

Lepton ID Update

Changhua Hao, Ligang Xia

Nanjing University

Updates

- 1) Will not consider the samples with angle=90 degrees because of TPC cathode plate. Instead we will use angle=85 degrees.
- 2) Use HCal energy/position information to suppress $\pi \rightarrow e$ faking rate
- 3) Fix a bug in my codes \rightarrow lower faking rate generally

A problem for particles with angle=90degrees

Associated track momentum Ecal cluster energy

```
* 1 * 0 * -99 * 14.571101 *
* 1 * 1 * -99 * 0.7703134 *
* 1 * 2 * 2.6498141 * 2.4197115 *
* 1 * 3 * -99 * 2.4097900 *
* 1 * 4 * -99 * 0.7135742 *
* 1 * 5 * -99 * 0.7872552 *
* 1 * 6 * -99 * 0.5370724 *
* 1 * 7 * 4.7981500 * 22.041257 *
* 1 * 8 * -99 * 2.4374325 *
* 1 * 9 * -99 * 21.323782 *
* 1 * 10 * -99 * 6.8366298 *
* 1 * 11 * 8.9585189 * 13.277712 *
* 1 * 12 * -99 * 8.2117967 *
* 1 * 13 * 1.9261008 * 8.1258878 *
* 1 * 14 * -99 * 1.0107168 *
* 1 * 15 * -99 * 0.7958690 *
* 1 * 16 * -99 * 0.2996896 *
Type <CR> to continue or q to quit ==>
* 1 * 17 * 7.0482516 * 6.8297715 *
* 1 * 18 * 10.929218 * 10.215898 *
* 1 * 19 * 18.855588 * 11.025893 *
* 1 * 20 * 78.494171 * 0.3806840 *
* 1 * 21 * 7.3692946 * 2.8815527 *
```

This screenshot shows 1 event.

- 3 particles (e,mu,pi) are generated
- 22 Ecal clusters are reconstructed.
- many clusters cannot find associated track (-99)
- only 1 cluster finds an associated track with $p=78.494171$ GeV.

It seems that:

- a particle breaks into small pieces like EM showering (but it is unlikely comparing with other angles for which this case rarely happens.)
- more likely, at this angle, it is difficult for a cluster to find its track partner (because the TPC cathode stops cluster/track from matching?)

So we will not study this angle and use 85 instead.

HCAL information for electron ID

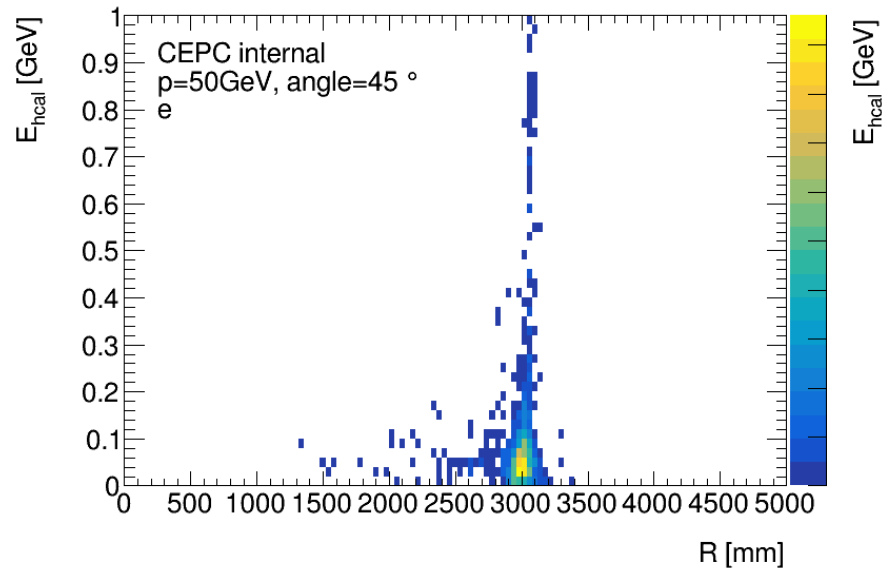
Example: $p=50\text{GeV}$, $\text{angle}=45$ degrees

Electrons have two features in HCAL:

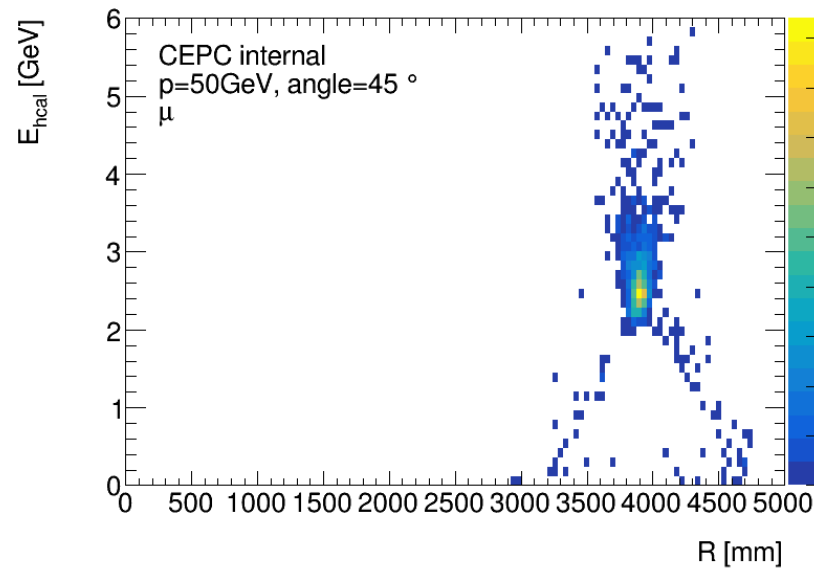
- 1) electrons **deposit much less energy** (< 1 GeV) than muon and pion in HCAL
- 2) electrons lose their **energy at the first layer** ($\sim 3000\text{mm}$ from the collision point).

