

# In-situ synthesis of carbonyl complexes with short-lived isotopes of group 6, 7 and 8 elements

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Y. Kaneya

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## RIKEN Wako (J)

H. Haba

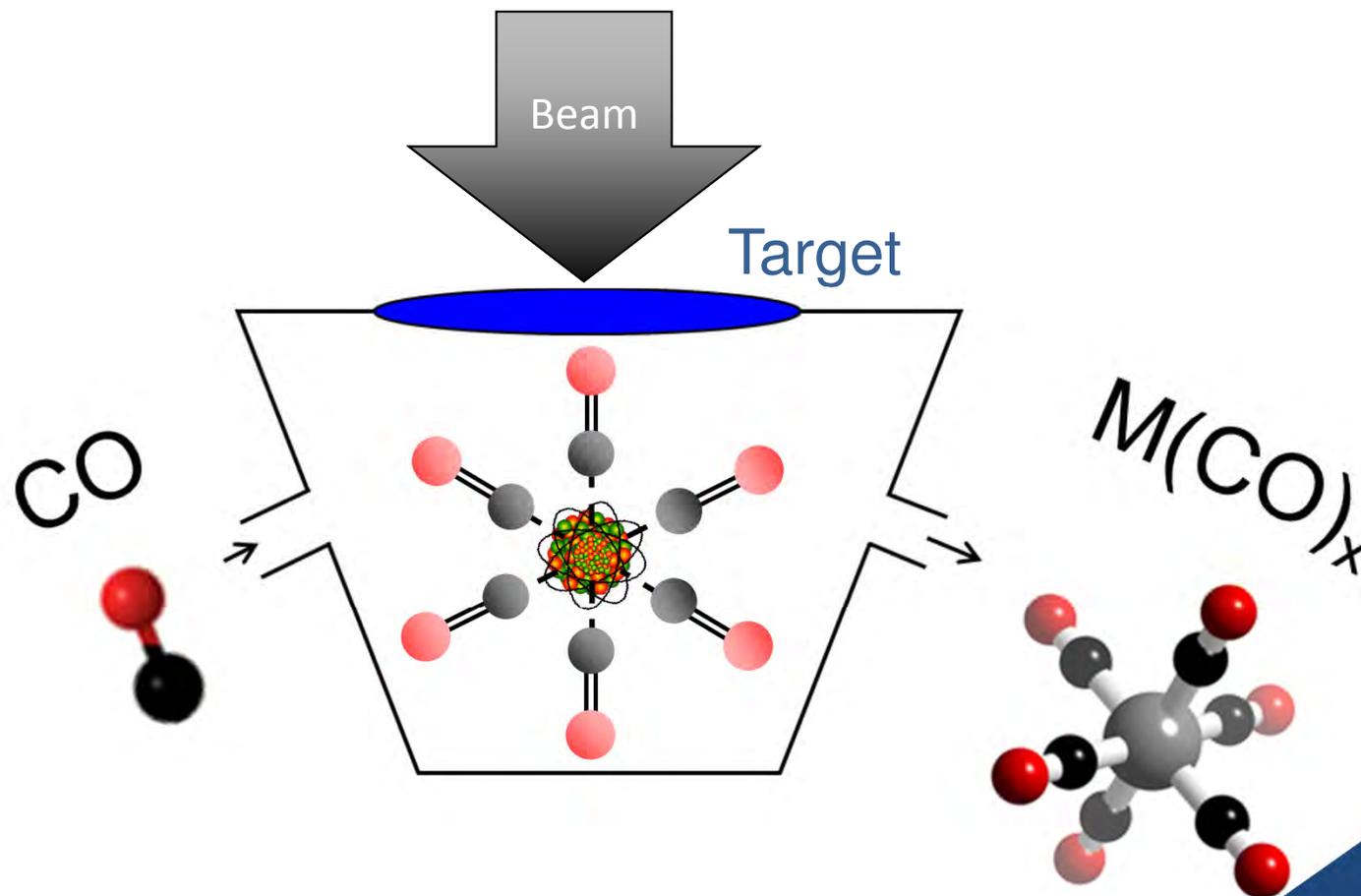
Y. Komori

# Basic concept:

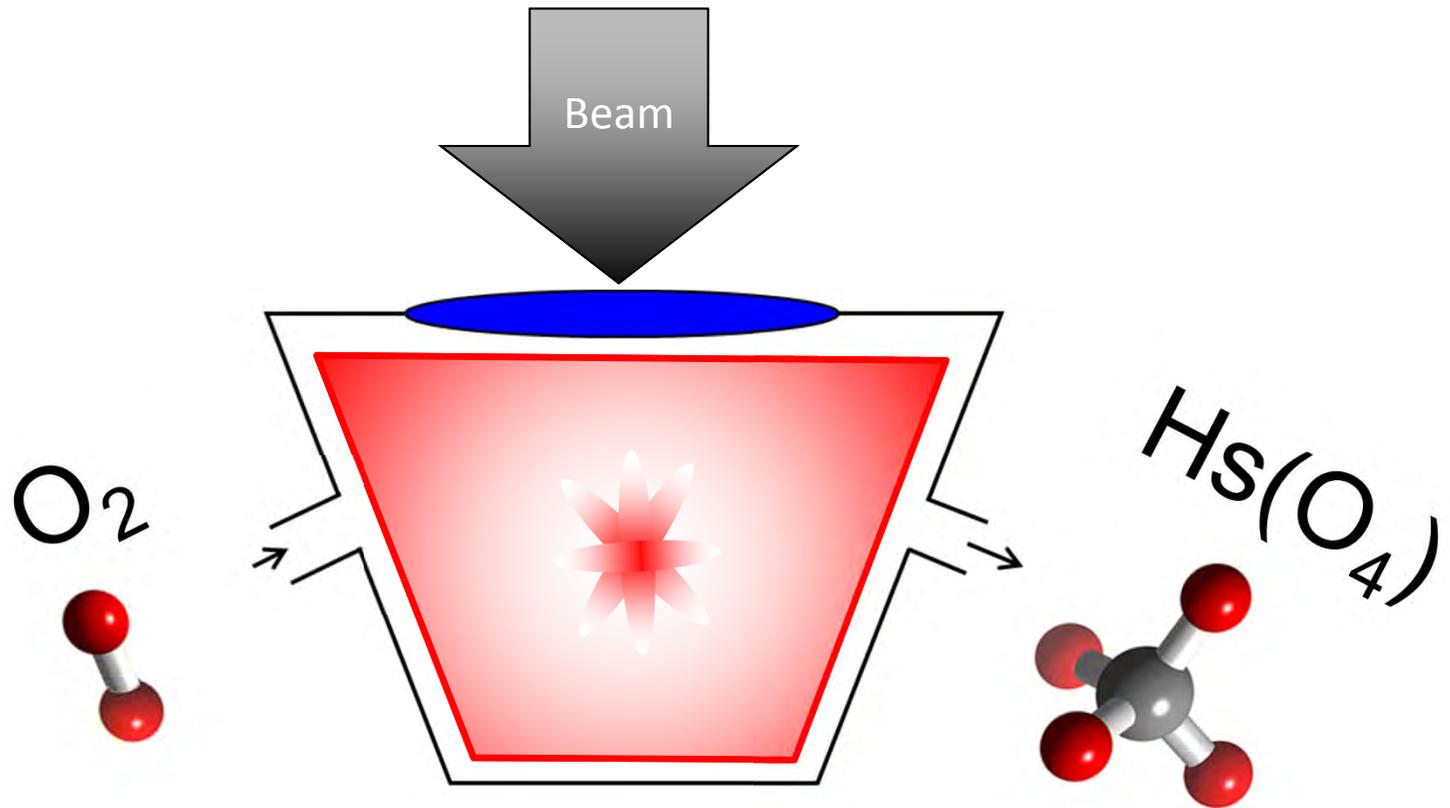
*J. Am. Chem. Soc.* **1999**, *121*, 10830–10831

