Inclusive Group Update

Renee Fatemi, Nobuo Sato and Barak Schmookler

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Catholic University of America
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DISCUSSION POINTS

1) Forward coverage in tracking and calorimeters for JB reconstruction

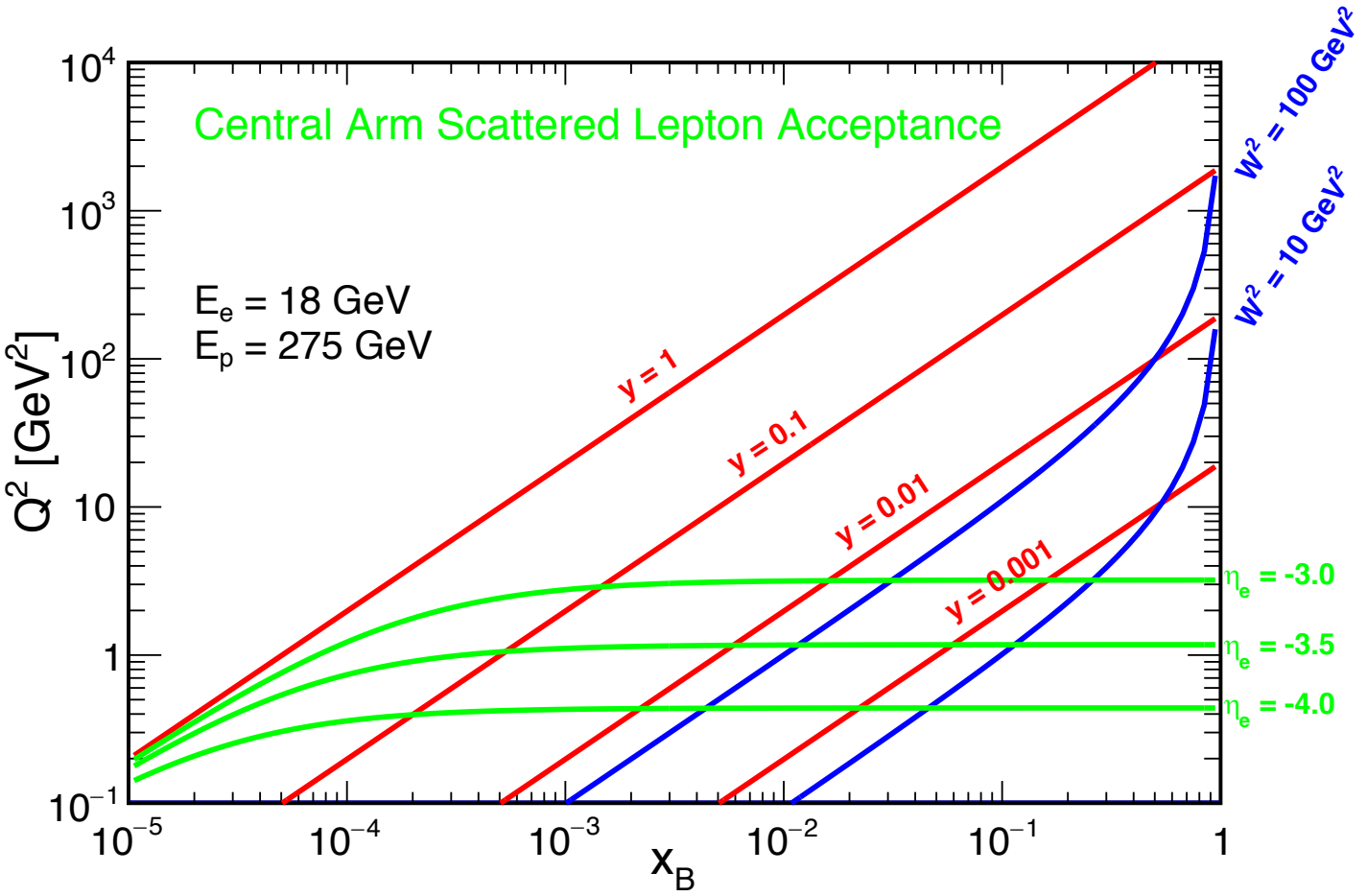
2) Hadronic Calorimeter resolution for JB purity and stability

3) Pion suppression at mid*ish*-rapidity $-2 < \eta < 1$

4) Minimize material to reduce pair-symmetric background.

η	Nomenclature			Tracking			Electrons		π/K/p		HCAL	Muons
				Resolution	Allowed X/X0	Si-Vertex	Resolution σE/E	PID	p-Range (GeV/c)	Separation	Resolution σE/E	
-6.9 to -5.8		Auxiliary Detectors	low-Q2 tagger	σθ/θ < 1.5%; 10-6 < Q2 < 10-2 GeV2								
...												
-4.5 to -4.0	↓ p/A		Instrumentation to separate charged particles from photons				2%/√E					
-4.0 to -3.5												
-3.5 to -3.0		Central Detector	Backward Detector	σp/p ~ 0.1%⊕0.5%	~5% or less X cannot evaluate without full detector simulations. Critical that this is minimized to reduce pair symmetric correction	TBD	2%/√E	suppression up to 1:104 cannot evaluate without full detector simulations and PID algorithms see e/pion	≤ 7 GeV/c		~45%/√E+6%	TBD
-3.0 to -2.5				σp/p 0.1%⊕0.5%			7%/√E					
-2.5 to -2.0				σp/p 0.05%⊕0.5%			7%/√E					
-2.0 to -1.5												
-1.5 to -1.0												
-1.0 to -0.5			Barrel	σp/p ~0.05%×p+0.5%		σxyz ~ 20 μm, d0(z) ~d0(rΦ) ~ 20/pTGeV μm + 5 μm			≤ 5 GeV/c	≥ 3 σ	~85%/√E+7%	
-0.5 to 0.0											~85%/√E+7%	
0.0 to 0.5											~85%/√E+7%	
0.5 to 1.0											~85%/√E+7%	
1.0 to 1.5			Forward Detectors	σp/p ~0.05%×p+1.0%		TBD			≤ 8 GeV/c			
1.5 to 2.0												
2.0 to 2.5									≤ 20 GeV/c		~45%/√E+6%	
2.5 to 3.0				σp/p ~ 0.1%×p+2.0%			(10-12)%/√E					
3.0 to 3.5									≤ 45 GeV/c			
3.5 to 4.0	↑ e	Auxiliary Detectors	Instrumentation to separate charged particles from photons	Forward coverage critical for JB reconstruction							Forward coverage critical for JB reconstruction	
4.0 to 4.5												
...			Neutron Detection									
> 6.2			Proton Spectrometer	σintrinsic(|t|)/|t| < 1%; Acceptance: 0.2 < pt < 1.2 GeV/c								

