A SISAK Extraction System for Chemical Studies of Hassium

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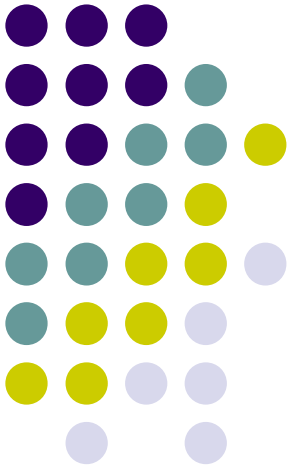
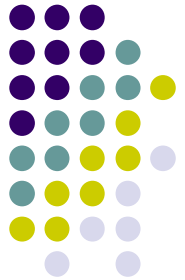


Outline

- SISAK system
- Element 108, Hs
- Developing stage at Oslo Cyclotron Laboratory (OCL)
- Pilot experiment at GSI
- Comparing Ru and Os, Hs predictions

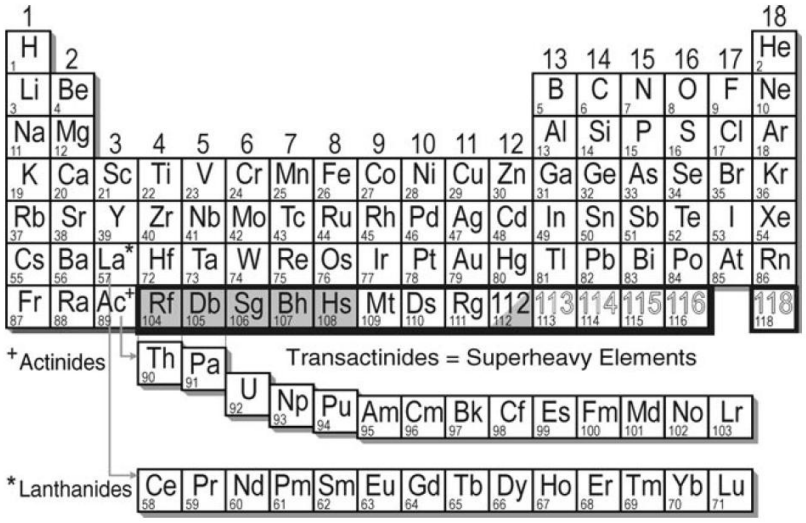
SISAK system



- Fast online automated solvent extraction system suitable for study of short-lived isotopes with one-atom-at-a-time sensitivity.
  - Successfully performed several 4-s ^{257}Rf chemistry experiments.
  - Successfully tested detection of 4-s ^{258}Db.

Previous Hs experiments

- Formation of HsO_4 analogous to OsO_4 and RuO_4 (gas phase experiments) [1,2]
- Evidence for formation of hassate $[HsO_4(OH)_2]^{2-}$ analogous to osmate $[OsO_4(OH)_2]^{2-}$ (gas phase experiments) [3]



[1] Düllmann et.al. Nature **418,** 859 (2002)

[2] Dvorak et. Al. Phys. Rev. Lett.

24, 242501/1-242501/4 (2006)

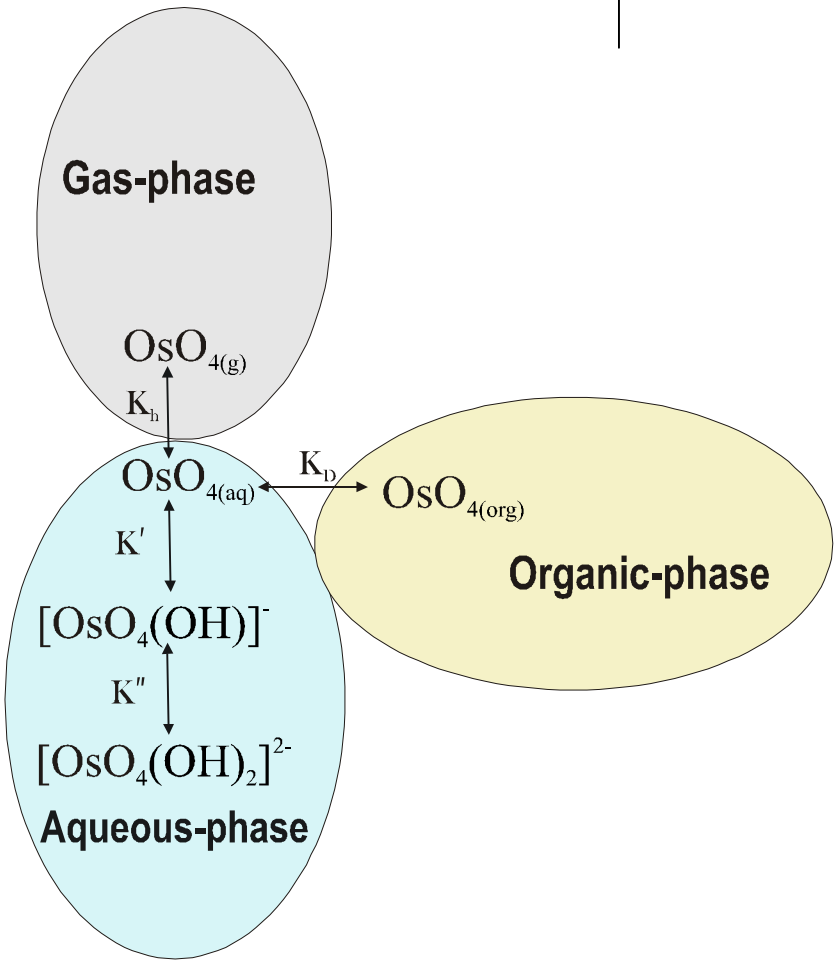
[3] von Zweidorf et.al. Radiochim Acta **92**, 855 (2004)

