Reconstruction of E resolution from mixture structure with single particle simulation of G4

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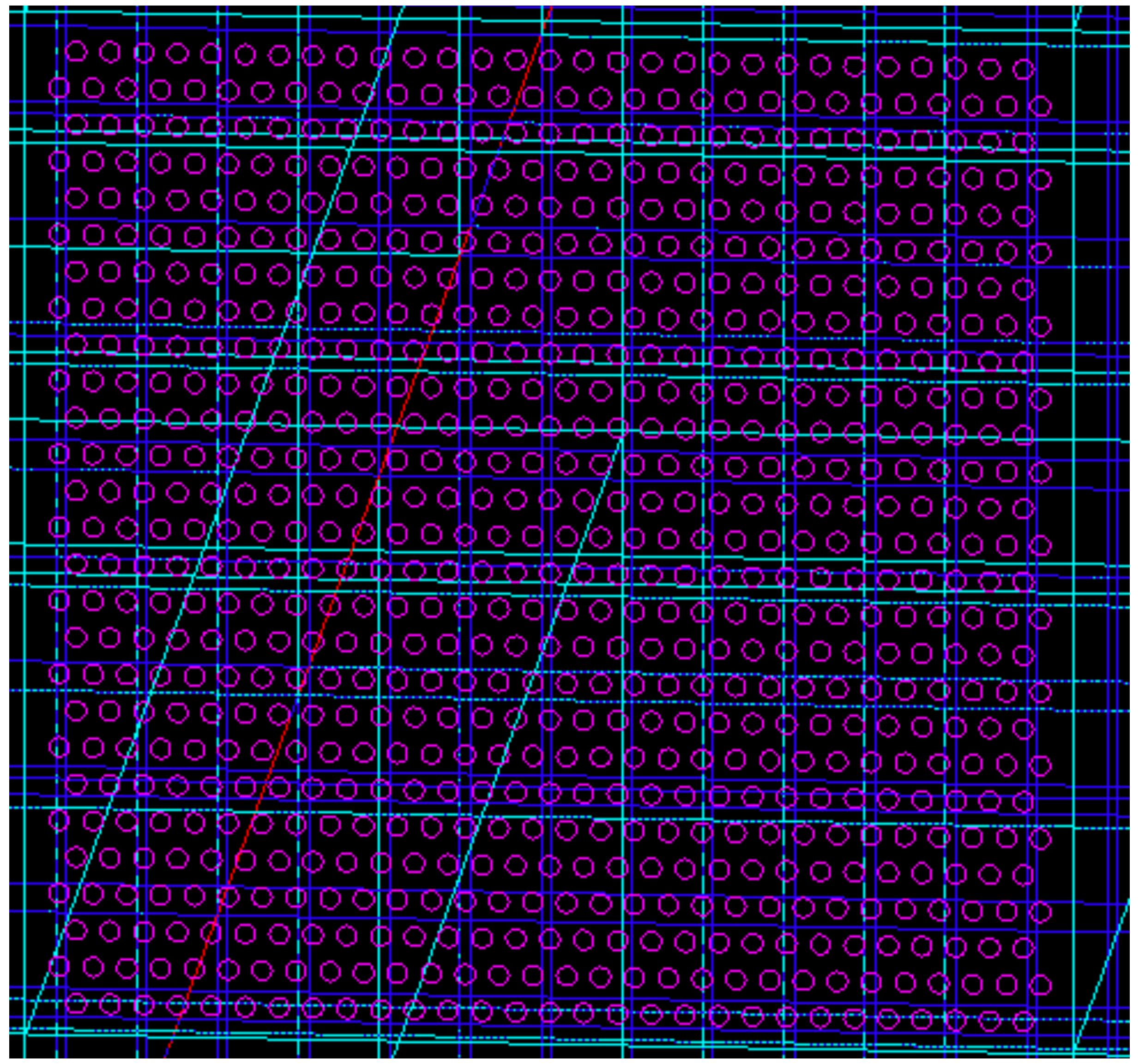
Mixture tower configurations



Fibers distributed inside one tower

	geometry fraction	material mass fraction
Absorber	78%	97% Tungsten+ 3% polystyrene
Fiber	22%	100% polystyrene

- **W/ScFi structure: 24 x 24 towers of 2.5 cm*2.5cm**
  - **796 Fibers placed in each tower, r = 0.235 mm.**

- **Mixture structure: 24 x 24 towers of 2.5 cm*2.5cm**
  - **Mixture material at same composition as W/ScFi**

- **Total material density to be 10.15 g/cm^3 (from experiment)**

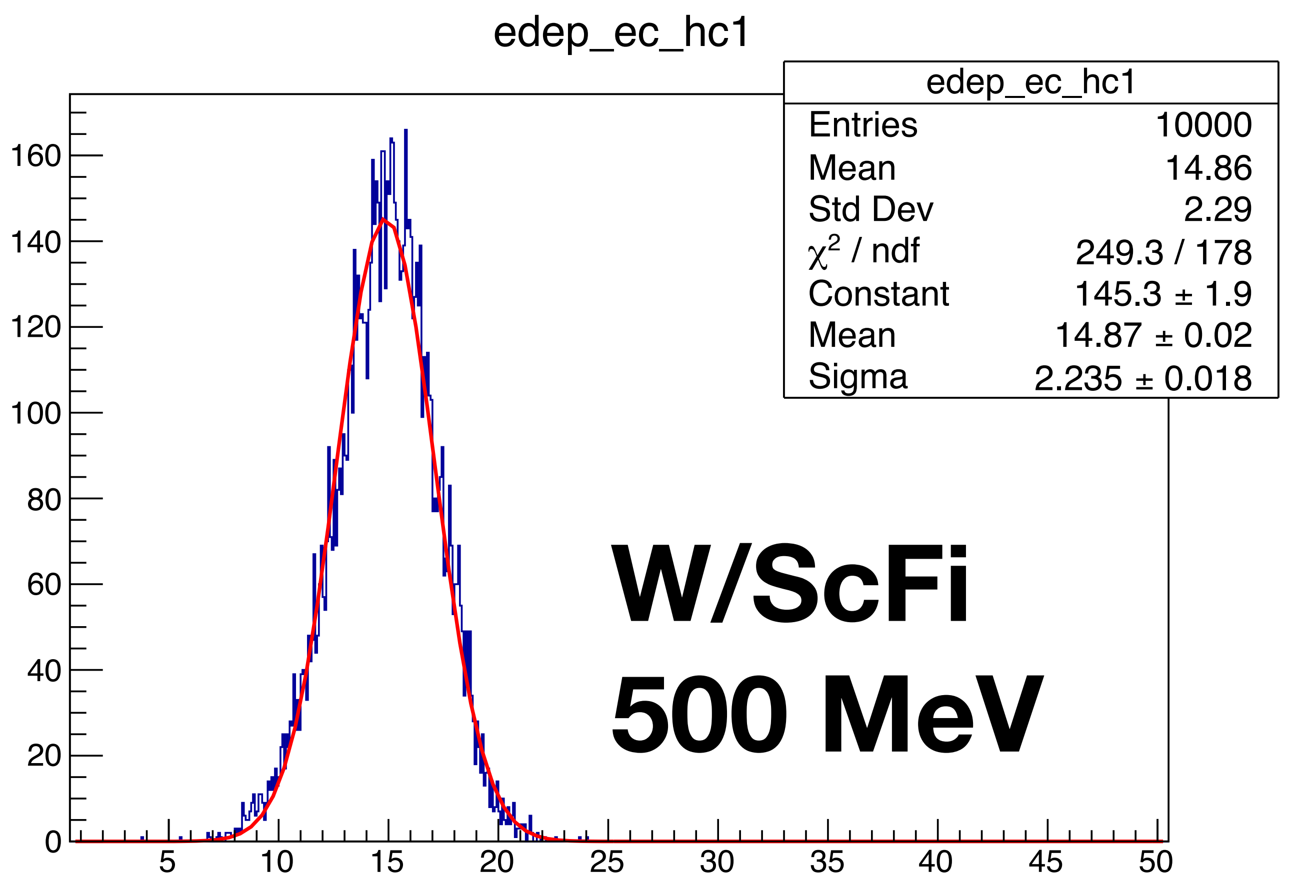
```
// Get materials
G4Material* defaultMaterial = G4Material::GetMaterial("Galactic");
G4Material* gapMaterial2 =G4Material::GetMaterial("G4_POLYSTYRENE");
G4Material* absorberMaterial2= G4Material::GetMaterial("G4_Fe");

G4double a=183.85*g/mole;
G4Element* elW=new G4Element("Tungsten","W",74.,a);

  G4Material* EMCal_abs_mat=new G4Material("EMCal_fiber_mat", 10.15*g/cm3,2);
  EMCal_abs_mat->AddElement(elW, 94.8*perCent);
  EMCal_abs_mat->AddMaterial(gapMaterial2, 5.2*perCent);
```

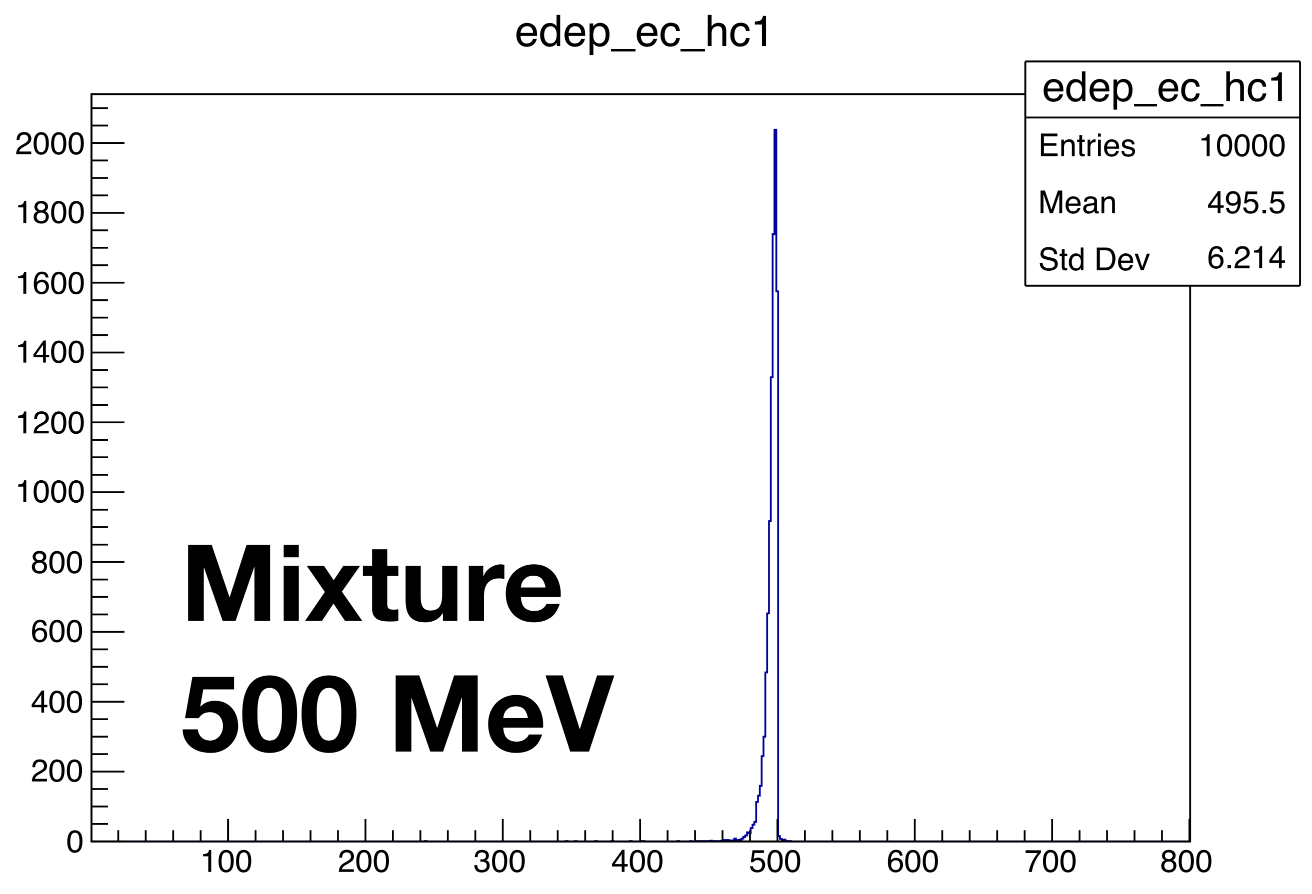
	mass fraction
Tungsten	94.8%
Polystyrene	5.2%

