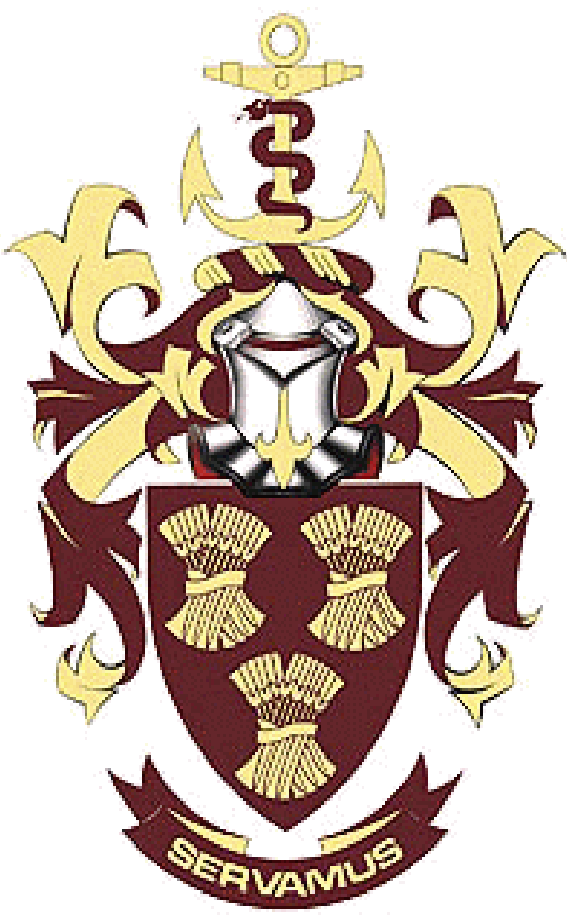




Dose Reduction and Image Preservation After the Introduction of a 0.1 mm Cu Filter into the LODOX Statscan Unit above 110 kVp

C Trauernicht¹, C Rall¹, T Perks², G Maree¹, E Hering¹, S Steiner³



- 1: *Division of Medical Physics, Groote Schuur Hospital LC-32, Private Bag Observatory, 7935, Cape Town, South Africa*
2: *University of Cape Town*
3: *LODOX Systems S.A.*

E-mail: christoph.trauernicht@uct.ac.za Fax: +27 21 404 6269

Introduction:

The LODOX Statscan unit is a low-dose, whole-body digital X-ray machine. The device was originally developed locally as a very-low-dose unit for the detection of smuggled diamonds. The prototype was thoroughly redesigned and tested as a trauma-specific unit suitable for medical use. The machine makes use of a rotating anode X-ray tube (1 mm of aluminium equivalent inherent filtration and 1 mm added aluminium filtration) mounted on one end of a C-arm. This emits a low-dose fan-beam of X-rays, which can be collimated to either 0.4 mm or 1.0 mm width. Fixed to the other end of the C-arm is the X-ray detector unit, which consists of scintillator arrays optically linked to charge-coupled devices (CCDs). The fundamental pixel size of the detectors is 60 µm, with a maximum image size of 12283 x 8000 pixels. Variations of spatial resolution from 1.0 to 5.0 line pairs per millimetre are possible. The C-arm is able to rotate axially around the patient up to 100°. The C-arm travels along the table length at speeds of up to 140 mm/s when emitting radiation, resulting in a full-body scan lasting 13 s, with smaller areas requiring proportionally less time.

The imaging technique factors have been selected by LODOX systems with the intention of optimizing image quality and dose. Preliminary calculations suggested a further dose reduction could be achieved by introducing a 0.1 mm Cu filter into the beam for energies above 110 kVp while maintaining image quality.

