

# A Platform for Characterizing the Thermodynamic Stability and Proportional Scintillation Signals of Argon-Xenon Mixtures

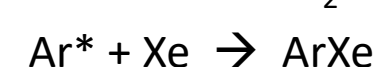
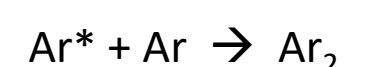
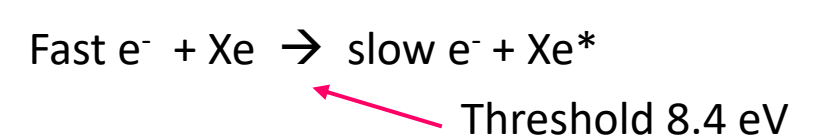
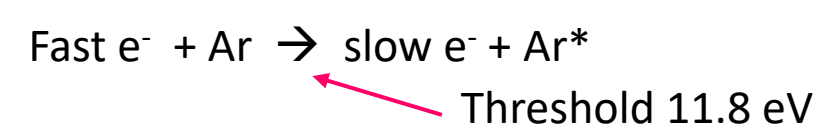
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## Chemistry of Electroluminescence Light Production



Inelastic collision of electron with argon

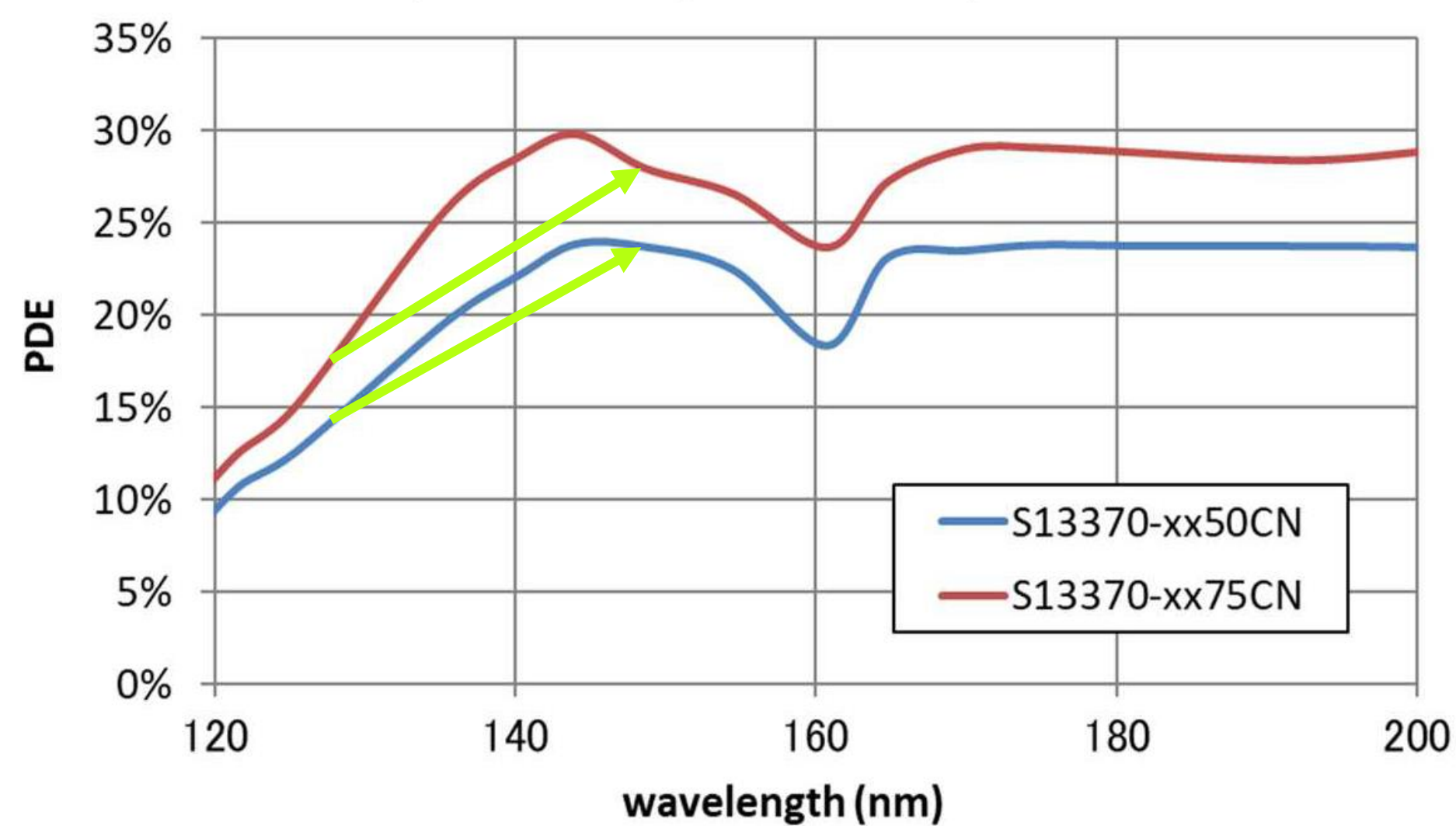
Inelastic collision of electron with Xenon