**Prediction of the Bond Lengths, Vibrational Frequencies, and Bond Dissociation Energy of Octahedral Seaborgium Hexacarbonyl,  $\text{Sg}(\text{CO})_6$**

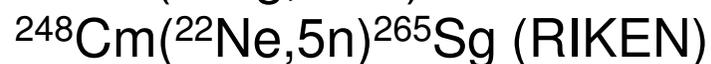
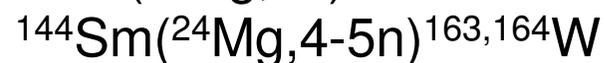
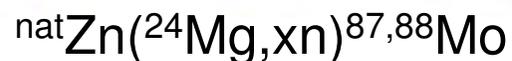
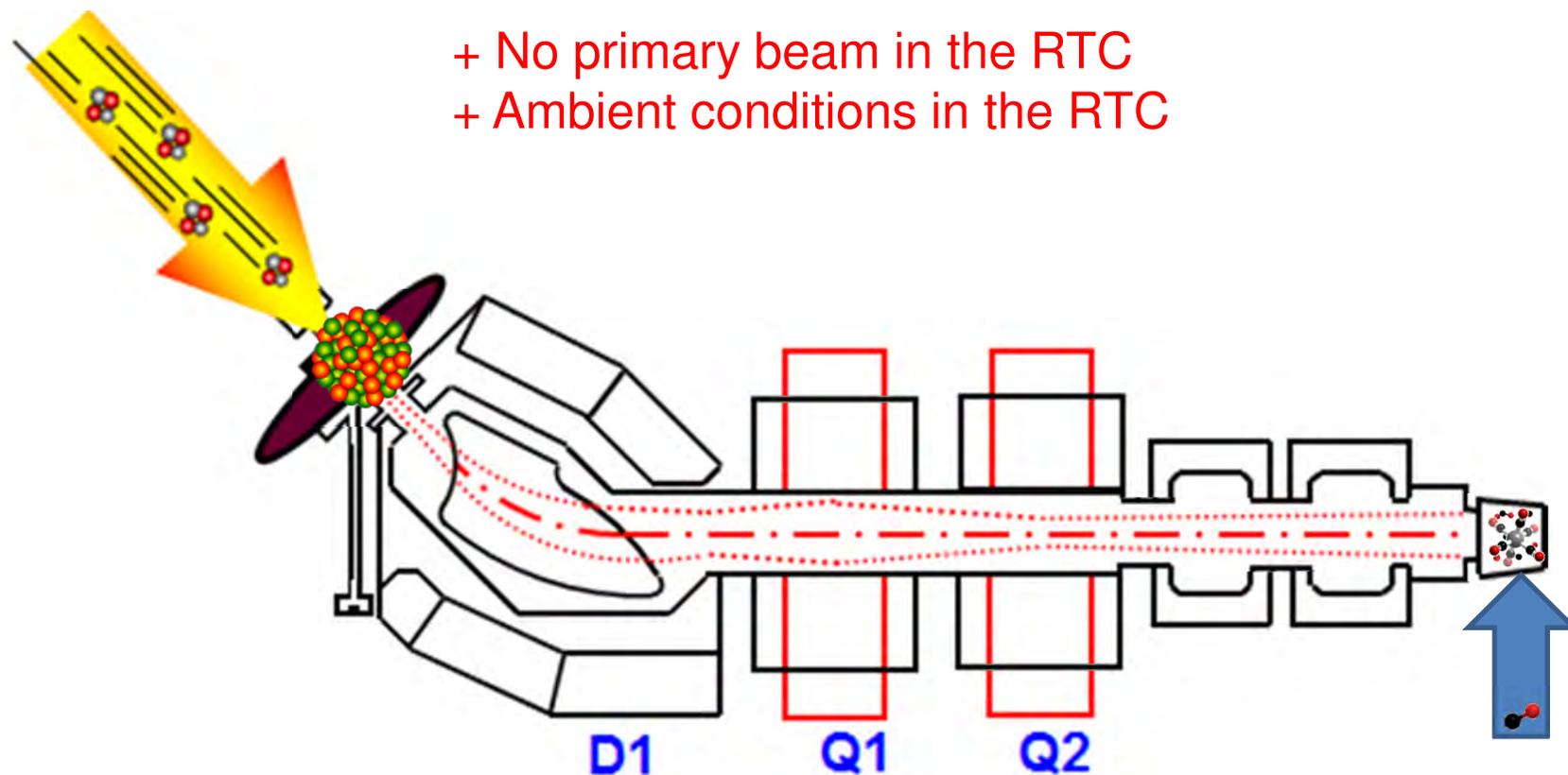
Clinton S. Nash\* Bruce E. Bursten\*



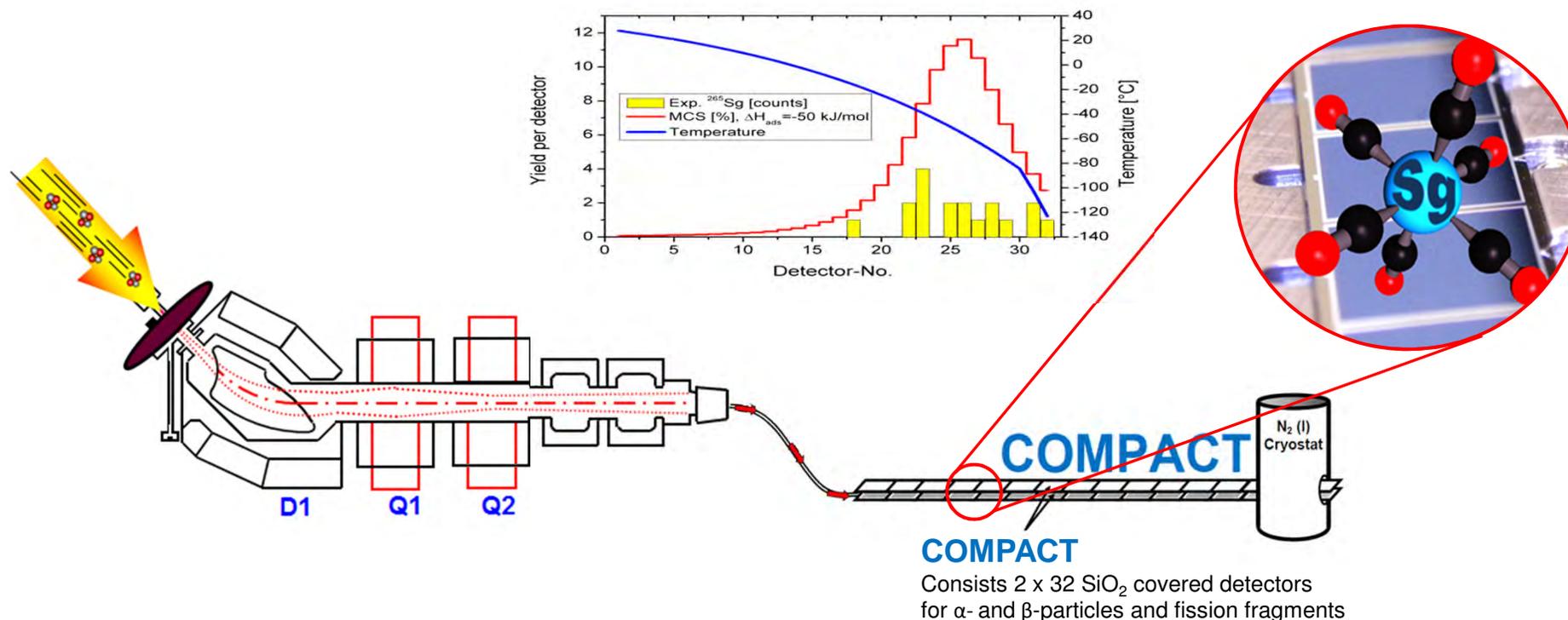
# Basic concept:



# Carbonyl experiment: Behind a separator



# Carbonyl experiment: Behind a separator

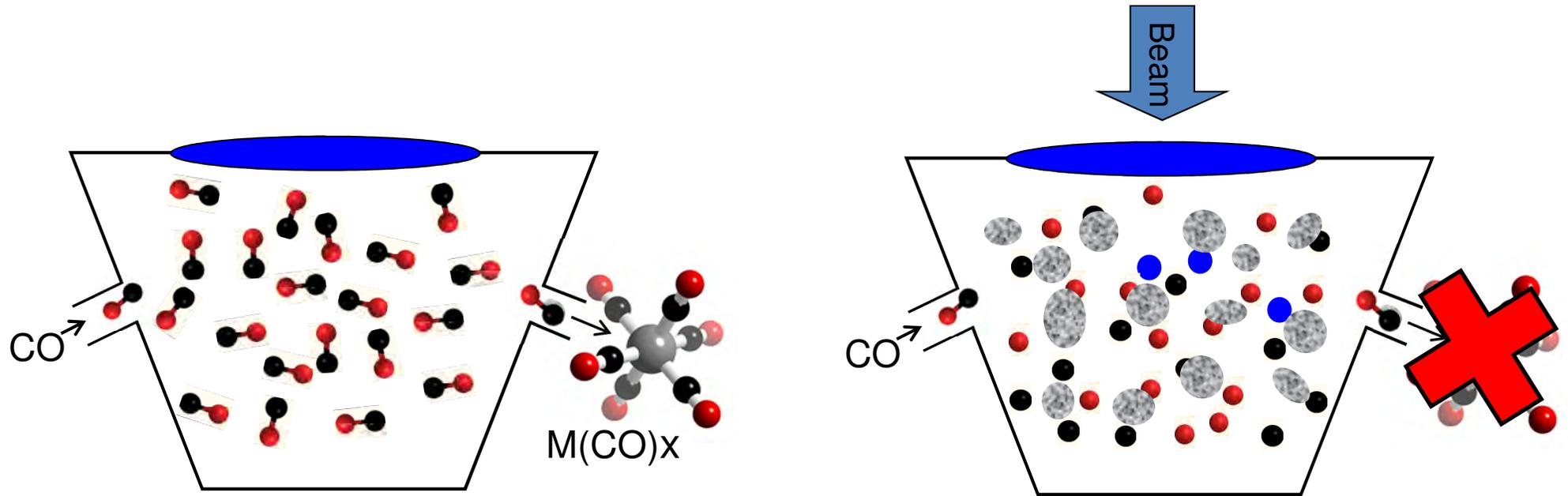


BUT:

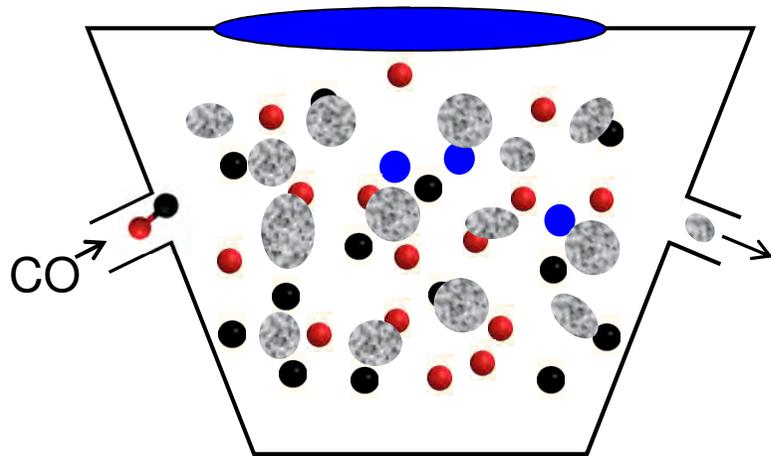
- low transmission of neutron-rich Sg, Bh, Hs, Mt and Ds
- through the separator (around 10%) → **Low overall yield**

**This approach was applied for the first synthesis of Sg(CO)<sub>6</sub>**

# Carbonyl experiment: Without a separator



# Carbonyl experiment: Without a separator



**No carbonyl complex formation observed due to:**

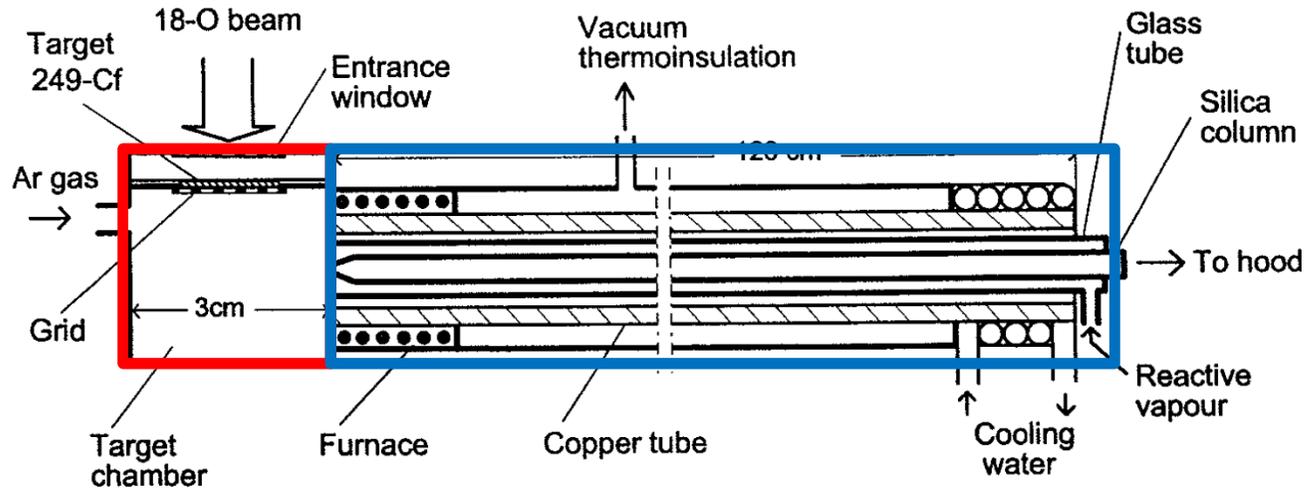
- beam induced plasma
- high temperatures
- decomposition of carbon monoxide
- carbon cluster formation

