

Pion-LT Run Plan - Part 1

June 6, 2022

10.56 GeV Beam Plan

Initial beam activities

- Configure the spectrometers for the detector checkout prior to beam delivery:
 1. SHMS angle = 7.50 deg (from TV).
 2. SHMS momentum = -5.27 GeV/c (negative polarity and all magnets cycled).
 3. HMS angle = 12.50 deg (from TV).
 4. HMS momentum = -5.890 GeV/c (negative polarity and all magnets cycled).
 5. $z = 0$ 0.5% r.l. carbon target. If rates are low, we might want to switch to one of the nuclear targets (if the current limits are known).
 6. Prescale GUI settings:

| | |
|---------------------------|-----------|
| HMS singles DAQ disabled | all PS=-1 |
| SHMS singles DAQ disabled | all PS=-1 |
| COIN DAQ: | |
| PS1(SHMS-3/4) | 0 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | 0 |
| PS4(HMS-ELREAL) | -1 |
| PS5(HMS-ELREAL×SHMS-3/4) | -1 |
| PS6(HMS-3/4×SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

- Beam checkout.
Follow the notes at:
https://hallcweb.jlab.org/wiki/index.php/Beam_Checkout_Procedures
including the “Carbon-hole” check to verify beam+target alignment and MCC raster size calibration. **Dave G. will need to be present to determine offsets from harp scans**
- Fix beam angle at target.
Use the gui at: `/home/cdaq/users/gaskelld/target_bpm/target_bpm.py`
Adjust 3H07Ax,y to remove slope while keeping 3H07Cx,y fixed
Recheck carbon hole and iterate as necessary.

Items to be done as soon as possible at this energy (time determined by RC).

- BPM calibration (bulls-eye scan).

This is not part of the typical beam checkout procedure. We want this done so that we have reliable absolute beam position information from the BPMs. Follow the procedure at: https://hallcweb.jlab.org/wiki/index.php/Bull%27s_Eye_Scan

- Energy determination with arc.

This should be completed as soon as possible. The Run Co-ordinator will coordinate the timing of this with the Program Deputy. MCC will have to set up a clean dispersive tune. It is important for the Shift Leader to make a full hclog entry of the MCC data. Follow the “Hall C Beam Energy Measurement Procedure” at MCC Ops Doc: MCC-PR-06-004.

- BCM calibrations.

The Run Co-ordinator will coordinate the timing of this with the Program Deputy. This requires MCC’s ability to reliably deliver 75-80 μA beam, so this calibration might have to wait at least a few days. The BCM calibration procedure is at <https://hallcweb.jlab.org/doc-public/ShowDocument?docid=957>. Dave Mack will analyze the data later.

- Subsequent BCM calibrations.

Dave Mack states “the BCMs are mostly reliable, but the gains might really drift at the 1% level. E.g., during this run cycle, the outside temperature is going to drop by 40-50°F, which can affect the temperature of the RF cables and even the machine frequency, which is important for the older analog receivers.” **He recommends a second BCM calibration 2 weeks after the first one, then every 2 weeks after that.** If Stephen checks the agreement of the full replay charge every few days, that will help to make educated decisions about the priority of doing more BCM calibrations.

Detector checkout

Mostly already done with cosmics, probably just some checks needed.

For hodoscope calibration, we want defocused settings to better fill the focal plane, so save two runs with increased Q2 by +20% current on both spectrometers compared to their nominal values.

Someone (Junaid) should look through the root tree of a short defocused run and ensure all variables are filling correctly. This should be done as soon as possible.

Carbon sieve check

While the spectrometers are still at negative polarity, we should quickly confirm that the optics are correct.

1. Restore the Q2 current on both spectrometers to their nominal values.
2. Insert the Carbon 0.5% r.l. target and sieve slit collimators on both SHMS and HMS. **Raster off. Current limit=40 μ A.** ELREAL singles. Take 100,000 HMS and 100,000 SHMS good electron events with $-8\% < \delta < +8\%$ in HMS and $-10\% < \delta < +24\%$ in SHMS. Adjust PS2(SHMS-ELREAL) and PS4(HMS-ELREAL) as necessary to keep the deadtime at reasonable levels (below 20%).

| | E_e | θ'_e | P'_e |
|-------|---------|-------------|---------|
| HMS: | 10560.0 | 13.00 | -4400.0 |
| SHMS: | 10560.0 | 13.00 | -5530.0 |

3. Look at HMS and SHMS $x - fp$ vs $y - fp$ scatterplots. The “hourglass” should be nicely aligned vertically, indicating alignment of the beam with the HMS and SHMS optical axes. Mark Jones or Holly Szumila-Vance should be consulted if anything looks amiss.

Carbon-Sieve Optics

10.56 GeV carbon-sieve optics run

| θ_{HMS} | P_{HMS} | θ_{SHMS} | P_{SHMS} | $Rate_{HMS}$ | $Rate_{DAQ}$ | Time |
|----------------|-----------|-----------------|------------|--------------|--------------|--------|
| 13.00 | -6.803 | 13.00 | -8.035 | Hz | Hz | 1.0 hr |

Set up the following configuration:

- (a) Set the SHMS magnets to -8.035 GeV/c.
- (b) SHMS angle = 13.00 deg (from TV).
- (c) Set HMS magnets to -6.803 GeV/c.
- (d) HMS angle = 13.00 deg (from TV).
- (e) Insert the Carbon 0.5% target.
- (f) Prescale GUI settings:

| | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | -1 |
| PS2(SHMS-ELREAL) | 0 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 0 |
| PS5(HMS-ELREAL \times SHMS-3/4) | -1 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

- (g) HMS sieve and SHMS sieve collimators.
- (h) Stable 80 μ A beam with 1×1 **raster on**. If a 1×1 raster is not possible, use a 2×2 raster.
- (i) Update *standard.kinematics* with the new settings.
- (j) **Jacob Murphy should be present for this run.** Take a first run for 15 minutes (at 100% data taking efficiency) which should be immediately analyzed using Holly's carbon optics script, then continue data collection. The statistics goal is 200 electron events per sieve hole. The first run should be used to estimate how long to run.
- (k) Insert Optical ± 8 Carbon target and repeat the same procedure as above.

Estimated Running Time: 2.0 hours at 100% efficiency.

Configure the spectrometers for the trigger checkout with Heep coincidences

1. **Switch the SHMS to positive polarity** (follow the cycling procedure) and set to +5.530 GeV/c.
2. HMS momentum = -5.890 GeV/c. Follow the cycling procedure.
3. SHMS angle = 23.12 deg (from TV).
4. HMS angle = 21.64 deg (from TV).
5. 10 cm LH2 target.
6. Prescale GUI settings:

| | |
|---------------------------|-----------|
| HMS singles DAQ disabled | all PS=-1 |
| SHMS singles DAQ disabled | all PS=-1 |
| COIN DAQ: | |
| PS1(SHMS-3/4) | -1 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | -1 |
| PS5(HMS-ELREAL×SHMS-3/4) | 0 |
| PS6(HMS-3/4×SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

Coincidence trigger checkout - Sawatzky, Jones, Murphy

We want to set up the following configurations in the coincidence DAQ:

HMS (e^- trigger): $A(\text{ELREAL } e^- + \frac{\pi^- + K^-}{5-10})$

SHMS (e^- trigger): $A(\text{ELREAL } e^- + \frac{\pi^- + K^-}{5-10})$

SHMS (π^\pm trigger): B (SCIN-3/4)

HMS $A \times$ SHMS B

- 3/4-trigger timing changes to reduce fADC reference time ambiguity have been implemented <https://logbooks.jlab.org/entry/3890337>. Need to verify that all timing adjustments and detector reference time windows are correctly set. Start with open Reference Time and Detector Time windows. Look at data and then tighten the windows up.
- fADC firmware has been updated to reduce the chance of missing pedestal information <https://logbooks.jlab.org/entry/3889989>. Checks with beam are likely needed to confirm everything is working as expected.
- Check the single arm trigger legs.

