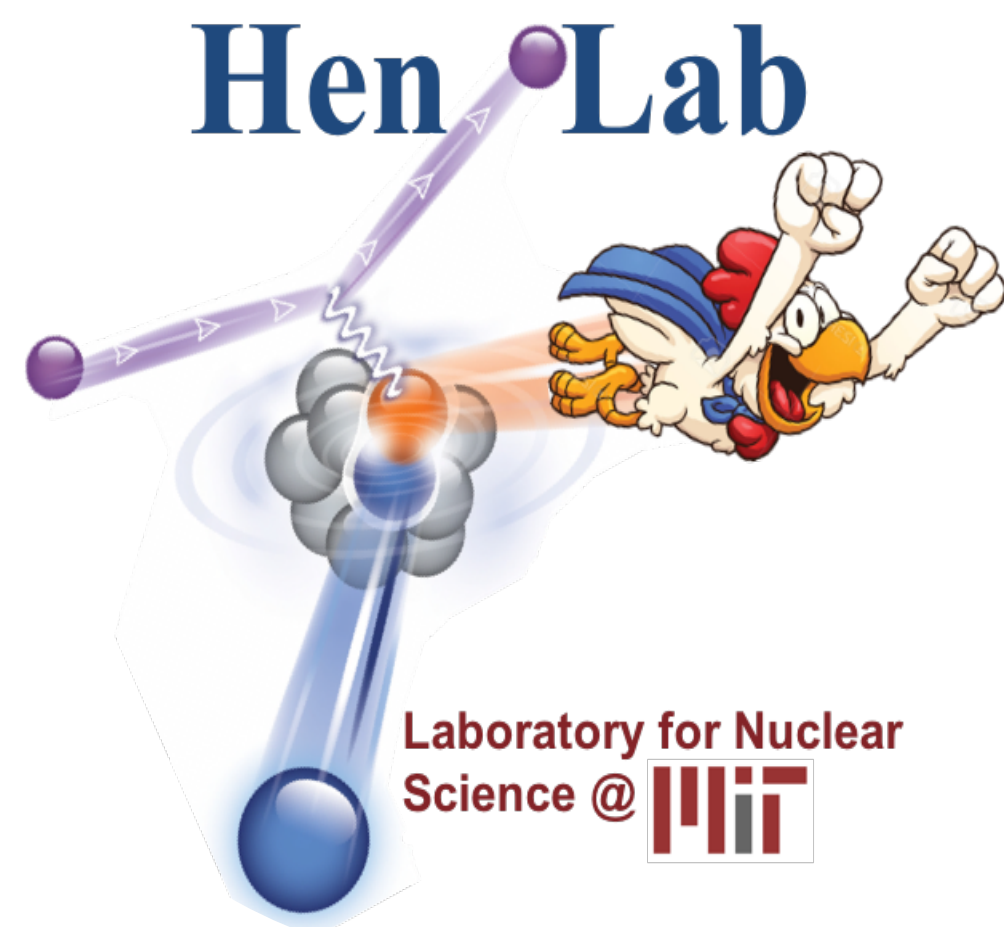


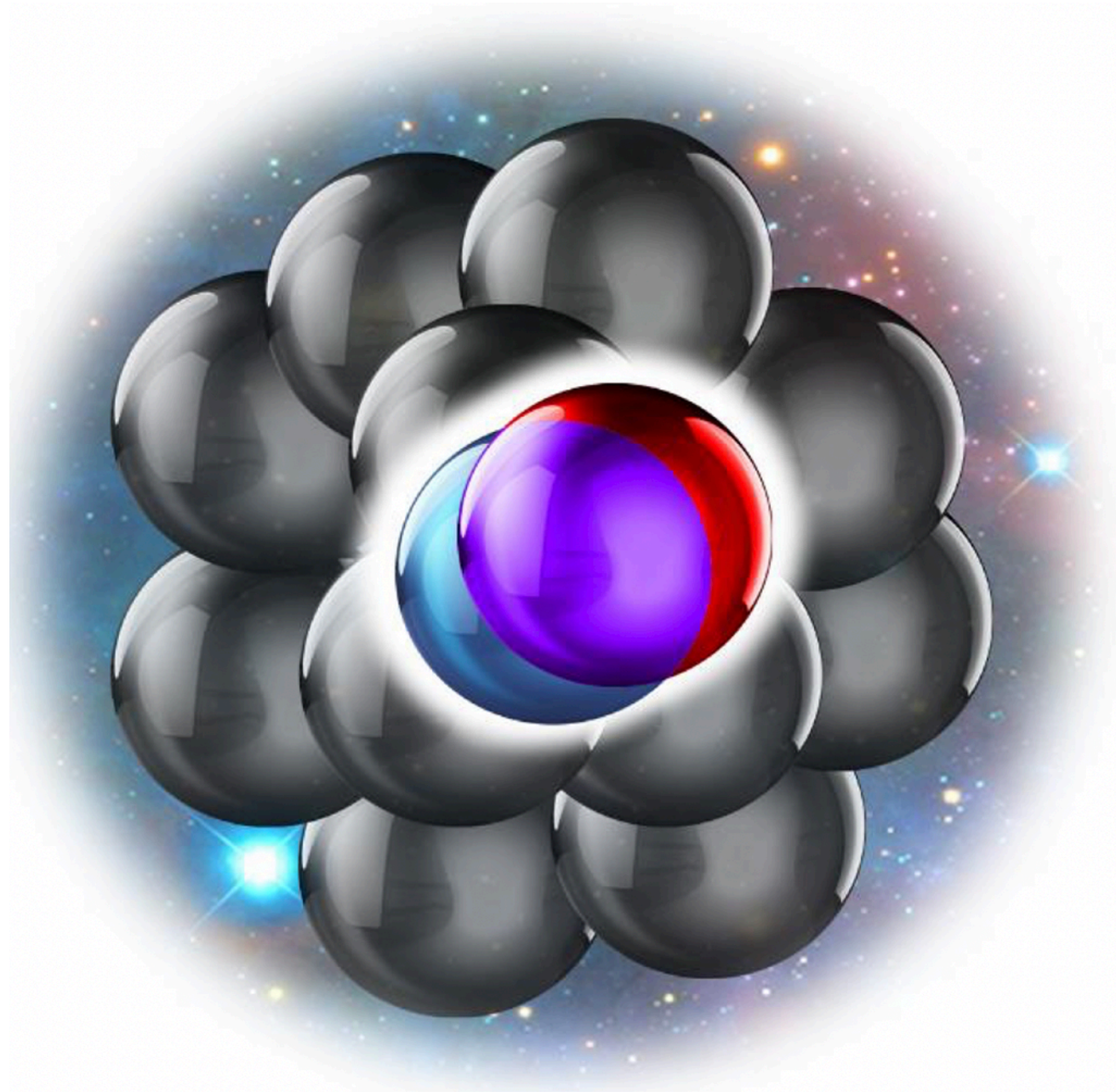
Testing the Universality of Nuclear Short-Range Correlations

Jackson Pybus



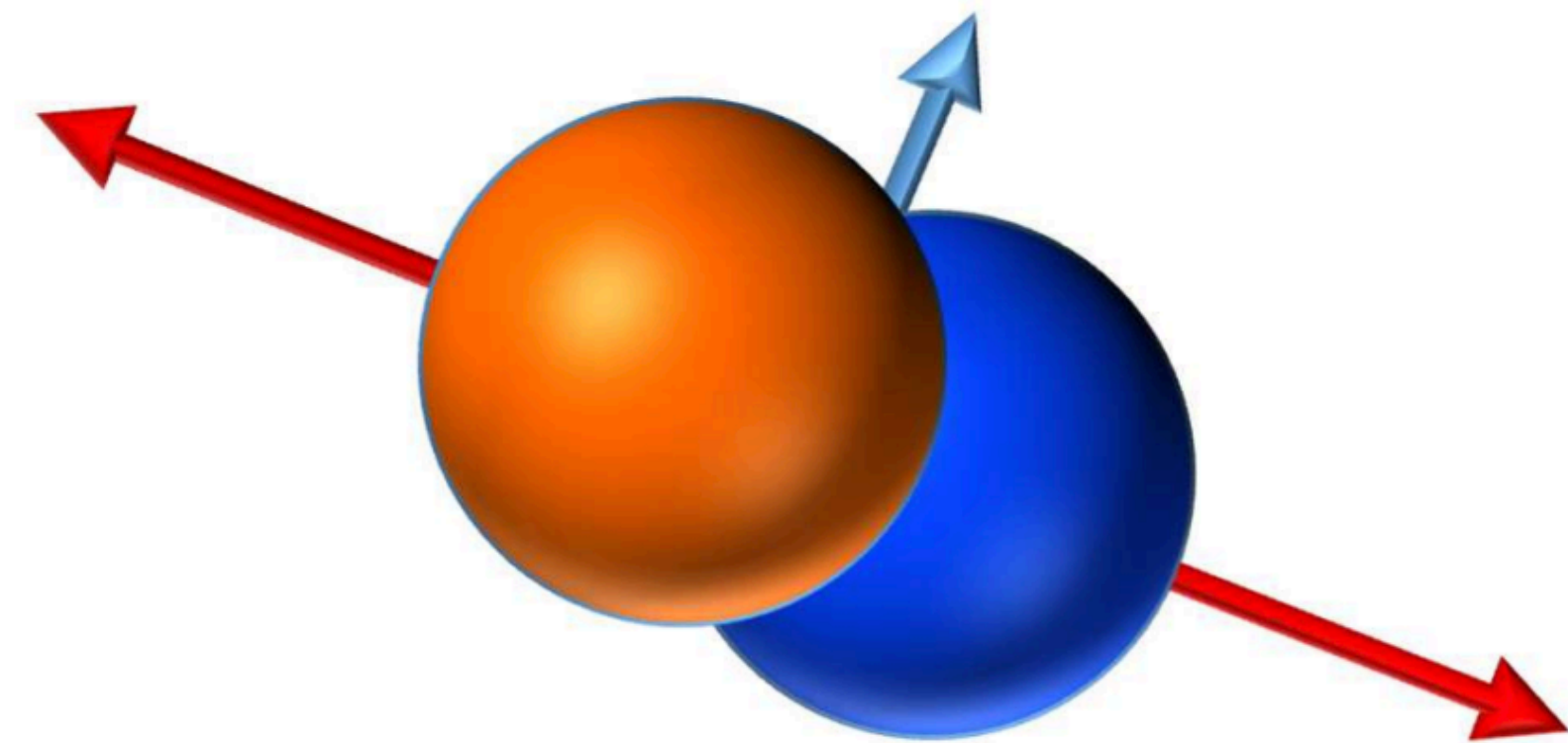
What do we know about SRCs?

Short-ranged, short-lived, highly correlated pairs of nucleons



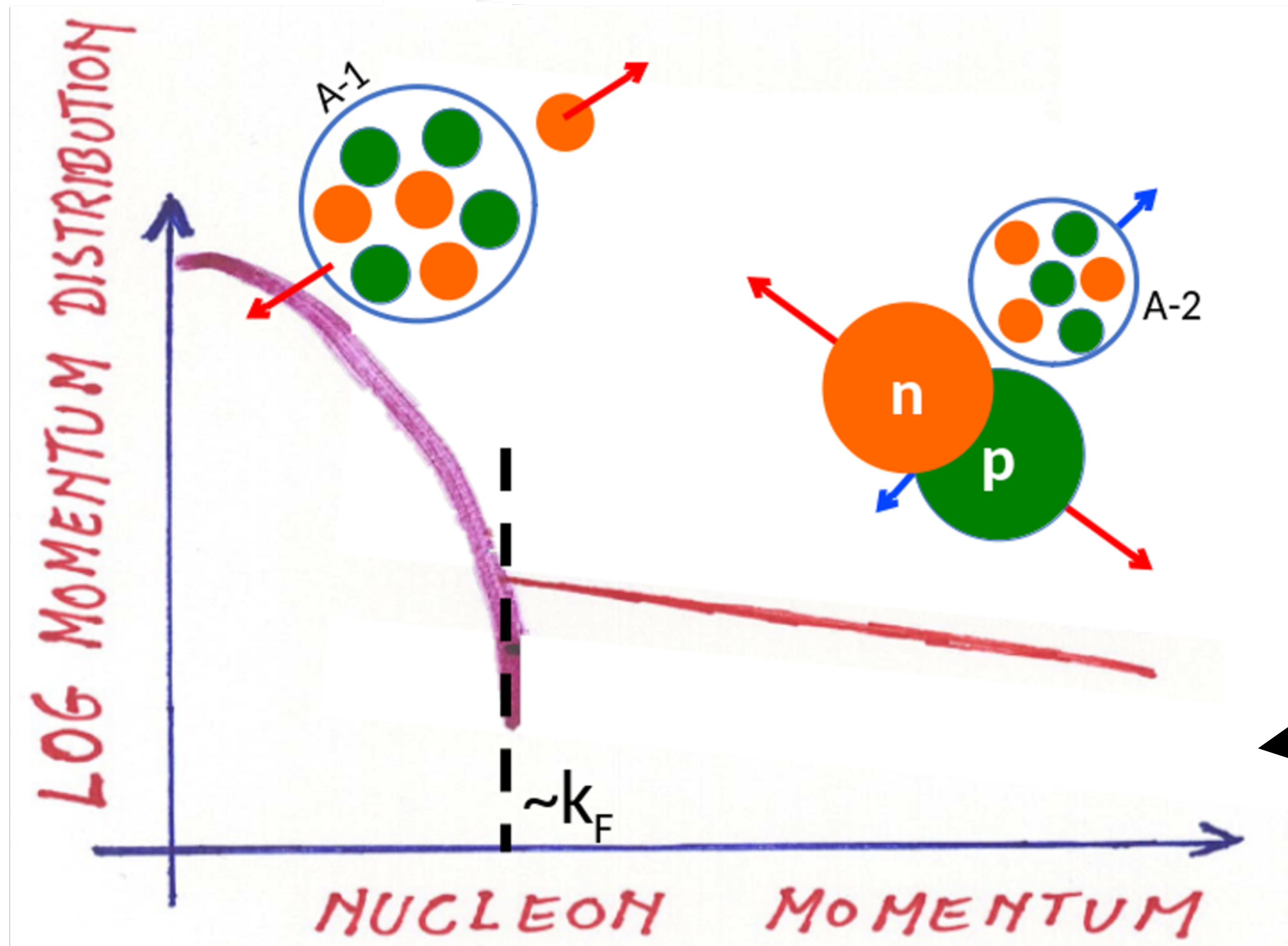
Position-space

High **relative** and lower **center-of-mass** momentum



Momentum-space

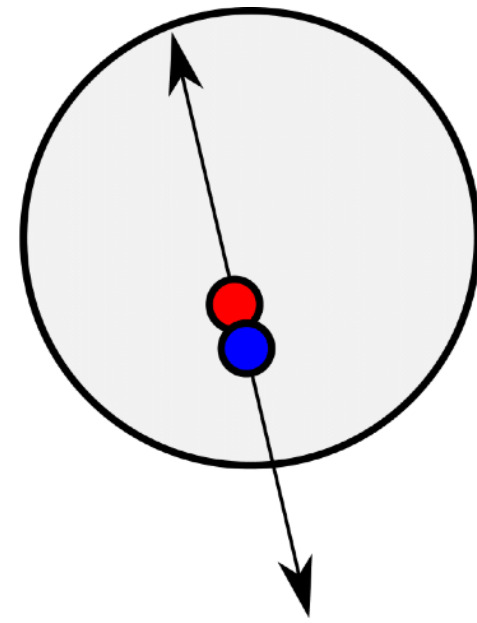
What do we know about SRCs?



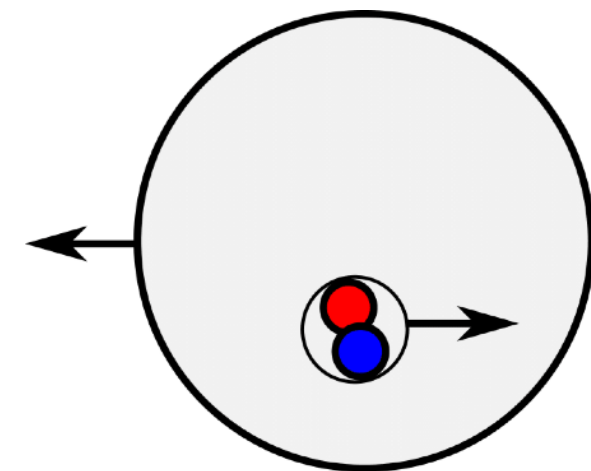
Universal high-momentum
"tail" – about 10-20% of
nucleons

Factorized approach to SRC modeling

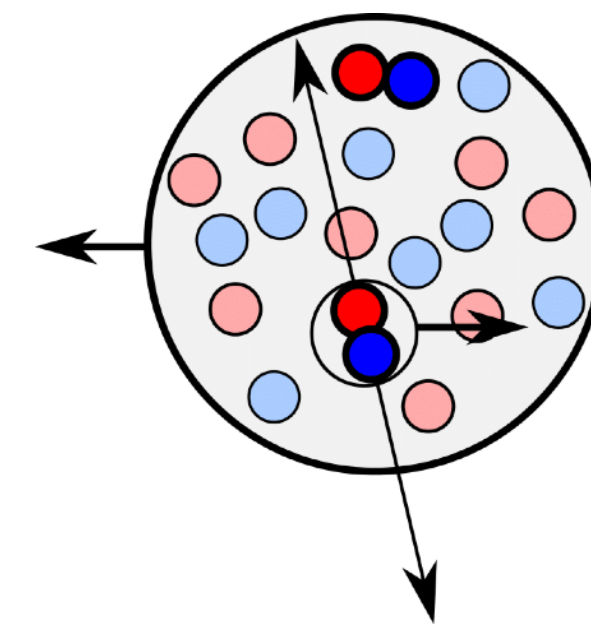
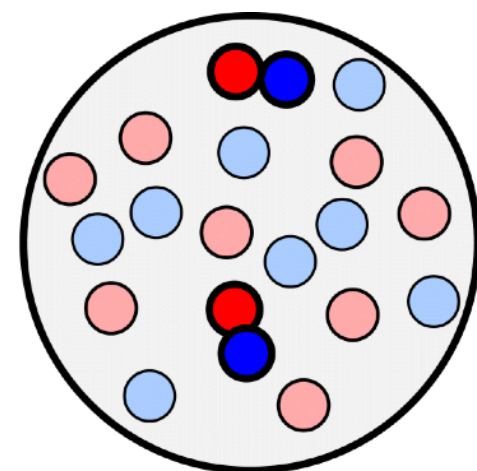
Pair interaction



Center-of-mass motion



Pair abundance



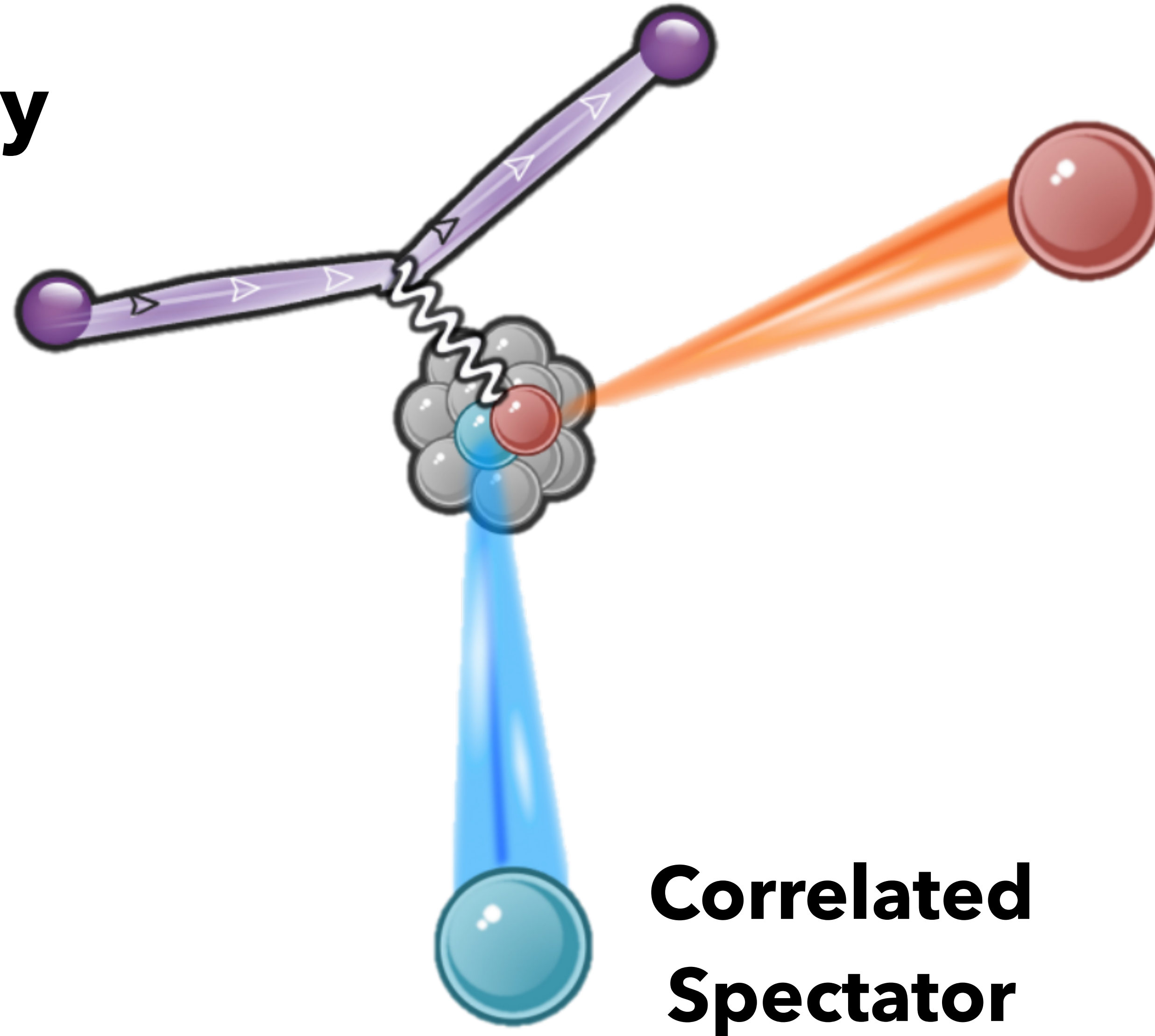
Factorized SRC spectral function:

$$S(p_i, E_i) \sim C_{NN} \cdot |\phi(k_{rel})|^2 \cdot n(p_{CM})$$

$$k_{rel} \gg p_{cm}$$

SRCs can be studied with hard breakup reactions

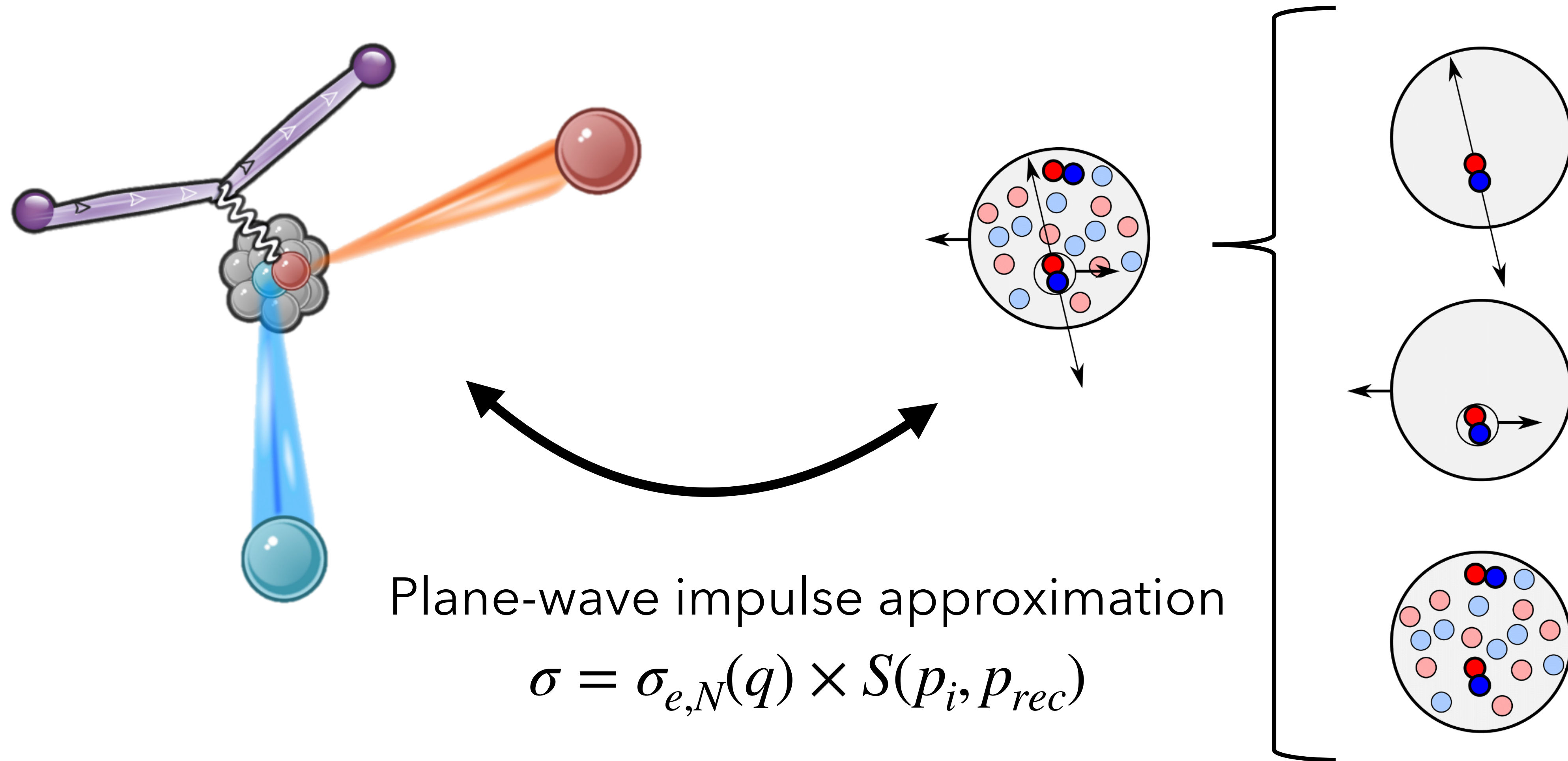
**High-Energy
Probe**



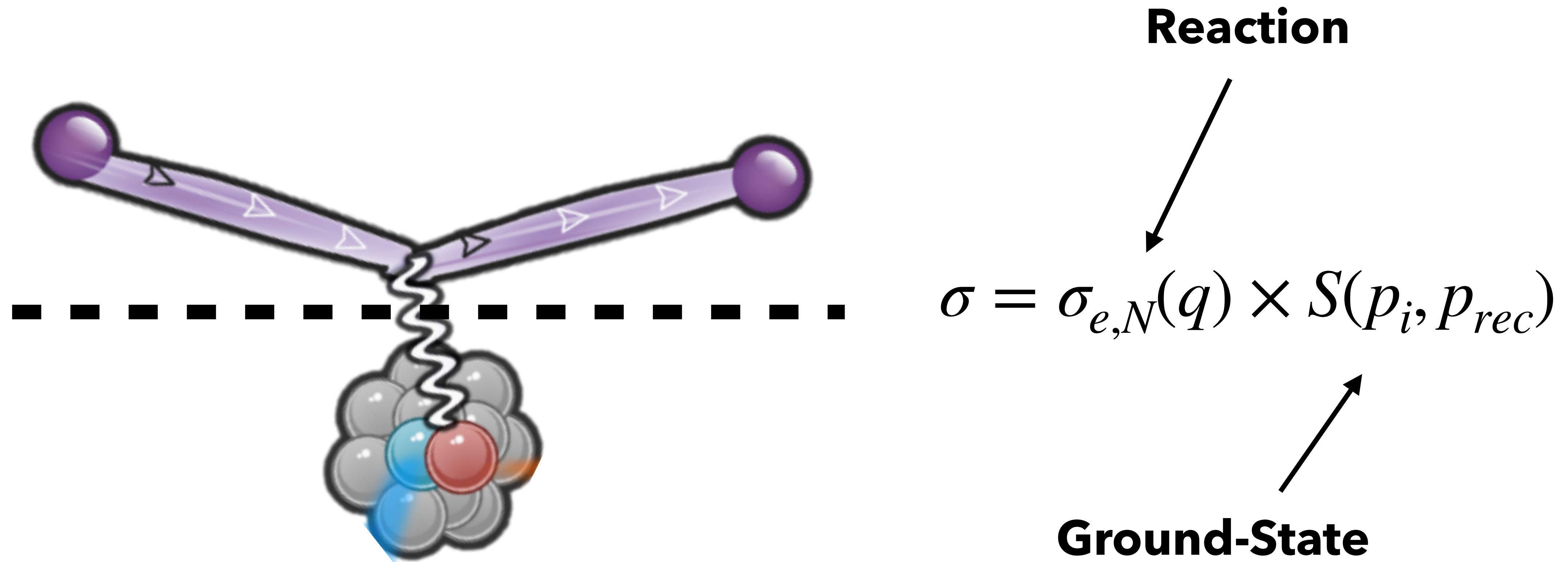
**Struck
Nucleon**

**Correlated
Spectator**

Scattering data can inform ab-initio theory

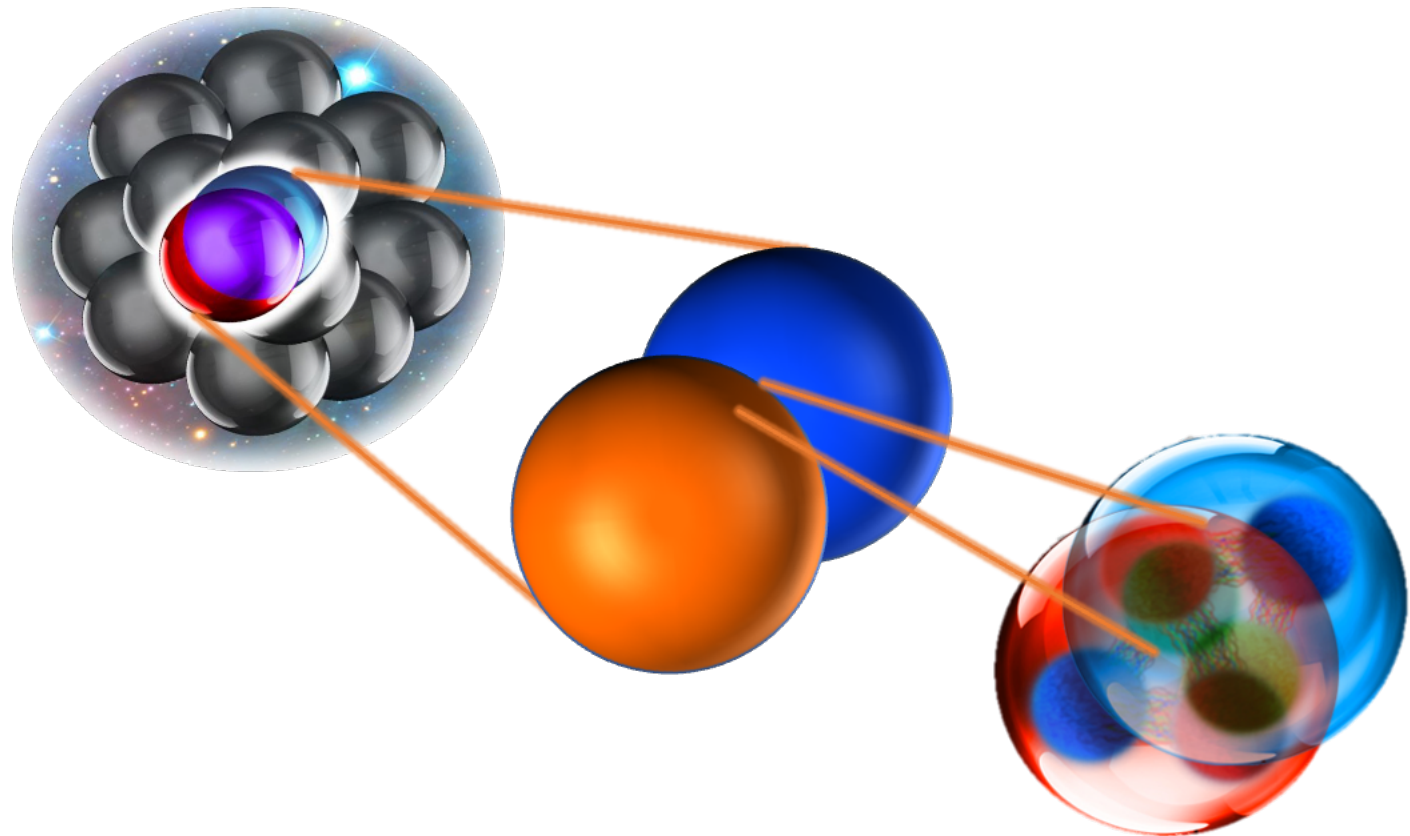


Ground-state interpretation requires establishing plane-wave factorization!



Two ways to examine reaction-dependence:

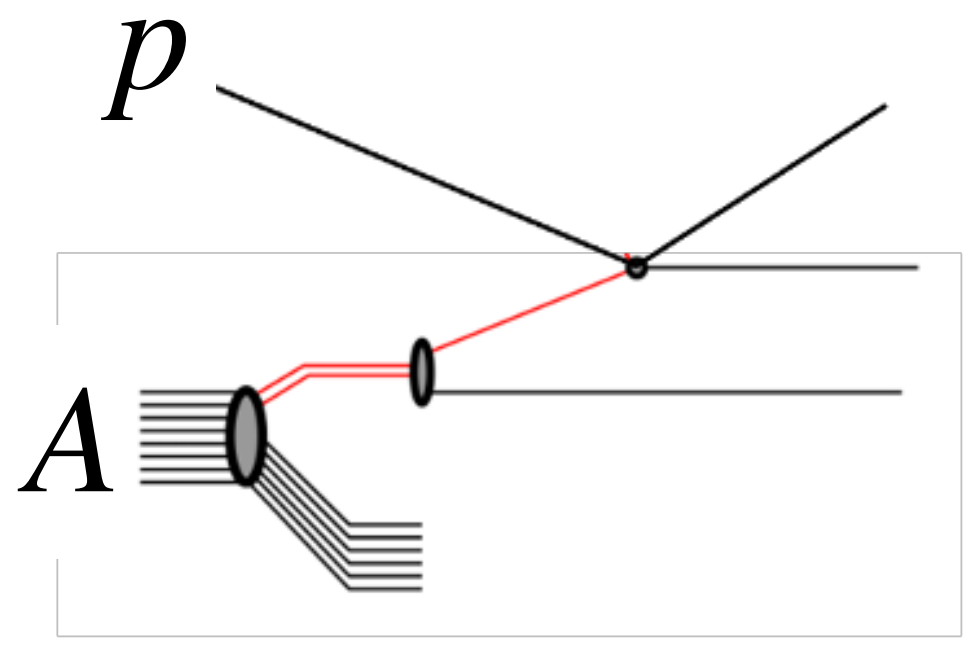
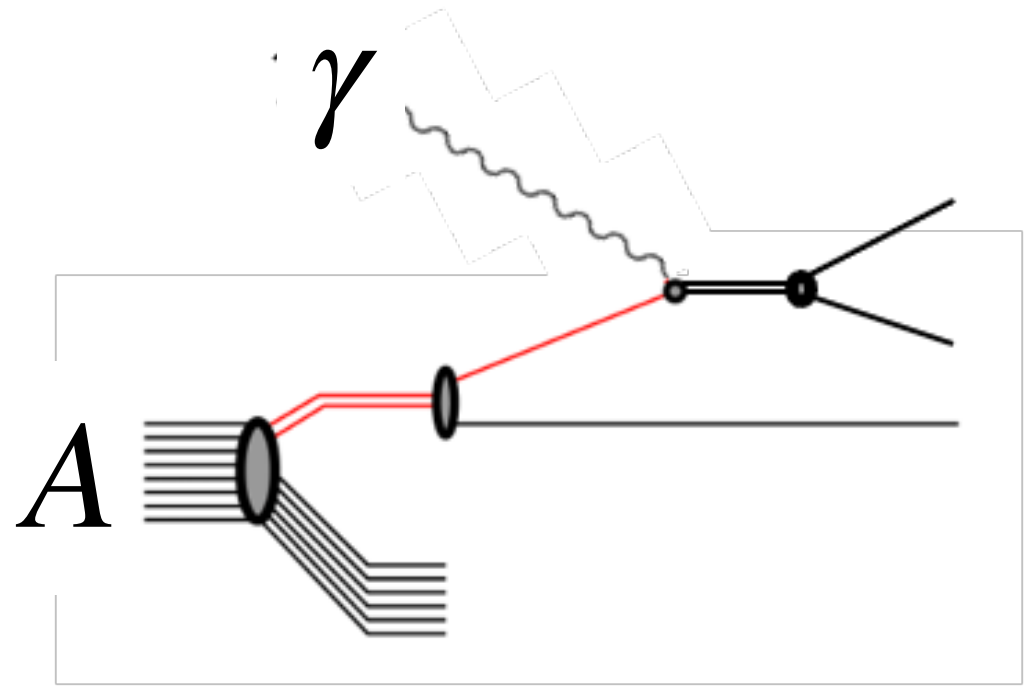
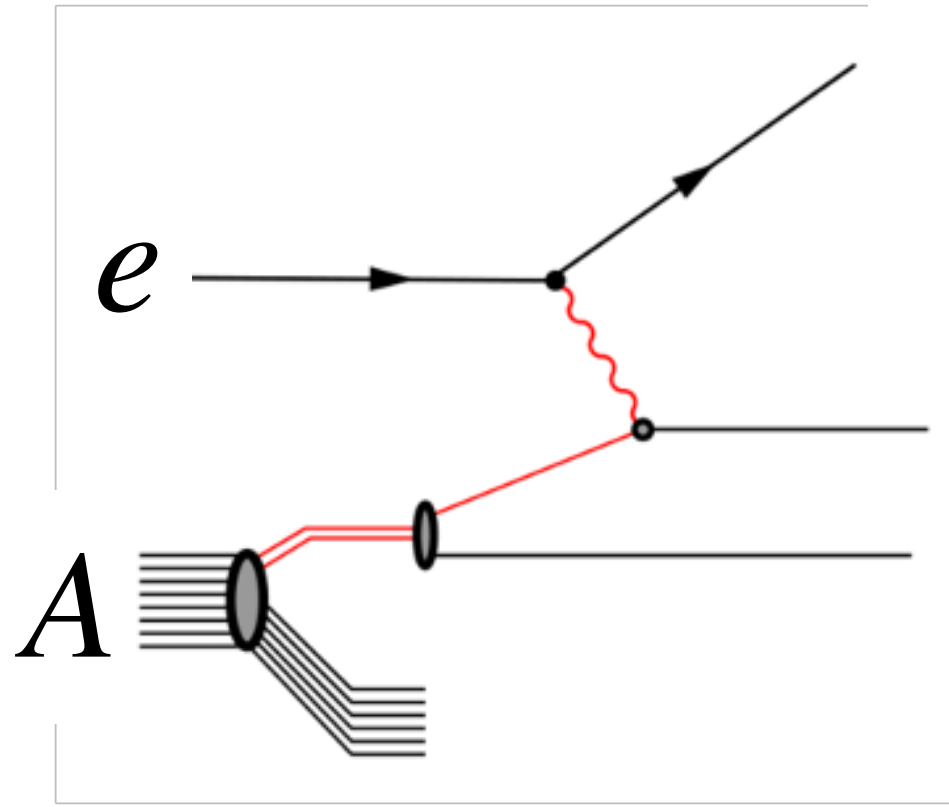
Scale



$Q^2, |t|$ change the resolution **scale**

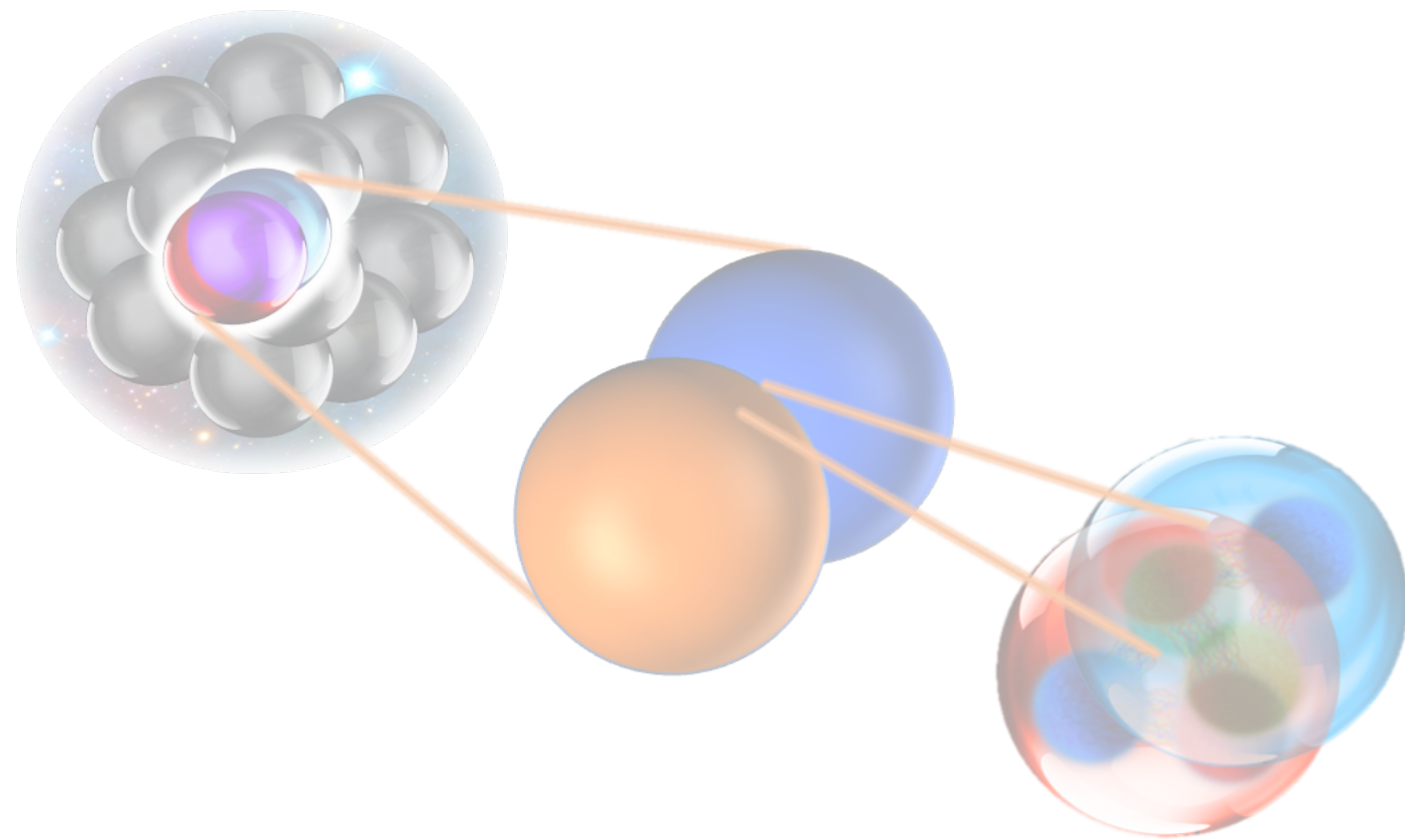
Probe

Different **probes**:
Electromagnetic (e^-),
Hadronic (p, A),
Photonuclear (γ)



Two ways to examine reaction-dependence:

