

Beam-dynamics-aware detectors

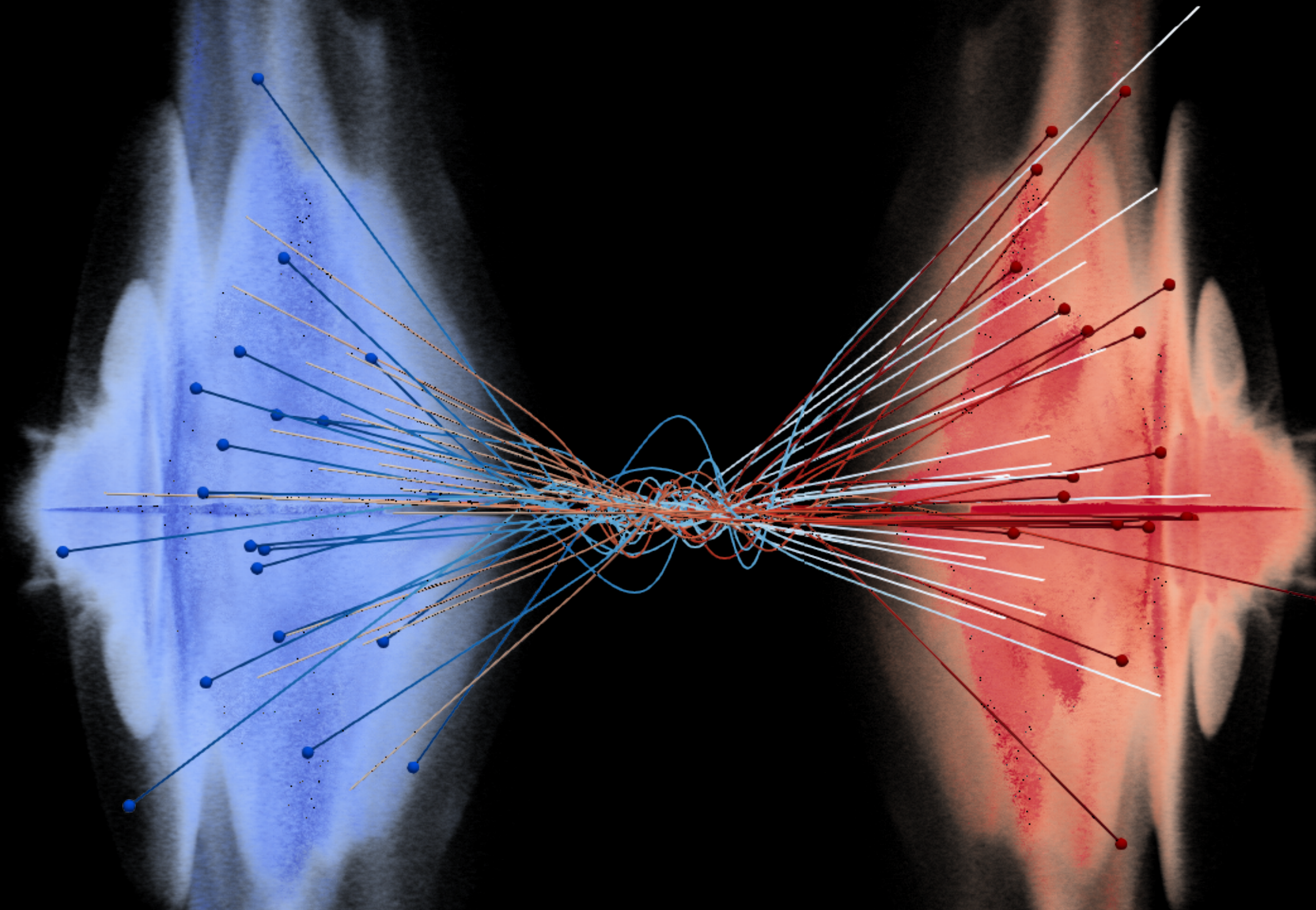


SMU

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Detector Optimization Weekly

Beam Dynamics

WarpX simulates the evolution of **particle species** (e.g., electrons, ions, etc.) in the presence of **electric and magnetic fields**.



