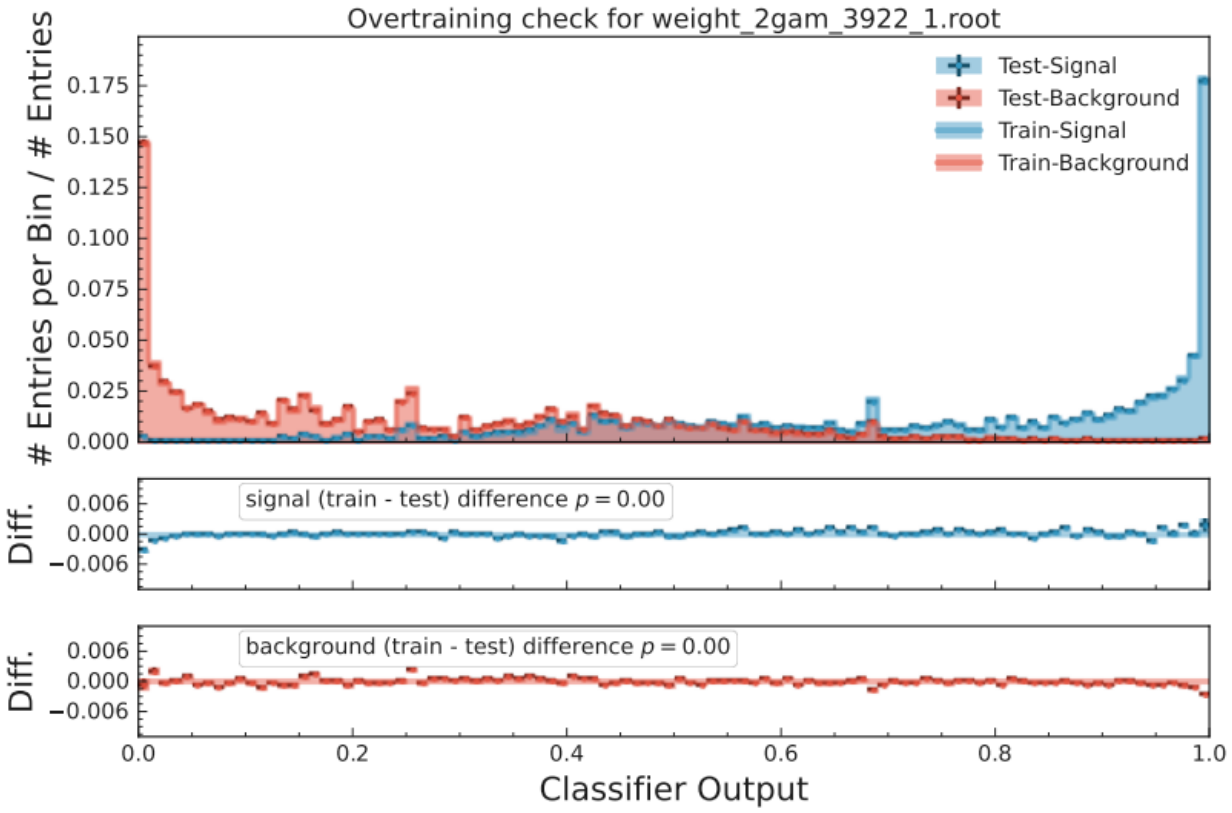
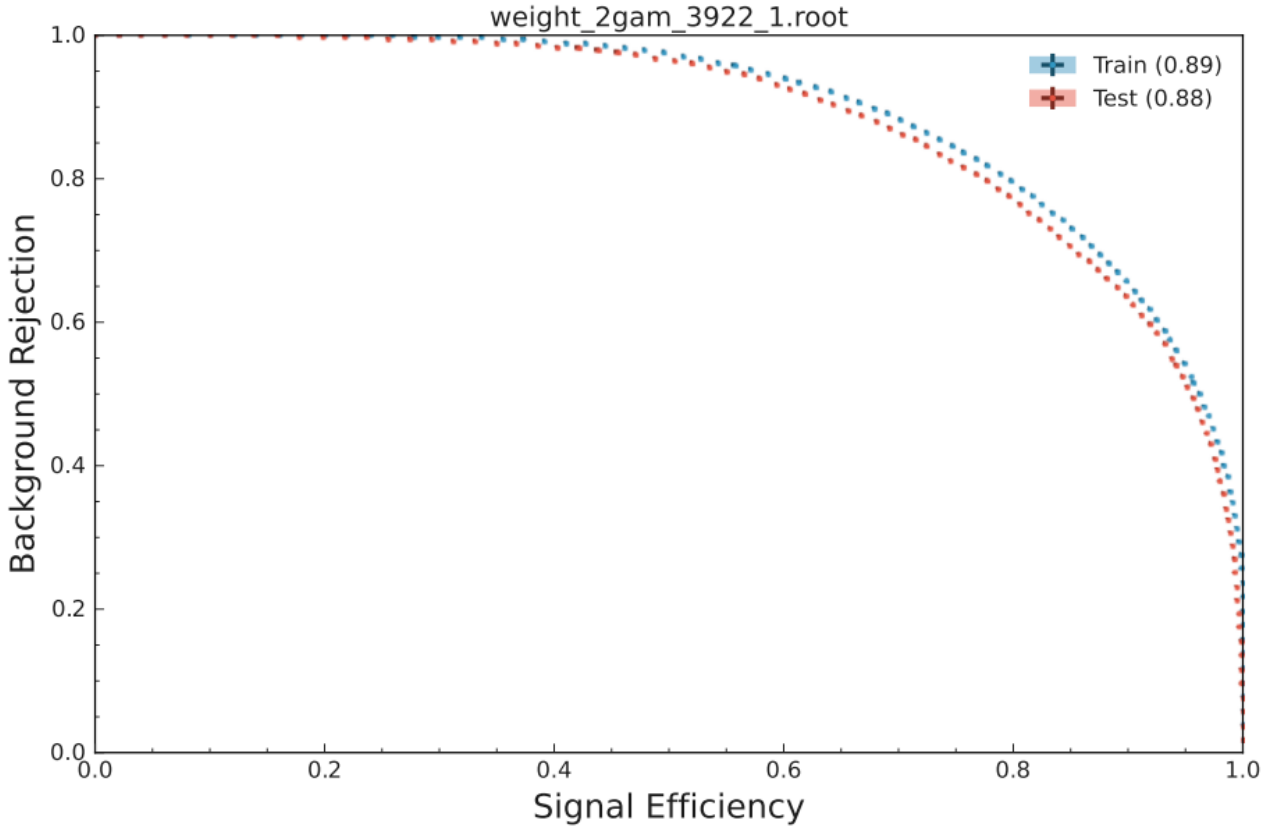
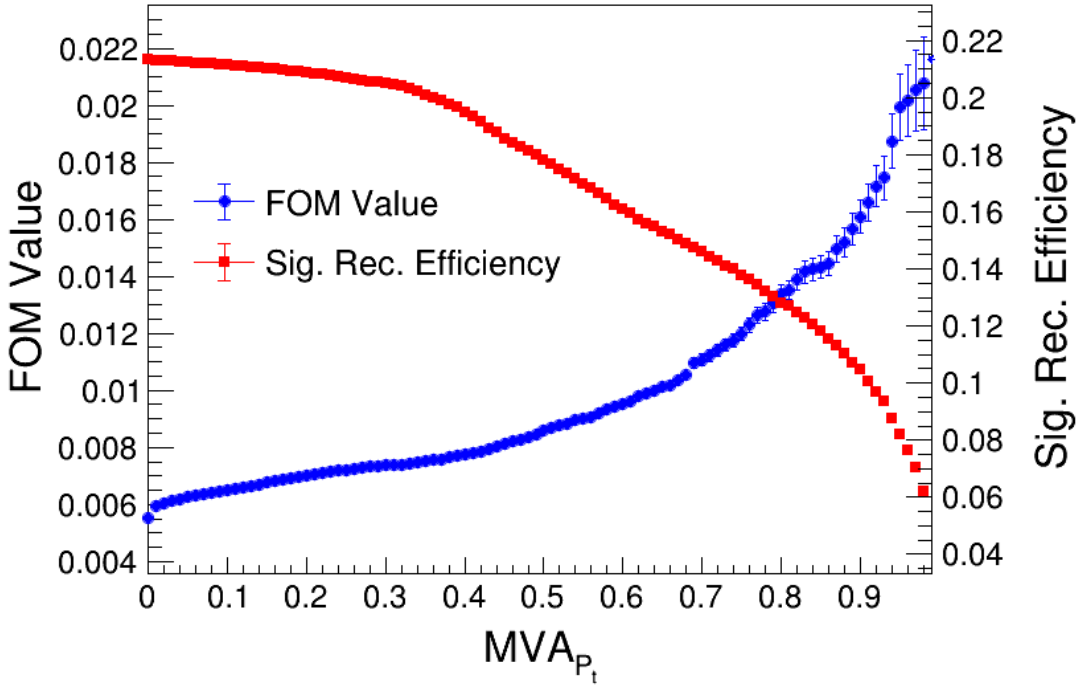
Weekly Meeting

- **Pt MVA**

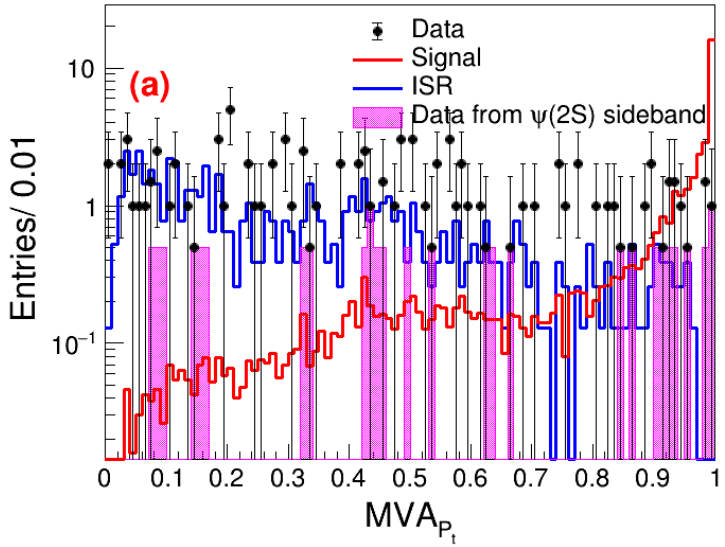

Overtraining check for weight_2gam_3922_1.root
Test-Signal
Test-Background
Train-Signal
Train-Background
Entries per Bin / # Entries
0.175
0.150
0.125
0.100
0.075
0.050
0.025
0.000
Diff.
signal (train - test) difference $p = 0.00$
0.006
0.000
−0.006
Diff.
background (train - test) difference $p = 0.00$
0.006
0.000
−0.006
0.0
0.2
0.4
0.6
0.8
1.0
Classifier Output

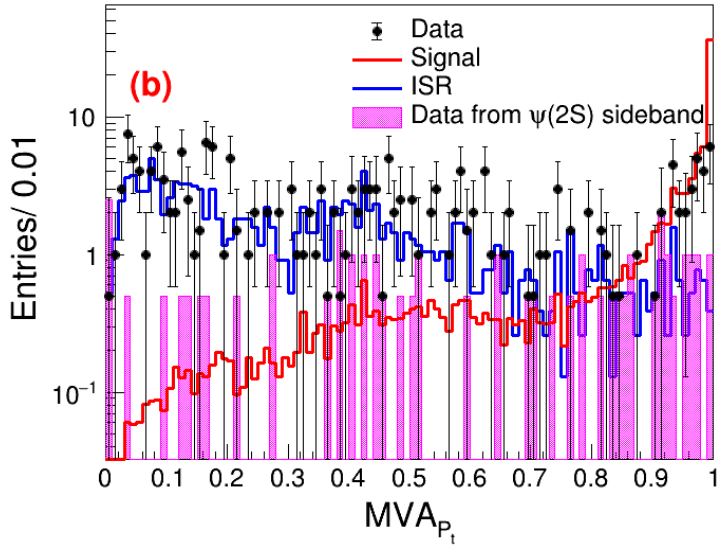

weight_2gam_3922_1.root
Train (0.89)
Test (0.88)
Background Rejection
1.0
0.8
0.6
0.4
0.2
0.0
0.0
0.2
0.4
0.6
0.8
1.0
Signal Efficiency

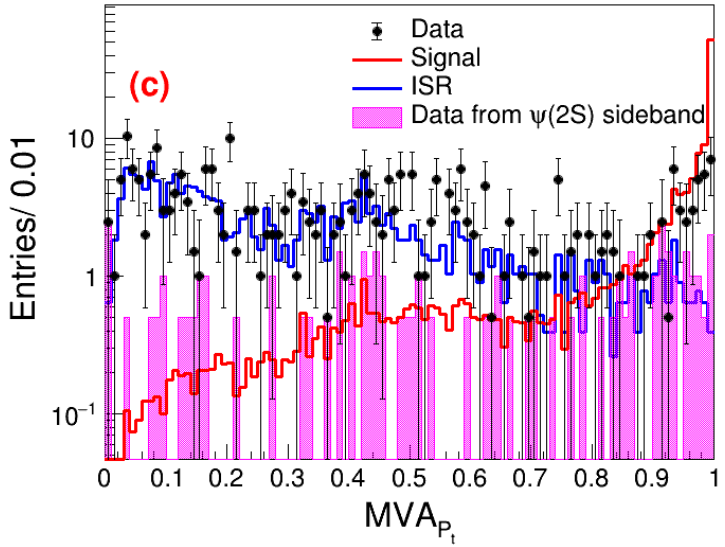
- **Pt MVA**



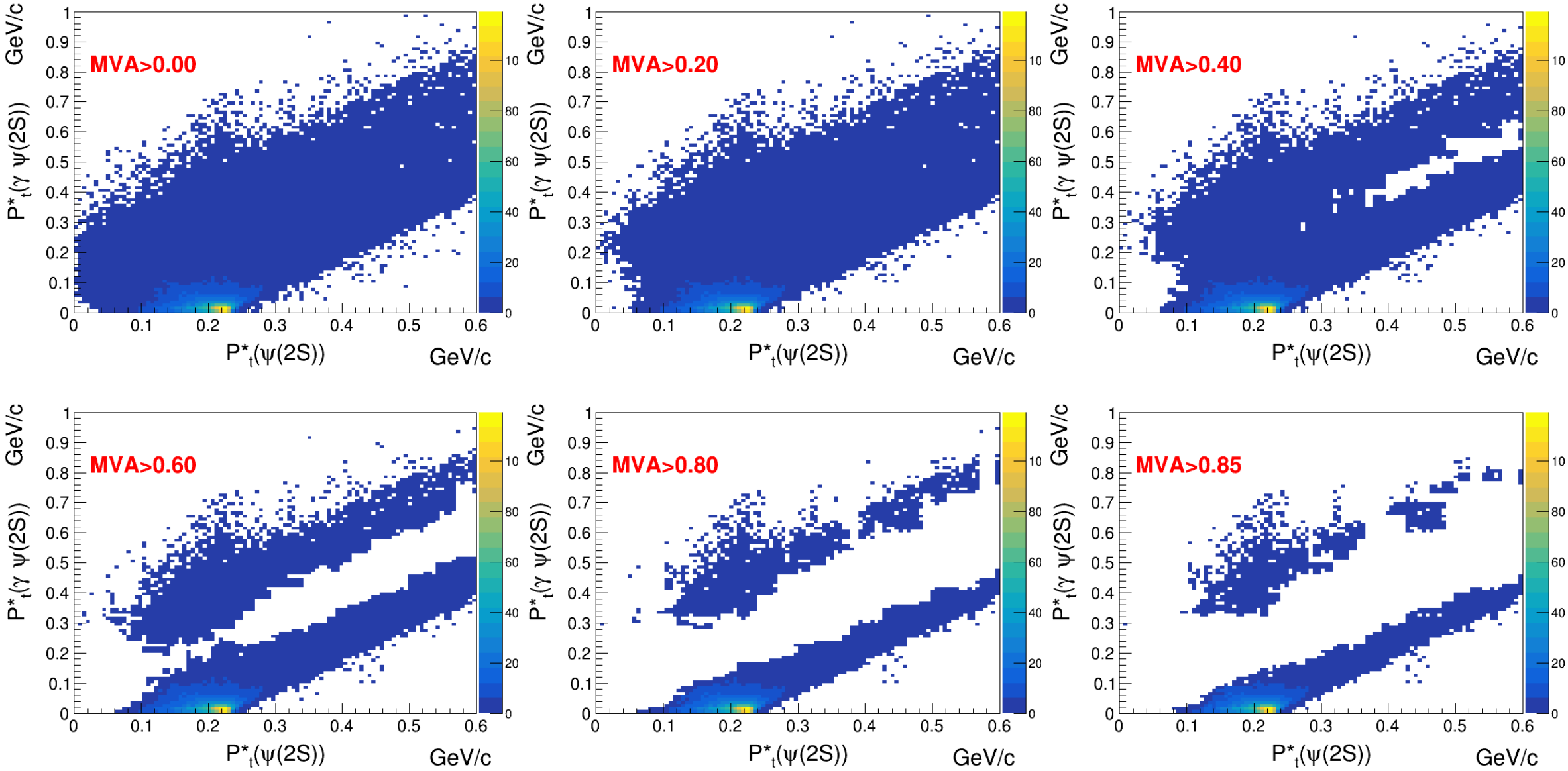
(a)-ee mode; (b)-mumu mode; (c)-both mode



