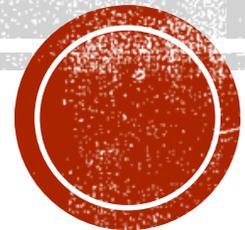


bHCAL Meeting — Neutron Calibration Update

Jan Vanek

University of New Hampshire

02/20/2026



OVERVIEW

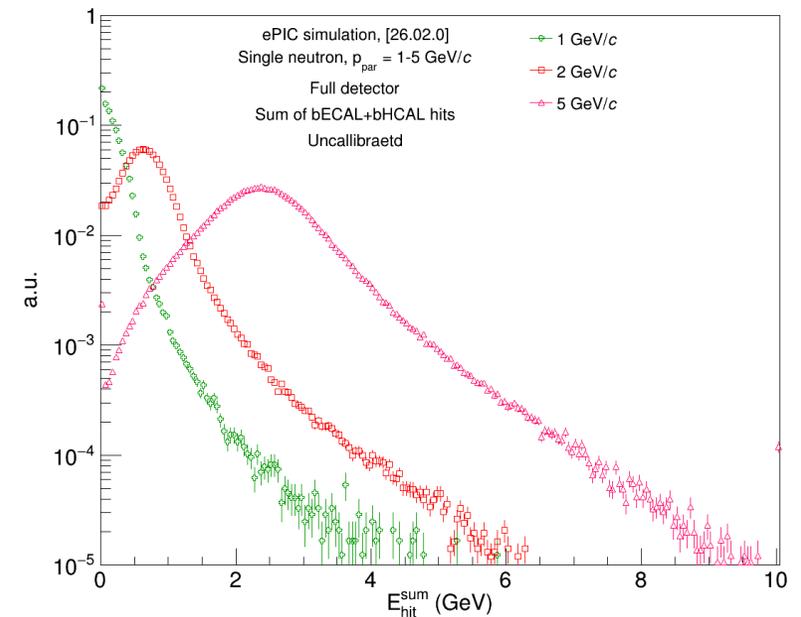
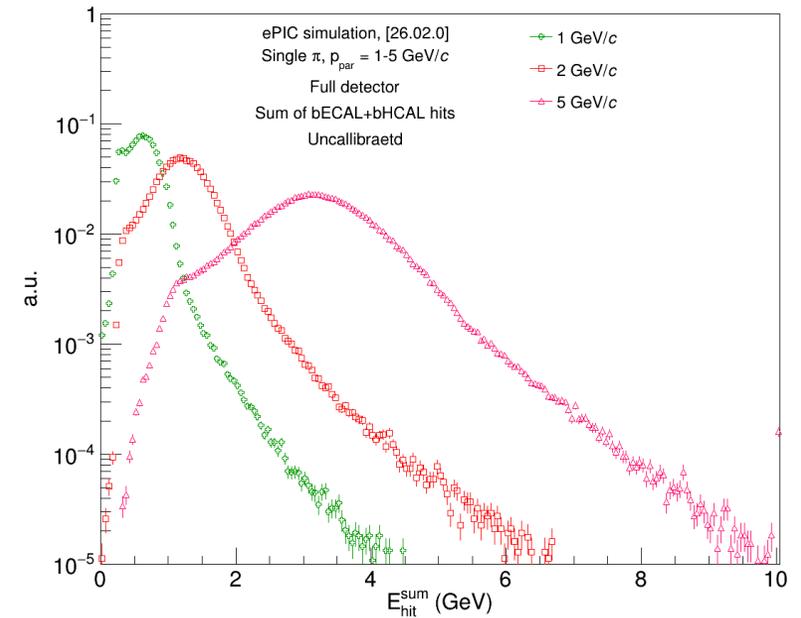
- Calibration using π^+
 - Using MC energy
 - Using momentum from tracking
- Comparison of π^+ calibration to original study using neutrons
 - Using MC neutron energy

MANUAL CALIBRATION METHODS

- Same methods used for π^+ and neutrons
- More advanced method(s) to be implemented
- Method 1
 - Used only for comparison to other methods
 - $E_{calib} = A(E_{EMCAL} + E_{bHCAL})$
 - Plot $(E_{EMCAL} + E_{bHCAL})/E_{par,MC}$
 - A is set as 1/mean of this distribution
- 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

