Shower Fits.

We fitted the data of Bathow et al (6 GeV electrons on Pb) using the shower form

$$\frac{d^2E}{dx\,dr} = \frac{C x^{\alpha} e^{-x/\beta}}{b_1^2 + g b_2^2} \left\{ r e^{-r/b_1} + g r e^{-r/b_2} \right\} \quad (1)$$

The parameters are highly correlated. The "standard" fit yielded (x in $r\ell$)

$C = 0.01581$
$\alpha = 2.1920$
$\beta = 2.7686 \quad r\ell$
$g(x) = 0.0052283 + \underline{x} \cdot 0.100210^{-5} + \underline{x}^2\, 0.36271 \quad 10^{-4}$
$b_1(x) = 0.076115 + \underline{x}\ 0.023798$ cm
$b_2(x) = 0.52264 + \underline{x} \cdot 0.088799 + \underline{x}^2 \cdot 0.10117\ 10^{-5}$

For comparison with CDF detector, we obtained the following scaling corrections.

$b_1(x)_{CDF} = b_1(x) \times 0.949$
$b_2(x)_{CDF} = b_2(x) \times 1.03$
$g(x)_{CDF} = g(x) \cdot 0.972$

b_i are given in cm, and are assumed (for CDF comparison) to scale with value of R_m ($R_m = 1.63$ cm in Pb, 3.53 cm in CDF

Accompanying Figures show calorimeter (integrated in depth) profiles compared with this shower model.

(0) Battow Longitudinal shower data versus fit.

(2) Radial profiles (Battow) at 5, 10, 12, 15, 24 rl.
(Data at 35 rl were included as a constraint)

(3) Radial profile (Battow) integrated over ~26 rl.

(4) Comparison of model, with empirical b_1, g scale corrections, with CDF shower profile integrated in depth. The integral profile is defined by

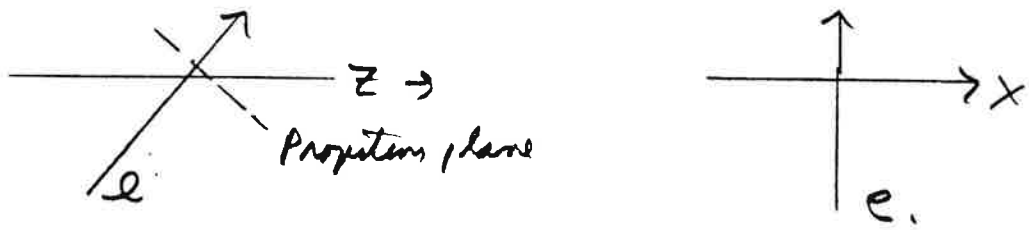
$$I(r>0) = \int_r^{\infty} dr \int_0^{x_{02}} \frac{dE}{dr\,dx}\, dx$$

where $x_0 = 19$ rl for CDF. The profile has been projected onto Z axis where "r" lies in X-Z plane. 50 GeV electrons are used for CDF data.

(5) Same projection in CDF detector for shower leakage in Hadron calorimeter ($x > 19$ rl). Solid curve shows model scaled by $\lambda_{MIN}(HAD)/\lambda_{MIN}(EM)$; dashed curve shows prediction for homogeneous calorimeter (i.e. Pb in Had compartment instead of Fe.)

(6a)(a) Comparison of Battow model with wire and strip profiles in CES strip chambers at 6 rl. Showers strike calorimeter obliquely in strip (Z) view, and profile has been projected onto plane perpendicular to

shower axis. In wire (x) view shower angle is perpendicular to calorimeter face.



(b) Double exponential fit at 0 rad to wire and strip profiles, eg

$$I(x) = \frac{0.5}{1+g}\left[e^{-x/b_1 - x^2/b_1'} + g\, e^{-x/b_2 - x^2/b_2'} \right]$$

where b_1', b_2' are required in general in going from radial to X-Z projection.

(7) Shower asymmetry in Z view caused by oblique shower angle; 10 GeV data compared with Bartow model prediction:

$$\delta I(x) = \frac{1}{2}\left[\int_x^{\infty} \frac{dE}{dx} - \int_{-\infty}^{-x} \frac{dE}{dx} \right] \times \cot\Theta$$

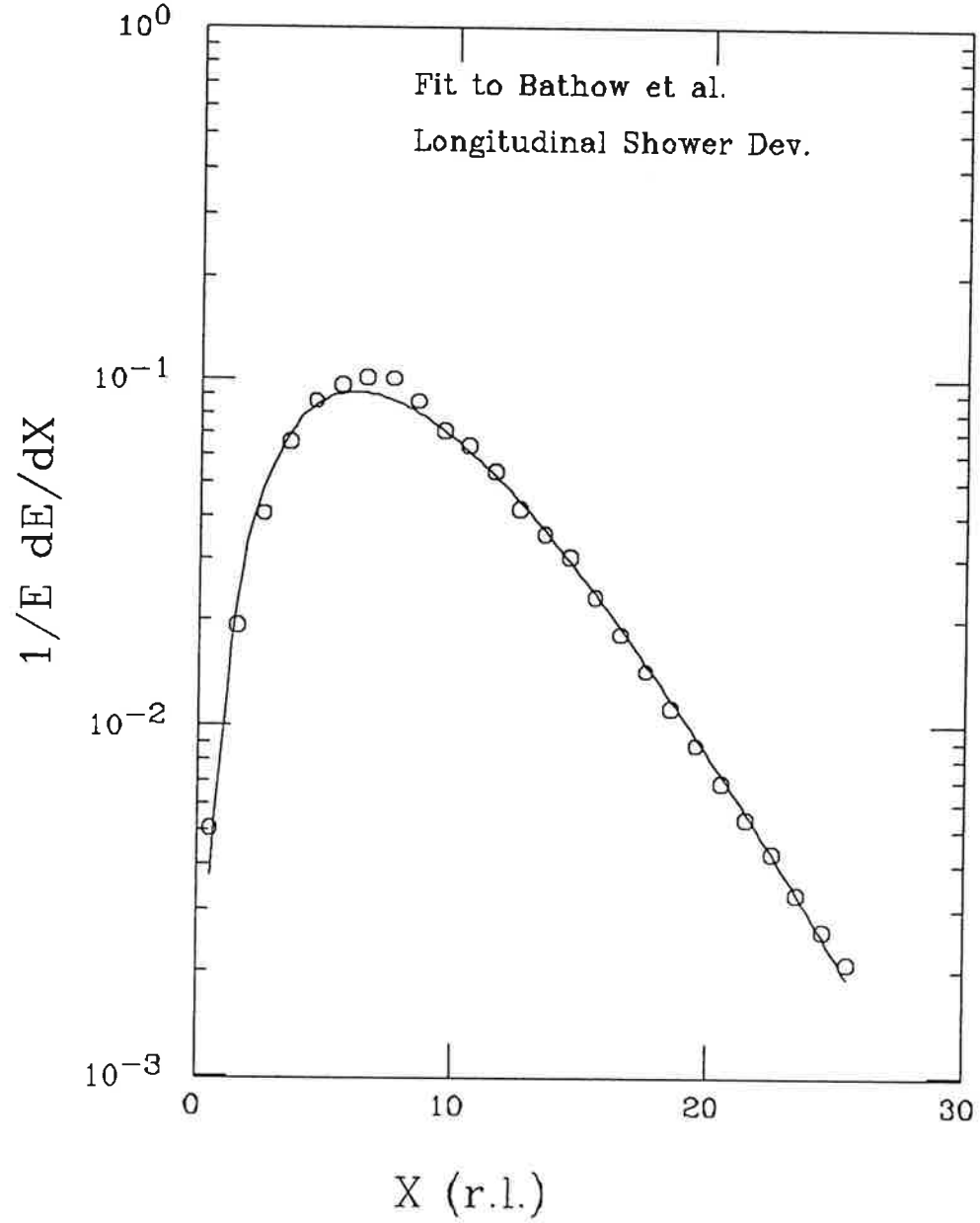
where Θ is angle of incidence between shower axis and detector plane.

