Slice Emittance Measurements Off-crest at PITZ
Longitudinal Resolution of the Setup

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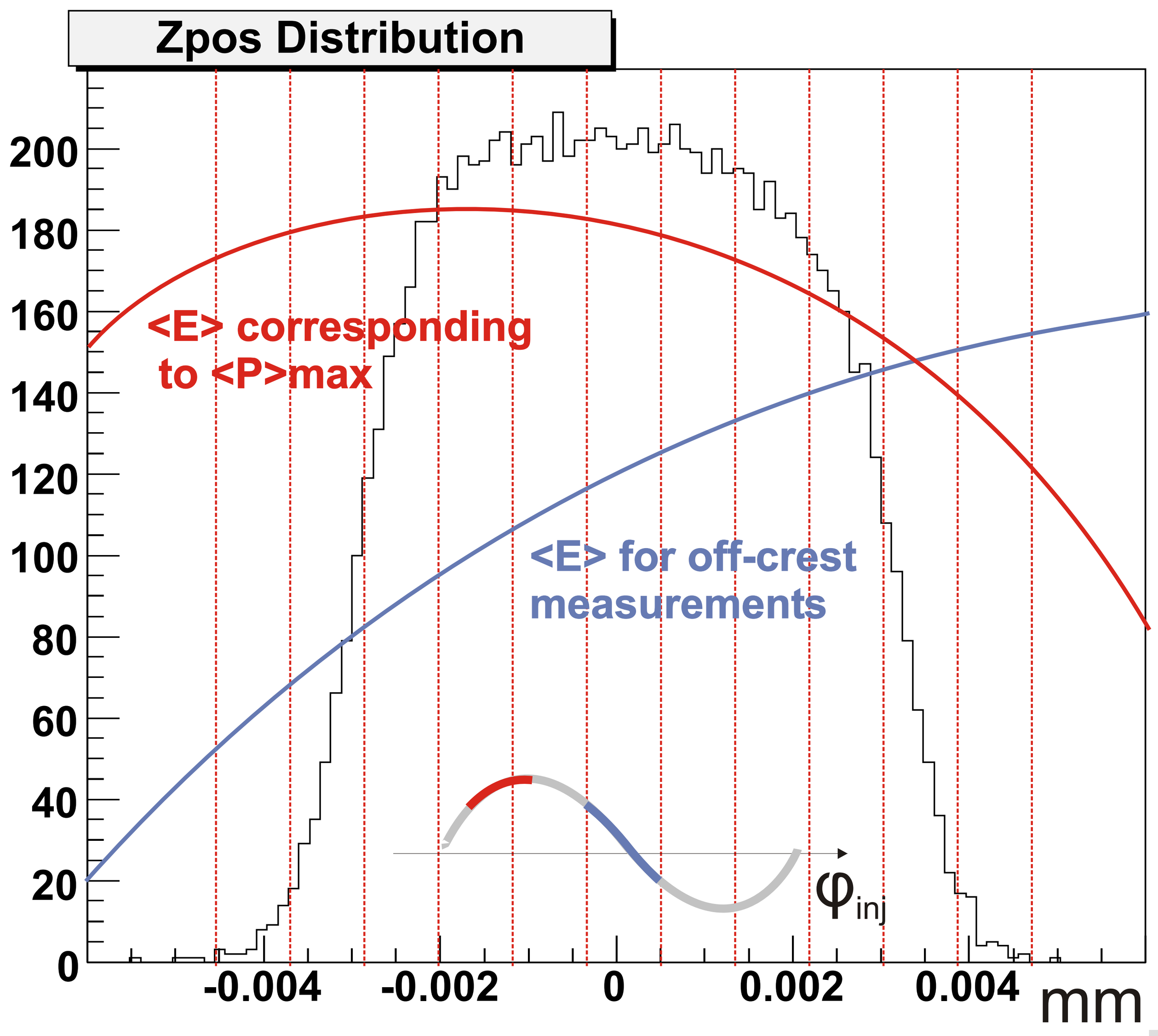
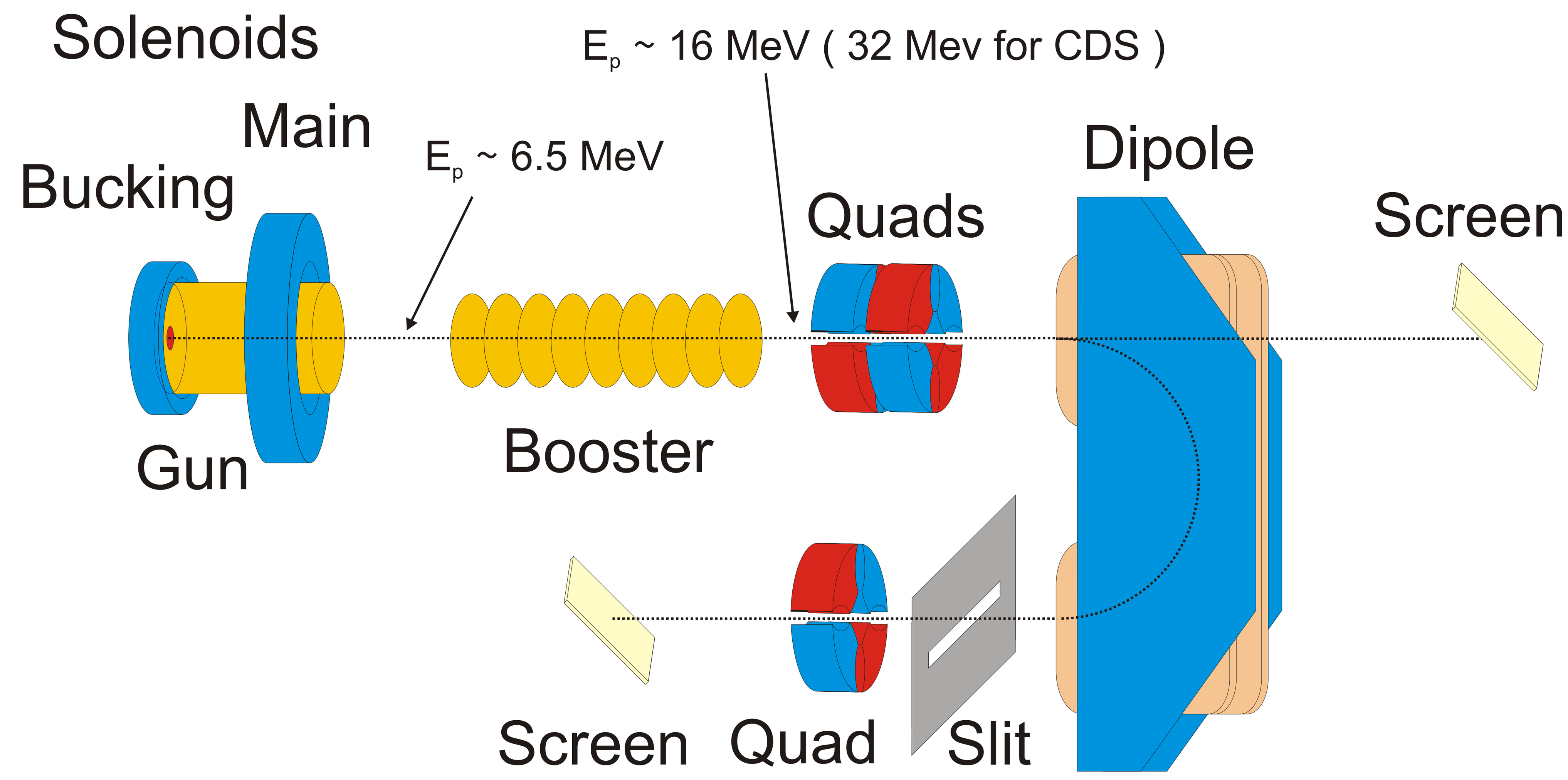
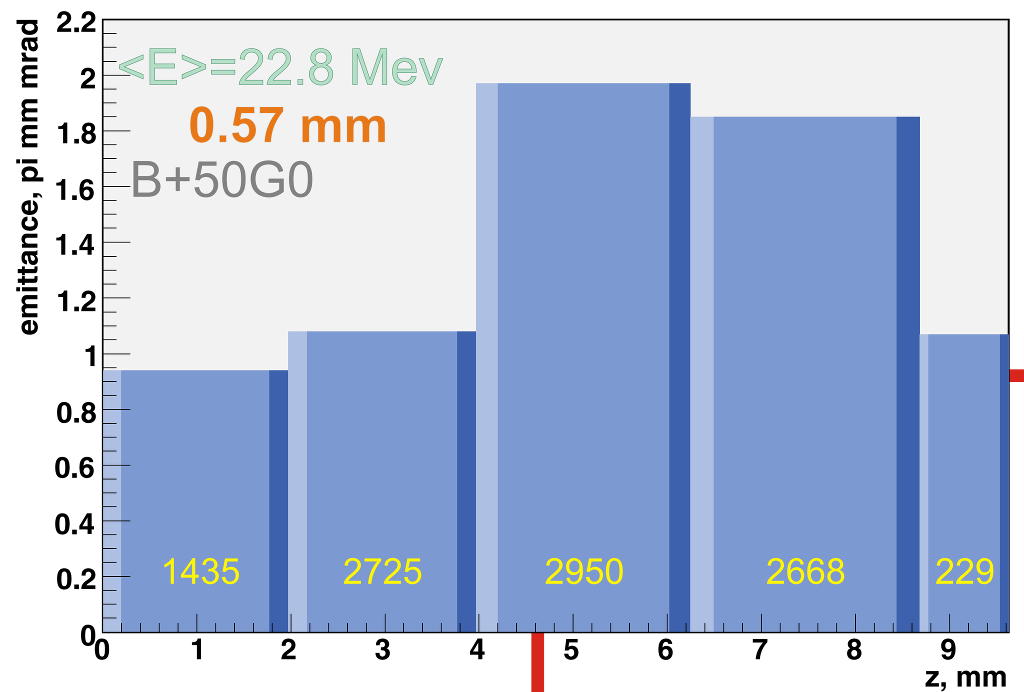


