About ion-feedback of Micro-Channel Plates (MCP):

Due to the nature of Micro-Channel Plates (MCP) an ordinary MCP having small and straight channels can not produce gains as large as a single (curved) channel electron multiplier (“Channeltron”). One reason for this is the so-called ion-feedback phenomenon: as the electron avalanche gets bigger and bigger on its way through a MCP channel (driven by the MCP bias) atoms from the rest gas or adsorbed atoms on the channel surface can be ionized. These ions are then accelerated by the MCP bias towards the MCP input side. If no counter-measures are taken they can achieve enough energy to release electrons as they hit the channel wall. Then a second avalanche will be initiated. These “false” after-pulses would not only disturb the measurement, they could ultimately lead to a permanent glow discharge and destroy the MCP over time.

Measures against ion feedback is the use of only “short” channels (with an aspect ratio typically between 40 and 80) and to tilt these channels slightly against the field direction.[i] Markers on the MCP rim (on input side) indicate the direction of tilt angle. Such a single MCP does not produce sufficient gain for “counting” single particles in the sense that a large-enough charge cloud for precisely recording position and time would be formed. Therefore, at least two MCP have to be stacked to achieve sufficient total gain.

In order to avoid ion-feedback to kick in for stacked MCP (channels simply being “prolonged” by the stacking) the relative angle between pores must be maximized: Neighbouring MCP in a stack must be rotated so that the tilt markers come to rest at 180^o relative azimuthal angle. In a side-view cross section this gives the appearance of a “Chevron” or V-shape when following the orientation of channels through the whole stack. Hence, the term “Chevron stack” (or V-stack) became common to describe a pair of stacked MCP. Stacking three MCP properly would result in a Z-shape (therefore: “Z-stack”).

Furthermore, it is necessary that the rest vacuum should be $< 10^{-6}$ Torr and the channels’ inner surfaces must be “clean”, i.e. free of adsorbates.

This allows total gains over 10^7 for single particle or photon detection with Chevron or Z-stacks. However, the ion-feedback phenomenon might still be present at a certain level and disturb the performance especially for multi-hit detection tasks: A second “signal“ may sometimes appear (typically at the same position than the earlier one) at times between few ns to few 100 ns after the first signal, although no second particle/photon has hit the detector. In most experimental situations it is unlikely that the same “pixel” in an image is hit in such a short time and it is possible to exclude those events by a software gate.

The remaining ion-feedback will strongly depend on the cleanliness of the MCP pore surface and the rest vacuum in the pores. Note, that a good vacuum level in the recipient does not guarantee an equally good vacuum level in the pores. **It may take several days until a freshly installed MCP has clean-enough pores for low ion-feedback and before dark count noise is minimized.** This is also the case for MCP stacks that have been operated before but have rested in ambient air for a while. A baking of the recipient/the MCP stack may shorten this time.

If the ion-feedback performance is not sufficient for an application although the MCP pores can be considered “clean” and at a good vacuum level is reached, one should first consider whether an operation at lower MCP gain is possible and whether the ion-feedback is tolerable at this lower gain (e.g. by introducing software gates as explained above). Otherwise it is advisable to add one more MCP to the stack. A Z-stack operated at same total gain as a Chevron-stack usually shows much less ion-feedback.

It is to note, however, that using a Z-stack increases the required total voltage across the stack (check high voltage ratings of feedthroughs, cables and power supplies).

As a thumb rule

- Chevron stacks of 40:1 MCP ("L/D", aspect ratio) show HIGH ion-feedback at gain levels for single particle/photon counting (not recommended for RoentDek detectors).
- Chevron stacks of 60:1 or 80:1 MCP show LOW ion-feedback.
- Z-Stacks of 40:1 (or higher) MCP show VERY LOW (or NO) ion-feedback.

Obviously, also the tilt angle (different for the various MCP types) plays a key role here. MCP with larger tilt angles will show less ion-feedback for a given configuration than MCP with lower tilt angles. A Chevron stack with L/D 80:1 and pore tilt angle close to 20^{o} can be considered as near-optimal in terms of ion-feedback suppression, comparable to a Z-stack configuration.

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[i] An alternative is manufacturing MCP with curved channels which is technically very difficult but feasible