UNIVERSITY OF BIRMINGHAM | SCHOOL OF PHYSICS AND ASTRONOMY

Update on systematics studies for inclusive cross section measurement

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Overview

- Systematic errors are expected to be dominant errors in inclusive NC cross section measurements for much of the EIC phase space

- It’s difficult to determine systematic uncertainties for a detector/accelerator that does not yet exist
  - Some guesswork is required based on experience of previous experiments (mostly HERA) and **dedicated simulation studies**

Possible systematic uncertainties

- There are many possible sources of systematic uncertainties → just look at H1/ZEUS papers

- Some notable ones are:
  - Electron/Hadronic Energy scale
  - Angular measurement
  - Track-cluster matching efficiency
  - Electron-finding efficiency
  - Background modelling
  - QED Radiative Corrections

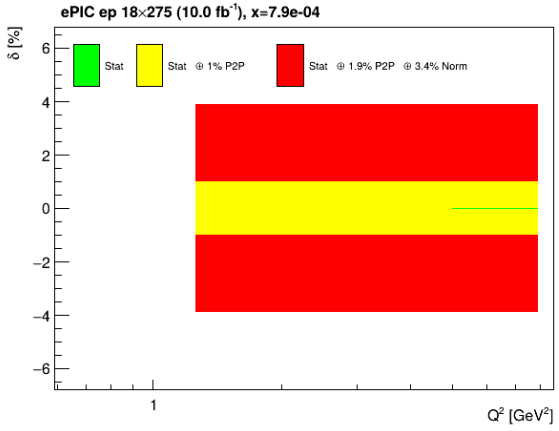
- ...and of course, the luminosity measurement

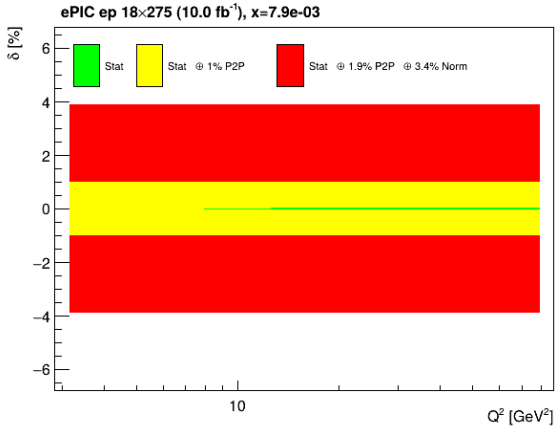
https://arxiv.org/abs/1312.4821

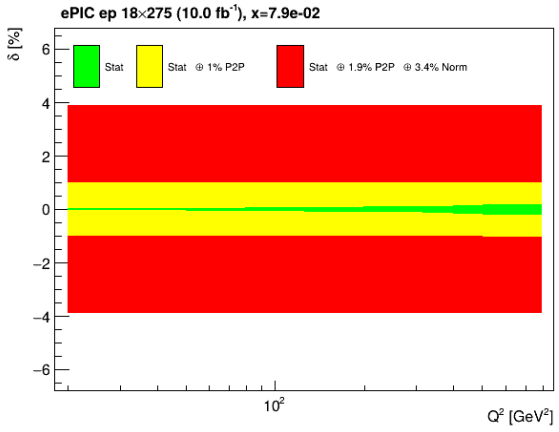
Source	Region	Uncertainty
Electron energy scale	$z_{\text{imp}} \leq -150\,\text{cm}$	0.5% unc. $\oplus$ 0.3% corr.
	$-150 < z_{\text{imp}} \leq -60\,\text{cm}$	0.3% unc. $\oplus$ 0.3% corr.
	$-60 < z_{\text{imp}} \leq +20\,\text{cm}$	0.5% unc. $\oplus$ 0.3% corr.
	$+20 < z_{\text{imp}} \leq +110\,\text{cm}$	0.5% unc. $\oplus$ 0.3% corr.
	$z_{\text{imp}} > +110\,\text{cm}$	1.0% unc. $\oplus$ 0.3% corr.
Electron scale linearity	$E'_e < 11\,\text{GeV}$	0.5%
Hadronic energy scale	LAr & Tracks	1.0% unc. $\oplus$ 0.3% corr.
	SpaCal	5.0% unc. $\oplus$ 0.3% corr.
Polar angle	θ_e	1 mrad corr.
Noise	$y < 0.19$	5% energy not in jets , corr.
	$y > 0.19$	20% corr.
Trigger efficiency	*high y*	$0.3 - 2\%$
	nominal	0.3%
Electron track and vertex efficiency	*high y*	1%
	nominal	$0.2 - 1\%$
Electron charge ID efficiency	*high y*	0.5%
Electron ID efficiency	*high y* $z_{\text{imp}} < 20\ (> 20)$ cm	0.5% (1%)
	nominal $z_{\text{imp}} < 20\ (> 20)$ cm	0.2% (1%)
Extra background suppression	$E'_e < 10\,\text{GeV}$	$D_{ele} > 0.80 \pm 0.04$ corr.
High y background subtraction	*high y*	1.03 ± 0.08 corr.
QED radiative corrections	$x < 0.1\,,\ 0.1 \leq x < 0.3\,,\ x \geq 0.3$	0.3% , 1.0%, 2.0%
	high y: $y < 0.8\ (y > 0.8)$	1% (1.5%)
Acceptance corrections	*high y*	0.5%
	nominal	0.2%
Luminosity		4% corr.

