Hadronic showers / missing energy in protoDUNE

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Outline

- Particle gun MC of pions and protons
- Studying the MC true energy deposited in protodune
- Also looking at the MC true energy deposited as photons
- Quantifying energy associated to primary, and to neutral secondaries (gammas, neutrons)

larsoft workflow

- Using dunetpc v06_12_00
  - protodune_v2 geometry
- protoDUNE_gensingle.fcl
  - Pion or proton, 0.1 – 3.0 GeV momentum
- protoDUNE_g4single.fcl
  - Modified SimPhotons to store G4 truth
- protoDUNE_detsim_single.fcl
- protoDUNE_reco.fcl
- No cosmics / multiparticle events

- I have to edit lardataobj/Simulation/SimPhotons.h to include the Geant4 true track information for what created the photon
  - This info was already stored in sim::IDE

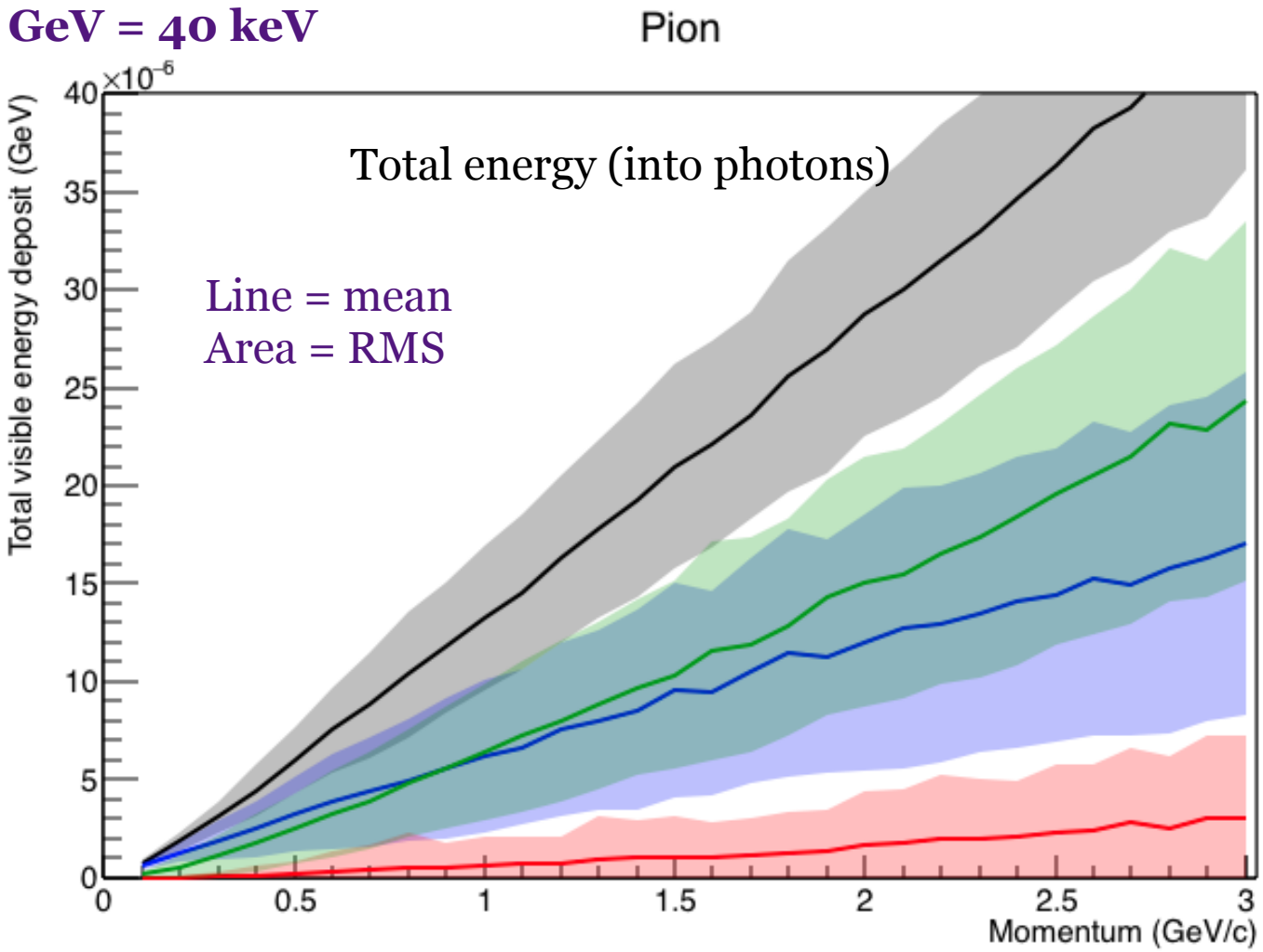
```
class OnePhoton
  {
  public:
    OnePhoton();

    bool           SetInSD;
    TVector3       InitialPosition;
    TVector3       FinalLocalPosition; // in cm
    float          Time;
    float          Energy;
    int            TrackID; // GEANT4 track id
  };
```

