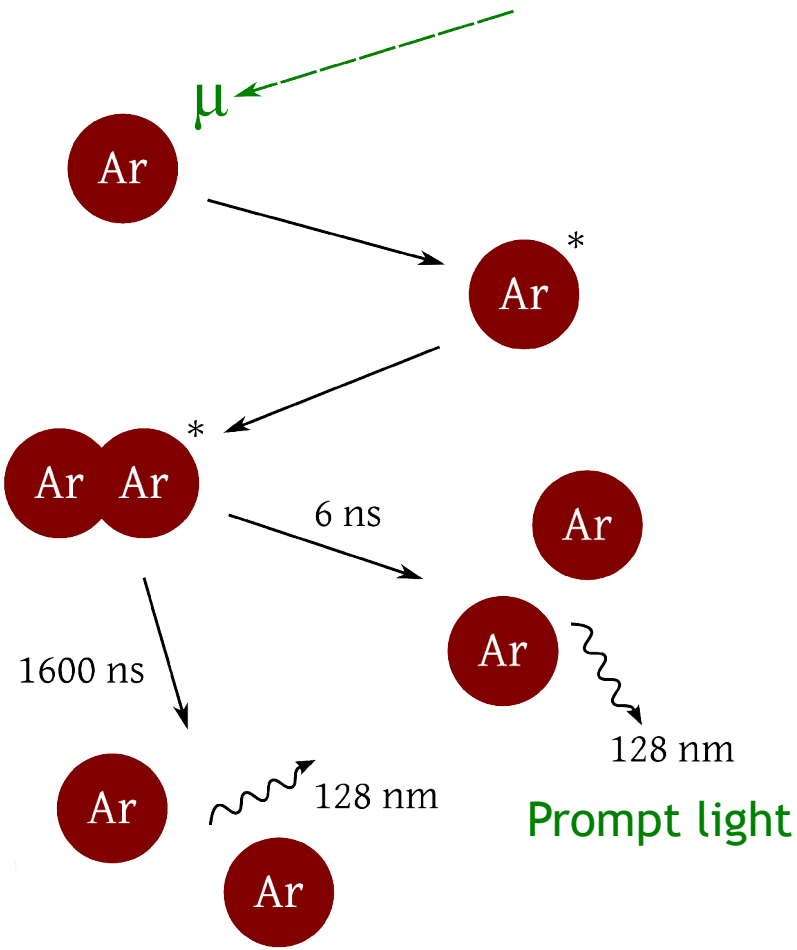
Introduction & Physics

Talk 1 of 6

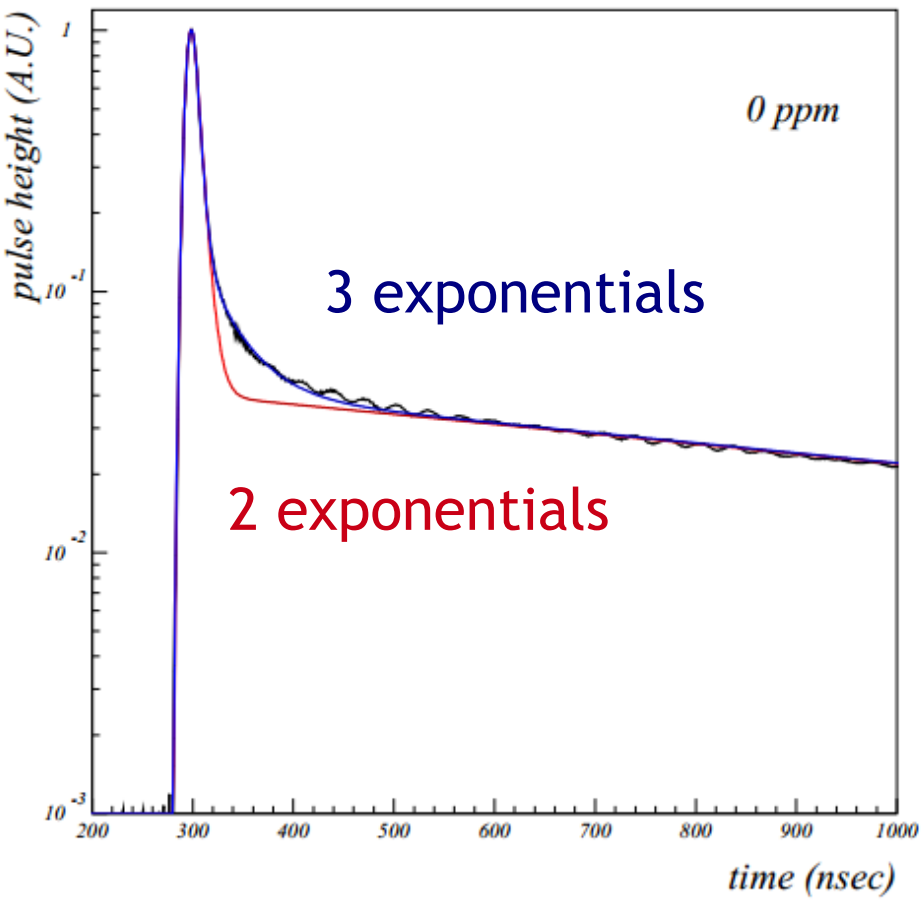
Christie Chiu
Bo VST: Feb 1 2013

Liquid Argon Scintillation:
Number of Time Constants

