

Off-line single-atom gas chromatographic adsorption studies of bismuth

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TASCA

International Cooperation on the
TASCA Recoil Separator for
Transactinide Chemistry and Physics

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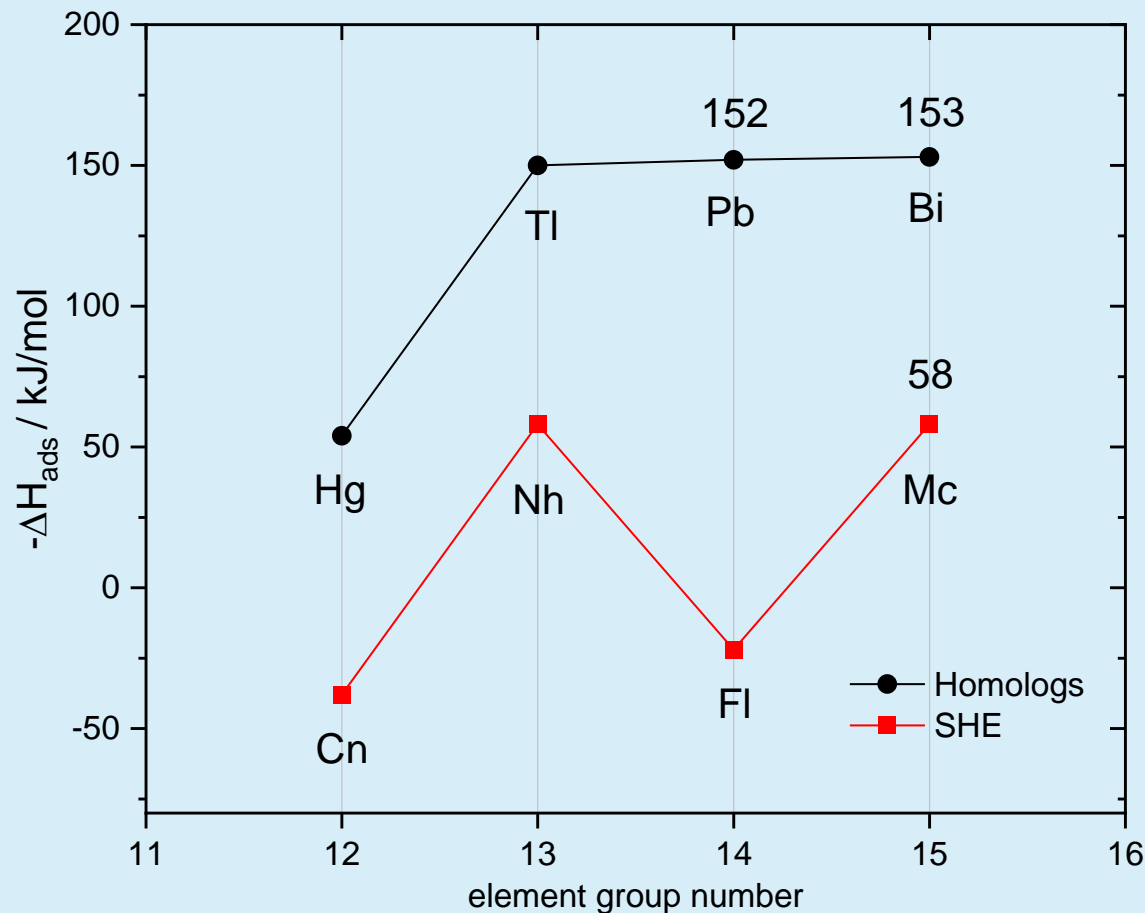
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Motivation: Preparation for Mc adsorption experiments

