Simulation Studies of a Total Absorption Dual Readout Homogeneous Calorimeter

Weekly Progress Report

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Electromagnetic Shower Profile

Longitudinal Profile

Parametrization:
[Longo 1975]

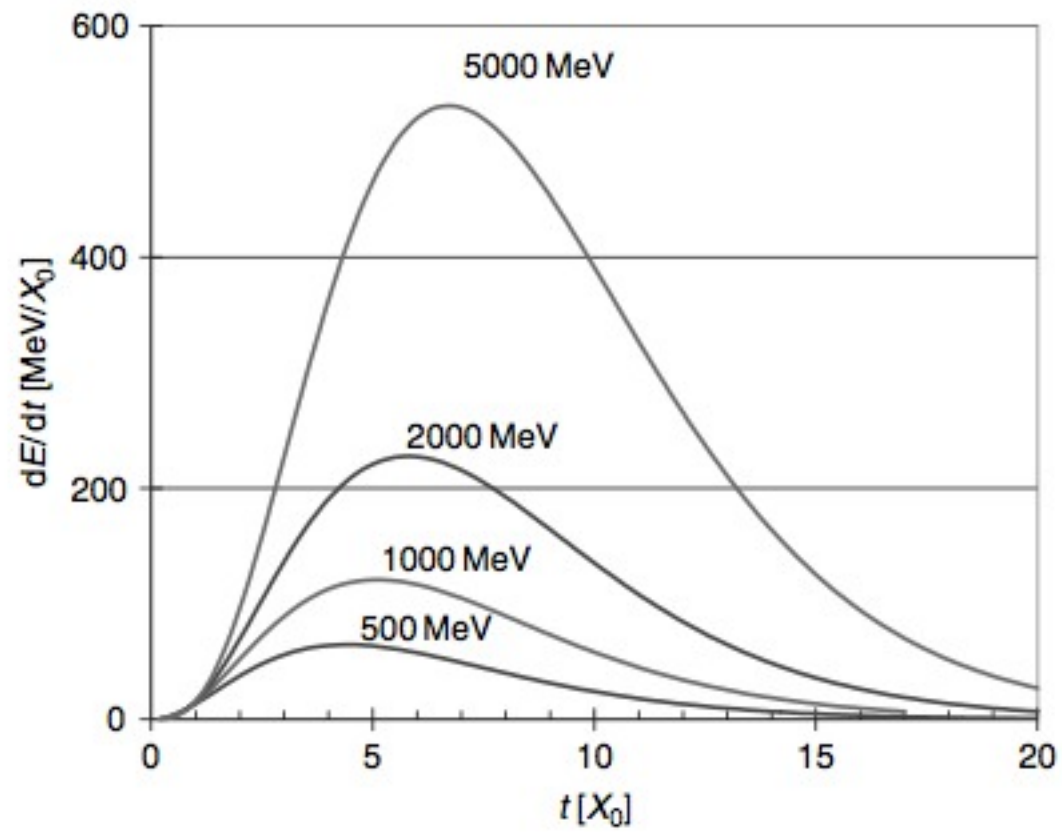
$$\frac{dE}{dt} = E_0 t^{\alpha} e^{-\beta t}$$

where:

α, β : free parameters

t^{α} : at small depth number of secondaries dominates

$e^{-\beta t}$: at larger depth absorption dominates



More exact
[Longo 1985]

$$\frac{dE}{dt} = E_0 \cdot \beta \cdot \frac{(\beta t)^{\alpha-1} e^{-\beta t}}{\Gamma(\alpha)} \rightarrow t_{\max} = \frac{\alpha - 1}{\beta}$$

[Γ: Gamma function]

Numbers for E = 2 GeV (approximate):

$\alpha = 2$, $\beta = 0.5$, $t_{max} = \alpha / \beta$

$\rho = 7.7 g/cm^3$

$X_0 = 0.93 cm$

$R_M = 2.2 cm$

PbF_2 crystal properties

Parametrization function comparison

For a 2.0 GeV electron incident in a lead fluoride homogeneous calorimeter ~ 267 radiation lengths long:

We obtain the em shower profile parameters distribution using:

$$dE/dt = E_0 t^{\alpha} e^{-\beta t}$$

E_0	$2.48 \times 10^5 \pm 547$
α	1.88 ± 0.003
β	0.4247 ± 0.0004
$t_{max}(\alpha/\beta)$	4.4314

