LAD Runplan for March 2025

March 19, 2025

1 Overview

This is an overview run plan for the LAD experiment for 40PAC days:

Condition	Scheduled Work	Target	Beam	Time
Beam setup	Sending beam to the Hall. Detector checking: scintillator, TOF, GEMs, spectrometers	C hole	6.6 GeV 1 uA	2 shifts
Low energy calibration (SHMS/HMS)	Elastic run for momentum calibration	LH2	6.6 GeV 10 uA	3 shifts
GEM & LAD timing calibration	(e,e'p) with GEM at forward angle (place scintillator bar around 40 deg)	LH2	6.6 GeV 1 uA	1 shifts
3 pass $\rightarrow$ 5 pass Beam checkout	NA			1 shift
Multi-foil target run: GEM	Doing GEM alignment	C Multi-foil	10.9 GeV 1 uA	3 shifts
Multi-foil target run: Spec	Install sieve and turn GEM off for optic calibration run	C Multi-foil	10.9 GeV 10 uA	3 shifts
Luminosity scan	Run with different currents to do luminosity scan for efficiency and luminosity check	LD2	10.9 GeV 0.6-1.5 uA	1 shift
BCM calibration	2-3 times during run (needs other halls off)	?	10.9 GeV 0.2-2 uA	1 shift
Cu run for LAD Timing	optional run if no photon peak with deuterium	Cu	10.9 GeV 1-5 uA	$<$ 1 shift
Physics run setting 1	HMS at 13.5° and 4.4 GeV - SHMS at 17° and 4.4 GeV - Dummy runs	LD2	10.9 GeV 1 uA	13 days
Physics run setting 2	HMS at 17° and 4.4 GeV - SHMS at 17° and 4.4 GeV - Dummy runs	LD2	10.9 GeV 1 uA	13 days
GEM & SHMS movement	Reposition GEMS after SHMS movement to 13.5°			
GEM optics calibration	Redo optical calibration following GEM movement	C Multi-foil	10.9 GeV 1 uA	1-2 shifts
Physics run setting 3	HMS at 17° and 4.4 GeV - SHMS at 13.5° and 4.4 GeV - Dummy runs	LD2	10.9 GeV 1 uA	13 days

This Prescale GUI settings for Triggers

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	?	- -
PS2 (SHMS E_{Real})	?	- -
PS3 (HMS 3/4)	?	- -
PS4 (HMS E_{Real})	?	- -
PS5 (LAD single & (PS2 or PS4))	?	- -
PS6 (LAD single)	?	- -
EDTM Target Prescale Rate	- -	10 Hz

Note: The pre-scale factor, PS = -1 (trigger disable), PS = 0 (accept all trigger, i.e no pre-scale). Check the trigger rate when the beam comes, and set the target 5kHz(?) to setup the pre-scale factor. Calibration and production data taking will use either single arm triggers or the combination (PS2 and PS4).

2 Detailed Plan

The beam energies for our running are expected to be 10.688 GeV and 6.476 GeV.

2.1 Pre-beam calibrations

Before beam in the hall, the settings for the FADCs and discriminators have to be set for LAD. This will be done via cosmic and laser system runs. For LAD, we will take data with the LAD single trigger i.e. pre-scale factors ps6=0, all else =1. For laser runs, the threshold in the v1495 logic board will be set to at least 10 bars fired. For cosmics, the threshold will be set lower (either each bar itself or at least 3 to have some adjacent bars firing by crossing cosmic).

From the laser system runs, initial calibrations for time walk, time offsets, gains and thresholds are obtained for the LAD bars. Other settings for LAD are DAQ readout windows which are intially determined by estimations based on measurements of timings and later refined by looking at coincidence spectra.

2.2 Pre-beam checkout

Before the beam comes to the hall, we need to setup the spectrometers, target and get ready for the beam check out. This spectrometer setup will be used for the first calibration study.

- Spectrometer Setup for calibrations studies
  1. Both HMS and SHMS set for electrons
  2. HMS: at 24.4 deg and 4.4 GeV
  3. SHMS: at 17 deg and 5.98 GeV
- Move target to the Carbon hole
- Update DBASE/../standard.kinematic for HMS and SHMS setting
- **Detectors: GEM and LAD HV OFF!**

2.3 Beam/Trigger Checkout

Beam check out for Pass3 (6.476 GeV).

