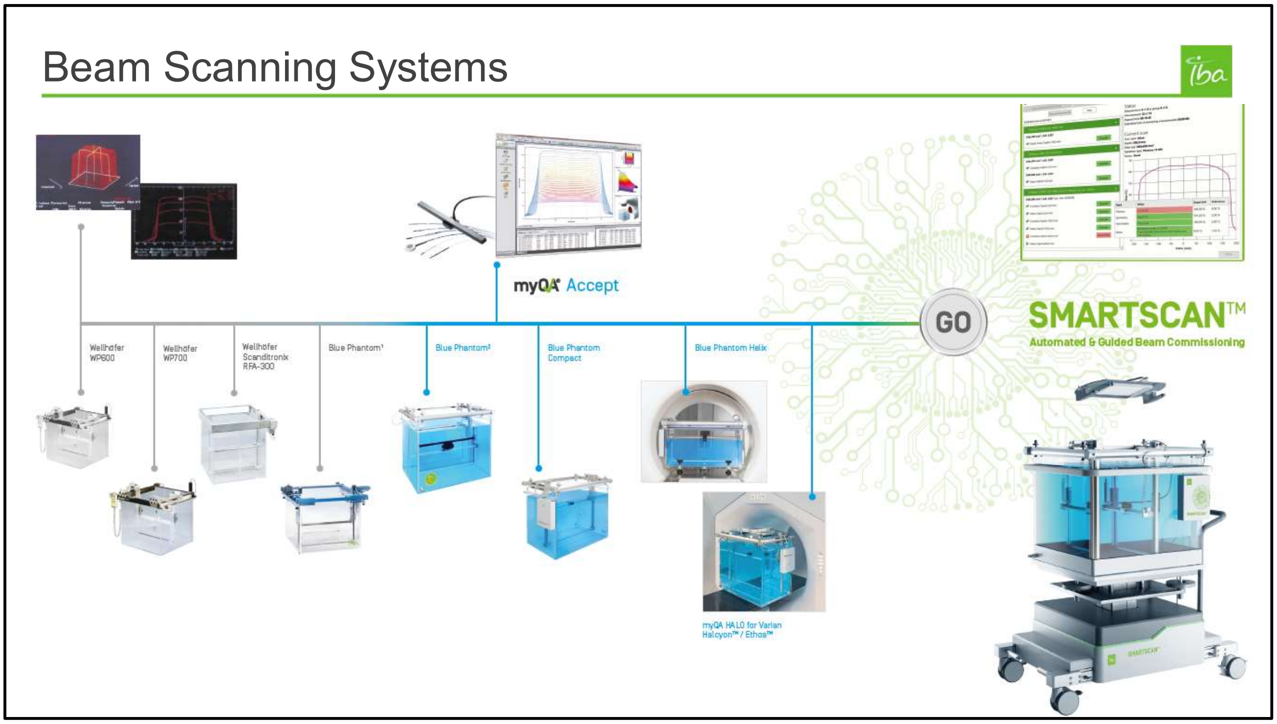
Beam Scanning Systems

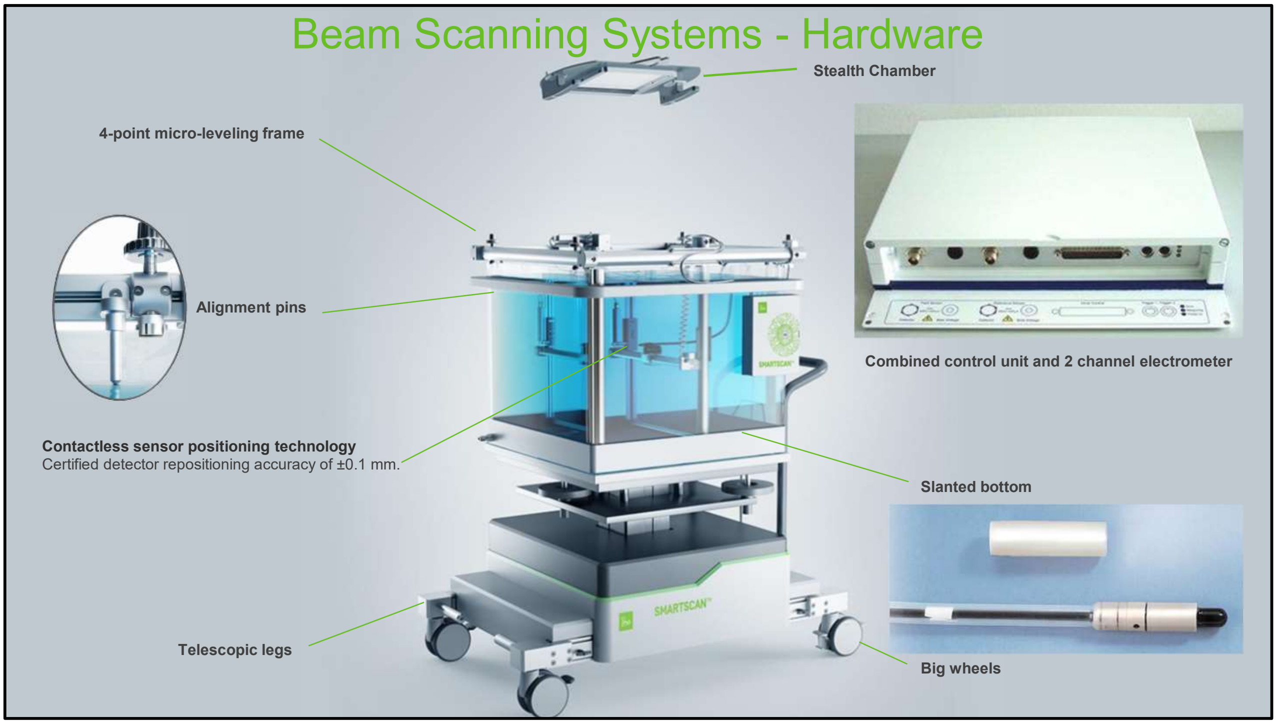
Quality. Automated. Efficiency. Automated.
Peace of mind. Automated.

