Traceability of measurements of the size distribution of radioactive aerosols formed by the short-lived radon progeny

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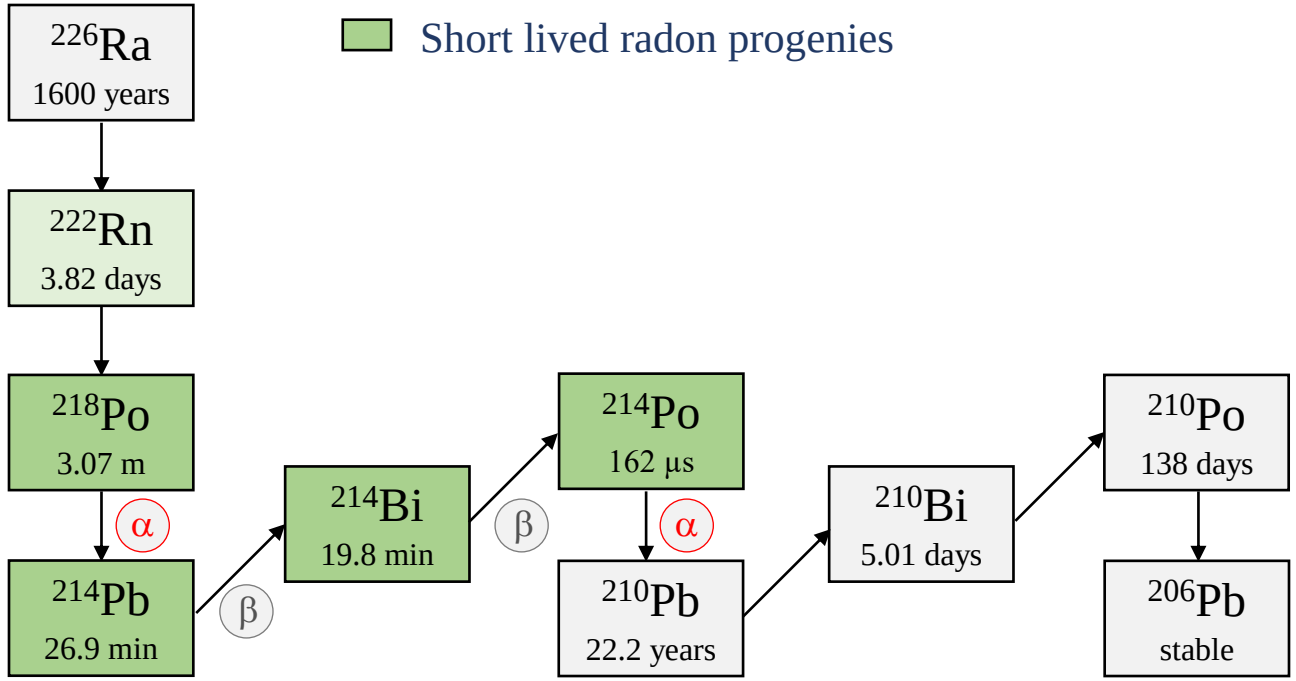
Short-lived radon progeny

Radon

- noble gas,
- naturally occurring gas,
- colorless and odoress, tasteless,
- half-life 3.8 days,