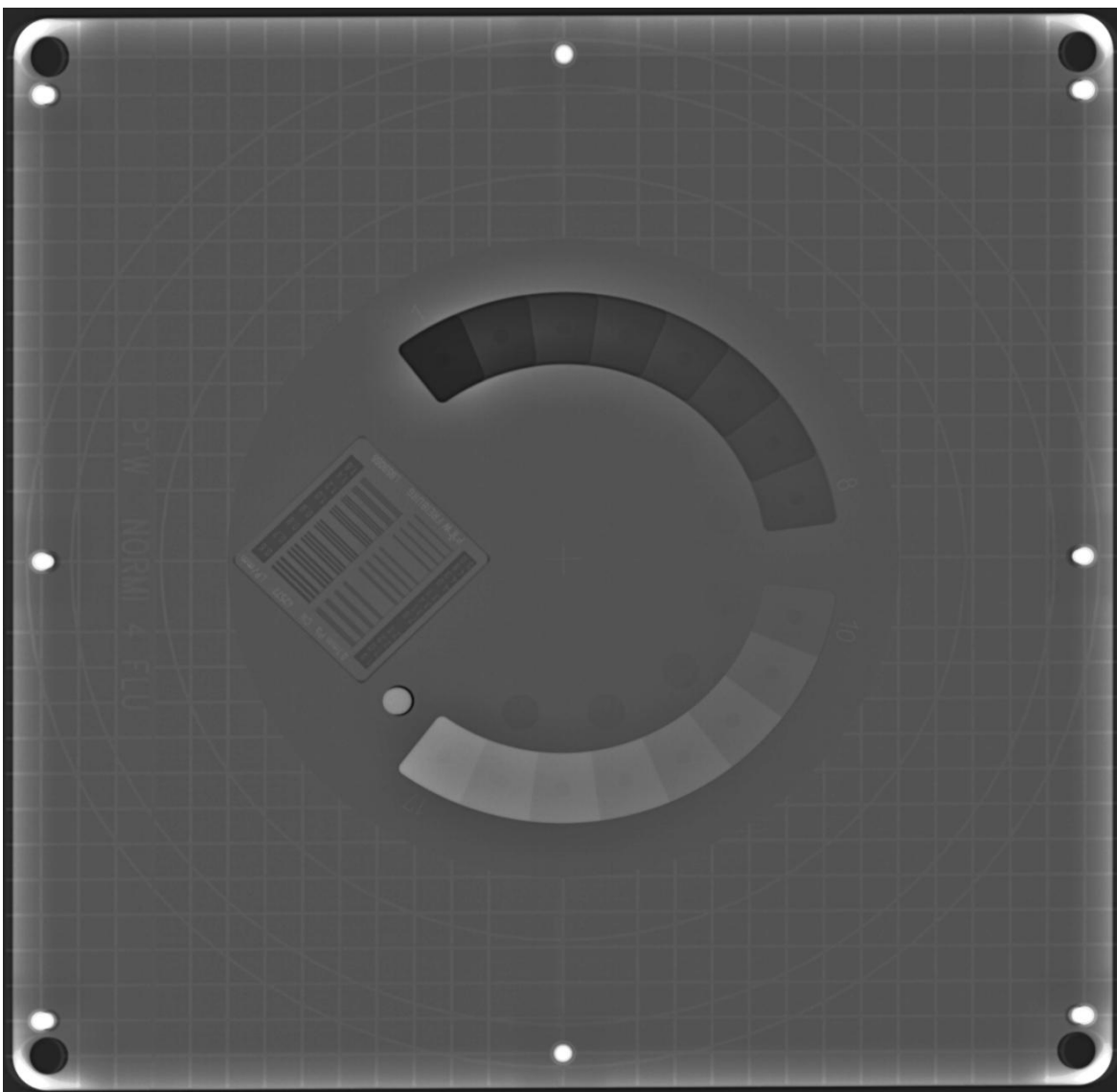
