Gain, Geant4

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Shot Muon into scintillator with 2 GeV/c

- Determine the volume of the scintillator at $1cm^3$
- Energy unit is MeV
- Length unit is cm
- Use table 2.1 in Techniques for Nuclear and Particle Physics Experiments

Bethe-Bloch formula

- $-\frac{dE}{dx} = 2\pi N_a r_e^2 m_e c^2 \rho \frac{Z}{A}\frac{z^2}{\beta^2}\left[\ln\left(\frac{2m_e\gamma^2 v^2 W_{max}}{I^2}\right) - 2\beta^2 - \delta - 2\frac{C}{Z}\right]$
- r_e : $classical\ electron$
- m_e : $electron\ mass$
- N_a : $Avogadro's\ number$
- I : $mean\ excitation\ potential$
- Z : $atomic\ number\ of\ absorbing\ material$
- A : $atomic\ weight\ of\ absorbing\ material$
- ρ : $density\ of\ absorbing\ material$

- $z : charge\ of\ incident\ particle\ in\ units\ of\ e$
- $\beta = \frac{v}{c}\ of\ the\ incident\ particle$
- $\gamma = \frac{1}{\sqrt{1-\beta^2}}$
- $\delta : density\ corrention$
- $C : shell\ correnction$
- $W_{max} : maximum\ energy\ transfer\ in\ a\ single\ collision$
- $I = 64.7 * 10^{-6}$
- $C_0 = -3.2$
- $a = 0.1610$
- $X_1 = 2.49,\ X_0 = 0.1464$
- $m = 3.24$
- $\eta = \beta\gamma$

- $W_{max} \cong 2m_e c^2 \eta^2 \quad (\because M >> m_e) \quad = 364.234$
- $\delta = 4.6052X + C_0 + a(X_1 - X)^m \quad (\because X_0 < X < X_1), \; X = 1.27596$
- $p = \frac{mv}{\sqrt{1-\frac{v^2}{c}}} \qquad \therefore v = 0.9986c$
- $Z_{eff} = \sum a_i Z_i \; = 33.1$
- $A_{eff} = \sum a_i A_i = 61.5429$

