

Low Radon Cleanroom for Underground Laboratories

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This work was carried out in the framework of the research projects :

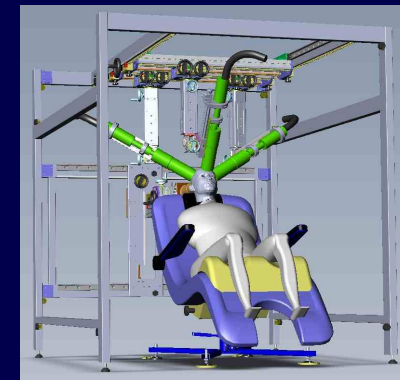
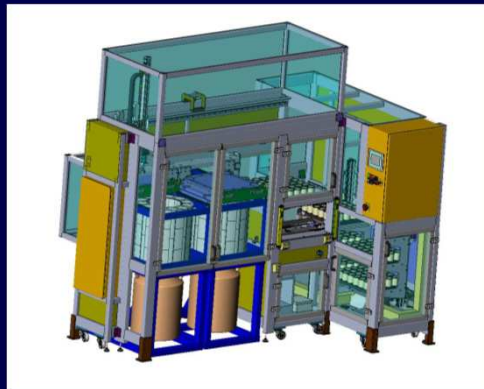
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REASON

for the minimization of Rn/Rn daughters concentration and aerosol concentration in the Radon Cleanroom air + enabling human stay

Fundamental Research:

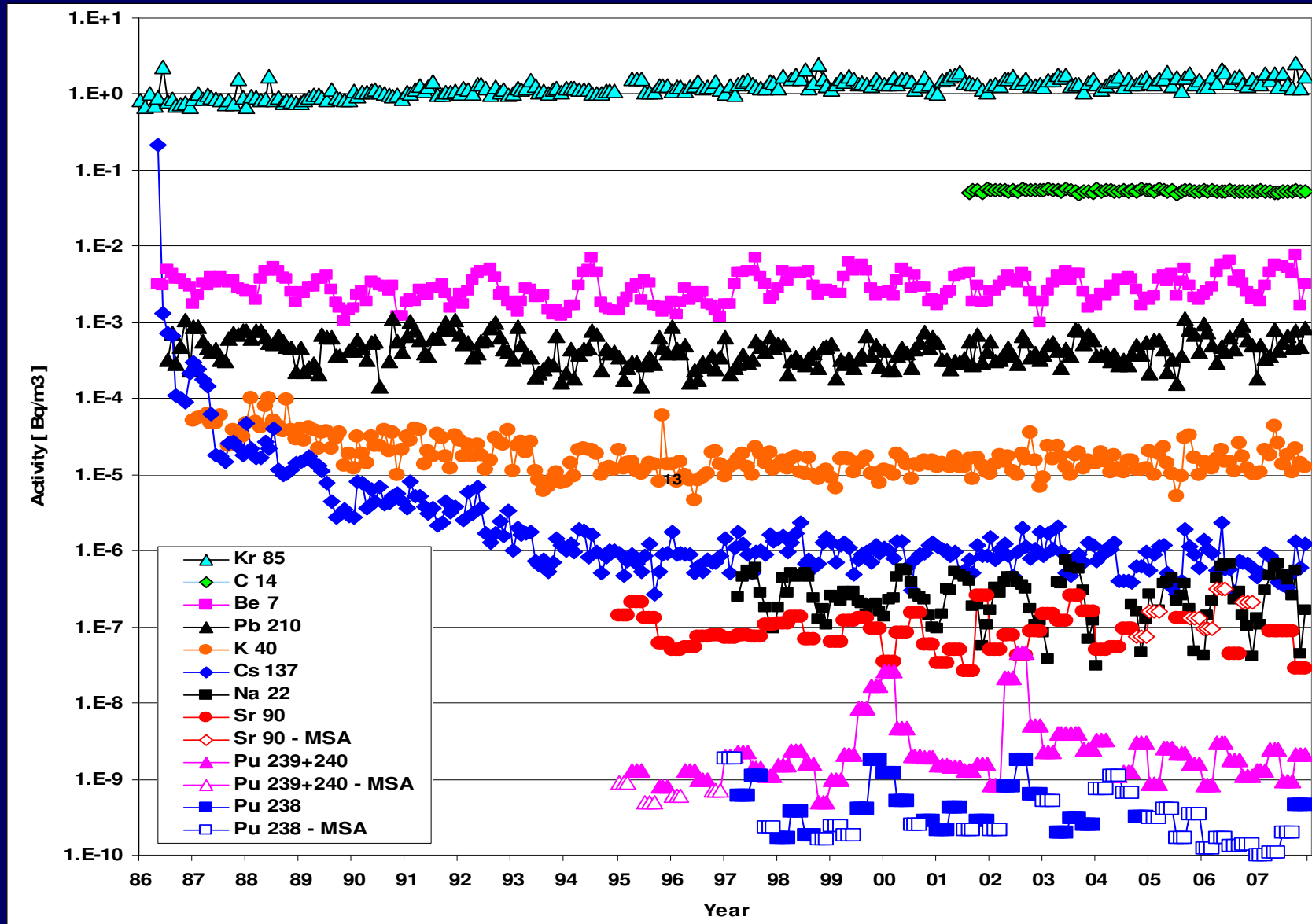
- ❑ behaviour of cells or DNA or animals in the radiation free „ZERO DOSE“ environment
- ❑ Ultra low activity self-contamination of „complex detection systems“
- ❑ ultra low activity measurements in human body (in vivo) or environmental samples, etc



Industry:

- ❑ detectors/sensors fabrication for low background experiments
- ❑ contamination in nano-electronics (the influence of „single event effect“ caused by alpha particles from radon decay product) .