Theory



WArP measurement

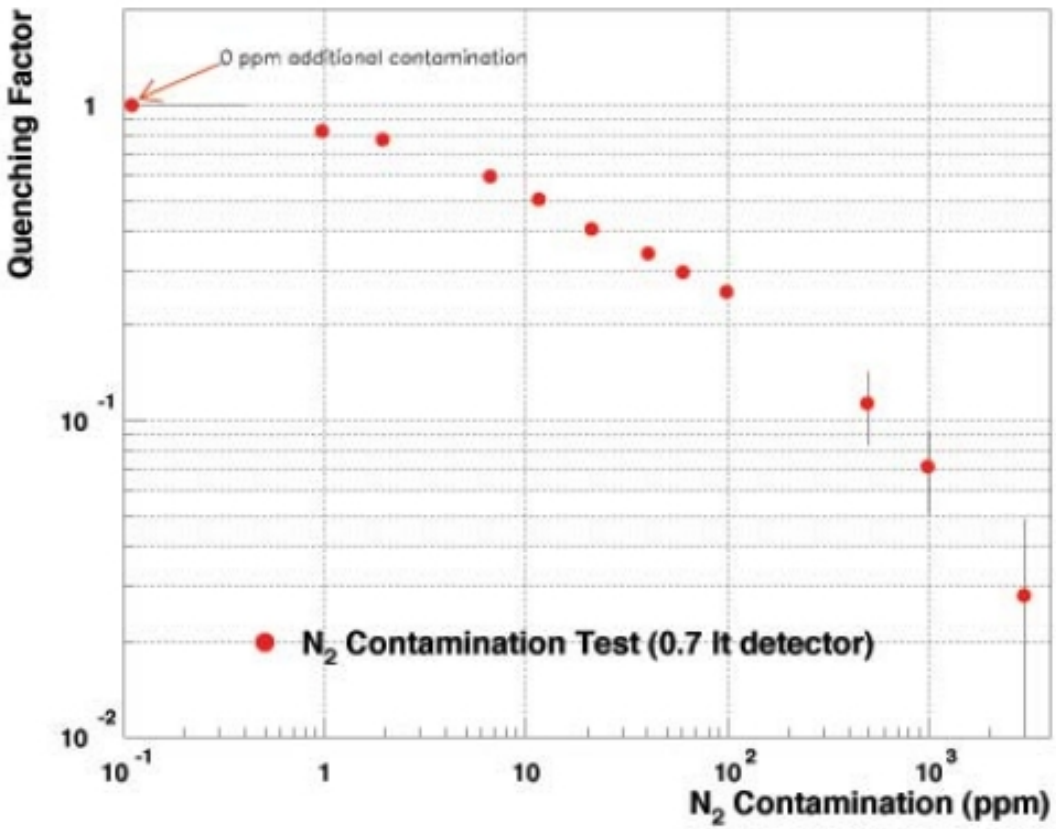


Liquid Argon Scintillation:
Nitrogen quenching

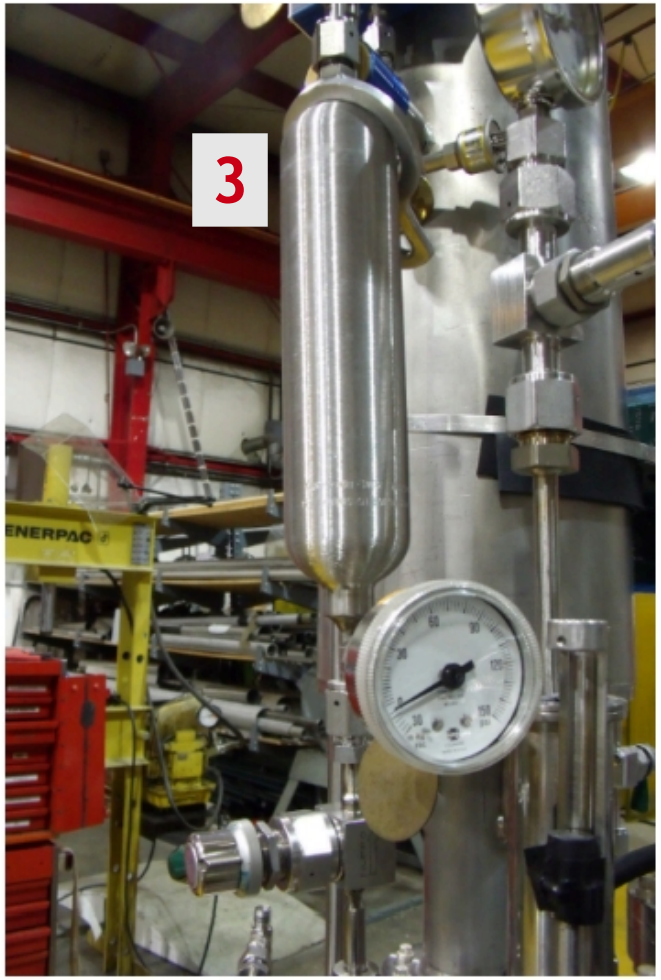
Theory

- Collision of impurities with Ar excimer may cause quenching
  - no light emission
- N2 is one such impurity
- Affects late light more than prompt light
  - Late light excimers live longer, so more time to collide with impurity

