

Report on EIC Early Science Workshop (ePIC)

Rongrong Ma (BNL)

05/20/2025

2025 RHIC/AGS ANNUAL USERS' MEETING

RHIC 25:

A quarter century of discovery

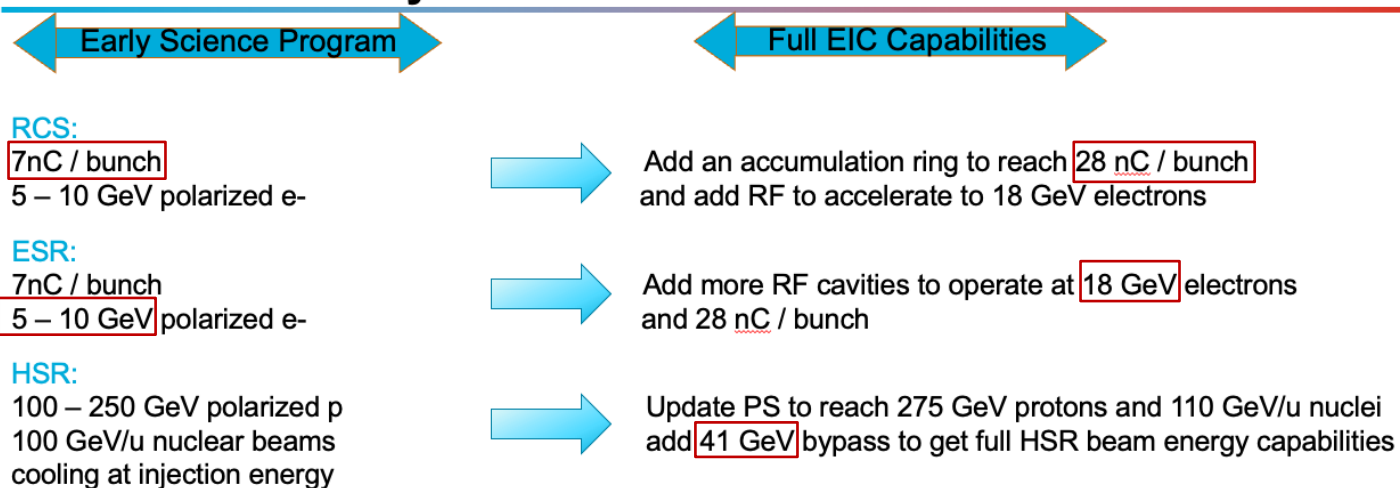
May 20–23, 2025



Why this exercise?

- Staged ramping up of EIC performance

Accelerator at Day One and Ultimate



Running scenario

	Species	Energy (GeV)	Luminosity/year (fb ⁻¹)	Electron polarization	p/A polarization
YEAR 1	e+Ru or e+Cu	10 x 115	0.9	NO (Commissioning)	N/A
YEAR 2	e+D e+p	10 x 130	11.4 4.95 - 5.33	LONG	NO TRANS
YEAR 3	e+p	10 x 130	4.95 - 5.33	LONG	TRANS and/or LONG
YEAR 4	e+Au e+p	10 x 100 10 x 250	0.84 6.19 - 9.18	LONG	N/A TRANS and/or LONG
YEAR 5	e+Au e+3He	10 x 100 10 x 166	0.84 8.65	LONG	N/A TRANS and/or LONG

Note: the eA luminosity is per nucleon

- Double the total luminosity at HERA for ep and provide new data for eA
- *What Early Science (ES) can ePIC do?*
 - ePIC detector fully installed in year-1 (except for RP and OMD)

Continuous efforts to define ES

- Jul. 2024: initial discussion at Coll. Meeting (Lehigh)
<https://indico.bnl.gov/event/20727/contributions/93191/>
- Sep. 2024: kick-off workshop
<https://indico.bnl.gov/event/24432/>
- Jan. 2025: plenary at Coll. Meeting (Frascati)
<https://agenda.infn.it/event/43344/sessions/31149/#20250122>
- **Apr. 24-25, 2025: workshop at SBU**
<https://indico.cfnsbu.physics.sunysb.edu/event/410/>
- Jul. 2025: plenary at Coll. Meeting (JLab)
<https://indico.jlab.org/event/934/overview>
- ~ Sep. 2025: workshop
- Spring/summer 2026: final report

ES workshop: Day 1

Thu, April 24

9:00 AM	Address by the ePIC spokesperson Contribution Speaker: John Lajoie
9:20 AM	
9:20 AM	Introduction by the Physics Analysis Coordinators Contribution Speakers: Salvatore Fazio, Rosi Reed
9:40 AM	
9:40 AM	Mining for gluon saturation at the Electron-Ion Collider Contribution Speaker: Farid Salazar
10:25 AM	
10:25 AM	Wellcome by the CFNS Director Contribution Speaker: Abhay Deshpande
10:35 AM	
11:05 AM	Thoughts on early EIC running with in eA Contribution Speaker: Wim Cosyn
11:50 AM	
11:50 AM	Key processes to access parton orbital angular momentum at the EIC Contribution Speaker: Shohini Bhattacharya
12:35 PM	
1:35 PM	
3:35 PM	Discussion on scientific opportunities - (Driven by Yuri Kovchegov) Session Convener: Yuri Kovchegov

