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Power Savings for Real Photon Experiments

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1 Introduction

In light of budget problems and high electricity costs, we present a revised running plan for the Real Photon experiments that reduces the total power needed, while completely preserving proposal error bars. The key factor that makes this possible for E159 and E160 is to keep the same average beam power (limited by the beam dump and the diamond radiator to 60 kW) but use 30 Hz rather than 120 Hz, and raise the peak current by a factor of four to 2×10^{11} e/spill (safely below the maximum of 4×10^{11} e/spill at 48 GeV). In the cases where the experiment is not limited by accidental coincidences, or by the instantaneous rates in the detectors, this allows the physics goals to be achieved in the same calendar time using less incremental power above normal PEP-II operations. The other key factor is that 30 Hz running up to 28.5 GeV does not incur incremental power costs for the linac. In the case where the power to run the A-line and the spectrometers does not dominate, it is less expensive to run at 60 Hz for twice as long as at 120 Hz. The next section summarizes the incremental power costs for the experiments as originally proposed, as well as an optimized scenario. The following sections give more details about the impact on each of the experiments.

2 Summary of power needs

Table 1 shows the power needs if the experiments had been run using the requested 2 weeks of checkout and 2 months of data taking at 120 Hz for each experiment. We note that each proposal also listed the option of running for 4 months at 60 Hz, which gives the same integrated luminosity. The calculations assume concurrent running with PEP-II, for which about 0.1 MW is needed for each GeV of energy above 28.5 GeV at 30 Hz. To go above 30 Hz, the extra power needed is about $0.1E * (R/30 - 1)$ MW, where R is the rep rate in Hz and E is the electron energy in GeV. The power to run the A-line bend, dump and sweep magnets when producing photon beams is calculated using $2.5(E/48.5)^2$ MW. The effective average energy (weighted by energy squared) is 40, 46, and 48 GeV for E159, E160, and

Experiment	Conditions	P (GW-hr)
E159	9 weeks, 120 Hz, $< E >= 40$ GeV	23
E160	9 weeks, 120 Hz, $< E >= 46$ GeV	33
E161	9 weeks, 120 Hz, $< E >= 48$ GeV	35

Table 1: Incremental power (above PEP-II) needed in GW-hr for E159-E161 under the nominal proposal conditions, assuming 2 months at 120 Hz for production running for each experiment. The power totals include 2 weeks of checkout at 30 Hz and 28.5 GeV in each case. See text for assumptions on incremental linac power, A-line power, and spectrometer power for each experiment.

E161 respectively. The power for spectrometers is assumed to be 3 MW for E160 and E161, and zero for E159 (which has no spectrometer magnet).

Table 2 shows the power needed after optimizing the peak current and spectrometer power for each experiment. For E159, the flux integration part of the experiment is done at 30 Hz in the same amount of beam time (1 month) as previously by using the higher current. The counting mode part of the experiment is done at the same current as previously, but running for twice as long (2 months) at 60 Hz. The average energy for the counting mode cross-check part of the experiment is 30 GeV. The total incremental power needed is reduced from 23 GW-hr to 8 GW-hr.

For E160, estimates show that the entire experiment can be run at 30 Hz with four times the peak current, and still reach the proposal goals in 2 months. In addition, the spectrometer power is reduced from 3 MW to 2 MW. The total incremental power needed is reduced from 33 GW-hr to 11 GW-hr.

For E161, accidental rates are likely to be the limiting factor, so running at higher peak power does not help. However, the new spectrometer design takes less than 1 MW, while the original design needed 3 MW. This makes it 30% more cost-effective to run for 4 months at 60 Hz, rather than 2 months at 120 Hz. The total incremental power needed is reduced from 35 GW-hr to 20 GW-hr.

In summary, the total calendar running time for all three experiments (including checkout) is increased from 33 weeks to 46 weeks, spread over 3 years. The integrated power for all three experiments (above PEP-II requirements) is reduced from 91 GW-hr to 39 GW-hr. At $40 to $90 per MW-hr, the power bill for the three experiments will likely be in the range $1.6M to $3.5M, a substantial savings over the the original estimates.

Experiment	Conditions	P (GW-hr)
E159	5 wk, 30 Hz, $< E >= 40$ plus 8 wk, 60 Hz, $< E >= 30$	8
E160	9 weeks, 30 Hz, $< E >= 46$ GeV	11
E161	18 weeks, 60 Hz, $< E >= 48$ GeV	20

Table 2: Incremental power (above PEP-II) needed in GW-hr for E159-E161 under the the revised conditions described in the text. The power totals include 2 weeks of checkout at 30 Hz and 28.5 GeV in each case.

3 E159 experiment

This experiment has no spectrometer magnet, and has two running modes. In the flux integration mode (half of the running time), there is no issue of detector pile-up or accidentals. The errors are expected to be dominated by systematic effects for these measurements. It therefore makes no difference if the data are taken at high current and 30 Hz. The other half of the running is in the counting mode, as a cross check on the flux integration mode at selected kinematic points. We chose points that all use electron beam energies less than 30 GeV, because the asymmetries are expected to be largest at low energies, making a cross check more meaningful. The maximum beam current in the counting mode is set by the pile-up, dead-time, and DAQ limits in the detectors, so we cannot increase the beam current for this part of the running. To obtain the same number of counts as in the proposal, we propose to run for twice as long (2 months) at half the repetition rate (60 Hz).

4 E160 experiment

The E160 experiment, scheduled to be the first to run, has seen an extensive design effort. The resulting final spectrometer configuration has a factor of two better figure of merit than in the proposal. For nominal running at 120 Hz with a beam current of 5×10^{10} e/spill, we expect about 0.5 sprinkle hit per detector, about 3 tracks per spill per detector quadrant, and about 0.5% (2%) accidental coincidences under the J/ψ (ψ') mass peaks. Running with 30 Hz and 2×10^{11} e/spill will quadruple the sprinkle hit and track rates, and increase the accidental fraction to $< 10\%$. Based on experience with a similar tracking system in E155, we are confident that we can handle these higher rates with an effective efficiency loss of $< 20\%$, and so could easily meet the proposal goals with the same total running time as in the proposal (2 months). If our rate estimates turn out to be too high, we will increase the vertical distance of the detectors from the beam line by 5 to 10 cm, and add extra shielding. This region just above and below the beam pipe is where most of the sprinkle hits and single tracks are to be found. We can therefore decrease singles and track rates by up to a factor of three, only decreasing the acceptance for ψ particles by 20%. We will still be able to meet our proposal goal in 2 months of running, unless background rates are more than 2 to 3 times higher than expected from detailed simulations.

5 E161 experiment

In the present stage of design, the E161 experiment is limited by accidental coincidences and high singles rates in the detectors. Therefore it would not be prudent to plan on running with a higher peak current and lower repetition rate. However, running for 4 months with 60 Hz yields the same number of beam pulses as 2 months at 120 Hz, and takes about 30% less power. The new spectrometer design (using magnetized iron instead of a large air gap) reduces the steady-state power needs considerably, which is the main reason that the 60 Hz running saves on power. It should be emphasized that of all the experiments, the true signal rates for E161 are the most uncertain. The total cross section for open charm photoproduction at 40 GeV has a 50% uncertainty, and additional uncertainties arise when evaluating the fraction of events that decay to high p_T muons. Measurements made during the E160 experiment will be crucial to optimizing the E161 experiment. If the signal to noise is higher than presently expected, the experiment may be able to performed in less than 4 months at 60 Hz.