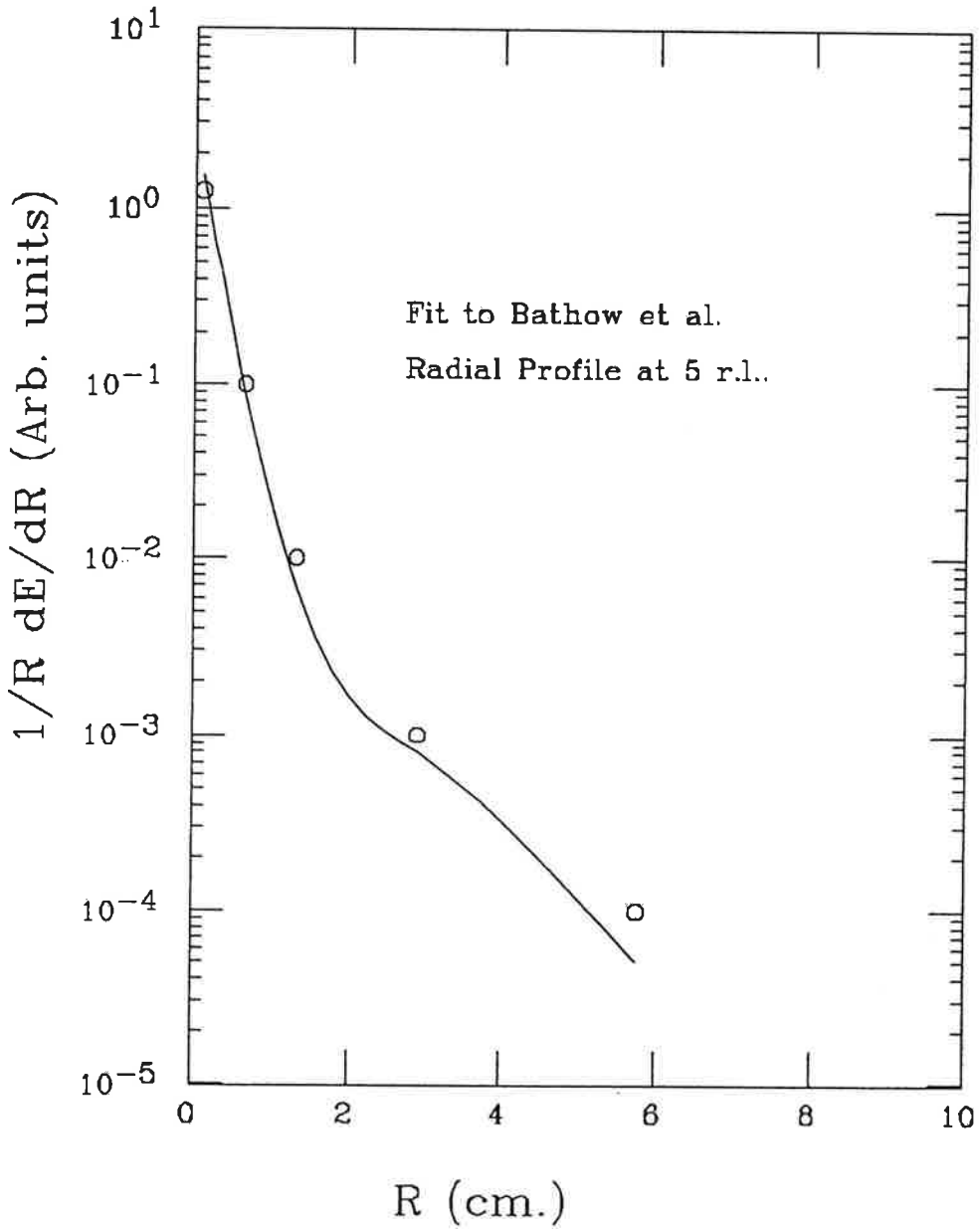
(8) Shower fit parameters at 6 GeV in CDF strip chamber compared with Battiston parameterization (6 GeV points). Here we use

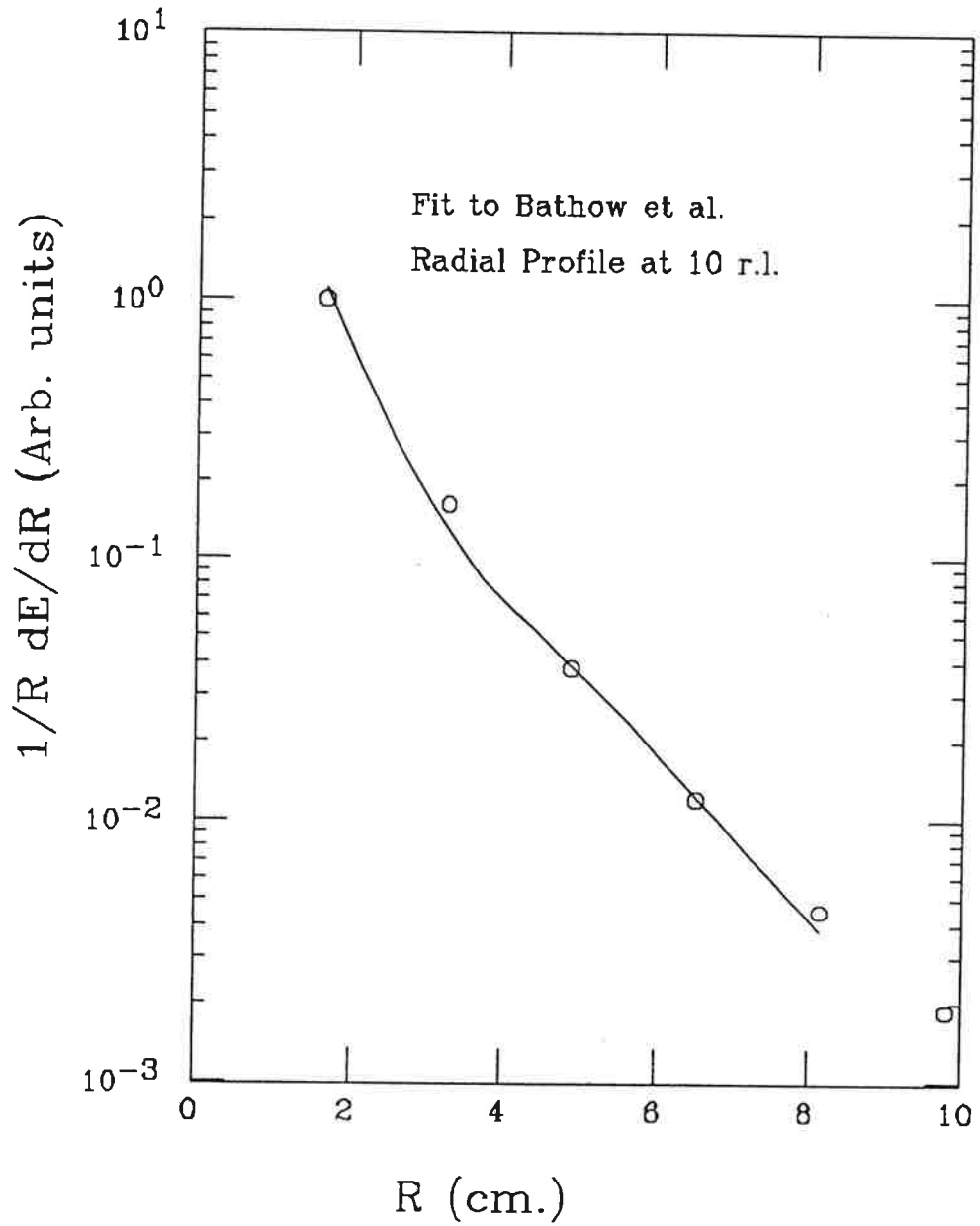
$$I(x) = \frac{0.5}{1+g}\left[e^{-x/b_1} + g\, e^{-x/b_2}\right]$$

