Project: Digital Calibration Certificates

Duncan Butler and Sabeena Beveridge
ARPANSA

- What the laboratory does
- How we create calibration reports now
- How we would like to create calibration reports
- The project components

Primary Standard Dosimetry Laboratory (the Lab)

We **calibrate** instruments (chambers) which detect X-rays

Calibrate means:

- Compare against a standard instrument
- Report the result
- Calibration coefficient

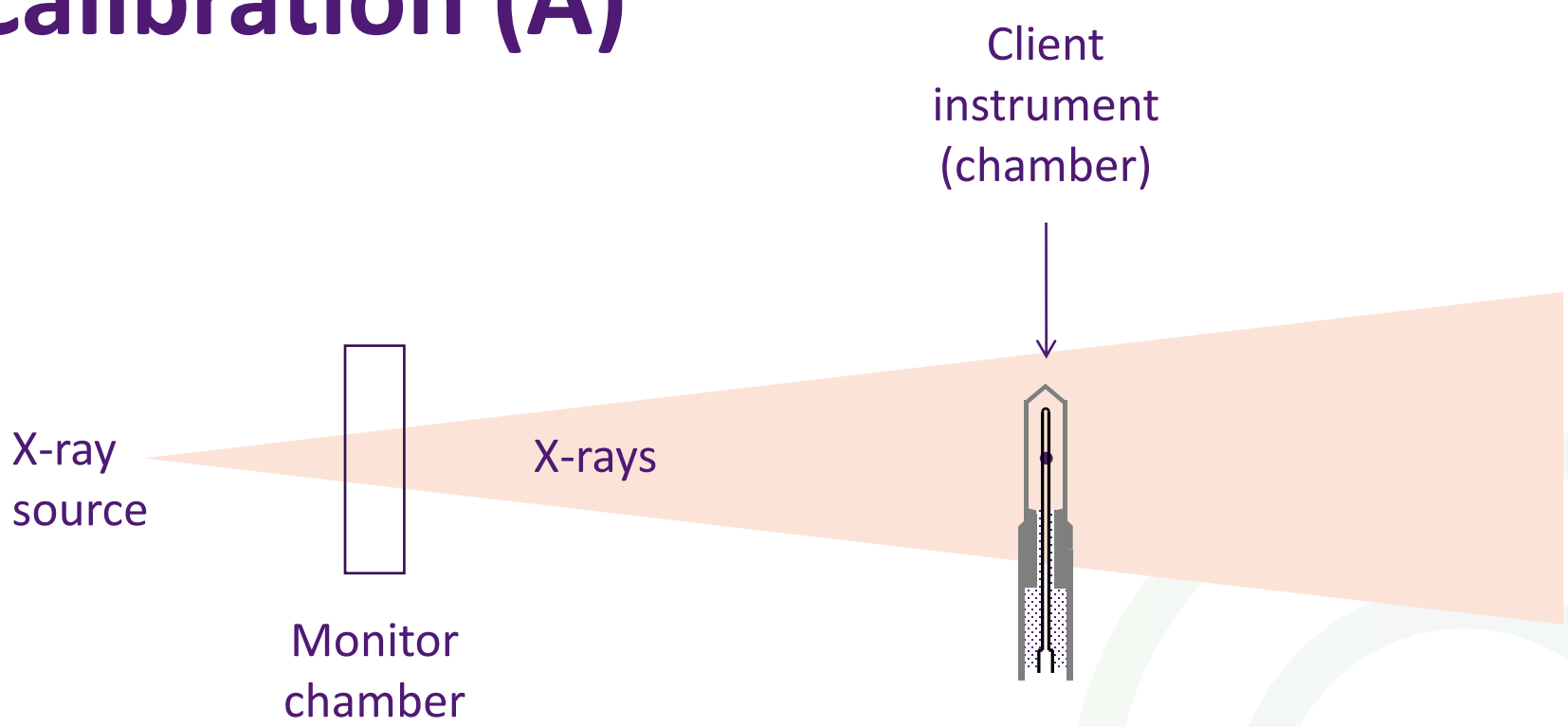
  N = (TRUE VALUE) / (CHAMBER READING)

  Units = Gy / C (Gray per Coulomb)

Chambers

Calibration (A)

