Simulation Studies of a Total Absorption Dual Readout Calorimeter

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Outline

- The Dual-readout correction
- Average Value of EM Fraction
- Fluctuations in <fem>
- How to describe <fem>?
- Simulation results

The Dual-readout correction

$$S = f_{em} + (1 - f_{em}) h_S$$
$$C = f_{em} + (1 - f_{em}) h_C$$

The *Dual Readout* concept is based on the responses from both *Scintillation* and *Cerenkov*.

EM fraction dominates in both responses & introduces *fluctuations* to the readings.

We will get rid of this later!

For now, we study how EM fraction behaves with increasing energy of the incoming particle

Average Value of EM Fraction

Some particles produced in the hadronic cascade decay through electromagnetic interaction

$$\pi^0, \eta \rightarrow \gamma\gamma$$

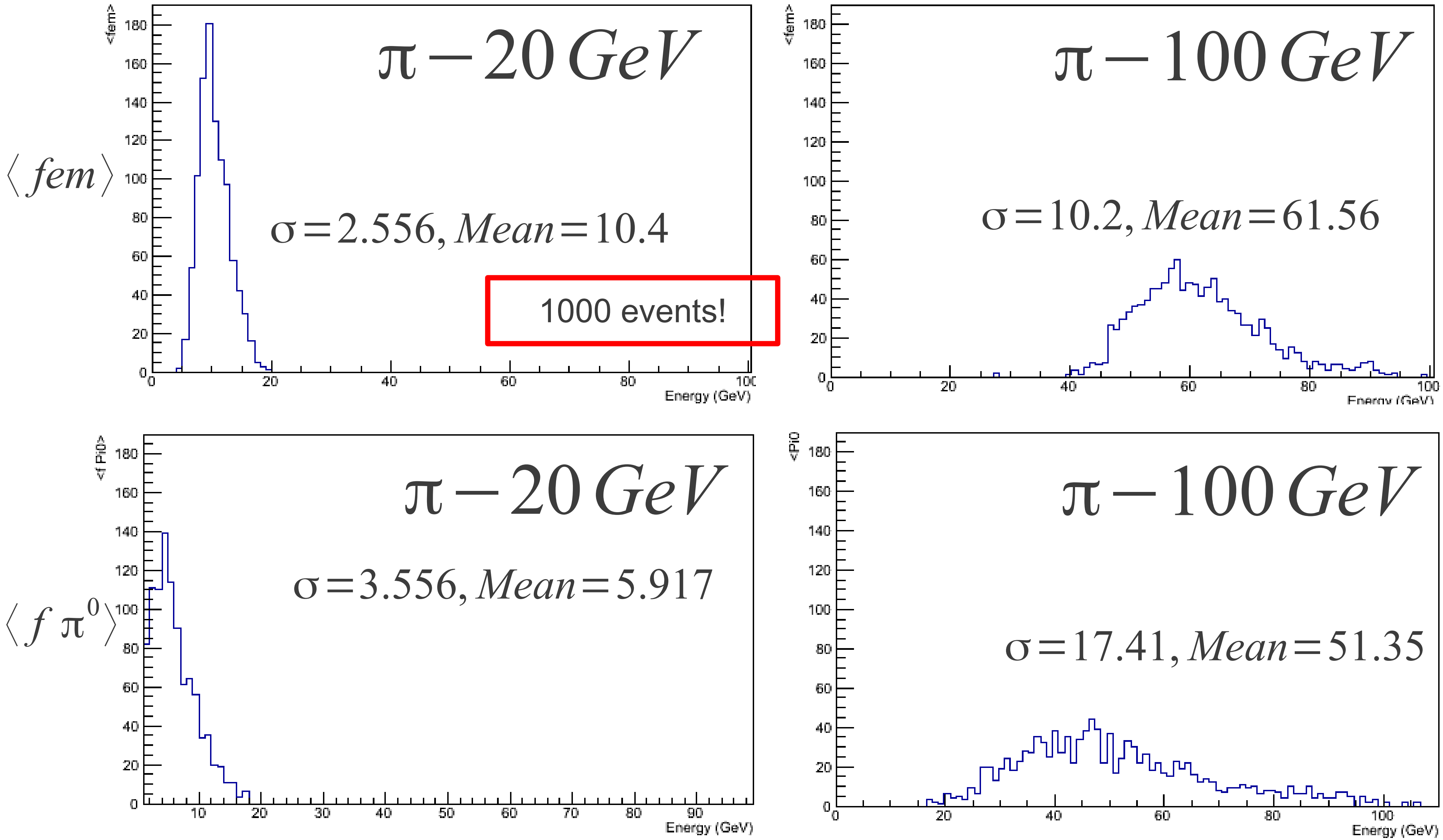
Hadron showers generally contain a component that propagates electromagnetically.