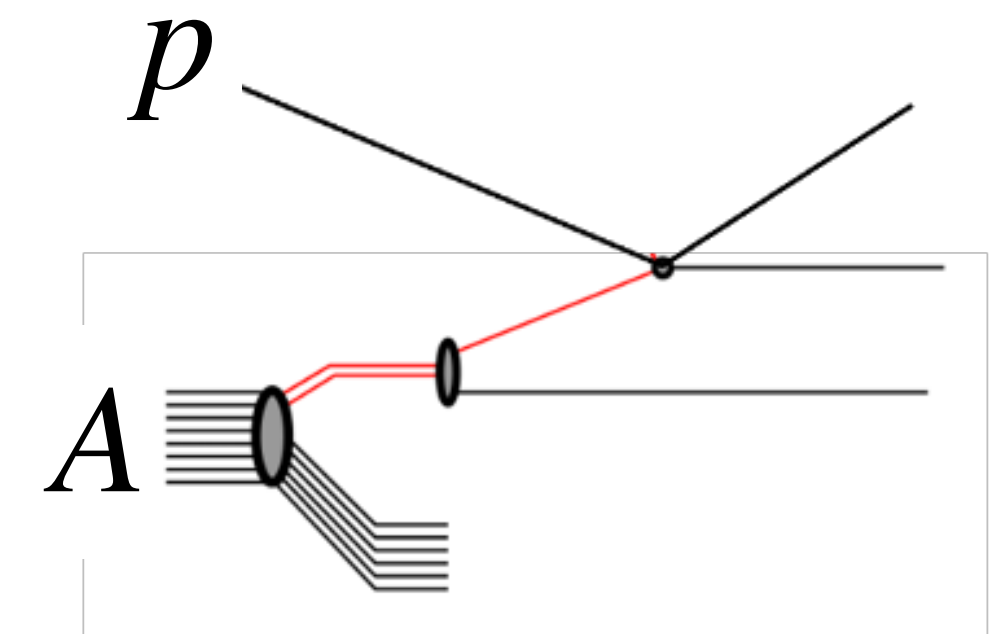
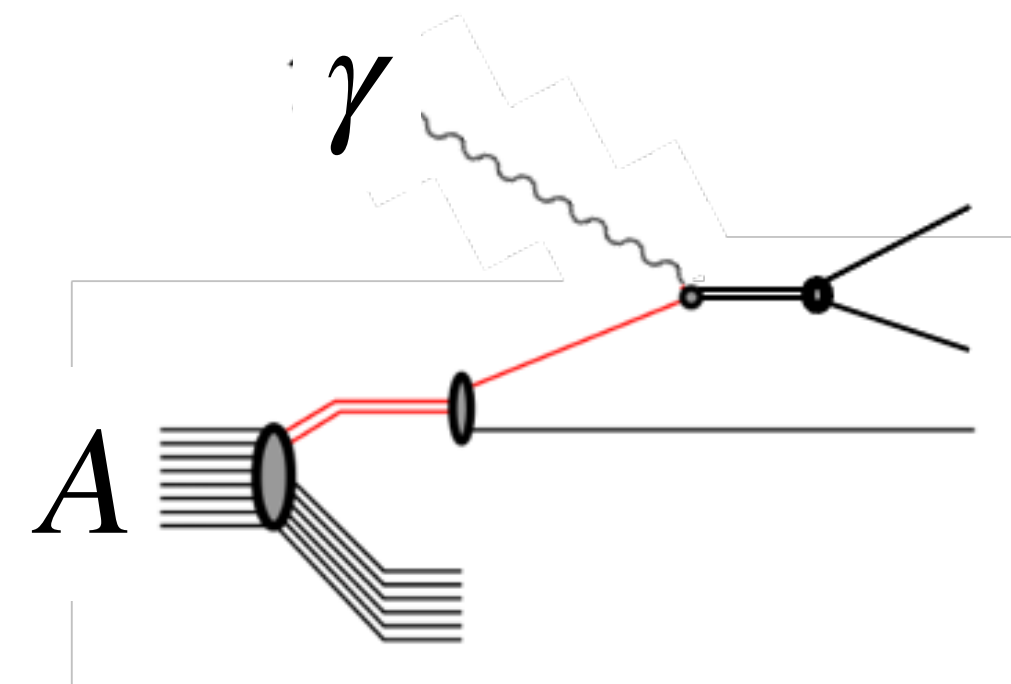
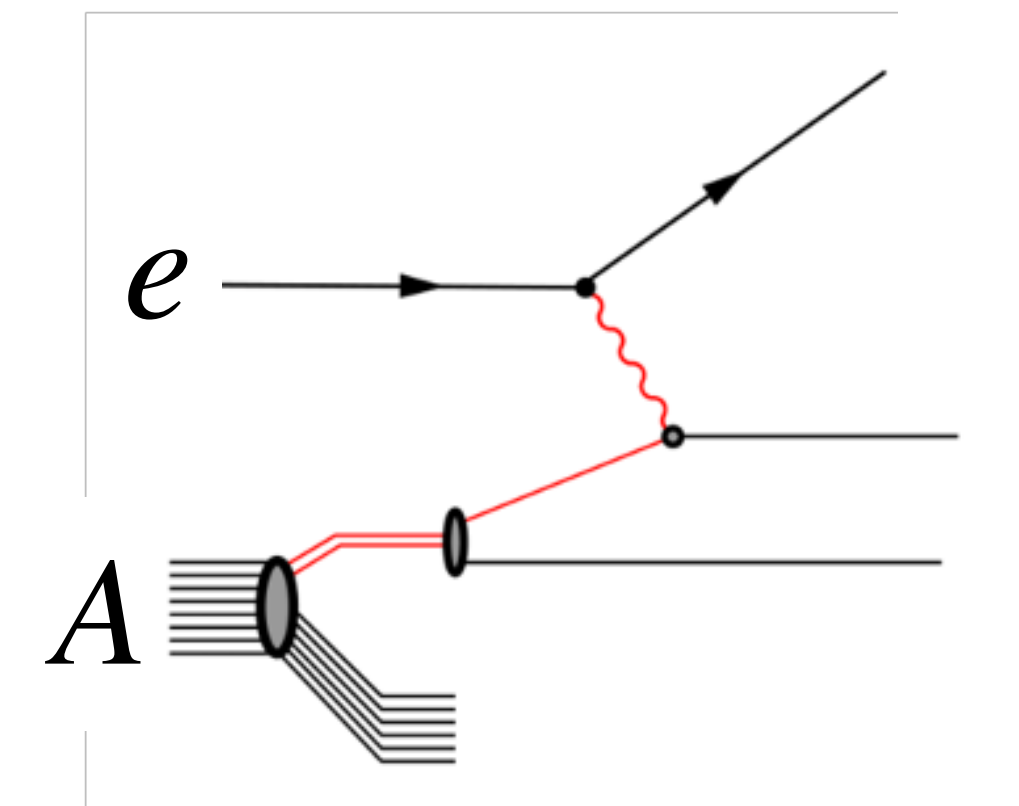
Scale



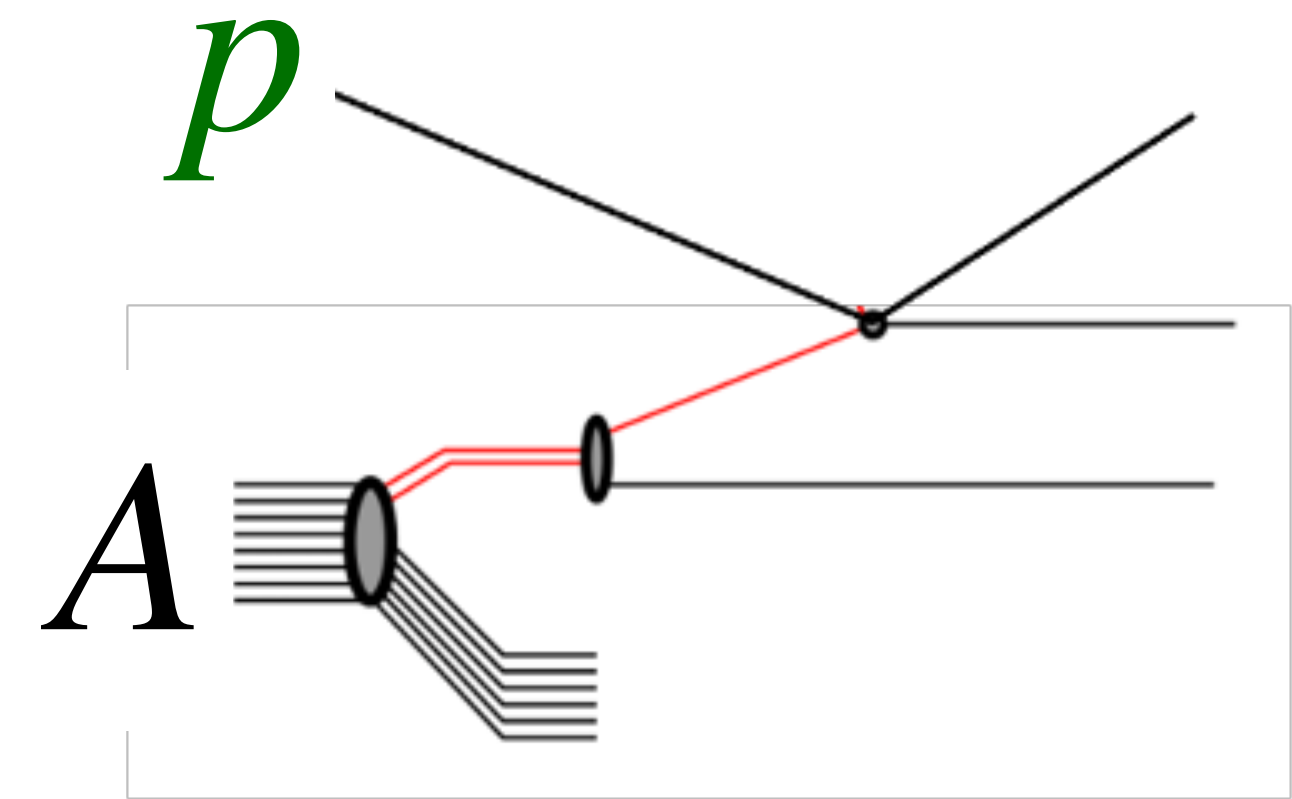
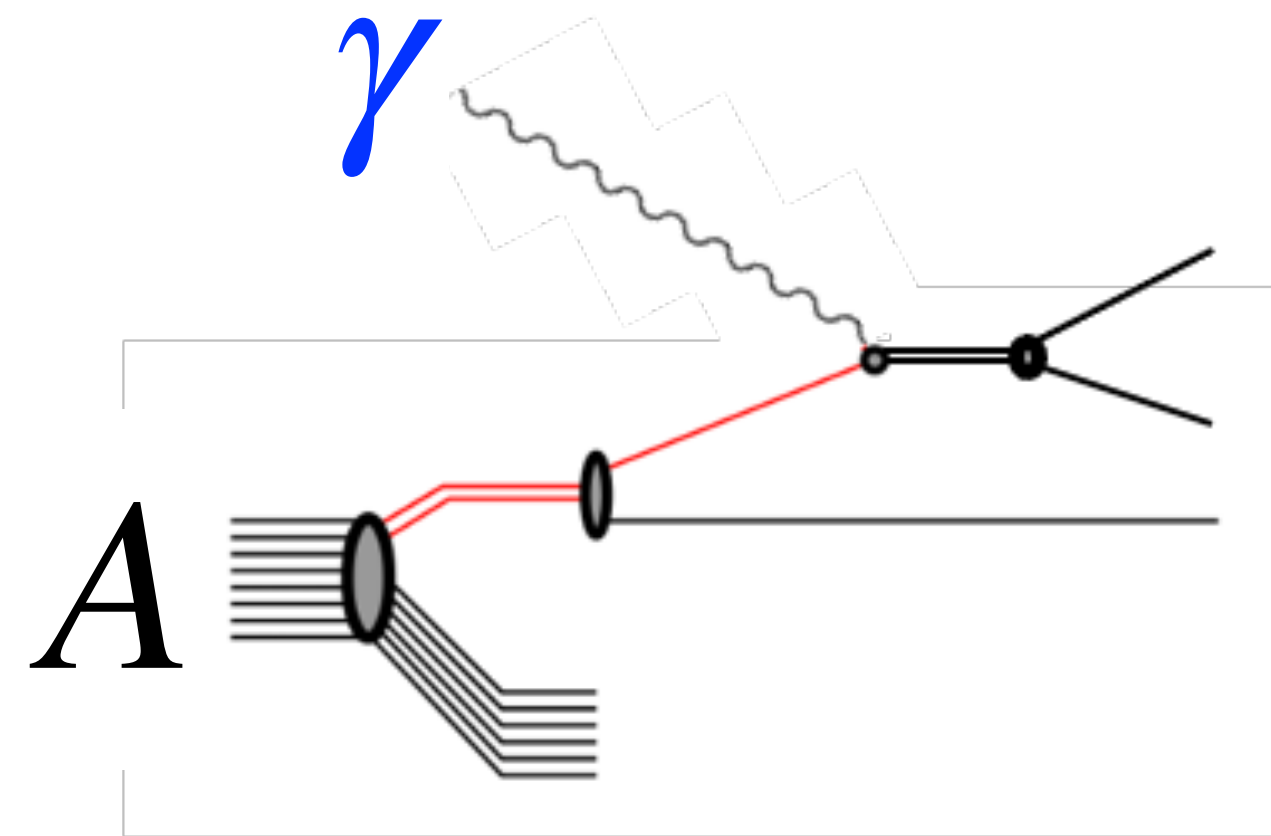
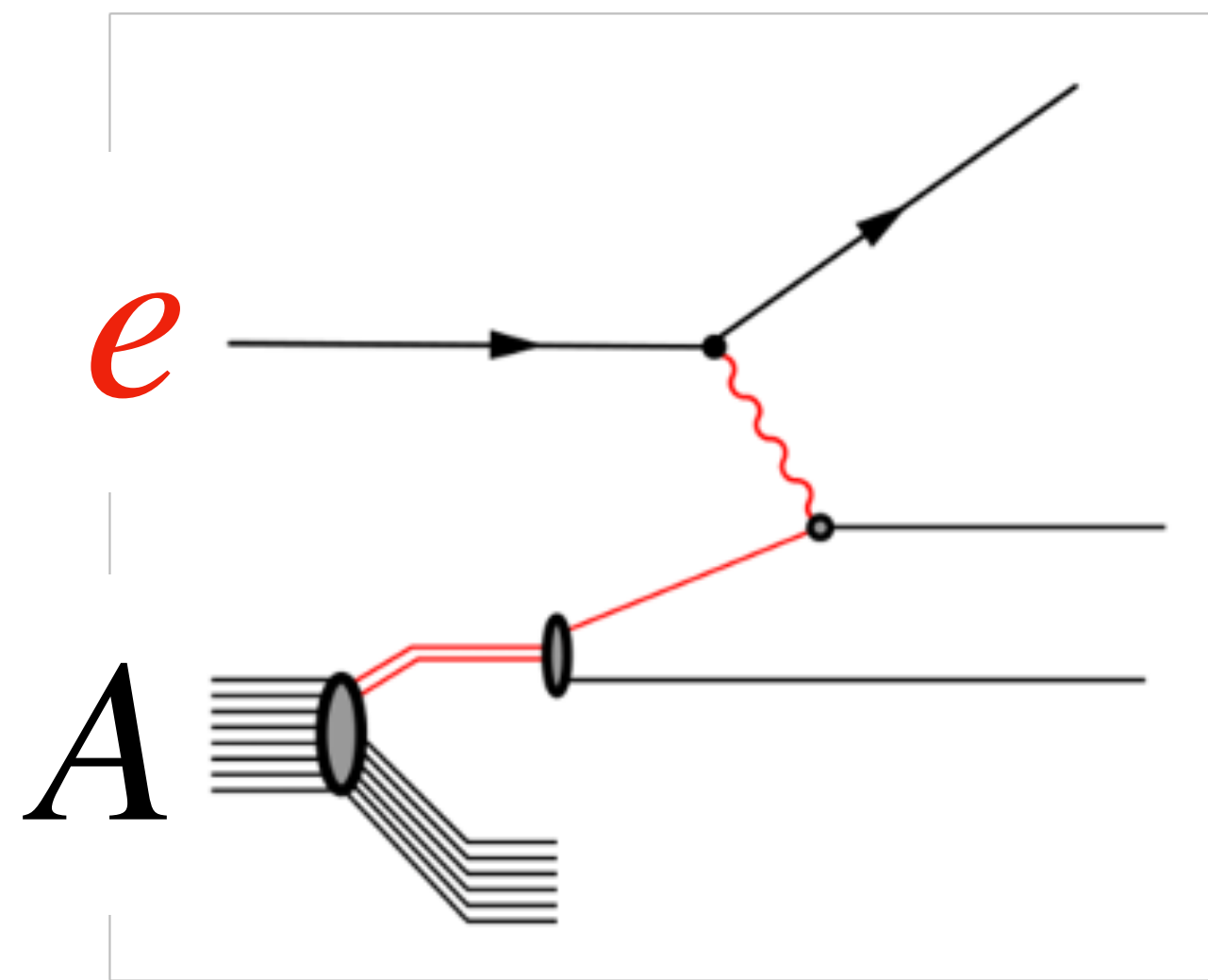
$Q^2, |t|$ change the resolution **scale**

Probe

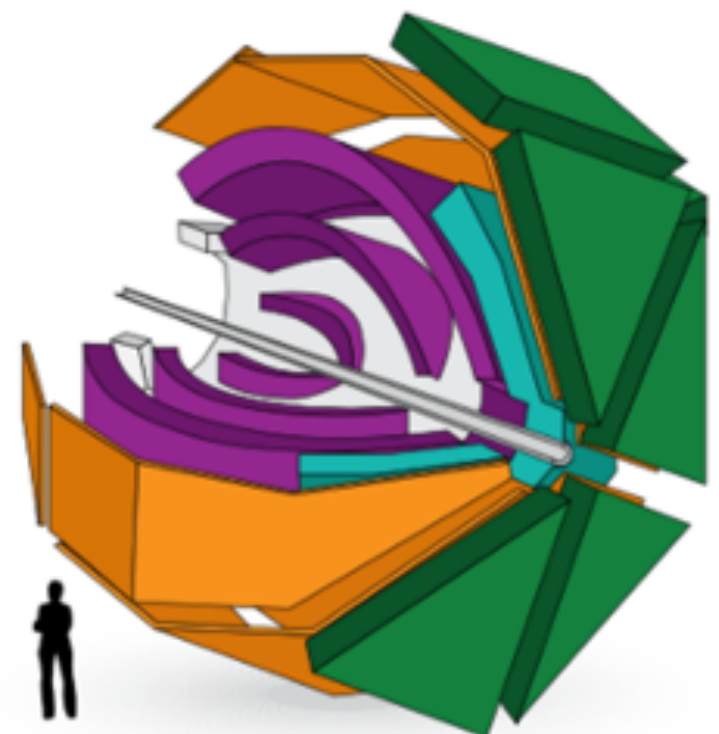
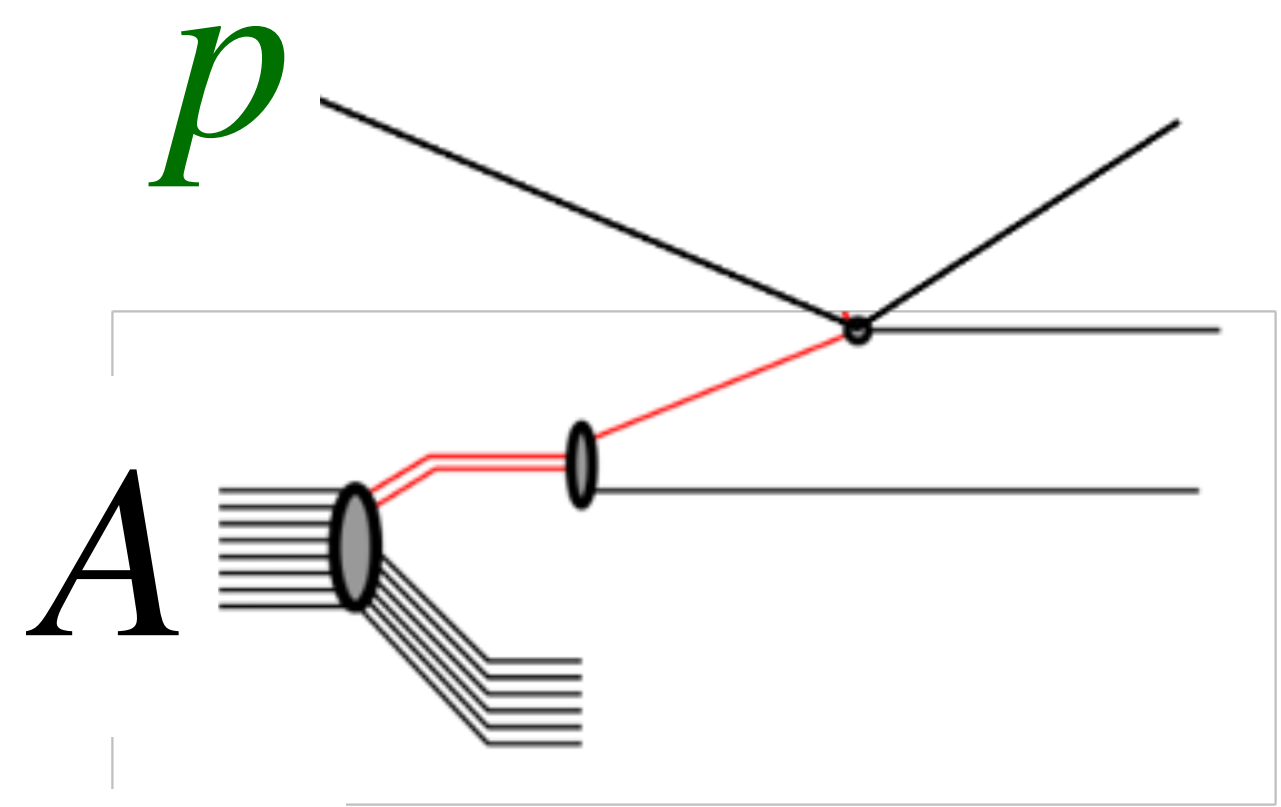
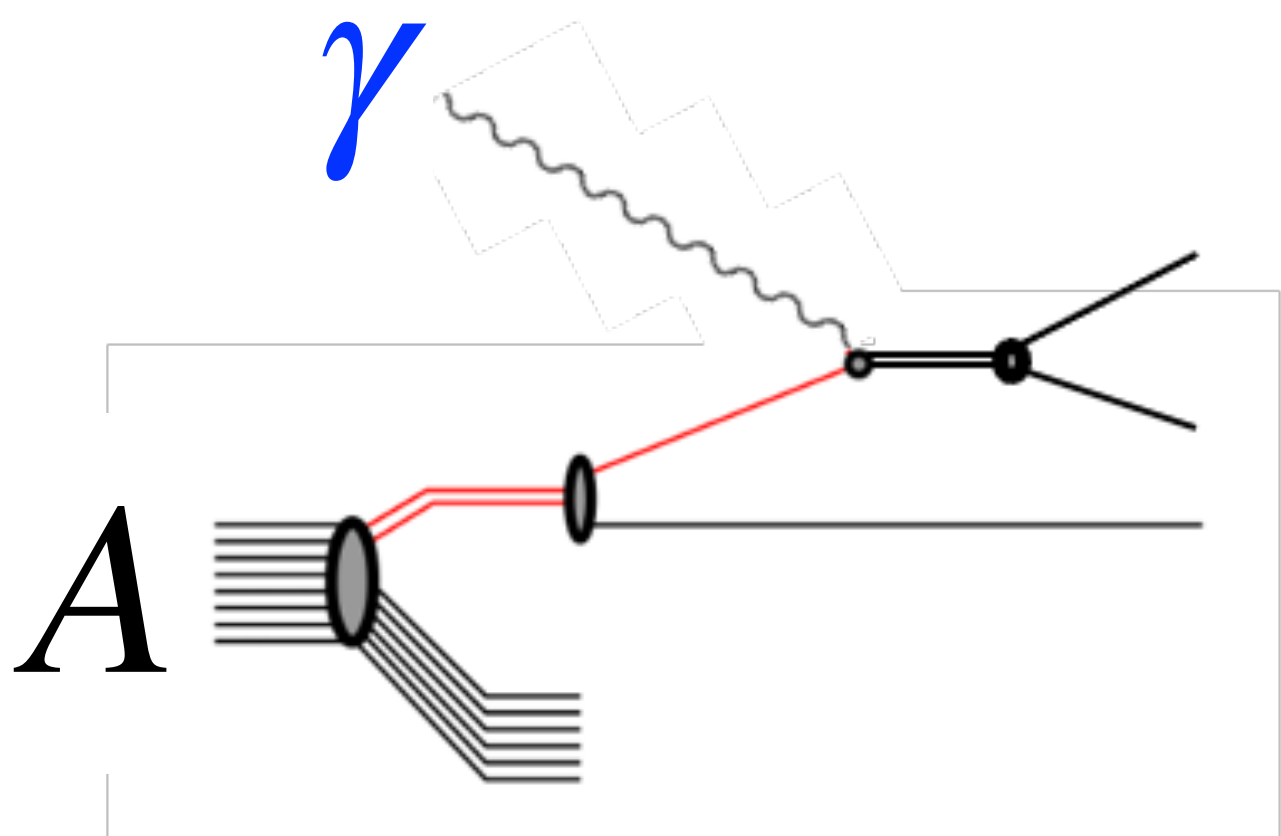
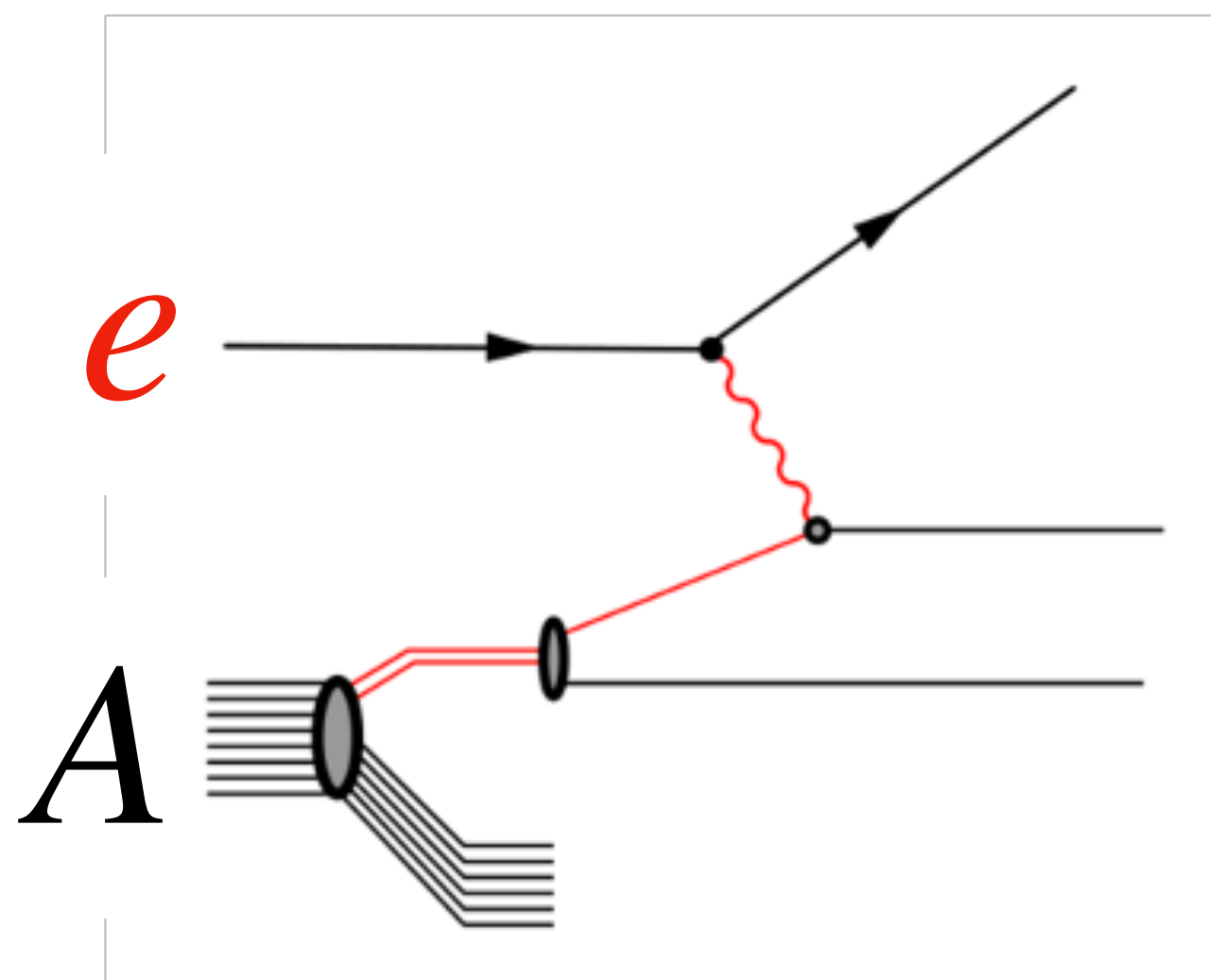
Different **probes**:
Electromagnetic (e^-),
Hadronic (p, A),
Photonuclear (γ)



