# Detection of single 172Yb+-Ions in a microstructured Paul trap

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## Application Note

### Introduction

In our experiment, we trap single $^{172}Yb^{+}$-ions in a microstructured linear Paul trap. This trap consists of a stack of three trap layers. The outer layers provide the confining potential, while the inner layer creates switchable magnetic fields and gradients. Another specialty of this trap is the 33 pairs of DC-electrodes, allowing to move ions along the trap axis.

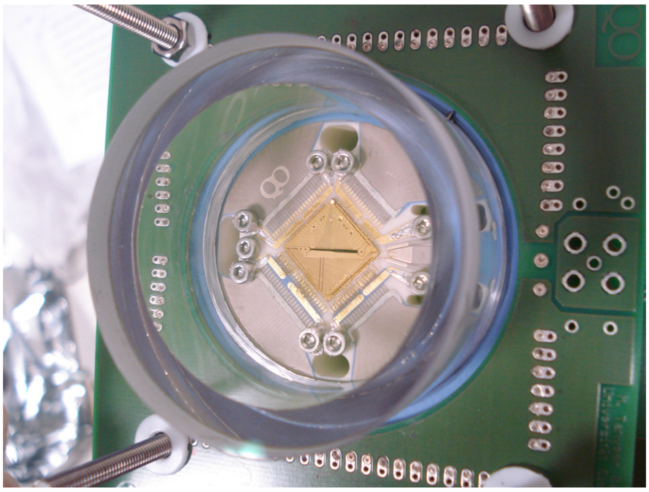


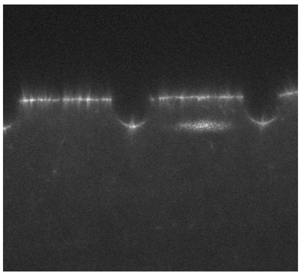
Figure 1: Mounted microstructured Paul trap inside an indium sealed UHV vacuum system [1]. The trap has an edge length of 11 mm. The slit where the ions can be trapped is 7.4 mm long.

### Experimental Setup

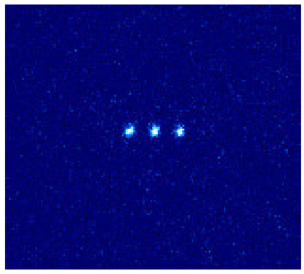
In figure 1, the mounted trap is shown. The trap is fixed on top of an $Al_2O_3$ ceramic block that provides the necessary electrical connections via thick film printed wires and acts as a vacuum interface [1]. Above the trap, an indium-sealed glass cap provides a good optical access to the system.

The light coming from the trap is collected by an objective and directed to the EMCCD camera iXon3 DU897 DCS-BBB. We use the camera for both imaging the trap itself and imaging the single trapped ions. This opens the possibility to accurately estimate the position of the camera in respect to the trap electrodes (see fig. 2(a)), and thus precisely image the correct middle position of the trap without seeing the ions. To achieve this we illuminate the trap by a simple LED, which has the same wavelength as our ion fluorescence light. Another nice feature is the possibility to directly look at the (attenuated) laser beams shining onto the top layer of our trap (fig. 2(a)).

Thus, we can check the overlapping of our laser beams close to the ions, and even check the exact position of the lasers. As we focus the lasers into our system using computer controlled, movable mirrors, with this information we can exactly place the laser beams in the correct trapping position. With this procedure, we can nicely prepare our system in order to trap the $^{172}Yb^{+}$-ions (fig. 2(b)).



(a)



(b)

Figure 2: (a) Image of RF electrode illuminated with LED light. In the photo, one can also see the attenuated 369 nm laser shining onto the RF electrode. (b) String of three Ytterbium ions. The exposure time was 0.1 ms, the EM-gain set to 300. The ions have a distance to each other of about 10 µm.

### Performance

We compared the quantum efficiency of the UV coated iXon3 DU897 DCS-BBB in relation to its predecessor in our lab, an iXon+ DU897 DCS-UVB camera. As our ions' fluorescence light is 369 nm, the iXon+ DU897 DCS-UVB camera provided a quantum efficiency of about 33%. The iXon3 DU897 DCS-BBB data sheet claims a quantum efficiency of about 50% at 369 nm. To check this, we exposed both cameras to a highly attenuated LED at 370 nm, illuminating a 10 µm pinhole (see fig. 3). Theoretically, the ratio between the counts per reading, comparing the iXon3 DU897 DCS-BBB with the iXon+ DU897 DCS-UVB, should be about 1.52. In the measurement, the ratio of the peak heights is 1.53, the ratio of the pixel's mean values is 1.64. The ratios were calculated with background corrected data. We conclude that the enhancement of the iXon3 DU897 DCS-BBB's quantum efficiency at 370 nm compared to the iXon+ DU897 DCS-UVB's is even slightly better than expected from the data sheets.

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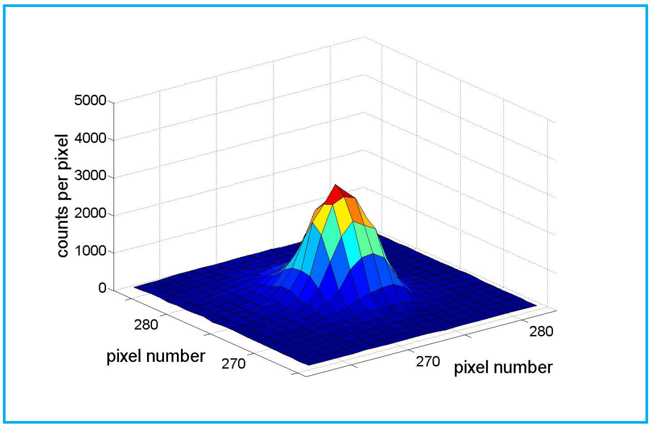
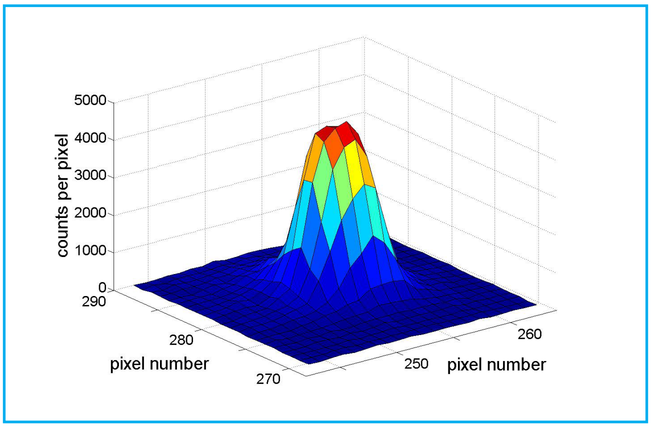



(a)




b)

Figure 3: Zoom-in to the pictures of the 10µm pinhole which was illuminated by the 370 nm light source. The pictures were taken with (a) the iXon+ DU897 DCS-UVB and (b) the iXon3 DU897 DCS-BBB cameras at 0.1 ms exposure time and an EM-gain of 20 each. Both pictures show 20 x 20 pixels.

**Reference**

[1] D. Kaufmann, et al., arXiv:1107.4082 [quant-ph]

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