Effect of Material on electron measurements in eEMCal (PWO). Simplified Studies

A.Bazilevsky

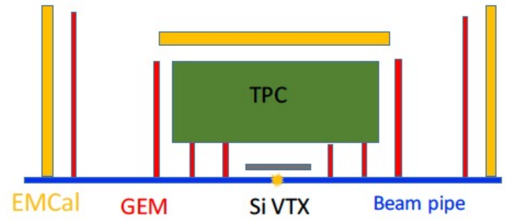
For ATHENA-Calorimetry Discussion

August 30, 2021

For ATHENA-Tracking Discussion

August 31, 2021

Back to YR studies

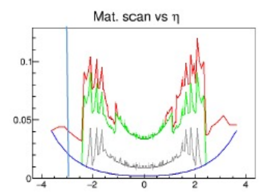


No PID detectors
No support/service material

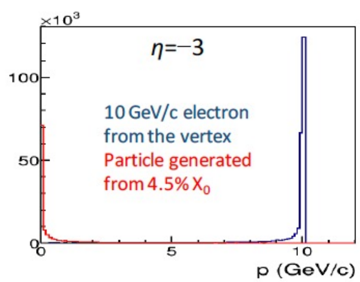
From my presentation for YR-Calorimetry, Jun 30, 2020

What hits the EMCal

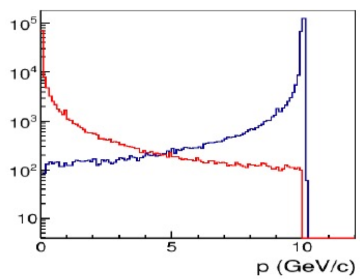
After ~4.5% of X_0



Lin. scale



Log. scale



Single 10 GeV/c electrons generated

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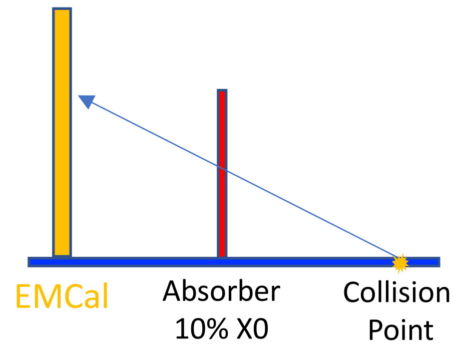
Original electron reaches EMCal with part of its energy radiated

Long and flat tail towards lower energy

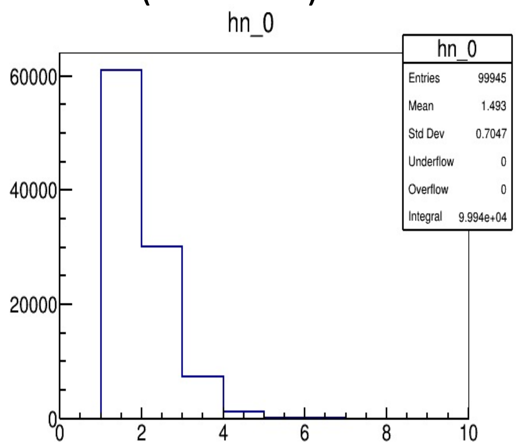
A lot of soft particles, mainly photons

Making setup simpler

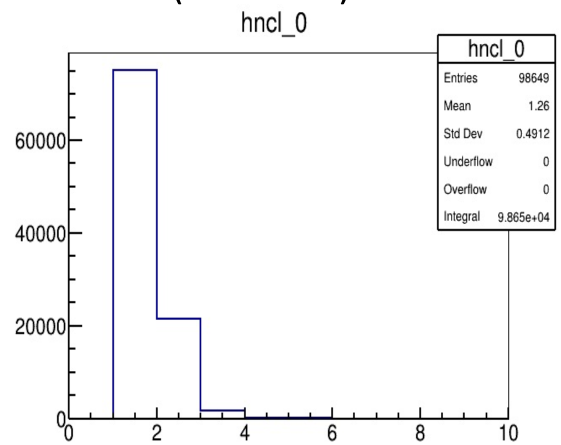
1 GeV/c electron



Number of particles hitting the EMCal (>20 MeV)



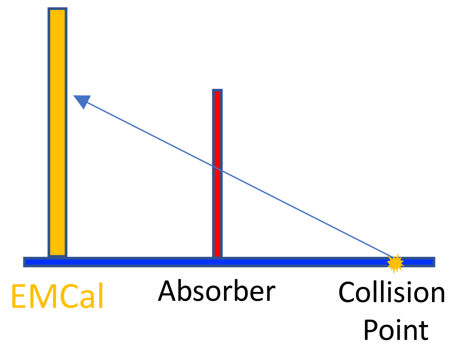
Number of clusters in the EMCal (>20 MeV)



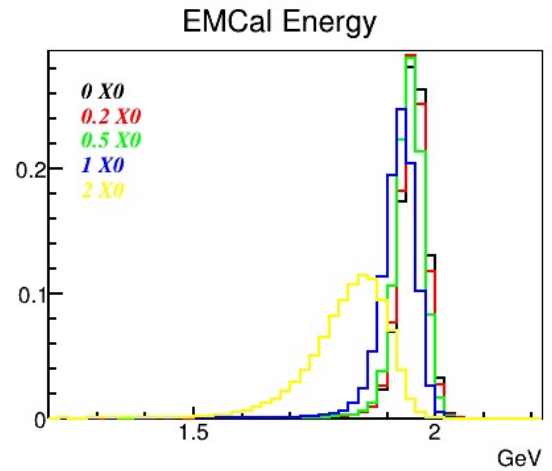
~40% of events with >1 particle hitting the EMCal (>20 MeV)