0.22% error

Now using

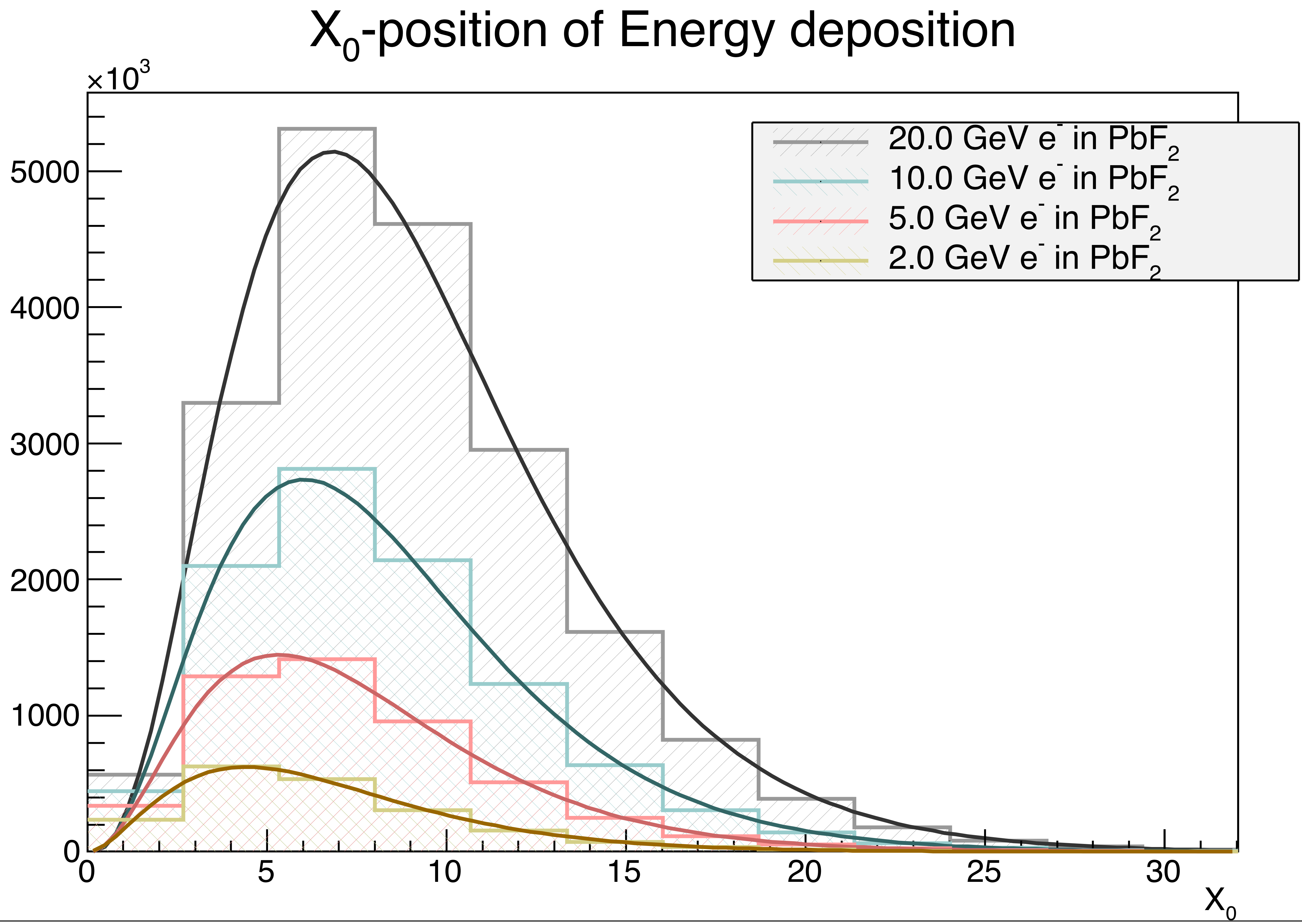
$$dE/dt = E_0 \beta \frac{(\beta t)^{\alpha-1} e^{-\beta t}}{\Gamma(\alpha)}$$

E_0	$5.26 \times 10^6 \pm 3700$
α	2.88 ± 0.003
β	0.4247 ± 0.0004
$t_{max}(\alpha-1/\beta)$	4.4314

