DATARATES AND TRIGGERING
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ABSTRACT
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Some numbers and thoughts concerning the eventrates and
triggering for charm experiments in EHS have been col-
lected in this note.

1. EVENTRATES
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1.1 Constraints on eventrates
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The driftchambers impose a limit on the number of charged particles
per SPS spill. This is due to the space charge effect and the fact that
transverse dimensions of the beam are very small; 2x30 mm at the centre of
HOLEBC. With the present set up one empirically limits the flux to <5x10
beam particles per spill. With the introduction of a rotating collimator,
expected for spring '82, this can probably be increased. ISIS can handle the
present rate thanks to 'gain switching' in between BC sensitive periods.

For comparisons we choose charge beam intensities limited to
8x10 particles per spill.

Other constraints come from the vertex detector repetition rate and
sensitive times and the camera system repetition rate. For certain beams
the beam itself imposes rate limitations. Below we summarize the present
state of art.

<table>
<thead>
<tr>
<th>presently achievable range</th>
<th>our choice for comparisons</th>
</tr>
</thead>
<tbody>
<tr>
<td>driftchambers and ISIS</td>
<td>&lt; 4x10^4 /spill</td>
</tr>
<tr>
<td>BC sensitive time</td>
<td>&lt; 600 microsec</td>
</tr>
<tr>
<td>BC expansion rate</td>
<td>30 - 50 Hz</td>
</tr>
<tr>
<td>camera rate</td>
<td>10 - 20 Hz</td>
</tr>
<tr>
<td>SPS cycle</td>
<td></td>
</tr>
<tr>
<td>K enriched beam</td>
<td>&gt; 7% K</td>
</tr>
<tr>
<td>photon beam</td>
<td>&lt; 1 Mpart/spill (&gt;50 GeV)</td>
</tr>
</tbody>
</table>
These are realistic numbers for a run for instance in spring 1982. It is certainly possible to improve several of these numbers but one should not expect dramatic improvements in very the near future.

1.2 Event rates for different beams

With the numbers given above one can attempt to make a comparison of event rates for different beam particles. For this comparison we will assume that the usable length of $H$ in HOLEBC is $10 \text{ cm}$. In Table 1 we compare cross sections and event rates per beam for different beam particles.

<table>
<thead>
<tr>
<th>beam</th>
<th>Z(tot) [mb]</th>
<th>Z(trigg) [mb]</th>
<th>L(trigg) [cm]</th>
<th>#events/beam [$%$]</th>
</tr>
</thead>
<tbody>
<tr>
<td>$\pi^+$</td>
<td>25</td>
<td>15</td>
<td>1775</td>
<td>0.56</td>
</tr>
<tr>
<td>$K^-$</td>
<td>20</td>
<td>10</td>
<td>2664</td>
<td>$2.7 \times 10^{-2}$</td>
</tr>
<tr>
<td>$p$ or $\bar{p}$</td>
<td>40</td>
<td>30</td>
<td>888</td>
<td>1.13</td>
</tr>
<tr>
<td>photon</td>
<td>0.1</td>
<td>$2.7 \times 10^5$</td>
<td>$3.8 \times 10^{-3}$</td>
<td></td>
</tr>
</tbody>
</table>

a) $Z(\text{trigg}) = Z(\text{tot}) - (Z(e1) + Z(2p) + \ldots) - 10 \text{ mb}$

b) this includes the fact that $K^+$ is only 7% of the beam

From these numbers one can obtain average number of events per SPS spill. In doing this one has to correct, downwards, for camera dead times and for the chance of having more than one interactions per expansion. In case of a small hydrogen BC, like HOLEBC or LEBC, the beam windows contribute background events at about the same rate as the hydrogen inside the fiducial volume. The presence of the background events will increase these corrections if the trigger cannot distinguish between events inside and outside the fiducial volume. In fact an 'electronic fiducial volume trigger' (EFVT), designed to do just that, will be described later.

In table 2 we compare cross section sensitivities we give two numbers in most cases; one without fiducial volume trigger and one were we assume that the EFVT will veto 70% of the background events. Moreover in
order to get some realistic estimates for an experiment we assume 50% overall efficiency in the datataking. This is meant to cover intermittent break downs of SPS and major spectrometer components which empirically always occur at about this rate.