They are used in the eID if available.

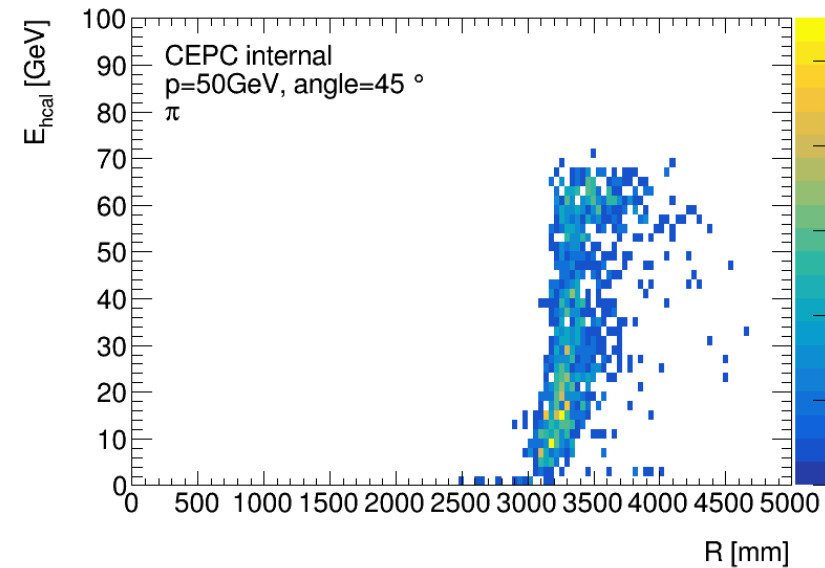
electron



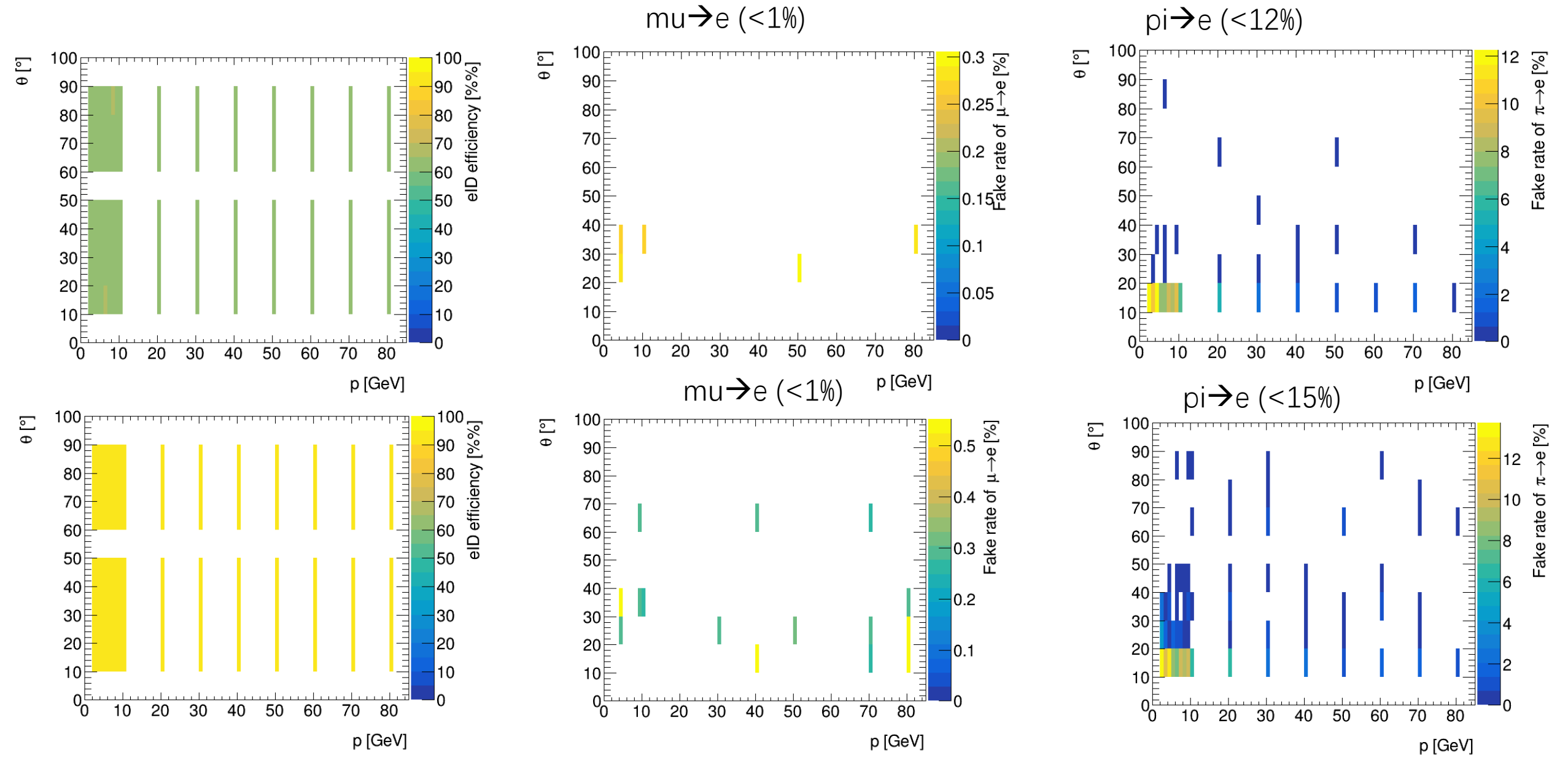