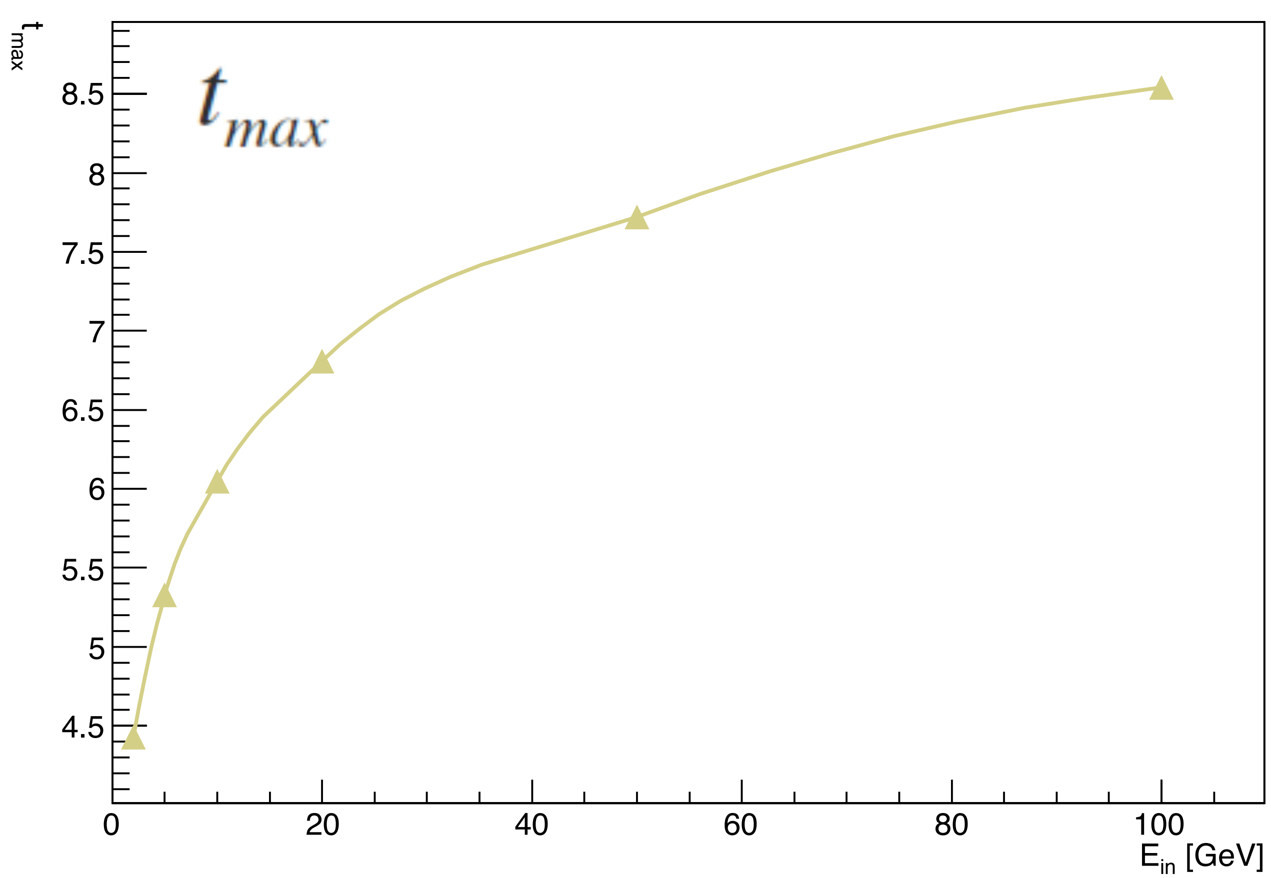
0.07% error

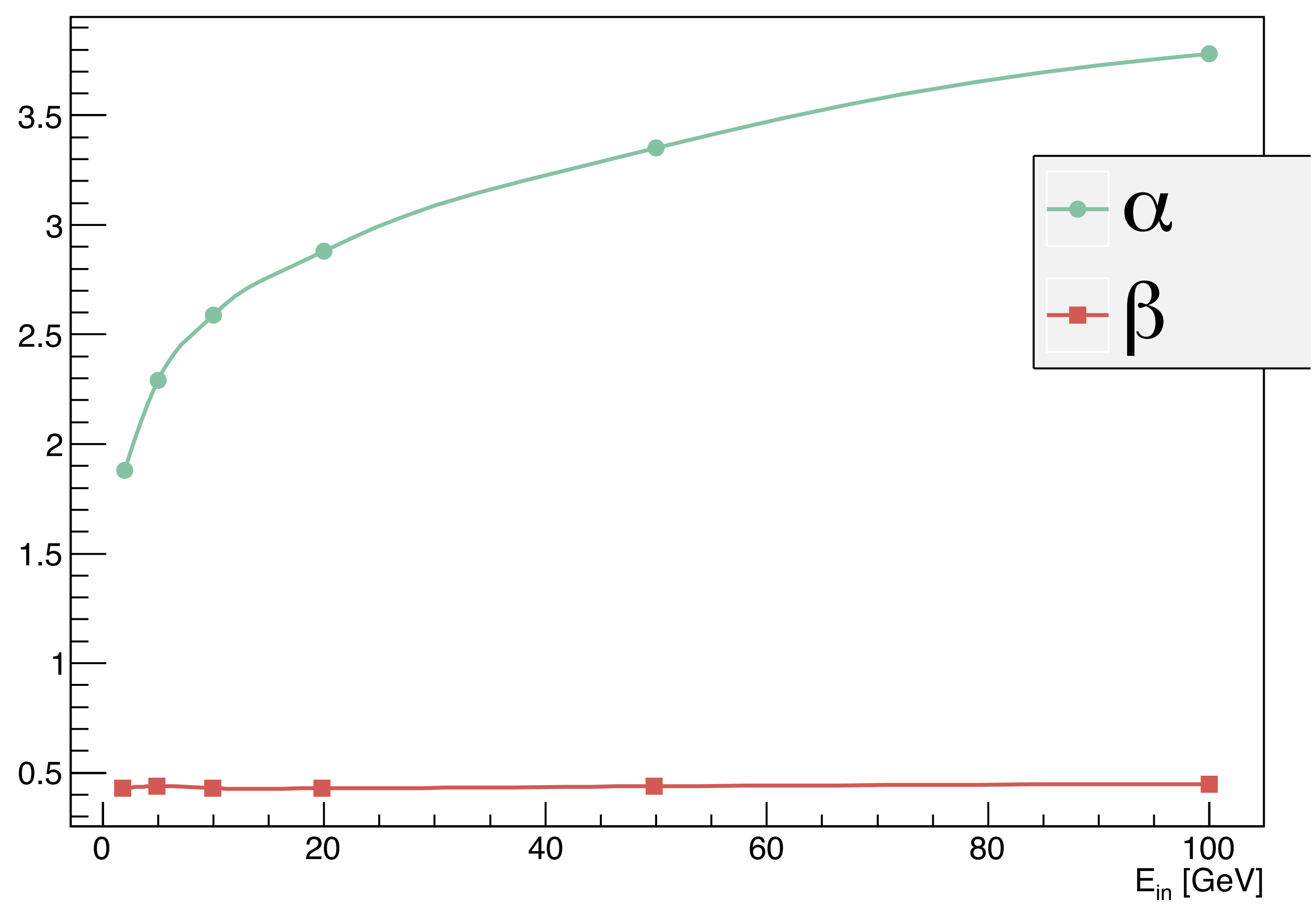
We obtain the same parameter for the number of radiation lengths at which the distribution peaks!

