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SOLENOIDAL DETECTOR NOTES

HIT RATES OF THE STRAW CHAMBER TRACKER

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Hit rates of the straw chamber tracker

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Abstract

We study hit rates for the straw-chamber tracker by using the PYTHIA event generator and the GEANT detector simulator. Radius dependences of the hit rates are obtained for the solenoidal field of 2, 1, and 0 Tesla. Pseudo-rapidity coverage dependences are also given. The hit rate for the straw of 5 mm and the pseudo-rapidity coverage of ±1.5 becomes more than 6 MHz at r=0.5 m with 2 Tesla

Introduction

Straw chamber tracker is one of the most promising tracker for the central tracking system of SSC experiments because the wire chamber technique has been well established. But for the SSC experiments, straw chamber may have a severe difficulty of the high hit rate.

Event rate of the minimum bias event is expected to be 100 MHz and the charged multiplicity per unit pseudo-rapidity is about seven. Not only the primary particles but also the secondary products such as delta-rays and positron-electron pair from g conversion should be taken into hit-rate account. Curling track inside the tracking volume by the solenoidal field is also expected to increase the hit rate significantly.

In this paper we studied hit-rate by using minimum bias events generated with PYTHIA. To simulate effects of the secondary interactions and curling-up by magnetic field, we employed GEANT.

Event samples

In this study, we used the event-generator code of PYTHIA version 4.8 to generate minimum bias events. Pseudo-rapidity distribution of the charged particles for minimum bias events is shown in Fig. 1. The distribution is almost flat for the central tracking region and the average charged multiplicity per pseudo-rapidity unit is about seven. Transverse

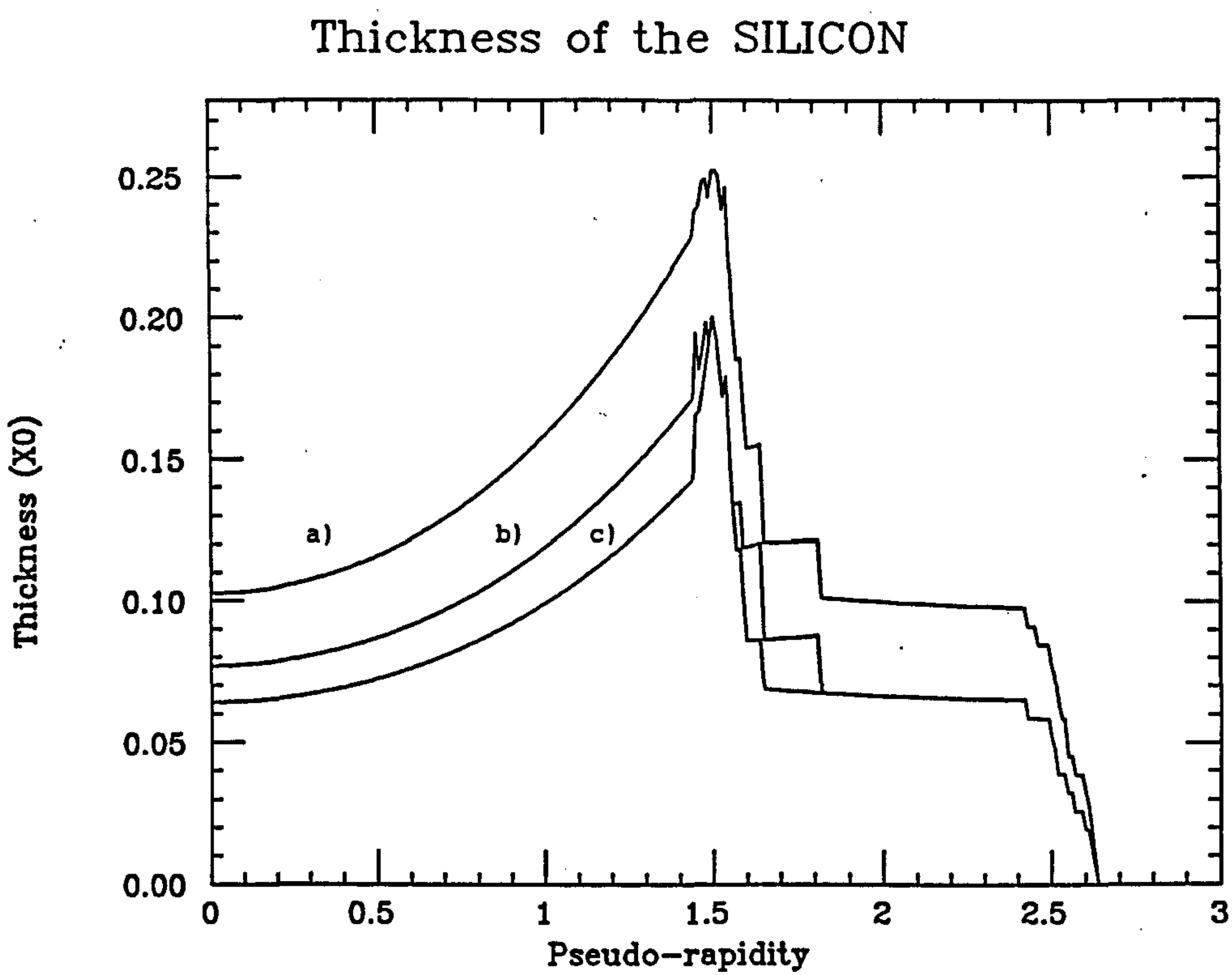

Thickness of the SILICON
Thickness (X0)
0.25
0.20
0.15
0.10
0.05
0.00
0
0.5
1
1.5
2
2.5
3
Pseudo-rapidity
a)
b)
c)

Fig. 7-b

presented. One can clearly see an increase of the hit-rate for higher field. The bump around r=50 cm for higher field is also observed. These are due to the curling track effects. The hits-rate when the secondary interaction are switched off are presented in Fig.5a and 5b for no field and 2 Tesla magnetic field, respectively. In comparison with Fig.4 and Fig.5, clearly the bump is due to the low energy, curling particles which is generated by the secondary interactions at the tracker materials. The difference between Fig. 5a and 5b indicates the curling track effect of particles produced at primary interaction. Statistical error is ~ 15% at 1MHz point so that the detail structure indicates statistical fluctuation.

