

# Probing short-range correlations using diffractive $J/\Psi$ production in *deuteron*

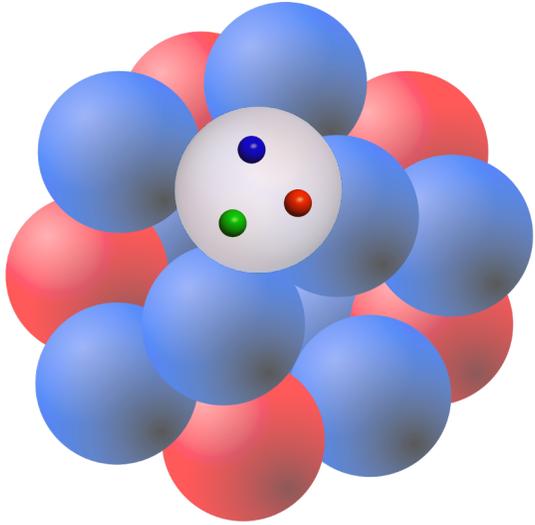
Zhoudunming Tu (*Kong*)

BNL

03.26.2021

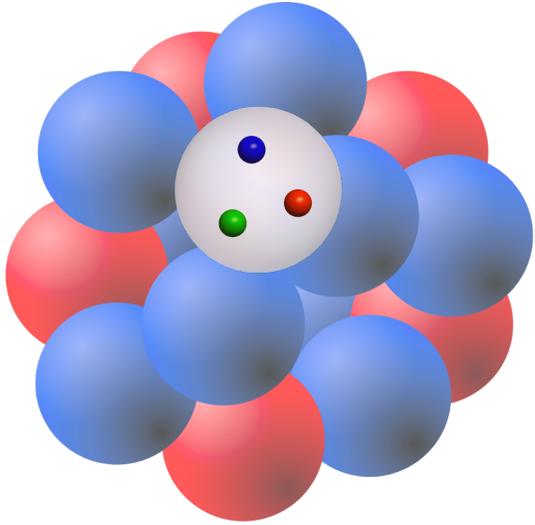
Collaboration with A. Jentsch , M. Baker , L. Zheng,  
JH. Lee , R. Venugopalan , O. Hen , D. Higinbotham  
, E. Aschenauer , T.Ullrich  
(*Phys.Lett.B* 811 (2020) 135877)

# Nucleon structure in nucleus

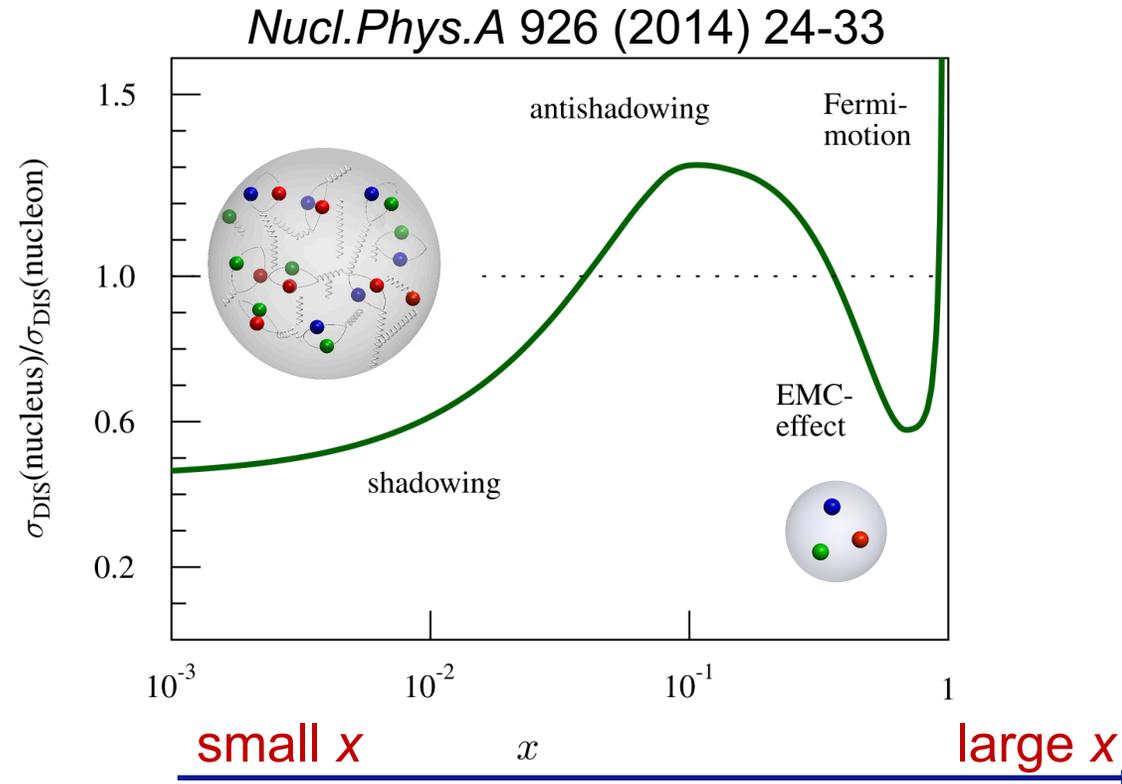


Nucleus  
Protons + Neutrons

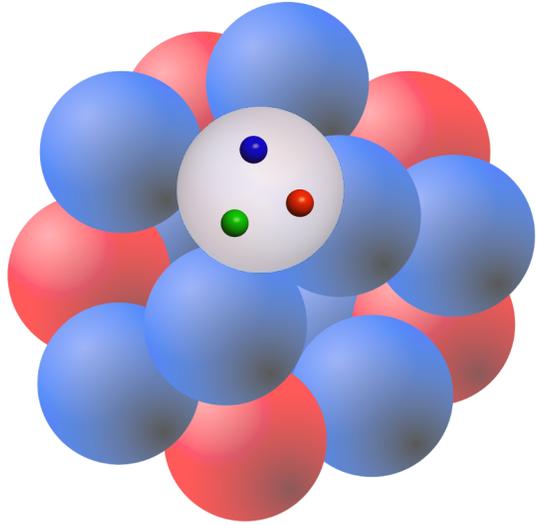
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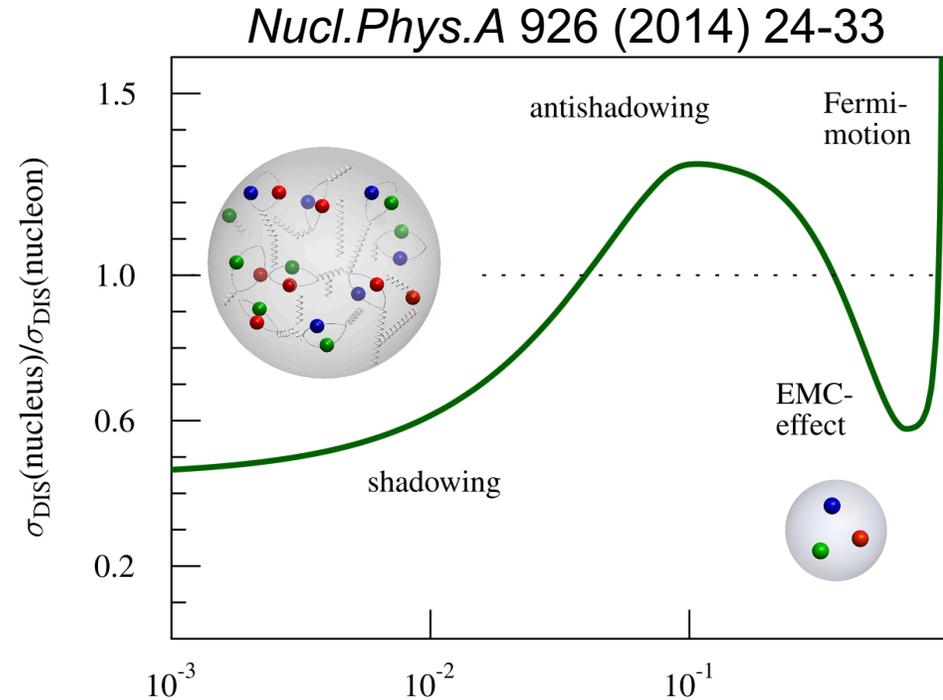
Nucleus  
Protons + Neutrons



# Nucleon structure in nucleus

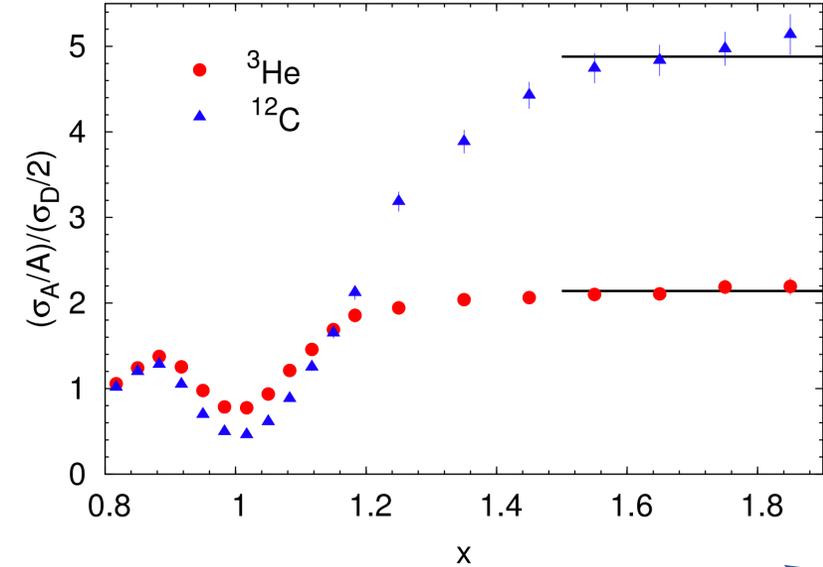


Nucleus  
Protons + Neutrons

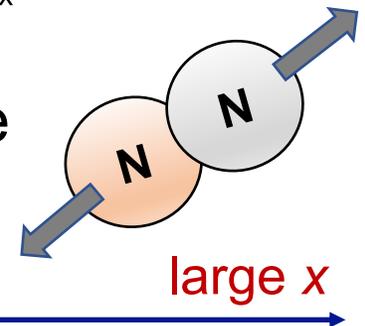


small  $x$

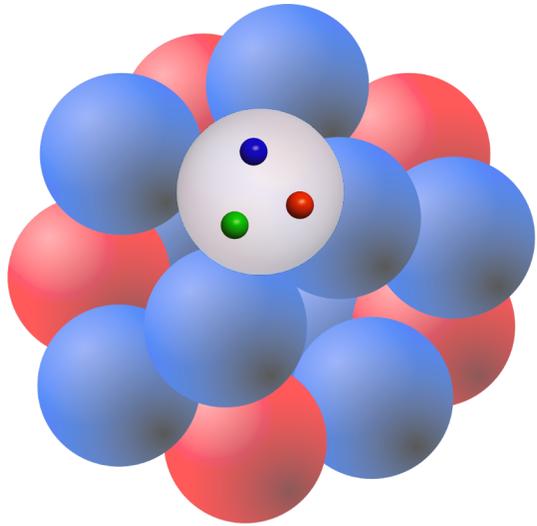
$x$



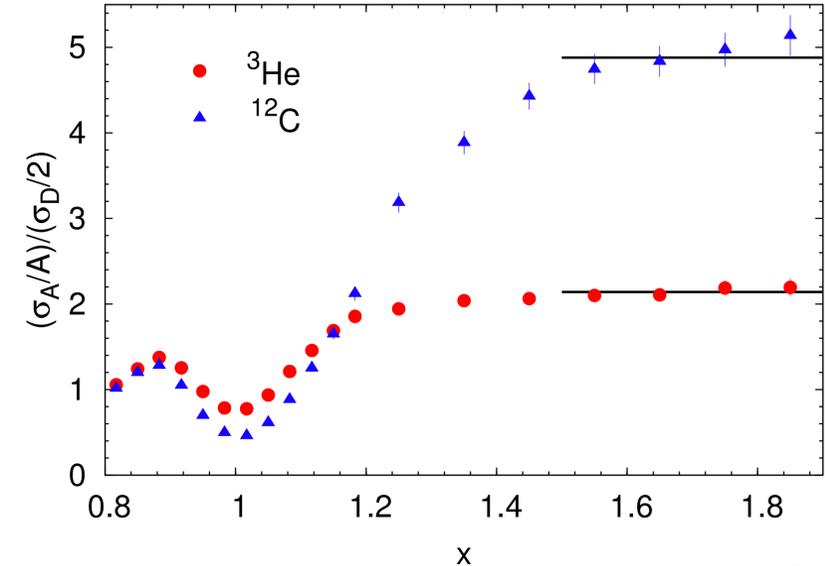
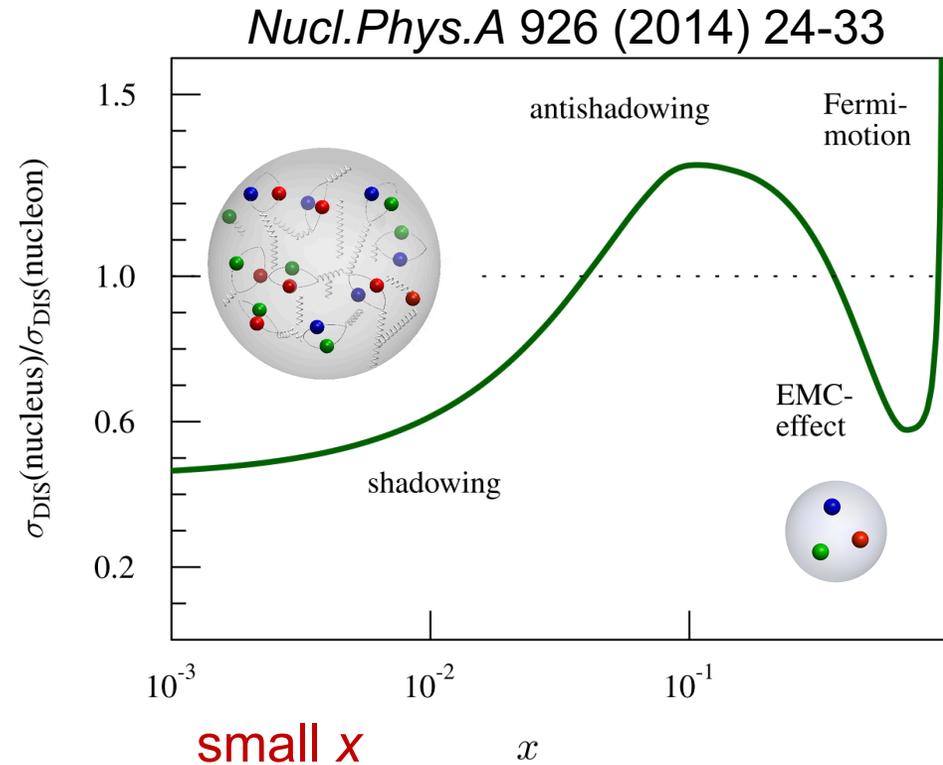
SRC:  
Short-Range  
Correlations



