Interesting Readout Possibilities

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Introduction - Classic readouts

Wires are probably the most common readout scheme in TPCs. With growing detector sizes and channel numbers, one should rethink this approach.

- Wire tension imposes stringent mechanical limits
- Still only a projection of events

Possible alternatives

Pixel based readouts seem to be a logical successor to this classical method. Let's see what pixels could bring to the table for future projects.

Pixel readouts

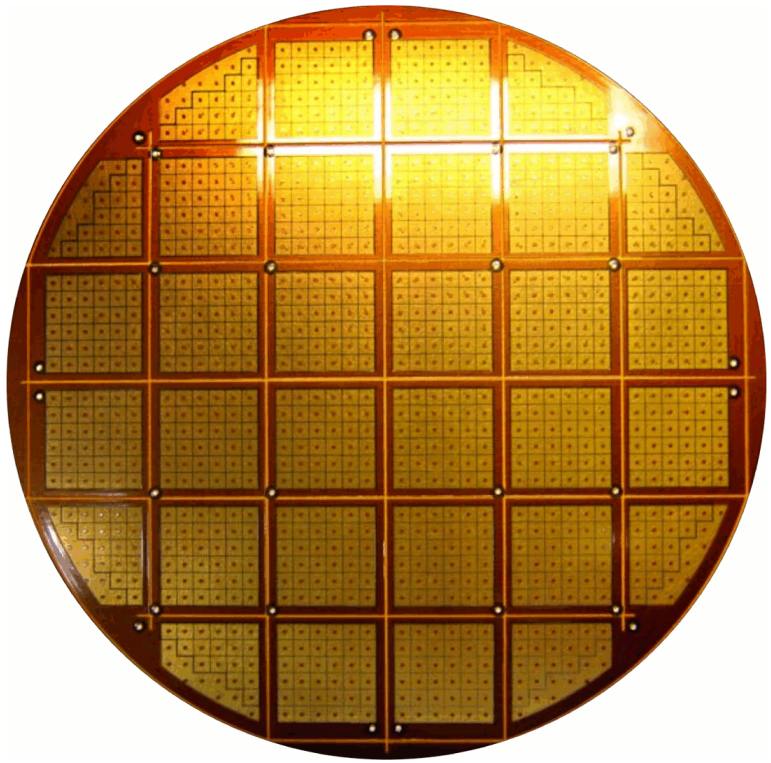
At first glance, pixel readouts might look too costly in terms of channels if every pixel needs to be read out individually.

- Some amount of multiplexing is necessary to keep the amount of channels under control.
- First possibility: Regions Of Interest (ROIs)
- Second possibility: Genetic Multiplexing

Let's have a quick look at both these possibilities and what they could reward us with.

Regions Of Interest

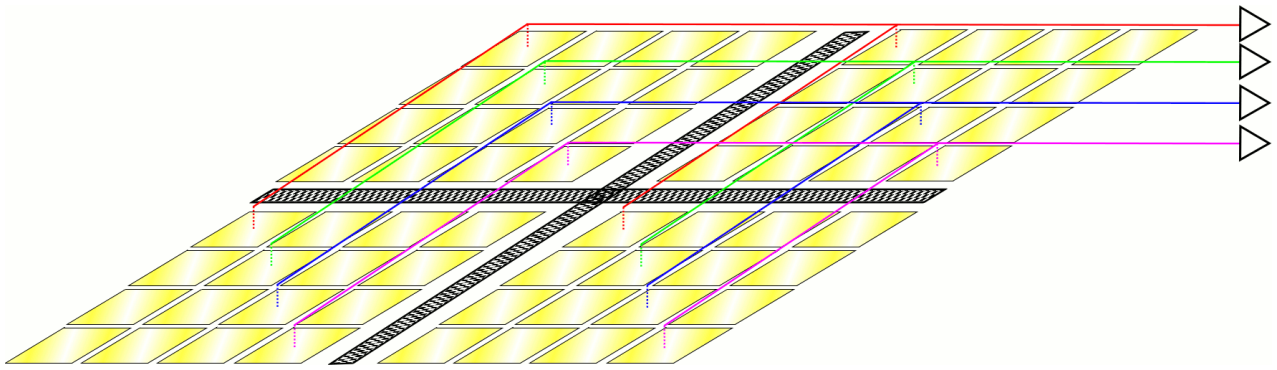
The idea is to separate your readout into larger regions that contain a pixel pattern. For example:



The segmented grid Micromegas. Using grid segments to define regions of interests, this particular model has 28 ROIs containing 36 pixels each.

