Tagged DIS on Deuterium at JLab

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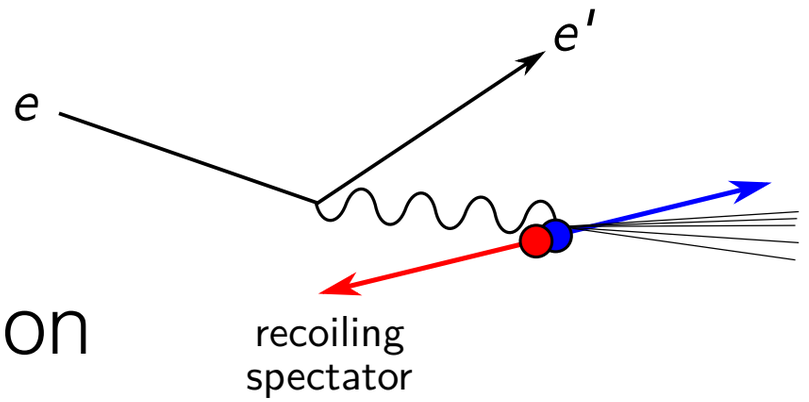
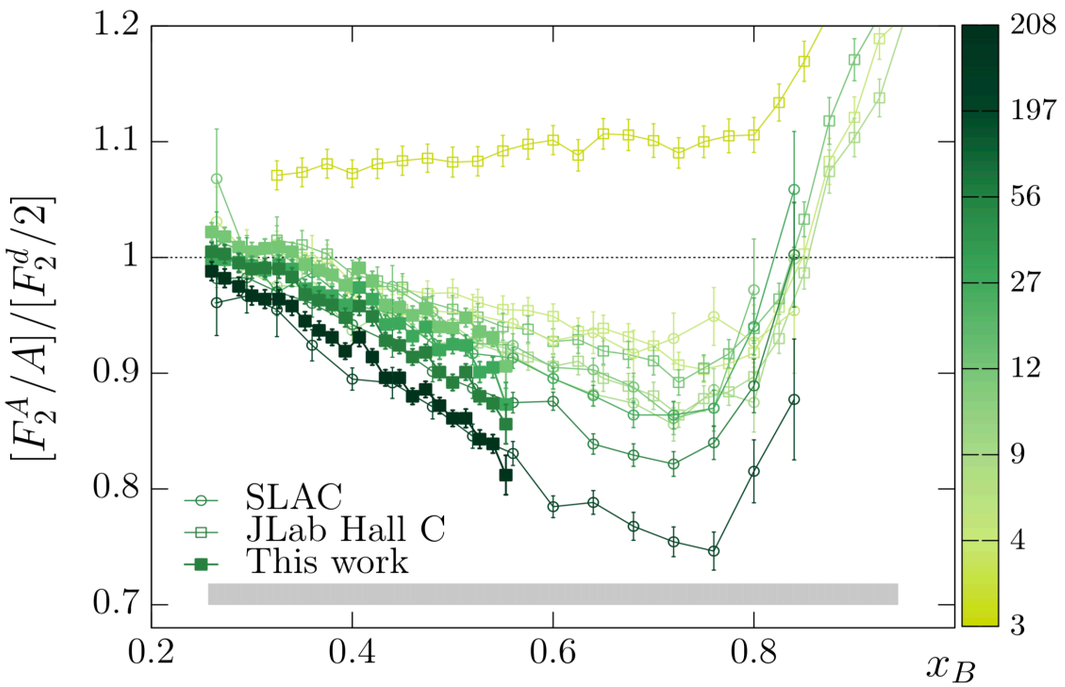
Outline

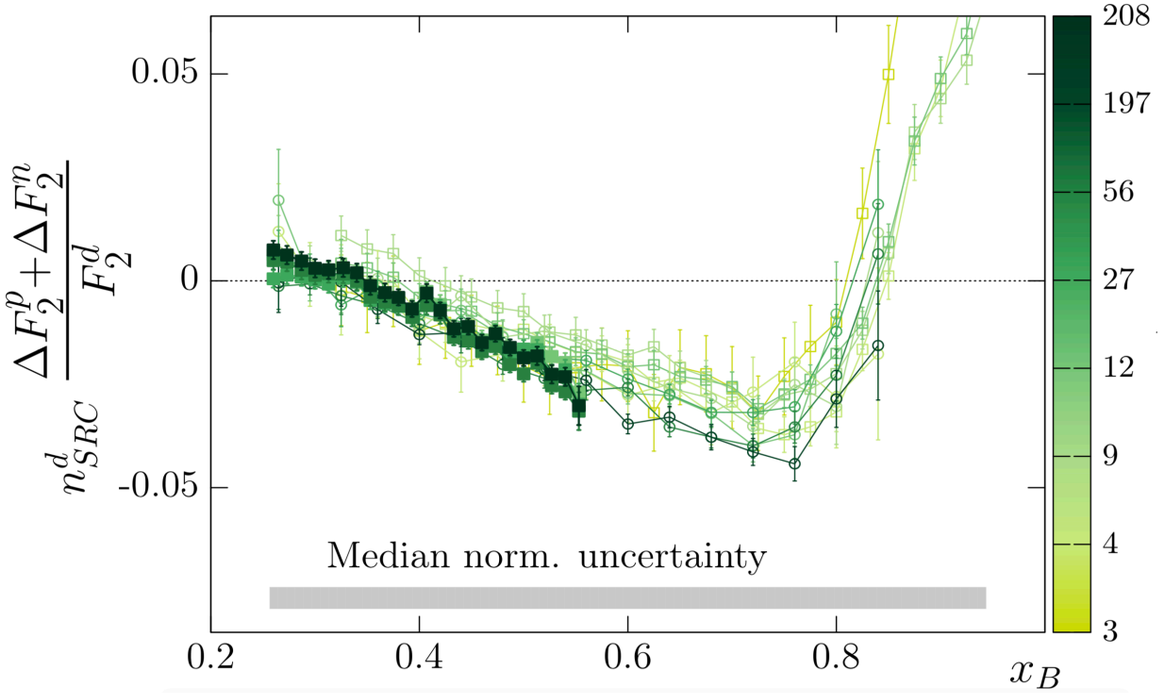
- Why tagged DIS
- HallB: Backward-Angle Neutron Detector (BAND)
- Calibration Status of BAND
- Very preliminary physics with BAND at CLAS
- Tagged DIS in HallC - LAD

Tagged DIS on Deuterium

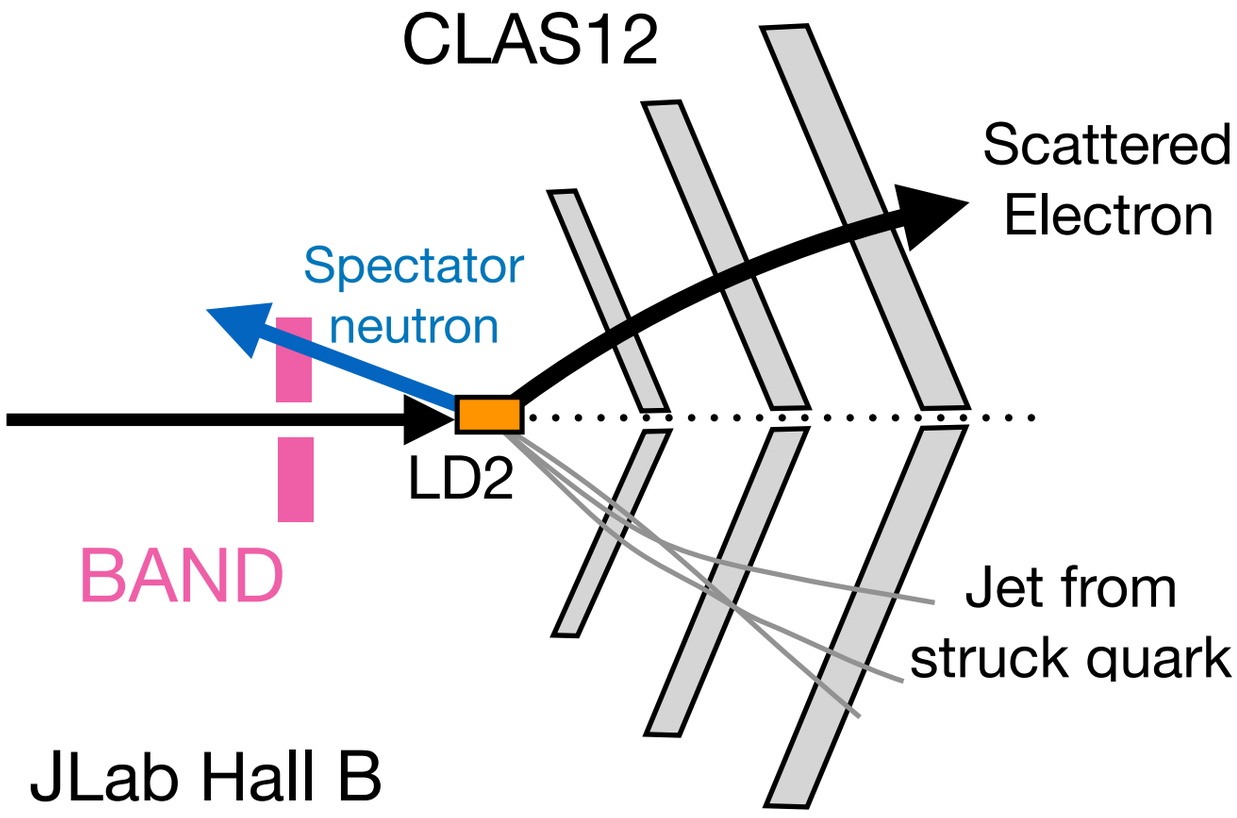
- "Tag" interacting nucleon by measuring spectator
- How does the bound nucleon structure function depends on nucleon momentum or virtuality
- Explaining the EMC effect



