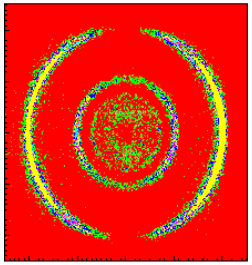


RoentDek Handels GmbH

UHV-Detectors
Supersonic Gas Jets
Multifragment Imaging Systems

Application Note:
DualHex 9.05.2018
Ottmar Jagutzki
public

The RoentDek DualHex delay-line anode

and general tests on split delay-line arrays for printed anode tracks (see Appendix)

By introducing the **Hexanode** detector **RoentDek** has many years ago improved the performance of micro-channel plate (MCP) detectors with delay-line anode read-out for recording multi-particle events which arise for example in radiation-induced atomic and molecular breakup processes.

A common two-dimensional delay-line read-out (i.e. like in the **RoentDek DLD** devices) codes the position of a particle into a time sequence of several signal travelling along the delay-lines.

The Hexanode adds a third layer to this two-dimensional read-out array to achieve redundant signal detection. If dead-time effects prevent the registration of some signals it is then in most cases still possible to reconstruct the event, unless two particles are too close in relative arrival time AND position.

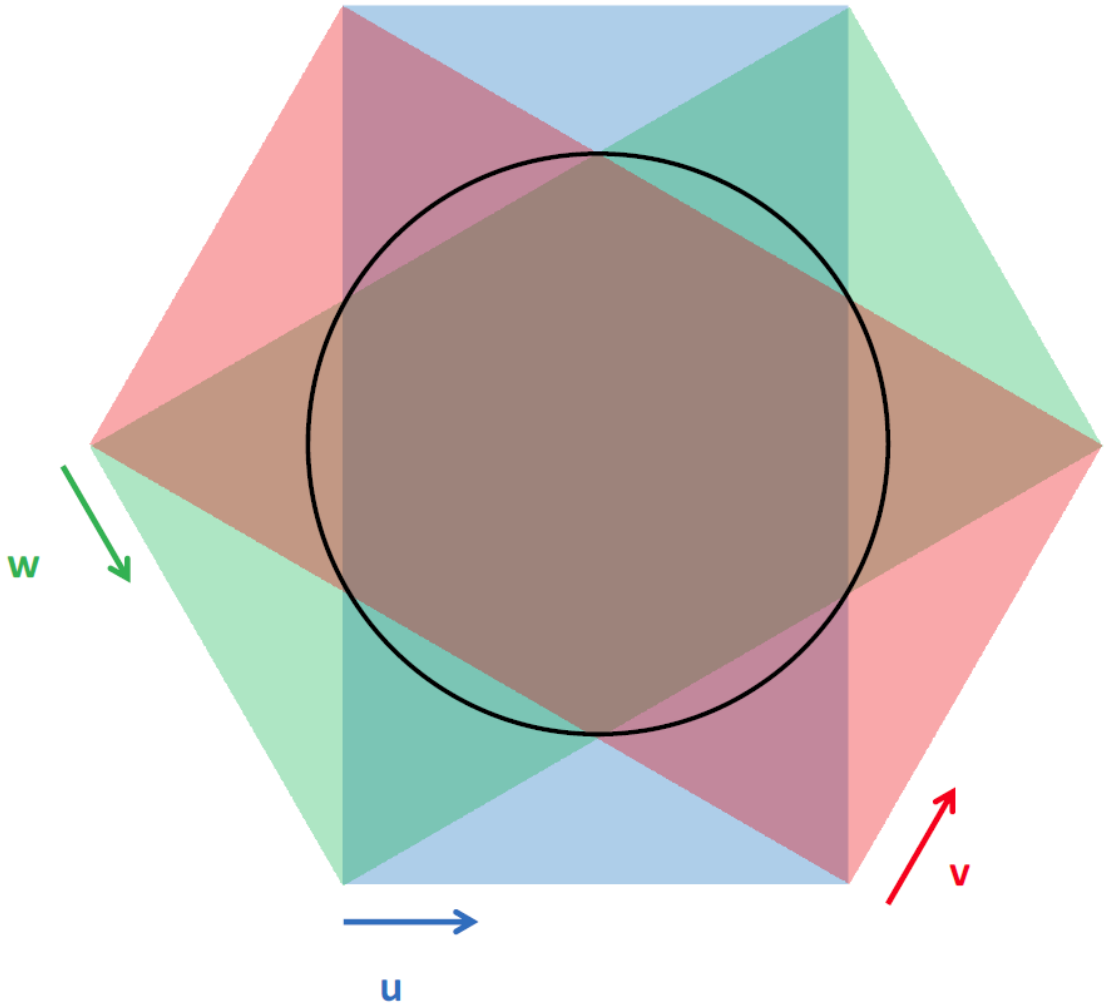
However, in case of high-multiplicity events with three or more particles arriving within the dwell time of signals on the anode array (typically 100 ns), the event recovery can fail.

