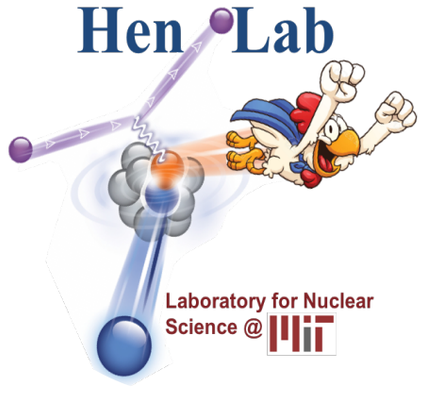
Hall C outlook:
LAD (E12-11-107)

Tyler Kutz
GW/MIT

Hall C User's Meeting
January 29, 2021

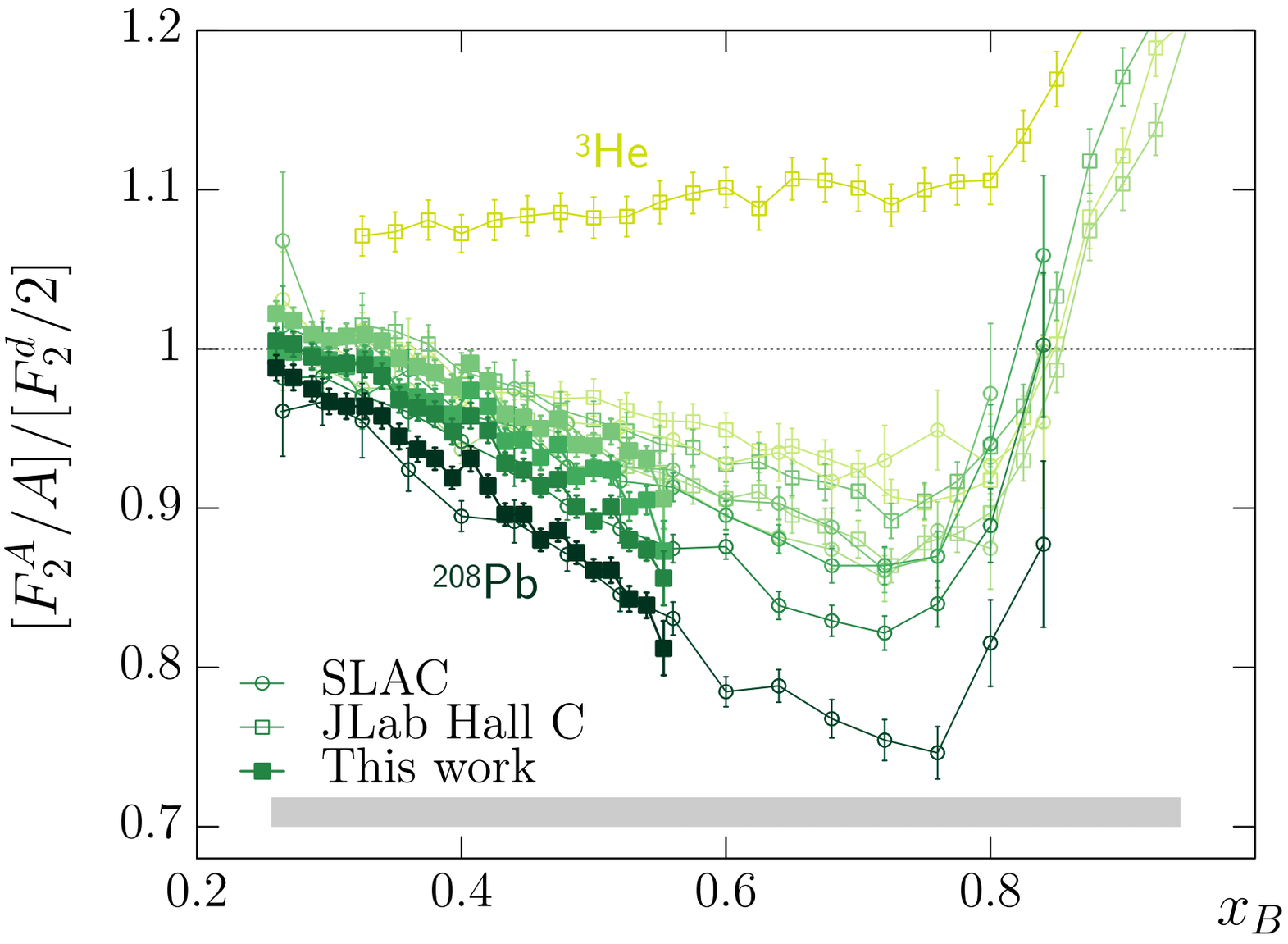


Summary

- Physics motivation
- Experimental overview
- Status

Protons and neutrons are modified in the nucleus

- EMC effect: $F_2^A \neq ZF_2^p + NF_2^n$
- Effect stronger than "known" nuclear effects (Fermi motion, binding...)
- Nucleon structure is modified

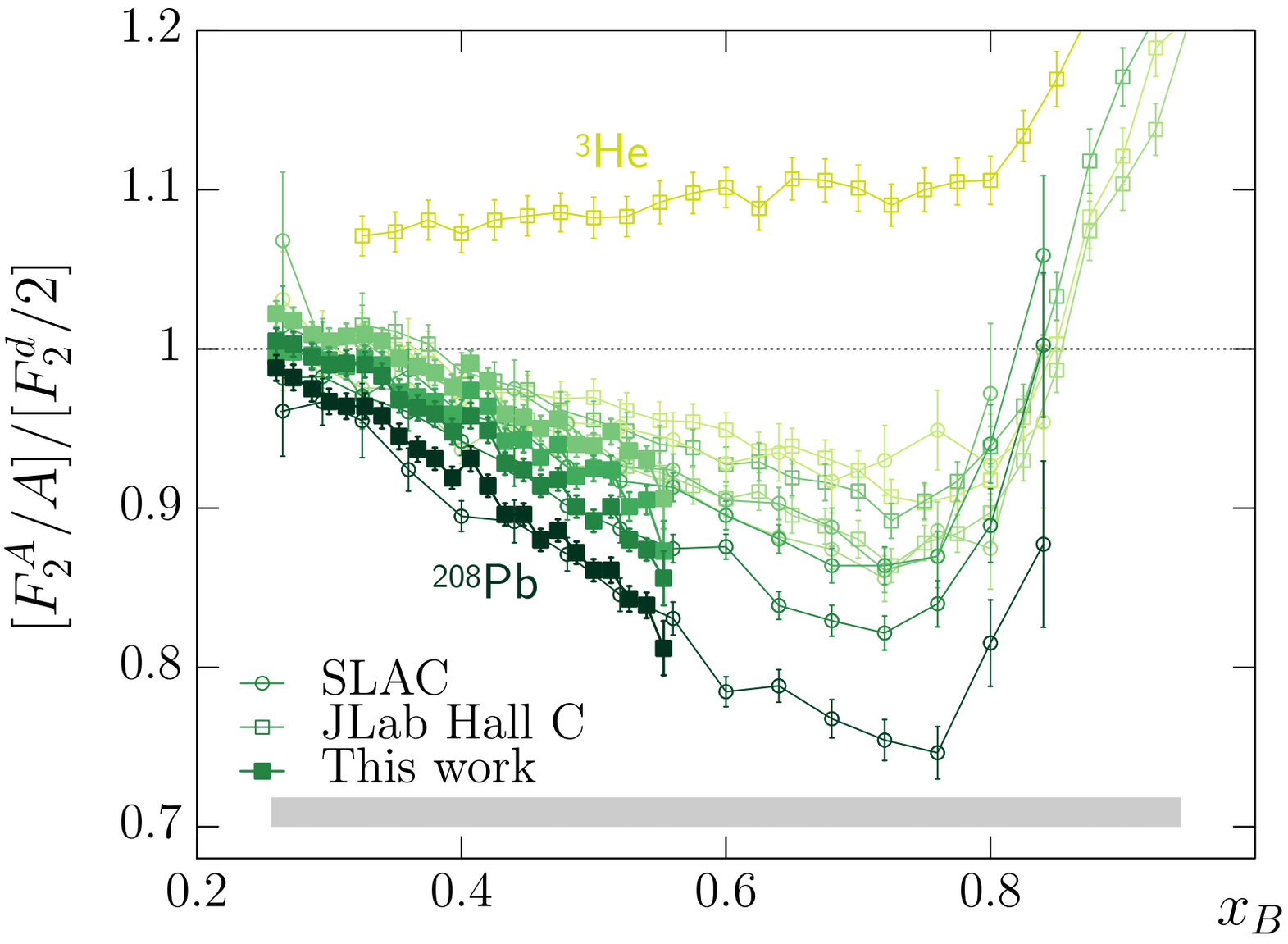


B. Schmookler et al., Nature 566, 354 (2019)

Protons and neutrons are modified in the nucleus

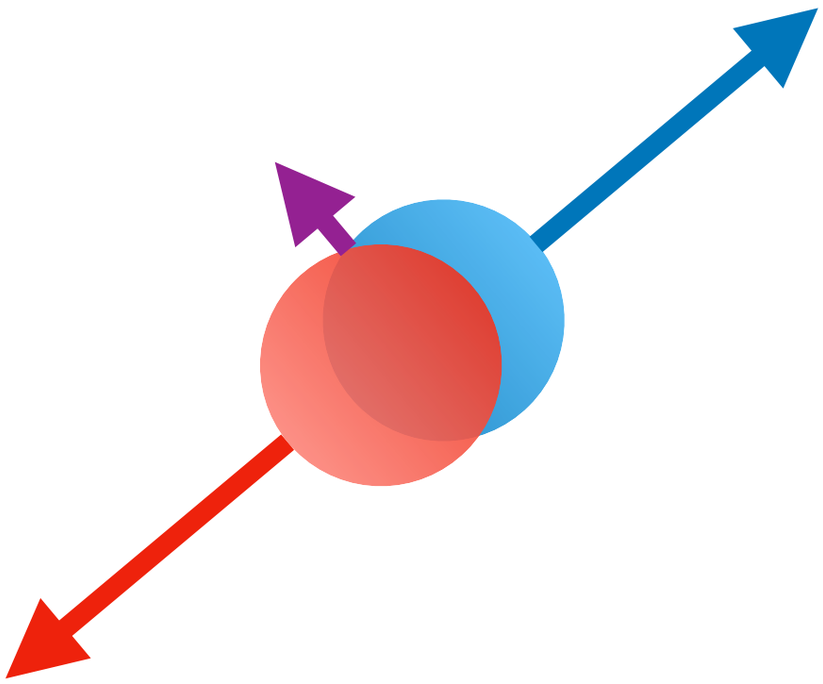
Are *all* nucleons *slightly* modified?

