

Geant4Reweight 2x2 Analysis Meeting

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Outline

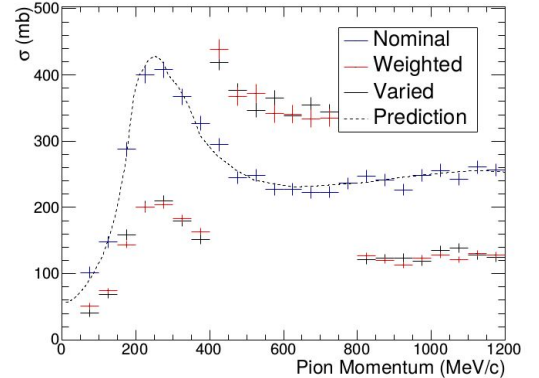
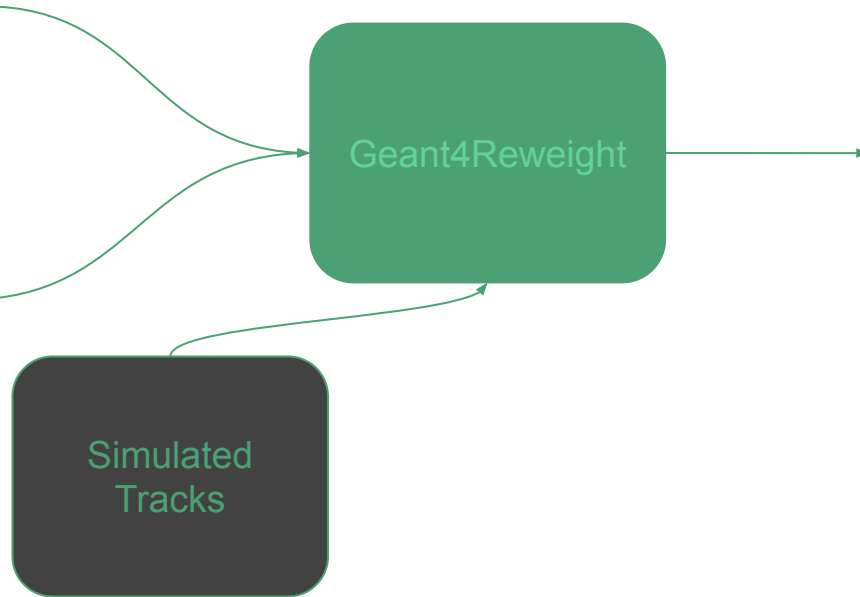
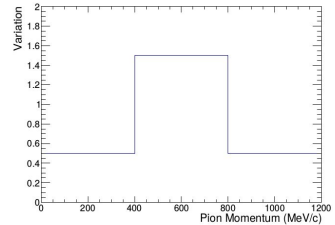
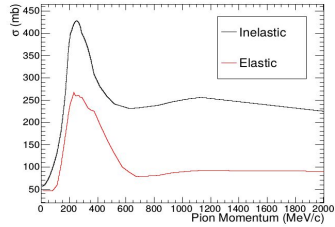
Introduction -- What is Geant4Reweight?

How to get/Integrate into protoduneana code

Example module

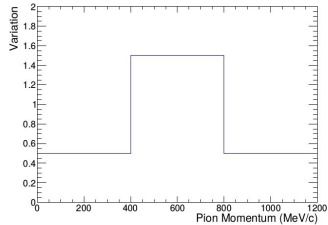
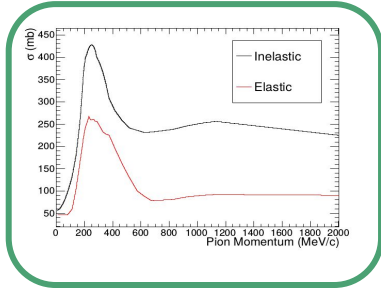
What is Geant4Reweight?