DOSIMETRY

Hello, my name is Anthony Nagle and I'm a product specialist with IBA Dosimetry. Today we'll talk about beam scanning systems. We'll start with an introduction of the hardware and software before looking at the process of beam scanning. Then we'll wrap things up with a comparison between a traditional manually operated system and an automated beam scanning system. All that should take about 15 minutes to discuss, but first, a disclaimer. This presentation is intended for informational purposes and is not intended to replace specific product training or experience. Please always follow guidance provided by device manufacturers in official users guides when operating beam scanning systems. OK, so let's get started.

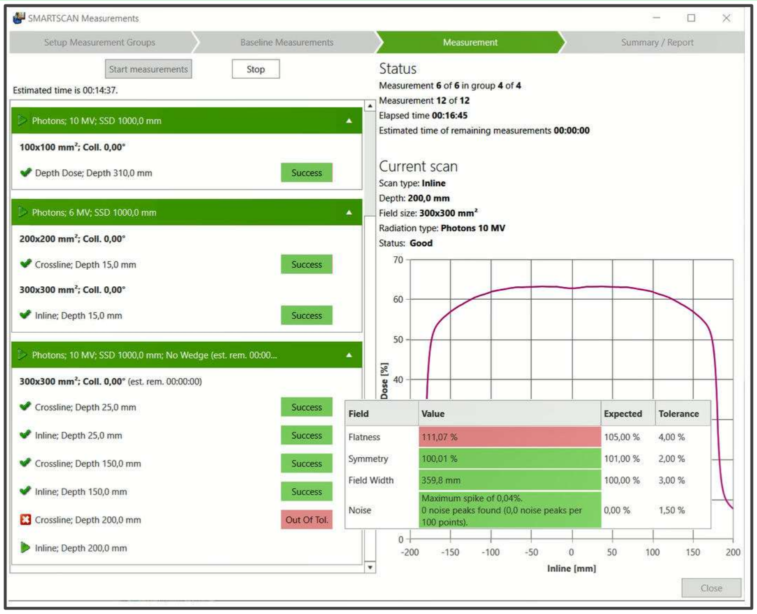


A beam scanning system is comprised of two parts. Ion chambers or diode detectors, an electrometer, and the water phantom make up hardware component. And on the software side there is a program to drive the system, receive the measured data, and provide some means of analyzing measured data.



The most common water phantom design is a square or rectangular tank capable of 3 dimensional movement in water. Other phantom designs include compact 2 dimensional tanks, 1 dimensional tanks, and a 3 dimensional cylindrical phantom. It's most common to find a 2 channel relative dosimetry electrometer accompanying a water phantom, and sometimes they are integrated into the same enclosure as the control unit for the water phantom. The field chamber is mounted on the movement arm of the phantom while the reference chamber is mounted on a fixed holder in an off axis location of the field. There are also reference chambers such as the Stealth which are mounted on the head of the linac that save time particularly for small fields by avoiding the need to position a reference chamber in a location that is inside the field but not interfering with the field chamber.

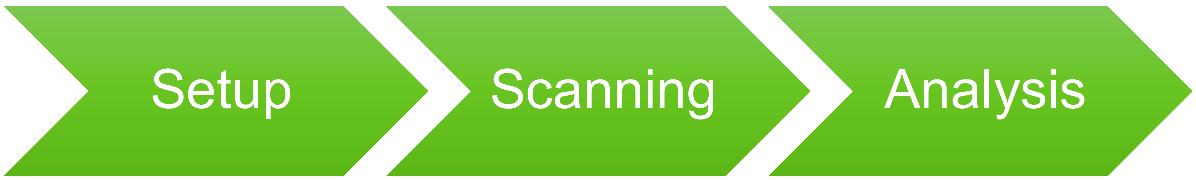
Beam Scanning Systems - Software



4

While the hardware physically performs the measurements, the software is the brains of the system. All beam scanning softwares contain the core functionality to define a queue of scans, acquire data, and do some processing and analyzing of the acquired data, but one software in particular offers unique automation features. After discussing an overview of the beam scanning process we'll compare that automated software to the traditional manual workflow.

