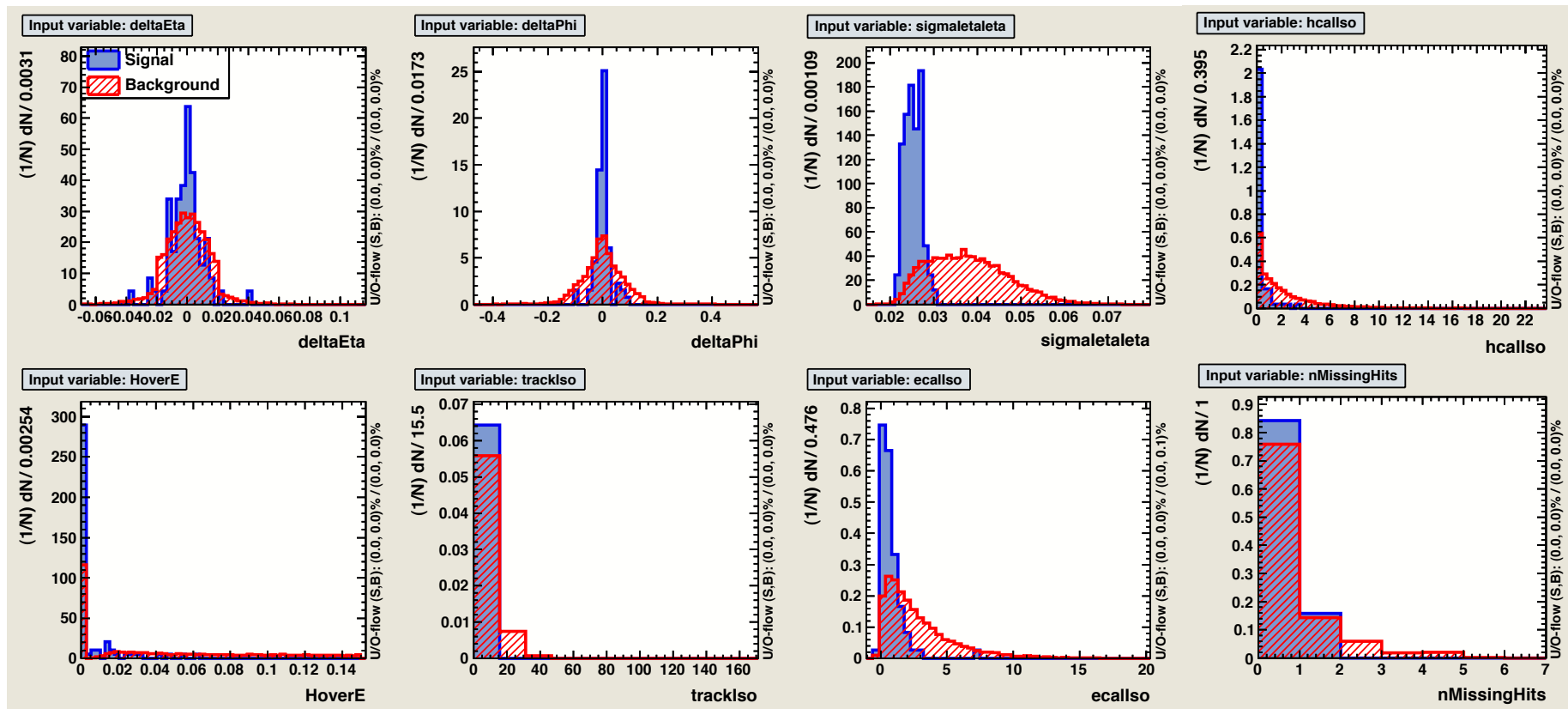
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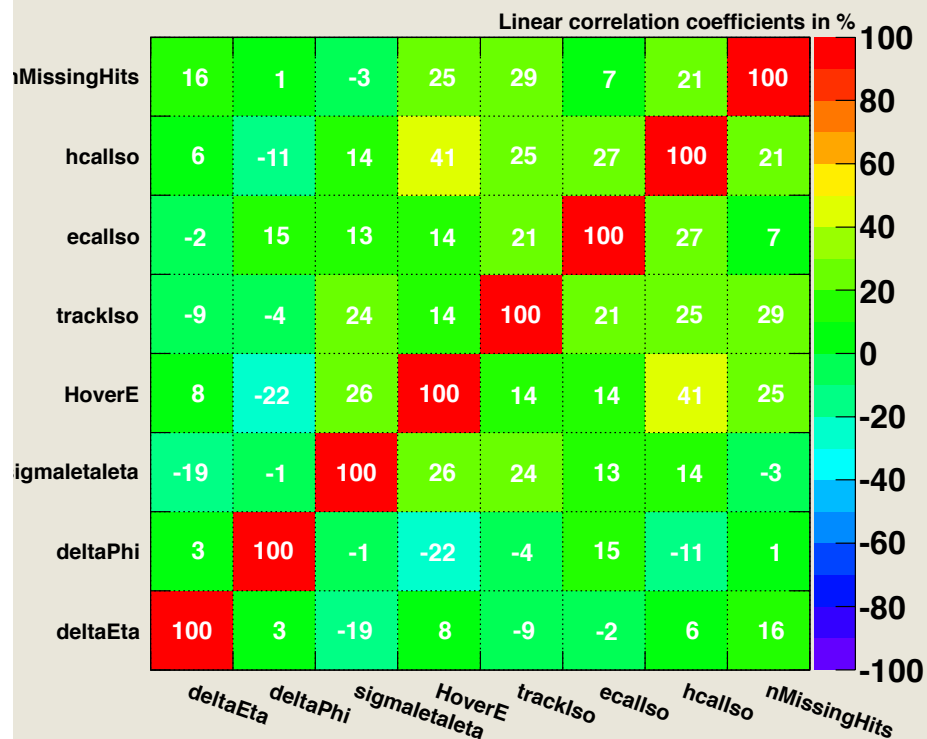