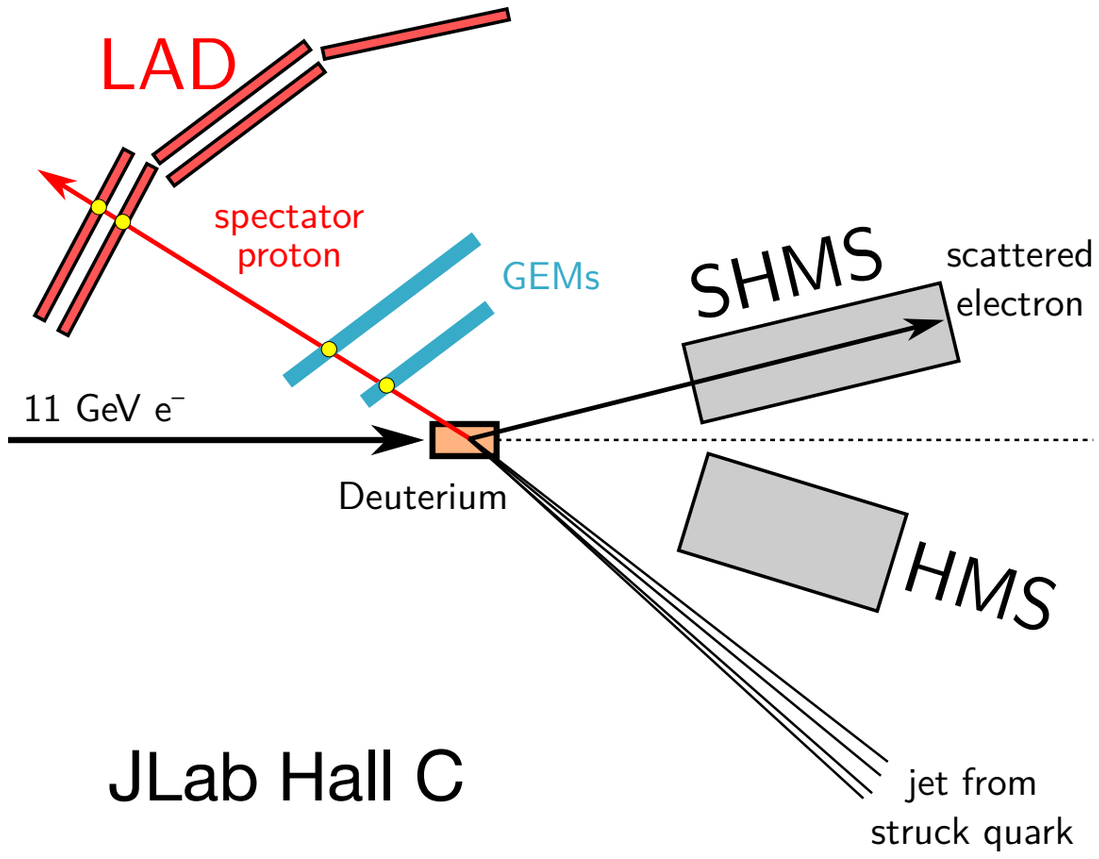




Tagged DIS at JLab



JLab Hall B



JLab Hall C

What will be measured

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

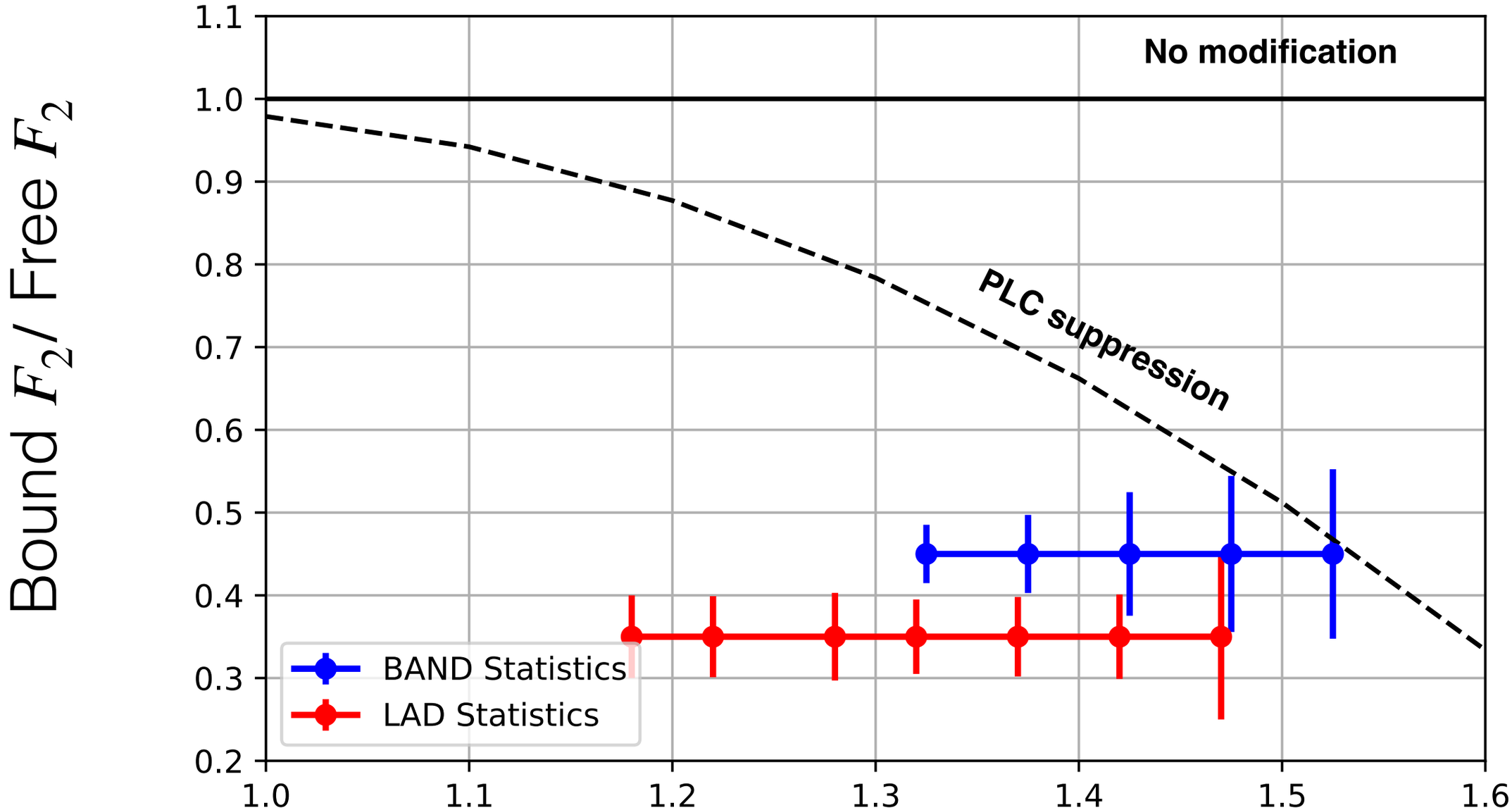
$$\frac{\sigma_{DIS}(x'_{\text{high}}, Q_1^2, \alpha_s)}{\sigma_{DIS}(x'_{\text{low}}, Q_2^2, \alpha_s)} \cdot \frac{\sigma_{DIS}^{\text{free}}(x_{\text{low}}, Q_2^2)}{\sigma_{DIS}^{\text{free}}(x_{\text{high}}, Q_1^2)} \cdot R_{FSI} = \frac{F_2^{\text{bound}}(x'_{\text{high}}, Q_1^2, \alpha_s)}{F_2^{\text{free}}(x_{\text{high}},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

measurement theory

- $x'_{\text{high}} > 0.45$
- Expect no EMC effect at low x': $0.25 \leq x'_{\text{low}} \leq 0.35$

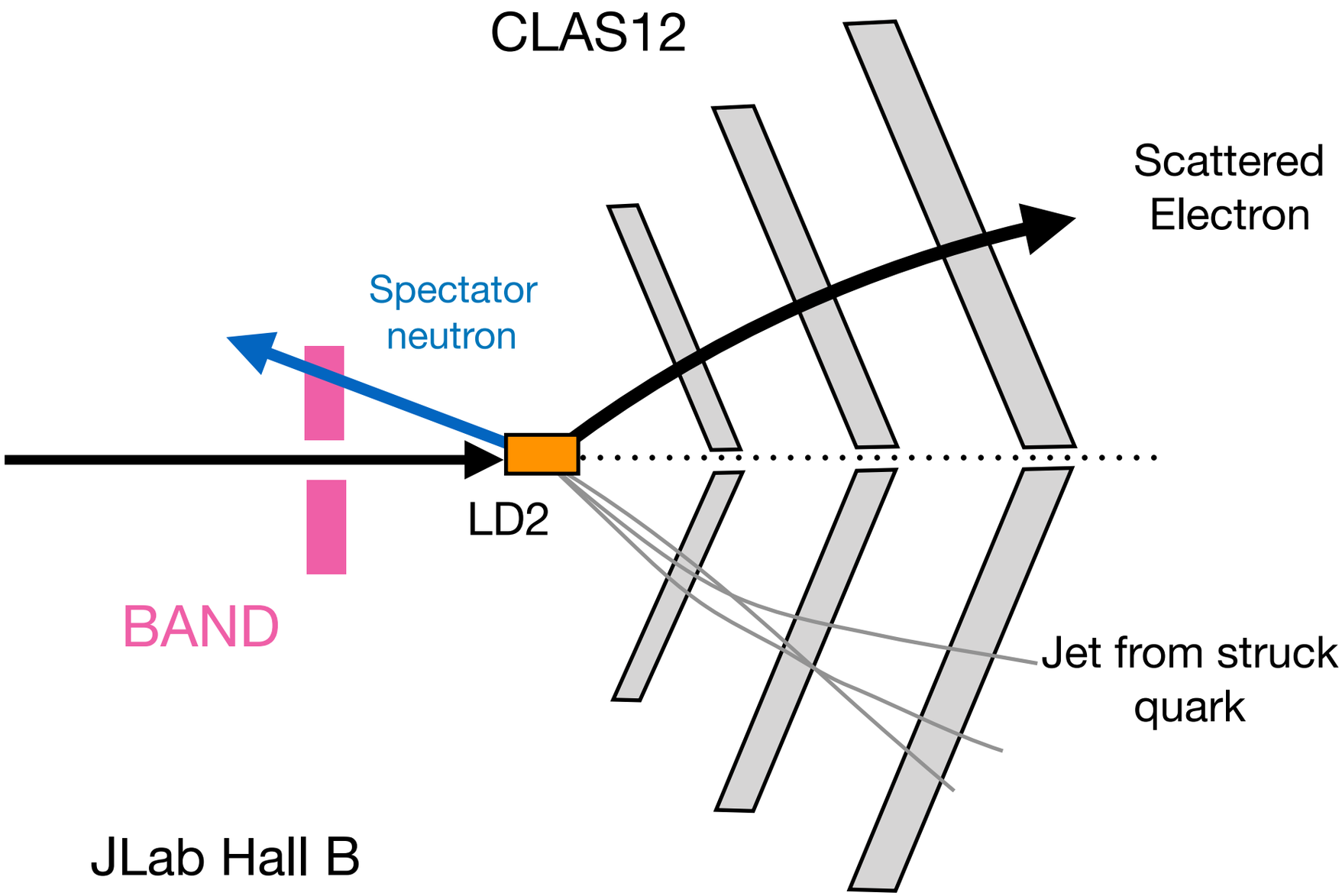
$$x'_B = \frac{Q^2}{2[(M_d - E_s)\omega + \vec{p_s} \cdot \vec{q}]} \qquad x_B = \frac{Q^2}{2m_N\omega} \qquad \alpha_s = (E_s - p_s^z)/m_s$$