Beam Scanning Systems - Workflow

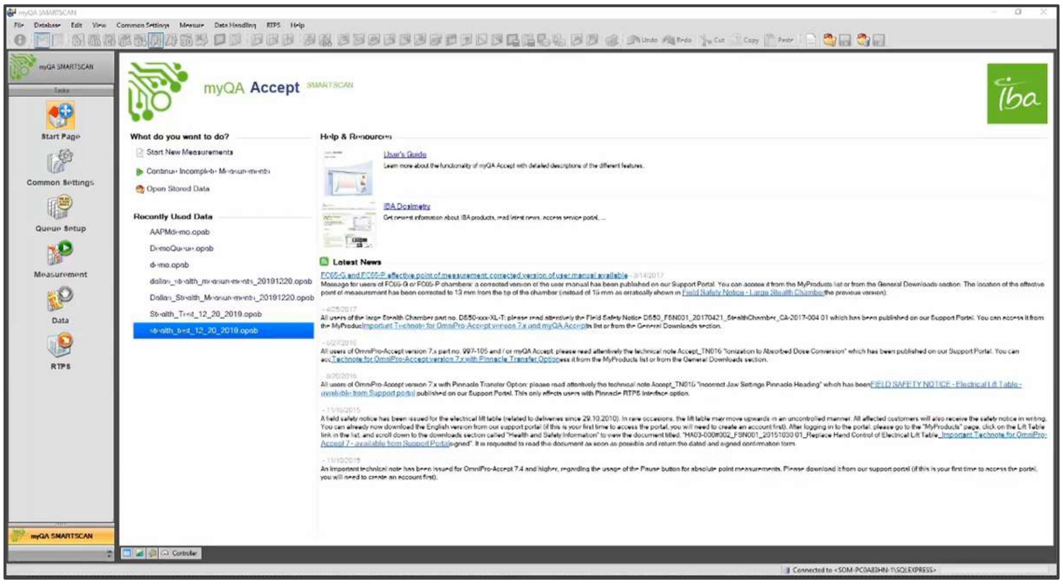


5

The beam scanning process is comprised of 3 major steps: setup, scanning, and analysis.

Setup begins with positioning the water phantom. From the time you wheel the water phantom into the room, setup can be finished in approximately 15 minutes depending on exactly which system you are using. The field and reference chambers are installed and cables are run to the electrometer. Room lasers can aid the alignment of the water phantom, and tank leveling can be accomplished in a few different ways. The whole tank can be leveled via the lift table with some systems, or in other systems the tank mechanics are leveled by adjusting leveling screws until alignment pins just break the water meniscus, indicating the mechanics are parallel with the water surface.

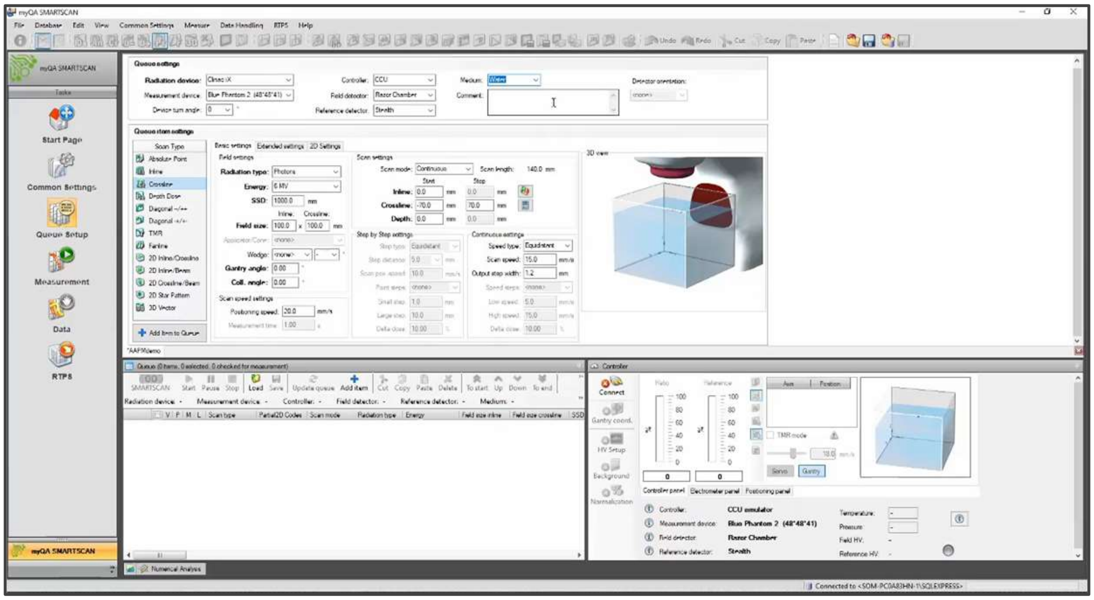
Beam Scanning Systems – Software Setup



7

For this presentation we will be using myQA Accept to illustrate the processes performed in the scanning software. The selections available in the queue setup area of the software depend on the information defined under the Equipment Setup area of Common Settings. This is where you can define which accelerators, water phantoms, and chambers you have. Particular attention should be paid to the definition of chamber details such as default and max bias voltage, effective point of measurement correction, and calibrations. Before defining the scans in your queue, it’s important to select the correct Queue Settings, telling the software which chambers and phantom you are using, and which machine you are measuring. This information is used in connection with field details to properly configure your scans.