Analysis

- For now, only looking at the true energy deposits
- Associating each energy deposit to
  - Primary – plus any charged daughters
  - Neutrons – and subsequent daughters
  - Gammas – and subsequent daughters
- Calculating the fraction of energy deposited into those three categories

Pions – total photonic energy

40×10^{-6} GeV = 40 keV

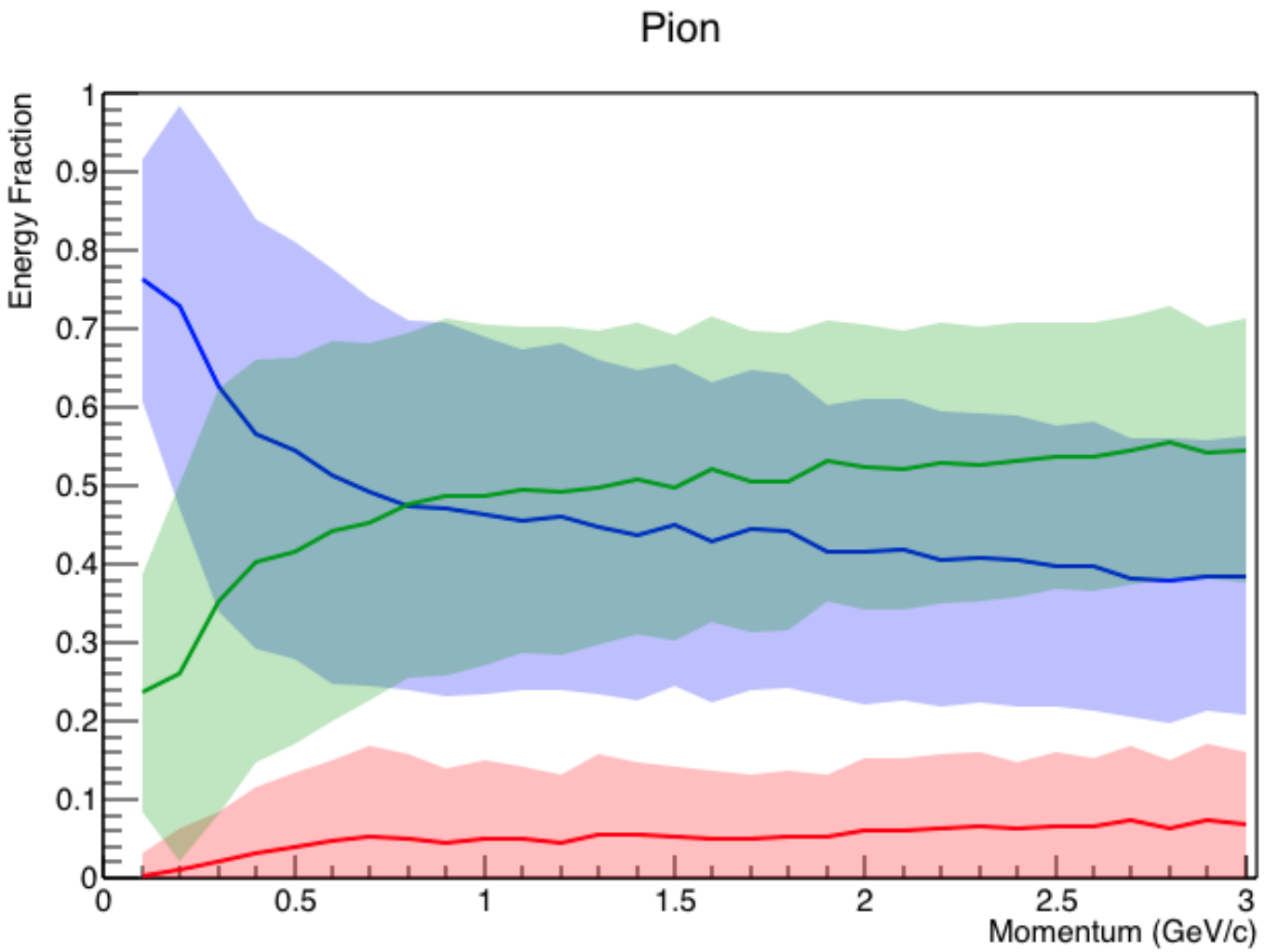


From gammas

From the primary & charged daughters

From neutrons

Pions – photonic component fraction