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



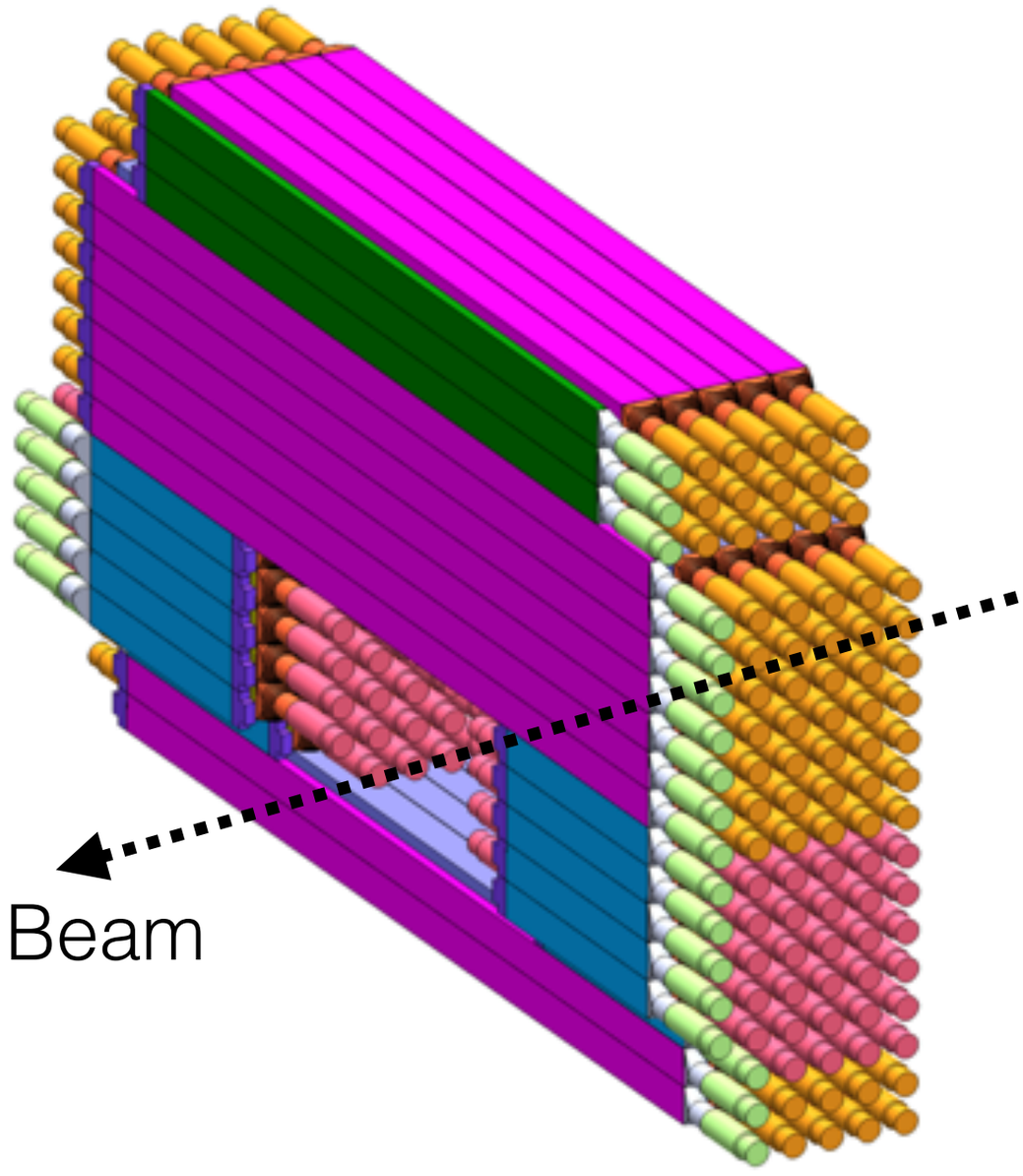
$$\alpha_s = (E_s - p_s^z)/m_s$$

BAND in HallB

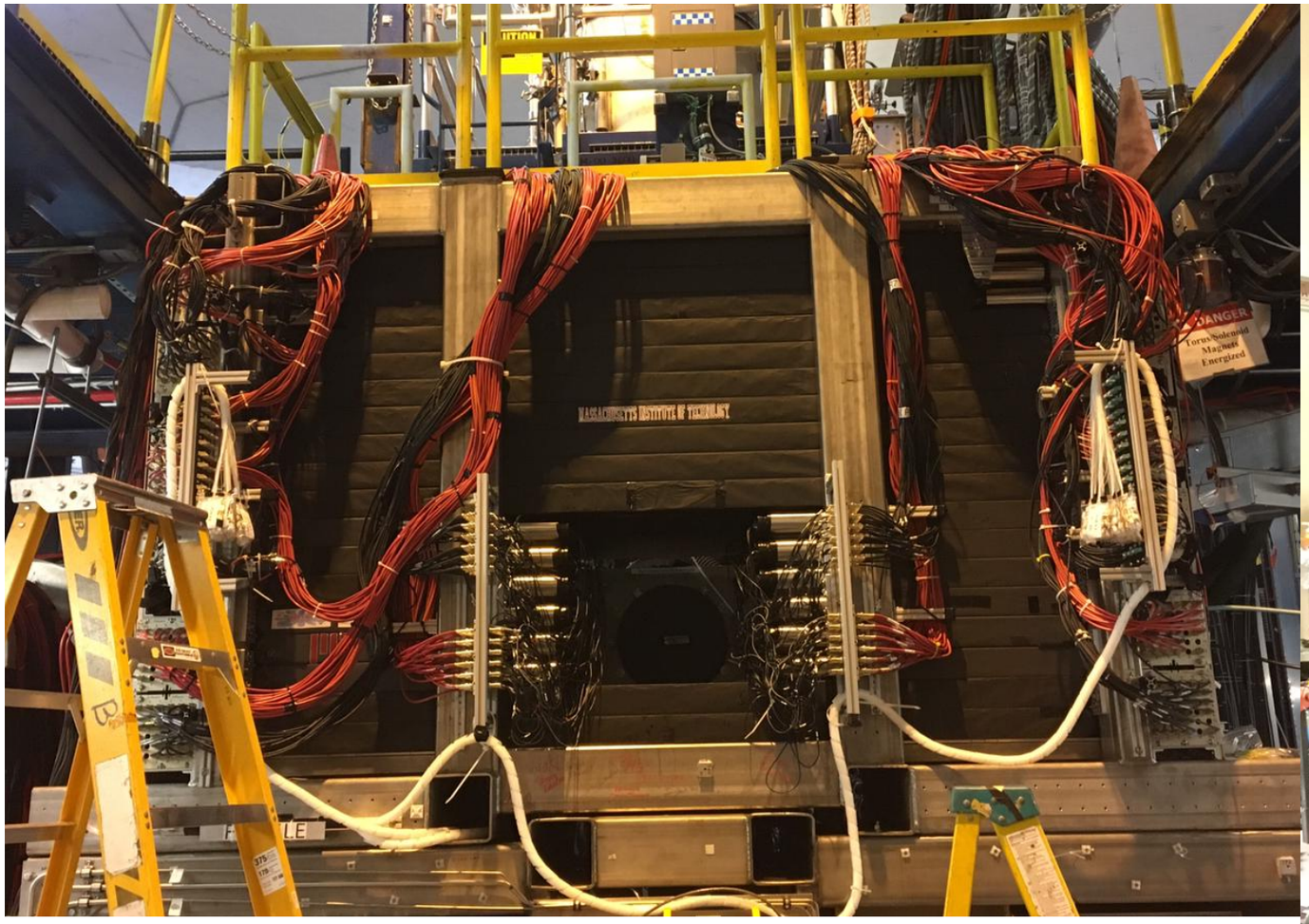


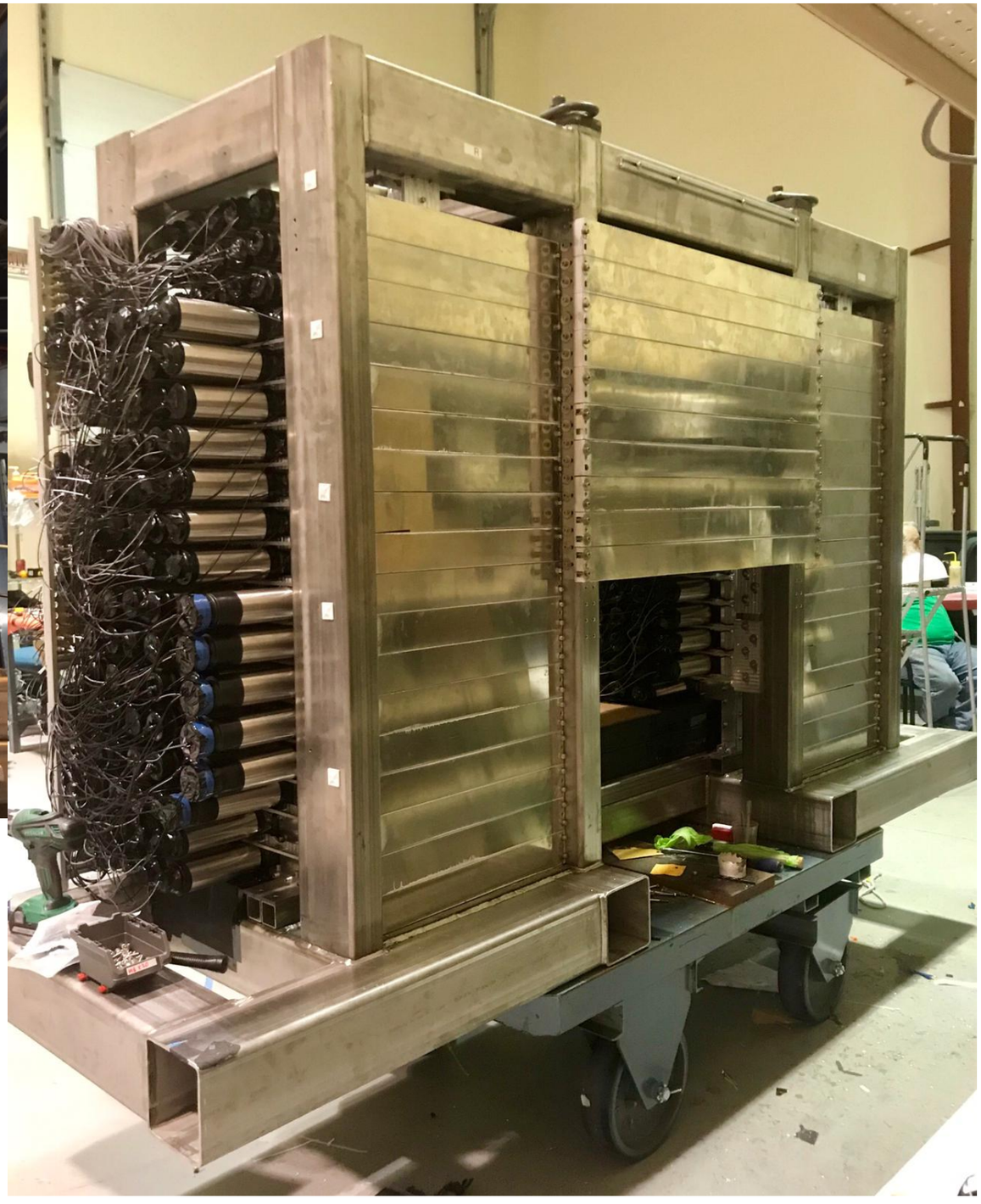
Overview of BAND

- 5 layers thick (36cm total) with veto layer (1cm thick)
- 140 bars
- Bar resolutions < 200 ps
- 3 meters upstream target cell, coverage in θ ~ 155-176°
- Design neutron efficiency ~35% and momentum resolution ~1.5% (*to be studied*)



Re-commissioning of BAND





- Laser system and fiber cables
- Mechanics and electronics
- Calibration on laser, cosmics, and sources

