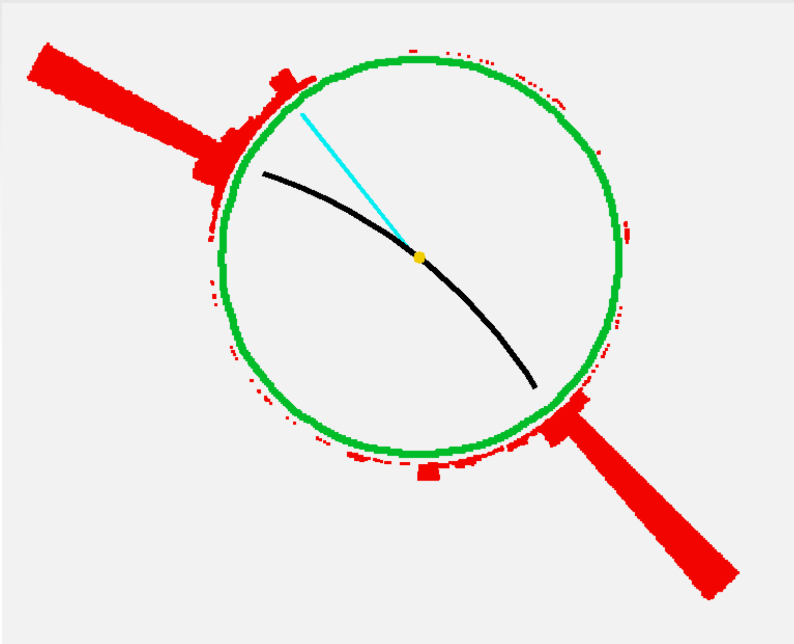
Particle ID with the EMC



Ronald Kunne
IPN Orsay, France
CNRS/IN2P3 – Université Paris Sud

Particle Identification

- Charged PID

  e, μ, π, K, p

- Neutral PID

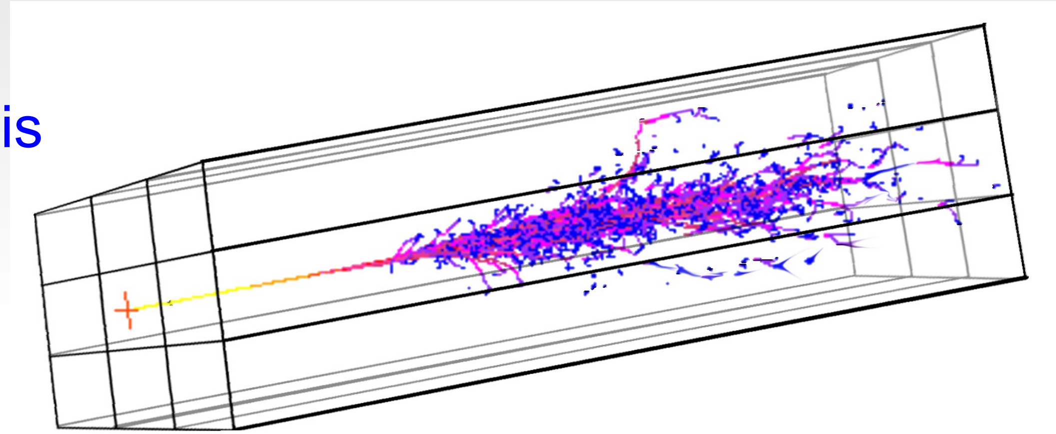
  π°/γ separation

Charged particle ID

- Generate e±, μ±, π±, K±, p± tracks, 1 million each,

  with 0.2 < p < 10 GeV/c, 0° < φ < 360°, 5° < Θ < 140°

- Run reconstruction macros μ hypothesis

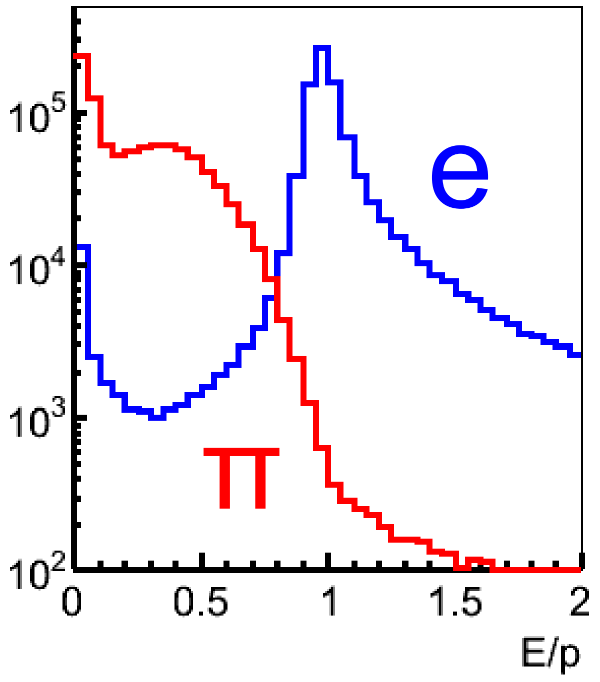


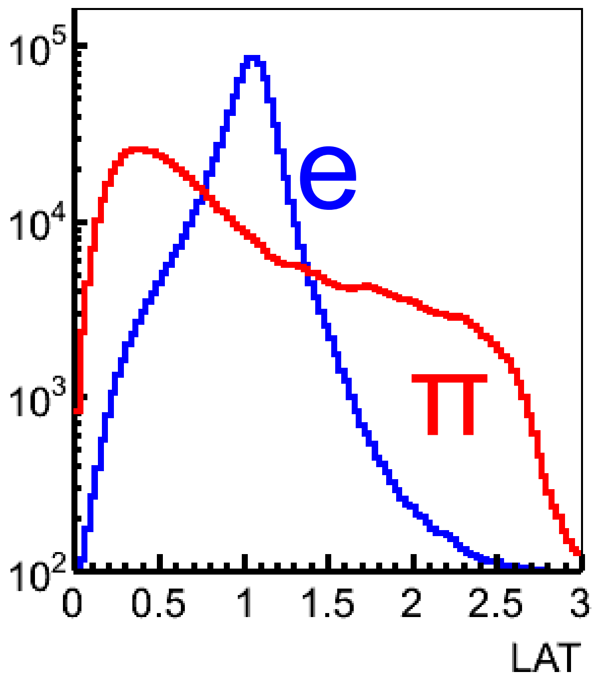
- Uses STT for tracking instead of TPC

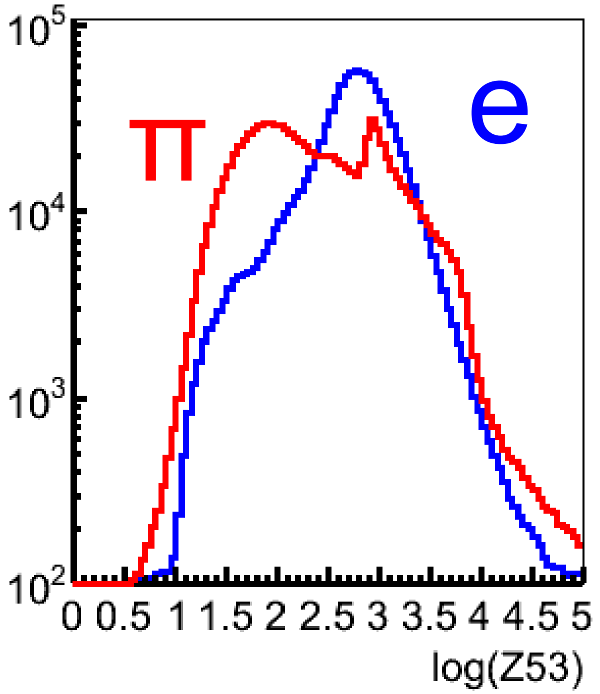
- Direct calculation using the Bayesian classifier method

- Implemented since PandaRoot version 14326

Three variables





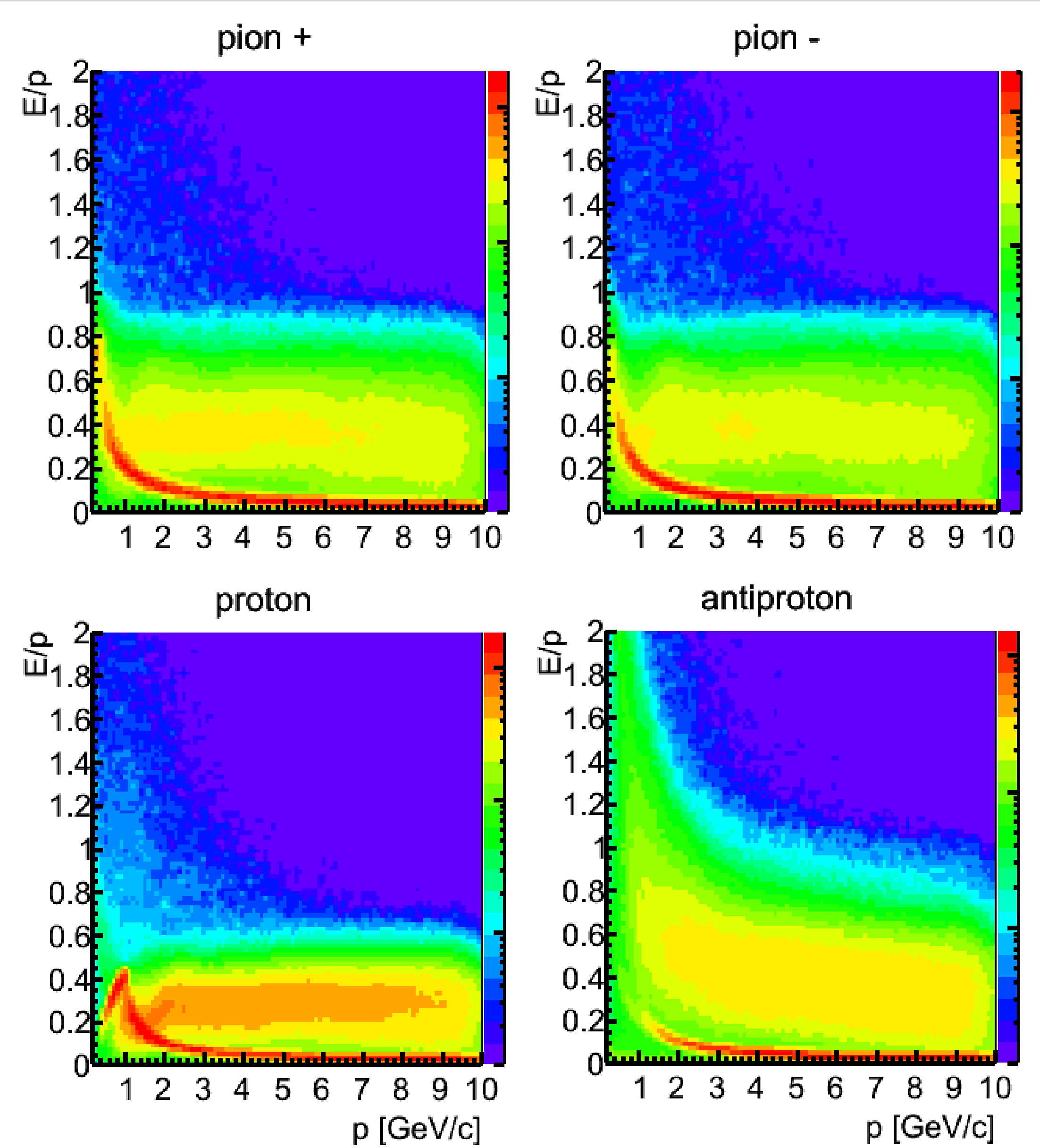


E/p

log(Lat)

