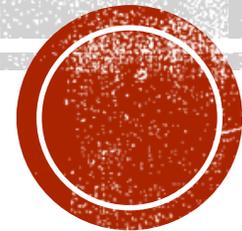# bHCAL Meeting – Neutron Calibration Update

Jan Vanek

University of New Hampshire

03/06/2026

# OVERVIEW

- Updated neutron calibration
  - Now able to calibrate $1\ \mathrm{GeV}$ neutrons

- Calibration using protons
  - Using information from tracking
  - Study to use proton information for neutrons

MANUAL CALIBRATION METHODS

- Same method used for protons and neutrons

- Method 2
  - $E_{calib} = A(E_{EMCAL} + BE_{bHCAL})$
  - Plot $(E_{EMCAL} + BE_{bHCAL})/E_{par,MC}$
    - First find B for which the distribution above has the smallest σ/μ
    - A is set as $1/$mean of the distribution with optimal B

- More advanced method(s) to be implemented

UNCALIBRATED ENERGY

- Sum of energy deposition in bECAL+bHCAL
  - (left) proton
  - (right) neutrons

- Similar energy deposition distributions for 2 GeV and 5 GeV

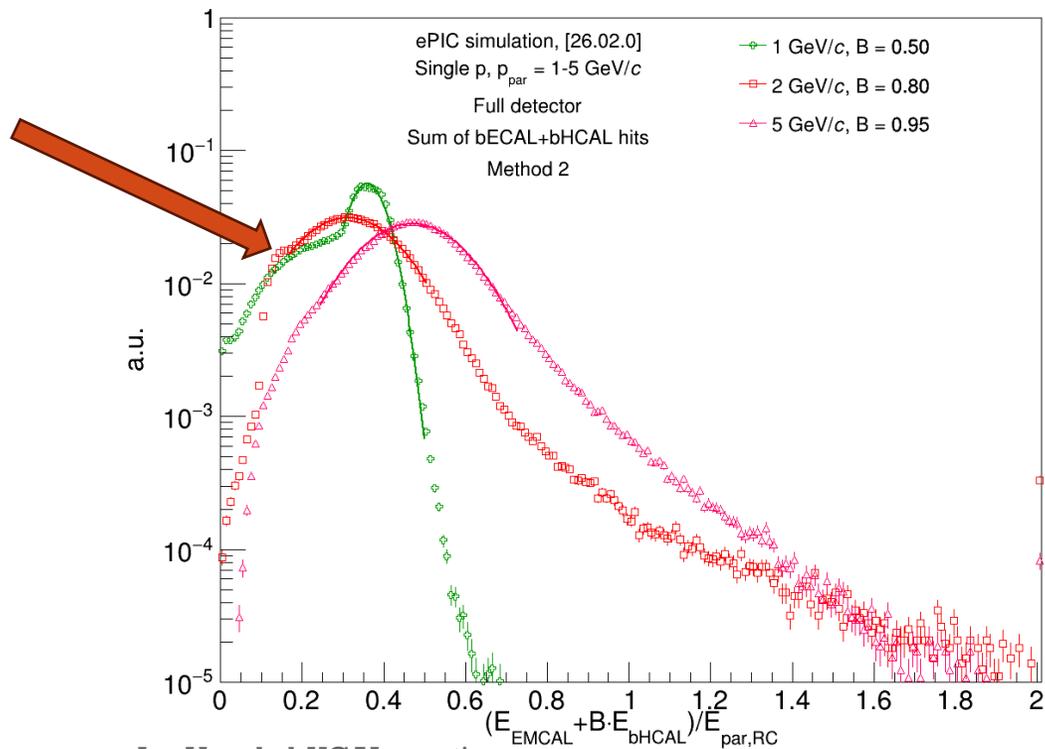- Clear difference for 1 GeV
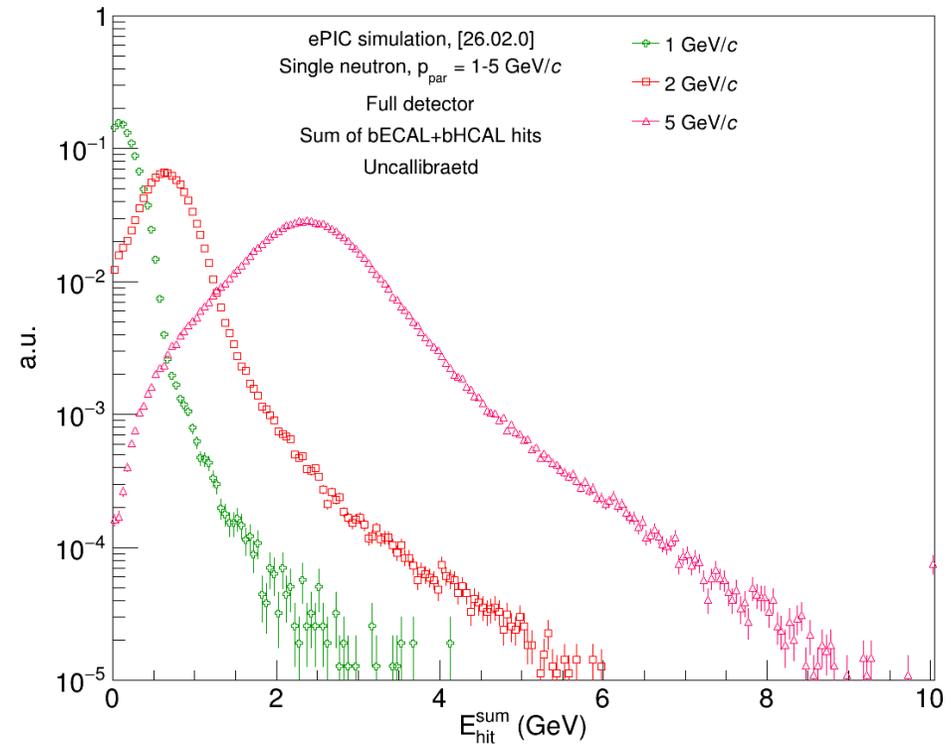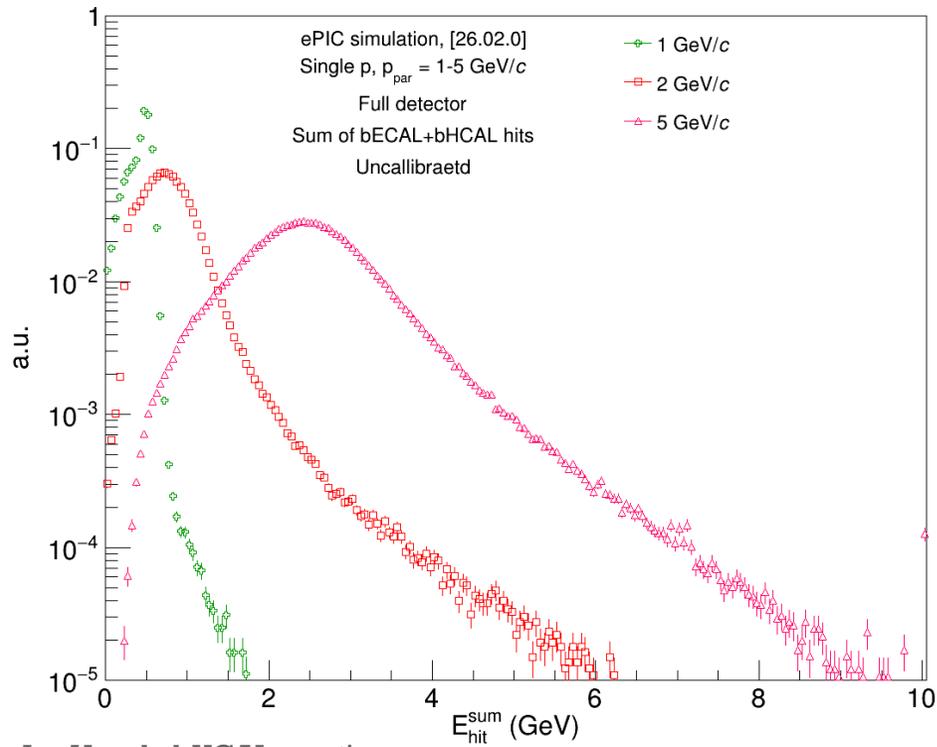
CALIBRATION DISTRIBUTIONS

