Dual-Readout Calorimeter Simulation

State of the Art

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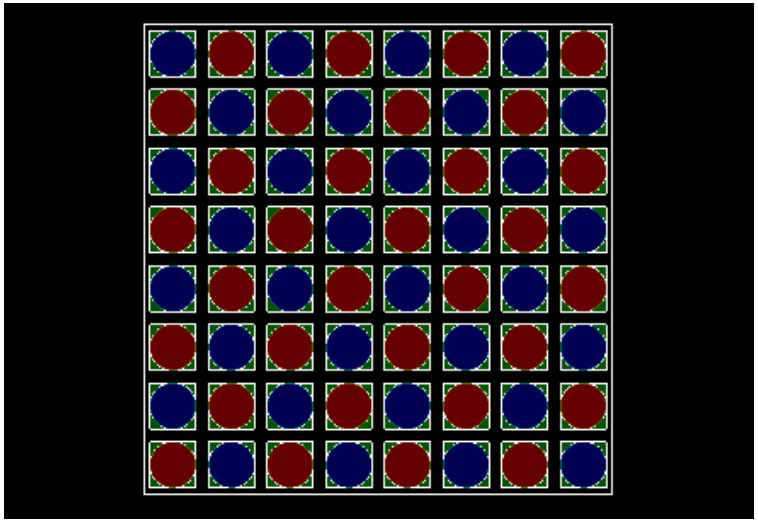
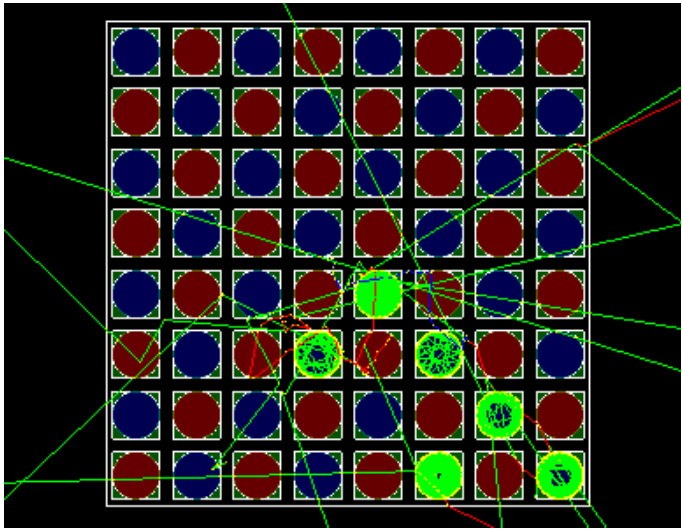
Geometry

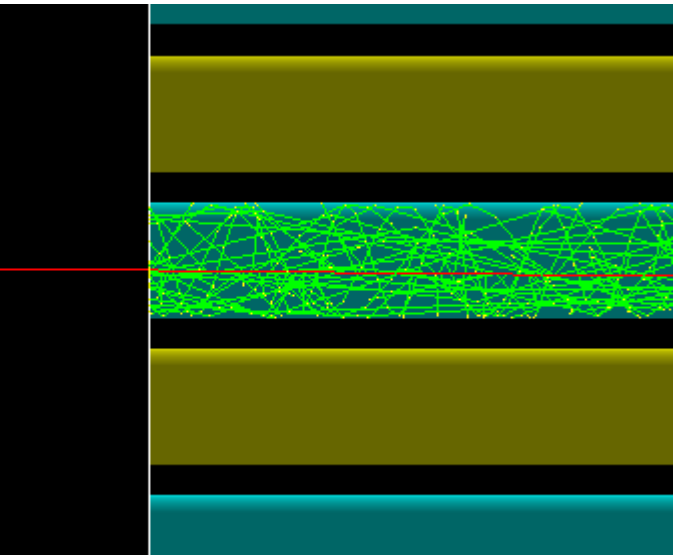
- Geant4 code to simulate the module built in Como: about 1 cm x 1 cm x 1 m copper module with 64 (clear and scintillating) fibres readout with SiPMs
- Compile with two latest versions of Geant4: 10.02.p01-10.03.p01
- The possibility to change materials, to add more modules in a matrix to simulate a full containment calorimeter and to rotate the calorimeter is already implemented
- Physics List: FTFP_BERT_HP

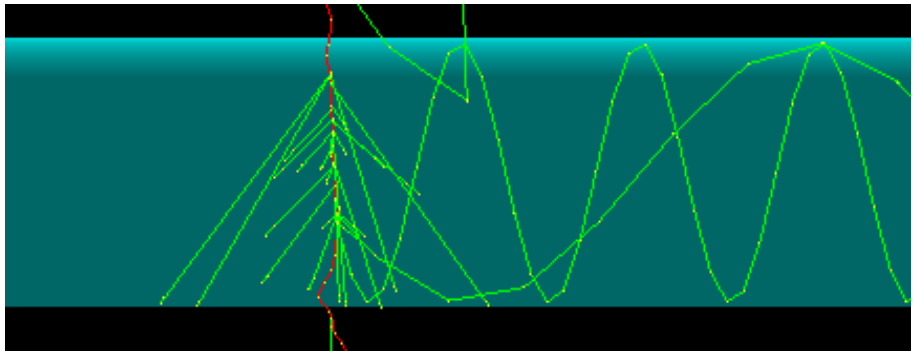


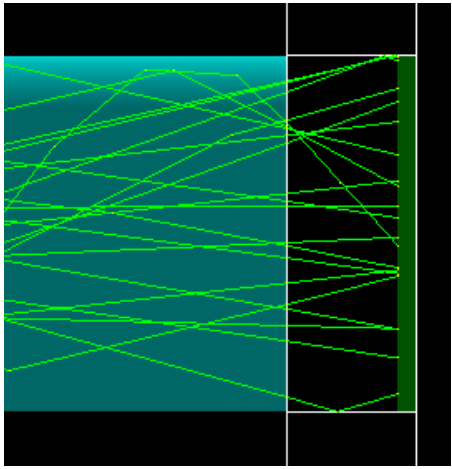


Light production and propagation

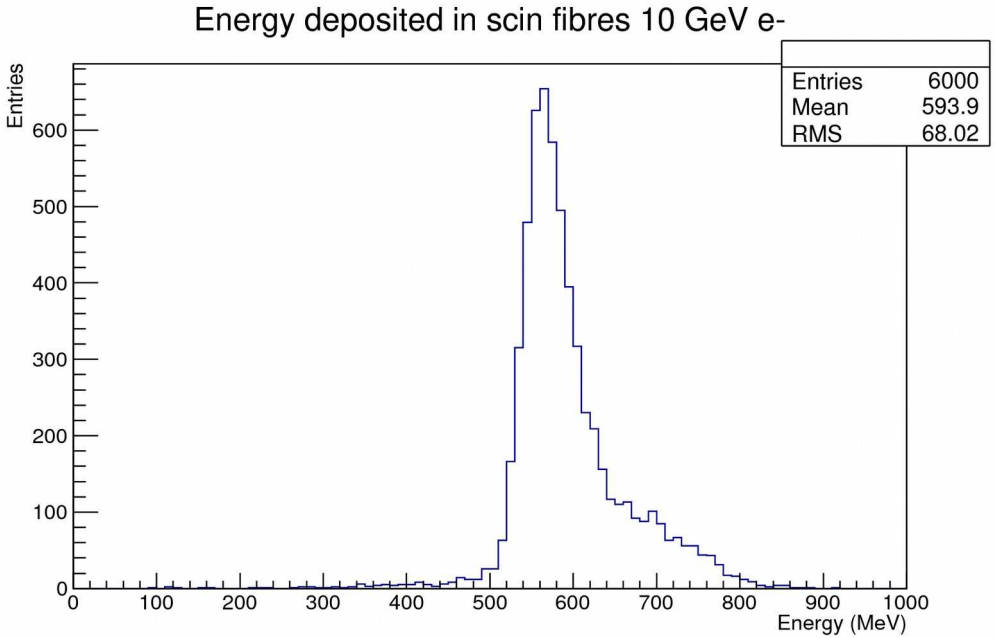
- We already have all the optical properties included in our simulation code: scintillation yield, light emission spectrum, refractive indices, attenuation lengths, and SiPM photon detection efficiency (PDE)
- We can produce and transport both photons from Cherenkov and scintillation processes → extremely time consuming!
- Need to parameterize light production and transportation → need to know exactly how light propagates in real fibres
- First parameterization: scintillation yield 1000 photons/MeV, 3% of them propagates towards SiPMs, attenuation length 5 m and 40% PDE

