Investigating the EMC effect in highly-virtual nucleons at Jefferson Lab

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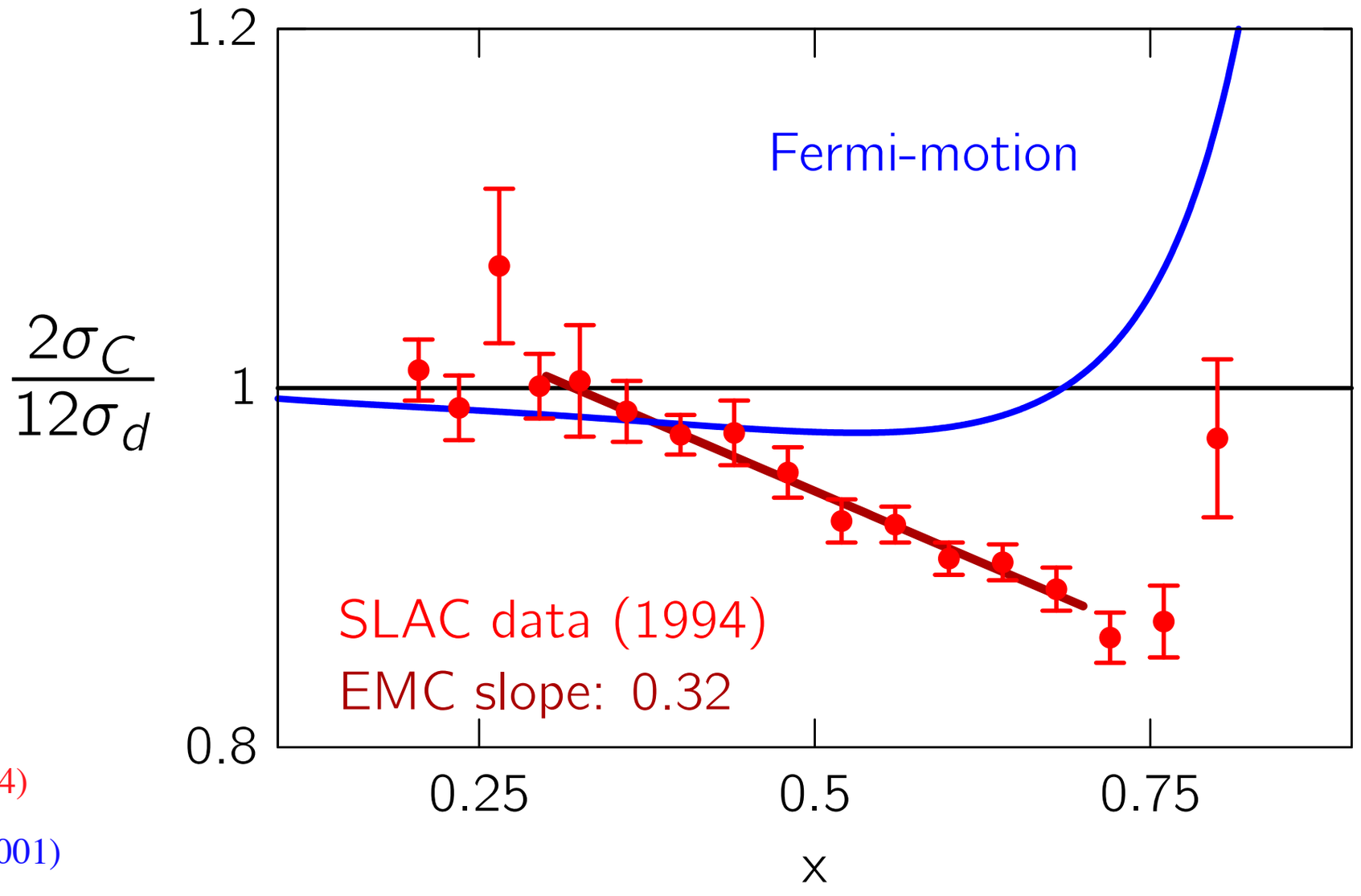
04/14/19

The EMC Effect in DIS Scattering

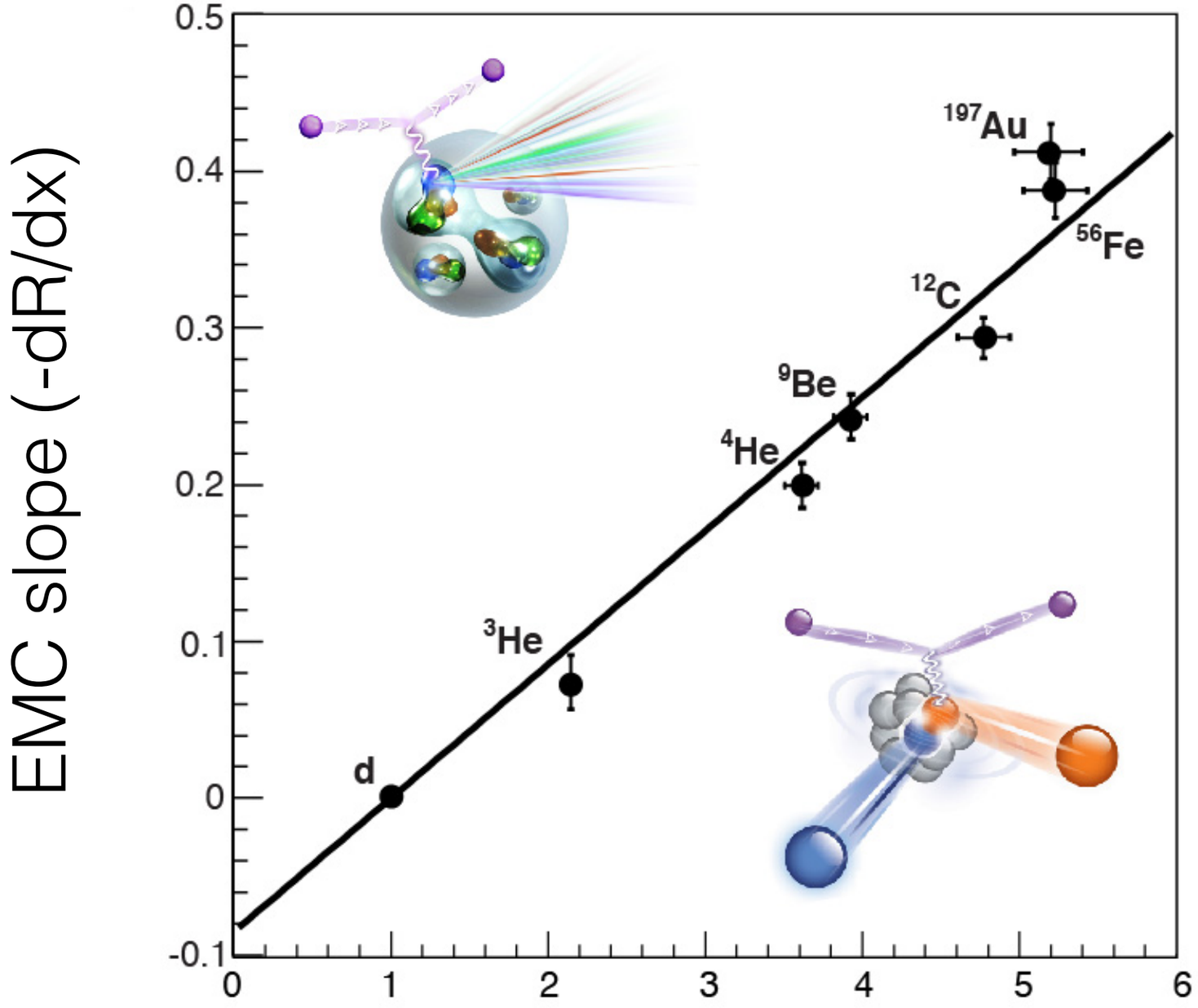


PRD 49, 4338 (1994)

PRC 65, 015211 (2001)

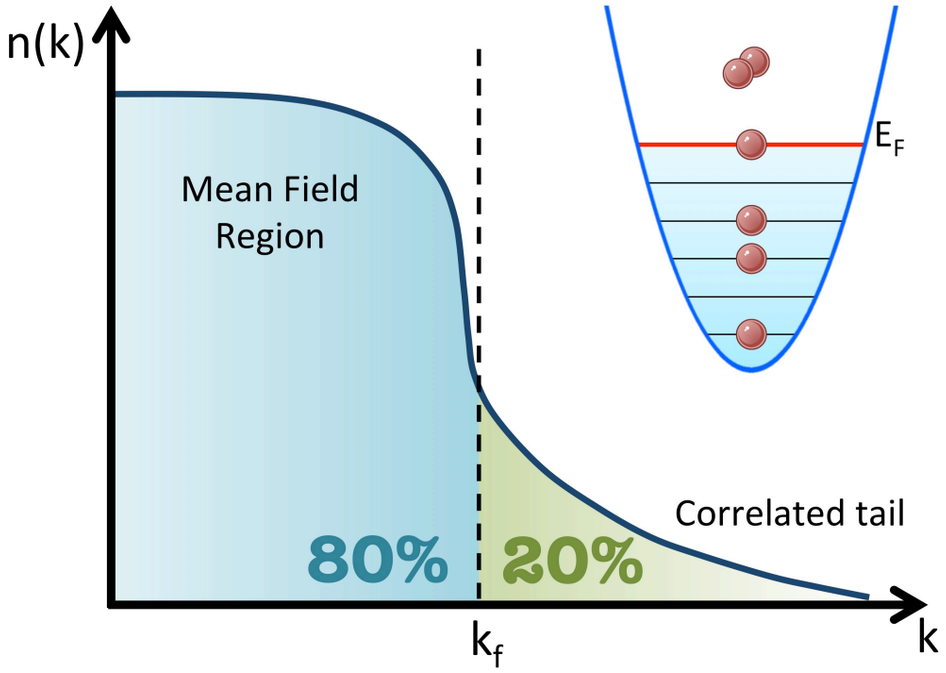
Quark distributions (F_2) in nucleons bound in nuclei different to distributions in free nucleons