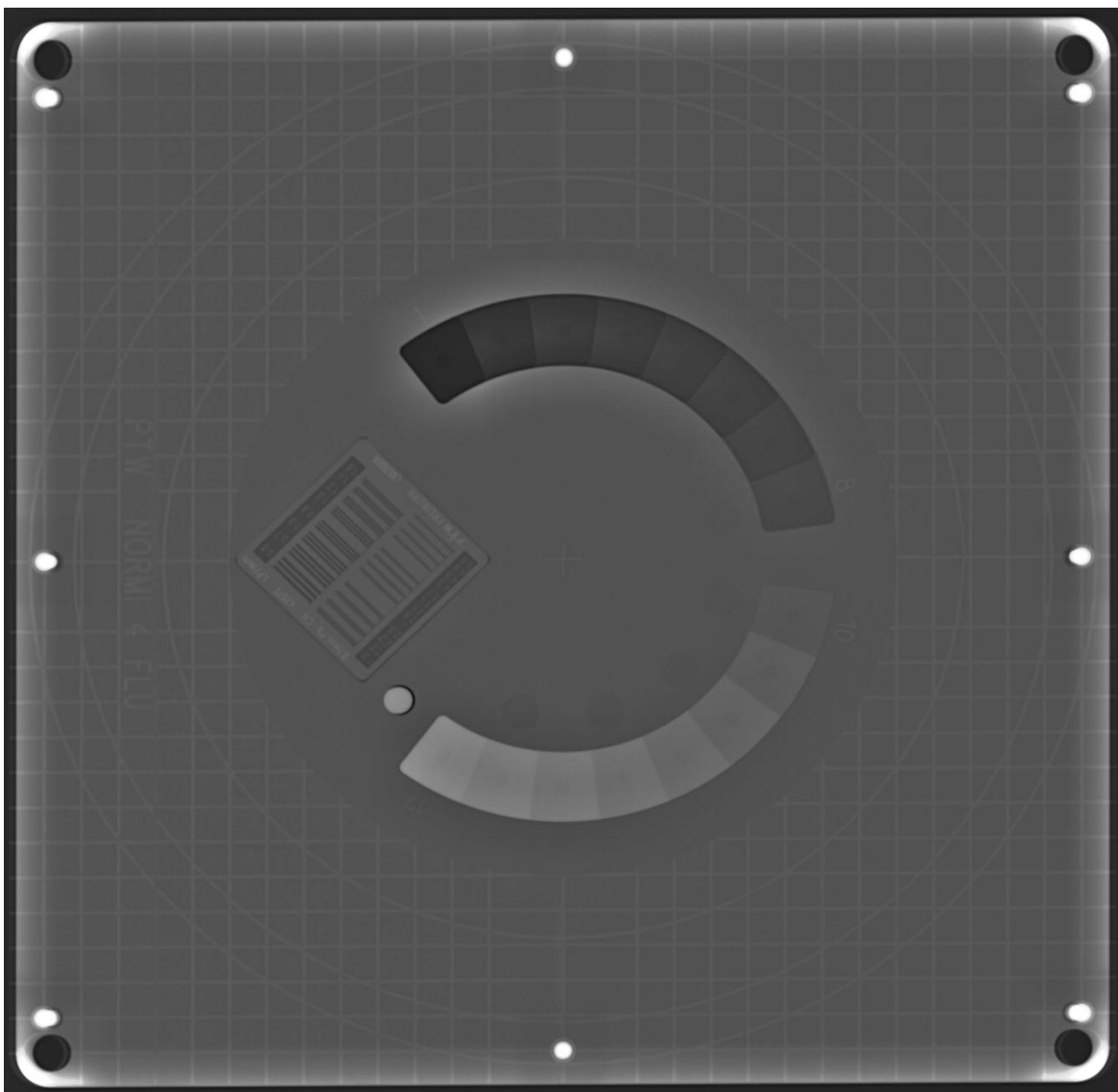
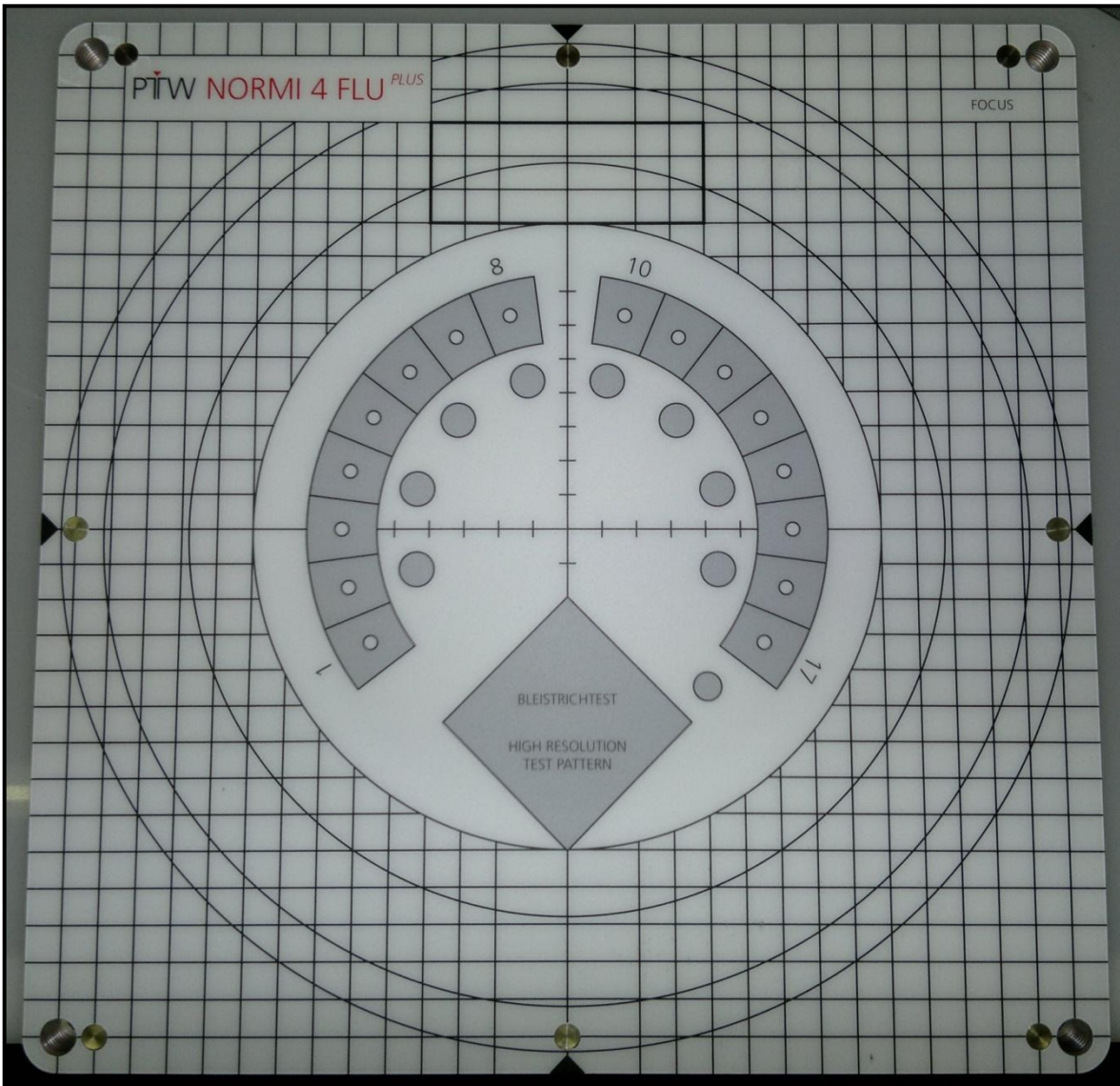
