

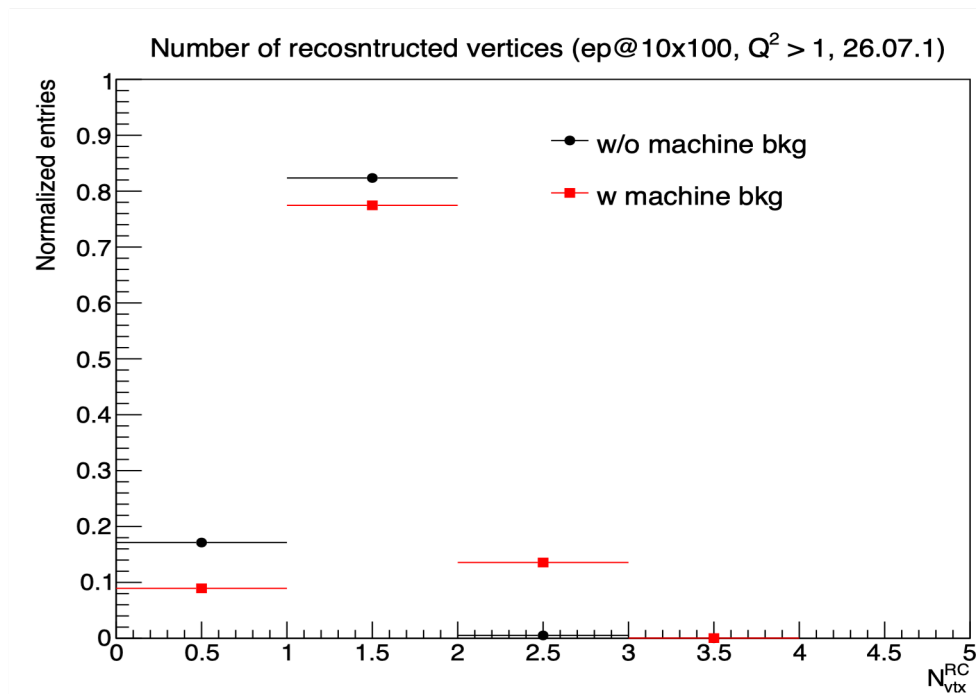
Impact of machine background on primary vertexing

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09/24/2026

Simulation samples

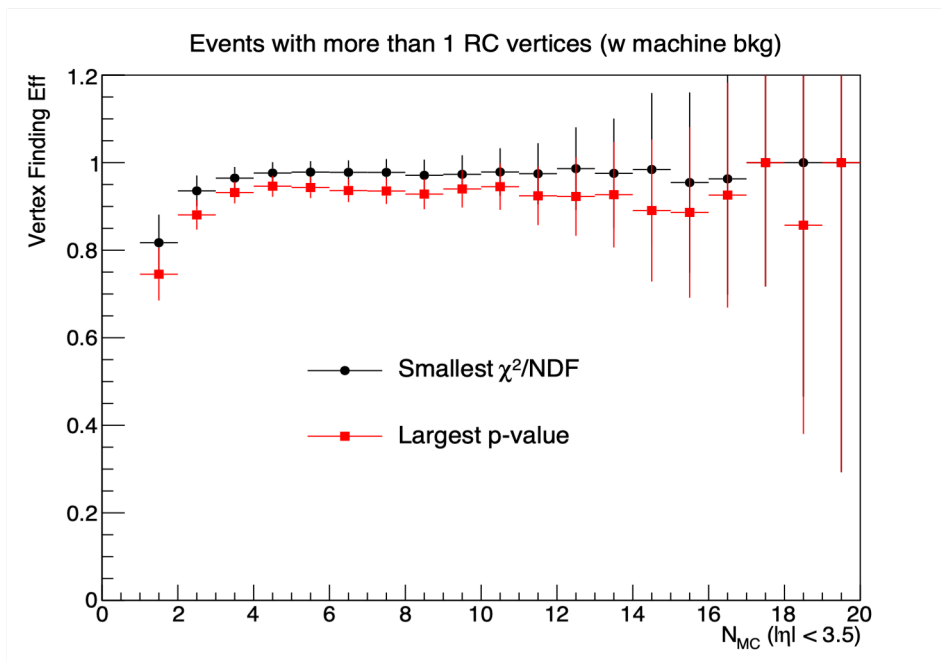
- **ep, 10x100, NC DIS, Q2 > 1**
- Without machine background
 - RECO/26.07.1/epic_craterlake/DIS/NC/10x100/minQ2=1
 - 3.8M events
- With machine background
 - RECO/26.07.1/epic_craterlake/Bkg_Exact1S_2us/GoldCt/10um/DIS/NC/10x100/minQ2=1
 - 145k events
- Default: primary vertices are found **using tracks with at least 4 hits**
- In case of multiple reconstructed vertices, choose the one with the **smallest χ^2/ndf**

