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Measurements of decay branching fractions of the Higgs boson to hadronic final states at the CEPC

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Status

- Measurements of decay branching fractions of the Higgs boson to hadronic final states at the CEPC
  - Application of ParT model under three circumstances
    - Using hadronic Hzz/Hww samples (TDR results)
    - Using inclusive Hzz/Hww samples
    - Using inclusive Hzz/Hww samples after extra isolated lepton veto selection criteria

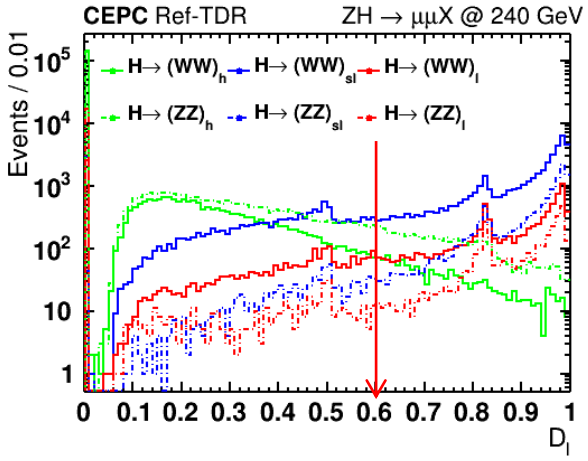
An attempt with isolated lepton

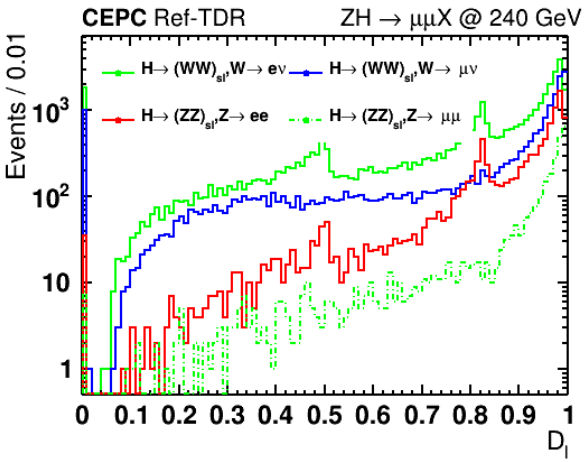
Process	$H \to WW^*$			$H \to ZZ^*$		
Final states	Hadronic	Semi-leptonic		Hadronic	Semi-leptonic	
		$e\nu + 2jets$	$\mu\nu + 2jets$		$ee + 2jets$	$\mu\mu + 2jets$
Simulated N	178264	56629	56801	185120	18221	17901
Muon pair & Z-mass	161636	51310	52175	167775	16526	17034
$D_l < 0.6^*$	160281	9640	4731	162909	654	175
Total efficiency	89.9%	17.0%	8.3%	88.0%	3.6%	1.0%

$*$: $lepton\ veto\ muons\ from\ Z$
($E > 5$GeV and in region($\Delta R < 0.4$): $max\ energy\ deposit\ for\ \mu/e$)