EMC and SRC Correlation

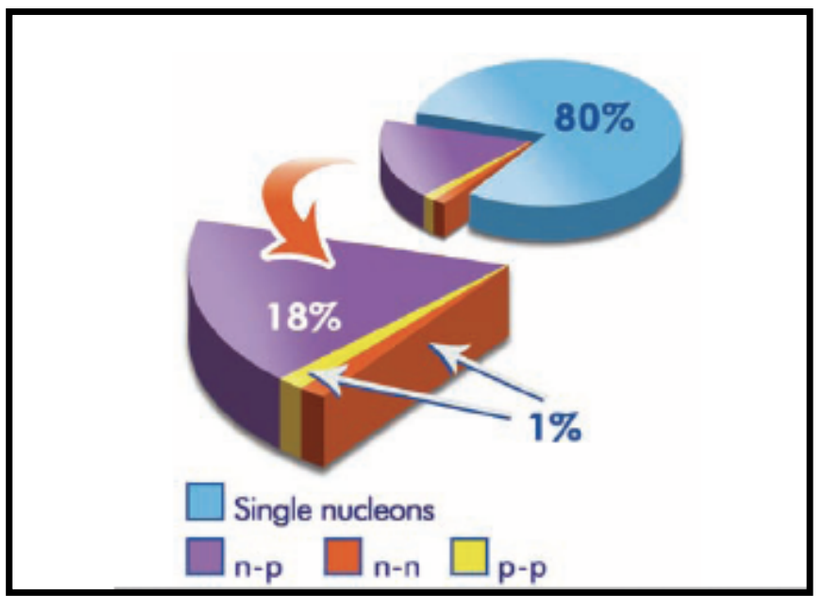


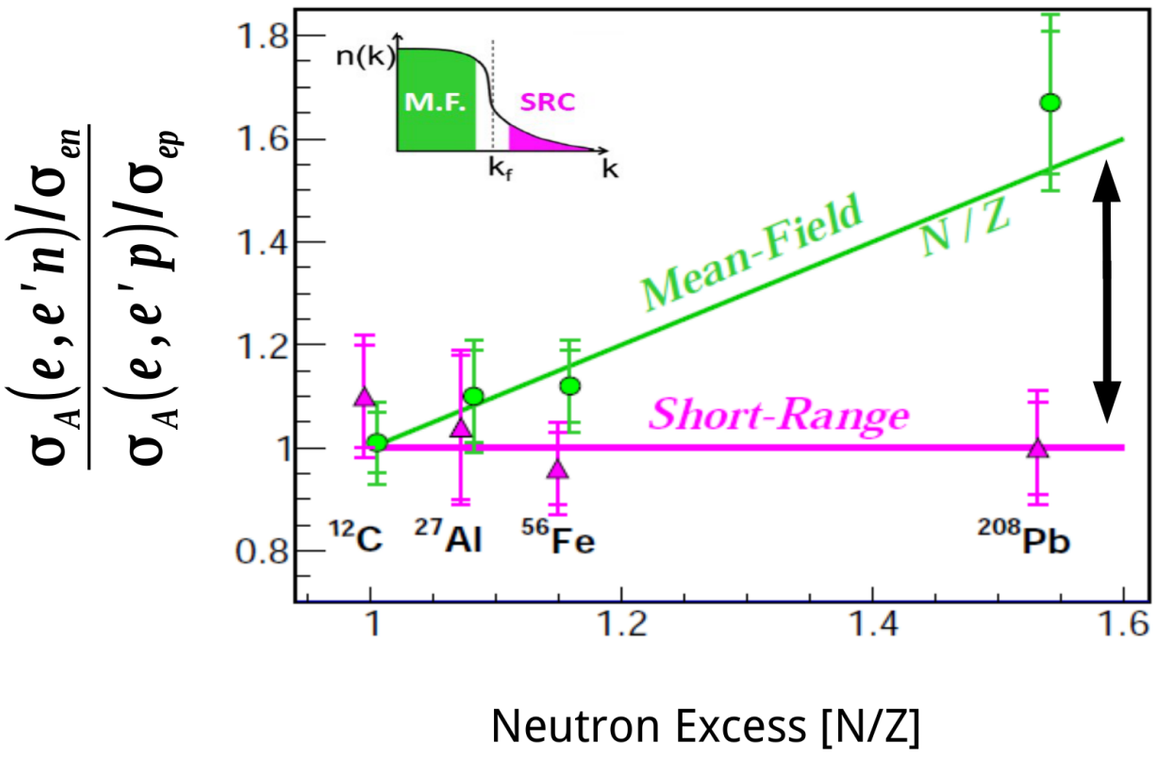
Weinstein et al., PRL 106, 052301 (2011), Hen et al.,PRC 85, 047301(2012)

Short Range Correlations



Subedi et al., Science 320, 1476 (2008)

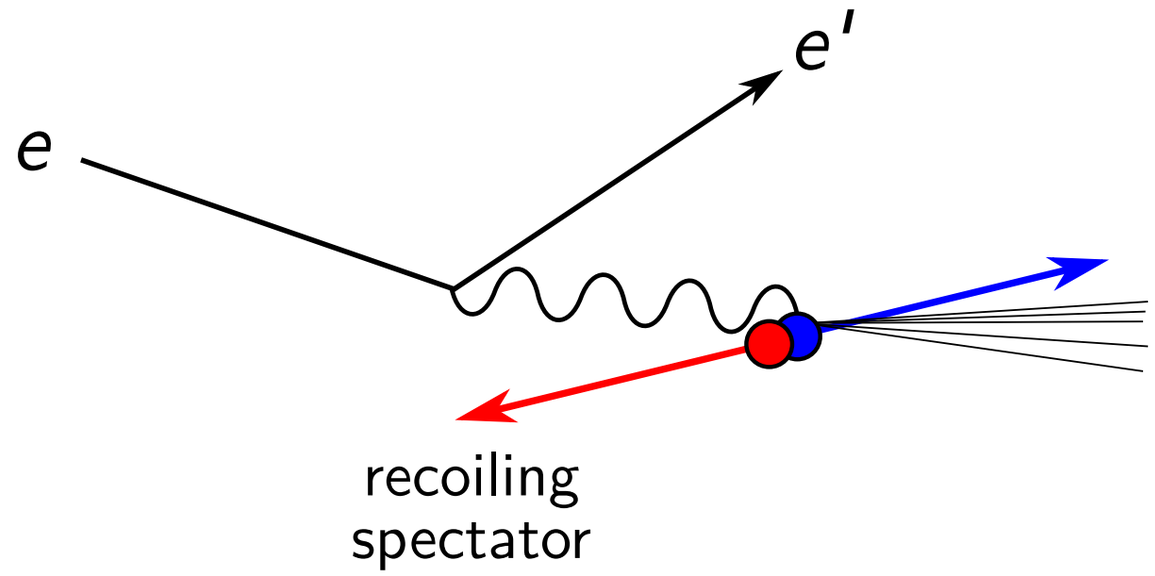




Duer et al. (CLAS collaboration), Nature 560, 617 (2018)

- NN pair with **large relative momentum and small c.m momentum**
- ~20% of nucleons in nuclei
- SRC pairs dominate nucleon momentum distribution above fermi momentum k_F
- **np dominance of SRC pairs** (about ~18 more likely than pp or nn)

Tagged DIS on Deuterium



- “Tag“ interacting nucleon by measuring spectator
- How does the bound nucleon structure function depend on nucleon virtuality $v = p^2 - m^2$
- Explaining the EMC effect

What will be measured

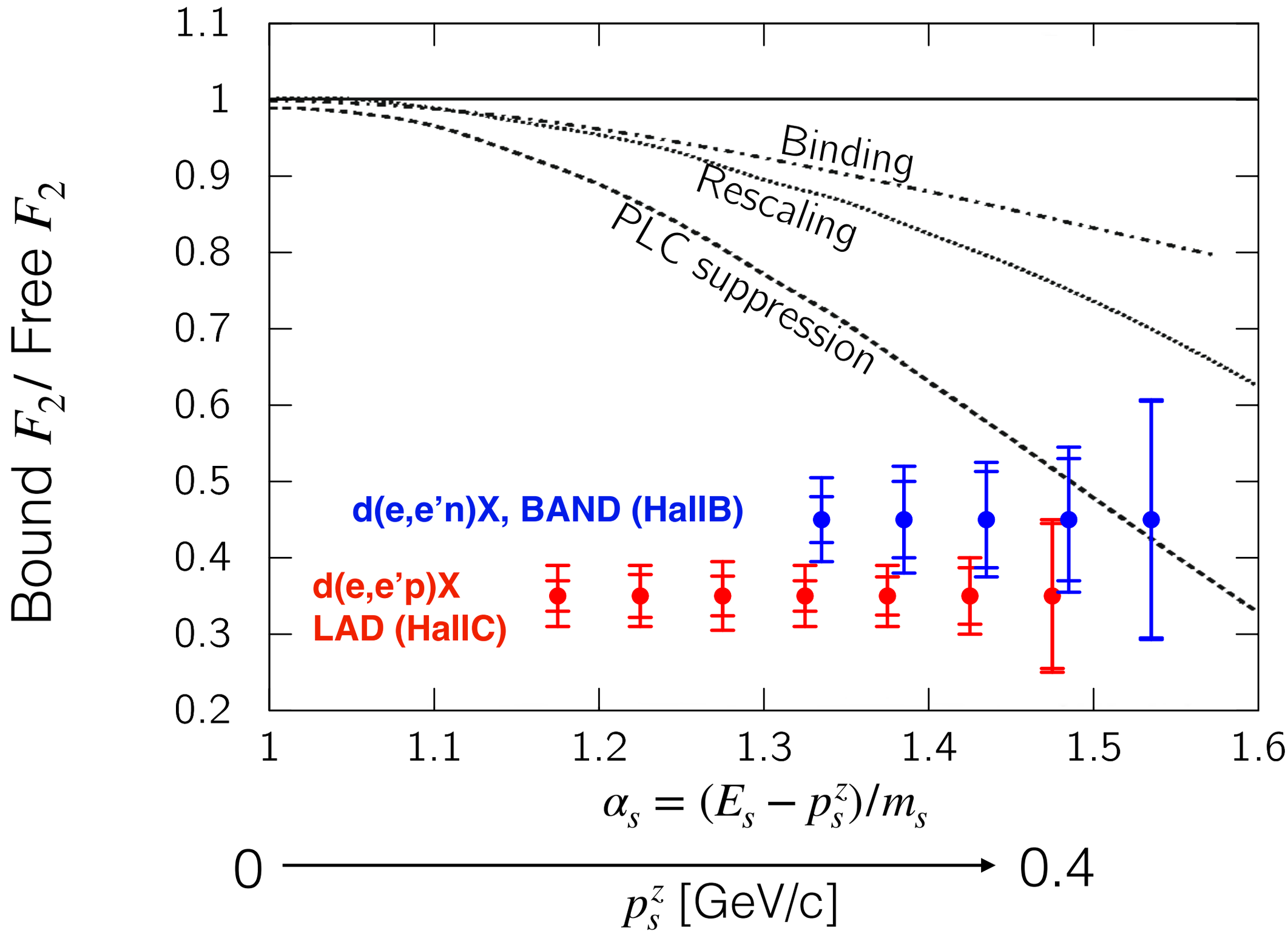
- Measuring cross section ratios to minimize uncertainties
- Choose kinematics with minimal FSI $\theta_{rq} > 107°$

$$\frac{\sigma_{DIS}(x'_{\text{high}}, Q_1^2, \alpha_s)}{\sigma_{DIS}(x'_{\text{low}}, Q_2^2, \alpha_s)} \cdot \frac{\sigma_{DIS}^{\text{free}}(x_{\text{low}}, Q_2^2)}{\sigma_{DIS}^{\text{free}}(x_{\text{high}}, Q_1^2)} \cdot R_{FSI} = \frac{F_2^{\text{bound}}(x'_{\text{high}}, Q_1^2, \alpha_s)}{F_2^{\text{free}}(x_{\text{high}}, Q_1^2)}$$

