GEM TN-92-227
IBPD-SSC-92-003

Monte Carlo Simulation of Timing Resolution of CSC's in the GEM Muon Barrel

Kwong Lau
University of Houston

November 3, 1992

Abstract:

The timing resolution of cathode strip chambers (CSC's) in the GEM muon barrel is studied by monte carlo simulation for two designs, one with 4 layers of 0.5 cm x 0.5 cm cells and another with 8 layers of 1.0 cm x 1.0 cm cells. It is found that for both designs, less than 2% of the tracks have a drift distance over 1.6 mm, which corresponds to a drift time of less than 16 ns for a gas of drift speed in excess of 100 mm / μs near the anode wire. These results are obtained for specific staggering schemes and averaged over the entire barrel angular region. The staggering scheme has not yet been optimized.

GEM TN-92-227
IBPD-SSC-92-003
November 3, 1992

Monte Carlo Simulation of Timing Resolution of CSC's in the GEM Muon Barrel

Kwong Lau

Physics Department
and
Institute for Beam Particle Dynamics

University of Houston
Houston, Texas 77204-5506

Abstract

The timing resolution of cathode strip chambers (CSC's) in the GEM muon barrel is studied by monte carlo simulation for two designs, one with 4 layers of 0.5 cm x 0.5 cm cells and another with 8 layers of 1.0 cm x 1.0 cm cells. It is found that for both designs, less than 2% of the tracks have a drift distance over 1.6 mm, which corresponds to a drift time of less than 16 ns for a gas of drift speed in excess of 100 mm/μs near the anode wire. These results are obtained for specific staggering schemes and averaged over the entire barrel angular region. The staggering scheme has not yet been optimized.

1. Introduction

One of the desirable features of a muon chamber technology in GEM is the ability to provide trigger signals with a timing precision of one bunch-crossing at the SSC (16 ns).[1] It is essential that the fraction of events whose timing exceeds 16 ns, which will result in wrong bunch tagging, be kept as small as possible. A few per cent is the nominal requirement. While the maximum drift time for the proposed CSC chambers generally exceeds 16 ns, the strategy proposed by CSC advocates is to use the earliest arrival time of wire signals in the N (N = 4 or 8) layers of chambers in a superlayer. This signal is expected to have a spread $\simeq$ maximum drift time/$\sqrt{N}$, which generally satisfies the timing requirement. But the conern is the tail of the distribution. The input needed to perform a calculation is the drift speed of electrons in the gas mixture at electric fields near the anode wires. Recent measurements showed that some CF4 mixitures (e.g. 50/50 CO2 CF4) have drift speeds of about 100 mm/μs for electric fields above 6 kV/cm.[2,3] The timing requirement translates to a drift distance of less than 1.6 mm if these fast gas mixtures are used. The timing of CSC in the endcaps has been studied and was found to meet the requirement.[3] In this note, monte carlo studies of the timing resolution of CSC technology in the barrel are described.

2. Baseline Designs

Two baseline designs are considered. These designs are selected for open profile chambers for which larger cell sizes are more appropriate. The first design (Design 1) assumes 0.5 cm x 0.5 cm cells and 4 chamber layers for each superlayer. The separation of the chambers (Hexcel thickness) is 0.5 cm. An equivalent design (in terms of the total number of electronic channels) is to have eight layers of 1.0 cm x 1.0 cm cells (Design 2). The same Hexcel thickness (0.5 cm) is assumed in Design 2.

3. The Calculations

The staggering schemes for the calculations are shown in Figure 1 for Design 1 and Figure 2 for Design 2. In Design 1, the cells in the three other layers are staggered by 1/2, +1/4, and -1/4 of the cell size, relative to the first layer, respectively. In Design 2, the cells of the other seven layers are staggered by -1/8, +3/8, -3/8, -1/4, +1/2 , +1/4, and +1/8 of the cell size, respectively. These staggering schemes are chosen to maximize the coverage for normal incidence muons at a polar angle of 90°. No attempt has been made to optimize the drift times in other angular regions. Tracks are generated to originate from the interaction point (IP) in the angular range ϑ from 0 to 60° in steps of 2°, where ϑ is measured from the normal (ϑ = 90° - θ, where θ is the polar angle). 10,000 tracks

are generated for each angular bin. The precision of the calculation is not limited by statistics. The shortest drift distance (d_{min}) from a track to the cells traversed by the track is calculated. d_{min} is defined as the perpendicular distance between the track and the nearest anode wire. To take into account the effect of scattering and magnetic bending, the incident angle of each track is smeared isotropically by $\pm$ 5°. The results are found to be insensitive to this choice for the smearing angle unless the smearing angle is less than 2°.

