ATHENA Inclusive Group: Discussion of Plans

ATHENA Inclusive meeting
12 July 2021

Two tasks:

- Detector configuration benchmarking
- Producing ‘golden’ plots for proposal

Work programme

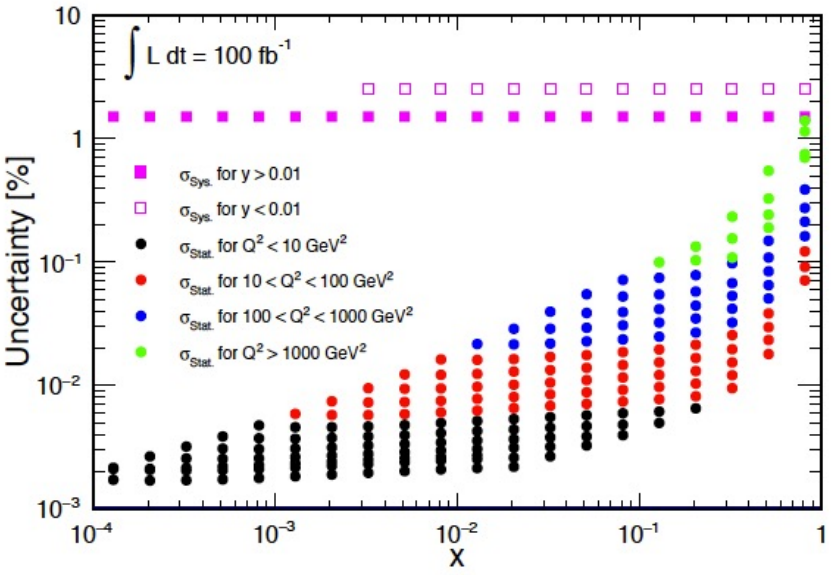
- Most important observable to study is inclusive NC DIS cross section at Large Q^2 → leading to several headline physics results

Golden channels	Physics Topic/goal
Unpolarized inclusive ep/d: $\sigma(x,Q^2) \rightarrow F_2, F_L$	Proton PDFs $q(x,Q^2)$, $g(x, Q^2)$
Unpolarized inclusive eA: $\sigma(x,Q^2) \rightarrow F_2, F_L$	Nuclear PDFs $q(x,Q^2)$, $g(x, Q^2)$
Polarized inclusive ep/d, $A_{LL} \rightarrow A_1(x,Q^2) \rightarrow g_1$	Proton spin structure Gluon & Quark Helicity $\Delta g(x,Q^2)$, Δu^+, Δd^+
Parity-violating DIS	Polarized/unpolarized PDF (strange)

- Also probably … Inclusive CC DIS

- Also possibly … Total cross section in photoproduction ($Q^2 \rightarrow 0$) limit

Detector Configuration Benchmarking



N.C. systematic uncertainties

	Point-to-Point (%)	Normalization (%)
Statistics (10 fb^{-1})	0.01-0.35	-
Luminosity	-	~1
Electron Purity	-	~1 (for 90% purity)
Bin-Centering	<0.5	<0.5
Radiative Corrections (*HERA*)	1	-
Acceptance / Bin-Migration + Trigger & Tracking Eff. + Charge-Symmetric Background	1-2	2-4
Additional uncertainty for y<0.01 bins	2	-
Total	1.5-2.3 (2.5-3 for y<0.01)	2.5-4.3

Plot from YR based on 100 fb^{-1} NC with 5 bins per decade in x, Q^2

... Everything is limited by systematics.

- Review assumptions on systematic sources and sizes …

… Derive directly from detector performance characterization when full (DD4HEP) sim available e.g.

Calo energy scale / res^n
Charged pion rejection ...

- Feed through selection and kinematic rec^n with energy flow algorithms etc to see impact on cross sections

Simulation Needs?