EM Shower Profile for 25 mm cube crystals setup

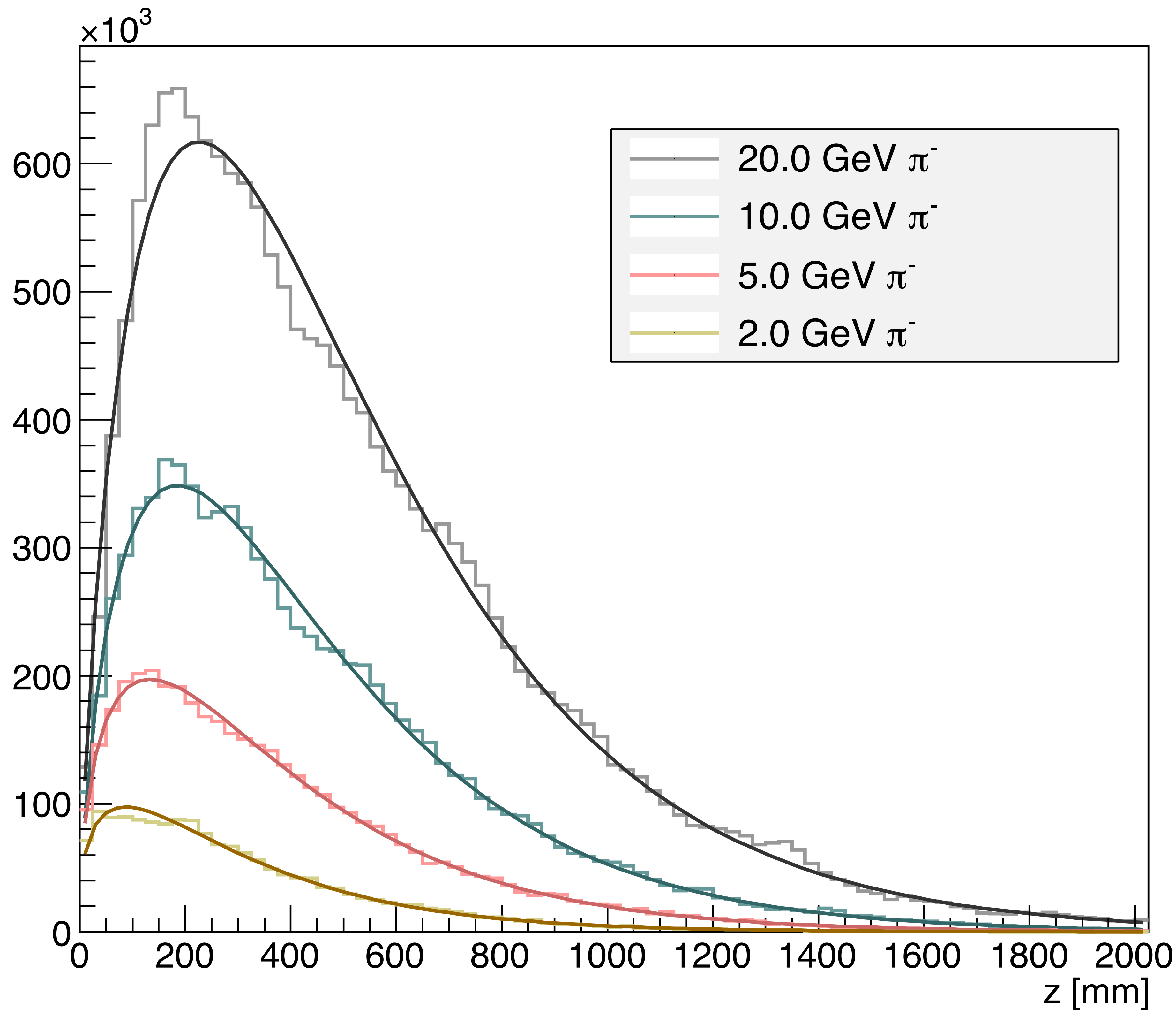


Energy [GeV]	E_0	α	$\Delta\alpha$	β	$\Delta\beta$	$t_{max}(\alpha/\beta)$	Δt_{max}
2.0	$2.48 \times 10^5 \pm 549$	1.88	0.003	0.4247	0.0004	4.43	0.008
5.0	$3.08 \times 10^5 \pm 550$	2.29	0.002	0.4295	0.0003	5.33	0.006
10.0	$3.47 \times 10^5 \pm 531$	2.59	0.001	0.4279	0.0002	6.05	0.004
20.0	$3.67 \times 10^5 \pm 479$	2.88	0.001	0.4231	0.0001	6.81	0.003
50.0	$3.73 \times 10^5 \pm 383$	3.35	0.001	0.4337	0.0001	7.72	0.003
100.0	$3.16 \times 10^5 \pm 275$	3.78	0.001	0.4428	0.0001	8.54	0.003