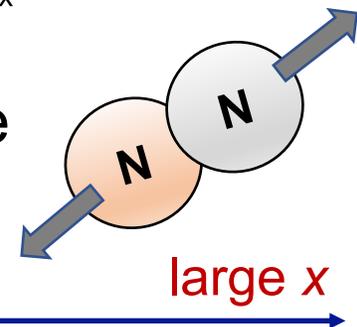
# Nucleon structure in nucleus



Nucleus  
Protons + Neutrons



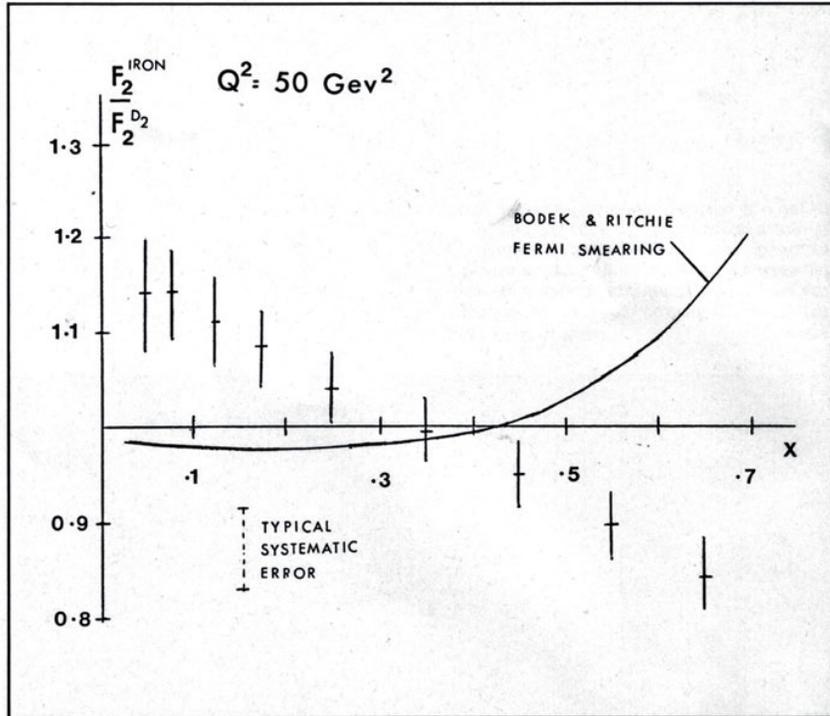
SRC:  
Short-Range  
Correlations



**Why is nucleus not a collection of free nucleons?**

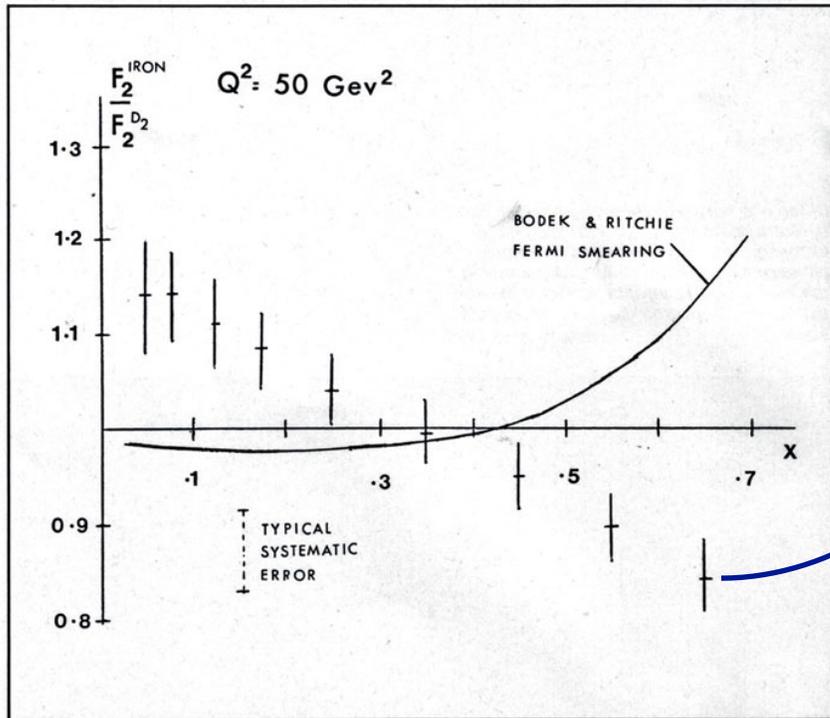
# EMC-SRC correlation

EMC puzzle (Aubert *et al.* 1983)



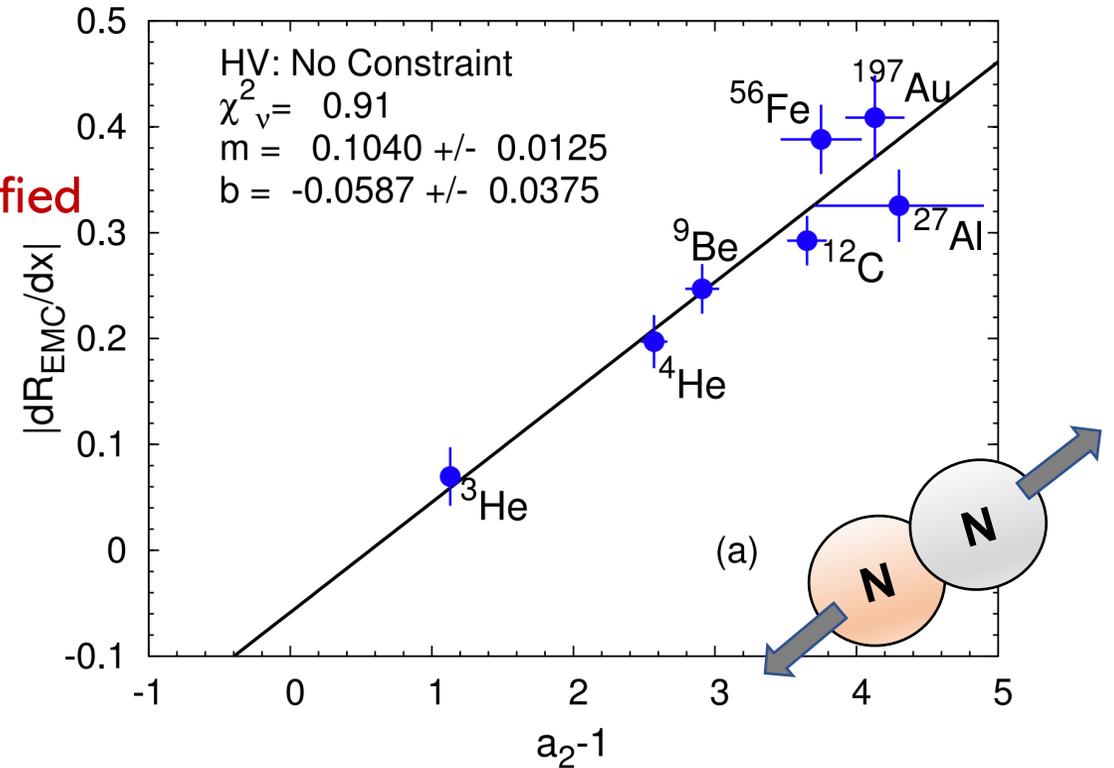
# EMC-SRC correlation

EMC puzzle (Aubert *et al.* 1983)



How much nucleon structure gets modified

EMC-SRC are correlated

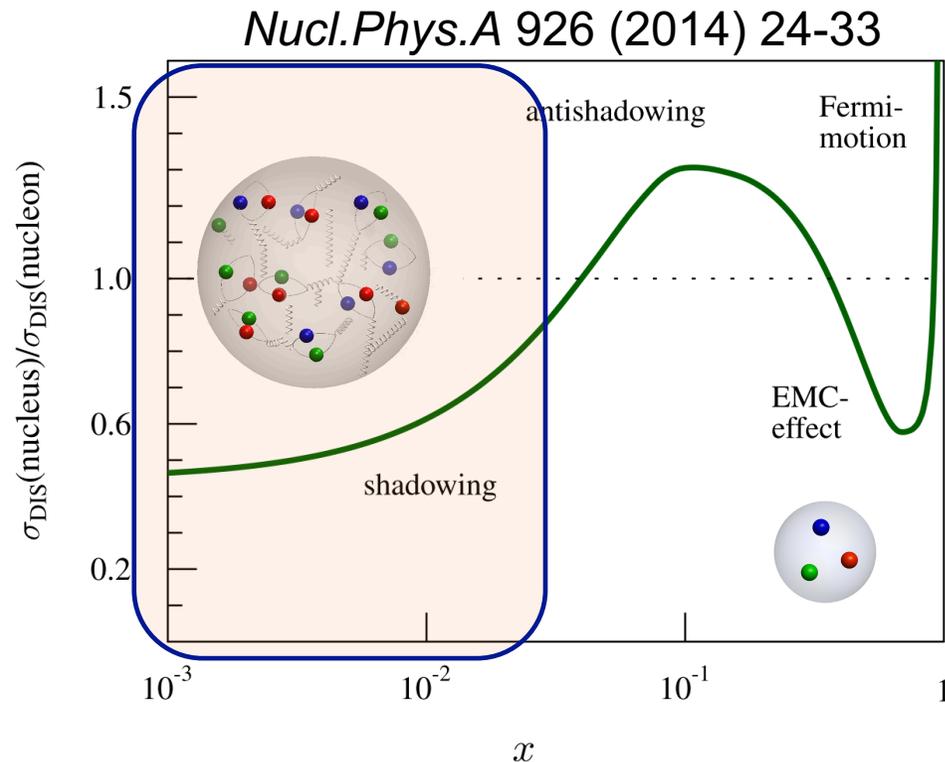


How strong the SRCs are

**Recent data indicated the SRC might be the cause of EMC**

# What about gluon?

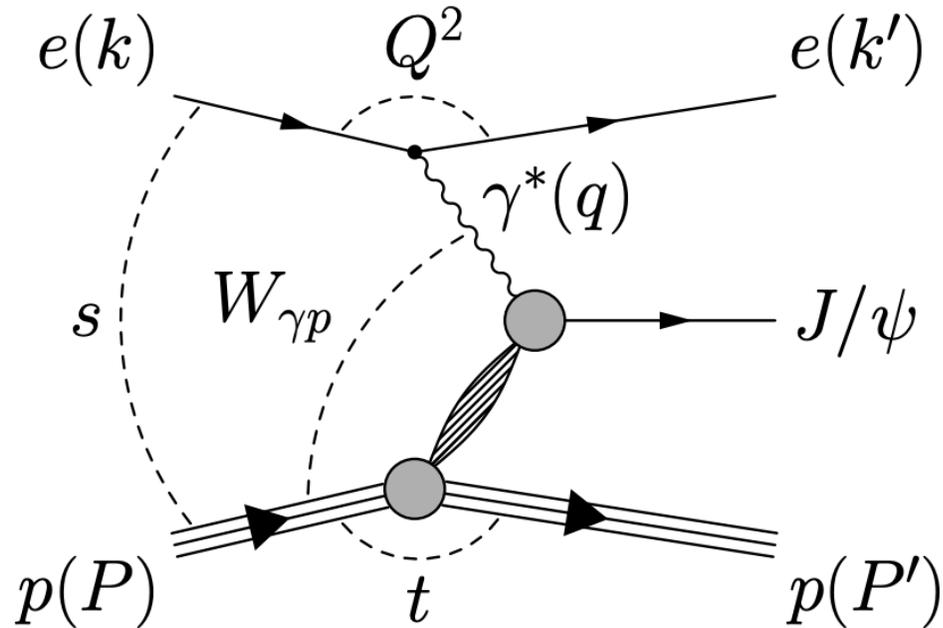
- A natural question to ask is whether SRC pairs would modify the gluonic structure of nucleons at low  $x$ .



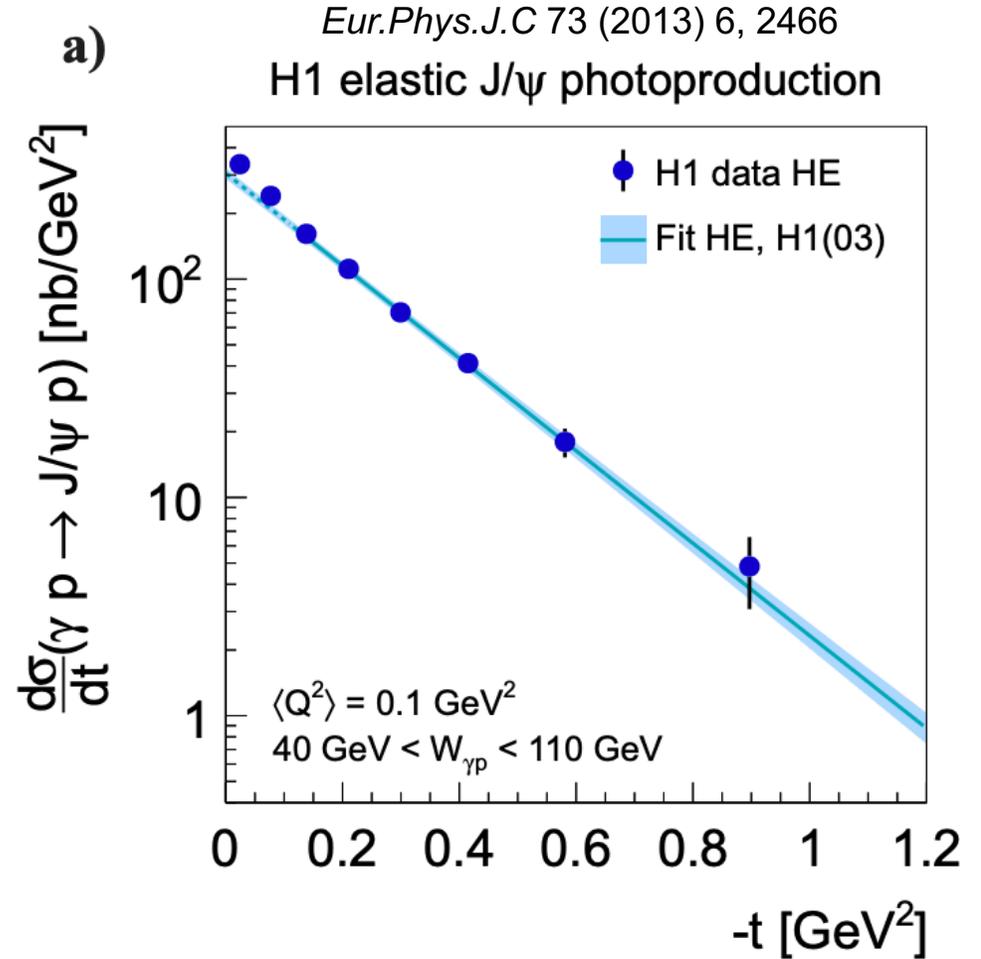
More specifically we ask:

1. What is the nucleon gluon density w. and without a SRC pair?
2. What is the gluon spatial distribution?

# Diffractive J/ψ production

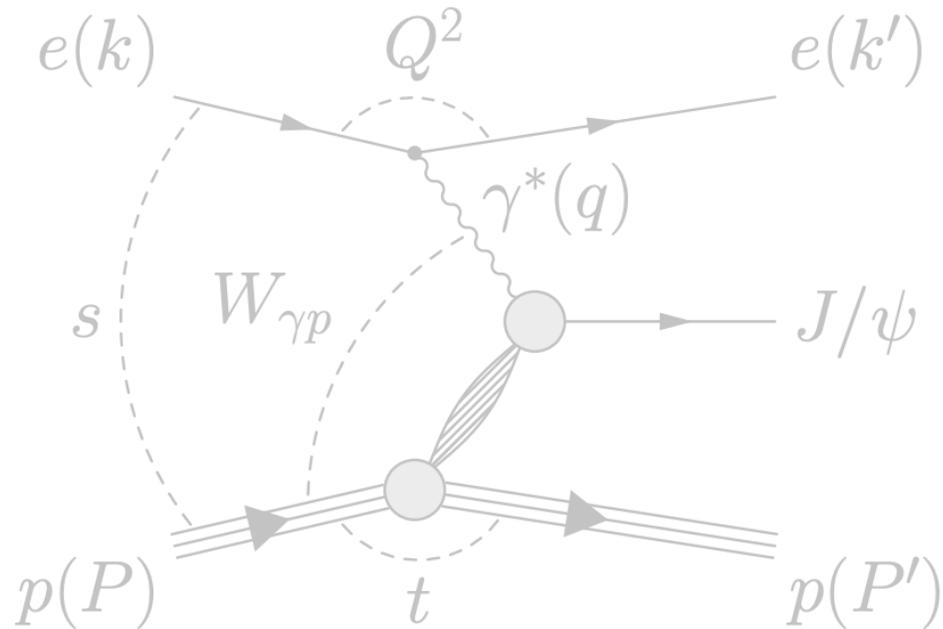


Diffractive J/ψ in ep



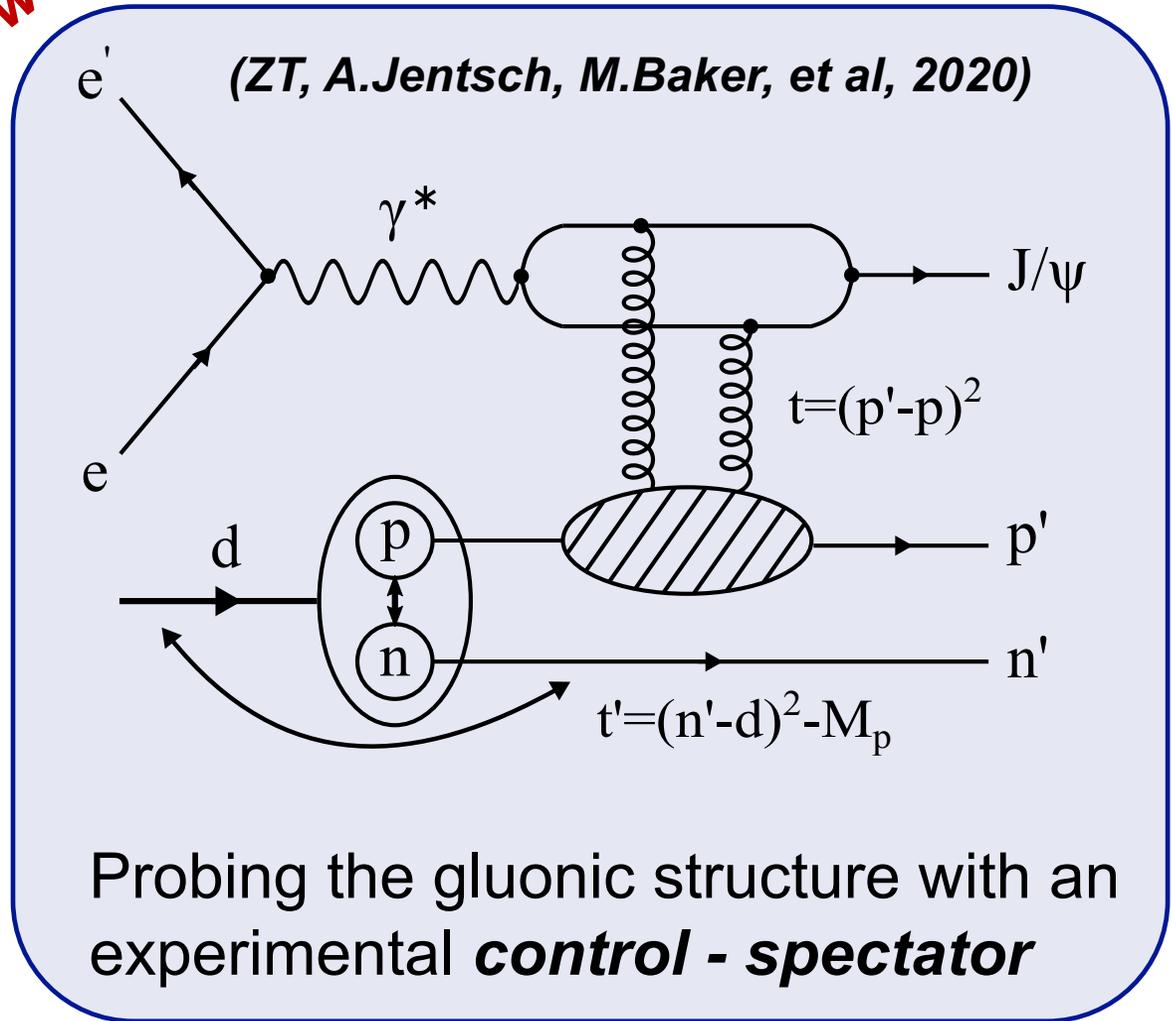
Momentum transfer  $-t$  distributions  $\rightarrow$  source distribution (gluons)

# Diffractive J/ $\Psi$ production in *deuteron*



Diffractive J/ $\Psi$  in ep

**New**

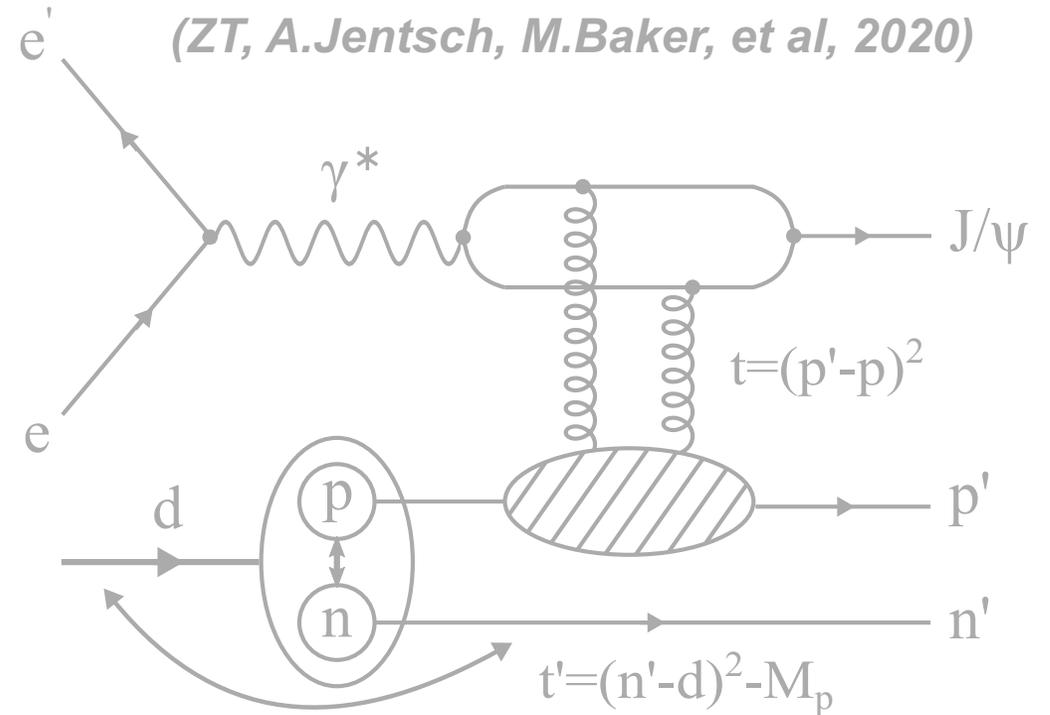


Probing the gluonic structure with an experimental **control - spectator**

# Diffractive $J/\psi$ production in *deuteron*

Advantages of this new measurement:

- Incoherent  $J/\psi$  production directly probes bounded nucleons;

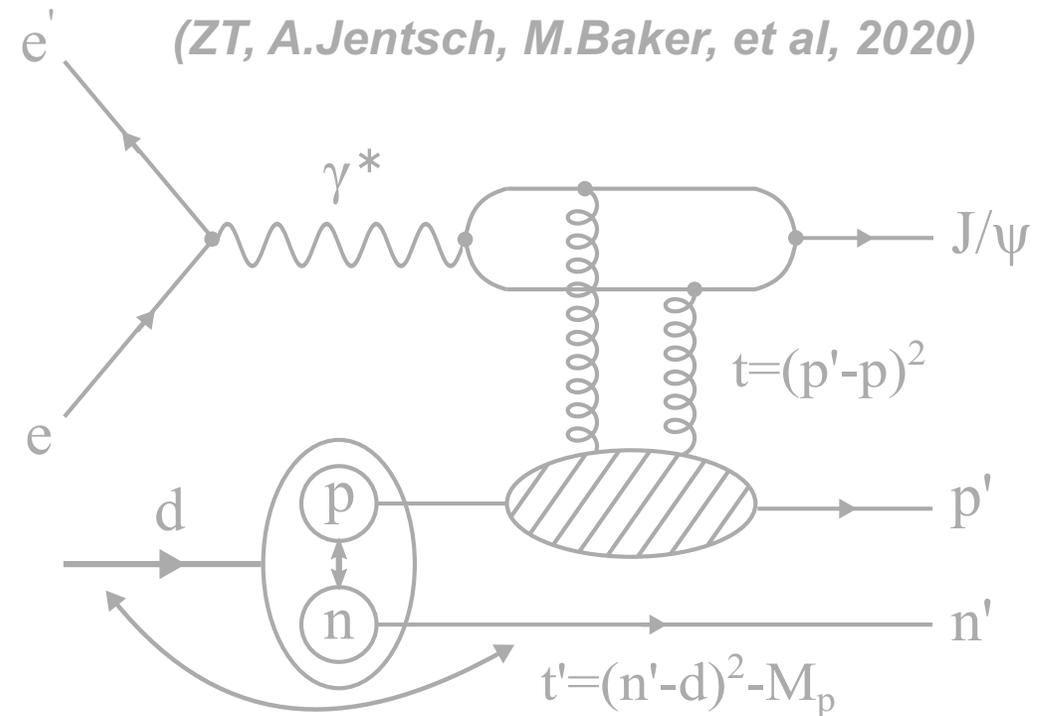


Probing the gluonic structure with an experimental *control - spectator*

# Diffractive $J/\psi$ production in *deuteron*

Advantages of this new measurement:

- Incoherent  $J/\psi$  production directly probes bounded nucleons;
- Tagging a spectator – *deuteron* configuration can be either:
  - NO nuclear effect – **free nucleons**
  - Nuclear effect – **deeply bound nucleons**



Probing the gluonic structure with an experimental **control - spectator**

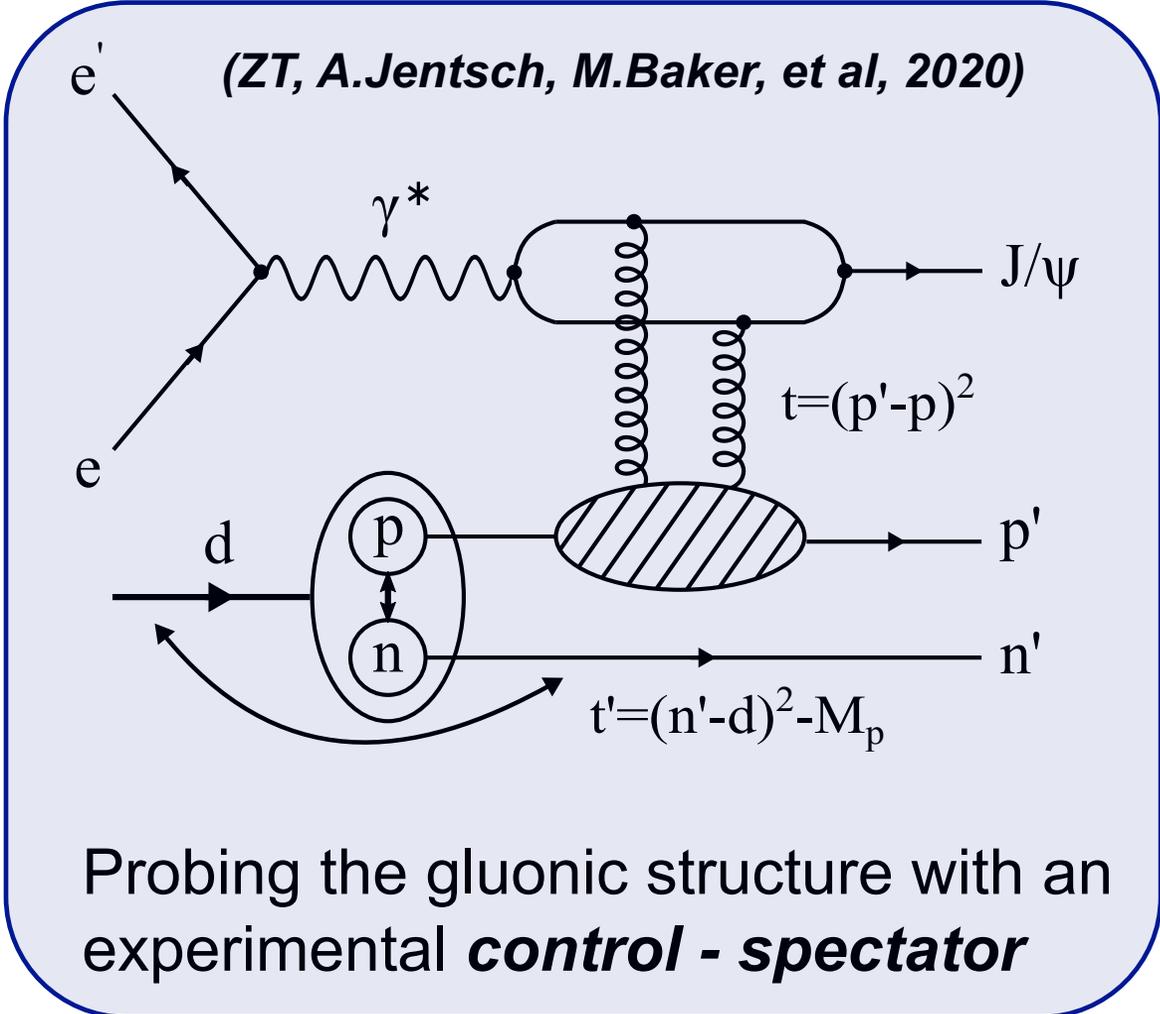
# Diffractive $J/\psi$ production in *deuteron*

How can we study this process now?



