Inclusive Working Group Summary

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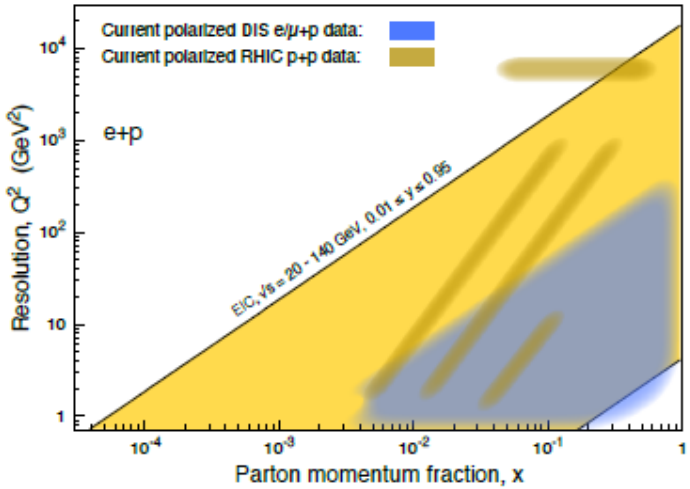
Thanks to everyone who worked on the detector proposals!

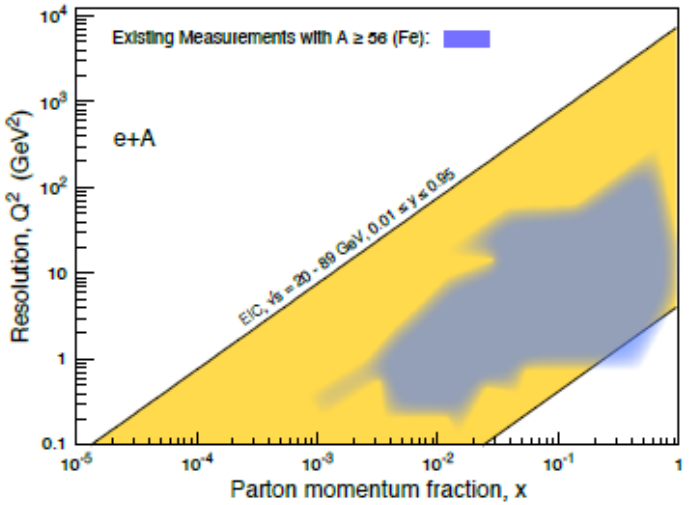
Outline

- Inclusive physics and associated detector challenges
- Summary of work done by Inclusive WGs for the *ECCE* and *ATHENA* proposals
- Role of the Detector-1 Inclusive WG
- Plans for our WG

