eID at EIC

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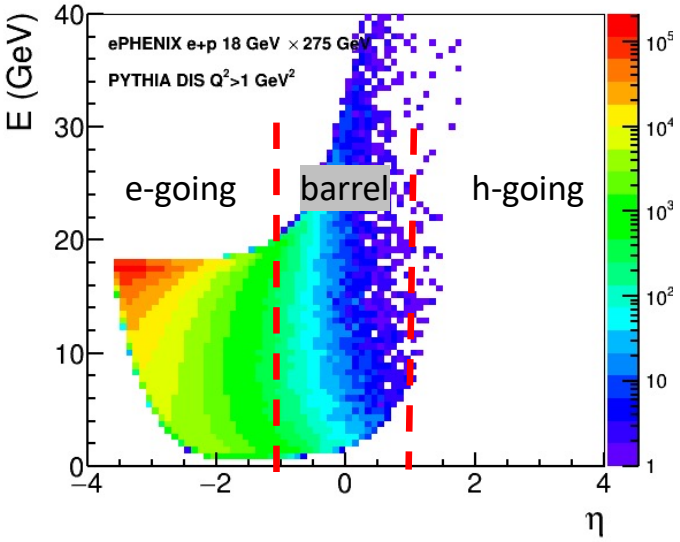
e+p 18x275 GeV



Need for eID:

Up to 18 GeV in e-endcap
Up to 40-50 GeV in barrel

Also decay electrons in all regions

eID tools

All methods in the box are strongly anti-correlated

EMCal+Tracking

Different EMCal response to electrons and charged hadrons => E/p cut

Different transverse profile of Had. and EM showers in EMCal

Different position resolution for electrons and hadrons in EMCal

HCal:

Different long. shower profile of Had. and EM showers => energy back leak out of EMCal

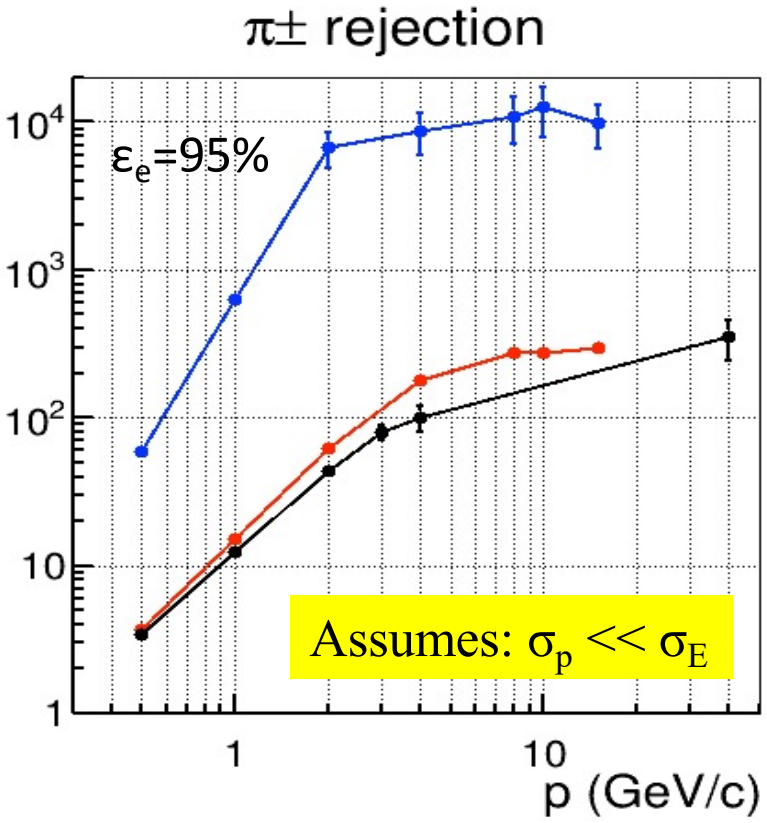
Other detectors:

dRICH

mRICH, ToF, etc (for lower momenta)

