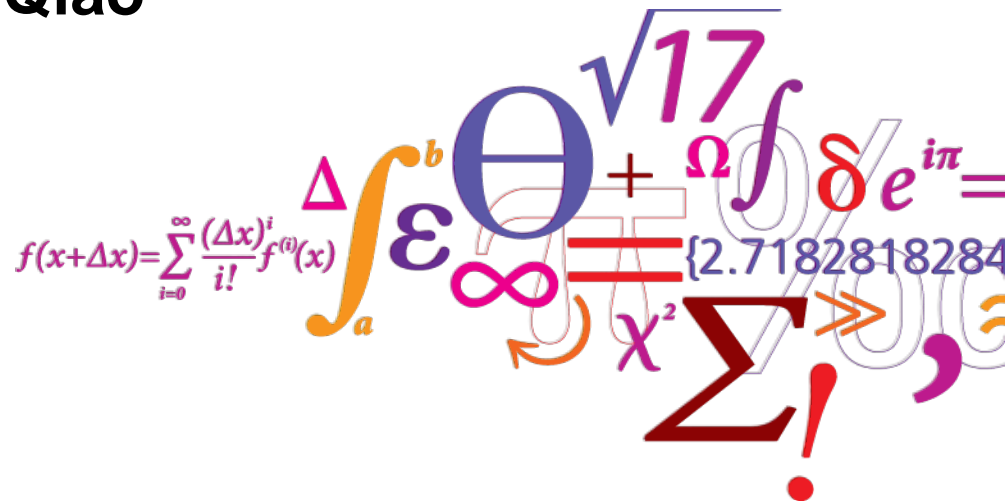
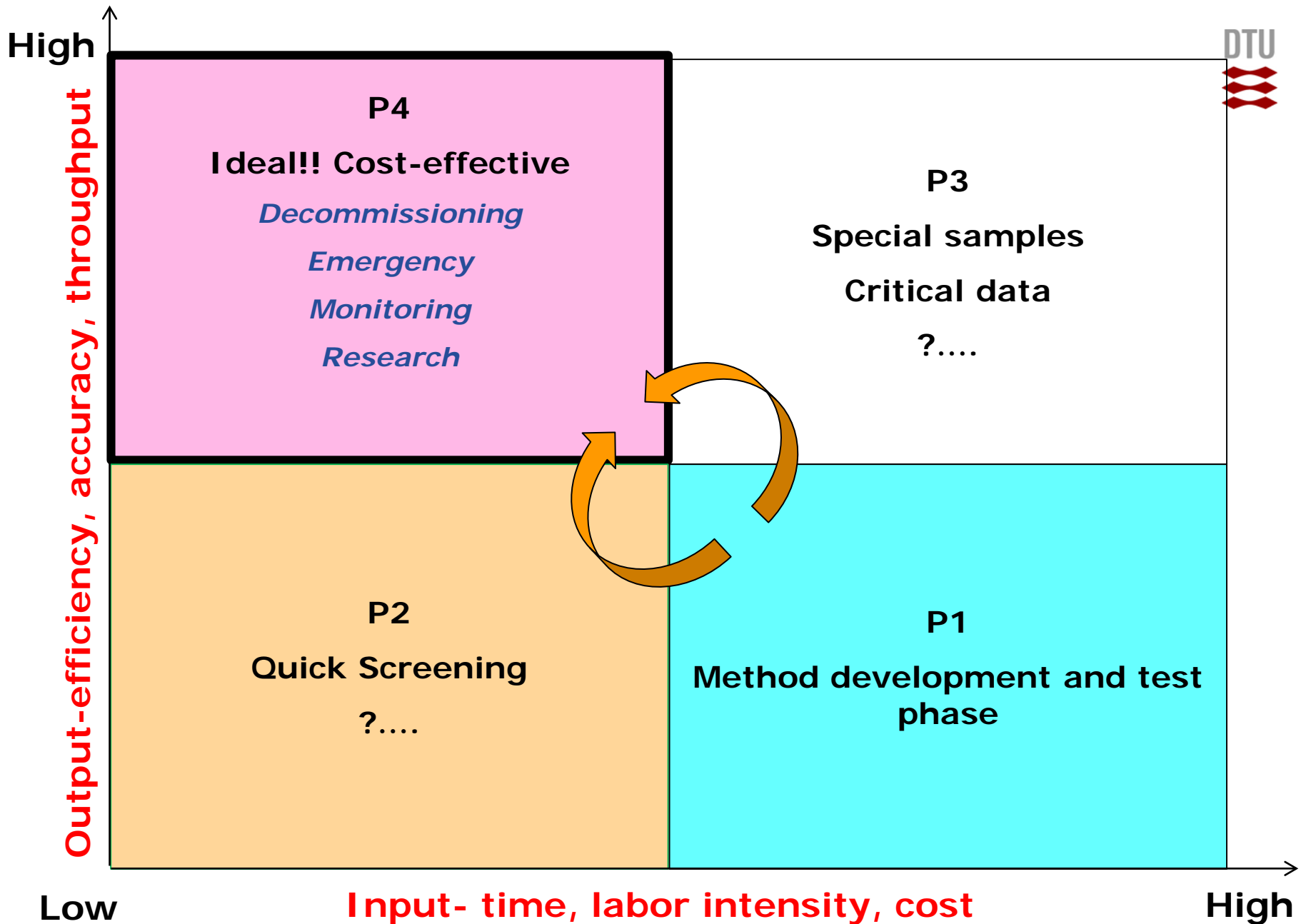