Table 2 shows the summary of the hit rate. If one consider about the maximum drift time of liberated electron and event pile-up, one had better uses a straw chamber less than 1 MHz. This means that the straw chamber for the central tracker of SSC experiments must be short enough, for example at r=50cm the straw length would be shorter than 40 cm resulting in 6 segments required for $|h| < 1.0$ coverage. This study in cojunction with the time resolution study[2] suggests that the straw chamber tracker (barrel part) is better to install outside the cylinder of r=100cm from beam line.

References

1) G.G.Hanson, S.Mori, L.G.Pondrom and H.H.Williams,"REPORT OF THE LARGE SOLENOID DETECTOR GROUP", Proceedings of the workshop on EXPERIMENTS, DETECTORS, AND EXPERIMENTAL AREAS FOR THE SUPERCOLLIDER, July 7-17,1987, Berkeley, California.
2) Hiroyuki Iwasaki, "A study on Time Resolution for a Straw Chamber", KEK Preprint 89-158, contributed paper to the workshop on 4 p Tracking System for the Superconducting Supercollider,TRIUMF, Vancouver, July 24-28, 1989.

Table Captions

1) Material list of the model central tracking system.
2) Summary of the hit-rate for the straw chamber as a central tracker under the standard SSC operating condition..

momentum distribution of the charged particles produced in the central region of |h| < 2 is shown in Fig. 2. The average transverse momentum for these particles is 590 MeV/c and the peak of the distribution is around 350 MeV/c.

Model straw chamber

The model chamber we used in this study is based on the large solenoid detector design, Berkeley '87 workshop [1]. The model tracker consists of 15 superlayers of straw chamber. One superlayer has 8 straw layers. The material list assumed for the model tracker is given in Table 1. The total thickness of the tracker is 0.08 X0. The inner radius of the most inner superlayer was 40 cm, the inter radius of the most outer superlayer was 152 cm.

In Fig. 3 a schematic view of the tracker and a sample event is superimposed. To make the simulation fast, superlayers are assumed to be filled with the material having average density of all materials. We put 40 probe straws per one superlayer as shown with small dots in the figure to count charged particles passing through. The diameter of these straws is 5 mm. If 10 mm straw is used, the hit rate will be twice as much.

Simulation

Secondary interactions such as pair production, decay in flight, hadronic interaction, delta-rays, multiple scattering, etc., were simulated by using GEANT simulator. The cut-off energies used in this study were set to 1 MeV. No albedo particle from calorimeter was taken into account. We examined three different field strength, which were 2, 1, and 0 Tesla, to study the effect of the curling-up tracks.

Since CPU resource is limited, we could accumulated only 100 minimum bias events for this study. Hit rate of model straw chamber in each superlayer was calculated by the averaging over 100 events and 40 symmetric probe straw chambers, and normalized to the 100 MHz which is the hit rates of the minimum bias event rate for the standard SSC luminosity. Multiple hits on one probe straw in one event were counted as only one hit.

Results

The radius dependences of the hit rate with respect to the solenoidal field of 2, 1, and 0 Tesla are shown in Fig.4a, 4b and 4c, respectively. Hit-rate for four different pseudo-rapidity coverages of the straw chamber are

Figure captions

Fig.1. Pseudo-rapidity distribution of the charged particle of the minimum bias events generated by PYTHIA.

Fig.2. Transverse momentum distribution of the charged particles produced in the central region of $|h| < 2$

Fig.3. A schematic view of the straw chamber tracker. A sample event is superimposed on the tracker.

Fig.4a, 4b, 4c. The radial dependences of the hit-rate with respect to the solenoidal field of 2, 1, and 0 Tesla, respectively.

Fig.5a, 5b. The curling track effect only particles coming from primary interaction. The particles produced at the secondary interactions are not counted.

Table I Material in the Central Tracking System

Material	Thickness (cm)	Radiation Length for Material (cm)	Radiation Length (%)
Mylar	1.12	28.7	3.9
Glue	0.062	35.0	0.1
Stainless Steel Wires	0.044	1.76	2.5
Argon	50	17,800	0.3
Ethane	50	32,450	0.2
Pads on Mylar	0.15	28.7	0.5
Epoxy Foam	9.0	1,720	0.5
Total	73.5	–	8.0

ref. Proceedings of the workshop on Experiments, Detectors, and Experimental Areas for the Supercollider, 1988 Berkeley, page353.

Table 2. Hit rate.

