9

Compton recoil electrons measurements

A first trial of Compton measurement was performed during the Dec. 2014 run. In this Chapter the measurement procedure is described, the measurement result is presented and compared with the expected signal level. Different ways to improve the visibility of Comptons signal are proposed.

In 3.6.4 it was mentioned that for the Comptons detection, large β_x optics is preferred. Therefore during the Dec. 2014 Run, BX100BY1000 optics was applied for Comptons measurement, which reduced the horizontal angular divergence to 1/10 of the nominal one at the IP.

Before the measurement, a timing scan and a fine alignment with respect to the laser wire scan were performed using the Shintake monitor as described in **??**. These scans were performed with a crossing angle of 5.5°. Both the timing and laser wire scans were fitted to the Gaussian distributions and after the scans the timing and laser position were set to the peak values obtained from the fitting (see Fig. 9.1).

After the adjustment of laser settings, a beam halo scan was first performed on the LE side of the beam with the IPBSM laser turned off. Then, the laser was turned on and the beam halo scan was done again. The measurement results are shown in Fig. 9.2.

Since 10 measurements were done at each point, the charge at each point is presented

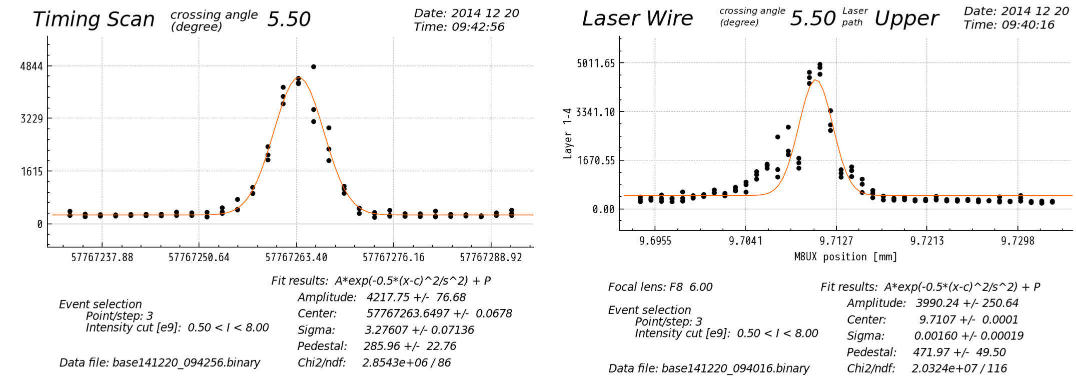


Figure 9.1: Laser timing scan and position scan performed on 20th Dec. 2014 before the Comptons measurement

with errors calculated as the standard deviation of the mean:

$$Q = Q_{mean} \pm \Delta Q_{mean} \quad with \quad \Delta Q_{mean} = \frac{1}{\sqrt{N}} \sqrt{\frac{\sum_{i=1}^{i=N} (Q_i - Q_{mean})}{N-1}} \tag{9.1}$$

However, as the measurements were done with a step of 0.5 mm and the signal fluctuation is too large, data binning is required. The mean value ($\bar{Q}$) and the error ($\Delta\bar{Q}$) after data binning are calculated as follow:

$$\bar{Q} = \frac{\sum_{i=1}^{i=N} (Q_{mean,i}/\Delta Q_{mean,i}^2)}{\sum_{i=1}^{i=N} (1/\Delta Q_{mean,i}^2)} \quad and \quad \Delta\bar{Q} = \sqrt{\frac{1}{\sum_{i=1}^{i=N} 1/\Delta Q_{mean,i}^2}} \tag{9.2}$$

Fig. 9.3 shows the distributions after data binning, the vertical axis is normalised to the number of electrons assuming a gain of 2.88 fC/electron. The bin size is $2\sigma_x$ where σ_x=1.32 mm.Taken into account the large error, no obvious change in the signal between laser on and off can be observed for this measurement.

The expected signal is also shown in Fig. 9.3 (in blue). The values are obtained from the tracking using Mad-x with the Comptons generated in CAIN as explained in 4.3. Since the total number of electrons is N_e=4.5×10^9, estimation of the Comptons in Equation 9.3 is $N_c = 1.56 \times 10^{-7} \times N_e$=702. Binning with a bin size equals to the width of CH1 strip (1.5 mm) was done for the Comptons signal.