- Mostly inputs from theory community
- *S. Bhattacharya 1:30 pm*

ES workshop: Day 2

Fri, April 25

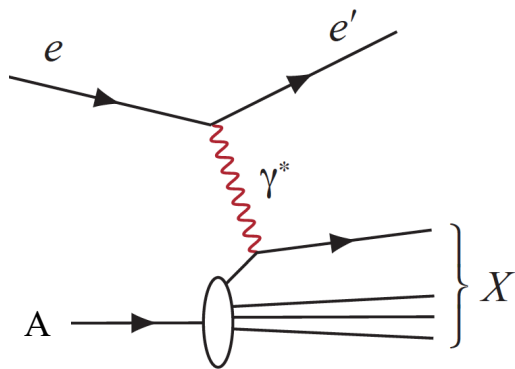
9:00 AM	Studies and projections by the inclusive PWG & the BSM+EW PWG Contribution Speakers: Stephen Maple, Tyler Kutz
9:45 AM	
9:45 AM	Studies and projections by the semi-inclusive PWG Contribution Speakers: Ralf Seidl, Stefan Diehl
10:30 AM	
11:00 AM	Studies and projections by the exclusive+diffractive+tagging PWG Contribution Speaker: Zhoukunming Tu
11:45 AM	
11:45 AM	Studies and projections by the jets+heavy-flavor PWG Contribution Speaker: Rongrong Ma
12:30 PM	
1:30 PM	Presentation of the image_browser for sharing results Contribution Speaker: Torri Jeske
1:50 PM	
1:50 PM	Beams effects and background in simulation Contribution Speaker: Alex Jentsch
2:20 PM	
2:20 PM	Discussion on Simulation Needs and Coordination - led by SCC Contribution Speakers: Markus Diefenthaler, Sakib Rahman, Wouter Deconinck
3:05 PM	

3:35 PM	Individual contributions Session
15:35 - 15:55	Impact of EIC early science eP runs on unpolarized PDFs Speaker Peter Risse
15:55 - 16:15	Exclusive lepton pair production at EIC/ePIC Speaker Krzysztof Piotrkowski
16:15 - 16:35	Light Meson Structure from Early EIC Physics Speaker Stephen Kay
16:35 - 16:55	Improving t measurement through exclusive coherent VM production Speaker Maci Kesler
16:55 - 17:15	A1n and g1n from polarized eHe3 DIS with double spectator tagging Speaker Win Lin
5:15 PM	

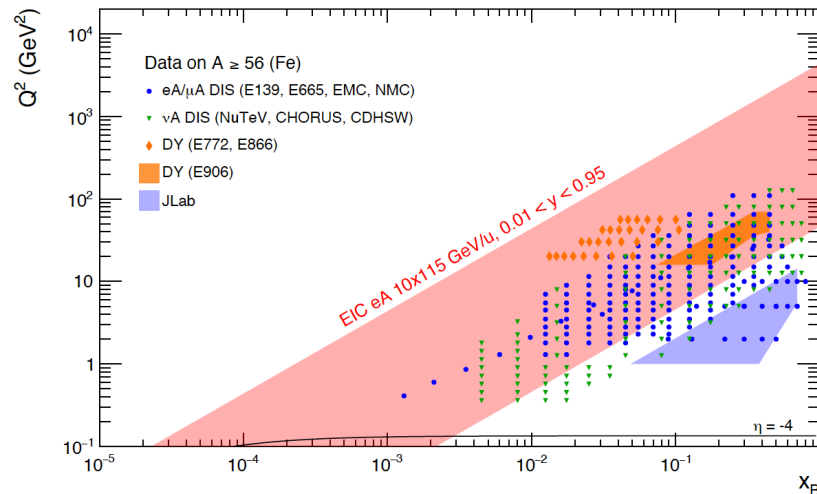
- Reports from ePIC working groups, S&C, and individual contributors
- *Disclaimer: only a selected list of results are shown*

