# Perspectives and Challenges for Chemistry Experiments in Solution Using the BGS

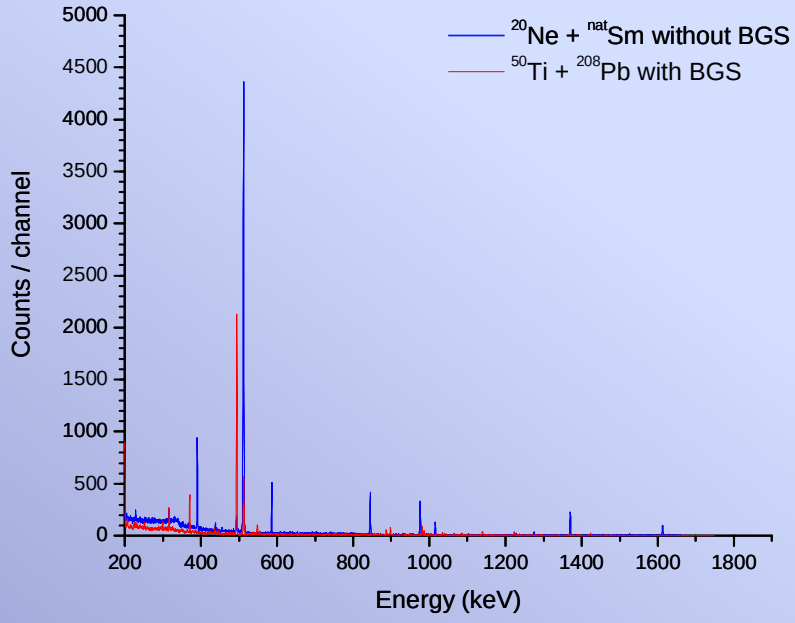
**R. Sudowe**

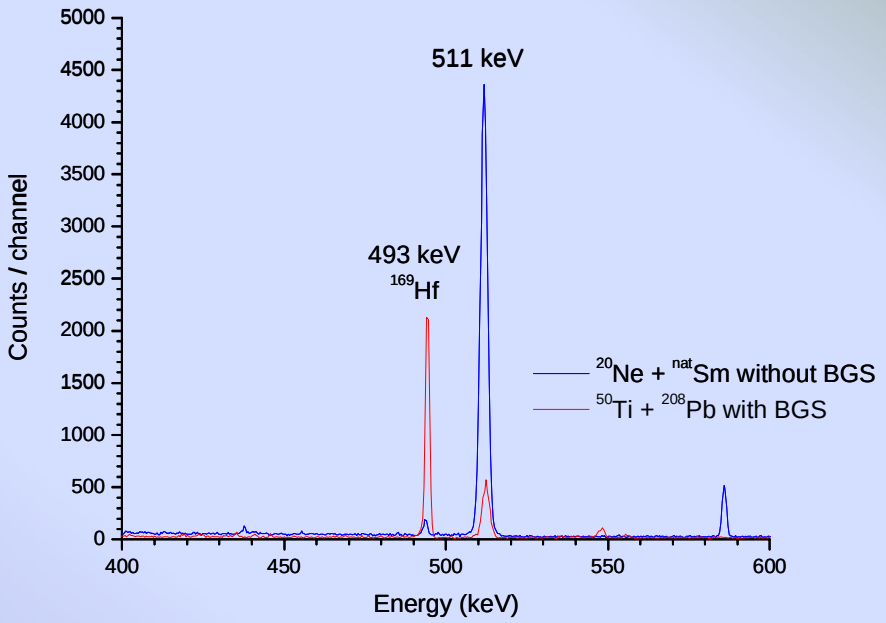
for the

Heavy Element Nuclear & Radiochemistry Group

Lawrence Berkeley National Laboratory, Berkeley, USA

# Advantages of Pre-separation: Background Reduction I




Direct catch measurement of nuclides produced in the $^{nat}$Sm($^{20}$Ne,xn) reaction without pre-separation.

vs.

Direct catch measurement of nulicdes produced in the $^{124}$Sn($^{50}$Ti,xn) reaction using the BGS as pre-separator.

