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**ESTIMATION OF HADRONIC AND EM RESOLUTION FOR
SCINTILLATOR PLATE CALORIMETER CONFIGURATIONS**

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Introduction

CALORS9 Simulation code has been used to estimate the hadronic and electromagnetic resolutions for the various scintillator plate calorimeter configurations. The goal of this study was to determine the optimum combination of Lead and Iron based calorimeter, which retains compensation and linearity. The configurations considered are Lead/Scintillator and Fe/Scintillator and their combinations. Ultimately, we hope to test these configurations in the hanging file beam test at Fermilab in this spring.

Analysis

This study was carried out for mainly 10 GeV incident pions and electrons (calculations at higher energies for a limited number of geometries are in progress and will be the subject of a later note). The lateral dimensions of the geometry chosen for this study were 200×200 cm². Earlier calculations have shown that this results in essentially 100% lateral containment of hadronic showers. For ease in comparison with the earlier work, we have chosen to simulate absorber plate thicknesses of 0.56 cm and 1.0 cm for Lead and 1.75 cm for Iron with scintillator plates of .25 cm. Only statistical errors are indicated in the following results. A detailed study of systematics in the CALOR simulation is in progress. Presently we estimate the largest systematic unknowns at +5% from the collision model and $\pm 4\%$ from the saturation properties of the scintillator.

Table I gives the summary results of electromagnetic resolutions for the Lead configurations. Two different configurations are studied with Lead/Scintillator

ratios of approximately 2 and 4. In the coarse sampling configuration the EM resolution is degraded by a factor slightly more than the ratio of the square root of the absorber thicknesses. The resolution worsens by 5% for the pseudo rapidity of 1.5 in finer sampling calorimeters. This effect is 10% in coarse sampling configurations.

Table II gives the Hadronic resolutions for three different Lead configurations, with Lead/Scintillator ratio .56/.25 and 1.00/.25 and for a combined system comprising an EM calorimeter with fine sampling and the hadronic section with coarse sampling. For the latter geometry the signal from the hadronic section is weighted by the ratio of the absorber thicknesses. In this case the simple weighting by $(dE/dX)\Delta X$ sampling is very effective and the resolution is degraded by only a few % compared to a fine sampling system. This justifies a calibration scheme by mips. As is observed in the single geometries, the resolution worsens by approximately the square root of the sampling thickness at a pseudo rapidity of 1.5.

Table III and Figure 1 give the summary results for the Lead-Iron configurations. The resolution and e/h of the combined system was calculated as the function of the location in depth of the Lead-iron boundary. Figure 2 gives the fractional energy in the Iron/scintillator module as a function of Lead/Scintillator thickness for these configurations. It can be seen that the fractional energy in the Iron section is significant upto a Lead calorimeter thickness of 4 λ .

Three relative weighting schemes were used to match the iron to the Lead response:

1. by the calculated (dE/dX) for the unit cell in the Lead and Iron stacks.
2. by the ratio of the EGS simulated e/mip value for both sections.
3. by using an arbitrary weight factor which forces $e/h=1$.

The third scheme gave the minimum hadronic resolution among the three.

The results show that this weighting factor is independent of the configuration. The correction in the weighting factor relative to the simple (dE/dX) scheme is only 15%. By this weighting scheme the configuration with 4λ Lead and 4λ Iron has a hadronic resolution very close to a pure Lead/Scintillator system. The corresponding resolution for a system comprising of 1λ Lead calorimeter (Lead EM section only) backed by the Fe/Scin section is about 25% worse.

The linearity of one of the configurations (4λ Lead and 4λ Iron) is being investigated with the optimum weighting scheme. So far 10 and 30 GeV pions have been simulated. Table IV give the preliminary results of this simulation. The linearity of response is good within 1% which is close to the statistical error in these calculations. We are planning to simulate 70 GeV pions which will strain our computing resources.