System Developed at OCL

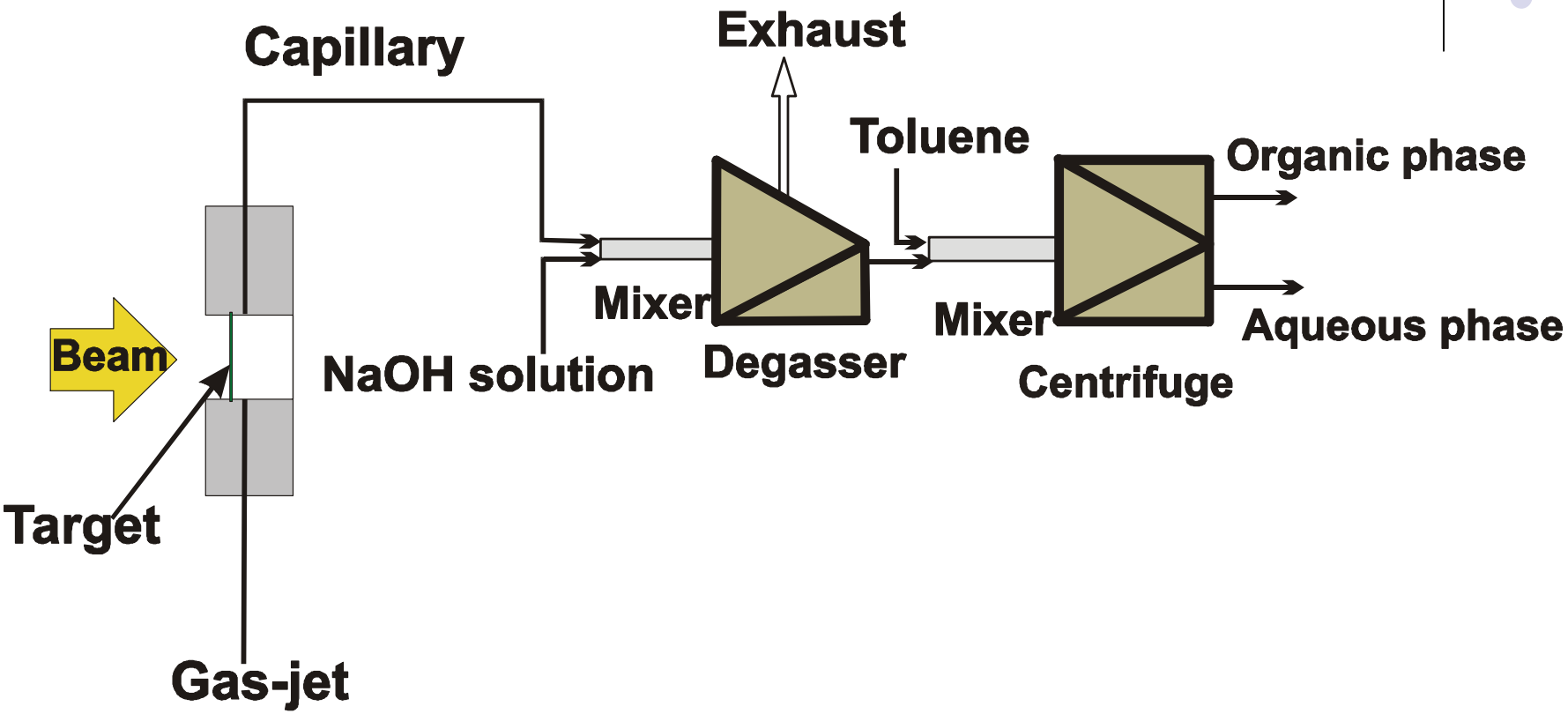
System developed based on known chemical properties of Hs:

- Transportation is based on in situ formation of volatile tetroxides of group VIII elements.

- Solvent extraction based on formation of hydroxo complexes of tetroxides.