Pseudo-Rapidity Coverages	|η| < 1			|η| < 1.5			|η| < 2		
Radius from Beam line (cm)	50	100	150	50	100	150	50	100	150
Length of Straw (cm)	117	235	353	213	423	639	363	725	1088
Field 2 Tesla. Hit rate (MHz)	4.0	1.9	1.0	6.2	3.1	1.5	9.2	4.6	2.0
Field 1 Tesla. Hit rate (MHz)	2.7	2.1	1.3	4.1	3.1	1.7	6.5	4.7	2.4
No magnetic field Hit rate (MHz)	2.3	1.2	1.0	3.2	2.0	1.5	4.5	2.4	2.1

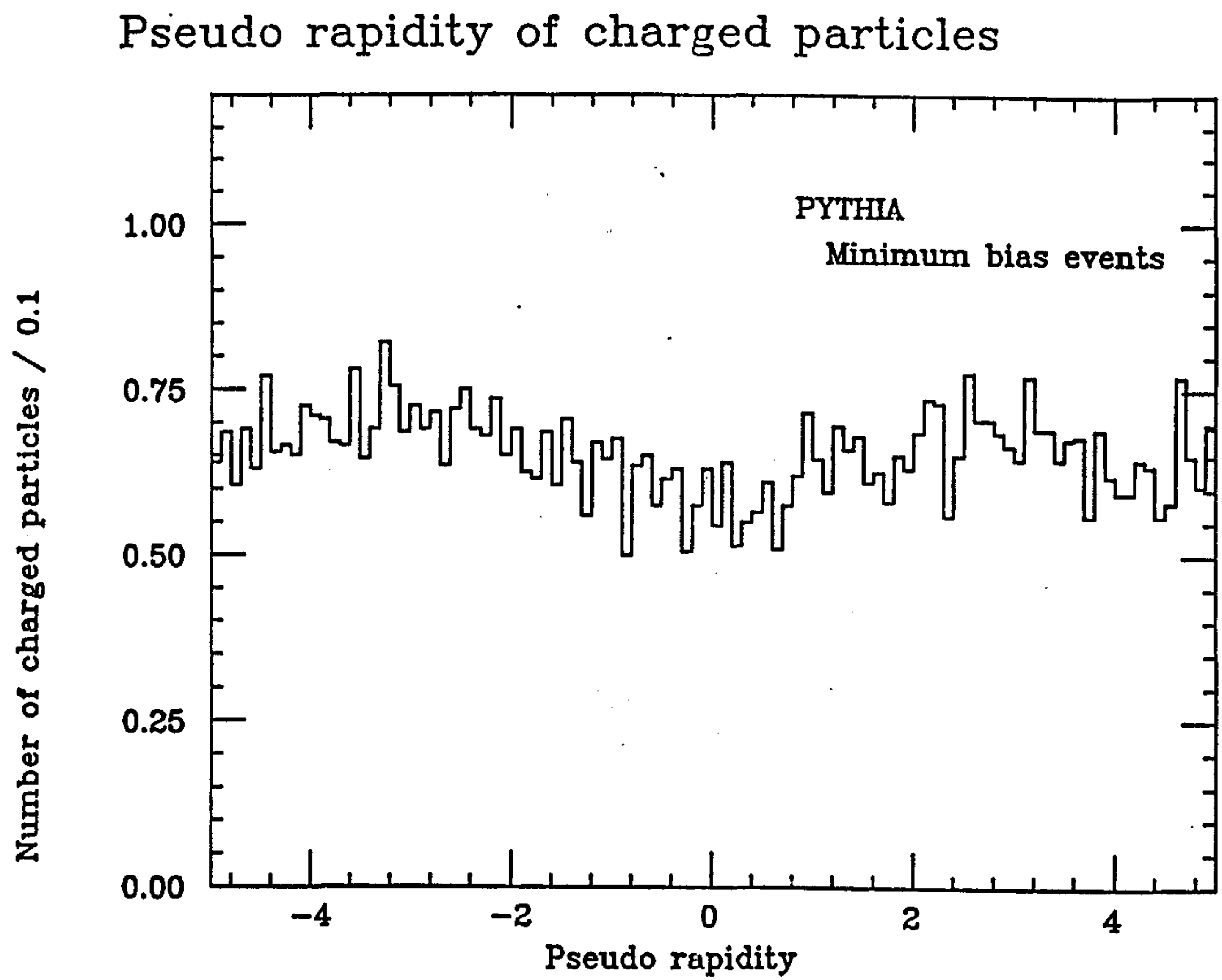

Pseudo rapidity of charged particles
PYTHIA
Minimum bias events
Number of charged particles / 0.1
1.00
0.75
0.50
0.25
0.00
−4
−2
0
2
4
Pseudo rapidity

