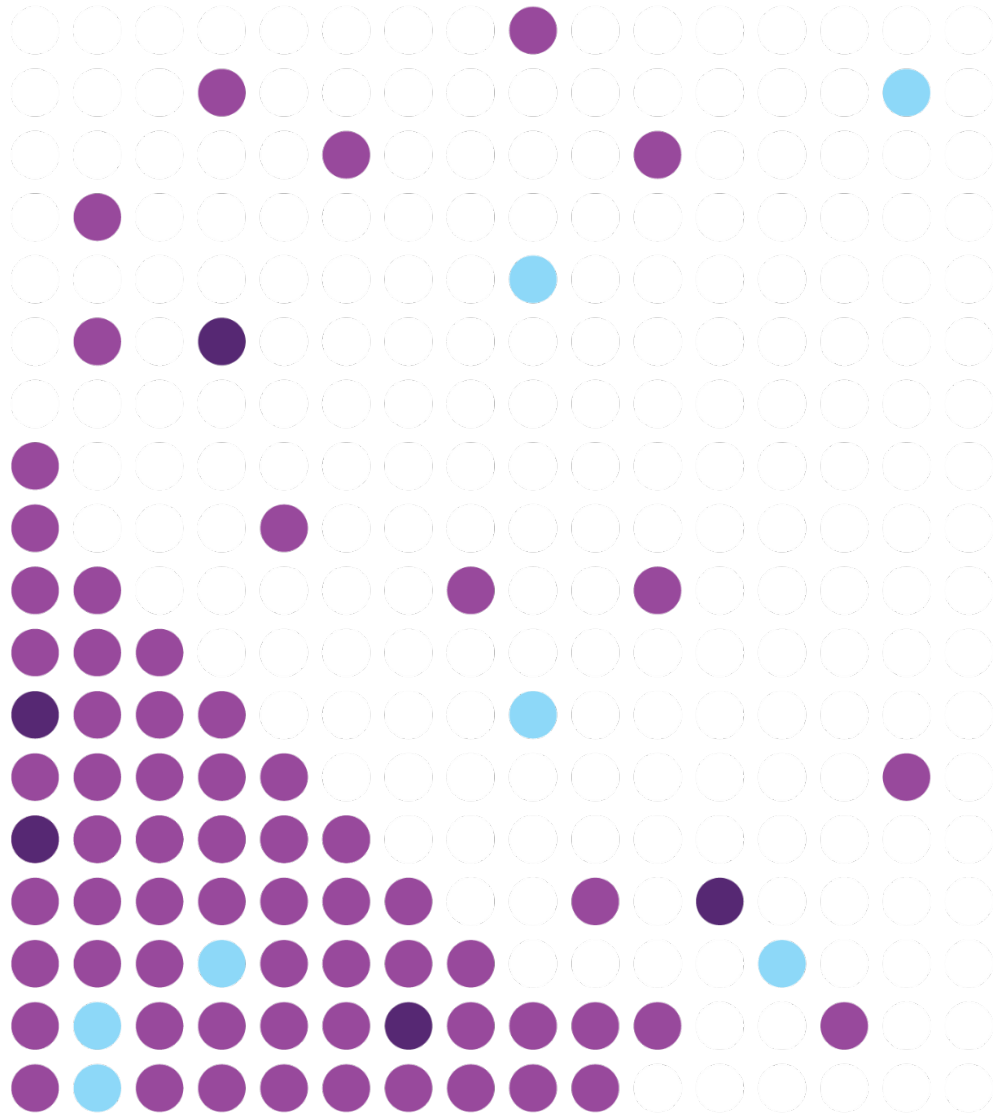


Liviu-Cristian Mihailescu 2024-01-18

cristian.mihailescu@sckcen.be

sck cen
Belgian Nuclear Research Centre

Digital transformation at the Laboratory for Nuclear Calibrations (LNK) of SCK CEN



- Introduction
- Evolution of LNK since ~1985
- Digital workflow
- Integrated Management System applied to LNK
- What can we do next?

Digitisation, digitalisation or digital transformation ?

- Digitisation is the process of converting analog data into digital format and it focuses on data conversion – end goal: “paperless” laboratory and more data easily accessible.
- Digitalisation is about improving processes with digital solutions, is the act of taking analog processes and making them digital – end goal: higher efficiency, less risk of errors.
- Digital transformation is using technology for a general organizational upgrade. Digital transformation is digitalisation-plus, a complete change of strategy – end goal: much higher efficiency, nicely integrated apps, user friendly...

Where is LNK ? Digital transformation or just digitalisation?

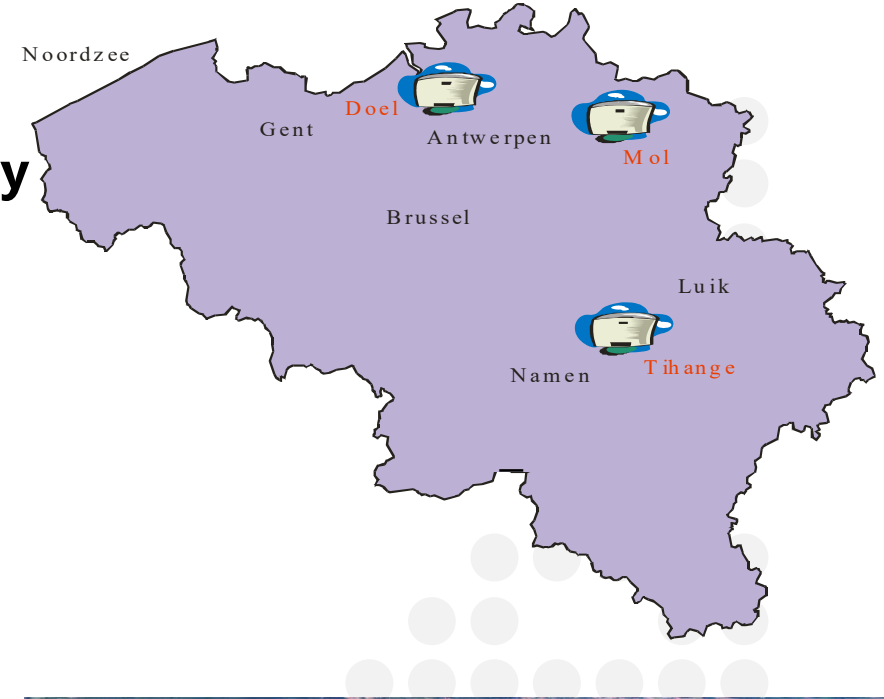
SCK CEN

SCK CEN

- Belgian Nuclear Research Centre: a **foundation of public utility** and global leader in the field of nuclear research, services and education.
- **mission & vision:** Driven by our passion for science. Boosted by our unique infrastructure. We expand our knowledge in various nuclear areas and develop innovative applications for society.
- location: Mol, B-2400, Boeretang 200, Belgium.
- created in 1952
- ~900 staff, > 1/3 with academic degree + ~ 70 PhD

LNK (Laboratory for Nuclear Calibrations)

- 3 staff members
- part of the RDC (Radiation Protection Dosimetry and Calibrations group)
- DI for metrology of ionizing radiation in Belgium



Why we need dosimetry calibrations ?

