Simulation studies for the positron source EPOS

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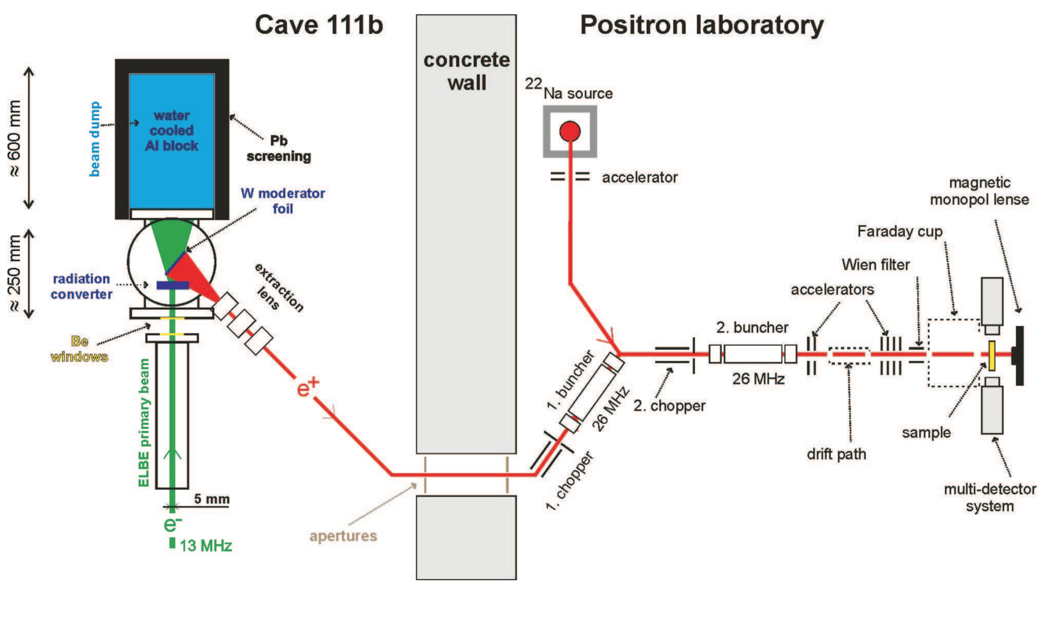
Introduction