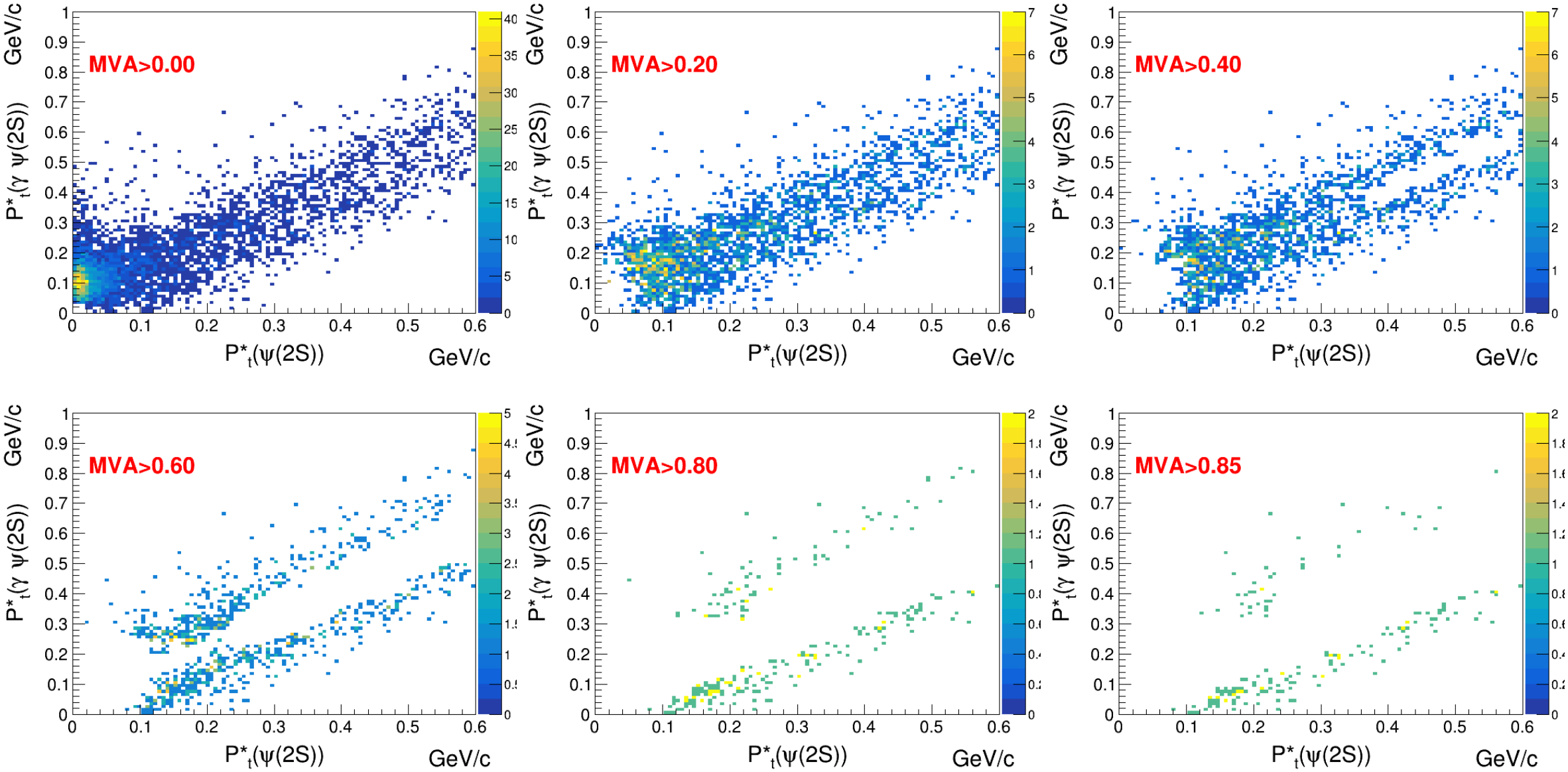




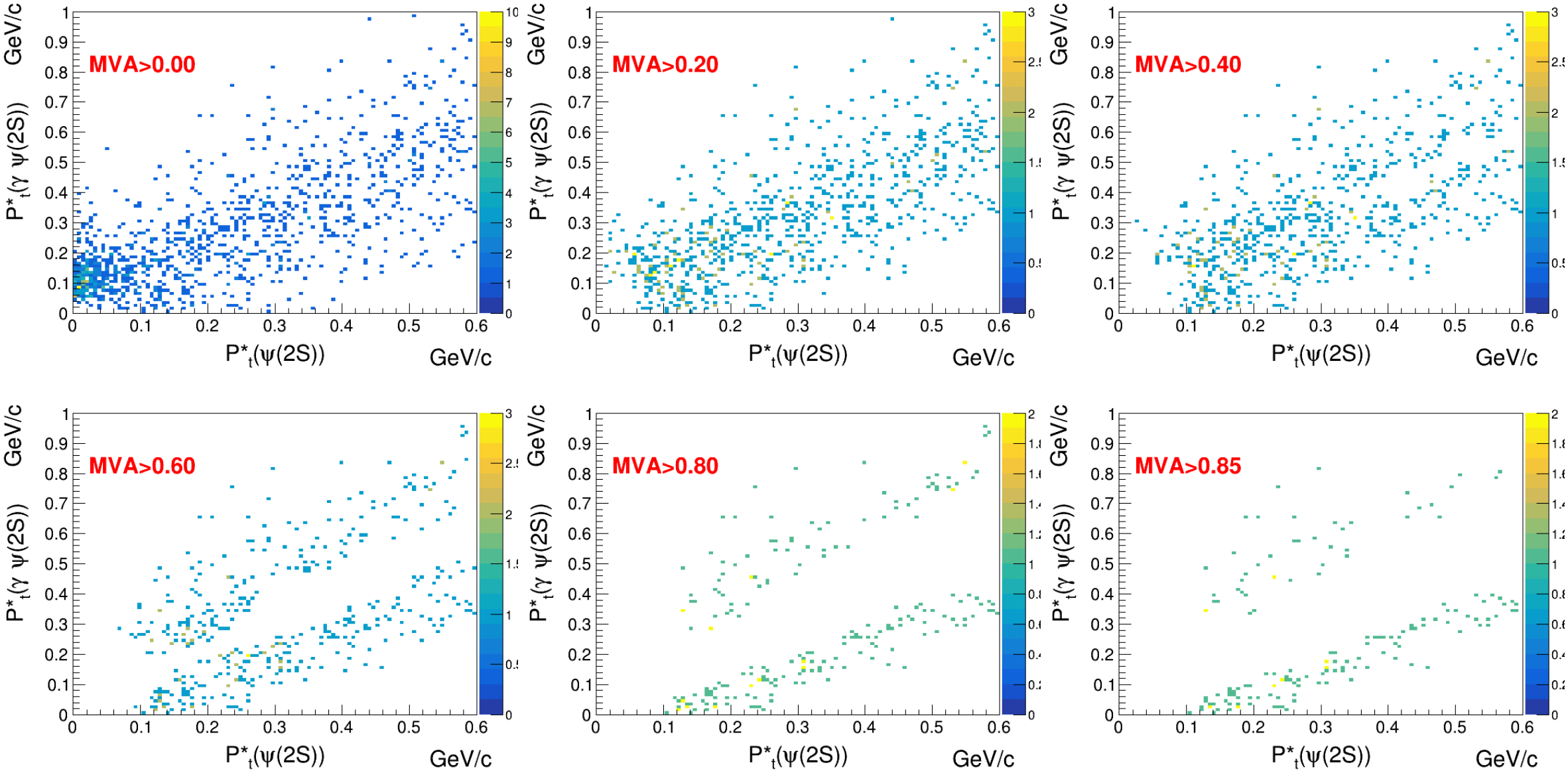
- Different MVA selections for signal MC sample:



- **Different MVA selections for ISR MC sample:**



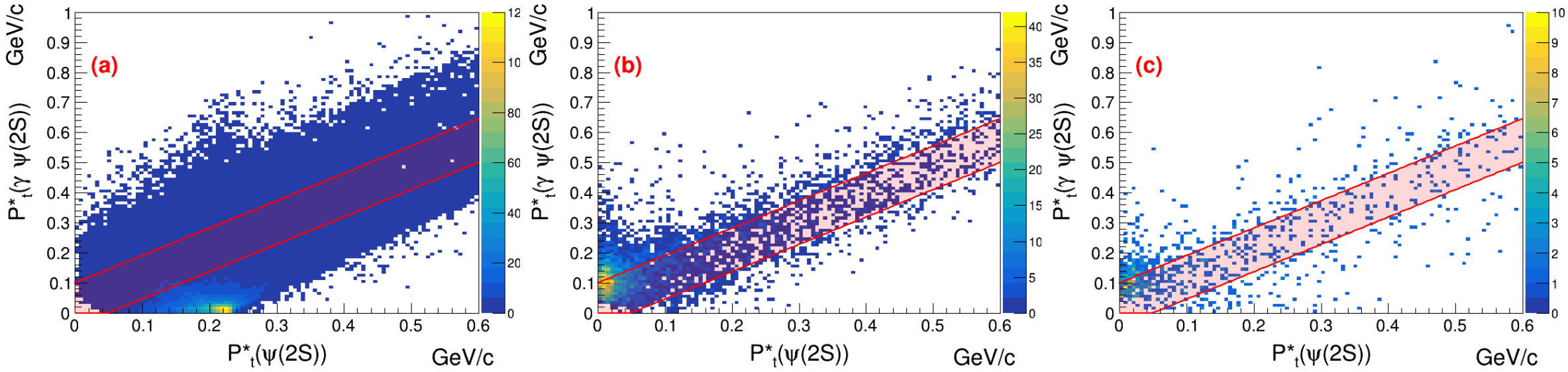
- **Different MVA selections for run1 data sample:**



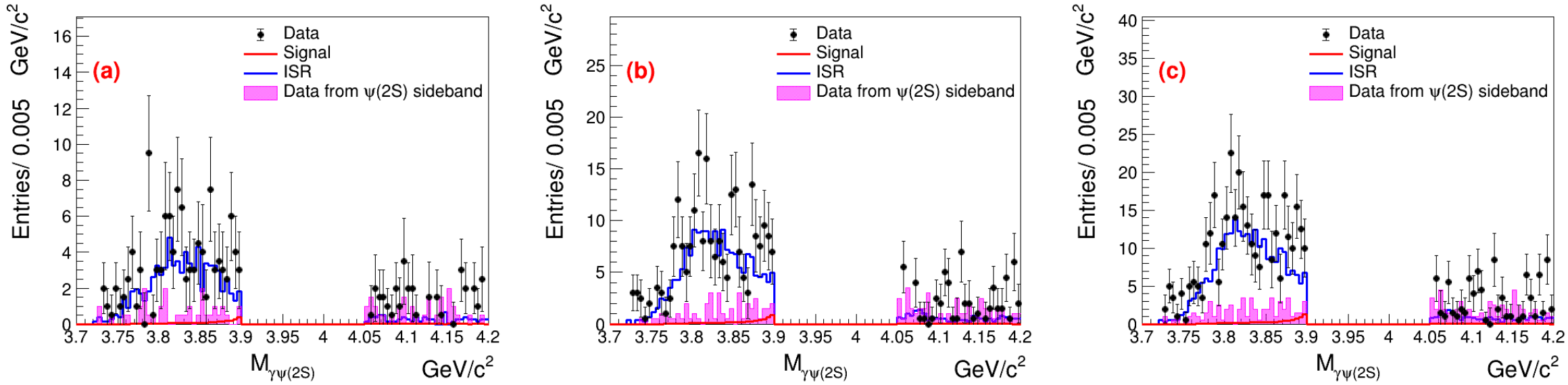
- From MVA selections to 2D Pt selections:

- $\varepsilon_{sig} \approx 11.3\%$
- $\mathrm{FOM} \approx 0.010 \pm 0.0002$

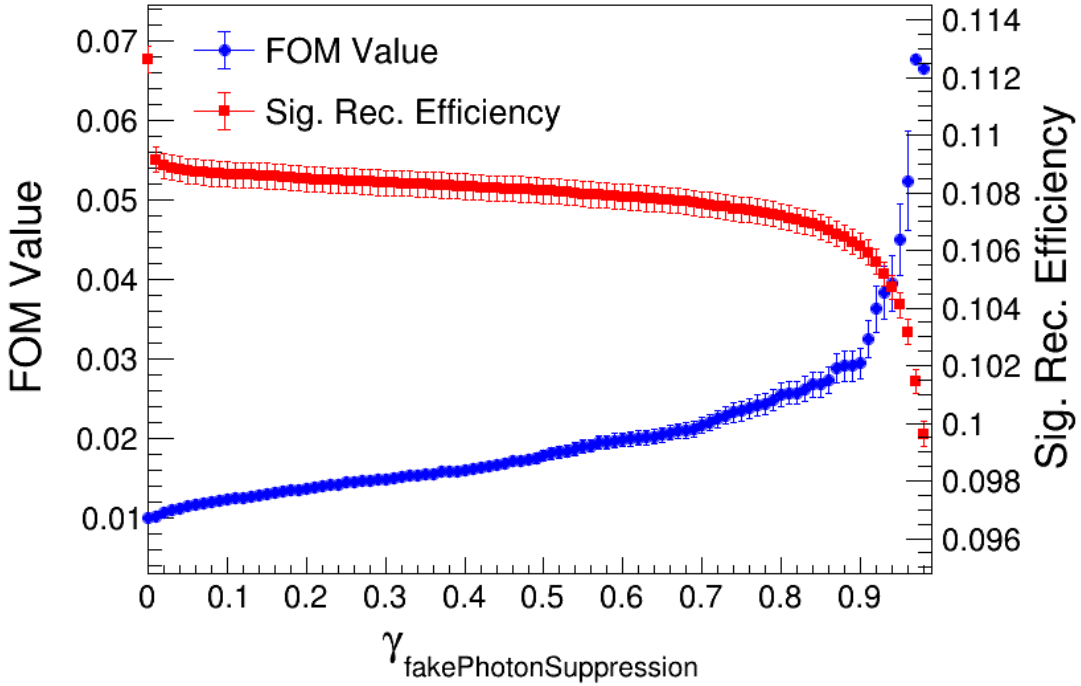
(a)-Signal; (b)-ISR; (c)-Data



(a)-ee mode; (b)-mumu mode; (c)-both mode

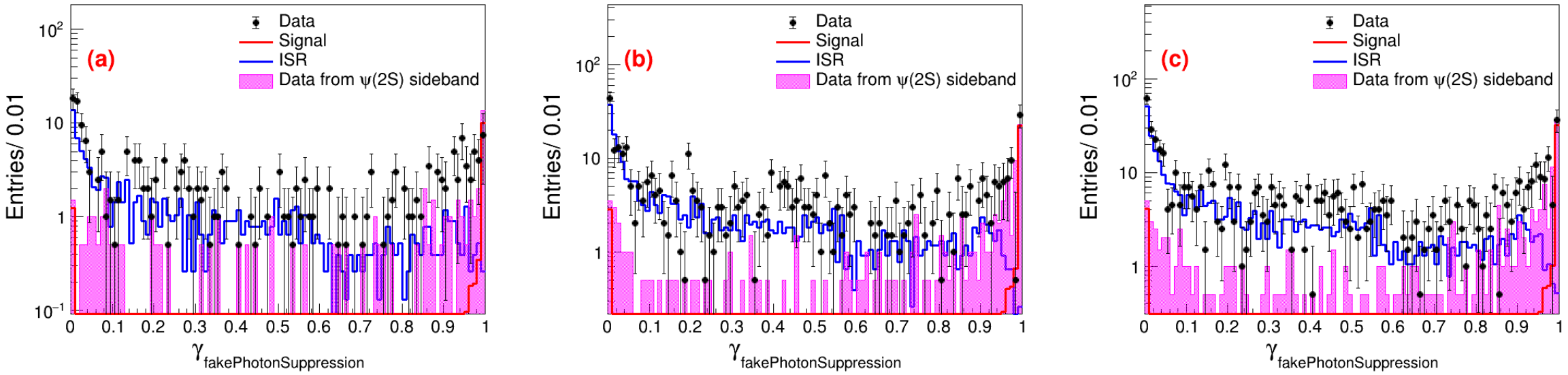


- **Based on 2D pt selection**



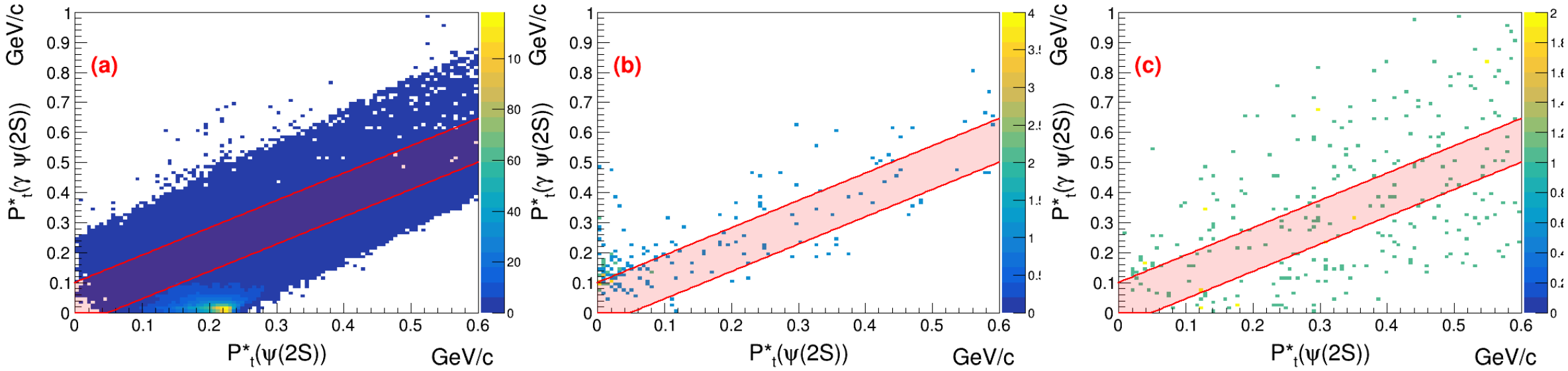
- $Score_{\gamma_{fake}} > 0.90$
- $\varepsilon_{sig} \approx 10.6\%$
- $\text{FOM} \approx 0.0295 \pm 0.0019$

(a)-ee mode; (b)-mumu mode; (c)-both mode

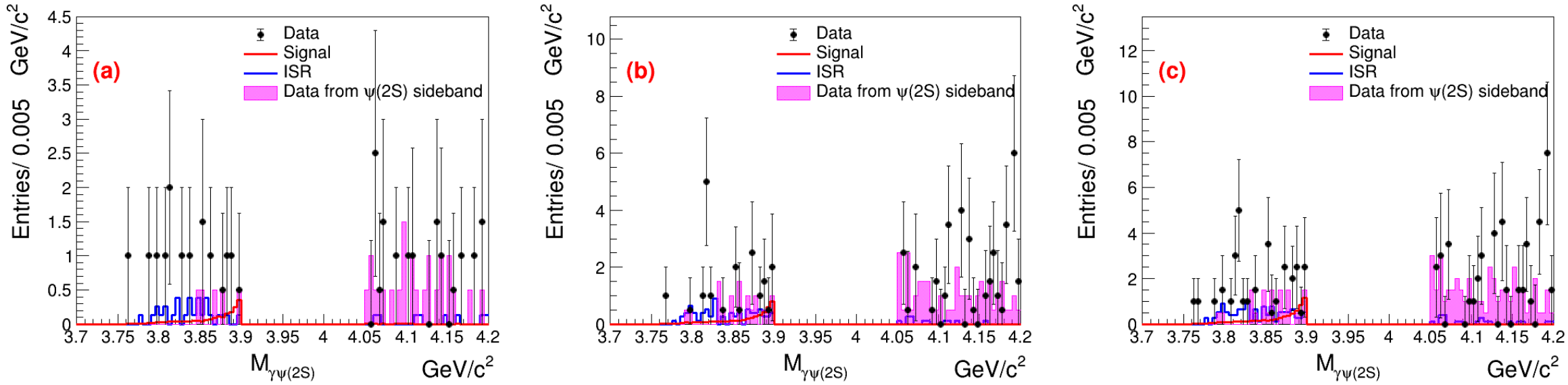


- 2D Pt scatter plots:($Score_{\gamma_{fake}}$>0.9)