Trigger setting for this:

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	-1	- -
PS2 (SHMS E_{Real})	0	- -
PS3 (HMS 3/4)	-1	- -
PS4 (HMS E_{Real})	0	- -
PS5 (LAD single & (PS2 or PS4))	-1	- -
PS6 (LAD single)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

- **Beam:** Follow the instructions on:
  https://hallcweb.jlab.org/wiki/index.php/Beam_Checkout_Procedures
  NOTE: CHECK to make sure the script to make plot working before beam comes
- **Target:** Check the image of Carbon hole and adjust the beam position
- **Trigger:** Setup the pre-scale for each trigger as table above, set Target rate is < 2 kHz. EDTM to 10 Hz. If the the rate is > 2kHz, adjust the pre-scale factors.

Trigger check out for Pass3 (6.476 GeV) done by Florian and/or Bill Henry. Pictures to take from the scope from the various trigger legs to check timings.

2.4 Low Energy Calibration (SHMS/HMS)

Trigger setup for this study if running combined DAQ:

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	-1	- -
PS2 (SHMS E_{Real})	0	- -
PS3 (HMS 3/4)	-1	- -
PS4 (HMS E_{Real})	0	- -
PS5 (LAD single & (PS2 or PS4))	-1	- -
PS6 (LAD single)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

- Ensure beam is off
- Move target to LH_2
- Make sure **GEM HV OFF**
- LAD HV could be on

NOTE: There are 9 settings for this momentum calibration, summarized in below table.
- **HMS: Momentum stays the same (4.4 GeV), ONLY changing angle**.
- **SHMS: Angle stays the same (17 deg), ONLY changing momentum**

Spectrometer settings for H(e,e') studies, $E_B = 6.476$ GeV:

δ_H	$P_{0,HMS}$ GeV	$\theta_{0,HMS}$ [deg]	δ_{SHMS}	$P_{0,SHMS}$ GeV	$\theta_{0,SHMS}$ [deg]
-9%	4.4	24.4	+20%	5.98	17.0
-6%	4.4	23.3	+15%	5.73	17.0
-3%	4.4	22.3	+10%	5.48	17.0
0%	4.4	21.3	+5%	5.23	17.0
**0%	4.4	21.3	**0%	4.98	17.0
+3%	4.4	20.3	0%	4.98	17.0
+6%	4.4	19.3	-5%	4.73	17.0
+9%	4.4	18.3	-10%	4.48	17.0
+9%	4.4	18.3	-13%	4.33	17.0

Detail for each setting for delta scan runs assuming running combined DAQ:
Checking what is the maximum current MCC.

Setting #1

- Checking the HMS and SHMS setup to make sure: HMS at 24.4 deg and 4.4 GeV. SHMS at 17 deg, 5.98 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting #2:

- Change HMS angle to 23.3 deg
- Change SHMS momentum to 5.73 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events
- Request MCC for beam off

Setting #3

- Checking the HMS and SHMS setup to make sure: HMS at 22.3 deg and 4.4 GeV. SHMS at 17 deg, 5.48 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting #4

- Checking the HMS and SHMS setup to make sure: HMS at 21.3 deg and 4.4 GeV. SHMS at 17 deg, 5.23 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting # 5: sieve on for both HMS and SHMS. We will stay at this setting for multiple foils optics runs

Setting #5

- Checking the HMS and SHMS setup to make sure: HMS at 21.3 deg and 4.4 GeV. SHMS at 17 deg, 4.98 GeV
- **Insert the sieve on both HMS and SHMS**
- Request MCC to send Beam: 10 μA, raster on
- Taking data for **30 mins**, verify to have 200 in each hole for W distribution. If not enough needs to take longer.

- Request MCC for beam off
- Move target to C12 foil
- Request MCC to send Beam: 10 μA, raster on
- Taking data for **30 mins**, verify to have 200 in each hole for W distribution. If not enough needs to take longer.
- Request MCC for beam off
- Move Target to multi-foil target
- Request MCC to send Beam: 10 μA, raster on
- Taking data for **30 mins**, verify to have 200 in each hole for W distribution. If not enough needs to take longer.
- Request MCC for beam off
- Move target to LH2
- Remove the sieves from both HMS and SHMS

Setting #6

- Checking the HMS and SHMS setup to make sure: HMS at 20.3 deg and 4.4 GeV. SHMS at 17 deg, 4.98 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting #7

- Checking the HMS and SHMS setup to make sure: HMS at 19.3 deg and 4.4 GeV. SHMS at 17 deg, 4.73 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting #8

- Checking the HMS and SHMS setup to make sure: HMS at 18.3 deg and 4.4 GeV. SHMS at 17 deg, 4.48 GeV
- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

Setting #9

- Checking the HMS stays at 18.3 deg and 4.4 GeV. SHMS is at 17 deg change momentum to 4.33 GeV

- Request MCC to send Beam: 10 μA, raster on
- Taking data for 10 mins, verify to have 2k good events within ($W \pm 0.02$ GeV).
- Request MCC for beam off

GEM optics: multiple foil target run
We need to have a GEM expert to monitor the detector during this run

- Turn on the GEM HV.
- Setting HMS at 17 deg, momentum 4.975 GeV
- Setting SHMS at 17 deg and momentum 4.4 GeV
- Move target to multi-foil target
- Insert the sieve in HMS
- Request MCC to send beam: 1 μA, raster on: it have to be low current run
- DN: Question for Holly: What plot needs to be checked? what statistics do we need?