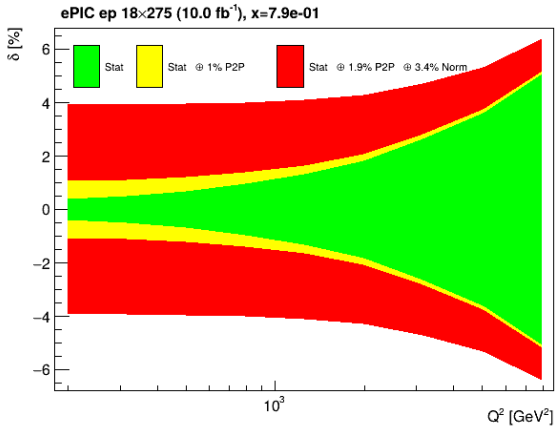
Studying systematic uncertainties

- To date we've estimated systematic uncertainties based on what was achieved at HERA, and how much we believe this might be improved at the EIC









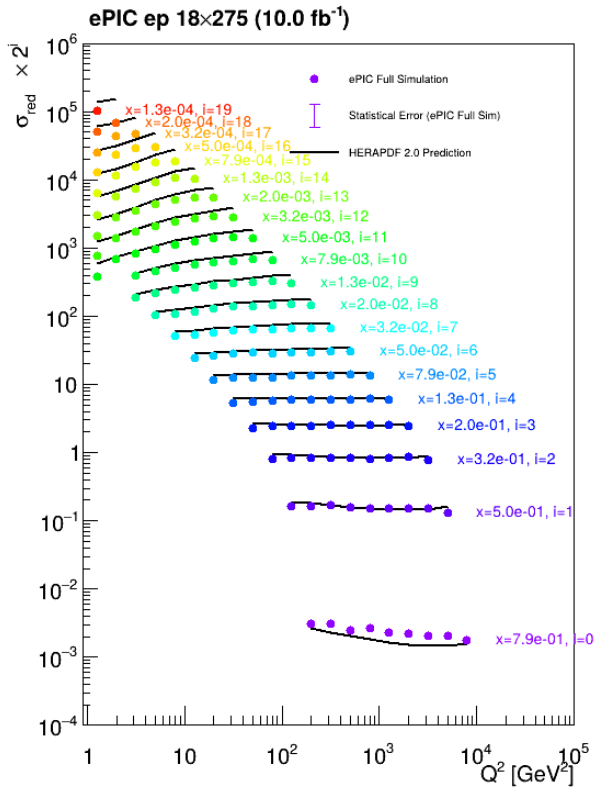
Red: HERA inspired + stat
Yellow: Optimistic EIC + stat
Green: Statistical only

Studying systematic uncertainties

- In reality, systematic uncertainties are typically informed by estimating the level of fluctuation in a quantity (e.g. electron energy scale) and repeating the same analysis with this fluctuation

