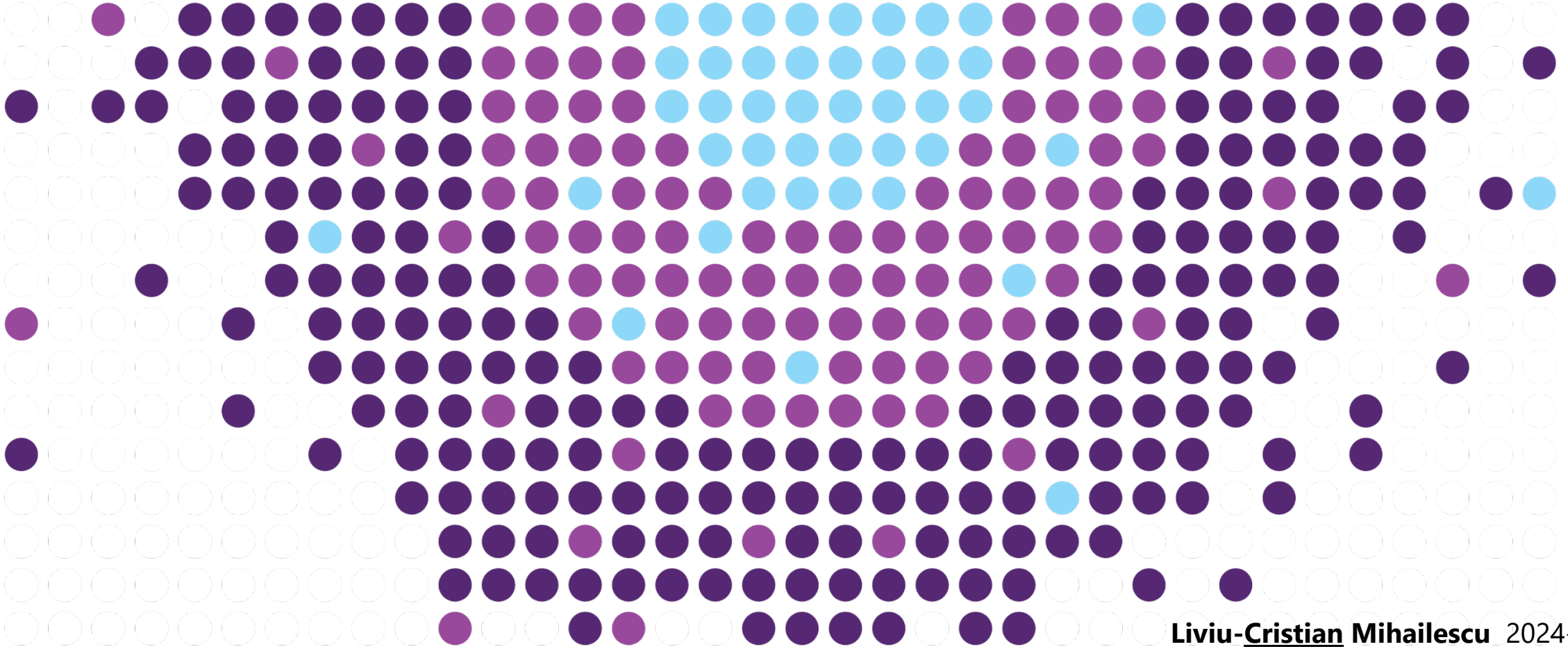


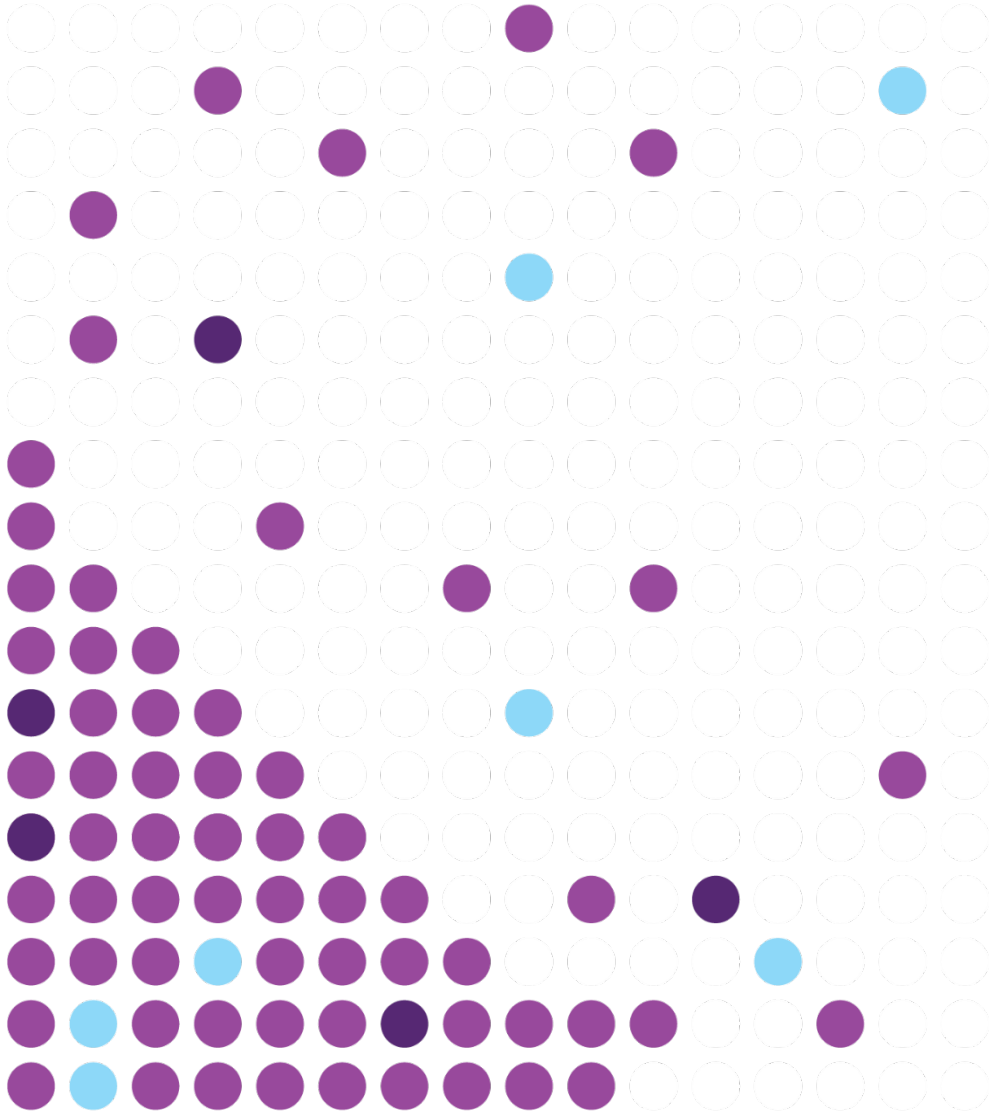
Liviu-Cristian Mihailescu 2024-01-18

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.

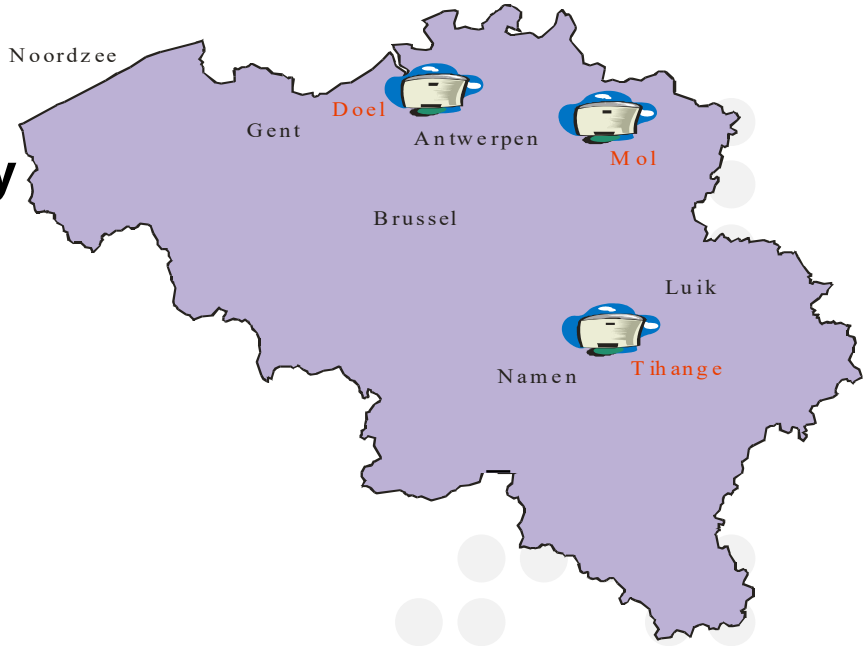
- Digital transformation is using technology for a general organizational upgrade. Digital transformation is digitalisation-plus, a complete change of strategy – end goal: much higher efficiency, nicely integrated apps, user friendly...