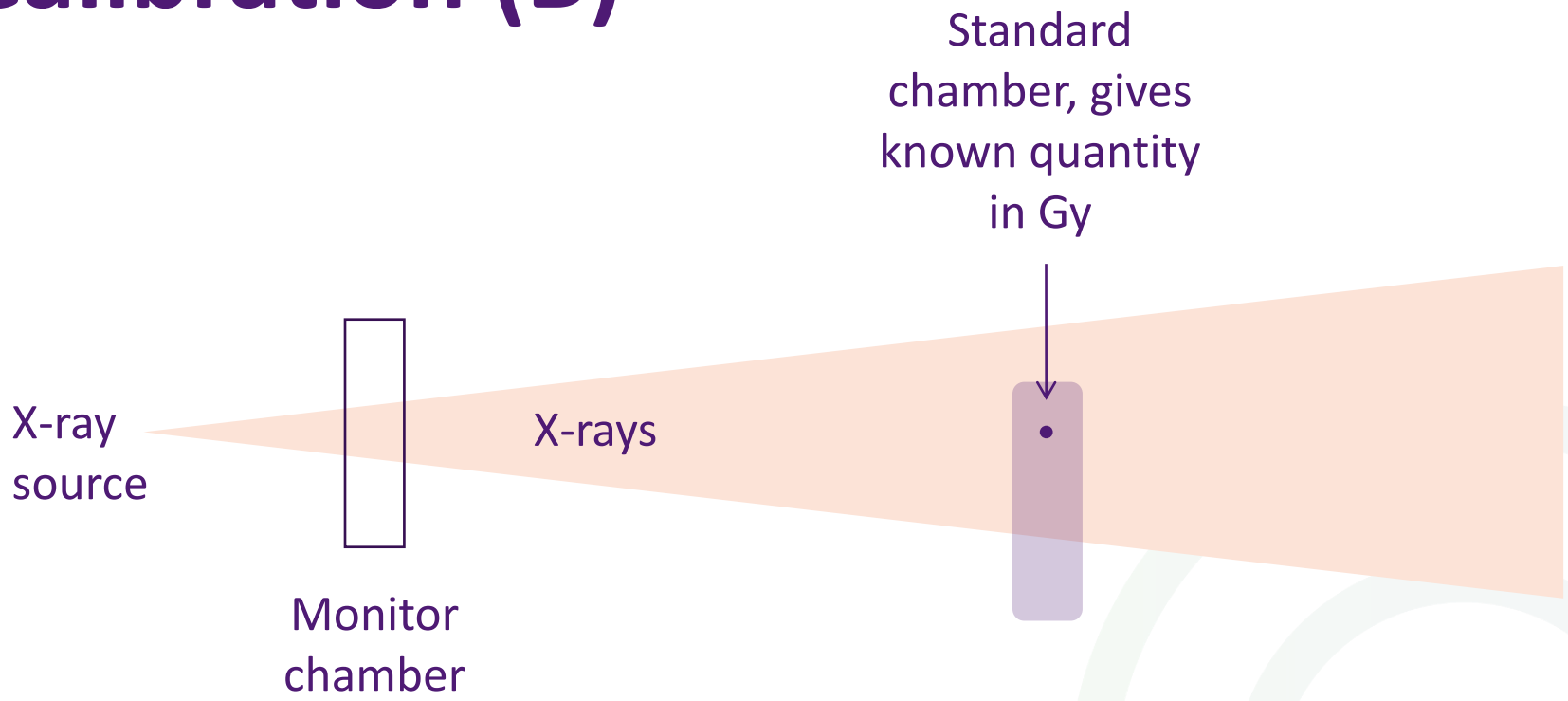
MEX =
Medium
Energy X-rays



Measurement result =
Electrical current from **client chamber**
Electrical current from **monitor chamber**

Raw MEX measurement data 1Client.csv

Calibration (B)



Measurement result =
Electrical current from **standard chamber**
Electrical current from **monitor chamber**

Raw MEX measurement data 1Lab.csv

Data

1 set of measurements = 2 files

Raw MEX measurement data 1Lab.csv

Raw MEX measurement data 1Client.csv

Excel analysis

Gives one set of results.

Entire measurement is repeated at least once, so have 1…5 sets of measurements.

