

ICTP November 7th, 2025



Humber Health
Partnership

VERT – a computer simulation tool for radiotherapy training: case study TRS398/483

Prof Andy Beavis, DSc hc, PhD

Hull University Teaching Hospitals, Hull, UK. University
College London, London, UK. Virtual Ltd, Hull, UK.



andy@virtual.co.uk

If you see this

.....You might want to snap a picture
with your phone

Might be something useful to refer
back to when we do the practical
session after the coffee break



Declaration

www.virtual.co.uk
andy@virtual.co.uk

NHS
Humber Health
Partnership

I am a co-inventor of VERT, Founder and Director of Virtual Ltd



Real World



VERT World

Background - Andy

- Radiotherapy Physicist since 1992
 - Head of Medical Physics in East Yorkshire, UK
 - Appointed as Medical Physics Expert 'by' Secretary of State
 - Lead Healthcare Scientist for hospital system of 17000 employees
 - Founder/ CSO/ Radiotherapy Director of Vertual Ltd
 - UK Pioneer/ advocate of high-end RT clinical applications
 - Comprehensive background in RT/ imaging
 - Well published – varied research
 - Experience teacher/ educator (internationally)
 - International network of collaborators
-
- Innovator/ advocate of computer simulation training for RT
 - Guided our department through developments from 2D/Cobalt therapy to IG/IMRT

Background – Virtual/ VERT



Algeria, Australia, Austria, Belgium, Brazil, Canada, Chile, China, Czech Republic, Denmark, England, France, Germany, Hong Kong, Ireland, Israel, Italy, Japan, Kazakhstan, Kyrgyzstan, Malta, Mexico, Morocco, Netherlands, New Zealand, Northern Ireland, Poland, Russia, Saudi Arabia, Scotland, Singapore, South Africa, Spain, Sweden, Switzerland, Thailand, United States, Wales

Bring the Linac into the classroom!



Humber Health
Partnership

Immersive VERT



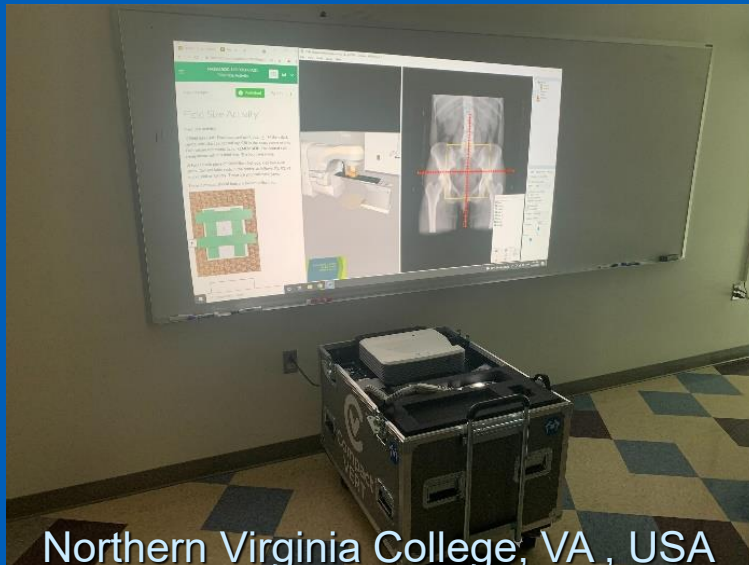
MD Anderson, Houston, Tx, USA

Seminar VERT



Grote Schuur, Cape Town, SA

Compat VERT



Northern Virginia College, VA, USA

- Turn-key systems
- Incl training the trainer
- Install into training centres
- 'traditional VERT systems'

VERT software



Humber Health
Partnership

- Accurate 3D Linac models
- Use DICOM data from local TPS, to simulate:
 - Patient, PTVs, OARs, imaging, delivered dose, treatment techniques
- patient models
- Imaging matching
 - CT, CBCT, MRI, PET
- Physics QA process and equipment
 - TRS 398/ TRS483, machine dosimetry, QC tests
- Ideal for supporting the transition to state of the art radiotherapy
 - IMRT (VMAT), IGRT, SGRT, ART, 4D planning, Proton,
- Functionality designed to illustrate RT concepts, need for treatment accuracy and safety
 - Create and explore simulations of Patient set up error and Linac mis-calibration

