Simulation Studies of a Dual Readout, Total Absorption Calorimeter

Progress Report, July 6th 2012

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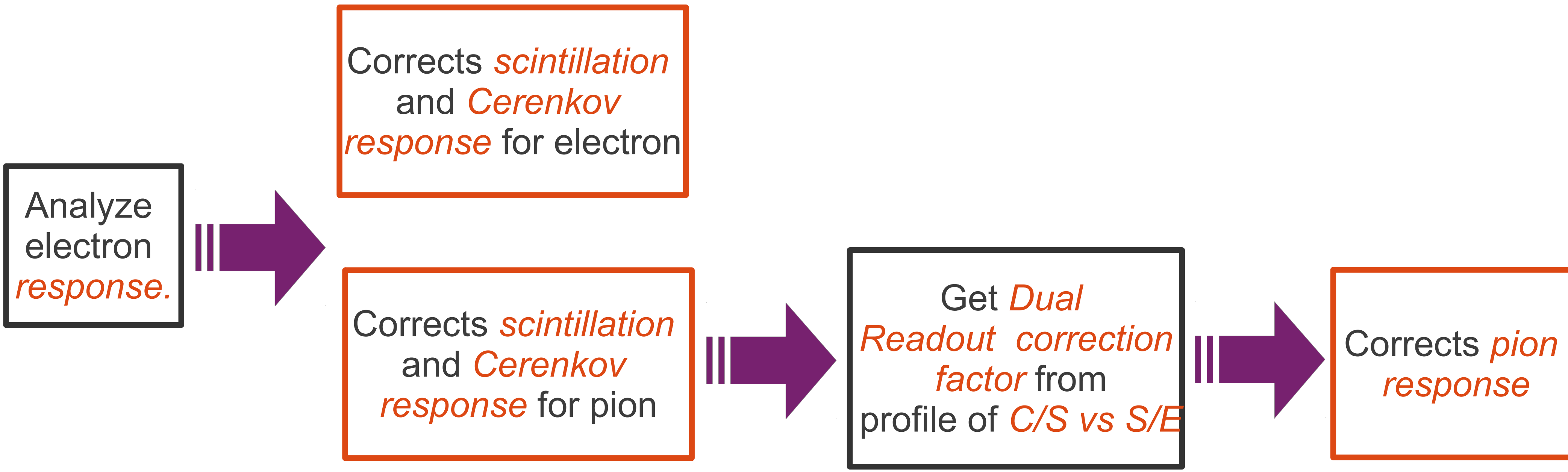
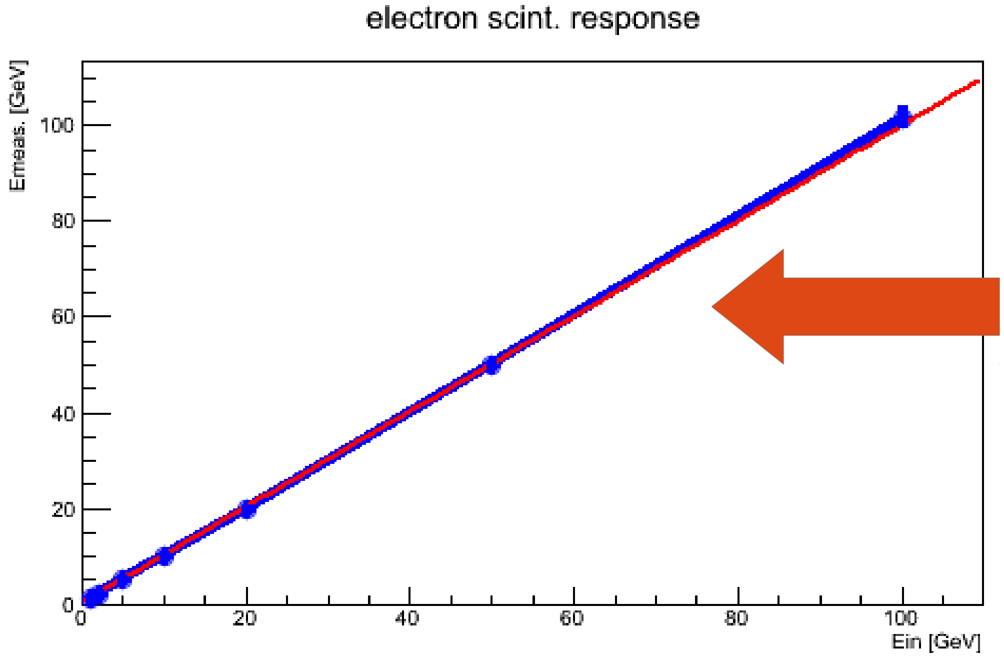
Calibration.cc

Routine to automate the *energy correction* for a *dual read out calorimeter*.



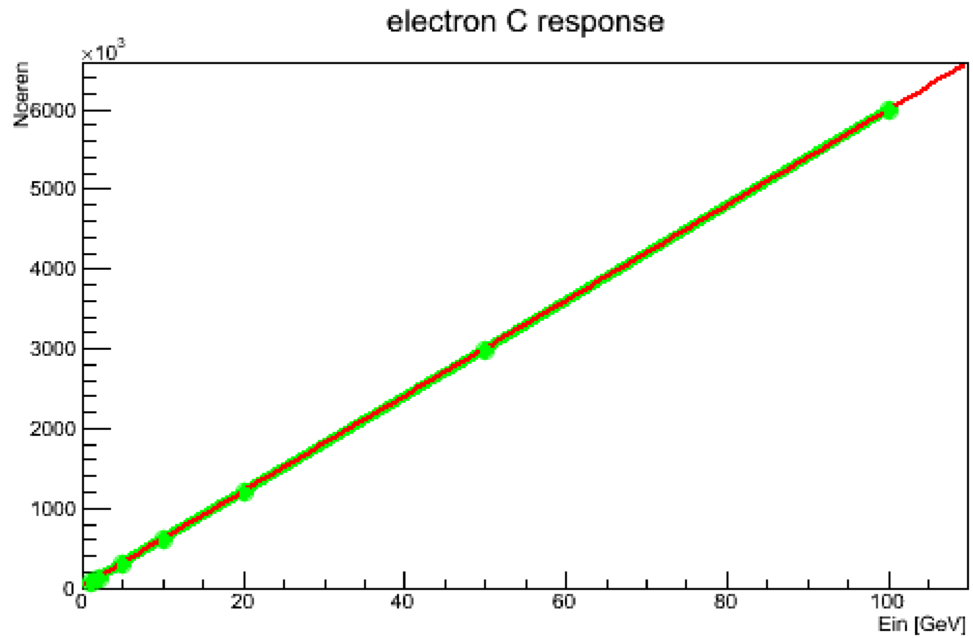
Electron Response Analysis (BGO)