Correlation among these variables on the next slide ➤

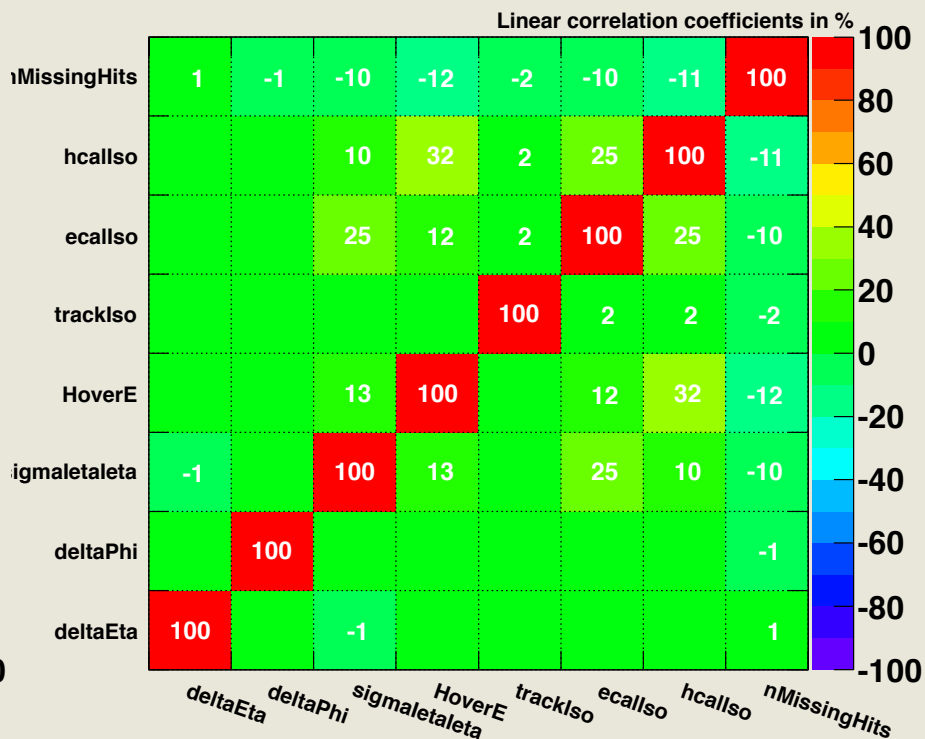
# EE: variable correlations



Correlation Matrix (signal)



Correlation Matrix (background)



Larger correlations compared to the ones in EB.