My approach

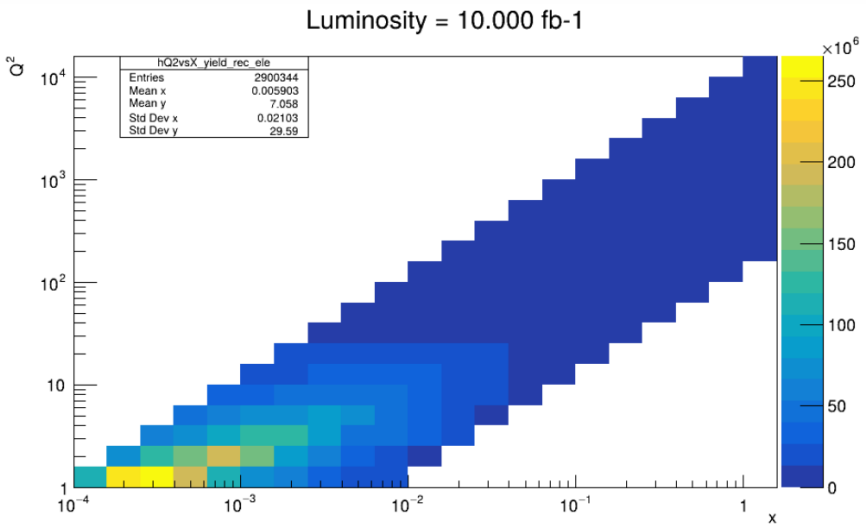
- I'm going to go through an example using my NC cross section code
  - The starting point is yields in different x-Q2 bins (electron method only for now)
  - Correct for acceptance → apply bin centre correction → cross section in bin

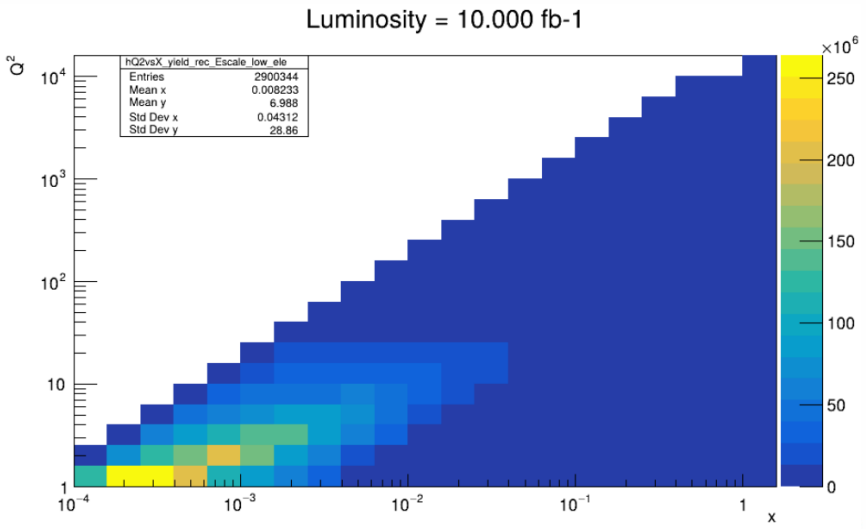


My approach

- I’ve chosen two systematics to look at initially:
  - Electron energy scale: 1% (HERA did better in the end)
  - Electron polar angle: 1mrad (HERA did about this well)

- I separately applied these errors to the scattered electron and extracted the new yields in each bin for electron method reconstruction

