Energy Flow in neutrino events in ND-GAr: Using ParamSim "caf" trees

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Motivation

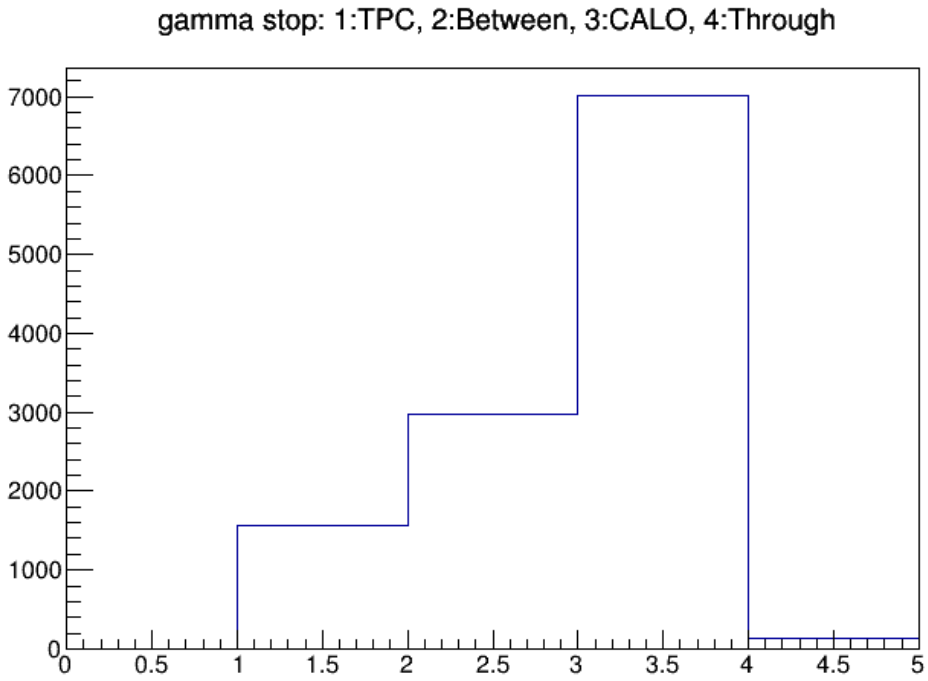
- Looking at location of energy deposits in the ECAL
  - Use both Truth and Reco variables (latter based on ParamSim)

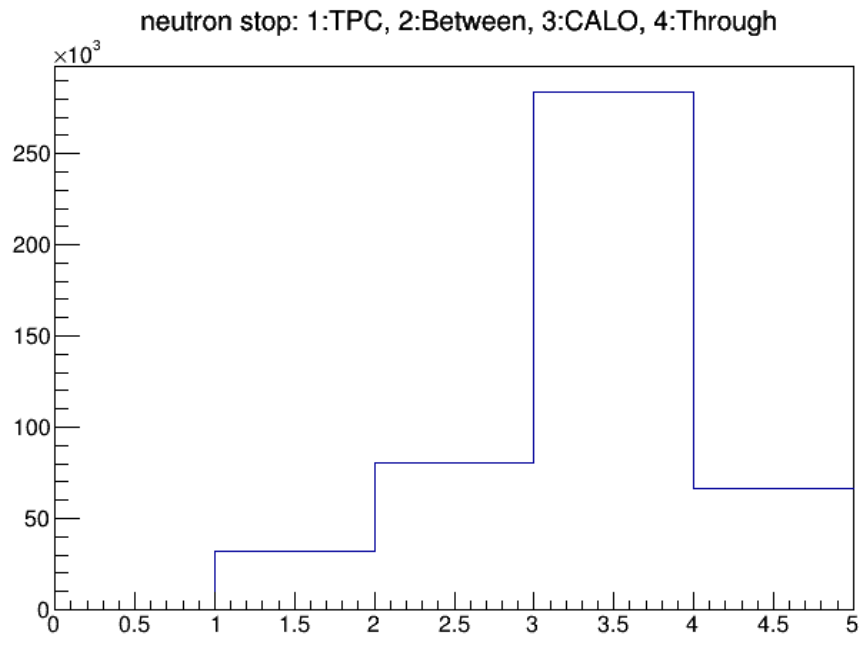
- I am looking at "caf " trees made by Eldwan/Tanaz, using ParamSim
  - Events are generated in ND-GAr
  - Center of coordinate system is (~0, -150.47, 1486) cm. Make cuts relative to this
  - Very nice documentation on github (https://github.com/ebrianne/ParamSim?organization=ebrianne&organization=ebrianne)

