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Radon Capture & Analytics

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# SUBbLIME MS

## Sheffield University Scrubber for LIME – Molecular Sieves

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**CYGNUS MEETING**  
22nd April 2021



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# SubbLIME Aims

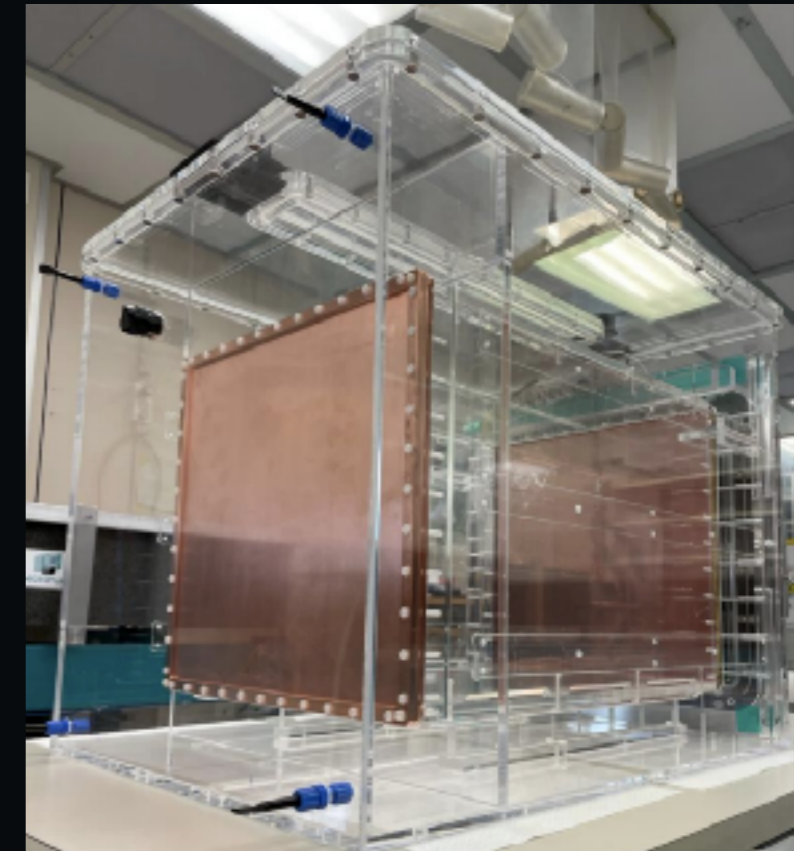
SubbLIME Aims  
MS Characterisation  
VSA Operation

## Identify a filter that:

- Purify\* CF<sub>4</sub> and Helium
- Removes radon from CF<sub>4</sub> and Helium
- Conserves the CF<sub>4</sub>:He mixing ratio
- Low background MS (Nihon-University)

## Vacuum Regeneration Operation

- Assist with the application of vacuum regeneration in LIME gas system
- Determine the breakthrough time and ideal VSA Operation
- Zero emission of CF<sub>4</sub> into the atmosphere



(100 L, 1 atm, CF<sub>4</sub>:He 60:40)