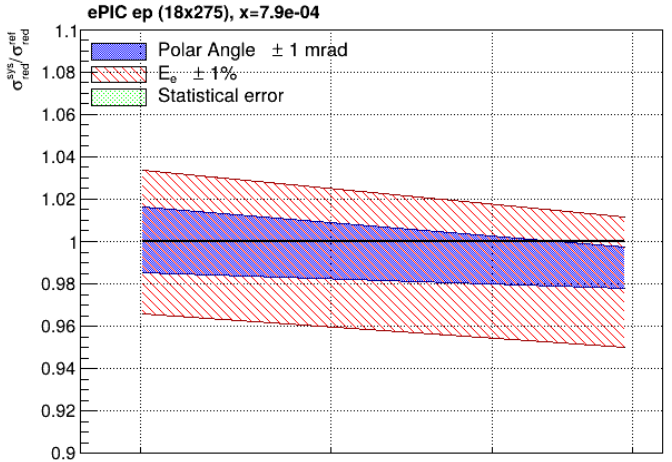


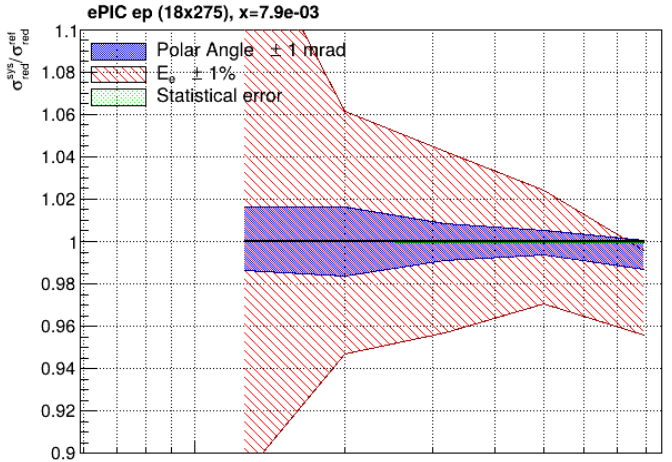


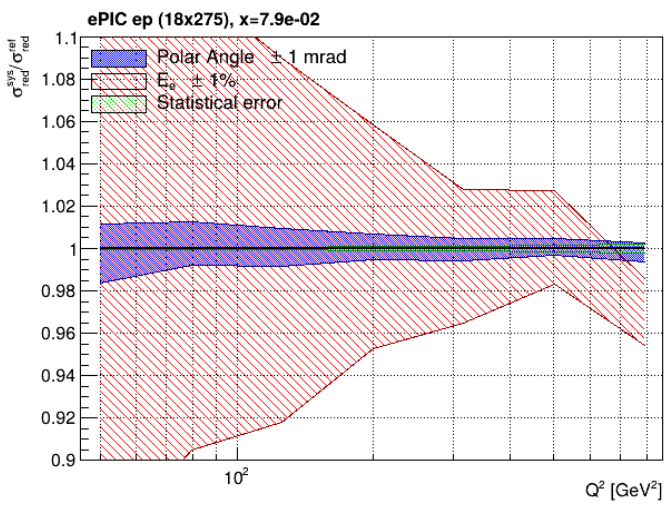
Results

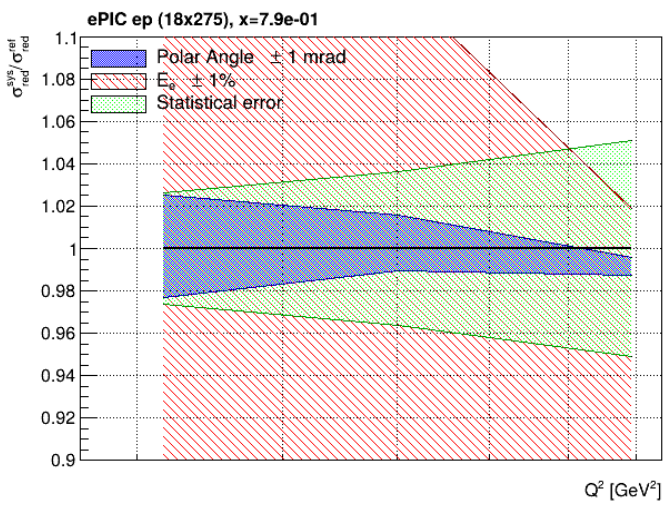
Very preliminary

- After repeating the same analysis procedure (same acceptance and BCC), compare result to original analysis
- Note: at fixed x, lower Q^2 = lower y
- Systematics can be addressed in different ways
  - E scale uncertainty? DA method
  - Extend/merge bins in x/Q^2