# Development of Rapid and Automated Radiochemical Separation Techniques

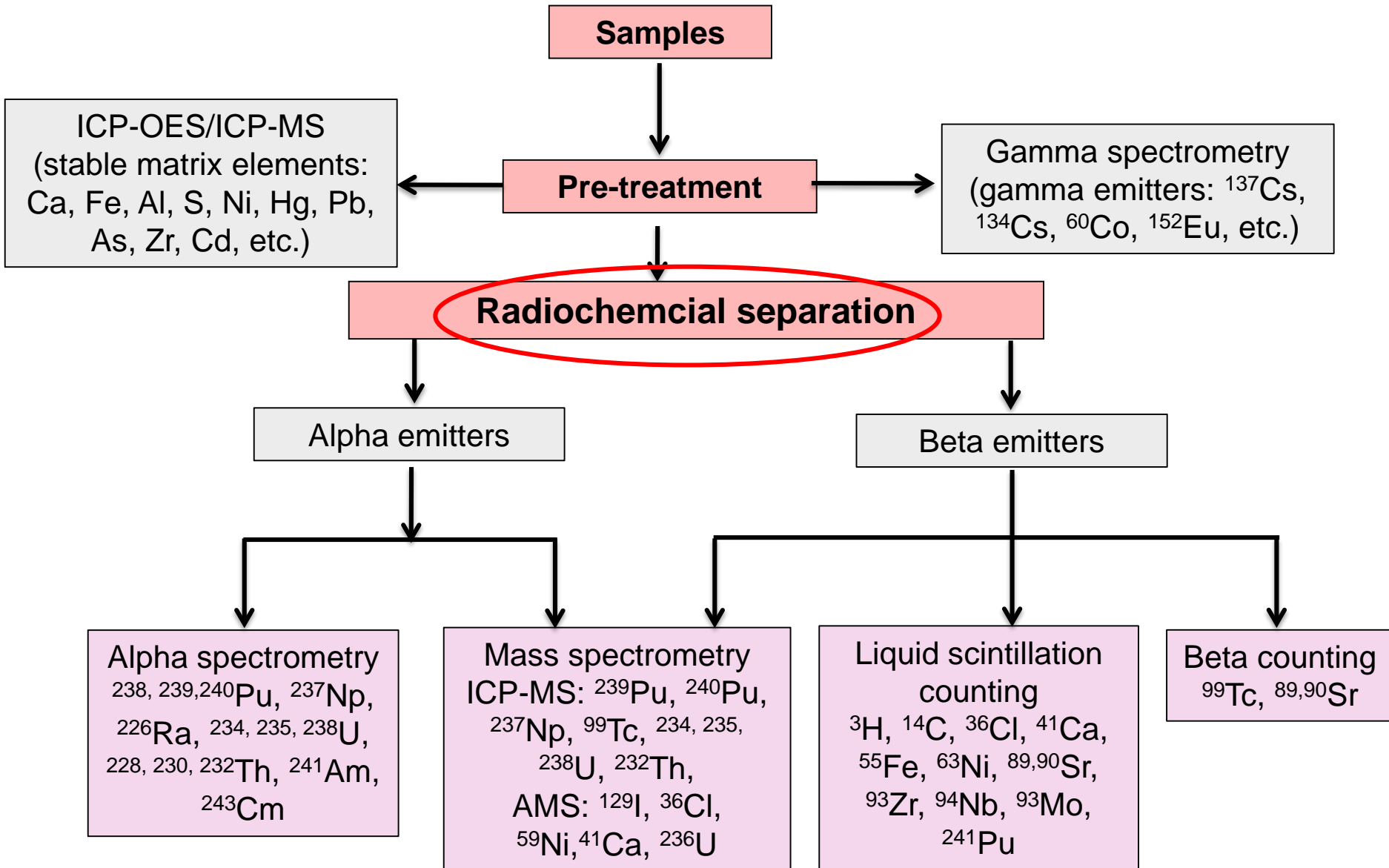
Jixin Qiao



Radworkshop 2018  
8-12 October 2018



# Scheme of Radioassay



## Emergency situations

- Nuclear accidents
- Radiological incidents (dirty bomb)

## Post-accident situations

- Long-term monitoring
- Remediation

## Routine situations

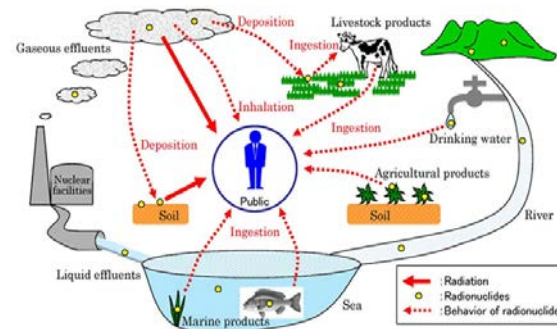
- Environmental monitoring
- Scientific research