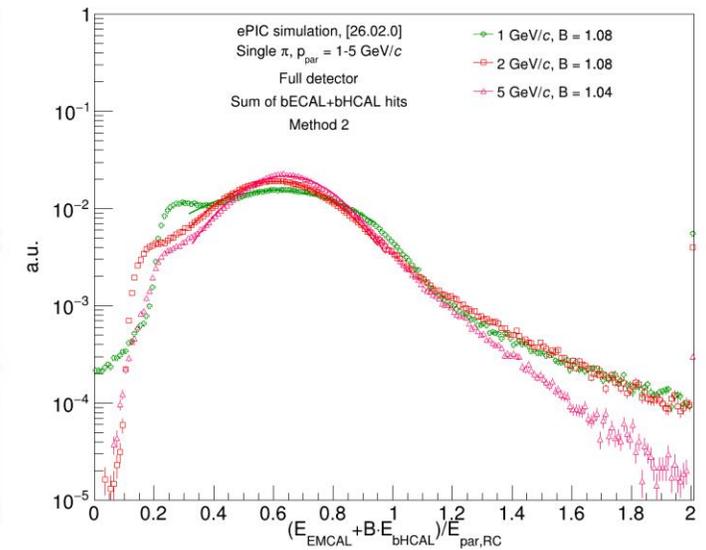
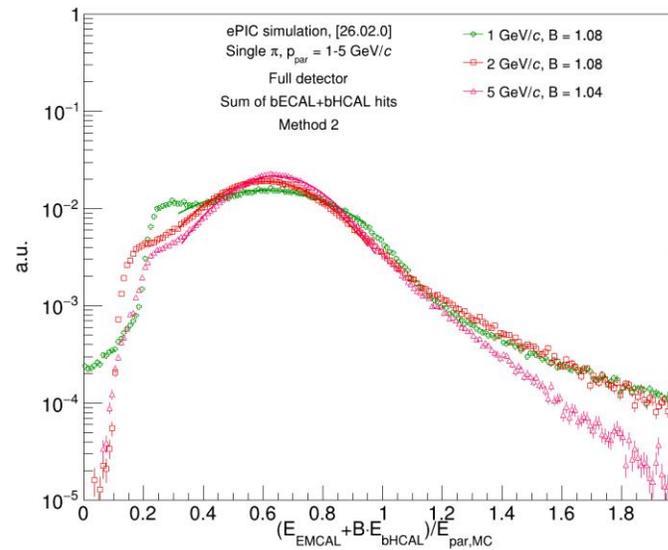
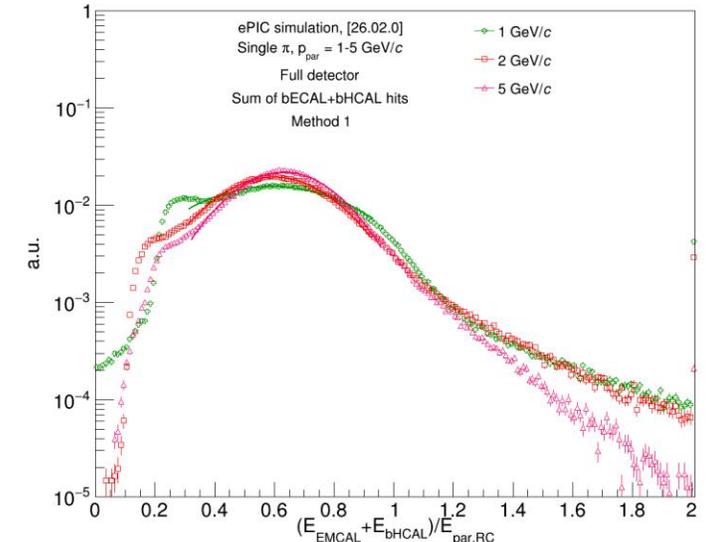
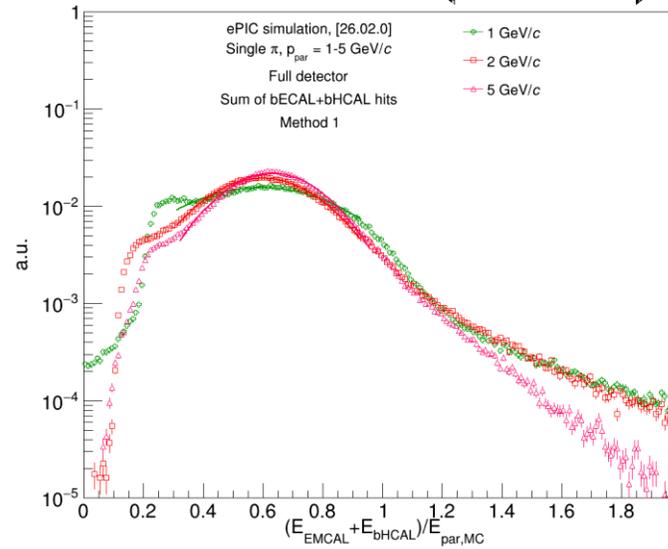
UNCALIBRATED ENERGY

- Sum of energy deposition in bECAL+bHCAL
 - (top) π^+
 - (bottom) neutrons
- Clear difference between π^+ and neutrons
 - Pions have larger averaged energy deposition in bECAL+bHCAL system



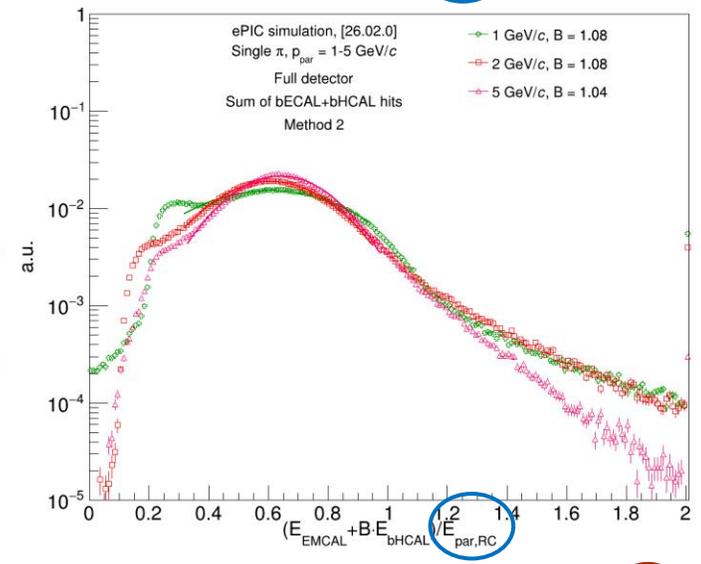
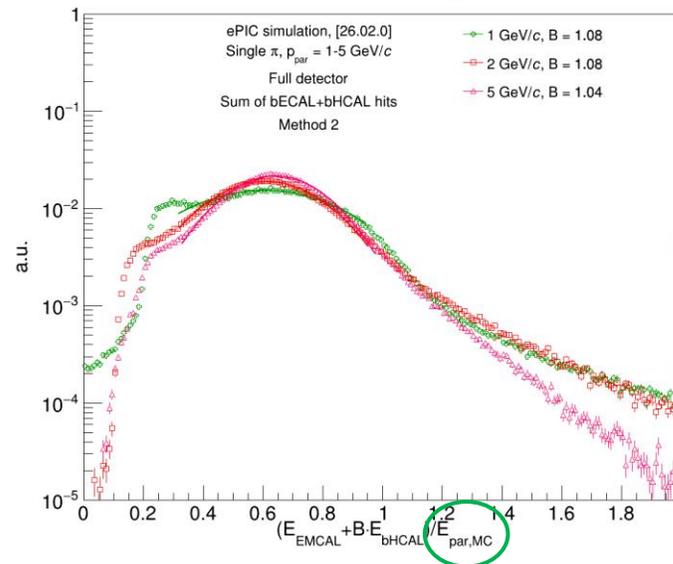
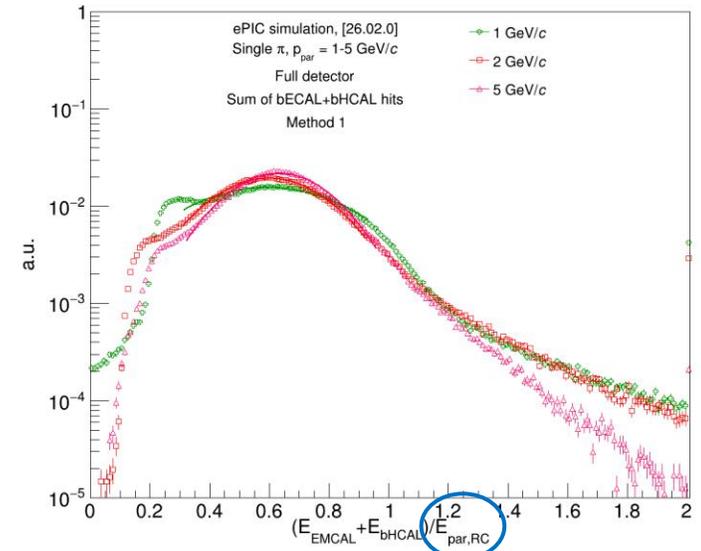
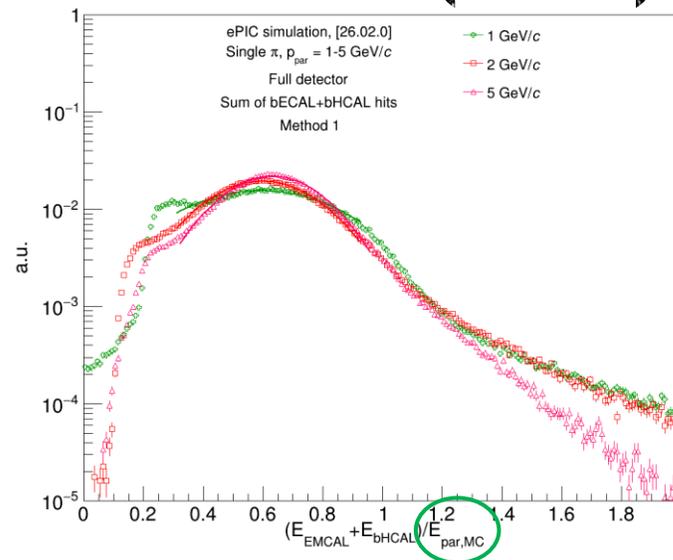
CALIBRATION DISTRIBUTIONS (π^+)