Base Level Calibrations

Cosmic Data

Source Data

- TDC/FADC phase offset
- TDC time walk
- Bar attenuation
- Timing offsets

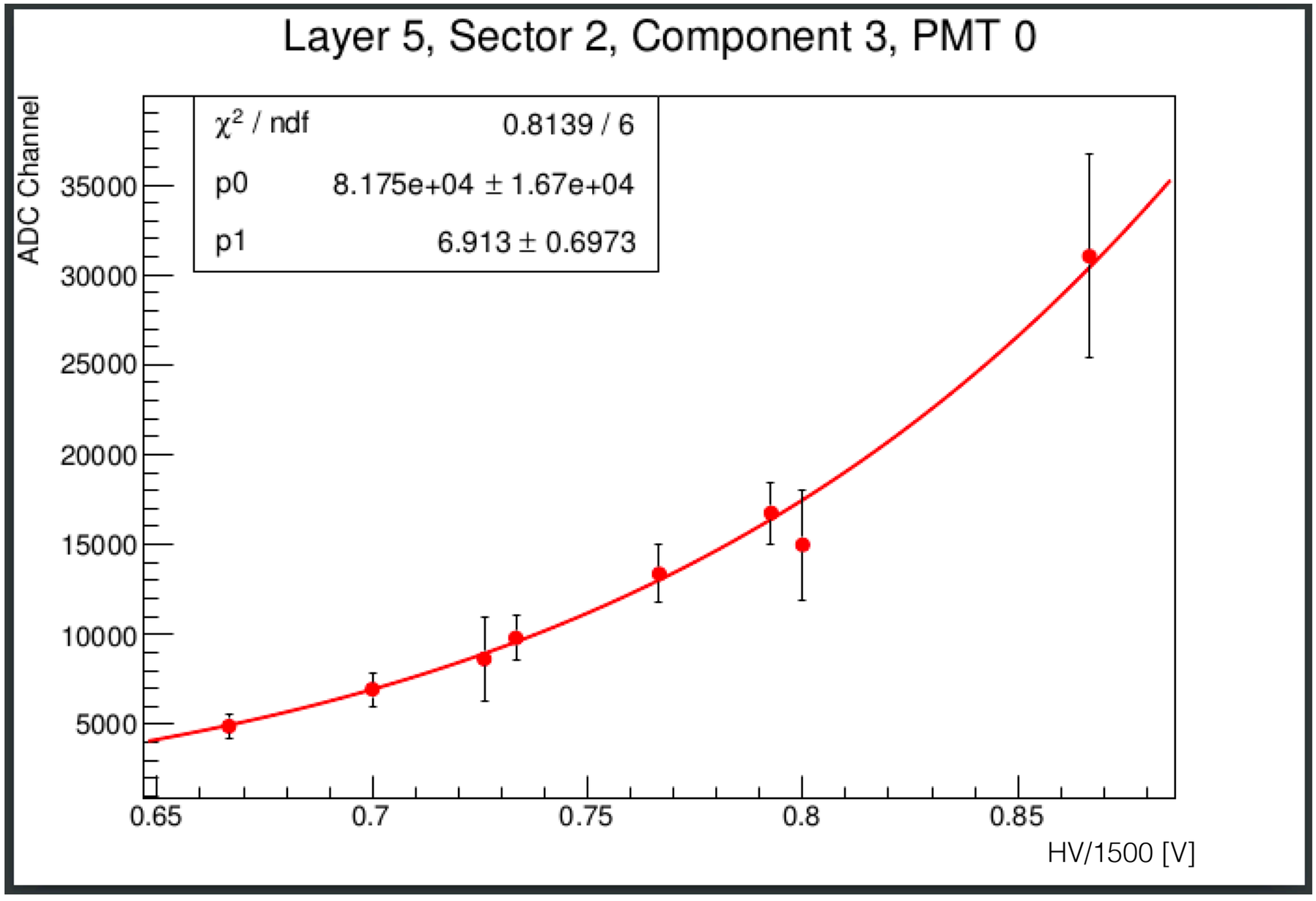
Laser Data

- Effective velocity

Prod Data

- Neutron efficiency
- Neutron momentum resolution

Gain Curves: Optimizing HV

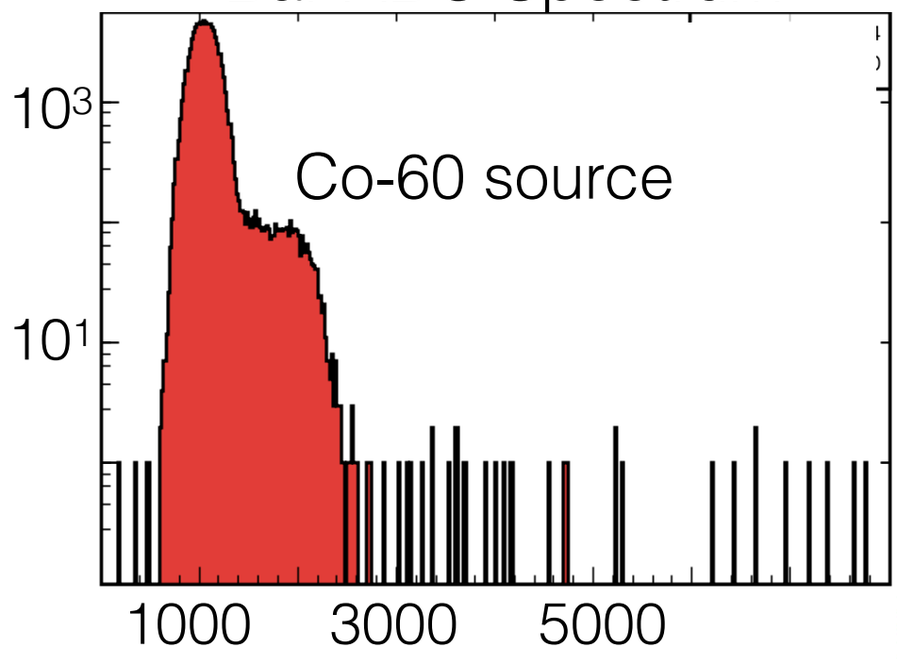


$$\text{ADC} = p_o \left(\frac{\text{HV}}{1500} \right)^{p_1}$$

Have most ADC channels possible for neutrons while not driving PMTs into non-linearity

Calibrating ADC to MeVee

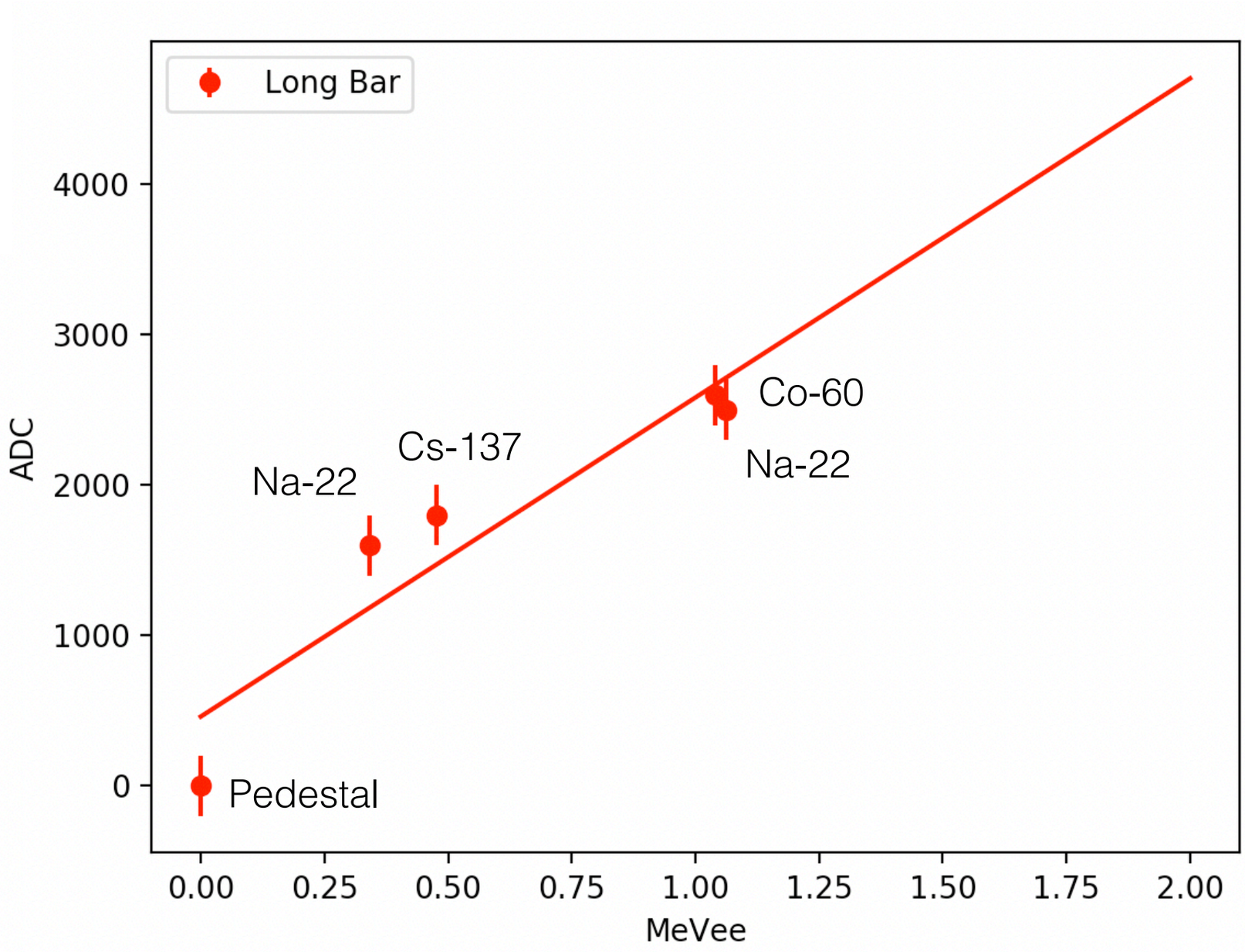
Bar ADC Spectrum



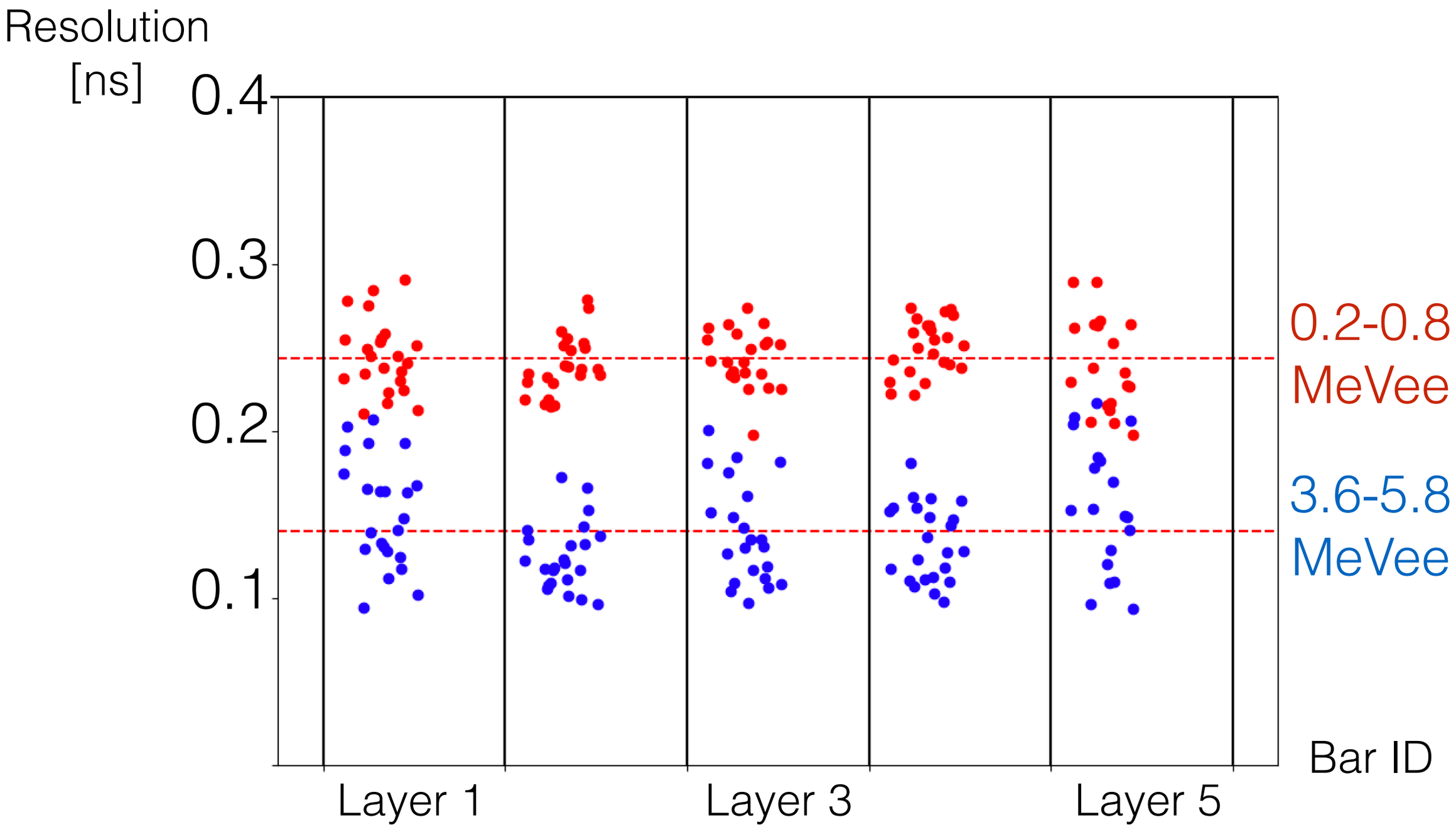
$$\sqrt{\mathrm{ADC}_L \cdot \mathrm{ADC}_R}$$