Or are a *few* nucleons *highly* modified?



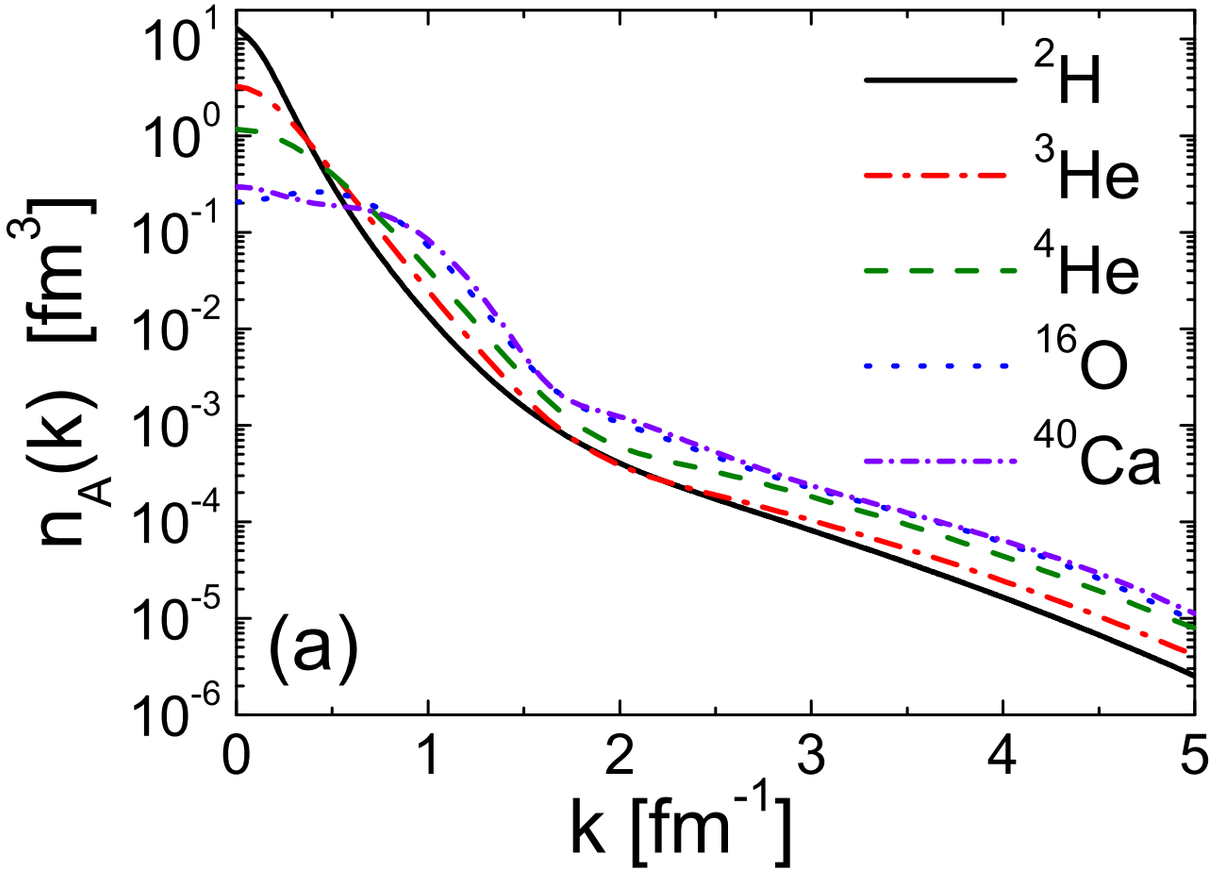
B. Schmookler et al., Nature 566, 354 (2019)

SRCs lead to high-momentum scaling



Short-range correlations:

- Separation $\lesssim$ radius
- Large relative, small center of mass momentum (relative to k_F)
- 90% neutron-proton pairs

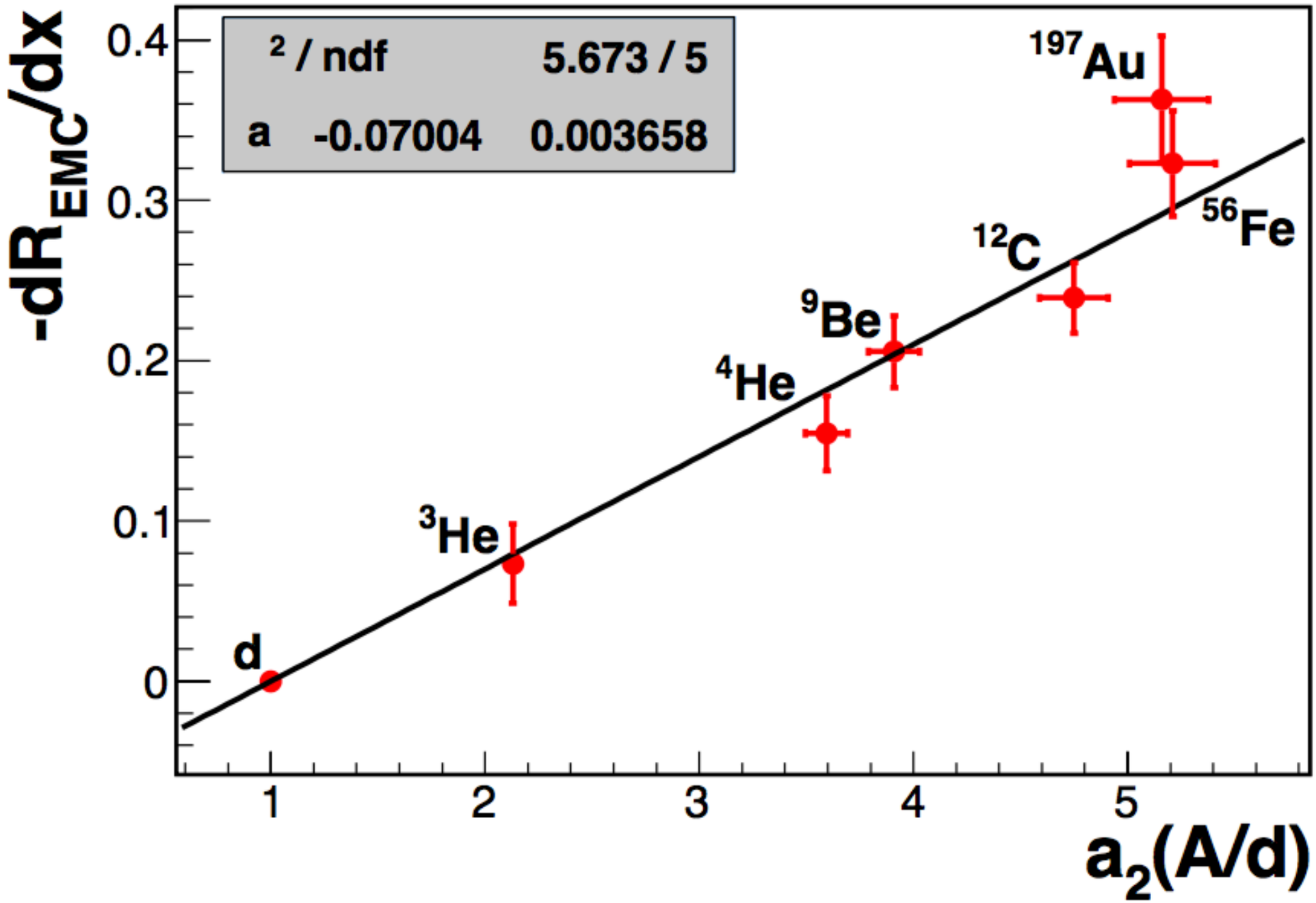


High-momentum tail:

- Universal shape
- Strength grows with nucleus

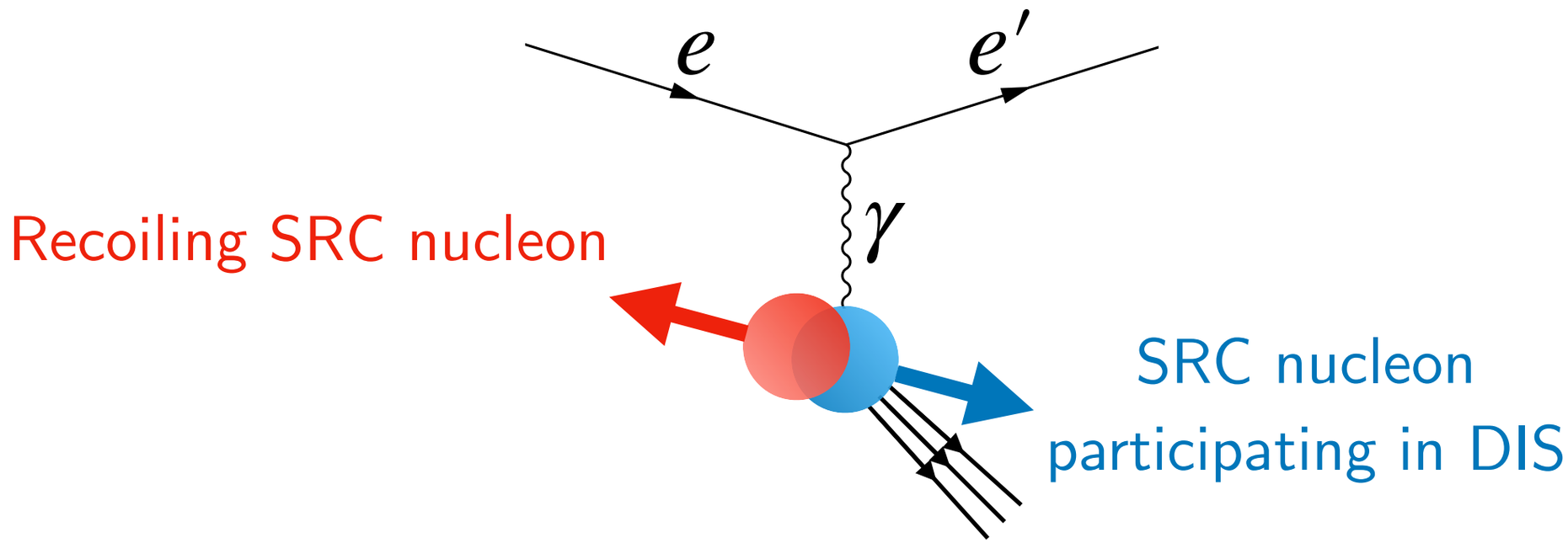
M. Alvioli et al., Phys. Rev. C 87, 034603 (2013)