How does our definition for <fem> differs from other studies (i.e. Wigmans)?

Wigmans defines it as the energy deposited in the calorimeter by means of the KE of a π^0

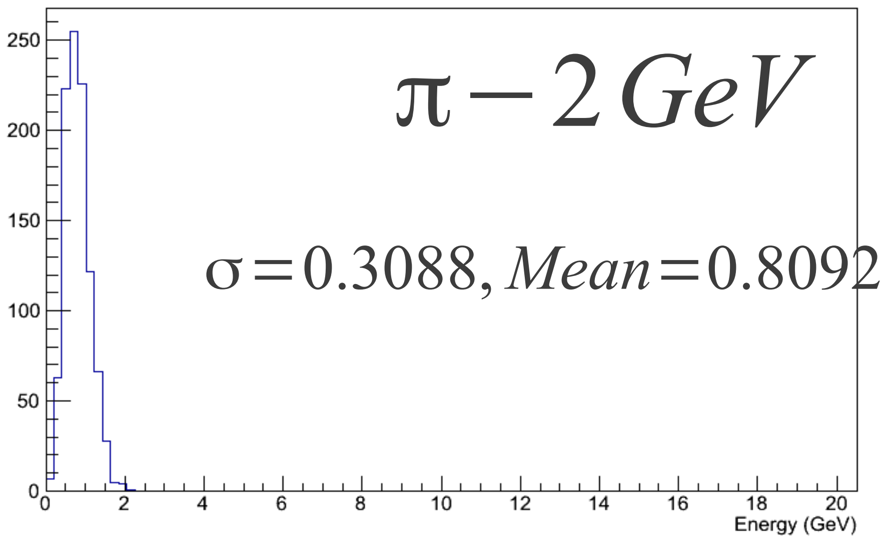
We defines it as the energy deposited by an electromagnetic particle: *electron, positron,* γ

