
ELEKTA ONCOLOGY
THE ELEKTA GROUP
Ionisation chamber array, for setting up of a linac, and comparison to a 3D Water Tank
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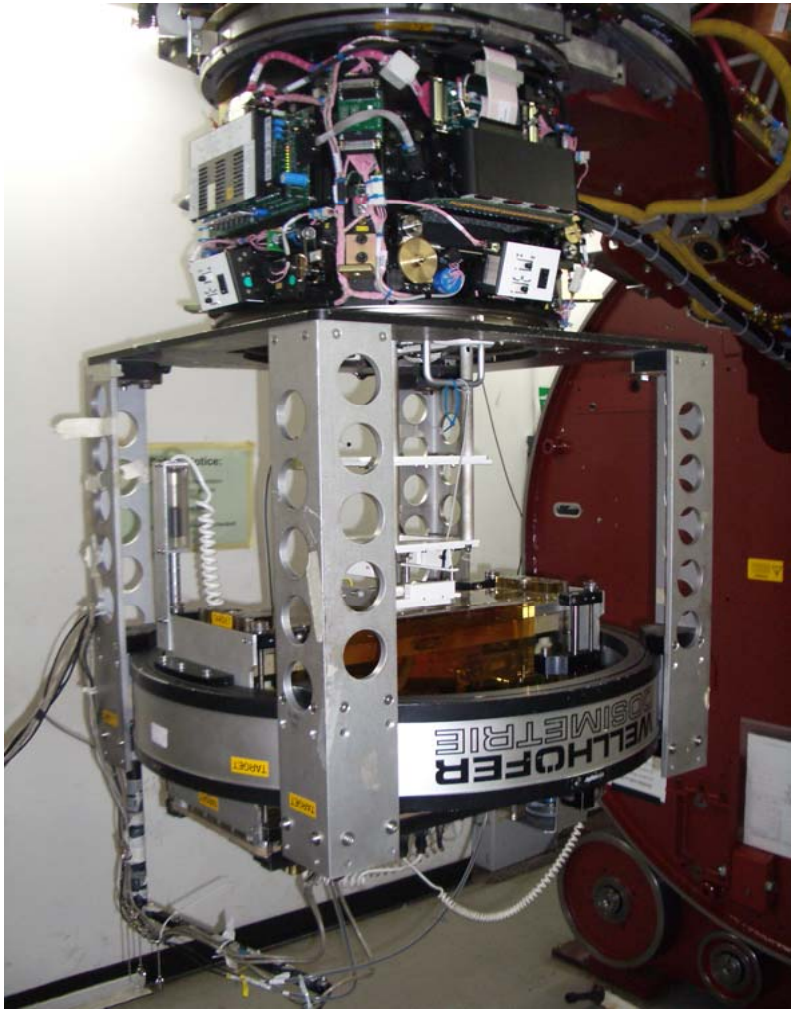
Human Care Makes
the Future Possible

Why new dosimetry equipment?

- Replace our ageing IBA Buddelship Systems.
- The Buddelship uses a travelling ion chamber; a series of scans can be a very time consuming task.
- The Buddelships are a bulky item with lots of easily damaged parts.



Why choose the IC Profiler?

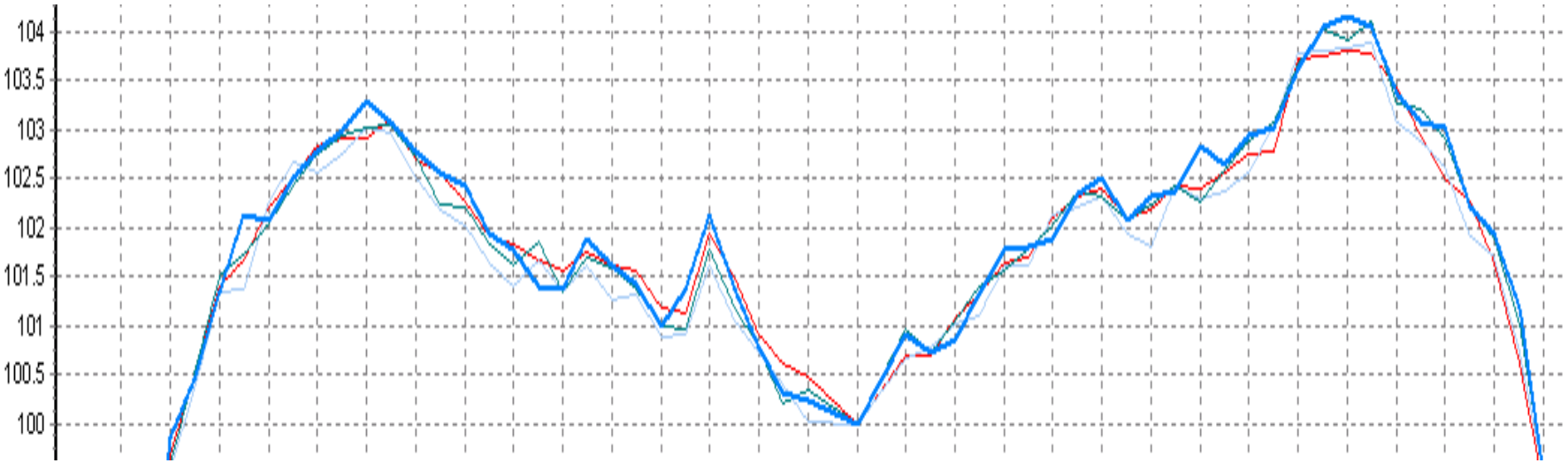
- Solid state, ion chambers, no moving parts (or water).
- Lightweight singular unit design and durability.
- One single cable for data/power.
- High speed acquistion of field profiles.
- High speed data aquisition – fast set-up of radiation field parameters.
- Enables simultaneous evaluation of very short duration beam start-up characteristics along orthogonals and true diagonals.
- Lower capital spend on replacement units and reduced maintenance costs.