Strength of EMC effect correlated with SRC abundance



O. Hen et al., Rev. Mod. Phys. 89, 045002 (2017)

Test SRC-EMC hypothesis with spectator-tagged DIS

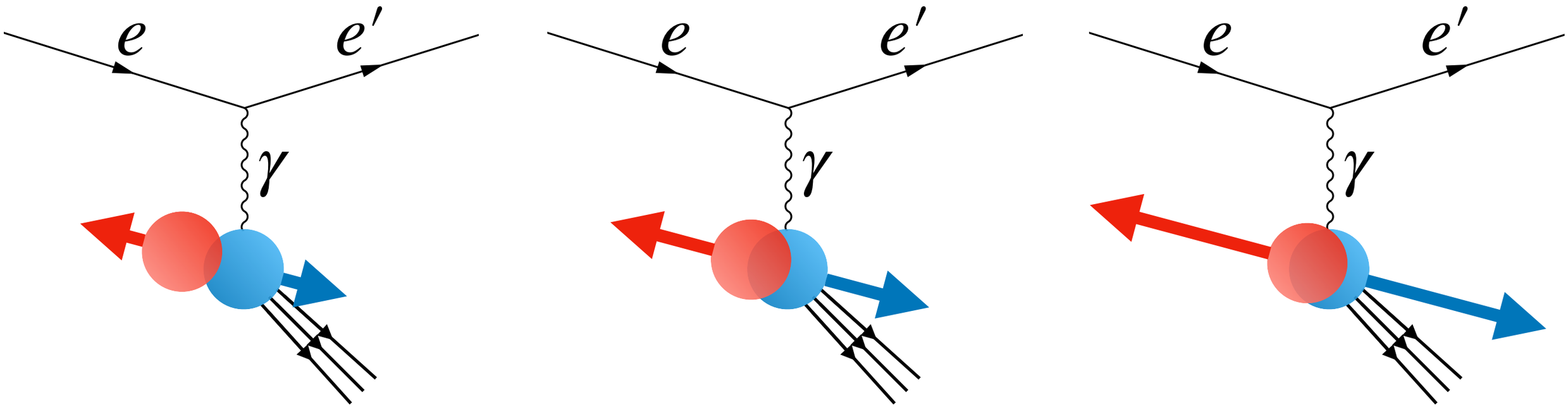


- "Tag" scattered electron with detection of recoiling SRC nucleon
- Allows initial momentum reconstruction of struck nucleon

Test SRC-EMC hypothesis with spectator-tagged DIS

larger distance
smaller momentum

shorter distance
larger momentum



- "Tag" scattered electron with detection of recoiling SRC nucleon
- Allows initial momentum reconstruction of struck nucleon

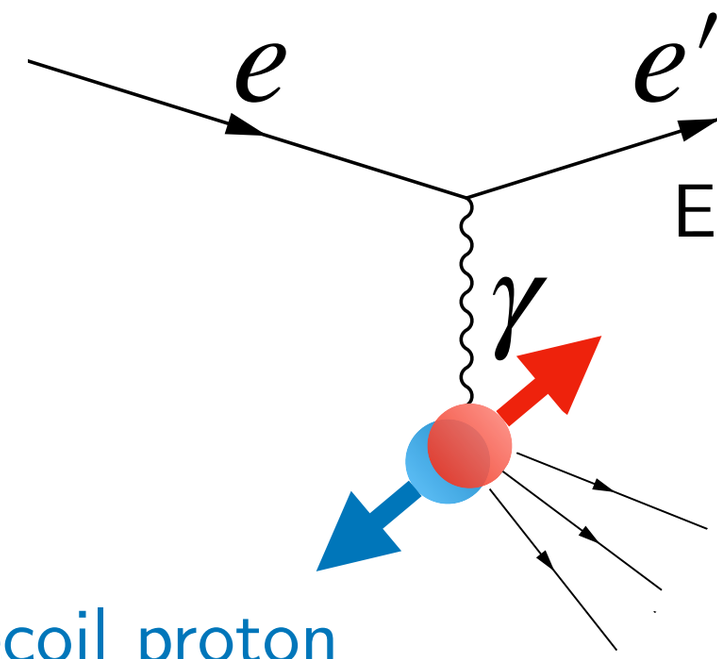
Test SRC-EMC hypothesis with spectator-tagged DIS

- Minimize experimental and theoretical uncertainties by measuring double ratio
- Measured to calculated cross section for high to low x' as function of initial nucleon momentum p_s

$$\frac{F_2^{bound}(x'_{high}, p_s)}{F_2^{free}(x_{high})} = \frac{\sigma_{tag}(x'_{high}, p_s) \Big/ \sigma_d(x_{high})}{\sigma_{tag}(x'_{low}, p_s) \Big/ \sigma_d(x_{low})} \times \frac{\sigma_d \Big/ \sigma_n^{free}(x_{high})}{\sigma_d \Big/ \sigma_n^{free}(x_{low}}$$