Fukushima, 2011



Thule, Greenland

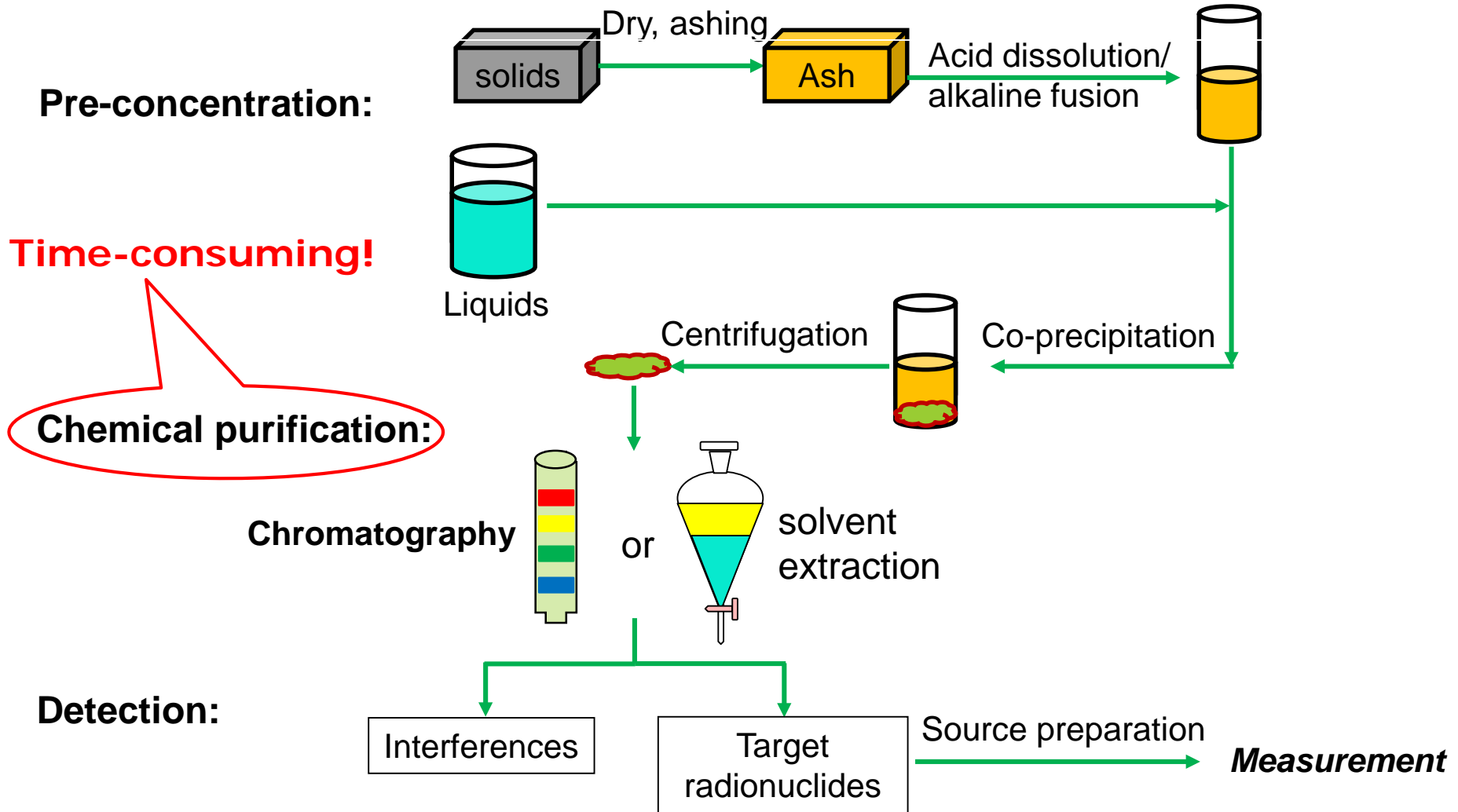


## Nuclear decommissioning

- A large number of samples
- Various matrix types and radionuclides
- Large variation in radioactivity levels
- High radiation exposure from high-level samples



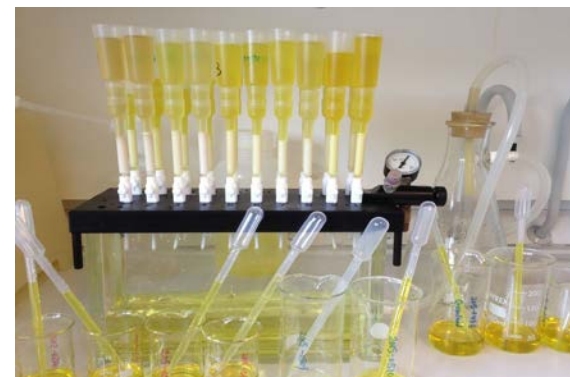
# Typical procedure for radiochemical analysis



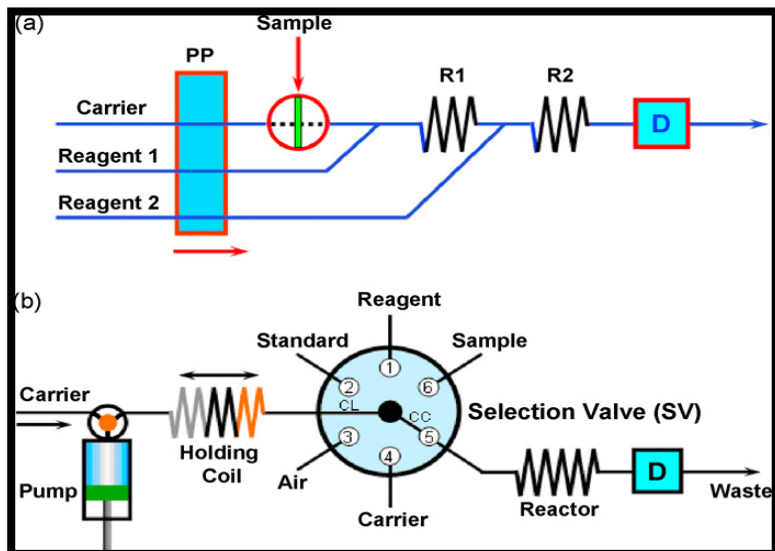


# Rapid radiochemical separation

- Vacuum box
- HPLC
- Flow & Sequential Injection



Vacuum box



Flow and sequential injection systems

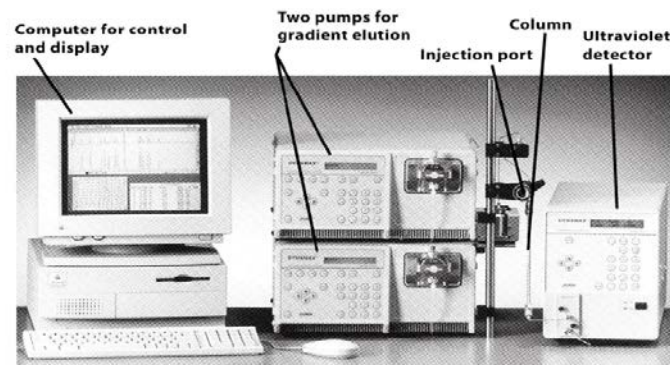


Figure 23-1  
Quantitative Chemical Analysis, Seventh Edition  
© 2007 W. H. Freeman and Company

HPLC system

# Research groups using FI/SI for radioassays

---

Name	Address
O. Egorov, J. Grate, M. O'Hara	Pacific Northwest National Laboratory, USA
C. K. Kim	Department of Nuclear Science and Applications, IAEA, Austria
C. S. Kim	Korea Institute of Nuclear Safty, Korea
K. J. Lee	Korea Advanced Institute of Science and Technioly, Korea
V. N. Evop	Environmental & Ressource Sutdies, Trent University, Canada & Vinogradov Istitute of Geochemistry SB RAS, Russia
V. Cedá, M. Miró	Department of Chemistry, University of the Balearic Islands, Spain
J. Qiao	Center for Nuclear technology, Technique University of Denmark



# Determination of long-lived radionuclides

1. Rapid determination of Pu, Np, U and Tc
2. Automation of the analytical procedure

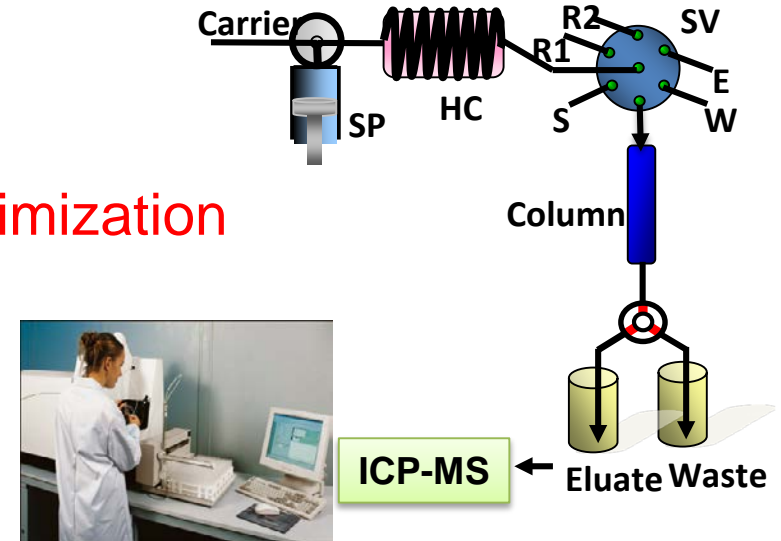
Specific focuses:

i. Chemical purification

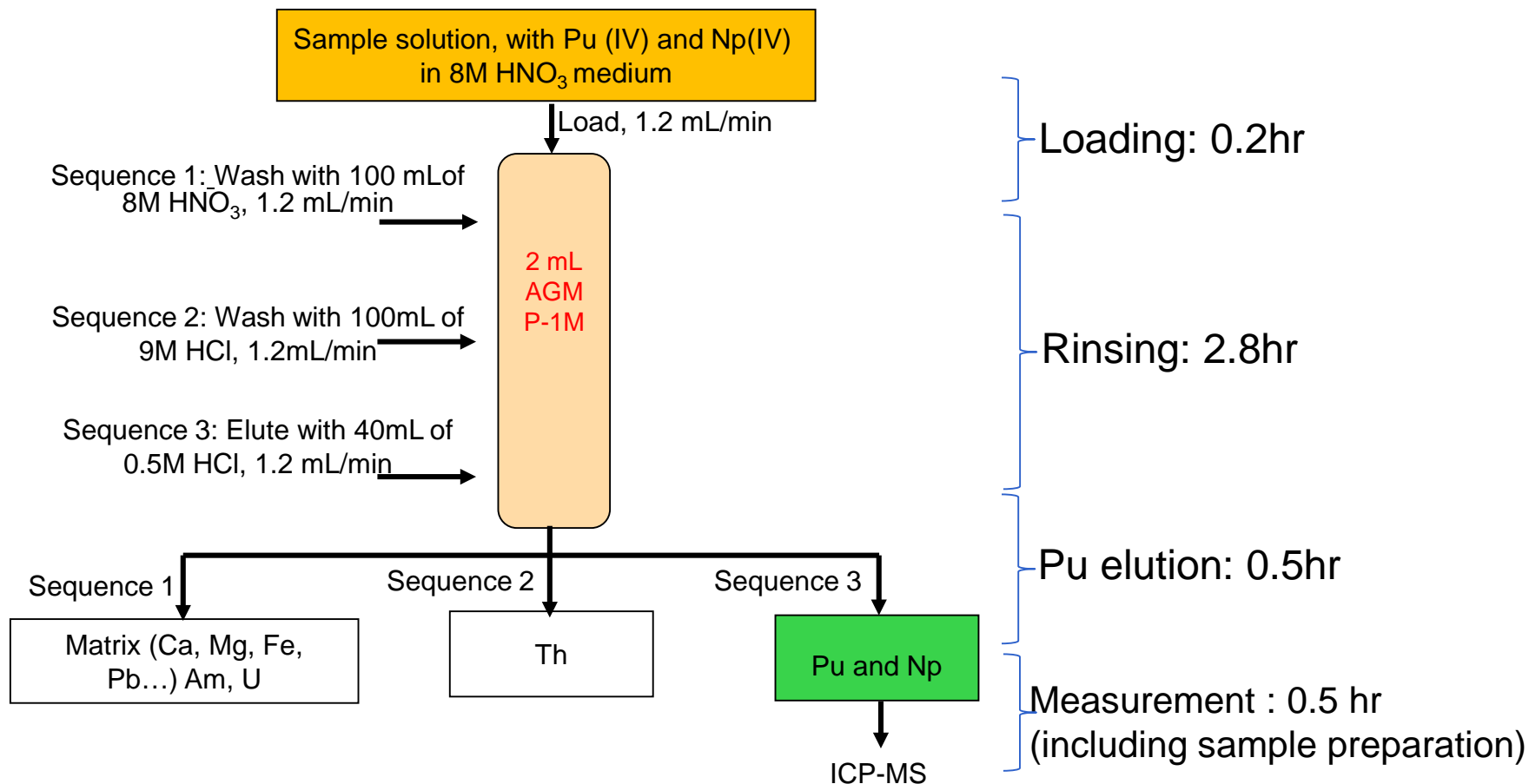
- Protocol simplification and optimization
- Automation

ii. Detection

- Mass spectrometry (ICP-MS)



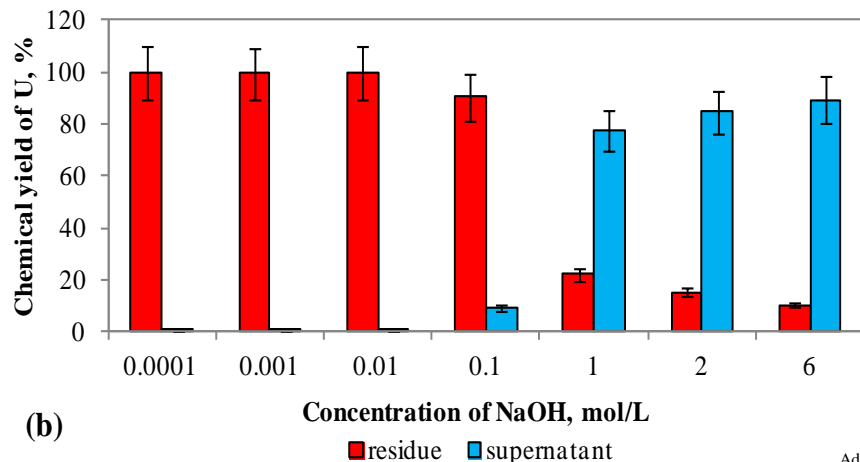
# Automated method for Pu and Np determination



