Study of vertexing performance in DIS events

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Analysis setup

Reminder

- PYTHIA ep 18x275
- Vertex position: afterburner to apply beam effects
- $Q^2 > 10$ GeV^2

- EIC geometry: *epic-24.06.0*
- EICrecon: branch *vertexing_group*

- **Default real seeding**

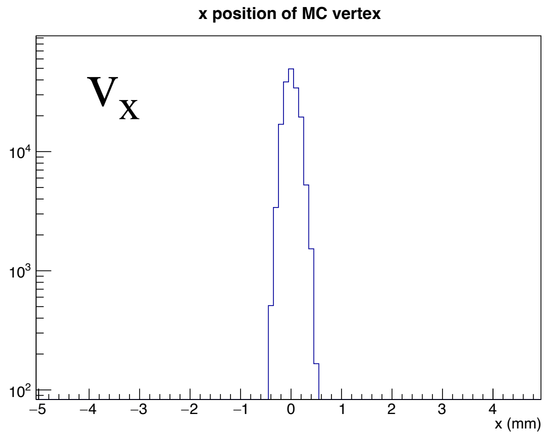
Definitions

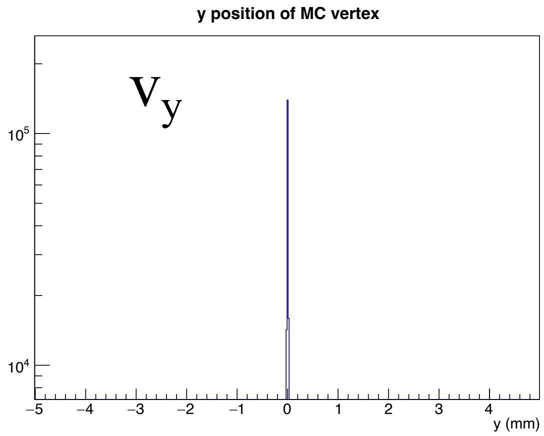
Reminder

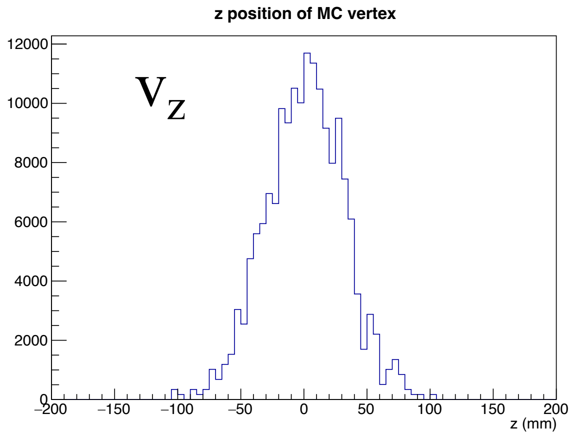
- N_{MC} = number of charged final-state MC particles within $|\eta| < 3.5$ that are associated with the MC vertex
  - Particle production vertex within $1e^{-4}$ mm of the MC vertex