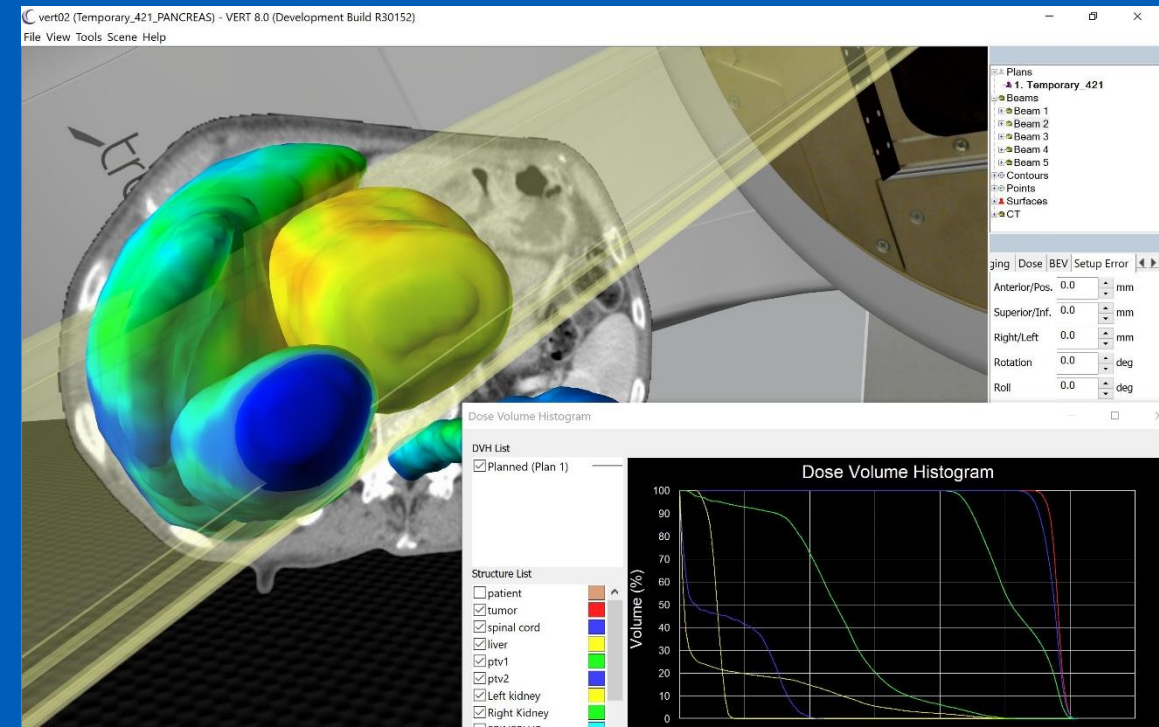
.....and much, much more!

Background: VERT

- VERT is used in 38 countries to provide simulation/ experiential learning for radiation therapy (mainly Radiographer) training
 - Since 2008



- Used to teach basic concepts for radiation therapy
- Practice delivery of treatments
- Understand treatment plans
- Can explore things that cannot do in the real treatment bunkers
 - **Perfectly set up Pancreas patient**