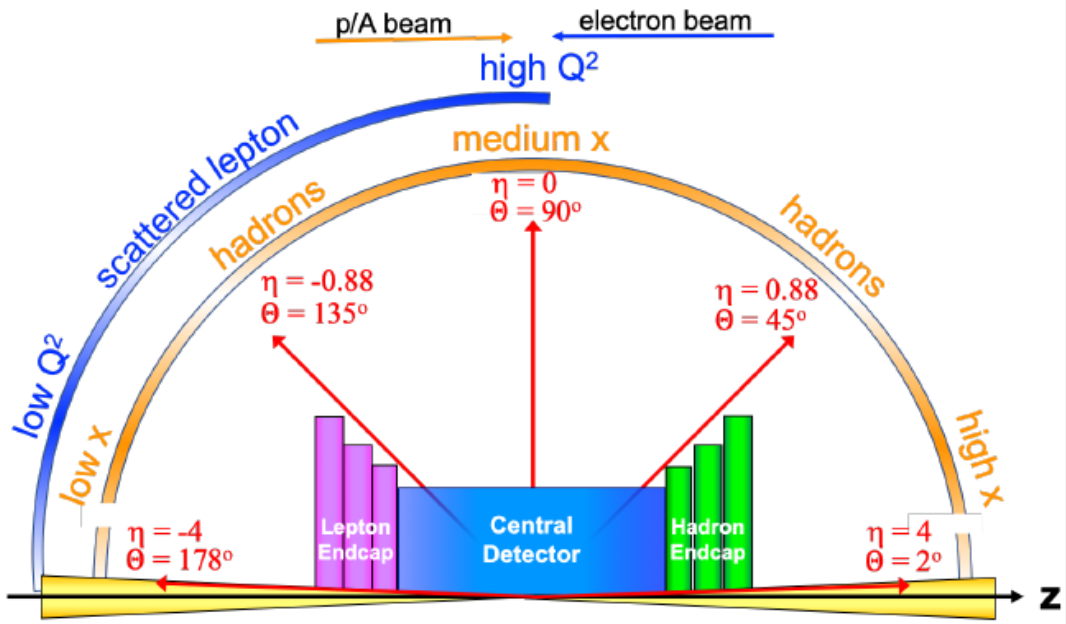
Inclusive scattering at the EIC

Measurement	Physics Topic/goal
$\sigma_{red,NC(CC)}(x,Q^2) \rightarrow F_2, F_L$	Proton PDFs $q(x,Q^2)$, $g(x, Q^2)$
$\sigma_{red,NC(CC)}(x,Q^2) \rightarrow F_2, F_L$	Nuclear PDFs $q(x,Q^2)$, $g(x, Q^2)$ Non-linear QCD dynamics
Inclusive $A_{\|\|}$ / $A_{\perp}$ for proton, deuterium, ^{3}He	Gluon & Quark Helicity $\Delta g(x,Q^2)$, Δu^+, Δd^+
Inclusive A_{PV}	Strange Pol and Unpolarized $\Delta s^+(x,Q^2)$, $s^+(x,Q^2)$ BSM & Precision EW ($\sin^2\theta_w$)





Detector requirements and associated challenges



Detector requirements from EIC Yellow report

η	Nomenclature			Tracking				Electrons and Photons			π/K/p PID		HCAL		Muons
				Min p_T	Resolution	Allowed X/X_0	Si-Vertex	Min E	Resolution σ_E/E	PID	p-Range (GeV/c)	Separation	Min E	Resolution σ_E/E	
-6.9 — -5.8	↓ p/A	Auxiliary Detectors	low-Q^2 tagger		$\delta\theta/\theta$ < 1.5%; 10^{-6} < Q^2 < 10^{-2} GeV²										
…															
-4.5 — -4.0			Instrumentation to separate charged particles from γ						2%/√E+(1-3)%						
-4.0 — -3.5														~50%/√E+6%	
-3.5 — -3.0		Central Detector	Backwards Detectors		σ_p/p ~ 0.1%×p+2.0%		σ_{xy}~30μm/p_T+40μm								
-3.0 — -2.5															
-2.5 — -2.0					σ_p/p ~ 0.05%×p+1.0%		σ_{xy}~30μm/p_T+20μm		7%/√E+(1-3)%					~45%/√E+6%	
-2.0 — -1.5															
-1.5 — -1.0															
-1.0 — -0.5			Barrel		σ_p/p ~ 0.05%×p+0.5%		σ_{xyz} ~ 20 μm, $d_0(z)$ ~ $d_0(r\varphi)$ ~ 20/p_T GeV μm + 5 μm								
-0.5 — 0.0				100 MeV π		~5% or less		50 MeV		π suppression up to 1:10^4	≤ 7 GeV/c	≥ 3σ	~500 MeV		
0.0 — 0.5														~85%/√E+7%	Useful for bkg, improve resolution
0.5 — 1.0				135 MeV K							≤ 10 GeV/c				
1.0 — 1.5			Forward Detectors		σ_p/p ~ 0.05%×p+1.0%		σ_{xy}~30μm/p_T+20μm		(10-12)%/√E+(1-3)%		≤ 15 GeV/c				
1.5 — 2.0											≤ 30 GeV/c				
2.0 — 2.5										3σ e/π	≤ 50 GeV/c			~35%/√E	
2.5 — 3.0					σ_p/p ~ 0.1%×p+2.0%		σ_{xy}~30μm/p_T+40μm				≤ 30 GeV/c				
3.0 — 3.5							σ_{xy}~30μm/p_T+60μm				≤ 45 GeV/c				
3.5 — 4.0	↑e	Auxiliary Detectors	Instrumentation to separate charged particles from γ												
4.0 — 4.5															
…															
> 6.2			Proton Spectrometer		$\sigma_{intrinsic}(\lvert t\rvert)/\lvert t\rvert$ < 1%; Acceptance: 0.2< p_T <1.2 GeV/c										

