

Simple Means to Improve the Robustness of ICP Spectrometry without Jeopardizing Detection Limits

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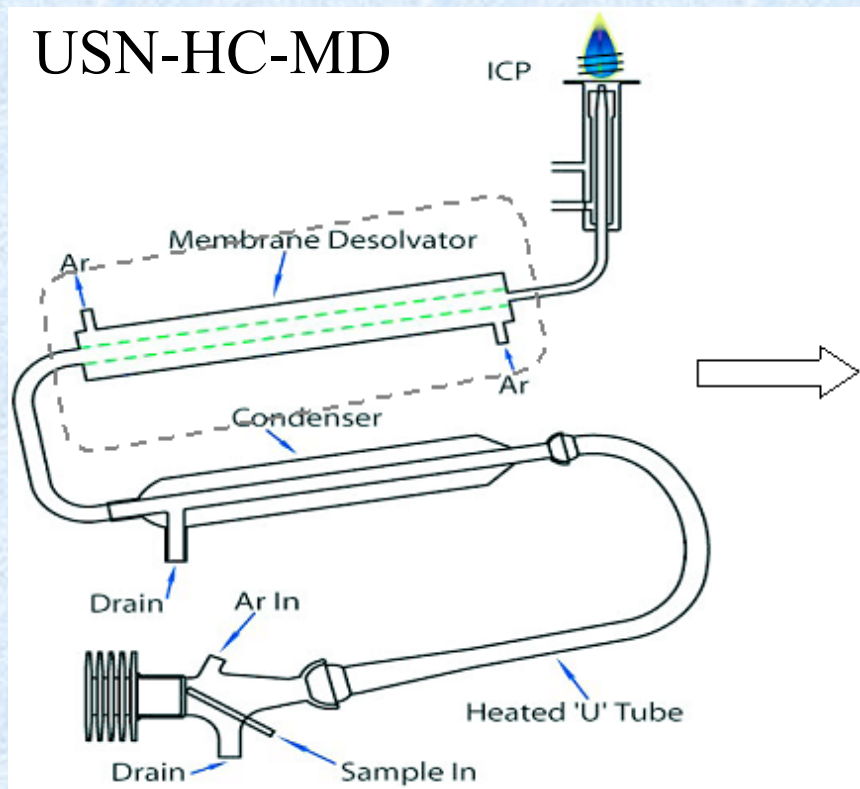
*Interview in the LCGC and Spectroscopy 2011 Pittcon Theater
(Atlanta, Georgia, March 14 & 15, 2011)*

Weakest link: sample introduction

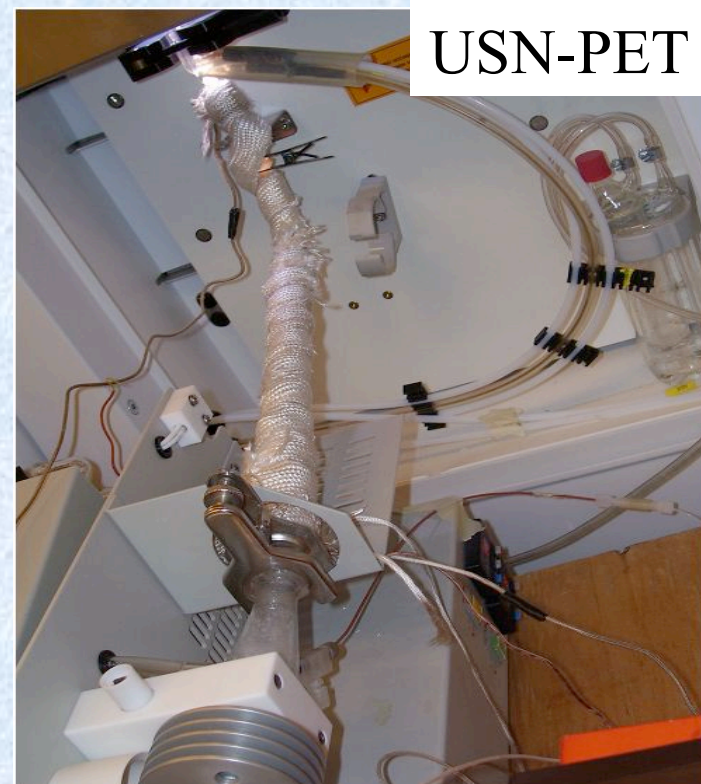
- **Conventional** (nebulizer + spray chamber)
 - **☒ 2-5% of the sample reaches the plasma**
- **Alternative** (ultrasonic nebulizer with desolvation, direct injection nebulizer, high efficiency nebulizer, etc.)
 - **Up to 100% of the sample reaches the plasma.**
 - **Cooling of ICP from increased solvent load.**
 - **Desolvation degrades plasma excitation capability***
 - **Potential loss of analyte during desolvation.**
 - **Potential memory effects from long sample path.**

