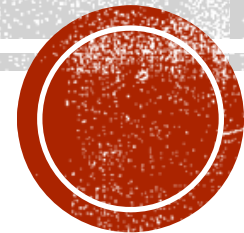


bHCAL Meeting — Neutron Calibration Update

Jan Vanek

University of New Hampshire

05/22/2026



OVERVIEW

- Background studies status
 - Calibrations with DIS events with and without background
- New calibration method
 - Initial look at sPHENIX calibration

BACKGROUND OVERVIEW

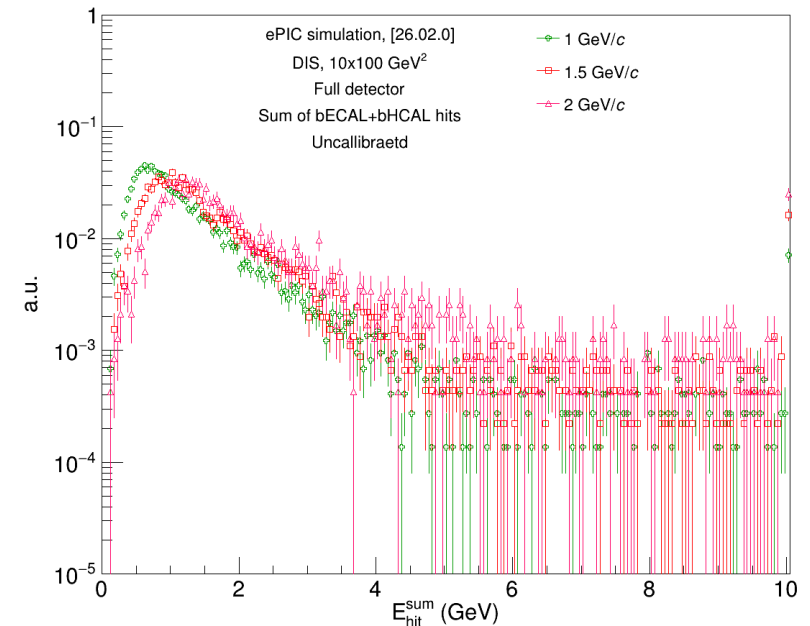
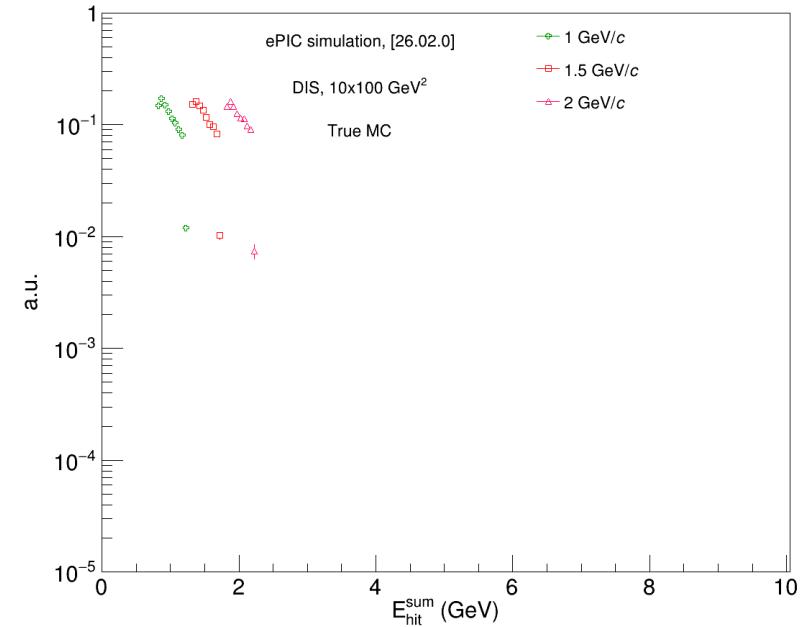
- Using recommended central DIS production
 - 26.02.0, DIS, NC, $10 \times 100 \text{ GeV}^2$, with and without background
- Efficiency vs. E (p) and η
 - First version implemented
 - Neutrons, protons, π^+
- Spatial resolution
 - First version implemented
 - Neutrons, protons, π^+
- Energy resolution vs. E and η
 - Now in progress

CALIBRATION METHOD IN DIS EVENTS

- Calibration done in bins of MC momentum:
 - **Now using π^+**
 - Neutron calibration difficult even in single particle simulations
 - $p_{n,1} = (1.0 \pm 0.2) \text{ GeV}/c, p_{n,2} = (1.5 \pm 0.2) \text{ GeV}/c, p_{n,3} = (2.0 \pm 0.2) \text{ GeV}/c$
 - Momentum range limited only up to 2 GeV/c due to low statistics of background sample
 - $E_{par,MC}$ for calibration taken as mean momentum of in given bin
- This study is using Method 2 calibration
 - $E_{calib} = A(E_{EMCAL} + BE_{bHCAL})$
 - 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 $1/\mu$ of the distribution with optimal B

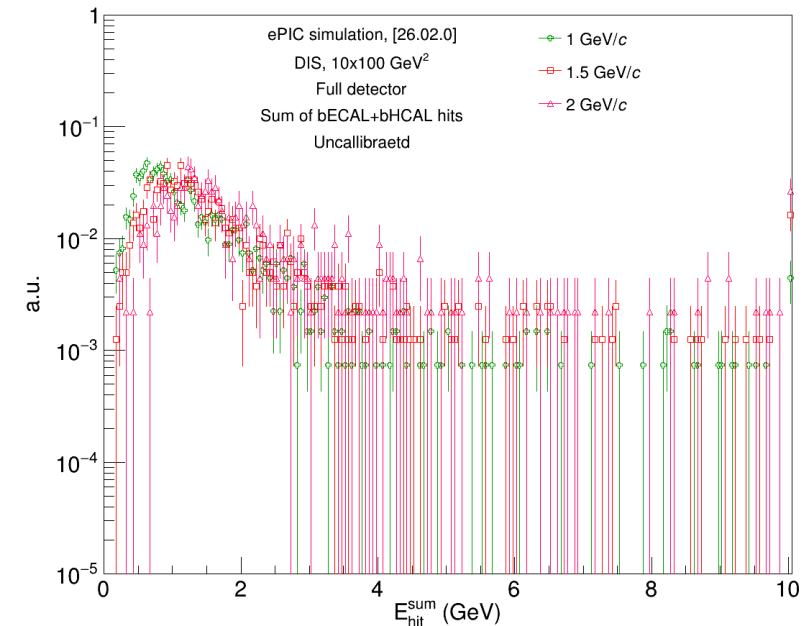
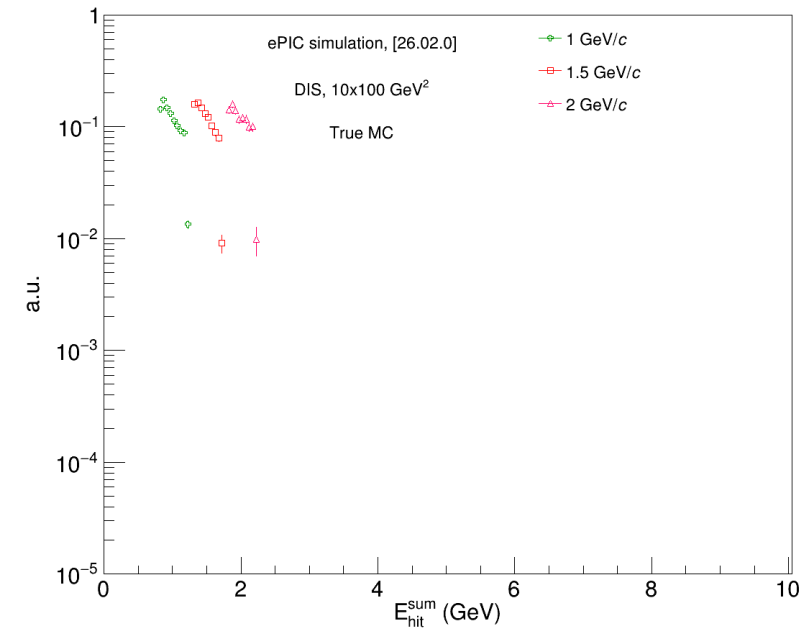
UNCALIBRATED ENERGY

- DIS events **without background**
- (top) Selected True MC energies of π^+
 - Individually normalized to unity
 - Legend energies approximate
 - Calibration uses mean MC energy in each bin
 - Can update to tracking information for charged particles
 - Should not make a difference for this study, as shown in single particle simulations
- (bottom) Corresponding RC energy
 - Sum of **clusters** in bECAL+bHCAL
 - Typo in axis label and legend (will fix later)
 - Must use clusters in DIS events to have matching between calorimeters and MC particles/tracks