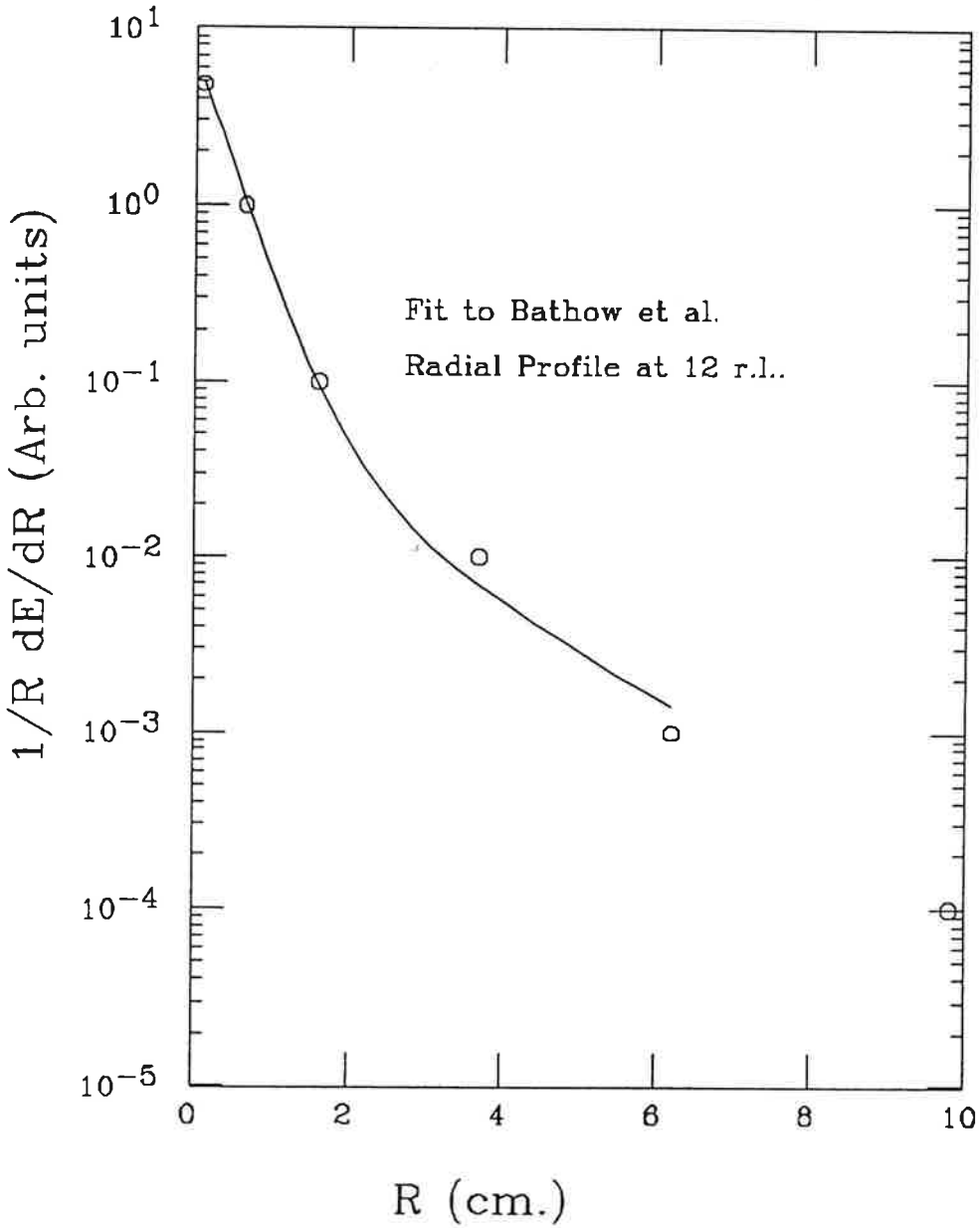
$$\delta I(z) = (a+bz)\, e^{-z/b_3}$$

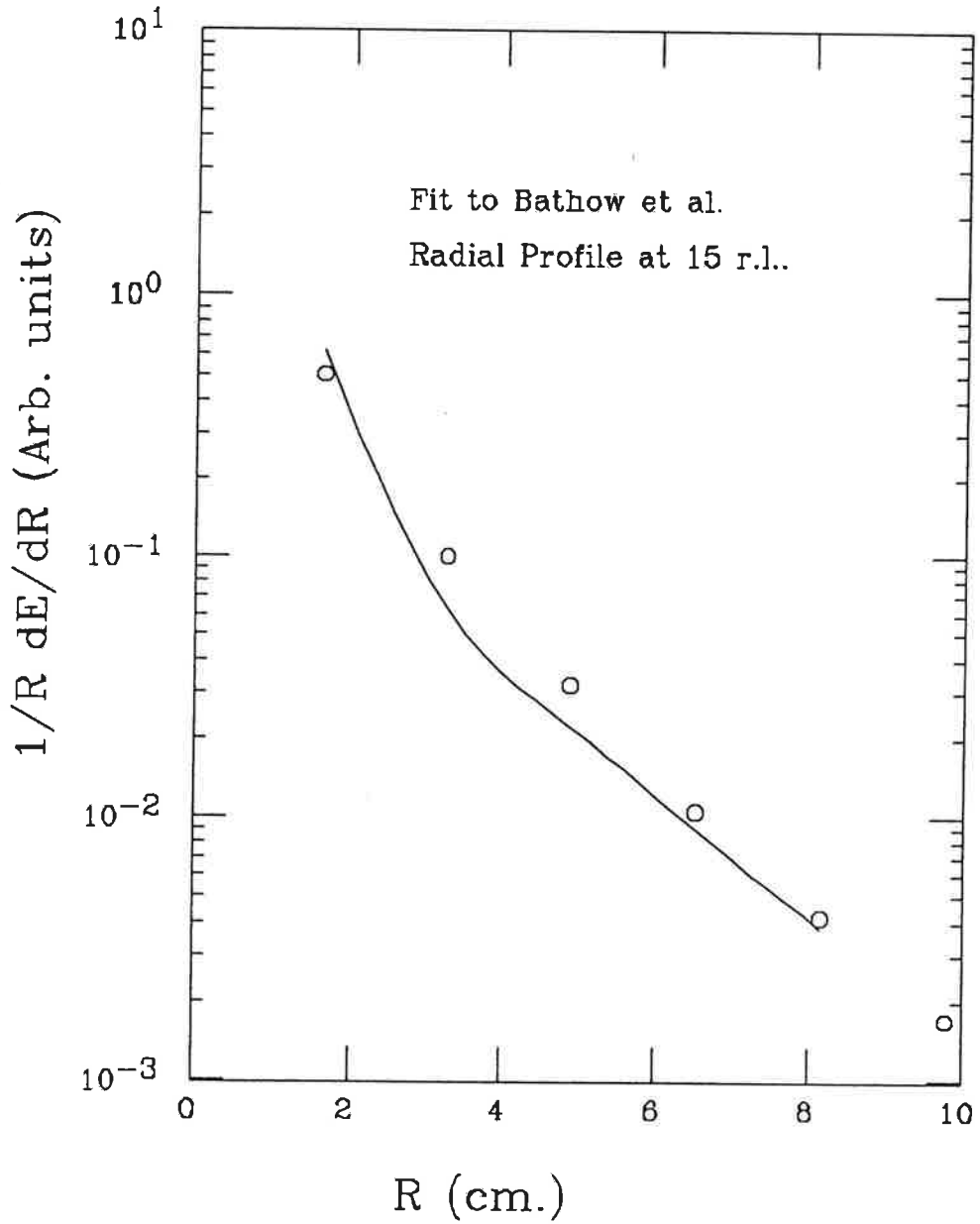
The parameters b_1 and b_2 are shown as open (X), solid (Z) points in Figures 8a, b respectively, and b_3 are shown as stars in 8b. Parameters a (b) are shown as open (solid) in Fig 8c. These data illustrate