- Not doing anything sophisticated here
  - Only use particles that are produced in the primary neutrino interaction.
    - If we have a primary π^0, use energy of its daughter photons, and ignore the π^0
    - A small fraction of the time, almost always in DIS events, we get primary strange hadrons – for now, pretend that they are fully detected, regardless of their decay mode:
      - This is done only for truth level information.
      - When using reco information, these particles are included only if they manage to get to the CALO, e.g., K_L, while K_s and Λ are likely to be ignored since their lifetimes are shorter.
    - Ignore outgoing neutrinos (in NC events), since they are always undetected

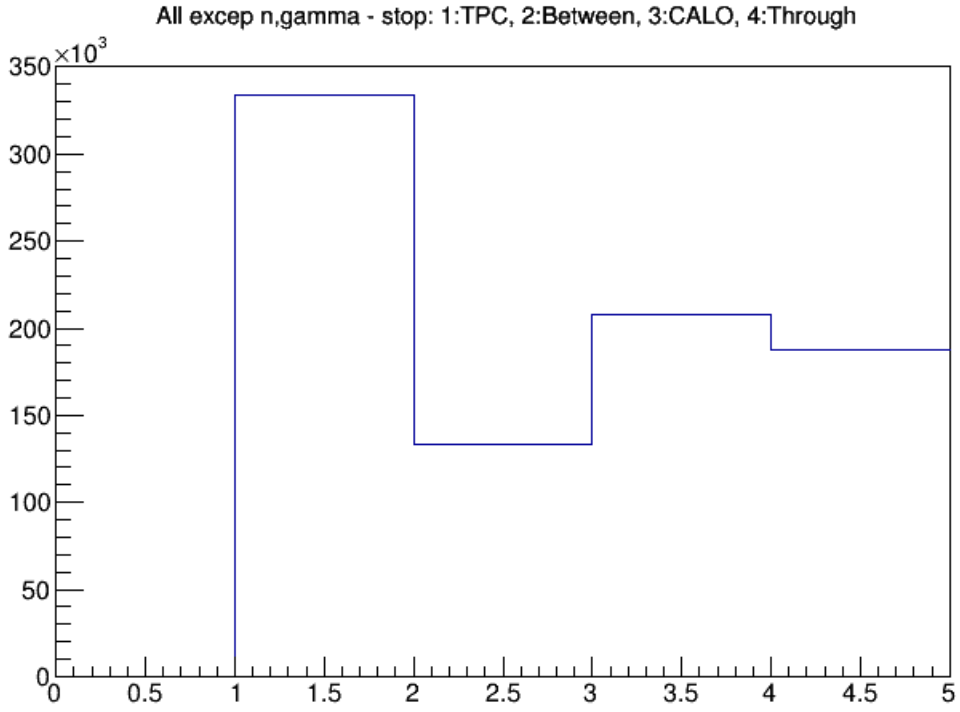
Reco variables

- Variables like preco, recopid are working
  - We need to fix some parameters in Gluckstern formula, but that doesn't affect this talk
- Worked with Eldwan on ECAL based variables, e.g., erecon
  - At the moment, we are using KE for all particles – this needs to be fixed so that we use KE only for nucleons, and total E for all others
  - CAF trees contain flags to tell us where the particle stops, e.g., in TPC, CALO, or if it goes through the CALO, etc.
    - Also, tells us if particle is in barrel or endcap
- Aggregated over all neutrino flavors, event types (QE, RES…), particle momenta





Where do various particles stop?