Initial testing of the IC Profiler

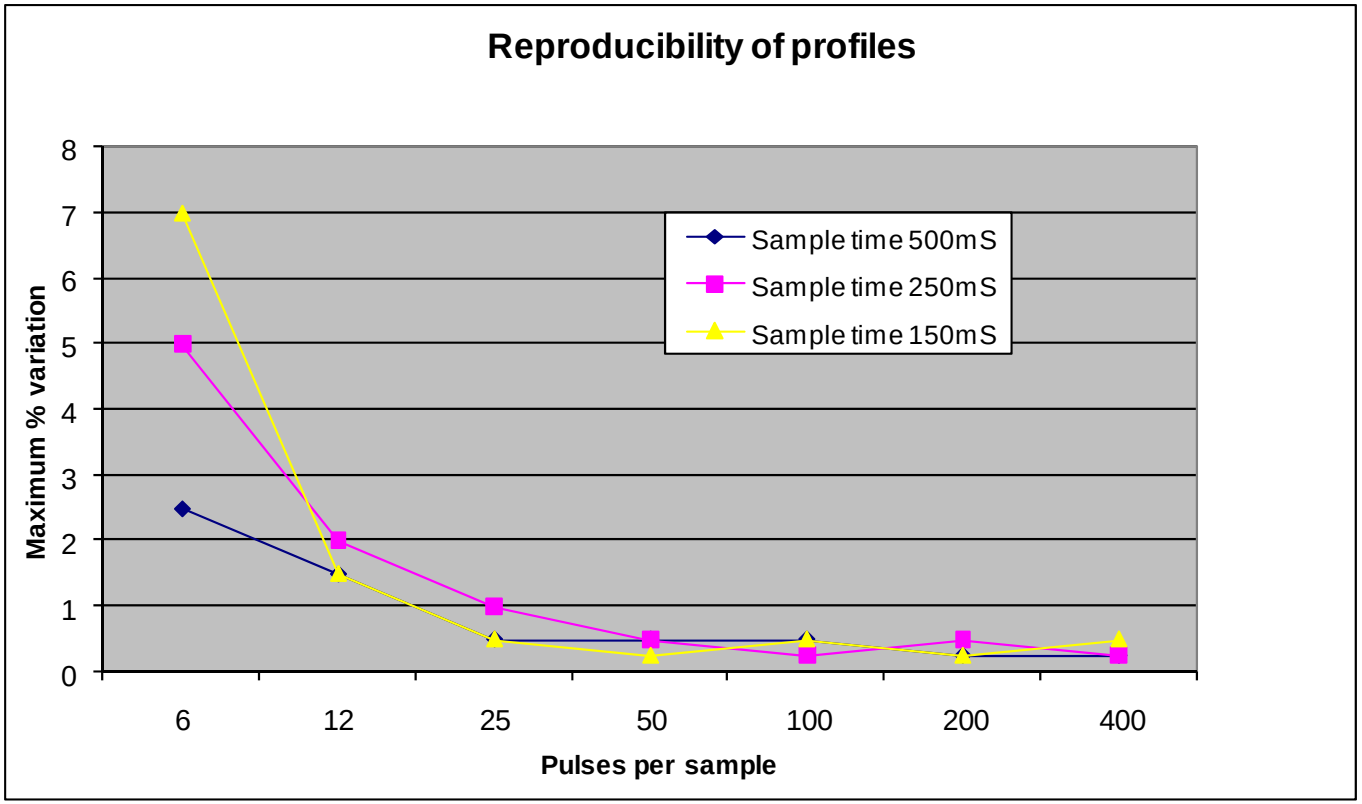
- Necessary to satisfy three main requirements:
- Stability
- Repeatability
- Resolution
- The following series of tests, based on these requirements, formed our basic ‘Customer Requirement Specification’ which decided the suitability of the IC Profiler.

A measure of stability

- These profiles were acquired at 6MV using a 30x30cm field over a period of 1.5hrs, the chamber to chamber response tracks well over all the measurements.

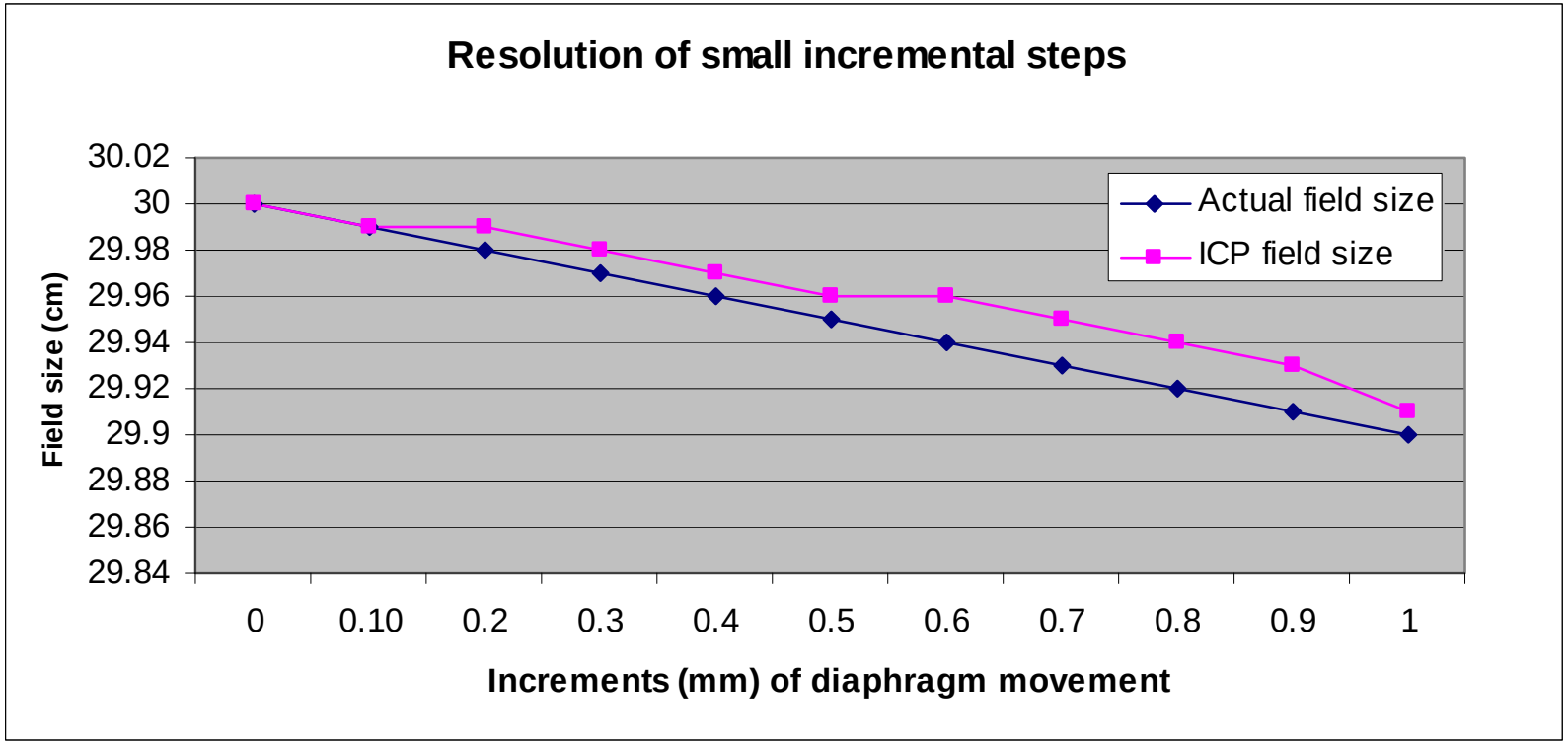


Reproducibility of profiles



- Groups of repeated profiles over time, using a 6MV beam over a 30x30cm field size, at different pulse per sample rates, done at varying sample times, form the basis of these tests.

Resolution of small position changes



Using 0.1mm increments in diaphragm movement at 6MV, the ICP position values were tracked against the actual field size (screen readout)

Benchmark to the IBA Blue Phantom

- In order to gauge the ICP performance, it has been bench-marked against the tried and trusted Blue Phantom water-tank.

IC Profiler set-up (table-top)

The IC Profiler viewed in a stand alone set-up.

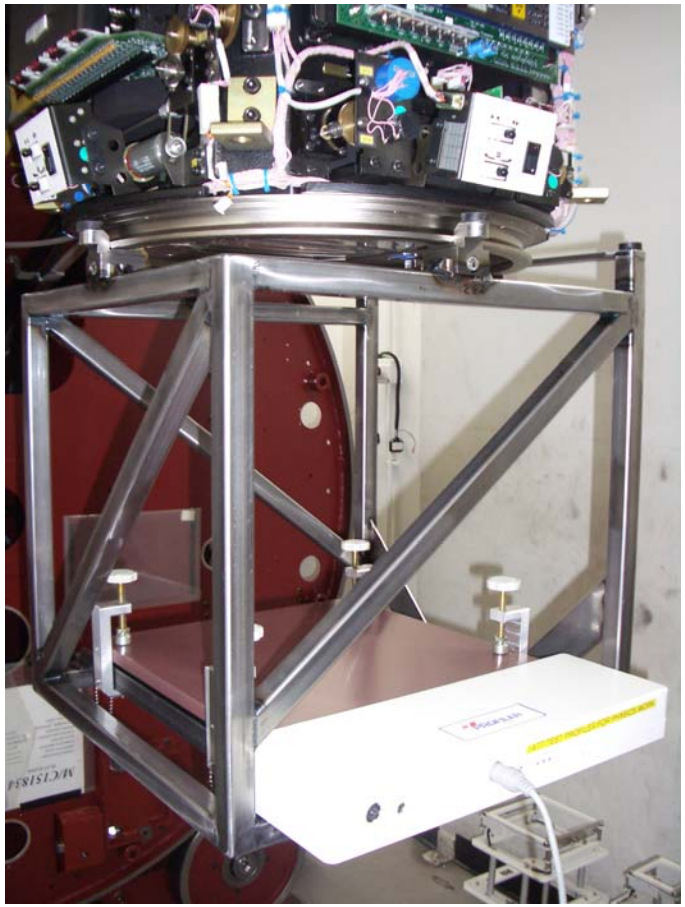
The ICP is ideal for service and installation work, as it easily transportable.

