

# $d(e, e'p)n$ 2023 Experimental Run Plan

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](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 <sup>†</sup>
PS3 (HMS-3/4)	0	5 kHz <sup>†</sup>
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). <sup>†</sup>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.

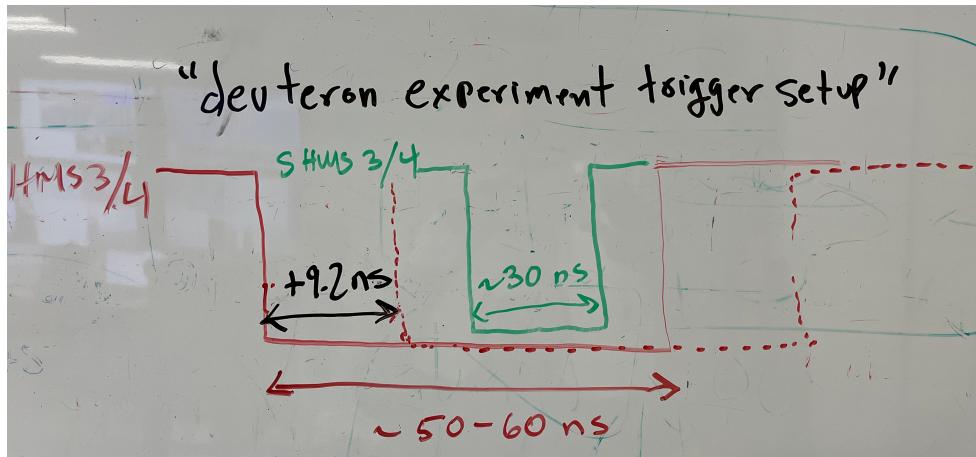
- carbon hole check (raster ON @ 2x2 mm<sup>2</sup>, hole diameter ~ 2 mm)
- do harp scans to check beam profile ( raster OFF, tune beam) (BPM calibrations can be done using the results from the harp scans and BPM positions as input).

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:

- SHMS 3/4 is delayed (arrives after) relative to HMS 3/4 >9.2 ns
- HMS 3/4 window should be wide enough (~ 50 – 60 ns) to accommodate a +9.2 ns shift in HMS 3/4 trigger signal leading edge without overlapping with the SHMS 3/4 leading edge



We may have to do  $d(e, e'p)$  trigger changes after CaFe concludes, since there is a fundamental change in the trigger windows / timing that cannot be simultaneously done for both experiments

### 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). Ensure all SHMS scintillator paddles are turned ON. 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 <sup>†</sup>
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: PS = -1 (trigger disabled) PS = 0 (accepts all triggers, i.e., no pre-scales). Will only use T6 trigger (0), and rest=-1. <sup>†</sup> ONLY enable T1 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.

#### 3.1 H( $e, e'$ ) Elastics Kin-Setting 1 ( $\theta_{\text{SHMS}} = 14.153^\circ$ , $\delta_{\text{SHMS}} = -8\%$ )

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: ~ 50,000 good ( $e, e'p$ ) counts
  - DATA estimated beam-on-target time: 1 h
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 1-hr): 15 Hz
  - SIMC estimated DAQ rates: 27 Hz
8. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` mid-run 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`  $\sim$  2-3 min. before run ends to begin full replay

#### 3.2 H( $e, e'$ ) Elastics Kin-Setting 2 ( $\theta_{\text{SHMS}} = 12.944^\circ$ , $\delta_{\text{SHMS}} = -4\%$ )

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: ~50,000 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  $\mu A$ , 1-hr): 29 Hz
  - SIMC estimated DAQ rates: 48 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` 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> heep_coin`  $\sim$  2-3 min. before run ends to begin full replay

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

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: ~50,000 good ( $e, e'p$ ) counts
  - DATA estimated beam-on-target time: 0.25 hrs (~15 min)
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 1-hr): 55 Hz
  - SIMC estimated DAQ rates: 89 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` 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> heep_coin` ~ 2-3 min.  
before run ends to begin full replay

### 3.4 H(e,e') Elastics Kin-Setting 3 (e,e') Singles ( $\theta_{\text{SHMS}} = 11.705^\circ$ , $\delta_{\text{SHMS}} = 0\%$ )

