# Electron beam in Geant4

JAROSLAV ADAM

202408.20

- Transport of beam electrons from IP6 to the front of Q3ER, comparison with reference from the lattice
- Lattice V6.3, closed orbit will be used to define the beam at IP6 and to provide the reference
- Geant 4-11-01-patch-02 to run the simulation of 1M events
- Good agreement with lattice both in position and divergence, horizontal and vertical

- Beam size σ is:

$$\sigma_{x,y} = \sqrt{\varepsilon_{x,y}\beta_{x,y}}$$

- β is given by the lattice, $\epsilon_{x/y} = 24/2$ nm
- IP6 is centered at $s = 0$
- Front of Q3ER is at $s = -42.464692$ m

Beam size at IP6 will be used to generate electrons, size at Q3ER front will be a reference from lattice
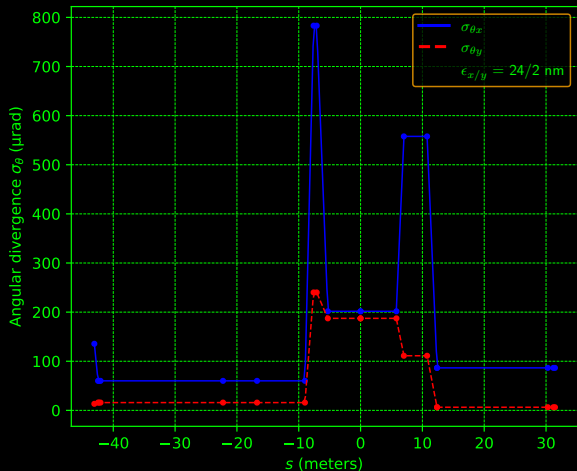
- Angular divergence σ_θ is:

$$\sigma_\theta = \sqrt{\epsilon \frac{1 + \alpha^2}{\beta}}$$
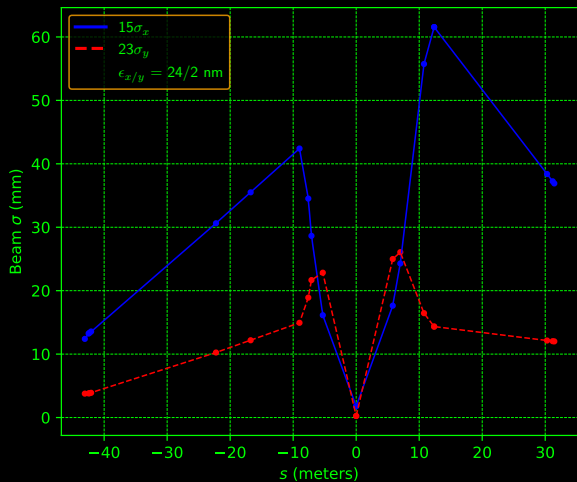
- α and β are given by the lattice, $\epsilon_{x/y}$ = 24/2 nm
- IP6 is centered at $s = 0$
- Front of Q3ER is at $s = $ -42.464692 m

Angular divergence at IP6 will be used to generate electrons, divergence at Q3ER front will be a reference from lattice
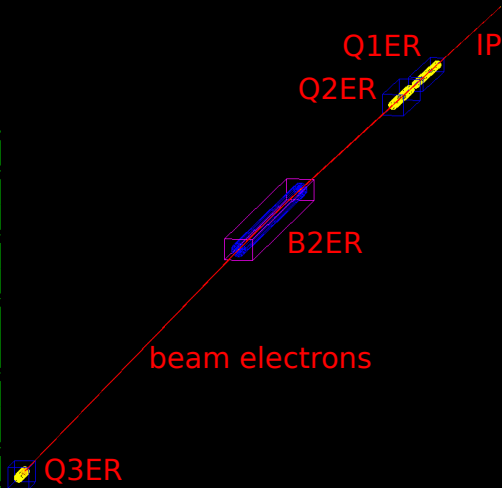
- Beam of e^- at 18 GeV is generated with position and angular spread according to beam size and divergence at IP6 from the lattice