- Method 2 calibration distributions
  - (left) proton
    - Using energy (momentum) from tracking
    - Need to investigate origin of shoulders at low energies
  - (right) neutrons

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions
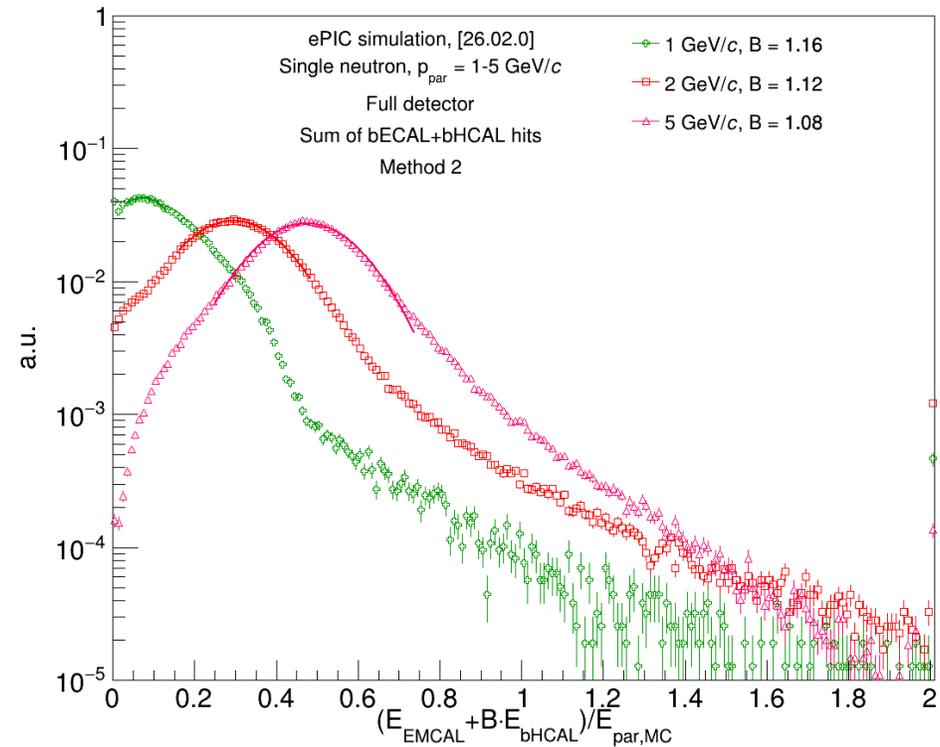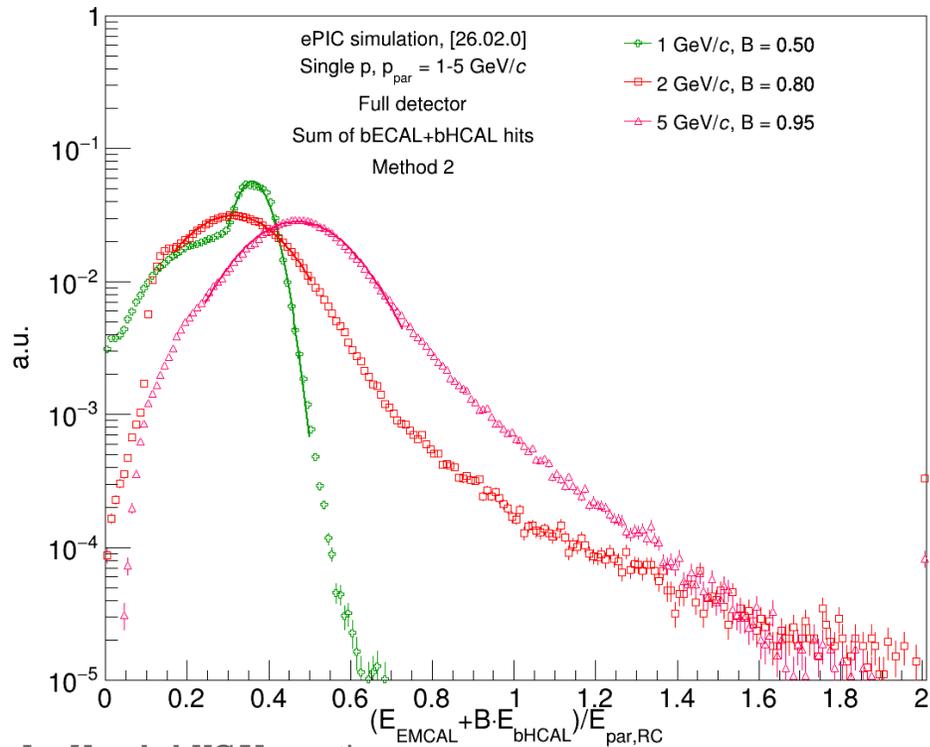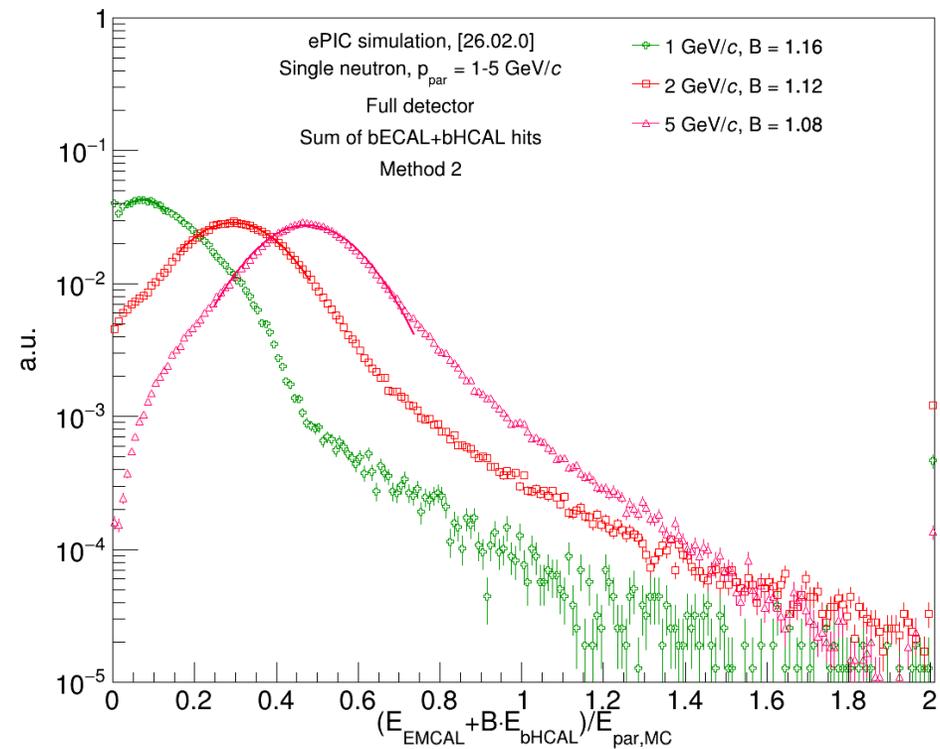