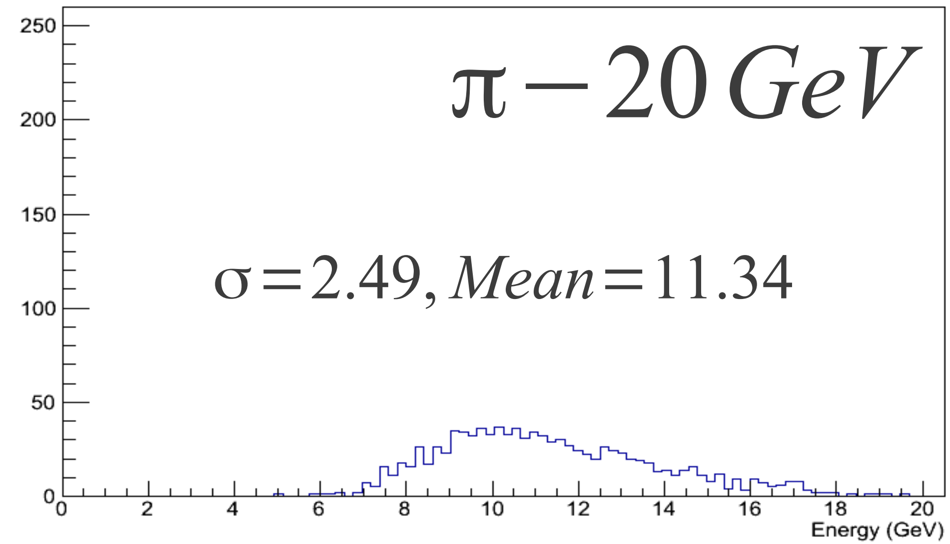
PbF_2 Total Absorption Calorimeter



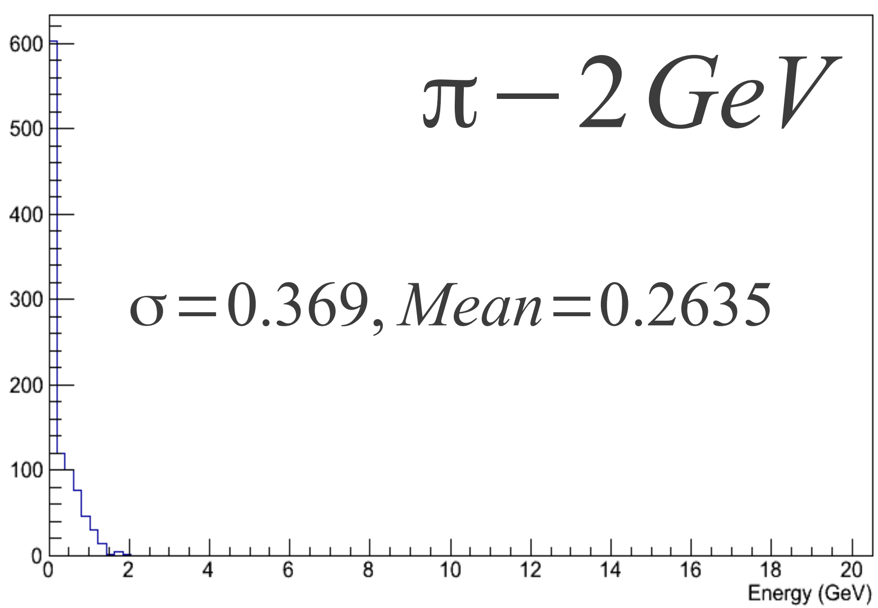
BGO Total Absorption Calorimeter

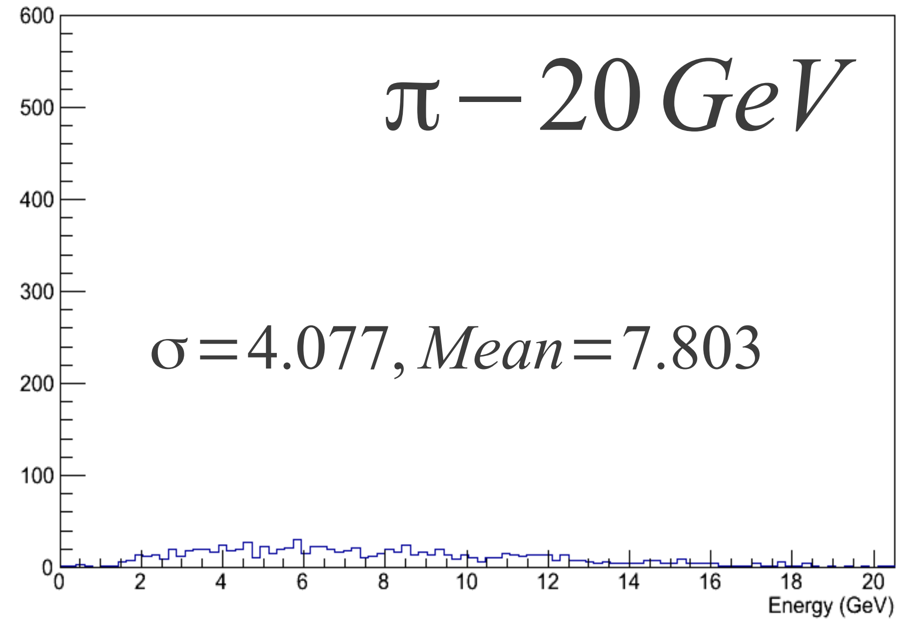
$\langle fem \rangle$





$\langle f\,\pi^0 \rangle$





Fluctuations in <fem>

This fraction *varies* strongly from *event to event,* possible explanations include:

Processes occurring in the early phase of shower development
i.e. energy available for these processes to occur...

The average fraction of the *initial hadron energy* converted into *pi0* increases with energy !

Once energy is used to create *pi0's* this energy goes into <fem> but energy from <fem> does not go to <fhad>.

How to describe <fem>?

We start from a very simplistic model...

Assuming in each interaction we expect to produce 2/3 of charged pions and about 1/3 of neutral pions:

After the first interaction: $$fem = \frac{1}{3}$$

After the n interactions: $$fem = 1 - \left(1 - \frac{1}{3}\right)^n$$

Now assuming a more realistic model,

i.e. a factor different from 1/3 for pi0 production, fluctuations in multiplicity with energy, energy loss by excitation of the calorimeter media, baryon number conservation, etc...

Baryon number conservation will also be observed in smaller <fem> for proton induced showers than in charged pion induced showers... future work!