Minimum bias simulation data available from the yellow report effort

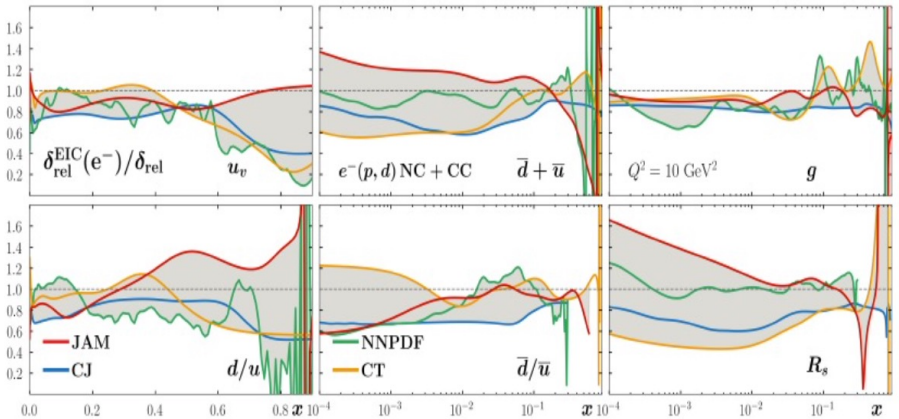
[Barak, our last meeting]

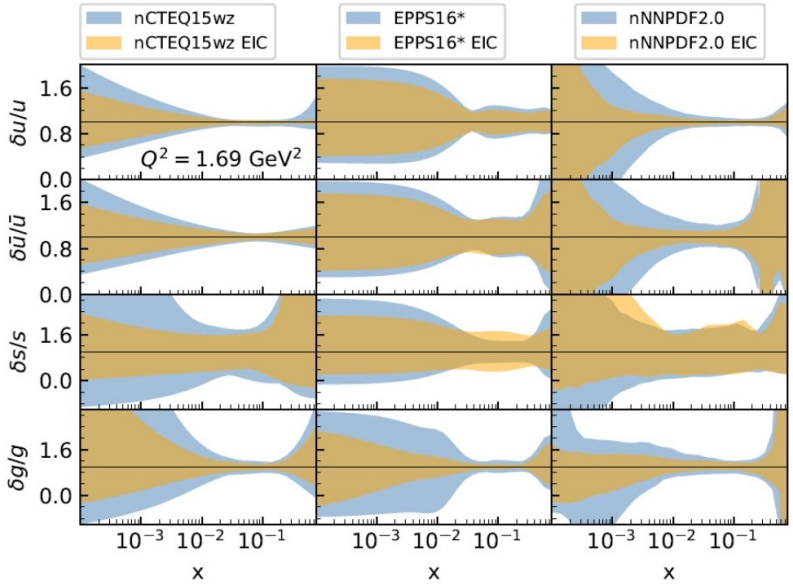
Data Set	Generator	Beam Energies	Run Information	Number of Events	Int. Luminosity
1	Pythia6	5x41 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	100 million	0.14 fb^{-1}
2	Pythia6	5x41 GeV e-p	$Q^2 > 3.0$ GeV^2; NC unpolarized; QED Radiation OFF	100 million	0.96 fb^{-1}
3	Pythia6	5x100 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	15 million	0.016 fb^{-1}
4	Pythia6	10x100 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	11 million	9.9e-3 fb^{-1}
5	Pythia6	10x110 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	15 million	0.013 fb^{-1}
6	Pythia6	18x110 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	15 million	0.011 fb^{-1}
7	Pythia6	18x275 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	15 million	9.0e-3 fb^{-1}
8	Pythia6	27.5x920 GeV e+p	$Q^2 > 1.5$ GeV^2; NC unpolarized; QED Radiation OFF	10 million	0.011 fb^{-1}
9	Djangoh	5x41 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	~10 million	0.014 fb^{-1}
10	Djangoh	5x100 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	~10 million	0.011 fb^{-1}
11	Djangoh	10x100 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	~10 million	9.1e-3 fb^{-1}
12	Djangoh	18x275 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation OFF	~10 million	6.6e-3 fb^{-1}
13	Djangoh	27.6x920 GeV e+p	$Q^2 > 1.5$ GeV^2; NC unpolarized; QED Radiation OFF	~2.5 million	3.5e-3 fb^{-1}
14	Pythia6	5x41 GeV e-p	Q^2 down to photo-production limit; NC unpolarized; QED Radiation OFF	500 million	6.3e-3 fb^{-1}
15	Pythia6	10x100 GeV e-p	Q^2 down to photo-production limit; NC unpolarized; QED Radiation OFF	300 million	2.3e-3 fb^{-1}
16	Pythia6	18x275 GeV e-p	Q^2 down to photo-production limit; NC unpolarized; QED Radiation OFF	300 million	1.7e-3 fb^{-1}
17	Djangoh	10x100 GeV e-p	$Q^2 > 0.5$ GeV^2; NC unpolarized; QED Radiation ON	~15 million	0.013 fb^{-1}