Note for expert check
The expected rates here are about 1 kHz total. We would expect to obtain 2k good events (in tight peak on $W \pm 0.02$ GeV) within the order of a few minutes. Each run should take no more than 10 minutes with stable beam. Including 10 minutes in between for setting momentum and angles, this section should take no more than 1 shift of beam. The delta optimization here assumes a fixed central momentum for the HMS changing only the angle, but the SHMS assumes a fixed angle and changes the central momentum (limited to a max angle of 20 deg *for this experiment).In the table above, the "**" indicates the runs with the respective HMS or SHMS* ***sieve*** *inserted. The $H(e,e')$ sieve run should take no more than 30 minutes. For this setting, we are looking for a minimum of 200 events in the sieve holes in the core W distribution.*

2.5 LAD Timing Calibration

The goal is to take elastic hydrogen data with electrons in HMS and protons in the reference bar on the pivot. The reference bar is relative calibrated in time with the LAD bars via the laser system. Its position is surveyed so the difference to other LAD bars comes from pathlength differences only. The elastic hydrogen data allows an absolute time of flight calibration of the bars in case no photon peak is seeing on the LAD bars at either beam energy. Trigger setting for this study:

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	-1	- -
PS2 (SHMS E_{Real})	-1	- -
PS3 (HMS 3/4)	-1	- -
PS4 (HMS E_{Real})	0	- -
PS5 (LAD single & (PS2 or PS4))	-1	- -
PS6 (LAD single)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

- Make sure target is LH2
- Check setting of HMS: 17 deg, momentum 4.975 GeV
- Request MCC to send beam: 1 μA: it has to be low current run
- Taking data for 10-20 mins, and do a replay as soon as possible to see the coincidence elastic peak. If not seen adjust possibly readout windows and retake data.

- Request MCC for beam off

In parallel or after the LAD timing runs one can try to check the LAD timing. For this purpose set the GEM latencies with respect to LAD latencies based off initial cosmic runs. Set beam current as low as possible and take data. Look for coincidence signals in GEMs with respect to LAD bars at larger angles (> 100 deg) from protons/pions produced in coincidence with HMS electron (setting of HMS at LAD timing calibration). Possible issues with this run could be a too large rate in the GEMs.

2.6 Changing Pass 3 → 5 Beam Checkout

Before the Pass 5 beam comes to the hall, doing the following pre-beam check: Trigger setting for this:

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	-1	- -
PS2 (SHMS E_{Real})	0	- -
PS3 (HMS 3/4)	-1	- -
PS4 (HMS E_{Real})	0	- -
PS5 (LAD single & (PS2 or PS4))	-1	- -
PS6 (LAD single)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

- Spectrometer Setup
  1. Both HMS and SHMS set for electrons
  2. HMS: at 13.5 deg and 4.4 GeV
  3. SHMS: at 17 deg and 4.4 GeV
- Move target to the Carbon hole
- Update DBASE/../standard.kinematic for this setting

Beam check for Pass5 (10.688 GeV).

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

- **Beam:** follow procedures above
- **Target:** Check the image of Carbon hole and adjust the beam position
- **Trigger:** Setup the pre-scale factors ps1=0, ps2=0, all else -1. Target rate is < 2 kHz. EDTM to 10 Hz. If the the rate is > 2kHz, adjust the pre-scale factors.
- After centering the beam request MCC beam off

2.7 Luminosity Scan

- Move target to LD2
- Request Beam current 0.6μA, 0.9 μA, 1.2μA, 1.5μA
- Each beam current take 1 run, for 10 min?

2.8 BCM Calibration

1. Contact/notify D. Mack (mack@jlab.org), He will perform the calibration.
   Follow instructions on:
   https://hallcweb.jlab.org/wiki/images/2/29/BCMCalibrationProcedureJuly2022v1.pdf

Check the replay to make sure it has scaler information for Dave calibration Check with Dave Mack if he will update the document for instrcution. Also get instructions for injector FC calibration for HallC.