Two separate studies

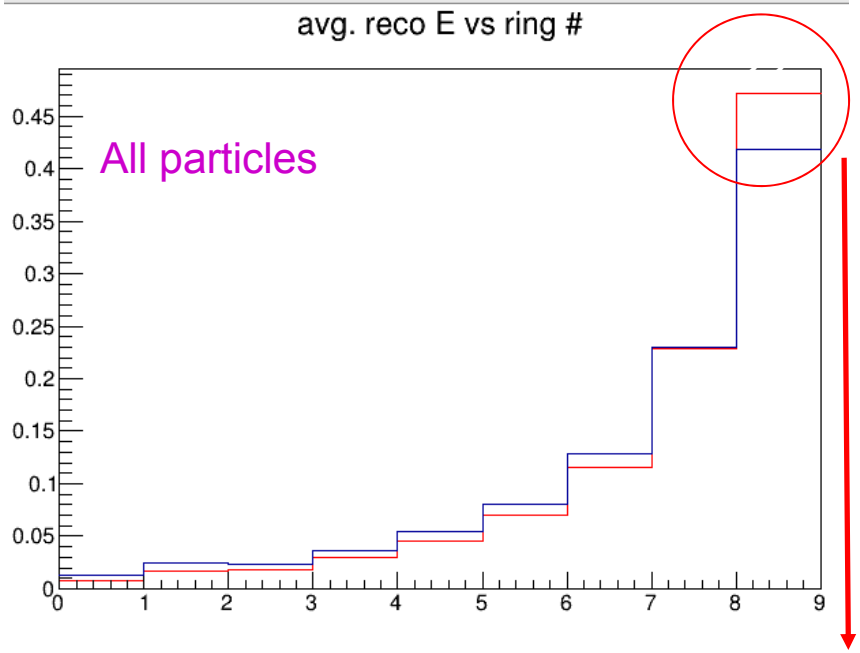
- Look at energy deposits in annular rings, where *angle is measured relative to the direction of the incoming neutrino*
  - Ring sizes chosen to have similar statistics
  - Look at E due to all particles, and also just neutrons/photons
  - For this check, I am aggregating over endcap and barrel

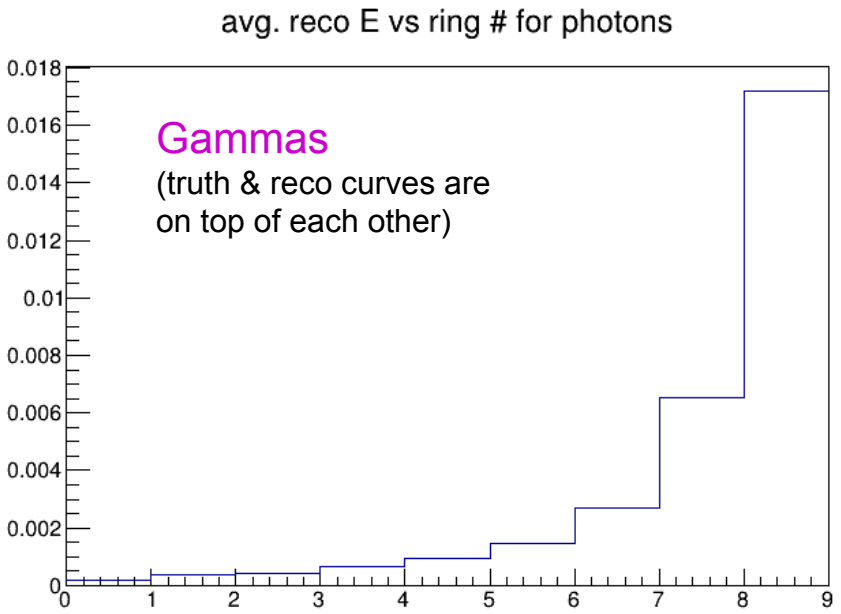
ring_0 : cosθ >= -1 & cosθ < -0.5 (very backward)
ring_1 : cosθ >= -0.5 & cosθ < 0
ring_2 : cosθ >= 0 & cosθ < 0.26 (forward hemisphere)
ring_3 : cosθ >= 0.26 & cosθ < 0.5
ring_4 : cosθ >= 0.5 & cosθ < 0.68
ring_5 : cosθ >= 0.68 & cosθ < 0.82
ring_6: cosθ >= 0.82 & cosθ < 0.92
ring_7: cosθ >= 0.92 & cosθ < 0.98
ring_8: cosθ >= 0.98 & cosθ <= 1. (very forward)