*Grotti, Lagomarsino & Mermet, *J. Anal. At. Spectrom.* 21 (2006) 963-969.

Pre-evaporation tube (PET) instead of desolvation in ICP-OES

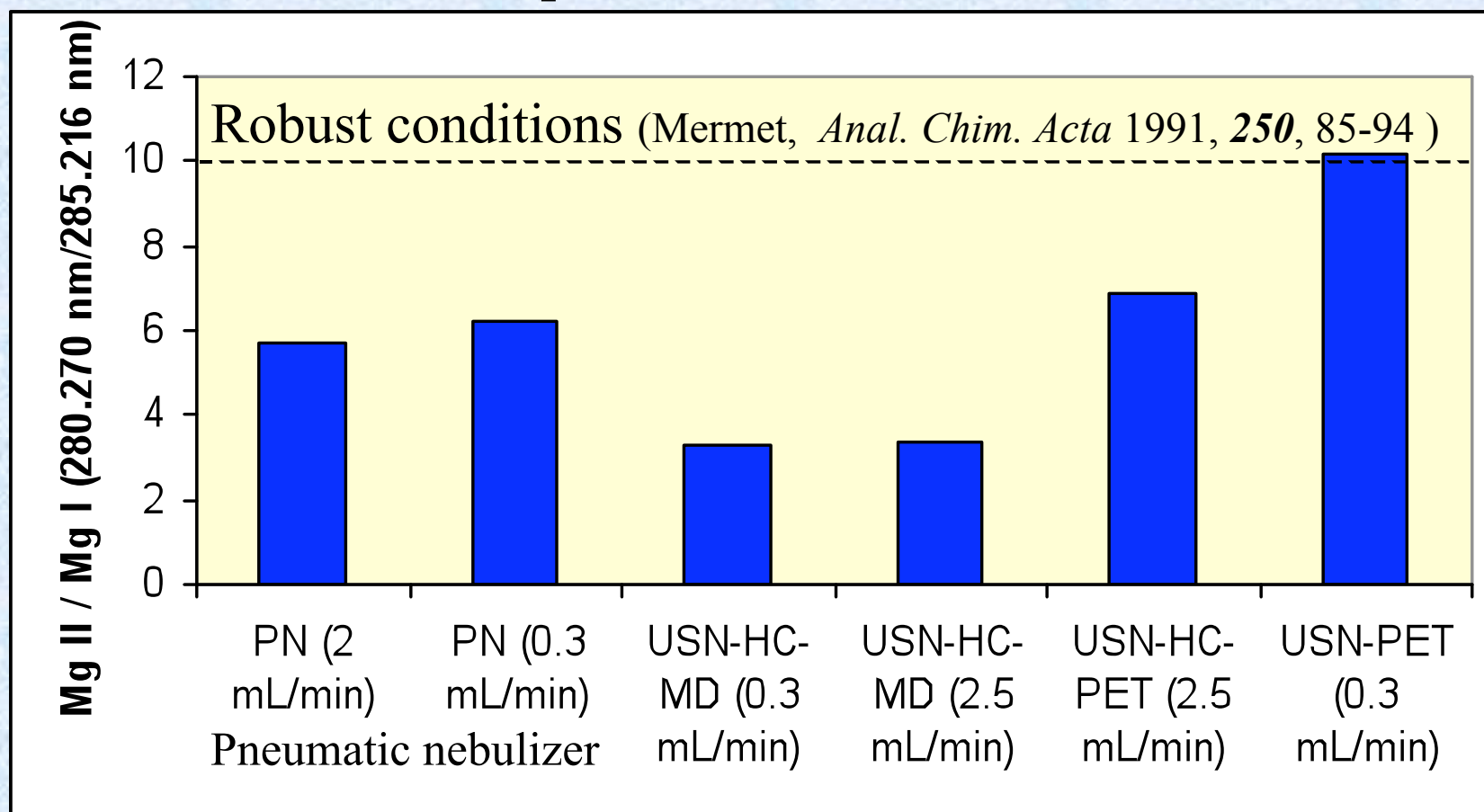


Ultrasonic nebulizer (USN)
(with spray chamber)-
heater/condenser (HC)-
membrane desolvator (MD)



PET between USN and ICP
