

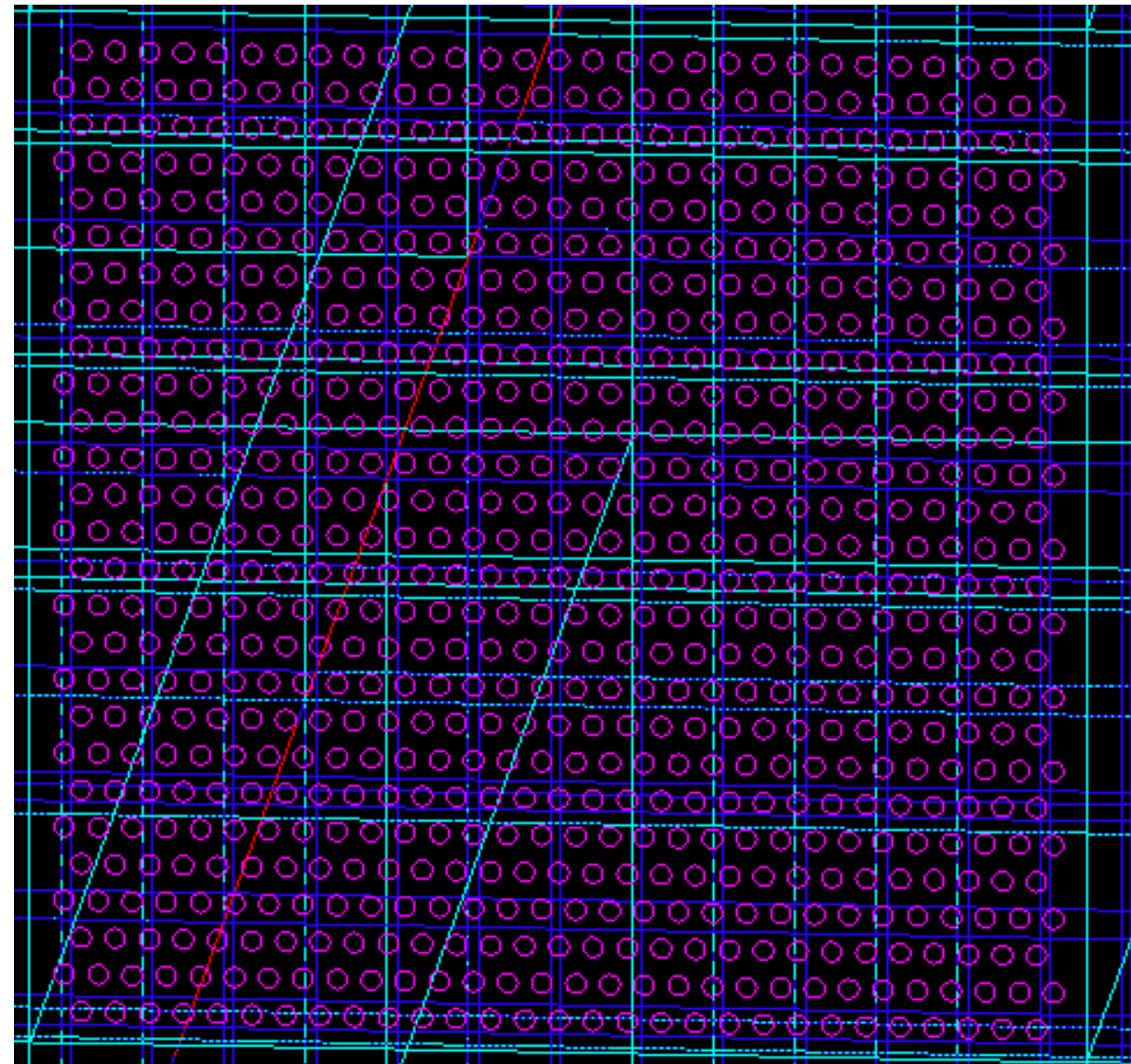
Reconstruction of E resolution from mixture structure with single particle simulation of G4

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UCLA

Mixture tower configurations



- **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);
```

Fibers distributed inside one tower

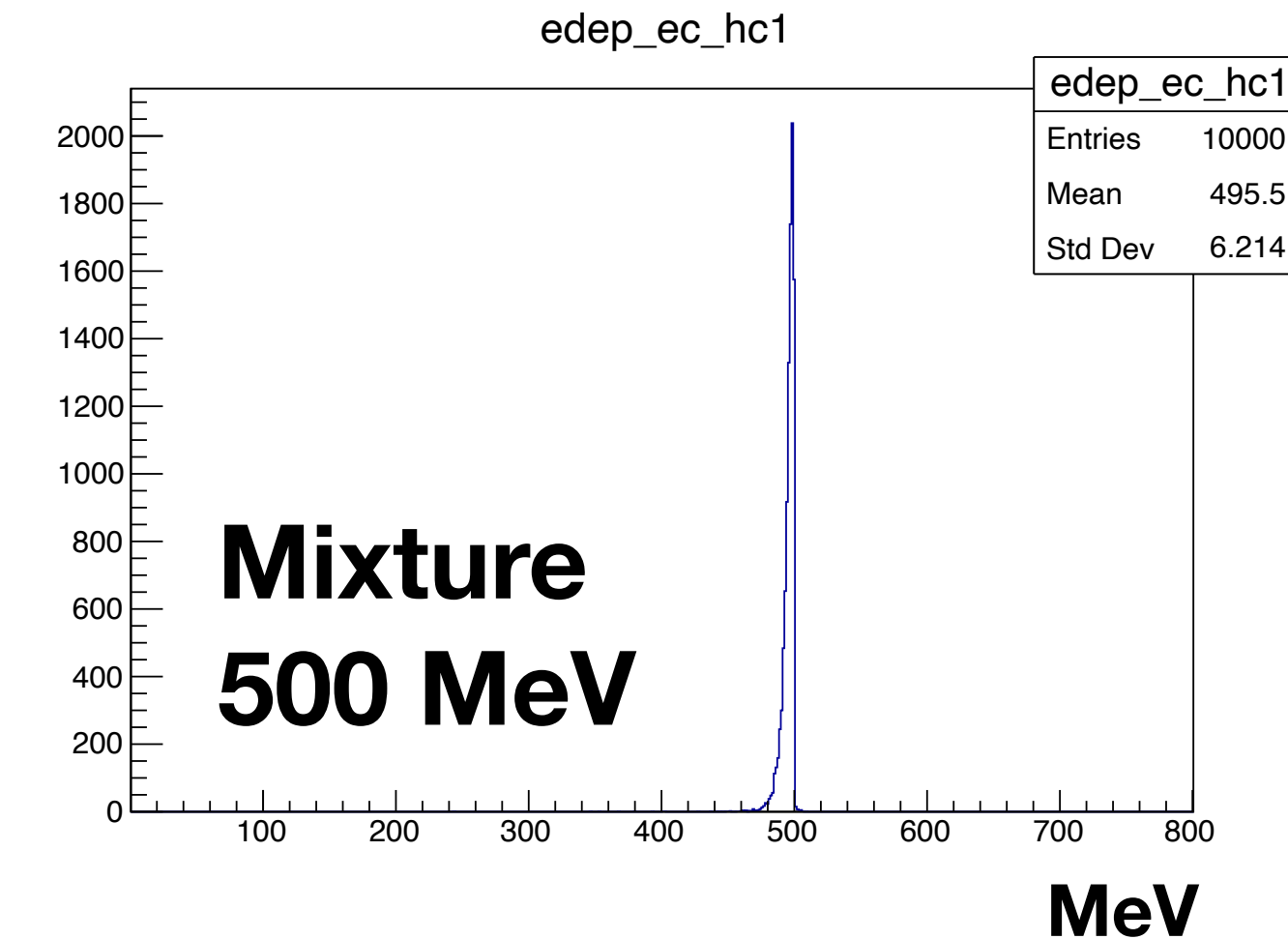
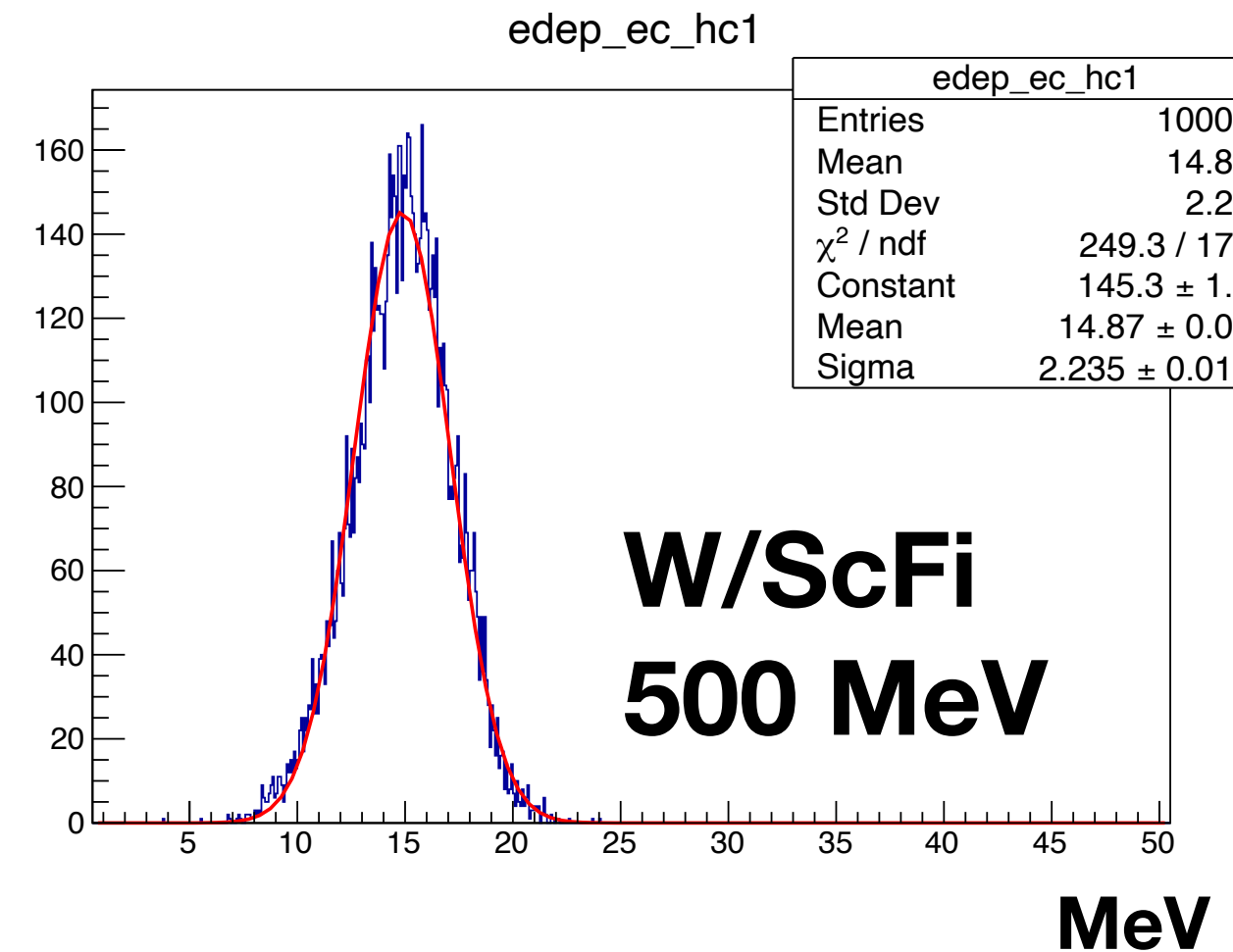
	geometry fraction	material mass fraction
Absorber	78%	97% Tungsten+ 3% polystyrene
Fiber	22%	100% polystyrene

	mass fraction
Tungsten	94.8%
Polystyrene	5.2%

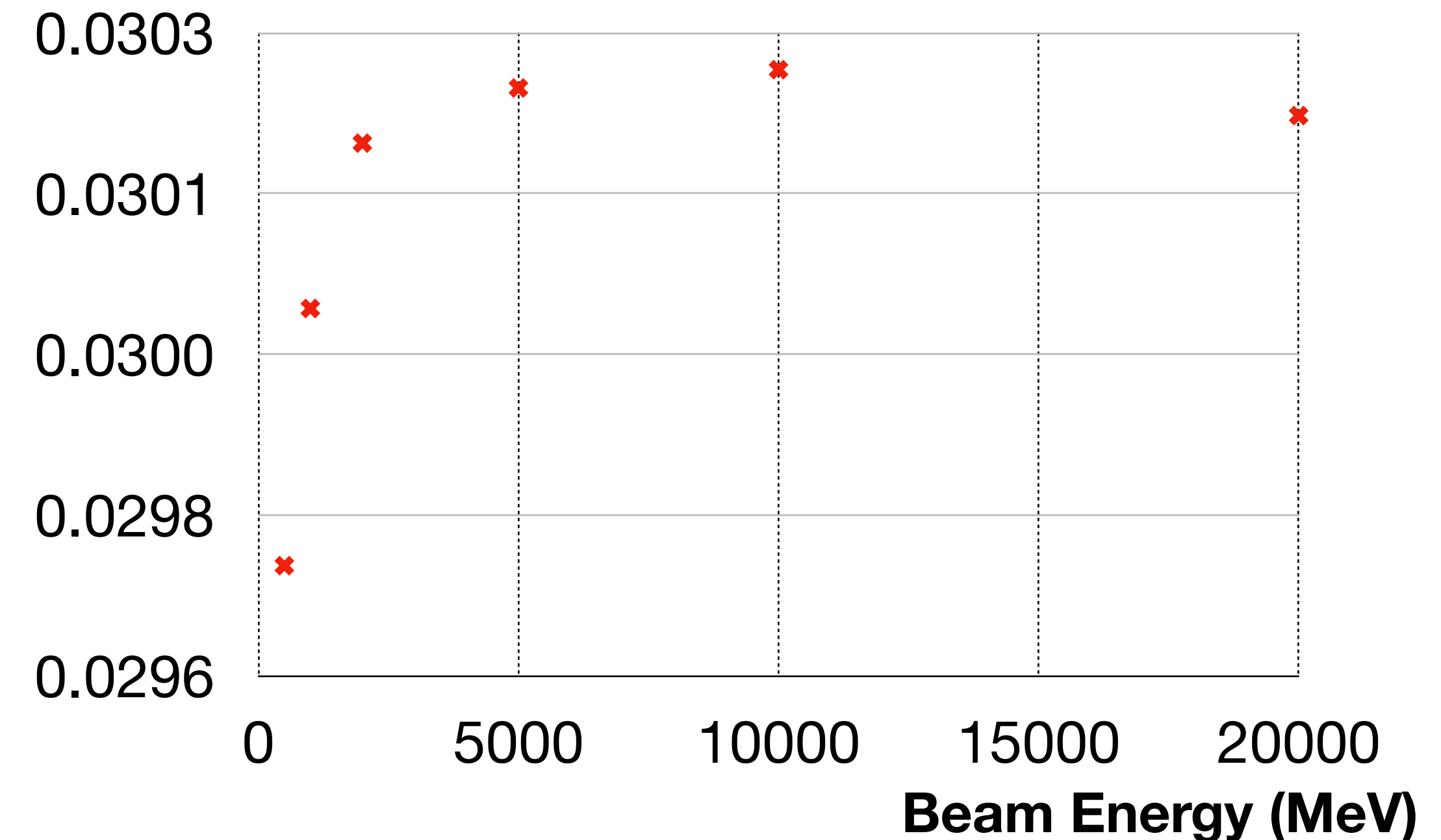
- **Next step: reconstructed the energy from this mixture tower configuration**

Sampling fraction for fibers

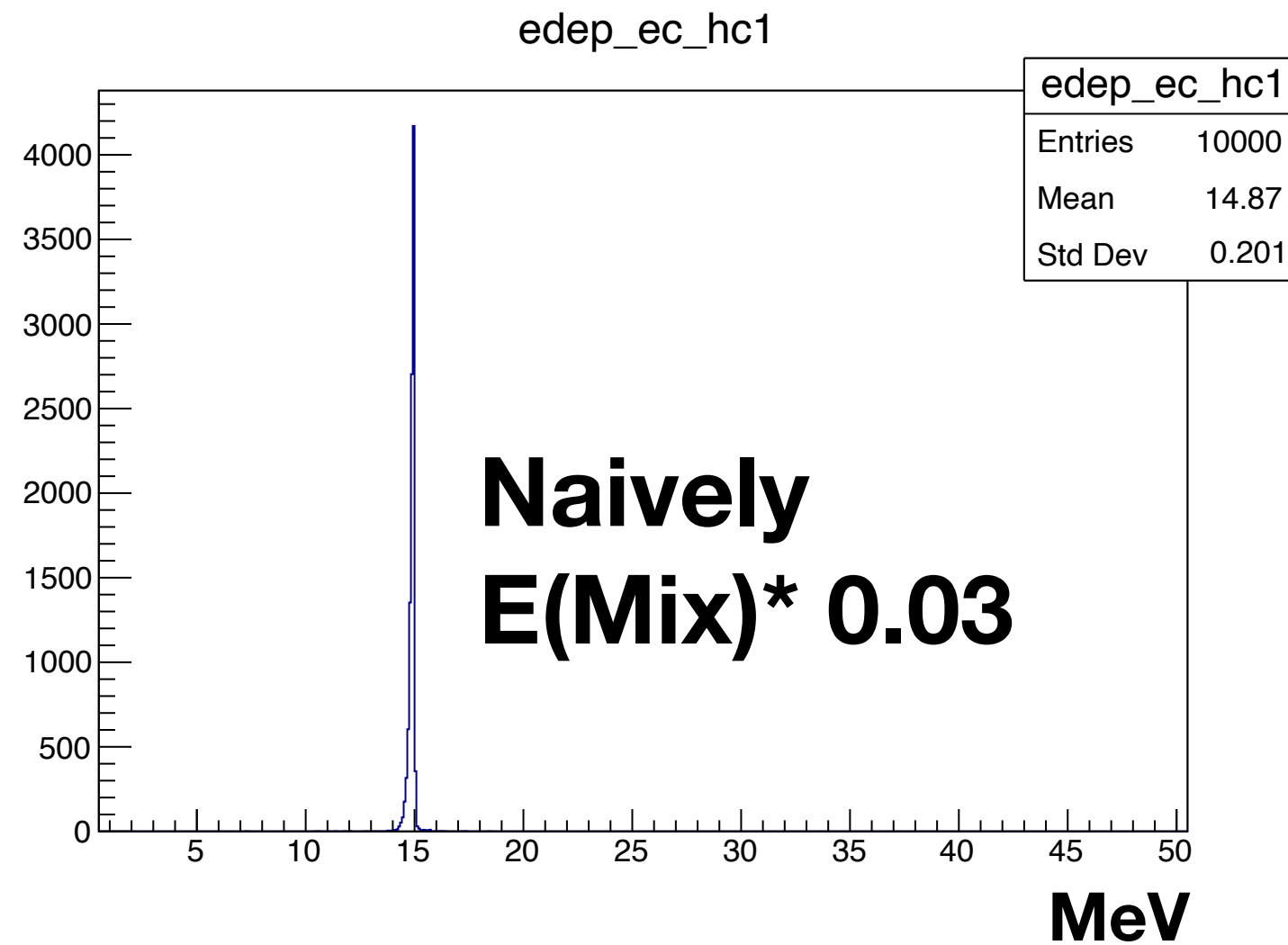
- Get the mean value of energy deposition for W/ScFi, and plot it out with respect to 6 beam energies.