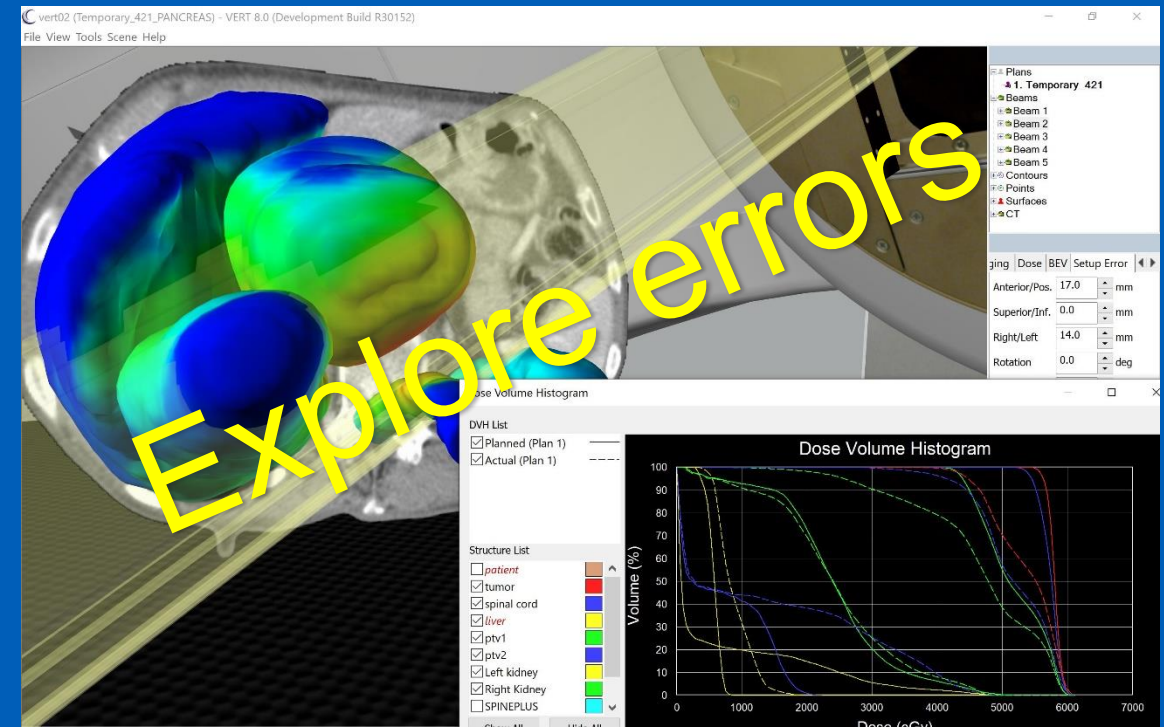


Background: VERT

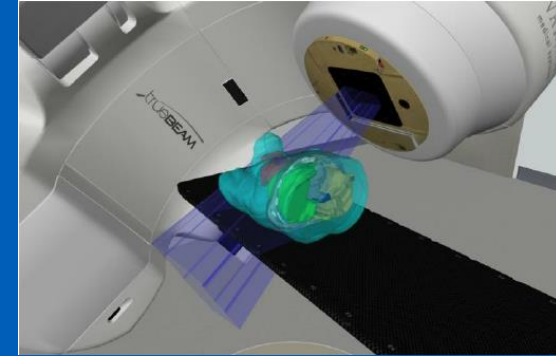
- VERT is used in 38 countries to provide simulation/ experiential learning for radiation therapy (mainly Radiographer) training
 - Since 2008



- Used to teach basic concepts for radiation therapy
- Practice delivery of treatments
- Understand treatment plans
- Can explore things that cannot do in the real treatment bunkers
 - 17mm ANT, 14mm R set-up error