Year 1: e+Cu/Ru @ 10x115

- Total and differential DIS cross section
→ nPDF in unexplored low- x region



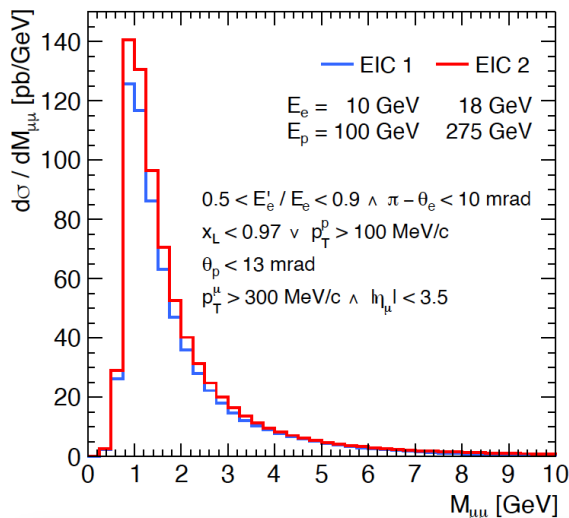
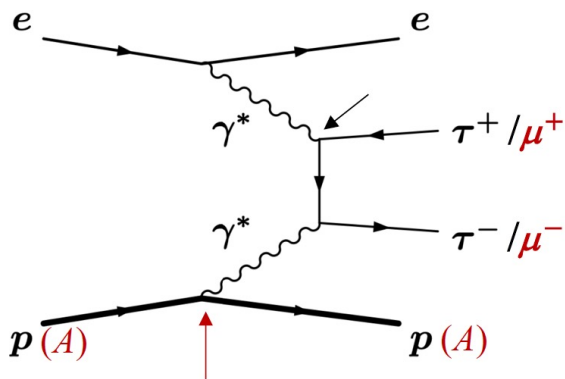
arXiv:2103.05419



Inclusive WG ([09:00](#))

Year 1: e+Cu/Ru @ 10x115

- Exclusive dimuon production in elastic interactions
→ Electric and magnetic form factors

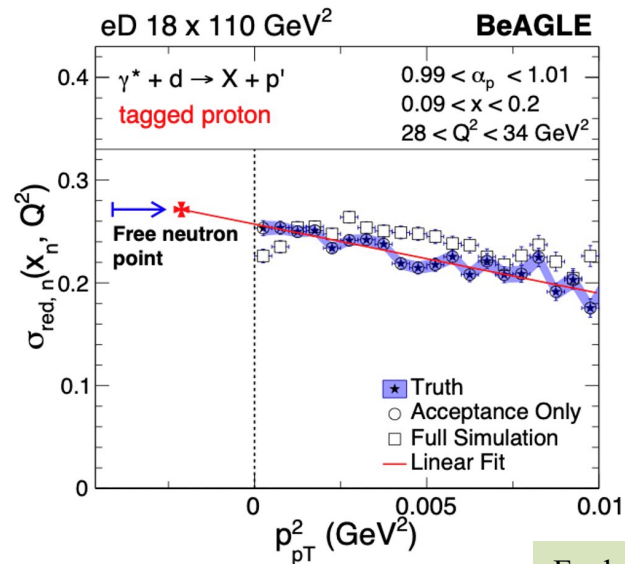
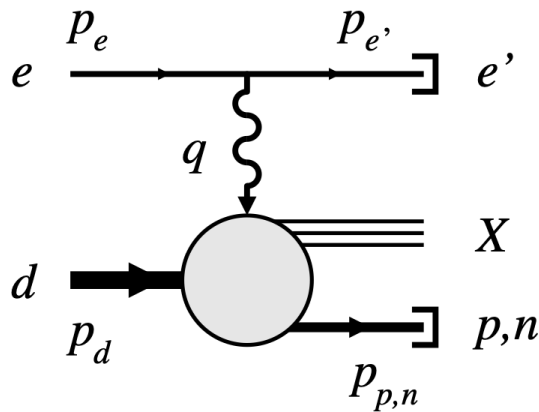


K. Piotrkowski ([15:55](#))

$\sigma_{\text{Ru}}(\gamma\gamma \rightarrow \mu\mu)$ per nucleon = $\mathcal{O}(10 \text{ nb}) \Rightarrow 10^7 \text{ events!}$

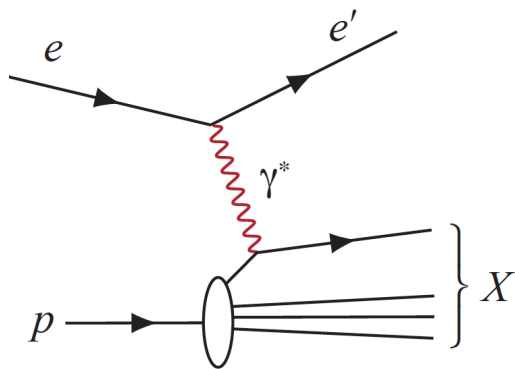
Year 2: e+D @ 10x130

- Reduced cross section with proton tagging + pole extrapolation
→ **Free neutron structure**