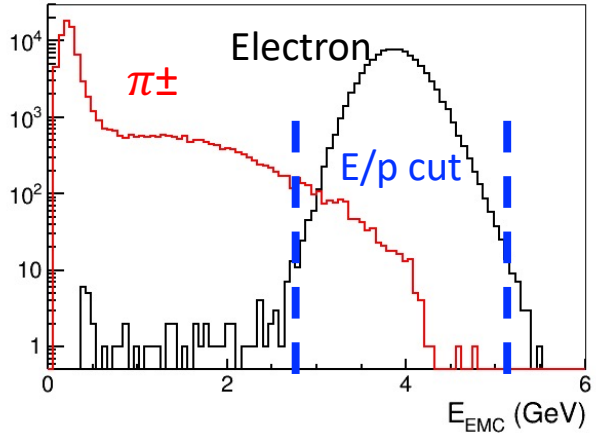
Preshower, TRD (if any)

E/p



E/p > 1 - 1.6·σ_{EMC} to keep ε_e=95%

EMCal response to p=4 GeV/c
(GEANT4 for SPACAL-like EMCal)



Ideal case:
- No material on the way to EMCal
- Perfect EMCal (no gaps/cracks)
- Gaussian response to electron

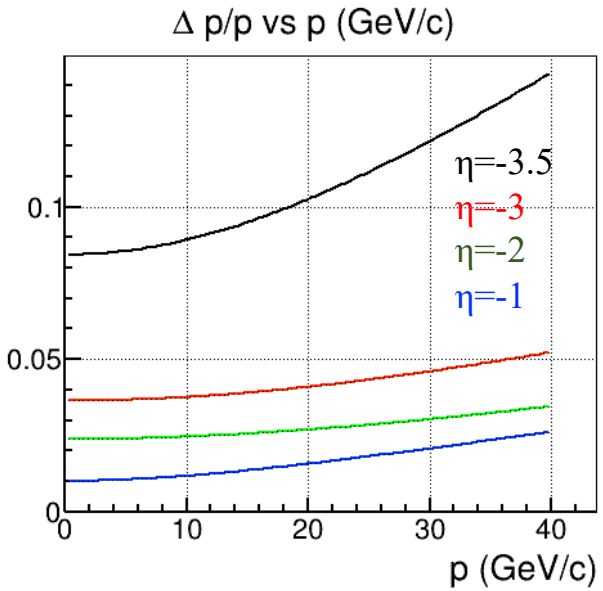
	$PbWO_4$ Crystal (GEANT)	W/SciFi (sPHENIX, GEANT)	PbSc (PHENIX, data)
Depth, X_0	20	~20	18
$\frac{\sigma_E}{E}$	$\frac{2.5\%}{\sqrt{E}} \oplus 1\%$	$\frac{13\%}{\sqrt{E}} \oplus 3\%$	$\frac{8\%}{\sqrt{E}} \oplus 2\%$
Depth, λ_I	0.87	~0.83	0.85
e/h	>2		<1.3

Including momentum resolution

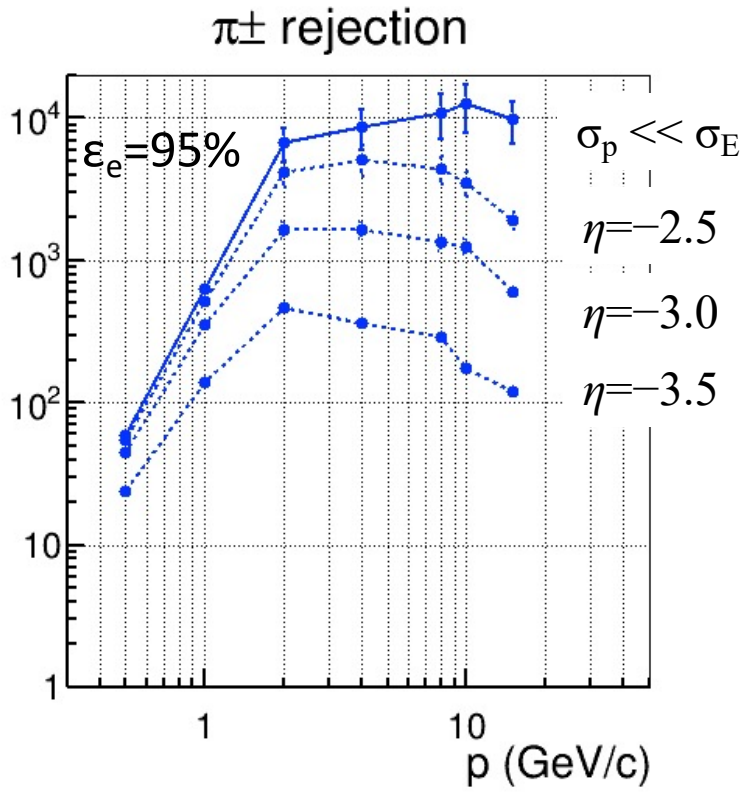
$PbWO_4$ Crystal (GEANT)

