

# Simulation for verter position

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## Transport model for spread in vertex position

- Electron and proton bunches are created at a time before the collision
- Particles in bunches have Gaussian distribution with the width in  $x$  and  $y$  as  $\sqrt{\text{RMS emittance}} \times \beta^*$
- Width in  $z$  is given by RMS bunch length, both from CDR Table 3.3
- Crossing angle of 25 mrad and ESR vertical shift of 100  $\mu\text{rad}$  are considered when the bunches are created
- Space in  $x, y, z$  around the interaction is divided into small volumes
- The bunches are transported in steps in time through interaction region
- Overlap in electron and proton bunches is calculated at each time step in each volume
- The overlap is given by intersection in number of electrons and protons in each particular volume, e.g. with 3 electrons and 10 protons the overlap is 3
- Evolution in bunch overlap is integrated over time
- Bunch overlap in  $x, y$  and  $z$  is obtained by integrating the other two coordinates

# Evolution in bunch overlap for ep at 18x275 GeV

- Bunches are rotated by half the crossing angle to account for crabbing
- Blue and red lines show particles direction, z is aligned along electron beam

Figure: Initial state

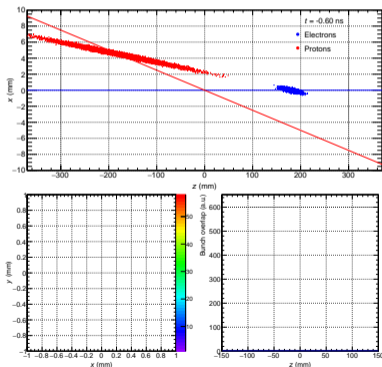


Figure: Bunches at the origin

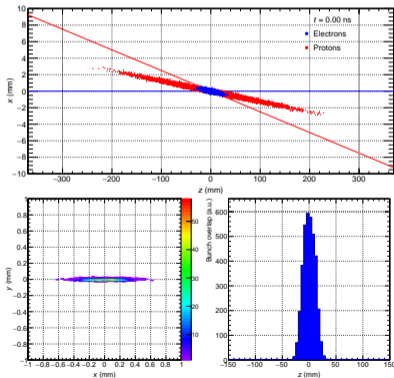
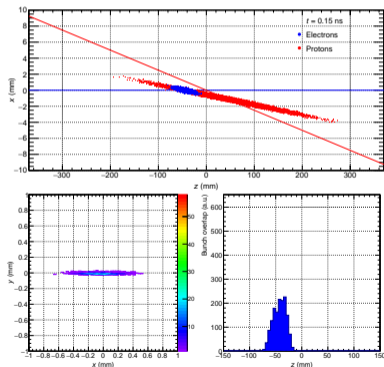
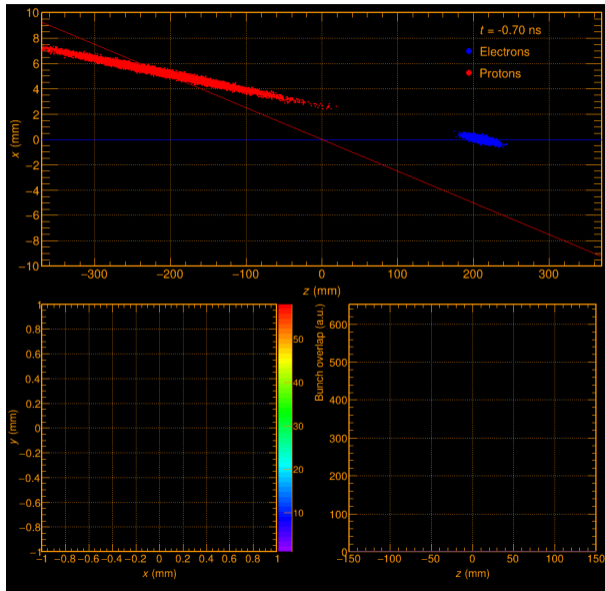