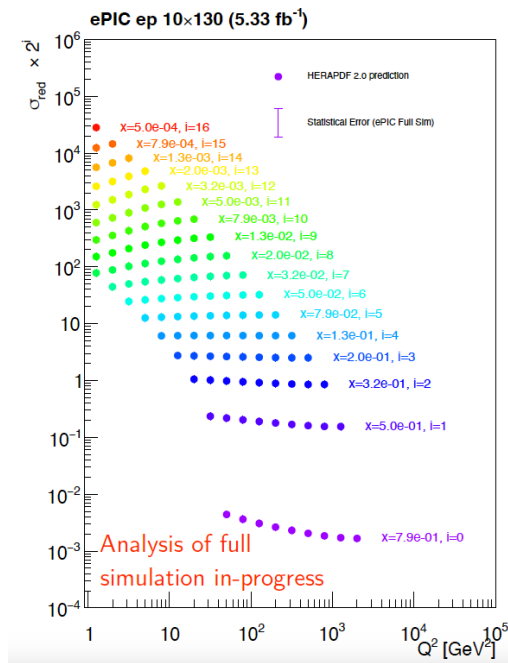


Year 2/3: e+p @ 10x130

- Total and differential DIS cross section
→ PDF, structure function



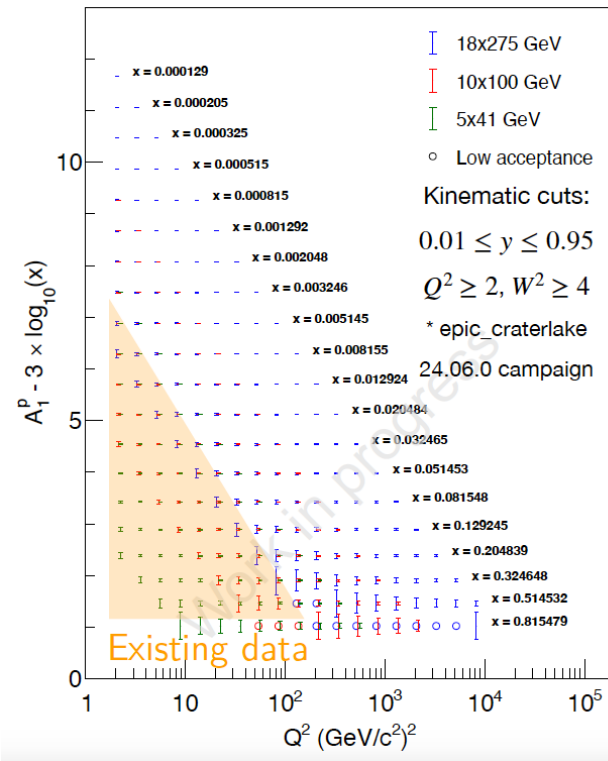
arXiv:2103.05419



Inclusive WG (09:00)

Year 4: e+p @ 10x250

- Longitudinal and transverse spin asymmetries
→ Proton spin structure (A_1^p)
- 10x130: partial overlap with existing data
- 10x250: access to lower x



Inclusive WG ([09:00](#))

Year 2/3/4

- Constraints on proton PDF
→ **Baseline for “saturation” effect**

Baseline: CJ22ht

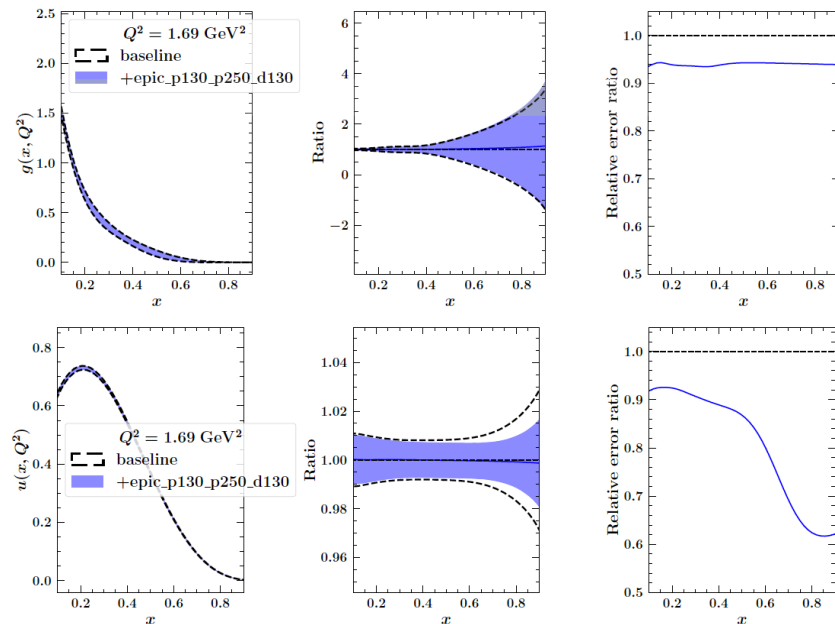
M. Cerutti, et. al., arXiv:2501.06849

Scenario C

Species:	$(e + D)$	$(e + P)$	$(e + P)$
Energy:	10x130 GeV	10x130 GeV	10x250 GeV
Luminosity:	11.4 fb ⁻¹	5.33 fb ⁻¹	9.18 fb ⁻¹