Backward Tracking and Calorimeter Coverage

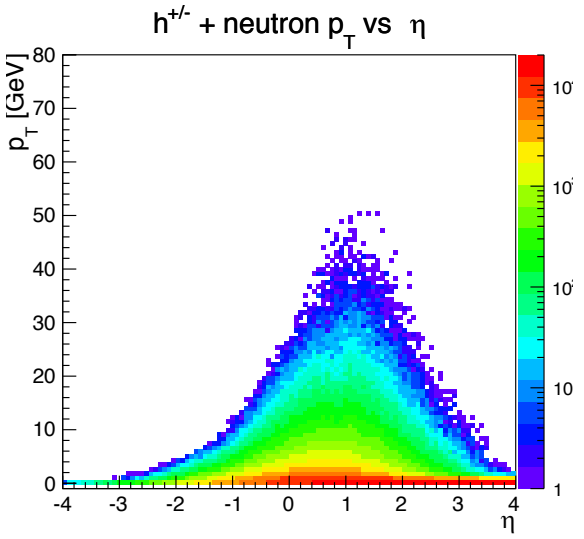


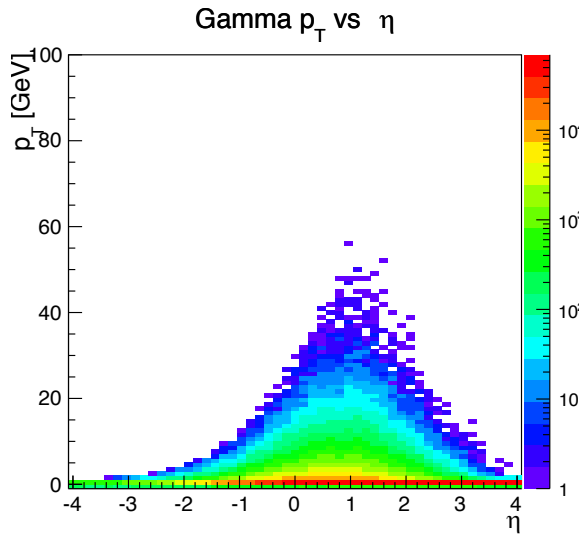
- Extending electron reconstruction out to $\eta = -4$ is not critical for majority of inclusive channels.
- The only exception may be studies on deviations from DGLAP and color glass condensate studies.
- Kinematic losses at $Q^2 < 1$ GeV^2 for all beam configurations.
- Work by **Barak Schmookler**.

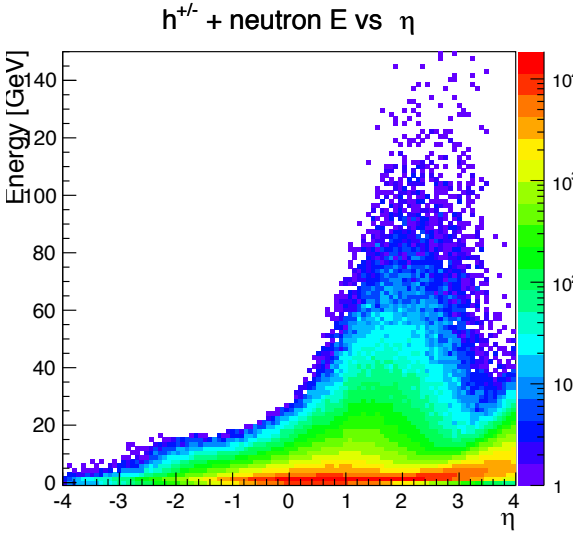
Forward Tracking and Calorimeter Coverage

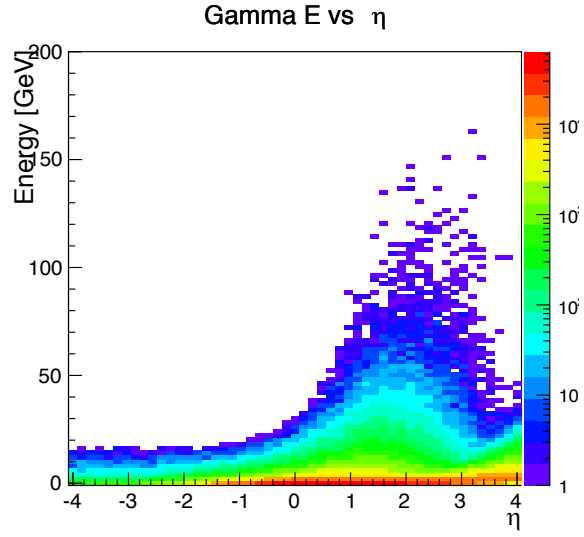
- JB reconstruction is the only option for reconstruction of charged-current observables.
- But JB reconstruction is also important for neutral current channels at small inelasticity, which is also high x.
- JB requires tracking as well as electromagnetic (photons) and hadronic calorimeters.
- Work by **Xiaoxuan Chu**

$$x_{JB} = \frac{Q^2_{JB}}{s y_{JB}}; \quad y_{JB} = \frac{(E - p_z)_h}{2E_e}; \quad Q^2_{JB} = \frac{p^2_{t,h}}{1 - y_{JB}}$$