energy dependence of shower profile at fixed depth compared with 6 GeV point. They do not include (~10%) saturation effects in b_1 at high energies due to detector space-charge effects.

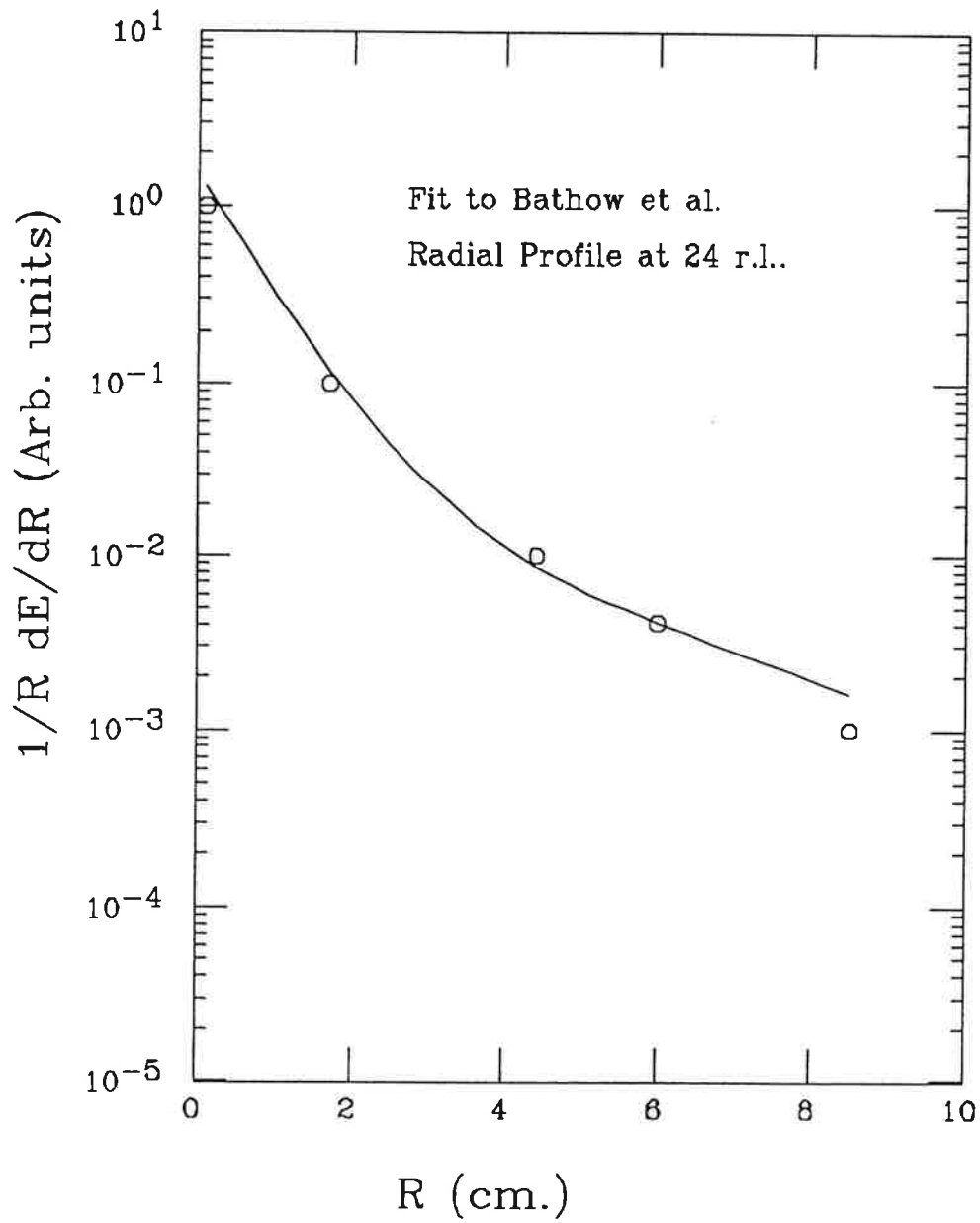

Fit to Bathow et al.
Longitudinal Shower Dev.
10^0
10^{-1}
10^{-2}
10^{-3}
1/E dE/dX
0
10
20
30
X (r.l.)

