DISSERTATION

Cool Science

ausgeführt am Atominstitut

der Technische Universität Wien
Fakultät für Physik

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durch

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1 Beam Characterization

1.1 Aluminum foil

In fig. 1.1 the inside of the 6-way cross of the first iteration is shown. On one side of the phosphor screen, aluminum foil was attached to simulate the aquadag coating inside a CRT. The beam was deflected on the aluminum foil and the BNC output was connected to ground through an ammeter to measure the beam current. As shown in fig. 1.2 there is close to no difference in the filament voltage (and therefore heating power) between an opened and sealed CRT while the beam current on the aluminum foil varies widely. One possible reason could be that electrons scatter around and not all choose the wire path to ground. Therefore a Faraday cup (see section 1.2) was used in the second iteration.

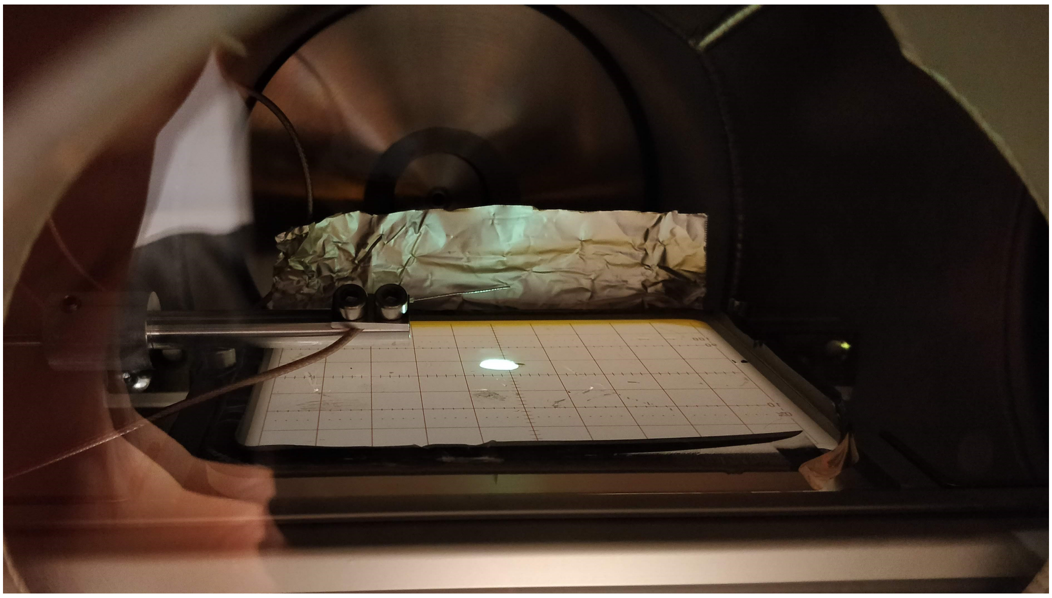

Figure 1.1: Front view of vacuum chamber (first iteration).

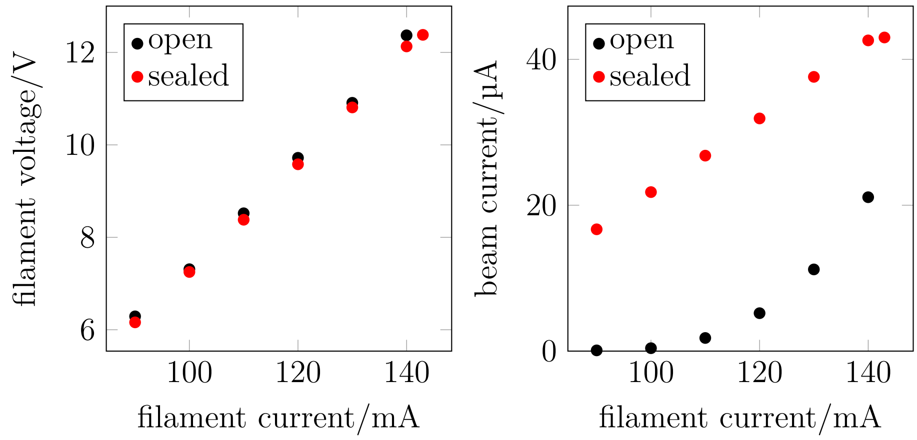

Figure 1.2: Difference in filament voltage and beam current between an open and sealed CRT.

1.2 Faraday cup

In order to accurately measure the beam current, a Faraday cup was built. A schematic is shown in fig. 1.3. A copper tube was cut at an 45° angle on one side and a Cu-sheet was soldered at the top and bottom. A small hole was drilled at the top and a coaxial cable was attached on the mantle which connects to a BNC feedthrough at the top of the chamber. The small opening and bent floor were made in order to reduce backscattering as indicated by blue arrows. At the top surface a phosphor coating was applied in order to make the beam visible which made it easier to guide it into the opening hole.

diameter?