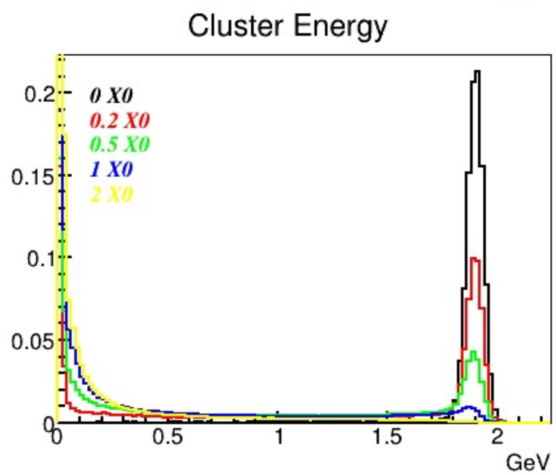
¼ of events with >1 cluster (> 20 MeV)

Making setup simpler



2 GeV/c electron





Energy is not lost for the thickness <0.5*X0
(Consistent with EM shower long. profile)

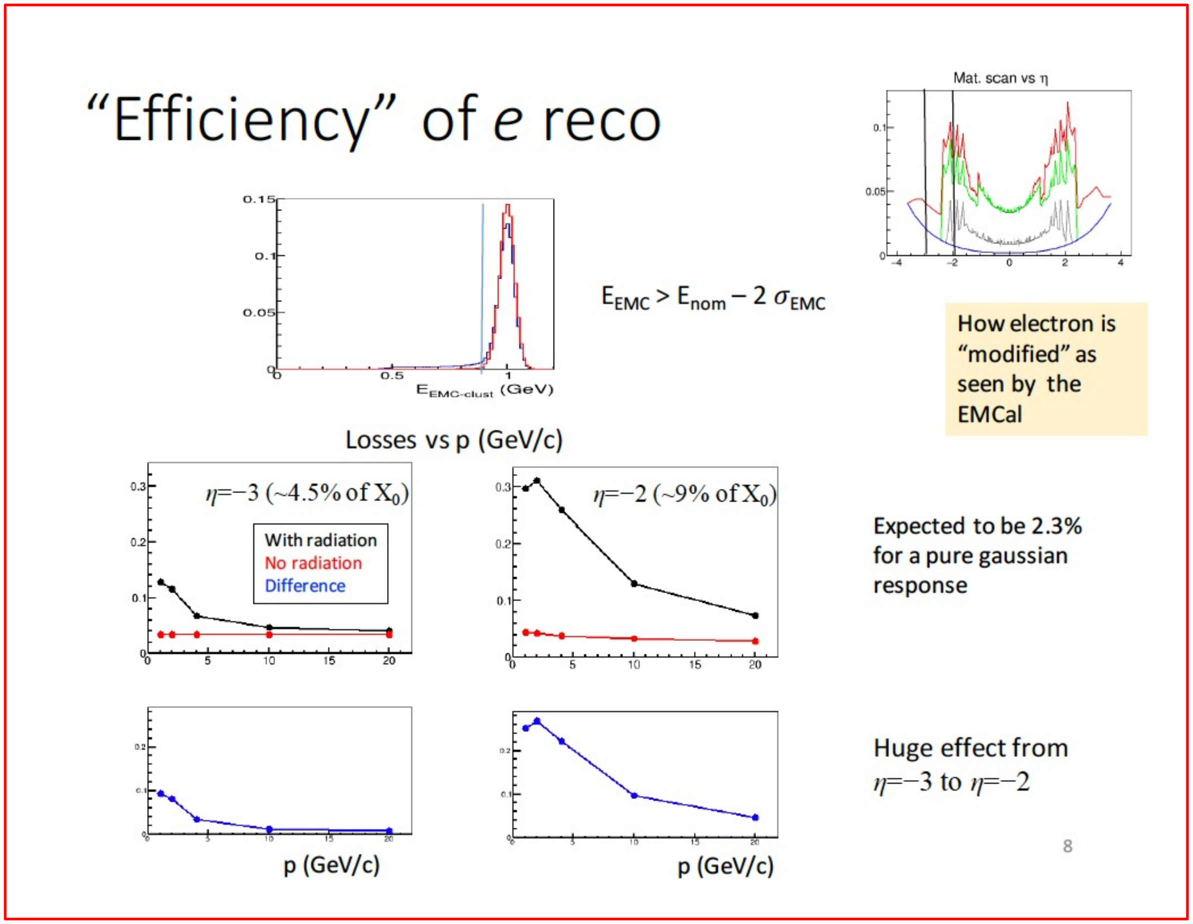
But energy gets redistributed in the EMCal
(Electron + radiated γ and e^+e^-)

For the material of <0.5*X0, no energy is missing

The key question is how well we can reconstruct/associate the energy related to original electron