- N_{trk} or N_{RC} = number of charged tracks used to reconstruct the vertex

MC vertex distributions

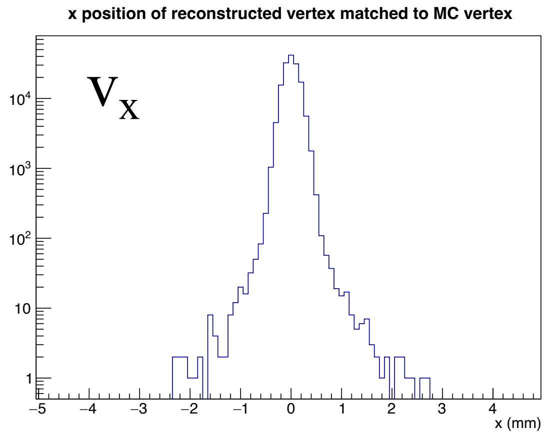


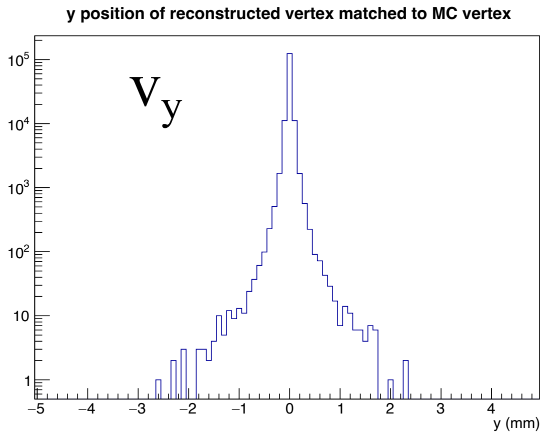


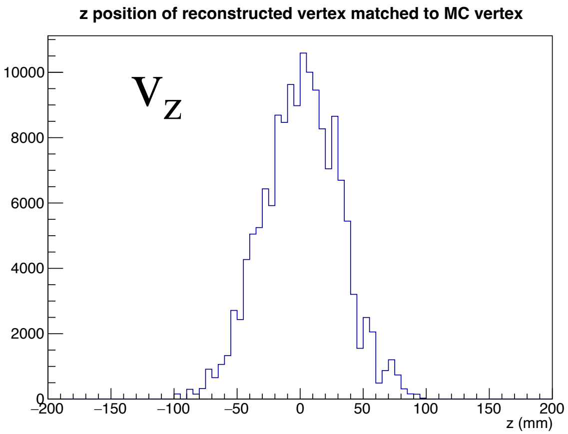


- Clear beam effects: v_z smeared out to 100 mm; negligible smearing for v_y

RC vertex distributions

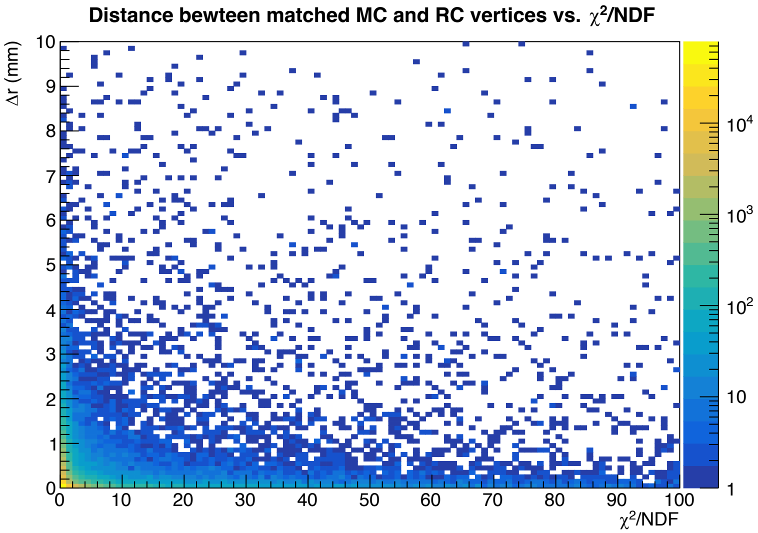


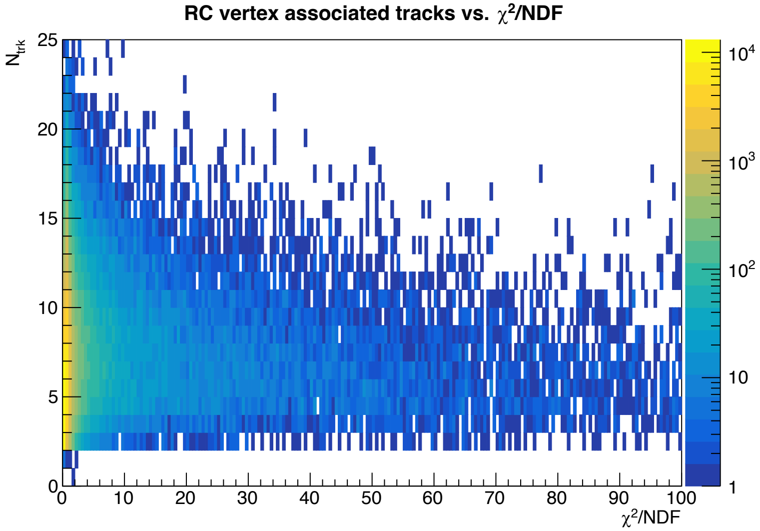




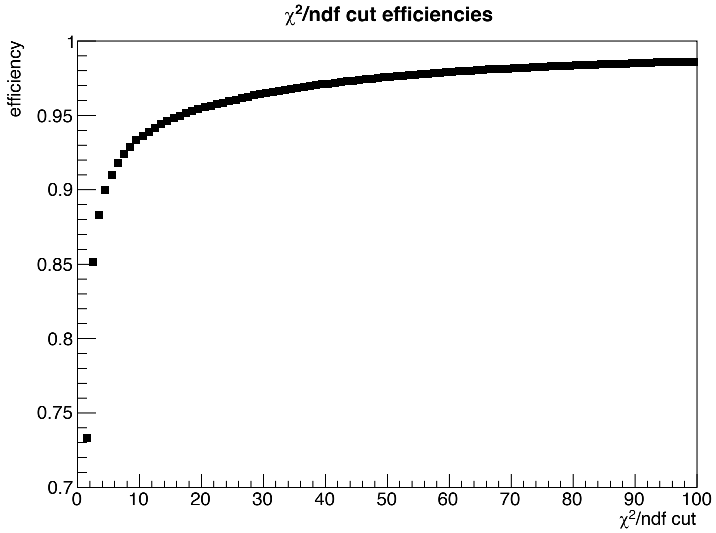