Beam Scanning Systems – Queue Setup

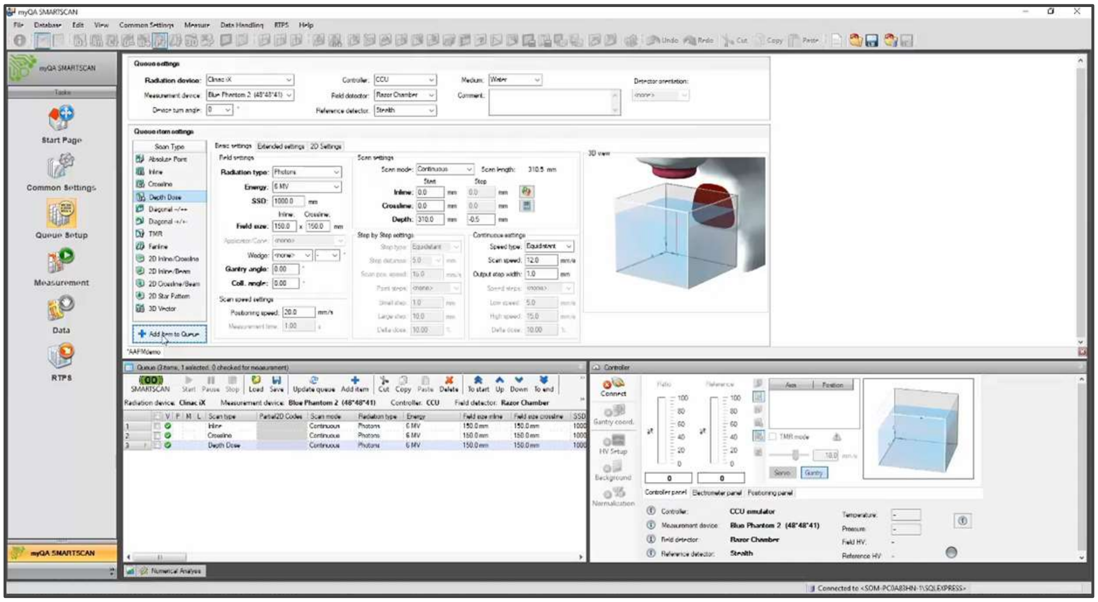


8

Next I'll demonstrate the process to define scans for a single field. In this case I'm using a 6 MV photon beam with a 150 by 150 millimeter square field. I enter the field size as well as the measurement depth for my scans into the basic settings area. Then I define advanced setting such as using a step by step measurement where the chamber stops for each point measured or a continuous scan that will, as the name implies, scan continuously while acquiring data. In either case, details like scan speed and step spacing can also be adjusted.

I confirm the desired scan type is selected on the left side of the software and add the selected scan to the queue. In this case I define an inline and crossline scan at 20 millimeters depth and a depth dose scan. Next I update my radiation type, energy, and field size before again selecting and adding the types of scans I would like to measure. As these properties are updated, the software automatically revises the start and end points for the scan to match the field selected. Once all scans are entered in the queue it's a good idea to save a copy for future use.

Beam Scanning Systems – Initialization

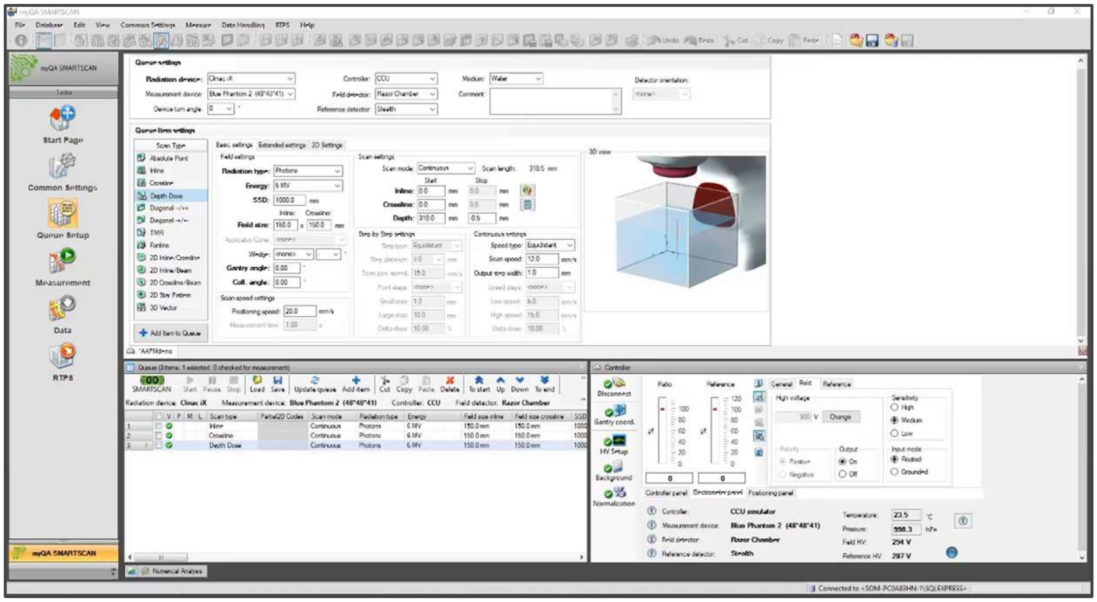


9

Let’s take a look at the water phantom at this point. We can see the phantom is visible to the software because the connect button is enabled, so the first step is to press that button to connect. When we do that we can see the information coming from the controller begin updating. We will need to set up the controller for the measurements we are about to take. Initially the high voltage is off and the system needs a background and normalization to be performed. If the correct voltage setting for the chamber you’re using isn’t defined in the common settings then you’ll need to define it manually. It’s common for ion chamber voltages to be around 300 volts while diode detectors should not have a voltage applied and typically require setting the input mode to grounded. The electrometer range must also be confirmed.

With the hardware setup defined and high voltage applied, it’s time to move the chamber to the depth at which I want to normalize and acquire a background with the beam off, followed by the normalization measurement which requires beam. Following normalization, I should see values of approximately 100% on my field and reference chambers. This normalization process would need to be repeated for each new field size or energy I intend to measure.

