Spatial resolution measurement with “switched-on channels” of an aged 120 mm MCP stack

Besides determining spatial resolution properties of an MCP detector via mask images, dark emission from single pores in an MCP stack can serve as single bright spot sources for investigating local imaging performance.

It occurs that a single MCP pore produces “dark counts” at a rate of several 10 Hz, while typical dark count noise is on the order of only few Hz per cm².

If it is assumed that the charge clouds of each single pore dark counts leave the final MCP stage with the same centroid this can serve as an ideal zero-size point source for the imaging anode: the width of the image corresponds directly to the spatial resolution capability at this position.

Figure 1 shows the imaging response of a DLD120 mm detector illuminated by an Am-241 source.

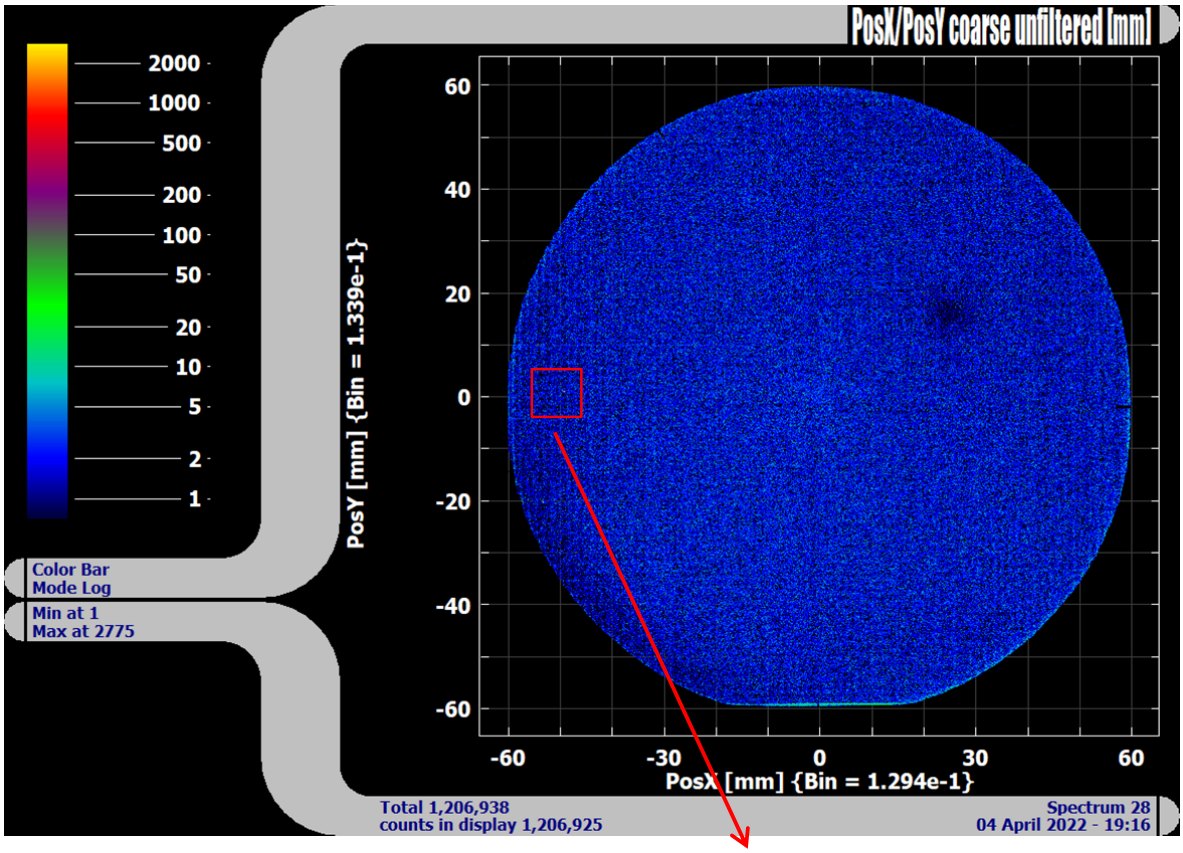
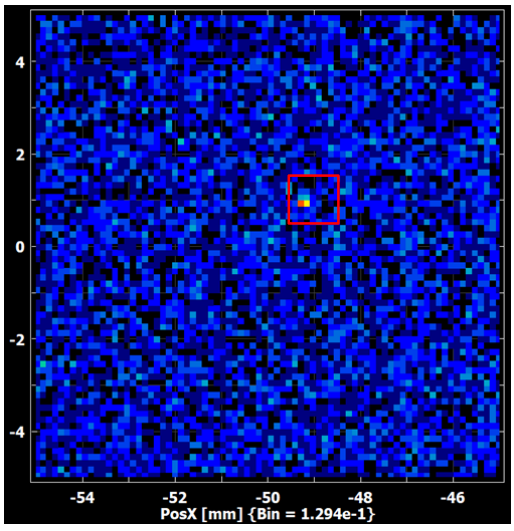