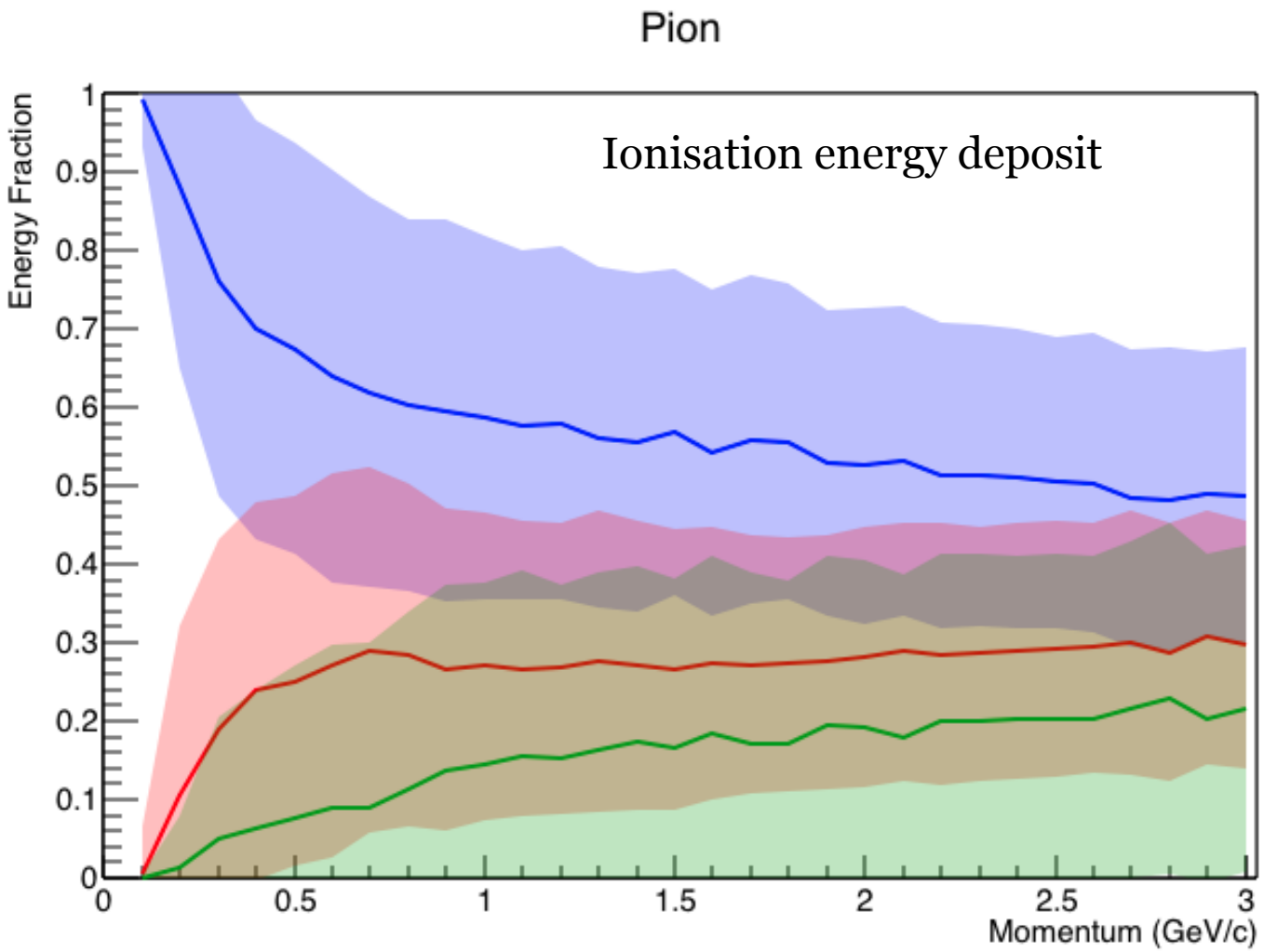


From gammas

From the primary & charged daughters

From neutrons

Equivalent plot for Ionisation

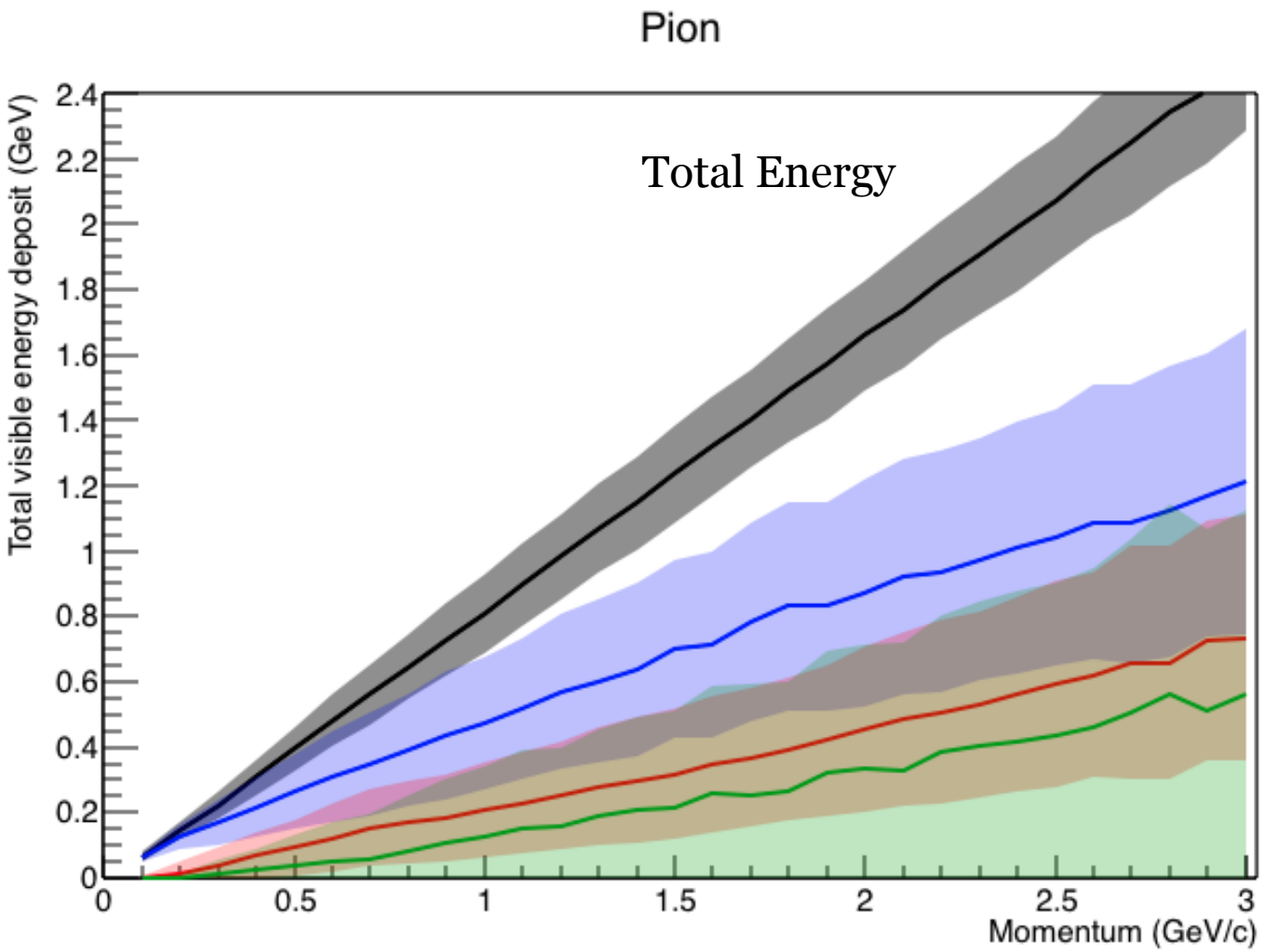


From the primary & charged daughters

From neutrons