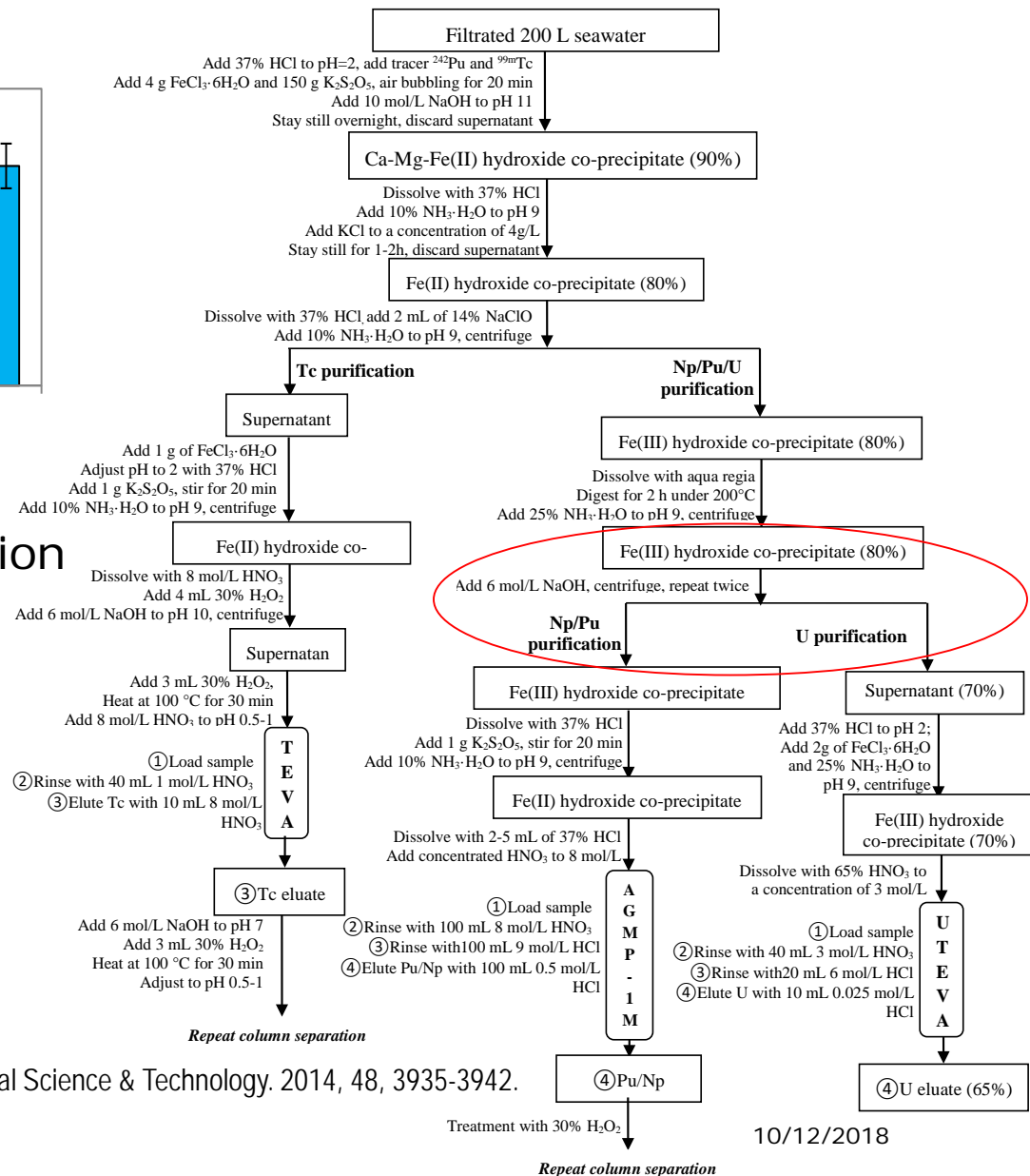
Comparison: 2-13 days using traditional method

Total: 3.5 + 0.5 = 4hr

# Sequential determination of Pu, Np, U and Tc



(b) Chemical yield of U, % vs Concentration of NaOH, mol/L. Legend: ■ residue, ■ supernatant.

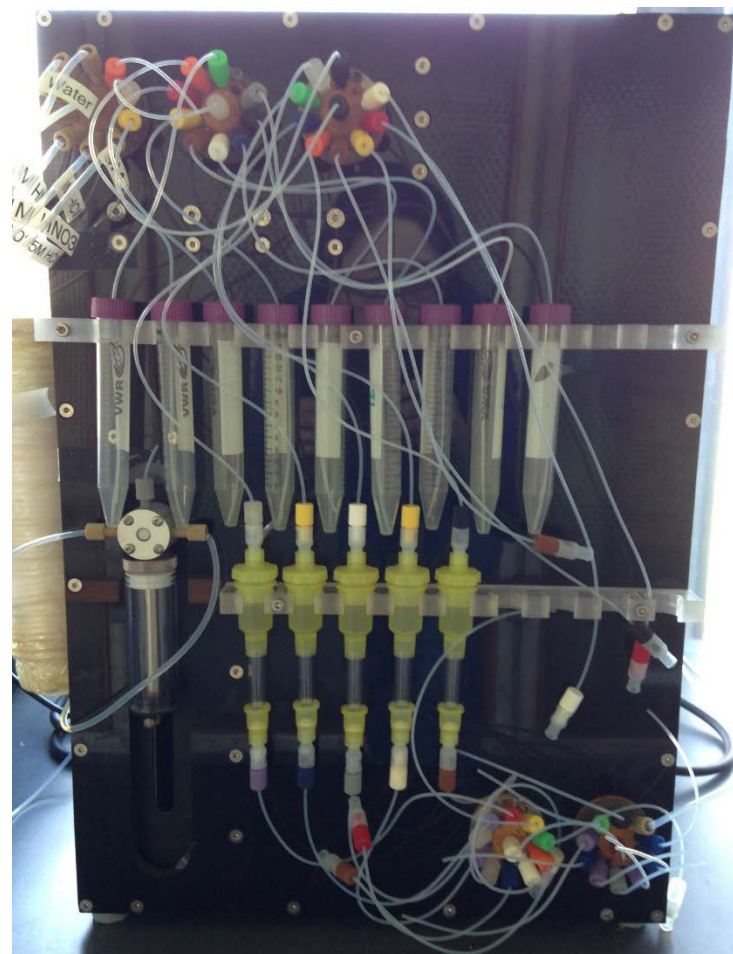
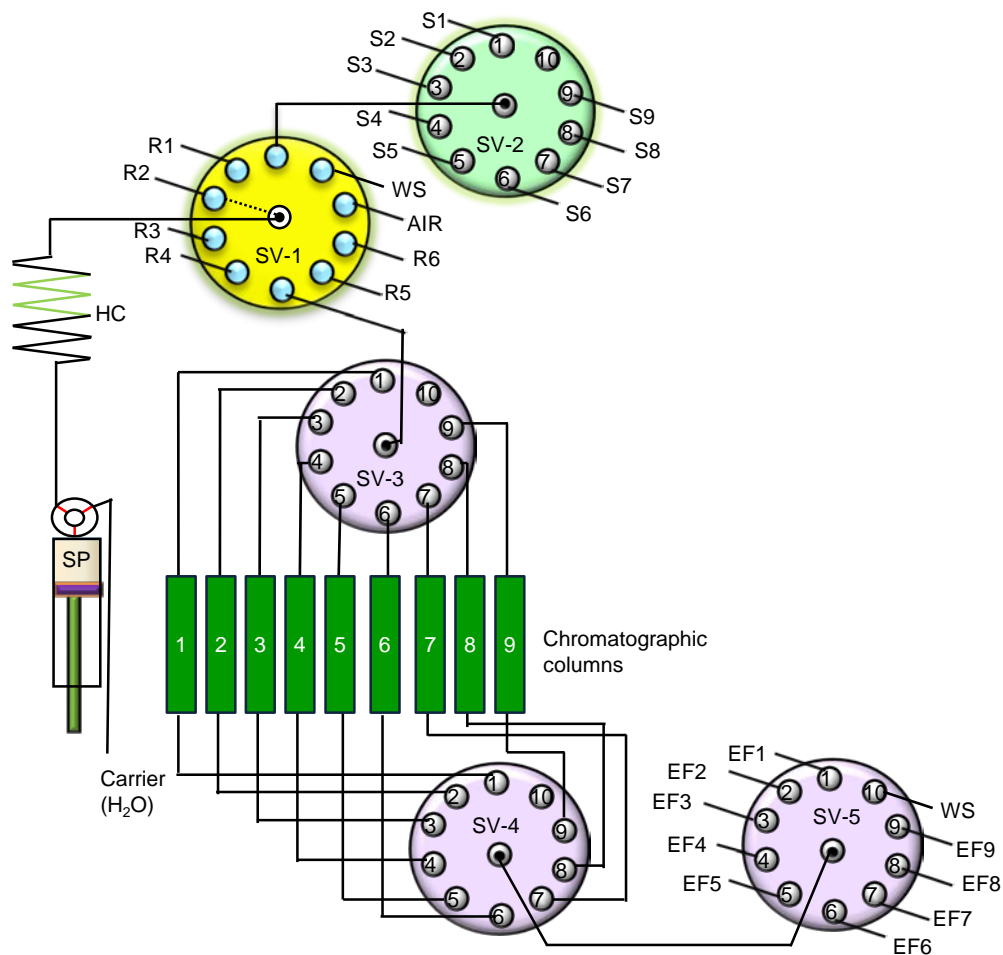