Click [here](#) for details

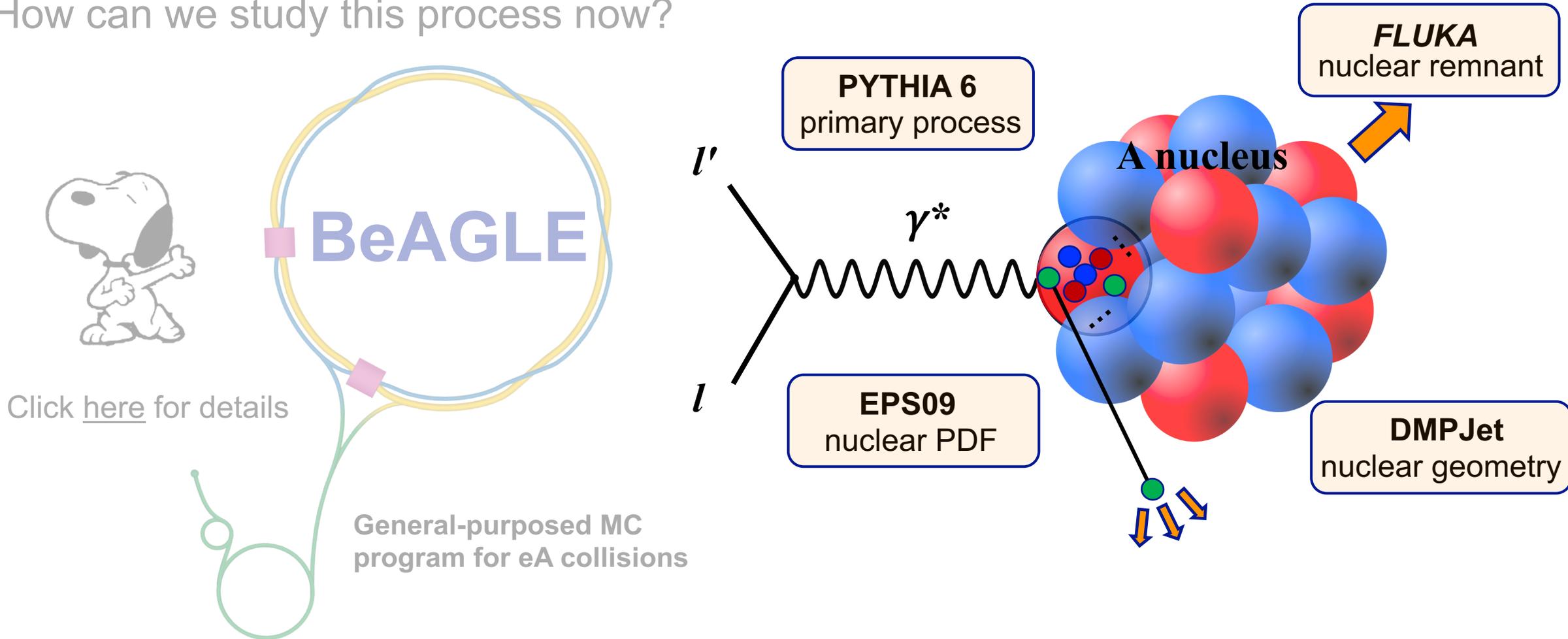
General-purposed MC program for eA collisions



(E. Aschenauer, M. Baker, J. Lee, ZT, and L. Zheng)

# Diffraction $J/\Psi$ production in *deuteron*

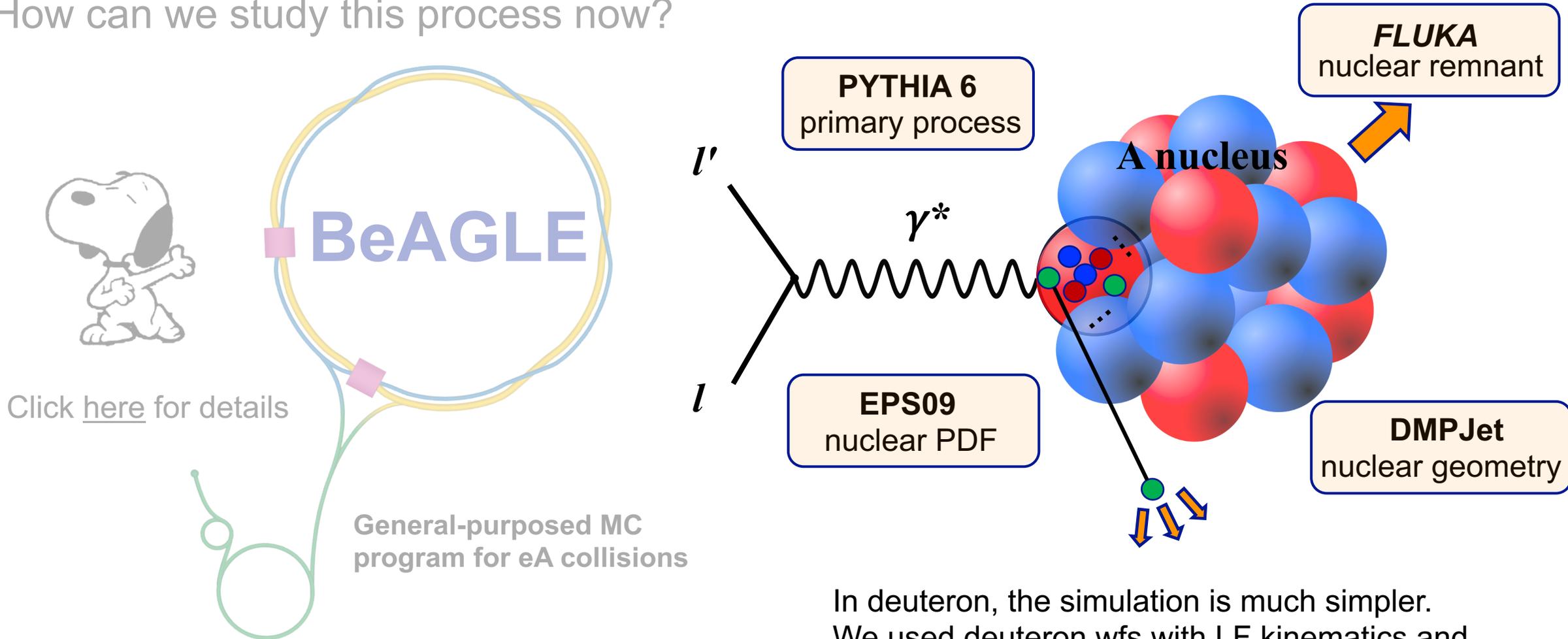
How can we study this process now?



(E. Aschenauer, M. Baker, J. Lee, ZT, and L. Zheng)

# Diffractional $J/\psi$ production in *deuteron*

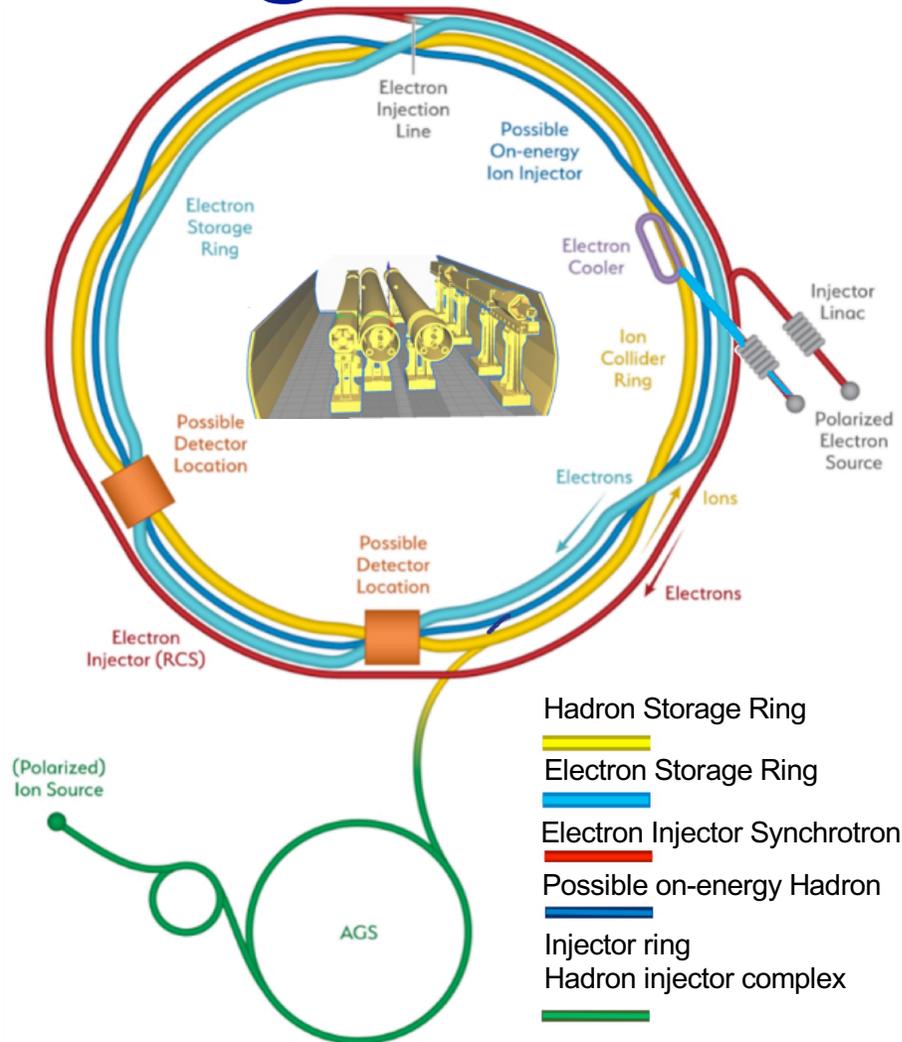
How can we study this process now?



(E. Aschenauer, M. Baker, J. Lee, ZT, and L. Zheng)

In deuteron, the simulation is much simpler.  
We used deuteron wfs with LF kinematics and  
assumes *Plane Wave Impulse Approximation*

# Next generation QCD machine - EIC



High energy & luminosity accelerator machine with beam polarization.

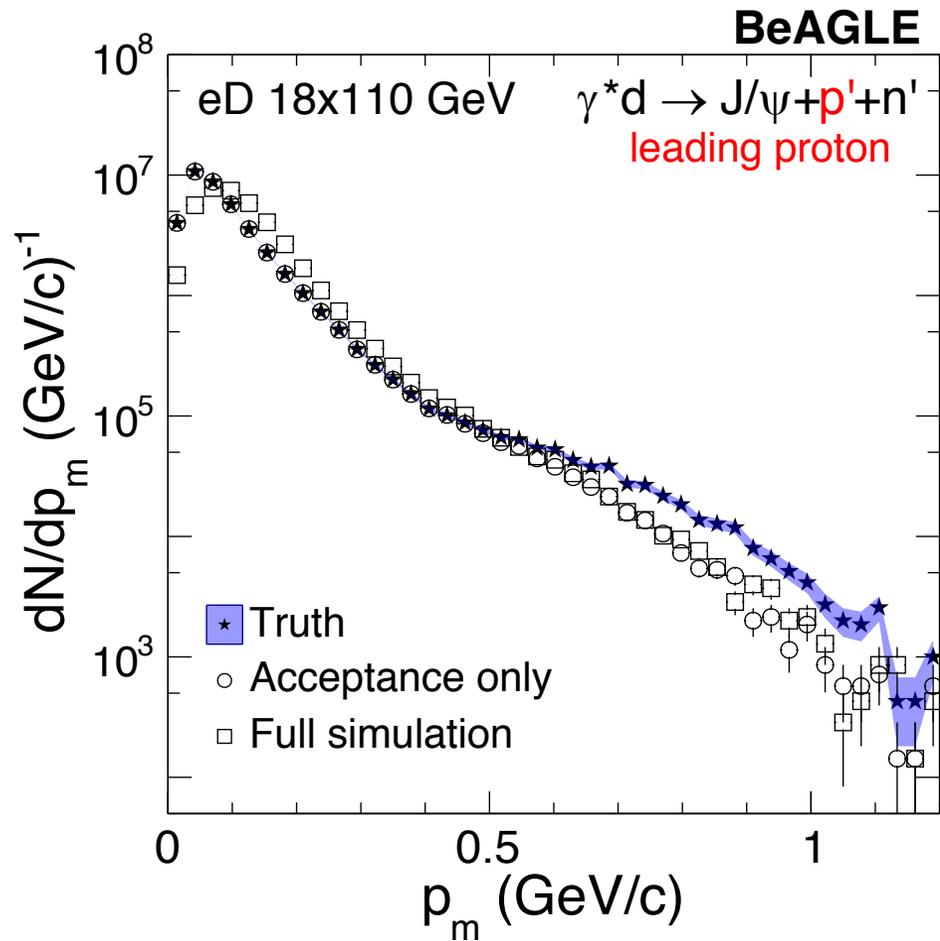
- $\sqrt{s} \Rightarrow 20 - 141 \text{ GeV}$
- $\mathcal{L}_{max} \Rightarrow 10^{34} \text{ cm}^{-2} \text{ s}^{-1}$