- **Next step: reconstructed the energy from this mixture tower configuration**

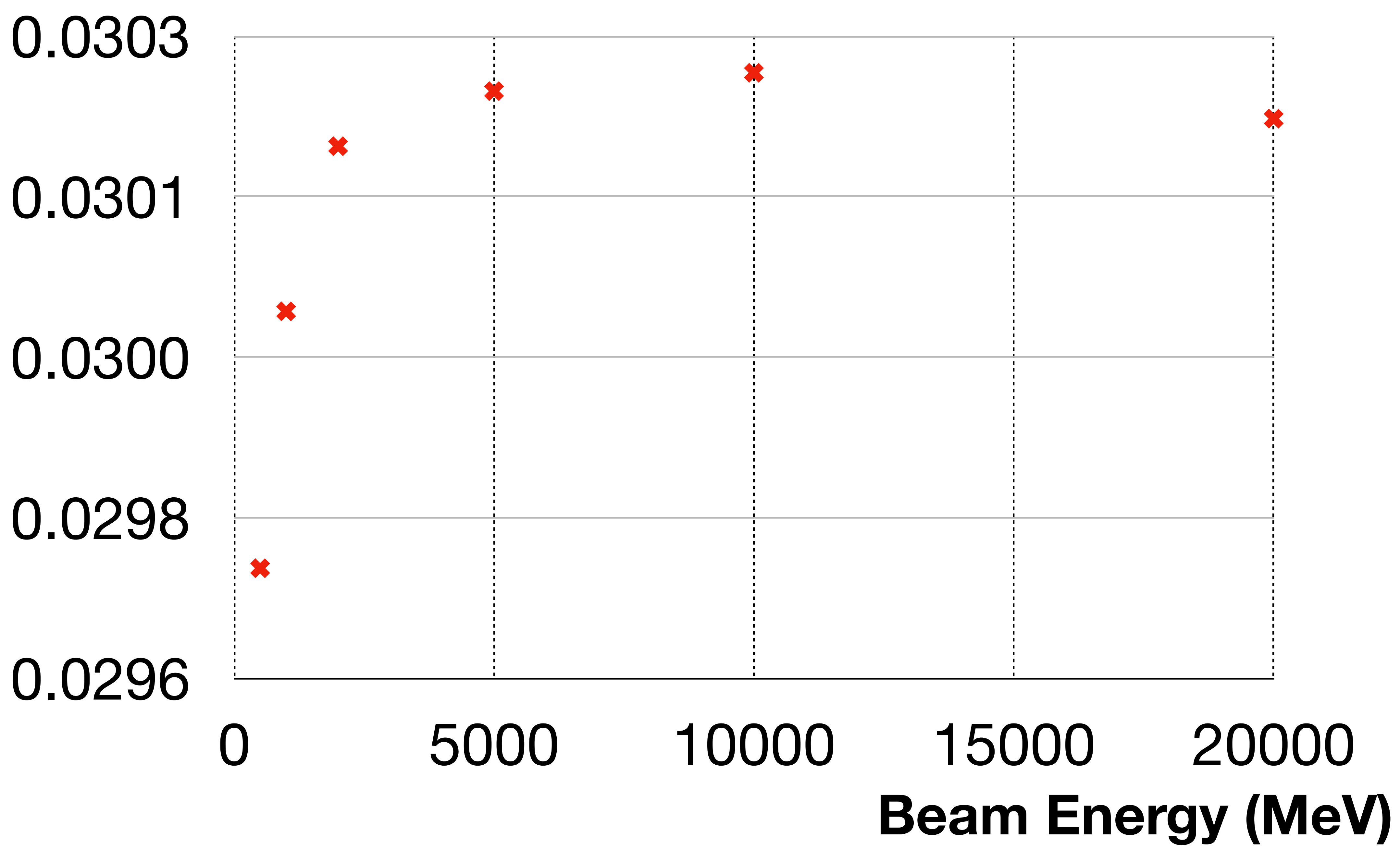
Sampling fraction for fibers

- Get the mean value of energy deposition for W/ScFi, and plot it out with respect to 6 beam energies.
- We have roughly 0.03 (at a 1% difference)

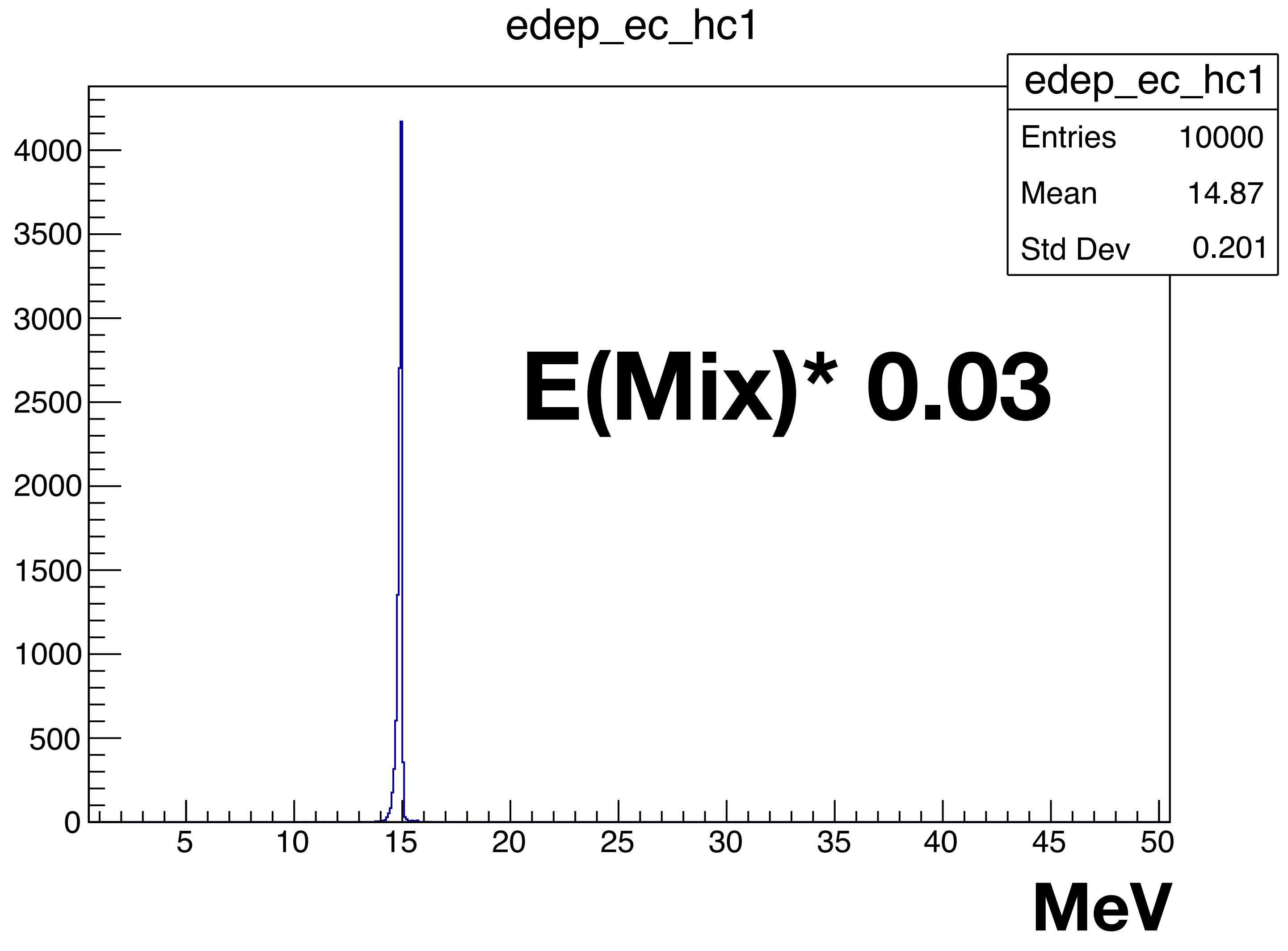




Beam Energy (MeV)	Energy in fibers(mean)	fraction
500	14.86	0.02972
1000	30.0	0.03000
2000	60.36	0.03018
5000	151.2	0.03024
10000	302.6	0.03026
20000	604.1	0.03021