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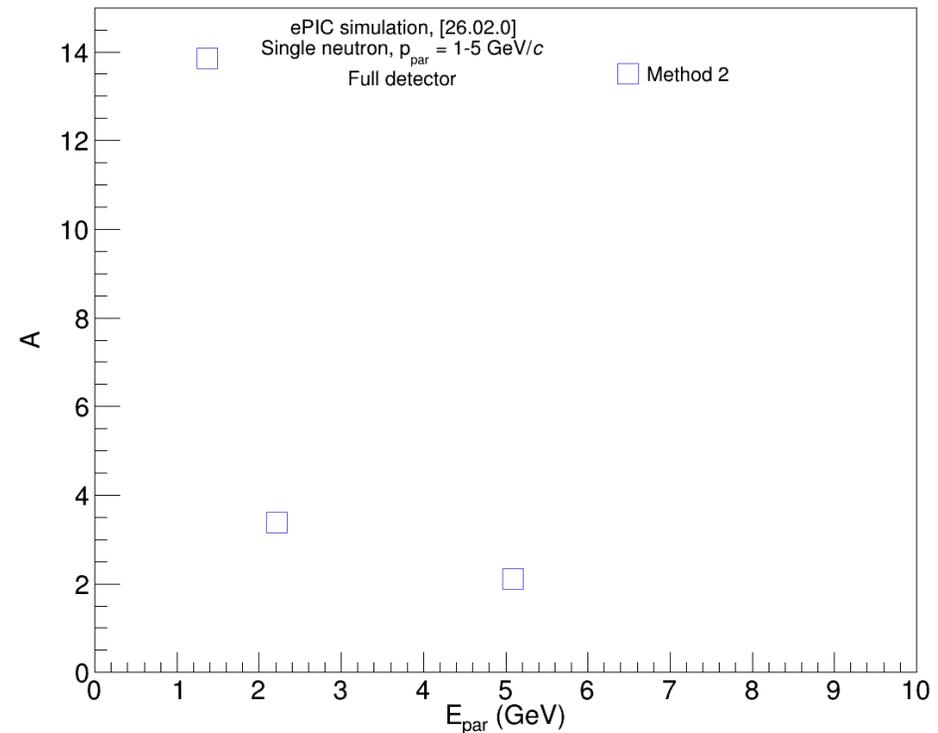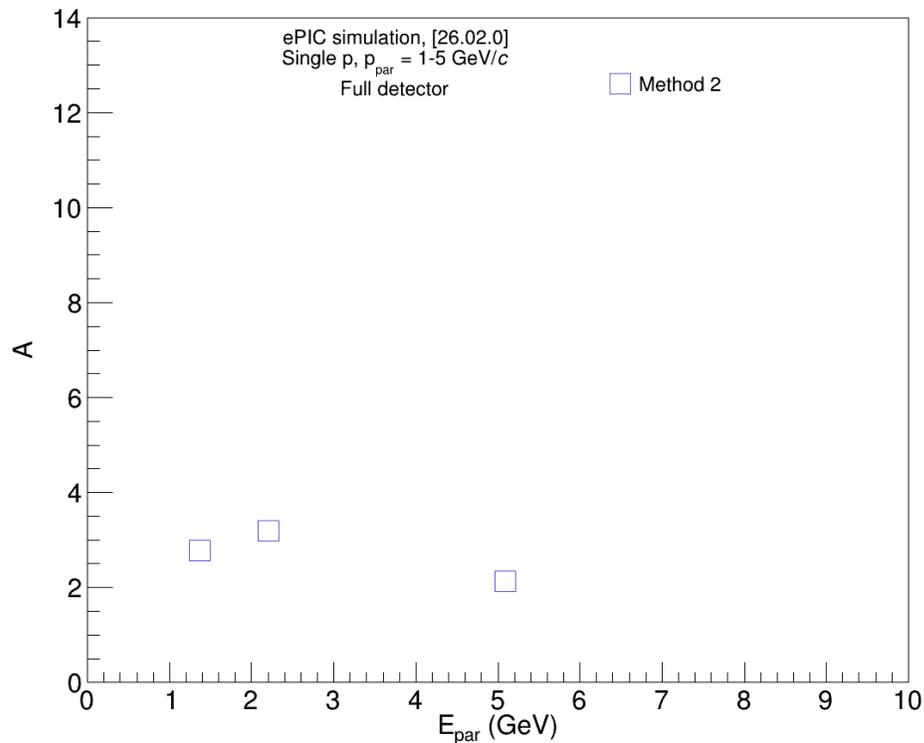
CALIBRATION PARAMETER A

- Parameter A in Method 2 calibration
  - (left) proton
    - Using energy (momentum) from tracking
  - (right) neutrons

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions

CALIBRATION PARAMETER B

- Parameter B in Method 2 calibration
  - (left) proton
    - Using energy (momentum) from tracking
  - (right) neutrons