- Calibration distributions for π^+
 - (top) Method 1
 - (bottom) Method 2
- Comparison of calibration using MC energy (left) and RC energy calculated from tracking (right)
 - RC tracks selected based on MC to RC matching
 - RC level information contains tracking efficiency and resolution
 - No PID effects
- Tracking seems to provide good resolution for π^+ to be used in calibrations



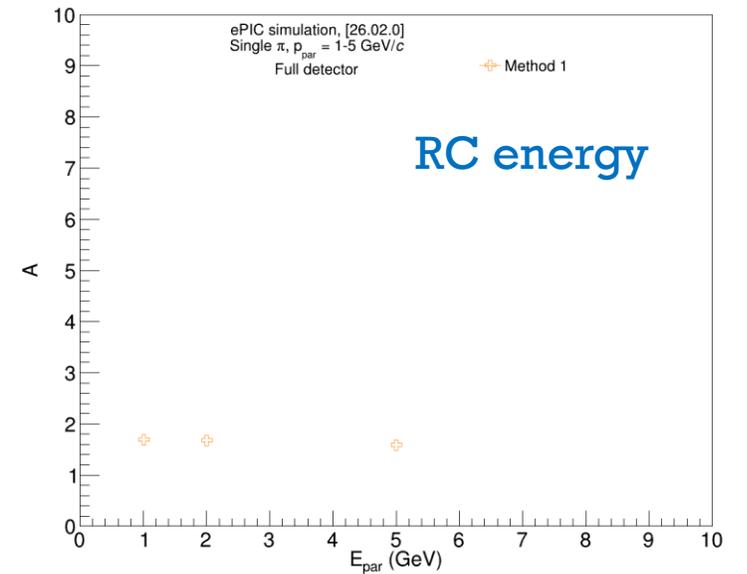
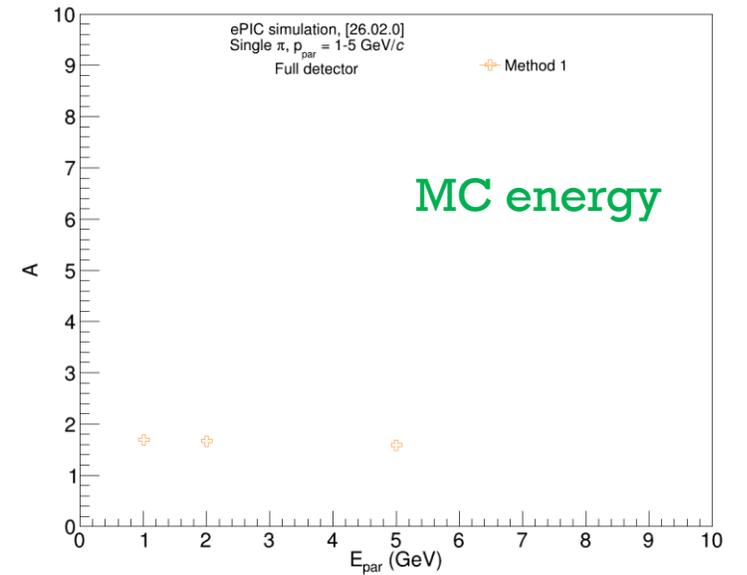
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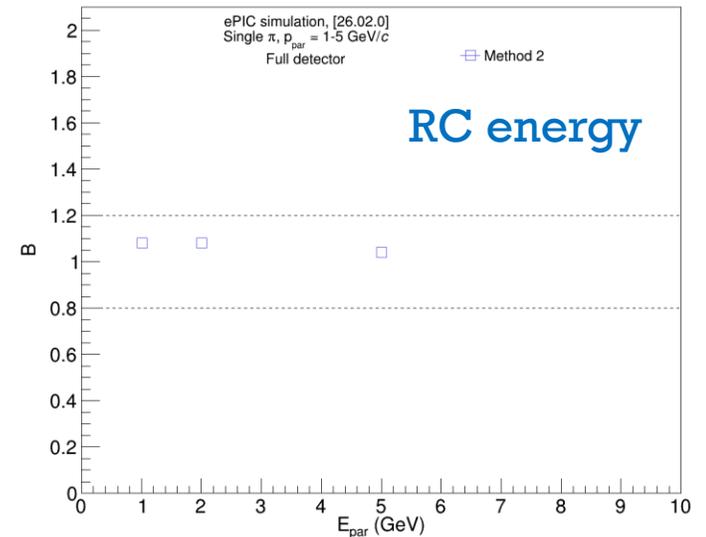
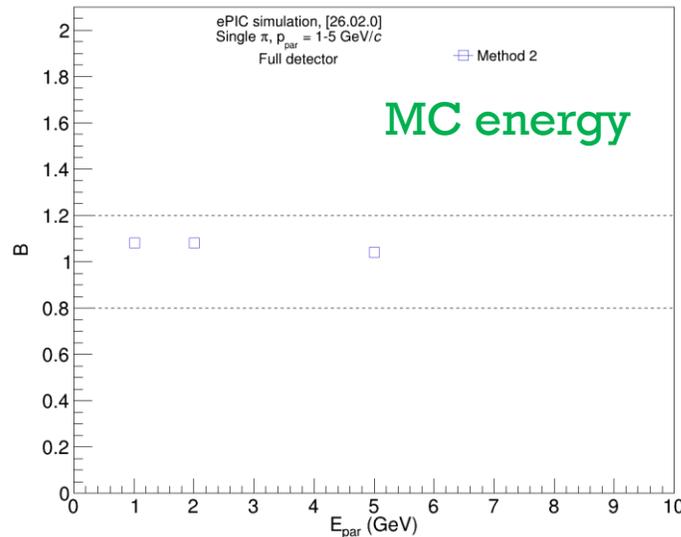
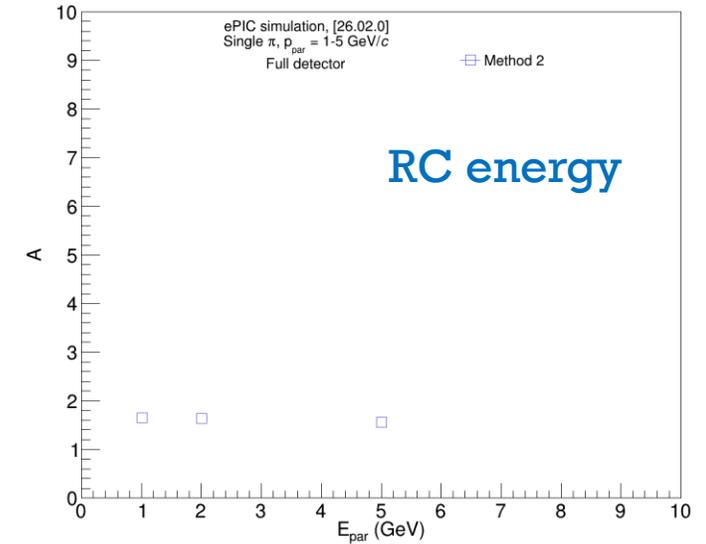
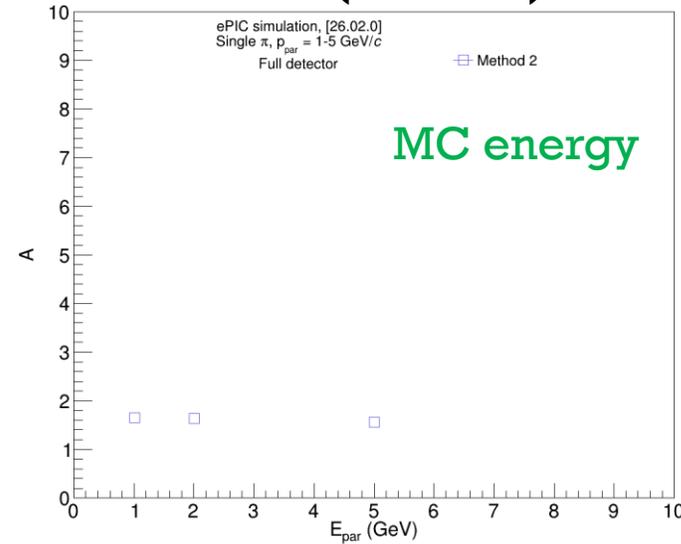
CALIBRATION PARAMETERS (π^+)

