Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin
Nationales Metrologieinstitut

PREPAREDNESS
Metrology for mobile detection of ionising radiation following a nuclear or radiological incident.

EURAMET

WP3: Monitoring of ionising radiation by non-governmental networks

Task 3.2: Feasibility study on the use of non-governmental dosimetry data for preparedness purposes

EMPIR Preparedness – Online Stakeholder Workshop, 10.12.2020

Viacheslav Morosh, 6.3 Radiation protection dosimetry

Non-governmental networks

- Safecast
- µRadMonitor
- GMC map
- Radmon
- Radiation network
- Radioactive@home

Iurlaro et al. (2019)

MINN type selection

MINN = Measuring Instrument used in Non-governmental Networks

Example of MINN	Supplier	Networks
uRAD Monitor Model A	Magna SCI	uRad Monitor
GMC-600	GQ Electronics	GMC map
bGaiger Nano	Safecast	Safecast
Radalert 100	International Medcom	Radiation Network/Safecast
GMC-320 Plus	GQ Electronics	GMC map / Radmon
GMC-500 Plus	GQ Electronics	GMC map / Radmon
uRAD Monitor model KIT1	Magna SCI	uRad Monitor
Monitor 4 Geiger Count KIT	S.E. International Inc.	Radiation Network
GMC-300 Plus	GQ Electronics	GMC map
RADEX 1212	Quarta-RAD Inc.	GMC map/ RadexRead Radiation Mapping
PMR 7000	Mazur	Radiation Network
Monitor 200	S.E. International Inc.	Radiation Network
uRAD Monitor Model D	Magna SCI	uRad Monitor
MyGeiger ver.3 PRO DIY	RH Electronics	Radmon
Inspector Alert	International Medcom	Radiation Network
Rad 100	International Medcom	Radiation Network/Safecast

Final list of 16 MINN types for the study:

MINN type	GM tube type
Gamma Scout	LND 712
Rad 100	LND 712
RadAlert Monitor 200	LND 712
Monitor 4 KIT	LND 712
µRAD Monitor A3	SI-29 BG
GMC 500+:	SI-29 BG and M 4011
Mazur PRM-7000	LND 713
µRAD Monitor A3.4	SBM 20
MyGeiger ver.3 pro	SBM 20
µRAD Monitor KIT1	SBM 20
Radex RD 1212 BT	SBM 20
Soeks Quantum	2 x SBM 20-1
Radex RD1706	2 x SBM 20-1
Radex RD1503+	SBM 20-1
GMC300E+	M 4011
GMC320+	M 4011
bGeigie Nano	LND 7317
Inspector Alert V2	LND 7317

MINN type selection

PTB

4x

ENEA

4x

∑ = 64 MINNs

NPL

4x

VINS

4x

Reading of a MINN

$$\dot{G}_{MINN} = \underbrace{\dot{M}_0}_{\text{Inherent background}} + \underbrace{q_{terr} \cdot \dot{H}^*_{ref,\,terr}(10)}_{\text{Terrestrial radiation}} + \underbrace{q_{SCR} \cdot \dot{H}^*_{ref,\,SCR}(10)}_{\text{Secondary cosmic radiation}} + \underbrace{q_{art} \cdot \dot{H}^*_{ref,\,art}(10)}_{\text{Artificial radiation}}$$

$\dot{M}_0$= inherent background or self-effect of the instrument

q_{SCR} =response to secondary cosmic radiation

q_{TR} =response to terrestrial radiation

q_{Art}=response to artificial radiation (function on E and direction of radiation)

$\dot{H}^*(10)_{ref,SCR}$ =ambient dose equivalent rate due to secondary cosmic radiation

$\dot{H}^*(10)_{ref,terr}$ =ambient dose equivalent rate due to terrestrial radiation

$\dot{H}^*(10)_{ref,art}$ = ambient dose equivalent rate due to artificial radiation

Test campaign at PTB in June 2019

(UDO II, lake platform, plume simulation)

Reference and Measuring Sites at the PTB (Working Group 6.32)

Reference site

Continuous measurement of separated contributions to $\dot{H}^*(10)$ in the environment caused by

- ➢ **terrestrial $\dot{H}^*(10)_{terr}$** and
- ➢ **secondary cosmic radiation (SCR) $\dot{H}^*(10)_{SCR}$**

Plume simulation setup

Simulation of a radioactive plume for quality assurance of dosimetry systems and measurement methods.