➢ Compton background reduced by 50%

$^{169}$Hf produced in the $^{nat}$Sm($^{20}$Ne,xn) reaction without pre-separation:

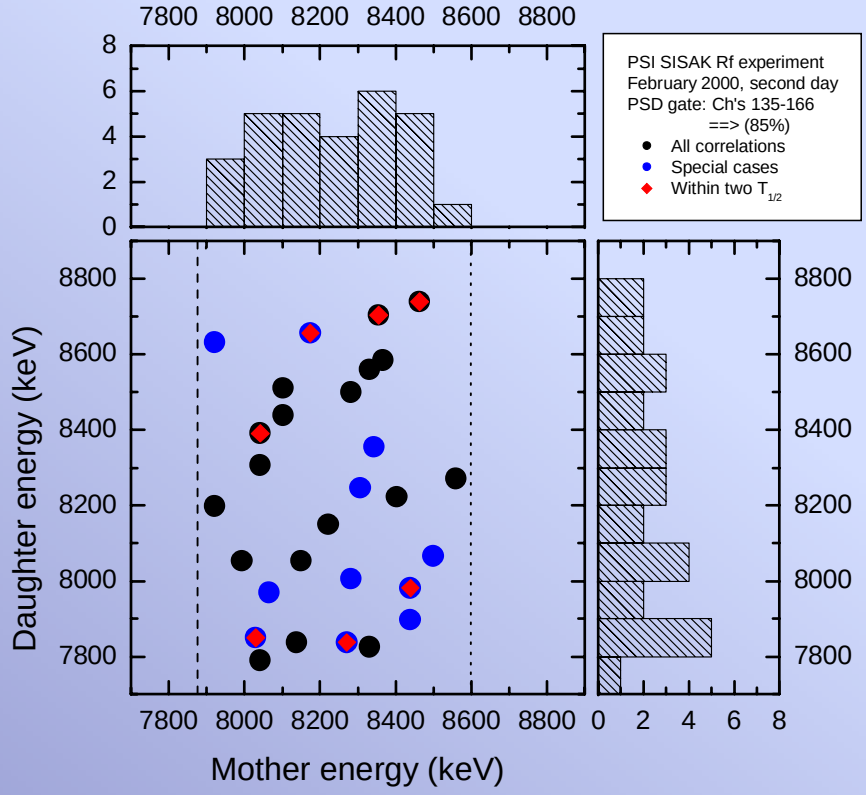
➢ Peak area 511 keV / 493 keV: 62

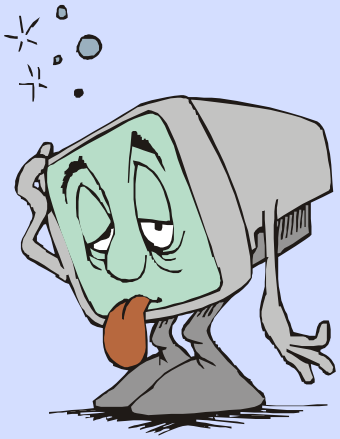
vs.

$^{169}$Hf produced in the $^{124}$Sn($^{50}$Ti,xn) reaction with pre-separation:

➢ Peak area 511 keV / 493 keV: 0.47

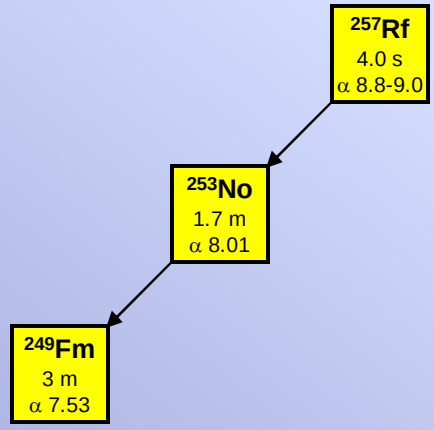
# Advantages of Pre-separation: SISAK without Pre-separation