Conclusions

CALOR simulation results for 10 GeV incident pions show that a macroscopic calorimeter geometry of 4λ of Lead in a compensating configuration followed by 4λ of Iron with moderate sampling is essentially as compensating as a purely Lead compensating calorimeter. Within the errors of this calculation the relative weight of Iron to Lead response used to obtain this result is independent of the fraction of depth (and energy deposition) of the Iron system. Therefore it is hoped that this weight will also be independent of the incident energy. Data from the first of the higher energy points indicate that the above deduction is indeed correct.

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Table I

EM RESOLUTION FOR LEAD CONFIGURATIONS

Configuration	Energy (GeV)	Thick. λ	η	EM Reso. (%)
EMC .56/.25 cm	10.0	1	0.	5.31 ± 0.70
EMC .56/.25 cm	10.0	$1 \cos \theta$	1.5	6.98 ± 0.78
EMC .56/.25 cm	30.0	1	0.	3.42 ± 0.46
EMC 1.0/.25 cm	10.0	1	0.	7.42 ± 0.73
EMC 1.0/.25 cm	10.0	$1 \cos \theta$	1.5	11.21 ± 0.75

Table II
 HADRONIC RESOLUTION AND e/h RATIO
 FOR LEAD CONFIGURATIONS (10 GeV π^-)

Configuration	Thick. λ	η	e/h Ratio	Had.Reso. (%)
EMC .56/.25 cm	1	0.	$0.99 \pm .01$	9.7 ± 0.70
HAC .56/.25 cm	7			
EMC 1.0/.25 cm	1	0.	$0.95 \pm .01$	12.1 ± 0.75
HAC 1.0/.25 cm	7			
EMC .56/.25 cm ^(a)	1	0.	$0.98 \pm .01$	11.4 ± 0.75
HAC 1.0/.25 cm	7			
EMC .56/.25 cm ^(a)	$1 \cos \theta$	1.5	$0.95 \pm .01$	19.8 ± 0.75
HAC 1.0/.25 cm	$7 \cos \theta$			

(a) Signal from HAC section is weighted by a factor 1.0/.56

Table III

HADRONIC RESOLUTION AND e/h RATIO
FOR LEAD-IRON CONFIGURATIONS (10 GeV π^-)

Pb/SCIN= 0.56/0.25 cm, Fe/SCIN= 1.75/0.25 cm

Configuration		Simple Sum	(dE/dX) ΔX Weighting	EMC Cali. Correction wrt. (dE/dX) weightg =0.715	$e/h = 1.00$ Correction wrt. (dE/dX) weightg =0.816
Pb 8 λ	e/h Reso.	0.99 ± 0.02 9.7 ± 0.75			
Pb 6 λ .Fe 2 λ	e/h Reso.	0.99 ± 0.02 11.2 ± 0.75	1.00 ± 0.0 11.1 ± 0.78	1.01 ± 0.02 11.0 ± 0.77	1.00 10.5 ± 0.75
Pb 4 λ .Fe 4 λ	e/h Reso.	1.03 ± 0.02 13.6 ± 0.75	0.98 ± 0.02 11.2 ± 0.78	1.00 ± 0.02 10.6 ± 0.77	1.00 10.5 ± 0.75
Pb 2 λ .Fe 6 λ	e/h Reso.	1.26 ± 0.02 23.3 ± 0.75	0.94 ± 0.02 14.1 ± 0.75	1.06 ± 0.02 12.0 ± 0.75	1.00 12.0 ± 0.75
Pb 1 λ .Fe 7 λ	e/h Reso.	1.65 ± 0.02 27.3 ± 0.75	0.90 ± 0.02 14.5 ± 0.80	1.12 ± 0.02 13.0 ± 0.77	1.00 12.9 ± 0.75
Fe 8 λ	e/h Reso.	1.19 ± 0.02 17.5 ± 0.75			