- Comparison of calibration parameters for calibration of π^+ energy using MC energy (top) and RC energy calculated from tracking (bottom) in Method 1
- Using RC energy is consistent with MC energy for Method 1



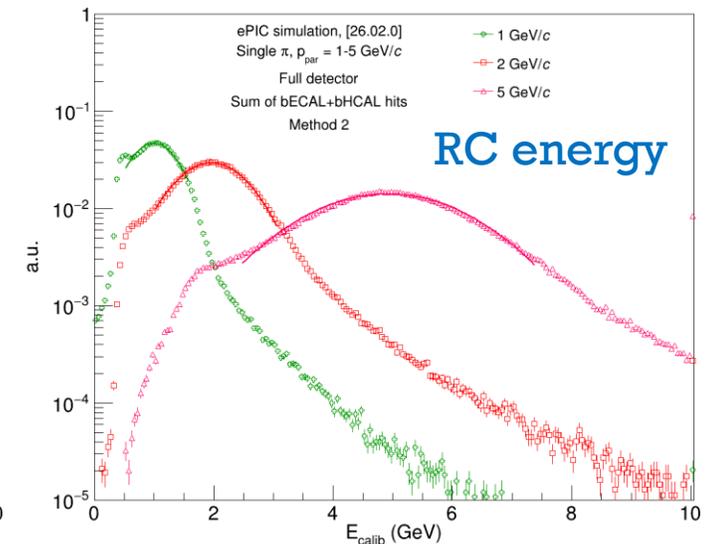
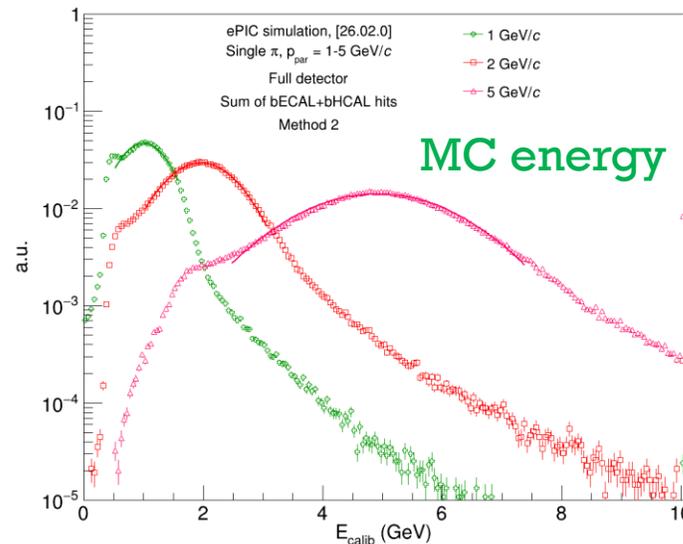
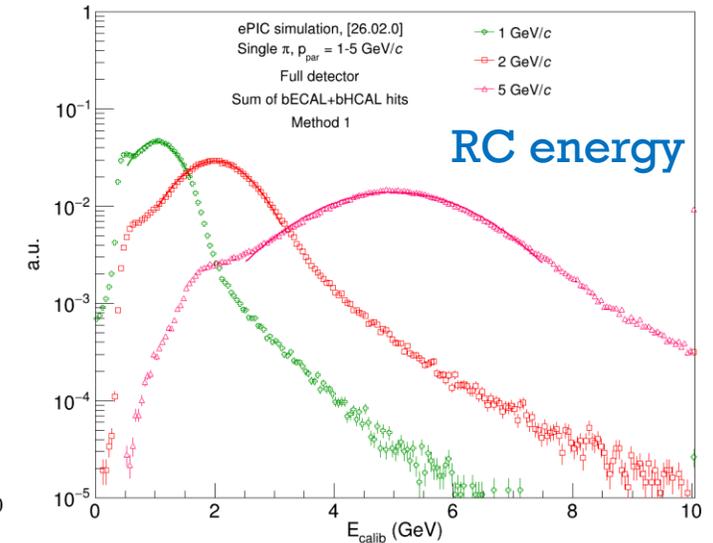
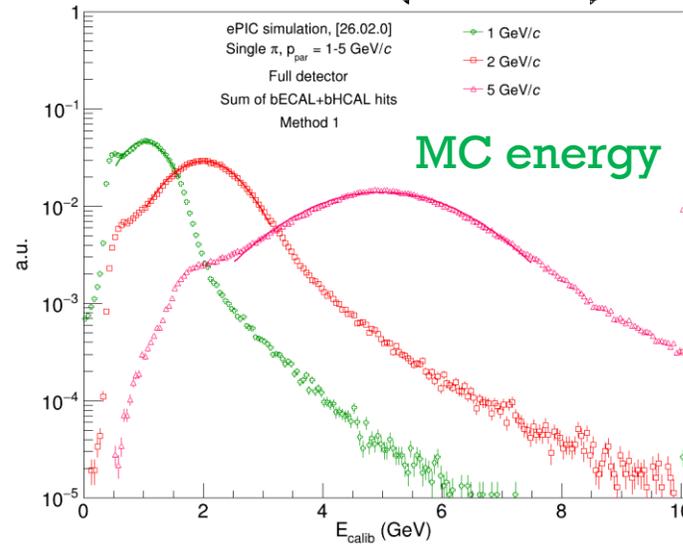
CALIBRATION PARAMETERS (π^+)