- We have roughly 0.03 (at a 1% difference)



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



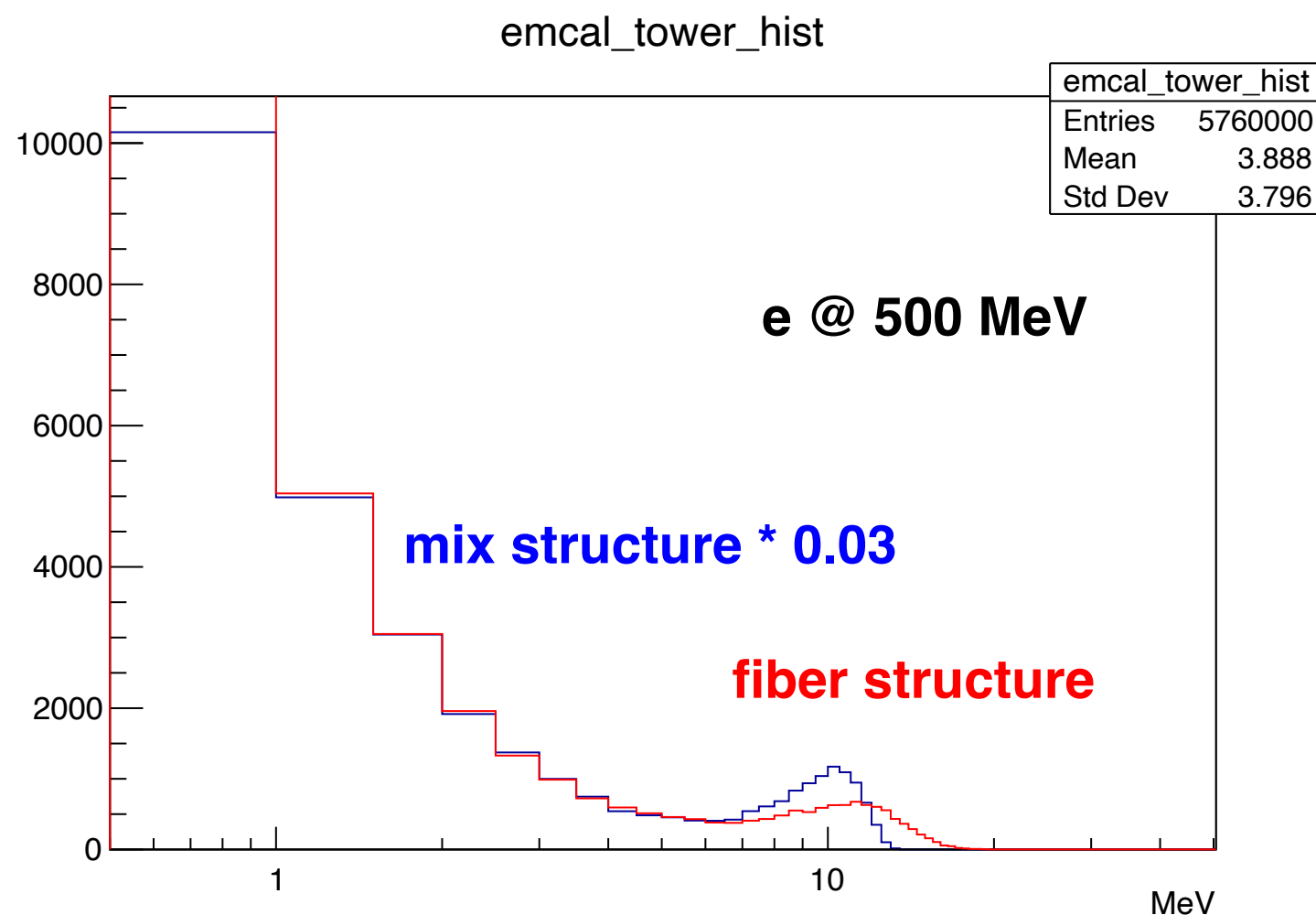
- Smearing process is required to help get the correct energy resolution

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

- Mean $\mu = 0.03E$
- Sigma $\sigma = E\sqrt{a^2/E + b^2}$
- $a = 0.1, b = 0.0015$

```
double threshold = 6.1;

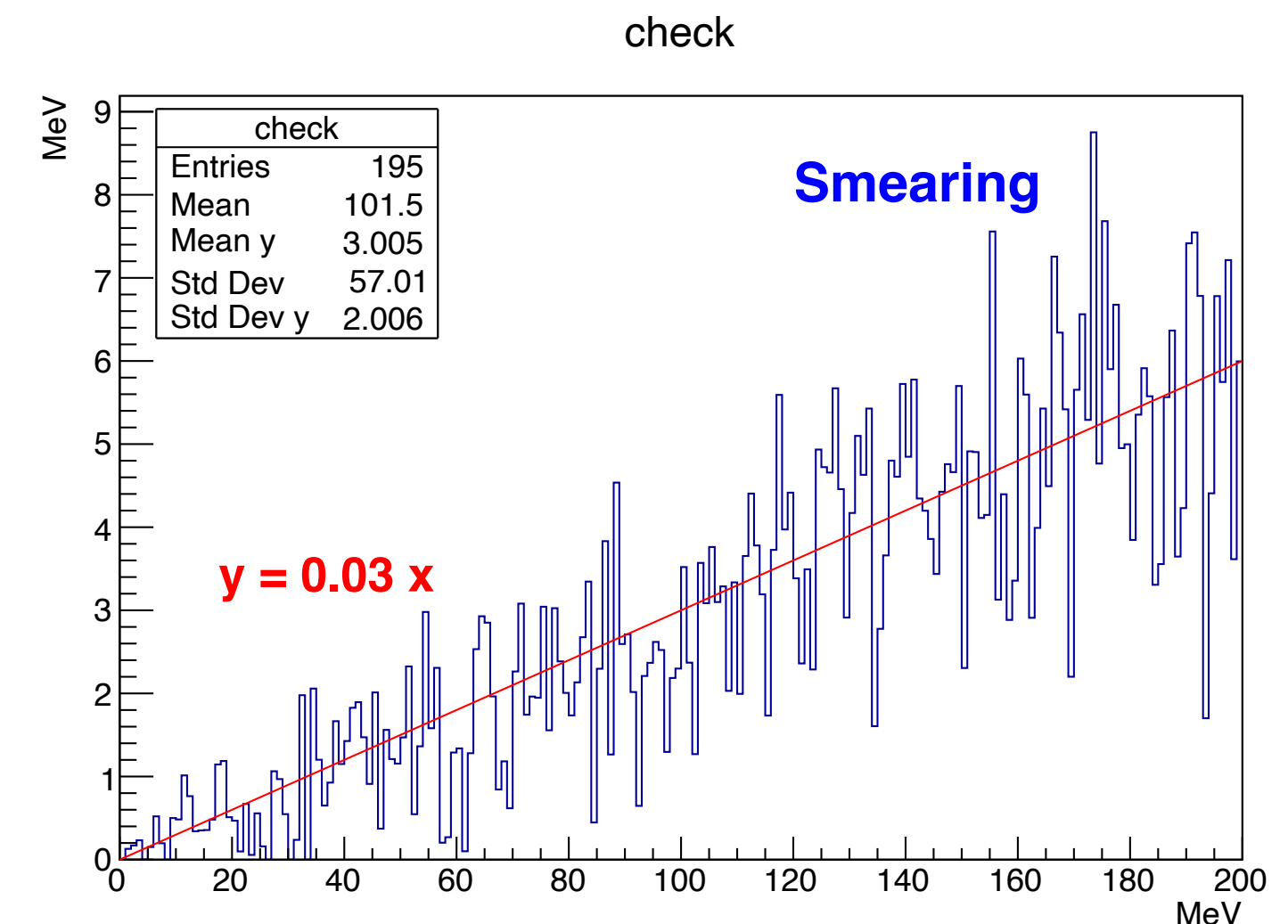
double reco(double E0)
{
  double E = E0;
  if(E0 < threshold) return 0;
  else{
    double a = 0.1;
    double b = 0.;
    double sigma = E * TMath::Sqrt(a*a/E + b*b) ;
    double random = gRandom->Gaus(E*0.03,sigma);
    E = random;
    return E;
  }
}
```



- Code on the right
