

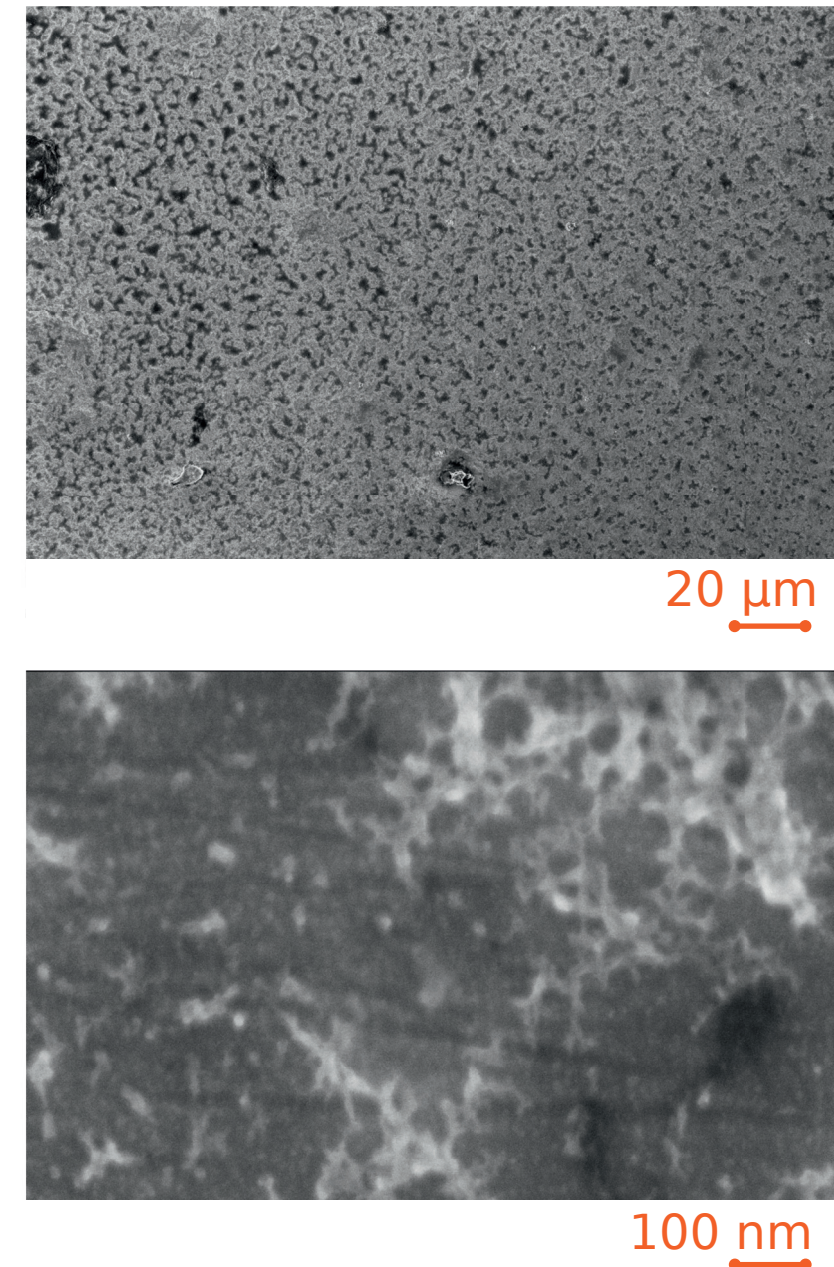
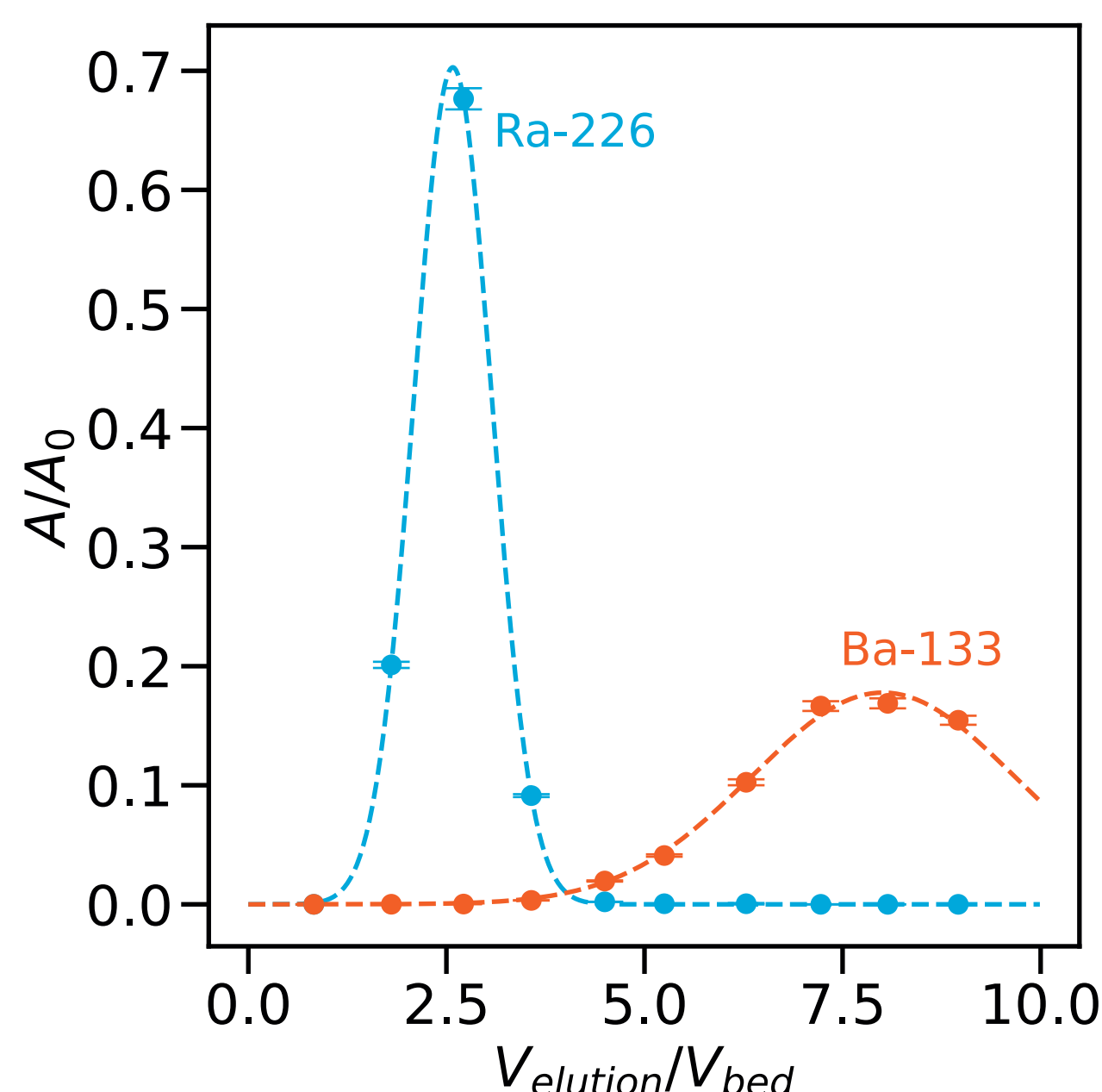
Towards new primary emanation sources for Rn-222