- Additional smearing due to resolution
- Suggested vertex cuts:
  - $|v_z| < 100$ mm
  - $\sqrt{(v_x^2 + v_y^2)} < 3$ mm

χ^2/ndf correlation





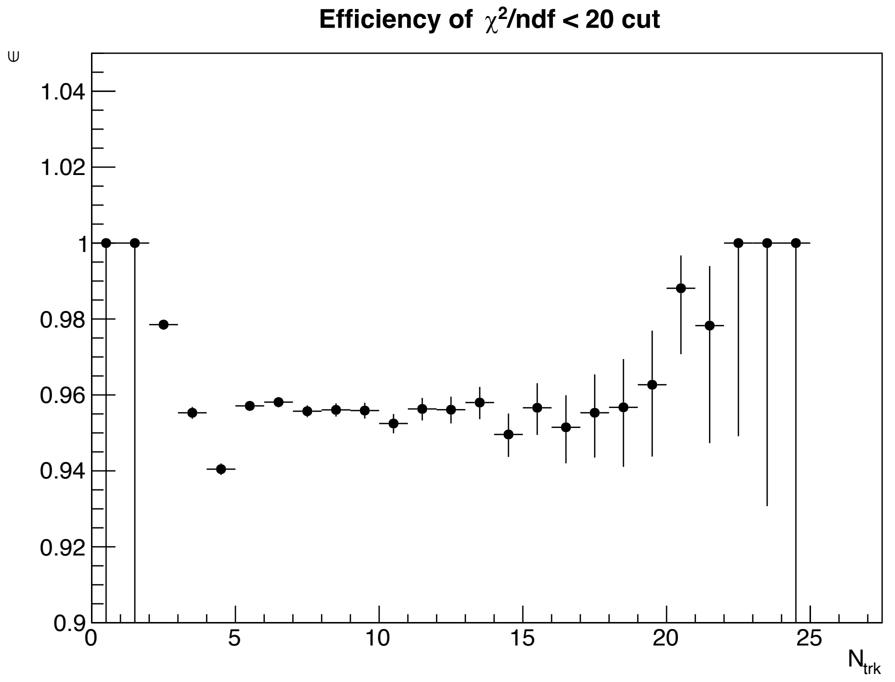
χ^2/ndf cut efficiency



χ^2/ndf cut	Efficiency
χ^2/ndf < 3	88.3%
χ^2/ndf < 5	91.0%
χ^2/ndf < 10	93.6%
χ^2/ndf < 20	95.6%
χ^2/ndf < 50	97.6%

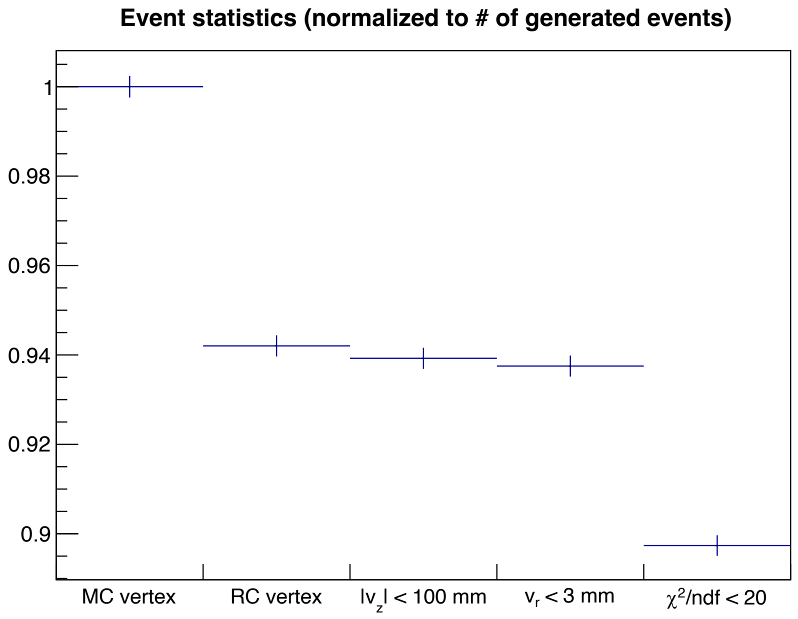
- Suggested vertex cuts:
  - χ^2/ndf < 20 to cut out the tail