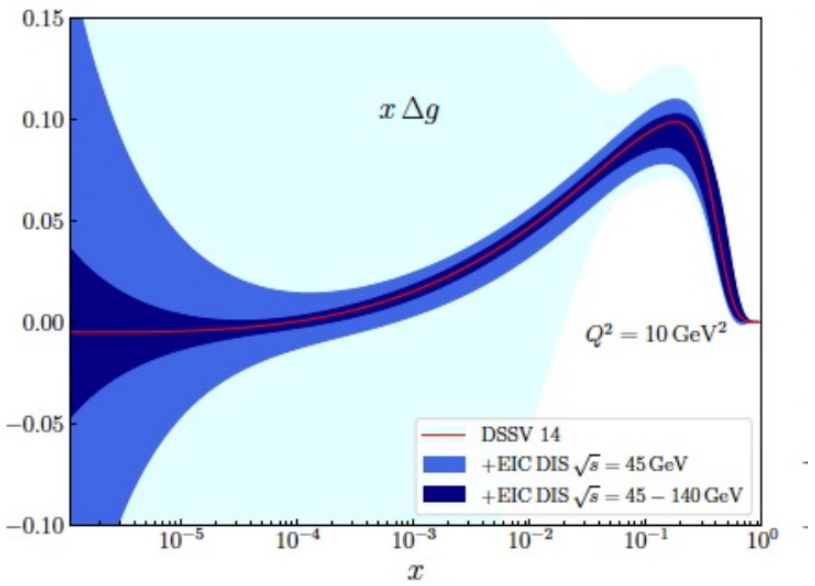
- How well do we know our needs for the systematics evaluation?
  e.g. 1% precision study in a bin needs 10k events?
  0.1% precision study needs 1M events?

Possible `Golden' Plots

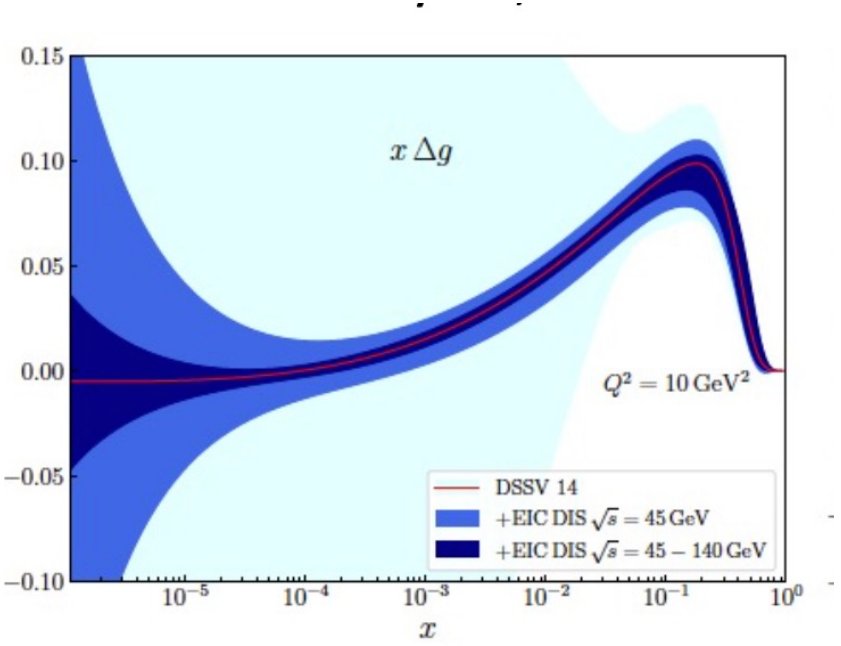
- Is statement of expected precision on cross sections sufficient for proposal?...
- … or should we be working (with theorists) towards plots showing impact on PDFs etc (proton inclusive + helicity; nuclear …)







Possible Derived Results (examples from YR)



Impact on gluon and singlet quark helicity distributions from adding EIC inclusive double spin asymmetry (A_{LL}) pseudodata

- Most effort will be in basic cross section simulations and benchmarking detector proposals, including full detector, background and beam effects
- Discussions ongoing about practicality and needs for further fitting step to extract PDFs etc.