Joint meeting PID and Calorimetry

Calorimetry working group perspective

- Electron identification is one of the main topics of the Calorimetry working group
- Identification is depends on activity of the three groups: calorimetry, PID, tracking
- Ideally $4\pi$ coverage by calorimetry
- Space for barrel limited, compact detector solutions
- Challenging region is electron endcap (backward region), expected degradation of the tracking momentum resolution, need very high resolution calorimetry. Adding material impact the resolution

**Detector Matrix for the calorimeters**

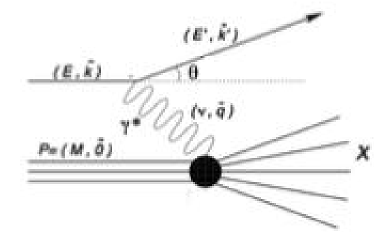
| η | Nomenclature | EmCal | | | | | | HCal | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Energy resolution % | Spatial resolution mm | Granularity cm^2 | Min photon energy MeV | PID e/π π suppression | Technology examples* | Energy resolution % | Spatial resolution mm | Granularity cm^2 | Technology solution |
| -3.5 : -2 | backward | $2/\sqrt{E} \oplus 1$ | $3/\sqrt{E} \oplus 1$ | 2x2 | 50 | 100 | $PbWO_4$ | $50/\sqrt{E} \oplus 10$ | $50/\sqrt{E} \oplus 30$ | 10x10 | Fe/Sc |
| -2 : -1 | backward | $7/\sqrt{E} \oplus 1.5$ | $3(6)/\sqrt{E} \oplus 1$ | 2.5x2.5 (4x4) | 100 | 100 | DSB:Ce glass; Shashlik; Lead glass | $50/\sqrt{E} \oplus 10$ | $50/\sqrt{E} \oplus 30$ | 10x10 | Fe/Sc |
| -1 : 1 | barrel | $(10\text{-}12)/\sqrt{E} \oplus 2$ | $3/\sqrt{E} \oplus 1$ | 2.5x2.5 | 100 | 100 | W/ScFi | $100/\sqrt{E} \oplus 10$ | $50/\sqrt{E} \oplus 30$ | 10x10 | Fe/Sc |
| 1 : 3.5 | forward | $(10\text{-}12)/\sqrt{E} \oplus 2$ | $3/\sqrt{E} \oplus 1$ | 2.5x2.5 (4x4) | 100 | 100 | W/ScFi Shashlyk, glass | $50/\sqrt{E} \oplus 10$ | $50/\sqrt{E} \oplus 30$ | 10x10 | Fe/Sc |

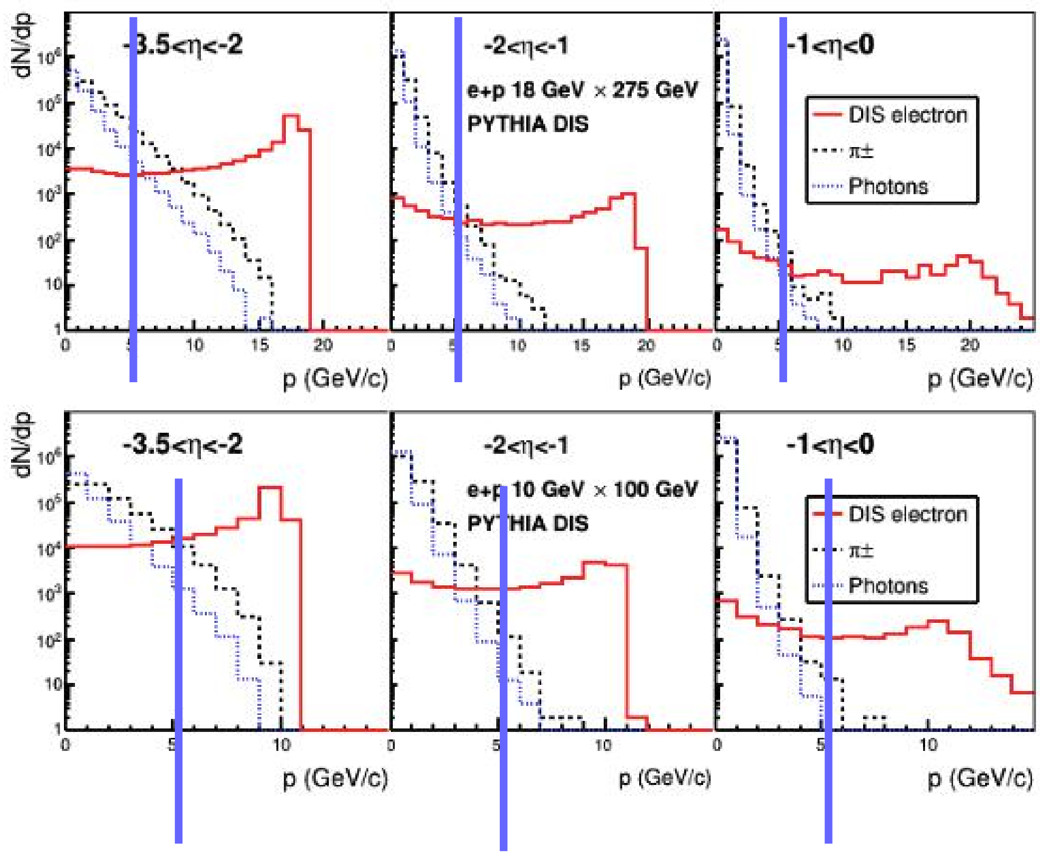
*Technology selection depends on the space available
Several other technologies are under consideration