There are many places where ionizing radiation is used:

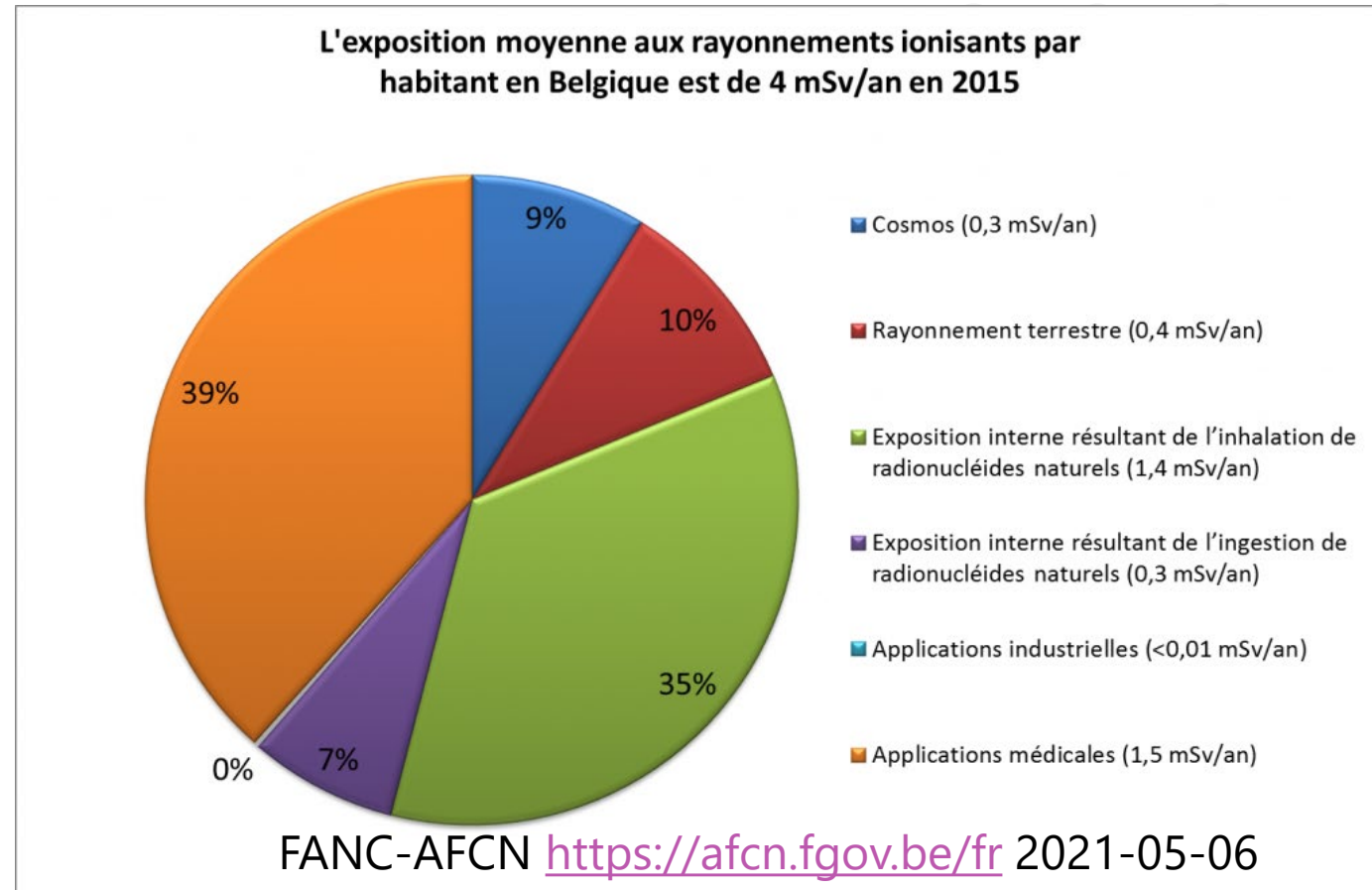
- nuclear power plants,
- research centers
- hospitals : radiotherapy, radiology (X-ray, CT, PET) and nuclear medicine,
- mines and ore industry



- Exposure of workers to radioactivity needs to be monitored with dosimeters (personal or ambient dosimeters).
- Uncertainties on delivered doses are linked to the success of the treatment in RT and NM.



Dosimeters need a traceable calibration (metrology of ionizing radiation)



Example of dosimeters

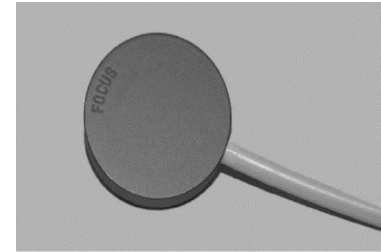
A device that measures the charge deposited by the radiation in a medium -> the reading is converted to units of dose (Joule/kg = Gy or Sv)

- ionisation chambers+ electrometers (the readers):

cylindrical Farmer type 0.6 cm³



plane-parallel Roos type 0.35 cm³



LNK primary standard for K_{air} 1.02 cm³



electrometer



- ambient dosimeters:



- personal dosimeters:



Evolution of LNK

KAL



KAL



100 km



Univ. Ghent



? < **1985** – Wooden tower ? (Mol) :

1985-2009 – KAL building (Mol) :

- 2 irradiation room (access to bunker via room of horizontal irradiator)

2009-2020 – KAL building Mol + Univ. Ghent:

- radiotherapy calibrations not on same site.
- old and manual irradiators
- no more spare parts
- no data acquisition software, no databases ...