P. Risse ([15:35](#))

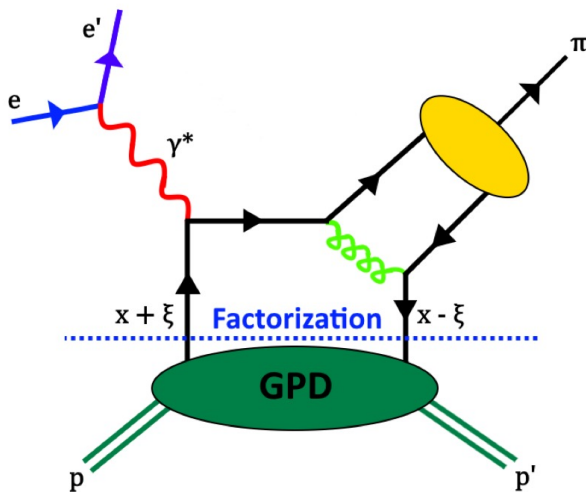
gluon



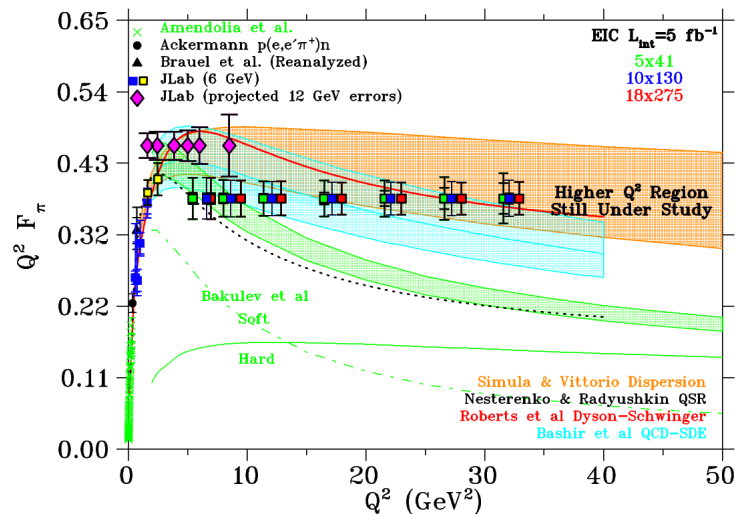
up

Year 2/3: e+p @ 10x130

- Deep Exclusive Meson Production (DEMP) for meson form factors
 → Hadron structure; hadron mass