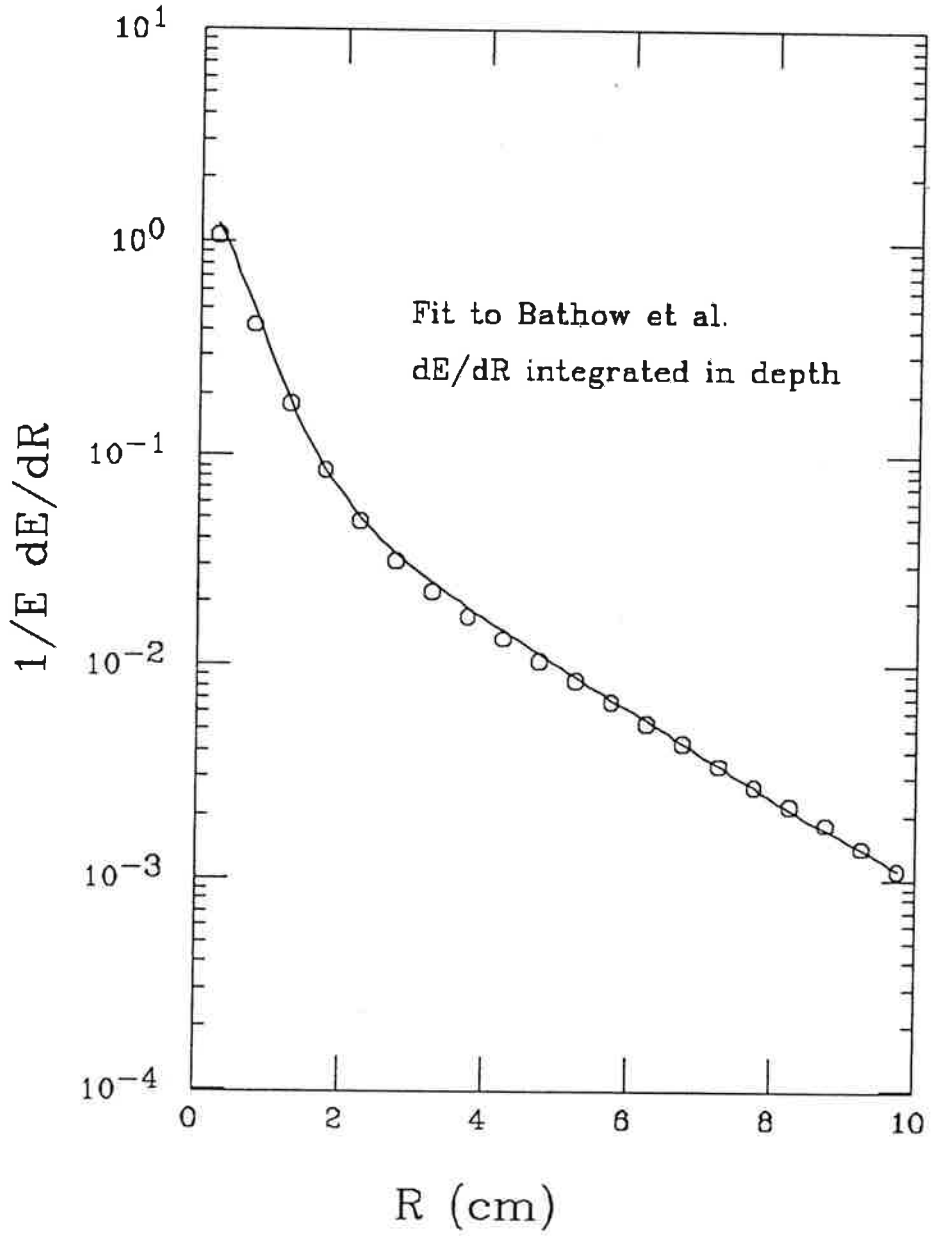

Fit to Bathow et al.
Radial Profile at 5 r.l..
1/R dE/dR (Arb. units)
R (cm.)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
2
4
6
8
10

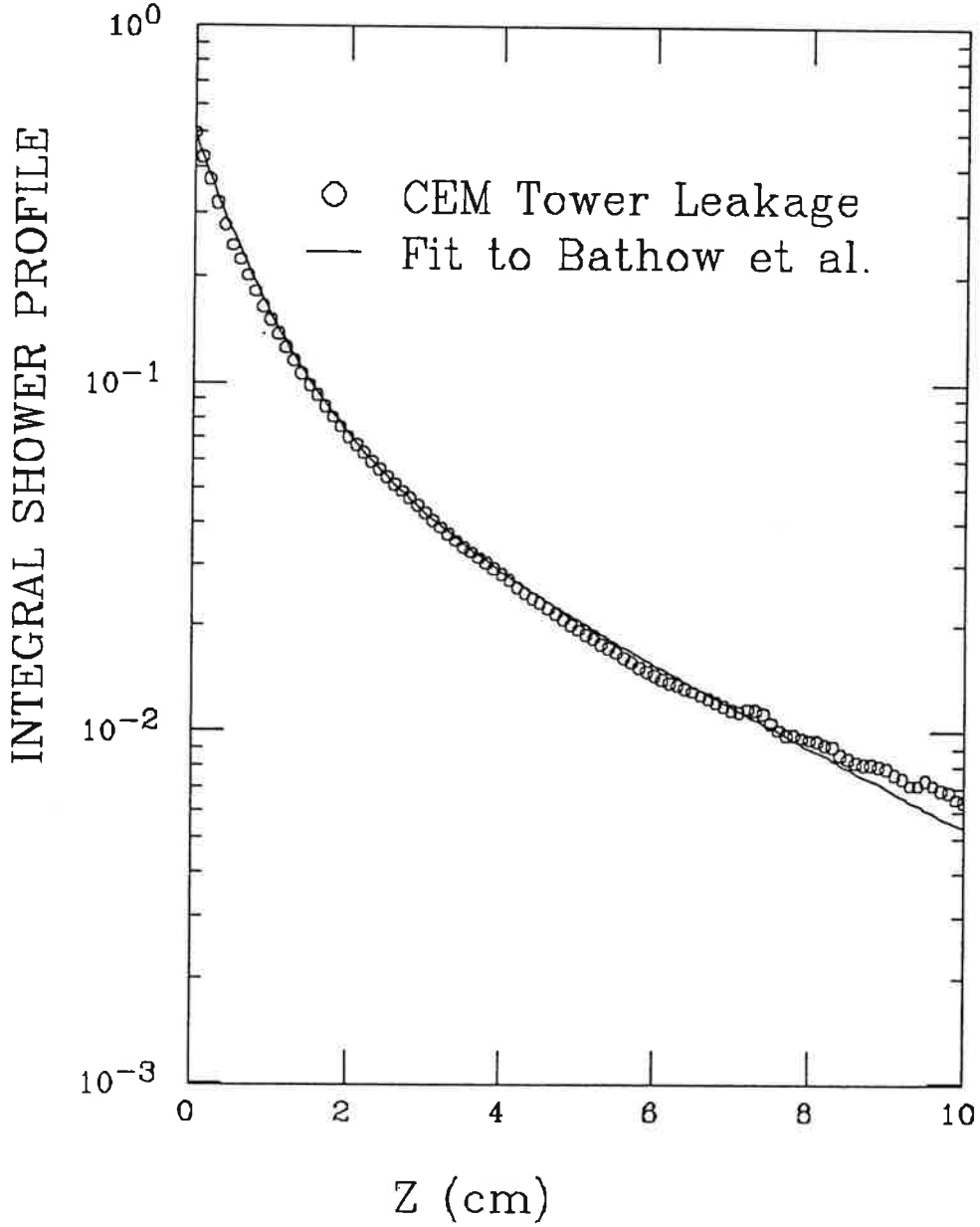

Fit to Bathow et al.
Radial Profile at 10 r.l.
1/R dE/dR (Arb. units)
R (cm.)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
2
4
6
8
10