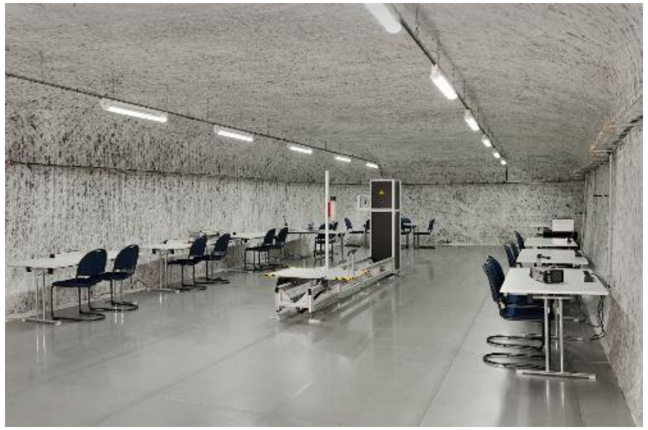
- ➢ **terrestrial, $\dot{H}^*(10)_{terr}$**
- ➢ **SCR, $\dot{H}^*(10)_{SCR}$**
- ➢ **Artificial, $\dot{H}^*(10)_{art}$**

Cs-137, Co-60, Ra-226

Measuring site for secondary cosmic radiation

- ✓ **No terrestrial radiation.**

(Climatic cabinet later)



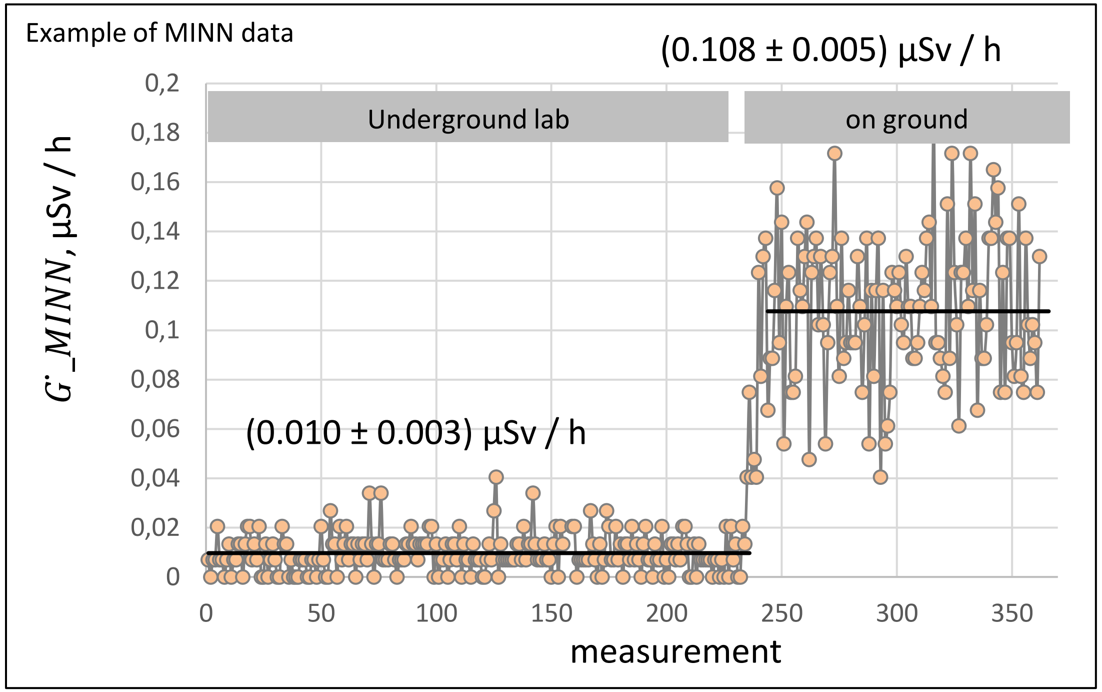
UDO II underground laboratory at a depth of 430 m

Calibration and characterization of measuring instruments

- ✓ **No SCR**
- ✓ **No terrestrial radiation**

Inherent background

(UDO II underground laboratory)