Argon and xenon form metastable excimer molecules

Excimer molecules decompose and emit photons.

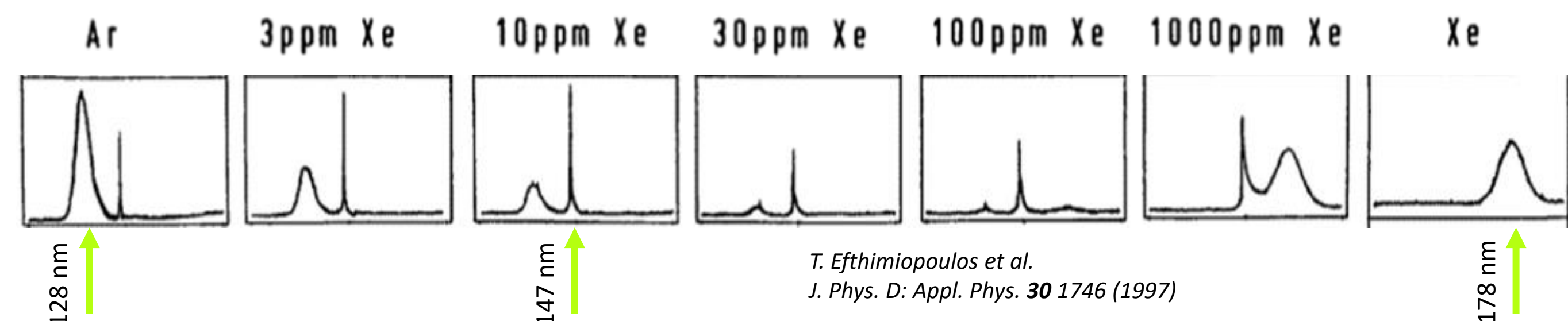
The presence of Xenon in the gas allows faster light emission at longer wavelengths.