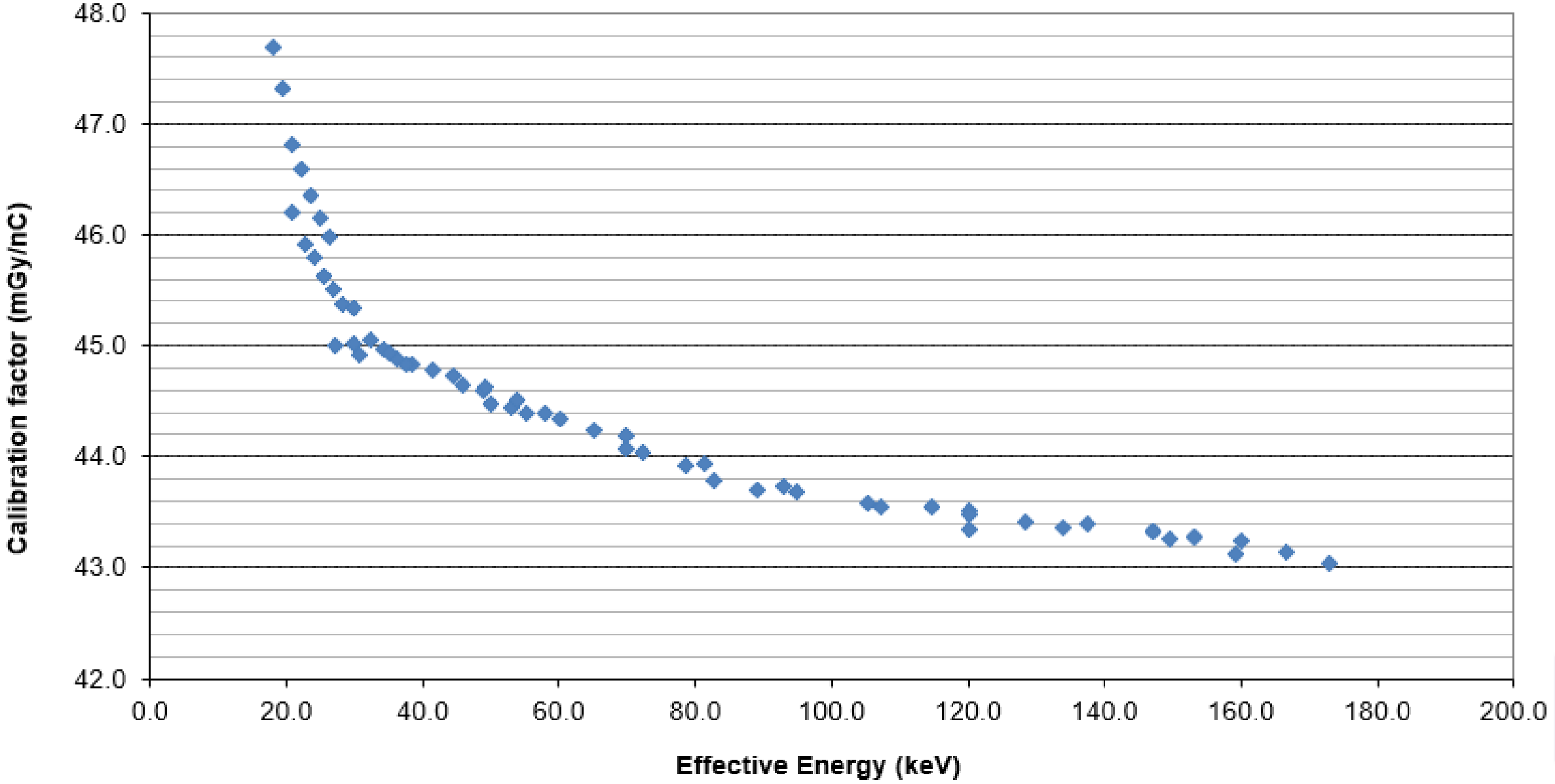
Excel – average and report

Raw MEX measurement data 1Client.csv

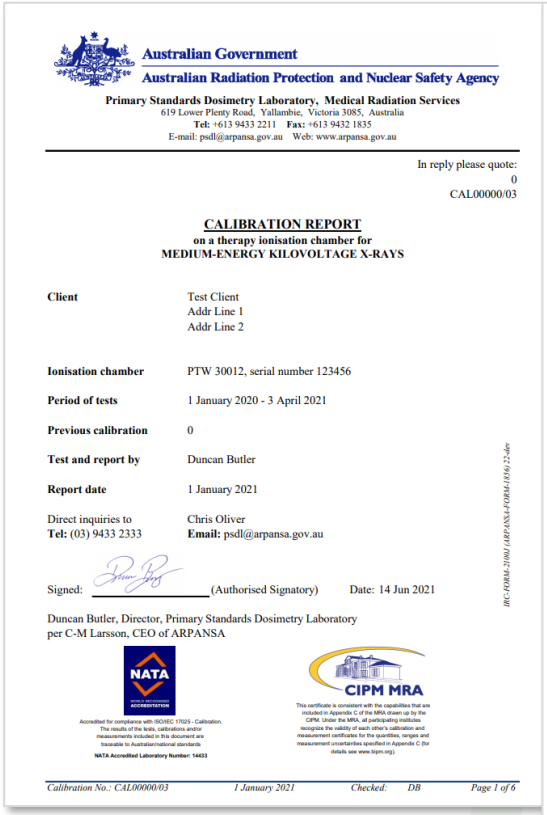
	A	B	C	D	E	F	G	H	I	J	K	L	M	N	O	P
1	[COMET X-RAY MEASUREMENT]									This is the machine we are doing the measurements on...we are asking y						
2	Filename		C:\CRData\2Jul2021-11-07_IBAFC65-Gsn1612.csv							This is just the location of where this .csv file lives						
3	Date		########							date of measurement						
4	Chamber		IBA FC65-G 1612							chamber id						
5	Description		Standard ratio measurement							text field						
6	Software		S:\Medical_Rad\Radiotherapy\Ionizing Radiation\IRS Inhouse Software\Twin Weblines LEX and MEX\Twin Webline Comet v8_1_PRODUCTION.vi													
7	Backgrounds		90							These change - changes the length of the file and records						
8	Measurements		30							There are the number of readings taken during the session - so we take E						
9	Trolley (mm)		1090							just a record						For the me
10	SCD (mm)		1000							just a record						
11	Aperture wheel		2 CM							Open, 1cm, 2cm...6cm These are fixed options (these are the seven optio						
12	Comment		QA chamber measurement set 1							Text field for comments						
13	Monitor electromete		Medium							Low, Med, High options						
14	Monitor HV		300							number						
15	MEFAC-IC electrome		Low							Low, Med, High options						
16	IC HV		-300							number						
17	[DATA]															
18	kV	mA	BarCode	XraysOn	HVLFilter(	Filter	FilterReac	HVLReady	N	Current1(	Current2(	P(kPa)	T(MC)	T(Air)	T(SC)	H(%)
19	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	1	-0.2	0	100.955	22.94494	23.08626	23.13623	45.06609
20	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	2	-0.35	0	100.955	22.94494	23.08626	23.13623	45.06609
21	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	3	0	0	100.955	22.94494	23.08626	23.13623	45.06609
22	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	4	0	0.001	100.955	22.94494	23.08626	23.13623	45.06609
23	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	5	0	0	100.955	22.94494	23.08626	23.13623	45.06609
24	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	6	0.1	0.001	100.955	22.94494	23.08626	23.13623	45.06609
25	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	7	-0.05	0.001	100.955	22.94494	23.08626	23.13623	45.06609
26	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	8	0	0.001	100.955	22.94494	23.08626	23.13623	45.06609
27	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	9	0.15	0.001	100.955	22.94494	23.08626	23.13623	45.06609
28	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	10	0.1	0	100.955	22.94494	23.08626	23.13623	45.06609
29	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	11	0	0.001	100.955	22.94494	23.08626	23.13623	45.06609
30	40	20	NXB	FALSE	0	NXJ40	FALSE	TRUE	12	0	0.001	100.955	22.94494	23.08626	23.13623	45.06609

