FETS LEBT comparison between measurement and simulation.

This note describes some initial findings of a comparison between GPT simulations of the FETS LEBT and measured data. The data is a set of measurements of the LEBT output phase space as a function of solenoid current taken on 17 August 2011 as presented in "H^- beam transport experiments in a solenoid low energy beam transport", Rev. Sci. Instrum. 83, 02B719 (2012).

The GPT model is based on the LEBT layout shown below, also taken from the above paper, using John's solenoid field map.

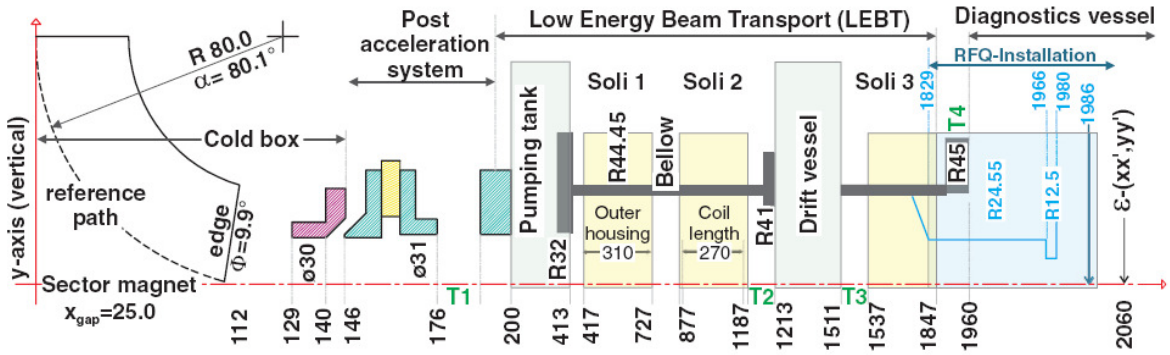

Figure 1 LEBT layout used for the GPT model

For each of the simulations the following procedure was followed: the LEBT input phase space was filled by a large beam containing a very large number of particles. Fig. 2 shows the x and y phase space plots of the large input beam. The beam was tracked through the LEBT in the absence of space charge and the surviving particles recorded in output phase space at the position of the emittance scanners. This allows the input acceptance to be defined as well as a permitted region in output phase space outside of which no particles can arrive.

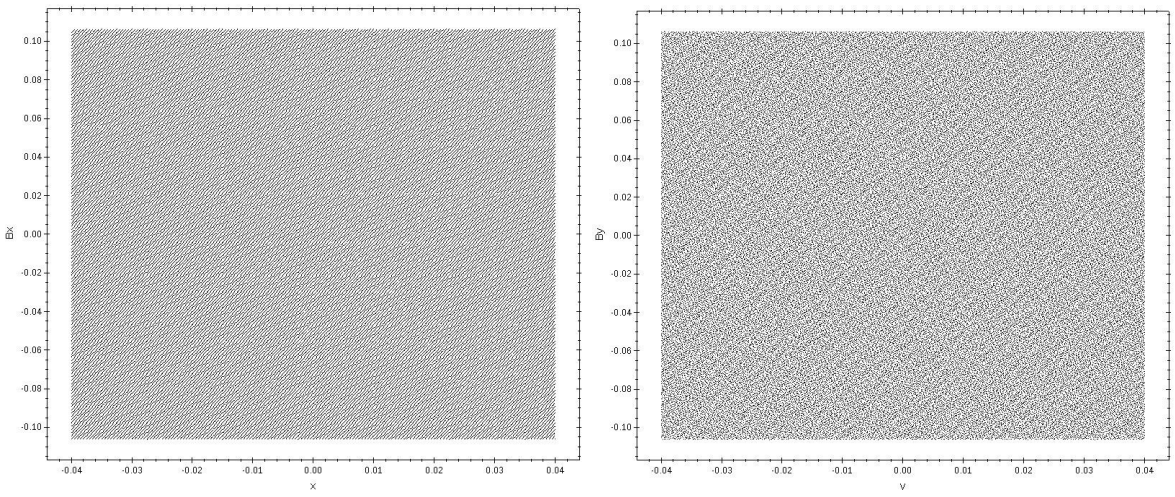

Figure 2 The very large LEBT input beam

The results of the simulations are presented below.

