NAL PROPOSAL #223

SCIENTIFIC SPOKESMAN:

P. Schlein
Physics Department
University of California
Los Angeles, California 90024

FTS/Off-Net 213-688-2000 + 825-4321

Proposal to Study High Transverse Momentum Energy Distributions and Correlations Using Total Absorption Calorimetry at NAL

E. Lorenz, R. Poster, P. Schlein, W. Slater, R. Webb

University of California, Los Angeles

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300 GeV CM-LAB KINEMATICS FOR A TOTAL ABSORPTION HADRON CALORIMETER TO STUDY LARGE P_t PHYSICS

The essential design criteria for a total-absorption calorimeter to measure outgoing hadronic energy distributions in, e.g., 300 GeV proton-proton interactions are obtained from an examination of the laboratory/centre-of-mass kinematics shown in Figure 1.

Lines of constant laboratory energy and angle are shown in the centre-of-mass X-P_t plane. Although the curves were calculated for outgoing pions, they are valid for all particles, except in the large angle ($\theta_{lab} \gtrsim 300$ mrad) or small P_t range ($P_t < 1$ or 2 GeV/c. Thus, energy measurement by pulse height of a particle at some angle θ_{lab} determines its X_{CM}-P_t values, independent of its mass.

To verify the range of validity of this approximation, we note that

$$\left(P_{\parallel}\right)_{CM} = \gamma \left(P_{\parallel}\right)_{lab} - \beta\gamma E_{lab}$$

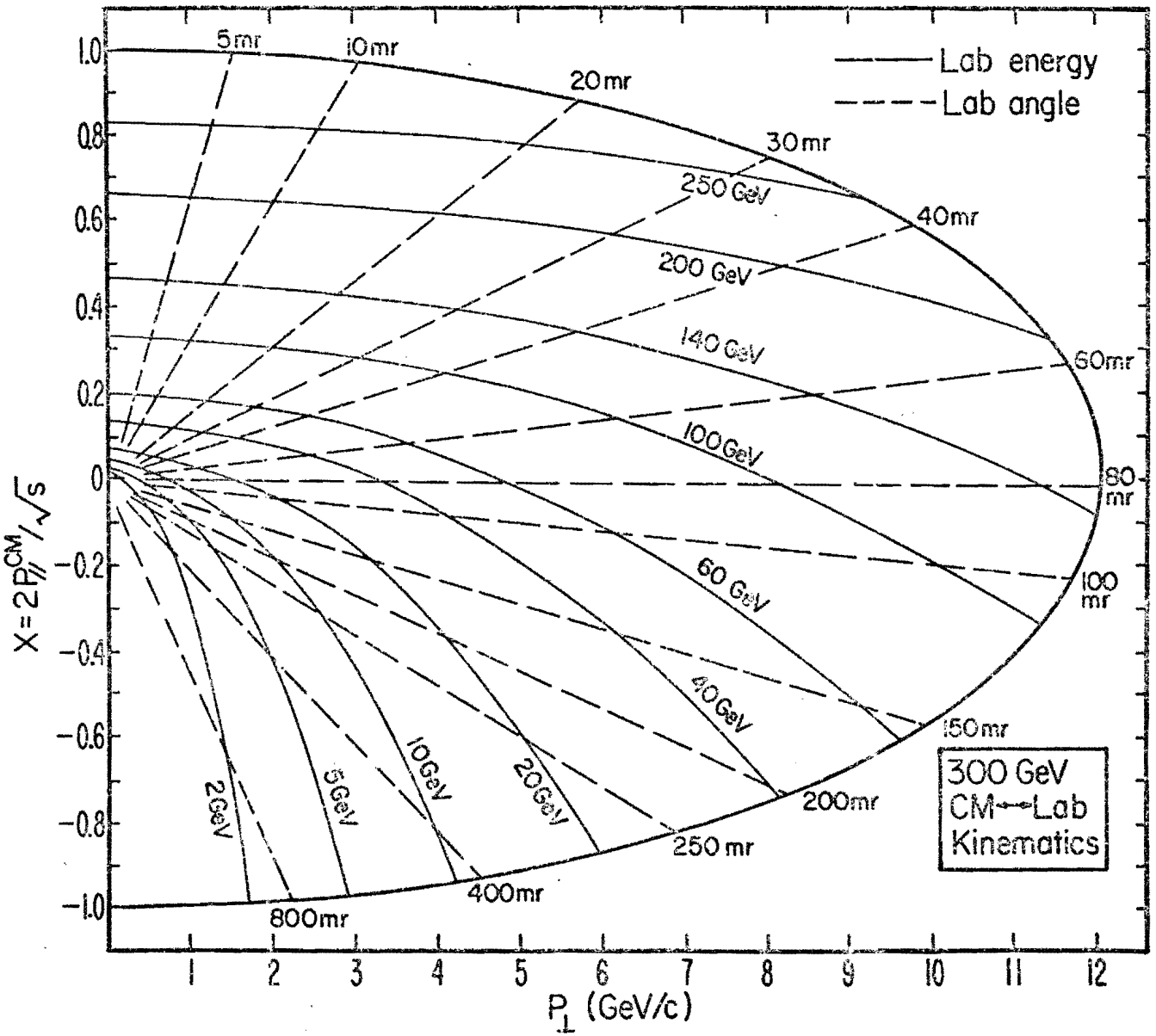
$$= P_t \left[\frac{\gamma}{\tan \theta_{lab}} - \beta\gamma \left(\frac{1}{\sin^2 \theta_{lab}} + \frac{m^2}{P_t^{\,2}} \right)^{\frac{1}{2}} \right]$$

For fixed θ_{lab}, we see that the linear dependence of $(P_{\parallel})_{CM}$ on P_t, seen in Fig. 1 follows, providing that

$$\left(\frac{m}{P_t}\right)^2 \ll \frac{1}{\sin^2 \theta_{lab}} \quad .$$

For $P_t \gtrsim 1$ or 2 GeV/c and $\theta_{lab} \lesssim 300$ mradians (which covers most of the CM angular range), this is seen to be a good approximation.

For fixed θ_{lab} and P_t, P_{lab} is uniquely determined and thus the curves of constant energy (or pulse height in the calorimeter) contain no further approximation, other than that $P_{lab} \approx E_{lab}$.


Lab energy
Lab angle
5mr
10mr
20mr
30mr
40mr
60mr
80 mr
100 mr
150mr
200mr
250 mr
400mr
800mr
250 GeV
200 GeV
140 GeV
100GeV
60 GeV
40GeV
20GeV
10GeV
5GeV
2GeV
300 GeV
CM↔Lab
Kinematics
$X = 2P_{//}^{CM}/\sqrt{s}$
$P_\perp$ (GeV/c)
1.0
0.8
0.6
0.4
0.2
0
−0.2
−0.4
−0.6
−0.8
−1.0
1
2
3
4
5
6
7
8
9
10
11
12