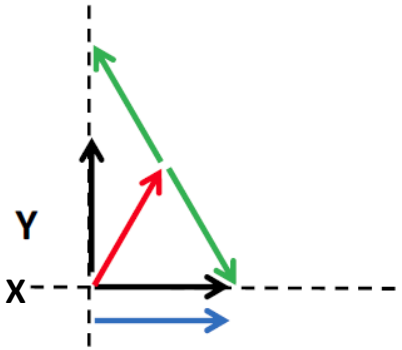
To improve this situation one can segment the delay-line anode into several segments, each backed by individual read-out electronics. This was described by Robert Continetti and coworkers in *K.A. Hanold et al., Rev. Sci. Instrum. 70 (1999) 2268ff*. Here, the multiplicity problem is addressed by introducing several independent read-out anodes, each backed by its own set of counting electronics. This “pixelising” approach can only partially improve the situation because only those events can be reconstructed where individual particle hits are ideally distributed over the segments since each segment can only handle one particle hit per event. Further disadvantages of this approach are “blind” detection regions at segment boundaries and the fact that the number of read-out channels is increased proportionally to the number of segments (see also Appendix of this report).

The Hexanode:

active 2D area: **"David Star"**

triple-layer coverage area: hexagon





$Y = (v - w)/\sqrt{3}$

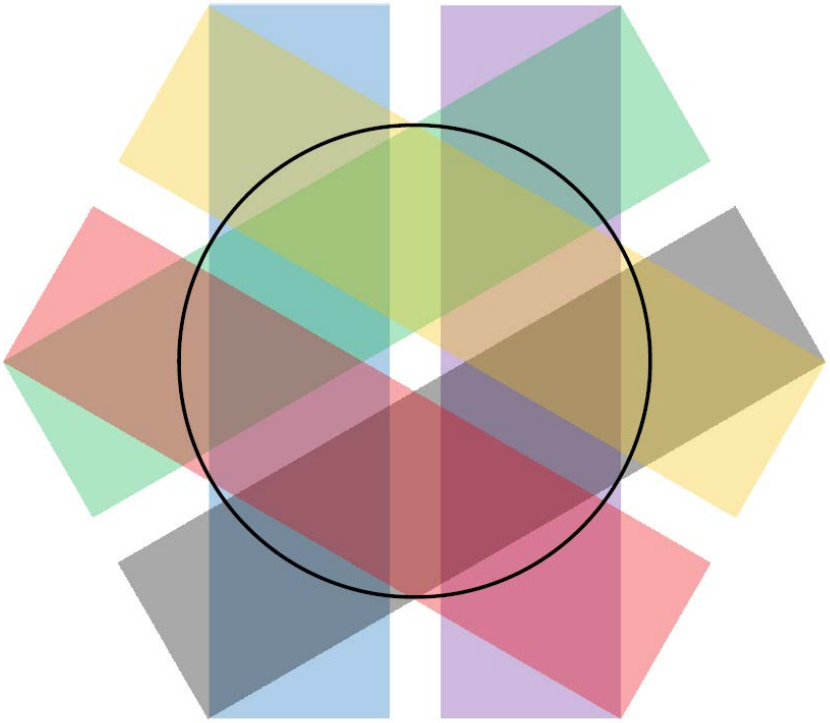
$X = u$ or

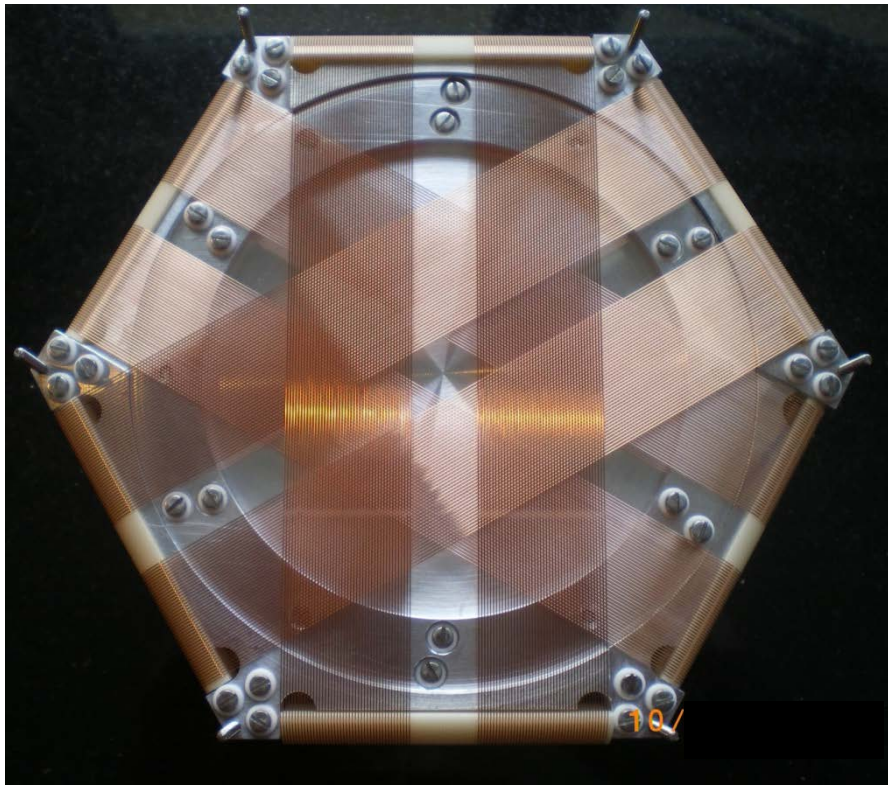
$X = v + w$ or

...