Software that produces weights for simulated particle tracks from Geant4



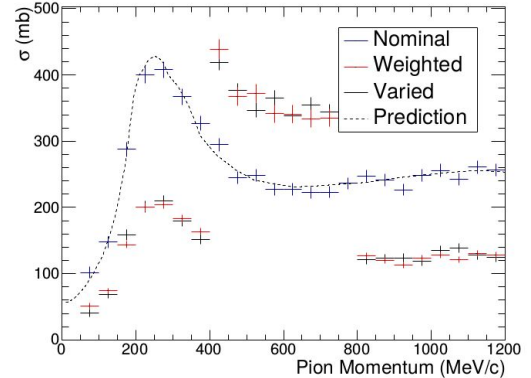
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Simulated Tracks

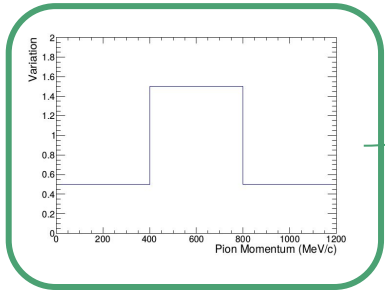
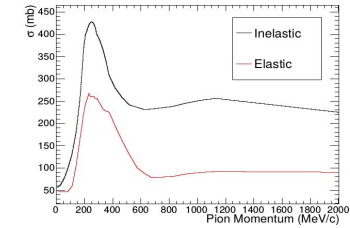
Geant4Reweight



**Nominal
Predictions**

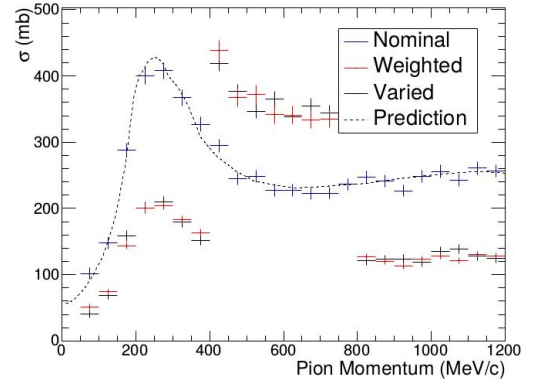
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Simulated Tracks

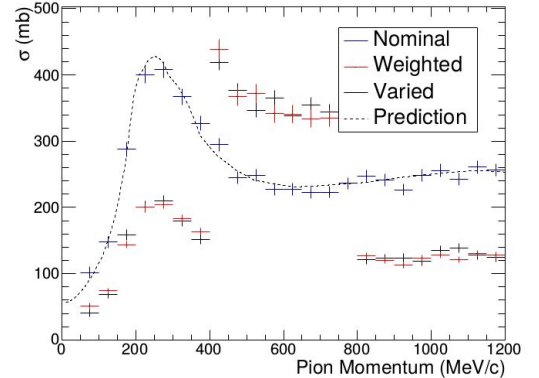
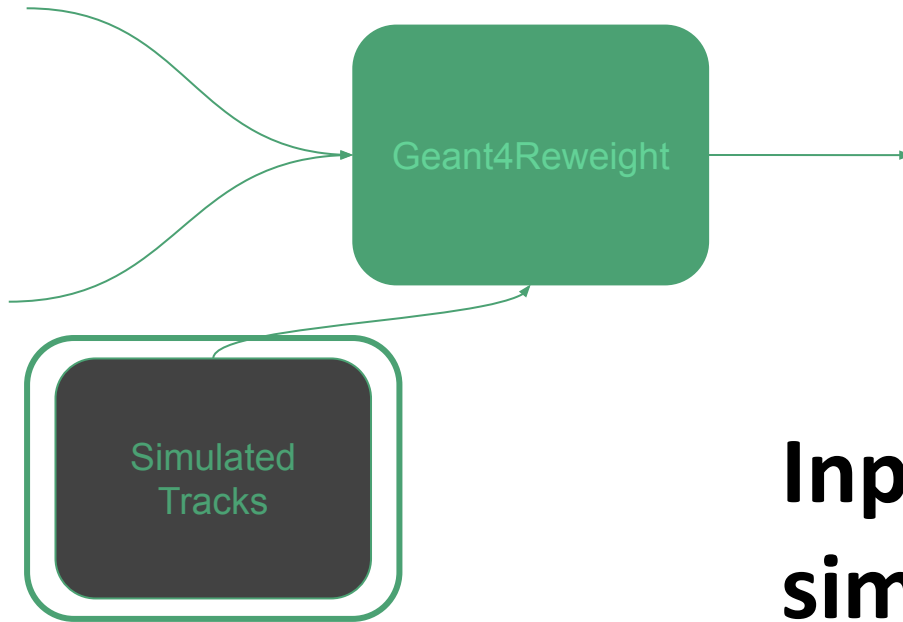
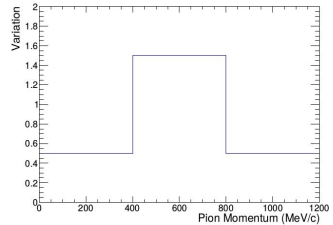
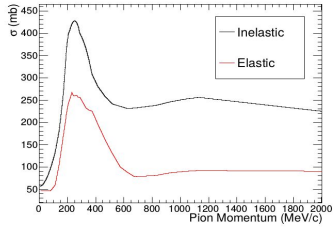
Geant4Reweight