Number of reconstructed vertices



- With machine background, a larger fraction of events have 2 vertices

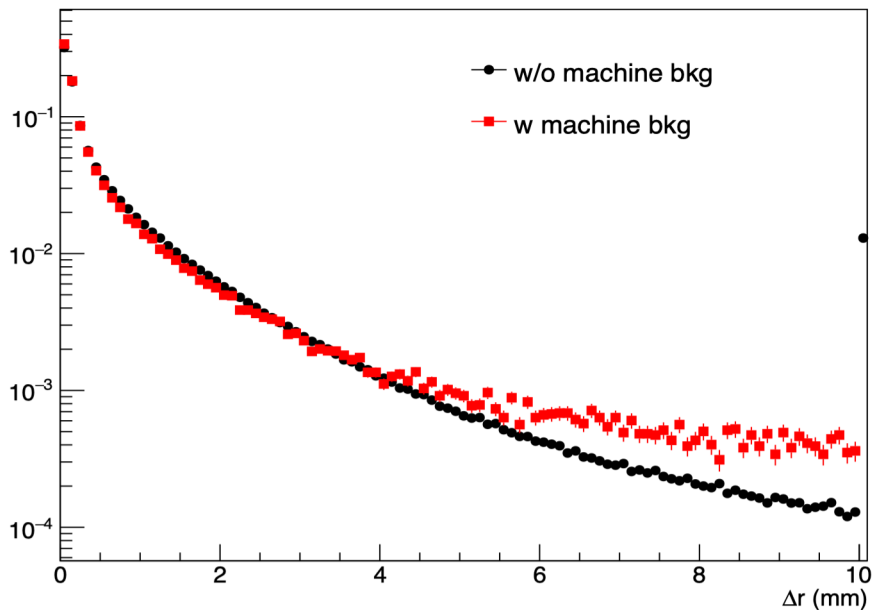
For events with more than 1 vertex



- Vertex finding efficiency: fraction of chosen RC vertex is also the one closest to MC vertex
- Slightly better performance by using χ^2/ndf compared to using p-value

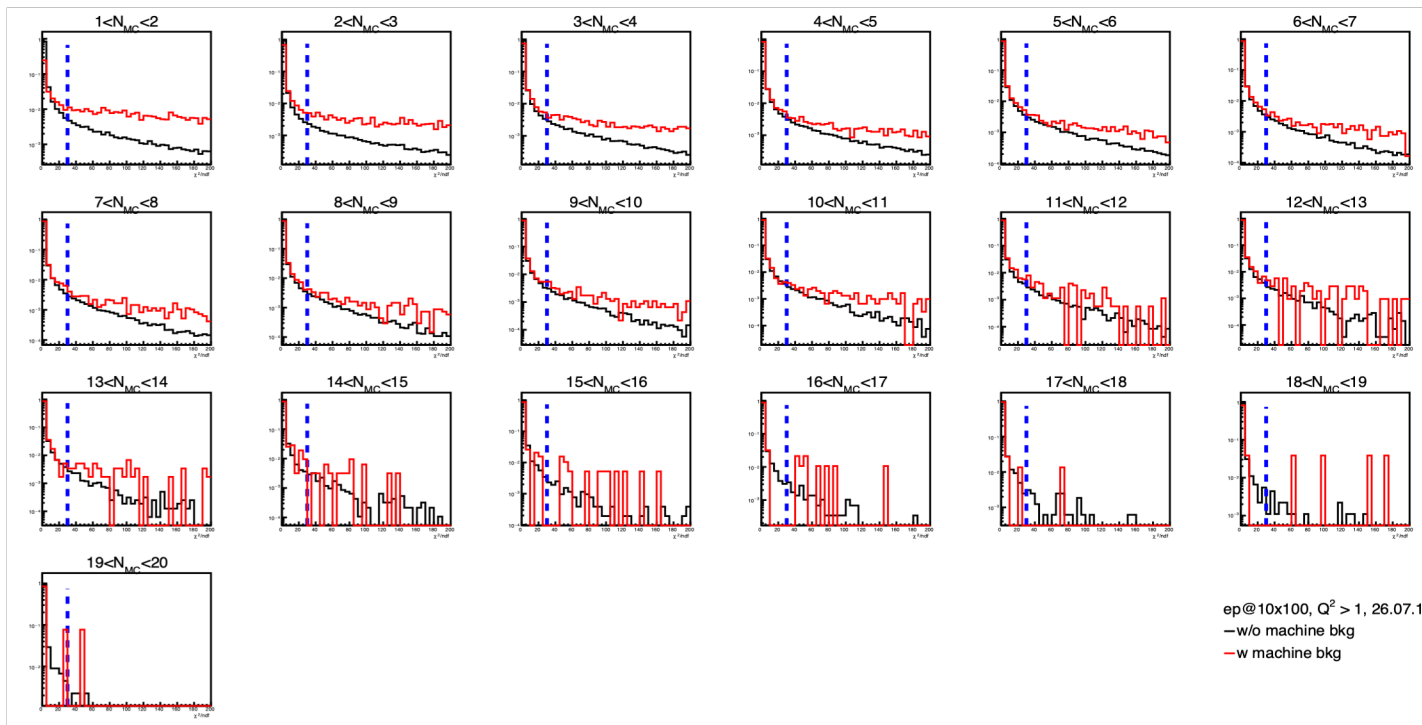
Distance between RC and MC vertices

Distance between MC and selected RC vertex (ep@10x100, $Q^2 > 1$, 26.07.1)



- 3D distance
- Enhanced tail when machine background is present
- Use $\Delta R < 3$ mm as a criteria to define good RC vertex