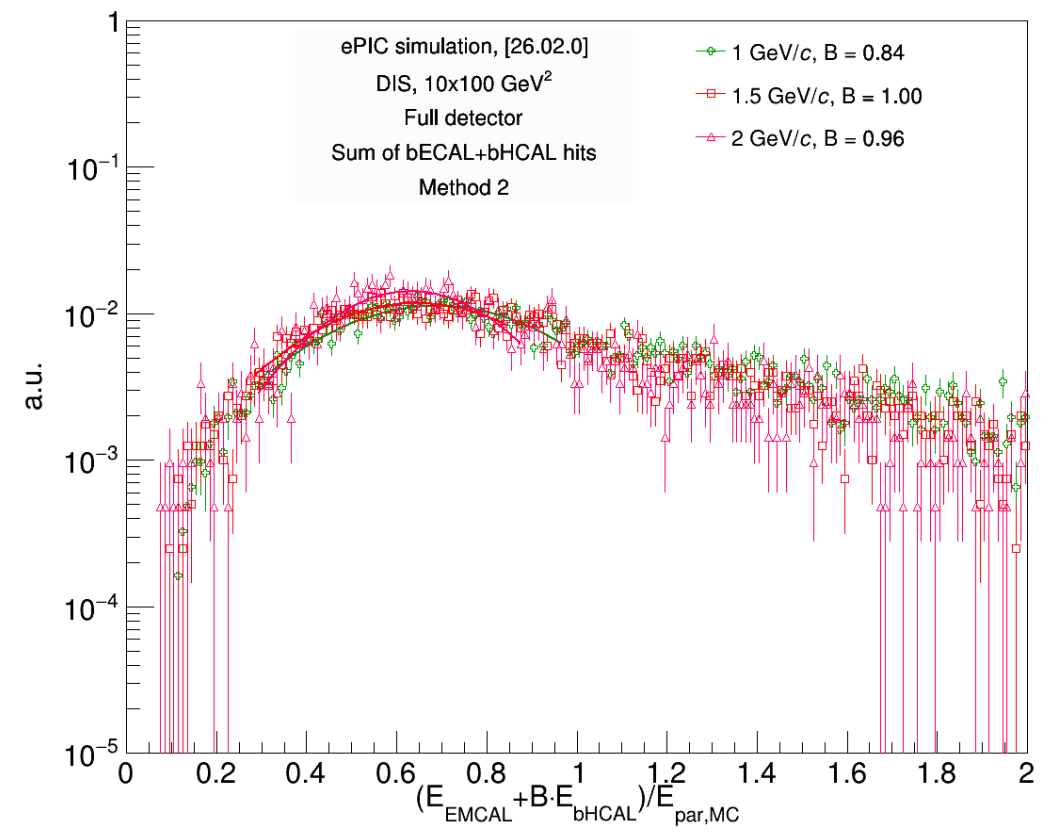
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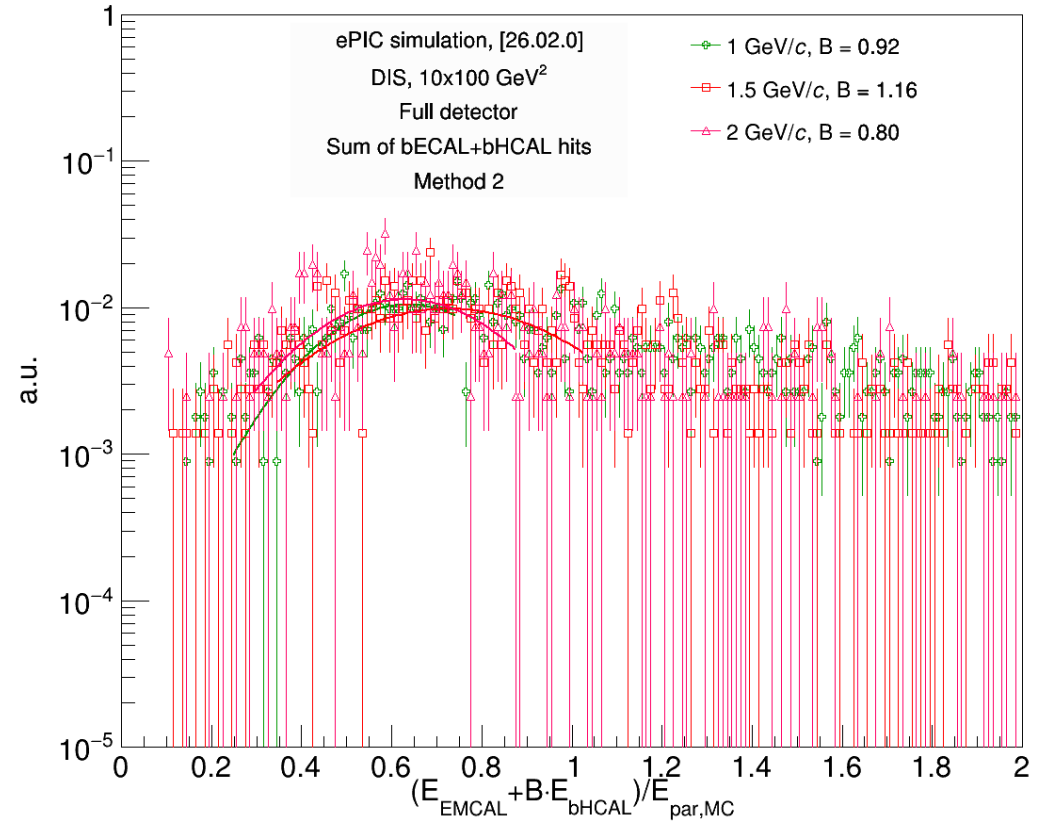
CALIBRATION ENERGY

- DIS events **without background**
- Calibration distributions for π^+
 - Gaussian fits



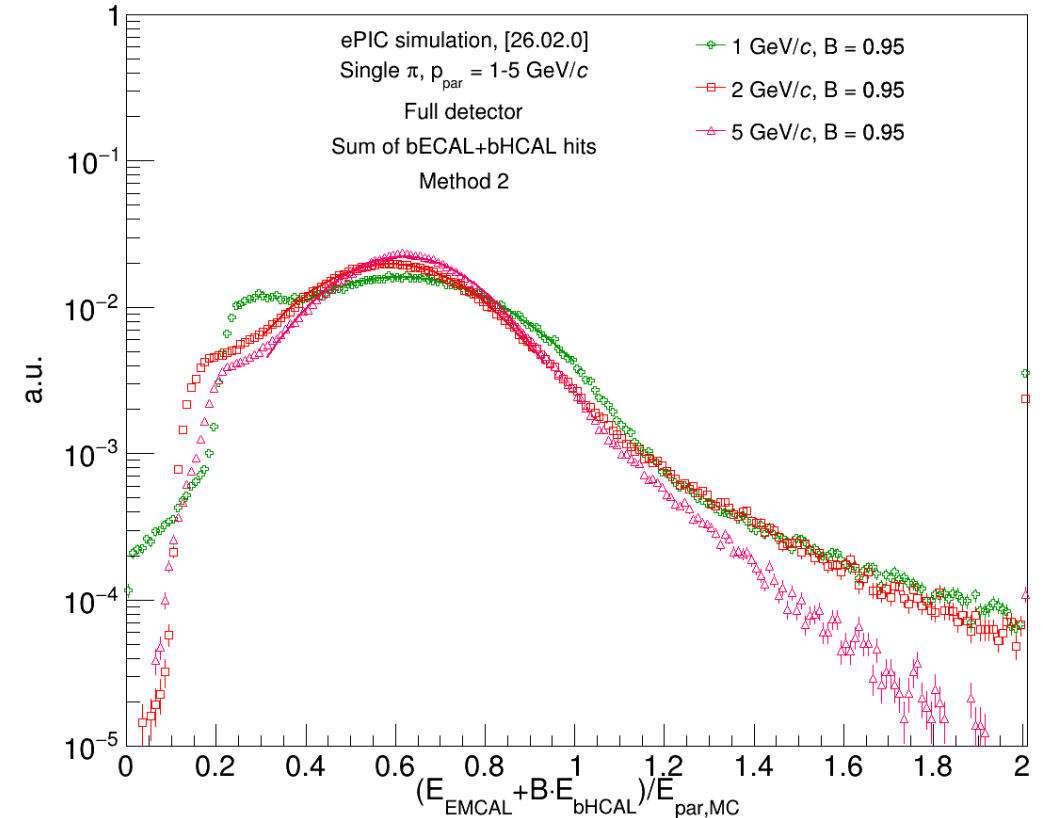
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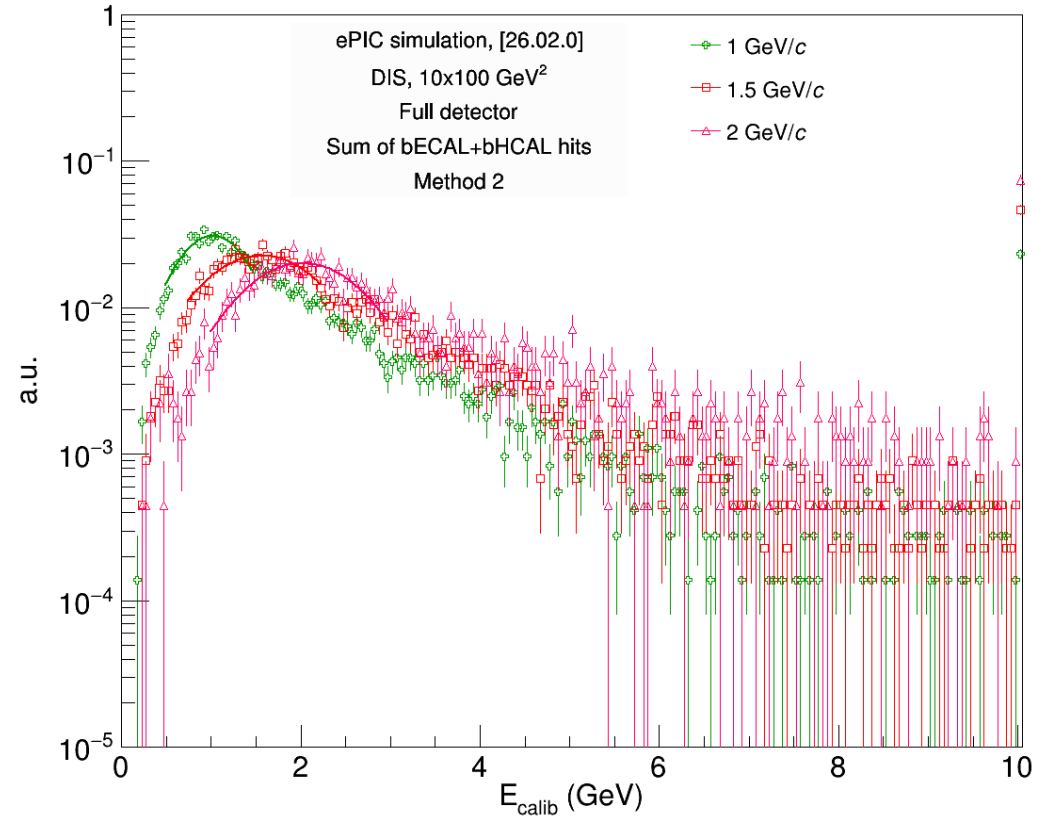
CALIBRATION ENERGY – SINGLE PARTICLE

- **Single particle simulation**
 - Marker types and colors are a bit different than in previous slide – compare based on legend
- Calibration distributions for π^+
 - Gaussian fits
- Here just as a reference for the DIS events
- DIS distributions have larger tails, but behave reasonably consistently with single particle simulations



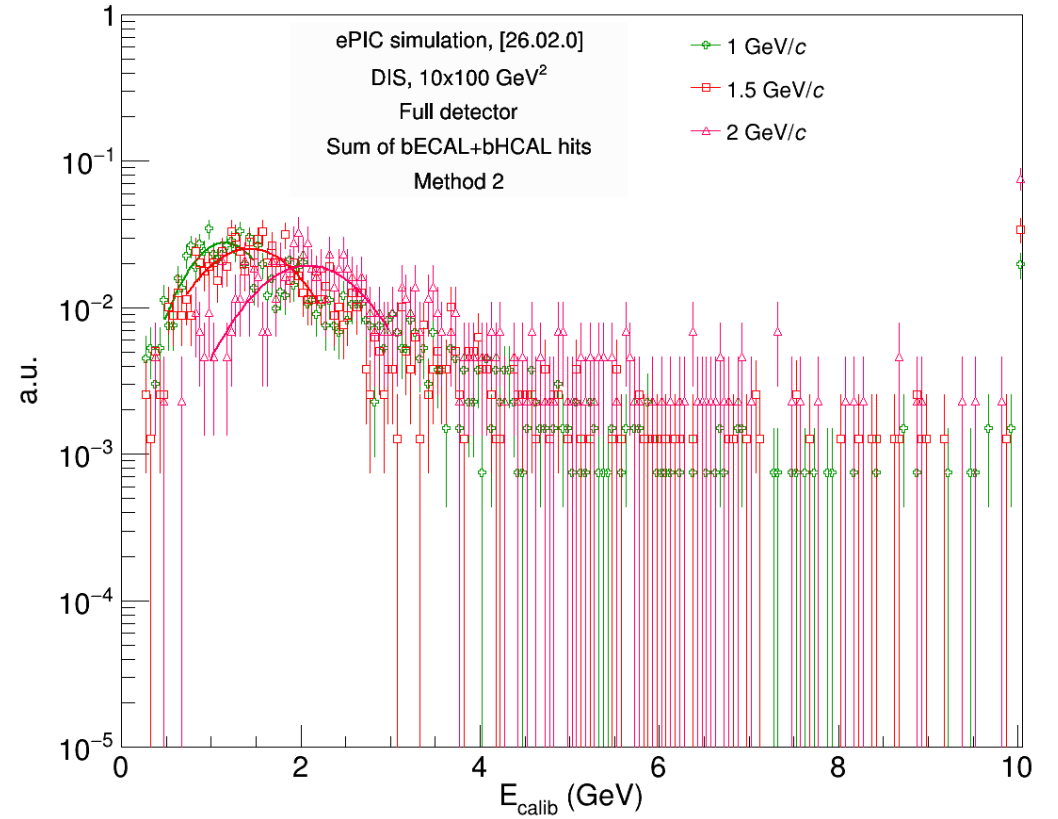
CALIBRATED ENERGY

- DIS events **without background**
- Calibration distributions for π^+
 - Gaussian fits