torch wrapped with heating
tape with bottom 3" of torch
and heated to 400°C

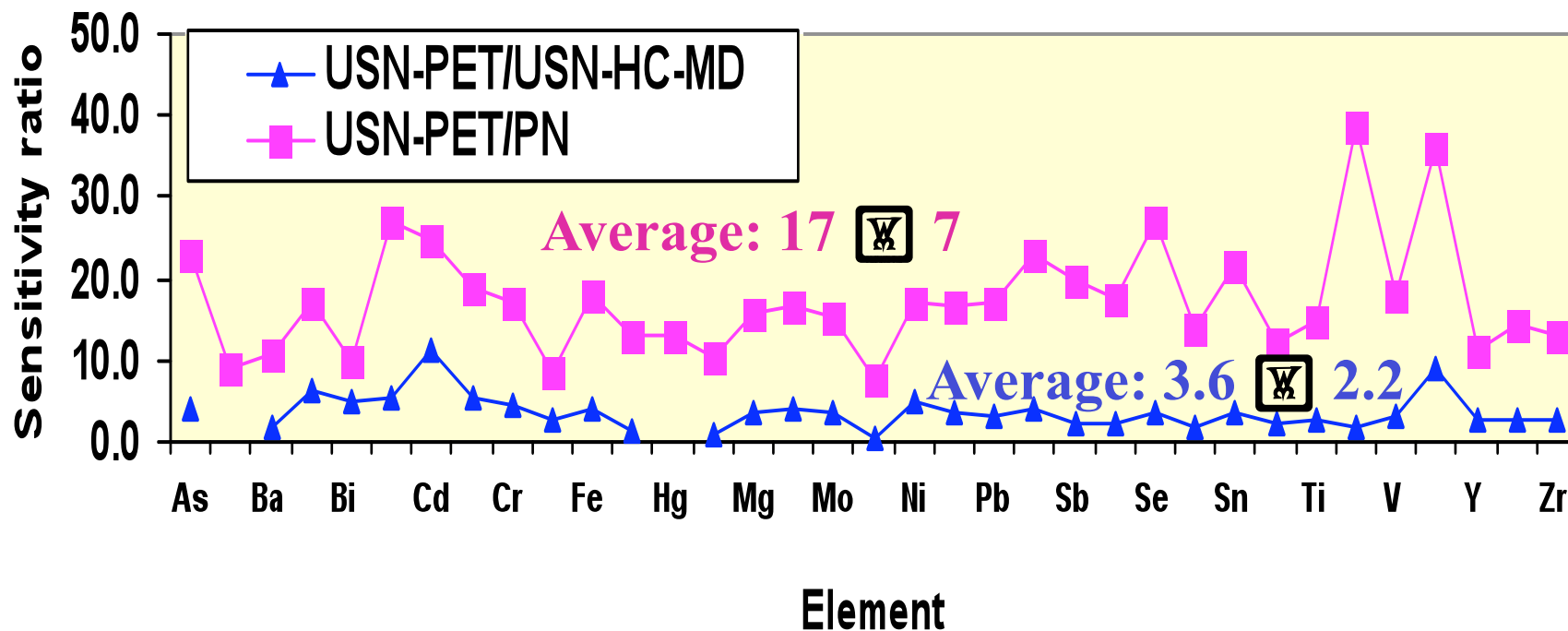
Effect on plasma robustness



- **Accurate analysis of soil digests with USN-PET using external calibration with multielement standards in 2% HNO₃ and with Ar I 763.511 nm as internal standard**