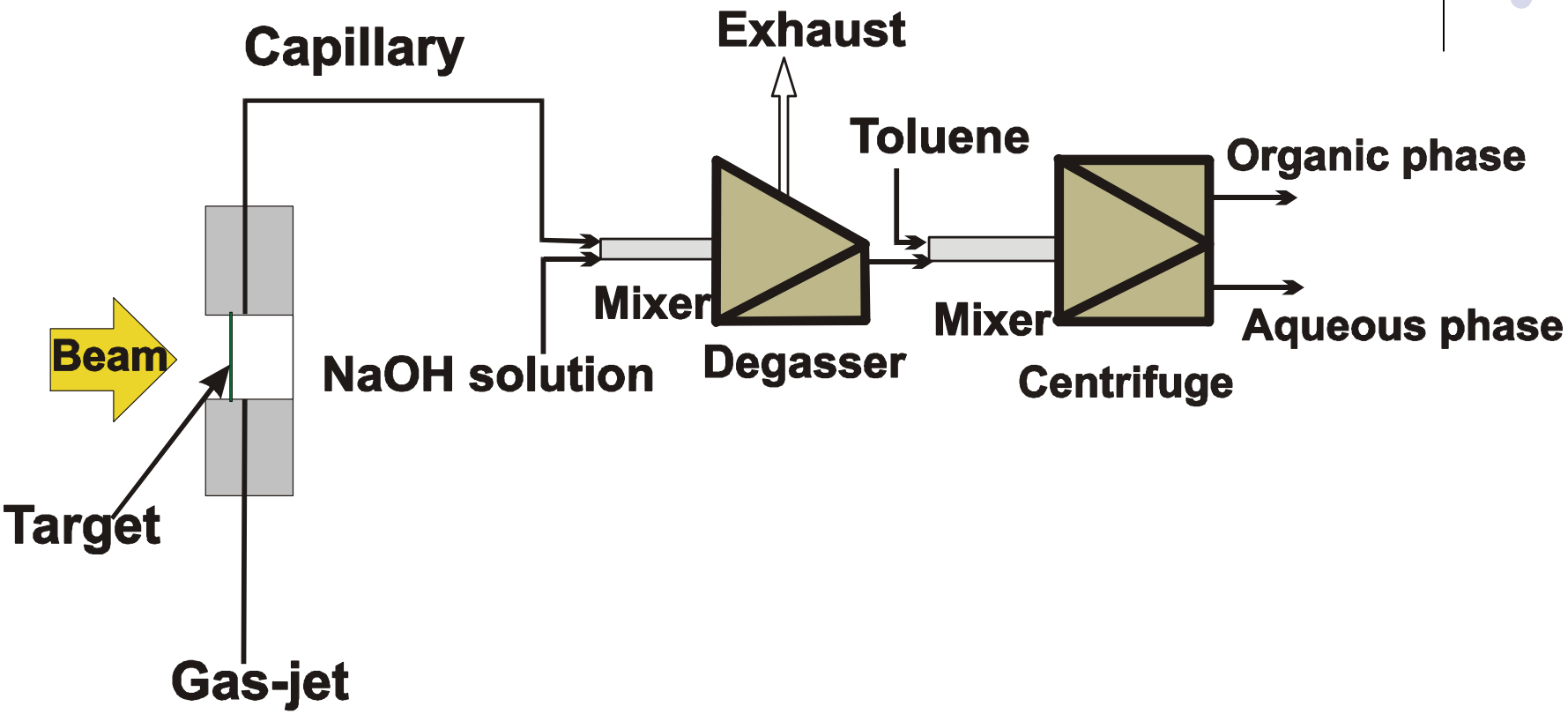
Os experiments at OCL



2.7-min ^{181}**Os** produced from 45 MeV ^{3}He on W-target.

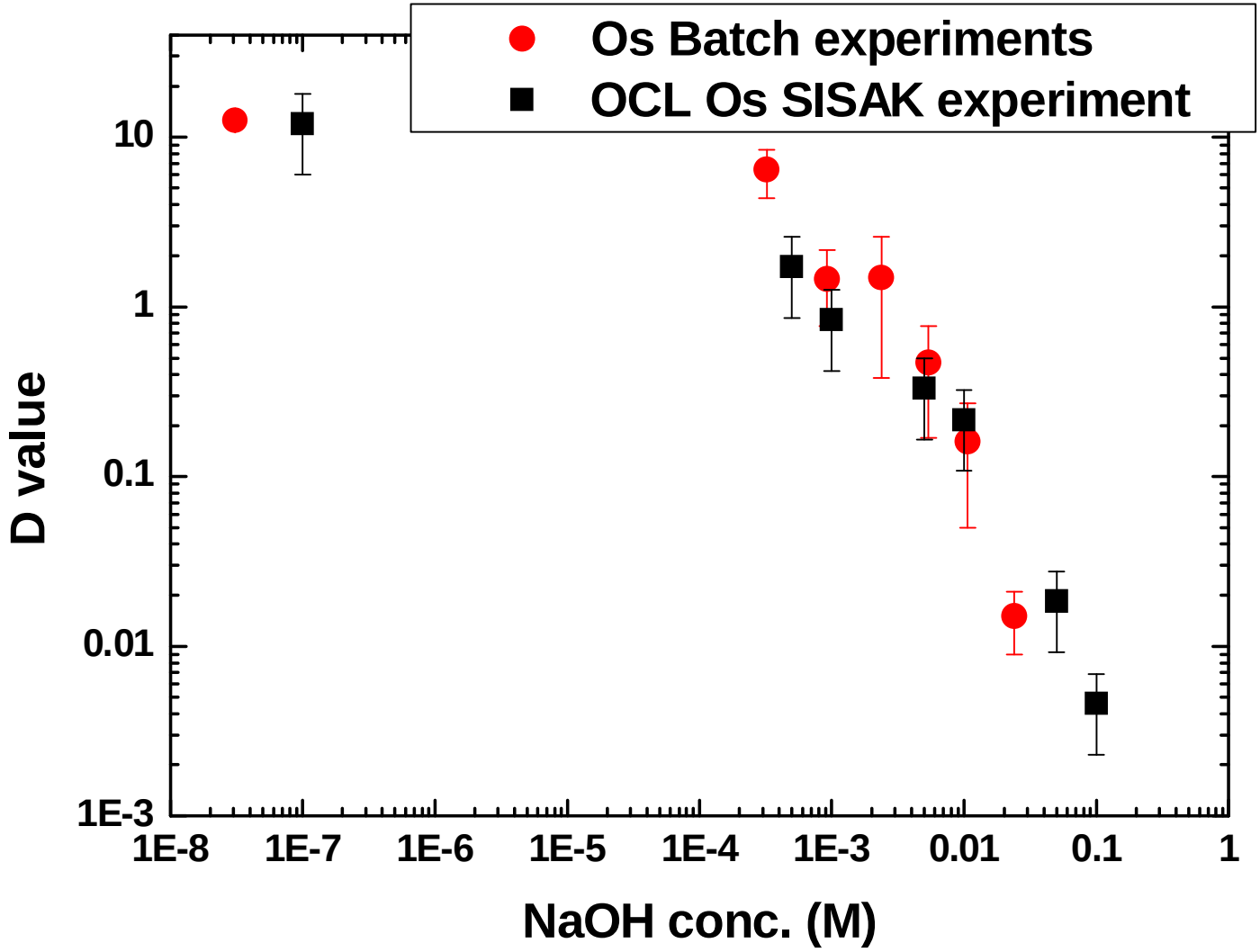
Os forms OsO_4 in a He/O_2 gas jet.

Os experiments at OCL



OsO_4 dissolved in diluted NaOH and extracted into toluene.