The cutflow

$$D_l := E_l/(E_l + E_{other})$$





energy deposit

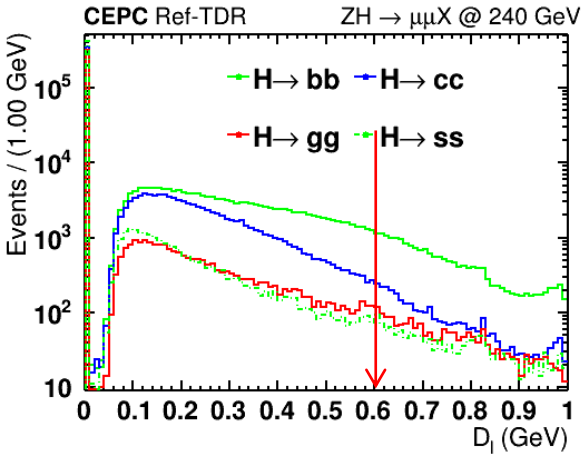
An attempt with isolated lepton

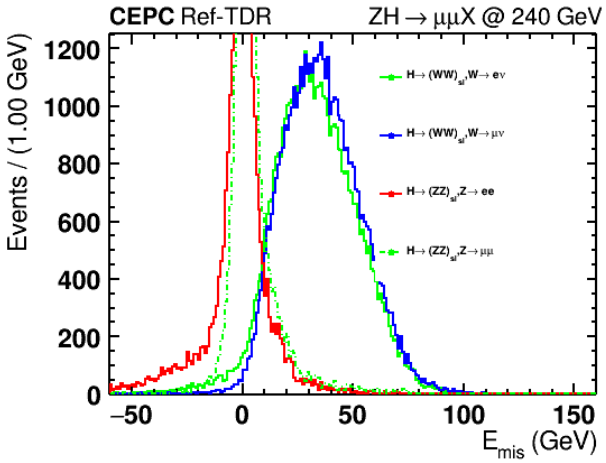
Process	$H \to bb$	$H \to cc$	$H \to gg$	$H \to ss$
Simulated N	495000	494500	371500	494250
Muon pair & Z-mass	449960	449169	337620	448584
$D_l < 0.6^*$	429627	445737	335633	447038
Total efficiency	86.8%	90.1%	90.3%	90.4%

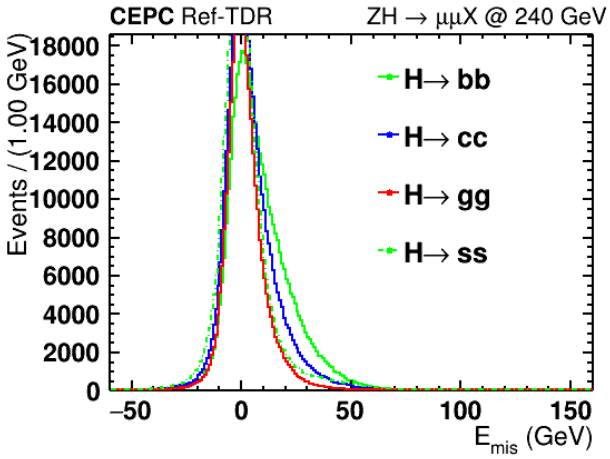
The cutflow

$*$: *lepton veto muons from Z*
($E > 5$GeV and in region($\Delta R < 0.4$): *max energy deposit for* μ/e)