Regions Of Interest

Each identical pixel from each ROI is read out by a single DAQ channel, like so:



So this detector has $28 * 36 = 1008$ individual pixels but requires only $36 + 28 = 64$ DAQ channels.
In general, this two-tiered multiplexing is optimized by separating your DAQ channels equally between pixels and ROIs for a maximal amount of pixels that follows: $p = \frac{n^2}{4}$

Genetic Multiplexing

Genetic Multiplexing is a rather new idea (to me). As its name implies it borrows an idea from genetics that the sequence of a specific order of acids can point to its unique place in a chromosome.

- Multiplex the channels so that no two "neighbor-pixel-pattern" repeats anywhere on your plane.
- An event generates a list of "hit" channels
- Find the unique place where those pixels are contiguous on you channel assignment map
- Necessary condition: charge sharing

Genetic Multiplexing

1D example

The simplest example we could look at is a 1D readout:

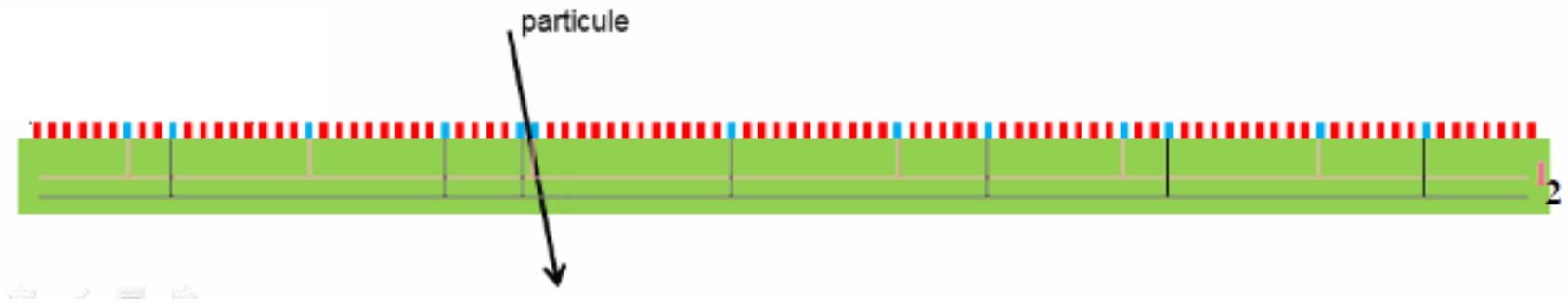


Figure 1 : Image by Sébastien Procureur 2013

Here, the "hit" channel list would comprise 1 & 2. Pixels connected to channels 1 & 2 are only contiguous in one area of the detector. The interaction happened there. Genetic multiplexing gives you a pixel to channels relation of about $p = \frac{n^2}{2}$

Genetic Multiplexing

Building a multiplexing array

The hard task in genetic multiplexing is building a suitable channel map that allows you to pinpoint the location of an event based solely on the channels that fire.

- Assume you have 18 pixels; you need only 7 DAQ channels (approximation of $p \approx n^2/2$ does not hold for smaller values of p)
- The first 7 pixels can be assigned serially from 0 to 6
- The next pixel can be on channel 0 again because it is not yet a neighbor of 6
- The following, however, cannot be on channel 1 because 0 and 1 are already neighbors. Then assign channel 2.
- So on.

Genetic Multiplexing

Passing to 2D

The transition to a 2D array of pixels seems a little tricky for now:

- The charge sharing condition has to extend to 4 pixels instead of 2
- Maps built on paper for small arrays: 4 *x* 4
- We're working on algorithms that could generate an appropriate channel map for *m x n* arrays.

Reconstructiong 2D

Identifying the region where the fired pixels are contiguous would be an easy job for the human eye. Easy for the brain almost always means hard for the computer.

- Turning the hit pixels map into an image and using image analysis tools to find the location of the largest contiguous "blob" would definitely be an option (GPU computing?)

Two approaches

The two approaches presented here are, at first glance, viable for a readout the size of which we are aiming for.

	ROIs	Genetic
Pixels vs. Channels	$p = n^2/4$	$p \approx n^2/2$
Relies on induction	yes	no
Minimal charge sharing pixels	1	4

We plan to test both these options on our small test-bench in Bern. We will be able to report more definitive advantages and drawbacks in the near future.

Thank You