Result of analysis

81	Formula (exposure): $N_X = R_S * k * k_T * k_H / [R_I * m]$; (air kerma) $N_K = N_X * 33.97$													
82										Cu	Calibration coefficient			
83	BEAM	kV	mA	Added Filter				HVL		Effective	Exposure	Exposure	Air-kerma	Air
84	No.		(during							energy	N_X	N_X	N_K	kerma
85			IC run)	mm Pb	mm Sn	mm Cu	mm Al	mm Cu	mm Al	keV	C/kg/C	R/C	Gy/C	mGy/nC
86														
87	NXJ40	40	20.0				0.50		0.57	18.0	1.405E+06	5.447E+09	4.774E+07	**47.741**
88	NXJ50	50	20.0				0.50		0.68	19.5	1.393E+06	5.398E+09	4.731E+07	**47.310**
89	NXJ60	60	20.0				0.50		0.79	20.9	1.382E+06	5.356E+09	4.694E+07	**46.937**
90	NXJ70	70	20.0				0.50		0.90	22.1	1.374E+06	5.326E+09	4.668E+07	**46.679**
91	NXJ80	80	20.0				0.50		1.02	23.5	1.368E+06	5.302E+09	4.647E+07	**46.467**
92	NXJ90	90	20.0				0.50		1.15	24.9	1.361E+06	5.277E+09	4.625E+07	**46.246**
93	NXJ100	100	19.9				0.50		1.30	26.3	1.356E+06	5.257E+09	4.607E+07	**46.074**
94	NXK40	40	20.0				1.00		0.93	20.9	1.359E+06	5.269E+09	4.618E+07	**46.180**
95	NXK50	50	20.0				1.00		1.12	22.6	1.354E+06	5.249E+09	4.600E+07	**46.004**
96	NXK60	60	20.0				1.00		1.29	24.1	1.349E+06	5.228E+09	4.582E+07	**45.817**
97	NXK70	70	20.0				1.00		1.46	25.4	1.346E+06	5.216E+09	4.572E+07	**45.717**
98	NXK80	80	20.0				1.00		1.64	26.8	1.342E+06	5.201E+09	4.559E+07	**45.586**
99	NXK90	90	20.0				1.00		1.84	28.3	1.339E+06	5.190E+09	4.549E+07	**45.487**
100	NXK100	100	20.0				1.00		2.05	29.9	1.336E+06	5.179E+09	4.539E+07	**45.389**
101	NXA40	40	20.0				4.00	0.06	1.90	27.1	1.330E+06	5.156E+09	4.519E+07	**45.192**
102	NXA50	50	20.0				4.00	0.08	2.39	29.9	1.328E+06	5.149E+09	4.513E+07	**45.129**
103	NXA60	60	20.0				4.00	0.10	2.81	32.3	1.330E+06	5.155E+09	4.518E+07	**45.183**
104	NXA70	70	20.0				4.00	0.11	3.19	34.3	1.330E+06	5.155E+09	4.518E+07	**45.178**


48.0
47.0
46.0
45.0
44.0
43.0
42.0
Calibration factor (mGy/nC)
0.0
20.0
40.0
60.0
80.0
100.0
120.0
140.0
160.0
180.0
200.0
Effective Energy (keV)

Report



Australian Government
Australian Radiation Protection and Nuclear Safety Agency

Primary Standards Dosimetry Laboratory, Medical Radiation Services
619 Lower Plenty Road, Yallambie, Victoria 3085, Australia
Tel: +613 9433 2211 Fax: +613 9432 1835
E-mail: psdl@arpansa.gov.au Web: www.arpansa.gov.au

In reply please quote:
0
CAL00000/03

CALIBRATION REPORT
on a therapy ionisation chamber for
MEDIUM-ENERGY KILOVOLTAGE X-RAYS

Client	Test Client Addr Line 1 Addr Line 2
Ionisation chamber	PTW 30012, serial number 123456
Period of tests	1 January 2020 - 3 April 2021
Previous calibration	0
Test and report by	Duncan Butler
Report date	1 January 2021
Direct inquiries to **Tel:** (03) 9433 2333	Chris Oliver **Email:** psdl@arpansa.gov.au

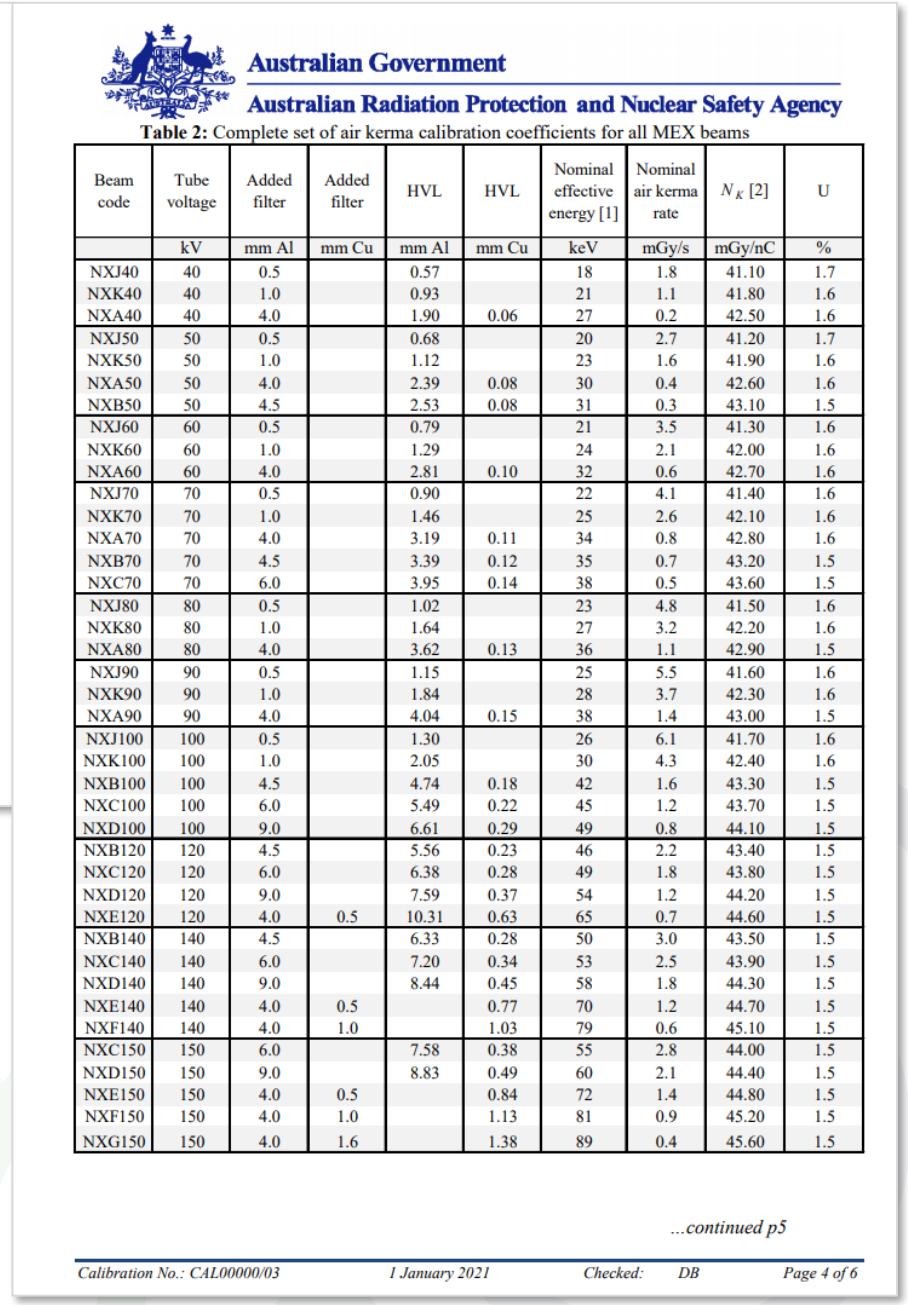
Signed: _____ (Authorised Signatory) Date: 14 Jun 2021