Models beamstrahlung photons and incoherent e^+e^- pairs that strike the detector every bunch crossing

<https://blast-warpX.github.io/warpX-tutorials/install.html>

Goals of the project

- Machine detector interface in bilevel detector optimization
 - Coupling WarpX beam-beam simulation into the ddsim signal chain
- Code has been set up on NERSC
 - Working on running the code on the slurm batch system
 - Progressing fast with Claude's help (currently subscribed to a high LLM-token tier model)



MDI stage

WarpX

Beam-beam at the IP:
beamstrahlung
+ pair production



Outer loop

ddsim

Geometry sweep
MDI overlaid



Inner loop

reco opt

Per-cell optimum
of reco parameters
Score: signal vs.
background

- Designing a minimal working version soon (~2 weeks or so) while deciding on person power: longer term could be a great undergrad/first year grad student project

Status as of July 2nd, 2026

- WarpX pipeline in place at Perlmutter@NERSC
- Can run pipeline on A100s
- Pipeline validation at Z-pole: 29,345 beamstrahlung γ generated
- Checked angular distributions and verified “soft” kinematics

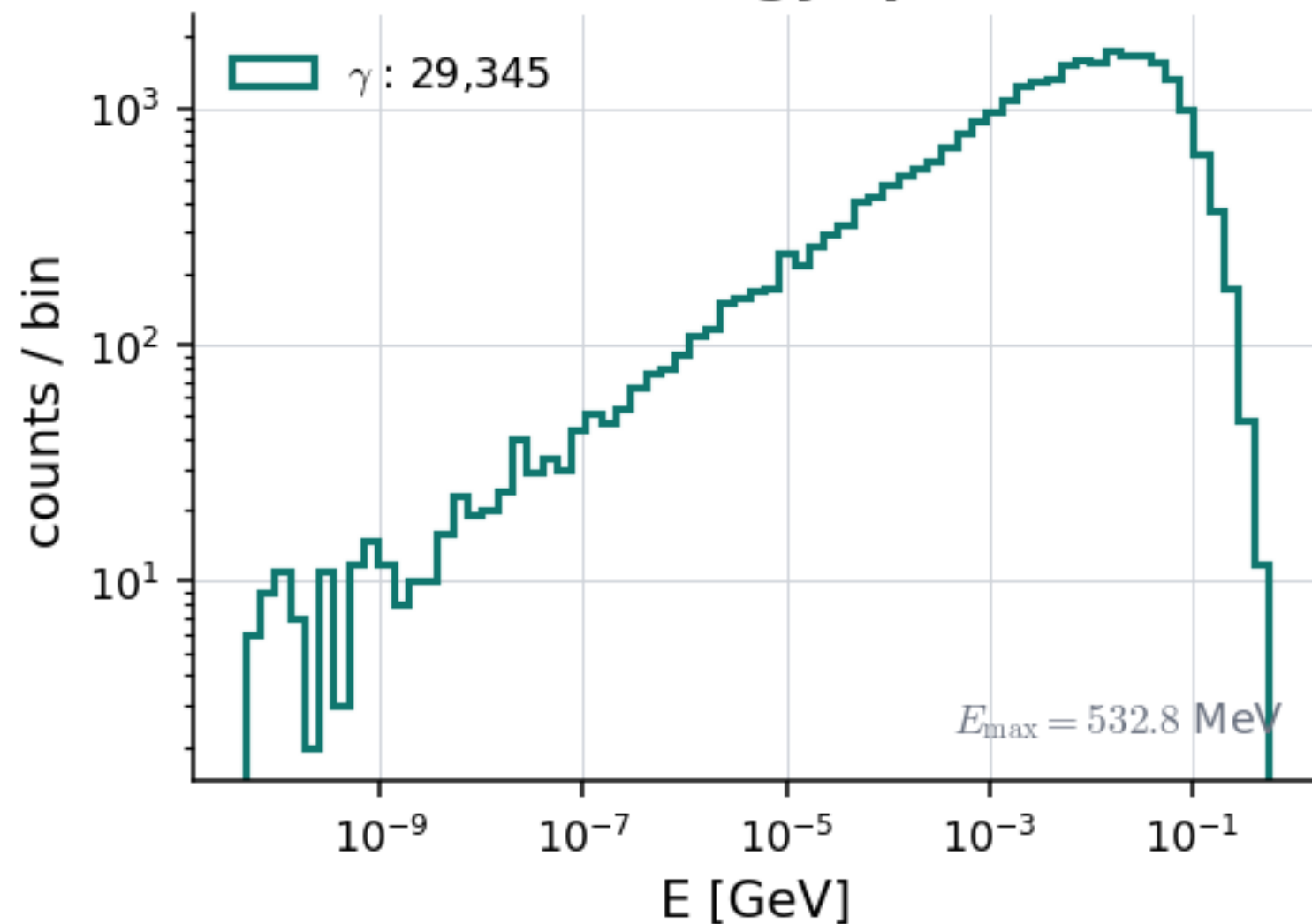


- WarpX parameters adjusted: might need to consult with an accelerator physicist later
- At the ddsim stage right now

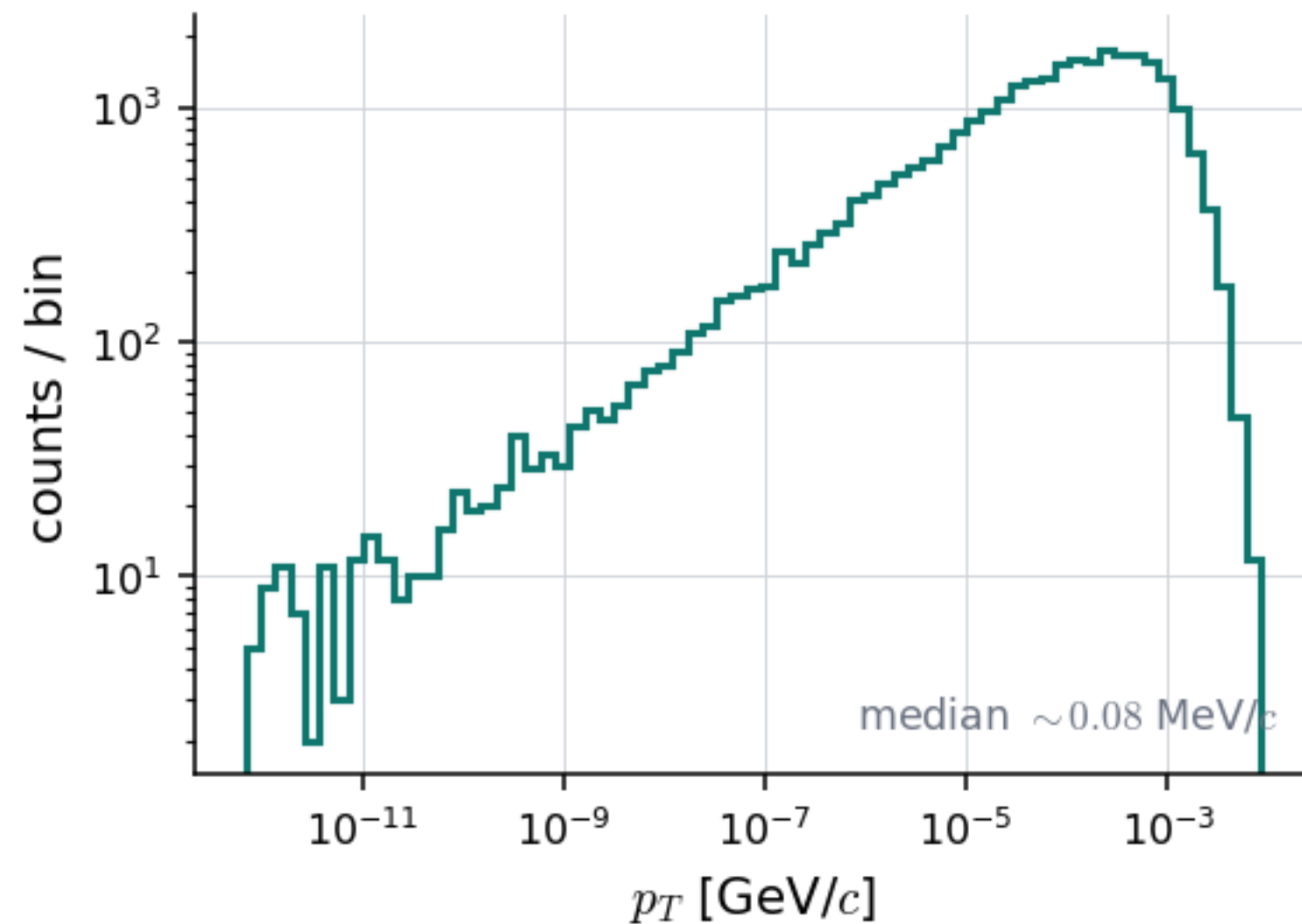
FCC-ee MDI smoke test — Z-pole, 29k photons