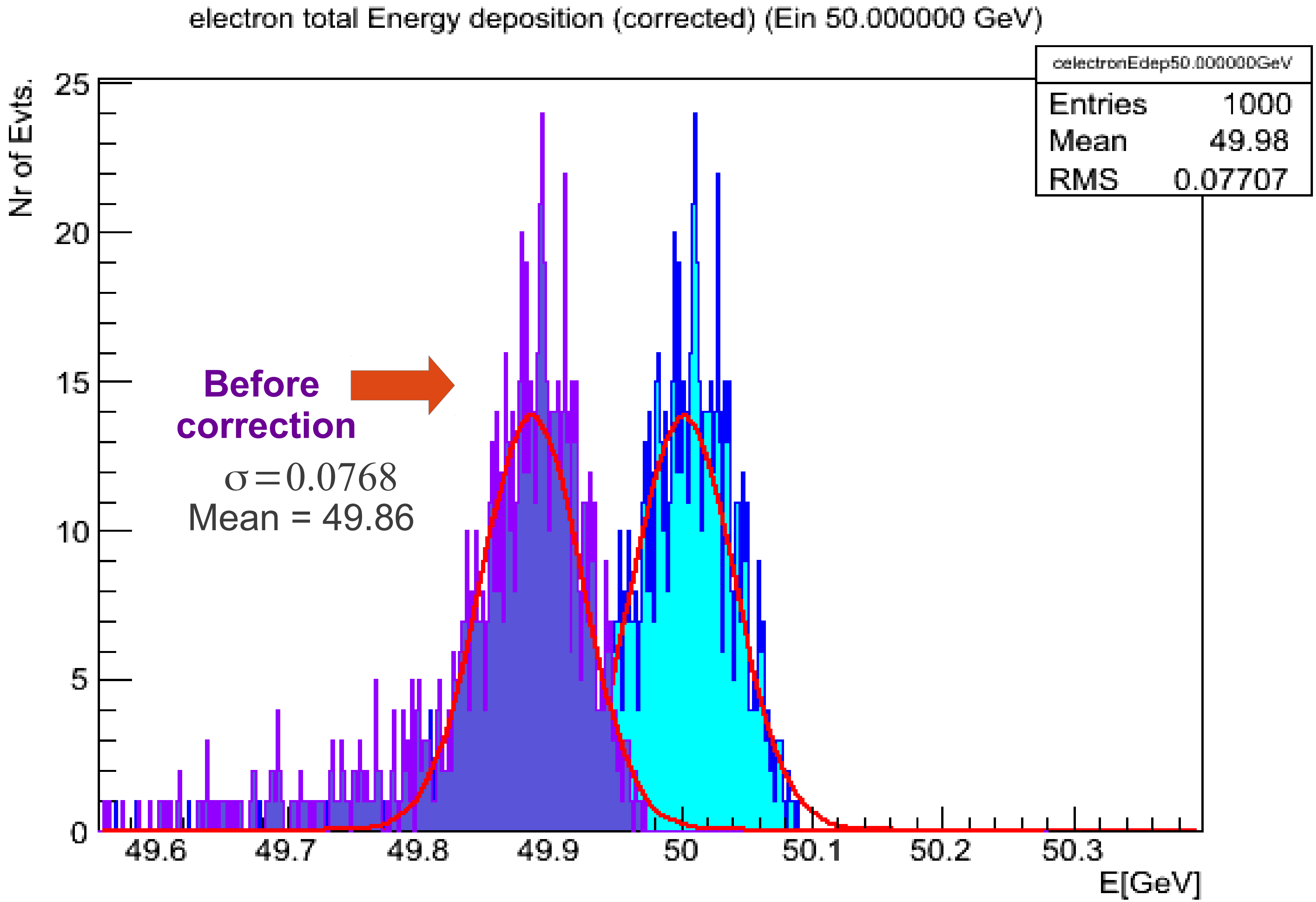
The slope of the curve is used as the correction factor for scintillation response scorr.