User-defined variations

What is Geant4Reweight?

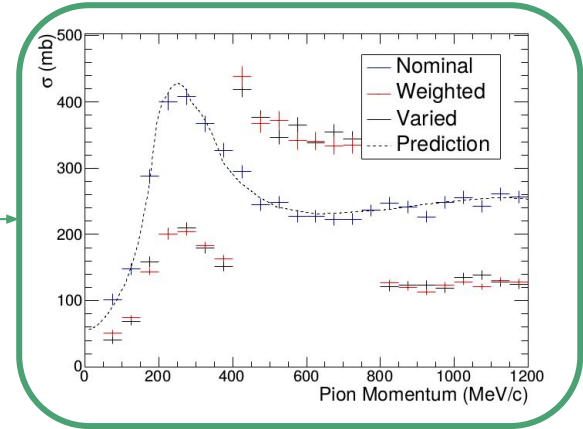
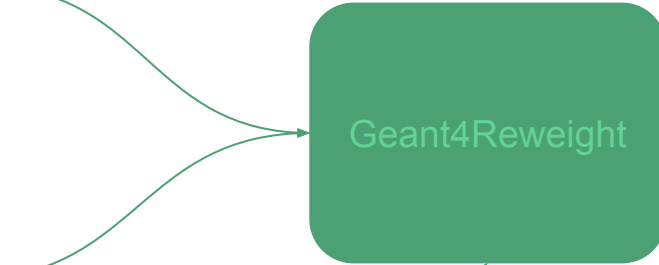
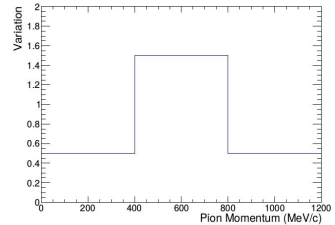
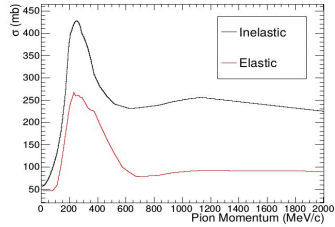
Software that produces weights for simulated particle tracks from Geant4



**Input
simulation**

What is Geant4Reweight?

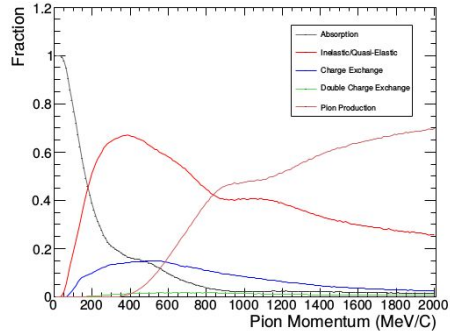
Software that produces weights for simulated particle tracks from Geant4