 - The parameter a and b is determined by fiber structure study

Purpose:

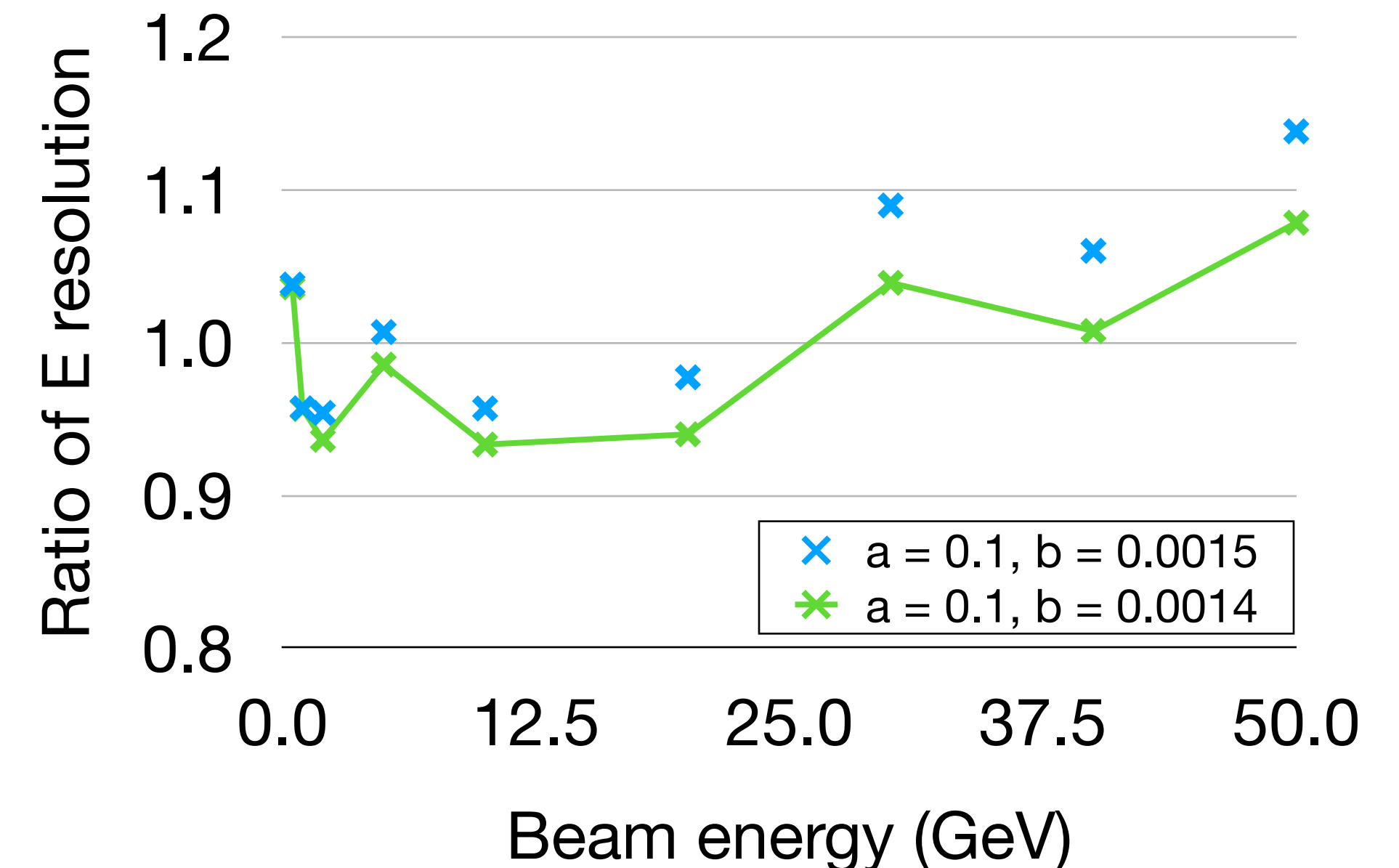
- Reproduce the fluctuation from Gaussian random
- keeps the mean $\sim 0.03 E_0$



Reconstructed Energy from mixture structure

electrons @ 0.5, 1, 2, 5, 10, 20, 30, 50 GeV

	Fiber energy resolution	Reconstructed 1	Ratio	Reconstructed 2	Ratio
		a = 0.1, b = 0.0015		a = 0.1, b = 0.0014	
500 MeV	0.1503	0.1560	1.0379	0.1557	1.0360
1 GeV	0.1163	0.1113	0.9569	0.1112	0.9564
2 GeV	0.0851	0.0812	0.9539	0.0797	0.9363
5 GeV	0.0570	0.0574	1.0068	0.0562	0.9855
10 GeV	0.0473	0.0452	0.9568	0.0441	0.9332
20 GeV	0.0391	0.0382	0.9772	0.0367	0.9399
30 GeV	0.0323	0.0352	1.0896	0.0335	1.0390