$$scorr = \frac{1}{m_{scint}}$$

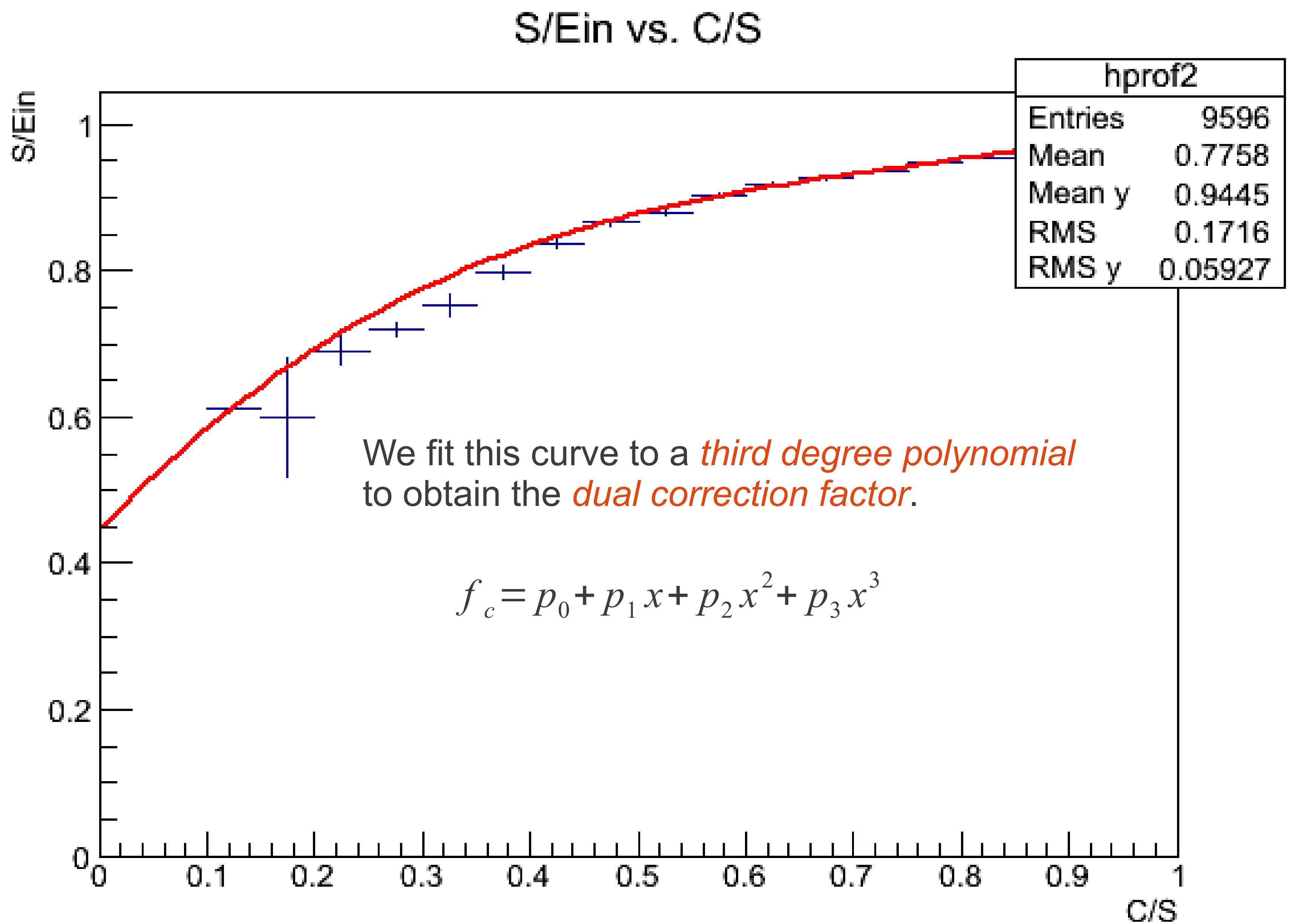
$$ccorr = \frac{1}{m_{Ceren}}$$



Electron Response Analysis (BGO)



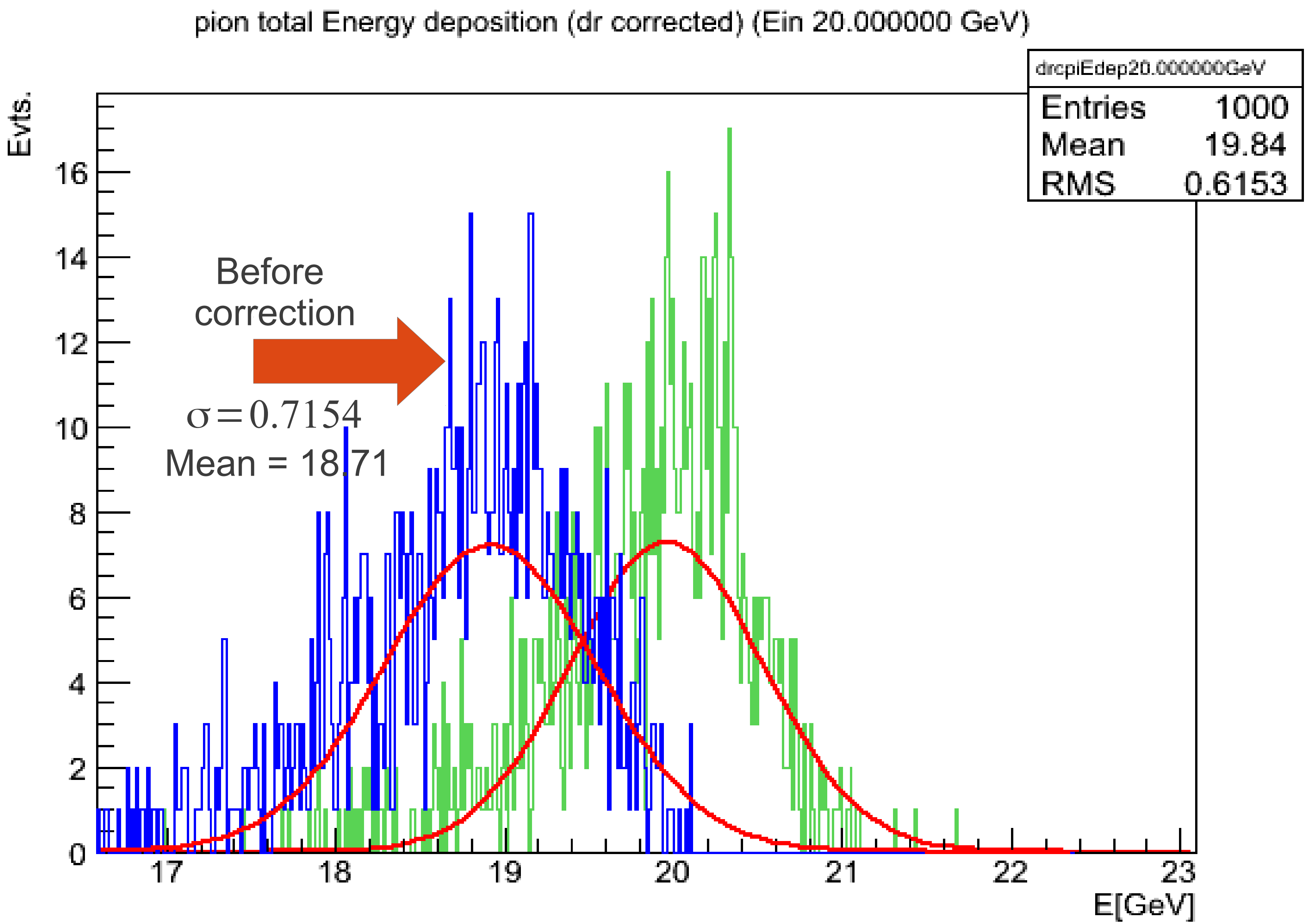
Dual Readout Correction (BGO)