Smearing procedure



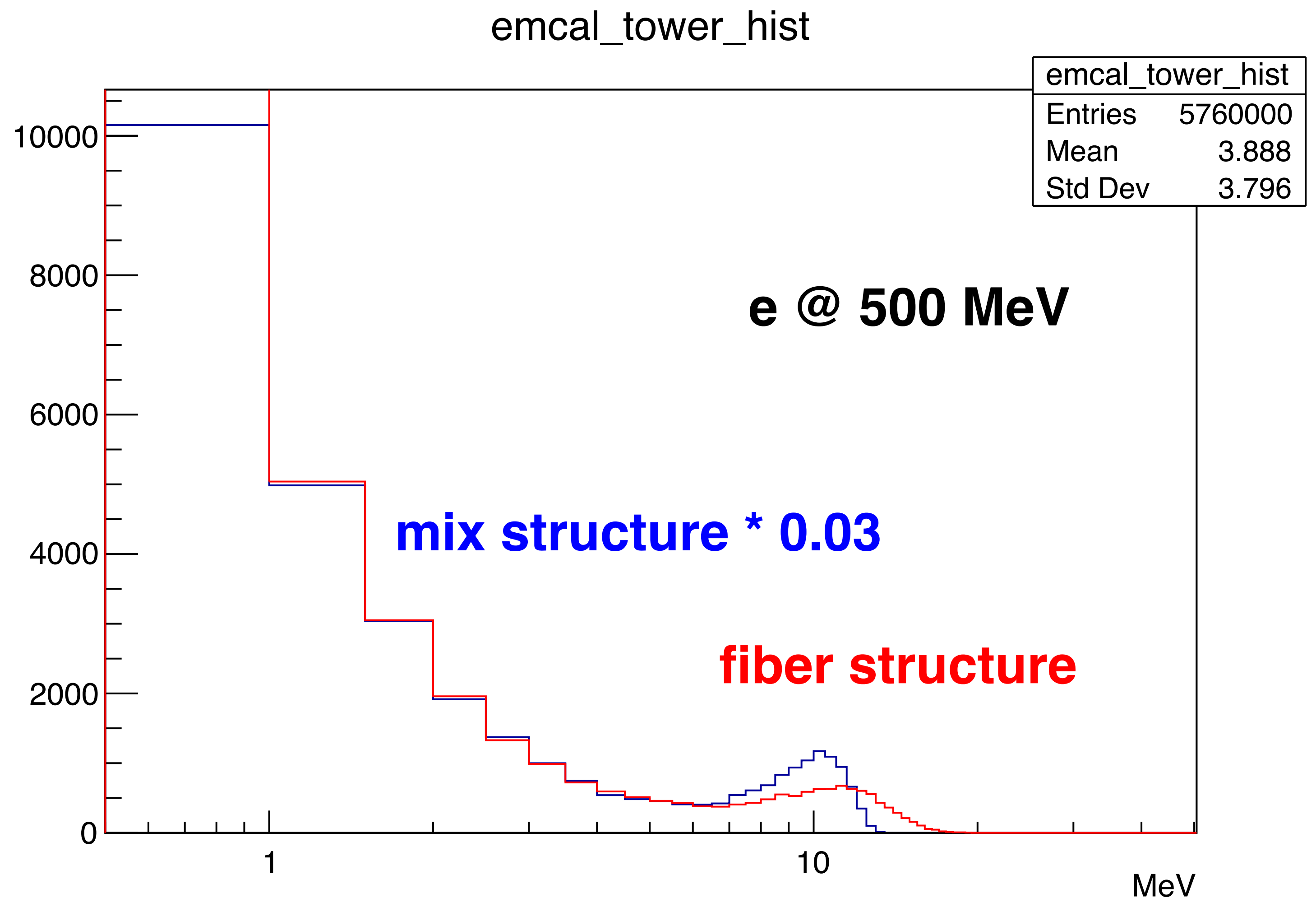
- **Smearing process is required to help get the correct energy resolution**

$$Gaus(E) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(E-\mu)^2}{2\sigma^2}}$$

  - **Mean** $\mu = 0.03E$
  - **Sigma** $\sigma = E\sqrt{a^2/E + b^2}$
  - **a = 0.1, b = 0**

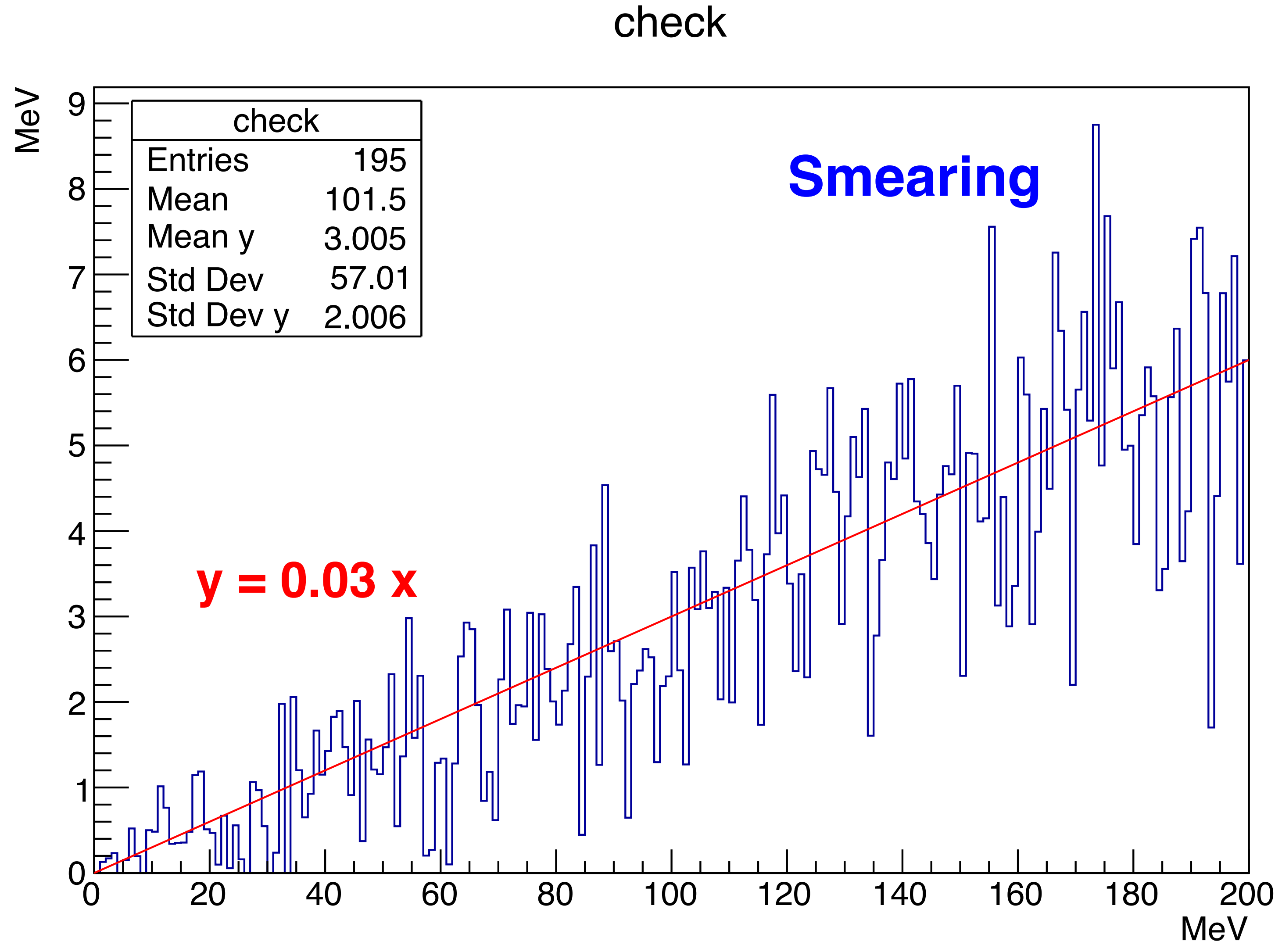
```
double threshold = 6.1;

double reco(double E0)
{
double E = E0;
if(E0 < threshold) return 0;
else{
double a = 0.1;
double b = 0.;
double sigma =  E* TMath::Sqrt(a*a/E +b*b) ;
double random = gRandom->Gaus(E*0.03,sigma);
E = random;
return E;
}
}
```