<table>
<thead>
<tr>
<th>beam</th>
<th>&lt;#event&gt;/spill</th>
<th>&lt;#ev/micb&gt;/10days</th>
<th>&lt;#pix&gt;/10days</th>
<th>&lt;#charmey&gt;/10days</th>
<th>produced EFVT</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>no FVT</td>
<td>EFVT</td>
<td>no FVT</td>
<td>EFVT</td>
<td>no FVT</td>
</tr>
<tr>
<td>pi-</td>
<td>10.4</td>
<td>8.2</td>
<td>12.5</td>
<td>15</td>
<td>374k</td>
</tr>
<tr>
<td>K⁺</td>
<td>0.86</td>
<td>0.56</td>
<td>1.5</td>
<td>1.5</td>
<td>31k</td>
</tr>
<tr>
<td>p or p⁻</td>
<td>14.8</td>
<td>12.1</td>
<td>8.9</td>
<td>11.1</td>
<td>533k</td>
</tr>
<tr>
<td>photon</td>
<td>1.5</td>
<td>0.98</td>
<td>270</td>
<td>270</td>
<td>108k</td>
</tr>
</tbody>
</table>

a) EFVT is assumed to veto 70% of events in BC windows
b) Z(charm) = 25micb for hadrons, 1micb for photon beam is assumed

In Table 2 we also give an estimate of the number of charm events produced in the different cases based on very crude assumptions for the corresponding production cross sections.

As can be seen from the numbers in Table 2 the fiducial volume trigger will increase the sensitivity of the experiment by ~20% and ~25% for pion or proton beam respectively. In addition one has to use 50% more film to arrive at a given sensitivity if one has no EFVT.

Concerning the number of produced charm events, pion, proton or photon beams seem to give about the same yield per unit of running time. The relative differences are certainly within the errors of our cross section estimates. For the case of a K⁺ beam the charm yield is however down by about an order of magnitude due to the nature of the beam. The only way to overcome this would be to increase the beam intensity by a corresponding amount. This in turn would imply a similar improvement of the rate capability in the BC (holography) and in the spectrometer (cure spacecharge effects in the beam region).

For the case of photon beam we have assumed that the amount of accom-
panying electron background from pairs and comptons is compatible with the charge particle rate capabilities at the assumed beam intensity. This can probably be verified only empirically. In addition this experiment will most probably require holographic read out of the BC in order to cope with the geometrical beam profile.

2. TRIGGERING
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2.1 Trigger Structure

The trigger has several functions which can be summarized as follows

i) strobing or gating all spectrometer components including the flash and kicker magnet;

ii) selecting different event types e.g.

- beam through
- wide beam for survey
- interactions

iii) selecting physically interesting events if possible

Based on timing properties the trigger is usually organized in trigger levels. In general one tries to put any given condition at the lowest possible level in order to save unnecessary dead times. The present EHS trigger is organized in the following way:

<table>
<thead>
<tr>
<th>level</th>
<th>purpose</th>
<th>implementation</th>
<th>timing</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>to give fast strobos to trigger detectors</td>
<td>coincidence between beam scintillators</td>
<td>&lt;~ 70 ns</td>
</tr>
<tr>
<td>1</td>
<td>interaction trigger or beam through to strobe spectrometer detectors (WC's, DC's...)</td>
<td>scintillators (NA23) MWPC's + SSD's (NA26)</td>
<td>&lt;~ 200 ns</td>
</tr>
<tr>
<td>2</td>
<td>refined interaction trigger e.g. tagging</td>
<td>CEDAR's and fast clears</td>
<td>&lt;~ 700 ns</td>
</tr>
<tr>
<td>3</td>
<td>veto BC picture and spectrometer read out for background events</td>
<td>OFVT (RCBC) EFVT (HOLEBC)</td>
<td>~ 10 mysec ~ 300 mysec</td>
</tr>
</tbody>
</table>

2.2 An Example
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As an illustration we can take the NA26 trigger. Fig 1 shows a sketch of the layout and some characteristics of the different detectors used.
The 0-level trigger is formed by the following coincidence condition for the beam scintillators:

\[ \text{beam strobe} = T_1 \times T_2 \times T_3 \times T_4 \times \frac{V_1 + V_2}{V} \]

which ensures a beam particle without companions and in the focal plane of the cameras. Figs 2-3 show the beam profiles and cluster sizes obtained in SSD1, W0 and W1 for this trigger.