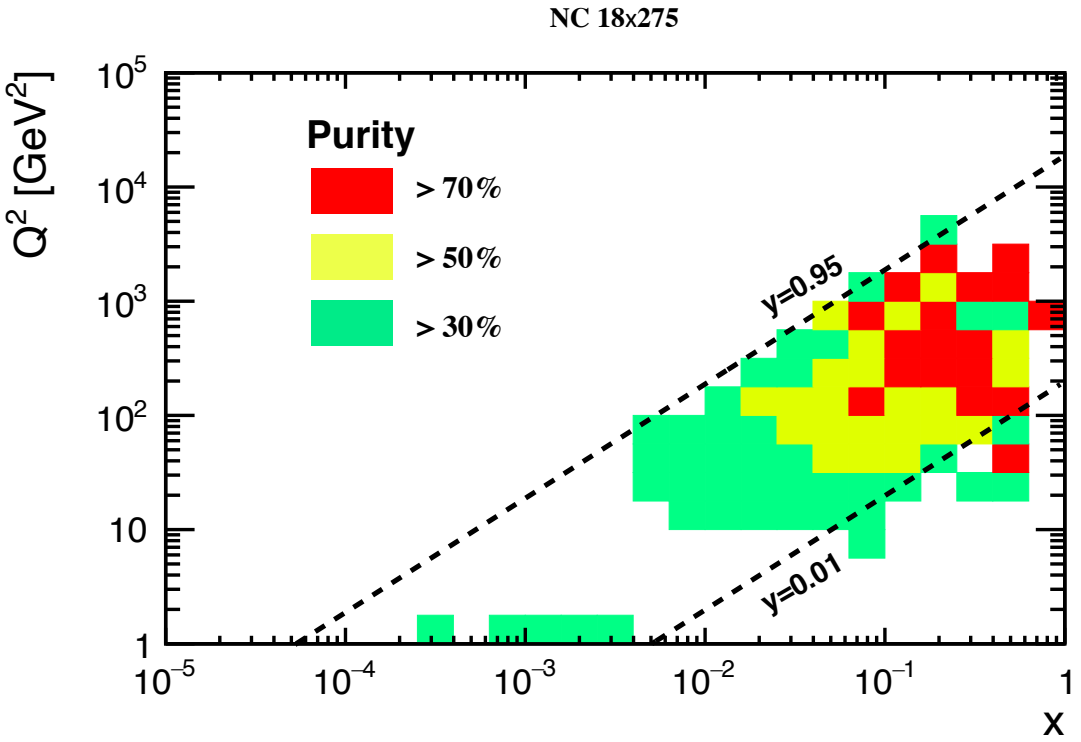


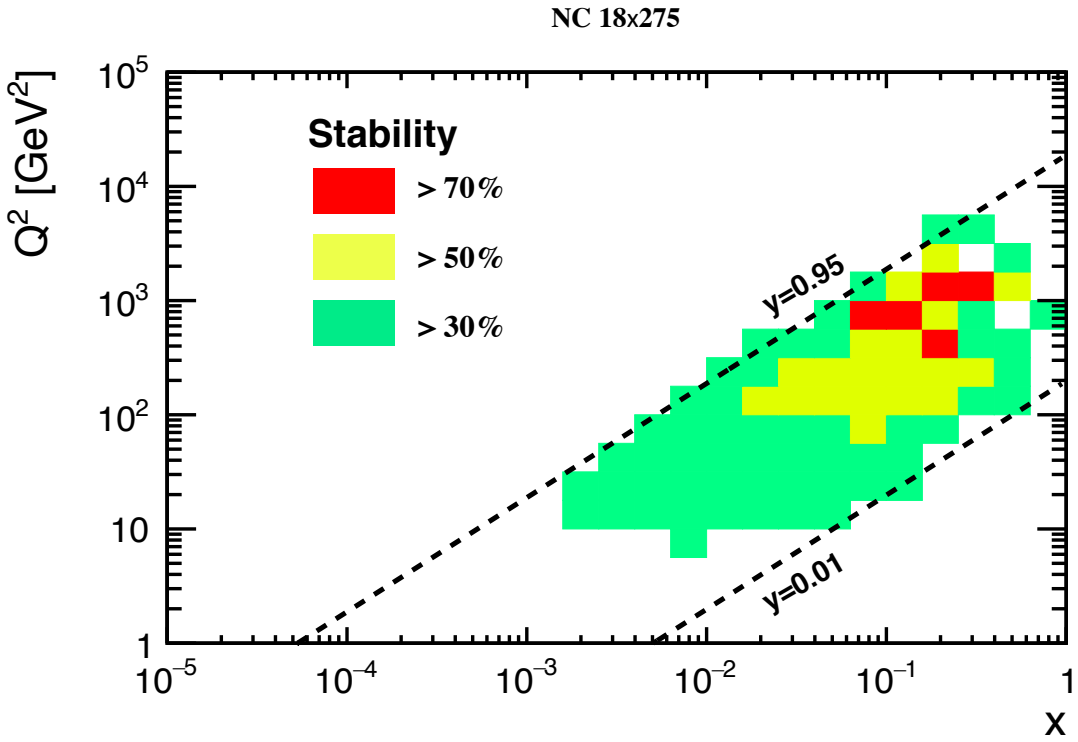




Hadronic Calorimeter Resolution

Need > 30%, higher is better for Purity and Stability.