Detector requirements and associated challenges

- Hermetic coverage for scattered electron – leave no gaps in EMcal coverage while also incorporating PID readout
- Scattered electron momentum resolution in backward direction – design trackers to optimize momentum resolution when the particle has a large component parallel to the solenoid field; use combined information from tracker and EMcal for reconstruction
- Scattered electron purity in the backwards direction and barrel – high-precision EMcals and additional detectors for low momentum
- Remove large ISR events and reduce photoproduction background – good measurement of total E-p_z of all particles.
- Forward detection – want good energy resolution for hadronic reconstruction methods at low y

Detector requirements from EIC Yellow report

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-0.5 — 0.0				100 MeV π											
0.0 — 0.5					σ_p/p ~ 0.05%×p+0.5%	~5% or less		50 MeV		π suppression up to 1:10^4	≤ 10 GeV/c	≥ 3σ	~500 MeV	~85%/√E+7%	Useful for bkg, improve resolution
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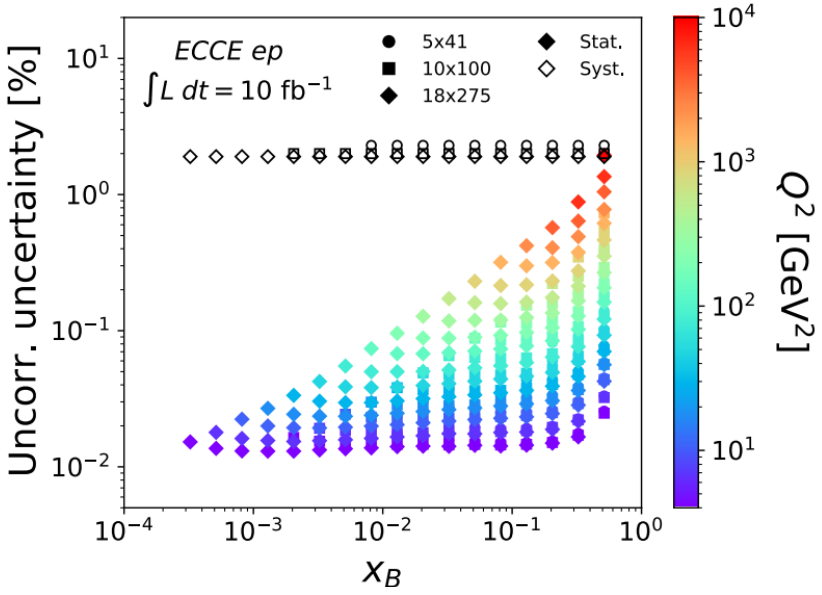
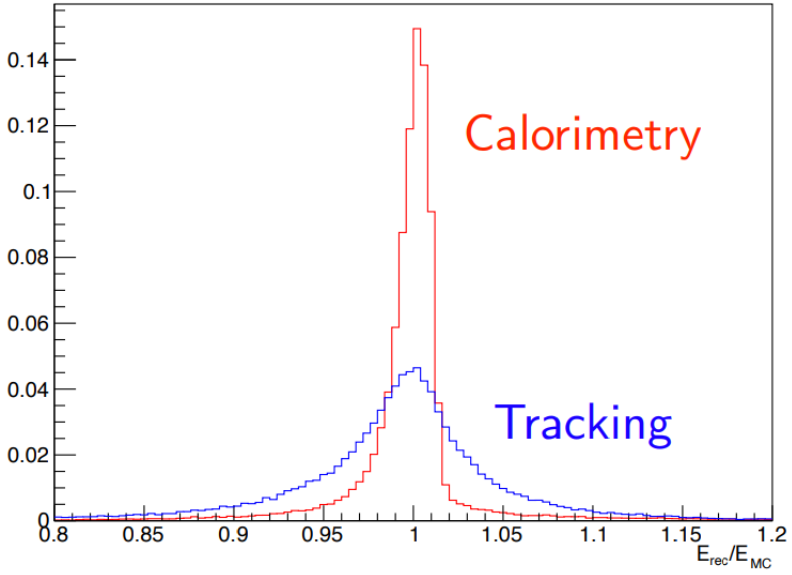
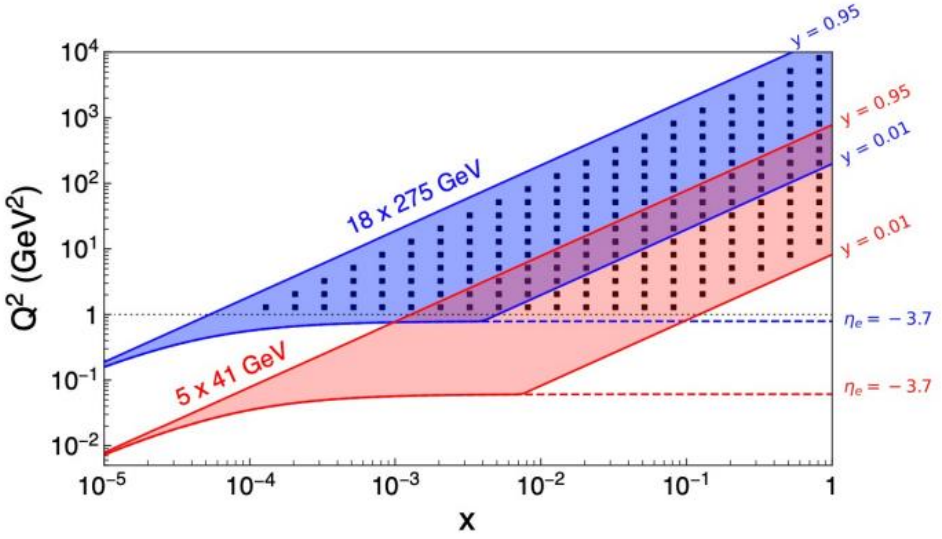
> 6.2			Proton Spectrometer		$\sigma_{intrinsic}(\lvert t\rvert)/\lvert t\rvert$ < 1%; Acceptance: 0.2< p_T <1.2 GeV/c										

