Run Plan for RCS: January-February, 2002

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Contents

1 The Big Picture

The current runplan calls for 24 different combinations of s and t. The detailed kinematics are contained in a table in the Appendix. We have been allotted a total of 33 days of beam time, which is tentatively broken down by beam energies as follows:

Beam Energy	Dates	Plan
2.34 GeV	January 12-13 (2d)	commissioning
2.34 GeV	January 14 (1d)	unpolarized running
4.62 GeV	January 15-20 (6d)	unpolarized running
5.76 GeV	January 21-28 (8d)	unpolarized running
3.48 GeV	January 29-January 30 (2d)	unpolarized running
3.48 GeV	January 31-February 10 (11d)	polarized running
	February 11-14	Maintenance
3.48 GeV	February 15-17 (3d)	polarized running

2 Useful Abbreviations

Abbreviation	Meaning
rad-h	15 cm LH_2 target with 6% copper radiator
norad-h	15 cm LH_2 target without radiator
optics	optics target
dummy	15 cm dummy target
endpt	endpoint kinematics, used for *ep* calibrations
offendpt	off-endpoint kinematics, used for RCS physics runs
moff	deflection magnet turned off
mon	deflection magnet turned on

3 Commissioning Procedure

3.1 Setup

It is assumed that the RCS detectors (calorimeter and veto) and HRS-L (HRS) detectors, including the FPP, have been previously checked out without beam using cosmic rays. The detector configuration is as follows:

- **beam energy:** 2.342 GeV (1139 MeV/pass)
- CALO **angle/distance:** 46°/12.0 m
- HRS **angle/momentum:** 33.97°/1.711 GeV/c
- HRS **collimator:** open
- **raster:** rectangular, ±2 mm amplitude

It is assumed that both the CALO and the HRS have been surveyed in these positions and that neither have been moved nor will move until the commissioning is completed. In these kinematics, the calorimeter angular acceptance is about 15% smaller than the equivalent hadron acceptance in both dimensions. The expected *ep* elastic counting rate is about 90 Hz for a 10 μA electron beam. It is also assumed that we are sufficiently happy with the beam tune to proceed with calibration of the CALO.

3.2 Initial Look at CALO: 0.5 hr

Conditions: **norad-h**, **moff**, **endpt**
This is just to give the data analyzers something to use for testing their codes while the next step is being performed.

3.3 Beam Positioning Setup: 3 hr

Doug Higinbotham responsible This is a necessary first step to assure that the beam is well-positioned for the next step. We will use a 5 μA beam, no target, and raster turned off.

1. BPM/HARP/OTR cross calibrations
2. Beam centering
3. Beam halo inspection using OTR

3.4 Initial Calibration of CALO: 1 hr

Alan Nathan responsible Conditions: **norad-h**, **moff endpt**

Run initially for 5 minutes using pulser trigger to obtain pedestals. Then run for 10 μA-hr (1 hour @ 10 μA) on *ep* elastic scattering with the coincidence trigger. The analysis team will then work as quickly as possible to do the following:

1. Determine gains, pedestals, thresholds, positions of calorimeter modules
2. Checkout of veto gains, TDC's, thresholds, positions, efficiencies
3. Calibration of threshold level on RCS detectors
4. HRS detector and physics analysis

This process may need to be iterated several times by adjusting HV to roughly match gains. Care needs to be taken to make sure that the full dynamic range of 0.80-4.00 GeV is within the ADC and discriminator range. The analysis technique is along the same lines as that used to analyze the test data from 1999. This will be written up as a separate document. The iterations in this process will be interspersed with the commissioning of the standard Hall A equipment, described in the next section.

3.5 Commissioning of Hall A Equipment: 15 hr

Conditions: **norad-h**, **moff endpt**
NOTE: The items listed below are to be interspersed with the RCS commissioning items listed in the next section as well as the RCS 2-pass running. The general rule is that whenever the RCS commissioning is ready for the next step, that will take priority over the other items, with the additional constraint that these things must be done prior to the end of 2-pass running.

1. White spectrum for HRS and FPP: 2.0 hr, shift crew responsible This will use OPT, endpt, MOFF, looking at quasi-elastic scattering from carbon, HRS singles only. Beam current should be 50 μA and the beam raster should be off.

2. Beam energy measurements[1]

   (a) Arc energy measurement: 4.0 hr, Doug Higinbotham responsible

   (b) ep energy measurement: 4.0 hr, Bodo Reitz responsible

3. Calibration of BCM with Unser, 2-50 μA range: 3.0 hr, Arun Saha responsible[2]

3.6 Additional RCS Commissioning Items: 12 hr

These runs take place only after we are satisfied with HV setting for the CALO and veto and that we have a good energy calibration and crude position calibration.

