PEAKFINDER Depth Calibration

The PEAKFINDER water column does not have an absolute depth calibration for particle beams on its delivery. This calibration has to be done by the customer. It is set by adjusting the offset-parameter in PeakScan (*Tools → Measurement Options → Advanced).*

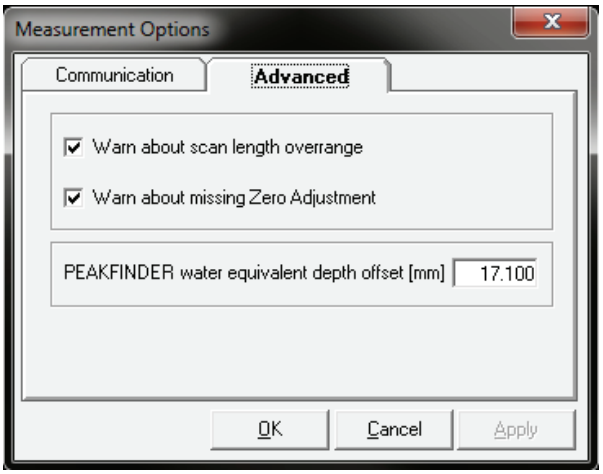

Figure 1: Advanced tab of the Measurement Options dialog

Different approaches to the calibration:

1. **Well understood beam and beam energy**

   Measure a Bragg peak curve; adjust the offset in PeakScan so that the Bragg peak is measured at the expected position. Lower offset values will shift the peak position to shallower depths.

2. **Cross calibration to known systems**

   If there already is a device giving absolute position, e.g. a film measurement, a water phantom or a second calibrated water column, measure the peak position for a given energy with this device, then repeat the measurement with identical beam parameters with the PEAKFINDER. Adjust the Offset in PeakScan so that the results are identical.

   Note1: In addition to the tolerances of the PEAKFINDER this method is limited by the tolerances (e.g. accuracy, reproducibility) of the devices used for the cross calibration

   Note2: The reference chamber has the largest thickness tolerance, as can be seen in the test certificate of the PEAKFINDER. In order to measure its actual thickness, the chamber can be removed from the PEAKFINDER. A Bragg peak is then measured with a second device. In a repeat measurement, the reference chamber is put in the beam path of that measurement. The difference in Bragg peak position gives the water equivalent thickness of the reference chamber.

3. Calibration using known water-equivalent thicknesses

The PEAKFINDER system comes with a test certificate. This certificate gives a value for the total water-equivalent (w.e.) thickness (photons) in front of the active detector volume at the minimum and maximum measurement position. To use these values for a calibration of the device, you have to take into account the relative electron densities, the mass densities and the stopping power ratios of water to SiO_2 and PMMA for protons. The water equivalent thickness for proton beams is then given by:

$$d_{Pr} = d_{Ph} \cdot \frac{r_{\rho_m}}{r_{\rho_{el}}} \cdot s_{mat,w}(E)$$

where d_{Pr} is the w.e. thickness for protons, d_{Ph} is the w.e. thickness for photons as given in the test certificate, r_{ρ_m} is the ratio of the mass densities of the material used and water, $r_{\rho_{el}}$ is the ratio of the electron density of the material used and water and $s_{mat,w}(E)$ is the energy dependent stopping power ratio of the material to water for protons.

Example:
Assume the values in table 1 for the values given in the PEAKFINDER certificate. Take the values from table 2 for PMMA and quartz glass.

	water equivalent thickness (photons) d_{Ph} [cm]
reference chamber	0.1995 ± 0.0232
quartz glass 1 (entrance window)	0.4048 ± 0.001
minimum water column	0.3500 ± 0.01
maximum water column	34.4607 ± 0.01
quartz glass 2 (slider window)	0.4113 ± 0.001
measuring chamber (entrance window)	0.0701 ± 0.0084
minimum w.e. measuring depth	1.4359 ± 0.0436
maximum w.e. measuring depth	35.5466 ± 0.0436

Table 1

Here we assume the reference chamber and first quartz glass window to be well within the plateau region of the beam and hence that the energy dependent stopping power ratio has a reasonably constant value. We also assume the second quartz glass window and the measurement chamber to be close to the Bragg peak.

Note 3: Values for ρ_m *are measured,* $r_{\rho_{el}}$ *were calculated correspondingly.* $s_{(mat,w)}$ *were calculated using data from [1].*

	ρ_m	$r_{\rho el}$	$s_{(mat., water)}$
reference chamber (PMMA)	1.190	1.158	0.973
quartz glass 1 (entrance window)	2.202	1.983	0.825
quartz glass 2 (slider window)	2.202	1.983	0.800
measuring chamber (entrance window, PMMA)	1.190	1.158	0.975

Table 2

With these you get the w.e. thicknesses for protons as given in table 3.

	water equivalent thickness (protons) d_{Pr} [cm]
reference chamber	0.1995 ± 0.0232
quartz glass 1 (entrance window)	0.3708 ± 0.0009
minimum water column	0.3500 ± 0.01
maximum water column	34.4607 ± 0.01
quartz glass 2 (slider window)	0.3654 ± 0.0009
measuring chamber (entrance window)	0.0702 ± 0.0084
minimum w.e. measuring depth	1.3559 ± 0.0434
maximum w.e. measuring depth	35.4666 ± 0.0434

Table 3

The minimum water equivalent measuring depth can then be used as the offset value for PeakScan. Be aware though, that this value has a tolerance of ±0.0434 cm and depends on your choice of stopping power ratios for the reference chamber and measurement chamber positions.

Disclaimer: The information in this document shall not be used as the sole basis for the calibration of the PEAKFINDER device. The calibration of the PEAKFINDER and the methods used are in the full responsibility of the end user. PTW is in no way responsible for incorrect calibrations caused by the application of the information contained in this technical note.

References

[1] *ICRU (1993). International Commission on Radiation Units and Measurements. ICRU Report 49, Stopping Powers and Ranges for Protons and Alpha Particles*

PTW-Freiburg
Lörracher Straße 7 • 79115 Freiburg • Germany
Phone +49 761 49055-0 • Fax +49 761 49055-70
info@ptw.de • www.ptw.de