Direct “Central Point Method” for the measurement of DLP, CTDI100, CTDIvol and CTDIw, using a solid state CT Detector.

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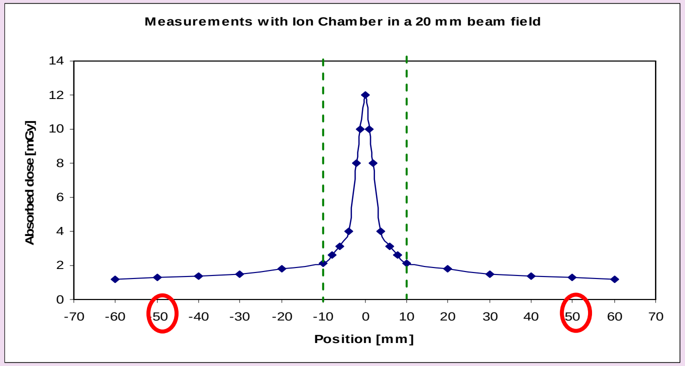
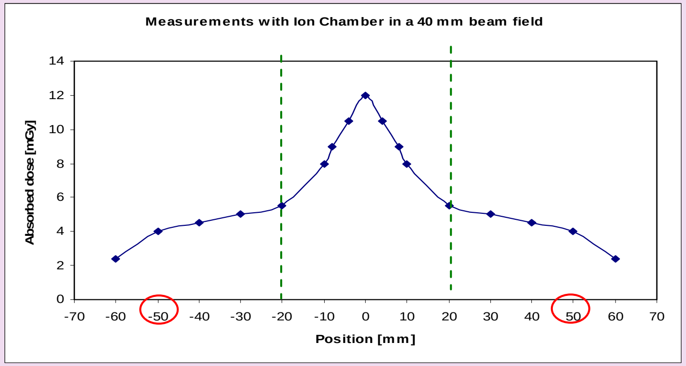
Need for a new instrument

Modern Multi-Slice CT machines have very wide fields which make it difficult to use traditional CT ion-chambers to measure the total dose given to the patient.



~5% of the dose is not detected in a 20 mm wide beam



~30% of the dose is not detected in a 40 mm wide beam

Current method of dose measurements

Pencil Ion chamber

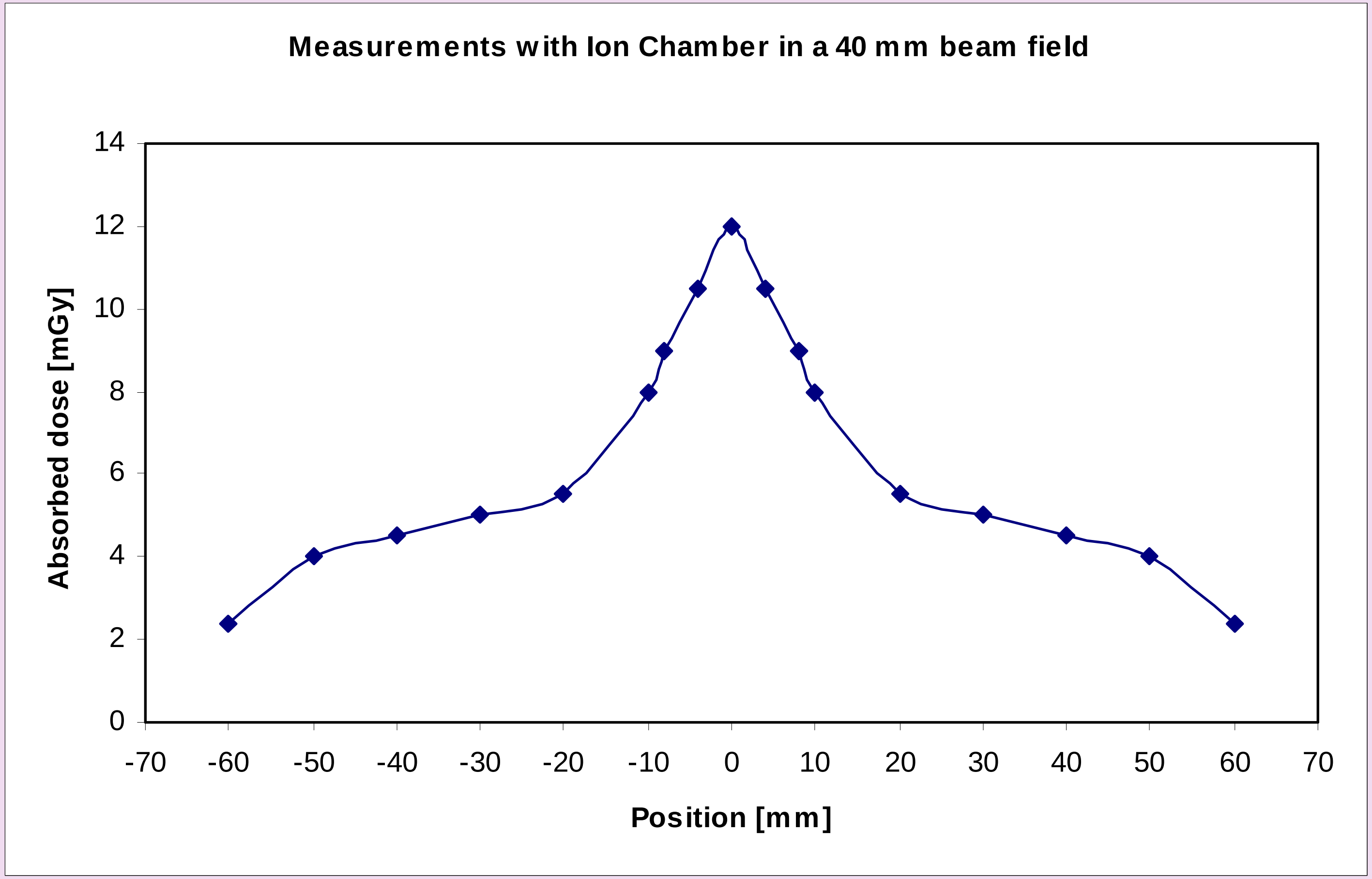
- Optimum measuring length of 10 cm.

