An Alternative to Helium Leak Checking

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AVS-69
Session: VT-TuA: Novel Vacuum Instrumentation
7th November 2023 5:00 – 5:20 PM

Introduction

- Motivation for an alternative to helium leak checking
- Remote plasma emission monitoring (RPEM)
- RPEM for leak checking
- Detection gas
- Ar leak detection
- Other uses
- Conclusions

Motivation

- “Helium Shortage 4.0”
  - Lack of supply driven by political pressures and production problems
  - Difficult to procure Helium even with long running gas contracts unless in key industries

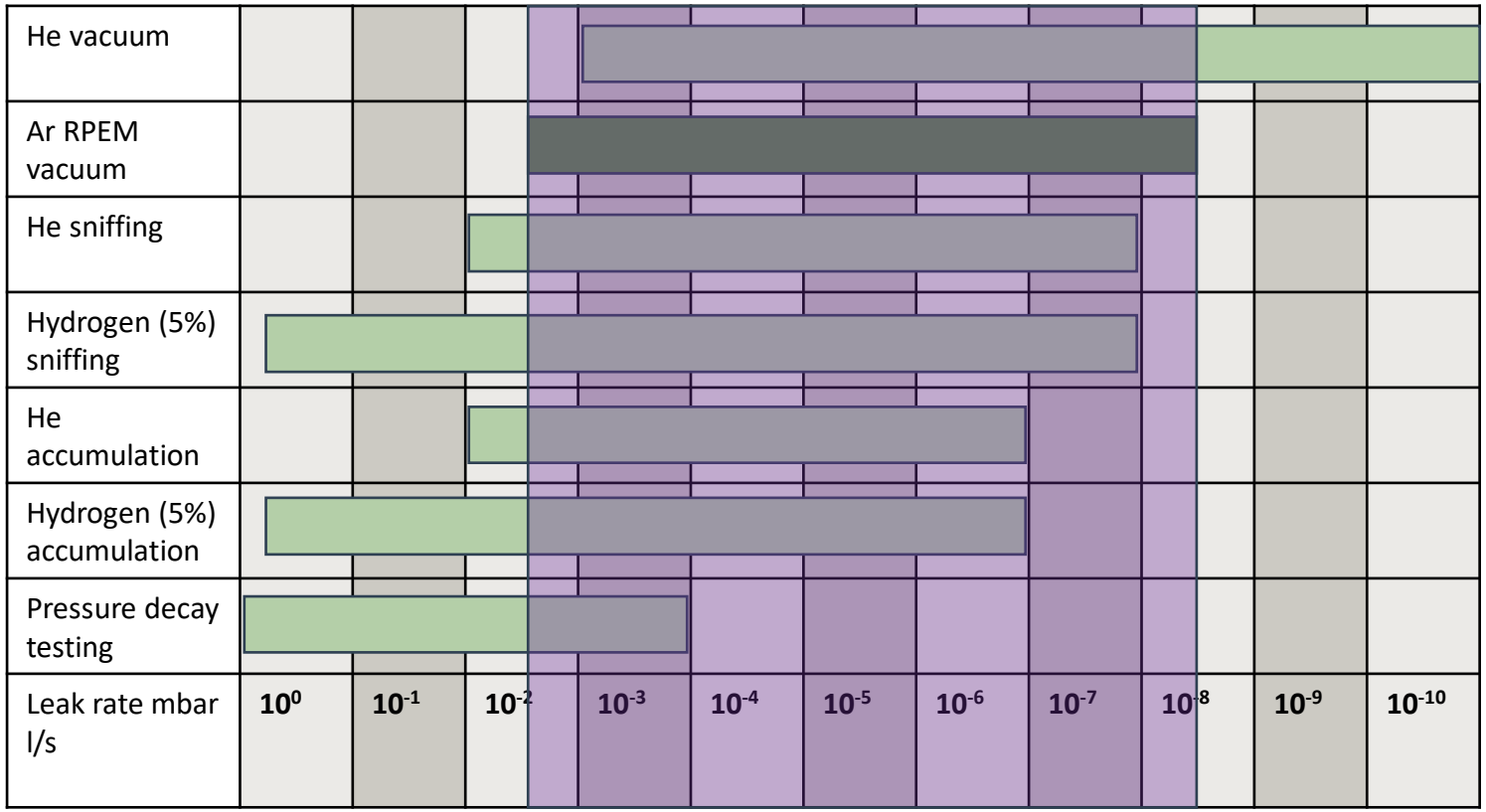
- Finite resource
  - Once released into atmosphere lost forever
  - Use should be prioritised for critical applications

- Technological
  - Mass spectrometer based mobile leak checkers
    - Costly to produce
    - Expensive to maintain
  - Detection limit down to 1E-12 mbar l/s often unnecessary

- Large component testing (e.g. fuel tanks) where minimising use of helium is advantageous typically in accumulation testing

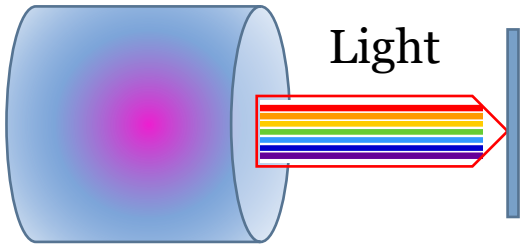
Motivation

- Existing techniques



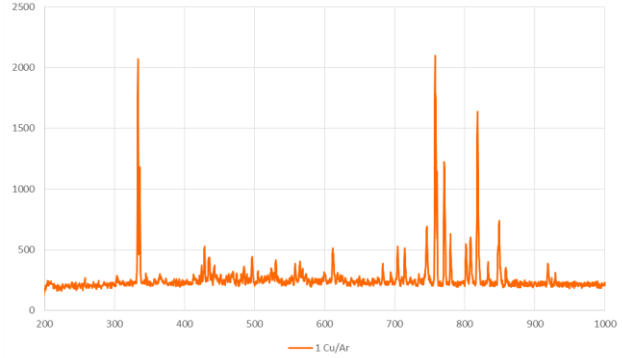
- Targeting helium-based technologies
  - Standalone / portable leak checker for helium vacuum initially
  - Leak rates <1E-7 to 1E-3 mbar l/s
- Accumulation / sniffing applications

