



HKIOEH Annual General Meeting 2021 &  
Annual Occupational Hygiene Technical Conference

# SOURCE IDENTIFICATION AND CONTROL FOR INDOOR RADON LEVEL

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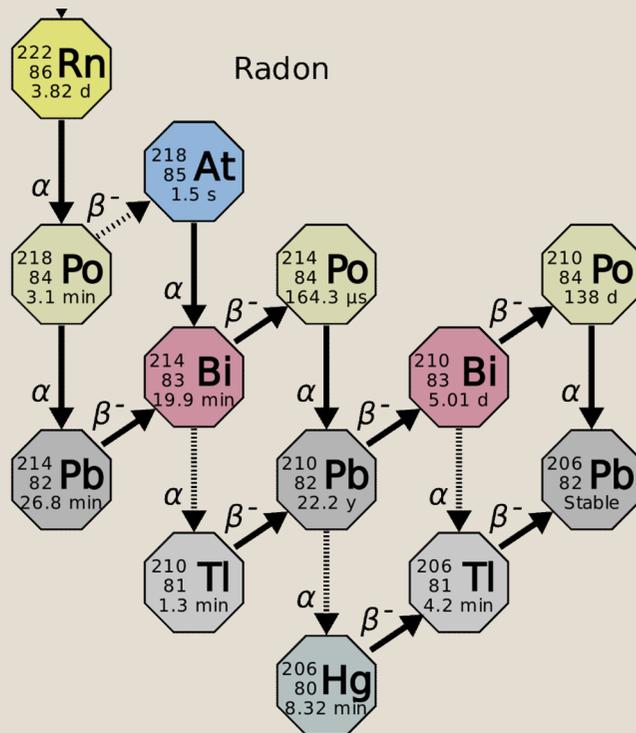
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# Radon Isotopes

- Rn-220 (Thoron, 釷射氣)
  - Source: Th-232 ... -> Ra-224 -> Rn-220
  - Half life: 55.6 s
- **Rn-222 (Radon, 氡氣)**
  - Source: U-238(99.274%) ... -> Ra-226 -> **Rn-222**
  - Half life : 3.82 d
- Rn-219 (Actinon, 錒射氣)
  - Source: U-235(0.72%) ... -> Ra-223 -> Rn-219
  - Half life : 3.96 s

# Rn-222 decay chain



- **Measurement of Rn-222**

- Gamma of daughters -> Carbon canister
- Alpha from Rn-222 & all alpha emitter daughters -> Luca cell
- Alpha from Po-218 and Po-214



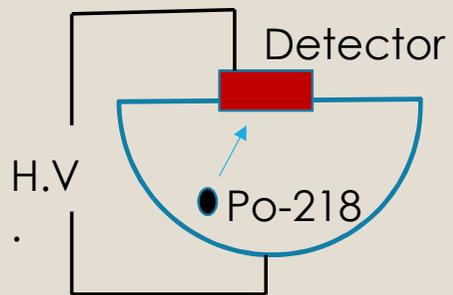
Image from:

[https://commons.wikimedia.org/wiki/File:Decay\\_chain\(4n%2B2,\\_Uranium\\_series\).svg](https://commons.wikimedia.org/wiki/File:Decay_chain(4n%2B2,_Uranium_series).svg)

# Professional Radon detector/monitor

Active Collection of Progenies & Alpha Spectrum  
Analysis with Semiconductor detector

**RAD7, Super sensitive Rn detector for Super  
Kamiokande, Daya Bay H<sup>3</sup>**



Passive total count detection of Progenies

**Pylon AB-5 & AB-6**



# Radon action level

- ICRP Publication 65 (1993): Protection Against Radon-222 at Home and at Work

<b>Action level (dwellings)</b>		
Radon concentration	(Bq m <sup>-3</sup> )	200–600 <sup>a</sup>
Annual effective dose	mSv	3–10
<b>Action level (workplaces)</b>		
Radon concentration	(Bq m <sup>-3</sup> )	500–1500 <sup>a</sup>
Annual effective dose	mSv	3–10

- In Publication 103 (ICRP, 2007), the Commission recommended upper values for **derived reference levels** of **600 Bq m<sup>3</sup> for homes** and **1500 Bq m<sup>3</sup> for workplaces**.
- ICRP PUBLICATION 115 (2010): Lung Cancer Risk from Radon and Progeny and Statement on Radon
  - In response to its review of radon epidemiology in Publication 115 (ICRP, 2010) and the increase of the nominal risk coefficient by approximately a factor of 2, the Commission reduced the upper reference level for homes from **600 Bq m<sup>3</sup> to 300 Bq m<sup>3</sup>** in the associated Statement on Radon.
  - the Commission also revises downwards the **reference level for workplaces**, recommending a single value of **1000 Bq/m<sup>3</sup>** which serves as an entry point for applying occupational radiological protection requirements.