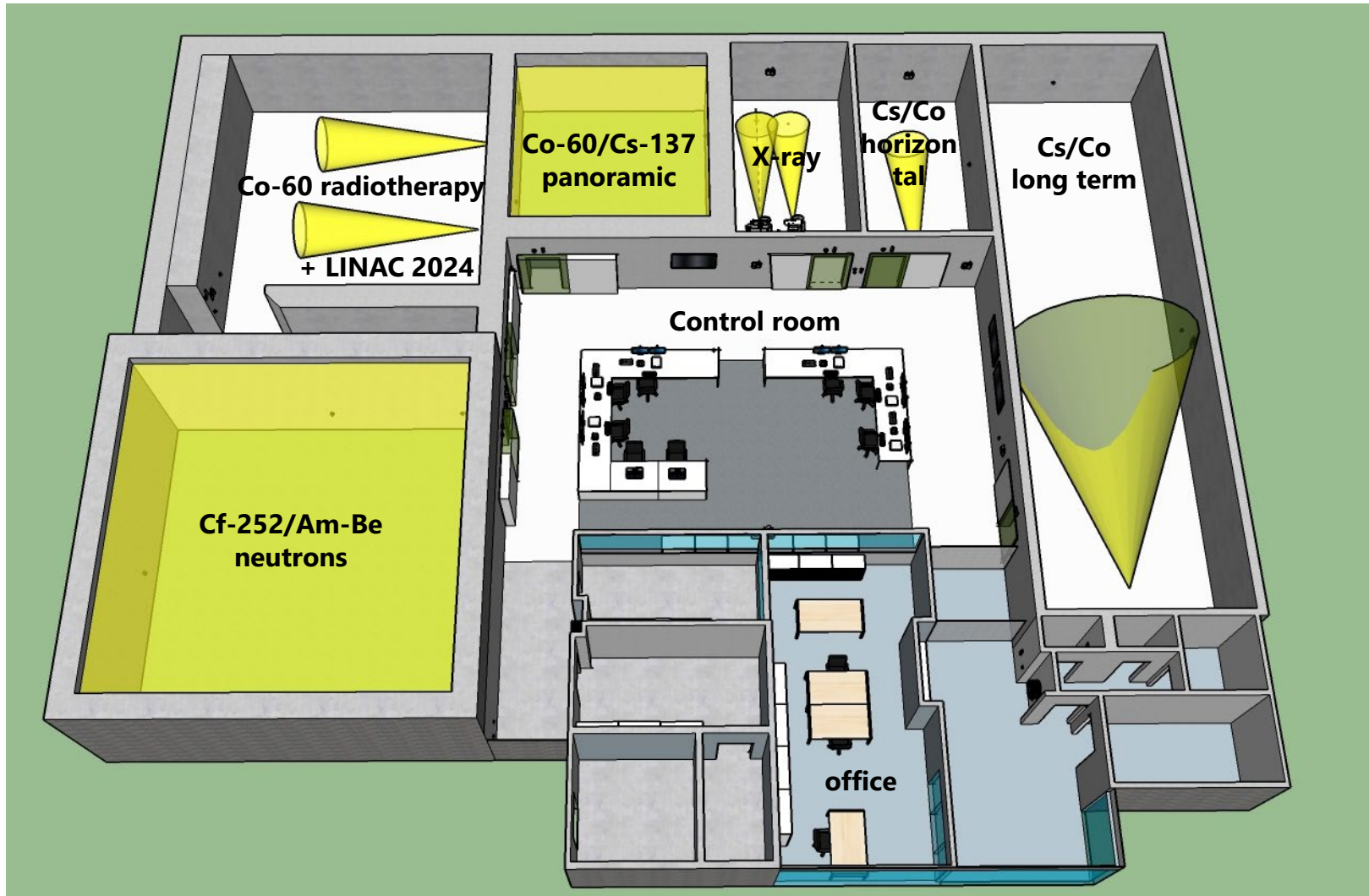
LNK



2021 -> **2055+** - new LNK (Mol):

- 6 independent irradiation rooms in one place
- modern irradiators
- latest safety and security requirements
- significant automation

New building and irradiators for LNK since 2021



Green field project Oct. 2018 – May 2020:

- 6 independent irradiation rooms with control room in the center.
- Stat-of-art safety system and modern irradiators.
- Located on main SCK CEN site from Boeretang 200, B-2400, Mol.
- All type of dosimetry calibrations in one laboratory (Cs-137/Co-60, neutrons, X-ray, Co-60 radiotherapy, α/β contamination sources).
- Secondary and primary standards used as reference.