## PDE measurement data (Vover = 4V, in vacuum)

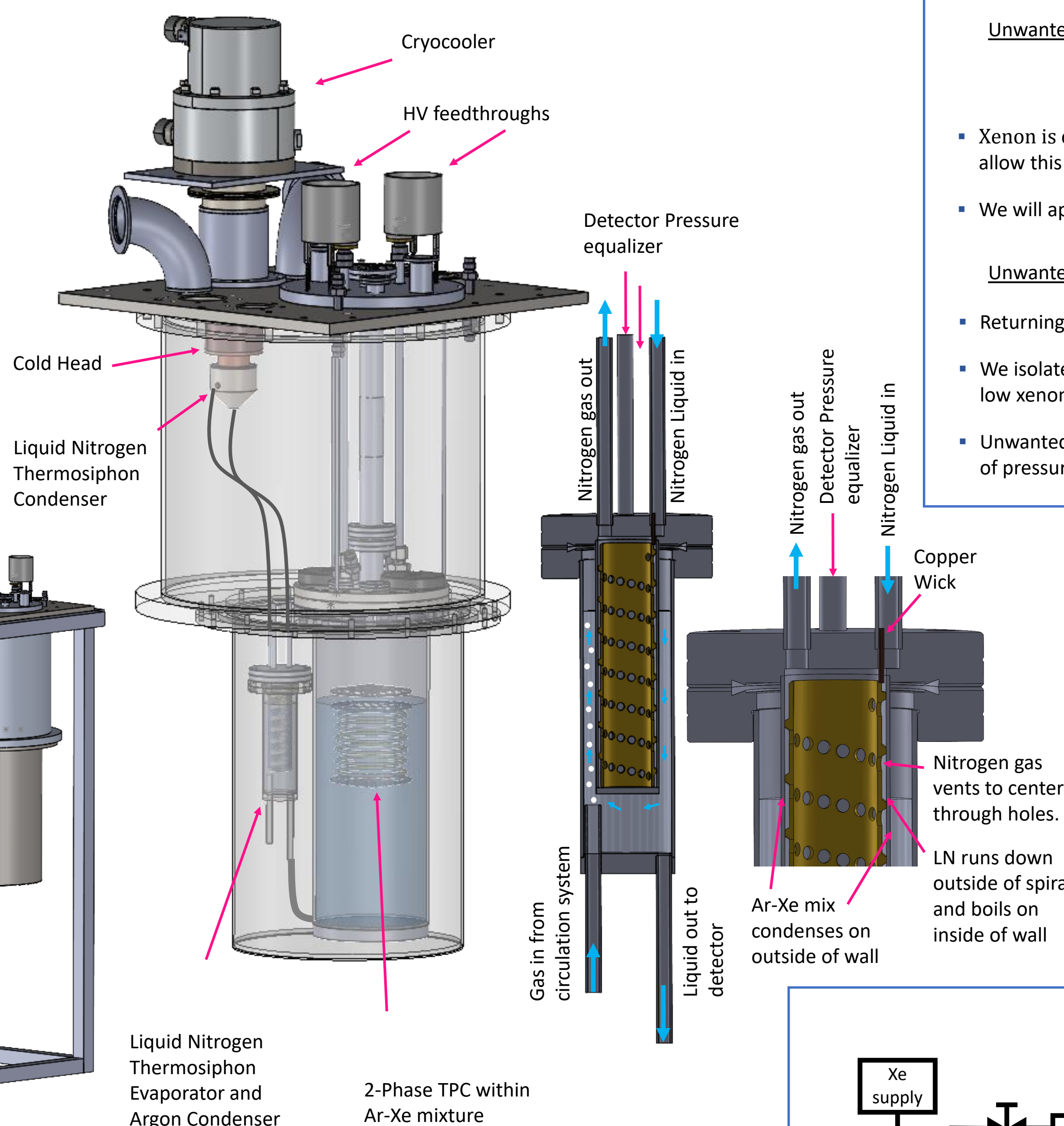


Yuto Ohashi, Hamamatsu Photonics K.K. CHEF Conference (2019)