From gammas

Pion – ionisation total energy



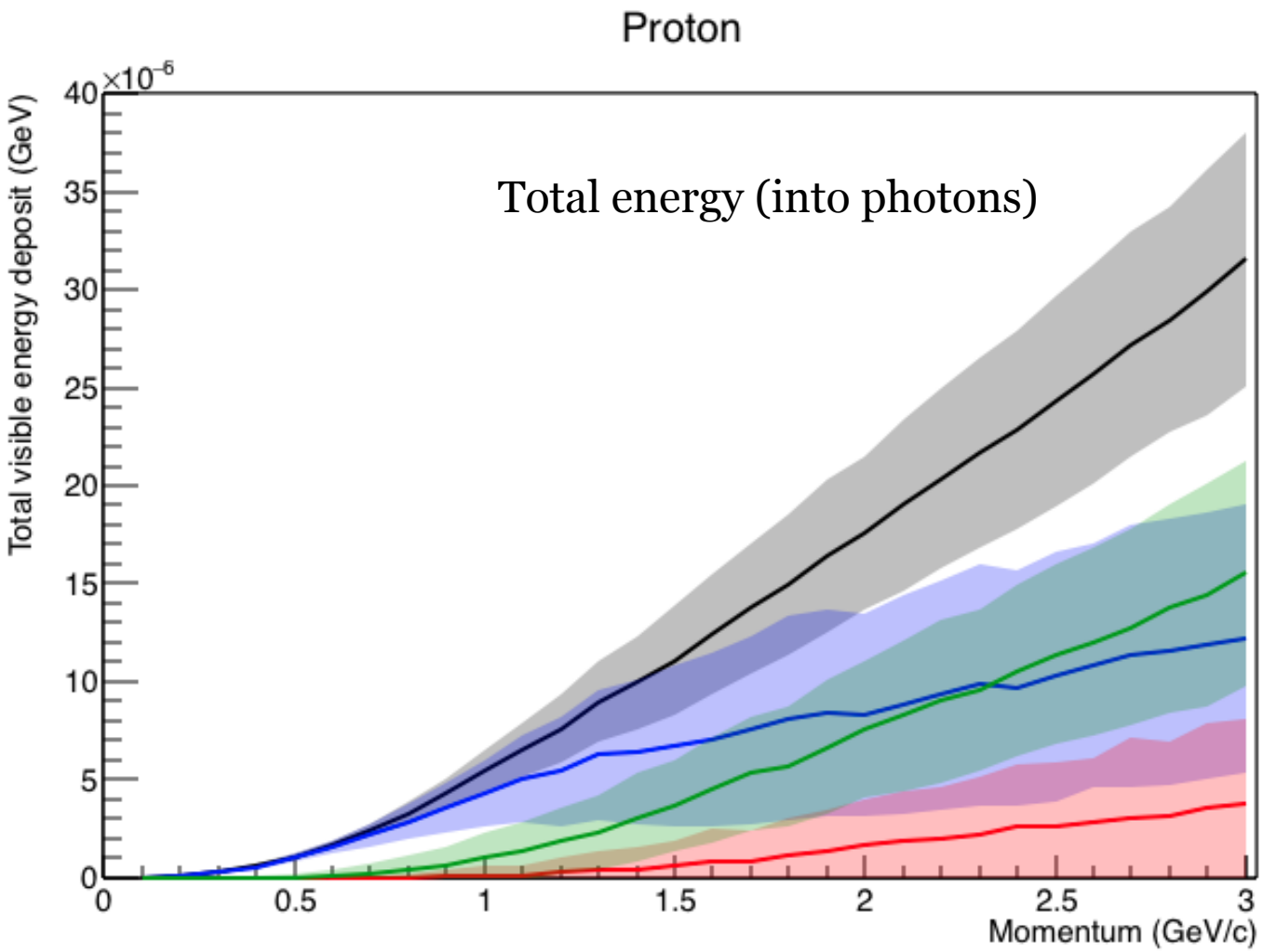
From the primary & charged daughters

From neutrons

From gammas

- And for protons…

Protons – total photonic energy

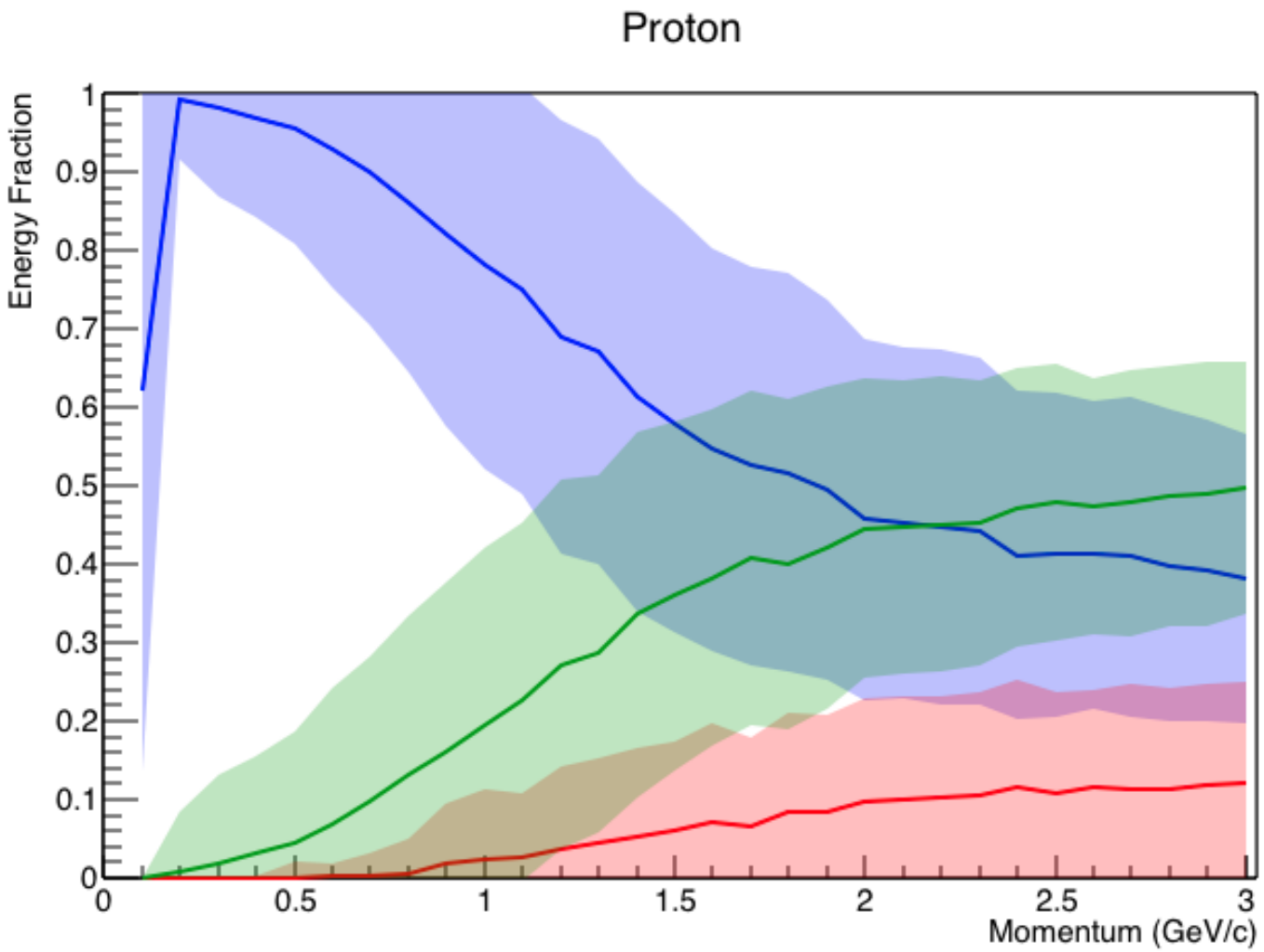