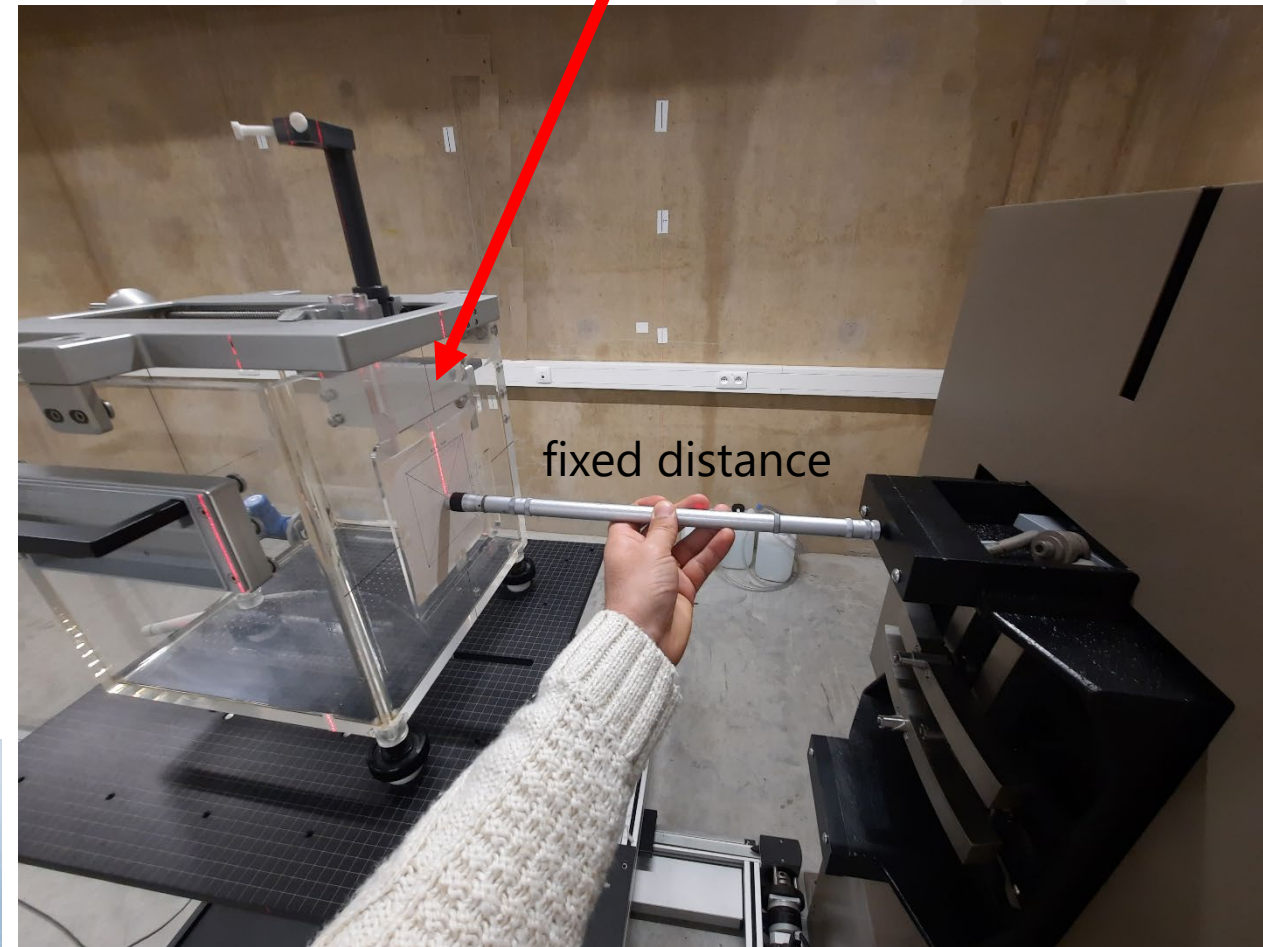
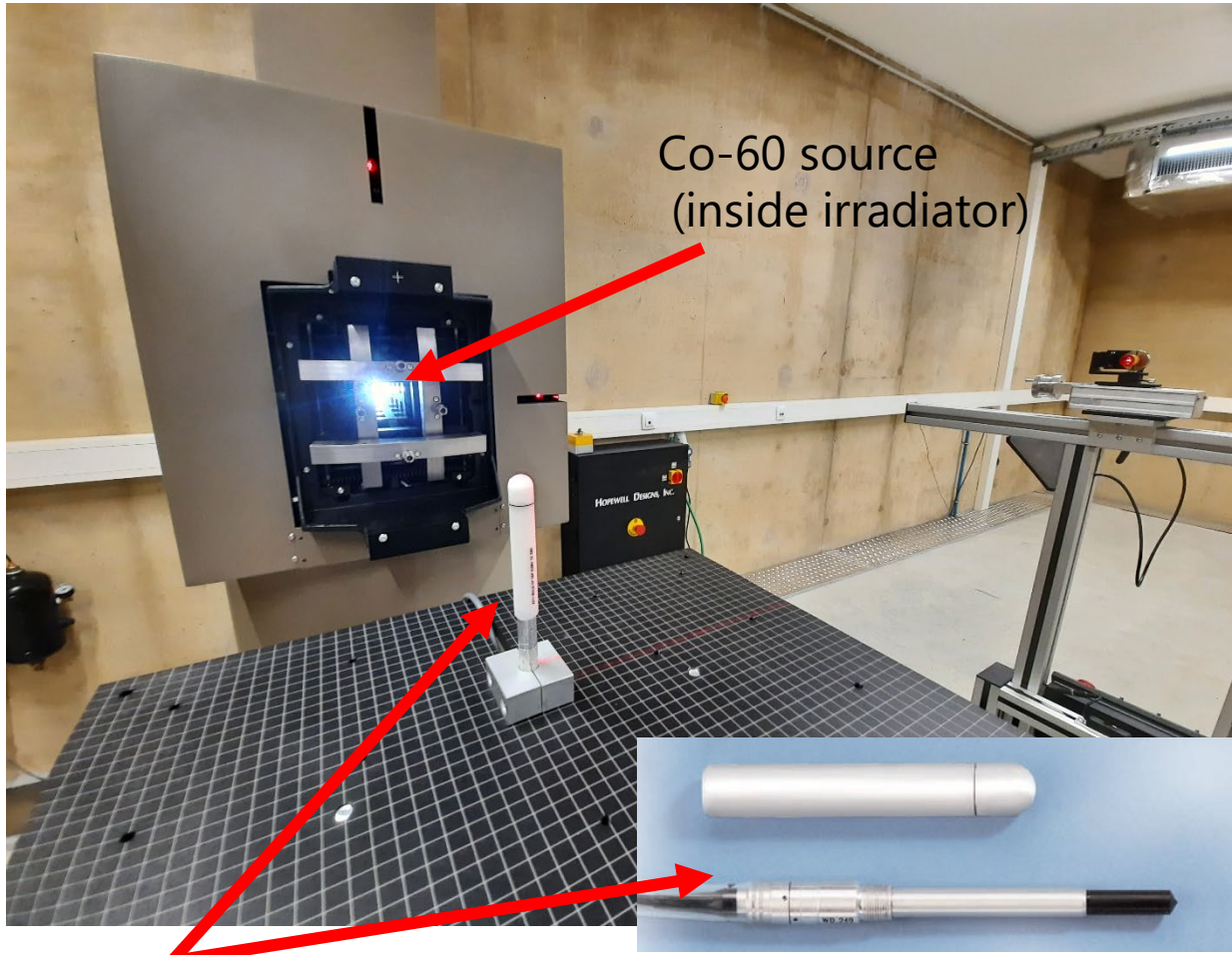
^{60}Co radiotherapy irradiator

Radiotherapy calibrations of ionization chambers at LNK (G-100 Hopewell Designs Inc. irradiator):

