Readout system for a GEM based TPC.

Basic principle is to read every pad continuously and extract timestamped waveforms of the charge.
The problem with reading out the Pads on a GEM detector is to connect the readout to the pads. It is proposed to use surface mount 0.8mm pitch connector strips mounted on the rear of the GEM pcb. This covers an area 6mm wide (taking into account the gap required between adjacent connectors) and as long as is required to a maximum of 180 connections over 144 mm. The electronics required for the readout is better suited to a power of two granularity so 128 channel format has been chosen, fitted into a board mounted at right angles to the plane of the GEM pcb. The board contains the components for 128 channels of readout using amplifiers, 4:1 multiplexers, 8 x 12bit FADC chips, and a Virtex4 Xilinx FPGA. See fig 1. The FPGA will communicate over serial links with a subsequent layer of data processing for collation of the track data, a controlling system (slow control) and adjacent FPGAs for eventual track re-construction.
The readout will be pipelined up to the FPGA. In the FPGA there will be a timestamp counter operating at the time of the conversion rate to provide a valid identification of any activity across the detector.

The data for a channel will, in the first instance, be independent of other channels and with a timestamp be made available to later processing for track building. The structures will be in place to allow adjacent boards to request data from apparently inactive pads (nearest neighbour).
Each channel will be triggered by it’s own discriminator operating to detect the rising and falling signal on the pad. A fixed number of data words will be saved in this event, and forwarded to the data output stage for sending to the processing system. The order and position of the event can be reconstructed later using the pad position data, and the timestamp. If an event is longer than one the fixed number chosen then a second timestamp will be taken , and a further packet of data sent with the same fixed length.

Questions

1. Will the amplifier and multiplexer idea work with small enough voxel size for correct track reconstruction.
2. Will the amplifier be saturated ? How long would it remain ‘dead’ ?
3. What is the required pad size to reliably detect a track.
4. Can the charge given up to the track be reliably measured by this method (no integration except later)
5. Is the Noise and potential crosstalk too much for the required accuracy ?
6. Can the boards be cooled ?
7. Is it possible to fit 8 amplifiers in a column ?

Parameters required to determine the average rate per Pad.

Questions :

1. How many times will a track branch ?
2.

Assumptions

1. The beam passes into the middle of the TPC along the longest axis.

Size of a Pad : A x D (mm)
Size of the TPC gas Volume : L x H x D (mm)
Rate of interactions in the volume : RT (tracks/sec)
Width of a track in pads N
Drift velocity in gas V:mm/sec
FADC sample rate : F s/sec
Multiplexer ratio M:1
Samples per readout : S

The number of pads in a track, PT, is given by

$$\frac{\text{Longest distance of travel in the gas x width of a track in pads}}{\text{Size of a pad side}} \qquad (1)$$

$$\Rightarrow \; PT = \frac{N \times Sqrt(\; L^2 \times (D/2)^2 \;)}{A} \quad \text{Pads} \qquad (1)$$

⇨

The number of pads readout per second, PR, = PT x RT pads/sec (2)

The average rate of readout per pad, RPP, is thus : $\frac{PR}{((L \times H \times D) / (A \times D))}$ (3)

If the data word is 16 bits, and a timestamp is 48, an id is 16, header = 4 words, and a block could be J words of data from the pad. The timestamp is taken at the discriminator point which is marked in the data, and a fixed number of samples is taken before and after.

The amount of data taken depends on the required smallest volume from the gas column. This is affected by the FADC sample rate, the multiplexer ratio, and the drift velocity.
Height of the volume in mm is V/(F/M) mm/sample (4)