New CT Scanners have wider effective beams due to scatter when measuring in a phantom. This length will give an under-estimation of the dose.

- Allows indirect measurements of CTDI

- Needs to be moved around in the five phantom positions.

- Gives a mean value over the whole rotation (no spatial information)


Measurements with Ion Chamber in a 40 mm beam field
Absorbed dose [mGy]
0
2
4
6
8
10
12
14
-70
-60
-50
-40
-30
-20
-10
0
10
20
30
40
50
60
70
Position [mm]

CT Dose Profiler

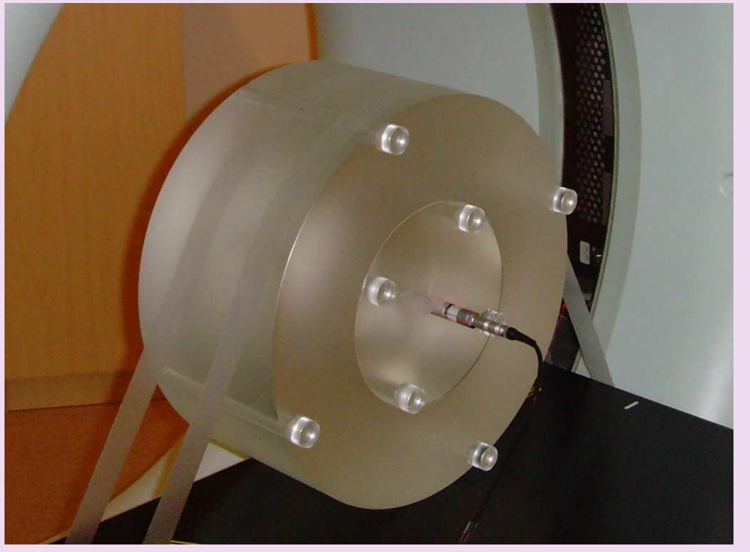
- Contains one very thin (thickness: 300um, size: 2x2 mm) diode.

- Cylindrical case in Aluminium filled with plexiglass.

- The software collects the dose profile data when the probe is moved through the beam. The width of the beam is no limitation.

- Calculations of CTDI and more are based on the dose profile.

- The diode is approximately 100 times more sensitive that existing CT pencil ion chambers.