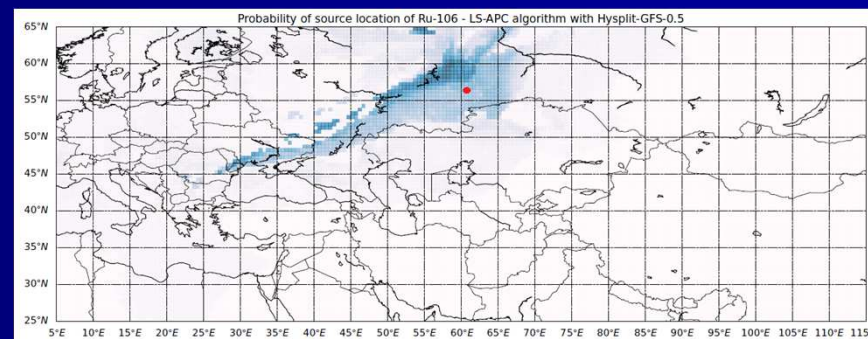
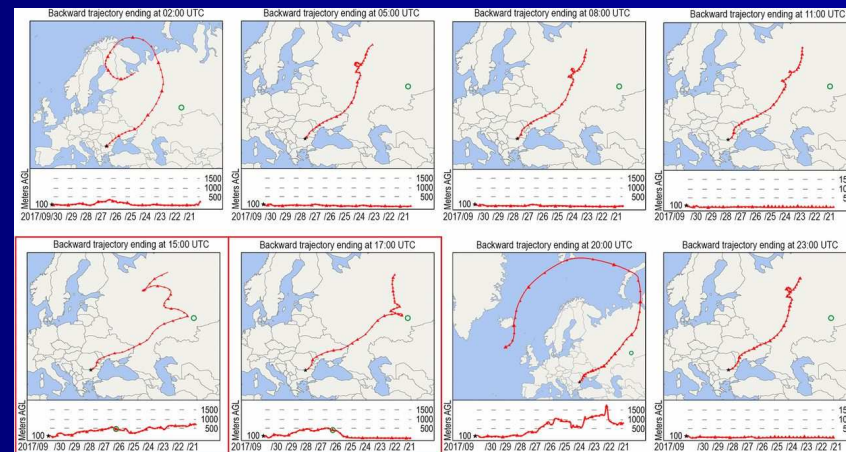
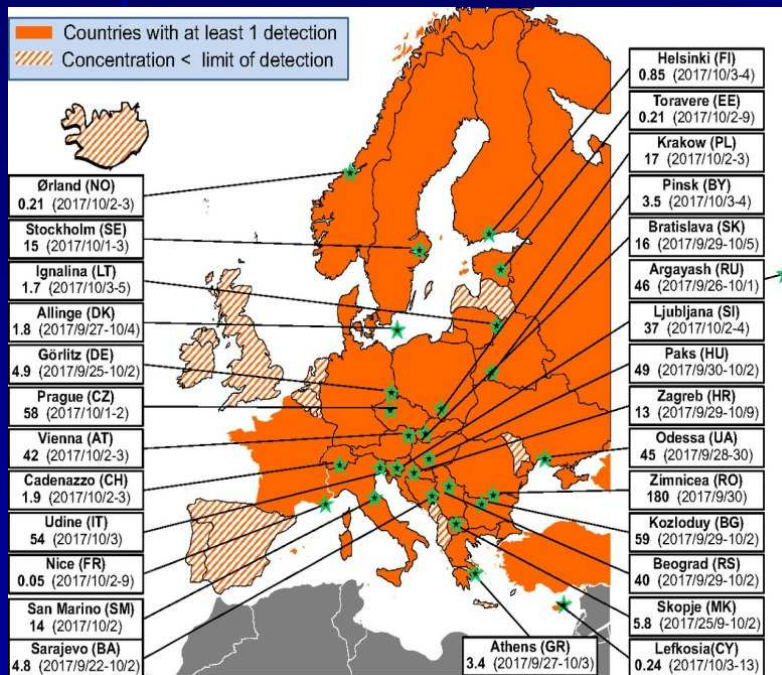
Example: Airborne radioactive isotopes concentrations (Prague)



Airborne concentrations of radioactive ruthenium from an undeclared major nuclear release in 2017 (PNAS August 20, 2019 116 (34))

In October 2017, most European countries reported unique atmospheric detections of aerosol-bound radoruthenium (^{106}Ru). The range of concentrations varied from some tenths of $\mu\text{Bq}\cdot\text{m}^{-3}$ to more than $150 \text{ mBq}\cdot\text{m}^{-3}$.