Background: VERT

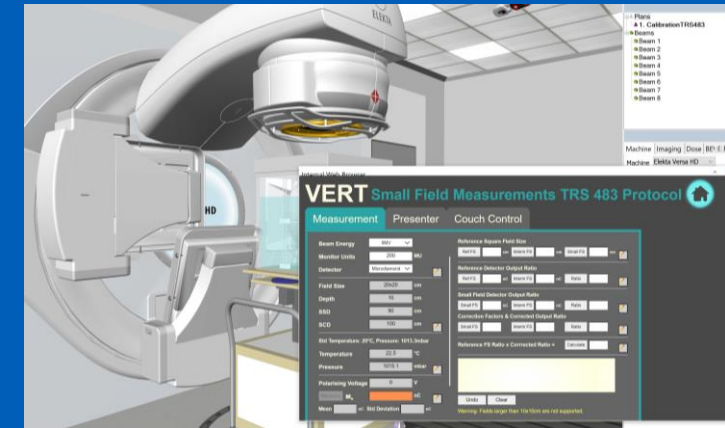


- Linac and Proton gantries to the classroom
 - Fully functional articulated 3D models
..... except they don't produce ionising radiation!
- Patients/ treatments modelled using TPS DICOM data
 - Structure sets, CT/ CBCT/ MRI/ PET, Dose, Plan/ Ion-Beam file
- Has embedded beam models: photon, electron, proton
- 'Deliver' treatments – correctly or with simulated errors/ challenge
 - simulate and explore actual clinical errors (misposition patient; explore impact)

VERT - bringing the Linac and practical dosimetry training into the classroom

Background: VERT

- Establishing user base with Physics MSc courses
- Physics module provides simulation of QC, clinical processes to allow simulation training for physicists
 - Incl: TG51, TRS398, TRS483, IPEM CoP, plotting tank simulations, QC measurements,
- Physics module: QC, calibration, commission equipment, ...
 - Explore the impact of Linac mis-calibrations and errors
- And much more is planned.....



VERT - bringing the Linac and practical dosimetry training into the classroom

VERT on Demand – cloud solution



Humber Health
Partnership

Login with own account, provided
by course admin

Workbooks/ exercises/
guided sessions

Course admin
controls which
workbooks the
trainee should work
through

Create individual VERT
sessions / exercises

The image displays two screenshots of the VERT on Demand web application. The left screenshot shows the login page with the text 'WELCOME TO VERT ON DEMAND' and 'VERTUAL VERT University'. It includes a login form with fields for 'Email Address' (containing 'andy@virtual.co.uk') and 'Password', a 'Remember me' checkbox, and a 'Login' button. The right screenshot shows the 'Content' dashboard for 'VERT on Demand VERT University'. It features a sidebar with 'Home', 'Content', and 'Results' options. The main area lists various workbooks under the heading 'Content'. A blue box highlights the 'IGRT' workbook, which has a progress bar at 7%. A blue arrow points from this box to a larger, detailed view of the 'IGRT' workbook on the right. This detailed view shows the workbook's title, tags (#IGRT, #bladder, #headandneck, #lung, #CBCT), a description ('This module contains 4 workbooks focusing on IGRT.'), and a list of related workbooks: 'IGRT Knowledge Quiz' (25% progress), 'IGRT Bladder' (5% progress), 'IGRT Lung' (0% progress), and 'IGRT Head and Neck' (0% progress). Each workbook entry includes a 'Launch' button and a 'Due Date: 30 Jun, 2023'.

VERT on Demand



Humber Health
Partnership

- Configure modules in line with curriculum
- Design practical sessions (learning exercises/ assessments)
- Launches INTERACTIVE session: configured to use a specific Linac, patient (or equipment) and e-learning package

andy@virtual.co.uk

The screenshot displays the VERT on Demand interface. On the left is a sidebar with 'Home', 'Content', and 'Results' options. The main area is titled 'International Centre for Theoretical Physics' and 'Content'. It features a search bar and filters for 'Due' (All) and 'Status' (All). A list of modules is shown, each with a progress bar (0%) and a 'Launch' button. The 'Launch' button for the 'TRS398 - MV photon' module is circled in red. A red text overlay on the right side of the interface reads 'Starts a live interactive VERT session'.

VERTUAL

International Centre for Theoretical Physics

Welcome, Andy Beavis
andyictpstudent@virtual.co.uk

Content

Search for content...