- Comparison of calibration parameters for calibration of π^+ energy using MC energy (left) and RC energy calculated from tracking (right) in Method 2
- Using RC energy is consistent with MC energy for Method 2



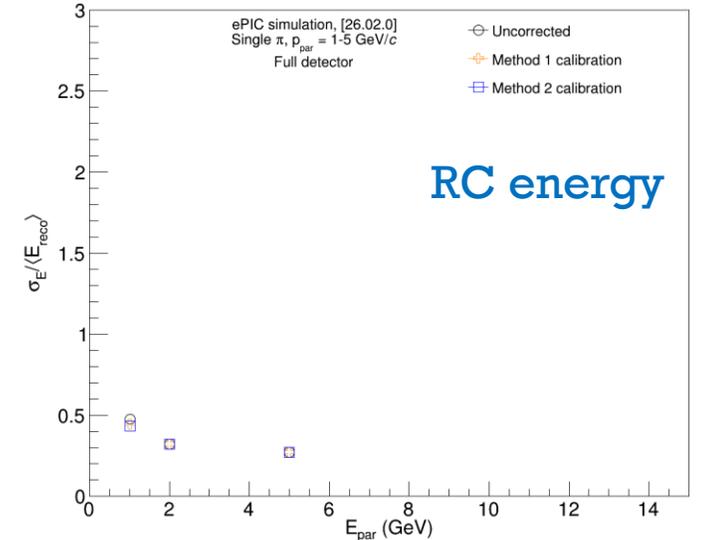
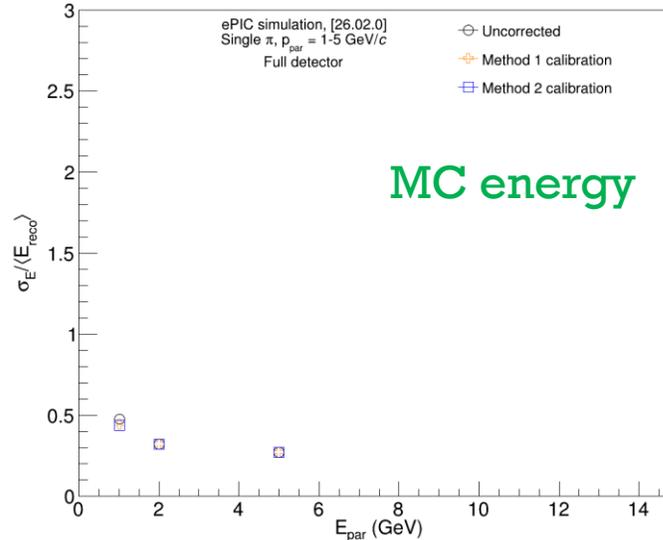
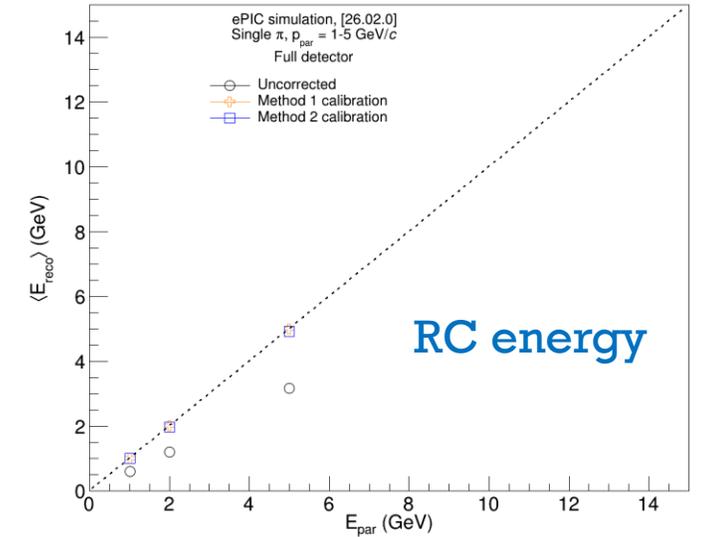
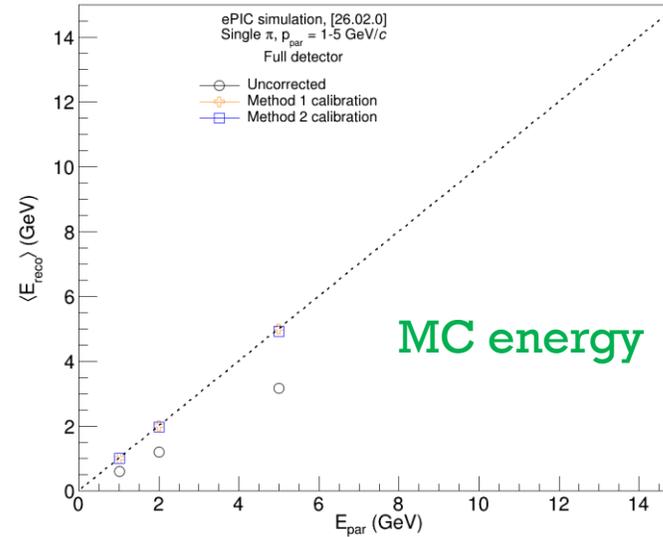
CALIBRATED DISTRIBUTIONS (π^+)