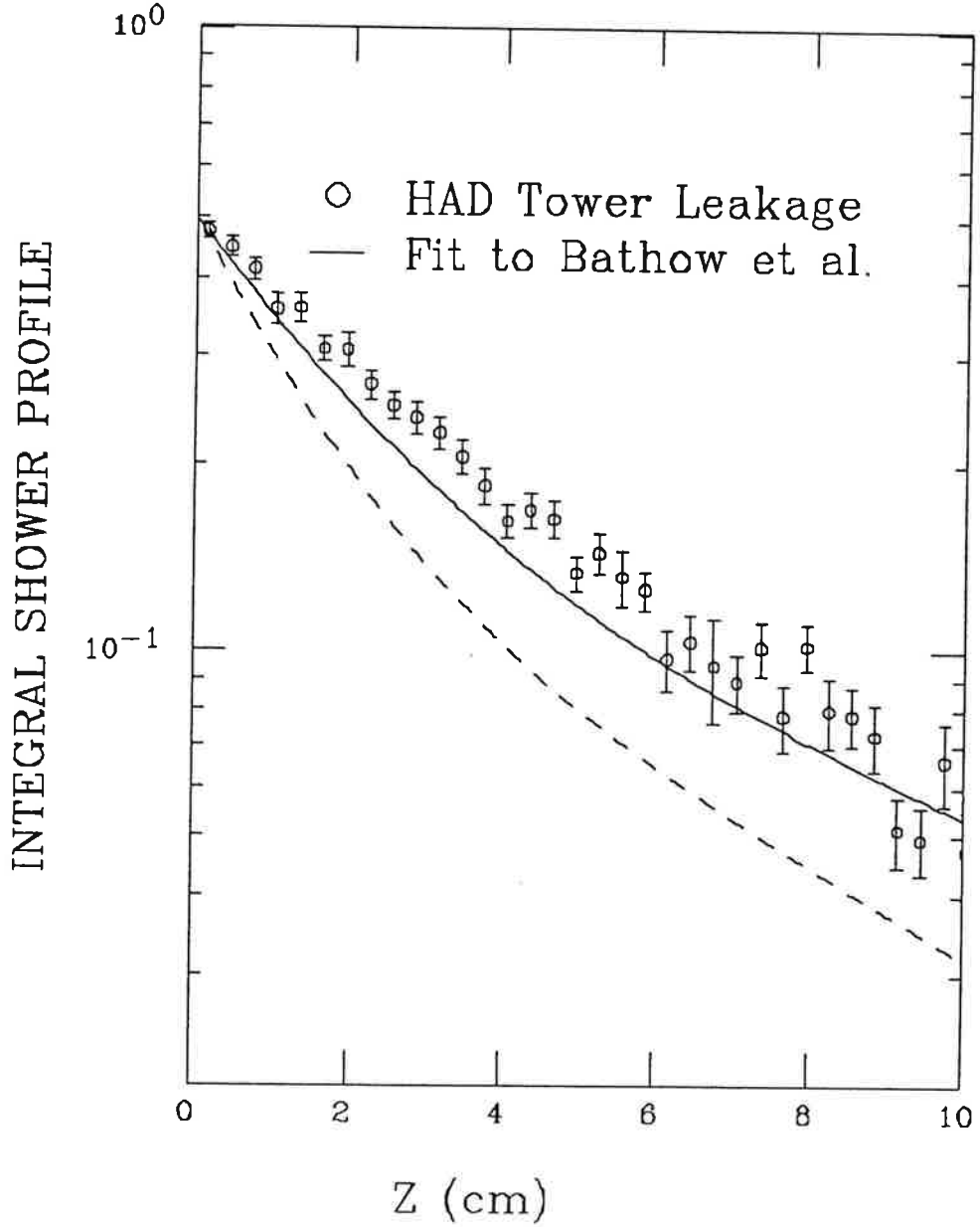

Fit to Bathow et al.
Radial Profile at 12 r.l..
1/R dE/dR (Arb. units)
R (cm.)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
2
4
6
8
10

