WIRE CHAMBERS FOR INELASTIC e-P SCATTERING

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(presented by D. Miller)

Any film-less spark chamber system is a delicate compromise between experimental objectives, technical feasibility, manpower, time and style. Many physicists feel that the detector should be a response to a particular experiment; in my view it must be suitable for a succession of experiments and should relate to more general considerations such as the accelerator.

An ordered list of our objectives would include:

1. to reduce the time between conception and publication of an experiment so that the work is topical

2. enough spatial resolution for 1% accuracy in momentum and angle with existing fields

3. a detector nearly transparent to neutral background, unless supplemented with converting material

4. full efficiency for several tracks or a shower

5. an output suitable for quantitative digital analysis

6. a repetition rate higher than the 60 cycle per second rate of our electron synchrotron

7. enough flexibility so that the physical arrangement of scintillators, spark detectors and absorbers can be altered in a few hours

8. enough on-line track identification so that we know the data can be successfully extracted from the background.

Figure 1 shows the electrode geometry. The plane cathode is aluminium 0.025 mm thick. The anode consists of 512 0.127 mm diameter copper wires which are 1.27 mm from each other and 6.34 mm from the cathode. The wires are first glued to a sheet of 0.025 mm mylar for ruggedness and ease of fabrication. Earlier etched versions proved less satisfactory because the wire diameter determines the strength of the pulsed electric field. Our spacer is glass and we blow through helium at one atmosphere.

Voltage pulses are developed with a triggered variable spark gap and delay line clipping. After 50 nsec we apply a 3 kV pulse of 50 nsec rise and 200 nsec duration. With a 150 volt clearing field, the sensitive time is 0.5 μsec.

Figure 2 shows that each anode wire threads through a ferrite core on its way to ground, as Krienen suggested. Before the event each of these charge discriminators is in the zero state. If a particular wire participates in the discharge initiated by the ionization, the corresponding core will switch to the one state. After the event these read and group read currents interrogate the cores in a regular order. Any core in the one state will switch back to the zero state and the accompanying flux change causes an induced output in the sense loop.

We want to be able to change detectors and still use the same core memory. So we have included a disconnect feature between the detector units and the core memory. One memory unit will accommodate four detector units. The memory unit as we receive it from the supplier costs half a Swiss franc per bit. It includes two lines for reading and half a sense loop. The completed memory unit requires 8 man-days. It has connectors which each receive a double-sided printed circuit board. Since the same spacing is maintained from anode to core, dip soldering is useful. Two half physicist-days and 600 Swiss francs yield one hodoscope unit.

Figure 3 is a block diagram of the core reader. Time runs down the slide from the top. When the core memory is full, the reader begins to interrogate cores, counting the wire number as it proceeds. The first read current interrogates 64 cores. The 64 induced outputs, after amplitude and time selection, are stored in the 64 flip-flops of a parallel to series converter. As these are shifted out the end of the converter, the ones are detected. When a one is found, the wire number is transferred to the computer memory and the beam of the hodoscope display is brightened.

Figure 4 shows the physical location of the elements of the system. The hodoscope display provides a projection looking along the anode wires. It is very useful for checking and on-line observation. In practice we raise the voltage applied to the chamber until minimum ionizing tracks look complete. Then on the average 1.5 cores per unit are written. The tracks are independent of voltage over 1.5 kV.

Several interesting observations emerge. Tracks which make a very wide angle with the normal are just as narrow as the normal tracks. This, of course, reflects the electric field distribution near the wires. We have studied the robbing problem by making the cathode of wires also. As you might expect, inductors in each cathode wire provide excellent isolation between discharges. As we went to larger hodoscopes robbing was no longer a problem, so we returned to the plane cathode. In this connection, delay line clipping at the spark gap is very useful for analysing the effects of hodoscope capacitance and inductance.

The reader interrogates cores at 3 Mc per sec and transmits wire locations to the computer memory at 200 kc per sec. So the reading dead time depends on the size of the hodoscope array. For 32 such units with 1/64 of the bits written, the detector must be inoperative for 1.5 msec.

Wire locations are transferred from the computer memory to magnetic tape at 5 kc per sec. The computer memory plays two roles. It buffers the magnetic tape transport from the random events. It also retains an ordered set of wire locations for on-line track identification.