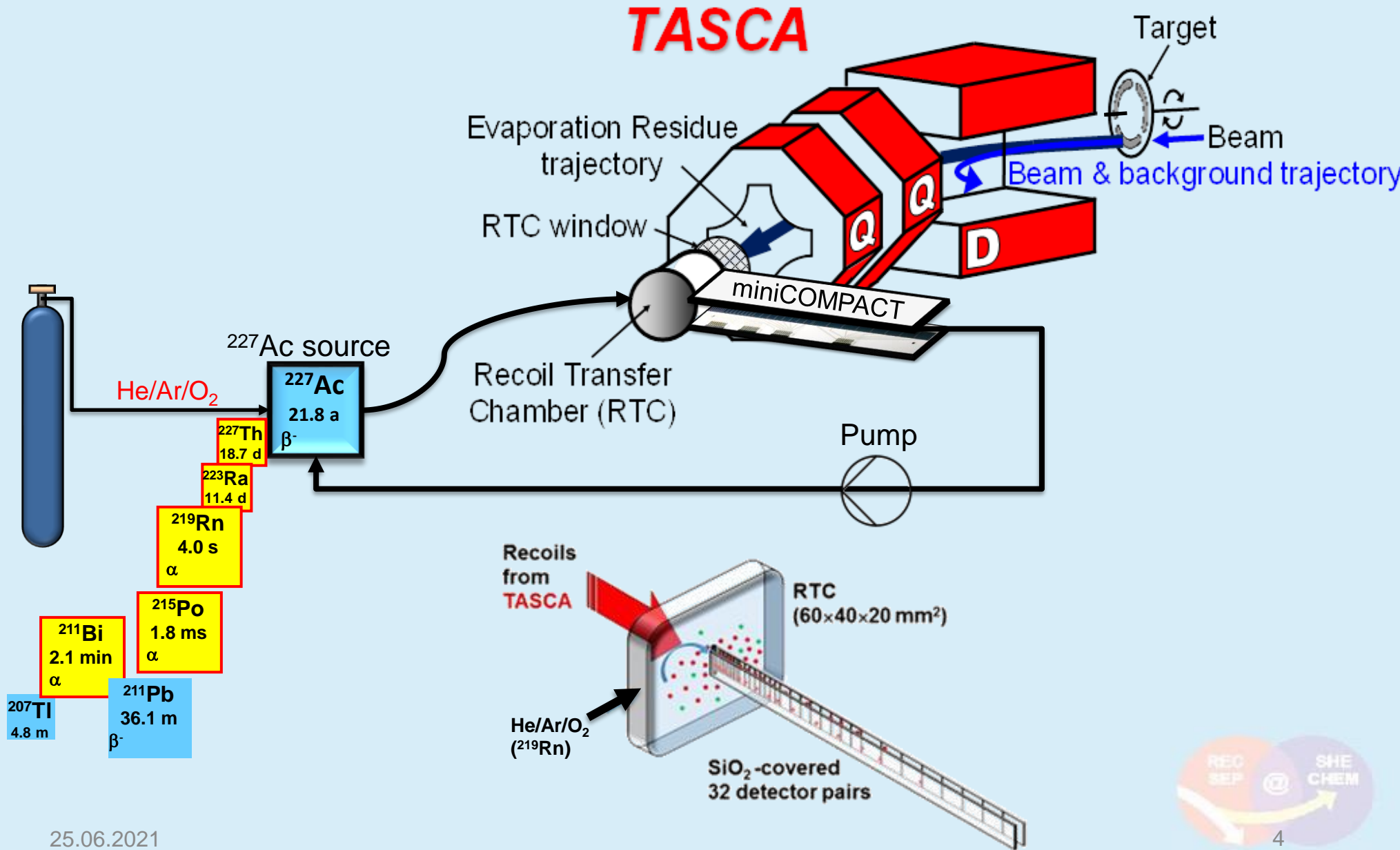
Characterizing new miniCOMPACT detection system

Theoretical predictions about formation of oxides in earlier talk by Miroslav Iliáš



Theoretical predictions of $-\Delta H_{\text{ads}}$ on hydroxylated SiO_2 ^[1]