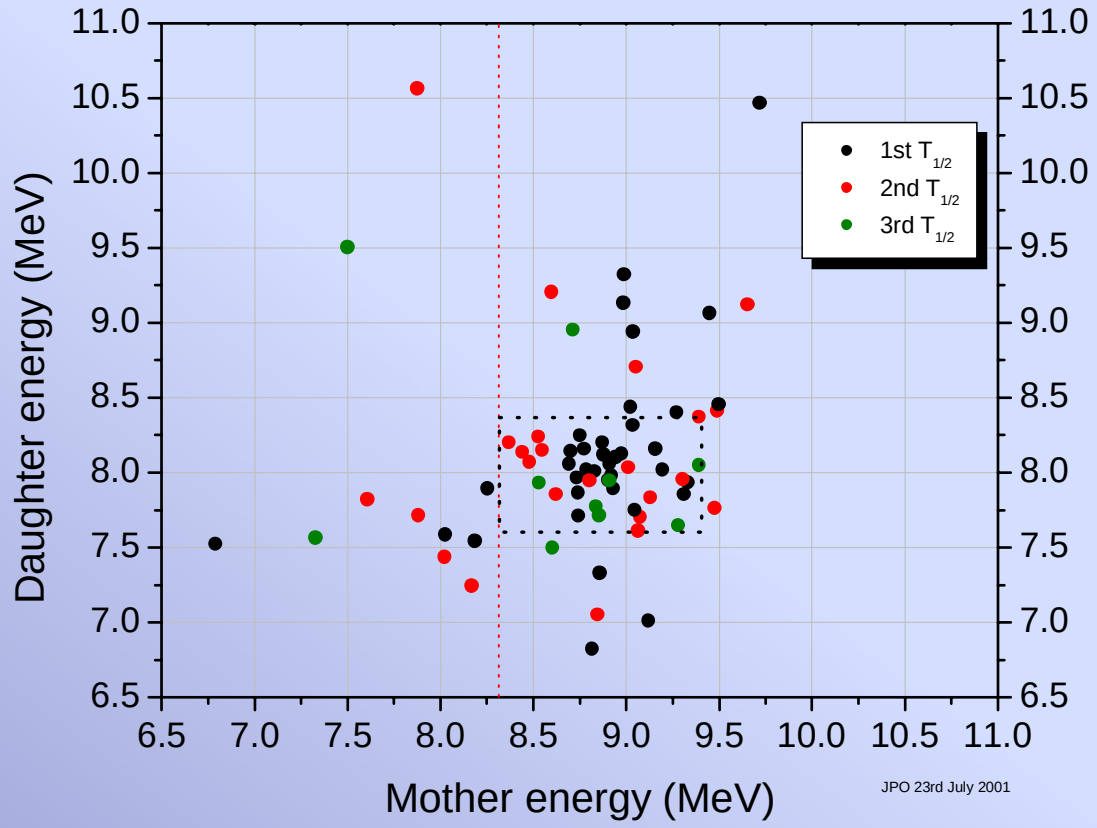


Correlation plot of α-events detected in the $^{261}$Rf - $^{257}$No energy region during a SISAK experiment in February 2000 at PSI.

# Advantages of Pre-separation: SISAK with the BGS




Correlation plot of α-events detected in the $^{257}$Rf - $^{253}$No energy region during a SISAK run in November 2000 at LBNL using the BGS.

# Advantages of Pre-separation: Opportunities for Chemistry

## Chemistry without pre-separation:

Chemical system needs to separate out all interfering nuclides.

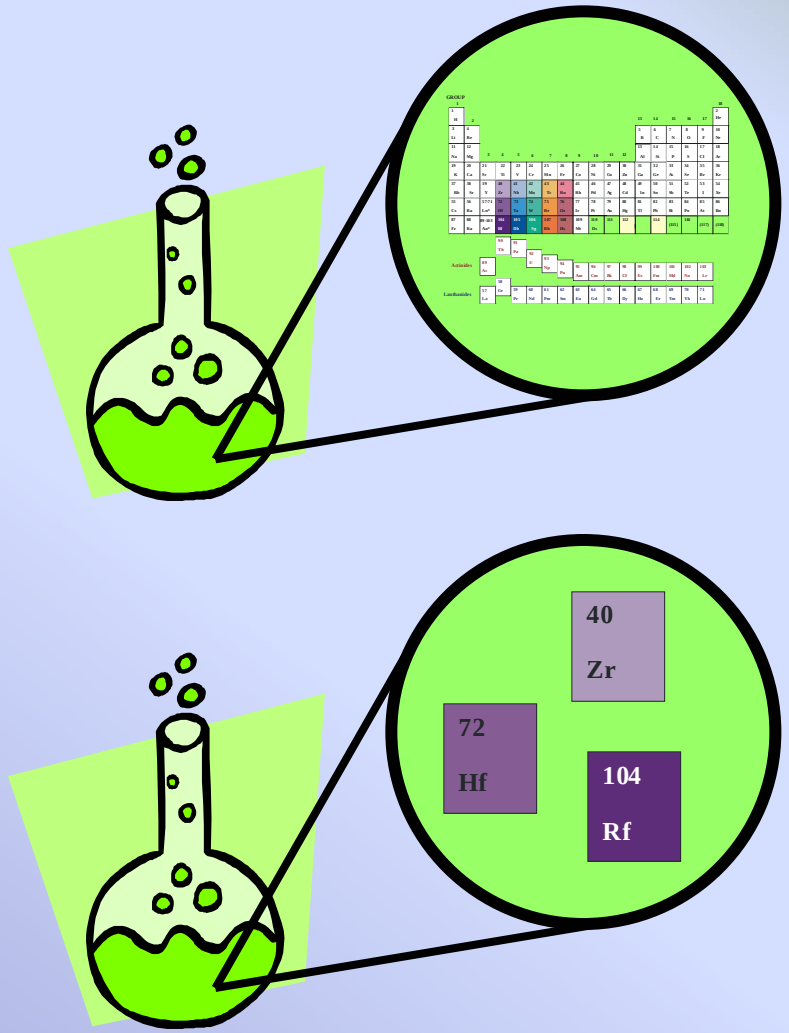
## Chemistry with pre-separation:

Chemical system can favor selectivity between homologues over removal of interfering nuclides.

This opens the way to classes of chemical systems that were previously unsuitable.

## But:

These systems may not be useable to place new elements into the periodic table.



# Current Status of Chemistry Experiments at the BGS

## Homologue experiments in the gas-phase:

- Production of Os isotopes for test experiments with the CTS.
- Production of Zr and Hf isotopes for test experiments with volatile metal complexes.

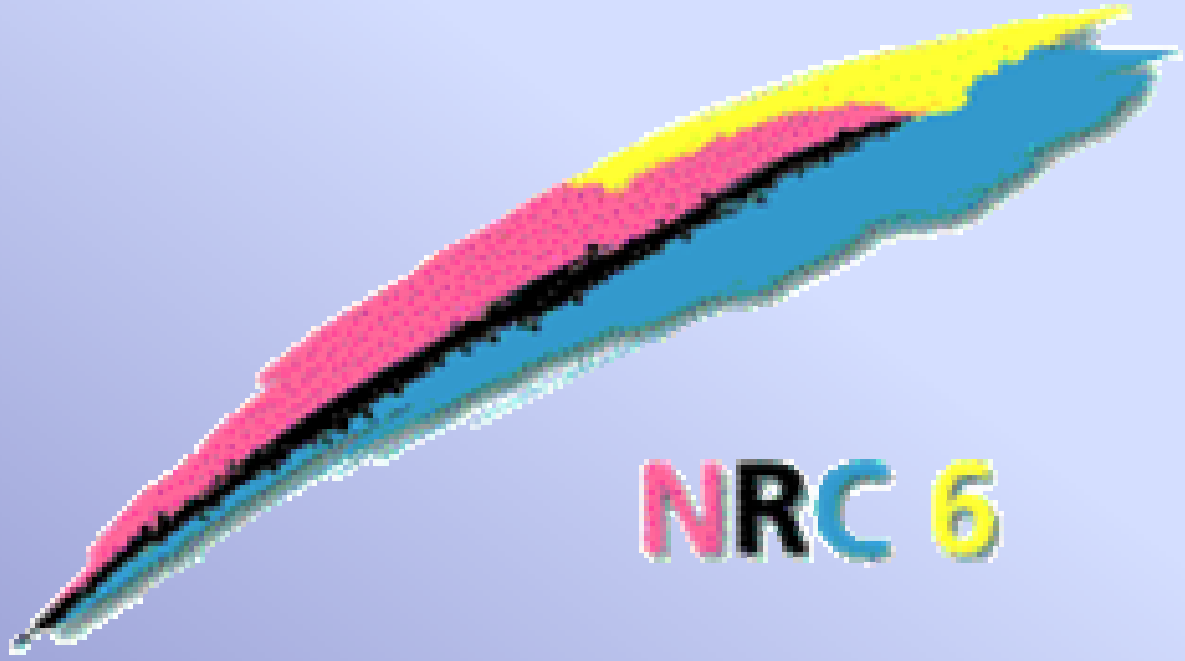
## Homologue experiments in solution:

- Production of Hf isotopes to test transport time and yield for SISAK runs.
- Production of Zr and Hf isotopes for manual extraction experiments with macrocyclic ligands.

## Transactinide experiments in solution:

- Successful SISAK experiments to study the extraction behavior of rutherfordium.

