The E158 Readiness Review

SLAC - March 1, 2002

Steve Williams reconvened the E158 Review Panel that met in September of last year. The purpose of the review was to determine what work has been accomplished since the review of last September, and to project forward to the upcoming running periods with regard to the likely outcome of the physics runs.

Coming in to this review, it had been essentially agreed that the running scenario for March-April-May would consist of raising the machine pulse rate to 60 Hz for the period of early March to March 31, then to go to 120 Hz for the month of April, then to drop back to 60 Hz for the month of May. This drop in rate in May was required to stay within the power limits and budget constraints. E158 would receive a majority of these pulses. Periodic PEP fills and keep-alive pulses would subtract from these rates as needed by PEP.

The Committee was chaired, as before, by Charles Prescott, with the following committee members: Stan Ecklund, Roger Miller, Peter Rowson, Sayed Rokni, Dave Schultz, and Bruce Schumm. All members are from SLAC, except for Bruce Schumm, from UCSC. The Charge to the Committee and the schedule of talks are appended to this report.

SUMMARY AND CONCLUSIONS

Overall, the Committee's impression is that E158 and the Accelerator Department has made remarkable progress since last September. There were no "show stoppers" identified in the current situation with regard to the beam and the experimental setup. Major concerns from September have largely been addressed and appropriately dealt with. The E158 experiment appears ready to run.

The E158 experiment proposes to make a precision measurement of the electroweak mixing parameter $\sin^2\Theta_W$ in the elastic scattering of electrons. The kinematics of high energy electrons scattering from quasi-stationary target electrons gives a measurement at low center-of-mass energy, far away from the Z-pole. The original proposed goals of the E158 experiment can be summarized in terms of the error on the electroweak mixing parameter, $\delta\sin^2\Theta_W = \pm.0007$ (Note: the world average is now $\sin^2\Theta_W = 0.23156 \pm 0.00017$ at the Z-pole). The E158 collaborators expect to achieve $\delta\sin^2\Theta_W = \pm.002$ to $\pm.003$ in the upcoming March/April/May run. This accuracy assumes approximately 4 weeks of running in March at ≈ 60 Hz, the month of April at ≈ 120 Hz, and the month of May at ≈ 60 Hz, at two energies, 45 and 48 GeV, with 50% efficiency in delivery of beam on target, and a charge of 5×10^{11} per pulse (3×10^{11} per pulse) at 45 GeV (48 GeV).

Major improvements have occurred in the time since the previous review. Considerable detector backgrounds had been observed, and were ascribed to photons scattering off primary collimators in the region downstream of the target. E158 designed a set of masks to intercept the rays between these collimators and the detector. During the intervening time between reviews, these masks were fabricated and installed. Accurate alignment of the masks was critical, since all are close in to the beam line. At the time of this review, it was known that the primary collimator QC1B was slightly misaligned, and time in the End Station to correct this misalignment was already planned for, shortly after the review.

Tests of backgrounds during January/February with the masks installed confirmed that the basic assumptions as to the nature and cause of the backgrounds were correct. The backgrounds with the detector phototubes blinded fell dramatically, close to zero response, which is what was desired. The inclusion of the beam line masks appears also to have eliminated the common mode noise associated with scattering of the beam from upstream apertures. This noise was limiting the per-pulse-pair asymmetry statistic to about 5×10^{-4}. The detector now seems to have a much lower common-mode noise, about 1.5×10^{-4}, which seems to be isolated to the readout electronics, and which should be possible, in principle, to eliminate. The current level of common-mode noise is incorporated in the collaboration's Run-I projection for $\sin^2 \theta_W$.

Phototube linearity has been explored with a test-bench setup, in which each tube was characterized as a function of excitation voltage. To the extent that these characterizations transfer to operation within the detector, the detector will operate well within the $\pm 5\%$ linearity spec for Run-I. Current attempts to verify the linearity *in-situ* are hampered by fluctuations in beam parameters, at least in the outer radii of the detector. However, it is likely that further off-line analysis will yield a robust method of confirming phototube linearity.

A profile monitor mounted on an "wheel" in front of the Moller detector was commissioned. It allows for r and θ scans at the face of the detector. Measurements with the beamline quads on and off showed the distributions of the Moller signal and the irreducible backgrounds from elastic and inelastic scattering from the target protons. Monte Carlo studies still fail to reproduce beam profiles in tests for which the Moller phase space is tightly controlled with extra collimation – a situation which could compromise the knowledge of Q^2. However, much work remains to be done on the Monte Carlo, and in light of the vastly improved constraints from the rebuilt profile monitor, the collaboration expects to meet its Q^2 uncertainty goal with little trouble.

No formal mention was made of the luminosity monitor, whose measurements will provide a critical independent assessment of the scale of false asymmetries in the E158 data. However, in a private conversation during the break, the reviewers learned that the inclusion of upstream collimation did not cure the common mode noise problem in this inner detector. There has been substantial improvement since the previous run, however, possibly due to the improved beam quality and/or the addition of the skew quads. The monitor should provide an accurate enough measurement to adequately constrain the magnitude of false asymmetries under reasonable model assumptions. The group should give the timely analysis of luminosity data a high priority in the upcoming run.

A new Moller polarimeter was commissioned, and showed good results. The beam was reported to have 84$\pm$4% polarization. The CTS lab report on a similar cathode was 80%.

