PrimEx Commissioning Plan

1 Establish a Good Electron Beam

1. Brems radiator out, collimator out, PrimEx target out, HYCAL out of beam, TAC out of beam, Beam Position Monitor (LG_BPM) out, tagger magnet on, tagger magnet interlock on.
2. Ask for 5 nA electron beam (or ask to start a photon beam).
3. Check electron beam spot on the beam dump screen.
4. BPM readings on 2C21 should be x,y = 0.0 +-0.2 mm
5. Take electron Harp scans, check the position, width, and ratio of signal to background.
6. Ask MCC to turn our laser off. Ask them to check bleed through. It should be a few percent.

2 Establish a Good Photon Beam

Note: radiators are as follows:
A: 3×10^{-4}
B: 1×10^{-4}
C: 1×10^{-5}
D: 1×10^{-5}

1. Beam off.
2. Insert brems radiator B.
3. Insert Beam Position Monitor (LG_BPM) into precalibrated position. (Need survey info here.)
4. Beam on, 5 nAmps.
5. Have them adjust beam (with correctors downstream of 2C21 but upstream of 2C24 (which is close to the radiator) so that photon beam is centered on LG_BPM.
5. Take photon harp scans and check the quality.
6. Note readings on 2C24.

3 Plateau Tagger Counters, x-y scan on LG_BPM

The following should take about 1/2 hour.

1. Plateau T and (possibly) E counters
2. At the same time (*i.e.* parasiticly) move LG_BPM to illuminate all the fibers in x and y.

4 Plateau Pair Spectrometer Counters

(Note: tests with LG_BPM can continue here, if necessary.)

1. Pair spectrometer magnet at 3159 Amps.
2. Insert $0.5\% X_o$ Be target (on Primex ladder).
3. Plateau pair spectrometer detectors as described in section 6.4 of the PrimEx HowTo.

5 Verify e^+e^- acceptance for pair spectrometer is o.k.

1. Look at T counter occupancy for PSMT triggered events. All T counters should have counts. Number of counts on each end of the focal plane should not vary by more than about 30%.

6 Regular TAC runs

1. Pair spectrometer magnet at 3150 Amps.
2. TAC out of beam at 1650 V.
3. Call MCC (x). Tell them to turn orbit locks off.
4. Request current of 70 picoAmps.
5. Remove *PrimEx* target.
6. Change trigger to MOR.
7. Put in radiator D. Note: Never put more than 1 nAmp on radiator D. MOR rate should be about 10 kHz.
8. Put the TAC in. (Go Beam on the gui.)
9. Check ADC gate timing in counting room or with web connected scope.
10. Get an access to fix timing (unless it is remote).
11. Check the ADC spectrum, HV and discriminator threshold ($\sim$ 1 GeV level).
12. Begin run.
13. End run.
14. Set PS B = 0.
15. Do another TAC run.
16. Insert 8.6 mm photon beam collimator.

17. Do another normalization run.
18. Set PS current to 3150 Amps
19. Do another normalization run.
20. If the 8.6 mm collimator cuts more than 1-2%, go to item 25. ACTUALLY, SINCE IT WILL TAKE TIME TO ANALYZE, LET'S CONTINUE ANYWAY. -DSD
21. Move collimator 1 mm beam left.
22. Do a normalization run
23. Move collimator 1 mm beam right.
24. Do a normalization run.
25. Insert 12.7 mm collimator.
26. Do a normalization run.
27. Set PS B=0.
28. Do a normalization run.
29. Set PS current to 3150 Amps.
30. Move collimator 1 mm beam left
31. Do a normalization run.
32. Move collimator 2 mm to left of beam center.
33. Do a normalization run.
34. Move collimator to 1 mm right of beam center.
35. Do a normalization run.
36. Move collimator to 2 mm right of beam center.
37. Do a normalization run.
38. **Make a decision on whether to run with photon collimator in or out.**
39. Take TAC out.
40. Put in radiator B.
41. Change trigger to production run.
42. Call MCC. Ask them to put orbit locks back on and increase beam current.

43. Insert the 5% C12 target in, B=20. KG, measure again
44. set PS B=0 KG back, measure again;
45. beam off, insert HYCAL in beam (center);
46. beam is back, B=0.KG, C12 in, measure again;
47. set PS B=20. KG, measure again;
48. move HYCAL x= +2 mm (from center), measure again
49. move HYCAL x= -2 mm , measure again;
50. move HYCAL y= +2 mm, measure again;
51. move HYCAL y= -2 mm, measure again;
52. bring HYCAL back to the center, insert Pb target, measure again;
53. set PS B=0. KG, measure again;
54. insert 1% Be target in, measure again;
55. set PS B=20. KG, measure again;

7 Radiator Thickness Study

Here, we study the effect of radiator thickness of beam profile and tagging ratio.