1. Set T1=0 (rest=-1) to take ( $e, e'$ ) singles. During stable beam-on-target, if T1>5 kHz, pre-scale T1 accordingly to keep >90% live time before starting the run
2. Start run / take data:
  - DATA statistics goal: at least ~50,000 good ( $e, e'$ ) counts  
(for valid measurement of proton absorption)
  - DATA rates will be higher than estimated previously kinematics, as this is inclusive trigger  
(no restrictions on proton arm)
  - DATA estimated beam-on-target time: a minimum of ~10 min.  
(even if stats. goal is reached)
3. (optional) Execute: `./run_deut_sample.sh <run_num> heep_singles` mid-run 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_singles` ~ 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

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

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: at least ~50,000 good ( $e, e'p$ ) counts
  - DATA estimated beam-on-target time: a minimum of ~10 min.  
(even if stats. goal is reached)
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 1-hr): 114 Hz
  - SIMC estimated DAQ rates: 183 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` 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> heep_coin` ~ 2-3 min.  
before run ends to begin full replay

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

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: at least ~50,000 good ( $e, e'p$ ) counts
  - DATA estimated beam-on-target time: a minimum of ~10 min.  
(even if stats. goal is reached)
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 1-hr): 268 Hz
  - SIMC estimated DAQ rates: 422 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` 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> heep_coin`  $\sim$  2-3 min.  
before run ends to begin full replay

### **3.7 H(e,e') Elastics Kin-Setting 6 ( $\theta_{\text{SHMS}} = 7.704^\circ$ , $\delta_{\text{SHMS}} = +12\%$ )**

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: at least ~50,000 good ( $e, e'p$ ) counts
  - DATA estimated beam-on-target time: a minimum of ~10 min.  
(even if stats. goal is reached)
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 1-hr): 778 Hz
  - SIMC estimated DAQ rates: 1191 Hz
5. (optional) Execute: `./run_deut_sample.sh <run_num> heep_coin` 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> heep_coin`  $\sim$  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  $4 < Q^2 < 5 \text{ GeV}^2$ , and (2) we are probing the high momentum tail of the deuteron (smallest cross-sections possible). 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 @ $P_m=120 \text{ MeV}/c$

1. Ensure beam is OFF (request MCC to mask the target); change target to 10 cm LD2
2. Set HMS momentum to  $+3.0523 \text{ GeV}/c$  (will need to cycle magnets)
3. Set SHMS angle to 12.2 deg (will stay fixed for remainder of experiment); HMS angle to 38.63 deg
4. Update the DBASE/COIN/STD/standard.kinematics with the new settings
5. Start run / take data (1-hr long runs):
  - o DATA statistics goal:  $\sim 22,000$  good ( $e, e'p$ ) counts (144 mC)
  - o DATA estimated beam-on-target time: 1 hr
  - o SIMC estimated ( $e, e'p$ ) rates based on ( $40 \mu A$ , 1-hr): 6 Hz
  - o 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`  $\sim 2\text{-}3$  min. before run ends to begin full replay

### 4.2 d(e,e'p) Production @ $P_m=580 \text{ MeV}/c$

1. Set HMS momentum to  $+2.2622 \text{ GeV}/c$  (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 (1-2 hr long runs):
  - o DATA statistics goal: at least  $\sim 840$  good ( $e, e'p$ ) counts (3456 mC)
  - o DATA estimated beam-on-target time: 24 hrs
  - o SIMC estimated ( $e, e'p$ ) rates based on ( $40 \mu A$ , 1-hr): 35 counts/hr  
(YES, you read the units right ! )
  - o 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`  $\sim 2\text{-}3$  min. before run ends to begin full replay

#### **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 (1-2 hr long runs):
  - DATA statistics goal: at least  $\sim 730$  good ( $e, e'p$ ) counts (15696 mC)
  - DATA estimated beam-on-target time: 109 hrs
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 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

#### **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 (1-2 hr long runs):
  - DATA statistics goal: at least  $\sim 351$  good ( $e, e'p$ ) counts ( 18720 mC)
  - DATA estimated beam-on-target time: 130 hrs
  - SIMC estimated ( $e, e'p$ ) rates based on (40  $\mu A$ , 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