4. Results

The d_{min} distribution for Design 1, averaged over the entire barrel region, is shown in figure 3. It is evident that most of the events have drift distances below 1.0 mm, with practically no event with d_{min} over 2.0 mm. The fraction of events with a d_{min} over 1.6 mm is about 1.2 %. The d_{min} distribution for Design 2 is shown in figure 4. Again, a cut-off of 2.5 mm is apparent. When averaged over the entire barrel region, 98% of the events have a d_{min} less than 1.6 mm.

5. Conclusions and Discussions

The timing resolution of CSC's in the barrel has been studied for two different designs, both suitable for open profile type construction. Both designs are found to be capable of generating trigger signals with a resolution of 1 bunch crossing over 98% of the time, if a fast gas is used. The timing performance of a superlayer consisting of eight layers of 1 cm cells is comparable to that of a superlayer composed of four layers of 0.5 cm cells, even though the latter design has better timing resolution in general. While the total number of electronic channels is the same for both designs, considerations based on pattern recognition and arrival time of the second signal may favor a design with more chamber layers. These issues will be addressed elsewhere.

References

1. F. Taylor's memo
2. H. Ogren, Proceedings of Symposium on Detector R&D for the SSC, 1990.
3. GEM TN-92-199

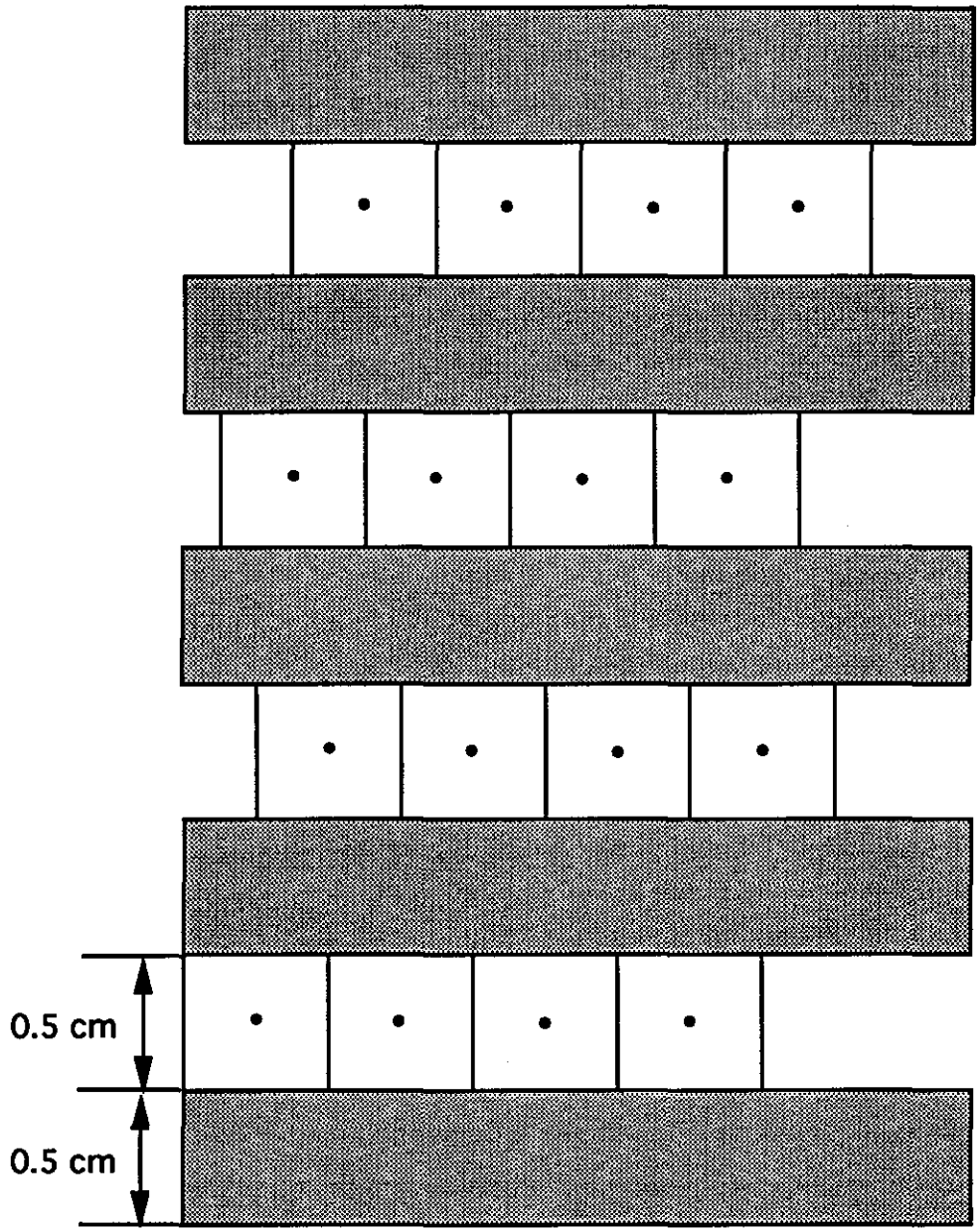


Figure 1. Design 1 (4 layers of 0.5 cm cells)

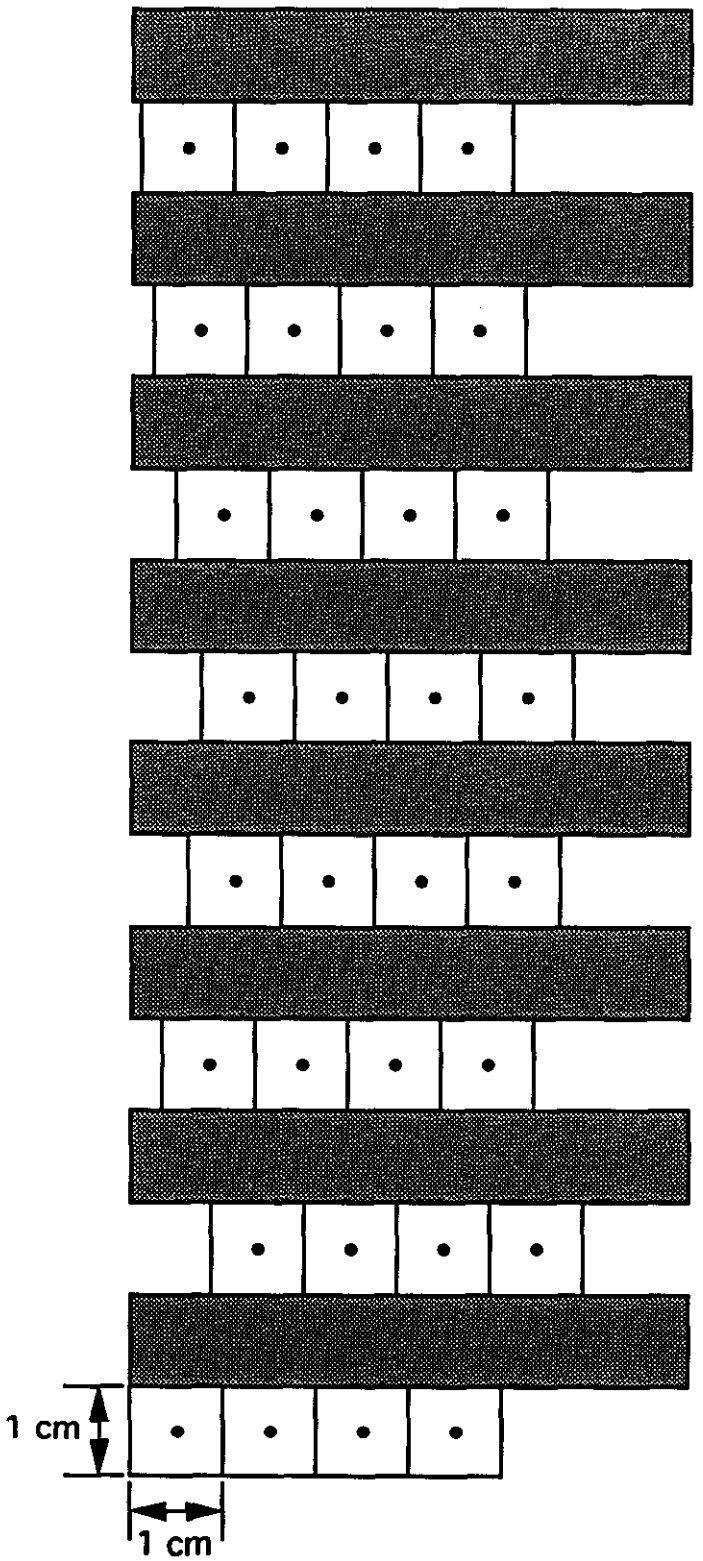


Fig. 2 Design 2 (8 layers of 1 cm cells)

Figure 3.