Due: All Status: All

Introduction to VERT
VERT basics
Orientation exercises.
Due Date: 31 Oct, 2025
smr4099

4. Anatomy Workbooks
This module contains anatomy workbooks
Due Date: 31 Oct, 2025
smr4099

Radiotherapy Dosimetry
dosimetry IAEA TRS protocols
Virtual Dosimetry Practicals
Due Date: 31 Oct, 2025
smr4099

TRS398 - MV photon
Radiotherapy dosimetry definitive calibration
IAEA TRS398 Dosimetry protocol for MV Photon clinical beams.
Due Date: 31 Oct, 2025
Launch

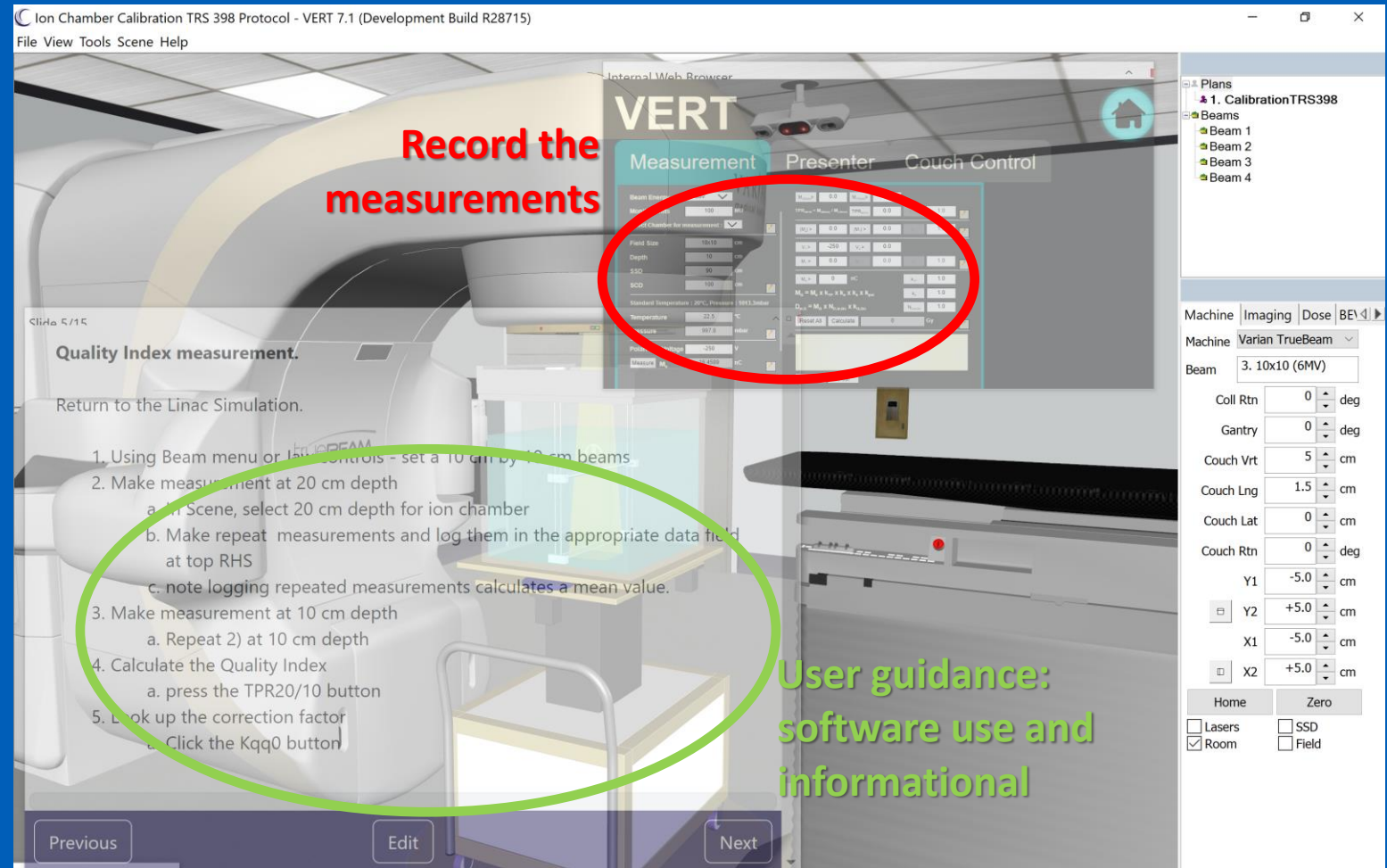
TRS483 - small field MV Photon
Radiotherapy dosimetry relative calibration
IAEA TRS 483 Dosimetry protocol
Due Date: 31 Oct, 2025
Launch