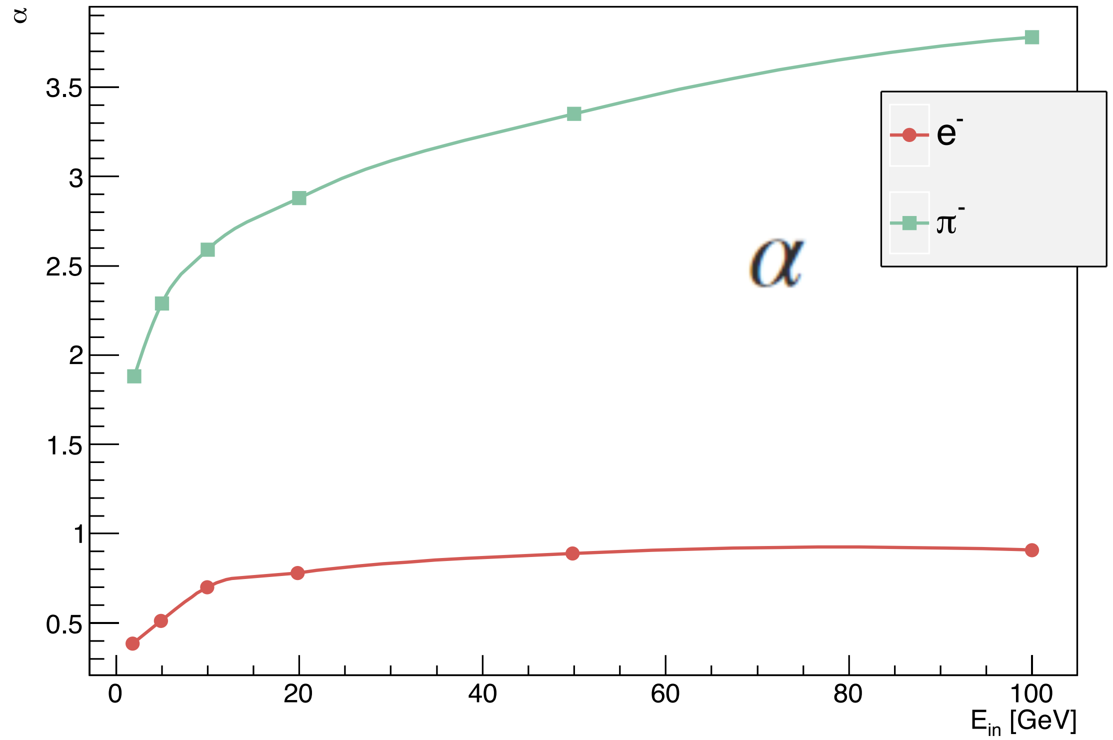


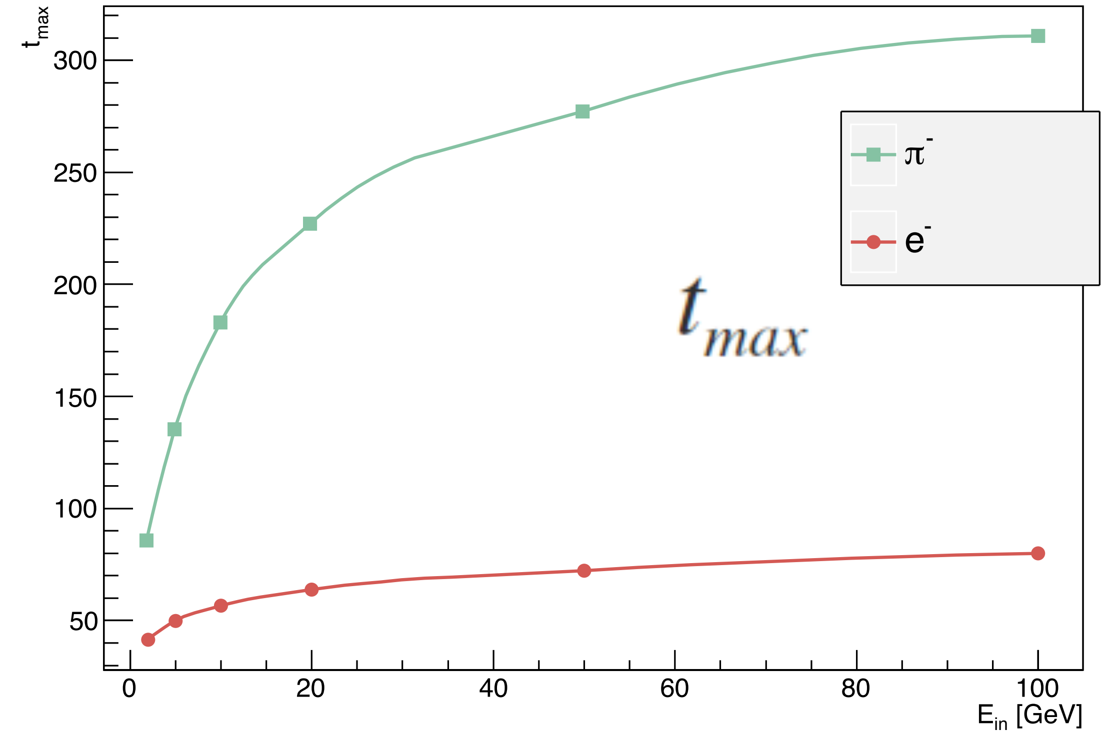
Shower Profile for pi- incident in 25 mm crystal cubes calorimeter

