

# *Tank Purging Studies at FNAL*

*Air to Argon without Vacuum*



# *Purpose of Tank Purging R&D*

- *In a large tank the majority of oxygen, nitrogen, and water vapor must be removed before liquid argon is introduced into tank*
  - *Must reach a yet to be determined contaminant spec before liquid phase filtration begins*
- *Use low velocity injection of heavier than air argon at tank bottom to act like a piston and push air out*
- *This requires fewer volume changes than “perfect” mixing*

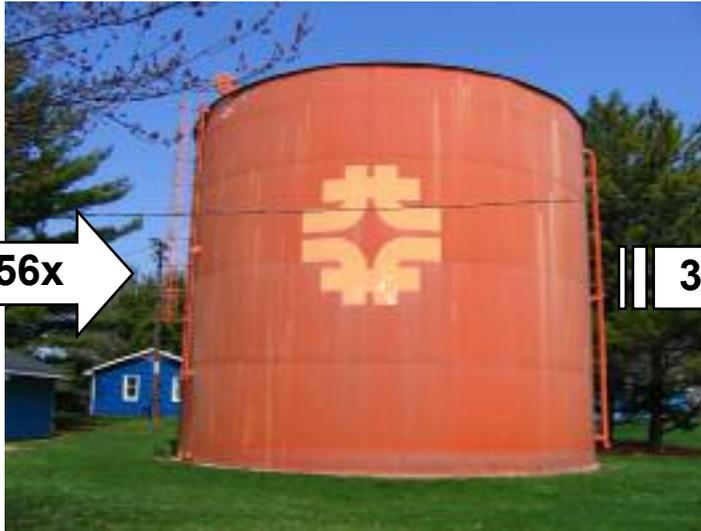
# Small, Big, Huge



156 ft<sup>3</sup>

PAB tank  
test

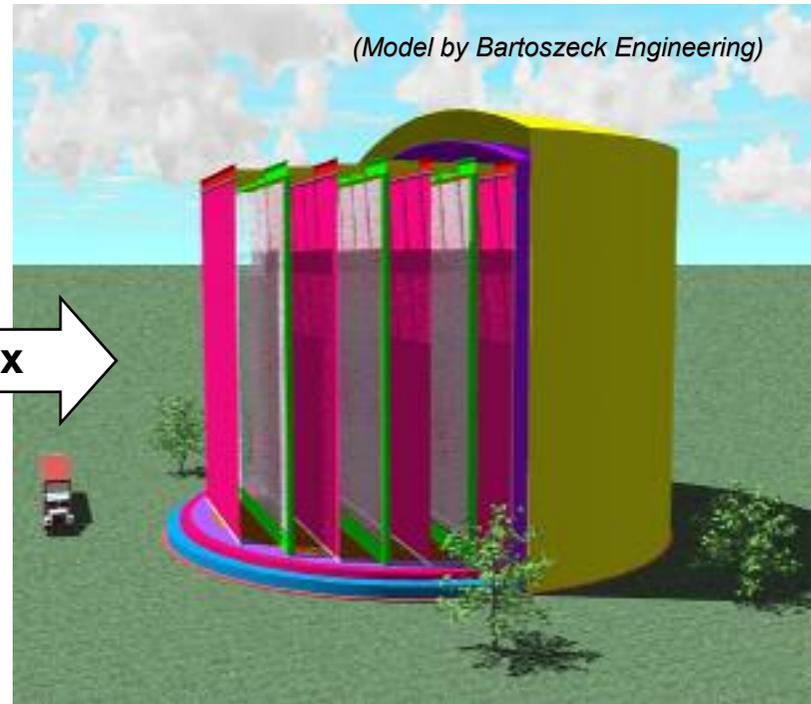
256x



40,000 ft<sup>3</sup>

FNAL Village Water Tank

38x



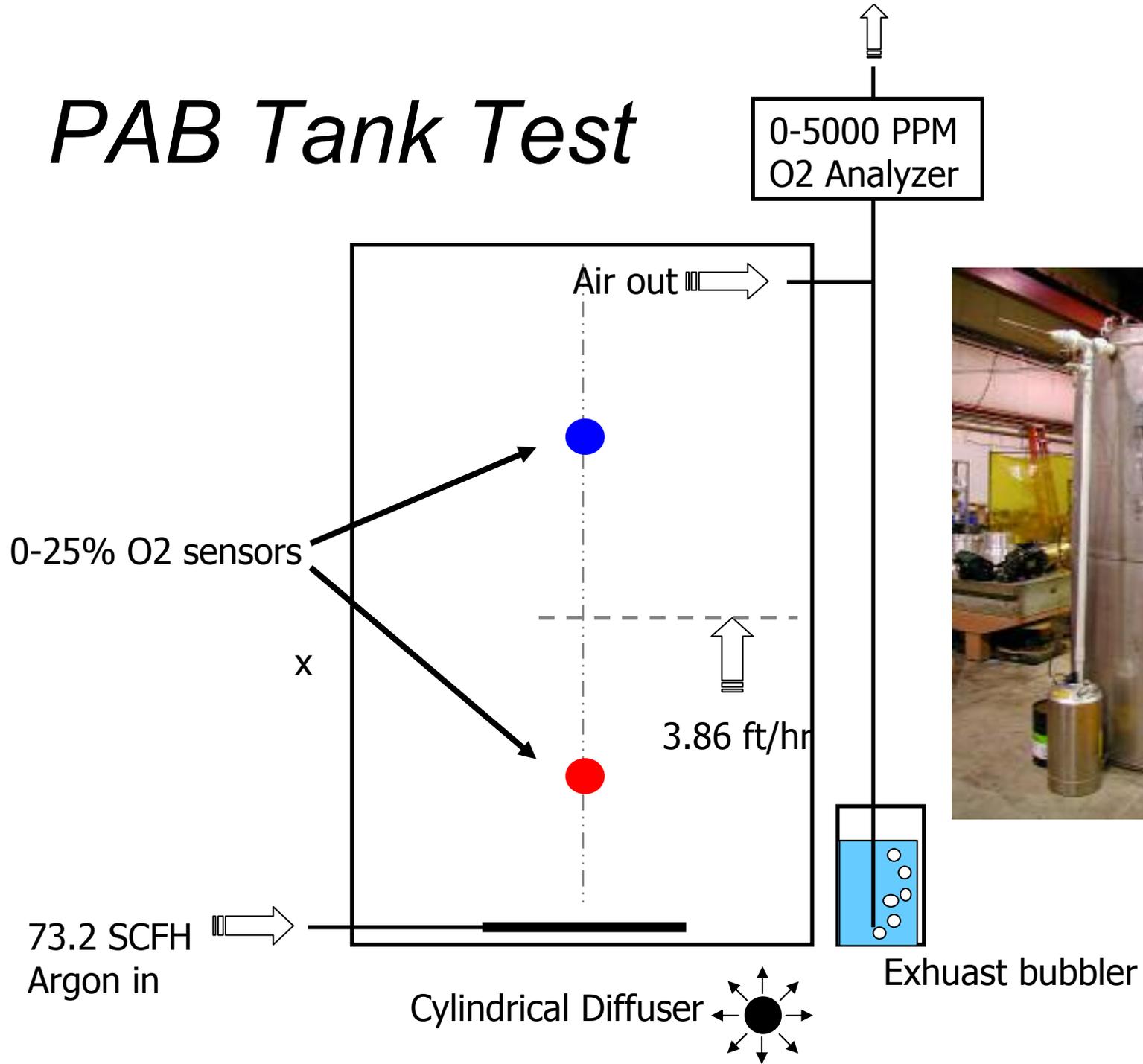
1,500,000 ft<sup>3</sup>