Solenoid currents 137A, 0A, 0A.

Fig 3 shows the surviving particles at the emittance scanners and Fig 4 shows the resulting acceptance.

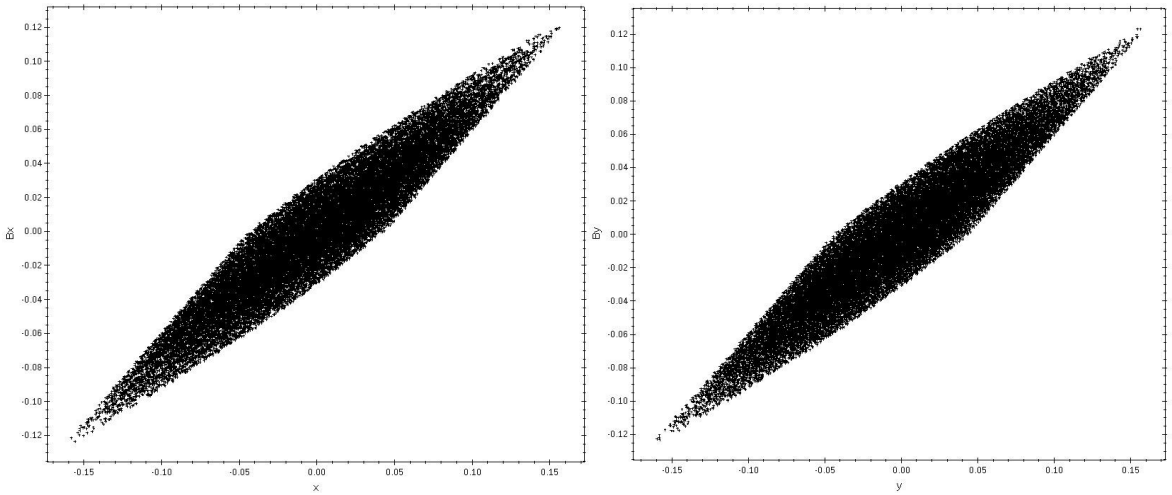

Figure 3 Surviving particles for 137A, 0A, 0A.

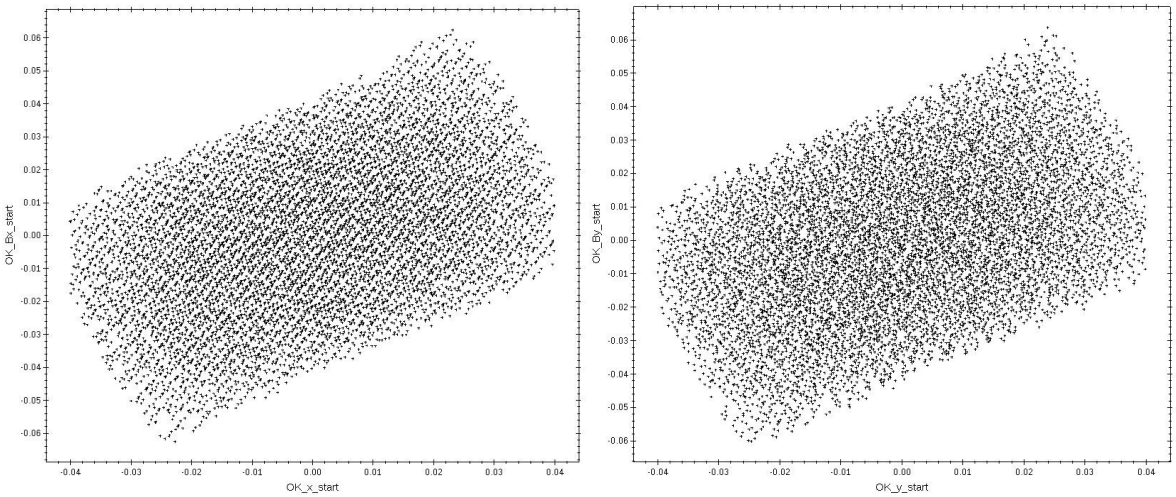

Figure 4 Acceptance for 137A, 0A, 0A.

