Monte-Carlo simulations for the timing-system of EPOS

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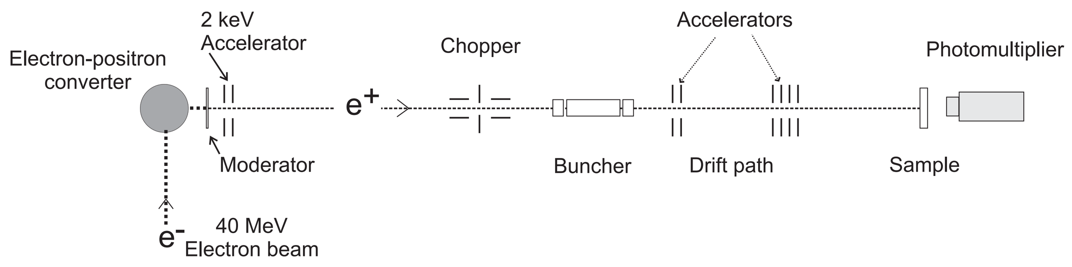
Introduction



Simplified scheme of the EPOS beam with focus on the timing system

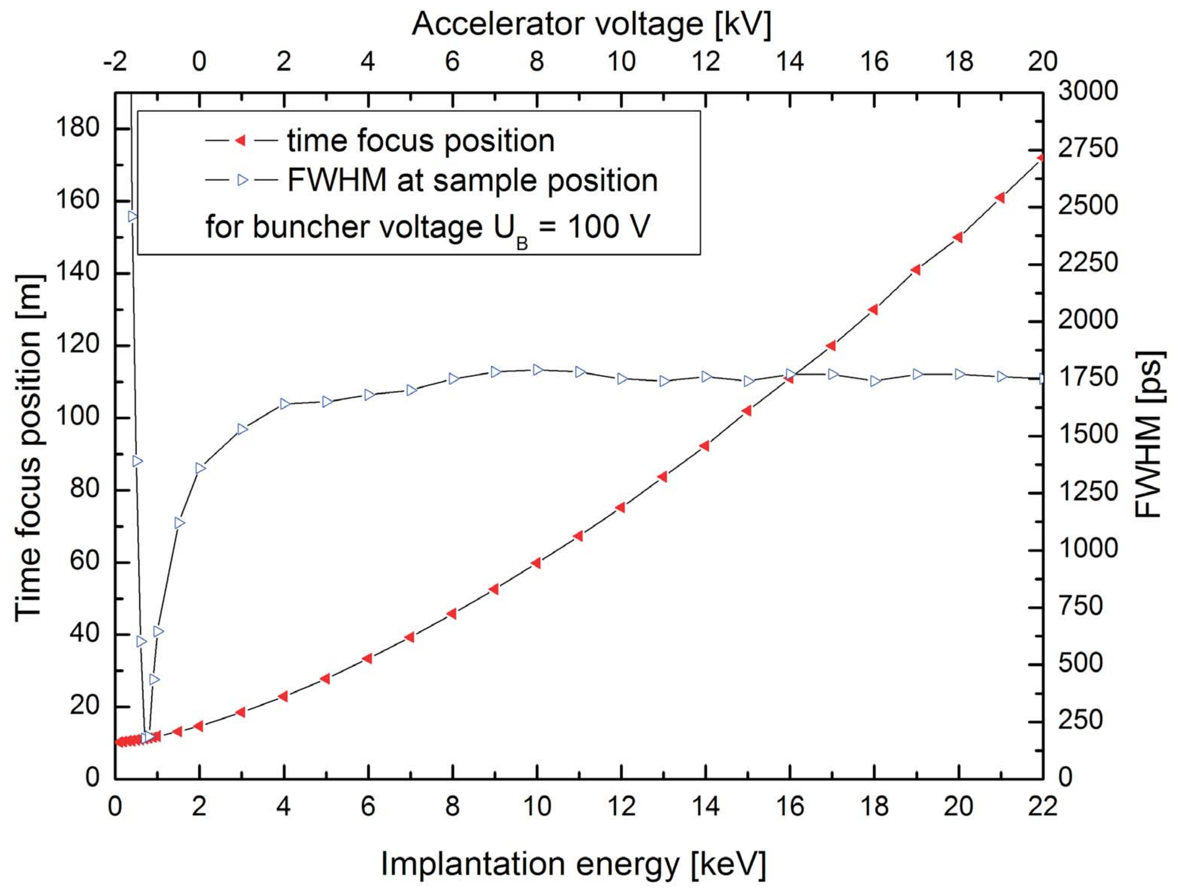
At Research Center Dresden-Rossendorf the 40 MeV electron beam ELBE (Electron Linac for beams with high Brilliance and low Emittance) is used to generate positrons by pair production.
An advantage of this source is the time structure (bunch width about 5ps; repetition rate 13 MHz) which makes ELBE to an ideal host for a bunched positron beam.
The extremely sharp time structure of the primary electron beam allows the realization of the positron lifetime spectroscopy in a worldwide unique way. For this purpose, the positron beam is treated by a system of choppers, double-slit bunchers and an additional drift path short before the final acceleration to improve the time structure.
Monte-Carlo simulations were done to calculate the dependency of the time structure of the positron beam for different settings. (i.e. change of beam energy, variation of the buncher RF-voltage and a variable drift path).