$$\frac{\sigma_E}{E} = \frac{2.5\%}{\sqrt{E}} \oplus 1\%$$

BaBar-based Tracking model:
TPC (barrel), Si +GEM (forw)
(Fun4All-GEANT4 simulation)



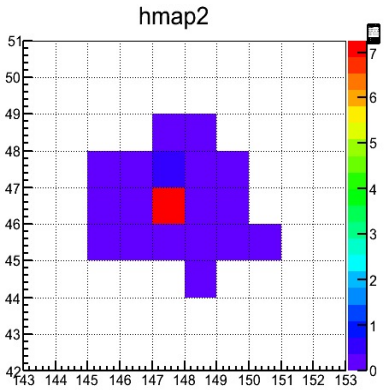
E/p > 1 - 1.6·$\sqrt{\sigma_{EMC}^2 + \sigma_p^2}$ to keep ε_e=95%



Tracking momentum resolution matters

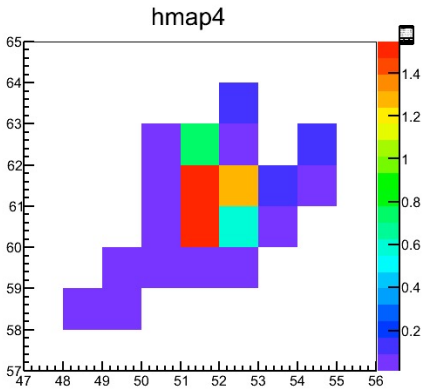
Evaluating shower profile

Electron

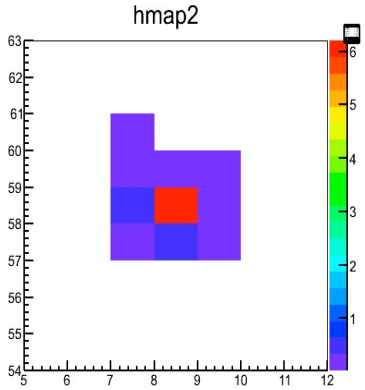


Well defined shower shape

π^-



Broader shape



Very similar to electron shower shape

$$\chi^2 = \sum \frac{(E_i^{meas} - E_i^{pred})^2}{\sigma_i^2}$$

E_i^{meas} – measured energy in a tower

$E_i^{pred} = E(x_i\text{-}x_{CG}, y_i\text{-}y_{CG})$ – predicted energy in a tower from electron shower parameterization

$\sigma_i = \sigma(x_i\text{-}x_{CG}, y_i\text{-}y_{CG})$ – fluctuations in a tower from electron shower parameterization

