An Update on Afterburner

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Where It All Started

- Goal
  - “afterburner” sanity check while using eA sample in far-forward simulation
  - Verify it shows still consistent after transformation
- What “afterburner” does
  - Head-on frame used in most event generator (no crossing angle nor beam effects)
  - Introduces beam crossing and any other beam effects to events
  - Translate from head-on frame to lab frame (detector design/simulation)
    - Electron is along z axis (solenoid axis is aligned with electron beam) and Hadron takes full crossing angle
    - Boost and rotation on all particles being stored in events
  - “afterburner” ep sample already validated with PYTHIA8 beam effects simulation
- This approach will be shown today
  1) Take “afterburner” ep and eA samples
  2) Undo what “afterburner” does on samples (reverse transformation/translation) from lab to head-on event generator frame: calculate Boost + Rotation
  3) Compare with nominal MC generator sample

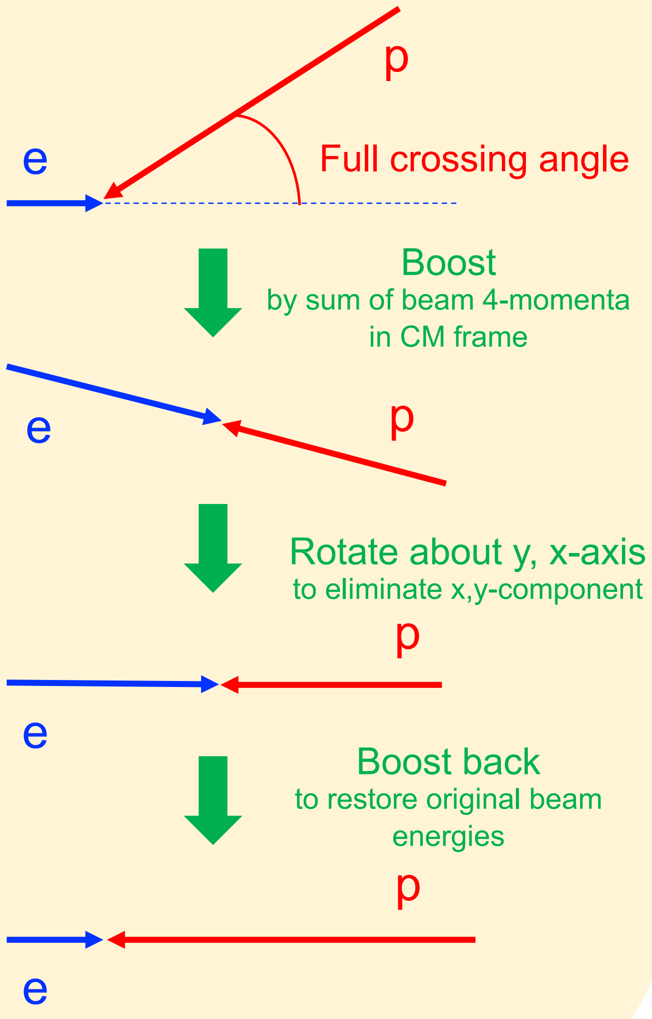
Samples – ep and eA

- Check a simple case (i.e. PYTHIA ep sample) to compare resulting particle distributions before and after "afterburner"
  - Used **PYTHIA6 SIDIS ep 18$\times$275 GeV^2** samples from Brian
    - PYTHIA6 generator HepMC3 file (Before "afterburner")
    - HepMC3 file after "afterburner" with IP-6 ep configuration ("afterburner")
    - Files are located in directory below
      /gpfs02/eic/bpage/home/EPIC/officialSimu/pythia6/sidis_minbias/HEPMCFILES
- Then, check with IP-8 BeAGLE ePb sample
  - Used **BeAGLE v1.03.02 ePb 18$\times$110 GeV^2** samples from Kong
    - BeAGLE generator HepMC3 file (Before "afterburner")
    - HepMC3 file after "afterburner" with IP-8 eAu configuration ("afterburner")
    - Files are located in directory below
      /gpfs02/eic/ztu/Analysis/BeAGLE/ePb_diffractive_VM/18x110_Q2_1_100/beagle_v1.03.02_ePb_18x110_Q2_1_100_batch_1

What to compare and How

- Compare between
  - Nominal sample from MC generator
  - “afterburner” sample
  - “afterburner” sample with reverse transformation
- Reverse transformation to “afterburner” sample
  - Calculate boost-rotation using beam particles
  - Apply all particles listed
  - Make crossing angle and beam effects removed
  - Transform to nominal distribution (original MC generator file)

Transformation Procedure



PYTHIA6 ep 18$\times$275 GeV^2

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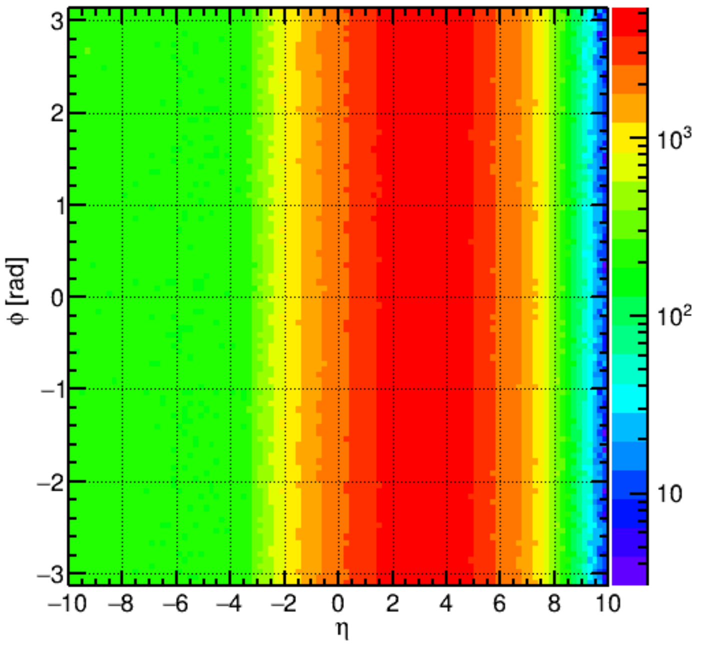
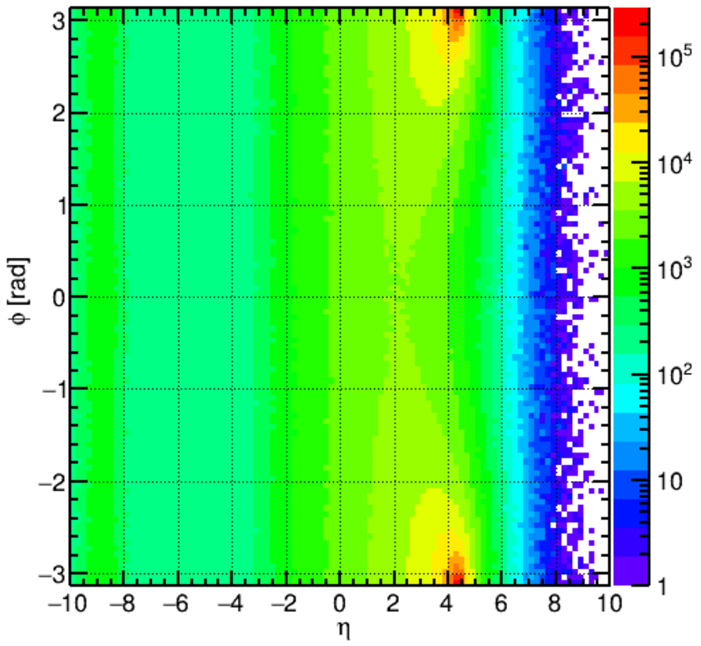
PYTHIA6 **ep** 18×275 GeV^2 Sample

All Final-state Particles: ϕ vs η

Nominal
from MC Generator

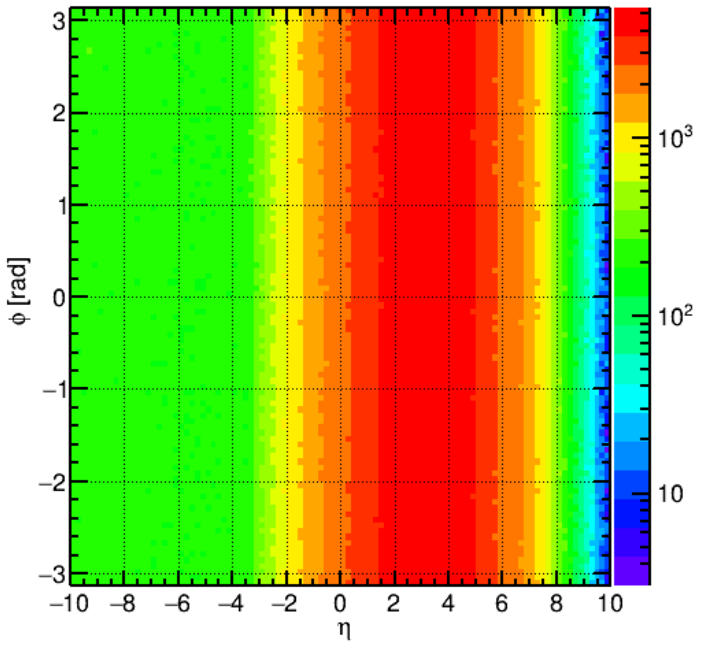


"afterburner"



transform

"afterburner"
with reverse transformation

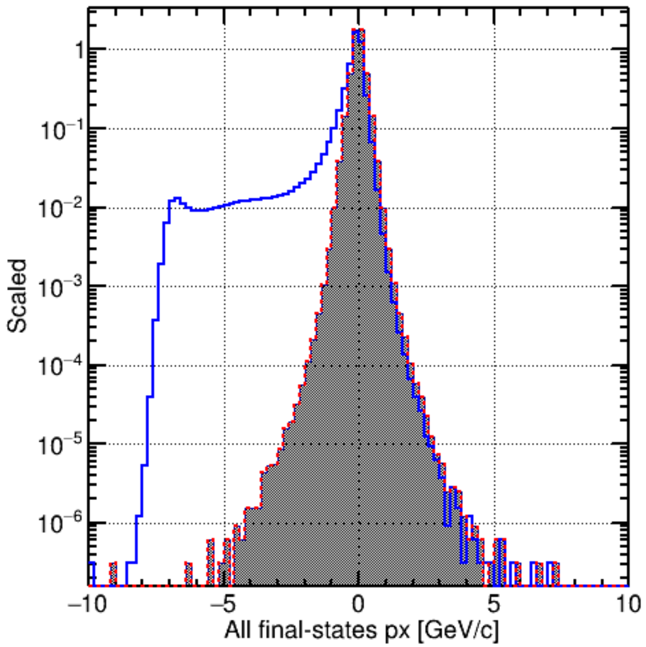


- Shown all final-state particles (status == 1) regardless of PID
- "afterburner" (middle): introduces a hot spot at η ~ 4.3 (crossing angle = 25 mrad) and $\phi = \pm\pi$ where IP-6 hadron beam is aligned along
- "afterburner" with reverse transformation (right): transformed to nominal distribution: what we expect!