50 kton LAr tank

# *PAB Tank Test*

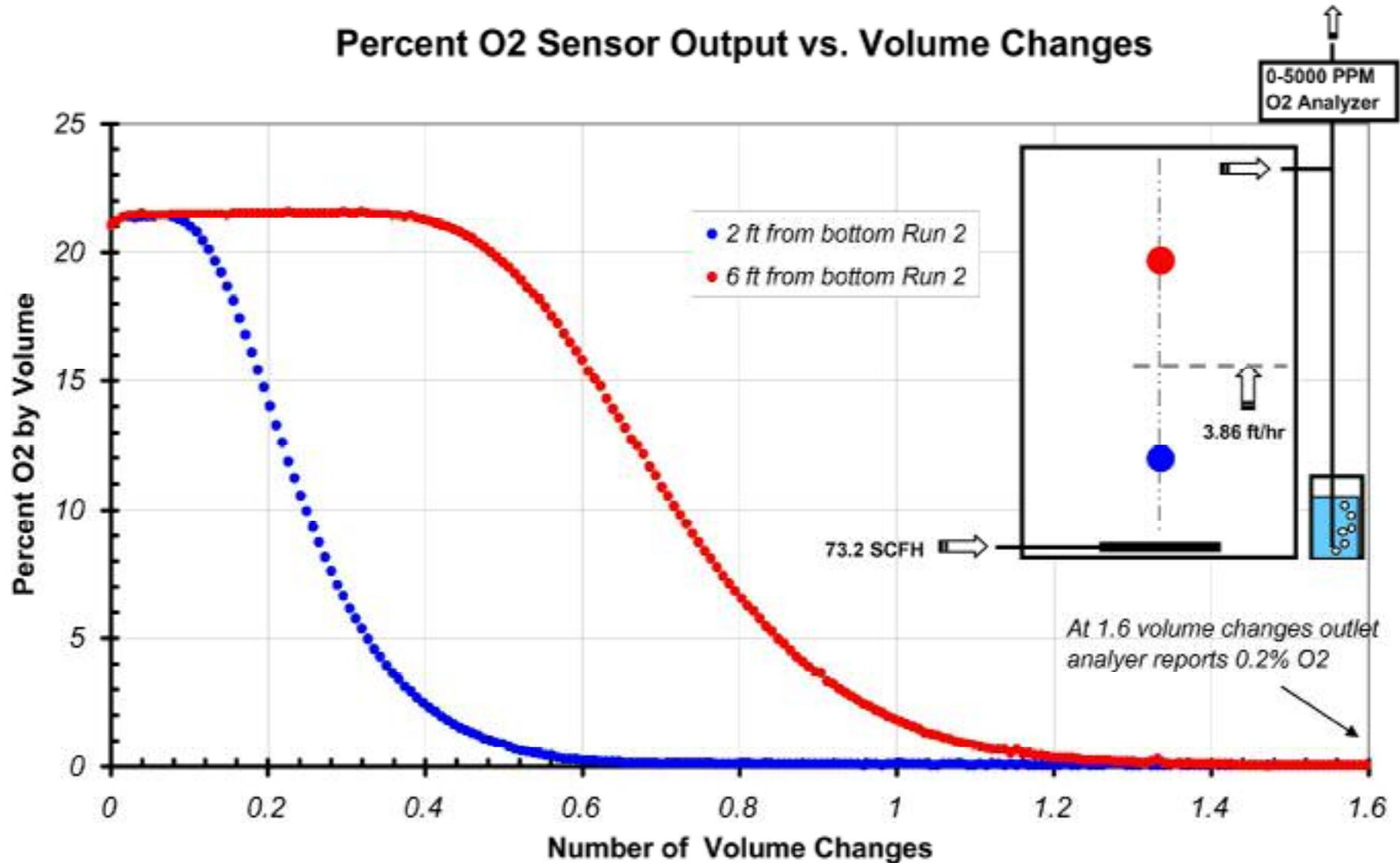
- *Small 156 ft<sup>3</sup> Tank inside large building*
- *Isothermal test conditions*
- *Argon introduced thru a diffuser in tank bottom*
- *Experimental O<sub>2</sub> data from air to 15 ppm obtained and compared to*
  - *ANSYS CFD model by Zhijing Tang*
  - *Analytical diffusion model*

