d$(e, e'p)n$ 2023 Experimental Run Plan, BEAM Energy 10.6 GeV

February 24 - March 20, 2023

1 Pre-Beam Checkout (February 2023)

The first two days (Mon-Tu, Feb 20-21) will be target ladder changeover / work in the Hall C. During this time, the following tasks summarized in the log-entry: Coincidence Trigger Restoration, also attached to this run plan. The following two days (Wed-Thr, Feb 22-23), CaFe experiment will complete data-taking. Then the deuteron experiment will start on Friday, Feb 24 and will conclude on Monday, March 20.

2 Beam / Trigger Checkout

Follow instructions on: `https://hallcweb.jlab.org/wiki/index.php/Beam_Checkout_Procedures`

Prescale GUI settings for Beam / Trigger Checkout:

COIN DAQ		
TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS-3/4)	-1	- -
PS2 (SHMS-ELREAL)	0	5 kHz†
PS3 (HMS-3/4)	0	5 kHz†
PS4 (HMS-ELREAL)	-1	- -
PS5 (SHMS-ELREAL x HMS-3/4)	0	- -
PS6 (HMS-3/4 x SHMS-3/4)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

NOTE: PS = -1 (trigger disabled) PS = 0 (accepts all triggers, i.e., no pre-scales). †Set a target rate of 5 kHz (to keep computer live time $> 90\%$), and if trigger rates exceed this threshold, a pre-scale factor will be automatically determined by the DAQ.

- carbon hole check (raster ON @ 2x2 mm^2, hole diameter $\sim$ 2 mm)
- do harp scans to check beam profile (raster OFF, tune beam) (BPM calibrations can be done using the results from the harp scans and BPM positions as input.

Check coincidence timing signals on the O'scope. For **CaFe**, the main coincidence trigger is T5 (SHMS EL-REAL x HMS 3/4) and the coincidence timing should be set such that:

- HMS 3/4 is delayed (arrives after) relative to SHMS EL-REAL
- SHMS EL-REAL window should be wide enough to accommodate a +8 ns shift in HMS 3/4.

For **deuteron**, the main coincidence trigger is T6 (SHMS 3/4 x HMS 3/4) and the coincidence timing should be set such that:

- HMS 3/4 is delayed (arrives after) relative to SHMS 3/4
- SHMS 3/4 window should be wide enough to accommodate a +17 ns shift in HMS 3/4.

3 Hydrogen H$(e, e'p)$ Delta Scan

We begin our experiment with a momentum scan of SHMS !. The SHMS momentum should already be set to -8.55 GeV/c (by cafe experiment). Will need to verify the T6 coincidence time spectrum looks OK on O'scope, for our first (Kin-Setting 1) elastic setting, and verify the spectrum from the 50k replay.

Please refer to Shift Instructions for general guidance for the shift takers.

Prescale GUI settings (for entire deuteron experiment):

COIN DAQ		
TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS-3/4)	-1	5 kHz†
PS2 (SHMS-ELREAL)	-1	- -
PS3 (HMS-3/4)	-1	- -
PS4 (HMS-ELREAL)	-1	- -
PS5 (HMS-ELREAL x SHMS-3/4)	-1	- -
PS6 (HMS-3/4 x SHMS-3/4)	0	- -
EDTM Target Prescale Rate	- -	10 Hz

NOTE: PS = -1 (trigger disabled) PS = 0 (accepts all triggers, i.e., no pre-scales). Will only use T6 trigger (0), and rest=-1. † ONLY enable T2 during H(e, e') singles during proton absorption measurement, and set a target rate of 5 kHz ONLY (to keep computer live time $> 90\%$), and if trigger rates exceed this threshold, a pre-scale factor will be automatically determined by the DAQ.

H(e,e') Elastics Kin-Setting 1 ($\theta_{\rm SHMS} = 14.153°$, $\delta_{\rm SHMS} = -8\%$)

1. Ensure beam is OFF (request MCC to mask the target); change target to 10 cm LH2
2. Set SHMS momentum to -8.55 GeV/c (should already set, stays fixed for entire experiment)
3. Set HMS momentum to +3.499 GeV/c (will need to cycle magnets)
4. Set SHMS angle to 14.153 deg; HMS angle to 33.344 deg
5. Ensure SHMS Collimator / HMS Large Collimator are inserted
6. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
7. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 1.85 hrs (∼111 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 15 Hz
   - `SIMC` estimated DAQ rates: 27 Hz
8. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
9. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

H(e,e') Elastics Kin-Setting 2 ($\theta_{\rm SHMS} = 12.944°$, $\delta_{\rm SHMS} = -4\%$)

1. Set HMS momentum to +3.145 GeV/c (going to smaller momentum/no cycling needed)
2. Set SHMS angle to 12.944 deg; HMS angle to 35.755 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 0.95 hrs (∼57 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 29 Hz
   - `SIMC` estimated DAQ rates: 48 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

H(e,e') Elastics Kin-Setting 3 ($\theta_{\text{SHMS}} = 11.705°$, $\delta_{\text{SHMS}} = 0\%$)

1. Set HMS momentum to +2.783 GeV/c (going to smaller momentum/no cycling needed)
2. Set SHMS angle to 11.705 deg; HMS angle to 38.549 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 0.5 hrs (∼30 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 55 Hz
   - `SIMC` estimated DAQ rates: 89 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

H(e,e') Elastics Kin-Setting 3 SINGLES ($\theta_{\text{SHMS}} = 11.705°$, $\delta_{\text{SHMS}} = 0\%$)

1. Set T1=0 (rest=-1) to take (e, e') singles to be used in proton absorption measurements
2. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts (or enough events for valid measurement of proton absorption)
   - rates will be higher than estimated previously, estimated time to collect good events might be < 30 min.
3. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
4. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay
5. Restore trigger configuration on Prescale GUI to T6=0 (rest=-1), and continue to next delta scan