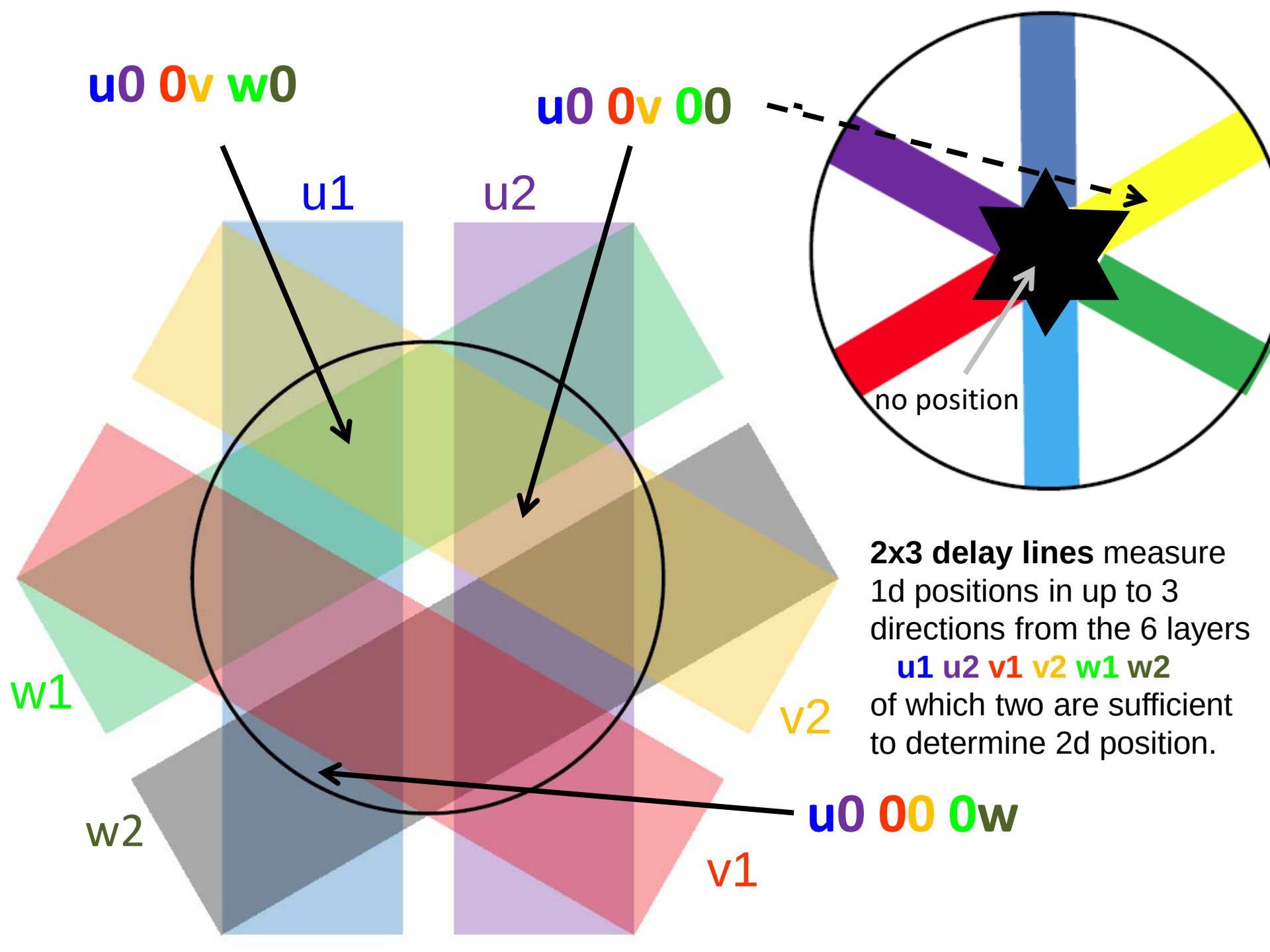
A **Hexanode** detector using three delay-line layers. A hexagonal detection area is backed by all of them (redundancy region for multi-hit detection). See discussions and literature-links on www.roentdek.com

The DualHex: - just twice as many read-out channels required
- multiple quasi-independent detection regions created