$$D_l := E_l/(E_l + E_{other})$$

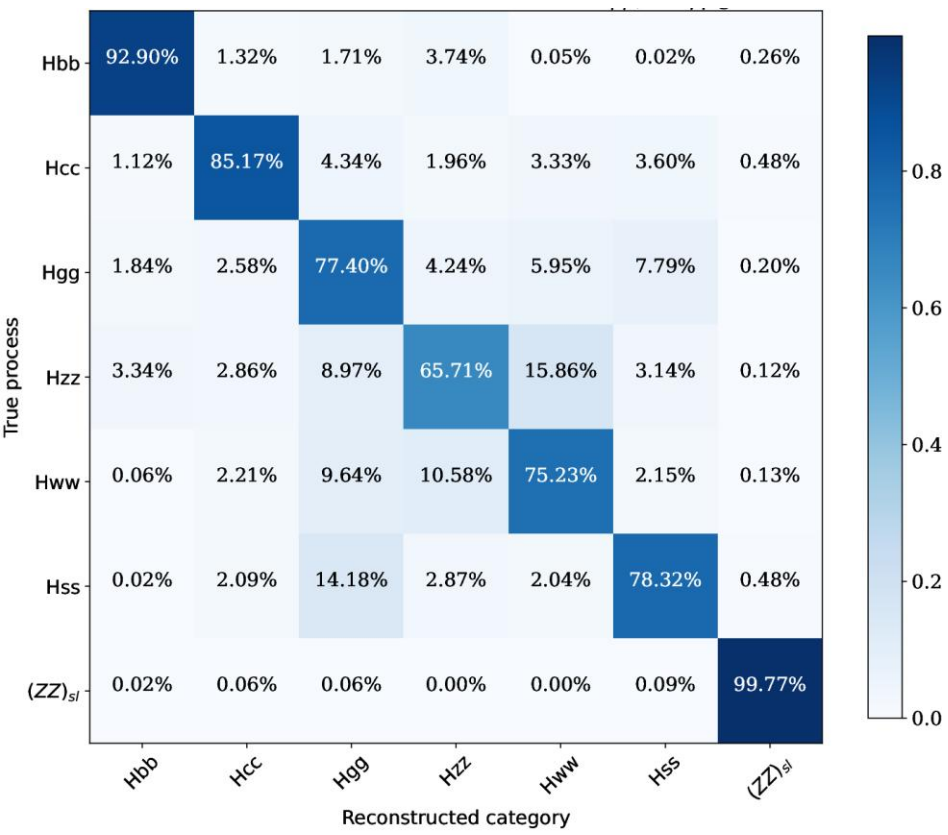






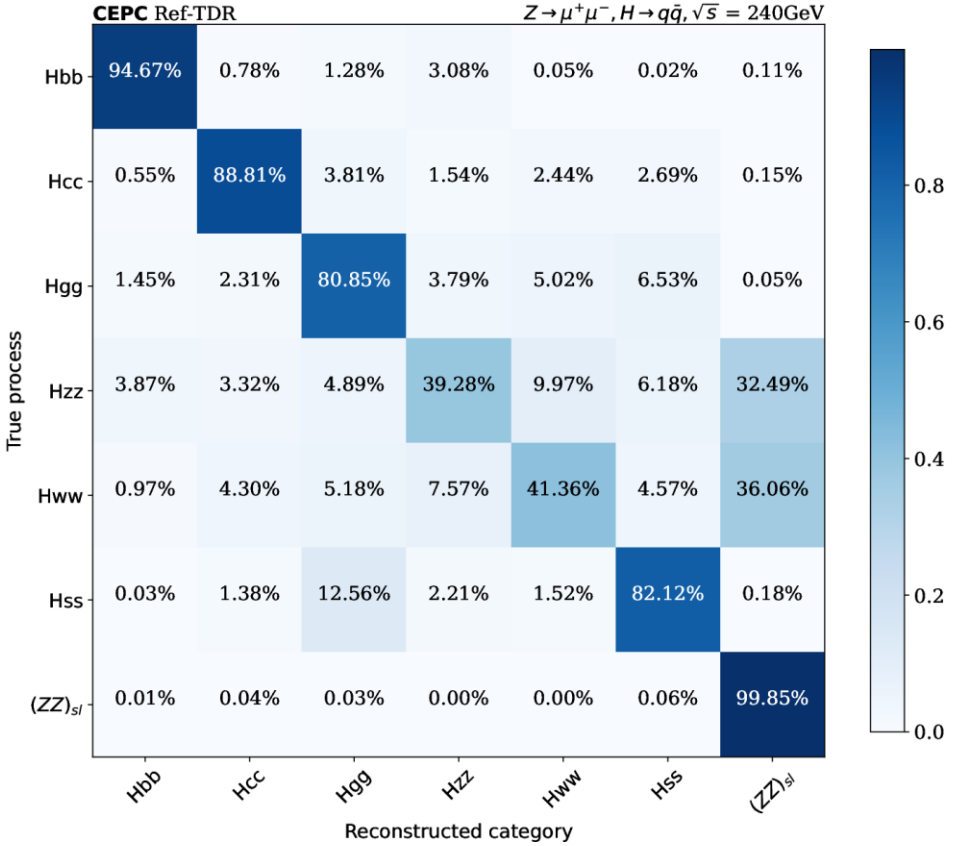
Comparison of model performance

The migration matrix with full sim bkg



- With hadronic Hzz/Hww
- Reconstructed category refers to one with maximum score
- Average accuracy: 82.1%