3. Basic Principles
The basic principles modules is split into 2 sub modules; 1. Techniques 2. IGRT
Due Date: 31 Oct, 2025
smr4099

Starts a live interactive VERT session

Example: Simulation Training for Absolute Dosimetry/ TRS398

- The TRS398 workbook leads the user through the software and the IAEA protocol/ exercise
- Using VERT, the user makes the required measurements
- User has to interactively set up the Linac/ equipment to make and record the measurements



Simulation Training for Absolute Dosimetry/ TRS398

- Charge measurements are simulated to reflect the set-up
- set-up or procedural errors will impact the observed results
 - T,P, Pol V, chamber set up, wrong field size, ...
- Can configure uncertainties

VERT Ion Chamber Calibration TRS 398 Protocol

Measurement Presenter Couch Control

Beam Energy: 6MV

Monitor Units: 100 MU

Select Chamber for measurement: A

Field Size: 10x10 cm

Depth: 5 cm

SSD: 95 cm

SCD: 100 cm

Standard Temperature: 20°C, Pressure: 1013.3 mbar

Temperature: 22.5 °C

Pressure: 997.8 mbar

Polarising Voltage: -250 V

Measure M_e : 20.3757 nC

$M_{(20cm)} >$ 11.4642 $M_{(10cm)} >$ 17.1594

$TPR_{20/10} = M_{(20cm)} / M_{(10cm)}$ $TPR_{20/10}$ 0.668 k_{Q,Q_0} 0.994

$|M_-| >$ 17.1521 $|M_+| >$ 17.2045 k_{pol} 1.002

$V_1 >$ -250 $V_2 >$ -50 $V_1 / V_2 = 5.00$

$M_1 >$ 17.1528 $M_2 >$ 16.8715 k_s 1.005

$M_e >$ 20.3757 nC k_{TP} 1.024

$M_Q = M_e \times k_{TP} \times k_e \times k_s \times k_{pol}$

$N_{D,w,Q} = M_Q \times N_{D,w,Q_0} \times k_{Q,Q_0}$

Reset All Calculate

0.997 Gy

$N_{D,w,Q} = 4.784e+7$

T=22.5°C, P=997.8mbar
M20=11.4642, M10=17.1594, TPR 20/10=0.668, kQQ0=0.994
|M-|=17.1521, |M+|=17.2045, kpol=1.002
V1=-250V, V2=-50V, M1=17.1528, M2=16.8715, ks=1.005
Me=20.3757, kTP=1.024, ke=1, N D,w,Q=4.784e+7, D w,Q = 0.997 Gy

Undo Clear

Measure/ calculate correction factors

Check output under calibration conditions

Please note

- If you haven't already accepted the invitation to create your VoD password – please do so
- Use your own laptop if available, or try to use the PC you used yesterday
- If you need to use a different one or haven't yet used one – you will have to create your ICTP account first
- Go to: vod.virtual.co.uk/ictp
- Login with your details – own email and created password
- This is the second time we have tried this on such a large scale – please be patient if necessary

Exercise:



Work through the steps and measurements required by the TRS398 protocol for 6MV

- 1) Chamber A is a Farmer
Use -250V as default PV
- 2) Some updates have been made
- 3) Linac calibrated to unity at
5cm depth, isocentrically
with a 10x10 field