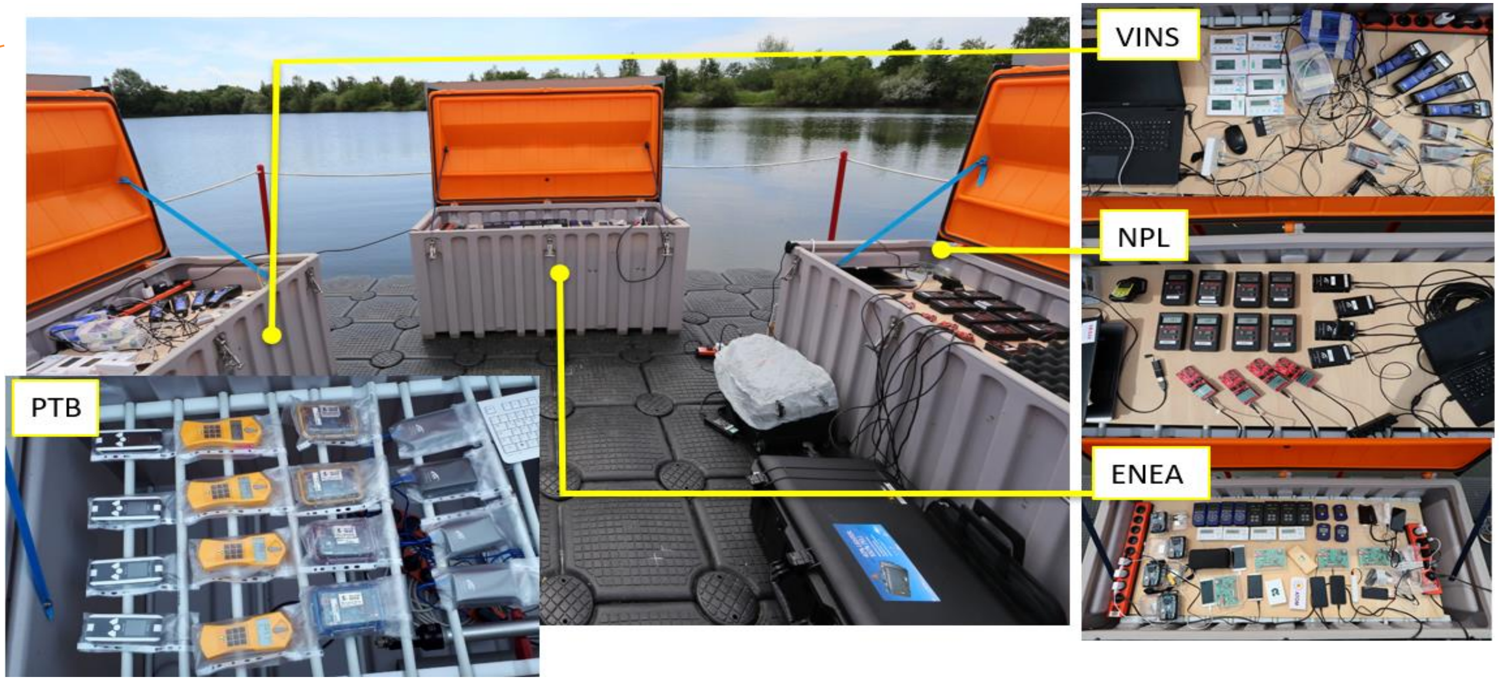


MINNs were exposed to the laboratory background of (1.5 ± 0.2) nSv/h.
Measurement duration was ca. 4 hours.

$$\dot{G}_{MINN} = \dot{M}$$

- Self-effect range: 10 to 55 in nSv/h.
- GM tubes of same type or similar size } { comparable self-effect
- larger sensors → higher self-effect (not valid for „pancake“ type!)

Response to secondary cosmic radiation (SCR)



Terrestrial radiation is „switched off“.

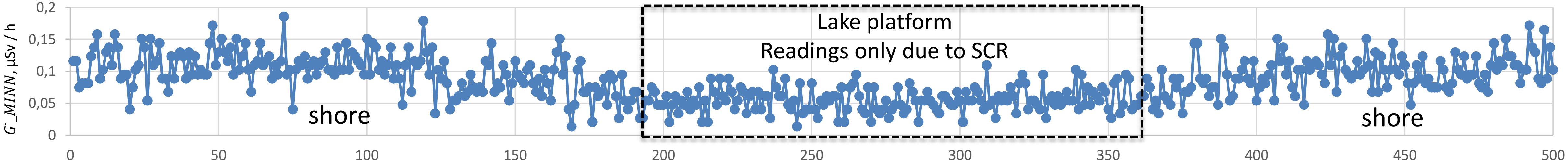
No artificial radiation.