- **The parameter a and b is determined bv fiber structure study**

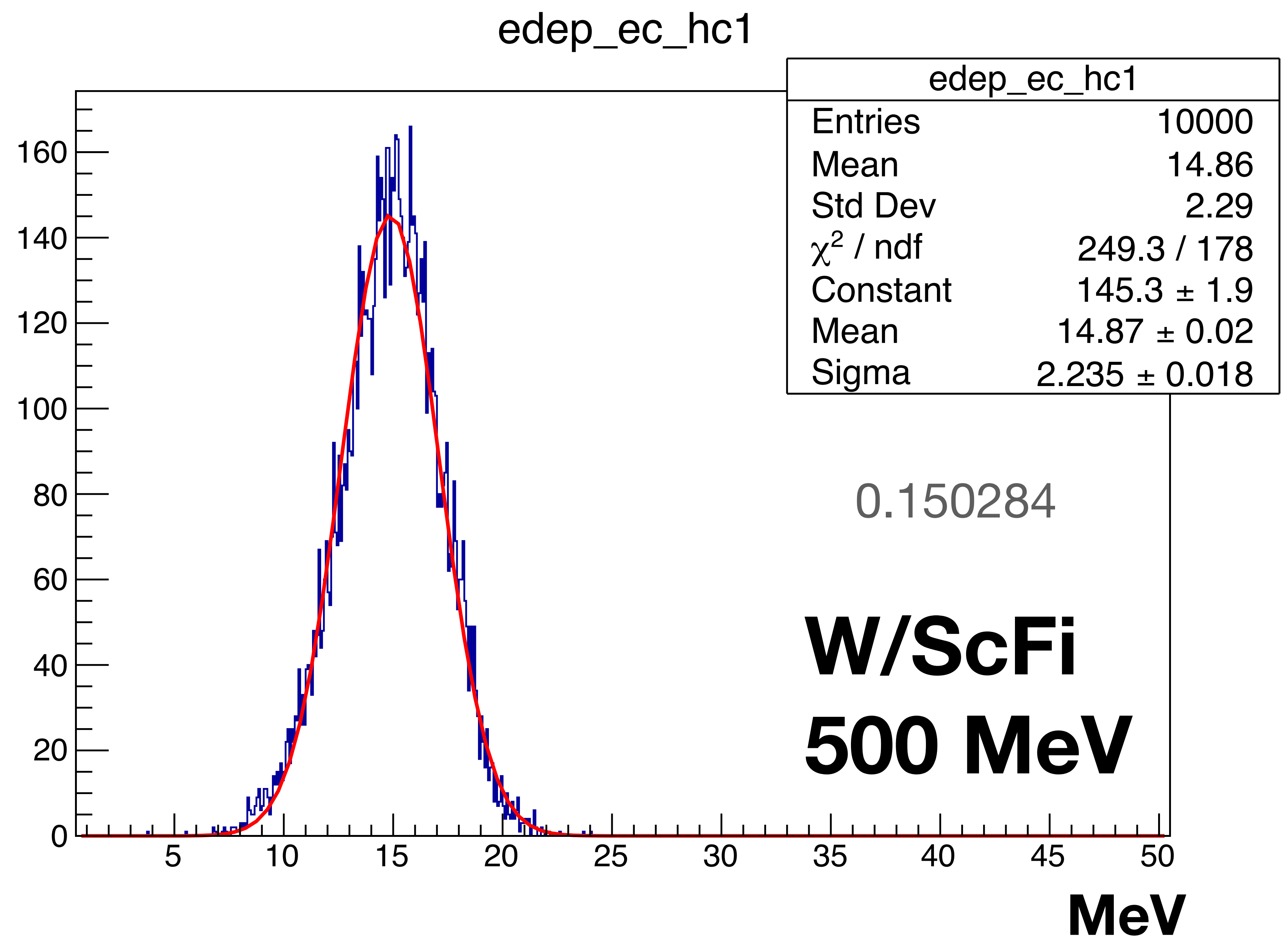


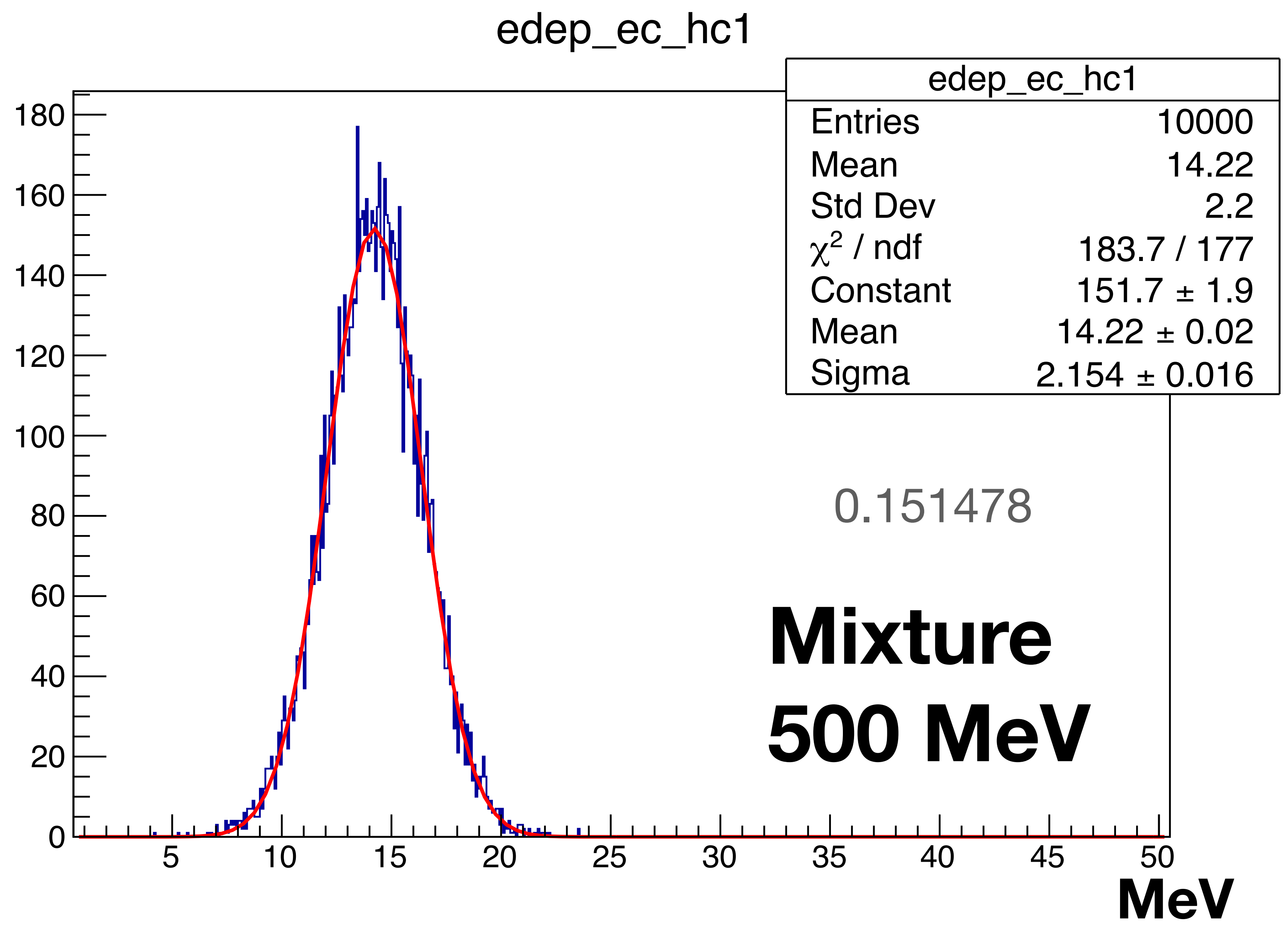
Purpose:

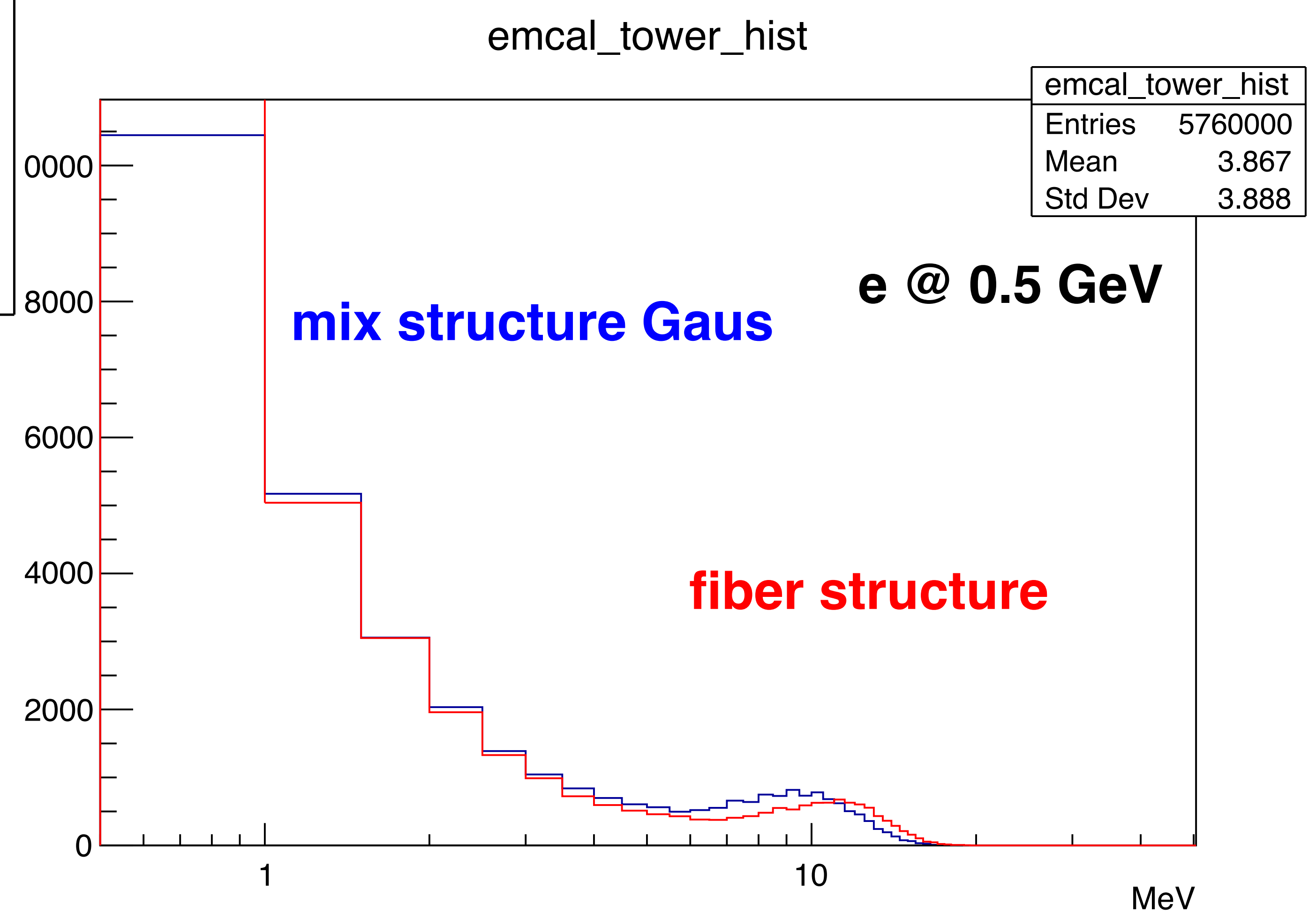
- **Reproduce the fluctuation from Gaussian random**
- **keeps the mean ~ 0.03 E_0**



