Charge State Distribution Scans on LEBT of Linac 3

J. Chamings

Revised by R Scrivens, 11 August 2004

Abstract

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A further scan has been completed at a lower extraction voltage to include the O^{1+} peak in the charge state distribution. Also another program was created to measure the pre-glow current of the ECR4 source.
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Modifications to the CSD Application
The application that was modified sets CCV values to up to four different elements on the LEBT line of linac 3, and retrieves a trace from an oscilloscope or an accelerator element. Then it displays the average value in the time interval set either by the oscilloscope cursors or using the trace data. After that it then increments the CCV value and repeats the process, therefore creating a scan of CCV values. Previously, Lab View and Visual Basic was used together. Visual Basic was the main programming language of the application, which sets and increments the CCV values. Lab View was used to take data from an oscilloscope and save to a text file, which then Visual basic could read and use the data accordingly.

The application now uses Visual Basic to take the trace from the oscilloscope and save it. This was done using Visual Basic GPIB functions taken from National Instruments programming documentation.

Post Processing Program
During a CSD scan, the total oscilloscope waveform trace is saved at every element increment. Therefore it is possible to read in this data into a program, select the time interval required, and average the data within this time interval. Then the program saves the new average data, with relevant comment material.

After-glow Results
Figure 1 shows the results for the scan of the bending magnet current at extraction voltage 20.5kV. Elements itl.bhz01 and itl.bhz02 were stepped from 60 to 100 Amps each in 0.05 Amp steps. Both bending magnet currents were scanned with equal values. Also elements itl.sol01 and itl.qdn01 were scanned proportionally to the bending magnets. The trace of the oscilloscope was taken from Faraday cup 2 (itl.mfc02) at each step of the scan. The average current was taken using the mean current measured on the oscilloscope between cursors located at 0µs and 370µs after the input trigger (IX.SEJ). These results were taken using extra magnetic suppression around Faraday cup two, to reduce negative signal between peaks.

A further scan was completed, with extraction voltage at 12.5 kV, as is shown in Figure 3. This was done because the bending magnets maximum current limit is approximately 100 Amps. With lower extraction voltage, ions have less energy, and so require less magnetic field to bend them around the spectrometer.

In Figure 4, the two scans were combined to give a wider charge state distribution. The scan at 12.5kV was increased in vertical scale by 45%, so the main Pb peaks compared well. The bending magnet
values were also scaled to coincide with the scan at 20.5kV. From these results it is seen that the O$^{1+}$ peak has a current of 101µA at a bending magnet current of 123Amps.

The Faraday cup 1 is collated before the spectrometer in Linac 3, whose current can compared with the sum of the peak currents after the bending magnets. When the peak currents were summed from Figure 1, the result was 0.717 mA, as shown in Table 1.

Figure 5 shows some traces from faraday cup 1 (itl.mfc01). Having taken several traces, the average current in the same time interval (0µs to 370µs from the trigger) was 0.666 mA. This is less than the total current found in faraday cup 2 (0.818 mA). Scanning the current of solenoid (itl.sol01) to reduce the beam width at the cup (see Figure 2) gave a maximum ion current of 0.724mA with 138Amps on the solenoid. However, simulations of the ion transport from the source through the solenoid show that it is not possible to simultaneously focus all the charge-states into Faraday Cup 1.

![Scan of Bending magnet Current with extraction voltage 20.5kV -11/04/03 - JCh](image)

**Figure 1:** Scan of bending magnet currents at 20.5kV.

<table>
<thead>
<tr>
<th>Bending Current at peak maximum (A)</th>
<th>Maximum Current of peak (mA)</th>
</tr>
</thead>
<tbody>
<tr>
<td>68.60</td>
<td>0.022</td>
</tr>
<tr>
<td>75.20</td>
<td>0.005</td>
</tr>
<tr>
<td>76.35</td>
<td>0.011</td>
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<td>77.50</td>
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<td>78.75</td>
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<tr>
<td>88.80</td>
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<tr>
<td>90.70</td>
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<tr>
<td>92.75</td>
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<tr>
<td>95.15</td>
<td>0.026</td>
</tr>
<tr>
<td>97.55</td>
<td>0.021</td>
</tr>
<tr>
<td><strong>Total Sum</strong></td>
<td><strong>0.717</strong></td>
</tr>
</tbody>
</table>

**Table 1:** Showing maximum current at each peak from Figure 1.
Average beam current in the after-glow when varying Magnetic field of itl.sol01 -08/05/03 -JCh

![Graph showing beam current variation](image)

Figure 2: The scan of itl.sol01 into faraday cup 1.

Scan of bending currents with extraction voltage 12.5kV -28/04/03 -JCh

![Graph showing bending current variation](image)

Figure 3: Scan of bending magnets at 12.5kV.

Graph showing combined CSD scans

![Combined scan graph](image)

Figure 4: Combined scan, from the different extraction voltage scans.
Pre-glow Results

Figure 6 shows the pre-glow scan, taken from the waveform data collected on the 11th April 2003. The time interval taken was 1800µs to 2000µs relative to the start of the oscilloscope trace. Relative to the input trigger on the oscilloscope, this corresponds to a time of -700µs to -500µs. A typical waveform trace is shown in Figure 7, and this shows the time interval used in this calculation. The ratio to the O$^{2+}$ peak to the lead peaks either side is 30. This value comes from the main peak having a maximum height of 0.177mA and the small Pb peaks having a maximum height of 0.006mA.

Oxygen Peak Waveforms

Figures 8 to 10 are a selection of waveforms taken from faraday cup 2 (itl.mfc02). They were taken from the data in Figure 1, around each maximum peak point. The bending magnet current, in amps, is given for each waveform.
Figure 7: Typical oscilloscope waveform trace from itl.mfc02, showing the approximate time interval used for pre-glow.

Figure 8: O$^+$ waveforms from CSD data.
**Figure 9**: $O^{2+}$ waveforms from CSD data.

**Figure 10**: $O^{1+}$ waveforms from CSD data.