20 May 1999

TOTEM - additional information for the referees

1 Results of simulation

Our Monte Carlo simulation program of low-t elastic scattering events was used to study the extrapolation to the optical point, the alignment and influence of systematic errors. Trajectories of the scattered protons are calculated for the high-β optics (β^*=1100 m). The program simulates the beam size and angular spread and the detector space resolution. It was used to calculate the acceptance as given in our Technical Proposal. Some results relevant to the questions from the Committee are given below.

1.1 Extrapolation to the optical point

A sample of 10^6 elastic events were generated with distribution $dN/dt \sim \exp(-B \mid t \mid)$ and B=20 GeV^{-2}. Simulated events after acceptance correction were fitted in the t interval from t_1 up to a maximum value of 0.1 GeV^2. The relative error on N_0, the reconstructed number of events extrapolated to t=0 is shown in Fig.1 as a function of t_1. The data points flatten below $\simeq$ 0.02 GeV^2 because in that region the acceptance becomes rather small as shown in Fig.11 of the Technical Proposal. The statistical error on the slope parameter B, for t_1= 0.02 GeV^2 is ΔB=$\pm$0.08 GeV^{-2}.

1.2 Alignment of the elastic scattering set-up

In order to evaluate the scattering angle correctly, alignment with respect to the actual beam axis has to be performed. In general the beam axis deviates from the nominal machine axis which is the reference frame for the survey of the Roman pots. The deviation may also be different for different machine runs. The alignment of each Roman pot unit (set of Up and Down detectors) is done using the sample of elastic events collected during the run by taking advantage from the fact that the angular distribution is very steep. An example of the procedure applied to the vertical plane is shown in Fig.2 and 3. The two dN/dt distributions for the two arm combinations Left-up$\times$Right-down (LU$\times$RD) and the Left-down$\times$Right-up ((LD$\times$RU) determined using the nominal distances from the machine axis are fitted by an exponential in t. In general, because of the misalignment, the two distributions will not be equal. A correction parameter $\bar{y}$ is introduced which corresponds to *displace rigidly* up and down the two Roman pots of the same unit *without changing their relative distance.* The use of this correction parameter is equivalent to introduce an angle of the incoming beam with respect to the nominal machine axis at the crossing point. Varying this correction parameter has opposite effects on the shape of the two dN/dt distributions. Alignment is achieved when the two distributions are the same i.e. when the fits give the same value of the slope parameter B. Result of a simulation with 10^6 generated events is shown in Fig.2. The error bar indicates the statistical error on B. The data sample is of course the same for all data points. For this specific case the alignment correction can be determined with uncertainty at the level of $\pm$ 30 μm. This uncertainty reflects in an error on the optical point extrapolation of 0.3%. The results shown in Fig.3 refer to a sample of 10^7 events. In this case the correction parameter can be determined at the $\pm$ 10 μm level.