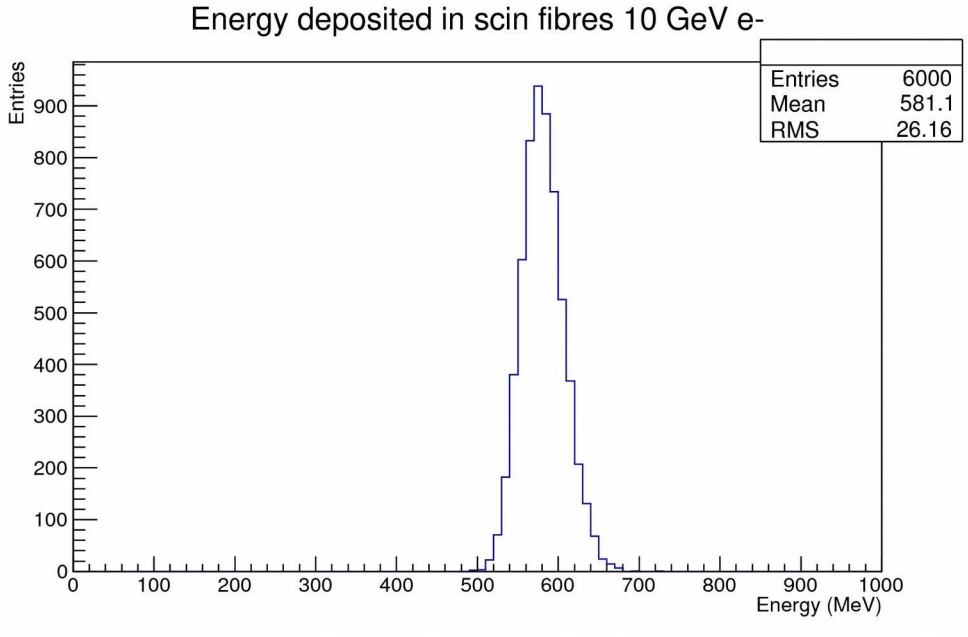


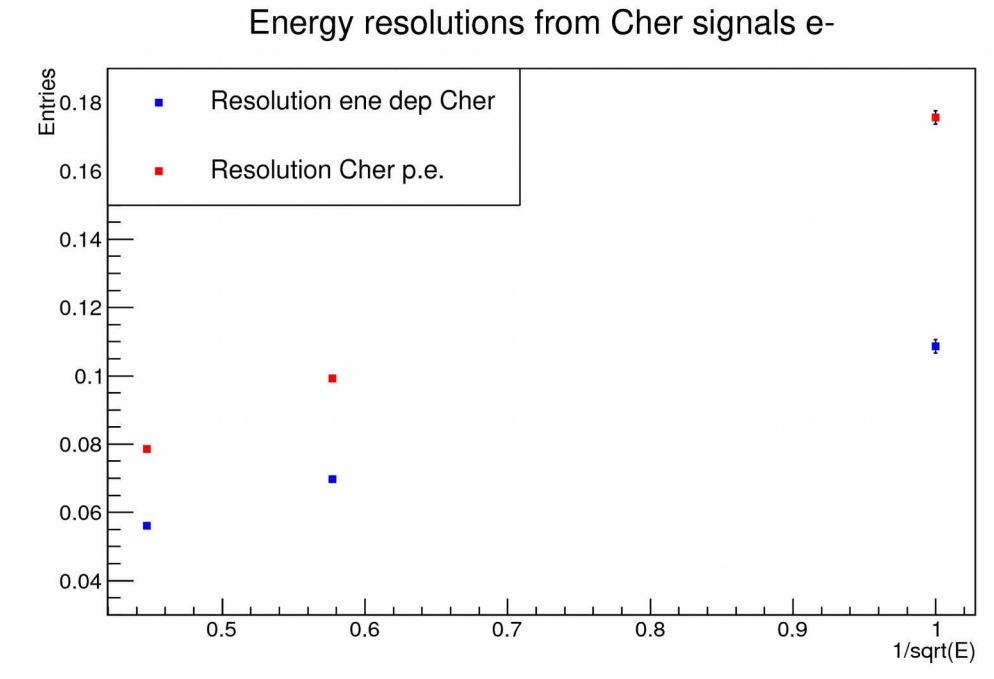


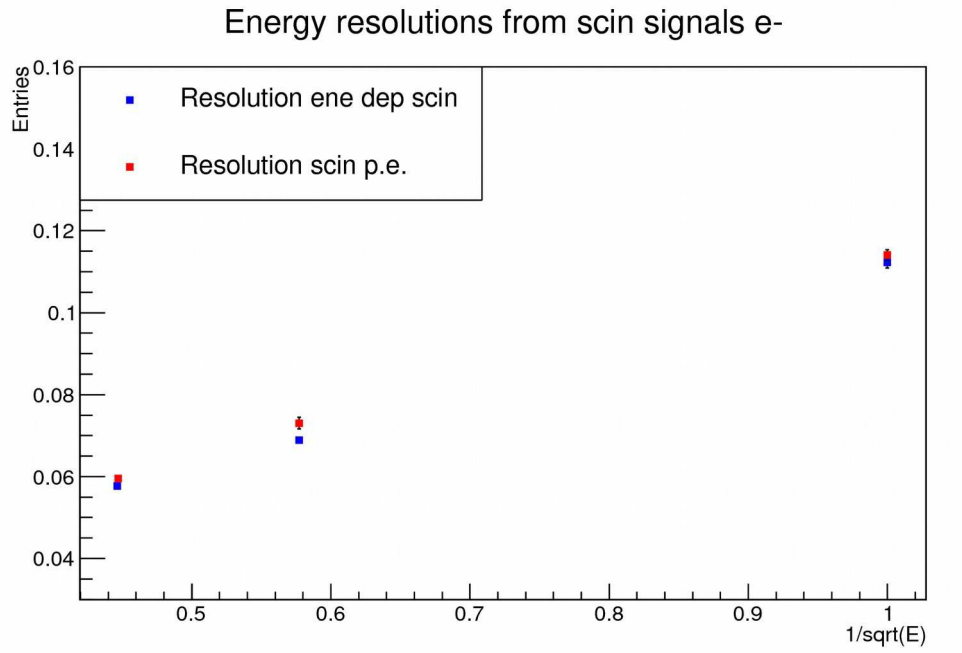


Channeling and fluctuations

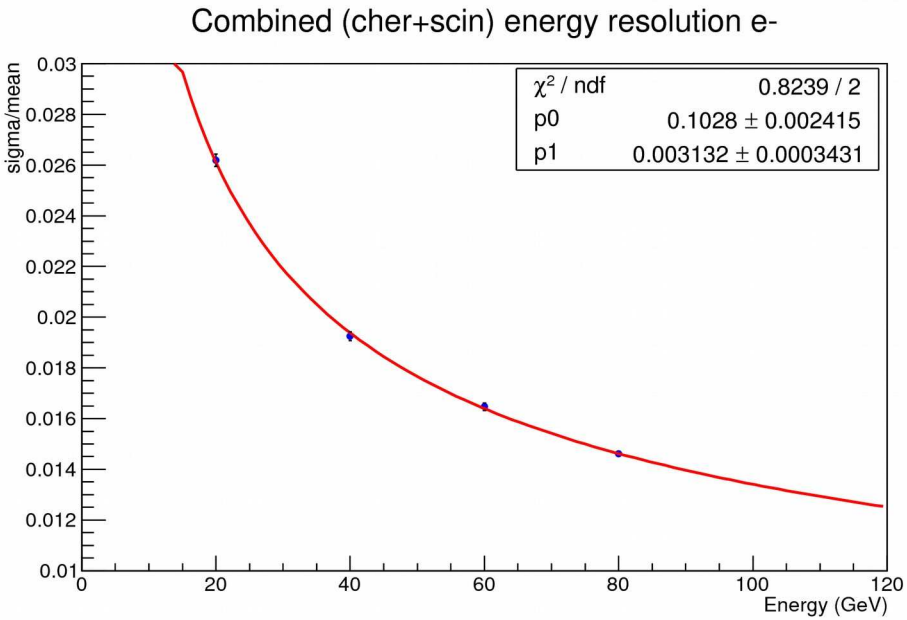


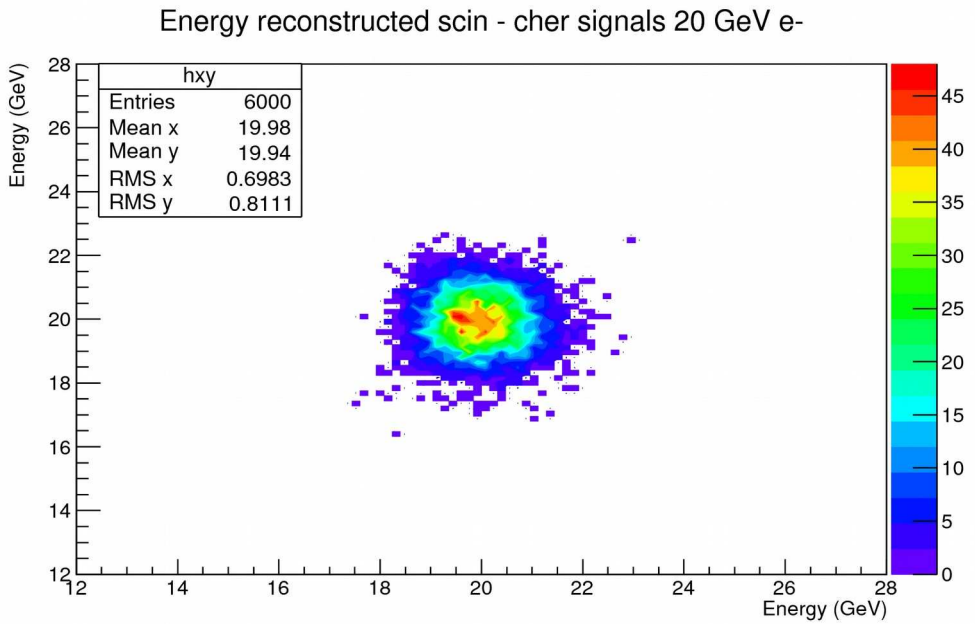






Electromagnetic energy resolution

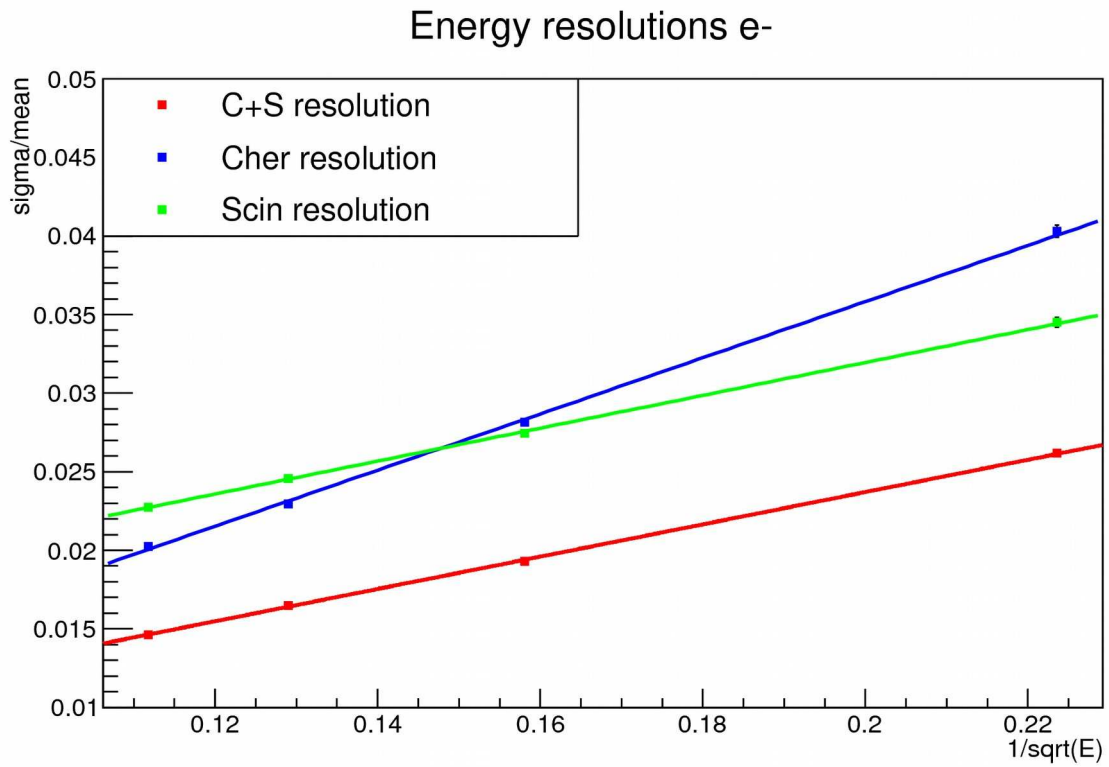




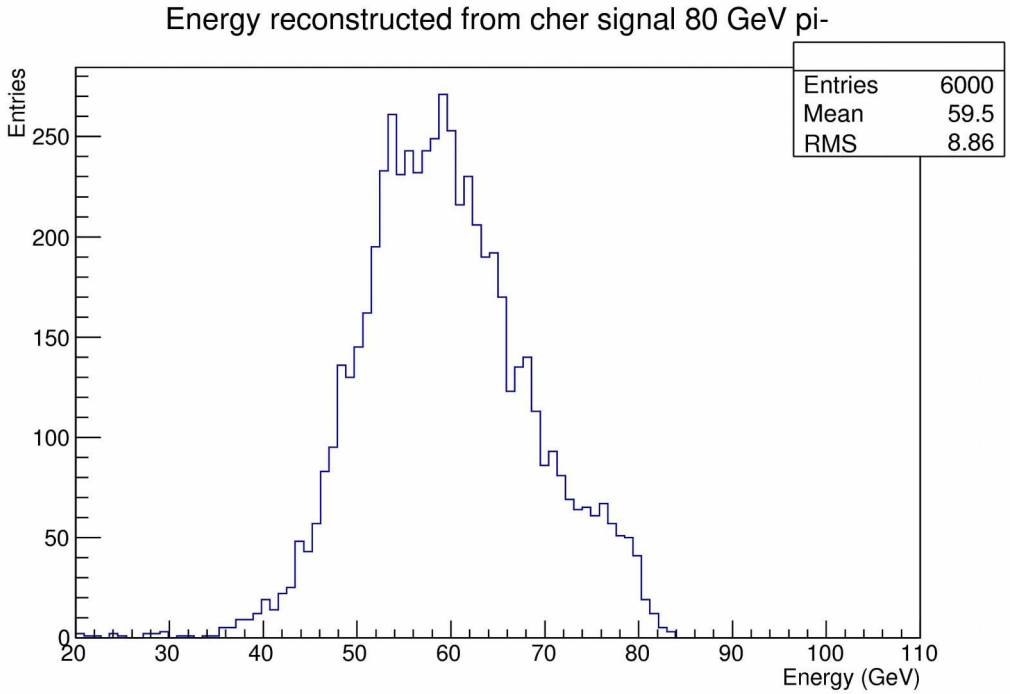