40 GeV	0.0313	0.0332	1.0599	0.0315	1.0075
50 GeV	0.0283	0.0323	1.1381	0.0306	1.0783



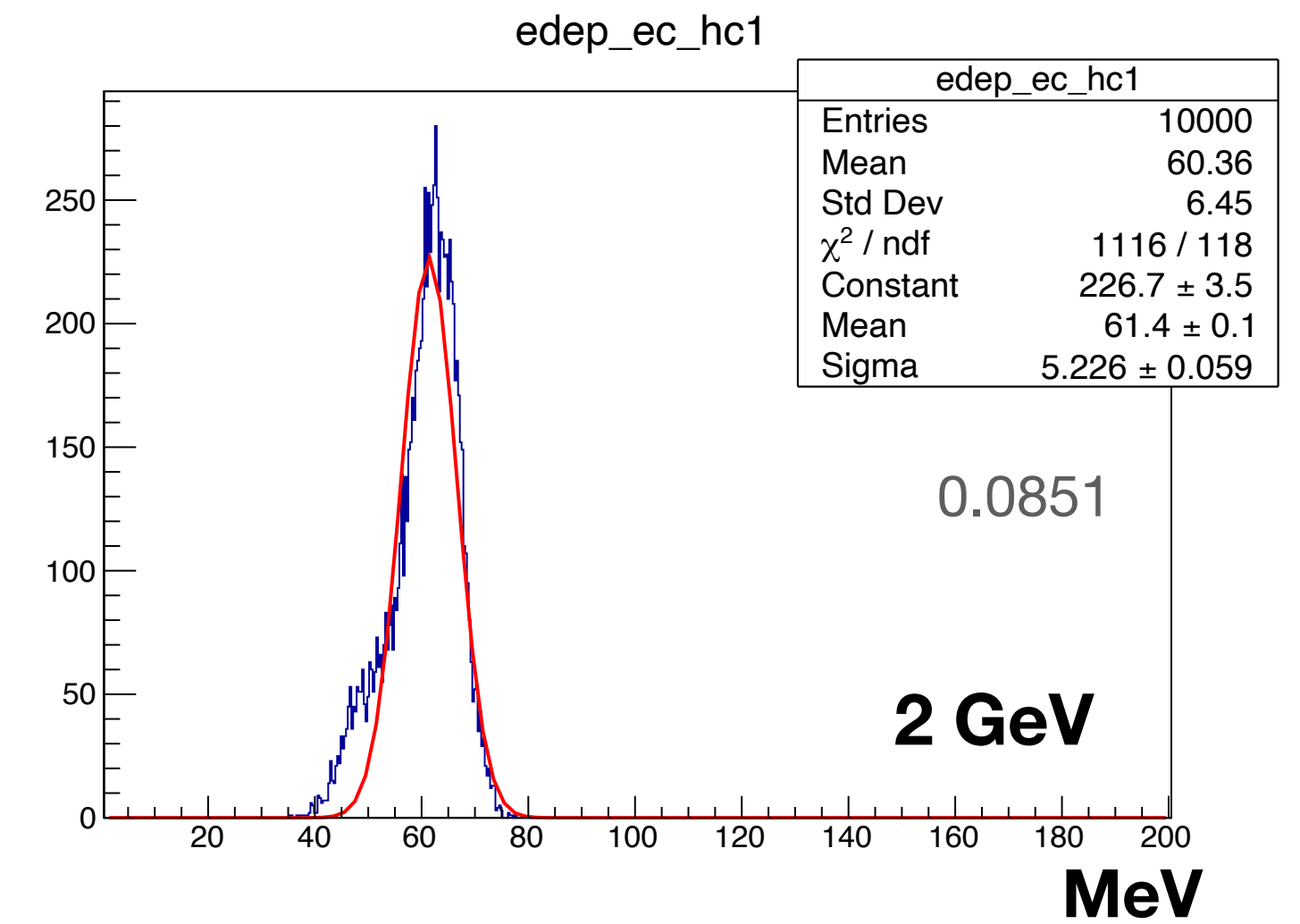
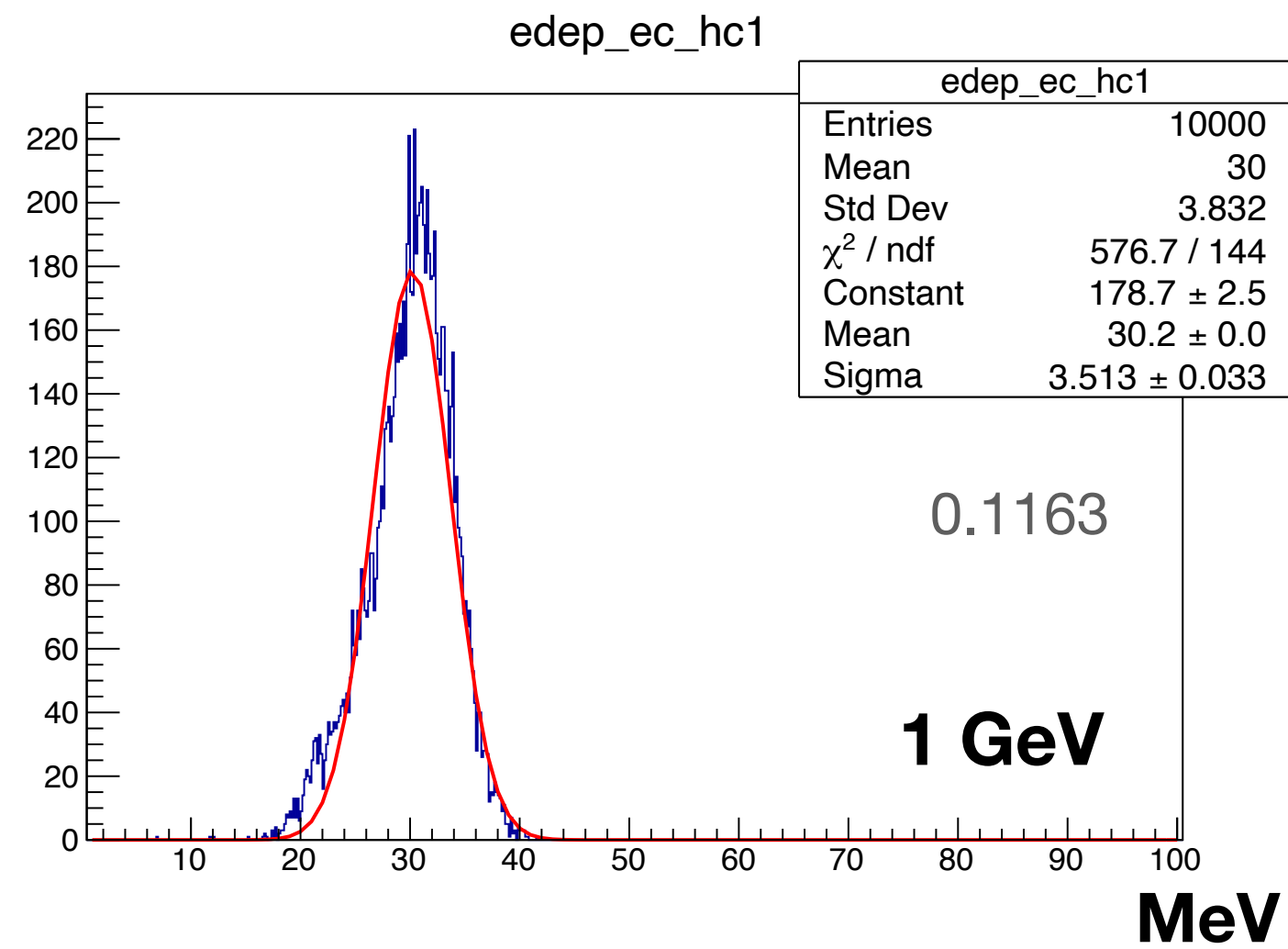
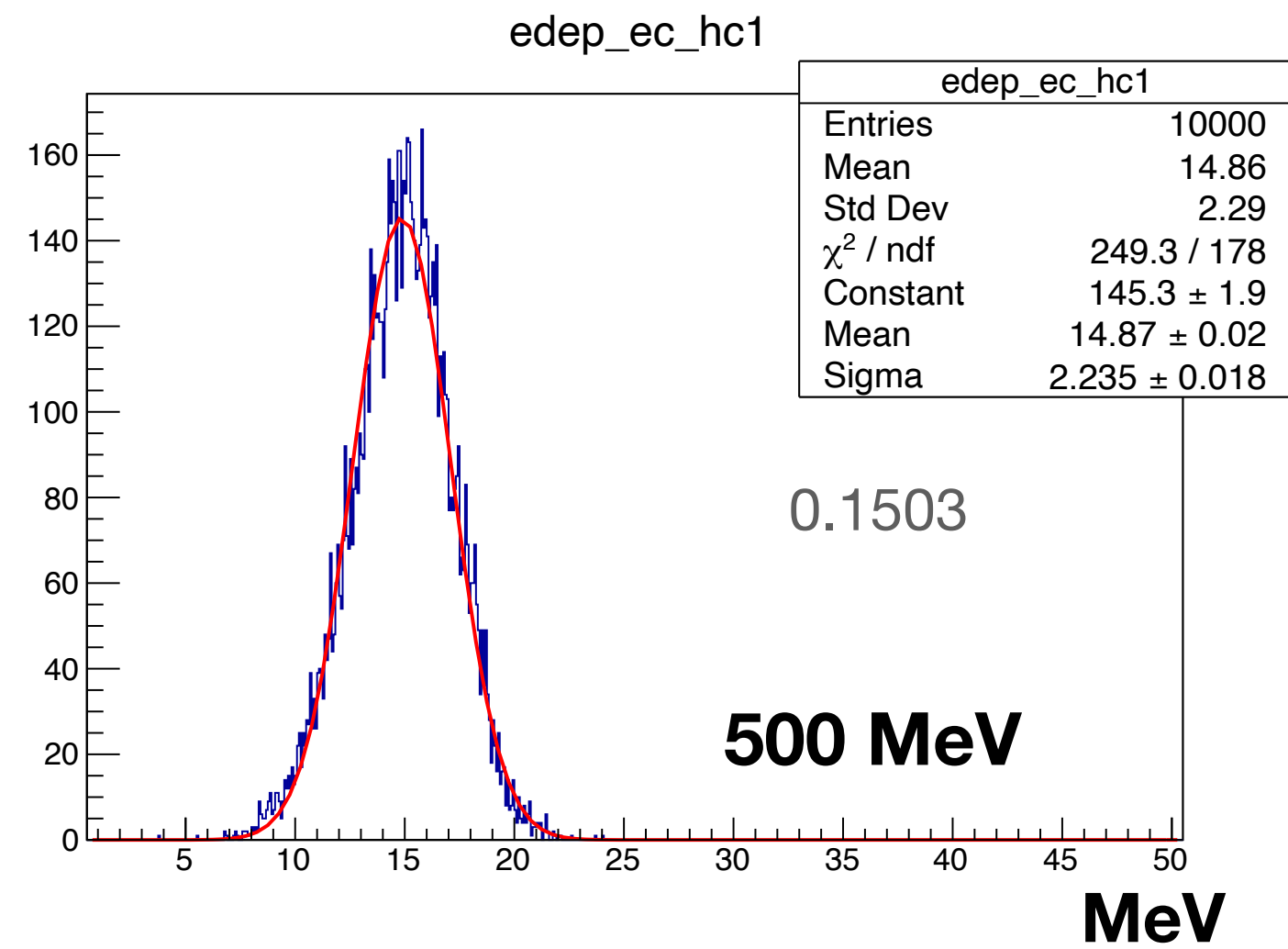
- The combination of **a = 0.1, b = 0.0015** has a better performance at lower energy, which is of main concern
- **We will choose this set of parameter for reconstruction**

Comparison at lower energy (electron @ 20 degree)

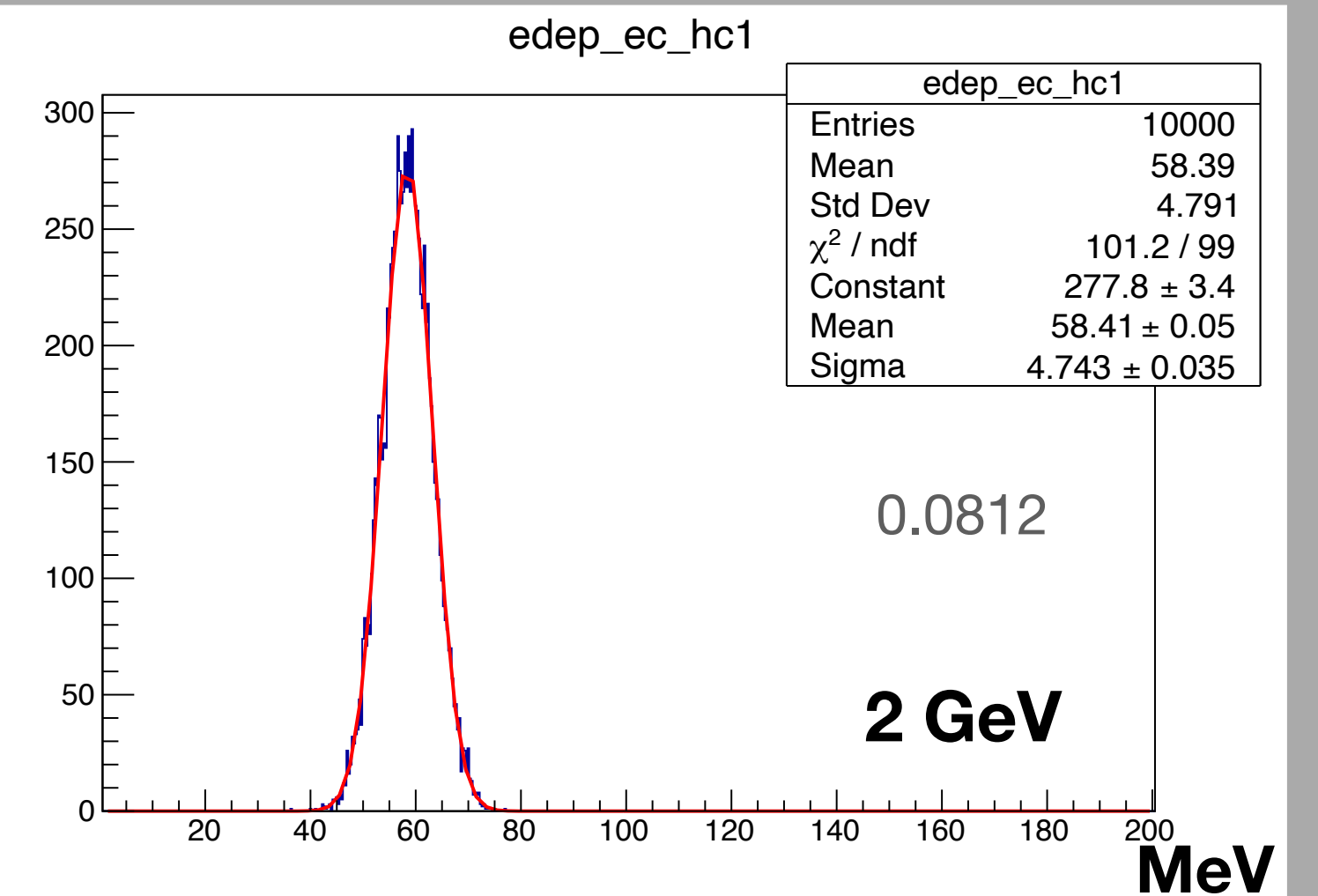
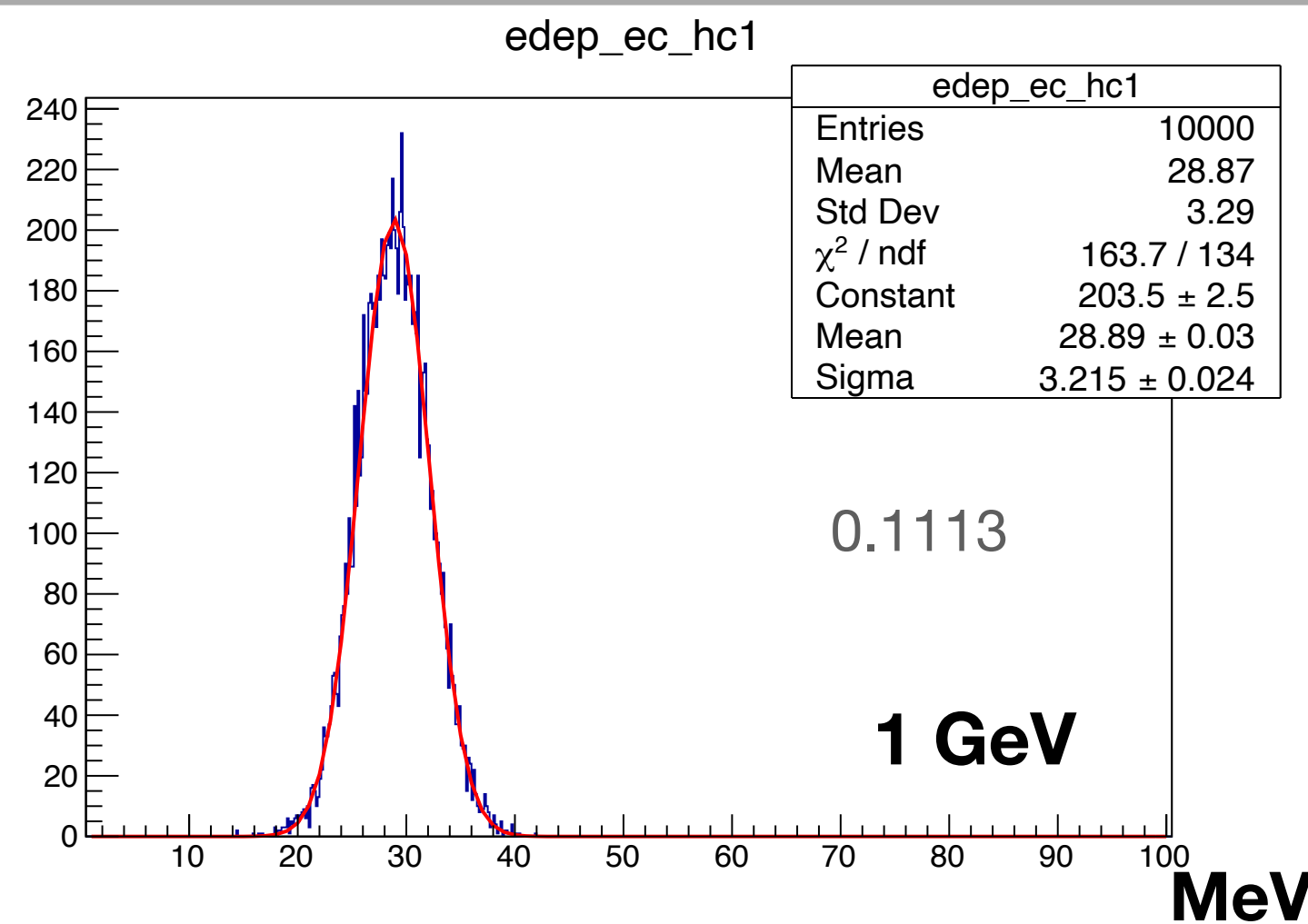
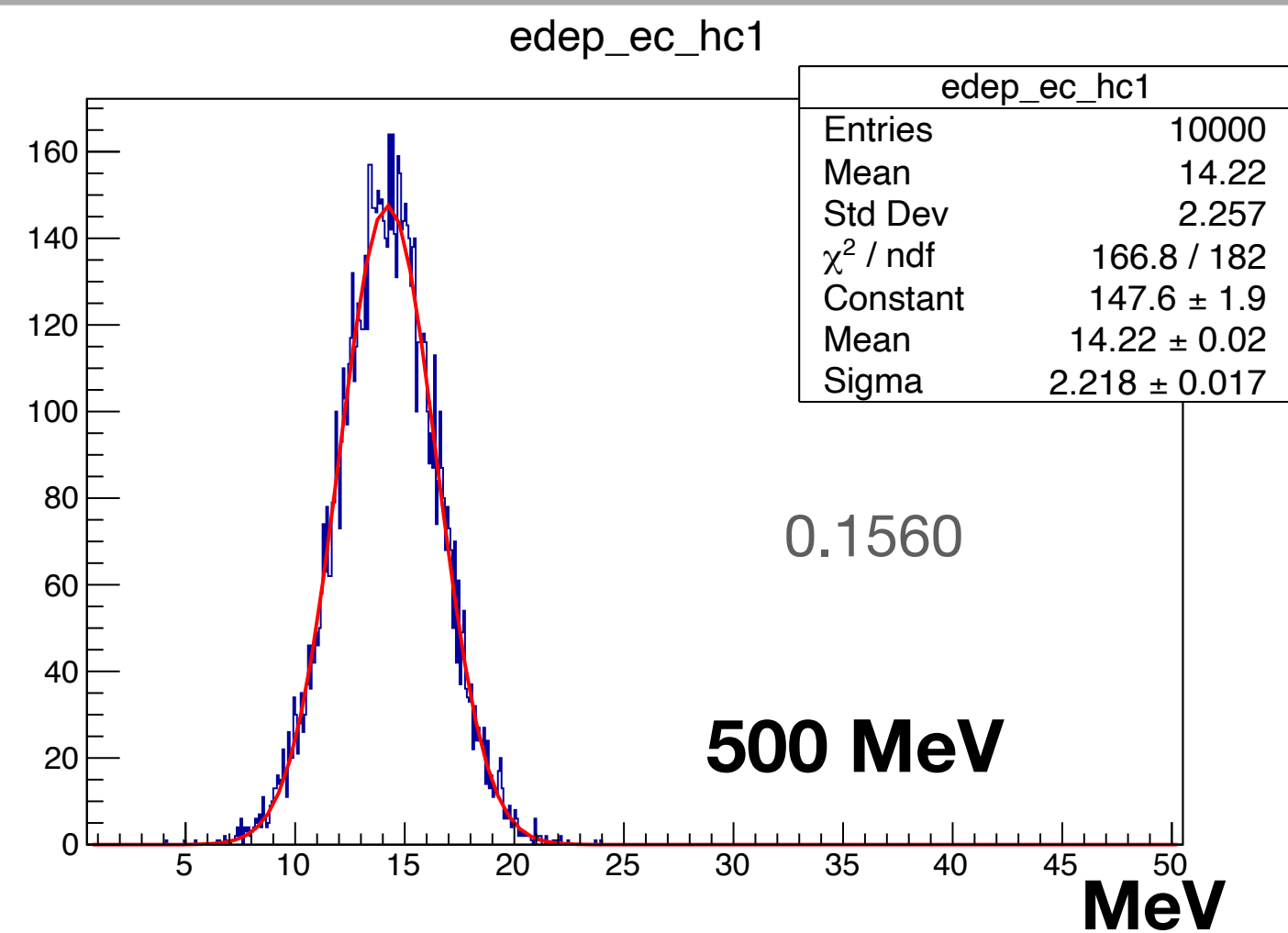
$a = 0.1, b = 0.0015$

- Both mean, sigma and resolution matches well

Fiber Structure



Reconstructed energy from mixture structure