$\sigma_y = 3 \mu\text{m}$, 2×10^6 macros, $256 \times 128 \times 256$ cells

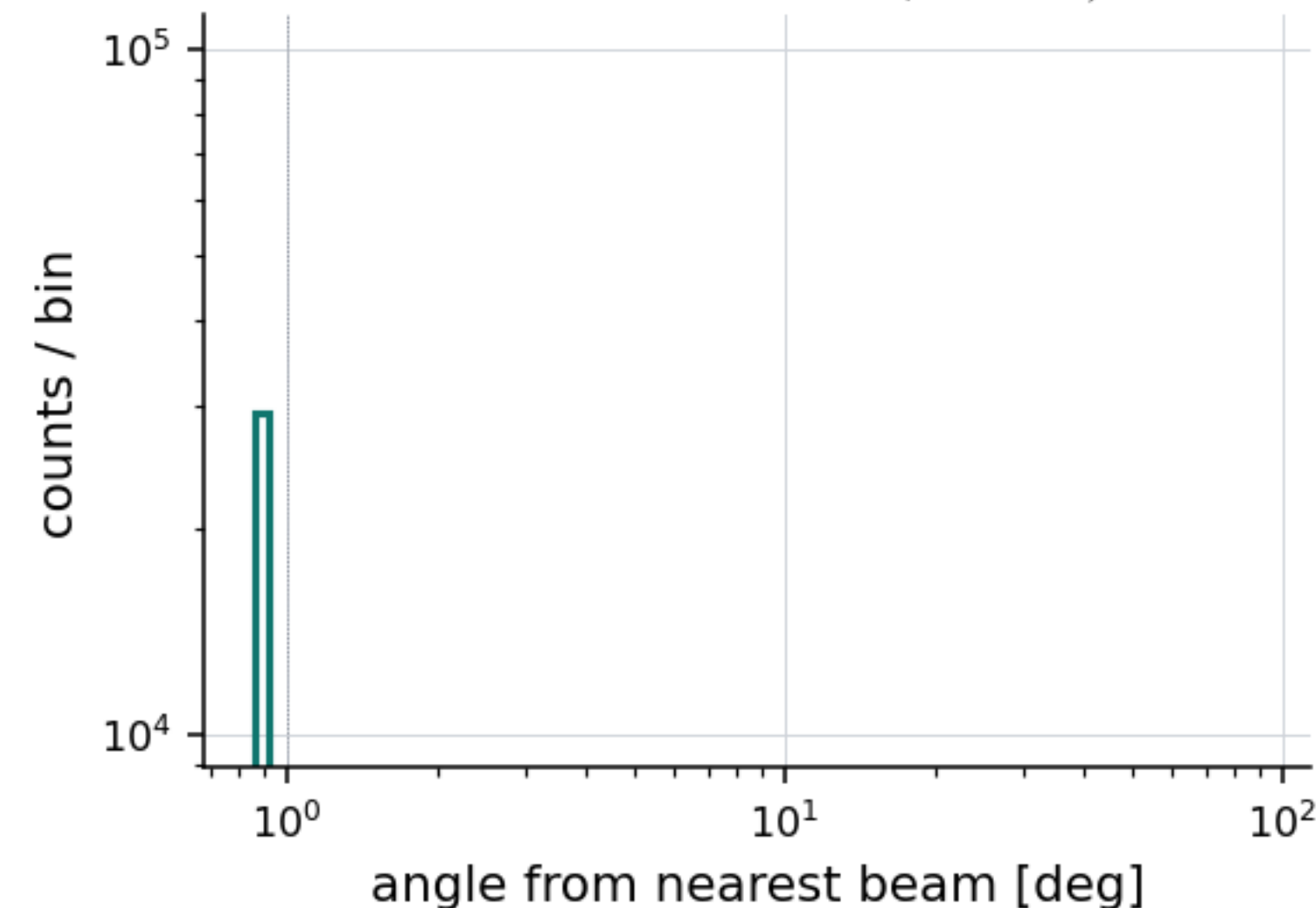