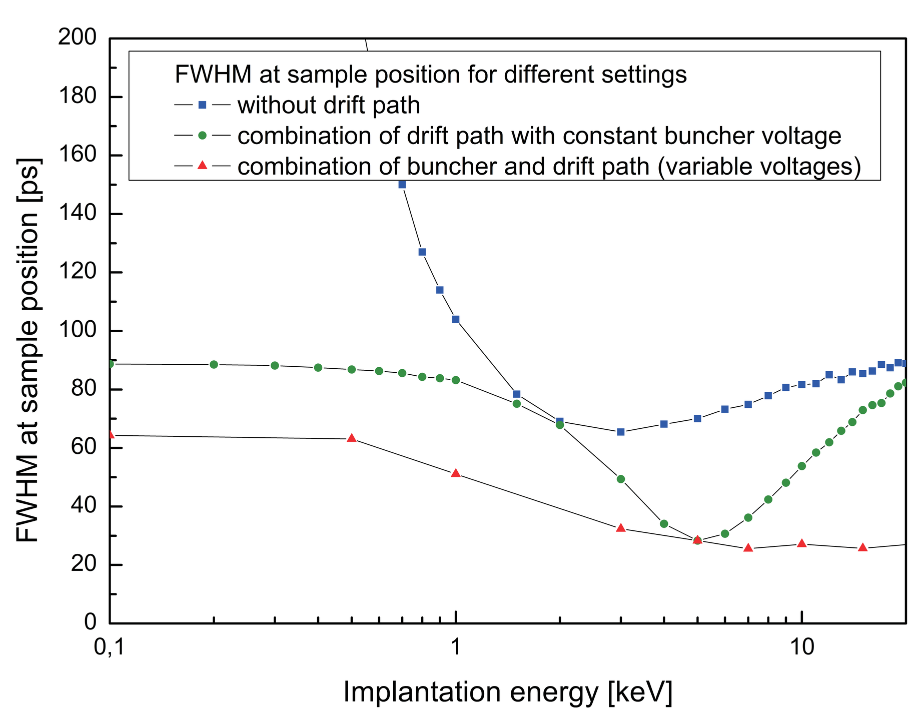


Simplified scheme of the EPOS beam

At Research Center Dresden-Rossendorf the 40 MeV electron beam ELBE (Electron Linac 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 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 of the beam.
Because the moderator and a part of the lens will be hit by the intense primary electron beam, it is necessary to investigate the temperature behaviour of both parts in the electron beam.
Simulations and their results concerning the timing system, the thermal behaviour and the digital detector system will be presented.

Monte-Carlo Simulations For The Timing System

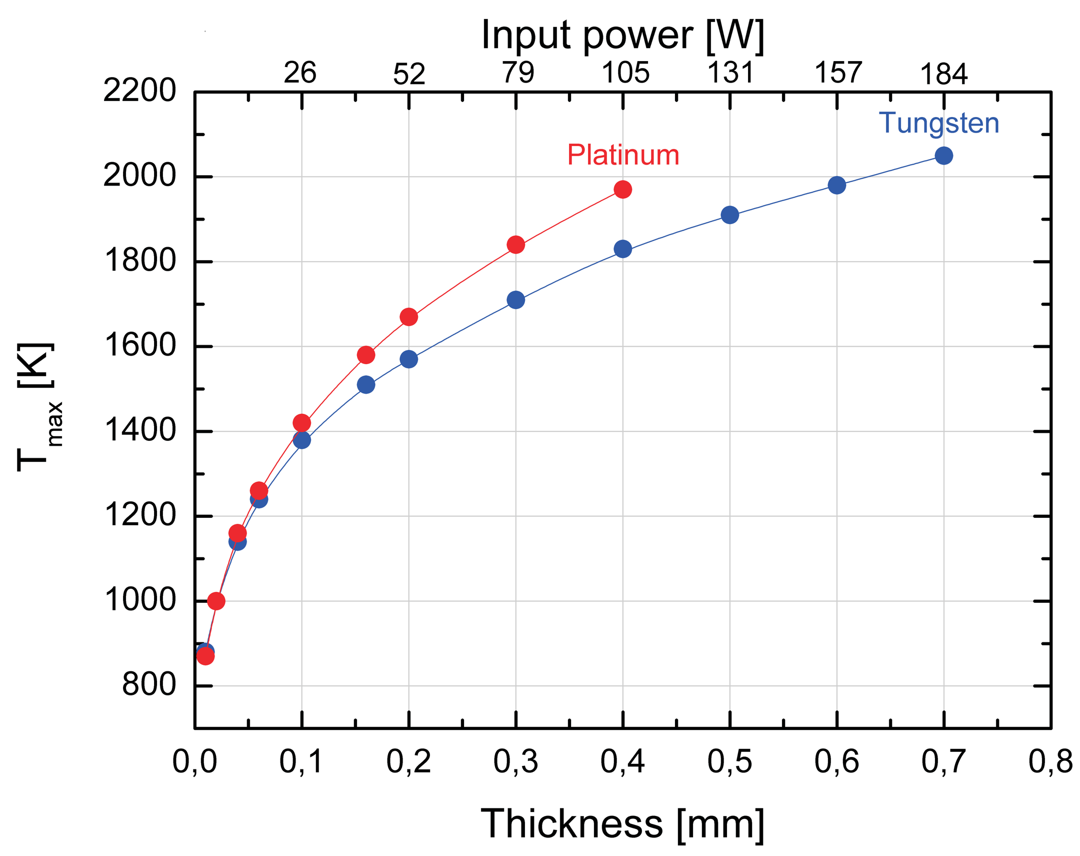
Monte-Carlo simulations were done to calculate the dependency of the time structure of the positron beam for different settings (i.e. change of beam energy, variation of the buncher RF-voltage and a variable drift path). Our simulations showed that indeed a combination of a buncher with a drift path gives the sharpest positron pulses when both devices are supplied with individual voltages for each positron implantation energy.