Examine *both sides* of nucleon modification

Modified neutron structure

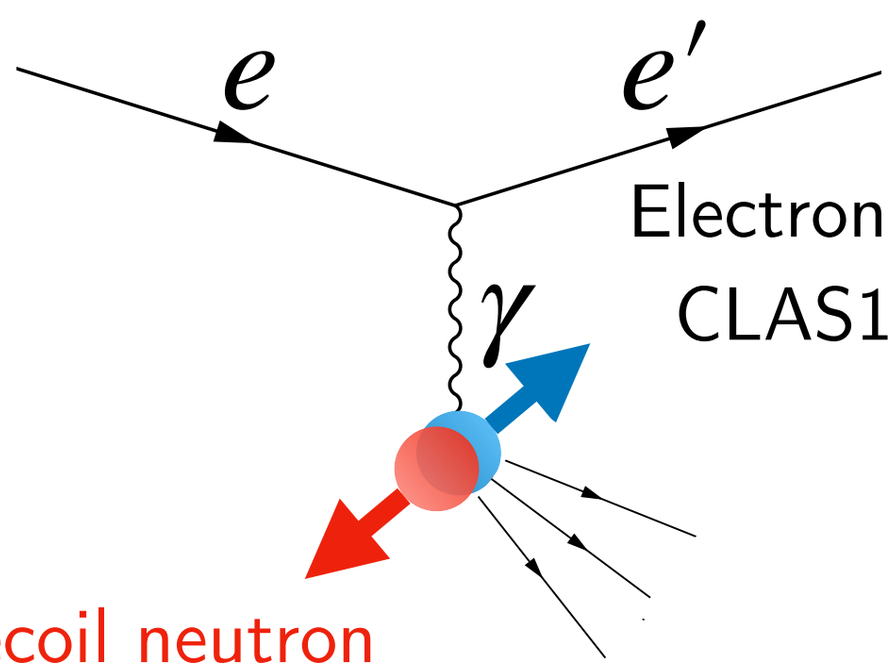


Electron to [S]HMS

Recoil proton to LAD

This talk

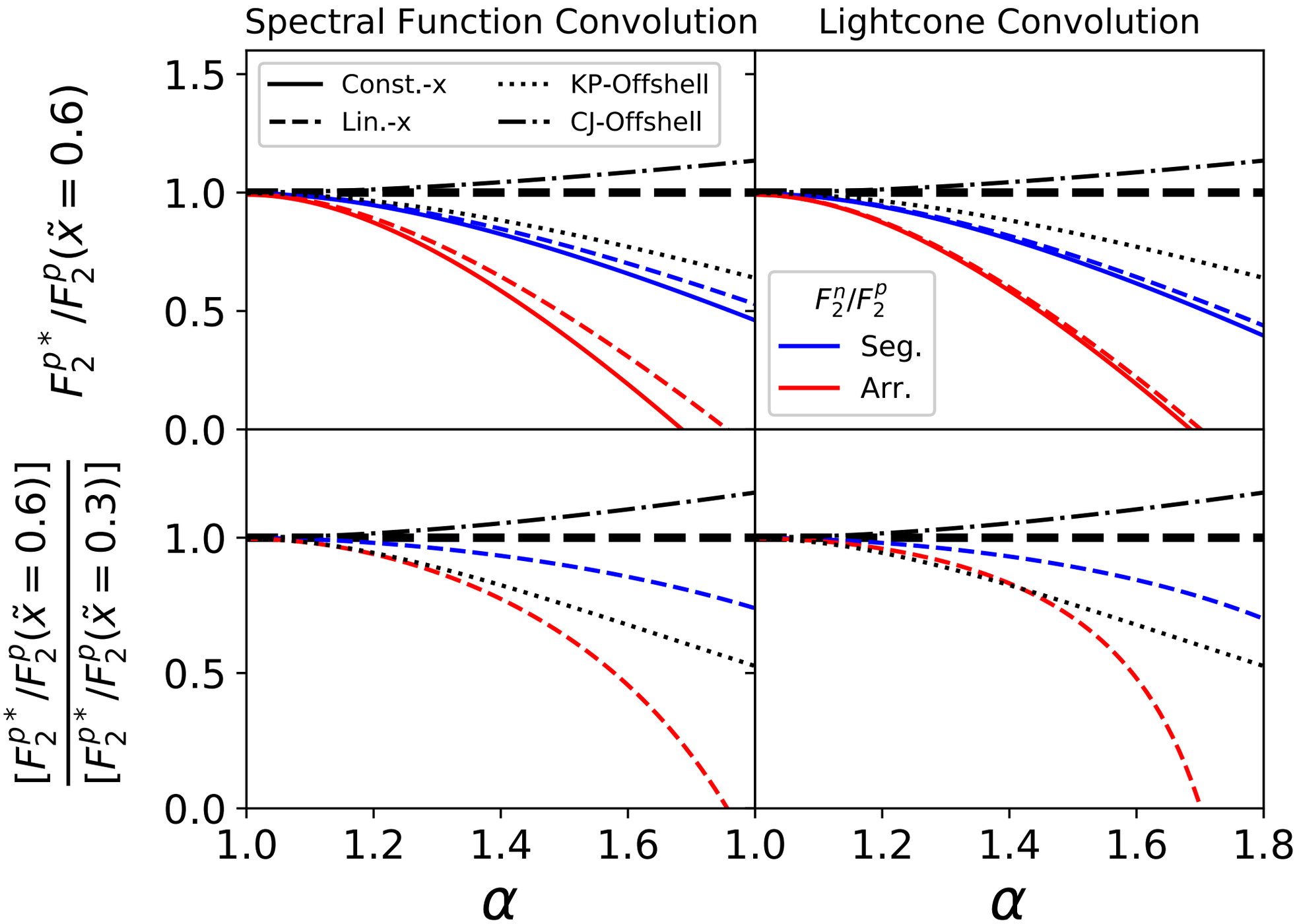
Modified proton structure



Electron to CLAS12

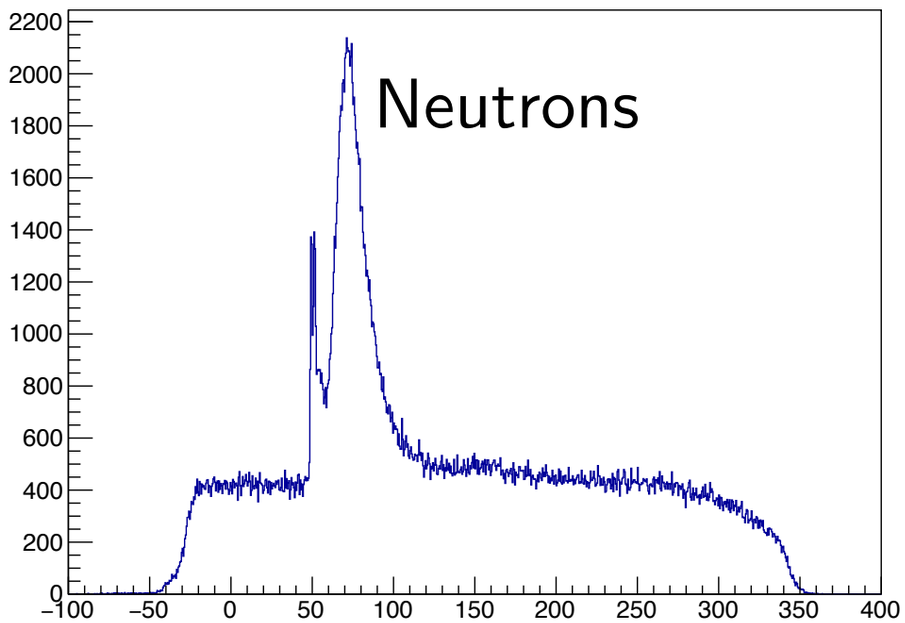
Recoil neutron to BAND

Examine *both sides* of nucleon modification

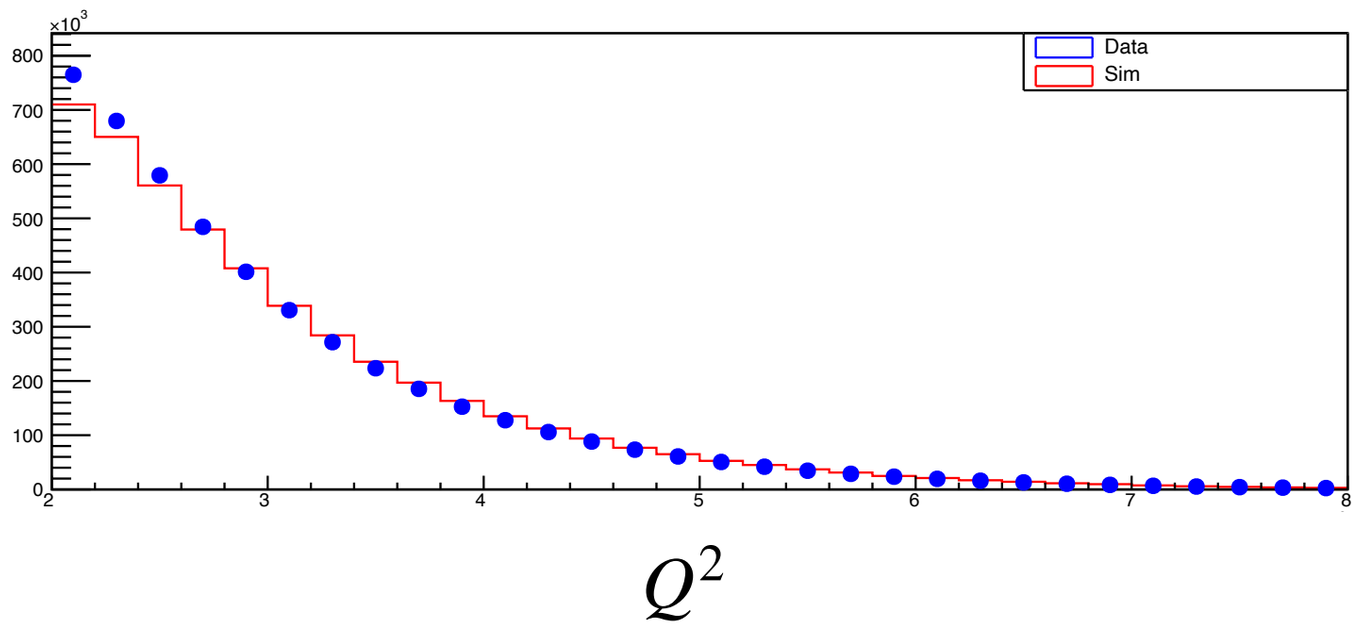


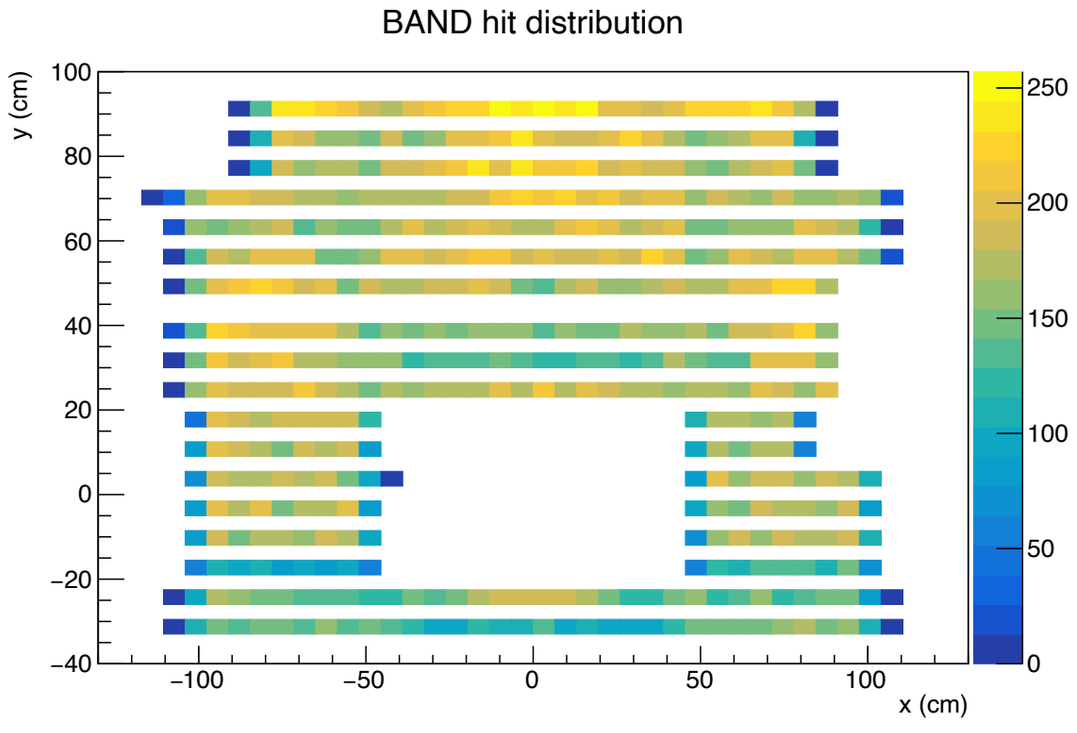
E. Segarra et al., arXiv:2006.10249v2 [hep-ph]