We fit this curve to a *third degree polynomial* to obtain the *dual correction factor*.

$$f_c = p_0 + p_1 x + p_2 x^2 + p_3 x^3$$

Dual readout correction (BGO)



Histogram Filling

In order to automate the Calibration process, we need the routine to be able to determine the range of the histograms by itself.

We calculate the mean of the histogram as well as the standard deviation. This allows us to center the histogram at the mean value and to set its range to 5 standard deviations.

We loop three times over the electron/pion indexes:

1. In the *first loop* we take the sum of energy deposited in all events and then divide by the latter to obtain the *mean energy deposition by event*.

2. In the *second loop* we calculate the *variance* by using the following formula where x represents the energy deposition in *event i*.

$$\frac{\sum (x_i - Mean)^2}{number\ of\ events}$$

We obtain the standard deviation by taking the square root of the variance.

3. In the *third loop* we fill the histograms and write them to file.

Values for hs & hc for electromagnetic and pi0 fractions

From the formulas for *Dual readout response*:

$$\frac{E_{scint}}{E_i} = f_{em} + (1 - f_{em}) h_s$$

$$\frac{E_{Ceren}}{E_i} = f_{em} + (1 - f_{em}) h_c$$

We can solve for *hs* and *hs*:

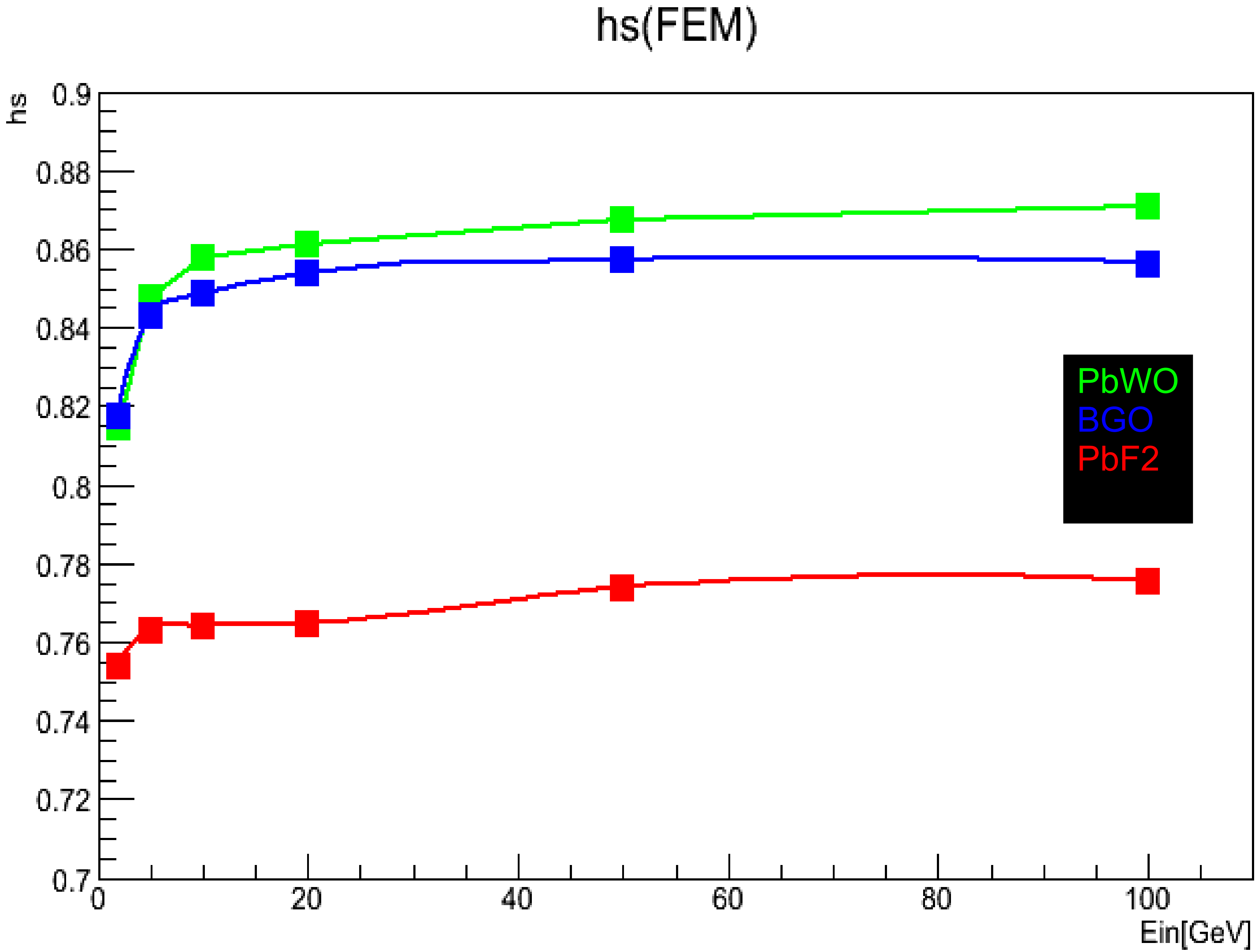
$$h_s = \left(\frac{E_{scint}}{E_i} - f_{em}\right) \frac{1}{1 - f_{em}}$$