muon



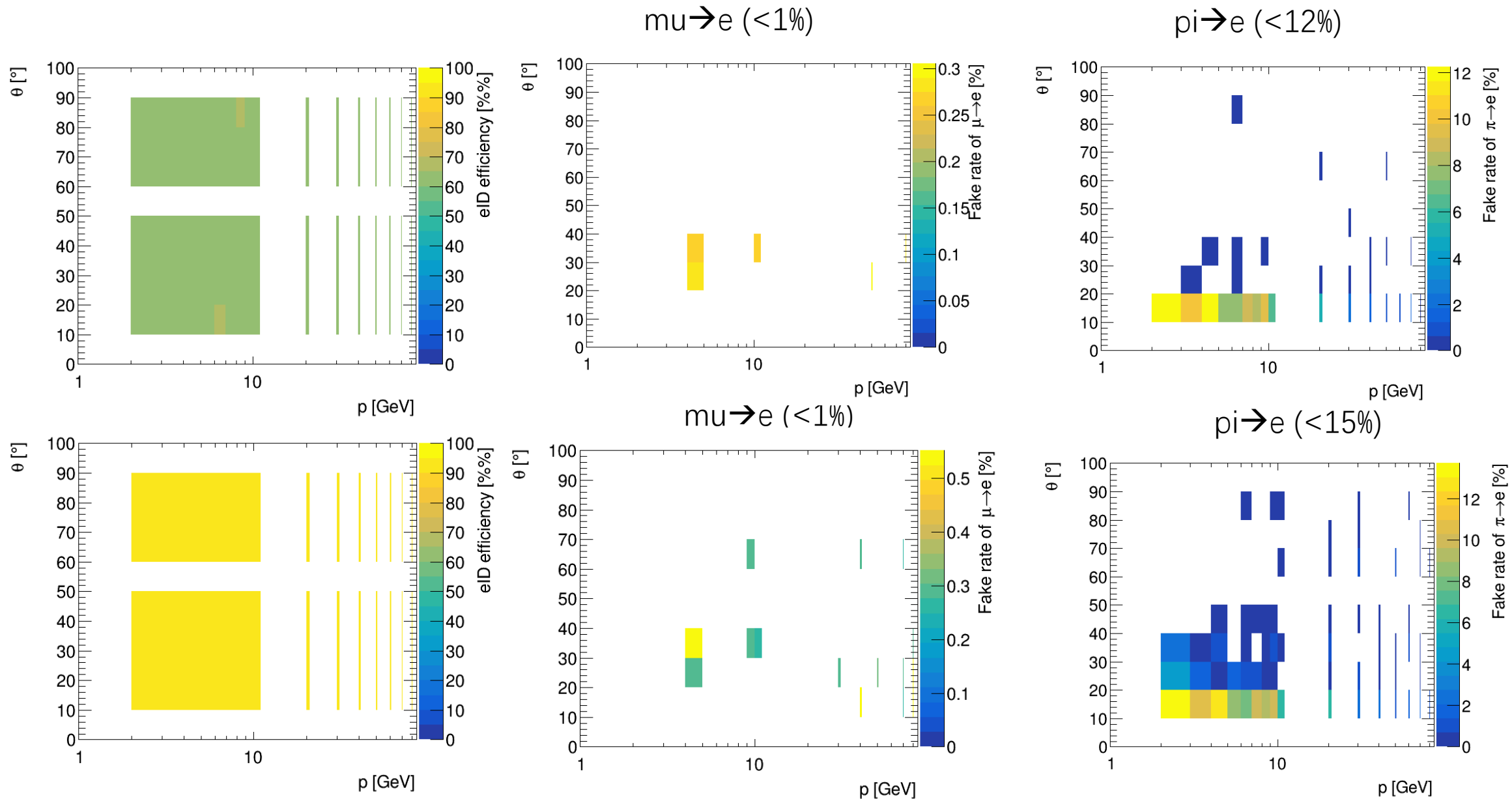
pion



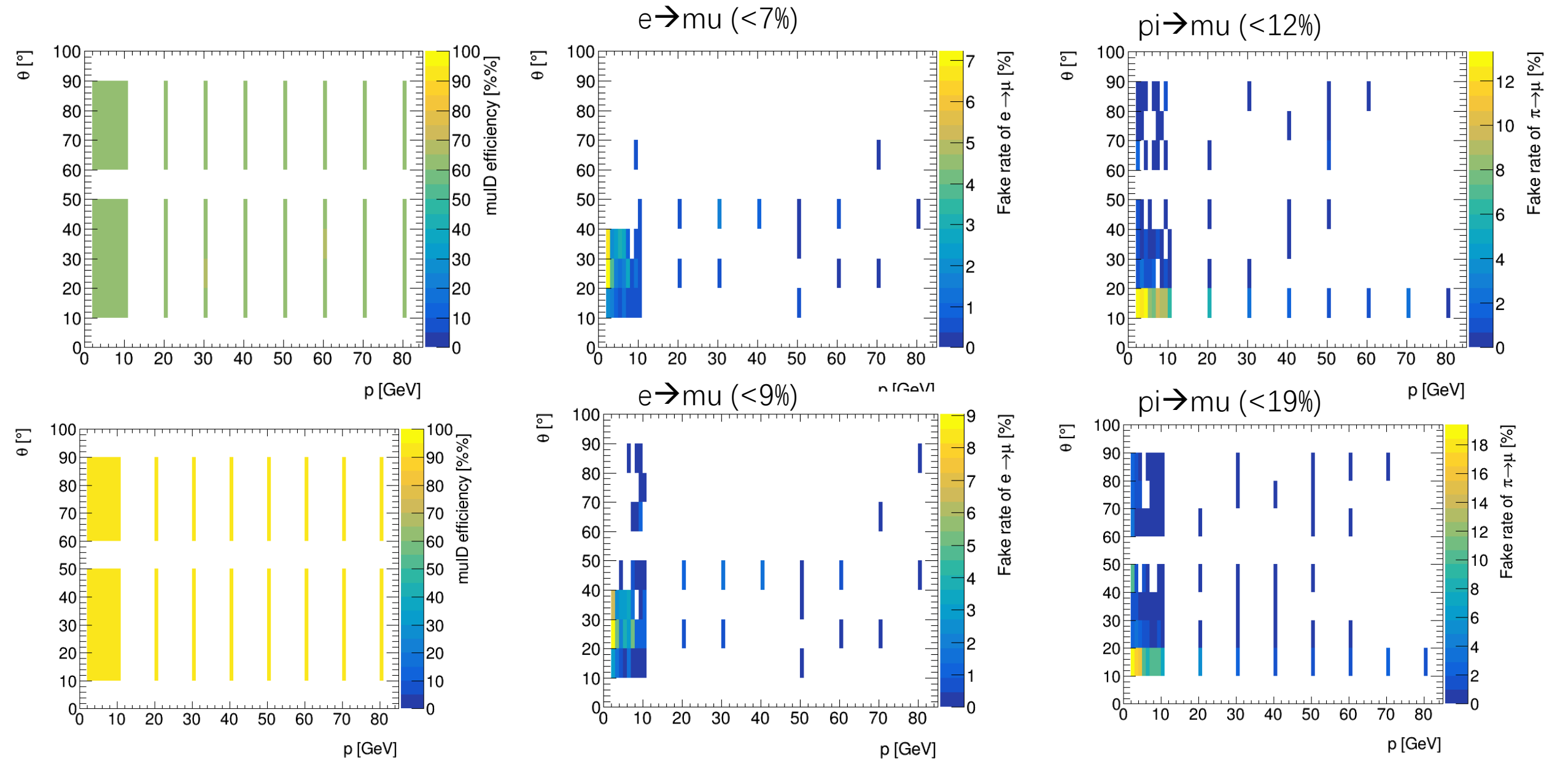
eID: 60% WP (top) and 90% WP (bottom)