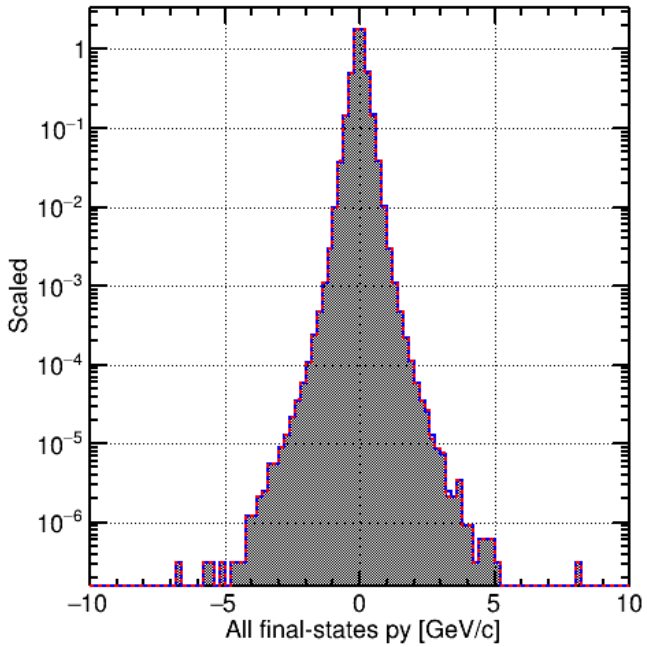
PYTHIA6 **ep** 18×275 GeV^2 Sample

All Final-state Particles: P_x, P_y, and P_z

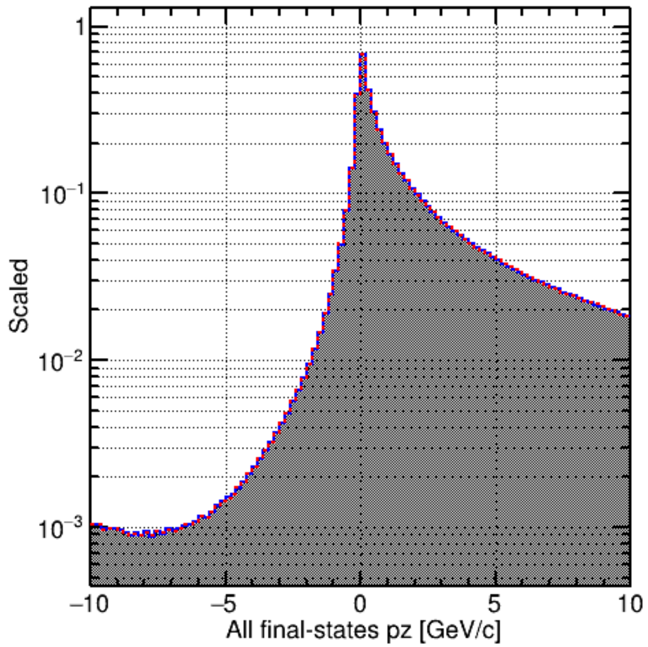
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum

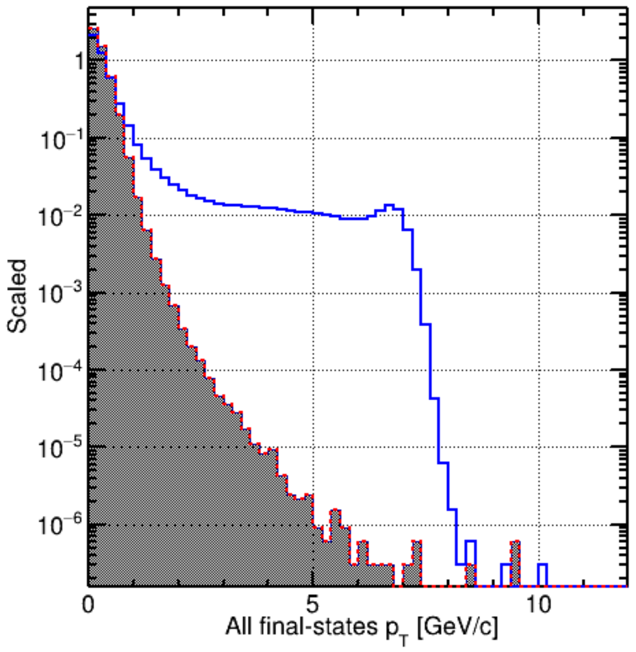


- Color scheme: Nominal, "afterburner", and "afterburner" with correction
- Normalized histograms by scaling by 1/integral and taking width into account
- Took "afterburner" (blue) distribution and applied correction → resulting is (red) distribution
- "afterburner" with reverse transformation (red) distribution transformed to nominal (shaded gray) distribution

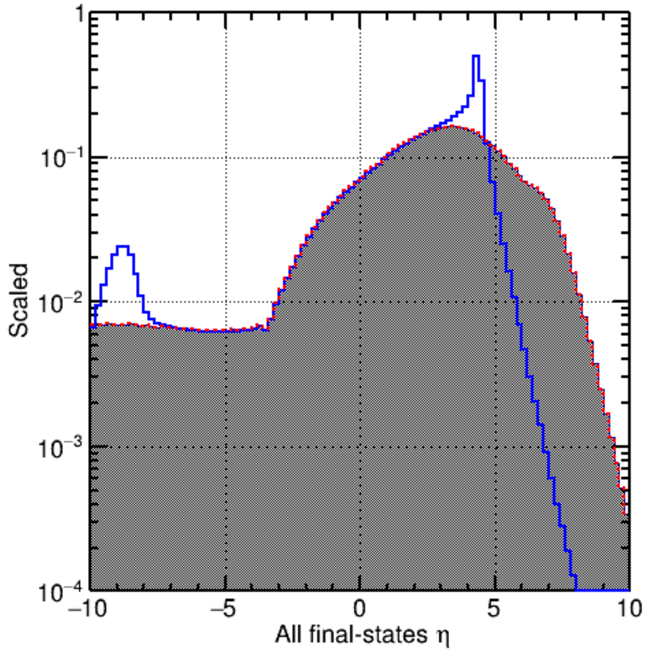
PYTHIA6 **ep** 18×275 GeV^2 Sample

All Final-state Particles: P_t, η, and ϕ

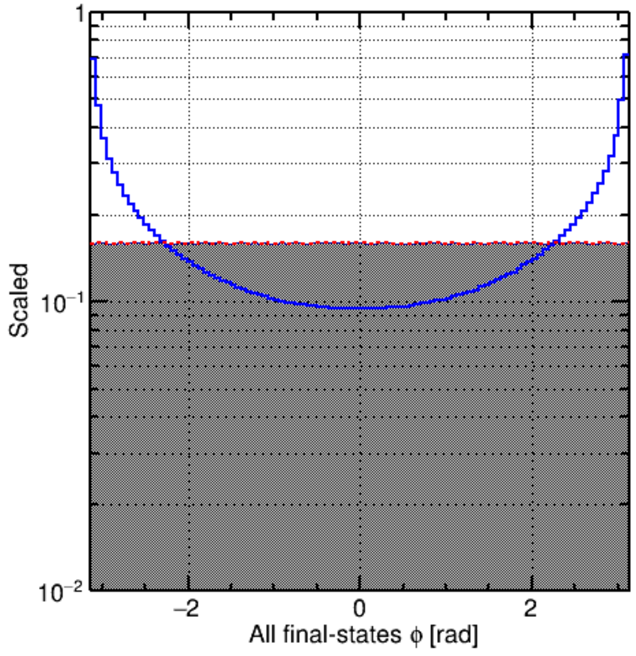
P_t
transverse momentum



η
pseudo-rapidity



ϕ
azimuthal angle



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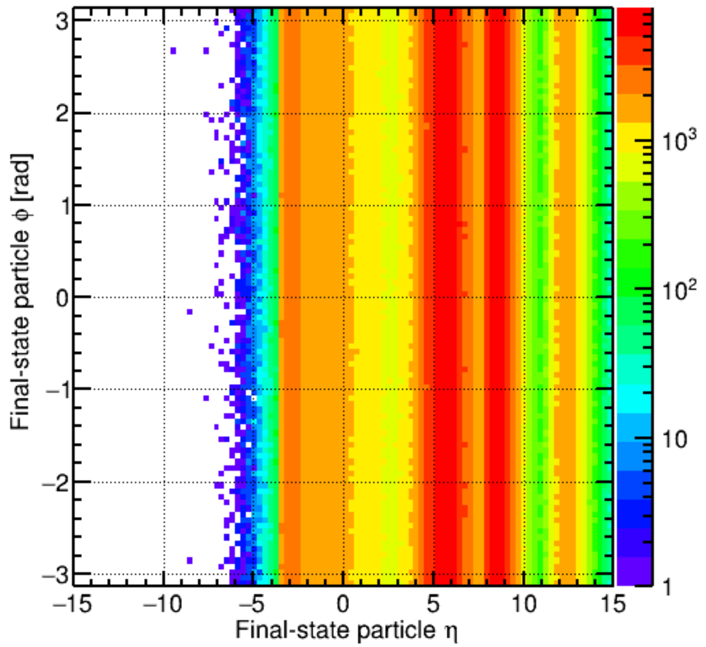
BeAGLE ePb 18$\times$110 GeV^2

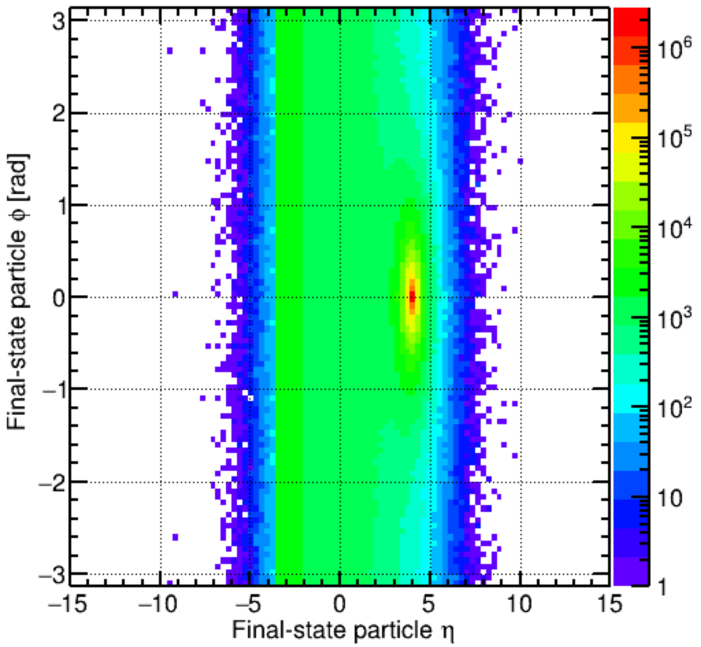
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

All Final-state Particles: ϕ vs η

Nominal
from MC Generator

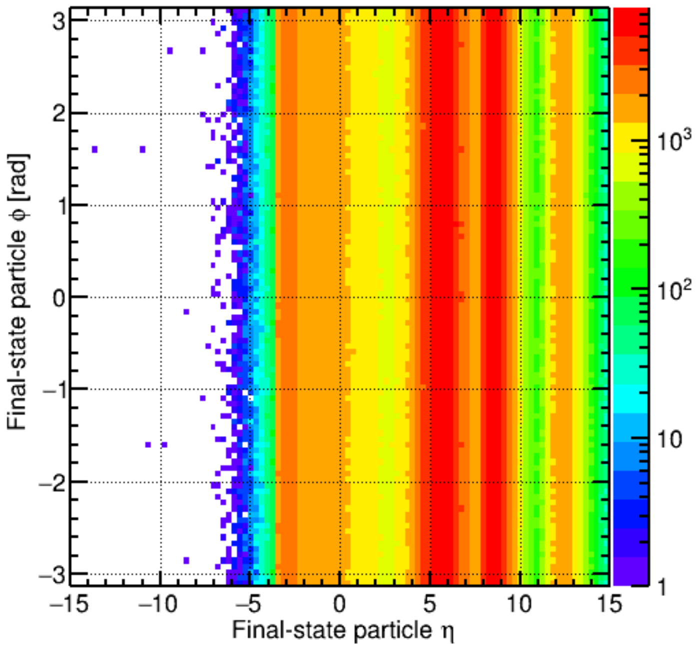


"afterburner"



transform

"afterburner"
with reverse transformation

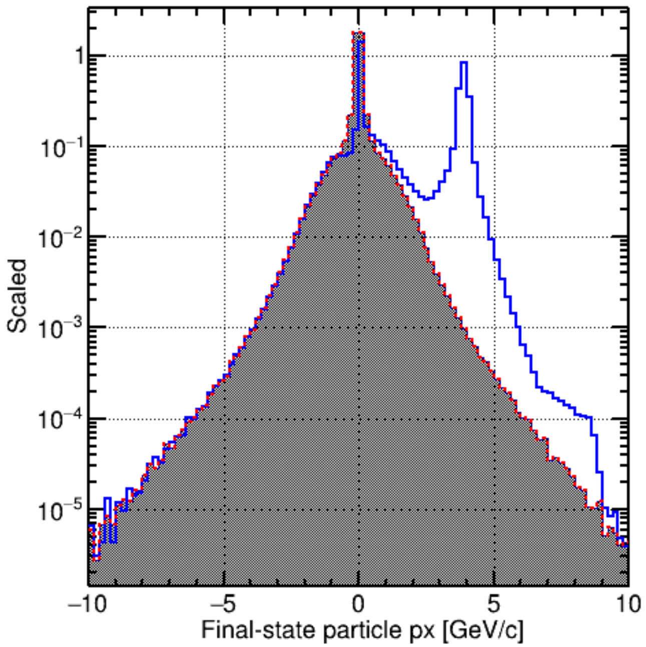


- Shown all final-state particles (status == 1) regardless of PID
- "afterburner" (middle): introduces a hot spot at η ~ 4 (crossing angle = 35 mrad) and $\phi = 0$ for IP-8 hadron beam is aligned along (opposite to IP-6)
- "afterburner" with reverse transformation (right): transformed to nominal distribution: what we expect!