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions
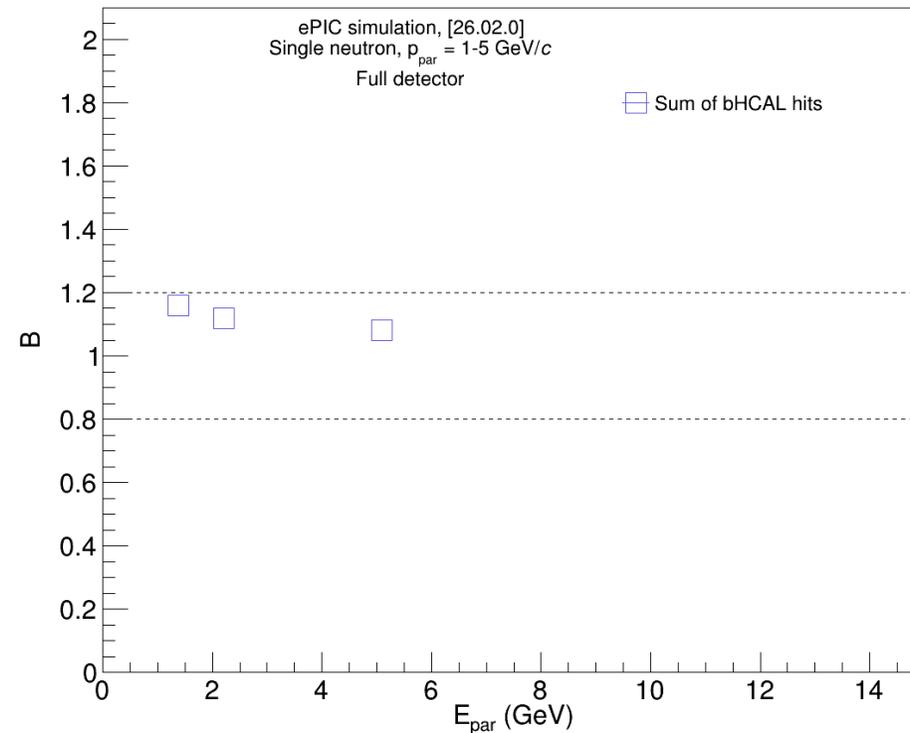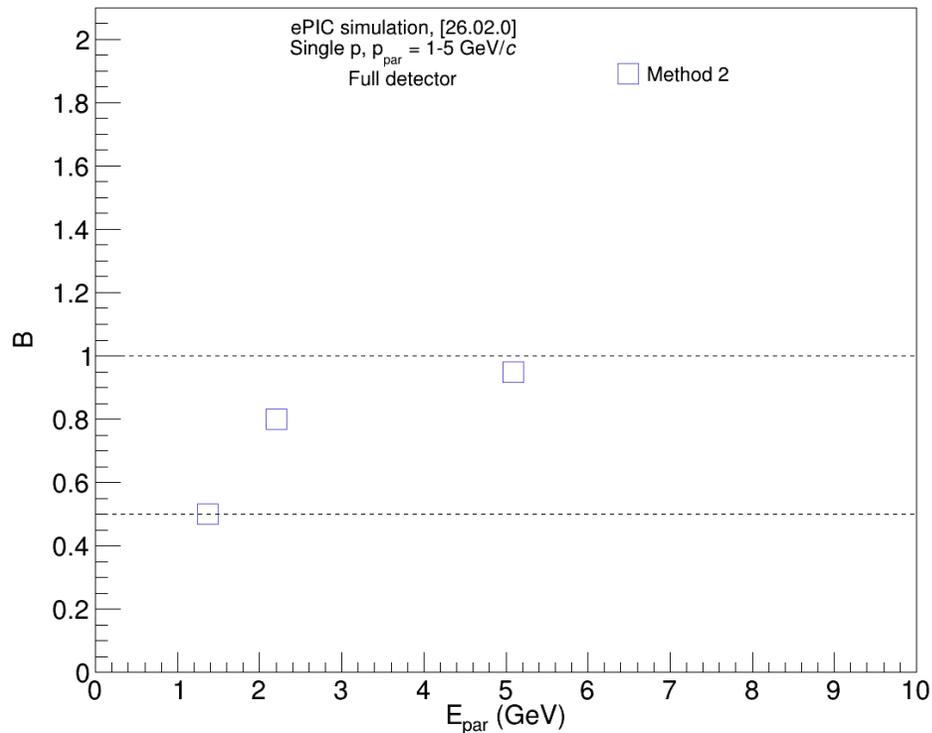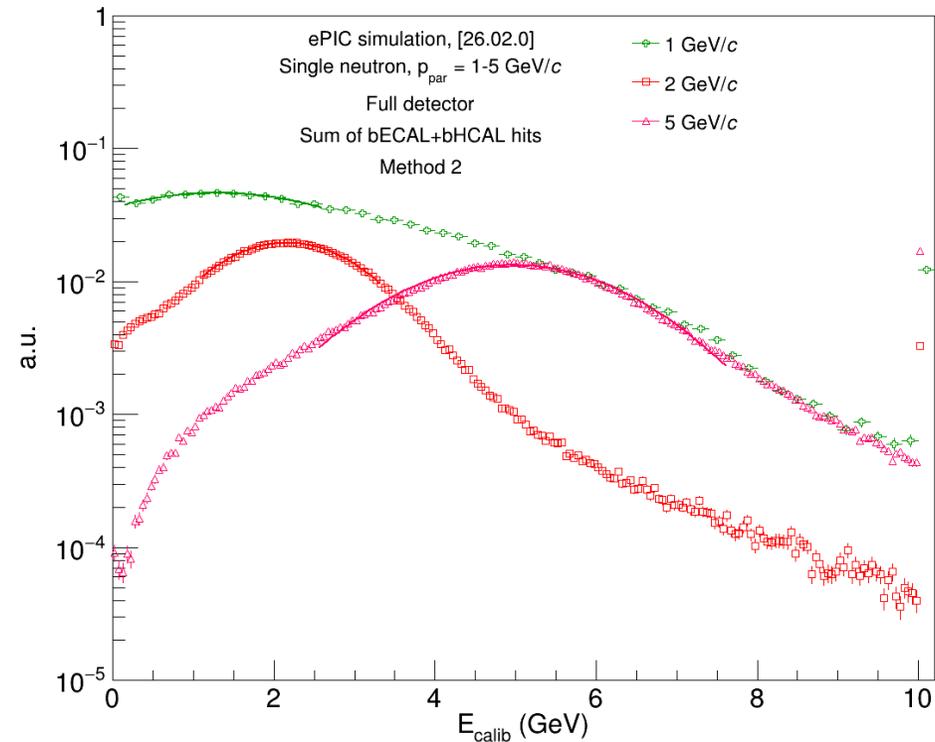