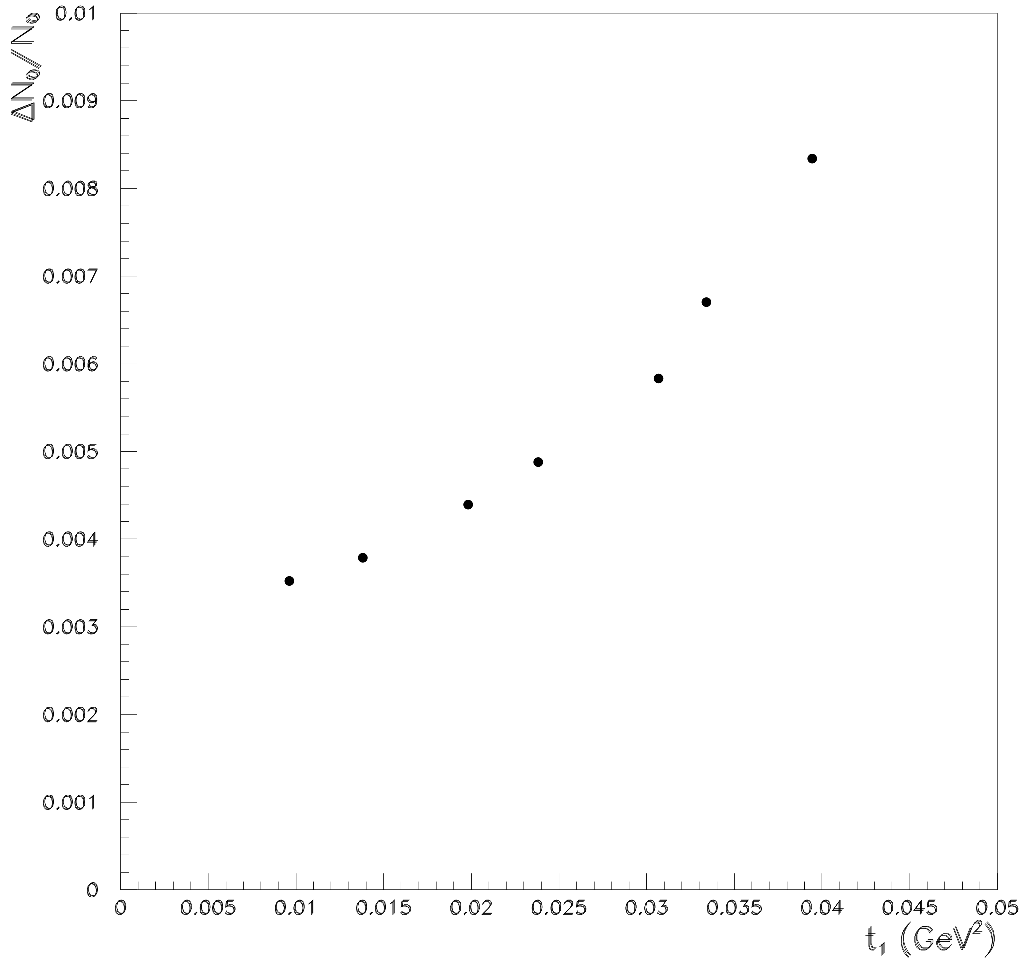

Figure 1: Statistical error on the extrapolation to the optical point as a function of the minimum value of t used in the fit. The acceptance and geometry are given in Fig.11,12 and 13 of our Technical Proposal. A sample of 10^6 elastic events were generated.

1.3 Systematic uncertainty

A source of systematic uncertainty is the error on the distance between up and down detectors of the same Roman pot unit. This could be the distance between two given horizontal strips of a Si detector. The effect induced on the extrapolation to the optical point was again simulated with Monte Carlo assuming error on only one Roman pot unit. The results are shown in Fig.4. If we take into account that in a left-right coincidence arm there are 4 Roman pot units, we conclude that the mechanical/geometrical precision of a Roman pot unit must be better than 20-30 μm.