Results of Oslo experiments



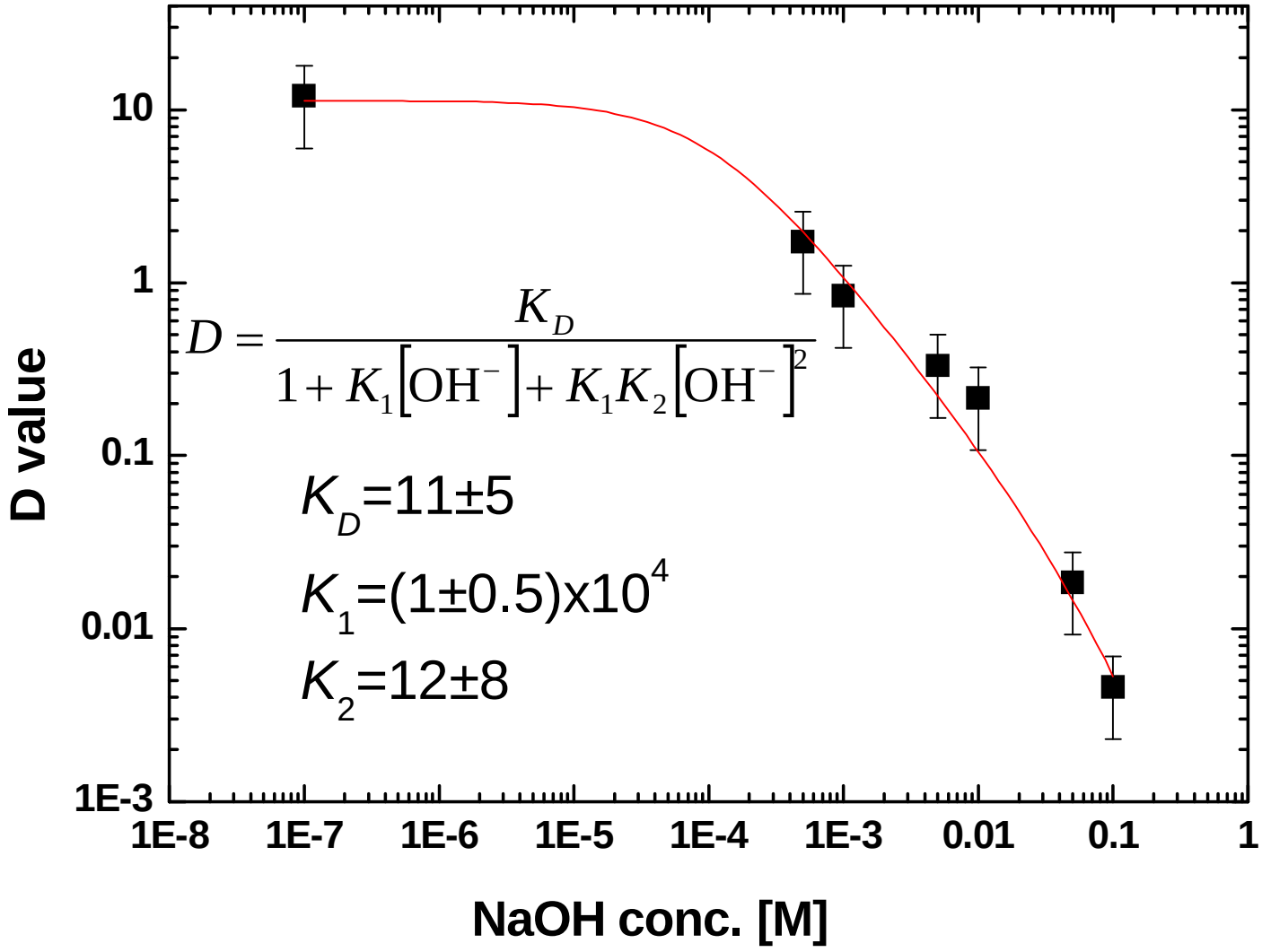
D value vs. conc. of NaOH

$$D = \frac{[OsO_4]_{org}}{[OsO_4]_{aq} + [OsO_4(OH)]^{-} + [OsO_4(OH)_2]^{2-}}$$

$$D = \frac{K_D}{1 + K_1[OH^-] + K_1K_2[OH^-]^2}$$

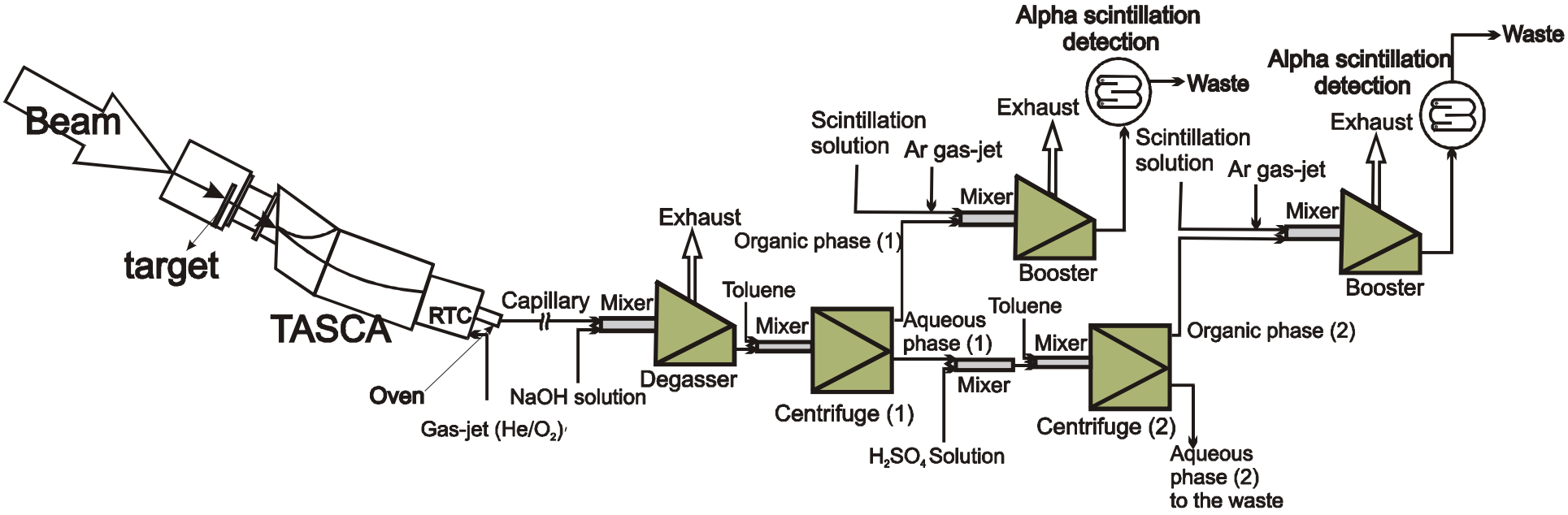
Where K_D is the distribution constant of OsO_4 between toluene and water and K_1 and K_2 *are* the equilibrium constant for the complex formation reactions.