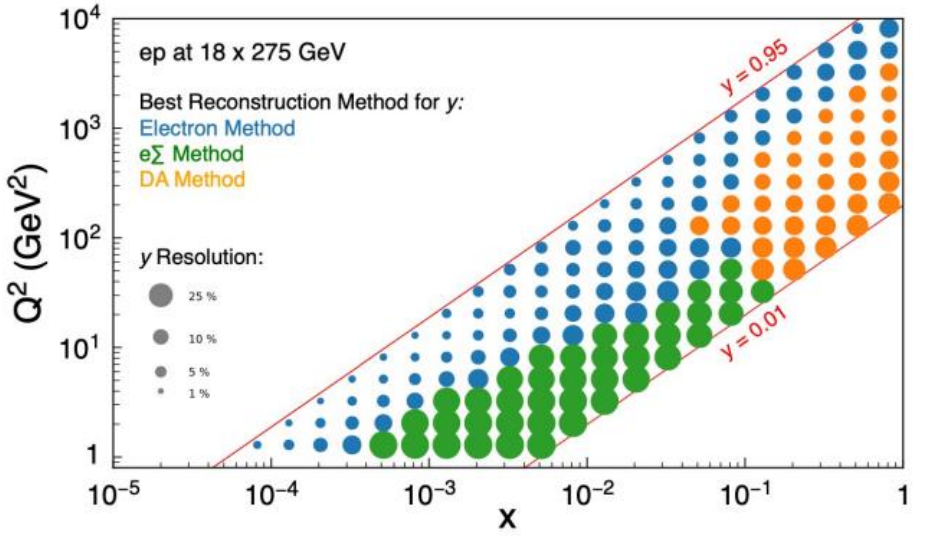
Proposal studies – Acceptance, statistics and kinematic reconstruction