This talk has been limited to features which are constructed and working. So far we have not tackled the serious ambiguity problem. Perhaps the most useful features are the short dead time and the physical flexibility of the detector. For example, I should note that information on wires will turn a corner without mirrors.

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<u>Figure captions</u>

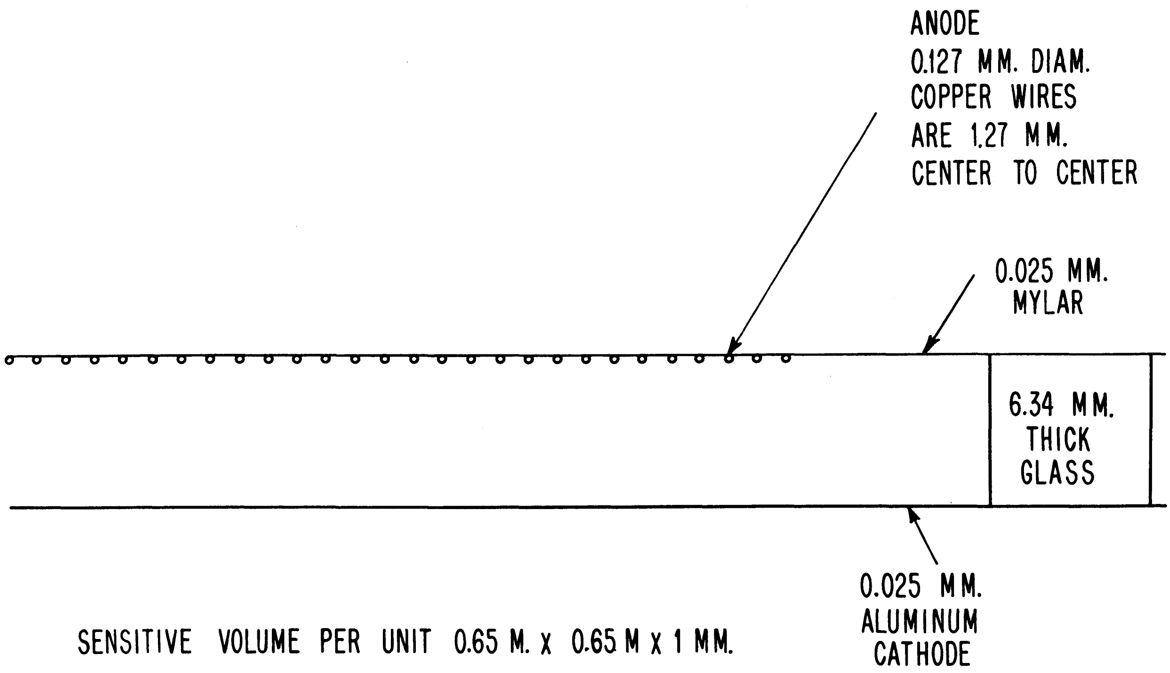

Fig. 1 ELECTRODE GEOMETRY

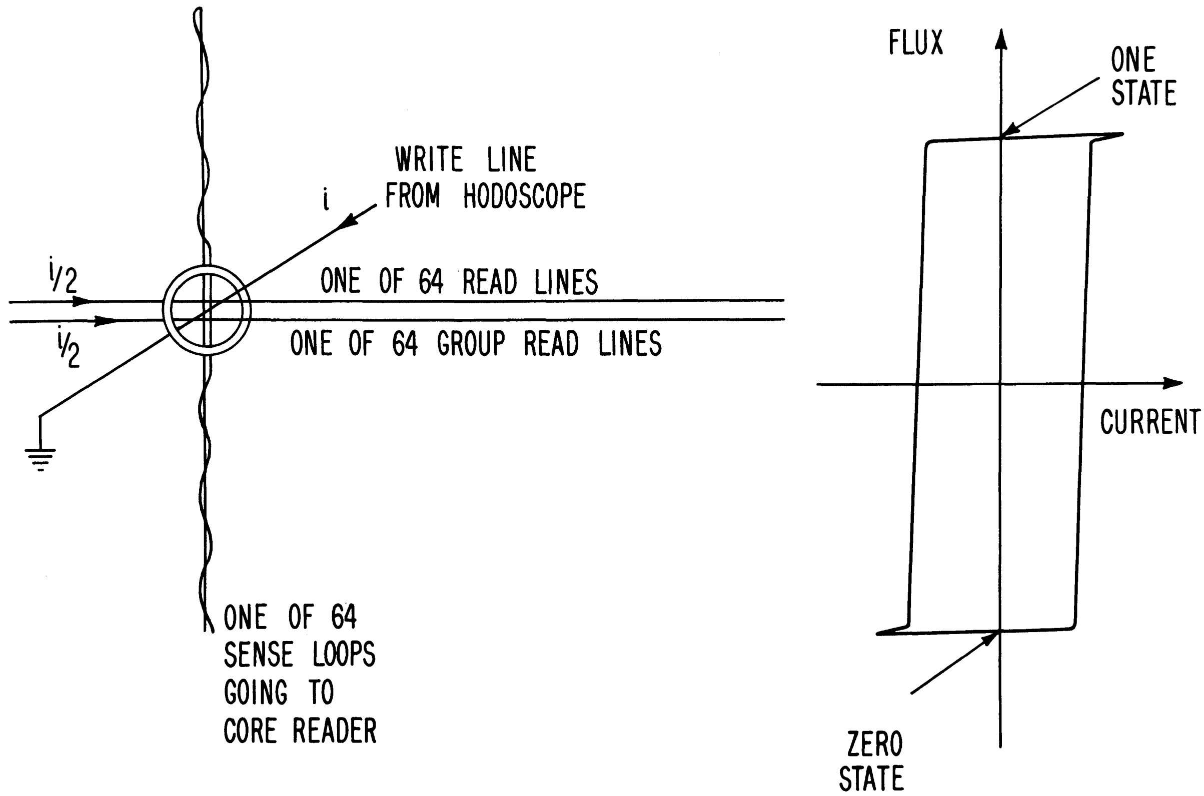

Fig. 2 THE MEMORY ELEMENT

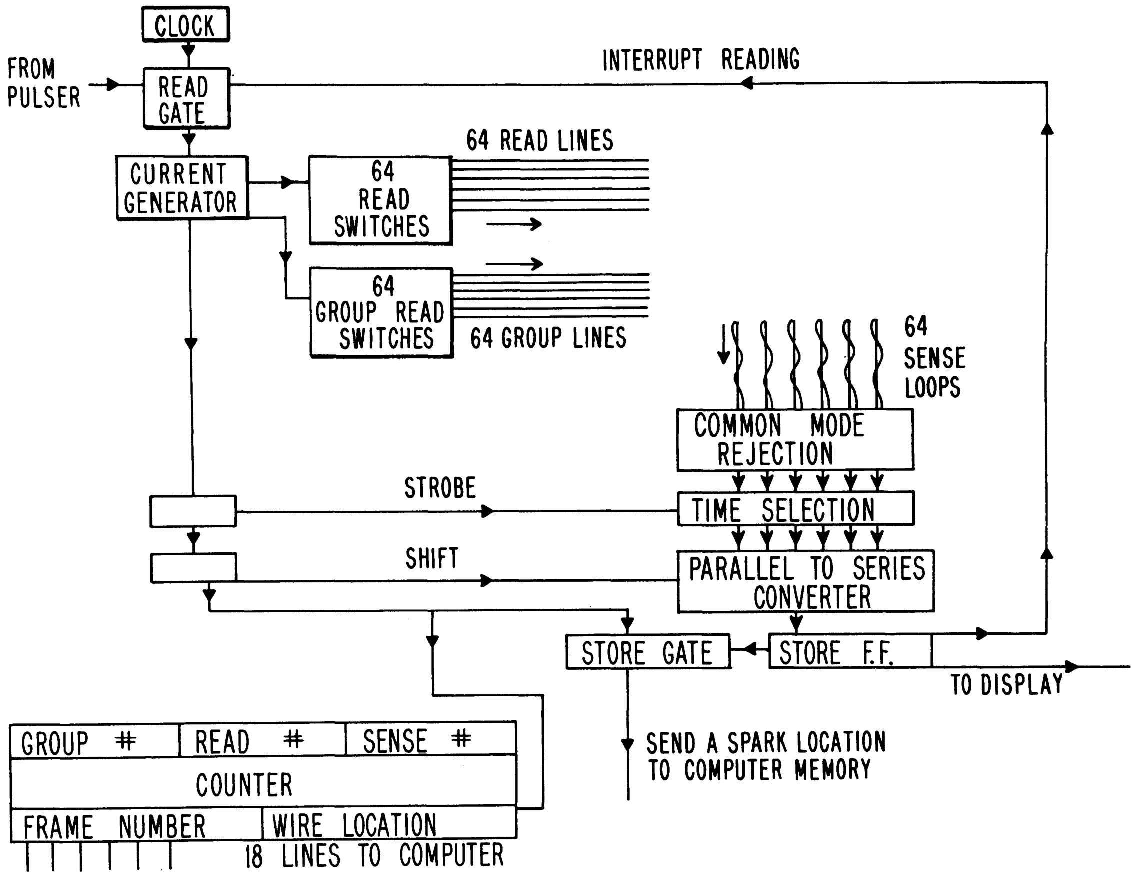