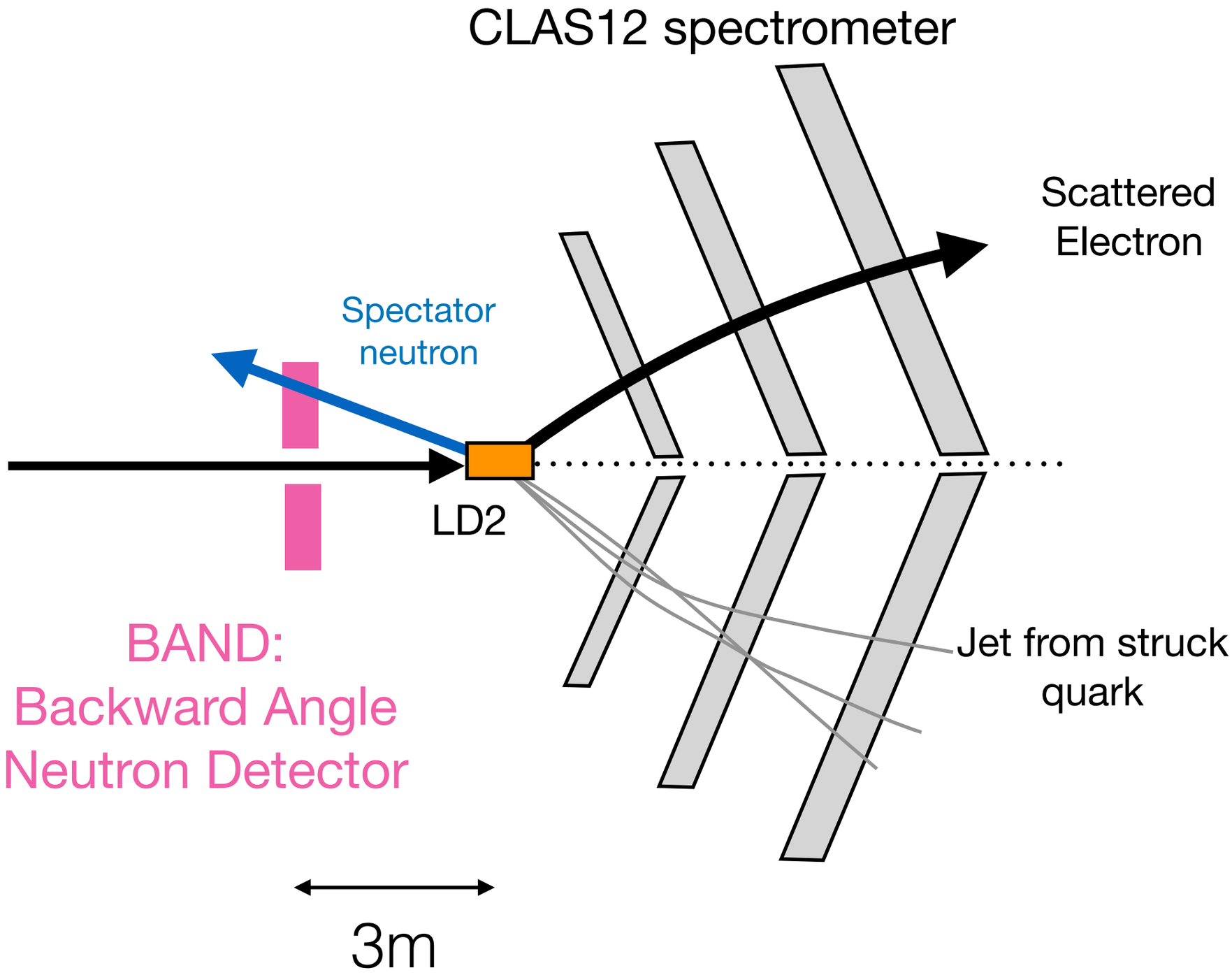
measurement theory

- $x' = x$ for moving nucleon $= Q^2/(2p \cdot q)$
- $x'_{\text{high}} > 0.45$
- no EMC effect at $0.25 \leq x'_{\text{low}} \leq 0.35$

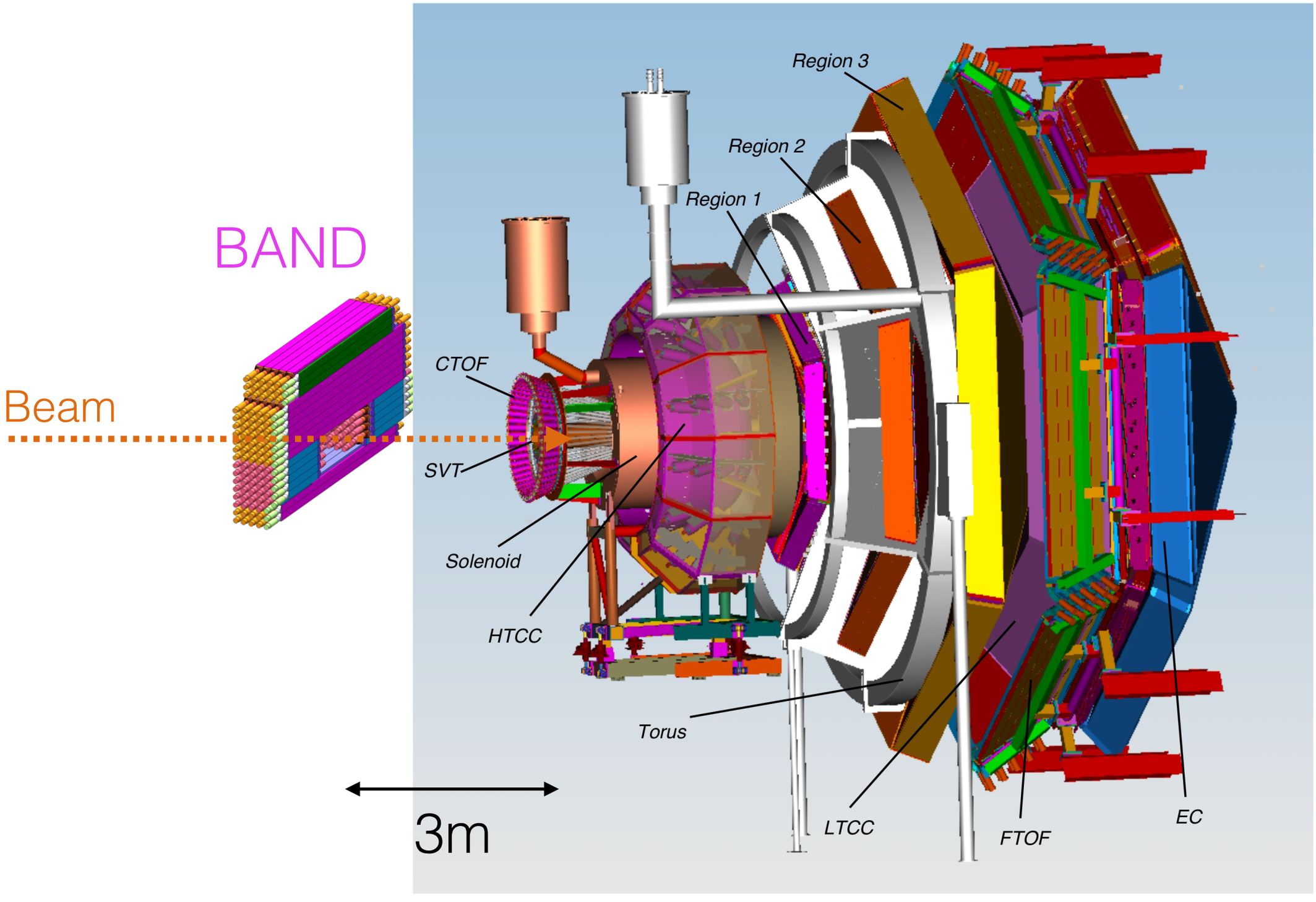
DIS Recoil Tagging d(e,e'N)X - Expected Results