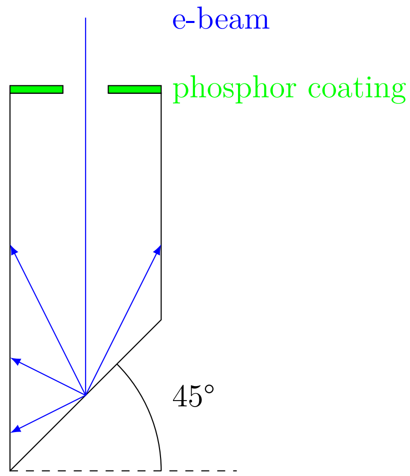

Figure 1.3: Schematics of Faraday cup.

With this improved setup, the beam current was measured again. A summary is shown in fig. 1.4. It can be seen that a current of over 300 µA was achieved, which is more than the necessary amount for the experiment. A problem is the fact, that the current is not stable. A measurement on the next day under the same settings resulted in a current between 50 µA to 120 µA.

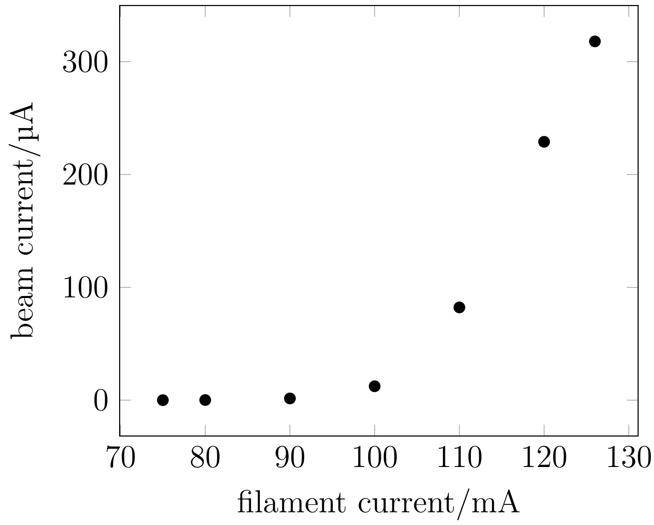

Figure 1.4: Beam current dependence on heater current.

1.3 Deflection frequency

This section describes a few observations that were made when letting the electron beam interact with a short piece of wire, that is mounted to the wobble stick. Originally, we hoped to be able to measure the beam waist, using the knives edge method, i.e. observing the current transported by the beam, while slowly moving a razor blade into the beam path. However the beam is bent, when it passes closely to a conductive part. Whenever we moved our wire close to the beam, the visible spot on the Phosphorous screen below was distorted. This will probably complicate the measurement of the beam waist in the future. When the wire is connected to an oscilloscope, one can see a sharp increase in voltage, when it is moved into the beam. This can be used to see whether our deflection plates work properly and to test how fast we are able to deflect the beam. If the beam oscillates back and forth on a straight line and crosses the wire on the midway point, we should see a spike in voltage on the wire, which repeats with twice the frequency of the beam. If the wire is not on the midway point, the periods between consecutive spikes should sum up to the period of the beam's oscillation (see fig. 1.5). At low frequencies we have indeed observed this behavior.

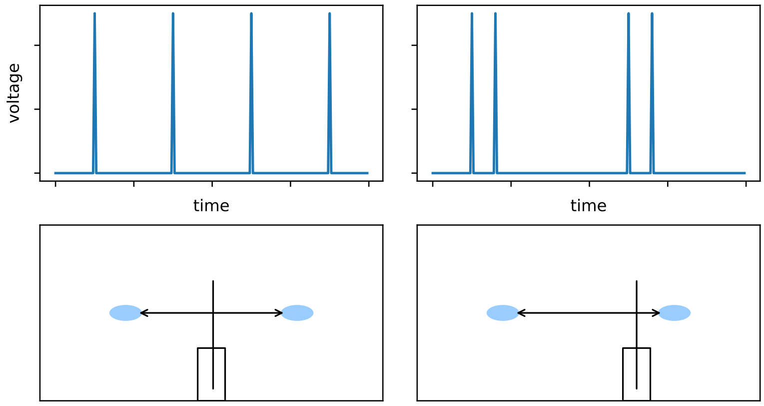

Figure 1.5

As the frequency is increased, the magnitude of the signal decreases. This is easily explained by the fact that the remain time close to the wire is inversely proportional to the frequency and the amplitude of beams deflection. It was possible to see the spikes up to a frequency of 100 kHz, before they where obscured by noise and some other periodical, but so far unexplained artifacts. At high deflection frequencies, the wire may also pick up some signal form the capacitive charging and discharging of the deflection plates and the corresponding oscillating electromagnetic field. In order to be able to see what happens at higher frequencies, a higher beam current and a smaller deflection amplitude would be beneficial, however the most important factor in order to understand what is happening is better focus and a better beam shape.

Todo list