It can be quickly set-up and utilises the PSS couch as a support table.

Ideal for linac QA.

IC Profiler set-up (frame)

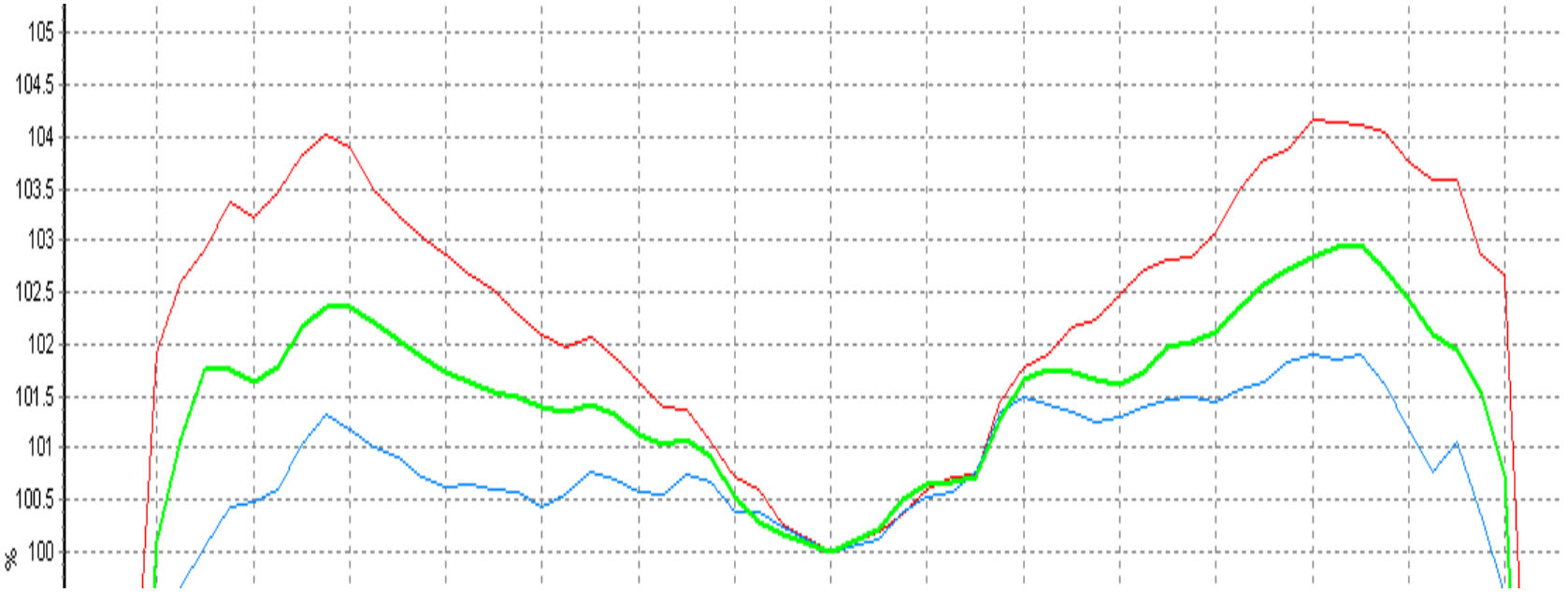
- This view shows the IC Profiler in it’s prototype frame design we intend to use both in the manufacturing facility and optionally on site.
- The frame is light-weight and easily fitted by one person.
- All measurements will be made at 100SSD.
- Build-up, however can be varied inside of the frame mount.



Test requirements

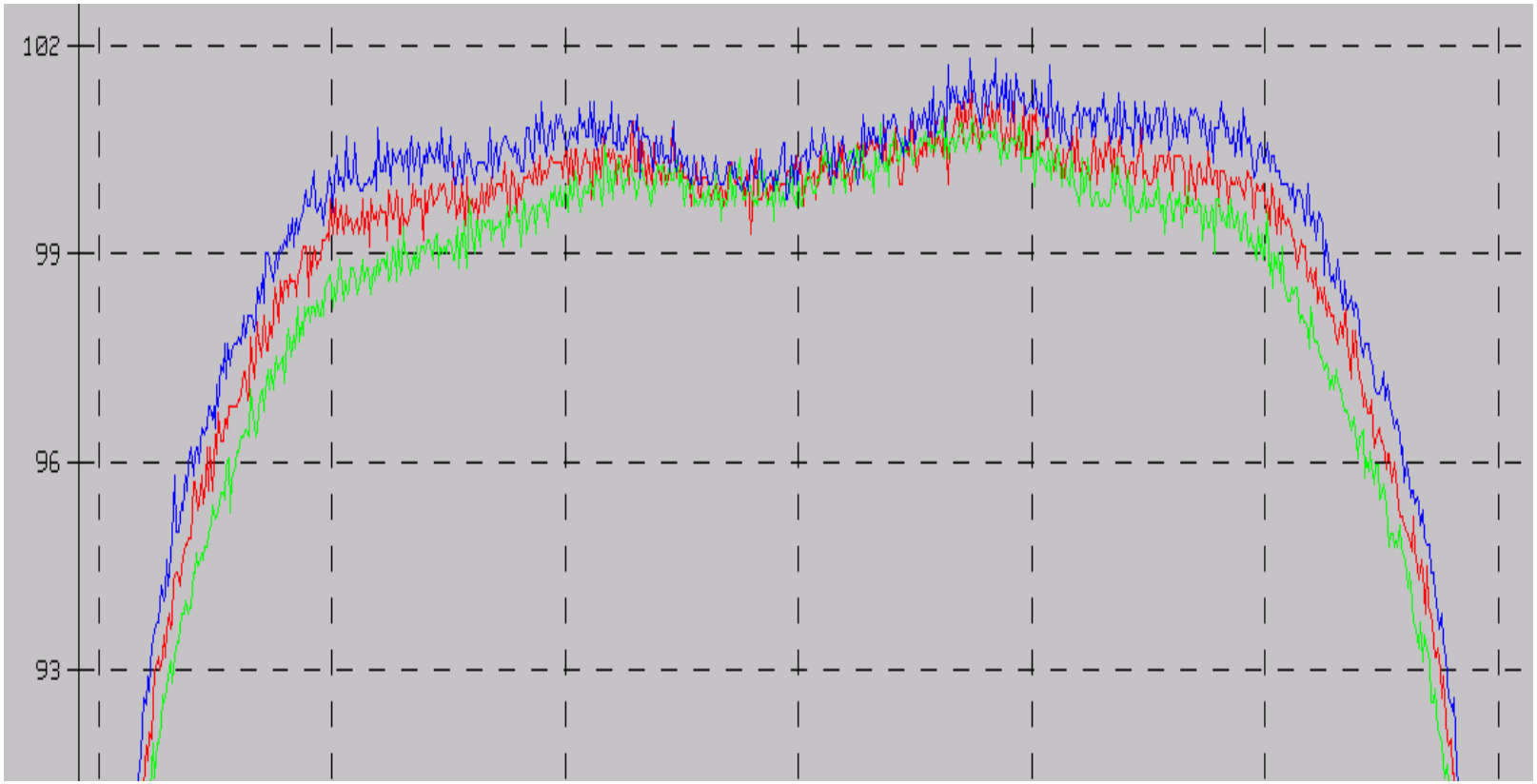
- Must be able to perform every test covered by the Buddelship, to an equal or better performance.
- Tests include:
- Beam symmetry across the largest field size.
- Flatness and energy for both photons and electrons.
- Doserate measurements.
- Uniformity with gantry rotation
- Uniformity performance over varying PRF rates.
- Measurement of different field sizes.