# Guidance Notes for the Management of Indoor Air Quality in Offices and Public Places

- [https://www.iaq.gov.hk/media/82253/gn\\_officeandpublicplace\\_eng-2019.pdf](https://www.iaq.gov.hk/media/82253/gn_officeandpublicplace_eng-2019.pdf)
- Indoor Air Quality Management Group, HKSAR
- Chinese version also available:
- <https://www.iaq.gov.hk/media/8688/certguide-chi.pdf>
- 辦公室及公眾場所 室內空氣質素 檢定計劃指南
- 香港特別行政區室內空氣質素管理小組

Table 3-2: IAQ Objectives for Office Buildings and Public Places (Effective on 1 July 2019)

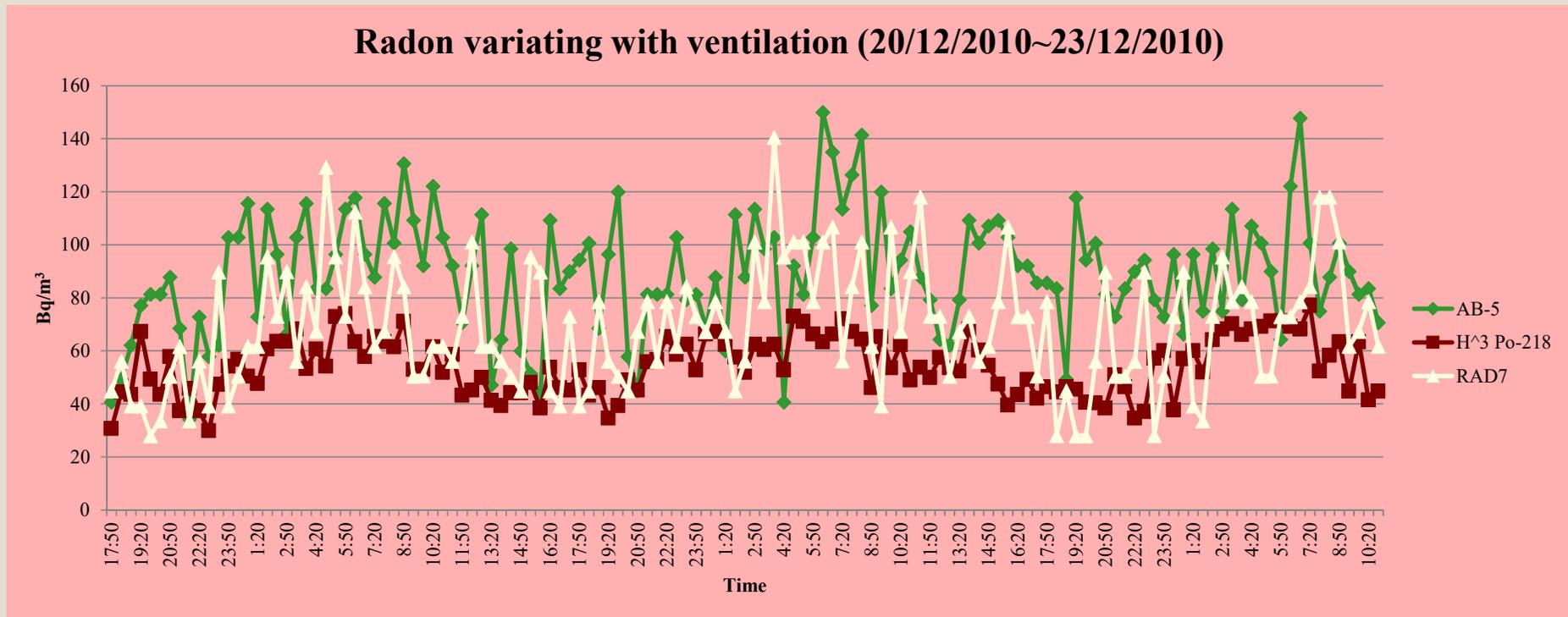
Parameter			Excellent Class	Good Class
Pollutant	Averaging Time	Unit		
Carbon Dioxide (CO <sub>2</sub> )	8-hour	mg/m <sup>3</sup>	1,440	1,800
		ppmv	800 <sup>a</sup>	1,000 <sup>a</sup>
Carbon Monoxide (CO)	8-hour	µg/m <sup>3</sup>	2,000 <sup>b</sup>	7,000 <sup>c</sup>
		ppmv	1.7	6.1
Respirable Suspended Particulates (PM <sub>10</sub> )	8-hour	µg/m <sup>3</sup>	20 <sup>d</sup>	100 <sup>d</sup>
Nitrogen Dioxide (NO <sub>2</sub> )	8-hour	µg/m <sup>3</sup>	40 <sup>c</sup>	150 <sup>e</sup>
		ppbv	21	80
	1-hour	µg/m <sup>3</sup>	100 <sup>c</sup>	200 <sup>c</sup>
		ppbv	53	106
Ozone (O <sub>3</sub> )	8-hour	µg/m <sup>3</sup>	50 <sup>b</sup>	120 <sup>f</sup>
		ppbv	25	61
Formaldehyde (HCHO)	8-hour	µg/m <sup>3</sup>	30 <sup>b</sup>	100 <sup>b</sup>
		ppbv	24	81
	30-minute	µg/m <sup>3</sup>	70 <sup>c</sup>	100 <sup>c</sup>
		ppbv	57	81
Total Volatile Organic Compounds (TVOC)	8-hour	µg/m <sup>3</sup>	200 <sup>b</sup>	600 <sup>b</sup>
		ppbv	87	261
Radon (Rn)	8-hour	Bq/m <sup>3</sup>	150 <sup>g</sup>	167 <sup>c</sup>
Airborne Bacteria	8-hour	cfu/m <sup>3</sup>	500 <sup>h,i</sup>	1,000 <sup>h,i</sup>
Mould	---	---	Assessment in form of prescriptive checklist (refer to <i>A Guide on Indoor Air Quality Certification Scheme for Offices and Public Places (2019)</i> <sup>j</sup> )	