WArP measurement



Bo's New Features:
Nitrogen Injection System



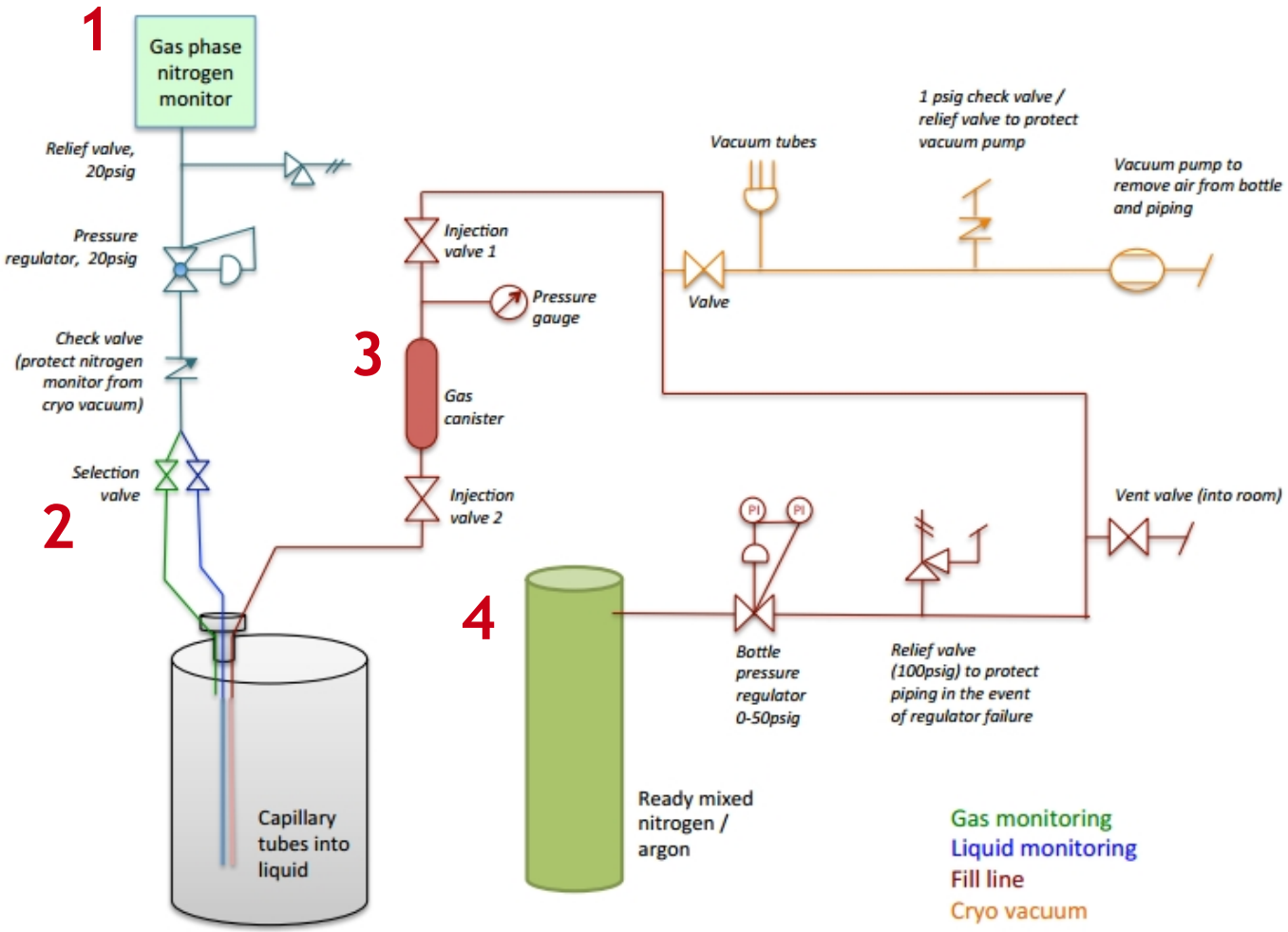


Figure 1: Bo nitrogen injection system

Nitrogen Injection System:
Thermodynamics Calculation

- For each N2 injection, how much ppm N2 do we get in Bo?
  - Nontrivial calculation!
  - Molar ratio of N2 in gas does *not* equal the molar ratio of N2 in liquid
    - Assuming this only gives us a rough estimate

Nitrogen Injection System:
Thermodynamics Calculation

- Assume both vapor and liquid mixtures behave as ideal solutions
- We have that *dG* = 0 at equilibrium

$$dG = V\ dP - S\ dT + \sum_i \mu_i\ dN_i$$

  - Also, *dP* = 0 and *dT* = 0
- For phases *a* and *B*, we know $dN_i^{\alpha} = -dN_i^{\beta}$
- Putting all this together*, we find $\boxed{y_i P = x_i p_i^{sat}}$
  - y_i : mole fraction of liquid component *i* in liquid
  - *P* : pressure
  - x_i: mole fraction of vapor component *I* in vapor
  - p_i^{sat} = saturation pressure of component *i*