Energy and Flatness (photons)



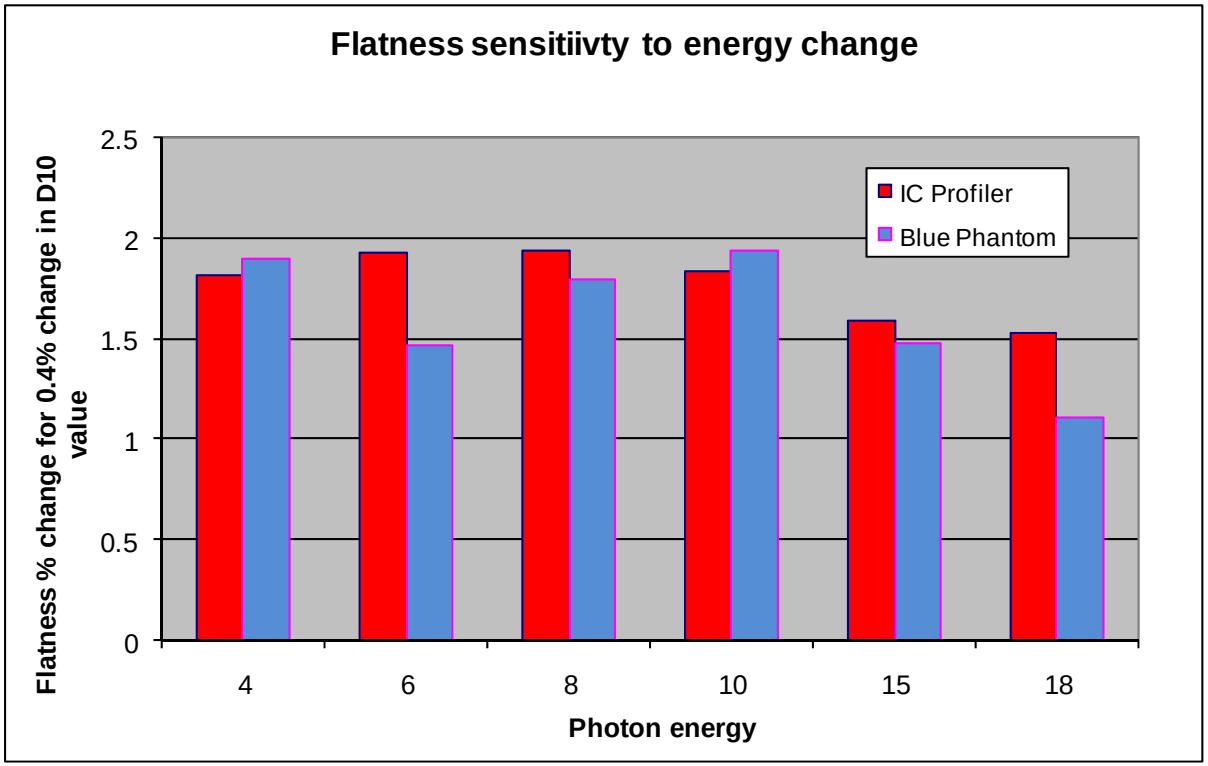
- We intend to use flatness as a measure of energy as oppossed to a CADD in water.
- The reason for this is good sensitivity, a small change in energy (+/-0.2% D10 value used for test) is easily discernable (seen here is a 6MV symmetrical profile using a 30x30cm field size).

Energy and Flatness (photons)



- The same small change in energy profiled using the Blue Phantom.

Energy and Flatness (photons)



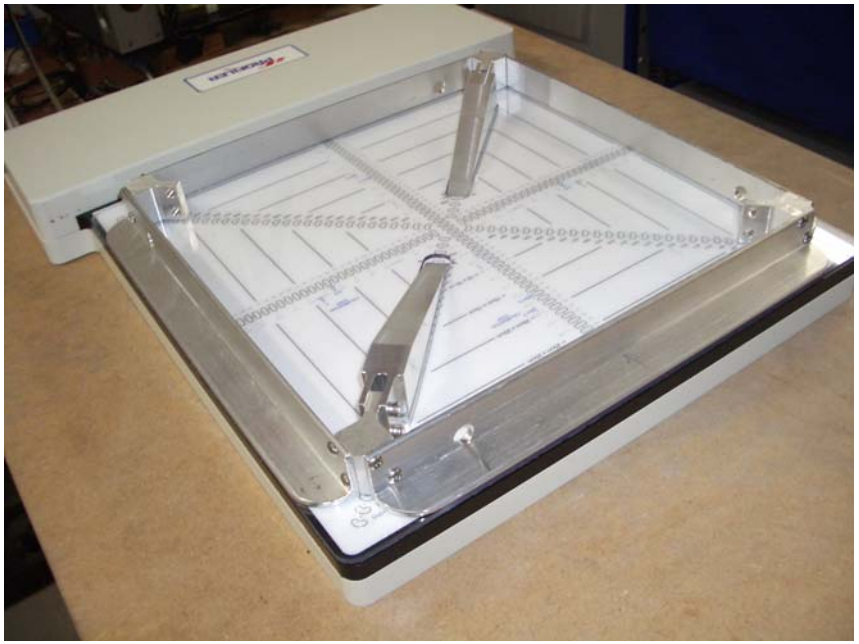
- Graph showing the relative flatness sensitivity, to a change of 0.4% D10 value of photon energy, on both the ICP and Blue Phantom.
- N.B. 2cm of build-up used for all energies.