Fig. 1

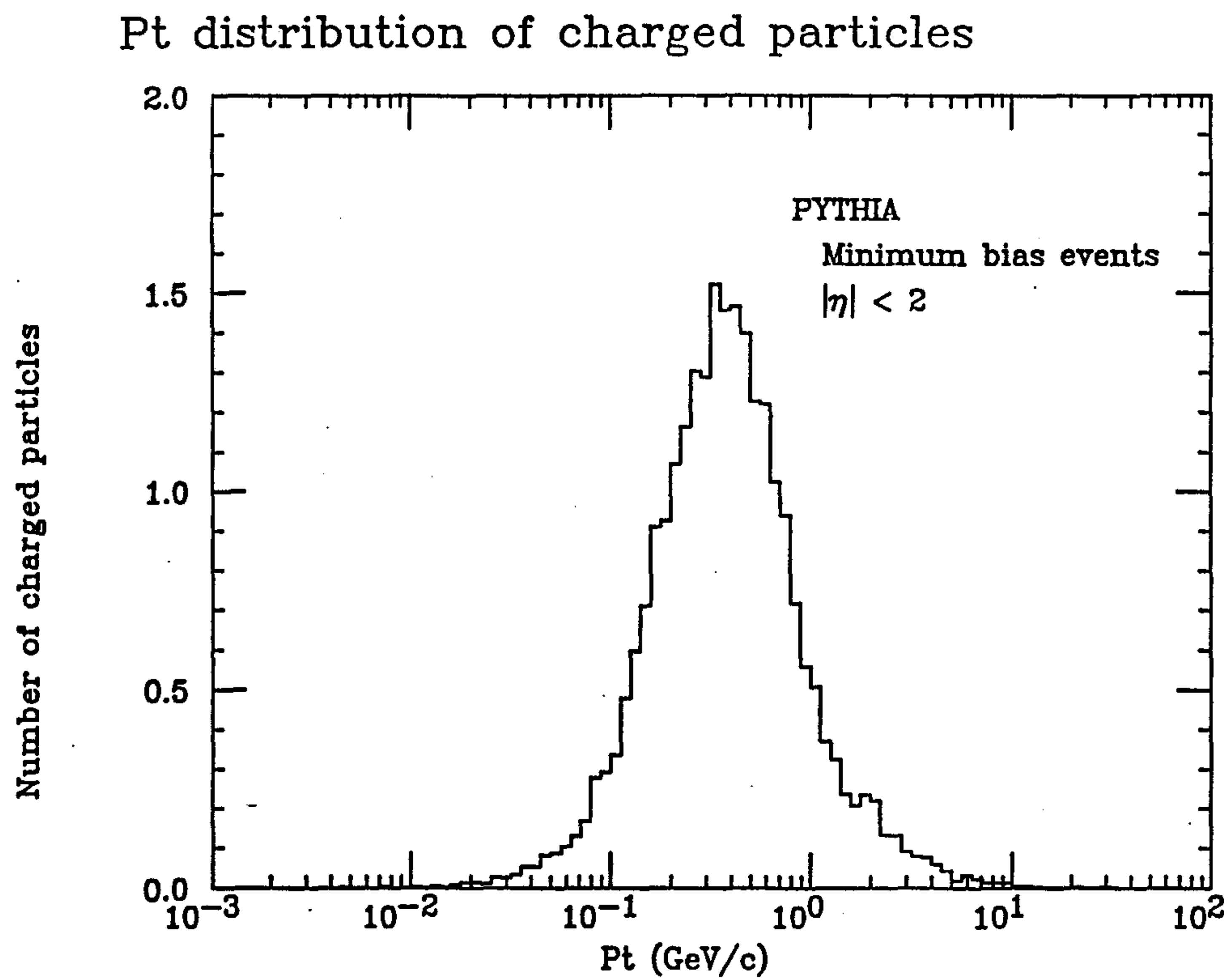

Pt distribution of charged particles
PYTHIA
Minimum bias events
|η| < 2
Number of charged particles
Pt (GeV/c)
2.0
1.5
1.0
0.5
0.0
10−3
10−2
10−1
10⁰
10¹
10²