*I can send you the calculation

Nitrogen Injection System:
Thermodynamics Calculation

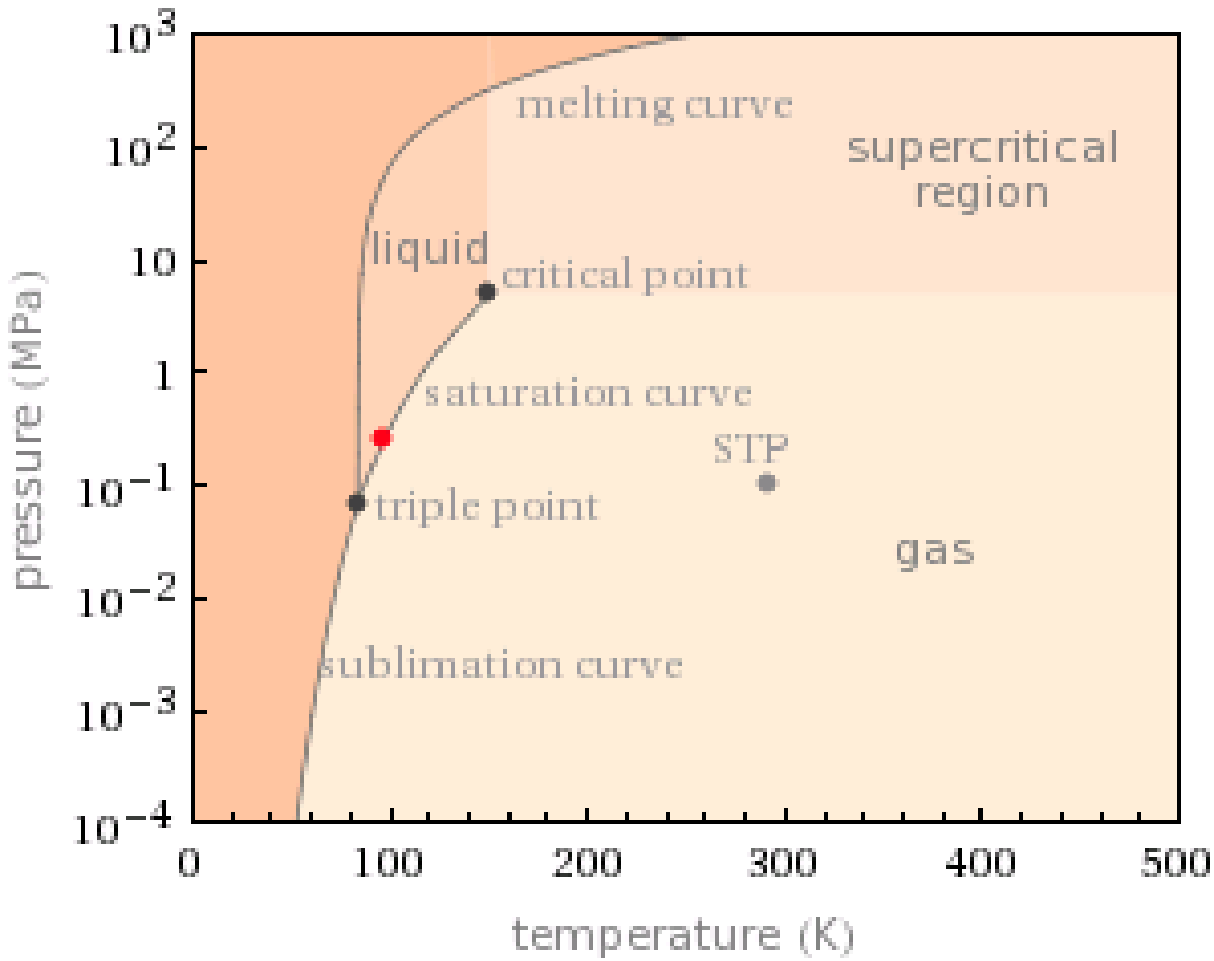
- Let argon be component 1
- Let nitrogen be component 2
- System of equations describing system:

$$y_1 P = x_1 p_1^{sat}$$
$$y_2 P = x_2 p_2^{sat}$$
$$x_1 + x_2 = 1$$
$$y_1 + y_2 = 1$$