- $-\frac{dE}{dx}$ =2.22579

MySimVer1.mac

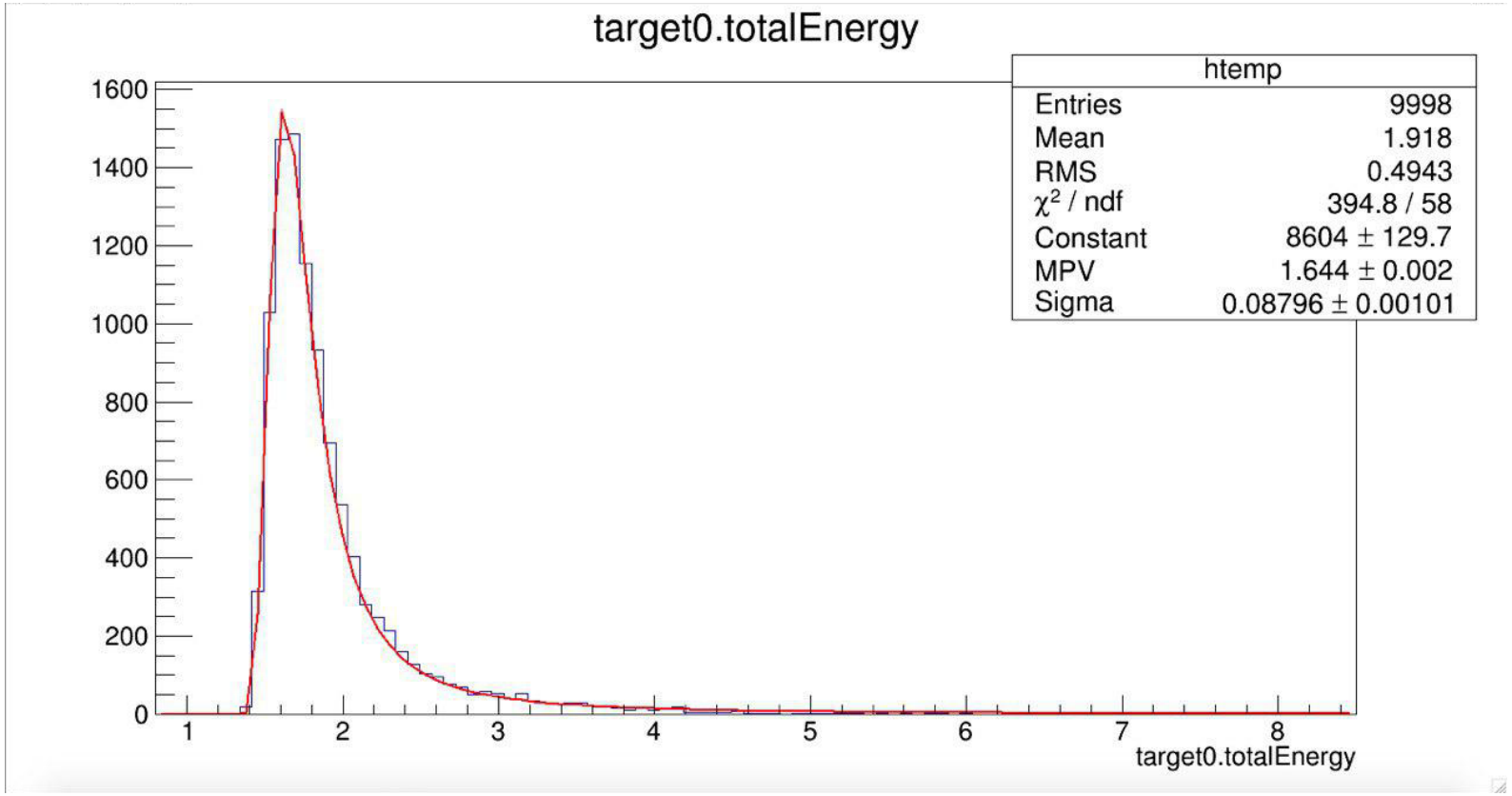
- /GsimPhysicsListFactory/QGSP_BERT/buildAndRegister
- /GsimPrimaryGeneratorActionFactory/GsimGeneralParticleSource/buildAndRegister gps
- /gps/particle mu-
- /gps/energy 2.0028 GeV
- /gps/position 0 0 -1.507 m
- /GsimDetector/world/e14/target0/setParameters 50 50*mm 10*mm
- /GsimDetector/world/e14/target0/setOuterMaterial G4_PLASTIC_SC_VINYLTOLUENE

/run/beamOn 10000

Detector’s elements

- G4_PLASTIC_SC_VINYLTOLUENE
- Density: 1.032 (g/cm^3)
- H: 10
- C: 9
- I: 64.7 (eV)

Myout_PLASTIC_SC_VINYLTOUENE.root



Calculation value & Simulation value

- Calculationvalue : $-\frac{dE}{dx}$ =2.22579
- Simulation value : 1.644

Why?

Calculation

- Z = 33.31
- I = 355(eV)