Figure 1: Image response (log scale) of a DLD120, equipped with a long-used 120 mm MCP stack (Photonis, 25 µm pore diam.) was illuminated for evaluation purposes. During this several local dark noise emitters (“hot spots”) habe been discovered. The pixel size of about 0.13 mm was arbitrarily chosen for image representation. The 1mm x 1 mm square in the inset to the right is the field-of-view displayed in figure 2.



A close inspection with finer bin size < 10 µm (down to the LSB-limit of the employed TDC8HQ time digitizer) showed that the local dark emission must come from a single pore because the width of the peak is on the order of the spatial resolution.

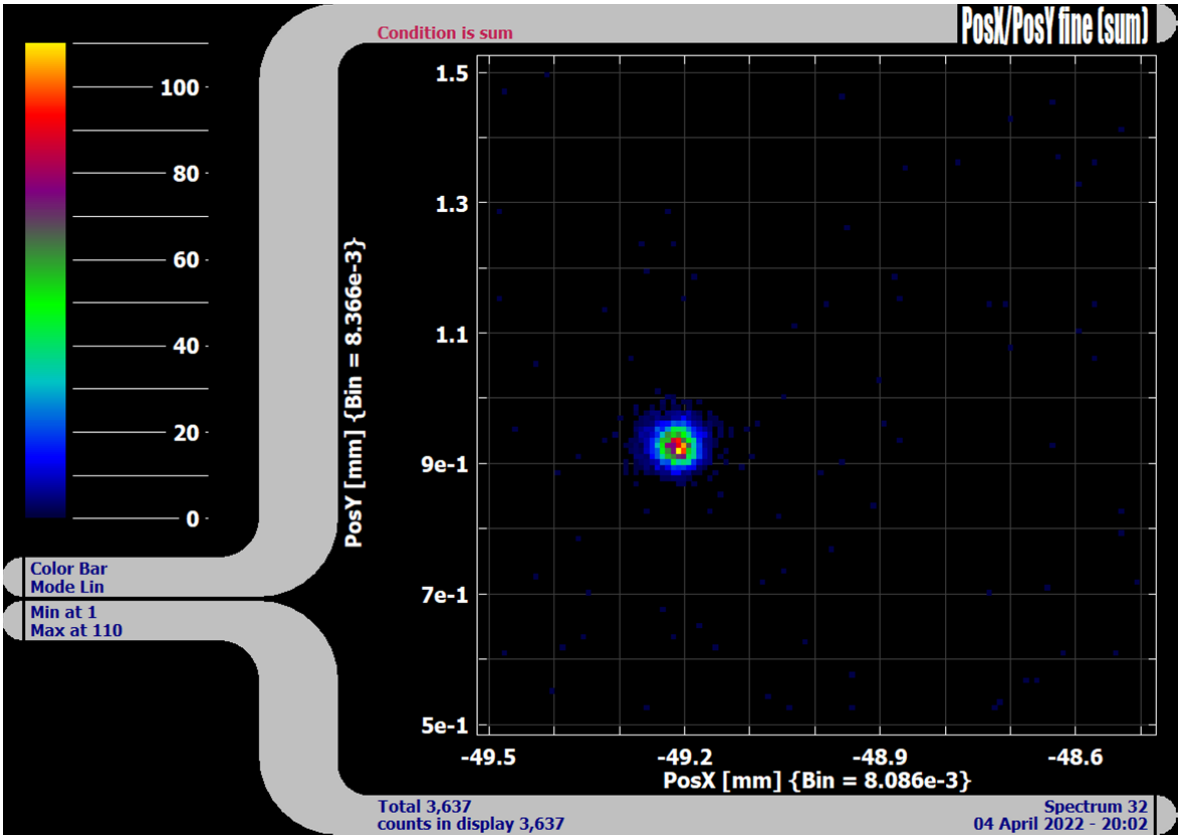
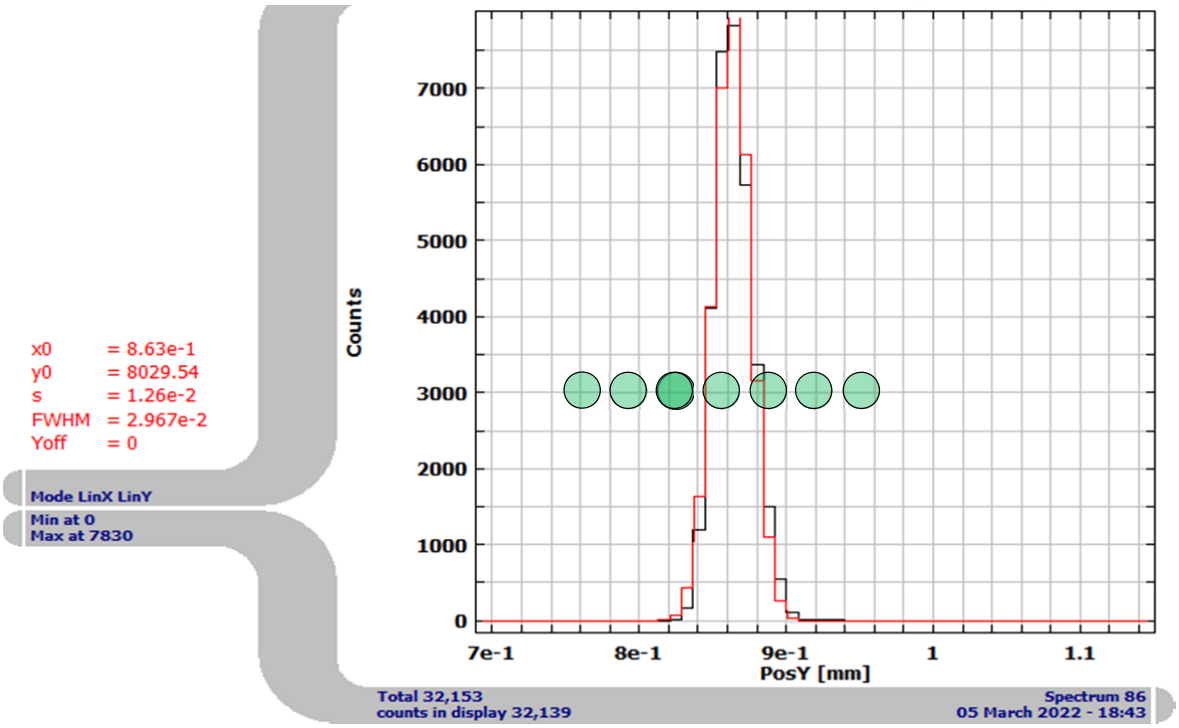


Figure 2: single pore hot spot. Pixel size here is determined by the limitation of the TDC's timing precision (LSB = 13 ps). Measurements with higher statistics at higher gain allowed assessing the spatial resolution to 30 µm FWHM (see below). Green circles show size and distance of the MCP pores (32 µm) at same scale.



For achieving this resolution it was necessary to compensate for "detector walk" as function of pulse height. The resolution corresponds to an 8k x 8k pixel image for a 120 x 120 mm² delay-line anode (rms < 15 µm).