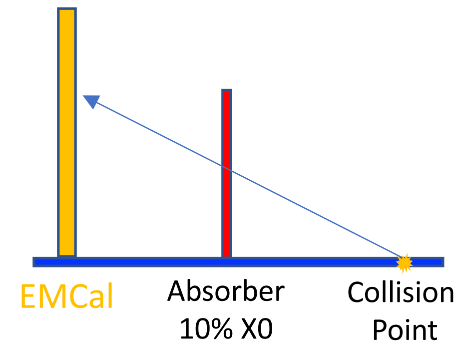
Quantifying the effect

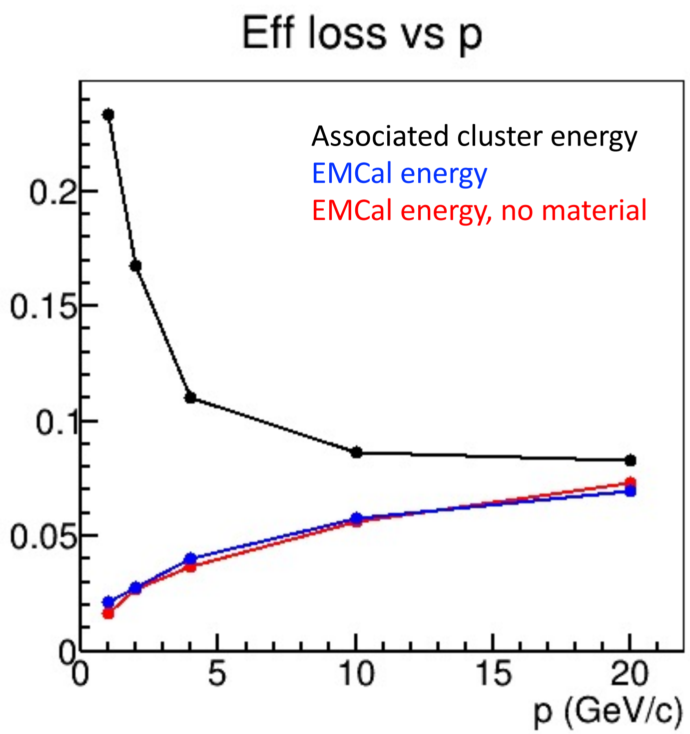
From my presentation for YR-Calorimetry, Jun 30, 2020



Now, do the same in the following

Associated cluster vs energy sum





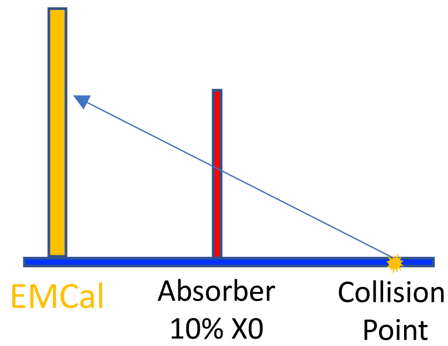
Single (track associated) cluster doesn't represent well the electron energy, particularly at low momenta

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

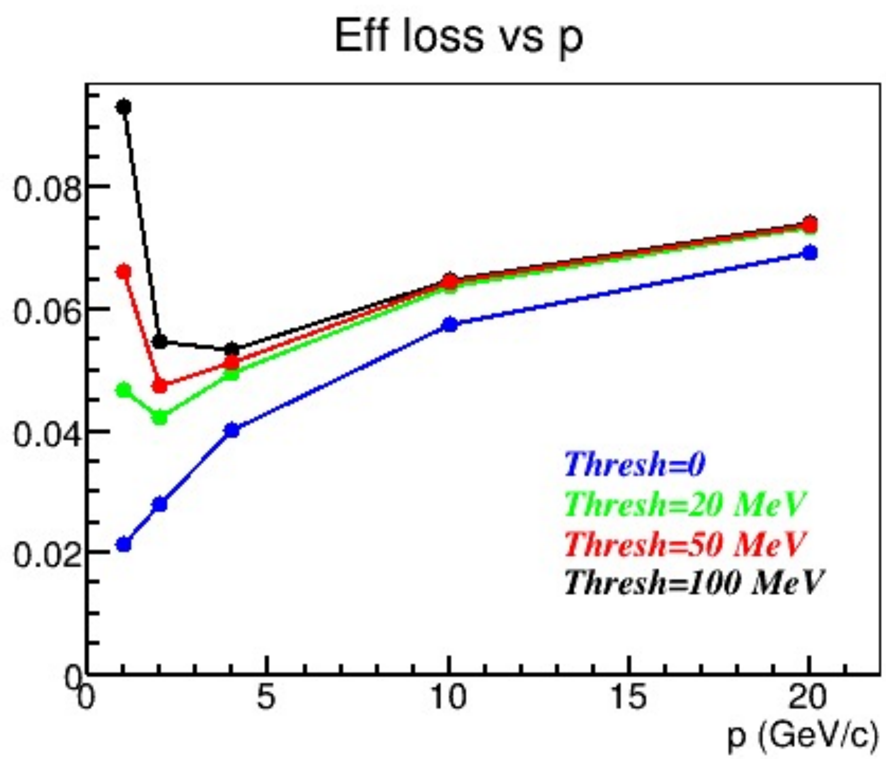
e-track associated cluster – not enough

Need to combine electron cluster with accompanying radiation (including very low energy one)

Energy sum:
cluster threshold effect



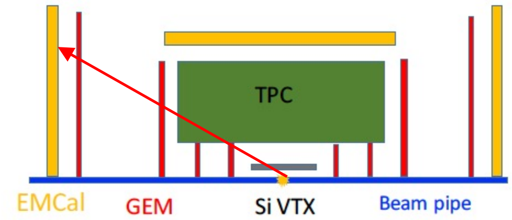
A lot of low energy radiated photons
=> sensitivity to energy threshold



Minor effect at p>5 GeV/c
Sharply increasing effect at p<2 GeV/c

Need to measure photons to as low energy as possible (down to 20 MeV)