Z. Ahmed, et. al., arXiv:2403.06000

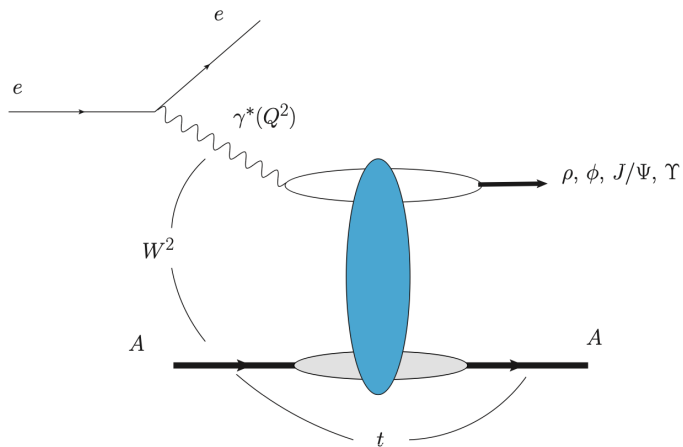


S. Kay (16:15)

Year 4/5: e+Au @ 10x100

- Exclusive coherent vector meson production
→ Gluon spatial distribution

M. Kesler ([16:35](#))

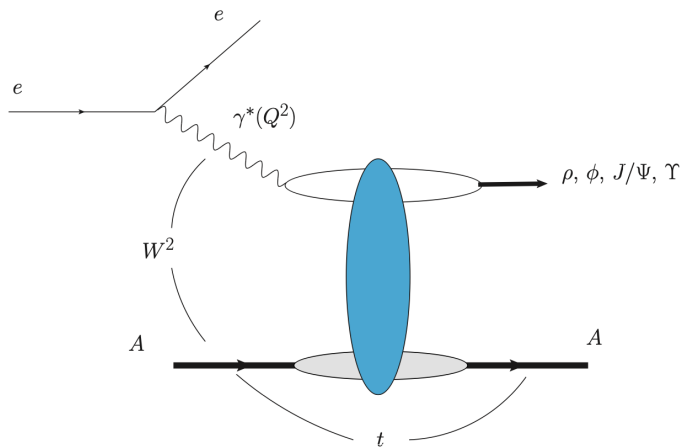


M. Krelina, et. al., NPA 989 (2019) 187

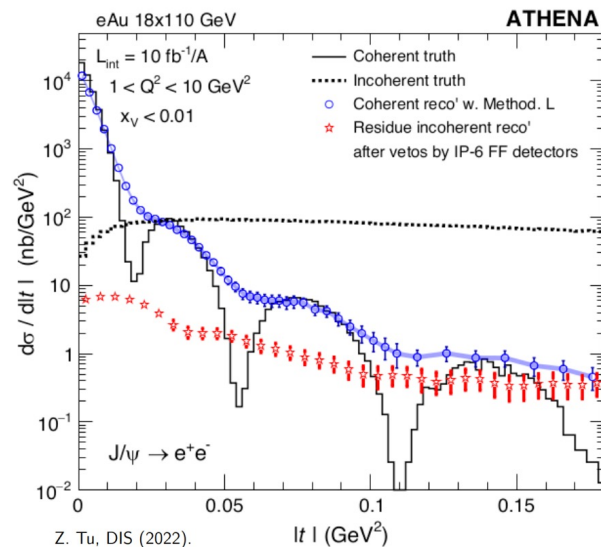
Year 4/5: e+Au @ 10x100

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→ Gluon spatial distribution

M. Kesler ([16:35](#))



M. Krelina, et. al., NPA 989 (2019) 187

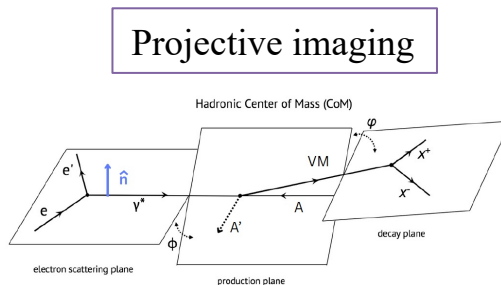
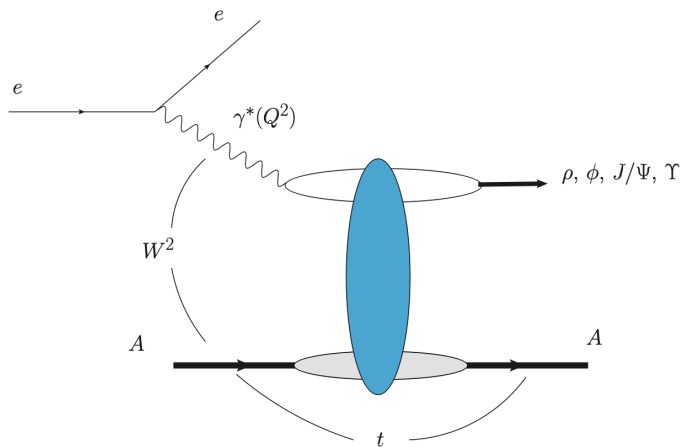


- Limited resolution in measuring $|t|$
- Overwhelming incoherent background

Year 4/5: $e+Au$ @ 10x100

- Exclusive coherent vector meson production
→ Gluon spatial distribution

M. Kesler ([16:35](#))

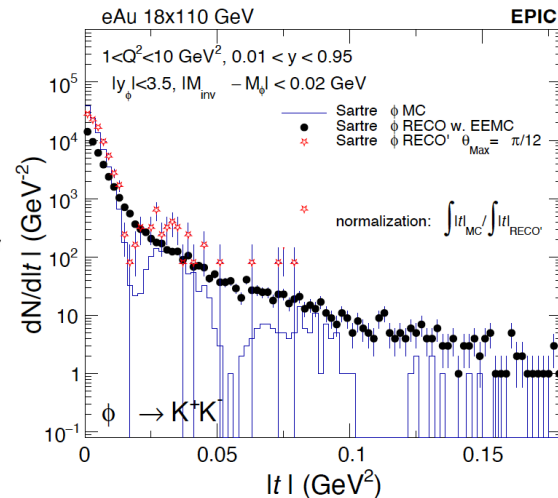
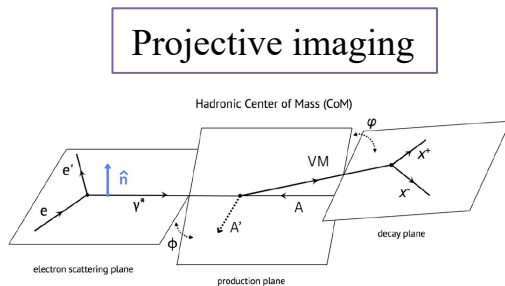
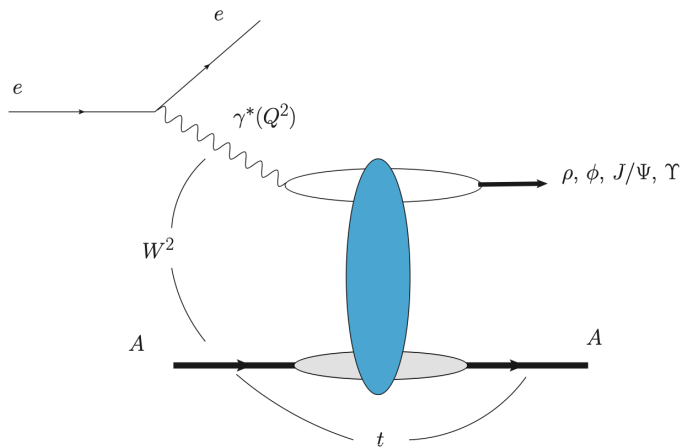