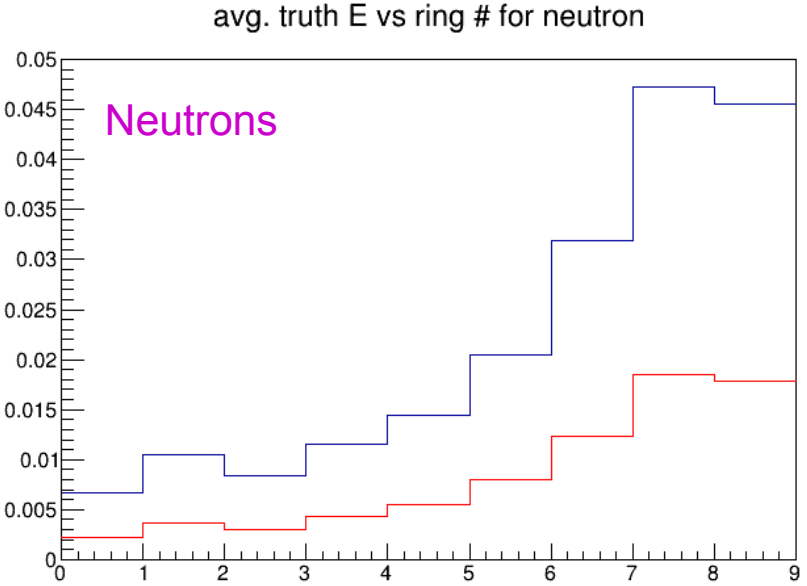
- Also have variables that tell us if a particle is in the barrel/endcap region
  - Combine with flags to see if it ends in the CALO or goes through it.
    - This is done as a separate check

These plots give the average E/event in various rings - each bin corresponds to one ring, and the normalization is the same for each bin (= total number of events in sample)
Energy in one event can be spread over different rings

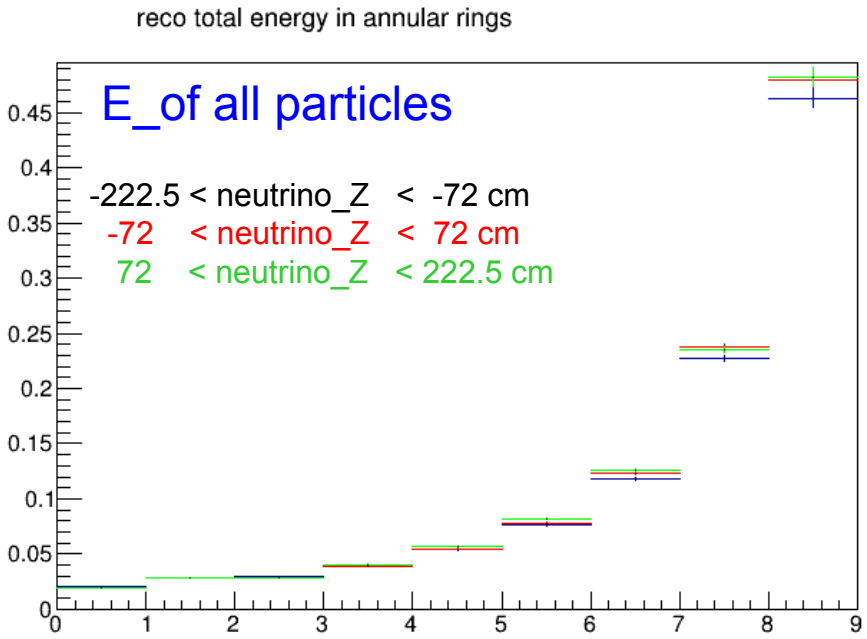
Plots made with both truth information, and reco variables