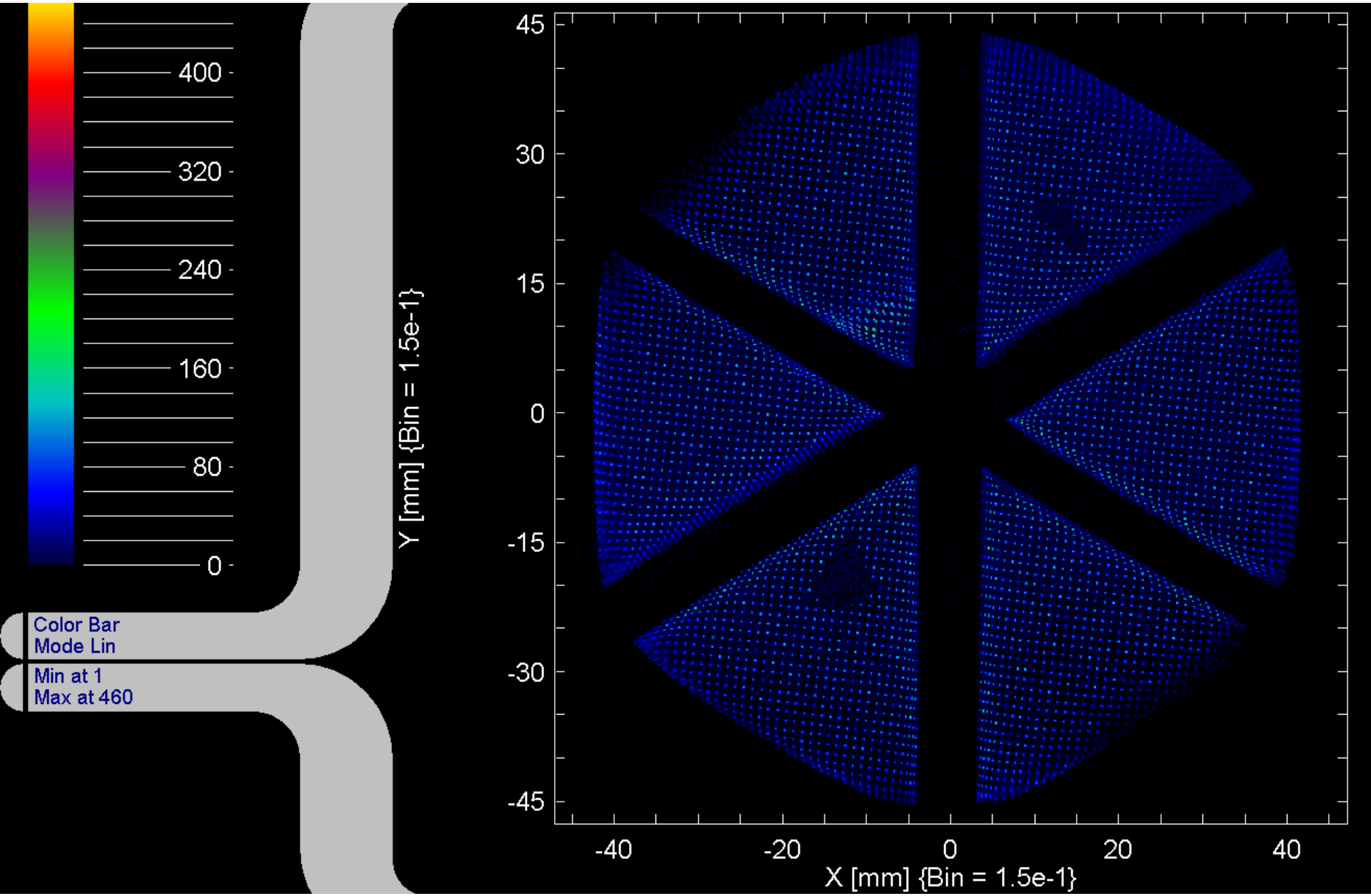


The **RoentDek DualHex** follows the concept of the standard Hexanode but splits every delay-line array along the middle line. Although the number of layers (and requirement for electronic read-out channels) is just doubled, the detection area is divided into a multitude of differently addressed regions (here visible as different color mixtures), each backed by two or three layers. There are no boundary effects, except for a prominent “blind” central spot which size depends on the chosen split width. It is to note, though, that the regions are not completely independent but can share one delay-line layer.