# EE: optimization using linear discriminant



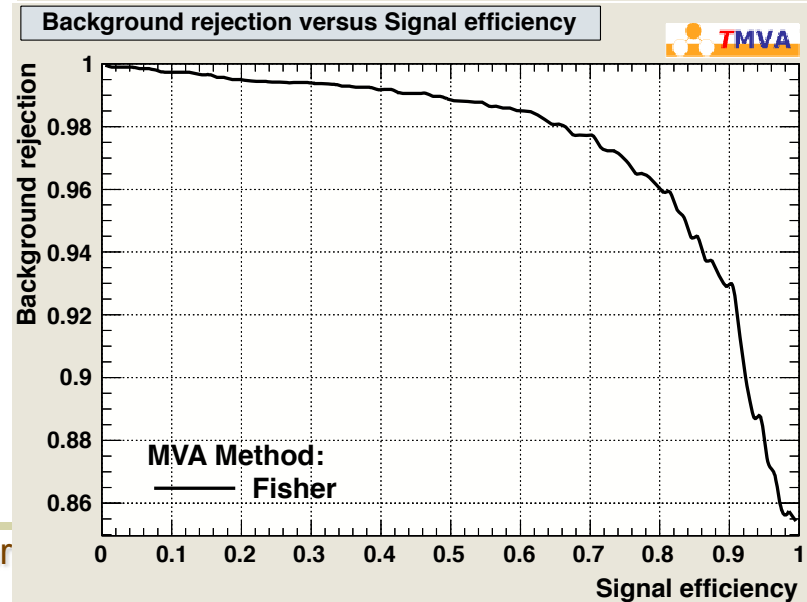
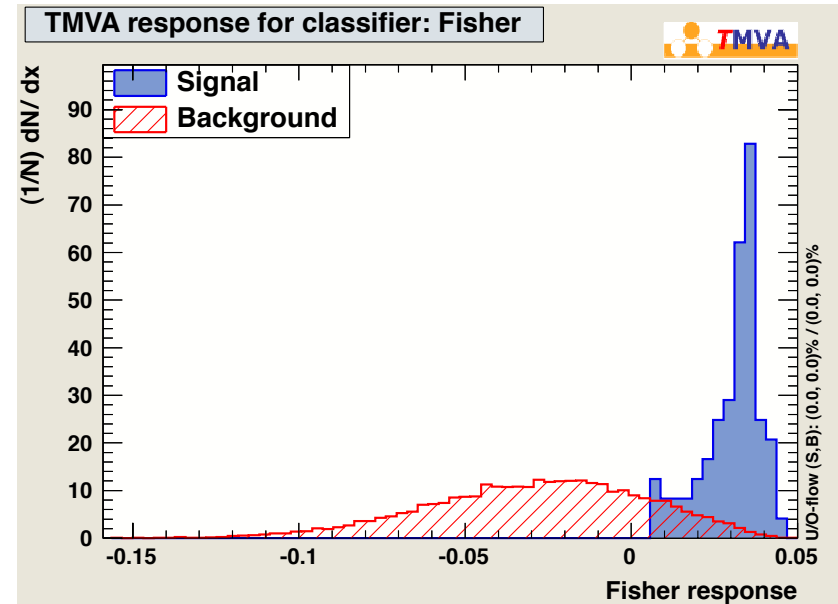
## Results for Fisher coefficients

Variable:	Coefficient
deltaEta:	-0.085
deltaPhi:	-0.000
sigmaletaleta:	-2.657
HoverE:	-0.270
trackIso:	-0.000
ecallso:	-0.002
hcallso:	-0.003
nMissingHits:	-0.013
(offset):	+0.101

can use as a template variable

Ranking result (top variable is best ranked)