Polarization (e & p)  $\Rightarrow 80\%$   
 A  $\Rightarrow$  proton to Uranium

**Diffractive & Exclusive reactions are one of the major physics at EIC**

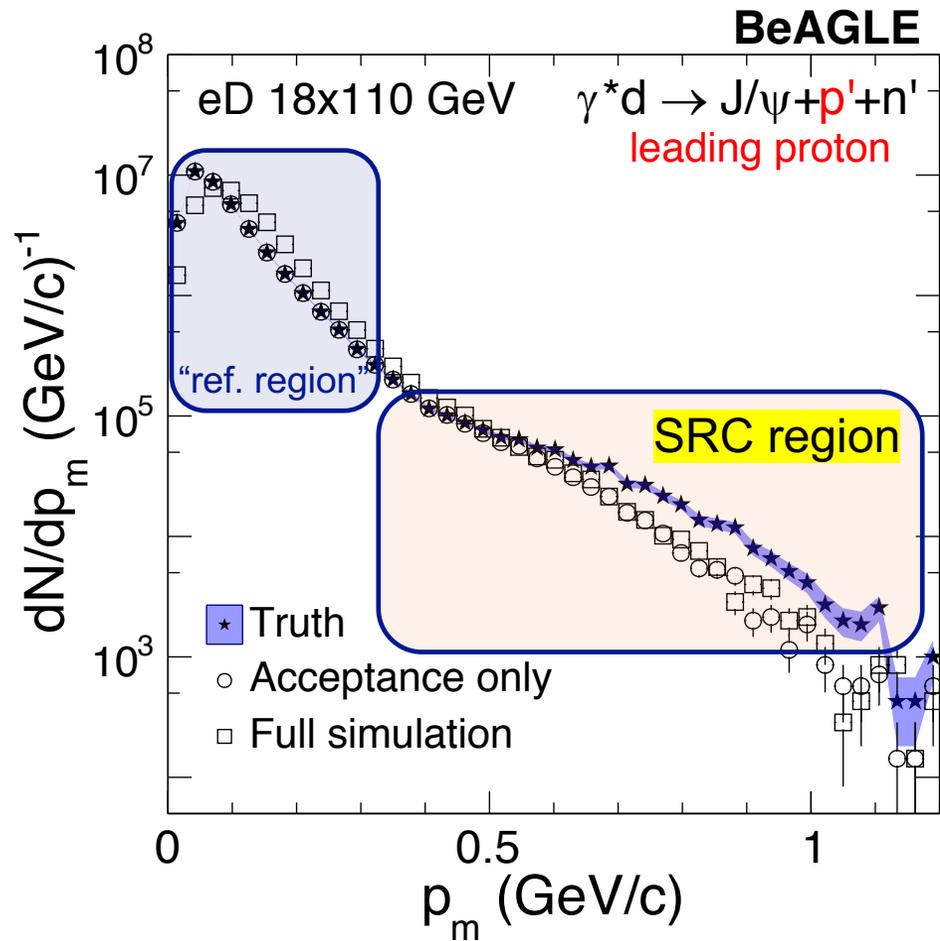
Sited at Brookhaven National Laboratory  
**Electron-Ion Collider**

# Results



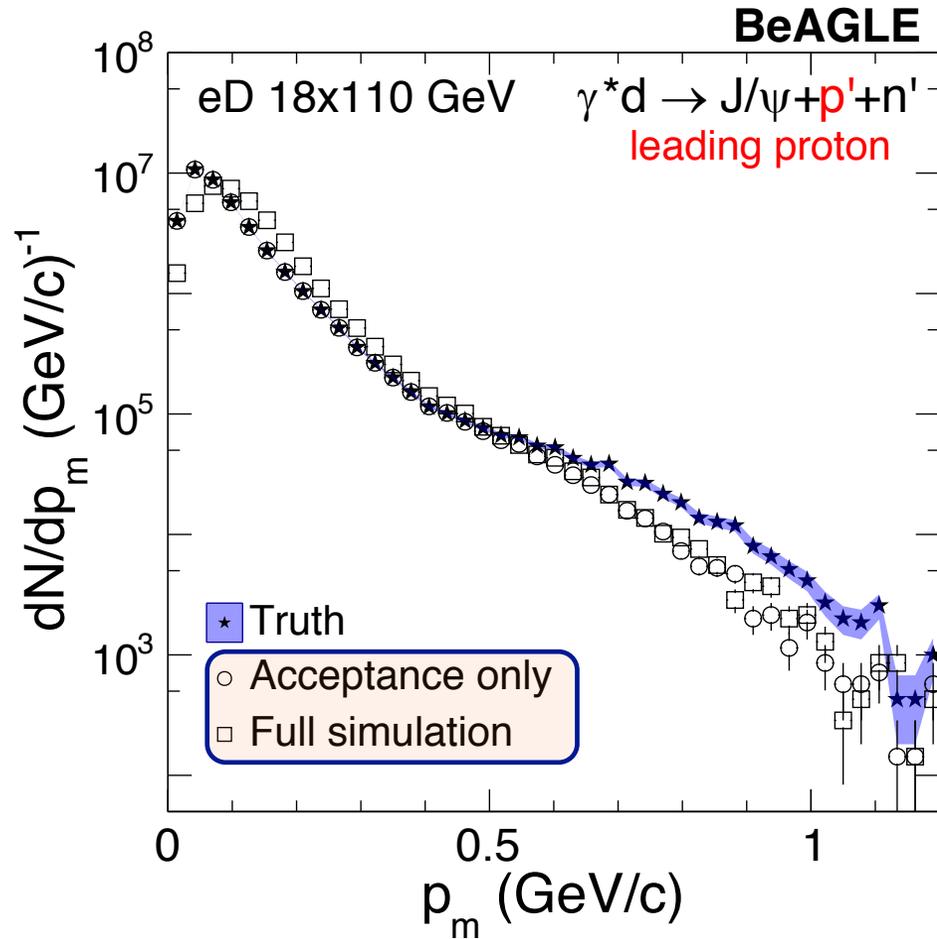
$P_m$  - total three-momentum of the spectator

# Results



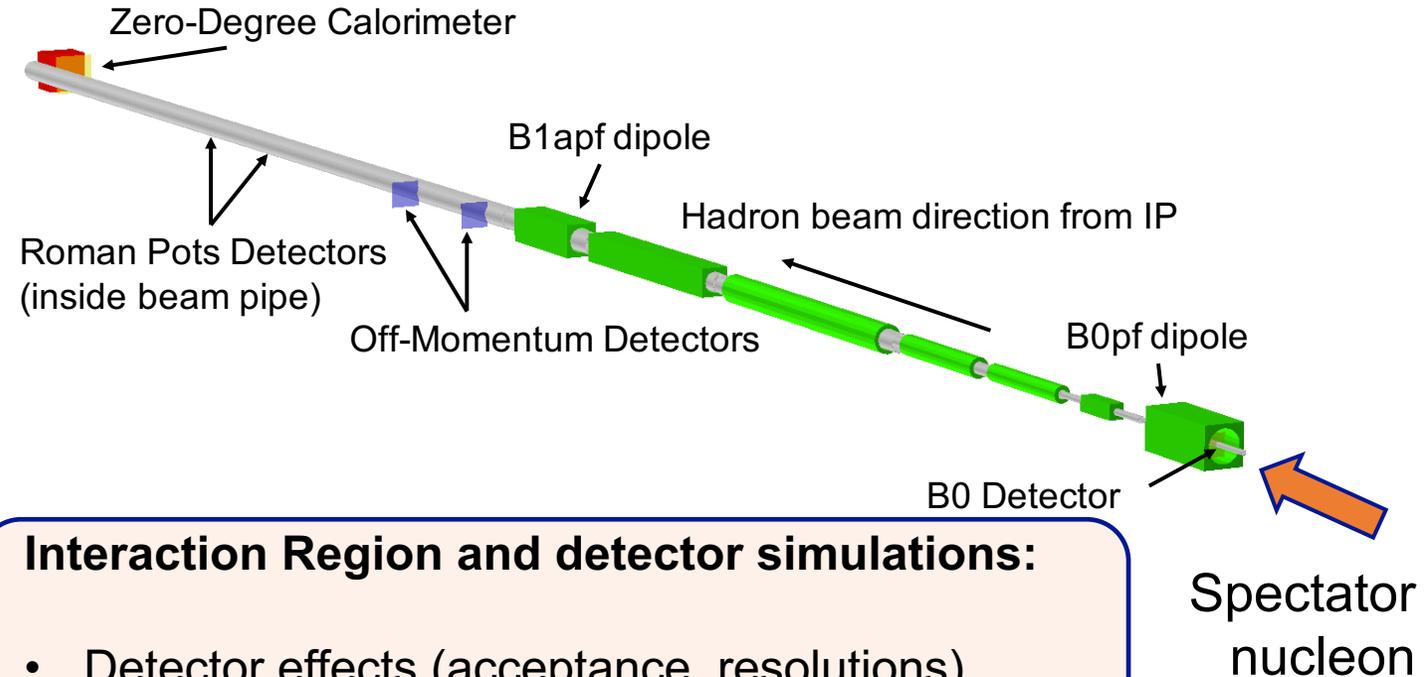
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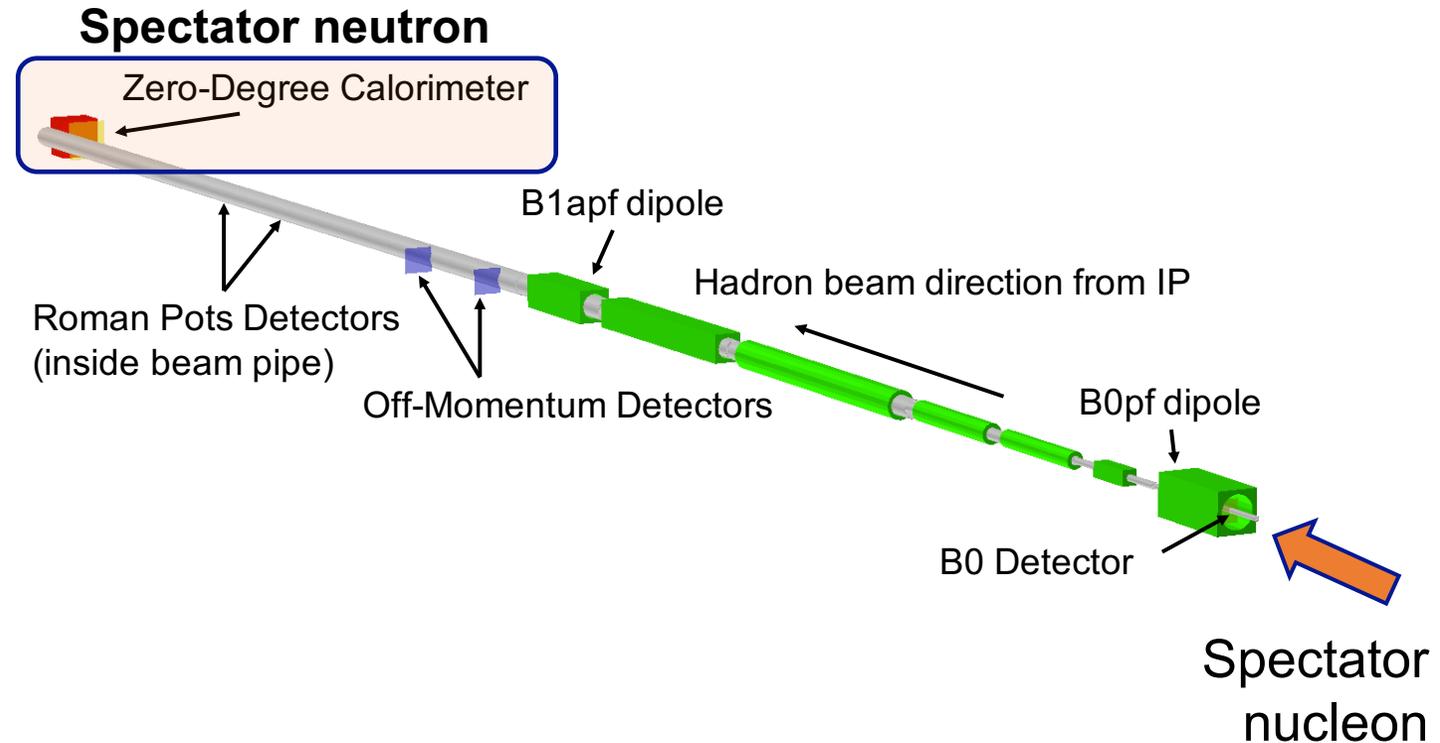
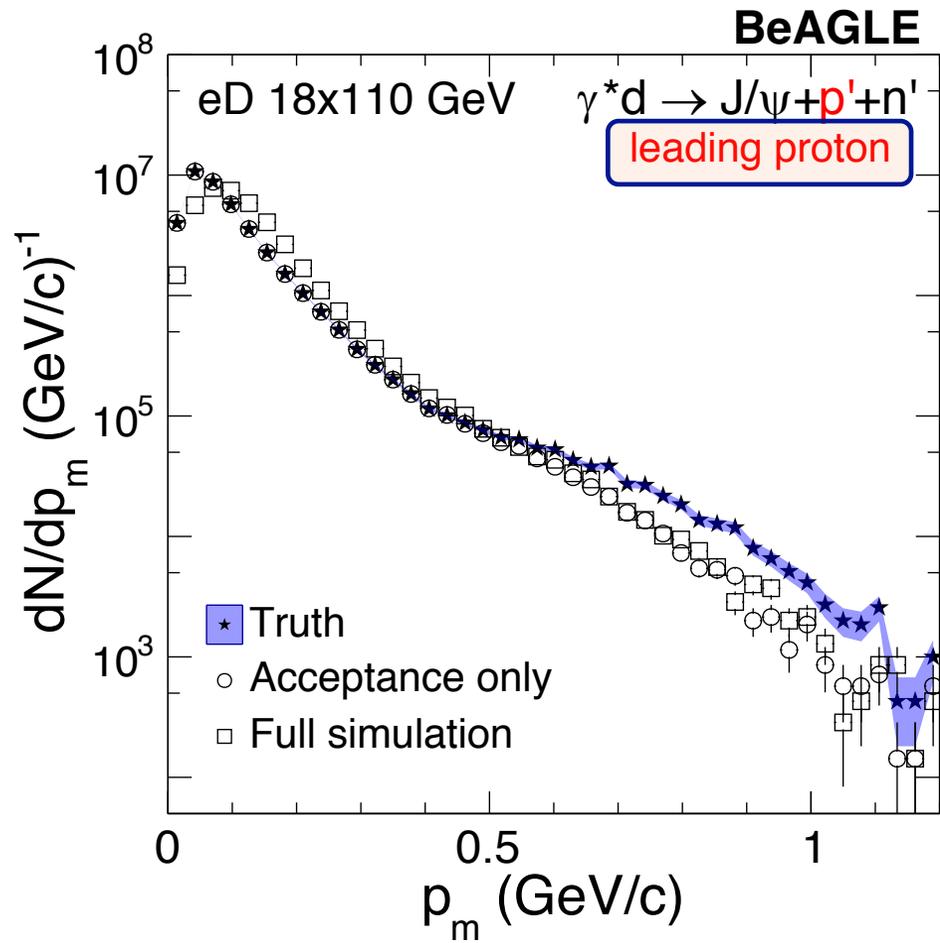
## EIC IR concept