- Check the coincidence trigger with existing HMS-ELREAL.
- Check SHMS, HMS detector fADC timing windows and thresholds.
- Check fADC pedestals. Check fADC reference times and ADC gates (widths should be 40 ns).
- PID leg checkout. Fine tune thresholds. Someone (?) might want to change momentum and/or angle to get a good e/π ratio.
- Take a short run with SCIN-3/4 trigger. Then based on that decide on specific cuts or scale factors appropriate for $p(e, e'\pi^+)n$ while not excluding $p(e, e'K^+)\Lambda$ and $p(e, e'p)\omega$ events.
- Double-check HMS \check{C} threshold in ELREAL. → Don't want to lose electrons.
- Double-check HMS Calorimeter threshold in ELREAL. → Should be a loose cut (5:1 π^- rejection is desired).
- Double-check SHMS HGC threshold in ELREAL. → Don't want to lose electrons.
- Double-check SHMS Calorimeter threshold in ELREAL. → Should be a loose cut.
- Double-check SHMS timing for pions, kaons, and protons. Burcu Duran??
- Double-check SHMS+HMS coincidence timing. HMS start, SHMS stop. To limit noise/background, narrow the gate as needed. Need to recheck and adjust timing.
Extremely important: Look at the coincidence time plot in online analysis, and count the number of random pulses on each side of the prompt peak. The prompt peak should be centered in the distribution, with about 6 random pulses on each side. Preferably, these random pulses are of nearly equal height.
 In Kaon-LT we had a 60 ns SHMS gate, and a narrower 30 ns HMS gate with its leading edge centered in the SHMS gate <https://logbooks.jlab.org/entry/3602842>. With the lined up SHMS-3/4 overlap timing, an even narrower gate might be possible.
- The EDTM (Electronic Dead Time Monitor) needs to be set to a rate to give on the order of 10^4 accepted EDTM triggers (i.e. triggers on disk after deadtime losses) over the course of a 1 hour run. This rate is now supposed to be set automatically, but Jacob should replay a run to confirm this is the case, and post the result on helog.

Heep-check coincidence runs

- $p(e, e'p)$ setting for both spectrometer momenta

10.56 GeV Heep-check coincidence run

| θ_{HMS} | P_{HMS} | θ_{SHMS} | P_{SHMS} | $Rate_{HMS}$ | $Rate_{DAQ}$ | Time |
|----------------|-----------|-----------------|------------|--------------|--------------|--------|
| 21.64 | -5.889 | 23.12 | 5.530 | 2.27 Hz | 193 Hz | 1.3 hr |

Set up the following configuration:

- Set the SHMS magnets to +5.53 GeV/c (follow the magnet cycling procedure).
- SHMS angle = 23.12 deg (from TV).
- Set HMS magnets to -5.889 GeV/c.
- HMS angle = 21.64 deg (from TV).
- Prescale GUI settings:

| | |
|---------------------------|-------|
| PS1(SHMS-3/4) | 0 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 0 |
| PS5(HMS-ELREAL×SHMS-3/4) | 0 |
| PS6(HMS-3/4×SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

- HMS large and SHMS collimators.
- Stable 80 μ A beam with 2×2 raster on.
- Update *standard.kinematics* with the new settings.

Take two runs with a combined total of 10,000 $e + p$ elastic scattering coincidences. The first run should be 15 minutes (at 100% data taking efficiency), and should be immediately analyzed, checking E_m and p_m , while taking the second run.

Estimated Running Time: 1.3 hours at 100% efficiency.

- $Al(e, e'p)X$ Thick Dummy target run for Heep-check.

Insert the “thick” dummy target (± 5 cm) and **run for 10 minutes** at 40 μ A (assuming 100% efficiency).

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 target).

$Q^2=3.85$, $W=2.02$, $x=0.55$, high ϵ data taking

| Nominal $Q^2=3.85$ GeV $^2/c^2$, $W=2.02$ GeV, $x=0.55$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 6.803 | 13.29 | 0.888 | 0.049 | 3.493 | -21.66 |

1. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 19.66^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 13.29 (from TV).
- (b) HMS momentum = -6.803 GeV/c. Negative polarity. Magnets will need to be cycled.
- (c) SHMS angle = 19.66 deg (from TV).
- (d) SHMS momentum = 3.493 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 430 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS | HMS | SHMS | SHMS | SHMS | Random coinc. | Real coinc. |
|------------|--------------|--------------|----------|----------|---|-----------------|
| e^- rate | π^- rate | π^+ rate | K rate | p rate | $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | $e^- \cdot \pi$ |
| 35 kHz | 0.6 kHz | 41 kHz | 12 kHz | 38 kHz | 195 Hz | 5.6 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 1 hour (at 100% efficiency) at 80 μ A to get about 81,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 19.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at $40 \mu\text{A}$.

3. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 21.66^\circ$) run.

(a) Move the SHMS to 21.66 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 319 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 35 kHz | 0.6 kHz | 17 kHz | 5 kHz | 20 kHz | 91 Hz | 5.6 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1 hour (at 100% efficiency) at 80 μ A to get about 81,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 21.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μ A.

$p(e, e'\pi^+)X$ coincidences fADC downtime study

Ensure the following configuration is unchanged:

- (a) SHMS momentum = +6.265 GeV/c.
- (b) SHMS angle = 8.77 deg (from TV).
- (c) HMS momentum = -4.267 GeV/c.
- (d) HMS angle = 13.39 deg (from TV).
item10 cm LH2 target.
- (e) Projected prescale GUI settings:

| | |
|---------------------------|-----------|
| HMS singles DAQ disabled | all PS=-1 |
| SHMS singles DAQ disabled | all PS=-1 |
| COIN DAQ: | |
| PS1(SHMS-3/4) | see table |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | see table |
| PS5(HMS-ELREAL×SHMS-3/4) | 0 |
| PS6(HMS-3/4×SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

- (f) Make sure the raster is on (2×2), and take coincidences at 65, 50, 30, 20, 12, 8 μA . Start at the highest current and take LH2 target data. Then go down in current and repeat. The goal is 50k prompt $p(e, e'\pi^+)X$ coincidences per setting.
- (g) At 40 μA , take one Thick Dummy target run. 125,000 electrons per run, about 0.3 hour.