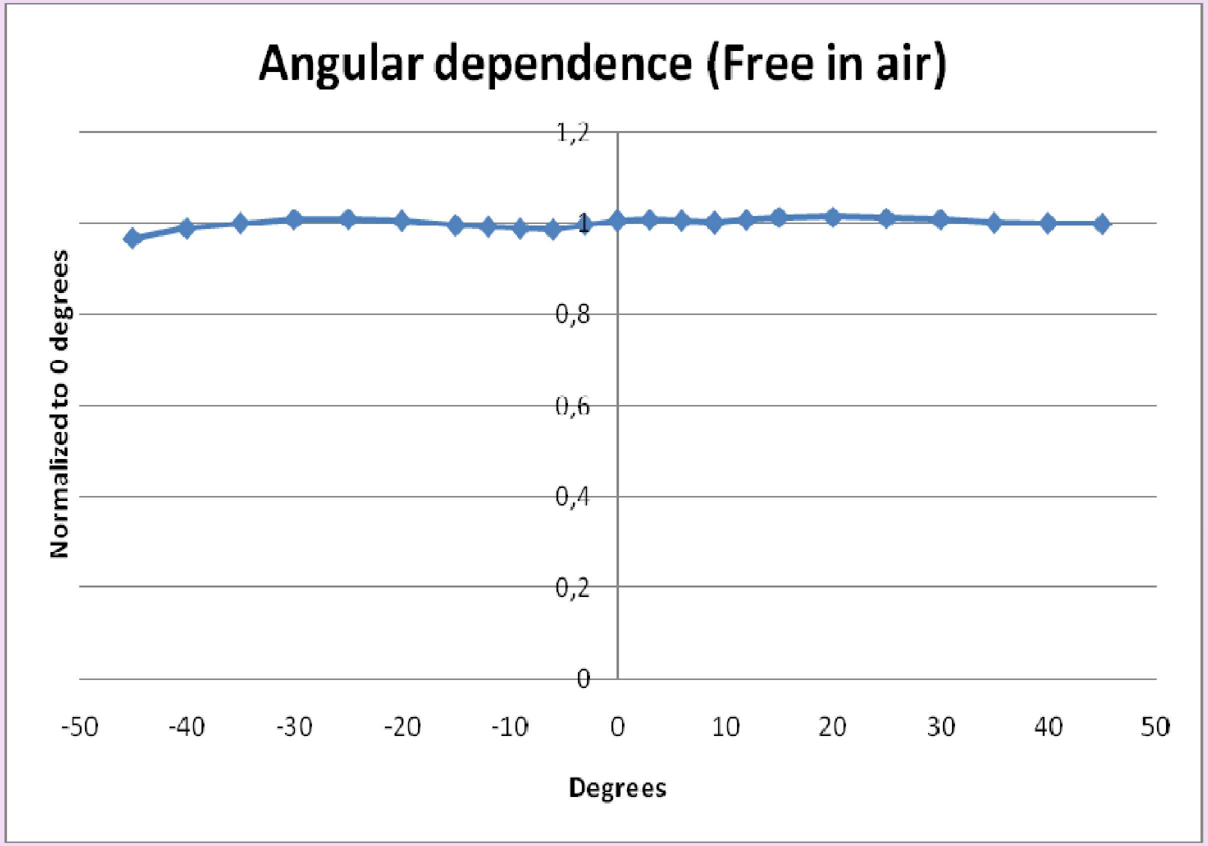

10cm

CT Dose Profiler

Angular Independence

The near-symmetric construction of the (very small) diode and connector delivers symmetric sensitivity throughout the sensor, eliminating the possible angular dependency of the incident beam on the dose response.

CT Dose Profiler



CT Dose Profiler

Negligible Energy Dependence

Due to:

- The unique diode design and manufacturing.