Wang et al., Radiochim Acta  
102:69-76 (2014)

# Thermochromatography experiments

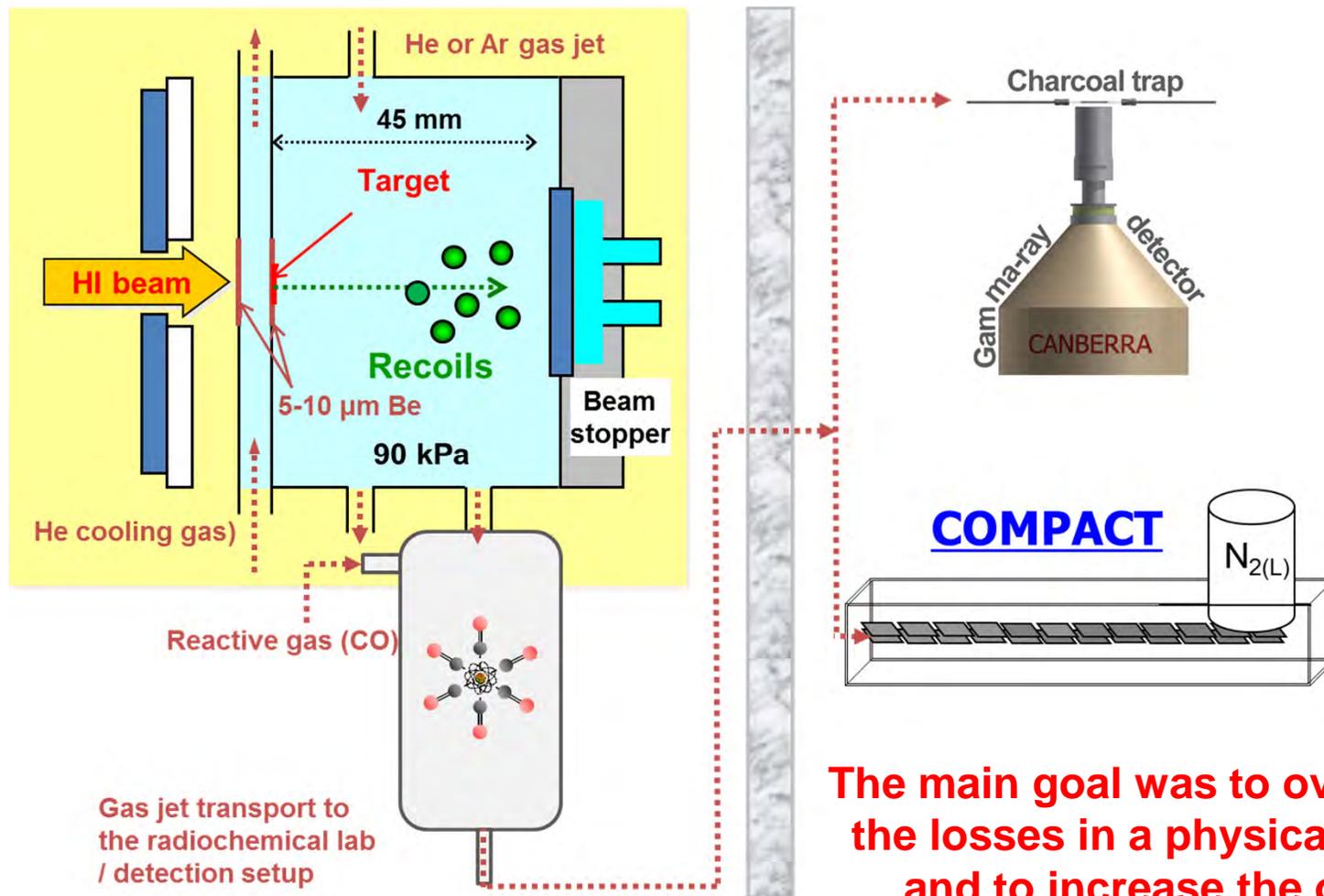
e.g.: Thermochromatography from Sg-oxochlorides

- $^{249}\text{Cf}(^{18}\text{O},4n)^{263}\text{Sg}$

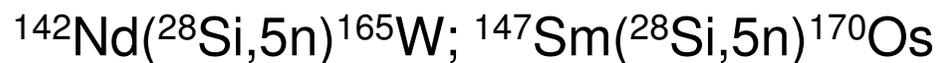


- Synthesis of oxochlorides (to avoid corrosion of recoil chamber)
- Transport efficiency from **60%** reported > separator efficiency