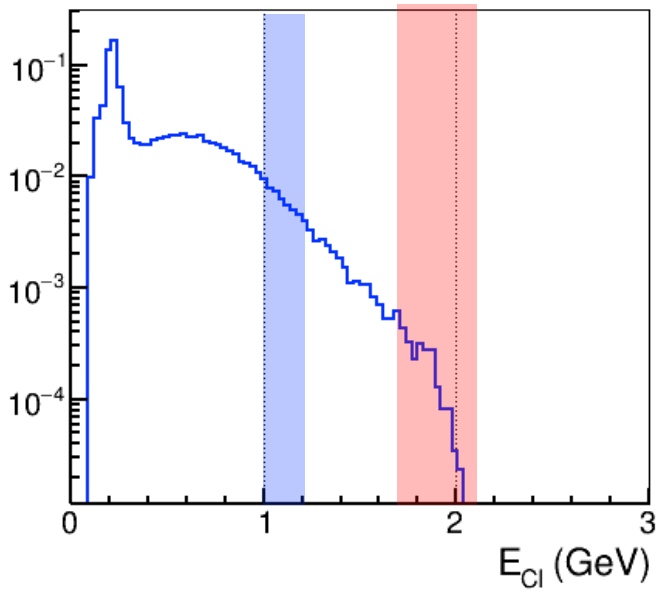
Profile χ^2 : electron vs π-

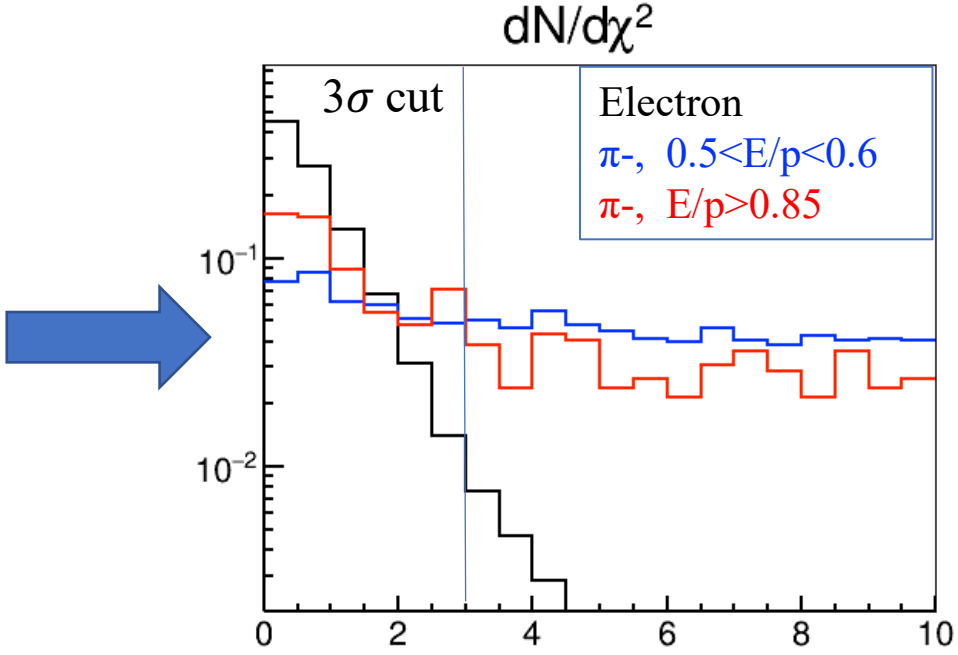
$PbWO_4$ Crystal (GEANT)

$$\frac{\sigma_E}{E} = \frac{2.5\%}{\sqrt{E}} \oplus 1\%$$

Additional hadron suppression with trans. profile strongly anti-correlates with E/p method