log(Z53)

protons ≠ antiprotons



E/p

π+ is like π-

But $\overline{p}$ are different

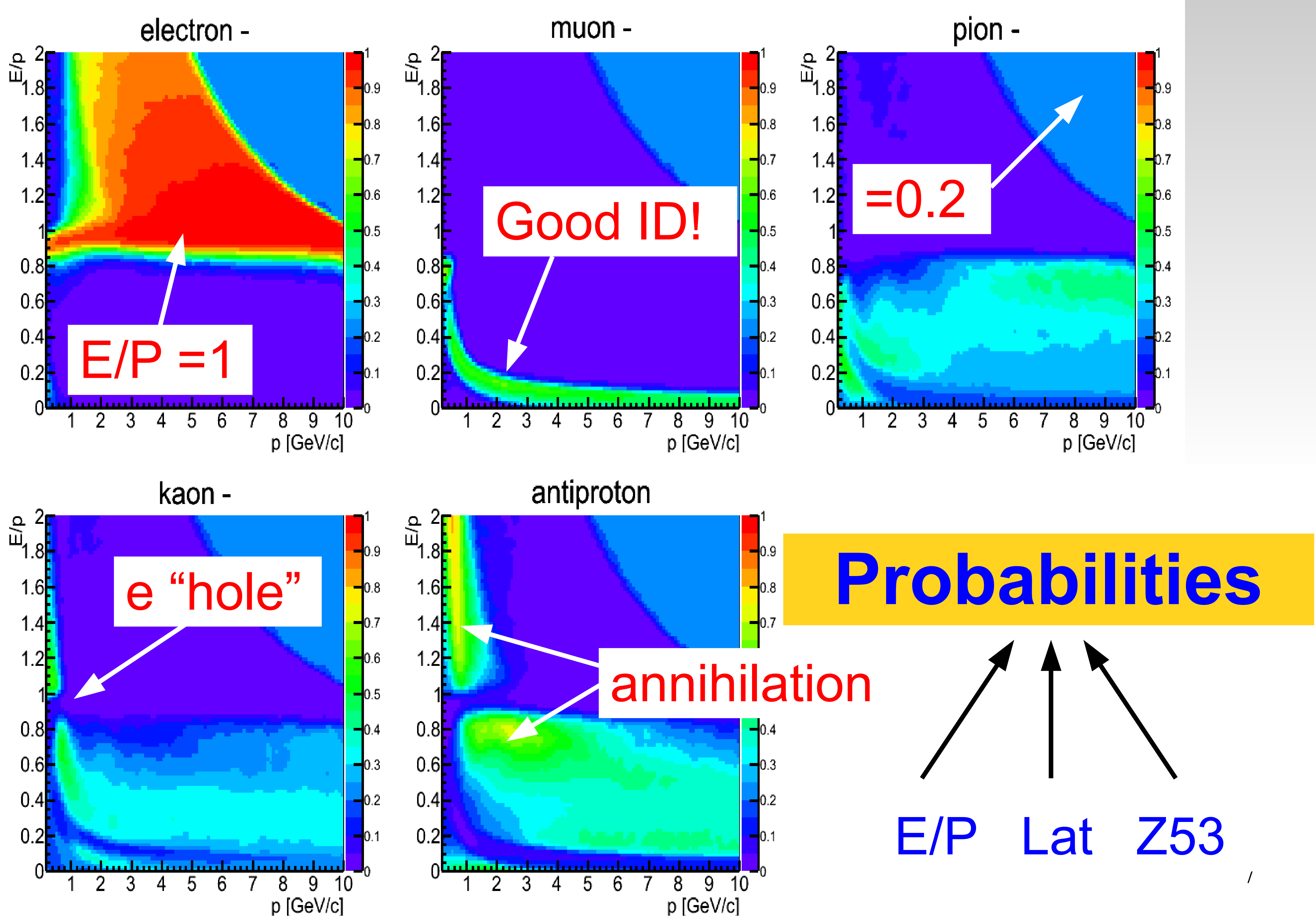
Construction of a "Naive" Bayesian classifier

2D histos (MC)

$$P(e \mid p, \text{variable}) = \frac{N(p,\text{variable} \mid e)}{N(p,\text{variable} \mid e) + N(p,\text{variable} \mid \pi) + \cdots}$$

"Convolution" of probabilities via likelihood factors:

$$\frac{P(e \mid EMC)}{1-P(e \mid EMC)} = \frac{P(e \mid var_1)}{1-P(e \mid var_1)} * \frac{P(e \mid var_2)}{1-P(e \mid var_2)} * \cdots\cdots$$



electron -
E/P =1
muon -
Good ID!
pion -
=0.2
kaon -
e “hole”
antiproton
annihilation
E/p
p [GeV/c]
Probabilities
E/P
Lat
Z53