Duncan Butler, Director, Primary Standards Dosimetry Laboratory
per C-M Larsson, CEO of ARPANSA

IRC-FORM-2100J (ARPANSA-FORM-1836) 12-dec

NATA
Accredited for compliance with ISO/IEC 17025 - Calibration. The results of the tests, calibrations and/or measurements included in this document are traceable to Australian/national standards.
NATA Accredited Laboratory Number: 14433

CIPM MRA
This certificate is consistent with the capabilities that are included in Appendix C of the MRA drawn up by the CIPM. Under the MRA, all participating institutes recognize the validity of each other's calibration and measurement certificates for the quantities, ranges and measurement uncertainties specified in Appendix C (for details see www.bipm.org).



Australian Government
Australian Radiation Protection and Nuclear Safety Agency

Table 2: Complete set of air kerma calibration coefficients for all MEX beams

Beam code	Tube voltage	Added filter	Added filter	HVL	HVL	Nominal effective energy [1]	Nominal air kerma rate	N_K [2]	U
	kV	mm Al	mm Cu	mm Al	mm Cu	keV	mGy/s	mGy/nC	%
NXJ40	40	0.5		0.57		18	1.8	41.10	1.7
NXK40	40	1.0		0.93		21	1.1	41.80	1.6
NXA40	40	4.0		1.90	0.06	27	0.2	42.50	1.6
NXJ50	50	0.5		0.68		20	2.7	41.20	1.7
NXK50	50	1.0		1.12		23	1.6	41.90	1.6
NXA50	50	4.0		2.39	0.08	30	0.4	42.60	1.6
NXB50	50	4.5		2.53	0.08	31	0.3	43.10	1.5
NXJ60	60	0.5		0.79		21	3.5	41.30	1.6
NXK60	60	1.0		1.29		24	2.1	42.00	1.6
NXA60	60	4.0		2.81	0.10	32	0.6	42.70	1.6
NXJ70	70	0.5		0.90		22	4.1	41.40	1.6
NXK70	70	1.0		1.46		25	2.6	42.10	1.6
NXA70	70	4.0		3.19	0.11	34	0.8	42.80	1.6
NXB70	70	4.5		3.39	0.12	35	0.7	43.20	1.5
NXC70	70	6.0		3.95	0.14	38	0.5	43.60	1.5
NXJ80	80	0.5		1.02		23	4.8	41.50	1.6
NXK80	80	1.0		1.64		27	3.2	42.20	1.6
NXA80	80	4.0		3.62	0.13	36	1.1	42.90	1.5
NXJ90	90	0.5		1.15		25	5.5	41.60	1.6
NXK90	90	1.0		1.84		28	3.7	42.30	1.6
NXA90	90	4.0		4.04	0.15	38	1.4	43.00	1.5
NXJ100	100	0.5		1.30		26	6.1	41.70	1.6
NXK100	100	1.0		2.05		30	4.3	42.40	1.6
NXB100	100	4.5		4.74	0.18	42	1.6	43.30	1.5
NXC100	100	6.0		5.49	0.22	45	1.2	43.70	1.5
NXD100	100	9.0		6.61	0.29	49	0.8	44.10	1.5
NXB120	120	4.5		5.56	0.23	46	2.2	43.40	1.5
NXC120	120	6.0		6.38	0.28	49	1.8	43.80	1.5
NXD120	120	9.0		7.59	0.37	54	1.2	44.20	1.5
NXE120	120	4.0	0.5	10.31	0.63	65	0.7	44.60	1.5
NXB140	140	4.5		6.33	0.28	50	3.0	43.50	1.5
NXC140	140	6.0		7.20	0.34	53	2.5	43.90	1.5
NXD140	140	9.0		8.44	0.45	58	1.8	44.30	1.5
NXE140	140	4.0	0.5		0.77	70	1.2	44.70	1.5
NXF140	140	4.0	1.0		1.03	79	0.6	45.10	1.5
NXC150	150	6.0		7.58	0.38	55	2.8	44.00	1.5
NXD150	150	9.0		8.83	0.49	60	2.1	44.40	1.5
NXE150	150	4.0	0.5		0.84	72	1.4	44.80	1.5
NXF150	150	4.0	1.0		1.13	81	0.9	45.20	1.5
NXG150	150	4.0	1.6		1.38	89	0.4	45.60	1.5

...continued p5

Workflow (now)

Client's equipment

Setup for calibration

Setup

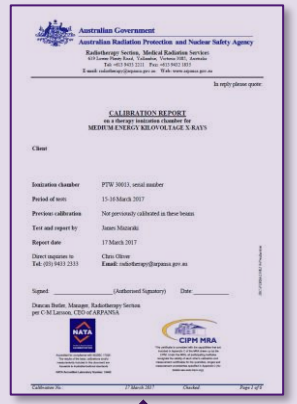
1

Measure

2

Select files

Data files



PDF

Excel

3

- Identification of equipment
- Settings
- Anything non-standard?

