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# EHS BEAM HEIGHT

## 1. GENERAL REMARKS

(a) The axis of the EHS vertex magnet is horizontal. This orientation has been imposed by cryogenic considerations related to the bubble chamber but may also prove to be of interest for other experiments at the SPS since it could be used (for instance with a polarized target) with the magnetic field axis parallel to the beam (a rotation of $90^{o}$ around a vertical axis is possible). However, this orientation means that the deflection of the secondary charged particles is in the vertical plane. The detection efficiency of secondary particles for EHS is therefore closely related to the beam height.

(b) EHS is a general facility. Various incident beam particles and beam energies will be used: negative, positive, neutral,with energies as low as 50 GeV and going up to the highest available.
The general conception of EHS is to preserve as much flexibility as possible to allow the evolution which will be necessary in the study of strong interactions at the SPS. Provision for additional downstream detectors and triggers must be made.

(c) It is very difficult, at SPS energies, to separate target fragmentation, central production and projectile fragmentation. This is why EHS is designed in such a way that the events can be reconstructed as completely as possible. However, it will never be possible to have complete information on the target fragmentation products for all events (backward production of $\pi^{o}$'s in the CMS). Fortunately, it is possible to avoid this difficulty in the study of proton-proton interactions. It is then sufficient, but necessary, to reconstruct completely all the secondary products emitted in the forward hemisphere. In fact, it is very likely that one of the major contributions of EHS to strong interactions will be in providing complete information (including $\pi^0$'s) on the forward hemisphere of pp interactions, allowing one to fill in the gap in energies between the PS and the ISR, thus completing in an essential way the experiments which are being performed at ISR. These considerations are particularly important when discussing the performance of an IGD.

(d) The detection and identification of the charged particles produced in the central region are of major importance for EHS physics. In particular, the identification of baryon-antibaryon and strange particle pairs in the 3-20 GeV/c momentum range should receive special attention.

Since the pairs of baryons and strange particles which are easily identified with EHS are $\bar{p}p$ and $K^+K^-$ and with the bending plane being vertical, one of the elements of the pairs will always be bent towards the floor. It is therefore not sufficient to get a good efficiency above the beam plane for the Cerenkov Co and ISIS.

## 2. DRIFT CHAMBERS

The influence of the beam height on the drift chamber acceptance has been studied by D. Toet (RCBC 76-20). The configuration adopted for this study is that given in the proposal (SPSC P42 Add.2).

The bubble chamber emittance (± 35° and ± 18° in the bending and dip planes respectively) are slightly larger than those quoted in the specifications under discussion for the stainless steel bubble chamber but they match the vertex magnet emittance and take into account that a new body with this emittance may be built in the future (using aluminium or titanium alloy).

In D. Toet's study, a track is defined to be reconstructible if

(a) its momentum is smaller than 2 GeV/c (BC measurements);
(b) its momentum is larger than 2 GeV/c and 3 drift chambers are hit.

These criteria may look rather pessimistic since the bubble chamber itself could guarantee a precision of $\Delta p/p < 1\%$ for 4 GeV/c tracks with a length of 45 cm and even up to 10 GeV/c if their lengths reach 70 cm. However, the precision on the momentum is not the only consideration to take into account. The data treatment of EHS, to be efficient, must rely on the downstream spectrometer measurements for the majority of the secondary particles. It is only with this possibility that the rate of good measurements can reach high values (80, 90%) and high speed. Under these conditions, the redundancy assumed in D. Toet's criteria is reasonable. It leads to a reduction of acceptance which is linearly related to the beam height: $\Delta a/a \sim \Delta h/h$ for secondary particles in the 3-7 GeV/c momentum range with a small transverse momentum for $D_2$ and $D_3$ Since the gain in precision over the bubble chamber alone is substantial for 7 GeV/c tracks, and because of the increased redundancy, there is every advantage in making $D_2$ as large as possible. As seen below, the need for $D_2$ to detect all the particles which go through ISIS leads to a beam height of 2.51 m. This assumes the use of wires of varying length, so that the full height of the drift chamber frame can be used apart from $\sim$ 1 cm lost due to edge effects. A constant 35 cm is estimated to be necessary for the supporting frame beneath the sensitive region. To maintain a sensitive region of 2 m below the beam for ISIS, and placing $D_2$ at 80 cm from the end of the ISIS sensitive volume, the useful height of $D_2$ below the beam level should be 216 cm, leading to a total beam height of 251 cm.

A similar problem concerns $D_1$ and Co since it is important to detect particles which traverse Co without interacting. For the present dimensions of Co, a drift chamber extending to ± 250 cm would be desirable. However, since the density of particles toward the outer edge of Co is rather low, an adequate solution could probably be found using scintillators to cover the last 50 cm and keeping to the ± 200 cm sensitive region for $D_1$. If Co is replaced by silica aerogel Cerenkov counters, it is likely that $D_1$ with the originally planned sensitive region (± 200 cm) will be enough.

To summarize ,a beam height of 236 cm would be necessary to guarantee the precision and the efficiency put forward in the proposal. In addition, the full exploitation of ISIS would need a beam height of 251 cm, at least for $D_2$.

## 3. GAMMA DETECTION

As mentioned in the introduction, the detection of $\pi^o$'s produced in the central region will be one of the major tasks of EHS. This will be the role of an Intermediate Gamma Detector (IGD) placed in front of the magnet spectrometer, at 13 m from the bubble chamber.