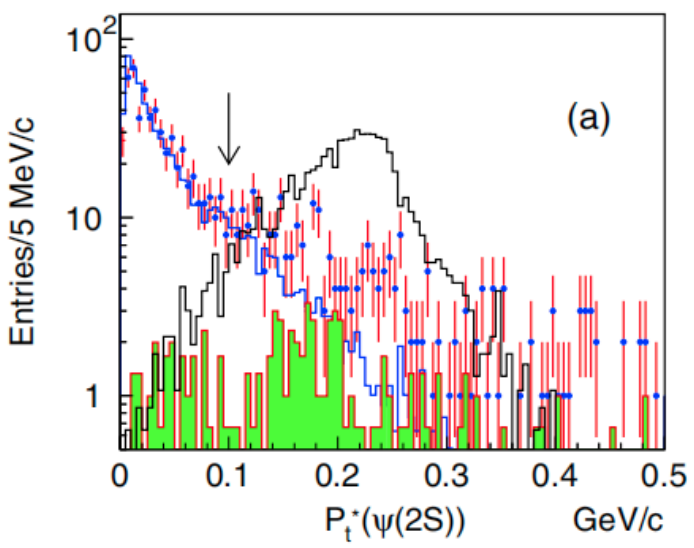
(a)-Signal; (b)-ISR; (c)-Data

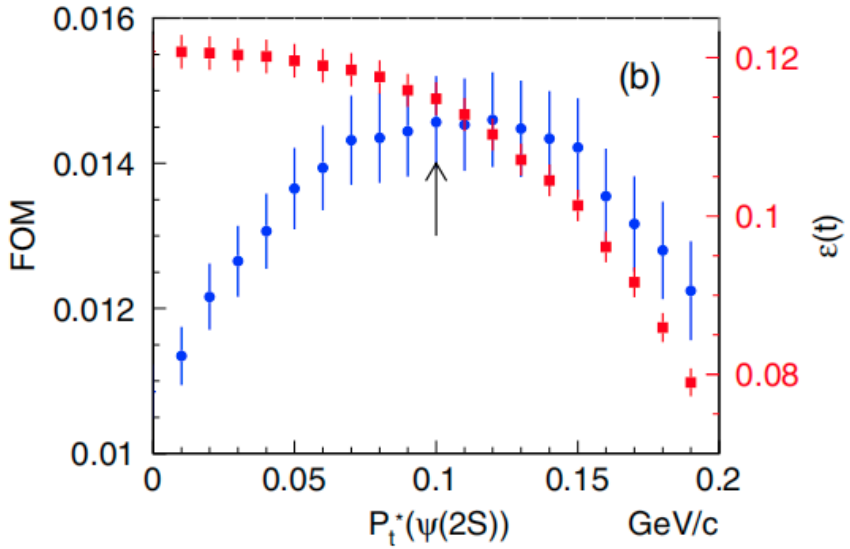


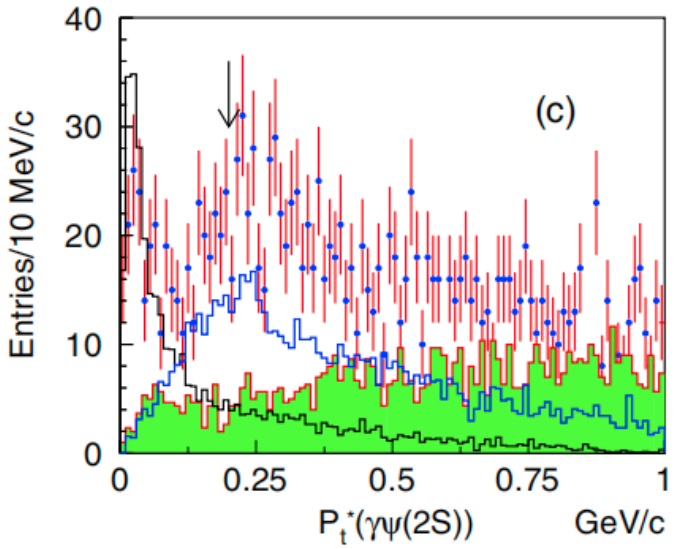
(a)-ee mode; (b)-mumu mode; (c)-both mode

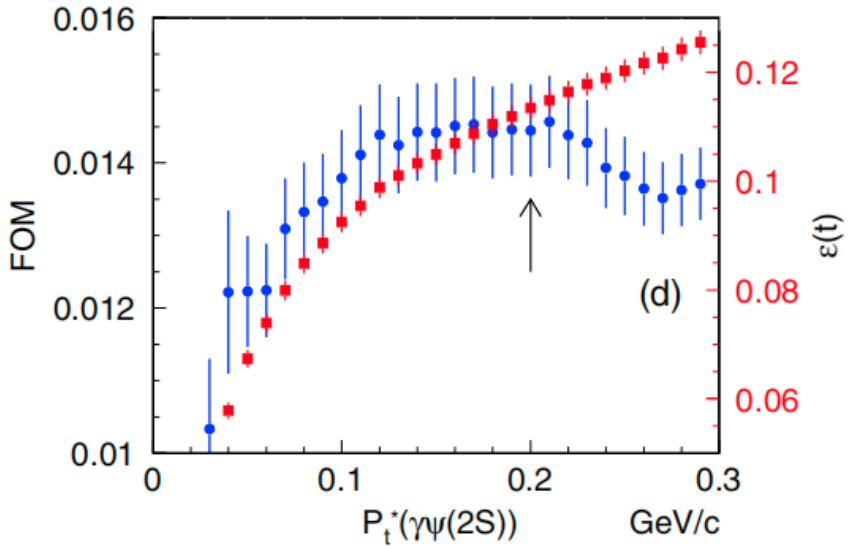


- # Previous Belle analysis









- **Previous Belle:**

$\varepsilon_{sig} \approx 11.5\%$

$\mathrm{FOM} \approx 0.0145$

- **Plan A: (MVA→2dpt)**

$\varepsilon_{sig} \approx 11.3\%$

$\mathrm{FOM} \approx 0.0105 \pm 0.0002$

- **Plan B: (MVA →2dpt + $Score_{\gamma_{fake}}$)**

$\varepsilon_{sig} \approx 10.6\%$

$\mathrm{FOM} \approx 0.0295 \pm 0.0019$

Selection Criteria

Selections for candidates

- Tracks

$dr < 1.0$ cm, $|dz| < 3.0$ cm, $P_t > 0.1$GeV/c, $-0.8660 < \cos\theta < 0.9563$, nGoodTracks $= 4$

- Photons

clusterNHits > 1.5, $|\text{clusterTiming}| < 200$ ns, $-0.8660 < \cos\theta < 0.9563$,
beamBackgroundSuppression > 0.9, fakePhotonSuppression > 0.80

- $K^{\pm}$

Selection of tracks + kaonIDNN > 0.90, eID_noSVD_noTOP < 0.9, muID_noSVD < 0.9

- $e^{\pm}$

Selection of tracks + eID_noSVD_noTOP > 0.9, muID_noSVD < 0.9, kaonID<0.1

- $\mu^{\pm}$

Selection of tracks + eID_noSVD_noTOP < 0.9, muID_noSVD > 0.9, kaonID<0.1

- $\pi^{\pm}$

~~pionIDNN > 0.1~~

- η'

$0.90 < M(\eta\pi^+\pi^-) < 0.10$ GeV/c^2

- η

$|M(\gamma_\eta\gamma_\eta) - m_\eta| < 0.04$ GeV/c^2

- γ_η

Selection of photons + $E_{forward} > 150$MeV, $E_{Barrel} > 150$MeV, $E_{barkward} > 180$MeV

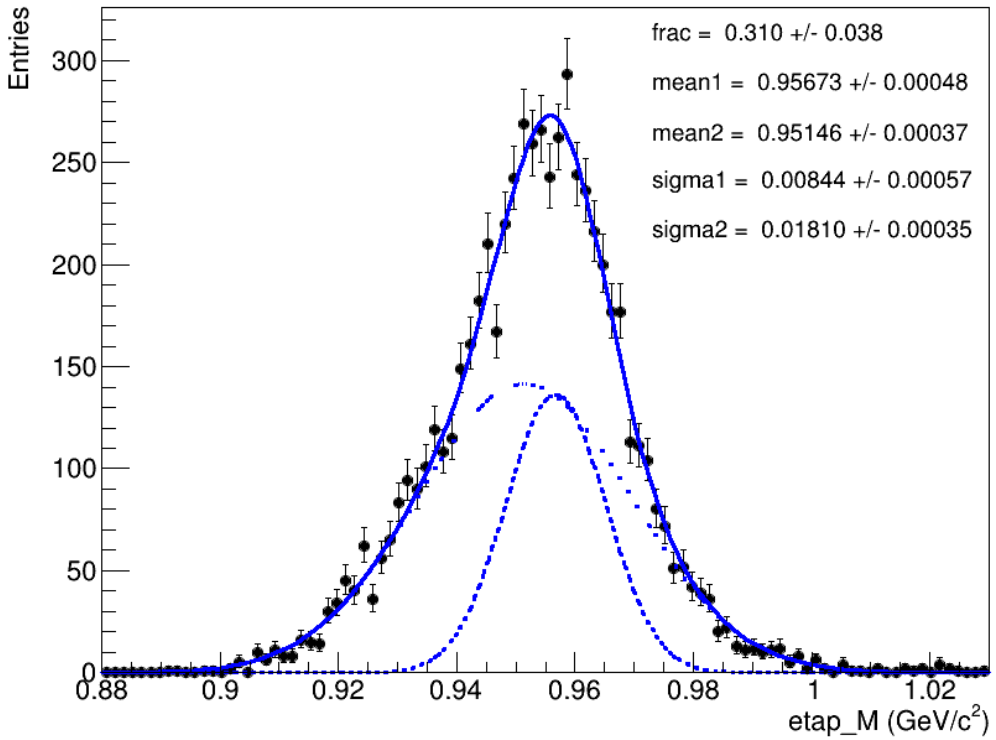
- γ_{π^0}

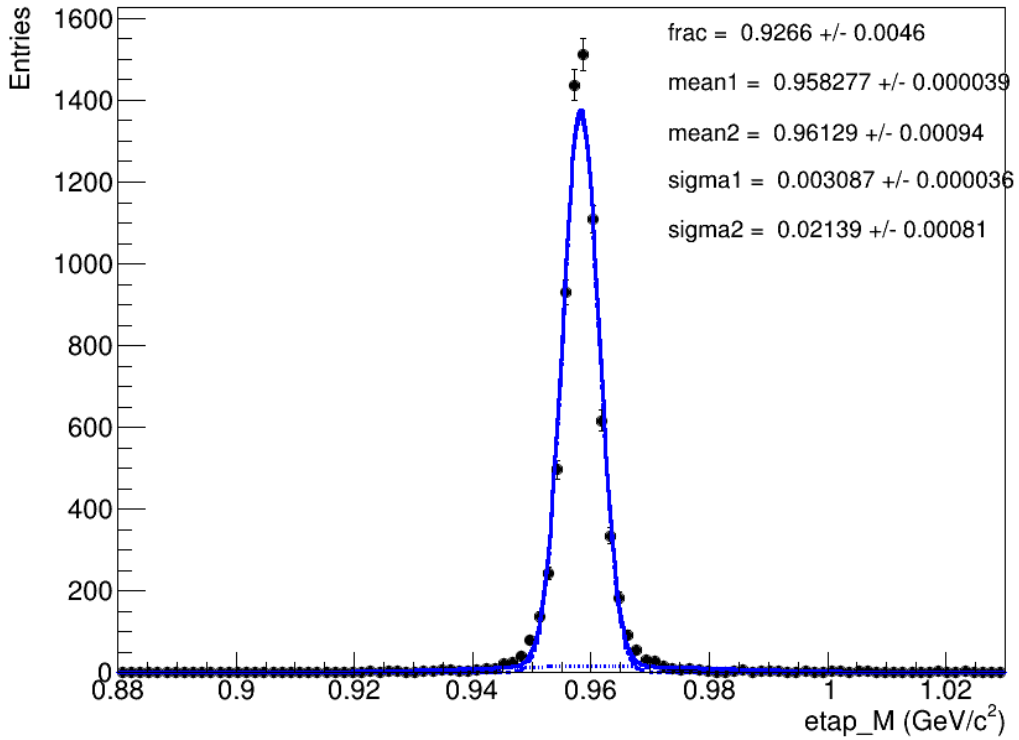
Selection of photons + $E_{forward} > 160$MeV, $E_{Barrel} > 80$MeV, $E_{barkward} > 140$MeV

- Event

$(\vec{p}_{sig}^{CM} \cdot \hat{t}) \cdot (\vec{p}_{tag}^{CM} \cdot \hat{t}) < 0$ for any pair of track or cluster in one event

Perform a mass constrain on η

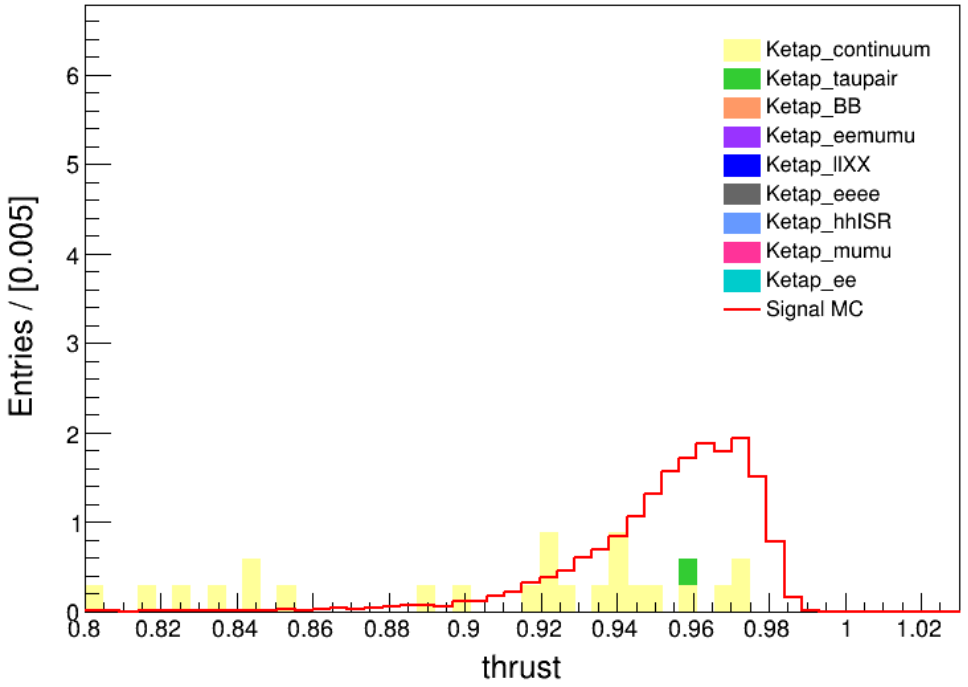


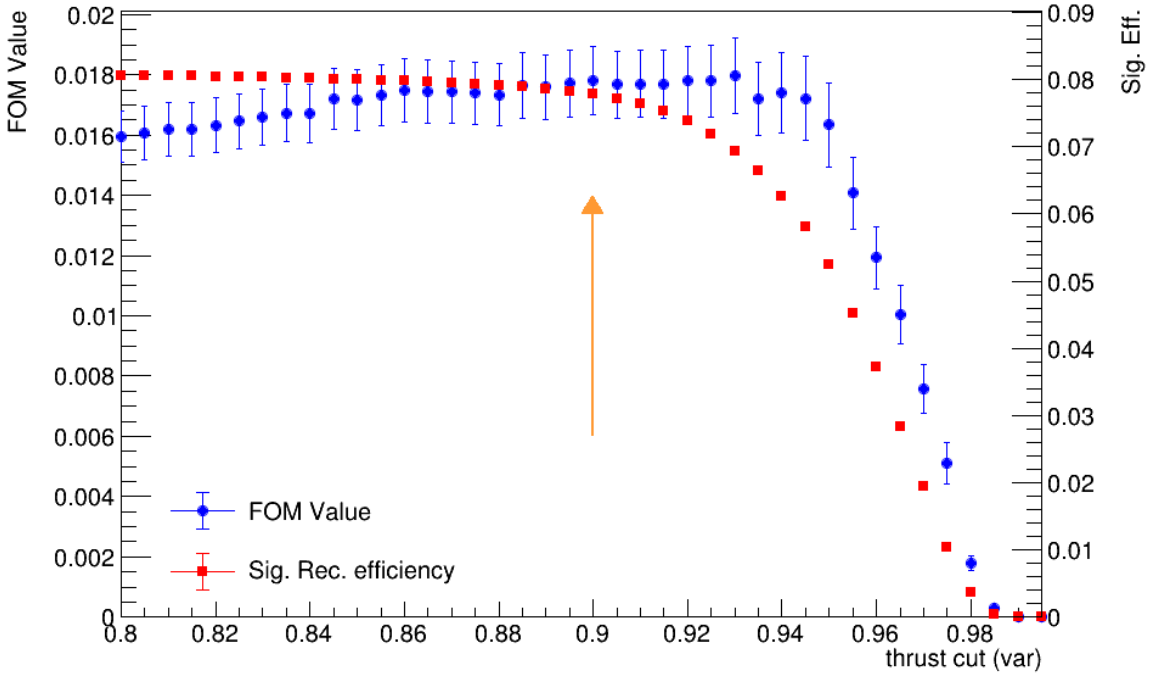


If we use thrust to remove continuum background:

From previous BarBar's paper:

Additional background suppression is achieved by requiring the magnitude of the event thrust to lie between 0.92 and 0.99.