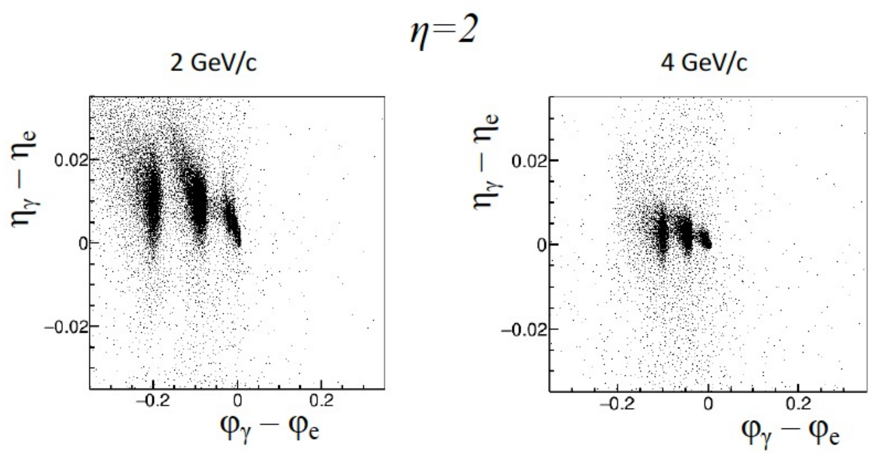
Radiated photons are not everywhere



From my presentation for YR-Calorimetry, Jul 14, 2020

Radiated photon topology

Radiated photon relative electron position at the EMCal



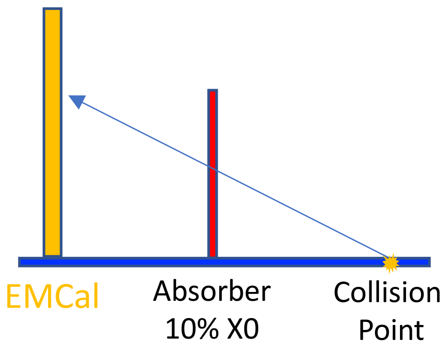
Radiated photons are distributed relative to a parent electron:
Nearly at the same η
At negative φ

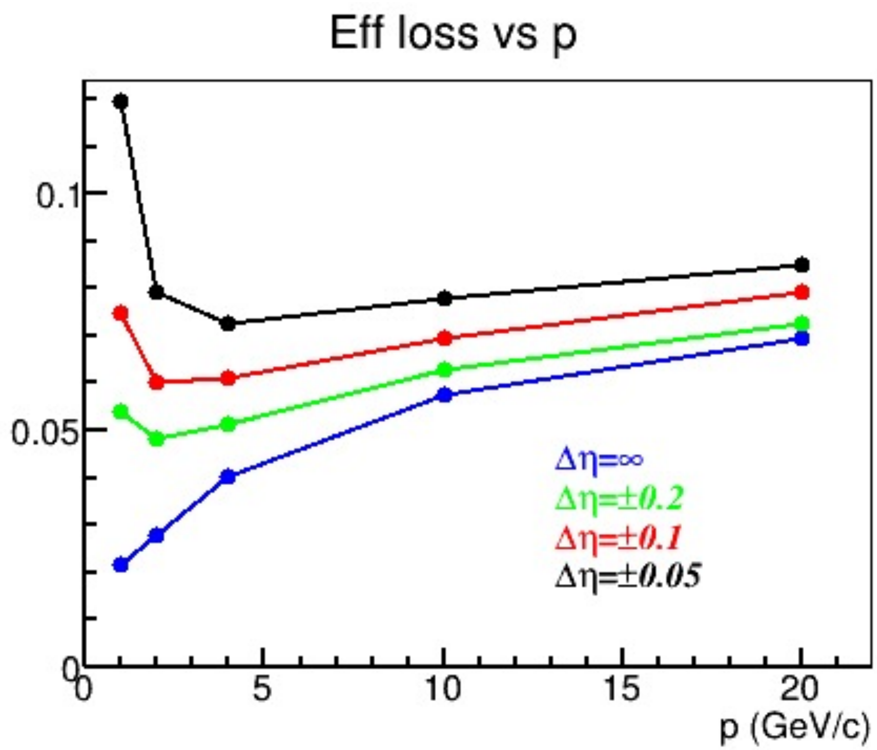
4

May not be able to sum up the cluster energy in the whole EMCal (will pick up not related energy)

But we may not need to: the radiated photons are distributed in arcs at pseudorapidity of the parent electron

Radiated Photon Topology Cut





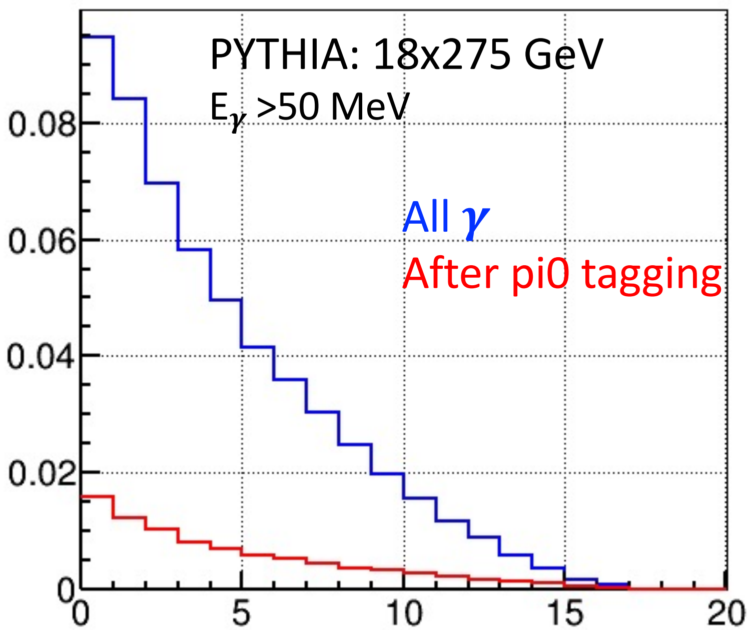
Just a very simple cut:

- $\Delta\eta=\pm0.2$ window leads to small enough eff loss
- $\Delta\varphi=\pm0.5$ doesn't introduce any losses

Smarter technique for radiated photon ID may provide better performance

Decay γ from PYTHIA

$f_{non\text{-}Isol}$ vs E_e



Fraction of events with decay photons in the vicinity of DIS electron:

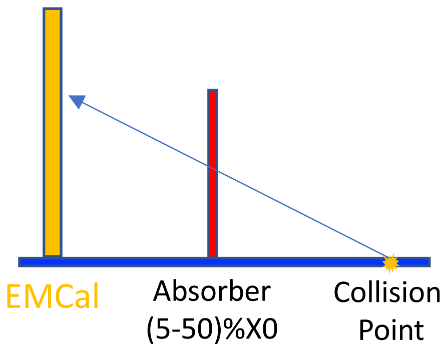
$\Delta\eta=\pm 0.2$

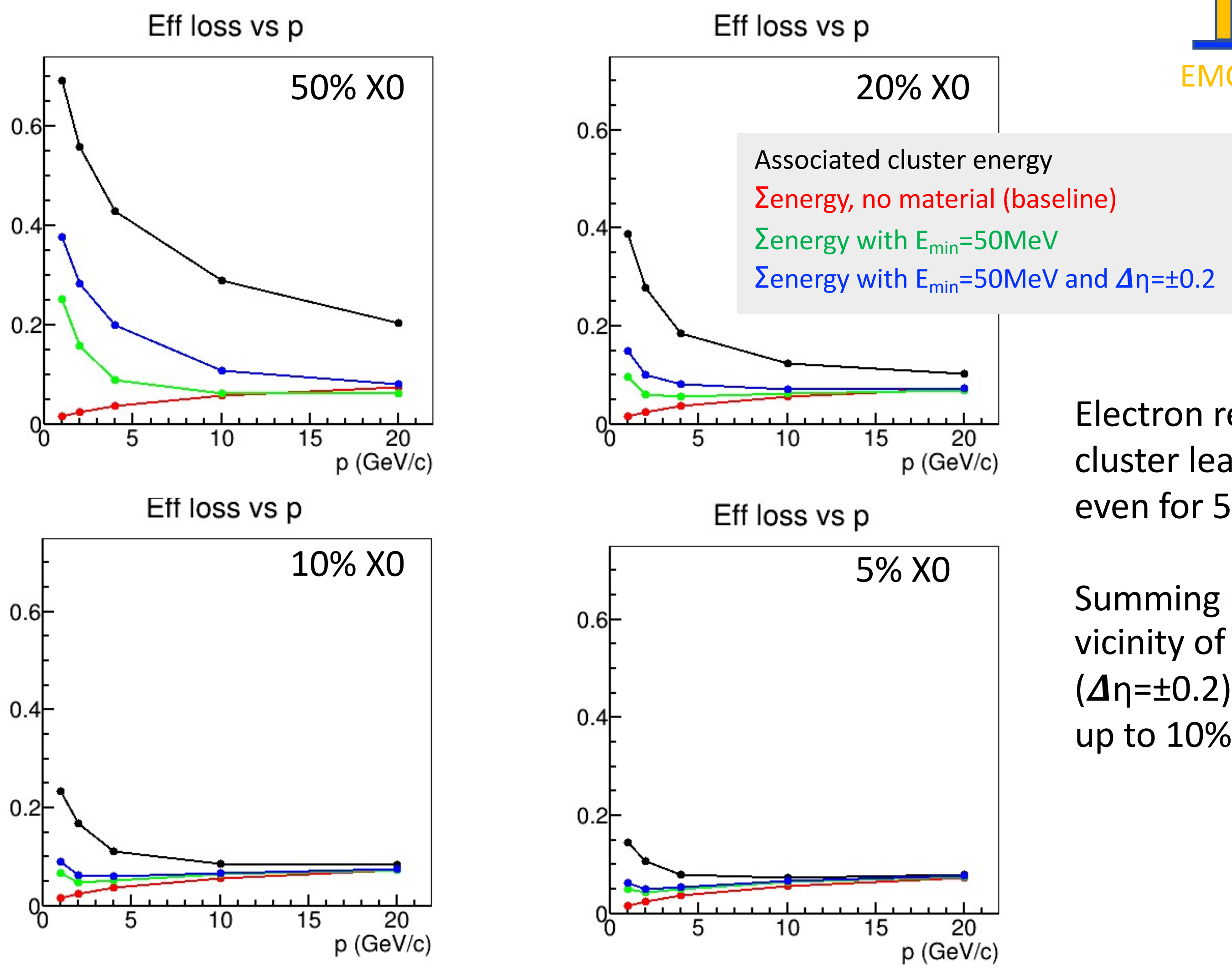
$\Delta\varphi=\pm 0.5$

The contribution of decay photons within topology cut (used for radiated photons) may be kept at low enough level

The other backgrounds need to be evaluated too (e.g. synchrotron rad.)

