APPLICATION NOTE

Cone Beam CT solutions from RTI

This application note describes the ability to measure with the Black Piranha on wide beam CT applications.

Introduction

Along with the development of Computed Tomography (CT) new procedures and tools for testing have to be developed. The main topic in this area for the past 10 years has been the testing on Cone Beam CT (CBCT). With the wider beam the standard $CTDI_{100}$ formalism is not enough anymore.
The IEC standard IEC 60601-2-44, Ed 3 amendment 1 is recommending new procedures for CBCT testing. IAEA has a report, that anyone can get for free, that guides you through that standard. It can be found here: http://www-pub.iaea.org/MTCD/Publications/PDF/Pub1528_web.pdf

A simplified definition of CBCT is that the beam width is larger than 40 mm. If the beam is 40 mm or less the standard $CTDI_{100}$ formalism can be used and measured with a CT Dose Profiler with helical scans or a Pencil Ion Chamber with axial scans.

With a beam width (NxT) larger than 40 mm you should use this formula to get the $CTDI_{(w,NxT)}$:

$$CTDI_{(w,NxT)} = CTDI_{(w,ref)} x \left(\frac{CTDI_{(free-in-air,NxT)}}{CTDI_{(free-in-air,ref)}} \right)$$

where ref is a reference beam width. Should be 20 mm if that option is possible for the CT. So let´s say you want to measure a 160 mm beam and you can use a 20 mm beam the equation would look like this:

$$CTDI_{(w,160)} = CTDI_{(w,20)} x \left(\frac{CTDI_{(free-in-air,160)}}{CTDI_{(free-in-air,20)}} \right)$$

The $CTDI_{(w,20)}$ should be measured in the standard way, with the CT Dose Profiler or a 100 mm pencil ion chamber in standard CTDI phantoms.

To get the $CTDI_{(free-in-air,20)}$ it is also straight forward; you put your detector in the iso-center without any phantom and ether measure the $CTDI_{100}$ with the CT Dose Profiler or the pencil ion chamber.

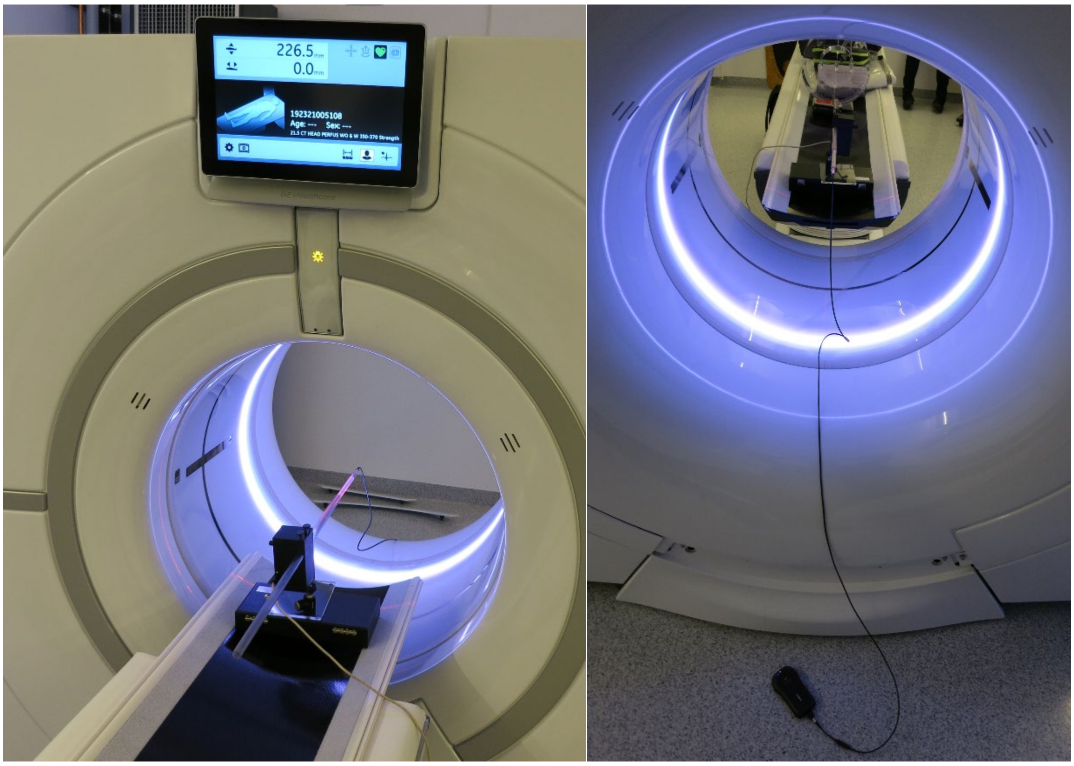
The tricky part is when you should measure the $CTDI_{(free-in-air,NxT)} = \frac{1}{NxT} x \sum_{-\infty}^{\infty} D$. It is not possible to measure the ∞ length but the thumb rule is that you should at least measure a distance that is NxT mm + 40 mm. For some CTs it is possible to do helical scans with 80 mm beam width and then it is possible to measure $CTDI_{(free-in-air,80)}$. with the CT Dose Profiler, but for most beams over 40 mm the table is still and it is not possible to do helical scans. For those situations, there are 3 possible ways to go:

1. Use the CT Dose Profiler and Mover
2. Use a 300 mm pencil ion chamber
3. Use a 100 mm pencil ion chamber in steps

Since the CBCT use one axial scan the pitch is 1 so $CTDI_{(w,160)} = CTDI_{(vol,160)}$.