Photon energy spectrum



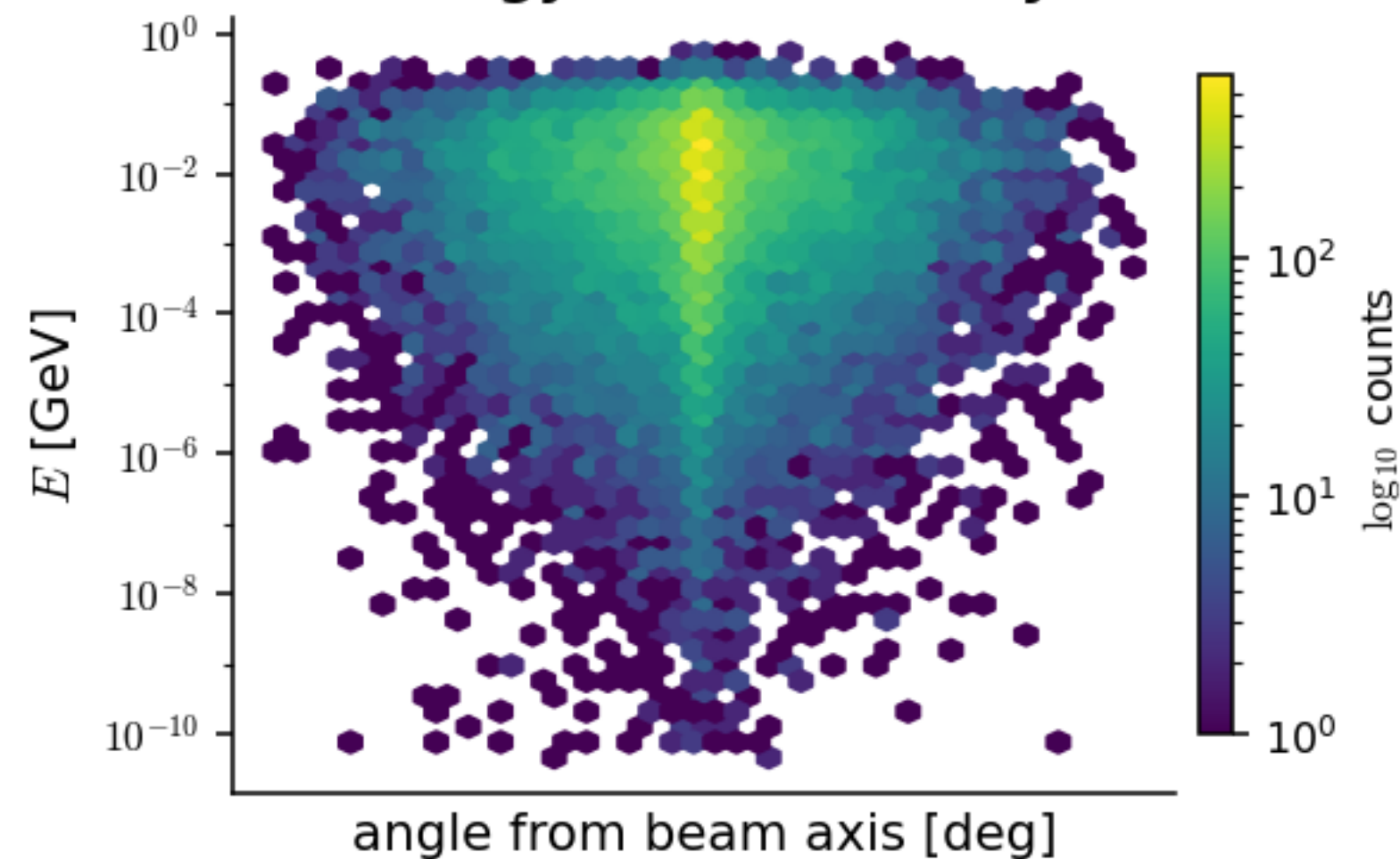