- Calibrated energy distributions for π^+
 - (top) Method 1
 - (bottom) Method 2
- Comparison of calibration using MC energy (left) and RC energy calculated from tracking (right)
 - RC tracks selected based on MC to RC matching
 - RC level information contains tracking efficiency and resolution
 - No PID effects
- Tracking seems to provide good resolution for π^+ to be used in calibrations



CALIBRATION RESULTS (π^+)

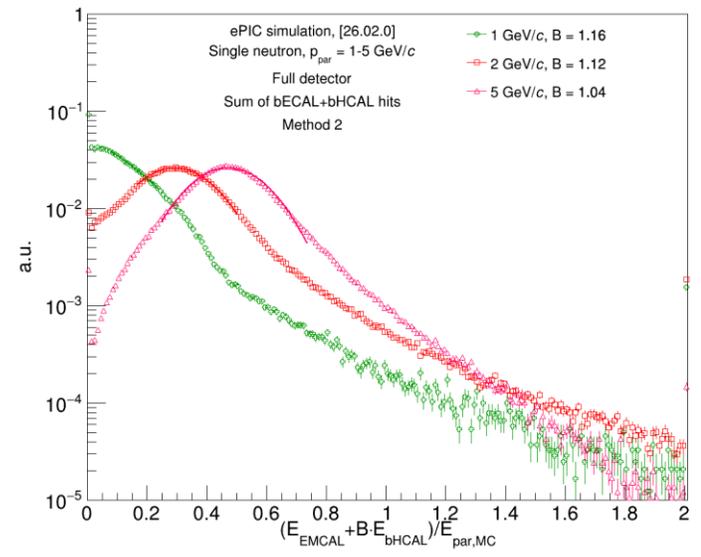
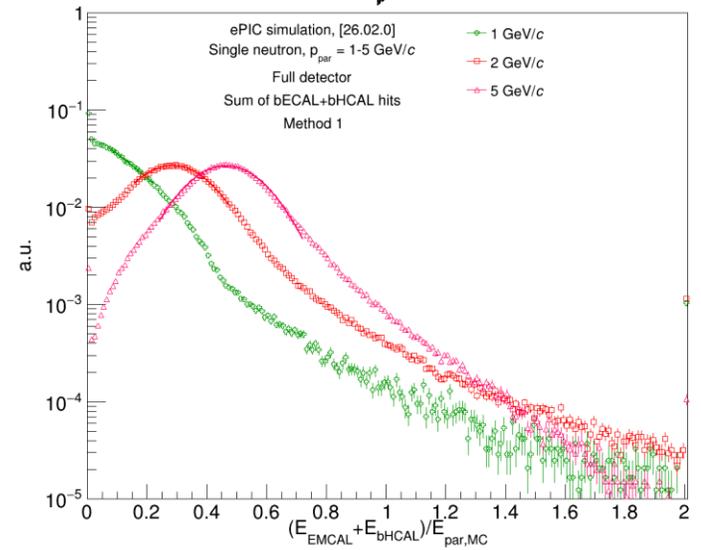
- Calibration result for π^+ using MC energy (left) and RC energy calculated from tracking (right)
 - (top) Calibrated vs. uncalibrated energy deposition in bECAL+bHCAL
 - (bottom) Energy resolution
- Using RC energy is consistent with MC energy for Method 2
- Calibration using Method 1 and 2 doesn't significantly change the energy resolution
 - We are only re-scaling the uncorrected distributions by a constant



CALIBRATION DISTRIBUTIONS (NEUTRON)

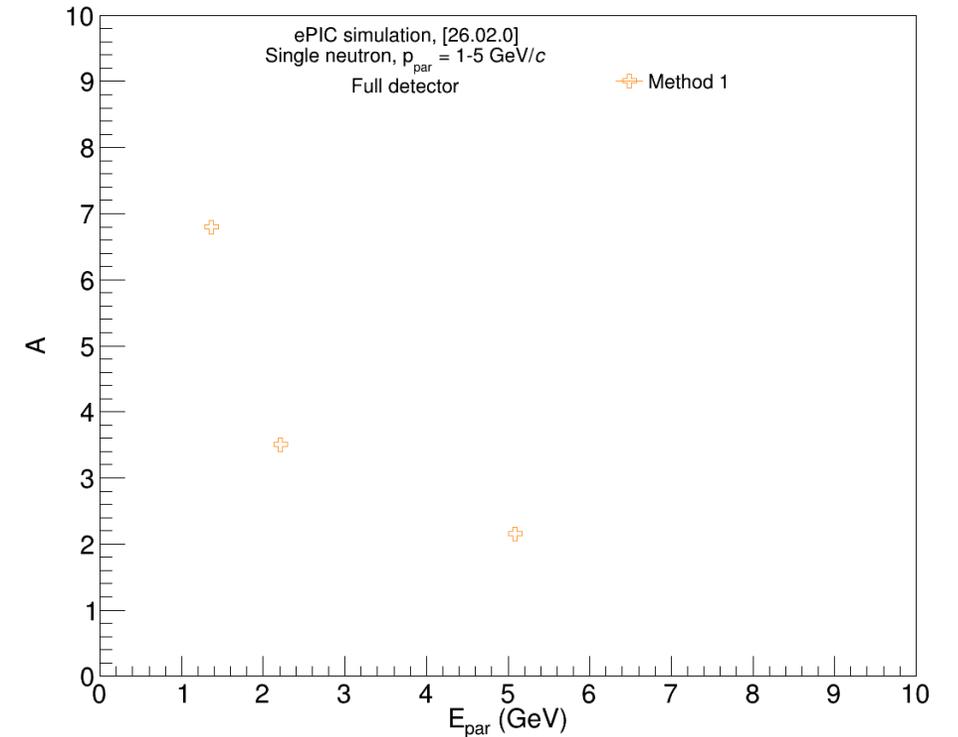
- Calibration distributions for neutrons
 - (top) Method 1
 - (bottom) Method 2

- No substantial difference between Method 1 and 2 for neutrons (and pions, see earlier slides)