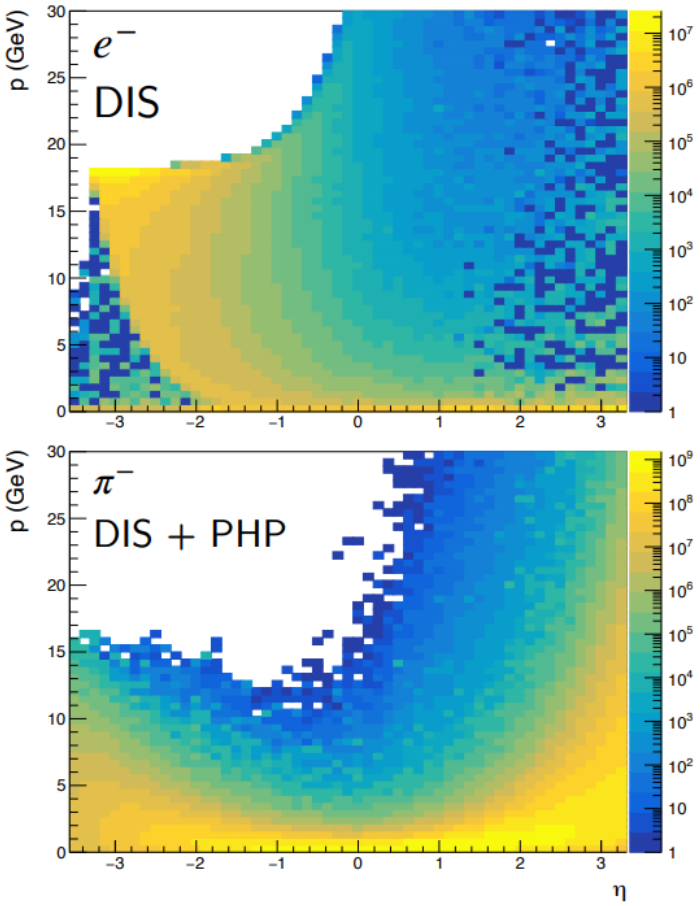


- Studies done using full detector simulations for both proposals
- Hadronic reconstruction methods combined tracking information (for charged particles) with calorimeter clusters (for neutrals). Full ‘particle flow’ algorithm was not implemented in either proposal.
- Systematic uncertainty estimations used yellow report studies as guidance, with some improvements/additions.