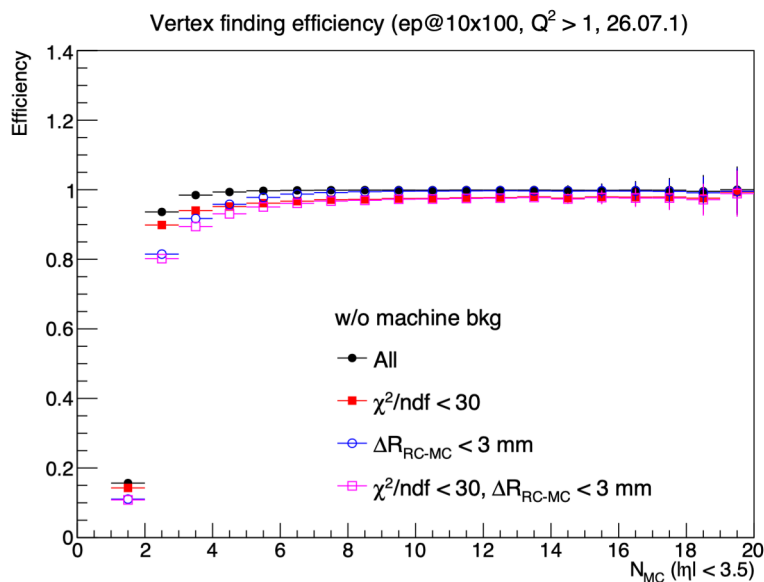
Compare χ^2/ndf distribution



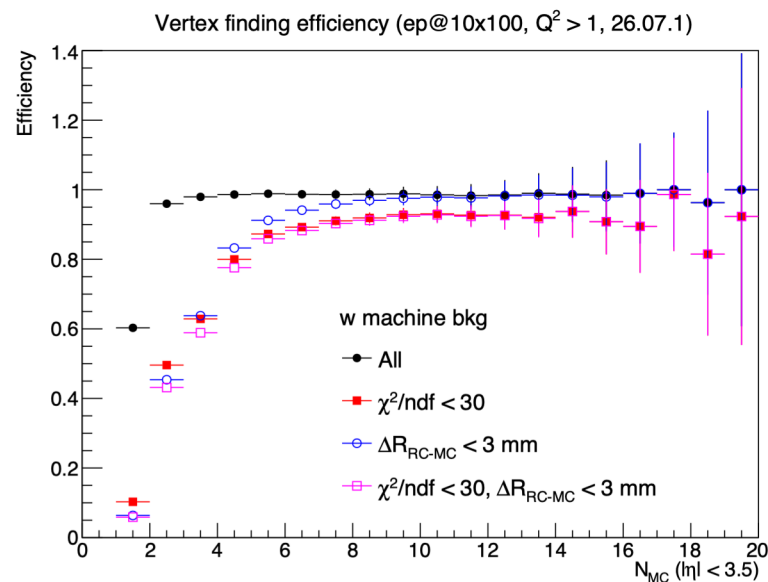
- Use $\chi^2/\text{ndf} < 30$ to select “good” RC vertex
- $N_{\text{MC}}(|\eta| < 3.5)$: # of charged MC particles within $|\eta| < 3.5$ and originating from MC vertex

Vertex finding efficiency

Without background



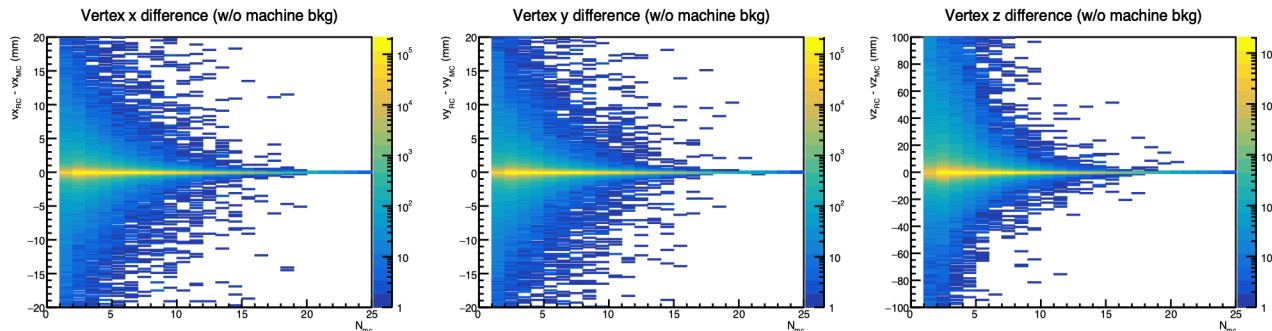
With background



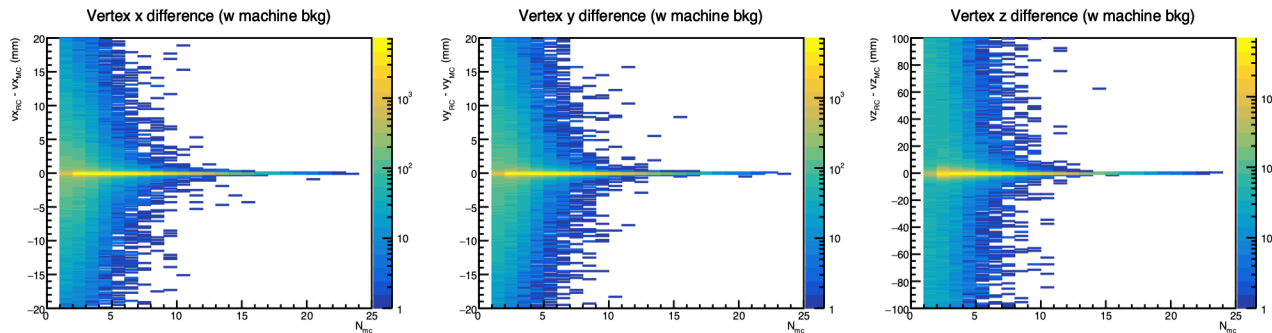
- Cutting on $\chi^2/ndf < 30$ has small impact for w/o background, but greatly improves “purity”, i.e. selected RC vertex is within 3mm of MC vertex, when background is present