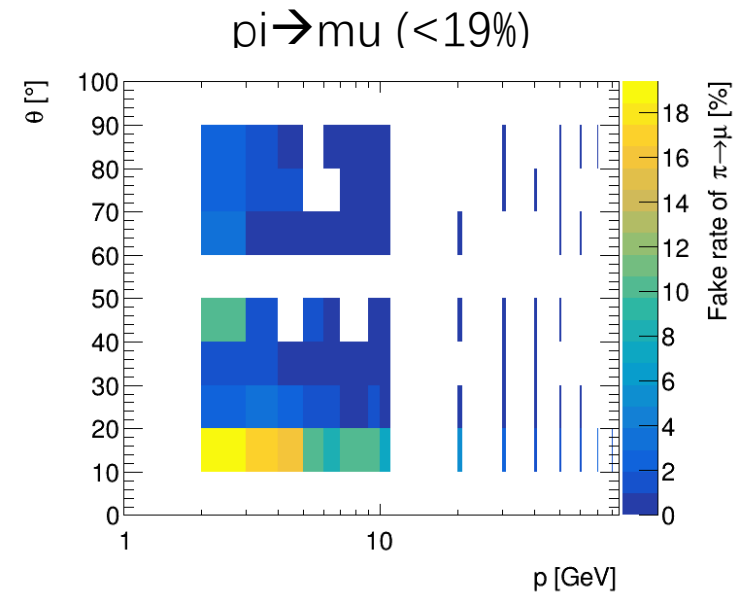
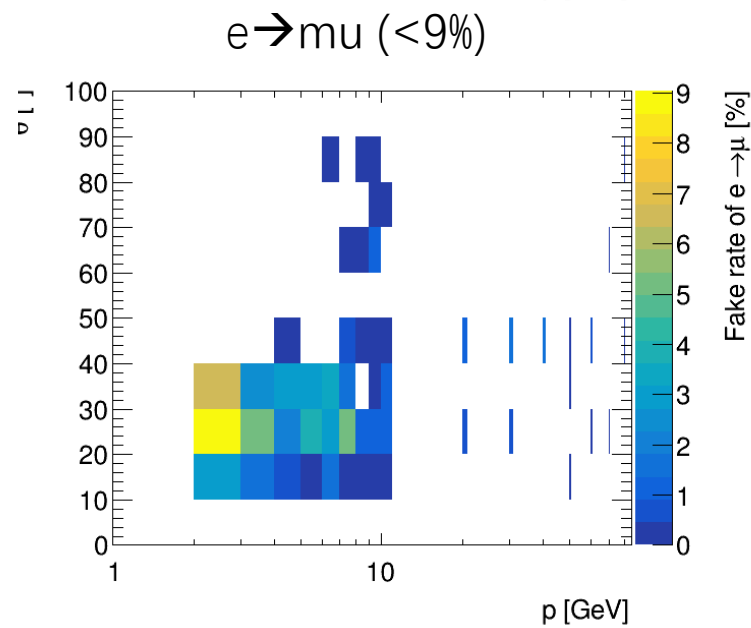
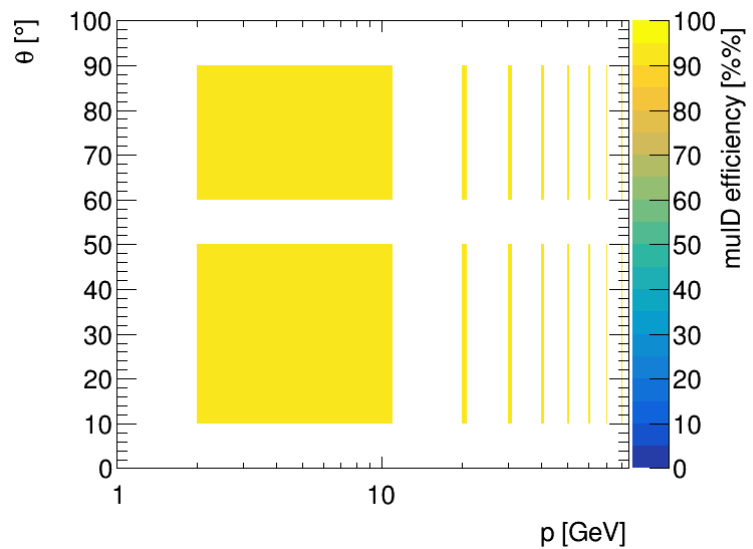