(MeVee =MeV Electron-Equivalent)

Planned software threshold of 2-3 MeVee

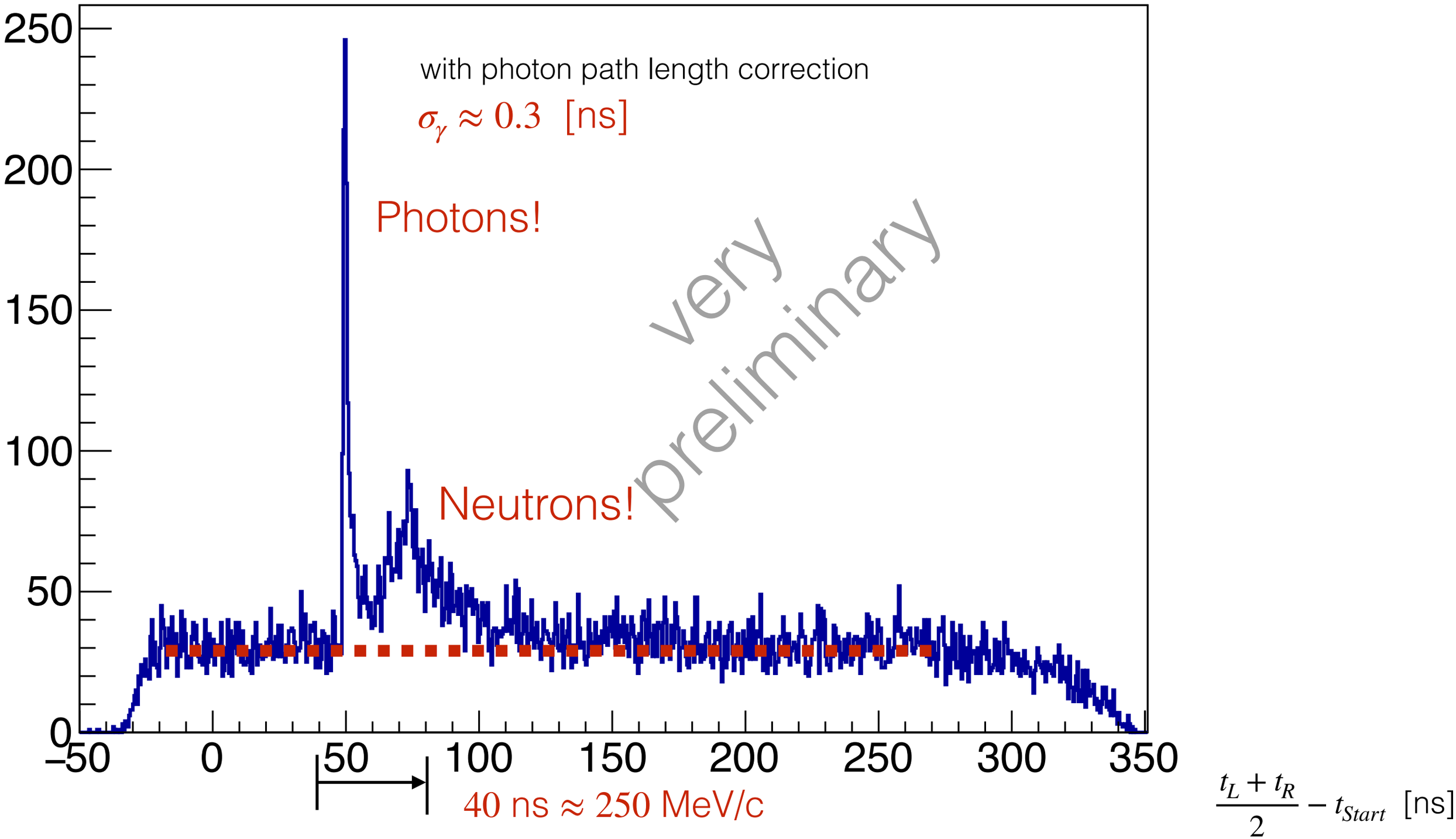


Resolutions of BAND Bars with Laser

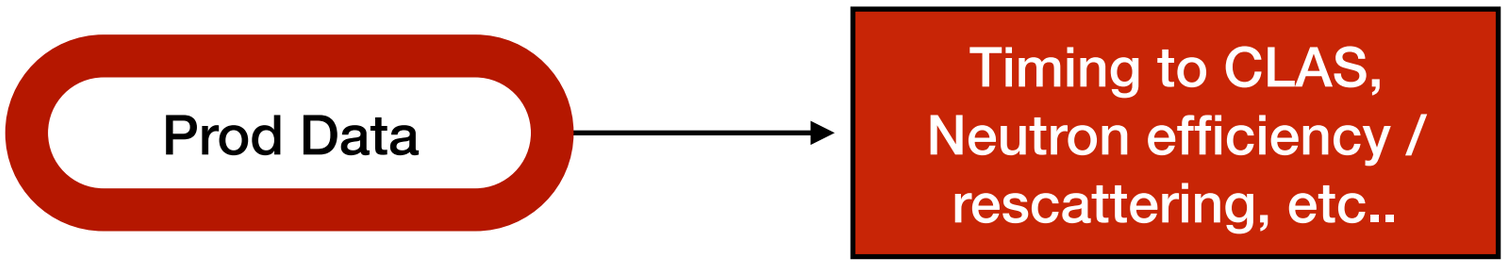


Time of Flight Distribution

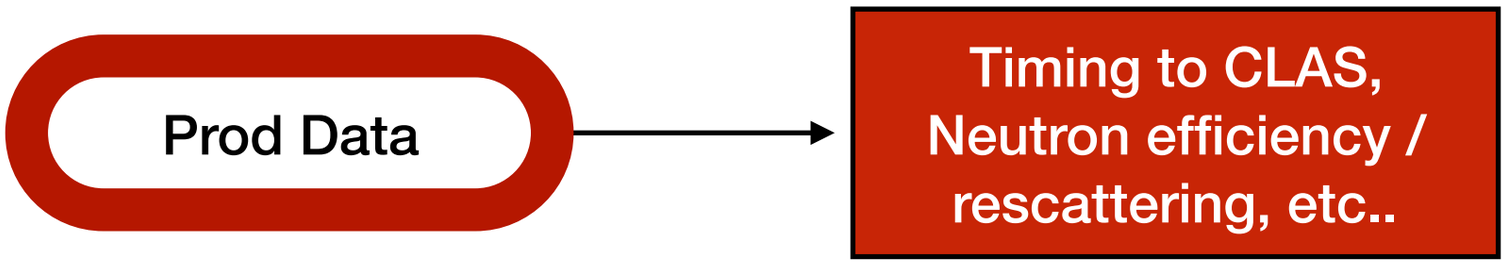
All long bars in BAND, e' from CLAS, ~3h run



BAND + CLAS


Prod Data
Timing to CLAS,
Neutron efficiency /
rescattering, etc..

BAND + CLAS



Calibrating with exclusive processes

$d(e, e'p)n$ (measure n efficiency)

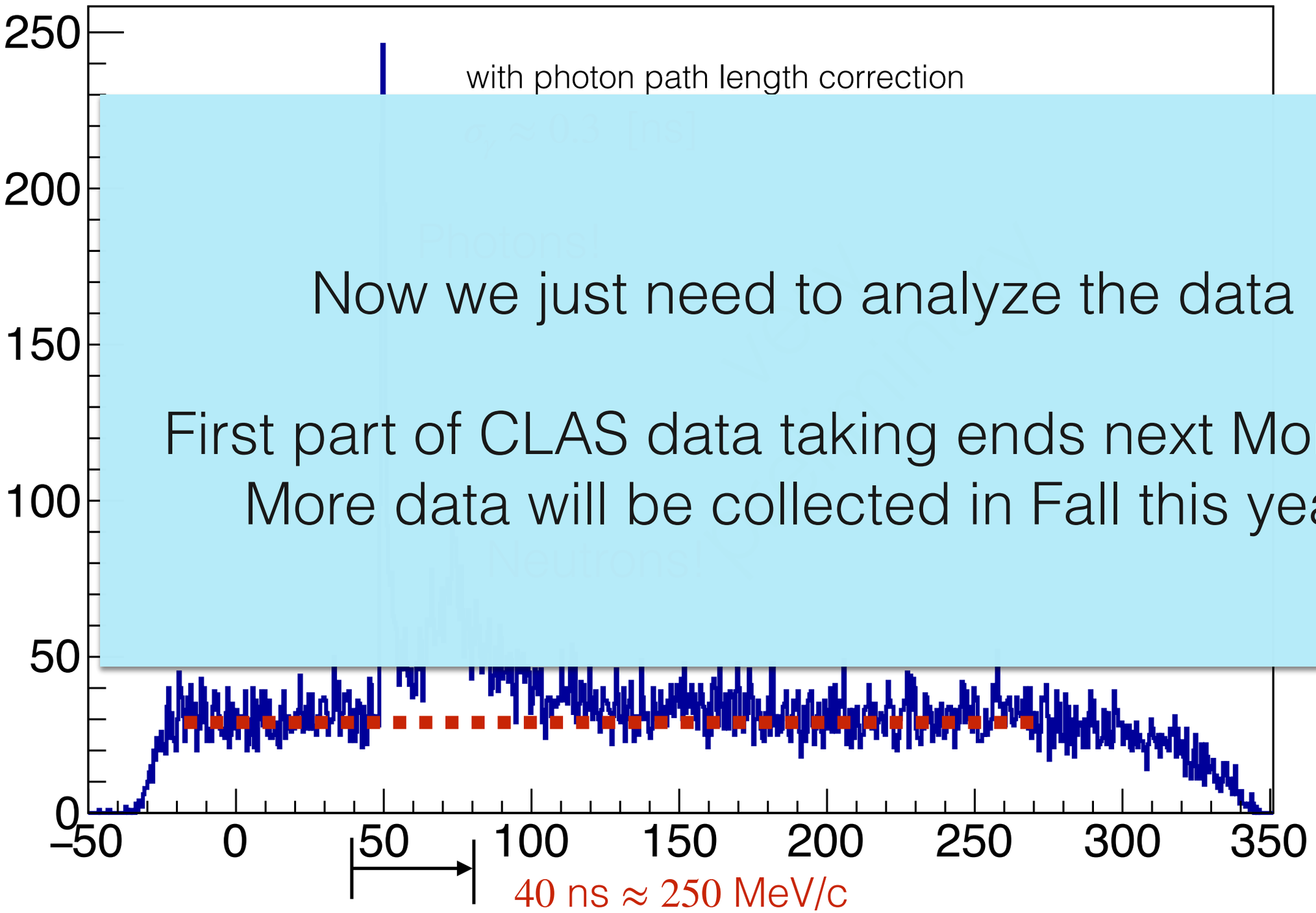
$d(e, e'p\pi^+\pi^-)n$ (measure n efficiency)

$d(e, e'pp\pi^-)$ (study resolution in CLAS)

Note 1: low energy run in fall to study neutron efficiency due to currently limited statistics
Note 2: Calibrations are too preliminary to study achievable resolution