Transverse momentum



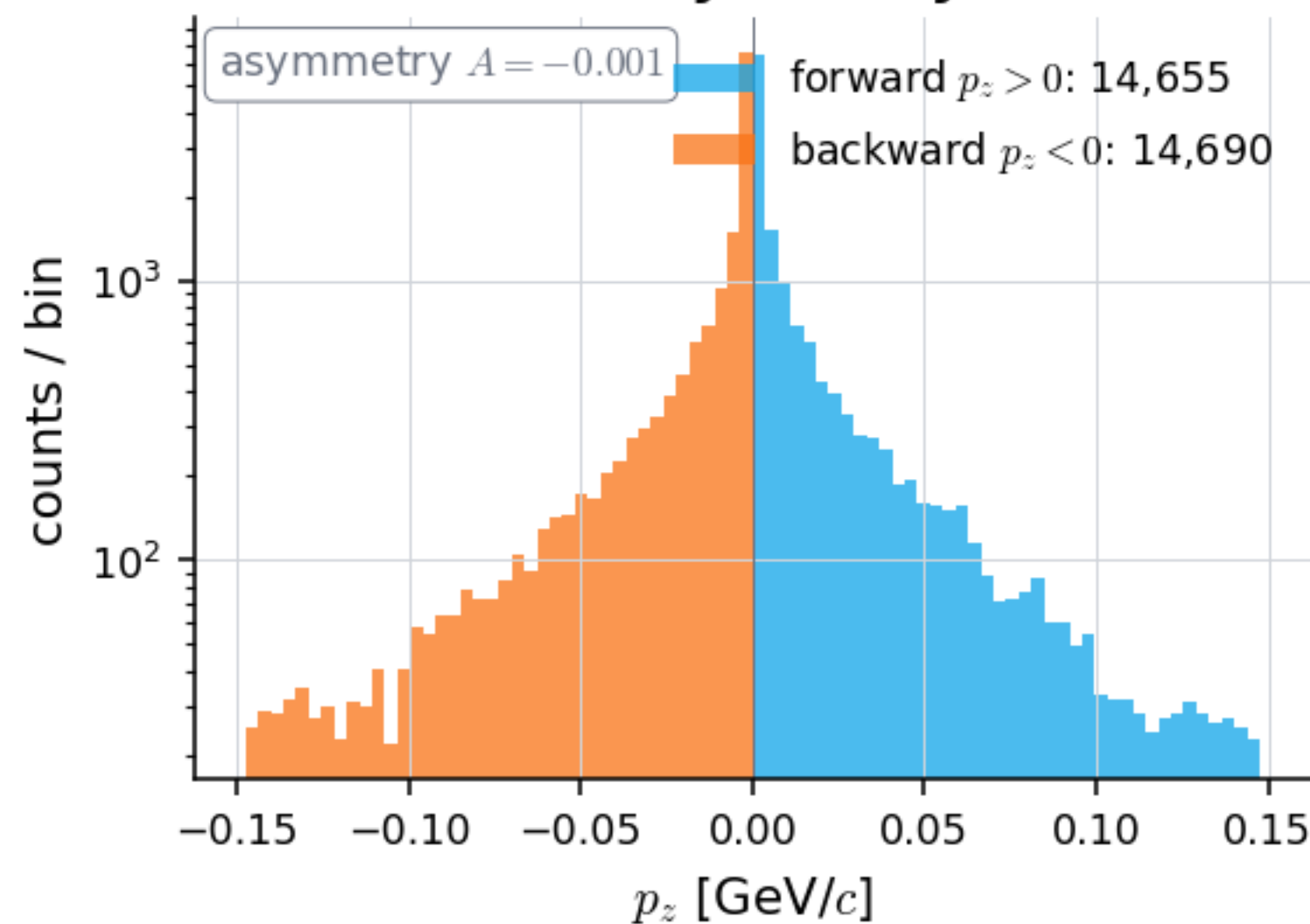
Collinearity, $\min(\theta, \pi - \theta)$