Fragment of the uranium series

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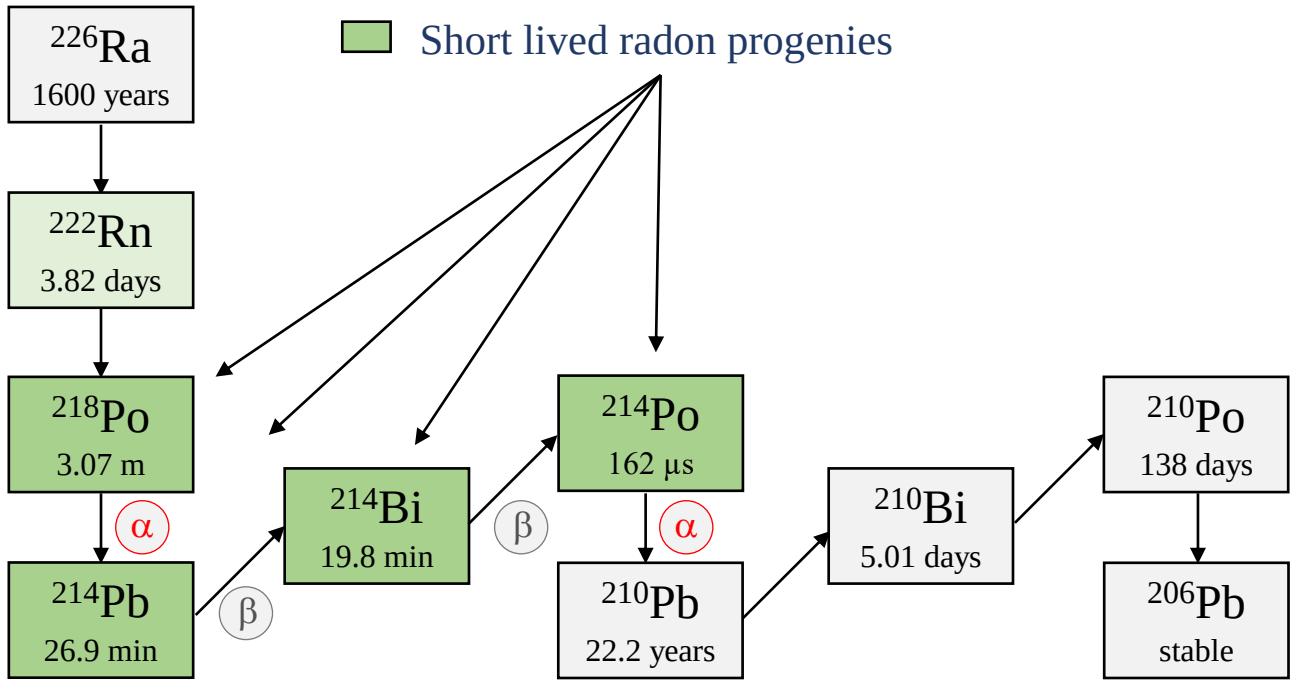