The beam delivery has been excellent. The major improvement has been in the stability of the laser, yielding $\pm$0.5% rms jitter. This jitter is down from $\pm$1.5% at the last review. Tuning and minor changes at the laser have achieved this important improvement.

Improvements in the linac tuning and feedbacks have lent stability to the linac operations. Pulsed magnets in sector 11 contributed to this improvement. Also, the installation of the A-line skew quad, controversial at the time of the last review, was done. The y-jitter at the target has been dramatically improved, in part due to the improved optics, in part due to the more stable beam. Other items which have been fixed are jitter in the injector klystron, the main drive line stabilization is working, and the linac feedbacks are effective. Energy and orbit are stabilized at the end of the linac, and beam tails are controlled using pulsed dipole correctors in Sectors 1 and 11. Dispersion feedback is planned to be commissioned within a few days.

Among the concerns is the potential for increased failure rate for the klystrons and thyratrons as repetition rate in the accelerator is increased to 120 Hz. Machine Protection System (MPS) trips may become high at the high repetition rate, as well. The overall beam availability may suffer.

At the source, gun HV problems have been cured. The gun is operating at its full voltage of 121 KV. A new "NLC-qualified" cathode has been installed, allowing for full current operation. The new strained-layer cathode has a high surface doping, which solves the problem of cathode surface charge limits, seen in earlier cathodes. Charge per pulse of 7×10^{11} electrons have been delivered. E158 expects to run at 5×10^{11} and 3.5×10^{11} per pulse at 45 GeV and 48 GeV respectively.

Beam monitoring and asymmetry control was summarized in considerable detail. It is too early to tell whether the asymmetry control and the beam monitoring will work at the systematic levels required by E158, but the preliminary results look very promising, and only until considerable running is completed will it be possible to look for any low level problems. At the present moment, the algorithm for correcting non-zero asymmetries still needs tuning. Work will continue on this item.

A new synchrotron light monitor has been very helpful for measuring the Lpotential concern for E158. Energy spread is monitored by the existing visible synchrotron light monitor, and a new digitizer has been added for this.

Based on the results of radiation measurements performed at 72 kW, when projected to two months of beam operation at 6×10^{11} electrons per pulse and 120 Hz, radiation levels around the ESA are expected to remain within the design goals for the E158 experiment. The shielding at some location around the ESA should be re-evaluated for a 3 months full beam power operation in the next fiscal year.

Looking forward to a future run, the projections of errors on the physics results have been made. Run I in TABLE II summarizes the expected performance planned for March-May, 2002. A future run (Run II) consisting of two weeks checkout, followed by 2 months of 120 Hz running at 48 GeV, 3×10^{11} per pulse and 1.5 months of 120 Hz running at 45 GeV and 5×10^{11} yields $\delta \sin^2 \Theta_W \approx 0.0009$, which is close to the original proposal result. TABLE II gives the Run I and Run II expectations for statistical and systematic errors on $\sin^2 \Theta_W$.

Table I: E158 Beam Summary

ITEM	Goal	Achieved
Beam Charge	6×10^{11}	6×10^{11}
Intensity Jitter	2% rms	0.5% rms
Position Jitter	10% of spotsize	5% of spotsize
Spotsize Jitter	<10% of spotsize	5% of spotsize
Energy Spread	0.3% rms	0.1% rms
Energy Jitter	0.2% rms	0.03% rms
Polarization	75%	80%

Table II: E158 Errors Summary

RUN	I	II	proposal
Statistics	21 %	9%	7.5%
Backgrounds	10%	3%	1%
Polarimetry	5%	3%	3%
Momentum scale	5%	2%	1%

TOTAL	25%	10%	9%

For next year, dispersion-free steering may be desirable. This is a non-trivial development project. Presently, dispersion-free steering is accomplished with use of both positron and electron beams and an offline analysis. This was done in December 2001 for the E158 lattice. If it is needed frequently, a more convenient setup is needed. In principle, a single beam with changes in energy can be used in an algorithm to accomplish dispersion-free steering. Software would have to be developed for this, and the effects of waveguide kicks associated with energy changes needs to be understood and accounted for in the algorithm. Perhaps the easiest and most appropriate way to vary the energy would be to dither the current by 5% or 10% during the resteering, and use the trailing edge positions.

This Committee expects that E158 will be asked to review the status again at an appropriate time when the current run will be analyzed, and well before the time when a schedule for a second run will be fixed.

The Committee would like to congratulate the members of the Accelerator Department and the E158 Collaboration for their strong and effective efforts in bringing the E158 run to readiness.

The Committee wishes all a successful run.

E158 Review - March 1, 2002
SLAC - Orange Room

SCHEDULE

8:45 am	Closed session (15')		
9:00	Overview	K. Kumar	(20')
9:20	Beam Delivery	F-J. Decker	(20')
9:40	Beam Perform.; Asymmetries	M. Woods	(40')
10:20	BREAK (30')		
10:50	Detector Asymmetry Analysis	Y. Kolomensky	(40')
11:30	Backgnds, Syst., Closeout	K. Kumar	(45')
12:15 pm	LUNCH (60')		
1:15	Closed Session (E158 available for questions)		
2:15 (est.)	CLOSEOUT		