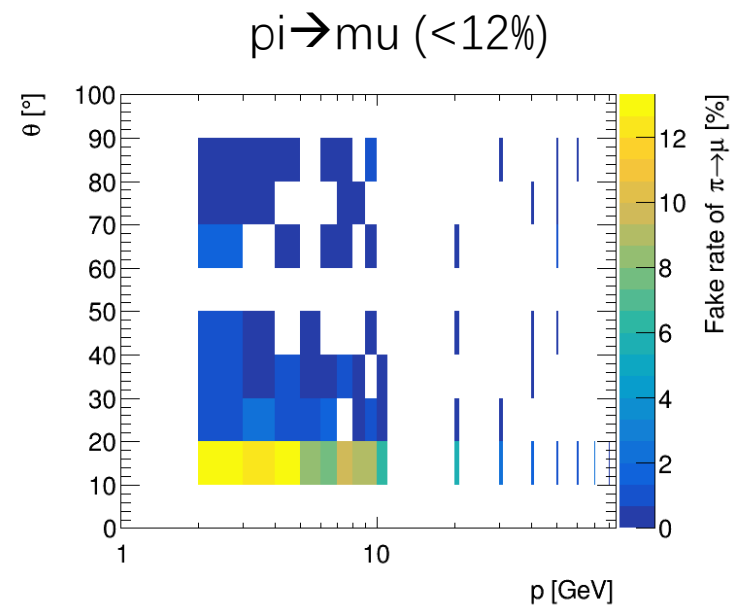
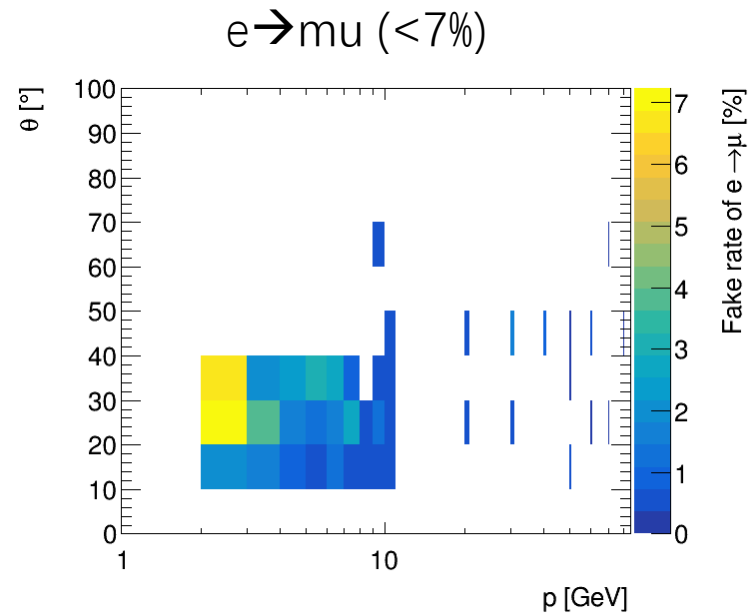
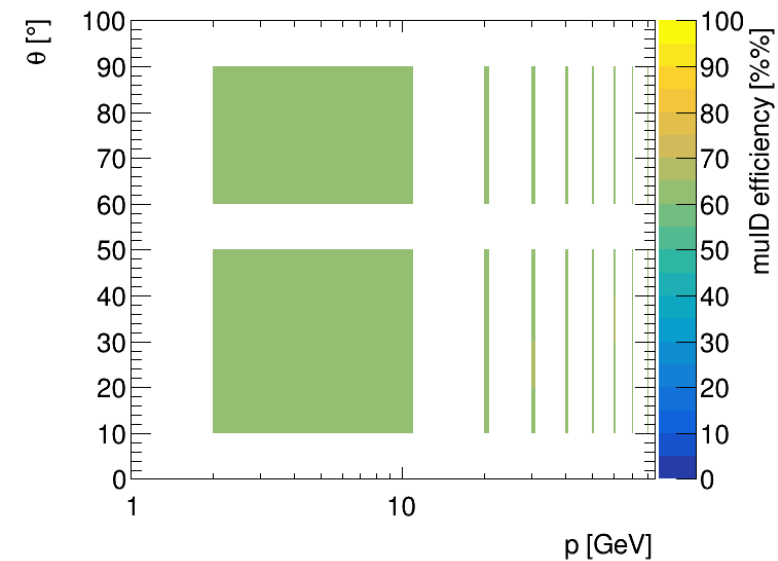
eID: 60% WP (top) and 90% WP (bottom)