Today most of these European networks are connected to each other via the informal "Ring of Five" (Ro5) platform for the purpose of rapid exchange of expert information on a laboratory level about airborne radionuclides detected at trace levels.



For such special cases the demand for **radon** minimum concentrations in ambient air should be the level **some mBq/m³**

and radon decay products
some mikroBq/m³.

Since Rn concentrations in buildings ... 10-1000 Bq/m³ ,
in outdoor atmosphere some tens of Bq/m³,

to achieve indoor level of mBq/m³
special sealed system able to reduce radon concentration

by factor more than 1000 times

in comparison to the standard environment.

Project objectives:

To build step by step a room (space) with minimal radon and radiation background enabling human stay

a) low radon concentration

< 100 mBq/m³

In future < 10 mBq/m³

(< 1 mBq/m³)

b) + with very low aerosol concentration

„Clean room“ in terms of ISO (class 5 - highest class of cleanliness) in the presence of

c) + Low cosmic radiation background

d) + Low external gamma background

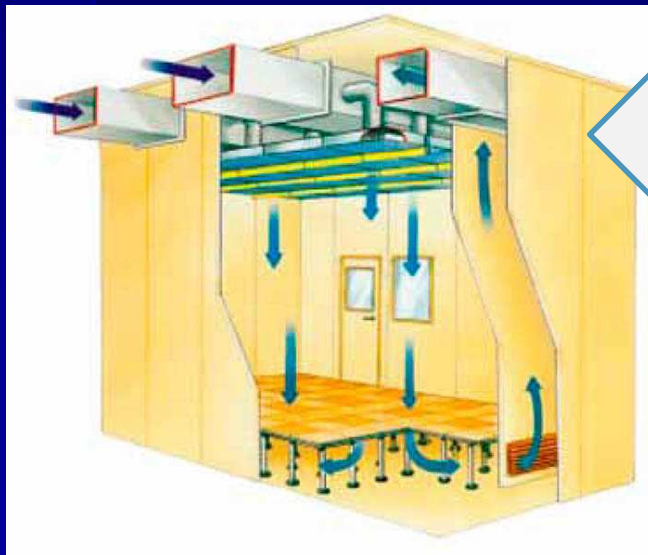
Principle: Clean and „radon free“ room (IEAP+SURO)

Principle of the normal “CLEAN ROOM”:

The room is intensively ventilated and filtered by HEPA filtration system with filtration rate of 8000 m³/h to reach highest class of cleanliness (ISO 5)
laminar air flow - to reach aerosol free space
Normal outdoor air is used for filtration

Principle of the “RADON FREE ROOM”:

- Clean uncontaminated building material (metal sandwich panels with thermal insulation)
- sealed against radon from soil and **outdoor radon**
- delivery of **only radon free air** (20 m³/h - 150 m³/h) (< 10 mBq/m³ from Radon reduction system facility)
- Minimize Rn exhalation from persons



combine both
properties

Indoor
10-100 mBq/m³



Outdoor
10-100 Bq/m³

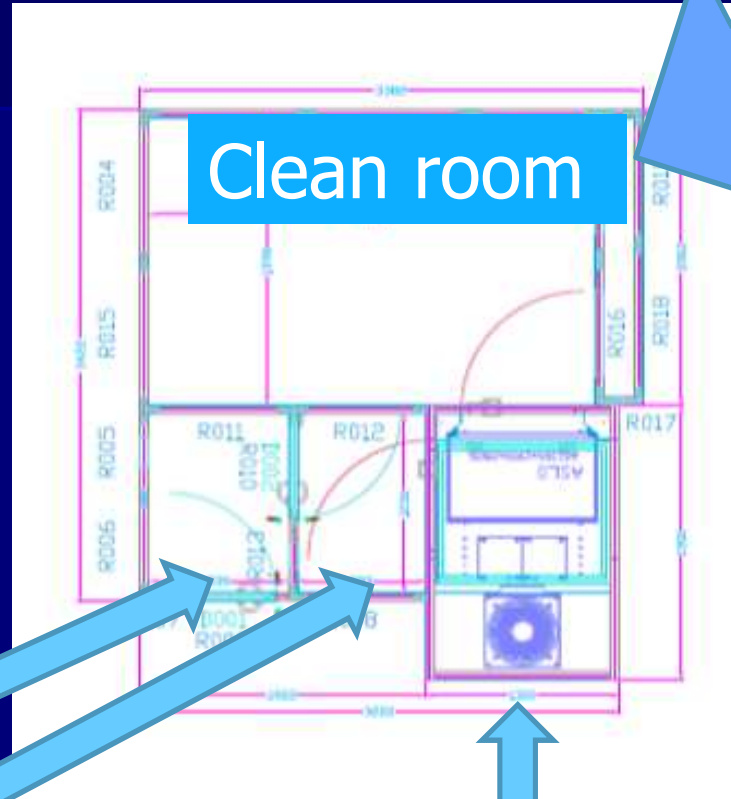
Schematic plan Low Radon Cleanroom



1. undressing room (unclean)