BAND in HallB

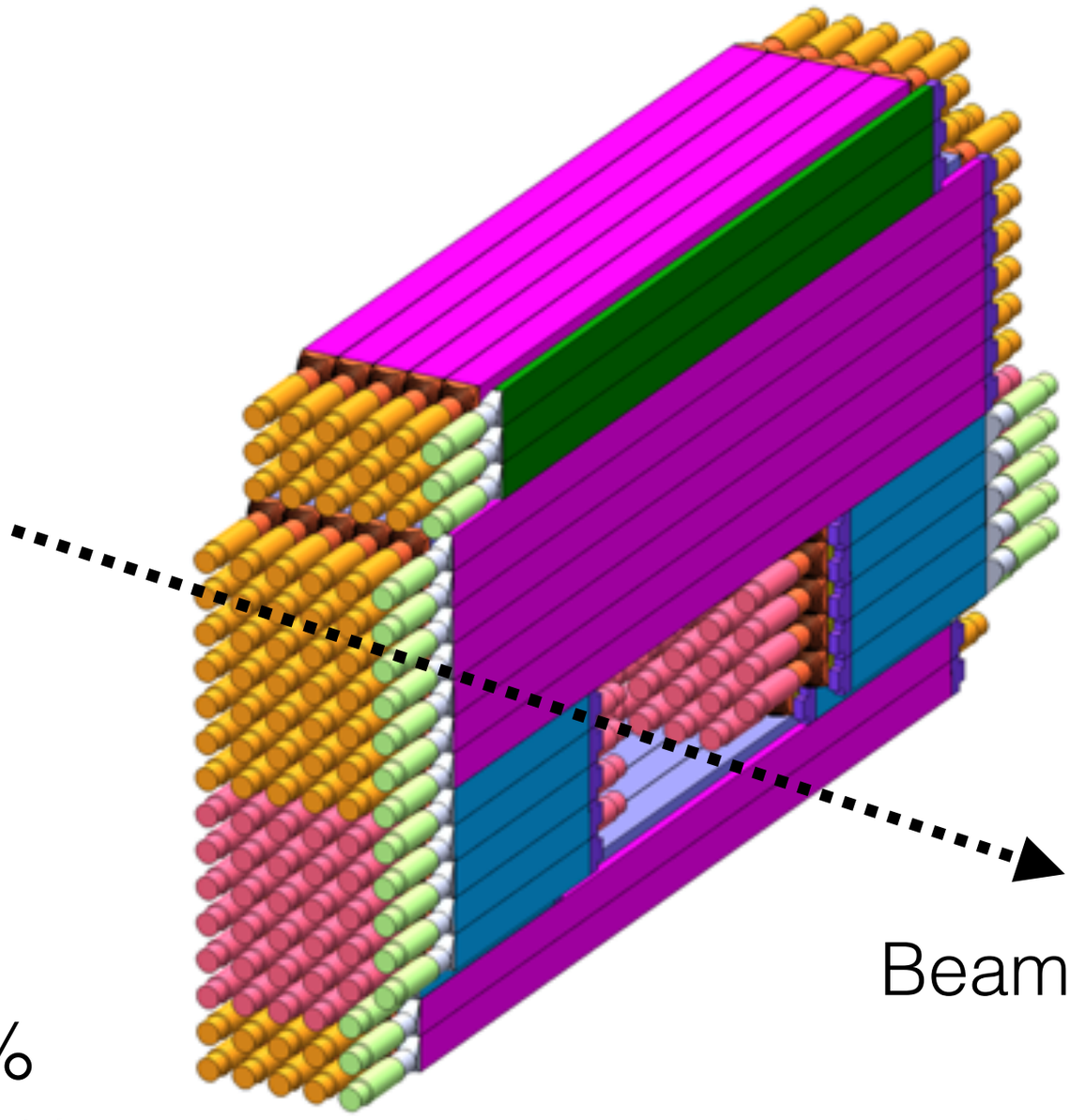


CLAS12 and BAND

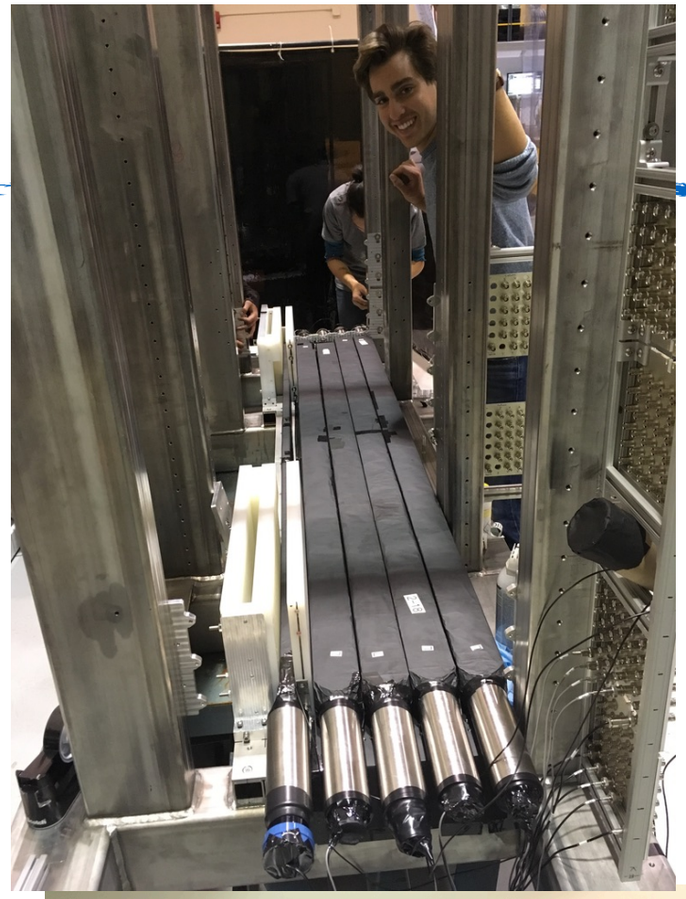


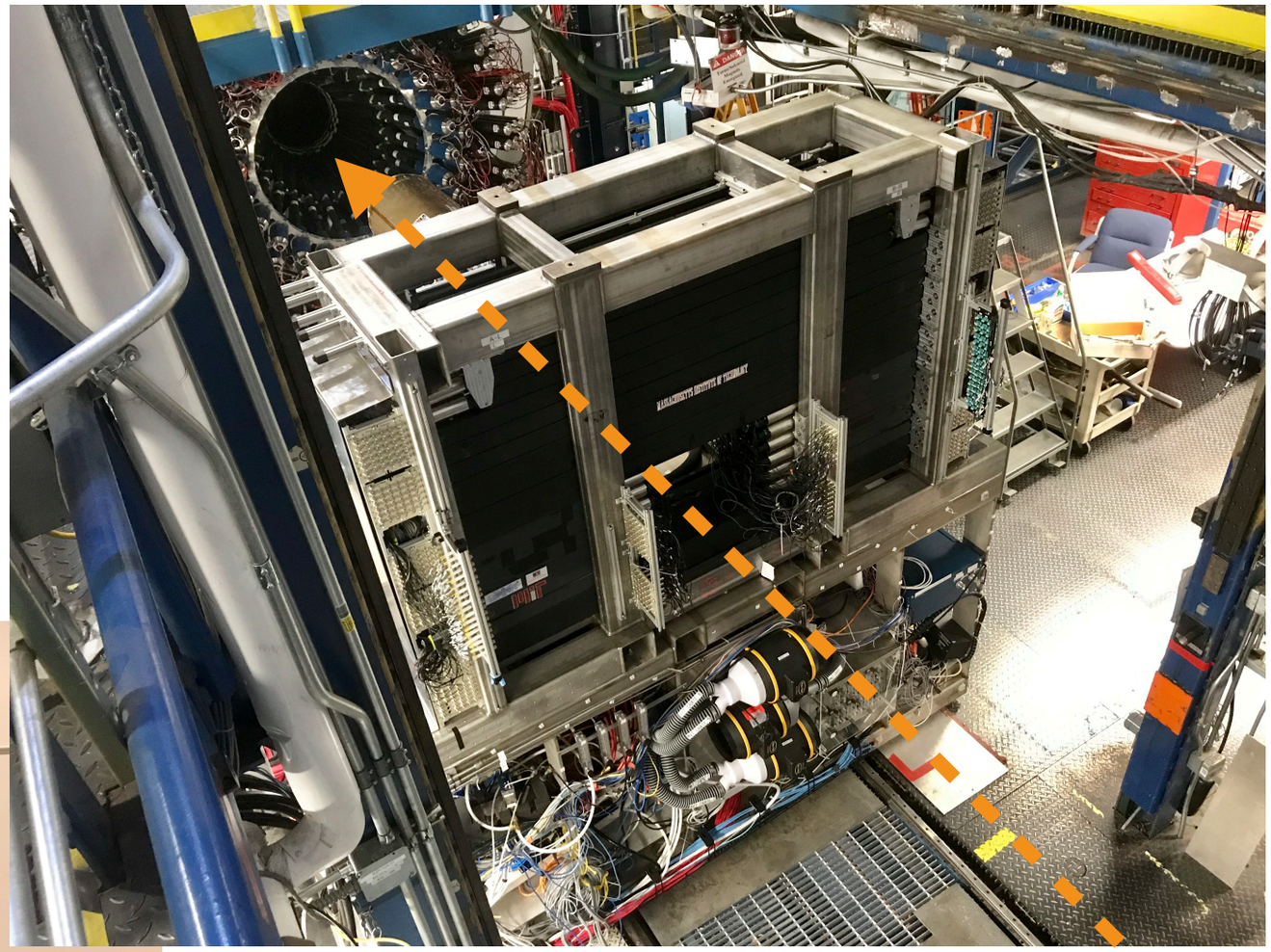
Overview of BAND

- 5 layers thick (36cm total) with veto layer (1cm thick)
- 140 scintillator bars
- Bar resolutions < 200 ps
- 3 meters upstream of target, coverage in θ ~ 155-176°
- Design neutron efficiency ~35% and momentum resolution ~1.5%
- Laser system for calibrations