| 9.177 GeV $p(e, e'\pi^+)X$ fADC Downtime Study | | | | | | | | |
|--|---------|-----------------------------|--------------------|----------------------------|-------------------|---------------------|--------------------|--------------------|
| μA | Targets | $\frac{Rate_{SHMS}}{LHrun}$ | $\frac{PS1}{SHMS}$ | $\frac{Rate_{HMS}}{LHrun}$ | $\frac{PS4}{HMS}$ | DAQ _{SHMS} | DAQ _{HMS} | $\frac{Time}{run}$ |
| $\theta_{HMS} = 12.40, P_{HMS} = -3.738$ GeV/c, $\theta_{SHMS} = 12.30, P_{SHMS} = +3.260$ GeV/c | | | | | | | | |
| 65 | LH2 | 303 kHz | 13 | 114 kHz | 10 | 1 kHz | 1 kHz | 0.25 hr |
| 50 | LH2 | 246 kHz | 13 | 93 kHz | 10 | 1 kHz | 1 kHz | 0.33 hr |
| 40 | Dummy | 189 kHz | 13 | 71 kHz | 9 | 1 kHz | 1 kHz | 0.3 hr |
| 30 | LH2 | 114 kHz | 12 | 43 kHz | 8 | 1 kHz | 1 kHz | 0.58 hr |
| 20 | LH2 | 76 kHz | 11 | 28 kHz | 8 | 1 kHz | 1 kHz | 0.83 hr |
| 12 | LH2 | 45 kHz | 11 | 17 kHz | 7 | 1 kHz | 1 kHz | 1.0 hr |
| 8 | LH2 | 30 kHz | 10 | 11 kHz | 7 | 1 kHz | 1 kHz | 1.0 hr |
| Total Time (at 100% efficiency): 8.3 hrs | | | | | | | | |

5. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 23.66^\circ$) run.

(a) Move the SHMS 23.66 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 338 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 35 kHz | 0.6 kHz | 7 kHz | 2 kHz | 10 kHz | 91 Hz | 5.6 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for approximately 1 hour (at 100% efficiency) at 80 μ A to get about 81,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

6. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS left ($\theta = 23.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μ A.

$Q^2=2.73$, $W=2.63$, $x=0.31$, high ϵ data taking

| Nominal $Q^2=2.73$ GeV ² /c ² , $W=2.63$ GeV, $x=0.31$ Kinematics | | | | | | |
|---|----------|---------------|------------|----------------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) ² | GeV/c | deg |
| 10.56 | 5.889 | 12.03 | 0.834 | 0.118 | 4.605 | -14.34 |

1. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 16.34^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 12.03 (from TV). **Follow the specific small angle rotation instructions on the Wiki. Beam off during the HMS movement. The Run Coordinator will need to arrange in advance which expert personnel (e.g. Amy Comer, Steve Lassiter) need to monitor remotely.**
- (b) HMS momentum = -5.889 GeV/c. Negative polarity.
- (c) SHMS angle = 16.34 deg (from TV).
- (d) SHMS momentum = 4.605 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 478 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|----------------|------------------|-------------------|---------------|---------------|---|-----------------------------|
| 79 kHz | 10..7 kHz | 21 kHz | 8 kHz | 16 kHz | 220 Hz | 9.9 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**

- (i) **Take data for approximately 1 hour (at 100% efficiency) at 80 μA to get about 145,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.
2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 16.34^\circ$) run.
- Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.
- If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.
- Current limit: 40 μA .
- DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).
- Take data for 0.2 hours (100% efficiency) at 40 μA .**

3. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 14.34^\circ$) run.

(a) Move the SHMS to 14.34 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 881 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 79 kHz | 10.7 kHz | 63 kHz | 21 kHz | 37 kHz | 592 Hz | 9.9 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1 hour (100% efficiency) at 80 μ A to get about 145,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 14.34^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μ A.

5. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 12.34^\circ$) run.

(a) Move the SHMS 12.34 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 1874 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 79 kHz | 10.7 kHz | 179 kHz | 56 kHz | 82 kHz | 1549 Hz | 9.9 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for approximately 1 hour (at 100% efficiency) at 80 μA to get about 145,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

6. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 12.34^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μA .

$Q^2=3.85$, $W=2.62$, $x=0.39$, high ϵ data taking

| Nominal $Q^2=3.85$ GeV $^2/c^2$, $W=2.62$ GeV, $x=0.39$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 5.320 | 15.04 | 0.779 | 0.208 | 5.127 | -14.28 |

1. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 12.28^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 15.04 (from TV).
- (b) HMS momentum = -5.320 GeV/c. Negative polarity.
- (c) SHMS angle = 12.28 deg (from TV).
- (d) SHMS momentum = 5.127 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 465 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 22 kHz | 3.7 kHz | 88 kHz | 31 kHz | 43 kHz | 218 Hz | 2.11 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for approximately 1.5 hour (at 100% efficiency) at 80 μ A to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 12.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.3 hours (100% efficiency) at $40 \mu\text{A}$.

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

3. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 12.28^\circ$) run.

- (a) Now put in the 10 cm LD2 and leave the spectrometer settings unchanged.
 (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 1118 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K+p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 43 kHz | 7.3 kHz | 176 kHz | 61 kHz | 85 kHz | 871 Hz | 2.11 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
 (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
 (e) **Take data for approximately 1.5 hour (at 100% efficiency) at 80 μ A to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 14.28^\circ$) run.

- (a) Move the SHMS to 14.28 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged. Leave the spectrometer magnet settings unchanged.

- (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 490 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 43 kHz | 7.3 kHz | 55 kHz | 20 kHz | 34 kHz | 294 Hz | 2.11 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (e) **Take data for 1.5 hours (100% efficiency) at 80 μ A to get about 61,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

5. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 14.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.3 hours (100% efficiency) at 40 μA .

During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

6. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 14.28^\circ$) run.

(a) Now put in the 10 cm LH2 and leave the spectrometer settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 270 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 22 kHz | 3.7 kHz | 27 kHz | 10 kHz | 17 kHz | 73 Hz | 2.11 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1.5 hours (100% efficiency) at 80 μ A to get about 61,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

7. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 16.28^\circ$) run.

(a) Move the SHMS 16.28 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μA beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 252 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 8 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 22 kHz | 3.7 kHz | 8 kHz | 3 kHz | 6 kHz | 24 Hz | 2.11 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for approximately 1.5 hours (at 100% efficiency) at 80 μA to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

8. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS left ($\theta = 16.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.3 hours (100% efficiency) at 40 μA .

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

9. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 16.28^\circ$) run.