Difference between MC and selected RC vertices

w/o bkg

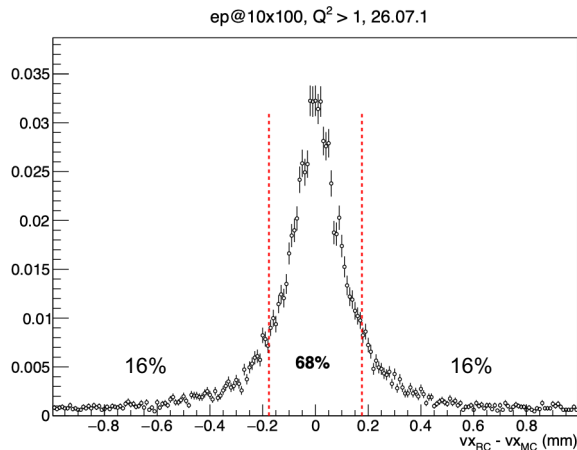


w/ bkg

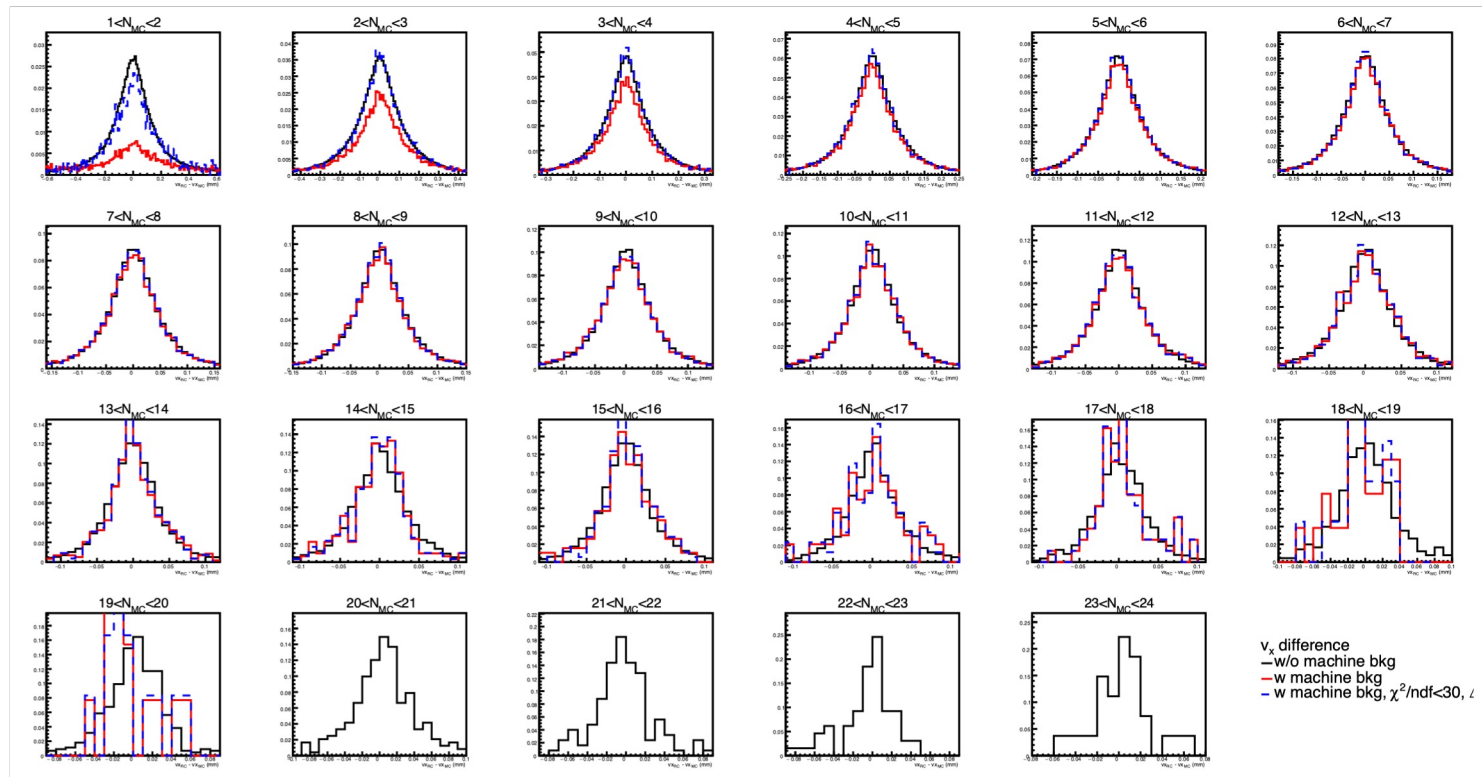


How to estimate resolution?

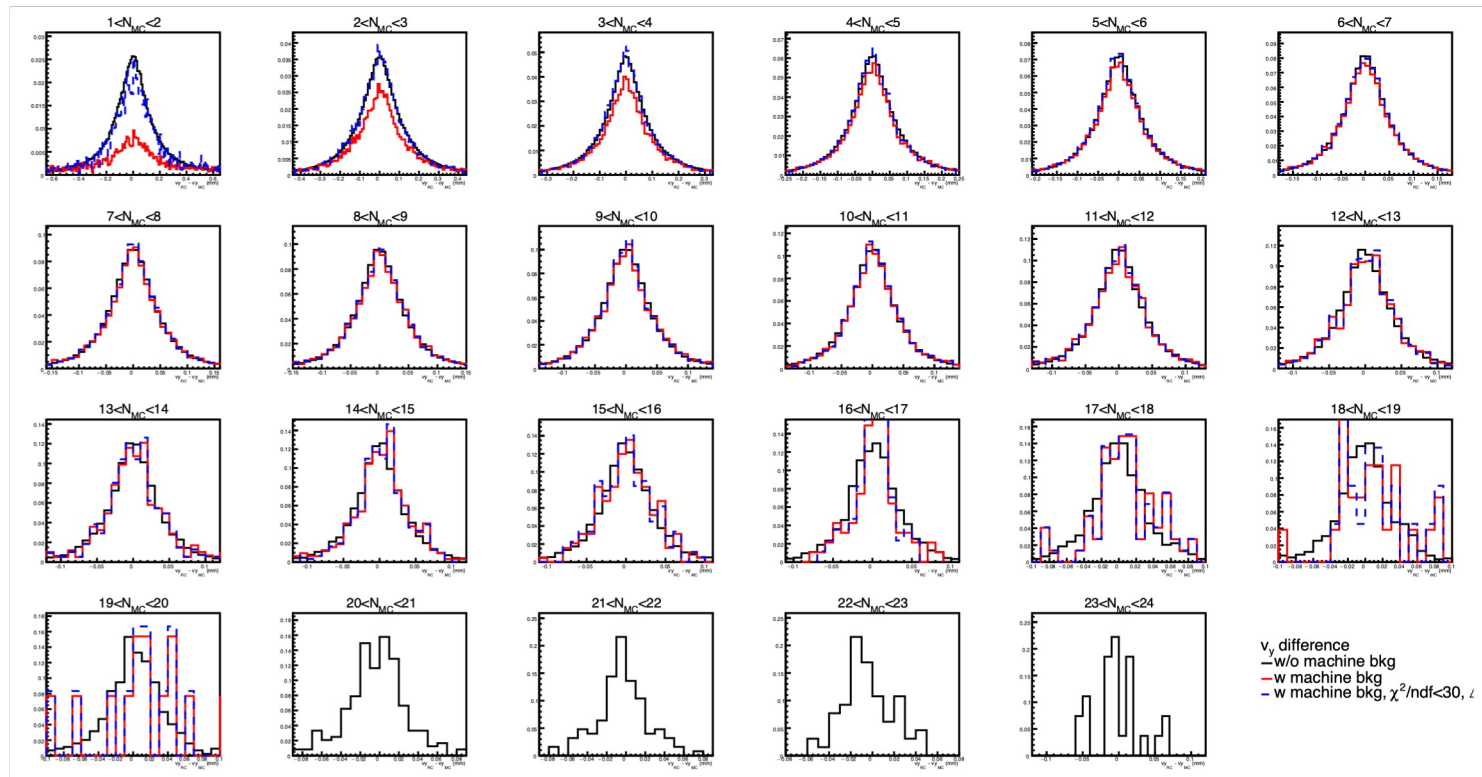
- Before: fit RC-MC distributions with Student's T distribution, and quote the width of the Gaussian core as the resolution. However, it probably underestimates the resolution by ignoring the tail
- New method: **take the 68% range of the distribution as $\pm 1\sigma$**
 - Quantiles at 16% and 84%: TH1:GetQuantiles()
 - Errors: bootstrap