e/π: pion suppression depends on the energy, and the energy and momentum resolutions
Material in front will affect the resolution

- More details see Alex Bazilevsky talk https://indico.bnl.gov/event/8231/contributions/37820/
- DIS electrons, DIS background: charge pions, photons from decays.
- Starting from high momentum expect clean sample of electrons
- Lower momentum <5 GeV/c  eID is crucial

# Inclusive DIS: background



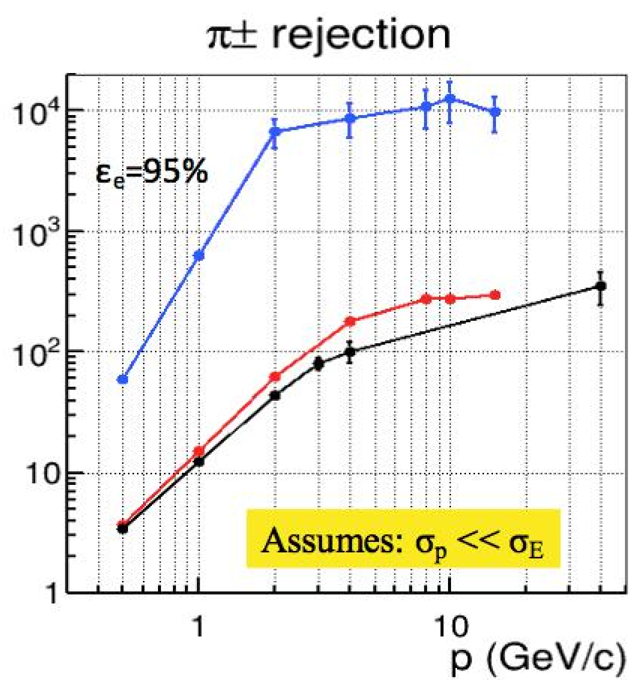




18x275 GeV

10x100 GeV

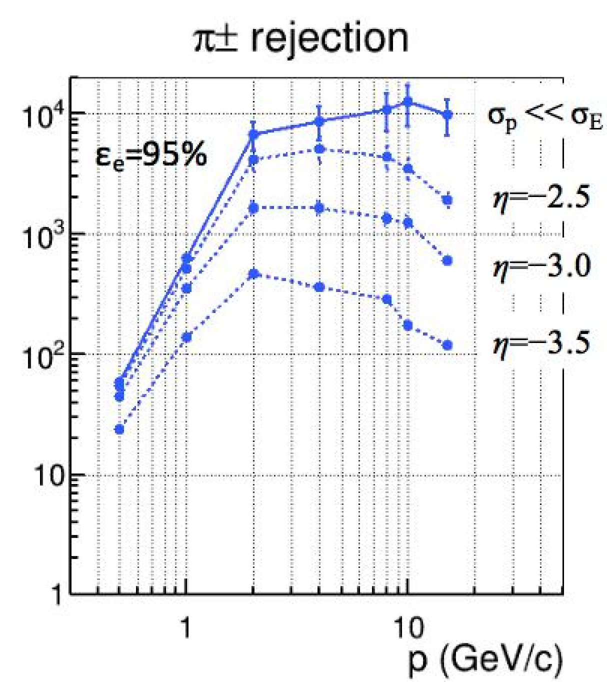
- Stand alone simulations
- No material in the way of EmCal in “ideal world”
- Perfect EmCal with no gaps, cracks
- Gaussian respond to electron
- Π± rejection with E/p cut applied for various calorimetry solutions
- Π± rejection dependence on momentum resolution in PWO case

| | $PbWO_4$ Crystal | W/SciFi | PbSc |
|---|---|---|---|
| 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, $\lambda_I$ | 0.87 | ~0.83 | 0.85 |
| e/h | >2 | | <1.3 |