free in air

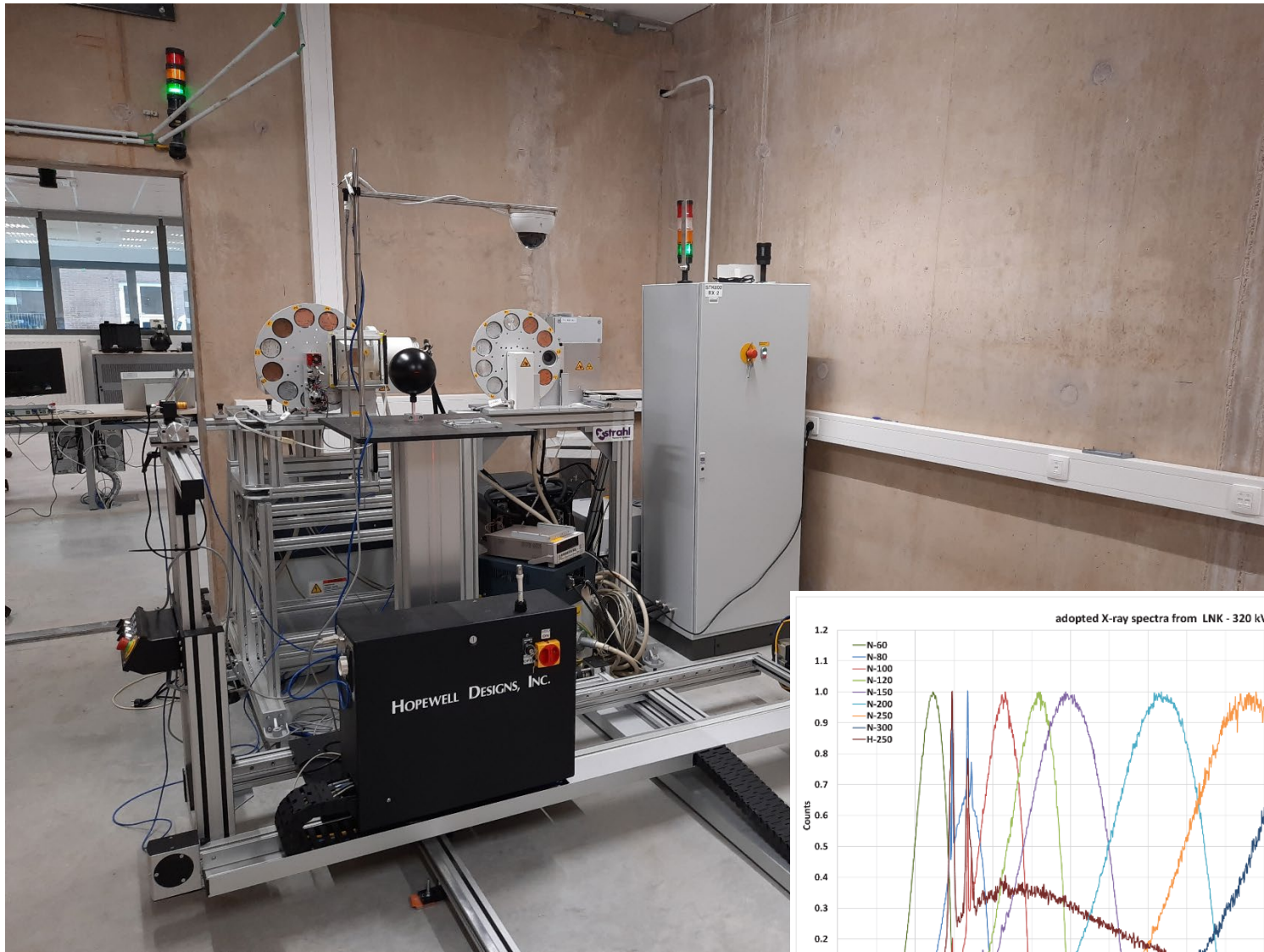
or

inside a water phantom ~"human body"

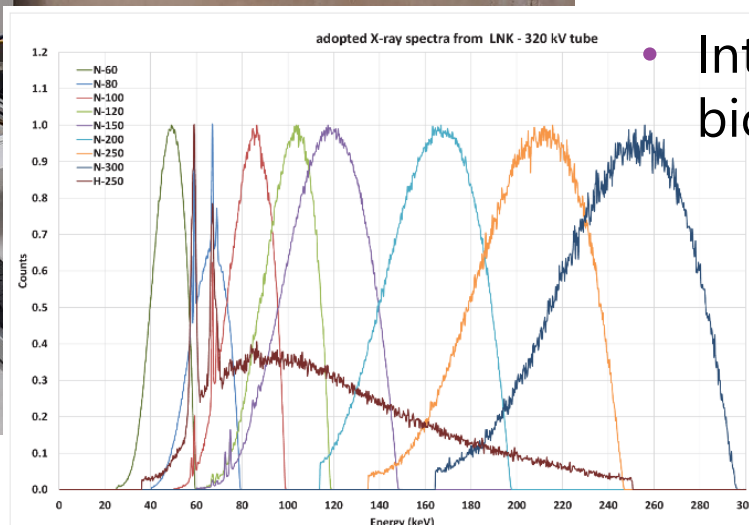


Ionization chambers are the reference dosimeters for radiotherapy departments of hospitals.

X-ray dual tube generator



- 10-300 kV tube potential
- Xstrahl generators + Hopewell Designs Inc. LPS
- tungsten target
- N-series, RQR-series, H-250 beam qualities (ISO 4037) matched & characterized using HPGe spectrometry (*L.C. Mihailescu, 2023 JINST 18 P09037*)
- typical dose rates ~200mGy/h (exception few Gy/h for N-250)
- Intensively used for irradiations of biological samples



$^{252}\text{Cf}/\text{Am-Be}$ neutron irradiator

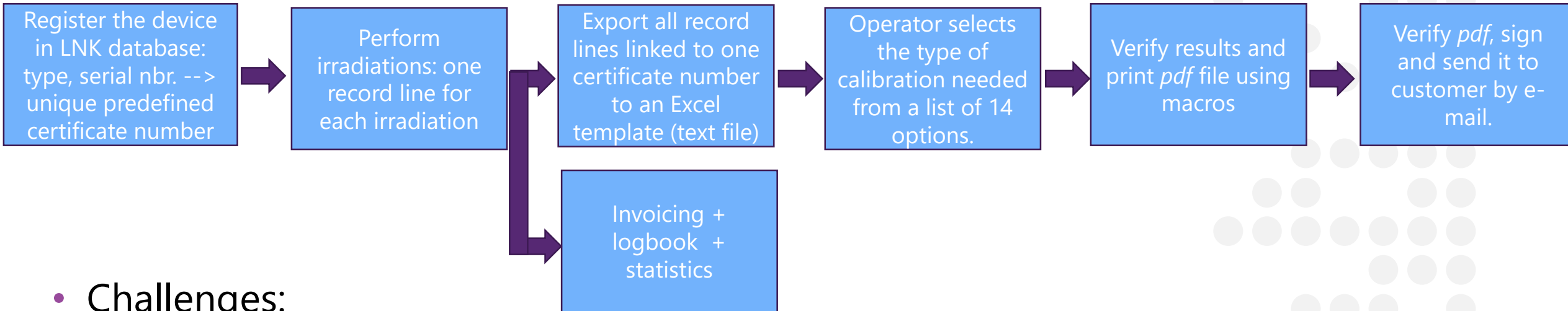


- Hopewell Designs Inc. N-40 irradiator model
- 1 Cf-252 source ->
range: 100 $\mu\text{Gy}/\text{h}$ - 5 mGy/h
- 1 Am-Be source ->
range: 5 $\mu\text{Gy}/\text{h}$ -150 $\mu\text{Gy}/\text{h}$
- large room of 10 m x 10 m x 5 m is needed to reduce scattering of neutrons
- measurement with and without a shadow cone is needed --> 2 irradiations

reference date (2021-05-18)