How to describe <fem>? ..continued

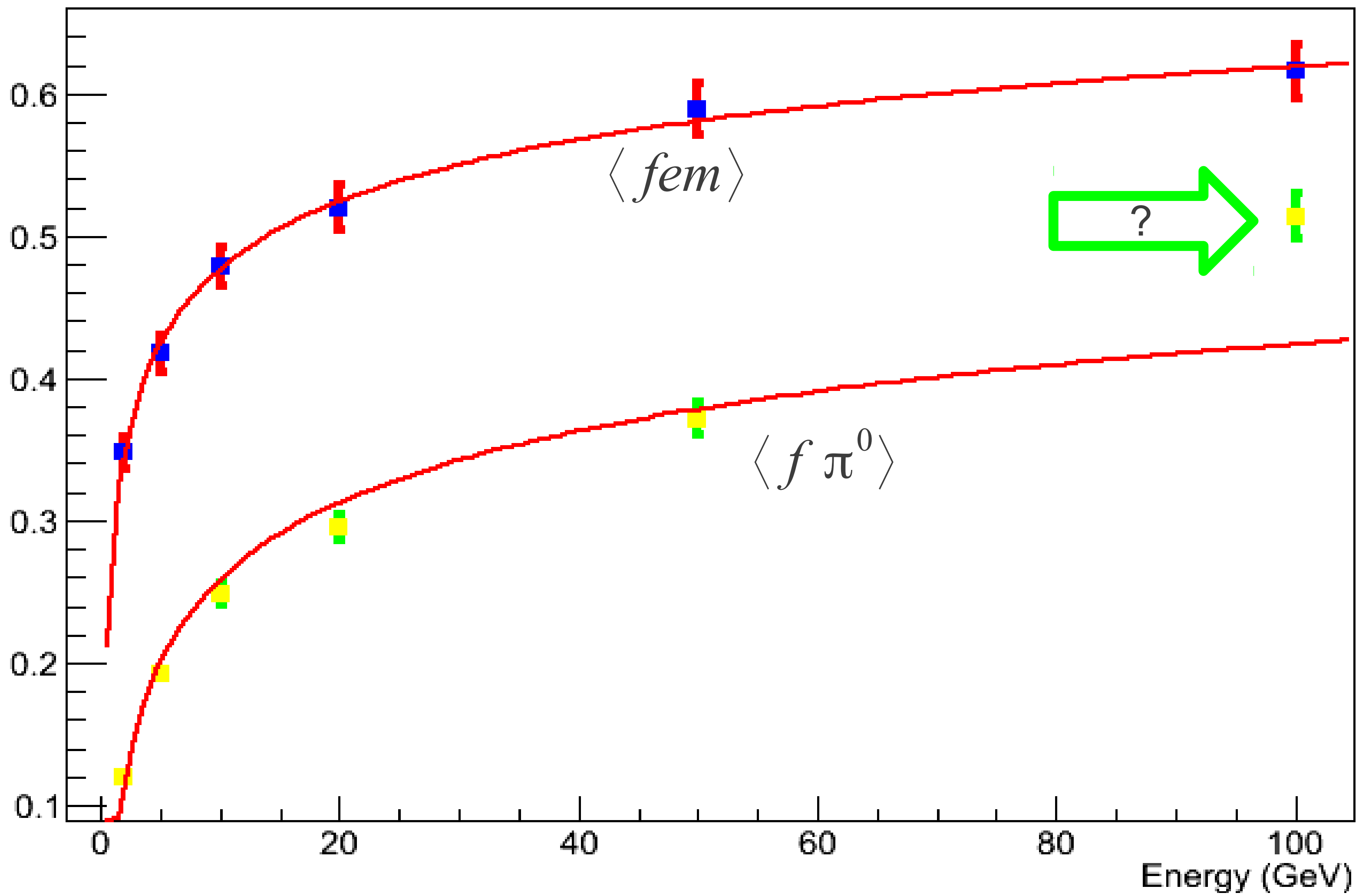
$$\langle fem \rangle = \left(\frac{E}{E_0} \right)^{m-1}$$

E_0 Is a scaling factor, which corresponds to the average energy needed for production of one pion (~ 1 GeV for incident charged pions)