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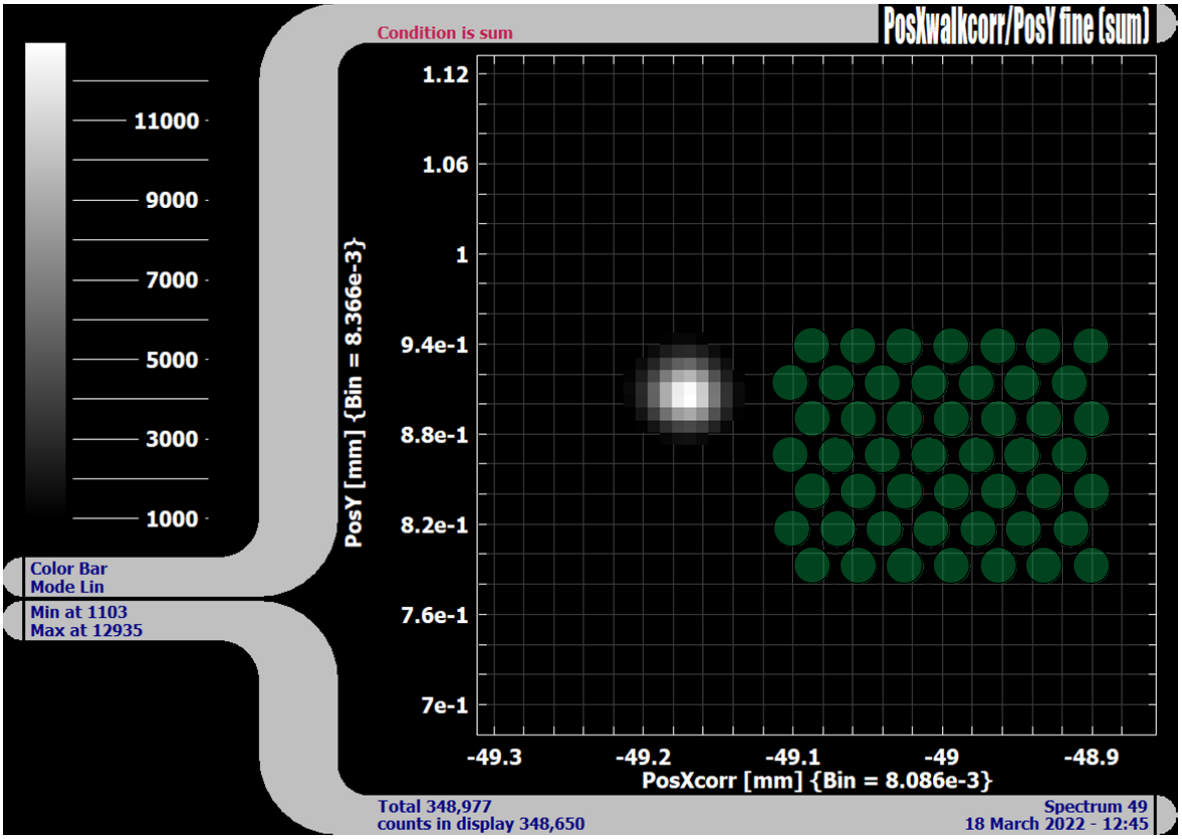
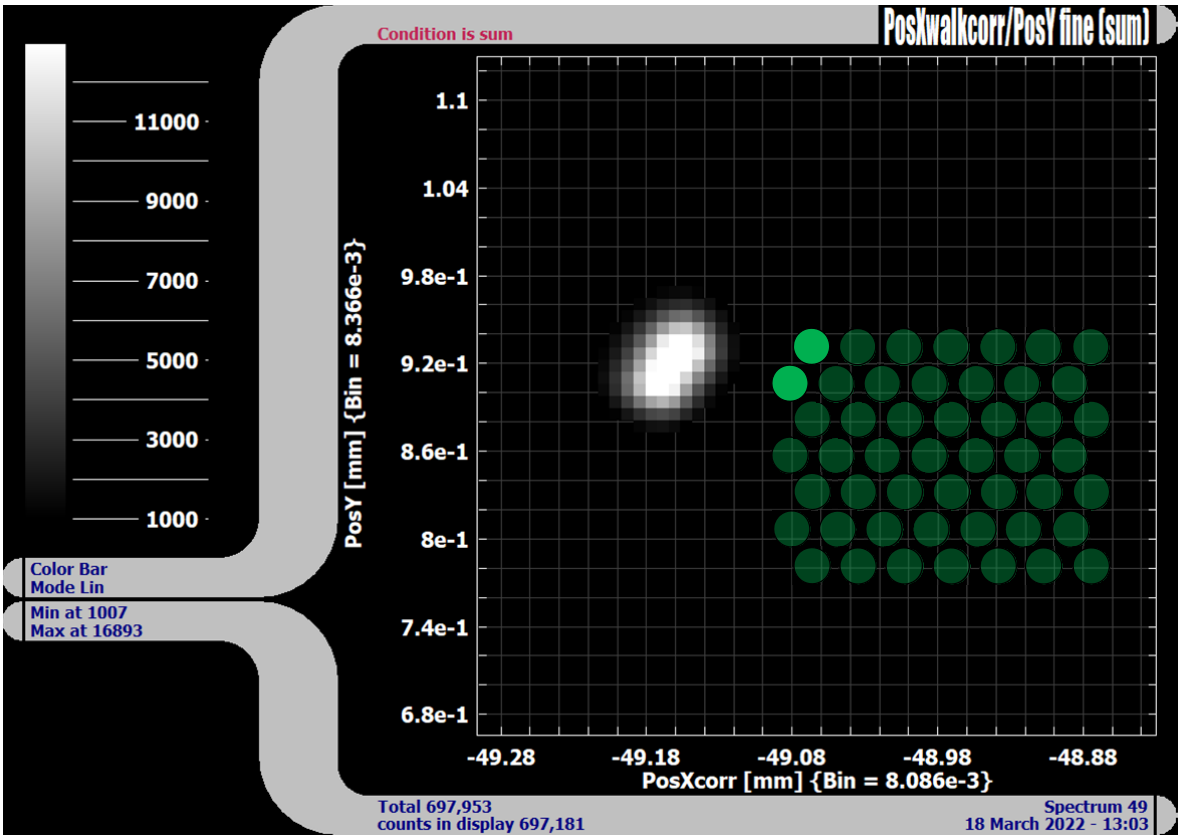