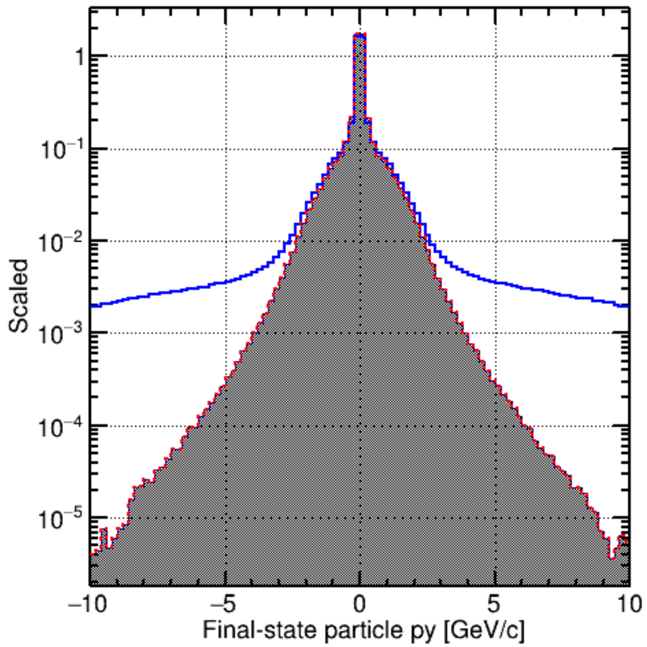
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

All Final-state Particles: P_x, P_y, and P_z

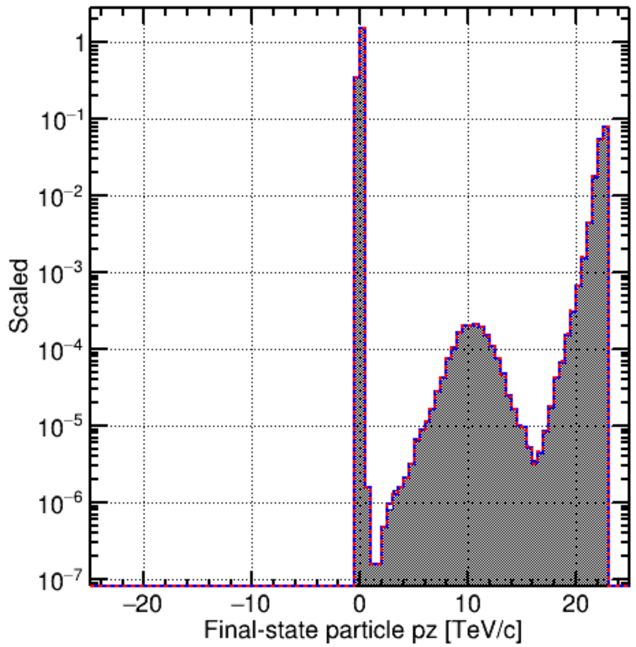
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



1 bin (i.e. 500 GeV)

- Color scheme: Nominal, "afterburner", and "afterburner" with correction
- Normalized histograms by scaling by 1/integral and taking width into account
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BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

All Final-state Particles: P_x, P_y, and P_z

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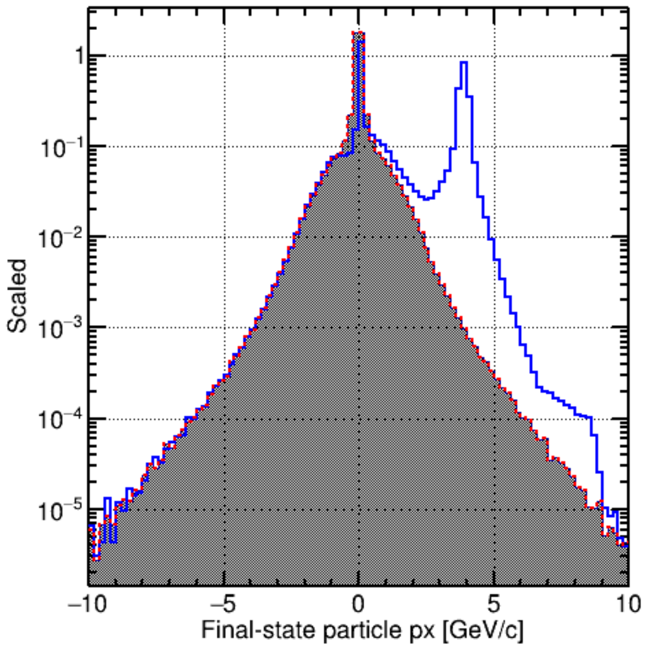
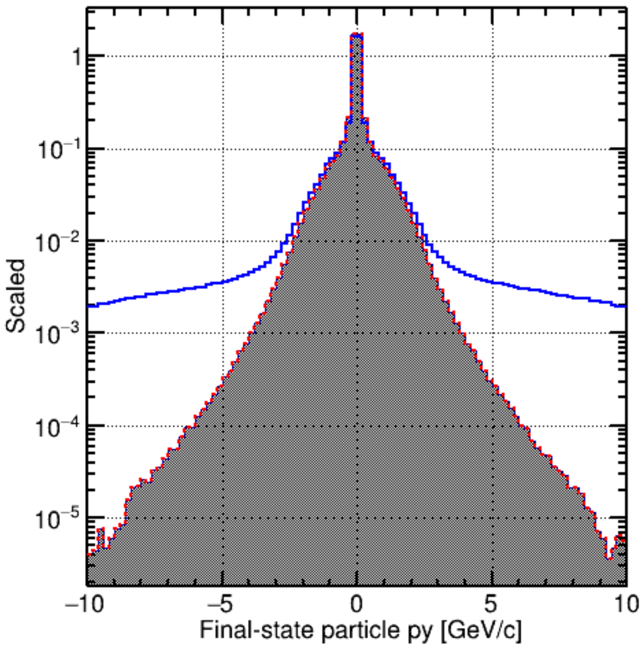
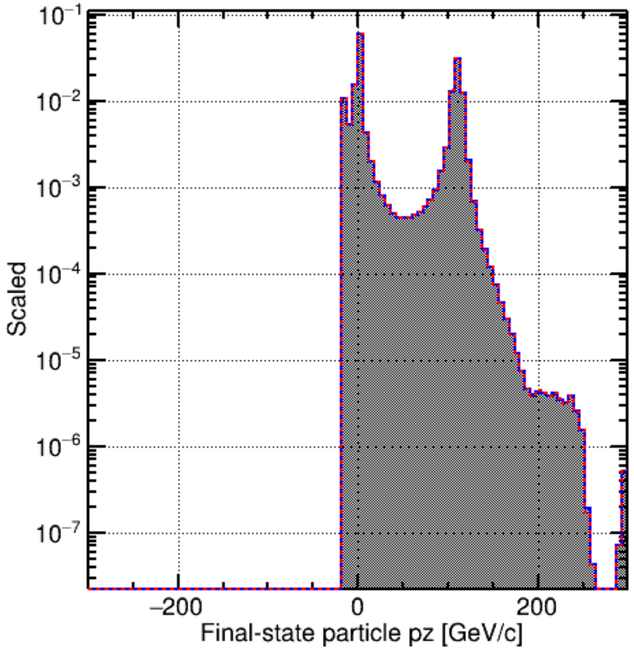
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



Zoomed into 300 GeV

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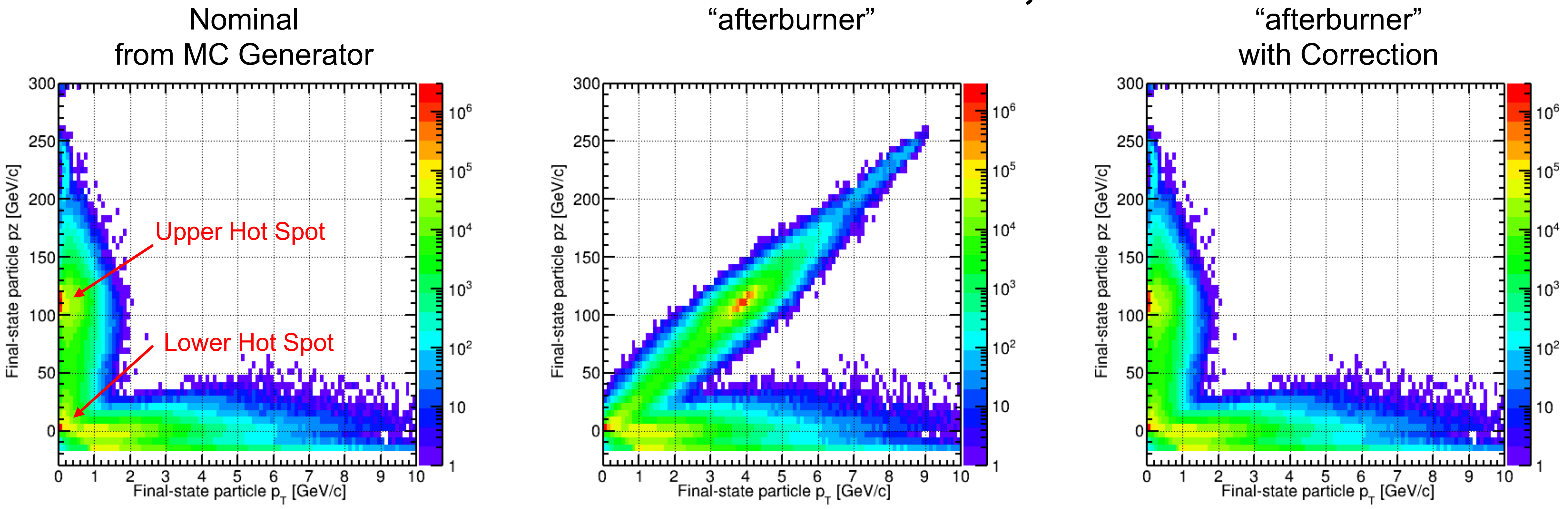
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