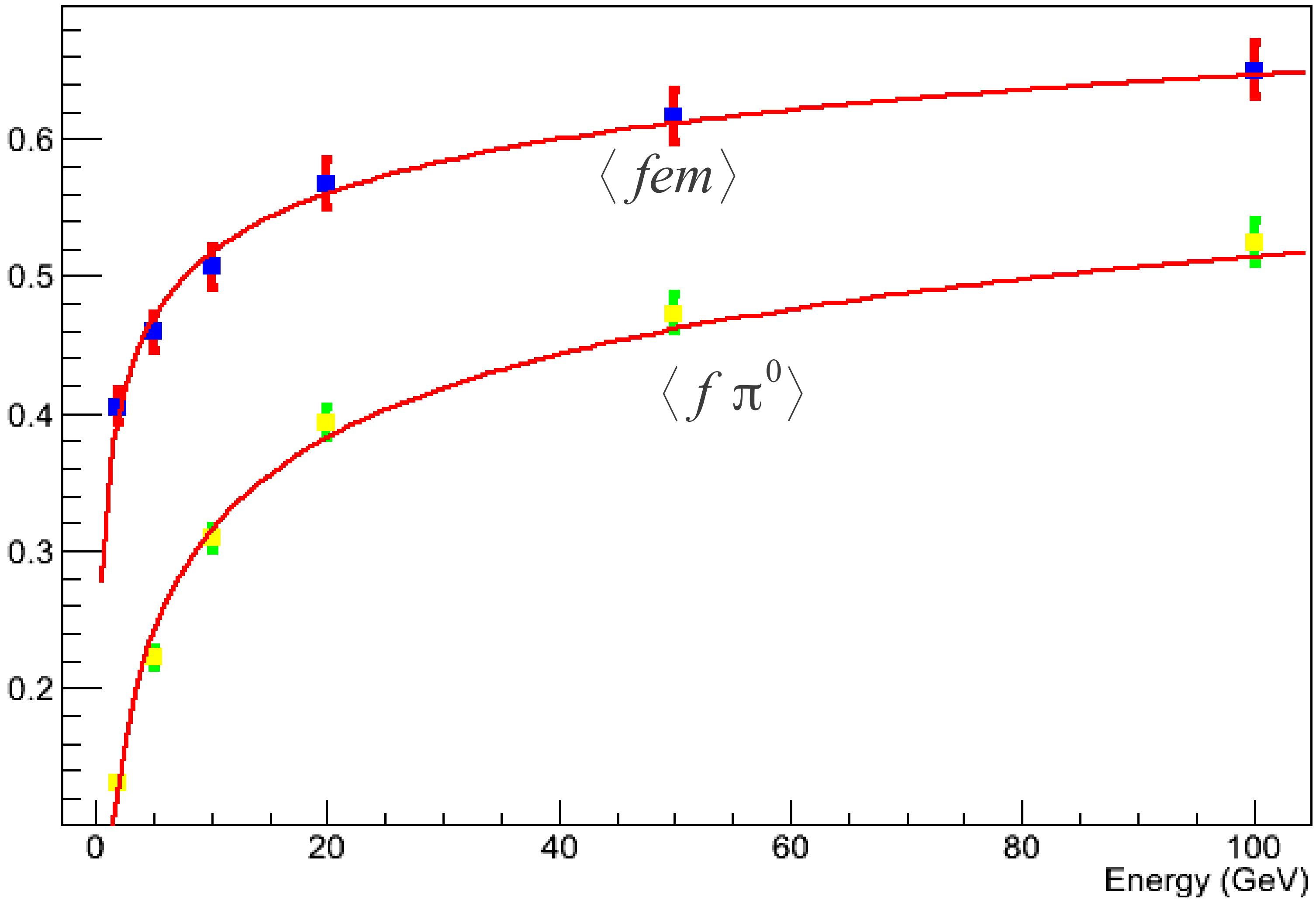
$m - 1$ is related to the average multiplicity and the average fraction of pi0's produced (~ 0.80 – 0.87 depending on the calorimeter)

We now check whether our results from simulation agree with this empirical formula!