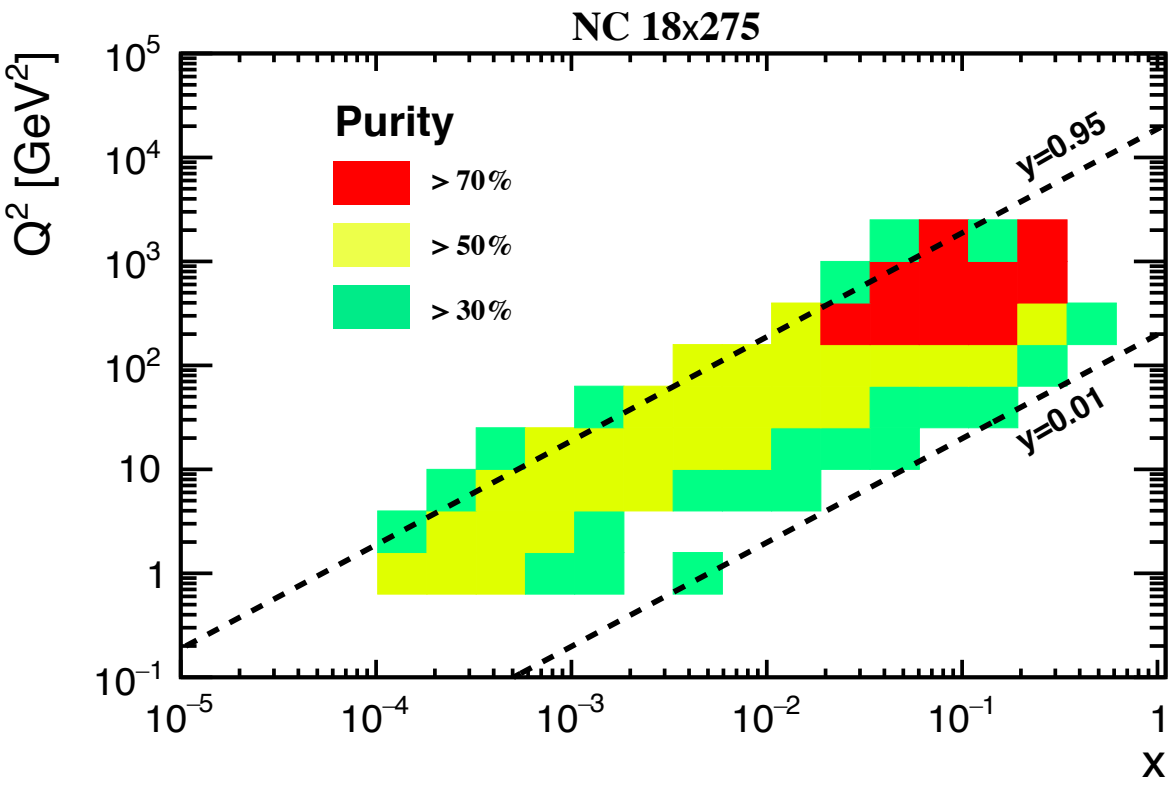


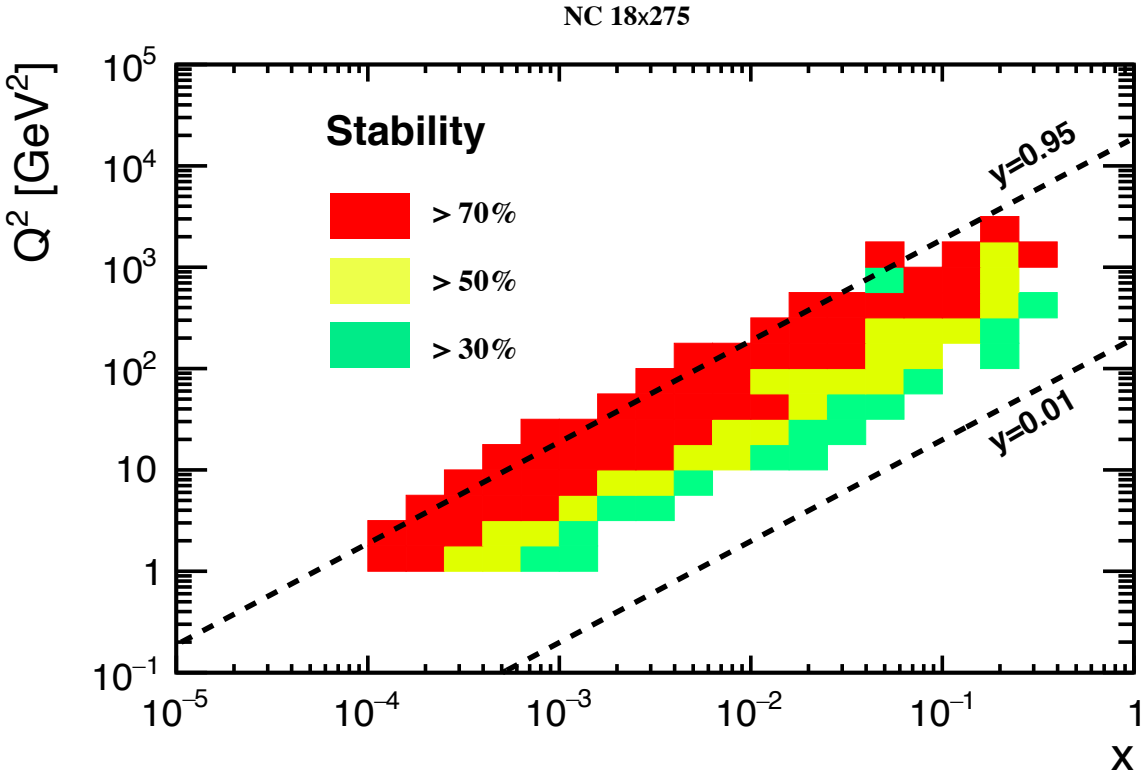
Purity : Fraction of events reconstructed in a bin i that were generated in bin i.
Reflects migration into bin i.