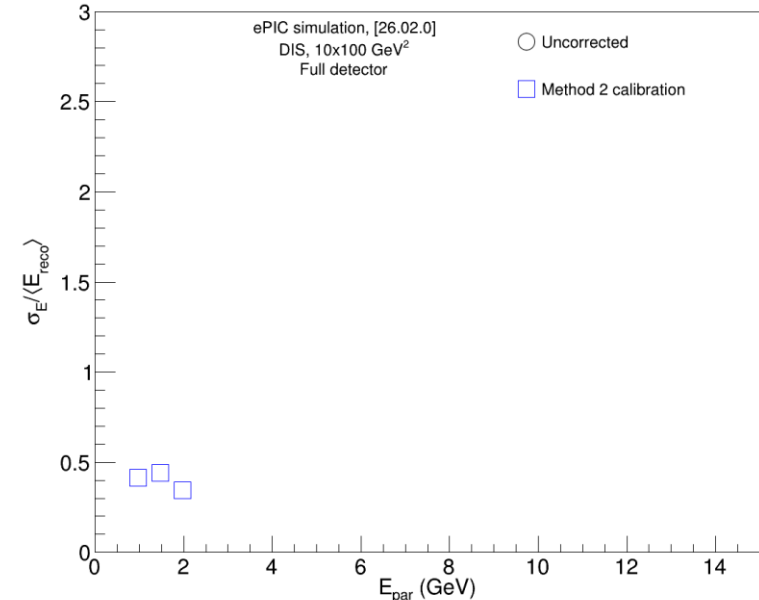
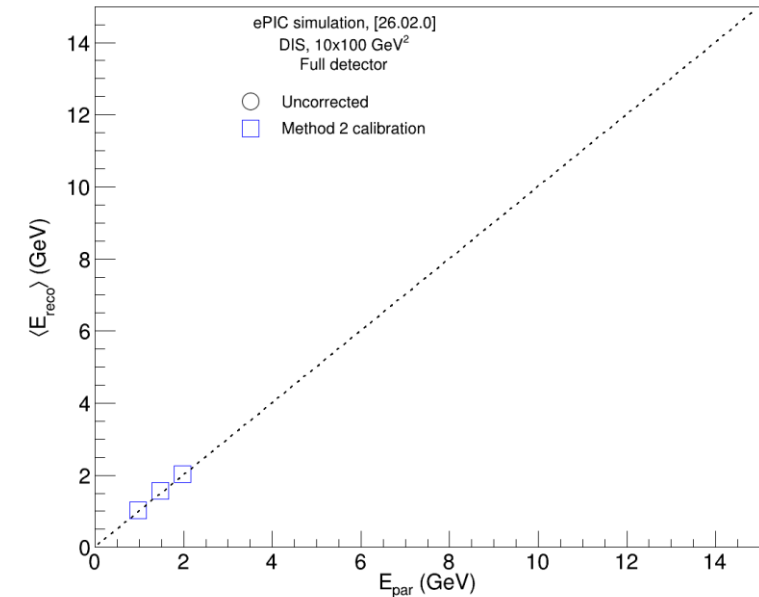
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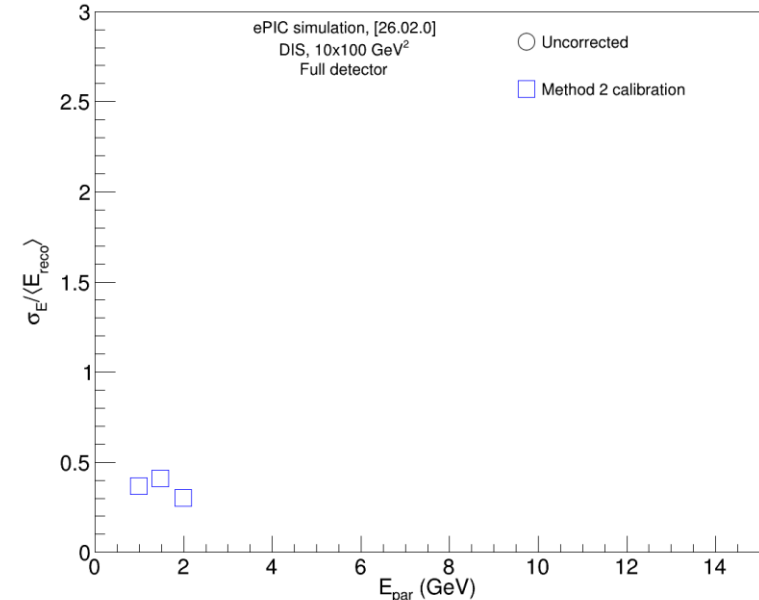
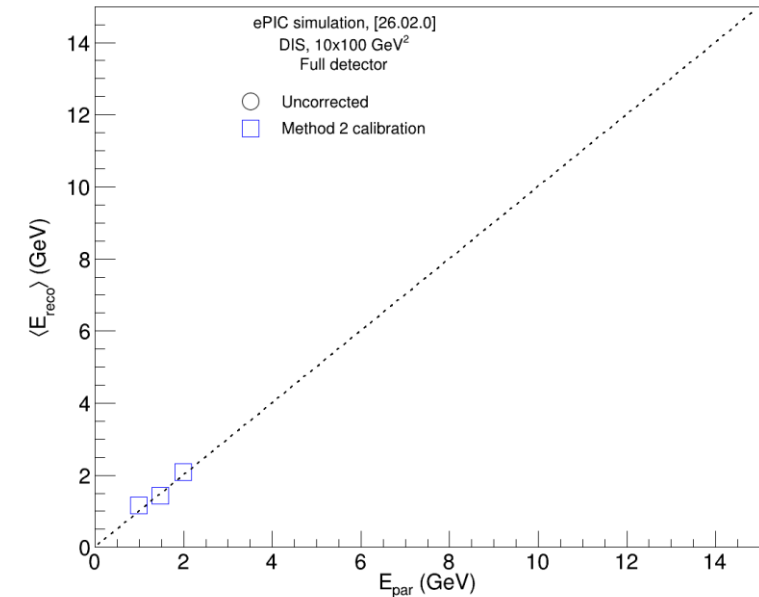
CALIBRATION RESULT

- DIS events **without background**
- (top) MC π^+ energy vs. mean RC π^+ calibrated energy
- (bottom) Energy resolution for π^+
- Now missing uncalibrated reference
 - Will be added



CALIBRATION RESULT

- DIS events **with background**
- (top) MC π^+ energy vs. mean RC π^+ calibrated energy
- (bottom) Energy resolution for π^+
- Now missing uncalibrated reference
 - Will be added
- **No significant difference observed in energy resolution**
 - Especially within statistical precision



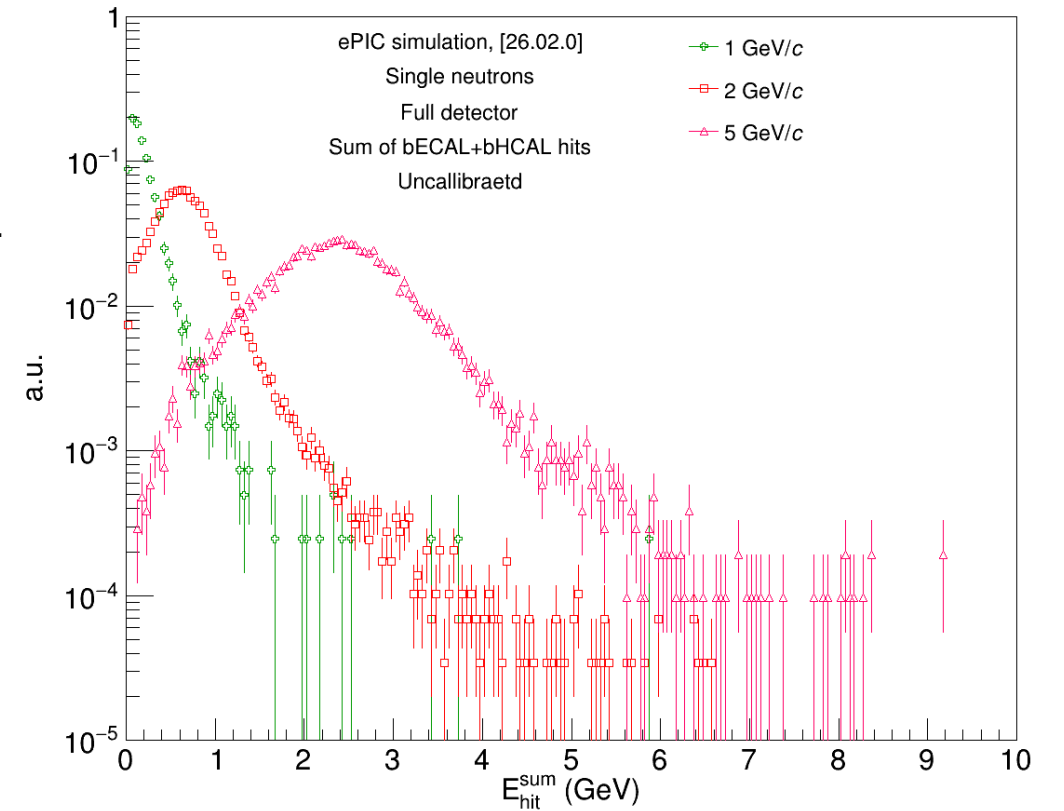
NEW CALIBRATION PROCEDURE

CALIBRATION METHOD FROM sPHENIX

- Single neutron simulations from 26.02.0 campaign
- This study is using Method 2 calibration
 - $E_{calib} = G_{bECAL}E_{bECAL} + G_{bHCAL}E_{bHCAL}$
 - Asymmetry: $A = (E_{bECAL} - E_{bHCAL}) / (E_{bECAL} + E_{bHCAL})$
 - Minimizing dependence of E_{calib} on asymmetry A
 - Based on 2D distribution E_{calib} vs. A
 - Manual scan for now for initial testing
 - Method described in [arXiv:1704.01461](https://arxiv.org/abs/1704.01461)