### Interaction Region and detector simulations:

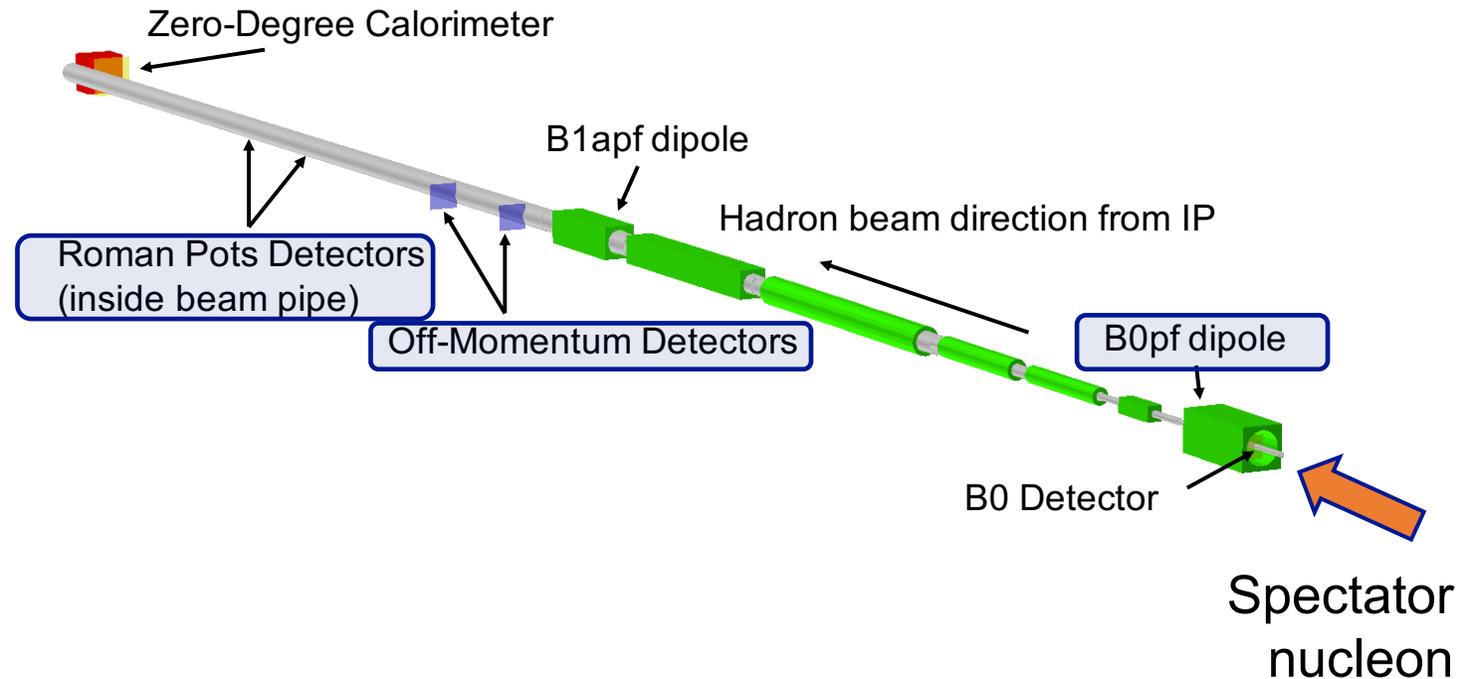
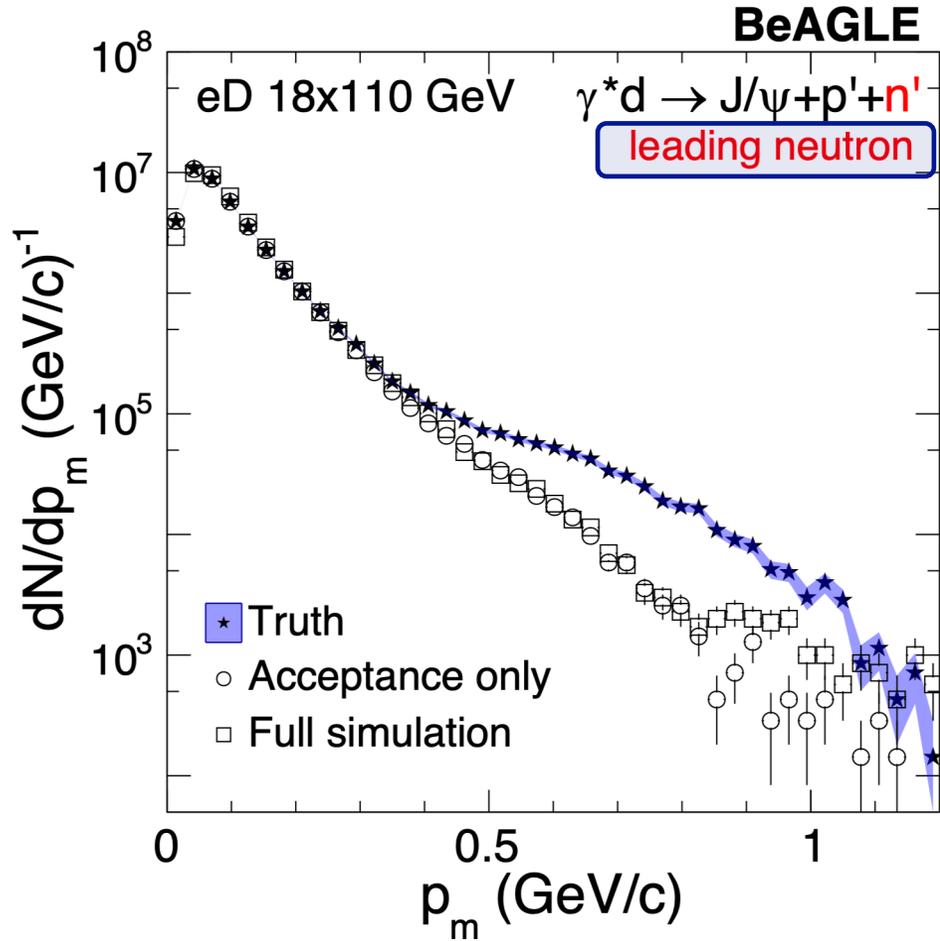
- Detector effects (acceptance, resolutions)
- Beam-related effects (e.g., angular divergence)

# Results



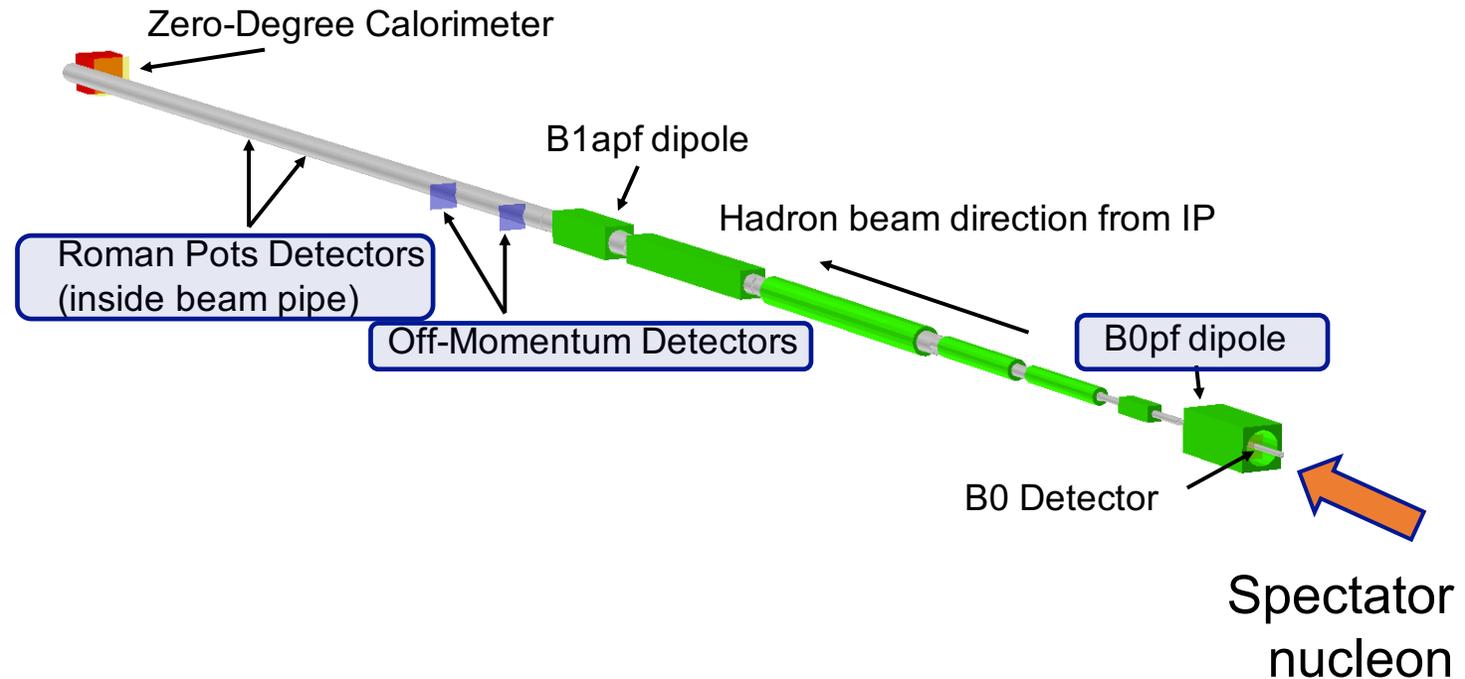
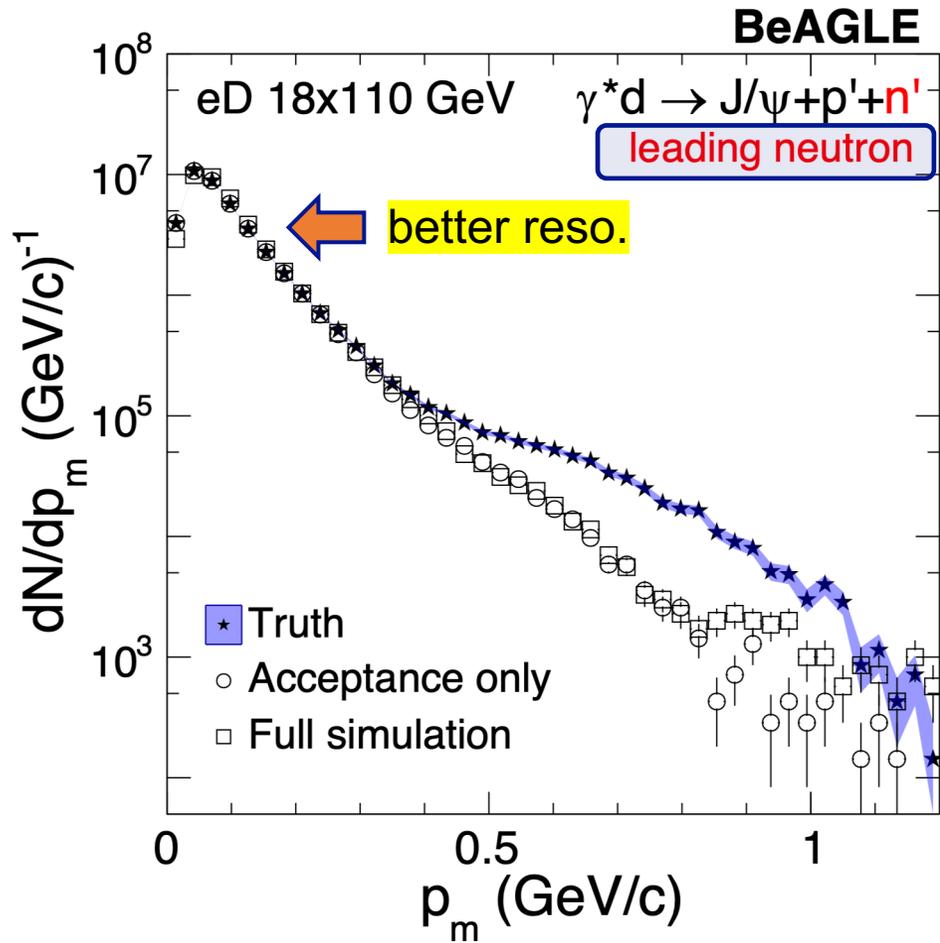
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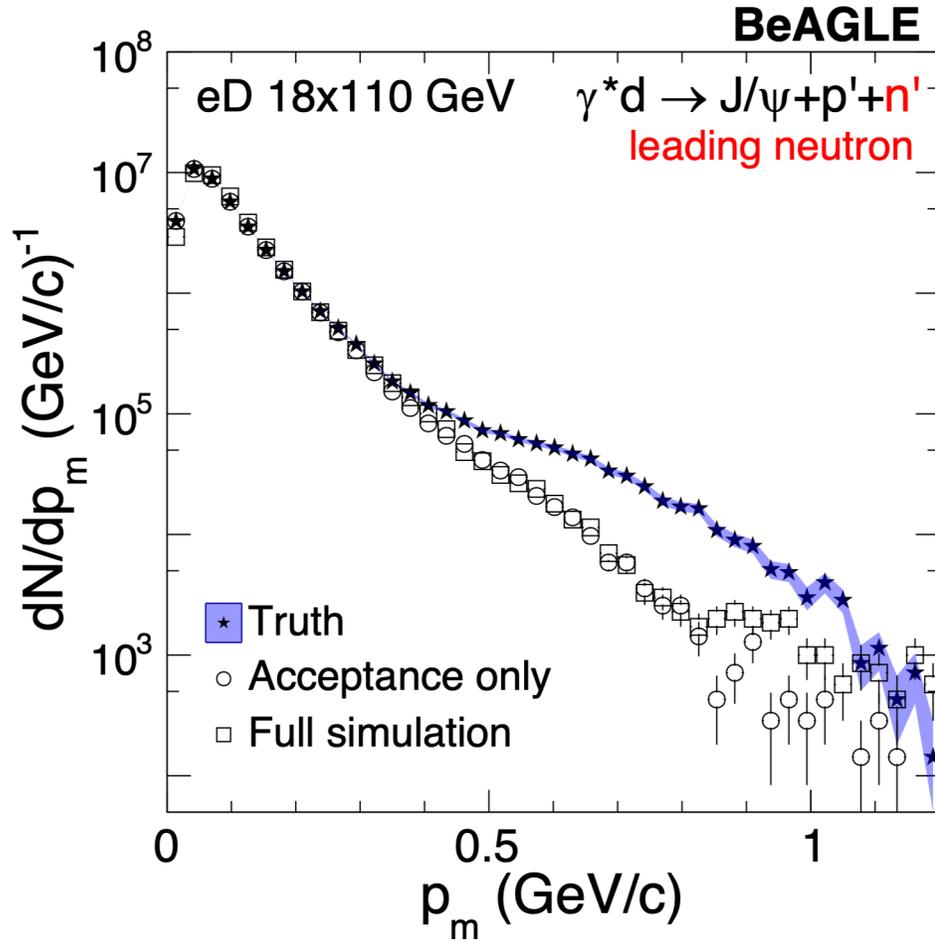
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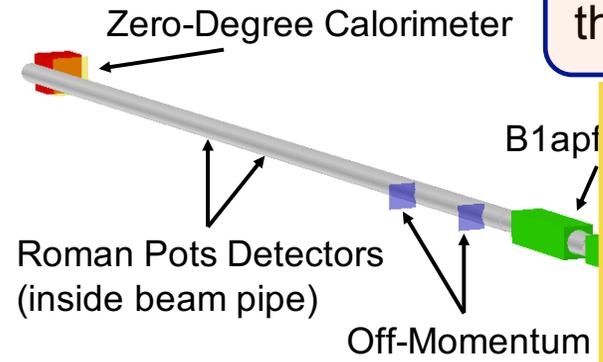
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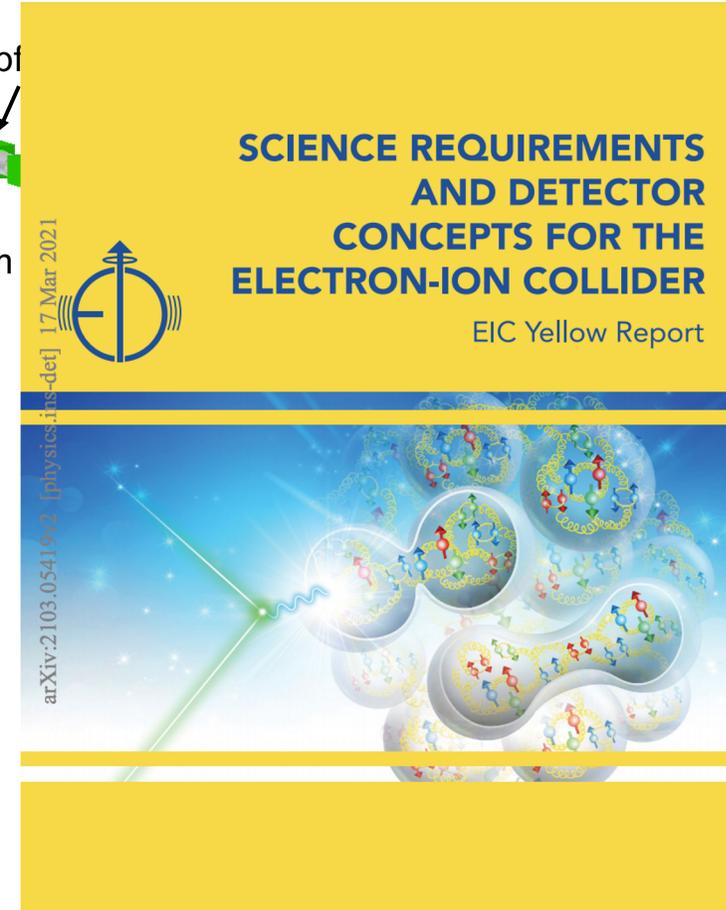