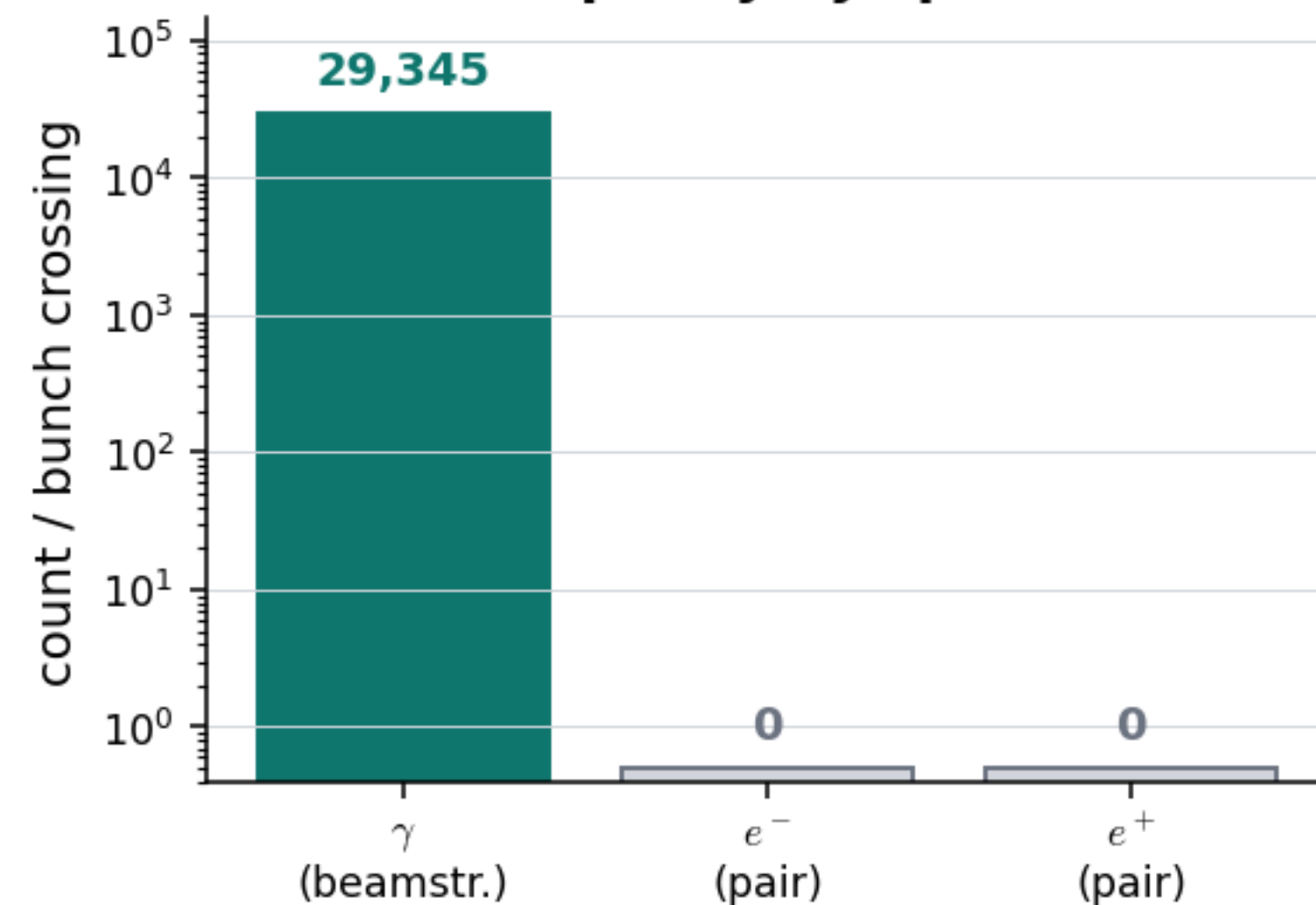
Energy vs. collinearity



F/B symmetry



Multiplicity by species



Smoke-test fidelity: $\chi_{\text{min}} = 10^{-5}$ engine threshold lowered to fire at our undersampled χ . Multiplicity and spectrum should NOT be quoted as FCC-ee predictions. pair species suppressed by Breit-Wheeler at $\chi \ll 1$