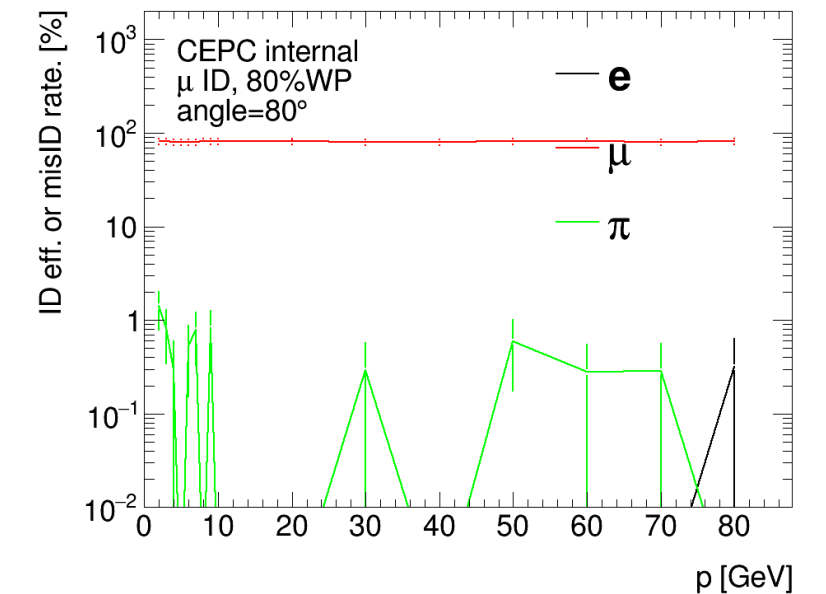
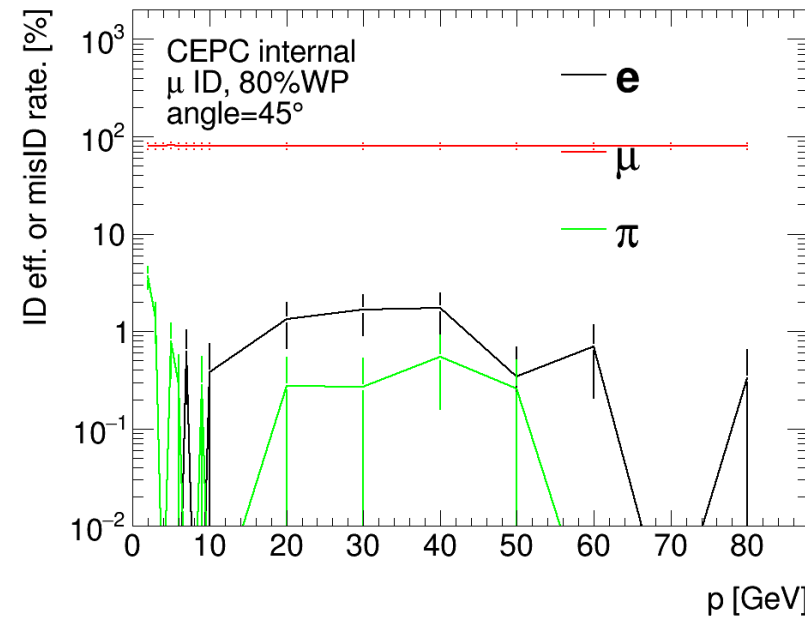
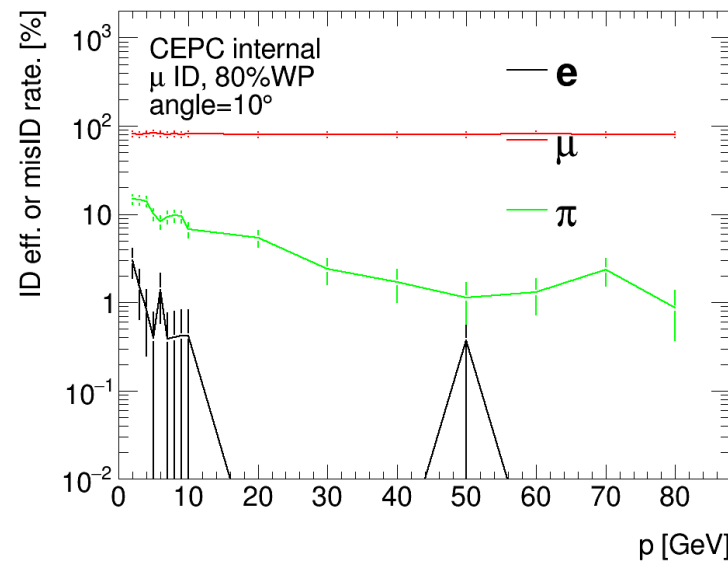
