Hall C Status

Mark Jones, Acting Hall A/C Group Leader PAC meeting July 2022

- Results for experiments that are near publication.
- Experiments scheduled for current June 2022 to March 2023 run period
- ➢ Future plans for July 2023 to March 2024







EMC effect in ¹⁰B and ¹¹B

- Previous experiments on 9Be found that the EMC slope for 9Be was similar to 4He.
 - 9Be has α -cluster component to nuclear structure, local density effect?
- Correlation between EMC effect and SRC.
 - Two theories: Local density or highly virtual nucleons in correlated pair.
- Part of <u>E12-10-008</u> on 9Be, 10B, 11B, 12C was completed as one of the SHMS commissioning experiments.
- An additional test of local density effect, since 10B and 11B are nuclei with α -cluster component.
- Submitting publication for PRL this week.
- Completion of <u>E12-10-008</u> starts in Aug 2022



- Error bars on points are statistical and point-to-point systematic in quadrature
- Percentage in parenthesis is the normalization error
- Black line is A-dependent fit from SLAC E139



Slope of line fitted to σ_A/σ_D between 0.3 < x < 0.7





Photoproduction of J/ψ

At DNP 2021: Released of final results of the <u>E12-16-007</u> "A Search for the LHCb Charmed "Pentaquark" using Photoproduction of J/ ψ at Threshold in Hall C at Jefferson Lab"

CERN LHCb found 3 narrow hidden charm states: Pc(4312), Pc(4440) and Pc(4457) Pentaquark states? Molecular states?

<u>Photoproduction of J/ ψ is excellent way to search for pentaquark</u>

- Hall D GlueX published results in 2019 (grey box in figure)
- Hall C (J/ ψ -007) measured 5x more statistics



New results are inconsistent with reasonable assumptions for true 5-quark states.





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E12-10-002: Proton and Deuteron F₂

- Inclusive ep and ed cross section.
- Main physics goals
 - Constrain PDFs
 - Quark hadron duality
 - Non singlet moments
 - Resonance/DIS modeling



> Good agreement in σ_D/σ_H between HMS and SHMS at 21 deg



Virtual Compton Scattering (VCS) Experiment

- Theory expects α_{E} to have a smooth Q^2 dipole dependence
- Experiments MAMI-1 and MAMI-IV measured α_E at Q²= 0.3 which deviated from the dipole behavior seen in other experiments.
- New JLab measurement of α_{E} has also has a deviation from the dipole behavior.
 - Smaller effect, but better statistical error.
- Fit all world data with dipole+Gaussian has factor 2 better chi2/dof compared to dipole fit.



Comparisons to theory





Experiments during June 2022 – March 2023 (Part 1a)

<u>E12-19-006</u> : Study of the L–T Separated Pion Electroproduction Cross Section at 11 GeV and Measurement of the Charged Pion Form Factor to High Q^2

- Low epsilon data taken from Sept 2021 to Feb 2022
- High epsilon data is currently being taken.

$$\frac{d^2\sigma}{dtd\phi_{\pi}} = \frac{1}{2\pi} \left(\frac{d\sigma_T}{dt} + \epsilon \frac{d\sigma_L}{dt} + \sqrt{2\epsilon(1+\epsilon)} \frac{d\sigma_{LT}}{dt} \cos\phi_{\pi} + \epsilon \frac{d\sigma_{TT}}{dt} \cos2\phi_{\pi}\right)$$

- Indirectly measure F_{π} using the pion cloud in p(e,e' π^+)n
- Need to isolate the σ_L at low t
- Measure F_{π} to $Q^2 = 8.5$





Online results: Clean identification of $p(e,e'\pi^+)n$ final state





Experiments during June 2022 – March 2023 (Part 1b)

<u>E12-19-006</u> : Study of the L–T Separated Pion Electroproduction Cross Section at 11 GeV and Measurement of the Charged Pion Form Factor to High Q²

- Low epsilon data taken from Sept 2021 to Feb 2022
- High epsilon data is currently being taken.

$$\frac{d^2\sigma}{dtd\phi_{\pi}} = \frac{1}{2\pi} \left(\frac{d\sigma_T}{dt} + \epsilon \frac{d\sigma_L}{dt} + \sqrt{2\epsilon(1+\epsilon)} \frac{d\sigma_{LT}}{dt} \cos\phi_{\pi} + \epsilon \frac{d\sigma_{TT}}{dt} \cos2\phi_{\pi}\right)$$

- Scaling study at fixed $x_{bj} = 0.31, 0.40$ and 0.55
- In Hard Scattering regime
 - σ_L scales at 1/Q⁶
 - $\sigma_{\rm T}$ scales at 1/Q⁸
- Study hard/soft factorization for GPD extraction
 - Does σ_L or σ_T dominate?