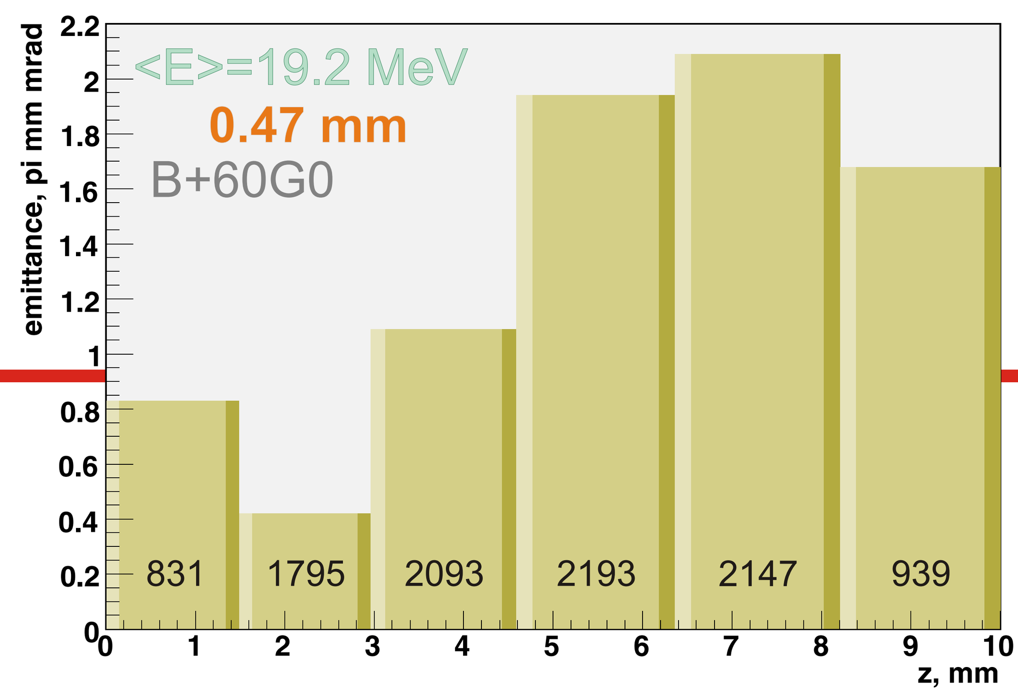


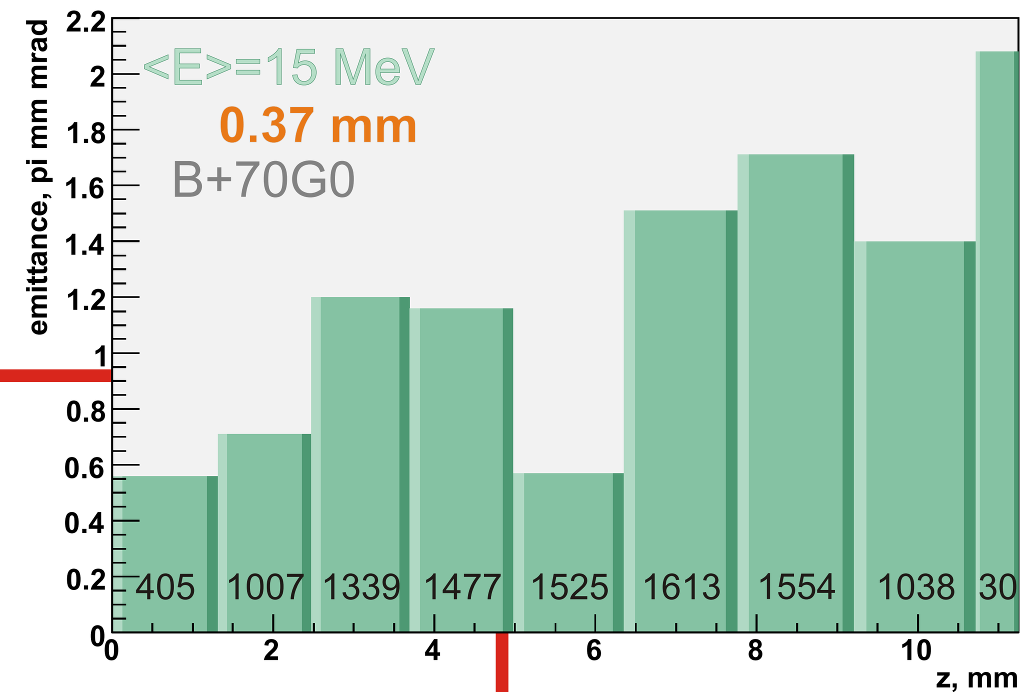
The recent development of high current low emittance electron beams leads to the strong advance in the beam diagnostics methods, which are intended to characterise the beam quality. The projected emittance measurement, as one of those methods, gives a value for the higher limit of the emittance inside the bunch, due to change of phase space distribution along the longitudinal axis inside the bunch itself. To explore the significance of the effect one can cut the bunch into several longitudinal slices and perform emittance measurements for each of the slices. The slice emittance off-crest RF wave measurement setup was designed at PITZ. Different longitudinal parts of the bunch get different energy gain linearly with the longitudinal position, such that the head part gets the highest and the tail - the lowest energy gain. It allows to convert longitudinal (z) coordinate distribution into the transverse (x), tracing particles through the dispersive section. After the dipole a slit is used to cut off the range of x positions which correspond to a certain range of z positions in the bunch. The beamlet emittance is measured by quadrupole scan. Technical realization (see Fig.) consists of a 180 deg dipole (up to 0.46 T, 300 mm bending radius), a removable slit (30 mm width), a scanning quadrupole, screen station with YAG and OTR screens. More details are here [1, 2].

[1] S. Khodyachykh et al., "Design of multipurpose dispersive section at PITZ", FEL conference, THPPH020, 26th of August - 1st of September 2006, Berlin.
[2] S. Khodyachykh et al., "Design and construction of the multipurpose dipersive section at PITZ", DIPAC conference, TUPC07, 20th - 23rd of May 2007, Venice.