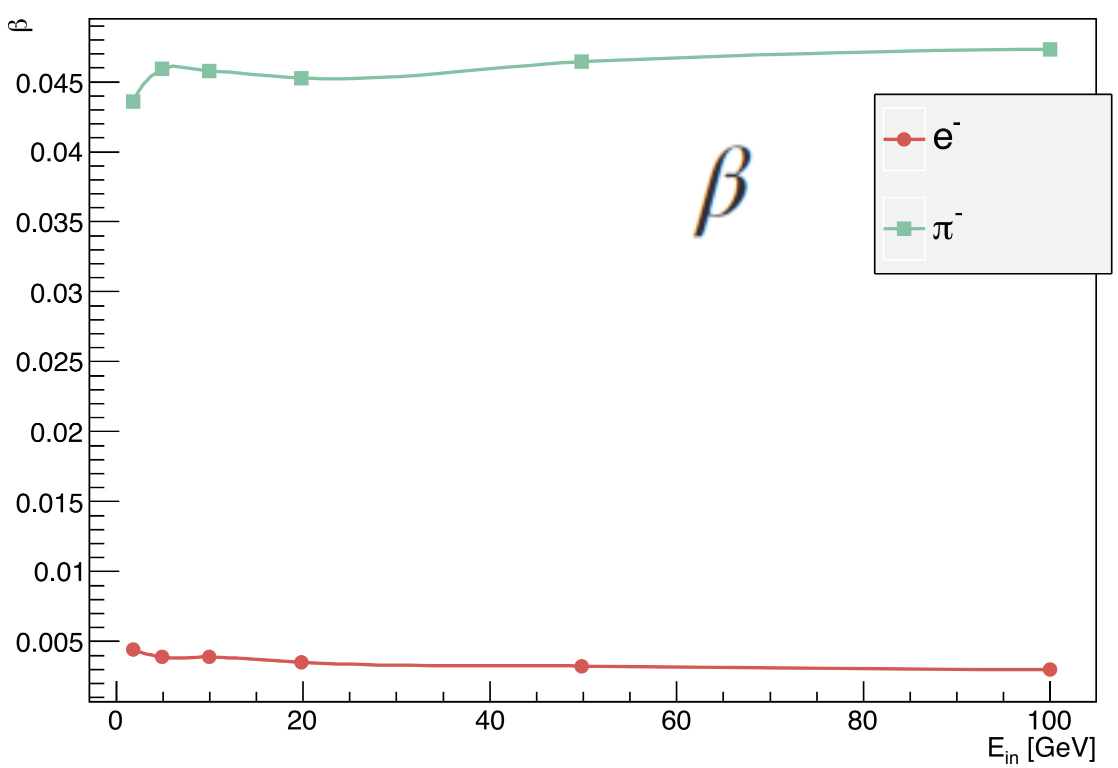


Energy [GeV]	E_0	α	$\Delta\alpha$	β	$\Delta\beta$	$t_{max}(\alpha/\beta)$	Δt_{max}
2.0	$2.65 \times 10^4 \pm 166$	0.3768	0.001	0.0044	0.000005	85.64	0.25
5.0	$2.70 \times 10^4 \pm 120$	0.5111	0.001	0.0038	0.000003	134.5	0.28
10.0	$1.85 \times 10^4 \pm 67$	0.6955	0.0008	0.0038	0.000002	183.03	0.23
20.0	$2.04 \times 10^4 \pm 56$	0.7716	0.0006	0.0034	0.000001	226.94	0.19
50.0	$2.32 \times 10^4 \pm 45$	0.8852	0.0004	0.0032	0.000001	276.63	0.16
100.0	$4.38 \times 10^4 \pm 57$	0.9005	0.0002	0.0029	0.000001	310.52	0.13