$E/p > 1 - 1.6 \cdot \sigma_{EMC}$ to keep $\varepsilon_e$=95%

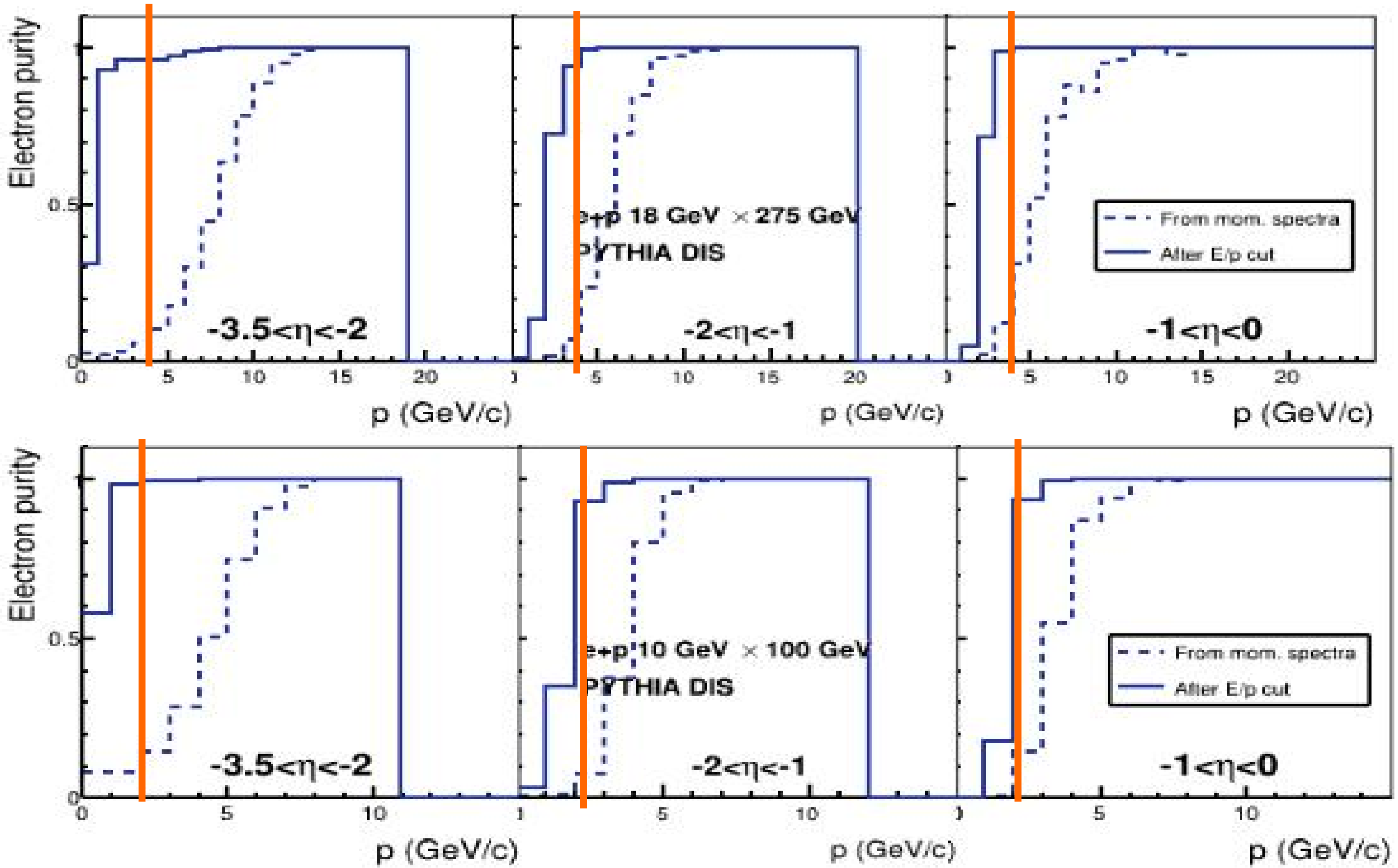
$E/p > 1 - 1.6 \cdot \sqrt{\sigma_{EMC}^2 + \sigma_p^2}$ to keep $\varepsilon_e$=95%



- Simulation done for “Ideal world”
- Clean eID at <4GeV/c for 18x275
- Clean eID at <2GeV/c for 10x100
- More detailed studies results

# DIS scattered electron purity

| $-3.5<\eta<-2$ | $-2<\eta<-1$ | $-1<\eta<1$ |
|---|---|---|
| $\frac{\sigma_E}{E}=\frac{2.5\%}{\sqrt{E}}\oplus 1\%$ | $\frac{\sigma_E}{E}=\frac{7\%}{\sqrt{E}}\oplus 2\%$ | $\frac{\sigma_E}{E}=\frac{12\%}{\sqrt{E}}\oplus 2\%$ |