(Asfaw and Beauchemin, *Spectrochim. Acta Part B* 65 (2010) 376–384)

Effect of PET on ICP-OES sensitivity



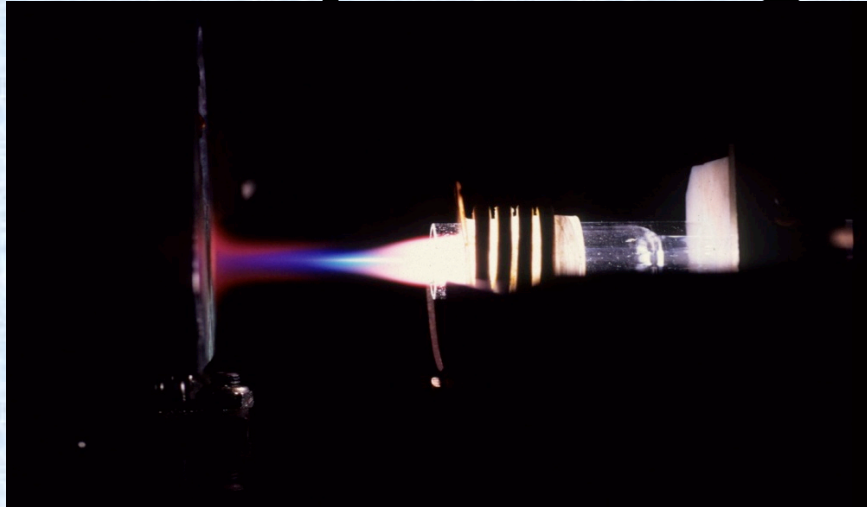
Improved sensitivity:

- For all elements vs pneumatic nebulization
- For most elements vs USN-HC-MD
- Hg and B can be determined, unlike with USN-HC-MD

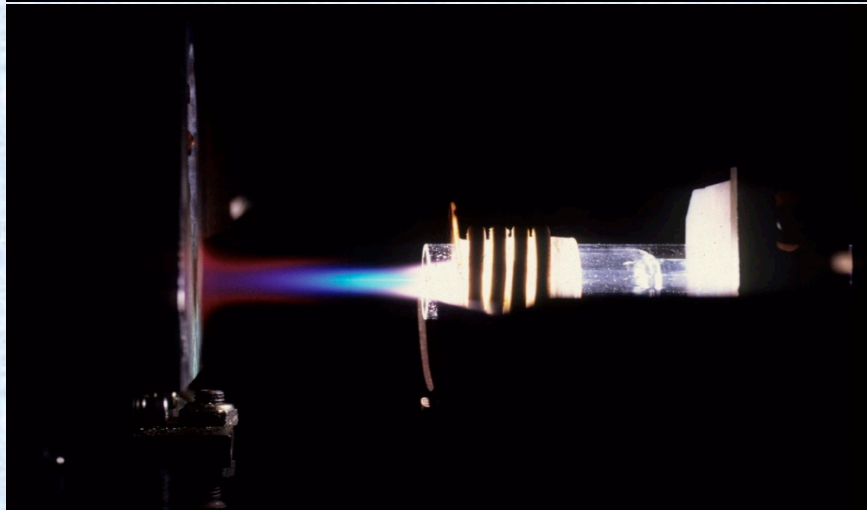
(Asfaw and Beauchemin, *Spectrochim. Acta Part B* 65 (2010) 376–384)