- o g. USEPA (2016): A Citizen's Guide to Radon. (Note: 4 pCi/L or 150 Bq/m<sup>3</sup> is EPA Action Level).
- o c. WHO (2010), WHO guidelines for indoor air quality: Selected pollutants. Information from WHO has been taken into account for radon value in the above table, though WHO has no 8-hour averaging reference level for radon.

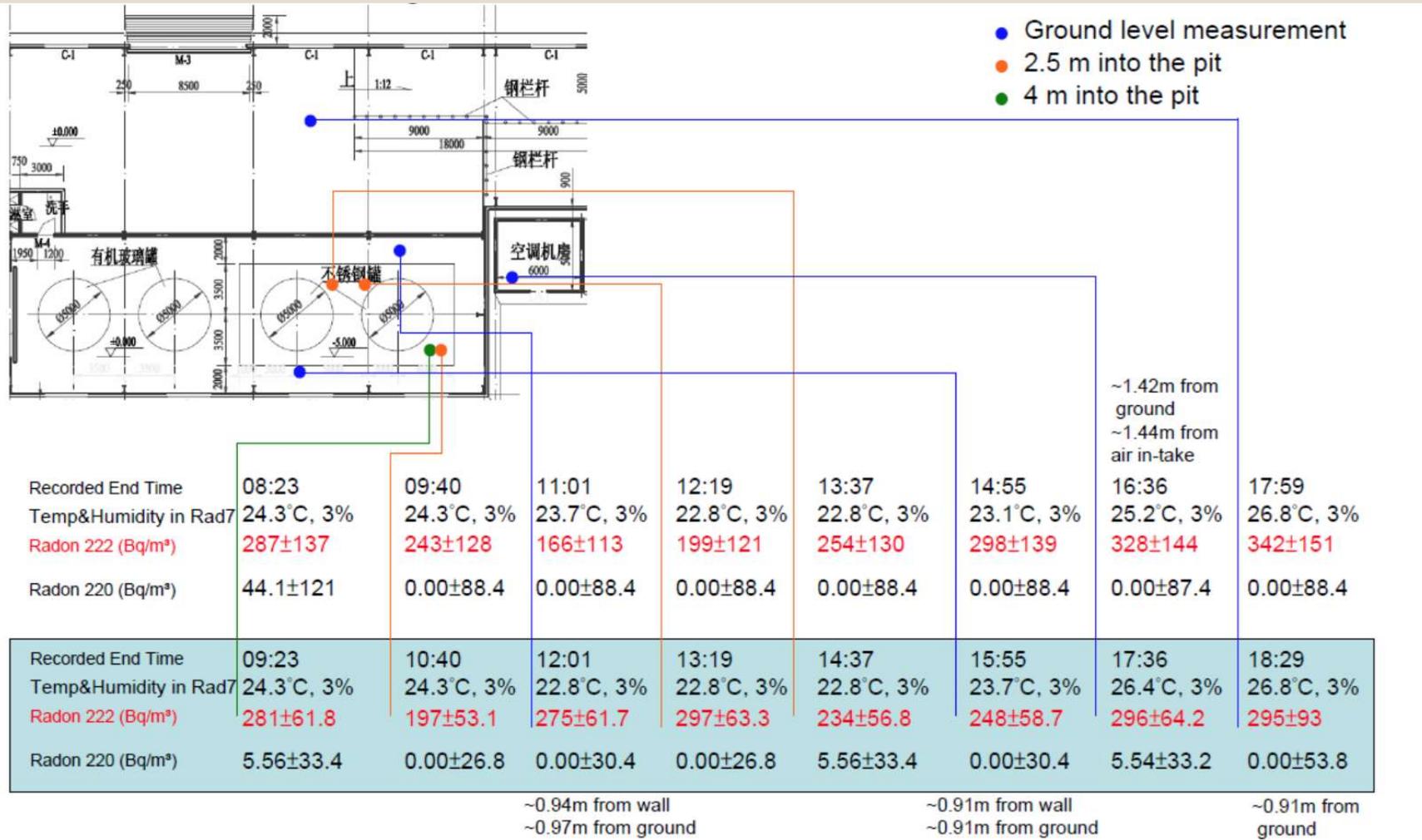
# Control of Radon Indoor

- Control of source
  - High Ra-226 construction material