Fitting of the results

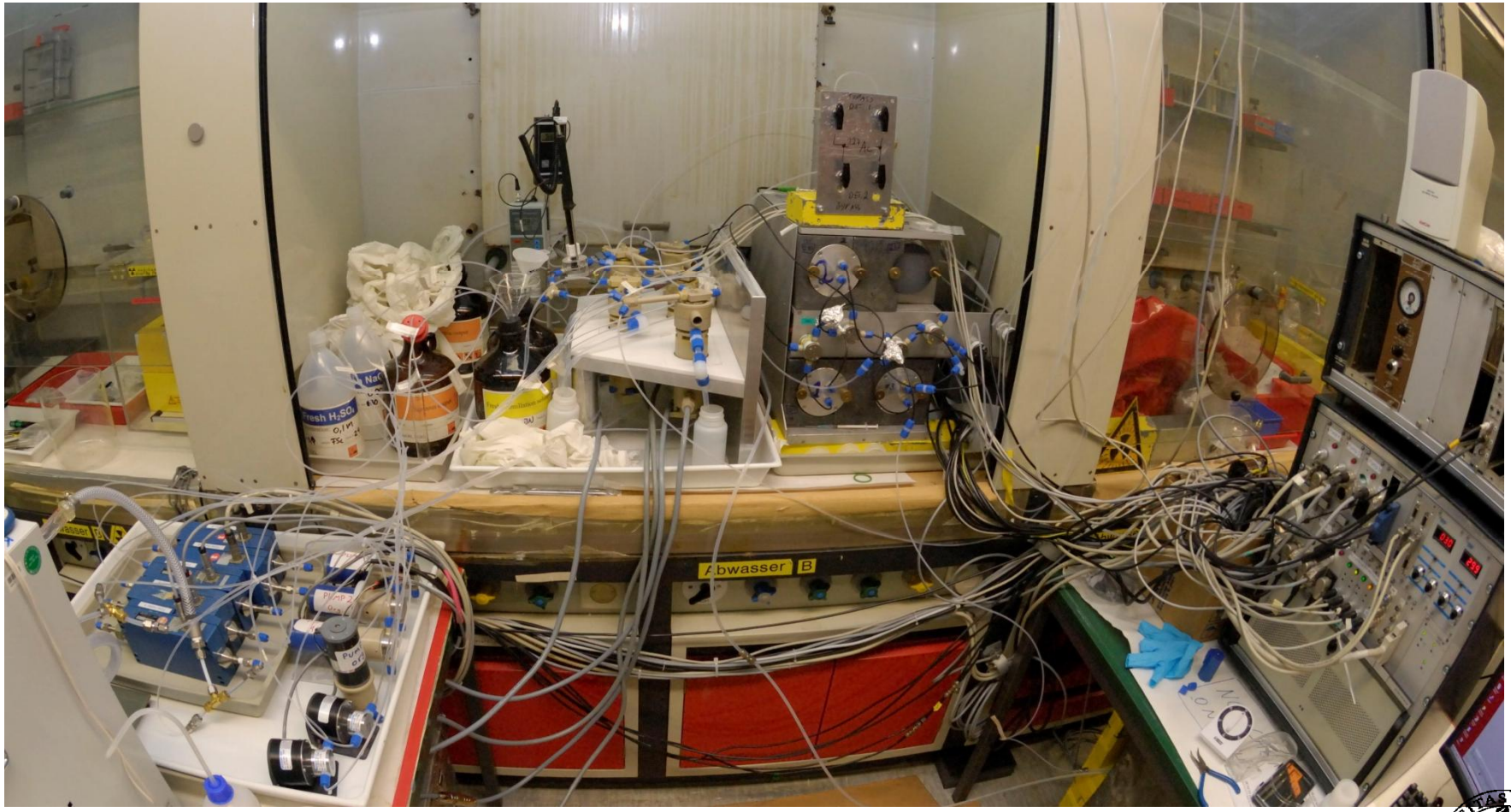


GSI experiments

- Pilot experiment performed at GSI to test the entire SISAK setup with double α-detector arrays.