By overlaying the surviving particle distribution on the measurement it's possible to determine where in the permitted phase space the measured beam lies. Fig 5 shows the measured phase space with the simulated beam distribution overlaid.

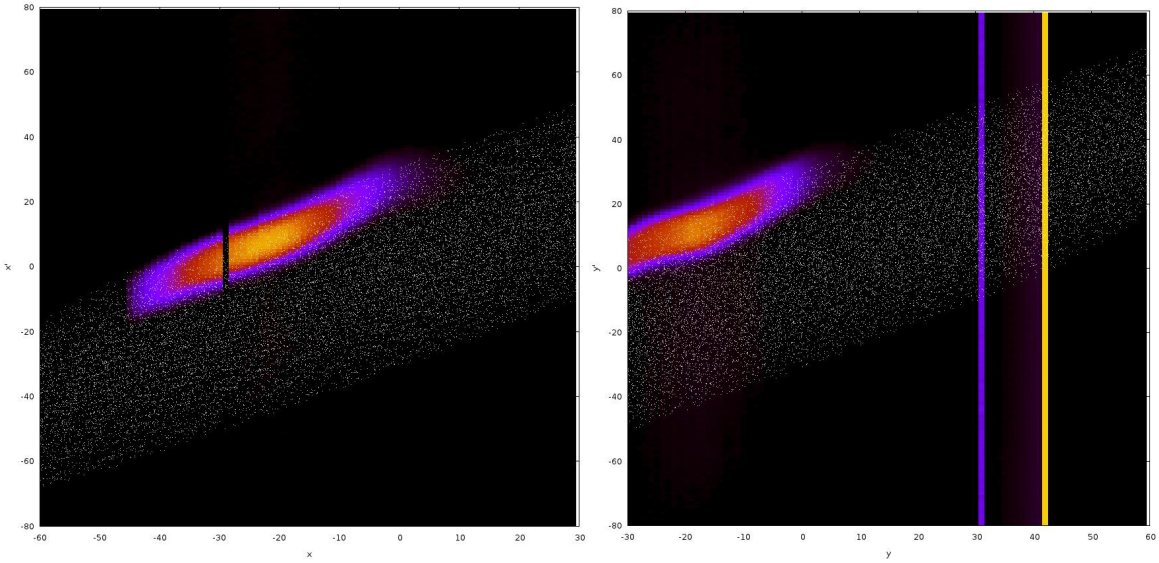

Figure 5 Simulated particle distribution overlaid on measurement for 137A, 0A, 0A.

As expected for such a badly misaligned and collimated beam the measurement lies right on the edge of the permitted area in phase space. However close inspection of Fig 5 suggests that some of the beam may actually lie outside the area permitted by the simulation. Although this may partly be explained by statistics subsequent results below indicate that it is not purely a statistical effect.

<u>Solenoid currents 137A, 0A, 100A.</u>

Fig 6 shows the surviving particles at the emittance scanners and Fig 7 shows the resulting acceptance. Fig 8 shows the measured phase space with the simulated beam distribution overlaid.