$P_m$  - total three-momentum of the spectator

Far forward region was found to be extremely important to the EIC



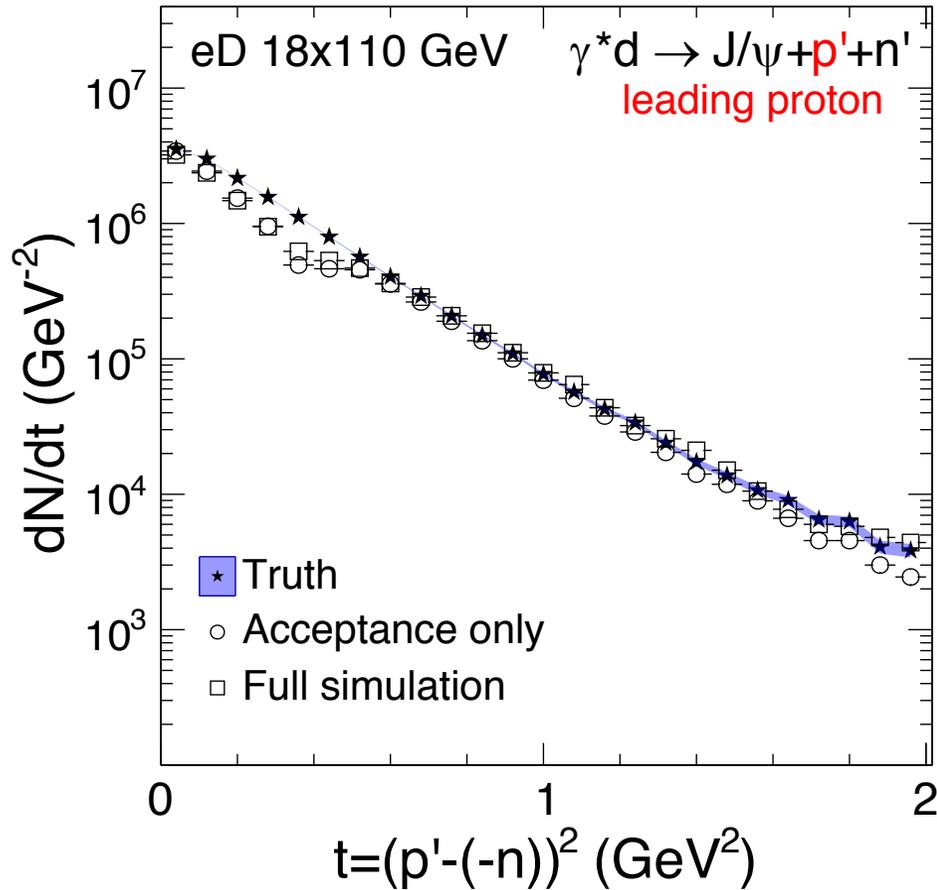
Details published in the Yellow Report, [arXiv:2103.05419](https://arxiv.org/abs/2103.05419)