Stability : Fraction of events generated in a bin i that were reconstructed in bin i.
Reflects event migration out of bin i.

Xiaoxuan Chu

Purity and Stability Comparison for e- Reco



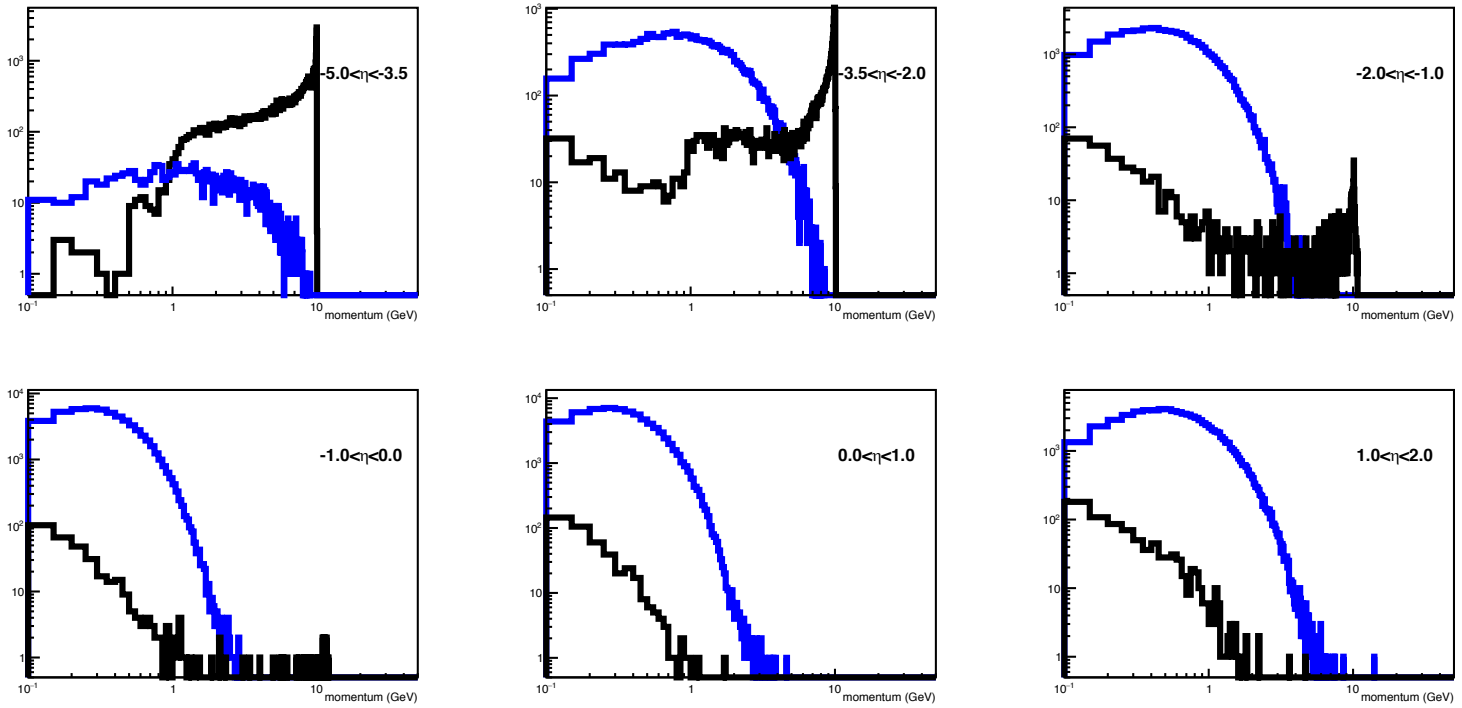


Note : The lack of coverage at low inelasticity is highlighted here. This region is filled in by the JB reconstruction and demonstrates what would be lost without forward coverage with good calorimeter and tracking resolution.