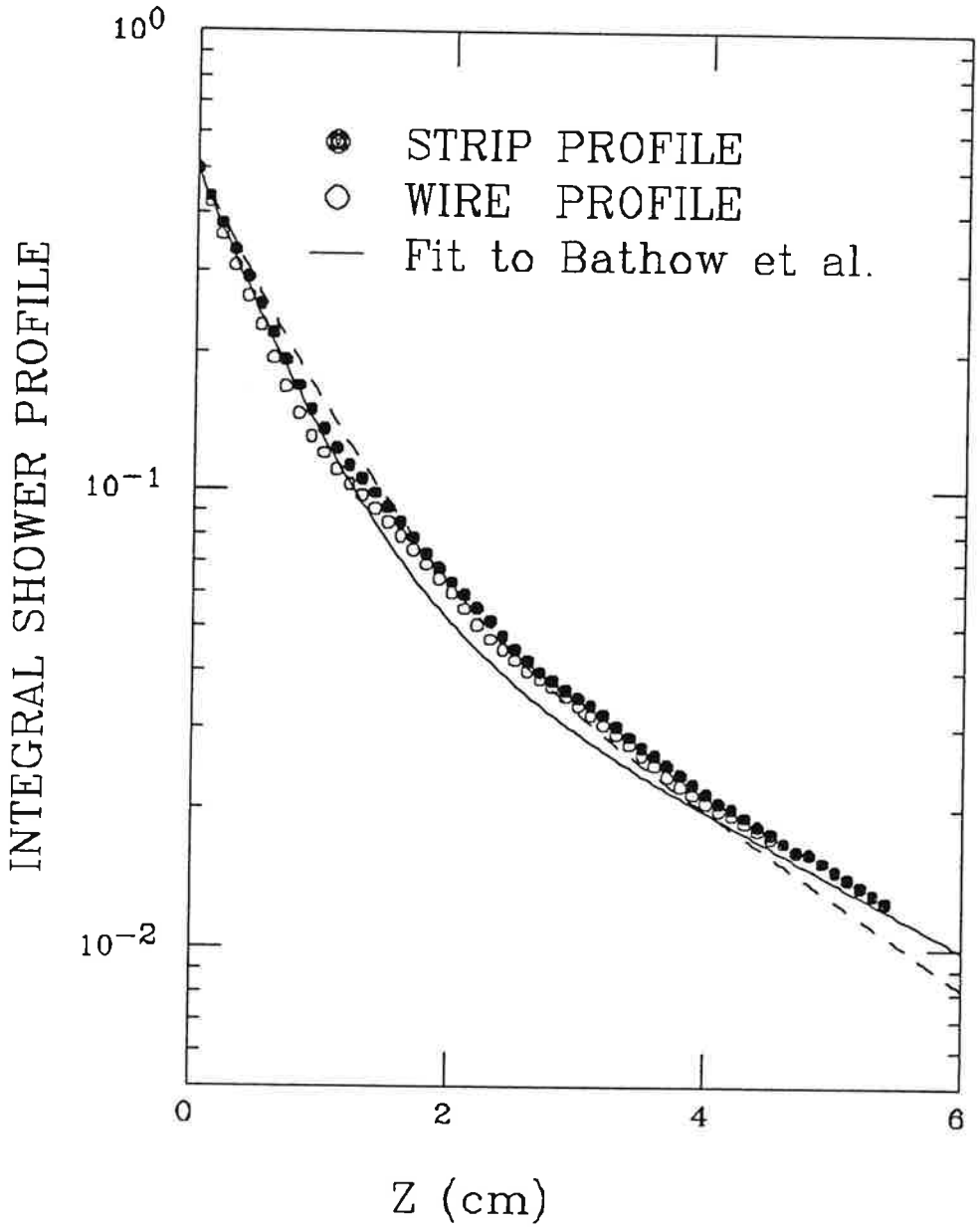

Fit to Bathow et al.
Radial Profile at 15 r.l..
1/R dE/dR (Arb. units)
R (cm.)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
0
2
4
6
8
10


Fit to Bathow et al.
Radial Profile at 24 r.l..
1/R dE/dR (Arb. units)
R (cm.)
10^1
10^0
10^{-1}
10^{-2}
10^{-3}
10^{-4}
10^{-5}
0
2
4
6
8
10

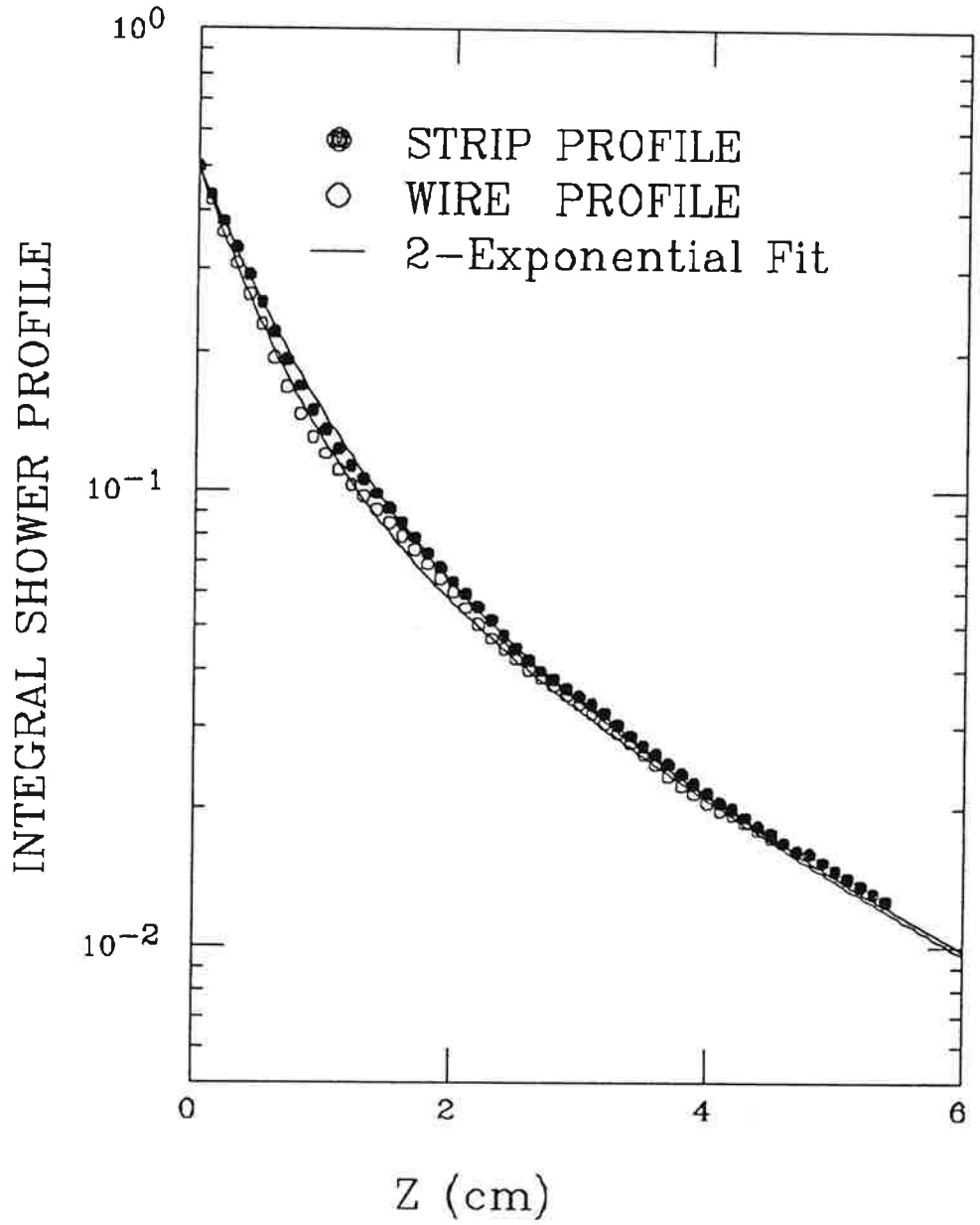

Fit to Bathow et al.
dE/dR integrated in depth
1/E dE/dR
R (cm)
10^{1}
10^{0}
10^{-1}
10^{-2}
10^{-3}
10^{-4}
0
2
4
6
8
10