Reconstruction using Smearing

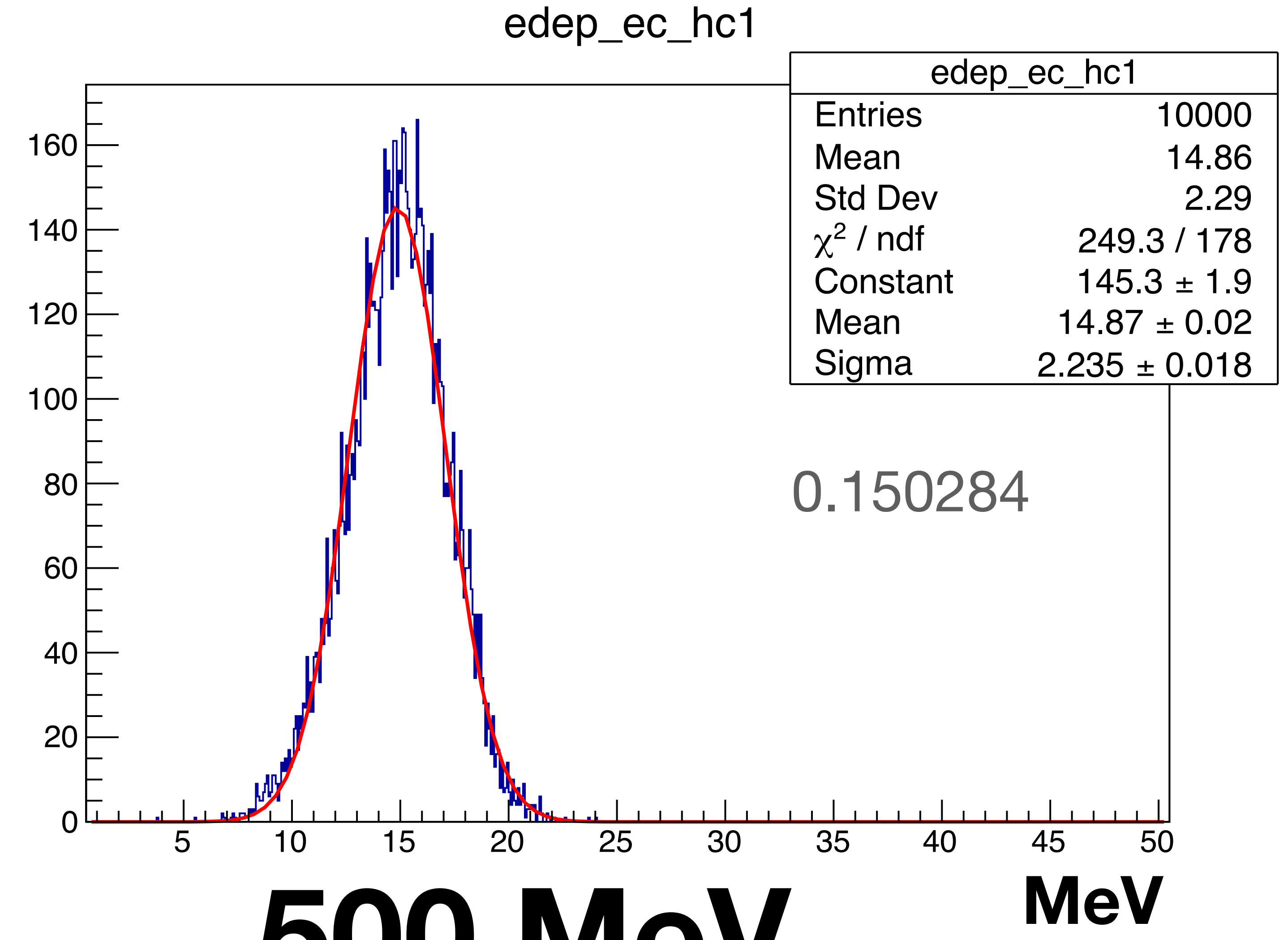




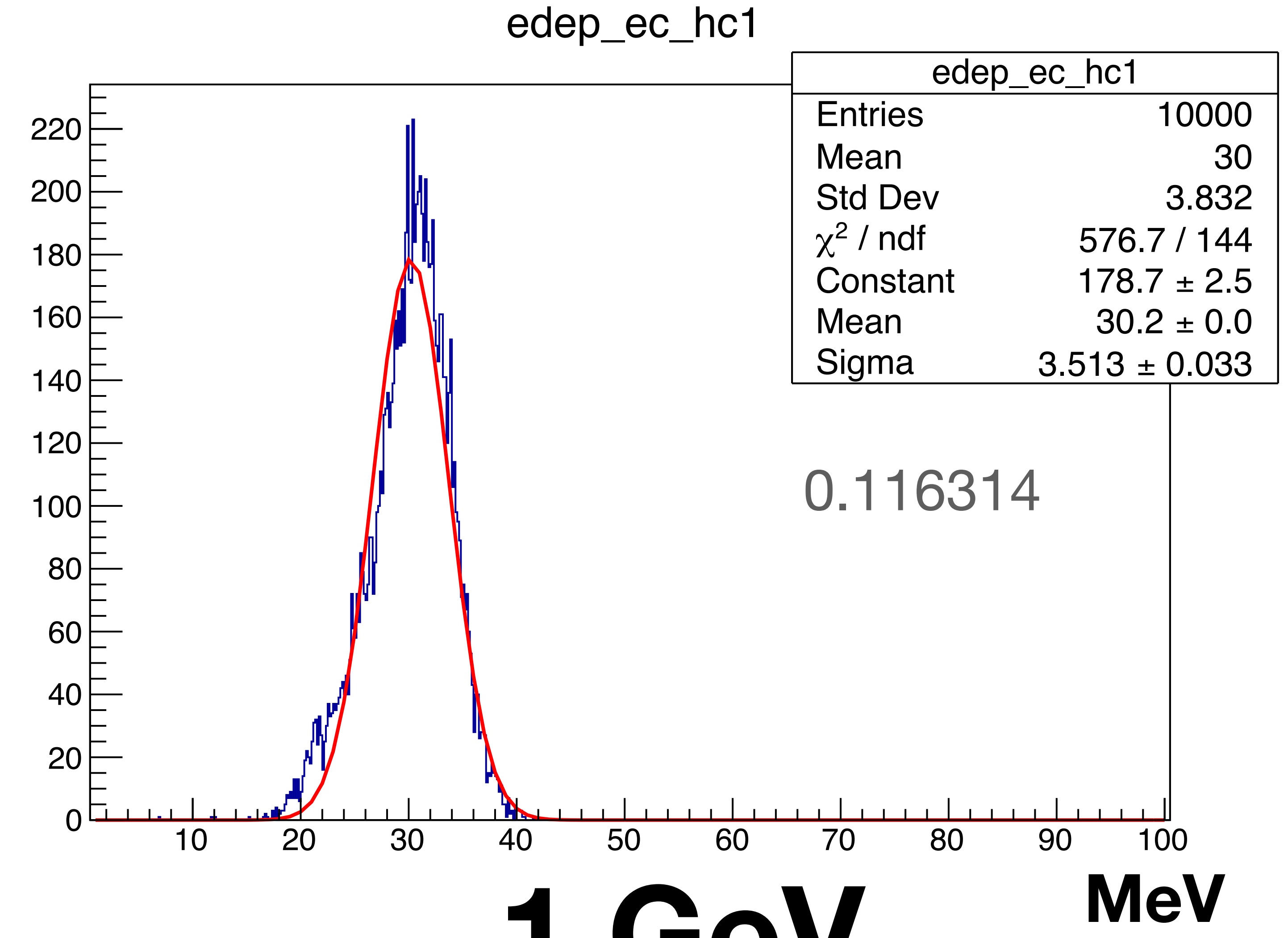


- The mean value and sigma roughly matches previous results
- The resolution is close to each other
- Tower check also has a good agreement