1 Put in 8.6 mm collimator.

2 Put in brems radiator A ("thick" $-3 \times 10^{-4} X_o$)

3 Bring up electron beam current until MOR is about 10 MHz.

4 Do a PS run (MOR and clock triggers) for 20 minutes.

5 Beam off, switch to brems radiator B ("thin" $- 1 \times 10^{-4}$).

6 Bring (down) electron beam current until MOR is about 10 MHz.

7 Do a PS run (MOR and clock triggers) for 20 minutes.

8 Study of Photon Collimator Scraping on Pair Spectrometer

1. 8.6 mm collimator in.
2. PrimEx target out.
3. Radiator B in.
4. Beam current such that MOR = 20 MHz.
5. 0.5 hour run with clock, MOR triggers.

9 PS Intensity Scan for Photon Flux Control

1. radiator B in
2. 12.7mm photon beam collimator
3. PS current at 3150 Amps
4. Carbon target.
5. HYCAL in(???).
6. TAC is in initially.
7. P.S. run, 50kHz on MOR -1.5 hour. Make sure max TAC rate is not exceeded (see HowTo).
8. P.S. run 150kHz on MOR - 3.0 hours (cross calibrates TAC and p.s.) Make sure max TAC rate is not exceeded (see HowTo).
9. TAC out.
10. P.S. run, 1 MHz on MOR - 0.25 hour
11. P.S. run, 10 MHz on MOR – 0.25 hour
12. P.S. run, 20 MHz on MOR - 0.25 hour
13. P.S. run, 30 MHz on MOR - 0.25 hour

For the above runs, verify ADC spectra do not change appreciably with rate. (See Itaru's PrimEx Note.)

10 Target Scan with PS and Beam

Goal: to map the relative thickness of physics targets.

1. Brems radiator "B" in.
2. 12.7 mm collimator in.
3. Carbon target in.
4. PS current 3150 Amps.
5. HYCAL maybe in, not important for these tests.
6. TAC out.
7. LG_BPM in.
8. MOR 10 MHz.
9. Measure relative tagging ratios for the central position;
10. Move the target X= +1, +2, +3, +4, +5 mm, for each position measure the same rate;
11. Move the target X= -1, -2, -3, -4, -5 mm and each time measure the same rate;
12. Move the target Y=+1,+2,+3, +4,+5 mm, each time measure the rate;
13. Move the target Y=-1,-2,-3,-4,-5 mm, measure

11 HYCAL Gain Equalizing

Goal: To reach ~5/

1. Radiator D (thinnest).
2. 12.7 mm photon collimator.
3. No targets in harp or PrimEx ladder
4. PS current = 3150.Amps
5. Beam current 50 pA (lowest possible).
6. HYCAL in "TOP" position.
7. Trigger = HYCAL or MOR (timing problem, talk to Dave L.).
8. WHICH T COUNTERS IN TRIGGER?? T1??-DSD T19 (5 GeV) and Tx (0.5 GeV).
8. HYCAL absorber in "open" position.

9. Insert "bottom right" LG module in (center).

10. Make a timing scan to define the gate delay.

11. Get access and set the delay (cable);

12. Decide the gain value for LG modules: E 5.GeV to ADC 5000 channel (think more);

13. Start gain equalizing: scan each centers, show the anode ADC and dynode ADC for that channel for T19 and Tx, change HV, wait 1 min., change again to bring the gain to preset ADC channel for the Dynode ADC, write and save the ratio anode ADC/dynode ADC;

14. Repeat this process for all LG modules (think here more).

15. Insert "bottom right" PbWO module in the beam (center), starting from item 12 and finish with 14 for all PbWO modules;

x. For the central 12 PbWO crystals (under the absorber) make sure that the photon beam is hitting the central 3mm hole of each module.

16. Leave the HYCAL "ON" for about 1 hour, randomly check gains of several groups by looking at the dynode sums. If there is time, do this for the entire HYCAL.