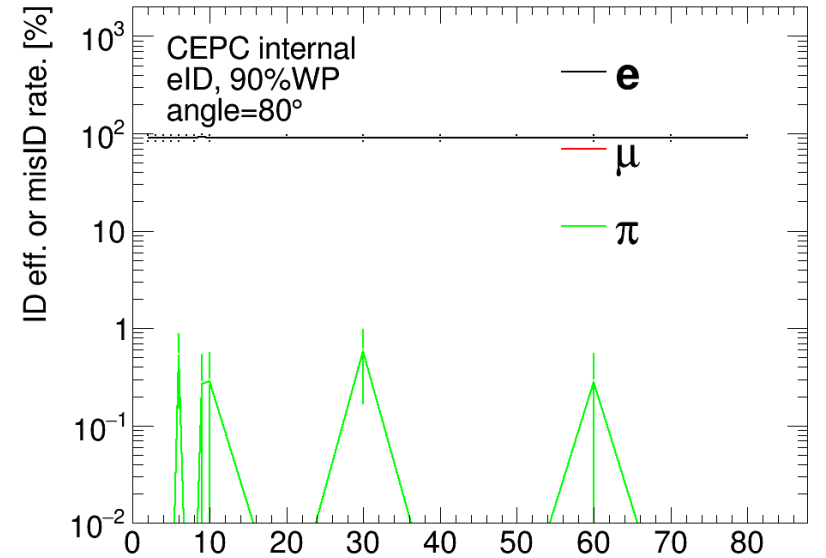
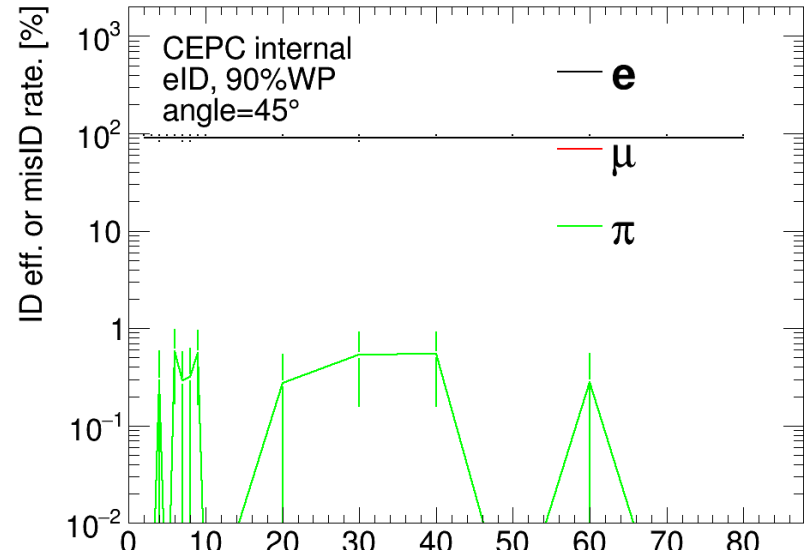
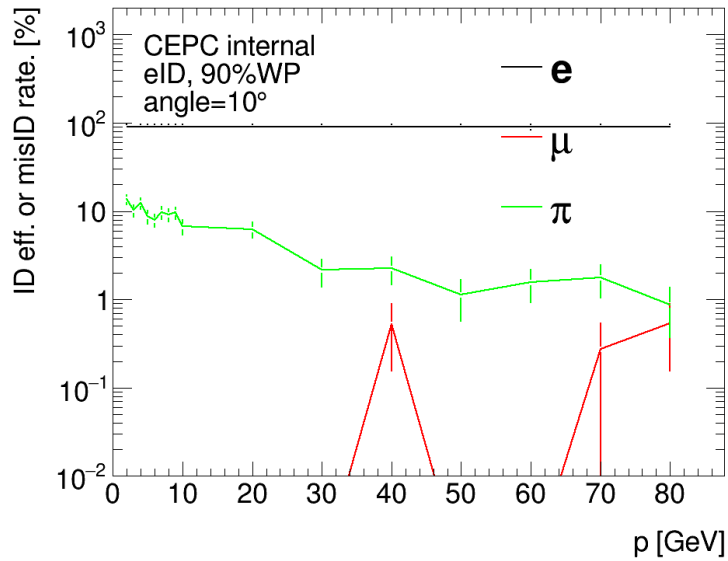
muID: 60%WP (top) and 90% WP (bottom)