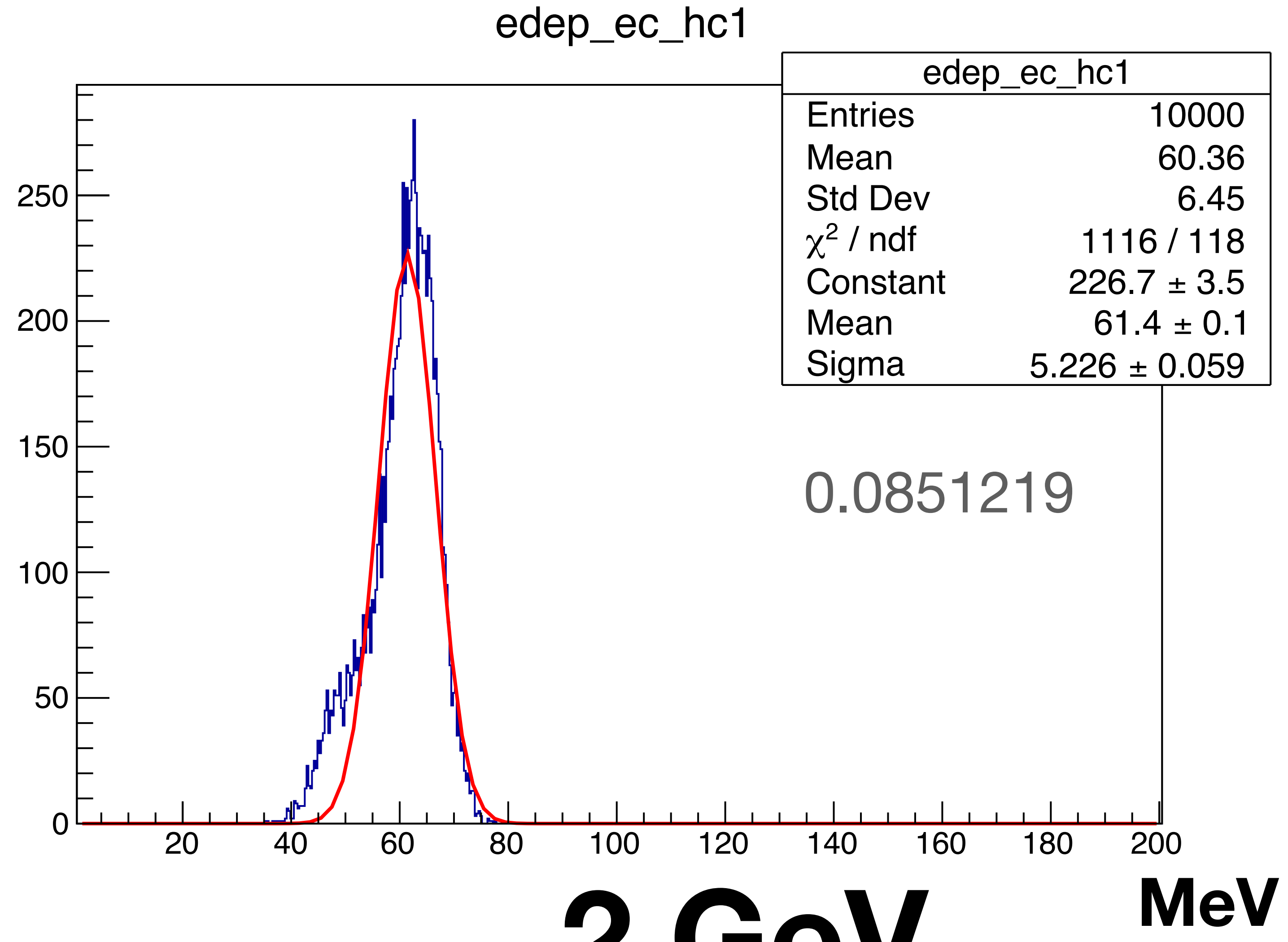
Fiber Structure



500 MeV

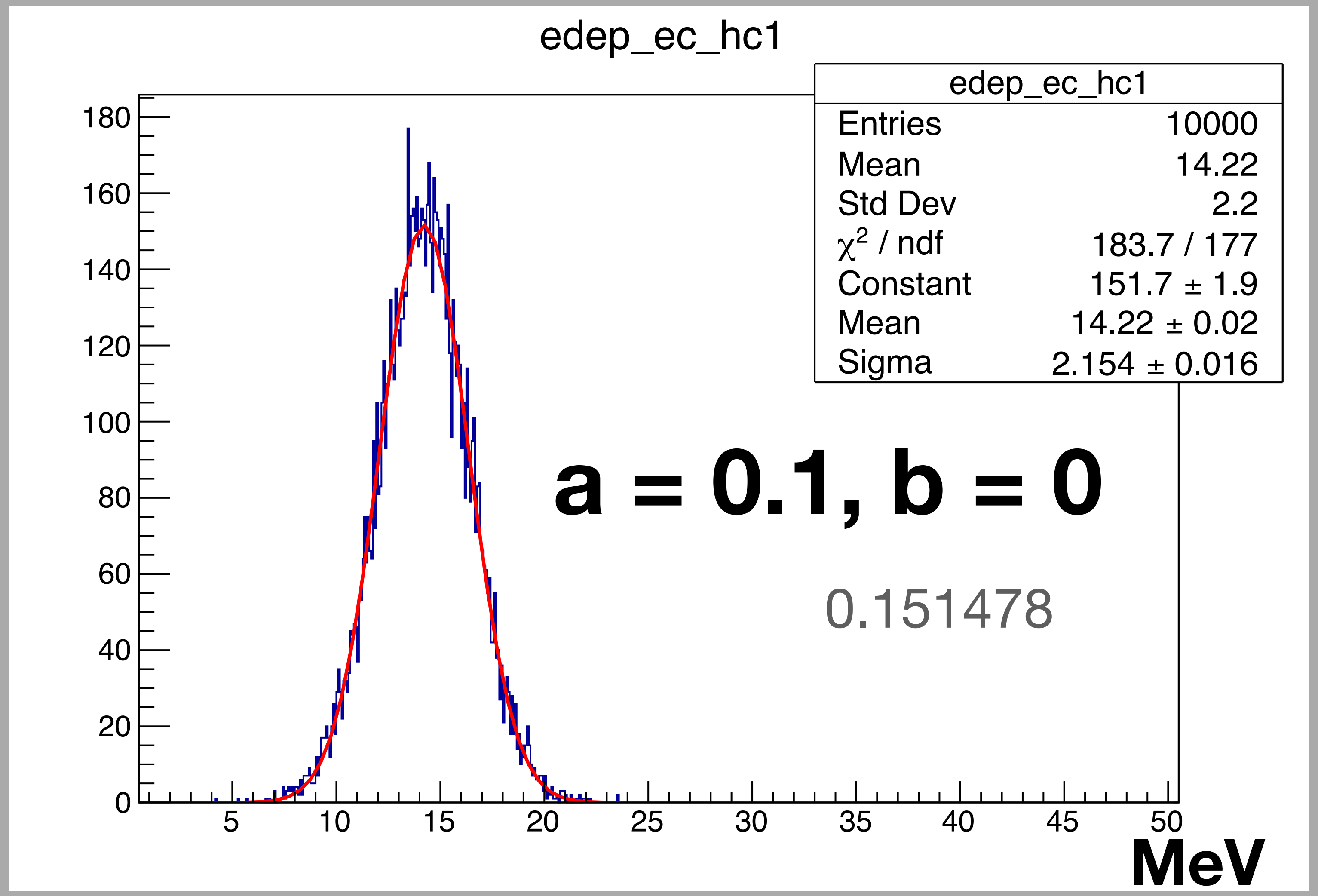


1 GeV

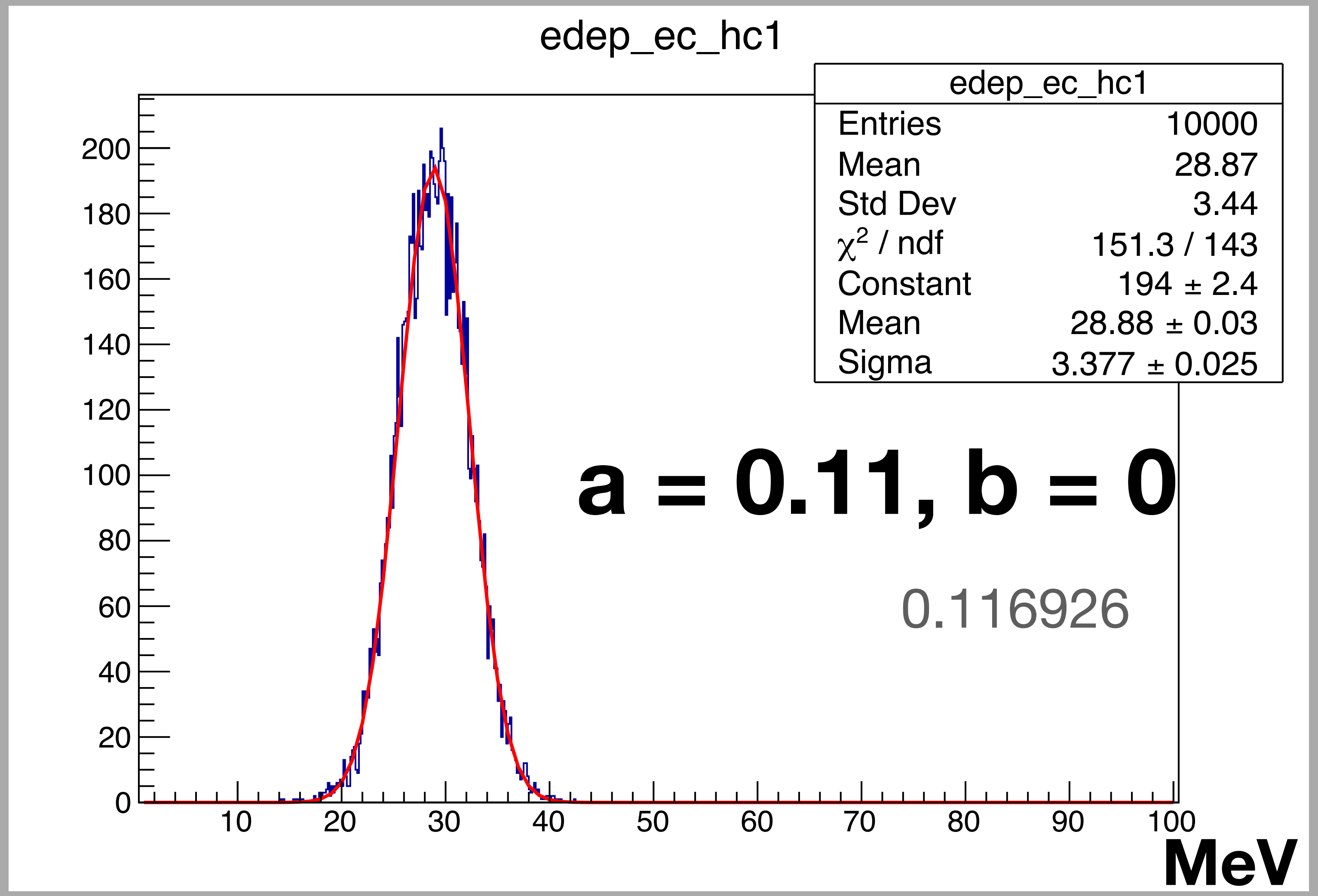


2 GeV

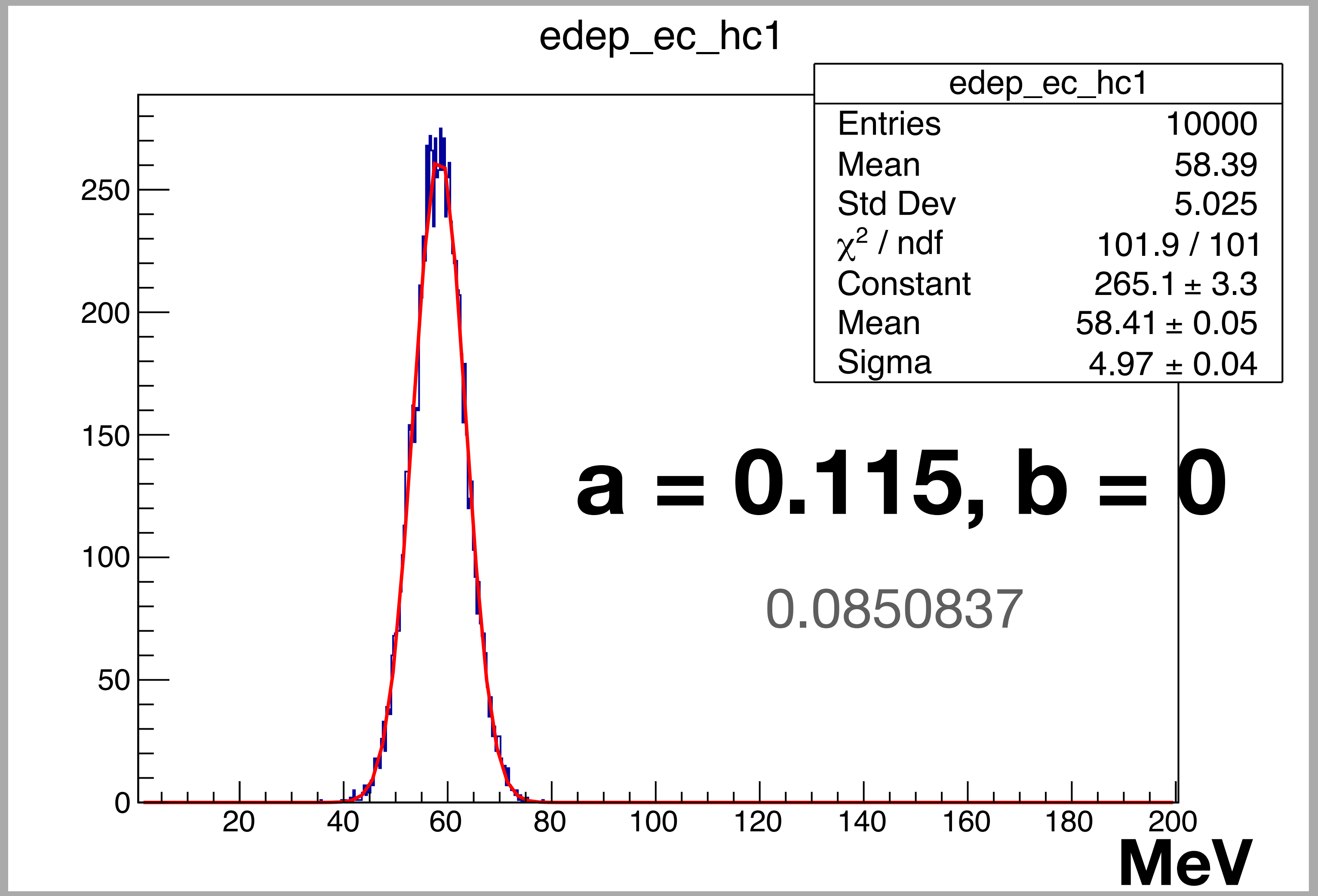
Reconstructed energy from mixture structure