Energy measurements on electrons

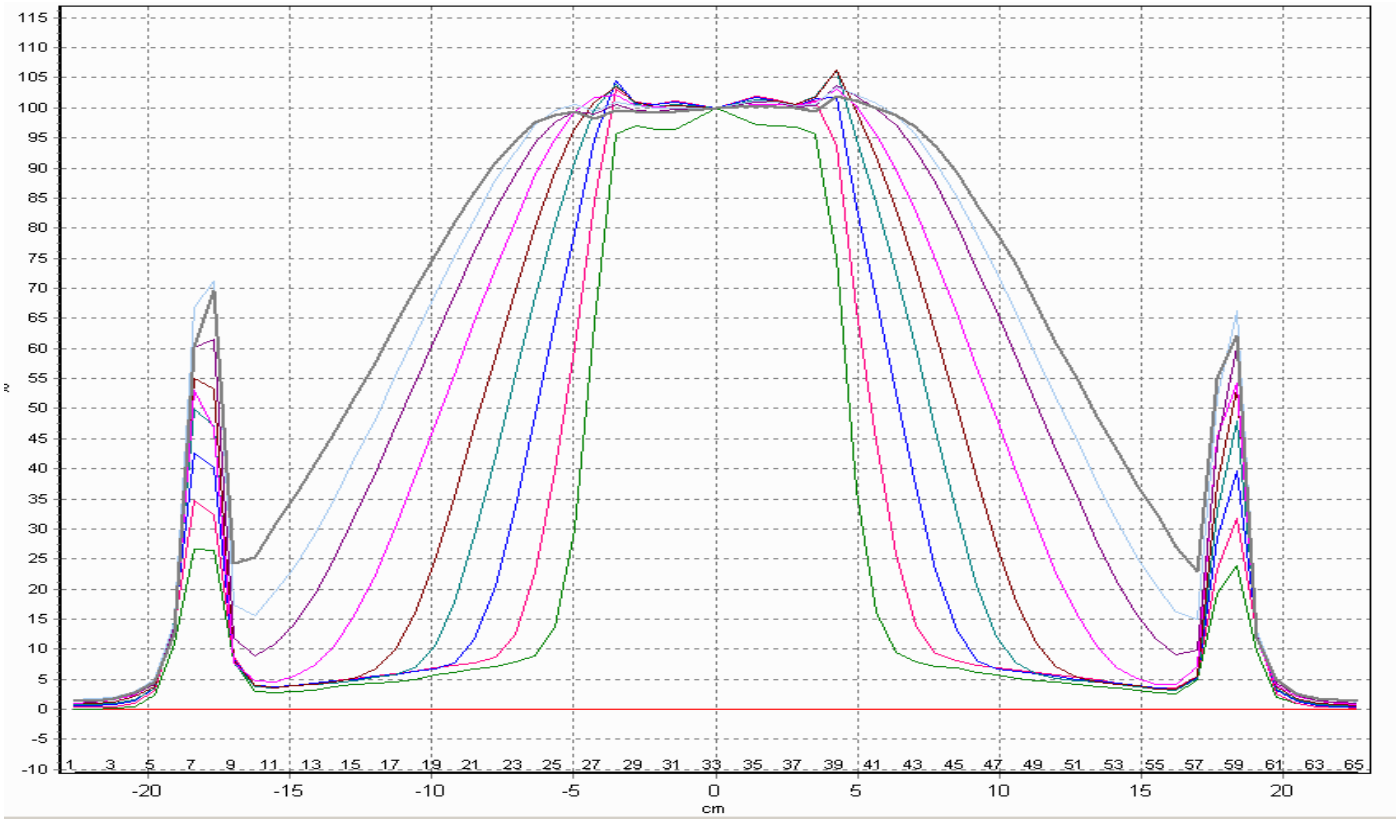
- Due to the insensitivity of flatness variations over small energy changes, the best practical solution for measuring electron energies was the use of aluminium wedges.
- Seen here is an early evaluation set-up of two pairs of wedges with different physical dimensions.

Energy measurements on electrons

- This view shows a more permanent frame to hold the wedges in.
- The important point is to ensure that the wedges remain at fixed distance from each other.
- Measurements of energy are derived as the distance between the two 50% dose points of the wedge pairs.



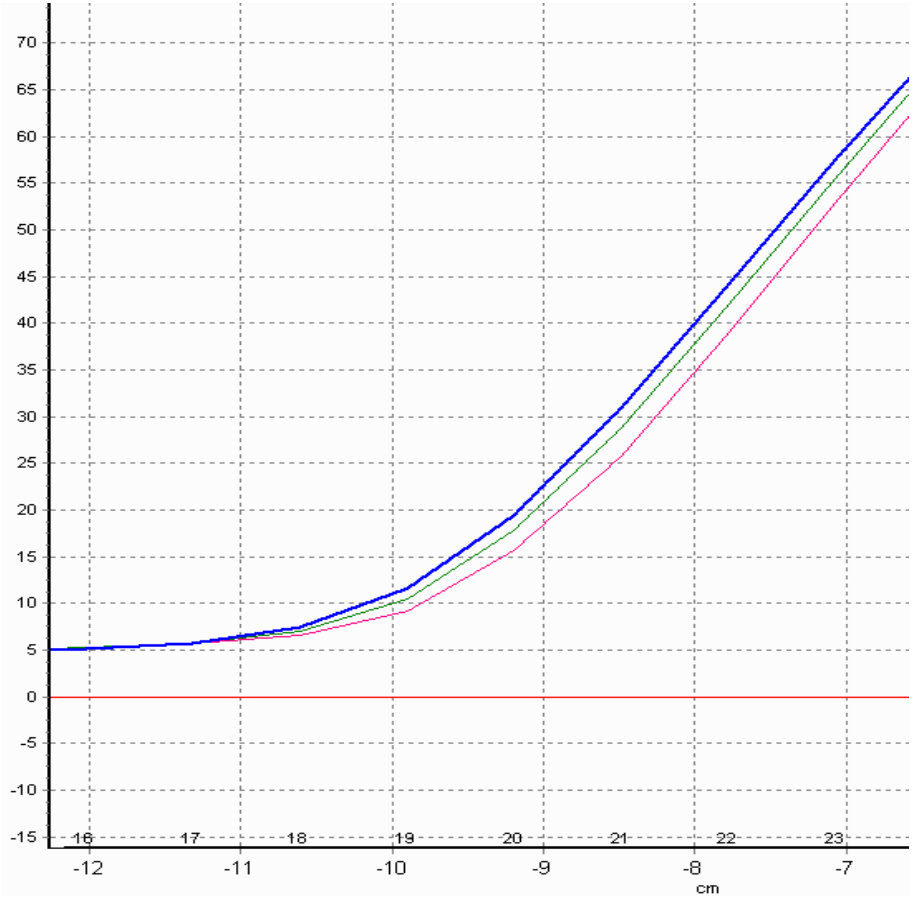
Energy measurements on electrons



- These wedge profiles, taken with the IC Profiler, show the increase in 50% point distance as energy increases over the range E4 to E22.

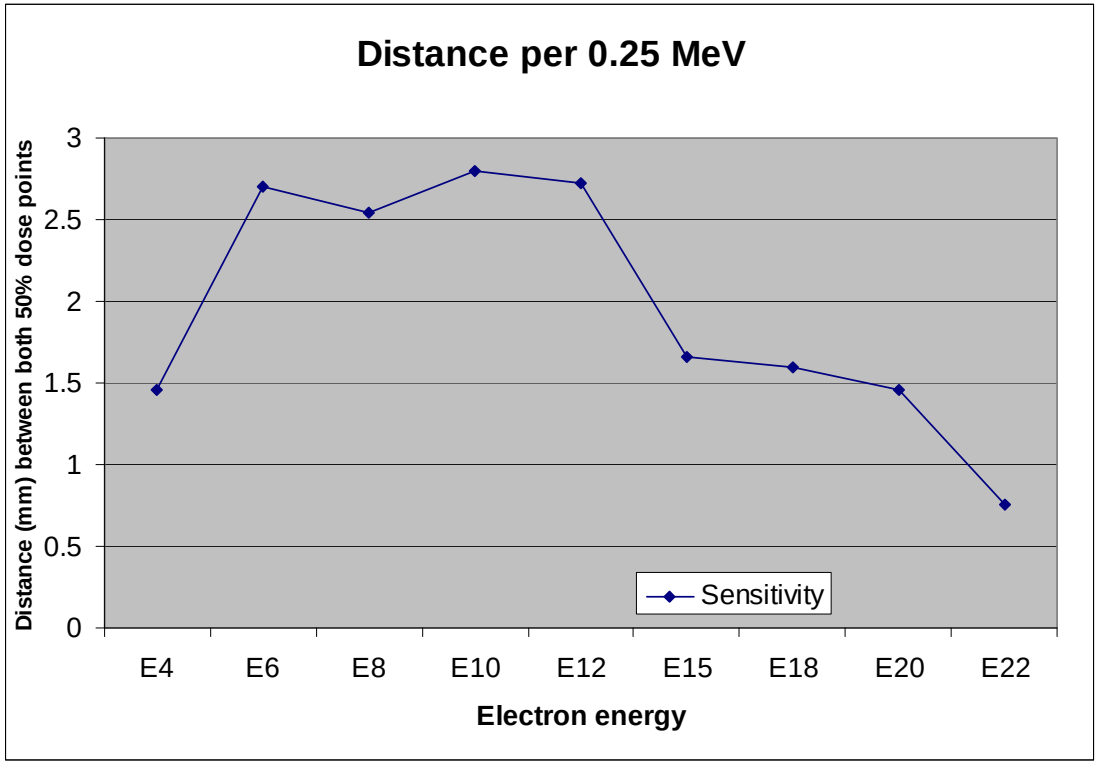
Energy measurements on electrons

- Seen here is an expanded view of the 50% dose point edges for the energy E10.