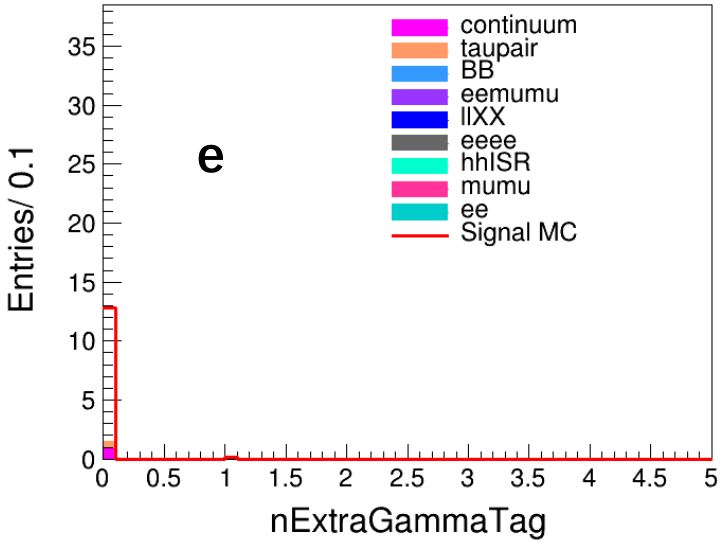
FOM=0.01585067 +/- 0.00085996

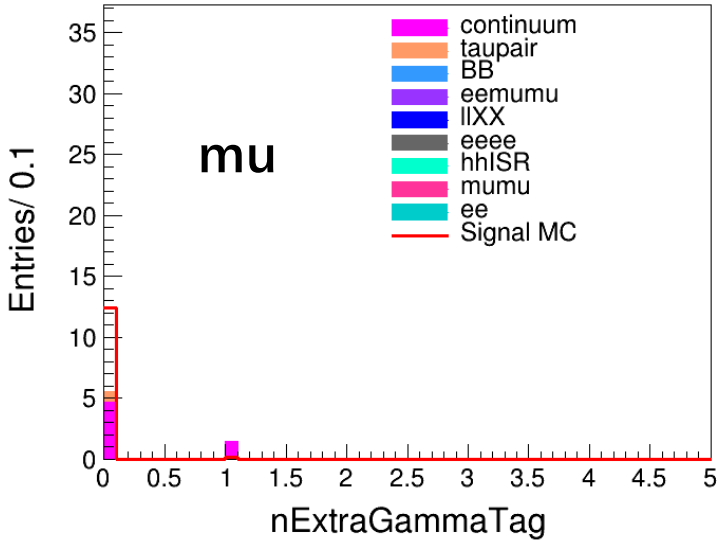
eff=0.080105 +/- 0.000664

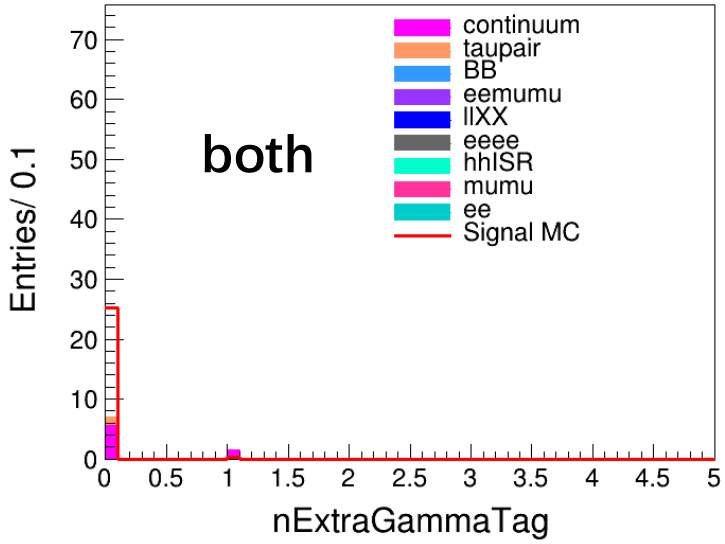
FOM=0.01770263 +/- 0.00110840

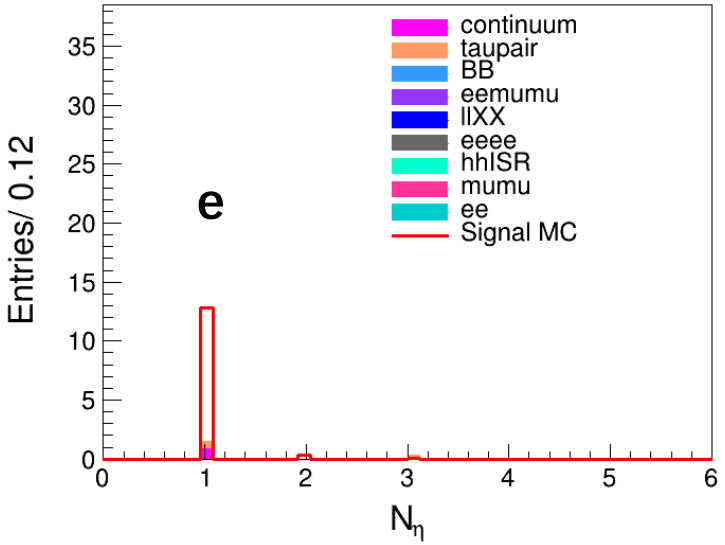
eff=0.077319 +/- 0.000653

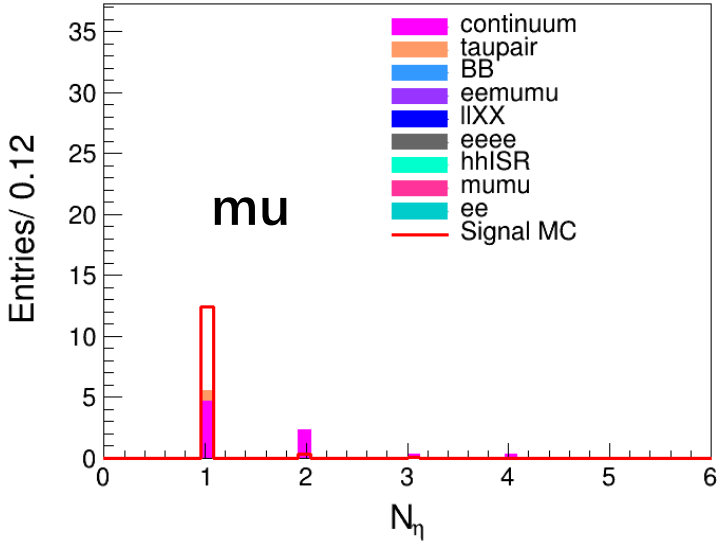
Some important distributions

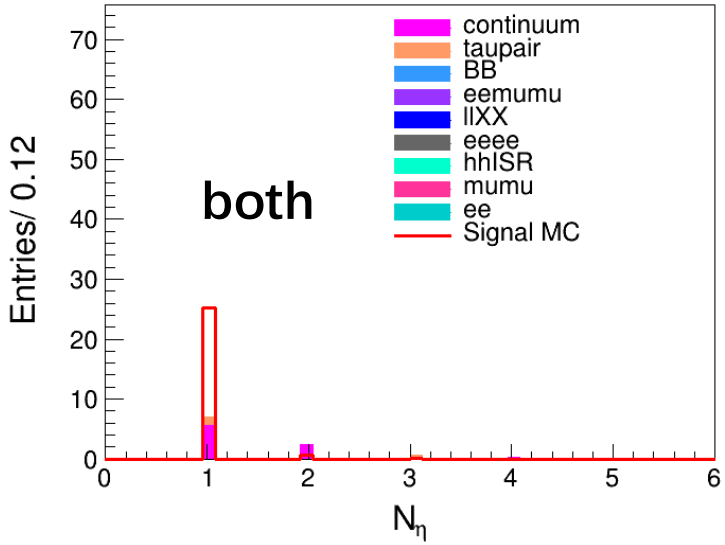




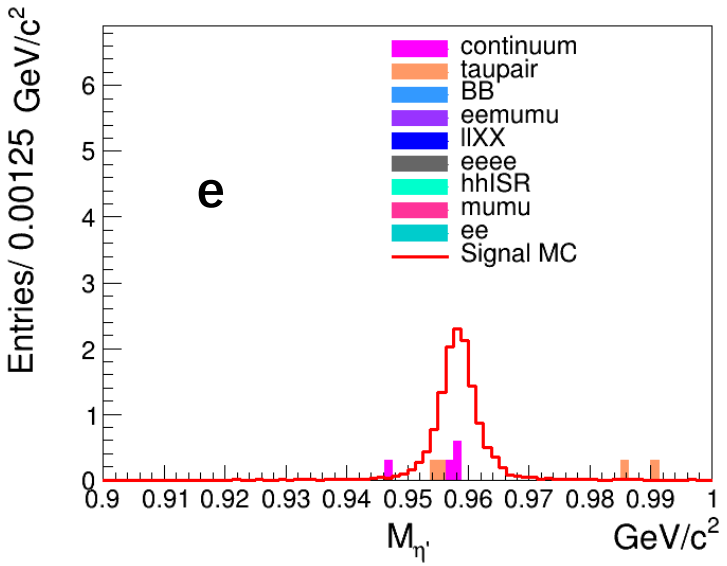


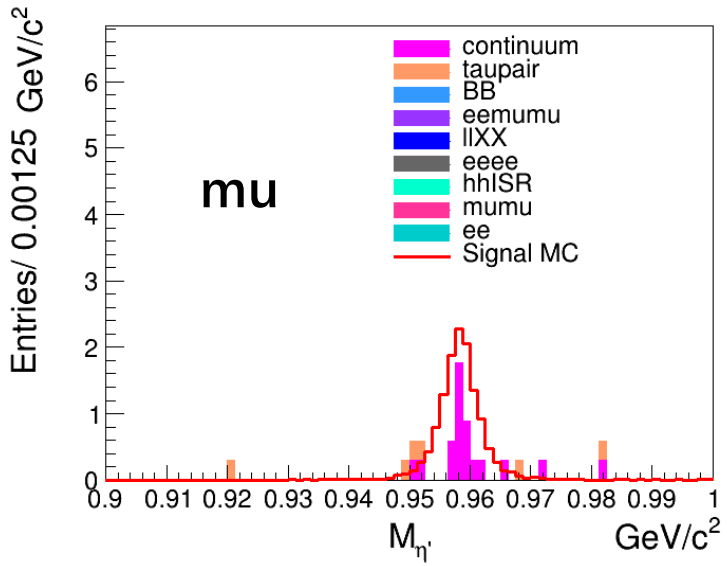


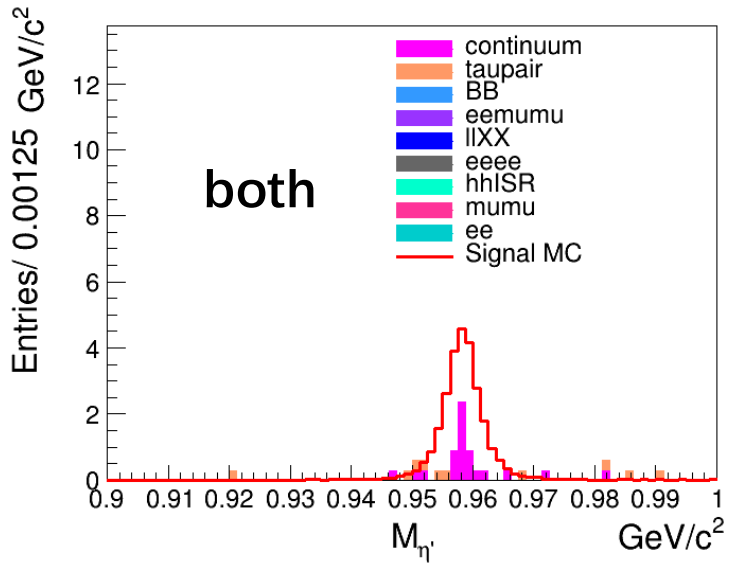


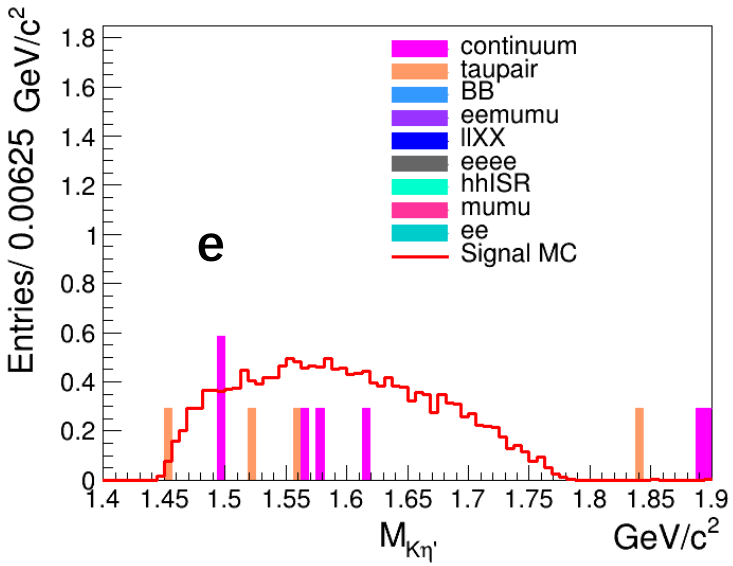


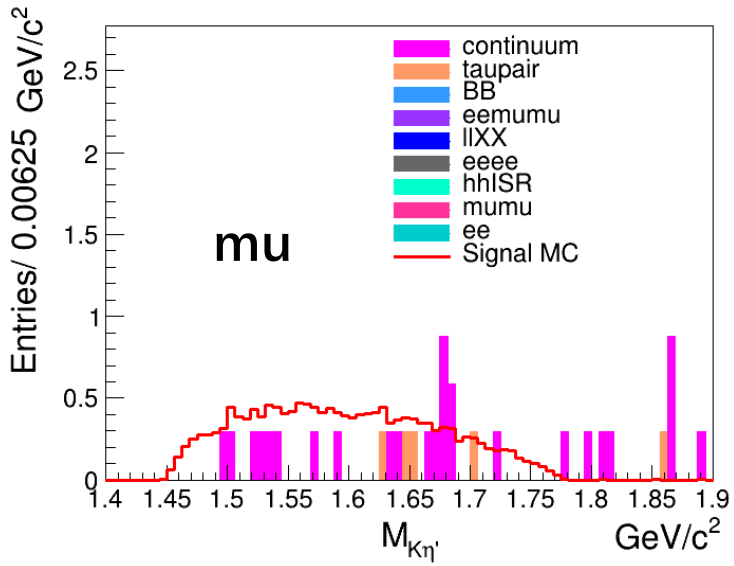
Some important distributions

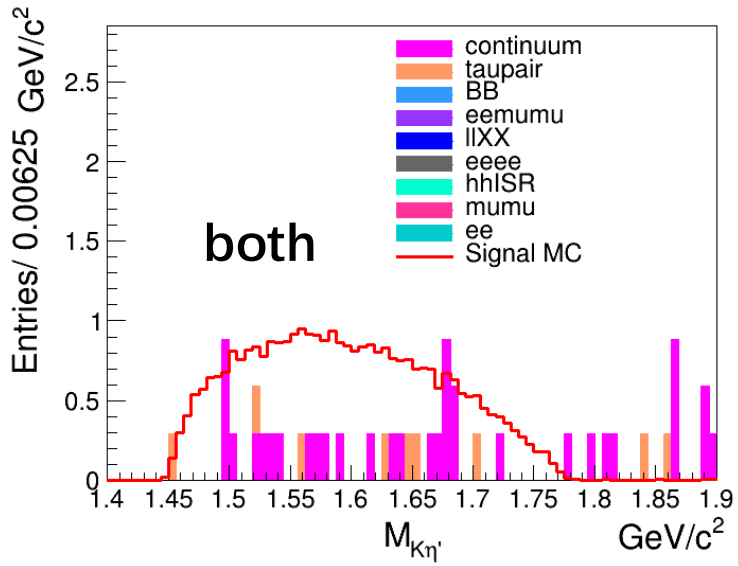










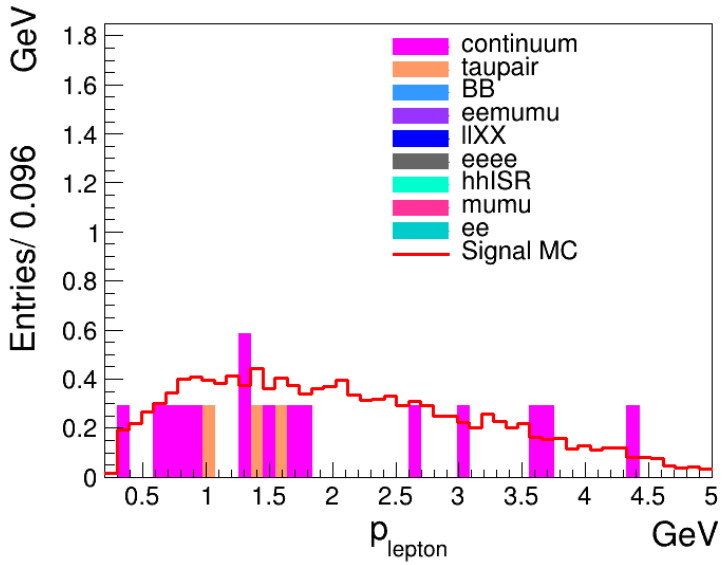


Different background situations for eTag and muTag

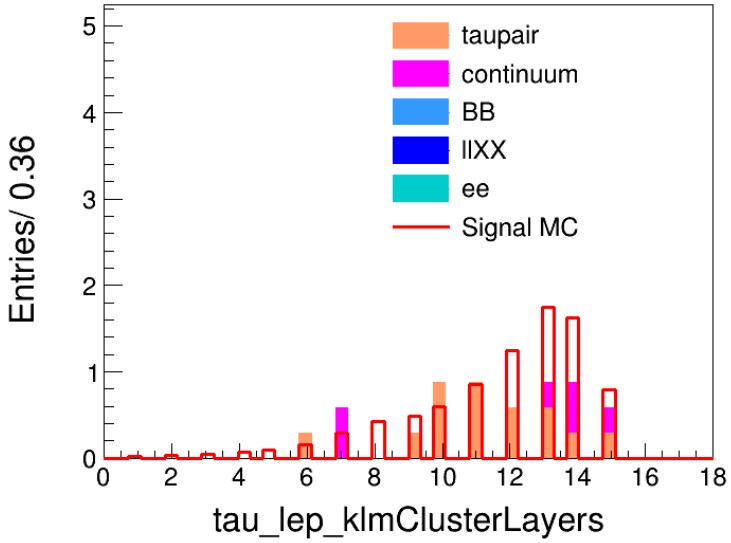
If we use MVA to remove continuum background

Train BDT for eTag and muTag separately

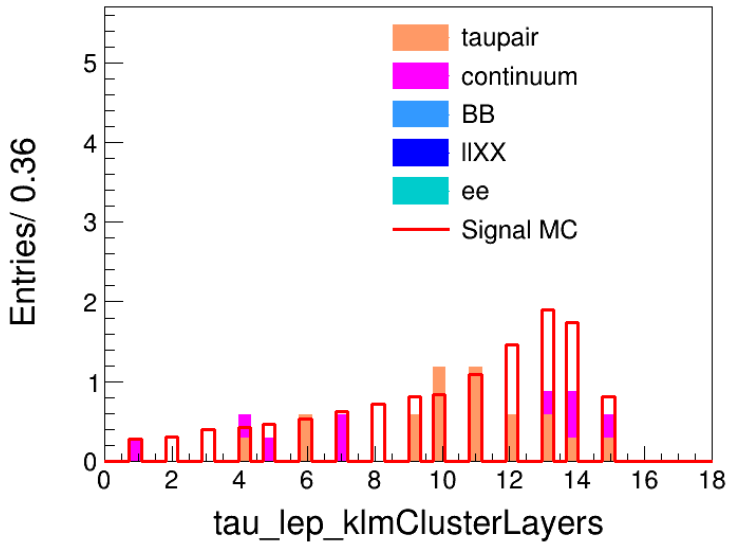
- 通过拓扑分析：大部分的mu tag的continuum是由于pi被误判为mu导致的