The following table gives some of the important parameters to be considered.

| $E_{incident}$ | $\gamma$ | $p_{\pi^o}^{+}$ ($p_t$ = 0.35 GeV/c) | Radius $\pi^o$ trajectory at 13 metres | Radius at 13 m of the $\gamma$ trajectories (relative to the $\pi^o$) |
|---|---|---|---|---|
| 100 GeV | 7.1 | 2.5 GeV/c | 1.8 m | 0.73 m |
| 200 " | 10.0 | 3.5 " | 1.3 " | 0.52 " |
| 400 " | 14.3 | 5.0 " | 0.9 " | 0.36 " |

+ For zero longitudinal momentum in the CMS.

It is difficult to make ISIS deeper than 200 cm in the horizontal plane. Thus the extension of $\gamma$ detection to radii greater than 1 m has to be done in the vertical direction. To be able to read out the data from such an IGD also needs space. If the Conversi detectors were adopted, the readout would need ~ 70 cm below the sensitive region. Limiting ourselves to incident energies above 200 GeV/c a beam height of 2.52 m would therefore be necessary (1.3 + 0.52 + 0.70).

Other techniques may require less space for the readout. They are however far more expensive.

4. ISIS

A useful drift distance of 2 m corresponds, for ISIS, to a beam floor distance of 2.35 m. (The plane at - 2 m is at - 200 kV. Insulation from the ground is essential).

For particles above 7 GeV/c, a reduction of beam height up to 30 cm on the 2.35 m value would not significantly affect the performance of ISIS since 90% of these particles would traverse the full length of ISIS anyway. However, this would not be the case for particles between 3 and 7 GeV/c, which would mainly leave ISIS through the base. For a particle which leaves ISIS after traversing about one half of its length, a reduction of 30 cm in beam height would correspond to a loss in track length of ~ 110 cm, i.e. 35%. The loss in statistical accuracy is therefore very serious. At 5 GeV/c, some 50% of the particles of a given sign are likely to be affected by this reduction in length *).

To guarantee good particle identification in the central region with ISIS, a beam height of 2.35 m is necessary. Even though it is only the particles of a given sign which are affected, EHS will have to identify pairs of particles of opposite sign.

5. Co

As originally drawn Co required a beam height $\gtrsim$ 2.33 m. At these momenta tracks of the two charges are completely separated, so a reduction of beam height only concerns one of the two tanks. However, the cylindrical form of the tank has to be preserved for reasons of strength (interior pressure ~ 3 atmospheres) so for a beam height of 2.06 m one assumes that the tank diameter is reduced by 27 cm from the original 160 cm.

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*) The situation is particularly delicate for K/p separation where the calculated length of track needed for 90% confidence does not fall below 3 m until p > 6 GeV/c.

This would lead to the loss of ~ 9 % of the particles in the range 1.8 to 5.6 GeV/c for the sign of charge selected. However, it must be emphasized that the effect varies substantially within this momentum range with the low momentum particles very much more affected than the others*). Similarly higher $p_T$ particles such as Ks would be more than proportionally affected.

## 6. CHAMBER AND MAGNETS

### (a) RCBC

A beam height larger than 2.06 m would considerably facilitate installation and operation of the chamber. In particular, it would allow the provision of shock absorbers below the magnet pole pieces. Such devices would decouple (and consequently all experimental equipment around RCBC) from the vibrations caused by the bubble chamber expansions. Increased beam height would also be of great advantage with respect to hydrogen safety requirements for the installation, since it would allow a ventilation duct of such a size between the bubble chamber and hydrogen control hut that all hydrogen carrying pipework could be housed conveniently and safely in it (which at 2.06 m is hardly possible).

### (b) Magnet M1

This superconducting magnet is actually being designed for a beam height of 2.06 m, in order to permit future use in other experiments. In connection with RCBC, however, the magnet will form one solid block with the bubble chamber, sitting on a common vibration damping system and requiring therefore the same beam height.

### (c) Magnet M2

Although it would be possible to use M2 at 2.06 m beam height, a larger value would be more convenient for increasing the clearance. A minimum height of 2.40 instead of 2.06 m would be much appreciated.

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*) D. Toet's calculations show that for $D_1$ a change of 25 cm on both ends of the chamber cuts the acceptance by ~ 12 % at 2 GeV/c.

## 7. CONCLUSION

In the table one summarises the requirements of the various detectors so far as they are known at the present time. On the grounds that one wishes to obtain:

- the maximum of data from ISIS,
- the maximum acceptance from $D_2$ both for processing ISIS data and for improving momentum measurement in the ~ 3-7 GeV/c range,
- sufficient clearance to build a large IGD with optical readout if that technique proves to be as suitable and as inexpensive as it now appears to be,
- sufficient height for Co as currently designed.

it is concluded that a beam height 2.5 m would be a satisfactory choice.

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## Table of preferred values

| | | |
|---|---|---|
| IGD | 2.50 | |
| ISIS | 2.35 | |
| Co | 2.33 | |
| $D_1$ - $D_3$ (essentially $D_2$) | 2.51 | (for momentum measurement) |
| $D_2$ for ISIS | 2.51 | (with ± 216 cm sensitive zone) |
| $D_1$ for Co | 2.85 | (for ± 250 cm sensitive zone) |
| | (2.51 | would be more reasonable to match $D_2$). |
| Chamber and magnet (M1) | - 2.06 | possible ~ 2.4 - 2.5 preferred |
| M2 | - 2.06 | possible but additional height desirable since clearance is small. 2.4 - 2.5 would be satisfactory. |
| $D_4$ - $D_6$ | - | no limitation |
| FGD | - | no limitation |
| Silica aerogel counter | - | if adopted, angular coverage would be less than Co so there would be no need to meet the requirements listed above for Co and $D_1$. |
| MWPC | - | no limitation |
| $C_1$ - $C_5$ | | in the place of ISIS - no limitations (the light is brought out sideways). |

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