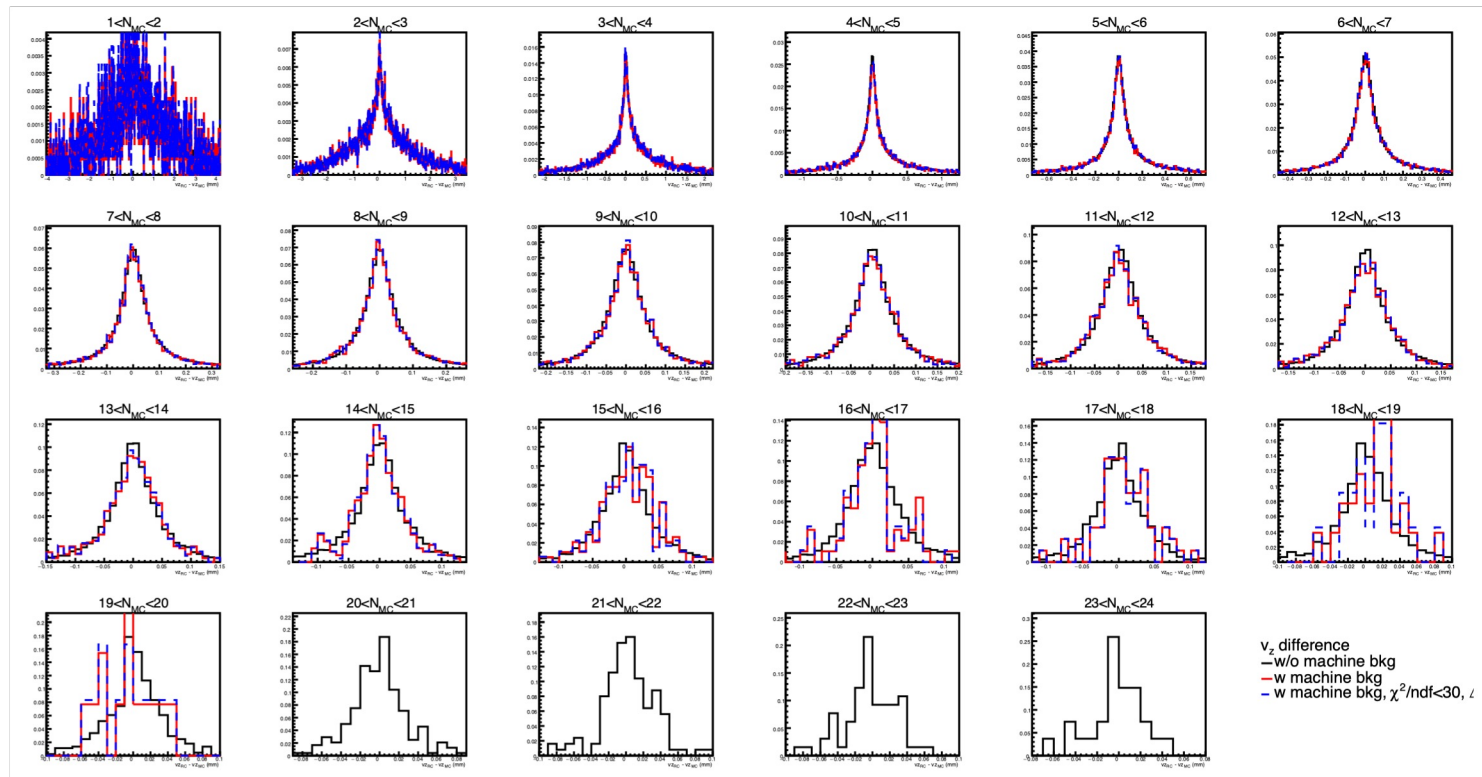
Compare v_x difference in N_{MC} bins



Compare v_y difference in N_{MC} bins

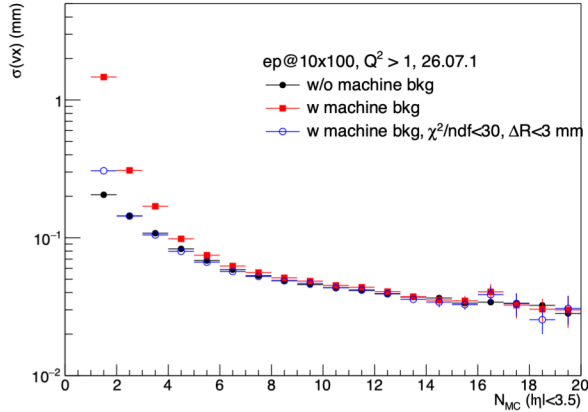


Compare v_z difference in N_{MC} bins

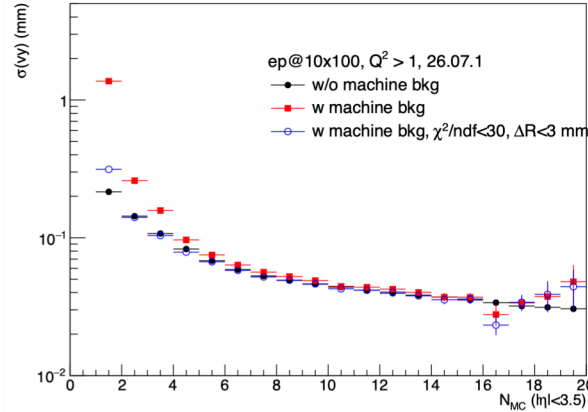


Primary vertex resolution

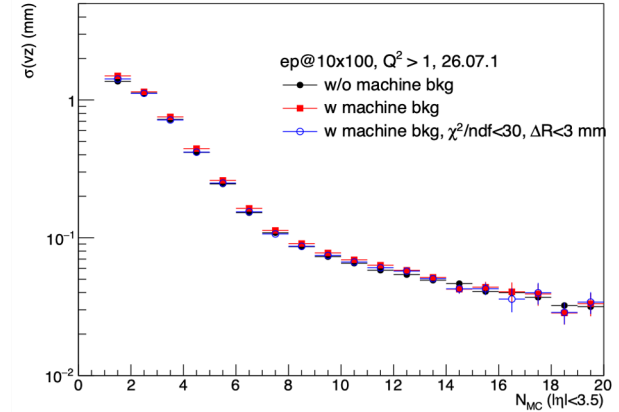
Resolution of vertex x reconstruction