χ^2/ndf < 20 cut efficiency

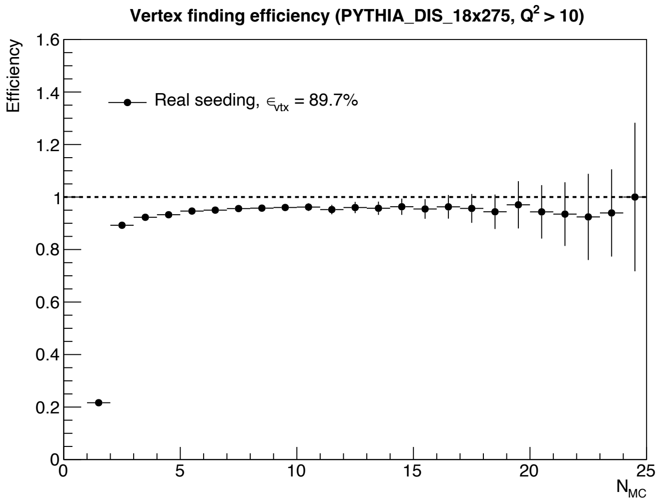


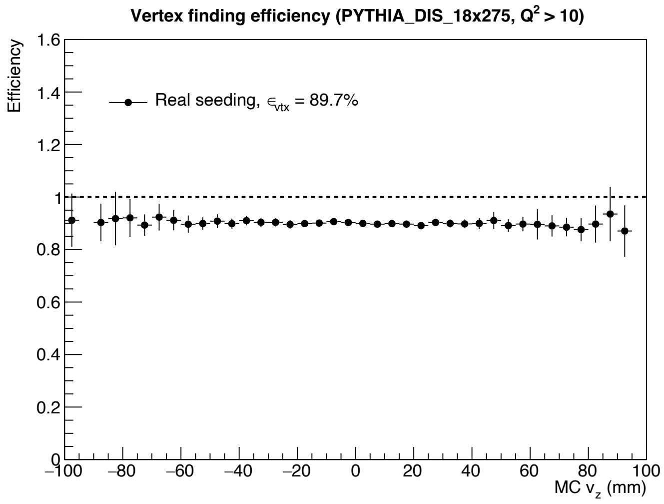
Suggested vertex cuts for DIS events

- Suggested vertex cuts:
  - $|v_z| < 100$ mm
  - $\sqrt{(v_x^2 + v_y^2)} < 3$ mm
  - $\chi^2/\mathrm{ndf} < 20$ (optional)



Vertex finding efficiency





- Low multiplicity: 5% loss due reconstruction and 5% due to χ^2/ndf cut
- High multiplicity (>5): 5% due to χ^2/ndf cut