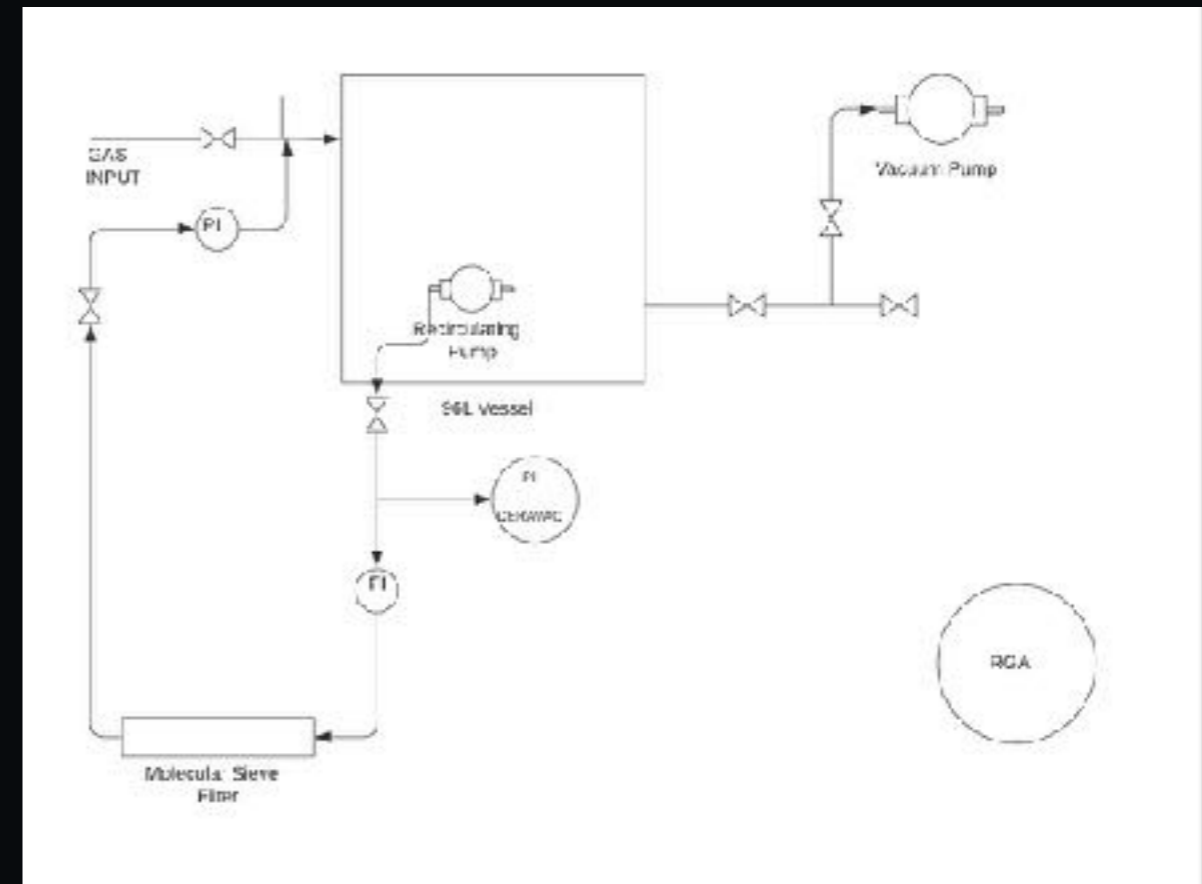
\*Removal of H<sub>2</sub>O, N<sub>2</sub>, O<sub>2</sub>

# MS Characterisation

SubbLIME Aims  
**MS Characterisation**  
VSA Operation

## Experiments:

1. Determine which MS (3A, 4A, 5A or 13X) absorbs He or  $\text{CF}_4$
2. Demonstrate MS ability to conserve the  $\text{CF}_4$ :He mixing ratio



## Absorption Test Method:

1. Measure starting pressure (MS OFF)
2. Allow filtration for one full volume cycle (MS ON, PUMP ON)
3. Measure end pressure (MS OFF)

**Vessel:** ~100L

**Pressure** ~ 1 atm

**MS Capacity:** ~500g

**Pump Flow rate:** 9 LPM for CF<sub>4</sub>; 3.5 LPM for He

**Filtration time:** Allow for one full volume cycle

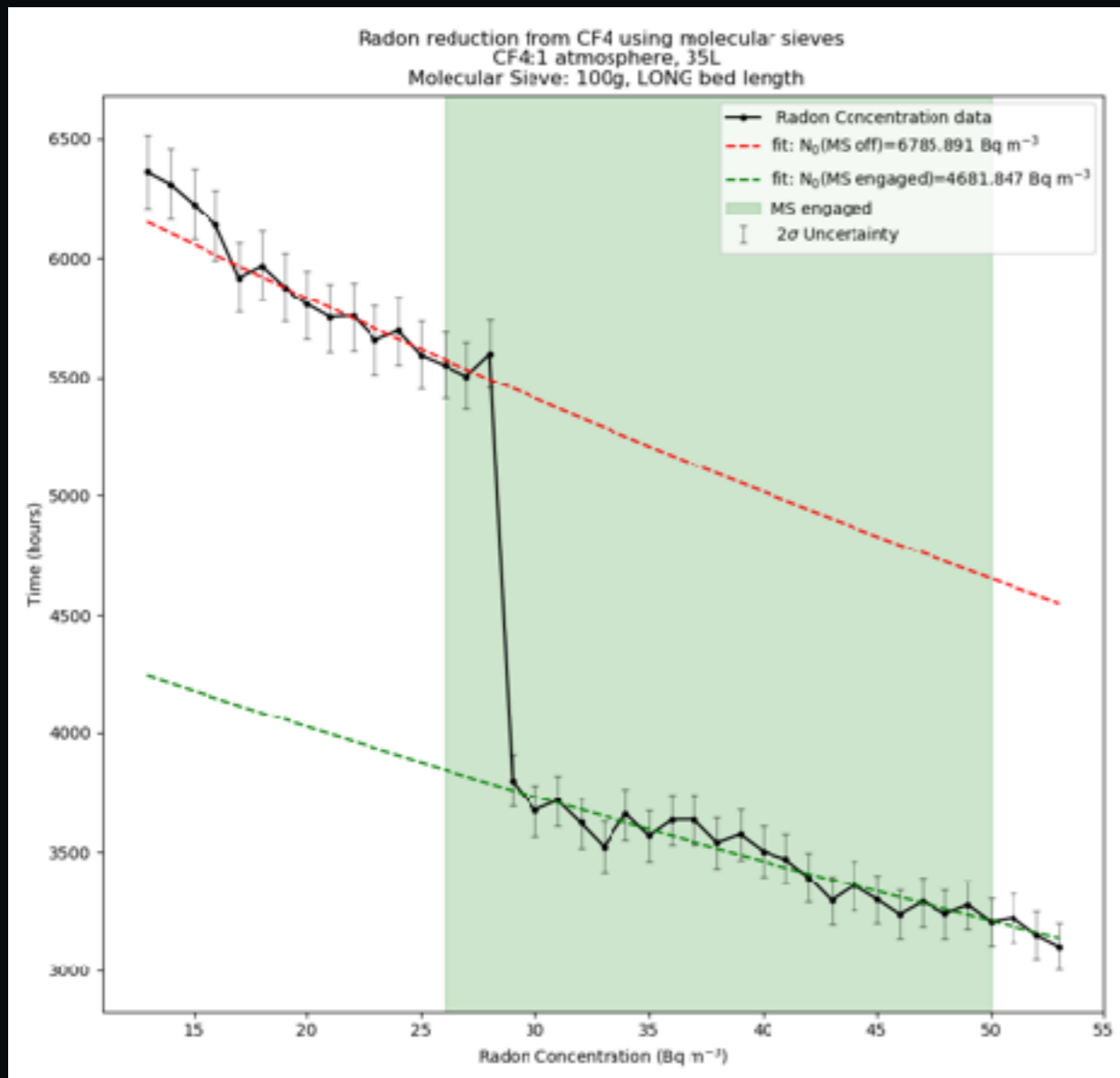
**Pressure Gauge:** CERAVAC Absolute Pressure Gauge