500 MeV

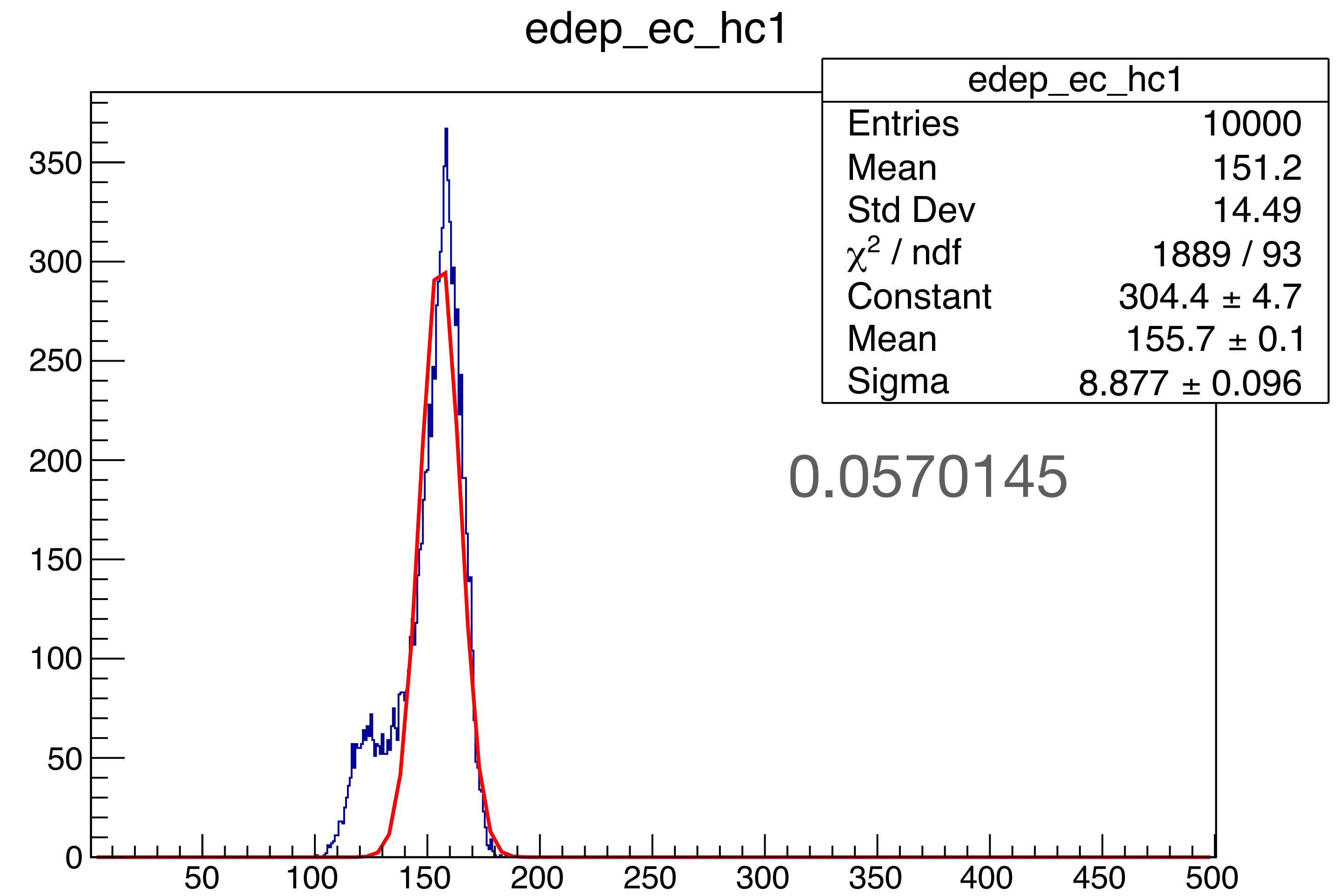


1 GeV

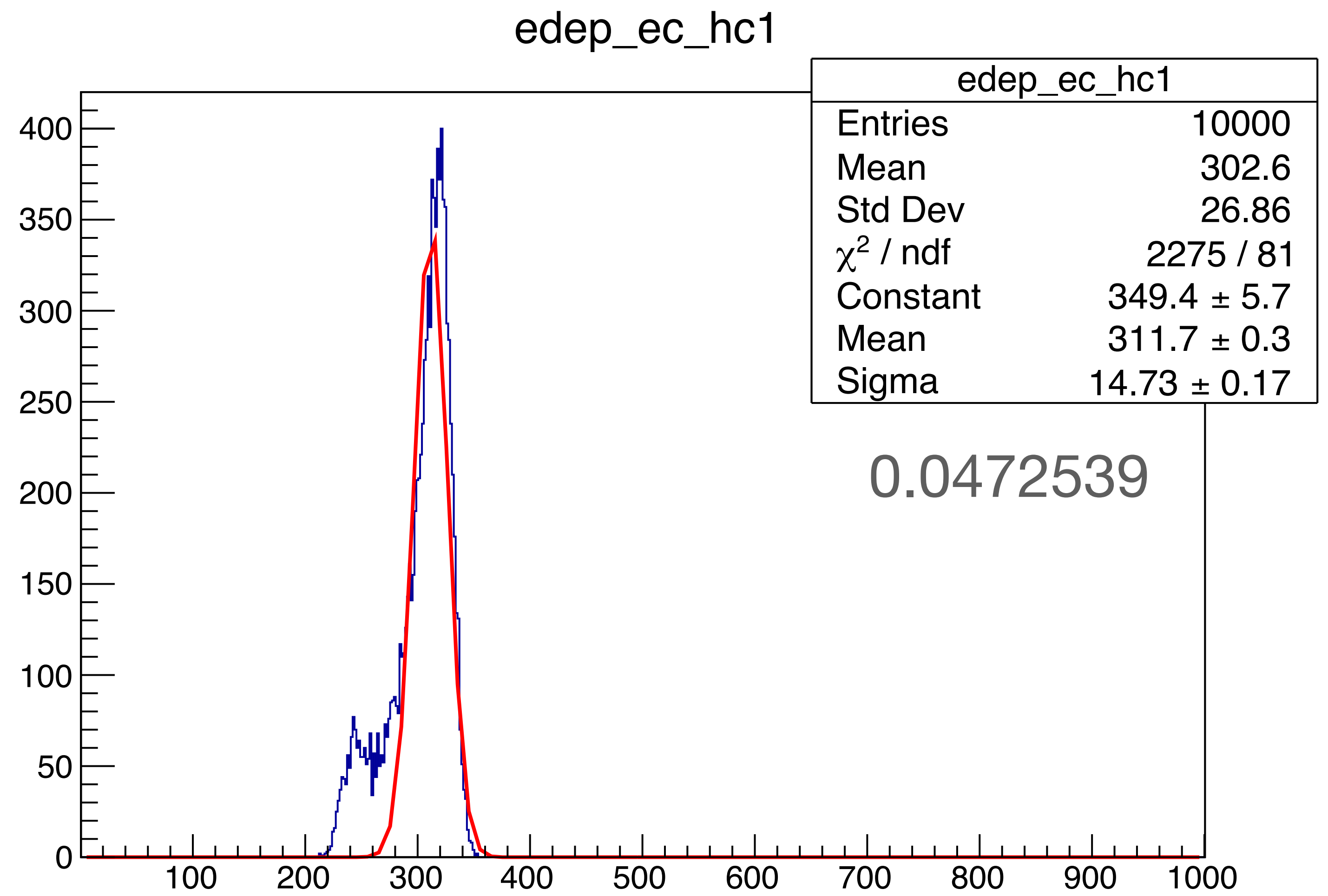


2 GeV

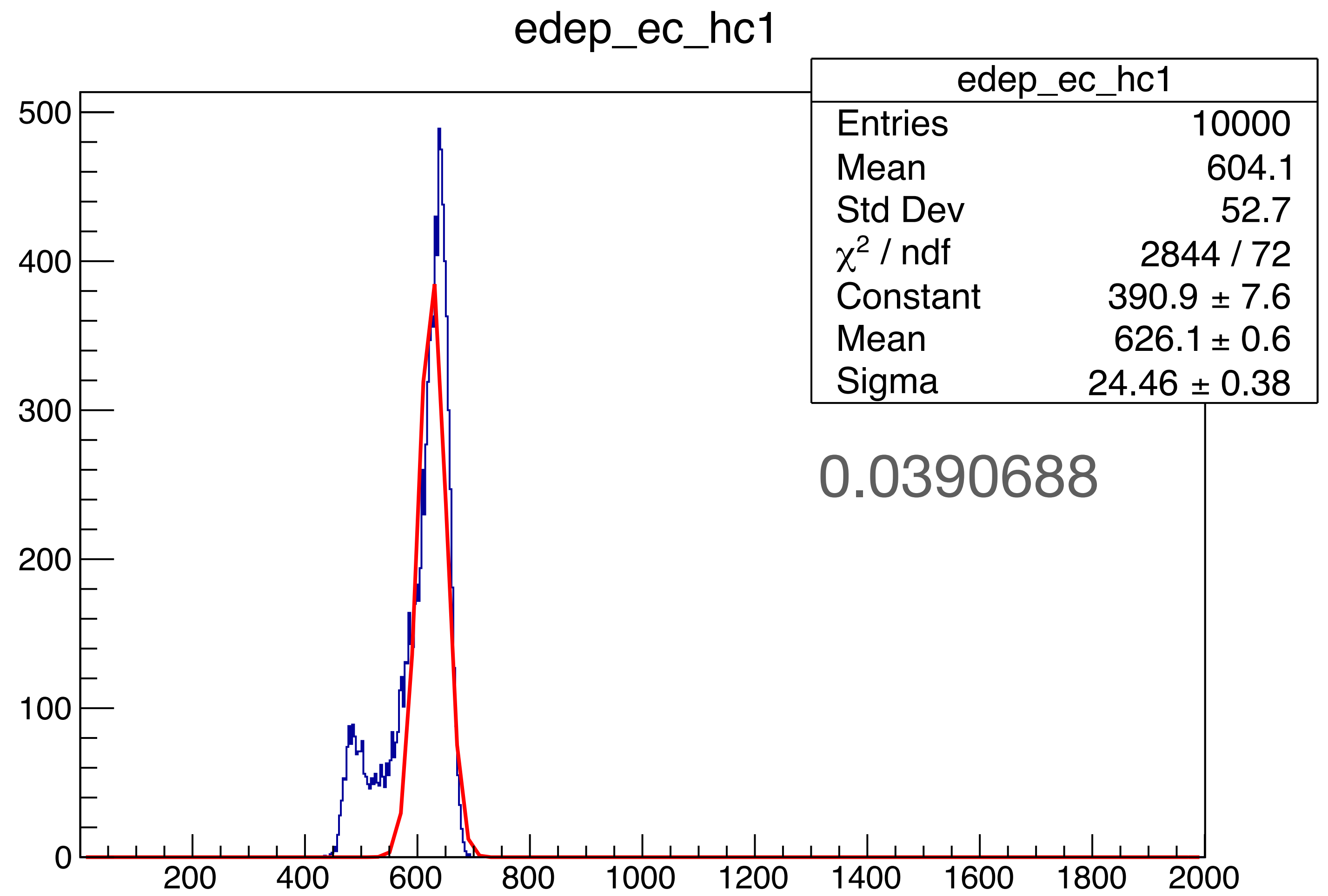
Fiber Structure



5 GeV **MeV**

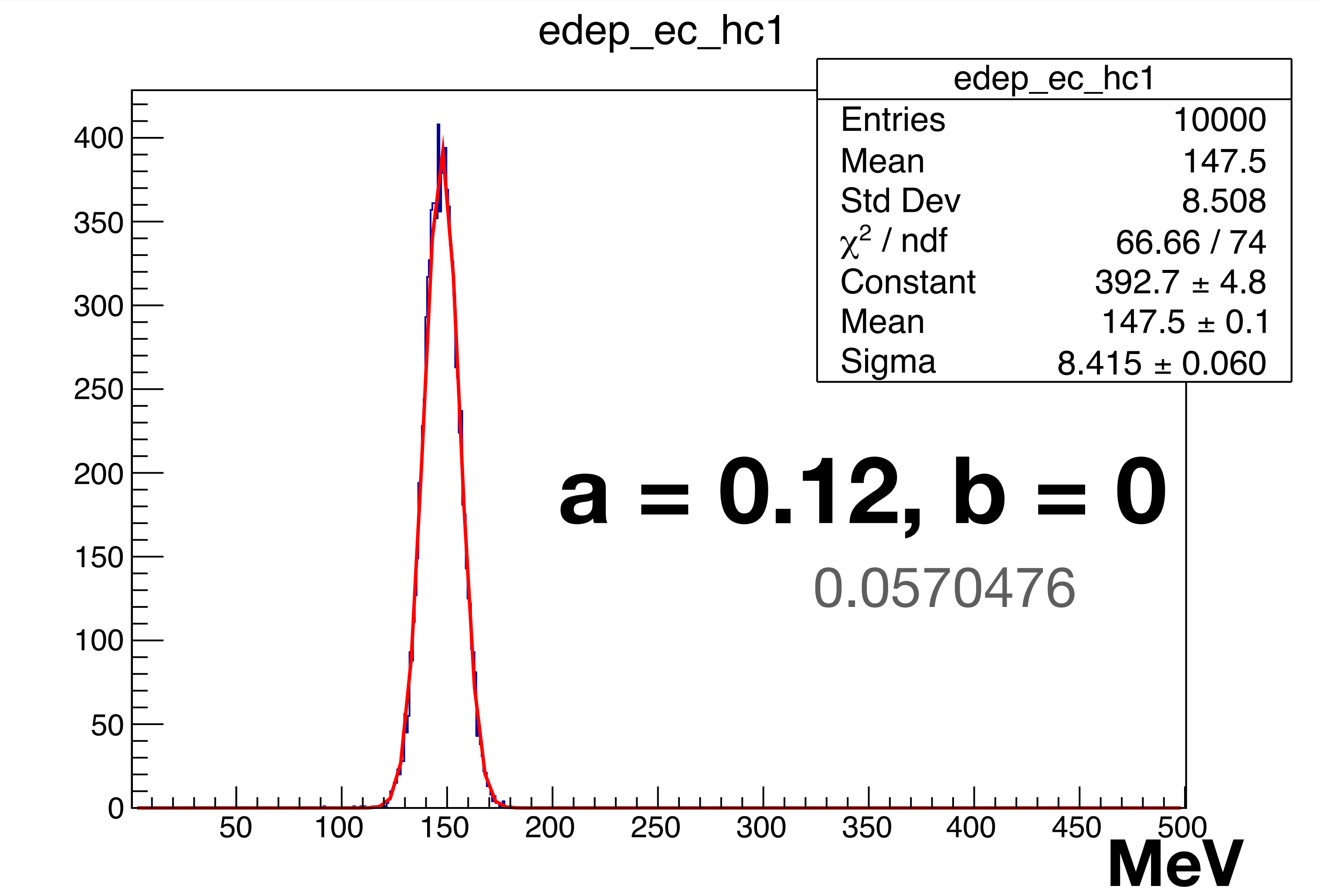


10 GeV **MeV**

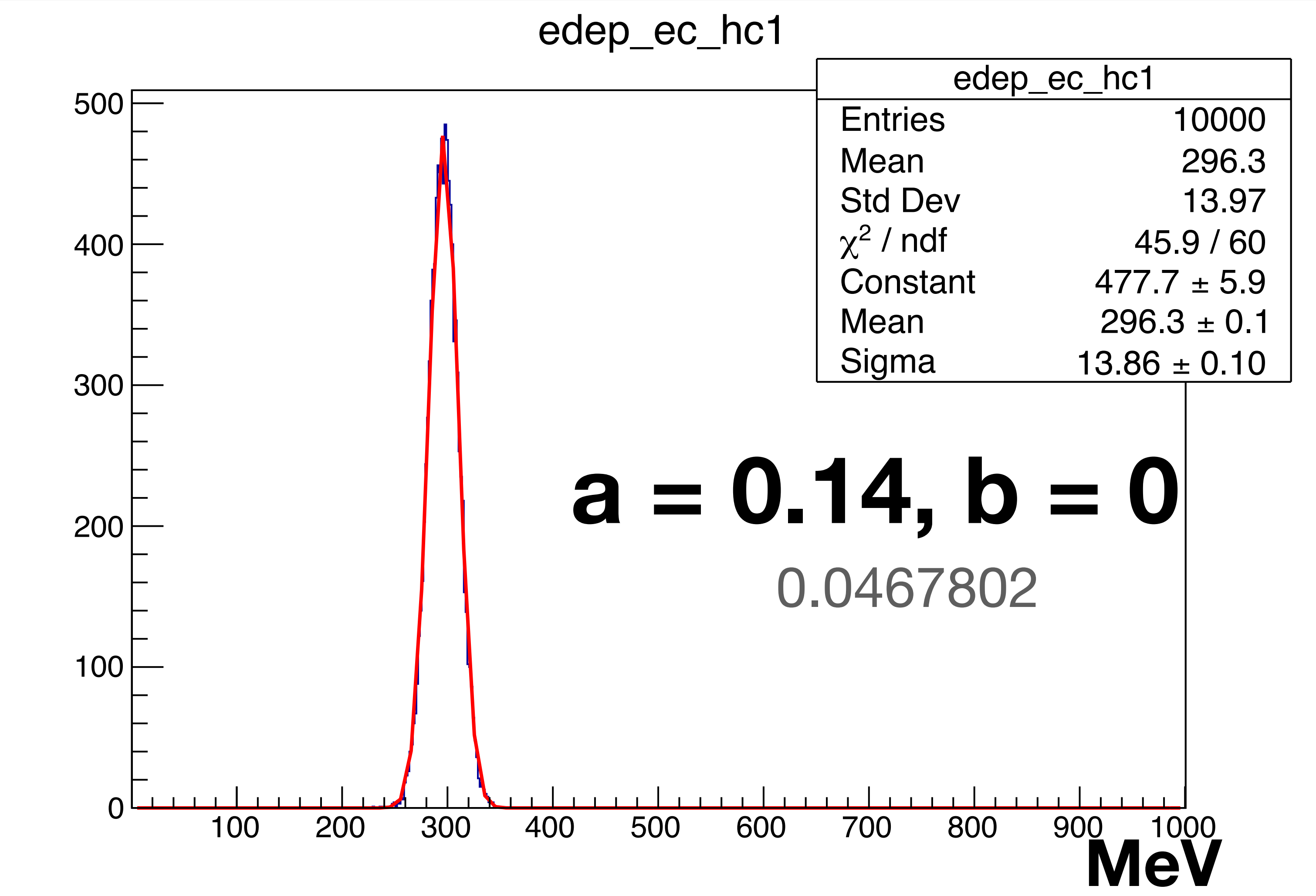


20 GeV **MeV**

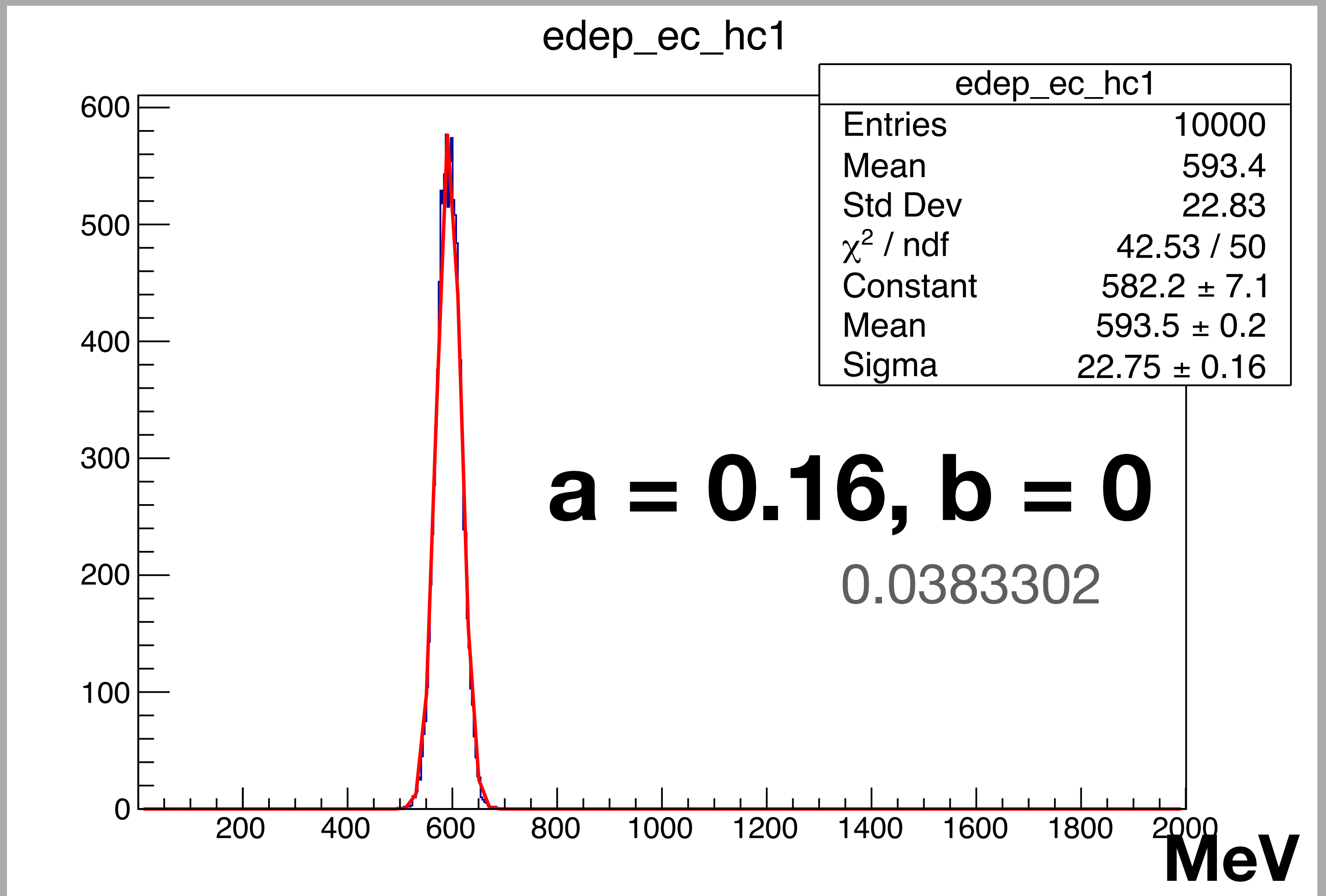
Reconstructed energy from mixture structure



5 GeV



10 GeV



20 GeV

Reconstruction using Smearing

	Fiber energy Resolution	Reconstructed from Mixture	parameter
500 MeV	0.1503	0.1515	**a = 0.1, b = 0**
1 GeV	0.1163	0.1169	**a = 0.11, b = 0**
2 GeV	0.0851	0.0851	**a = 0.115, b = 0**
5 GeV	0.0570	0.0570	**a = 0.12, b = 0**
10 GeV	0.0473	0.0468	**a = 0.14, b = 0**
20 GeV	0.0391	0.0383	**a = 0.16, b = 0**

$$Gaus(E) = \frac{1}{\sigma\sqrt{2\pi}} e^{-\frac{(E-\mu)^2}{2\sigma^2}}$$

- **Mean** $\mu = \quad 0.03E$
- **Sigma** $\sigma = \quad E\sqrt{a^2/E + b^2}$
- **a = 0.1, b = 0**

- **a) EM can be smeared. With the use of one parameter a, it could be a function of energy, or add constant term b in order to keep a constant, TBD**
- **b) next step is to look what happen with hadrons once we will use mixture and apply same smearing as for electrons, i.e. smearing as a function of energy deposited in tower.**