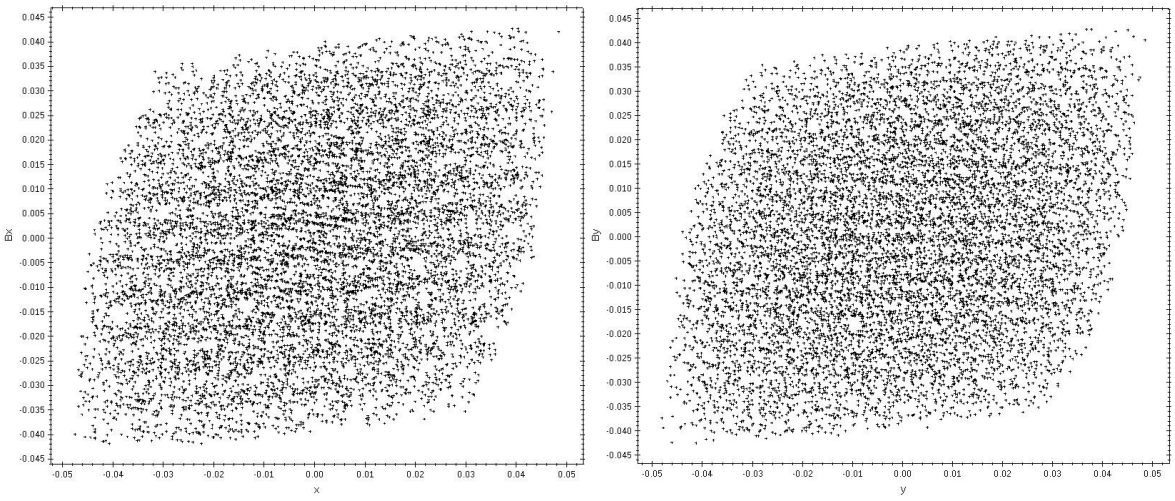

Figure 6 Surviving particles for 137A, 0A, 100A.

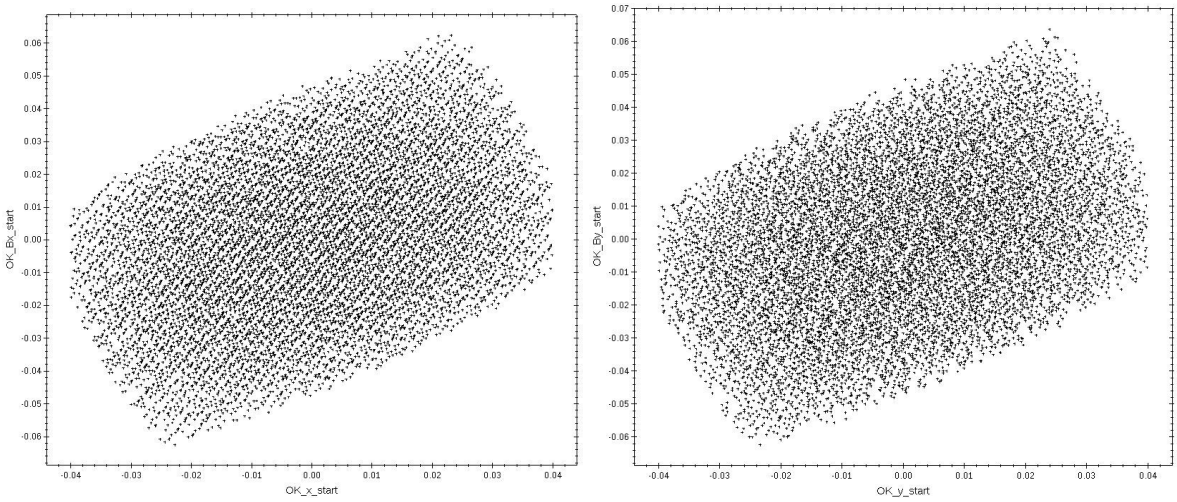

Figure 7 Acceptance for 137A, 0A, 100A.