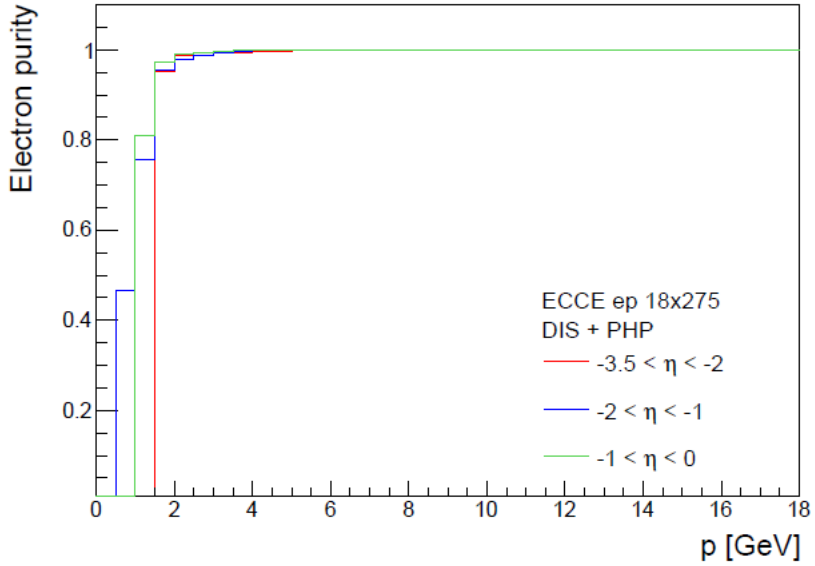


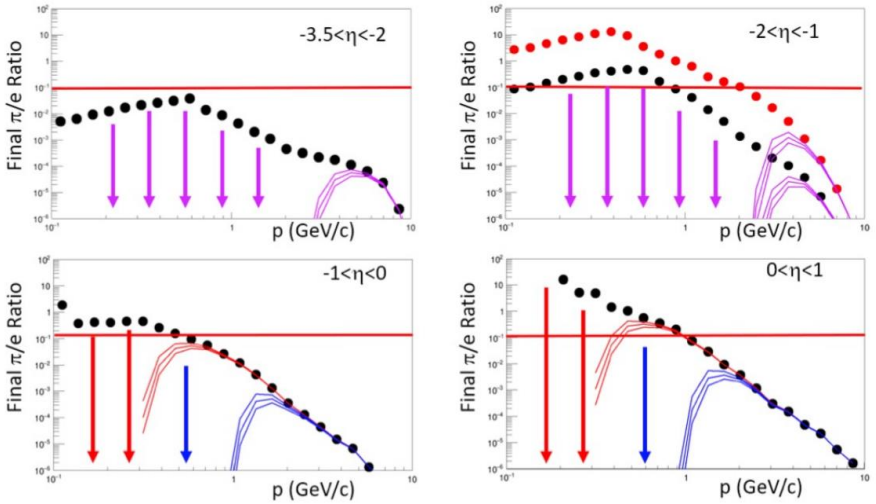


Proposal studies – Electron purity

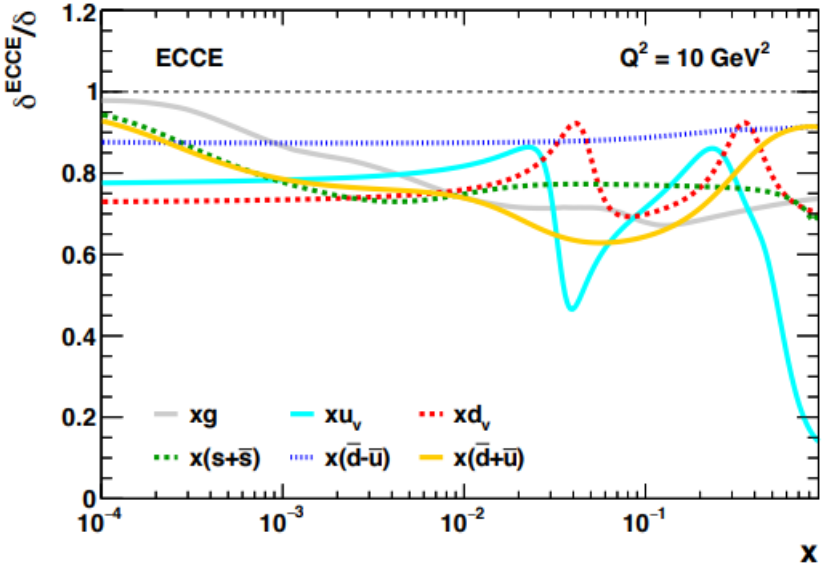


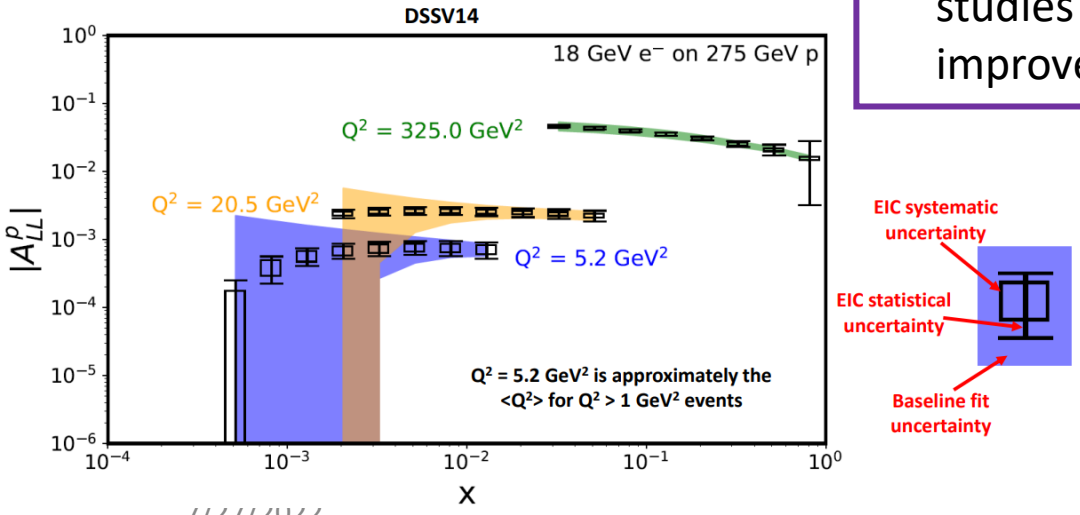
- Studies done using raw pion-to-electron ratios and applying parameterizations of calorimeter and PID detector responses.