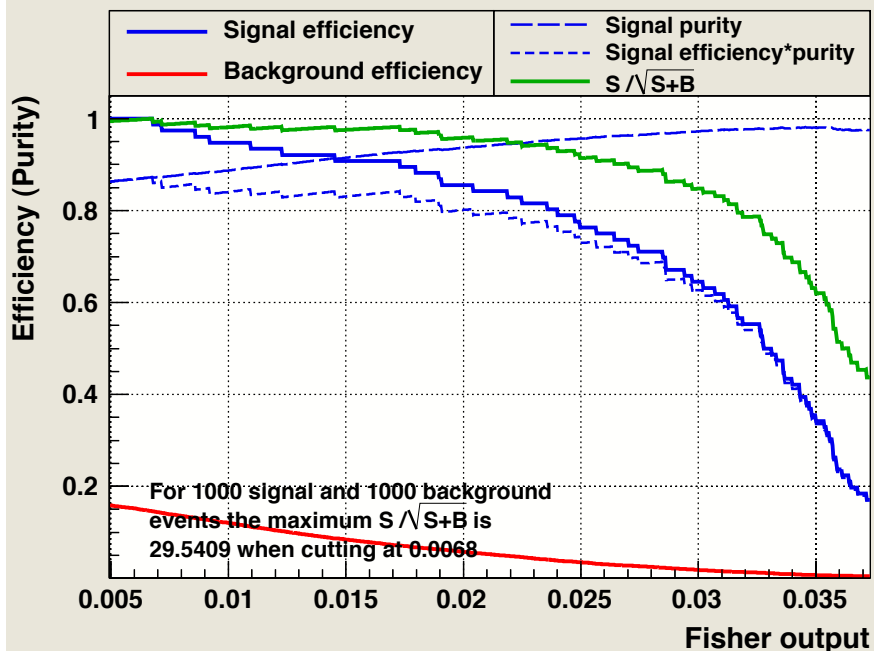
Rank	Variable	Discr. power
1	sigmaletaleta	3.807e-03
2	HoverE	2.676e-03
3	ecallso	1.964e-03
4	hcallso	1.963e-03
5	nMissingHits	4.358e-04
6	trackIso	3.667e-05
7	deltaEta	2.224e-05
8	deltaPhi	1.706e-07



# EE: optimized performance

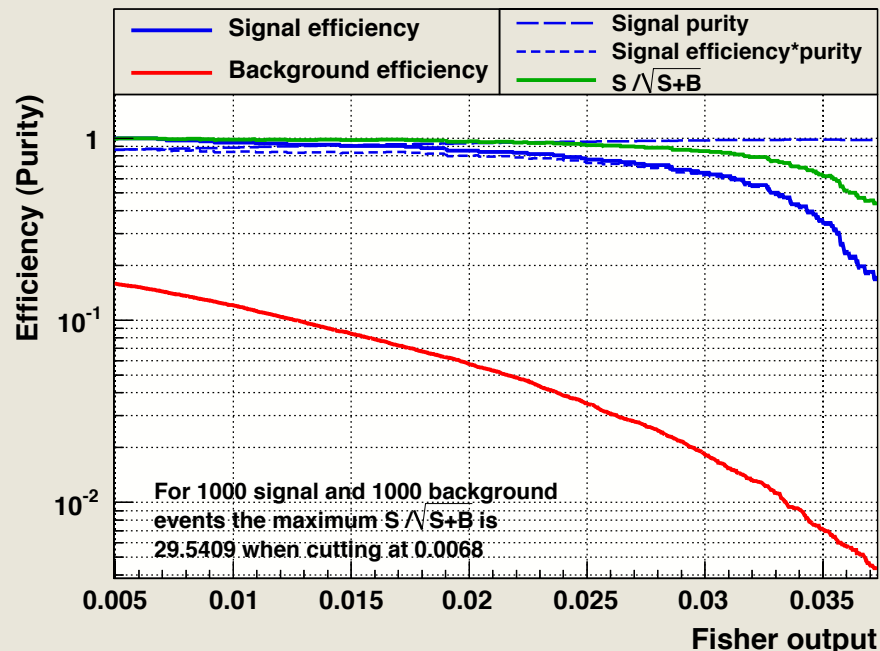


Cut efficiencies and optimal cut value



Y-axis scaled linear

Cut efficiencies and optimal cut value



Y-axis scaled logarithmic

Possible to achieve 96% purity for 80% efficiency point using an optimal cut.