- (a) Now put in the 10 cm LD2 and leave the spectrometer settings unchanged.
- (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μA beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 324 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 9 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 43 kHz | 7.3 kHz | 16 kHz | 6 kHz | 13 kHz | 96 Hz | 2.11 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (e) **Take data for approximately 1.5 hours (at 100% efficiency) at 80 μA to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

$Q^2=6.00$, $W=2.40$, $x=0.55$, high ϵ data taking

| Nominal $Q^2=6.00$ GeV ² /c ² , $W=2.40$ GeV, $x=0.55$ Kinematics | | | | | | |
|---|----------|---------------|------------|----------------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) ² | GeV/c | deg |
| 10.56 | 4.763 | 19.89 | 0.711 | 0.531 | 5.512 | -14.92 |

1. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 16.92^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 19.89 (from TV).
- (b) HMS momentum = -4.763 GeV/c. Negative polarity.
- (c) SHMS angle = 16.92 deg (from TV).
- (d) SHMS momentum = 5.512 GeV/c. Positive polarity.
- (e) 10 cm LD2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 194 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 8 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 4.8 kHz | 2.1 kHz | 4.4 kHz | 4 Hz | 1.55 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unlick the fadcmode10 setting button**.
- (i) **Take data for approximately 2 hours (at 100% efficiency) at 80 μ A to get about 30,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 16.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.4 hours (100% efficiency) at $40 \mu\text{A}$.

During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

3. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 16.92^\circ$) run.

(a) Now put in the 10 cm LH2 and leave the spectrometer settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μA beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 190 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 7 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 3.2 kHz | 0.5 kHz | 2.4 kHz | 1.0 kHz | 2.2 kHz | 1 Hz | 1.55 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for approximately 2 hours (at 100% efficiency) at 80 μA to get about 30,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

4. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 14.92^\circ$) run.

(a) Move the SHMS to 14.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 257 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 8 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 3.2 kHz | 0.5 kHz | 9.2 kHz | 3.8 kHz | 6.6 kHz | 4 Hz | 1.55 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2 hours (100% efficiency) at 80 μ A to get about 30,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

5. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 14.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.4 hours (100% efficiency) at 40 μ A.

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

6. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 14.92^\circ$) run.

(a) Now put in the 10 cm LD2 and leave the spectrometer settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 269 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 9 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 18.5 kHz | 7.5 kHz | 13.1 kHz | 15 Hz | 1.55 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2 hours (100% efficiency) at 80 μ A to get about 30 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

7. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 12.92^\circ$) run.

- (a) Move the SHMS 12.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz. For 80 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 278 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 67 kHz | 26 kHz | 37 kHz | 50 Hz | 1.55 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (e) **Take data for 2 hours (at 100% efficiency) at 80 μA to get about 30,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.
8. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 12.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.4 hours (100% efficiency) at 40 μA .

During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

9. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 12.92^\circ$) run.

(a) Now put in the 10 cm LH2 and leave the spectrometer settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 240 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K+p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 3.2 kHz | 0.5 kHz | 33 kHz | 13 kHz | 18 kHz | 13 Hz | 1.55 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2 hours (at 100% efficiency) at 80 μ A to get about 30,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

$Q^2=2.45$, $W=3.20$, $x=0.21$, high ϵ data taking

| Nominal $Q^2=2.45$ GeV $^2/c^2$, $W=3.20$ GeV, $x=0.21$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 4.267 | 13.39 | 0.679 | 0.048 | 6.265 | -8.77 |

1. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 10.77^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 13.39 (from TV).
- (b) HMS momentum = -4.267 GeV/c. Negative polarity.
- (c) SHMS angle = 10.77 deg (from TV).
- (d) SHMS momentum = 6.265 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 460 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS | HMS | SHMS | SHMS | SHMS | Random coinc. | Real coinc. |
|------------|--------------|--------------|----------|----------|---|-----------------|
| e^- rate | π^- rate | π^+ rate | K rate | p rate | $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | $e^- \cdot \pi$ |
| 38 kHz | 70 kHz | 45 kHz | 19 kHz | 20 kHz | 268 Hz | 6.3 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 1 hour (at 100% efficiency) at 80 μ A to get about 92,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 10.77^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at $40 \mu\text{A}$.

3. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 8.77^\circ$) run.

(a) Move the SHMS to 8.77 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 1221 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 38 kHz | 70 kHz | 176 kHz | 68 kHz | 59 kHz | 963 Hz | 6.3 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1 hour (100% efficiency) at 80 μ A to get about 92,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 8.77^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μ A.

5. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 6.77^\circ$) run.

- (a) Move the SHMS 6.77 deg (from TV). **Follow the specific small angle rotation instructions on the Wiki. The Run Co-ordinator will need to arrange in advance which expert personnel (e.g. Amy Comer, Steve Lassiter) need to monitor remotely.** Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) **Adjust the beam current to keep the SHMS-S1X rate comfortably below 1 MHz.** We project the current for this run to be about 40 μA .
- (c) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 40 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 1050 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 19 kHz | 35 kHz | 326 kHz | 113 kHz | 76 kHz | 818 Hz | 3.2 Hz |

- (d) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (f) **Take data for 1 hour (at 100% efficiency) at 40 μA to get about 46,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

6. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 6.77^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 0.2 hours (100% efficiency) at 40 μA .

$Q^2=3.85$, $W=3.07$, $x=0.31$, high ϵ data taking

| Nominal $Q^2=3.85$ GeV $^2/c^2$, $W=3.07$ GeV, $x=0.31$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 3.955 | 17.46 | 0.632 | 0.120 | 6.538 | -9.92 |

1. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 7.92^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 17.46 (from TV).
- (b) HMS momentum = -3.955 GeV/c. Negative polarity.
- (c) SHMS angle = 7.92 deg (from TV).
- (d) SHMS momentum = 6.538 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 520 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 8 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 10 kHz | 16 kHz | 229 kHz | 90 kHz | 69 kHz | 318 Hz | 1.4 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 2.1 hours (at 100% efficiency) at 80 μ A to get about 48,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 7.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.5 hours (100% efficiency) at $40 \mu\text{A}$.

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

3. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 7.92^\circ$) run.

Set up the following configuration:

- (a) Now put in the 10 cm LD2 and leave the spectrometer settings unchanged.
- (b) **Adjust the beam current to keep the SHMS-S1X rate comfortably below 1 MHz.** We project the current for this run to be about $60 \mu\text{A}$.
- (c) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For $60 \mu\text{A}$ beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 938 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 15 kHz | 24 kHz | 343 kHz | 135 kHz | 104 kHz | 715 Hz | 1.1 Hz |

- (d) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (f) **Take data for 2.7 hours (at 100% efficiency) at $60 \mu\text{A}$ to get about 46,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

4. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 9.92^\circ$) run.

(a) Move the SHMS to 9.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 550 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 20 kHz | 32 kHz | 113 kHz | 48 kHz | 47 kHz | 341 Hz | 1.4 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2.1 hours (100% efficiency) at 80 μ A to get about 48,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

5. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 9.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.4 hours (100% efficiency) at 40 μ A.

During this period, the Target Operator should park the LD2 target and prepare for LH2 data taking.

6. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 9.92^\circ$) run.

(a) Now put in the 10 cm LH2 and leave the spectrometer settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 294 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 8 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 10 kHz | 16 kHz | 57 kHz | 24 kHz | 24 kHz | 85 Hz | 1.4 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2.1 hours (100% efficiency) at 80 μ A to get about 48,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

7. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 11.92^\circ$) run.

(a) Move the SHMS 11.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 231 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 9 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 8 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 10 kHz | 16 kHz | 13.1 kHz | 5.9 kHz | 7.2 kHz | 22 Hz | 1.4 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 2.1 hours (at 100% efficiency) at 80 μ A to get about 48,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

8. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS left ($\theta = 11.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2, LD2 targets).