Beam Scanning Systems – CAX & Measurements

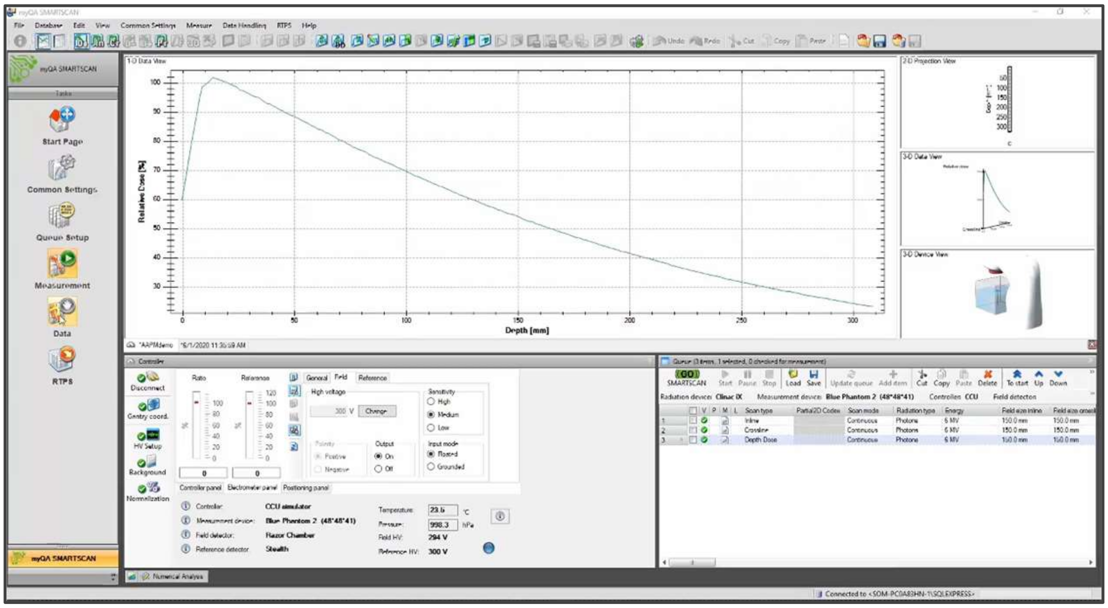


10

Prior to measuring the scans in my queue I first perform a central axis check. This is done by performing inline and crossline measurements at two different depths to check the angle and position of the beam with respect to the tank. Both shift and angle deviations are possible. myQA Accept performs this check by adding a separate workspace and automatically populating the scans needed based on the field details entered by the user. Each beam scanning system will have a slightly different way to account for these deviations. In this case we will be able to correct for shift deviations via the software while angle deviations require adjusting the tank mechanics via the quick adjustment knobs while using the leveling pins as a guide. When the 4 measurements are complete a pop up will present the results of the check, and in this case no correction will be needed. If a correction is needed for shift, the popup will let the user confirm the shift applied. At this point I'll pause for just a moment to allow the central axis check to finish.

Now we're ready to measure the scans in our queue. I select all the scans associated with the first field I'm going to irradiate and press start. While measuring, I watch the signal levels of my field and reference chambers to ensure I have my normalization and input sensitivities set correctly. I also pay particular attention to my reference chamber signal level, and reposition as needed to avoid excessive noise or poor signal levels. Once a scan is measured in the queue an icon will appear in the M column indicating that there is data to view for this queue item. myQA Accept will generate a popup when all selected scans have been measured. The user would then update the linac with the next field to be measured before coming back to myQA Accept and selecting the associated scans in the queue. The process repeats until all required fields have been measured.