**If you want to know whether crown ethers make a good extraction system for rutherfordium…**




**…come and see the poster in Aachen**

# Challenges: Available Nuclides

## Rutherfordium:

**$^{257}$Rf ($T_{½}$= 4.0 s)** 0.5 Atoms/min behind BGS

Reaction: $^{208}$Pb($^{50}$Ti, 1n)$^{257}$Rf, $\sigma \approx 10$ nb

Used in SISAK chemistry experiments.

## Dubnium isotopes:

**$^{258}$Db ($T_{½}$= 4.4 s)** Reaction: $^{209}$Bi($^{50}$Ti,1n)$^{258}$Db, $\sigma \approx 3$ nb

Used in SISAK detector test experiments.

## Heavier elements:

**Currently no isotopes with $T_{½} > 0.5$ s can be produced and separated with BGS.**

# Solutions: Actinide Targets for the BGS

Goal: Preparation of segmented wheel targets of uranium and plutonium with thickness up to 500 µg/cm$^2$ by electroplating.

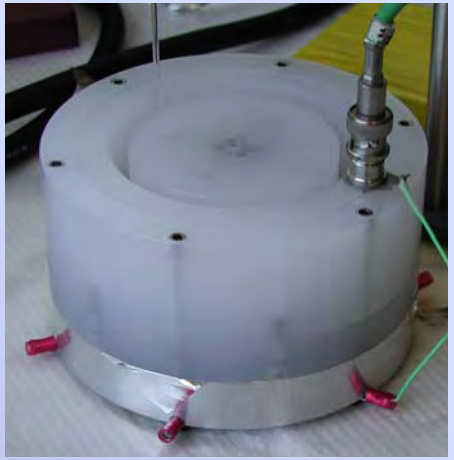
Wheel: 3.5 inch aluminum disk with thin metal foil glued to the back

Plating cell: Made from Teflon (Volume 40 mL)
Aluminum base plate
Ring shaped palladium anode

First test plating of Lu on thin Al foil successful.

Currents tests: One-Step vs. Multi-Step Plating
Effect of voltage (50 – 1000 V)
Choice of solvent

Problems: Heat resistant glue



# Challenges: Transport Time

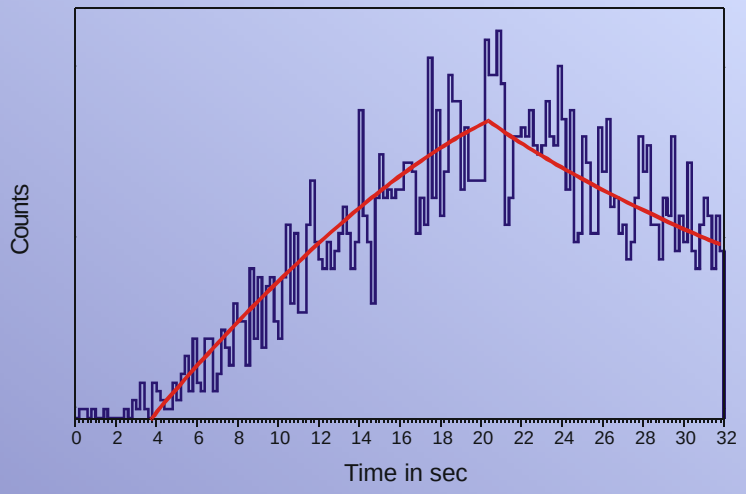
RTC configuration currently used for SISAK experiments:

RTC Volume (depth 45 mm): 350.68 $cm^3$

Capillary to chemistry setup: 22 m length, 1/16 inch inner diameter

Gas flow: ~2 L/min

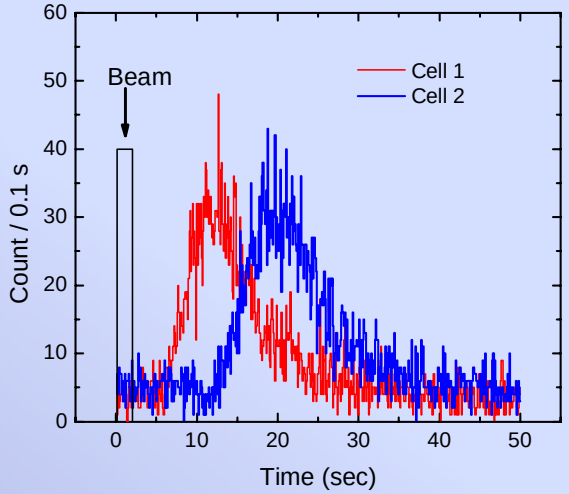
Time necessary to exchange gas in total volume: 11.83 sec




Transport time test using MG

Pulsed beam: 16 s on / 16 s off

➢ Breakthrough time: ~ 4 s




Transport time test using SISAK

Pulsed beam: 2 s on / 58 s off

➢ Breakthrough time: ~ 7 s

# Solutions: Transport time

Current transport time may be acceptable for gas-phase chemistry but it needs to be improved for chemistry in solution!