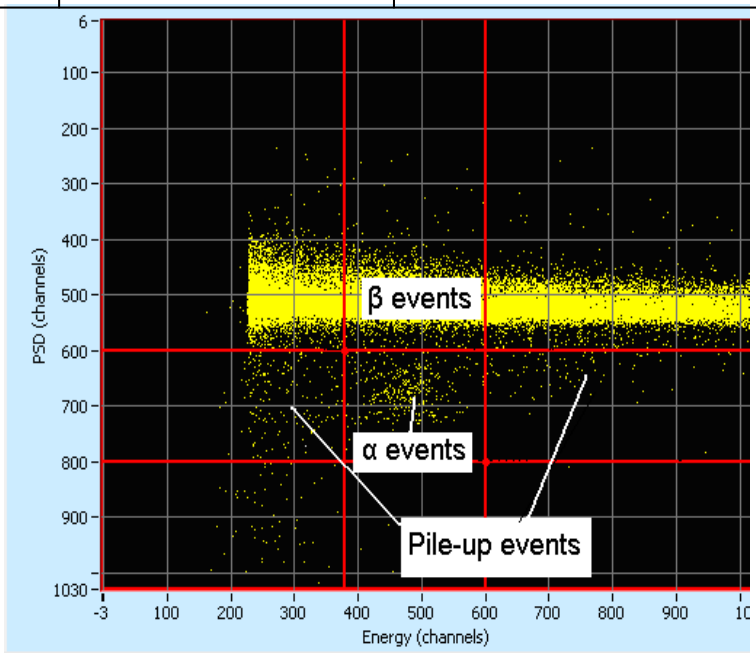


The setup at GSI

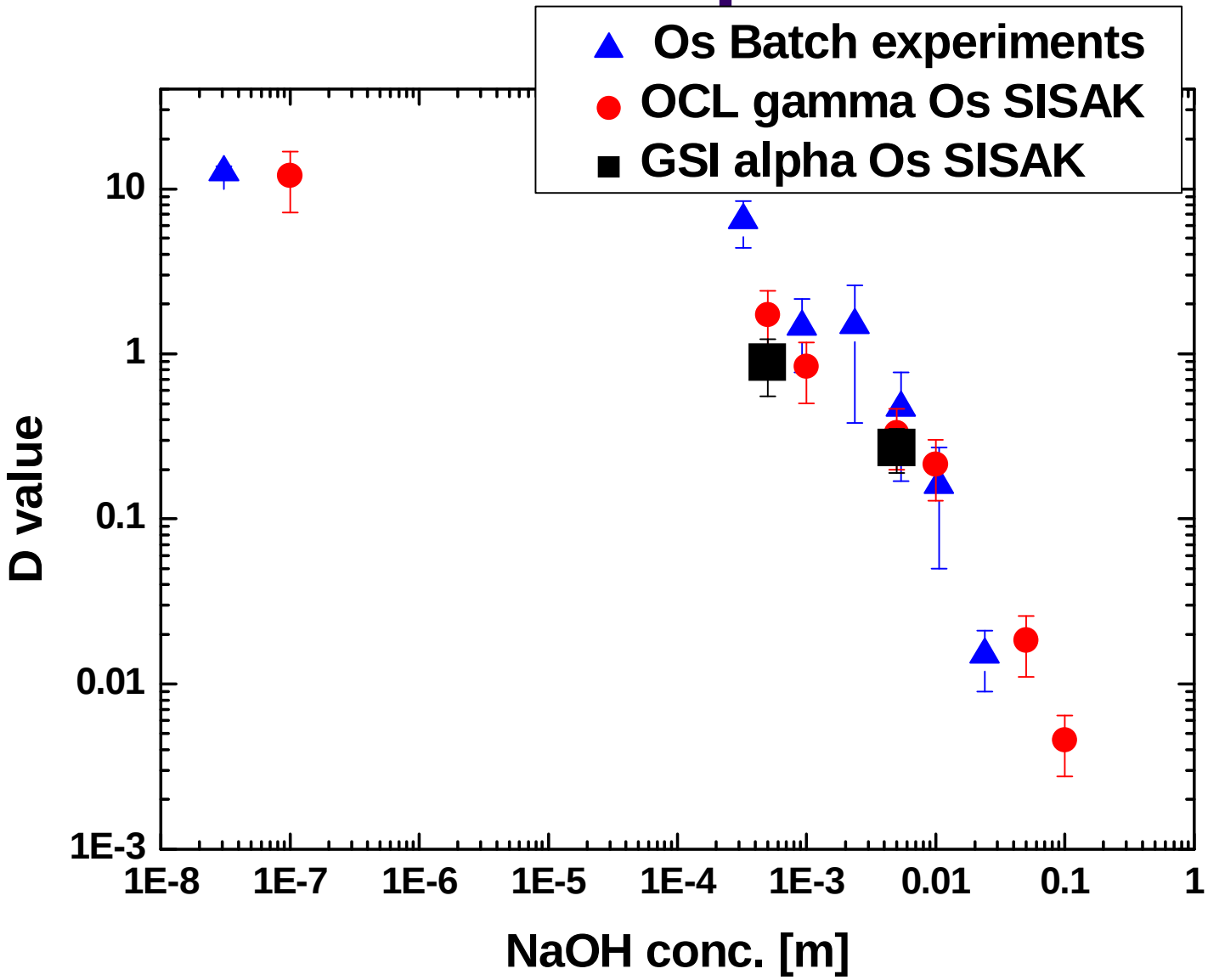


α emitting Os isotopes at GSI experiments

Isotope	^{172}Os		^{173}Os		^{174}Os	
Mode	ε+β$^+$	α	ε+β$^+$	α	ε+β$^+$	α
Branching (%)	99.02	1.02	99.979	0.021	99.980	0.020
Half-life	45 s		22.4 s		19.2 s	