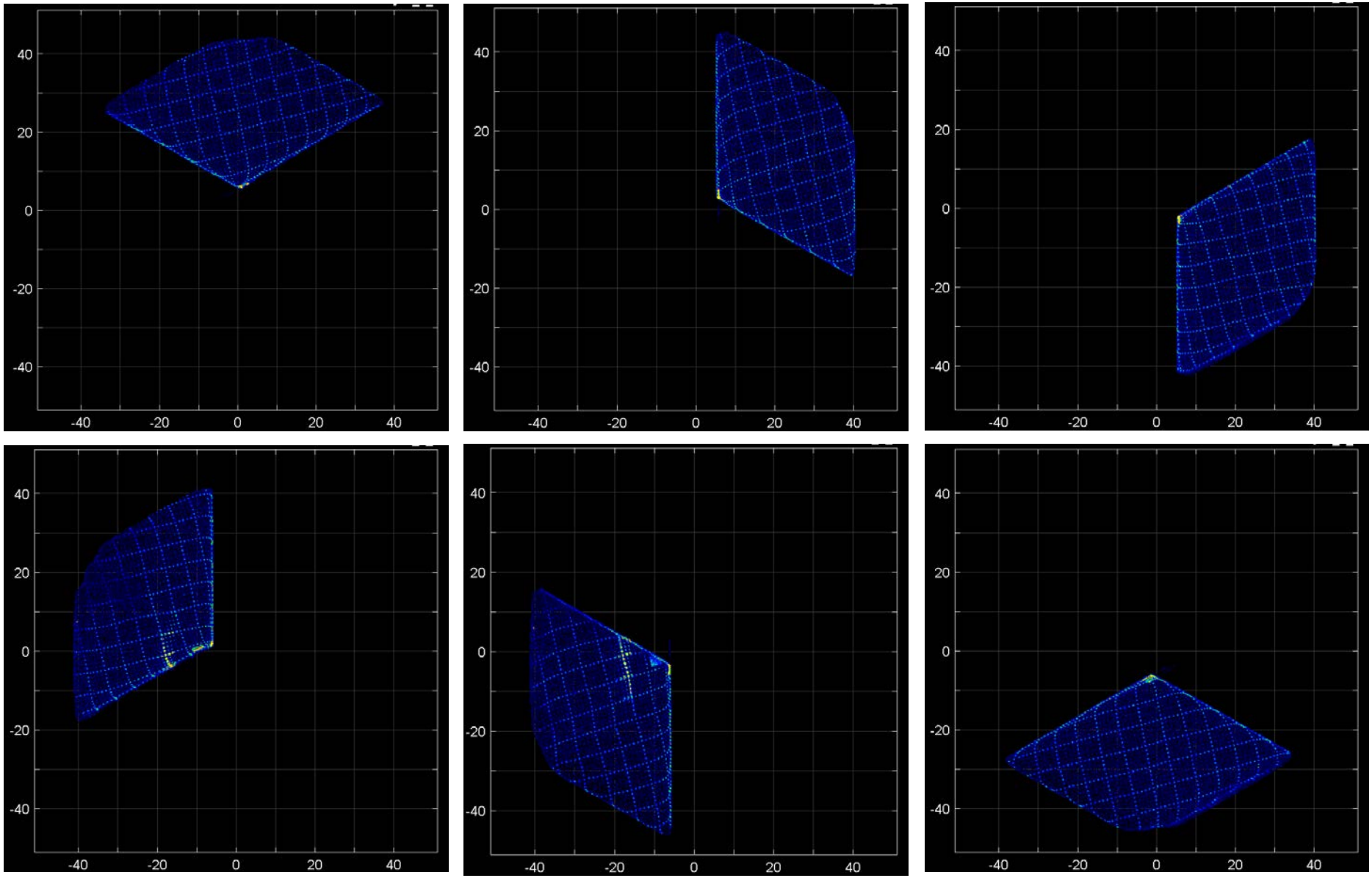
2x3 delay lines measure 1d positions in up to 3 directions from the 6 layers
u1 u2 v1 v2 w1 w2
of which two are sufficient to determine 2d position.

All triple layer events from a shadow mask image response summed up:



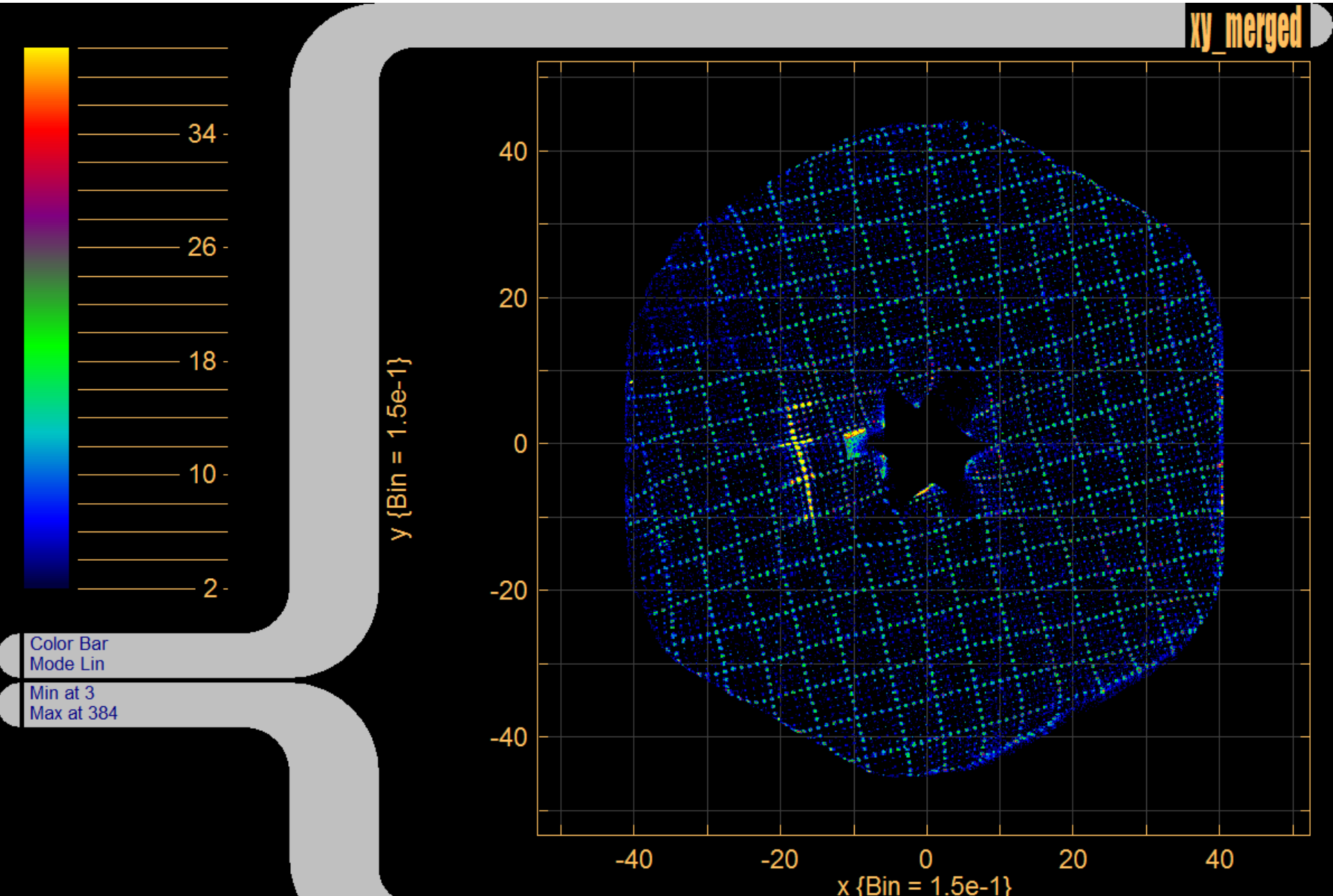
The missing areas are determined by…

Partial images (of a shadow mask) from the different combinations of two overlapping layers



Due to overlap between images a merging “sum” image is obtained :

Complete image of shadow mask after merging two-layer combinations (proof of principle achieved)



Current status of the development:

A merged image from a **DualHex** without boundary loss could be obtained as proof of principle.

Relative linearisation of the image response is a straightforward task using the intrinsic linearity control options of a Hexanode (not yet implemented in the read-out code here).

Global linearisation beyond that can be achieved by a 2d look-up table.

Codes for reconstructing multi-hits using the advantages of the DualHex concept are in development.

Test/control data for developing and testing such an advanced routine are easily obtained by mixing the recorded single hit event data here towards artificial but experimentally realistic multi-hit events. Since the test data were acquired using with fast ADC units (**RoentDek fADC4**) in list mode, recording the analog signals tracks from real hits, some of these can simply be summed up to generate multi-hit events, introducing selectable delays between such simulated multi-particle hits.

The reverse reconstruction to the observed original individual hit positions and introduced time delays can thus be tested.

Appendix: **Test measurements on a split delay-line array with printed anode tracks**

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