Where is LNK ? Digital transformation or just digitalisation?

SCK CEN

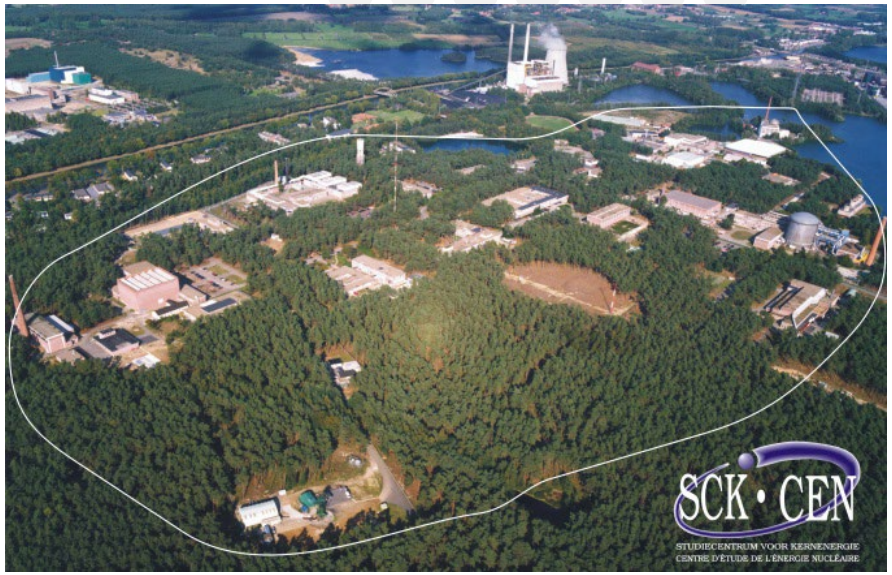
SCK CEN

- 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 develope 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



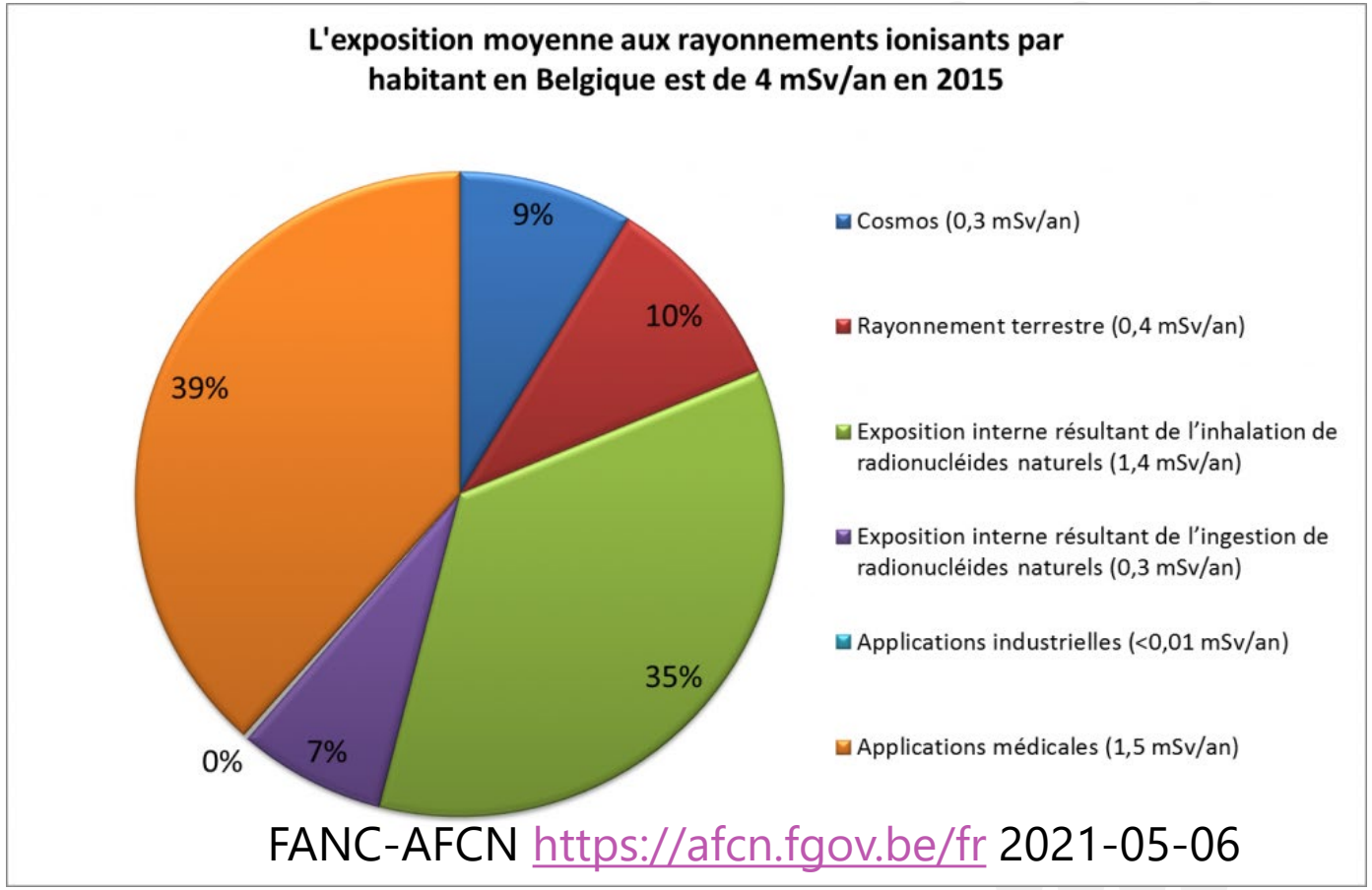
Why we need dosimetry calibrations ?

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 dosemeters (personal or ambient dosemeters).
- Uncertainties on delivered doses are linked to the success of the treatment in RT and NM.

Dosemeters need a traceable calibration (metrology of ionizing radiation)



FANC-AFCN https://afcn.fgov.be/fr 2021-05-06

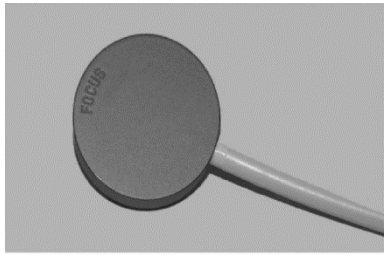
Example of dosemeters

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 cm^3

plane-parallel Roos type 0.35 cm^3

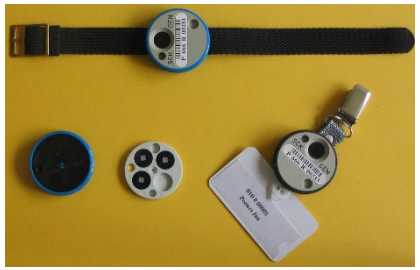


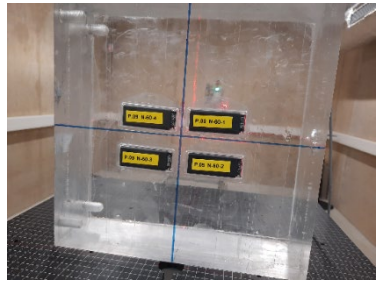
LNK primary standard for K_{air} 1.02 cm^3

electrometer

- ambient dosemeters:

- personal dosemeters:





Evolution of LNK

? < 1985 – Wooden tower ? (Mol) :

1985-2009 – KAL building (Mol) :