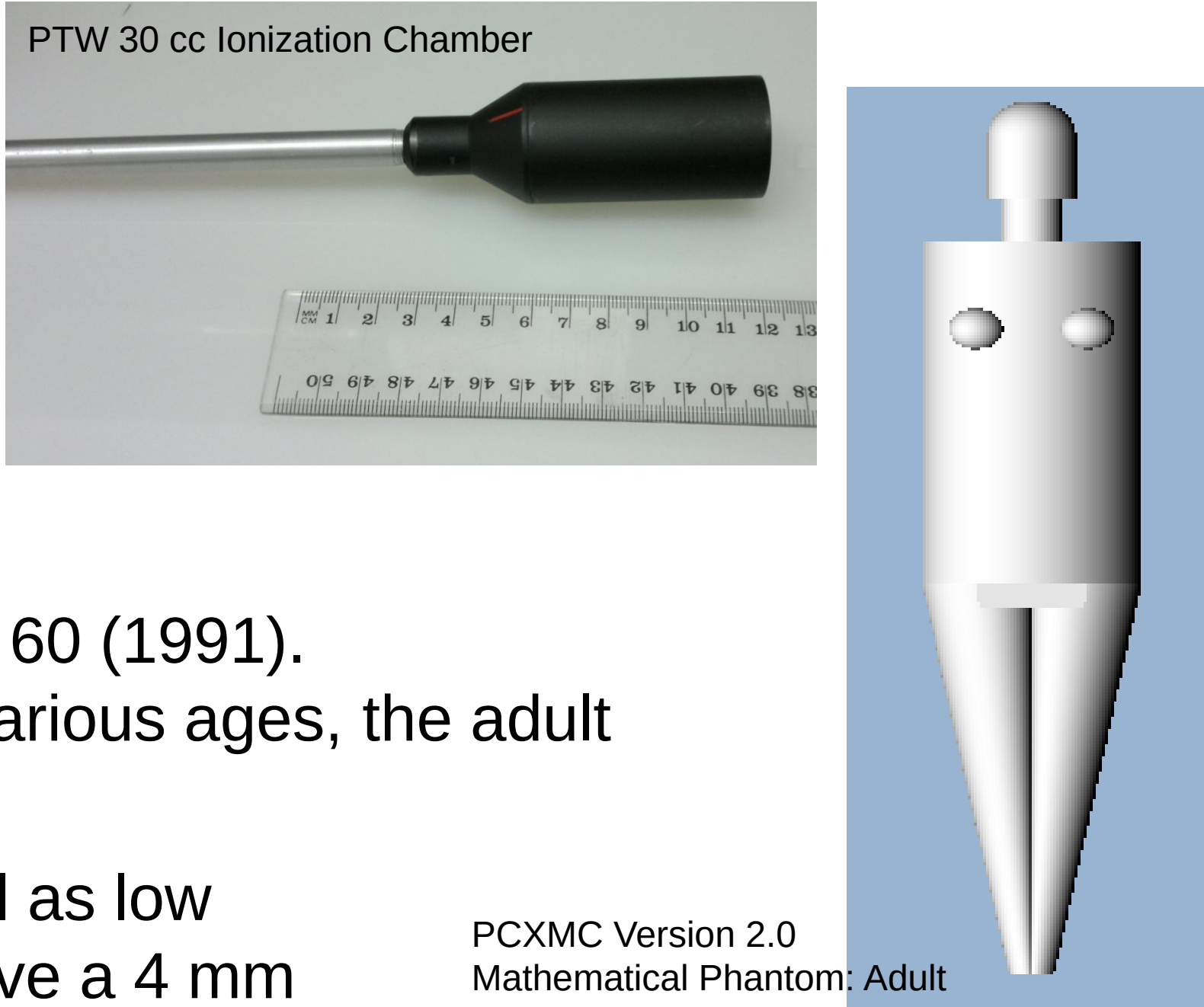