Vertex resolution

Fitting function

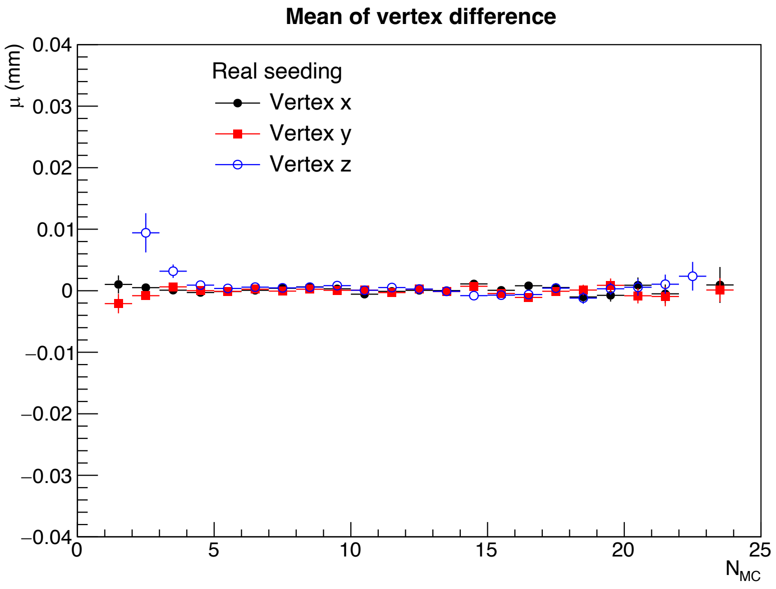
Reminder

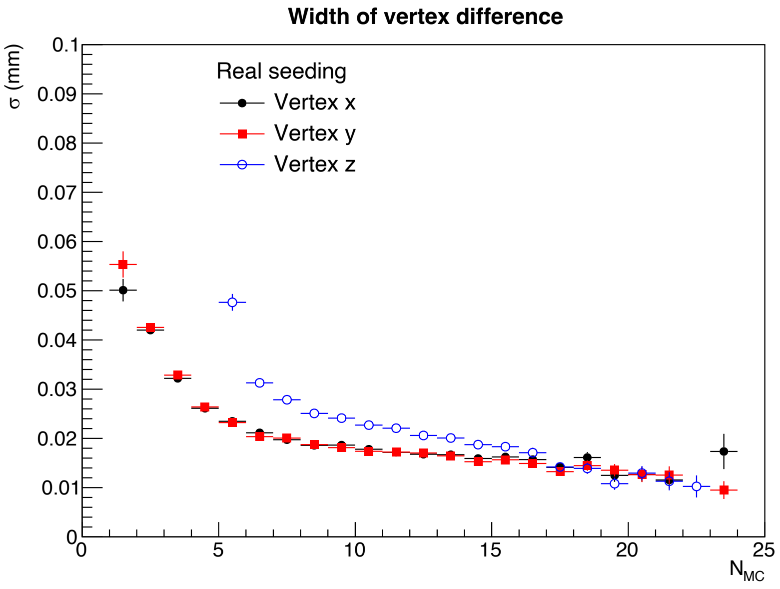
- Due to the significant tails seen in the vertex difference distributions, use *Student's t-distribution* for fitting.

$$f(t) = \frac{\Gamma\left(\frac{\nu+1}{2}\right)}{\sqrt{\pi \nu}\,\Gamma\left(\frac{\nu}{2}\right)} \left(1 + \frac{t^2}{\nu}\right)^{-(\nu+1)/2},$$

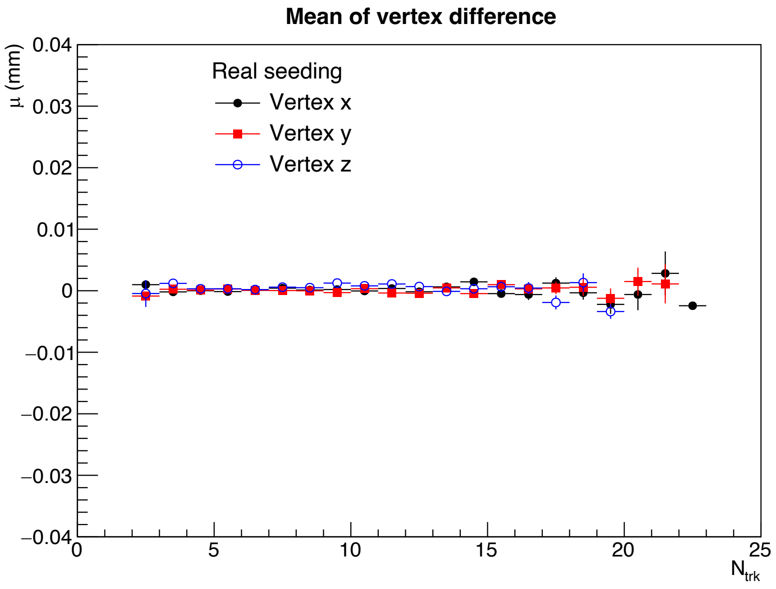
- It is essentially a Gaussian function with a tail. When $\nu \to \infty$, it becomes the Gaussian function.