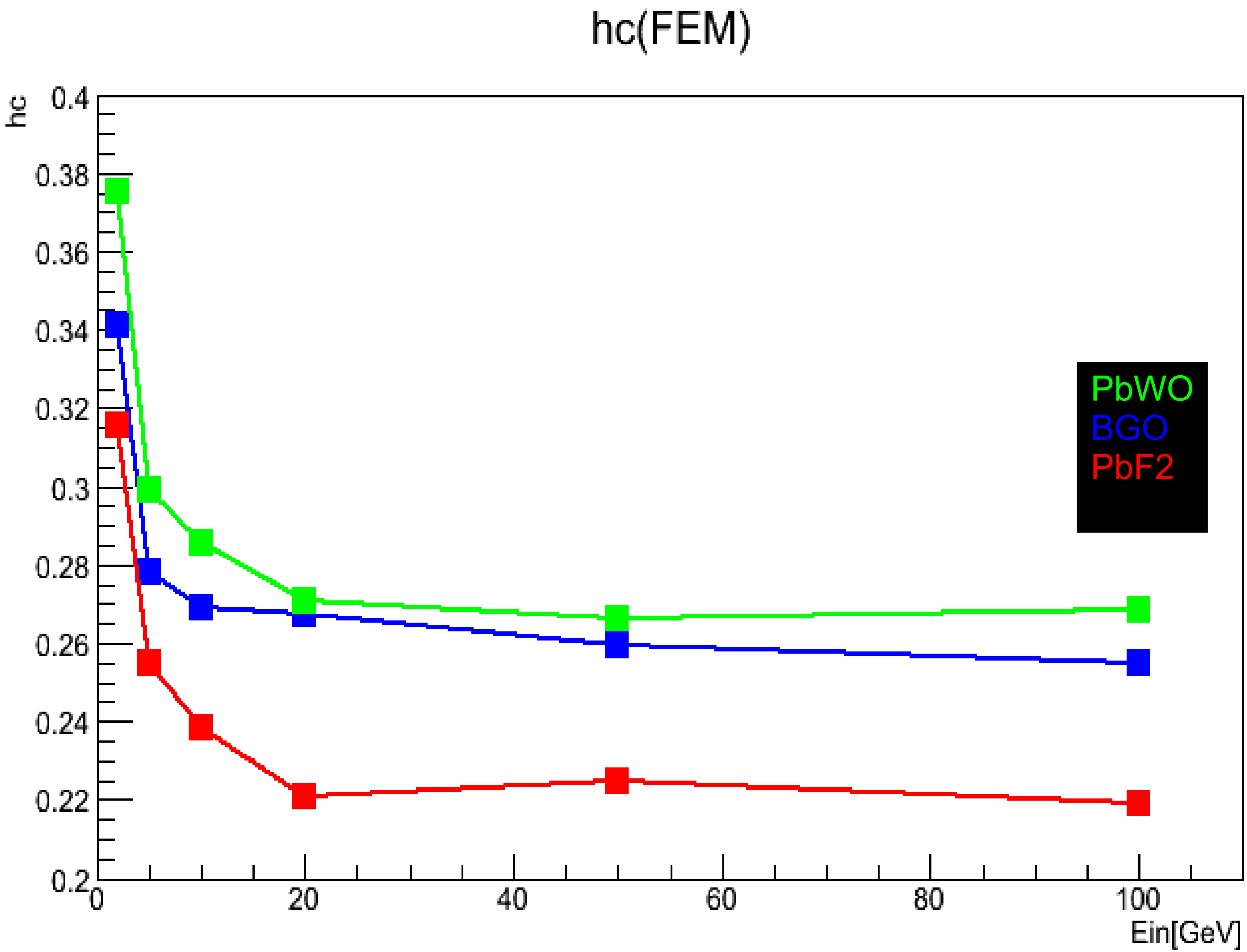
$$h_c = \left(\frac{E_{Ceren}}{E_i} - f_{em}\right) \frac{1}{1 - f_{em}}$$