Time of Flight Distribution

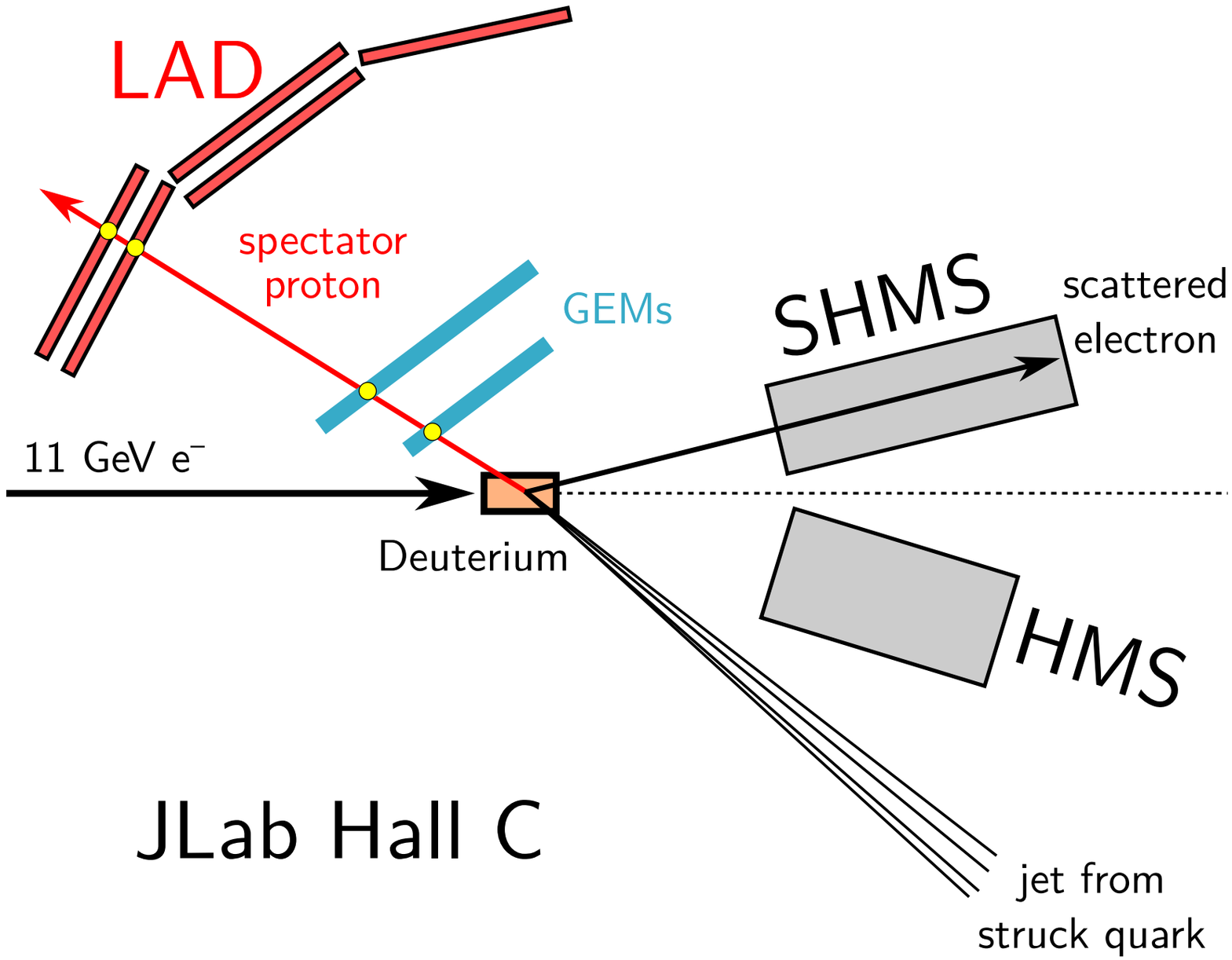
All long bars in BAND, e' from CLAS, ~3h run



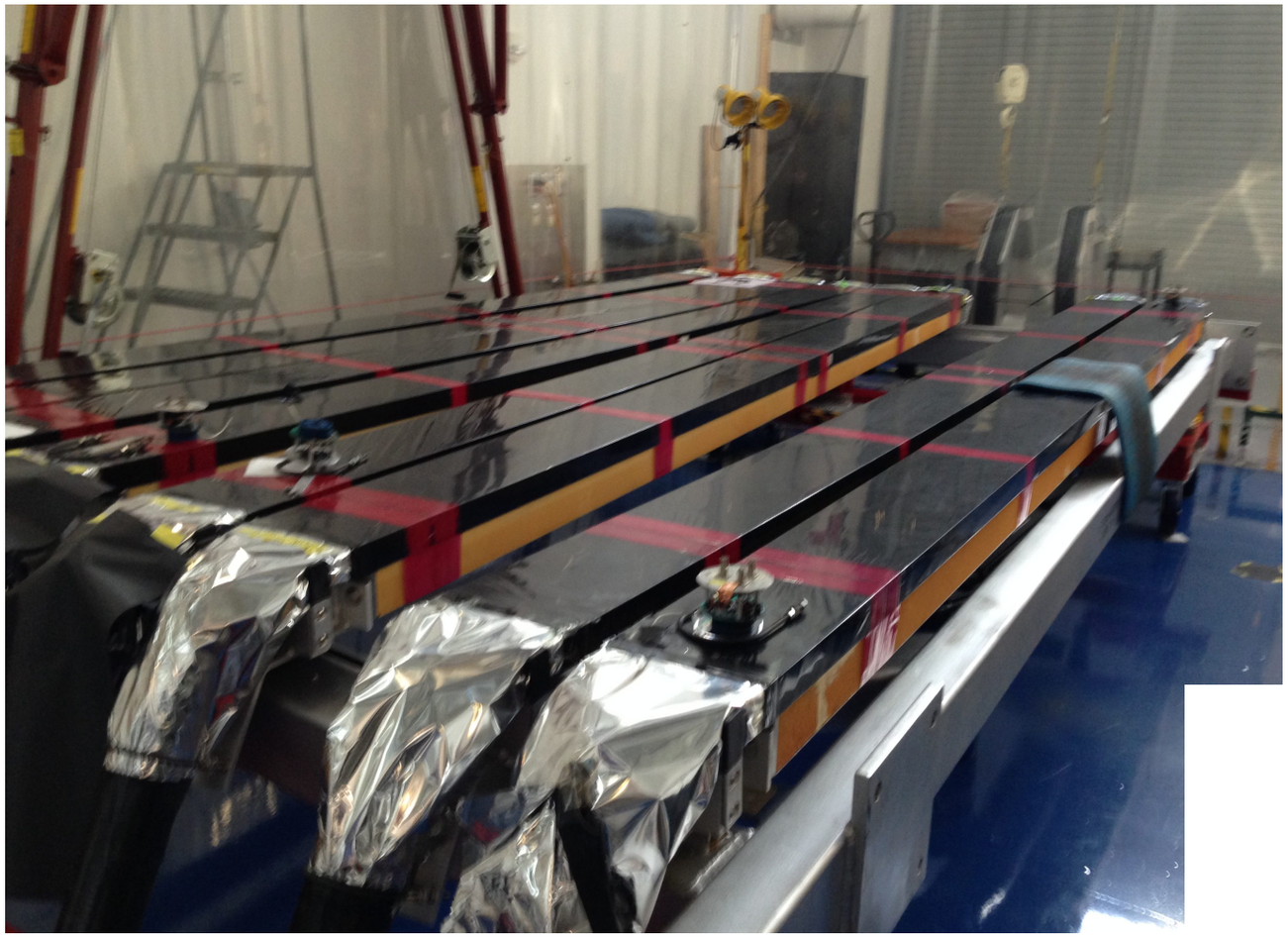
Now we just need to analyze the data

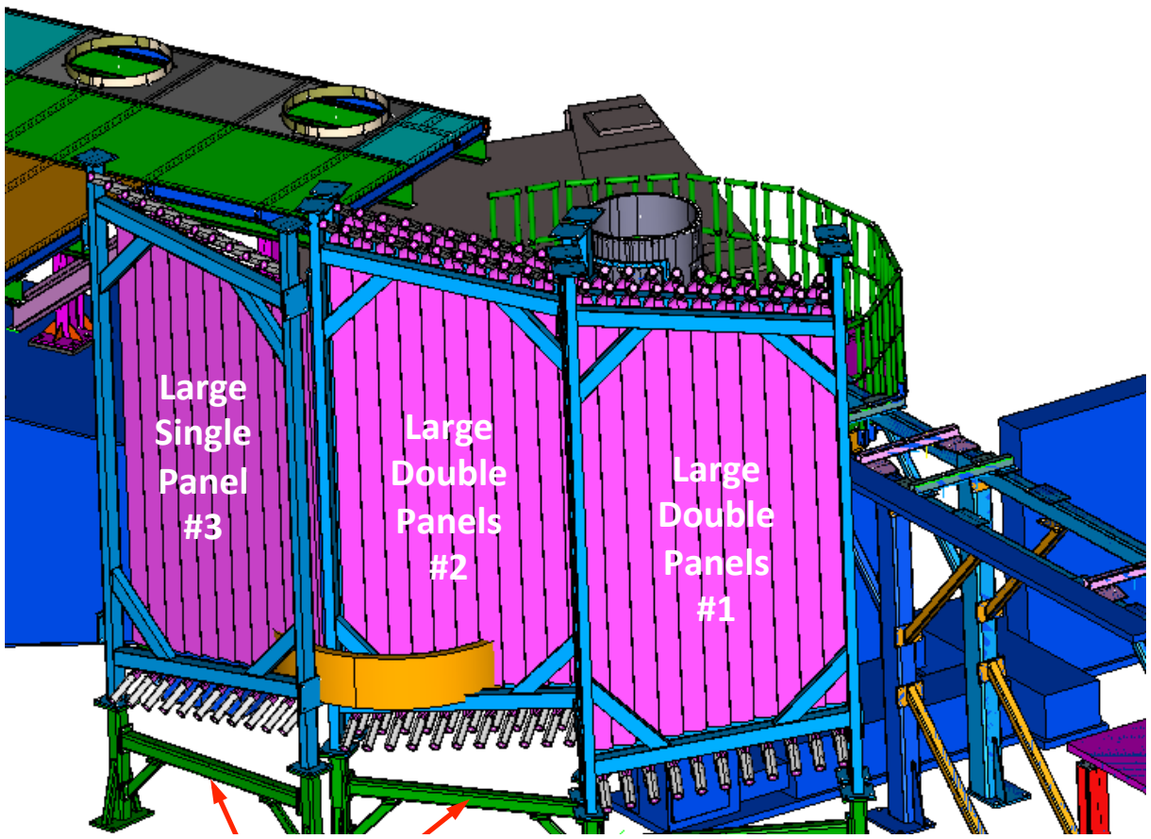
First part of CLAS data taking ends next Monday
More data will be collected in Fall this year

LAD in HallC


LAD
spectator
proton
GEMs
SHMS
scattered
electron
11 GeV e⁻
Deuterium
HMS
JLab Hall C
jet from
struck quark