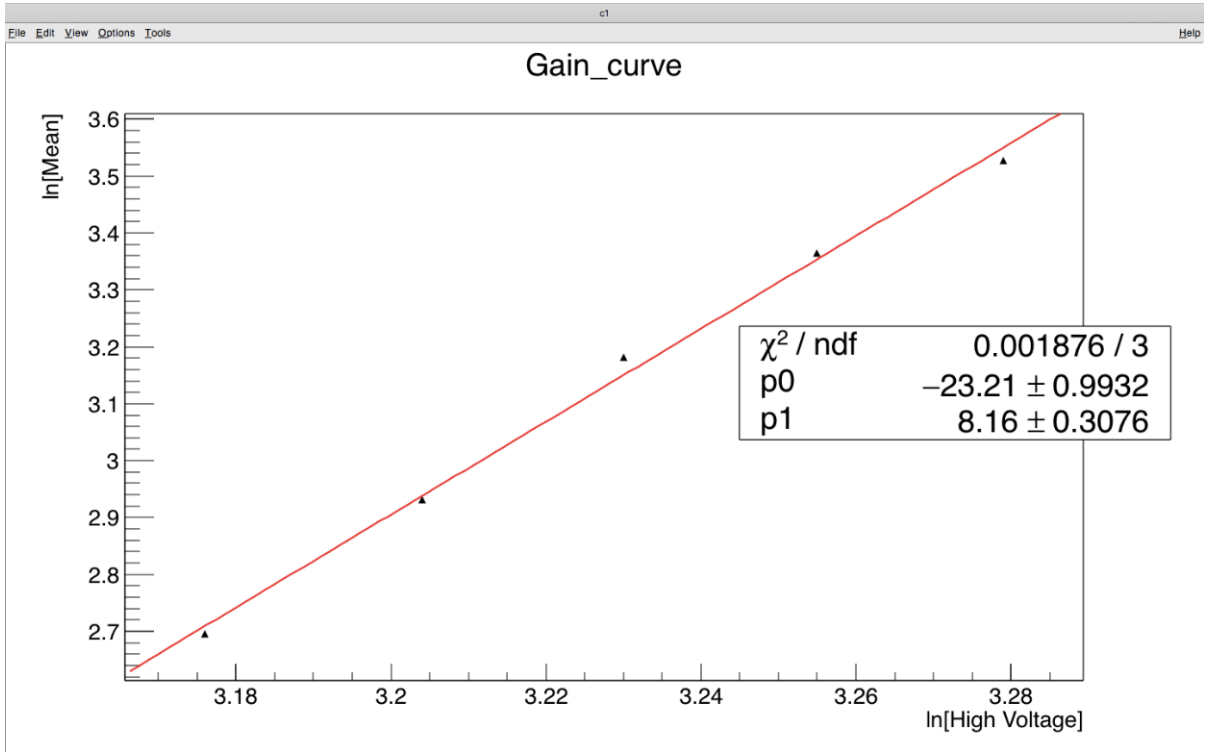
simulation

- I = 64.7(eV)
- Z=?
- I/Z=12+7/Z (Z<13)
- $I/Z=9.76+58.8Z^{-1.19}$ ($Z \geq 13$)

Gain curve

```
4     const int n_points = 5;
5     double x_vals[n_points] = {3.176,3.204,3.230,3.255,3.279};
6     double y_vals[n_points] = {2.696,2.932,3.182,3.362,3.527};
7  // double y_errs[n_points] = {0.418,0.684,1.18,1.68,2.26};
8  // double y_errs[n_points] = {-0.379,-0.165,0.0719,0.0225,0.354};
auto f  = new TGraphErrors(n_points,x_vals,y_vals,nullptr,y_errs);
13        f->SetTitle("Gain_curve");
14        f->GetXaxis()->SetTitle("ln[High Voltage]");
15        f->GetYaxis()->SetTitle("ln[Mean]");
20 auto g = new TF1("gain_curve","[0] + [1]*x",2,3);
              f->Fit(g);
26 f->SetMarkerStyle(22);
27 f->Draw("AP");
```

Gain curve



- $\mu = A * V^{kn}$
- $V: supply\ voltage$
- $n:\ of\ dynodes$
- $A: const$
- $\frac{\mu_1}{\mu_2} = (\frac{V_1}{V_2})^{kn}$
- $kn: slope\ of\ the\ straight\ line$, graph of $\ln(mean) - \ln(V)$

- kn=8.153