# *PAB Tank Test*

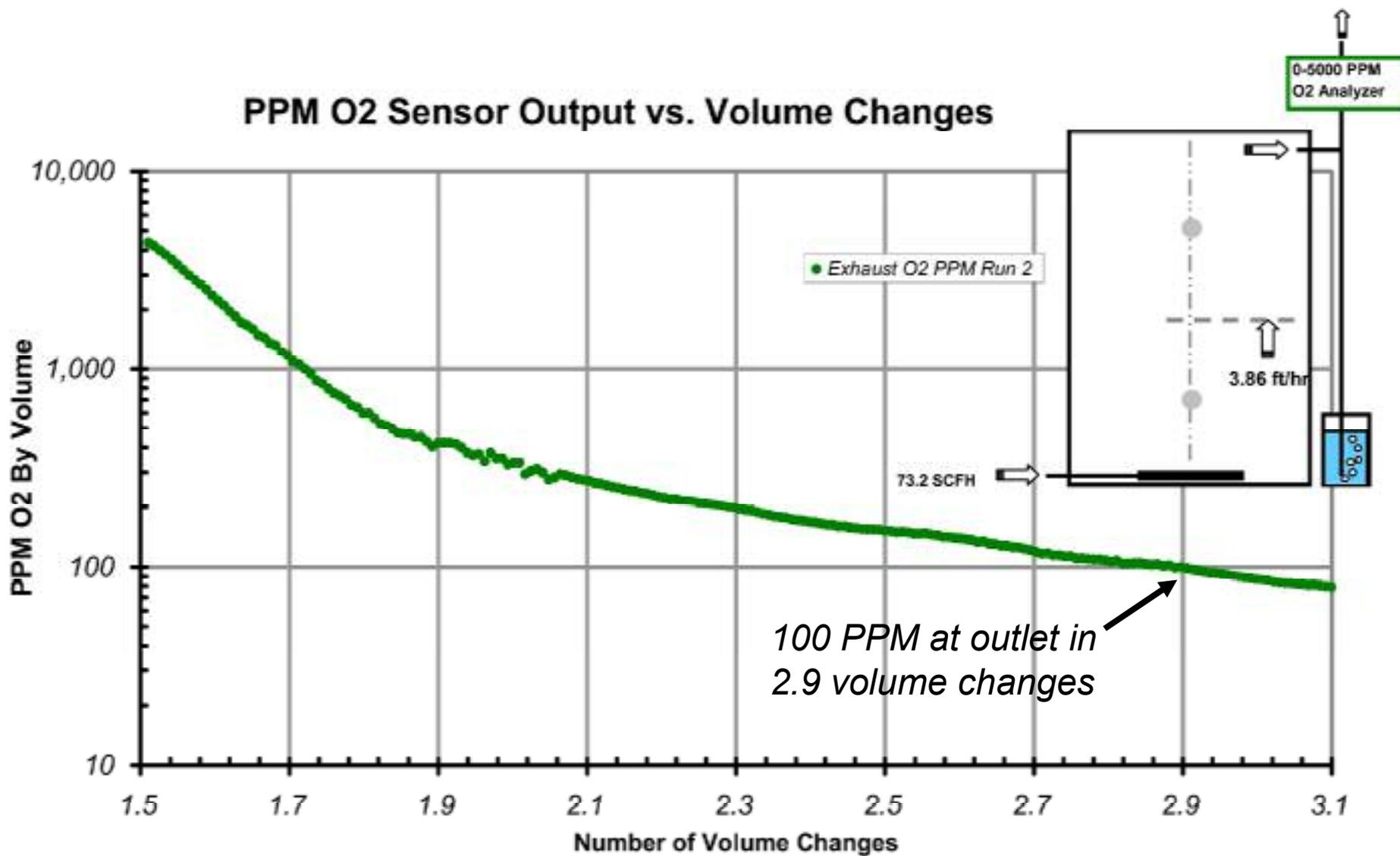


# PAB Tank Experimental Results