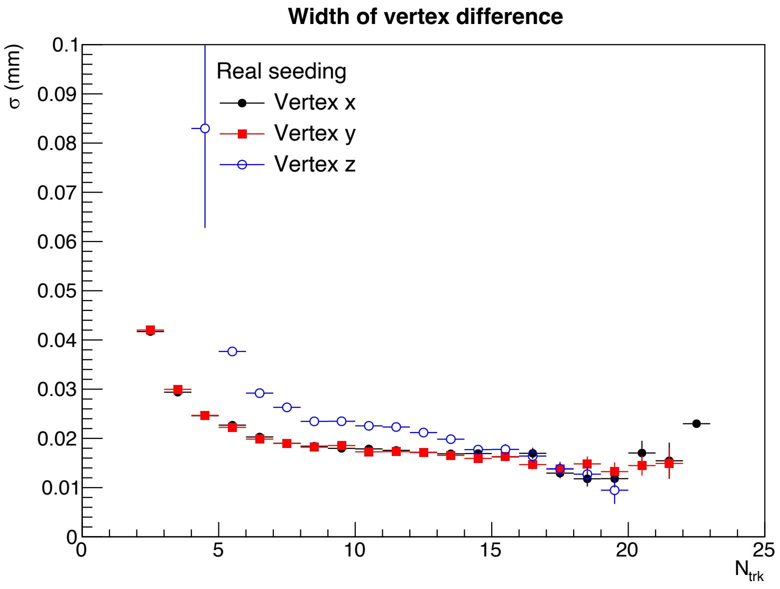
Mean and sigma vs. N_{MC}



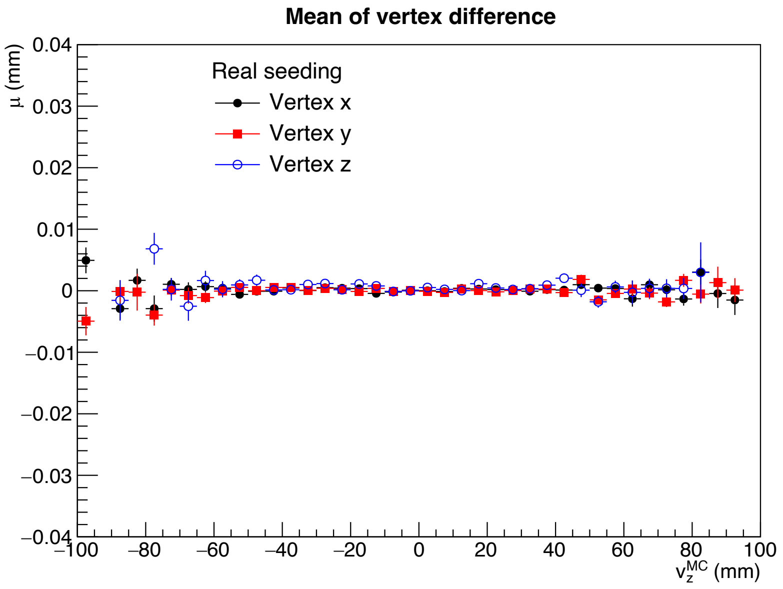


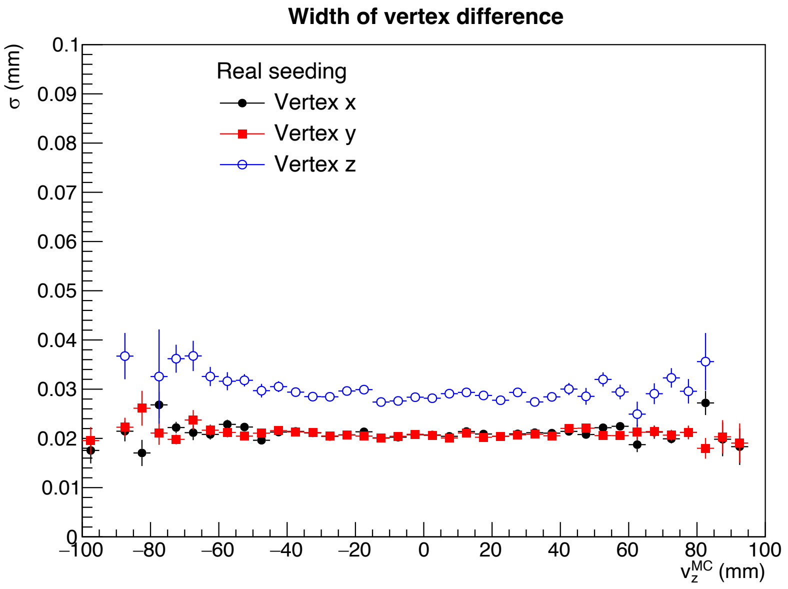
Mean and sigma vs. N_{trk}



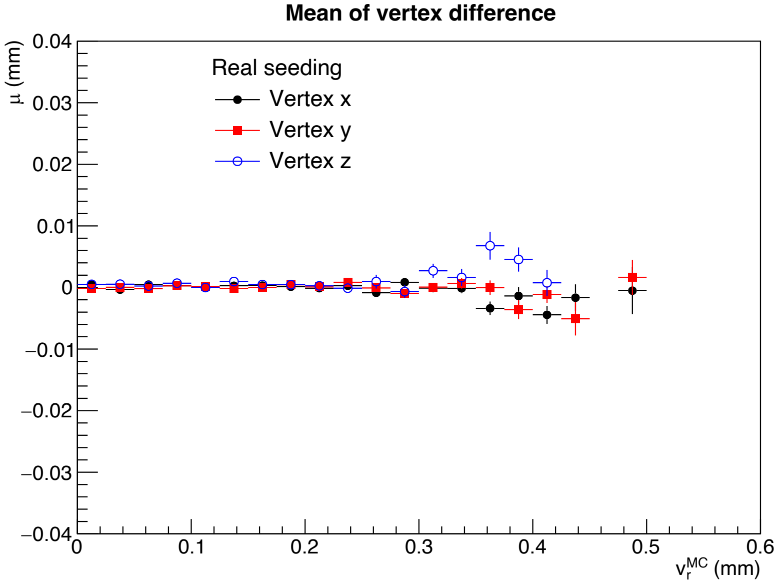


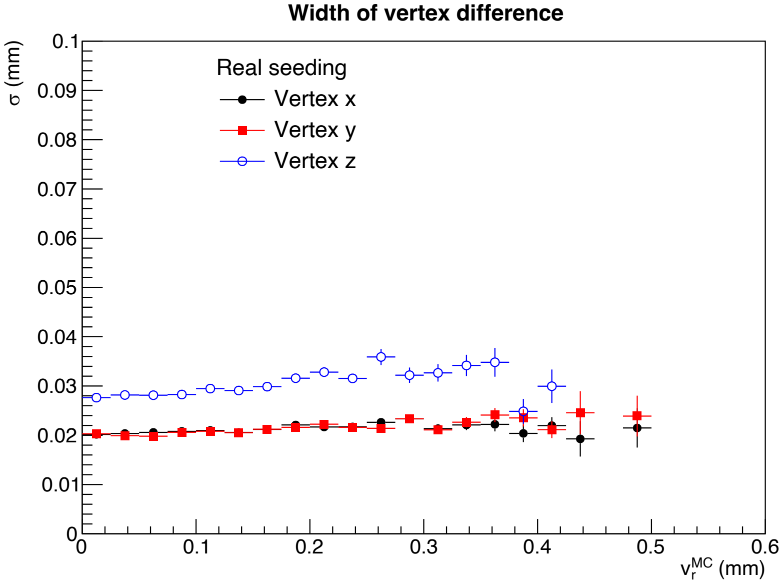
Mean and sigma vs. MC v_z





Mean and sigma vs. MC v_r





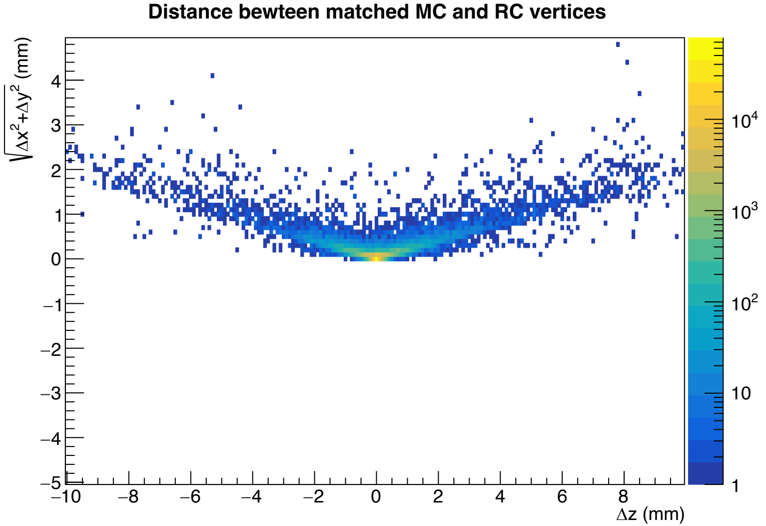
Summary

- Suggested vertex cuts:
  - $|v_z| < 100$ mm
  - $\sqrt{(v_x^2 + v_y^2)} < 3$ mm
  - $\chi^2/ndf < 20$ (optional)
- For DIS events with $Q^2 > 10$ GeV^2
  - Inclusive vertex finding efficiency: ~90%
    - 5% loss from reconstruction, mainly at low multiplicity
    - 5% loss from χ^2/ndf cut independent of event multiplicity
  - Resolution
    - Approach 15 um at high multiplicity along *x* and *y* directions
    - Worse resolution along *z* direction