Fig. 3 CORE READER

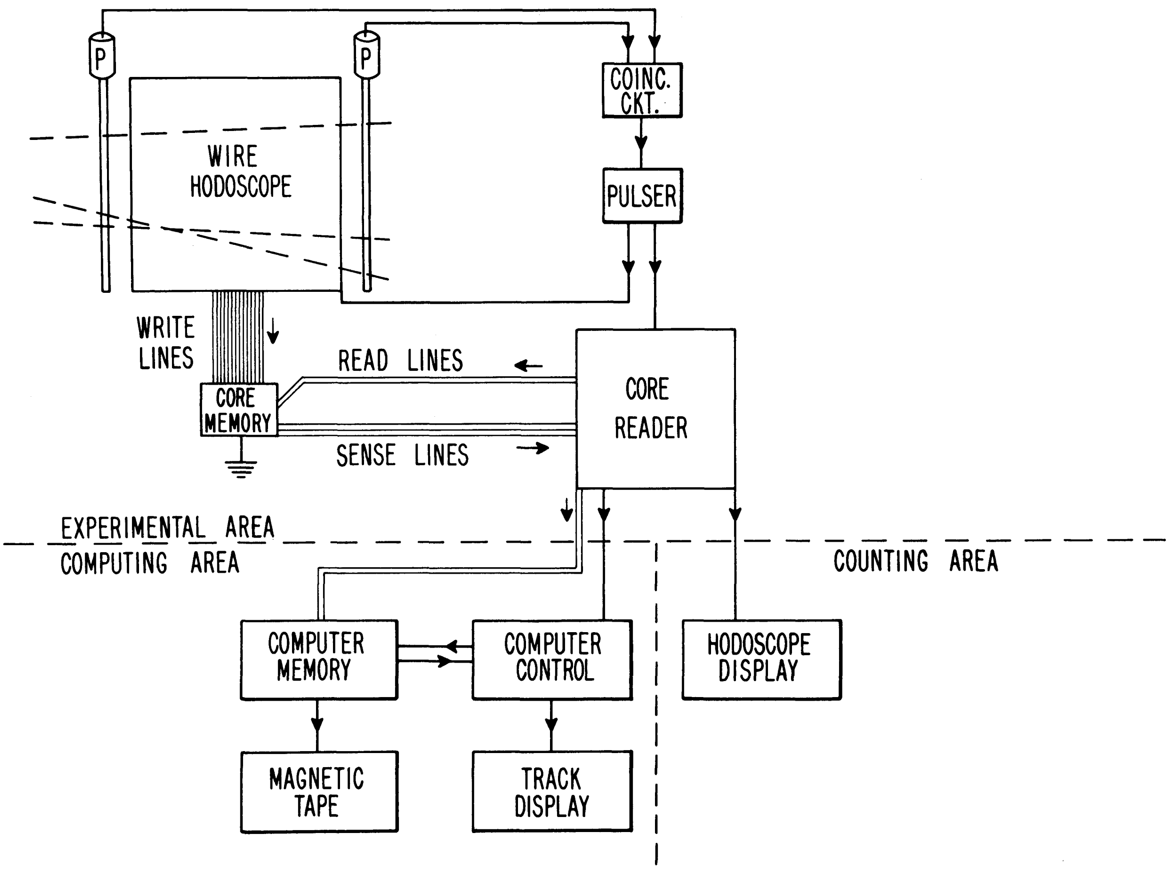

Fig. 4 SYSTEM BLOCKS

DISCUSSION

COLLINS: May I ask whether you have pulsed this large discharge plane ? We were worried that the increased capacity would cause a large number of cores to be flipped.