Test at end – use all factors to
Check calibration is correct

VERT Ion Chamber Calibration TRS 398 Protocol

Measurement Presenter Couch Control

Beam Energy: 6MV

Monitor Units: 100 MU

Select Chamber for measurement: A

Field Size: 10x10 cm

Depth: 10 cm

SSD: 90 cm

SCD: 100 cm

Standard Temperature: 20°C, Pressure: 101325Pa

Temperature: 22.5 °C

Pressure: 99780.5 Pa

Polarising Voltage: -250 V

Measure M_e nC

Mean nC Standard Deviation

M_{20cm} 0.0 M_{10cm} 0.0

$TPR_{20/10} = M_{20cm} / M_{10cm}$ $TPR_{20/10}$ 0.0 k_{Q,Q_0} 1.0

$|M_L|$ 0.0 $|M_L|$ 0.0 k_{pol} 1.0

V_1 -250 V_2 0.0

M_1 0.0 M_2 0.0 k_s 1.0

M_c 0 nC k_{TP} 1.0

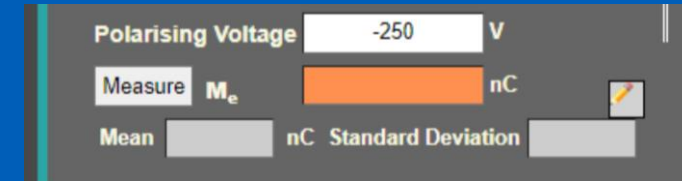
$M_Q = M_e \times k_{TP} \times k_e \times k_s \times k_{pol}$ k_e 1.0

$D_{w,Q} = M_Q \times N_{D,w,Q_0} \times k_{Q,Q_0}$ N_{D,w,Q_0} 1.0

Reset All Calculate 0 Gy

Undo Clear

Updates



- 1) Use measure tool and consider the StDev as an uncertainty
- 2) When satisfied with mean – click in appropriate box on RHS to transfer the value across, can then start on next data collection
- 3) The ‘pencils’ record some of the data in the scratch pad – can use it for reference.
- 4) To change the polarity of the PV – edit the sign (kpol)
- 5) When select the 1/2, 1/3, 1/4, 1/5 values for PV (ks) MUST click on V2 on RHS to register the value.

Ideas for further simulations....

- 1) Explore impact of only taking one measurement
- 2) Explore what would happen if you make QI measurement with a 20 x 20 field
- 3) Repeat for 15 MV
- 4) Try Ch B for 6MV – the kpol has been artificially set high (1%) to illustrate the role of kpol
 - You could make the output measurement with -250V and then repeat at +250V, with/without kpol and explore....



Implementation in Physics courses

- Have used TRS398/483 and IPEM CoP applications in VERT during practical courses run at the National Physical Lab in Teddington, UK
 - Exploration of uncertainties/ commonly experienced mistakes in practice
 - Practical virtual demonstrations
- ESTRO Practical Dosimetry Audit course 2023 and will be used again Dec 2025
- NPL Practical Course on Reference Dosimetry (PCRD) 2023
 - Added VERT TRS483 (small field) application for PCRD 2024
- Working on use of VERT on Demand for the pre-course study for the 2026 PCRD course
- UCL – used in the Med Phys MSc in 2025; to be integrated fully into the Radiotherapy module in the 25/26 academic year
- ICTP – biggest group we have tried!!!!!!

Conclusions – use of comp sim for Physics training

- Computer Simulation (VERT) is widely implemented for Therapist / Radiographer/ RTT training globally and is now a key feature of NPL training courses for Physicists
- VERT continues to be developed
 - update release each year
 - Including specific Physicist training features (focus)
- Physics module is essentially a virtual experimental platform
 - Rather than an illustrative or demonstration platform

After this course

You have access to VERT on Demand until the end of January 2026

All we ask for is lots of feedback

If you like it and suggest to your Head of Department that colleagues should have access then please get in touch, we will add more content/exercises

We will work out some introductory offer to reflect your connection with the ICTP