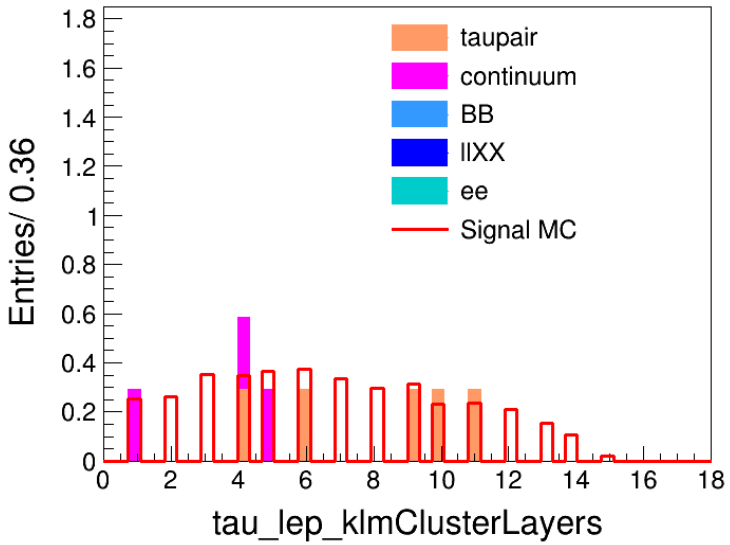


要求$P_\mu > 1.5$ GeV

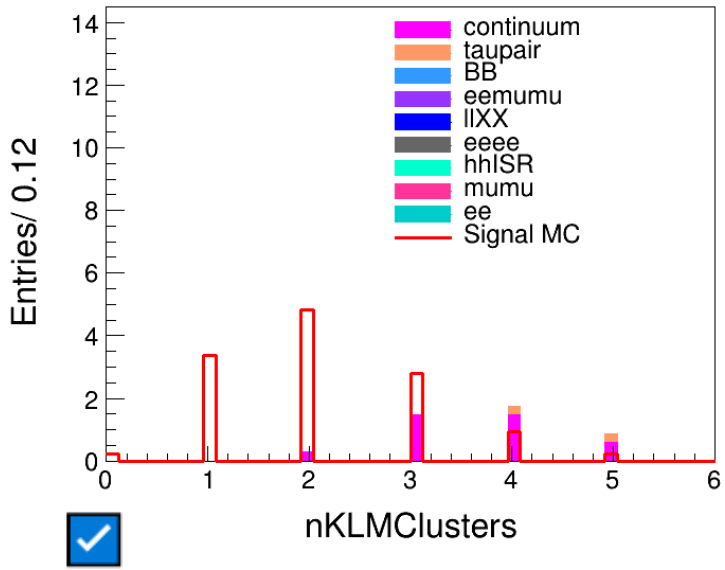


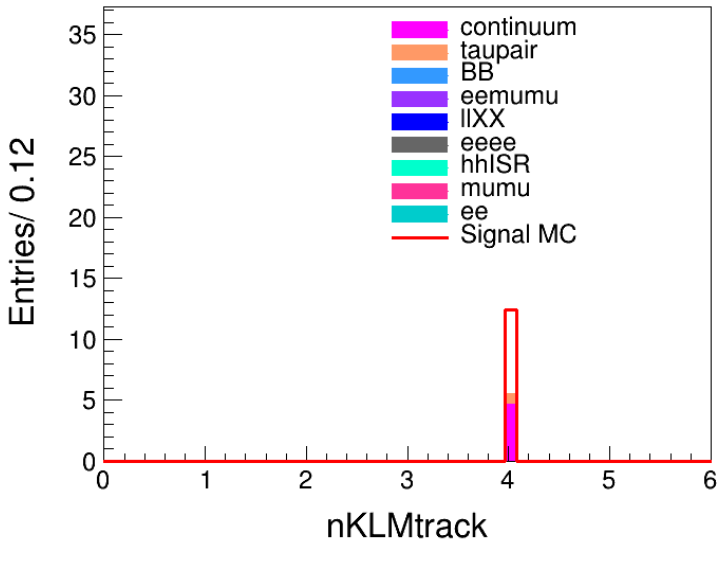
要求$P_\mu < 1.5$ GeV

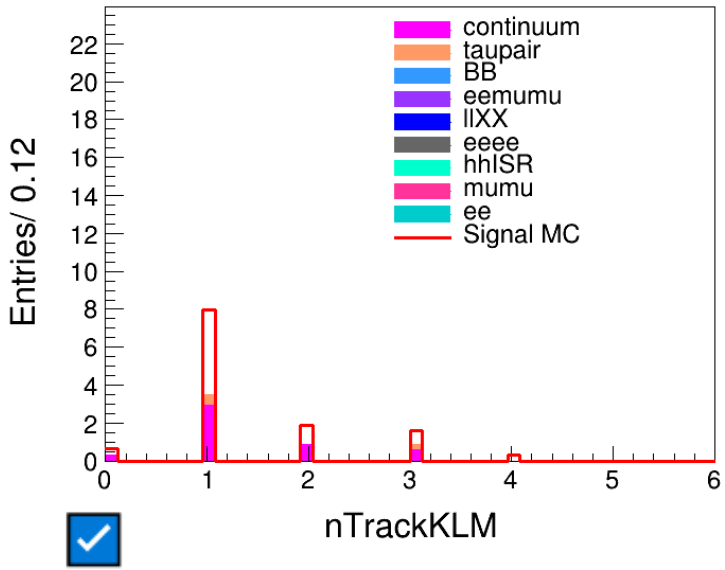


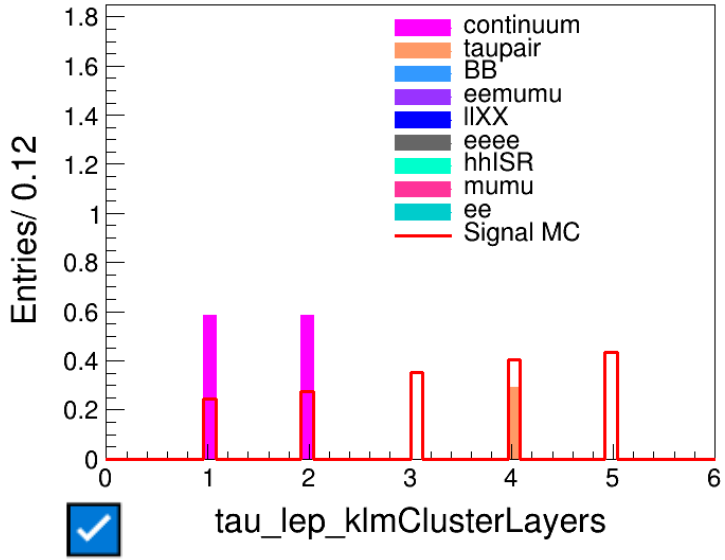


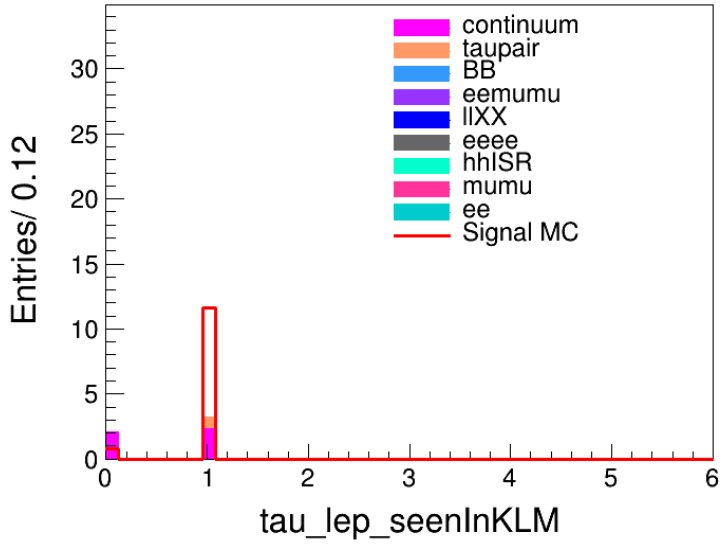
- 大部分的mu tag的continuum是由于pi被误判为mu导致的

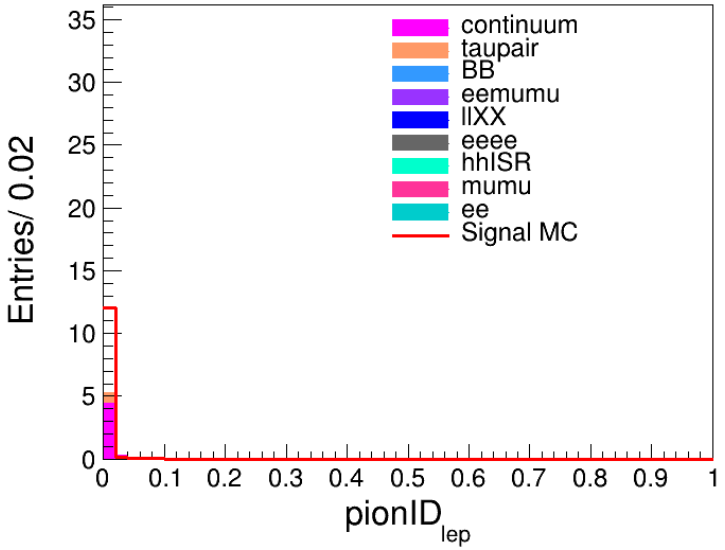






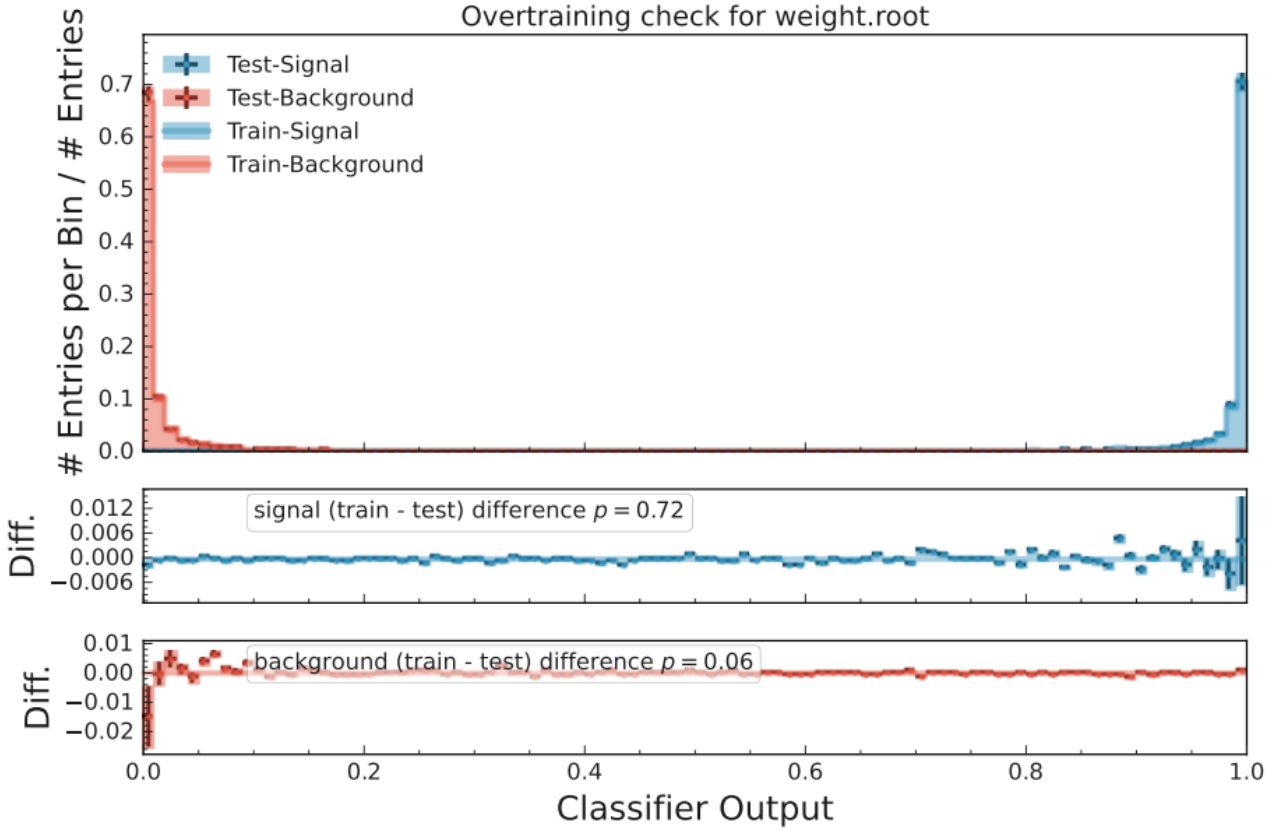


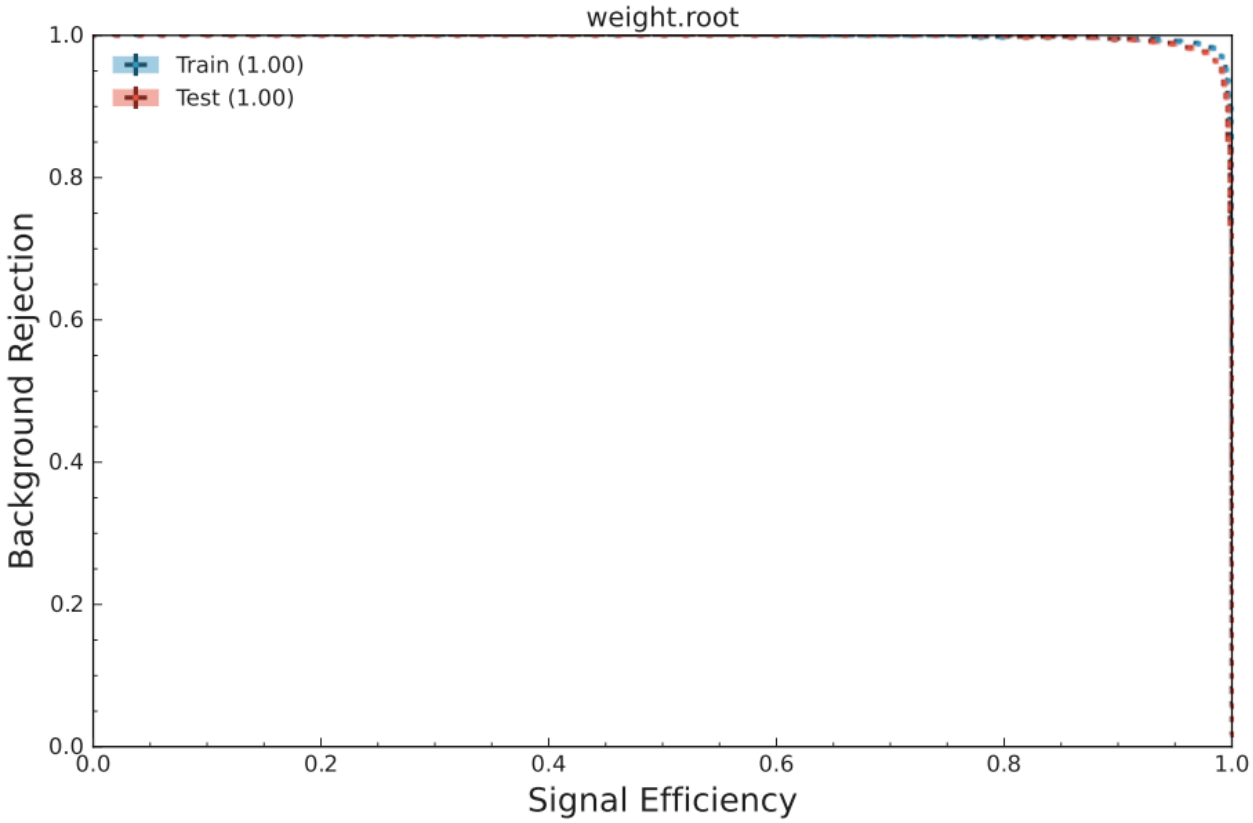




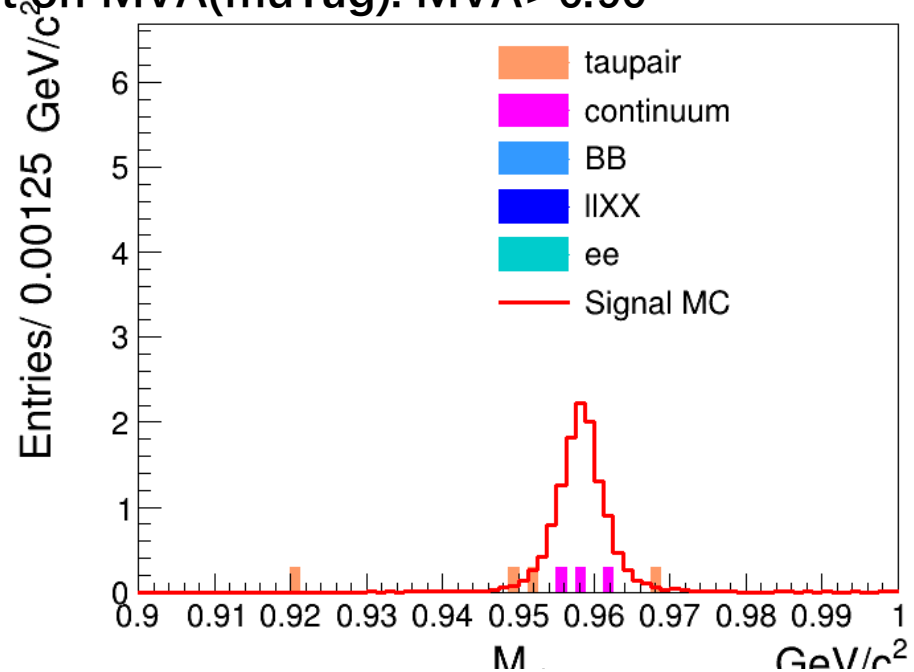
加入KLM相关的变量去除mu/pi误判，专门给mu tag训练BDT

tau_sig_R2	tau_sig_thrustOm	tau_sig_cosTBTO
tau_sig_cosTBz	tau_sig_KSFWVariablesmm2	tau_sig_KSFWVariableshso10
tau_sig_KSFWVariableshso12	tau_sig_KSFWVariableshso14	tau_sig_KSFWVariableshso20
tau_sig_KSFWVariableshso22	tau_sig_KSFWVariableshso24	tau_sig_KSFWVariableshoo0
nKLMClusters	nTrackKLM	tau_lep_klmClusterLayers