M. Krelina, et. al., NPA 989 (2019) 187

Year 4/5: e+Au @ 10x100

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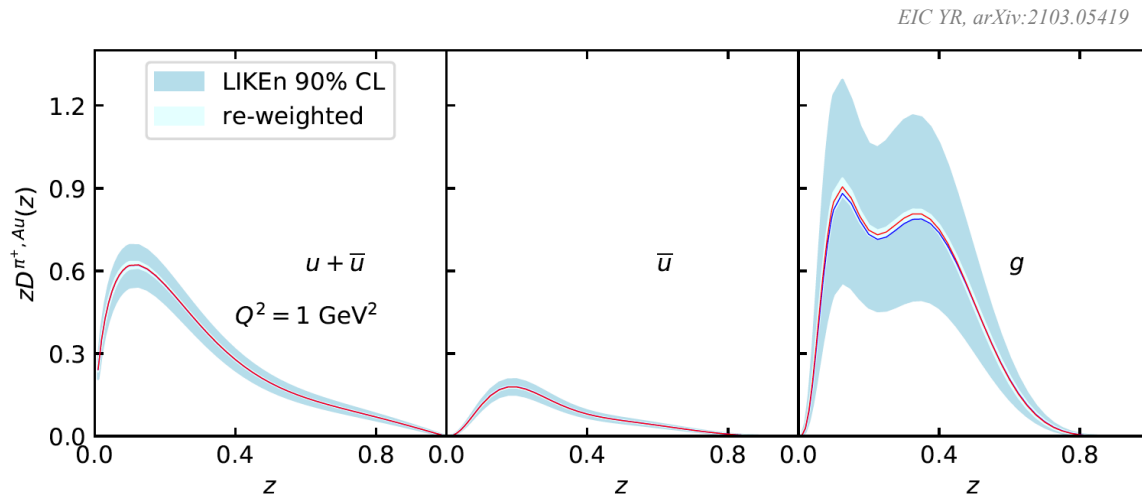
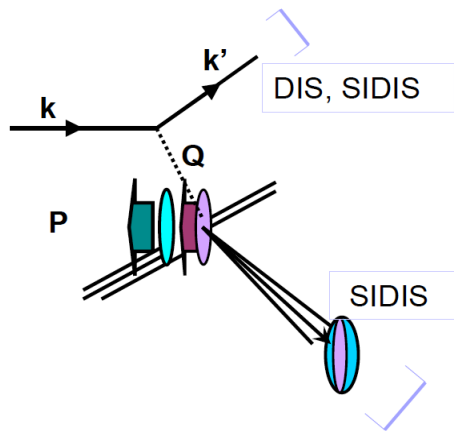
M. Kesler ([16:35](#))



M. Krelina, et. al., NPA 989 (2019) 187

Year 4/5: e+Au @ 10x100

- Measure charged hadron production
→ Constrain **nFF**

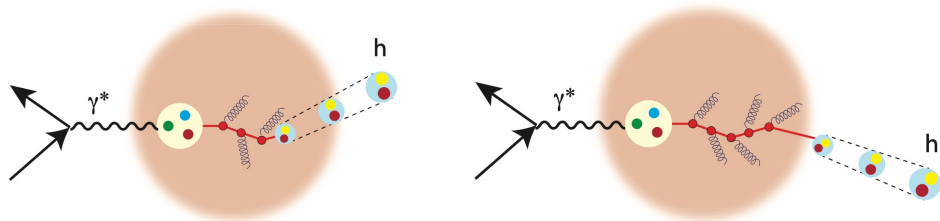


SIDIS WG([09:45](#))

Year 4/5: $e+Au$ @ 10x100

- Modification of charm hadron production
→ Nuclear effects; hadronization

Nuclear absorption vs. energy loss



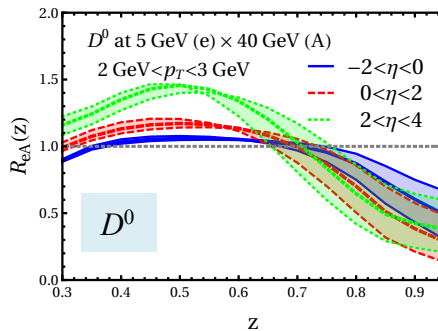
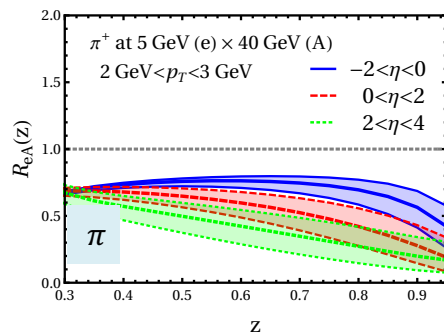
A. Accardi, et. al., EPJA 52 (2016) 268