Resolution of vertex y reconstruction



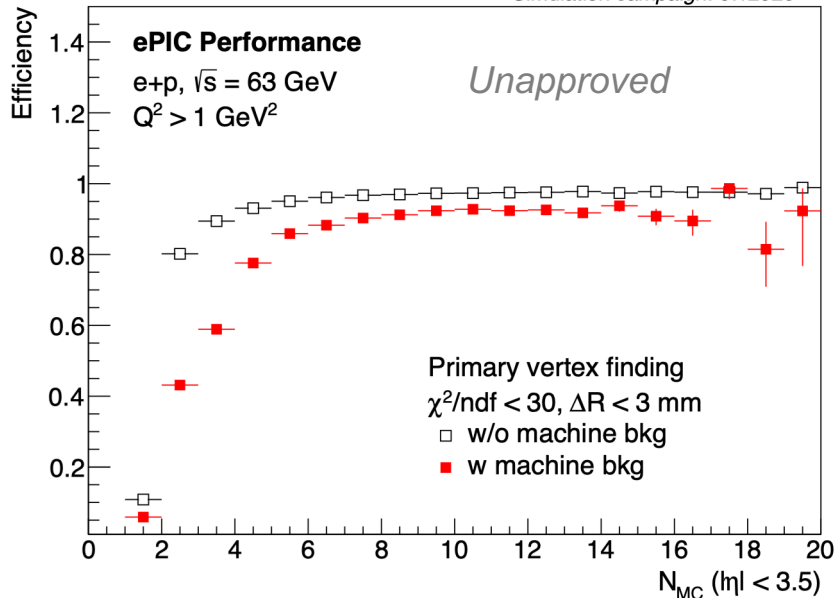
Resolution of vertex z reconstruction



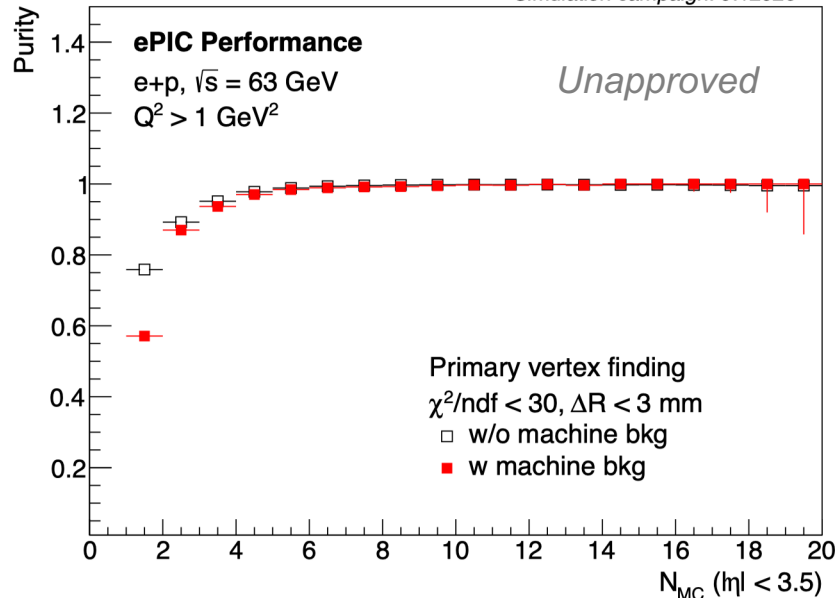
- Large difference at small N_{MC} for x and y directions, but improved with $\chi^2/ndf < 30$ cut
- Similar resolution w/ and w/o machine background, except at very small multiplicity

