Charge Dispersion Data Taking & Analysis

The charge dispersion test measurements were made with a modified GEM test cell. A 50 μm thick mylar film with the desired surface resistivity (2.5 M-Ohm/sq was glued to the readout pad PCB using a double-sided adhesive film of thickness 50 +- 5 μm. The GEM test cell geometry was otherwise unaltered. The modified test cell is shown schematically in Fig. 1.

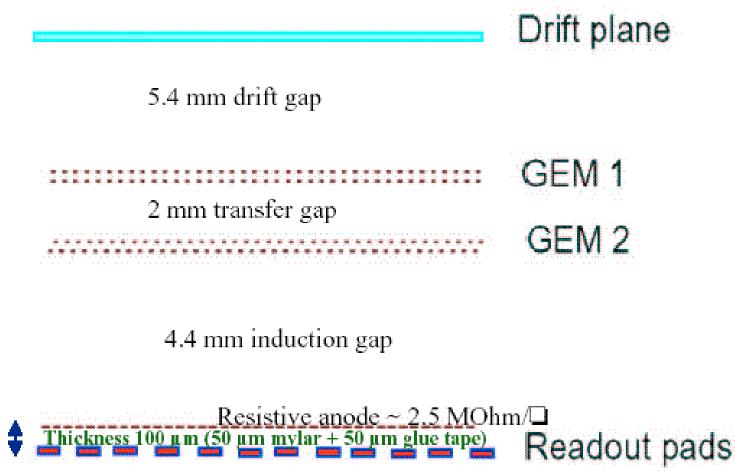

Fig 1

(Note at present, the foil resistivity is 1 M-Ohm/sq and the induction gap is 2.4 mm.)

Startup procedure

1) Get the gas flowing through the detector
2) Turn on the 2 Tektronix scopes to monitor detector signals.
   Scope 0, Channel 1 trigger (from NIM logic), +50 mV,
   Scope 1, Channel 4 trigger (from NIM logic), +50 mV
   Connect other scope channels as needed for monitoring or as needed for data collection
   The scope triggering can be enabled/disabled by using the switch in the NIM majority-logic coincidence box

3) Turn HV supplies on, and bring up voltages in steps to operating levels:
   V(GEM) = 3104 (2280) volts, V(DRIFT) = 3260 (2440) volts
4) Monitor GEM and drift HV supply currents as the voltages are being brought up
5) Watch the detector signals on the scope for possible electrical breakdown or discharge pulses as the voltages are brought up.
6) When the voltages are up, occasional cosmic ray signals should be seen ~1-2 per second
7) Get a trickle of water flowing through the copper tube around x-ray tube for cooling
8) Position the x-ray tube with the 50 μm collimator near the centre of the detector

9) Close the x-ray box. Ensure that the safety interlock screw is in place
10) Turn on the x-ray tube, HV = 6.6 kV, I ~ 0.9 amp
11) At this point, the x-ray signals should be seen

Low energy 4.5 keV x-rays (collimated to ~ 50 μm) from a copper x-ray tube interact with argon gas producing a localized charge cluster in the detector. After avalanche multiplication and diffusion in Ar/CO2 90/10, the charge cluster size at the resistive anode plane is about 500 μm. The GEM readout strips were 7 cm long and 1.5 mm. The front-end consisted of Aleph preamplifiers followed by a receiver amplifier. Amplified signals from 8 strips were digitized using Tektronix 500 MHz oscilloscopes. A computerized stage translation stage moved the x-ray spot in small steps across the 3 central strips. 1000 events were recorded on an event by event basis for each x-ray spot position.