<u>MINN exposed to only SCR!</u>

Measurement duration: ca. 1.5 h

$$\dot{G}_{MINN} = \dot{M} + q_{SCR} \cdot \dot{H}^{*}(10)_{ref,\,SCR}$$

<u>Almost all MINNs have an overresponse (>150 %) when exposed to SCR.</u>
<u>Inherent background has been subtracted.</u>



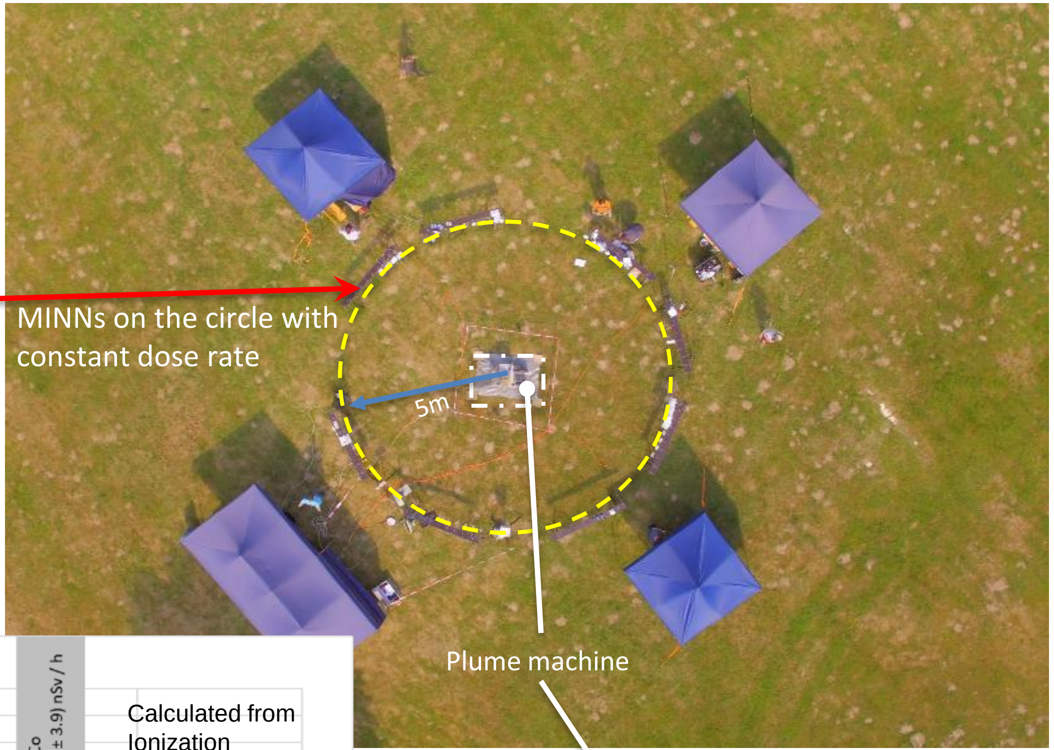
Plume simulation

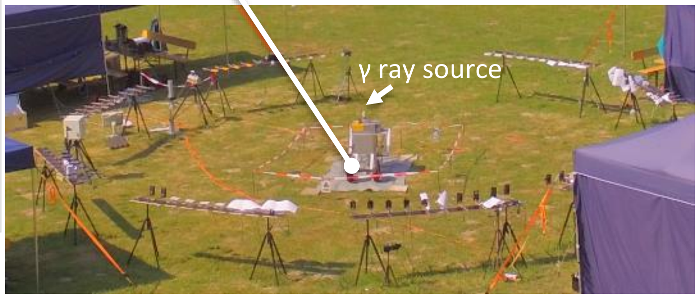
Contribution to the MINN readings due to terrestrial and SCR are const over the whole testing period:

$$\underbrace{\dot{G}_{MINN}}_{\text{const}} = \dot{G}^*_{BG} + \underbrace{q_{art} \cdot \dot{H}^*_{ref,\,art}(10)}_{\text{varying}}$$