The 1-level trigger selects a multiplicity of one in SSD1 and a range of multiplicities in W0 and W1. Fig 4 shows the logic layout for this trigger. Fig 5-6 show results from this trigger obtained from a testrun in Nov 1981. With the multiplicity requirement \( >2 \) in both W0 and W1 we measured an interaction rate of 2.7\%, with chamber (HOLEBC) full and 1.3\%, with chamber empty in a proton beam (200GeV). This gives an interaction rate of 1.4\% which is in excellent agreement with Table 1 considering that the total length is 12cm in HOLEBC.

The 3-level trigger is an 'electronic fiducial volume' trigger, EFVT. The principle of the trigger is illustrated in Fig 7. The idea is to look up extreme hits in W0, predict the corresponding hit regions in W1 assuming the interaction to be placed in either of the beam windows. When predictions match real hits in W1 the event is considered to be a window event and vetoed. Simulations indicate about 70\% veto efficiency and about 5\% loss of useful events. Some data were taken in the testrun mentioned above but the off-line analysis is not yet advanced enough to be compared with the simulation results.

There is also within NA26 active work going on on a charm trigger. The trigger is based on a set of small high precision high pressure drift chambers modules placed very close to HOLEBC. This trigger however is not foreseen in the on-line logic but rather as an off-line trigger to select frames for scanning. For details we refer to the NA26 proposal and internal reports (Zumerle...).

2.3 Physics Trigger

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Charm events occur in \( \ll 1/1000 \) of all reactions for hadronic beams.
For EHS (NA16 and NA27) the physics trigger so far is 'the scanning of events in the BC-picture'. This trigger has the great and often underestimated advantage of being a 'minimum bias' trigger. However, if high statistics (few x 10^3) is sought this trigger soon becomes unmanagable.

An on-line trigger can be added in the trigger system at the latest in the 3-level i.e. it has to be faster than 5-10 mysec otherwise it has to be off-line.

In a sense a photon beam experiment is a solution since the relative charm event rate over is better by about an order of magnitude when compared to hadronic beams. However, as can be seen in Table 3 the yield per unit of running time is similar the one obtained in the present hadronic beam experiments.

With a hadronic beam one could easily increase the beam intensity and hence the yield if a selective on-line trigger could be found. This of course implies holographic BC recording and fixes in the spectrometer in order to cope with these higher rates.

3. CONCLUSIONS

For a 'minimum bias' triggered charm experiment with pion or proton beams in EHS and with a small BC (e.g. HOLEBC) the data rates and analysing power seem to be well matched. Such experiments (NA16,NA27) will produce samples of a few hundred reconstructed events.

An electronic fiducial volume trigger for this case is being developed. In addition a candidate for an off-line trigger for charm based on high precision drift chambers is being pursued.

For the next step, i.e. a few thousand charm events and some with beauty, one has to do either or, hopefully, both of two things:

i) increase the running time by an order of magnitude and use a high energy photon beam together with holographic BC read out.

ii) Find an on-line charm trigger for the use with a high intensity hadron beam and holographic BC read out.
NA 26 TRIGGER

Detectors:

<table>
<thead>
<tr>
<th></th>
<th>Pitch</th>
<th>Yxz [cm²]</th>
</tr>
</thead>
<tbody>
<tr>
<td>SSD1</td>
<td>0.2 mm</td>
<td>100 strips along y-axis 3 x 2</td>
</tr>
<tr>
<td>W0</td>
<td>0.5 mm</td>
<td>160 wires 8 x 8</td>
</tr>
<tr>
<td>W1</td>
<td>1 mm</td>
<td>320 wires 32 x 32</td>
</tr>
<tr>
<td>T3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>T4</td>
<td>Scintillators</td>
<td></td>
</tr>
<tr>
<td>T1/T2</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

0-level trigger:

Beam strobe = T1 · T2 · T3 · T4 · (V1+V2)

Fig. 1 Layout of NA26 trigger
Fig. 2 Wiremaps for beam trigger. a) SSD1, b) W0, c) W1.
Fig. 3 Clusters sizes for beam trigger. a) SSD1, b) W0, c) W1.
Fig. 4 Logic of the interaction trigger

\[
y = X_2 \cdot X_3 \cdot X_4 \cdot X_6
\]

Fig. 5 Number of wires hit for interaction trigger events i.e. discr. level set to 100 mV.

a) W0, b) W1.
Fig. 6 Wiremaps for interaction trigger events. a) W0, b) W1.

Fig. 7 Principles of the 'electronic fiducial volume trigger', EFVT.