Cherenkov: 17.9%/sqrt(E)

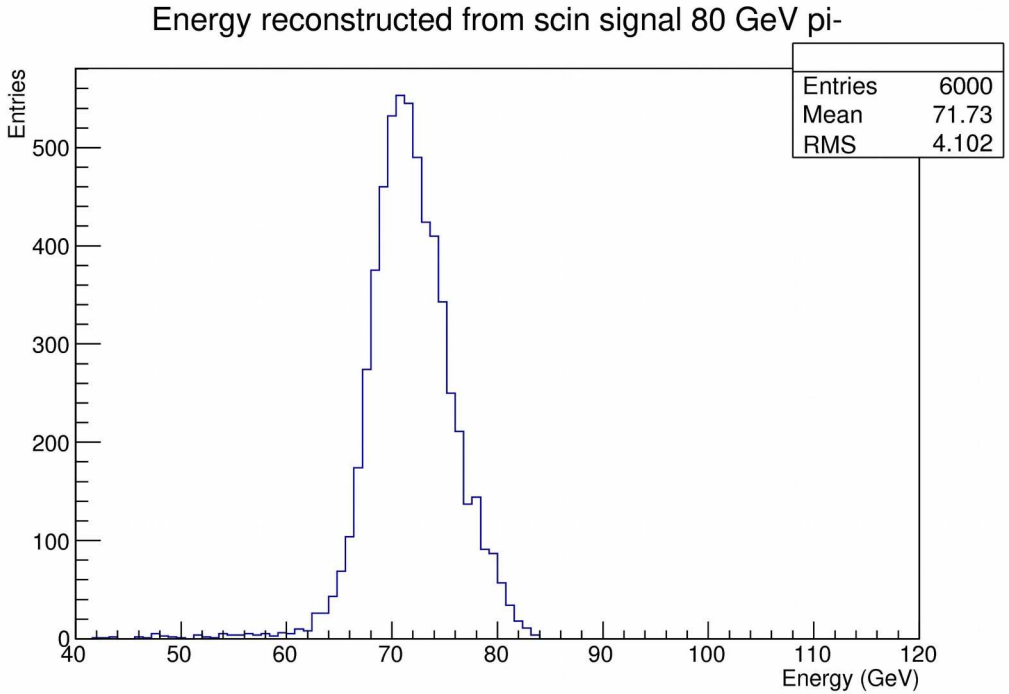
Scintillation: 10.5%/sqrt(E)+1.1%

C+S: 10.3%/sqrt(e)+0.3%

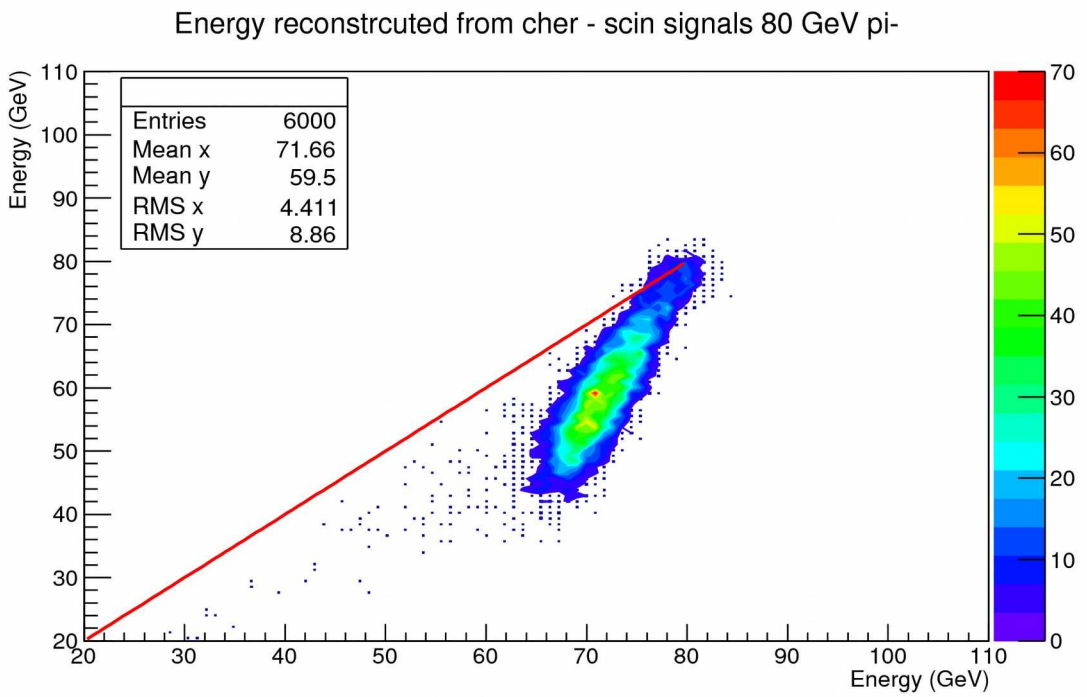


Signals from hadrons

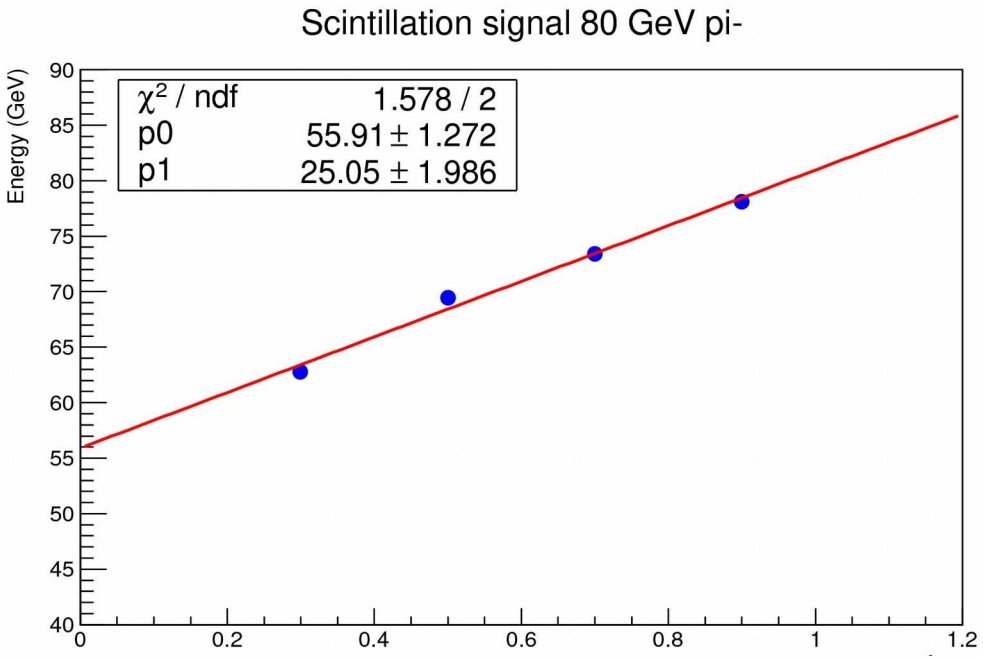


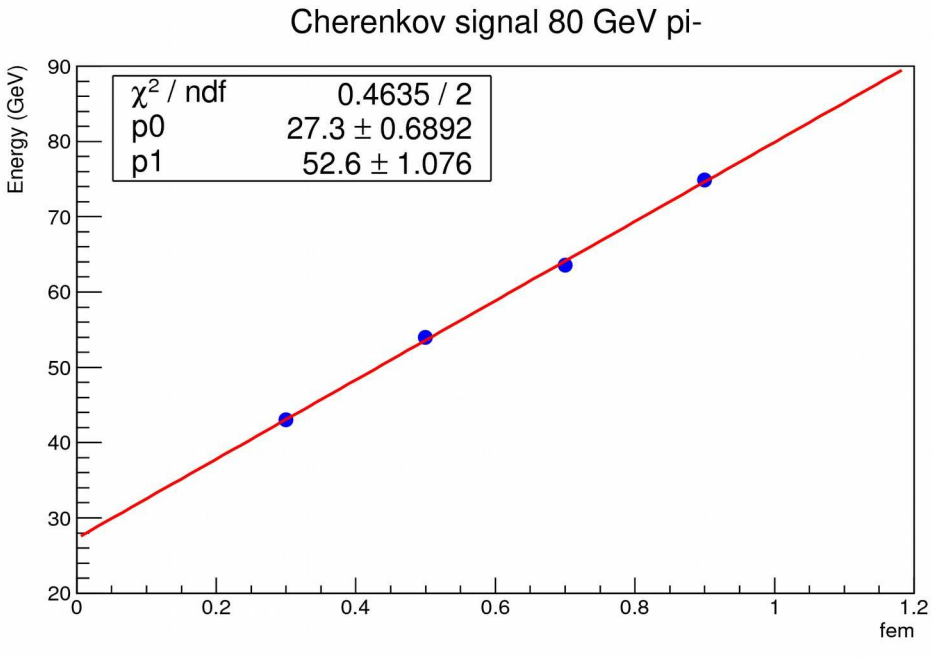


Important to introduce Birk saturation law for scintillating fibres!