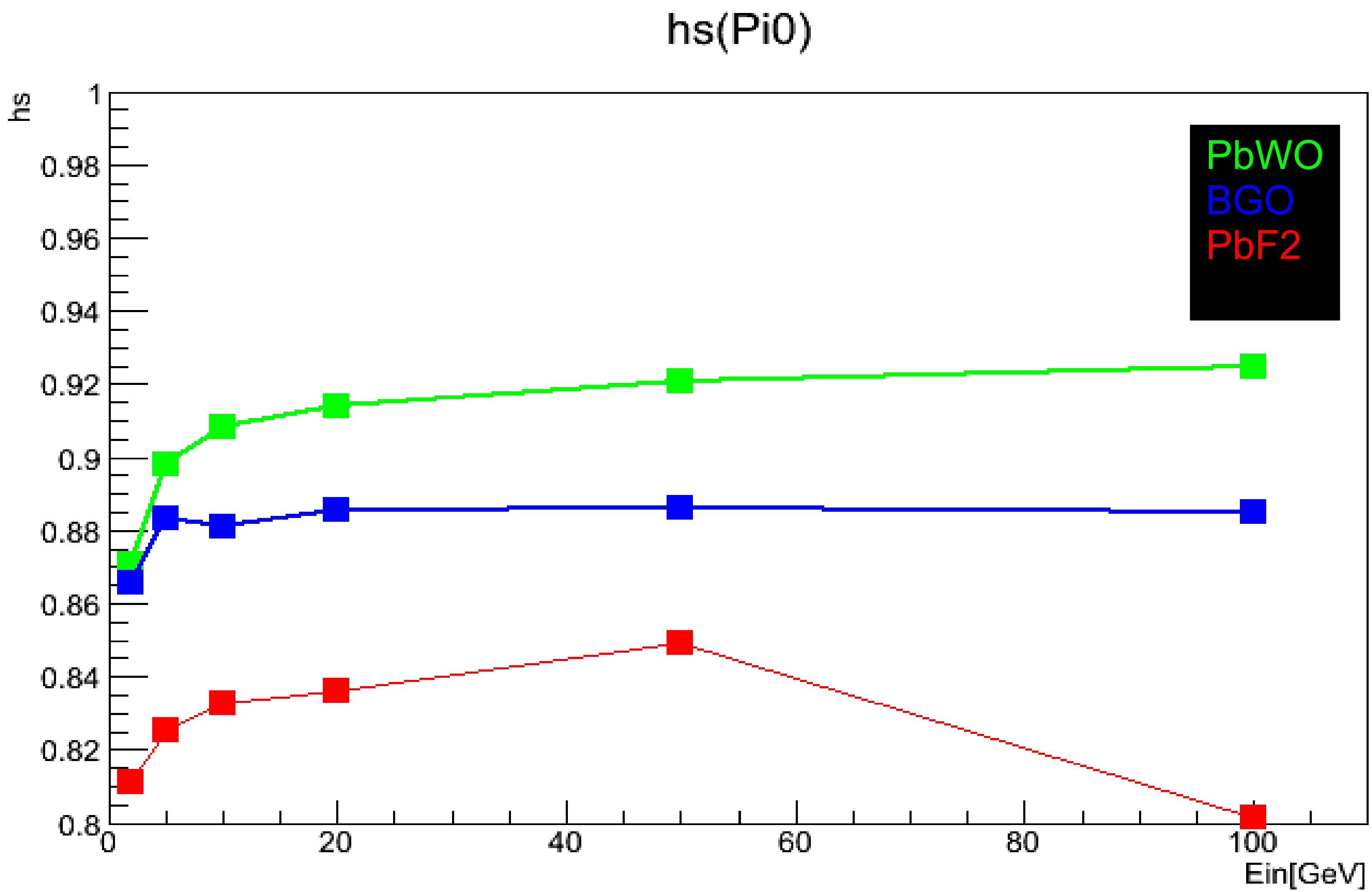
Values for hs & hc for electromagnetic and pi0 fractions

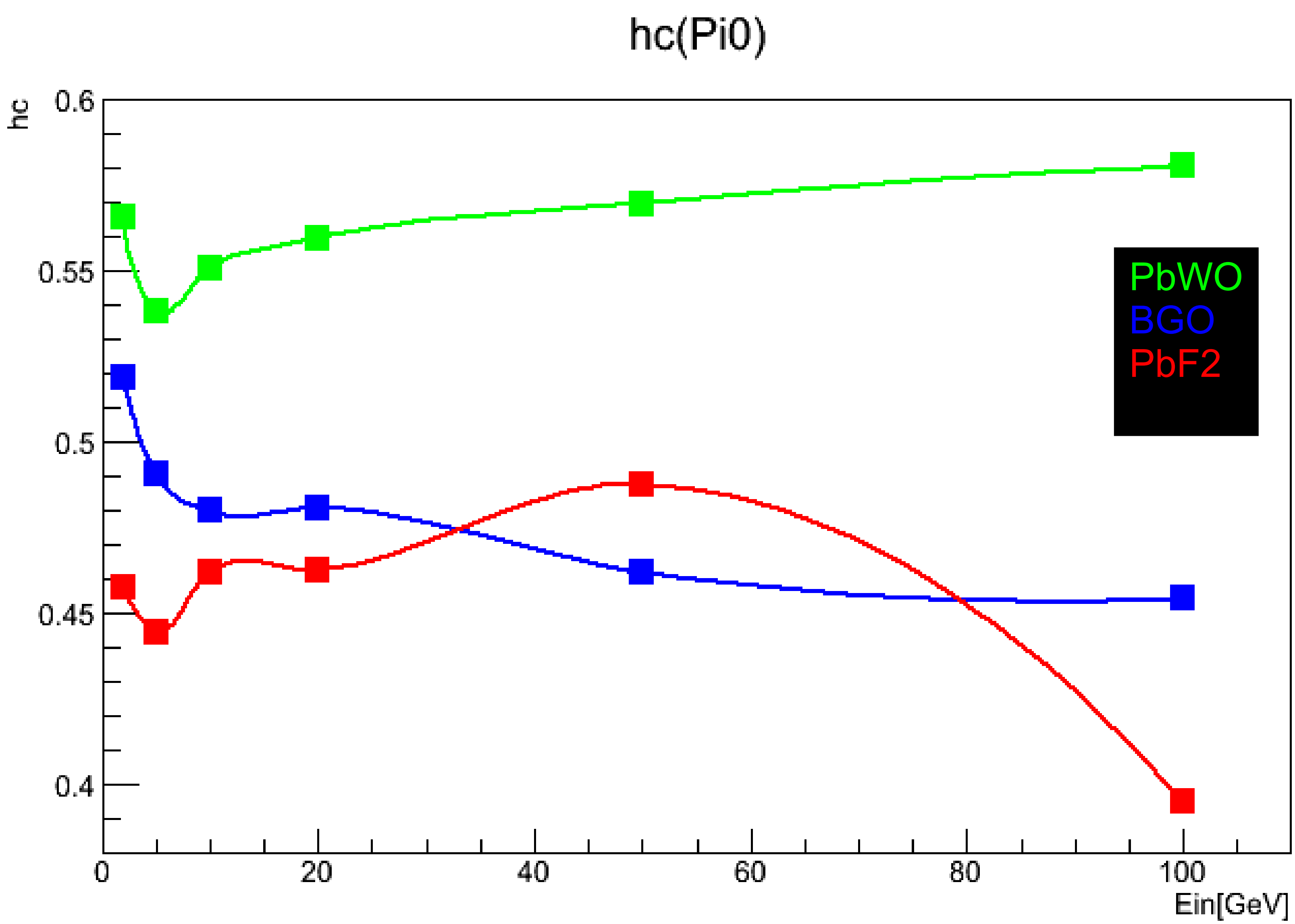
Energy [GeV]	PbF_2			BGO			PbWO		
	$\langle f_{em} \rangle$	hs	hc	$\langle f_{em} \rangle$	hs	hc	$\langle f_{em} \rangle$	hs	hc
2	0.3472	0.7537	0.3156	0.404	0.8173	0.3412	0.4333	0.8144	0.3754
5	0.4167	0.7626	0.2549	0.4599	0.8429	0.2753	0.4883	0.8473	0.2989
10	0.4787	0.7642	0.2385	0.5067	0.8484	0.2688	0.5363	0.8579	0.2855
20	0.5199	0.7642	0.2205	0.5669	0.8536	0.2674	0.5937	0.8608	0.2706
50	0.5892	0.7733	0.225	0.6169	0.8571	0.2593	0.6328	0.8676	0.2662
100	0.6156	0.7753	0.2193	0.6550	0.8562	0.2546	0.6703	0.8706	0.2685