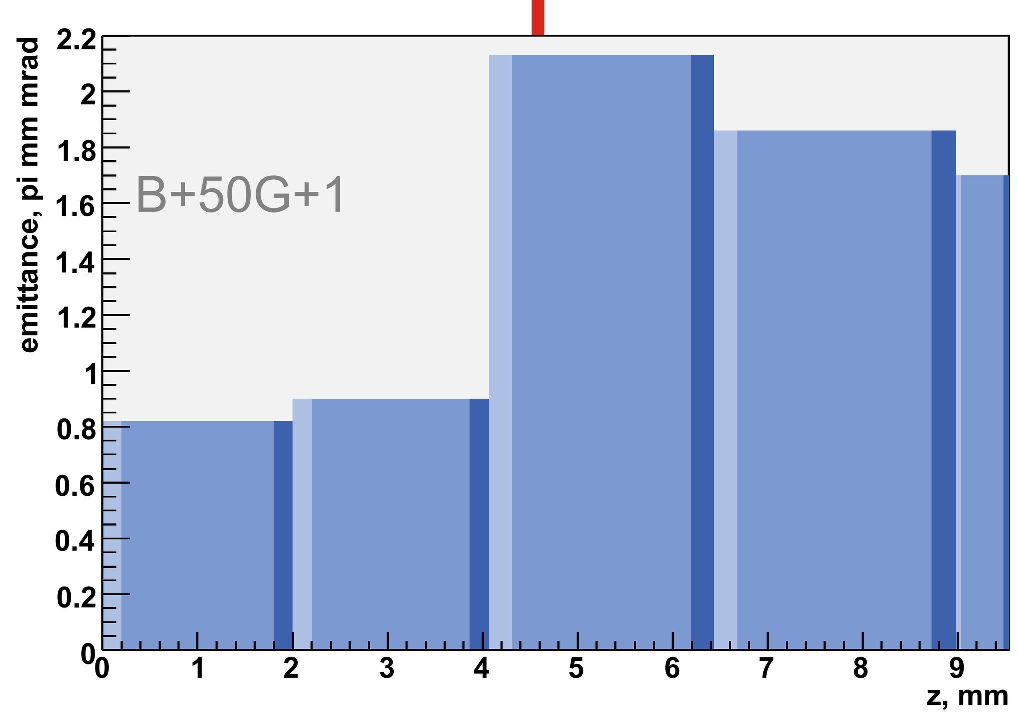
CDS







Regime: Charge - 1 nC (10000 particles); initial pulse structure: flat-top pulse with 2 ps rise/fall time and 16 ps plateau; the gun cavity - max energy gain; the solenoid - to minimize the bunch projected emittance at the dipole input.

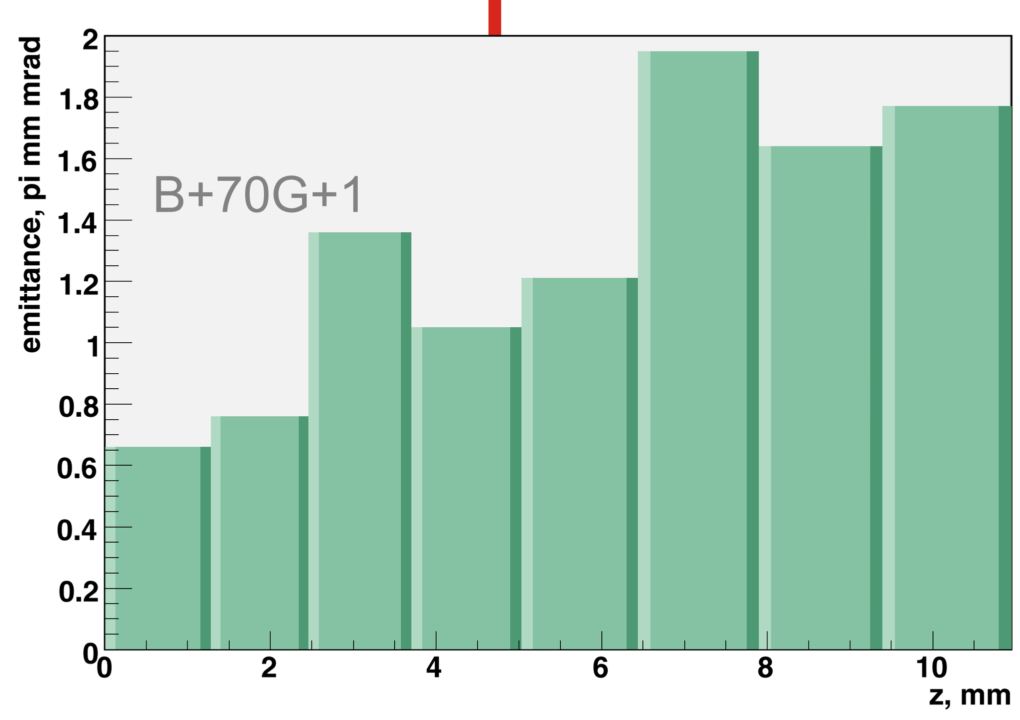


The aim of the simulations is to show the longitudinal resolution of the slice cutting part of the system. The bunch of particles was traced till the entrance in to the dipole using ASTRA. Afterwards matrix transformation is applied to transport the bunch through the diplole.