## Target Gas Absorption Test Results

Molecular Sieve Filter	Helium Captured (Torr/kg)	CF <sub>4</sub> Captured (Torr/Kg)	Notes
Activated Charcoal	-	197±11	Control - Absorbs CF <sub>4</sub>
3A	-4±12	*	Does not absorb He or CF <sub>4</sub>
4A	-8±12	-3±6	Does not absorb He or CF <sub>4</sub>
5A	-8±12	87±7	Absorb CF <sub>4</sub> not He
13X	*	67±8	Control (MS) (Rod geometry)

**3A & 4A** - Used for water, nitrogen and oxygen removal  
**5A** - Used for radon removal

## Does 5A MS still absorb radon from CF<sub>4</sub> ?



Radon is still captured from CF<sub>4</sub> at comparable capacity to SF<sub>6</sub> work but CF<sub>4</sub> pressure decreases....

## Next steps:

- Demonstrate 3A:4A ability to conserve the  $\text{CF}_4$ :He mixing ratio with a residual gas analyser
- Quantify 3A:4A water/air absorption capacity per unit amount with residual gas analyser
- Explore 5A radon removal whilst conserving the  $\text{CF}_4$ :He Ratio (Dynamic equilibrium?)

# VSA Operation

## Sheffield SF<sub>6</sub> Gas System



Dual MS design utilises **Vacuum Swing Adsorption (VSA)** Technique

- ✓ Allows on-site Vacuum MS regeneration
- ✓ Enables the MS filter to be reused allowing continuous long-term operation of the filtration setup

For more information please see:

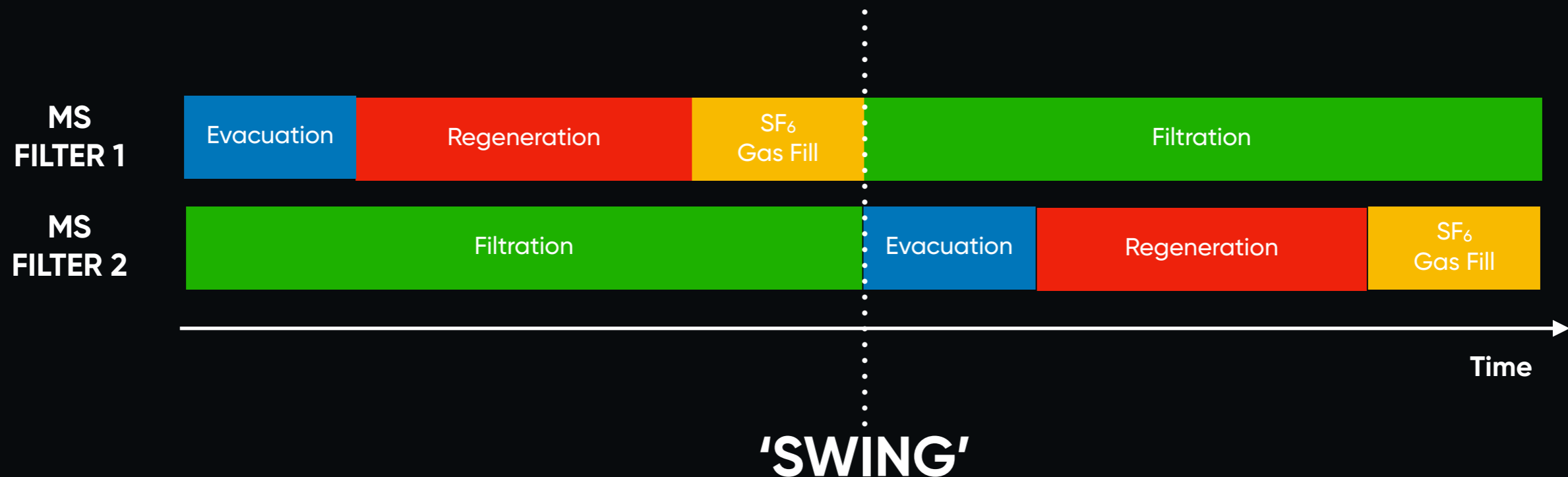
Towards a Gas Filtration Setup for Ultra-Sensitive SF<sub>6</sub> Gas Based Rare-Event Physics Experiments  
IOP APP, HEPP & NP Conference 2021



# Vacuum Swing Adsorption

SubbLIME Aims  
MS Characterisation  
**VSA Operation**

Vacuum Swing Adsorption allows for **simultaneous filtration** and **vacuum regeneration** enabling long-term continuous use