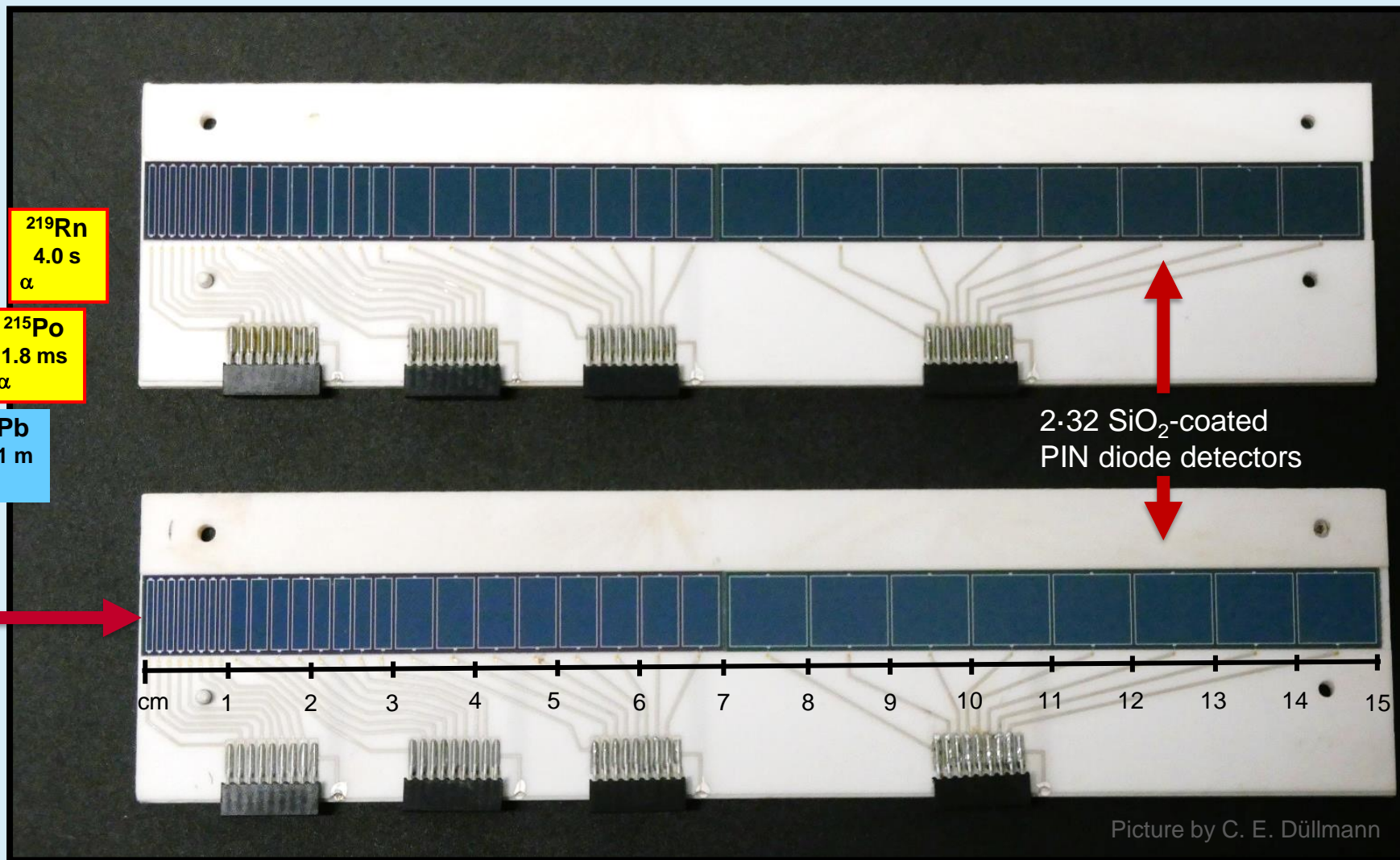
Experimental setup



Experimental

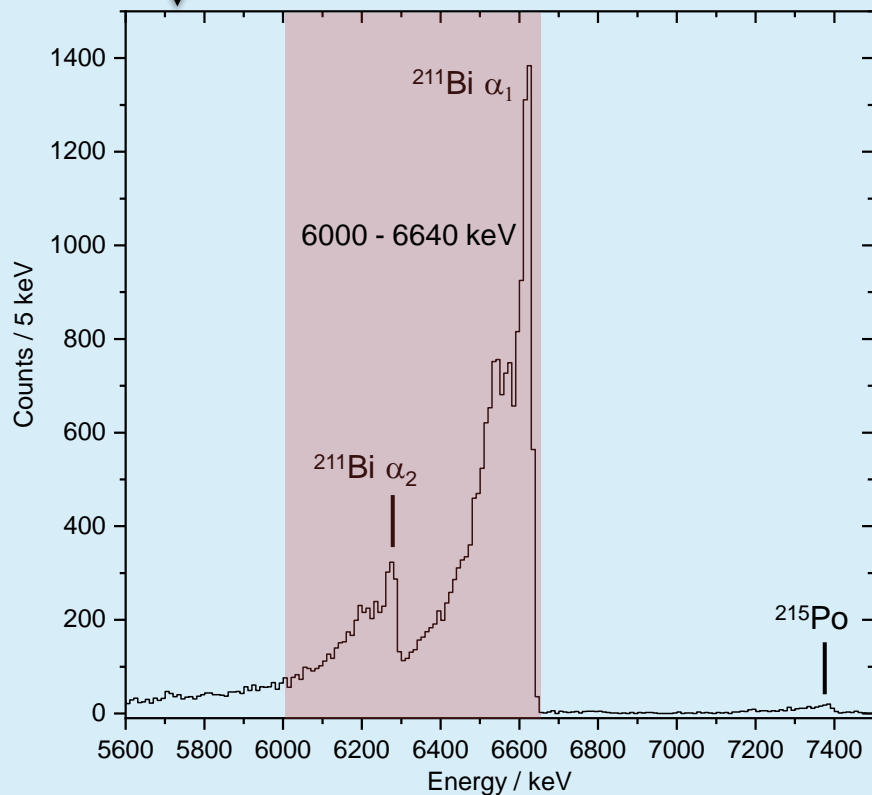
- Measurements with He, Ar, and O₂ as carrier gases
 - Different stoichiometries in gas mixtures
 - 0.5 – 1 bar pressure
 - 1-4 L/min carrier gas flow
- Monte-Carlo-Simulations for estimation of the lower limit value for ΔH_{ads} .
- Estimation of the efficiency of the system for extraction of Pb/Bi from RTC into miniCOMPACT