Motivation

- Rn-222 exposure is the second most important cause of lung cancer [1]
- Recent reevaluation of Rn-222 dose conversion coefficient [2]
- European Basic Safety standards demand Rn-222 < 300 Bq/m³ [3]
- Suitable calibration techniques necessary for low activity concentrations
- Increasing interest in stable Rn-222 reference atmospheres for calibration of devices
- European collaboration MetroRADON [4]

Sample preparation and source production

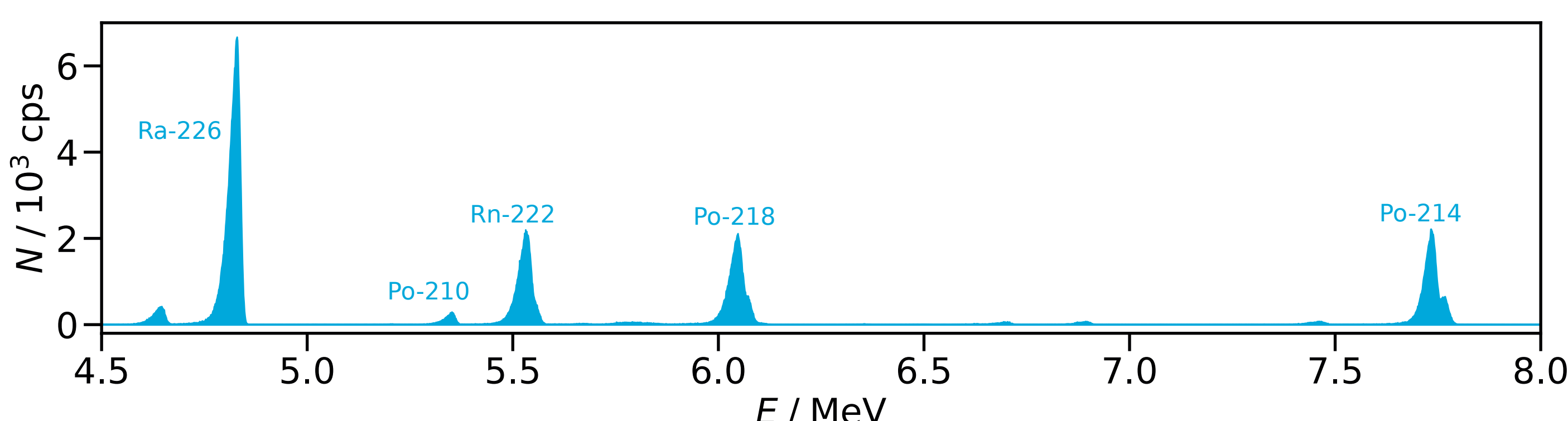
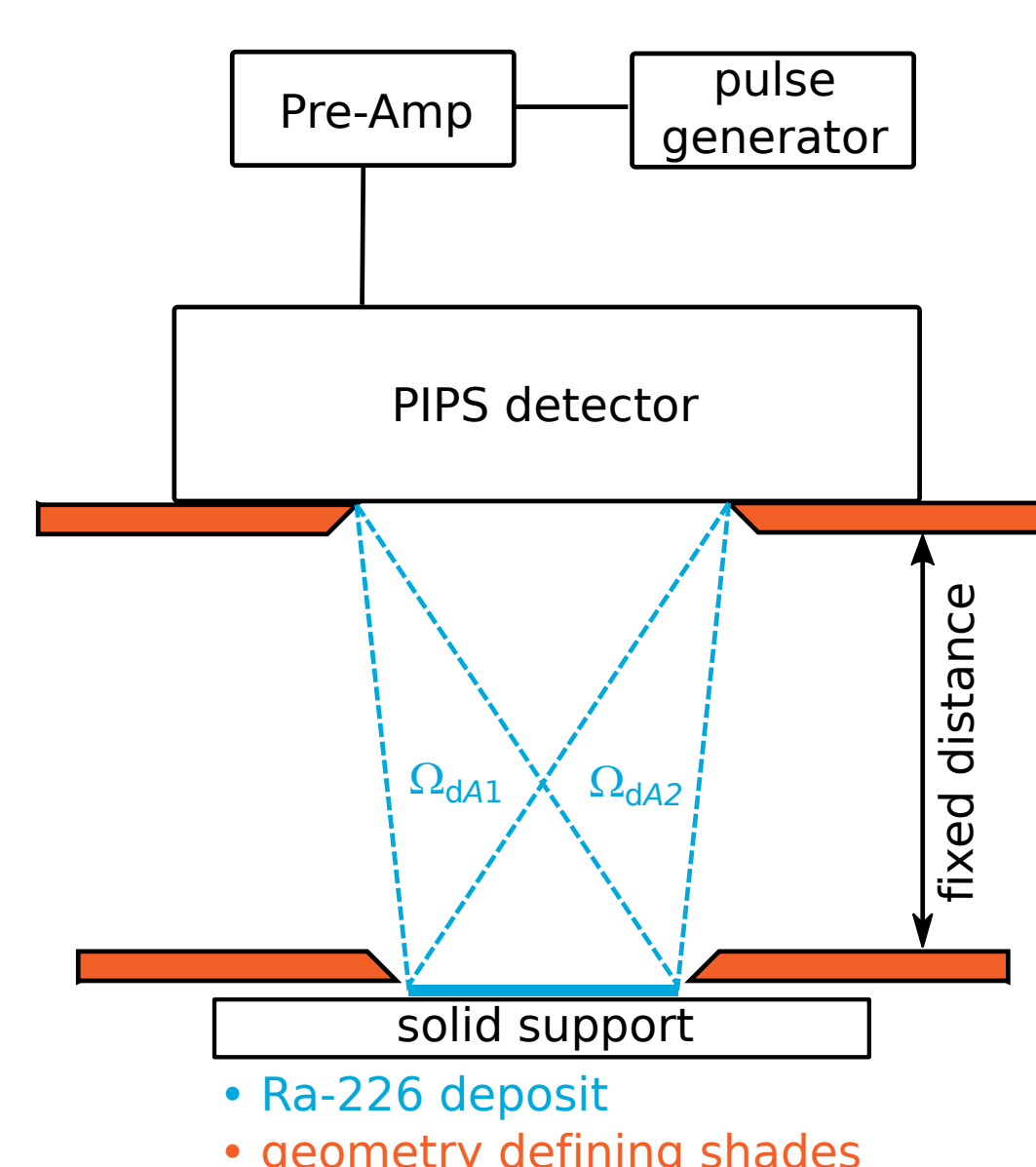
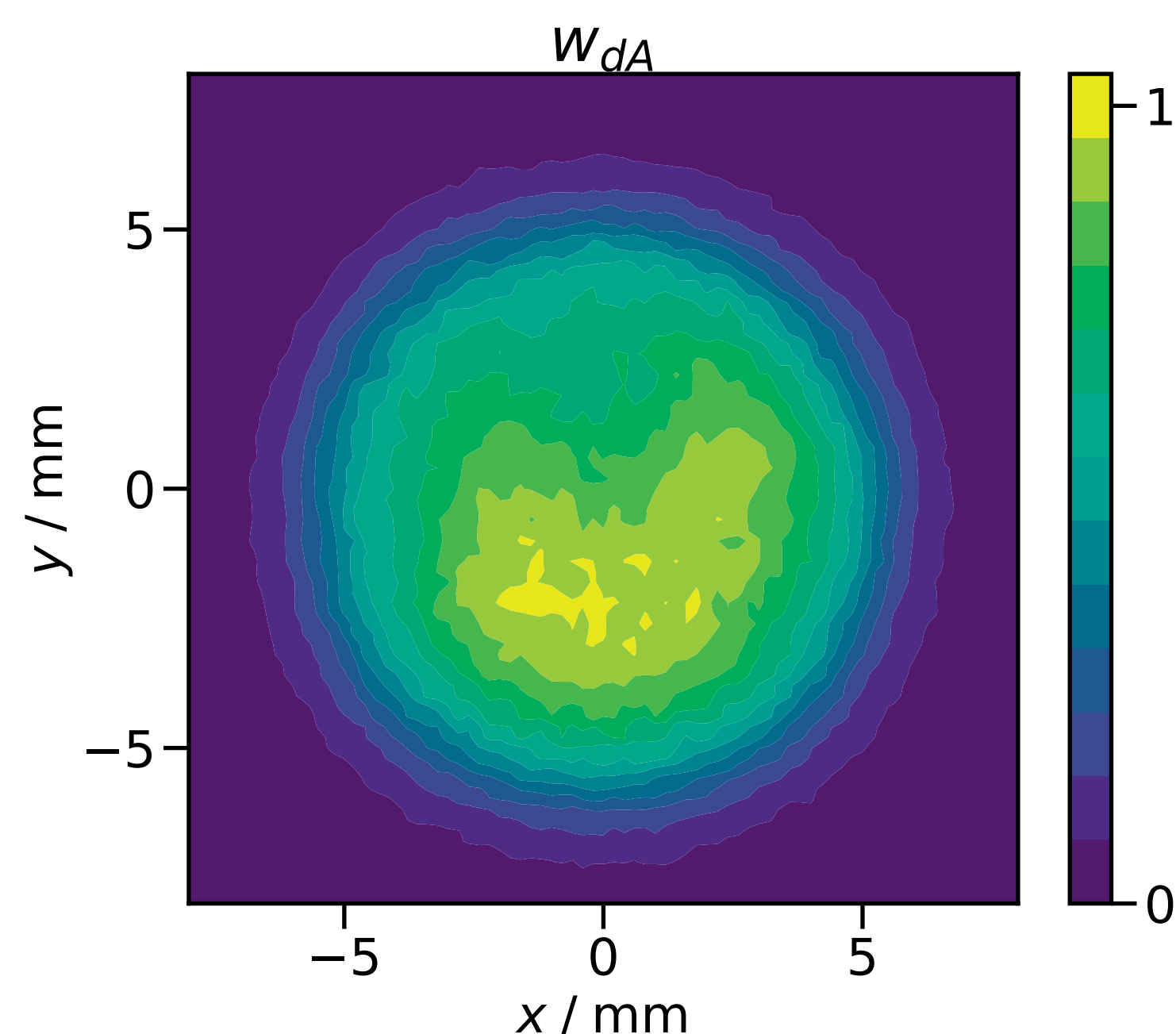
- Ra-226 standard solutions are only available with Ba²⁺ carriers
- Reduction of Ba²⁺ content necessary for source production [5,6]
- Purification of Ra²⁺ by extraction chromatography (Sr-Resin®)
- Deposition from nitric acid/ethanol (1:9) at 35 V vs. a rotating Pt mesh anode [7]
- Solid support made of mirror finished stainless steel (Ø 30 mm)