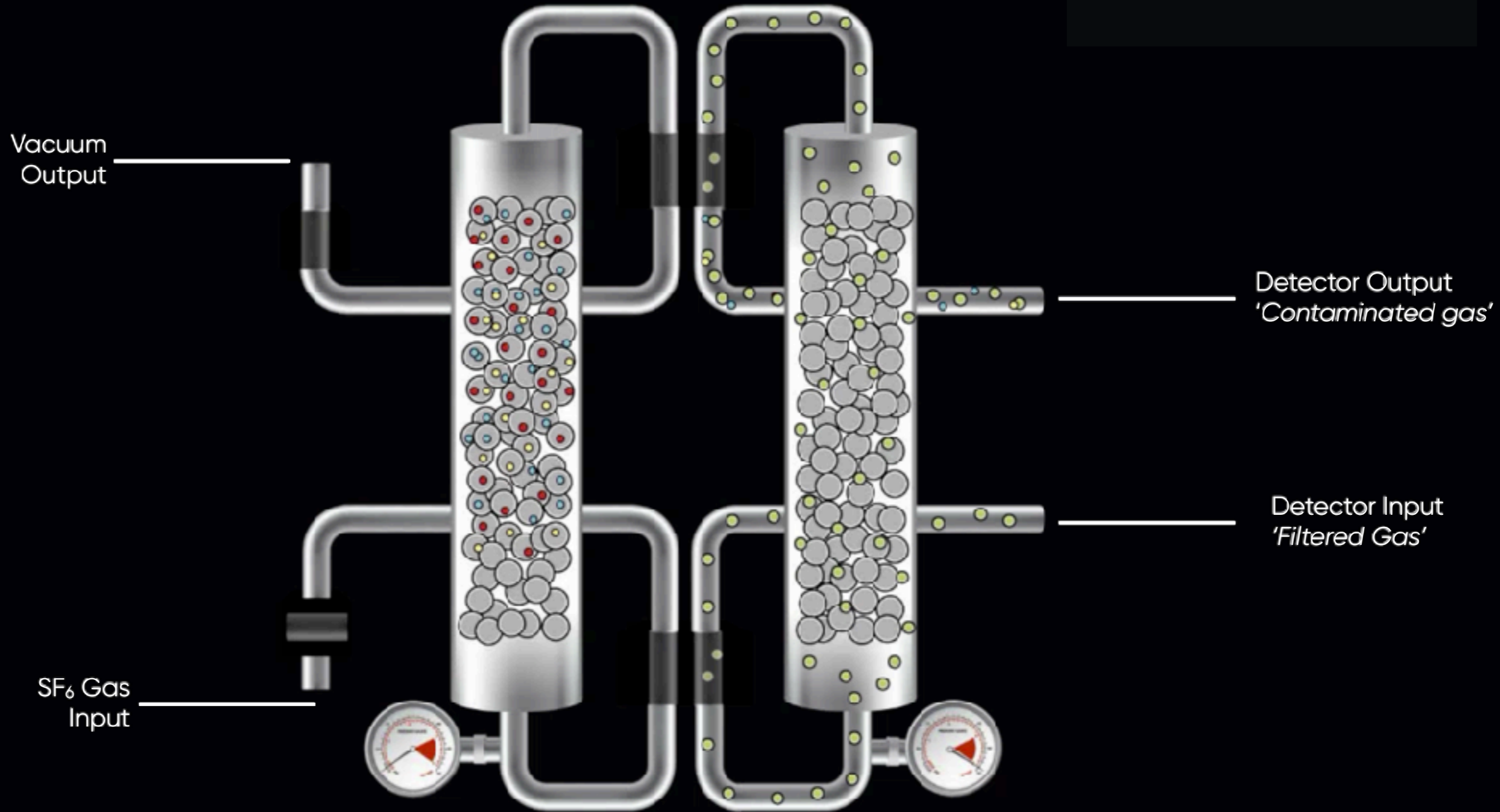


From IOP APP, HEPP & NP Conference | 12th April 2021 Talk

Towards a Gas Filtration Setup for Ultra-Sensitive SF<sub>6</sub> Gas Based Rare-Event Physics Experiments