miniCOMPACT: detector and gas chromatograph

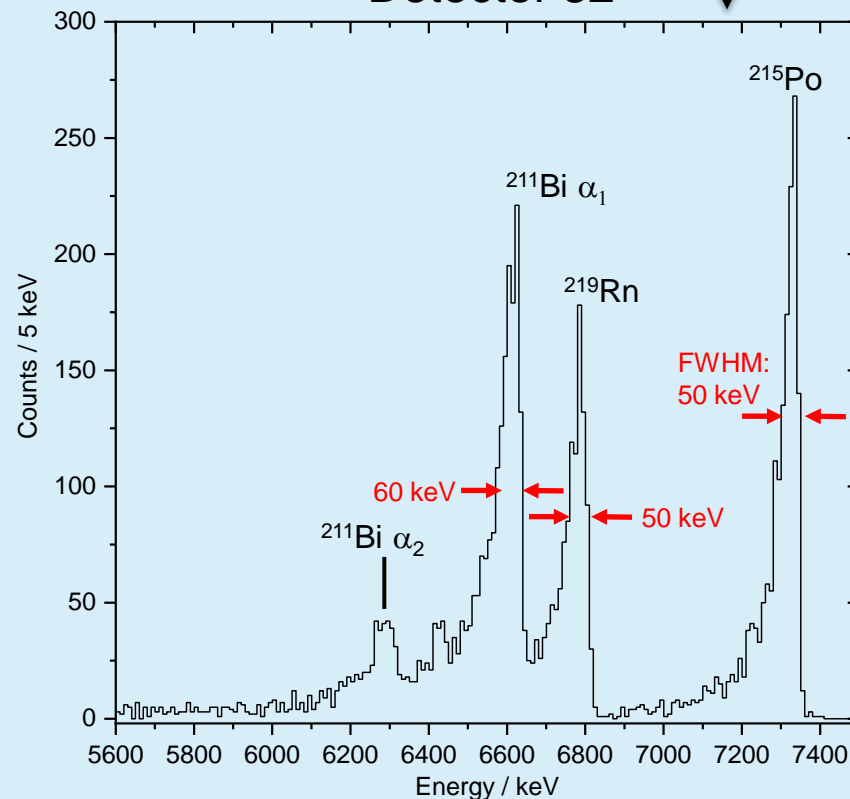




Detector 4

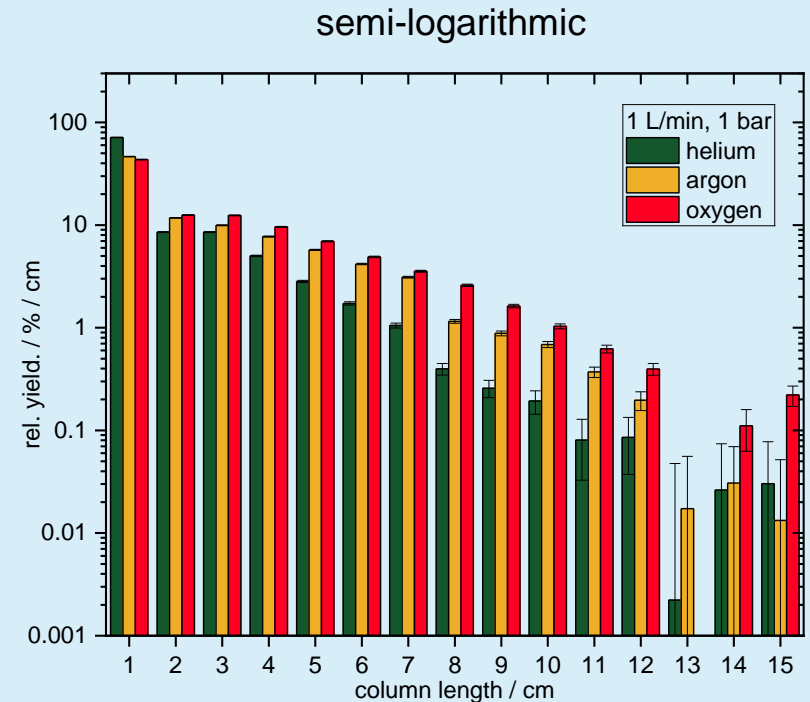
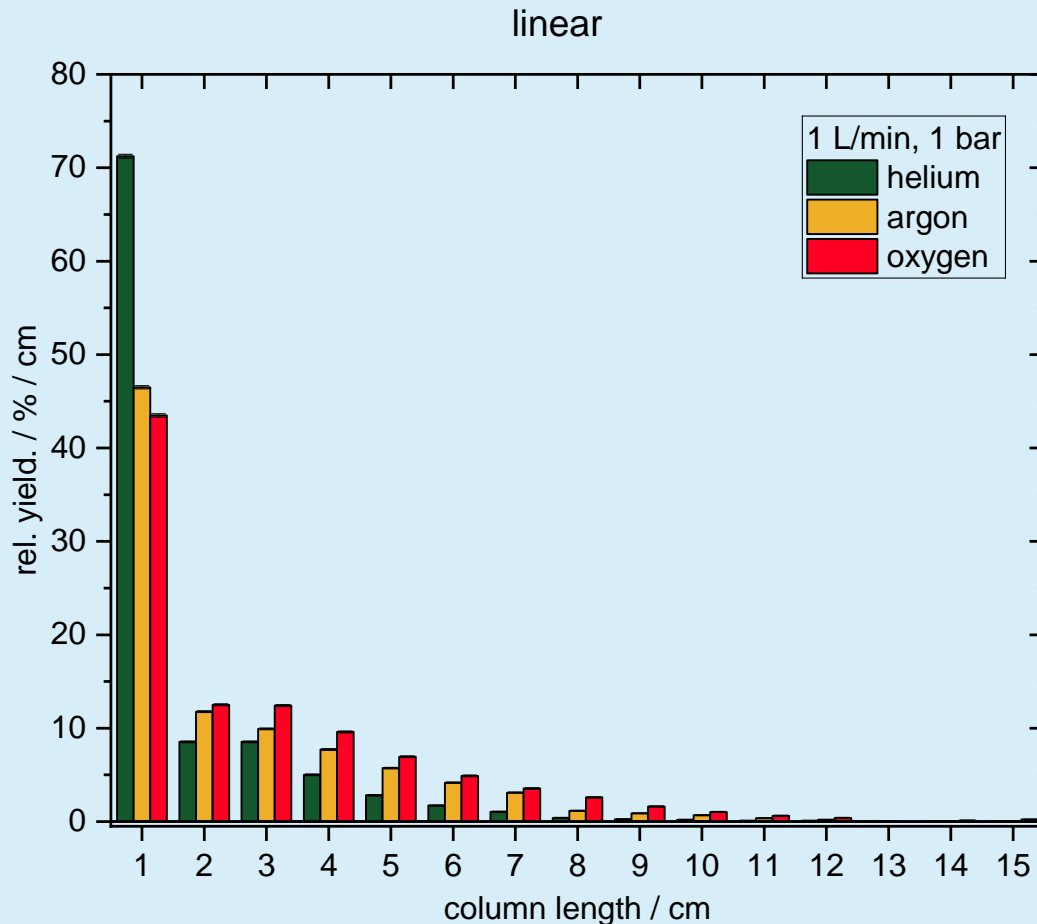