Fig. 2

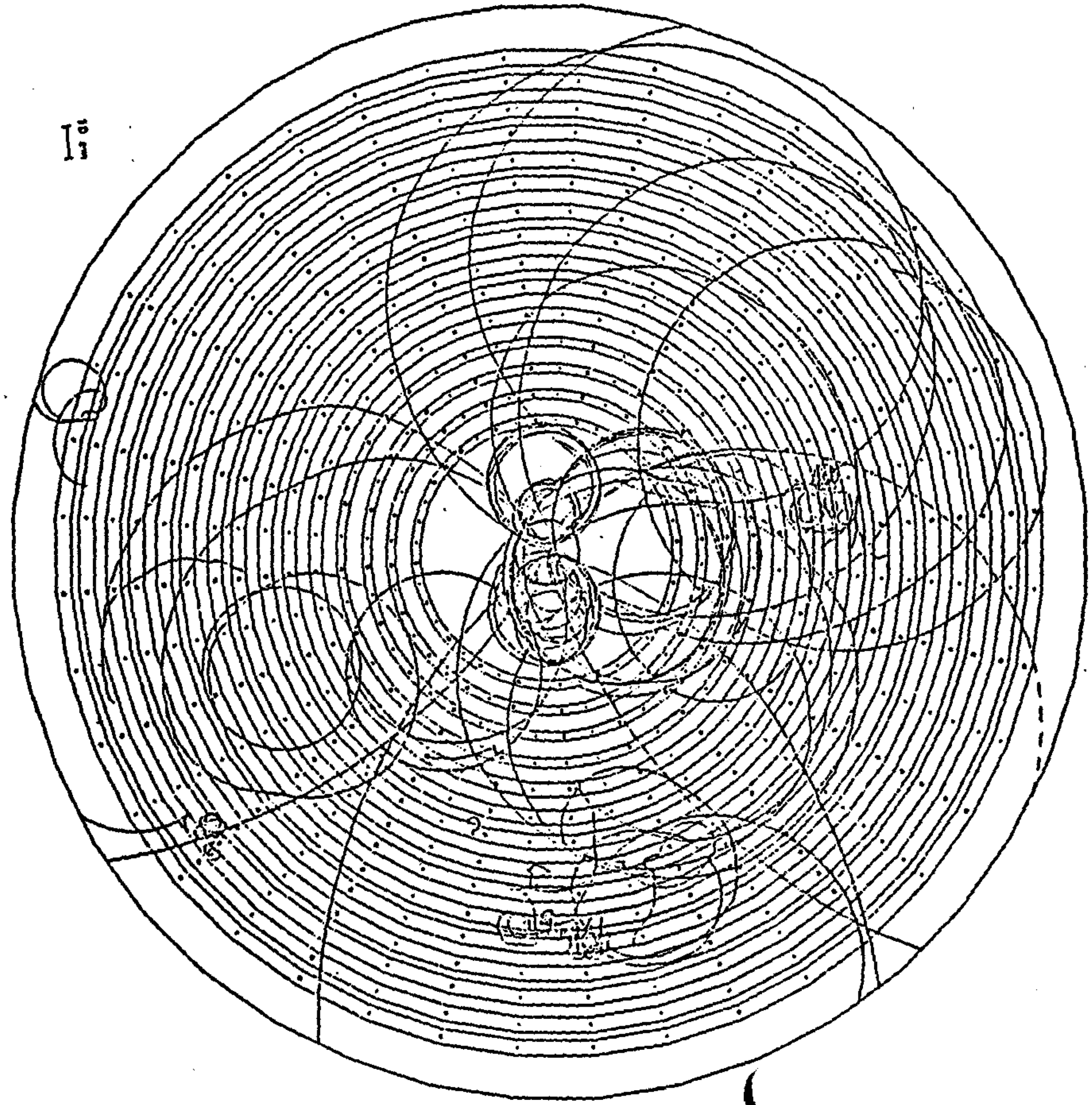