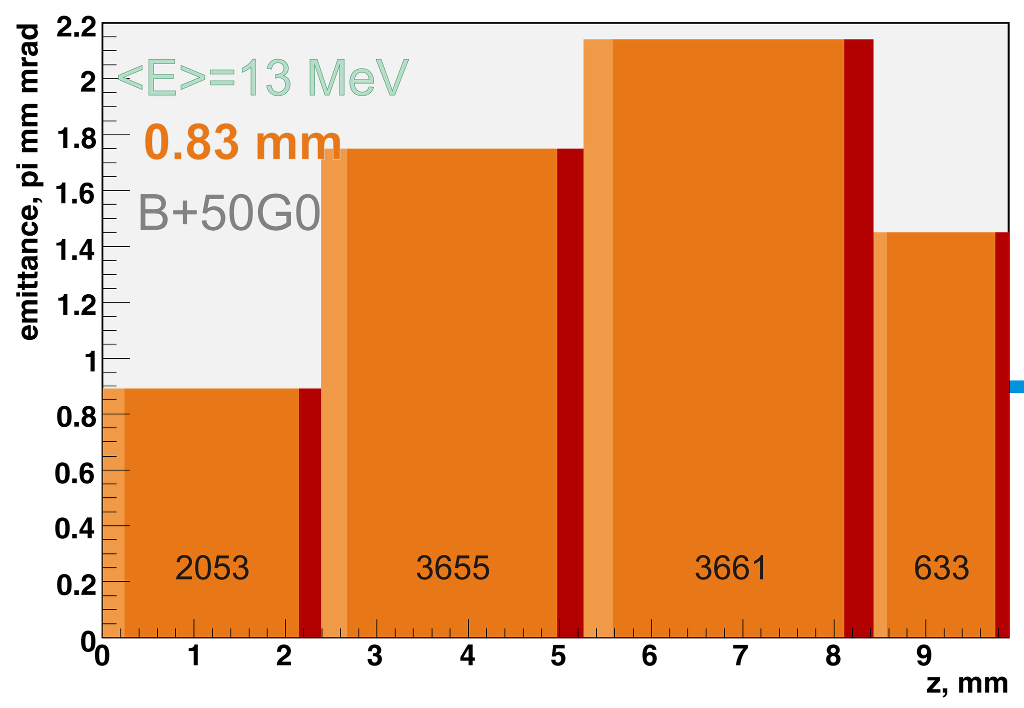
For 180deg dipole the matrix is:

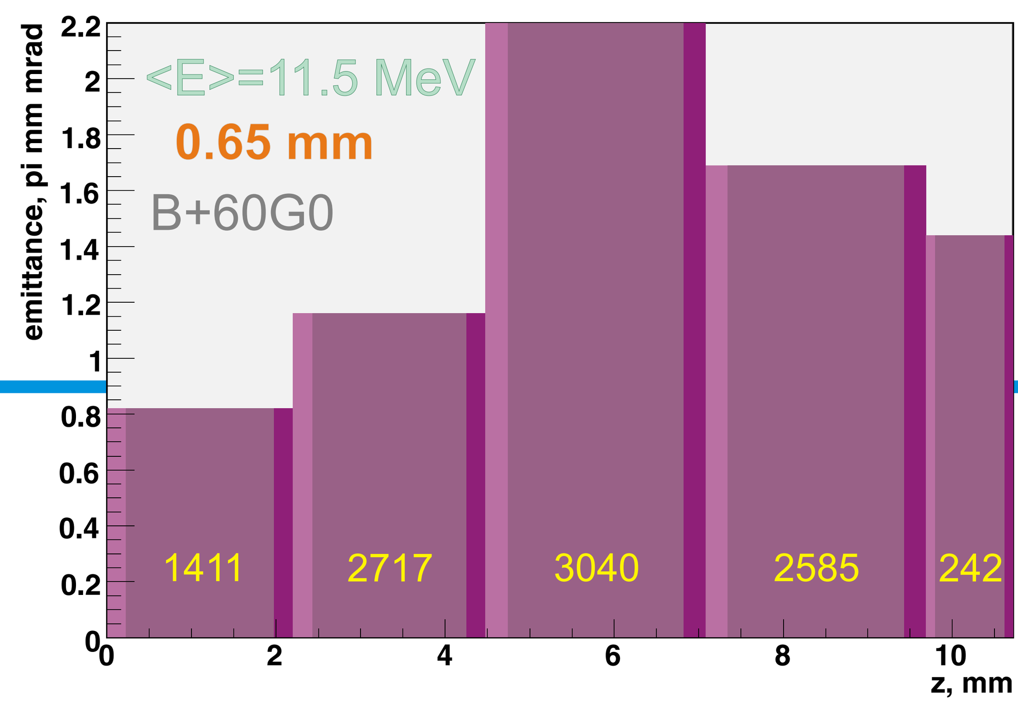
$$M = \begin{pmatrix} -1 & 0 & 2r \\ 0 & -1 & 0 \\ 0 & 0 & 1 \end{pmatrix}$$