Detector 32



- 3 L/min helium, 1 bar
- opened ^{227}Ac source
- Collecting and counting for 87 min

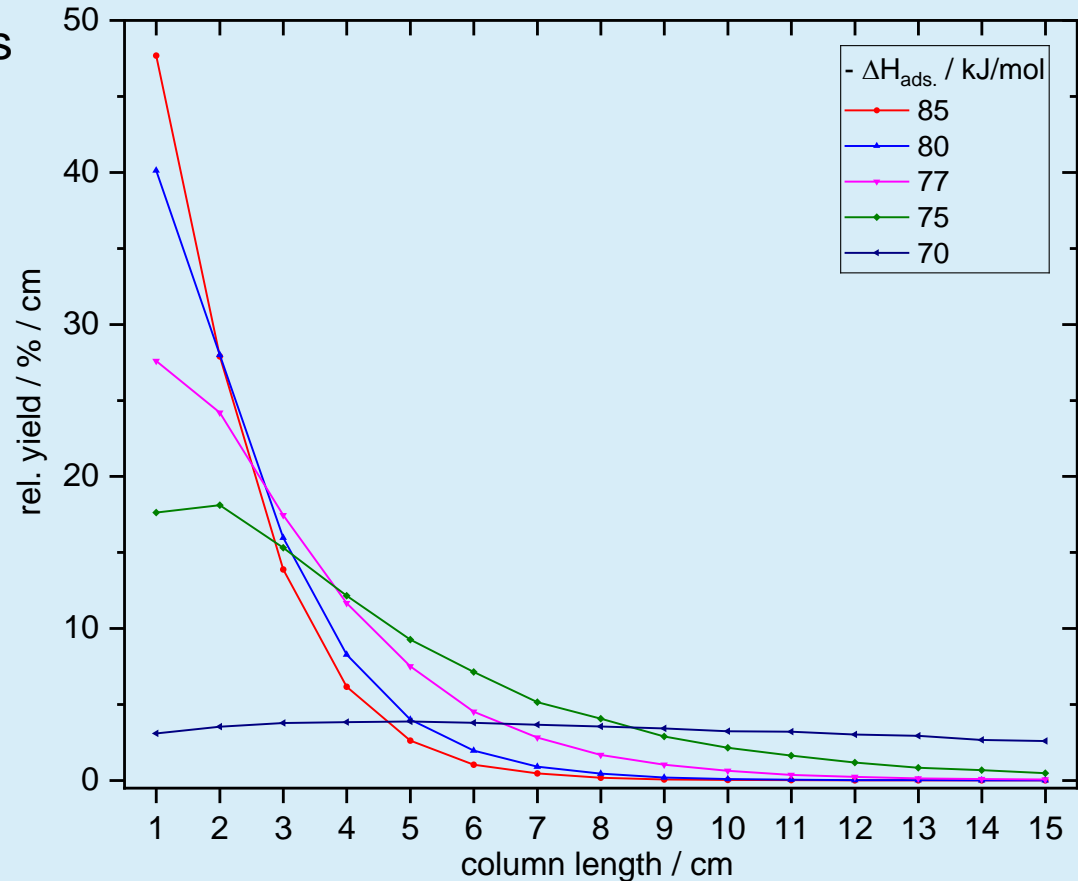
Distribution of ^{211}Bi activity



- ^{211}Bi is fully adsorbed in the detector (>99%)
- No significant differences in argon and oxygen → not sensitive to oxides

Monte-Carlo-Simulation of ^{211}Bi distribution

- Simulation of random pathways of atoms
- Estimation of $-\Delta H_{\text{ads}}$
- Decay marks final position

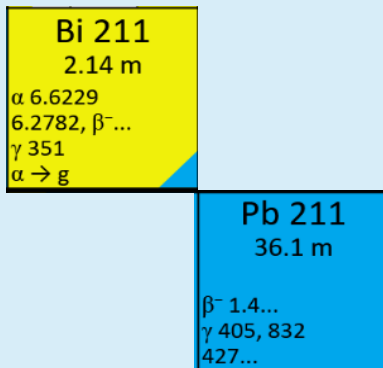


Monte-Carlo-Simulations for different adsorption enthalpy values $-\Delta H_{\text{ads}}$

