RPC-TN-25
January 28, 2002

Photon Beam Commissioning Plan

P. Bosted and ...

Abstract

The program for commissioning the coherent bremsstrahlung photon bam line for E159-E161 is outlined. We estimate that approximately on month of beam time will be needed. It is likely that several accesses to the beam switchyard will be needed. This makes it preferable to schedule the commissioning in several shorter time intervals, rather than a single large block of time.

1 Introduction

The sections below discuss in some detail each of the tasks that will be involved in commissioning the photon beam line, approximately in the logical order in which they should take place. It is assumed that the reader is familiar with the proposed beam line elements. For more information, please consult RPC-TN-11.

2 Setting up the electron beam

To be compatible with low-impact joint running with BaBar, we plan to do most of the commissioning with a beam energy of 25.9 GeV, a repetition rate of 10 to 30 Hz, and a beam current of up to 5×10^{10} electrons per spill.

Our first step will be to establish the desired electron beam energy and current. This will be done with no radiator in position, and the beam deflected into End Station A. We will use the roller and PR screens to steer the beam straight into the secondary emission quantameter (SEQ). If we find that the beam does not make it from the alcove to the SEQ, several shifts may be needed to identify the problem and correct it. Obstructions could occur from a large mis-alignment of the new End Station A beam-line element, in particular the pin-cushion monitor, the 3DC2 collimator, or the E160 spectrometer 2 cm diameter beam pipe (if installed). This will be done with the dump and sweep magnets turned off. By limiting the rep. rate to 10 Hz, the power level will be below 8 kW. We will also steer the beam so that it is centered in all of the A-line quadrupoles. The estimated time for establishing the electron beam is two days.

3 Optics

Our next step will be to make sure the optics is correct by looking at the E158 wire array signals. If the beam is larger or smaller than expected, or shows non-Gaussian tails, then re-tuning of the linac may be needed (particularly in the front end). Based on experience from E158, this might take up to 3 shifts.

4 Feedback loops

New feedback loops will be needed for these experiments, since all steering must be done up-beam of the goniometer, and no electron beam position readouts will be available past B33. This will likely take about 2 days to commission.

5 Pin-cushion detector

The next step will be to establish the alignment of the four-quadrant pin-cushion tungsten wire monitor that will be installed between D1 and D2. This will be done relative to the roller screen and PR2 screens, by steering the beam up/down and left/right. If the pin-cushion detector is off more than 1 mm, it will have to be r-aligned. At the same time, we will commission the readout electronics and software for this device. This includes setting the gate on the ADC to match the observed signals. The estimated time for this step is up to 2 days.

6 Ion chamber, Cherenkov, and SEQ

We will look for signals on each of these devices and time them in to the ADC gates. We may need to adjust the electronics to obtain the desired pulse heights by changing high voltages or adding amplifiers or attenuators. We will then ramp the beam current, as measured by the ESA toroids, from 0.5 to 5×10^{10} to measure linearity of the devices. Next we will reduce the beam energy in five steps to 5 GeV, to measure the SEQ linearity versus energy. The beam will have to re-steered and the optics checked for each energy. These operations will likely take about 3 days.

7 Dump magnets, wire array, and dump

We will then go back to 25.9 GeV energy, and after establishing stable beam into End Station A (with current measured in the alcove toroids), turn on the dump magnets and deflect the beam into the dump at 1 Hz. We will commission the wire array by looking at the signals and timing them into the ADC gate. A few hours change-over time will be needed to swap cables with the alcove wire array. If no beam signal is seen, we will adjust the dump magnet current until it is found. We can then see if there is any horizontal steering from magnet mis-alignments, and if the curve for integrated field versus current is correct. We can also verify that the beam spot size matches the expected optics. We will also be able to calibrate the two beam dump toroids against the values measured in the alcove. Deliberate mis-steering of the beam at 1 Hz will be used to set the ion chamber trip levels. These steps will take about 1 day.

8 Goniometer

The goniometer small SEM will then be used to center the beam on the diamonds. With the C37 collimator wide open, and an amorphous radiator inserted into the beam line, the steering will adjusted to simultaneously minimize the SEM and pin cushion detector signals. Then the large goniometer SEM will be put in place, and the C24 collimator adjusted to prevent beam from hitting the diamond holder. Next we will switch between the three goniometer positions (diamond, amorphous, and no-radiator for this setup) to make sure the relative flux into the SEQ approximately matches the expected values. If there are any problems with the SEM and/or diamond positioning devices, or with the read-backs, and access would likely be needed to fix them. If we cannot avoid hitting the holders, a new alignment may be needed. We estimate this stage will take about 2 days.

9 C37 collimator

With the photon beam centered on the amorphous radiator and the pin cushion detector, we will then close down the C37 slits to about 3 mm. We will then move the assembly up/down and left/right with new stepping motors to maximize the transmission to the SEQ. An access may be needed if the new motors control/read-back system does not work correctly the first time.