Determination of Ra-226 activity

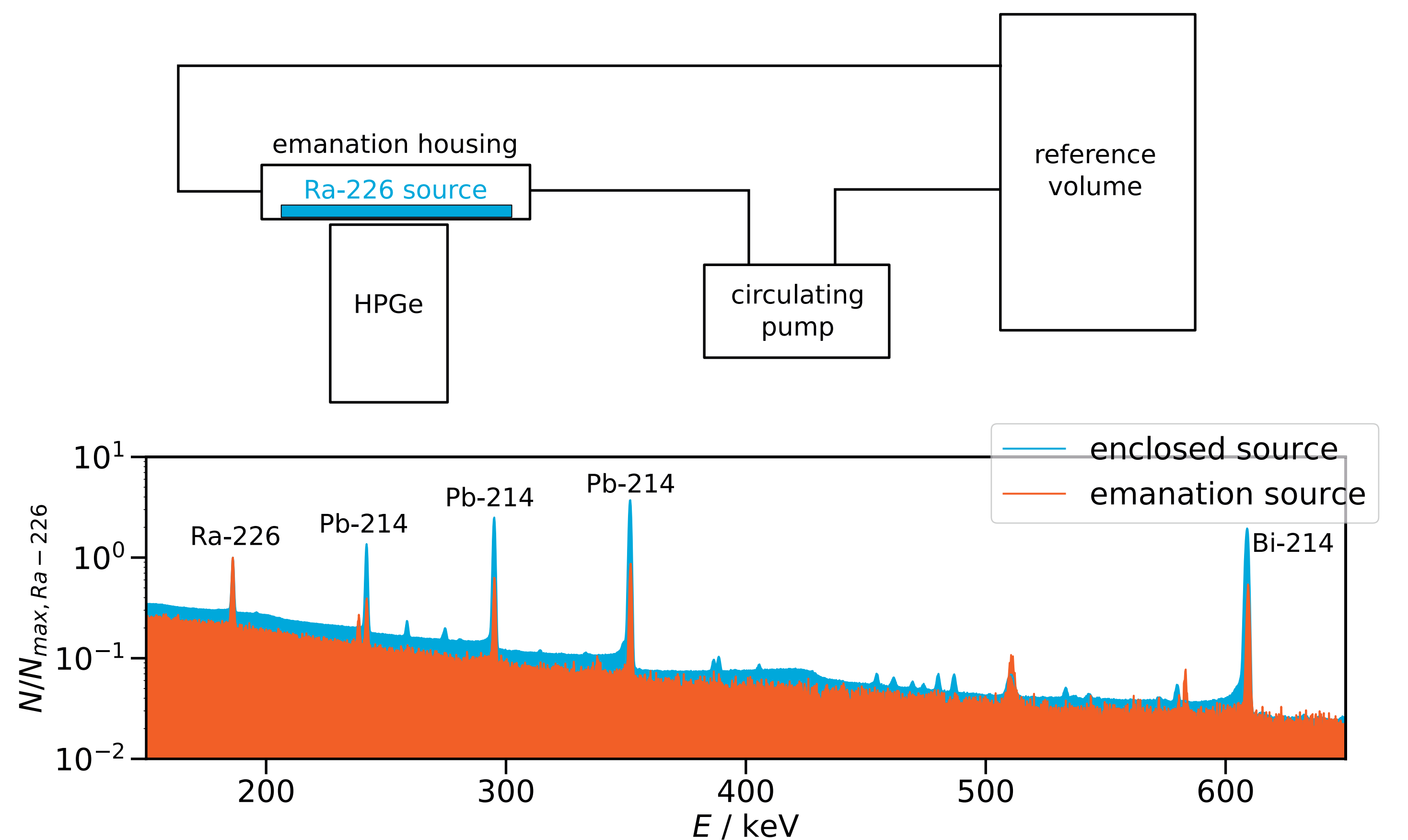
- Absolute activity determination by defined solid angle alpha spectrometry [8]
- Efficiency is defined by two alpha-opaque shades
- Determination of setup dimensions traceable to national standards
- Dead-time correction with a high-precision pulse-generator connected to pre-amplifier
- Calculation of geometrical efficiency with numerical integration of eq (1)
- Determination of relative activity weights w_{dA} through digital autoradiography

$$\epsilon_{geo} = \frac{\int_A \Omega_{dA} \cdot w_{dA} dA}{4\pi \int_A w_{dA} dA} \quad (1)$$



Measurements of emanation power

- Sources are installed in a metal housing that allows to attach a circulating pump
- Emanation power χ (fraction of escaping Rn-222) is calculated from the distorted equilibrium between Ra-226 and Rn-222 decay products due to Rn-222 escape [9]
- Emanation power is thus continuously measured by gamma-spectrometry
- Calibration of equilibrium count rate ratios between Pb-214 and Ra-226 with a gas-tight source of the same geometry
- Reduction of uncertainties by making detector efficiency and gamma-probability obsolete
- Typical uncertainties around 1 % ($k = 1$, 1 day average, 48 Bq Ra-226)
- In the course of 140 days, no time dependency of χ was identified



description	A_{Ra-226} / Bq	$\bar{\chi}$	$std(\chi)$	N
Source 1	48.06 ± 0.17	0.804	0.011	40
Source 2	$58.5 \pm 0.9^{(a)}$	0.727	0.005	7
Source 3	$57.5 \pm 1.3^{(a)}$	0.869	0.007	11

^(a) determined by gamma-spectrometric comparison with Source 1

Conclusion and outlook

- Electrodeposition is a suitable method for the manufacture of sources with high resolution for alpha-spectrometry, allowing for primary determination of Ra-226
- Absolute measurements of emanation power possible by gamma-spectrometry
- Depending on volume, atmospheres below 100 Bq/m³ can be generated
- Adaptation to higher activities shortly
- Combined uncertainty of Rn-222 activity concentrations below 2 % for $k = 1$
- Application of portable LaBr₃/CeBr₃/SrI₂ detectors for emanation measurements in the future
- Distribution of sources and portable measurement setups to MetroRADON partners in 2019

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References

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