## Improvement on U decontamination

Qiao, J. X., Shi, K. L., Hou, X. L., Nielsen, S., Roos, P. Environmental Science & Technology. 2014, 48, 3935-3942.



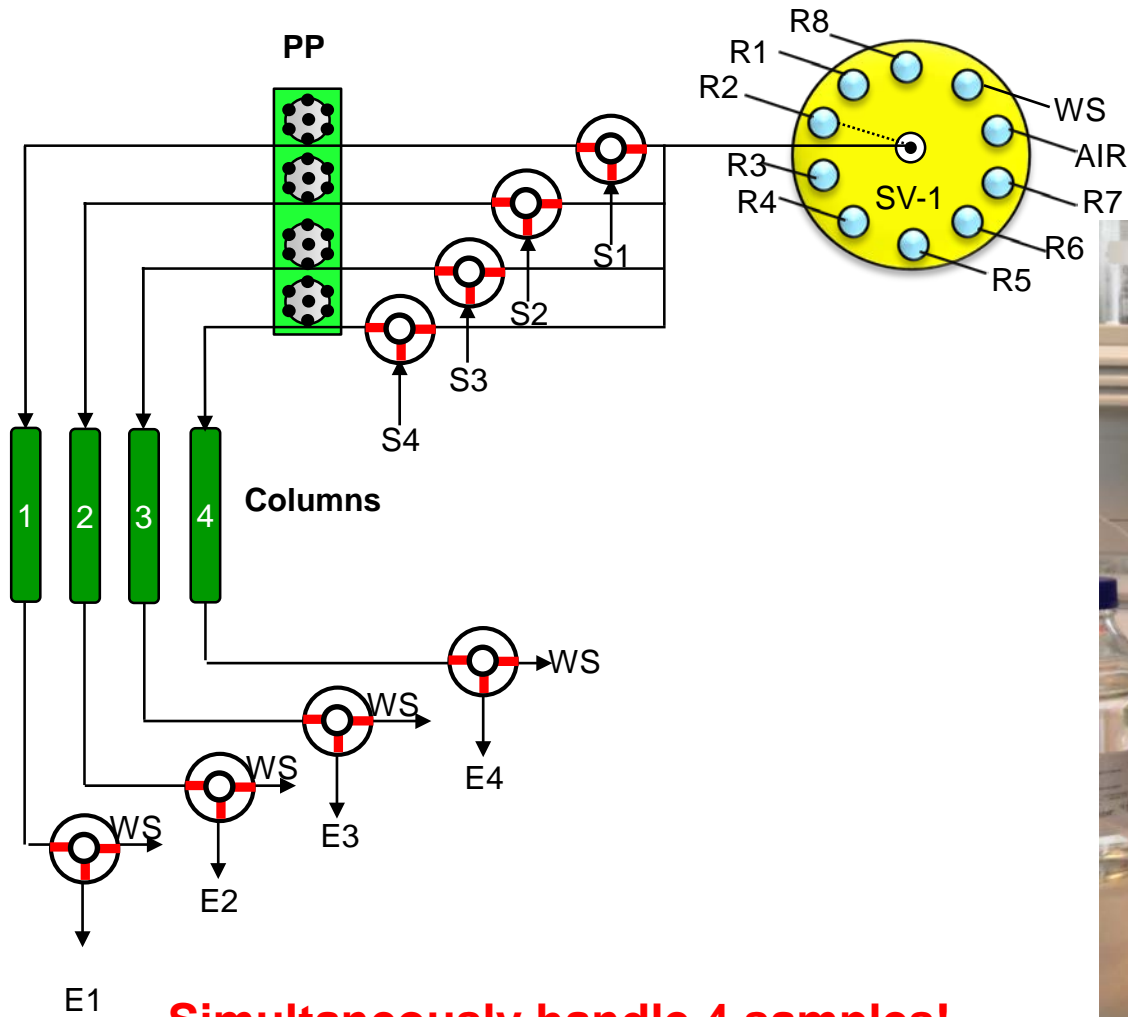
# Automation unit-1



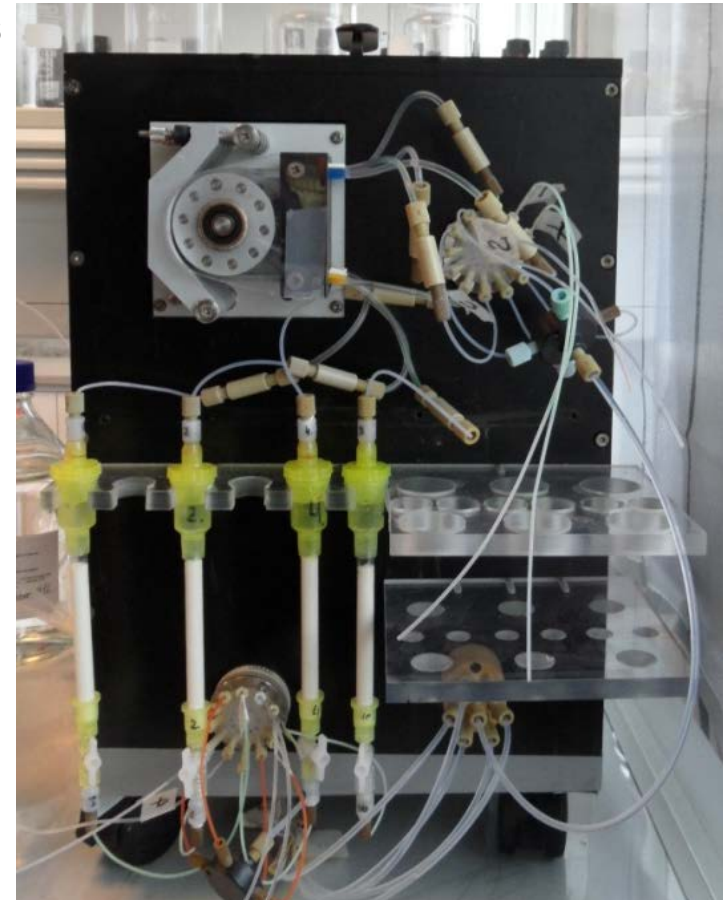
- **Automatically handle 9 samples!**
- **Work overnight !**