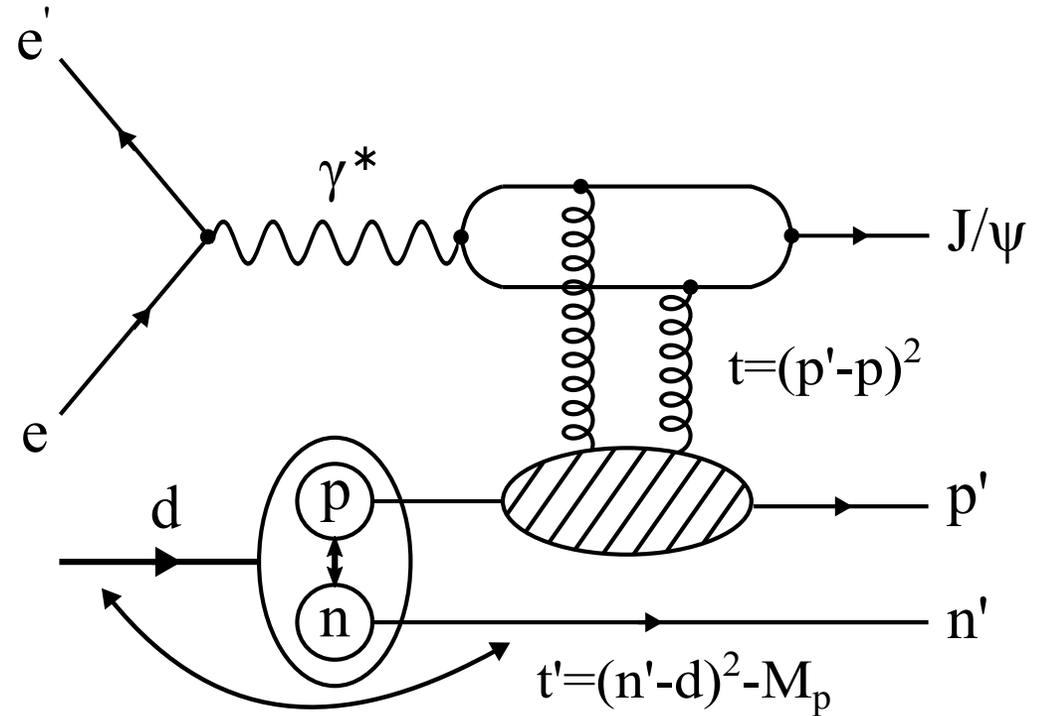
tator  
neon

# -t distribution

BeAGLE



New method of reconstructing  $|t|$   
 - complementary



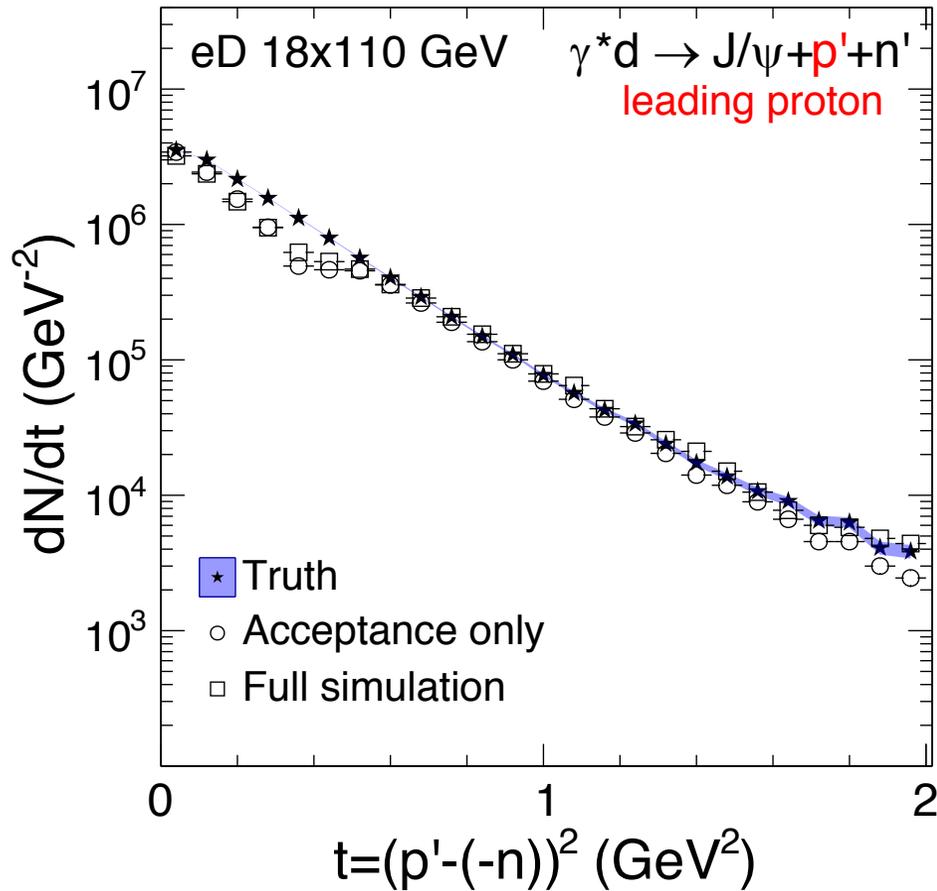
**Double tagging!**

Initial leading nucleon momentum is unknown unless we tag a spectator

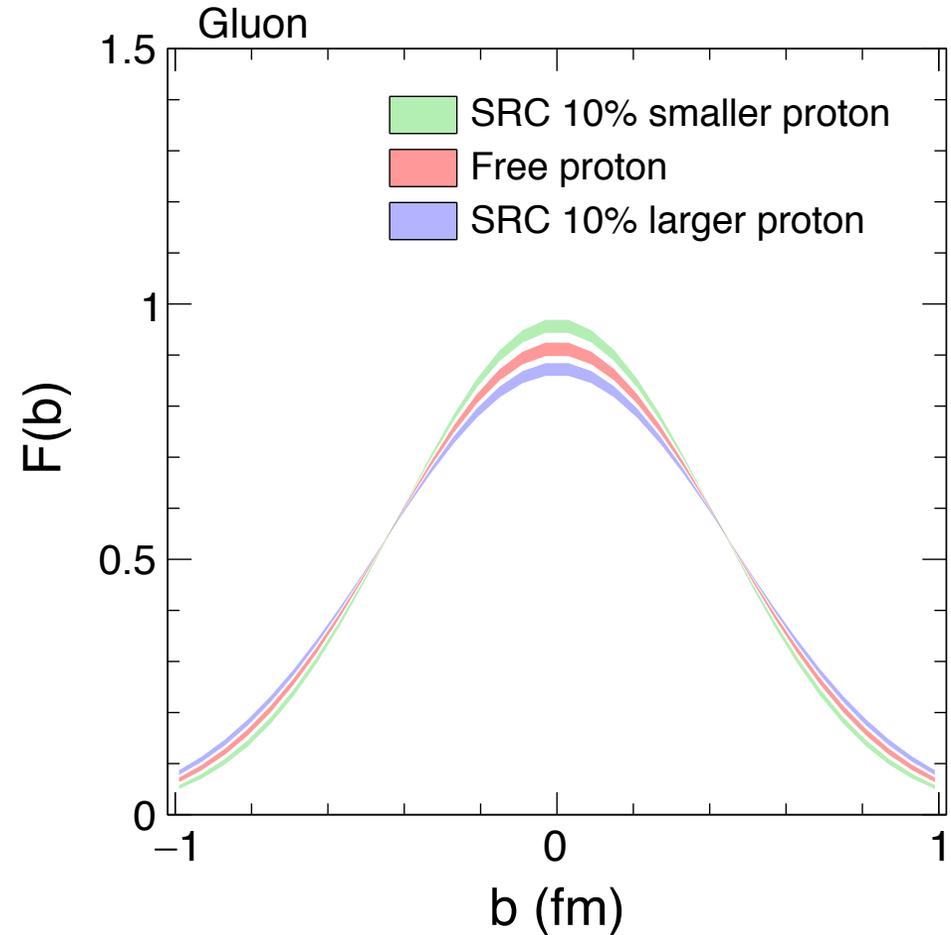
# -t distribution

Integrated luminosity  $\sim 10\text{-}30 \text{ fb}^{-1}$

BeAGLE



New method of reconstructing  $|t|$   
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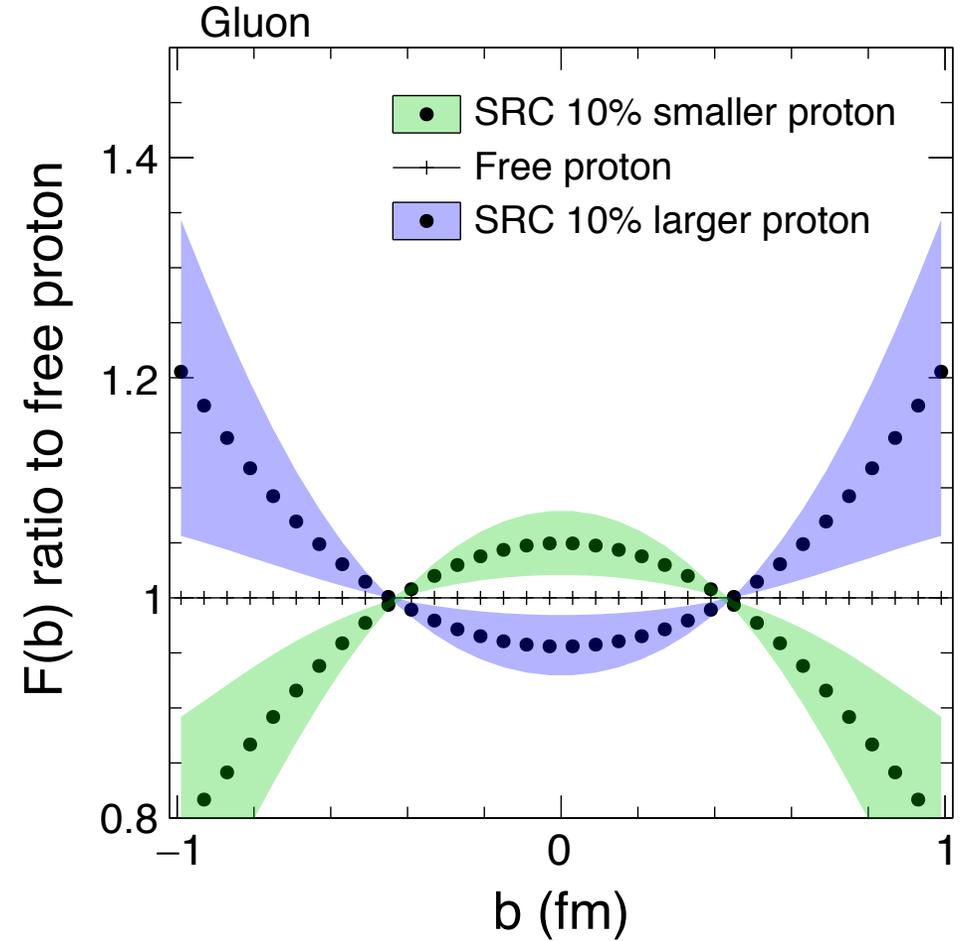
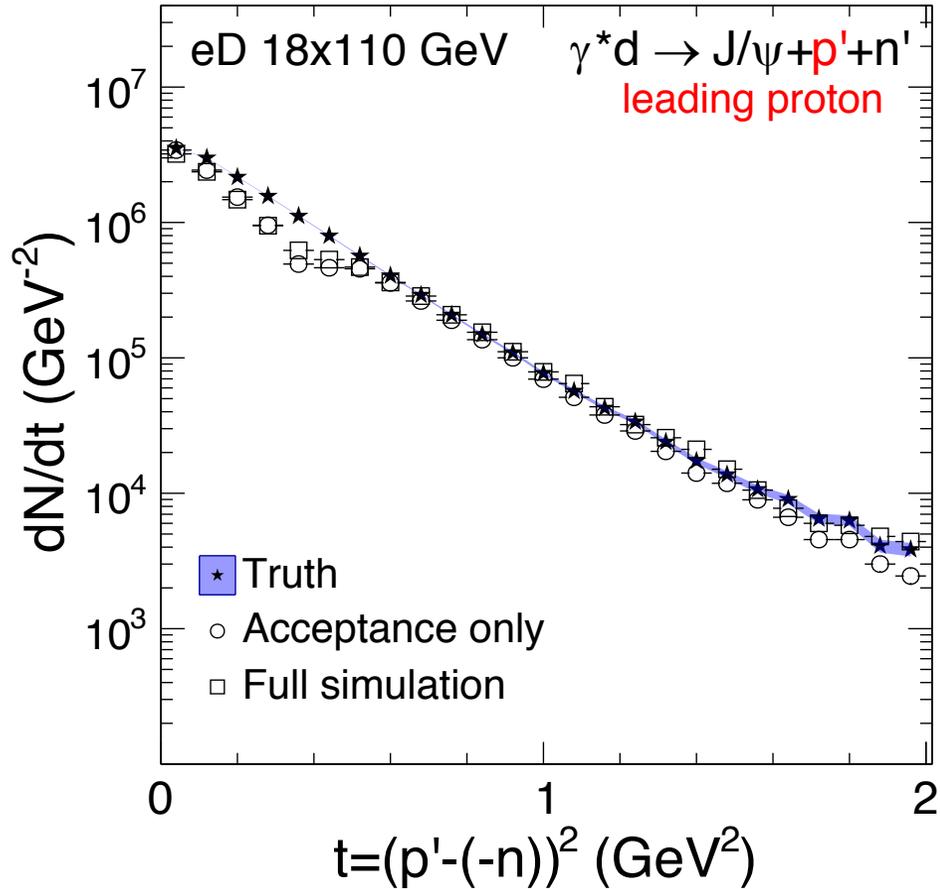


Comparison between SRC nucleon with free nucleon

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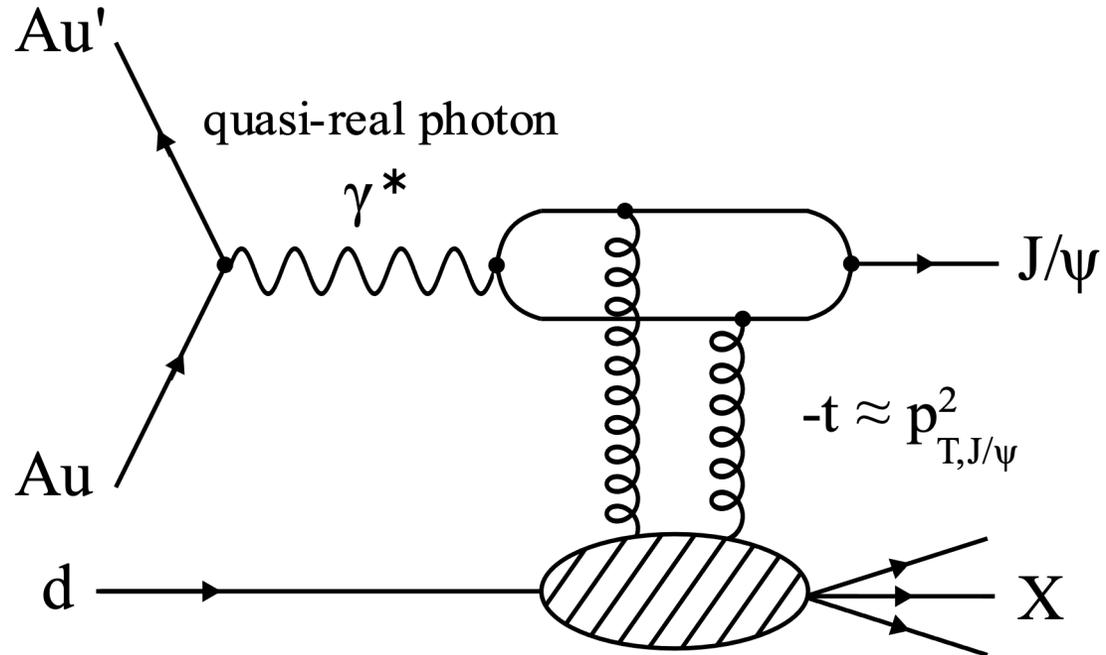
BeAGLE



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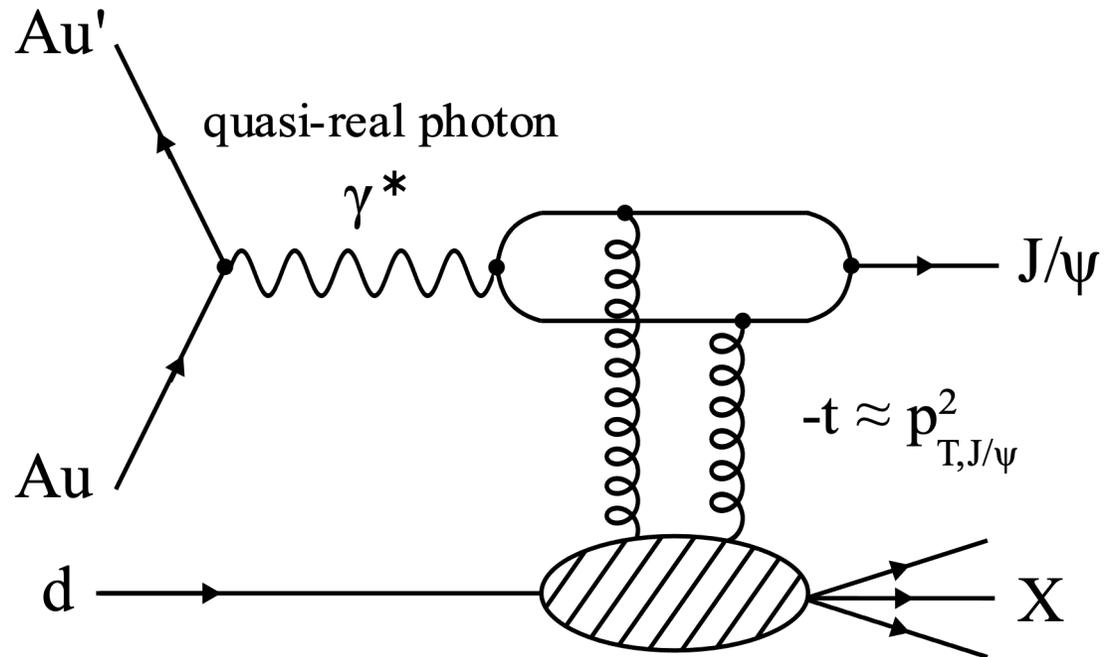
Comparison between SRC nucleon with free nucleon

# Ultra-peripheral collisions in d+Au



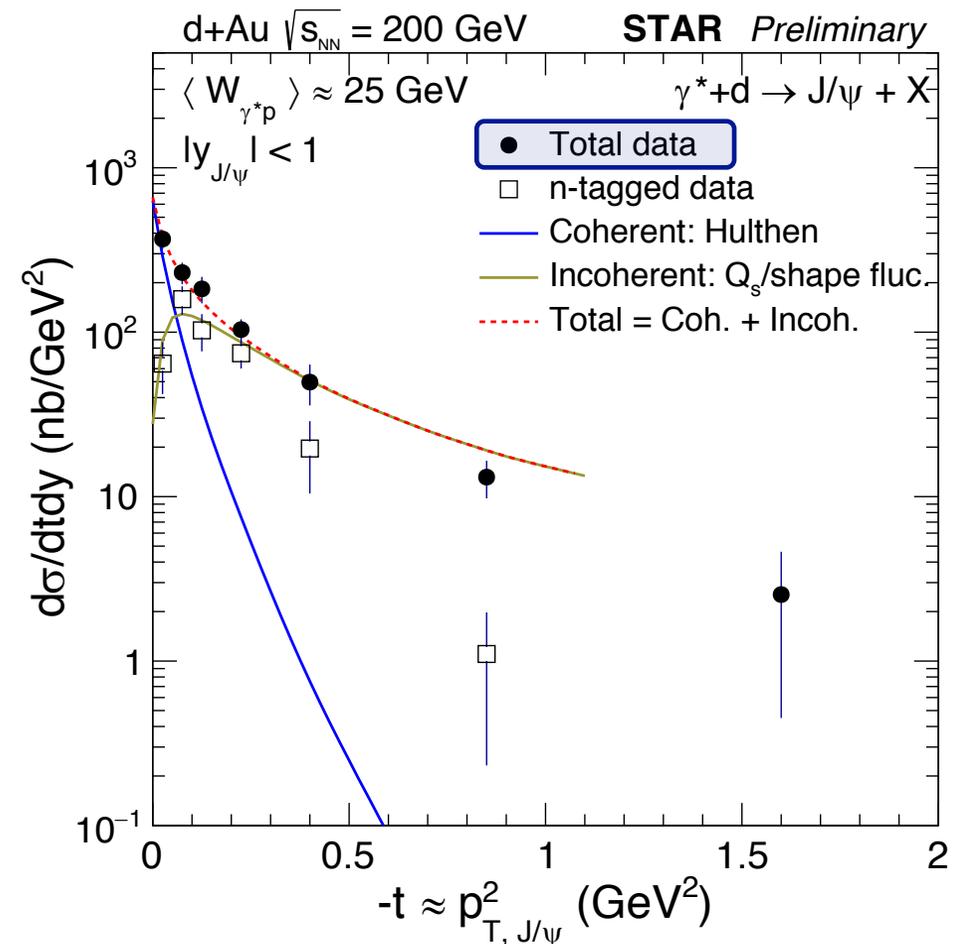
UPC data provides a promising result related to this study – photoproduction of  $J/\psi$

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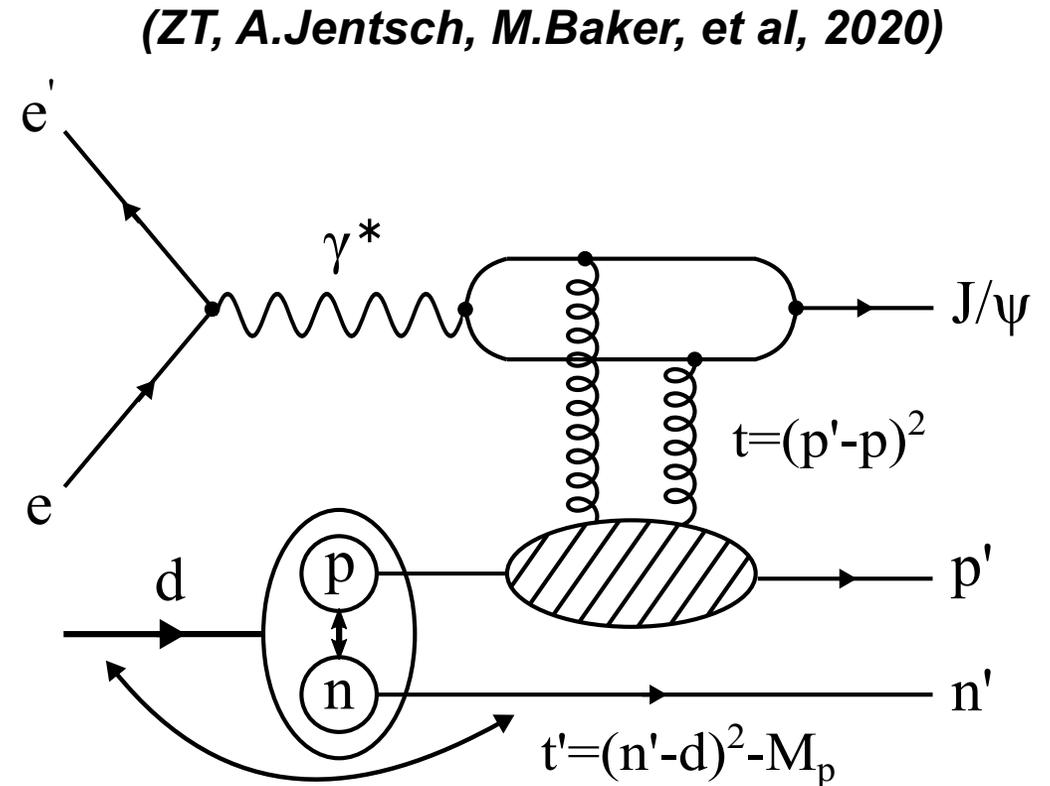
- Total = Coherent + incoherent (incoherent = elastic and dissociative)



# Summary

## Incoherent diffractive $J/\Psi$ production in electron-deuteron scattering:

- Physics:
  - gluonic structure and nuclear modifications
- Advantages:
  - Directly probe bounded nucleons;
  - Short-range correlations might provide a “nuclear-like” environment.
- Electron-Ion Collider:
  - Complex IR and great forward detectors;
  - Great acceptances and resolution to tag a spectator and the  $J/\Psi$



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