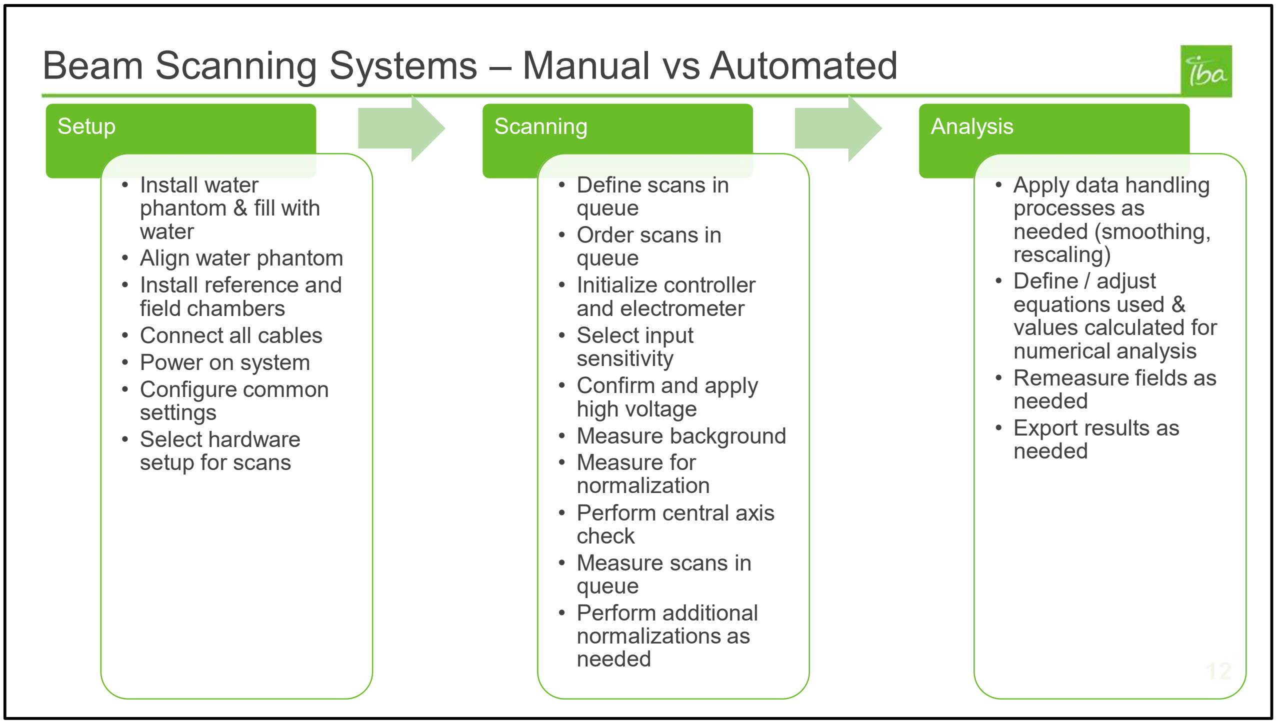
Beam Scanning Systems – Analysis



11

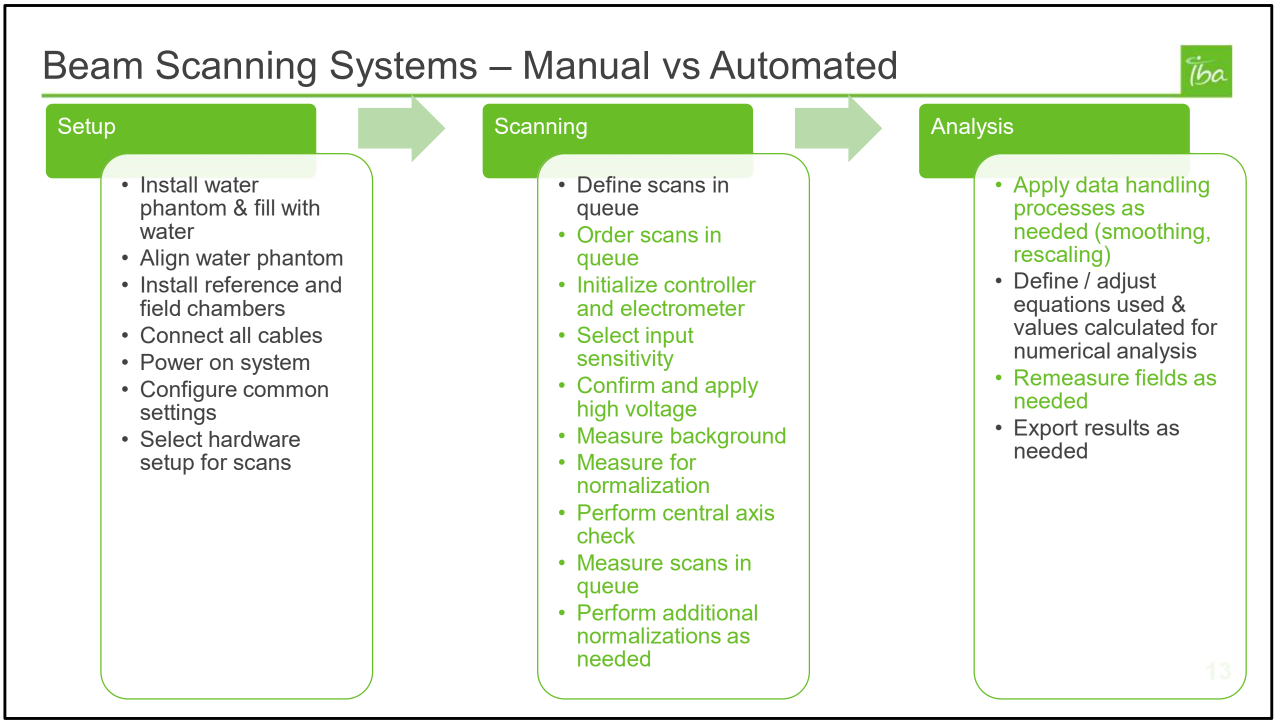
The last big step in the beam scanning process is analysis. The data workspace of myQA Accept allows the user to view the completed scans as well as perform any data manipulation steps such as applying shifts, smoothing, rescaling, and other processes. The charts are color coded to correspond to the data table found in the bottom right of the screen. The user can define exactly which analysis are performed and which equations are used in the Common Settings area of the software. The details included in the numerical analysis table can be adjusted by right clicking and selecting “template editor”.

It’s also possible to define a macro that will combine a series of processing steps together. This can be helpful if part of a workflow always includes applying a specific series of manipulations. If your workflow requires more detailed analysis or recording results in another location this can easily be done by selecting the needed entries in the numerical analysis area, right clicking, and selecting “copy table”.