2. dressing room („cleaner“)
special dress



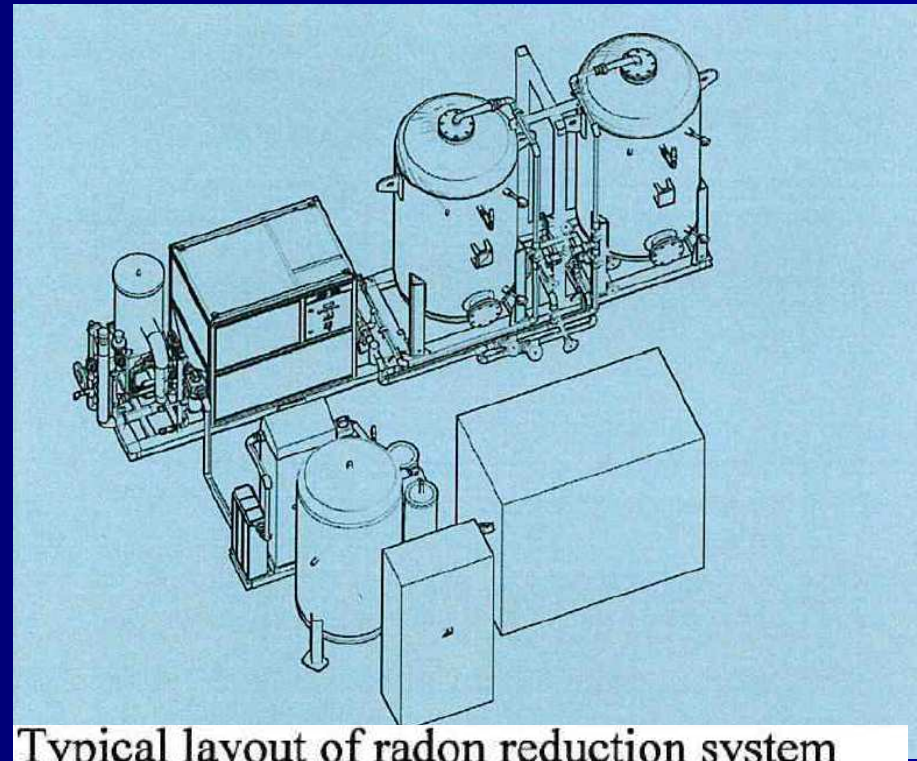
continuous
supply of
low radon air



air shower
To clean special
dress surface



**Source of radon free air
(Radon reduction facility e.g.ATEKO
(20 – 300 m³/h of „radon free air“)
radon from air is trapped at cooled activated carbon**