Correlations between input variables and MVA response:

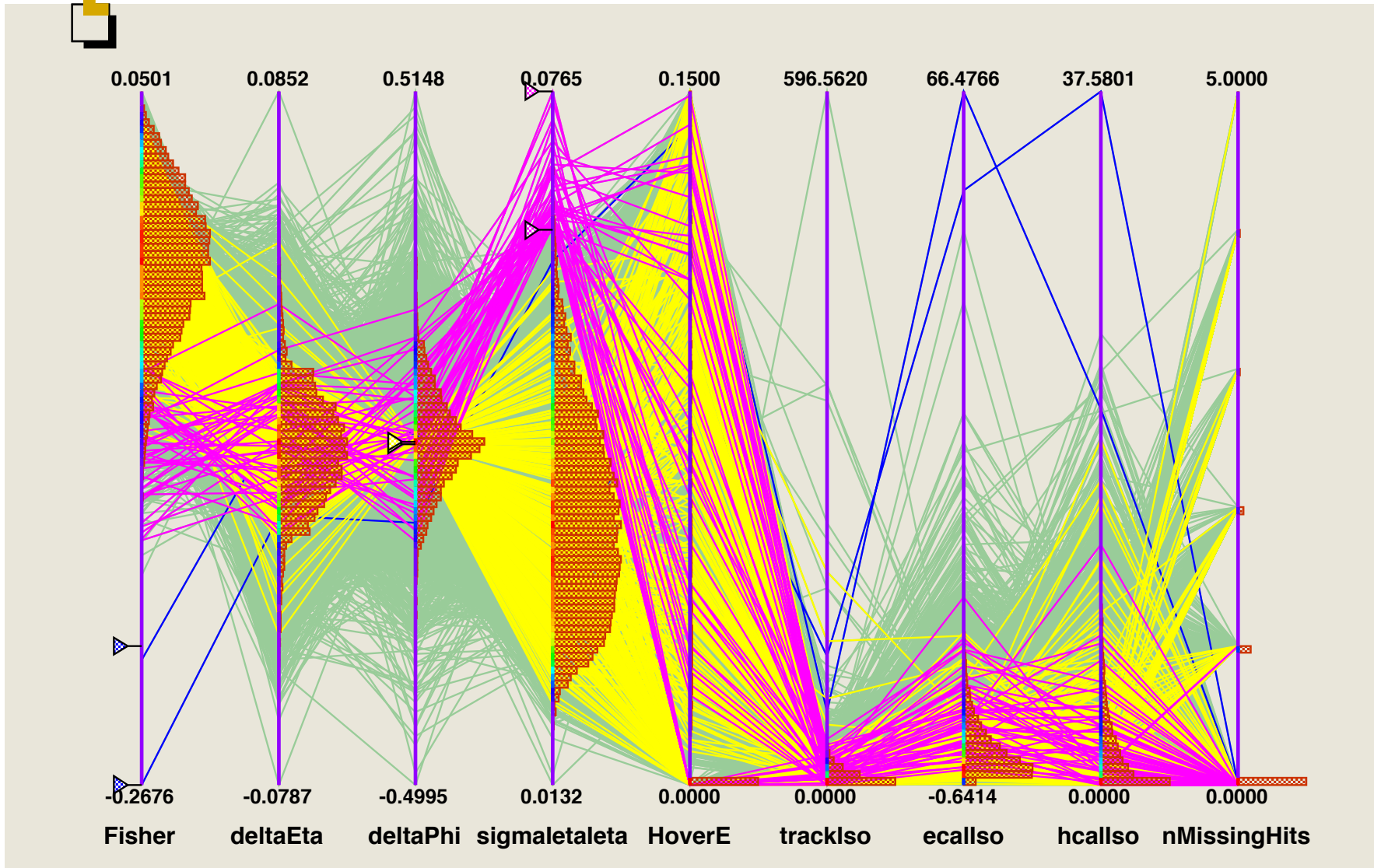
Sig

	Fisher
deltaEta:	-0.047
deltaPhi:	+0.249
sigmaletaleta:	-0.648
HoverE:	-0.708
trackIso:	-0.002
ecallIso:	-0.160
hcallIso:	-0.434
nMissingHits:	-0.386

Bkg

	Fisher
deltaEta:	-0.039
deltaPhi:	+0.004
sigmaletaleta:	-0.797
HoverE:	-0.539
trackIso:	-0.226
ecallIso:	-0.417
hcallIso:	-0.417
nMissingHits:	-0.160

# EE: parallel visualization of variables (signal)



# EE: parallel visualization of variables (backgrd)