Overall efficiencies

Similar for
+ and -

MC Input

Reco& PID

	e	μ	π	K	p
e	95	0	2	2	2
μ	0	97	36	41	24
π	2	1	23	15	11
K	1	1	3	5	3
p	2	1	36	37	60

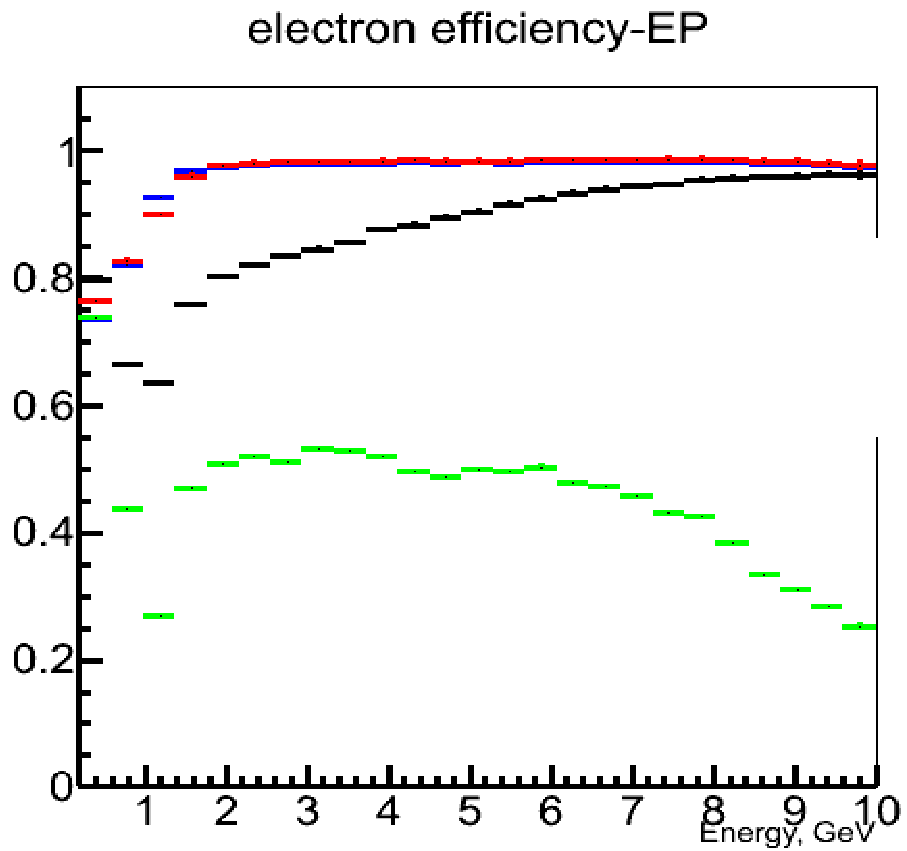
e and μ OK

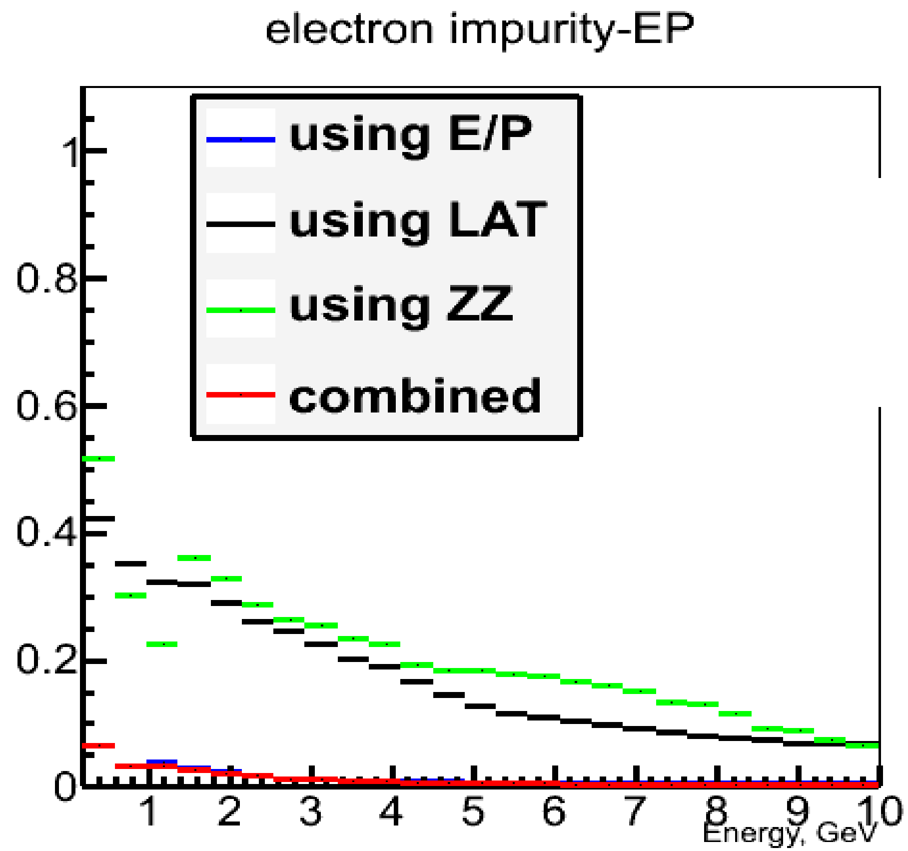
μ impure

Confusing
the hadrons

Annihilation

Efficiency et impurity

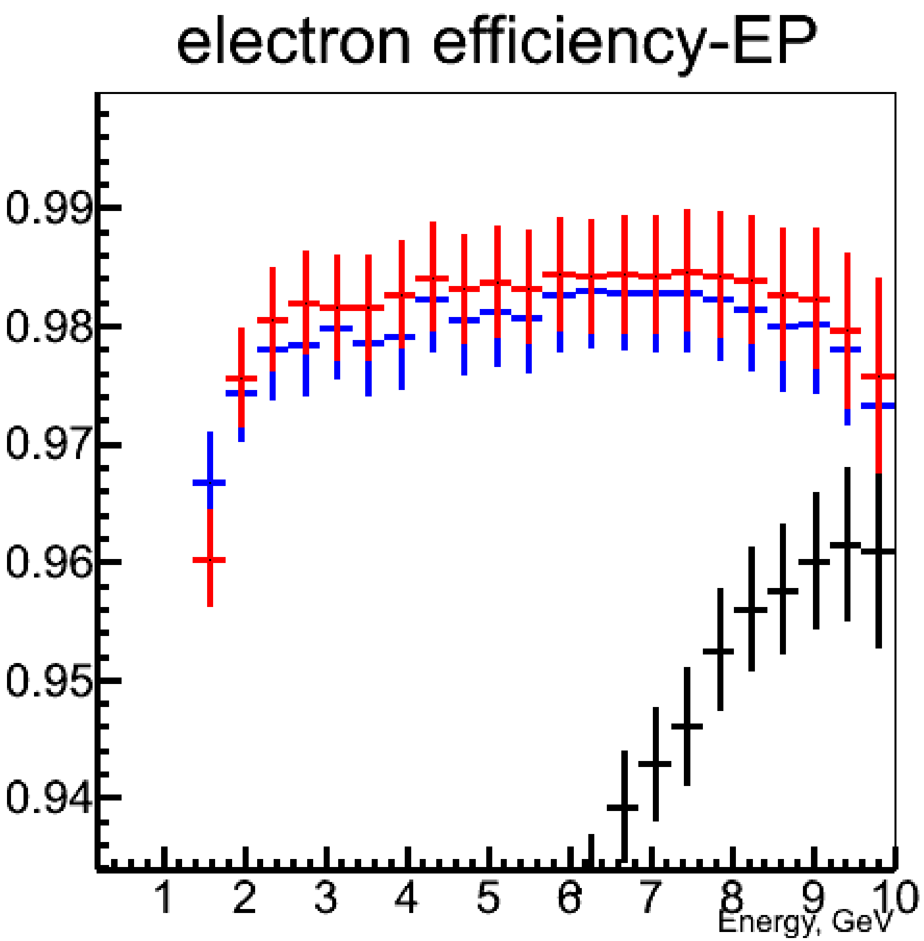


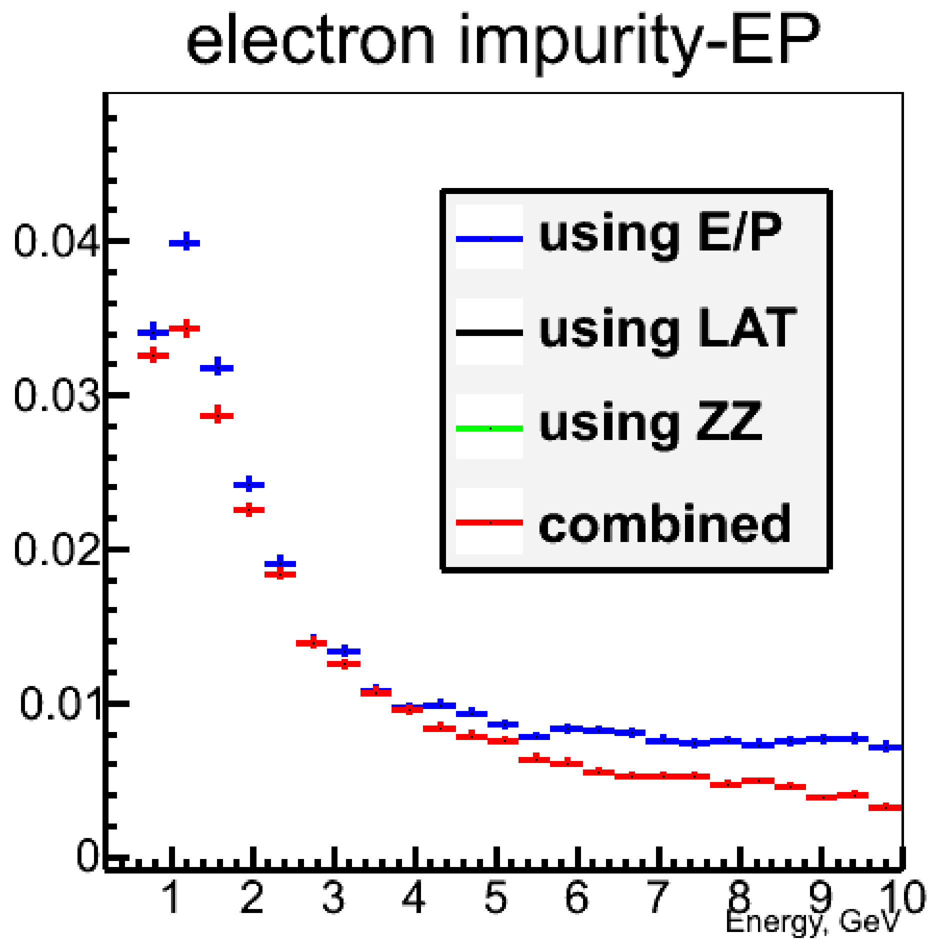


- E/P does most of the job
- ~ independent of charge

- Low E problematic

Efficiency et impurity

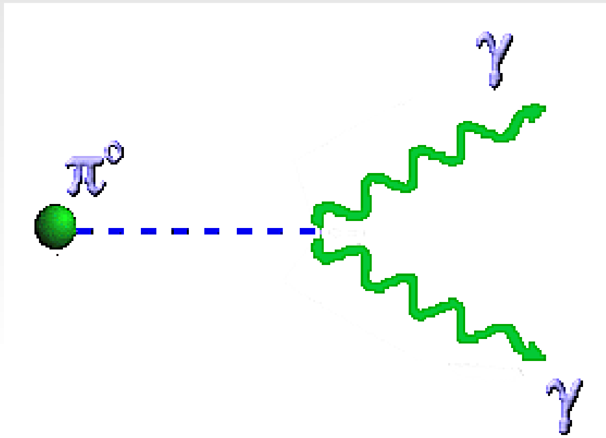




- 98% efficiency above 2 GeV
- border effects at high E

- <1% impurity per track

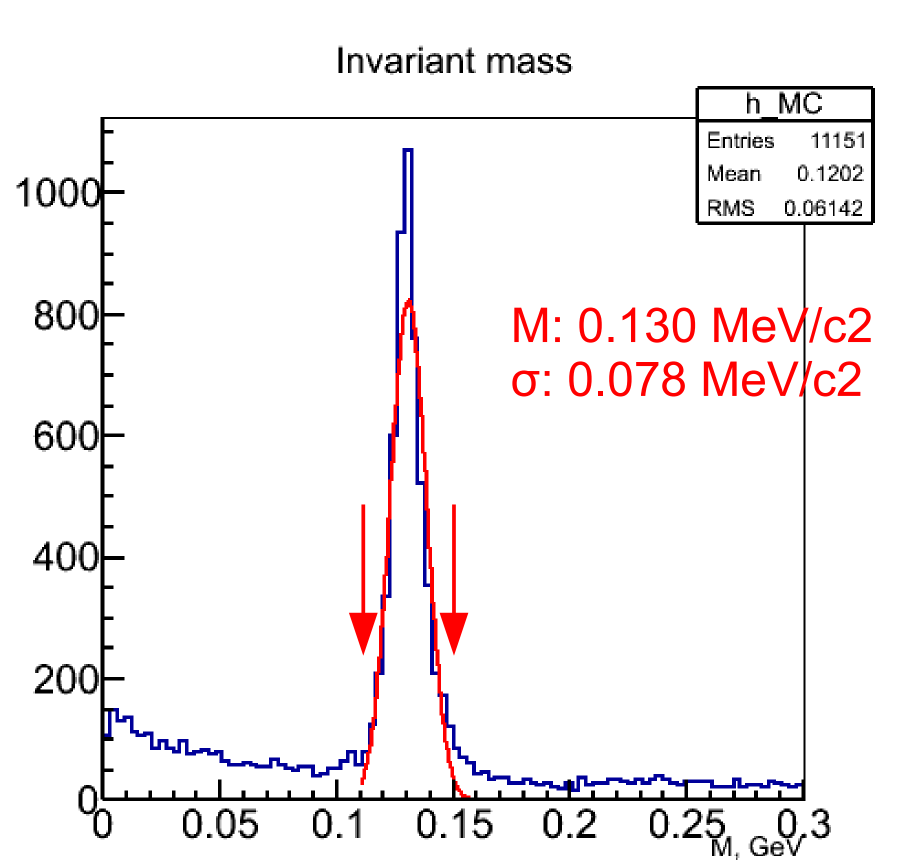
Neutral particle ID

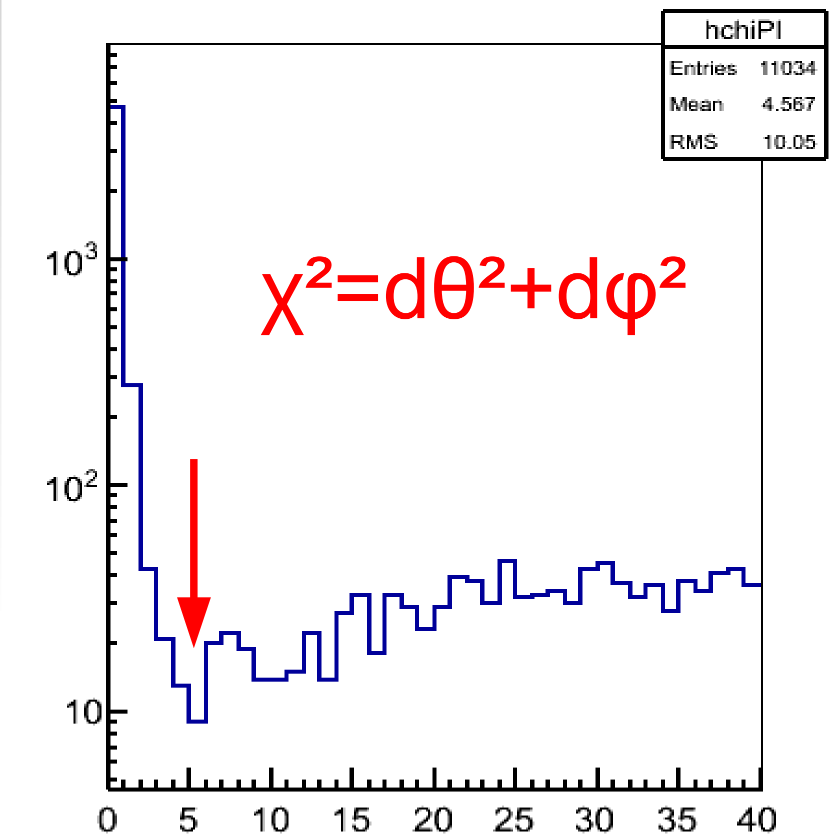


- Problem:

  - $\pi°$'s with small opening angles do not resolve
  - can not be distinguished from single γ's