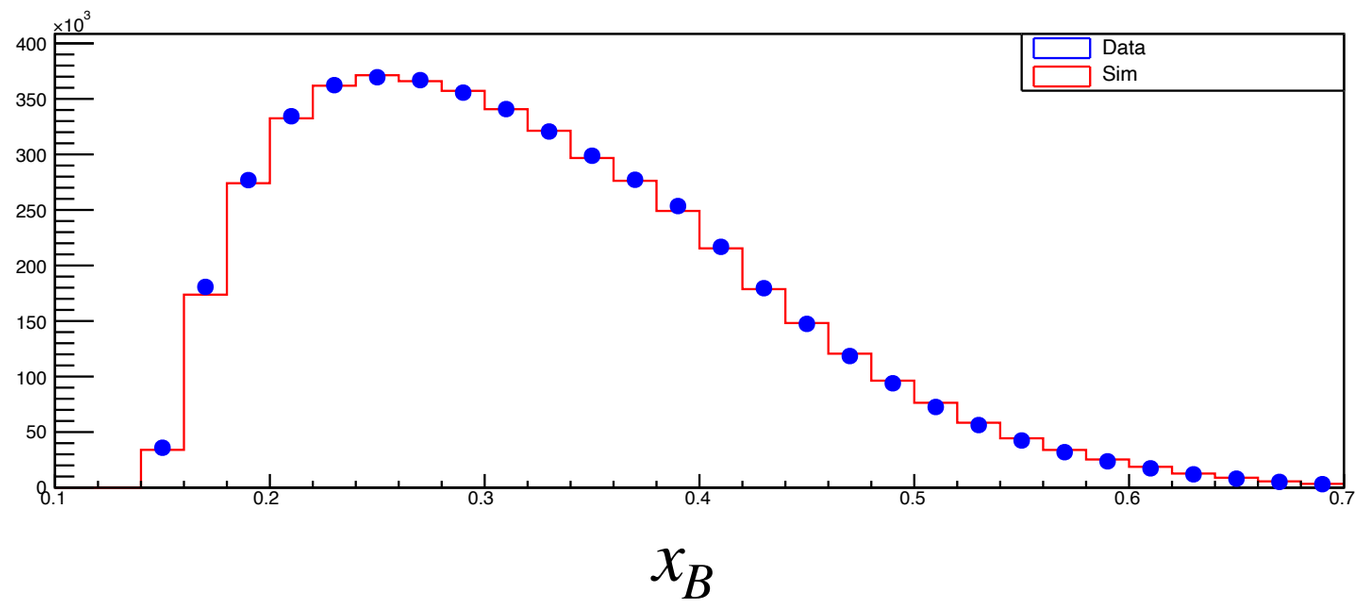
BAND analysis flash



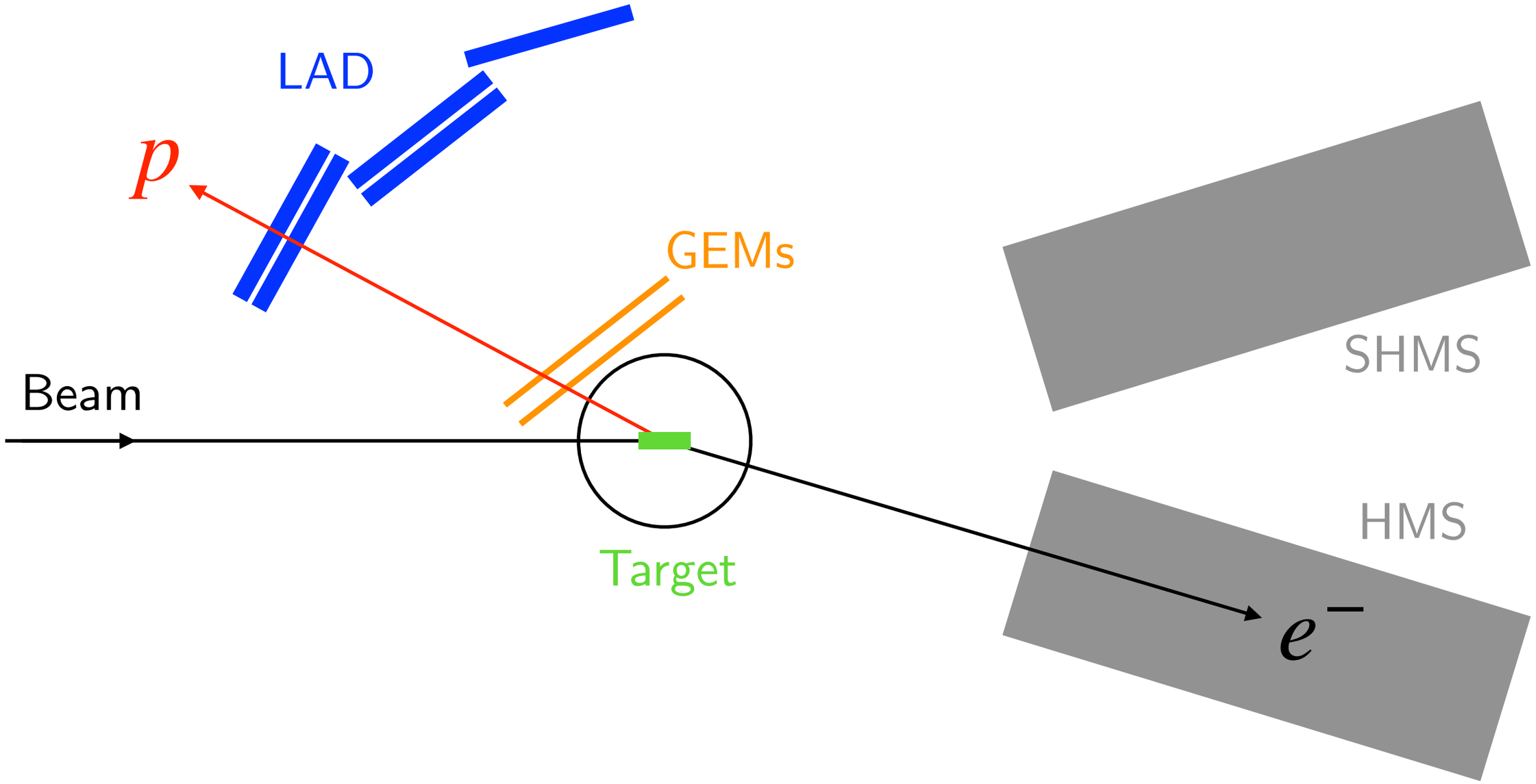
Inclusive data/MC comparison







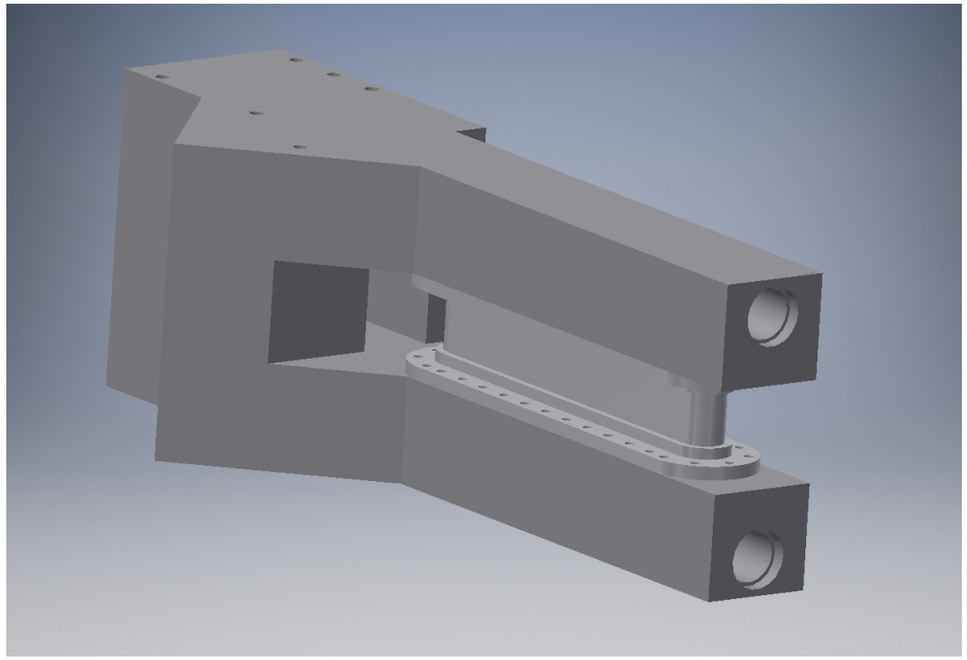
LAD experimental setup

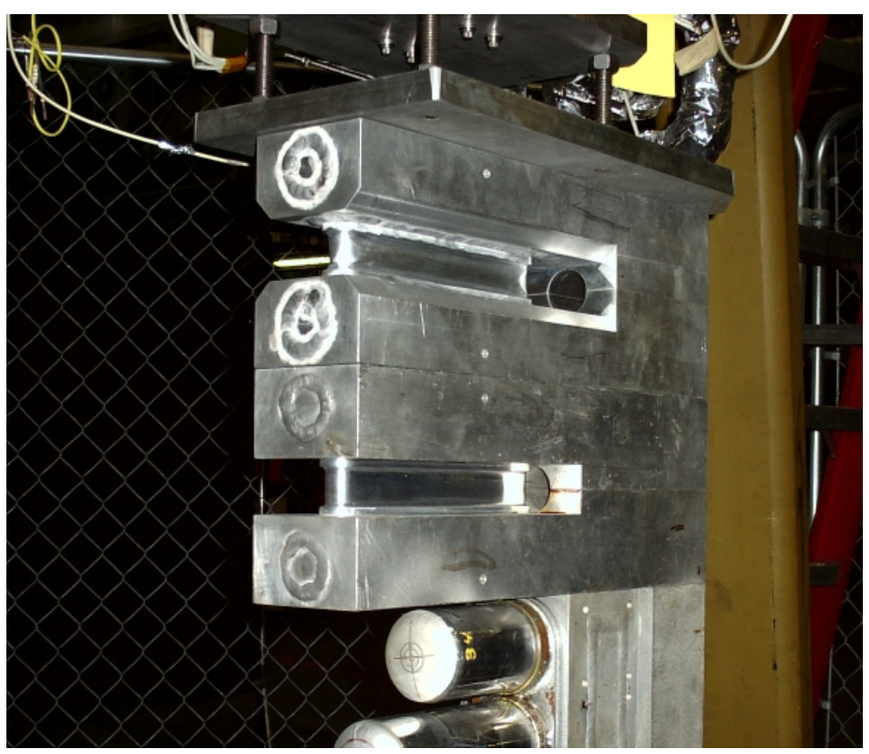


- 1 μA at 10.9 GeV
- Scattered electron to HMS/SHMS
- Recoil proton to LAD

	Low x'	High x'
E' (GeV)	4.4	4.4
θ_e	13.5°	17°
Q^2 (GeV^2)	2.7	4.2
x_B	0.22	0.34

LAD target





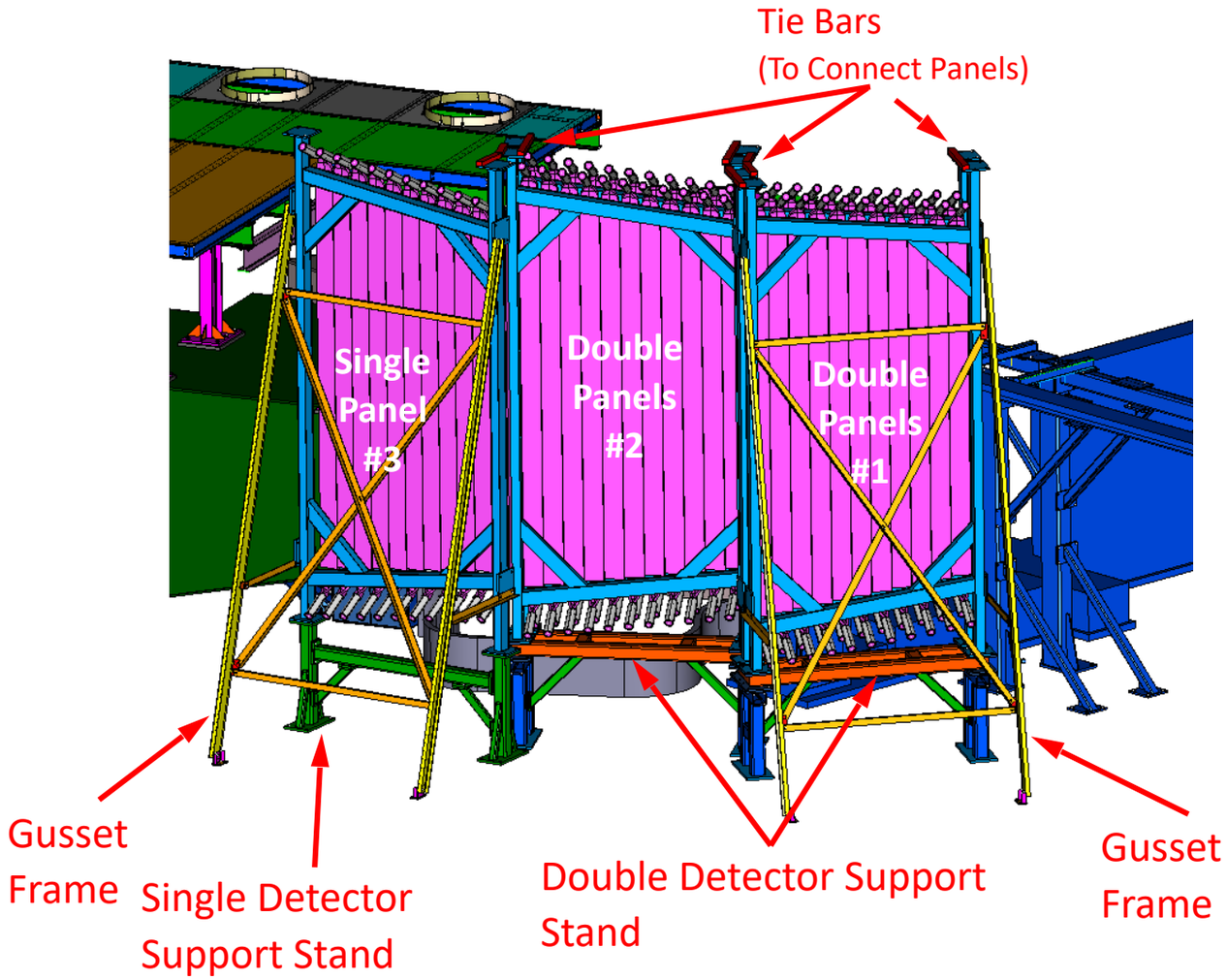
from D. Meekins

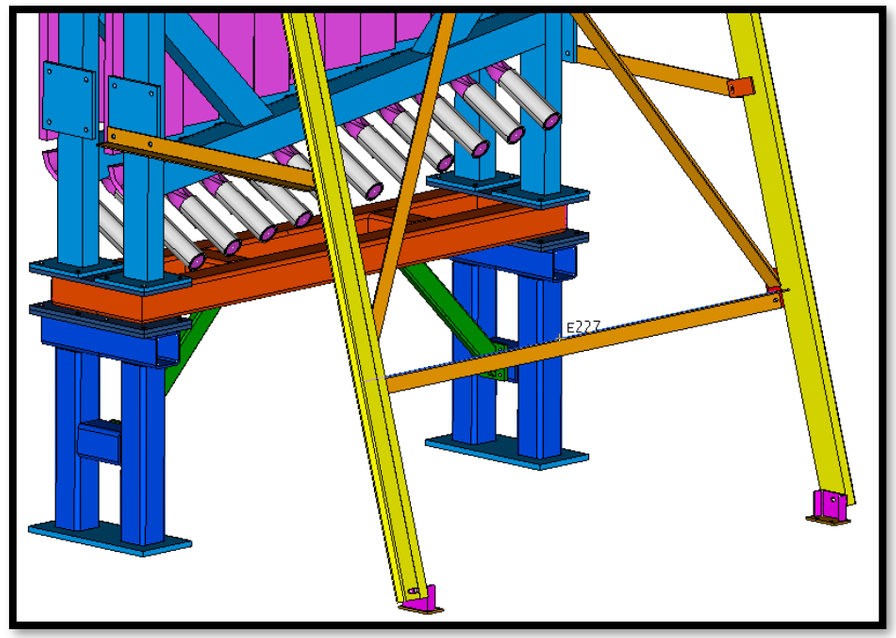
- HAPPEX cell design