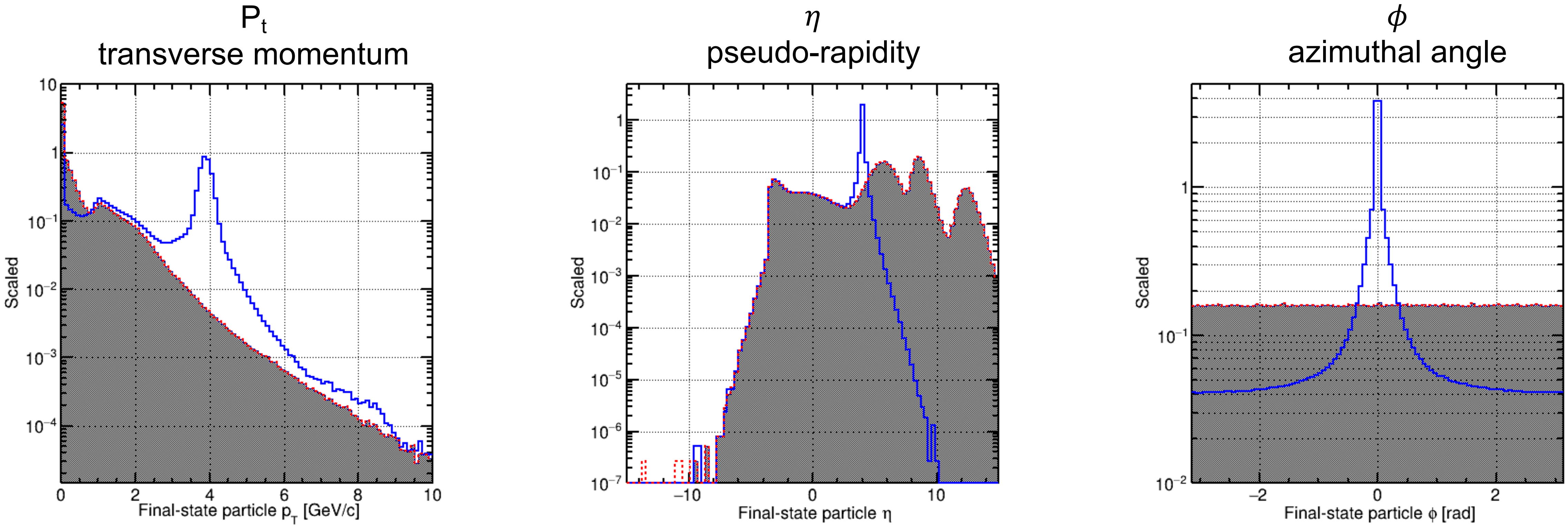
All Final-state Particles: P_z , and P_t



- Two hot spots are seen
- (p_T,p_z) ~ (0.2 GeV, 0.2 GeV): turned out to be soft photons (a few 100 MeV) from de-excitations! (lower hot spot)
- (p_T,p_z) ~ (0.2 GeV, ~100 GeV): turned out to be evaporated neutrons! (upper hot spot)
- Checked with BeAGLE output file to look up origin flag for final-state particles

BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

All Final-state Particles: P_t, η, and ϕ



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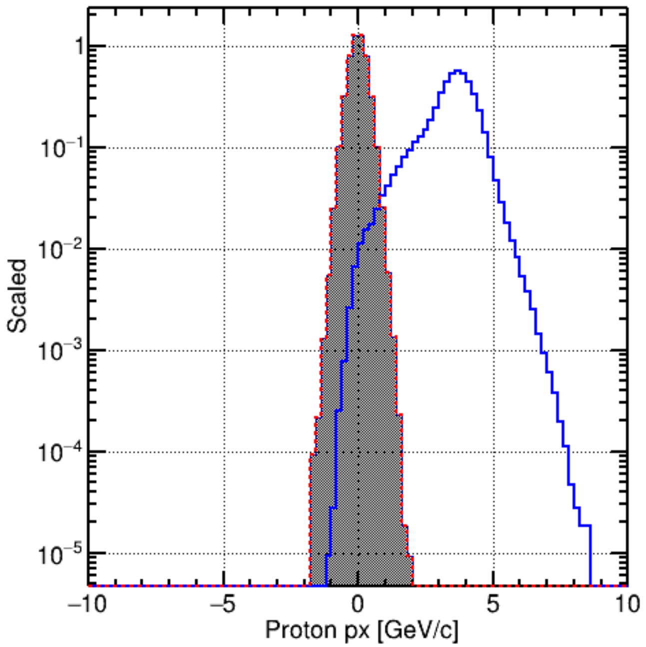
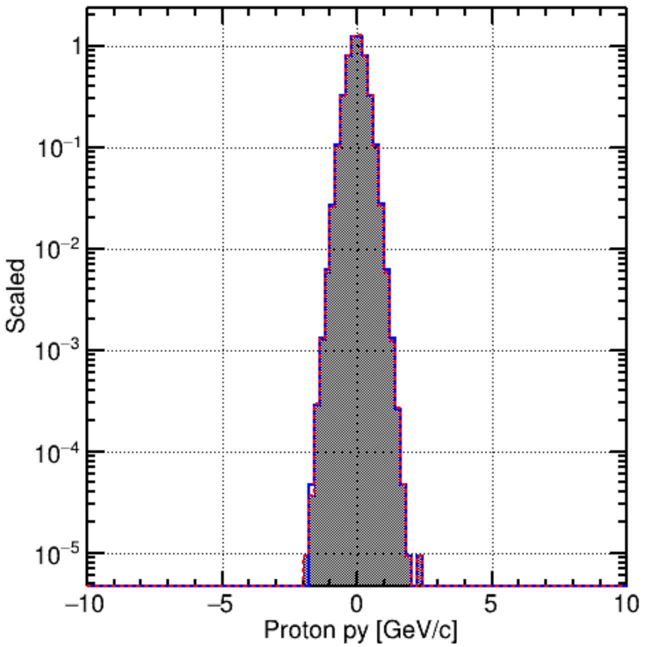
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Proton: P_x, P_y, and P_z

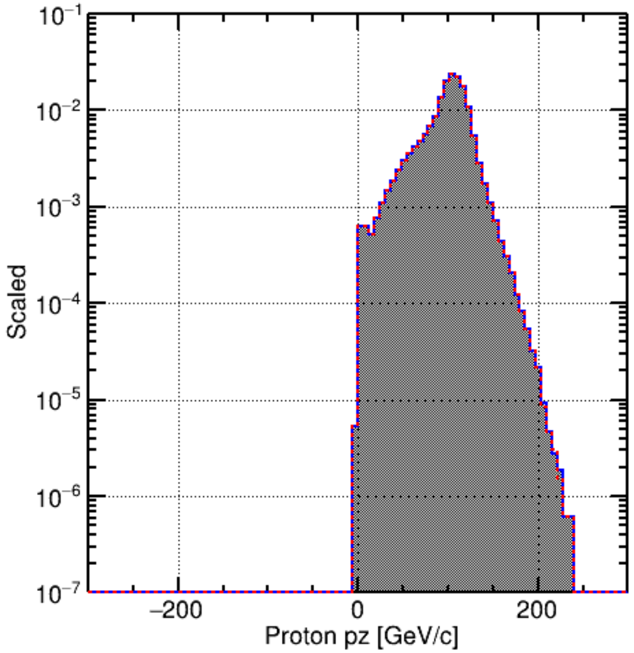
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



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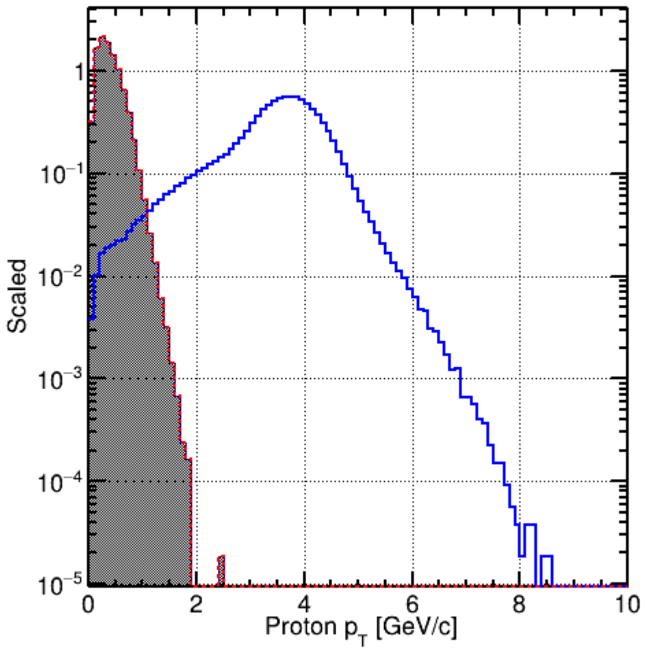
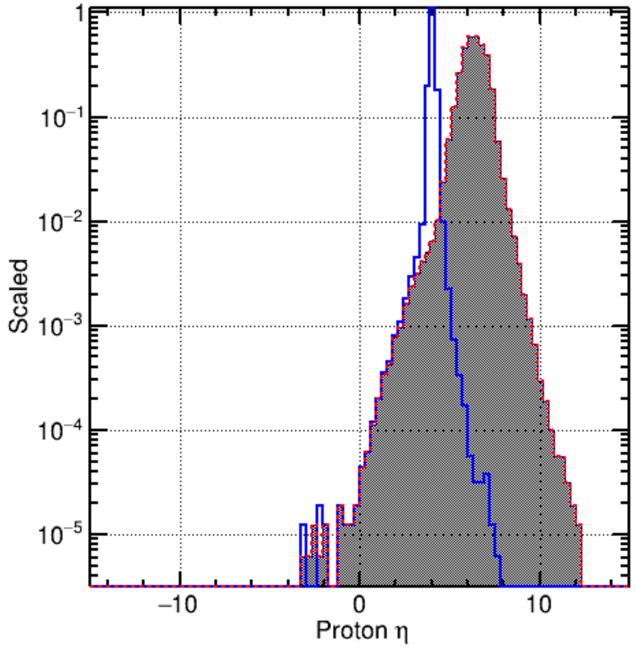
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Proton: P_t, η, and ϕ

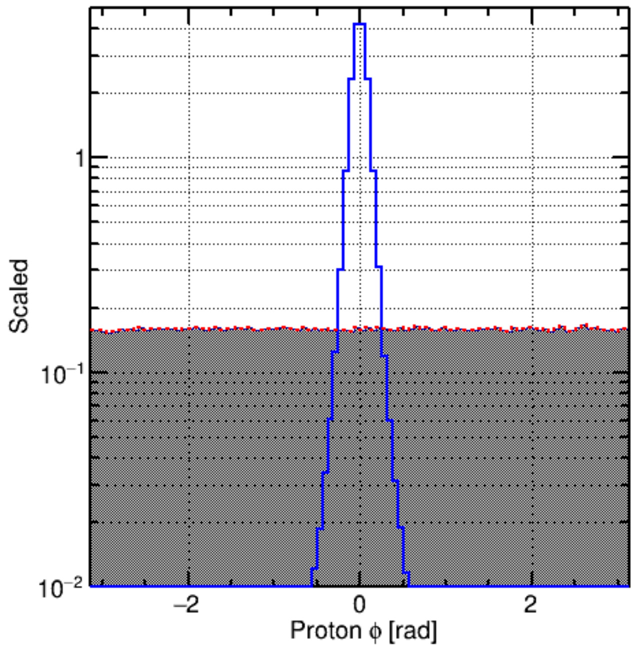
P_t
transverse momentum



η
pseudo-rapidity



ϕ
azimuthal angle



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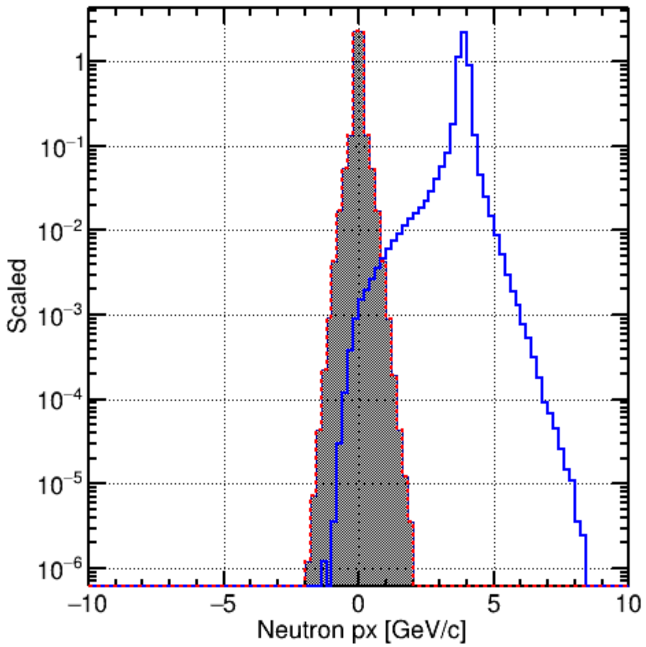
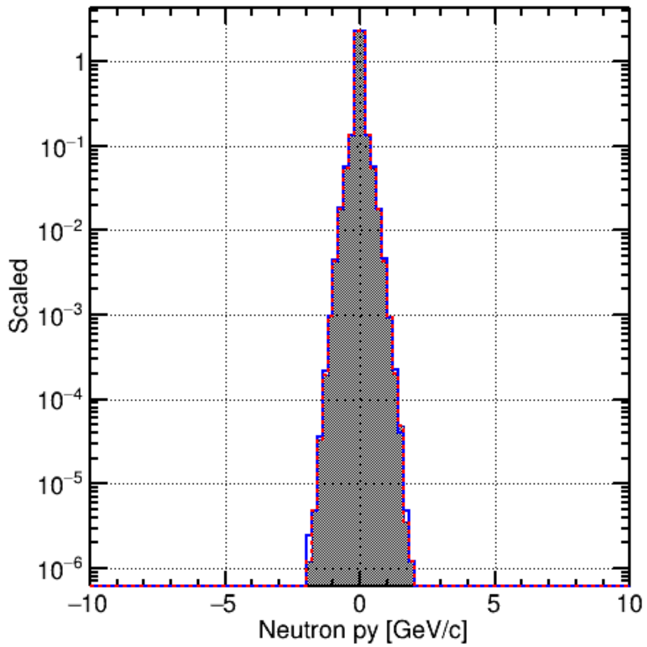
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Neutron: P_x, P_y, and P_z

