Measurements of spread-out-Bragg-peaks with the PEAKFINDER and MP3-P

Basics:

In particle therapy the spread-out-Bragg-peak (SOBP) method is used to vary the depth of the particle beam and so to fully irradiate the target volume.

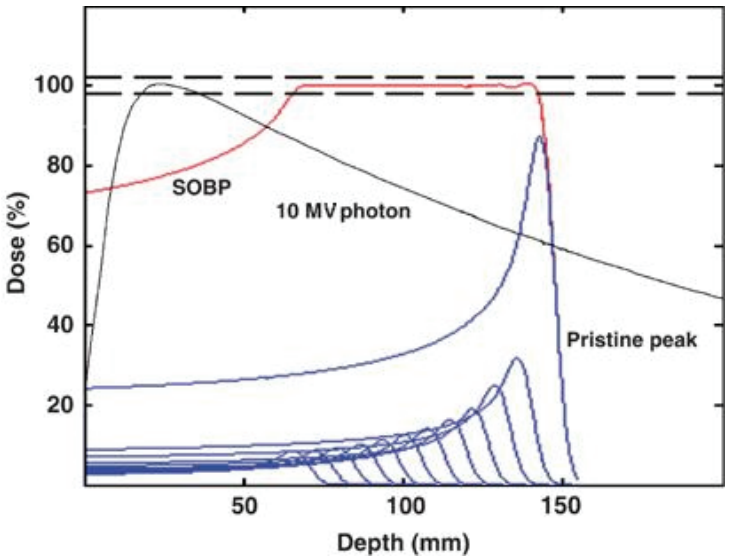

Figure 1: SOBP made of pristine peaks

With the exception of a few centers like HIT in Heidelberg, Germany, which is able to select all necessary beam energies directly from the synchrotron, particle therapy centers change the maximum depth of their beams by using 'modulation', i.e. by introducing absorbers of several thicknesses in order to generate an SOBP.

This modulation can happen instantaneously by using e.g. a ridge filter, but more commonly a modulation wheel (Fig. 2) is used.

These wheels rotate at a given frequency (e.g. 10Hz) and therefore modulate the range of the beam depending on which segment of the wheel the beam is traversing at any given point in time.

Further to this a beam gating can be added, so that only a defined part of the wheel is used, so an even more limited range modulation is possible.

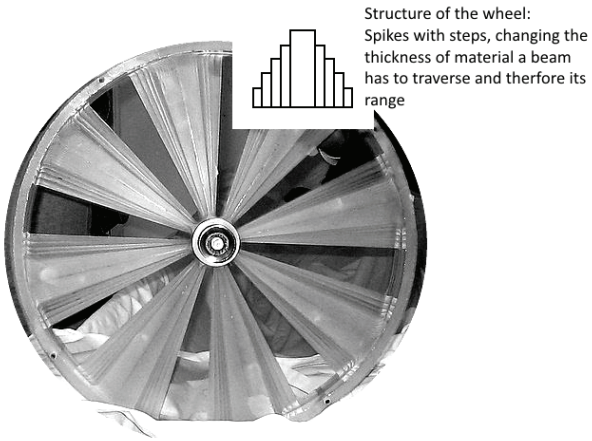

Figure 2: Modulation Wheel

Measuring an SOBP with a scanning device like the PEAKFINDER or a water phantom:

SOBP that are produced by a ripple filter can be directly measured, similar to a measurement with a linac, so no further details are given on this here.

In order to do a proper measurement of a SOBP that is produced by a modulation wheel, the time structure of this SOBP has to be taken into account. If the time structure is well understood and very stable, individual measuring points can be taken by measuring for integer multiples of the time needed for a full rotation of the wheel. If the time structure is variable, the measuring time at a given point on the depth dose curve has to be such, that the statistical difference between measurements with slightly different numbers of rotations of the wheel are no longer statistically significant.

> **Example:** If a modulation wheel spins with 10Hz, a one second measurement at the plateau region of the SOBP (Fig. 3) would see the contribution of all pristine peaks to the dose at that point 10 times.
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> If for a repeat measurement the rotation frequency or the measurement time is slightly off the result will change.
>
> Let's assume a rotation frequency of 10.5Hz. The measurement time is the same, but overall some of the pristine peaks will be contributing to the total signal for more time than the other pristine peaks created by the modulator wheel.
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> If the plateau dose of these pristine peaks is higher than the average plateau dose of all pristine peaks, the repeat measurement will have a higher total dose at this position compared to the original measurement. If it is lower than average then the effect is reversed, the repeat measurement will have collected less dose at the measuring position.
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> In this case the measurement time per point has to be increased to e.g. 5 seconds so that the variation is no longer statistically significant.

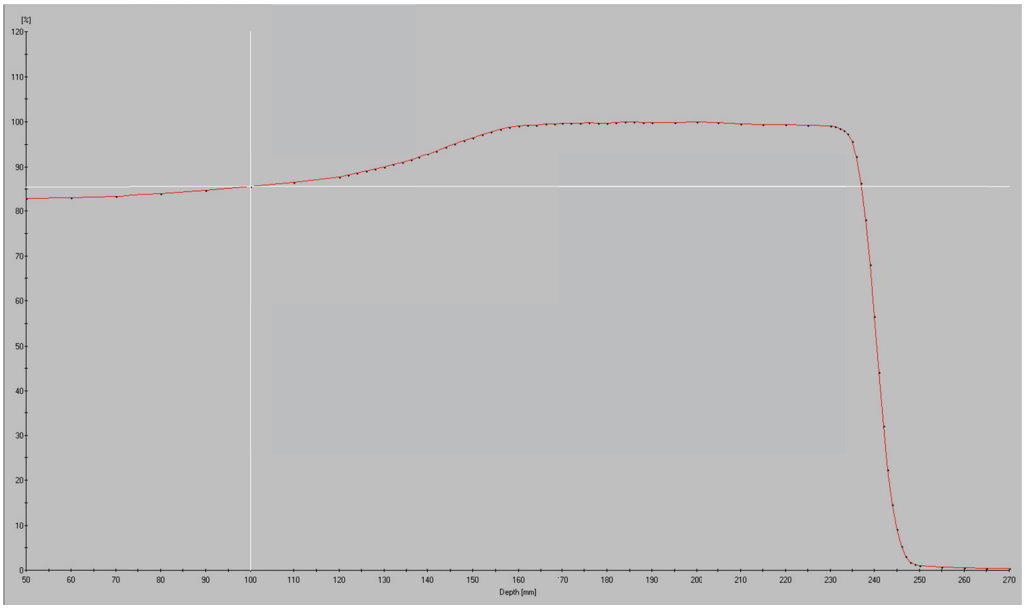

Fig. 3 SOBP

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