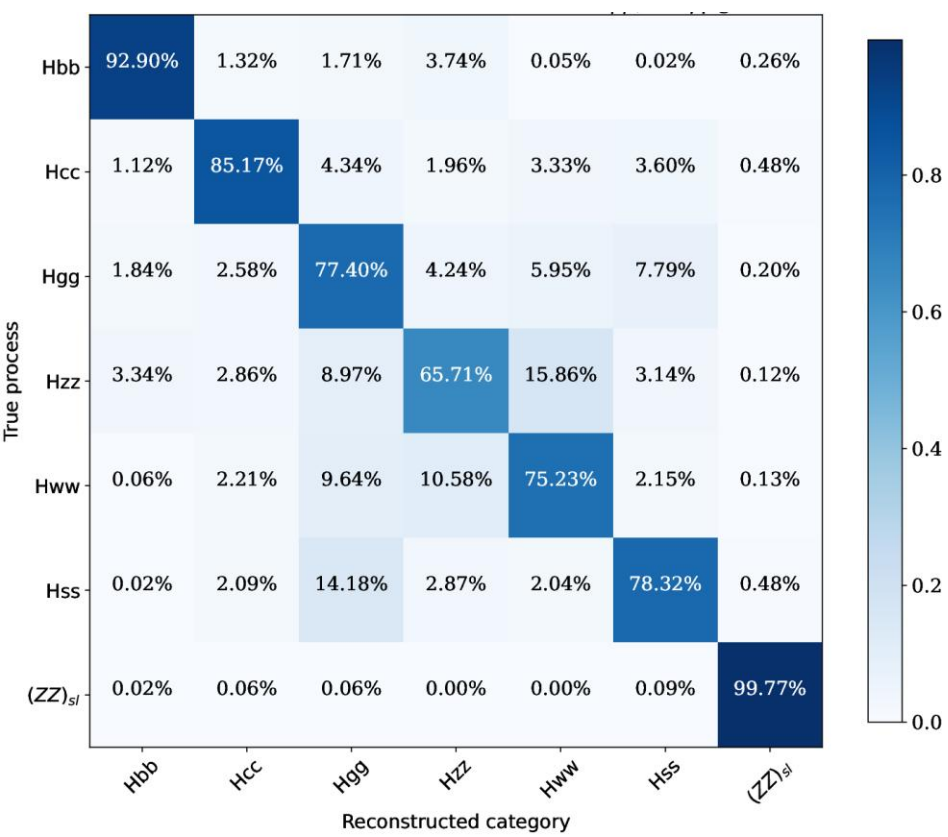
The migration matrix with full sim bkg



- With inclusive Hzz/Hww
- The sum of each row equals 1
- Average accuracy: 75.3%

Comparison of model performance

The migration matrix with full sim bkg



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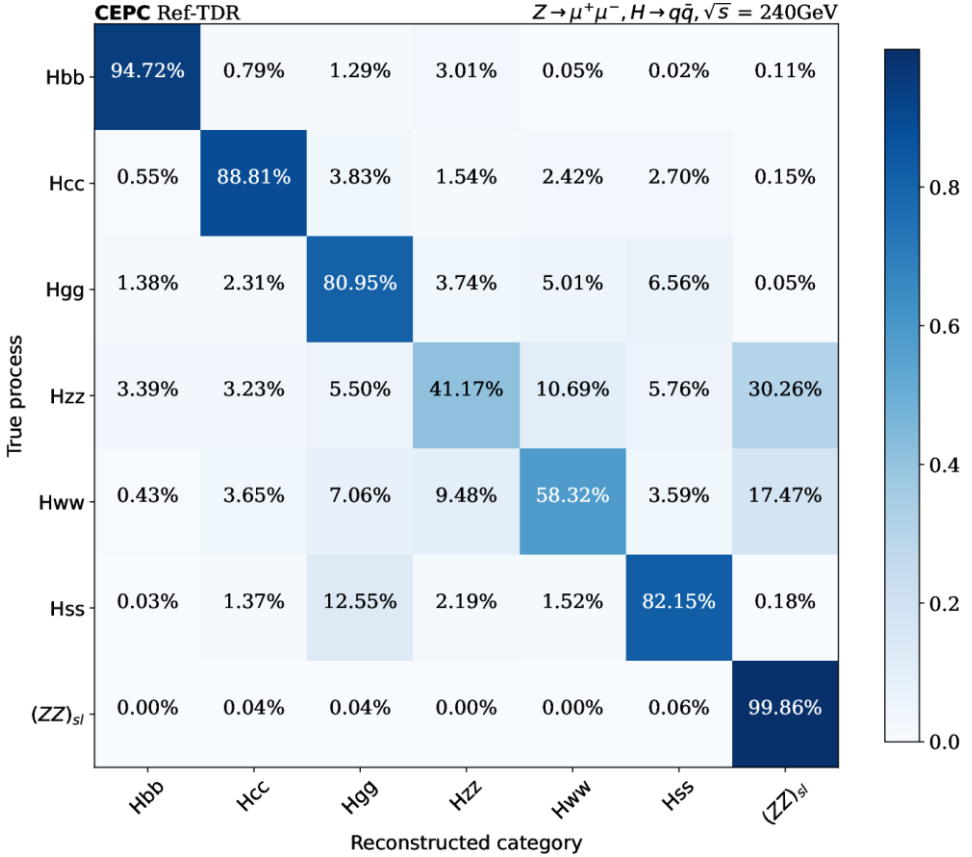