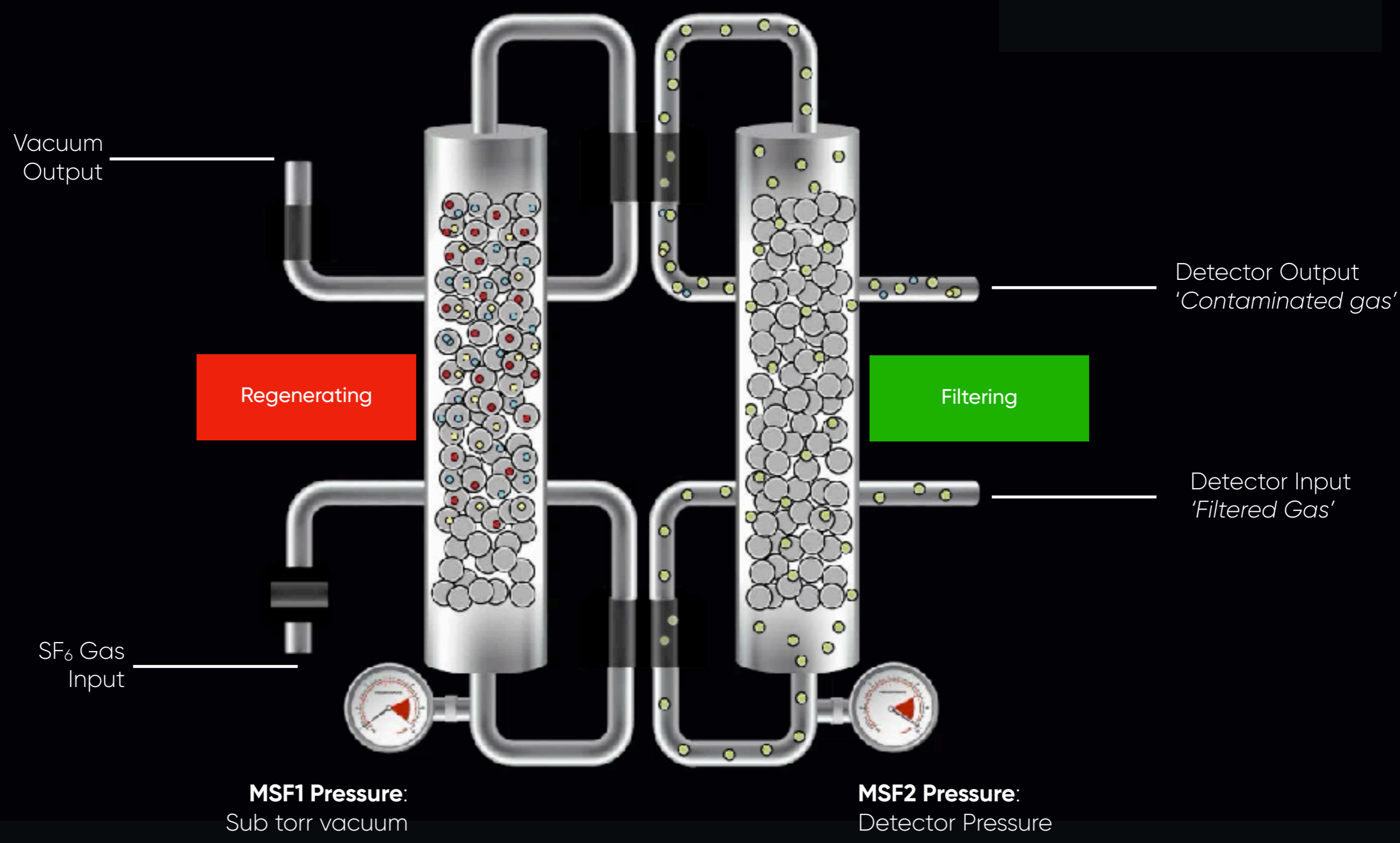
# Vacuum Swing Adsorption

SubbLIME Aims  
MS Characterisation  
**VSA Operation**



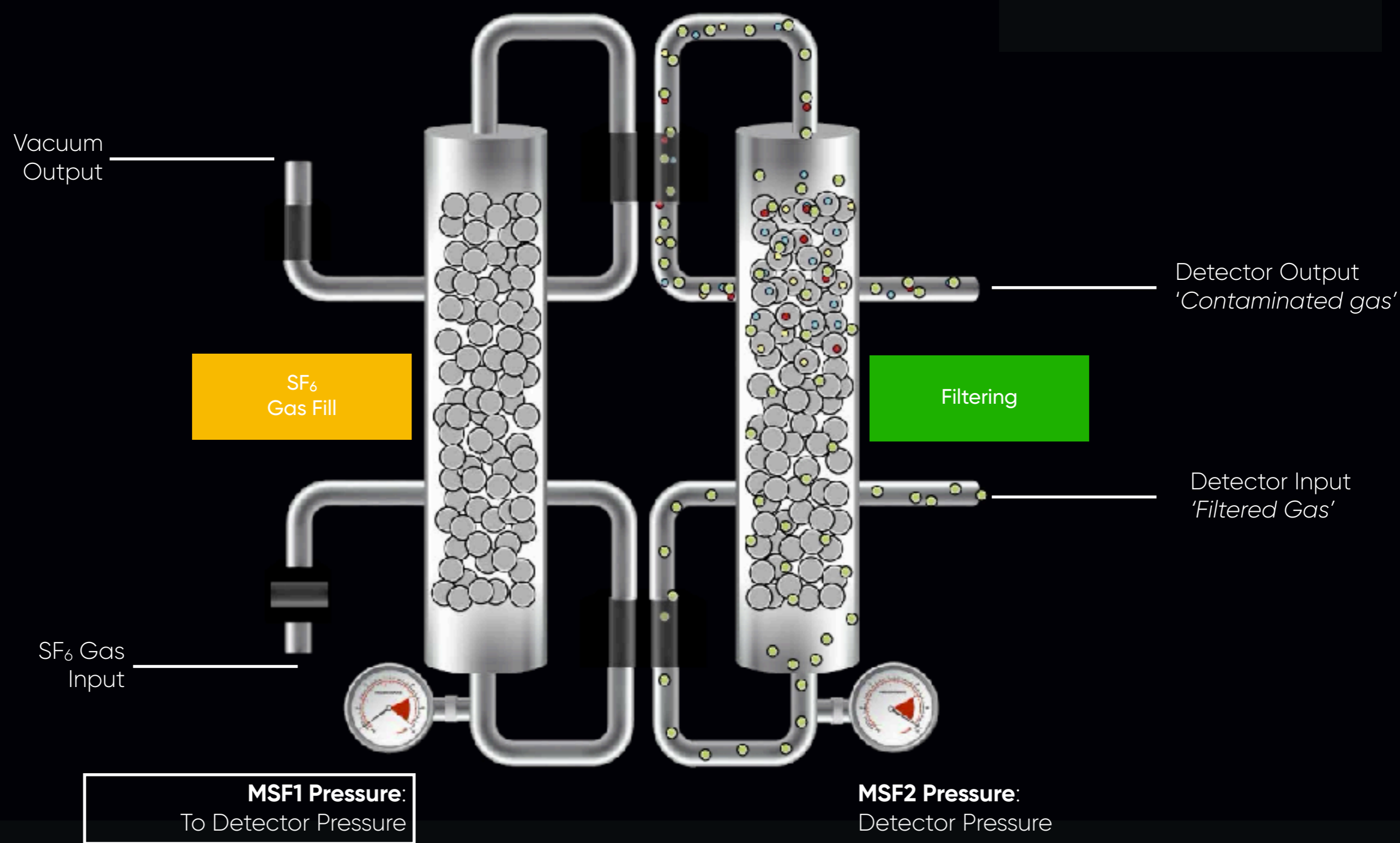
# Vacuum Swing Adsorption

SubbLIME Aims  