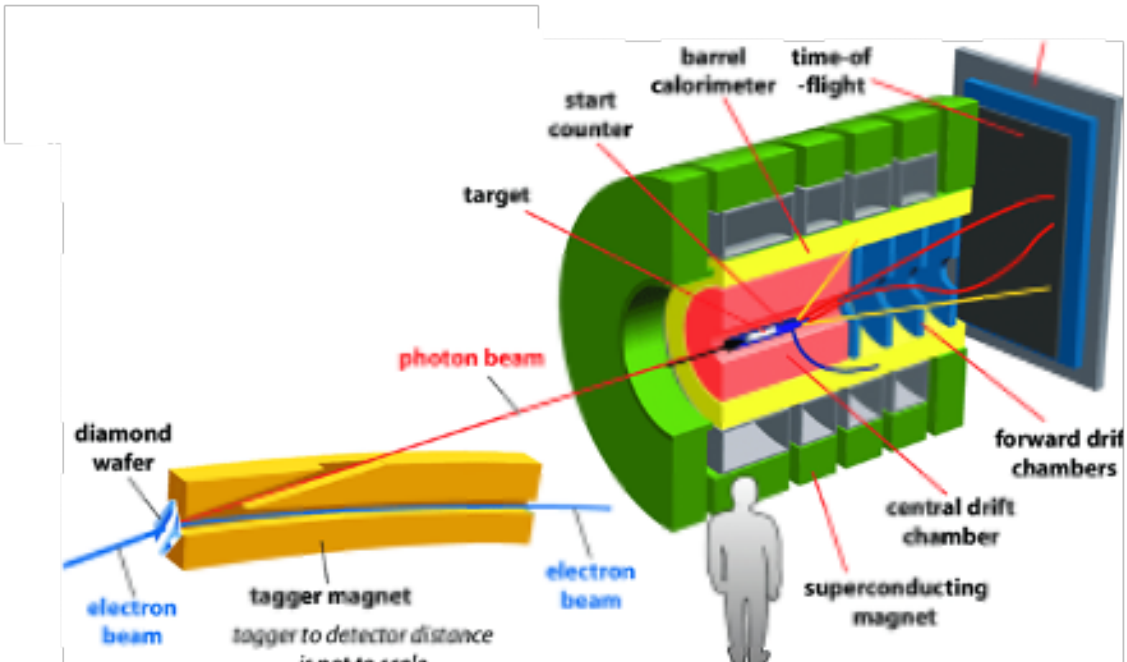
Probe Dependence of SRCs



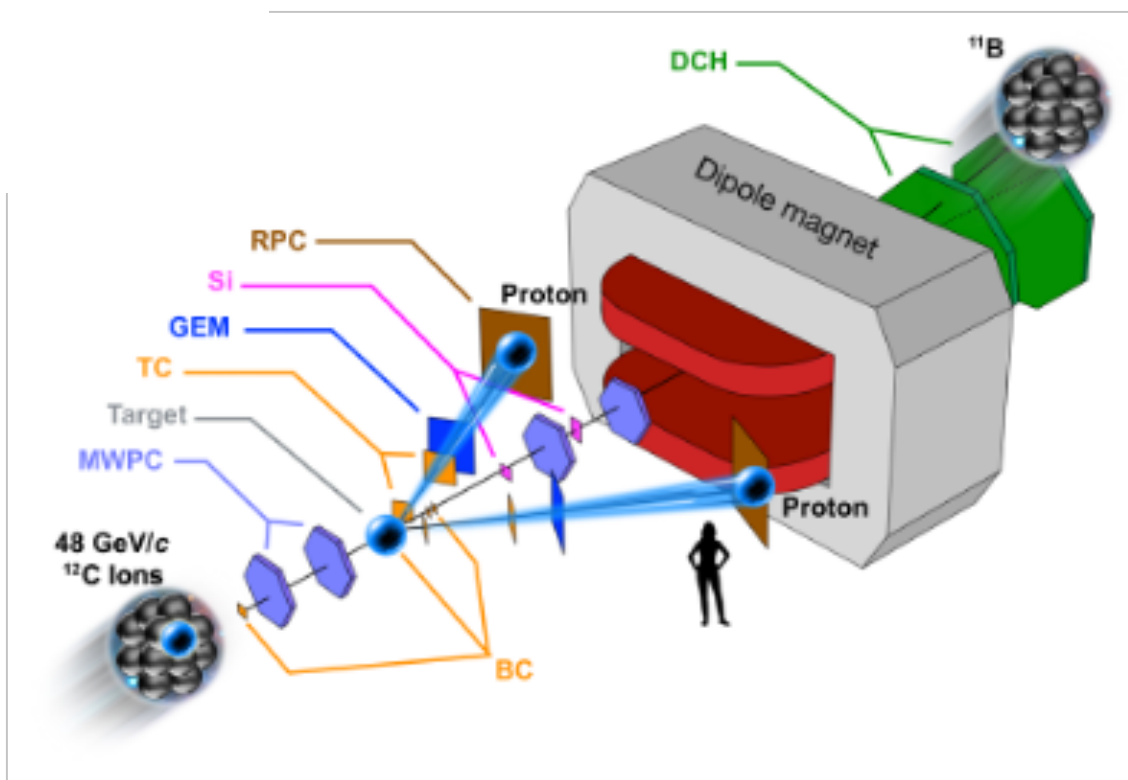
Probe Dependence of SRCs



CLAS12

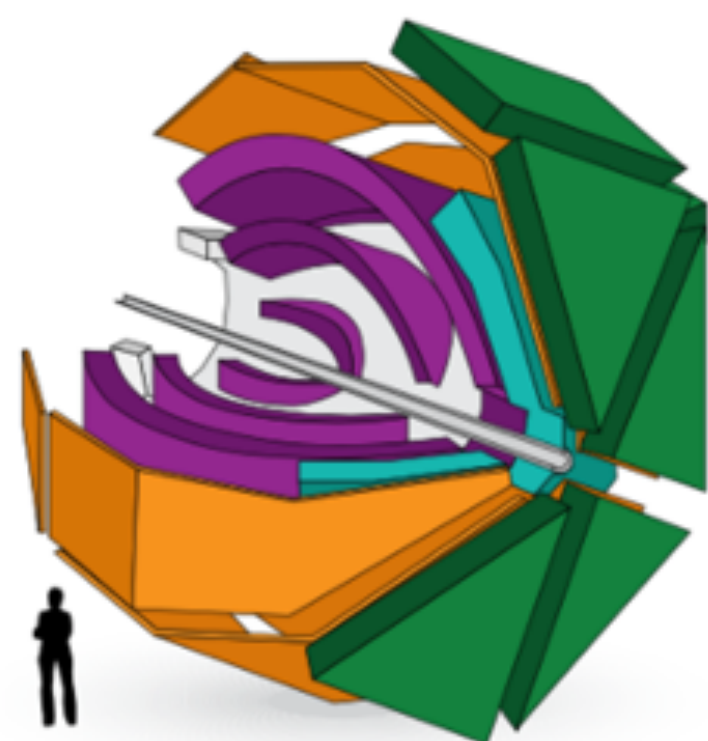
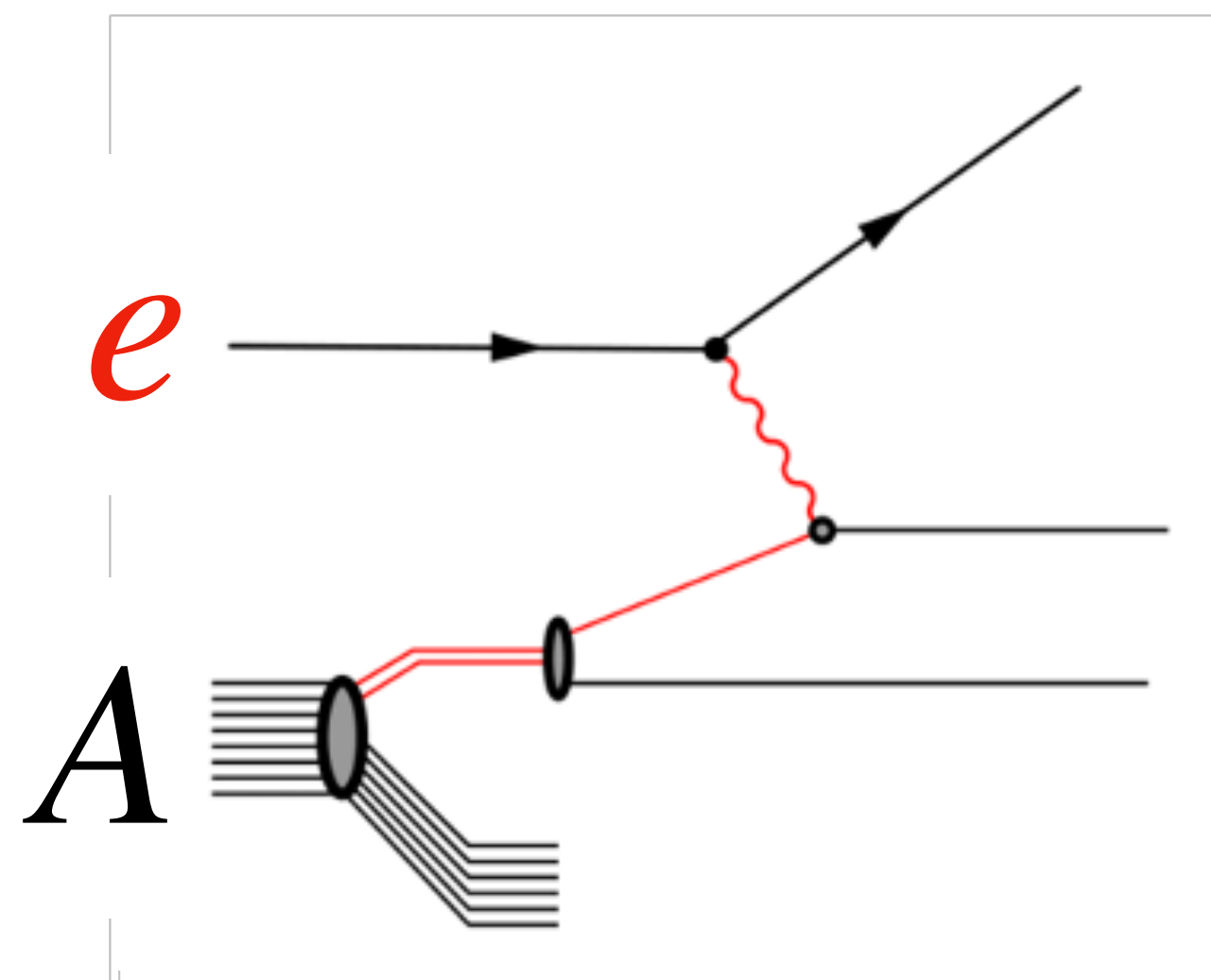


GlueX

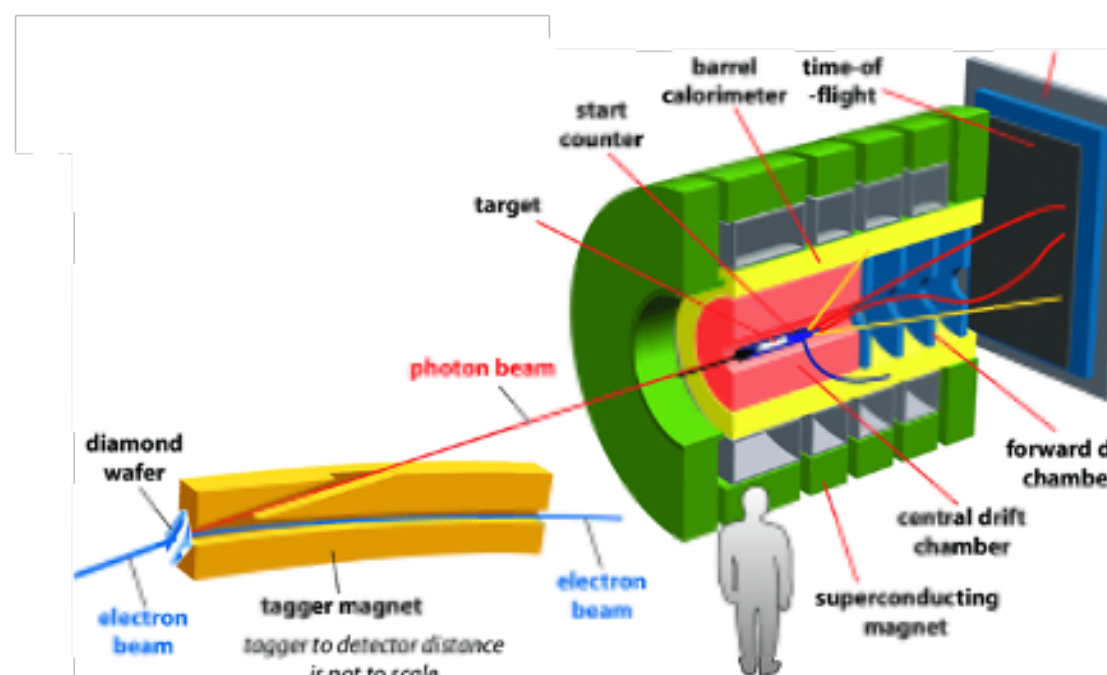
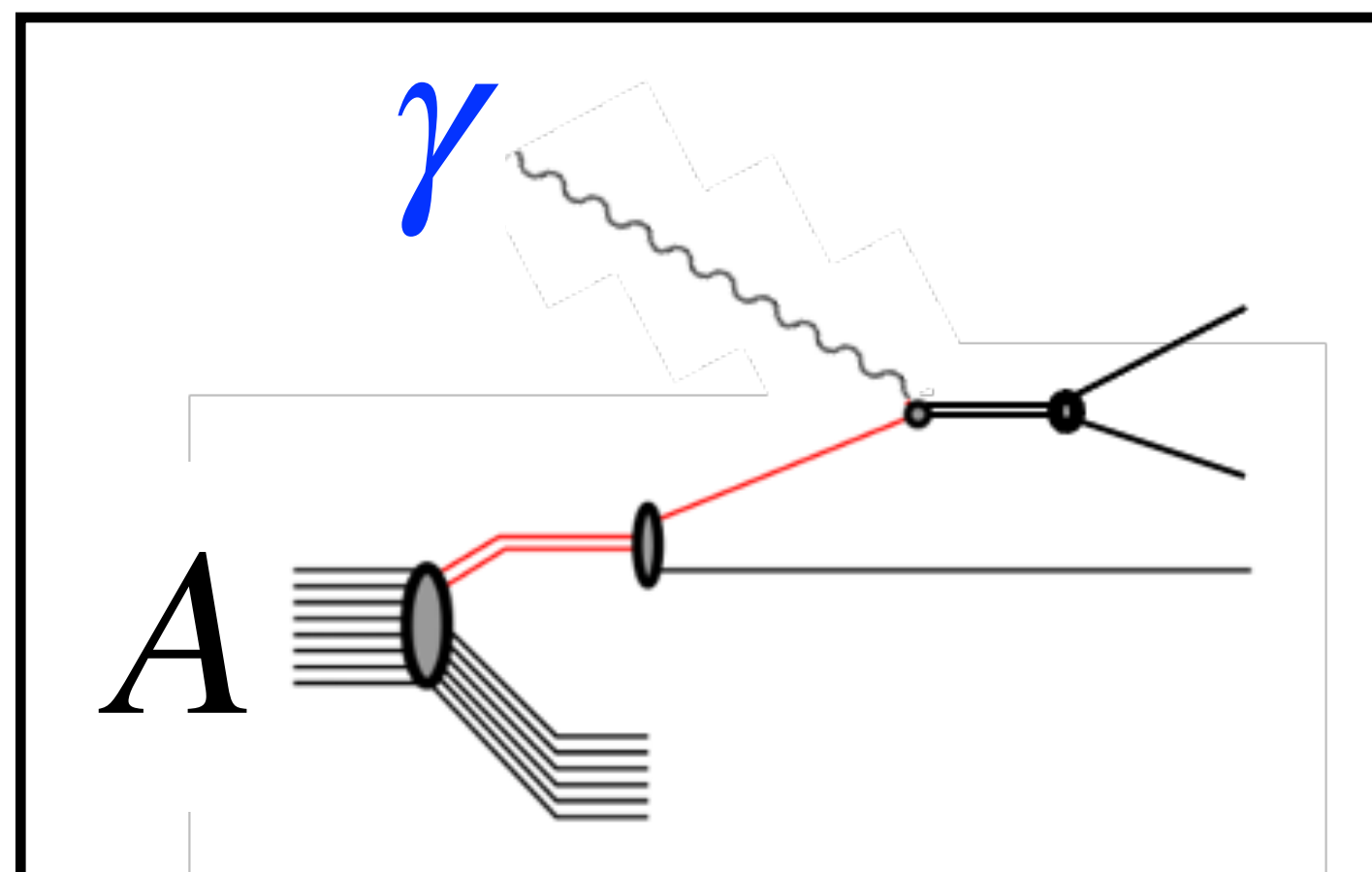


BM@N / R3B

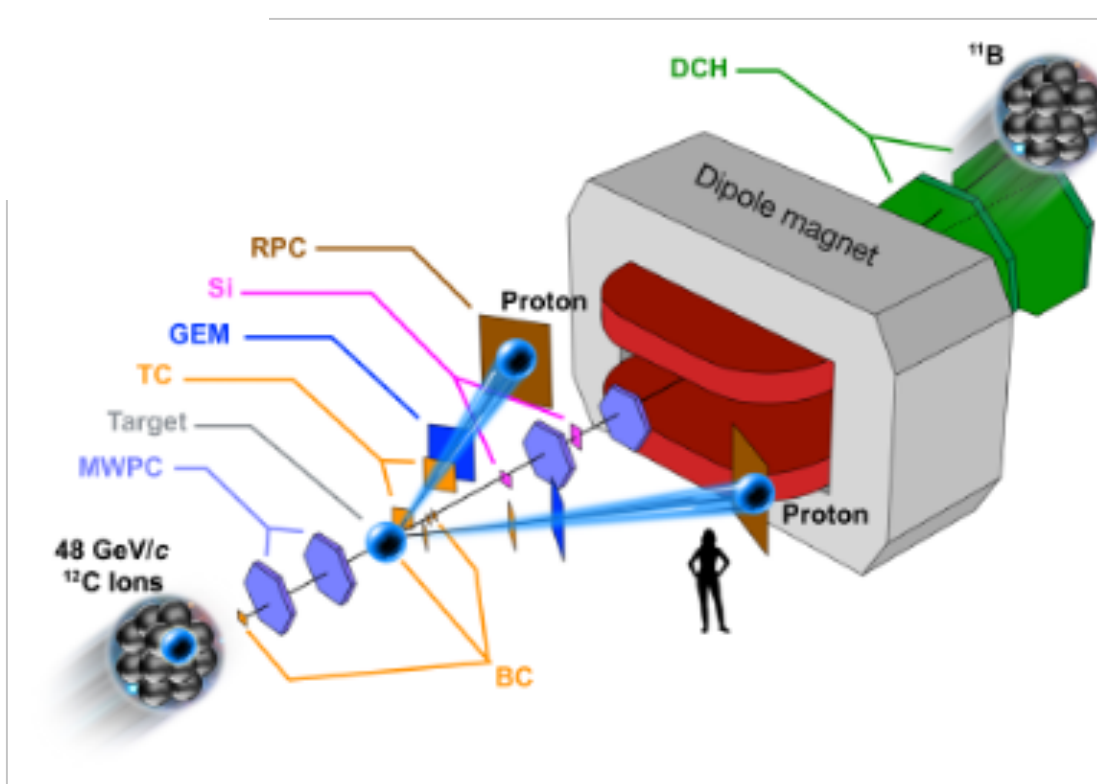
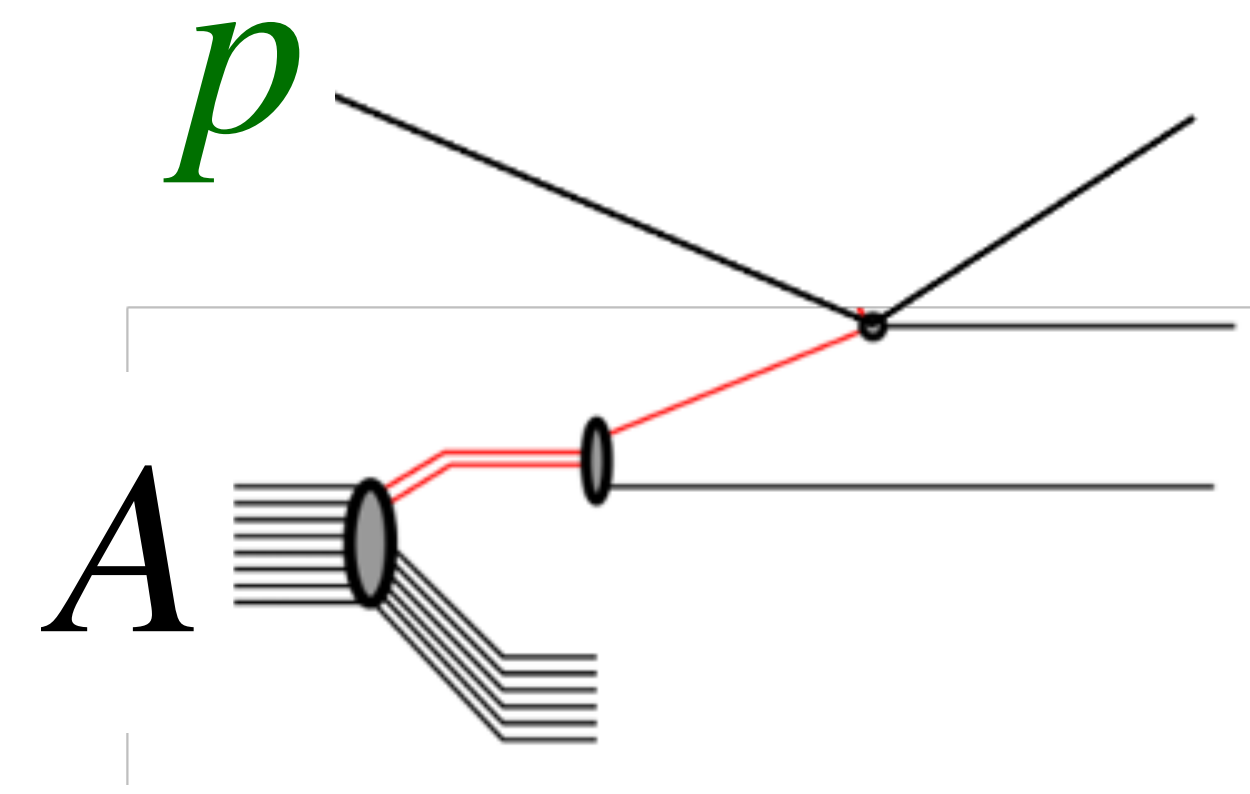
Probe Dependence of SRCs