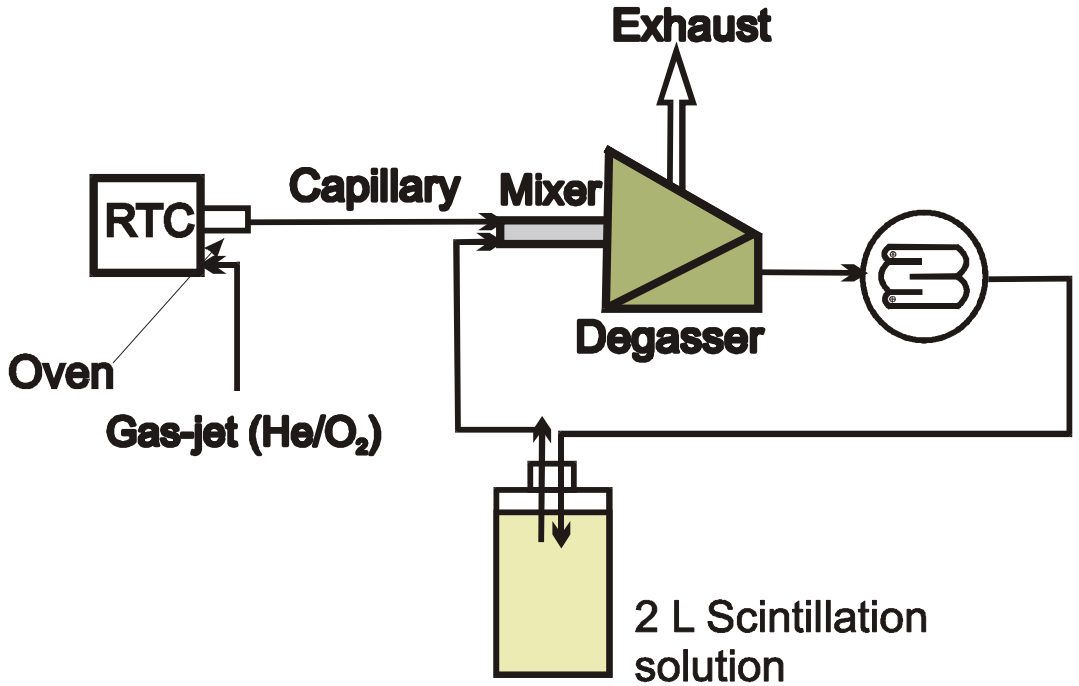


Results of GSI experiments

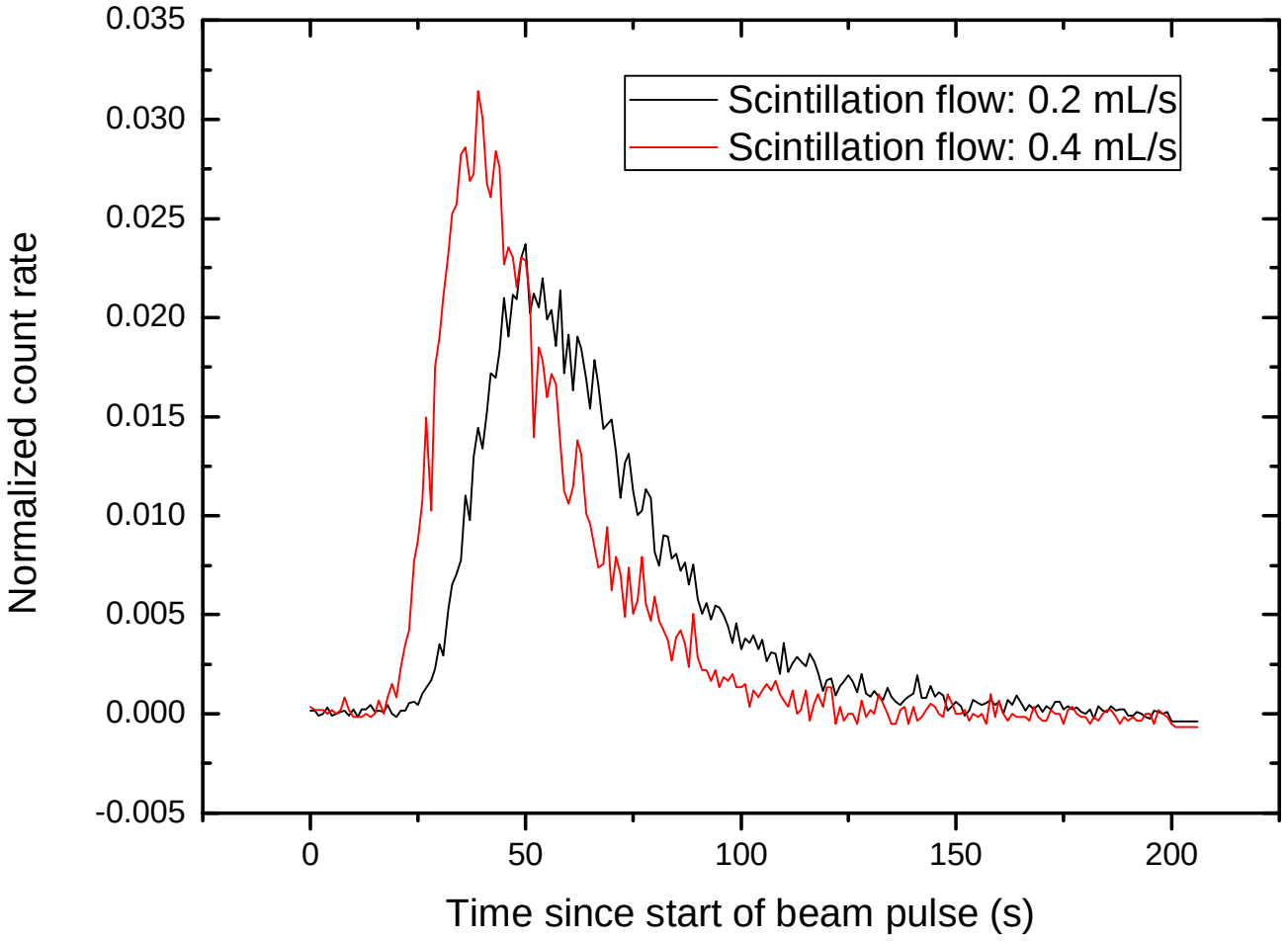


Transport time measurements

Performed by pulse bombardment of the target followed by a break (beam pulse =10 s, break=190 s) repeated for about 1 hour



Transport time curve



Transport time measurement

- Both ^{173}Os and ^{174}Os are transported to the degasser.
- Both are short-lived. Thus, the ^{173}W and ^{174}Re daughter products were measured.

$$\frac{792 / 0.5^{t/45}}{3801} = \frac{601 / 0.5^{t/22.4}}{1519}$$

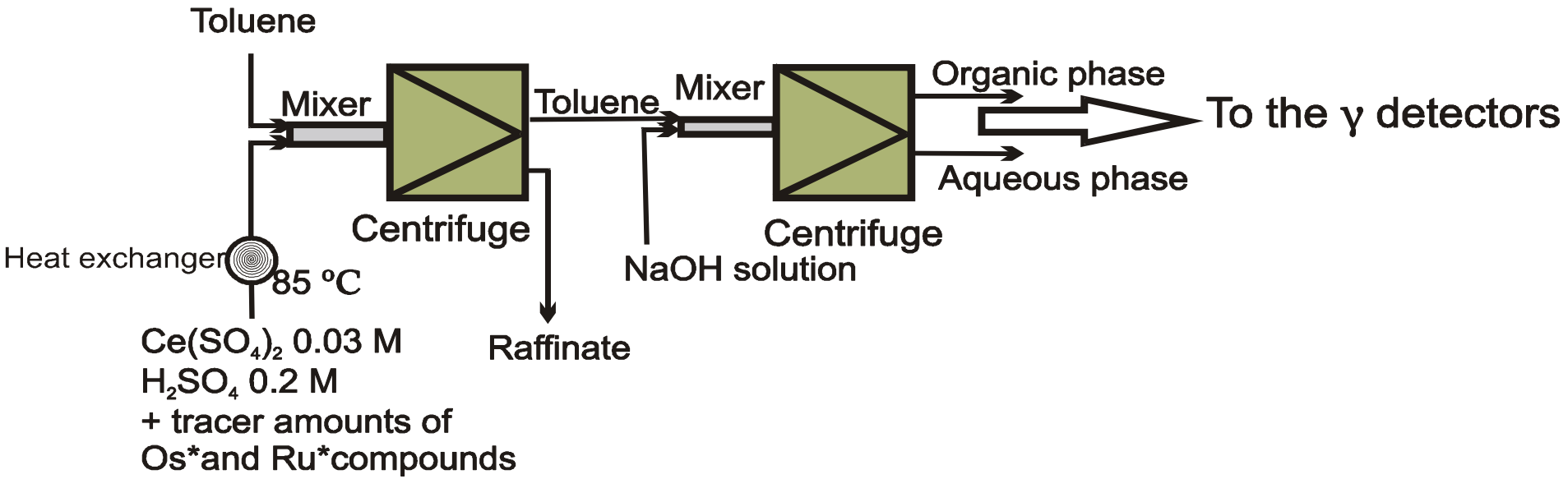
- From this the transport time = 41 s was calculated.