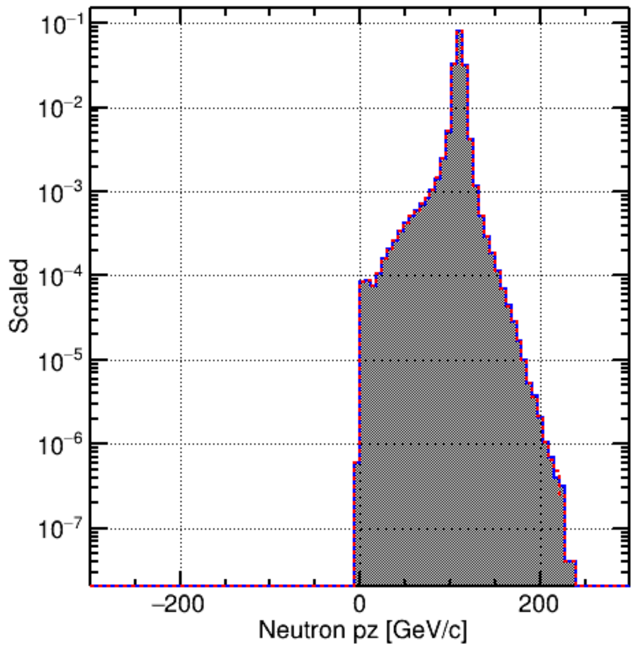
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



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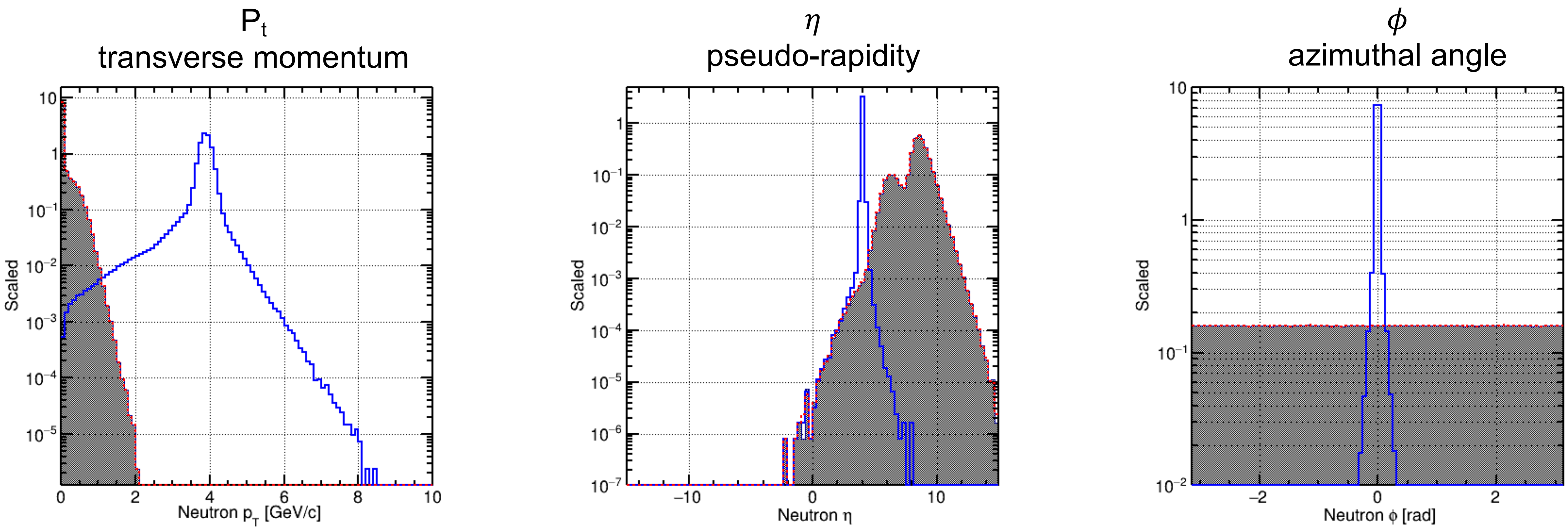
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Neutron: P_t, η, and ϕ



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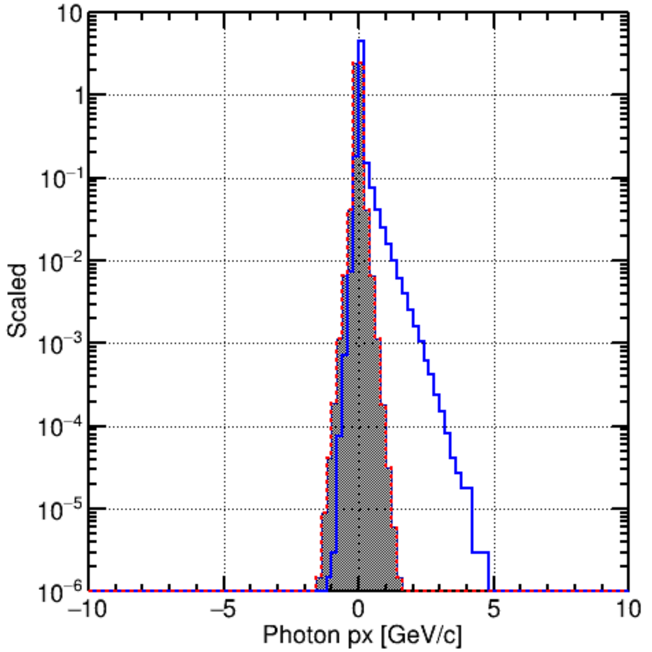
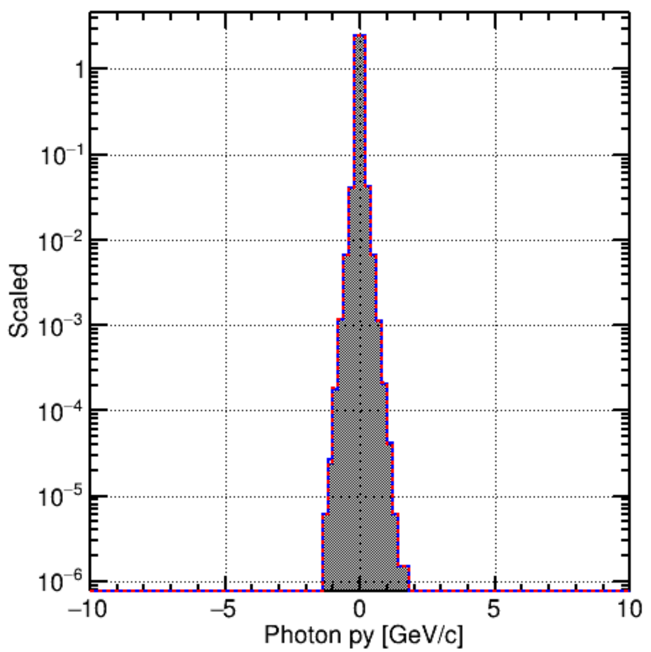
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Photon: P_x, P_y, and P_z

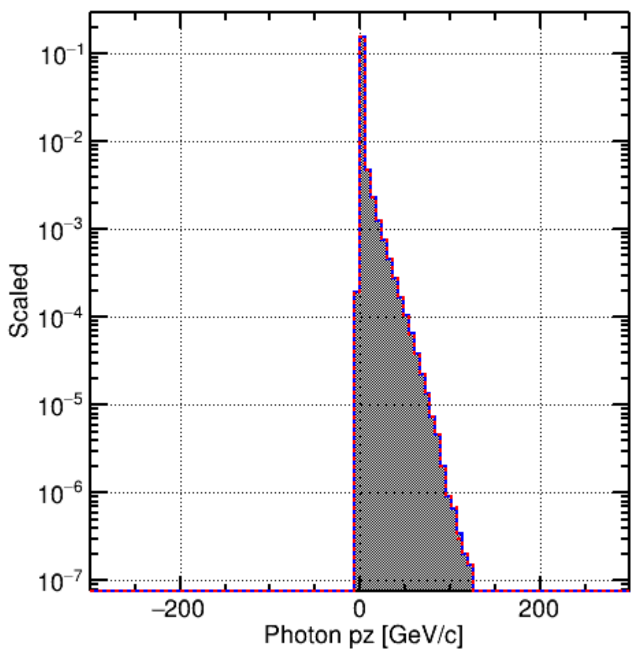
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



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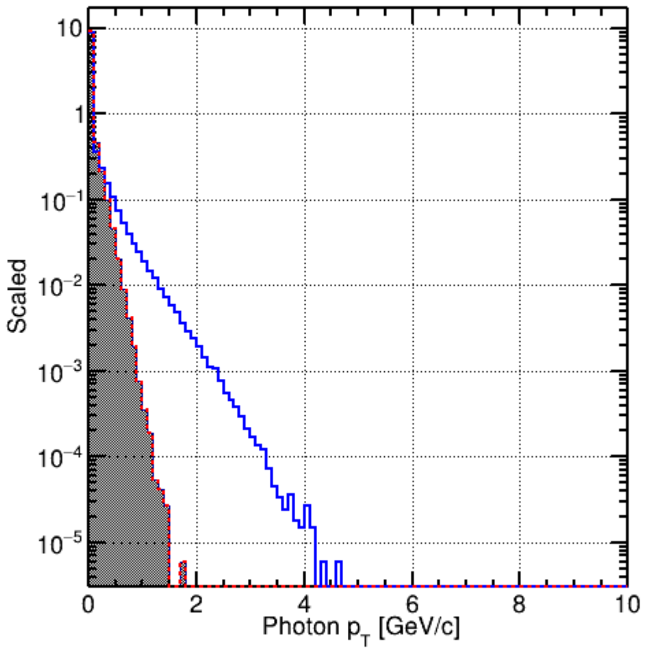
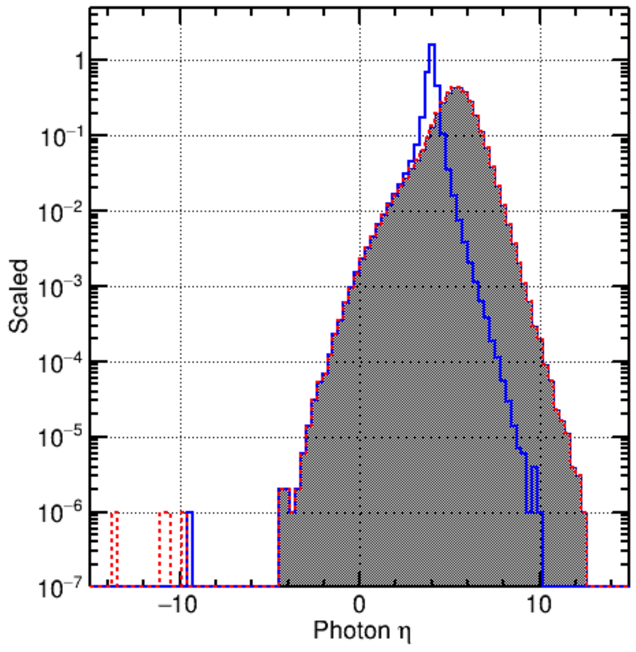
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Photon: P_t, η, and ϕ