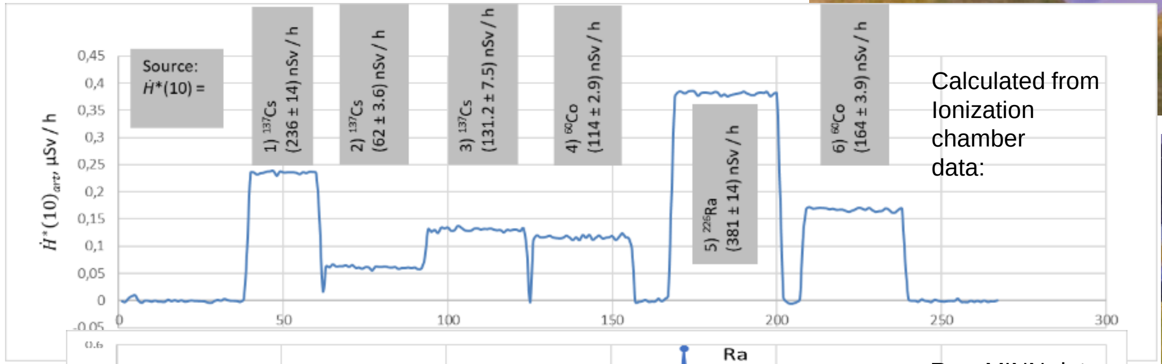
with $\dot{G}_{BG} = \dot{M}_0 + q_{terr} \cdot \dot{H}^*(10)_{ref,\,terr} +$
$+\, q_{SCR} \cdot \dot{H}^*(10)_{ref,\,SCR}$

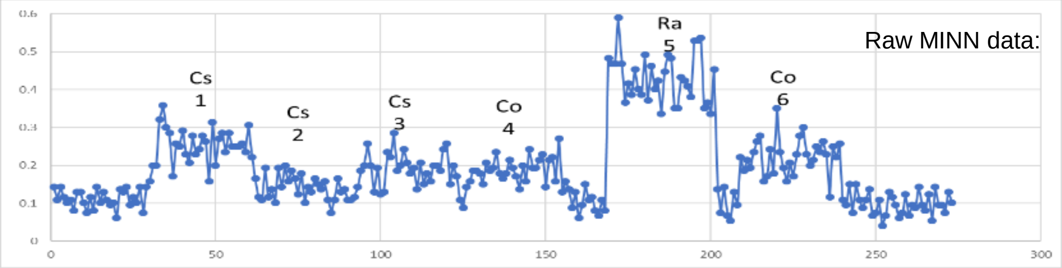
Used gamma ray sources: Cs-137, Co-60, Ra-226





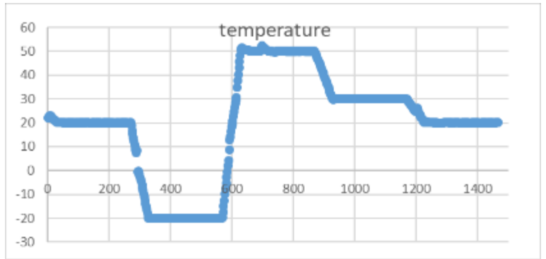
Artificial dose rate profile:

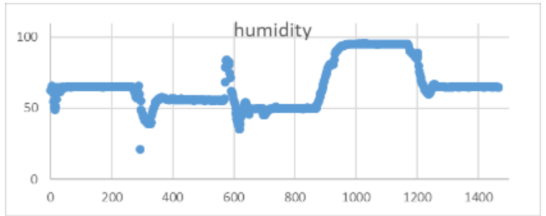




Performance is dependent on nuclide.
Most of the MINNs under-estimate the $\dot{H}^*_{ref,\,art}(10)$ for all nuclides in test.

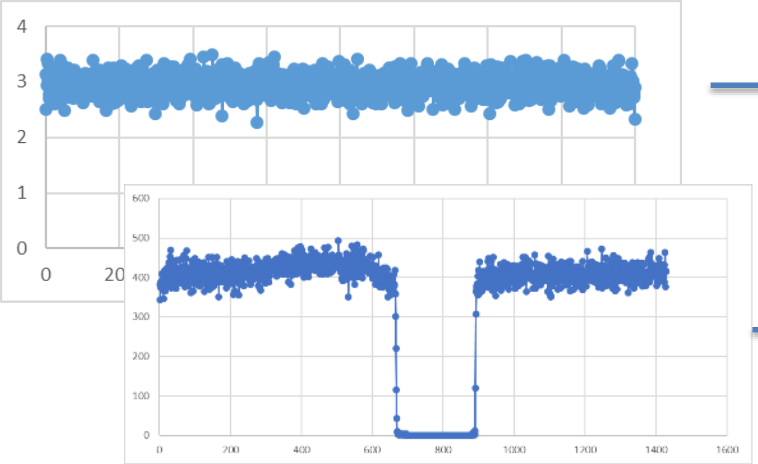
Climatic test



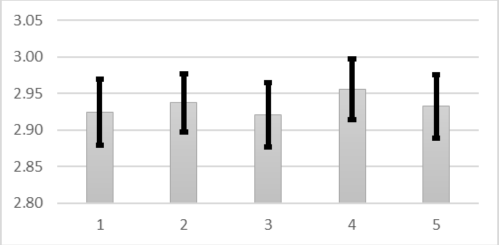


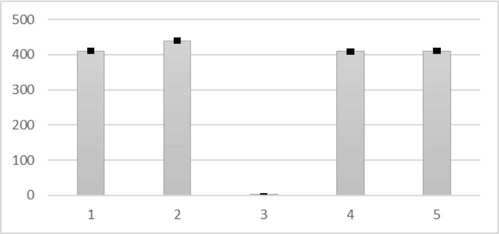
t, °C	r.h., %
20	65
-20	0
50	50
30	95
20	65