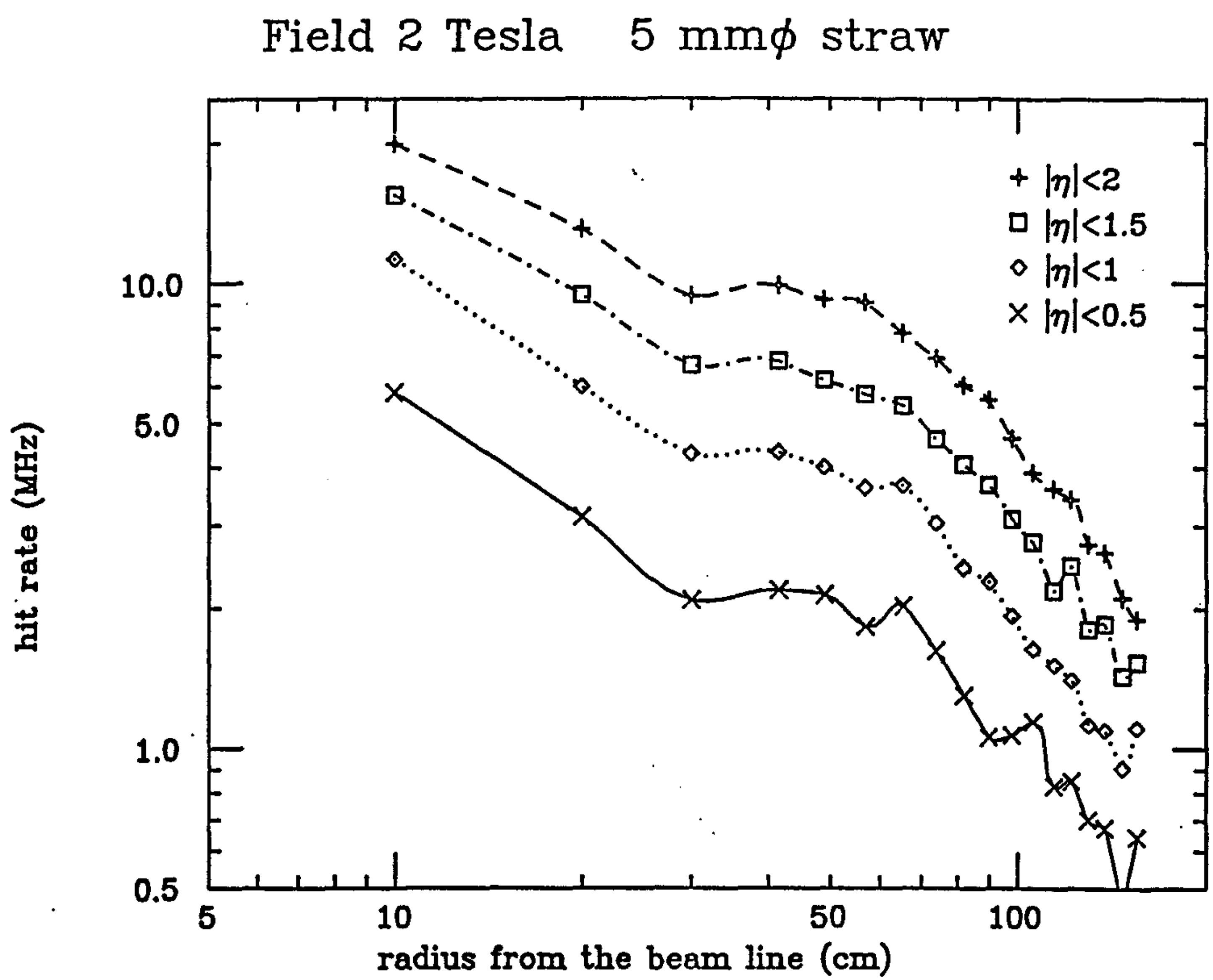
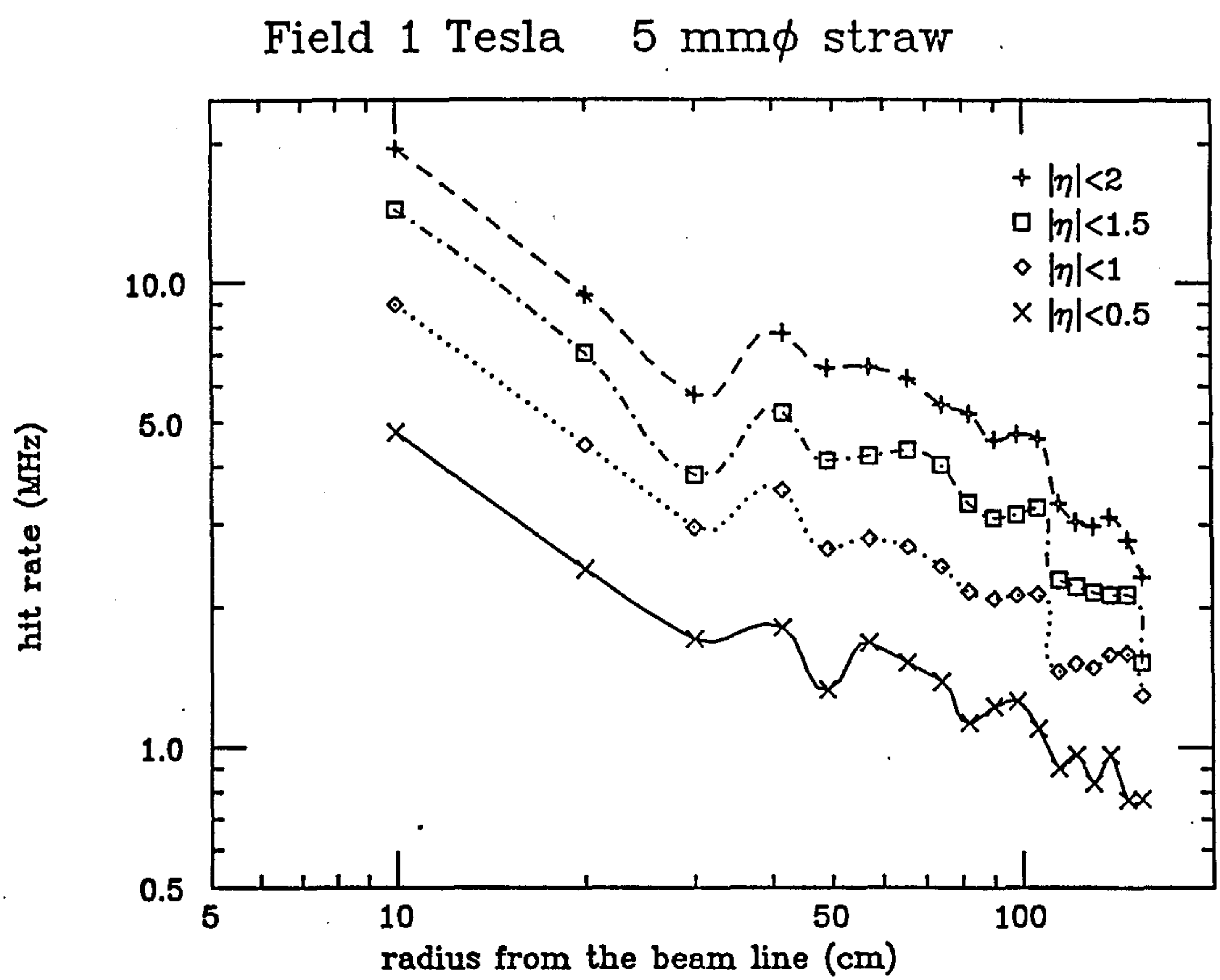