Comparison between all three methods of bunching: FWHM at sample position for different positron energies

Thermal Calculations

Based on the code ANSYS®, a finite element model is used to calculate the transient temperature distribution in the moderator, the grid and in the electrostatic extraction lens. Heat conduction within the material and radiation heat transfer at the surface is considered.
The lens and the grid are made of stainless steel. For the positron moderator material Pt and W are considered.
The thickness of the Moderator should be chosen under the condition that the maximum temperature is far from the melting temperature of the moderator material (W: 3683 K, Pt: 2045 K)



Maximum moderator temperature in dependence on thickness

On the electrostatic lens and the mesh grid we expect a temperature not higher than 1150 K. This is far from the melting temperature of stainless steel (1760 K).
The ideal thickness of the moderator foil by the electron beam energy of 40 MeV is in the range of 0.5 to 2 mm, but in this region the temperature is too high.
Because the annealing temperature of platinum is lower then tungsten, the moderator should be made of platinum with a thickness of 0.2 mm. In this case, the temperature on the moderator is 1550 K and the point defects can anneal.

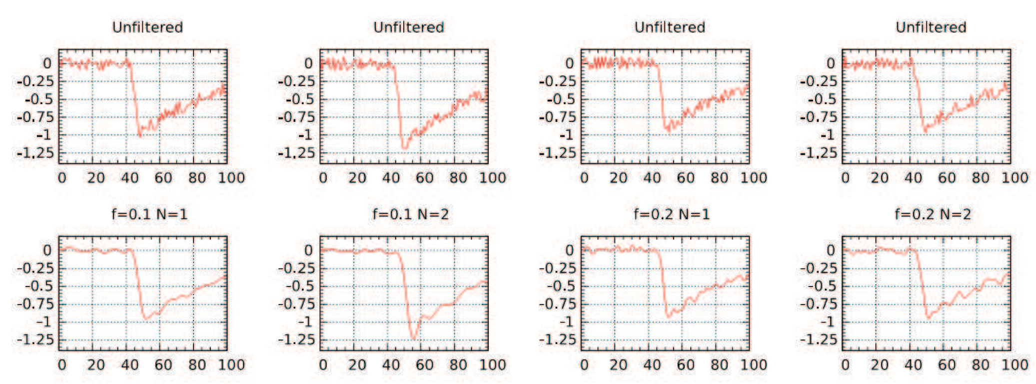
Simulations For The Timing Resolution Of The Detectors

Developed for the operation at the upcoming high intense positron beam source EPOS, a software package has been evolved to process the digitalized pulses and to benefit from the expected large counting rate. The software, which is available as open-source project [3], will be able to rapidly analyze the data and to present graphical and numerical results online to the user.
To research the different influences on the timing resolution independent from each other, artificial signals where created and evaluated using the algorithms used for the lifetime spectrometer.

For the pulses several parameters can be set in the EPOS- software [3]:

1. The amplitude (and distribution) of each Channel individually, used to simulate a 22-Na energy spectrum
2. The distribution of the time-spread between the pulses
3. The bit-depth of the vertical resolution
4. The level of white noise added to simulate the analog electronics

To reduce noise, one of the best options is to apply a lowpass filter on the raw data. A butterworth-filter from literatur was used for these tests.



Raw pulses generated for these simulations and the effect of the filtering on these pulses

The main source for the bad timing-resolution seems to be the noise reducing the bit-depth, especially in the 8-bit-digitizers. It is pretty clear, removing the noise from the sampled data improves the timing resolution.
We found that applying lowpass-filters from the dsp-world gives the good results.
The following table shows the three best resulting timing resolutions compared to each other.

Method	Relative Timing FWHM [samples]	4GS/s "real" FWHM [ps]
Vertical quantization only (8 bit)	0.202 samples	50 ps
Noise of effective 6.5 bit	0.612 samples	153 ps
Butterworth-Lowpass f=0.05 N=1	0.314 samples	75 ps

References

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[2] M. Werner, E. Altstadt at al.: Thermal Analysis of EPOS components,FZD Rossendorf, 2008
[3] http://positron.physik.uni-Halle.de/EPOS/Software/

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