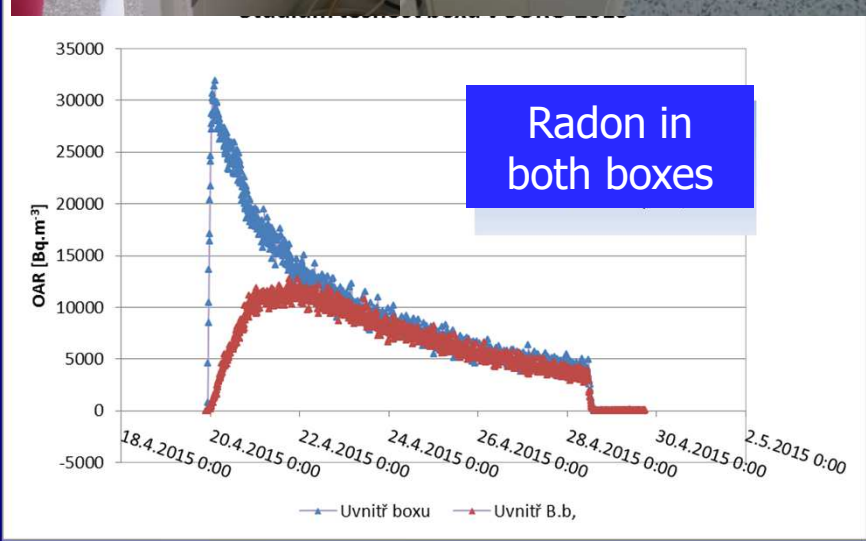


Typical layout of radon reduction system

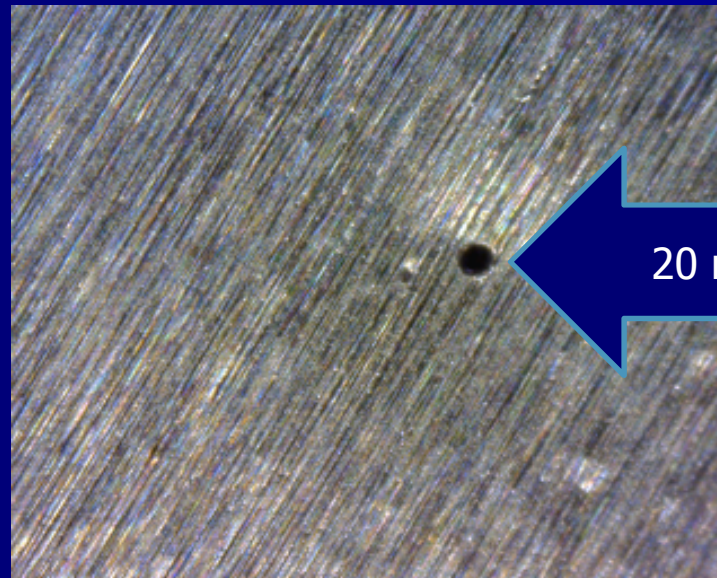
The problems we encountered while building low radon clean room (enabling human stay)

- Room tightness problem:
- Room tightness problem in case of high volume ventilation and filtration
- The effect of radon exhalation from human body

Room tightness problem: testing of seals and leaks

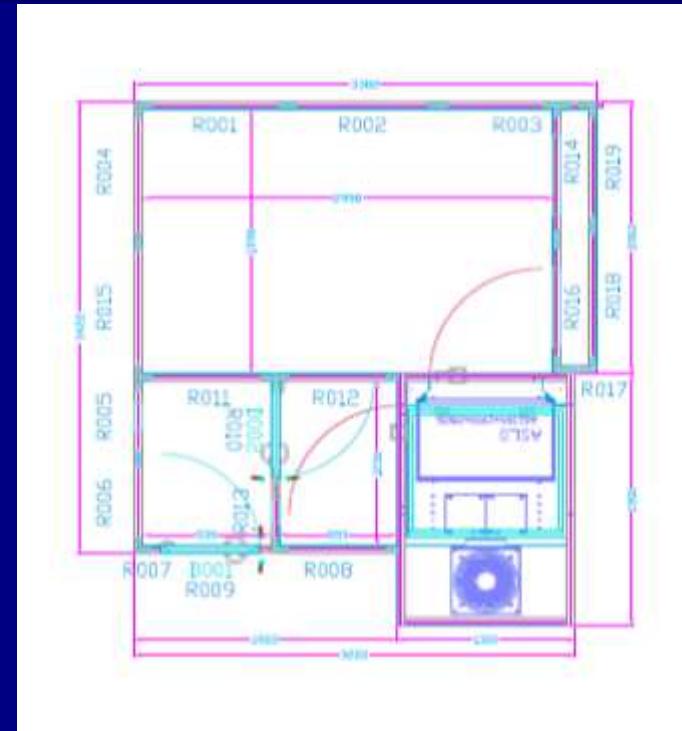
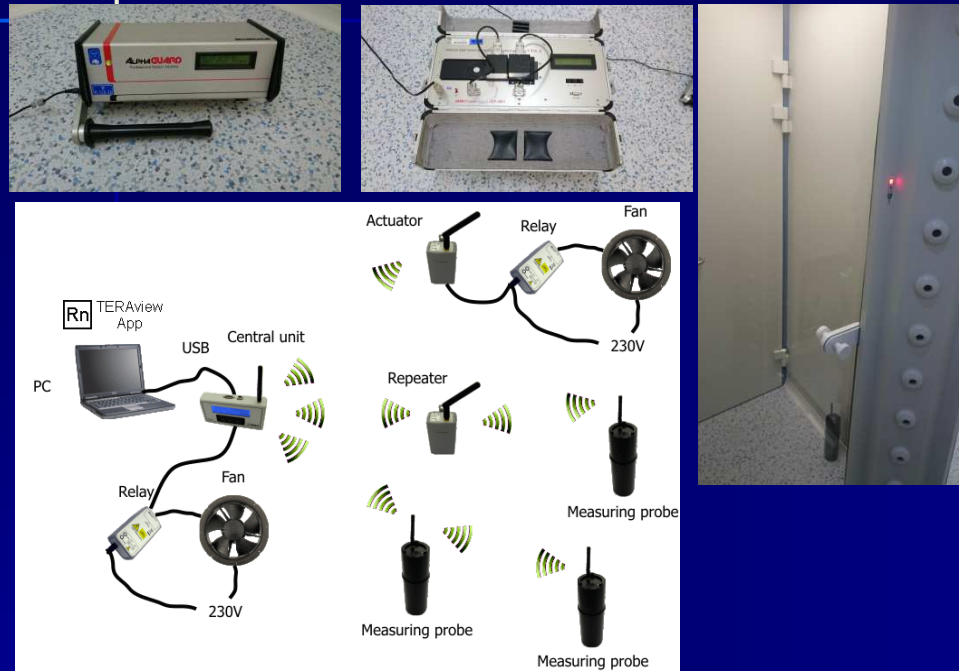


Study of leak of radon through small holes (TROPAC foil)