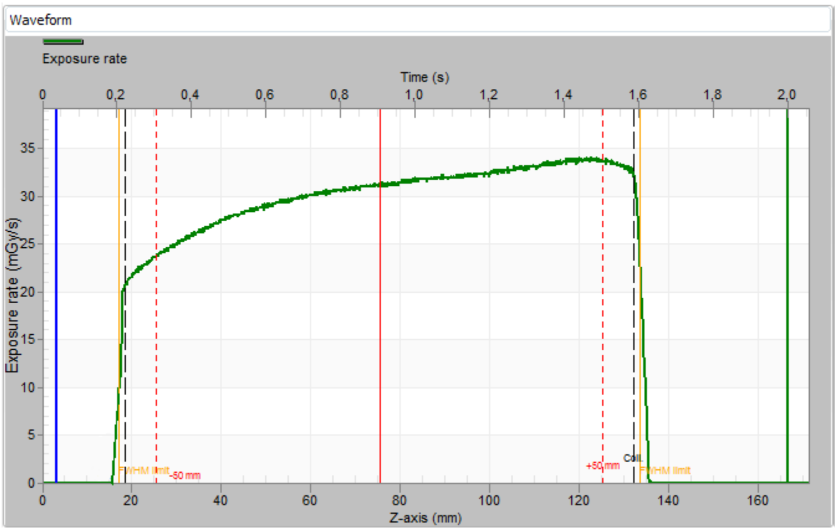
CT Dose Profiler and Mover

Put the RTI Mover on the table and make sure it stands stable and that the CT Dose Profiler is in the isocenter (Figure 1.). You can use a premade template in Ocean for the measurement. In Ocean you will control both the CT Dose Profiler measurement and the RTI Mover at the same time, which make the measurement easy. You can double check that the detector can be moved through the beam you should measure on before you do the real measurement by using the software.



1. RTI Mover and CT Dose Profiler and Piranha for Cone Beam measurements

After the measurement, you will collect the dose profile of, for example, 120 mm (Figure 2.) or 160 mm etc. The RTI Mover can move the detector 83.3 mm/s so to get the result only takes a few seconds and you will get the full $CTDI_{(free-in-air,160)}$ as well as a visible view of the dose profile.



2. Dose profile measured on beam with 120 mm collimation

Use a 300 mm pencil ion chamber

Connect the 300 mm pencil ion chamber to the RTI Chamber Adapter and connect it to the Piranha. Then you put the pencil ion chamber free in air in the isocenter in the CT and the middle of the pencil ion chamber in the center of the CT. Now you can do any axial scan with beam widths up to 260 mm, for example 160 mm, and directly measure $CTDI_{(free\text{-}in\text{-}air,160)}$ (after dividing with 16 = NxT if the ion chamber is calibrated in mGycm).

Use a 100 mm pencil ion chamber in steps

Connect the 100 mm pencil ion chamber to the RTI Chamber Adapter and connect it to the Piranha. Then you put the pencil ion chamber free in air along the z-axis in the isocenter in the CT. Depending on the beam width you must now try to position the pencil ion chamber so that you will "catch" the whole dose profile in two or three exposures by stepping the chamber through the beam for each exposure, see picture 4. Remember that you must have an active length of NxT + 40 mm so for 160 mm beam it is no real margin to do the measurement in two scans. (The sum of the measurements should be divided with 16 = NxT to get the $CTDI_{(free\text{-}in\text{-}air,160)}$ if the chamber is calibrated in mGycm).

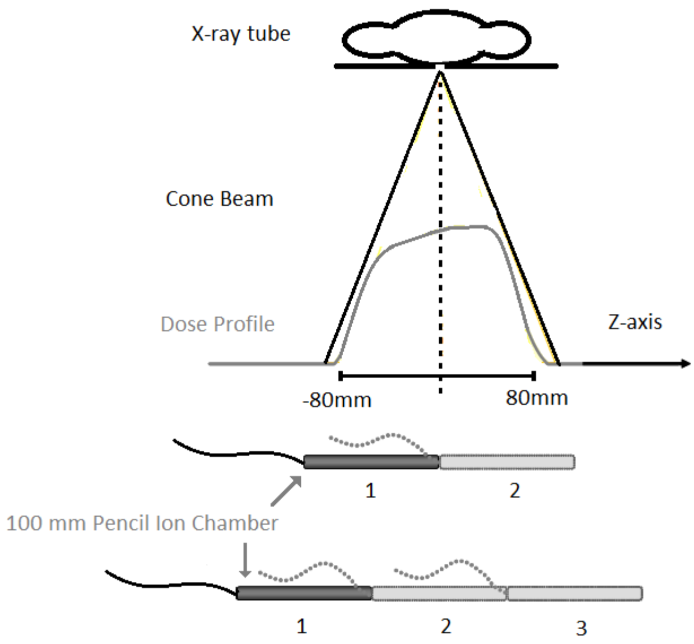


Figure 4. A pencil ion chamber in 2 or 3 steps to measure the $CTDI_{(free\text{-}in\text{-}sir,160)}$

When you move the pencil ion chamber in steps there are a lot of things to think about and things that can increase the inaccuracy. For your normal CTDI measurements free in air with the pencil ion chamber in thin beams the pencil ion chamber is exposed in the center and no primary beam is on the edges of the chamber. Then it is no problem to measure. Now when you move the pencil ion chamber in steps it is very important that you know where the active area of the chamber starts and stops. Are you even sure that the active length is exactly 100 mm? Many pencil ion chambers have longer length but it does not really matter for the standard CTDI measurements but can affect a lot now when you expose the edges of the chamber. It is also hard to position very exact in the steps with the pencil ion chamber. Small errors in positioning can affect the $CTDI_{(free\text{-}in\text{-}air,160)}$ a lot and can make it hard to get good reproducibility over time.

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