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

100 km

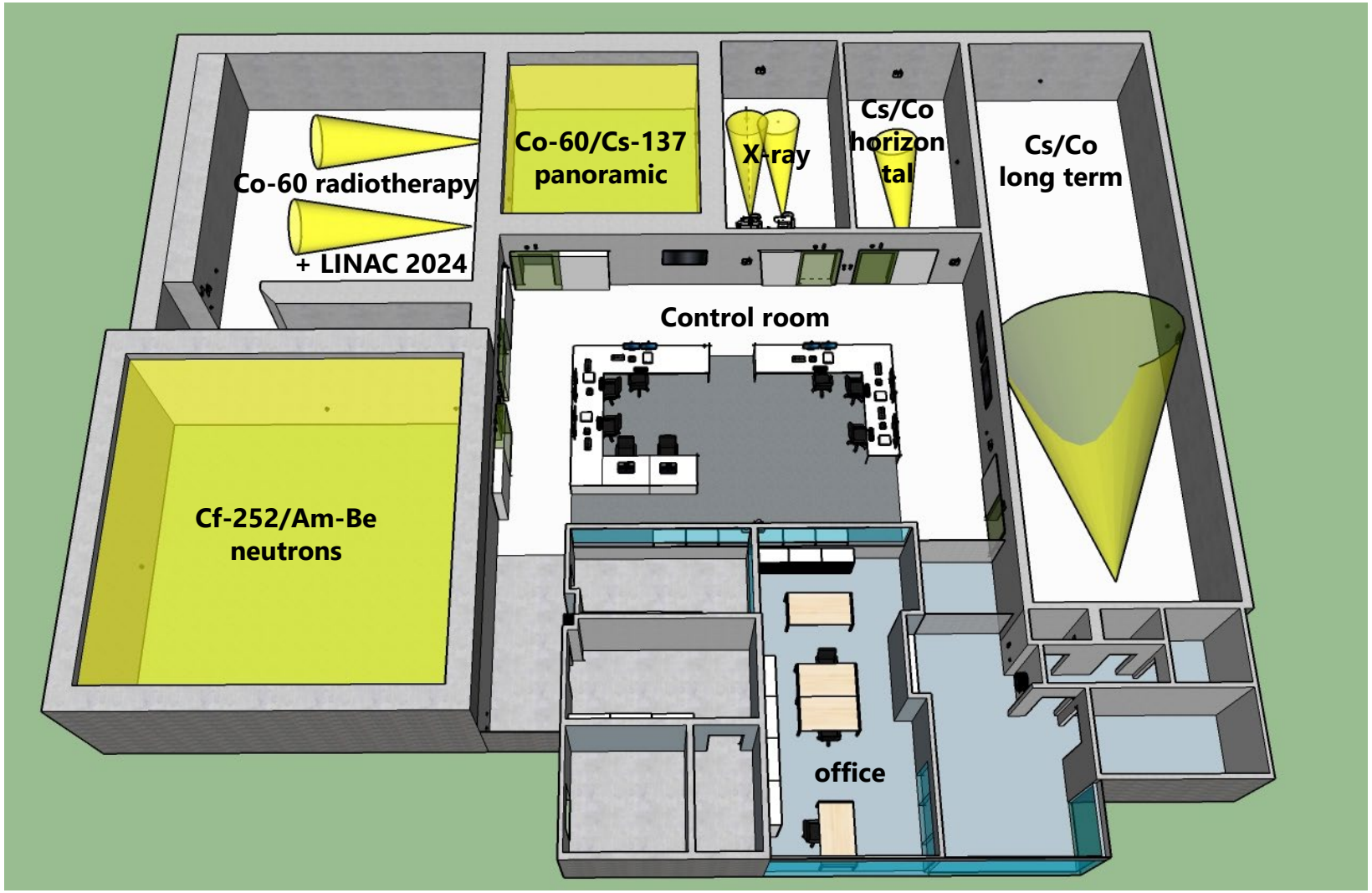
2009-2020 – KAL building Mol + Univ. Ghent:

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

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



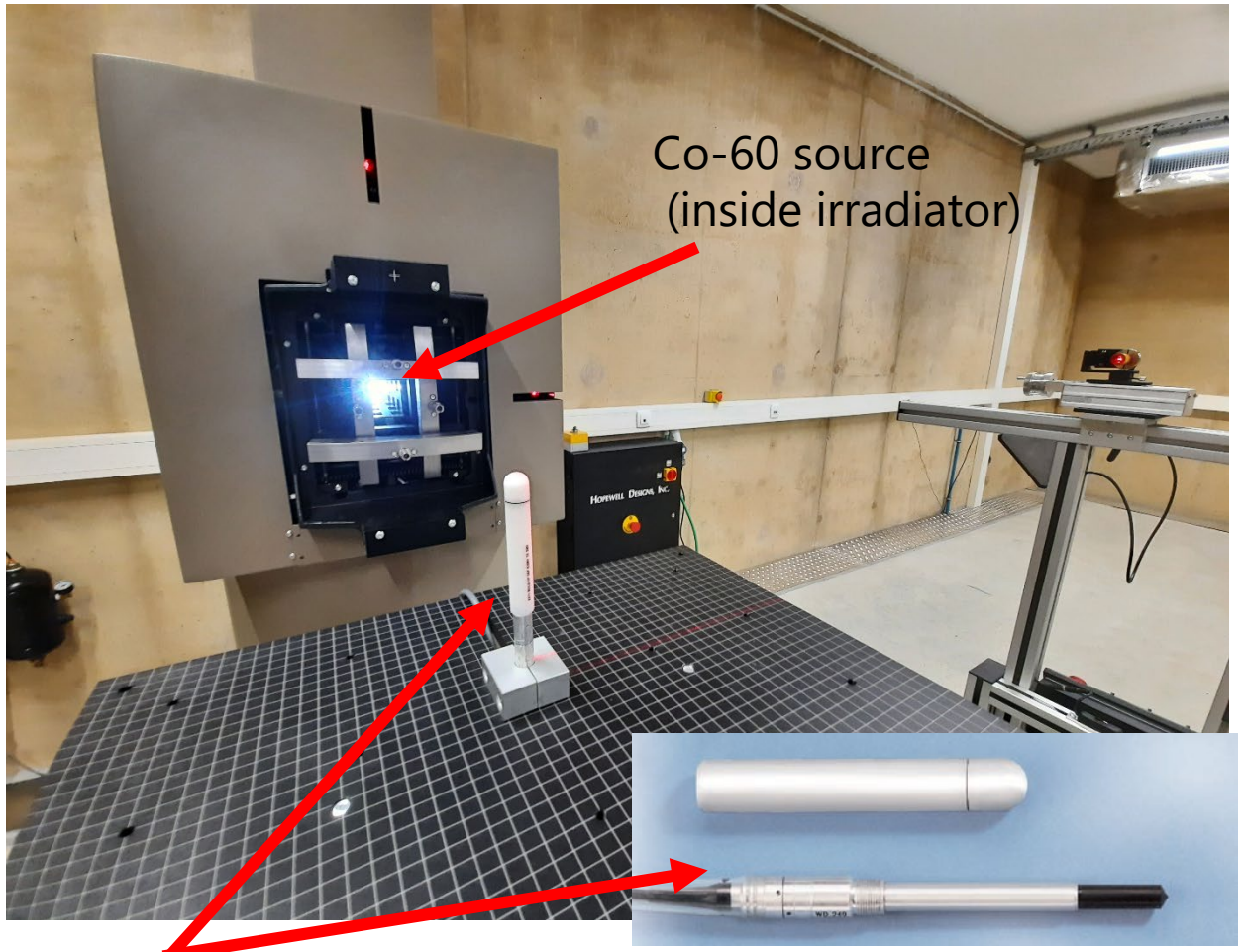
Green field project Oct. 2018 – May 2020:

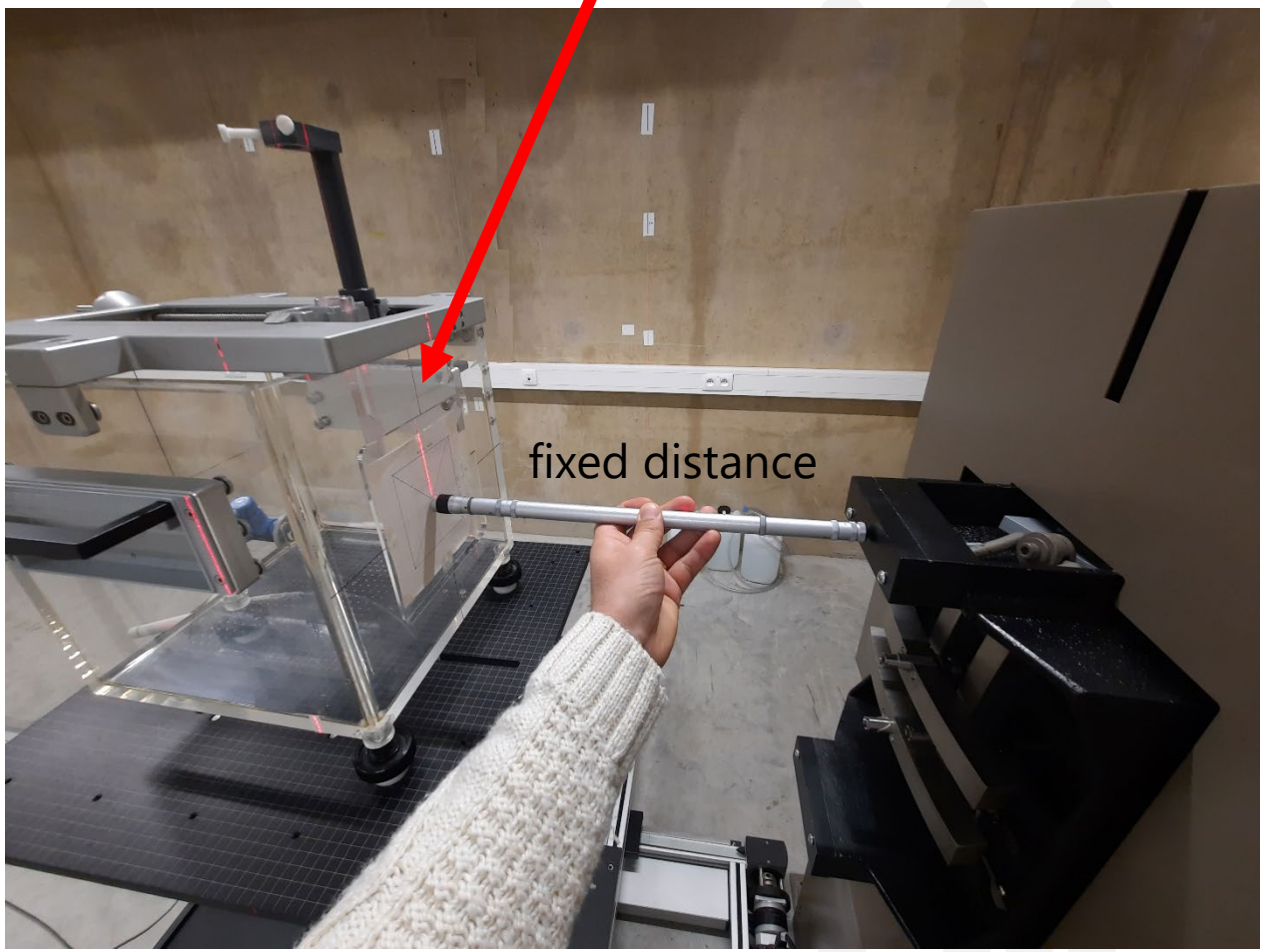
- 6 independent irradiation rooms with control room in the center.
- Stat-of-art safety system and modern irradiators.
- Located on main SCK CEN site from Boeretang 200, B-2400, Mol.
- All type of dosimetry calibrations in one laboratory (Cs-137/Co-60, neutrons, X-ray, Co-60 radiotherapy, α/β contamination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

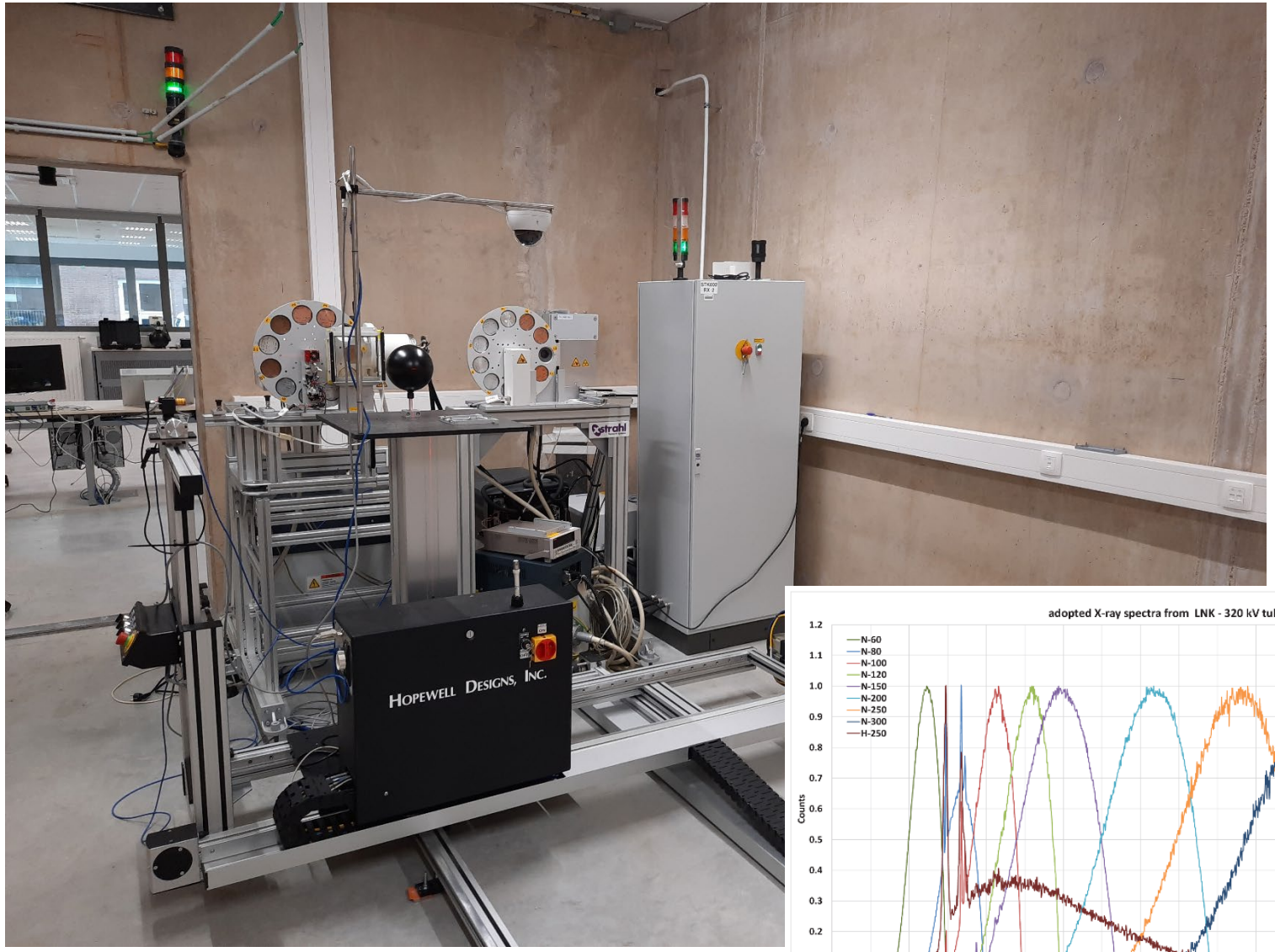
free in air or inside a water phantom ~"human body"



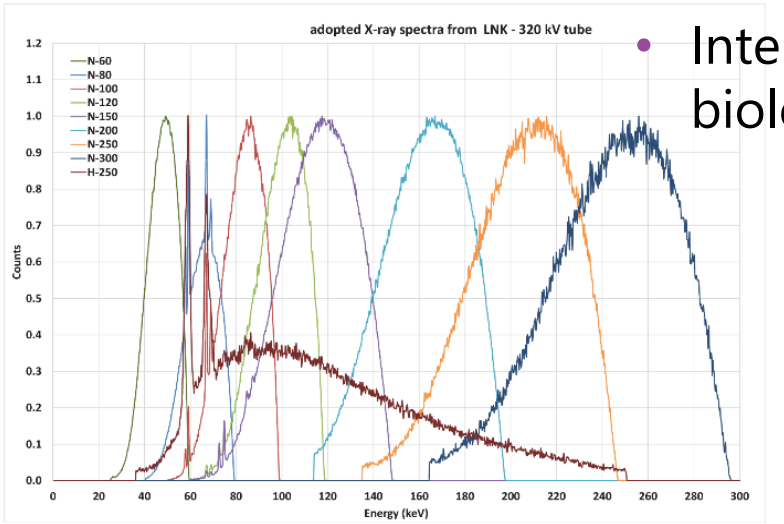


Ionization chambers are the reference dosemeters for radiotherapy departments of hospitals.