E/H estimation

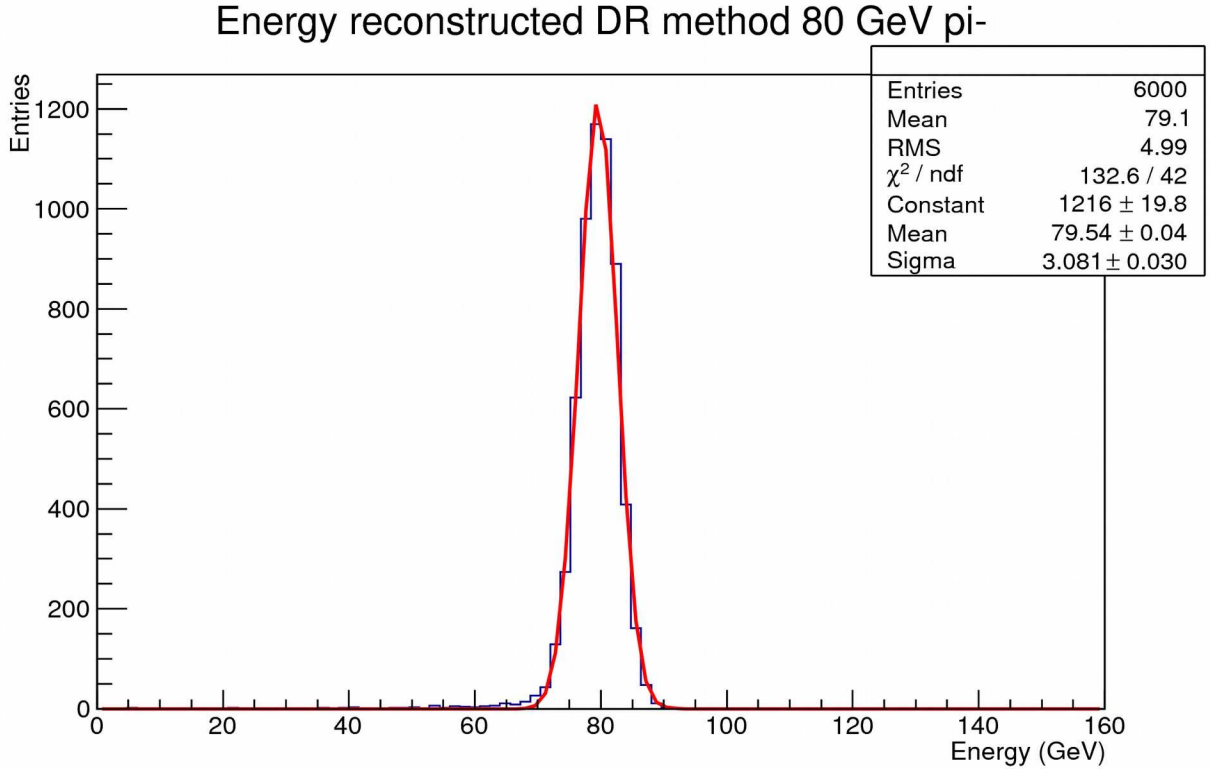




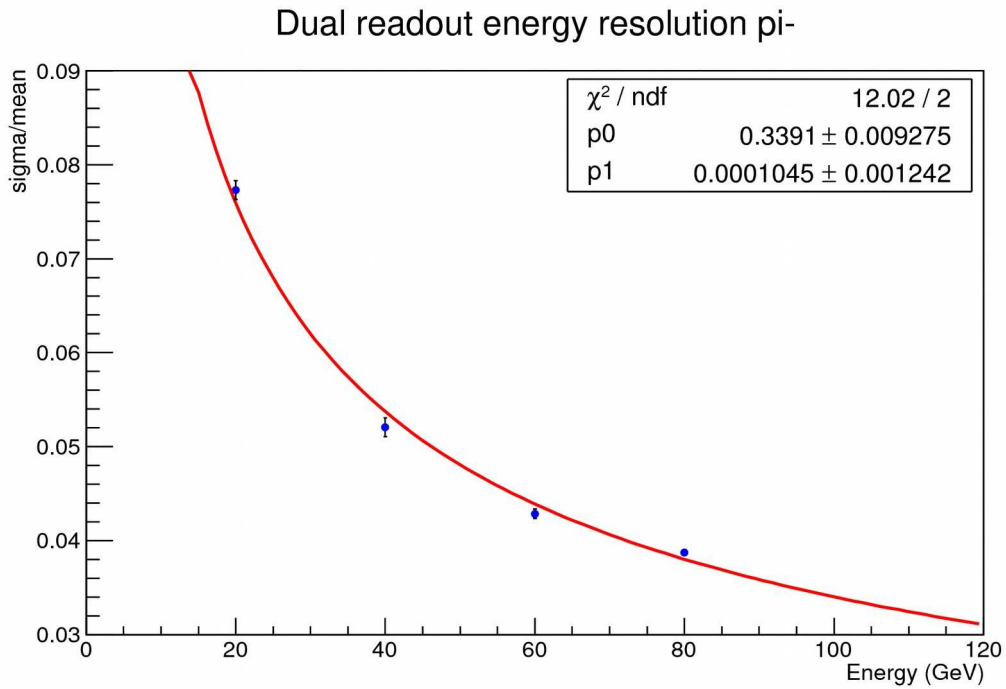
Scintillation: h/e = 0.73

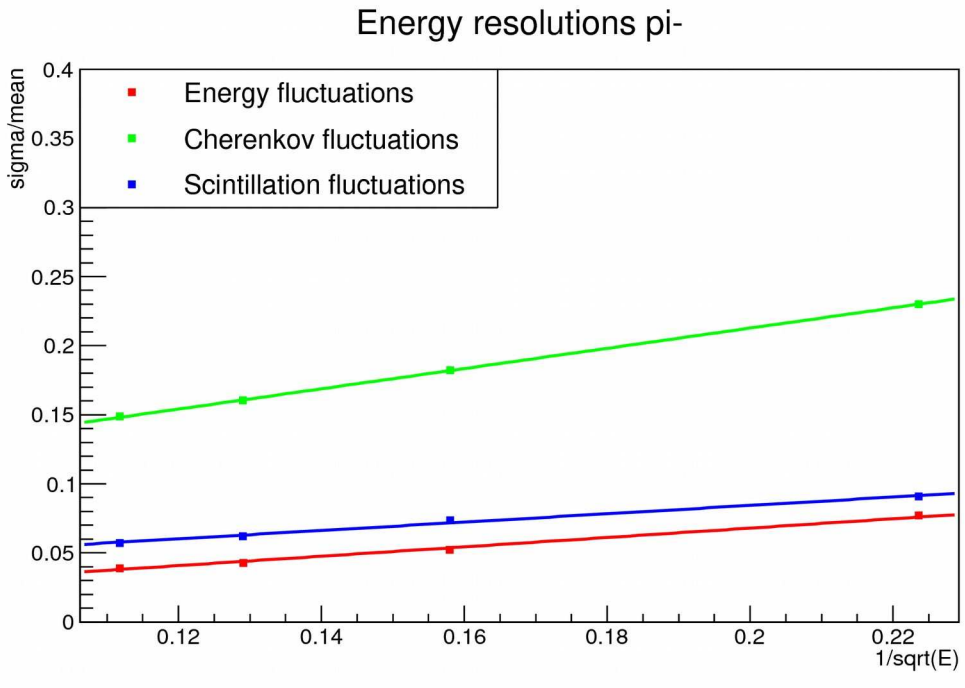
Cherenkov: h/e = 0.29

Chi = 0.38



Hadronic energy resolution