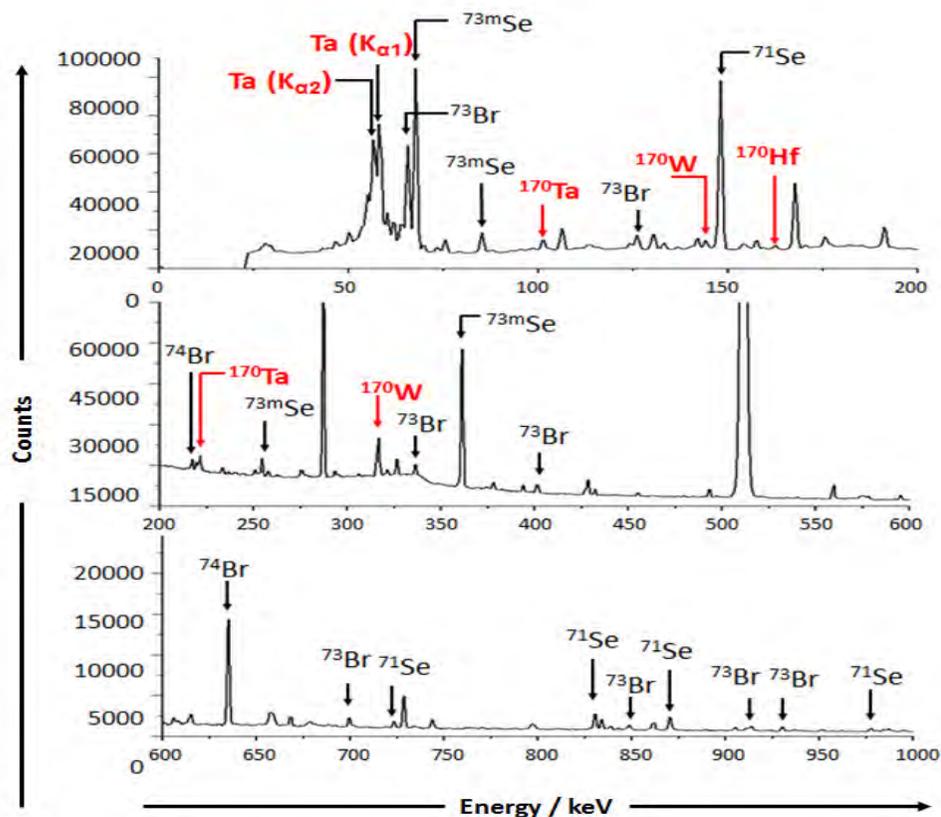
# Carbonyl experiment: Tokai-mura



**The main goal was to overcompensate the losses in a physical preseparator and to increase the overall yield**



# Carbonyl experiment: Tokai-mura



Os-170  
7.37 s

Estimated transport time to charcoal filter: ~ 20-30 s

Re-170  
9.20 s

W-170  
2.42 min

Ta-170  
6.76 min

Hf-170  
16 h

☺ Lines of  $^{170}\text{W}$ ,  $^{170}\text{Ta}$ ,  $^{170}\text{Hf}$  and Ta x-rays visible

☹ No lines from  $^{165}\text{W}$  or daughters observed due to decay losses ( $T_{1/2}$  of  $^{165}\text{W}$ : 5 sec)

☹ Dominant lines: from beam reactions with HAVAR vac. window / Ti target backing

# Carbonyl experiment: Tokai-mura

Yield relative to pure He/Ar transport			
Only He/Ar	+ O <sub>2</sub>	+ CO	
<b><sup>170</sup>Os</b> (T <sub>1/2</sub> = 7.1 s)			
100%	150%	135%	<100%
<b><sup>170</sup>W</b> (T <sub>1/2</sub> = 2.4 min)			
100%	147%	655%	103%

## Known volatile Os compounds:

-with O<sub>2</sub> (traces are sufficient): **OsO<sub>4</sub>**

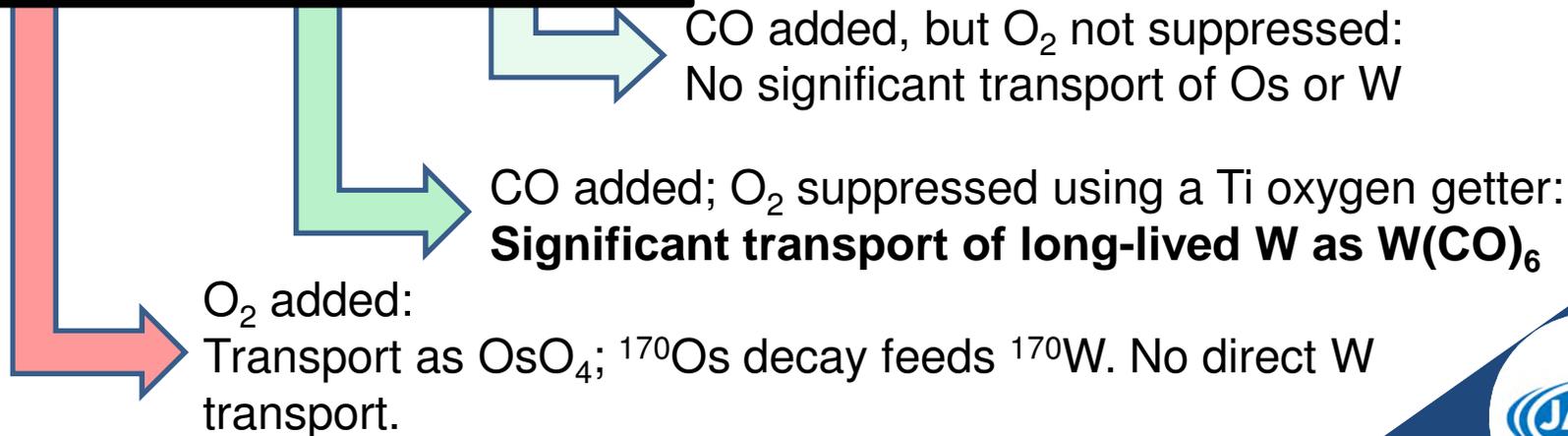
-with CO: **Os(CO)<sub>5</sub>**

## Known volatile W compounds:

-with O<sub>2</sub>: **None!**

-with CO: **W(CO)<sub>6</sub>**

Traces of O<sub>2</sub> sufficient to suppress formation of W(CO)<sub>6</sub>



# Conclusions: Tokai experiment 2015

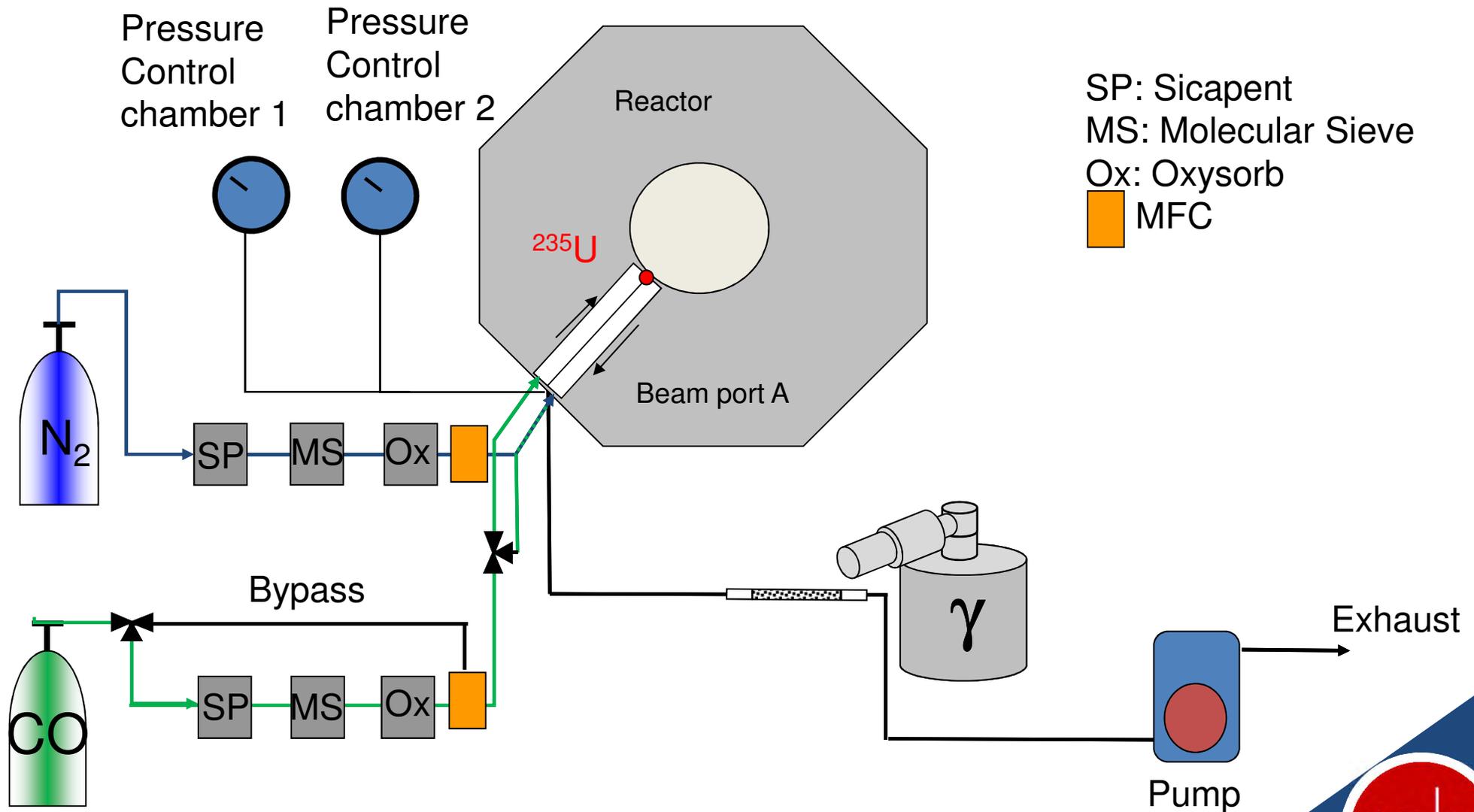
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☺ Synthesis of carbonyl complexes without preseparator appears possible!