Fig. 3

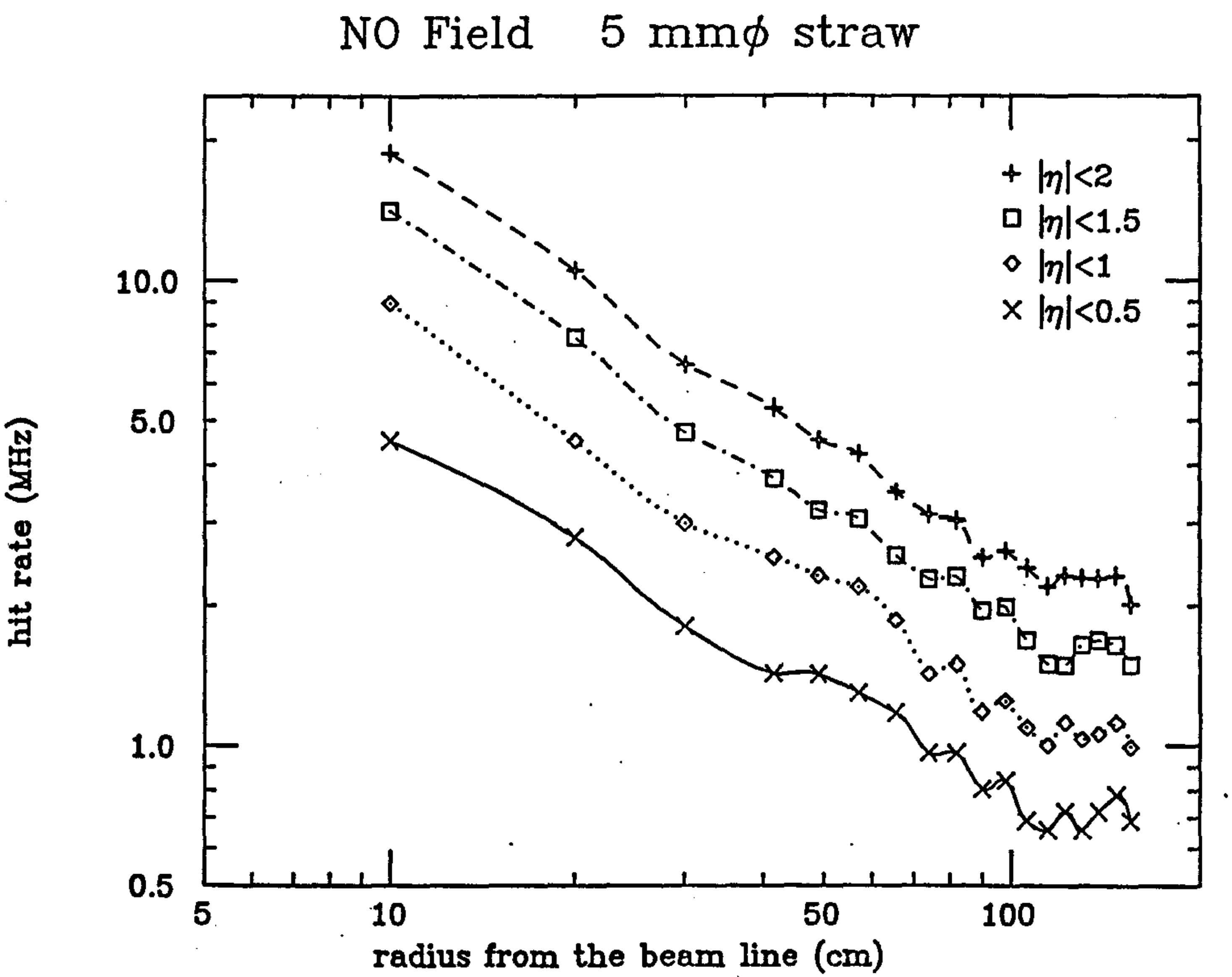


Field 2 Tesla 5 mmϕ straw
+ |η|<2
□ |η|<1.5
◇ |η|<1
× |η|<0.5
10.0
5.0
1.0
0.5
5
10
50
100
hit rate (MHz)
radius from the beam line (cm)

Fig. 4a



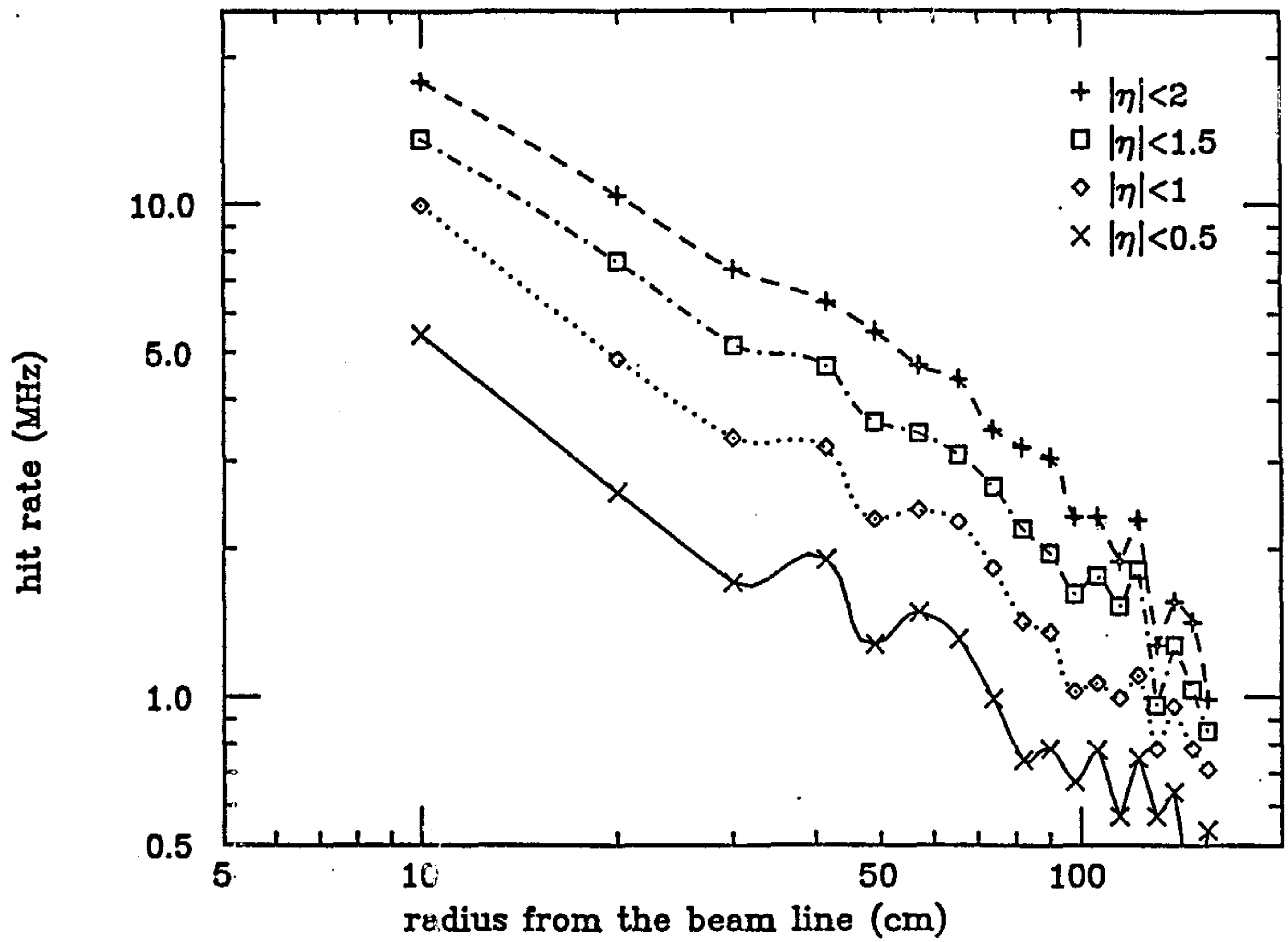
Field 1 Tesla 5 mmϕ straw
hit rate (MHz)
10.0
5.0
1.0
0.5
5
10
50
100
radius from the beam line (cm)
|η|<2
|η|<1.5
|η|<1
|η|<0.5