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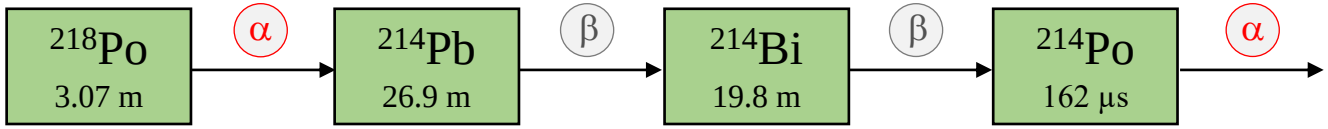
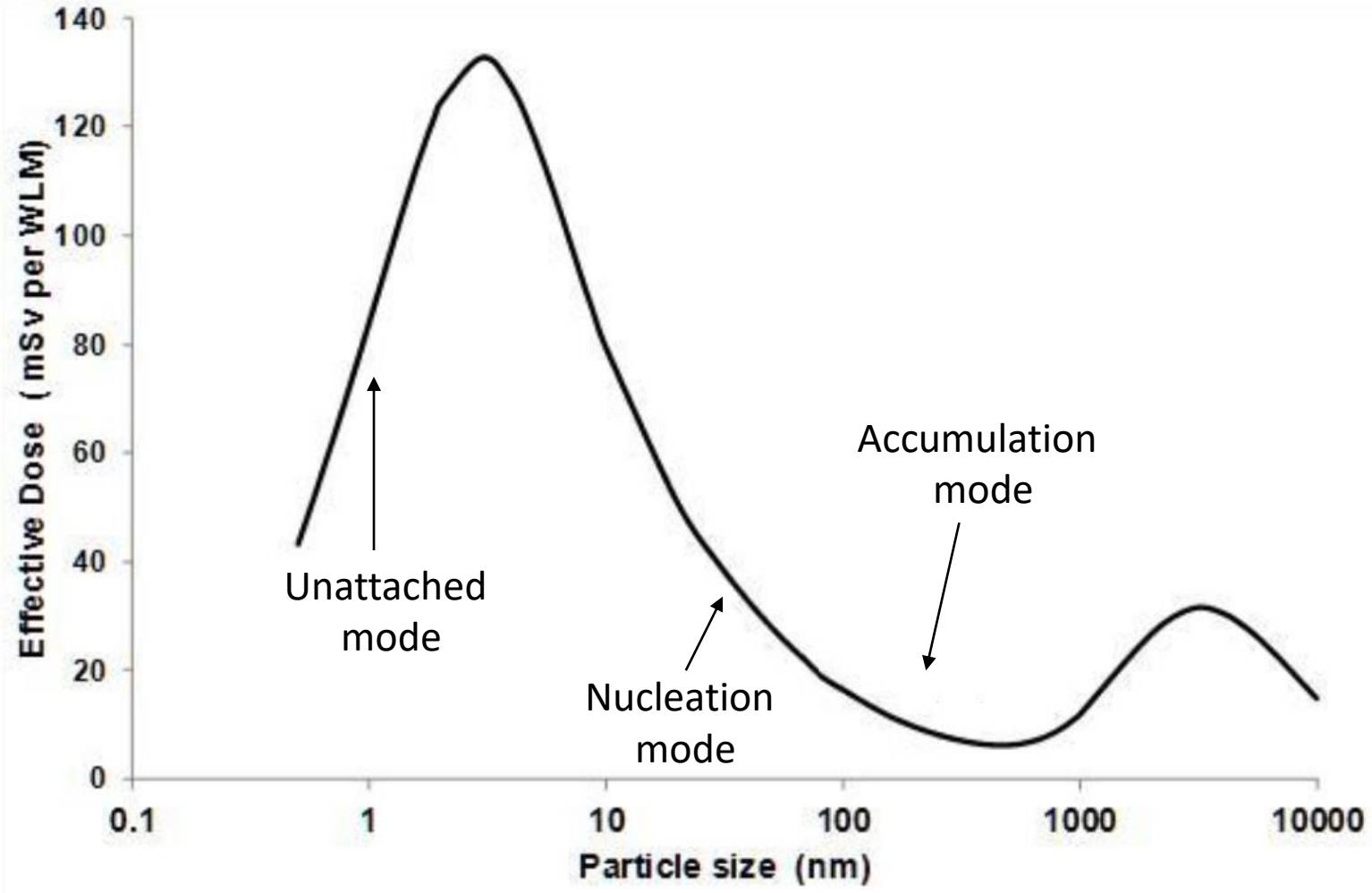
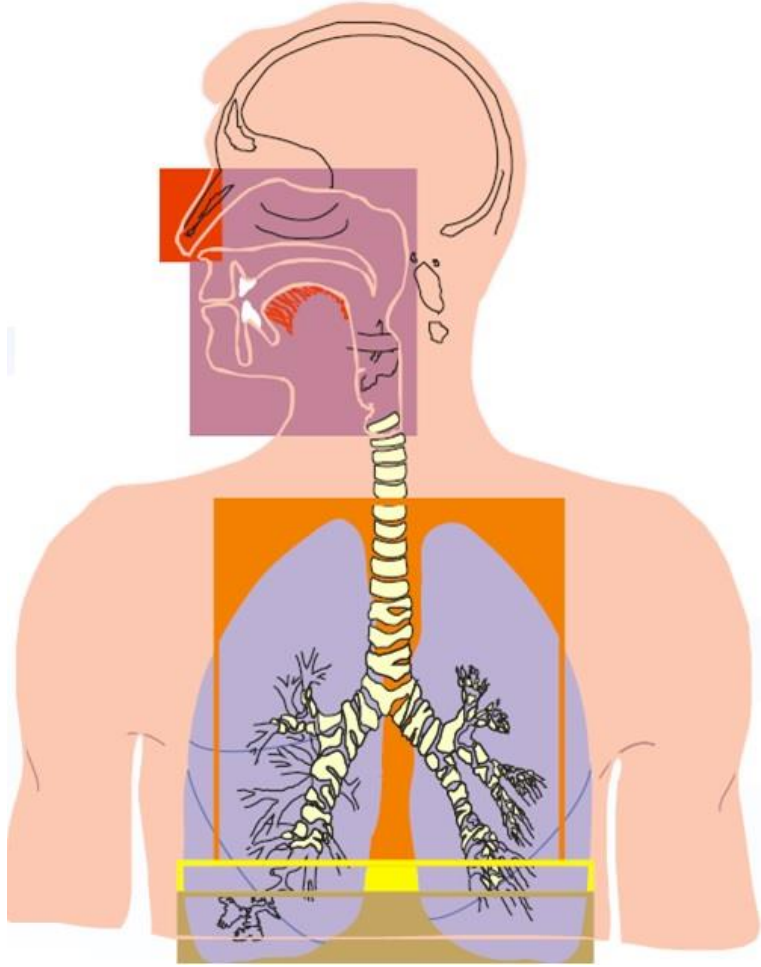
Short-lived radon progeny