  - High Rn in soil (tens of kBq/m<sup>3</sup>) -> High Rn underground/basement
- Control of transportation
  - Release from underground water
  - Emanate from walls, floor
- Control of accumulation
  - Ventilation

# Radon varying with ventilation



# High Radon Level in a Clean Room

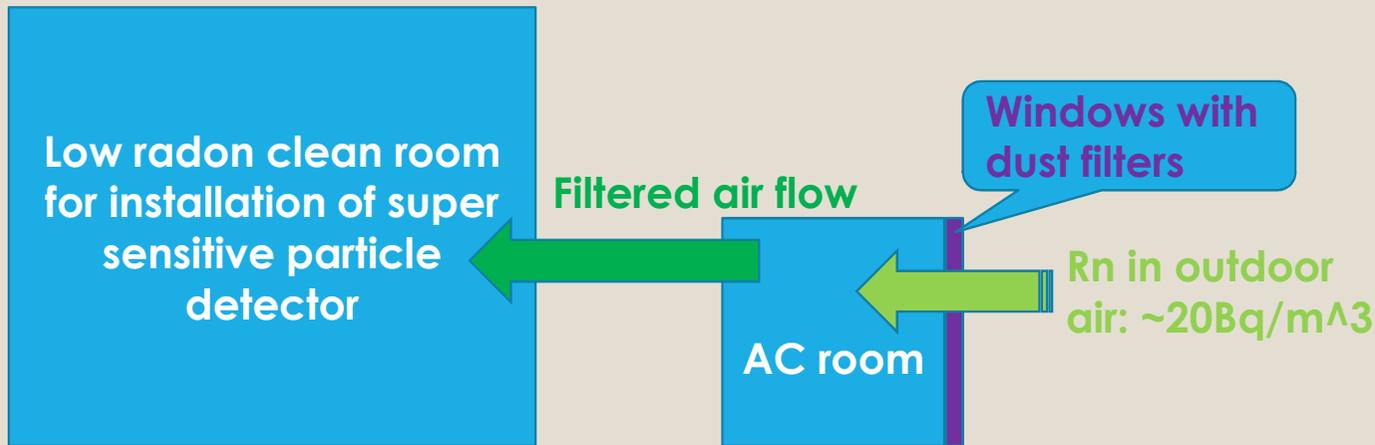


# High Radon Level in a Clean Room

- **Where does Radon come from ?**



Rn in clean room and AC room: up to ~ 300 Bq/m<sup>3</sup> ???