Project: replace Excel

Raw MEX measurement data 1Client.csv

Raw MEX measurement data 1Lab.csv

Raw MEX measurement data 2Client.csv

Raw MEX measurement data 2Lab.csv

Raw MEX measurement data 3Client.csv

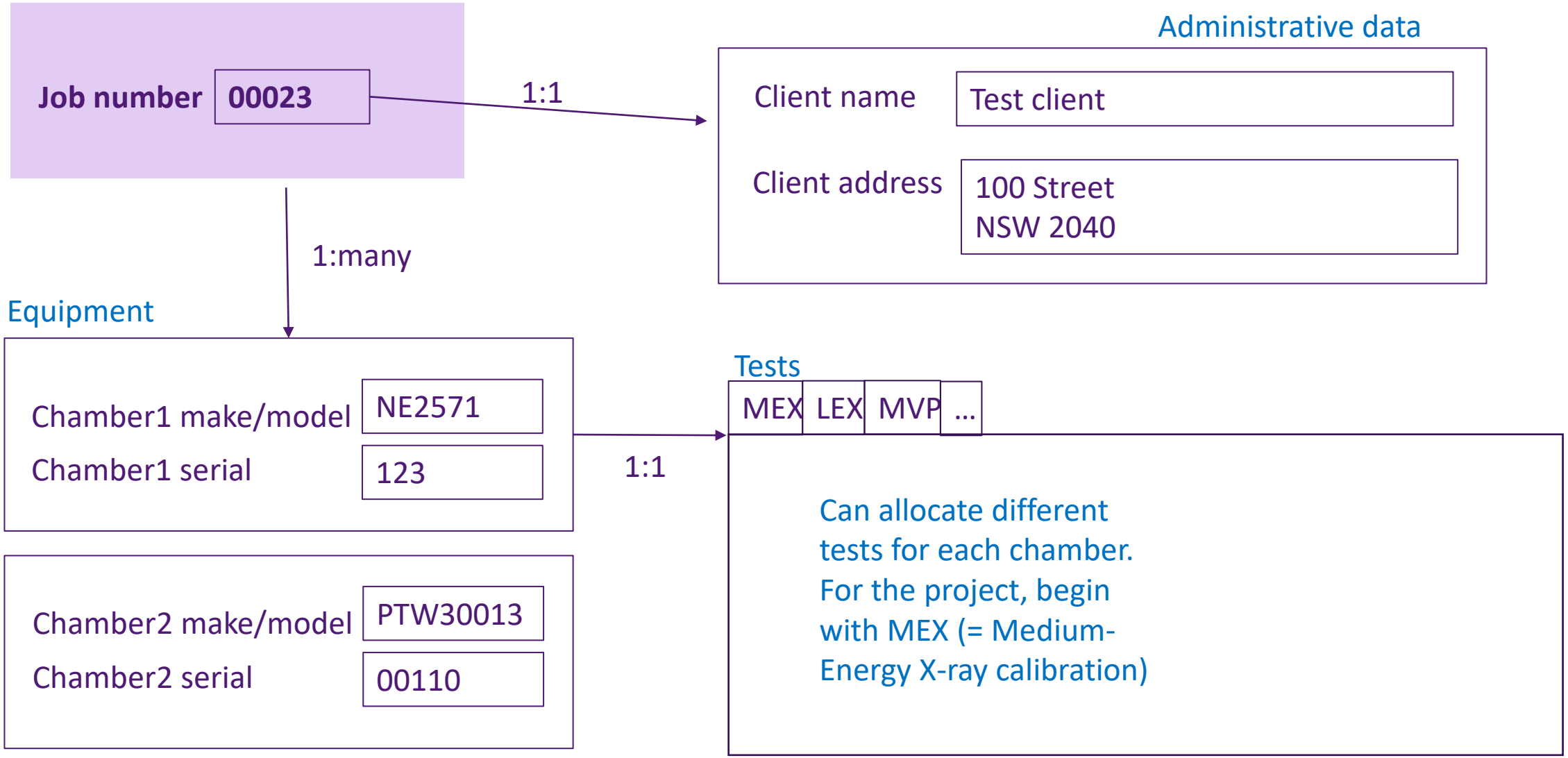
Raw MEX measurement data 3Lab.csv

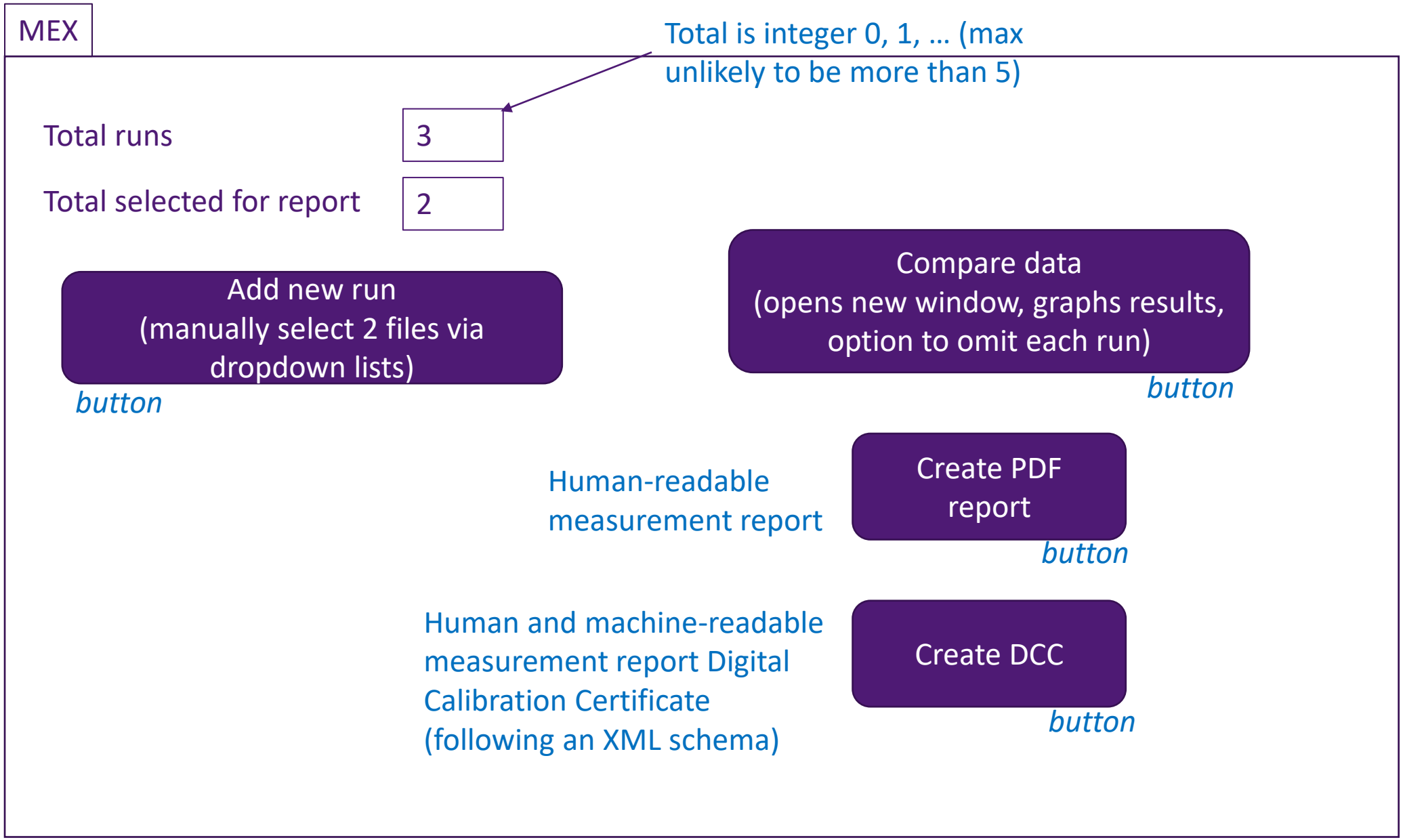
Database

GUI

Report

GUI/database suggestion



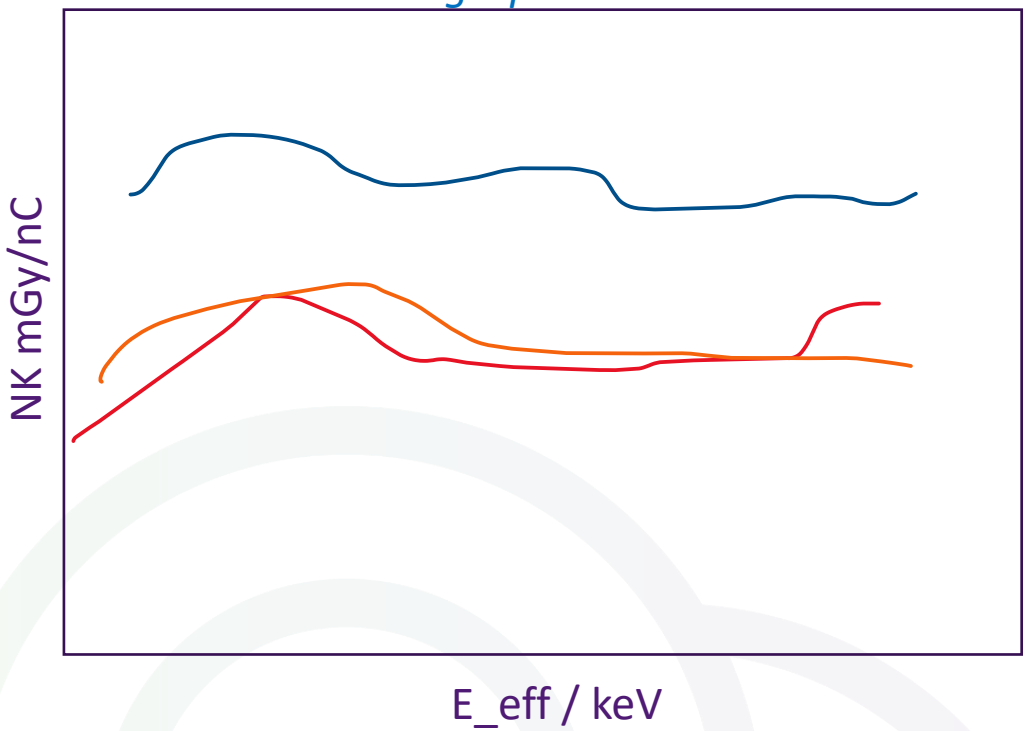

MEX
Total is integer 0, 1, … (max unlikely to be more than 5)
Total runs
3
Total selected for report
2
Add new run (manually select 2 files via dropdown lists)
button
Compare data (opens new window, graphs results, option to omit each run)
button
Human-readable measurement report
Create PDF report
button
Human and machine-readable measurement report Digital Calibration Certificate (following an XML schema)
Create DCC
button

MEX compare data

			Include
Run	1	Raw MEX measurement data 1Client.csv Raw MEX measurement data 1Client.csv	X
Run	2	Raw MEX measurement data 2Client.csv Raw MEX measurement data 2Lab.csv	X
Run	3	Raw MEX measurement data 3Client.csv Raw MEX measurement data 3Lab.csv	

chkbox

graph



Beam quality	E_eff	Run1_NK	Run2_NK	Run 3_NK	Average	Run1/Average	Run2/Average	Run3/Average
NXJ40	40.1	33.1	33.6	38.1	36.0	0.920	0.933	1.050
NXJ50	40.1	33.2	33.7	38.1	36.0	0.920	0.933	1.050
..								
..								
..								
..								
NXF320……								

Proposed calibration workflow

Administrative data, manual entry (for now)

Request sequence of measurements?