EMCal response to 2 GeV/c π-

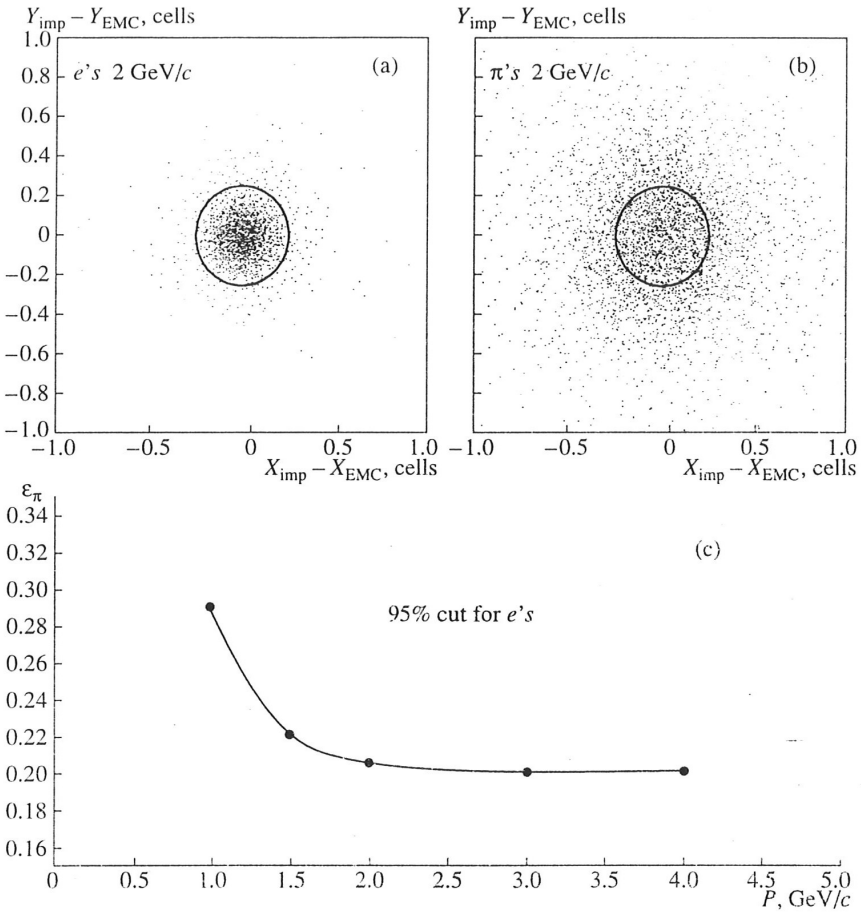




Rejection ~10

Rejection ~4

Position resolution in EMCal



Position resolution for electrons and pions in the EMCal are different

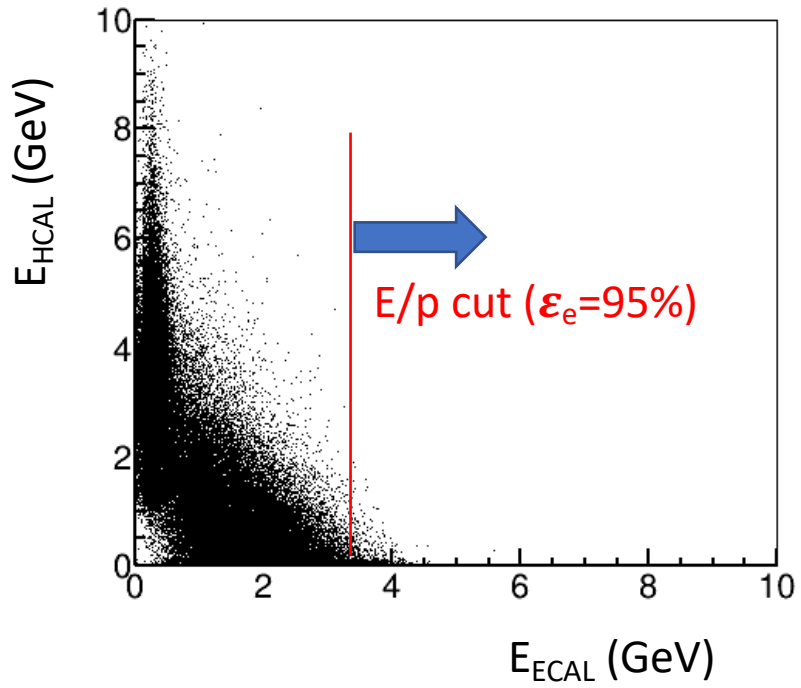
In principle, may give a suppression factor of ~5 … if no other cuts applied