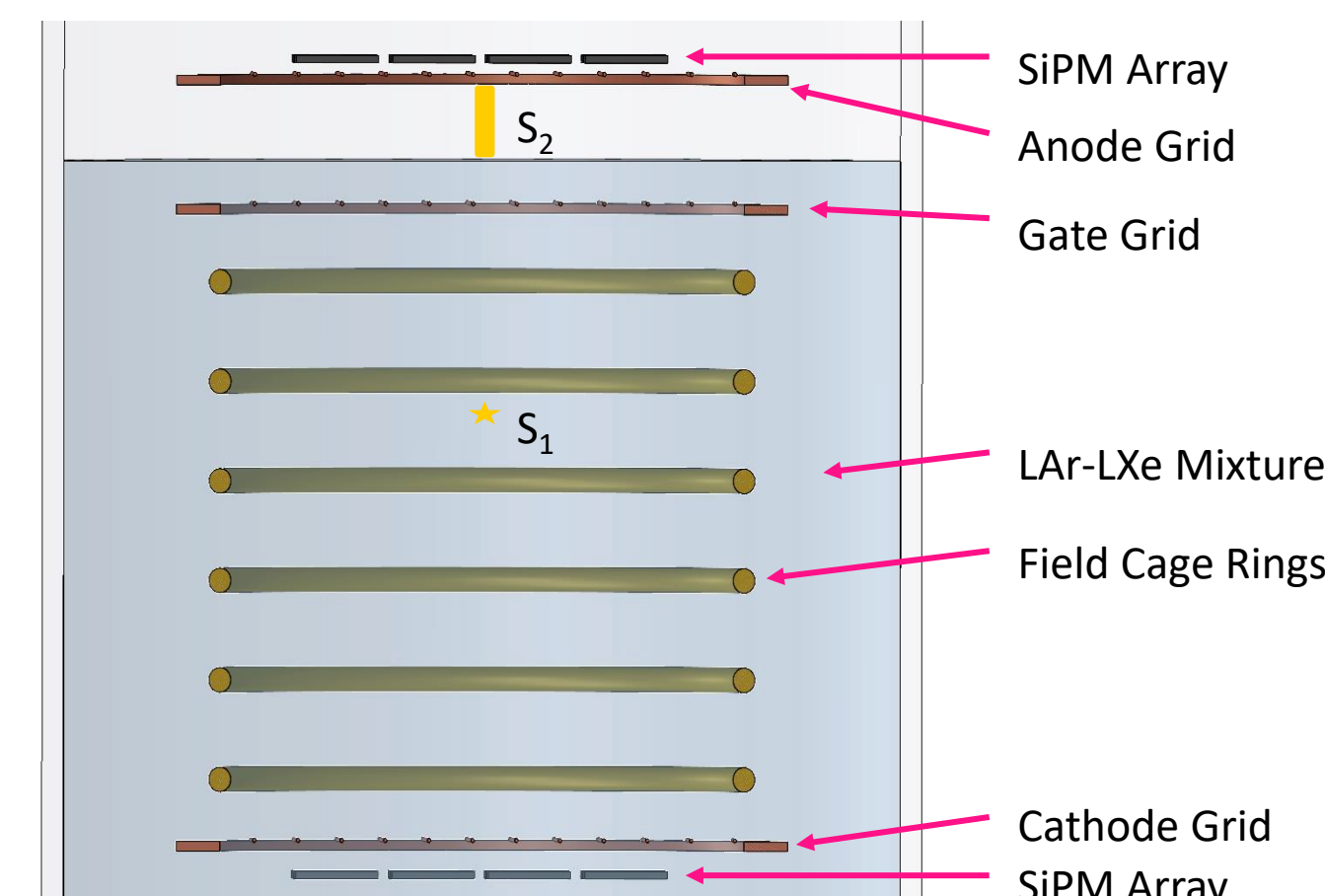
## Addition of Xe to Ar Gas Mixtures Under Ion Beam Excitation Shifts Emission to Longer Wavelengths