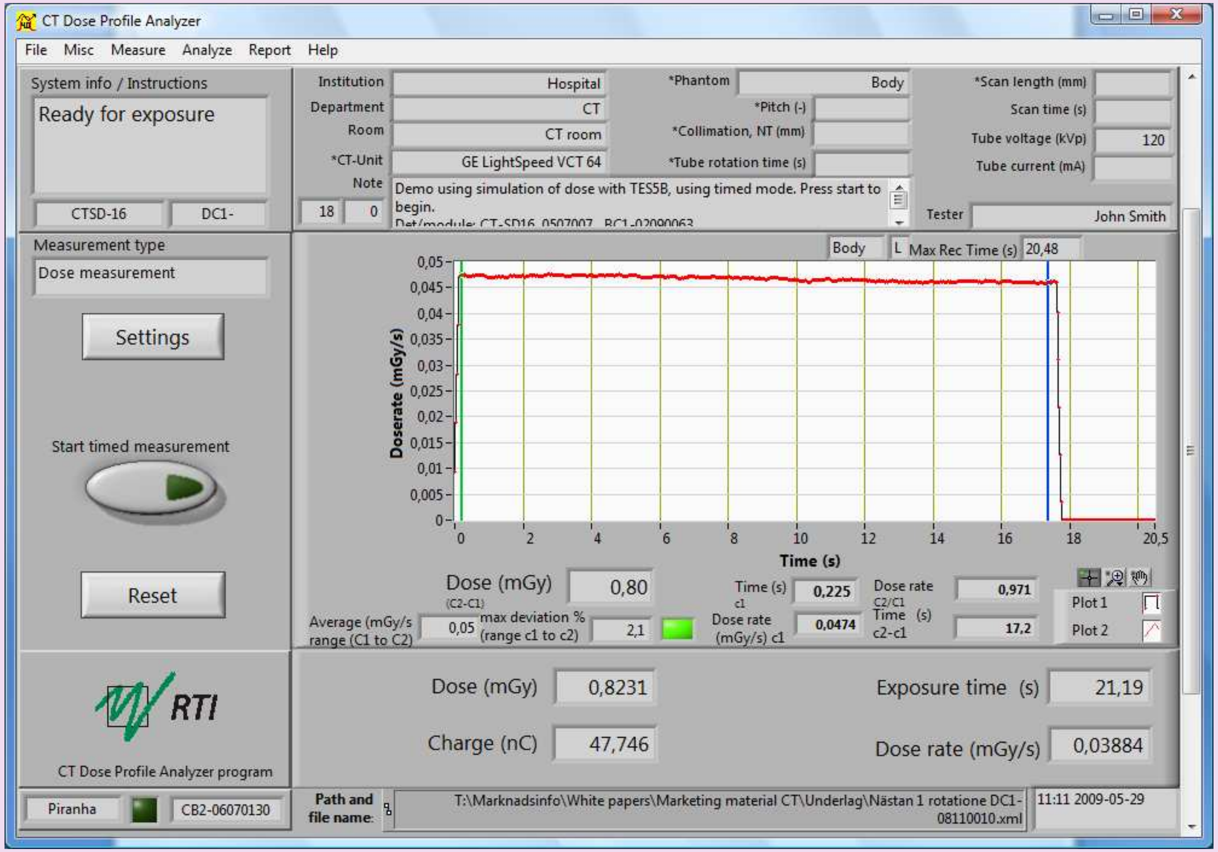
-The solid state diode, which has a flatter energy response than ion chambers at high diagnostic kVs.

- Very small detector dimensions: response is principally that of plexiglass

CT Dose Profiler

Rotational Symmetry

The diode is not circular yet the rotational symmetry is proven by comparing it to the liquid ion chamber.



To measure CTDI in Axial vs. Spiral Scans

Axial scan = One rotation with non-moving table.	Consecutive axial scans = Rotation – move table – rotation and so on.	Spiral (Helical) Scan = Rotation and table movement simultaneously

CT Dose Profiler

Calculates CDTI during spiral scan since CTDI is based on the dose profile. The dose profile is only acquired when the probe is moved through the beam.

For axial scans, point doses are measured.

Pencil Ion chamber

Can only measure CTDI in axial scans. Underestimates the total dose given to the patient.

Remember – it is always spiral scans that are used for real patient examinations!

The CT Dose Profile Analyzer

The k-factor which is specific to a CT scanner and the phantom, would be a more interesting way of looking at CTDI. The software has a wide enough database to account for the CT's available in the market.

$$k = \frac{CTDI_w}{CTDI_{100,c}}$$

<u>Typical values:</u>
Head phantom ≈ 1.0
Body phantom ≈ 1.78

A small difference between CT models (app. ±5%)

By using the k-factor, it is enough to measure once in the central hole to get CTDI, $CTDI_{100}$, $CTDI_w$, $CTDI_{vol}$ and DLP.