RPEM



Remote plasma

Spectrum analysis gives species composition and concentration



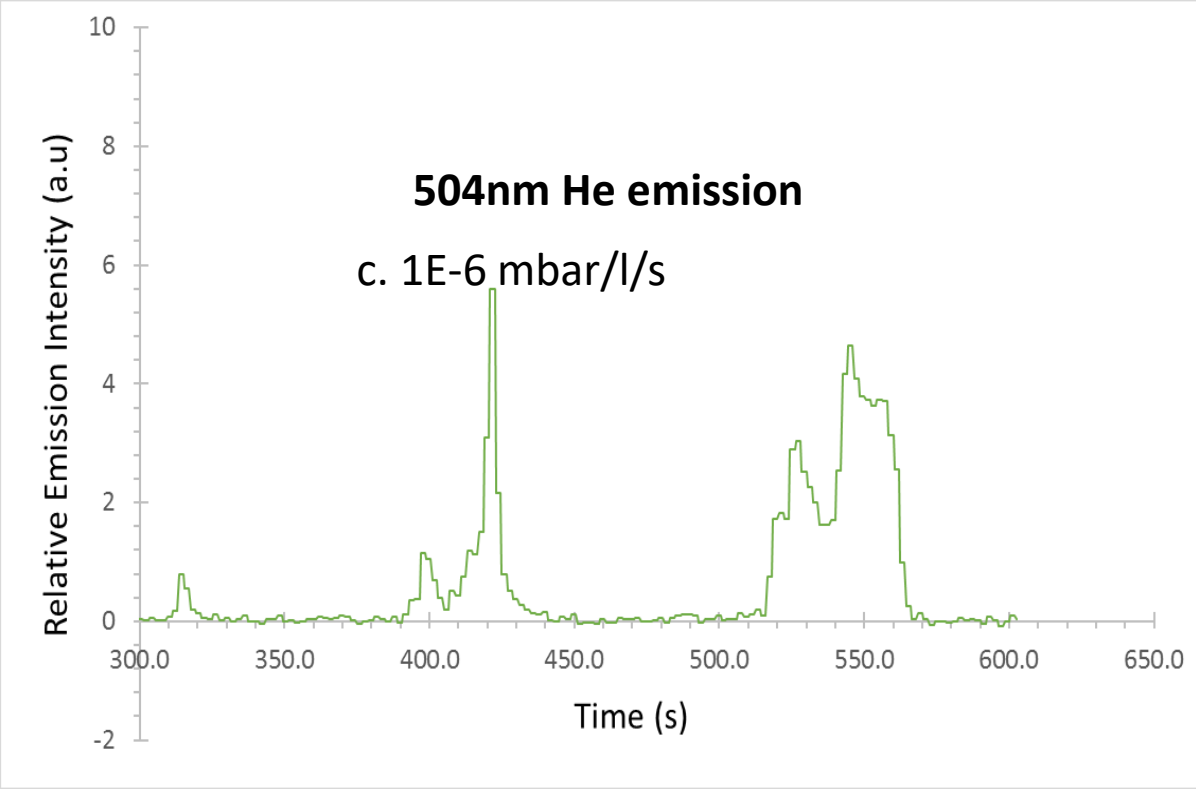
Vacuum Process

Remote plasma generator

Plasma

Miniature spectrometer

RPEM for He leak detection



- Possible to localise air leaks by monitoring He emission
- Not a complete replacement for a dedicated He leak detector
- Leak rates are not directly quantifiable

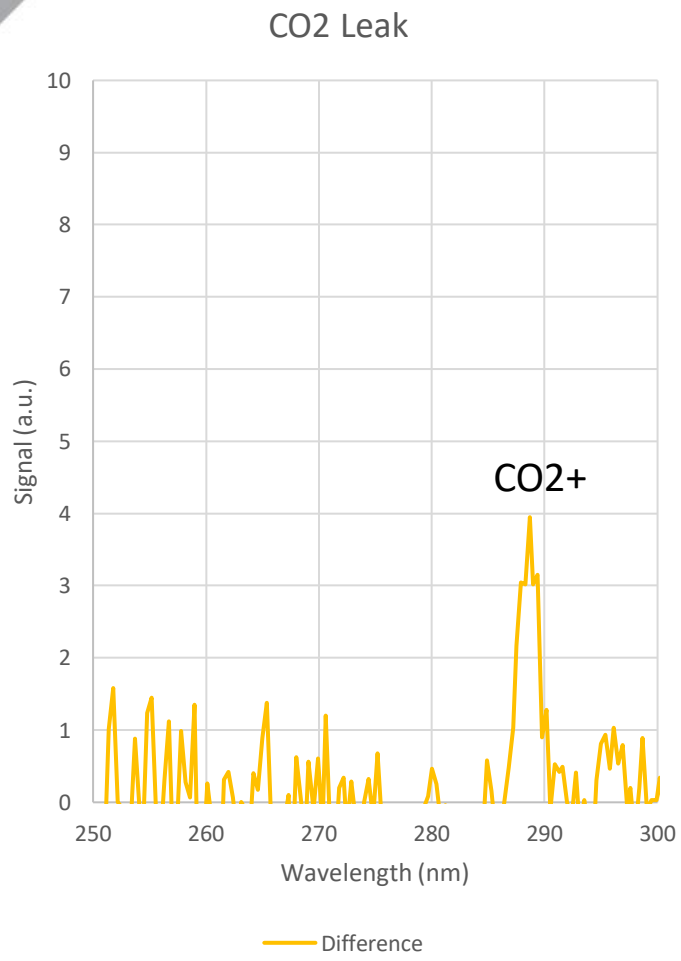
Why not use helium?