Reconstruction from two γ





- Cut on invariant mass

$0.11 < M_{\pi^\circ} < 0.15$ GeV

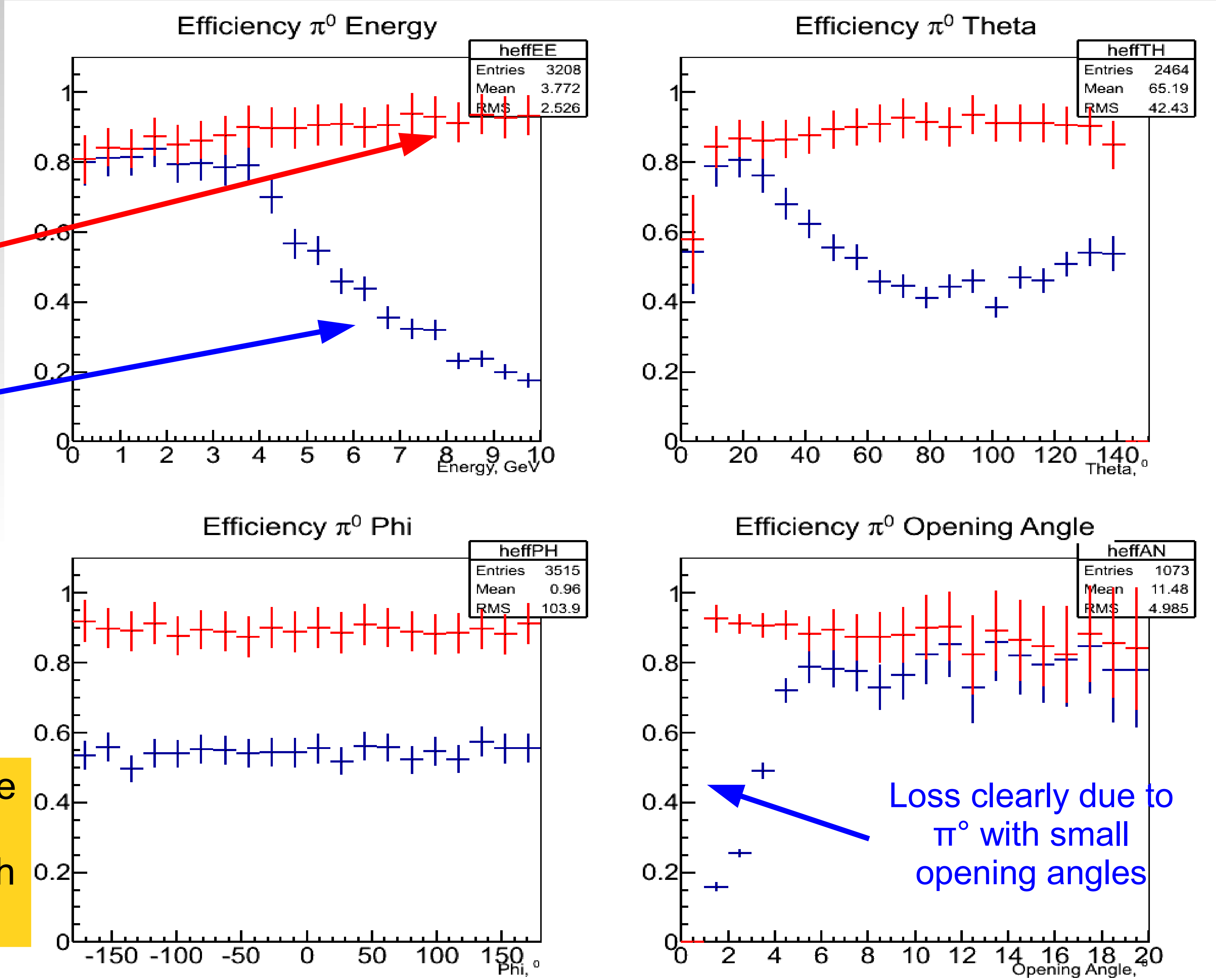
- Good reconstruction if

$\chi^2 = d\theta^2 + d\varphi^2 < 5\ deg^2$

Reconstruction efficiency

Theoretical efficiency

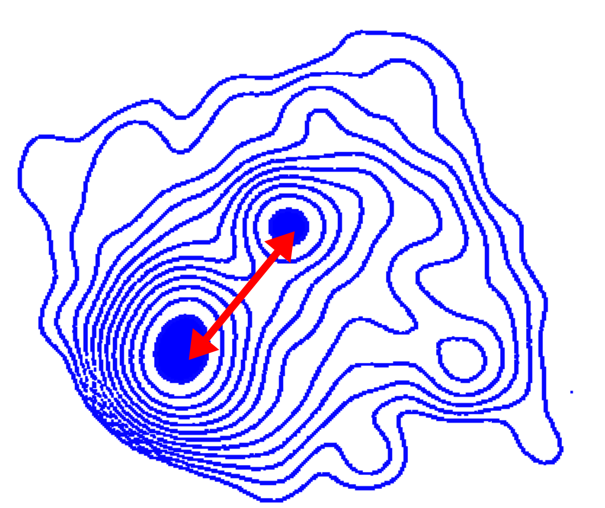
Efficiency from π° reconstruction



Can we recuperate these π°, without admitting too much gammas?

Recuperate unsplit clusters using moments

- Two extra "moments" are defined :



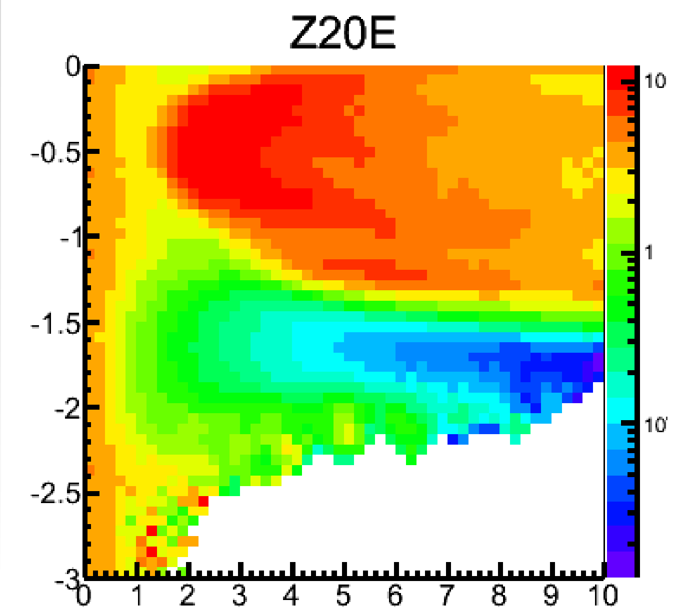
- Shower mass : $(\sum E_i)^2 - (\sum p_i)^2$

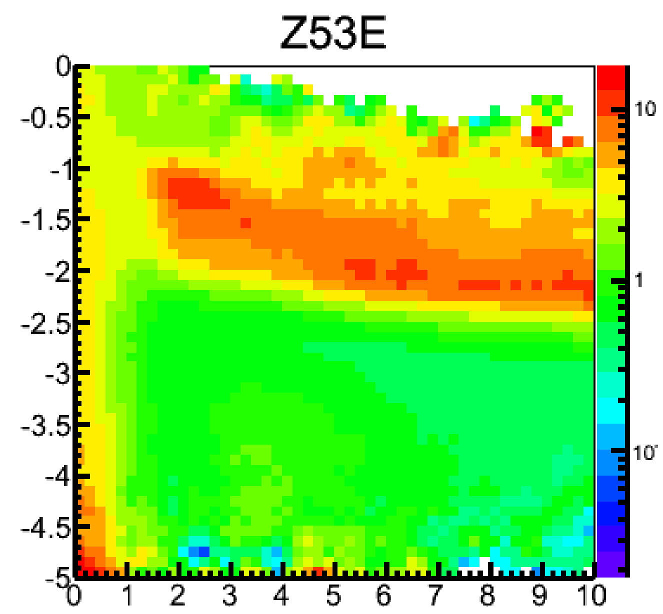
- Correlated maximum separation :

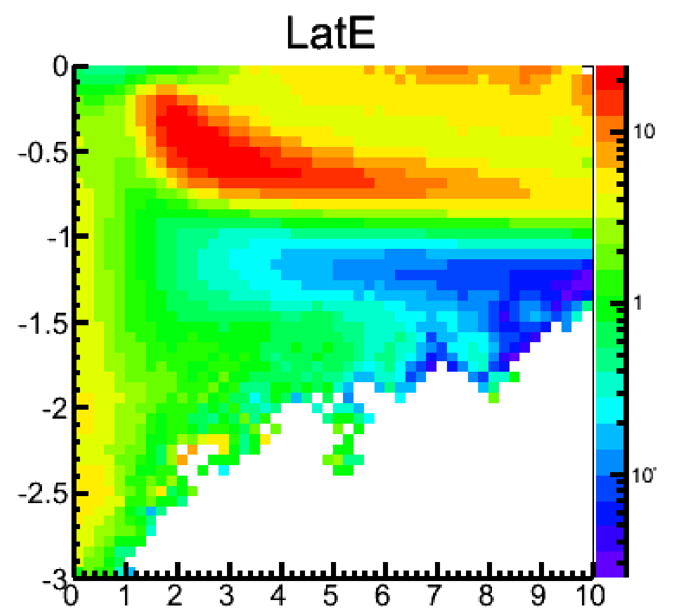
  $\max [E_i E_j (d\theta_{ij}^2+d\varphi_{ij}^2)]$

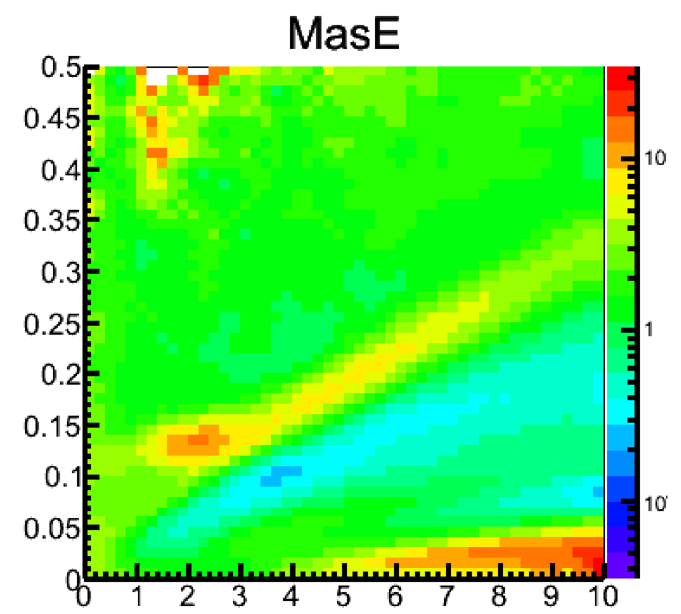
  (where the indices run over the cluster hits)