Proposed pTDR figure: efficiency & purity

Simulation campaign: 07/2026

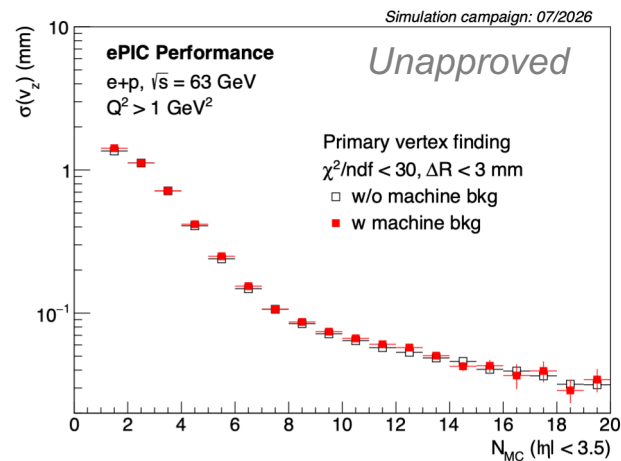
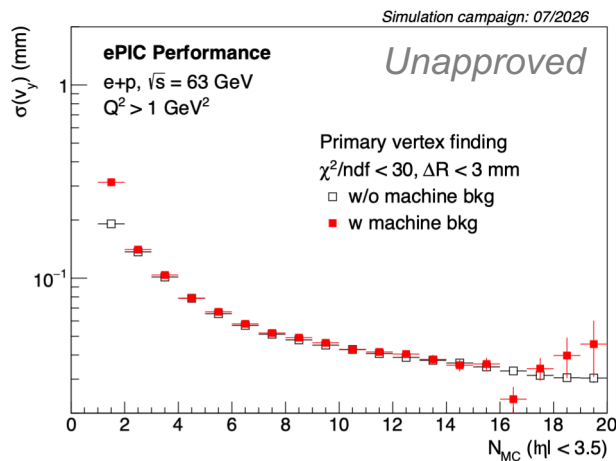
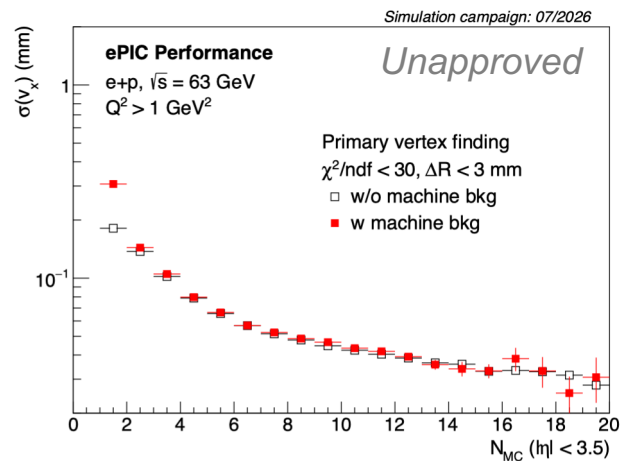


Simulation campaign: 07/2026



- Efficiency: fraction of good RC vertex to all MC vertex
- Purity: fraction of good RC vertex to RC vertex with $\chi^2/\text{ndf} < 30$
- Good RC vertex: $\chi^2/\text{ndf} < 30$, $\Delta R < 3$ mm

Proposed pTDR figure: resolution

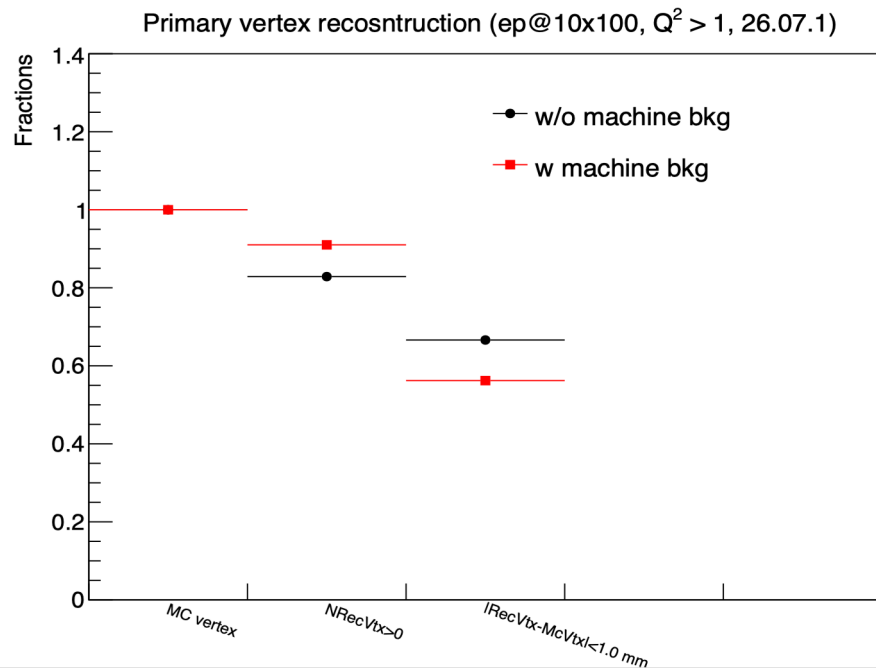


Summary

- Analyzed July campaign with and without machine background for 10x100 ep, NC DIS, $Q^2 > 1$
- With the inclusion of machine background
 - More events with >1 reconstructed vertices $\rightarrow$ select the one with smallest χ^2/ndf
 - Cut on $\chi^2/\text{ndf} < 30$ improves “purity”
 - Vertex finding efficiency and purity deteriorate
 - Vertex reconstruction resolutions are similar to those without background
- Action item: order primary vertices based on χ^2/ndf
 - Branch: *PrimaryVertices_objIdx.index*