CLAS12

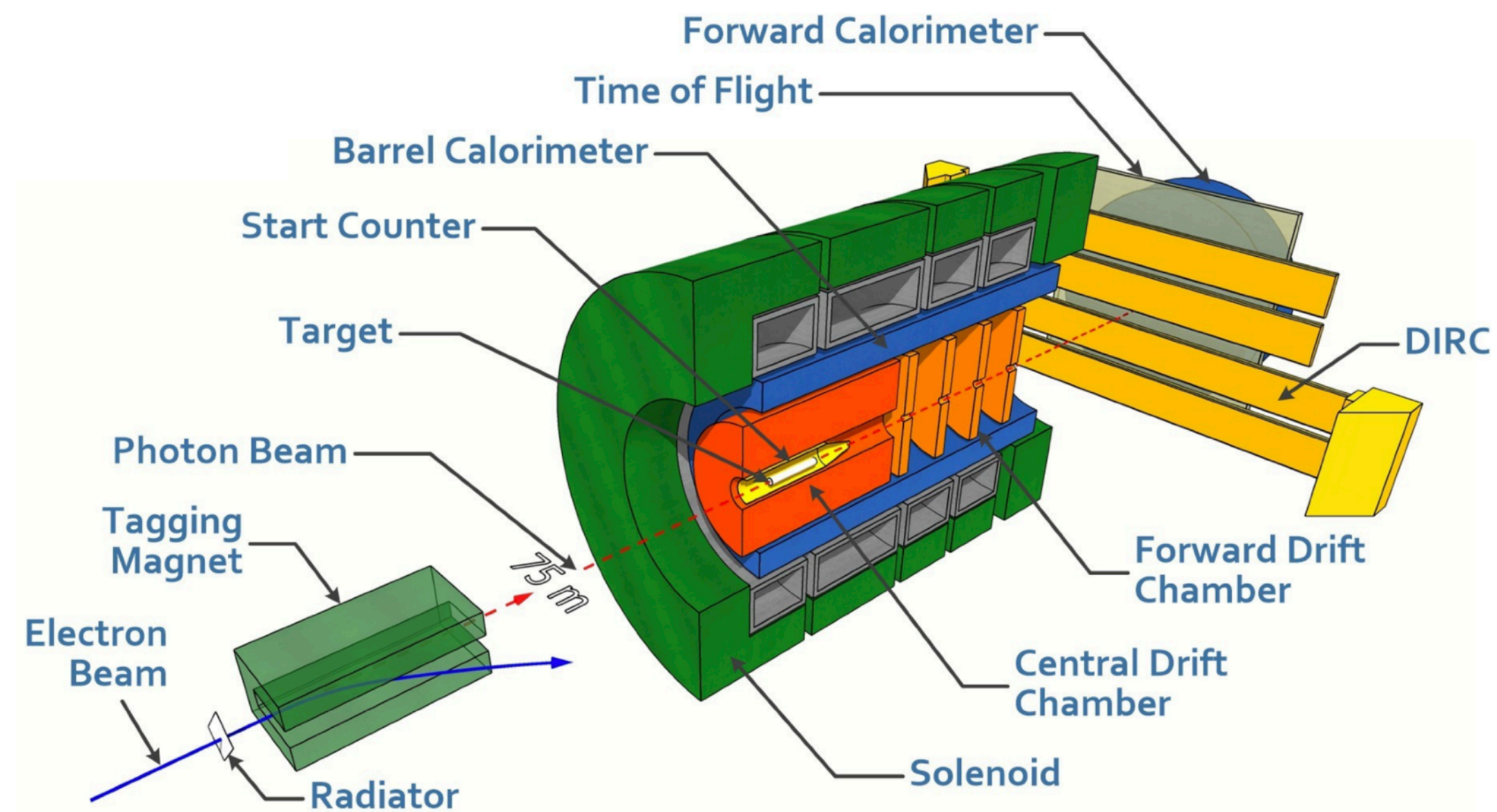


GlueX

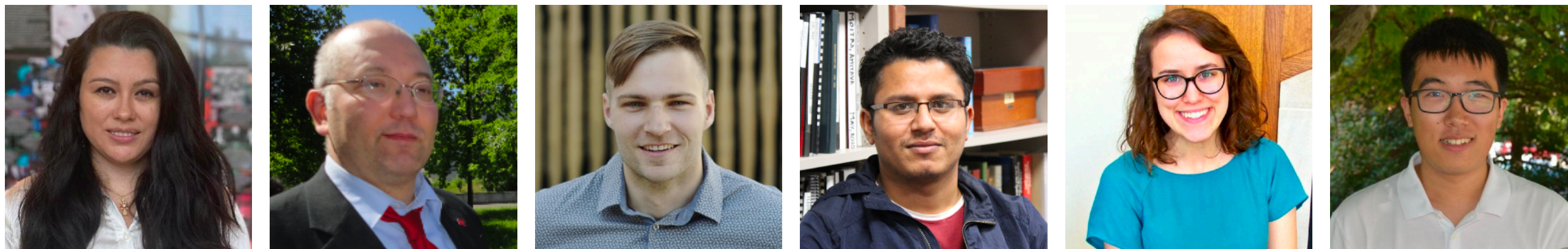


BM@N / R3B

SRC Photoproduction in Hall D

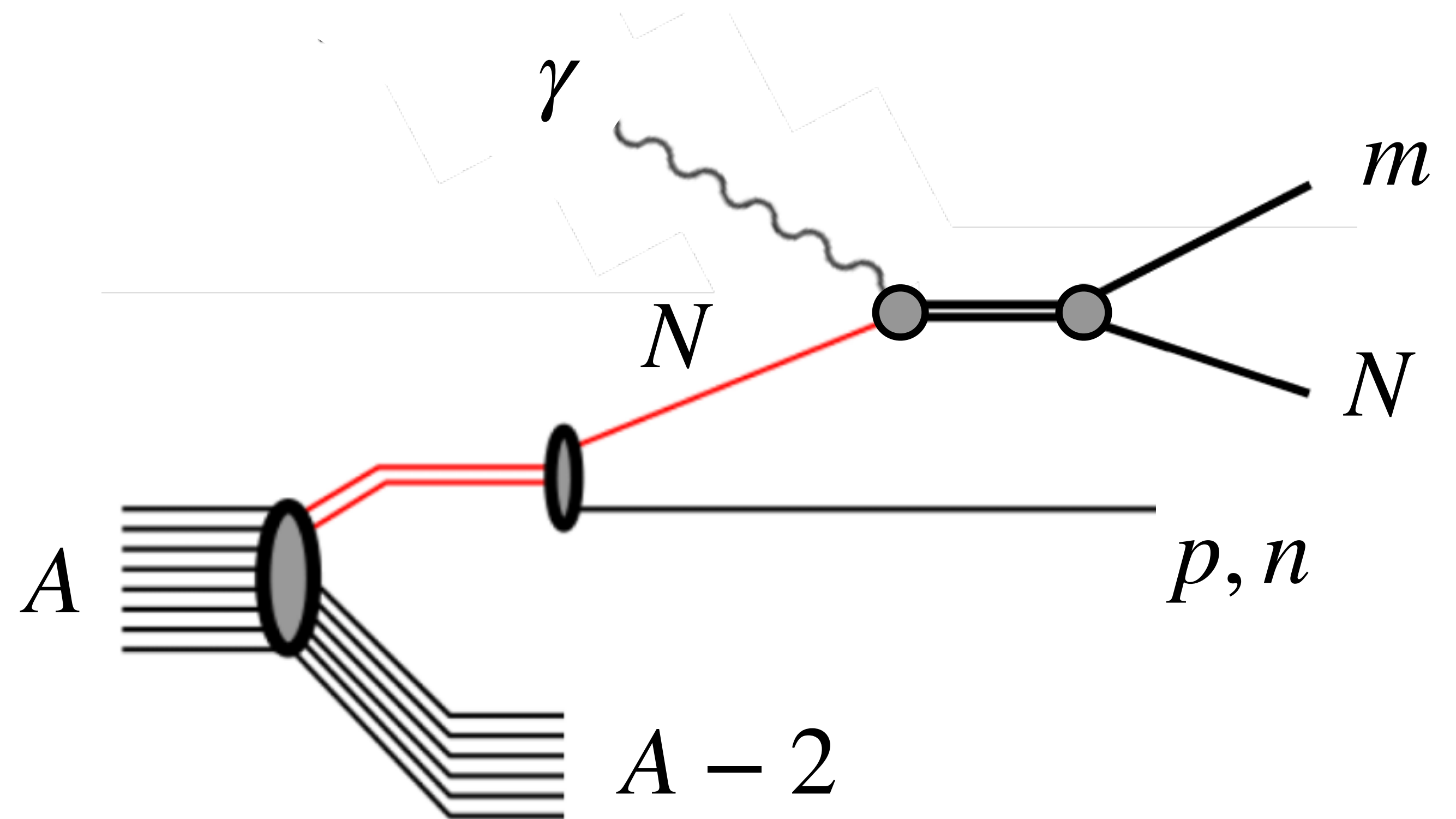


- At Jefferson Lab, Fall 2021
- 10.8 GeV e^- on diamond radiator
- E_γ from electron tagging
- GlueX spectrometer
- ^2H , ^4He , ^{12}C



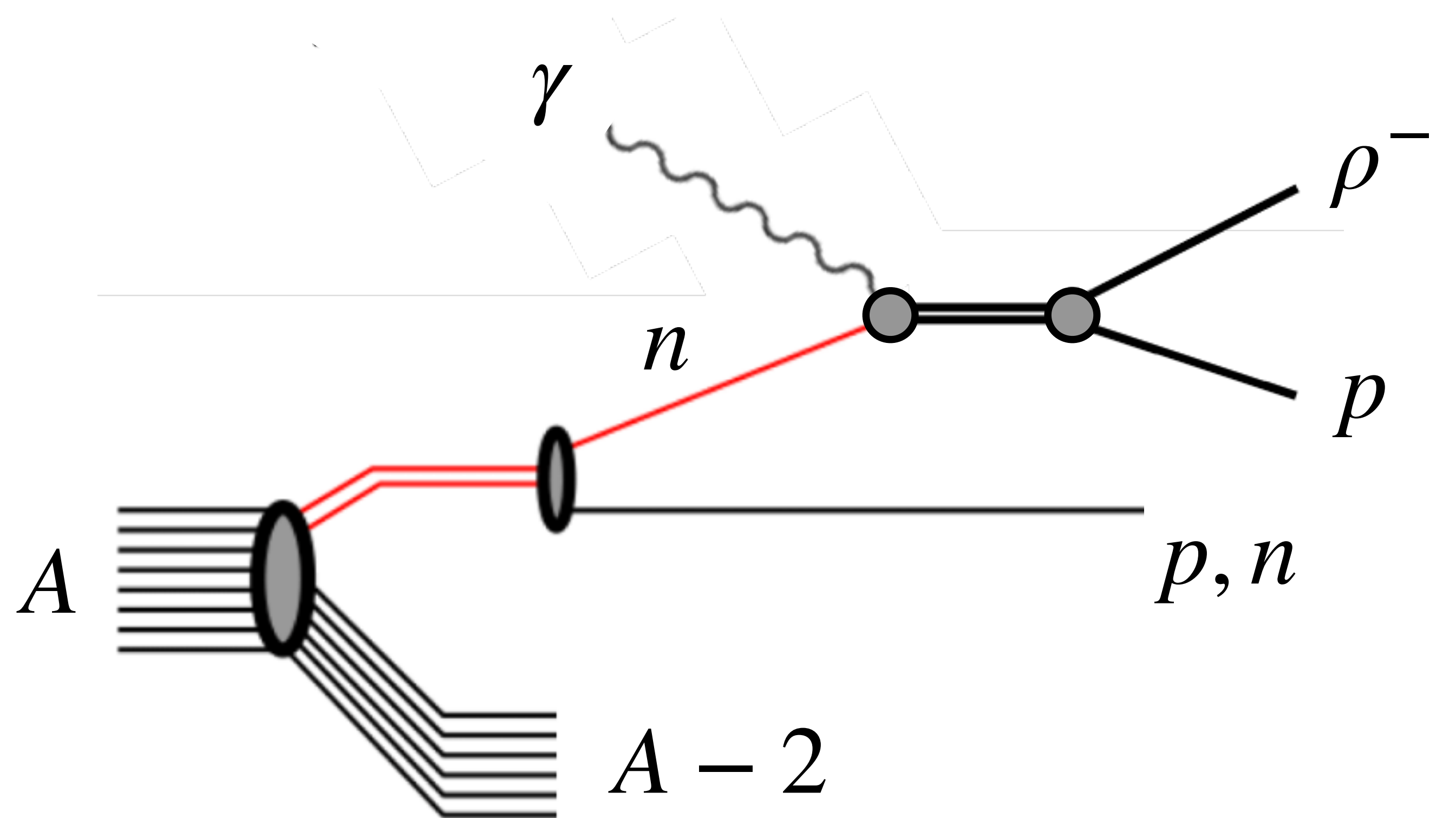
SRC Photoproduction in Hall D

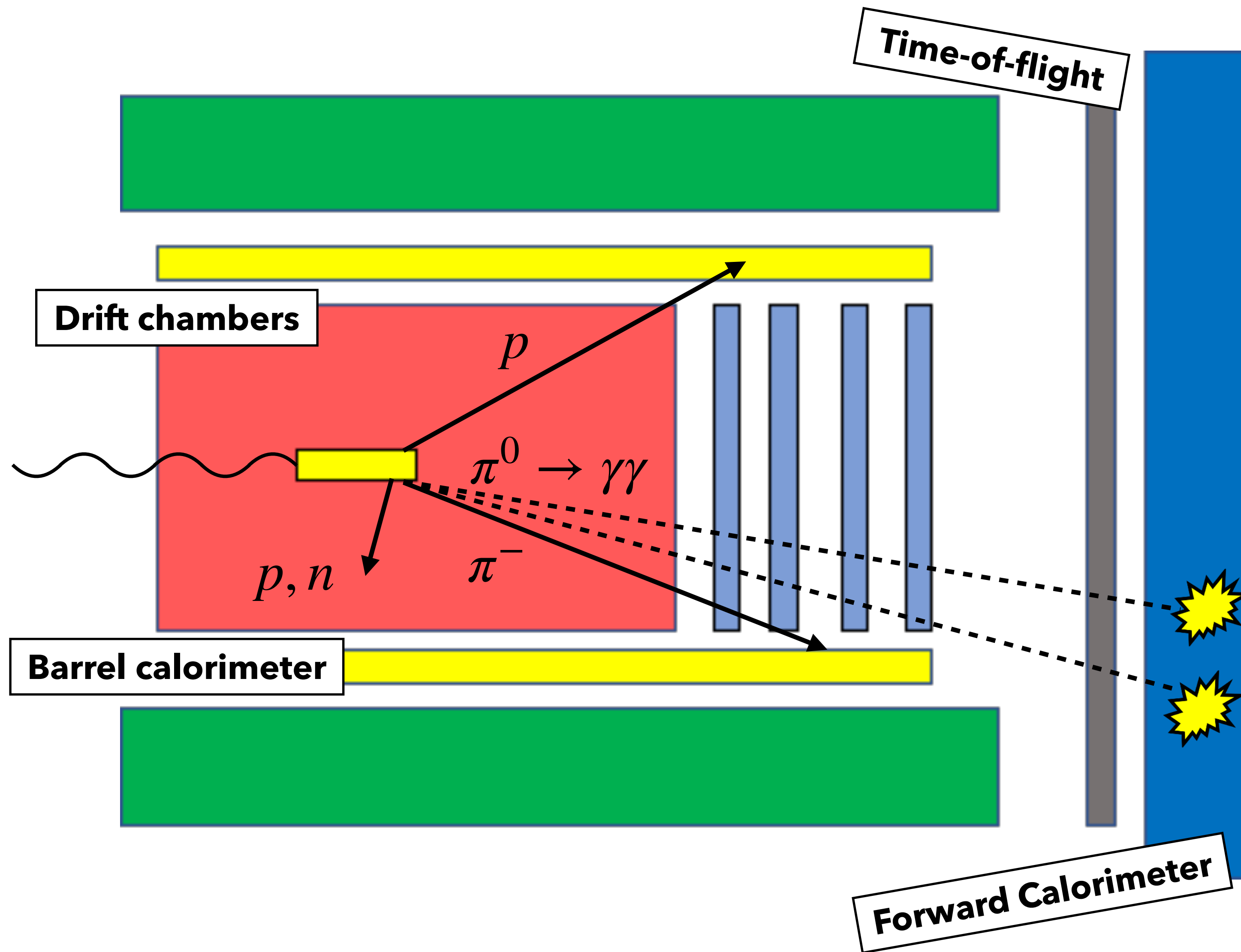
- Quasi-elastic photoproduction: hard photon-nucleon interaction



SRC Photoproduction in Hall D

- Quasi-elastic photoproduction: hard photon-nucleon interaction
- ρ^- photoproduction:
 - Initial-state neutron
 - Distinctive $\rho^- \rightarrow \pi^- \pi^0$ decay
- Measurements of $(\gamma, \rho^- p)$ and $(\gamma, \rho^- pp)$

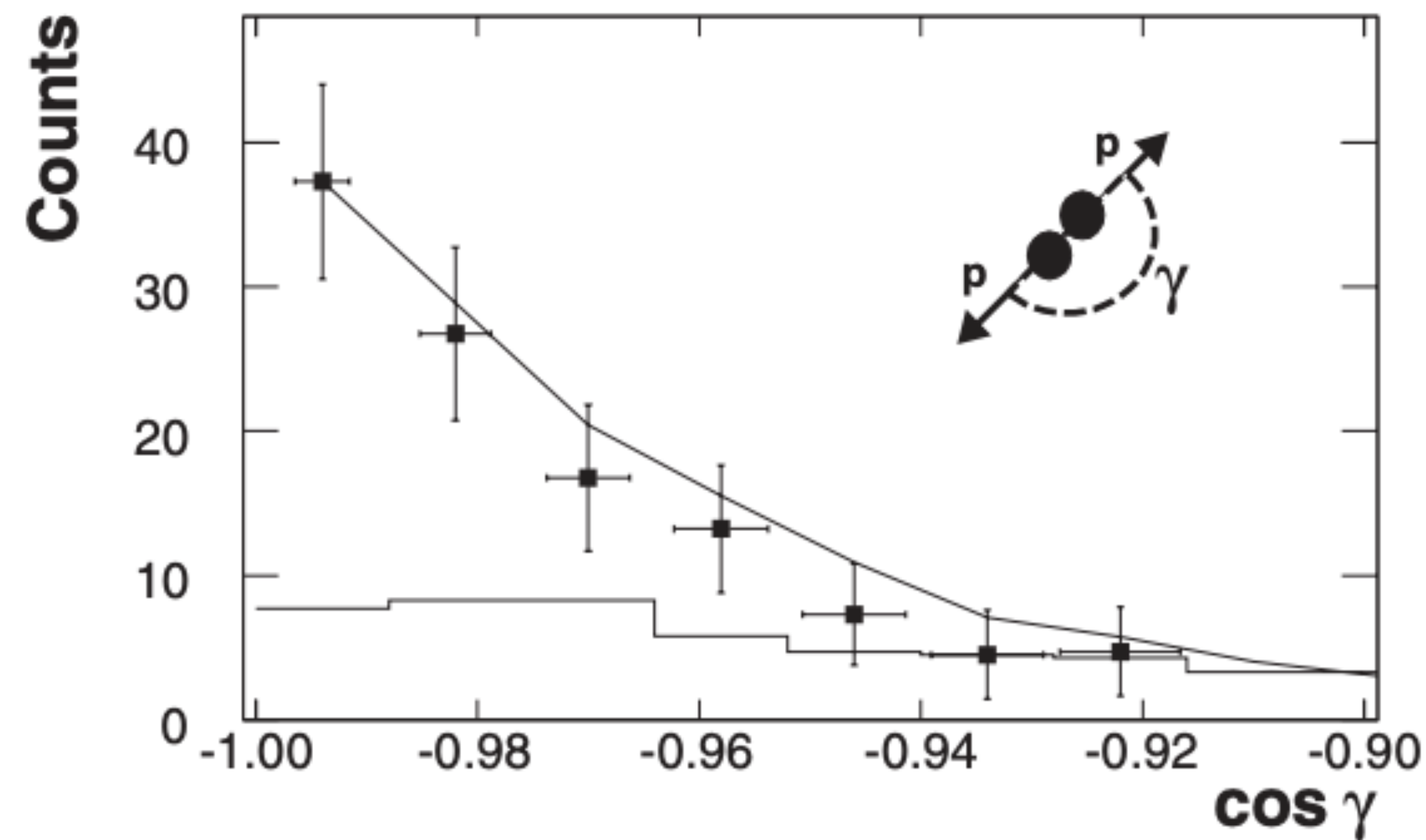




Also require:

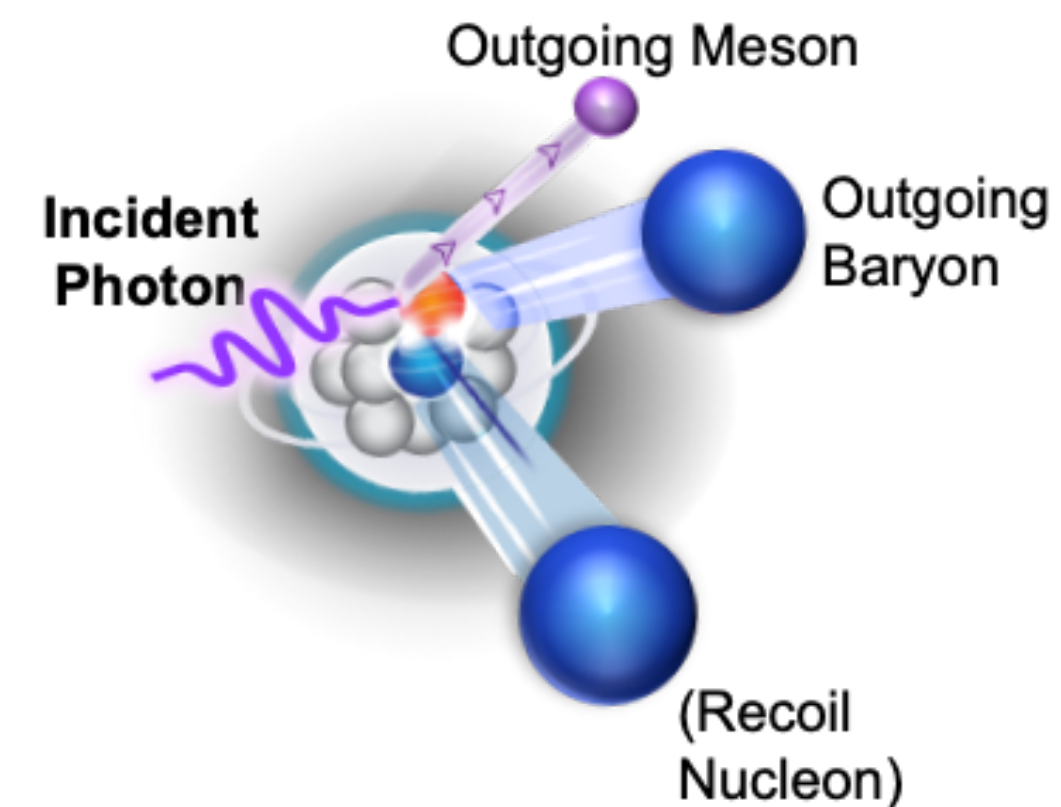
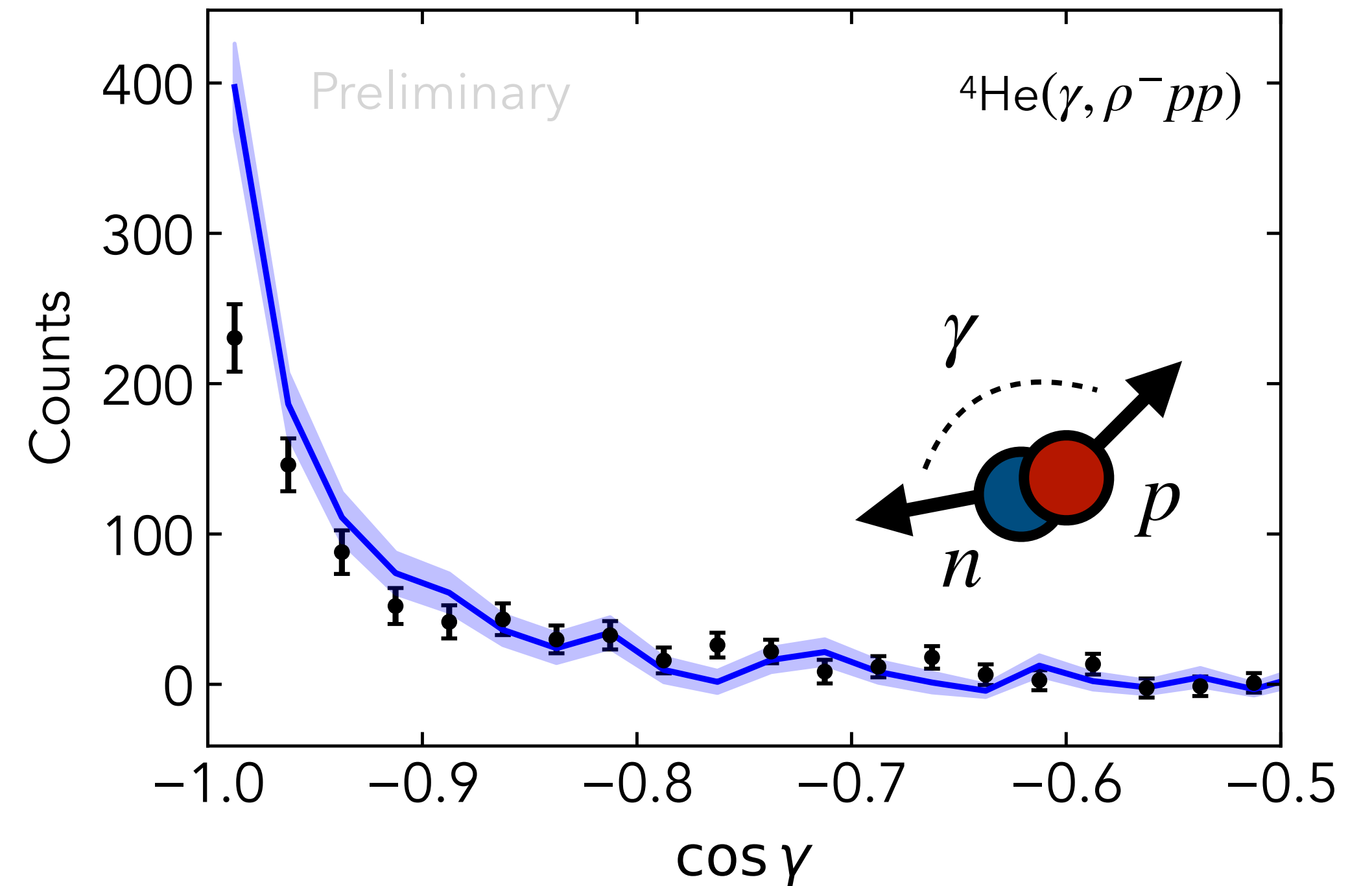
- Large momentum-transfer
 $|t|, |u| > 1.5 \text{ GeV}^2$
- Large nucleon momentum
 $k_{miss} > 400 \text{ MeV}/c$
- Removal of PID-related backgrounds

First observation of SRCs in photoproduction



PRL 2007

Back-to-back correlation in
 $(e, e'pp)$ @ Hall A



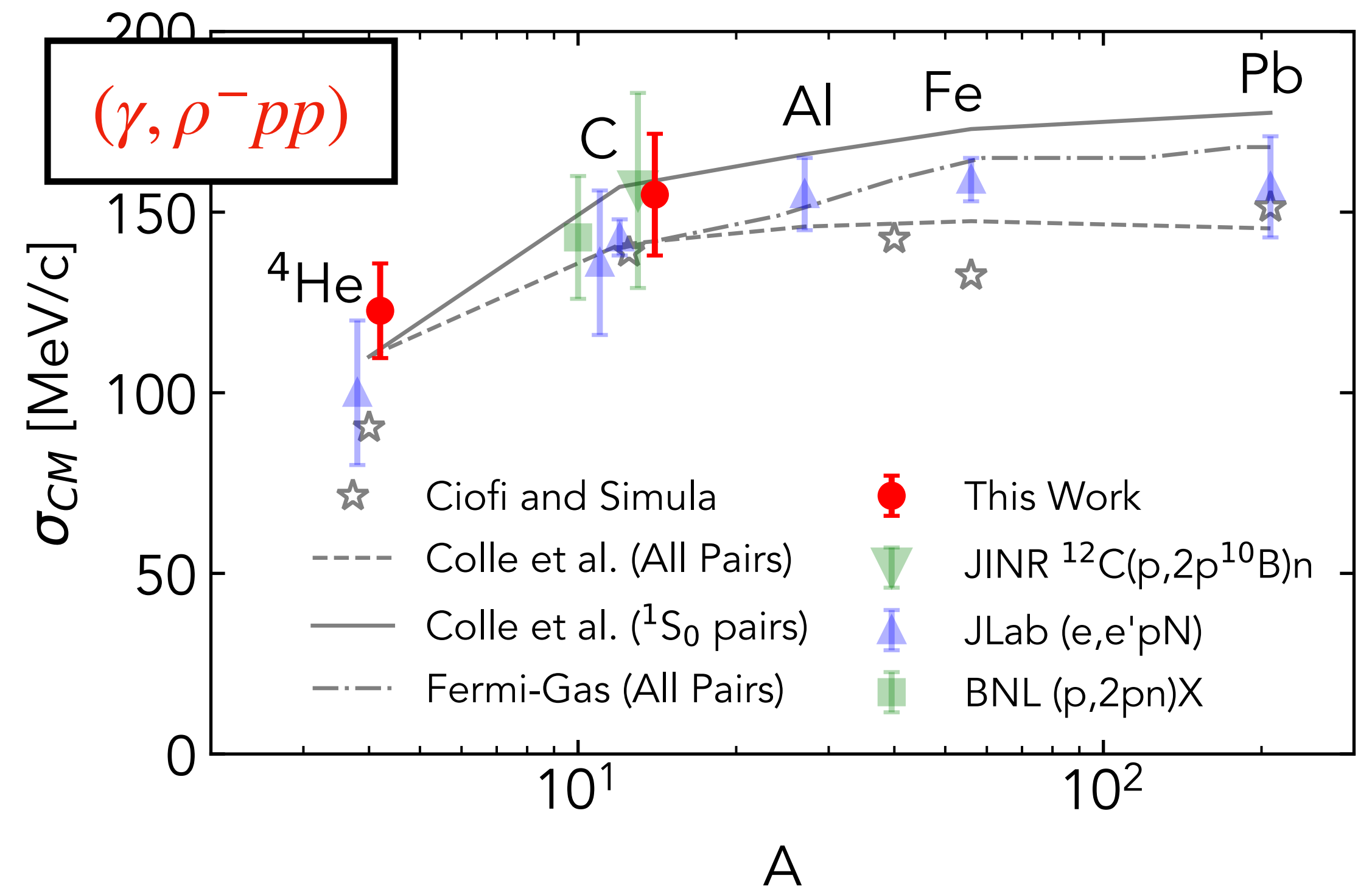
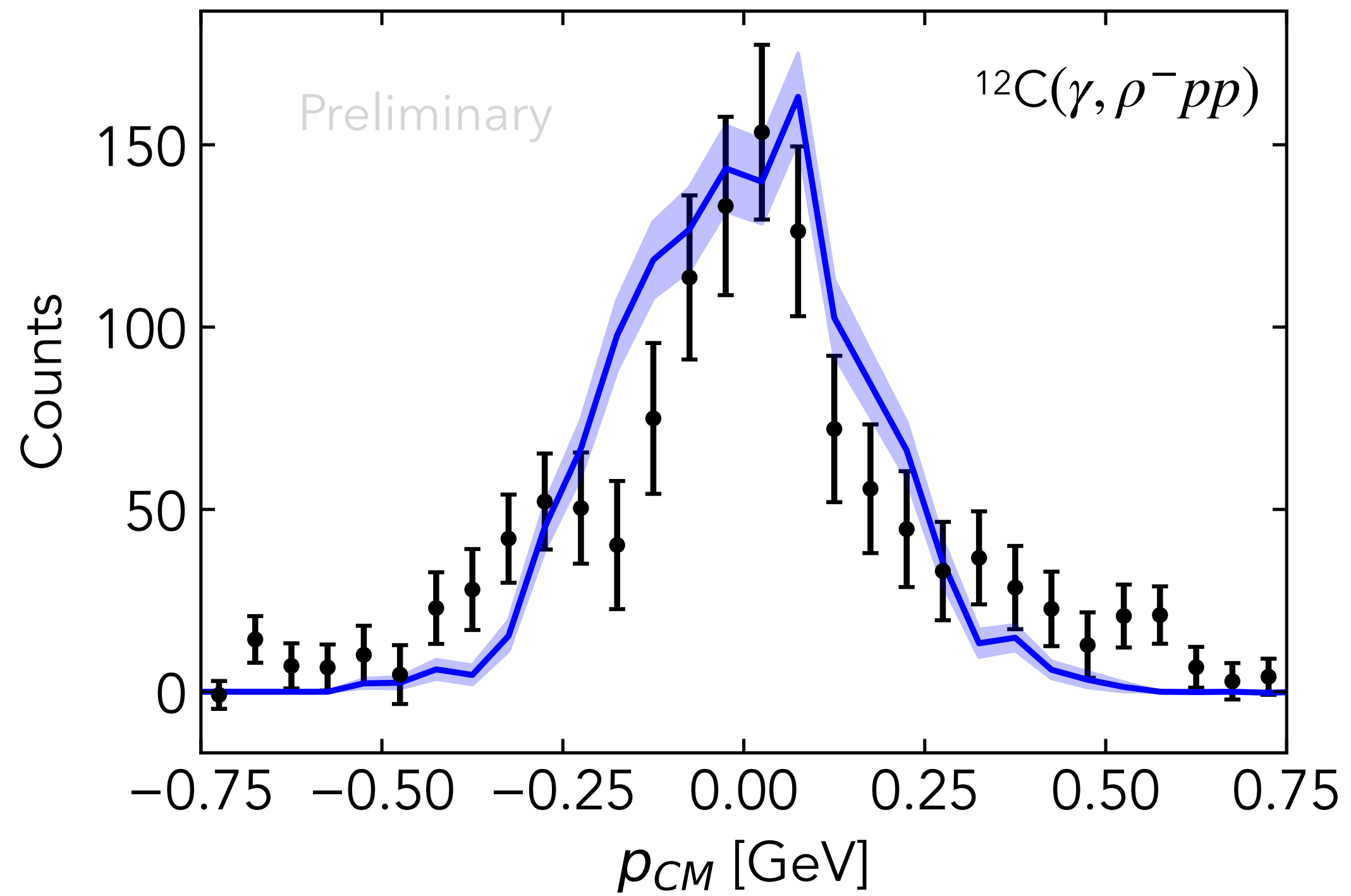
$\gamma np \rightarrow \rho^- pp$
 @ Hall D

SRC Center-of-Mass Motion

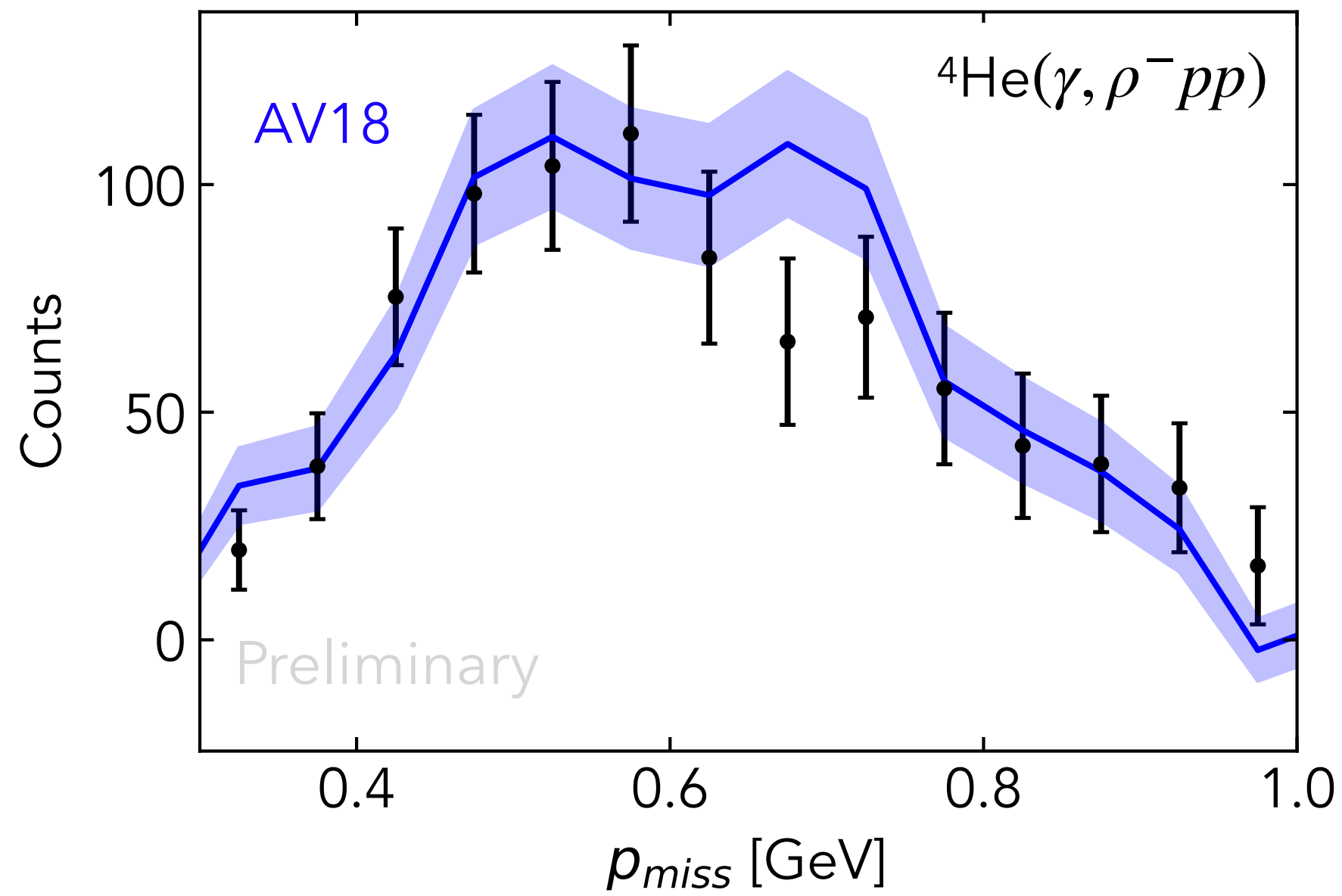
e^- : PRL (2018)

p : Nature Physics (2021)

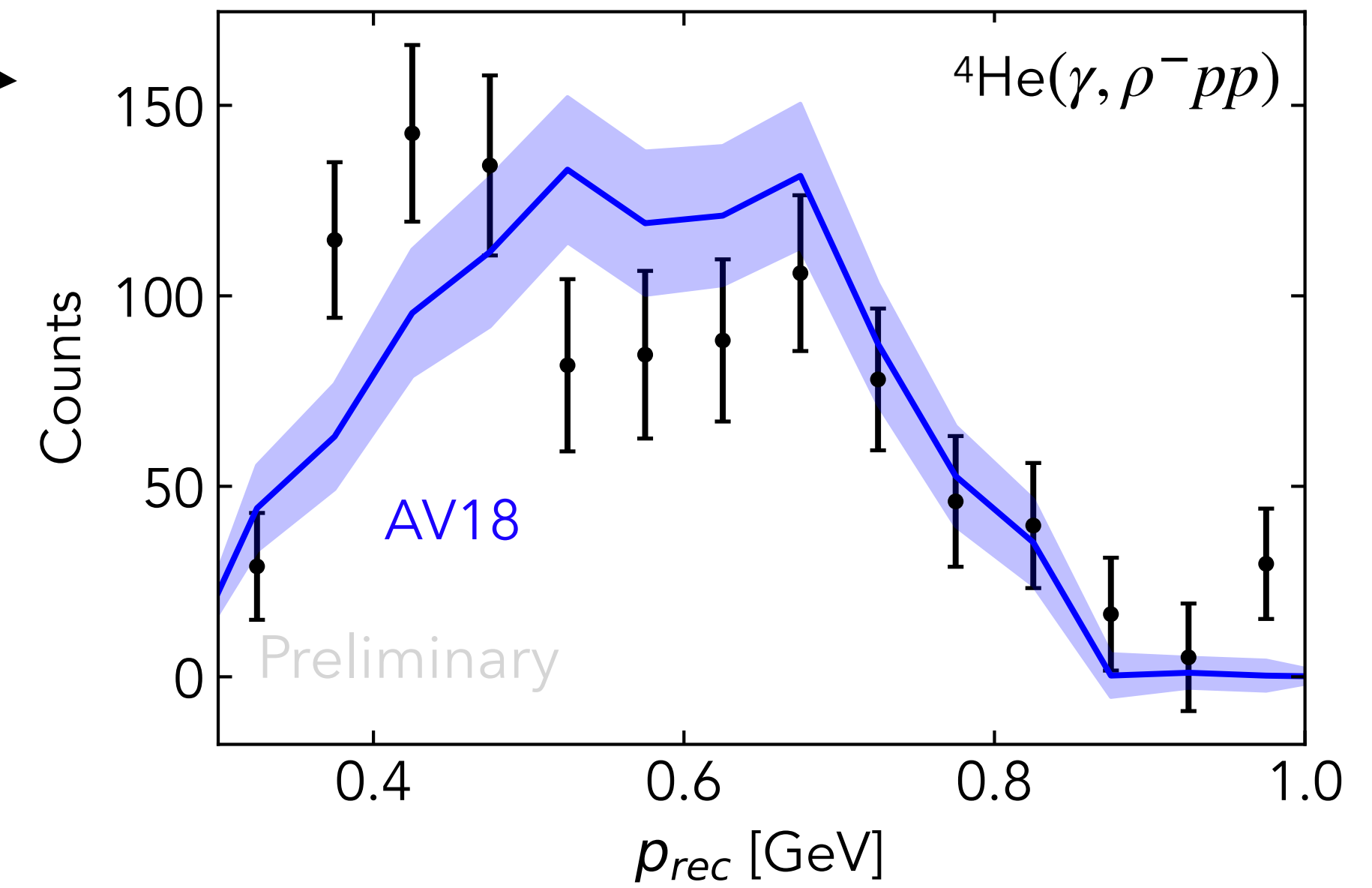
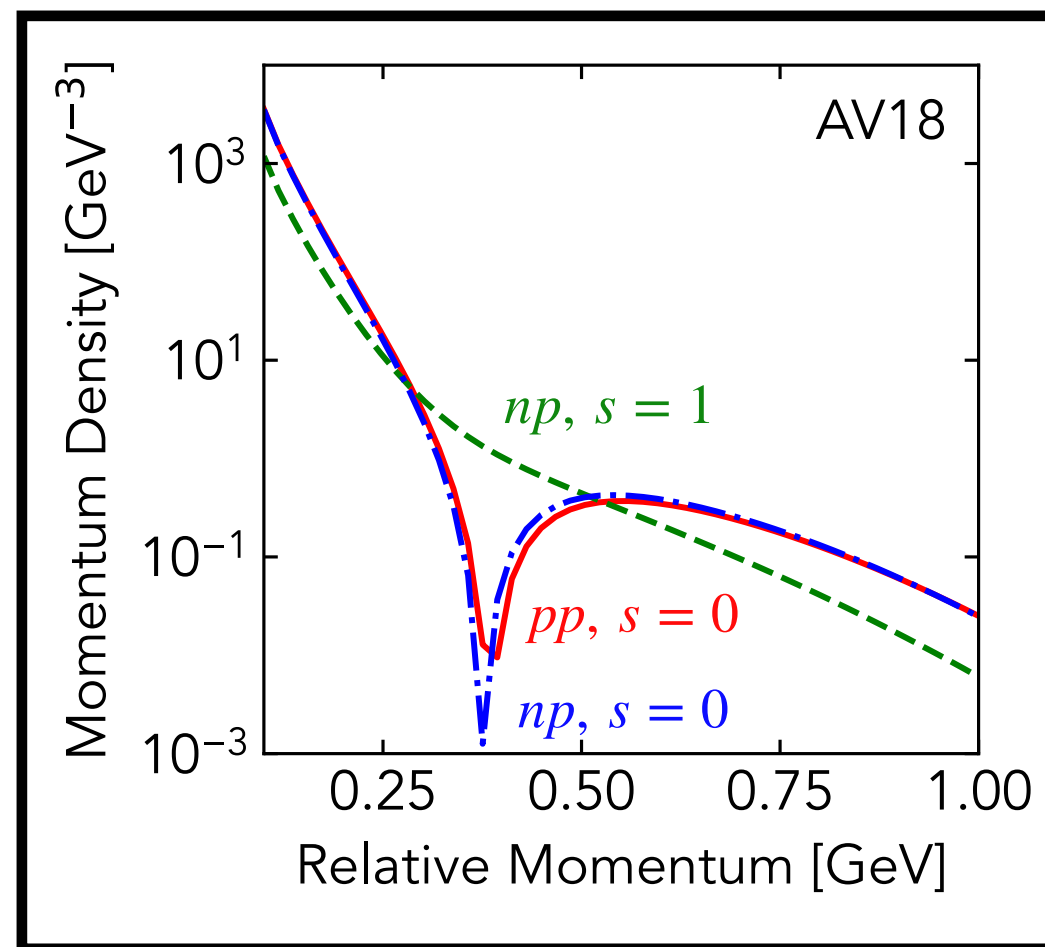
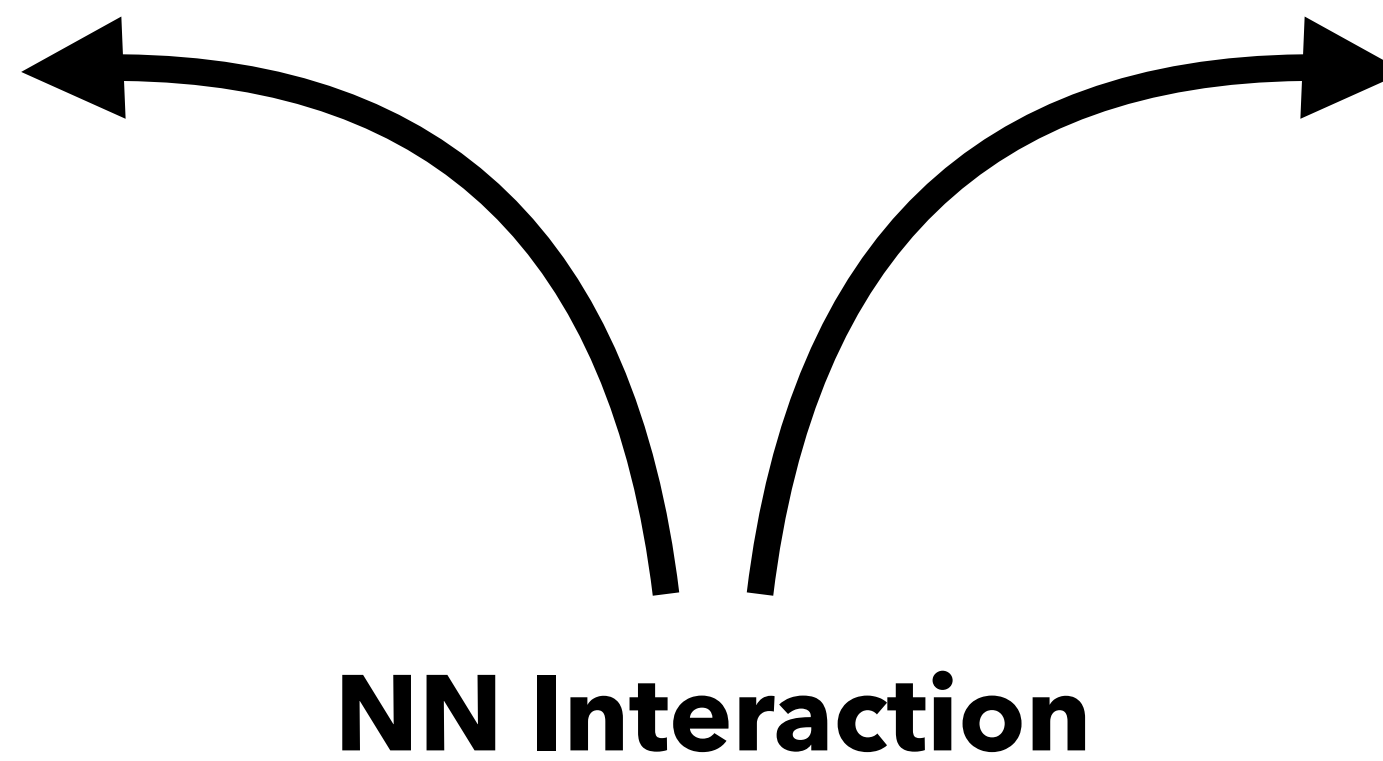
γ : SRC-CT (2024)