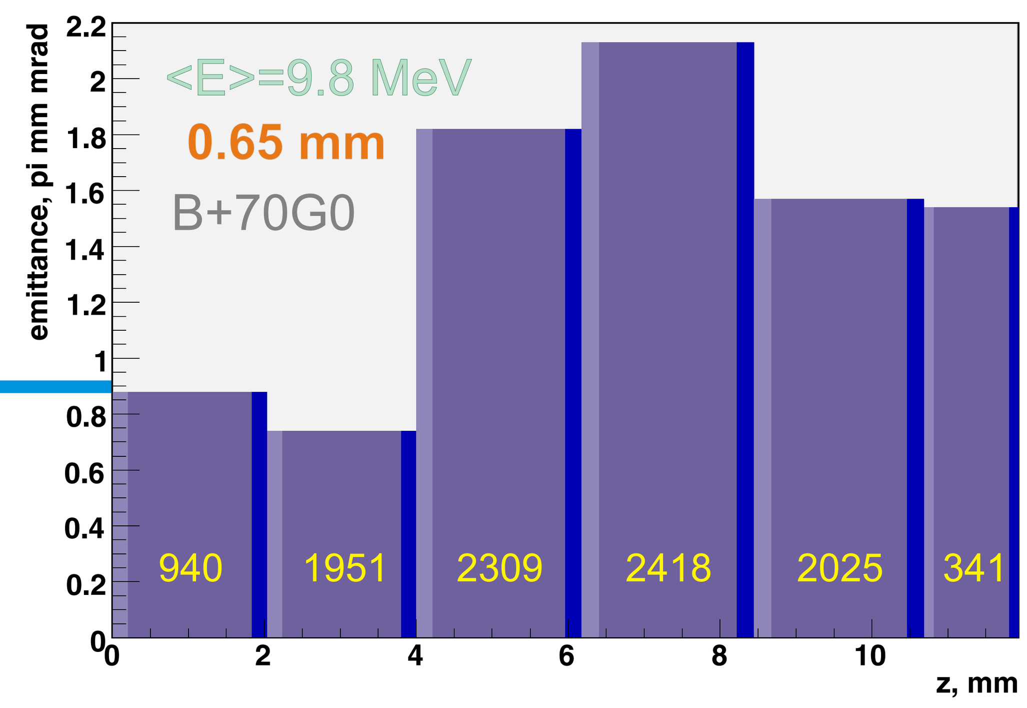
Selecting th particles that have passed through the slit one can find their longitudinal distribution. As a spatial resolution the rms length of a slice with maximum current is taken. The resolution was obtained for the different systems: the TESLA type booster cavity (9 cells, Emax 16 MeV), the CDS type cavity(14 cells, Emax 32 MeV) , several phases off-crest were examined. One should underline that for the TESLA case the mean energy value is critical for signal to noise ratio, while for the CDS case larger phases off-crest can be still applied.



TESLA







Conclusion

The setup longitudinal resolution was simulated for the two types of accelerating cavities and several regimes off-crest. For the TESLA one has limitation, because of lower energy, which leads to low signal to noise ratio, that is why the +60 deg off-crest regime is chosen. In case of the CDS cavity the slit width can be reduced to improve resolution, the optimization signal-resolution is still to be done. The slit size does not define the resolution, it only sets the lower limit for it.

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