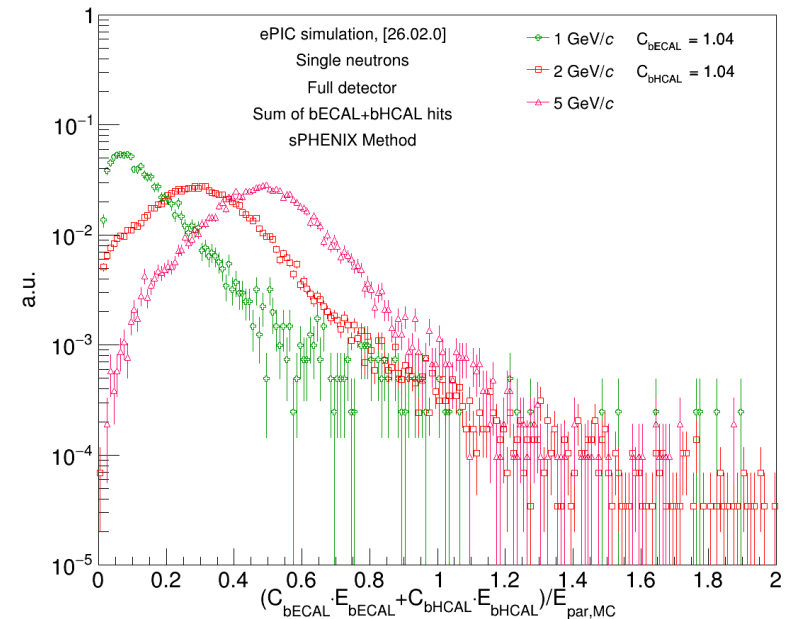
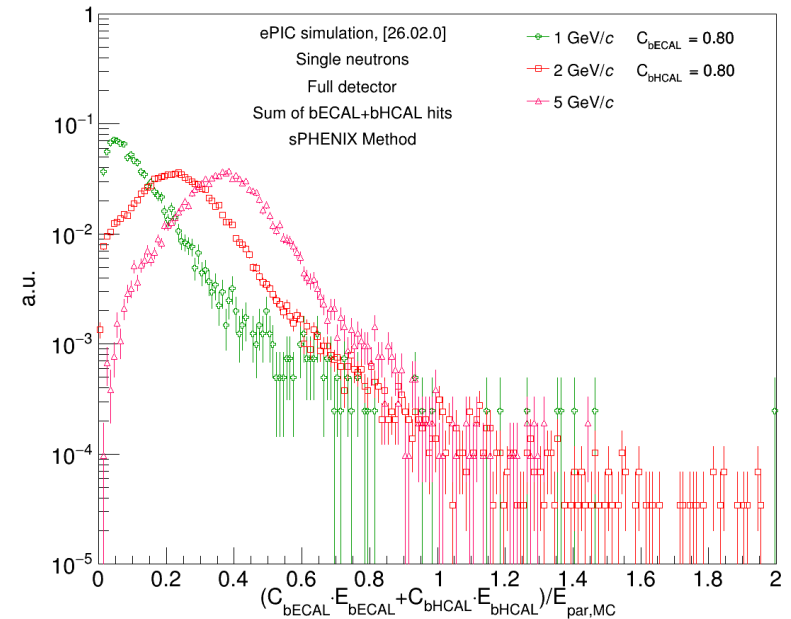
UNCALIBRATED ENERGY

- **Single neutron simulation**
- **Uncalibrated RC energy**
 - Sum of **hits** in bECAL+bHCAL
 - Using hits in single particle simulation to avoid issues with clustering



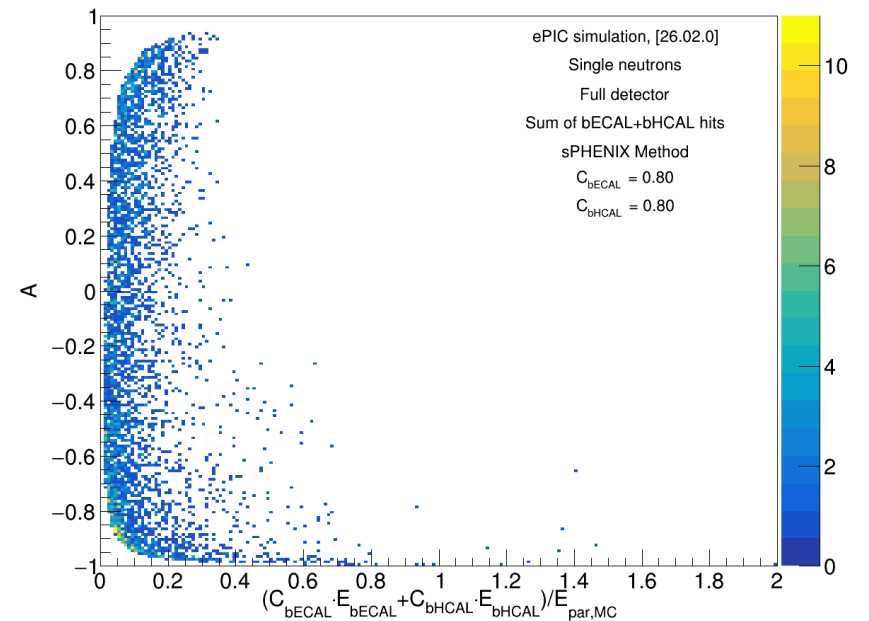
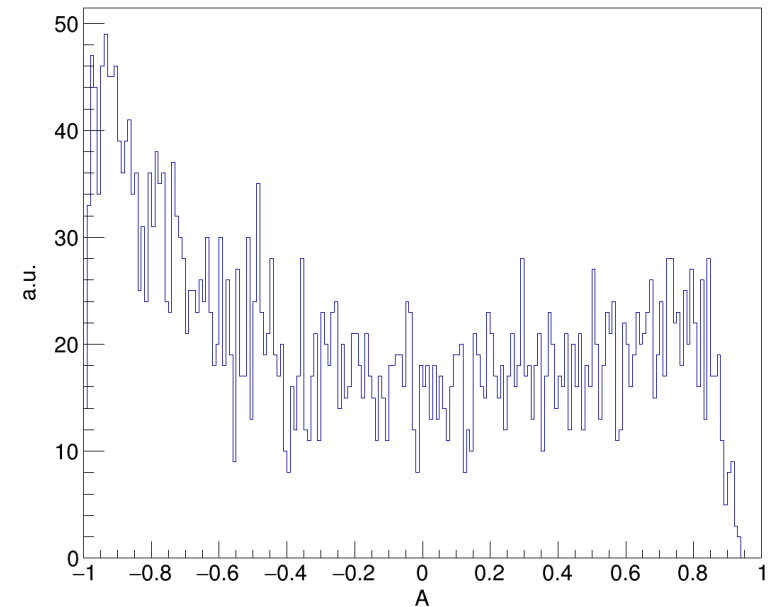
CALIBRATION DISTRIBUTIONS

- **Single neutron simulation**
- **Selected calibration distributions**
 - Scaled to MC energy: E_{calib}/E_{MC}
 - Test scan of calibration parameters for 5x5 values
 - $0.8 < G_{bECAL/bHCAL} < 1.2$
- **Distributions look reasonable**
 - Relatively good distributions for 1 GeV/c neutrons
 - Should potentially perform better than Method 2 at low E



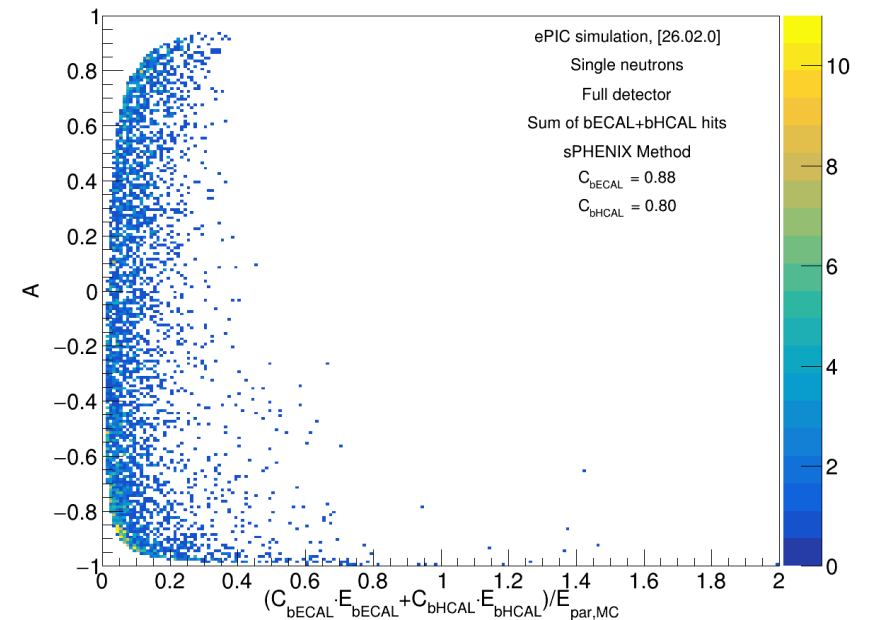
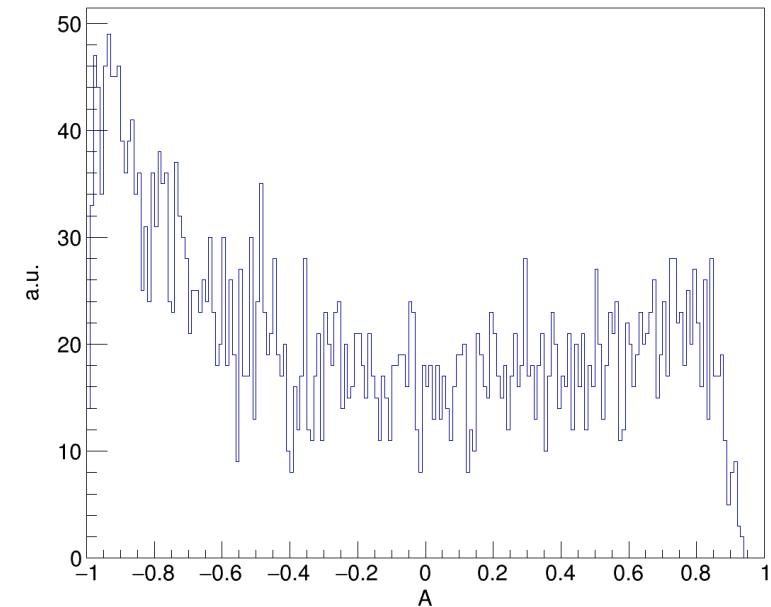
ASYMMETRY – 1 GeV/c

