

# Magnetic field in Geant and DD4hep

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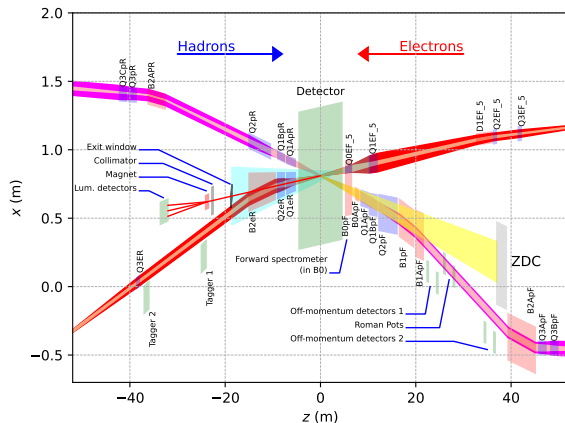
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# Beam magnets in far-backward area

- Q1eR, Q2eR, B2AeR, B2BeR magnets are simulated in Geant luminosity framework and in DD4hep
- Input is electron beam generated with nominal vertex spread, angular divergence and momentum spread
- The beam is captured at the front of Q3eR after passing through fields of Q1eR, Q2eR, B2AeR, B2BeR
- Shape of the beam is compared to lattice results for the front of Q3eR
- Geant was found well compatible with lattice results
- DD4hep needed corrections to achieve the compatibility



# Magnets location and fields

Name	$z_0$ (m)	$z_1$ (m)	$d_0$ (mm)	$d_1$ (mm)	$B$ (T or T/m)	$x_0$ (m)	$x_1$ (m)	$\theta_y$ (mrad)
Q1eR	-5.3	-7.1	96	111	13.3153	0	0	0
Q2eR	-7.6	-9	129	129	-12.0595	0	0	0
B2AeR	-9.61	-11.39	140	140	0.192	0	0	0
B2BeR	-11.685	-14.865	196	196	0.238	0	0	0
Q3eR	-37.7	-38.3	100	100		-0.46003	-0.47087	18.08

**Table:** Start and end position along  $z$  is  $z_0$  and  $z_1$ . Same convention is used for diameter  $d$  and position in  $x$ .

## Layout in Geant and DD4hep

- Q1eR, Q2eR, B2AeR, B2BeR magnets are shown as cylinders
- Rectangular marker at the front of Q3eR captures the beam
- Separate vacuum volumes (even in surrounding vacuum) had to be defined in DD4hep and more precise field transport had to be set for correct beam transport

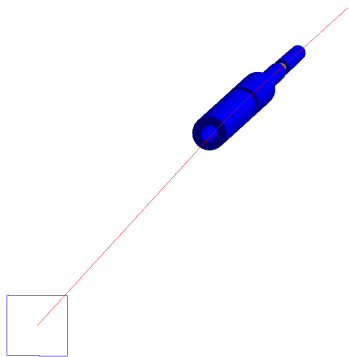


Figure: Geant layout and electron trajectory

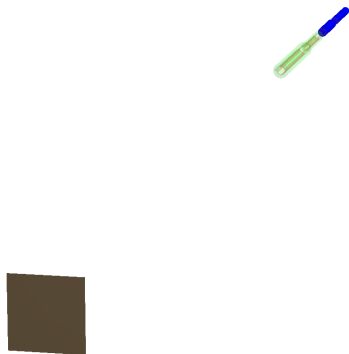


Figure: DD4hep layout

# Beam shape at Q3eR from Geant

	$\mu_x$ (mm)	$\mu_y$ (mm)	$3\sigma_x$ (mm)	$3\sigma_y$ (mm)
Lattice reference	0	0	10.19	0.41
Geant results	$-2.733 \pm 0.025$	$-0.003 \pm 0.001$	$10.247 \pm 0.062$	$0.379 \pm 0.003$

- Fit to beam position on the front of Q3eR
- Comparison to lattice calculation
- Slight offset in  $x$  vs. lattice
- Good agreement for beam width

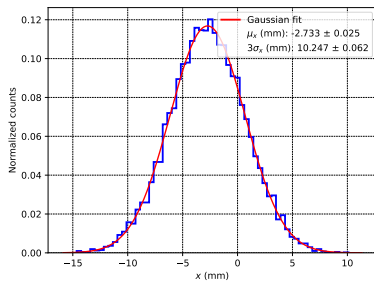


Figure: Beam along  $x$  in Geant

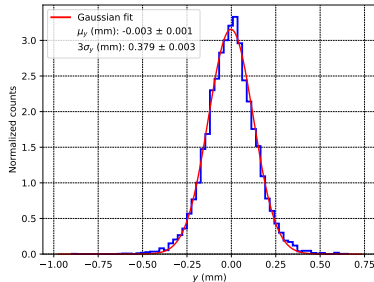


Figure: Beam along  $y$  in Geant

# Beam shape at Q3eR from DD4hep

	$\mu_x$ (mm)	$\mu_y$ (mm)	$3\sigma_x$ (mm)	$3\sigma_y$ (mm)
Lattice reference	0	0	10.19	0.41
Geant results	$-2.733 \pm 0.025$	$-0.003 \pm 0.001$	$10.247 \pm 0.062$	$0.379 \pm 0.003$
DD4hep results	$-2.991 \pm 0.036$	$-0.003 \pm 0.006$	$10.290 \pm 0.087$	$0.565 \pm 0.014$

- Fit to beam position on the front of Q3eR
- Comparison to lattice calculation and Geant
- Mean and  $\sigma_x$  is consistent with Geant and lattice
- Vertical distribution ( $y$ ) is more wide than the lattice reference

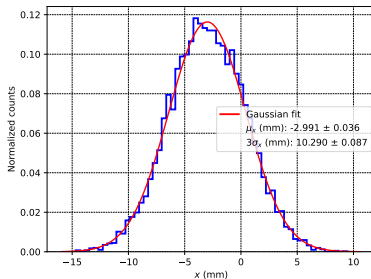


Figure: Beam along x in DD4hep

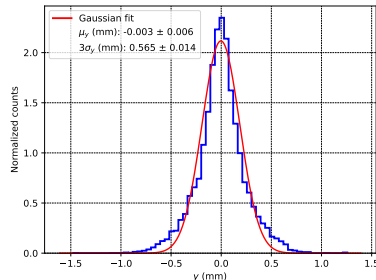


Figure: Beam along y in DD4hep

# Summary

- Geant agrees with lattice calculations
- DD4hep is acceptable after the corrections (separate vacuum volumes and more precision)
- Quadrupoles have to be rotated by 90 degrees along  $z$  to get the same convention as comes from lattice
- The rotation is achieved either in magnet placement or by inverting the sign of field gradient
- Original problem with DD4hep can't be reproduced in Geant as of now – Geant is very stable to changes in precision and in equations for field stepping
- Same hepmc3 input file is used with Geant and DD4hep
- Same physics list (FTFP\_BERT) and random seed are set in both simulations
- Identical Geant version (10.7.p01) was used to build the DD4hep (and Athena framework)