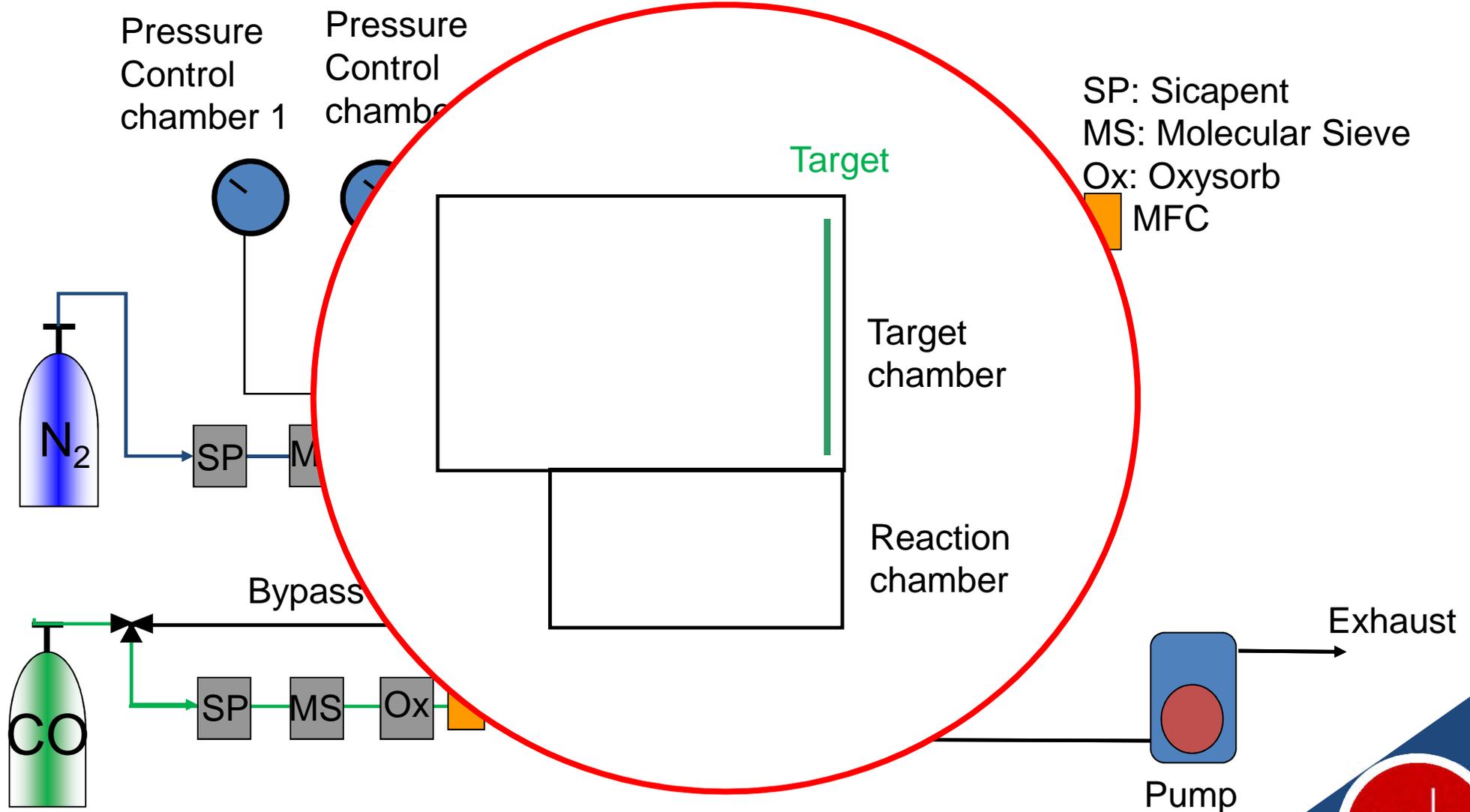
## Problems:

- ☹ Long transport time reduced  $^{170}\text{Os}$  yield and prevented  $^{165}\text{W}$  observation
- ☹ Dominant lines in  $\gamma$  spectra are from unwanted byproducts: e.g:  $^{73}\text{Br}$ ,  $^{73}\text{Se}$
- ☹ Gas-purification issues due to long transport lines