MINN output:



Mean values of the MINN output:

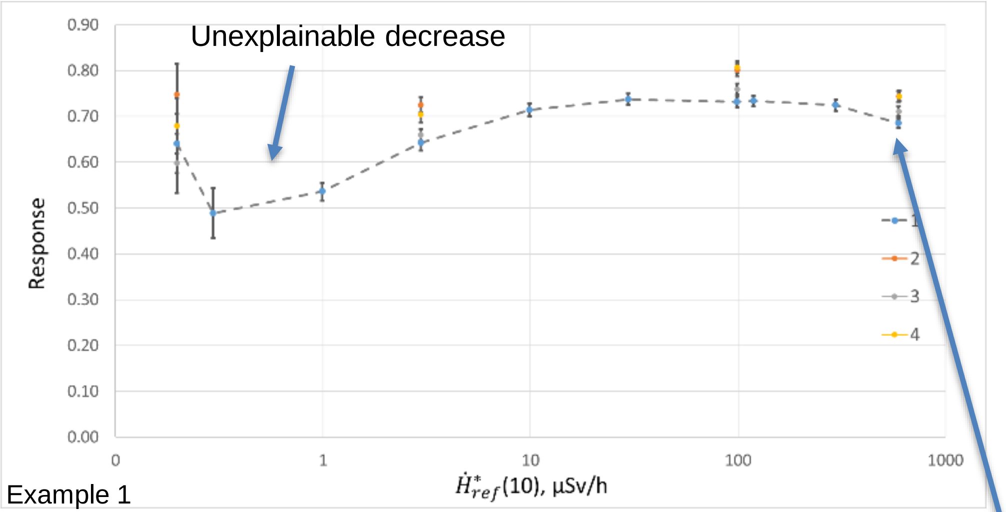


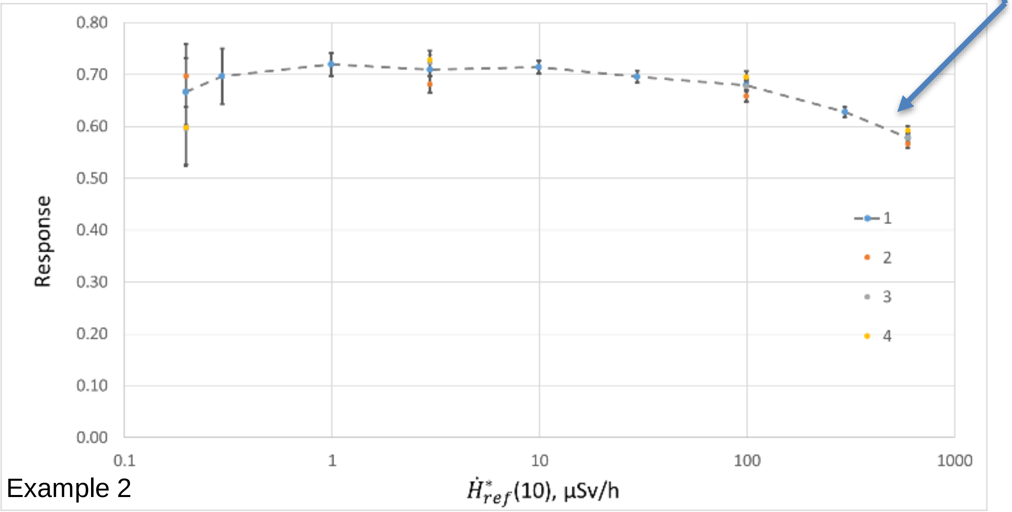


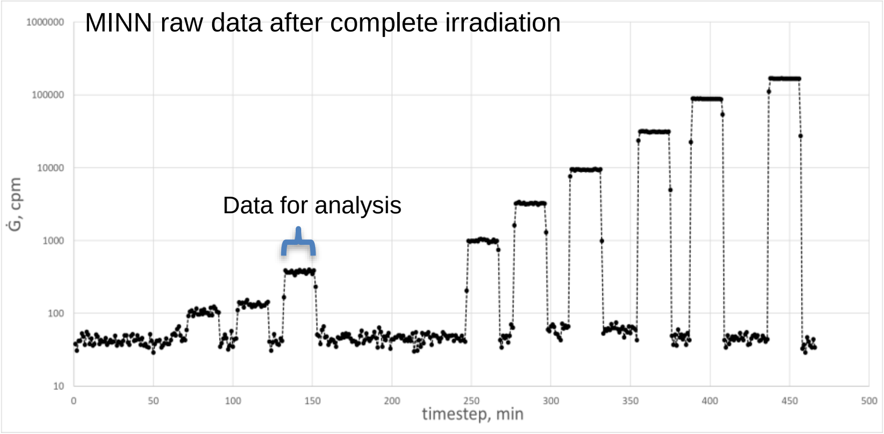
Most tested MINN types showed no significant deviations!

Linearity of the response