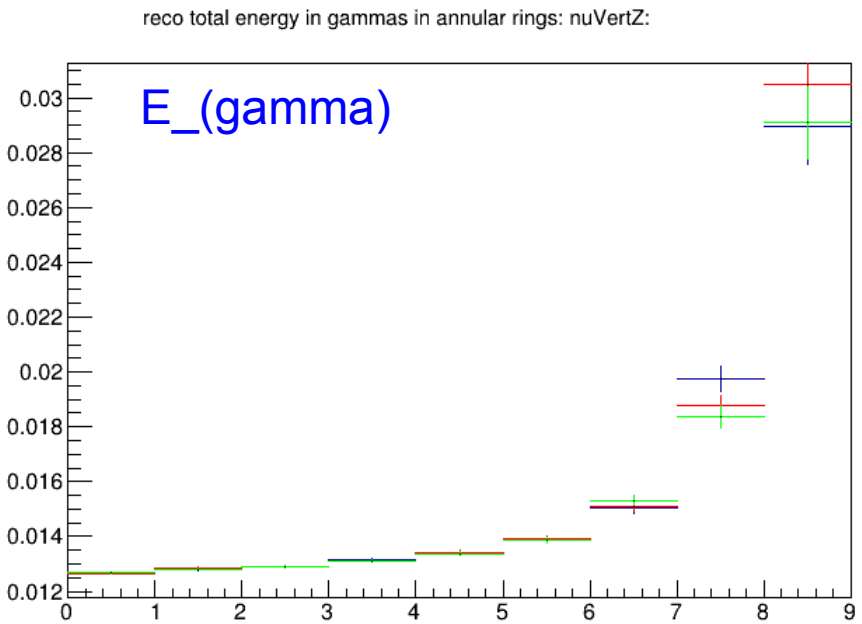


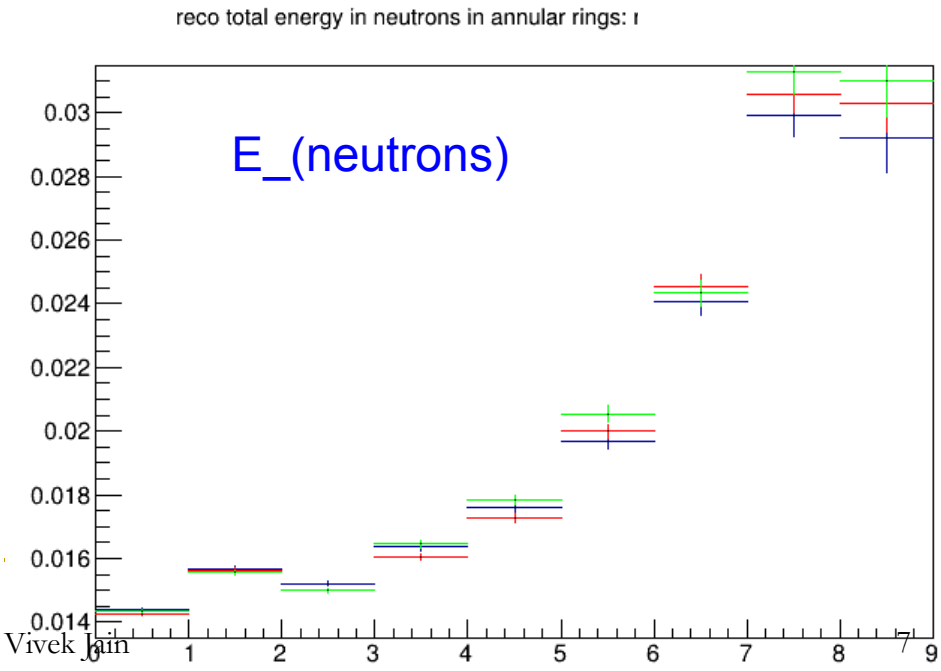
Discrepancy seems to be from strange hadrons??
probably the approximation I alluded to earlier is causing this weird behavior – *will sort it out*