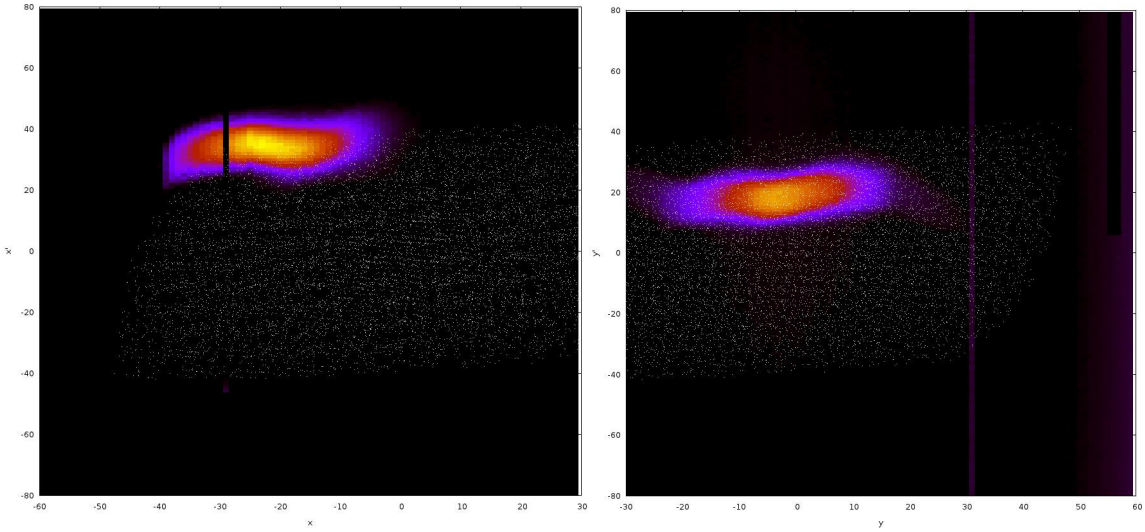

Figure 8 Simulated particle distribution overlaid on measurement for 137A, 0A, 100A.

In the horizontal plane it is clear that a considerable amount of the measured beam lies outside the phase space area permitted by the simulation.

<u>Solenoid currents 137A, 100A, 100A.</u>

Fig 9 shows the surviving particles at the emittance scanners and Fig 10 shows the resulting acceptance. Fig 11 shows the measured phase space with the simulated beam distribution overlaid.

Again in the horizontal plane it is clear that a considerable amount of the measured beam lies outside the phase space area permitted by the simulation

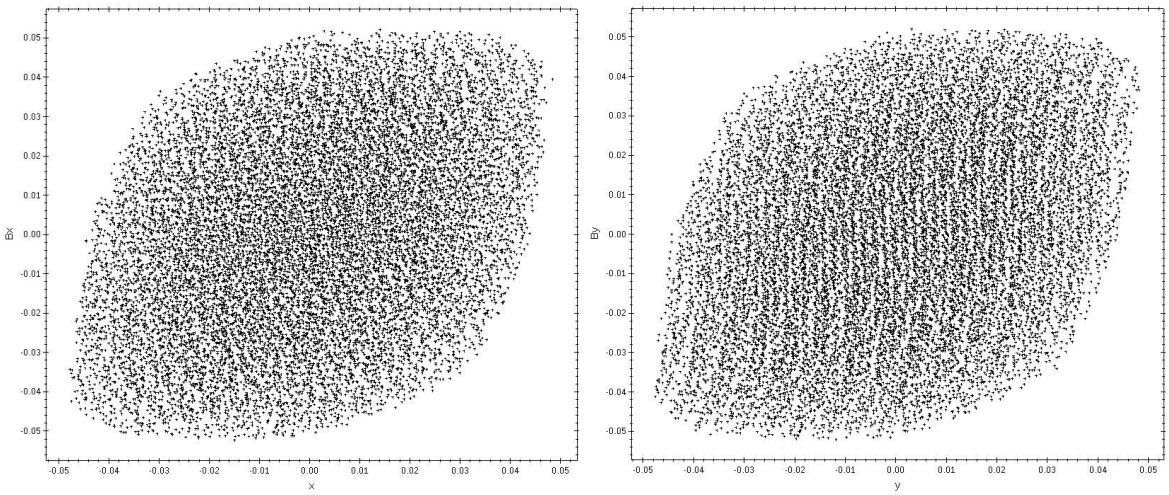

Figure 9 Surviving particles for 137A, 100A, 100A.