There are a lot of k-factors in the software's database – select a template that corresponds to your measurement setup!

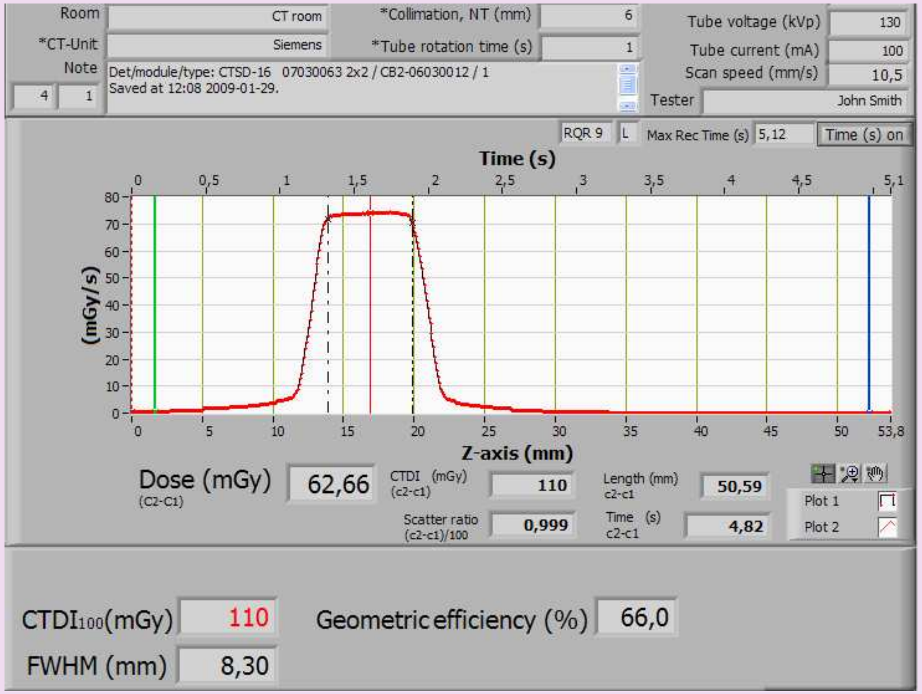
CT – Geometric Efficiency

The geometric efficiency needs to be checked according to IEC standard (60601-2-44), which can be done relatively easily in the software.

Gives the difference between collimation and the true beam width, that is, how much radiation that goes beyond the detectors.

Two vertical lines = collimation Nominal Thickness.

Because of effects like penumbra and more, a geometric efficiency above 70 % is considered to be good on a multislice CT.