- 20 cm cell length
- Target ladder:
  - LH2
  - LD2
  - Empty
  - Carbon multi foil
  - Solid targets for checkout

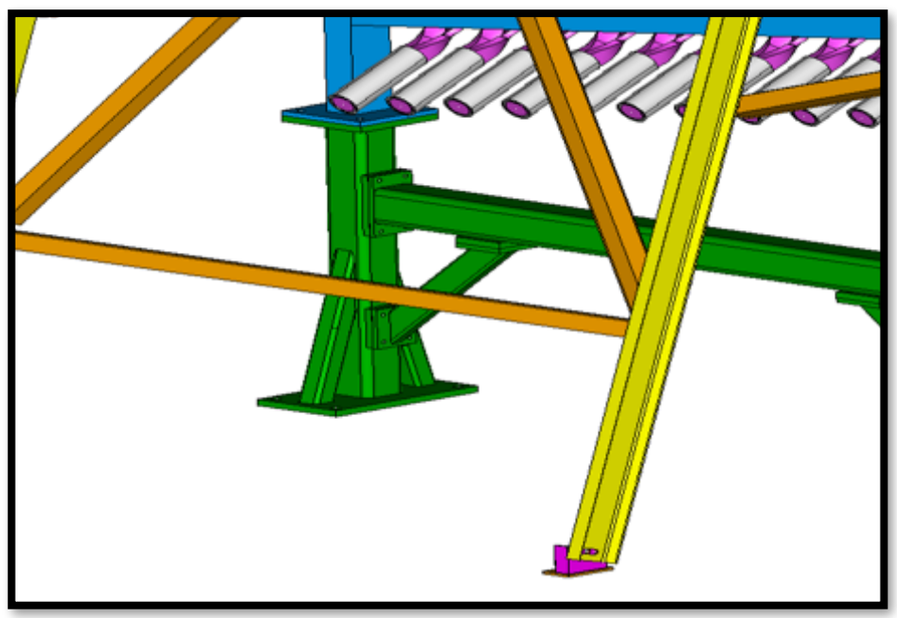
Large angle detector (LAD)

- 5 panels of refurbished CLAS6 TOF scintillators
  - 55 paddles, each 22 cm long and 4 cm thick
  - One panel at smaller angle, two panels at larger angle
- Positioned 5-5.4 m from target covering $95^\circ < \theta_p < 157^\circ$
- Proton ID using dE/dX vs. TOF
- Proton momentum from TOF
- Laser calibration system for timing and energy calibration