**Strong ventilation does NOT help.**



# Cable Trough Terminal in AC Room

Before block: ~1200 Bq/m<sup>3</sup>  
Feel warm air flowing in



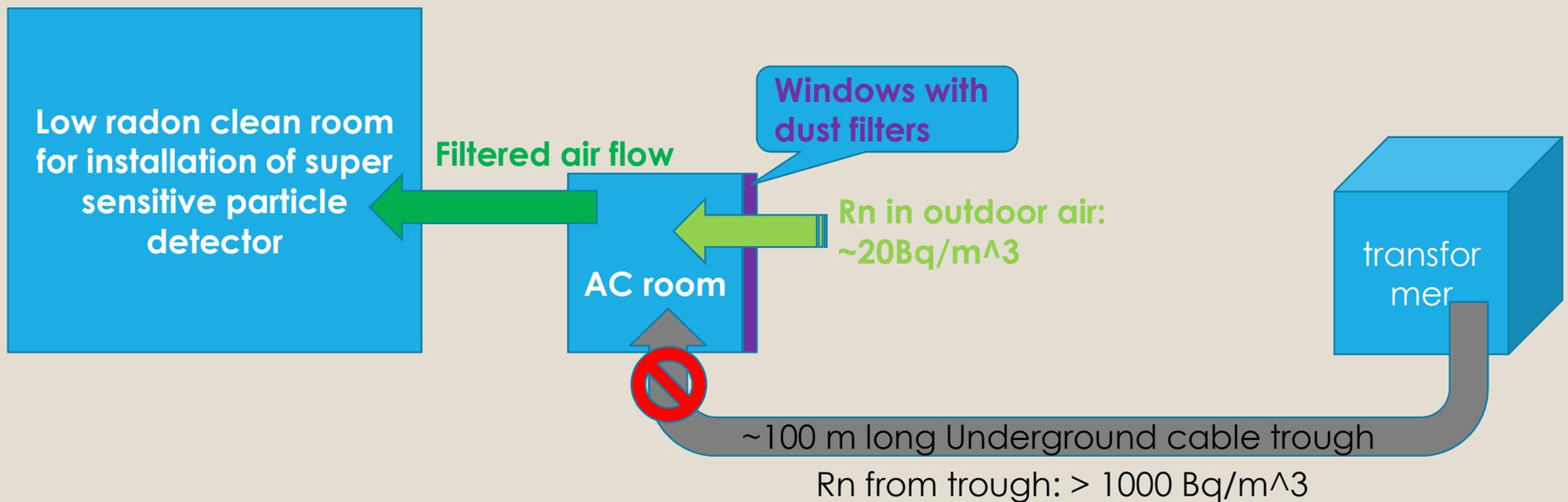
After temporarily block: ~ 700 Bq/m<sup>3</sup>