PbF_2 Total Absorption Calorimeter



BGO Total Absorption Calorimeter



$$\langle fem \rangle = \left(\frac{E}{E_0} \right)^{m-1}$$

Parameter Results

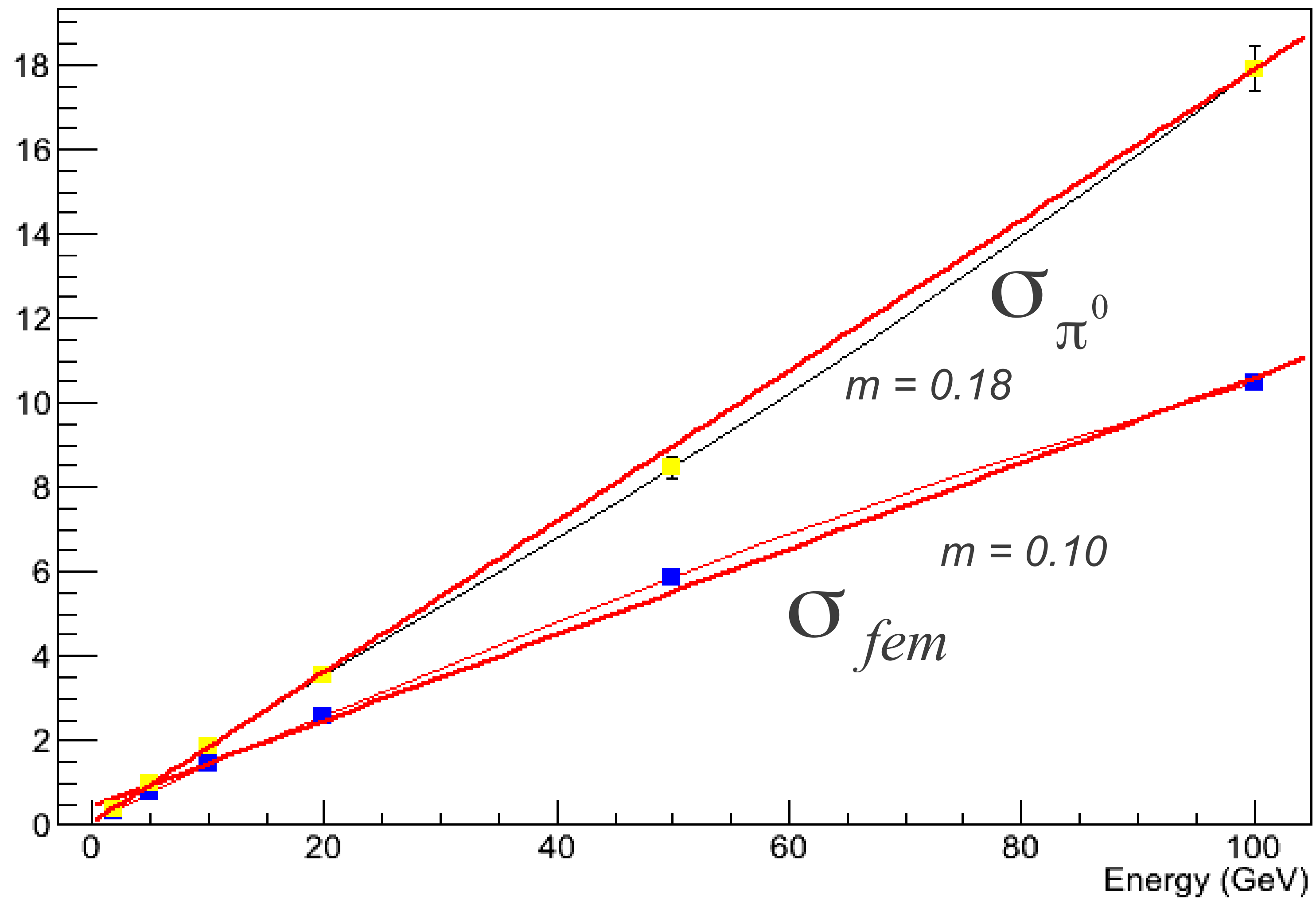
PbF_2 Total Absorption Calorimeter

	<fpi0>	<fem>
E0	0.66534 ± 0.043	0.09122 ± 0.0025
m	0.8897 ± 0.0035	0.8625 ± 0.009