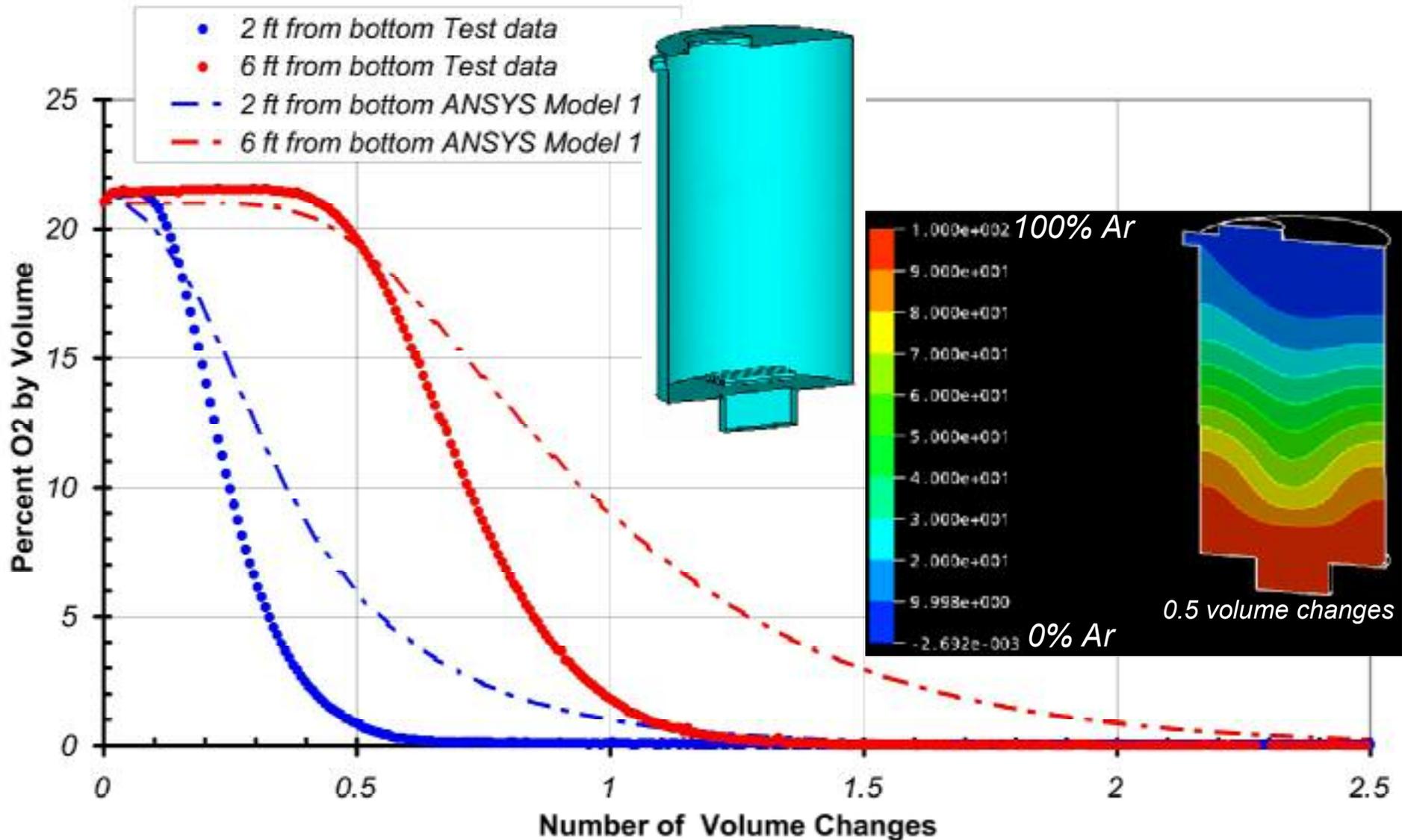
## Percent O2 Sensor Output vs. Volume Changes