On top of E/p and Profile cuts, the additional suppression will be modest

For non-projective EMCal the gain will be even smaller (worse EMCal position resolution)

HCal

4 GeV pi- in Pb/SciFi + HCal

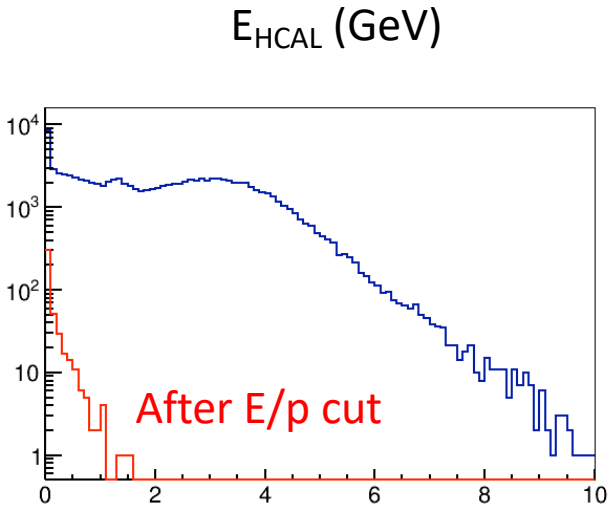


Pion rejection:

$E_{HCal} < 0.1$ GeV: x12

E_{ECAL}/p cut: x200

E_{ECAL}/p & $E_{HCal} < 0.1$ GeV: x300



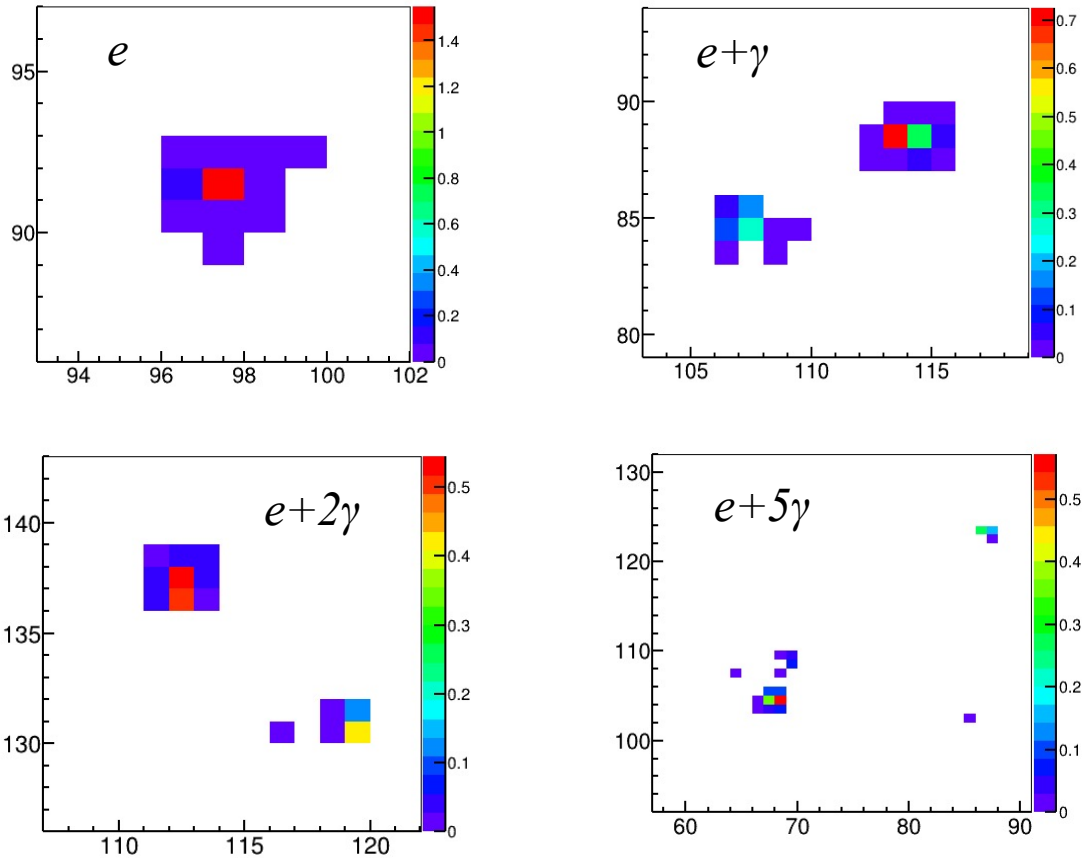
Additional hadron suppression with HCal strongly anti-correlates with E/p (and shower profile methods)