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



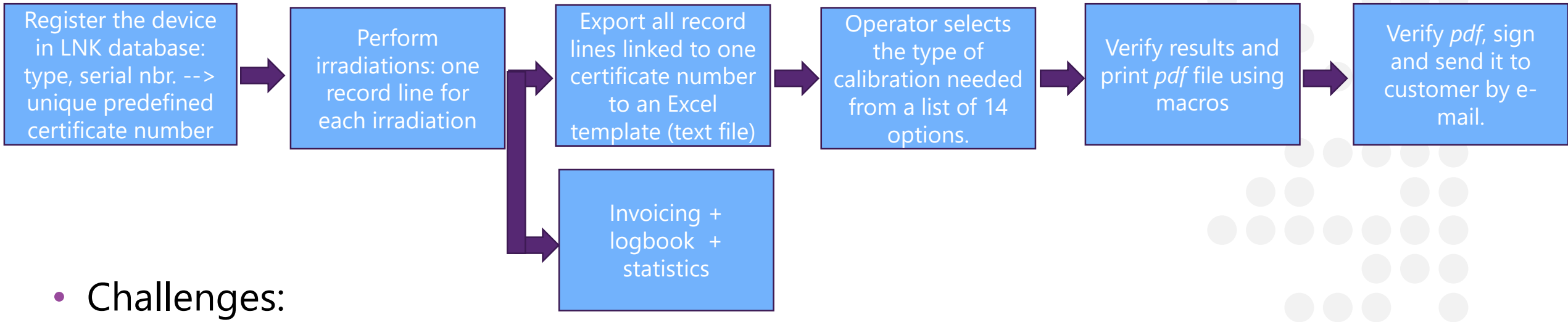
^{252}Cf/Am-Be neutron irradiator

- Hopewell Designs Inc. N-40 irradiator model
- 1 Cf-252 source ->
  range: 100 µGy/h- 5 mGy/h
- 1 Am-Be source ->
  range: 5 µGy/h-150 µGy/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)

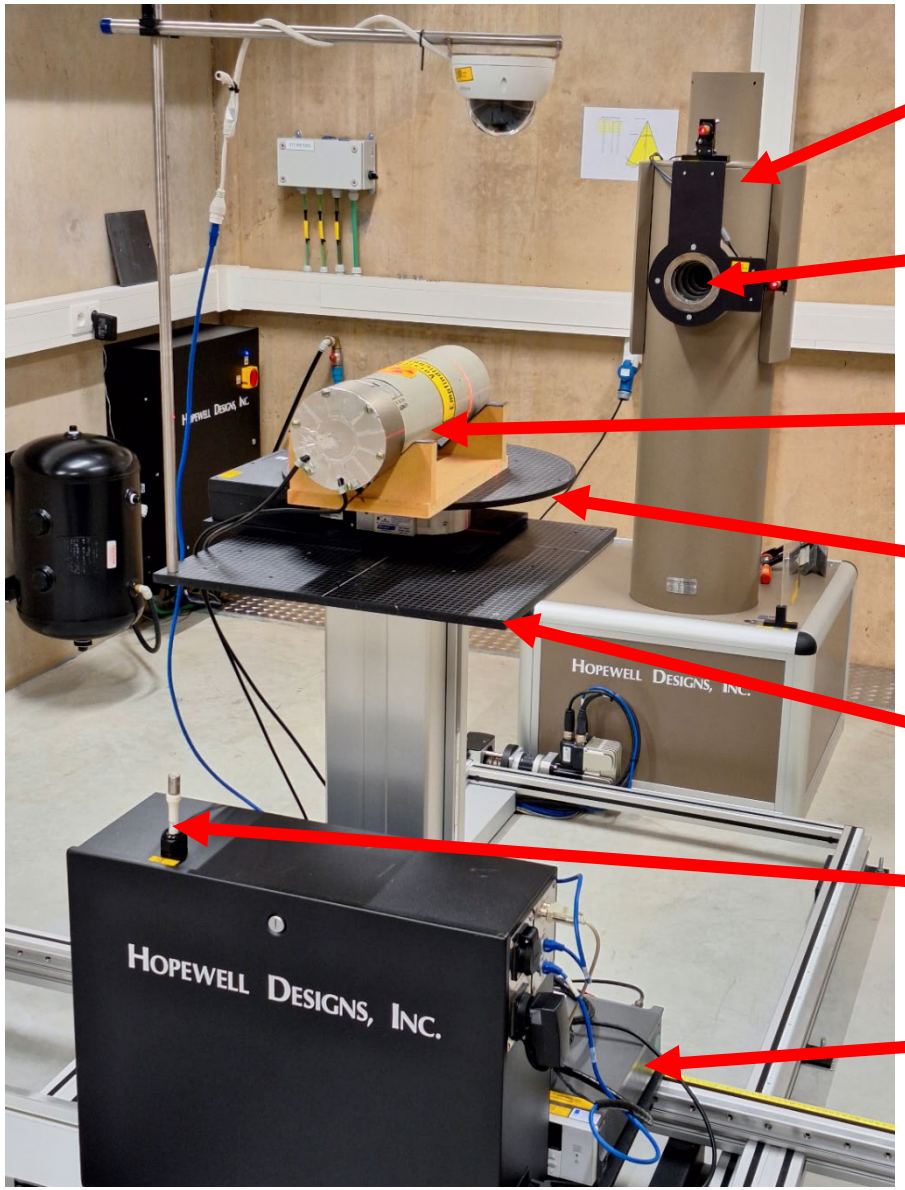
Digital workflow and chalenges?

- 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 dosemeters 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)

20º conical collimator)

Detector (sealed ionisation chamber)

Rotary table (plug & play)