10 Sweep Magnets

We will then turn on the sweep magnets, and look at the counting rate in one of the E160 detectors (or a single scintillator paddle about 80 cm above the beam line near D3, if the E160 spectrometer is not in place). The rate should drop to well below 1/spill when the integrated sweep magnet field exceeds 50 kG-m. This should take about 1 shift.

11 Spent electron detectors

With the amorphous radiator in, we will look at the signals in the spent electron detectors in B33 and B34, and time them into the ADC gates. Amplifiers or attenuators may be needed to get the signals on scale. The new software to look at the spectra will be checked out. The signals will be stored as references. This will take about one day.

12 Goniometer tuning

The diamond will then be placed in the beam, and the vertical and horizontal angles scanned to look for the (022) and $(02\bar{2})$ ridges using the ratio of the "thin" ion chamber and Cherenkov detectors to the "thick" SEQ. We will also use the spent electron detectors to find the coherent peaks, once we are near one of the ridges. This will involve commissioning of new, somewhat sophisticated software. If coherent peaks cannot be found, an access would be needed to investigate the goniometer alignment and controls. Once the goniometer calibration is established, we would establish a peak at 15 GeV, and examine the stability of the peak position and height as a function of beam steering and current. Next we would make sure that the position and height are stable over a many hour time period, and that feedback loops on the beam position and quality are working correctly. If the observed photon spectrum in the spent electron detectors does not match the simulations, we would likely make an access to try a different diamond. Based on the recent commissioning experience at JLab, this may have to be done more than once. We estimate about 3 days for this step.

13 Compton Polarimeter

For E160, the Compton polarimeter will mainly serve to measure the shape of the photon spectrum after collimation. We will use the amorphous radiator to calibrate the lead glass and scintillator voltages and timing. The readout and analysis software will be checked out, and calibration constants adjusted to optimize the energy measurements in the lead glass blocks. The amorphous spectrum will be compared to the expected $1/k$ distribution. Then a thin diamond will be inserted to measure the coherent bremsstrahlung peak after collimation, and comparisons made to the predictions. Finally, we will make a measurement of the photon beam circular polarization (needed to make sure E159 and E161 will work as advertised) across the coherent peaks. This step will probably take about 10 days, of which two thirds is needed for the polarization measurement. We note that this will the first time circular polarization of coherent bremsstrahlung is directly measured, and will be a publish-able result in its own right. The polarized source must be used for this measurement.

14 Scheduling Issues

Except for the Compton Polarimeter commissioning, all of the commissioning could be done with minimal interference with E158. The pin-cushion detector can be installed at any time (since it is larger than the 3DC2 aperture), and in fact could be very useful for E158 run II to make sure the photons are going through the middle of 3DC2. The only other modification to the E158 would be to remove the 10-foot section of pipe down-beam of Q4, and install the the photon detectors (ion chamber, Cherenkov, and SEQ). Each detector has a only one signal and high voltage cable, and alignment is not critical. They could be removed and the beam pipe replaced in a day or so.

To set up the Compton Polarimeter (only needed for the last phase of commissioning), the big 1 m diameter beam pipe would be removed, and the target, dipole magnet, and detector arrays of the polarimeter would be installed. This is a considerable installation effort, but to take it out for additional E158 running could be done relatively quickly (on th order of a few days). It would then be much easier to install a second time, once all th cabling, control, and alignment issues had been worked out in the first installation.

Because we will likely have to make several accesses to the beam switchyard to fix problems or change radiators, it would be best to schedule the commissioning in several few-day time intervals between ROD days, rather than in a single long block of time. In the later case, either the PEP-II program would have to be interrupted, or a lot of time might be spent waiting for the next repair opportunity. We would therefore prefer to have several shorter commissioning periods, perhaps alternating with experiments using the FFTB bam line.

15 Summary

As noted in Table I, we will need about 18 days for the first phase of the coherent bremsstrahlung bam checkout, and about 10 days for the second phase (Compton polarimeter), for a total of 28 days, or one month in round numbers. Based on previous experience at SLAC, JLab, and Mainz, we will probably have to make several one-shift accesses to the beam switchyard to fix problems or change radiators.

Checkout task	Estimated time
Electron beam setup	2 days
Optics	1 days
Feedback Loops	2 days
Pin-cushion detector	2 days
Ion chamber, Cherenkov, and SEQ	3 days
Dump magnets, wire array, and dump	1 day
Goniometer	2 days
C37 collimator	0.5 day
Sweep Magnets	0.5 day
Spent electron detectors	1 day
Goniometer tuning	3 days
Total Phase I	18 days
Compton Polarimeter	10 days
Grand Total	28 days

Table 1: Summary of estimated time needed for each of the commissioning tasks.