The more suppression from E/p (+profile) the less additional gain from HCal

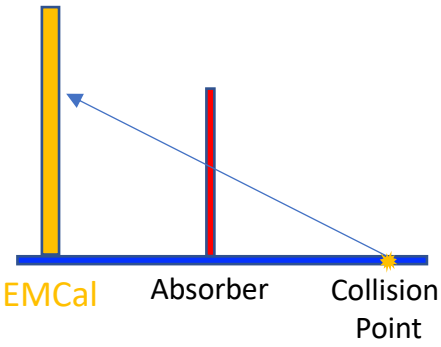
eReco in EMCal with material on the way

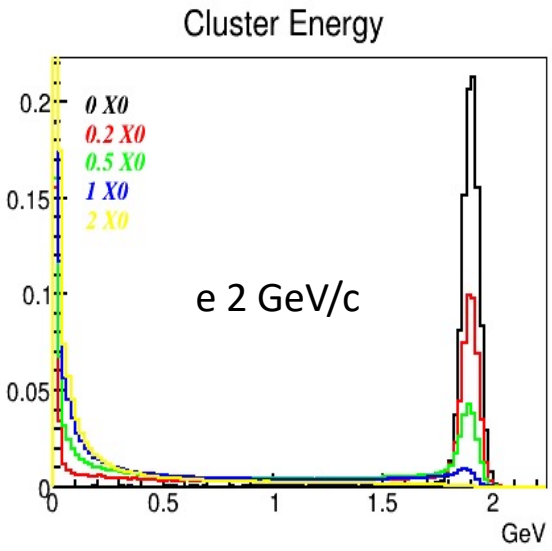
Single 2 GeV electrons simulation
with ~5% material on the way to EMCal

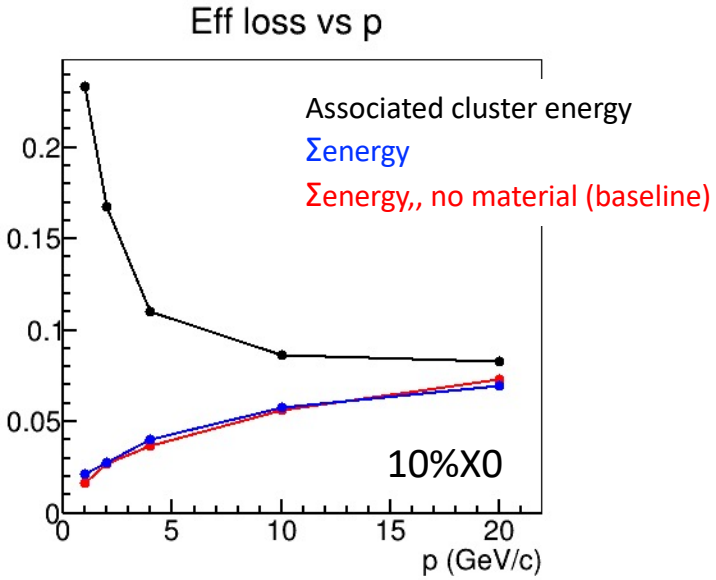
Energy in EMCal towers



eReco in EMCal with material on the way







Electron energy gets redistributed in the EMCal (Electron + radiated γ and e^+e^-)

Single (track associated) cluster doesn't represent well the electron energy, particularly at low momenta