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

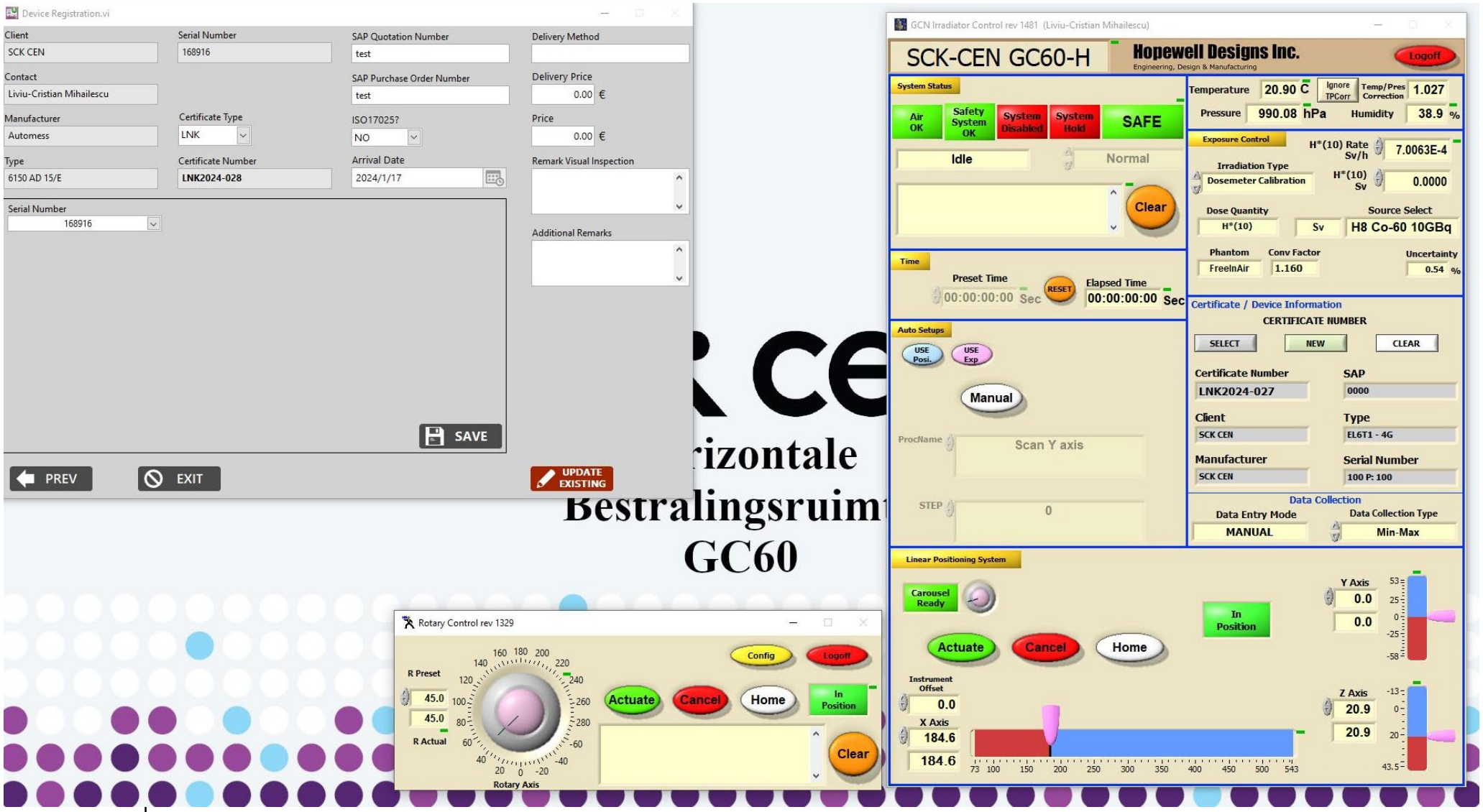
PTH sensors

Electrometer

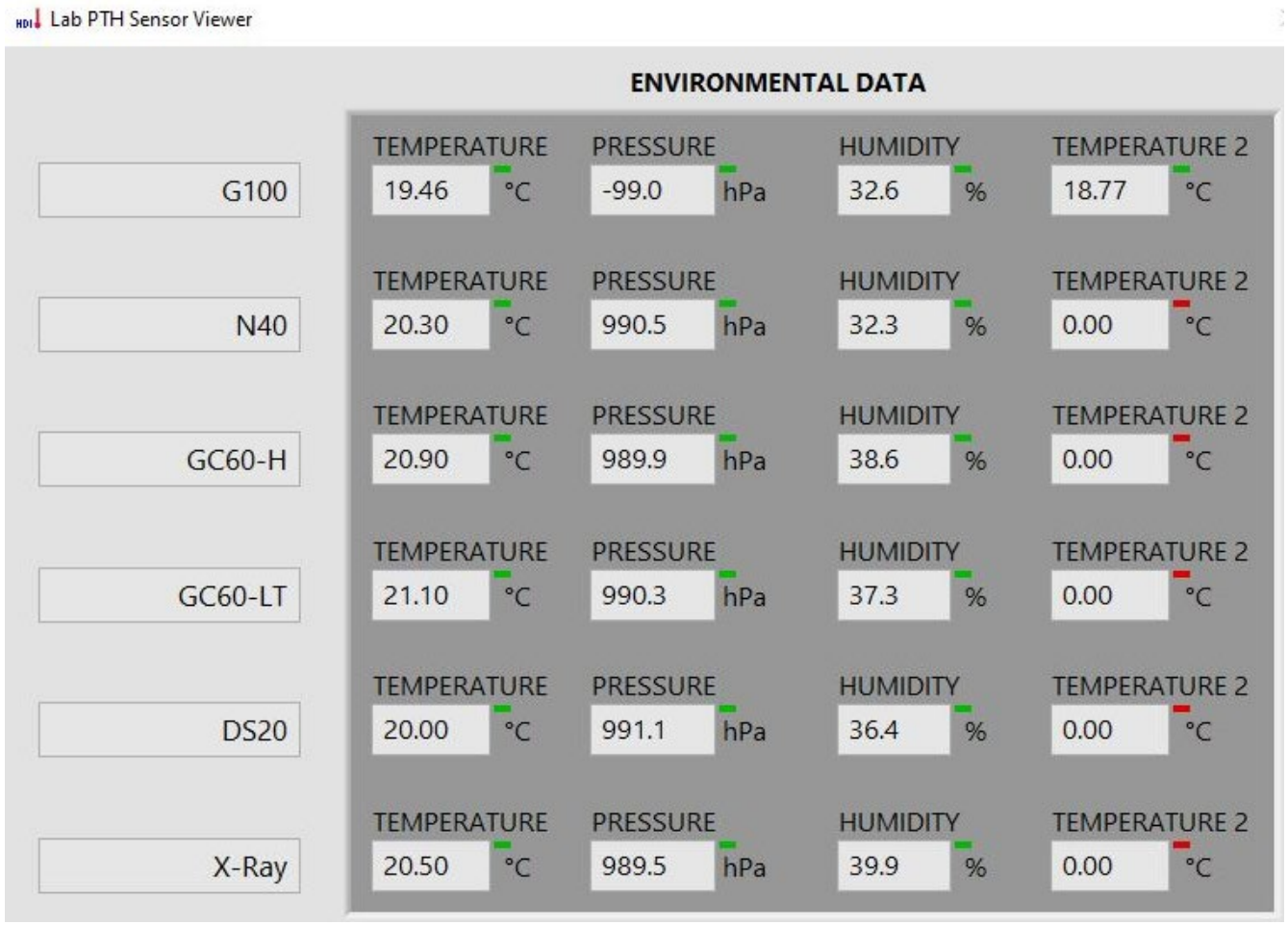
Digital workflow

Utilities based on LabView:

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

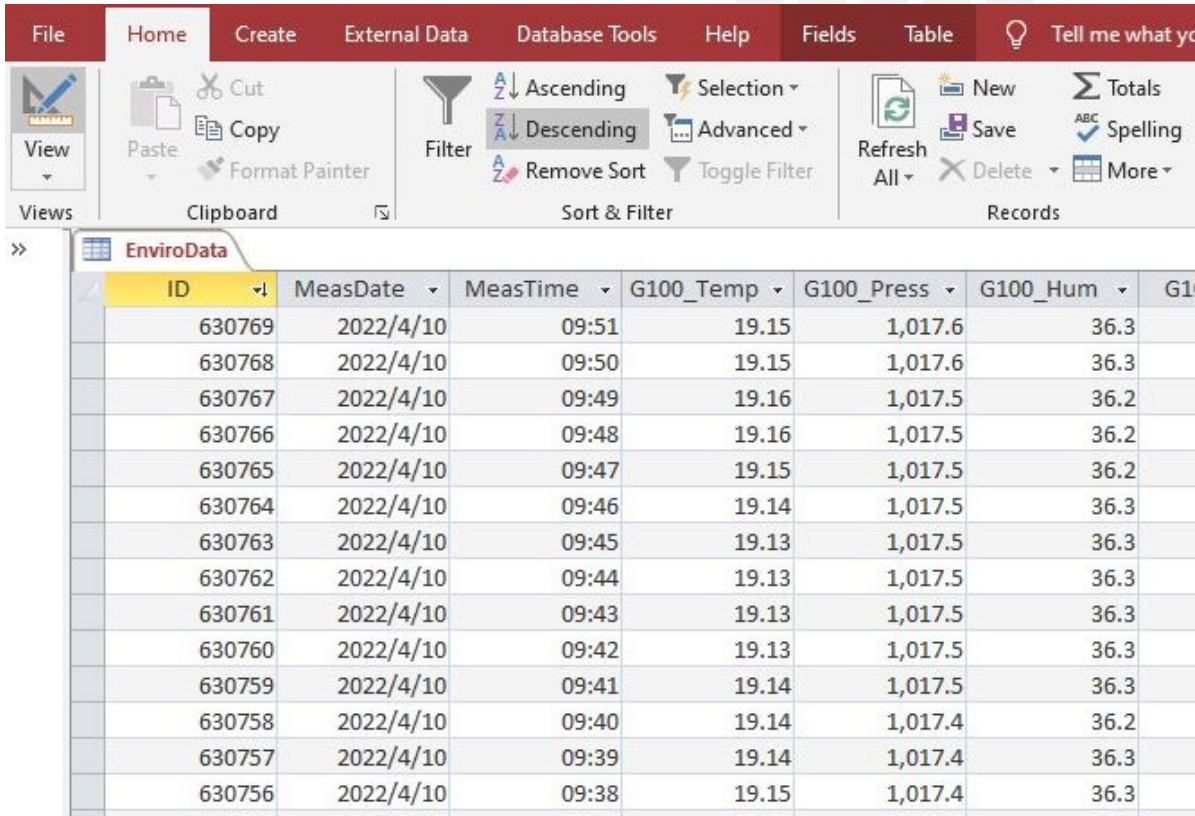


Digital workflow



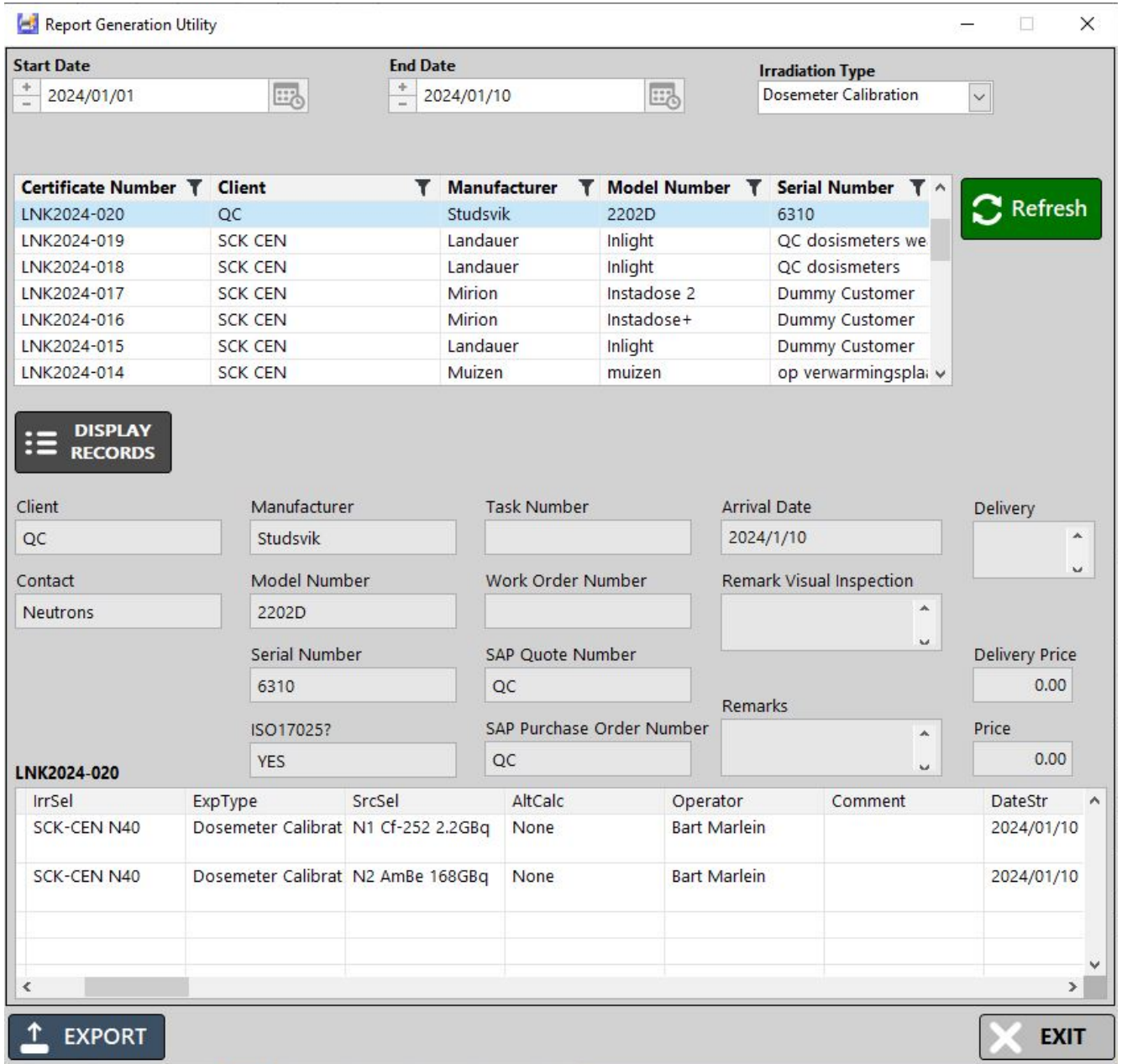
Two independent databases:

- *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
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



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

2	Input parameters	Taal	Nederlands				Maximum 30 irradiation
3		Template	Bestralingen	select if different from Default			
4		TP Correction Enable?	No	Choose if Temperature and Pressure correction is applied on detector reading! Needed for ionisa			
5		BELAC logo ISO17025 accreditation ?	Yes	The logo will also be hidden if NO or Trescal is selected.			
6		RP	Manual Data Entry Mode	select if different from Default			
7		Uitgevoerd door (operator)	Bart Marlein	copied from RAW sheet and used as information only			All cells are locked exce
8		Certificate verified by second staff member	Liviu-Cristian Mihailescu	select if different from Default			
9		Save path for PDF files:	Z:\Reports\	type in if different from Default			
10		Radius Neutron Detector (cm):	12.5	Only used for neutrons: Berthold =12.5 --> type in if different from Default			
11		Chamber alone or paired with electrometer ?	Pair:chamber+electrometer	Only used for radiothera	Number of EPD's	0	
12					number of irradiations (lines in certificat	7	
13	Information copied from RAW sheet	certificaat nummer		LNK2023-649			
14		toestel model en SN		Hartmann&Braun KG122 sn. RMG-151 Nr.13511.8.043			
15		certificaat afgeleverd op:		2024-01-17			
16		klant naam:		SCK CEN			
17		klant adres (straat + nummer):		Boeretang 200			
18		klant adres (zip+ stad+land):		2400, Mol, Belgie			
19		aangeboden door:					
20		e-mail					
21		referentie klant:		BBR220401			
22		prijs offerte (SAP nummer):		BBR220401			
23		prijs (euro BTW excl.):		500			
24							

		Min	Max
	pressure range (hPa):	1027.0	1029.0
	temperature range (°C):	20.0	21.0
	relative humidity range (%):	41.0	41.0

Please fill in only the white fields!

		Irradiator	Bron	Bundel qualiteit	Beam shape	ModelNo	SerialNo
25	Data header						
26	umenet	SCK-CEN GC60-H	H1 Cs-137 0.3GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.1
27		SCK-CEN GC60-H	H1 Cs-137 0.3GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.1
28		SCK-CEN GC60-H	H2 Cs-137 4.4GBq	Cs-137	20 deg. cone, horizontal	Hartmann&Braun, KG122	RMG-151 Nr.1

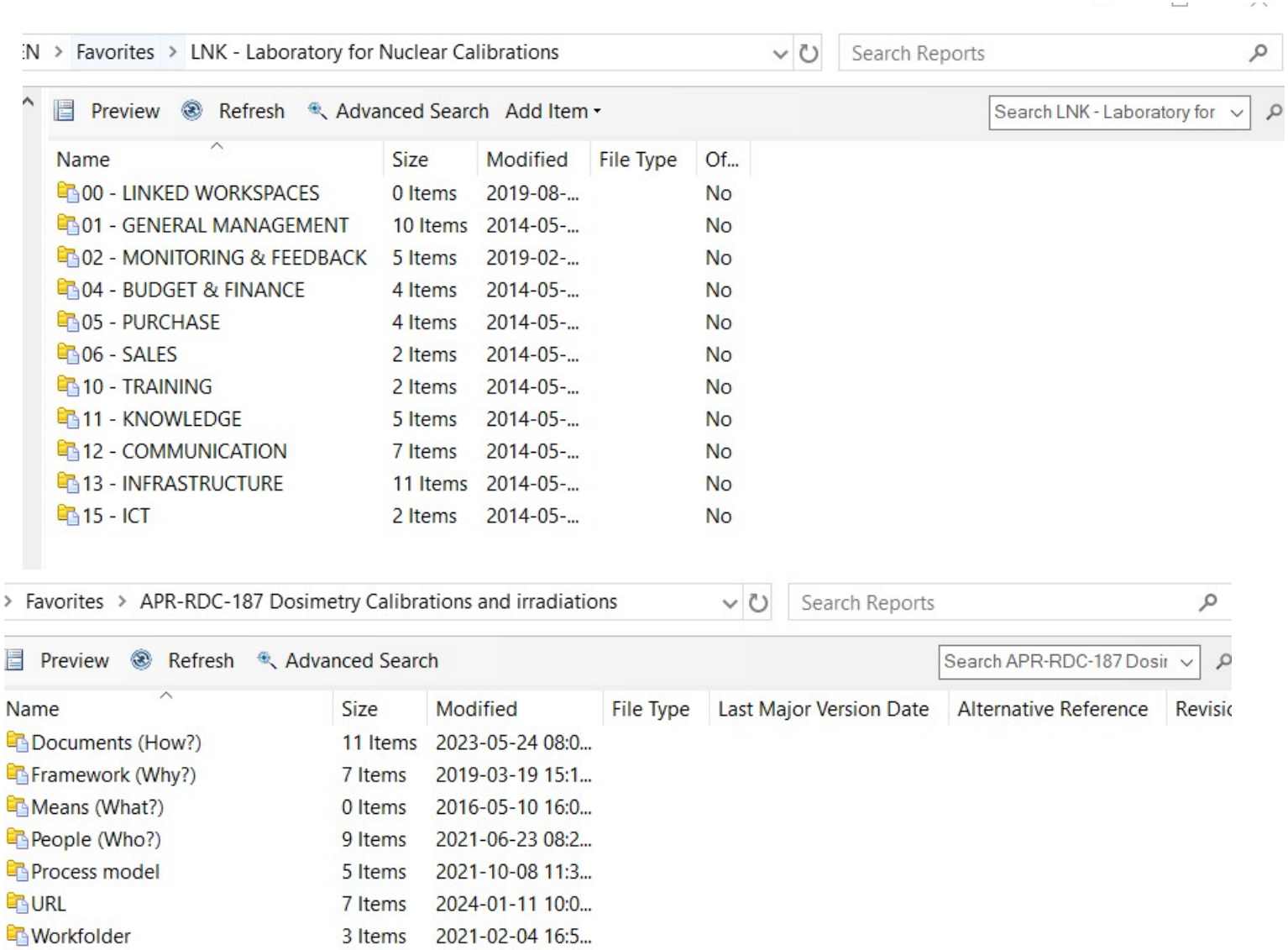
Excel template for data analysis and *pdf* generation:

- 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 dosemeter,
  - 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

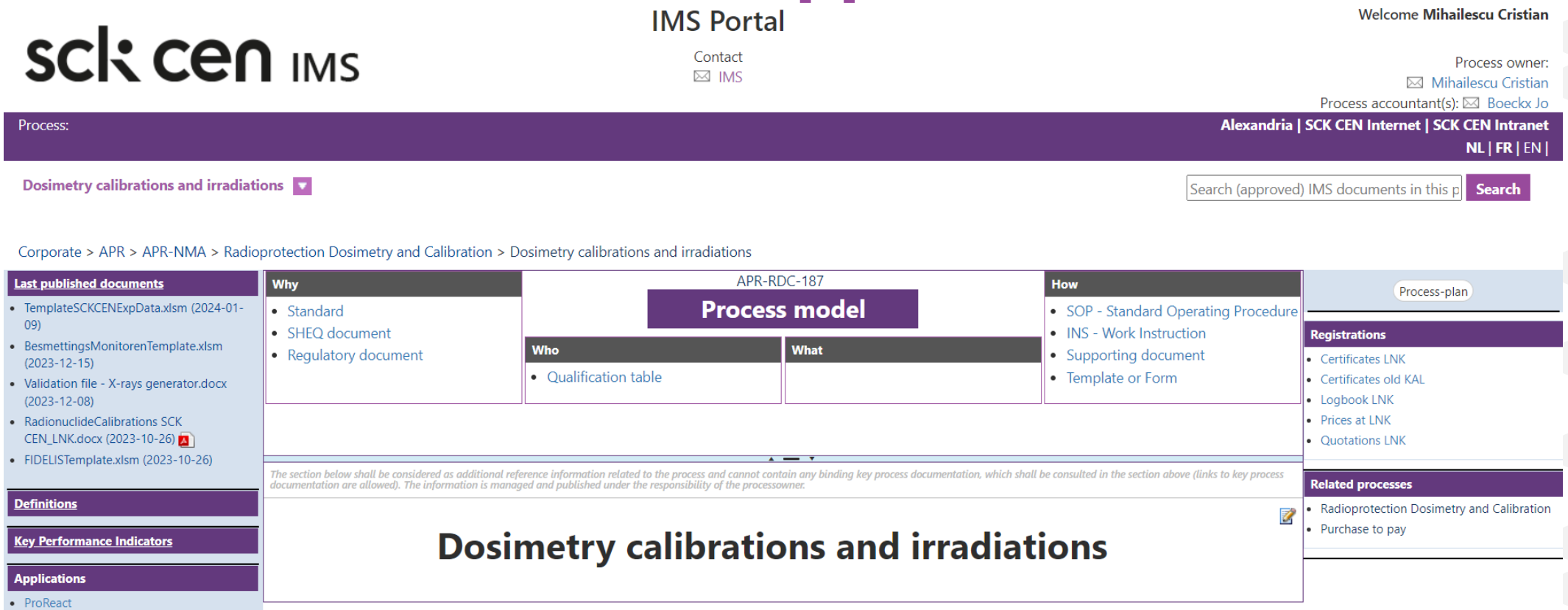


Document storage solution “Alexandria”:

- + cloud based
- + predefined folder structure for 2 levels
- + daily centralized back-up
- + multiple versions stored.

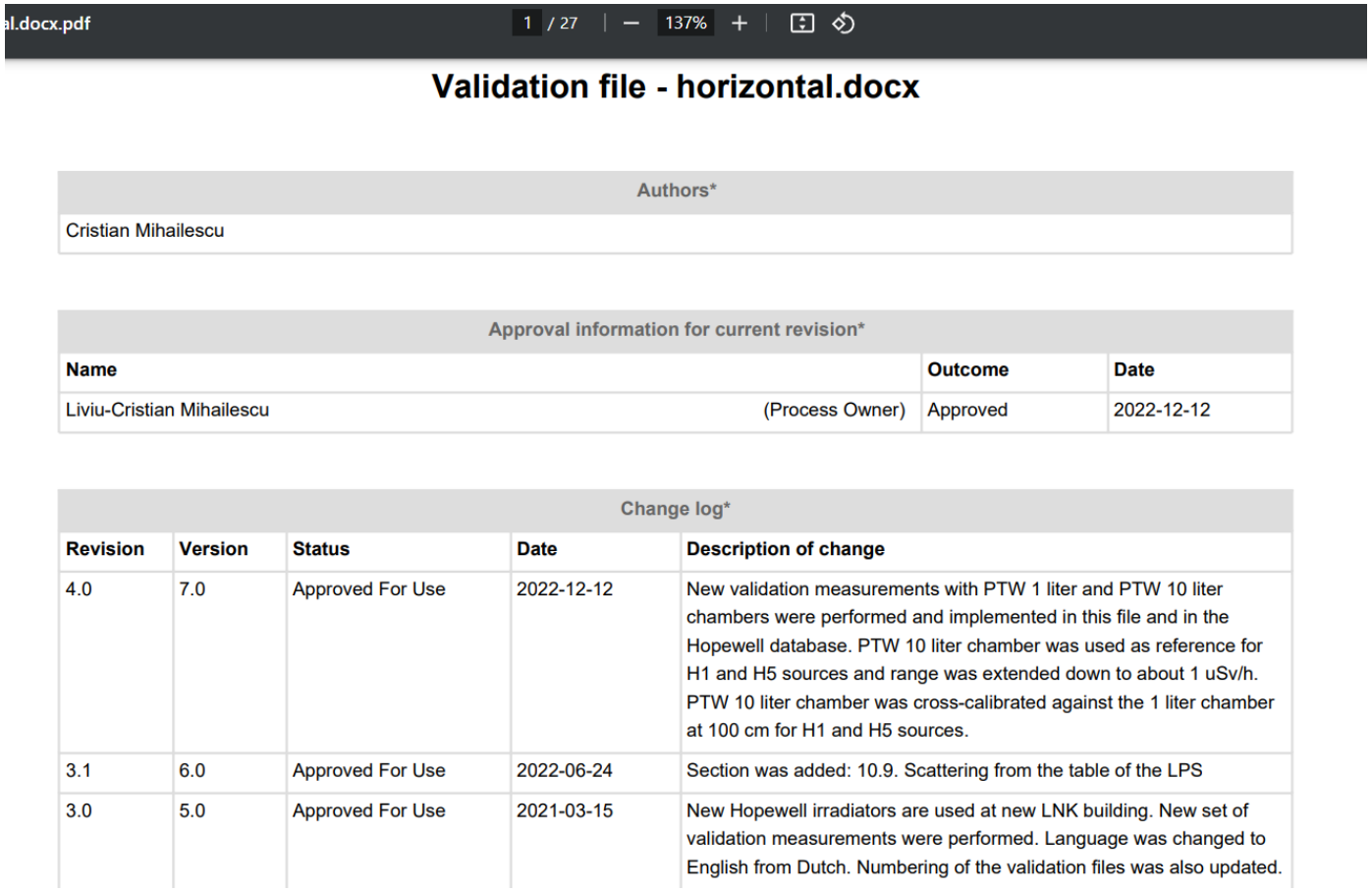
- - not well suited for large amount of data or uncommon data files (raw measurement data, binary files, executables,...)
- - interface with data acquisition software is difficult

QA documents – IMS applied at LNK



- 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



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* …

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Belgian Nuclear Research Centre

Foundation of Public Utility

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