From gammas

From the primary & charged daughters

From neutrons

Protons – photonic component fraction

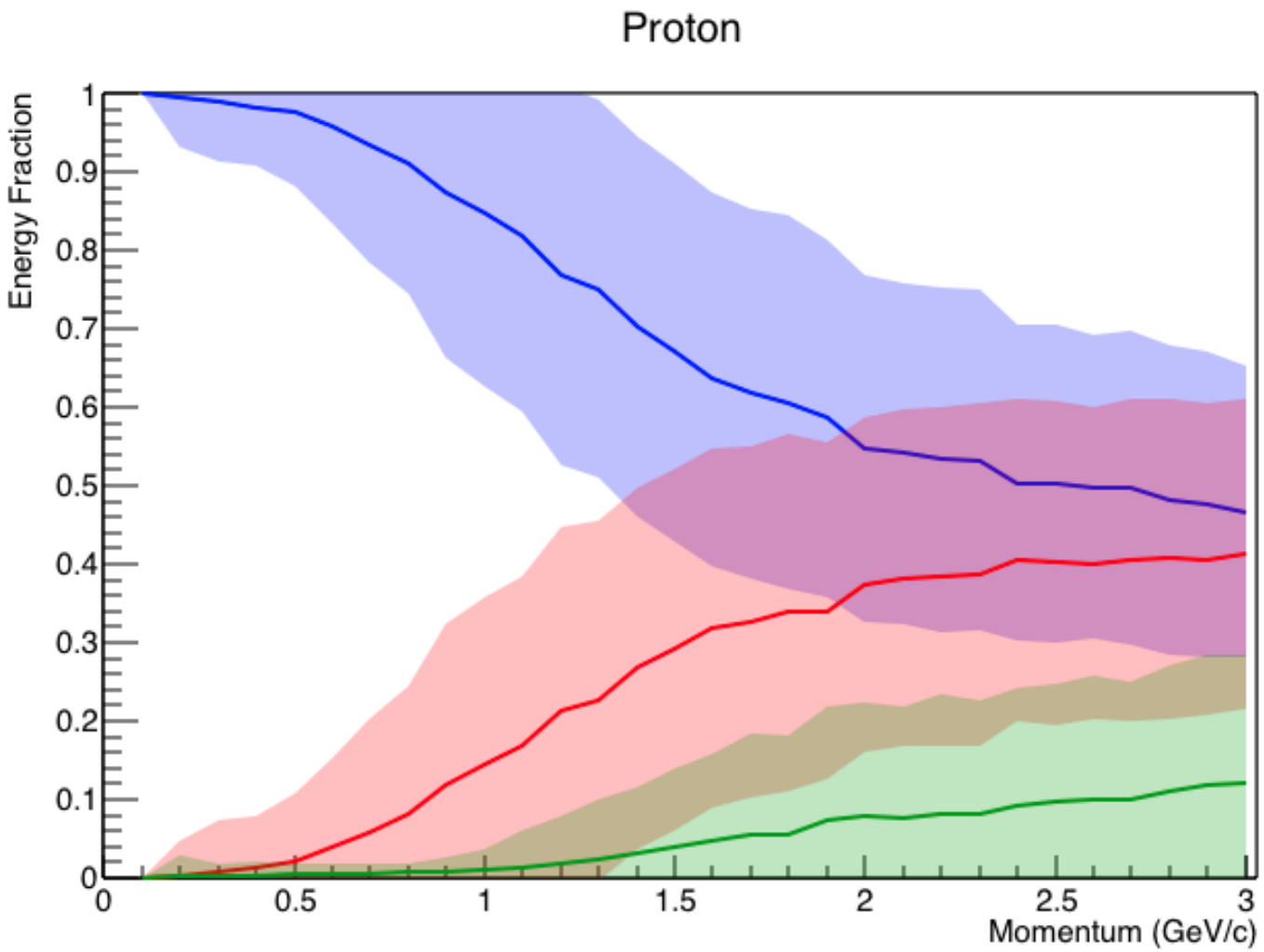


From gammas

From the primary & charged daughters

From neutrons

Equivalent plot for Ionisation