- **Single neutron simulation**
- (top) Asymmetry for 1 GeV/c neutrons
- (bottom) Calibration energy vs. asymmetry for 1 GeV/c neutrons
 - Scan for different calibration parameters
 - Example for:
 - One, fixed $G_{bHICAL} = 0.8$
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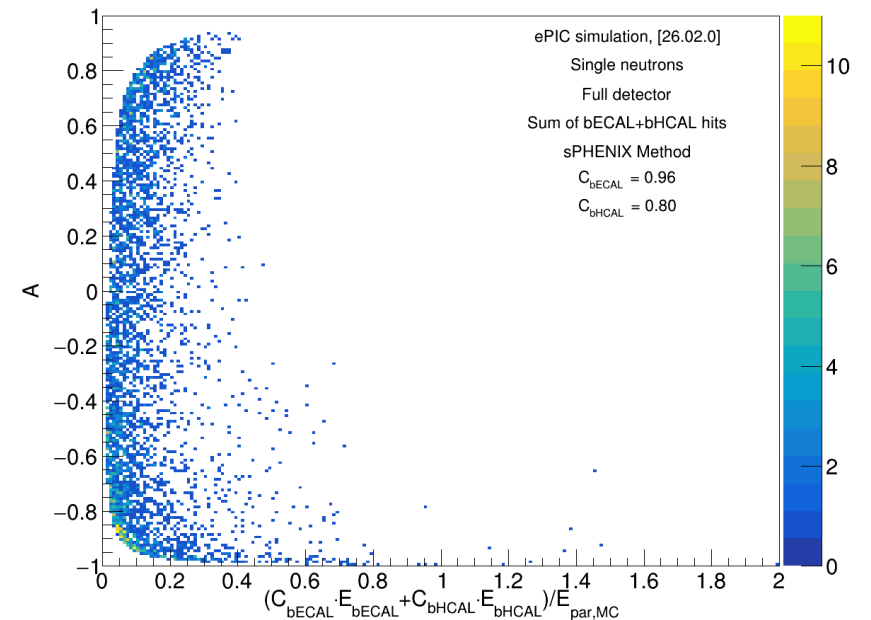
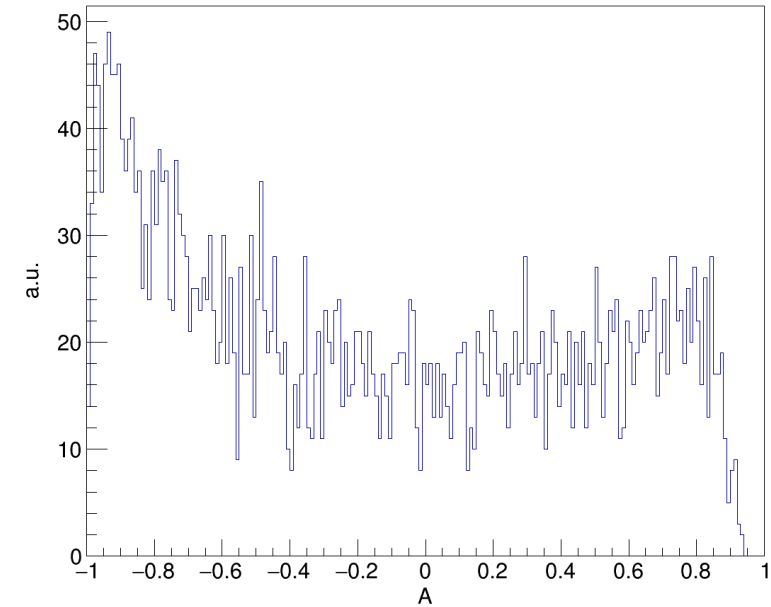
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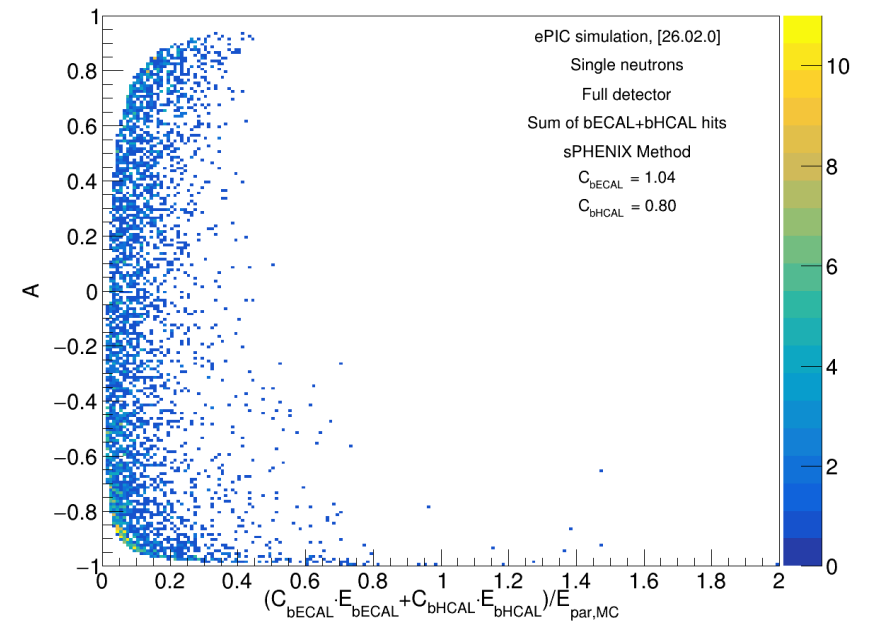