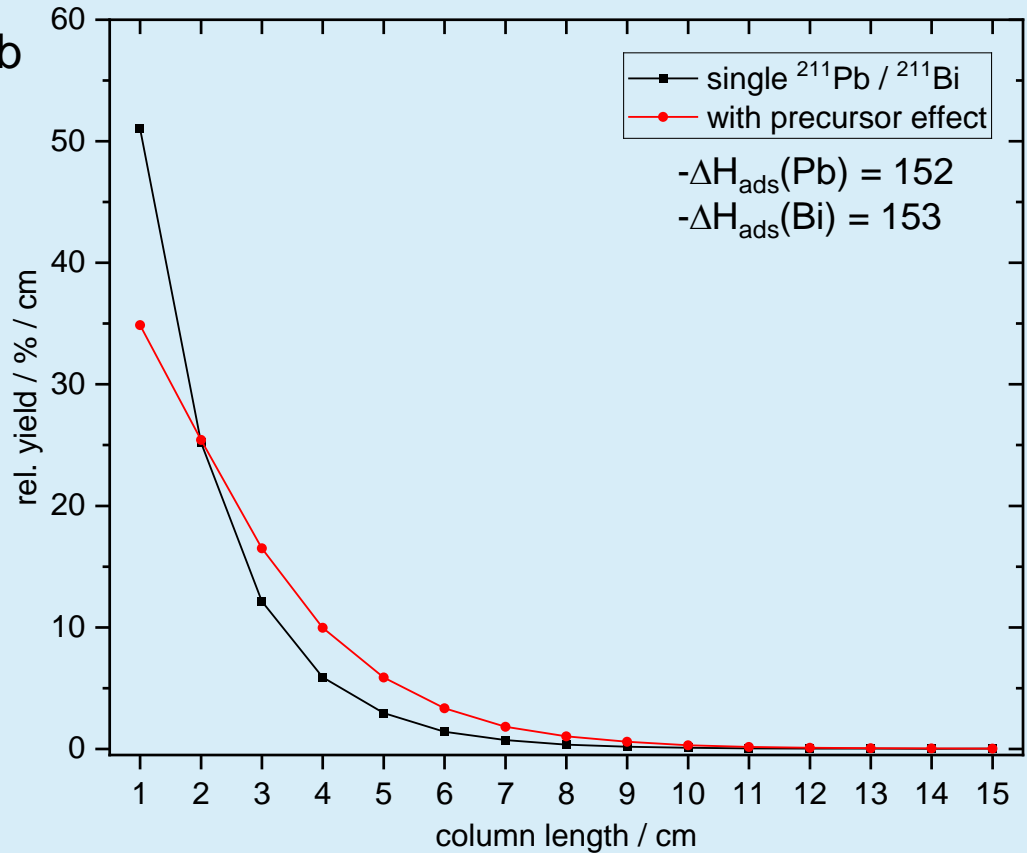


Precursor effect

- Detection of ^{211}Bi as the daughter of ^{211}Pb
- Bismuth emerges from lead distribution
→ Broadening of distribution



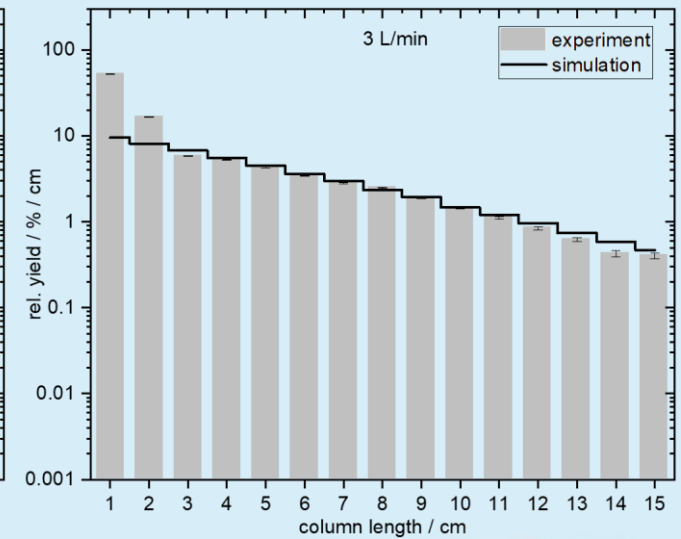
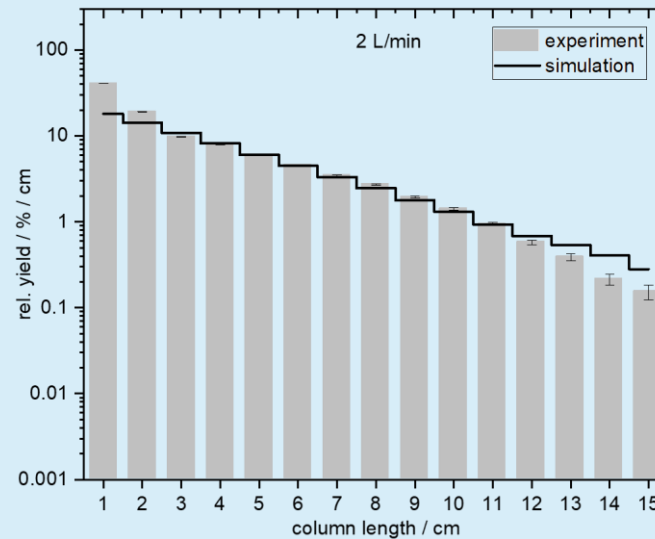
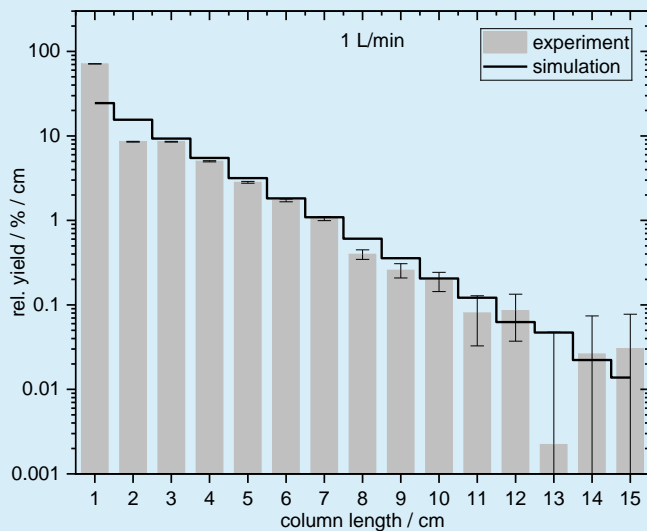
Monte-Carlo-Simulations (He, 3 L/min)