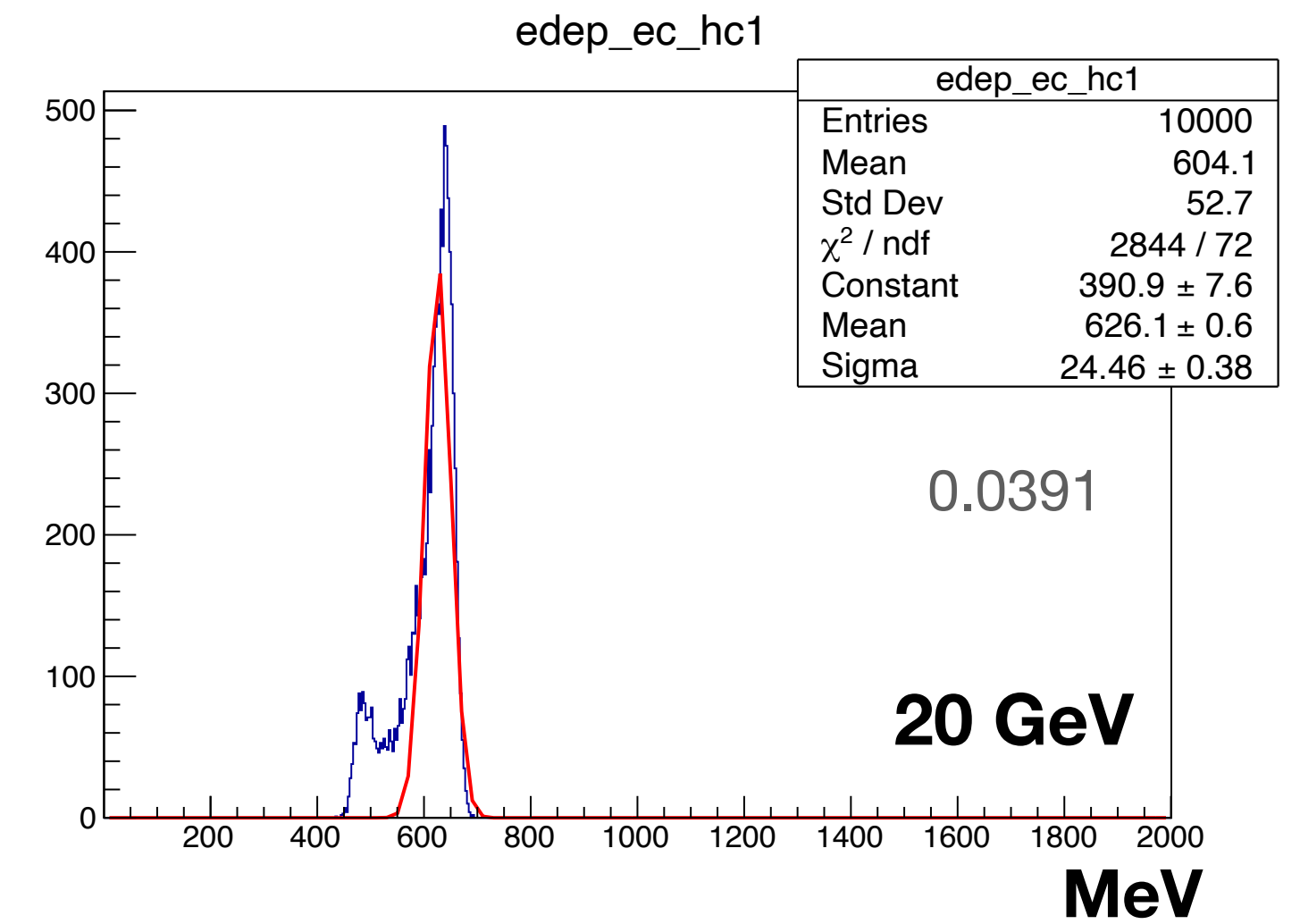
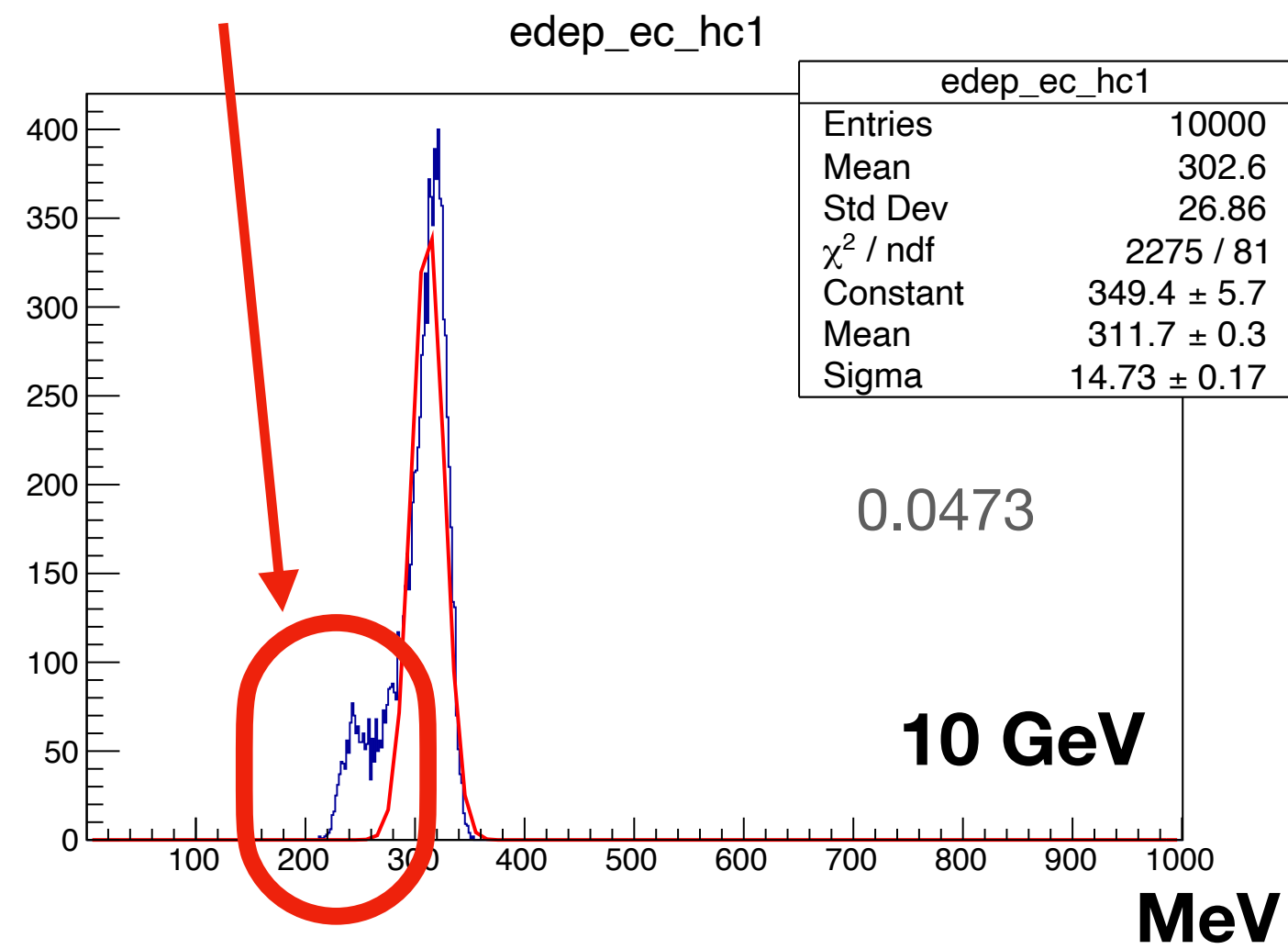
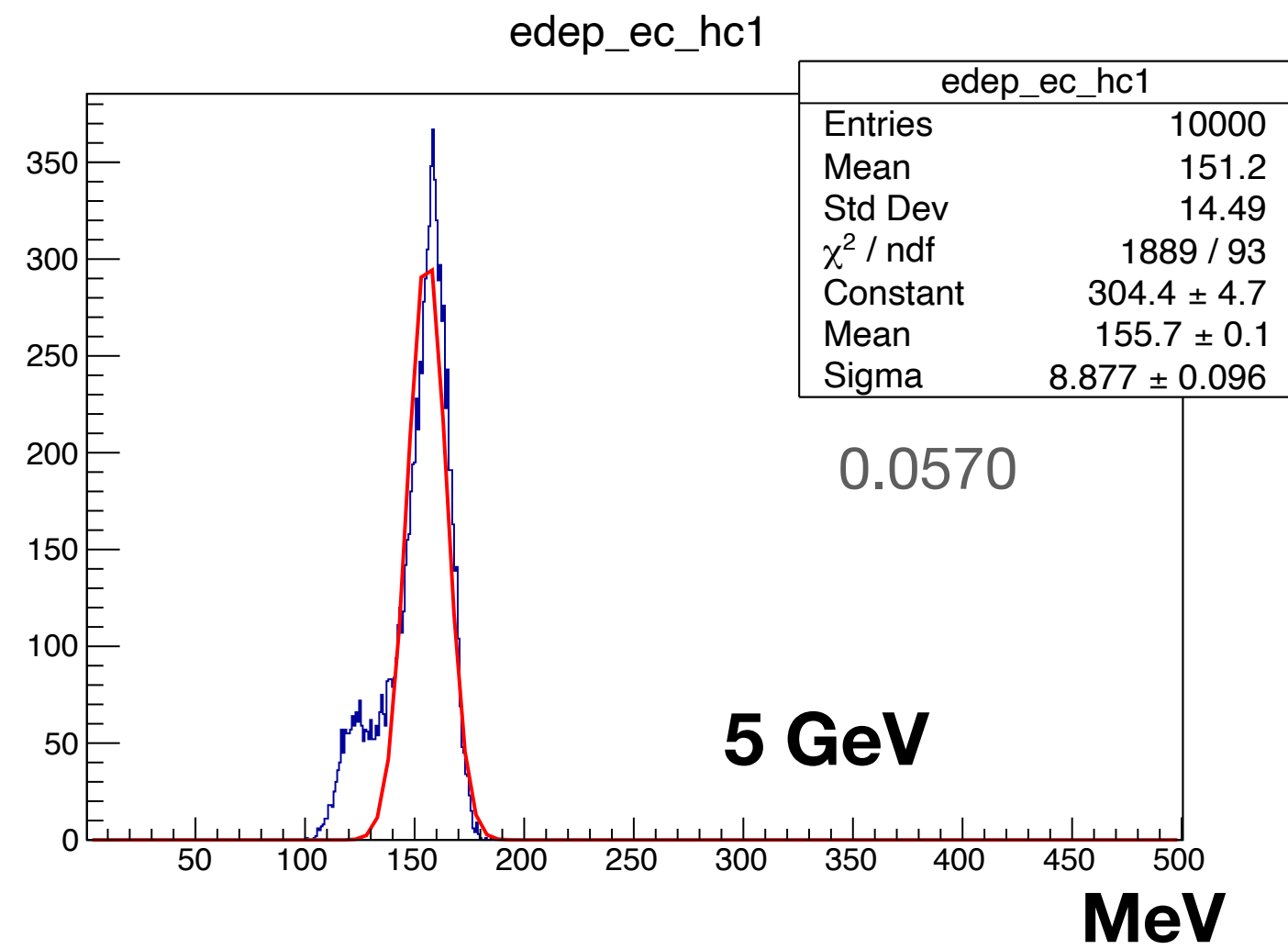


Comparison at lower energy (electron @ 20 degree)

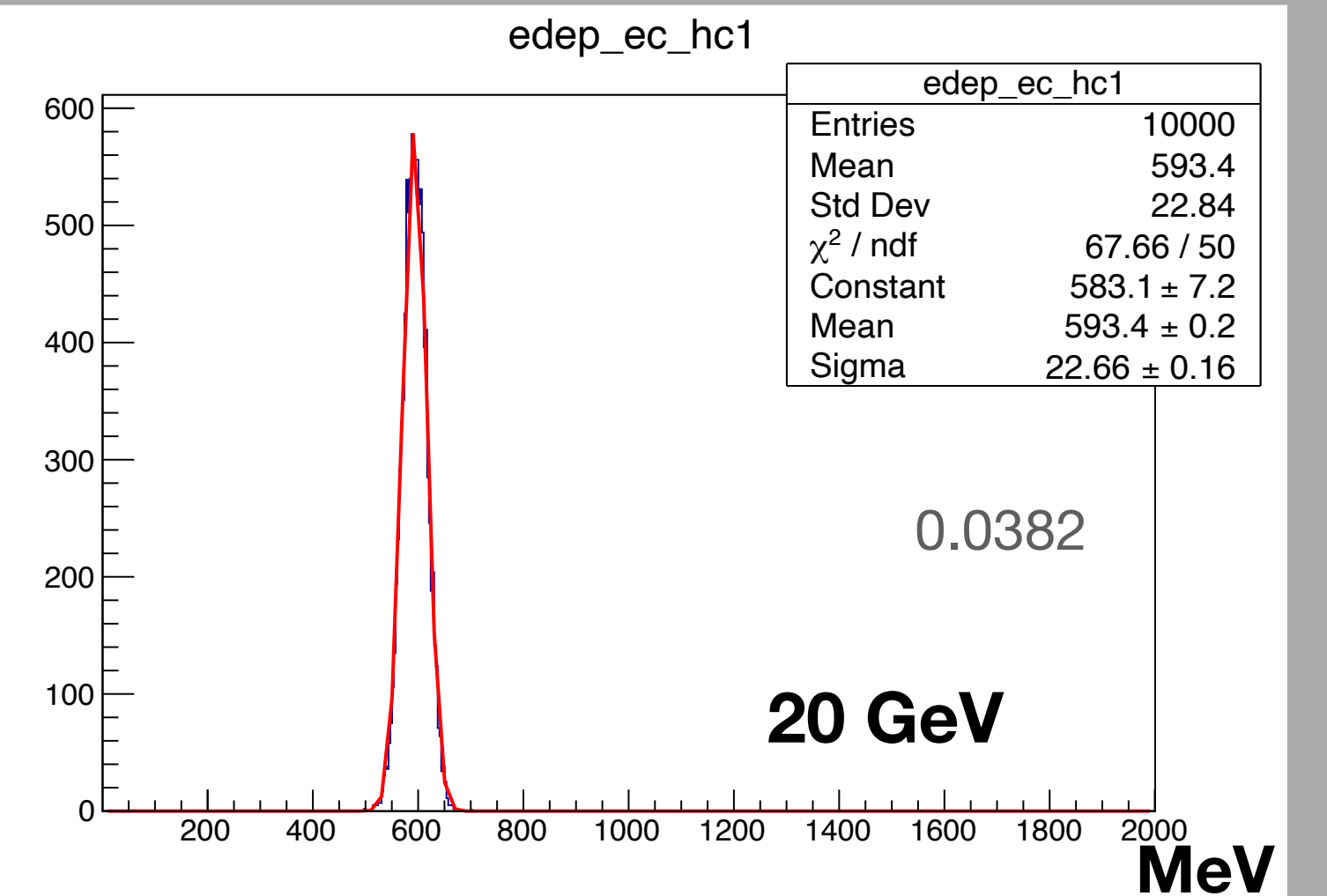
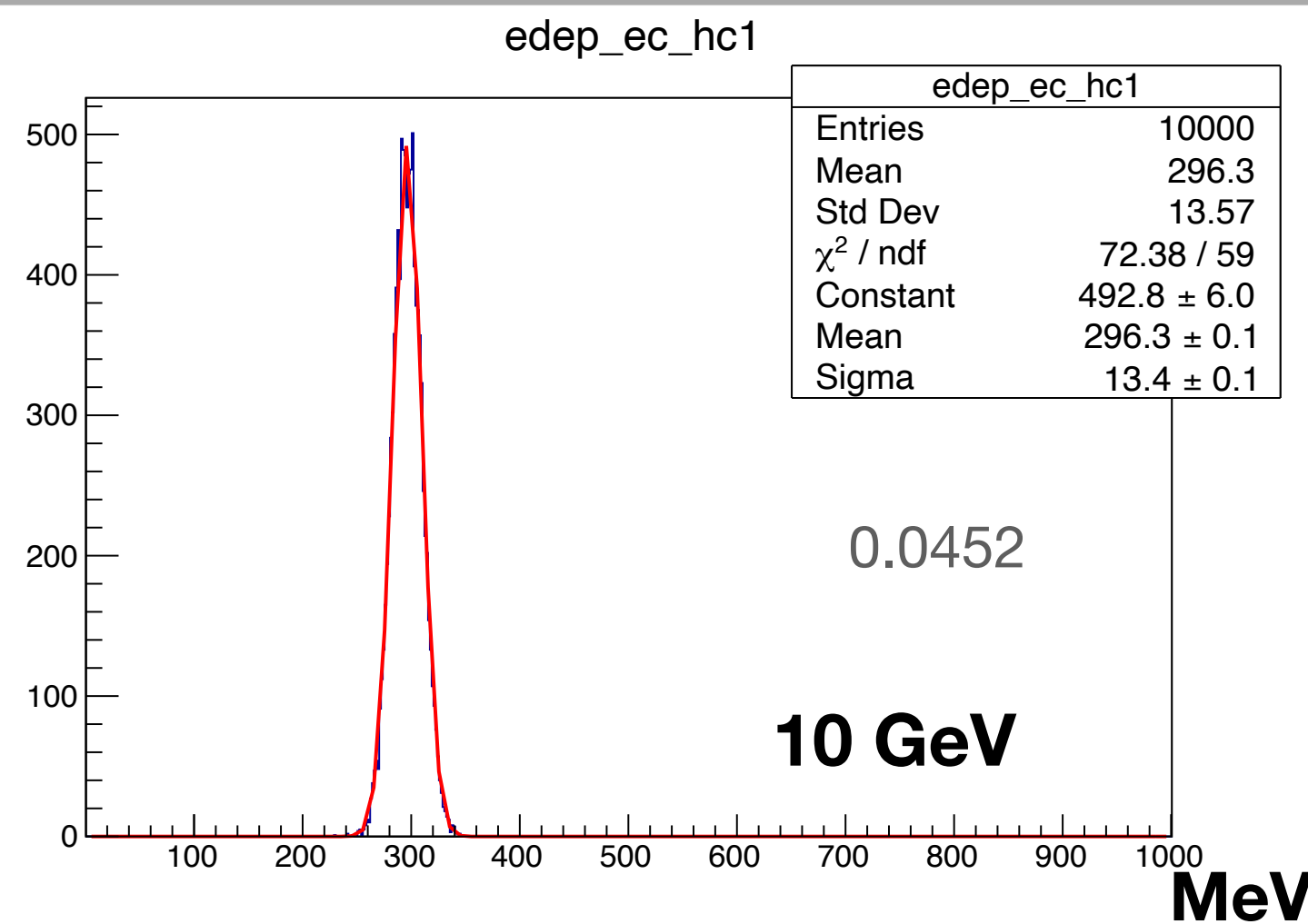
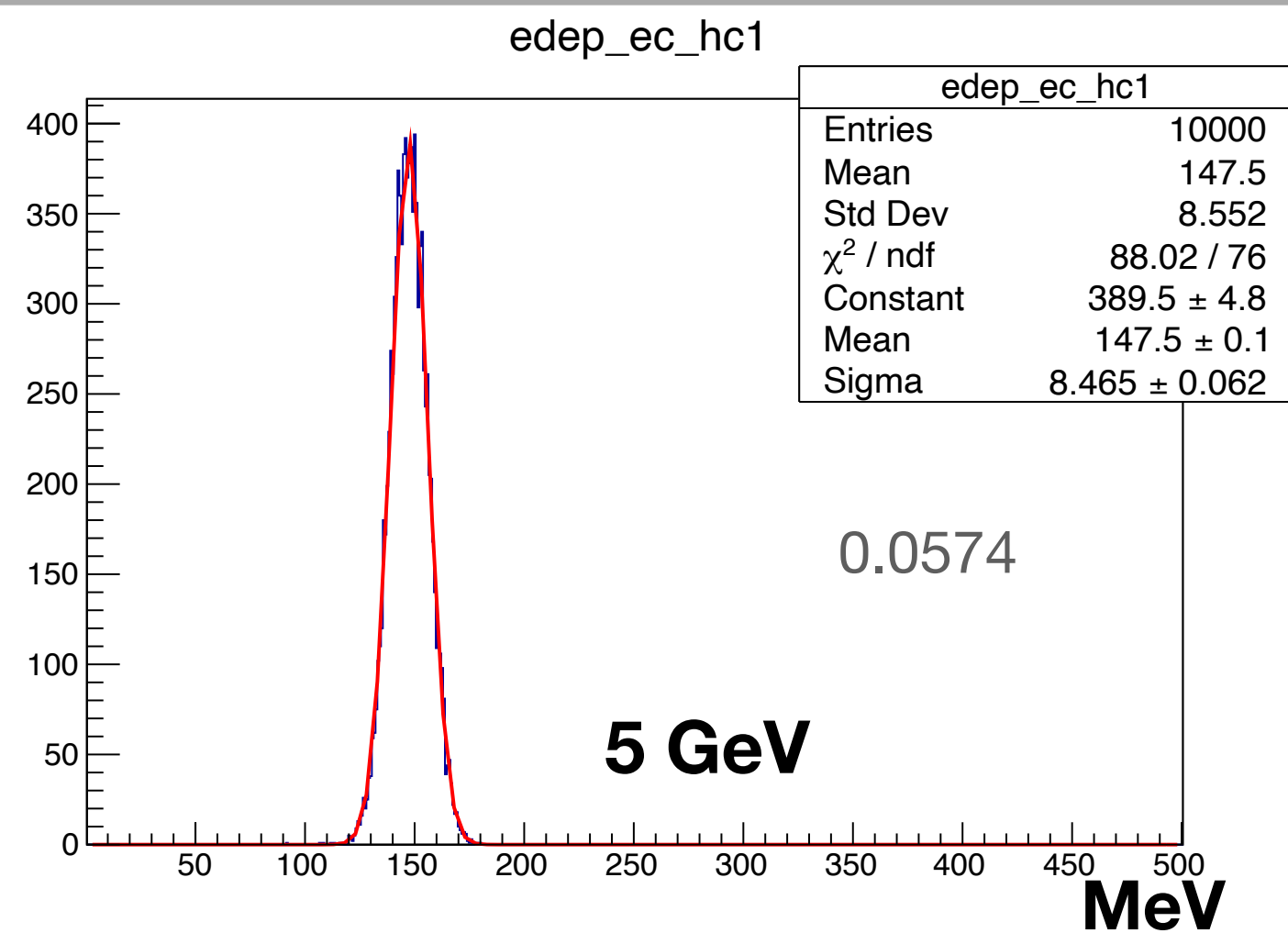
$a = 0.1, b = 0.0015$

Fiber Structure

- Both mean, sigma and resolution matches well
- **extra tails** on the left fiber: might related to electrons in SiFi



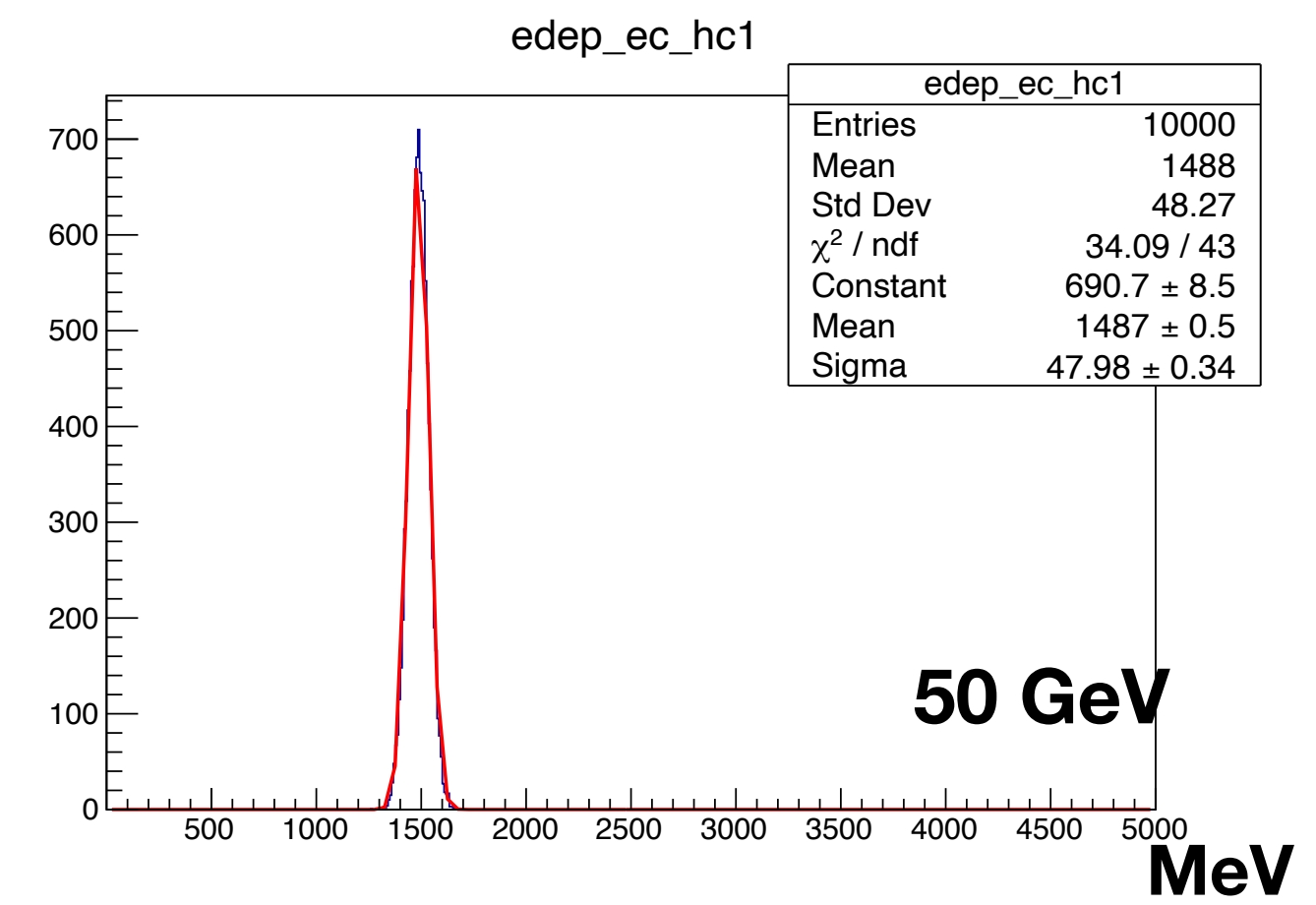
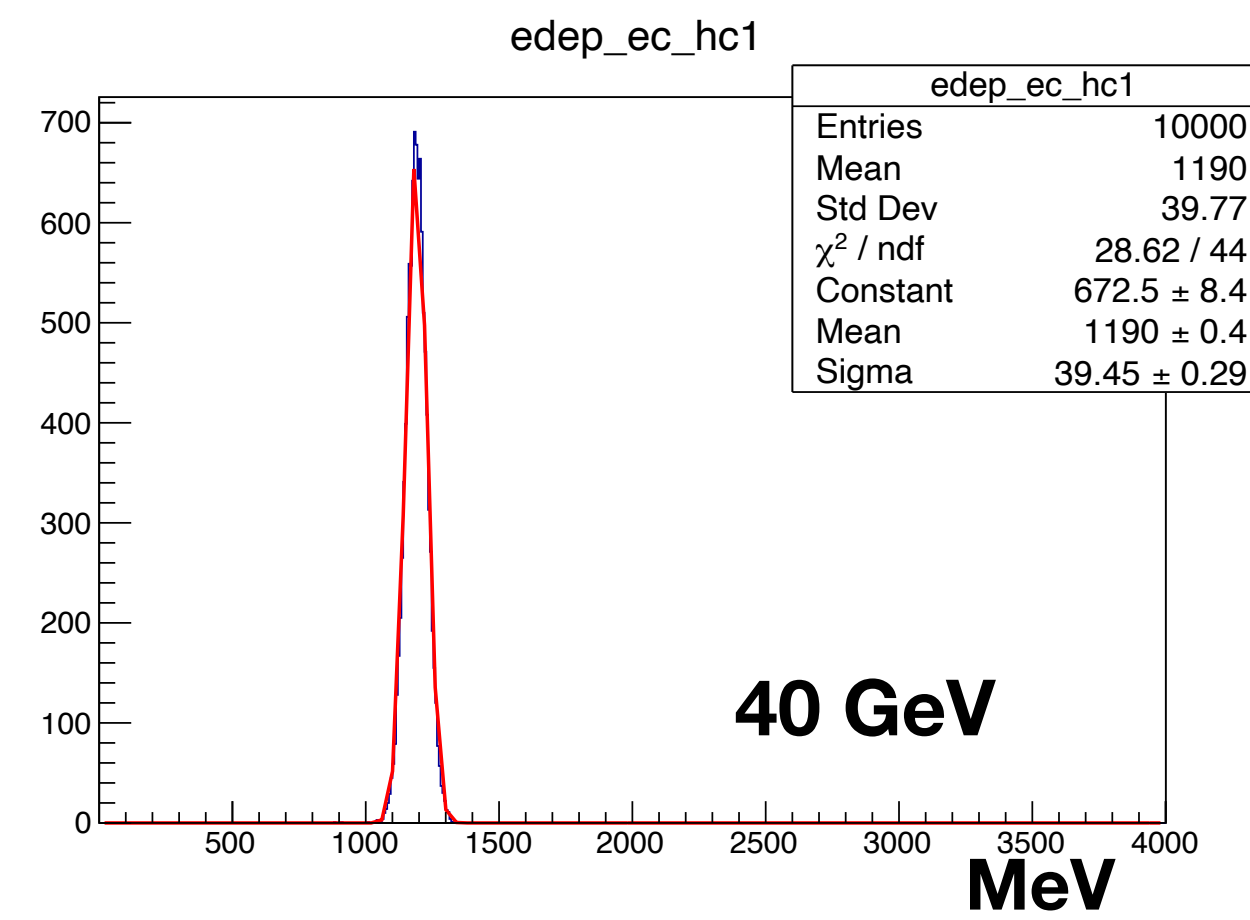
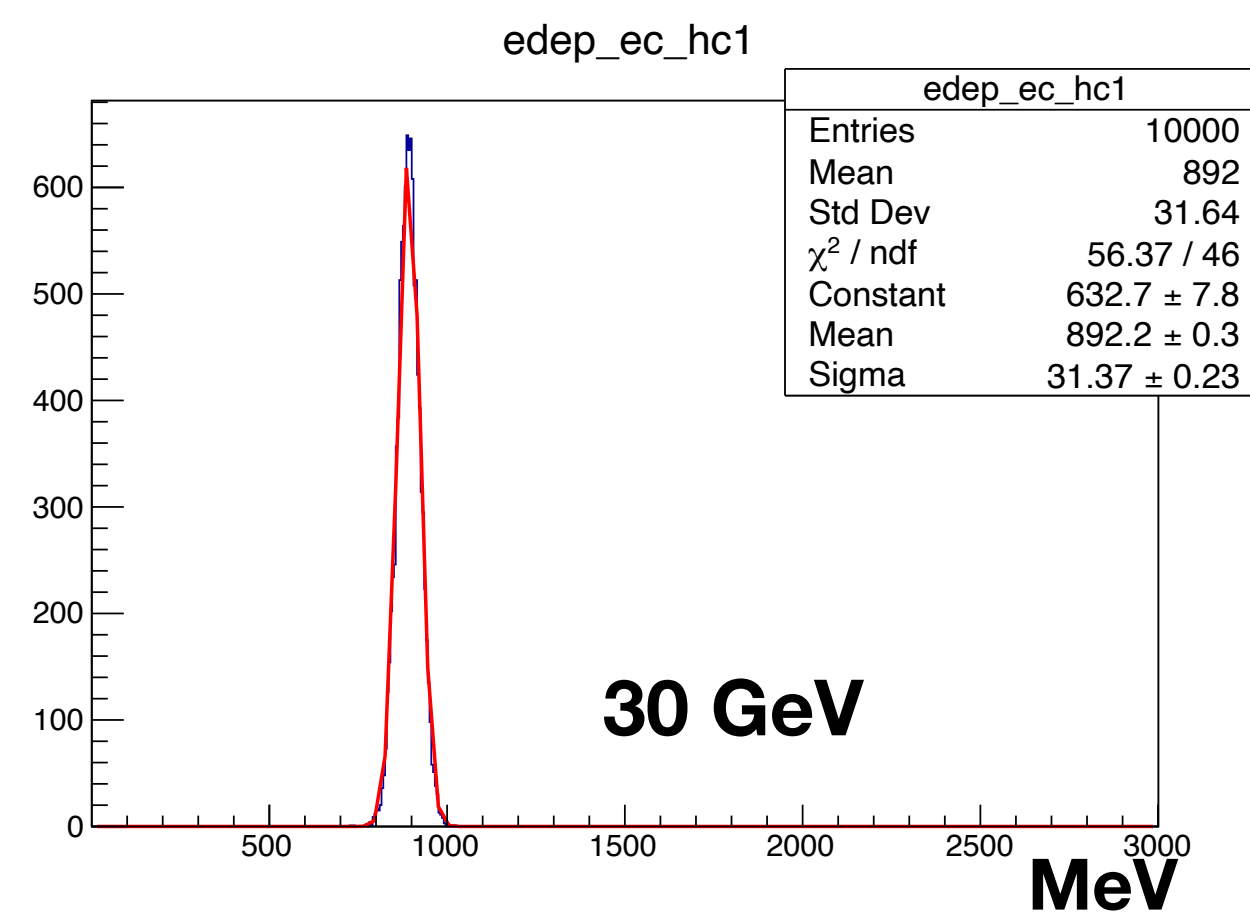
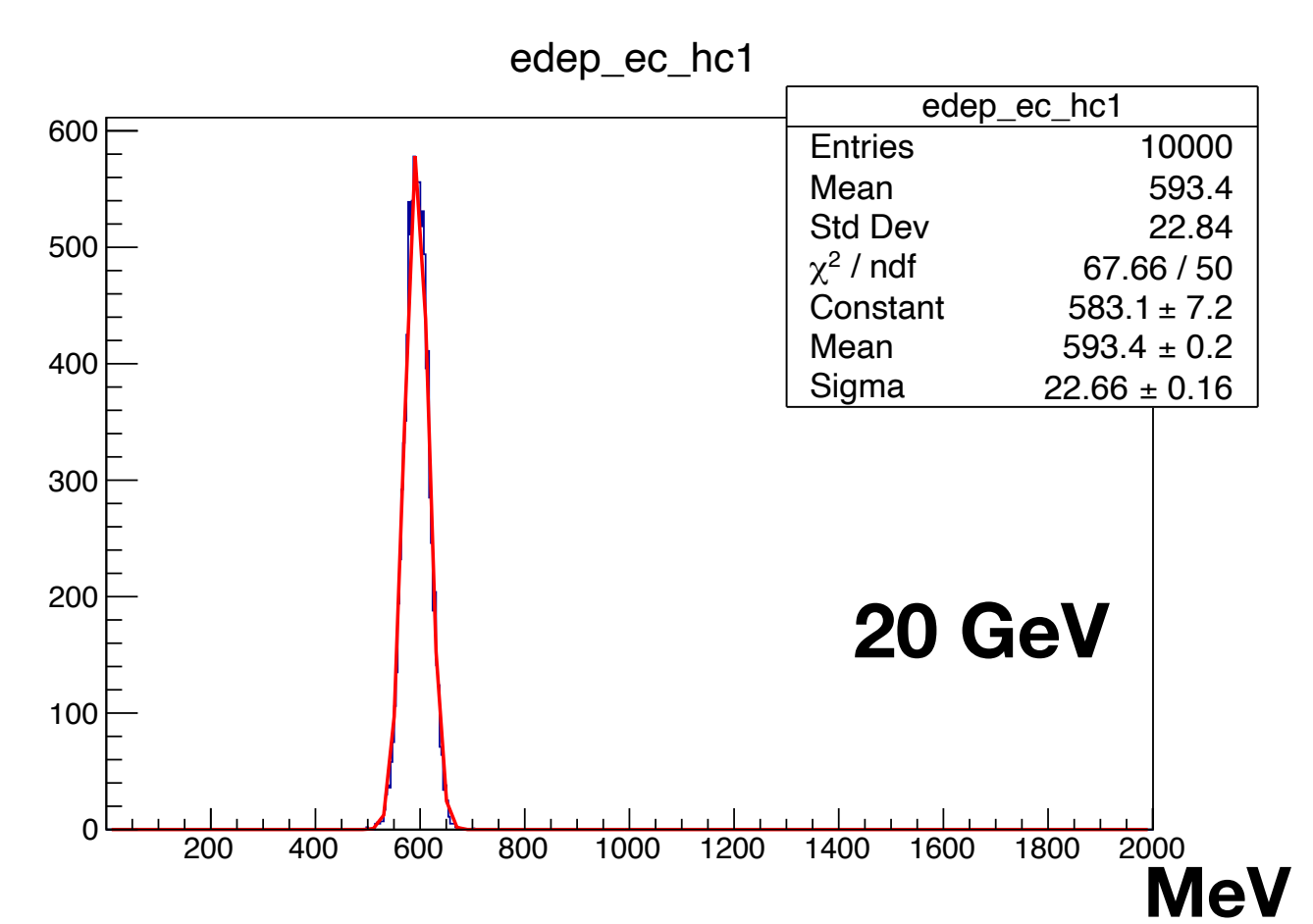
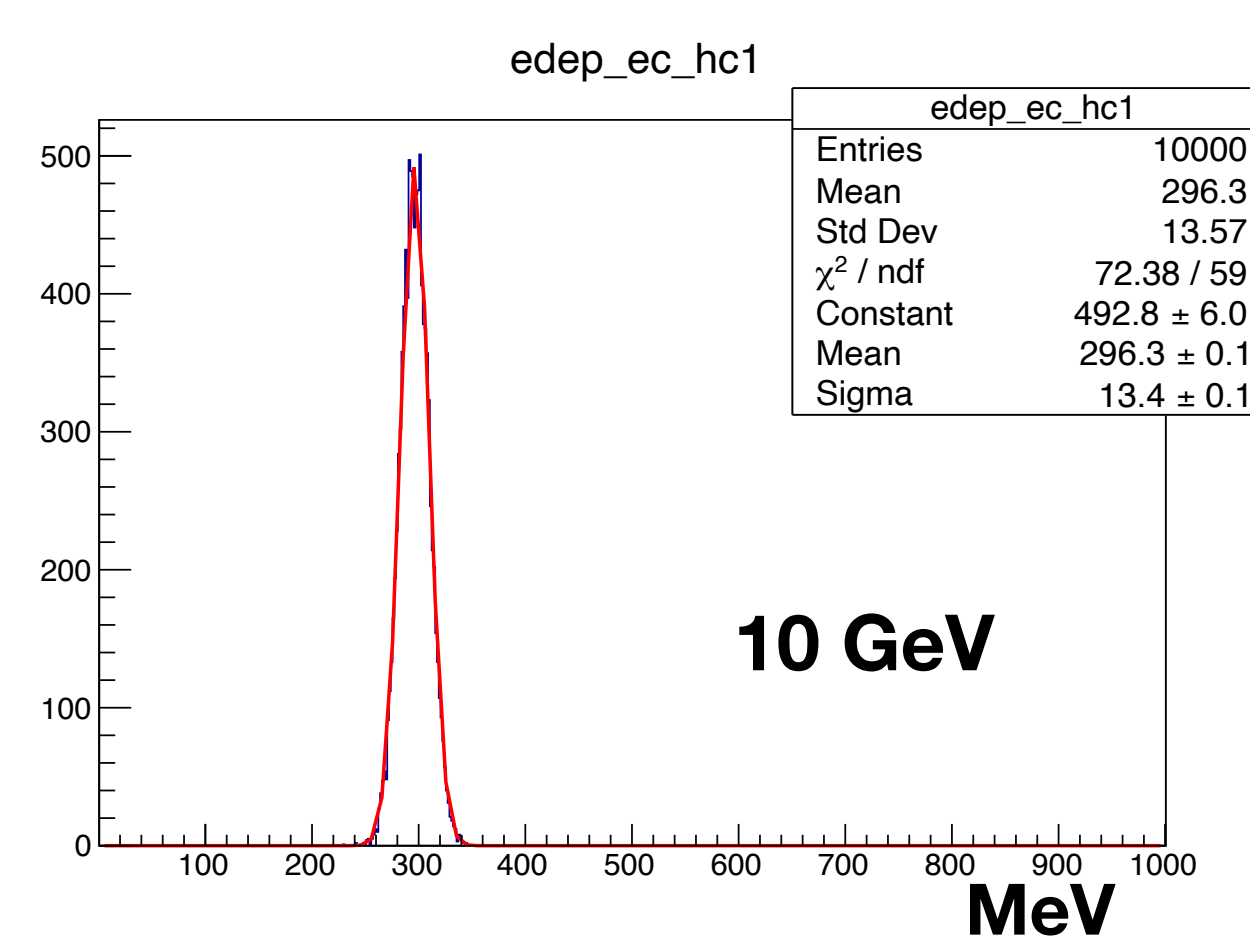
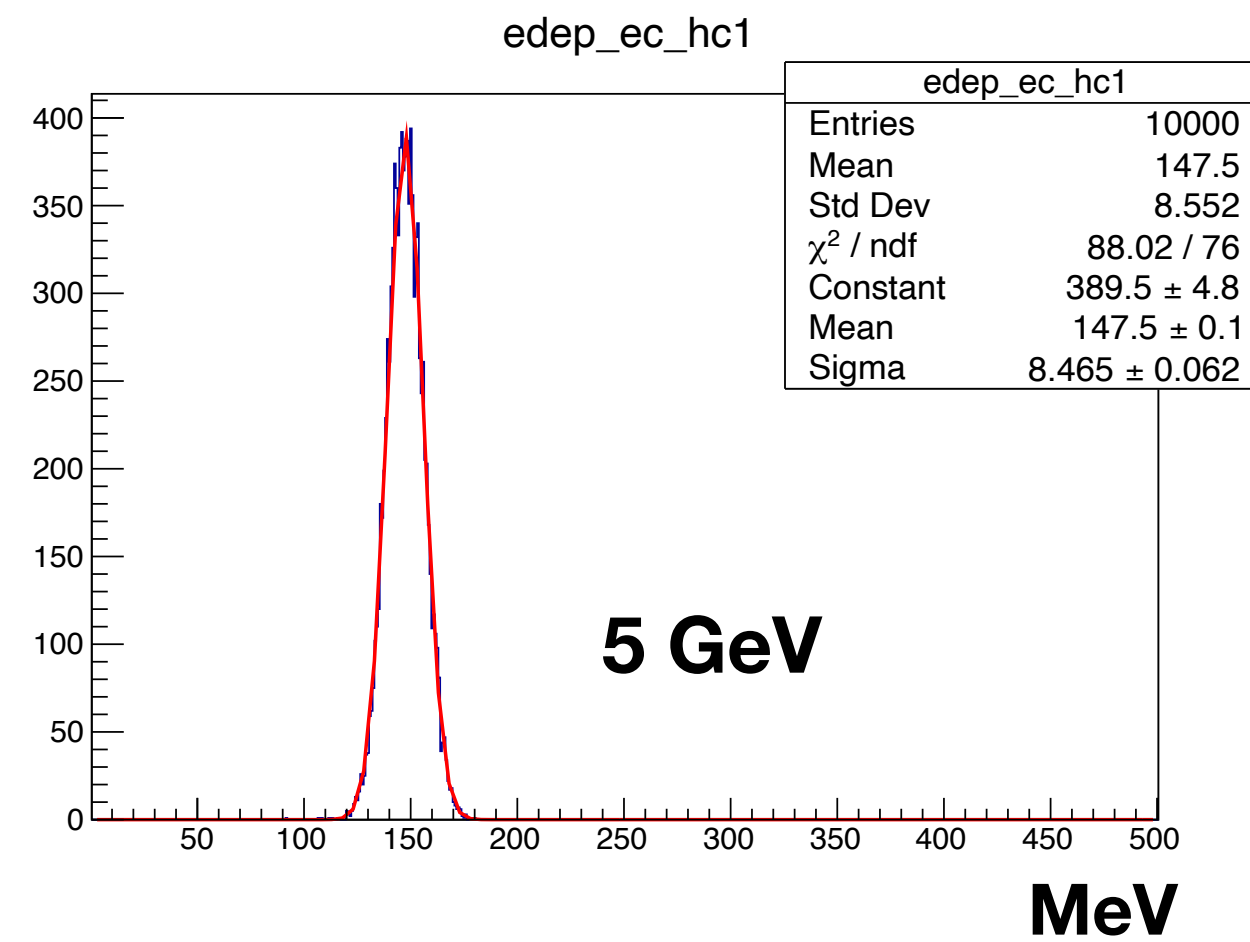