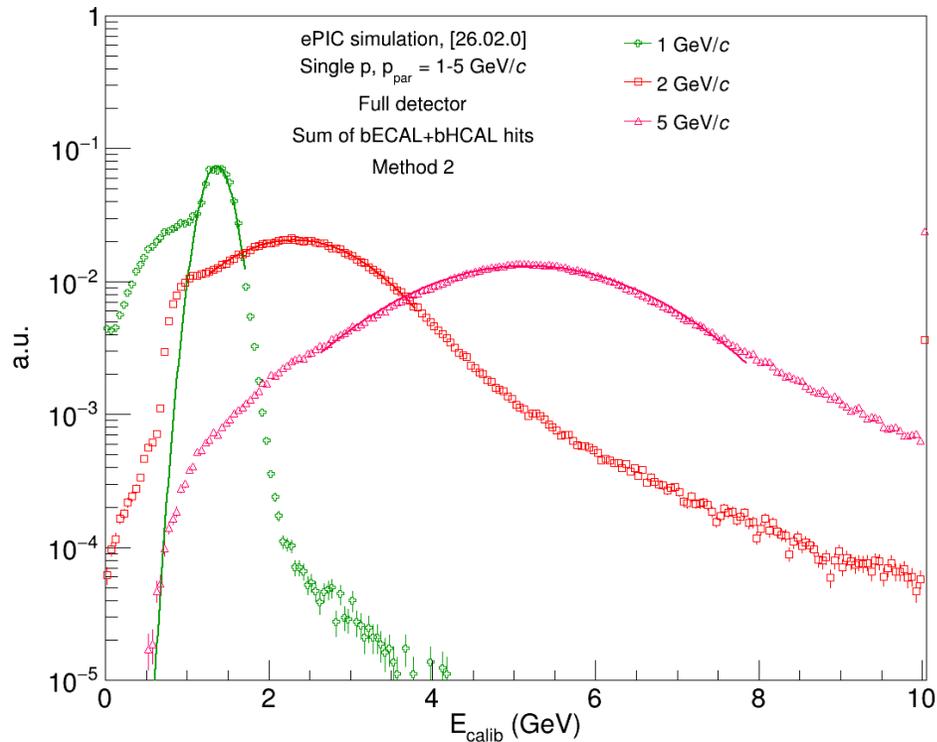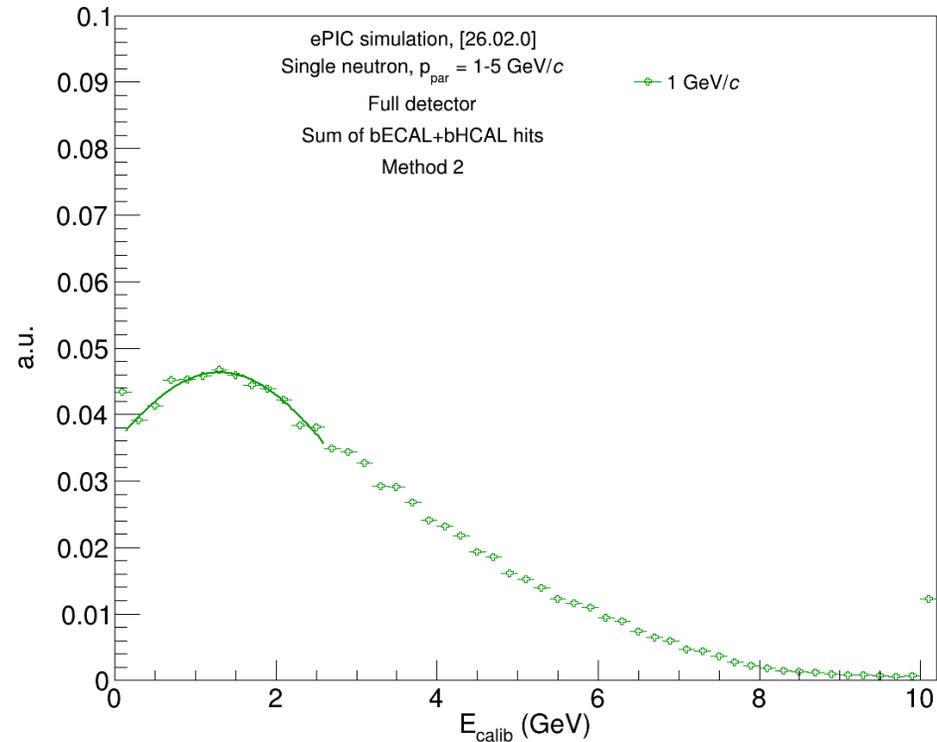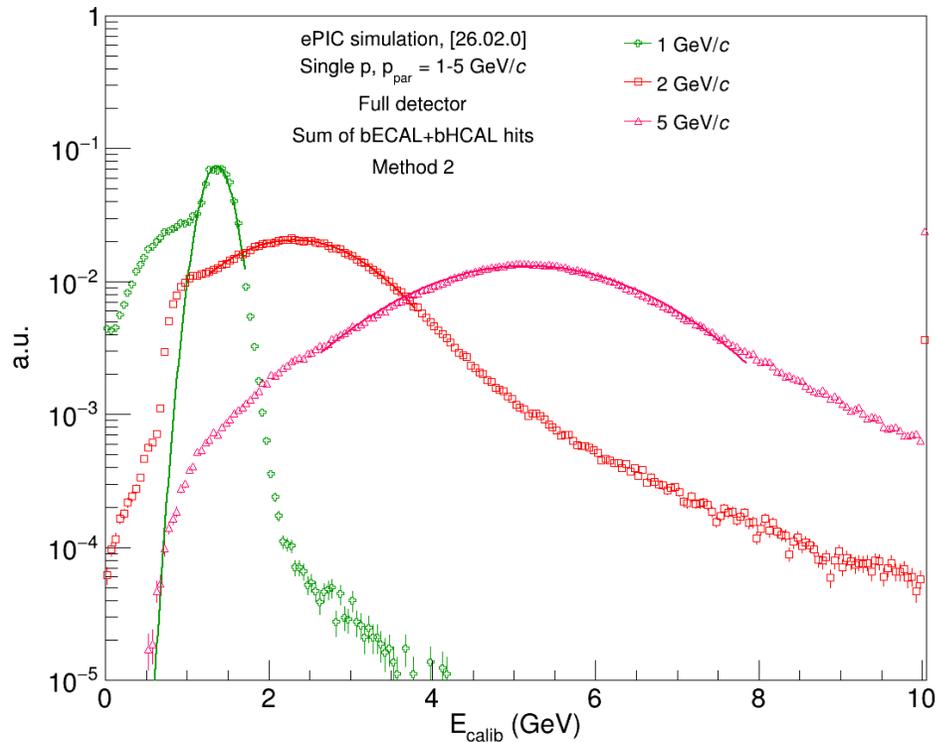
CALIBRATED DISTRIBUTIONS