The Yield Measurements

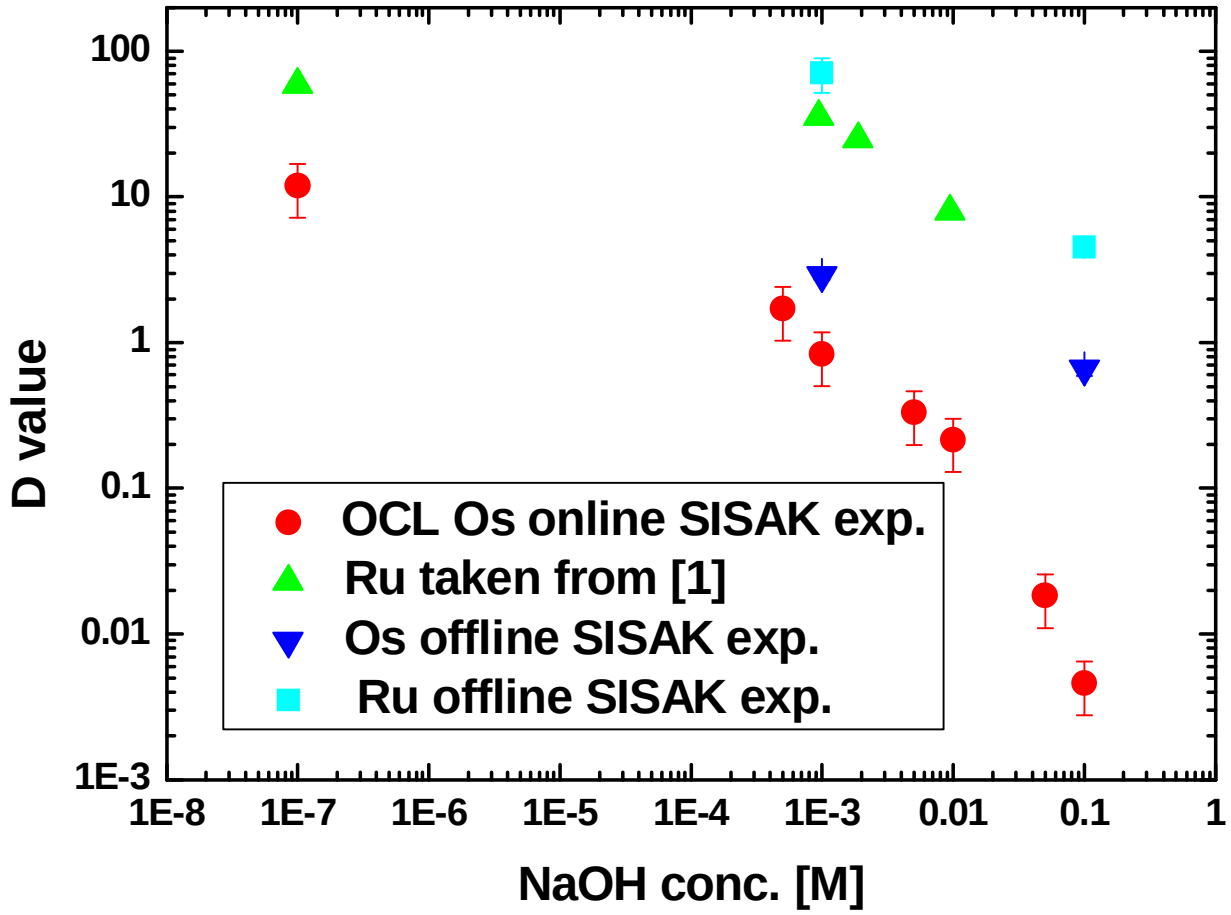
- Was measured by calculating the ratio of activity of ^{174}Re the daughter of ^{174}Os in an Al catcher foil to its activity in the samples from degasser.

- Yield for the transferring from RTC to the liquid phase was (75±15)% independent of oven temperature.

Off-line SISAK experiment



Comparing Ru and Os



[1] Martin. J. Chem. Soc., 2564(1954)

Comparing Ru and Os

- D value for RuO_4 is higher than for OsO_4
- According [1] predicted trend for the formation of $Na_2[MO_4(OH)_2]$ in the reaction:

$$2NaOH+HsO_4 \rightarrow Na_2[HsO_4(OH)_2]$$

in group 8 is:

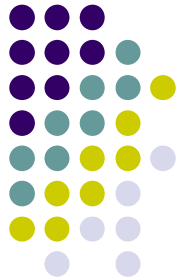
$$Os > Hs >> Ru$$

- The trend in D value then can be predicted to be like this:

$$Ru >> Hs > Os$$

[1] Pershina. Radiochim Acta **93**,373(2005)

Conclusion



- In this work an extraction system for chemical study of Hs was developed using Os as a model.
- The full system was tested using α-emitting Os.
- The system is basically ready for an Hs experiment.

Acknowledgement

- Oslo group: J. Alstad, T. Bjørnstad, J. Nilssen, J.P. Omtvedt, K. Opel, H.B. Ottesen, S. Qureshi, F. Schulz
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