Take data for 0.4 hours (100% efficiency) at 40 μ A.

During this period, the Target Operator should park the LH2 target and prepare for LD2 data taking.

9. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 11.92^\circ$) run.

- (a) Now put in the 10 cm LD2 and leave the spectrometer settings unchanged.
 (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 296 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 20 kHz | 32 kHz | 26.3 kHz | 11.9 kHz | 14.4 kHz | 86 Hz | 1.4 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
 (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
 (e) **Take data for 2.1 hours (at 100% efficiency) at 80 μ A to get about 48,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

$Q^2=5.00$, $W=2.95$, $x=0.39$, high ϵ data taking

| Nominal $Q^2=5.00$ GeV ² /c ² , $W=2.95$ GeV, $x=0.39$ Kinematics | | | | | | |
|---|----------|---------------|------------|----------------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) ² | GeV/c | deg |
| 10.56 | 3.727 | 20.53 | 0.596 | 0.209 | 6.719 | -10.48 |

1. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 12.48^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 20.53 (from TV).
- (b) HMS momentum = -3.727 GeV/c. Negative polarity.
- (c) SHMS angle = 12.48 deg (from TV).
- (d) SHMS momentum = 6.719 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 188 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 8 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 4.1 kHz | 5.5 kHz | 6.3 kHz | 3.0 kHz | 3.9 kHz | 4 Hz | 0.45 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 6.7 hours (at 100% efficiency) at 80 μ A to get about 59,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 12.48^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 1.3 hours (100% efficiency) at 40 μA .

3. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 10.48^\circ$) run.

(a) Move the SHMS to 10.48 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 209 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 4.1 kHz | 5.5 kHz | 29 kHz | 13 kHz | 14 kHz | 18 Hz | 0.45 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 6.7 hours (100% efficiency) at 80 μ A to get about 59,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 10.48^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 1.3 hours (100% efficiency) at 40 μ A.

5. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 8.48^\circ$) run.

- (a) Move the SHMS 8.48 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz. For 80 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 260 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 4.1 kHz | 5.5 kHz | 126 kHz | 53 kHz | 43 kHz | 70 Hz | 0.45 Hz |

- (c) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (e) **Take data for 6.7 hours (at 100% efficiency) at 80 μA to get about 59,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.
6. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 8.48^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 1.3 hours (100% efficiency) at 40 μA .

$Q^2=6.00$, $W=3.19$, $x=0.39$, high ϵ data taking

| Nominal $Q^2=6.00$ GeV ² /c ² , $W=3.19$ GeV, $x=0.39$ Kinematics | | | | | | |
|---|----------|---------------|------------|----------------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) ² | GeV/c | deg |
| 10.59 | 2.409 | 28.10 | 0.398 | 0.214 | 8.035 | -7.66 |

1. $p(e, e'\pi^+)n$ LH2 SHMS right ($\theta = 5.66^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 28.10 (from TV).
- (b) HMS momentum = -2.409 GeV/c. Negative polarity.
- (c) SHMS angle = 5.66 deg (from TV). **This requires a hall access. The Run Coordinator will need to arrange in advance which expert personnel (e.g. Amy Comer, Steve Lassiter) need to be present.**
- (d) SHMS momentum = 8.035 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 282 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS | HMS | SHMS | SHMS | SHMS | Random coinc. | Real coinc. |
|------------|--------------|--------------|----------|----------|---|-----------------|
| e^- rate | π^- rate | π^+ rate | K rate | p rate | $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | $e^- \cdot \pi$ |
| 0.9 kHz | 10.6 kHz | 253 kHz | 117 kHz | 63 kHz | 81 Hz | 0.15 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (i) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3

instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

- (j) **Take data for 19.3 hours (at 100% efficiency) at 80 μA to get about 53,000 $\text{p}(\text{e}, \text{e}'\pi^+)\text{n}$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 5.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 3.9 hours (100% efficiency) at 40 μA .

3. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 7.66^\circ$) run.

(a) Move the SHMS to 7.66 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 200 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 0.9 kHz | 10.6 kHz | 48 kHz | 25 kHz | 18 kHz | 17 Hz | 0.15 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

(f) **Take data for 19.3 hours (100% efficiency) at 80 μ A to get about 53,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 7.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 3.9 hours (100% efficiency) at 40 μA .

5. $p(e, e'\pi^+)n$ LH2 SHMS left ($\theta = 9.66^\circ$) run.

(a) Move the SHMS 9.66 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 231 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 8 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 6 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS π^+ rate | SHMS K rate | SHMS p rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|----------------------|------------------|------------------|--|--------------------------------|
| 0.9 kHz | 10.6 kHz | 8.3 kHz | 4.6 kHz | 4.2 kHz | 3 Hz | 0.15 Hz |

(c) Update *standard.kinematics* with the new settings. Use proton as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

(f) **Take data for 19.3 hours (at 100% efficiency) at 80 μ A to get about 53,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

6. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 9.66^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 3.9 hours (100% efficiency) at $40 \mu\text{A}$.

$Q^2=8.50$, $W=2.79$, $x=0.55$, high ϵ data taking

| Nominal $Q^2=8.50$ GeV $^2/c^2$, $W=2.79$ GeV, $x=0.55$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 2.352 | 34.01 | 0.375 | 0.550 | 7.913 | -8.69 |

1. $p(e, e'\pi^+)n$ LH2 SHMS center ($\theta = 8.69^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 34.01 (from TV).
- (b) HMS momentum = -2.352 GeV/c. Negative polarity.
- (c) SHMS angle = 8.69 deg (from TV).
- (d) SHMS momentum = 7.913 GeV/c. Positive polarity.
- (e) 10 cm LH2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 198 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 3 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS | HMS | SHMS | SHMS | SHMS | Random coinc. | Real coinc. |
|------------|--------------|--------------|----------|----------|---|-----------------|
| e^- rate | π^- rate | π^+ rate | K rate | p rate | $(e^- + \frac{\pi^-}{5}) \cdot (\pi + K + p)$ | $e^- \cdot \pi$ |
| 0.2 kHz | 1.6 kHz | 23 kHz | 12 kHz | 10 kHz | 1 Hz | 0.05 Hz |

- (g) Update *standard.kinematics* with the new settings. Use proton as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unlick the fadcmode10 setting button.**
- (i) **HMS-3/4 trigger run:** Since the HMS momentum is fairly low, take a 20 minute run with HMS-3/4 triggers enabled instead of hELREAL (i.e. PS6 instead of PS5, and PS3 instead of PS4). This is to monitor the ELREAL threshold and will count as part of the physics run total. If the PS3 trigger rate is excessive, adjust PS3 to a higher level to compensate.

- (j) **Take data for 61.3 hours (at 100% efficiency) at 80 μA to get about 68,000 $\text{p}(\text{e}, \text{e}'\pi^+)\text{n}$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS center ($\theta = 8.69^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LH2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LH2 targets).

Take data for 12.3 hours (100% efficiency) at 40 μA .

Calibration runs with SHMS at negative polarity (Part 1)

$p(e, e')p$ Hydrogen elastic singles, and associated Dummy target runs.