- Calibrated energy distributions
  - (left) proton
  - (right) neutrons
    - 1 GeV distribution re-binned due to large calibration factors

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions
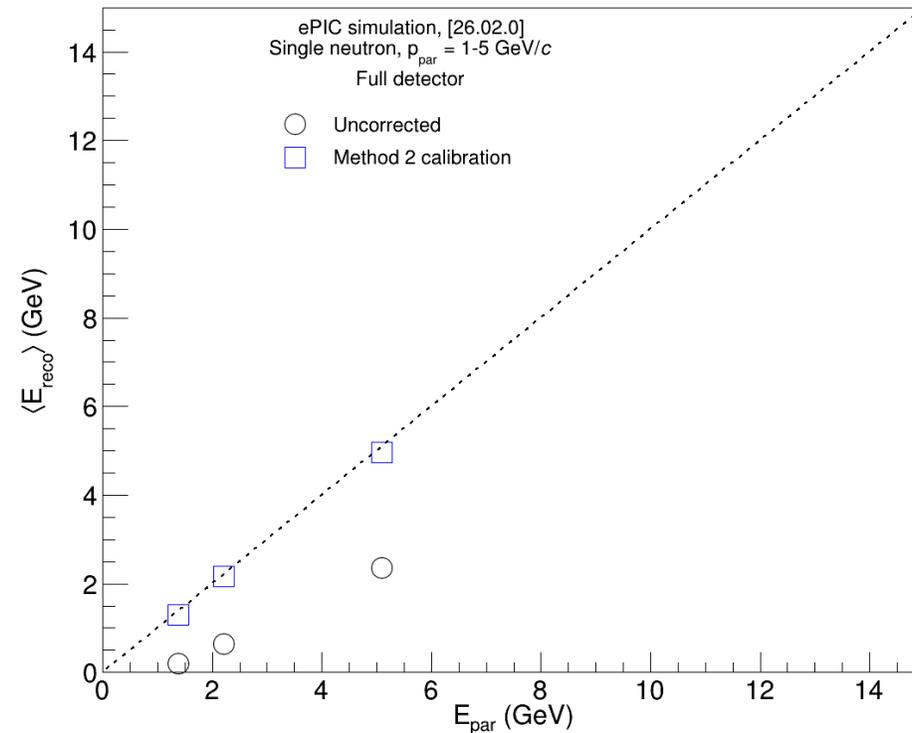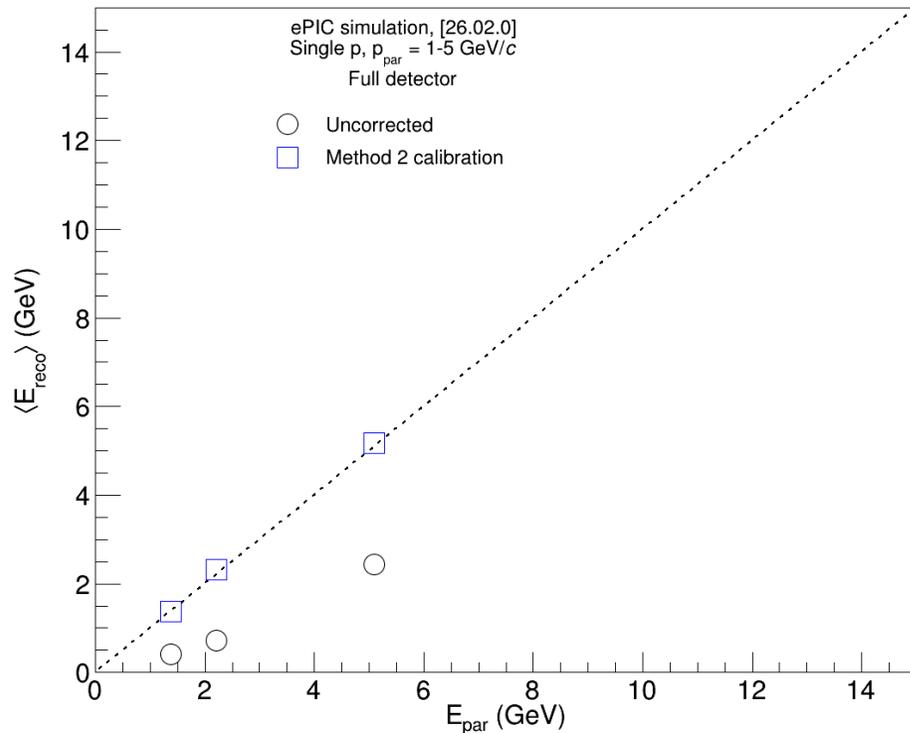
CALIBRATED DISTRIBUTIONS

- Calibrated energy distributions
  - (left) proton
  - (right) neutrons
    - Detail for 1 GeV to show distribution shape

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions

CALIBRATION RESULT — ENERGY

- Calibrated energy distributions
  - (left) proton
  - (right) neutrons

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions

CALIBRATION RESULT — RESOLUTION

- Calibrated energy distributions
  - (left) proton
  - (right) neutrons

- **Update:** Require to have both bECAL and bHCAL information for calibration distributions
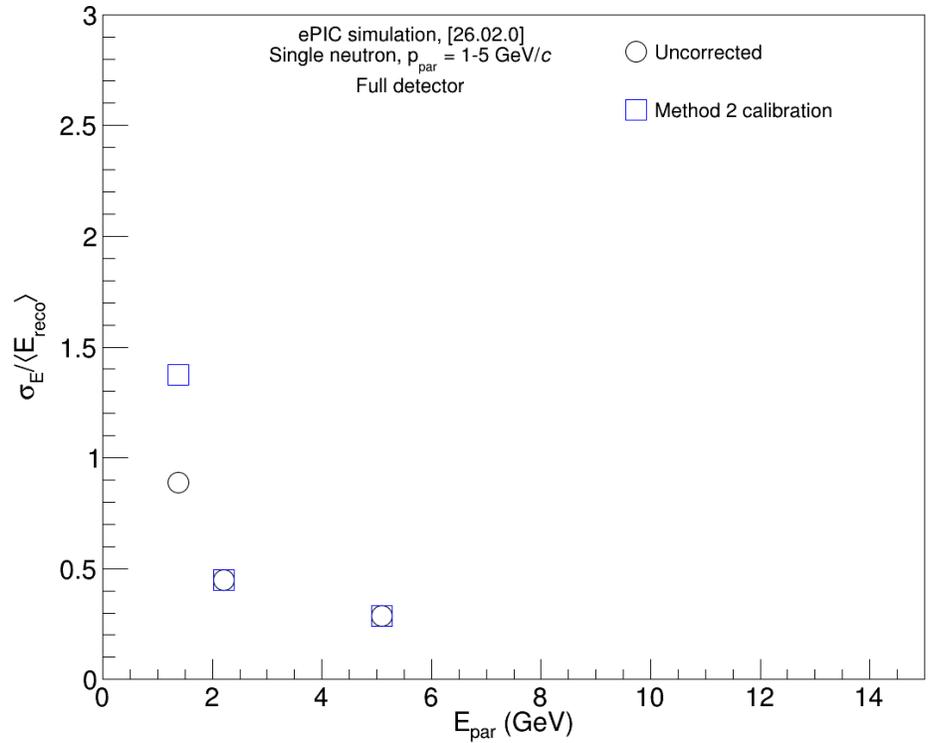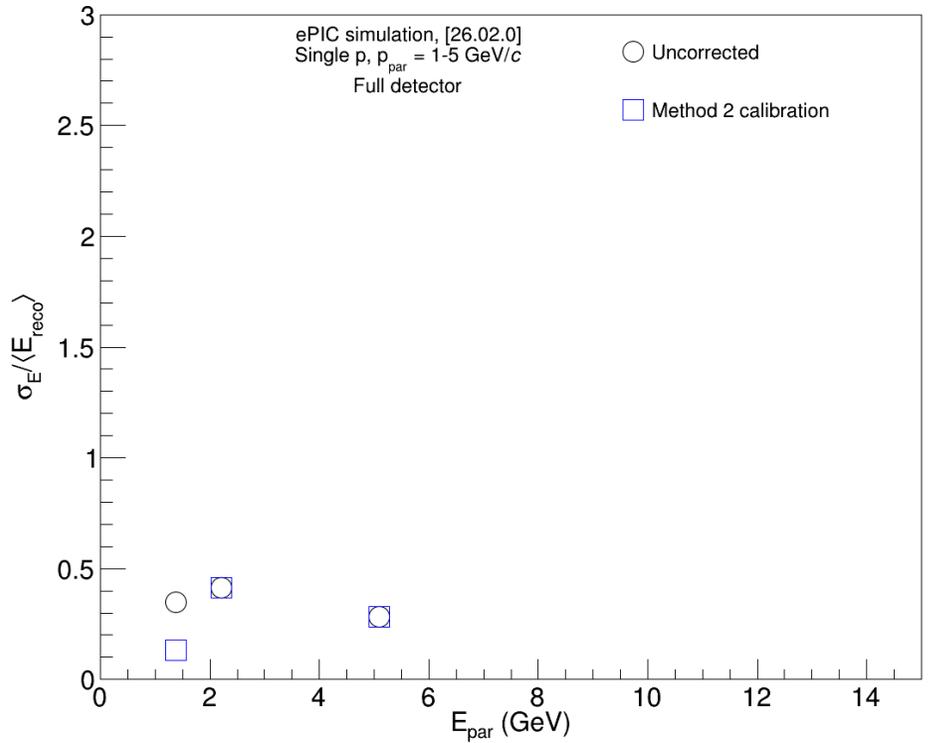
CALIBRATION DISTRIBUTIONS — LOW E