Need to sum it up with with other clusters from radiated photons

This is a separate topic for another … hour

Concluding Remarks on eID

Eventually, all methods will participate

- And will be optimized, e.g. through ML

The most power comes from E/p

- π suppression: from 100 to a few 1000 at > 3 GeV/c

Then, additional power provided by shower profile

- π suppression: additionally by x(2-4)

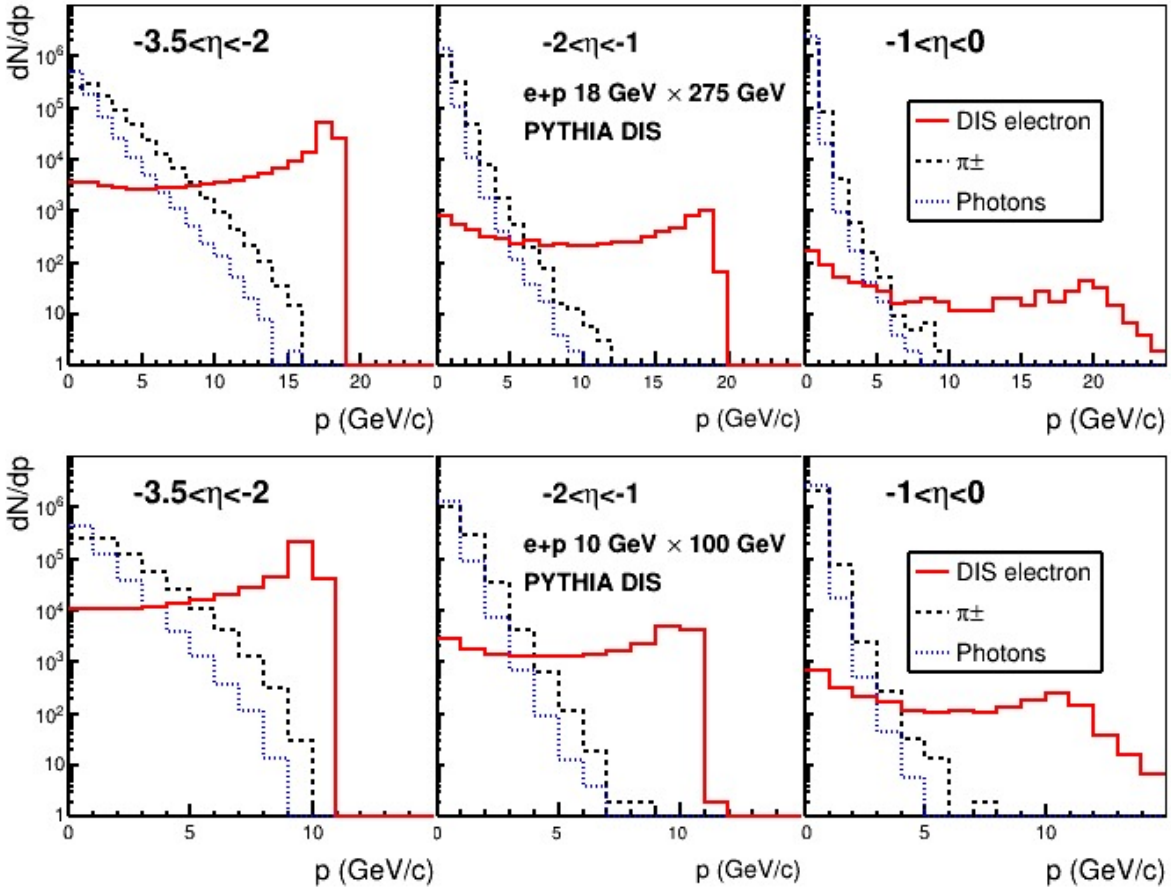
Then, some more power provided by position measurements and HCal

- π suppression: by (20-50)% on top of above

Other detectors (e.g. dRICH, mRICH, TOF, TRD) provided independent eID

Need to look in the effect of material!

- EMCal Cluster associated with a track may be not enough for eReco



18x275 GeV

10x100 GeV

Clean measurements at higher momenta
Huge background at lower momenta