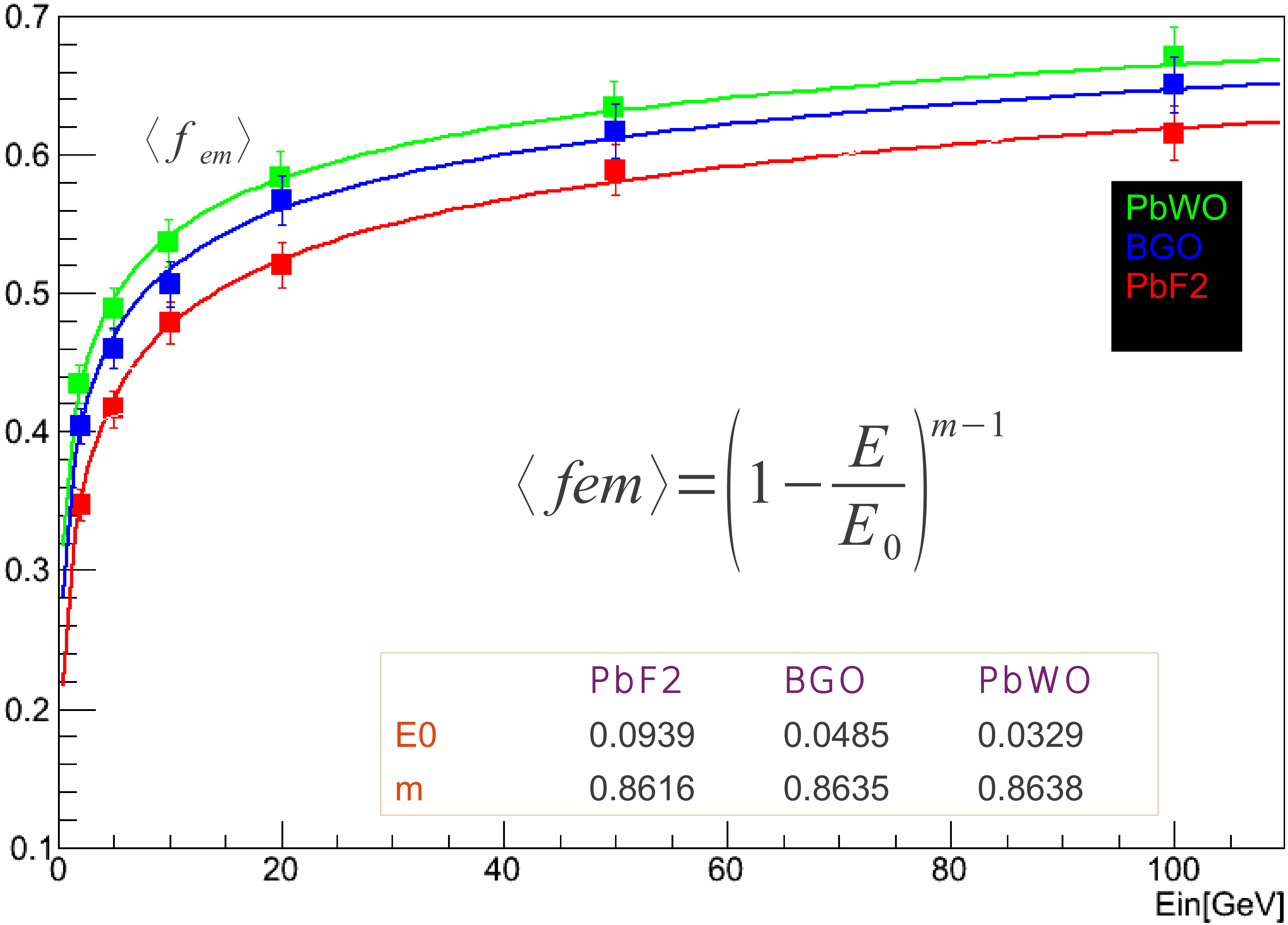
Energy [GeV]	PbF_2			BGO			PbWO		
	hs	hc	$\langle f_{\pi^0} \rangle$	hs	hc	$\langle f_{\pi^0} \rangle$	hs	hc	$\langle f_{\pi^0} \rangle$
2	0.8113	0.4571	0.1189	0.8654	0.5185	0.1309	0.8706	0.5656	0.1213
5	0.8521	0.4441	0.1924	0.883	0.4905	0.2211	0.898	0.5379	0.196
10	0.8327	0.4615	0.2485	0.8812	0.4795	0.3069	0.9082	0.5504	0.2497
20	0.8362	0.4621	0.2959	0.8858	0.4803	0.3883	0.9139	0.5589	0.3039
50	0.8493	0.4873	0.3714	0.8862	0.4615	0.4668	0.921	0.5692	0.3673
100	0.8015	0.3944	0.5109	0.8852	0.4538	0.5172	0.9247	0.5801	0.4205


hs(FEM)
hs
0.9
0.88
0.86
0.84
0.82
0.8
0.78
0.76
0.74
0.72
0.7
0
20
40
60
80
100
Ein[GeV]
PbWO
BGO
PbF2