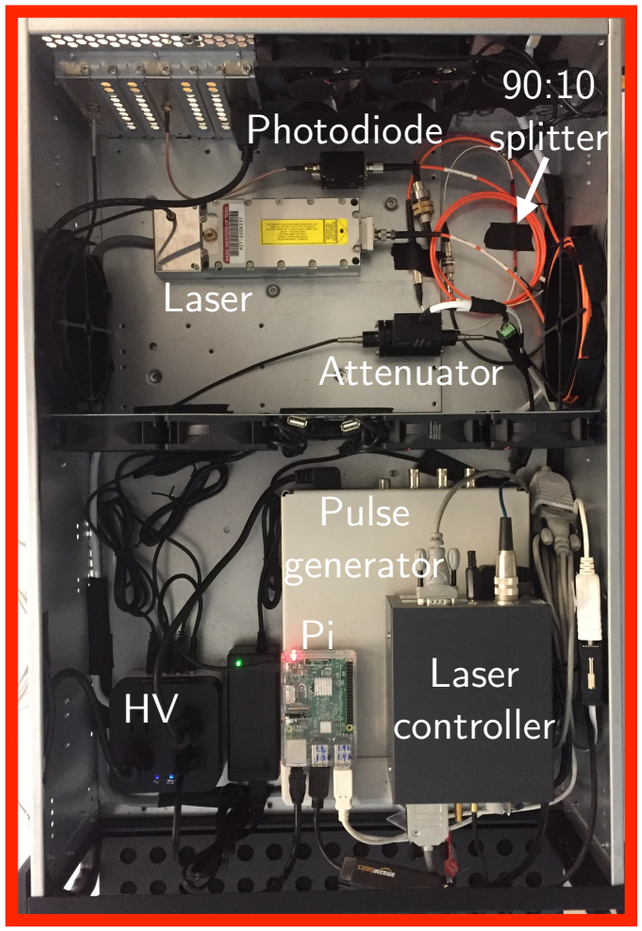
LAD support design complete



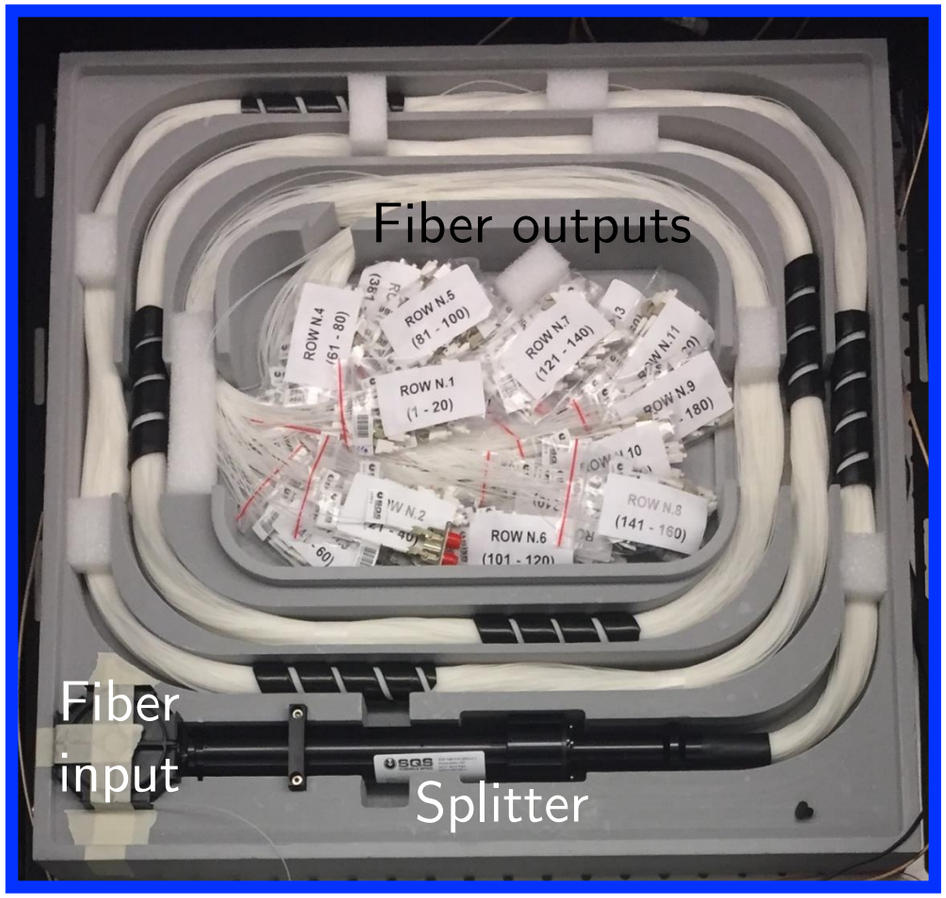




Laser calibration system

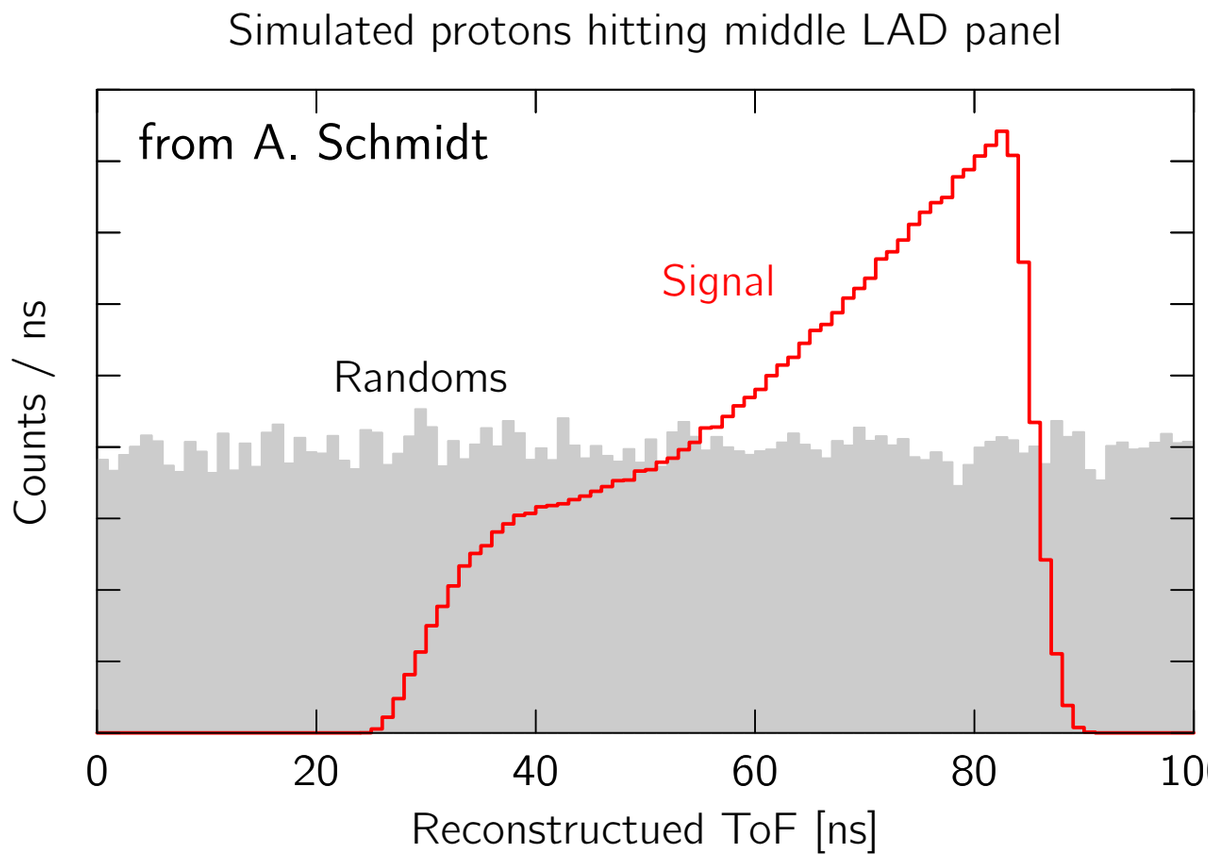


- Following laser calibration system developed for BAND*
- Rack-mountable box contains laser system
- Splitter distributes laser pulse to scintillators
- Laser completely contained in fiber-optic cables
- Web GUI allows remote operation
- Time resolution $\leq$ 100 ps



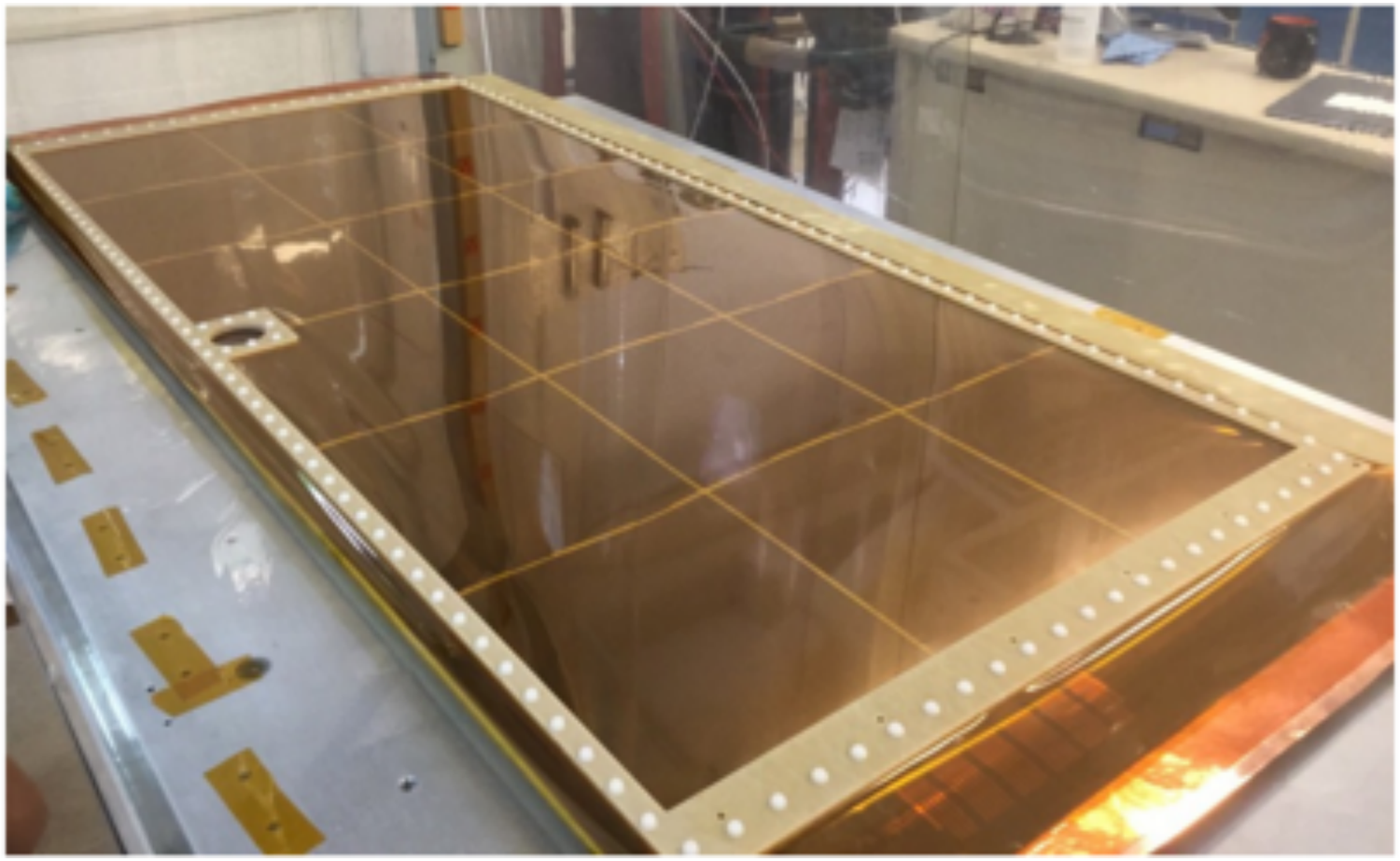
*A. Denniston, et al., NIM A 973 164177 (2020)