- GPS configuration:

```
/gps/ang/type beam2d
/gps/ang/sigma_x 0.0002017 rad # 201.7 urad
/gps/ang/sigma_y 0.0001873 rad # 187.3 urad
/gps/pos/type Beam
/gps/pos/sigma_x 0.119 mm
/gps/pos/sigma_y 0.0107 mm
/gps/energy 17846.263 MeV # kinetic energy, not total, thanks Andrii:)
/gps/particle e-
```

- 1M events was simulated

- Magnets are placed according to the lattice
- Beam spot is captured at the front of Q3ER (field is not simulated there)

z (mm)	x (mm)	θ (rad)	K1L or angle
Q1ER			
-6200	0	0	-0.000414
Q2ER			
-8300	0	0	0.0003164
B2ER			
-19499.862501	-27.499542	0.01	0.02
Q3ER			
-42760.222219	-465.263731	0.02	
Beam $\gamma = 34924.26476$			

Q1ER

IP

Q2ER

B2ER

beam electrons

Q3ER

- Horizontal beam position x and angles θ_x at the front of Q3ER
- Mean μ and std.dev. σ for x and θ_x projections is compared with the lattice

	Position (mm)		Divergence (µrad)	
	$\mu(x)$	$\sigma(x)$	$\mu(\theta_x)$	$\sigma(\theta_x)$
Geant4	-0.009 ±0.001	0.884 ±0.001	0.344 ±0.060	60.126 ±0.043
Lattice	0	0.883	0	60.111
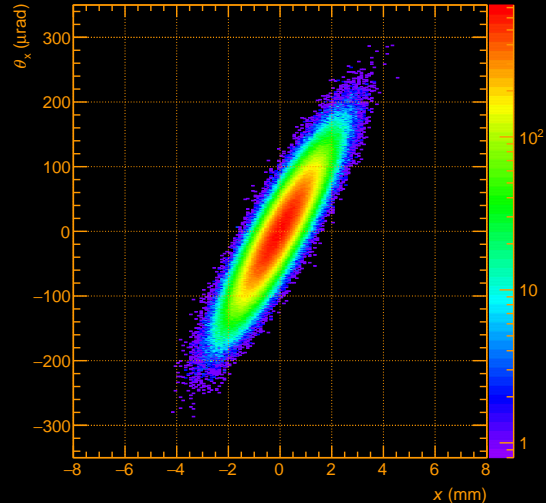
- Vertical beam position y and angles θ_y at the front of Q3ER
- Mean μ and std.dev. σ for y and θ_y projections is compared with the lattice

	Position (mm)		Divergence (µrad)	
	$\mu(y)$	$\sigma(y)$	$\mu(\theta_y)$	$\sigma(\theta_y)$
Geant4	-0.00012 $\pm$0.00017	0.1655 $\pm$0.0001	-0.017 $\pm$0.016	15.848 $\pm$0.011
Lattice	0	0.165	0	15.851
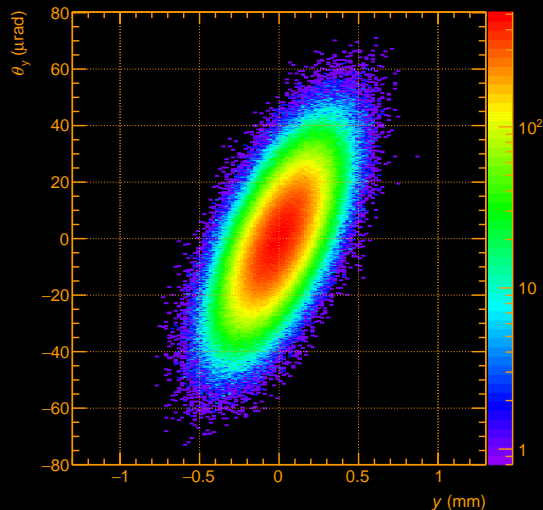
- Good agreement of Geant4 results with lattice reference in full phase space
- Previous problem was caused by incorrect energy for generated electrons (the `/gps/energy` sets the kinetic energy, not the total)