- With inclusive Hzz/Hww
- Add extra lepton cut
- The sum of each row equals 1
- Average accuracy: 78.0%

Comparison of results

- Results of the measured Higgs branching fractions with relative statistical and systematic uncertainties:

Sig	$H \to b\bar{b}$	$H \to c\bar{c}$	$H \to gg$	$H \to ZZ^*$	$H \to WW^*$	$H \to s\bar{s}$
Branching fraction	57.7%	2.91%	8.57%	2.64%	21.5%	4.4×10^{-4}
Rel. Stat. Un.	0.3%	2.2%	1.3%	7.9%	1.1%	96.9%

➢ With incl Hzz/Hww

Sig	$H \to b\bar{b}$	$H \to c\bar{c}$	$H \to gg$	$H \to ZZ^*$	$H \to WW^*$	$H \to s\bar{s}$
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Comparison of results

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Sig	$H \to b\bar{b}$	$H \to c\bar{c}$	$H \to gg$	$H \to ZZ^*$	$H \to WW^*$	$H \to s\bar{s}$
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➢ With incl Hzz/Hww adding extra lepton cut

Sig	$H \to b\bar{b}$	$H \to c\bar{c}$	$H \to gg$	$H \to ZZ^*$	$H \to WW^*$	$H \to s\bar{s}$
Branching fraction	57.7%	2.91%	8.57%	2.64%	21.5%	4.4×10^{-4}
Rel. Stat. Un.	0.3%	2.2%	1.2%	7.7%	1.0%	100.0%

Back up

Separate hadronic decays from inclusive Hzz and Hww

Z DECAY MODES

Γ_1	e^+e^-	(3.3632 ±0.0042) %
Γ_2	$\mu^+\mu^-$	(3.3662 ±0.0066) %
Γ_3	$\tau^+\tau^-$	(3.3696 ±0.0083) %
Γ_7	invisible	(20.000 ±0.055) %
Γ_8	hadrons	(69.911 ±0.056) %

W^+ DECAY MODES

Γ_2	$e^+\nu$	(10.71 ±0.16) %
Γ_3	$\mu^+\nu$	(10.63 ±0.15) %
Γ_4	$\tau^+\nu$	(11.38 ±0.21) %
Γ_5	hadrons	(67.41 ±0.27) %

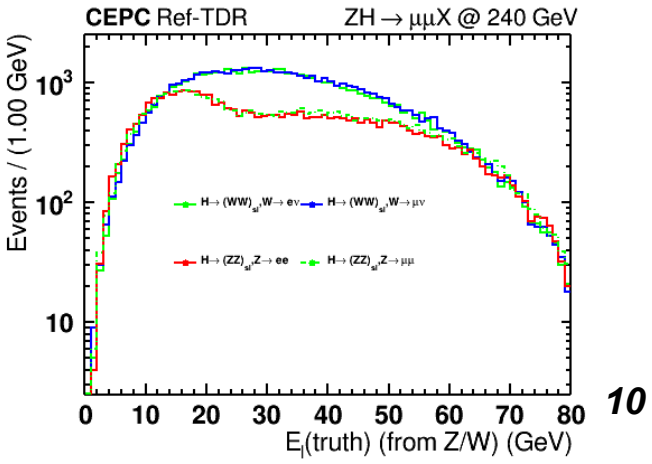
τ^- DECAY MODES

Γ_3	$\mu^-\overline{\nu}_\mu\nu_\tau$	[1]	(17.39 ±0.04) %
Γ_4	$\mu^-\overline{\nu}_\mu\nu_\tau\gamma$	[2]	(3.67 ±0.08) $\times10^{-3}$
Γ_5	$e^-\overline{\nu}_e\nu_\tau$	[1]	(17.82 ±0.04) %
Γ_6	$e^-\overline{\nu}_e\nu_\tau\gamma$	[2]	(1.83 ±0.05) %
Γ_7	$h^- \geq 0K^0_L\,\nu_\tau$		(12.03 ±0.05) %
Γ_8	$h^-\nu_\tau$		(11.51 ±0.05) %
Γ_{12}	$h^- \geq 1\,\pi^0\nu_\tau$ (ex.K^0)		(36.50 ±0.09) %

pdgLive

For $H \rightarrow ZZ$:
Hadronic 48.9%
Semi-leptonic 42.0%
Leptonic 9.1%
For $H \rightarrow WW$:
Hadronic 45.4%
Semi-leptonic 44.0%
Leptonic 10.6%