Profile plots
X-axis: ring #
Y-axis: ave. E/event in ring

Is there any dependence on neutrino Z-vertex position?
Not really

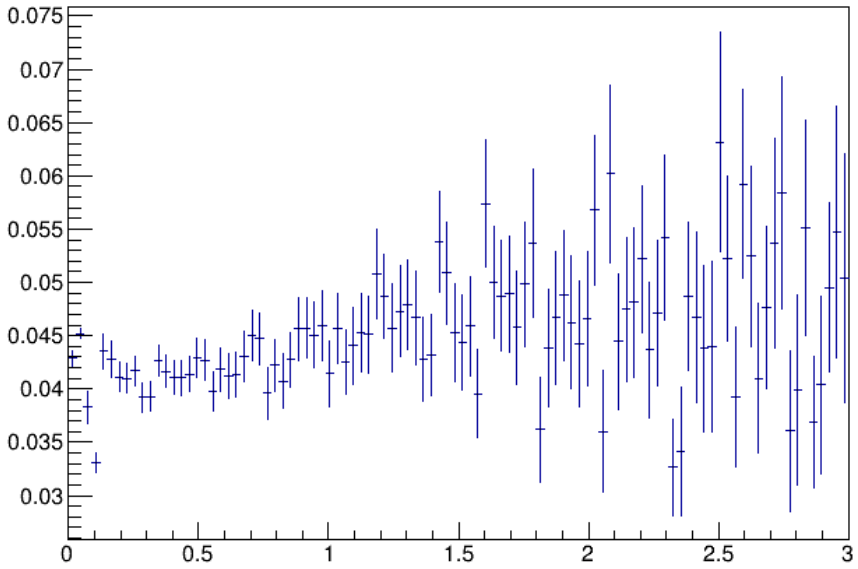




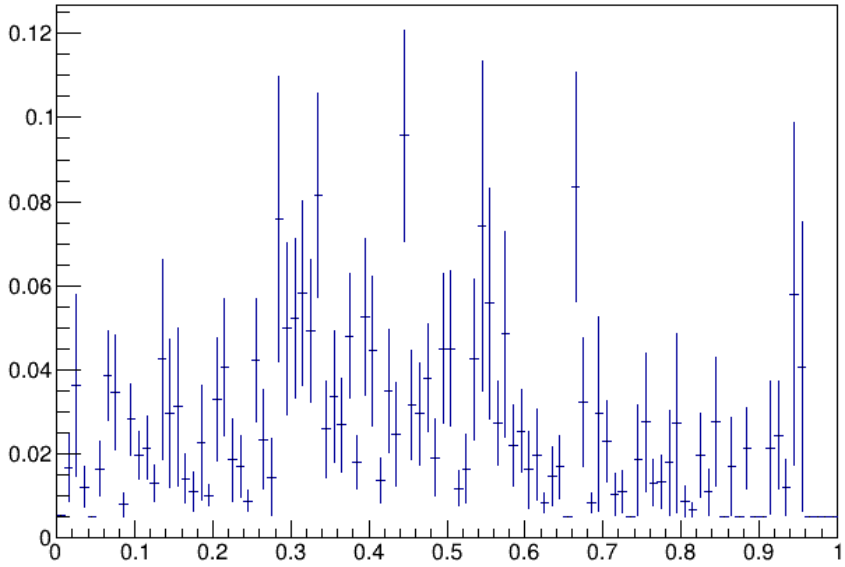
Now look at E in barrel vs. E in endcap for a given event – aggregate over all events

X-axis: avg E/event in barrel, *Y-axis:* avg E/event in endcap

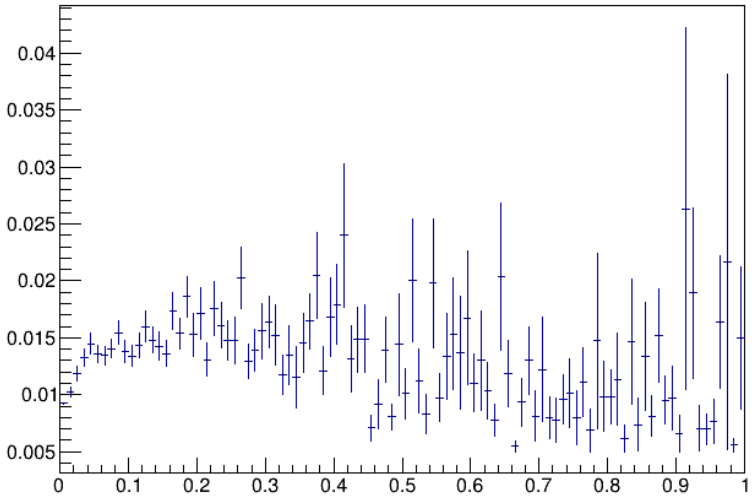
Total reco E in endcap vs. barrel CALO



Gamma reco E in endcap vs. barrel CALO



Neutron reco E in endcap vs. barrel CALO



Summary

- Work in progress – will incorporate your comments into the next presentation.

Extra Slides