muID: 60%WP (top) and 90% WP (bottom)



Performance examples:



Use lepton ID at analysis level

- The leptonID json files:
/afs/ihep.ac.cn/users/x/xialg/public/database_for_leptonID/
- An [example script](#) of applying the muID is also here.

```
[xialg@lxlogin002 ~/public/database_for_leptonID]$pwd
/afs/ihep.ac.cn/users/x/xialg/public/database_for_leptonID
[xialg@lxlogin002 ~/public/database_for_leptonID]$ll
total 62
drwxr-xr-x 2 xialg physics 2048 Mar 14 09:29 .
drwx----- 4 xialg physics 2048 Feb 17 16:21 ..
-rw-r--r-- 1 xialg physics 1375 Mar 14 09:29 application.py
-rw-r--r-- 1 xialg physics 28425 Mar 14 09:29 eID_database.json
-rw-r--r-- 1 xialg physics 28008 Mar 14 09:29 muID_database.json
```

```
def chi2(x, mean, sigma):
    return pow((x-mean)/sigma,2)

# import the json file
database_filepath = 'muID_database.json'
database = None
with open(database_filepath, 'r') as f:
    database = json.load(f)
#print('database =', database)
print(database['readme'])
tag = 'momentum%iGeV_angle%idegree' % (p, theta)
chi2_Eecal = chi2(Eecal, database[tag]['Eecal mean'], database[tag]['Eecal sigma'])
chi2_Ehcal = chi2(Ehcal, database[tag]['Ehcal mean'], database[tag]['Ehcal sigma'])
chi2_Rhad = chi2(Rhad, database[tag]['Rhad mean'], database[tag]['Rhad sigma'])
chi2_tot = chi2_dndx + chi2_tof + chi2_Eecal + chi2_Ehcal + chi2_Rhad

for WP in database['WPs']:
    chi2_cut = database[tag][WP]
    flag = 'pass'
    if chi2_tot >= chi2_cut:
        flag = 'fail'
    print('chi2_tot, chi2_cut, Working point =', chi2_tot, ',', chi2_cut, WP, flag)
```

There is a short
readme.

```
[xialg@lxlogin002 ~/higgs/analysis]$python3 application.py
Some notes to use muID:
1) argument is 'momentum?GeV_angle?degree';
2) muID uses dNdx from TPC, tof from TOF, Eecal [GeV] from EM calorimeter, Ehcal [GeV] from HAD calorimeter and the distance Rhad [mm] between HAD cluster and the collision point;
3) To apply the cut on chi2, you will have to define chi2=chi2(TPC)+chi2(TOF)+chi2(Eecal)+chi2(Ehcal)+chi2(Rhad). Here chi2(x)=(x-mean)^2/sigma^2.
```

```
chi2_tot, chi2_cut, Working point = 12.433755586623892 , 6.0 60WP fail
chi2_tot, chi2_cut, Working point = 12.433755586623892 , 9.0 70WP fail
chi2_tot, chi2_cut, Working point = 12.433755586623892 , 13.0 80WP pass
chi2_tot, chi2_cut, Working point = 12.433755586623892 , 23.0 90WP pass
```

In this example, the muon passes the 80 and 90WP, but fails to pass 60 and 70 WP.

Summary

- Use HCAL info for electron ID.
- Main results:
 - Consider 4 WPs: 60, 70, 80, 90
 - $\mu \rightarrow e$ faking rate is less than 1% among all momenta and angles considered here.
 - $\pi \rightarrow e$ faking rate is at percentage level with at most 15 % at low momenta (<10GeV) and low polar angle (~ 10 degrees)
 - $e \rightarrow \mu$ faking rate is at percentage level with at most 9 % at low momenta (<5GeV) and low polar angle (~ 20 degrees)
 - $\pi \rightarrow \mu$ faking rate is less than 5% for most of phase space with at most 19% at low momenta (<10GeV) and low polar angle (~ 10 degrees)
- An example script to use it at analysis level is provided.
- Work to do:
 - Integrate the results in CEPCSW
 - Update with latest version 25.3.4

- BACK UP