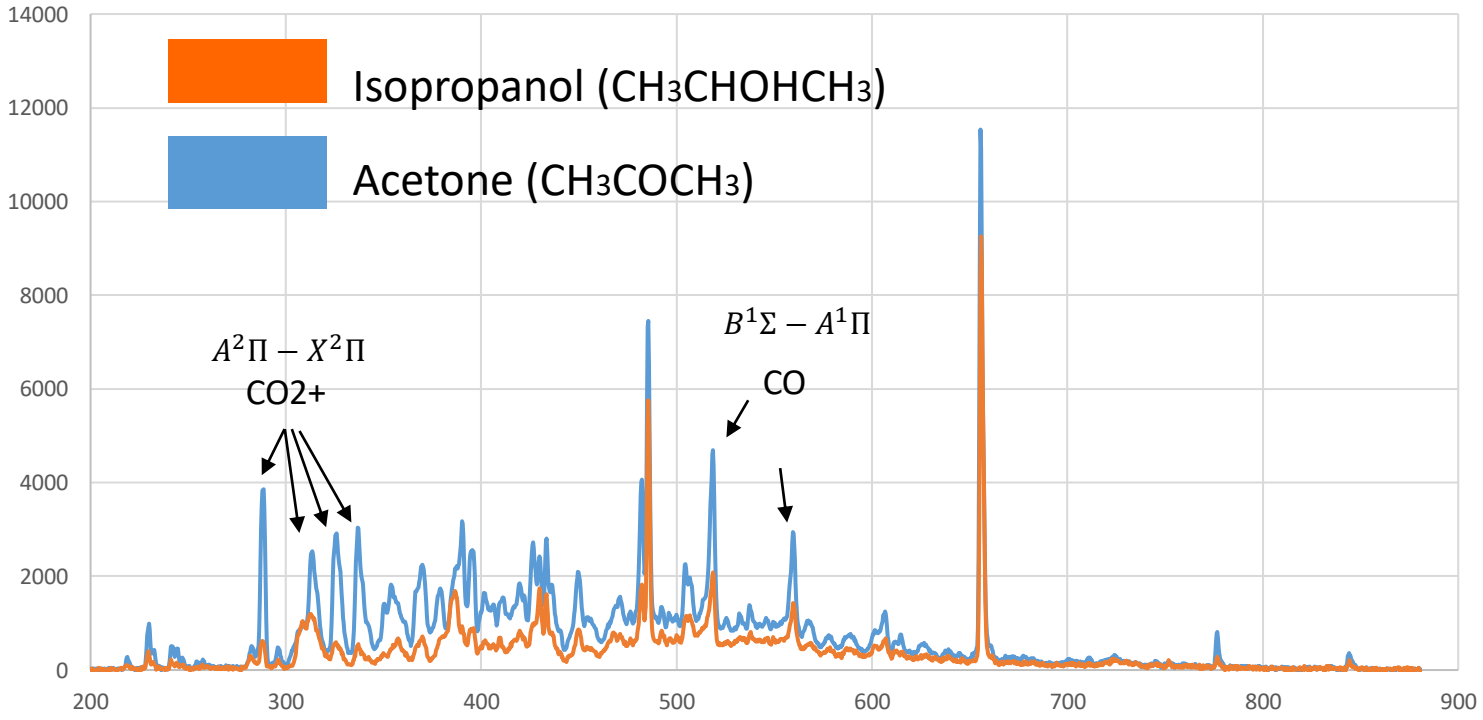
- He low light emitter
- Easily supressed by larger molecules

Detection gas

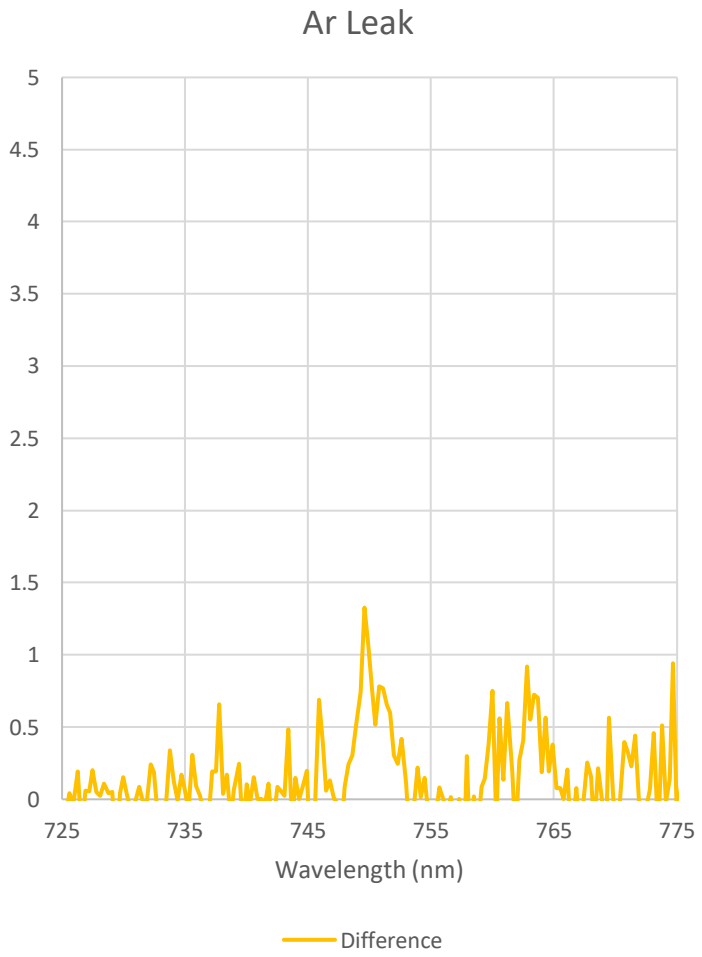
CO2:

- Low presence in atmosphere (~0.04%)
- Complex interactions in plasma
- Organic species dissociating in plasma could make calibration challenging





Detection gas



Argon:

- Higher presence in atmosphere (~1%)
- Inert
- Defined peak at 750nm

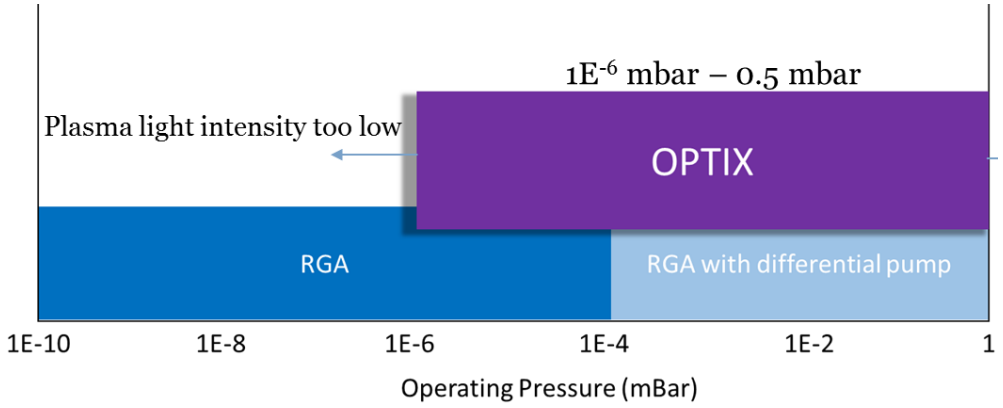
Vacuum Setup

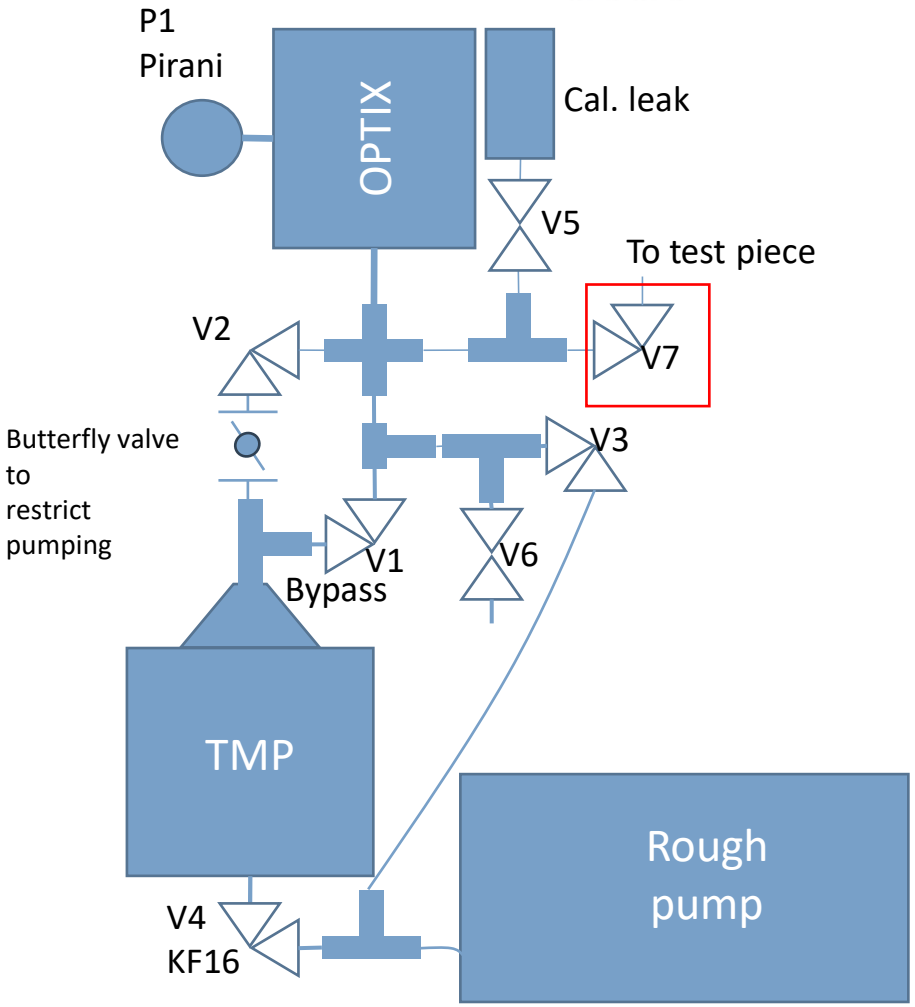
Why not re-tune existing mass spectrometer to detect Argon?

- Conventional leak checkers rely on back-streaming
- Opportunity for a lower cost / more robust unit based on RPEM technology

RPEM leak checker pumping differences?

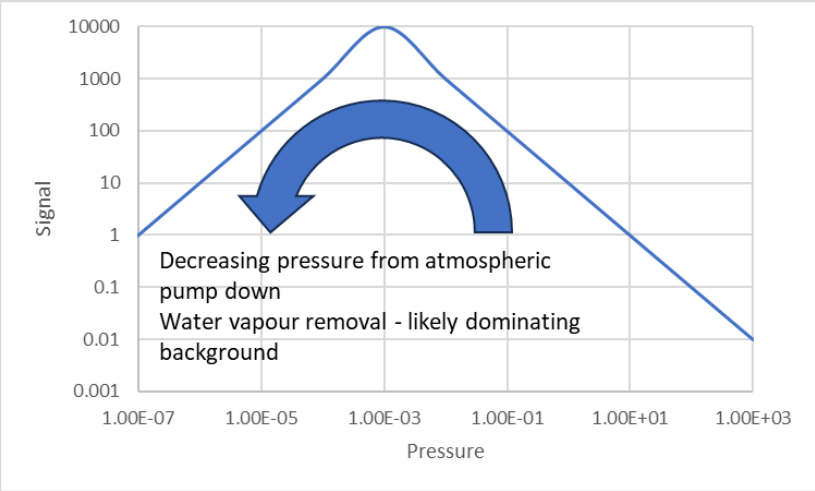
- Can start measuring directly at higher pressures
- Reduced sensitivity below certain pressure; reduce pumping if vacuum <~1E-4 mbar, opposite to He LC which have greater sensitivity at higher vacuum