NO Field 5 mmφ straw
hit rate (MHz)
10.0
5.0
1.0
0.5
5
10
50
100
radius from the beam line (cm)
|η|<2
|η|<1.5
|η|<1
|η|<0.5

Fig. 4c

Field 2 Tesla   primary particle only



5a

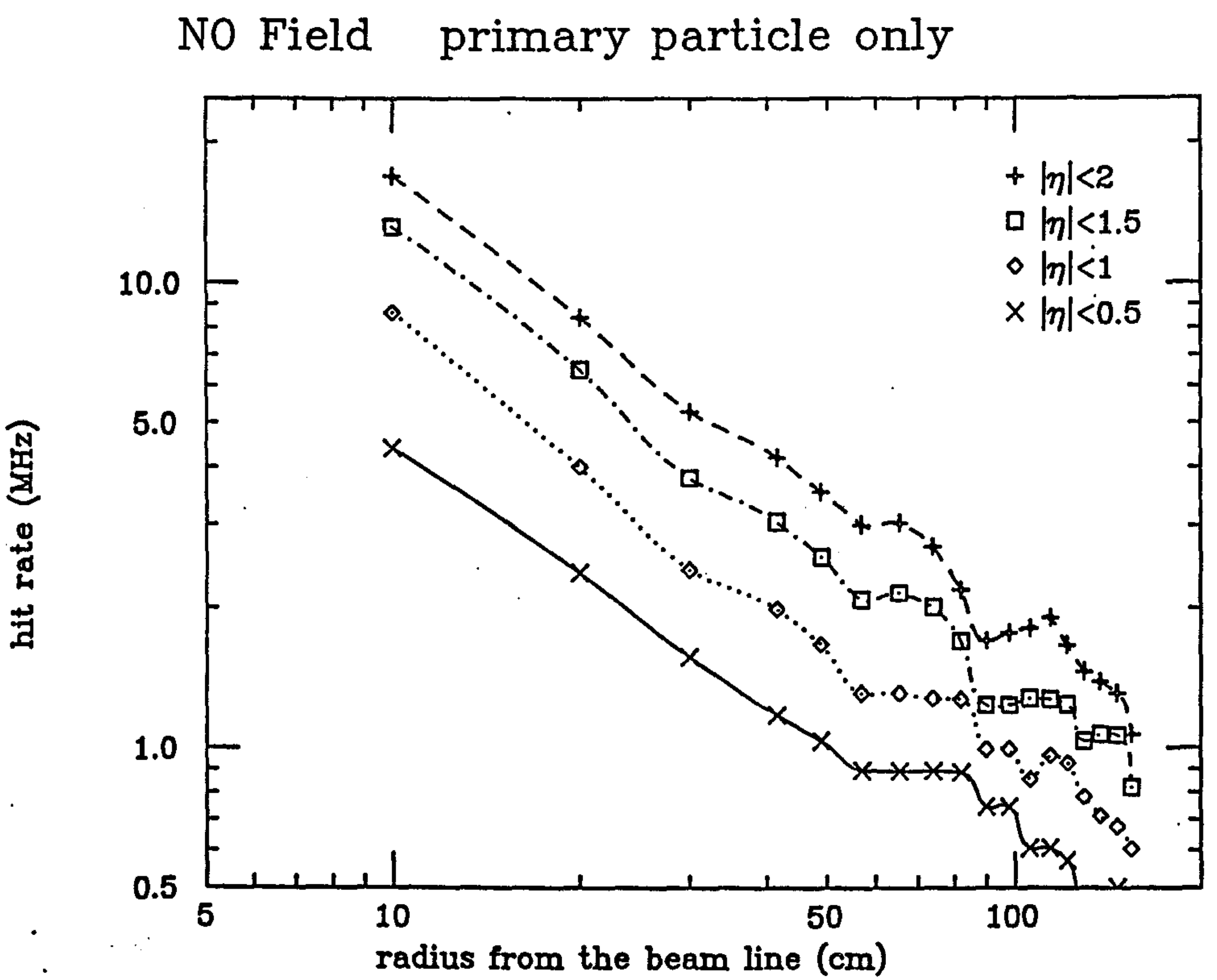

NO Field primary particle only
hit rate (MHz)
10.0
5.0
1.0
0.5
5
10
50
100
radius from the beam line (cm)
|η|<2
|η|<1.5
|η|<1
|η|<0.5

Fig 5-b