- First look at calibration distributions for low energy neutrons
  - 100 MeV, 200 MeV, and 500 MeV
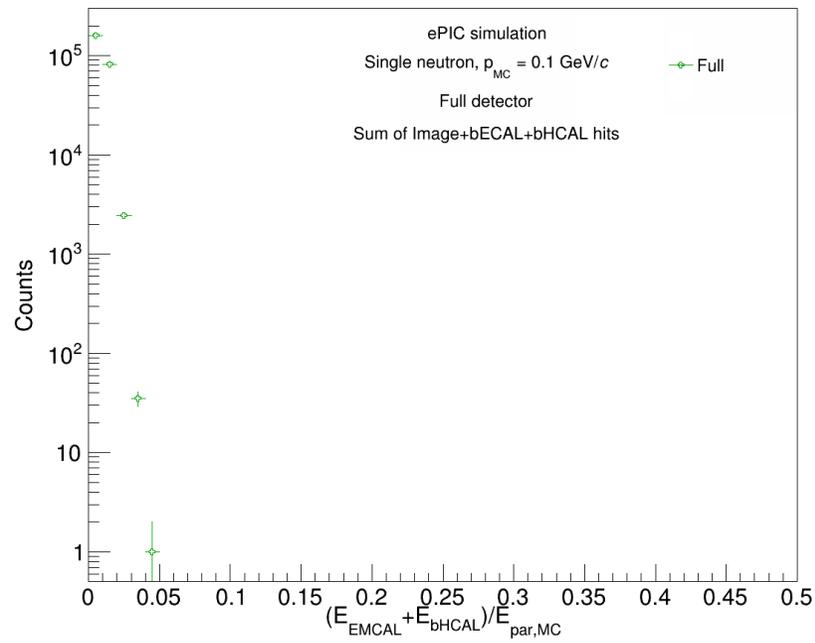 - Different x-axis scale compared to higher energies

- Using bECAL+bHCAL information
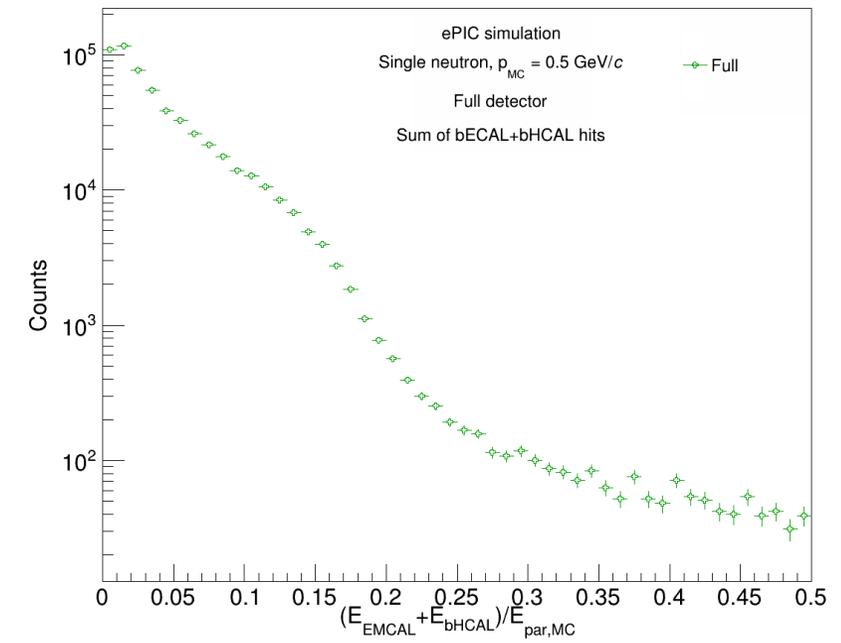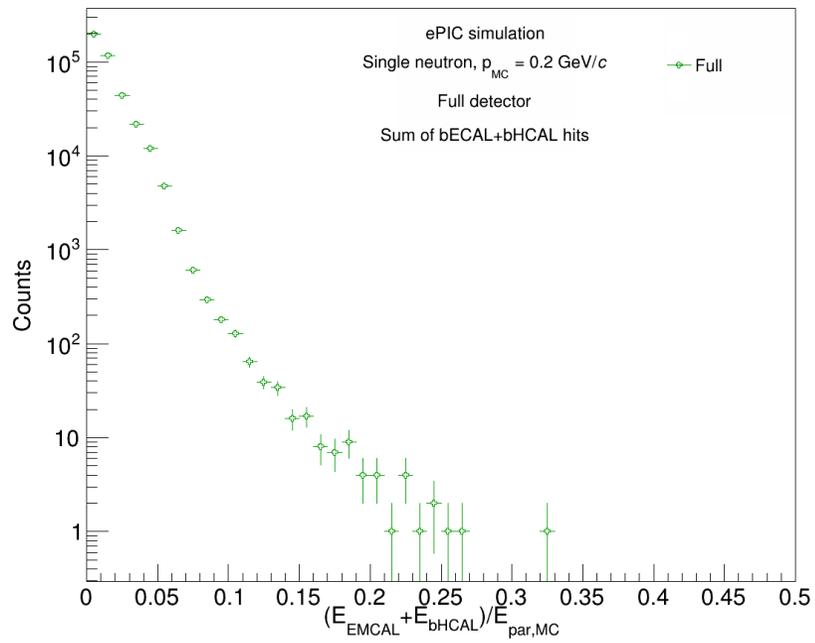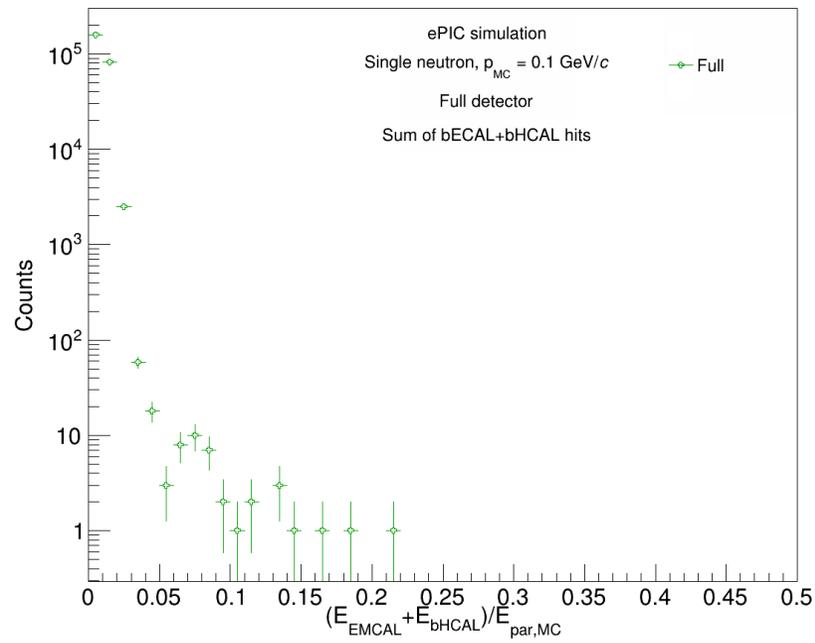
CALIBRATION DISTRIBUTIONS — LOW E