1. **Iterations on Calibration of CALO, Alan Nathan responsible.** Iterate the calibrations of Sec. 3.4, as necessary.

2. **Deflection Magnet: 2 hr, Bogdan Wojtsekhowski responsible**
   Conditions: **norad-h**, **endpt**, I=10 μA
   The purpose of these runs is to map out electron deflection versus magnetic field; to study hysteresis in the magnet by observing the deflection when the magnet is turned off after having been at the maximum current; and to study the effect of the magnet on the counting rate in the veto detector due to the effect of the magnet on the primary electron beam. If the magnet does affect the primary beam at full field, we will have to devote more time to this. Initially run with no target and raster turned off. Observe the viewer at the beam dump to determine beam movement as the magnet is turned up to full current. Also observe the counting rate in the veto detectors and in the downstream ionization chambers. Then put in the **norad-h** target and do the following sequence of runs:

   - *ep* coincidences with **moff**, 1.5 μA-hr

[1] If the arc measurement agrees with the "Tiefenback" energy, then we may opt not to do the ep energy measurement.

[2] This item will need to wait until Arun Saha is available. In his absence, the BCM should be calibrated against the injector current (OLO2). Since Hall C is not running and since Hall B uses very little beam, all of the injector current should appear in Hall A.

- *ep* coincidences with **mon**, 25% of full current, 1.5 μA-hr
- *ep* coincidences with **mon**, 50% of full current, 1.5 μA-hr
- *ep* coincidences with **mon**, 75% of full current, 1.5 μA-hr
- *ep* coincidences with **mon**, 100% of full current, 1.5 μA-hr
- *ep* coincidences with **moff**, 1.5 μA-hr

3. **Threshold Calibration: 1 hr, Alan Nathan responsible**
   Conditions: **norad-h**, **endpt**, I=10 μA, **moff**
   Calibrate the threshold on the calorimeter discriminators (controlled by a single DAC) by doing a series of short runs (each $\approx$15 minutes) with the T1 trigger (calorimeter singles) and with the threshold changed to see how the energy threshold depends on the electronic threshold. In order for this to be effective, it is necessary for the gains to be well enough matched so that the electronic threshold is approximately the same energy threshold for each of the 56 discriminators. For the remainder of these runs, place the energy threshold at 0.4 GeV, which is 1/3 the expected energy for *ep* elastic scattering.

4. **Counting Rate Studies: 2 hr, Alan Nathan responsible**
   Conditions: **norad-h** and **rad-h**, **endpt**, variable I, **mon**
   The purpose this set of runs is to study the beam-current dependence of counting rates in calorimeter and veto, pedestals and laser peaks, veto efficiency, energy and position resolution in the calorimeter, etc. Use this information to set the maximum allowable counting rate on the veto and calorimeter.

   - noradH, vary I from 10 to 50 μA in 10 μA steps
   - radH, determine I that give same counting rate in veto detector as we get with 50 μAand no radiator

5. **Calorimeter Efficiency Calibration: 1 hr, Alan Nathan responsible**
   Conditions: **norad-h**, **endpt**, I=10 μA, **mon** and **moff**
   Run with a special T7 trigger (S0 synchronized with calorimeter and all other triggers rate-divided out) trigger only. Run for 5 μA-hr with **mon** and 5 μA-hr with **moff**.

4 Running Procedure

4.1 First RCS Run–(Kinematics 2A): 9 hrs

Calorimeter still at 46°, 12.0 m.
HRS setting initially same as for commissioning.

1. **dummy**, **endpt**, **mon** ... 15 min (background check)
2. **optics**, **endpt**, **moff** ... 15 min (pointing run), HRS singles only
3. **norad-h**, **endpt**, **moff** ... 15 min (alternate pointing run)

4. **rad-h**, **endpt**, **mon** ... 15 min (alternate pointing run)
5. **rad-h**, **endpt**, **moff** ... 15 min (check change in calo acceptance)
6. **rad-h**, **offendpt**, **mon** (physics run) ... 1 hour
7. **rad-h**, **offendpt**, **moff** (physics run, ep background)[3] ... 1 hour
8. **norad-h**, **offendpt**, **mon** ... 1 hour (effect of virtual photons)
9. **dummy**, **offendpt**, **mon** ... 15 min (background check)
10. **optics**, **offendpt**, **mon** ... 15 min (pointing run), HRS singles only

4.2 N(E_e) Measurement): 4 hrs

Make a series of 6 runs with kinematics given in the table in Appendix. 6.2. Calorimeter should still be in the kinematics 2A.

4.3 Post-Scattering Radiator Study: 2 hrs

Controlled Access: insert 1-cm Aluminum plate between target and magnet.. CALO and HRS are at the same location as in first RCS run.