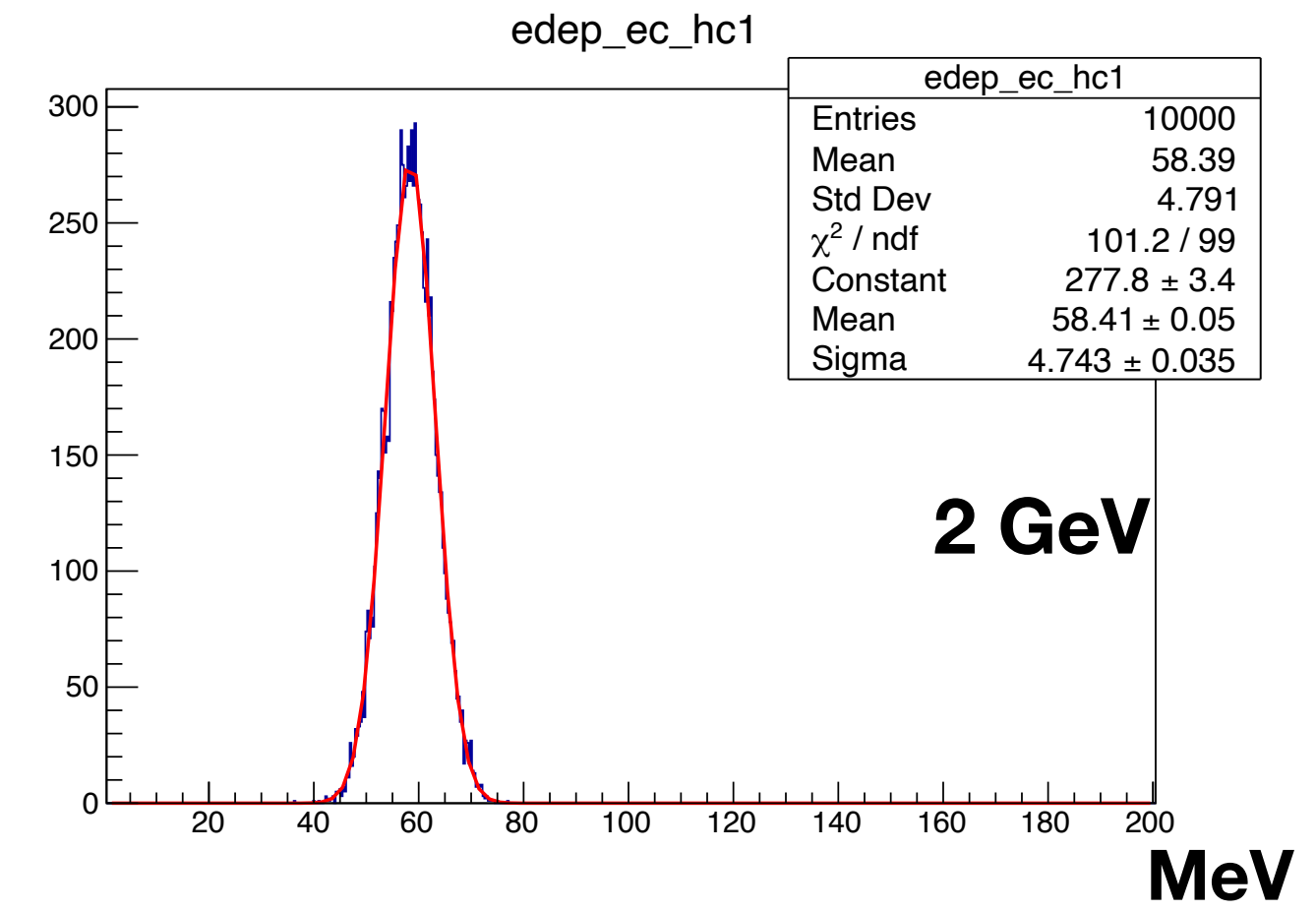
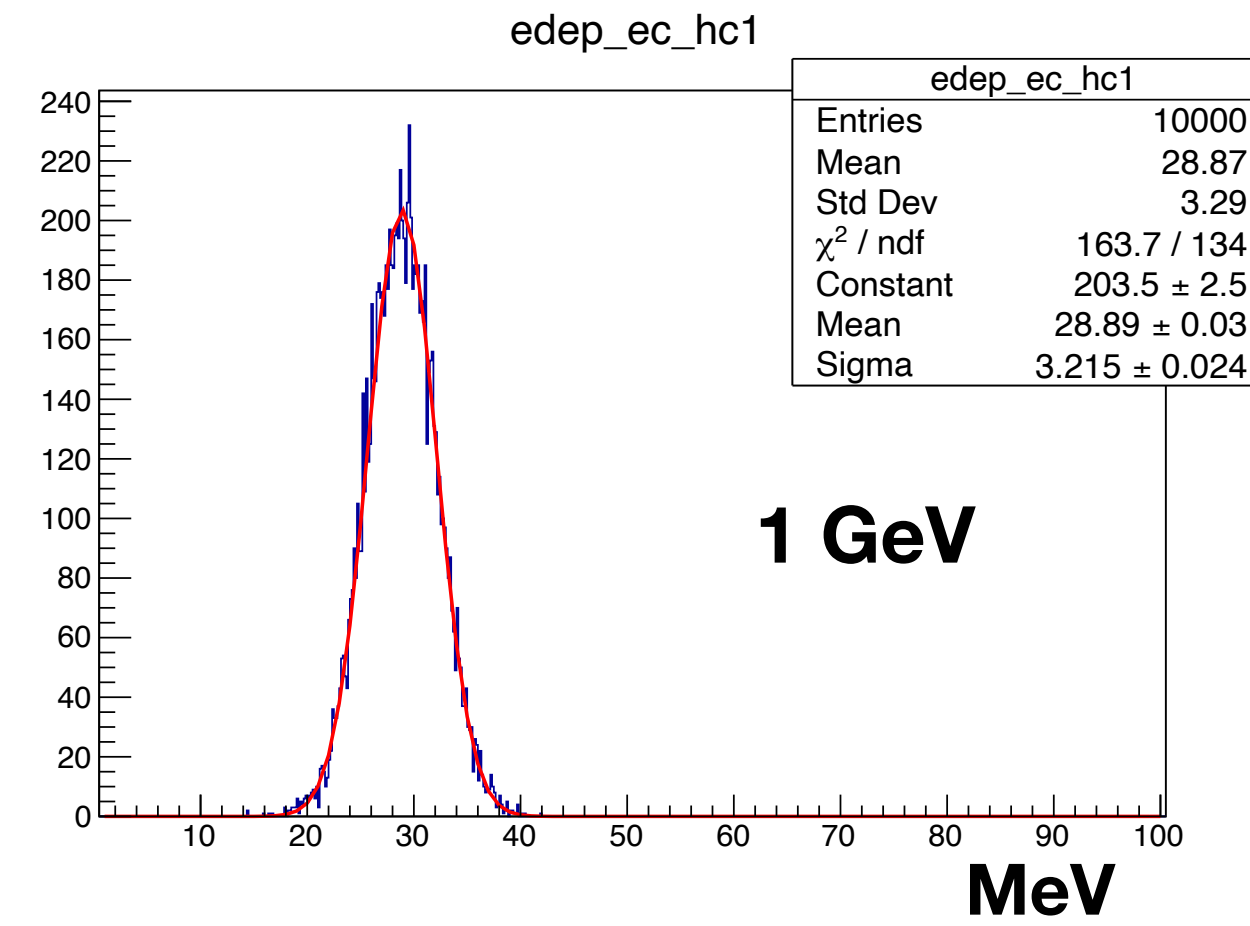
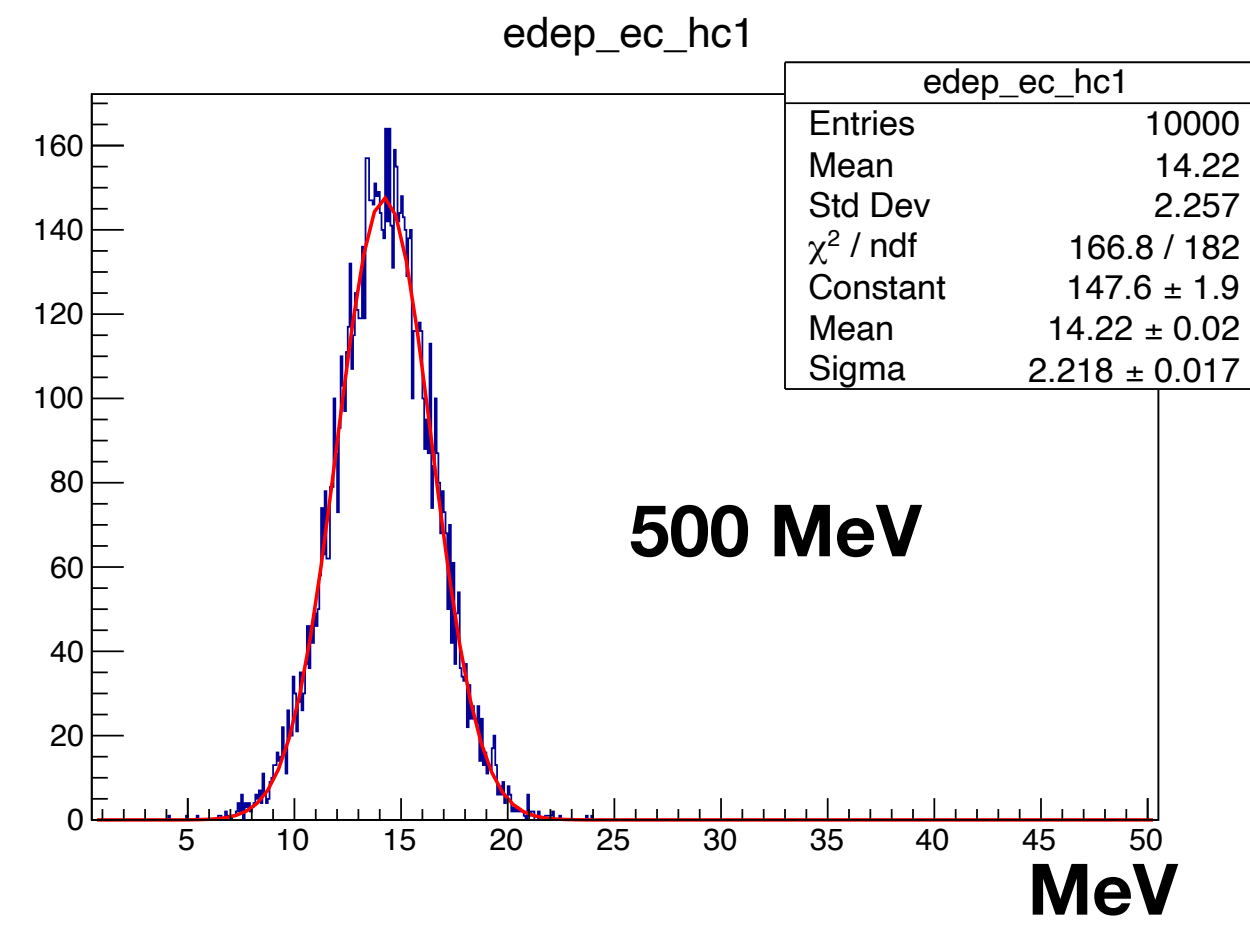
Reconstructed energy from mixture structure



**electrons @
0.5, 1, 2, 5,
10, 20, 30,
40, 50 GeV**

a = 0.1, b = 0.0015

**Reconstructed
energy
deposition from
fiber structure**



Reconstructed Energy from mixture structure pion+ @ 20 degree

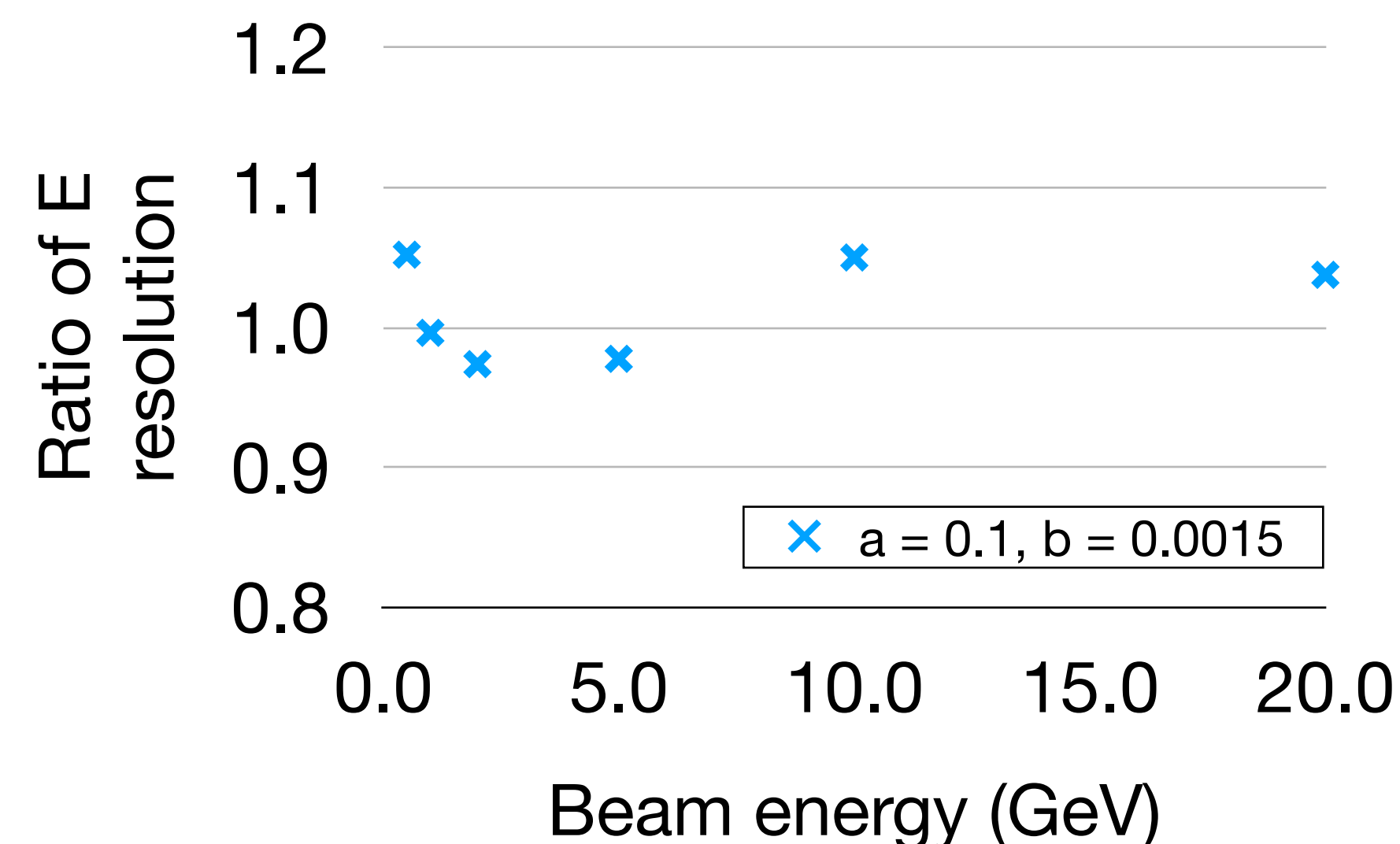
$a = 0.1$, $b = 0.0015$, we check the performance of mixture structure with pion+ at 20 degree

	Fiber energy resolution	Optimal weighting w_0	Reconstructed Energy Resolution	Optimal weighting w_1	Energy resolution Ratio
			$a = 0.1, b = 0.0015$		
500 MeV	0.2744	0.95	0.2887	0.8	1.0520