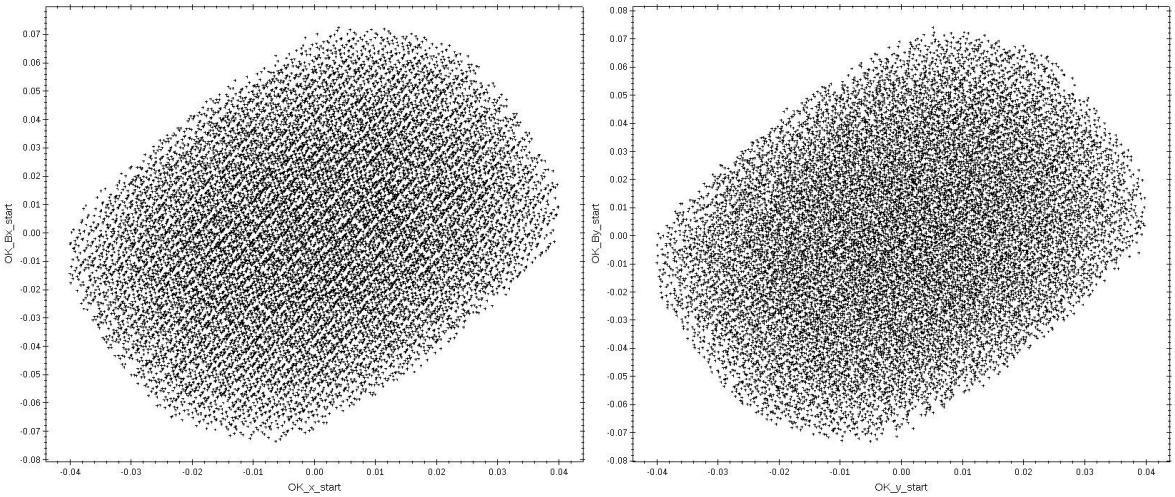

Figure 10 Acceptance for 137A, 100A, 100A.

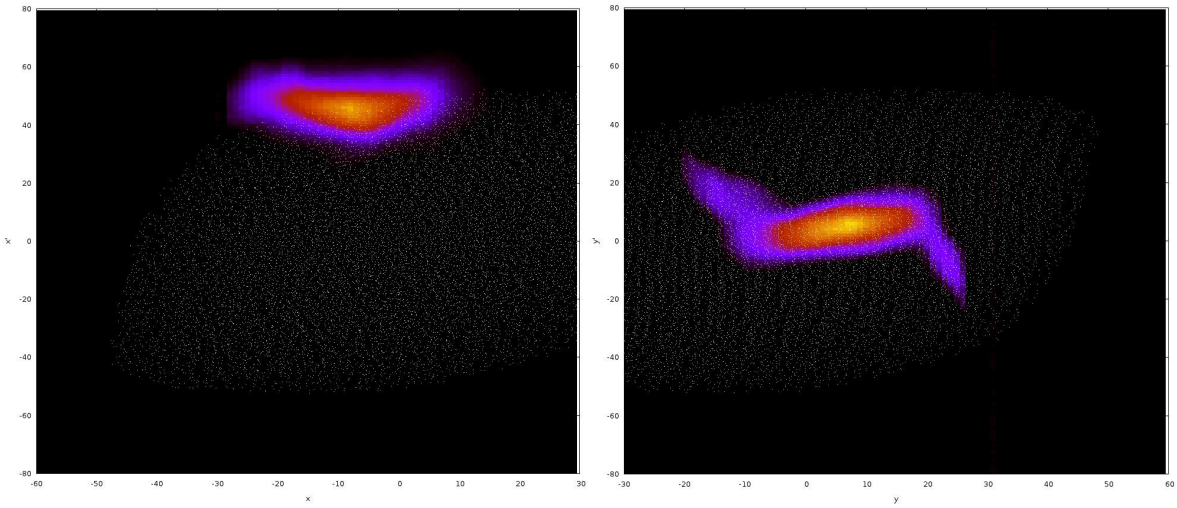

Figure 11 Simulated particle distribution overlaid on measurement for 137A, 100A, 100A.

For the sake of brevity no more data is presented. Except for the highest solenoid currents (127A, 123A, 216A) the measured beam is always outside of the horizontal phase space area permitted by zero current GPT simulations.

Conclusions

Although these measurements are of a severely misaligned beam which it will be necessary to correct, the measurement of beam in areas of phase space which the simulations simply do not allow indicate an error of some sort. The error may be:

Something wrong with the measurements.
Something wrong with the GPT LEBT layout.
Something wrong with the field map.
Something wrong with the field map calibration factor.
Something else.