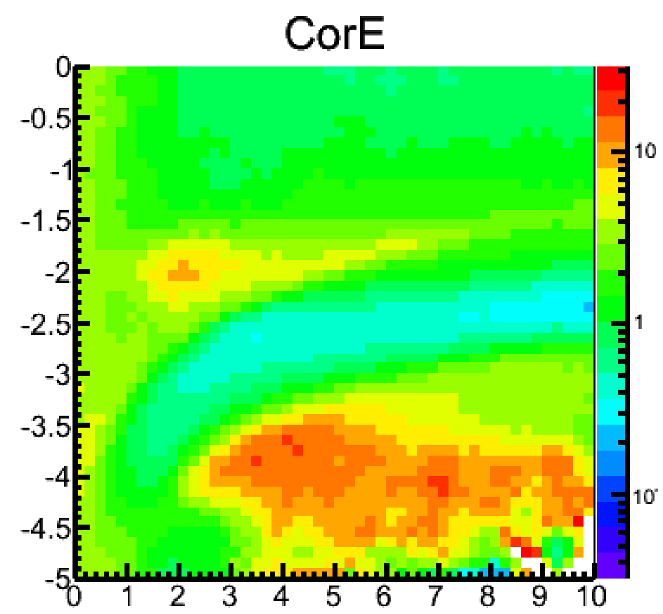
Likelihood factors











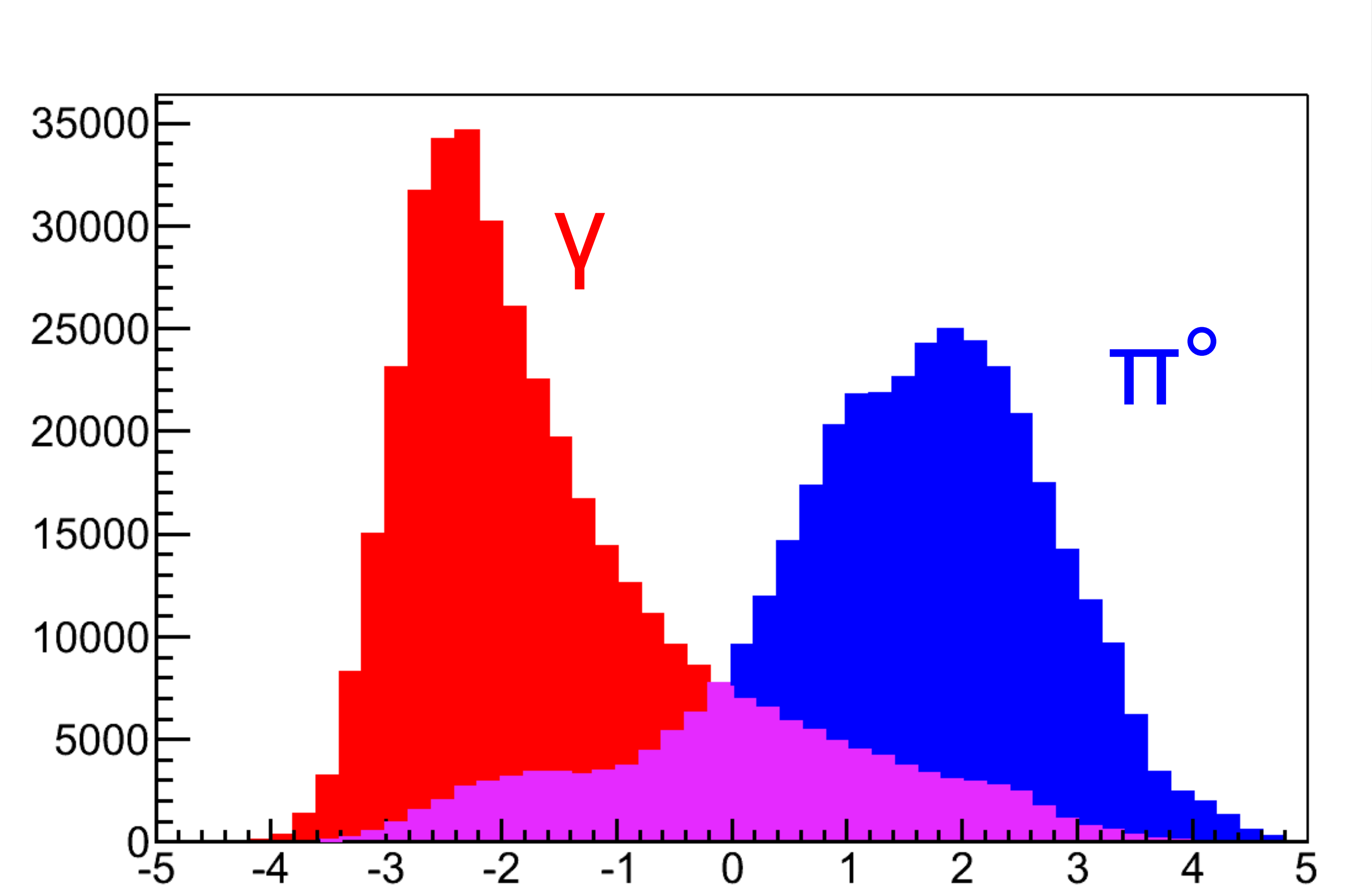
N (E,z |π°) / N(E,z |γ)

Blue : more γ than π°

Red : more π° than γ

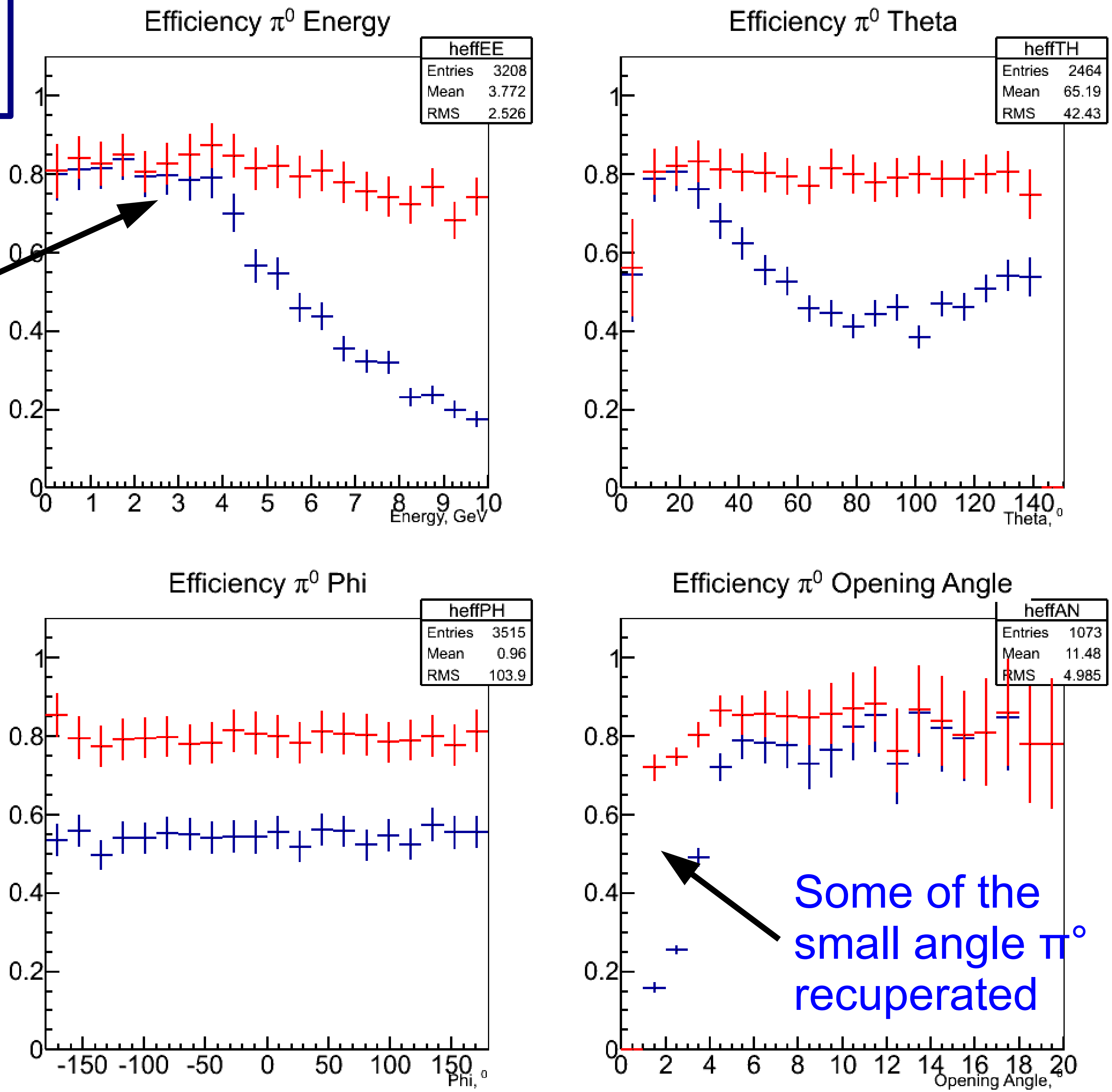
Green : about equal

Bayesian classifier = Σ log(likelihood factor)



events as function of Bayesian classifier

Efficiency π° : five moments

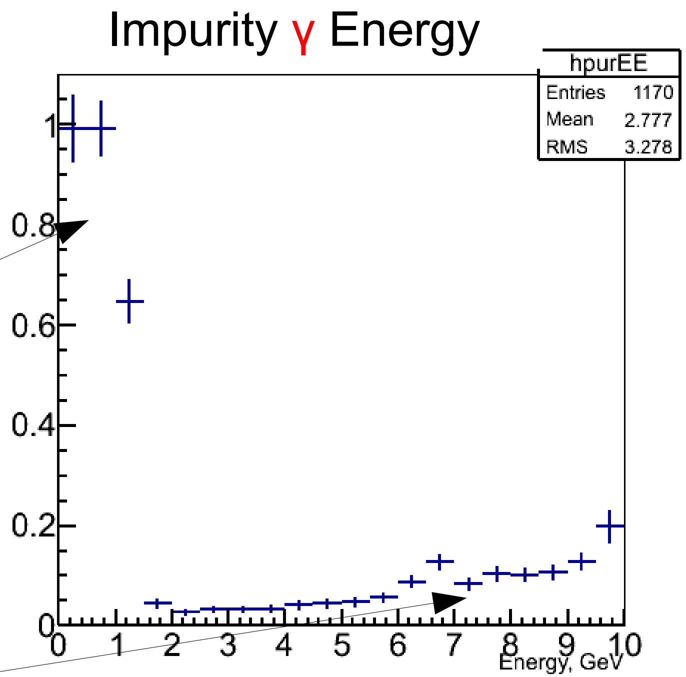


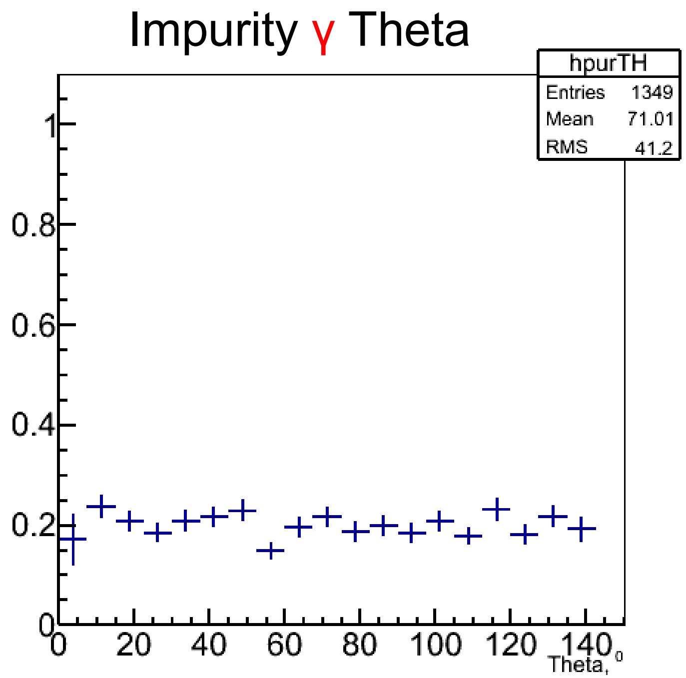
Not needed below 4GeV/c

80% total efficiency

Some of the small angle π° recuperated

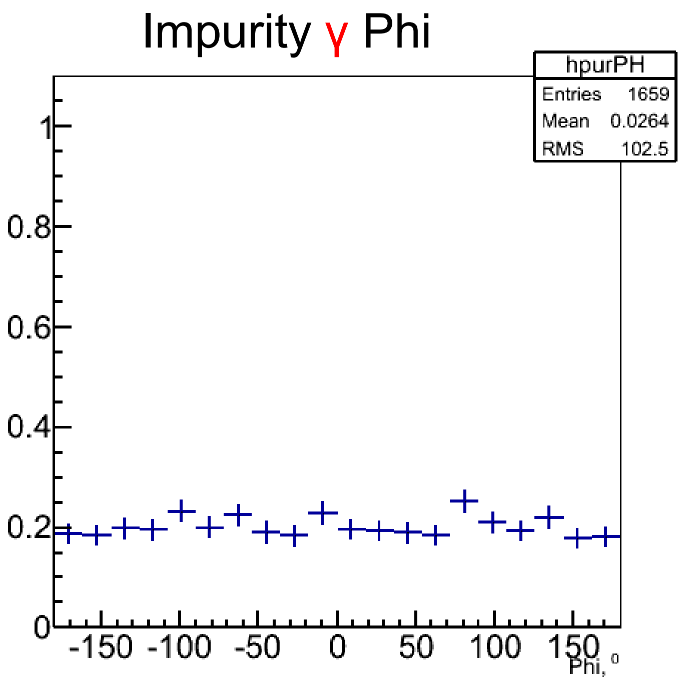
Impurity from gammas





Harmful
below 2GeV/c

5-20% above
2 GeV/c



Impurity is the fraction of γ accepted as π°

Conclusions

- Charged particle ID:

  - Bayesian classifiers combine E/P, LatMom, Z53

  - 98% efficiency for e and μ, above 2 GeV/c

  - 1% impurity for Π, above 3 GeV/c

- Π° reconstruction using bumps :

  - loss due to unresolved clusters, can be recuperated with cluster moments

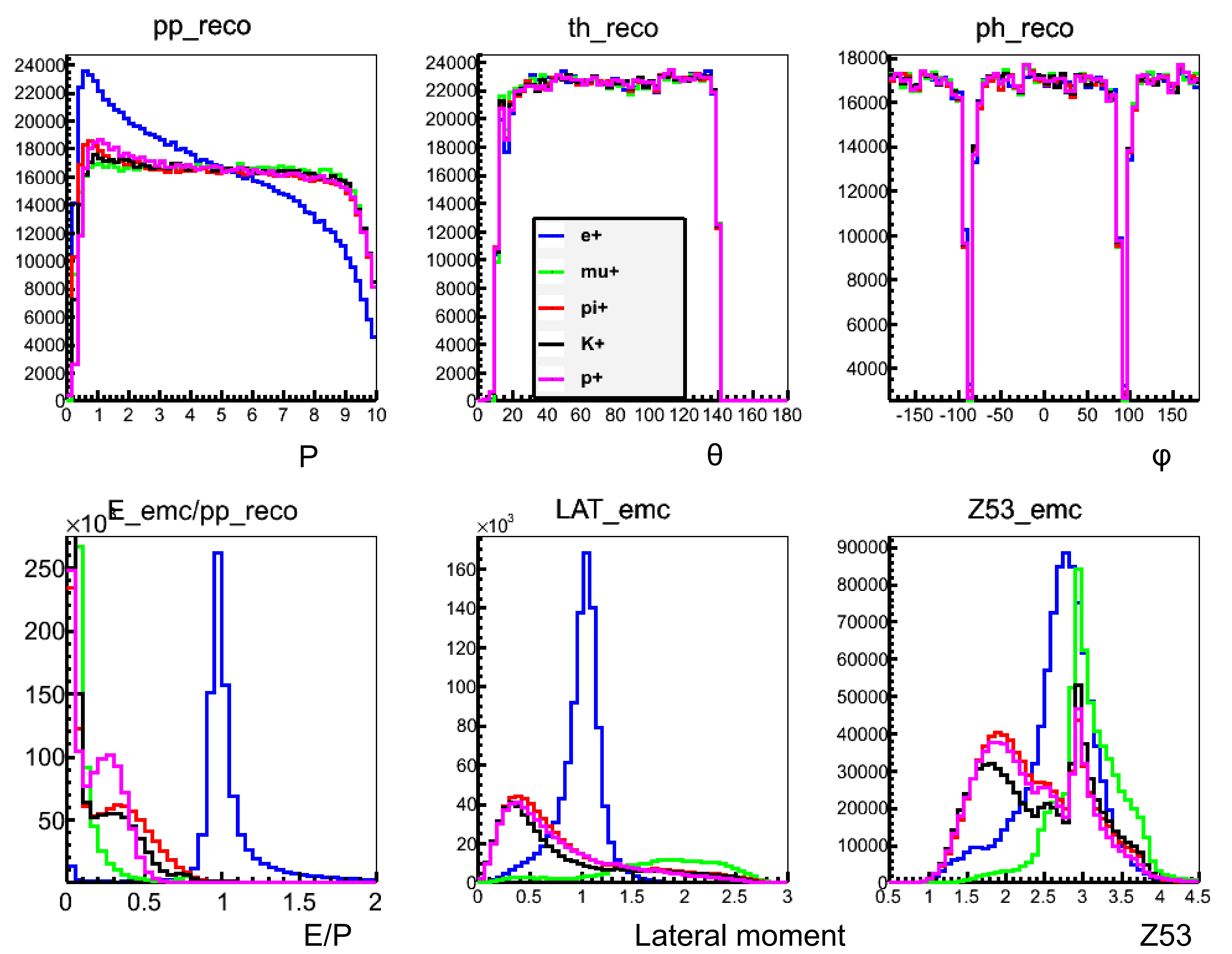
  - price to pay : 5-20% of the single γ pass the test

- - can be implemented as a PndPid class which outputs the

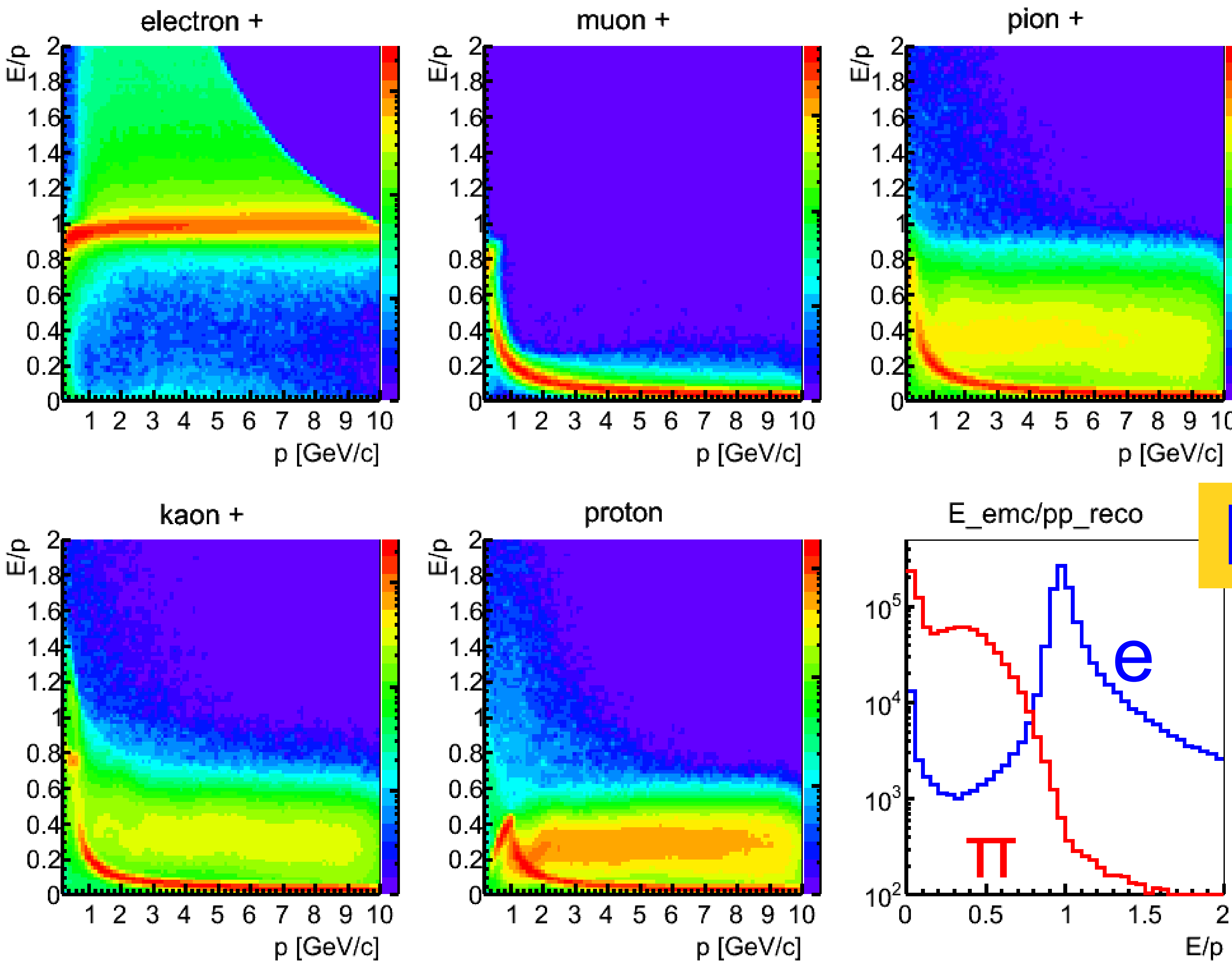
  γ / Π° probability plus momentum

Thank you for your attention !