LAD - Refurbished CLAS6 TOF paddles





LAD Experimental Conditions

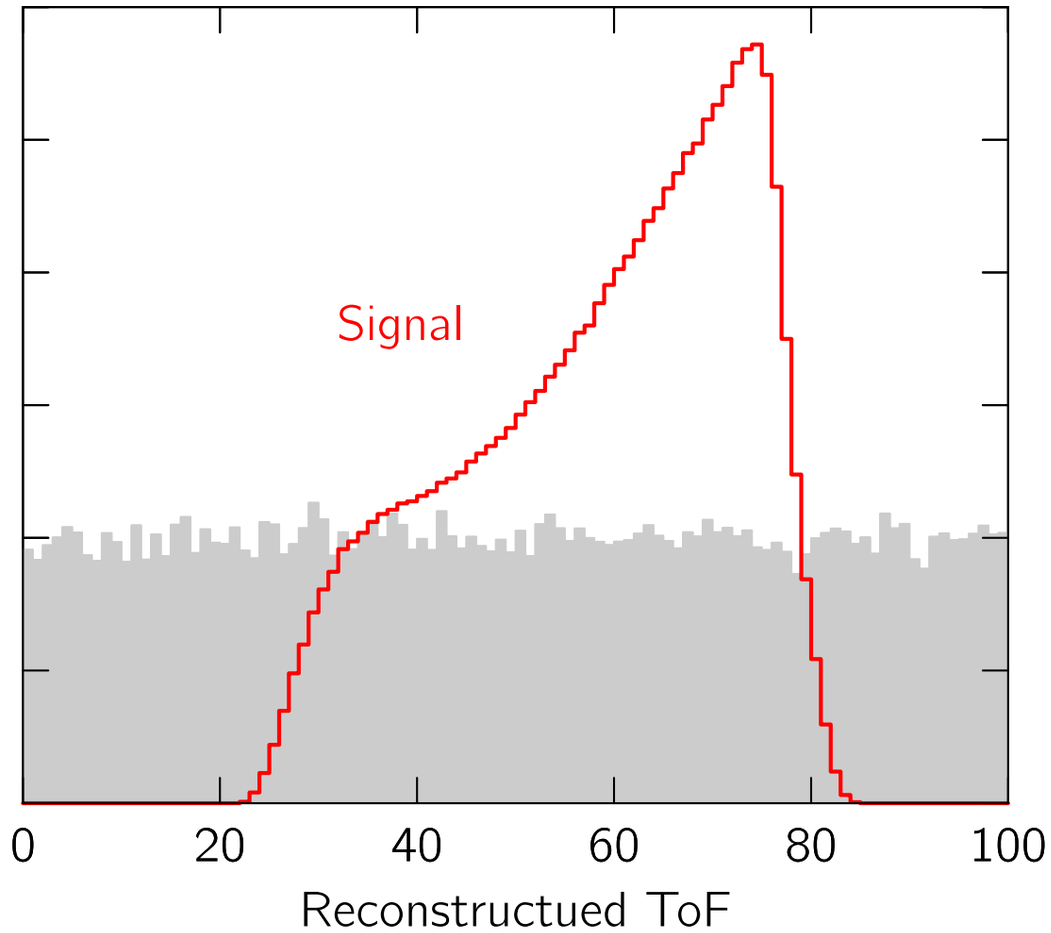
- Experiment E12-11-107
- Approved for ~34 days
- Extended LD_2 target
- 11 GeV electron beam
- 10^{36} $cm^{-2}s^{-1}$ luminosity (x10 higher than HallB)
- Low x and high x settings for e^- in HallC spectrometers

Protons in LAD

- 5 panels with 11 bars each
- 90-170 degree coverage
- +/- 20 degree out-of-plane coverage

Statistical Limit - Random background

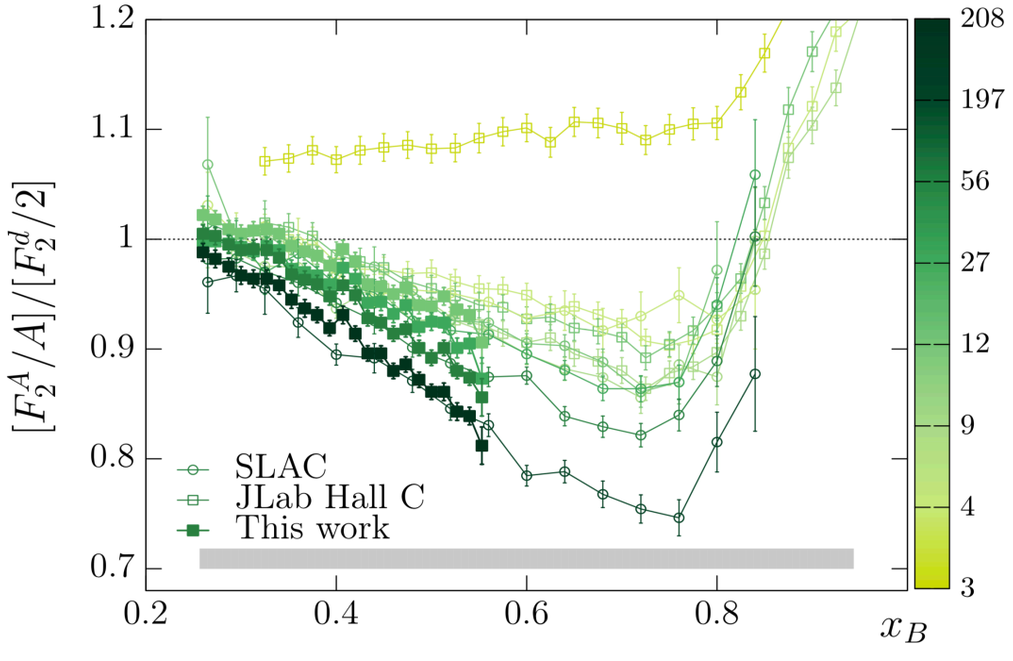
- Background subtraction by “off-time“ events
- Reduction in background gives increased statistics
- Background conditions better than in HallB
  - Less material between target and LAD
  - Tracking of protons with GEMS