From Fig. 9.3 it can be seen that the signal from Comptons are quite small comparing with the signal from halo and its fluctuations. This may explain that why no difference is observed between the laser on and laser off data.

The number of expected Comptons can be calculated from Equation 3.28 to be:

$$N_c = N_\gamma = f \cdot N_e \cdot \frac{E_l}{E_\gamma} \frac{1}{2\pi} \frac{1}{\sigma_{yl}\sigma_{tl}} \sigma \tag{9.3}$$

From Equation 9.3 and Fig. 9.3, we can find several ways to improve the visibility of the Comptons signal:

- Increase the laser energy (E_l): since the number of Comptons (N_γ) is proportional to the laser energy as shown in Equation 9.3, by upgrading the laser energy from 0.2 J to 1.4 J, the number of Comptons can be increased by factor 7;
- Improve the sensitivity of the DS by shielding the DS to get rid of the signal pickup and then amplifiers can be used for small signals;
- Put a collimator upstream to collimate the beam halo: if the horizontal beam halo can be collimated upstream to $10\sigma_x$ level then the Comptons in $> 10\sigma_x$ region can be visible.

It is worth mentioning that although the number of Comptons is also proportional to the beam intensity (N_e) as shown in Equation 9.3, the increase of beam halo is proportional to the increase of beam intensity as discussed in section 8.4.3, therefore increasing the beam intensity can not increase the visibility of the Compton signal.

Besides, although the number of Comptons in the BX10BY1 optics is almost twice of the one in the BX100BY1000 optics (see Table 4.1), the beam halo level is also higher for the BX10BY1 optics. Fig. 9.4 shows the comparison of Compton signal visibility between the two optics. It can be seen that even with the designed laser power (1.4 J) which is 7 times larger than the present one, the Compton signal is still completely covered by the beam halo in the BX10BY1 optics. However, with BX100BY1000, the edge of the Comptons maybe detectable if the sensitivity of the DS can be improved.

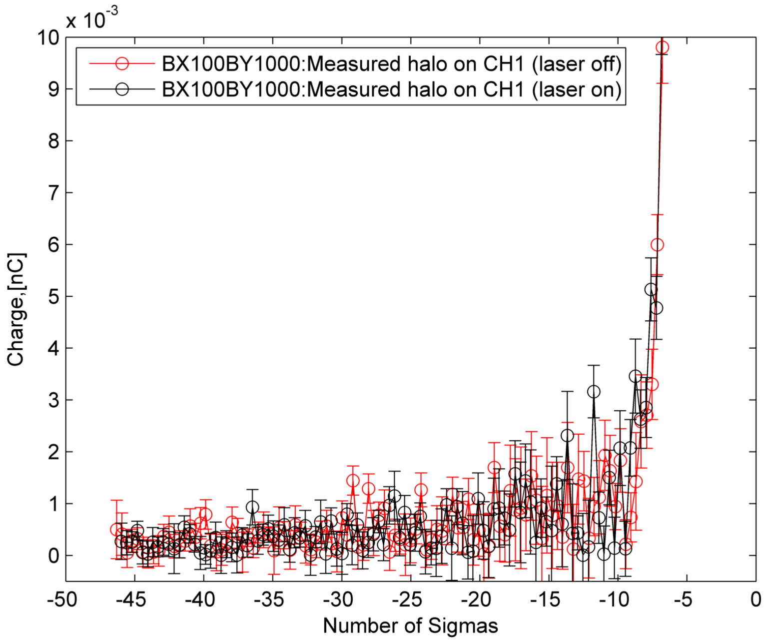


Figure 9.2: Measured beam halo distribution with laser off (red) and laser on (black) (data taken on 20-12-2014)