Vs converter thickness

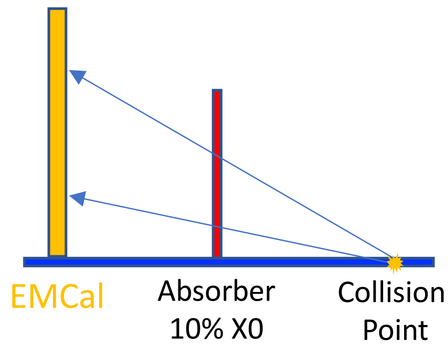


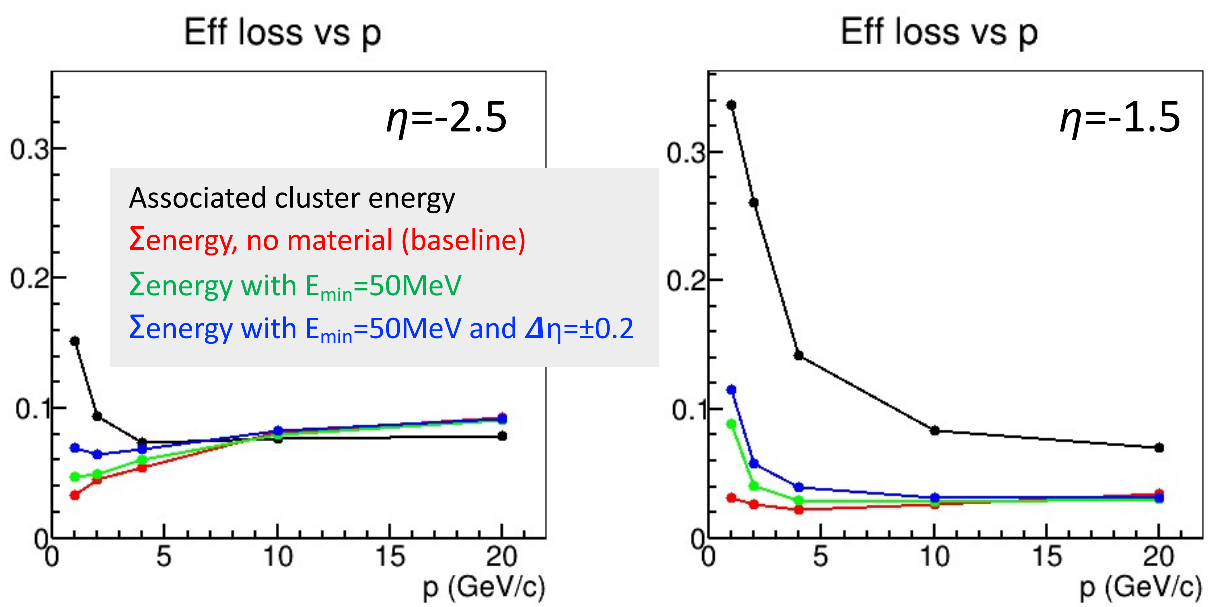


Electron reco from associated cluster leads to sizable eff loss even for 5%X0 absorber

Summing up the energy in the vicinity of the electron rapidity ($\Delta\eta=\pm0.2$) recover the eff well up to 10%X0 thickness

Vs rapidity (Bdl)





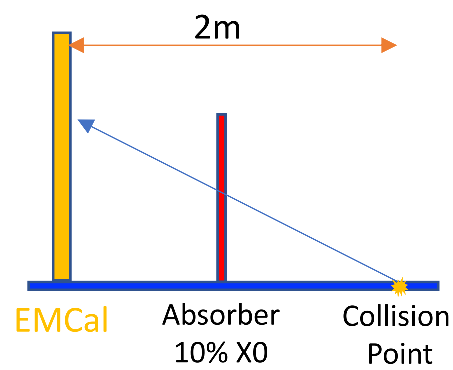
η=1.5 vs 2.5:

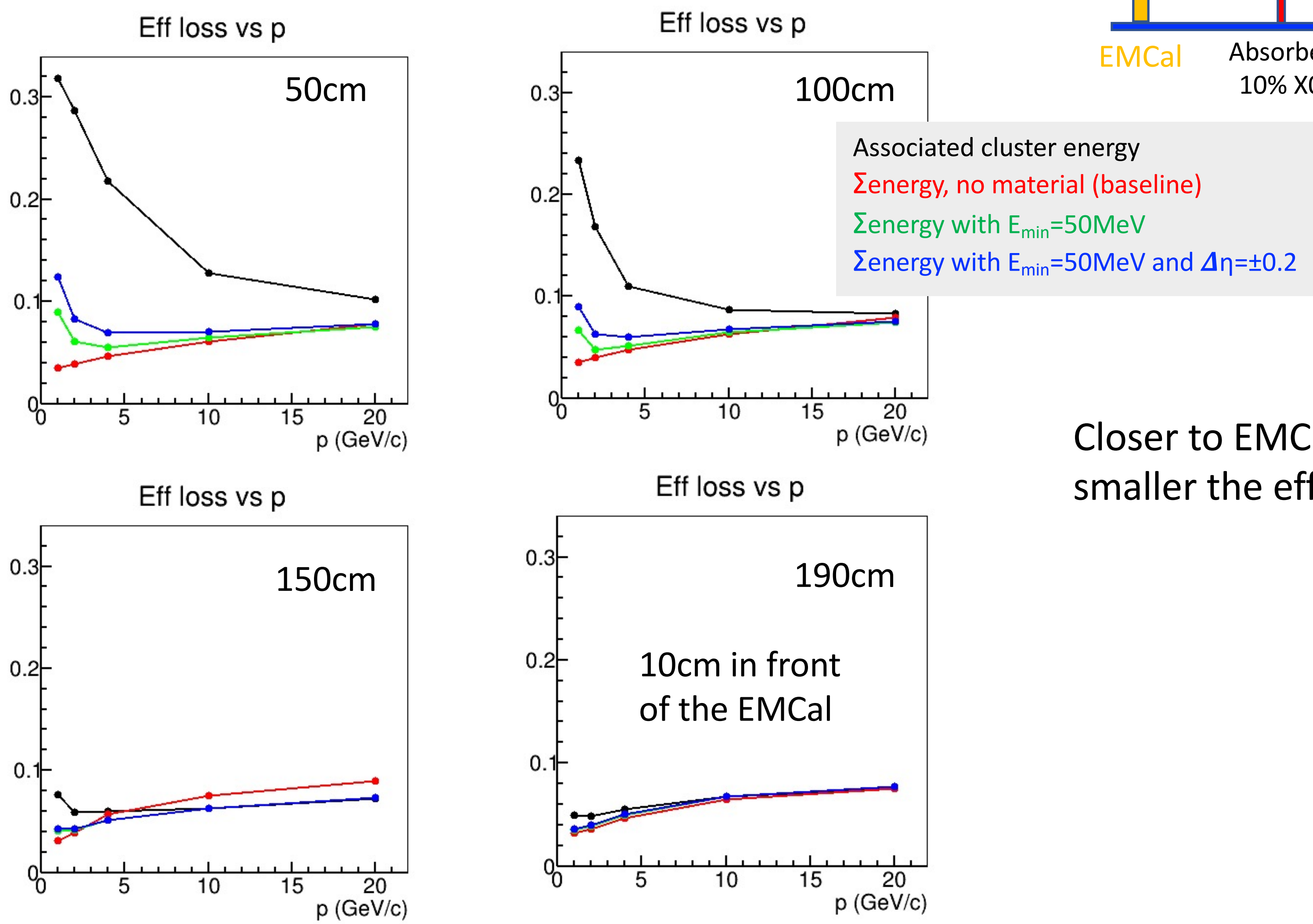
A factor of 3 larger Bdl

~10% larger material thickness

Lager eff loss for larger Bdl

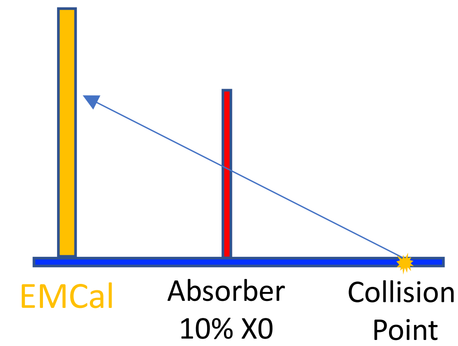
Vs location



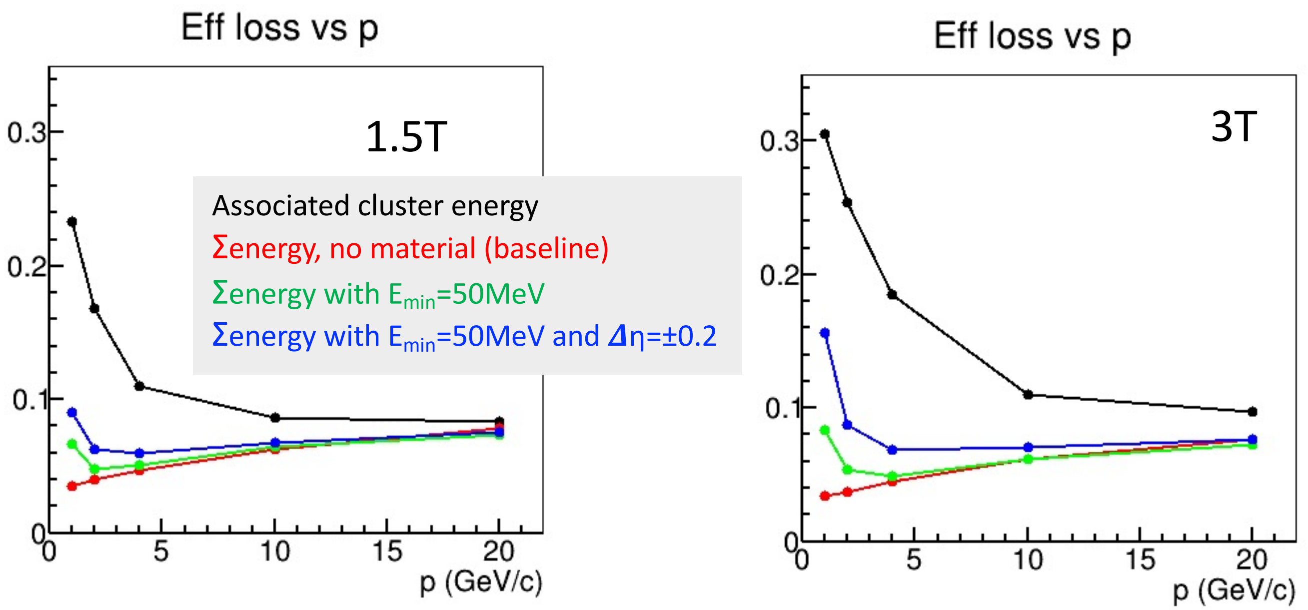


Closer to EMCal – smaller the eff loss

Vs magnetic field



All my previous plots are for 1.5T solenoid



Lager eff loss for larger Bdl

Summary

Electron reco from associated cluster leads to sizable eff loss even for 5%X0 absorber