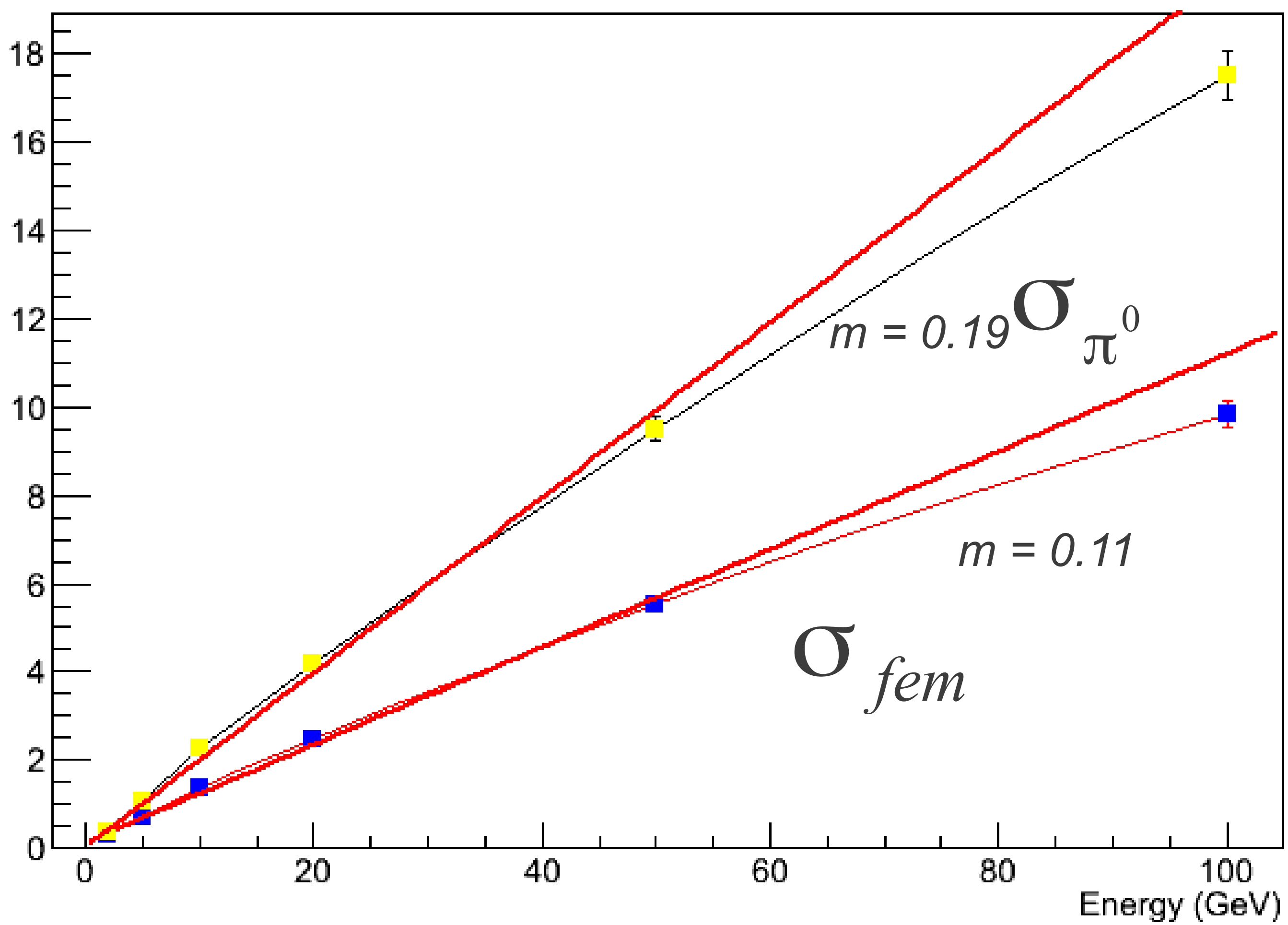
BGO Total Absorption Calorimeter

	<fpi0>	<fem>
E0	0.7976 ± 0.039	0.04783 ± 0.0186
m	0.8507 ± 0.0043	0.8645 ± 0.010

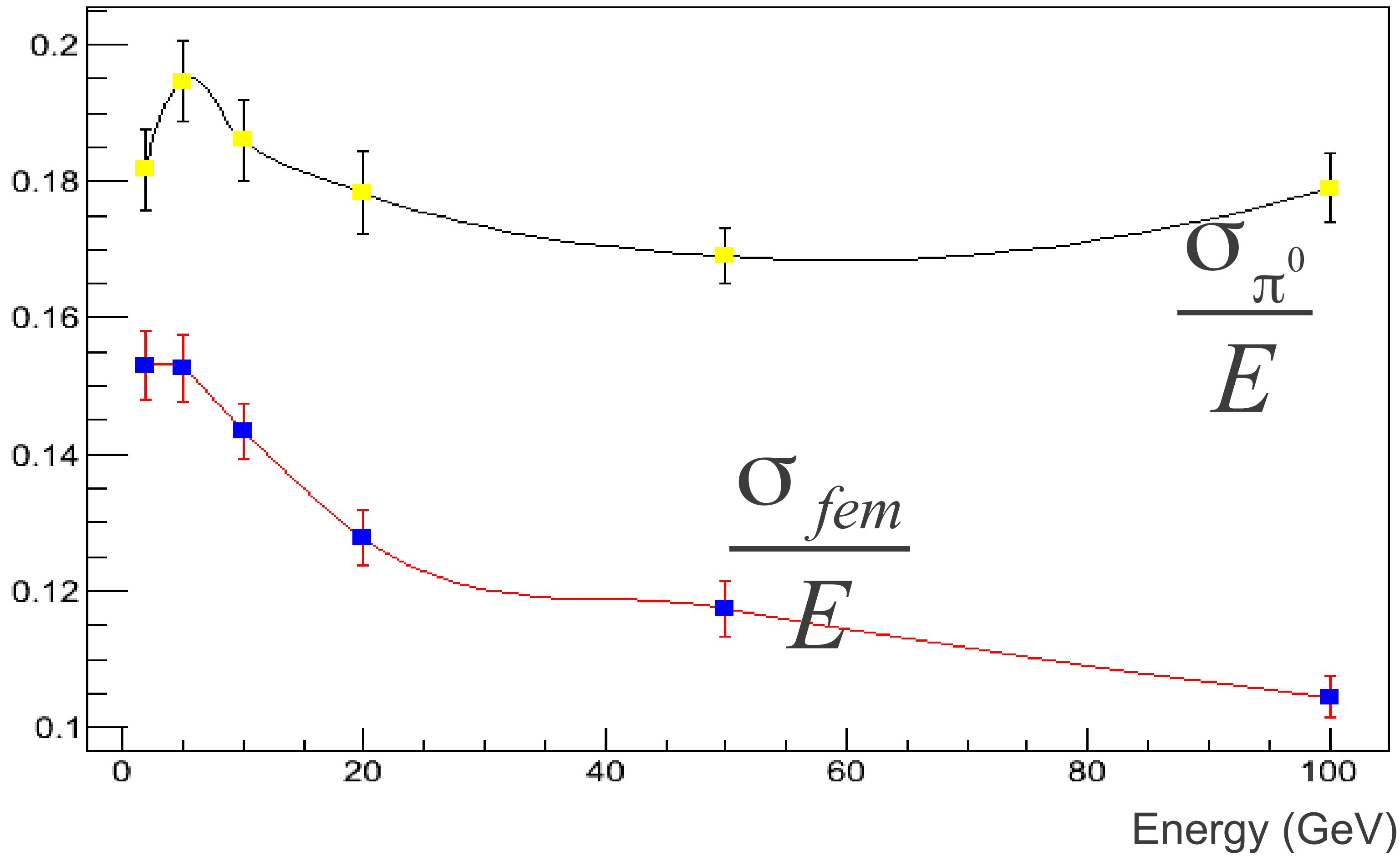
PbF_2 Total Absorption Calorimeter



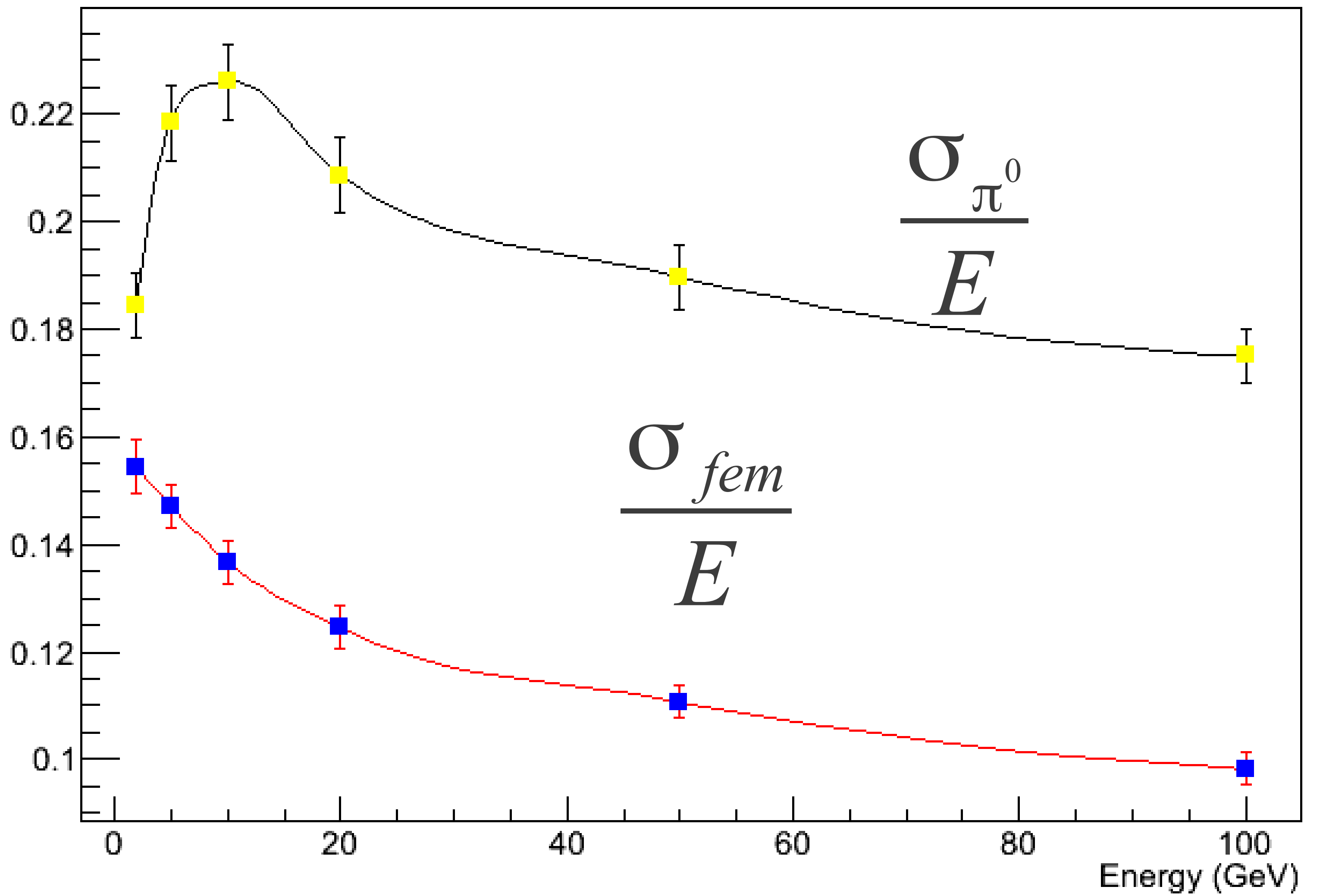
BGO Total Absorption Calorimeter



PbF_2 Total Absorption Calorimeter



BGO Total Absorption Calorimeter



Future Work

- Study the effects of sampling on Dual Read Out Correction.
- Check <fem> for protons to check the effects of baryon number conservation.
  - *i.e. smaller <fem> for incoming protons.*
- Study the remaining components of <fem>.
- Explore how <fem> behaves at energies > 100 GeV.