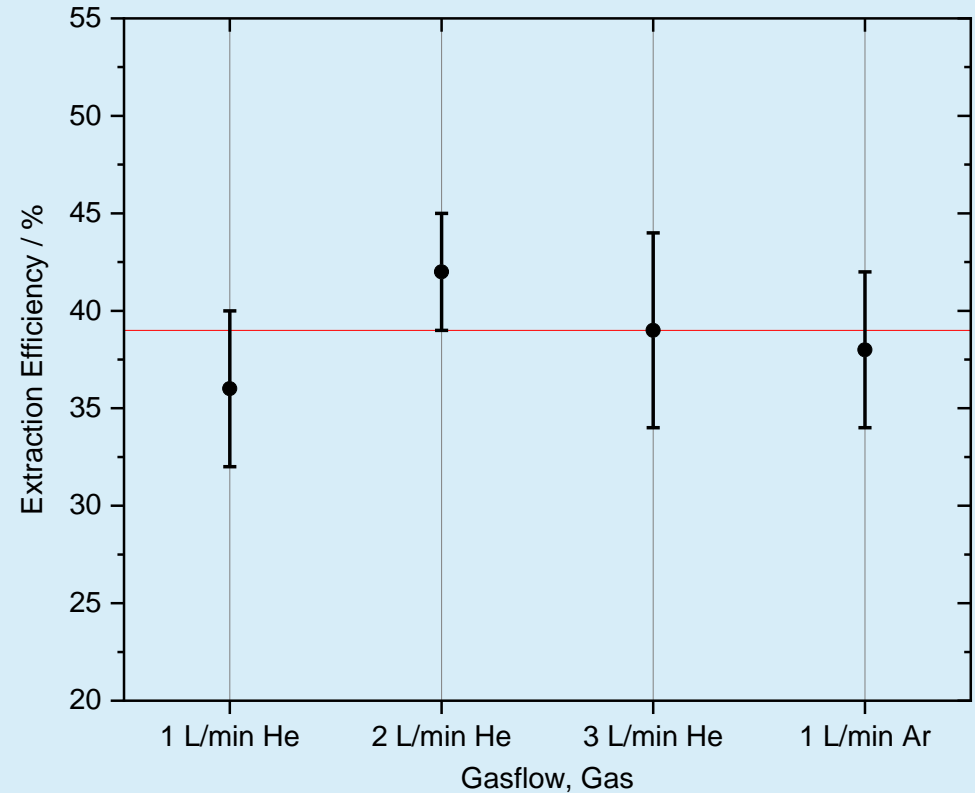
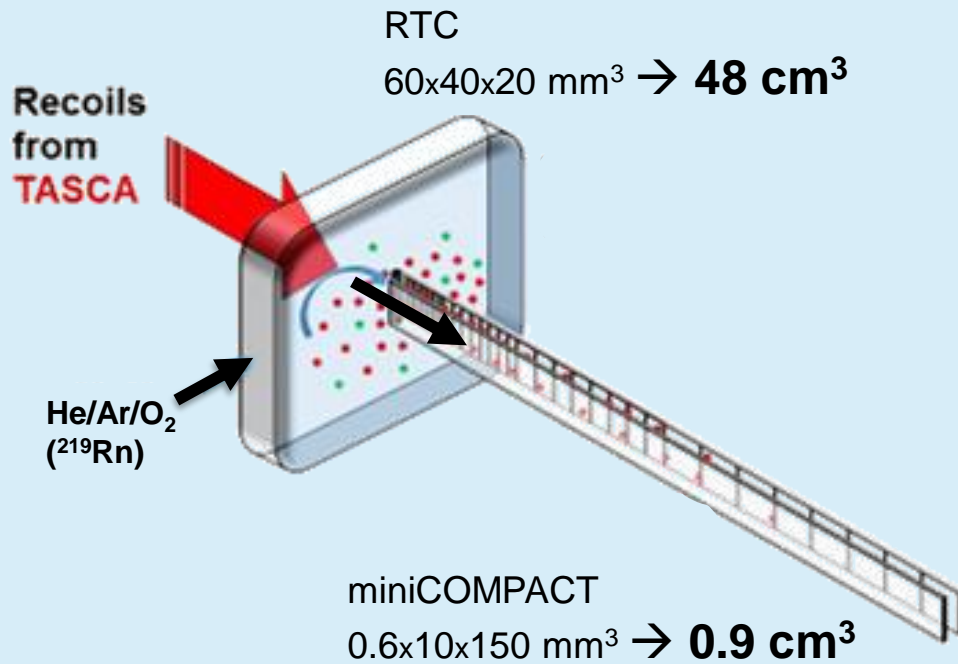
Results