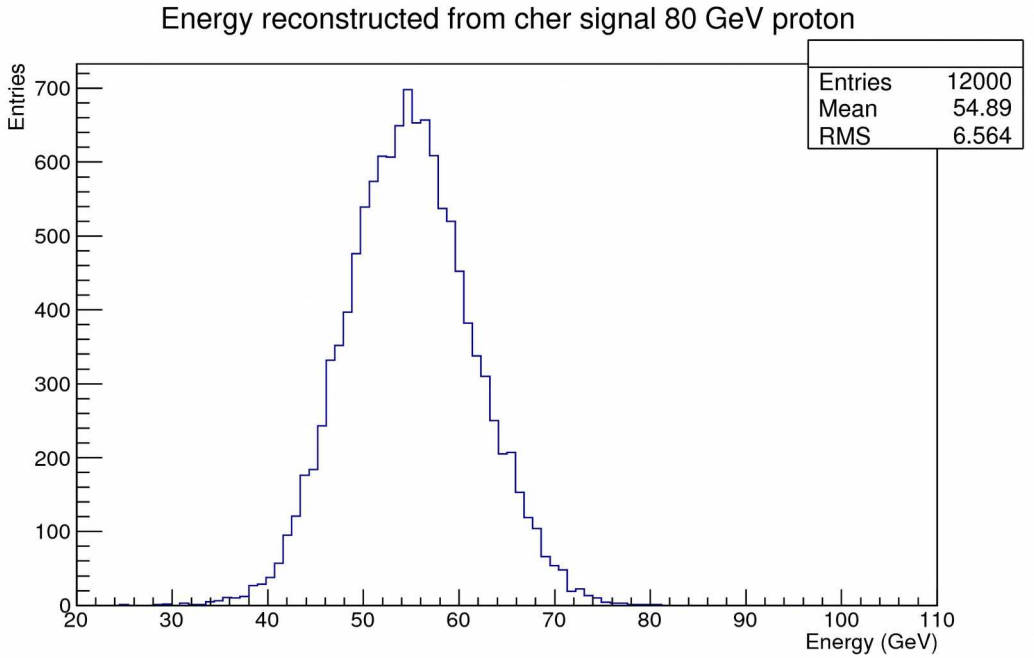


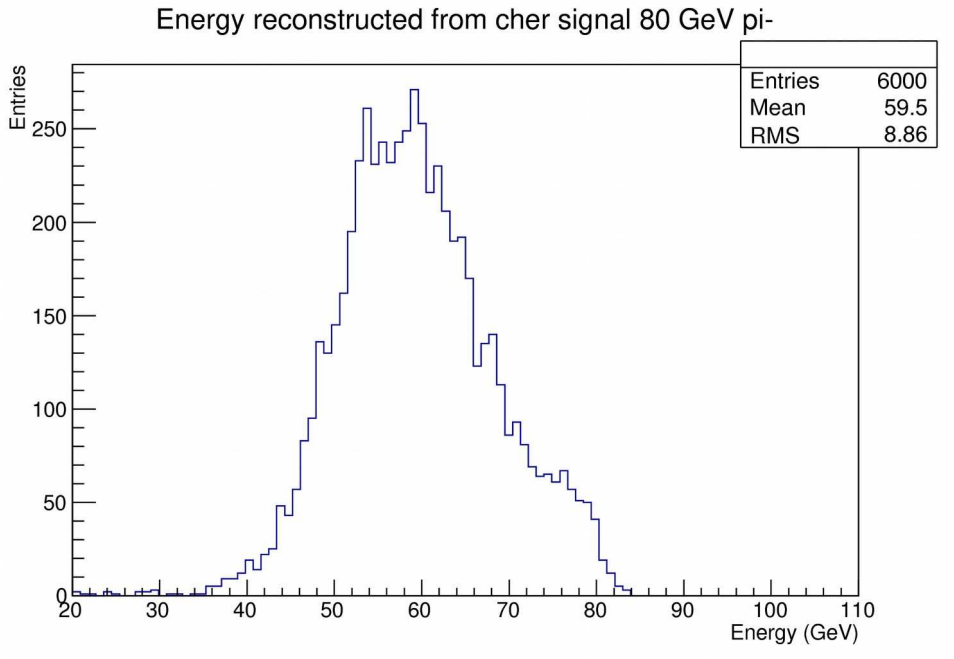
Scintillation: 30%/sqrt(E) + 2.4%

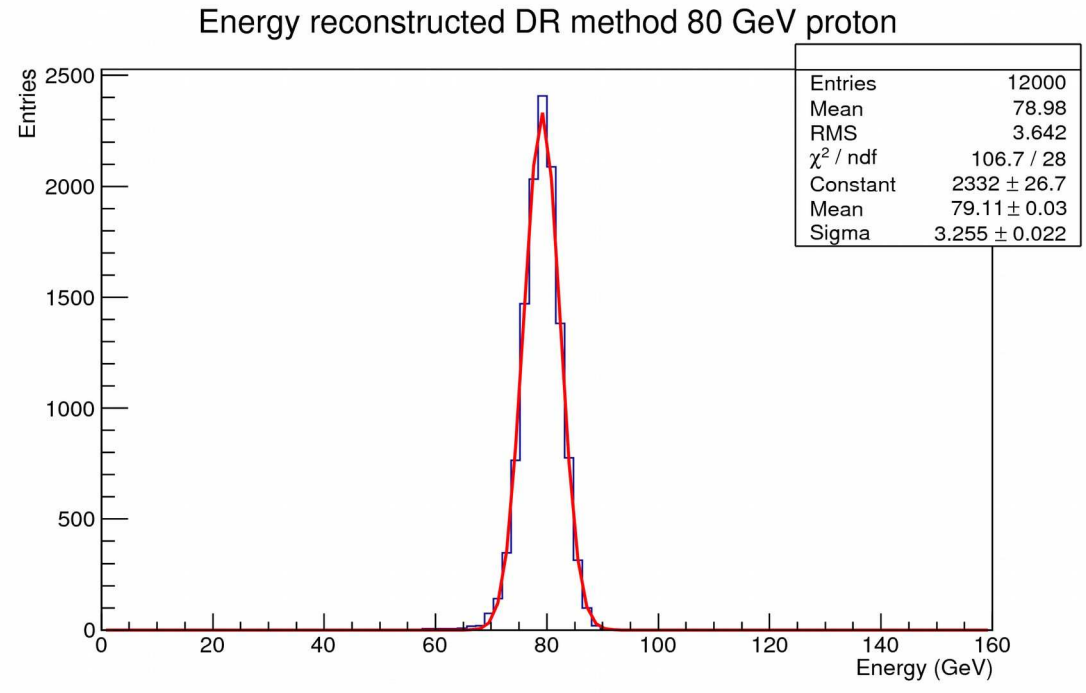
Cherenkov: 73%/sqrt(E) + 6.6%

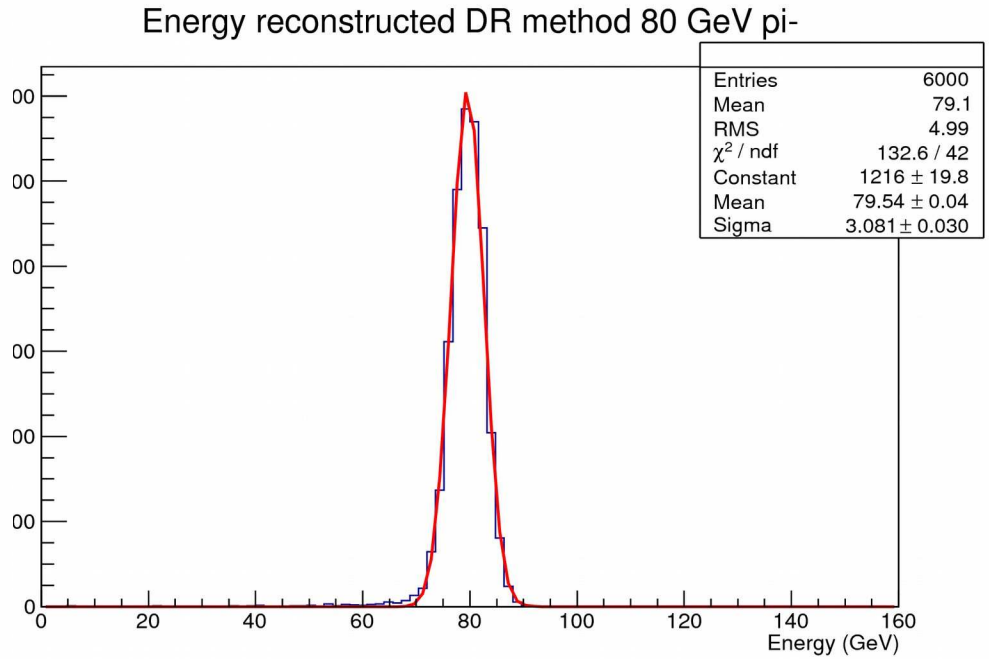
Dual readout method: 34%/sqrt(E)