Data connect to ab-initio theory at high momentum

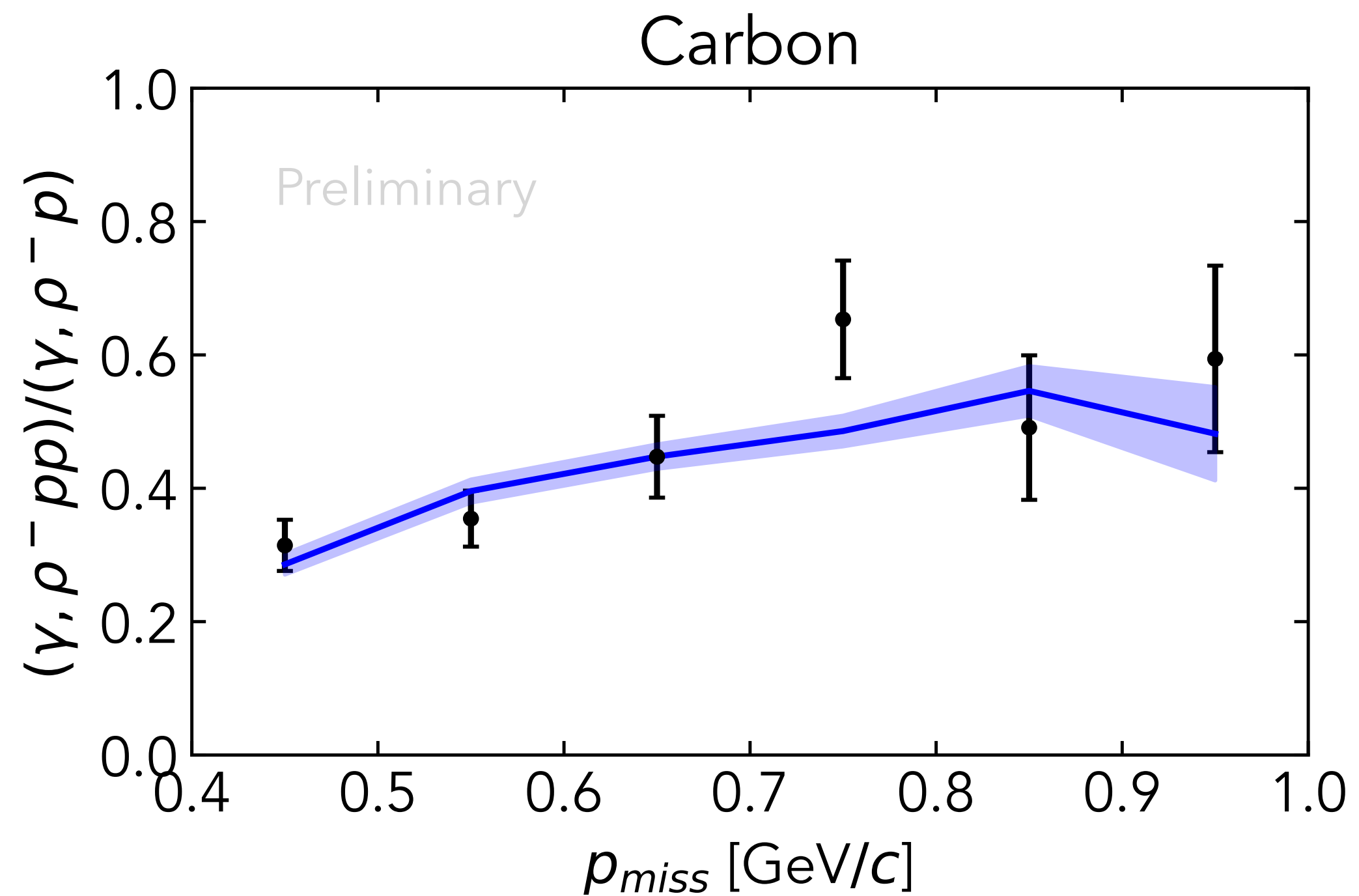


Initial neutron momentum
Inferred from momentum
conservation

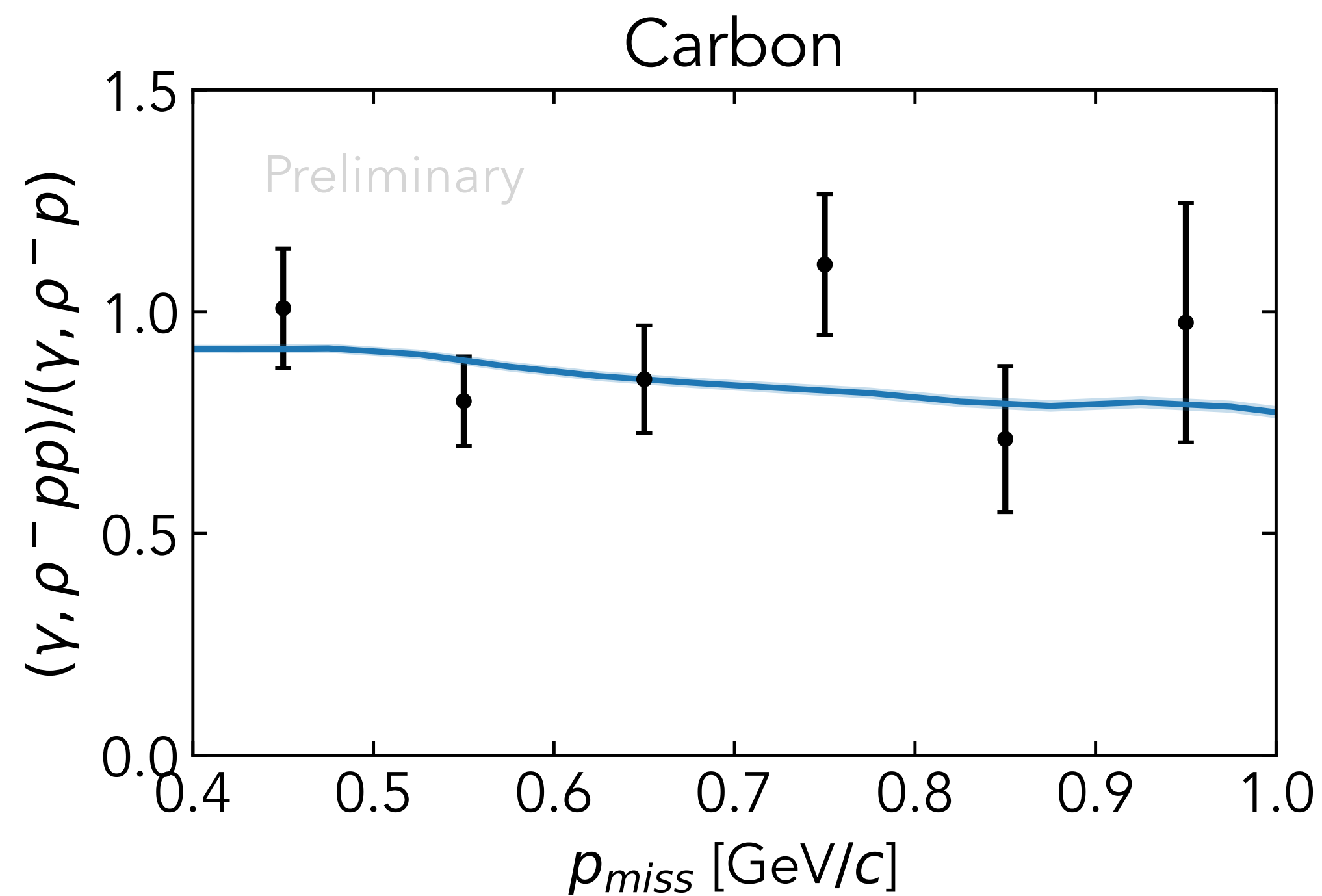
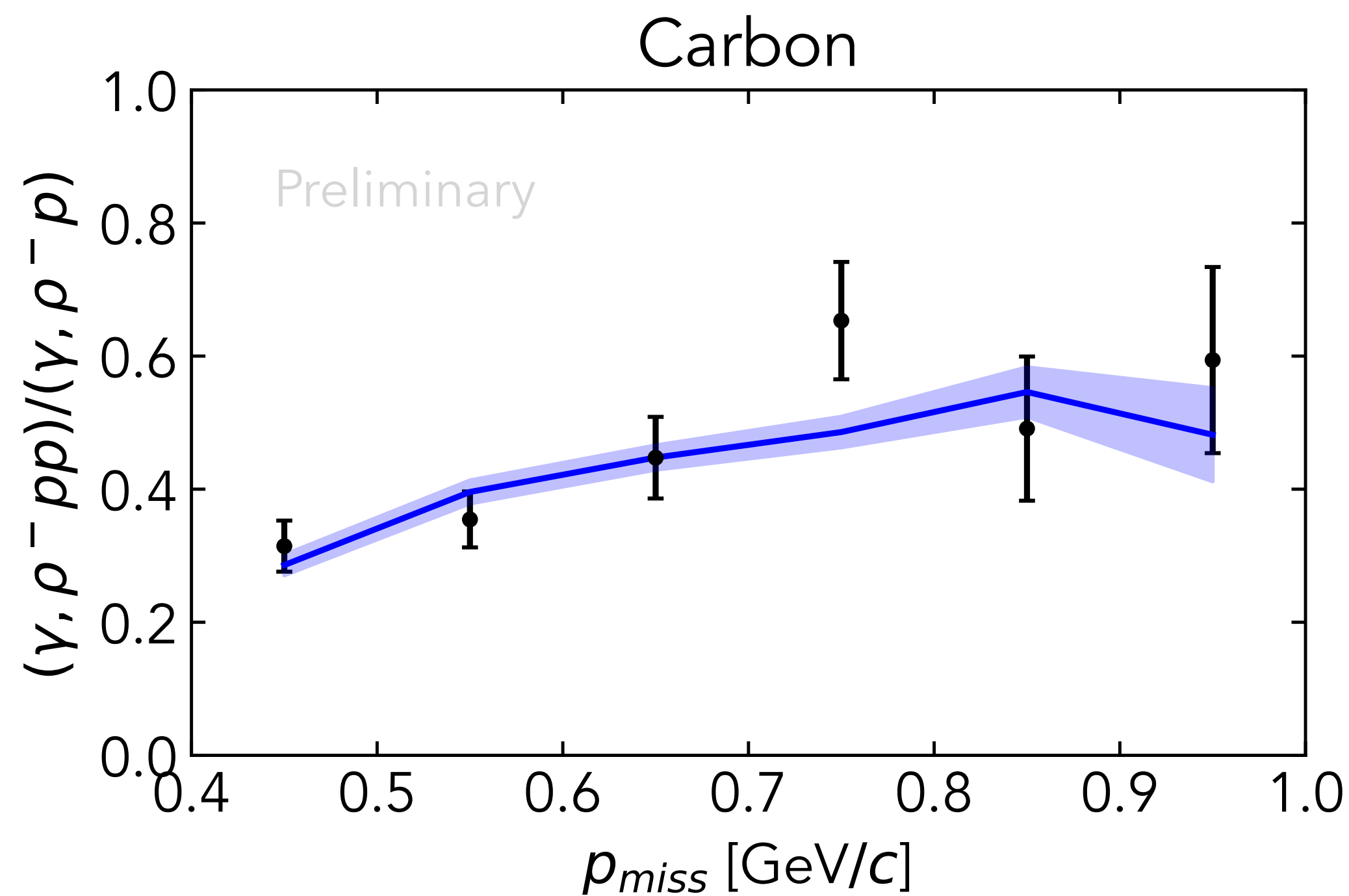


Initial recoil proton momentum
Directly measured

More interesting: How often do we have a recoil proton?

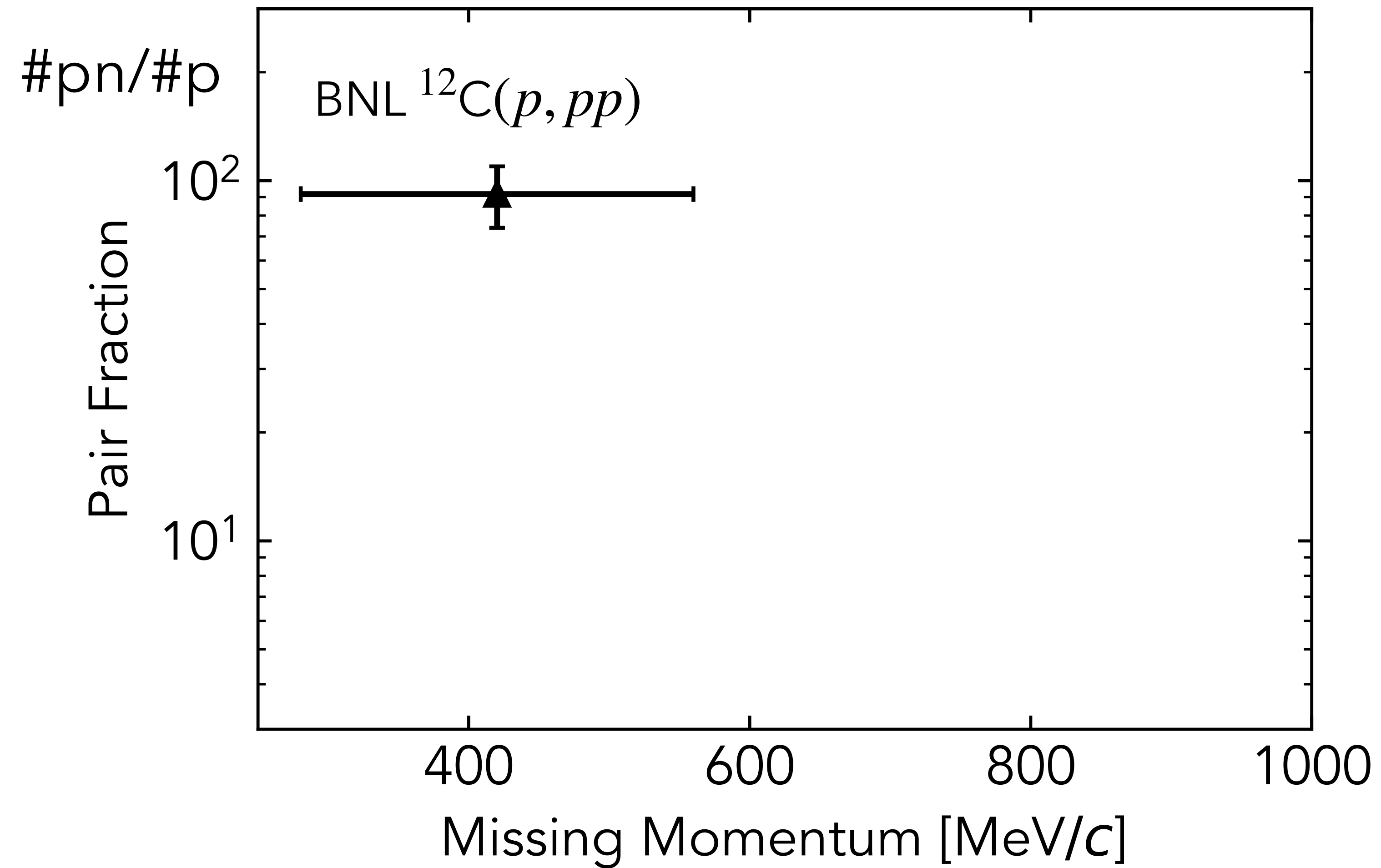


More interesting: How often do we have a recoil proton?