- Radon decay products **are no longer gases but are solid particles**,
- Radon and its decay products are inhaled to the lungs,
- Inhaled radon is generally exhaled, however, progenies remain in the respiratory system, mainly in the bronchi and lungs and undergo radioactive decay, **making a major contribution to the dose**,
- To **assess the dose accurately**, it is important to know, among others potential alpha energy concentration PAEC and size distribution of radioactive aerosols,

Activity size distribution of radon progeny





Devices & methods

Radon Progeny Particle Size Spectrometer

- Measurement range 0.6 nm – 2494 nm,
- The spectrometer has 8 stages working simultaneously: one open face stage, 4 stages with diffusion screens and 3 stages with inertial impactor system,
- Activity of isotopes collected on filters and mylars is measured by alpha semiconductor detectors mounted close to their surface,
- Results are processed by deconvolution analysis for 43 size ranges between 0.60 nm and 2493.9 nm,
- The **Twomey** non-linear iteration and the expectation maximization method **Emax** is applied to achieve the size distribution of short lived radon progeny.

Devices & methods

Cascade impactor called the electrical low-pressure impactor (ELPI)

- Determination of the size distribution of aerosol particles in size ranges from 17 nm to 10 µm (in fourteen stages),
- The individual stages of the impactor are equipped with a set of braking foil (Mylar) and detection foil (LR-115), which allows the determination of the equivalent equilibrium radon activity concentration.

Devices & methods

Ambient aerosols

2.5 nm – 20 000 nm measuring range,
160 of size channels

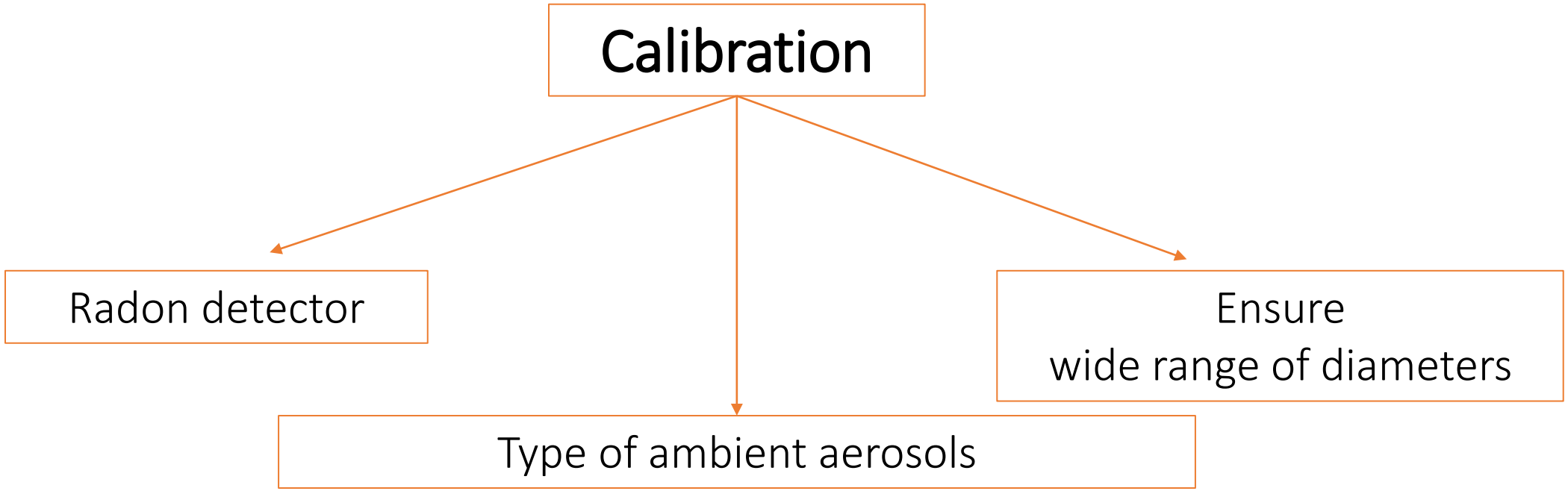
$$X = \int_0^{\infty} \beta(d_p) Z'(d_p) \mathrm{d}d_p \qquad \beta(d_p) = \frac{2\pi D_f d_p}{\frac{8D_f}{d_p v_f} + \frac{d_p}{2\left(\frac{d_p}{2} + \lambda_f\right)}}$$