SIDIS WG([09:45](#))

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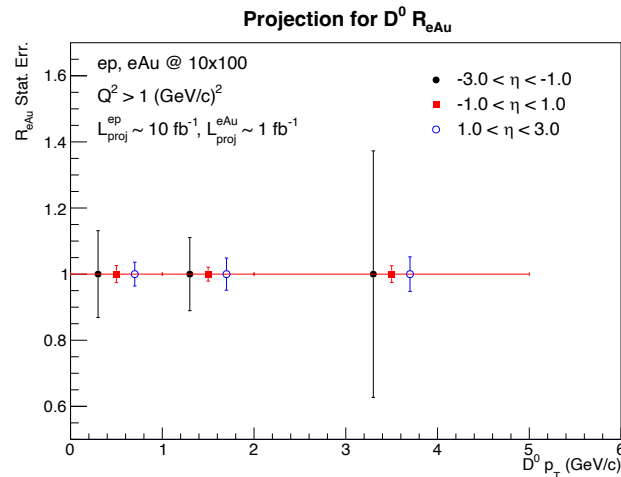
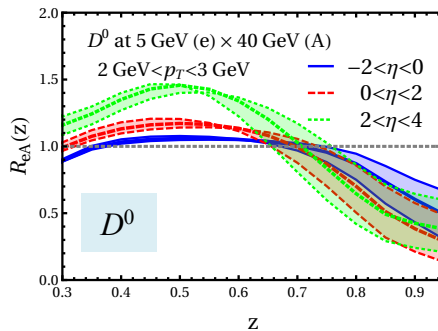
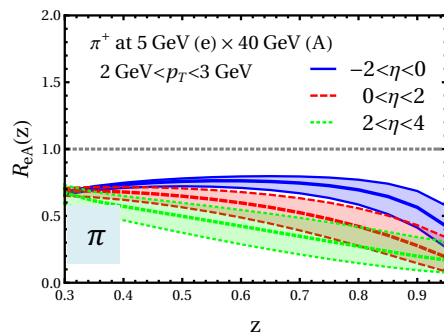


H. Li, et. al., PLB 816 (2021) 136261

Year 4/5: e+Au @ 10x100

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→ Nuclear effects; hadronization

Nuclear absorption vs. energy loss

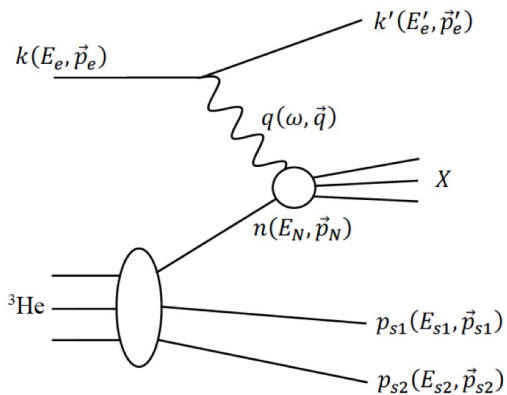


H. Li, et. al., PLB 816 (2021) 136261

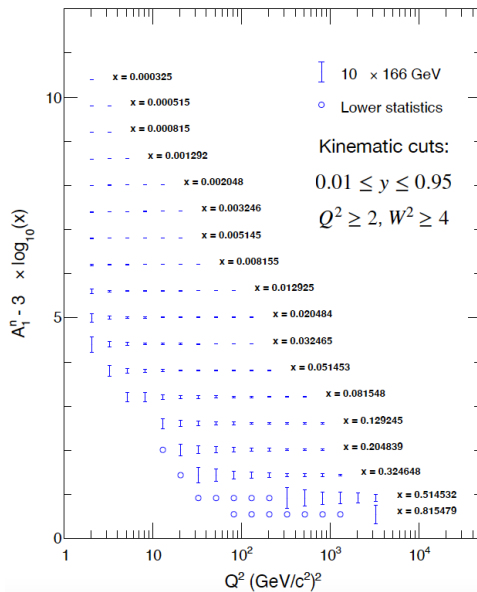
Jets&HF WG([11:45](#))

Year 5: $e+^3\text{He}$ @ 10x166

- Access to **neutron spin structure** (A_1^n) through double-spectator tagging
 $\rightarrow$ **Quark orbital angular momentum**



I. Friscic, et. al., PLB 823 (2011) 136726



- Wide range of acceptance in x and Q^2
- Good statistics at unexplored low x region

W. Lin ([16:55](#))

Summary

- The **staged ramp-up of EIC** to full capacity leads to discussion of **early science**
 - First 5 years
 - Double HERA ep luminosity + new eA data
- ePIC: a series of plenary sessions and workshops to define **meaningful and impactful** ES measurements
 - Tied to EIC science mission
 - Physics working groups: simulation, analysis, precision projection
- Plan to write up a report in ~ 1 year