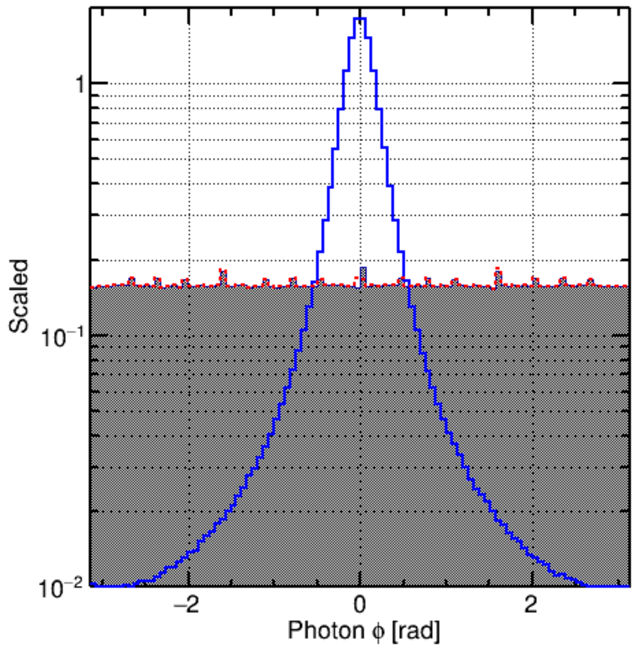
P_t
transverse momentum



η
pseudo-rapidity



ϕ
azimuthal angle



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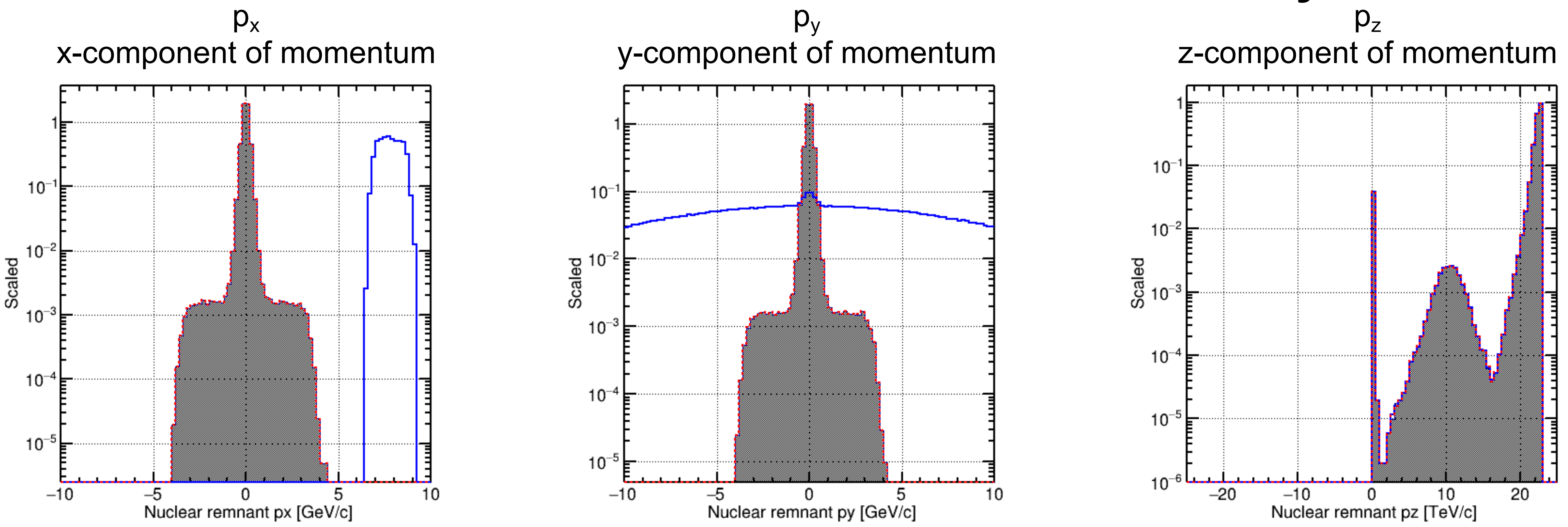
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Nuclear Remnants: P_x, P_y, and P_z



1 bin (i.e. 500 GeV)

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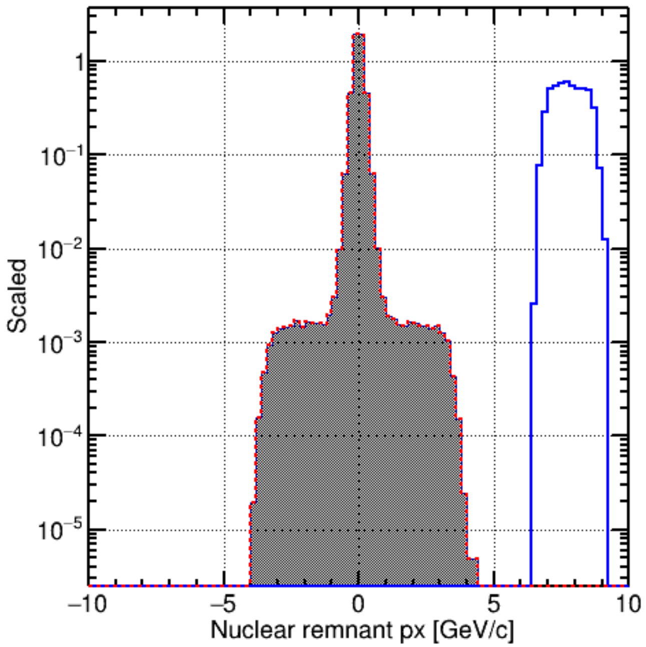
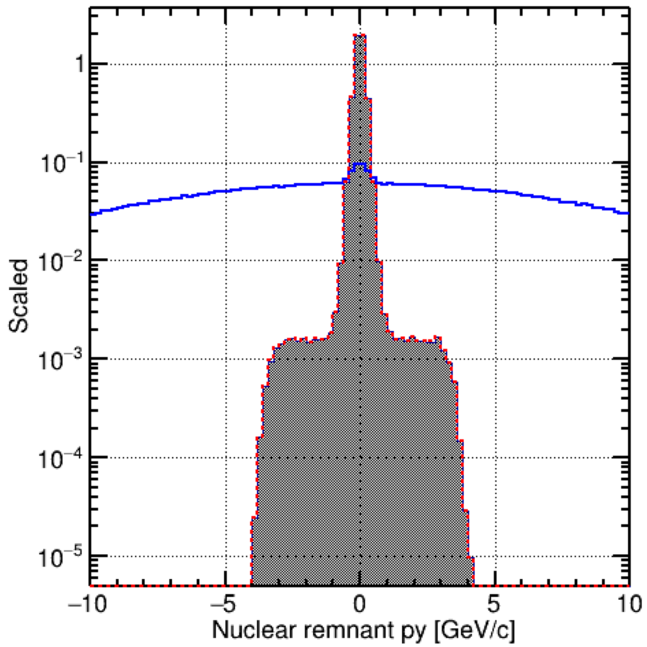
Final-state Nuclear Remnants: P_x, P_y, and P_z

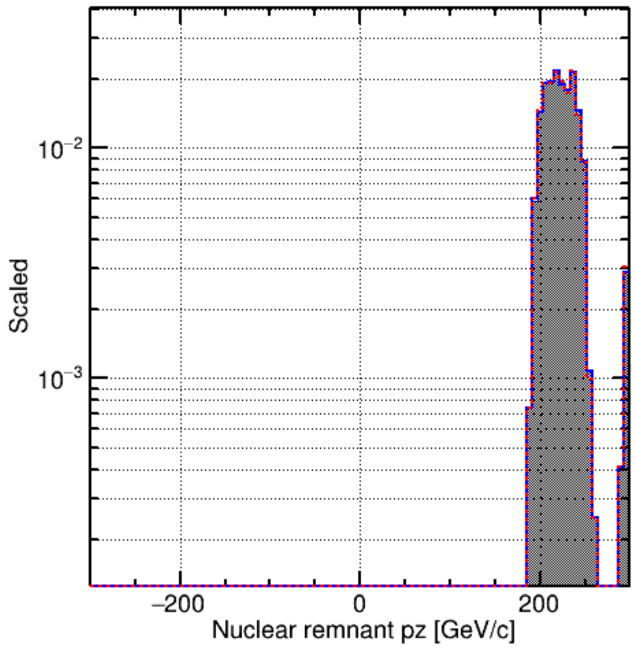
p_x
x-component of momentum



p_y
y-component of momentum



p_z
z-component of momentum



Zoomed into 300 GeV

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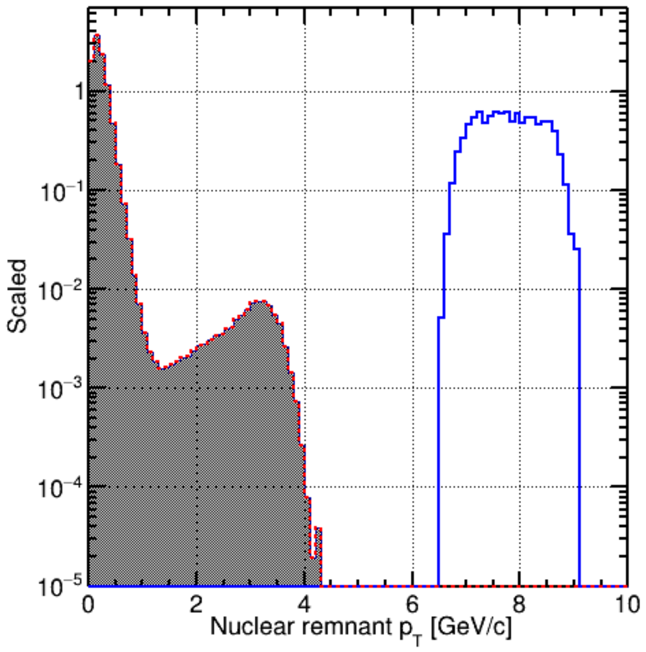
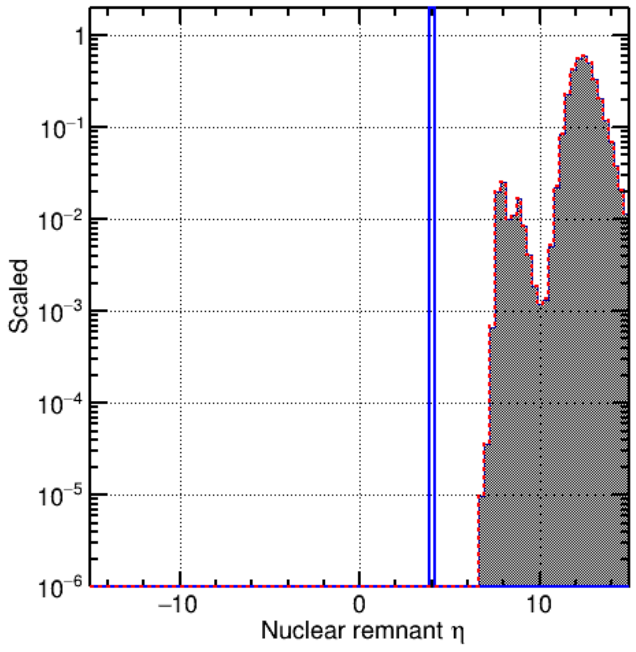
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Final-state Nuclear Remnants: P_t, η, and ϕ