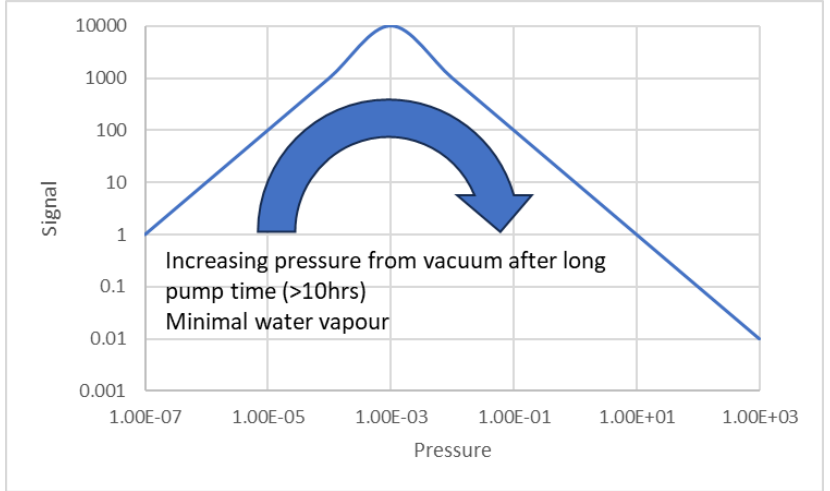




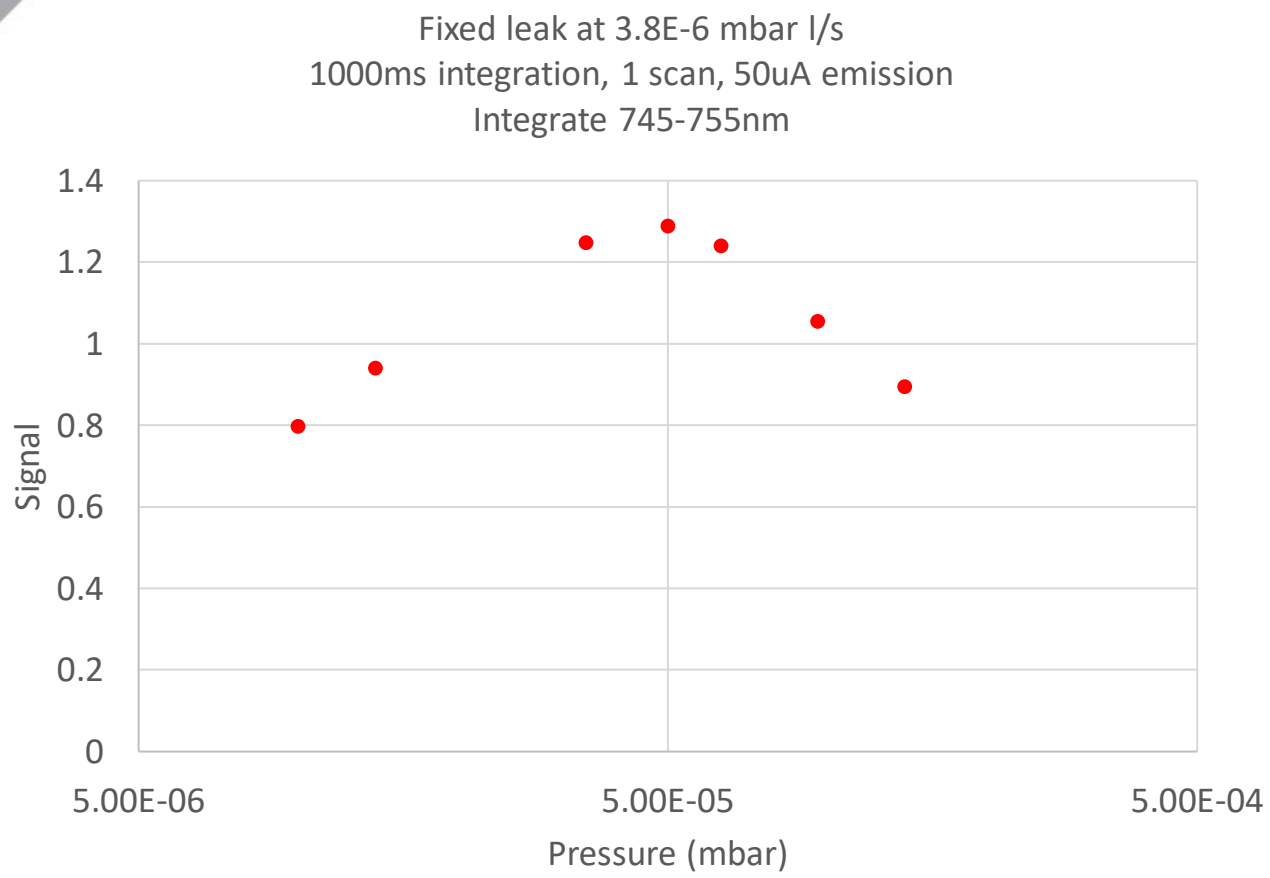
Vacuum Setup

- Sensor pressure critical in determining signal level
- Optimum pressure for signal strength; requires crossover to low conductance pumping
- Required parameters:
    - Low conductance path orifice size
    - Pressure to switch to low conductance mode





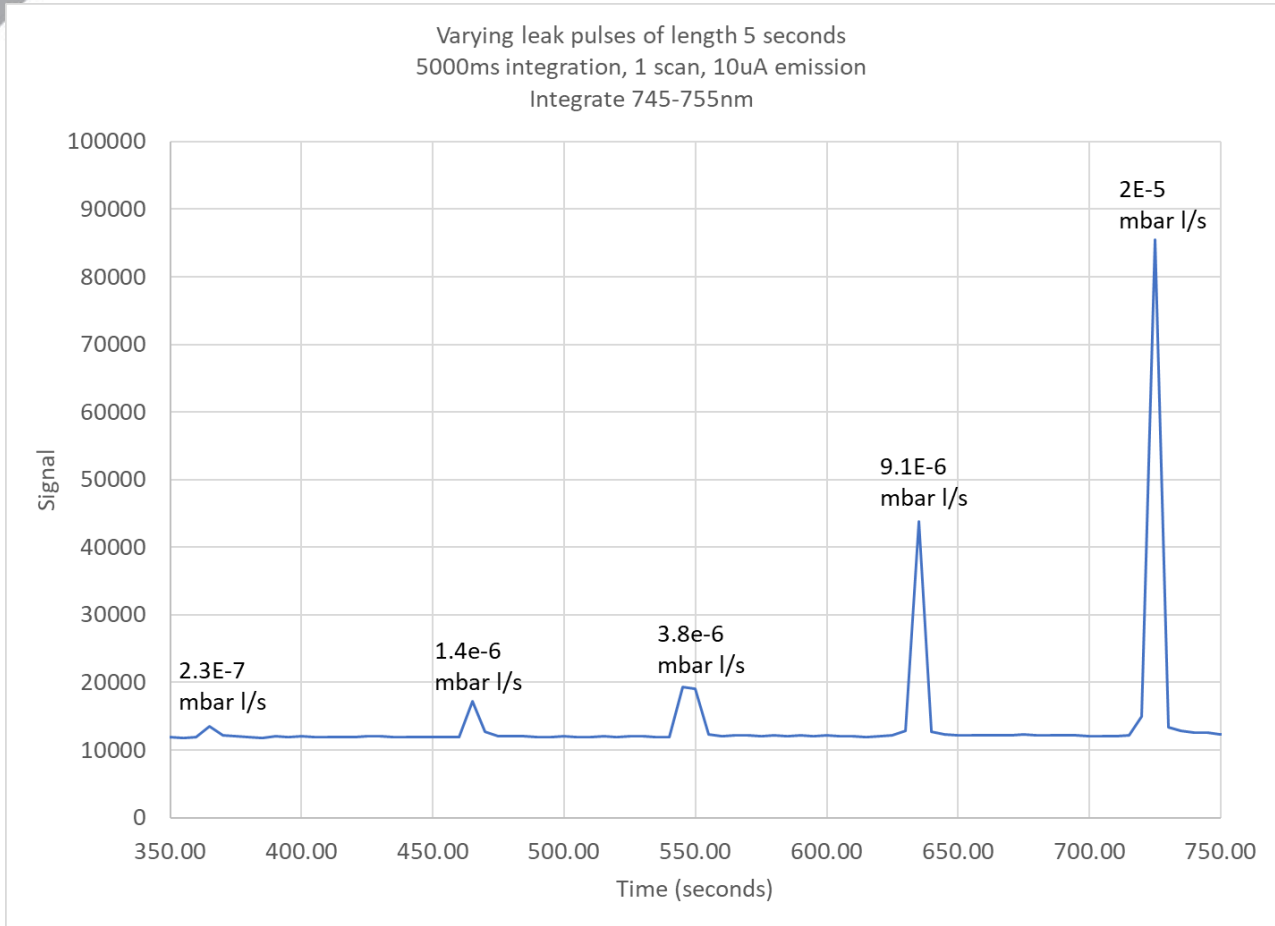
Ar Leak Detection



Pressure response:

- Sensor pressure increased by throttling TMP
- Increase in signal strength by 50% by working at optimum pressure
- Signal falls off when Argon background increases with high throttling

