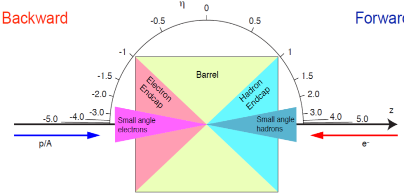
YR DWG Calorimetry: Summary

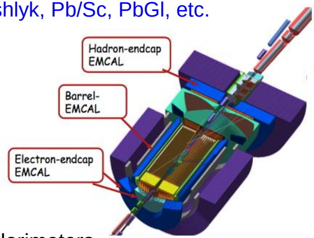
2nd EIC YR Workshop - Pavia, 2020 May 21
Conveners: Vladimir Berdnikov & Eugene Chudakov

- Contribution to the Detector Matrix
  - A number of technologies can provide resolutions close to the required by the Matrix
  - A tight space allocated would limit the choice of technologies and, in some cases, the performance
  - The performance may be affected by the material in front of the calorimeters. The effect is neglected at this stage.
- Parallel Sessions
  - DWGs Tracking, PID, Calorimetry:
    Talk by Alexander Bazilevsky dedicated to e/π separation;
    Useful discussions
  - PWGs, DWGs: useful discussions

EIC Calorimetry overview

Several options including crystals, glass, W/SciFi, Shashlyk, Pb/Sc, PbGl, etc.





Detector Matrix for the calorimeters

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

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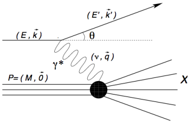
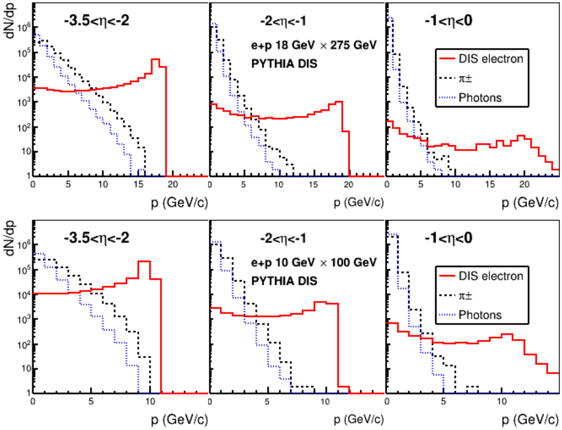
Inclusive DIS: background





18x275 GeV

10x100 GeV

Clean measurements at higher momenta
Huge background at lower momenta

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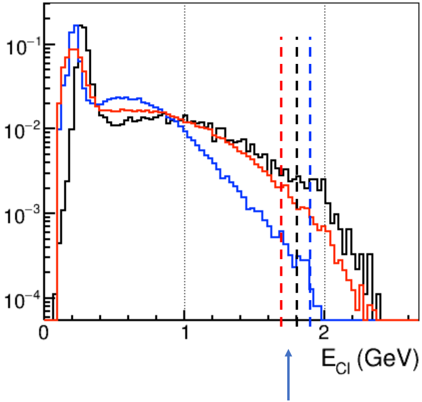
h± response in EMCal

Ideal case:

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



E/p > 1 - 1.6 · σ_{EMC} to keep ε_e=95%

	$PbWO_4$ 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

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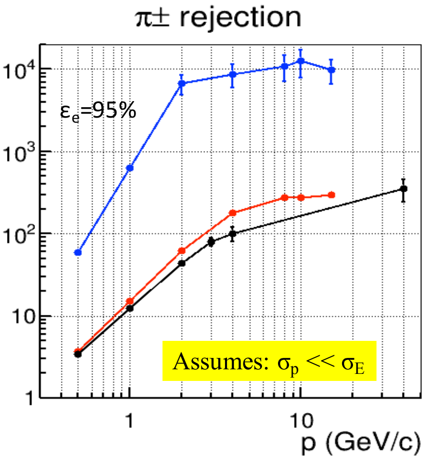
π± rejection with E/p cut

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

E/p > 1 - 1.6 · σ_{EMC} to keep $\boldsymbol{\varepsilon}_e$=95%

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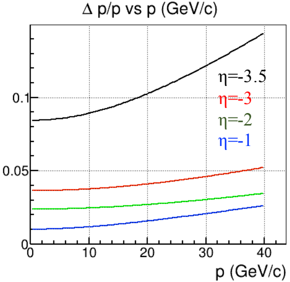
Including momentum resolution

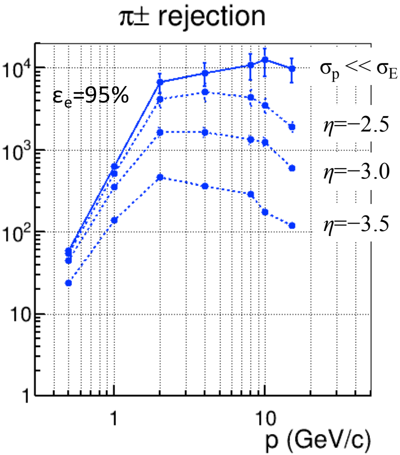
PbWO$_4$ Crystal (GEANT)

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

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

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





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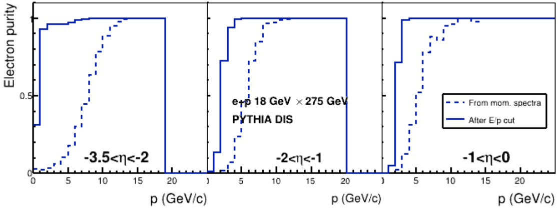
DIS scattered electron purity

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

Ideal case:

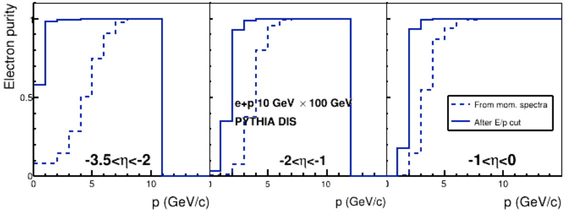
- No material on the way to EMCal
- Perfect EMCal (no gaps/cracks)
- Gaussian response to electron

Purity = e / (e+h)



18 GeV × 275 GeV:

Clean eID at >4 GeV/c



10 GeV × 100 GeV:

Clean eID at >2-3 GeV/c

Need additional eID capabilities at p<4 GeV/c

Discussion Highlights

- Input for a “parametric simulation” (eicsmear): resolution factors (provided) + formulas for e^-/π^- PID
- Conclusion: additional detectors are needed to improve e^-/π^- separation at $p < 5$ GeV/c
- Important: simulation with more or less realistic material distribution:
  - Impact on resolutions
  - Impact on e^-/π^- separation
  - Impact on efficiency and resolution in the transition areas ($\eta \approx \pm 1$)
- Impact of the space allocation: more studies needed including an engineer’s look
- Hermiticity requirements (HCAL) for jet physics