1 Response to TR Recommendation 4.2b

GEANT calculations have been done for the energy and position resolution of BIGCAL with a 20cm aluminum block in front. In Fig. 1, the energy resolution (σ_E/E_{peak}) is plotted versus the initial electron energy. The red open circles are GEANT calculations for the BigCal setup during the Gep3 experiment. During Gep3, a 10cm aluminum block was in front on the lead glass. In addition, during Gep3, a lucite plate and a 2.5cm aluminum plate were in front of BigCal. The filled red circle at an incident electron energy of 1.0 GeV is a measurement of the energy resolution during Gep3. The agreement with the GEANT simulation is good. The purple diamonds are GEANT calculations for a 20cm aluminum block in front of BigCal. At 1 GeV, the simulation predicts a resolution of 18% which is close to the estimate of 15-16% cited on pg. 113 of the CDR. For the Gep5 experiment the scattered electron energy is between 3.3 and 3.5 GeV for all the kinematics, so the energy resolution would be about 8.8%.

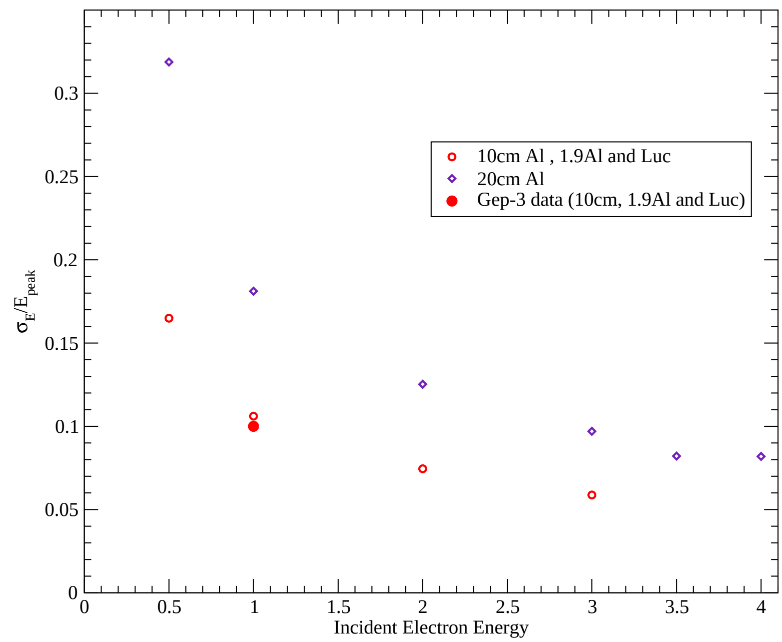

Figure 1: The calculated energy resolution (σ_E/E_{peak}) plotted versus the initial electron energy for 20cm aluminum block in front of BigCal.

The next question is the effect of radiation damage on the BigCal energy resolution. The deterioration of the BigCal energy gain and resolution due to radiation damage was studied during the Gep3 and Gep2g experiments. Since the experiment was continually measuring ep elastic kinematics, the degradation of the calorimeter gain and energy resolution was continuosly measured.The BigCal was placed at a different distance and angle for each kinematic point. For estimation of the effect for Gep5, one can focus on the kinematic with BigCal at $\theta_e = 32^\circ$ and a distance of 11m from the target. The measurements of gain loss were fitted with ae^{bC} with b= 0.53%/C. As explained on pg. 110-111 of the CDR, a GEANT simulation of the expected soft photon flux was done for this Gep2g kinematics and for the Gep5 highest Q2 point and the ratio of 13 was found. Using this factor would give an expected b=6.7%/C for the gain loss. To estimate the effect on the energy resolution, the data from Gep3 and Gep2g can be used. In Fig. 2, the energy resolution (normalized by $\sqrt{E_{peak}}$) is plotted versus total charge for all Gep3 and Gep2g kinematics. Normalizing by the $sqrtE_{peak}$ matches the end one data set to the beginning of the next set to first order. One clearly sees a different slope in the degradation of the energy resolution for each kinematic point. When the BigCal is at more forward angles the rate of degradation is faster. The highest rate of soft photon flux was during the RCS experiment which used a radiator in front of the hydrogen target and BigCal at it most forward angle. RCS was run after the 2nd $\theta_e = 105°$ data set. During RCS, constant monitoring of the BigCal energy resolution with elastics wasn't possible. At the end of RCS, elastic data was taken and the energy resolution for this data is shown as a purple triangle in Fig. 2. The slope between the last point of the 2nd $\theta_e = 105°$ data set and the RCS data is the steepest of the graph. A UV curing of the BigCal was done during a break between the the RCS data and the $\theta_e = 69°$ data. One can see a dramatic improvement in the resolution. For the $\theta_e = 30.°$ kinematic point a slope of 0.15%/C was measured for the loss in energy resolution per coulomb. Using the factor of 13 gives a slope of 1.95%/C for Gep5. A 75μA beam gives 1.1C in 8 hours (assuming 50% accelerator efficiency), so the Gep5 experiment will get 2% increase in the resolution.