X - attachment rate expressing the adsorption velocity of the unattached radionuclides to the atmospheric aerosols with number particle concentration Z,

$\beta(d_p)$ - attachment coefficient,

$Z'(d_p)$ - size distribution of ambient aerosols.

Calibration



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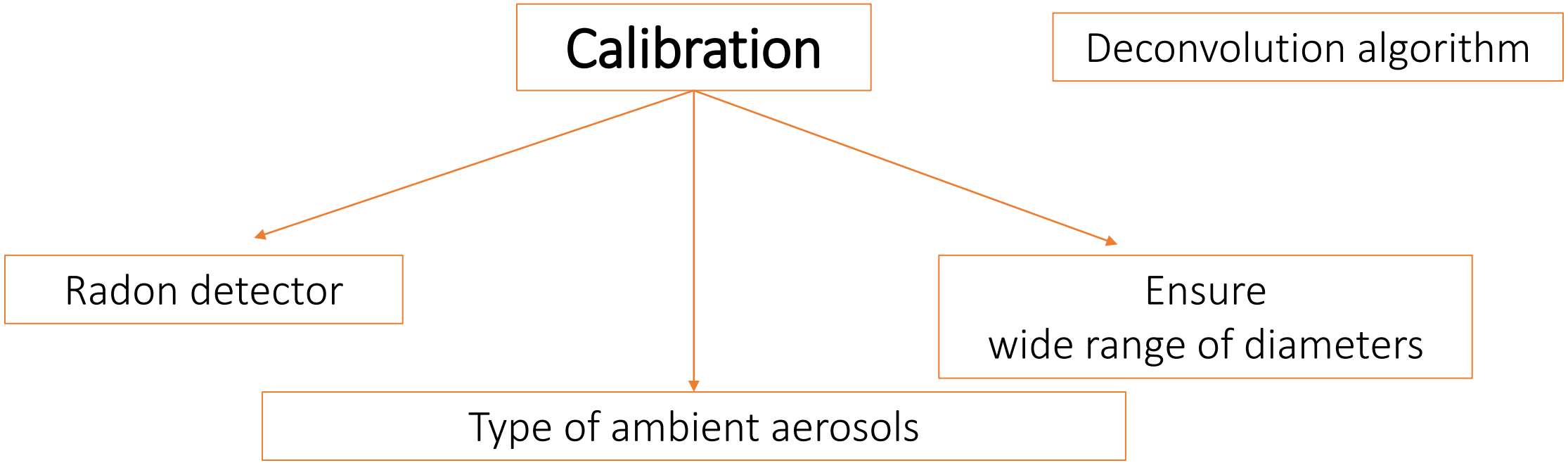

Conclusions

- Not (yet) commercially available devices.
- Rather for professionals, not for routine measurements.
- Provide more accurate dose assessment- allows for the determination of the dose coefficient for a specific location dependent on size distribution.

Problems to be solved

- Lack of calibration laboratory providing **comprehensive** calibration in this field.
- Reference device/reference devices/reference atmosphere?
- Lack of intercomparison measurements campaigns
  - flow mode,
  - different times of measurements,
  - different modes- grab sampling or continuous mode.

Thank you
for your attention

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