Helium:

- Comparison with Monte-Carlo-Simulation → Limit for $-\Delta H_{\text{ads}}$
- With best fit for 3-15 cm:
Limit for $-\Delta H_{\text{ads.}} \approx 75 \text{ kJ/mol}$
- lower limit for pure diffusion controlled adsorption

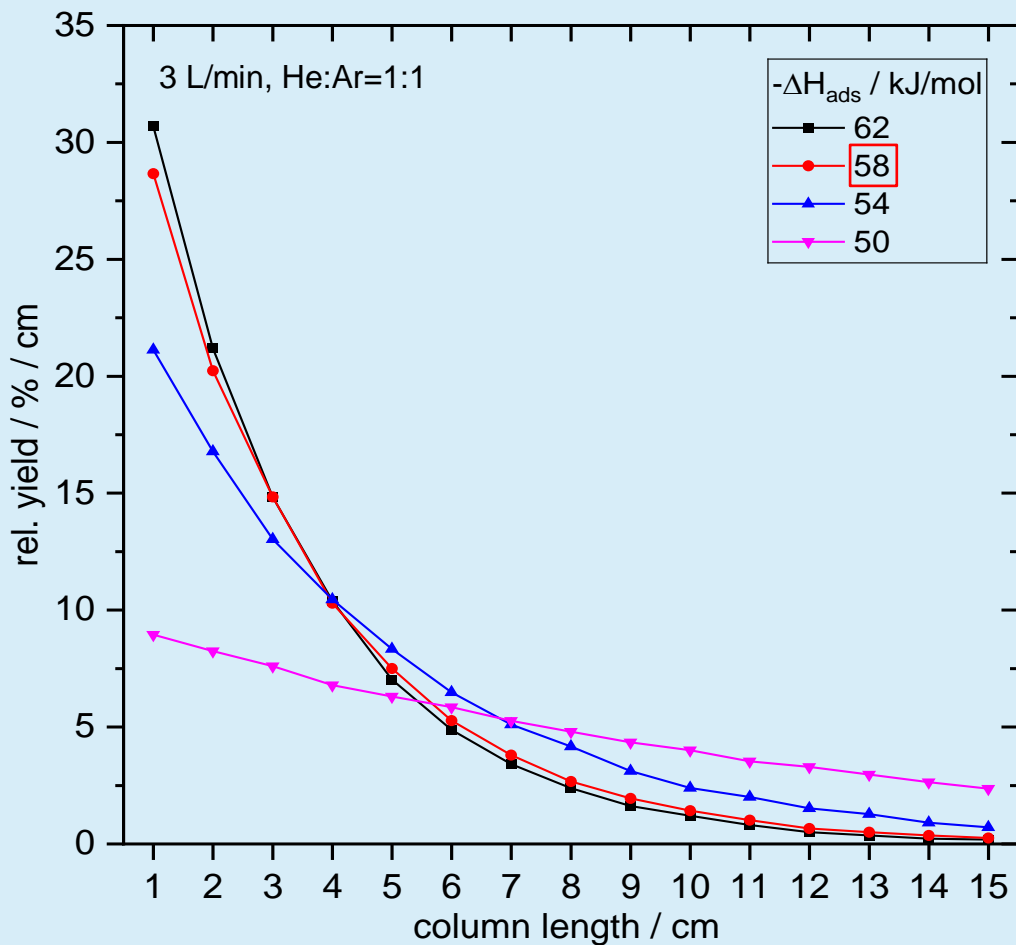


Estimation of efficiency



Outlook to ^{288}Mc adsorption experiments

Simulations with ^{288}Mc ($t_{1/2} = 164 \text{ ms}^{[2]}$)



- Moscovium should adsorb mainly in the first part of the column
- If Mc leaves the miniCOMPACT $\rightarrow -\Delta H_{\text{ads}}$ is lower than 58 kJ/mol
- If $-\Delta H_{\text{ads}}$ is higher \rightarrow not sensitive

Summary

1. New setup with miniCOMPACT detector directly connected to RTC
2. ^{227}Ac -chain with ^{211}Bi as daughter of ^{211}Pb → precursor effect
3. Extraction of non-volatile elements from RTC possible
4. Overall efficiency for the extraction of Pb/Bi from the RTC $\approx 39\%$
5. Bismuth is reactive and is deposited on SiO_2 in a diffusion-controlled manner at room temperature.
The lower limit for $-\Delta H_{\text{ads}}$ is $\approx 75 \text{ kJ / mol}$

**READY FOR MOSCOVIUM
EXPERIMENTS**

**Acknowledgements:
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Thank you all for your attention!



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