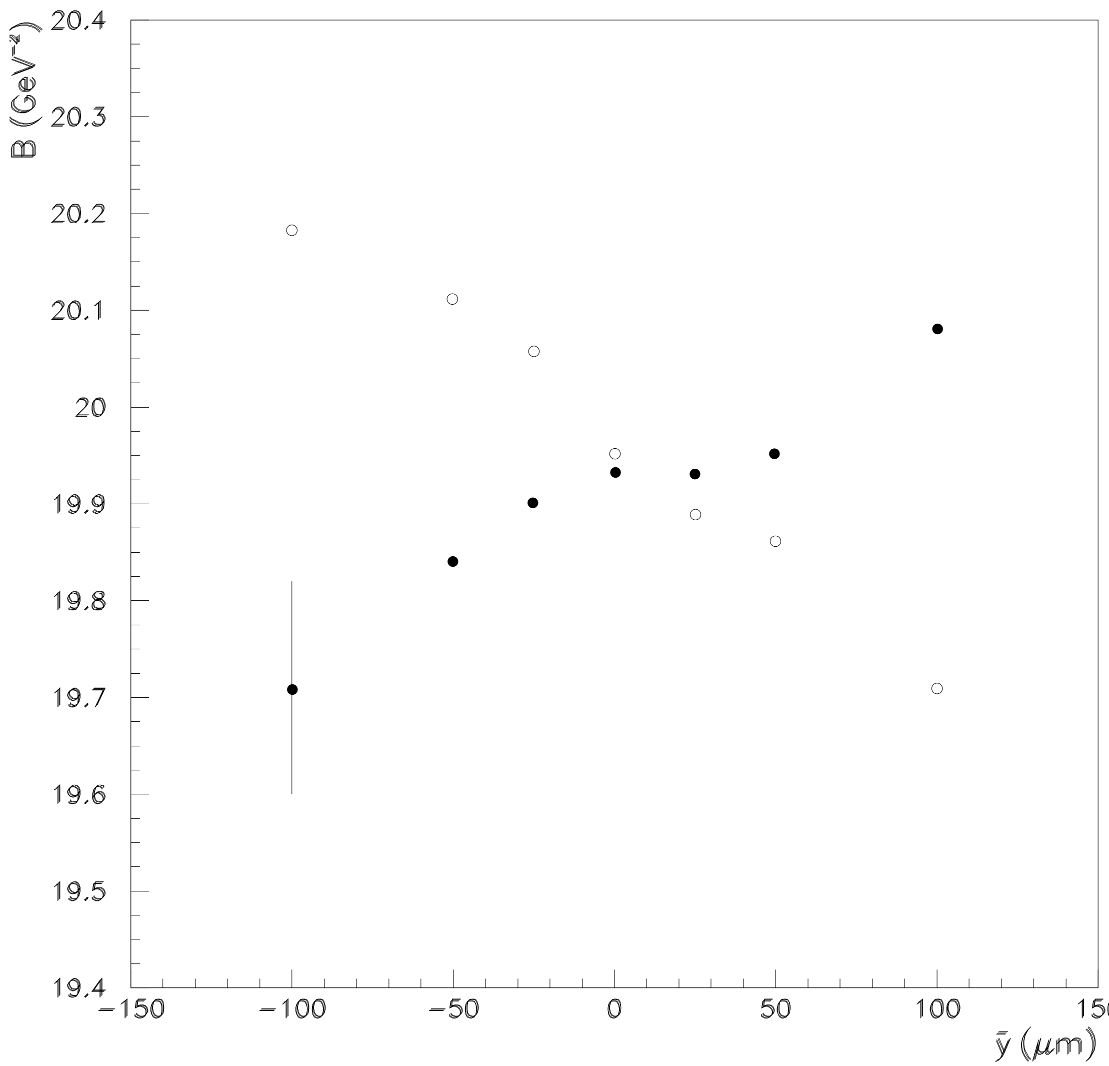

Figure 2: Simulation of the alignment procedure on the real beam axis. Fitted values of the slope parameter B for the two arms combinations LU×RD and LD× RU, as a function of the alignment correction $\bar{y}$. The sample corresponds to 10^6 generated events. The error bar indicates the statistical uncertainty.

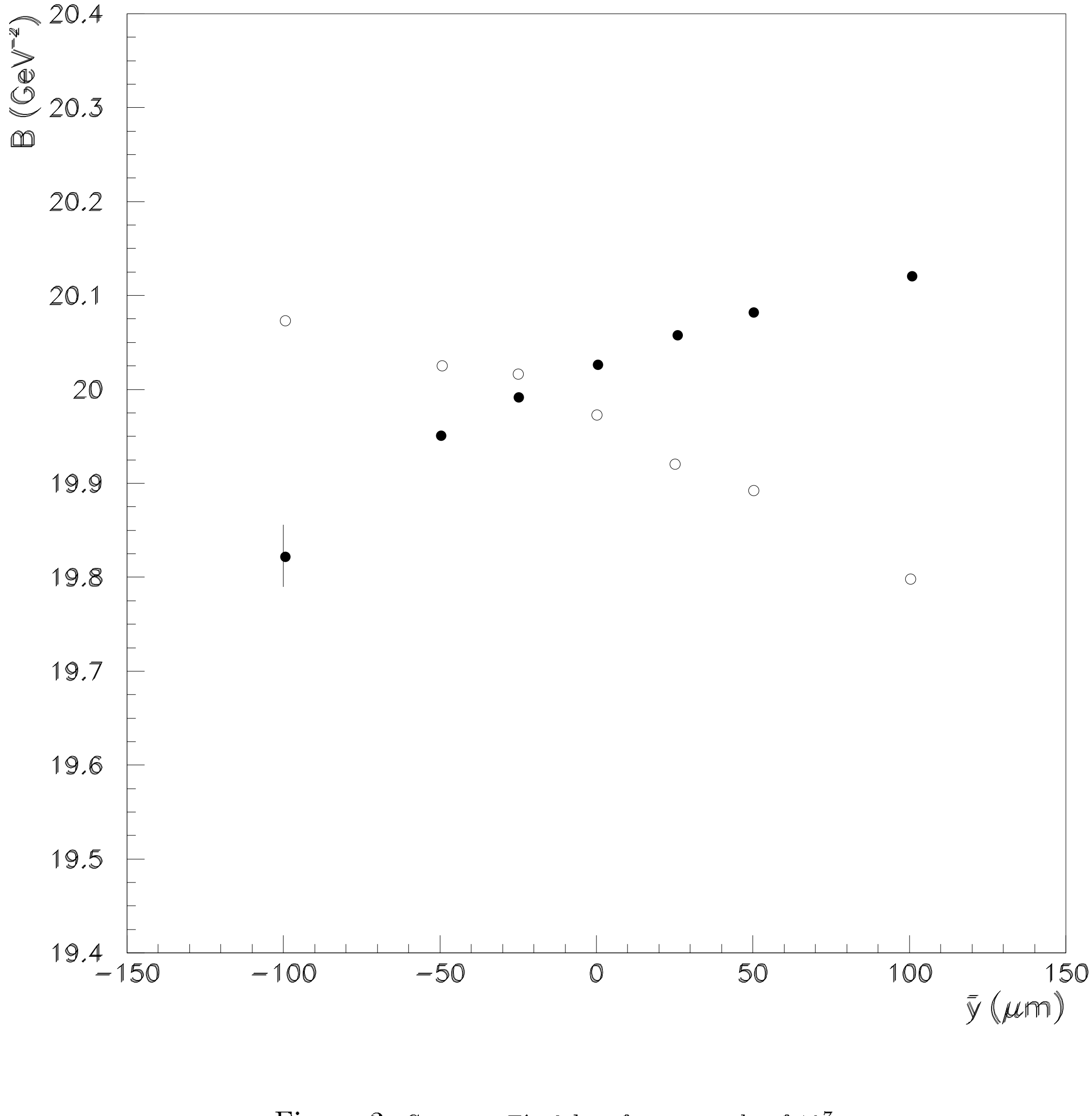

Figure 3: Same as Fig.2 but for a sample of 10^7 events.