SHMS polarity change. Set up the following configuration:

1. HMS and SHMS angles and momenta as specified in the tables below. Both spectrometers are negative polarity, and both will have to be cycled initially.
2. Record all TV angle values on run sheets and hclog. Update *standard.kinematics* with the new settings.
3. 10 cm LH2 and “thick” dummy target data should be taken with the HMS large and SHMS collimators.

LH2 target runs:

Stable 80 μA beam with 2×2 **raster on**. Set the PS2(SHMS-ELREAL) and PS4(HMS-ELREAL) target rates to 1000 Hz, all others disabled (i.e. -1). As a guide, projected rates and PS factors are given in the table below. We want at least 10,000 elastics, which typically requires at least 500,000 total electron events (times below are only a guide). The total event estimate in right-most column includes inelastics.

Thick Dummy target runs:

One run for each angle and momentum setting, taken immediately after the corresponding LH2 run. Current limit: 40 μA .

Noble Gas Cerenkov Check:

During the HeeP singles runs, an expert should ensure the noble gas Cerenkov npe Sum looks reasonable. **It is important this is examined before physics data collection begins at negative polarity following the completion of the HeeP Singles.**

HeeP Singles Analysis:

For the rates listed below, **the HMS delta cuts were widened to $-10\% < \delta < +10\%$** from the original $\pm 8\%$. The analysis scripts for these runs should be adjusted for this to ensure accurate estimates of counts. If the delta cuts are unchanged, then the 1st and 5th – 6th settings will have significantly reduced HMS events, as they extend to the outer momentum acceptance of the HMS.

Delta Scans:

The HeeP singles settings include SHMS and HMS delta scans at fixed momenta of -8.035 and -6.803 GeV/c, respectively. **It is crucial that the HMS dipole NMR be stable and locked for the delta scan at -6.803 GeV/c.** Shift workers should keep a live plot of the NMR reading open in the magnet GUI. **Shift leads should take screenshots of the strip chart.** Contact Jacob Murphy with any questions.

| 10.560 GeV Heep-check singles runs | | | | | | | | | | |
|--|-----------|-----------------|------------|--------------|-------------------|---------------|--------------------|-----------------------|----------------------|-----------------|
| θ_{HMS} | P_{HMS} | θ_{SHMS} | P_{SHMS} | $Rate_{HMS}$ | $\frac{PS4}{HMS}$ | $Rate_{SHMS}$ | $\frac{PS2}{SHMS}$ | $\frac{Time}{LH2run}$ | $\frac{Time}{ALrun}$ | $Events_{SHMS}$ |
| * Widen HMS delta cuts | | | | | | | | | | |
| 16.025 | -6.803 | 12.715 | -8.035 | 4.4 kHz | 3 | 29.3 kHz | 6 | 12 min | 6 min | 1268k |
| * Check the Noble Gas Cherenkov npe Sum | | | | | | | | | | |
| 17.015 | -6.803 | 12.715 | -8.035 | 1.7 kHz | 0 | 29.3 kHz | 6 | 12 min | 6 min | 1268k |
| 18.025 | -6.803 | 13.57 | -8.035 | 0.57 kHz | 0 | 14.8 kHz | 5 | 24 min | 6 min | 1247k |
| 19.06 | -6.803 | 14.425 | -8.035 | 0.16 kHz | 0 | 7.13 kHz | 3 | 21 min | 6 min | 1787k |
| 20.125 | -6.803 | 15.285 | -8.035 | 0.04 kHz | 0 | 3.23 kHz | 2 | 15 min | 6 min | 964k |
| 20.125 | -6.803 | 16.15 | -8.035 | 0.04 kHz | 0 | 1.36 kHz | 0 | 15 min | 6 min | 811k |
| 20.125 | -6.803 | 14.06 | -7.913 | 0.04 kHz | 0 | 0.25 kHz | 0 | 15 min | 6 min | 95k |
| 21.68 | -5.889 | 18.385 | -6.719 | 0.12 kHz | 0 | 1.38 kHz | 0 | 21 min | 6 min | 1139k |
| 21.68 | -5.889 | 19.075 | -6.538 | 0.12 kHz | 0 | 1.04 kHz | 0 | 27 min | 6 min | 1107k |
| Total Time (including overhead): 9.6 hrs | | | | | | | | | | |

$Q^2=3.85$, $W=2.62$, $x=0.39$, high ϵ data taking

| Nominal $Q^2=3.85$ GeV $^2/c^2$, $W=2.62$ GeV, $x=0.39$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 5.320 | 15.04 | 0.779 | 0.208 | 5.127 | -14.28 |

1. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 12.28^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 15.04 (from TV).
- (b) HMS momentum = -5.320 GeV/c. Negative polarity.
- (c) SHMS angle = 12.28 deg (from TV).
- (d) SHMS momentum = -5.127 GeV/c. **Negative polarity. Cycle magnets.**
- (e) Now put in the 10 cm LD2.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For 80 μ A beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 1033 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS | HMS | SHMS | SHMS | SHMS | Random coinc. | Real coinc. |
|------------|--------------|------------|--------------|------------|---|-----------------|
| e^- rate | π^- rate | e^- rate | π^- rate | K^- rate | $(e^- + \frac{\pi^-}{3}) \cdot (e^- + \pi^- + K^-)$ | $e^- \cdot \pi$ |
| 43 kHz | 7.3 kHz | 157 kHz | 126 kHz | 12 kHz | 798 Hz | 2.11 Hz |

- (g) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 1.5 hours (at 100% efficiency) at 80 μ A to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS right ($\theta = 12.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 0.3 hours (100% efficiency) at 40 μA .

3. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 14.28^\circ$) run.

(a) Move the SHMS to 14.28 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 518 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 11 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 43 kHz | 7.5 kHz | 72 kHz | 40 kHz | 4 kHz | 314 Hz | 2.11 Hz |

(c) Update *standard.kinematics* with the new settings. Use neutron as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1.5 hours (100% efficiency) at 80 μ A to get about 61,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 14.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 0.3 hours (100% efficiency) at 40 μ A.

5. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 16.28^\circ$) run.

(a) Move the SHMS 16.28 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 325 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 10 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 43 kHz | 7.5 kHz | 32 kHz | 12 kHz | 6 kHz | 136 Hz | 2.11 Hz |

(c) Update *standard.kinematics* with the new settings. Use neutron as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 1.5 hours (at 100% efficiency) at 80 μ A to get about 61,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total. The first run should be ~ 20 minutes (at 100% data taking efficiency), and should be immediately analyzed to get an indication of the pion rate. Use this to calculate how long to run to get the desired statistics.

6. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS left ($\theta = 16.28^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 0.3 hours (100% efficiency) at 40 μ A.