Strict cut on MVA(muTag): MVA>0.90



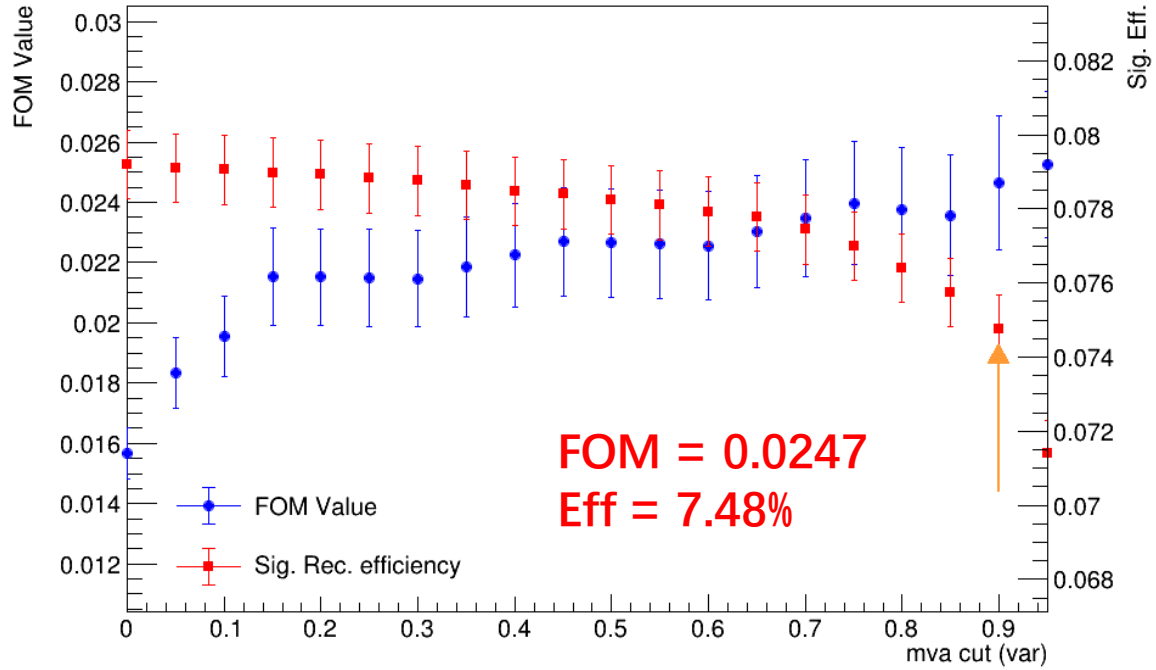
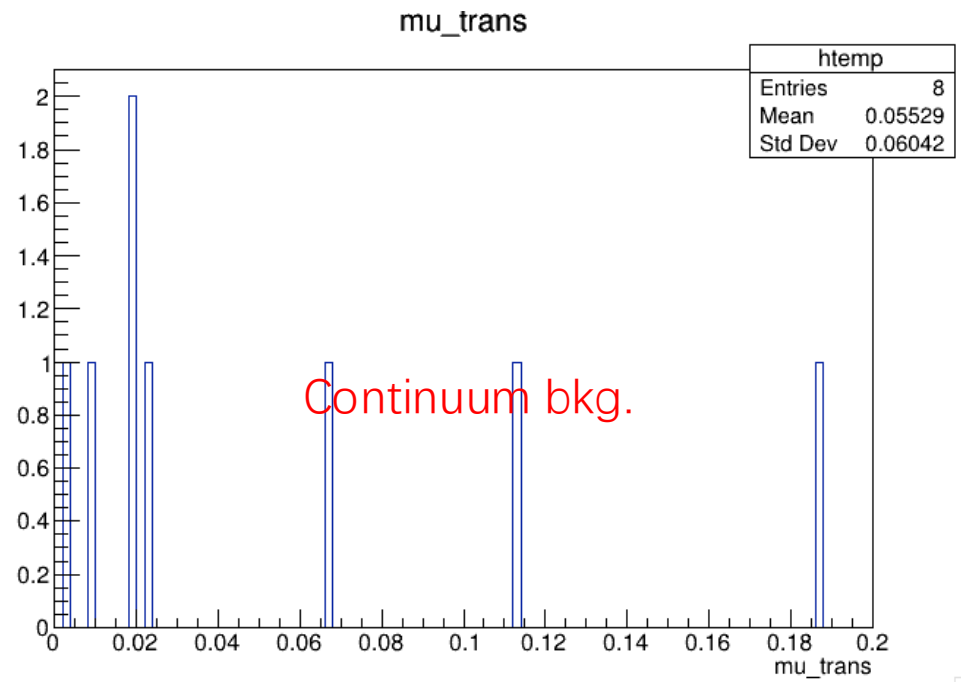
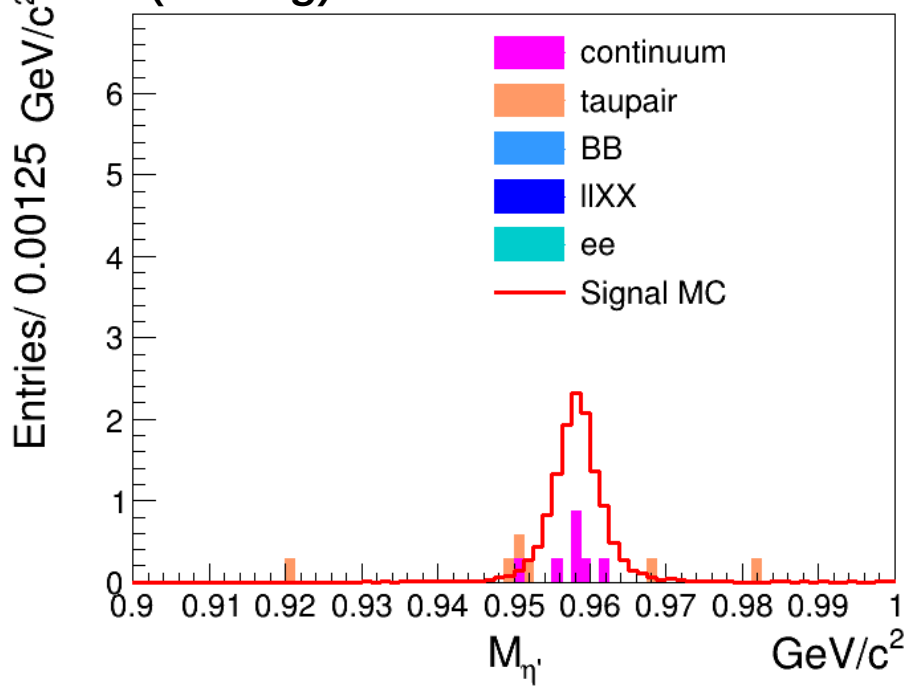


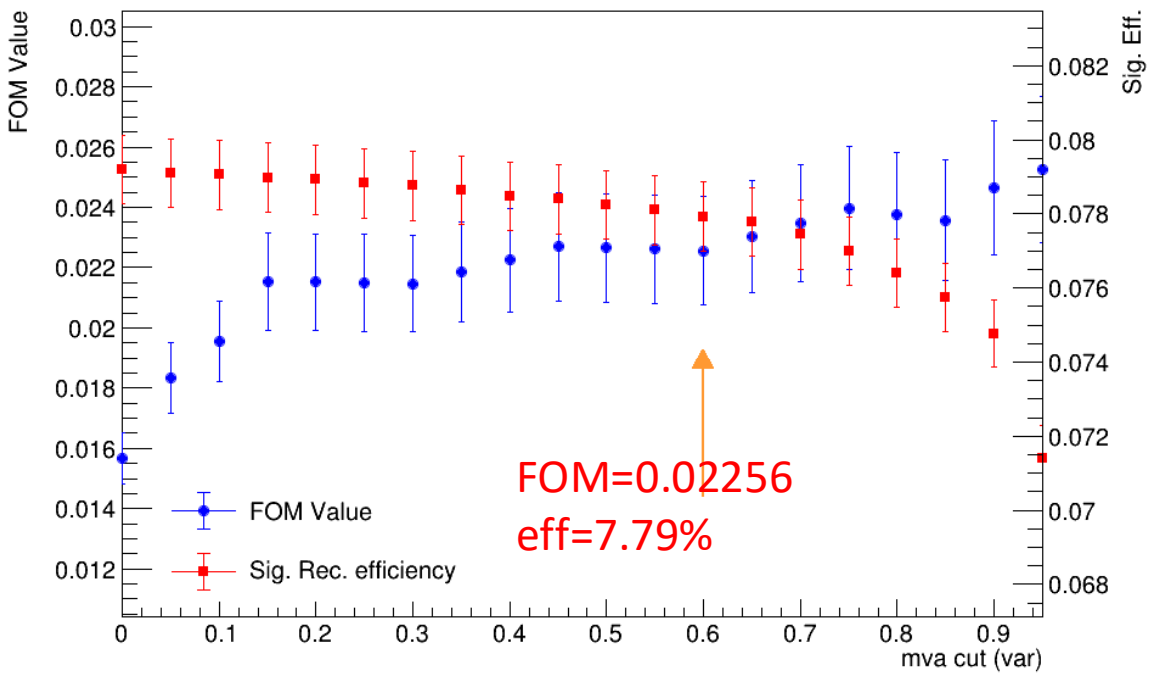
Table 1: Decay trees and their respective initial-final states.

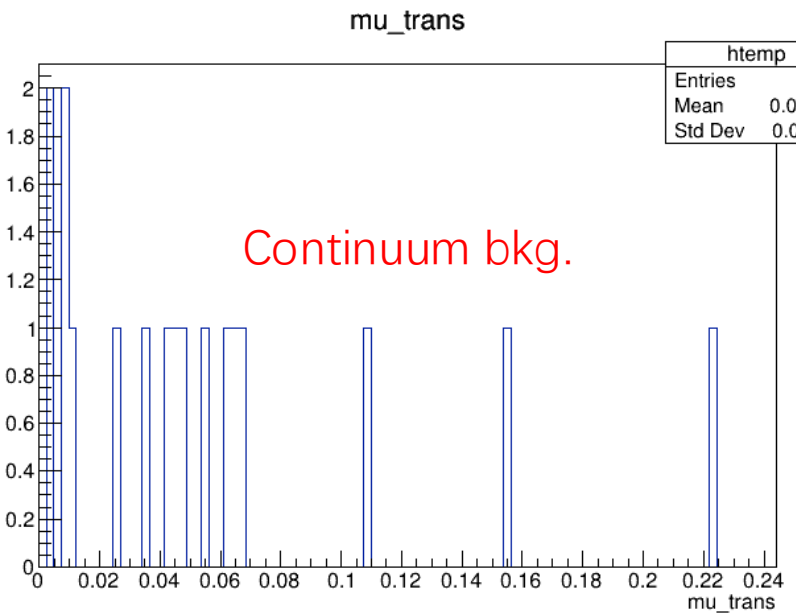
rowNo	decay tree (decay initial-final states)	iDcyTr	nEtr	nCEtr
1	$e^+e^- \to \omega\omega K^+ K^{*-}, \omega \to \pi^0\pi^+\pi^-, \omega \to \pi^0\pi^+\pi^-, K^{*-} \to \pi^-\bar{K}^0, \bar{K}^0 \to K^0_L$ $(e^+e^- \dashrightarrow \pi^0\pi^0 K^0_L \pi^+\pi^+\pi^-\pi^-\pi^- K^+)$	0	1	1
2	$e^+e^- \to \pi^+ K^0 K^- \eta'\gamma^I, K^0 \to K^0_L, \eta' \to \pi^+\pi^-\eta, \eta \to \gamma\gamma$ $(e^+e^- \dashrightarrow K^0_L \pi^+\pi^+\pi^- K^-\gamma^I\gamma\gamma)$	1	1	2
3	$e^+e^- \to K^+ D^0 D^{*-}_s, D^0 \to K^0_L\eta', D^{*-}_s \to D^-_s\gamma, \eta' \to \pi^+\pi^-\eta, D^-_s \to \mu^-\bar{\nu}_\mu, \eta \to \gamma\gamma$ $(e^+e^- \dashrightarrow \mu^-\bar{\nu}_\mu K^0_L \pi^+\pi^- K^+\gamma\gamma\gamma)$	2	1	3
4	$e^+e^- \to \pi^-\bar{K}^0\bar{K}^0 K^* K^+\eta', \bar{K}^0 \to K^0_S, \bar{K}^0 \to K^0_S, K^* \to \pi^0 K^0, \eta' \to \pi^+\pi^-\eta, K^0_S \to \pi^+\pi^-,$ $K^0_S \to \pi^+\pi^-, K^0 \to K^0_S, \eta \to \gamma\gamma, K^0_S \to \pi^+\pi^-$ $(e^+e^- \dashrightarrow \pi^0\pi^+\pi^+\pi^+\pi^+\pi^-\pi^-\pi^-\pi^-\pi^- K^+\gamma\gamma)$	3	1	4
5	$e^+e^- \to \pi^0\pi^-\omega\bar{K}^0 K^+, \omega \to \pi^0\pi^+\pi^-, \bar{K}^0 \to K^0_S, K^0_S \to \pi^+\pi^-$ $(e^+e^- \dashrightarrow \pi^0\pi^0\pi^+\pi^+\pi^-\pi^-\pi^- K^+)$	4	1	5
6	$e^+e^- \to \pi^0\pi^-\omega\bar{K}^0 K^+\gamma^I, \omega \to \pi^0\pi^+\pi^-, \bar{K}^0 \to K^0_S, K^0_S \to \pi^+\pi^-$ $(e^+e^- \dashrightarrow \pi^0\pi^0\pi^+\pi^+\pi^-\pi^-\pi^- K^+\gamma^I)$	5	1	6
7	$e^+e^- \to \pi^0\pi^+ K^0 K^-\eta'\gamma^I, K^0 \to K^0_L, \eta' \to \pi^+\pi^-\eta, \eta \to \gamma\gamma$ $(e^+e^- \dashrightarrow \pi^0 K^0_L \pi^+\pi^+\pi^- K^-\gamma^I\gamma\gamma)$	6	1	7