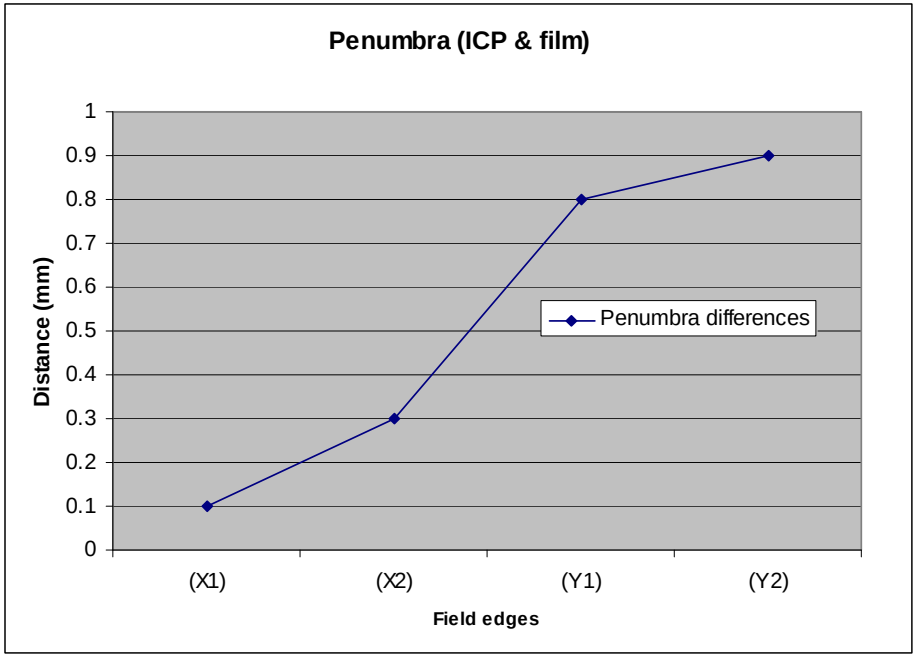
Energy measurements on electrons

- The sensitivity of small changes in energy can be seen on this graph, ranging from E4 to E22 (on average 2mm per 0.25MeV).
- The total variation of repeated profiles adds up to less than 0.5mm difference, still allowing for good energy discrimination.



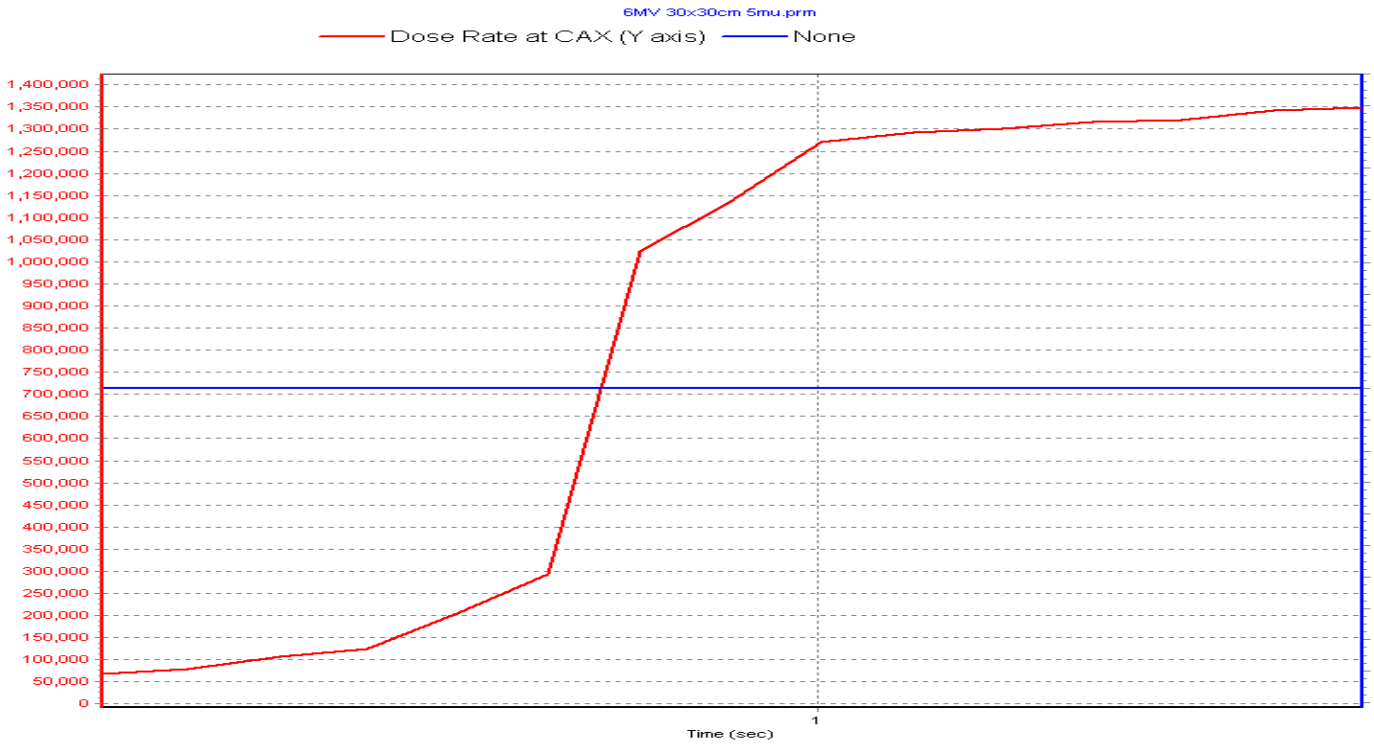
Penumbra (ICP to film)

- Example penumbra at 18MV, using a 20x20cm field, with a 1cm of build-up for both cases.
- Penumbra measurements made between film and ICP.
- Repeatability of film measurement analyses is very ambiguous.
- Agreement of penumbra to within 1mm.