12 HYCAL "Consistency" Check vs. HV Reset ("zero tolerance" policy check

Goal: to see if we can fix a HYCAL inside problem with HV disconnection for some time (or what if HV tripped?).
Possible method: temporarily calibrate a part of HYCAL (say 7x7 PbWO area), get good statistics in the middle of this area, disconnect HV for 1 hour (?), bring them up to the same HV, measure the energy on the center again, use LMS information here, cross check with the LMS reference tubes, which are supplied with separate (uninterreupted) power supplies (the hardware is done now.)

13 HYCAL Calibration

Goal: to get the calibration constants for each module.

1. Run HYCAL about 5 hours after the gain equalizing (think what can be done during this time).

2. Start from one corner ("bottom right" probably) move the HYCAL with 1min/module continuous motion and illuminate all modules with a continuous motion. Run the DAQ without sparsification, store the data with x,y cooordinates from EPICS.

x. trigger: MOR, with Eg = 0.1 - T20(max) GeV; radiator C, collimator in, no targets, PS current =3150 Amps, beam current 100 pAmps.

HYCAL absorber in the open position

start from one corner (bottom right probably) move HYCAL with 1 min/module continuous motion and illuminate all modules with DAQ continuously running. Run DAQ without sparsificatrion, store the data with HYCAL x,y, coordinates from EPICS.

3. Stop DAQ by the end of each row (or 1 hour), move HYCAL one row down, take a new run starting from pedestals and LMS.

   For the central 12 PbWO crystals (under the absorber) make sure tha the photon beam is hitting the central 3 mm hole of each modules.

4. End the calibration at the last "top left" module.

5. Come up with online calibration constants, use two methods: iteration and Chi-square methods.

14 HYCAL at the Transition Regions

Goal: from the above scanned data we should have good enough information for the transition regions. But, to make sure we have enough statistics at the edges, we had better run these regions separately.

Setup the same as the previous section, except we may need to insert the samllest collimator ('2.7 mm ??? WE DON'T HAVE THIS -DSD), the absorber is in the "locked" position (WHAT DOES THIS MEAN? -DSD)

1. LG-PbWO transition: pick up one of the transition corners (say, "top-right" corner), start from the center of the left third PbWO module, go to the right with "slow motion" (5min/module, to be determined later), go and pass LG transition region up to the center of the right third LG module. From here go down by hald crystal size (10.3 mm)and repeat the same path toward the left. In this scan include seven horizontal rows, which makes three full crystal sizes. Include in this scan three horizontal rows at least;

2. Central transition region (the beam hole): start from the beam center, on the level of the center of the crystal (Wxxxx) and move "slowly" to the right up to the middle of the 3rd crystal. Go one crystal size down, scan to the left and finish beam center.

3. edge of the HYCAL: pick up one of the outside corners (say "bottom right"), in the same way start with the upper left center of the LG module from that 3x3 section, slowly move to the right exiting HYCAL by 20 mm, go down by a half module (19.1 mm) and repeat the scan to the left up to the center of the 3rd LG module, end the scan with the middle line of the last LG modules.

15 HYCAL Energy and Coordinate Resolutions

Goal: to get a measurement of the energy and position resolutions.

1. the setup is the same as before;
2. Energy resolution: stop at the middle of PbWO crystal area get "reach" statistics (one run with phase 1 included). The same way go to the middle of LG area and get data;
3. Position resolution: there is now way to get a precision calibration of the coordinate reconstruction with this setup. We will use the earlier tests from the 6x6 prototype, the publications (LG part) and the data from the upper scans. There are other difficulties coming from the hybrid nature of HYCAL: these are the shifted rows. Start with the center of the 3td PbWO module (Wxxxx) from the transition line, which is also located in the middle (by X) of HYCAL. Fix the Y axis and slowly chang only X value down, with taking continuous data pass the transition region and stop at the end of the 3td LG module. Next, for the transition between LG sectors: start from the center of 3td LG from the transition line (Wxxxx) and repeat the steps before.

16 HYCAL Gain vs. Rate

Goal: to get quantitative information for the PbWO gain change vs. intensity of the beam.

gain change during the calibration: the setup is the same as in "calibration" 11,

no beam, select an area of PbWO crystals, measure the gain factors for that area (run DAQ with phase 1 and 2 (pedestals and LMS));

ask for lowest beam intensity, measure the gain factors again;

try to change intensity without harming crystals (think here), measure the gain factors again.

gain change during the experiment: set HYCAL in the center of the beam; beam line: same as for the run: radiator "B", "collimator" in, PS B 20.KG; C12 target in;

start with no beam, measure the gain factors (see before);

ask for I 1nA beam, measure the same; ask for I 10 nA, measure again;

ask for I 20nA, measure again;

ask for I 50nA, measure again;

ask for I=75nA, measure again;

17 HYCAL Photon Registration Efficiency Measurement

Goal: to measure the energy resolution degradation and possible change of the efficiency as a result of the "cracks" between modules. We should be able to extract this numbers from the upper data (if the trigger was from the tagger MOR, and very low intensity).