Figure 3: size comparison of single pore spot image to the multi-pore arrangement of an MCP. A simulation below shows the expected image if two neighboring pores would be emitting with same intensity. For this the measured single pore image was copied and overlaid with a shift towards a neighboring pore position.



(note, that the picture above and pictures of Figure 4 are not measurements!)

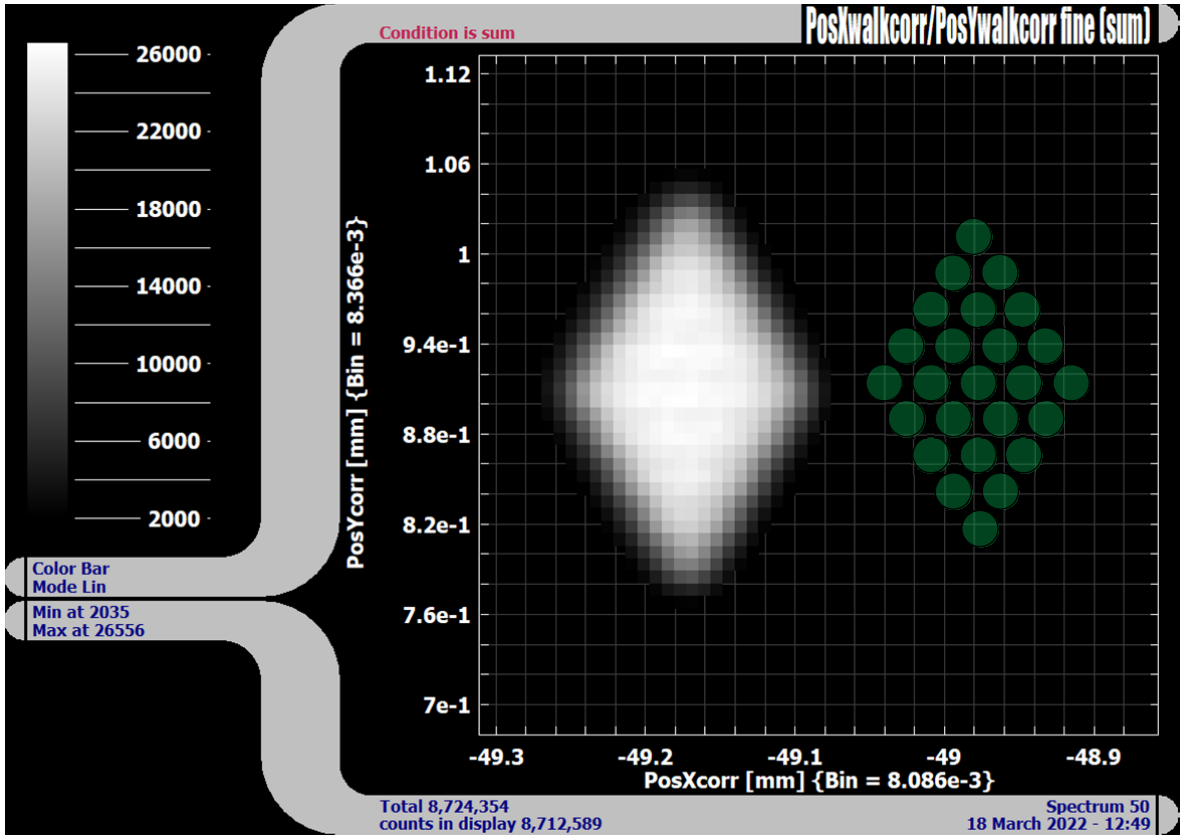
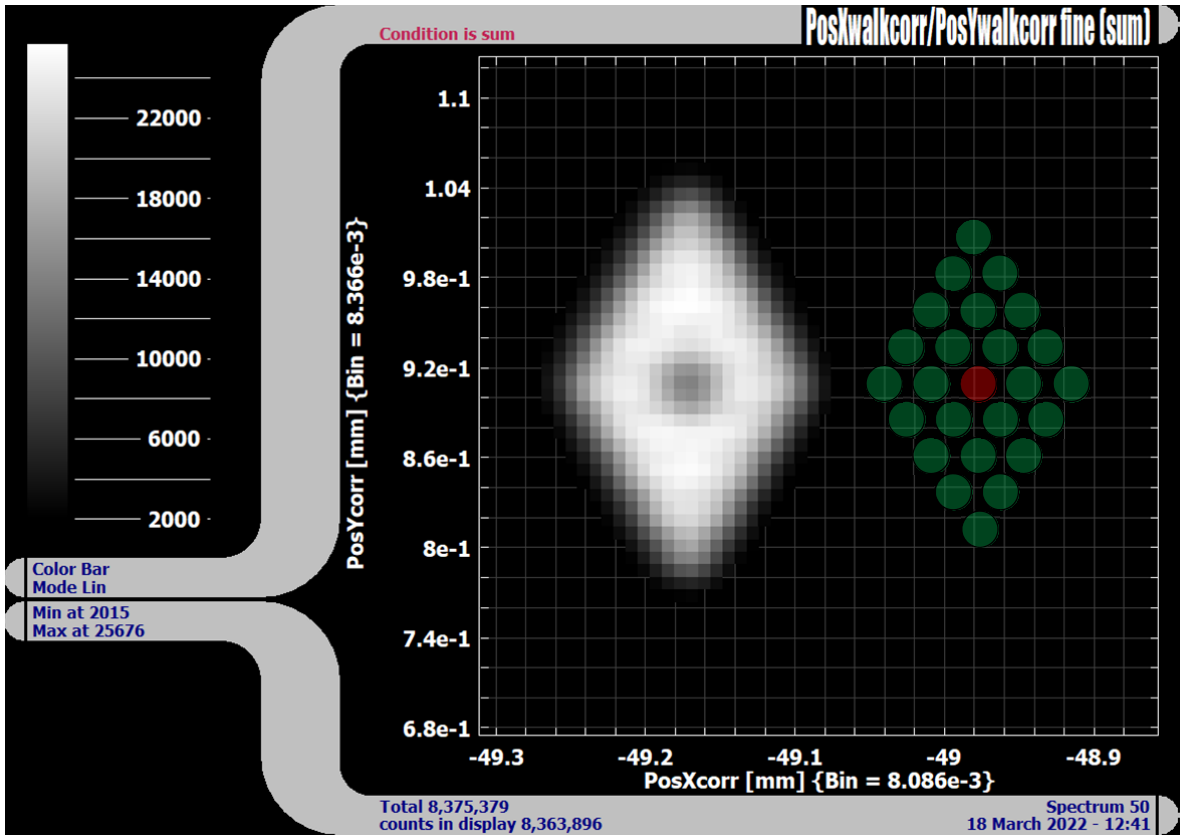