$\Rightarrow$ Need to include clusters from radiated photons

EMCal should be capable to measure radiated photons down to at least 50 MeV (or, better, down to 20 MeV)

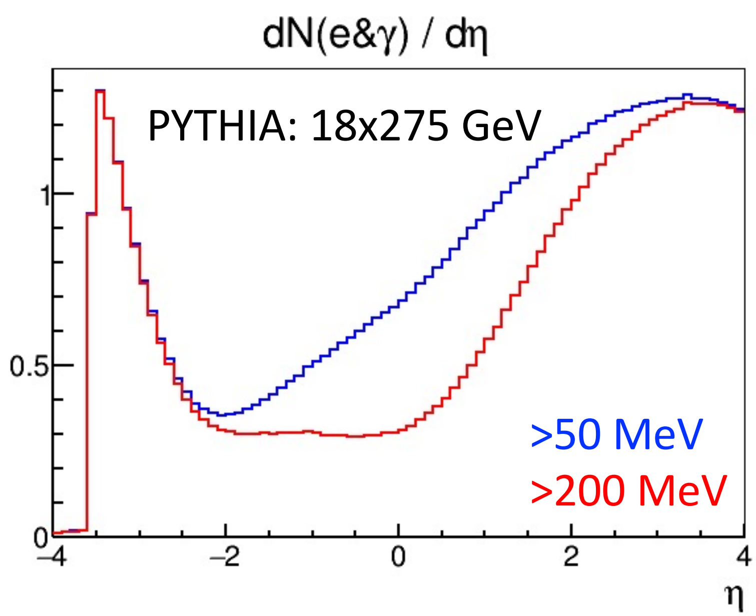
=> The level of noise should be minimized

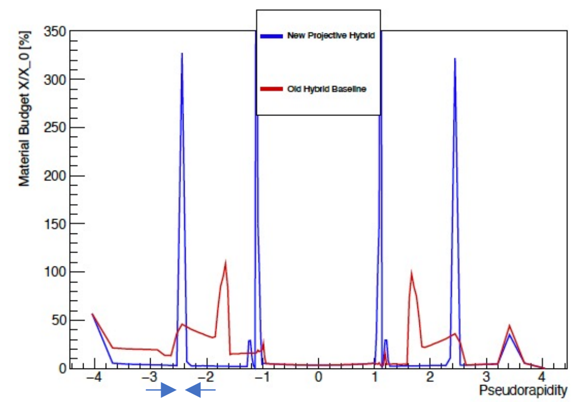
Effect of material after electron reco:

5%X0 looks ok, 10%X0 may be acceptable
Minimized if just in front of EMCal (no effect from 10% X0)
Larger for larger Bdl
Increases from high to low p

More developed techniques for e-reco (plus rad. photons) and considering other backgrounds may modify the conclusions in some way

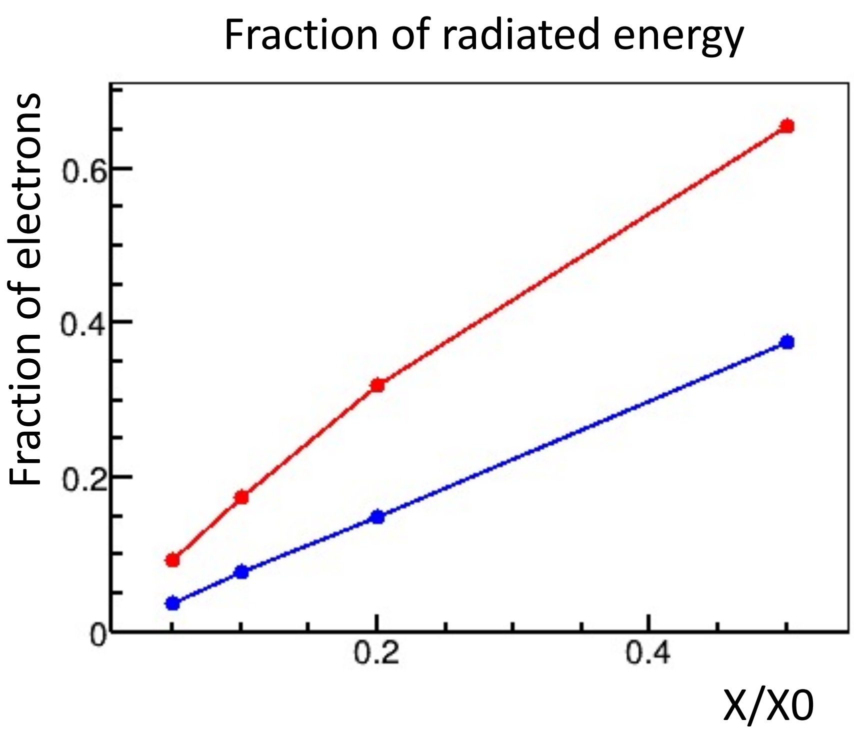
PYTHIA: e&$\boldsymbol{\gamma}$ rapidity density





For $\boldsymbol{\Delta}$η=0.2 the probability to have a shower from e or $\boldsymbol{\gamma}$ may be >10%

Electron radiated energy



Fraction of electrons loosing:
20% of its energy
50% of its energy