H(e,e') Elastics Kin-Setting 4 ($\theta_{\text{SHMS}} = 10.435°$, $\delta_{\text{SHMS}} = +4\%$)

1. Set HMS momentum to +2.417 GeV/c (going to smaller momentum/no cycling needed)
2. Set SHMS angle to 10.435 deg; HMS angle to 41.812 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 0.24 hrs (∼ 15 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 114 Hz
   - `SIMC` estimated DAQ rates: 183 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

H(e,e') Elastics Kin-Setting 5 ($\theta_{\text{SHMS}} = 9.125°$, $\delta_{\text{SHMS}} = +8\%$)

1. Set HMS momentum to +2.048 GeV/c (going to smaller momentum/no cycling needed)
2. Set SHMS angle to 9.125 deg; HMS angle to 45.667 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 0.1 hrs (∼ 6 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 268 Hz
   - `SIMC` estimated DAQ rates: 422 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

H(e,e') Elastics Kin-Setting 6 ($\theta_{\rm SHMS} = 7.704°$, $\delta_{\rm SHMS} = +12\%$)

1. Set HMS momentum to +1.664 GeV/c (going to smaller momentum/no cycling needed)
2. Set SHMS angle to 7.704 deg; HMS angle to 50.498 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data:
   - `DATA` statistics goal: ∼100,000 good $(e, e'p)$ counts
   - `DATA` estimated beam-on-target time: 0.035 hrs (∼ 2 min)
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 778 Hz
   - `SIMC` estimated DAQ rates: 1191 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` once 100k DAQ events reached to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> heep_coin` ∼ 2-3 min. before run ends to begin full replay

4 d(e,e'p) Production Run Plan

Prescale GUI settings for deuteron d$(e, e'p)$ Production

COIN DAQ		
TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS-3/4)	-1	- -
PS2 (SHMS-ELREAL)	-1	- -
PS3 (HMS-3/4)	-1	- -
PS4 (HMS-ELREAL)	-1	- -
PS5 (SHMS-ELREAL x HMS-3/4)	-1	- -
PS6 (HMS-3/4 x SHMS-3/4)	0	- -
EDTM Target Prescale Rate	- -	10 Hz

NOTE: You will notice that the predicted count rates are unusually small. The reason is that (1) we select events at 4< Q^2 <5 GeV^2, and (2) we are probing the high momentum tail of the deuteron (smallest cross-sections). Expect the actual DAQ coincidence (T6) rates to be higher, as these do not have these tight kinematical restrictions imposed.

4.1 d(e,e'p) Production @ P_m=120 MeV/c

1. Ensure beam is OFF (request MCC to mask the target); change target to 10 cm LD2
2. Set HMS momentum to +3.0523 GeV/c (will need to cycle magnets)
3. Set SHMS angle to 12.2 deg (will stay fixed); HMS angle to 38.63 deg
4. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
5. Start run / take data:
   - `DATA` statistics goal: ∼22,000 good $(e, e'p)$ counts (144 mC)
   - `DATA` estimated beam-on-target time: 1 hr
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 6 Hz
   - `SIMC` estimated DAQ rates: 43 Hz
6. (optional) Execute: `./run_deut_sample.sh <run_num> deep` mid-run to check rates / make extrapolations based on the output report file that automatically pops-up
7. Execute: `./run_deut_prod.sh <run_num> deep` ∼ 2-3 min. before run ends to begin full replay

4.2 d(e,e'p) Production @ P_m=580 MeV/c

1. Set HMS momentum to +2.2622 GeV/c (going to smaller momentum/no cycling needed)
2. Set HMS angle to 54.96 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data (1-hr long runs):
   - `DATA` statistics goal: ∼ 840 good $(e, e'p)$ counts (3456 mC)
   - `DATA` estimated beam-on-target time: 24 hrs
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 35 counts/hr (YES, you read the units right !)
   - `SIMC` estimated DAQ rates: 0.1 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> deep` mid-run to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> deep` ∼ 2-3 min. before run ends to begin full replay

4.3 d(e,e'p) Production @ P_m=800 MeV/c

1. Set HMS momentum to +2.121 GeV/c (going to smaller momentum/no cycling needed)
2. Set HMS angle to 59.39 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data (1-hr long runs):
   - `DATA` statistics goal: $\sim$ 730 good $(e, e'p)$ counts (15696 mC)
   - `DATA` estimated beam-on-target time: 109 hrs
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 6.7 counts/hr (YES, you read the units right, again !)
   - `SIMC` estimated DAQ rates: 0.024 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> deep` mid-run to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> deep` $\sim$ 2-3 min. before run ends to begin full replay

4.4 d(e,e'p) Production @ P_m=900 MeV/c

1. Set HMS momentum to +2.0474 GeV/c (going to smaller momentum/no cycling needed)
2. Set HMS angle to 61.34 deg
3. Update the `DBASE/COIN/STD/standard.kinematics` with the new settings
4. Start run / take data (1-hr long runs):
   - `DATA` statistics goal: $\sim$ 351 good $(e, e'p)$ counts (18720 mC)
   - `DATA` estimated beam-on-target time: 130 hrs
   - `SIMC` estimated $(e, e'p)$ rates based on (40 μA, 1-hr): 2.7 counts/hr (YES, you read the units right, once again !)
   - `SIMC` estimated DAQ rates: 0.012 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> deep` mid-run to check rates / make extrapolations based on the output report file that automatically pops-up
6. Execute: `./run_deut_prod.sh <run_num> deep` $\sim$ 2-3 min. before run ends to begin full replay