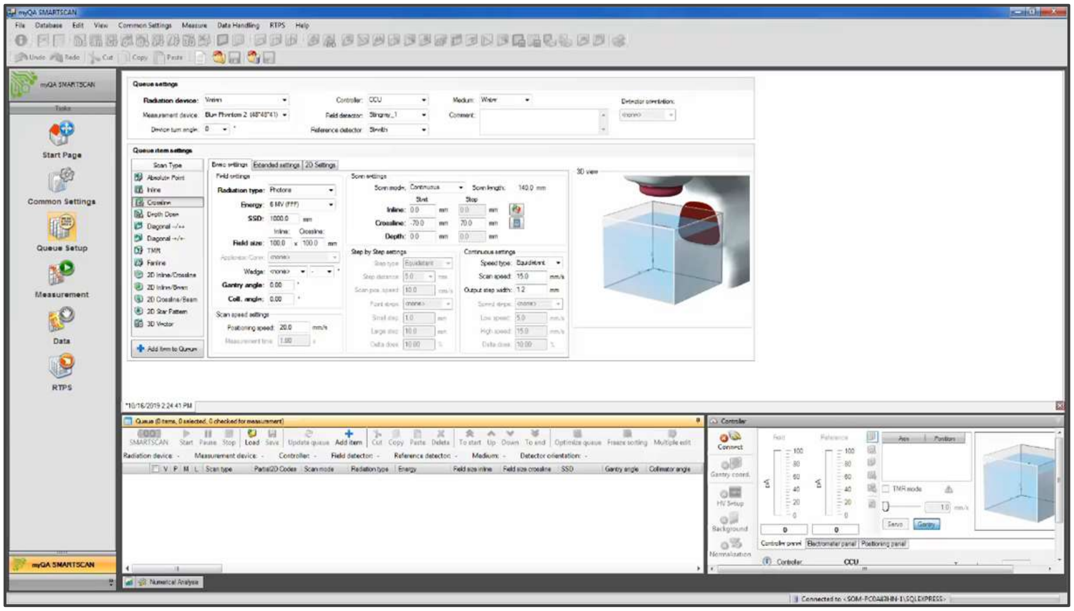
We've just discussed the beam scanning process using my QA Accept as a visual reference. Let's pause here briefly to look at the process at a high level. The initial 3 step process we started with actually contains quite a few details which the physicist must confirm in order to achieve a quality scan. This level of detail in the process means it can be easy to forget something small that can impact the quality of the resulting measurements.

In an effort to help physicists ensure no detail is missed, SMARTSCAN was developed, offering automation and user guidance.



SMARTSCAN is an automated software offered by IBA Dosimetry which works by guiding the user through each step of the initialization and scanning processes. Here we have the beam scanning process with the text highlighted in green representing the steps which are automated. Poor scans are minimized a result of this consistent and repeatable process. This means the user will save time in the analysis phase because any fields which failed the analysis criteria would have been immediately reported to the user during scanning. One way to think about a manual beam scanning software vs an automated one is to consider the difference between paper map and a navigation system. Either option will perform the same job, but one will provide active guidance through the process and it may save you time.

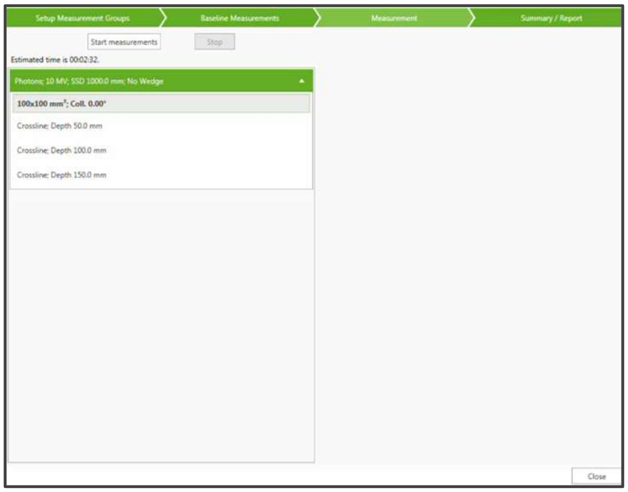
SMARTSCAN – Less Commissioning Effort – Quick Setup

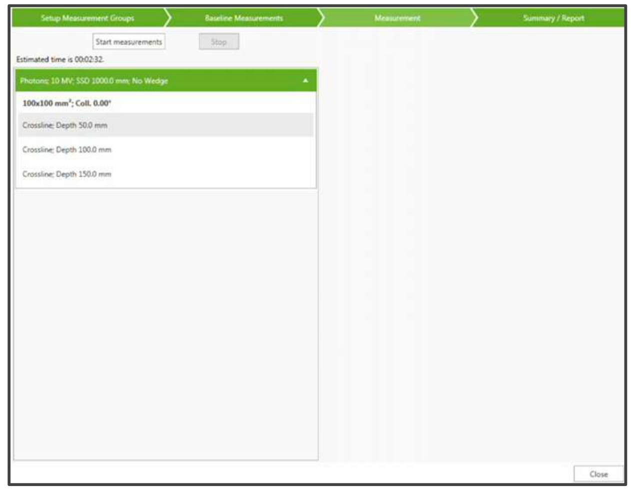


14

Just to illustrate the point, I'd like to talk through a quick example of how SMARTSCAN automatically ensures the quality of scanning data. Imagine you are a junior physicist setting up your SMARTSCAN system to perform annual machine QA. You install the water phantom, connect your chambers, fill the tank with water, and level the mechanics using the quick leveling pins and adjustment screws. Back in the treatment control room you open myQA Accept and import the annual QA queue. After connecting to the CCU you launch the SMARTSCAN module. You confirm the desired chambers and protocols to use and move on the baseline measurements. Background and dose rate checks are successful. SMARTSCAN reports the central axis check is off by 1.3 millimeters in crossline and 0.9 millimeters in the inline direction. Smartscan prompts you that you can either physically correct this or it can apply an offset for you. You decide to apply an offset and continue to the preliminary scans. The preliminary scans are an optional but recommended step which checks the impact of scattered radiation, ion chamber leakage current, and cable integrity. The overall smartscan performance and quality outcome is not minimized if the user elects to skip the preliminary scans as any suspicious results will still be flagged in real time as they are measured in the queue, the preliminary scan is just a way to see these results prior to running through the entire queue.