For τ
~35% Leptonic



Event selection

- At least two muons with opposite charge. (muon ID @ BEST WP and $E > 10$ GeV)
  - Choose the muon pair closest to the Z boson mass.
- $|\cos\theta_{\mu^+\mu^-}| < 0.996$: to further reduce the two-fermion backgrounds.
- $N_{\text{charged}} > 7$: to reduce the backgrounds.
- $M_{\mu\mu}$ in Z-mass window [75 GeV, 105 GeV].
- $M_{\mu\mu}^{\text{recoil}}$ in H-mass window [120 GeV, 140 GeV]. $M_{\mu\mu}^{\text{recoil}} = \sqrt{(\sqrt{s} - E_{\mu^+} - E_{\mu^-})^2 - (\overrightarrow{P_{\mu^+}} + \overrightarrow{P_{\mu^-}})^2}$

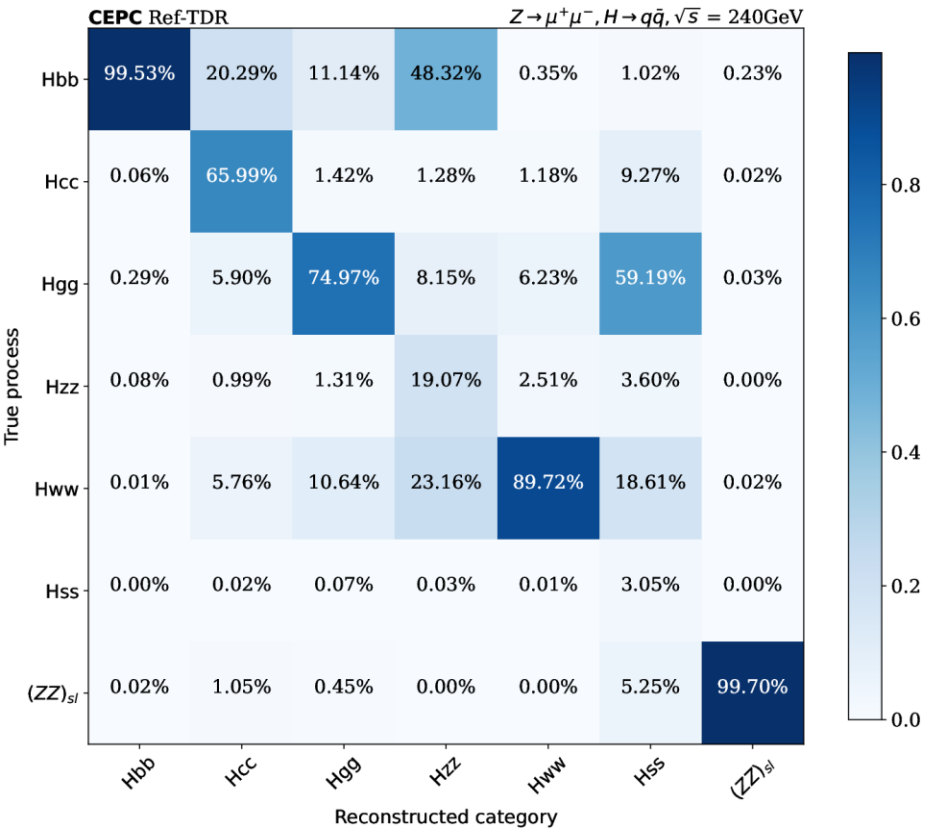
The cutflow selection efficiency

Process	$b\bar{b}$	$c\bar{c}$	gg	WW^*	ZZ^*	$s\bar{s}$	$(ZZ)_{sl}$
Muon pair	96.9%	96.7%	96.7%	96.7%	96.7%	96.6%	21.1%
Isolation	90.3%	90.3%	90.5%	90.4%	90.7%	90.5%	19.7%
$\lvert\cos\theta_{\mu\mu}\rvert$ <0.996	90.0%	90.0%	90.2%	90.1%	90.4%	90.1%	3.0%
N_{tracks} >7	90.0%	90.0%	90.2%	90.1%	90.4%	90.1%	3.0%
Z mass window	86.4%	86.4%	86.5%	86.4%	86.7%	86.5%	1.4%
H mass window	82.4%	82.3%	82.5%	82.4%	82.8%	82.4%	0.7%