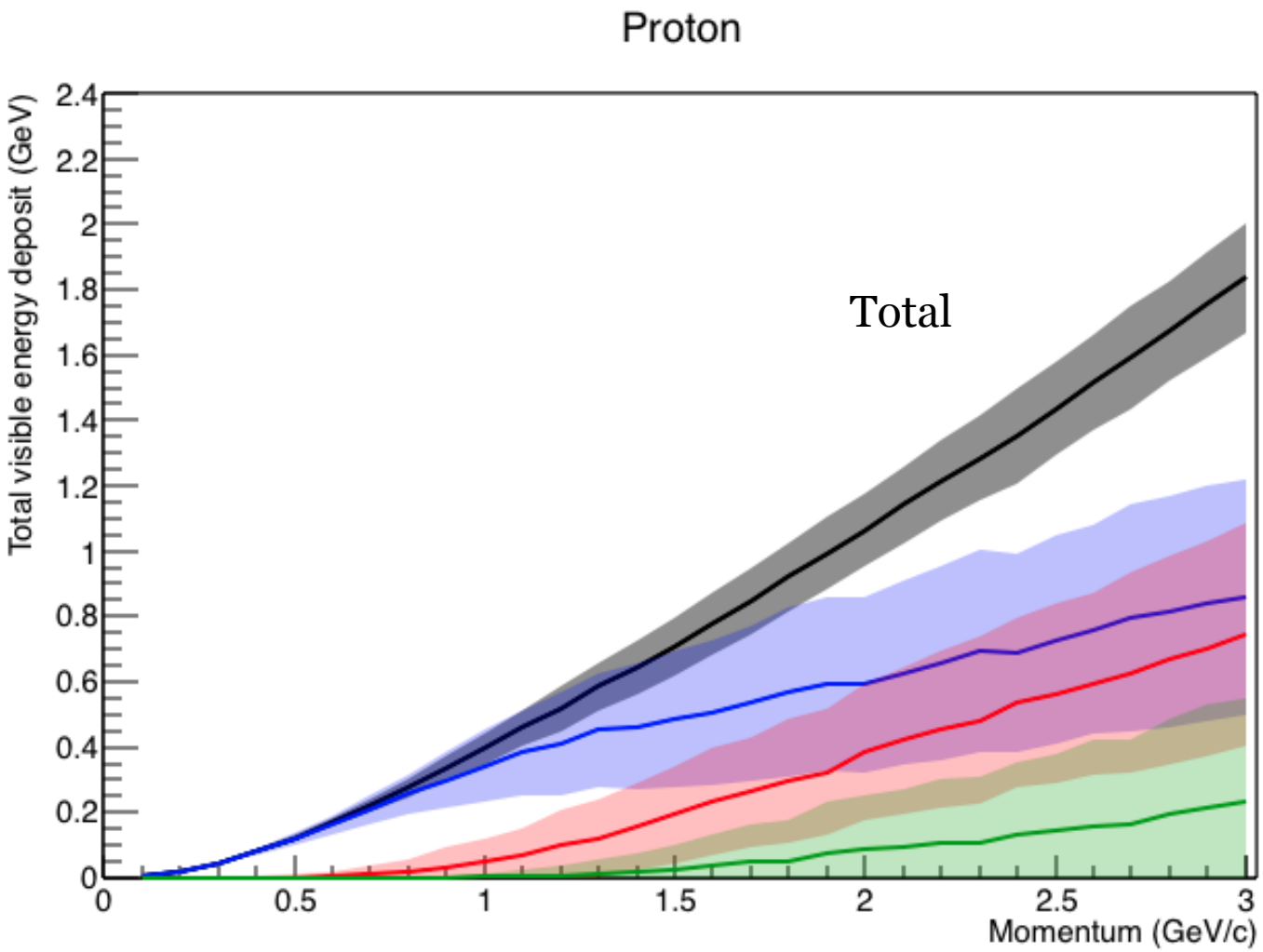


From the primary & charged daughters

From neutrons

From gammas

Protons – ionisation energy deposit



From the primary & charged daughters

From neutrons

From gammas

Summary

- Total energy deposited as detectable photons is of order keVs
  - Will need to be calibrated
- Complementarity between Light & Ionisation for EM showers & neutron showers
- I haven't looked at light reconstruction (OpFlash), that works on SimPhotonsLite