Effect of adding N₂ to outer plasma gas of ICP

1.2
kW
all
Ar



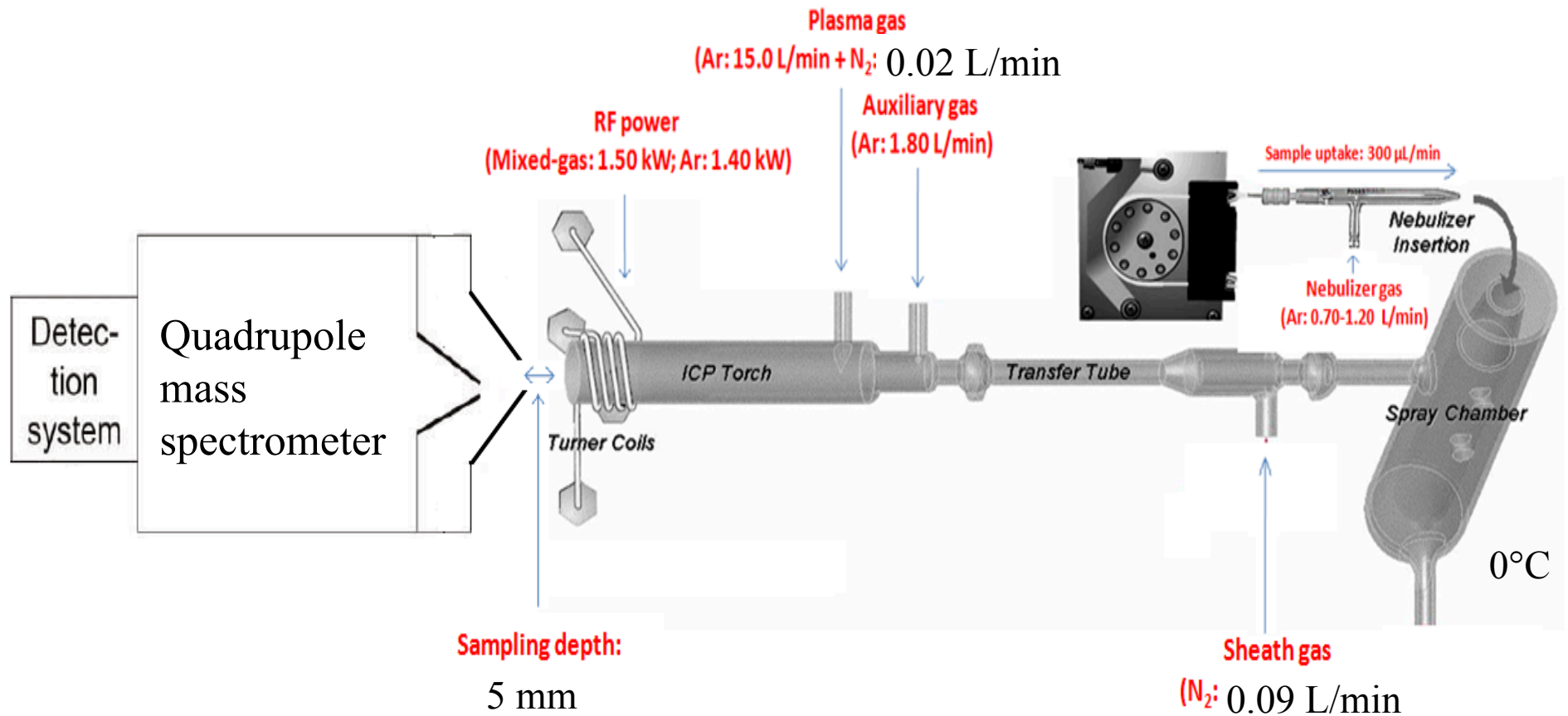
1.2
kW
2%
N₂



- increases plasma power density
- decreases sensitivity
- makes the plasma more robust
- suppresses oxide formation