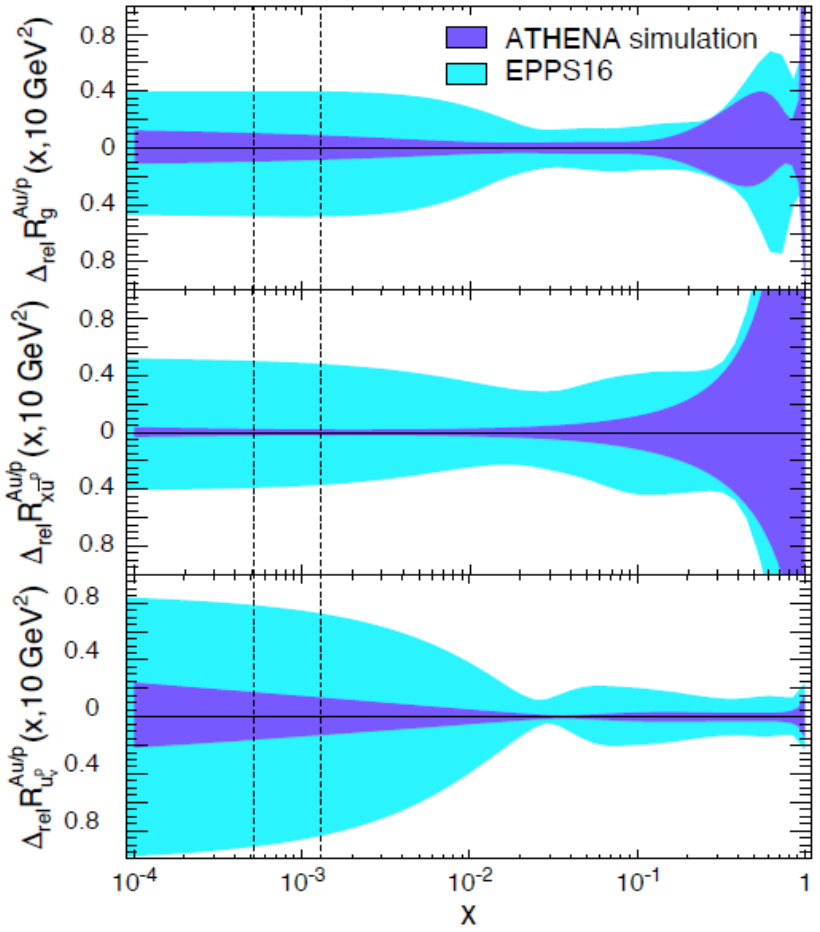


Proposal studies – Physics impact of inclusive measurements





- Impact studies done for both unpolarized ep and eA, as well as polarized ep.
- Binning used was similar in both proposals.
- Systematic uncertainty estimations used yellow report studies as guidance, with some improvements/additions.



Role of the Detector-1 physics WGs

- The role of new Detector-1 physics working groups is to "[w]ork with the Detector Working Groups to perform constant validation of the performances for physics observables."
- In practice, this means that the physics WGs should
  1. Understand the work that was done during the proposals and be able to repeat those studies for proposed Detector-1 configurations.
  2. Update the proposal studies to include more realism on the technical and physics level. (See following slide.)
- We should try to develop quantitative criteria to evaluate different detector designs.

Planned updates to proposal studies

- Development of an algorithm to reconstruct the scattered electron (electron finder) and testing this algorithm using minimum-bias (i.e. photo-production+DIS) data.
- Inclusion of state-of-the-art QED radiative effects in our generator samples.
- Studies of background to the scattered electron due to, for example, Dalitz decays.
- More realistic treatment of the hadronic final state reconstruction
- Inclusive kinematic reconstruction using kinematic fitting / machine learning techniques.

How to get involved in the Inclusive WG

- Sign up for our mailing list.
- We have WG meeting approximately every 10 days right now, interchanging between Mondays at 12pm Eastern time and Wednesdays at 9am Eastern time.
- Everyone is welcome to attend. You can find information on prior and upcoming meetings here.