Xiaoxuan Chu

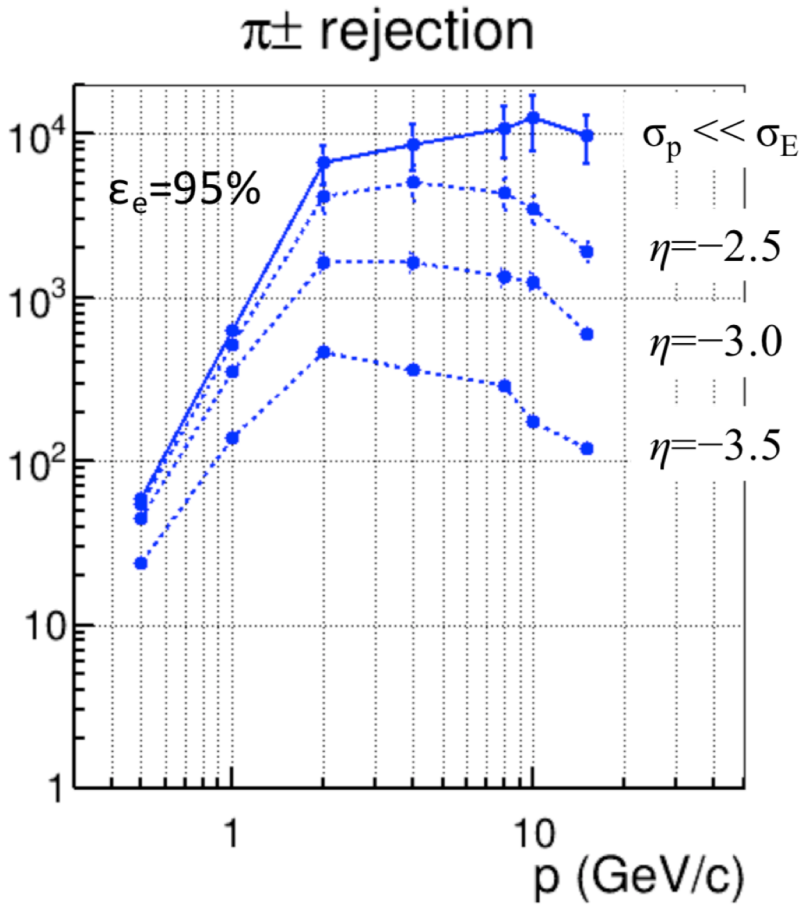
Charged pion suppression

ΔG needs pi/e 10^{-3} , A_{PV} needs pi/e 10^{-4}. Using only raw yields and no algorithms, suppression in η bins -2 to 1 are marginal for ΔG and 10x too large for A_{PV}. Need full simulation and algorithm development for more robust answer.



10 x 100 GeV Pion/e- Ratio (Work by **Hanjie Liu**)

NOTE: Detector matrix has 10^4 suppression. But GEANT studies show this is is idealized and only true at high electron momentum. ***Is 10^4 realistic?***



GEANT Studies from **A. Bazilevsky**

Impact studies

- Parity violating DIS (A_{PV})
- Double spin asymmetry (A_{LL})
- Unpolarized NC and CC DIS
- New tools for impact studies

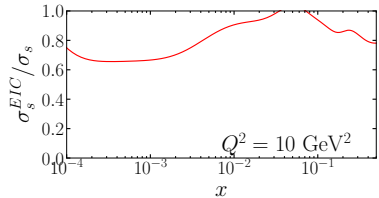
Parity violating DIS (A_{PV})

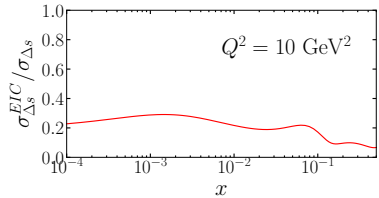
Physic objectives

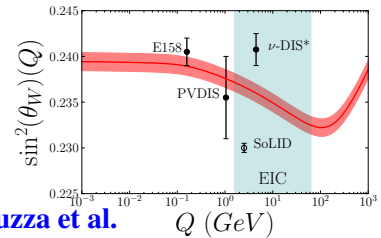
- polarized strangeness (significant impact)
- upolarized strangeness (moderate impact)
- $\sin^2\theta_w$ (moderate impact)

Progress

- error estimation (✓)
- global analysis with EIC pseudo data (near completion)







Coccuzza et al.

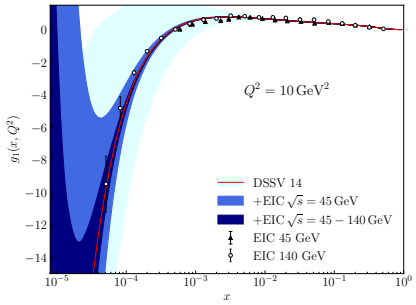
Double spin asymmetry (A_{LL})

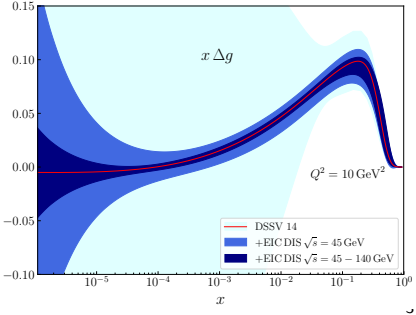
Physic objectives

- Δg (significant impact)

Progress

- error estimation (✓)
- global analysis with EIC pseudo data (completed)
- based on g_1 **extrapolation**





Borsa et al.
arXiv:2007.08300

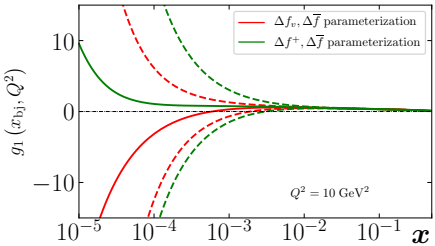
Double spin asymmetry (A_{LL})

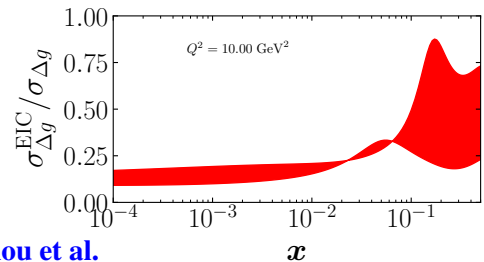
Additional questions

- how important is the g_1 extrapolation?
- is the impact on Δg stable under different g_1 scenarios

Progress

- impact on Δg stable against g_1 extrapolation
- Analysis near completion





Zhou et al.