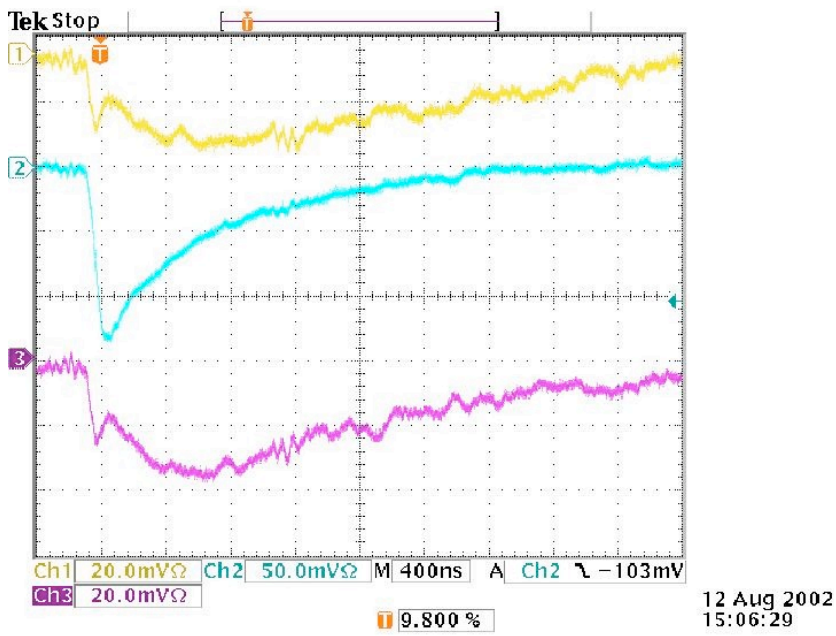

Fig 2

Fig. 2 shows a typical event with the x-ray spot in the centre of the middle strip. A prompt charge pulse is observed on the central strip. There is a delayed charge dispersion pulse on the adjacent strips. As well, a small prompt short duration charge pulse is observed on pads adjacent to the main charge-collecting pad induced by electron motion in the GEM induction gap. We have previously investigated localization accuracy of GEM induced pulses. For charge dispersion measurements described here, the induced pulse information is not used.

For a given anode surface resistivity and GEM geometry, the peaking time and the amplitude of the charge dispersion pulse depends only on the position of the primary charge cluster relative to the signal readout strip. We first determined the strip boundaries by equalizing signal on 2 adjacent strips. The strip width measured determined this way was consistent with readout pcb design.

For resolution tests, amplitudes of the early charge pulse and the delayed charge dispersion pulses were determined by fitting 4^{th} or 5^{th} order polynomials to the digitized pulse shape data in the expected time region.

Alignment & data taking

1) First, the x-ray tube is moved using computer controlled motors to position the x-ray beam spot in a known position with respect to the various detector readout strips/pads. Horizontally, this can be done as by equalizing the average scope signal on two consecutive strips being monitored on the scope. Vertically by finding the position where the strip signals disappear.
2) Now bring the x-ray spot to the desired location with respect to the detector for data taking
3) Record 1000 event runs for each position
4) The DAQ progam to collect the data and move the motorized stage runs on the Windows PC. To run the program, double click the desktop link – "DAQ with Motion"

Data screening

Data is screened for calibration and analysis to discard bad data. The event by event data was first screened using a fortran program (written by Alasdair) to discard noise and cosmic ray events (~20% of data). These are pulses that have much ringing, too large an amplitude etc. Criteria to discard this type of data were established by comparing the characteristics of obviously good x-ray events with that for undesired events.

Calibration & data analysis:

We use 500 events for calibration and the remaining 500 events for resolution studies.

We need to calculate (on an event by event basis) amplitudes of the main charge pulses and the delayed charge dispersion pulses. This is tricky since the main charge pulse peaks early and the charge dispersion pulse is smaller and peaks at a later time. Another complicating factor is that the late charge dispersion pulse is preceded by a small early induced pulse which should not be used.

The following procedure was therefore applied to the screened data sample to determine amplitude.

a) Form average pulse shape data sums from event by event data for each x-ray spot position.
b) Visually examine average pulses to make a table of channel ranges which will be used to determine amplitudes for main charge pulse, and delayed dispersion pulses taking care to exclude the prompt induction pulse.
c) Determine amplitudes from 4^{th} or 5^{th} order polynomials fits to the summed average data run within chosen channel ranges. From this point on, the

polynomial coefficients will be fixed to the fitted values for the run (fixed x-ray spot position) for the given strip.

d) Next do an event by event amplitude determination for strip signals in the calibration data sample. However, even for a 50 μm x-ray spot, because of finite range of conversion electron in the gas and transverse diffusion, the RMS position of an event can vary by up to a mm. So the peaking time for the individual events will be somewhat different from that for the average data. To account for this for each event, although we fix the polynomial coefficients as above, we allow the channel range of the fit to slide in time (both ways, within a reasonable bounds) until the chi-squared of the fit is acceptable. Also, the overall amplitude of the polynomials is allowed to vary (using a scale factor)
e) In the last analysis there were only 3 strips with measurable signals. Having found the peak amplitudes for the event, we compute a centre of gravity of strips signals.
f) Compute the mean value of centroid and its RMS error for the run from calculated event by event centroids of calibration data.
g) Plot the mean centroid against the known x-ray spot position from micrometer reading. This gives the bias correction curve for the calculated centroid.
h) For resolution studies, the centroid values for the remaining event by event data is determined as for the calibration data. However, each calculated event centroid is converted to “true position” by interpolating using bias correction function determined from the calibration data.
i) A Gaussian is fitted to the distribution of bias corrected values of centroids to determine resolution.