# Carbonyl experiment: TRIGA Mainz 2016



# Carbonyl experiment: TRIGA Mainz 2016



# Carbonyl experiment: TRIGA Mainz 2016

Pres  
Con  
char

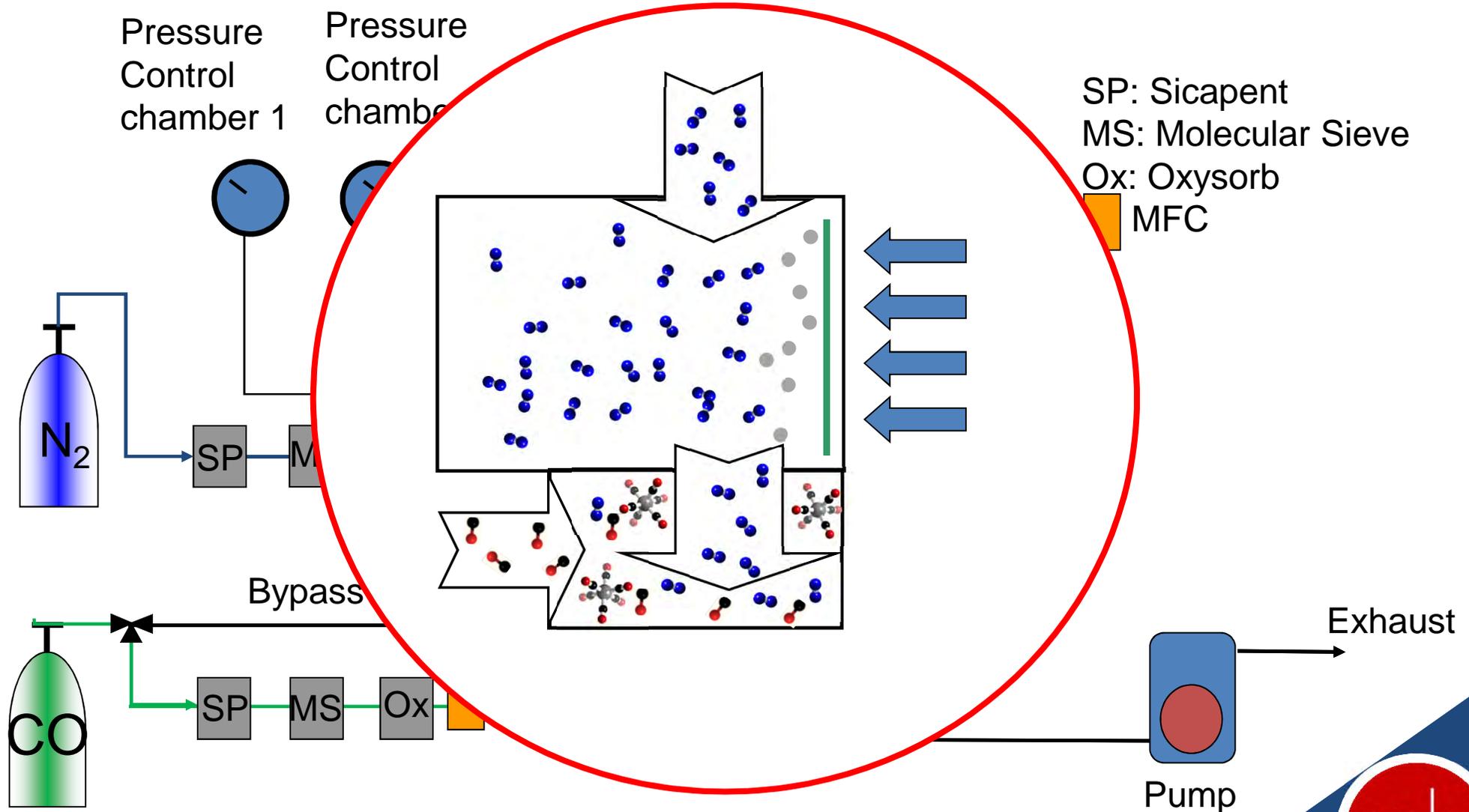
Hole size: 4, 6 mm  
Connection length: 2 mm (arc shaped)

Exhaust

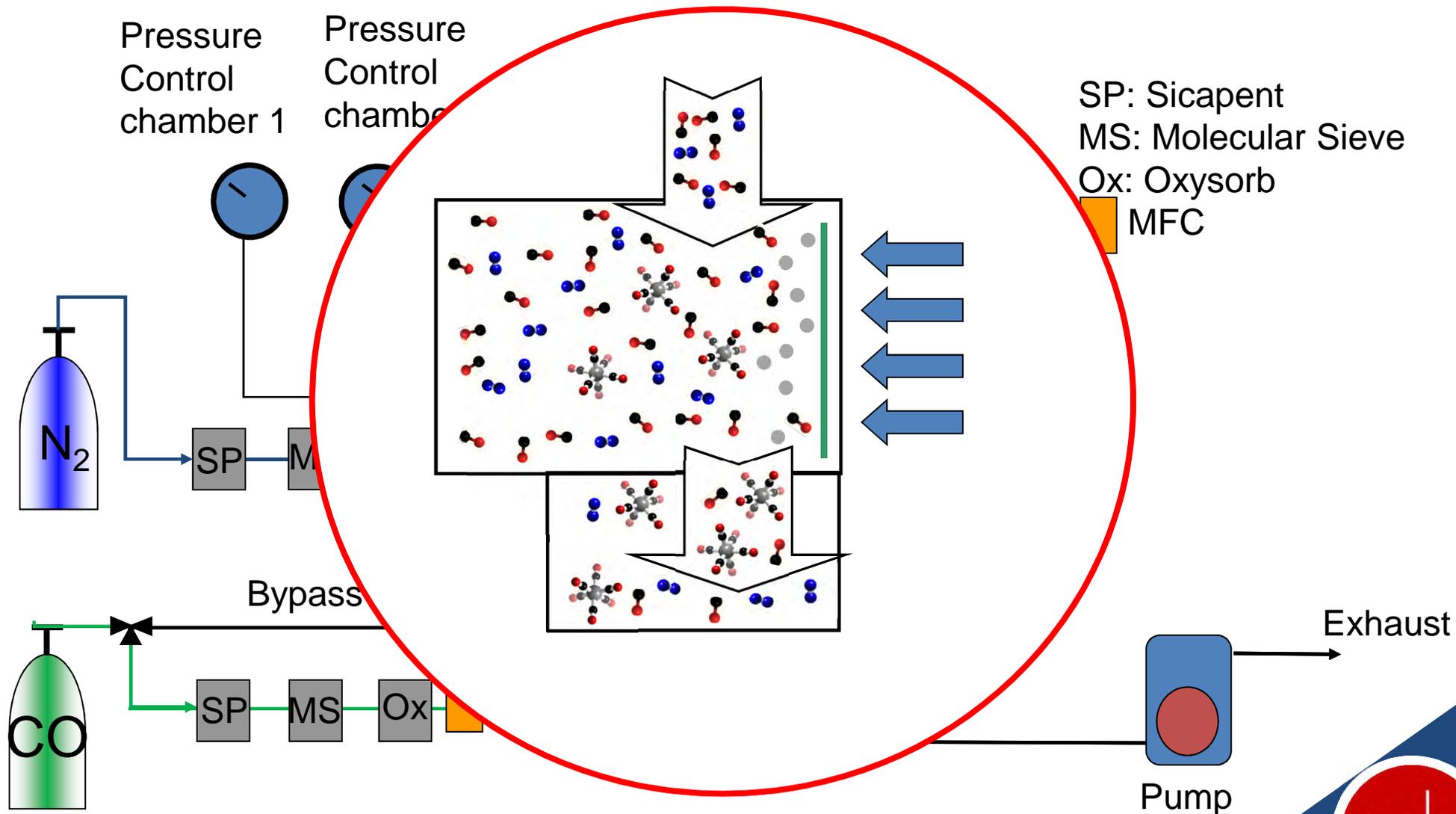
Pump

Far Sieve

# Carbonyl experiment: TRIGA Mainz 2016



# Carbonyl experiment: TRIGA Mainz 2016



# Preliminary results

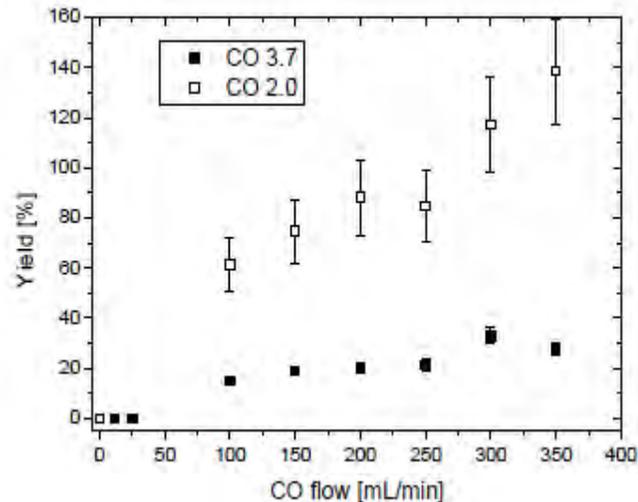
☺ Transport efficiency from target chamber to reaction chamber is 10-20% !