BAND Construction

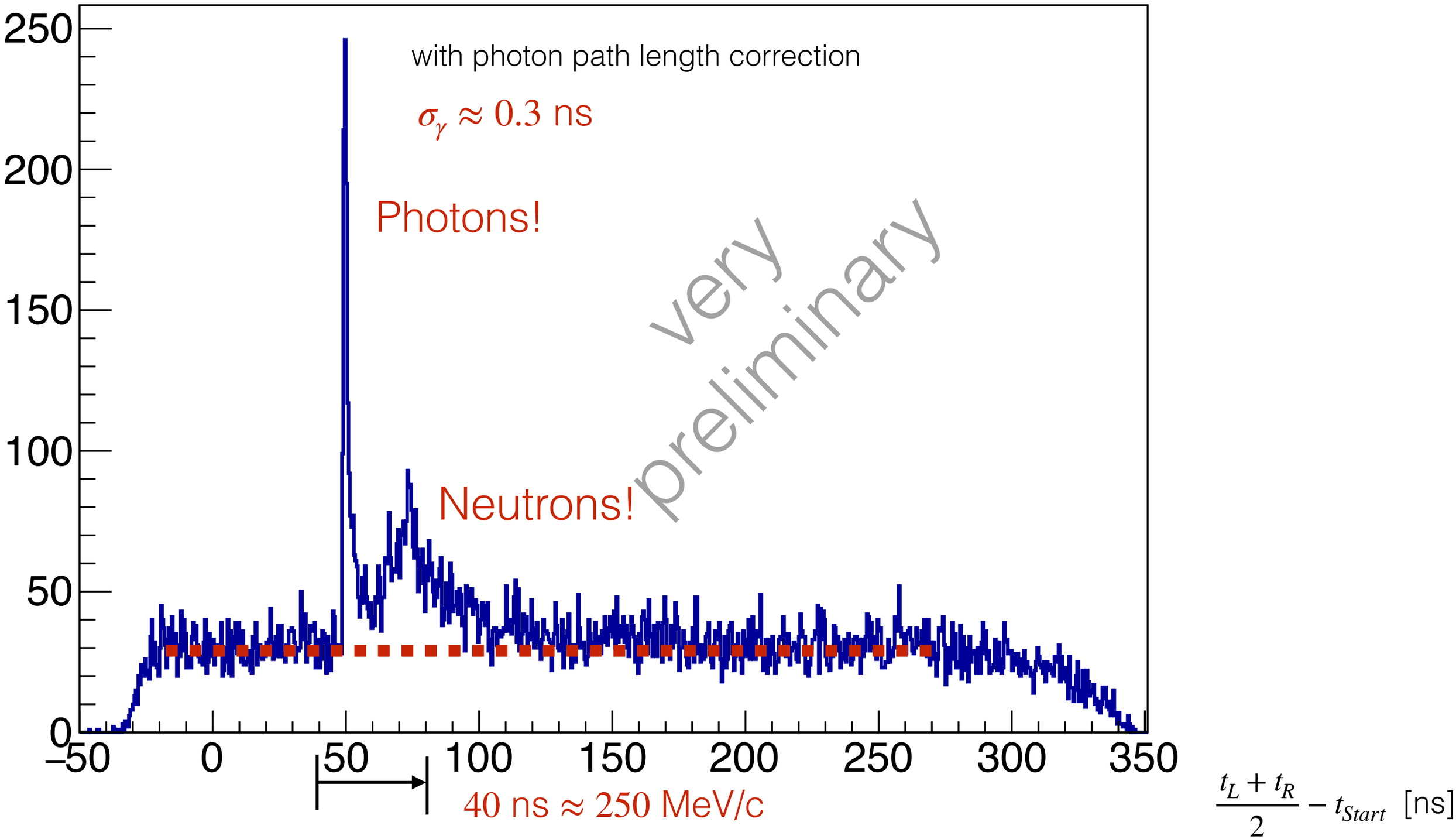




Installed in the Hall

Time of Flight Distribution

All long bars in BAND, e' from CLAS, ~3h run



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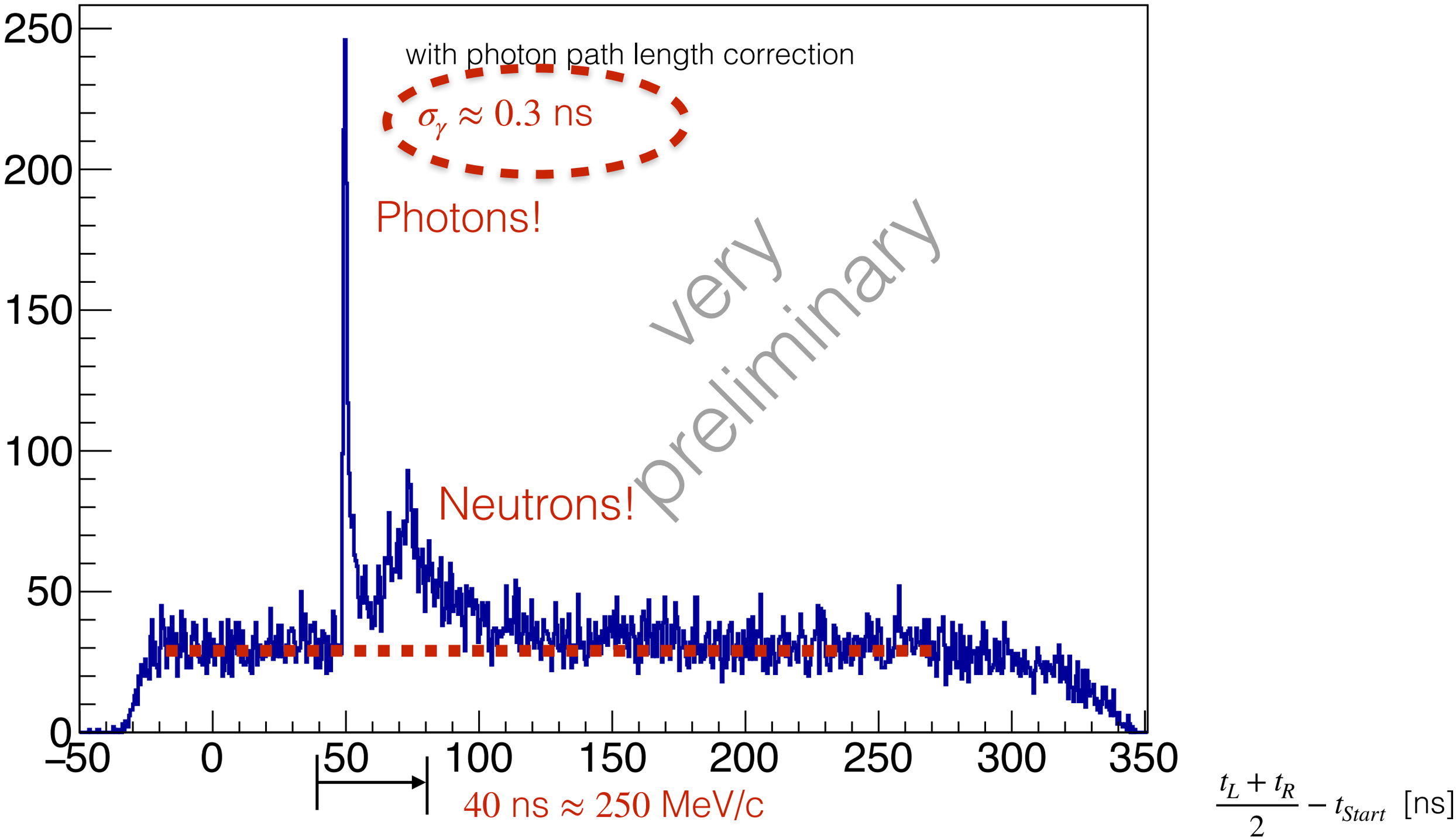

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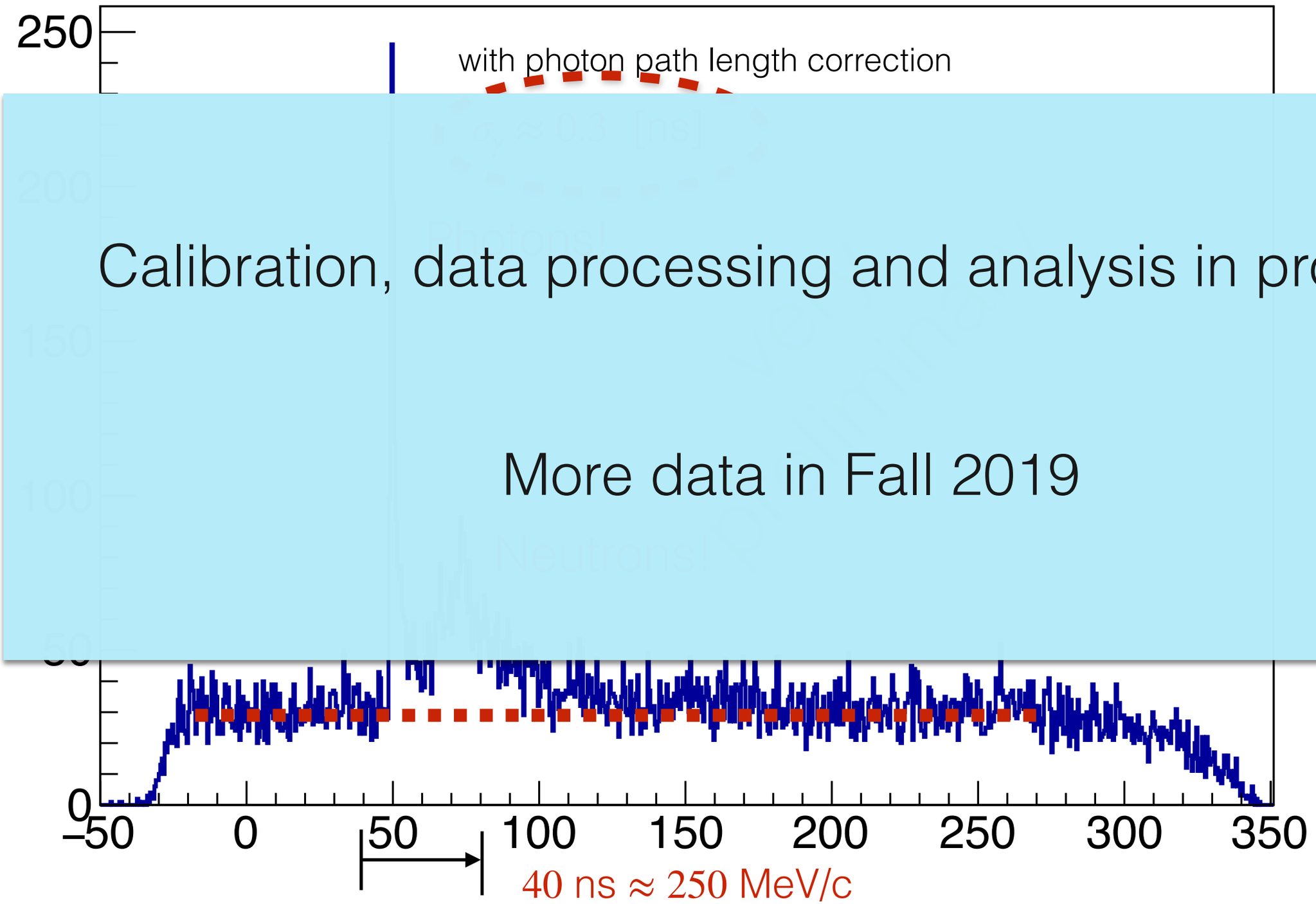
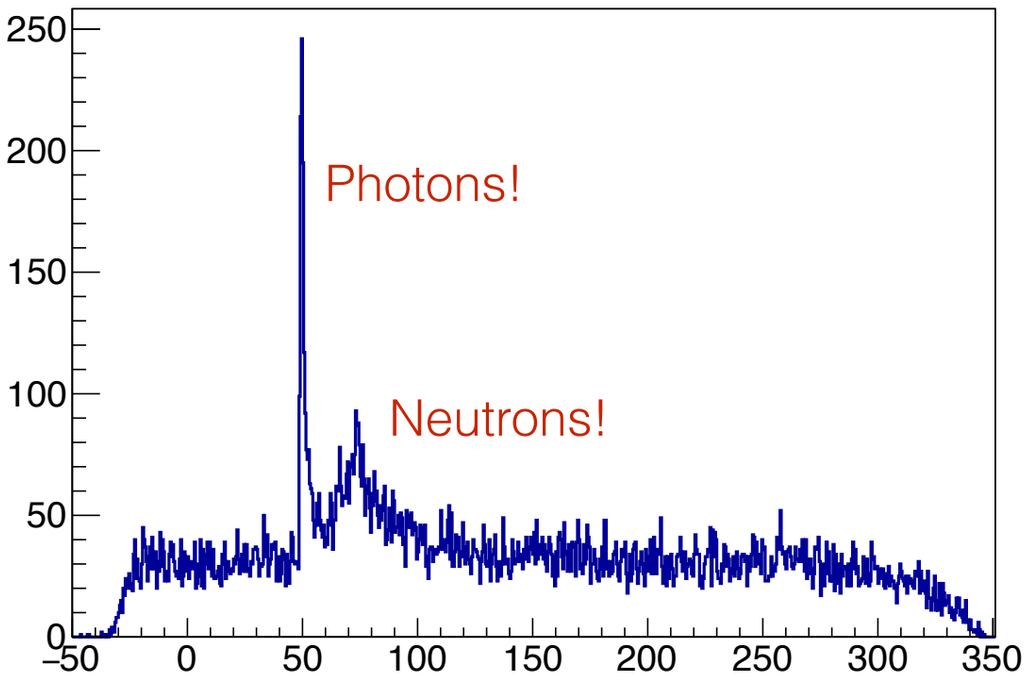