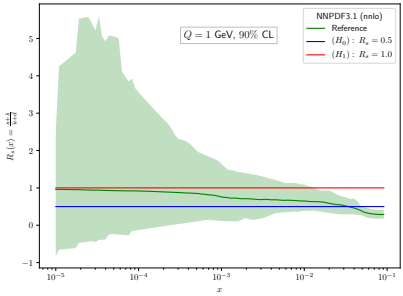
New tools

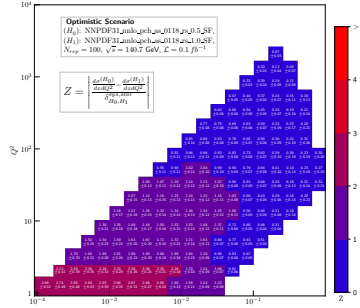
Physic objectives

- bin-by-bin hypothesis test at EIC
- complementary to full global fits

Progress

- numerical tools are ready
- case study R_s





Rabah et al.

Unpolarized NC and CC DIS

Physic objectives

- flavor separation (u, d)
- gluon PDF in the intermediate x region

Progress

- error estimation (✓)
- global analysis with EIC pseudo data p, d (in progress)

Global analyzers

CT, NNPDF, CJ, JAM

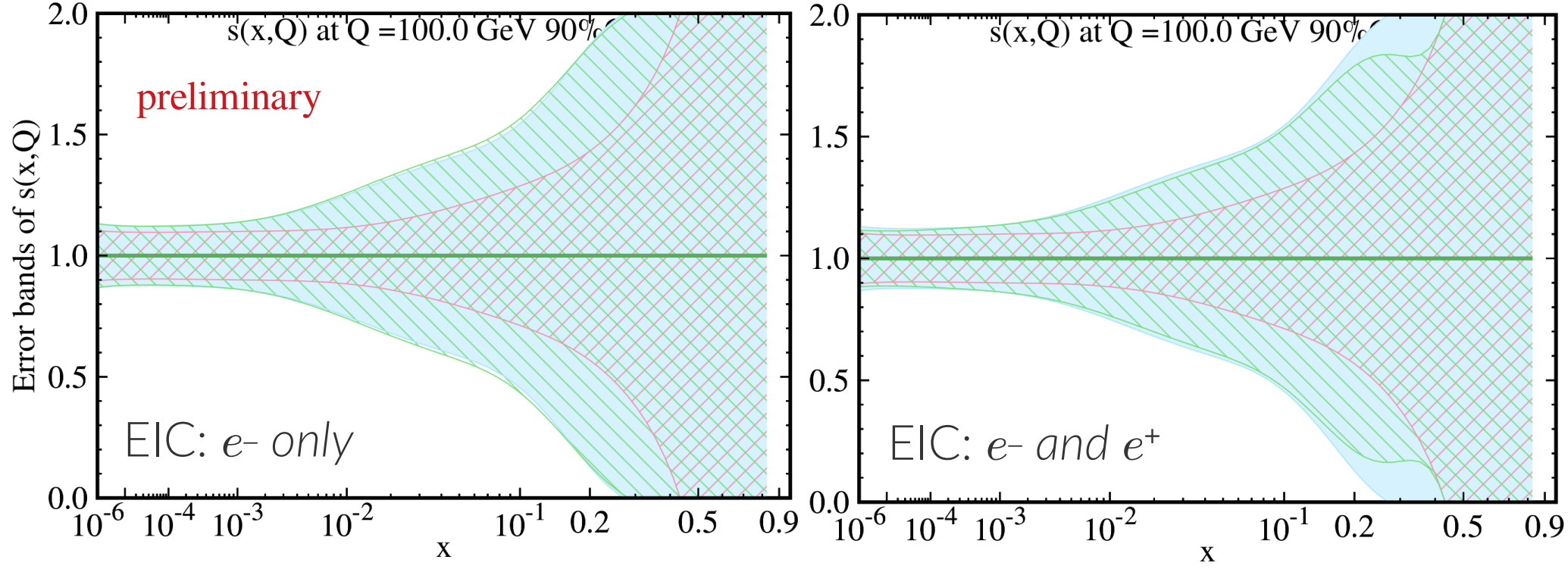
nucleon strangeness: EIC **inclusive** pseudodata & legacy CT data

- beyond fitting EIC over present data, comparisons with legacy data are instructive
- in CT, vFe dimuon production (NuTeV, CCFR) are important constraints on $s(x,Q)$
- especially without e^+, EIC CC <u>inclusive</u> DIS data struggle to compete <u>*by themselves*</u>

→ some high-x pull → inputs from tagged CC data helpful

CT14$_{\text{HERA2}}$ NNLO (*no* dimuon) no dimon + EIC CC DIS (inclusive)

CT14$_{\text{HERA2}}$ NNLO (*with* dimuon)