Proton vs Pions

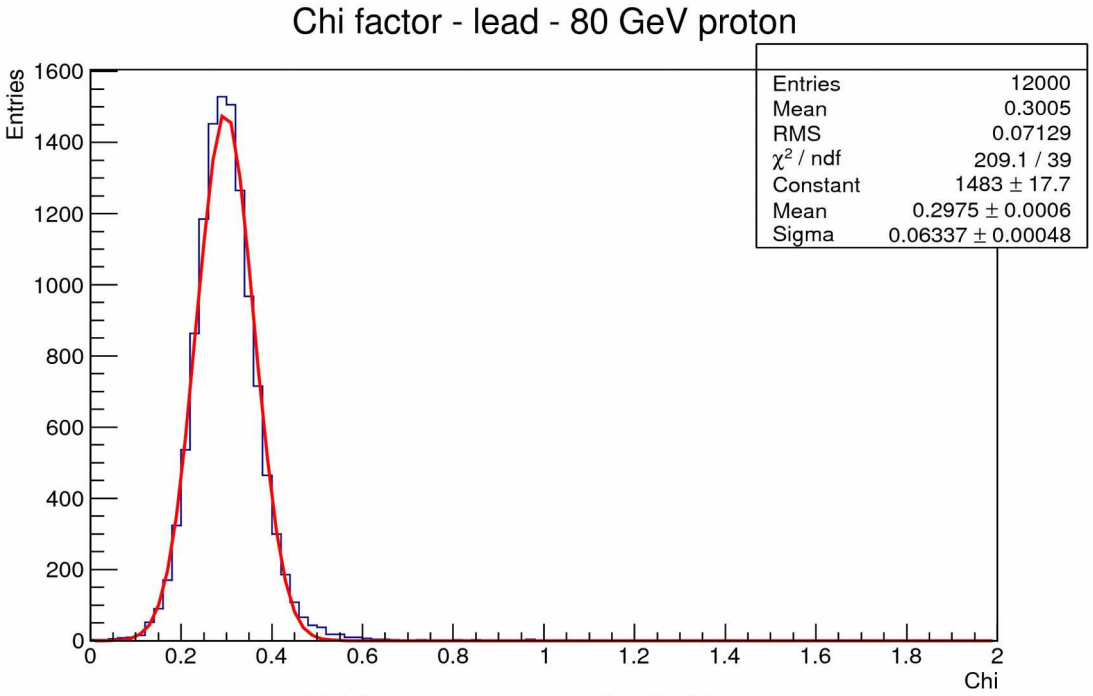


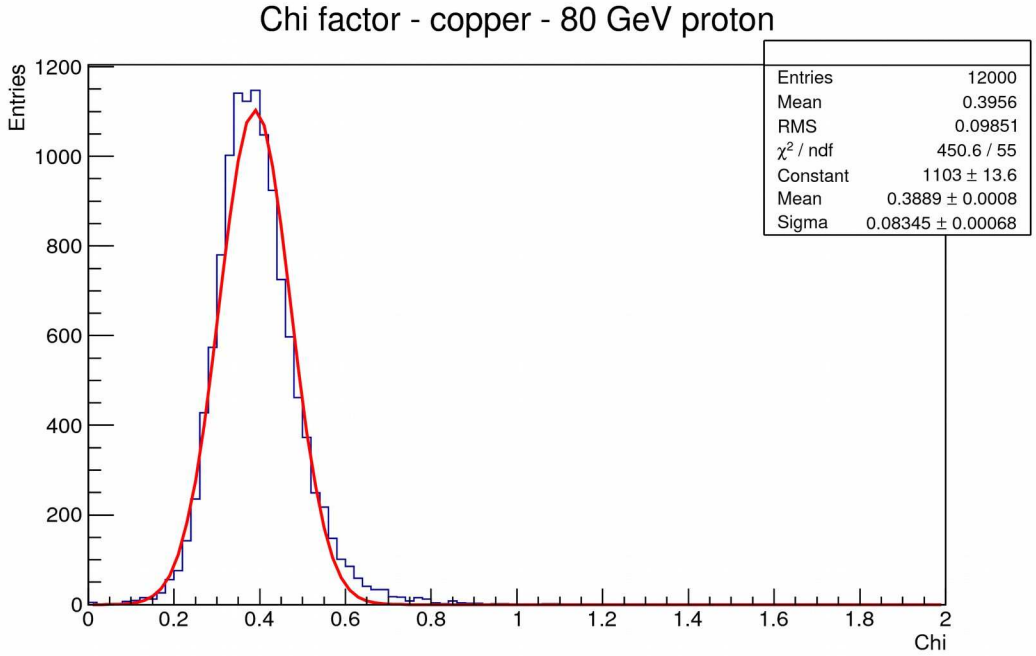






Lead vs Copper: chi factors



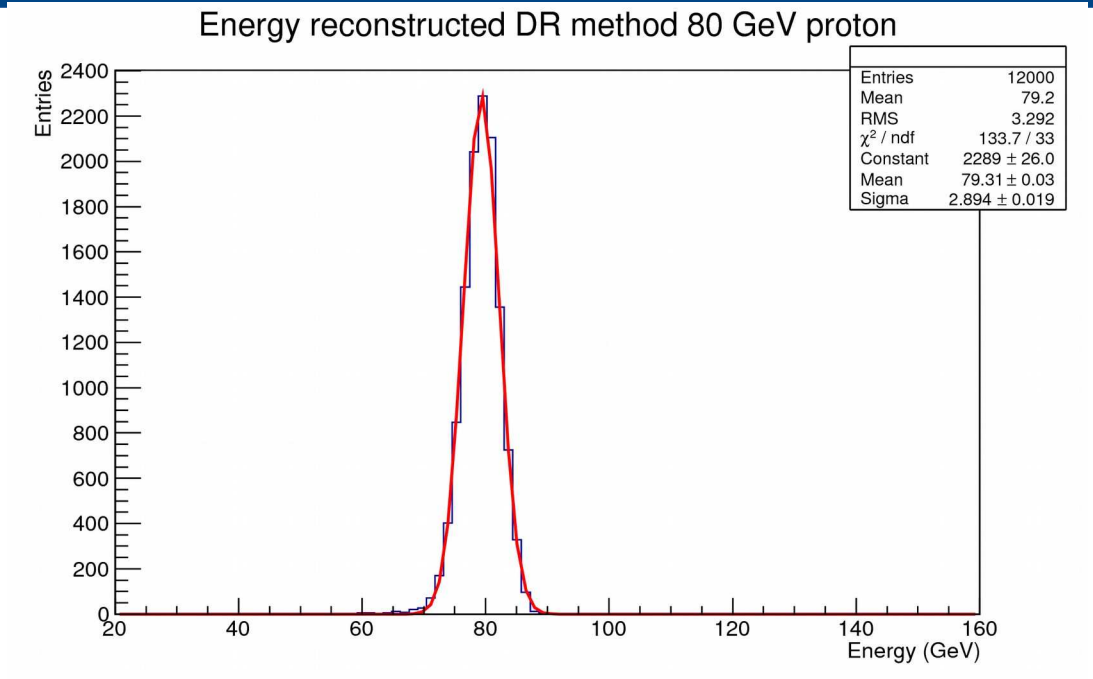


Lead: Chi = 0.3

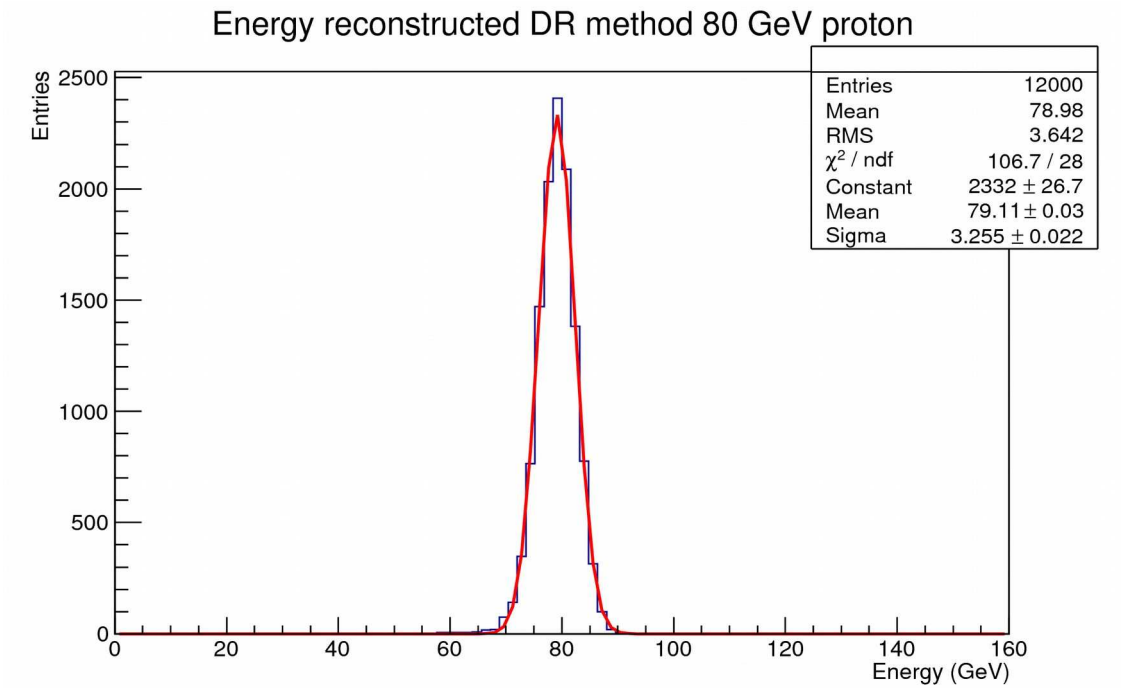
Chi = (E-S)/(E-C)