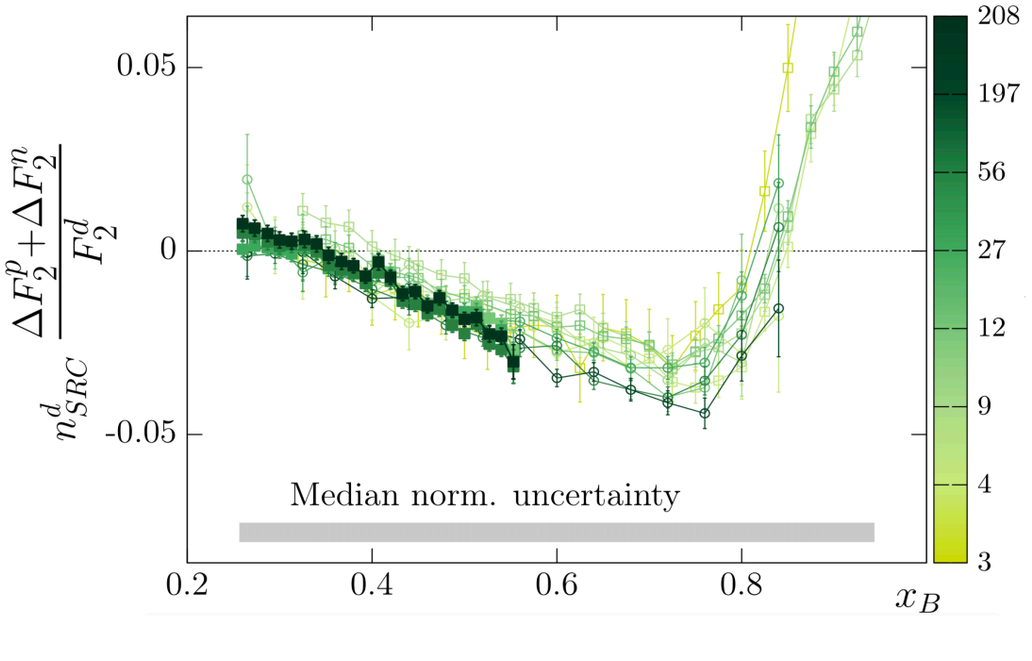


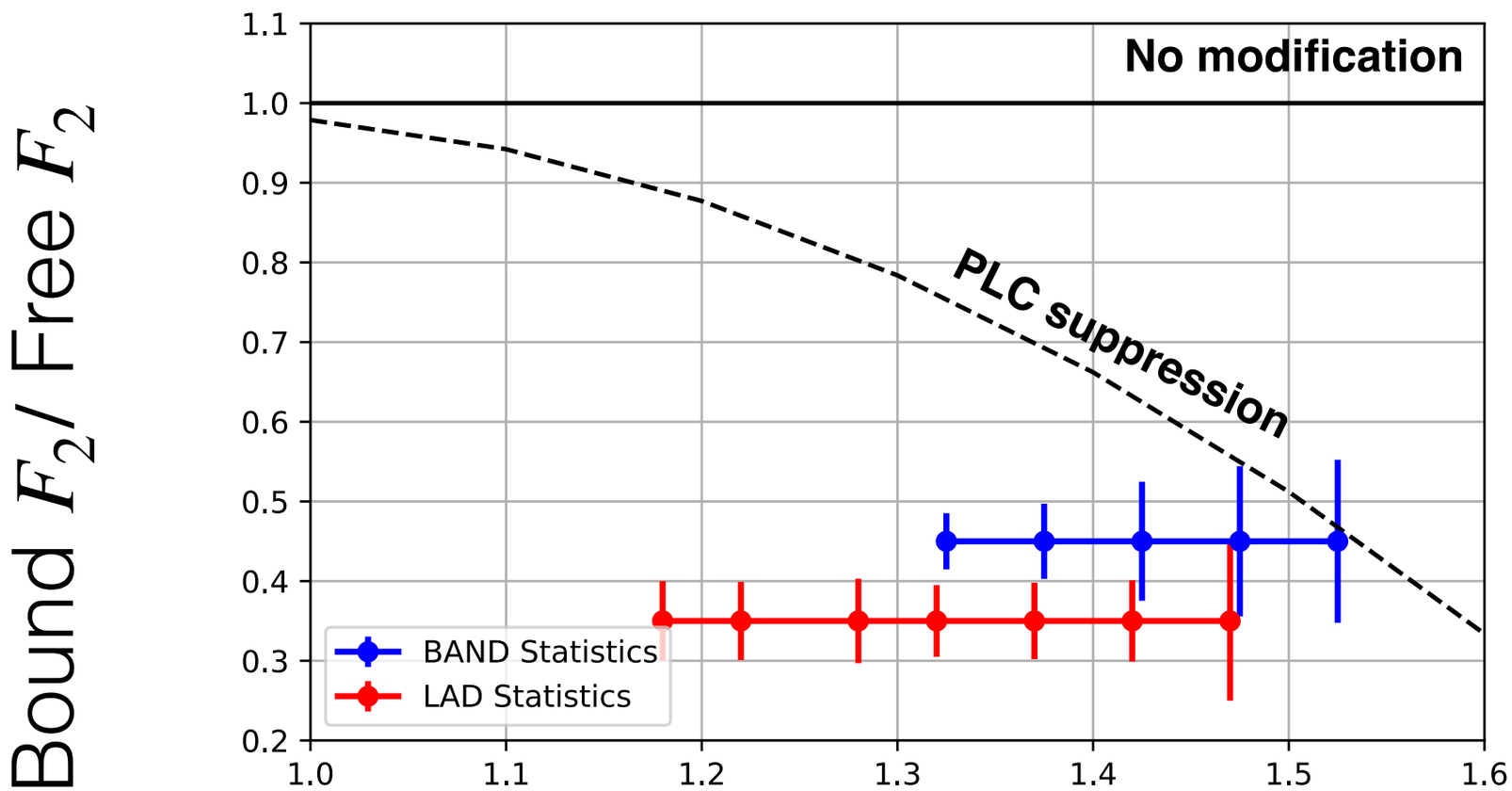
Simulation by A. Schmidt

—> Higher luminosity, higher statistics, higher x’ coverage

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





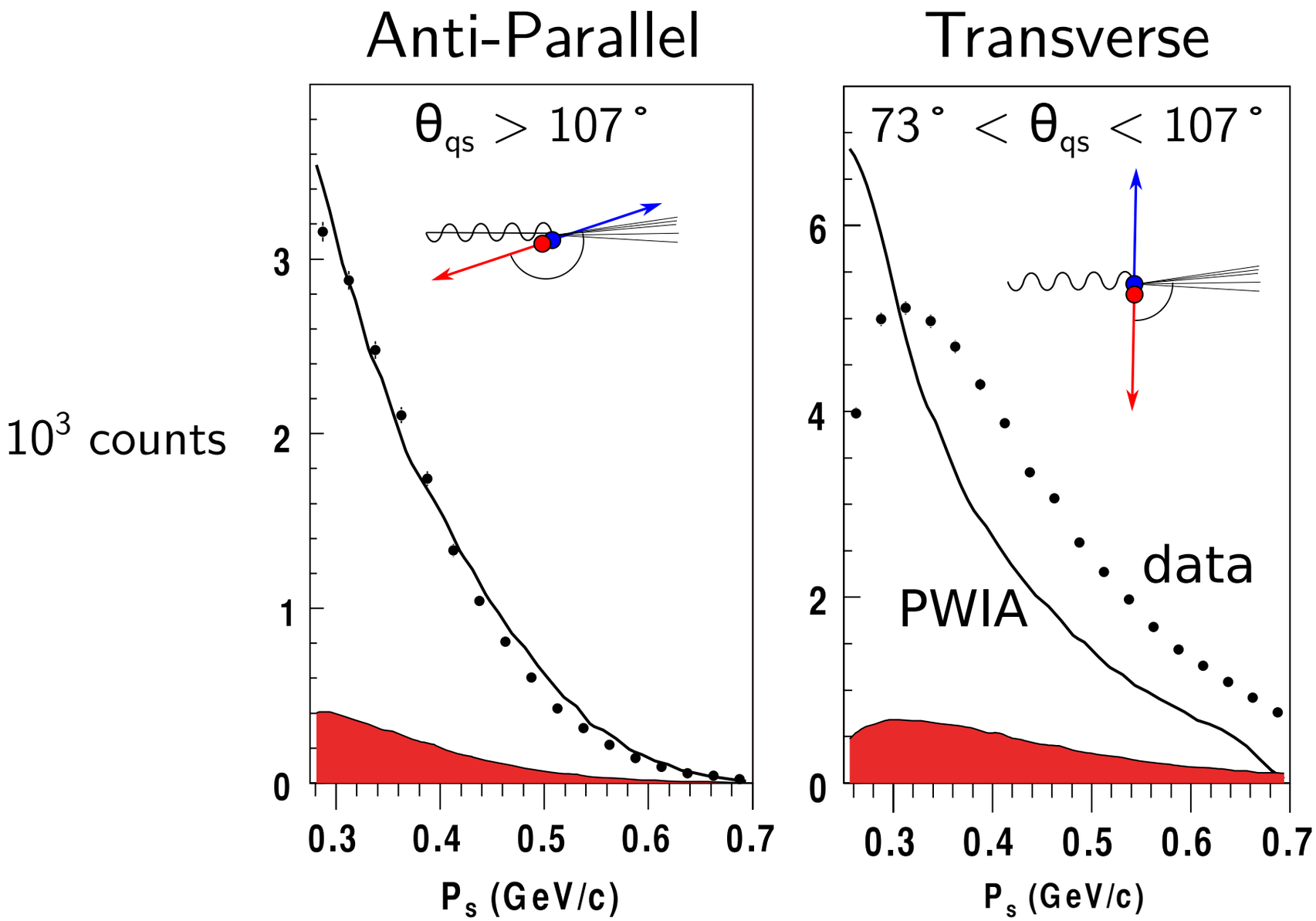


$$\alpha_s = (E_s - p_s^z)/m_s$$

Back up slides

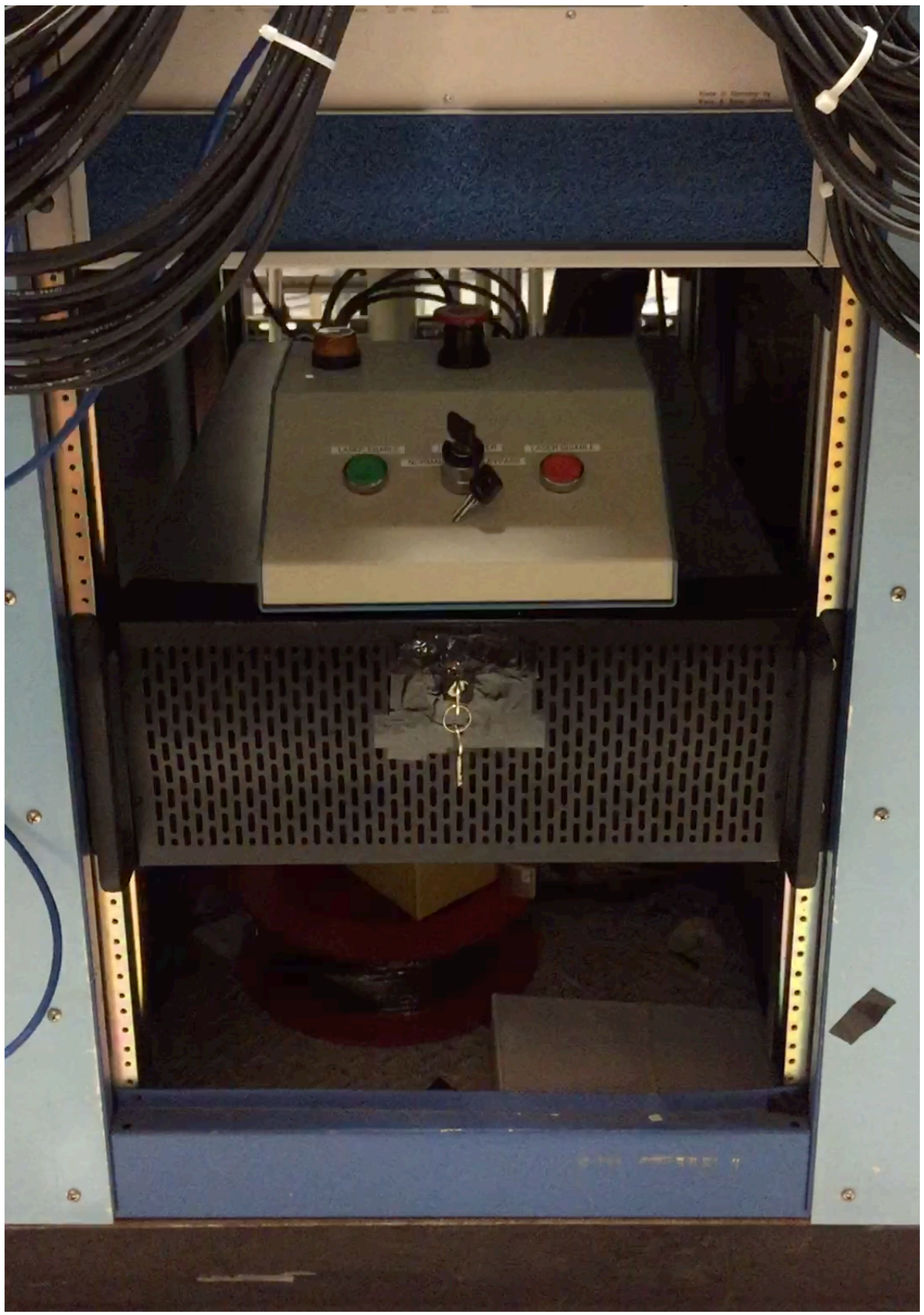
FSI in Tagged DIS

DEEPS showed little FSI at back angles.

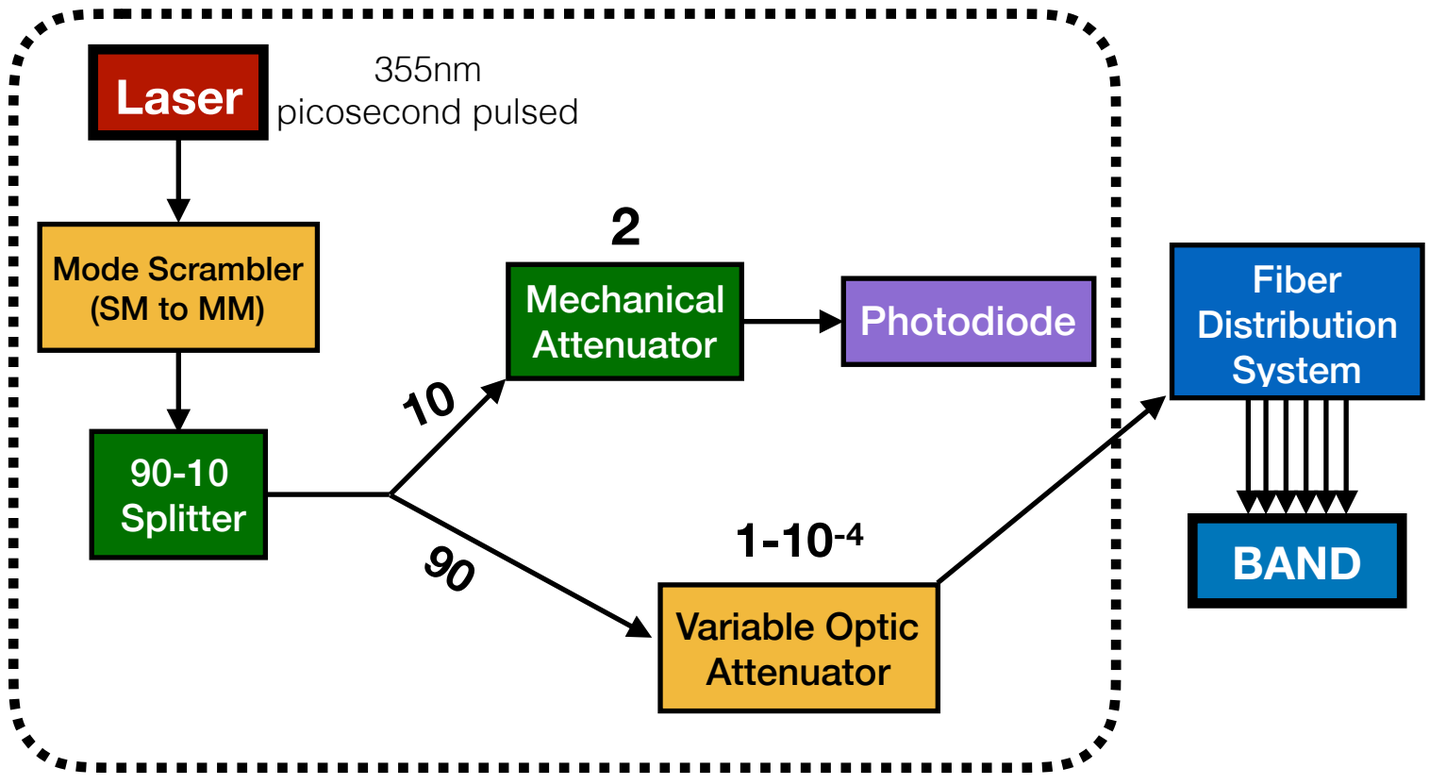


Klimenko et al., PRC 73 035212 (2006)

Laser System



Used to monitor PMT stability



N_{Signal} and uncertainty

Run 6164, 900 splits, 3 hours of beam

Cuts MeVee	S+B	B	S	σS	S:B	σS/S [%]
—	21499	**16596**	**4903**	195.18	0.3	3.98
1	12232	**8592**	**3640**	144.31	0.42	3.96
2	5151	**2904**	**2247**	89.75	0.77	3.99
3	3366	**1640**	**1726**	70.75	1.05	4.1
4	2253	**880**	**1373**	55.97	1.56	4.08
5	1613	**440**	**1173**	45.31	2.67	3.86

N_{Signal} and uncertainty

Run 6327, 600 splits, 1 hours of beam

Cuts MeVee	S+B	B	S	σS	S:B	σS/S [%]
-	8808	**7224**	**1584**	127	0.22	8.02
1	4914	**3767**	**1147**	93	0.3	8.11
2	1972	**1244**	**728**	57	0.59	7.83
3	1250	**698**	**552**	44	0.79	7.97
4	833	**357**	**476**	34	1.33	7.14
5	590	**162**	**428**	27	2.64	6.31
6	487	**121**	**366**	25	3.02	6.83