Incl Hzz/Hww: 0.8239,0.8233,0.8249,0.7498,0.7374,0.8240,0.0066
add Dl<0.6: 0.7878,0.8178,0.8206,0.6443,0.4984,0.8218,0.0065

Comparison of purity matrix

The purity matrix with full sim bkg



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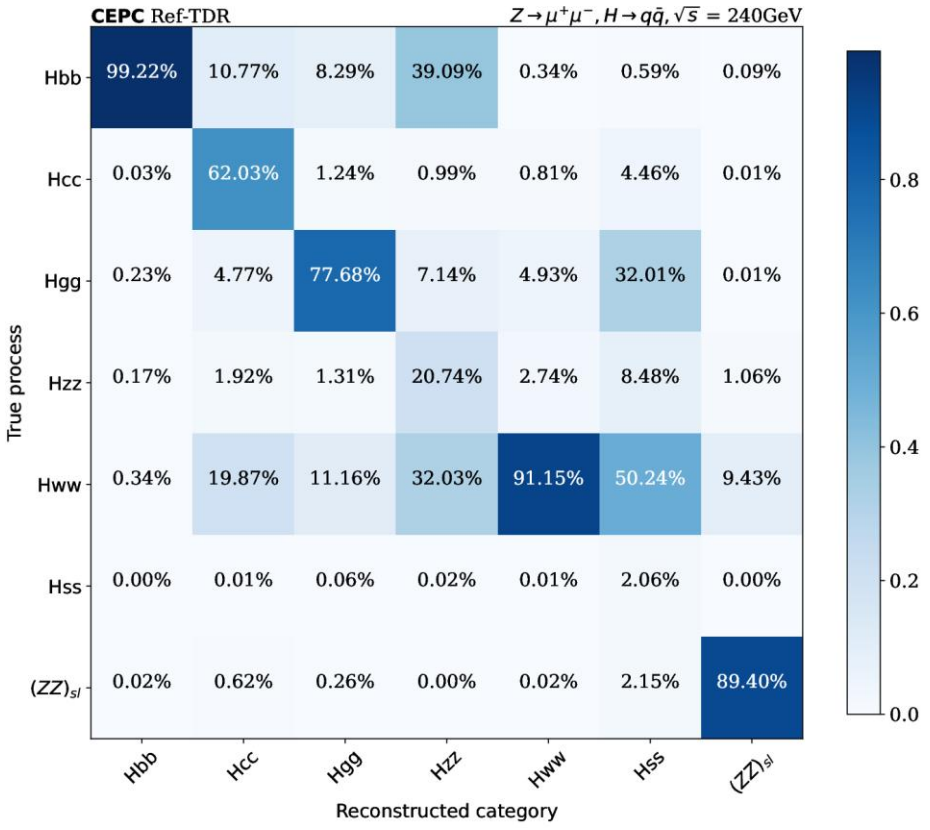