Still to consider:

- ☹ Back diffusion can not be excluded completely !
- ☹ Gas-purification issues: Yield fluctuations by different cartridge-combinations!

Proposed investigation:

- ☞ Gas purification studies with
- ☞ Investigation of back diffusion conditions

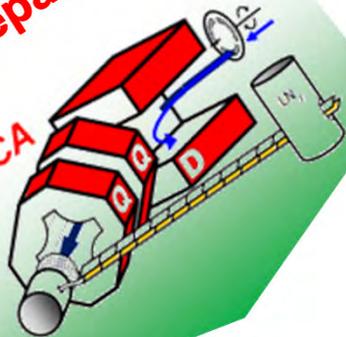


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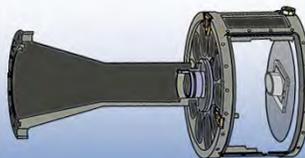
# Summary:

**With Separator**

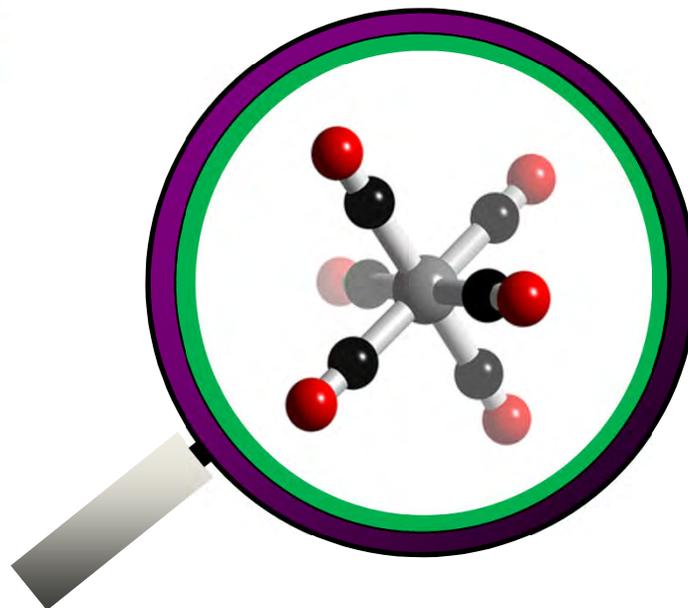
TASCA



**Without Separator**  
One chamber design



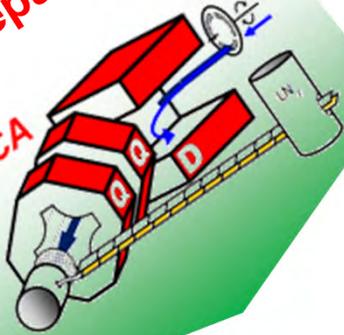
**Without Separator**  
Two chamber design



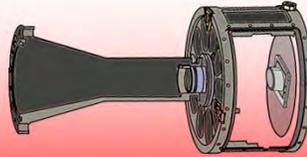
# Summary:

**With Separator**

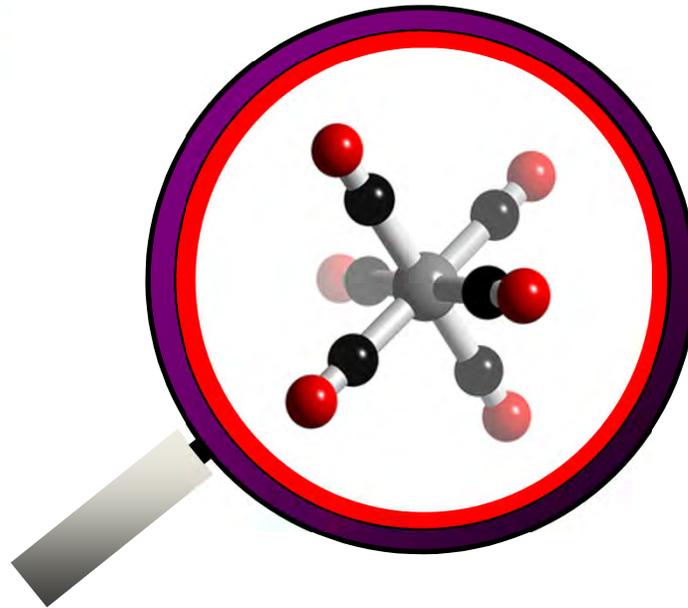
TASCA



**Without Separator**  
One chamber design



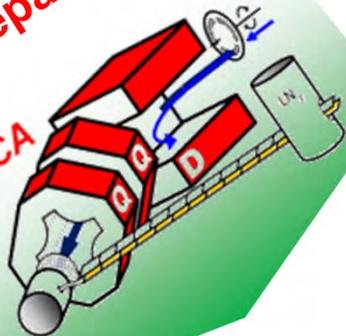
**Without Separator**  
Two chamber design



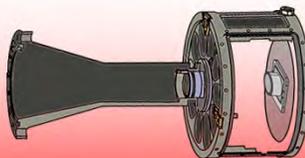
# Summary:

**With Separator**

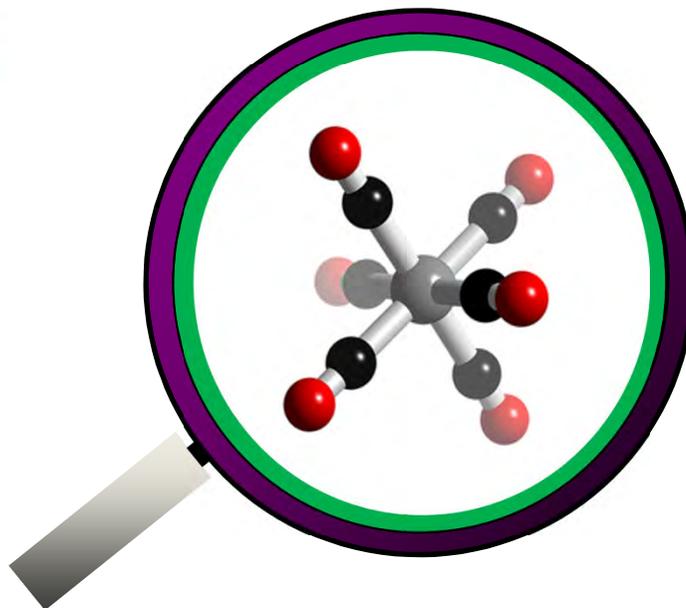
**TASCA**



**Without Separator**  
**One chamber design**



**Without Separator**  
**Two chamber design**



# Outlook:

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Repeat online experiments at the TANDEM accelerator in Tokai-mura:

- ☞ Change vacuum window and target backing material to Be
- ☞ Improve the gas cleaning
- ☞ Perform experiments with longer-lived isotopes of W, Re and Os in prior to experiments with short-lived isotopes