Monte Carlo Simulation

The converter has a fixed energy of 2 keV with a standard derivation of 10 eV.
To realize energies between 0.2 keV and 30 keV the positrons will additional being accelerated. The simulation calculates the derivation of counts for different times. The results are a peak that gives information about the lifetime of positrons and parameters like the full width at half maximum (FWHM) or the position of time focus. These parameters are used to value the effect of the devices.

Each calculation was done several times for a number of 2000 positrons and a positron lifetime of 100 ps.

The result is an useless FWHM of about 1750 ps (a good value would be lower than 100 ps) and a shift of the time focus.
Therefore the use of a timing-system that improves the beam´s time structure is very important.



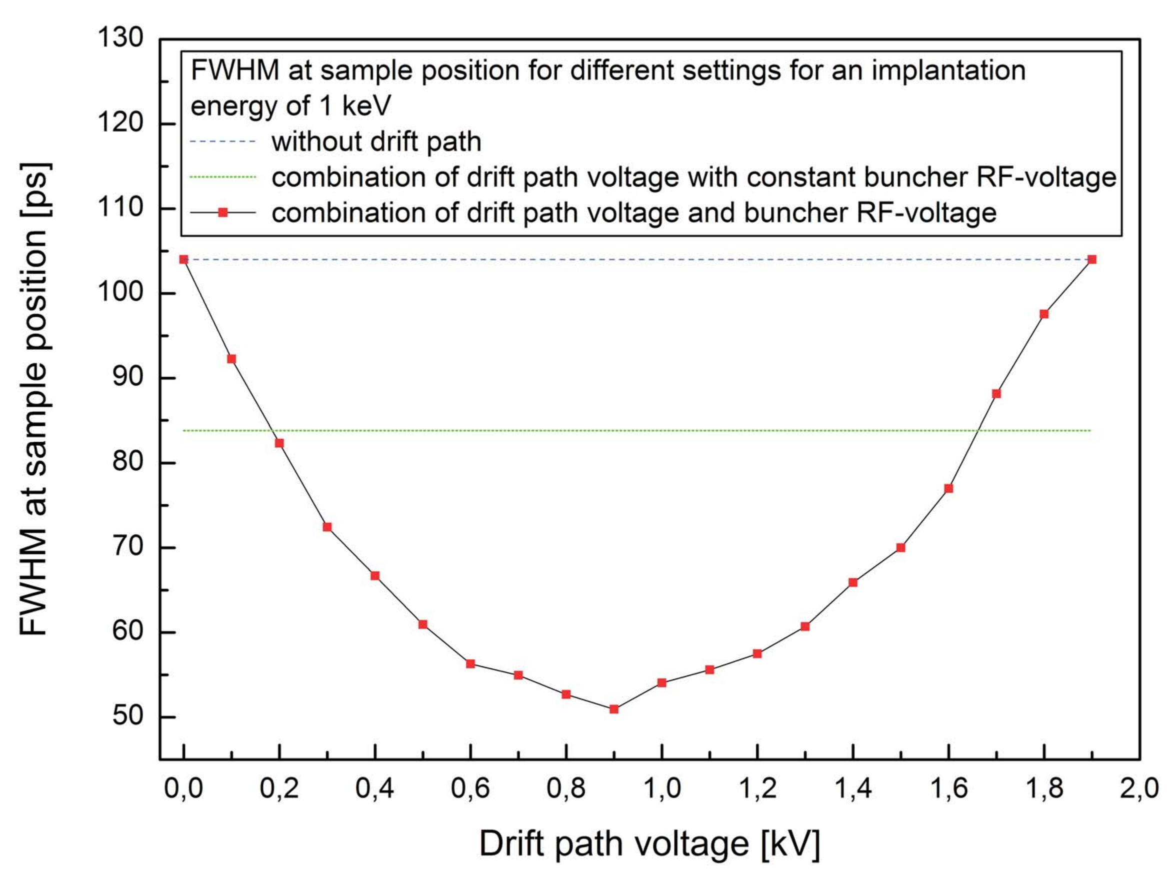
Time focus position and FWHM at sample position for different Positron energies