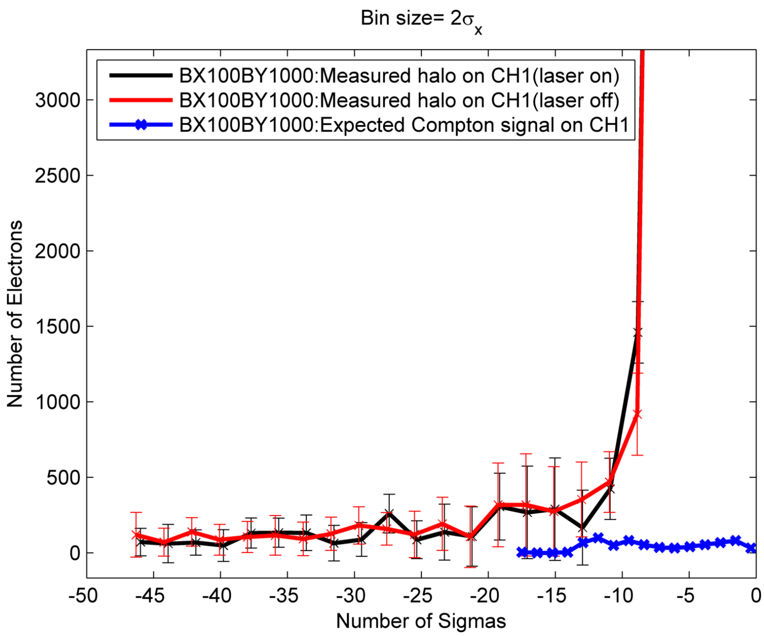
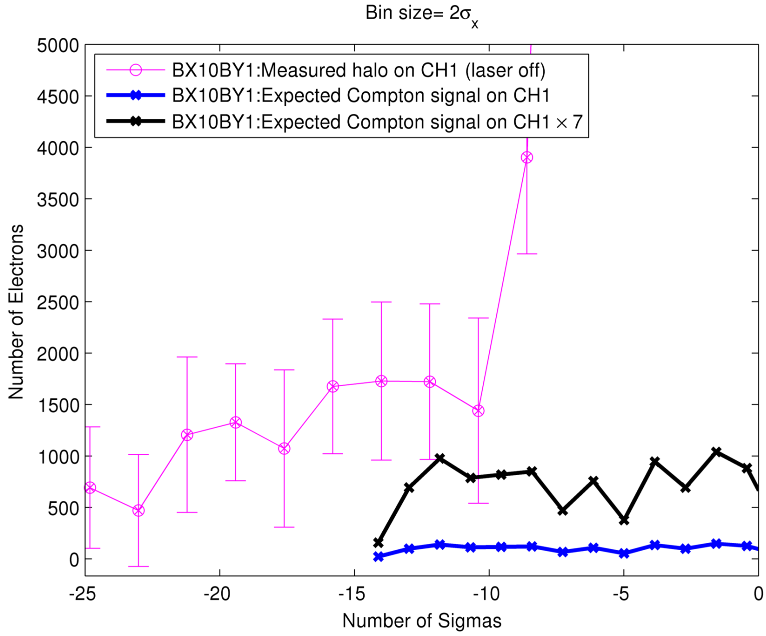
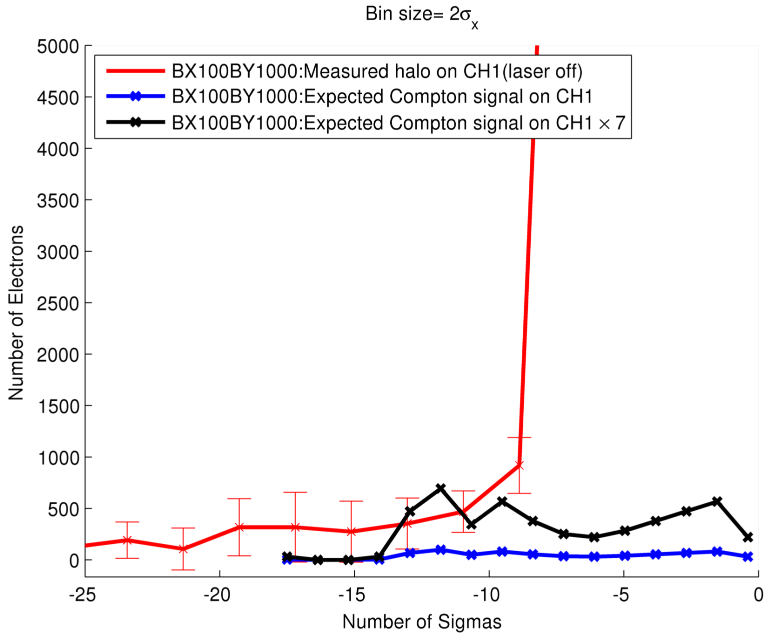


Figure 9.3: Beam halo distribution with data binning with laser off (red) and laser on (black) and expected Compton recoil electrons signal (blue)



(a)



(b)

Figure 9.4: Comparison of Compton signal visibility between BX10BY1 (a) and BX100BY1000 (b) optics