Projected errors for $x_{bj} = 0.40$



Experiments from June 2022 to March 2023 (Part 2)

• E12-17-005 : The CaFe Experiment:Short-Range Pairing Mechanisms in Heavy Nuclei

- Measure (e,e'p) on 40 Ca, 48 Ca, 54 Fe at Θ_{ng} < 40 deg which minimizes FSI.
- Ratio of cross sections in the mean field region (k < k_{fermi}) to the SRC region (k > k_{fermi})
- The measurements will allow separation of SRC pairing probabilities for protons and neutrons in order to determine how pairing depends on nuclear mass and proton-neutron asymmetry.
- Complements (e,e') studies of SRC in E12-06-105



	Co	Co	Co	Co	Co	Co	Co	Co	Co		
e	46 Fe	47 Fe	48 Fe	49 Fe	50 Fe	51 Fe	52 Fe	53 Fe	⁵⁴ Fe		
n	45 Mn	46 Mn	47 Mn	48 Mn	49 Mn	50 Mn	51 Mn	52 Mn	Mn	M	S C
r	44 Cr	45 Cr	46 Cr	47 Cr	48 Cr	49 Cr	50 Cr	51 Cr	s: Cr	53 C:	to
,	43 V	44 V	45 V	46 V	47 V	48 V	49 V	50 V	5: V	52 V	Pro
i	42 Ti	43 Ti	44 Ti	45 Ti	46 Ti	47 Ti	48 m 1	49 m4	5(1714	51 T :	y
c	41 Sc	42 SC	43 5C	44 Sc	45 SC	46 Sc	47	19.0		50	+
Г	⁴⁰ Ca		42 Ca	43 Ca	44 Ca	45 Ca	46	⁴ °Ca			-
L	ĸ	Ţ	41 K	42 K	43 K	44 K	45	K	K	┛	

8 Neutrons



Experiments from June 2022 to March 2023 (Part 3)

• <u>E12-10-008</u> Detailed studies of the nuclear dependence of F_2 in light nuclei. • <u>E12-06-105</u> Inclusive Scattering from Nuclei at x > 1 in the quasielastic and deeply inelastic regimes

- Both experiments use:
 - Inclusive electron scattering
 - Variety of nuclei to study:
 - Density effects
 - N/P= # Neutron/# Proton dependence
 - Isospin dependence (e.g. ⁴⁰Ca/⁴⁸Ca)

E12-10-008 studies EMC effect

- Add 6Li and 7Li to light nuclei
- Flavor dependence with 40Ca and 48 Ca





E12-06-105 studies 2N and 3N SRC

- Precision measurement of 2N SRC
 - A-dependence in light nuclei
 - Variation with neutron excess
 - Connect EMC effect and SRC
- First observations of 3N SRC
- Nuclear PDFs at x > 1 and look for superfast quarks



Experiments from Aug 2022 to March 2023 (Part 4)

E12-10-003 Deuteron Electro-Disintegration at Very High Missing Momentum

- Ran 3 days of experiment as commissioning data. Published in PRL
- At PAC Jeopardy, approved to complete the remaining 18 days.
- Focus at Θ_{na} = 35 where FSI are minimal.



SHMS

n

 $(E_{
m r}, ec{p_{
m r}})$

 (E', \vec{k}') e'

 (ω, \vec{q})

 $(M_T, \vec{0})$

 (E, \vec{k}) e

Plan to run the NPS experiments in July 2023 – Mar 2024

- Install Neutral Particle Spectrometer (NPS) during March 2023 to July 2023 down
- Magnet with calorimeter
 - 1080 Lead-Tungstate blocks in Calorimeter to detect γ and π^0
 - Remove the SHMS HB magnet
- Experiments
 - <u>E12-13-010</u> is two concurrent experiments
 - Exclusive Deeply Virtual Compton on proton
 - SIDIS p(e,e', π^0) cross section. Map the transverse momentum dependence.
 - 53 PAC days.
 - E12-06-114 is completion of Hall A DVCS experiment
 - 35 PAC days.
 - Note that new proposal for Neutron DVCS could change the schedule
 - Two experiments with photon beam running concurrently
 - <u>E12-14-003</u> : Wide-angle Compton Scattering at 8 and 10 GeV Photon Energies (18 PAC days)
 - <u>E12-14-005</u> :Wide Angle Exclusive Photoproduction of pi-zero Mesons





NPS preparation status

- All 1080 blocks have been inspected and tested.
- In month of May all blocks wrapped.
- Stored in EEL108 for installation.



- French CNRS-IN2P3 group built calorimeter frame which was shipped to USA.
- From May 31st to June 16th, the French group is at Jlab to assemble the calorimeter.
- •Completed assembly!



- Test installation of NPS platform and rails was done in Hall C during Feb-June 2022 down.
- Has been disassembled and stored.



Hall C Near term future after March 2024

Options of experiments to install after March 2024

- Standard SHMS/HMS
 - <u>E12-06-104</u> $R=\sigma_L/\sigma_T$ in SIDIS
 - <u>E12-06-107</u> Complete CT experiment
 - E12-11-107 Spectator tagged DIS d(e,e'p_s)

Install Large Angle Detector HMS/SHMS detect electron



<u>Longer term future</u>

- Standard SHMS/HMS experiments
- Experiments using the Compact Photon Source
 - Capital project is ongoing
- Hypernuclear physics
- Experiments using the NPS