Monitoring systems

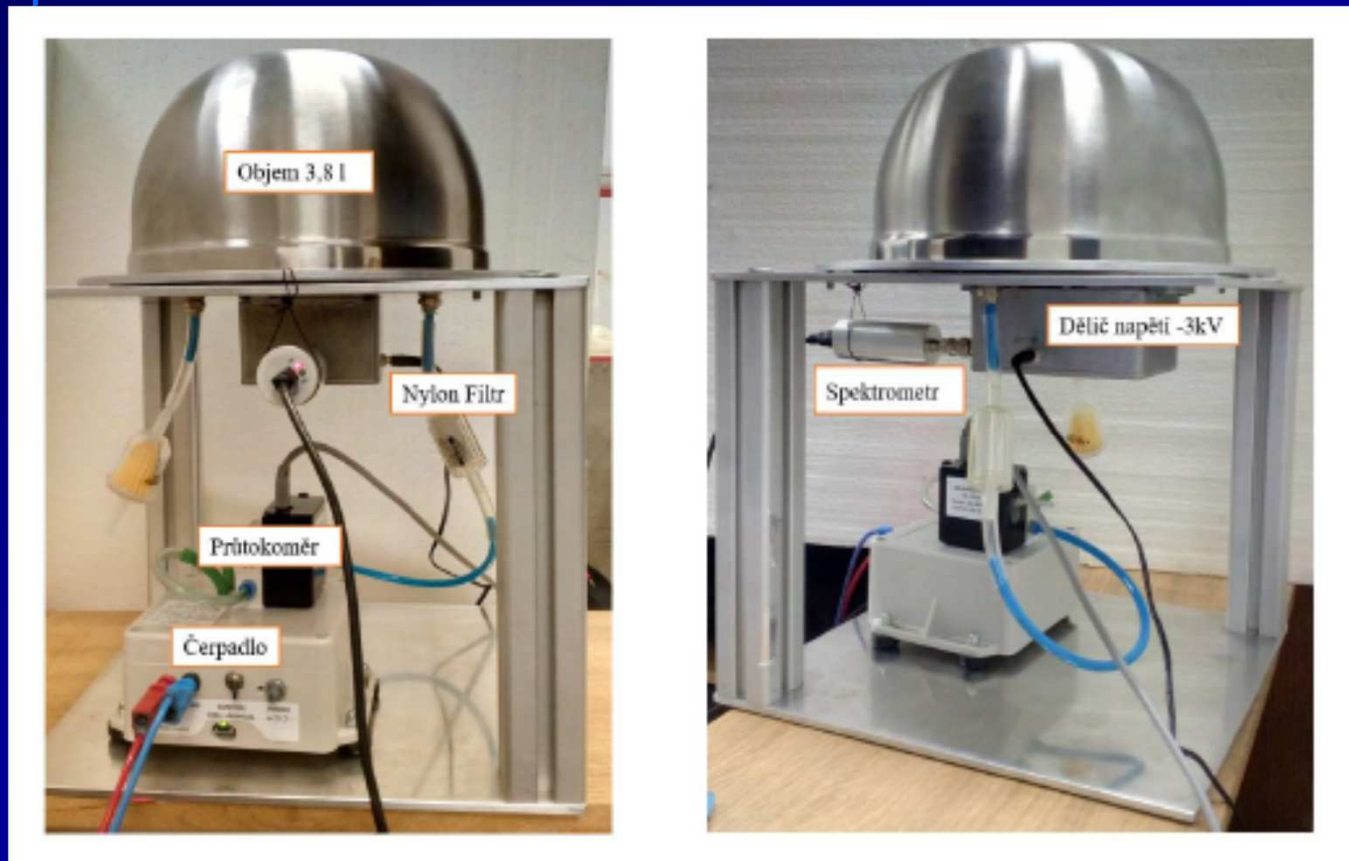
FRITRA, AlphaGuard, and TESLA TERA radon probes were used for on-line radon monitoring in different parts of system and outdoor (to control the environment)