Different methods of bunching were simulated and their effect was investigated.
One method is the variation of the buncher RF-voltage. The result was apositron pulse with a FWHM of around 60 ps.
Another improvement is the combination of such a buncher with a variable drift path short before the final acceleration which is operated by a DC voltage. The FWHM here was 30 ps.
One can see the great influence of the drift path.

But the simulations showed that indeed a combination of a buncher with a drift path gives the sharpest positron pulses when both devices are supplied with individual voltages for each positron implantation energy.

Combination of a buncher with a drift path

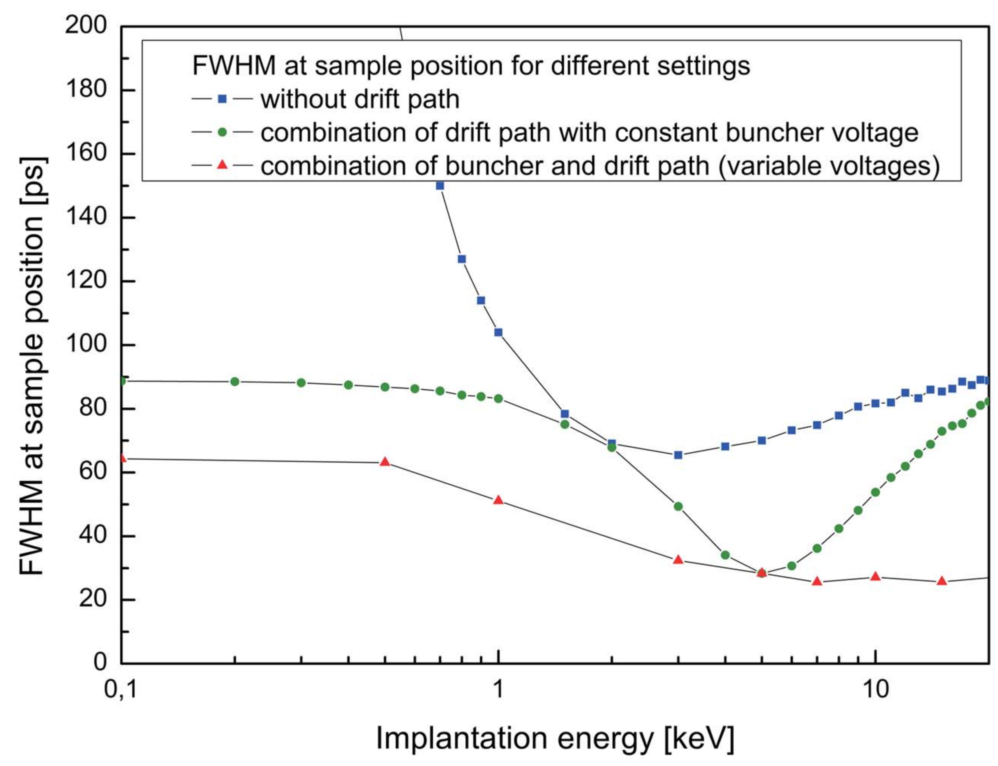
When both voltages (buncher RF-voltage and drift path´s DC voltage) are variable for one positron energy the FWHM has a parabolic dependence on the drift path voltage with a clear minimum.
One can see that in a certain area the FWHM is better than for the other methods.



FWHM at sample position for the combination of drift path voltage and Buncher RF-voltage for one positron energy of 1 keV

Comparison between all methods

A comparison between all three methods (variation of the buncher RF-voltage, combination of a buncher with a variable drift path, combination of a buncher with a drift path with individual voltages for each positron implantation energy) shows obviously that the combination gives the sharpest positron pulses for all positron implantation energies.



Results

It is clearly obvious that the combination of a buncher with a drift path gives the sharpest positron pulses for all positron implantation energies when both devices are supplied with individual voltages for each positron implantation energy.
One can improve the FWHM of the positron pulses about more than one hundred percent for some energies.

References

[1] R. Krause-Rehberg, S. Sachert, G. Brauer, A. Rogov, K. Noack, EPOS - An intense positron beam project at the ELBE radiation source in Rossendorf, Applied Surface Science 252 (2006) 31063110, p.3107

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