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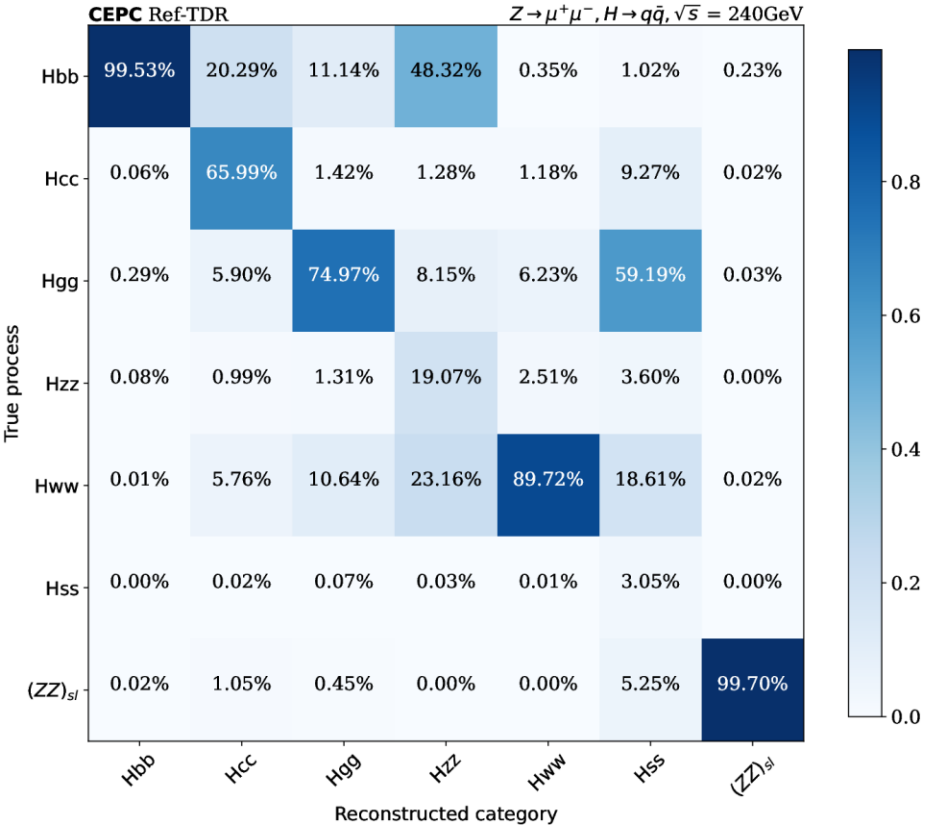

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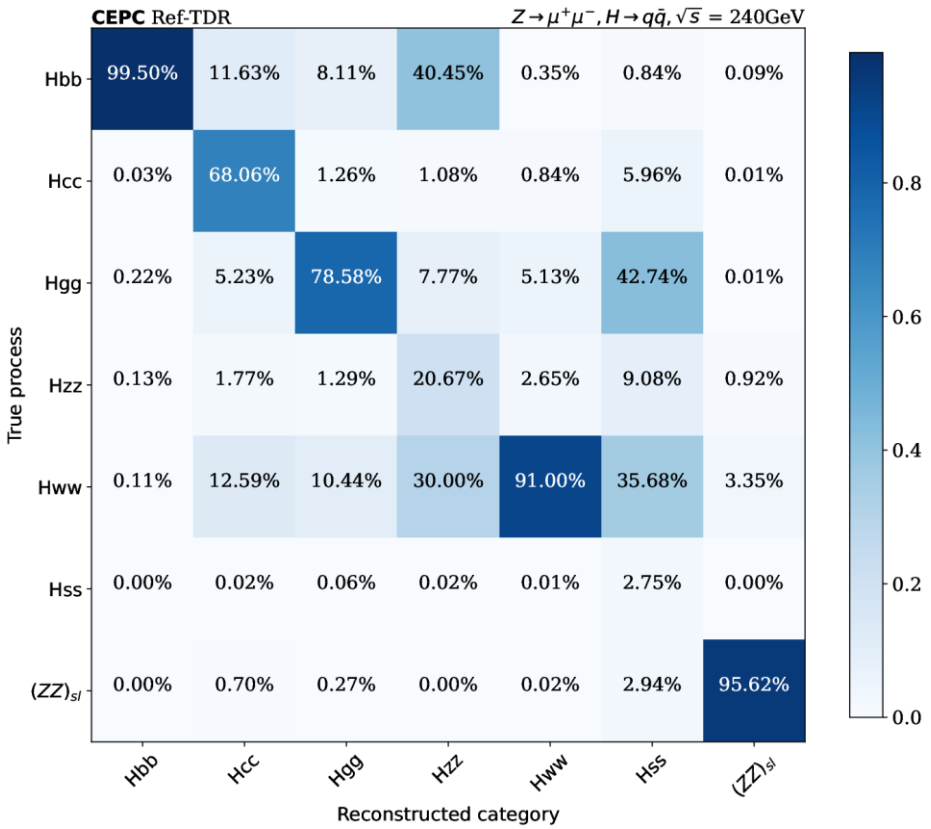

- With inclusive Z/W
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