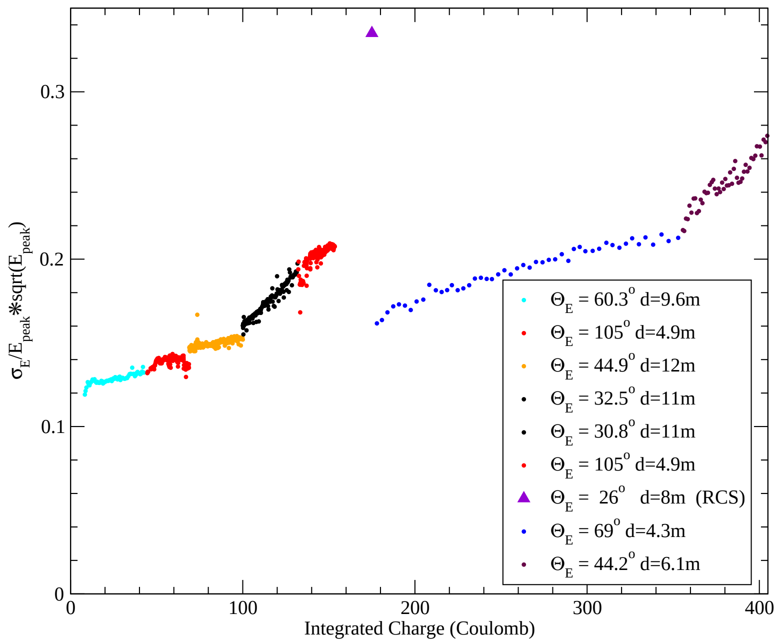

Figure 2: The measured energy resolution (σ_E/E_{peak}) (normalized by $\sqrt{E_{peak}}$) versus charge through out the Gep3, Gep2g and RCS experiments.

Now, estimations of the BigCal trigger rate using the predicted energy resolutions can be made. Combining the GEANT estimation for 20cm absorber with the effect of radiation damage gives a predicted energy resolution of 10.8%. On pg 107 of the CDR, it is stated: *we need an energy resolution better than 10%/$\sqrt{E}$. This is dictated by the trigger rate considerations.* As the Technical Review points out this is contradicted on pg 113 in the CDR where a energy resolution of 16% at 1 GeV was extrapolated from previous GEANT simulations using a 10cm aluminum block in front of BigCal. For the trigger rate calculation in the CDR a resolution of ? was used. With the updated energy resolution estimation, the trigger rate is predicted to be ?.

For the same GEANT simulations, the position resolution was determined for the conditions of a 20cm aluminum absorber in front of BigCal. The position resolution was 0.6 cm . The resolution was independent of the incident energy.

What is the impact of the BigCal position resolution? For separation of elastic and background (mainly from $\gamma p \rightarrow \pi^\circ p$) in the final offline analysis. A Monte Carlo was done for the CDR with a position resolution of 1.0 cm and estimated that there would be a 10% background contamination. With the updated estimate of 0.6 cm, the background contamination is reduced to ?%.

Position resolution of BigCal will also effect the proton tracking algorithm outlined in the CDR. In the CDR, the proton tracking algorithm starts with a prediction of a the initial proton position on the SBS front tracker using the measured electron angle and the assumption of elastic kinematics to determine the initial search area in the SBS front tracker. The 40 cm long target determines the horizontal search area of 18 cm. But the vertical search area can be much smaller depending on the vertical position resolution for the electron. The Coordinate Detector (CD), which consists of two GEMs with an X plane separated by 4 cm, will determine the vertical position. Reasonable BigCal position is needed to reduce the search area to find the electron in the CD among the background of low energy photons. In the CDR, a position resolution of 0.4 cm was assumed. The increase of the resolution to 0.6 cm will increase the predicted number pseudo-hits from 0.028 to 0.042 in the Coordinate Detector.

The expected radiation rate for Gep5 is expected to be a factor of 13 times higher than the highest rate estimated during the Gep2g experiment. With this large rate, the lead glass would have a gain loss of 6.7%/C. For 75μA beam and a 50% accelerator efficiency, the gain loss would be 0.87%/hr. In the CDR, a plan is presented to UV cure the lead glass for one hour for every seven hours of beam which needs a curing rate of 6%/hr to make up for the 6% gain loss during the preceding seven hours. During a down time in the Gep3 and Gep2g experiments, the lead glass was cured with UV light source and the curing rate was found to be 1.24%/hr. Steps are outlined in the CDR which would increase the UV light intensity by a factor of five which be needed to reach a curing rate of 6%/hr. The Technical Review report expresses skepticism that that the needed curing rate can be achieved by increasing the UV light intensity used in Gep3/Gep2g by a factor of five. The curing during Gep3/Gep2g was done during a one month down so it is not clear which part of the increase in gain was due top the UV curing or just having the lead glass naturally cure itself without UV light. To determine what UV light intensity is needed to reach the curing rate needed by Gep5, we will perform tests. We plan to put lead glass in Hall A during the fall running of the DVCS experiment. We will then cure the lead glass with the UV light intensity proposed in the CDR and measure the curing rate. We plan to setup an area in the EEL building to do the UV curing tests. The effort will be lead by Mark Jones with help from the other Gep5 spokepersons.