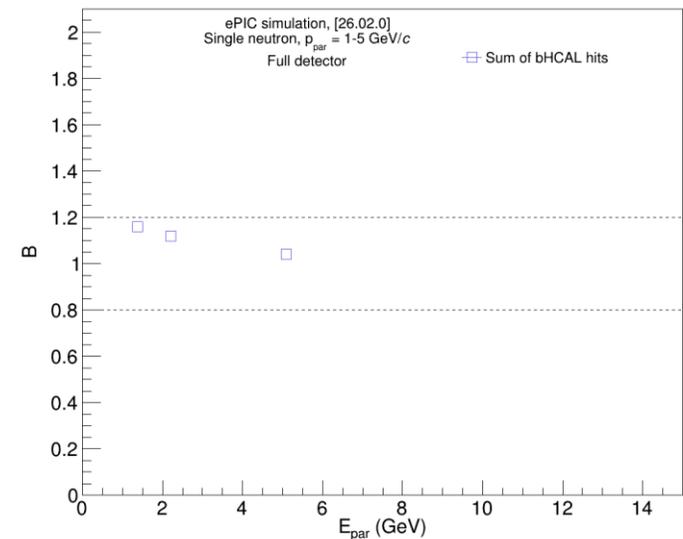
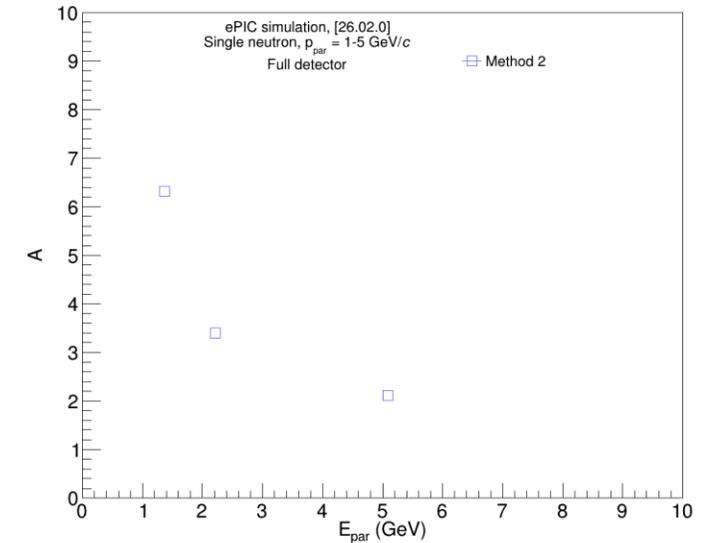
CALIBRATION PARAMETERS (NEUTRONS)

- Calibration parameters for neutron energy using MC energy in Method 1
- Substantially different energy dependence compared to pions



CALIBRATION PARAMETERS (NEUTRONS)

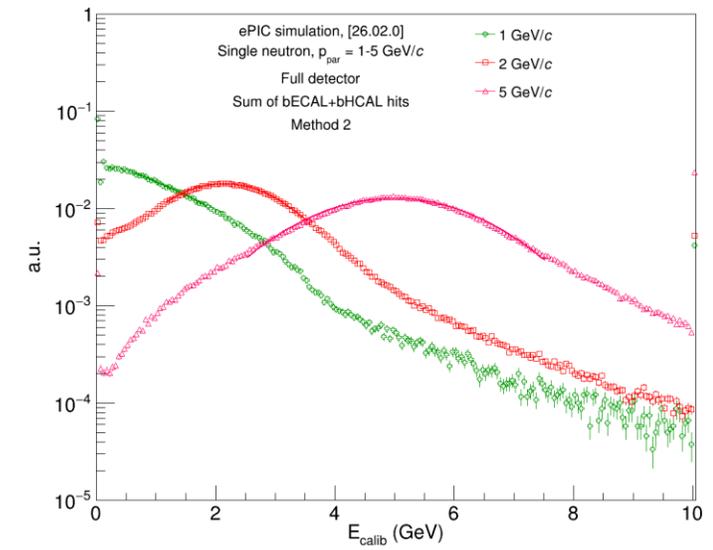
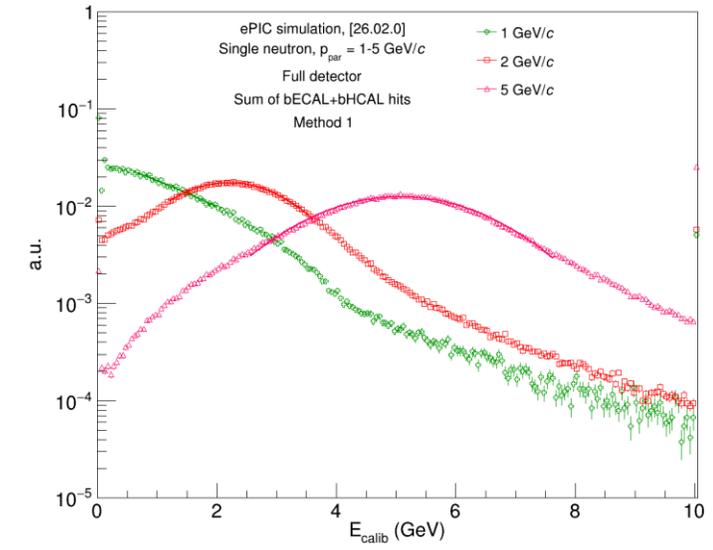
- Calibration parameters for neutron energy using MC energy in Method 2
- Substantially different energy dependence for neutrons compared to pions



CALIBRATED DISTRIBUTIONS (NEUTRONS)

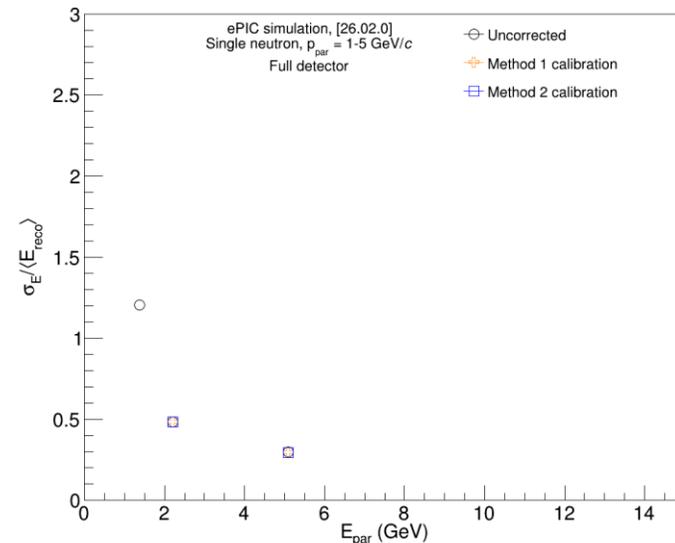
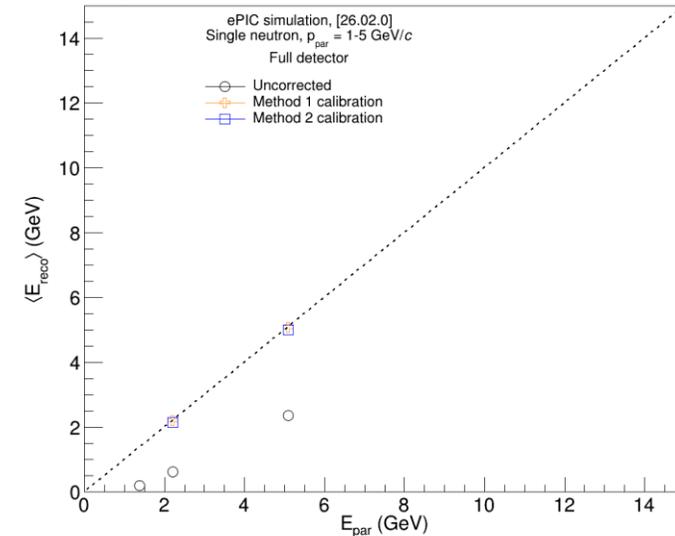
- Calibrated energy distributions for neutrons
 - (top) Method 1
 - (bottom) Method 2