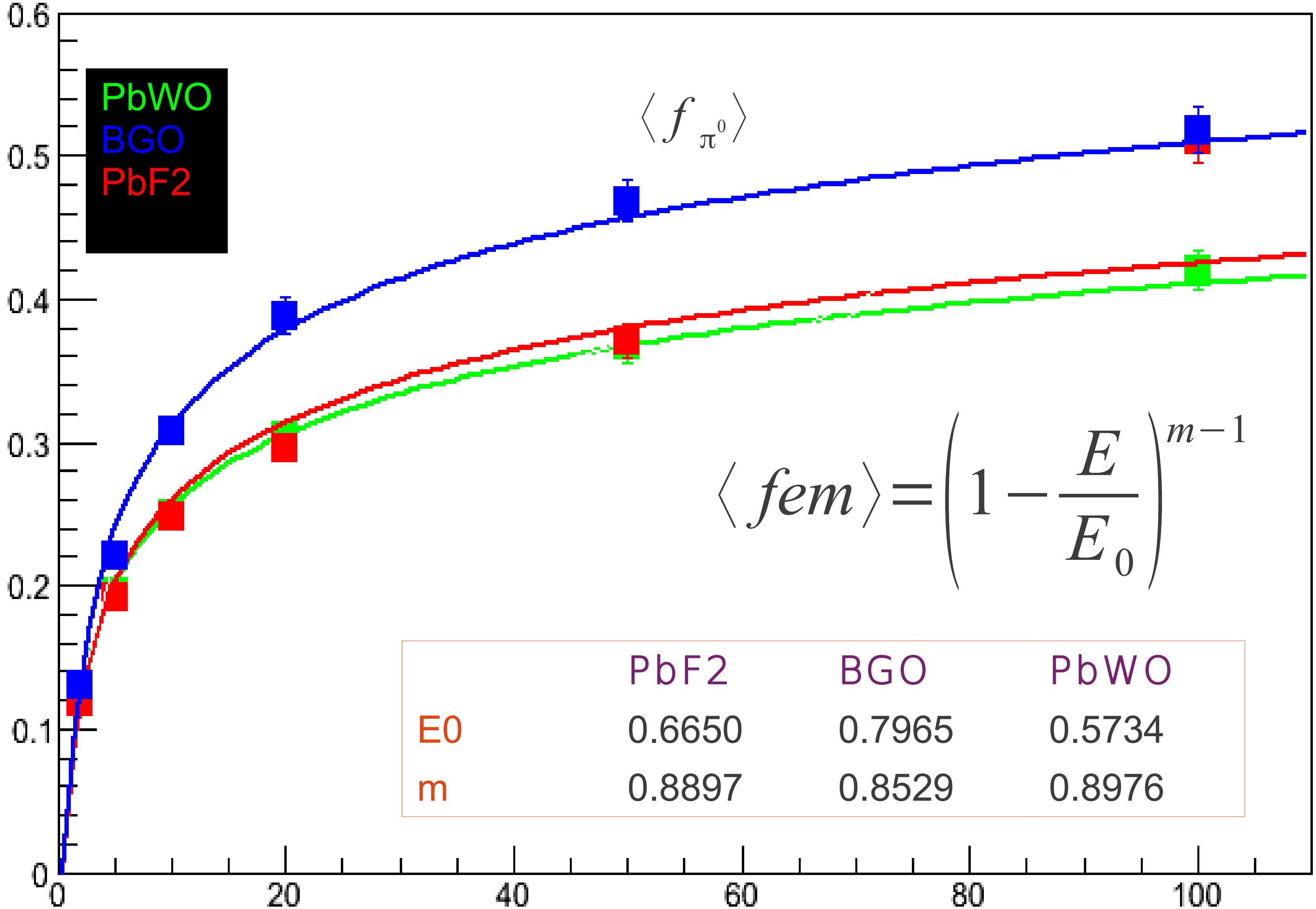

hc(FEM)
hc
0.4
0.38
0.36
0.34
0.32
0.3
0.28
0.26
0.24
0.22
0.2
0
20
40
60
80
100
Ein[GeV]
PbWO
BGO
PbF2


hs(Pi0)
hs
1
0.98
0.96
0.94
0.92
0.9
0.88
0.86
0.84
0.82
0.8
0
20
40
60
80
100
Ein[GeV]
PbWO
BGO
PbF2


hc(Pi0)
hc
0.6
0.55
0.5
0.45
0.4
0
20
40
60
80
100
Ein[GeV]
PbWO
BGO
PbF2



$\langle f_{em} \rangle$
PbWO
BGO
PbF2
$\langle fem \rangle = \left(1 - \frac{E}{E_0}\right)^{m-1}$
PbF2 BGO PbWO
E0 0.0939 0.0485 0.0329
m 0.8616 0.8635 0.8638
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0
20
40
60
80
100
Ein[GeV]



PbWO
BGO
PbF2
$\langle f_{\pi^0} \rangle$
$\langle fem \rangle = \left(1 - \frac{E}{E_0}\right)^{m-1}$
PbF2 BGO PbWO
E0 0.6650 0.7965 0.5734
m 0.8897 0.8529 0.8976
0 0.1 0.2 0.3 0.4 0.5 0.6
0 20 40 60 80 100

Future Work

- Introduce sampling function to Calibration.cc routine to explore how this calibration process will work.

- Understand the behavior of Lead Fluoride Calorimeter response for high energy- incoming particles (above 200 GeV)