Random background will be limit to LAD precision



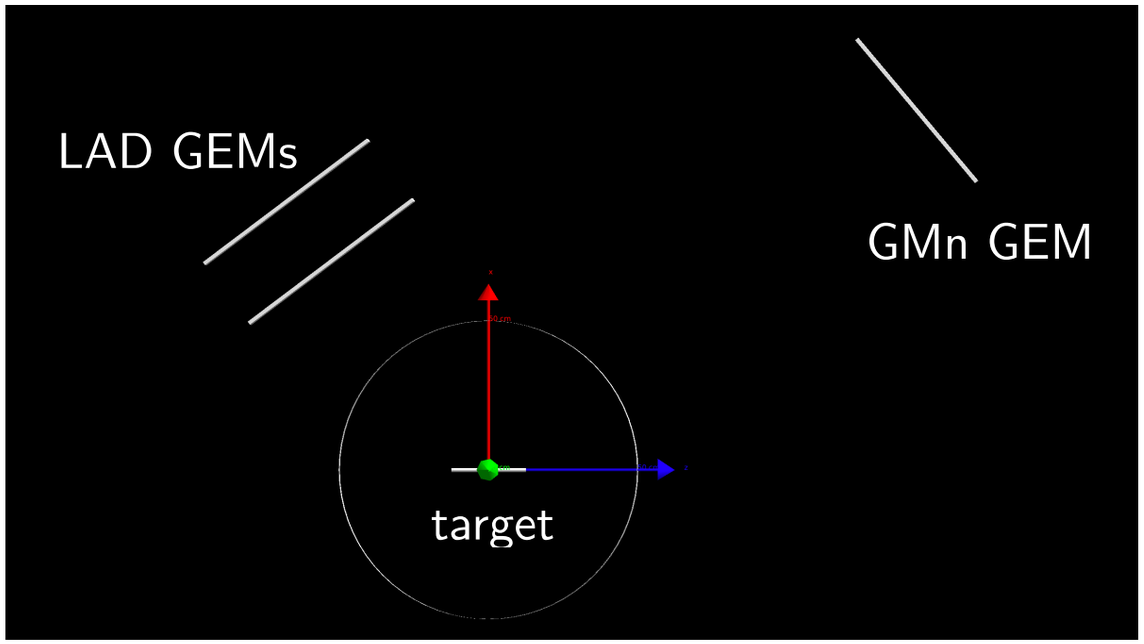
- Anticipate accidental background rate 4-8x signal
- Suppress background using
  - Energy deposition (dE/dX)
  - Proton vertexing (GEMs)

GEMs for proton vertexing



- Repurpose PRad GEMs
- Active area: 120 x 55 cm^2
- Positioned at 127°
  - First plane 75 cm from target
  - Second plane 95 cm from target

Background rate at GEMs is manageable

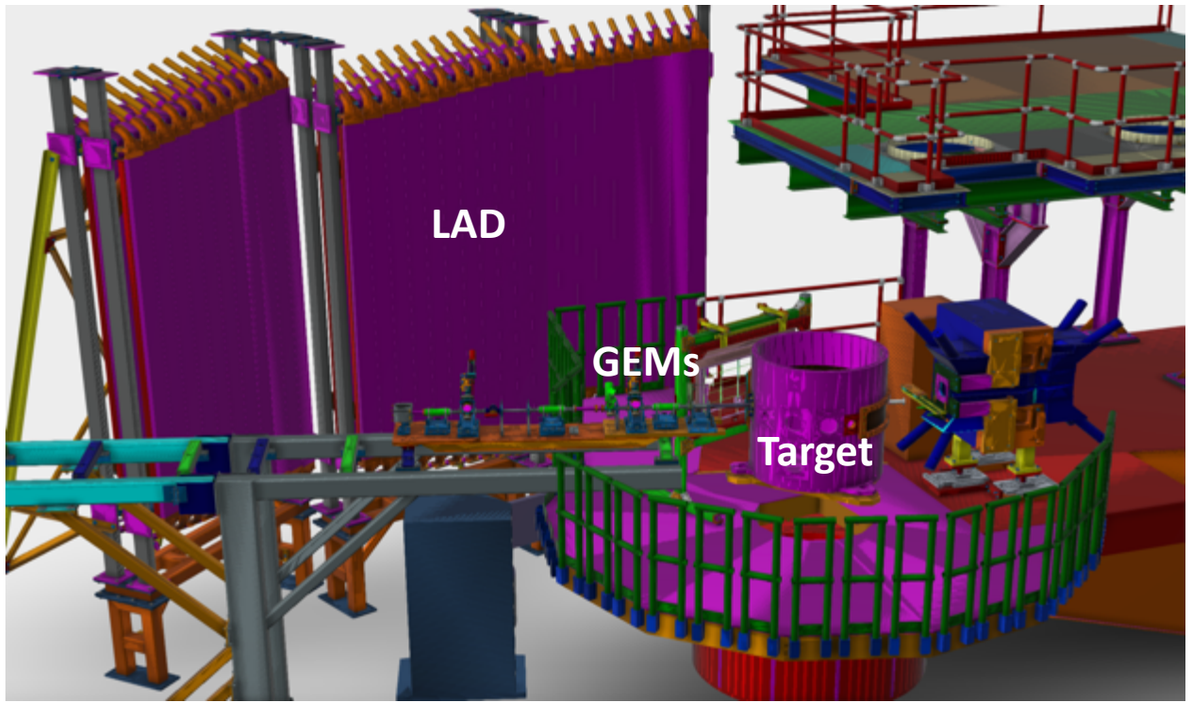


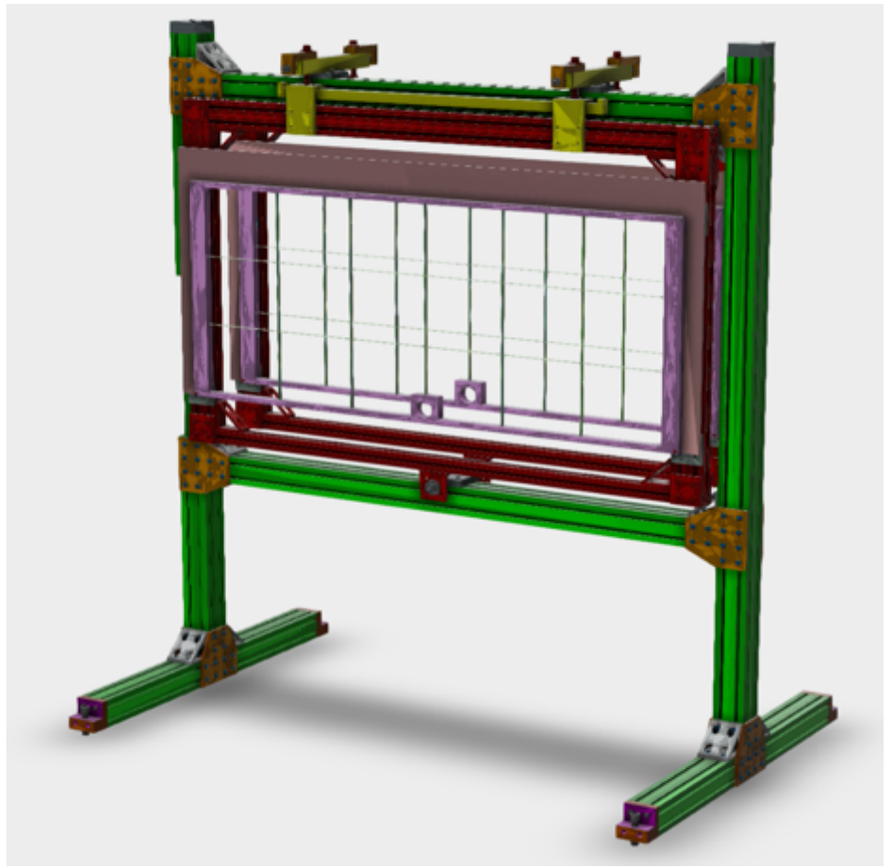
- Estimate rate with GEANT4 simulation
- 10.9 GeV electron beam on 20 cm LD2 target
- Include GMn GEM for photon rate comparison

- Rates for LAD GEMs from GEANT4
  - Photons = 22.5 GHz (0.5% efficiency per PRad simulations)
  - Electrons = 15 GHz (4 GHz with aluminum window and 1mm polyethylene)
  - Consistent with previous calculations by Pavel Degtiarenko

- Simple simulation shows 40 ns time resolution achievable with these rates
- With 40 ns time resolution, vertexing able to suppress background to 10% level

GEM support design complete





Experimental status

- ERR approved November 2020
- Beam time request submitted December 2020
- Key remaining tasks:
  - Detailed simulation of GEMs and LAD in GEANT4
  - Commissioning of PRad GEMs for LAD

Thank you!