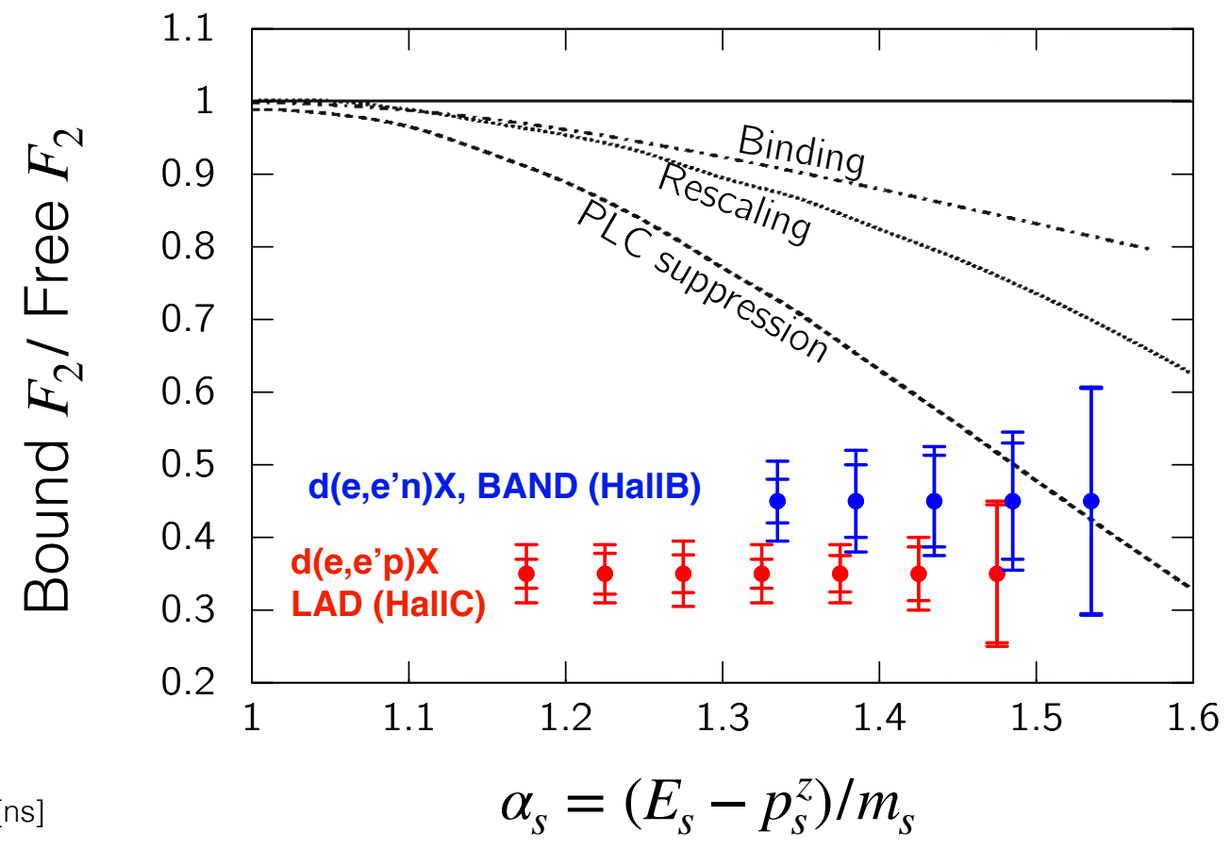
Calibration, data processing and analysis in progress

More data in Fall 2019

Summary and Outlook

- Tagged DIS measurements to explain EMC effect
- Measurement of F2n in Hall C with LAD 2021???
- Measurement of F2p with CLAS12 plus BAND
  - Spring and fall 2019
  - Backward going neutrons clearly seen
  - Data analysis under way



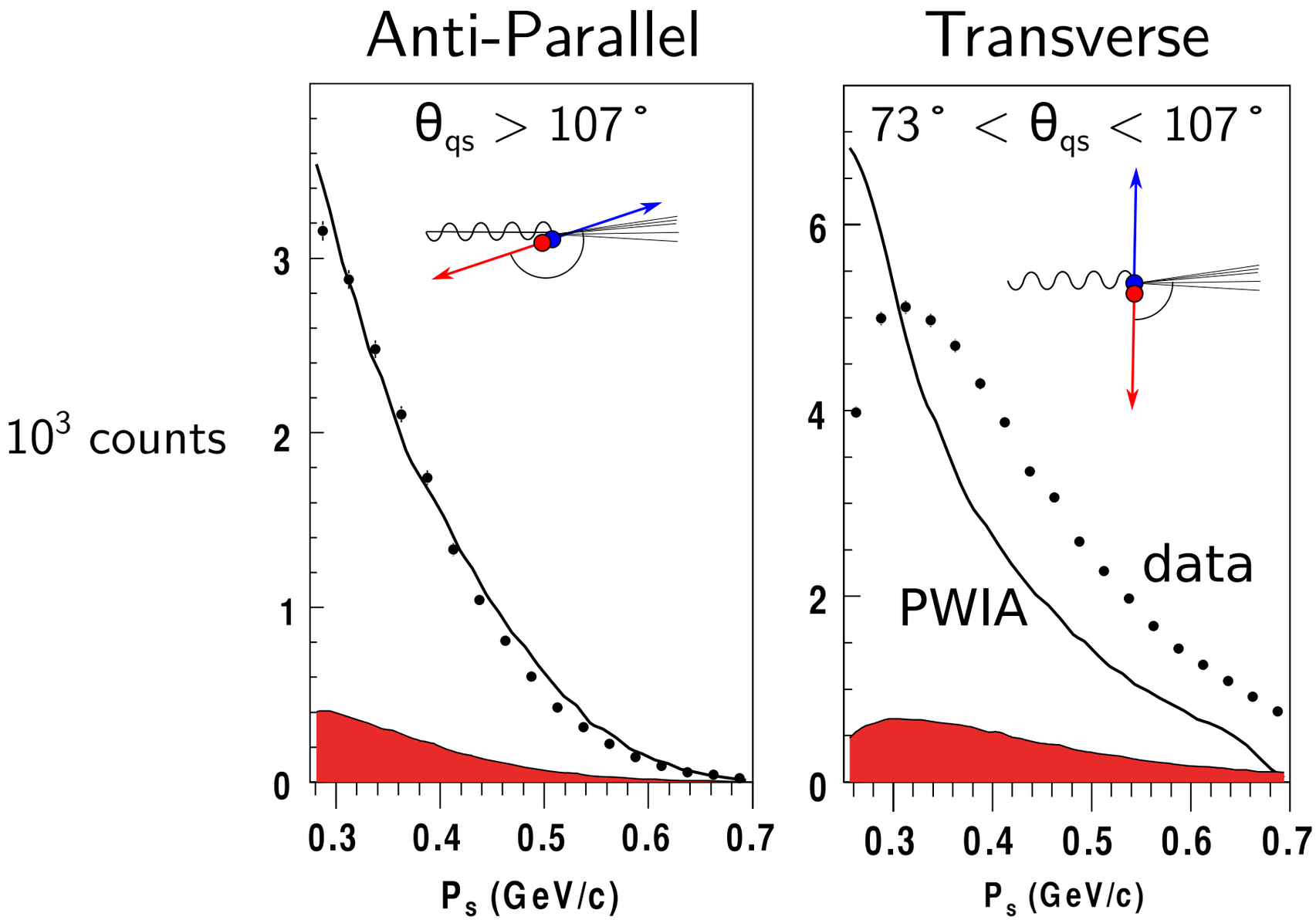


Many thanks to the BAND crew Rey and Efrain

Back up slides

FSI in Tagged DIS

DEEPS showed little FSI at back angles.

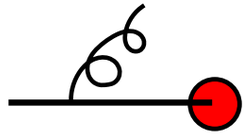
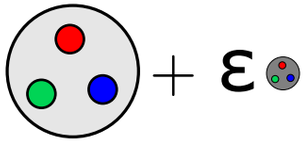
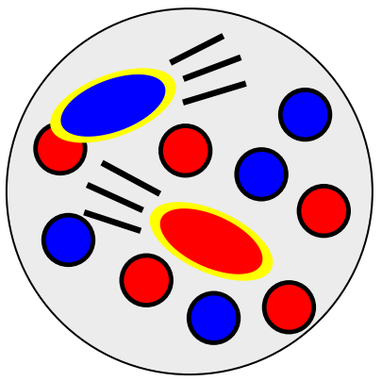
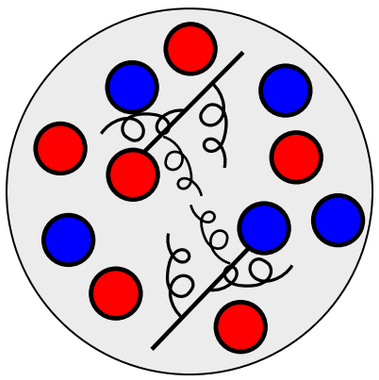
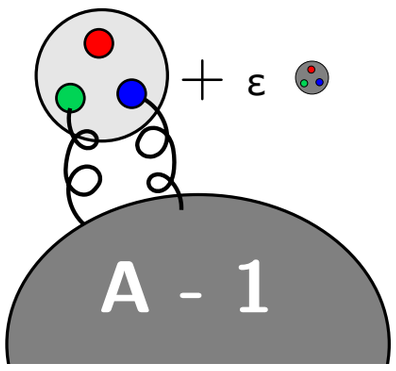


Klimenko et al., PRC 73 035212 (2006)