SMARTSCAN – Less Commissioning Effort – Quick Setup



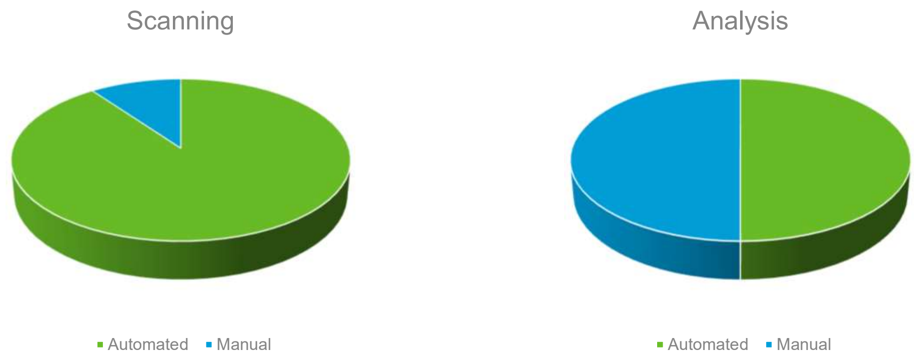


Passing **Suspicious**

15

Continuing our example, here we can visualize how smartscan behaves both in the case of a passing and of a suspicious scan. On the left side we can see a series of scans which are taken at the start of a long queue of measurements. After 90 minutes of scanning the user notices that SmartScan has halted the scan queue after recording 3 scans as failing due to excessive noise. These scans can be seen on the right. The user investigates by repeating some previously completed scans and observes that they are now noisy as well. Fortunately another chamber was available and after swapping the chamber the noise disappeared. The root cause of the error was an old and slightly porous chamber that had a rising leakage current as humidity started entering the chamber. In this case smartscan flagged the questionable scans in realtime which prompted investigation by the physicist. This correction during scanning prevented the need to either go back and remeasure or to apply data processing to remove the artifacts.

Beam Scanning Automation Benefit

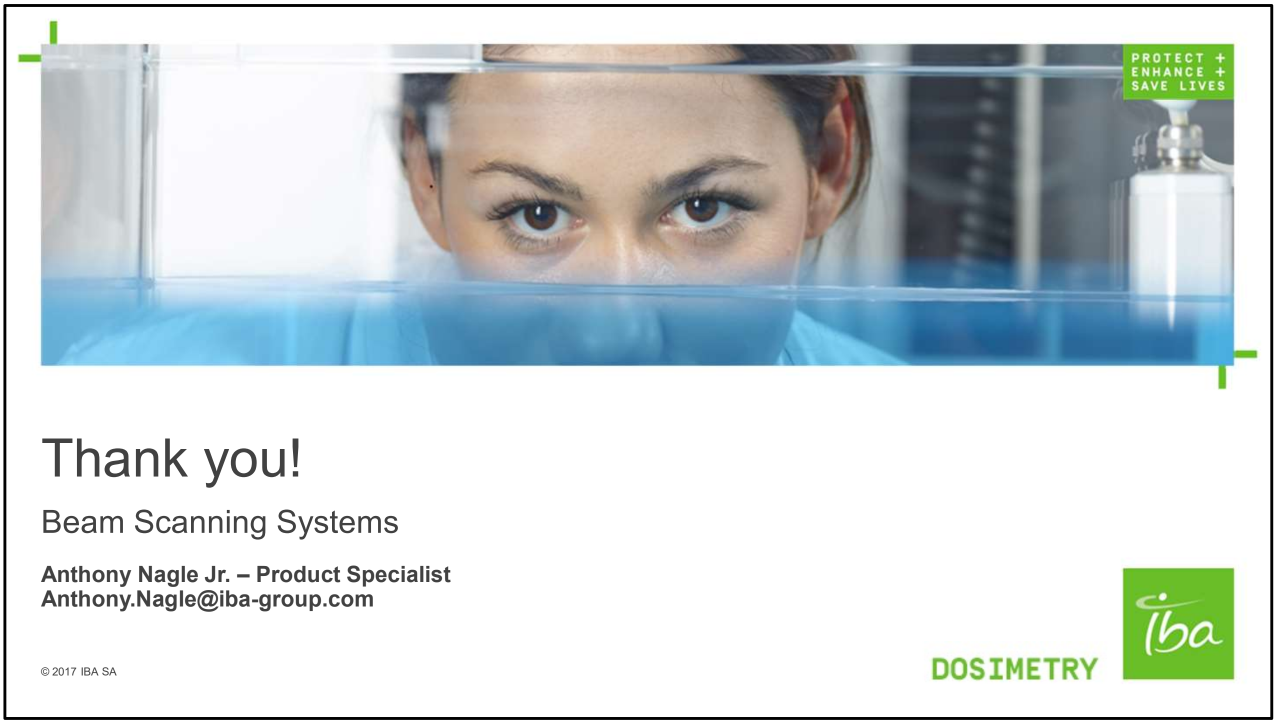


Automated beam scanning systems offer >75% reduction in the effort required to commission a linac.

- 11 of 14 steps (78.6%) in the Scanning and Analysis process are automated.

16

Calculating an exact percentage of time saved is a difficult task because such a calculation would need to assume details about the scanning process, clinic, and physicist, which we don't know. Rather than speak in terms of time saved, let's frame the discussion in terms of tasks which are automated and effort required to commission. Any beam scanning system, automated or not, will need to be physically set up by the physicist. Once installed, SMARTSCAN provides automation for 11 of the remaining 14 steps in the Scanning and Analysis process. This is why I would estimate using an automated beam scanning system represents over a 75% reduction in effort required to commission a linac.



So to summarize this discussion: We introduced beam scanning hardware and software, talked our way through the beam scanning process using myQA Accept as a visual reference, compared the manual process to an automated process, and discussed the benefit provided by an automated software such as SMARTSCAN. Again, I'm Anthony Nagle with IBA Dosimetry and I thank you for joining me today.