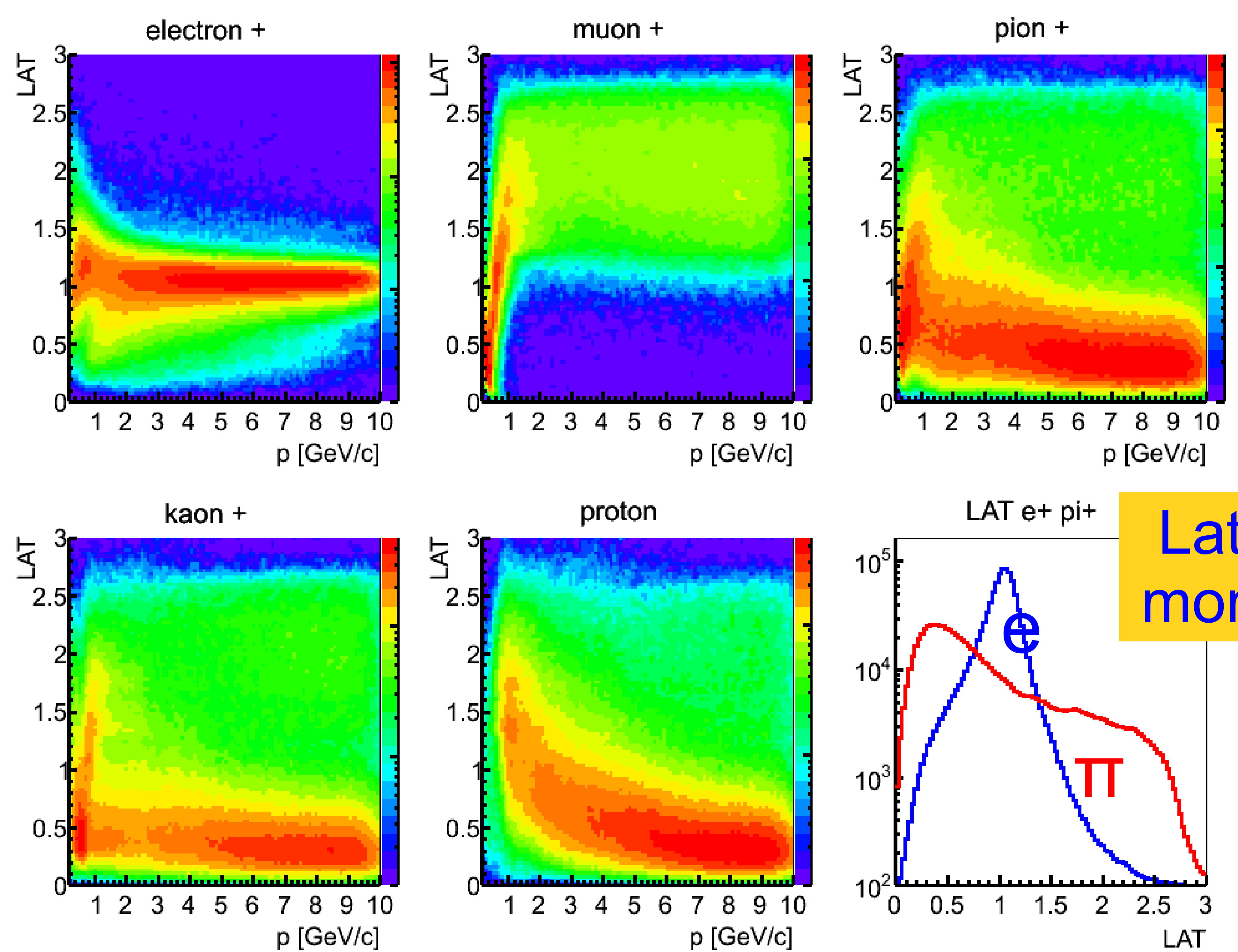
Back up slides

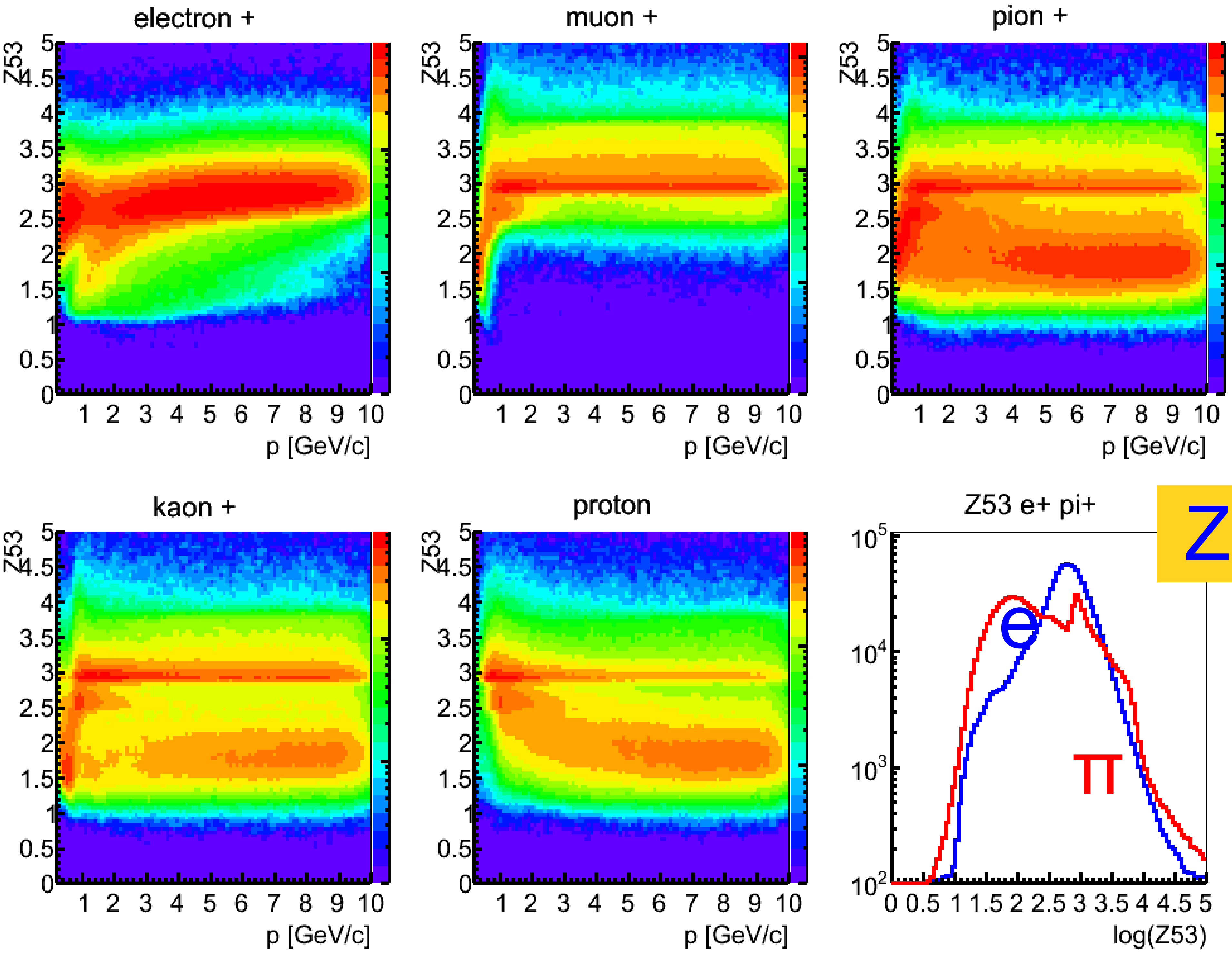

pp_reco
th_reco
ph_reco
P
θ
φ
e+
mu+
pi+
K+
p+
E_emc/pp_reco
LAT_emc
Z53_emc
E/P
Lateral moment
Z53