1 GeV	0.2678	1.1	0.2667	0.85	0.9961
2 GeV	0.2329	1.3	0.2268	1.2	0.9737
5 GeV	0.1991	1.35	0.1946	1.3	0.9775
10 GeV	0.1552	1.45	0.1630	1.35	1.0500
20 GeV	0.1303	1.45	0.1352	1.4	1.0376

- Optimal weighting is applied to get the total energy, w is constant:

$$E = \frac{E_{EM}}{w_{opt}} + E_{HCAL}$$

- The combination of $a = 0.1$, $b = 0.0015$ works well for hardron

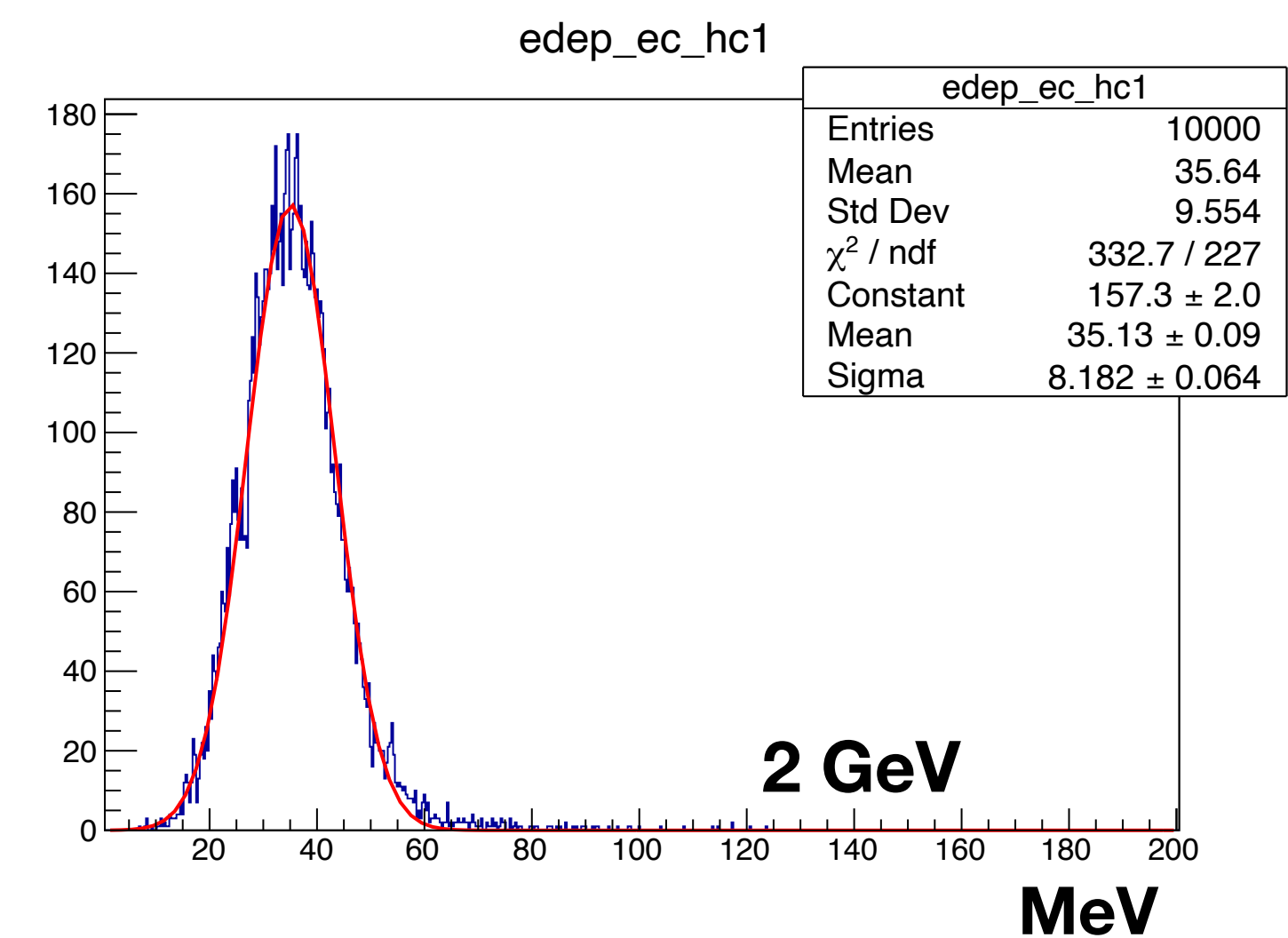
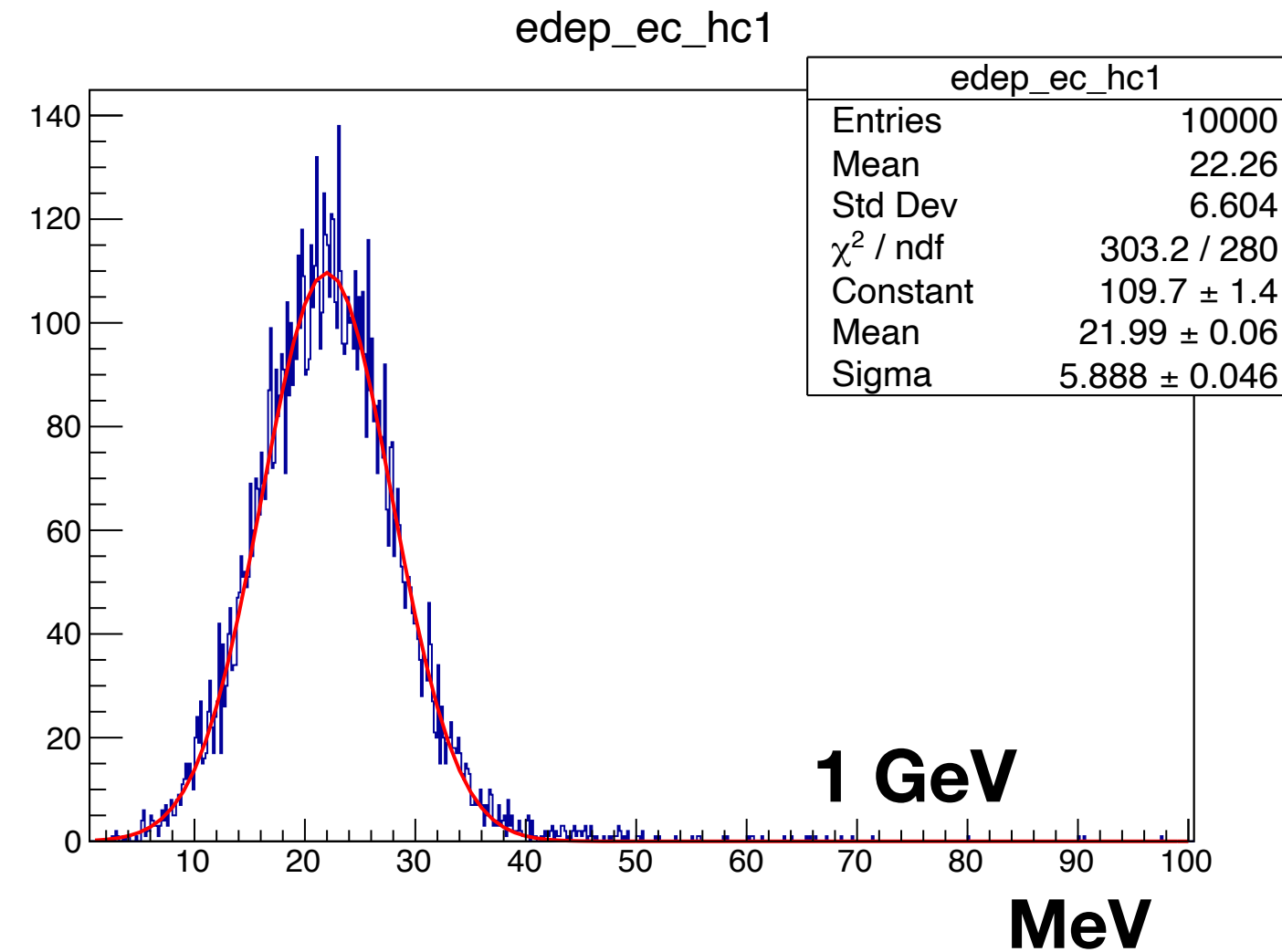
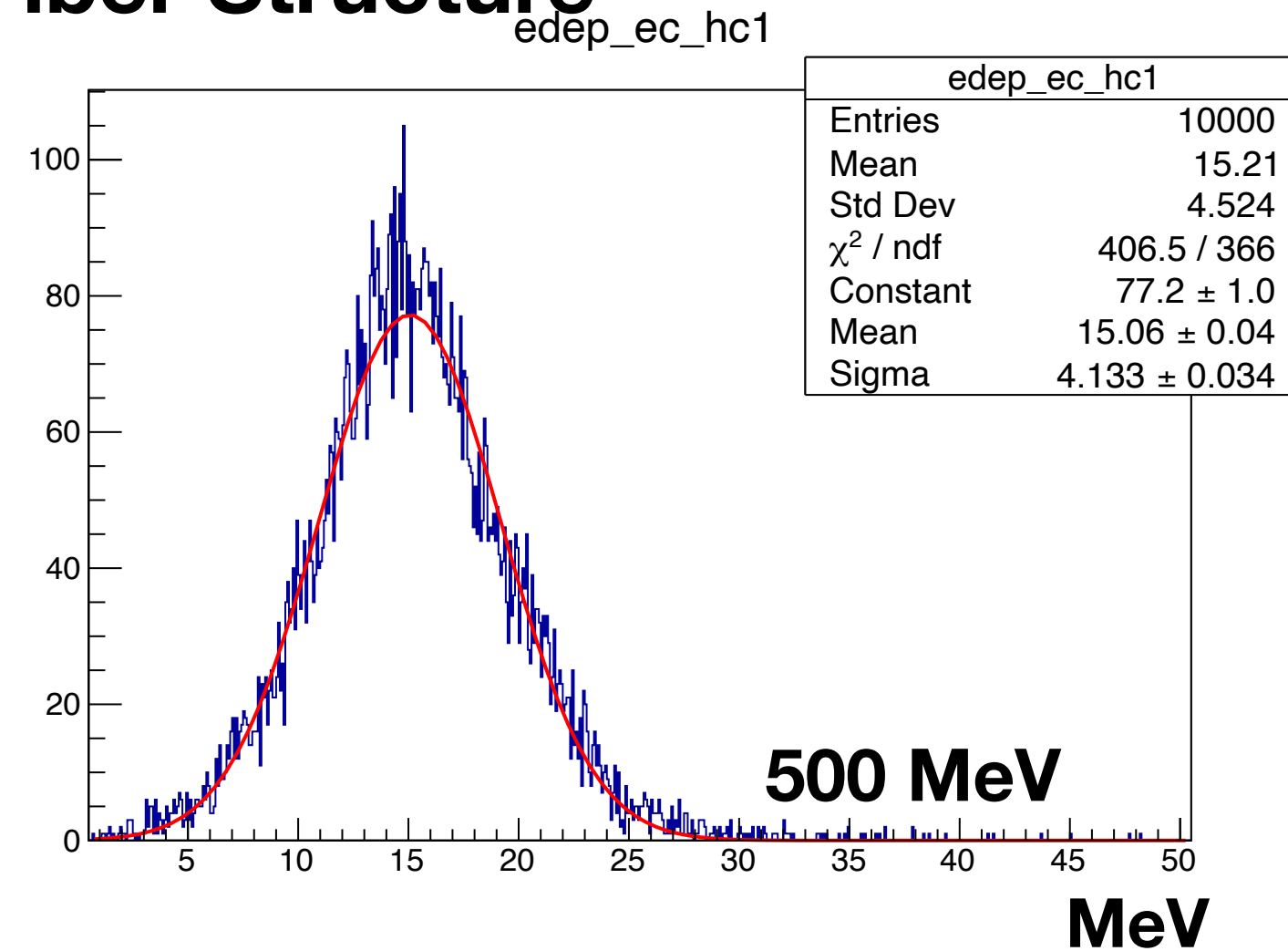


Comparison at lower energy (pion @ 20 degree)

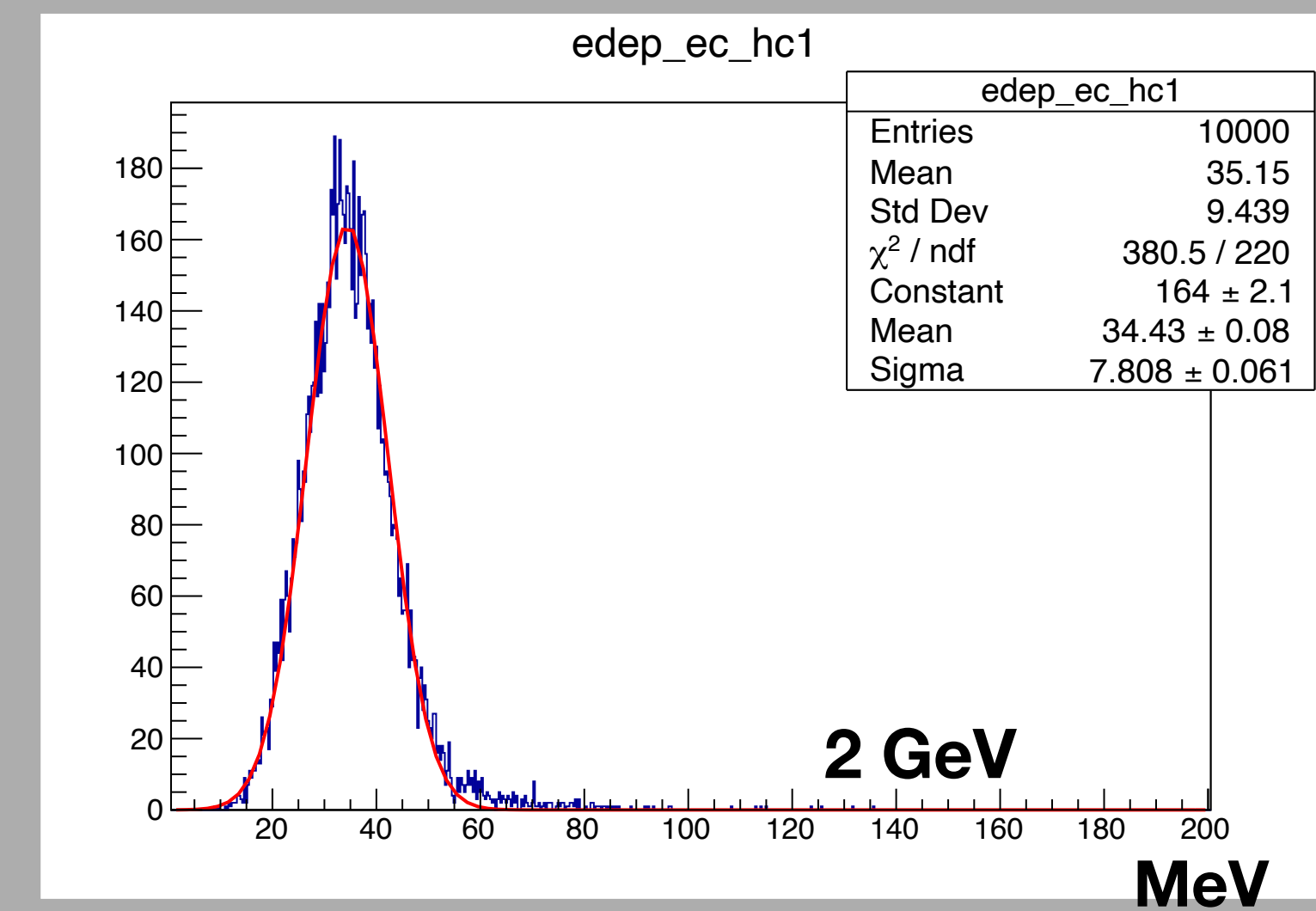
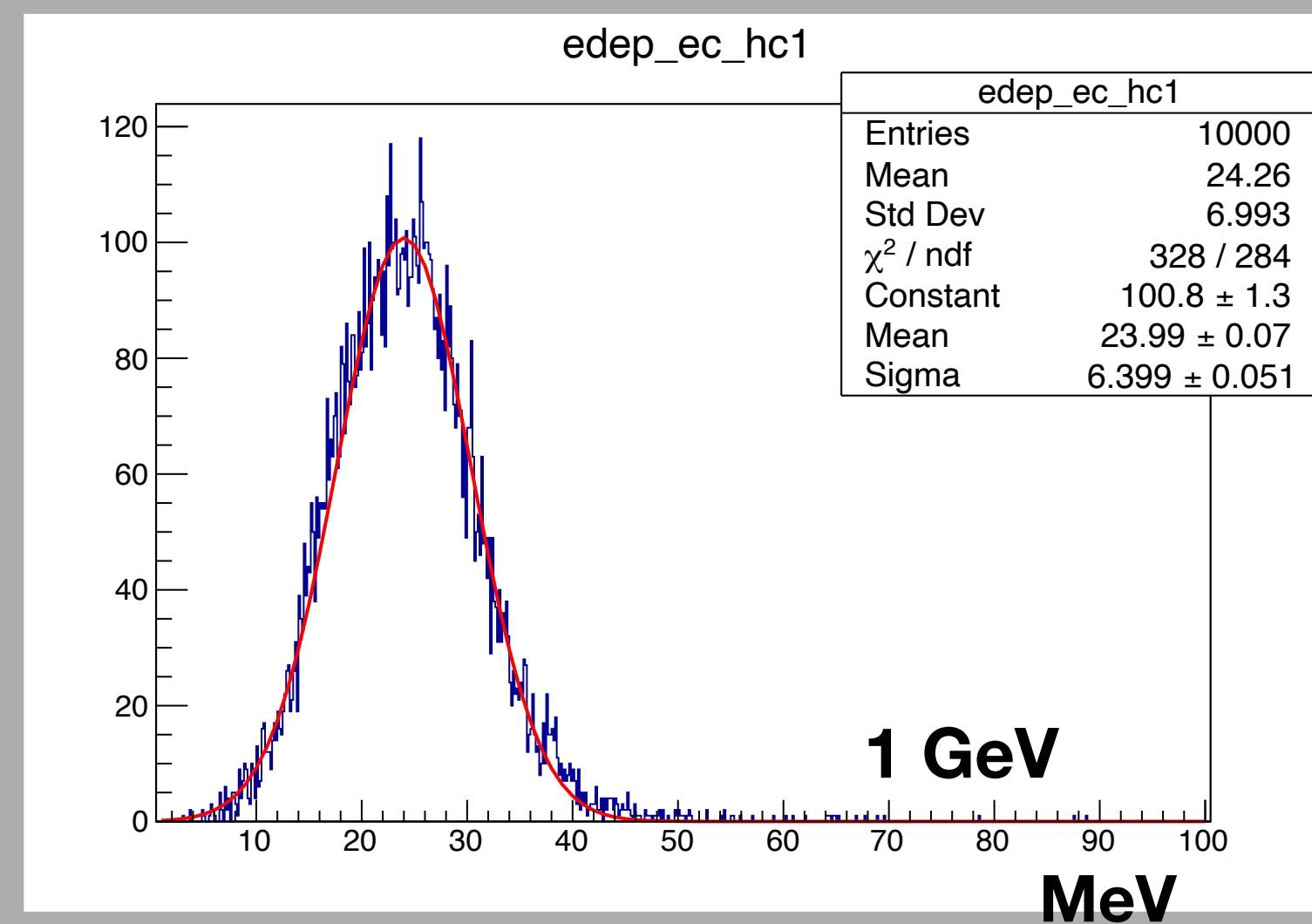
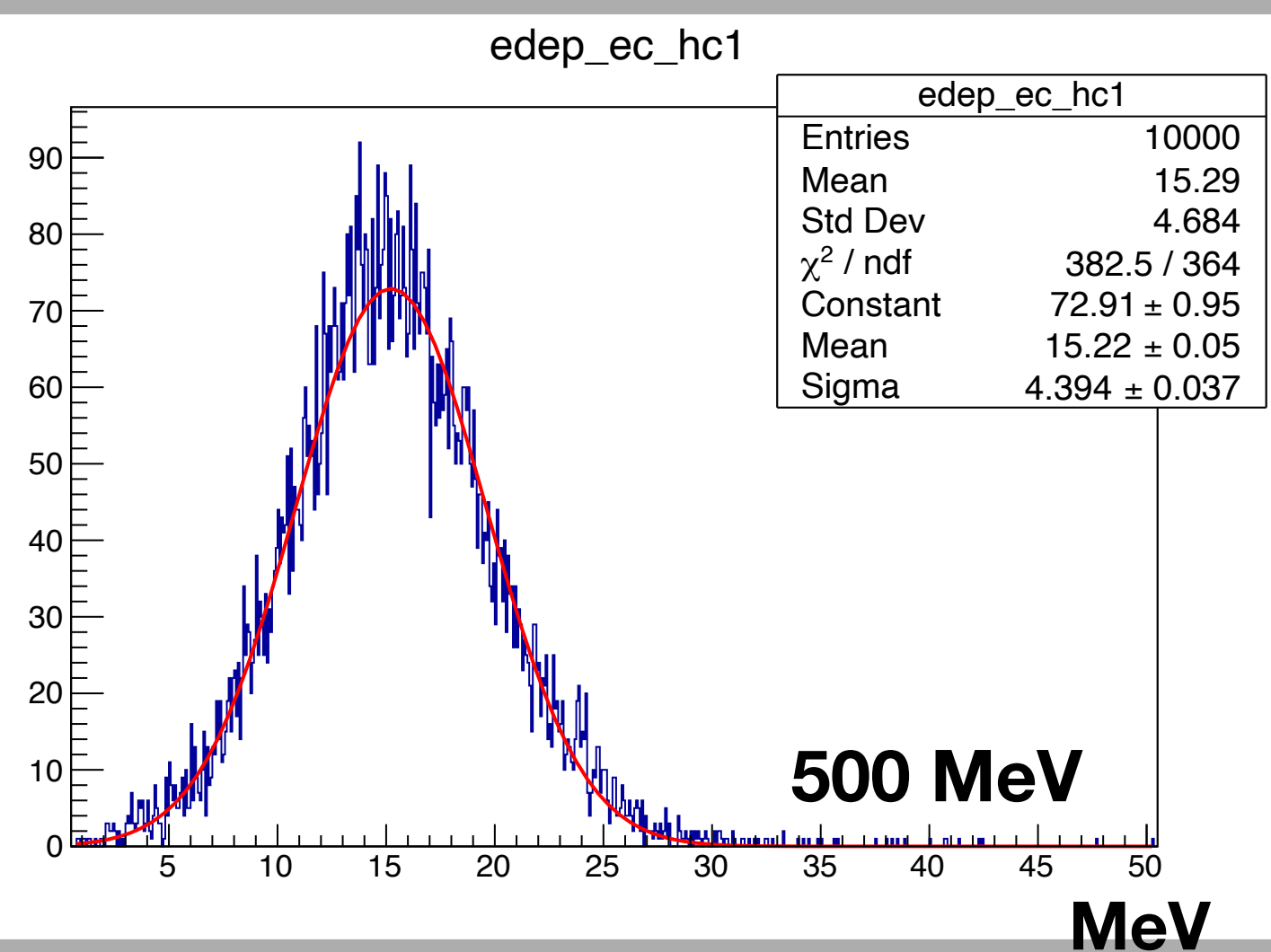
- Both mean, sigma and resolution matches well