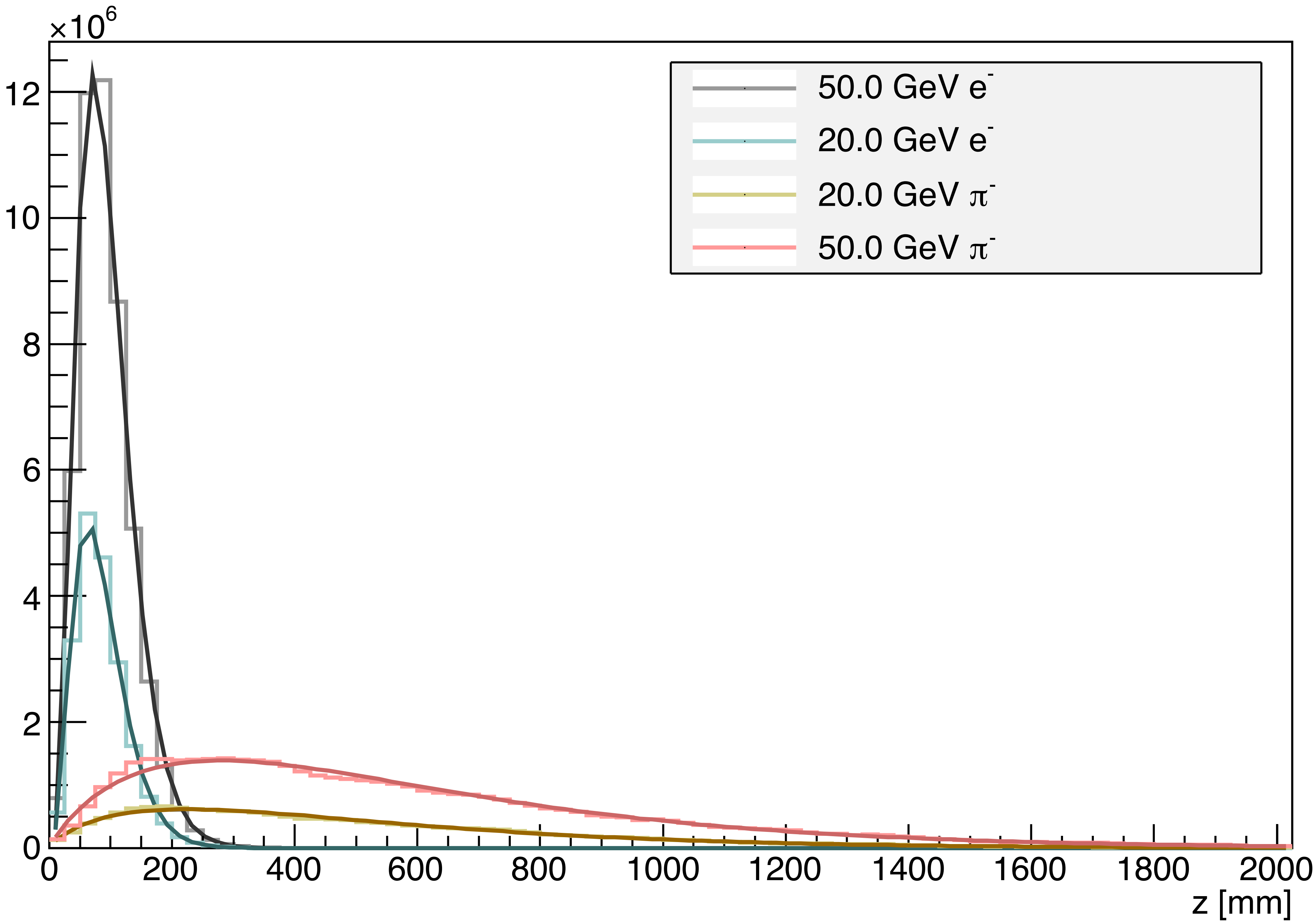
Energy [GeV]	E_0	α	$\Delta\alpha$	β	$\Delta\beta$	$t_{max}(\alpha/\beta)$	Δt_{max}
2.0	3688 ± 28.1	1.88	0.003	0.04356	0.00005	41.45	0.08
5.0	1820 ± 10.4	2.29	0.003	0.04587	0.00003	49.92	0.05
10.0	1068 ± 4.9	2.59	0.001	0.0457	0.00001	56.67	0.03
20.0	585.2 ± 2.2	2.88	0.001	0.04519	0.00001	63.73	0.03
50.0	208.8 ± 0.6	3.35	0.001	0.04632	0.00001	72.32	0.03
100.0	68.04 ± 0.2	3.78	0.001	0.04729	0.00001	79.93	0.03