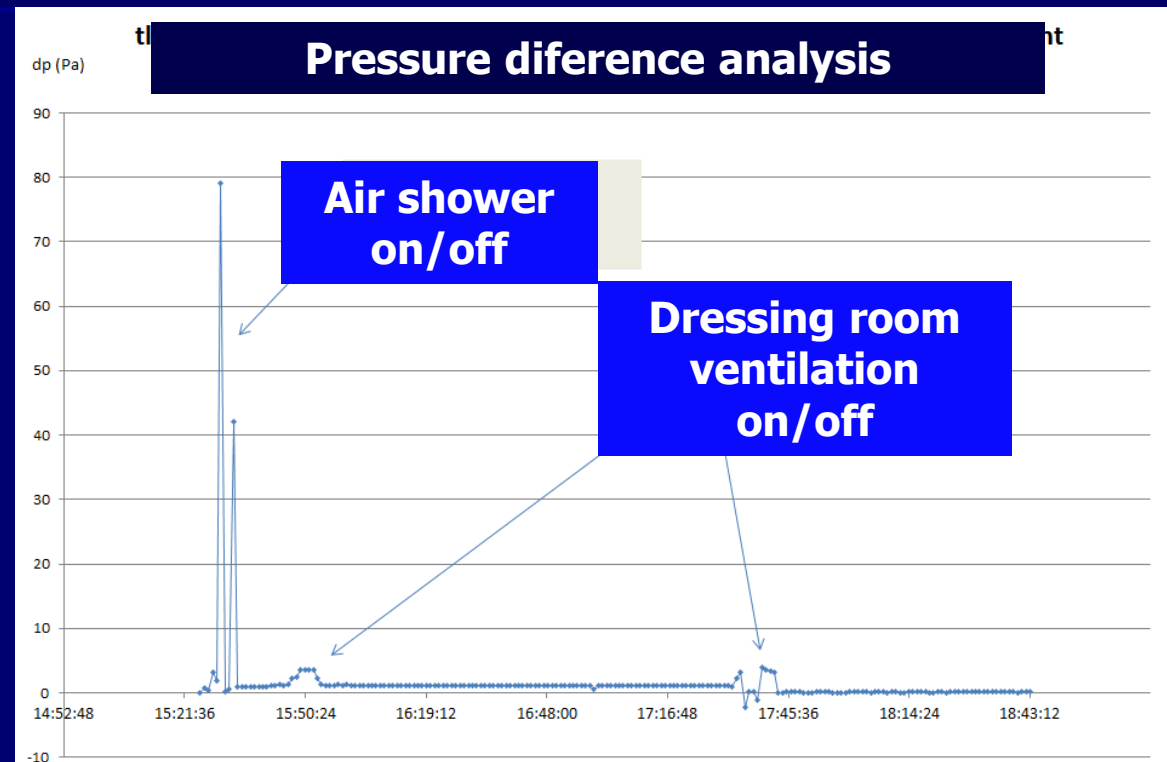
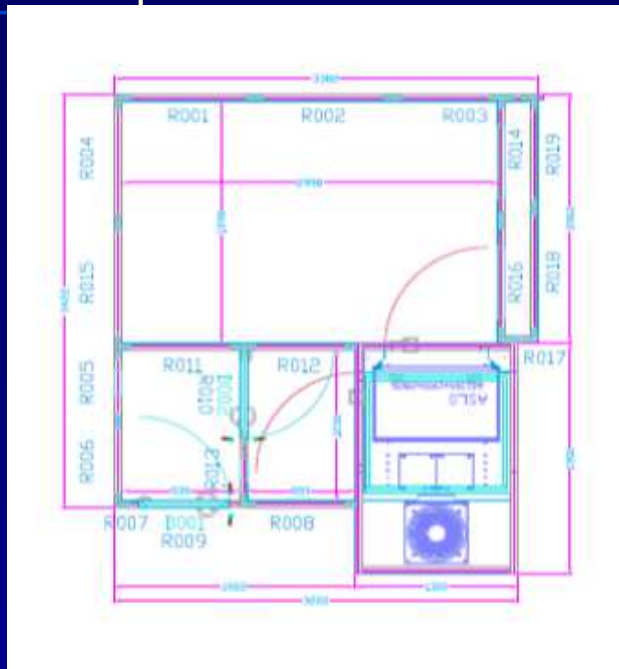
Rn injection or constant emanation source were used to study radon and air transport and kinetics

How to measure ultra low concentration (mBq/m³) ?

Ultra sensitive (<10 mBq/m³) continual radon monitor for measurement in radon clean room developed by IEAP CVUT Prague
(electro-deposition of Rn decay products to Si detector)

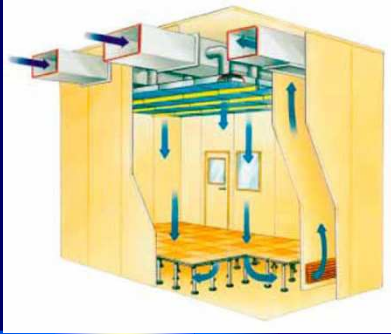


Influence of pressure gradient (between adjacent rooms)



Small overpressure (some 10 Pa) in radon free room is necessary (overpressure done by radon free air supply from ATEKO system)