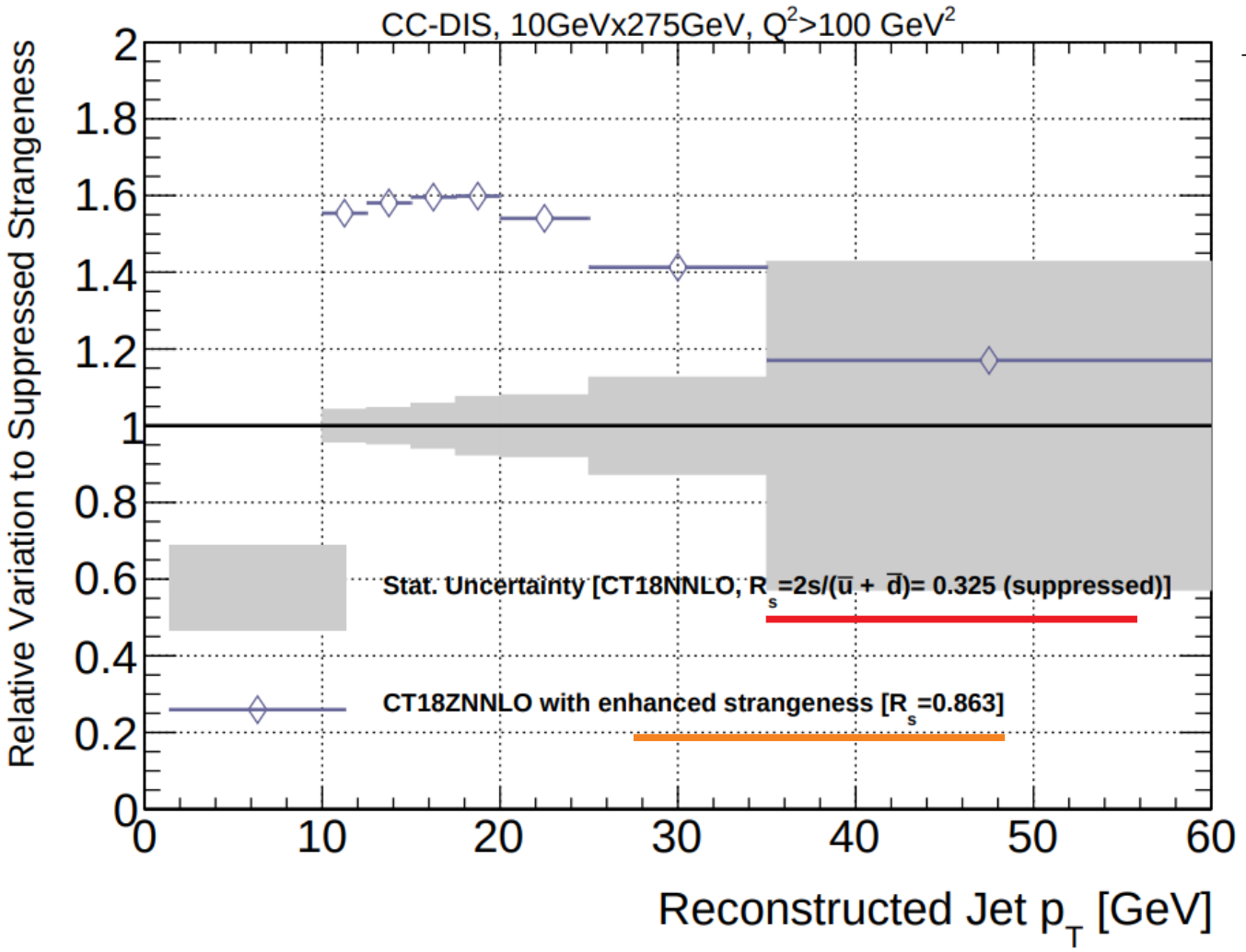
charge-current charm-jet production sensitive to strange sea

Arratia, Furletova, Hobbs, Olness, Sekula

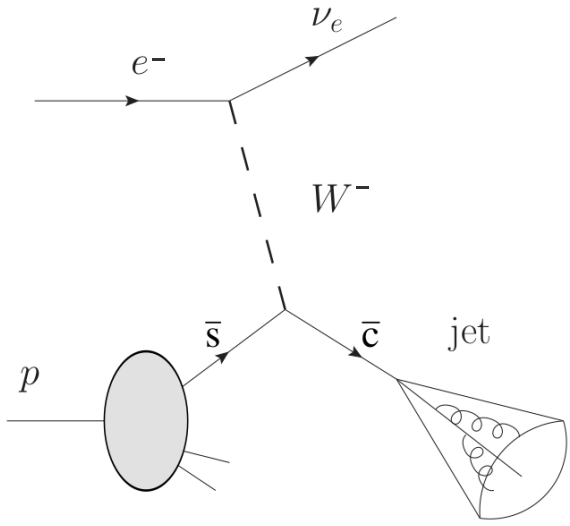
arXiv: 2006.12520

- 100 fb^{-1} CC DIS (10M simulated events), at 10x275 GeV (e^- on p); $Q^2 > 100$ GeV^2

- **even assuming conservative charm-tagging efficiency, event-level discrimination potential is substantial, relative to statistical uncertainties**



$$R_s = \frac{s+\bar{s}}{\bar{u}+\bar{d}} \quad = 0.325\ (\mathrm{CT18})^* \quad = 0.863\ (\mathrm{CT18Z})^*$$



final-state tagging will provide a critical lever arm for flavor separation

Conclusions

- Detector studies are complete for this stage of evaluation. There is still a substantial amount of work to be done in evaluating electron PID and backgrounds once a realistic detector, with full material budget is proposed.

- Impact studies are well underway and include several published results. These are on track to be finalized by Berkeley Workshop (or sooner).

Detector Group Questions

- Have MC been validated? Can they reproduce world data?

YES! Very good agreement with HERA and existing PDF extractions.

- CC cross-sections by Xiaoxuan Chu
  https://indico.bnl.gov/event/8389/
- NC cross-sections by Matt Posik
  https://indico.bnl.gov/event/8658/
- NC cross-sections by Barak Schmookler
  https://indico.bnl.gov/event/9093/