Materials and Method:

Entrance dose “free-in-air” was measured using a PTW-UNIDOS dosimeter and a PTW 30 cc cylindrical ionization chamber (type 23361) for a range of examinations and views. Measured doses were corrected for ambient temperature and pressure, as well as kV sensitivity of the ionization chamber and focus-to-skin distance.

The effective doses were obtained from the entrance doses using the PCXMC (Version 2.0) Monte Carlo code. PCXMC is a computer program for calculating patients' organ doses and effective doses in medical x-ray examinations. The doses are calculated in 29 organs and tissues and the program calculates the effective dose with both the present tissue weighting factors of ICRP Publication 103 (2007) and the old tissue weighting factors of ICRP Publication 60 (1991). The phantoms used in PCXMC version 2.0 are computational hermaphrodite phantoms representing human beings of various ages, the adult phantom is shown on the right.

The image quality was assessed using the PTW NORMI 4 FLU ^{PLUS} phantom, which has a resolution test pattern as well as low contrast and detail inserts. 16 contrast detail elements are within the steps of the copper wedge (labelled 1 – 17) and have a 4 mm diameter, while the eight larger contrast detail elements have a diameter of 10 mm each. Images were assessed in terms of how many steps of the copper wedge were visible on the images with and without the addition copper filter in the beam, how many of the contrast detail elements within the steps of the wedge were visible and how many of the 10 mm circular objects were visible. The spatial resolution was read off the test pattern of the phantom.