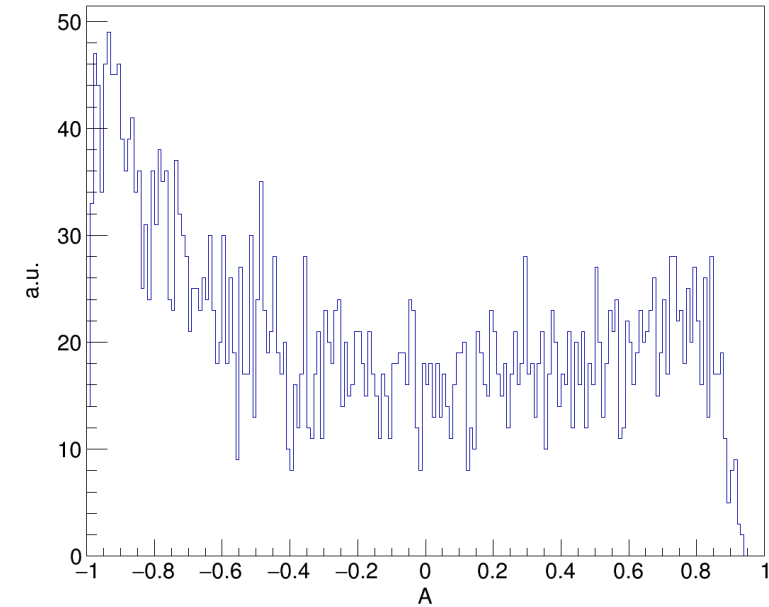
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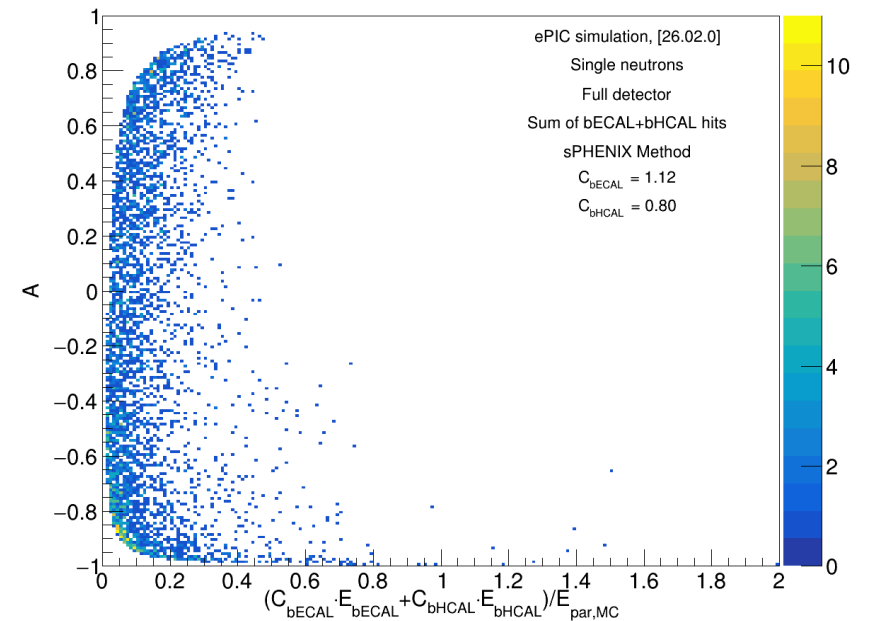
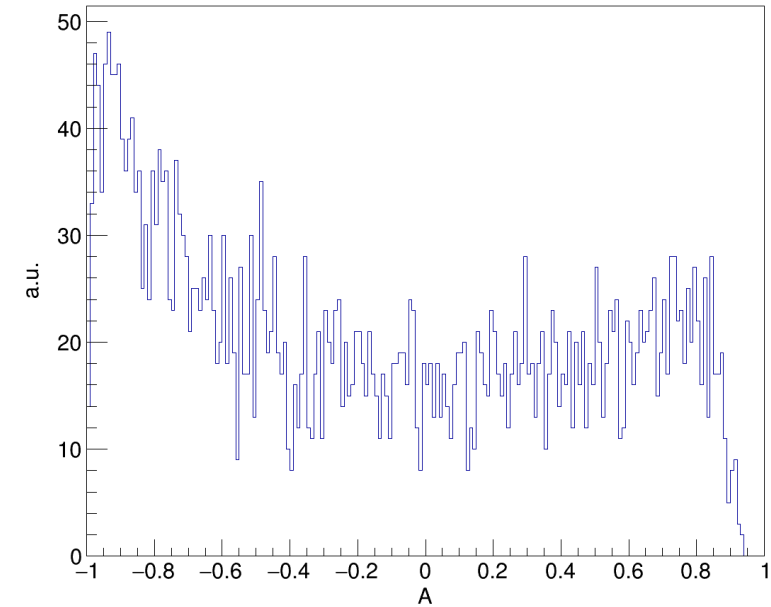
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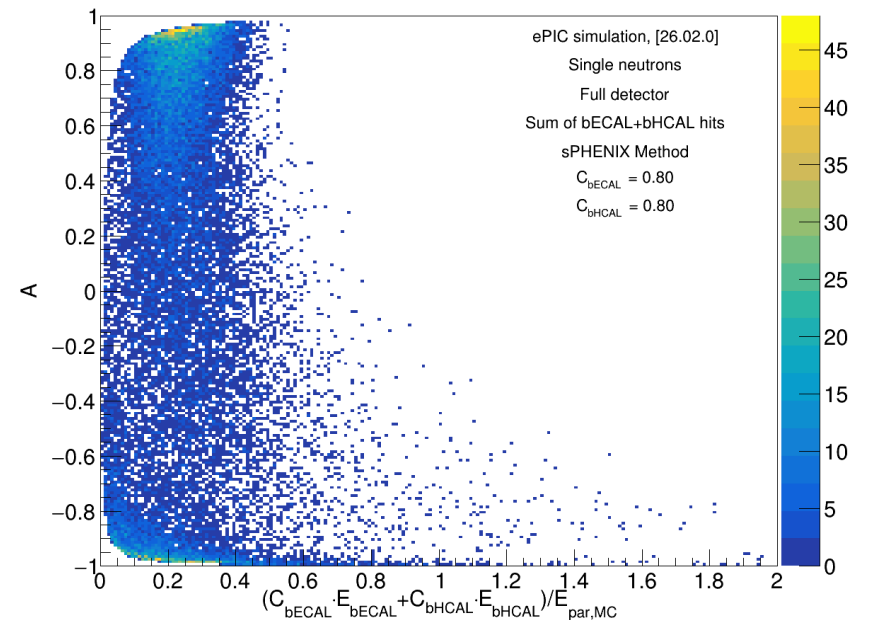
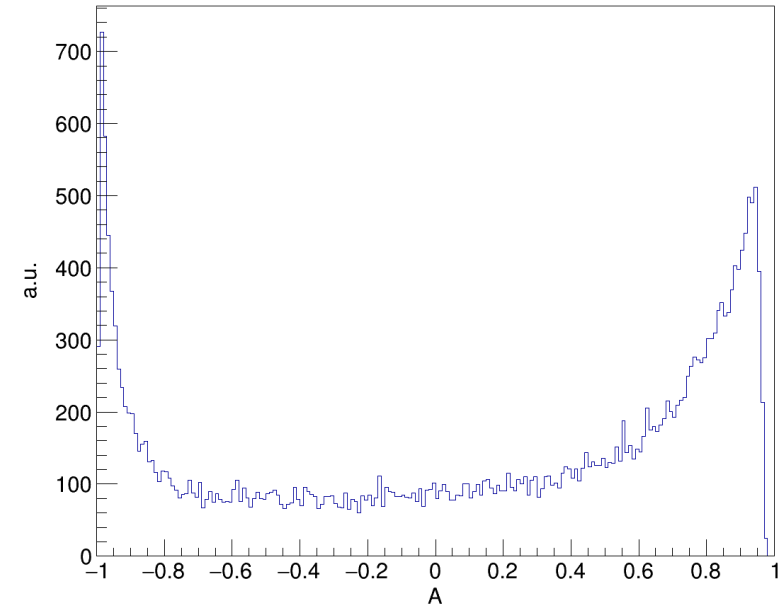
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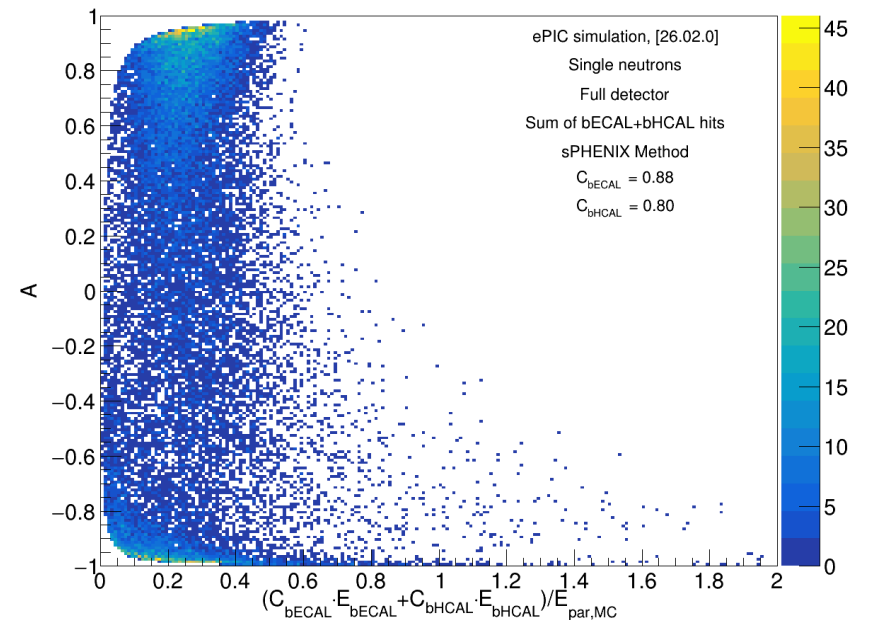
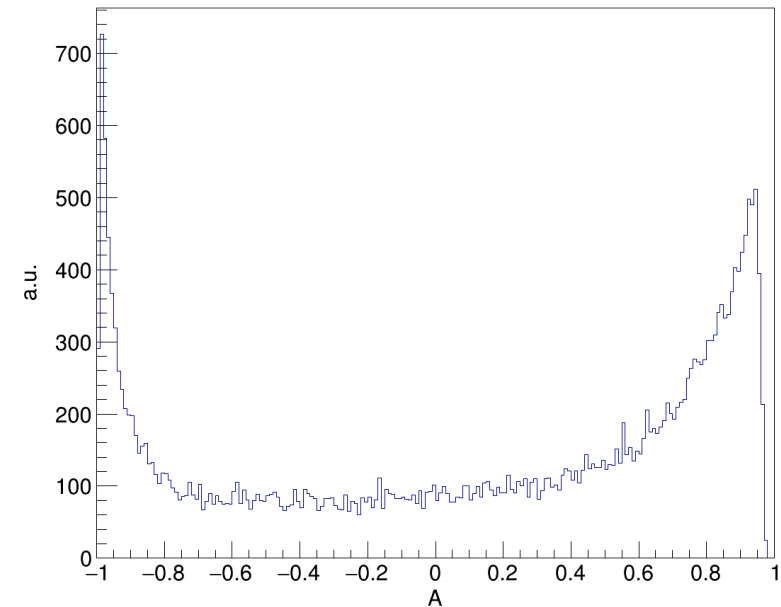
ASYMMETRY – 2 GeV/c