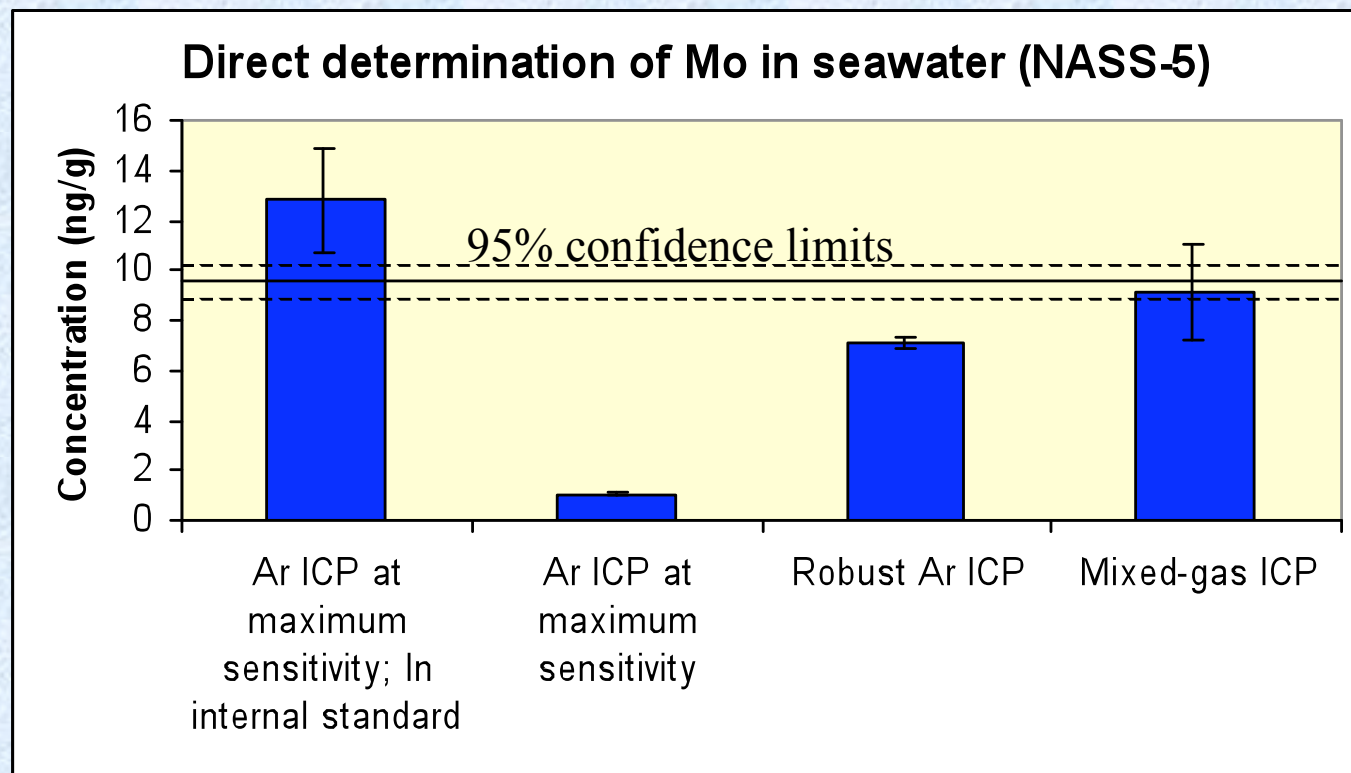
Holliday and Beauchemin, *J. Anal. At. Spectrom.* 18 (2003) 289-295.

Set-up for mixed-gas plasma



- N₂ added to plasma gas to increase robustness
 - N₂ added as a sheathing gas to increase energy transfer from bulk plasma to central channel
- (Agatemor and Beauchemin, Spectrochim. Acta Part B 66 (2011) 1-11)

Effect on plasma robustness



- **Best results with mixed-gas ICP**
- **No need for internal standard**

- Average suppression from 0.1 M Na (16 analytes, from Al to U): $1.9 \pm 4.2\%$ (mixed-gas) vs $49.1 \pm 7.1\%$ (Ar, max. sens.)
- Improved DL for Al, Co, Pd, V vs Ar ICP at max. sens.
- 70% suppression of signal from argon dimers