1. **norad-h**, **endpt**, **moff** ... 30 min run
2. **norad-h**, **endpt**, **mon** ... 30 min run

4.4 Each Kinematic Setting

Kinematics is shown in the table in Appendix 6.1. Nominal beam current is 10 μAḢowever, the decision on the actual beam current will depend on the counting rate in the veto detector and how the counting rate affects its performance. This will not be known until the commissioning runs have been completed. The run plan allows for a 4-hour access to change the angle/distance of the CALO. Download the appropriate delay file. Adjust the calorimeter discriminator threshold to the value given in the table in Appendix 6.1.

1. **optics**, **endpt**, **moff** ... 15 min (pointing run...HRS singles only, 50μA)
2. **norad-h**, **endpt**, **moff** ... 5,000 *ep* elastic events. If rates are favorable, increase beam current. Try to complete in 15 minutes. Verify that the CALO-HRS TDC peak is in the right place.
3. **norad-h**, **endpt**, **mon** ... 5,000 *ep* elastic events. If rates are favorable, increase beam current. Try to complete in 15 minutes. Magnet current should be the highest possible consistent with the deflection of elastic electrons less than 0.4 m at the front of the calorimeter.

[3]This may be skipped, at the discretion of Alan Nathan

4. **rad-h**, **endpt**, **mon** ... 5,000 *ep* events. Run at beam current compatible with good veto efficiency, as determined from commissioning runs. Measure veto efficiency at these rates in endpoint kinematics.
5. **rad-h**, **offendpt**, **mon** (physics run) for the number of μA-hr shown in the last column of the table of kinematics (Sec. 6.1). Beam current should be the same as in the previous run in endpoint kinematics.
6. **dummy**, **offendpt**, **mon** ... 15 min (background check)
7. **optics**, **offendpt**, **moff** ... 15 min (pointing run...HRS singles only, 50μA)

4.5 Each Beam Energy

1. BCM calibration
2. $ep\gamma$ studies with post-radiator, as described in Sec. 4.3. This is done at the forward-most CALO angle for each energy. (1 hr. required for access and 1 hr. required for measurement)
3. N(E_e) measurement. For the 2-pass energy, the measurement will involve scans of the *ep* cross section with both **norad-h/endpt** and **rad-h/offendpt**, as described in Sec. 4.2. Assuming that there is good agreement between the two sets of data, subsequent beam energies will utilize only the **norad-h/endpt** scans (three per energy) in the kinematics given in Appendix 6.2. This is done *just before* the forward-most CALO angle for each energy. (2 hours required for measurements.)
4. ep and/or arc beam energy measurements (4 hrs. required)

5 Optics Runs for HRS

5.1 Sieve Slit Runs with Negative Polarity

After kinematics 4A is completed, the HRS will have its polarity reversed in order to do optics studies. An access is needed to move the calorimeter to a large distance and angle in order to allow increased luminosity. The sieve slit is mounted in the HRS. A series of singles runs are done on the carbon quasielastic peak with as large a beam current as possible (I $\geq$ 50 μA) in the following kinematics, negative polarity, optics target:

HRS momentum	HRS angle	# events
4.300	14.5	3 x 10^5
4.200	14.5	3 x 10^5
4.100	14.5	3 x 10^5
3.000	27.0	3 x 10^5
2.000	42.6	3 x 10^5

After the sieve slit runs are completed, the polarity of the HRS should be restored to positive and the calorimeter should be placed in the 5A kinematics while the beam energy is changed to 5.76 GeV.

5.2 Momentum Scan at 4.3 GeV

In the **endpt** runs prior to the start of kinematics 5G, a momentum scan will be done with the HRS central momentum at 4.3 GeV/c using *ep* elastic coincidences. The CALO is at the 5G angle. The scan is done with the HRS at a **fixed central momentum but variable angle**. Using the **norad-h** target, **moff**, and with I=50 μA, do the following series of runs, each for 15 minutes:

1. $\theta = 22.5°$
2. $\theta = 21.5°$
3. $\theta = 20.5°$
4. $\theta = 19.5°$
5. $\theta = 18.5°$