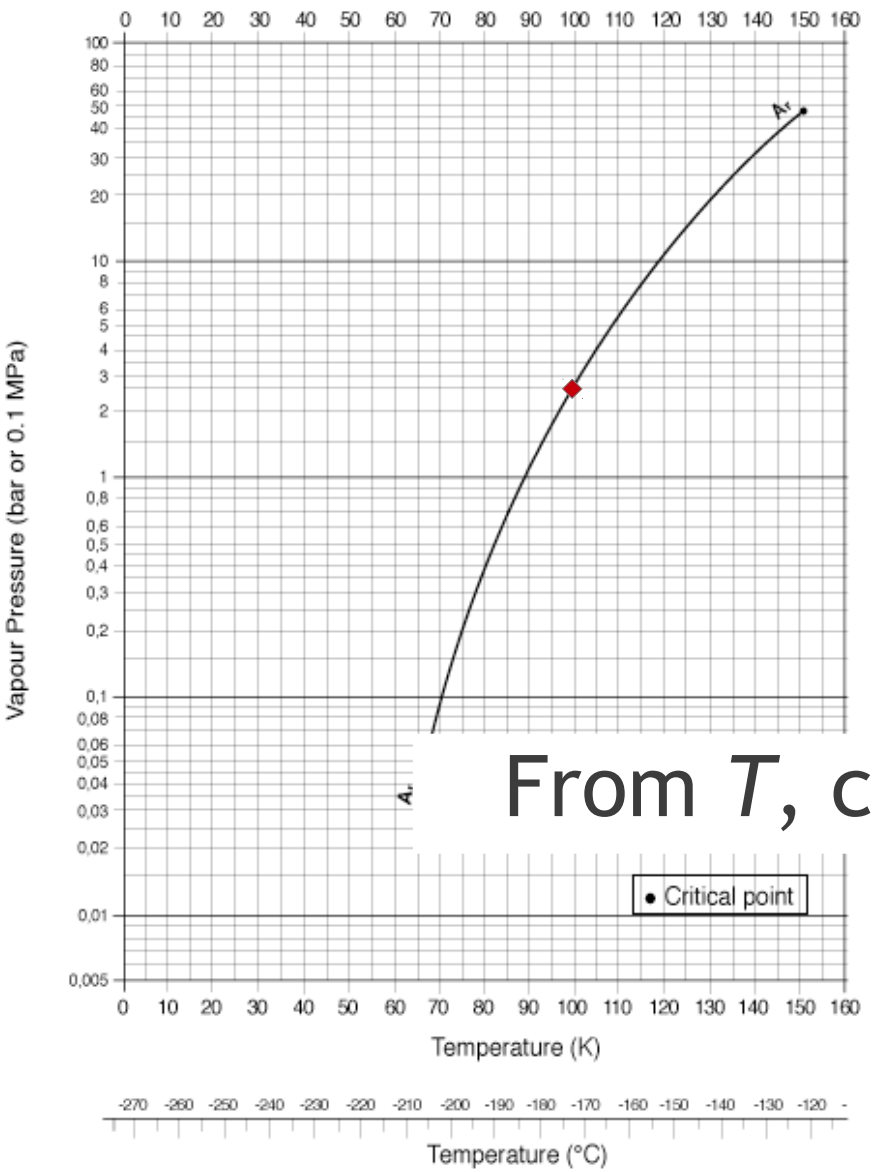
- Monitors measure *P* for us. Need to determine p_1^{sat} and p_2^{sat}