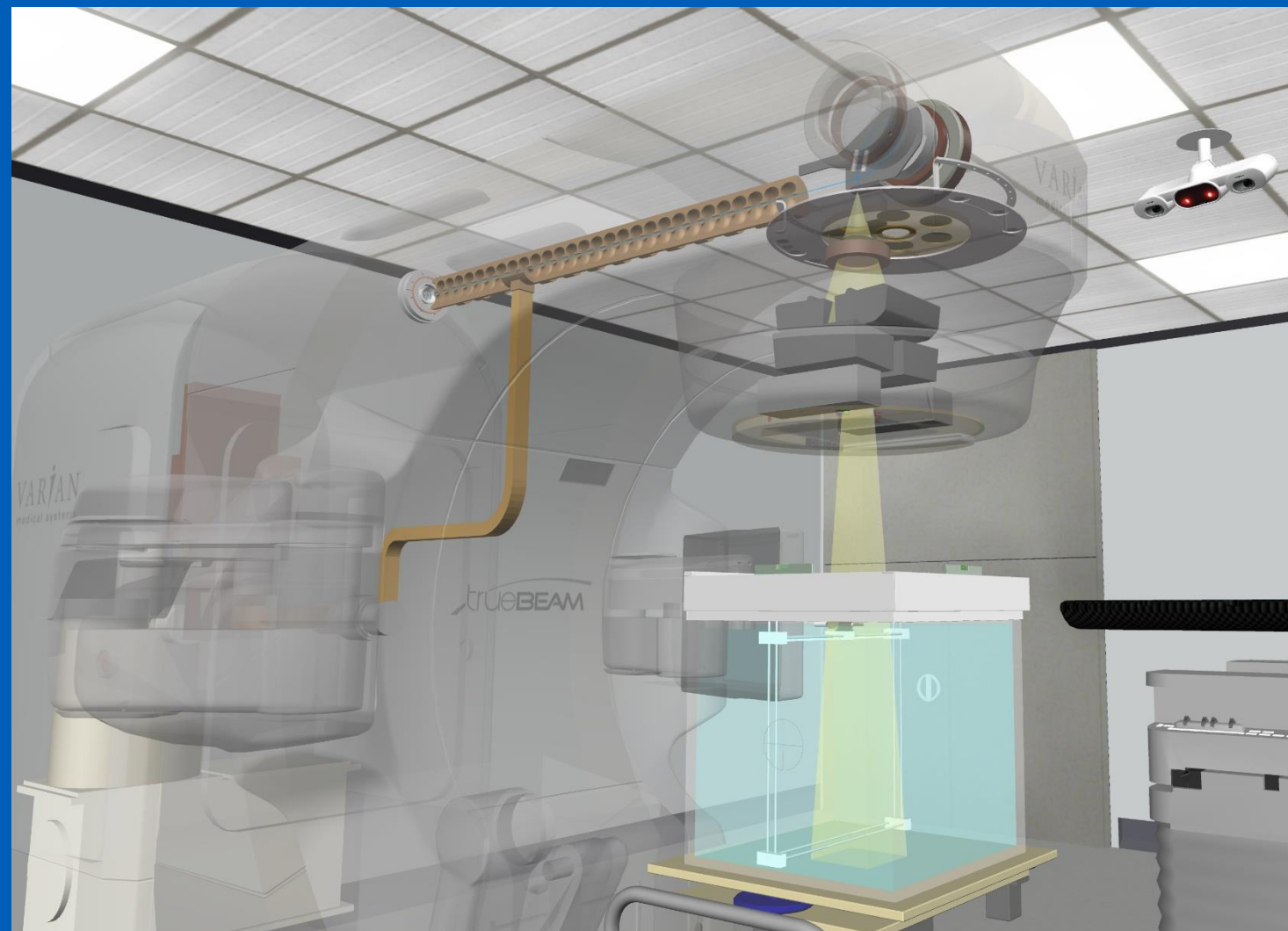


andy@virtual.co.uk
www.virtual.co.uk

Thank you

- For your attention and your interest, we hope you enjoyed it.
- To Marco and Zakithi for the opportunity to present in this session
- My colleagues and project collaborators
 - CHH
 - National Physical Lab, UK
 - Univ College London
 - Vertual Ltd (James Ward)

andy@vertual.co.uk



New: anatomy of a Linac feature