Dose start-up using the ICP

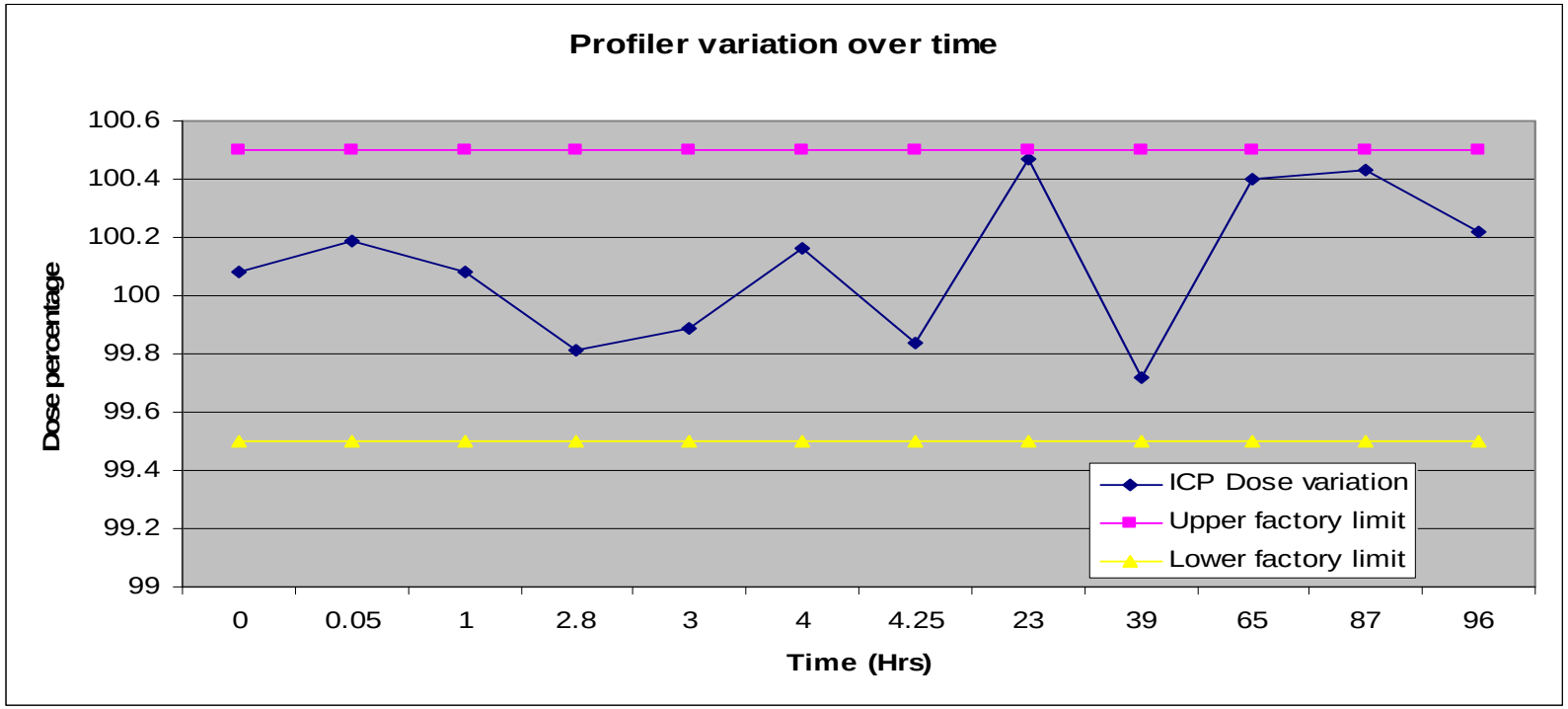
- Beam start-up characteristic (short 6MV beam), 8 samples per second.
- Note: beam set-up altered from optimum for this profile.



Symmetry on start-up using the ICP

- This image shows the beam symmetry servo-capture from a 6MV beam.

Dose calibration



- The dose calibration was done using the test IC Profiler at 6MV.
- Dose checks were performed over a number of times during the day, then over several days, this is less than +/-0.5%.

Comparable measurements

- The aim is to achieve a level of repeatable measurements using the IC Profiler that is comparable to the Blue Phantom water tank.
- In order to achieve this the total uncertainty from both devices must be measured.
- The total uncertainty i.e. Repeatability of measurements using any specific ICP and Blue Phantom needs to be gauged using a series of tests, to see how the two devices directly compare to each other.

Sensitivity of photon energy measurements

- For photon energy measurements:
- Total variation of repeated D10 values using the Blue Phantom= 0.2%
- A 0.2% change in D10 value equates to an average change of 0.9% in flatness as detected by the ICP.
- As the repeatability of flatness profiles is 0.25%, a small change in energy (0.2% D10) is easily detectable.

Repeatability of profiles using the Blue Phantom

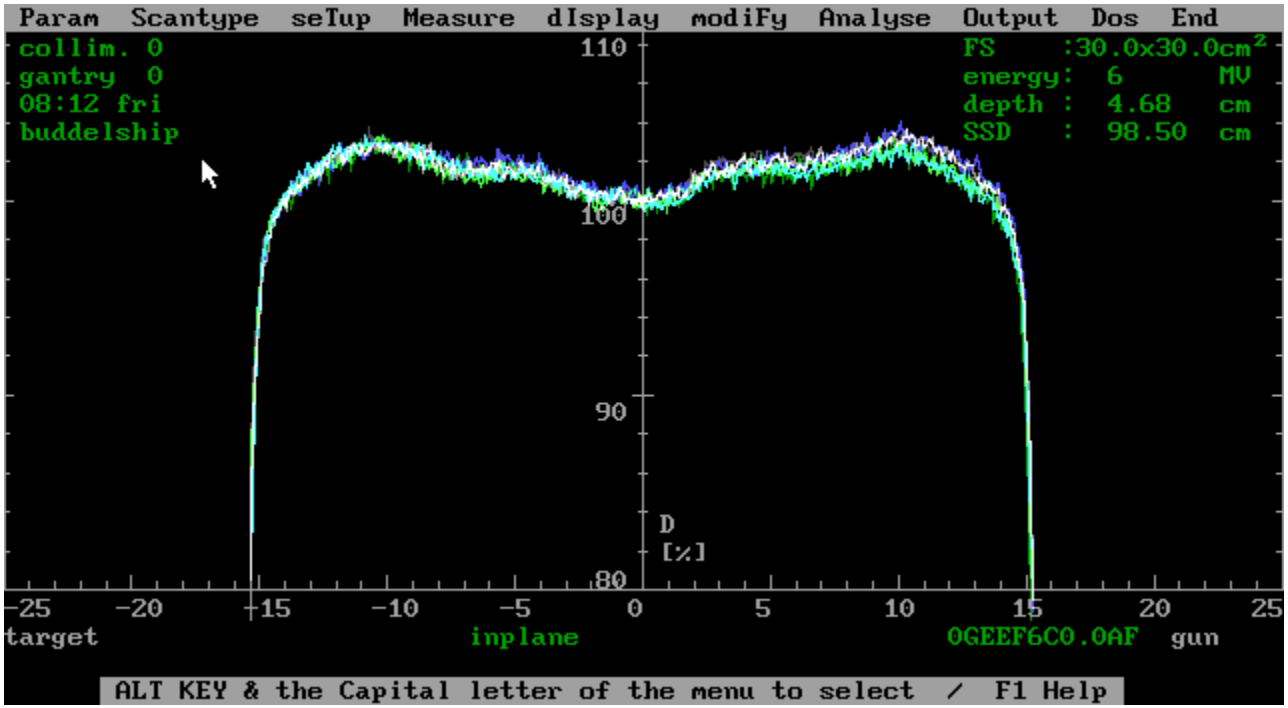
- For the Blue Phantom, the repeatability of a flatness profiles using one Blue Phantom with different ion chambers and different electrometers, came out with a total variation of up to 0.8%.