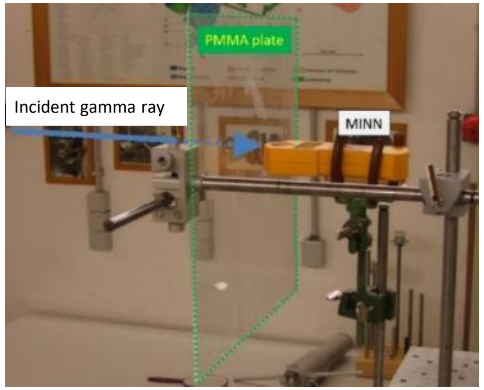
Characterization at partner institutions in accordance with ISO 4037-1 standard

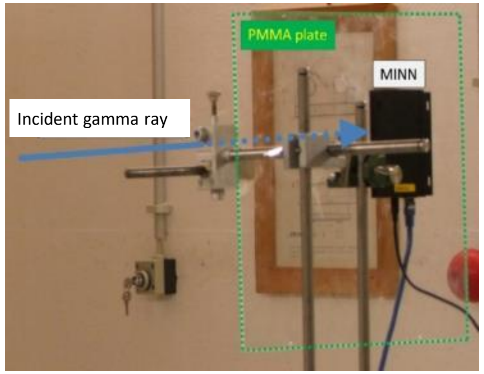


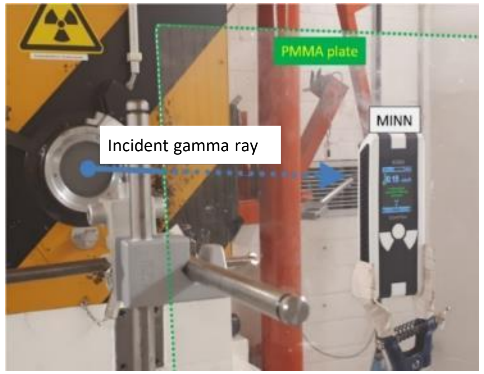




Decrease due to dead time effect → no or „gentle“ correction!