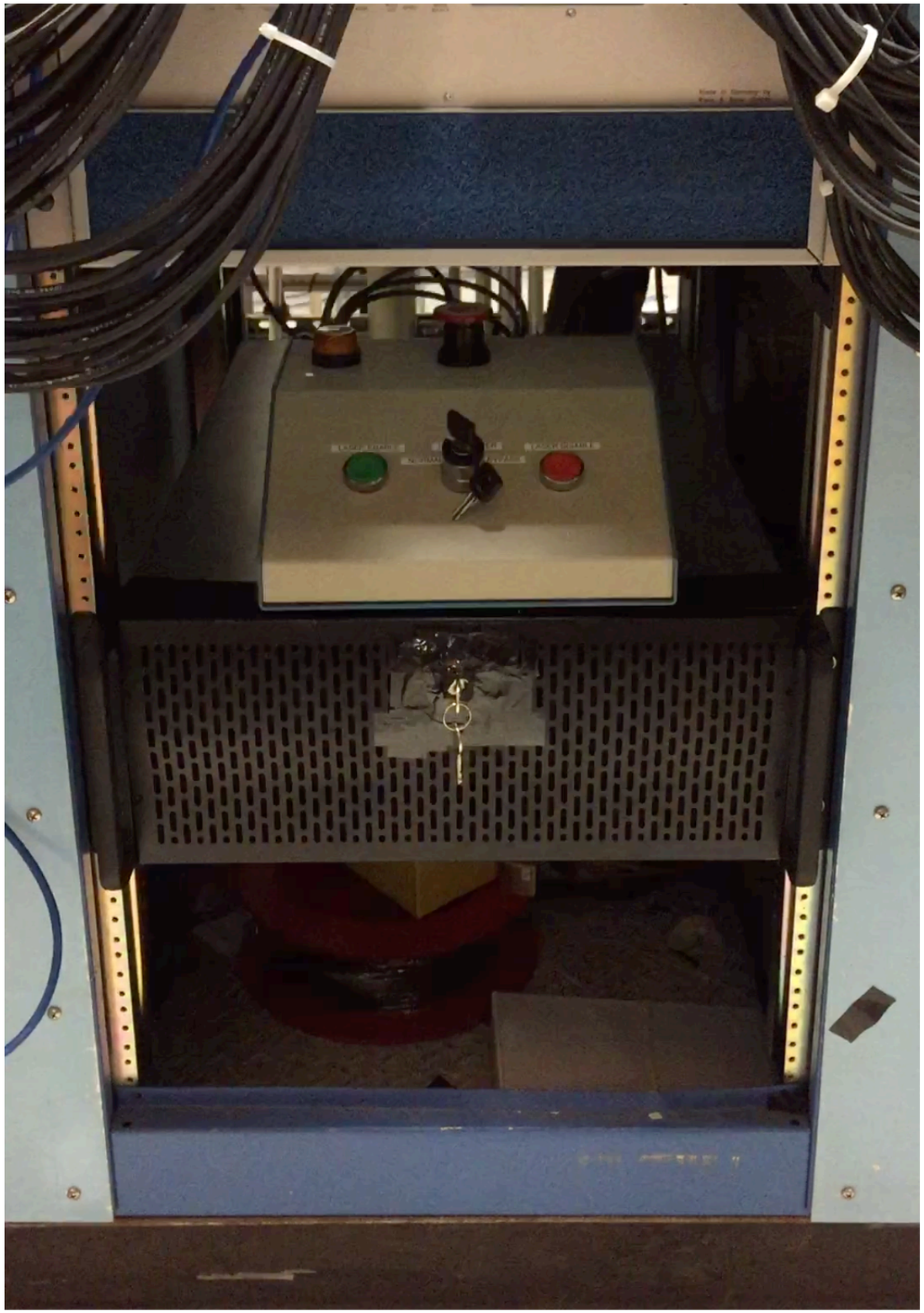
BAND Experimental Conditions

- Data taking during Run Group B of CLAS12
- Approved for 180 days (90 PAC days)
- ~50% of approved beam time in spring and fall 2019
- 11 GeV electron beam
- 10^{35} $cm^{-2}s^{-1}$ luminosity
- Scattered e’ in CLAS12