- Difficult to calibrate low energy ($E \leq 1$ GeV) neutrons
 - Now working on possible method to use information from charged pions



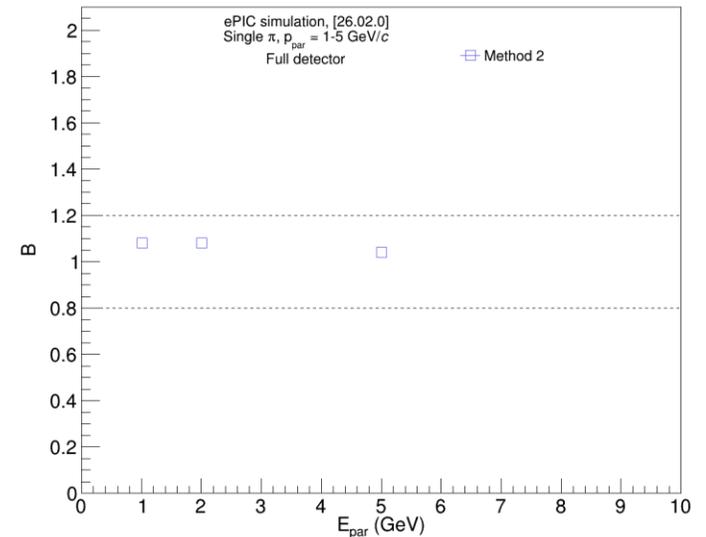
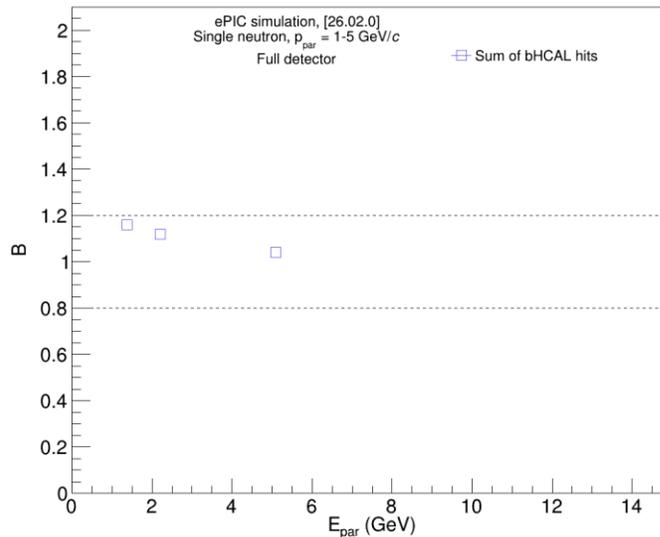
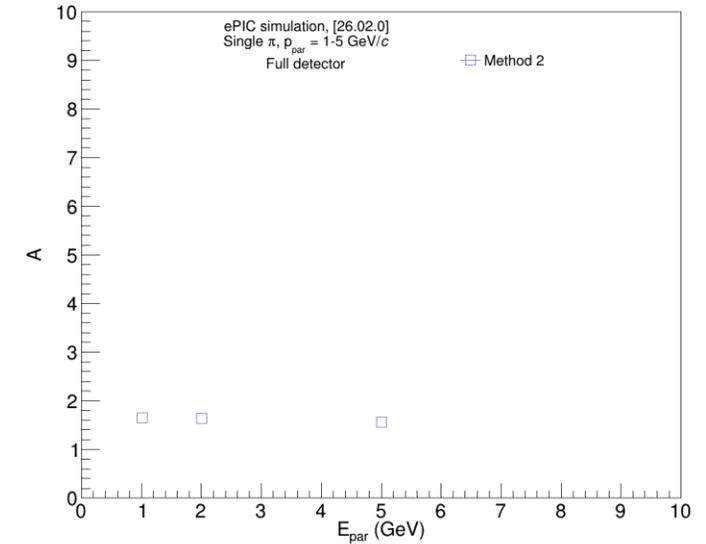
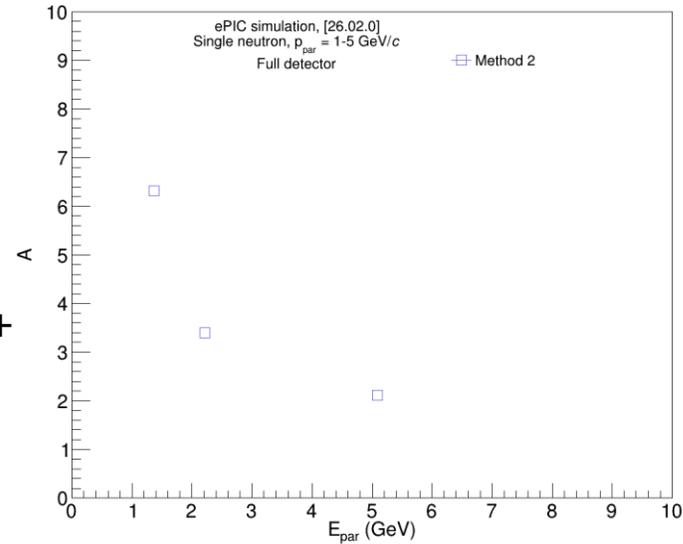
CALIBRATION RESULTS (NEUTRONS)

- Calibration result for neutrons (without external input)
 - (top) Calibrated vs. uncalibrated energy deposition in bECAL+bHCAL
 - (bottom) Energy resolution
- Substantially different energy dependence of difference between uncalibrated and calibrated energy for neutrons compared to pions
 - Already seen in parameter A dependence
- Calibration using Method 1 and 2 doesn't significantly change the energy resolution
 - We are only re-scaling the uncorrected distributions by a constant



SUMMARY

- Implemented calibration framework of bECAL+bHCAL system for π^+
- Tracking appears to provide good resolution to be used for calibration of π^+
- Repeated calibration procedure for neutrons
 - Using existing framework
- The calibration parameters for neutrons (left) have significantly different energy dependence compared to π^+ (right)
 - Example for Method 2
 - Strong energy dependence for neutrons
 - Almost no energy dependence for π^+



THANK YOU FOR ATTENTION