T. Efthimiopoulos et al. J. Phys. D: Appl. Phys. 30 1746 (1997)



Liquid Nitrogen Thermosiphon Evaporator and Argon Condenser  
2-Phase TPC within Ar-Xe mixture



## Considerations for Circulation System Design

### Unwanted Distillation

$$\text{Henry's Law: } H^{cc} = \frac{\text{Fractional concentration of Xe in liquid}}{\text{Fractional concentration of Xe in gas}} \sim 250 - 450 \text{ at } 90 - 95 \text{ K}$$

- Xenon is concentrated in the liquid by the evaporation process. Circulation must allow this concentrated xenon to mix with the main argon bath.
- We will apply heat broadly to the detector can walls below the liquid surface.

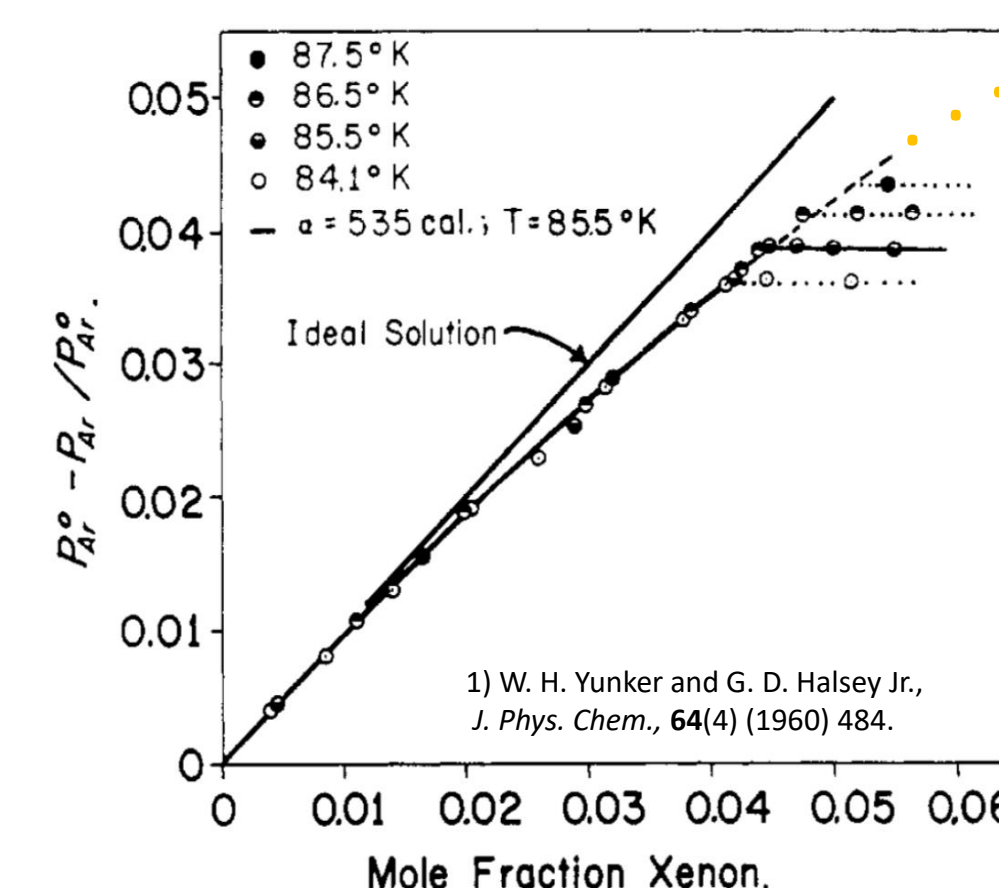
### Unwanted Freezing

- Returning gas must be condensed in a way that prevents gas from contacting very cold surfaces, where xenon may freeze and clog the plumbing.
- We isolate the Ar-Xe mixture condensation in a separate volume that is upstream of the main detector bath. This ensures that only liquid of low xenon concentration is exposed to the cold components in the condenser.
- Unwanted freezing sets a hard limit on the concentration of xenon that can be added to the liquid. This solubility limit increases as a function of pressure and temperature. (See below.)

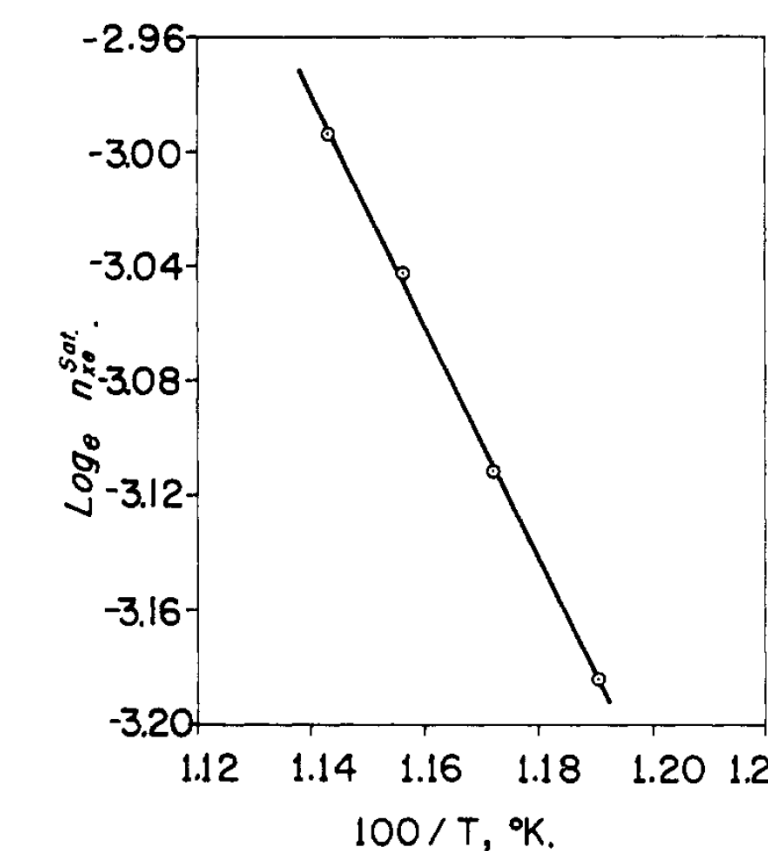
Xenon strongly prefers the liquid over the gas

50 ppm in gas  $\rightarrow$  1.25 to 2.25% in liquid

## How much Xe can we dissolve in Lar?



- Assume 5% vapor pressure suppression due to Xe addition
- Assume 5% vapor pressure suppression: Vapor curve of 94.84 K @ 2.0 Bar
- Assume extension of the solubility vs temp plot:

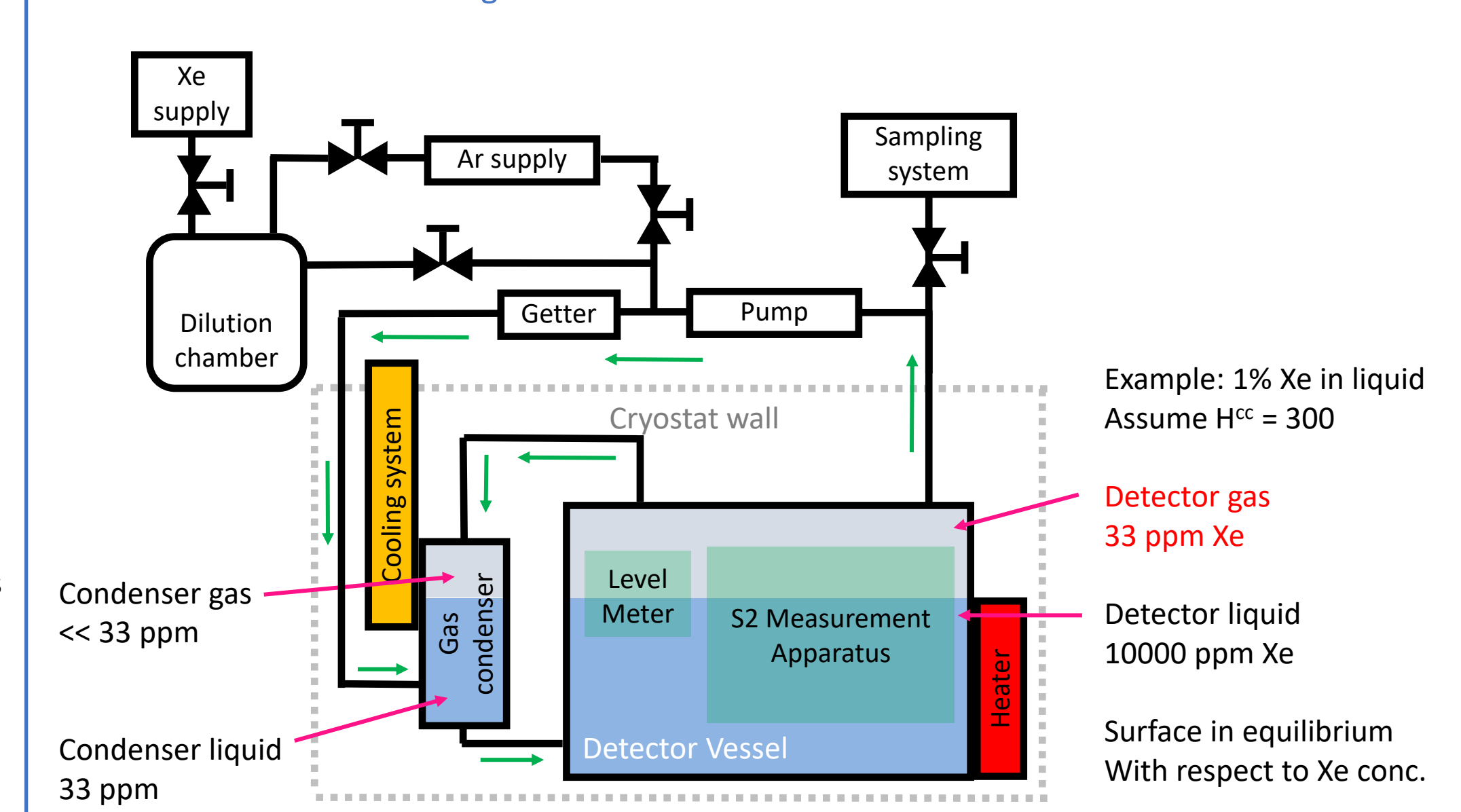


5% Xe fraction in liquid may be a comfortable place to operate.

$100 / T = 1.0544$  from plot at right Predicts  $n^{sat} = 7.1\%$

Temp. (°K.)	$\alpha$ (at./mole)
84.0	560 ± 55
85.5	536 ± 39
86.5	504 ± 39
87.5	504 ± 20
Av.	535 ± 58

## Argon-Xenon Mixture Circulation Scheme



Example: 1% Xe in liquid Assume  $H^{cc} = 300$

Detector gas 33 ppm Xe  
Detector liquid 10000 ppm Xe  
Surface in equilibrium With respect to Xe conc.

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