E/p



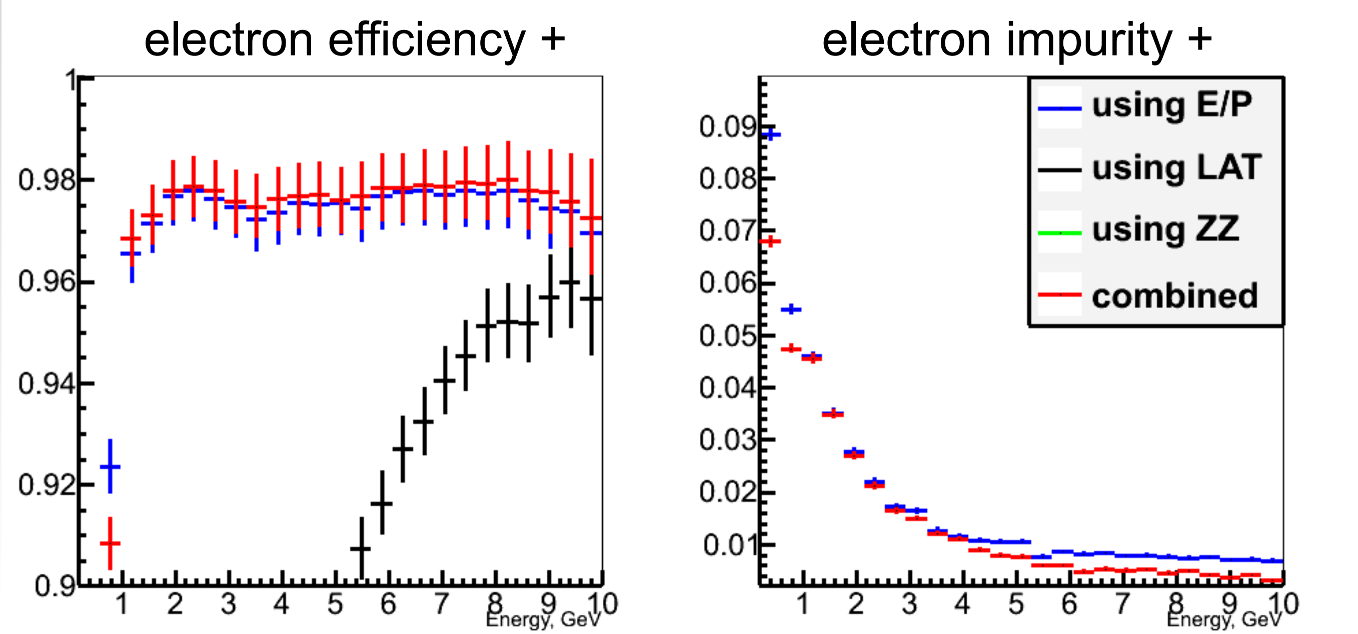
Lateral moment

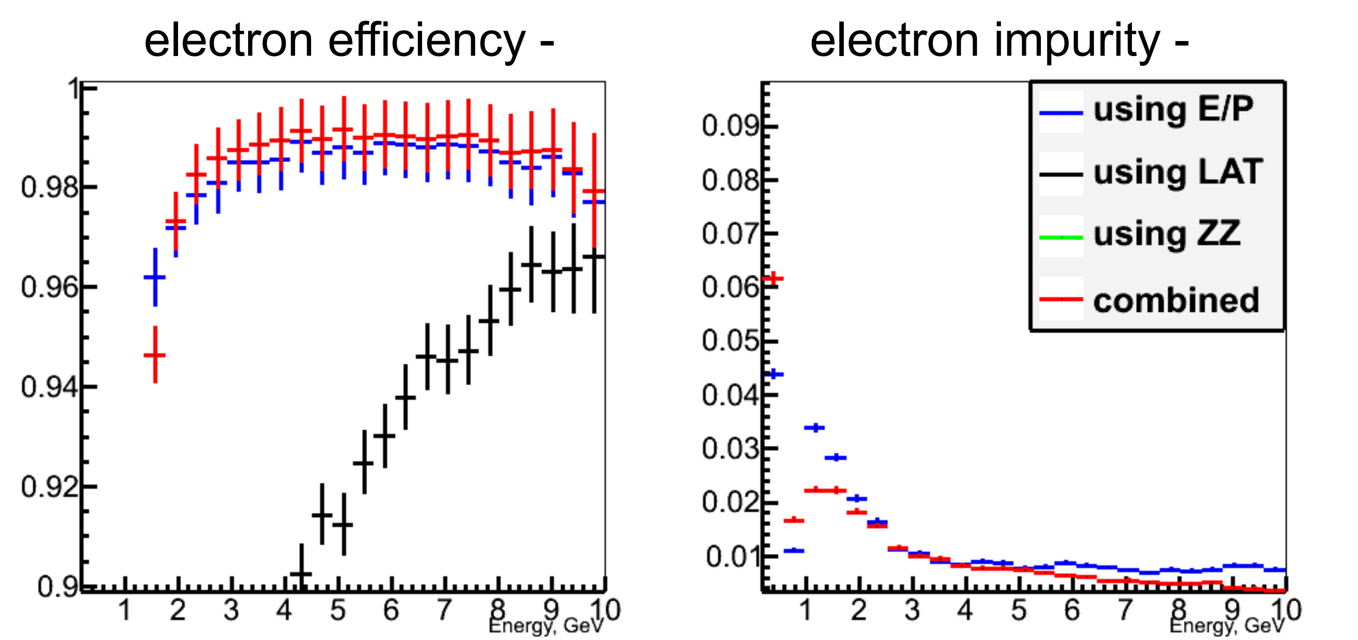




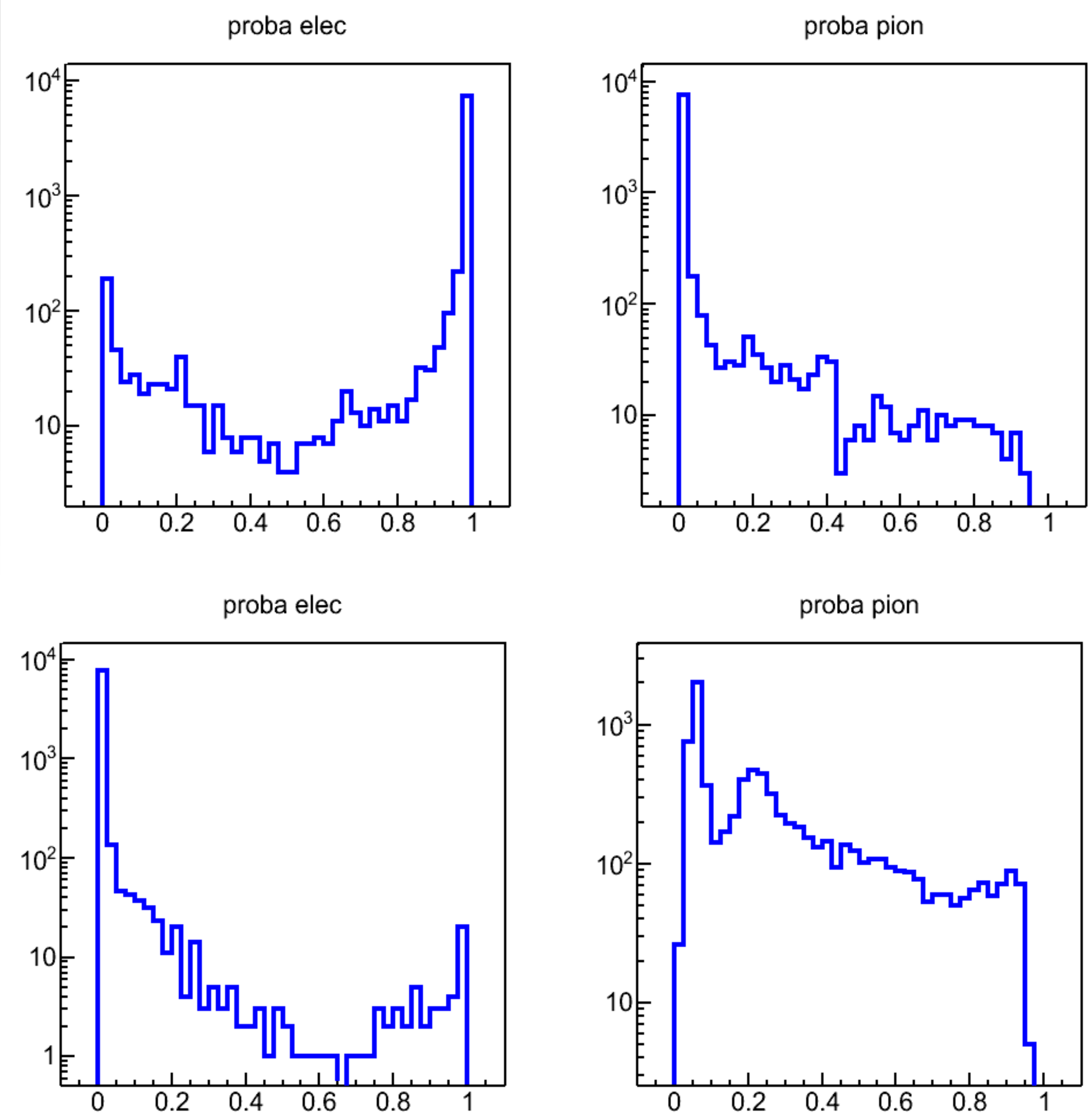
Z53

Charge dependence





Access to probabilities



class PndPidProbability

e+

π+

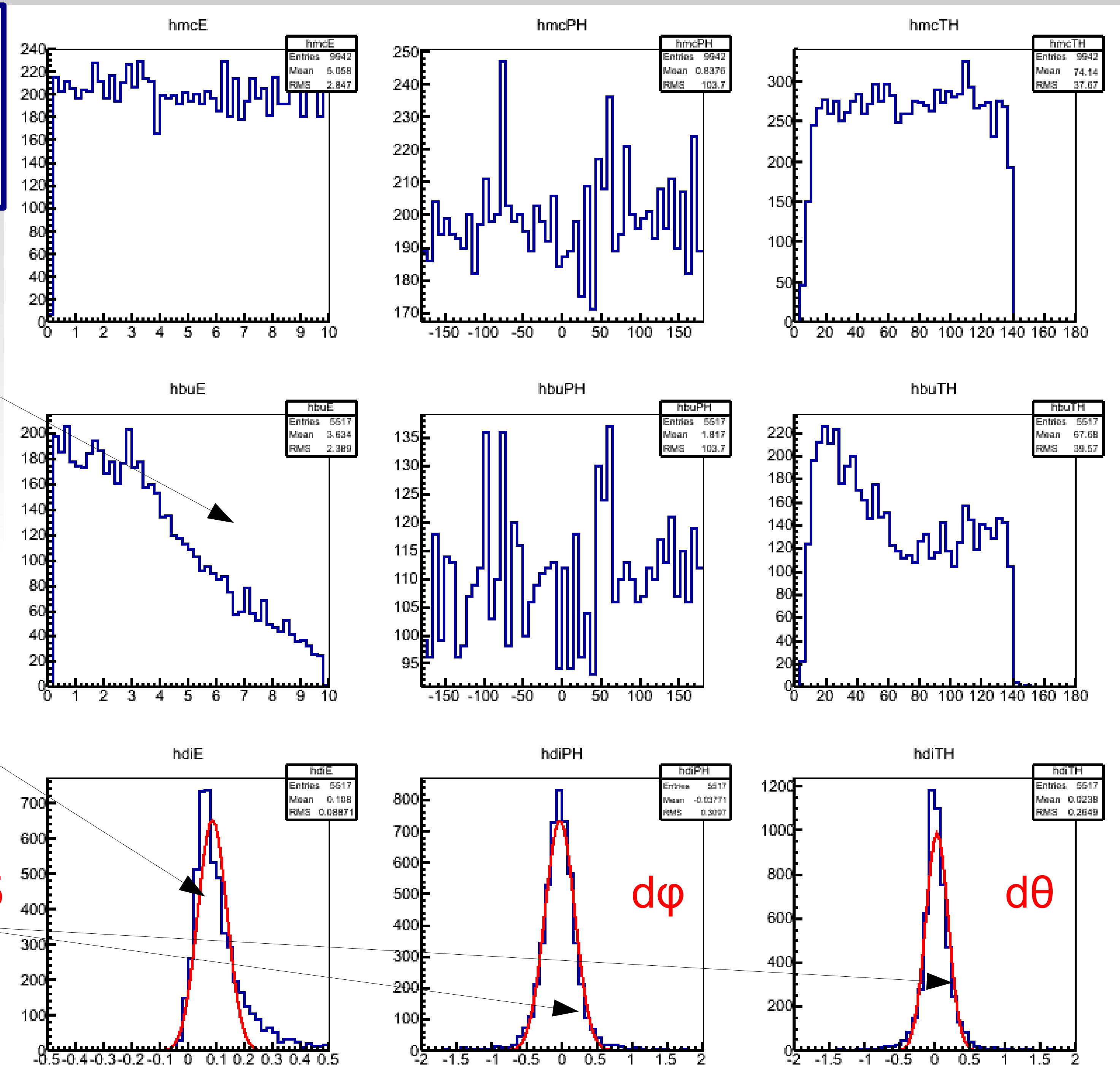
Correlation MC π°- reconstructed π°

Losses !

10K events

Using Bump energies

$\chi^2=d\theta^2+d\varphi^2 < 5$



MC

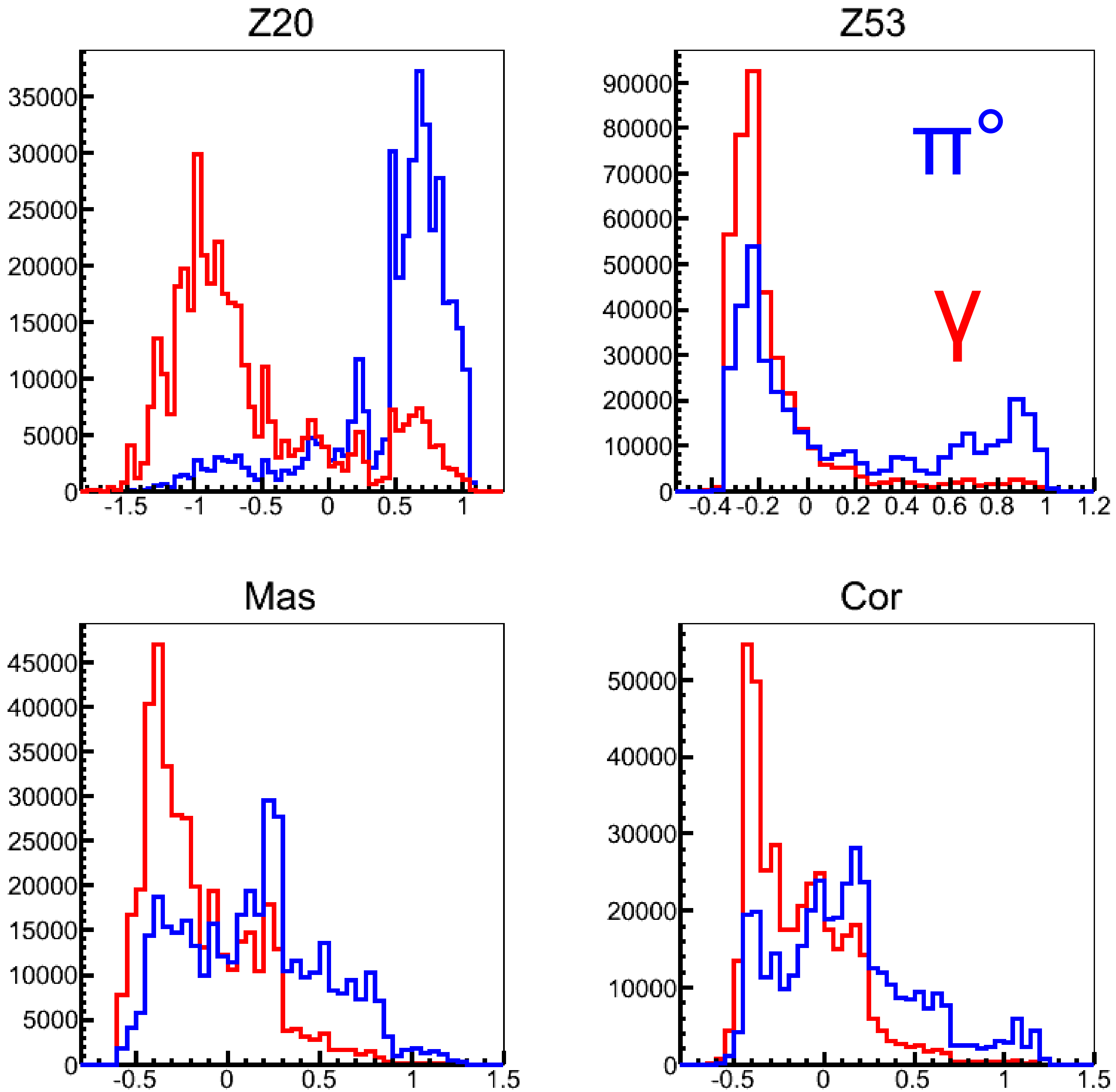
Reco

Residu

Sixteen moments tested

Z00	Z20	Z40	Z11
Z31	Z51	Z22	Z42
Z62	Z33	Z53	Z44
Z64	LatMom	ShowerMass	CorMax

- Not all moments are efficient classifiers
- Many are correlated between them



Separation power

Access to probabilities

```
for (Int_t j=0; j< tree->GetEntriesFast(); j++){
  tree->GetEntry(j);

  cout << "processing event " << j << "\n";

  for (Int_t ii=0; ii<cand_array->GetEntriesFast(); ii++) // Loop over pid candidates
   {
    PndPidCandidate   *cand= (PndPidCandidate *)  cand_array->At(ii);


    PndPidProbability *emc = (PndPidProbability *) emc_array->At(ii);

    ...
   }
}
```