Room tightness problem II case of high volume ventilation and filtration

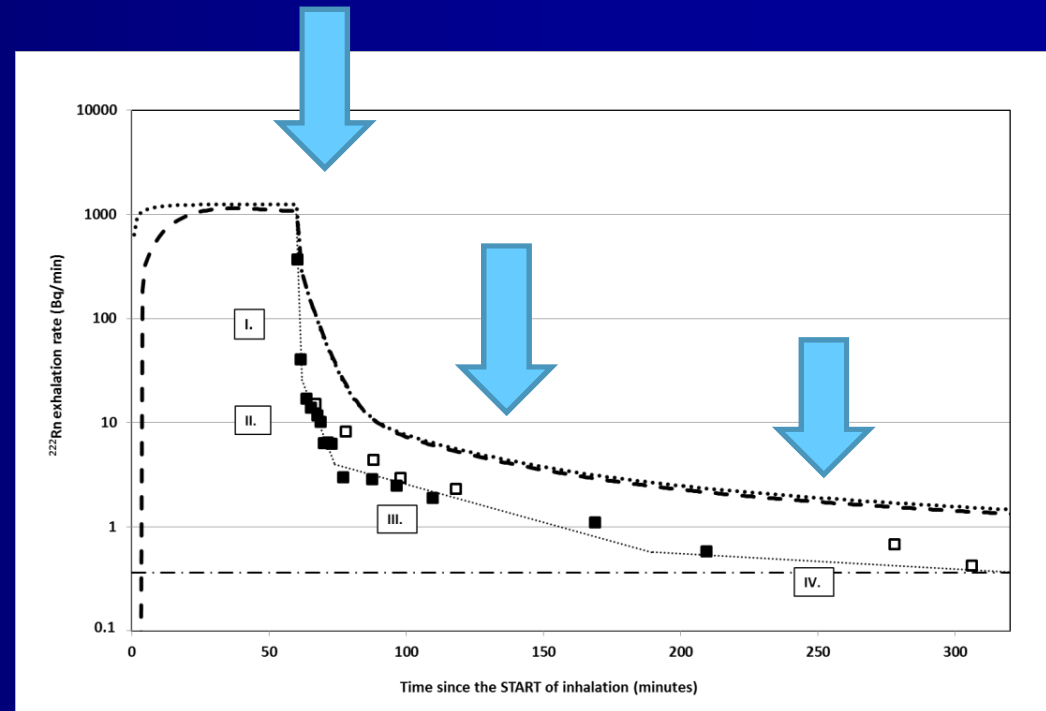


III. Radon in the body and Rn exhalation from it - effect at low radon clean room

(experiment in SURO Rn chamber with volunteer)



- Human body contains usually some 1-100 Bq of dissolved radon
- Exhalation from the body (breathing dominates) can cause sharp Rn increase after human entry at low radon clean room
- Fortunately, radon emanates from the body quickly (breathing)
- However, temporary stay outside, should be taken into account



Results at „low radon cleanroom“ (SURO + IEAP)

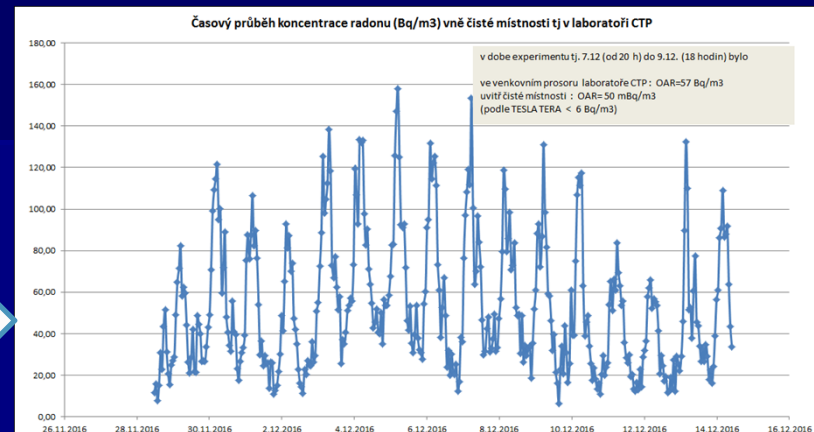


**Radon
outdoor**

20-160 Bq/m³

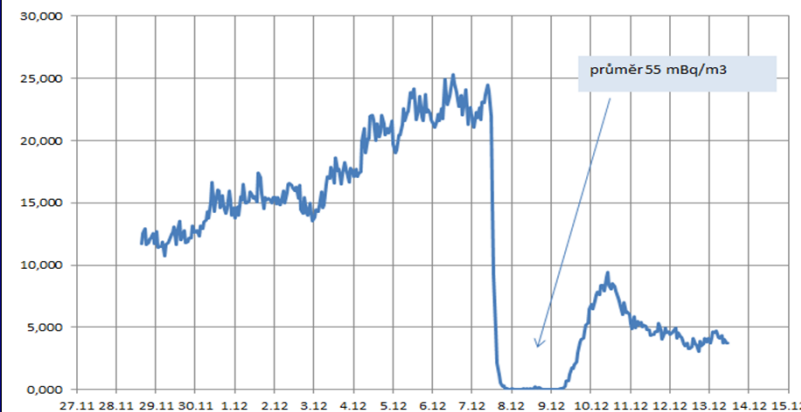
**Rn concentration
in the
low radon cleanroom**

**it was reached
< 60 mBq/m³**



Měření v prostoru laboratoře CTP (vně čisté místnosti) – prosinec 2016

Časový průběh koncentrace radonu (mBq/m³) v čisté místnosti po finálním utěsnění a max.přísunu nízkoradonového vzduchu (20 m³/h) dne 7.12.



Měření v čisté místnosti – prosinec 2016

Two Radon clean rooms were built:

- 1) SURO Prague – for research of technology
- 2) at LSM (Laboratoire Souterrain de Modane - Ultra low level background) – prepared for testing



Thank you

"No Animals Were Harmed in the Experiments"