Rn in clean room and AC room: ~ drop by half the second day

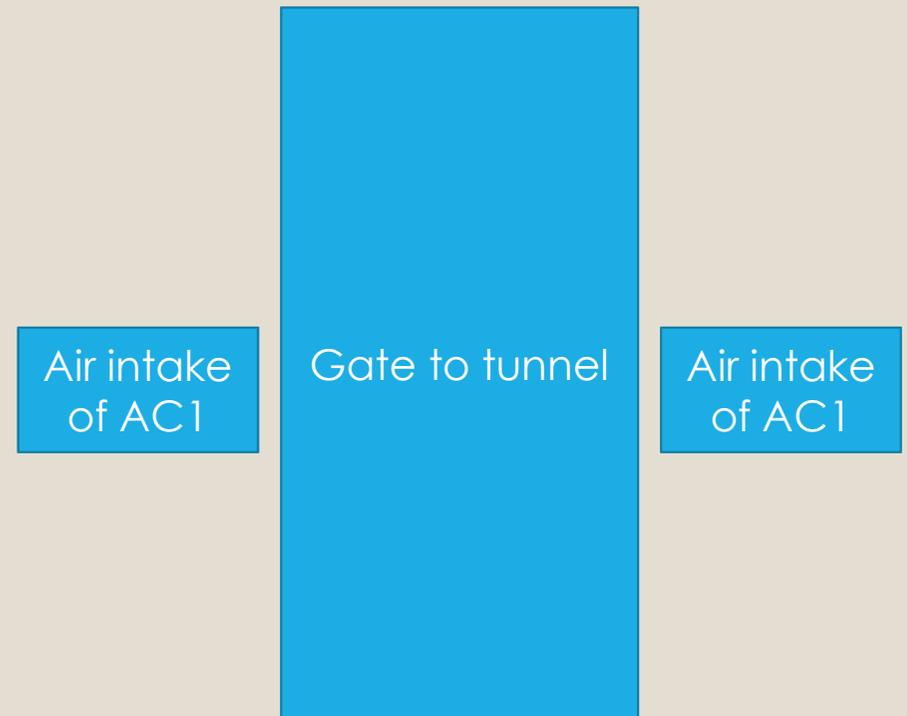
# Issues & Examples

- **Example 4: Where does Radon come from ?**



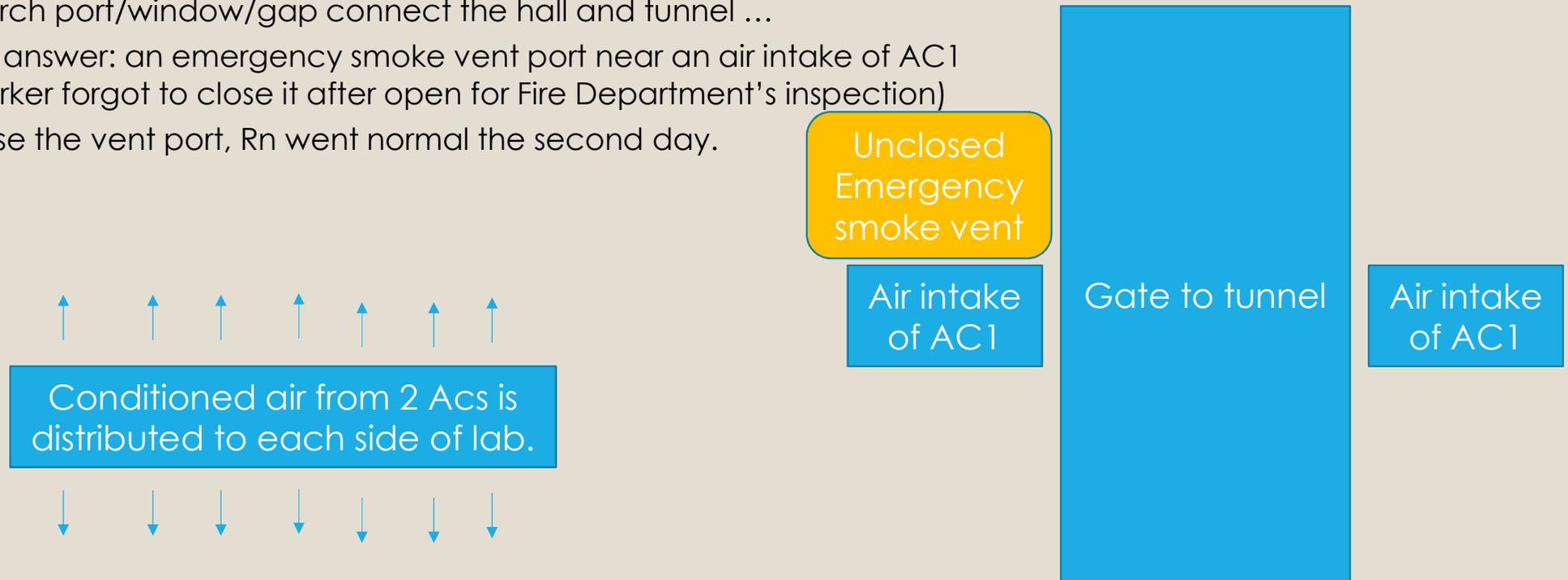
# High Radon Level in Underground Lab

- **Where comes the Radon ? History repeats again?**
  - Rn in a underground lab :  $\sim 800 \text{ Bq/m}^3$  every where???
  - Fresh air supplied to lab via long duct in a tunnel.
  - Lack of fresh air due to resistance in long( $>1\text{km}$ ) duct?
  - In-line fan added at middle. No improvement observed.