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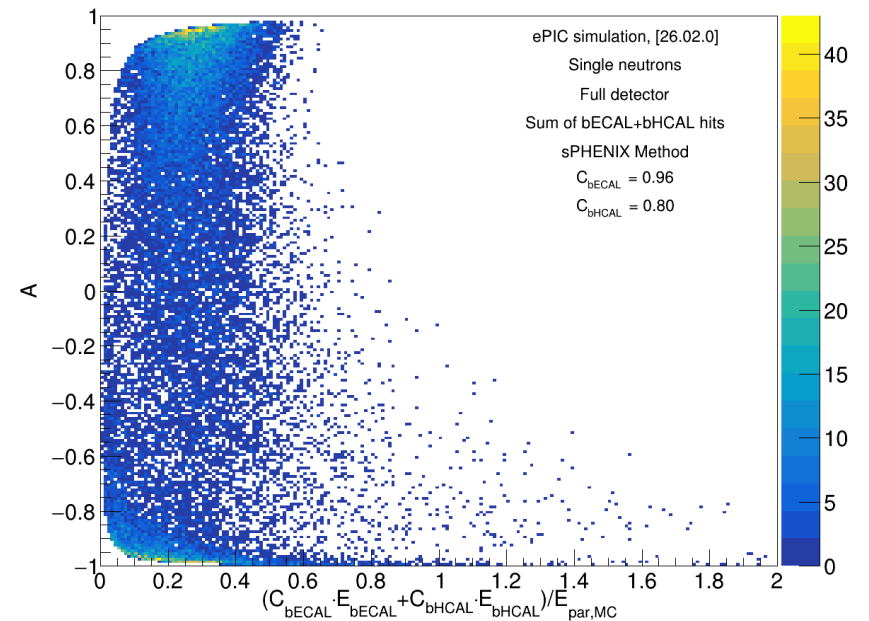
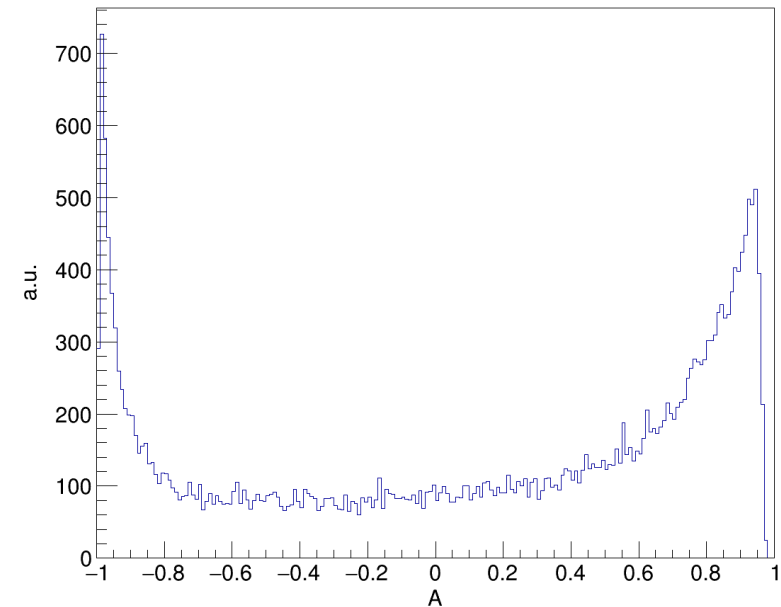
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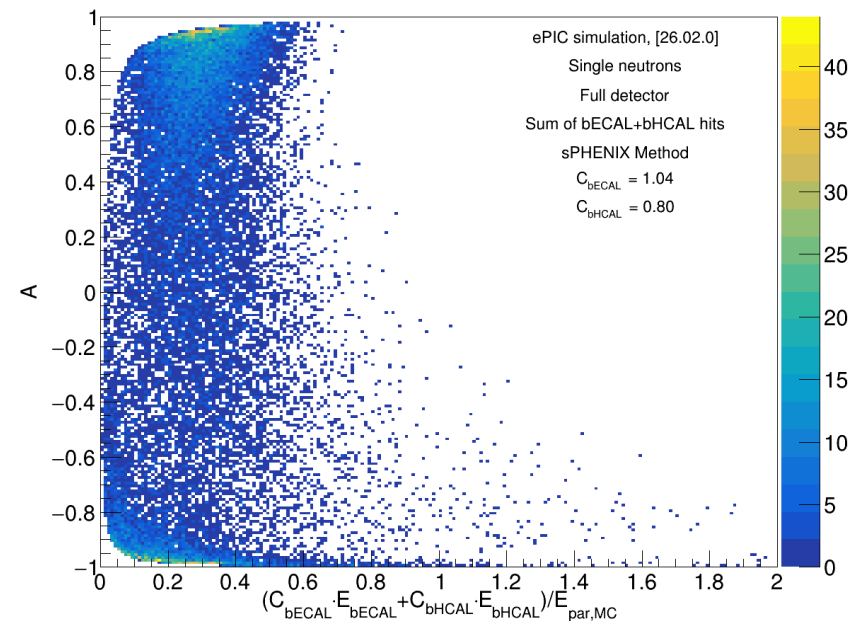
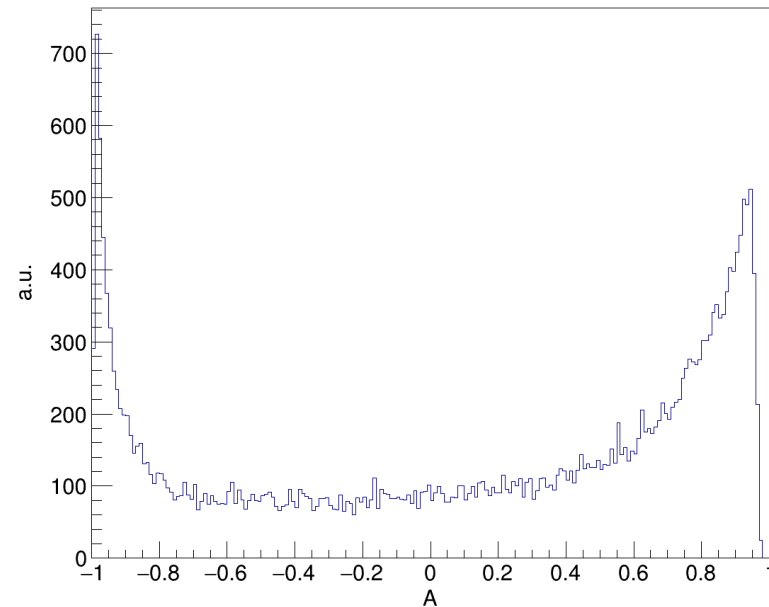
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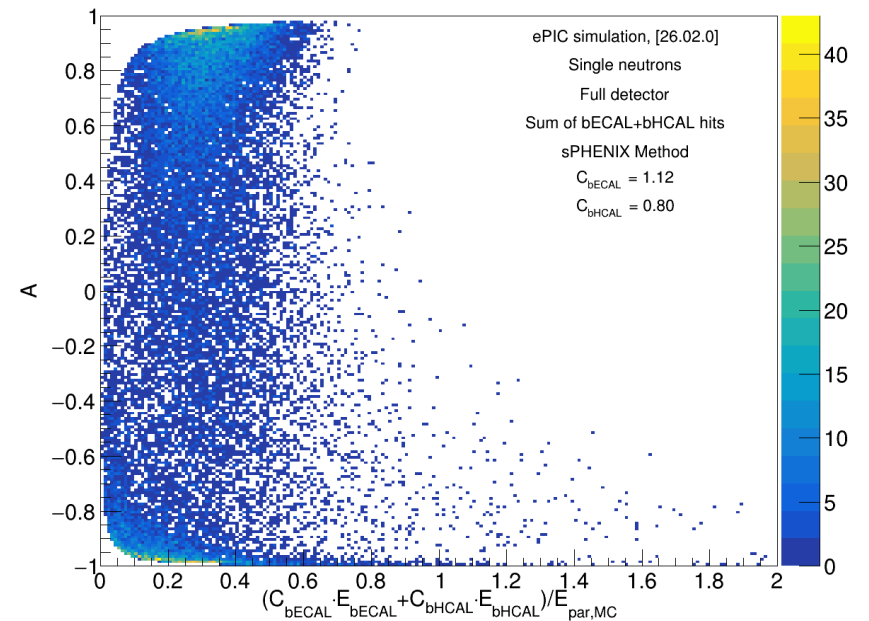
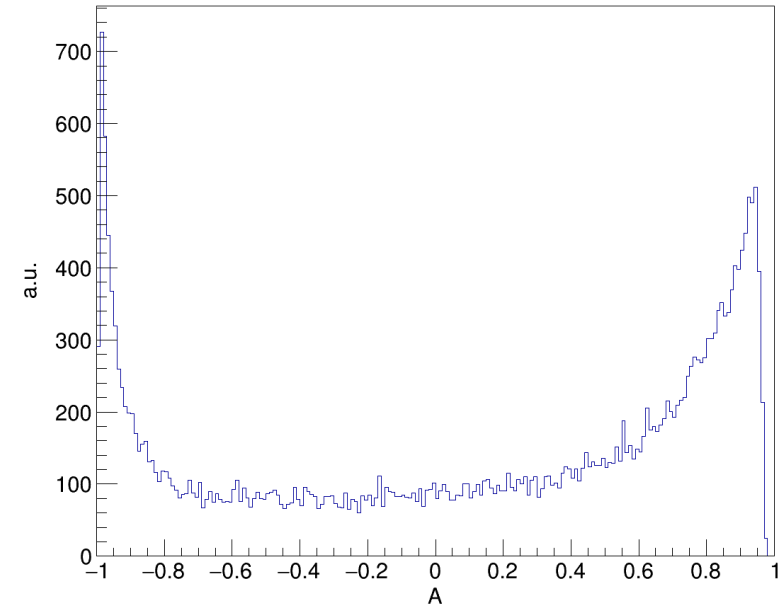
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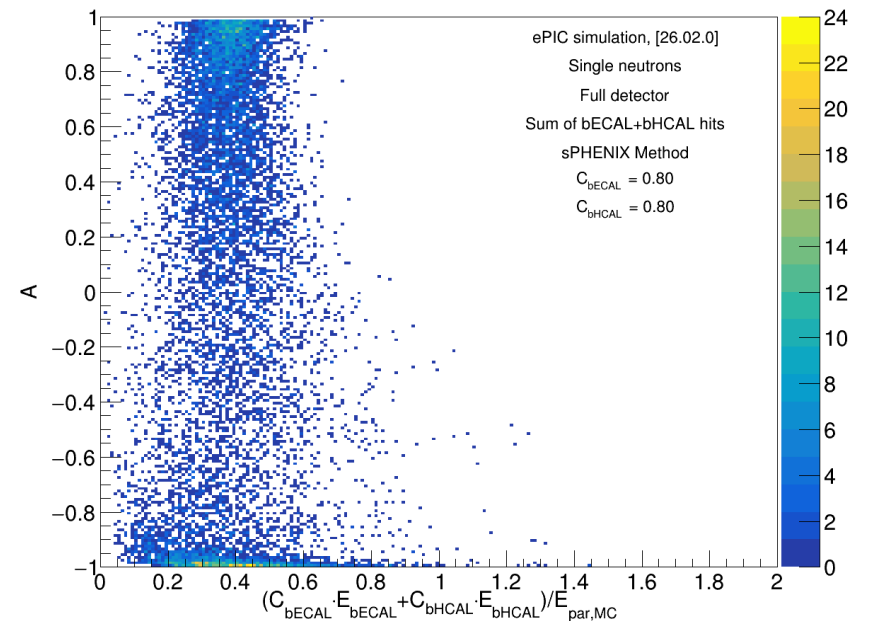
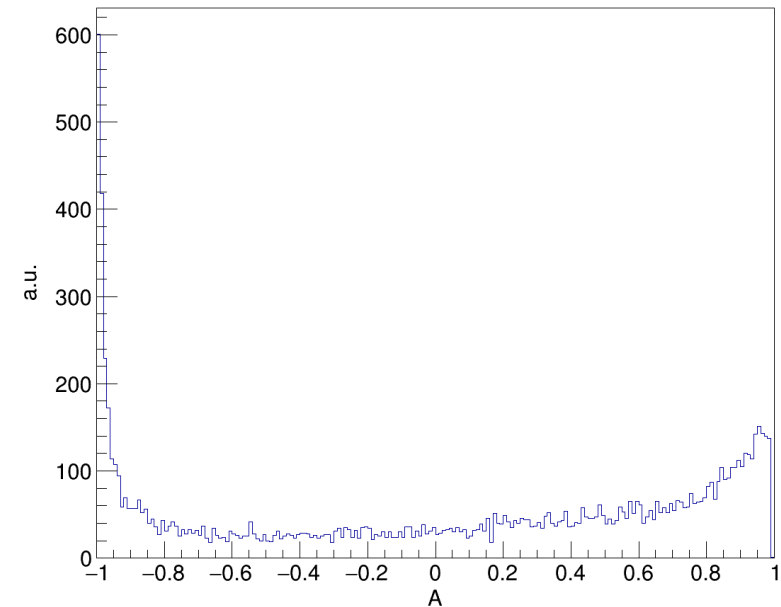
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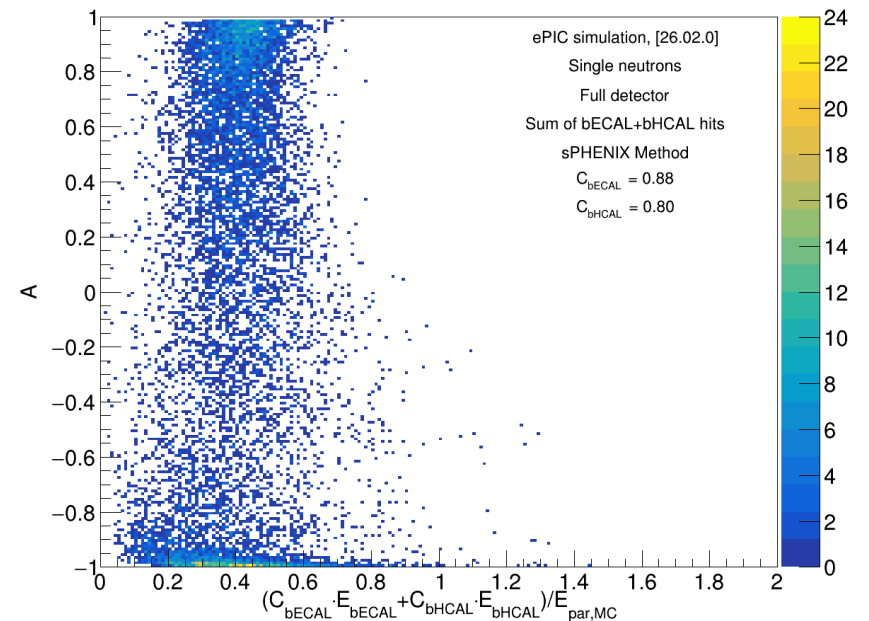
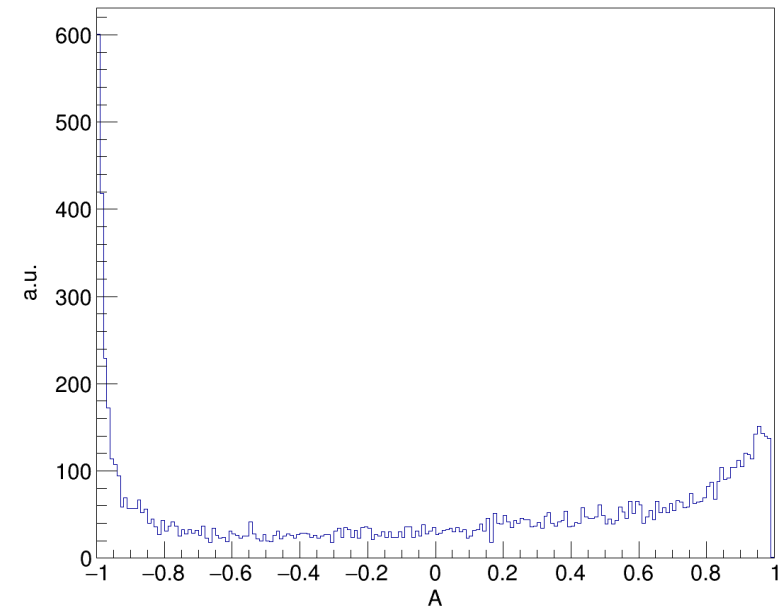
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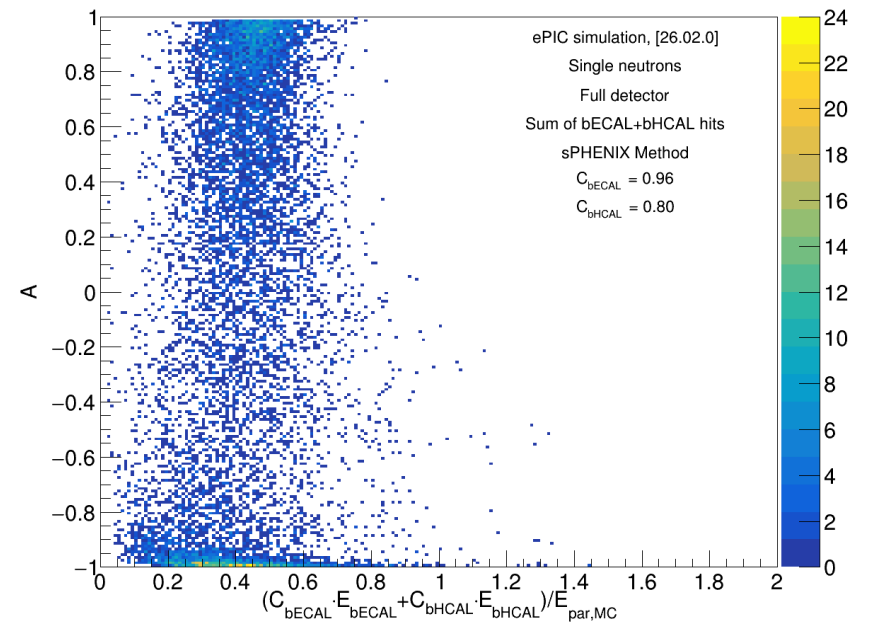