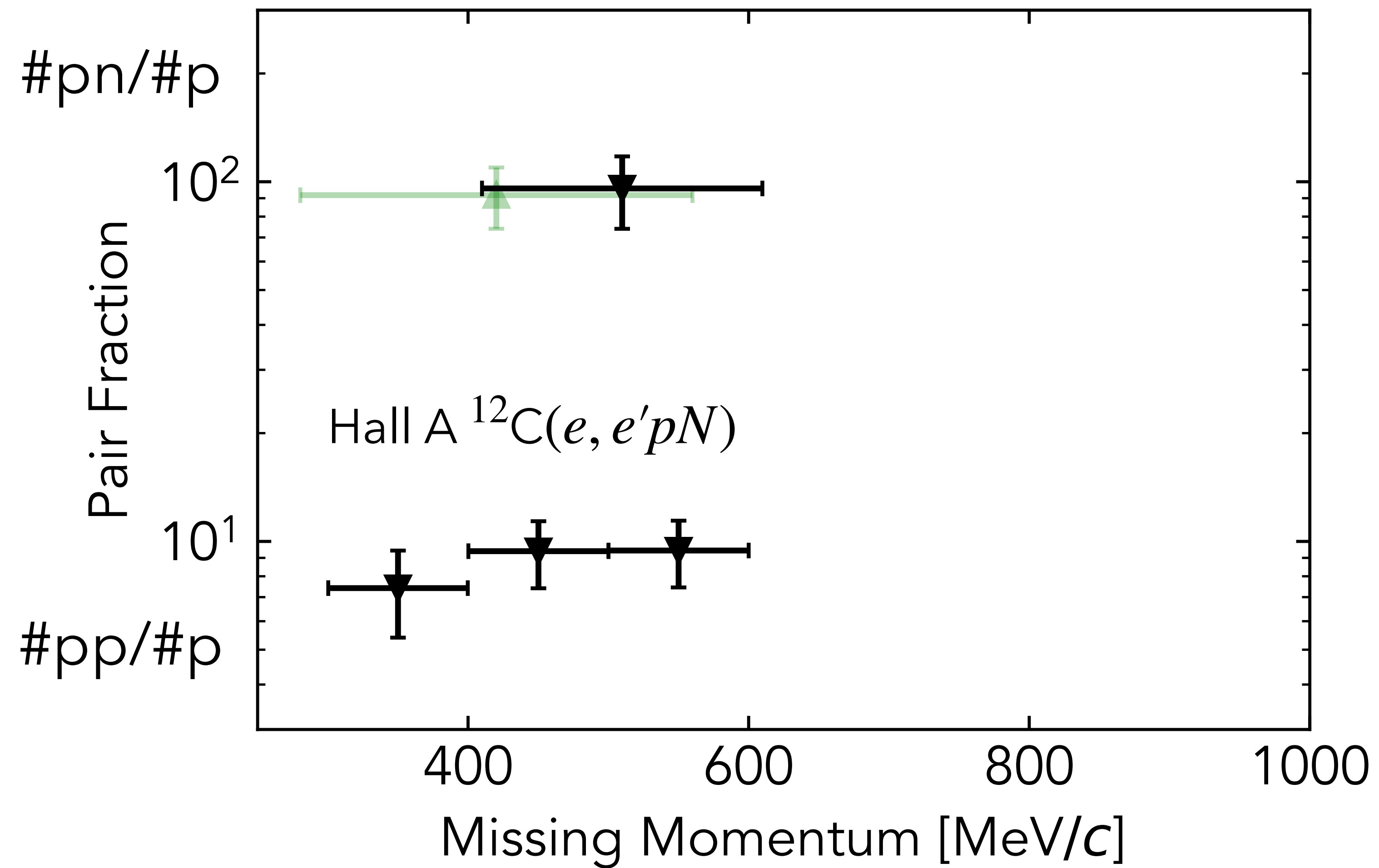


Acceptance corrections

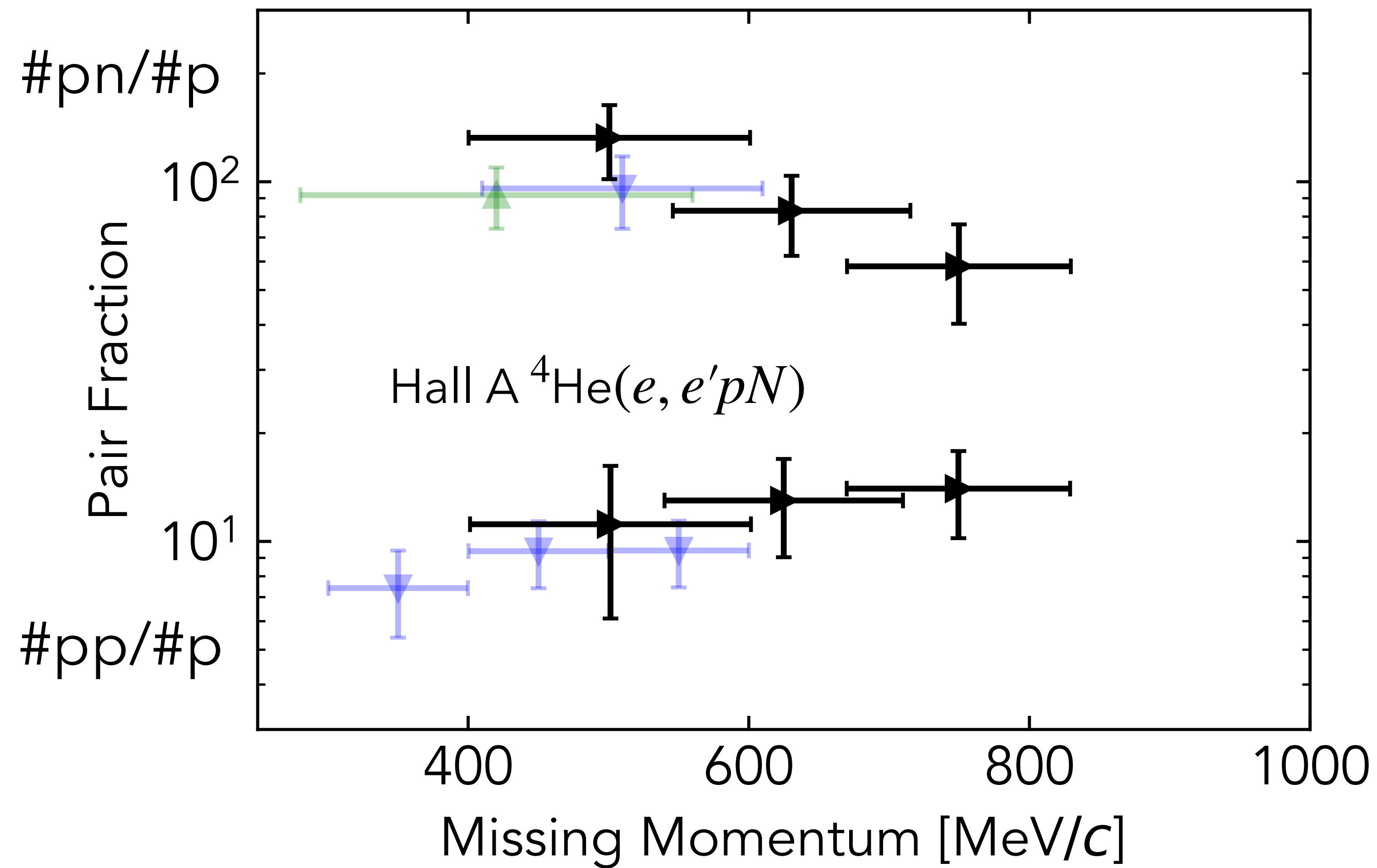
Where do we fit in?



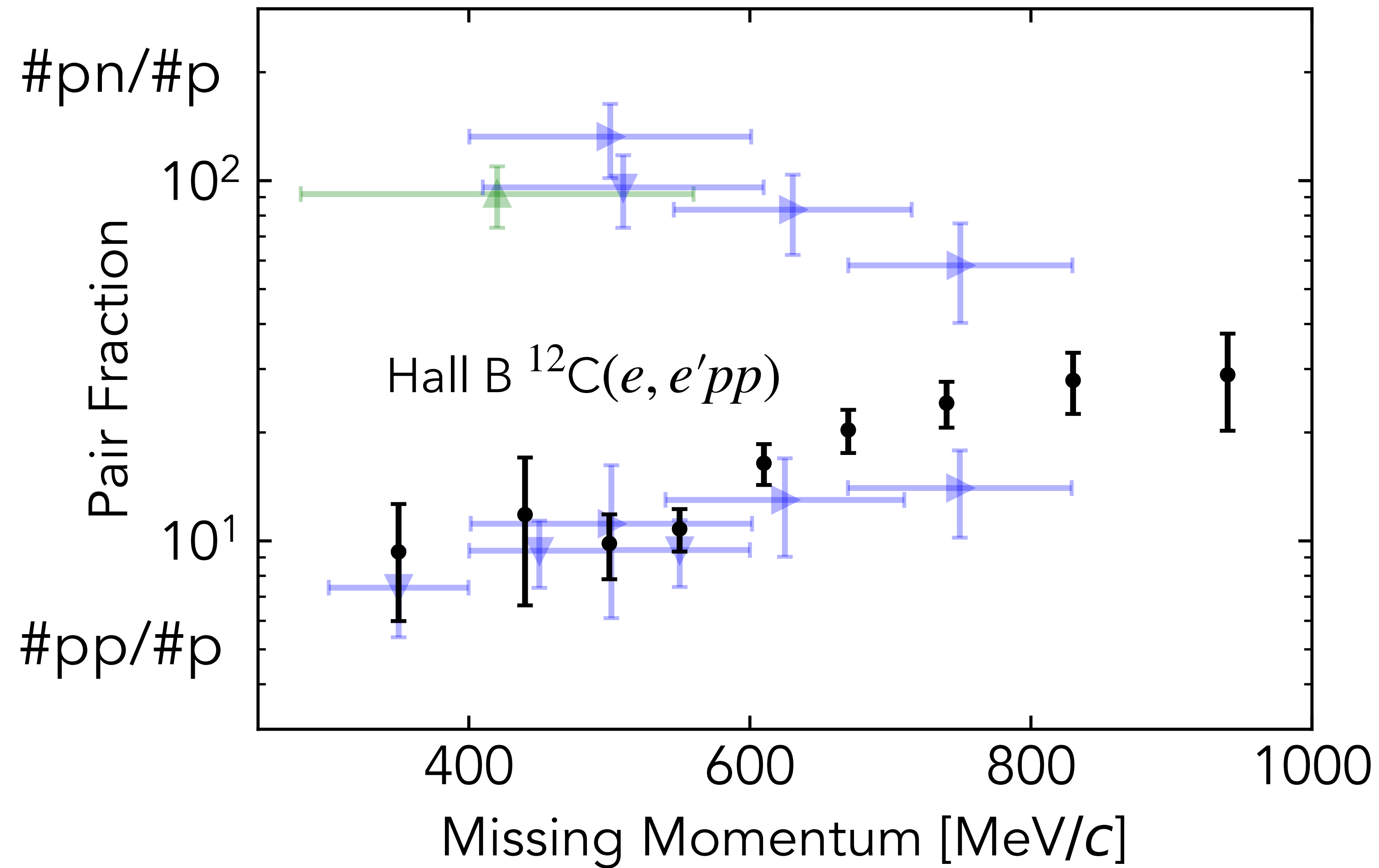
Where do we fit in?



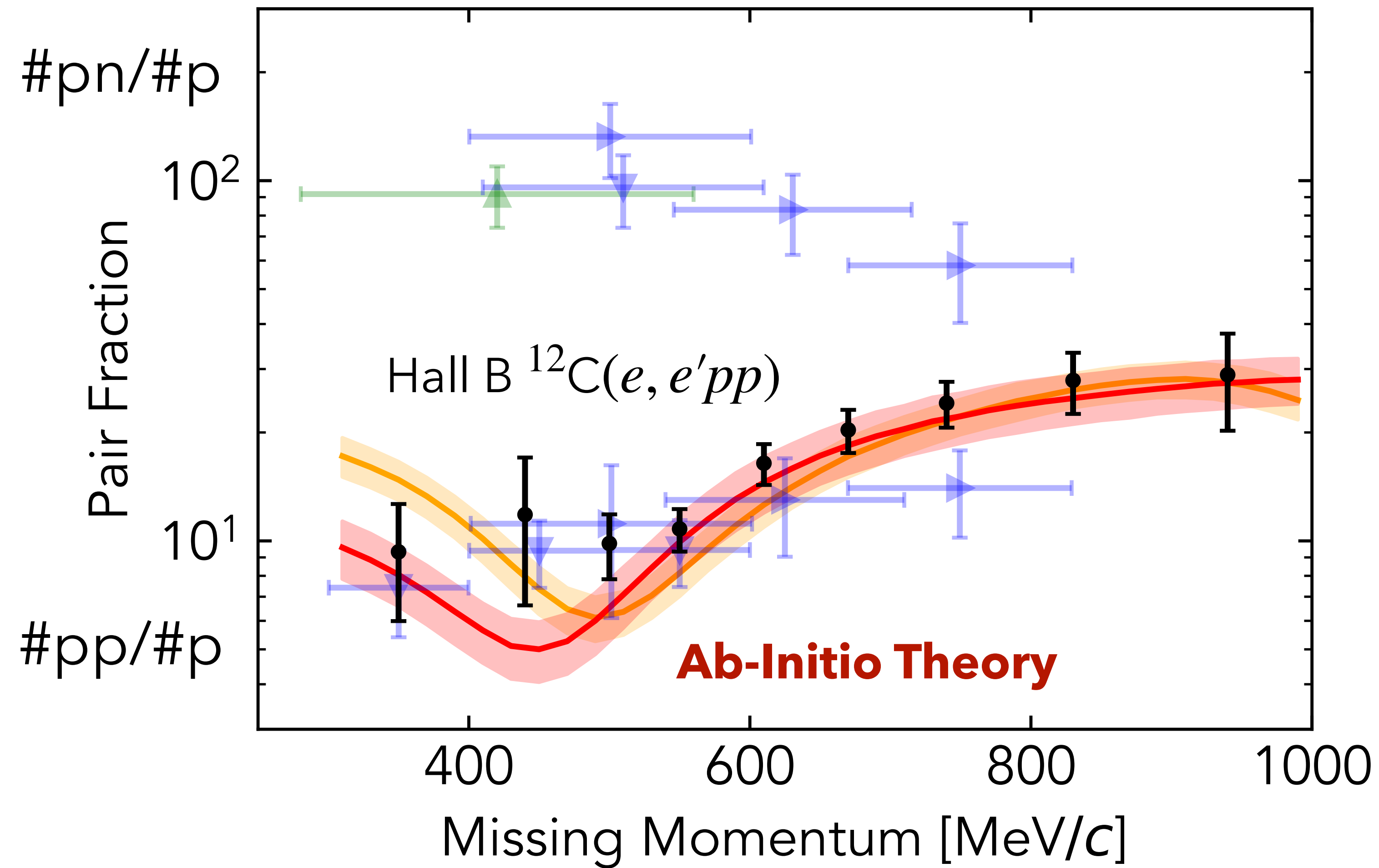
Where do we fit in?



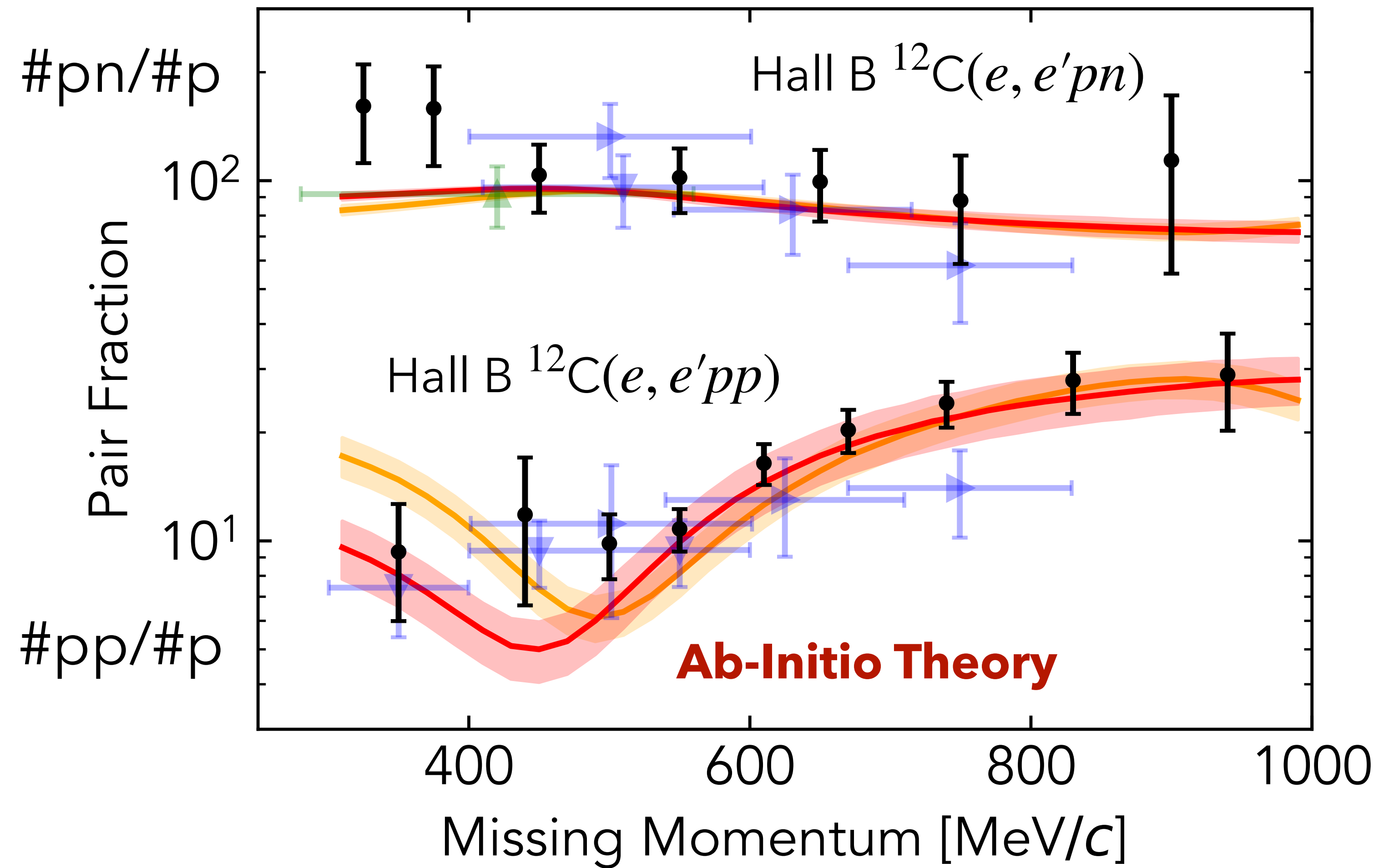
Where do we fit in?



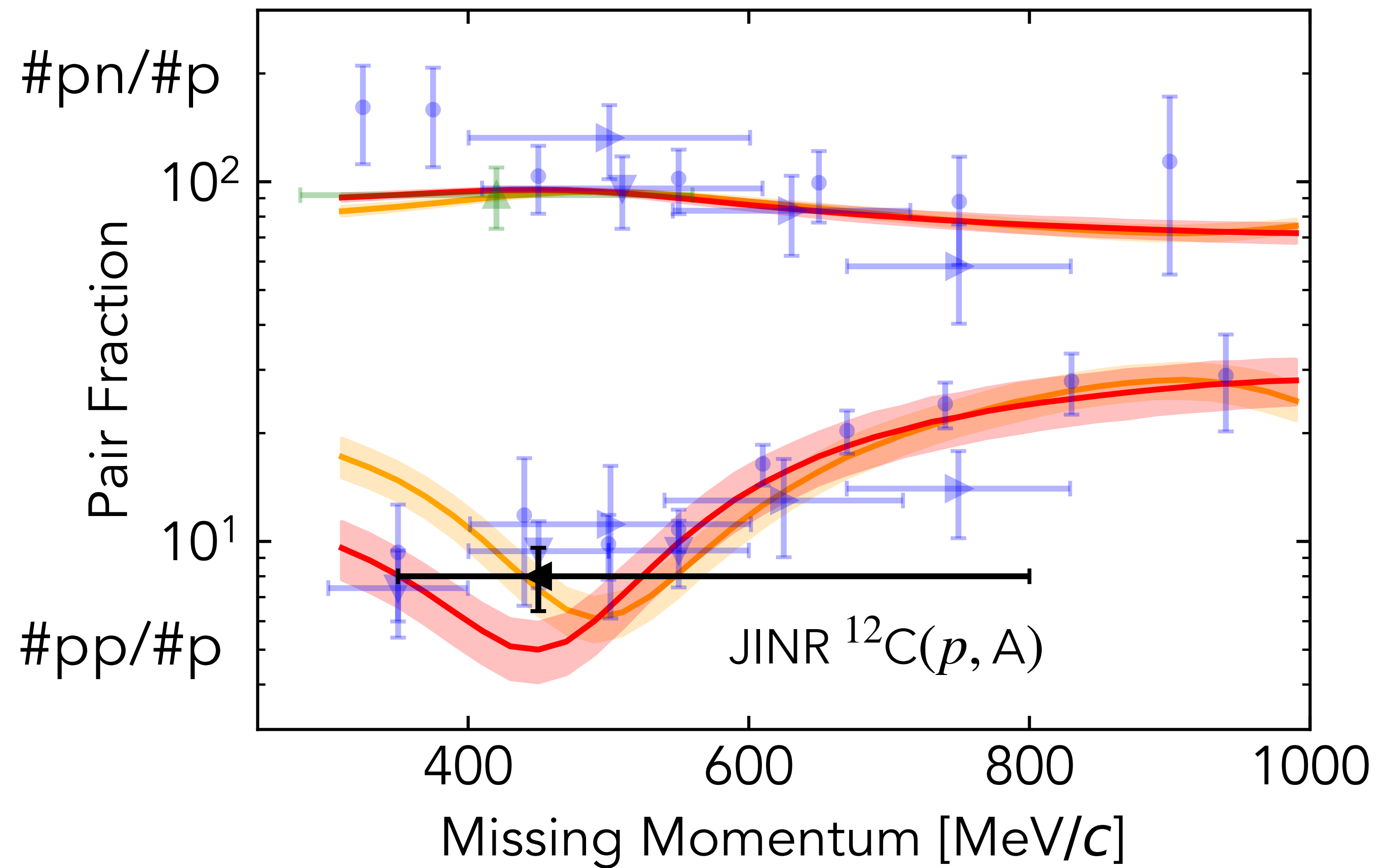
Where do we fit in?



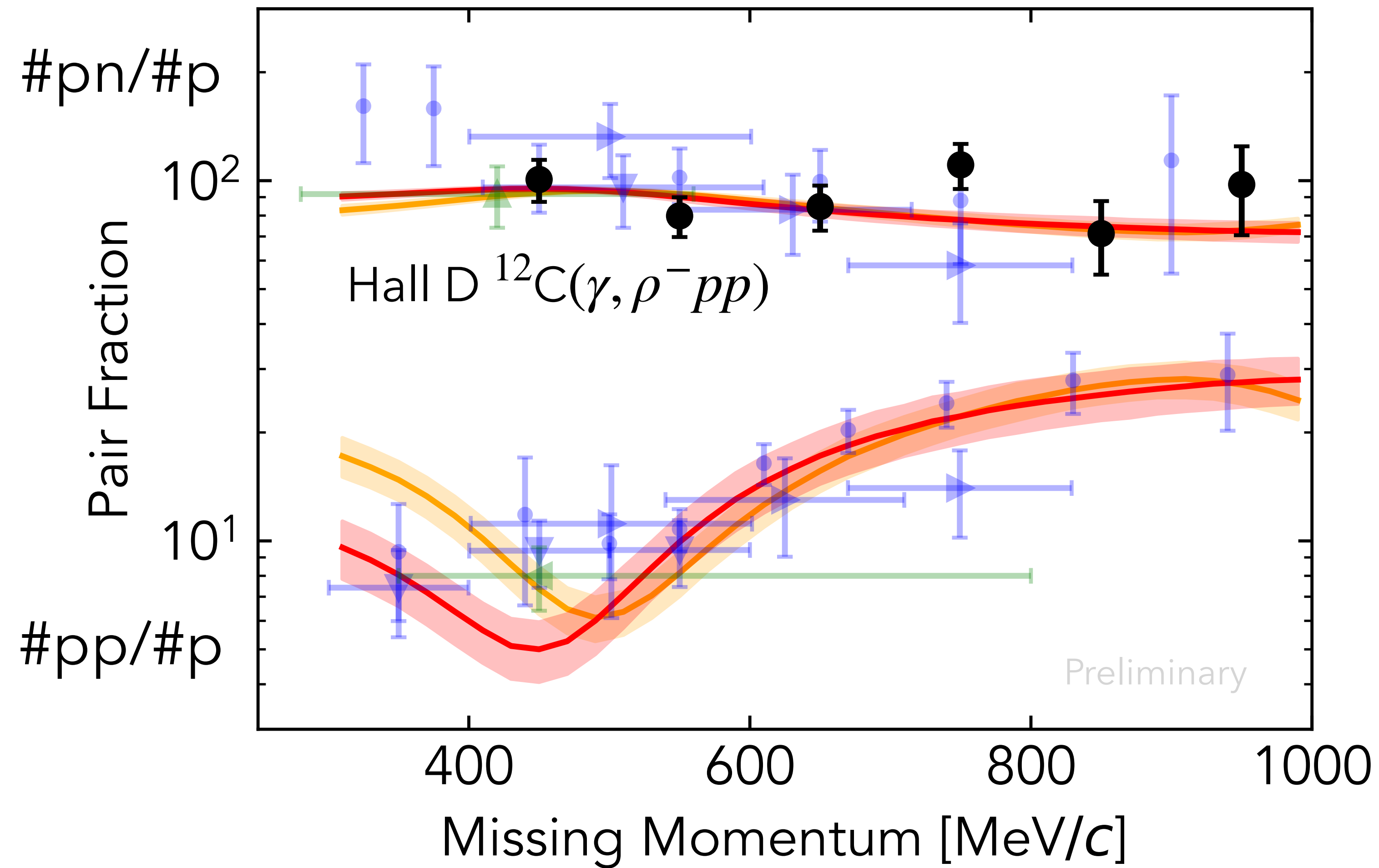
Where do we fit in?



Where do we fit in?



Where do we fit in?



Conclusions

- First observation of Short-Range Correlations using photoproduction
- Ab-initio calculations describe photoproduction data well
- Consistency with electron, hadron scattering point to consistent, **universal** picture of SRCs