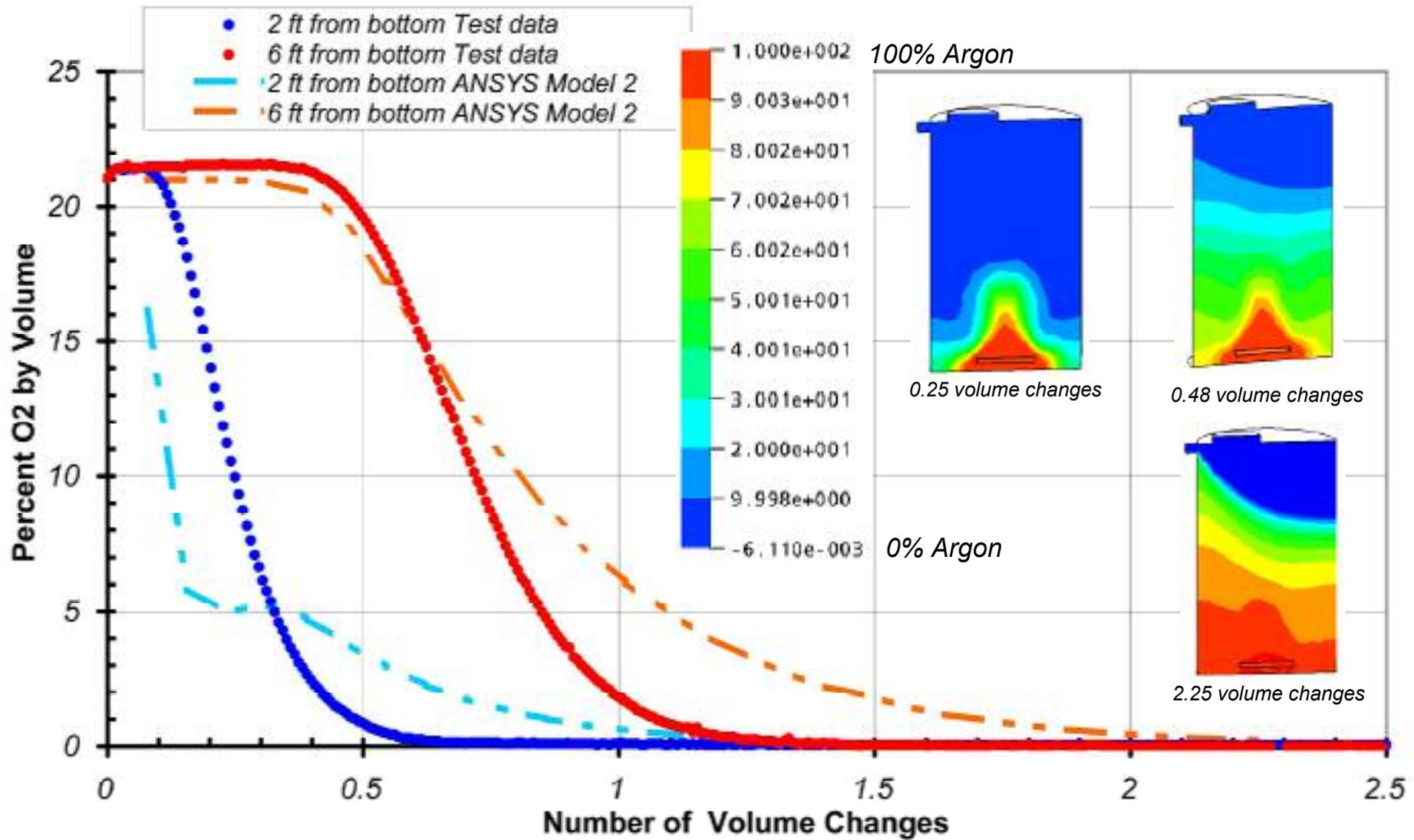
# PAB Tank Experimental Results



# PAB Tank ANSYS Results – 1<sup>st</sup> Model



# PAB Tank ANSYS Results – 2<sup>nd</sup> Model



# Analytical Diffusion Model

- For 1D species diffusion in  $x$

$$D_{AB} \frac{\partial^2 C_A}{\partial x^2} = \frac{\partial C_A}{\partial t}$$

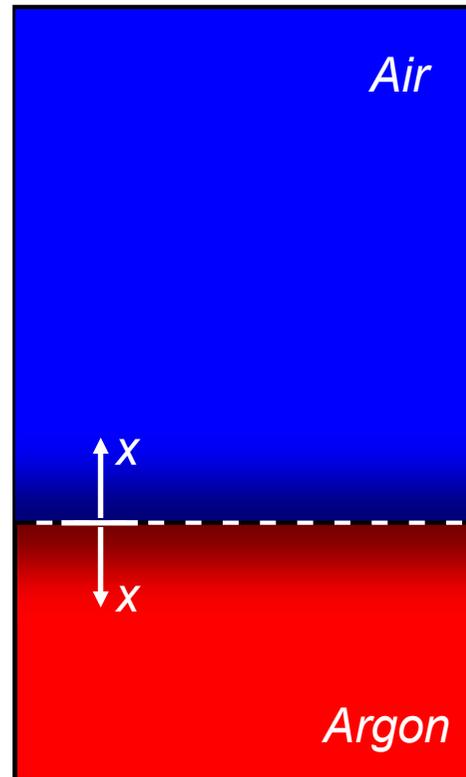
$C_A$  = molar concentration

$D_{AB}$  = mass diffusion coefficient

$D_{AB} = 1.9E-5 \text{ m}^2 \text{ s}^{-1}$  for Ar-Air

Boundary between Air and Argon is always 50% Argon and 50% Air,  $x = 0$  at boundary

$$C_A(x,t) = \frac{1}{2} C_{A,s} \left\{ 1 - \operatorname{erf} \left[ \frac{x}{2(D_{AB}t)^{1/2}} \right] \right\}$$