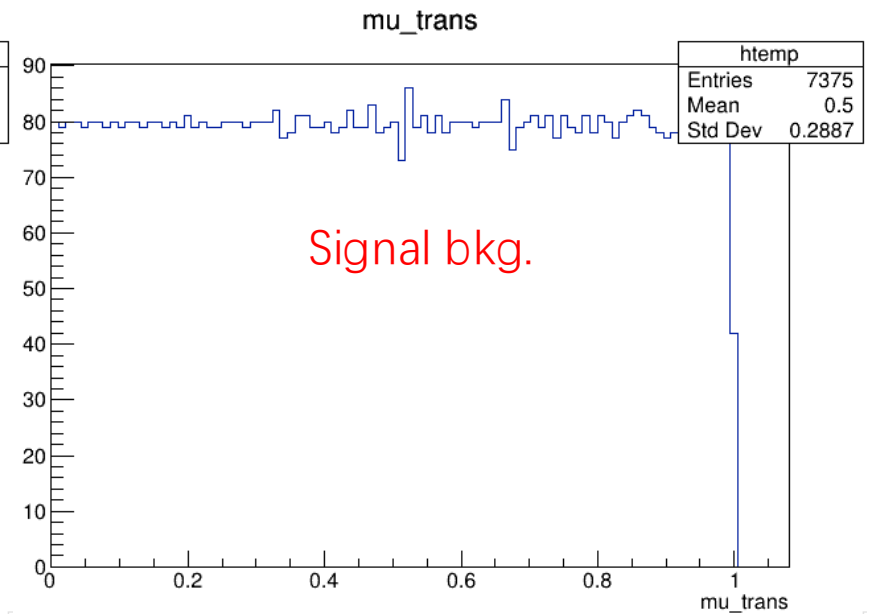


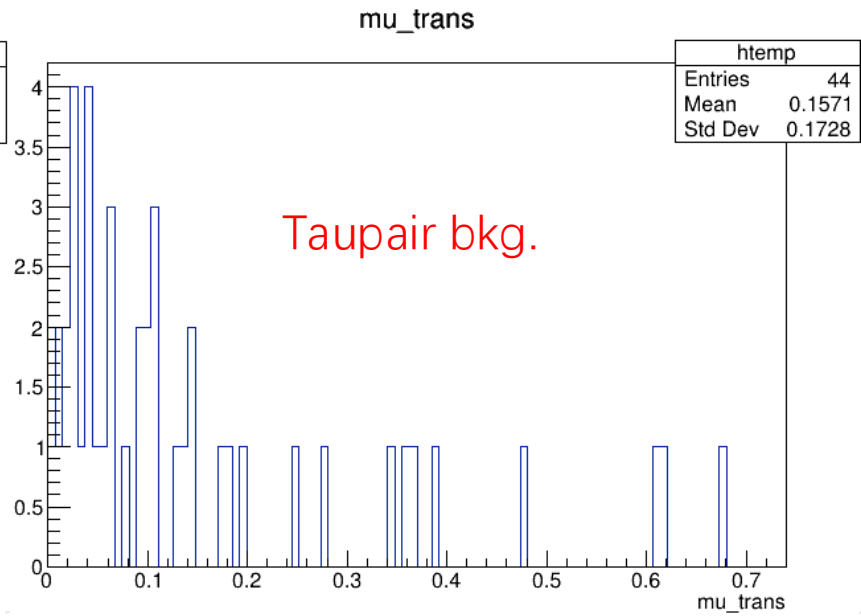
loose cut on MVA(muTag): MVA>0.60



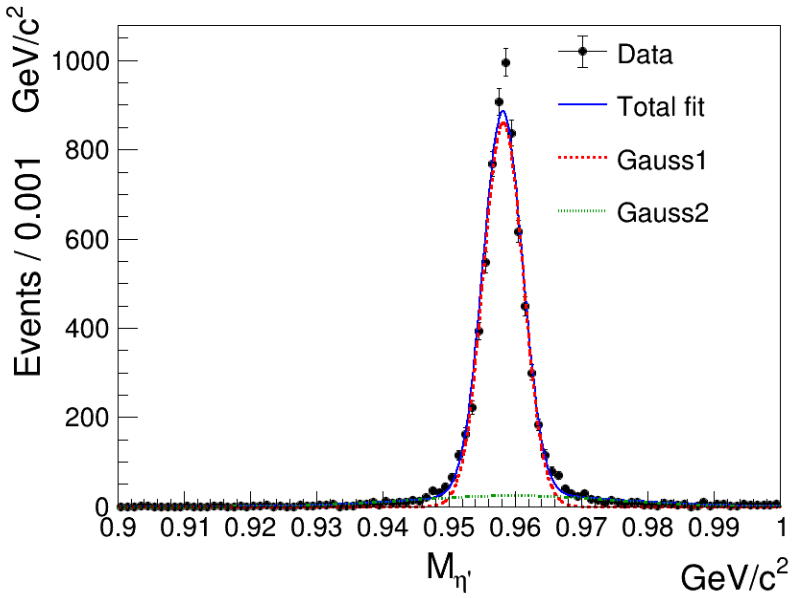


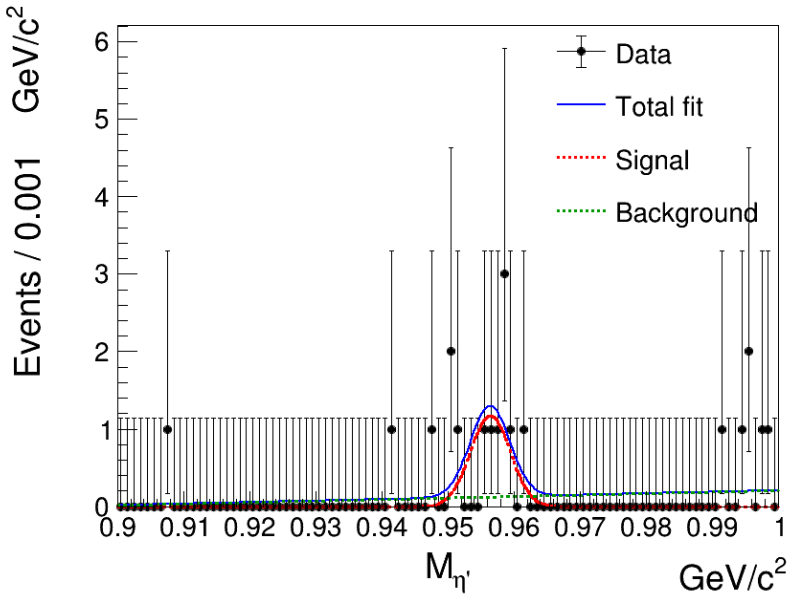


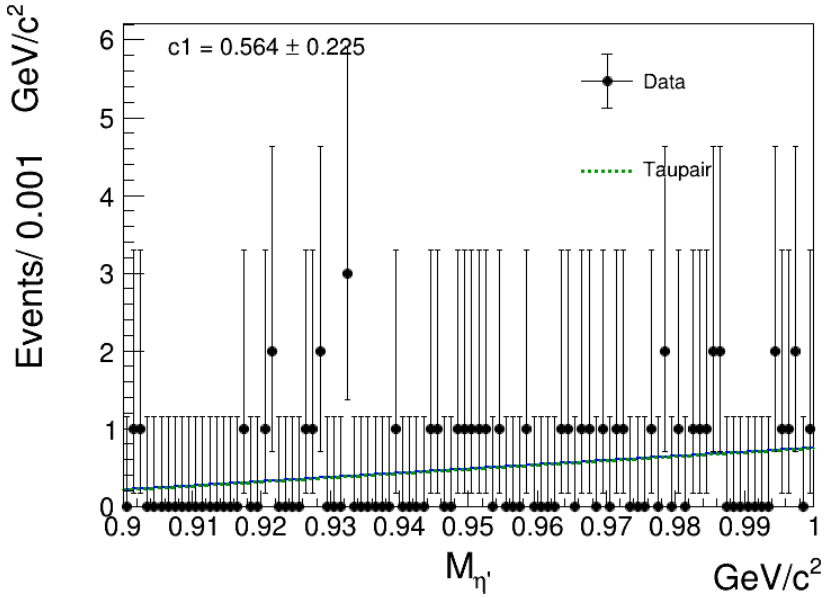




- PDF of nominal mass of η'
  - Simultaneous fit to **signal** and **continuum** to get mass resolution of η'







Evaluation of signal yield-muTag

- **Under the requirement of MVA>0.60**

$$N_{signal} = \varepsilon_{rec} \cdot Br\left(\tau^- \to e^-\bar{\nu}_e\nu_\tau \; or \; \tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau\right) \cdot Br(\eta' \to \eta\pi^+\pi^-) \cdot Br(\eta \to \gamma\gamma) \cdot Br(\tau^+ \to K^+\eta'\bar{\nu}_\tau) \cdot \sigma_{\tau\tau} \cdot \mathcal{L}$$

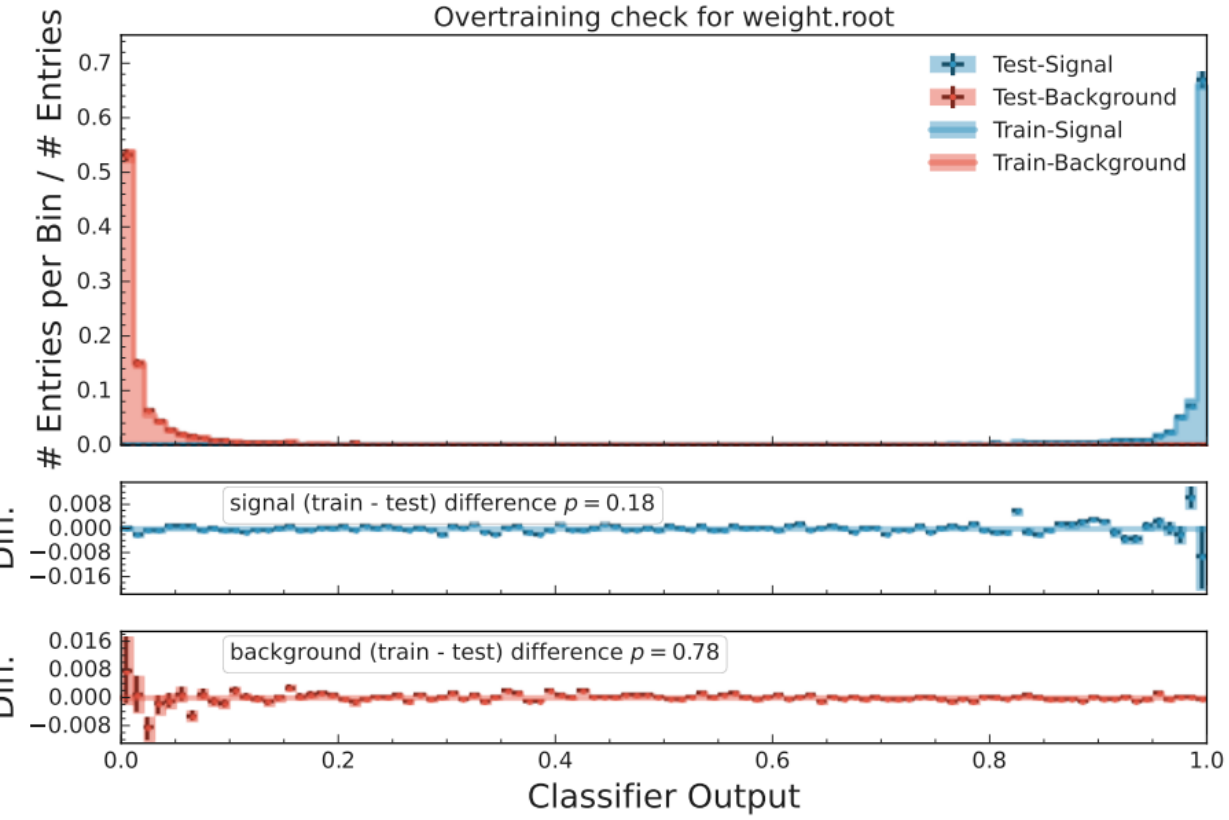
- ε_{rec}
- $Br(\tau^- \to e^-\bar{\nu}_e\nu_\tau) = 17.39\%$
- $Br\left(\tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau\right) = 17.82\%$
- $Br(\eta' \to \eta\pi^+\pi^-) = (42.5 \pm 0.5)\%$
- $Br(\eta \to \gamma\gamma) = (39.36 \pm 0.18)\%$
- $Br(\tau^+ \to K^+\eta'\nu_\tau) < 2.4 \times 10^{-6}$
- $\sigma_{\tau\tau} = 0.919\ nb$
- $\mathcal{L} = 428\ fb^{-1}$(run1 all data)

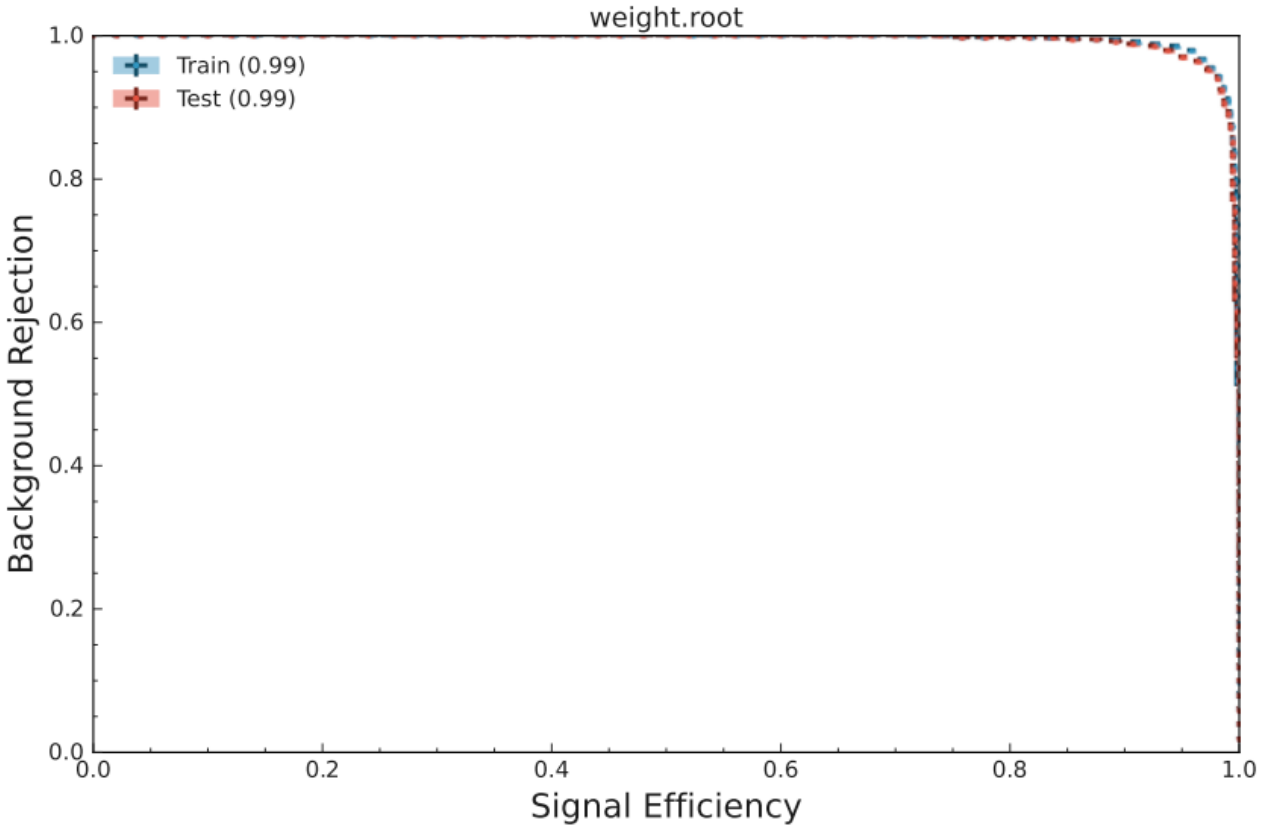
If $\varepsilon_{rec} = 7.79\%$ and $Br(\tau^+ \to K^+\eta'\nu_\tau) = 2.4 \times 10^{-6}$, then $N_{signal} \approx 2$.

- $N_{bkg} = 3 \pm 1.7$

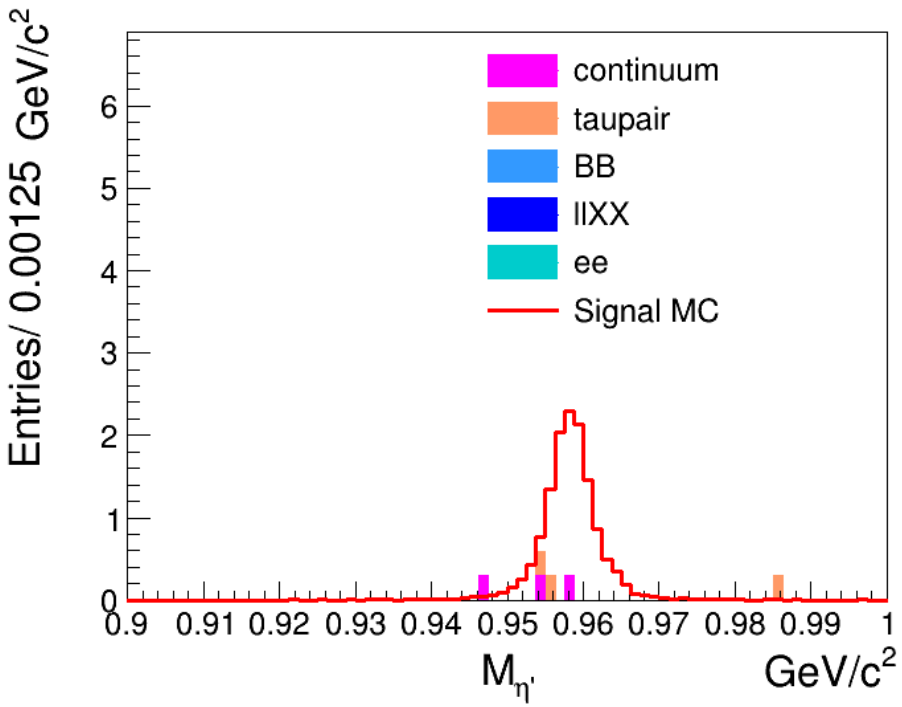
BDT for eTag

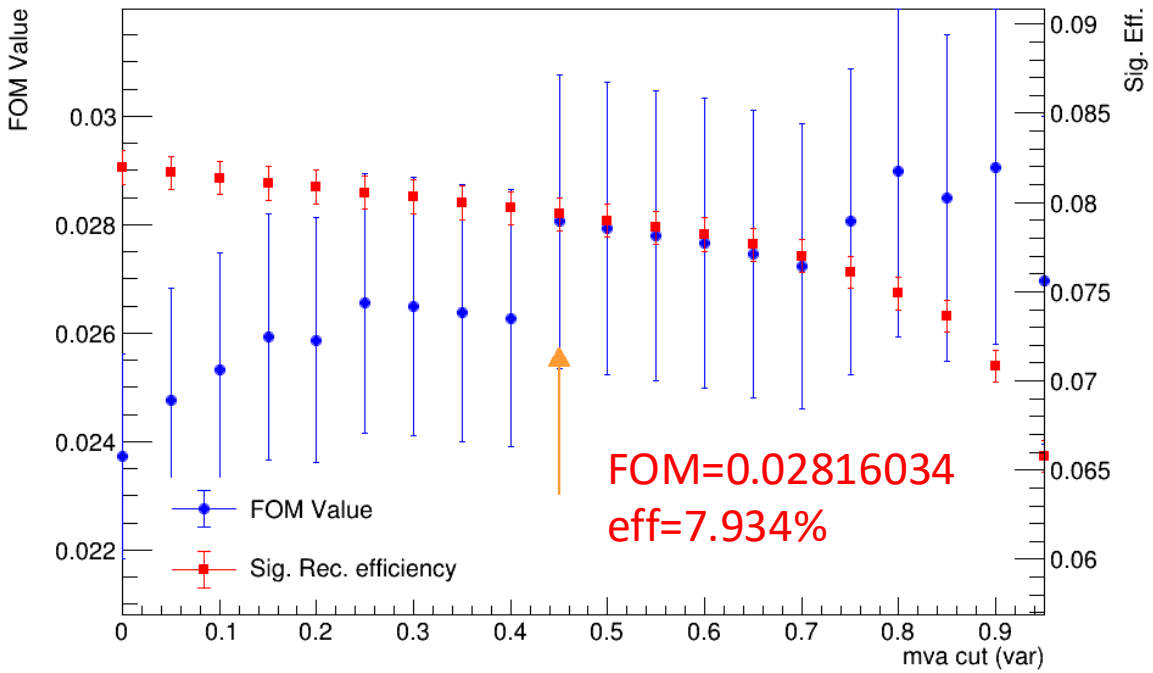
tau_sig_R2	tau_sig_thrustOm	tau_sig_cosTBTO
tau_sig_cosTBz	tau_sig_KSFWVariablesmm2	tau_sig_KSFWVariableshso10
tau_sig_KSFWVariableshso12	tau_sig_KSFWVariableshso14	tau_sig_KSFWVariableshso20
tau_sig_KSFWVariableshso22	tau_sig_KSFWVariableshso24	tau_sig_KSFWVariableshoo0