Backup

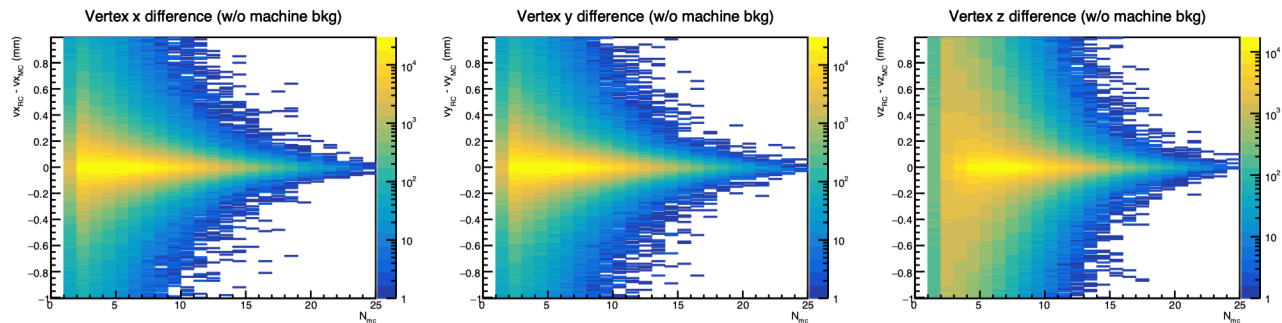
Event fractions



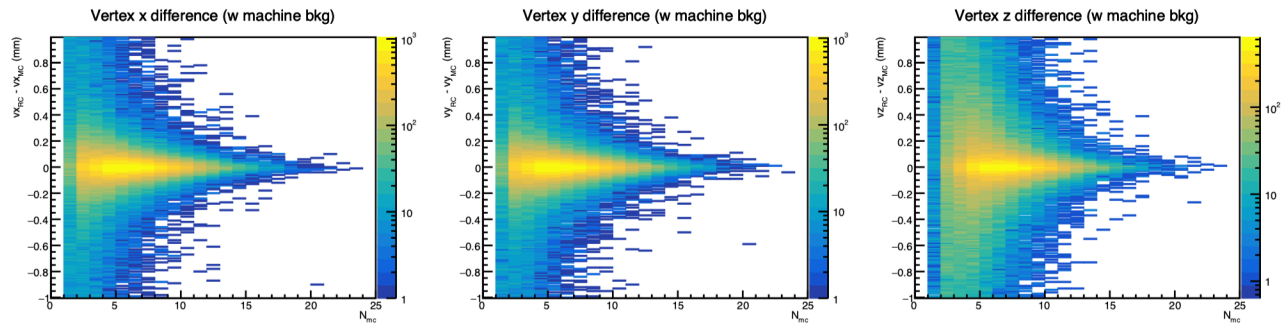
- With machine background, more events have at least one reconstructed vertex, but less of those are within 1mm of the MC vertex

Difference between MC and selected RC vertices

w/o bkg

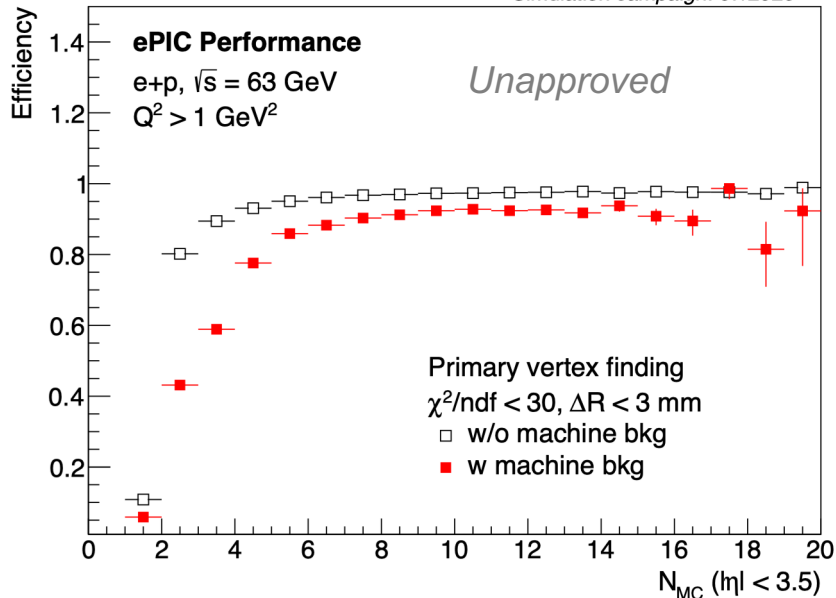


w/ bkg

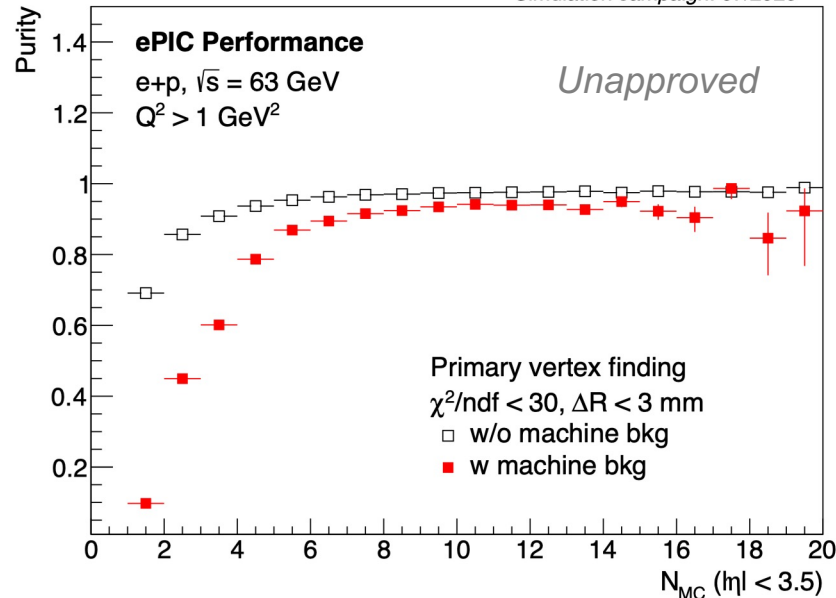


Proposed pTDR figure: efficiency & purity

Simulation campaign: 07/2026



Simulation campaign: 07/2026



- Efficiency: fraction of good RC vertex to all MC vertex
- Purity: fraction of good RC vertex to all RC vertex
- Good RC vertex: $\chi^2/\text{ndf} < 30$, $\Delta R < 3$ mm