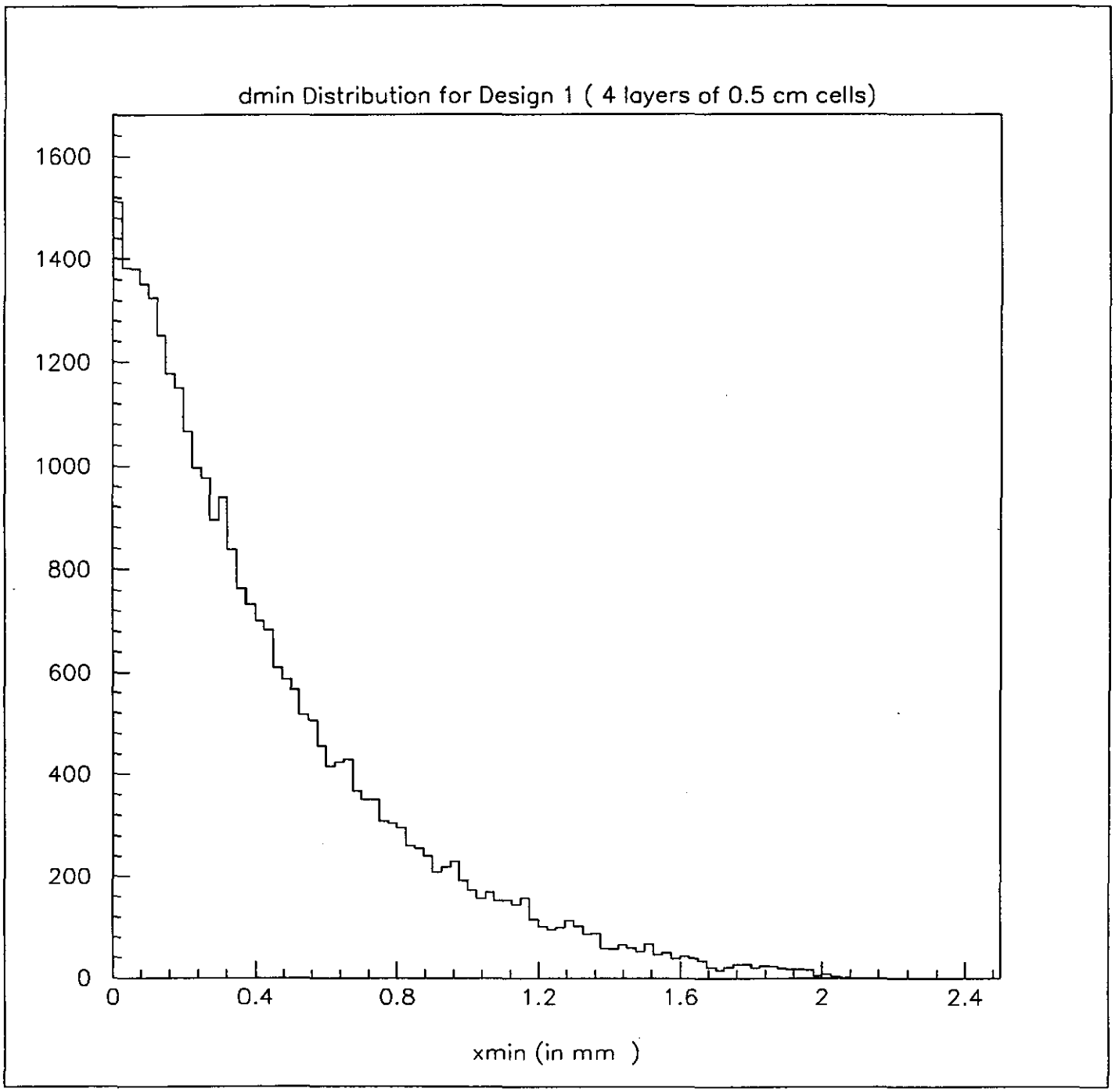
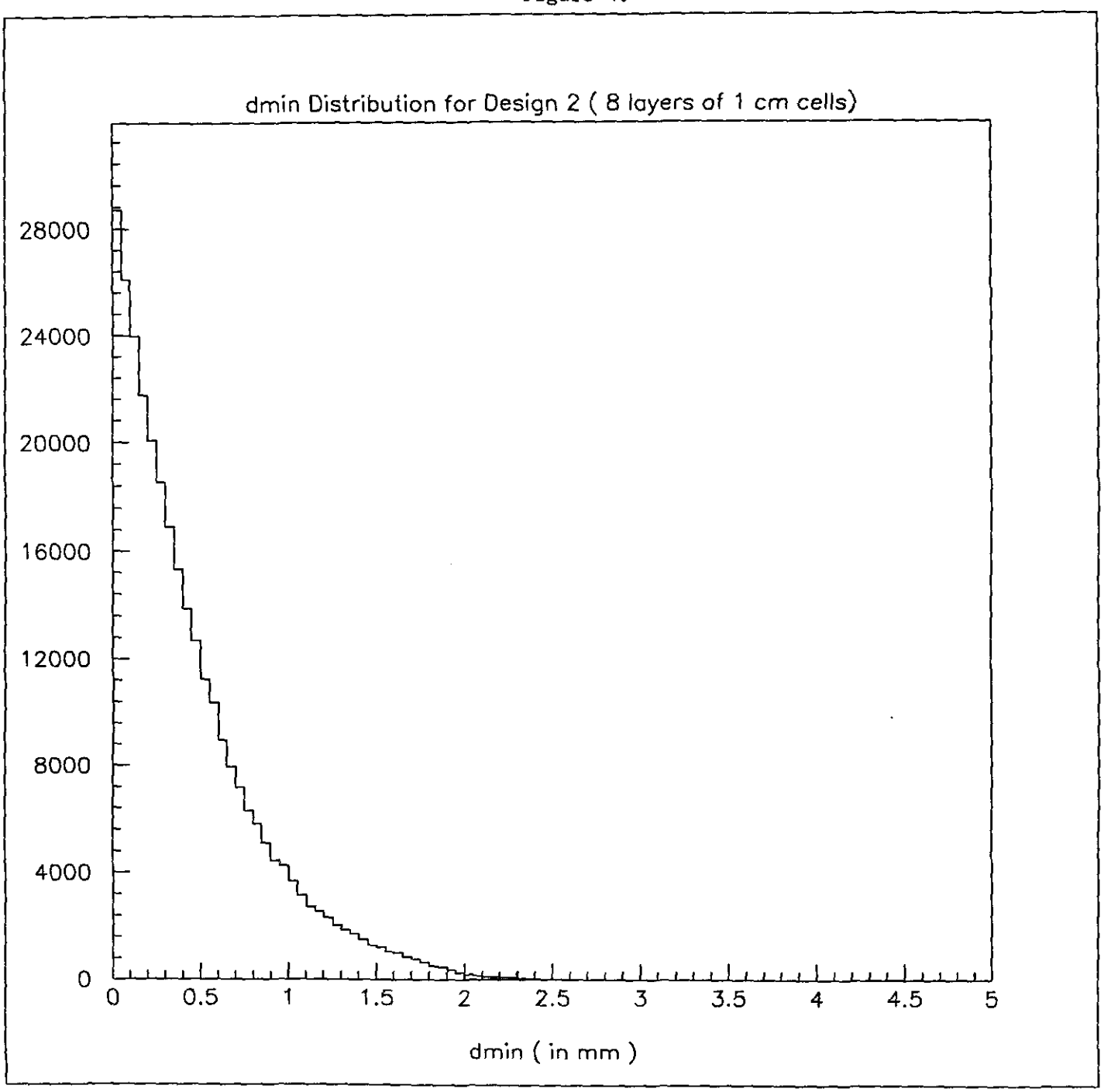

dmin Distribution for Design 1 (4 layers of 0.5 cm cells)
1600
1400
1200
1000
800
600
400
200
0
0
0.4
0.8
1.2
1.6
2
2.4
xmin (in mm)

Figure 4.


dmin Distribution for Design 2 (8 layers of 1 cm cells)
28000
24000
20000
16000
12000
8000
4000
0
0
0.5
1
1.5
2
2.5
3
3.5
4
4.5
5
dmin (in mm)