- First look at calibration distributions for low energy neutrons
  - 100 MeV, 200 MeV, and 500 MeV

- Using **Imaging ECAL**+bECAL+bHCAL information

- Neutron calibration for energies below 1 GeV difficult
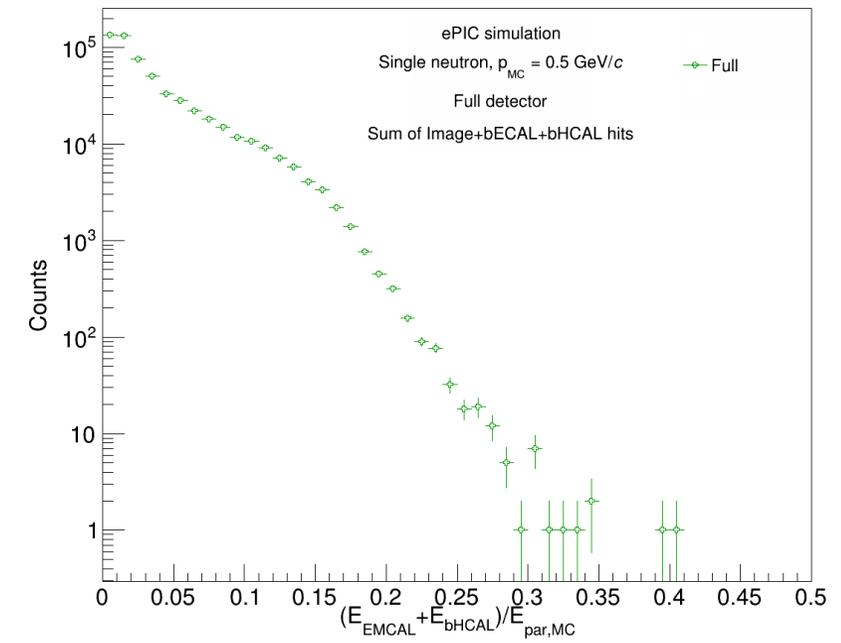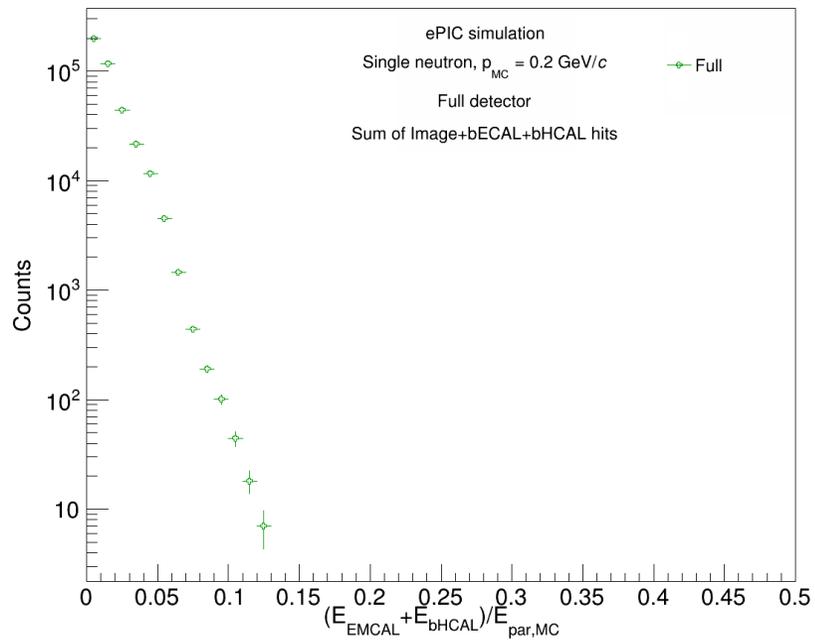
SUMMARY

- Implemented calibration framework of bECAL+bHCAL system for protons
  - Tracking appears to provide good resolution to be used for calibration of protons, similar to π^+

- Updated calibration procedure for neutrons
  - Require both bECAL and bHCAL information for calibration
  - Can calibrate 1 GeV neutrons with updated framework (using MC info only for now)

- Protons and neutrons appear to have similar response for higher energes
  - 2 GeV and 5 GeV
- Substantial difference in response for lower energies (1 GeV)

- Calibration appears difficult for neutrons below 1 GeV
  - From first look at low energy neutrons in official campaign (100 MeV, 200 MeV, and 500 MeV)

THANK YOU FOR ATTENTION