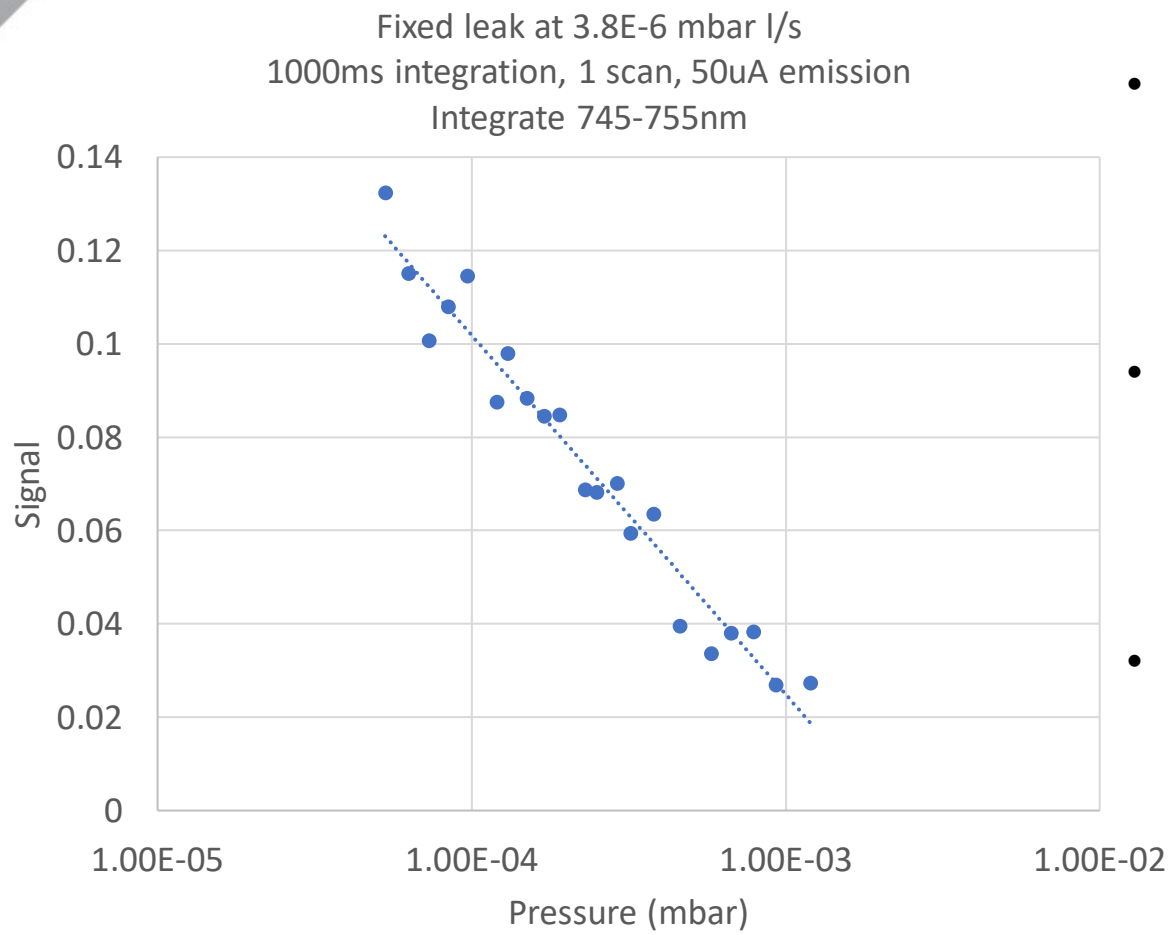
Ar Leak Detection



Pulsed leak response:

- 2E-7 mbar l/s detectable without throttling
- Response time < 5secs
- Opportunity to improve detection signal strength