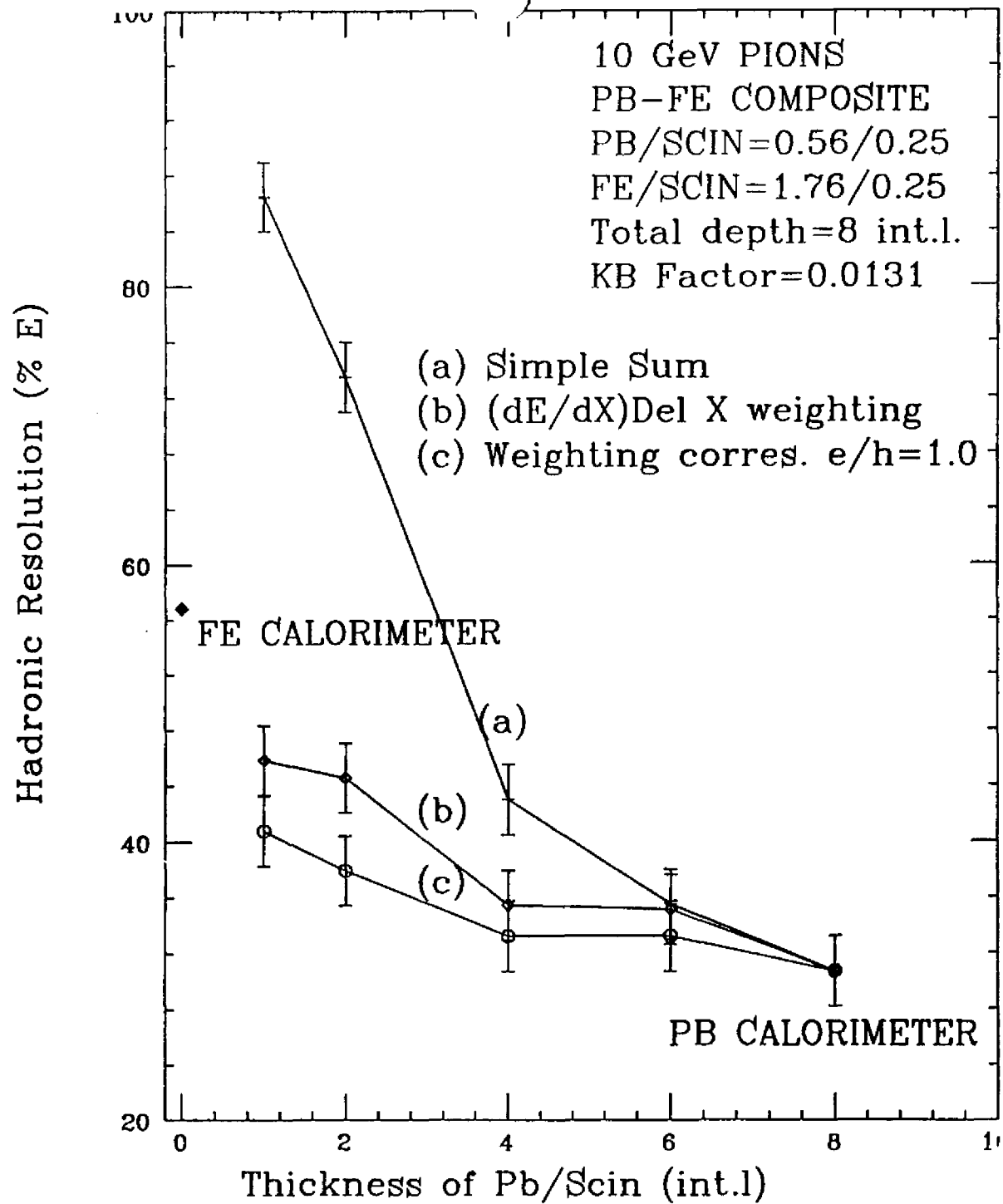


Figure.1

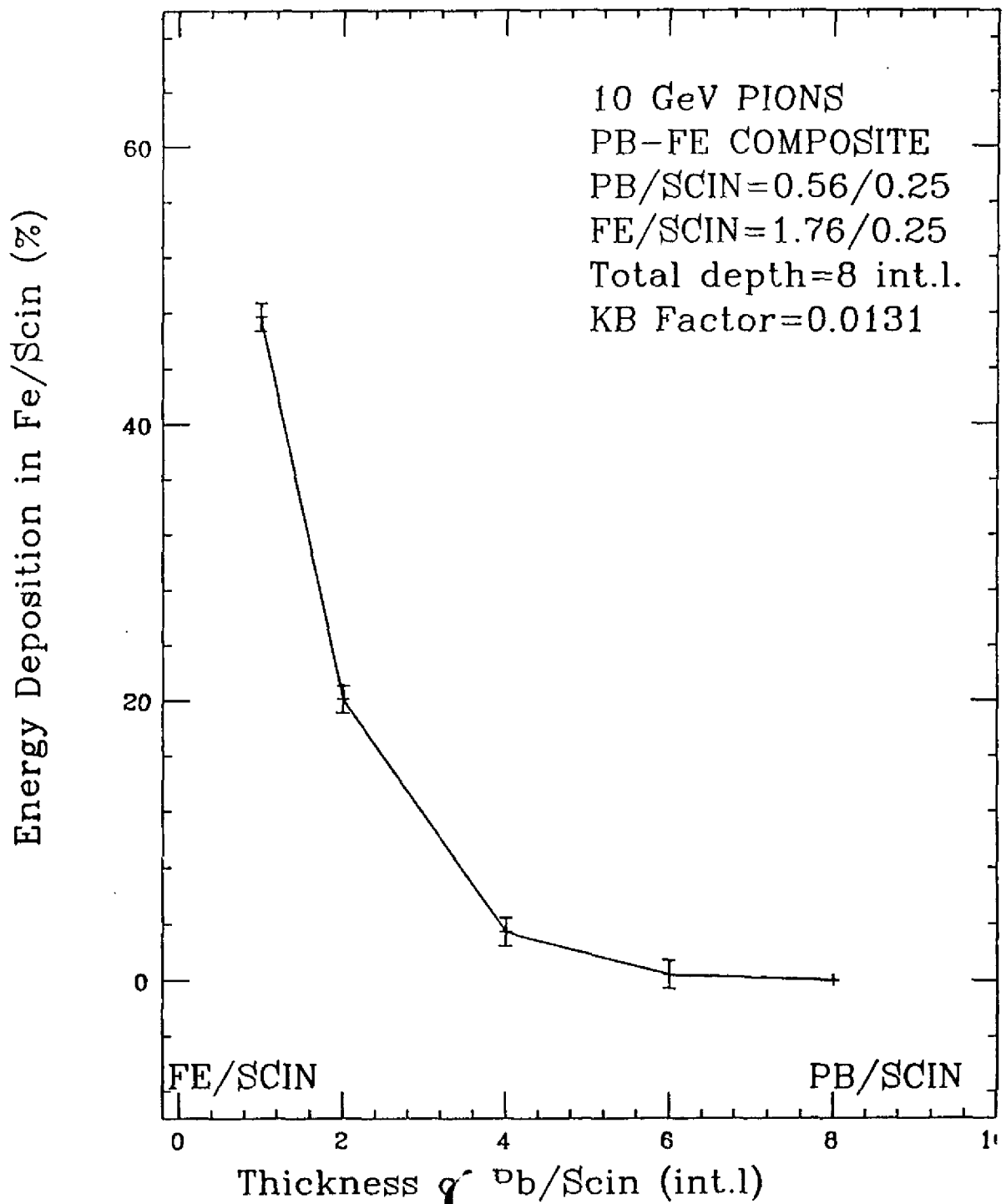


Figure.2

Table IV

LINEARITY OF LEAD-IRON CONFIGURATIONS

Pb/Scin=0.56/0.25 cm, Fe/Scin=1.75/.25 cm

Pb/scin= 4 λ , Fe/Scin= 4 λ

Energy (GeV)	Hadron ⁽¹⁾ Reso.(%)	Rel. Signal/GeV	
		Elec.Mag.	Hadronic ⁽¹⁾
10.00	10.50	4.007	4.025
30.00	8.23	3.951	3.931
75.00			

(1) Optimum weighting (e/h=1.00)