PTW NORMI 4 FLU ^{PLUS} Phantom

Image at 120 kVp, 160 mA (Large Full Body AP) without additional filter

Image at 120 kVp, 160 mA (Large Full Body AP) with additional filter

Results:

The following table gives the results of a number of different examinations. A large patient was taken to be 188 cm tall and weighing 100 kg, while an extra-large patient was taken to be 200 cm tall and weighing 130 kg. The reference point (z) refers to the position of the center of the X-ray beam on the patient. This information is used in the effective dose calculation of PCXMC. The three contrast columns refer to: 1) Amount of copper steps visible 2) Number of 10 mm diameter contrast-detail inserts visible 3) Number of 4 mm diameter contrast-detail inserts visible on the images of the PTW NORMI 4 FLU ^{PLUS} phantom.

Procedure Name and Patient Size	Tube Voltage [kV]	Slit Width [mm]	Focal Spot	Tube Current [mA]	Scan Speed [mm/s]	FSD [cm]	Field Size		Reference Point – Z [cm]	Entrance Dose without 0.1 mm Cu Filter [mGy]	Entrance Dose with 0.1 mm Cu Filter [mGy]	Effective Dose without 0.1 mm Cu Filter [mSv] ICRP 103	Effective Dose with 0.1 mm Cu Filter [mSv] ICRP 103	Percentage Dose Reduction [%]	Image Quality without 0.1 mm Cu Filter				Image Quality with 0.1 mm Cu Filter			
							Beam Width [cm]	Beam Height [cm]							Line Pairs	Contrast			Line Pairs	Contrast		
Chest (lung) AP - XL	140	0.4	S	160	70	99.3	39.5	38.5	60.50	0.315	0.200	0.114	0.084	26.7	2.2	17	5	15	2.2	17	5	15
Full Body (Abdomen) AP - Large	120	0.4	S	160	140	98.0	41.5	188.0	7.03	0.131	0.078	0.106	0.077	27.5	2.0	17	5	16	2.0	17	5	16
Full Body (Abdomen) AP - XL	145	0.4	L	200	140	98.0	45.5	200.0	7.48	0.222	0.147	0.190	0.147	22.7	1.6	17	4	15	1.6	17	4	15
Abdomen AP - XL	120	1.0	L	200	70	98.0	42.0	42.5	19.80	0.891	0.548	0.228	0.176	23.2	2.2	14	5	11	2.2	14	5	11
Pelvis AP – XL	120	1.0	L	200	70	98.0	45.0	32.5	13.80	0.913	0.544	0.159	0.118	25.7	2.2	14	5	11	2.2	14	4	11
Skull AP – XL	120	0.4	S	200	70	93.5	19.6	22.2	96.00	0.329	0.190	0.008	0.006	29.0	2.8	17	5	16	2.8	17	5	16
Chest (lung) Lat – Large	130	0.4	S	160	70	72.4	21.0	32.5	58.00	0.381	0.234	0.042	0.031	26.0	1.2	17	6	15	1.2	17	6	15
Chest (lung) Lat – XL	140	1.0	L	125	70	72.4	23.0	34.5	62.00	0.969	0.627	0.101	0.078	23.2	1.0	13	6	11	1.0	13	6	11
Pelvis / Hip Lat - Large	120	1.0	L	200	70	72.4	19.0	29.0	13.20	1.243	0.744	0.055	0.043	22.5	1.2	13	6	11	1.2	12	6	10
Pelvis / Hip Lat - XL	130	1.0	L	200	70	72.4	20.0	30.0	14.00	1.399	0.876	0.055	0.044	20.6	1.0	11	7	9	1.2	11	7	9

Conclusion:

Image quality is maintained in all images with the insertion of the 0.1 mm Cu filter above 110 kVp, while the effective dose is reduced between 20.6 % and 30.1 %. The filter is now standard on all LODOX Statscan units.