$Q^2=6.00$, $W=2.40$, $x=0.55$, high ϵ data taking

| Nominal $Q^2=6.00$ GeV ² /c ² , $W=2.40$ GeV, $x=0.55$ Kinematics | | | | | | |
|---|----------|---------------|------------|----------------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) ² | GeV/c | deg |
| 10.56 | 4.763 | 19.89 | 0.711 | 0.531 | 5.512 | -14.92 |

1. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 16.92^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 15.04 (from TV).
- (b) HMS momentum = -4.763 GeV/c. Negative polarity.
- (c) SHMS angle = 16.92 deg (from TV).
- (d) SHMS momentum = -5.512 GeV/c. Negative polarity.
- (e) 10 cm LD2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 208 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 9 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 21 kHz | 3.6 kHz | 0.3 kHz | 10 Hz | 1.92 Hz |

- (g) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 5 hours (at 100% efficiency) at 80 μ A to get about 75,500 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 16.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: $40 \mu\text{A}$.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 1.0 hours (100% efficiency) at $40 \mu\text{A}$.

3. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 14.92^\circ$) run.

(a) Move the SHMS to 14.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.

(b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 260 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 10 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 53 kHz | 13.7 kHz | 1.3 kHz | 26 Hz | 1.55 Hz |

(c) Update *standard.kinematics* with the new settings. Use neutron as the target mass.

(d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.

(e) **Take data for 5 hours (100% efficiency) at 80 μ A to get about 75,500 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 14.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μ A.

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 1.0 hours (100% efficiency) at 40 μ A.

5. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 12.92^\circ$) run.

- (a) Move the SHMS 12.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz. For 80 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 259 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 6.4 kHz | 0.5 kHz | 126 kHz | 49 kHz | 5 kHz | 70 Hz | 1.55 Hz |

- (c) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (d) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (e) **Take data for 5 hours (at 100% efficiency) at 80 μA to get about 75,500 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.
6. $\text{Al}(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 12.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 1.0 hours (100% efficiency) at 40 μA .

$Q^2=3.85$, $W=3.07$, $x=0.31$, high ϵ data taking

| Nominal $Q^2=3.85$ GeV $^2/c^2$, $W=3.07$ GeV, $x=0.31$ Kinematics | | | | | | |
|---|----------|---------------|------------|--------------|---------|------------|
| E_e | $E_{e'}$ | $\theta_{e'}$ | ϵ | $ t $ | p_π | θ_q |
| GeV | GeV | deg | | (GeV/c) 2 | GeV/c | deg |
| 10.56 | 3.955 | 17.46 | 0.632 | 0.120 | 6.538 | -9.92 |

1. $p(e, e'\pi^+)n$ LD2 SHMS left ($\theta = 11.92^\circ$) run.

Set up the following configuration:

- (a) HMS angle = 17.46 (from TV).
- (b) HMS momentum = -3.955 GeV/c. Negative polarity.
- (c) SHMS angle = 11.92 deg (from TV).
- (d) SHMS momentum = -6.538 GeV/c. Negative polarity.
- (e) 10 cm LD2 target.
- (f) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **80 μ A beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 565 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 12 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 20 kHz | 32 kHz | 194 kHz | 19.1 kHz | 11.8 kHz | 352 Hz | 1.41 Hz |

- (g) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (h) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button**.
- (i) **Take data for 2.1 hours (at 100% efficiency) at 80 μ A to get about 48,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

2. $\boxed{\text{Al}(e, e'\pi^+)X}$ Thick Dummy target SHMS left ($\theta = 11.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 0.4 hours (100% efficiency) at 40 μA .

3. $p(e, e'\pi^+)n$ LD2 SHMS center ($\theta = 9.92^\circ$) run.

- (a) Move the SHMS to 9.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) **Adjust the beam current to keep the SHMS-S1X rate comfortably below 1 MHz.** We project the current for this run to be about 70 μA .
- (c) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz.

For **70 μA beam** and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and a 1027 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 9 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 18 kHz | 28 kHz | 480 kHz | 70 kHz | 6 kHz | 797 Hz | 1.23 Hz |

- (d) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (f) **Take data for 2.4 hours (100% efficiency) at 80 μA to get about 48,000 $d(e, e'\pi^+)nn_{sp}$ coincidences.** Use the physics replay to keep track of the event total.

4. $\text{Al}(e, e'\pi^+)X$ Thick Dummy target SHMS center ($\theta = 9.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 0.5 hours (100% efficiency) at 40 μA .

5. $p(e, e'\pi^+)n$ LD2 SHMS right ($\theta = 7.92^\circ$) run.

- (a) Move the SHMS 7.92 deg (from TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged.
- (b) **Adjust the beam current to keep the SHMS-S1X rate comfortably below 1 MHz.** We project the current for this run to be about 25 μA .
- (c) Set the PS1(SHMS-3/4) and PS4(HMS-ELREAL) target rates to 100 Hz. For 25 μA beam and the projected rates listed below, these prescale factors should give 100 Hz HMS and SHMS singles event rates to disk, and an 584 Hz DAQ rate overall.

| Projected prescale GUI settings: | |
|-----------------------------------|-------|
| PS1(SHMS-3/4) | 13 |
| PS2(SHMS-ELREAL) | -1 |
| PS3(HMS-3/4) | -1 |
| PS4(HMS-ELREAL) | 7 |
| PS5(HMS-ELREAL \times SHMS-3/4) | 0 |
| PS6(HMS-3/4 \times SHMS-3/4) | -1 |
| EDTM Target Prescale Rate | 10 Hz |
| cermode10 | ON |

| HMS e^- rate | HMS π^- rate | SHMS e^- rate | SHMS π^- rate | SHMS K^- rate | Random coinc. $(e^- + \frac{\pi^-}{5}) \cdot (e^- + \pi^- + K^-)$ | Real coinc. $e^- \cdot \pi$ |
|-------------------|---------------------|--------------------|----------------------|--------------------|--|--------------------------------|
| 6 kHz | 10 kHz | 493 kHz | 98 kHz | 8 kHz | 306 Hz | 0.44 Hz |

- (d) Update *standard.kinematics* with the new settings. Use neutron as the target mass.
- (e) **fadcmode10 Run:** Start by taking a 2 minute fadcmode10 run. Be sure to mark this clearly on the Run Sheet. After the run, it is extremely important to **unclick the fadcmode10 setting button.**
- (f) **Take data for 6.5 hours (at 100% efficiency) at 25 μA to get about 46,000 $p(e, e'\pi^+)n$ coincidences.** Use the physics replay to keep track of the event total.

6. $Al(e, e'\pi^+)X$ Thick Dummy target SHMS right ($\theta = 7.92^\circ$) run.

Now put in the “thick” dummy target (± 5 cm) and initially set prescale factors to the same as the LD2 run.

If the HMS and SHMS singles event rates to disk are significantly less than 100 Hz each, the PS1,4 factors can be decreased accordingly.

Current limit: 40 μA .

DO NOT modify *standard.kinematics* for this run (i.e. keep as for LD2 targets).

Take data for 1.3 hours (100% efficiency) at 40 μA .