Qiao, J. X., Hou, X. L., Roos, P., Miró, M. Analytica Chimica Acta. 2011, 685, 111-119.

# Automation unit-2

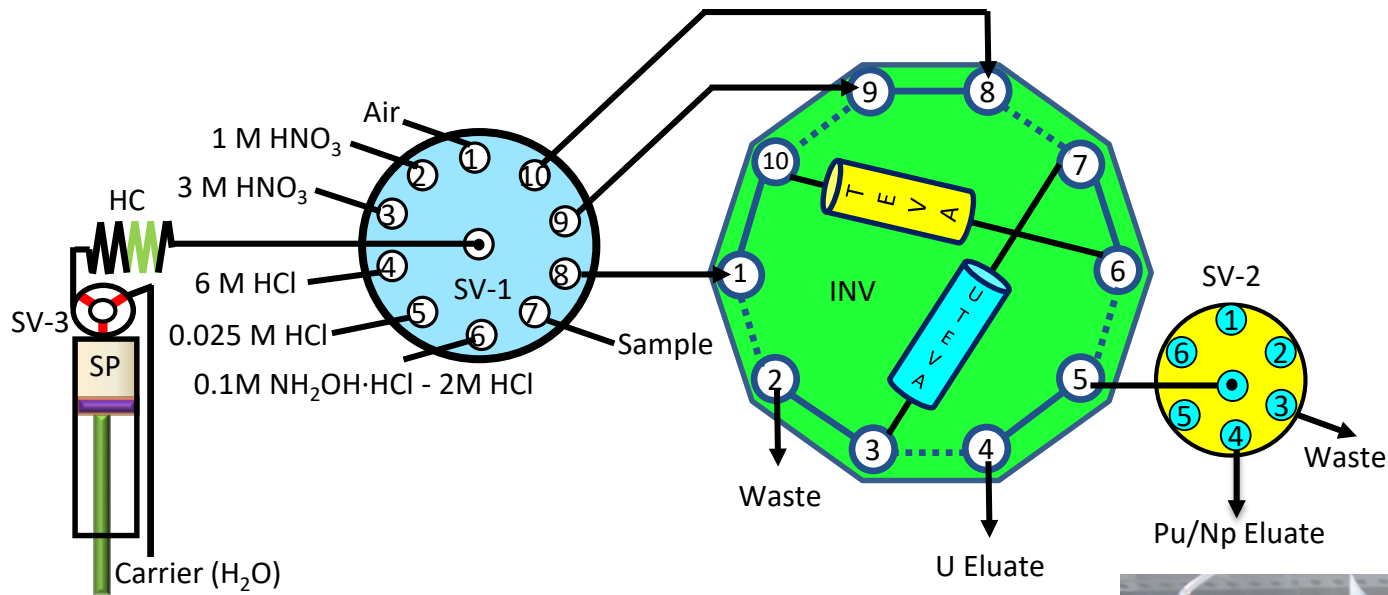


**Simultaneously handle 4 samples!**

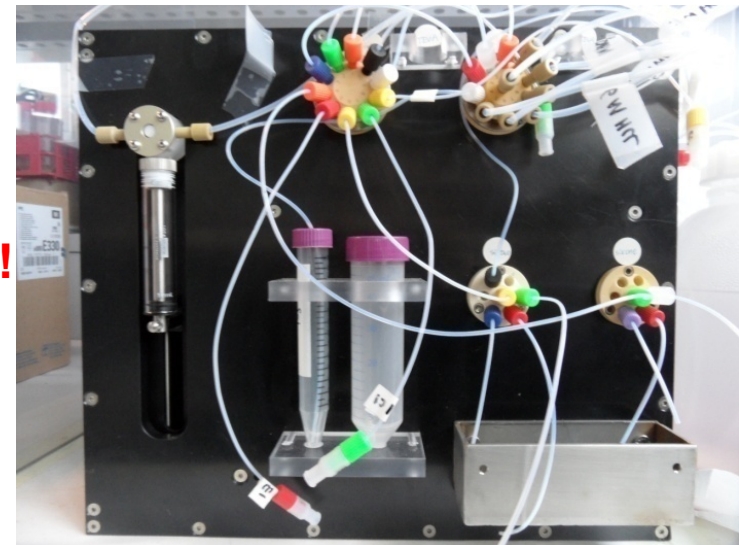


Qiao, J. X., Shi, K. L., Hou, X. L., Nielsen, S., Roos, P. Environmental Science & Technology. 2014, 48, 3935-3942.