18 Efficiency of Veto counters

Goal: there are three points here: one is the efficiency of the veto counters to detect a charge particle, the second is the "photon conversion" efficiency inside the scintillator material, and the third one is the Y coordinate calibration with beam. For the first one the e+e- pair will be used when HYCAL is on the "run cart". The second one will be extracted from the upper data.

for the third one (the UMass group will comment here), here is my version: set the same condition as was in xx, plus: insert the 0.5%r Be target (from target ladder), set PS B 10 KG (to have 2.5GeV on HYCAL edge), start from the "bottom" center of HYCAL and scan to "top" with continuous data taking.

19 HYCAL on the "Run Cart"

Goal: to measure the e+e- diff. cross section vs. beam intensity to estimate the tolerable "trigger rate", finalize the setup for the experiment.

get "controlled access", release HYCAL from the "transporter" and put on the "run" cart; move HYCAL to the "run" position;

survey it to the beam center, get accurate Z-position;

install the "He bag" (or extend it to the new position)

set the PrimEx trigger: any two "cluster" with Eg¿0.5 GeV;

radiator "B", "collimator" is the same, insert C12 target in:

ask for beam (I 100 pA);

scan with PS magnetic field: from B=0 to B=20 KG, for 10 points (B=0, 1, 3, 5, 8, 10, 13, 16, 20 KG, to be corrected soon), take enough data (to be determined soon) for the each B setting. The goal: measure the pair production diff. cross section for the each setting;

set PS B 8. KG (to be fixed soon) in order to hit with g-¿e+e- pair (max photon energy) in the middle of HYCAL (correct soon);

measure the symmetrical pair production diff. cross section. Scan the beam intensity to determine the upper level of the trigger rate when we still measure the e+e- production diff. cross section in within the 5% level (see attachment). This trigger rate must be used to set the intensity for the pio run, (I= 0.1, 1.0, 3.0, 5.0 10.0, 15.0, 20.0 nA, the range will be calculated soon);

the efficiency of the Veto counters will be measured from these e+e- data (think about the ADC gate timing);

20 Compton Runs

The setup configuration: radiator "B", "collimator" is the same as for pio, PS B=0, HYCAL trigger is about the same: any two "cluster", only energy threshold is E(cluster) ¿ 0.2GeV; Tagger energy range: (T1-T20) + (two T counters from E = 2.5 and 3.0GeV), The trigger = (MOR + HYCAL) (think here a little more)

Local goal: to check the intensity effect and HYCAL alignment: Insert the 0.5% Be target (on the target ladder), establish the beam current so that the trigger rate is "tolerable" defined from the e+e- intensity scan, then reduce the beam intensity by factor of 2, run for 4 hours. Select Compton effects (see attachment C1), check the HYCAL alignment by the intersection point of the e-g lines on HYCAL.

Local goal: get high statistics on Be target: increase the current twice and run for 16 hours (2 shifts);

Local goal: to have a high statistics data on C12 target: insert C12 target, set beam current according to the "tolerable" trigger rate, run for 8 hours;

Local goal (not high priority): check target thickness effect, and possibly use for the energy calibration: insert 0.1% Be target (on photon harp), with the same manner define the intensity level, run for 4 hours;

21 Start the pio Life-Time Measurement

1)Goal: to extract the pion–¿ g + g decay width with an unseen precision. (we will need to discuss this part separately soon, the bottom few items are very preliminary yet).
2)insert the C12 target in, set back the pion trigger (any two "cluster" with Eg ¿ 0.5 GeV); 3)set the intensity to not exceed the maximum trigger rate defined from the e+e- intensity scan (see item 15.7); 4)run for 20 days; 5)we will see then?
Appendix for Compton Run (C1)
Assume 1x10-4 R.L. radiator, 4 GeV photon beam energy, 1nA electron beam current, 1% $\delta E/E$ energy bin size on the tagger, the Compton events registered on the HYCAL are as following:

Target	Compton event rate
0.5% R.L. 9Be	23/hour
0.15% R.L. 12C	167/hour