MS Characterisation  
VSA Operation



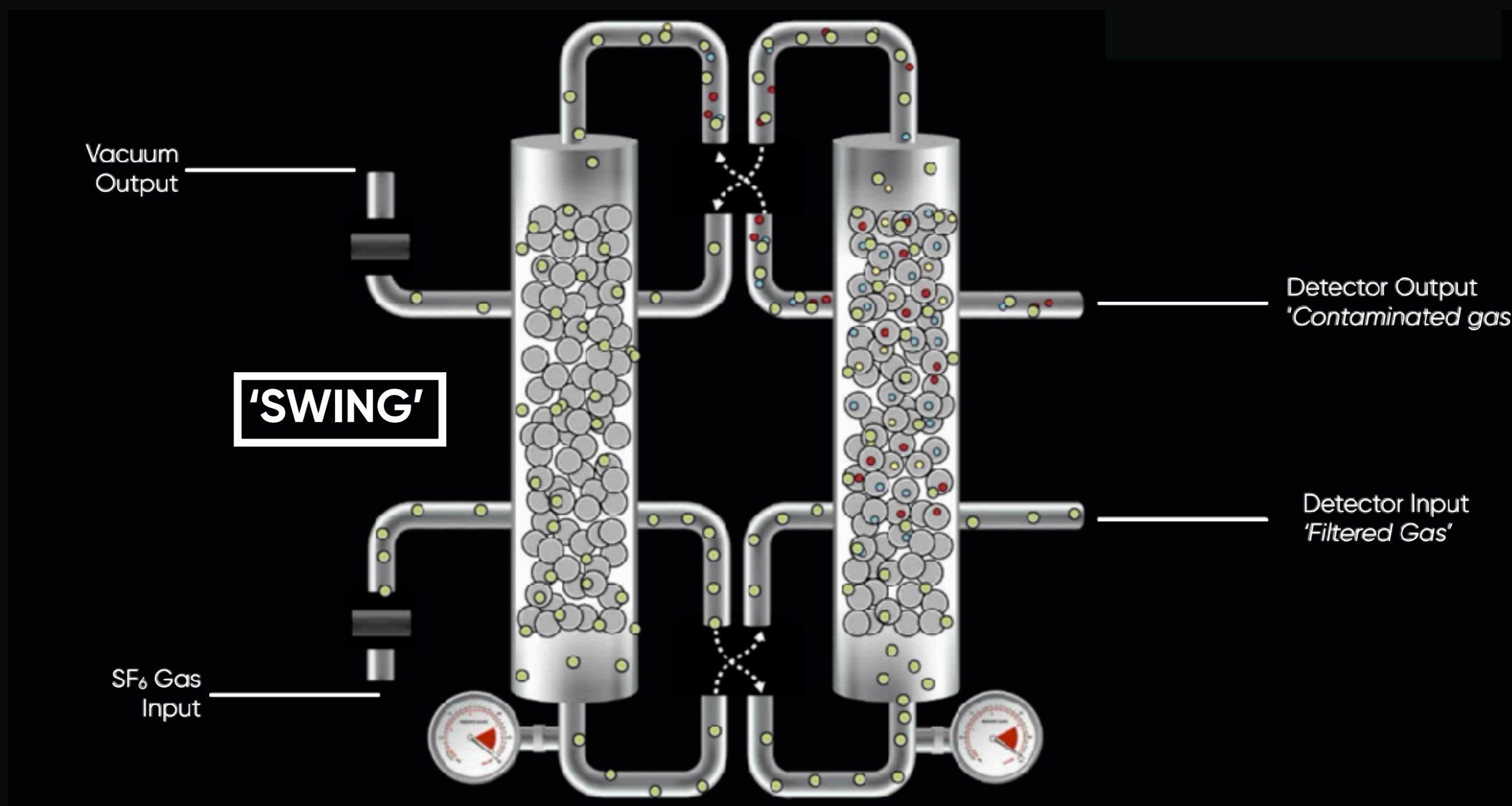
# Vacuum Swing Adsorption

SubbLIME Aims  
MS Characterisation  
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# Vacuum Swing Adsorption