Repeatability of profiles on the ICP

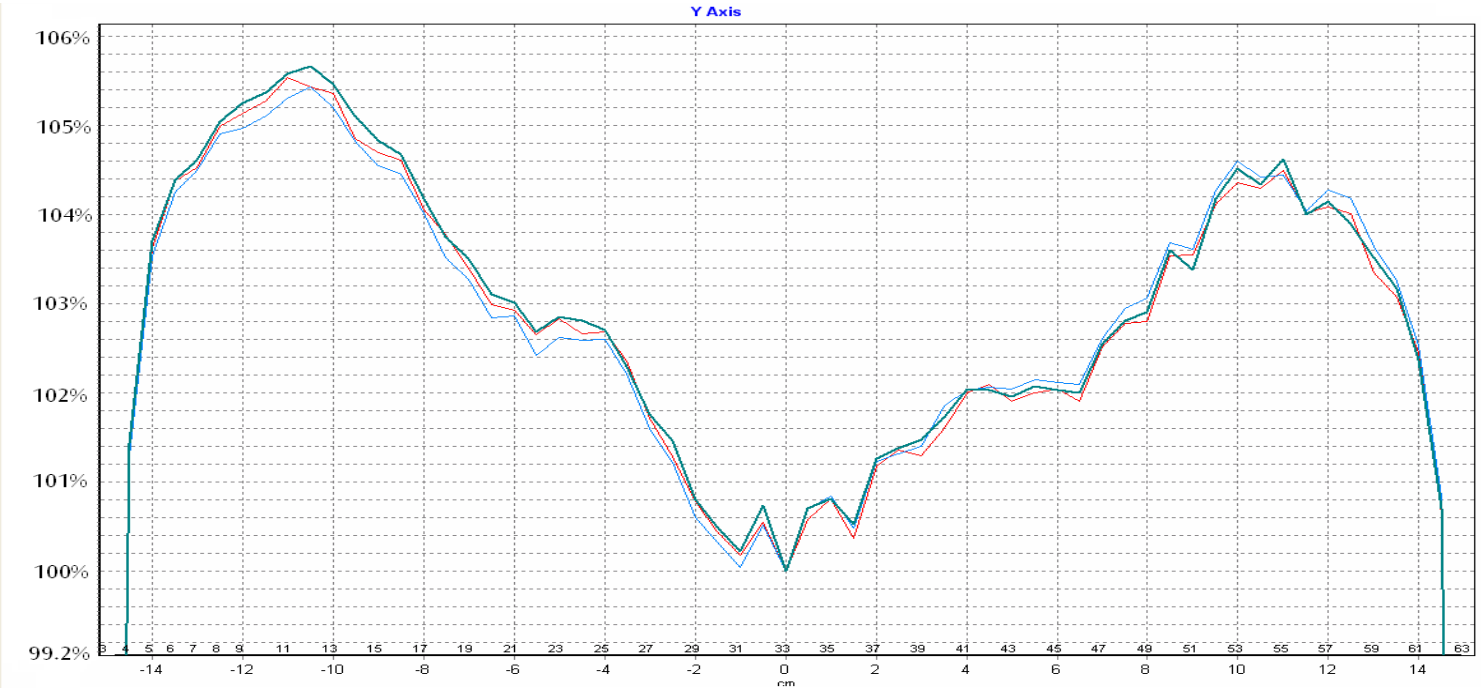
- The repeatability of flatness profiles across a number of different IC Profilers came out at 1.25%, based on our measurements.
- These results are based on the repeatability of profiles on a particular IC profiler coupled with measurements on several other Profilers.

Buddelship repeatability

- The repeatability of flattened profiles on a number of different Buddelships came out at 1.5%.



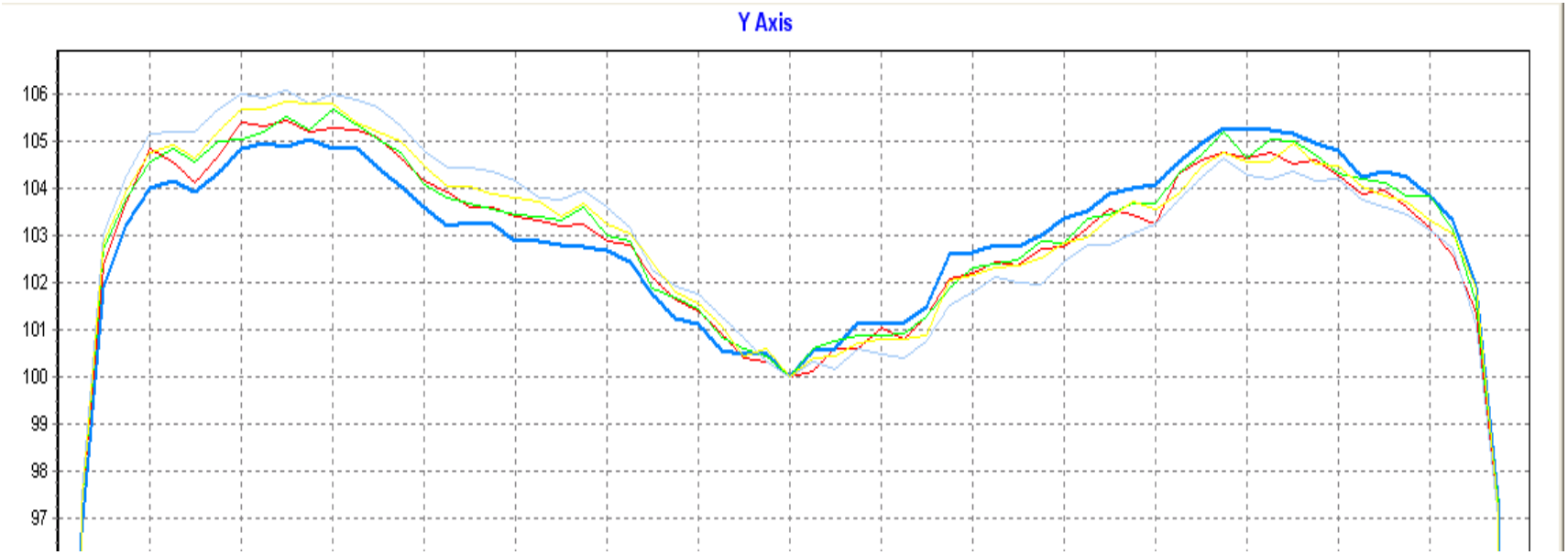
Repeatability of profiles



- The repeatability of ICP profiles has been exhaustively tested at different energies, sample times and PRF rates.
- For a typical 6MV energy, at a sample rate of 150mS, 200PPS, a repeatability of profiles over time can be as low as 0.25%.
- These sample profiles were taken at 20 seconds apart.

Rotational profiles using the frame

- Displayed here is the flatness variation for 6MV at every 90 degrees of gantry angle, for the inplane axis.
- The frame's rigid design is reflected in the repeatability of the field edges.



Life-testing of the IC Profiler

- We need the IC Profiler to be able to withstand large volumes of accumulated dose.
- As we utilise our test facility to a maximum, we have estimated that a maximum dose exposure of 100kGy in a single year is possible.
- We are therefore undertaking a program of work to exposure an IC Profiler to this level of dose in an accelerated time-scale.

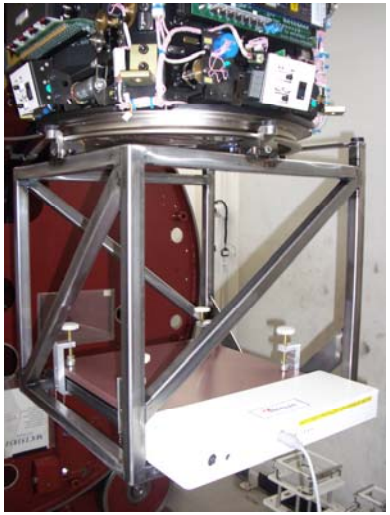
‘Gold’ Data collection

- Gold – as in standardised profiles for all energies.
- Using the Blue Phantom as reference data.
- The same linac parameters used to acquire a standard set of measurements using the IC Profiler.

What's next with the IC Profiler?

Now we have evaluated the performance of the IC Profiler, it's time to start setting up a linac using the instrument.

- Initially the linac set-up, carried out using an IC Profiler, will be checked against the Blue Phantom to ensure that the test specification is met.
- The comparison will be submitted in a paper at a later date.



Summary

- The results in these slides shows that the ICP is very comparable with the Blue Phantom for being able set-up the linac, and evaluate its performance with confidence for both factory test and customer installation.
- The ICP enables us to improve the quality of factory set-up and customer installation.
- The improved accuracy provides some cushion for performance tolerances to be tightened in the future.

Question time

- Are there any questions, if not now please feel free to talk to me over the next few days.

- Thank you for your time today