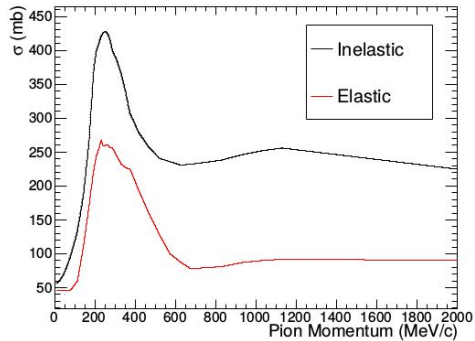
Weighted observables

Reweighting Inputs

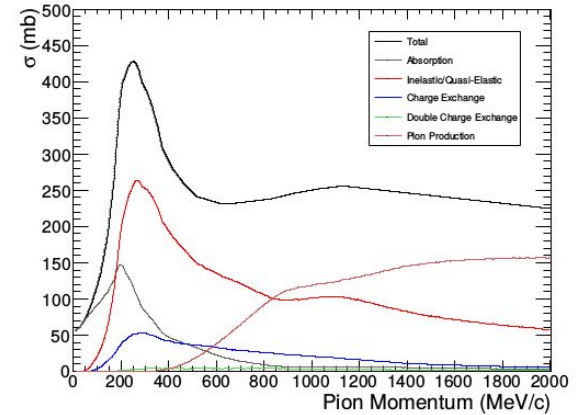
Exclusive Final State Fractions



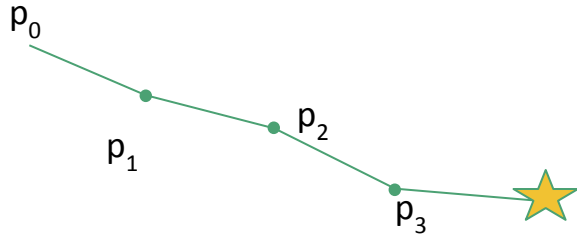
Total Inelastic Cross Section



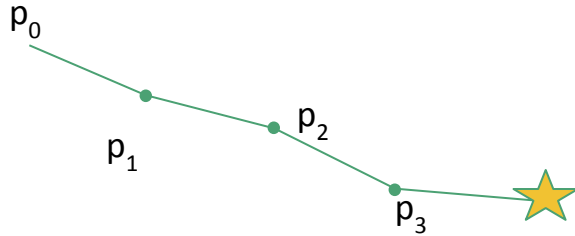
Exclusive Cross Sections



How Reweighting is Done

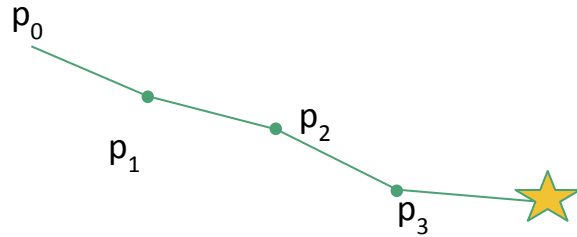


How Reweighting is Done



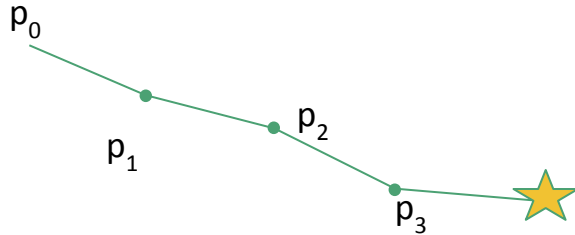
The hadron takes a set of steps,
possibly interacting each time
-- Geant4 samples cross section
tables
at each step (energy dependent)

How Reweighting is Done



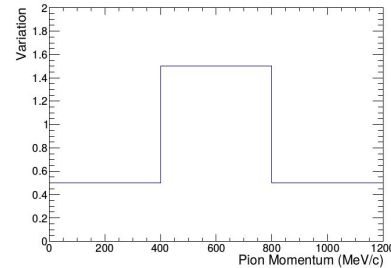
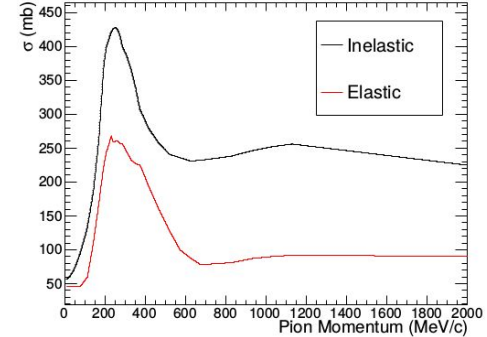
The hadron ends in an interaction
-- Possibly the interaction we want
to reweight

How Reweighting is Done

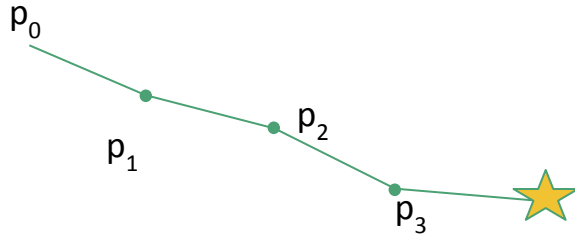


For each step:

- Find the cross section from G4 table
- Get the varied cross section from variation input
- What happened?
 - Interaction? Transportation?