Ar Leak Detection

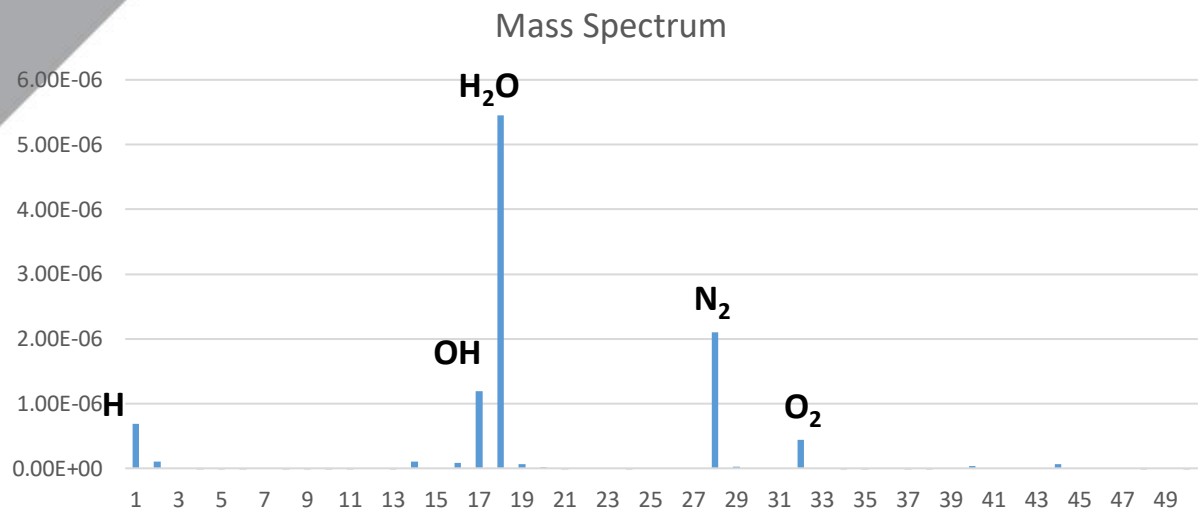


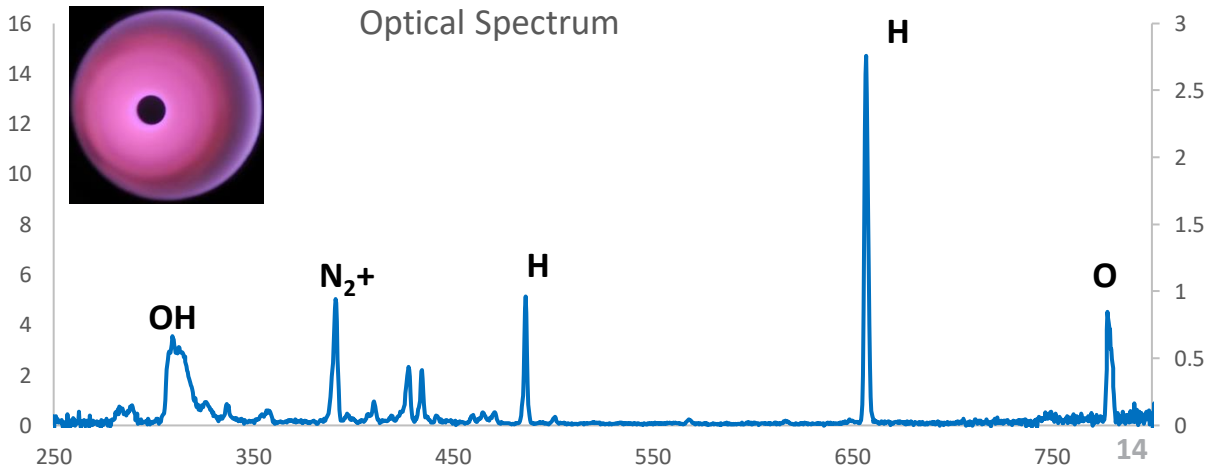
- Required Calibration curves:
  - Pressure vs signal (at fixed leaks / pulse length / current)
  - Signal vs leak (at fixed pressures / pulse length / current)
  - Steady state (i.e. long pulse) signal vs leak
- Understanding to date:
  - **Calibration will require pressure correction**
  - Good fit to pressure in range tested
  - Assume operation at fixed current
- He equivalent Ar leak rate will be a function of integration time (I), signal (S), pressure (P) and potentially partial pressure (PP)

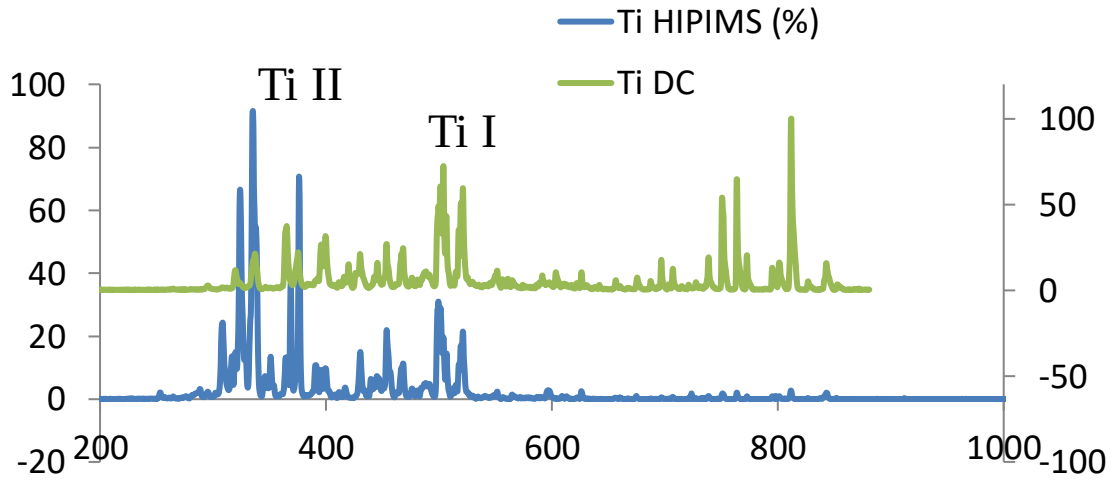
LR(He equivalent mbar l/s) = fn(I,S,P,PP?)