6 Tables of Kinematics

6.1 Kinematics for RCS endpt and offendpt

Run ID	E	D(m)	θ	TOF† ns	HRS θ/p **offendpt**	HRS θ/p **endpt**	$\approx\mu$A-hr‡
2A	2.342	12.0	46.0	59	35.68/1.556	33.97/1.711	10.0
2B	2.342	7.1	56.0	73	29.82/1.779	28.28/1.951	3.9
2C	2.342	5.2	79.0	76	20.29/2.129	19.14/2.322	5.3
3A	3.481	14.4	31.0	48	39.08/1.768	37.44/1.928	11.5
3B	3.481	10.0	39.0	59	32.46/2.142	30.95/2.332	14.0
3C	3.481	7.9	45.0	65	28.54/2.380	27.14/2.586	15.5
3D	3.481	6.2	57.0	69	22.53/2.752	21.36/2.981	20.0
§**3E**	3.481	5.7	65.0	70	19.47/2.939	18.43/3.176	**many**
3F	3.481	5.3	75.0	71	16.36/3.118	15.47/3.362	35.5
4A	4.620	18.0	22.0	29	42.58/1.789	40.97/1.943	22.6
4B	4.620	16.4	26.0	38	37.73/2.109	36.17/2.290	28.9
4C	4.620	13.1	30.0	48	33.69/2.407	32.21/2.611	35.1
4D	4.620	10.1	35.0	56	29.53/2.741	28.16/2.970	40.9
4E	4.620	7.9	42.0	62	24.95/3.137	23.74/3.391	51.0
4F	4.620	6.9	50.0	65	20.96/3.496	19.90/3.769	75.0
4G	4.620	6.2	57.0	67	18.21/3.742	17.27/4.025	100.0
4H	4.620	5.6	66.0	68	15.38/3.987	14.57/4.278	135.1
5A	5.759	18.0	20.0	26	40.01/2.133	38.47/2.311	49.2
5B	5.759	18.0	22.0	28	37.28/2.354	35.78/2.550	59.8
5C	5.759	14.5	26.0	41	32.66/2.772	31.25/3.002	76.5
5D	5.759	11.4	30.0	51	28.91/3.154	27.60/3.410	93.8
5E	5.759	9.5	34.0	56	25.83/3.494	24.62/3.772	112.8
5F	5.759	8.8	37.0	58	23.86/3.722	22.72/4.013	132.7
5G	5.759	8.1	41.0	60	21.59/3.992	20.54/4.298	174.4

† Difference between photon/electron and proton propagation time from target to trigger detector, according to the formula TOF = $85/\beta$ - 3.3D, with D in meters, TOF in ns, and $\beta = p_p/E_p$.
‡ Approximate beam charge for **offendpt** runs to get 1500 RCS events.
§ Kinematics for the polarization transfer experiment using the FPP.

6.2 Kinematics for $N(E_e)$ Measurements

Energy	Target	CALO θ/D	TOF ns	HRS θ	HRS p	magnet	μA-hr
2.342	**norad-h**	46.0/12.0	66	34.59	1.768	**mon**	1
2.342	**norad-h**	46.0/12.0	66	33.99	1.709	**mon**	1
2.342	**norad-h**	46.0/12.0	66	33.40	1.654	**mon**	1
2.342	**rad-h**	46.0/12.0	66	34.95	1.621	**mon**	10
2.342	**rad-h**	46.0/12.0	66	35.70	1.554	**mon**	10
2.342	**rad-h**	46.0/12.0	66	36.38	1.496	**mon**	10
3.481	**norad-h**	31.0/14.4	48	38.14	1.999	**mon**	1.5
3.481	**norad-h**	31.0/14.4	48	37.44	1.927	**mon**	1.5
3.481	**norad-h**	31.0/14.4	48	36.76	1.860	**mon**	1.5
4.620	**norad-h**	22.0/20.0	29	41.72	2.019	**mon**	1.5
4.620	**norad-h**	22.0/20.0	29	40.97	1.943	**mon**	1.5
4.620	**norad-h**	22.0/20.0	29	40.23	1.872	**mon**	1.5
5.759	**norad-h**	20.0/20.0	26	39.23	2.406	**mon**	1.5
5.759	**norad-h**	20.0/20.0	26	38.46	2.312	**mon**	1.5
5.759	**norad-h**	20.0/20.0	26	37.71	2.223	**mon**	1.5

7 Sequencing of Runs

1. Commissioning
2. 2A
3. 2-pass N_e
4. 2-pass $ep\gamma$
5. 2B
6. 2C
7. 4H
8. 4G
9. 4F
10. 4E
11. 4D
12. 4C
13. 4B
14. 4-pass N_e
15. 4A
16. 4-pass $ep\gamma$
17. 4-pass optics run
18. 5-pass δ scan
19. 5G
20. 5F
21. 5E
22. 5D
23. 5C
24. 5B
25. 5-pass N_e
26. 5A
27. 5-pass $ep\gamma$
28. 3F
29. 3D
30. 3C
31. 3B
32. 3-pass N_e
33. 3A
34. 3-pass $ep\gamma$
35. 3E
36.
37.
38.
39.
40.

A Detailed Kinematics