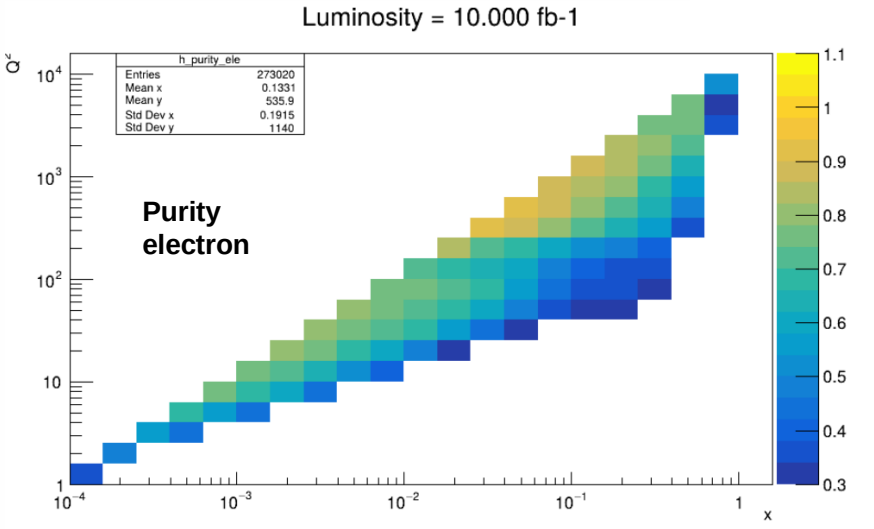


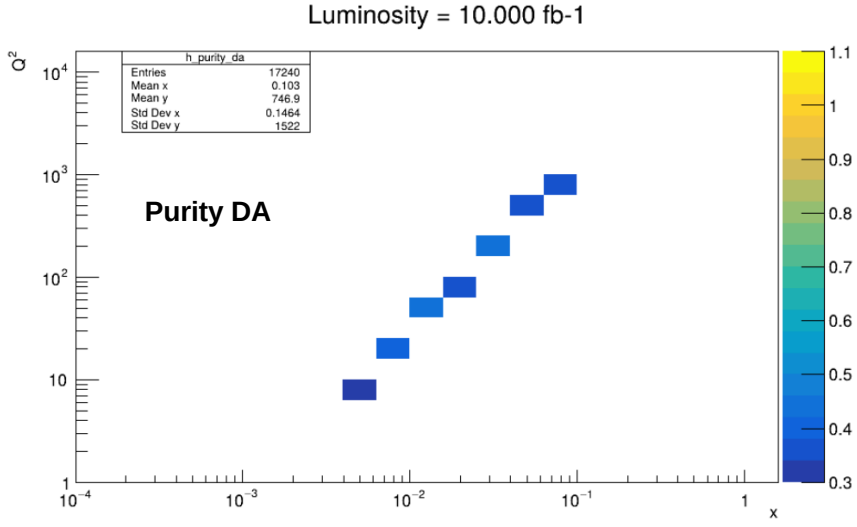
Current state of reconstruction

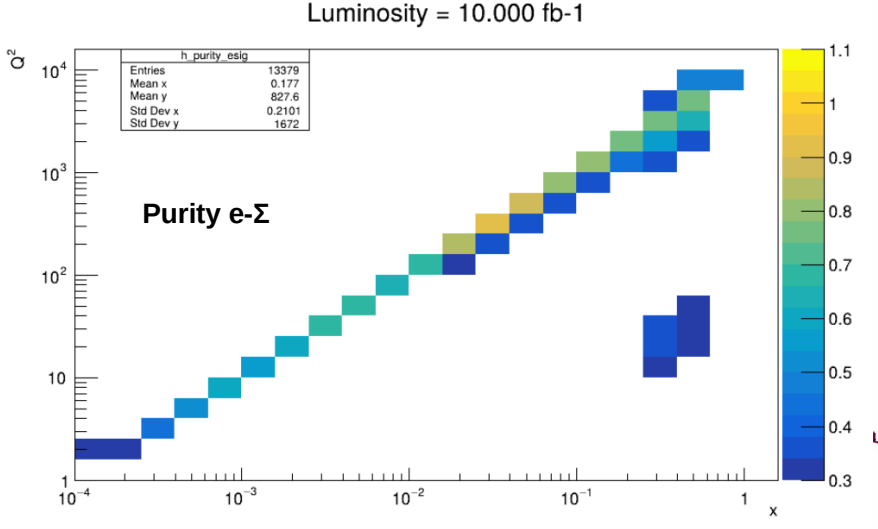
$$Purity = \frac{N_{rec\&gen}}{N_{rec}}$$

- Only looking at electron method currently
  - Methods using hadronic information aren't giving great results for me in 25.04.1 campaign

- Need to look into this further, and perform systematic studies for different recon methods







Summary

- Estimated impact of two (pessimistic) systematic uncertainties on NC σ_{red} measurement
- It's clear that in order to extract the best performance with "realistic" systematic uncertainties, consideration will need to be given to
  - Which reconstruction method is used and in which part of the x-Q^2 plane
  - How we choose to bin in x and Q2
- Can continue with such studies, once issue with mixed methods has been sorted (for me at least, others may not see this issue!)