D. MILLER: Oh yes, we have had about 2 months experience with it now, but we were also worried about this. We tried to first mock up the situation by using our little chambers and adding some more capacitance because we thought that was all we would be adding when we went to the larger chambers. If you keep the duration of your applied voltage the same then what you realise is that just because the product of C and V is larger you are releasing more charge to the core and you get wider collections of wires in one gap. Our first solution to this was to shorten the duration of the voltage pulse applied to the chamber. This satisfied us at that point so we built our larger chamber with the increased lead inductance due to our disconnect feature. But with so much inductance the voltage pulse was too short so we lengthened the voltage pulse again to accommodate the extra inductance. (Incidentally, the delay line clipping at the pulse is very important in order to understand the effects of capacitance and inductance.) After making these changes we were able to get the desired width collections.

PIZER: Do you make the wire electrodes yourself or purchase them ?

D. MILLER: We purchased wires, 5 mils in diameter, in lengths of 15 feet which are pre-glued to mylar in groups of 192 wires across. We did not find this one on the market - we had to sort of cajole it out of them. We used these 192 wire units by splicing them together to make the 512 wire units that you can see.

ROBERTS: You mentioned something about seeing many simultaneous tracks in the chamber. Does this imply that you are using your chambers in triple arrays ?

D. MILLER: What we have done so far is to just use 'n' gap arrays where all the wires are pointing in the same direction. Although we have some ideas about the ambiguity problem which has been discussed earlier, at the moment we have no experience on this.

ROBERTS: In other words you are not really measuring the 3rd dimension at all ?

D. MILLER: That is correct. I see no problem, in principle, but we are not doing it and I have tried to talk about things which have been done.

ANDERSON: Could you describe how you stretch your wire planes on the frames ?

D. MILLER: Yes, we use a mechanical stretcher which stretches the mylar after the whole unit has been built to the correct area. Then we measure tensions before and after glueing to the glass frames. It is quite important that we have the mechanical strength of the glass and that we make these tension measurements. Once you understand what you want it is easy to reproduce it but it takes a little time to learn what you want.

ANDERSON: But do you only stretch in one direction ?

D. MILLER: No, we have 4 sides which can independently be backed off.

NEUMANN: What explains the surprisingly low field of 3 kV on $\frac{1}{4}$ inch ?

D. MILLER: The field is not determined by the separation between the anode and the cathode, but rather by the diameter of the anode wires and the spacing between them. The field distribution is such that under the conditions in which we operate about 5/6ths of the chamber is insensitive.

NEUMANN: If the sensitive area is confined to the region of concentrated fields, how long should the pulse be and what is the corresponding efficiency ?

D. MILLER: With this size chamber I think the answer is about 120 nsec. With the earlier chamber, having 1/9th of this area, the answer was about 18 nsec.

ROBERTS: Are you sure that you really are operating with 5/6ths of the chamber insensitive or is it merely that the ions that are formed there have to first be drawn into the so-called sensitive region before they start multiplying ?

D. MILLER: You are correct - I am not sure. The only observation that we have which we cannot explain any other way is the fact that we can get tracks which are at a very large angle in respect to the normal essentially the same as those which are along the normal. The explanation could quite possibly be wrong.

COLLINS: Why did you attach copper wires to the mylar and not aluminium ?

D. MILLER: Aluminium can be fabricated, but one of the things I learned early in this business is that when you are dealing with American industry and with products which they have not yet made but which you would like them to make - you try for just a certain amount at a time, and if you rock the boat too much you may end up making it yourself. There is no problem in principle.

COLLINS: You have no objection to aluminium ?

D. MILLER: No, it is entirely a question of glueing techniques and finding a firm that has those techniques.