$a = 0.1, b = 0.0015$

Fiber Structure



Reconstructed energy from mixture structure

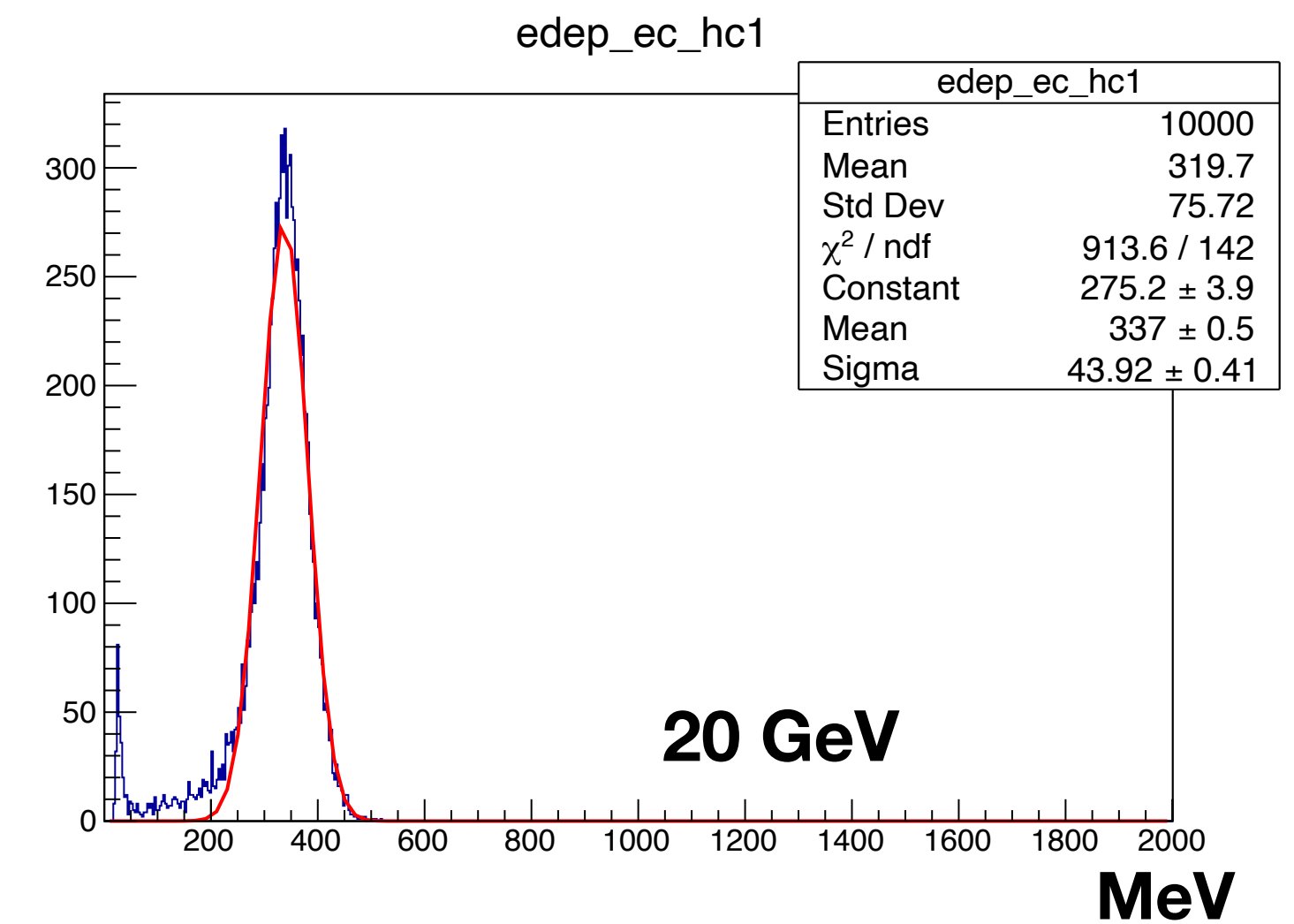
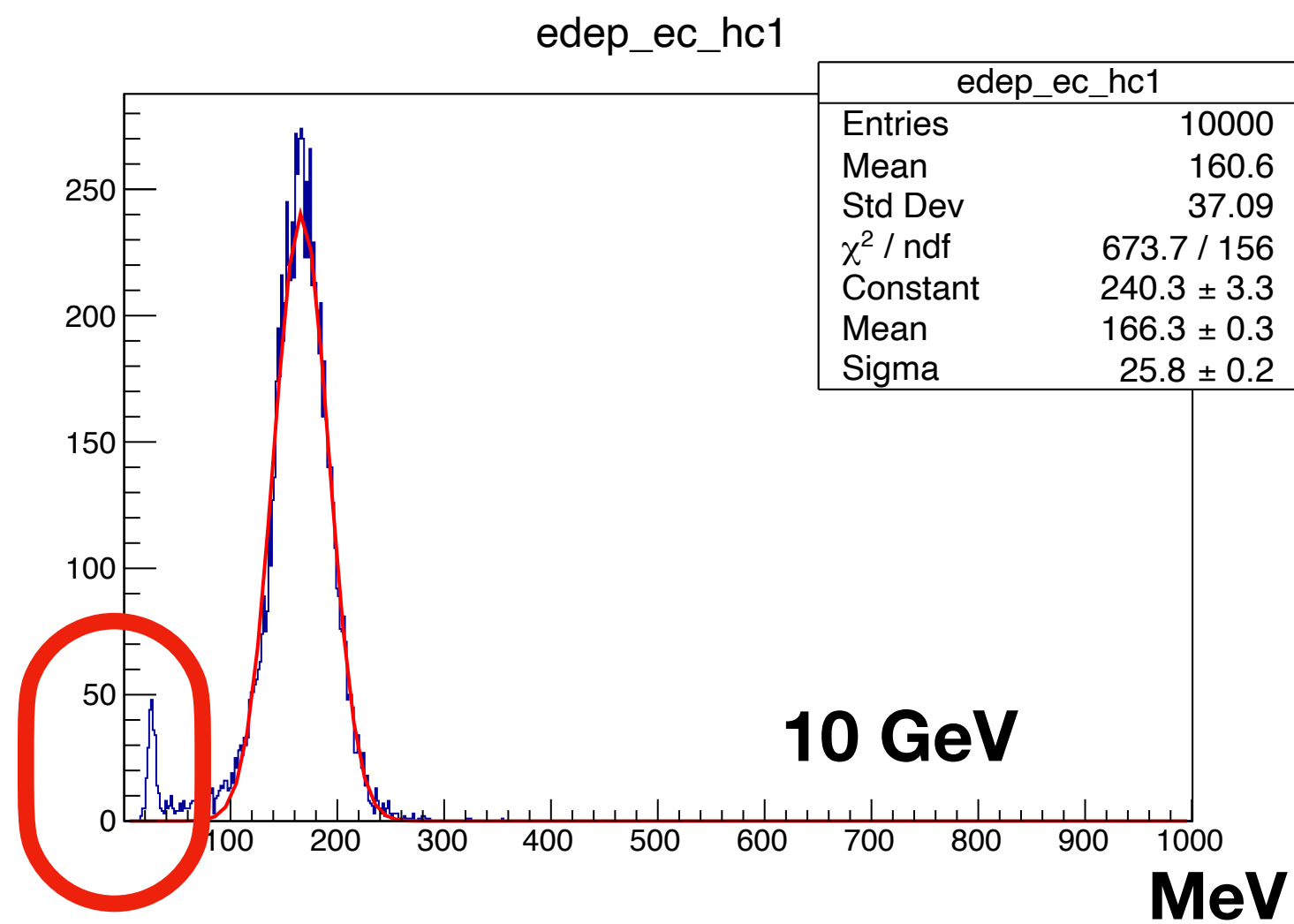
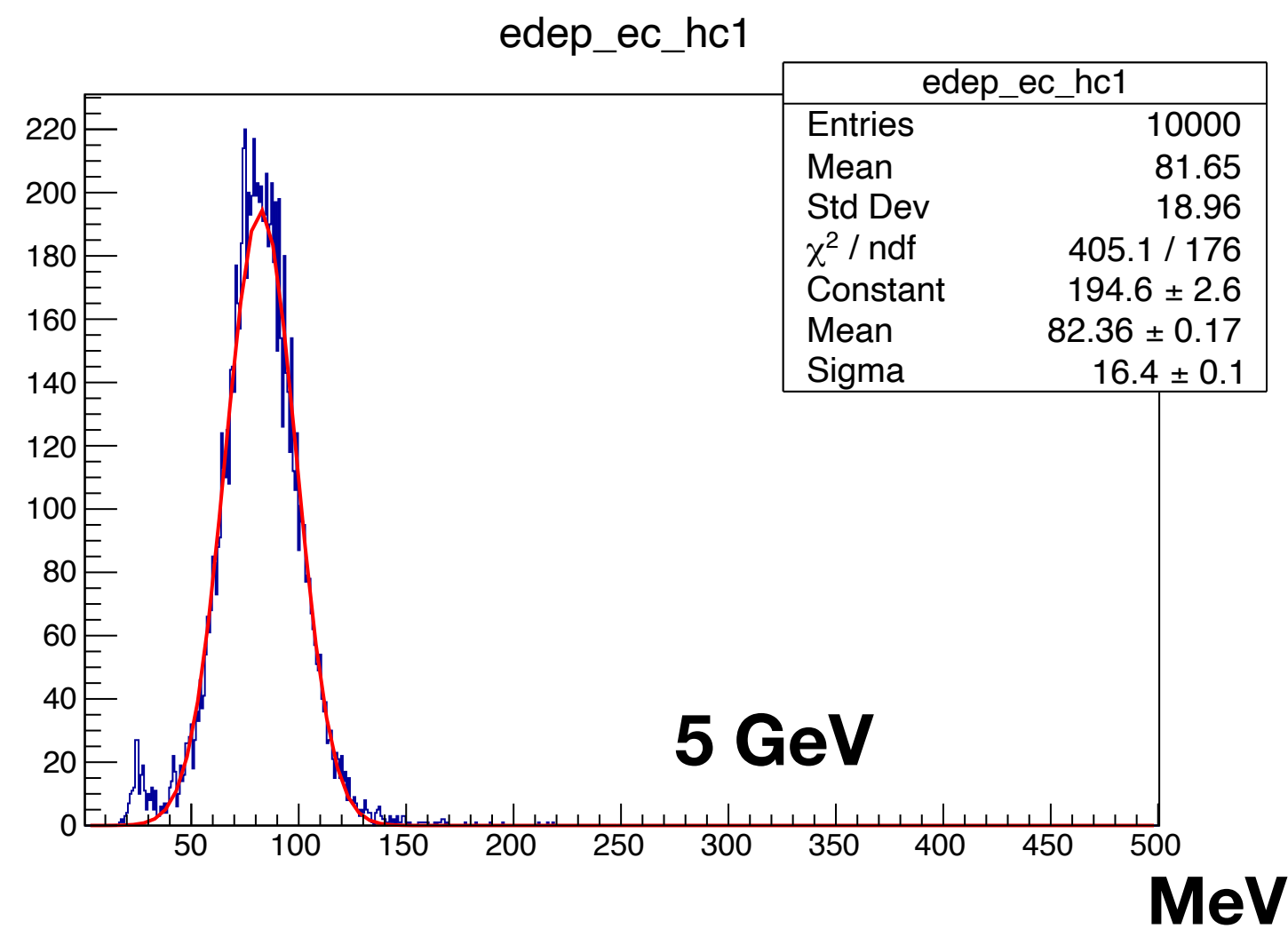


Comparison at lower energy (pion @ 20 degree)

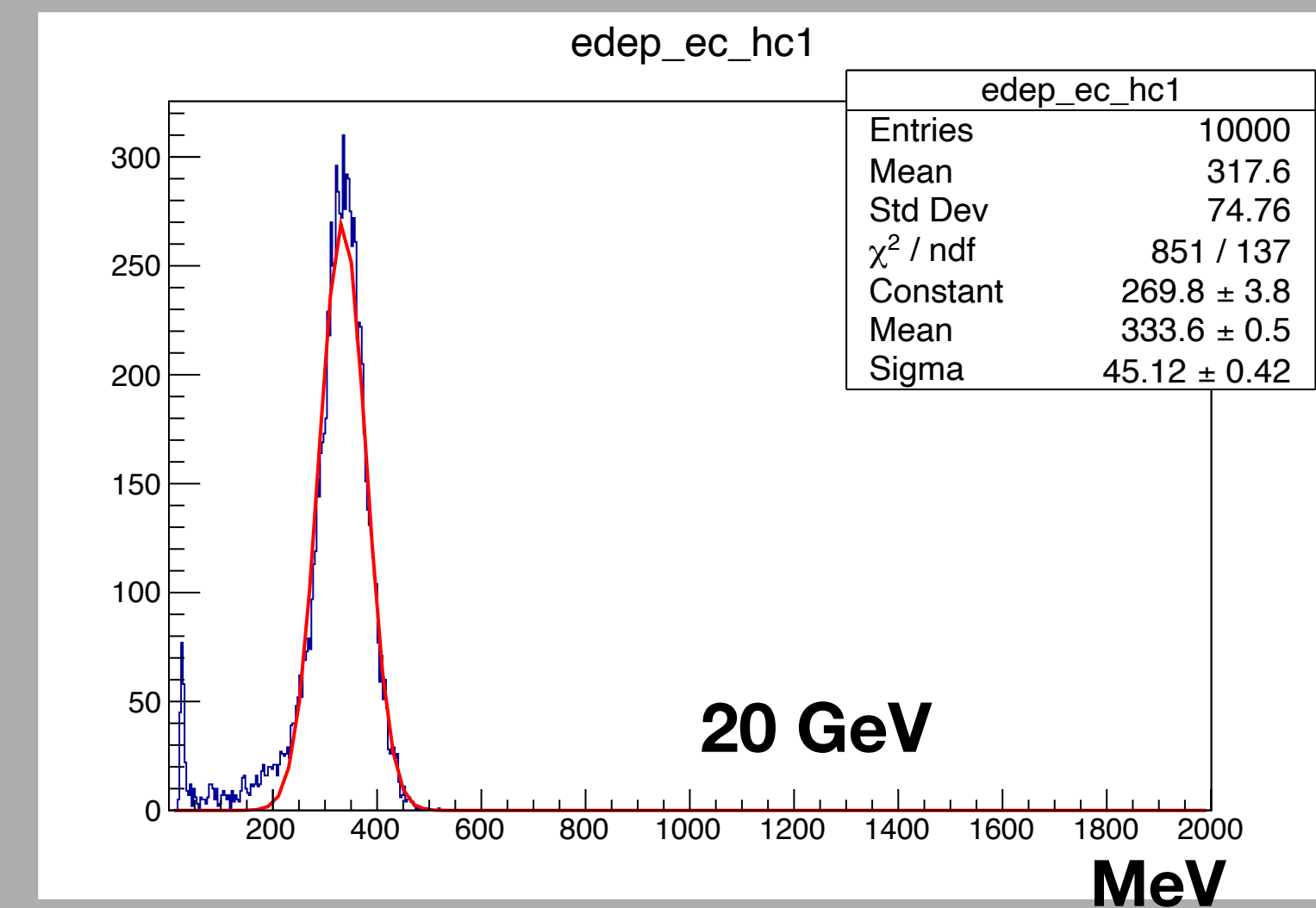
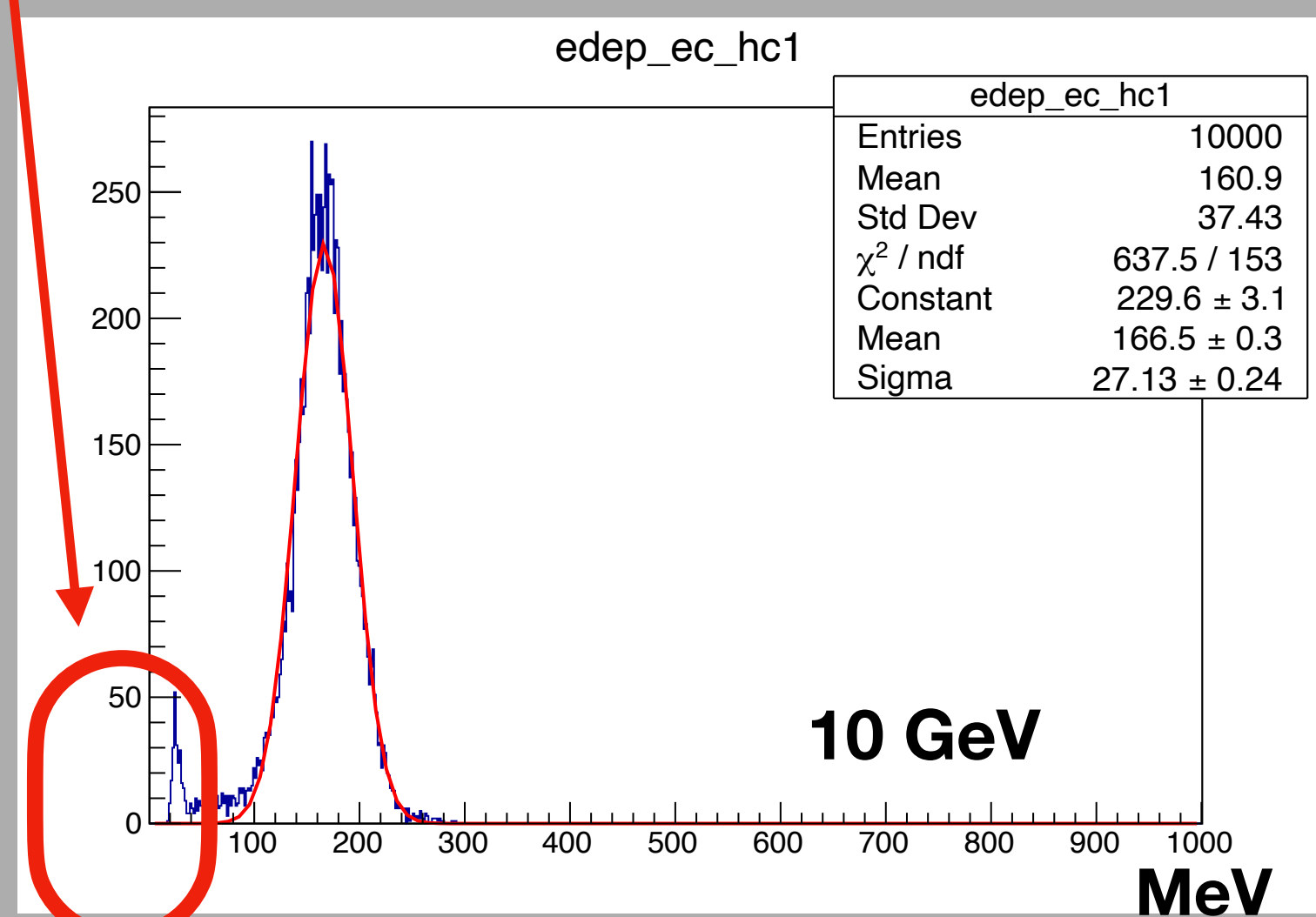
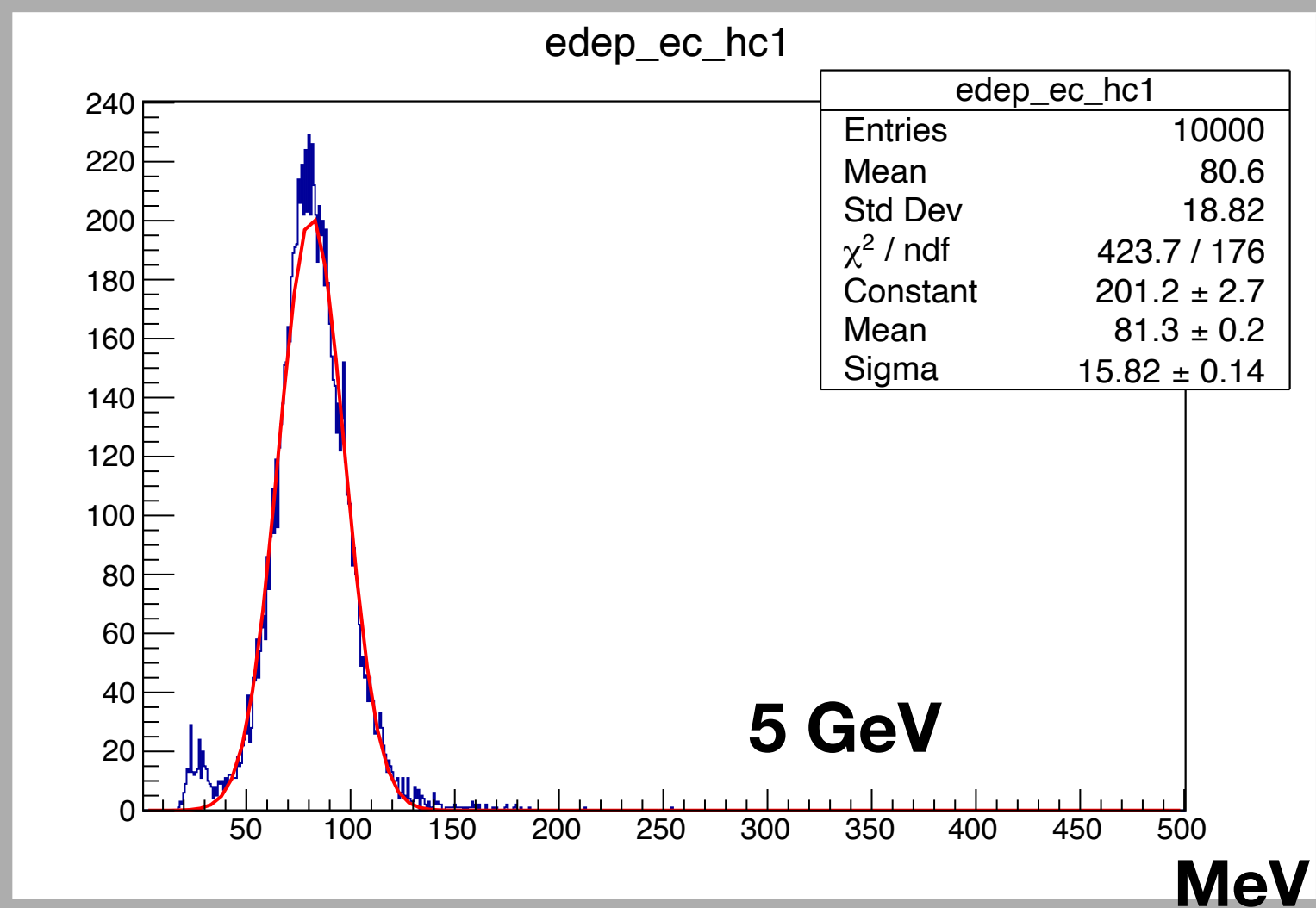
a = 0.1, b = 0.0015

Fiber Structure

- Both mean, sigma and resolution matches well
- **tail is also reconstructed.**



Reconstructed energy from mixture structure



2D plot for E_{HCal} vs E_{EM} (pion @ 20 degree)

- Event by event 2D distribution of energy between EMCal and HCal is nearly same for both structure