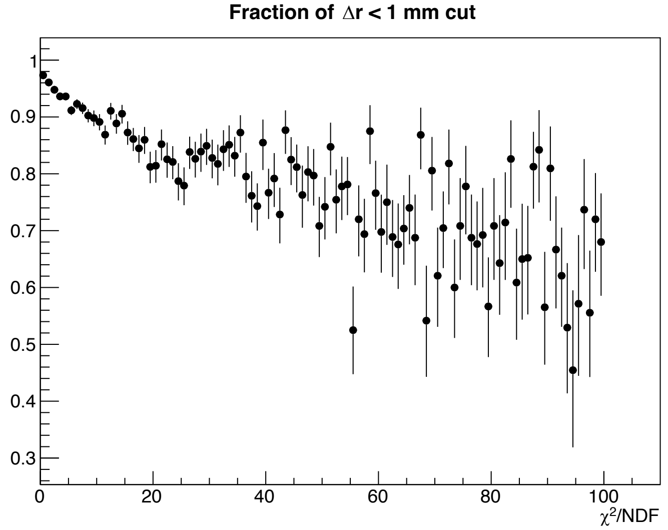
- Outlook: further tune the vertex selection cuts using events with pileup

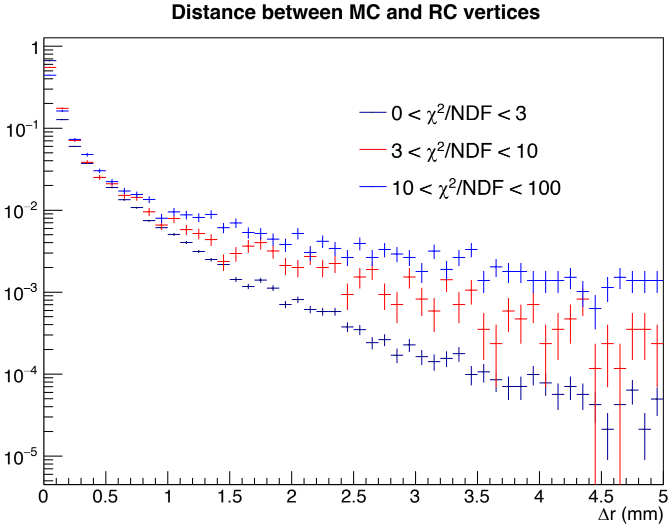
Backup

Vertex matching

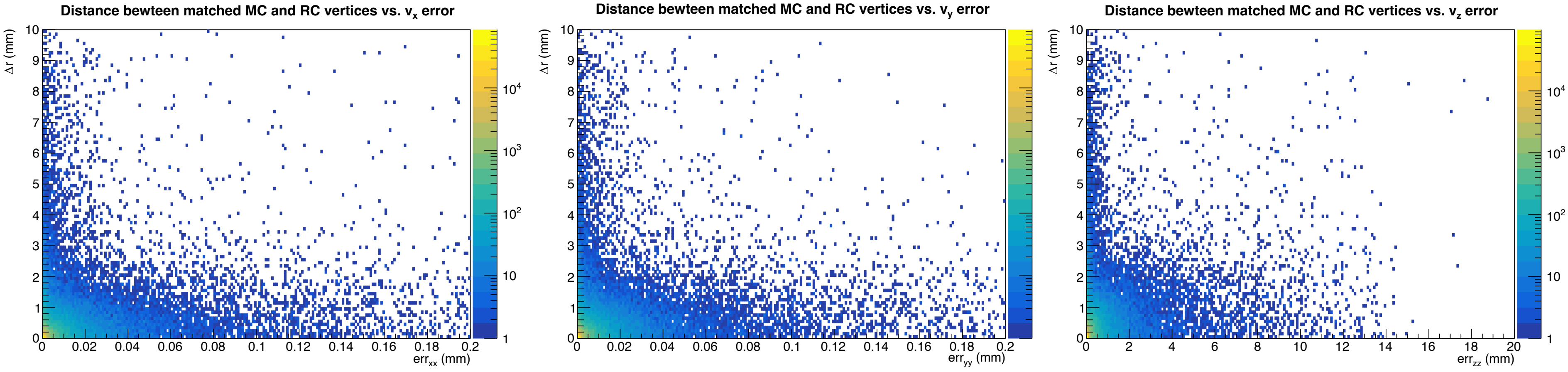


χ^2/ndf correlation





Vertex matching: Δr vs. vertex error



- Only the diagonal elements are shown
- Note that the x-axis scale is much larger for zz component (right) than xx and yy

Vertex matching: χ^2/ndf vs. vertex error