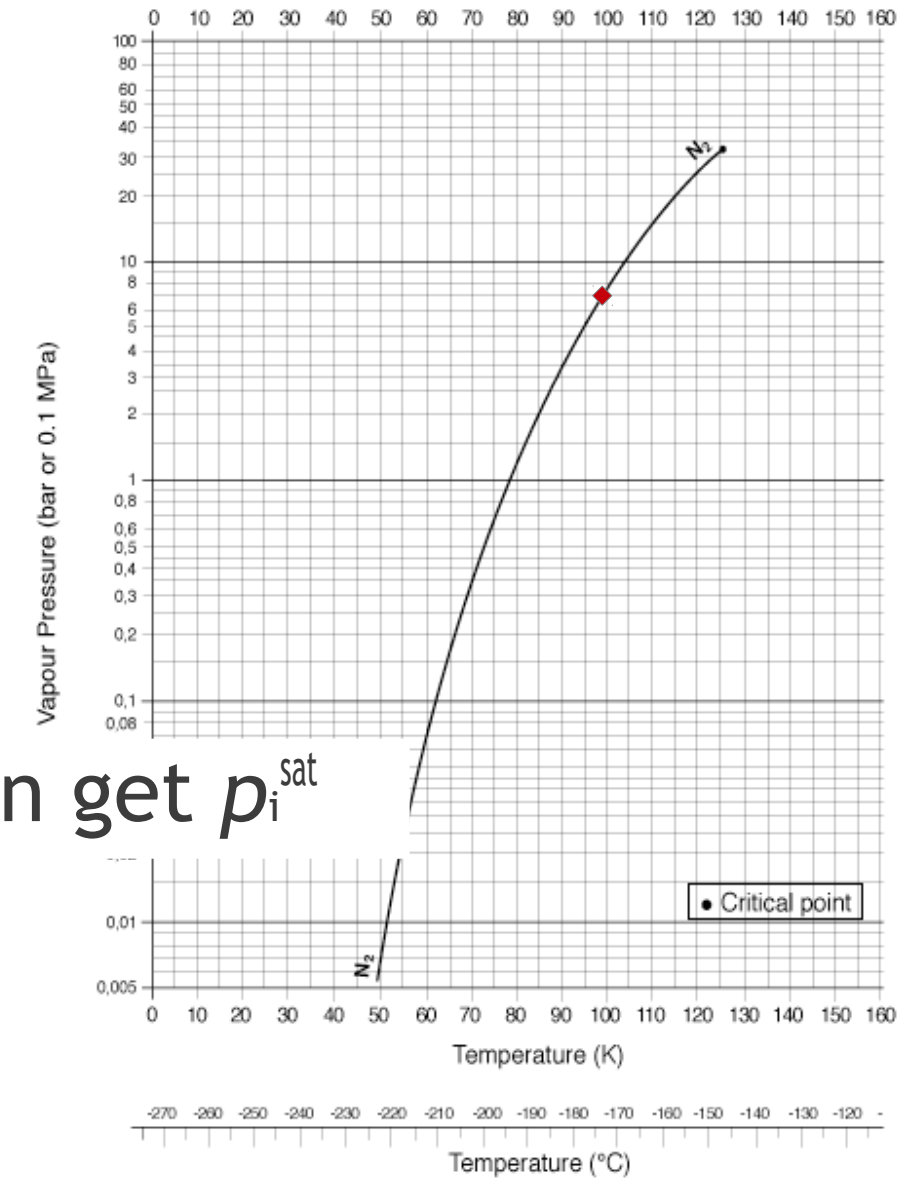
Nitrogen Injection System:
Thermodynamics Calculation

- From *P*, can get *T*
  - We must be at a vapor-liquid phase boundary
  - Use phase diagram for argon