Figure: Leaving the interaction

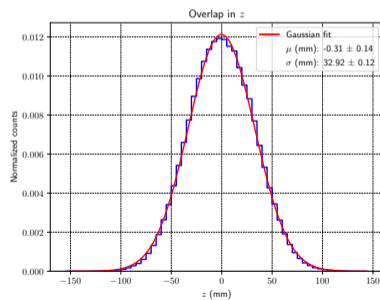
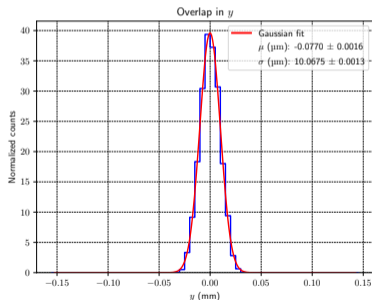
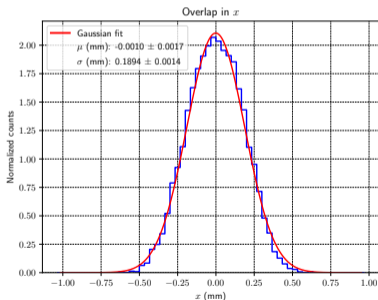


# Movie for ep at 18x275 GeV



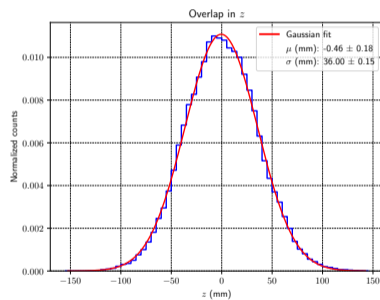
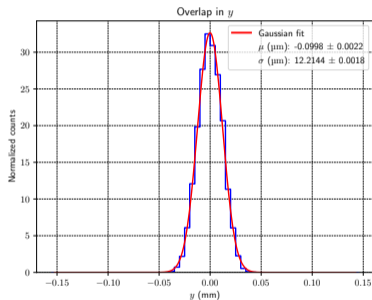
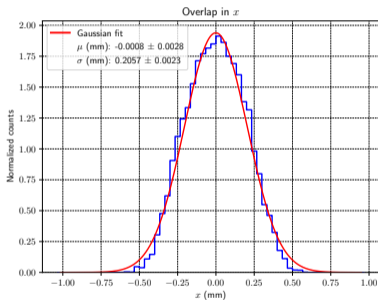
# Interaction vertex by integrated bunch overlap for ep at 18x275 GeV

- Overlap in electron and proton bunches is integrated over time
- Possible vertex locations in  $x$ ,  $y$  and  $z$  separately are given by the overlap integrated over the other two coordinates
- Gaussian fits give the width of vertex spread in each coordinate



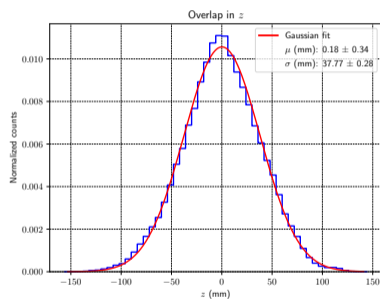
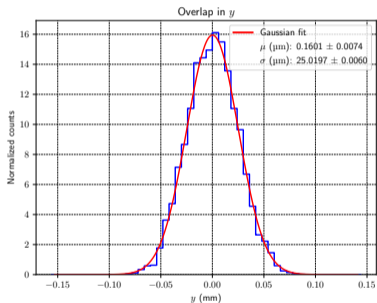
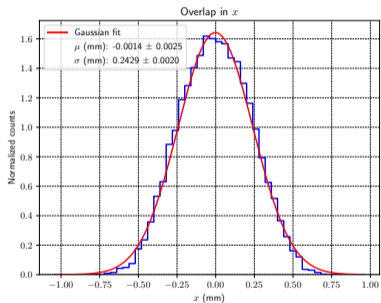
# Interaction vertex for ep at 10x100 GeV

- The procedure is repeated for 10x100 GeV, Table 3.3



# Interaction vertex for ep at 5x41 GeV

- The procedure is repeated for 5x41 GeV, Table 3.3



# Summary

- Overview of beam effects was given by Elke and Brian in [indico.bnl.gov/event/12022/](https://indico.bnl.gov/event/12022/)
- Results are compatible with the model by Brian: width in  $x$  is 0.14 mm, 6  $\mu\text{m}$  in  $y$  and 30 mm in  $z$  vs. values obtained here: 0.19 mm, 10  $\mu\text{m}$  and 33 mm, both for 18x275 GeV
- All the codes are here: [https://github.com/adamjaro/eic\\_beam\\_shape](https://github.com/adamjaro/eic_beam_shape)