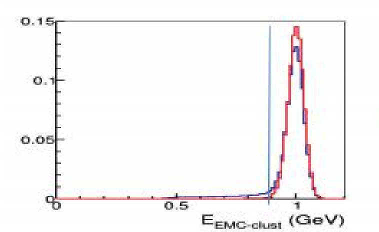



18 GeV x 275 GeV

10 GeV x 100 GeV

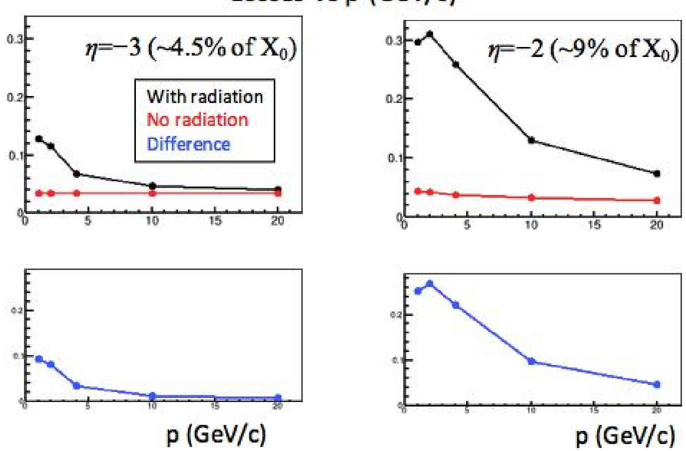
- Effect of the material in front of calorimeters, studies in progress
- https://indico.bnl.gov/event/8854/ More details
- Results for PWO calorimeter under specific configuration
- No PID detectors included, no dead material from services and gaps
- Effect dominant at  low momenta

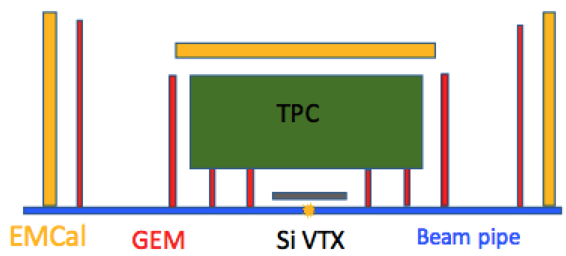
# "Efficiency" of *e* reco



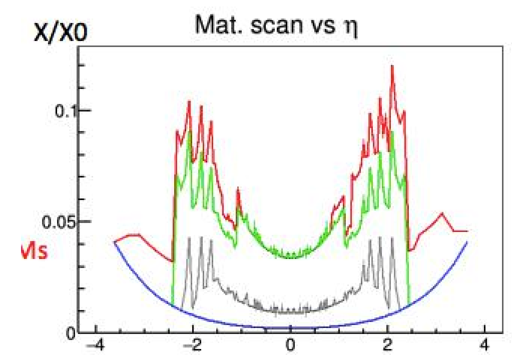

$E_{EMC} > E_{nom} - 2\,\sigma_{EMC}$

Losses vs p (GeV/c)




How electron is "modified" as seen by the EMCal

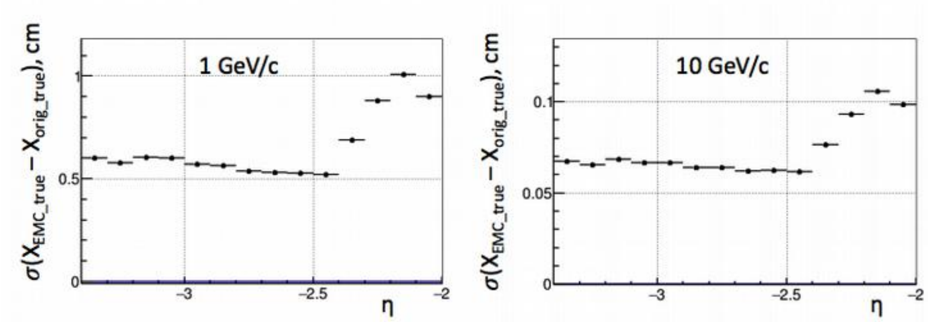



GEM: ~0.7% of X0 per plane

Expected to be 2.3% for a pure gaussian response

Huge effect from $\eta$=−3 to $\eta$=−2

Electron position smearing (in cm) at the PWO EMCal due to multiple scattering



Discussion topics:

- Technology solution for various momentum regions, especially <(2-3)GeV/c
- Threshold, lowest momentum
- Dead material introduce by PID detectors services
- Material budget close to IP and in front of the calorimeter towers
- Complementarity of various solutions
- Path forward