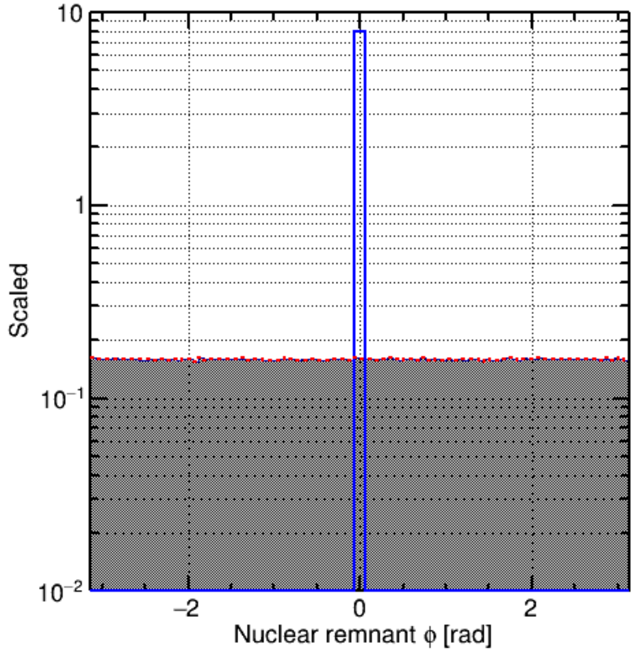
P_t
transverse momentum



η
pseudo-rapidity



ϕ
azimuthal angle



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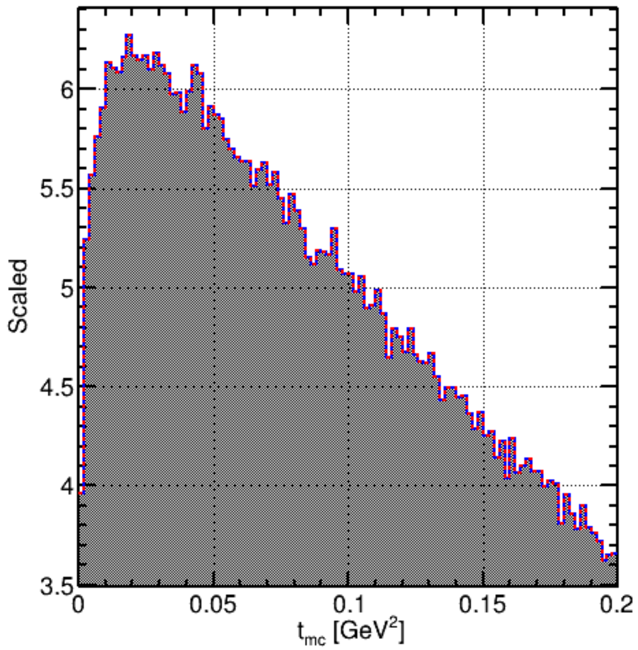
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

t Reconstruction: $(Q^2 - \mathbf{VM})$



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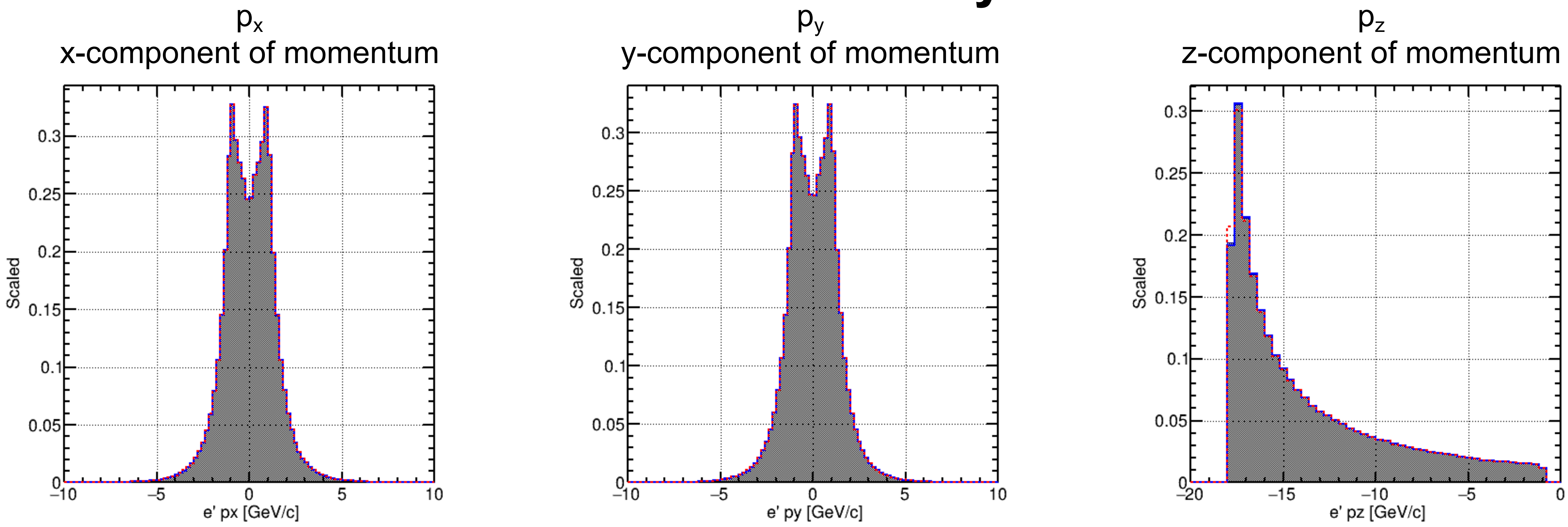
- "afterburner" with reverse transformation (red) distribution transformed to nominal (shaded gray) distribution
- t is invariant

BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

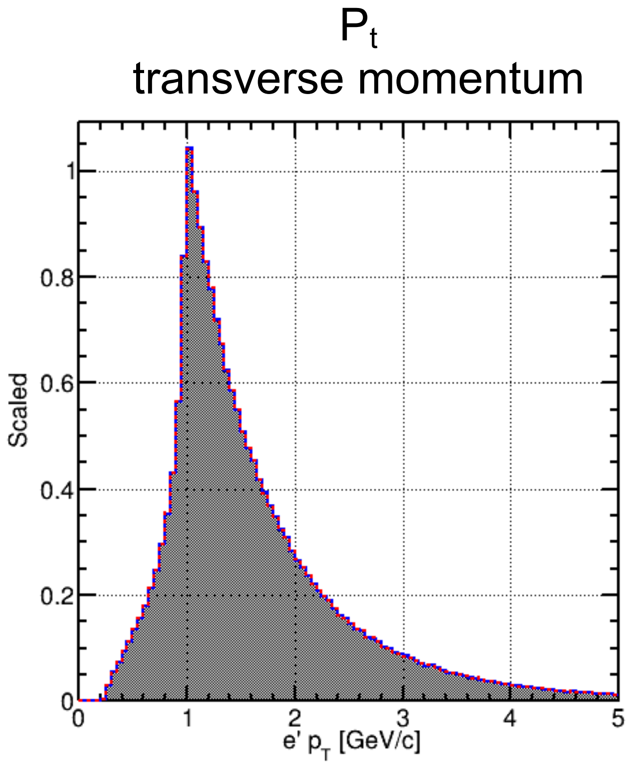
Scattered Electron: P_x, P_y, and P_z

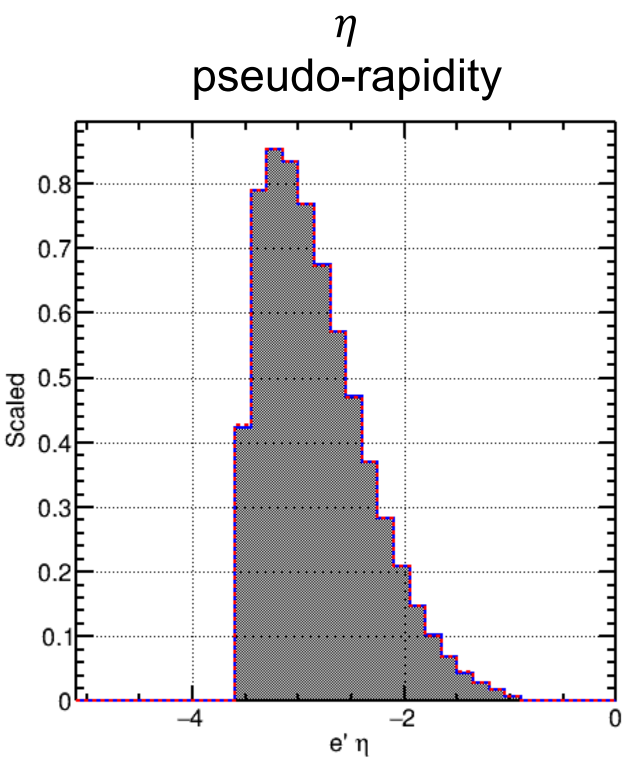


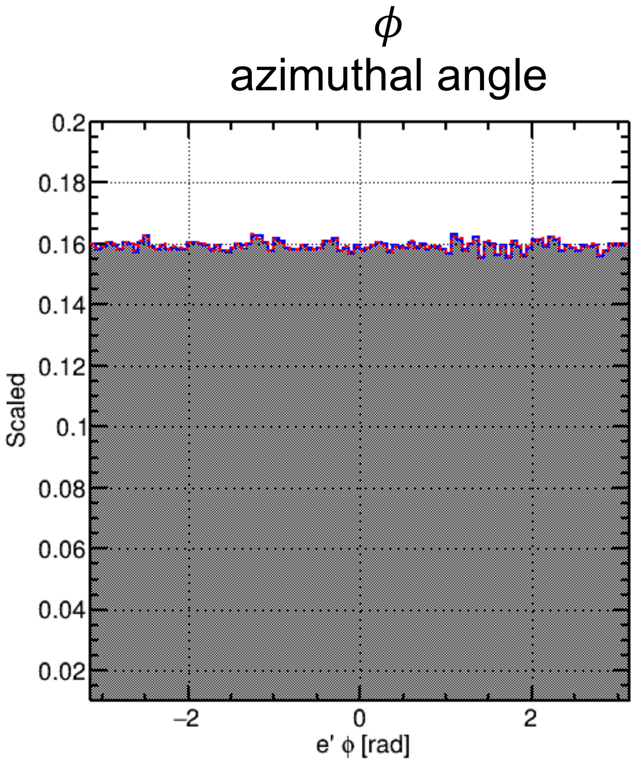
- Color scheme: Nominal, "afterburner", and "afterburner" with correction
- Normalized histograms by scaling by 1/integral and taking width into account
- Took "afterburner" (blue) distribution and applied correction → resulting is (red) distribution
- "afterburner" with reverse transformation (red) distribution transformed to nominal (shaded gray) distribution

BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Scattered Electron: P_t, η, and ϕ