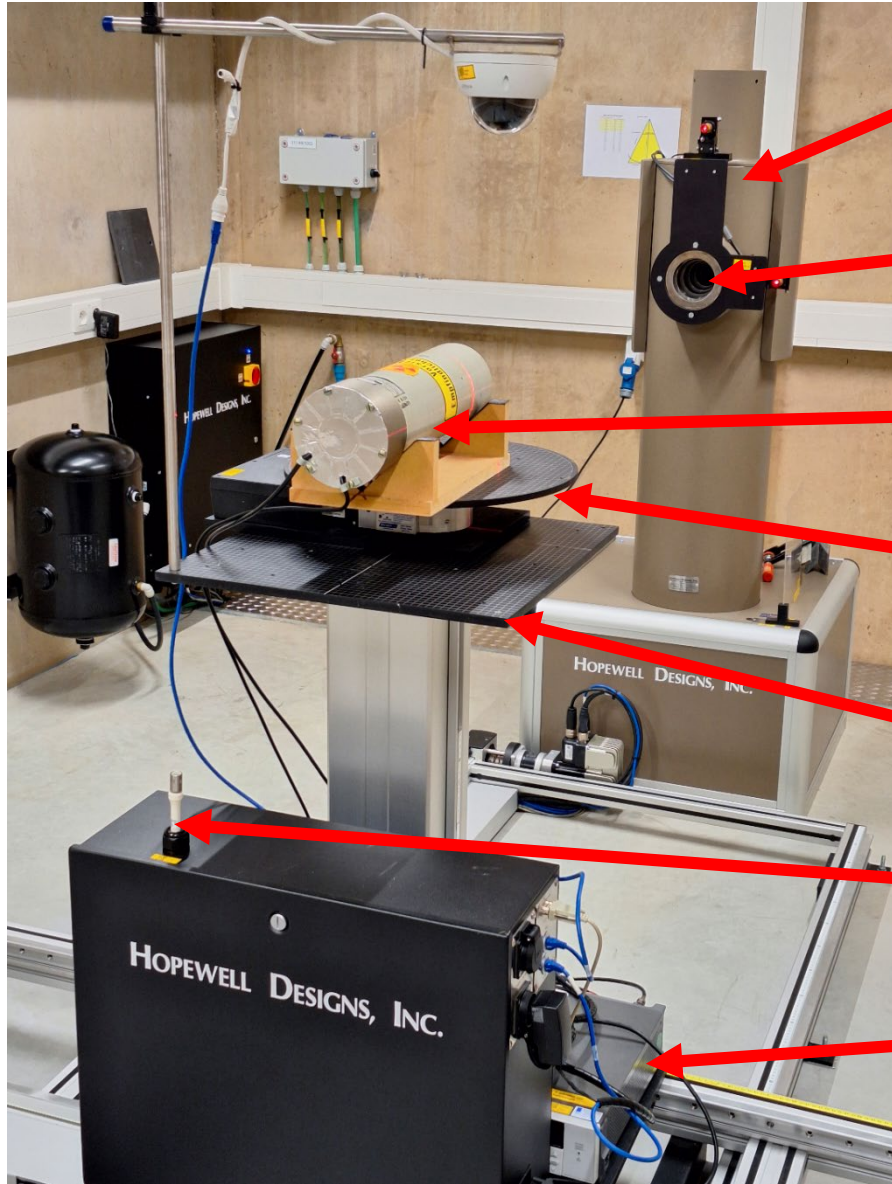
Digital workflow and challenges?

- The data acquisition system was fully customized for the LNK workflow:
 - workflow and procedure are fixed – all steps must be followed (leakage, multiple readings...).



- Challenges:
 - Diversity of dosimeters on the market
 - Diversity of methods in one common database (template):
 - about 11 calibration methods / CMC's (neutrons, X-ray, γ -rays, beta particles...)
 - 5 quantities (K_{air} , $H_p(10)$, $H^*(10)$),
 - 2 units (Gy, Sv)
 - 5 "phantoms" (slab, cylinder, pillar, rod, *free in air*)
 - **automate, but still remain flexible.**

Digital workflow



Hopewell GC-60
irradiator (^{137}Cs ,
 ^{60}Co sources)

20° conical collimator)

Detector (sealed
ionisation chamber)

Rotary table
(plug & play)

LPS table (automated
x,y,z-axis)

PTH sensors

Electrometer



Digital workflow

Utilities based on LabView:

- Registration,
- Irradiator Control,
- Report,
- Irradiator Calibration,
- Rotary table.

Device Registration.vi

Client: SCK CEN
Serial Number: 168916
SAP Quotation Number: test
Delivery Method:
Contact: Liviu-Cristian Mihailescu
SAP Purchase Order Number: test
Delivery Price: 0.00 €
Manufacturer: Automess
Certificate Type: LNK
ISO17025?: NO
Price: 0.00 €
Type: 6150 AD 15/E
Certificate Number: LNK2024-028
Arrival Date: 2024/1/17
Remark Visual Inspection:
Additional Remarks:
Serial Number: 168916
SAVE
PREV EXIT UPDATE EXISTING

RCE
horizontale
Bestralingsruim
GC60

Rotary Control rev 1329

R Preset: 45.0
R Actual: 45.0
Actuate Cancel Home In Position Clear
Rotary Axis

GCN Irradiator Control rev 1481 (Liviu-Cristian Mihailescu)

SCK-CEN GC60-H Hopewell Designs Inc. Logoff

System Status: Air OK Safety System OK System Disabled System Hold SAFE
Temperature: 20.90 C Ignore TPCorr Temp/Pres Correction: 1.027
Pressure: 990.08 hPa Humidity: 38.9 %
Exposure Control: H*(10) Rate Sv/h: 7.0063E-4
Irradiation Type: Dosemeter Calibration H*(10) Sv: 0.0000
Dose Quantity: Source Select: H*(10) Sv H8 Co-60 10GBq
Phantom: Conv Factor: Uncertainty: FreeInAir 1.160 0.54 %
Certificate / Device Information: CERTIFICATE NUMBER: SELECT NEW CLEAR
Certificate Number: SAP LNK2024-027 0000
Client: SCK CEN Type: EL6T1 - 4G
Manufacturer: SCK CEN Serial Number: 100 P: 100
Data Collection: Data Entry Mode: MANUAL Data Collection Type: Min-Max
Linear Positioning System: Carousel Ready In Position Actuate Cancel Home Instrument Offset: 0.0 X Axis: 184.6 Y Axis: 0.0 Z Axis: 20.9
STEP: 0

Digital workflow

hdi Lab PTH Sensor Viewer

ENVIRONMENTAL DATA

	TEMPERATURE	PRESSURE	HUMIDITY	TEMPERATURE 2
G100	19.46 °C	-99.0 hPa	32.6 %	18.77 °C
N40	20.30 °C	990.5 hPa	32.3 %	0.00 °C
GC60-H	20.90 °C	989.9 hPa	38.6 %	0.00 °C
GC60-LT	21.10 °C	990.3 hPa	37.3 %	0.00 °C
DS20	20.00 °C	991.1 hPa	36.4 %	0.00 °C
X-Ray	20.50 °C	989.5 hPa	39.9 %	0.00 °C

Two independent databases:

- *Irradiation database*: source, quantity, time, beam size, phantom, Monitor Chamber – (1 record=1 irradiation)
- *PTH database*:
 - saves every minute
 - PTH used by Irradiator Control Utility for real time corrections
 - start and stop PTH during irradiation are saved also on Irradiation database.