Copper: Chi = 0.38

Lead vs copper: energy resolution

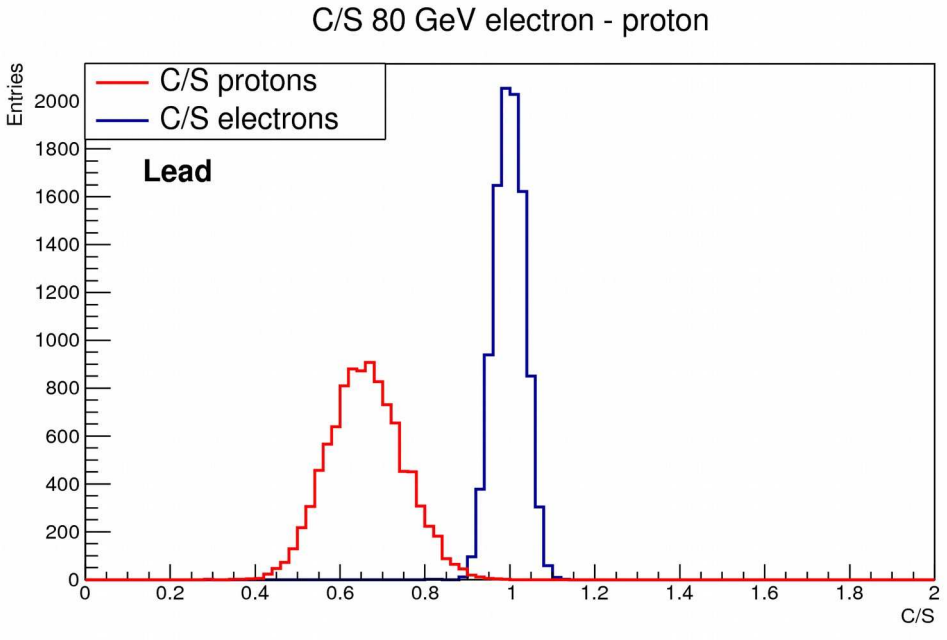


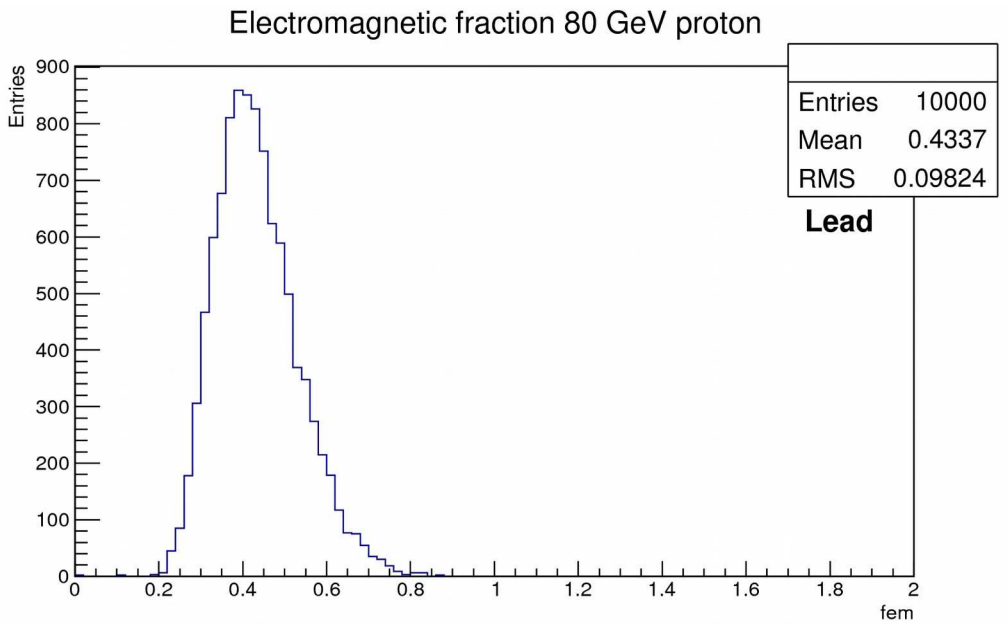
Lead: mean 79.3 sigma 2.89

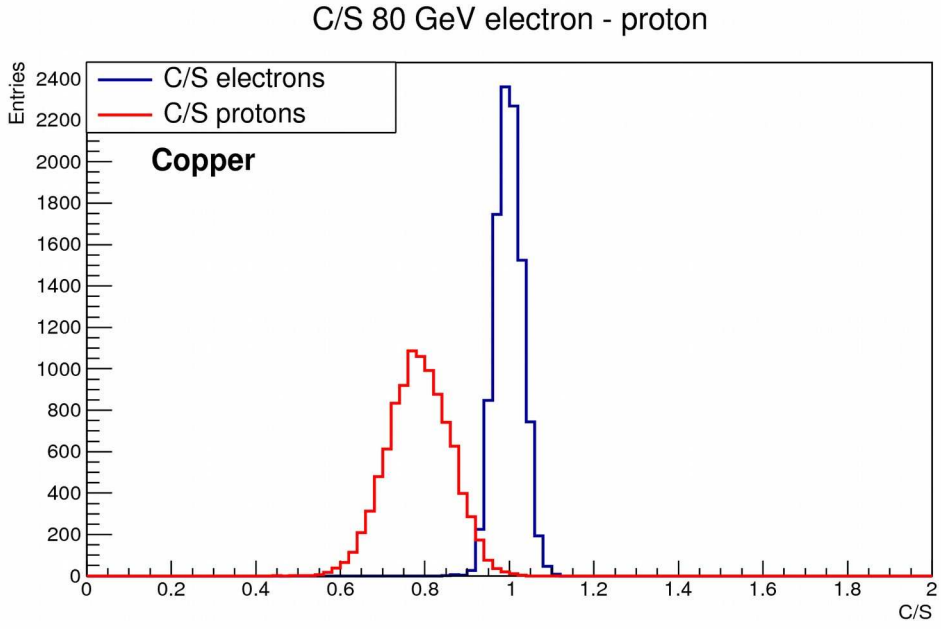


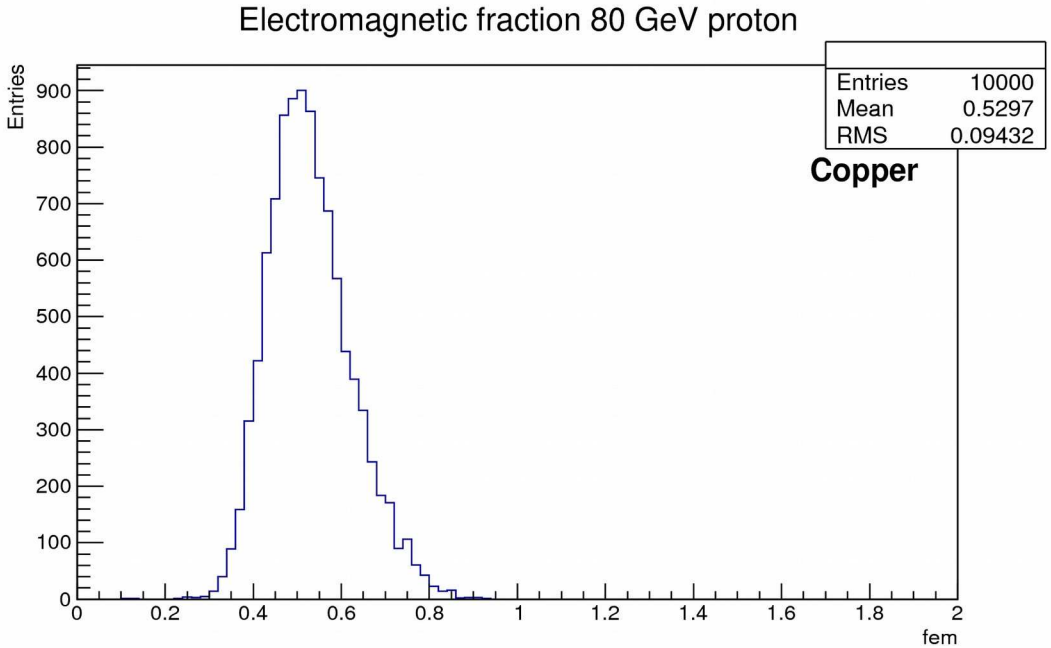
Copper: mean 79.11 sigma 3.25

Lead vs copper: particle identification







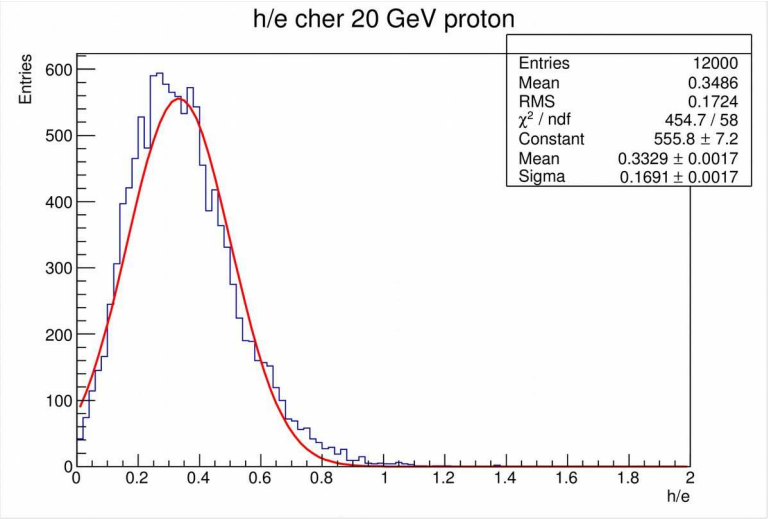


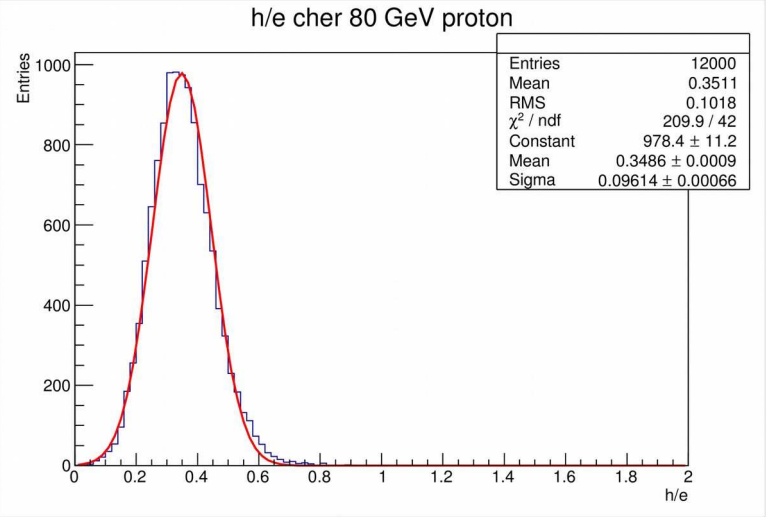
H/E estimation from simulation

Cherenkov: h/e = (C/E – fem)/ (1-fem)

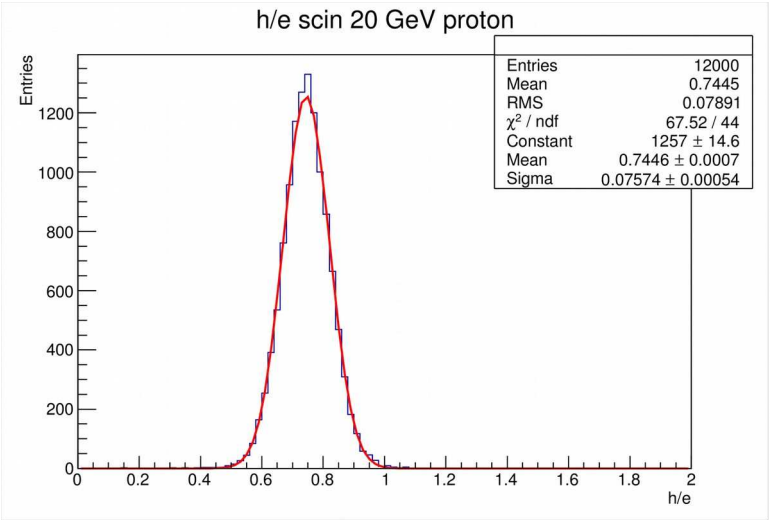
Scintillation: h/e = (S/E – fem)/(1-fem)