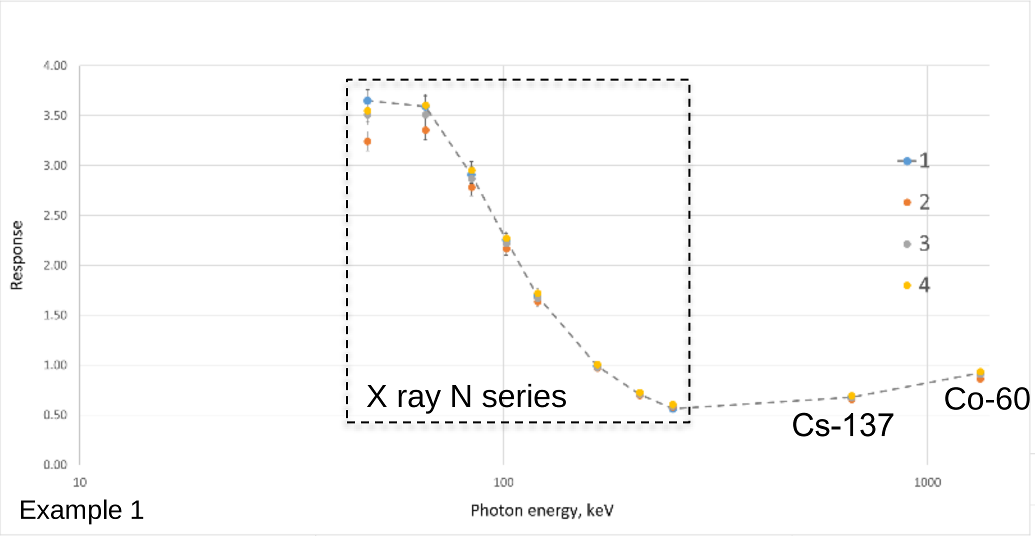


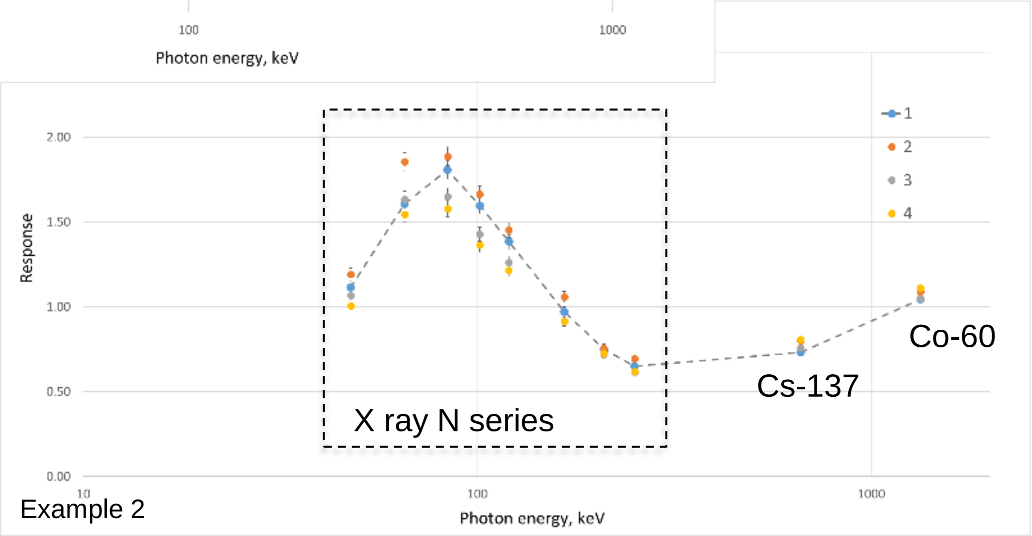


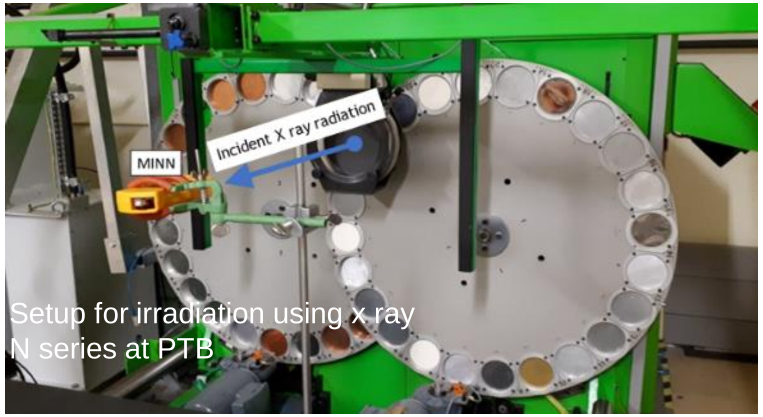


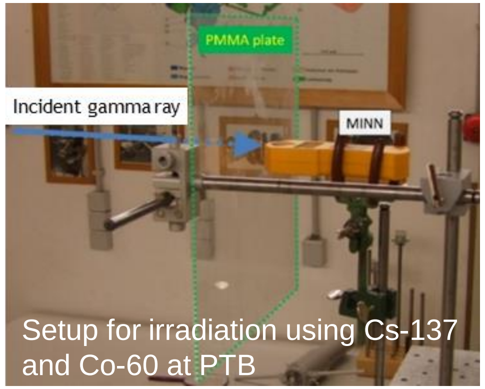
Energy dependency of the response

Characterization at partner institutions in accordance with ISO 4037-1 standard









Strong energy dependence at low energies!

Conclusions

- Information based on non-governmental measurements using MINNs should be used with great precautions

(e. g. fake data, malfunctioning MINNs, bad energy response, proper location, outdated data).

- Large amount of data might be useful to track radioactive plumes and to detect radioactive contaminations.
- A paper which summarizes and analyses all results of this study has been submitted for publication.

Thank you!

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