How Reweighting is Done



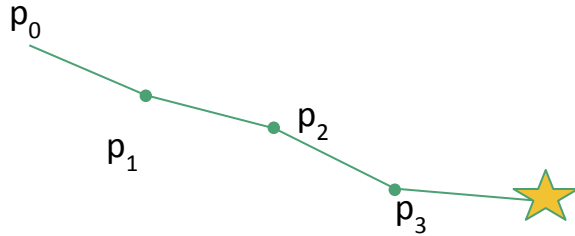
Particle did not interact at end
(maybe it stopped, or decayed, or
left volume)

-- It gets a 'survival' weight

Runs over all steps in
trajectory

$$W_{\text{No Int.}} = \prod_{i=0}^{N_{\text{steps}}} \frac{e^{-\sigma'_i L_i}}{e^{-\sigma_i L_i}}$$

How Reweighting is Done



Particle interacted at end
-- It gets an 'interacting' weight

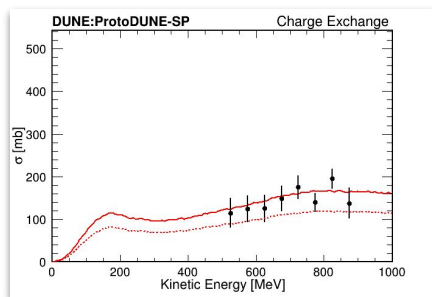
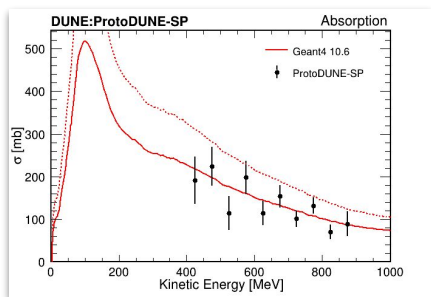
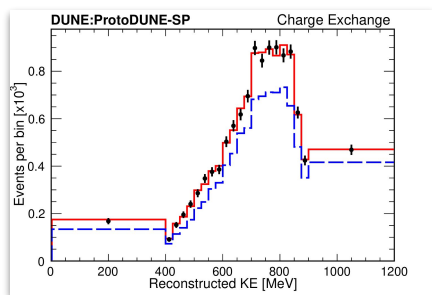
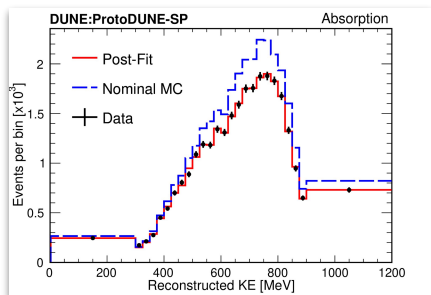
$$W_{\text{Int.}} = f \prod_{i=0}^{N_{\text{steps}}} \frac{e^{-\sigma'_i L_i}}{e^{-\sigma_i L_i}}$$

Cross section
variation at last step

What Can You Use It For?

Fake data studies i.e. Below: Pion-Ar Fit to Absorption (Ch. Exch.) scaled by 0.7 (1.4)

Systematic Uncertainties – some care is needed in current implementation



Using in your Code – Considerations

Written in C++ and built with MRB, available in UPS → I (or any helpers :)) might need to enable generic building, or wrap for python

If any ‘sparsifying’ of true trajectories is done → Limits weight accuracy

G4 cross sections defined for a given material → Need to know the material at each step (composite materials also tricky)

Need to know momentum at each step

Single reweighter objects per material

Using in your code – General Ideas

For a continuous G4 trajectory: Loop over trajectory steps & get momentum (check material) & step length

- Use this to make a reweightable trajectory object

Have a reweighter object with set of variations (flat variations over some range for a specific ‘channel’ – only works on a single particle type (i.e. pi+, p))

Pass RW trajectory to RWer and get a weight for the trajectory

Multiple trajectories in an event? Multiply their weights together to get a full event weight

Discussion

What code will this be integrated in?

- Might need some extensions

Do you need anything more sophisticated?

- I have some improvements in mind on how to improve some things
 - Need to 'dust off' the code

Any questions?

Thanks for Listening