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CT Dose Profiler

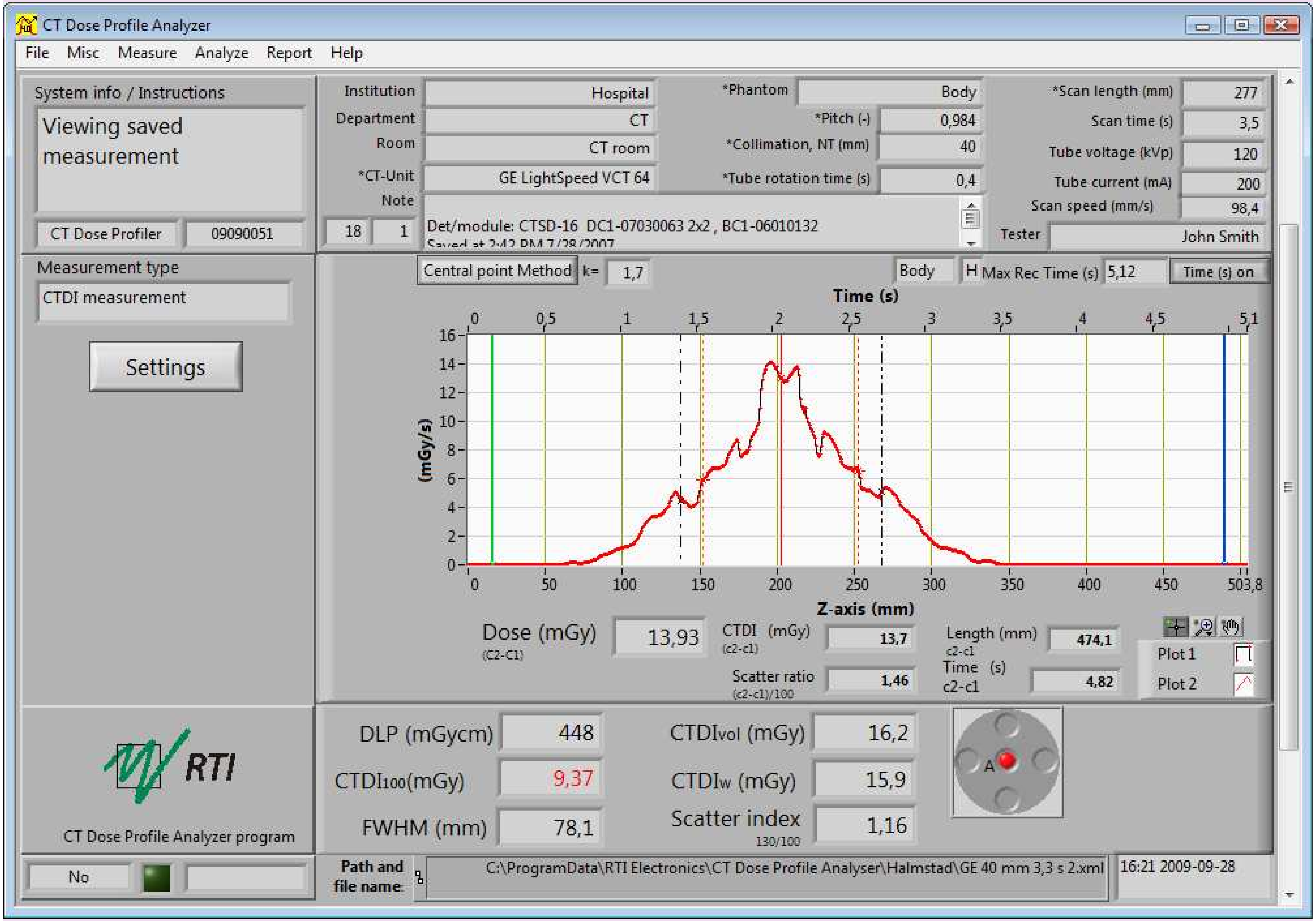
Has potential to replace the CT ion chamber and more

The CT Dose Profiler measures the same parameter ($CTDI_{100}$) and more:

- All the parameters needed at the same time
- No film needed to check the beam width.
    - Quicker and efficient measurements
    - Higher accuracy and stability
    - Better understanding of CT Scanners
    - Has diagnostic and predictive value

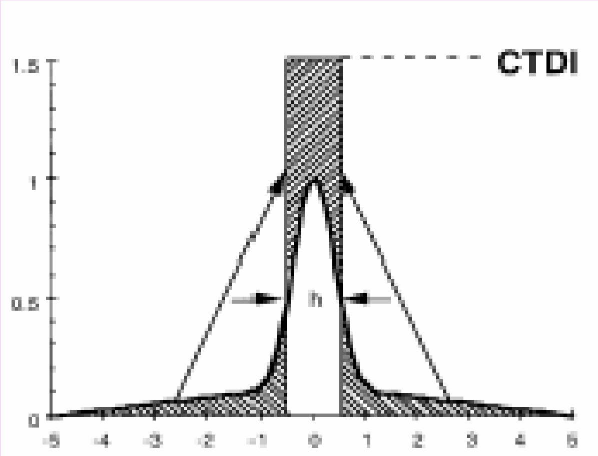
GE Lightspeed Ultra

Collimation	CT Dose Profiler	Pencil ion chamber	Value given by the CT consol
20 mm	19,6	21,43	19,14
15 mm	25,4	27,08	24,6
10 mm	25,4	27,40	25,01
5 mm	32	34,27	31,32
1.25 mm	25,9	29,02	27,07