ID	MeasDate	MeasTime	G100_Temp	G100_Press	G100_Hum	G100_Temp2
630769	2022/4/10	09:51	19.15	1,017.6	36.3	
630768	2022/4/10	09:50	19.15	1,017.6	36.3	
630767	2022/4/10	09:49	19.16	1,017.5	36.2	
630766	2022/4/10	09:48	19.16	1,017.5	36.2	
630765	2022/4/10	09:47	19.15	1,017.5	36.2	
630764	2022/4/10	09:46	19.14	1,017.5	36.3	
630763	2022/4/10	09:45	19.13	1,017.5	36.3	
630762	2022/4/10	09:44	19.13	1,017.5	36.3	
630761	2022/4/10	09:43	19.13	1,017.5	36.3	
630760	2022/4/10	09:42	19.13	1,017.5	36.3	
630759	2022/4/10	09:41	19.14	1,017.5	36.3	
630758	2022/4/10	09:40	19.14	1,017.4	36.2	
630757	2022/4/10	09:39	19.14	1,017.4	36.3	
630756	2022/4/10	09:38	19.15	1,017.4	36.3	

Digital workflow

Report Generation Utility

Start Date: 2024/01/01 End Date: 2024/01/10 Irradiation Type: Dosemeter Calibration

Certificate Number	Client	Manufacturer	Model Number	Serial Number
LNK2024-020	QC	Studsvik	2202D	6310
LNK2024-019	SCK CEN	Landauer	Inlight	QC dosimeters we
LNK2024-018	SCK CEN	Landauer	Inlight	QC dosimeters
LNK2024-017	SCK CEN	Mirion	Instadose 2	Dummy Customer
LNK2024-016	SCK CEN	Mirion	Instadose+	Dummy Customer
LNK2024-015	SCK CEN	Landauer	Inlight	Dummy Customer
LNK2024-014	SCK CEN	Muizen	muizen	op verwarmingsplai

Refresh

DISPLAY RECORDS

Client: QC Manufacturer: Studsvik Task Number: Arrival Date: 2024/1/10 Delivery:

Contact: Neutrons Model Number: 2202D Work Order Number: Remark Visual Inspection:

Serial Number: 6310 SAP Quote Number: QC Delivery Price: 0.00

ISO17025?: YES SAP Purchase Order Number: QC Remarks: Price: 0.00

LNK2024-020

IrrSel	ExpType	SrcSel	AltCalc	Operator	Comment	DateStr
SCK-CEN N40	Dosemeter Calibrat	N1 Cf-252 2.2GBq	None	Bart Marlein		2024/01/10
SCK-CEN N40	Dosemeter Calibrat	N2 AmBe 168GBq	None	Bart Marlein		2024/01/10

EXPORT EXIT

Reporting:

- Report Utility as a text field exported to an Excel template,
- Excel templates with macros for analysis,
- Acrobat Reader macro to create a pdf ready for signatures,
- Signed and locked *pdf* file sent by e-mail.

Digital workflow

	A	B	C	D	E	F	G	
Input parameters		Taal		Nederlands			Maximum 30 irradiation	
		Template		Bestralingen	select if different from Default			
		TP Correction Enable?		No	Choose if Temperature and Pressure correction is applied on detector reading! Needed for ionisation			
		BELAC logo ISO17025 accreditation ?		Yes	The logo will also be hidden if NO or Trescal is selected.			
		RP		Manual Data Entry Mode	select if different from Default			
		Uitgevoerd door (operator)		Bart Marlein	copied from RAW sheet and used as information only		All cells are locked except	
		Certificate verified by second staff member		Liviu-Cristian Mihailescu	select if different from Default			
		Save path for PDF files:		Z:\Reports\	type in if different from Default			
		Radius Neutron Detector (cm):		12.5	Only used for neutrons: Berthold =12.5 --> type in if different from Default			
		Chamber alone or paired with electrometer ?		Pair:chamber+electrometer	Only used for radiotherapy	Number of EPD's	0	
						number of irradiations (lines in certificate)	7	
Information copied from RAW sheet		certificaat nummer		LNK2023-649				
		toestel model en SN		Hartmann&Braun KG122 sn. RMG-151 Nr.13511.8.043			Min Max	
		certificaat afgeleverd op:		2024-01-17	pressure range (hPa):	1027.0	1029.0	
		klant naam:		SCK CEN	temperature range (°C):	20.0	21.0	
		klant adres (straat + nummer):		Boeretang 200	relative humidity range (%):	41.0	41.0	
		klant adres (zip+ stad+land):		2400, Mol, Belgie				
		aangeboden door:						
		e-mail						
		referentie klant:		BBR220401				
		prijs offerte (SAP nummer):		BBR220401				
		prijs (euro BTW excl.):		500				
Irradiator Data header		Irradiator	Bron	Bundel qualiteit	Beam shape	ModelNo	SerialNo	
		SCK-CEN GC60-H	H1 Cs-137 0.3GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.13	
		SCK-CEN GC60-H	H1 Cs-137 0.3GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.13	
		SCK-CEN GC60-H	H2 Cs-137 4.4GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.13	

Please fill in only the white fields!

Excel template for data analysis and pdf generation:

- Selection of calibration type: photon, neutron, active detector or passive, calibration v.s. (just) irradiation,
- Language selection (NL, FR, EN),
- PTH correction or ISO 17025 accreditation logo....

Digital workflow and challenges?