Database

Calculations to produce results

Check validity of data (QA)

Generate reports

PDF

PDF

DCC (xml)

Laboratory

Reference instrument

Human

Client instrument

PC with data acquisition software

Measurement results (text files)

PDF of measurement report

Calibration Laboratory Logo / Masthead

Laboratory details: Web site: Address

The Laboratory Name, Calibration Section
E-mail: laboratory@lab.org.au **Web:** www.laboratory.org.au

References:
REF2019/01
CAL00099

CALIBRATION REPORT
on a radiotherapy electrometer

Client The Demo Company
106 Client Street
Montmorency
Victoria 3000

Electrometer PTW UNIDOS T10002, serial number 12345

Period of tests From 9 June 2020
To 14 June 2020

Test by Max Hanlon
Report by Chris Oliver
Report date 20 June 2020

Direct inquiries to Chris Oliver
Tel: (03) 0000 0000 **Email:** laboratory@lab.org.au

Doc-ID-0000

Signed: Fred Jones (Authorised Signatory)

Fred Jones,Laboratory Technical Manager

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Calibration No.: CAL00099 *20 June 2020* *Checked: DB* *Page 1 of 4*

GENERAL COMMENTS

lectrometer
240V, 50 Hz.

no obvious damage or faults on receipt.

fect the calibration factor
nce quantities such as temperature and pressure, if present, were disabled.

cient is the number by which the charge reading on the screen must be obtain the "true" charge.

calibrated by first measuring the current from a Farmer-type ionisation eletherapy source.
chamber was then used to deliver a known charge to the electrometer, and is the ratio of the known charge to the charge shown on the electrometer.
ue calibration is traceable to Australian standards of voltage and resistance. rge combine the current with measurements of time, which are traceable to rd for time.

olifier is *floating,* which means the outer electrode of a connected ionisation potential and the guard electrode and collector are at the bias voltage.
lectrometer use different conventions for specifying the polarising voltage. rity of the collecting electrode as either "Central Electode Positive (CEP)" or egative (CEN)". Here "Central Electrode" refers to the electrode connected to triaxial connector.

ng Voltage
e was measured with the chamber attached using an 11 GΩ resistor in series er to provide a displayed voltage which is proportional to the polarizing mpedance that did not interfere with the electrometer. The electrometer was ated voltage source which was adjusted until the reading on the voltmeter eading when the electrometer was in place.

e triaxial connector was found to be at a potential of -301 V. The inner the guard electrode of the chamber. The electrometer at the time was set to display and the resulting polarity was CEP.

Calibration No.: CAL00099 *20 June 2020* *Checked: DB* *Page 2 of 4*

Leakage checks
- The electrometer leakage current was checked with and without an ionisation chamber NE 2571 er 2384 attached, using the 'Low' range and polarizing voltage setting '+300 V' on splay. The results are shown in Table 1.

eakage checks

up	Settings	Time s	Charge collected pC	Average leakage current, fA
chamber hed	Low	300	1.00	3.33
er attached	Low	300	1.00	3.33

meter was tested in accordance with ARPANSA Standard Operating Procedure -SOP-0000 Version 10.

L00099 *20 June 2020* *Checked: DB* *Page 3 of 4*

ibration Laboratory Logo / Masthead

oratory details: Web site: Address

eter Charge Calibration Certificate

e Demo Company
W UNIDOS T10002 sn 12345
ins 240V, 50 Hz
00 V' on Webline display
e Table 2
5 pA
un 2020 - 14 Jun 2020
nce level of approximately 95% (k=2)

2: Electrometer calibration factors

Timer	Units of electrometer	Calibration factor	Uncertainty
	reading	nC per *reading*	%
Internal	nC	1.001	0.3
External	nC	1.002	0.3
Internal	nC	0.999	0.3
External	nC	0.999	0.3

tinuously and a charge measurement is started manually and terminated r
collecting charge continuously and the source is turned on manually and ted timer

Calibrated by Max Hanlon

Calibration No.: CAL00099 *20 June 2020* *Checked: DB* *Page 4 of 4*

Digital Calibration Certificate (DCC)

Demo_Excel_DCC_v1.dcc - Notepad

File Edit Format View Help

```
<?xml version="1.0" encoding= "UTF-8"?>
<dcc:digitalCalibrationCertificate
xmlns:xsi = "http://www.w3.org/2001/XMLSchema-instance"
xsi:schemaLocation = "https://ptb.de/dcc https://ptb.de/dcc/v2.3.0/dcc.xsd"
xmlns:dcc = "https://ptb.de/dcc"
xmlns:si = "https://ptb.de/si"
schemaVersion="2.3.0">
<!--Schema Copyright (c) 2019 PTB -->
<!--This DCC produced using Excel VBA for demonstration purposes only. -->
<dcc:administrativeData>
<dcc:dccSoftware>
<dcc:software id="Excel VBA script">
<dcc:name>
<dcc:content>VBA script - Demo_Excel_DCC.xlsm - testing only</dcc:content>
</dcc:name>
<dcc:release>v0.0.0</dcc:release>
<dcc:description id="dcc44-1">
<dcc:content lang="en">Homepage: None
</dcc:content>
</dcc:description>
</dcc:software>
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<dcc:coreData>
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</dcc:coreData>
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Project components

1. **Create database for raw data**
2. **Calculation: analyse two raw files -> results**
3. **Develop GUI for above**
4. Create PDF from results
5. Create DCC (xml) from results