CT Dose Profile Analyzer
File Misc Measure Analyze Report Help
System info / Instructions
Viewing saved measurement
CT Dose Profiler 09090051
Institution Hospital
Department CT
Room CT room
*CT-Unit GE LightSpeed VCT 64
Note
18 1
Det/module: CTSD-16 DC1-07030063 2x2 , BC1-06010132
*Phantom Body
*Pitch (-) 0,984
*Collimation, NT (mm) 40
*Tube rotation time (s) 0,4
*Scan length (mm) 277
Scan time (s) 3,5
Tube voltage (kVp) 120
Tube current (mA) 200
Scan speed (mm/s) 98,4
Tester John Smith
Measurement type
CTDI measurement
Settings
Central point Method k= 1,7
Body
H Max Rec Time (s) 5,12
Time (s) on
Time (s)
(mGy/s)
Z-axis (mm)
Dose (mGy) (C2-C1) 13,93
CTDI (mGy) (c2-c1) 13,7
Scatter ratio (c2-c1)/100 1,46
Length (mm) c2-c1 474,1
Time (s) c2-c1 4,82
Plot 1
Plot 2
DLP (mGycm) 448
CTDI100(mGy) 9,37
FWHM (mm) 78,1
CTDIvol (mGy) 16,2
CTDIw (mGy) 15,9
Scatter index 130/100 1,16
A
RTI
CT Dose Profile Analyzer program
No
Path and file name
C:\ProgramData\RTI Electronics\CT Dose Profile Analyser\Halmstad\GE 40 mm 3,3 s 2.xml
16:21 2009-09-28

- It’s like having instantaneous readout from a hundred TLDs

- Thank you for listening….



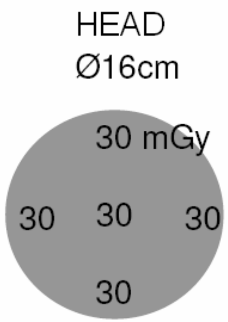
$$CTDI = \frac{1}{T}\int_{-\infty}^{\infty} D(z)dz$$

Quantity	**Symbol**	**Remarks**
CT Dose Index	CTDI	General dose description for CT
Multiple Scan Average Dose	MSAD	As CTDI but corrected for pitch
CTDI (100)	$CTDI_{100}$	Current definition of CTDI
Weighted CTDI	$CTDI_w$	Main descriptor of local dose
Volume CTDI	$CTDI_{vol}$	As $CTDI_w$ but corrected for pitch, same as $CTDI_{eff}$
Dose length product	DLP	Takes the irradiated volume into account

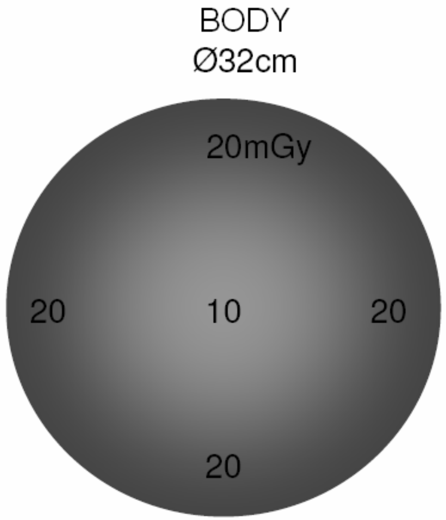
Used Equations

Some basic equations that are used in the program:

$$CTDI_w = \frac{1}{3} CTDI_{100cen} + \frac{2}{3} CTDI_{100per}$$



$CTDI_W \approx CTDI_{100}$



$$\frac{CTDI_{100,\,cen}}{CTDI_{100,\,per}} \approx 0{,}5$$

$$CTDI_{vol} = \frac{CTDI_W}{pitch}$$

DLP= Dose Length product (mGy*cm)

$$DLP = CTDI_{VOL}\,(mGy) \bullet \text{Scanlength}\,(cm)$$

Simplified model for calculating of CTDI100, CTDIw, CTDIvol and DLP, based on one measurement in the middle hole only using CT-SD16 Dose-profile detector. Also the FWHM and the Scatterindex CTDI130/100 can be calculated.

Effective Dose can then be estimated from DLP,Scatterindex and organ dose weighting factors.

CT – Geometric Efficiency

CTDI free in air

- No phantom - ”scatter index” not interesting anymore. Instead, the geometric efficiency needs to be checked (according to IEC standard, see manual).

Gives the difference between collimation and the true beam width, that is, how much radiation that goes beyond the detectors.

Two vertical lines = collimation NT.

Because of effects like penumbra and more, a geometric efficiency above 70 % is considered to be good on a multislice CT.