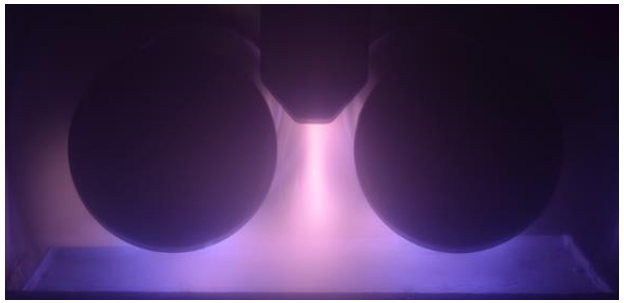
Other uses for RPEM

Vacuum process control / quality monitoring



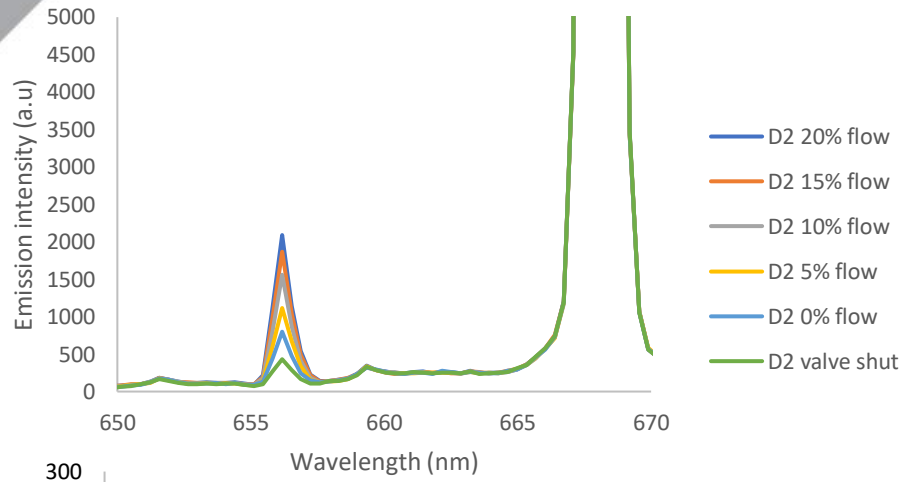


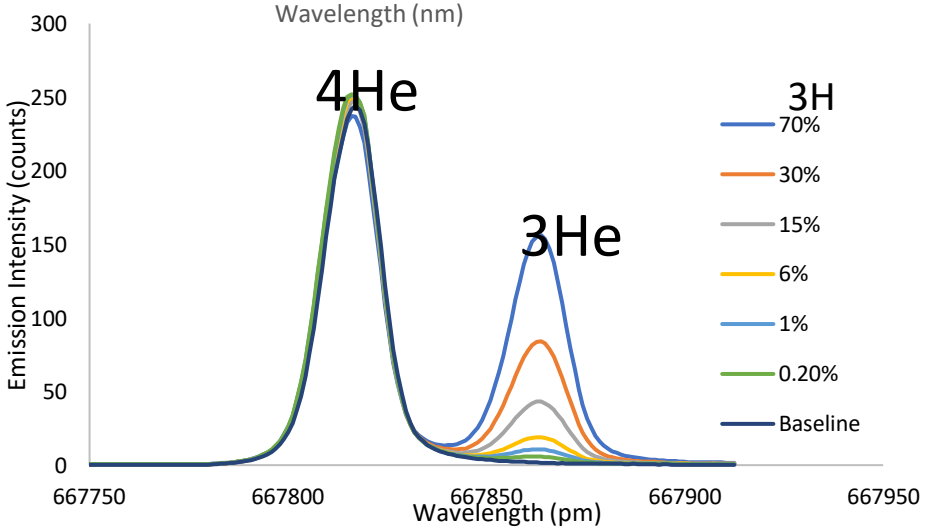


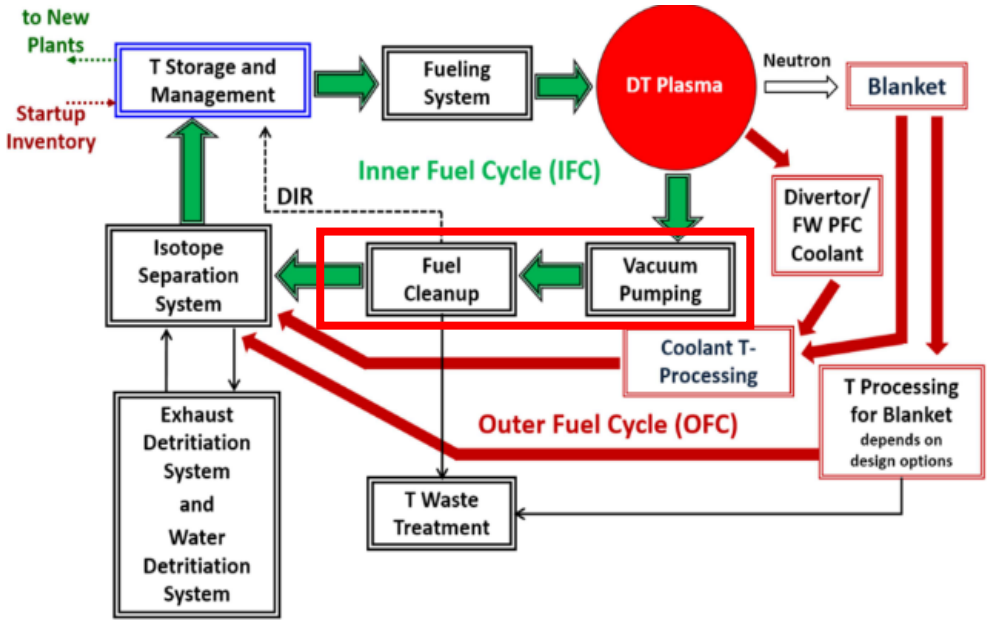


Other uses for RPEM

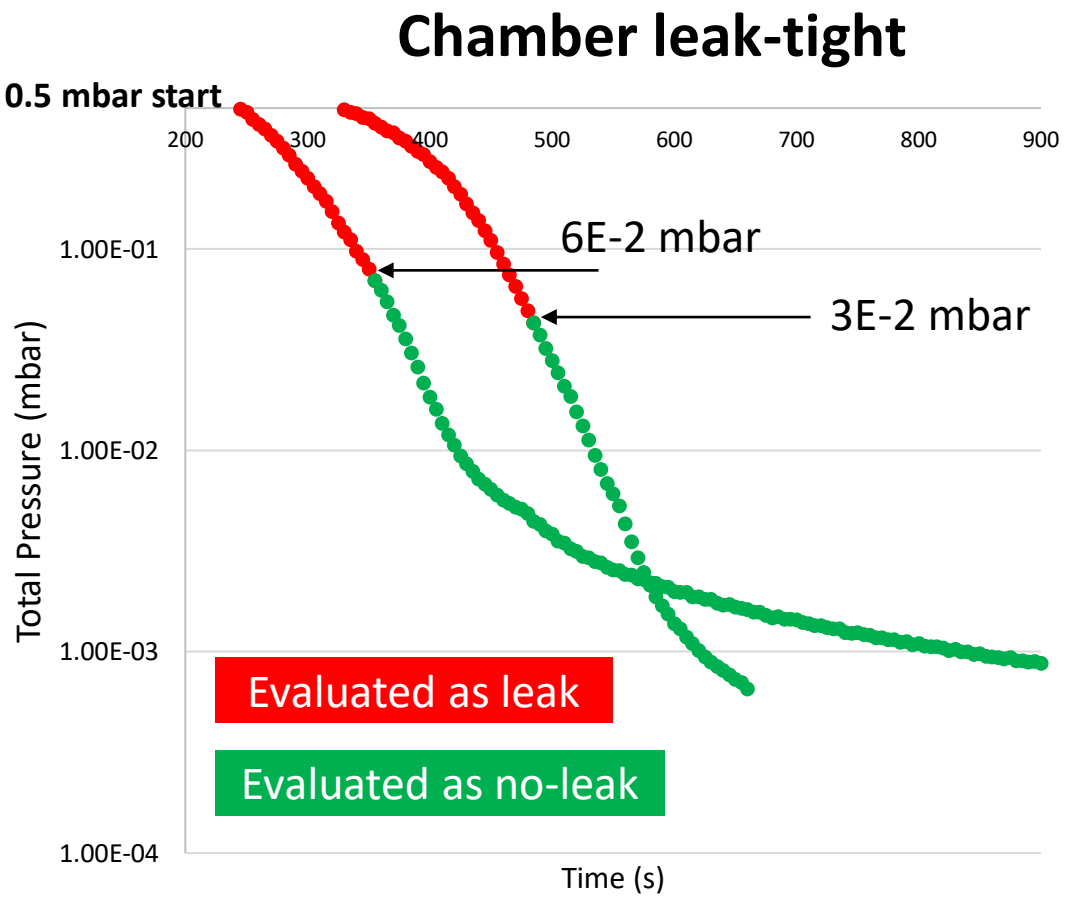
Fusion neutral gas sensing







AI based leak detection



- Uses partial pressure data from RPEM spectrum
- Could be incorporated into RPEM leak checker – advantage of a technique that detects more than a single species
- Chamber determined leak-tight in less than 10 minutes pumping time
- Leak checking algorithm successful below **3E-2 mbar**

Conclusions

- RPEM used to detect He equivalent leaks down to low E-7 mbar l/s
- Heavier gas leak detection requires different pumping arrangement to regular mass spec based systems
- Higher pressure of RPEM works well in such systems
- Calibration more complex but possible by linking pressure and water vapour data
- Offers additional spectral data compared to single species mass spectrometry

Thank you

Project No. 10055251

Leak detection by remote plasma optical emission spectroscopy

- Thank you for your attention
- Please visit us at the exhibition – Booth 704