2.9 Arc Energy Calibration

Add some details here. Done by MCC. Probably two measurements during the beam time at 5th pass. Maybe an additional one for 3rd pass.

2.10 Optional: Cu Run for LAD Timing

We might need to take data with a target with much larger Z than deuterium to see coincidence photons on the LAD bars for an absolute timing. This data will be at the same settings as the production running. We expect a maximum of couple of hours of running to see the photon peak with the Cu target. This run should be taken within the first days of running at 5 pass. LAD experts should be present.

3 Production run plan

The trigger prescaler setting for the production run:

TRIGGER	PRE-SCALE	TARGET RATE
PS1 (SHMS 3/4)	?	- -
PS2 (SHMS E_{Real})	0	- -
PS3 (HMS 3/4)	?	- -
PS4 (HMS E_{Real})	0	- -
PS5 (LAD single & (PS2 or PS4))	-1	- -
PS6 (LAD single)	-1	- -
EDTM Target Prescale Rate	- -	10 Hz

3.1 Physics Run Setting 1

Kinematic setting for Physics run setting 1 (Following the ERR run plan for now, we may need to adjust it later due to the results of the luminosity scan for beam currents and obtained statistics in the first setting)

1. Ensure beam is off
2. Ensure target is at LD2 and raster is off
3. Move HMS to: angle = 13.5 deg and momentum = 4.4 GeV
4. Move SHMS to: angle = 17 deg and momentum = 4.4 GeV
5. Update the DBASE/../standard.kinematic with the new setting (if necessary)
6. Request MCC to deliver 1uA beam
7. Checking trigger PS2 and PS4 rate to ensure the rate ¡ 2kHZ, otherwise set target rate to 1kHz each
8. Start the run for 30 mins,
    - Run basics-analysis code to check coincidence spectra, background and how many physics events (with physics cuts) we get
    - Estimate the run time needed to reach the goal
    - Checking physics plots to ensure everything is reasonable
9. Make adjustments to beam current and/or trigger pre-scales
10. Start checking accumulated physics events after each 1-hour run until reaching the goal.
    - Statistical goal ???K event
11. Taking dummy target run for this setting or empty target runs

3.2 Physics Run Setting 2

1. Ensure beam is off
2. Target stays at LD2
3. Move HMS to new setting: angle = 17 deg and momentum = 4.4 GeV
4. Keep SHMS at in the same setting: angle $\theta_0 = 17°$, $p = 4.4$ GeV
5. Request MCC to deliver 1uA beam
6. Checking trigger PS2 and PS4 rate to ensure the rate ¡ 2kHZ, otherwise set target rate to 1kHz each
7. Start the run for 30 mins,
   - Run basics-analysis code to check coincidence spectra, background and how many physics events (with physics cuts) we get
   - Estimate the run time needed to reach the goal
   - Checking physics plots to ensure everything is reasonable
8. Start checking accumulated physics events after each 1-hour run until reaching the goal.
   - Statistical goal ???K event
9. Taking dummy target run for this setting or empty target runs

3.3 GEM repositioning

3.4 GEM Optics Calibration

See same procedure as above.

3.5 Physics Run Setting 3

1. Ensure beam is off
2. Target stays at LD2
3. Move SHMS to new setting: angle = 13.5 deg (needs Hall access to observe move) and momentum = 4.4 GeV
4. Keep HMS at in the same setting: angle $\theta_0 = 17°$, $p = 4.4$ GeV
5. Request MCC to deliver 1uA beam
6. Checking trigger PS2 and PS4 rate to ensure the rate ¡ 2kHZ, otherwise set target rate to 1kHz each
7. Start the run for 30 mins,
   - Run basics-analysis code to check coincidence spectra, background and how many physics events (with physics cuts) we get
   - Estimate the run time needed to reach the goal
   - Checking physics plots to ensure everything is reasonable
8. Start checking accumulated physics events after each 1-hour run until reaching the goal.
   - Statistical goal ???K event
9. Taking dummy target run for this setting or empty target runs

4 Other

4.1 Optics Calibration

For the carbon multi-foil target, we should consider different foil angles. Eg. if LAD were at 90deg, scattered electrons would pass through lots of target material before exiting, if the foils are in the standard orientation. Even if we pick the standard orientation (orthogonal to the beamline), we should have some justification, since Or has asked about this a couple times.

The foils are 0.25 mm in width so it does not save us much to angle the foils.

4.2 SHMS Movement

LAD is on the same platform as the SHMS, so when we move the SHMS from 17° to 13.5°, we'll have to reposition the GEMs. Do we need to run optic and/or momentum calibrations?

A: Yes