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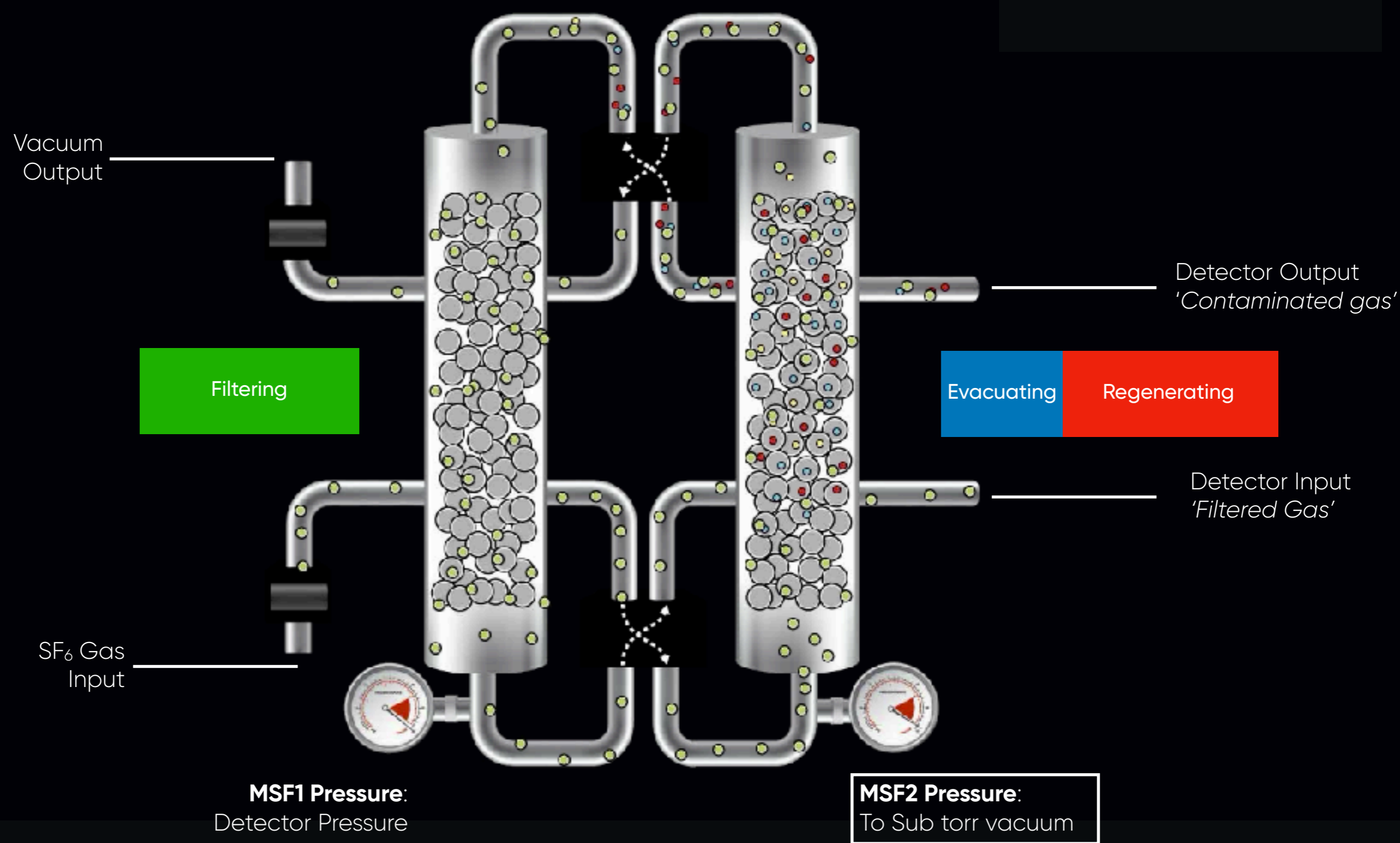
**'SWING'**

**MSF1 Pressure:**  
Detector Pressure

**MSF2 Pressure:**  
Detector Pressure

# Vacuum Swing Adsorption

SubbLIME Aims  
MS Characterisation  
VSA Operation



**ISSUE - vacuum regeneration output will release a very small amount of CF<sub>4</sub>...**

**Aim is ZERO CF<sub>4</sub> emission to atmosphere**

- Recovery bottle to vacuum output?
- Activated Charcoal filter to output (CF<sub>4</sub> Capacity 197±11 torr/kg)
- Amount of CF<sub>4</sub> is expected from MS filter when regenerating depends of size of filter and packing efficiency

## **Suitable Filter Mixture:**

- Identified a filter for CF<sub>4</sub>:He purification from water/air (3A:4A)
- Demonstrated removal of radon from CF<sub>4</sub>. However CF<sub>4</sub> is also absorbed

## **Vacuum Regeneration Operation:**

- Highlighted issue of small amount of CF<sub>4</sub> released from regeneration output
- Presented possible solution to achieve zero CF<sub>4</sub> emissions

## **Low Background MS (Nihon University)**

- Verbal agreement from Kentaro for MS supply (08-APR-21)



## **Suitable Filter Mixture:**

- Demonstrate 3A:4A ability to conserve the  $\text{CF}_4$ :He mixing ratio with a residual gas analyser
- Explore 5A radon removal whilst conserving the  $\text{CF}_4$ :He Ratio (Dynamic equilibrium process?)

## **Vacuum Regeneration Operation in LIME:**

- Quantify amount of MS filter required for water/air purification
- Determine the expected amount of  $\text{CF}_4$  released during MS vacuum regeneration
- We need to determine the contamination rate in LIME
  - > RGA measurements overtime (If possible)
  - > Dew meter measurements would provide approximate idea