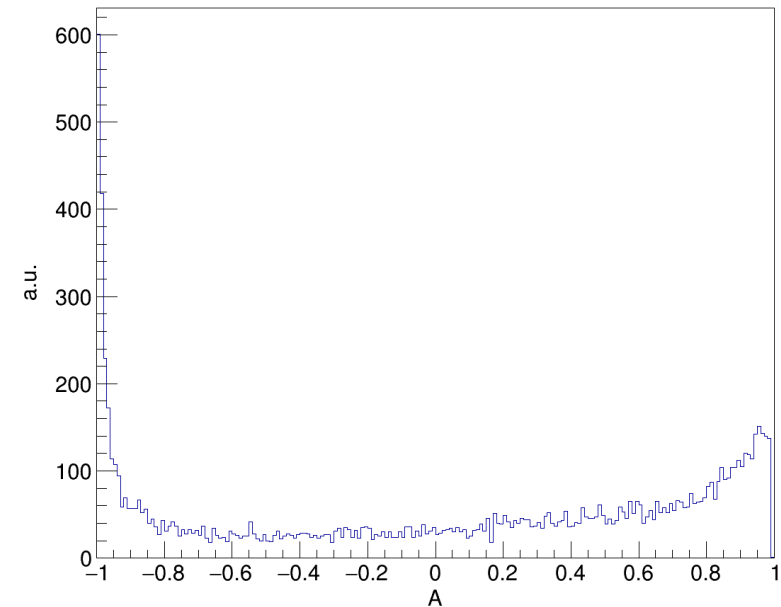
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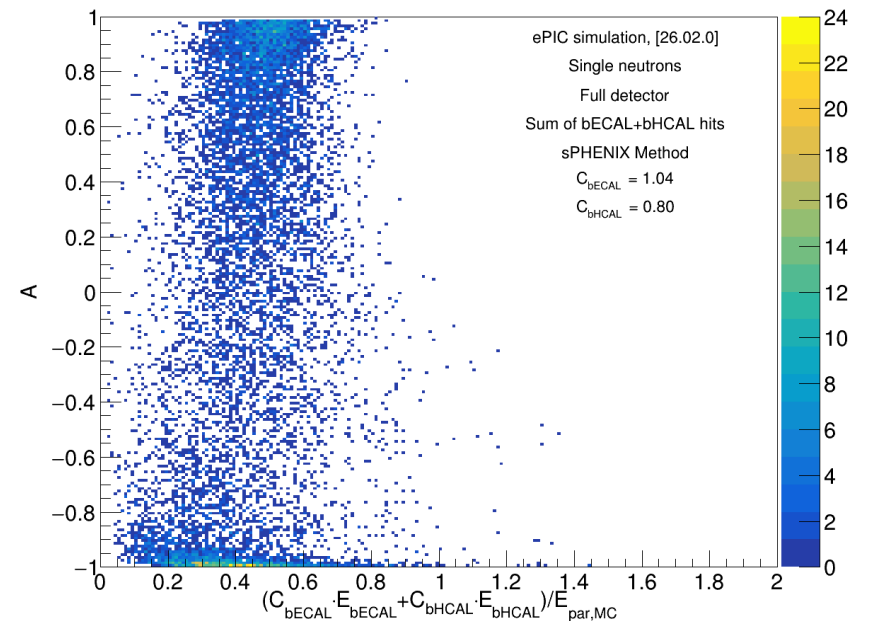
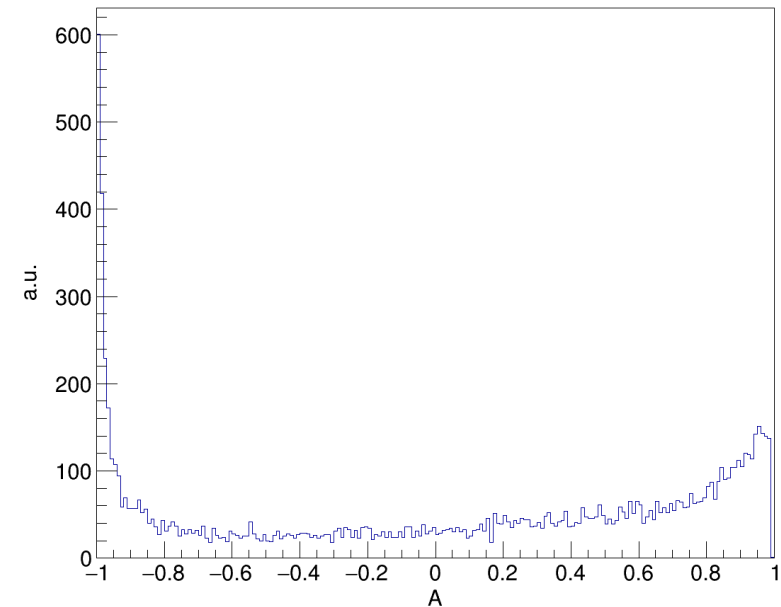
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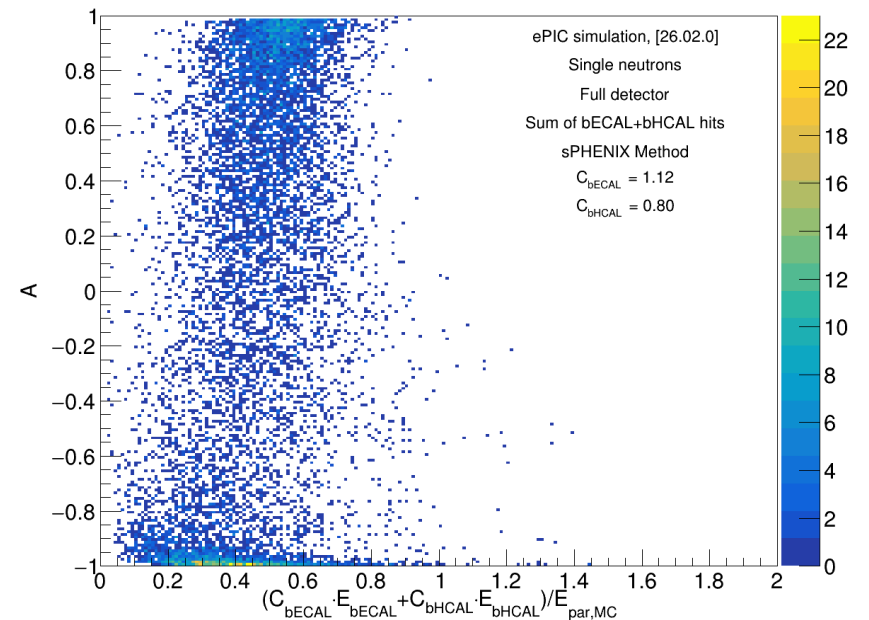
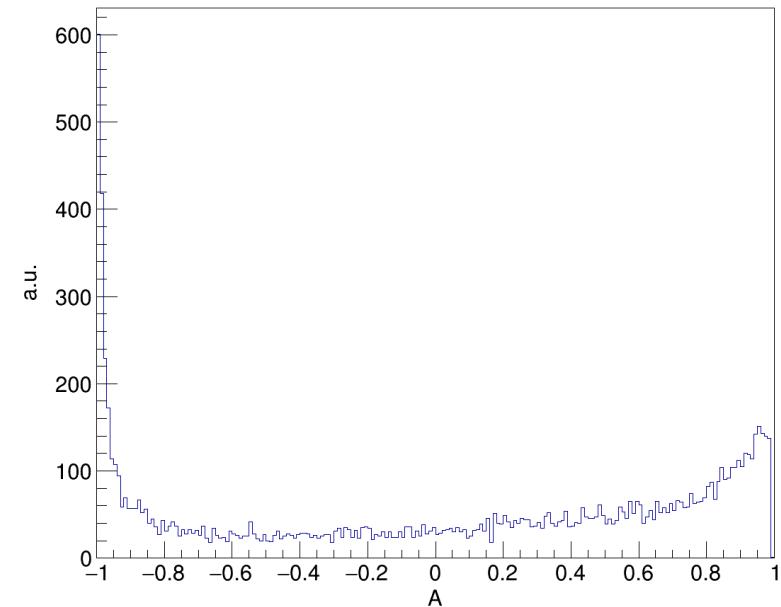
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SUMMARY AND OUTLOOK

- No significant difference in energy resolution in DIS sample with and without background
 - Using π^+ with True MC information
 - Tried also neutrons, but those are difficult in DIS events
- Implemented initial framework for sPHENIX calibration method
- Outlook:
 - Can make more iterations of background study
 - Use tracking
 - Use minimizer for sPHENIX method to perform calibration

THANK YOU FOR ATTENTION