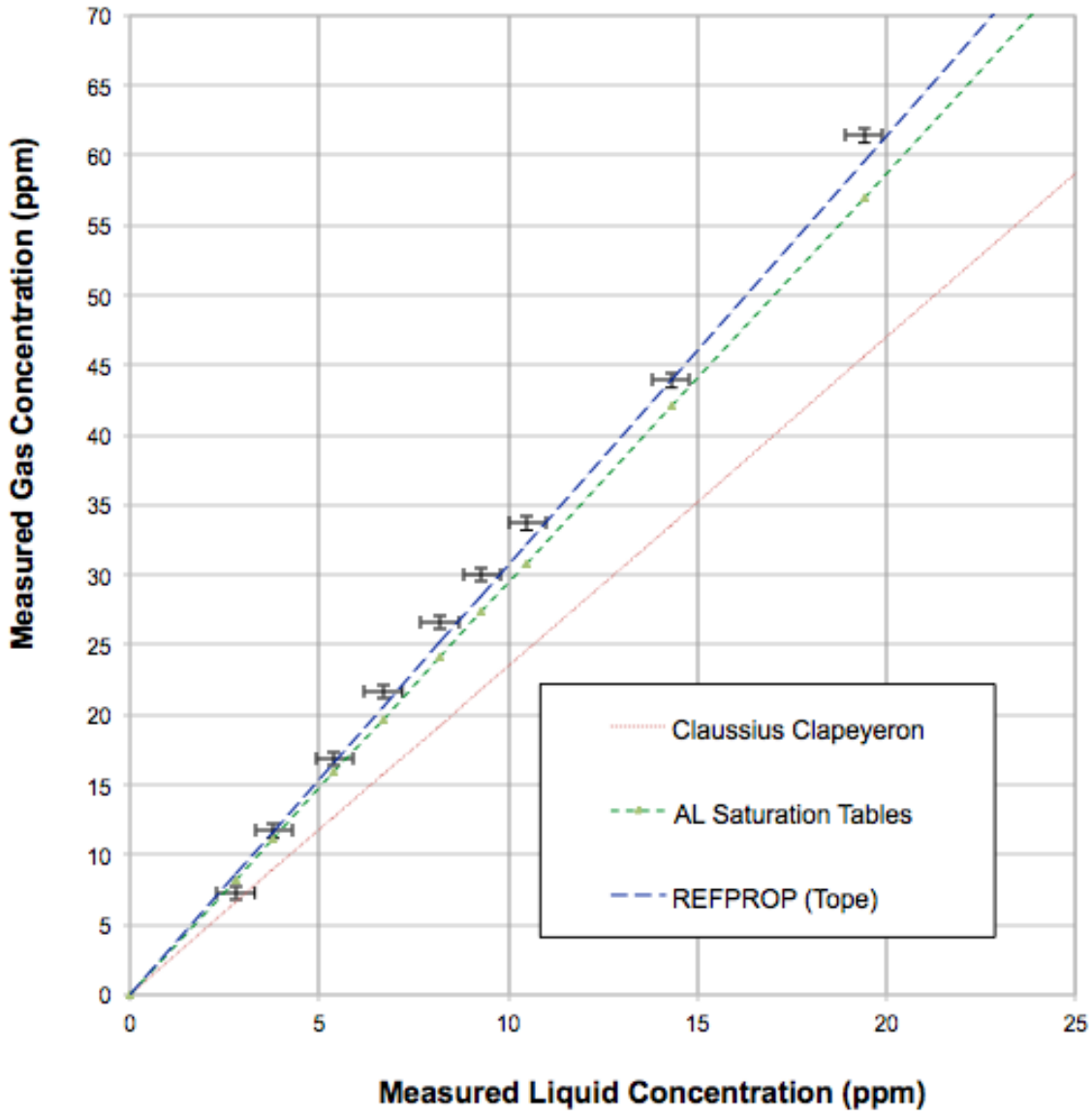
Nitrogen Injection System:
Thermodynamics Calculation





From T, can get p_i^{sat}

Nitrogen Injection System:
Injection Details



- Claussius Clapeyeron:
  - From describing phase boundaries with Claussius Clapeyeron equations
- AL Saturation Tables:
  - From our calculation
- REFPROP:
  - Simulation written by NIST
- Black data points:
  - Measured from gas & liquid lines

Goals

1. Measure time constants accurately
2. Determine conclusively whether there are 2 or 3 components
3. Examine how these components change as nitrogen is added