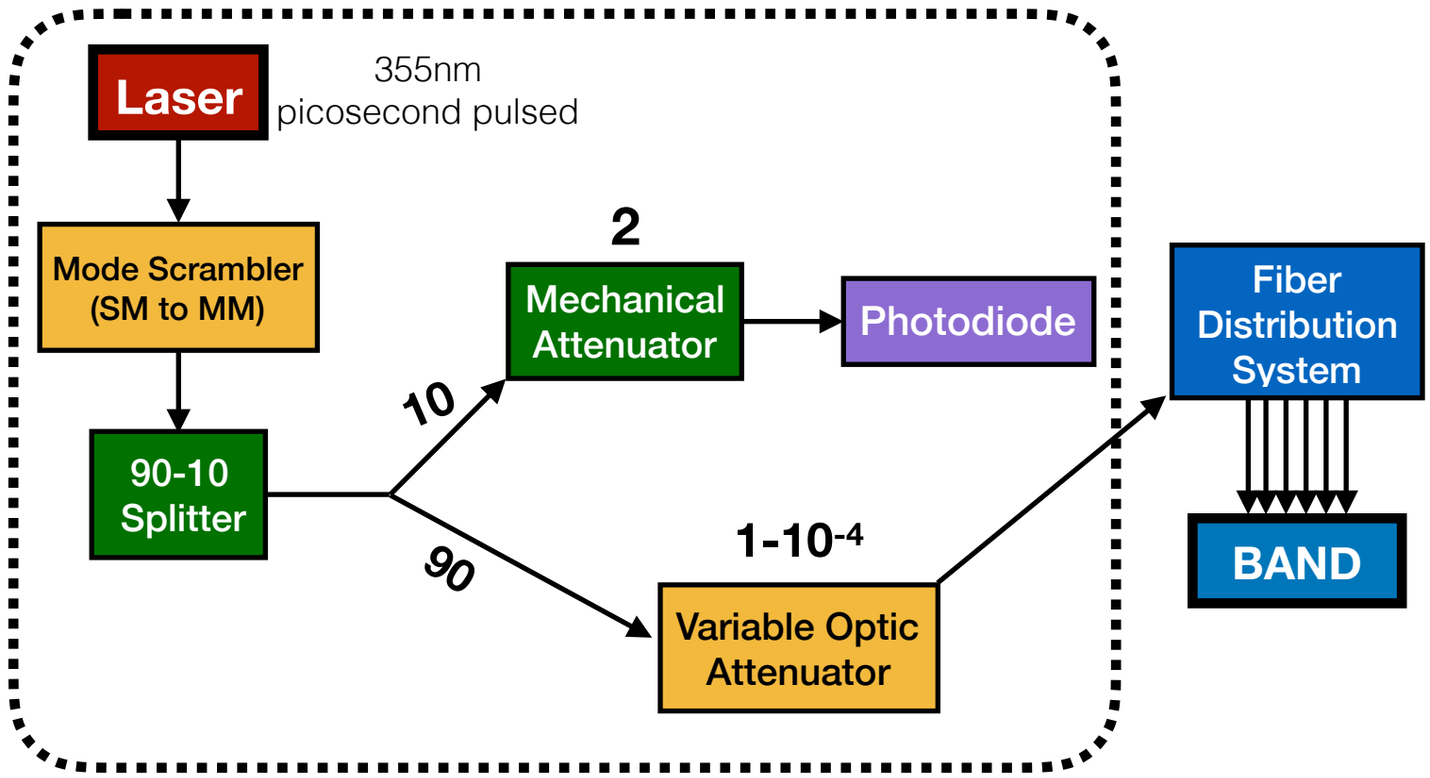
Theories

	Binding	Rescaling	Point-like Configuration Suppression
Free			
Bound			

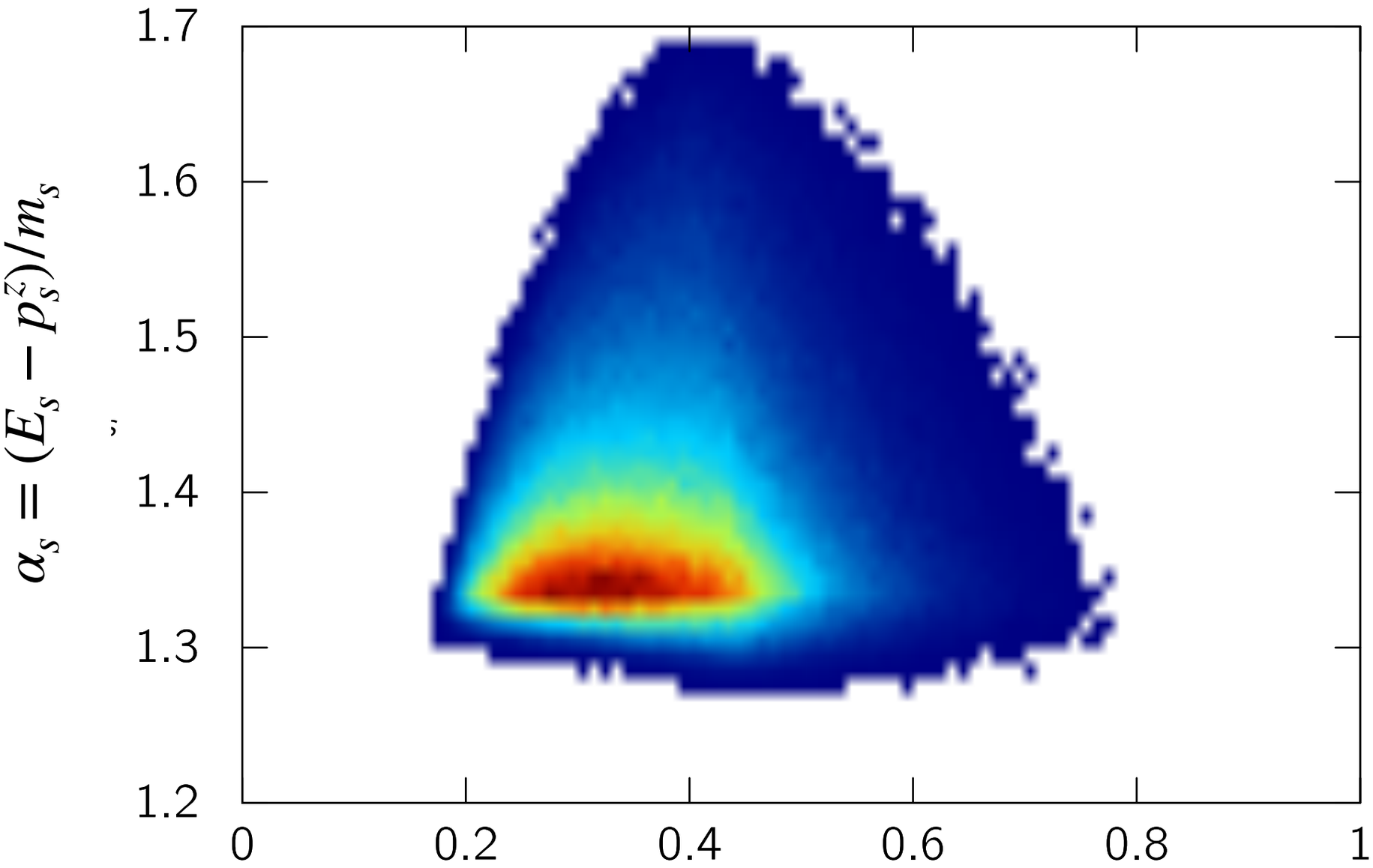
Laser System



Used to monitor PMT stability



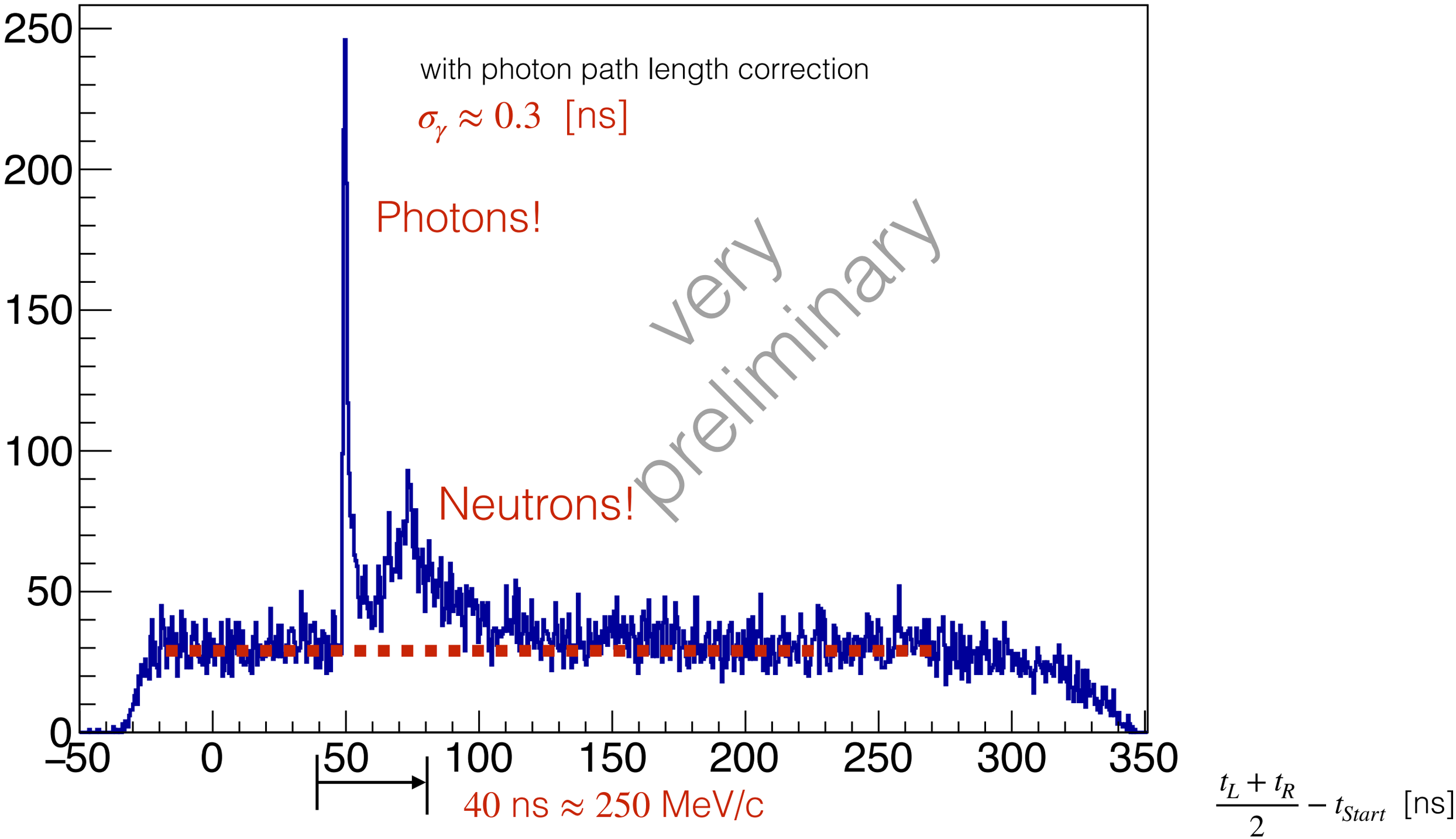
BAND Kinematical Coverage



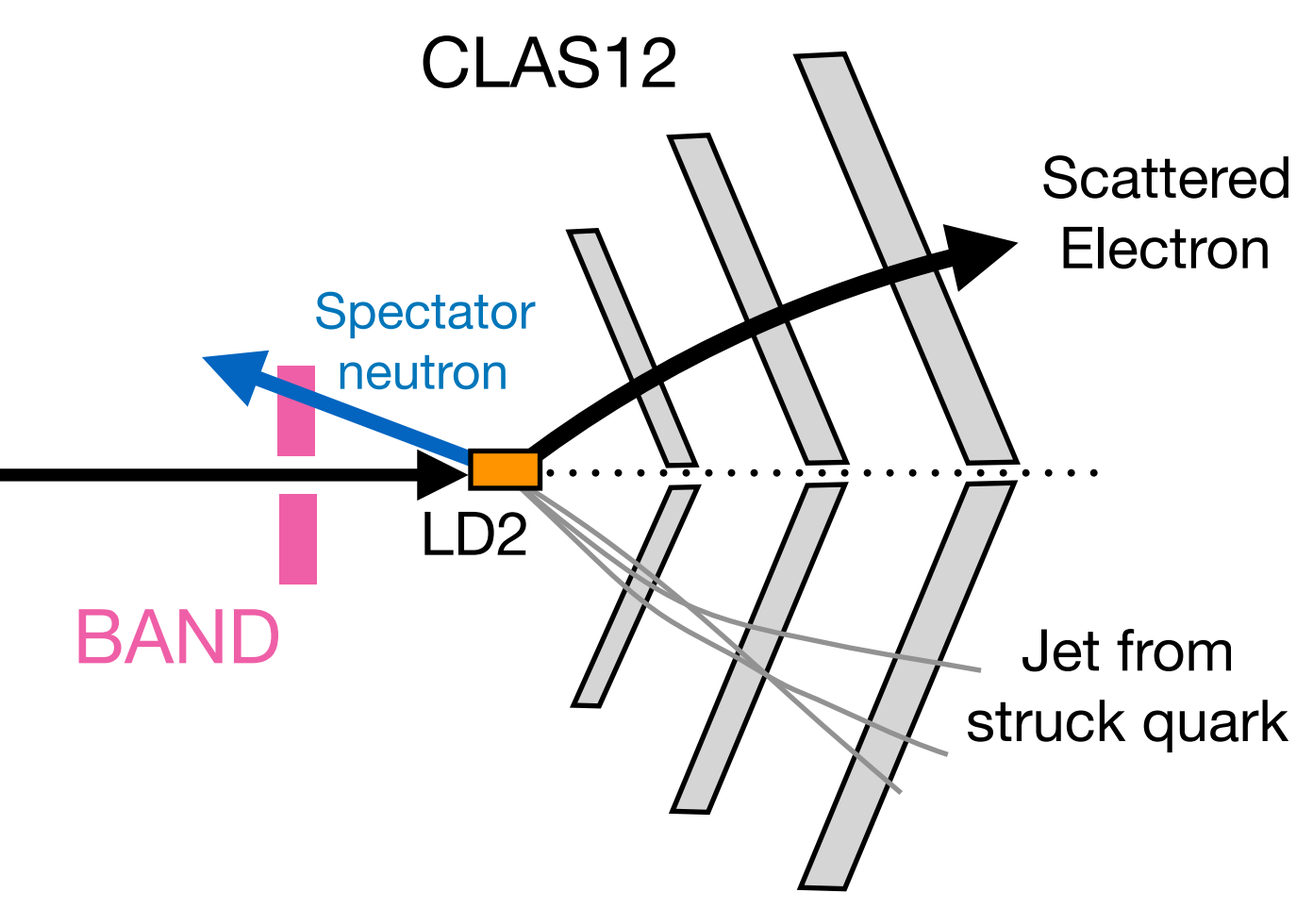
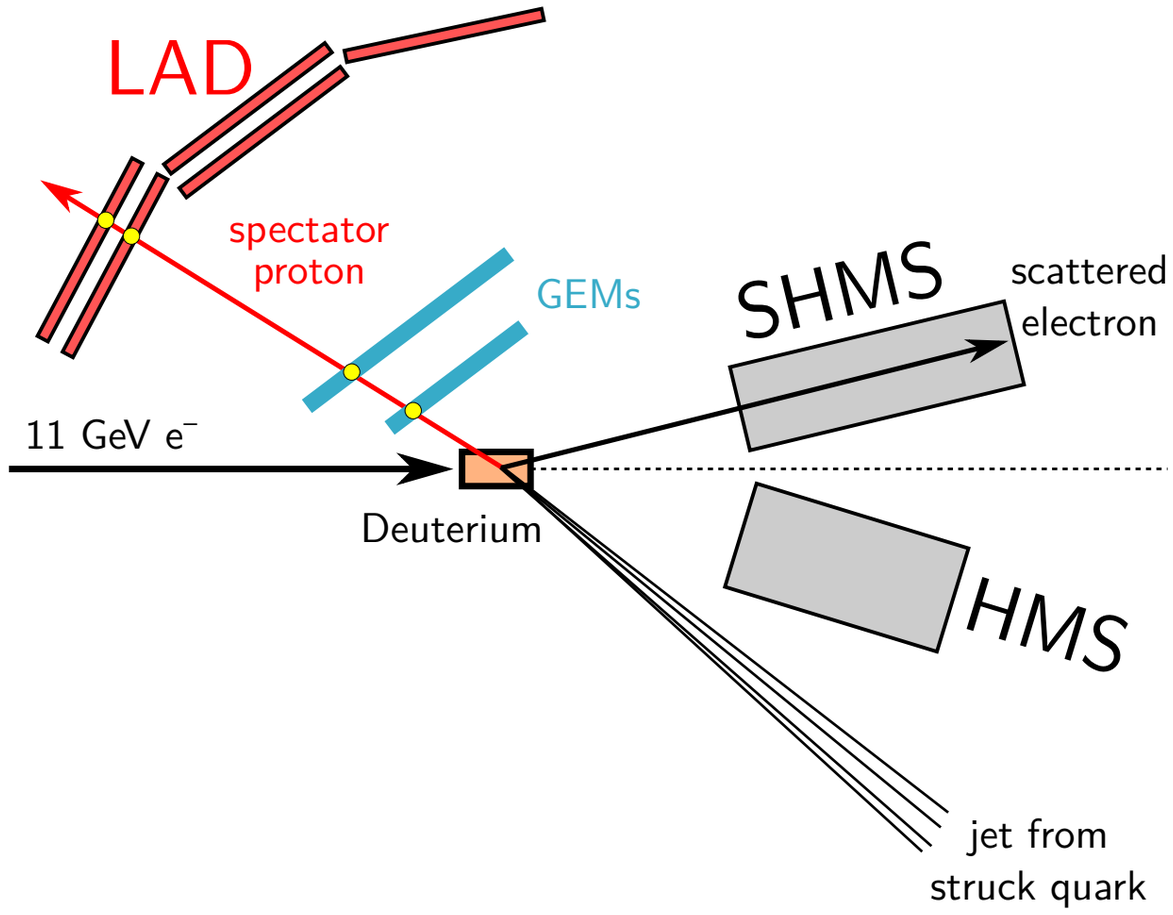
$$x_B^{'} = \frac{Q^2}{2[(M_d - E_s)\omega + \vec{p_s} \cdot \vec{q}\,]}$$

Time of Flight Distribution

All long bars in BAND, e' from CLAS, ~3h run



Tagged DIS at JLab

Hall B:
CLAS 12 + Backward Angle Neutron Detector (BAND)

Hall C:
SHMS/HMS + Large Angle Detector (LAD)