What can be done?

- **Optimize gas-jet parameters.**
- **Reduce volume of Recoil Transfer Chamber.**

  **Use degrader foils to slow recoils down and reduce the stopping range.**

  **A new design for a recoil separator for chemistry should not have a wide focal plane dispersion.**
- **Bring chemistry setup closer to the separator.**

  **Limitations, because solution chemistry setups need more manual handling than gas-phase chemistry setups.**

# Solutions: Transport Efficiency

- Optimize geometry of the Recoil Transfer Chamber

- Investigate the use of different aerosols with higher transport yields.

  First test experiments show that the use of $PbCl_2$ aerosols instead of KCl aerosols increases the transport yield.

  These aerosols can be used in combination with RTC and BGS. Pre-separation eliminates the production of transfer products between beam and aerosol.

# Challenges: Automated Chemistry Systems

or “How many men does **this** automated chemistry need?” (R. Lougheed)

Currently systems for chemistry in solution have serious drawbacks compared with systems for gas-phase chemistry.
This is especially true for the study of the heavier transactinide elements.

Most automated aqueous phase chemistry systems are not well suited to work with the BGS.

- Require to much time to work with the currently available isotopes.
- Can not be brought close to the recoil separator.

Currently SISAK is the only automated solution chemistry system that can work with the nuclides available at the BGS.

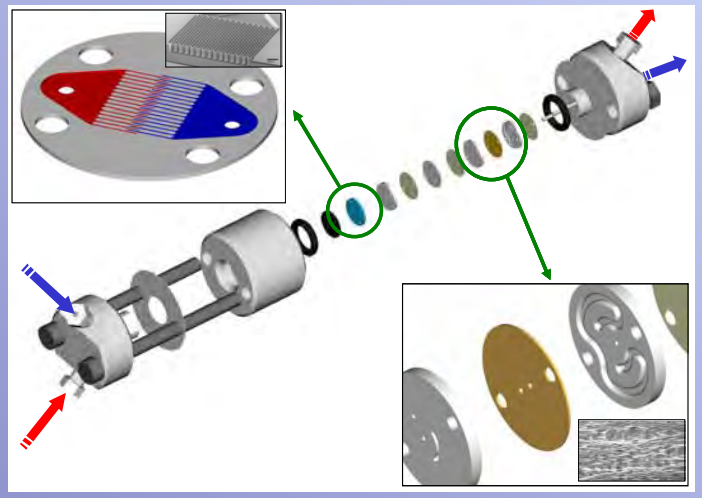
Problems: Transport time
Transport efficiency
Amount of chemicals necessary.

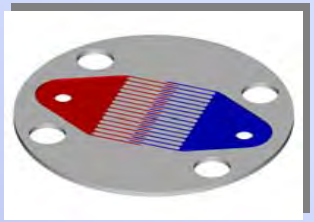
# Solutions: Next Generation of Automated Chemistry Systems

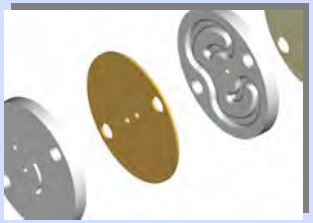
Requirements for new automated chemistry systems:

- Smaller devices that can operate close to the recoil separator.
- Allow larger degree of remote operation and control.
- Use small amounts of chemicals to minimize waste and the need to refill reservoirs.
- Able to run for weeks without large amounts of maintenance.

**A possible solution…..MicroSISAK?**







**Mixer**

**diameter: 8 mm**

**2 x 15 channels (30 µm wide)**

**volume: 2 x 1.5 mm³**

**Filter unit**

**diameter: 8 mm**

**channels: 20 x 0.4 x 0.3 mm³**

**volume: 2 x 2.5 mm³**

**Goal: Hold-up time < 1 s / Flow rate < 1ml/min.**

Pictures courtesy of K. Eberhardt and the MicroSISAK collaboration