Calibration runs with SHMS at negative polarity (Part 2)

1. Luminosity scans on LH2, LD2 and $z = 0$ Carbon targets.
 - (a) **SHMS polarity change.** Set the HMS momentum to -5.270 GeV/c, and the SHMS momentum to -5.470 GeV/c, both negative polarity.
 - (b) Rotate the HMS to 12.50 degrees, and the SHMS to 9.00 degrees. Record the TV camera angles on the runsheet to 0.005 degree accuracy.
 - (c) ELREAL trigger in both arms. Set the PS2, PS4 target DAQ rates to 1 kHz, to give a total rate to disk of about 2 kHz.
 - (d) Make sure the raster is on (2×2), and take HMS and SHMS runs at 80, 60, 40, 20, 15, 10, 7, 5, 2.5, 1 μ A on LH2 target. Start at the highest current, then go down in current and repeat.
 - (e) **Try to get runs with a minimum of beam trips (if possible).**
 - (f) Take one Thick Dummy target run at 40 μ A. 125,000 electrons per run, about 0.3 hour. During this run, the Target Operator should park the LH2 target and prepare for LD2 data taking.
 - (g) Repeat the scans with Carbon 0.5% r.l. target. If the C rates are too low, we may be able to substitute the Gold target (consult the RC before doing this).
 - (h) Repeat the scans with LD2 target at 80, 60, 40, 20, 15, 10, 7, 5, 2.5, 1 μ A.
 - (i) An expert (Jacob) should do a sanity-check of the EDTM (and any other hardware deadtime measurement system) by comparing runs over a range of detector rates but with low software deadtimes.

| 10.56 GeV Luminosity Scan 1 | | | | | | | | |
|---|--------------------|-----------------------------|--------------------|----------------------------|-------------------|---------------------|--------------------|--------------------|
| μ A | Targets | $\frac{Rate_{SHMS}}{LHrun}$ | $\frac{PS2}{SHMS}$ | $\frac{Rate_{HMS}}{LHrun}$ | $\frac{PS4}{HMS}$ | DAQ _{SHMS} | DAQ _{HMS} | $\frac{Time}{run}$ |
| $\theta_{HMS} = 12.50, P_{HMS} = -5.270$ GeV/c, $\theta_{SHMS} = 9.00, P_{SHMS} = -5.470$ GeV/c | | | | | | | | |
| 80 | LH2, C, LD2 | 613 kHz | 13 | 85 kHz | 7 | 1 kHz | 1 kHz | 10 min |
| 60 | LH2, C, LD2 | 460 kHz | 12 | 64 kHz | 6 | 1 kHz | 1 kHz | 10 min |
| 40 | LH2, Dummy, C, LD2 | 306 kHz | 12 | 43 kHz | 6 | 1 kHz | 1 kHz | 10 min |
| 20 | LH2, C, LD2 | 192 kHz | 11 | 27 kHz | 5 | 1 kHz | 1 kHz | 10 min |
| 15 | LH2, C, LD2 | 138 kHz | 11 | 19 kHz | 5 | 1 kHz | 1 kHz | 10 min |
| 10 | LH2, C, LD2 | 92 kHz | 10 | 13 kHz | 4 | 1 kHz | 1 kHz | 10 min |
| 7 | LH2, C, LD2 | 61 kHz | 9 | 9 kHz | 3 | 1 kHz | 1 kHz | 10 min |
| 5 | LH2, C, LD2 | 38 kHz | 9 | 5 kHz | 2 | 1 kHz | 1 kHz | 10 min |
| 2.5 | LH2, C, LD2 | 19 kHz | 8 | 3 kHz | 1 | 1 kHz | 1 kHz | 10 min |
| 1 | LH2, C, LD2 | 8 kHz | 6 | 1 kHz | 0 | 1 kHz | 1 kHz | 10 min |
| Total Time (including overhead): 9.5 hrs | | | | | | | | |

2. Second set of Luminosity scans on LH2, LD2 and $z = 0$ Carbon targets.

- (a) If things go well, we could to do a second set of luminosity scans. In Fpi-2, this proved helpful in disentangling rate and current effects in the π^- analysis. In this scan, the rates are roughly half of the first scan, at the same current.
- (b) Move the HMS to 13.00 deg, and the SHMS to 10.00 deg (on TV). Be sure to record and photograph the actual achieved vernier value to 0.005 degree precision. Leave the spectrometer magnet settings unchanged. Leave the spectrometer magnet settings unchanged.
- (c) ELREAL trigger in both arms. Set the PS2, PS4 target DAQ rates to 1 kHz, to give a total rate to disk of about 2 kHz.
- (d) Make sure the raster is on (2×2), and take HMS and SHMS runs at 55, 40, 25, 18, 10, 5 μA on LD2 target. Start at the highest current, then go down in current and repeat.
- (e) **Try to get runs with a minimum of beam trips (if possible).**
- (f) Take one Thick Dummy target run at 40 μA . 125,000 electrons per run, about 0.3 hour. During this run, the Target Operator should park the LD2 target and prepare for LH2 data taking.
- (g) Repeat the scans with Carbon 0.5% r.l. and LH2 targets at 70, 55, 40, 25, 18, 10, 5 μA . If the C rates are too low, we may be able to substitute the Gold target (consult the RC before doing this).

| 10.560 GeV Luminosity Scans #2 | | | | | | | | |
|--|--------------------|-----------------------------|--------------------|----------------------------|-------------------|---------------------|--------------------|--------------------|
| μA | Targets | $\frac{Rate_{SHMS}}{LHrun}$ | $\frac{PS2}{SHMS}$ | $\frac{Rate_{HMS}}{LHrun}$ | $\frac{PS4}{HMS}$ | DAQ _{SHMS} | DAQ _{HMS} | $\frac{Time}{run}$ |
| $\theta_{HMS} = 13.00, P_{HMS} = -5.270 \text{ GeV}/c, \theta_{SHMS} = 10.00, P_{SHMS} = -5.470 \text{ GeV}/c$ | | | | | | | | |
| 80 | LH2, C, LD2 | 374 kHz | 12 | 68 kHz | 7 | 1 kHz | 1 kHz | 10 min |
| 60 | LH2, C, LD2 | 280 kHz | 12 | 51 kHz | 6 | 1 kHz | 1 kHz | 10 min |
| 40 | LH2, Dummy, C, LD2 | 187 kHz | 11 | 34 kHz | 6 | 1 kHz | 1 kHz | 10 min |
| 25 | LH2, C, LD2 | 117 kHz | 10 | 21 kHz | 5 | 1 kHz | 1 kHz | 10 min |
| 18 | LH2, C, LD2 | 84 kHz | 10 | 15 kHz | 4 | 1 kHz | 1 kHz | 10 min |
| 12 | LH2, C, LD2 | 56 kHz | 9 | 10 kHz | 4 | 1 kHz | 1 kHz | 10 min |
| 8 | LH2, C, LD2 | 37 kHz | 9 | 7 kHz | 3 | 1 kHz | 1 kHz | 10 min |
| 5 | LH2, C, LD2 | 23 kHz | 8 | 4 kHz | 2 | 1 kHz | 1 kHz | 10 min |
| 2.5 | LH2, C, LD2 | 12 kHz | 7 | 2 kHz | 0 | 1 kHz | 1 kHz | 10 min |
| 1 | LH2, C, LD2 | 5 kHz | 6 | 1 kHz | 0 | 1 kHz | 1 kHz | 10 min |
| Total Time (including overhead): 7.7 hrs | | | | | | | | |

To be determined in consultation with the RC: If we are waiting for the linac gradient change, go back to the ($e, e'\pi^\pm$) setting with the lowest statistics and take more data, or do one of the deferred calibration studies.