α
3.5
3
2.5
2
1.5
1
0.5
0
20
40
60
80
100
E_in [GeV]
e-
π-
α

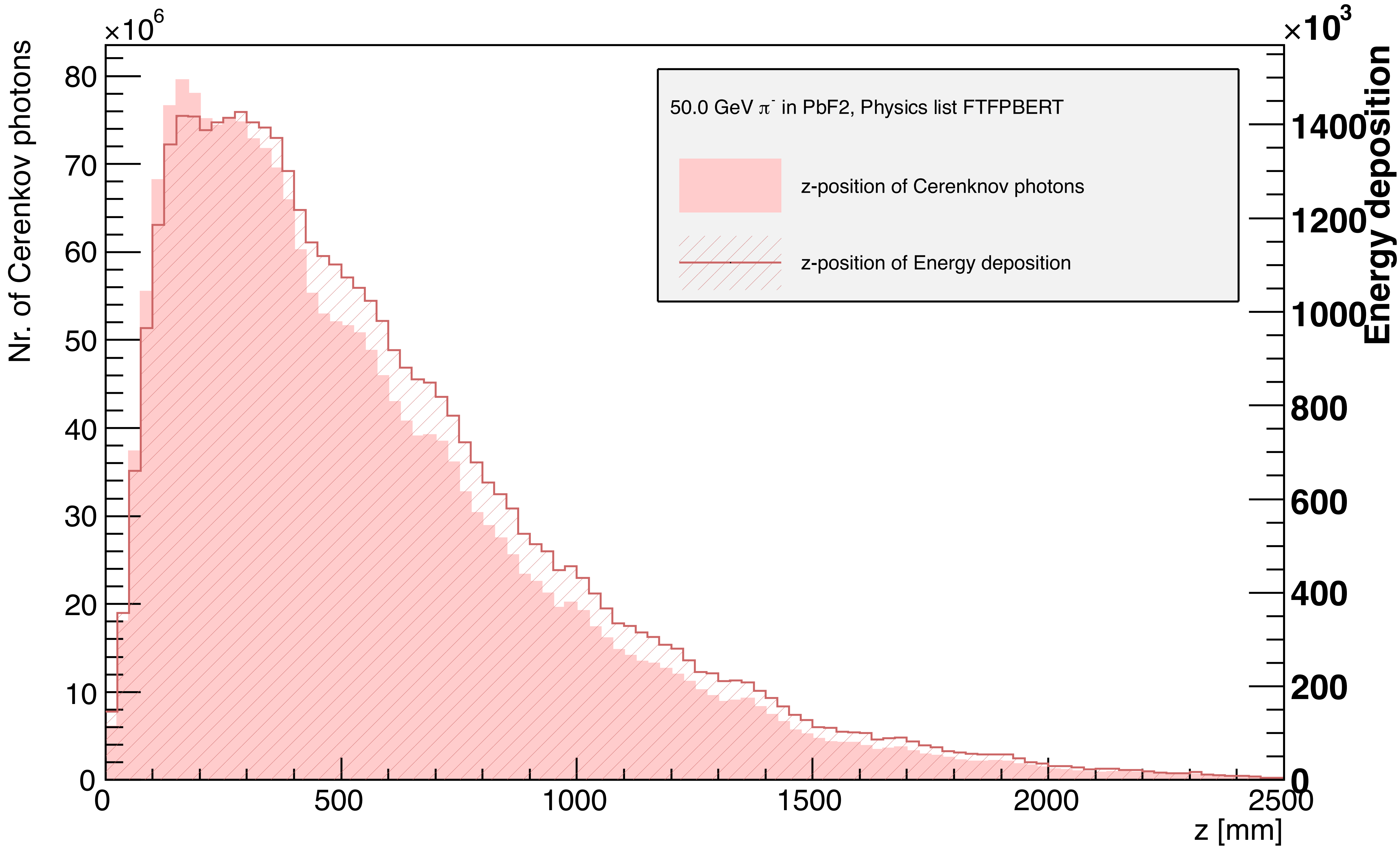

t_max
300
250
200
150
100
50
0
20
40
60
80
100
E_in [GeV]
π-
e-
t_max


β
0.045
0.04
0.035
0.03
0.025
0.02
0.015
0.01
0.005
0
20
40
60
80
100
E_in [GeV]
e-
π-
β

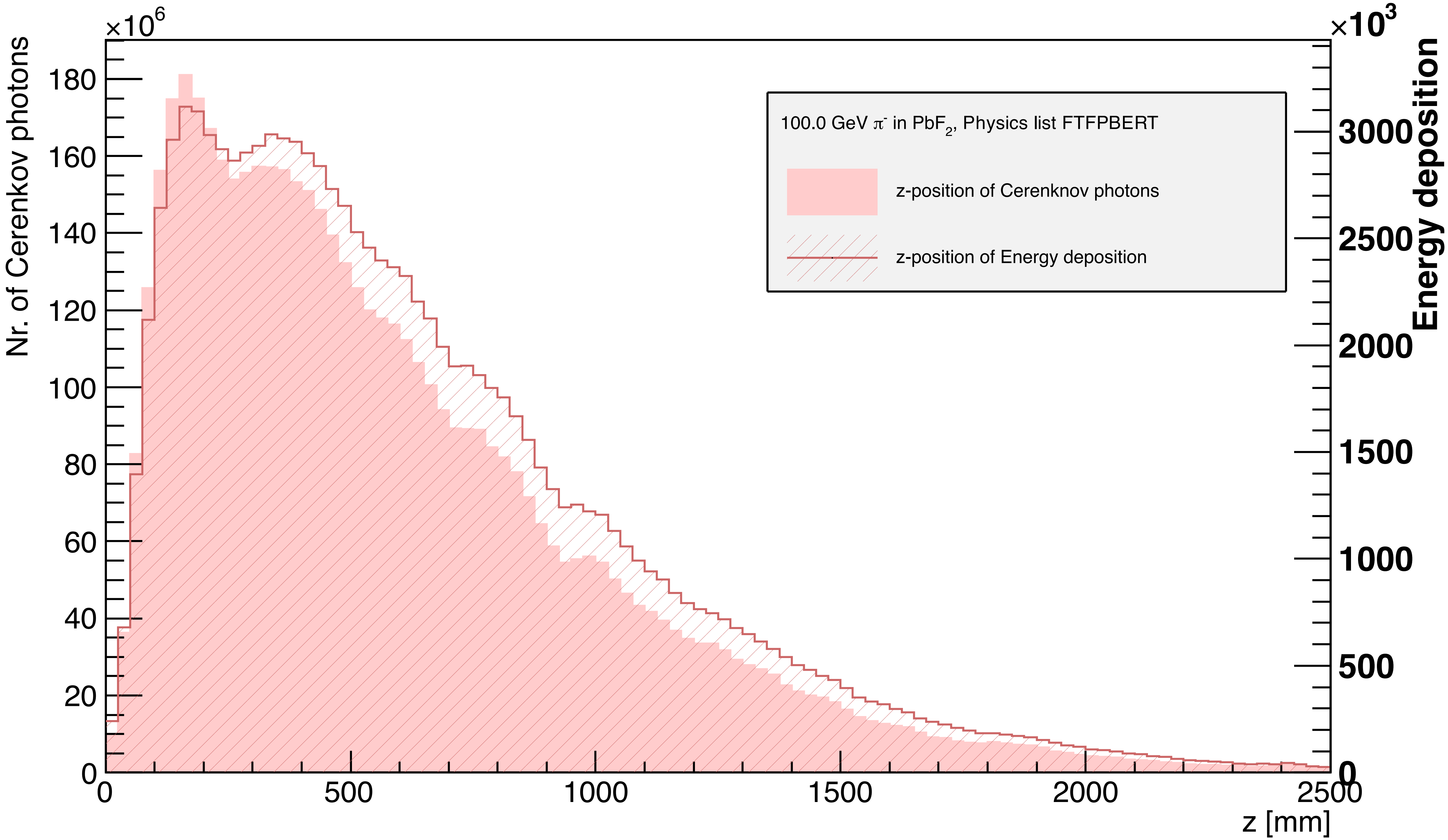
Longitudinal Shower Profile as a function of Depth z for electrons and charged pions.



Cherenkov & Scintillation response



Cherenkov & Scintillation response



Cherenkov & Scintillation response