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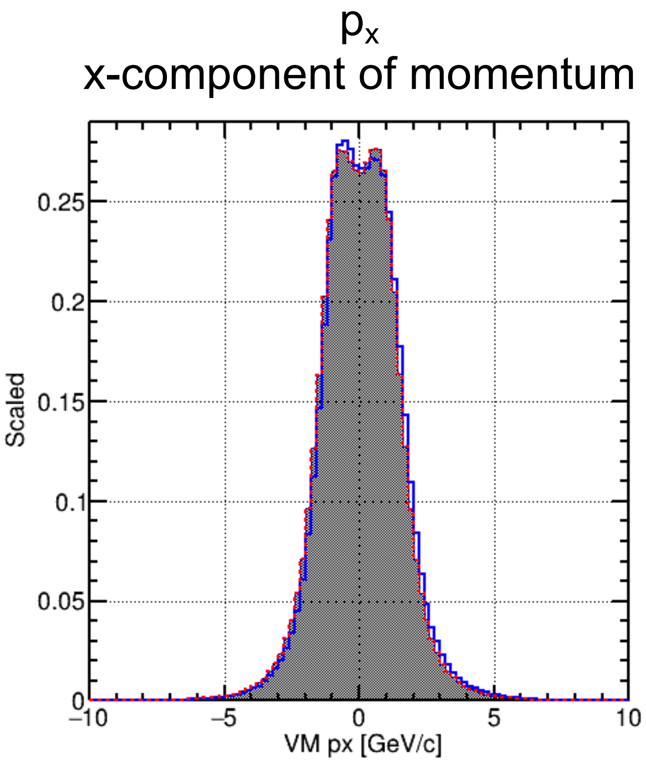
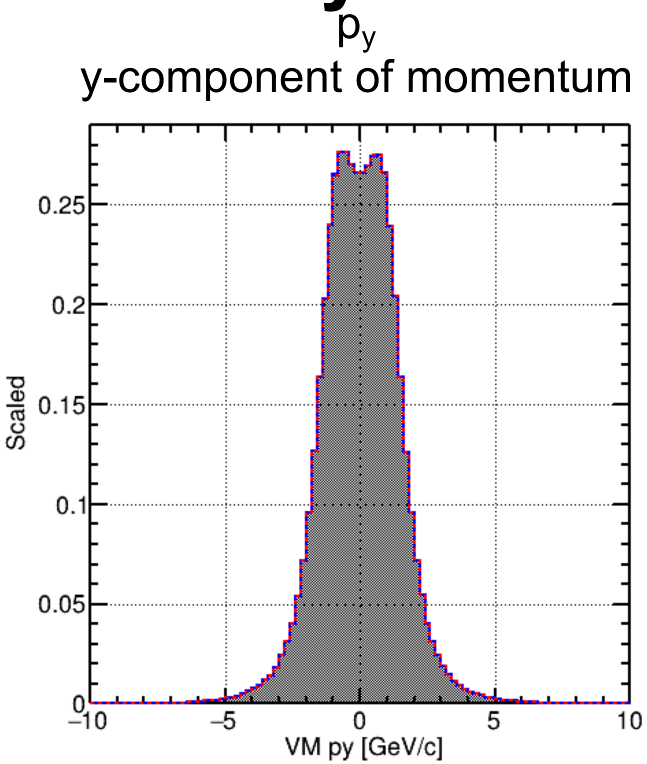
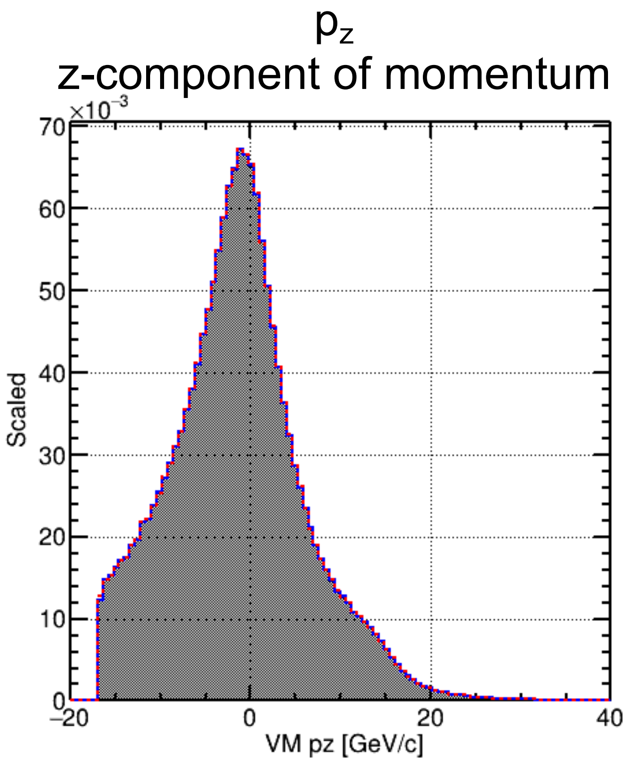
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Vector Meson: P_x, P_y, and P_z







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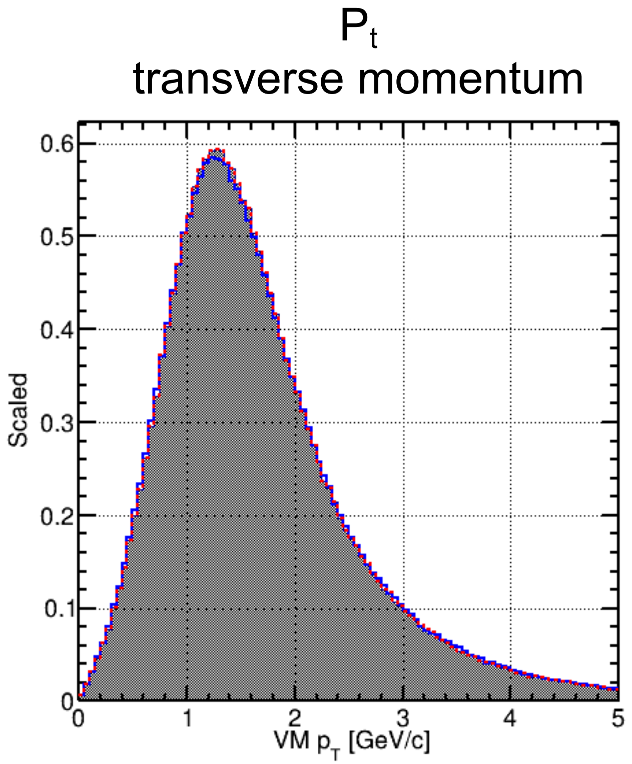
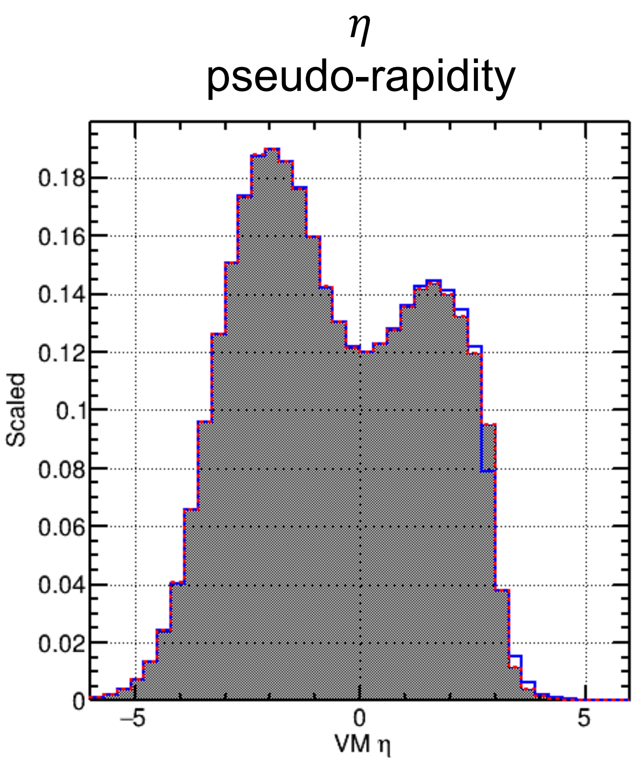
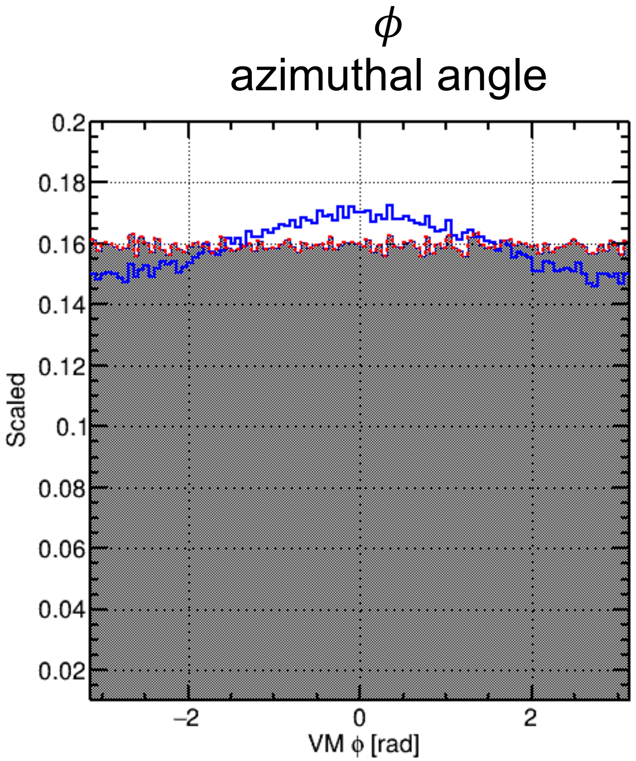
BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

Vector Meson: P_t, η, and ϕ







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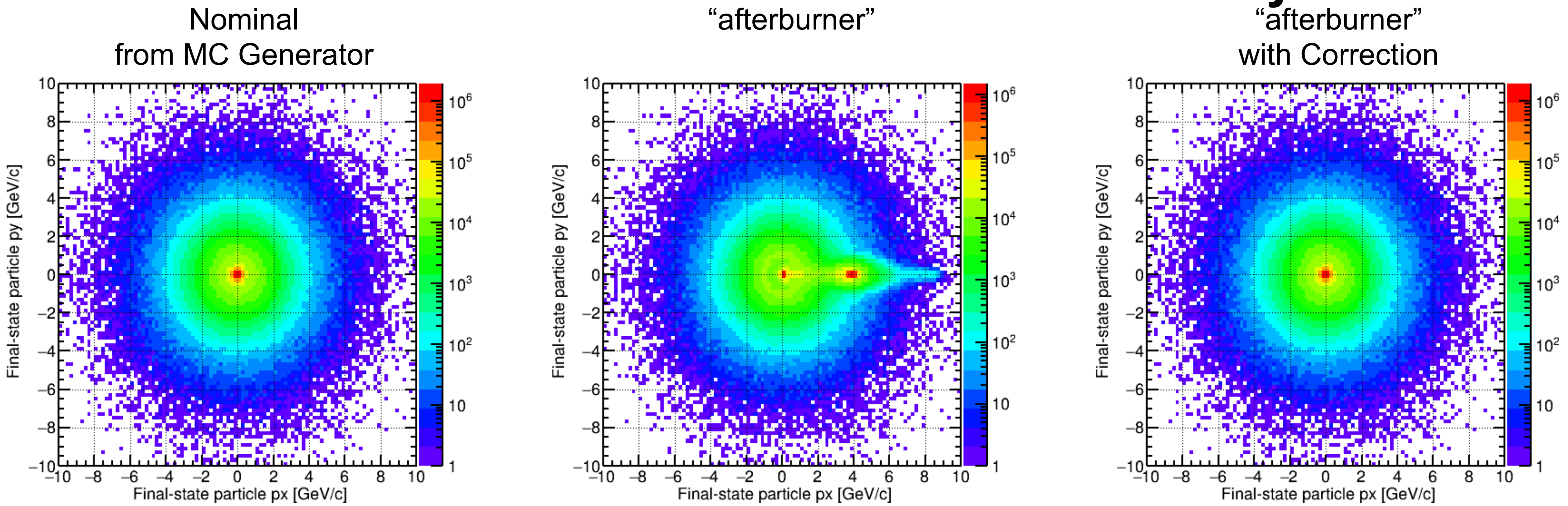
Summary

- Checked simple ep sample between before and after “afterburner” and confirmed that transform does what we expect. Good.
- Checked ePb sample between before and after “afterburner” and confirmed that transform does what we expect. Good.
- From discussion with Brian and Alex, we should summarize this transformation procedure and it would be good to add into “beam effect simulation” note.

Back Up Slides

BeAGLE v1.03.02 **ePb** 18×110 GeV^2 Sample

All Final-state Particles: P_x, and P_y



- (p_x, p_y) ~ (0.2 GeV, 0.2 GeV): turned out to be soft photons (a few 100 MeV) from de-excitations!