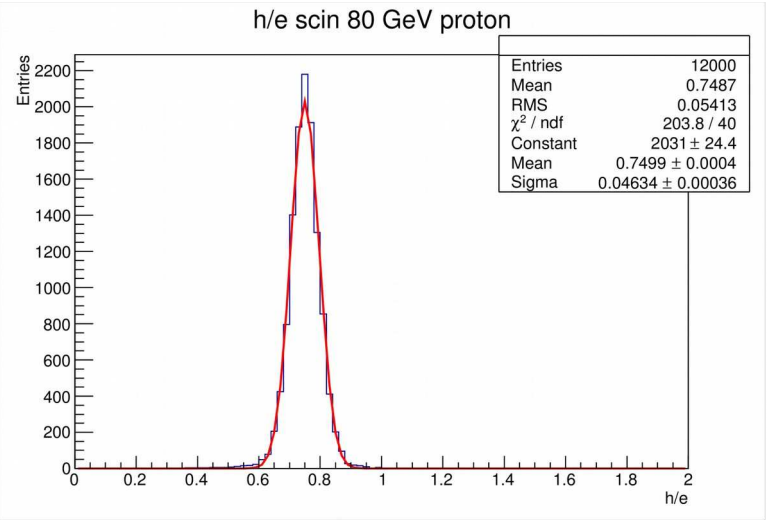
Cu h/e factors – proton 20 & 80 GeV





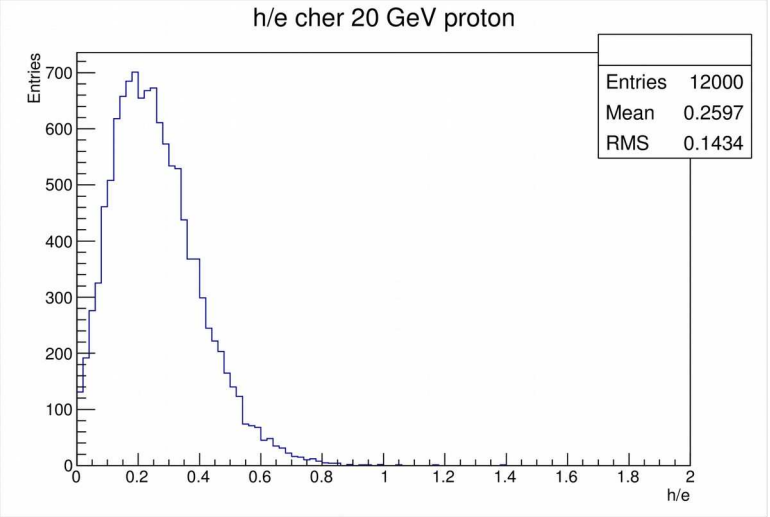
Cher. h/e ≈ 0.35

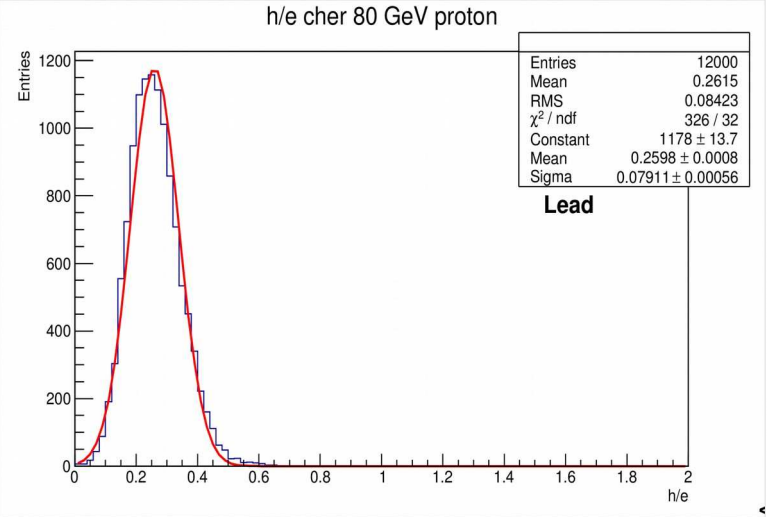




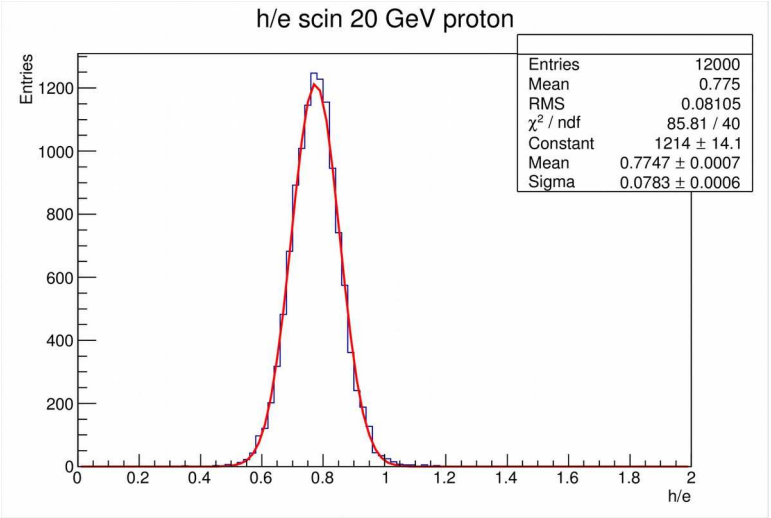
Scint. h/e ≈ 0.75

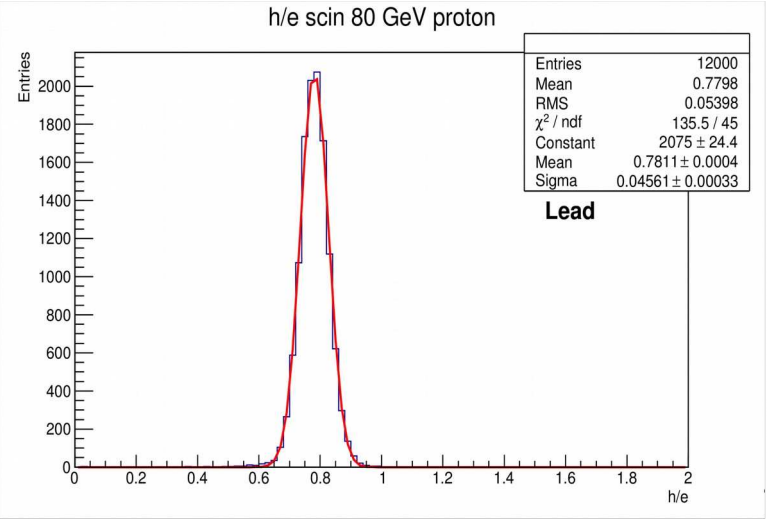
Pb h/e factors – proton 20 & 80 GeV





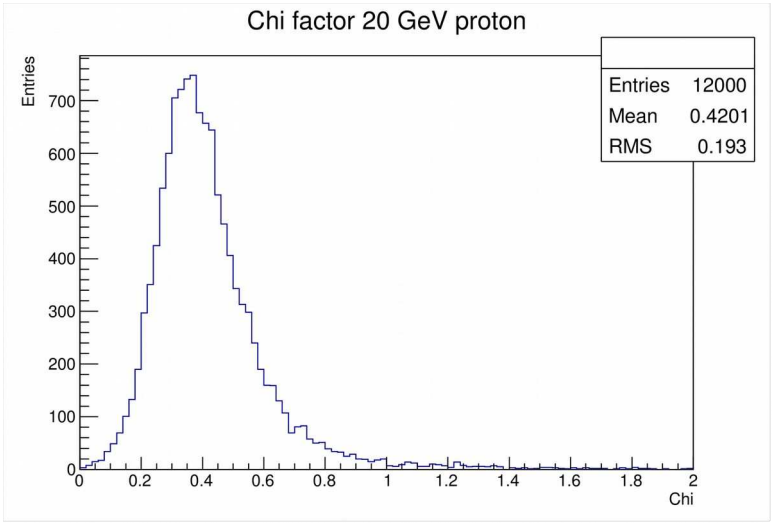
Cher. h/e ≈ 0.26

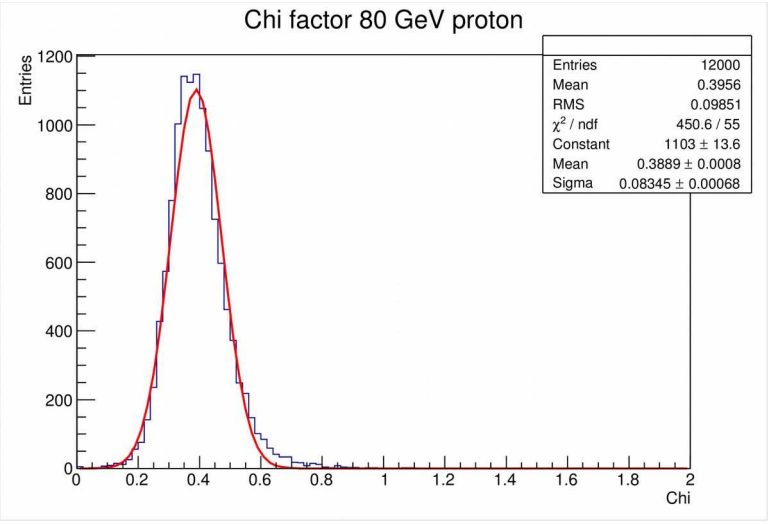




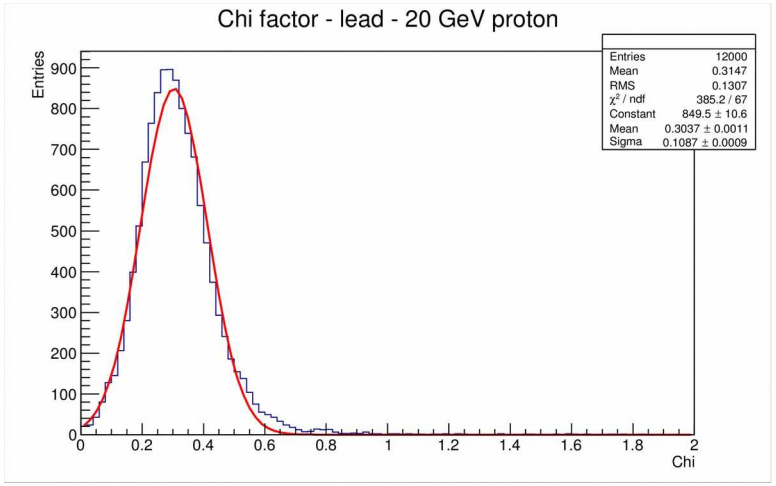
Scint. h/e ≈ 0.78

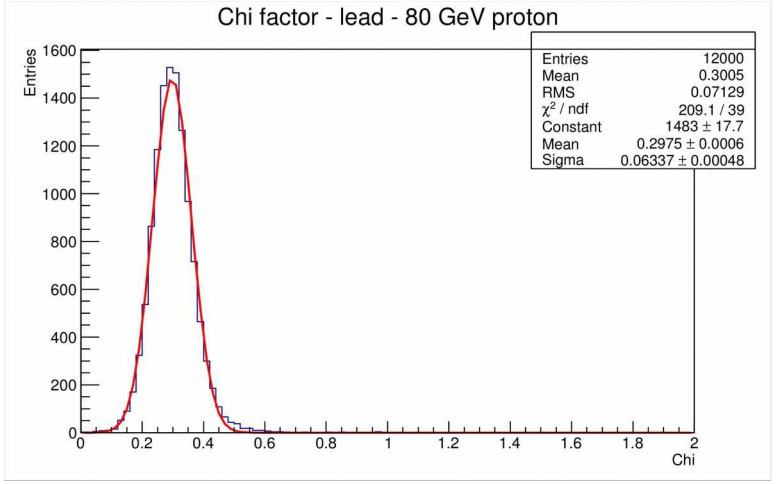
Cu & Pb Chi factors – proton 20 & 80 GeV





Cu X ≈ 0.39





Pb X ≈ 0.30