Figure 4: More simulations based on measured single pore imaging response and knowledge on the spatial arrangement of 25 neighboring pores. In case of uniform illumination single pores could not be distinguished. However, a clogged pore (non-operating channel) would be recognized (see simulation below).



Comparison to TDC8HP with 25 ps / 100 ps LSB (and cTDCx with 88 ps LSB, estimated)

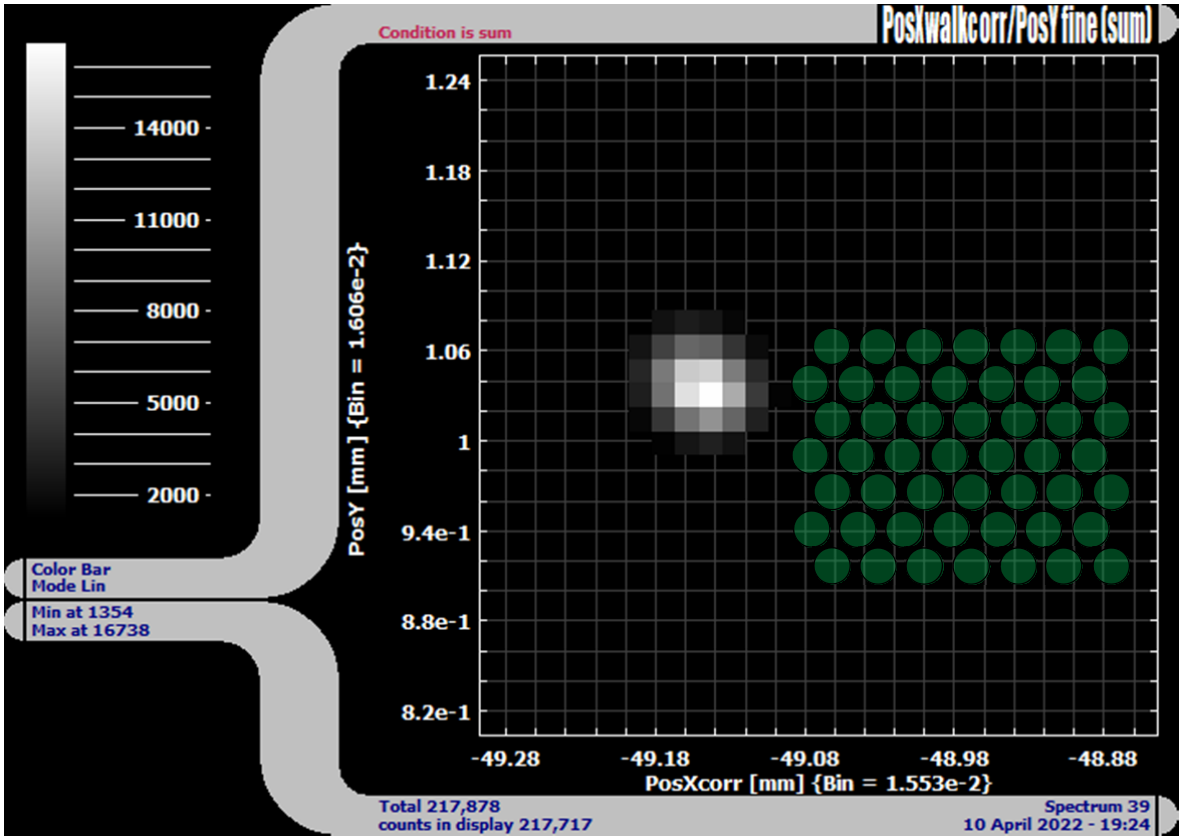
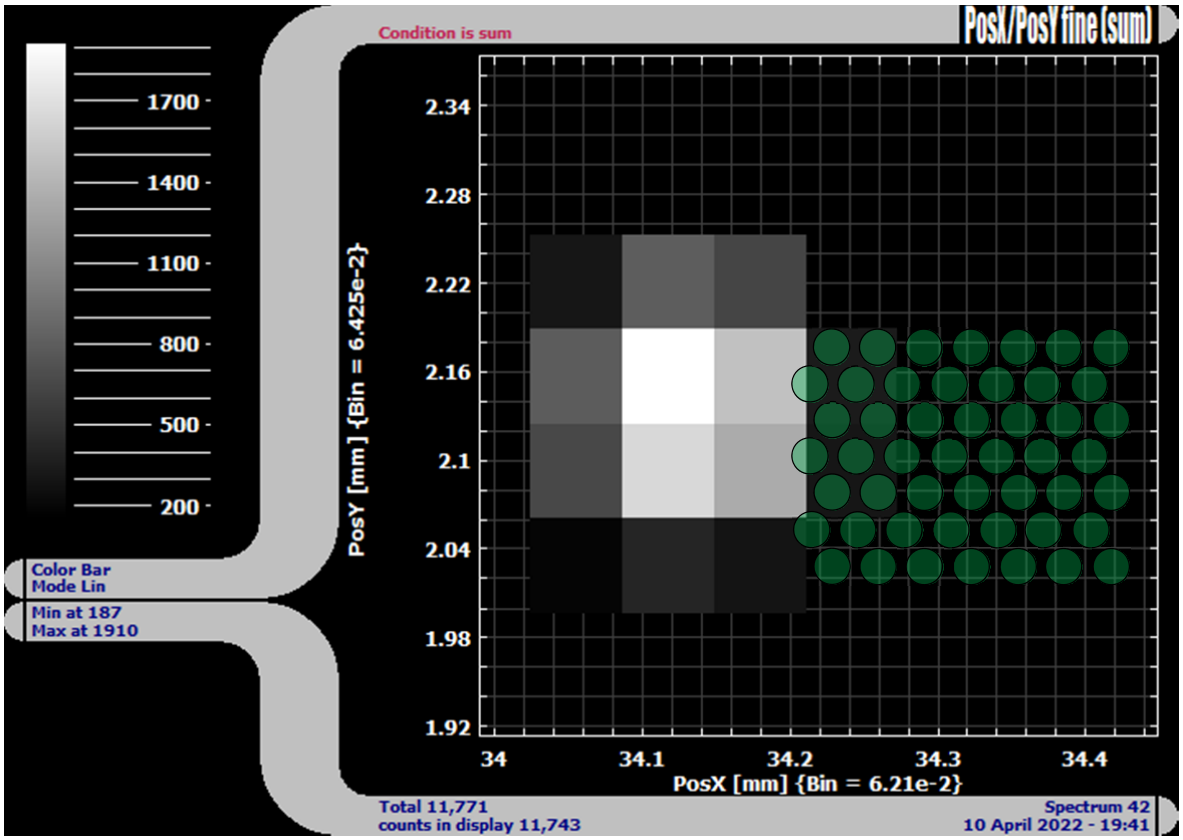


Figure 5: 25 ps bin size: FWHM 0.050 mm (above) below: 100 ps bin size: FWHM 0.121 mm



Estimation for 88 ps TDC bin size (e.g. cTDCx):

FWHM 0.11 mm, imaging performance expected to be similar as above, only pixels/width about 10% smaller.