# Source Identification

- Where comes the Radon ? History repeats again?
  - Rn in tunnel :  $> 1000 \text{ Bq/m}^3$ . Might be the source
  - Search port/window/gap connect the hall and tunnel ...
  - The answer: an emergency smoke vent port near an air intake of AC1 (worker forgot to close it after open for Fire Department's inspection)
  - Close the vent port, Rn went normal the second day.

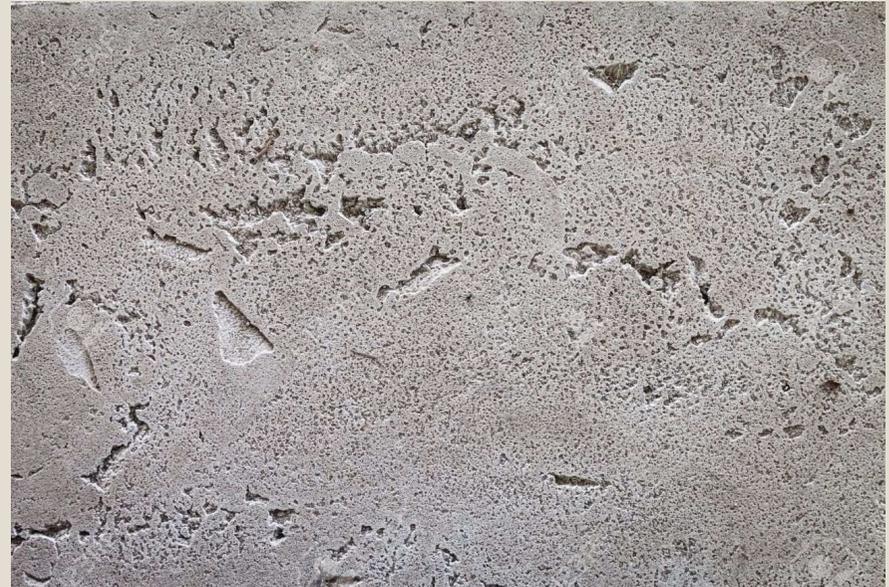


# High Radon level in general office/home ?

Tiles



Concrete



# Emanation Test for source identification and control evaluation

Electronic Radon Detector with wireless connection with cell phone

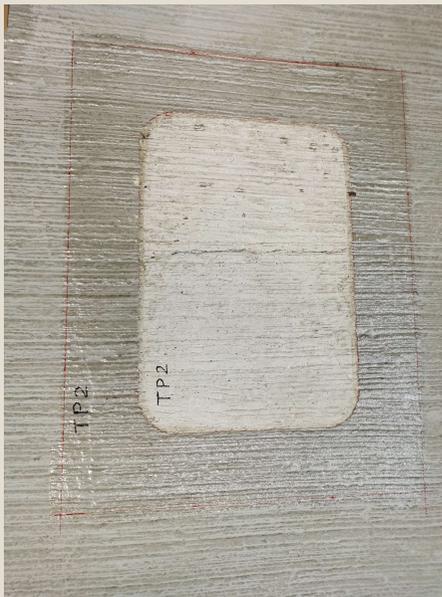


Emanation Test Setup





Raw concrete



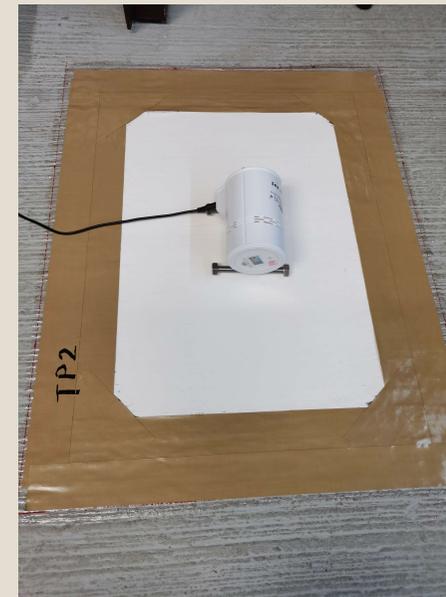
Concrete with filling



With prime wall painting



With surface wall painting





# Summarize

- **Hong Kong adopts high radon safety standard;**
- **High radon level might occur in rare cases in local office and public places;**
- **Ventilation not always work for control of radon at work place;**
- **It needs experience to identifying the source by direct measuring of radon in air;**
- **Emanation test could help to identify surfaces which release higher radon;**
- **Proper commercial painting helps to reduce radon.**

# Thanks!

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