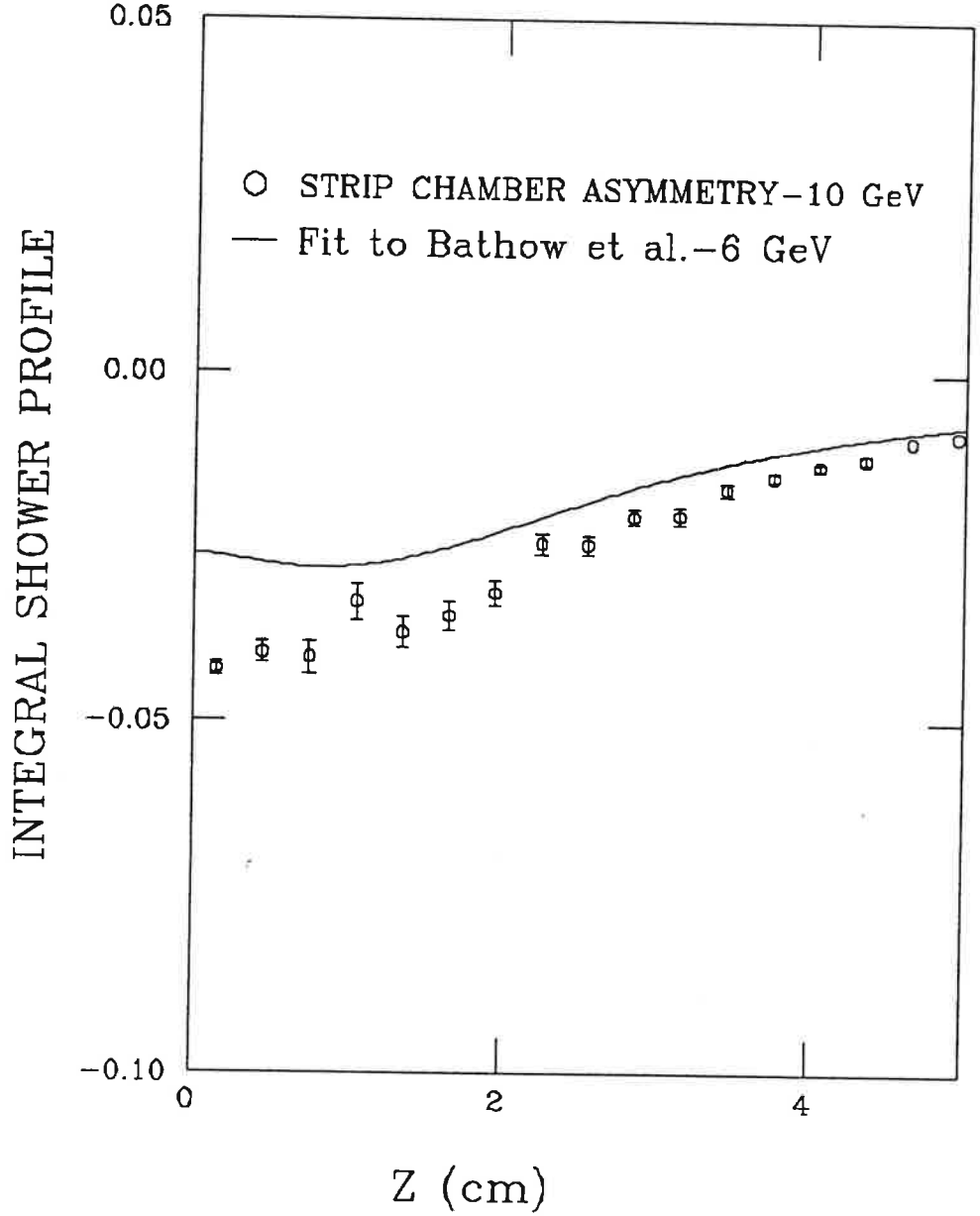

INTEGRAL SHOWER PROFILE
10^0
10^{-1}
10^{-2}
10^{-3}
0
2
4
6
8
10
Z (cm)
CEM Tower Leakage
Fit to Bathow et al.


HAD Tower Leakage
Fit to Bathow et al.
INTEGRAL SHOWER PROFILE
Z (cm)
10^0
10^{-1}
0
2
4
6
8
10

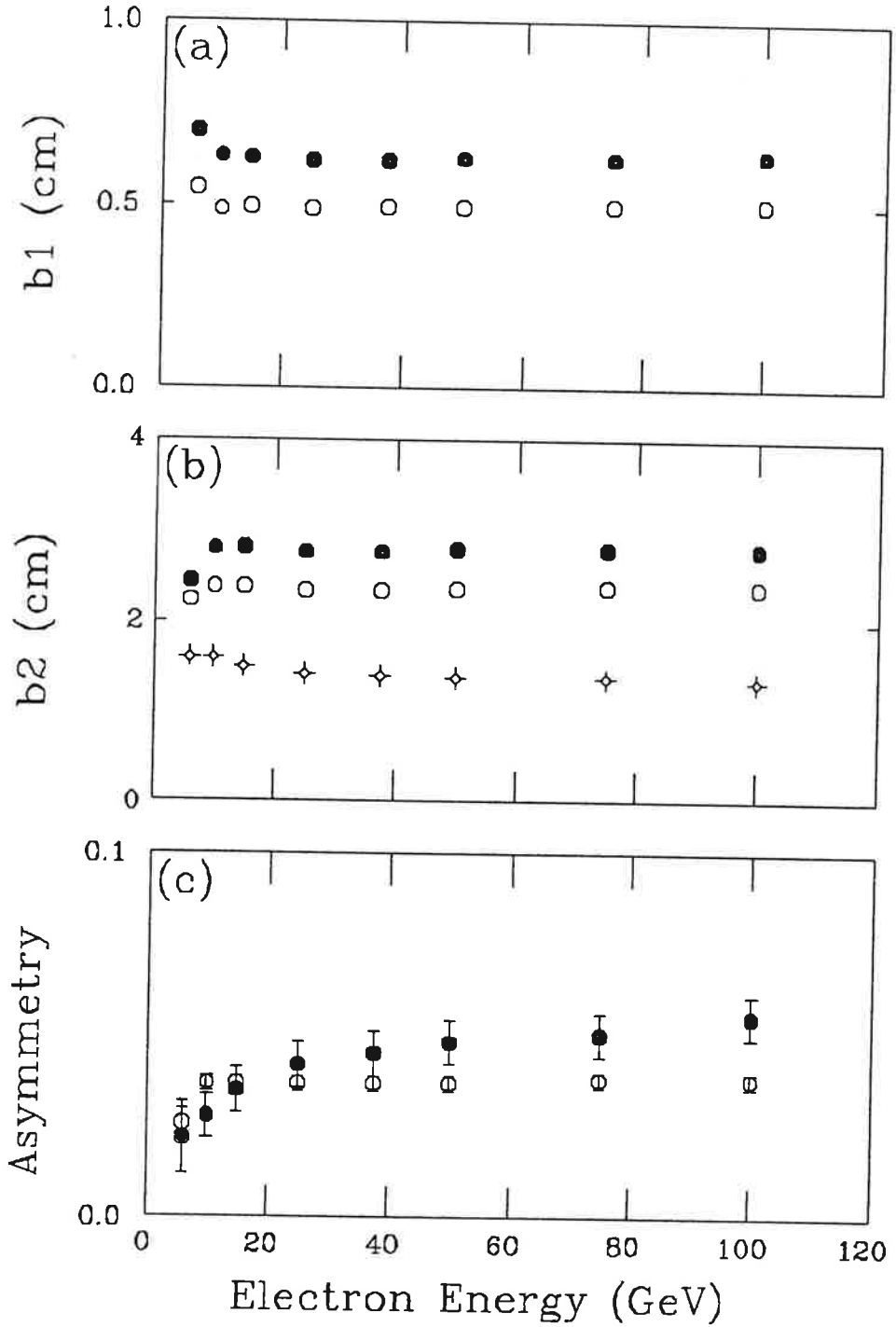

STRIP PROFILE
WIRE PROFILE
Fit to Bathow et al.
INTEGRAL SHOWER PROFILE
10^0
10^{-1}
10^{-2}
0
2
4
6
Z (cm)

6a


STRIP PROFILE
WIRE PROFILE
2-Exponential Fit
INTEGRAL SHOWER PROFILE
10^0
10^{-1}
10^{-2}
0
2
4
6
Z (cm)


STRIP CHAMBER ASYMMETRY–10 GeV
Fit to Bathow et al.–6 GeV
INTEGRAL SHOWER PROFILE
0.05
0.00
−0.05
−0.10
0
2
4
Z (cm)

(2)


(a)
b1 (cm)
1.0
0.5
0.0
(b)
b2 (cm)
4
2
0
(c)
Asymmetry
0.1
0.0
0
20
40
60
80
100
120
Electron Energy (GeV)