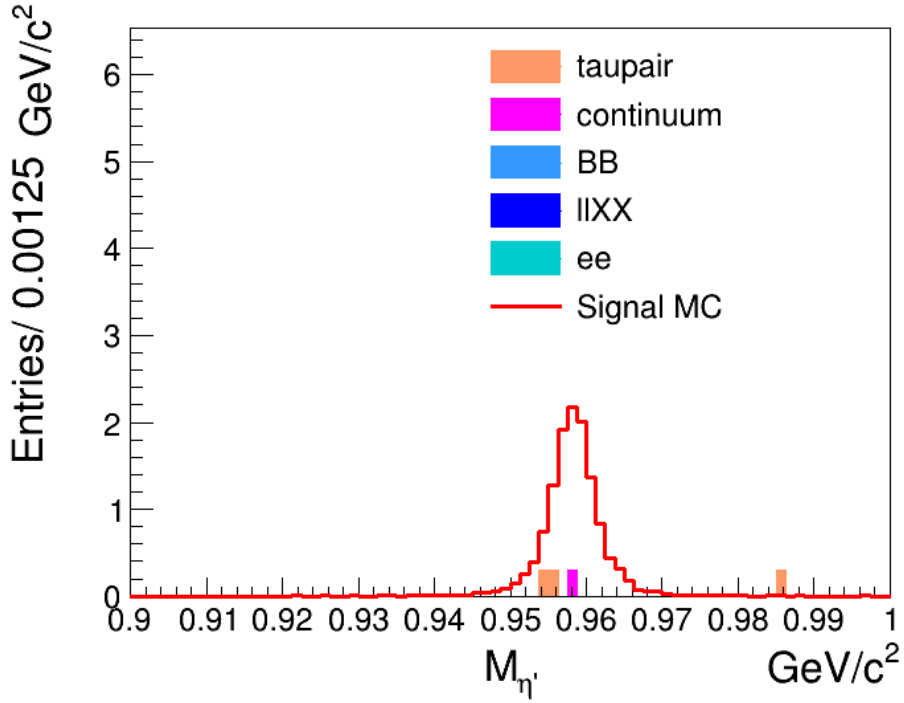
loose cut on MVA(eTag): MVA>0.45





Strict cut on MVA(eTag): MVA>0.80

FOM = 2.89844500e-02
Eff = 7.490%



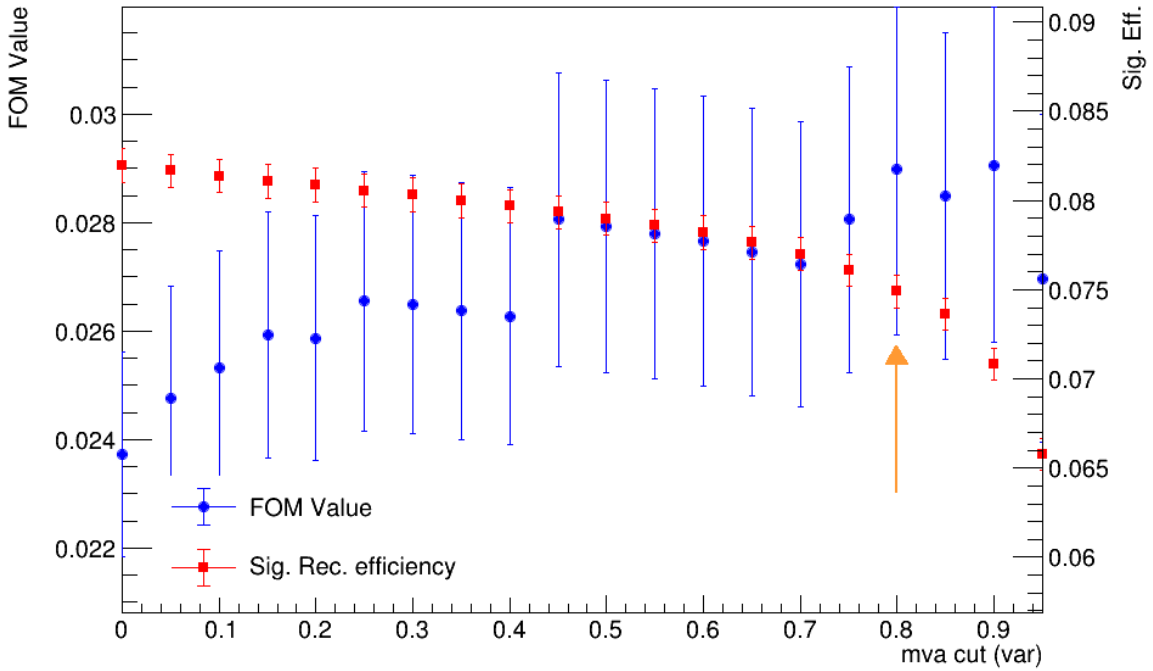


Table 1: Decay trees and their respective initial-final states.

rowNo	decay tree (decay initial-final states)	iDcyTr	nEtr	nCEtr
1	$e^+e^- \to \rho^+K^-\eta' n\bar{\Lambda}\gamma^I, \rho^+ \to \pi^0\pi^+, \eta' \to \pi^+\pi^-\eta, \bar{\Lambda} \to \pi^+\bar{p}, \eta \to \gamma\gamma$ $(e^+e^- \dashrightarrow \pi^0\pi^+\pi^+\pi^+\pi^-K^-n\bar{p}\gamma^I\gamma\gamma)$	0	1	1

Evaluation of signal yield-eTag

- **Under the requirement of MVA>0.45**

$$N_{signal} = \varepsilon_{rec} \cdot Br\left(\tau^- \to e^-\bar{\nu}_e\nu_\tau \; or \; \tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau\right) \cdot Br(\eta' \to \eta\pi^+\pi^-) \cdot Br(\eta \to \gamma\gamma) \cdot Br(\tau^+ \to K^+\eta'\bar{\nu}_\tau) \cdot \sigma_{\tau\tau} \cdot \mathcal{L}$$

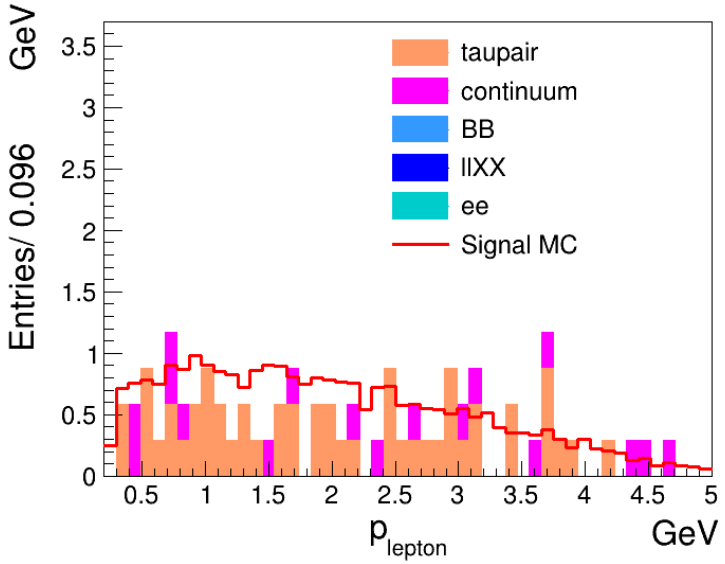
- ε_{rec}
- $Br(\tau^- \to e^-\bar{\nu}_e\nu_\tau) = 17.39\%$
- $Br(\tau^- \to \mu^-\bar{\nu}_\mu\nu_\tau) = 17.82\%$
- $Br(\eta' \to \eta\pi^+\pi^-) = (42.5 \pm 0.5)\%$
- $Br(\eta \to \gamma\gamma) = (39.36 \pm 0.18)\%$
- $Br(\tau^+ \to K^+\eta'\nu_\tau) < 2.4 \times 10^{-6}$
- $\sigma_{\tau\tau} = 0.919\ nb$
- $\mathcal{L} = 428\ fb^{-1}$(run1 all data)

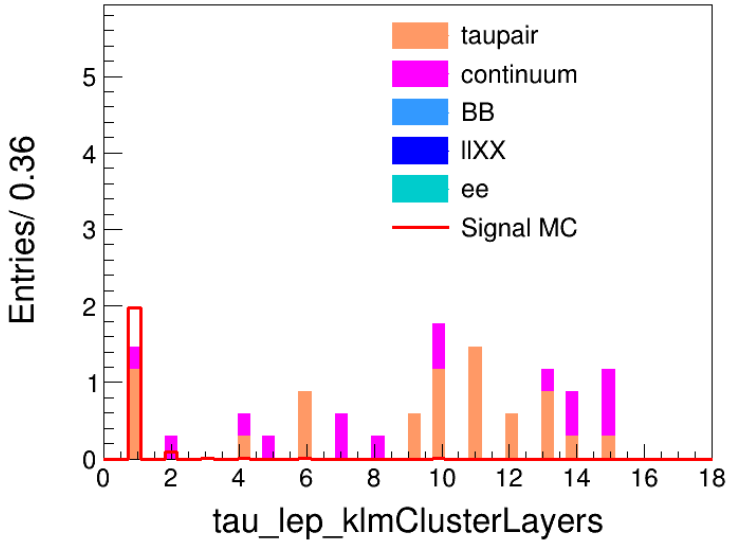
If $\varepsilon_{rec} = 7.49\%$ and $Br(\tau^+ \to K^+\eta'\nu_\tau) = 2.4 \times 10^{-6}$, then $N_{signal} \approx 2$.

- $N_{bkg} = 1.5 \pm 1.2$

顺便检查一下eTag侧在KLM留下的信息

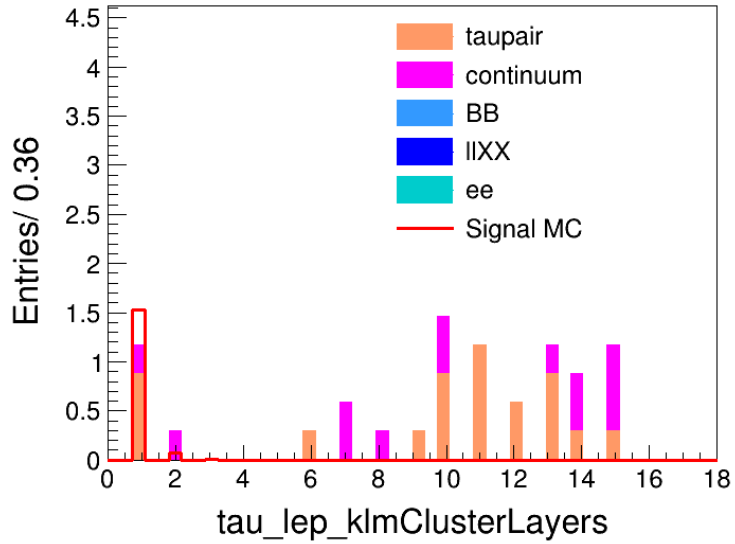
这个变量似乎也能用在eTag侧?

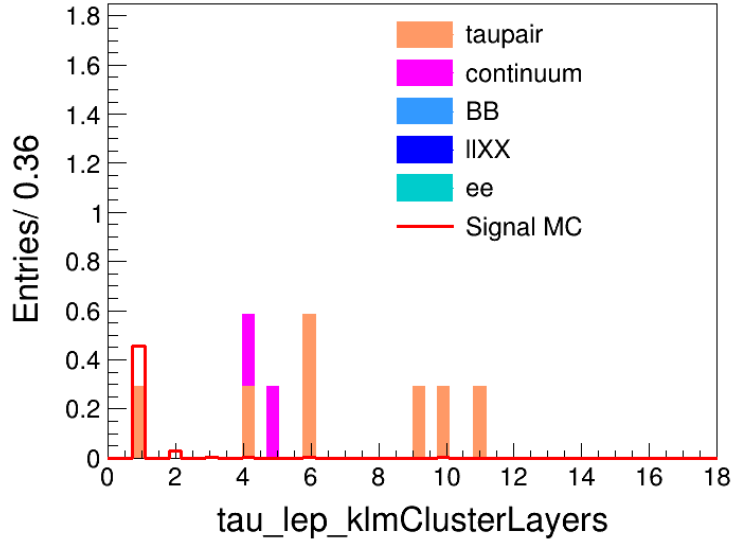




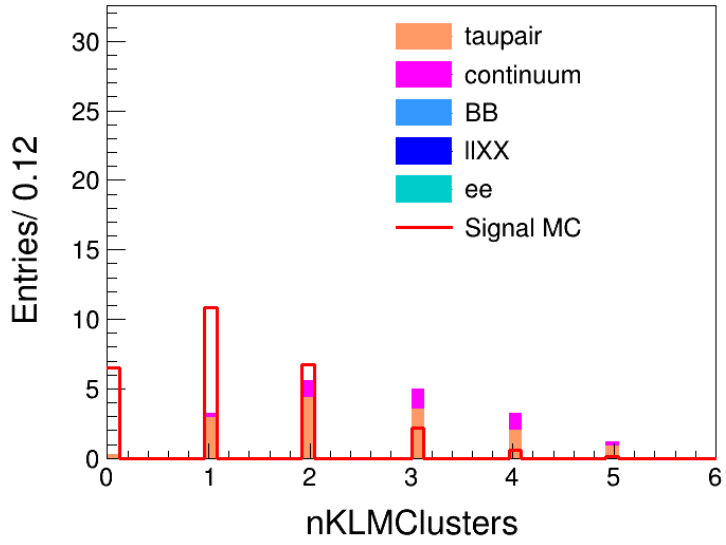
要求$P_e > 1.5$ GeV

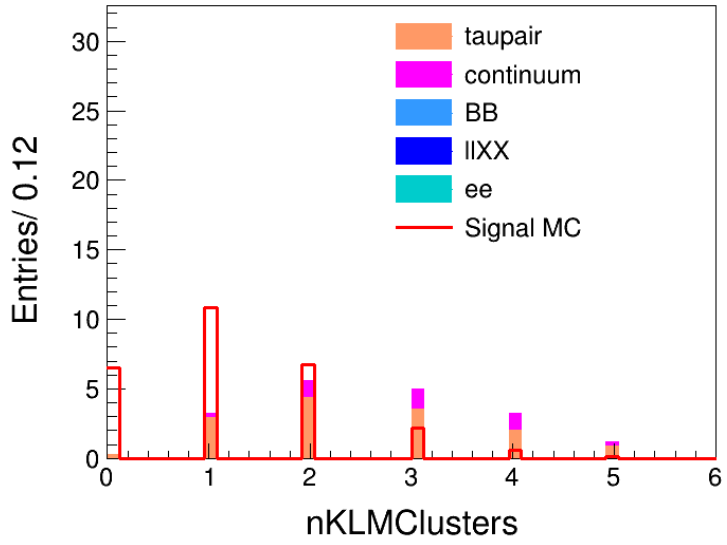
要求$P_e < 1.5$ GeV

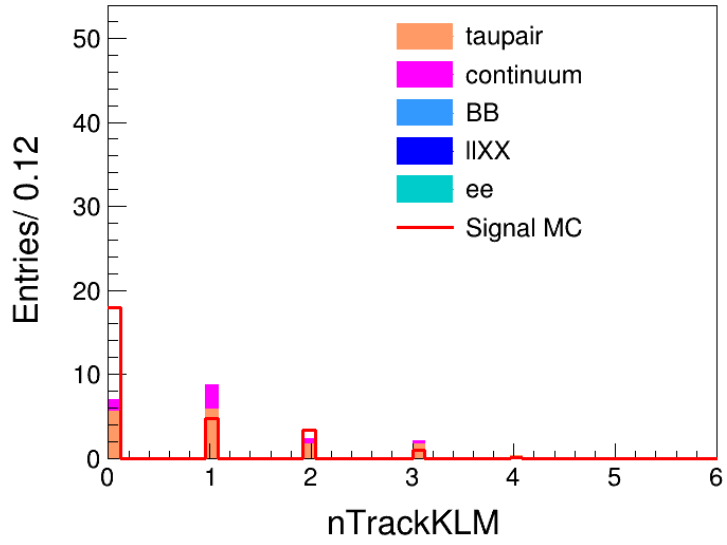


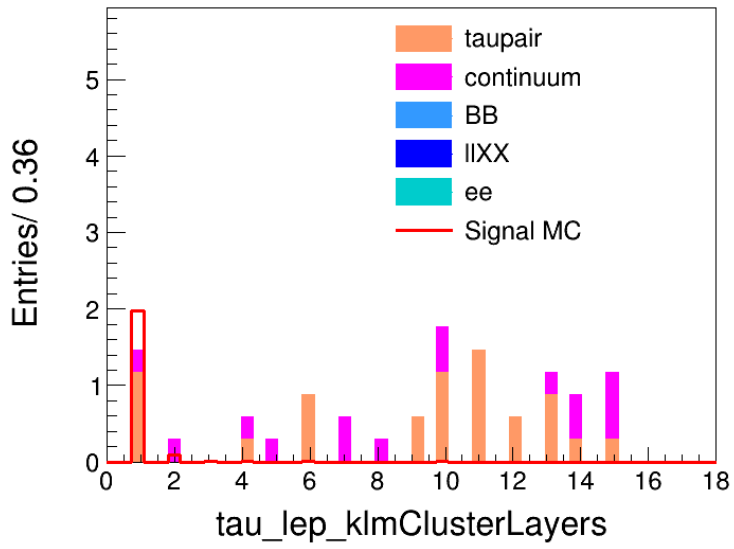


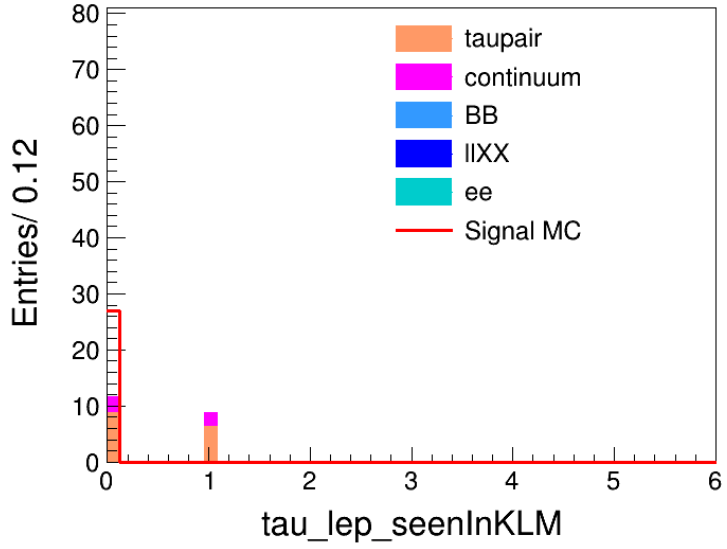
eTag侧在KLM留下的其他信息

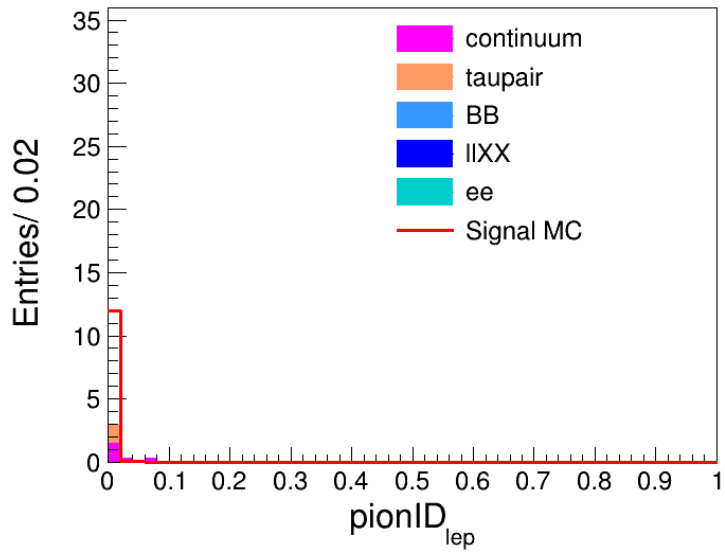












planA: (loose MVA selection to retain some continuum event) ❌
Perform 2D fitting between MVA and mass of eta'

Problem: Even if we do not require MVA, there are only (11)28 events of continuum background left for eTag(muTag). -> hard to model

planB: (strict MVA selection to maximize to FOM value)
Select a pure continuum background sample -> get the data to mc ratio ->fix in the fitting

Problem: unable to remove all continuum background.

Need to resubmit grid jobs