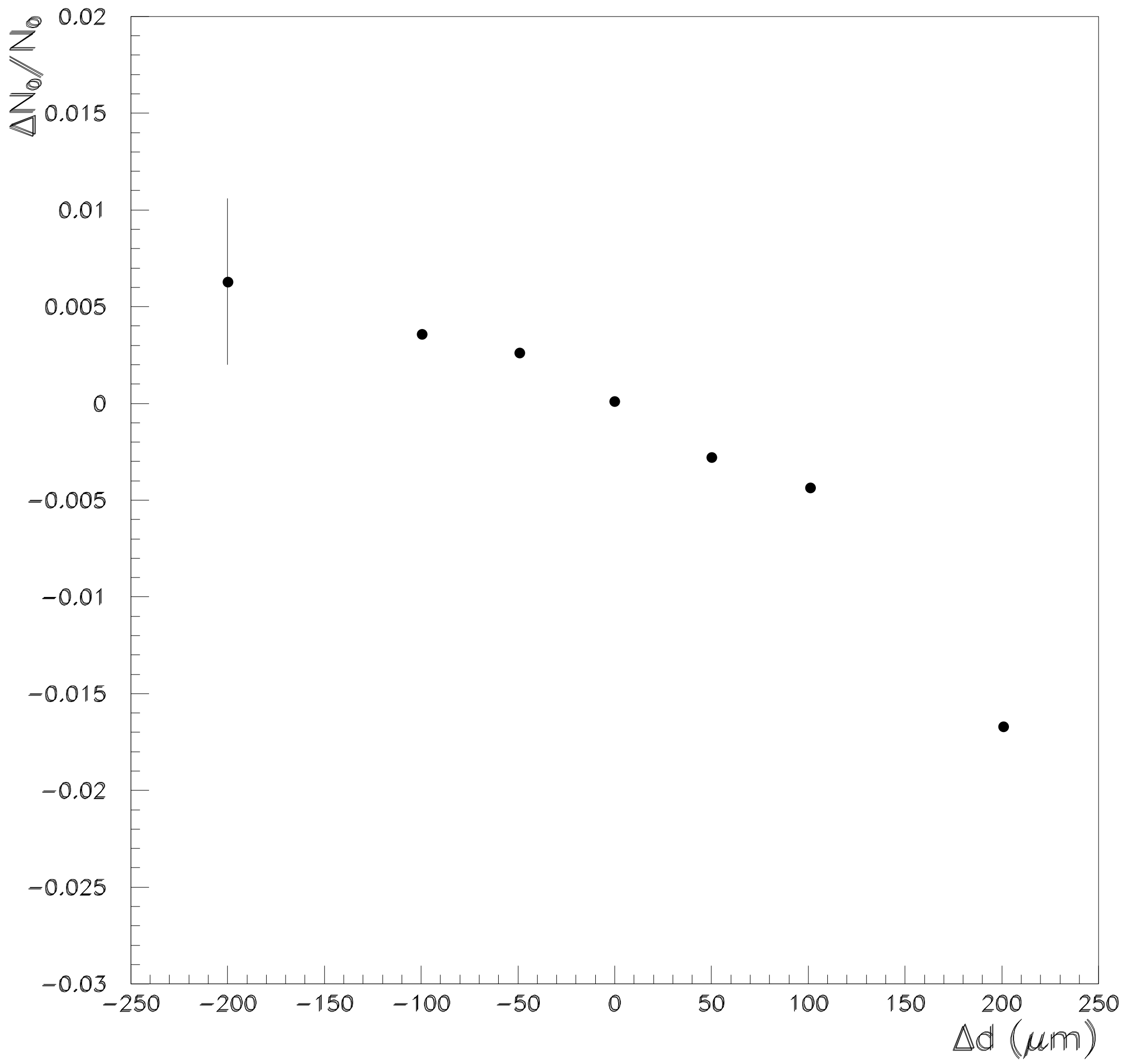

Figure 4: Systematic error on the extrapolation to the optical point due to the uncertainty on the absolute distance between the Up and the Down detectors of the same Roman pot unit. The sample is of 10^6 events.