- Digital reading from electrometers:
 - presently only 1 type of electrometer is fully implemented,
 - not all electrometers on the market can be easily implemented (from a total of 4-6 types we typically get from customers).
- Manual reading is always needed and it may not be easily replaced:
 - digital screens are available but no possibility to connect to the dosimeter,
 - digital screens are in bad condition (old models, broken, light reflection...),
 - analog devices with a needle.
- All method (re-)validation measurements are performed automatically:
 - digital electrometers with RS-232 connection
 - fully automated LPS with automated calibration procedures defined in the Hopewell data acquisition system.
- Raw data from 3 CMC remain outside the databases-> only Excel templates:
 - Radionuclide calibrators for nuclear medicine
 - Surface contamination monitors
 - Beta calibrations

Document storage

LNK - Laboratory for Nuclear Calibrations

Search Reports

Preview Refresh Advanced Search Add Item

Search LNK - Laboratory for

Name	Size	Modified	File Type	Of...
00 - LINKED WORKSPACES	0 Items	2019-08-...		No
01 - GENERAL MANAGEMENT	10 Items	2014-05-...		No
02 - MONITORING & FEEDBACK	5 Items	2019-02-...		No
04 - BUDGET & FINANCE	4 Items	2014-05-...		No
05 - PURCHASE	4 Items	2014-05-...		No
06 - SALES	2 Items	2014-05-...		No
10 - TRAINING	2 Items	2014-05-...		No
11 - KNOWLEDGE	5 Items	2014-05-...		No
12 - COMMUNICATION	7 Items	2014-05-...		No
13 - INFRASTRUCTURE	11 Items	2014-05-...		No
15 - ICT	2 Items	2014-05-...		No

APR-RDC-187 Dosimetry Calibrations and irradiations

Search Reports

Preview Refresh Advanced Search

Search APR-RDC-187 Dosir

Name	Size	Modified	File Type	Last Major Version Date	Alternative Reference	Revisio
Documents (How?)	11 Items	2023-05-24 08:0...				
Framework (Why?)	7 Items	2019-03-19 15:1...				
Means (What?)	0 Items	2016-05-10 16:0...				
People (Who?)	9 Items	2021-06-23 08:2...				
Process model	5 Items	2021-10-08 11:3...				
URL	7 Items	2024-01-11 10:0...				
Workfolder	3 Items	2021-02-04 16:5...				

Document storage solution "Alexandria":

- + cloud based
- + predefined folder structure for 2 levels
- + daily centralized back-up
- + multiple versions stored.
- - not well suited for large amount of data or uncommon data files (raw measurement data, binary files, executables,...)
- - interface with data acquisition software is difficult

QA documents – IMS applied at LNK

Process:

Dosimetry calibrations and irradiations ▾

Search (approved) IMS documents in this p

Corporate > APR > APR-NMA > Radioprotection Dosimetry and Calibration > Dosimetry calibrations and irradiations

Last published documents <ul style="list-style-type: none">• TemplateSCKCENExpData.xlsm (2024-01-09)• BesmettingsMonitorenTemplate.xlsm (2023-12-15)• Validation file - X-rays generator.docx (2023-12-08)• RadionuclideCalibrations SCK CEN_LNK.docx (2023-10-26) • FIDELISTemplate.xlsm (2023-10-26)	Why <ul style="list-style-type: none">• Standard• SHEQ document• Regulatory document	APR-RDC-187 Process model		How <ul style="list-style-type: none">• SOP - Standard Operating Procedure• INS - Work Instruction• Supporting document• Template or Form	Process-plan
	Definitions	Who <ul style="list-style-type: none">• Qualification table	What	Registrations <ul style="list-style-type: none">• Certificates LNK• Certificates old KAL• Logbook LNK• Prices at LNK• Quotations LNK	
Key Performance Indicators	Dosimetry calibrations and irradiations				Related processes <ul style="list-style-type: none">• Radioprotection Dosimetry and Calibration• Purchase to pay
Applications <ul style="list-style-type: none">• ProReact	<p><i>The section below shall be considered as additional reference information related to the process and cannot contain any binding key process documentation, which shall be consulted in the section above (links to key process documentation are allowed). The information is managed and published under the responsibility of the processowner.</i></p>				

- IMS: quality, safety, security, economics and environmental impact
- All LNK activities are grouped as one IMS process:
 - Online portal for easy access to all procedures
 - **ProReact** app for complaints and NCR's registrations and follow up
 - **LabTool** app for calibration calendar and reminders
 - 1 validation file and 1 work instruction for each CMC/installation of LNK
 - **Connect** app for Human Capital Management based on SAP SuccessFactor

QA documents – IMS applied at LNK

al.docx.pdf | 1 / 27 | 137% + | [Icons]

Validation file - horizontal.docx

Authors*

Cristian Mihailescu

Approval information for current revision*

Name	Outcome	Date
Liviu-Cristian Mihailescu (Process Owner)	Approved	2022-12-12

Change log*

Revision	Version	Status	Date	Description of change
4.0	7.0	Approved For Use	2022-12-12	New validation measurements with PTW 1 liter and PTW 10 liter chambers were performed and implemented in this file and in the Hopewell database. PTW 10 liter chamber was used as reference for H1 and H5 sources and range was extended down to about 1 uSv/h. PTW 10 liter chamber was cross-calibrated against the 1 liter chamber at 100 cm for H1 and H5 sources.
3.1	6.0	Approved For Use	2022-06-24	Section was added: 10.9. Scattering from the table of the LPS
3.0	5.0	Approved For Use	2021-03-15	New Hopewell irradiators are used at new LNK building. New set of validation measurements were performed. Language was changed to English from Dutch. Numbering of the validation files was also updated.

Work instruction, validation files, templates and forms:

- 1 validation file and 1 work instruction for each CMS/installation of LNK.
- Automated versioning – major and minor update/change.
- All approved versions are locked and cannot be deleted.
- *Pdf* is generated automatically from MSWord after approval.
- Description of the change and list of approvers are automatically included in the *pdf*.

What can we do next ?

- Photos taken at start of each irradiation and their storage place linked to the certificate number.
- Automated reading of the screens.
- Web interface for ordering the calibrations, follow up, communication with customer and delivery of certificates. Customer's feedback can be implemented as well.
- QR codes printed on the calibration labels with direct link to the calibration certificate on the server of LNK.
- User accessible calibration factors for ambient sensors (p, T, H).
- *Automate as much as possible but still be flexible ...*

Copyright © SCK CEN

PLEASE NOTE!

This presentation contains data, information and formats for dedicated use only and may not be communicated, copied, reproduced, distributed or cited without the explicit written permission of SCK CEN.

If this explicit written permission has been obtained, please reference the author, followed by 'by courtesy of SCK CEN'.

Any infringement to this rule is illegal and entitles to claim damages from the infringer, without prejudice to any other right in case of granting a patent or registration in the field of intellectual property.

SCK CEN

Belgian Nuclear Research Centre

Foundation of Public Utility

Registered Office: Avenue Herrmann-Debrouxlaan 40 – BE-1160 BRUSSELS

Operational Office: Boeretang 200 – BE-2400 MOL