# Automation unit-3



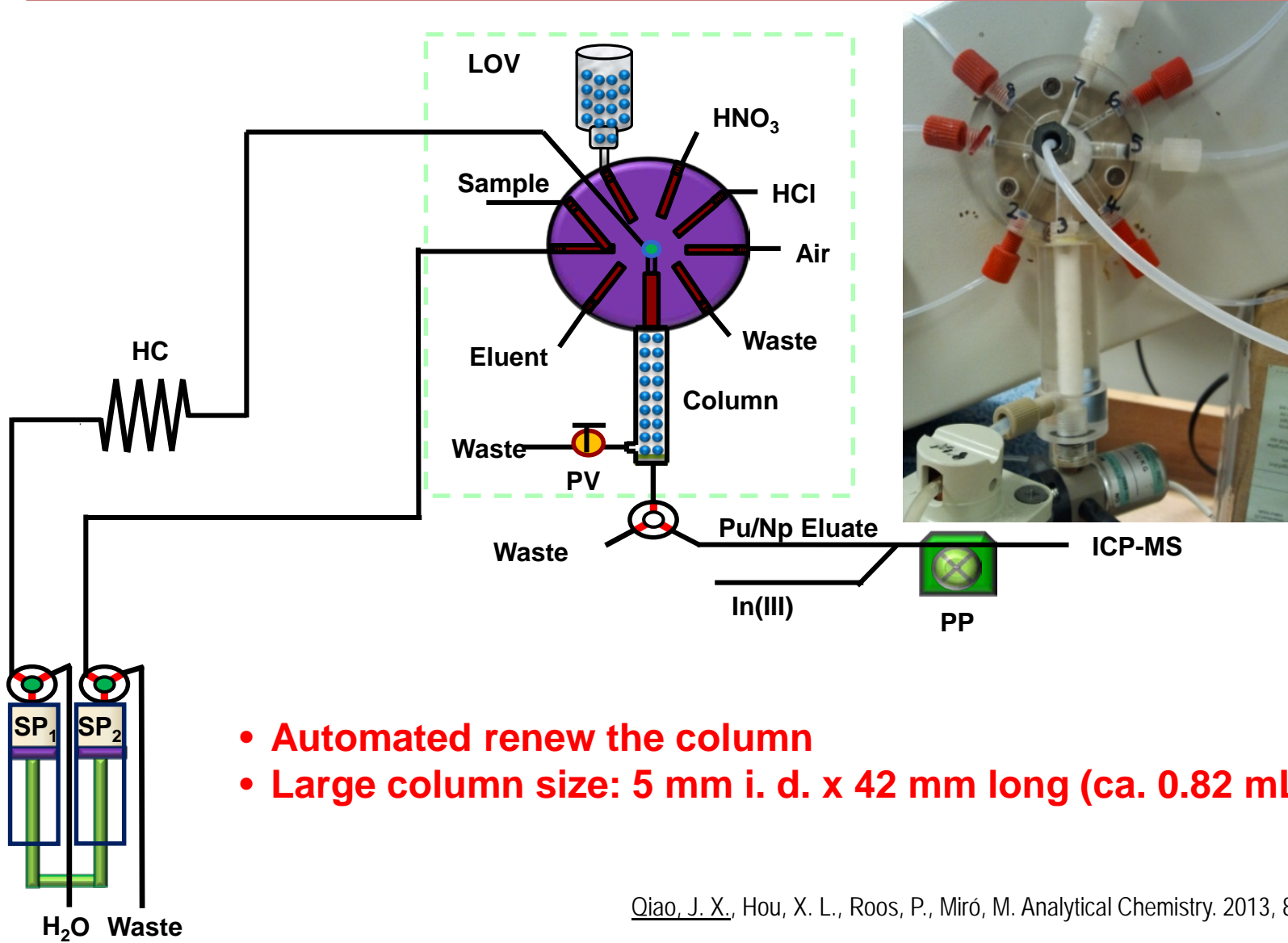
**Flexible control the connection of two columns!**



Qiao, J. X., Hou, X. L., Steier, P., Golser, R. Analytical Chemistry. 2013, 85, 11026-11030.



# Automation unit-4

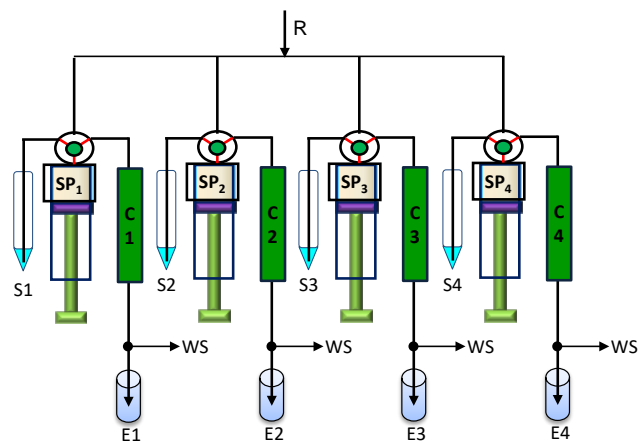


- Automated renew the column
- Large column size: 5 mm i. d. x 42 mm long (ca. 0.82 mL)

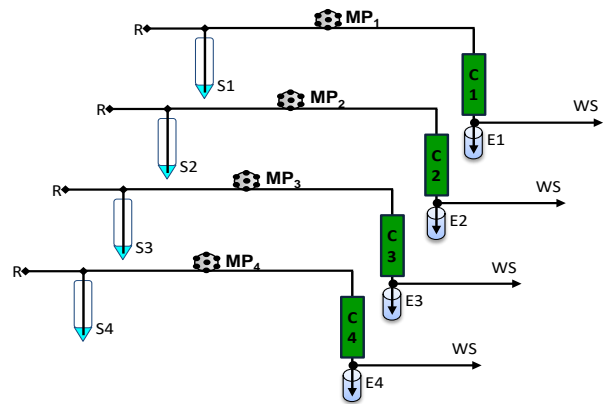
Qiao, J. X., Hou, X. L., Roos, P., Miró, M. Analytical Chemistry. 2013, 85, 2853-2859.

# Automated Radiochemical Separation System (Auto-Rass)

Radiochemical Automated Analysis System (RAAS) with four syringe pump (SP-4)



Radiochemical Automated Analysis System (RAAS) with four milligat pump (MP-4)



- Research
- Routine analysis
- Commercialization
- Collaboration

Thank you!  
Tak!  
谢谢!

Jixin Qiao

[jqiqi@dtu.dk](mailto:jqiqi@dtu.dk)