IC and BC's

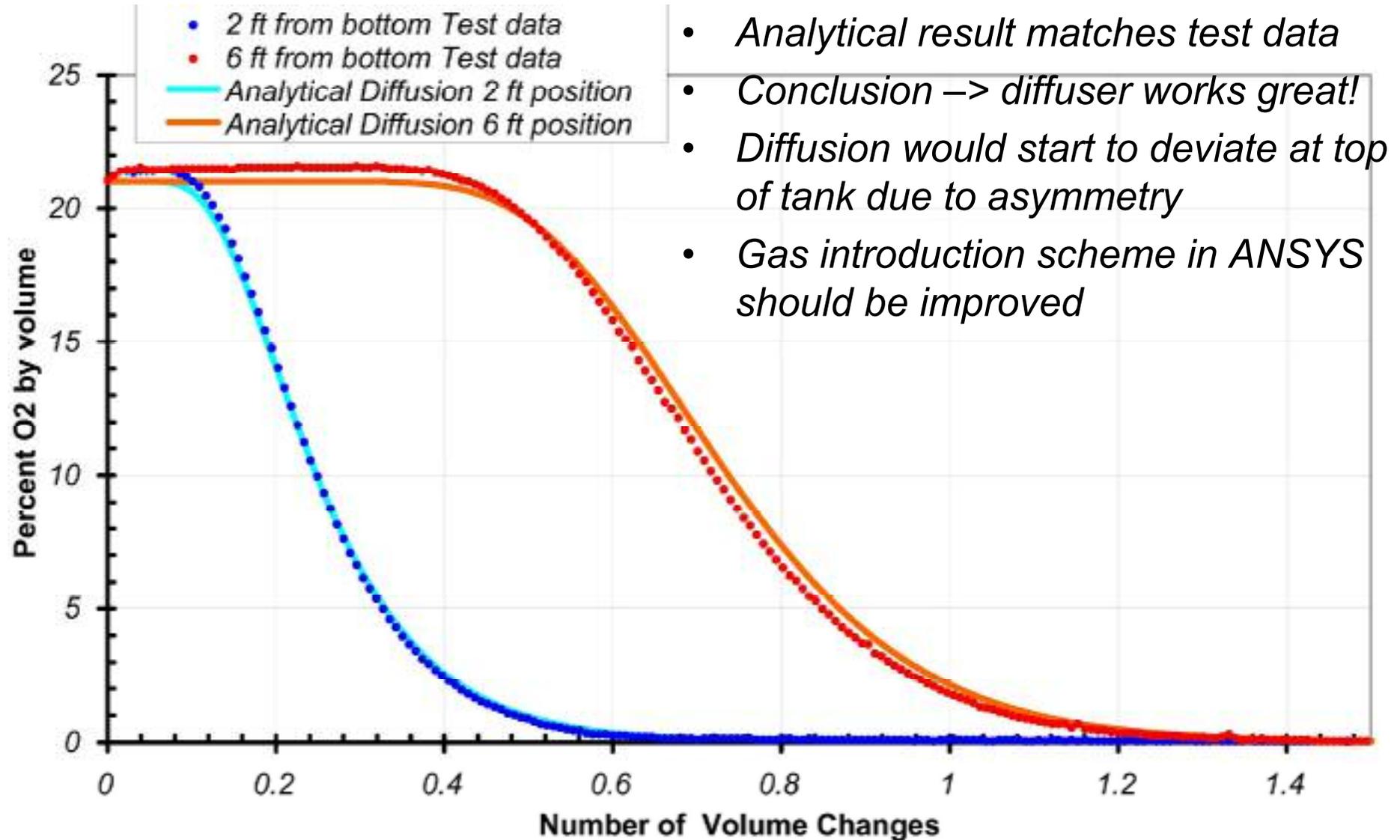
$$C_A(x,0) = C_{A,i} = 0$$

$$C_A(\infty, t) = C_{A,i} = 0$$

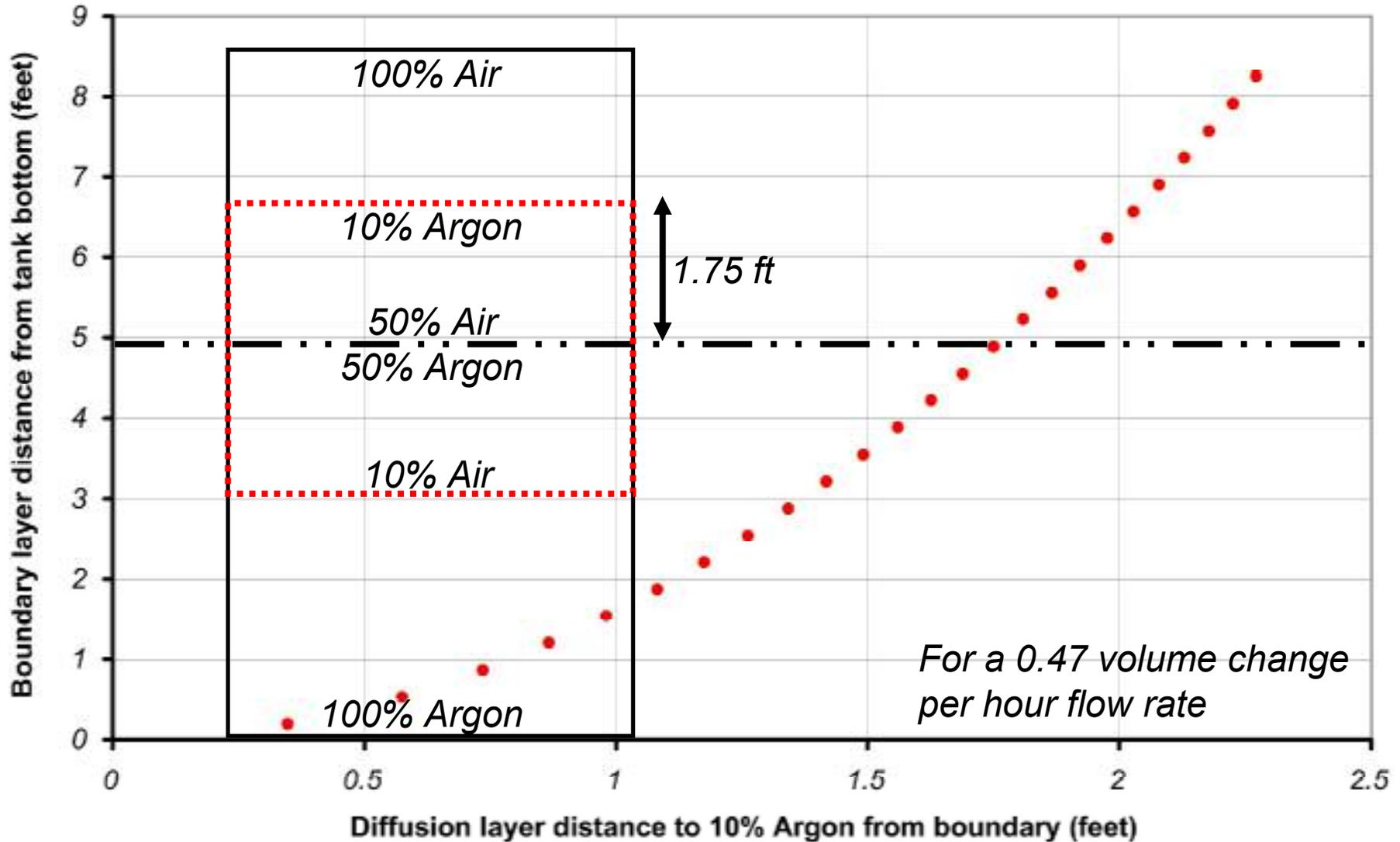
$$C_A(0, t) = \frac{1}{2} C_{A,s}$$

Boundary moves upward at a constant known speed

# Analytical Diffusion Model



# Analytical Diffusion Model



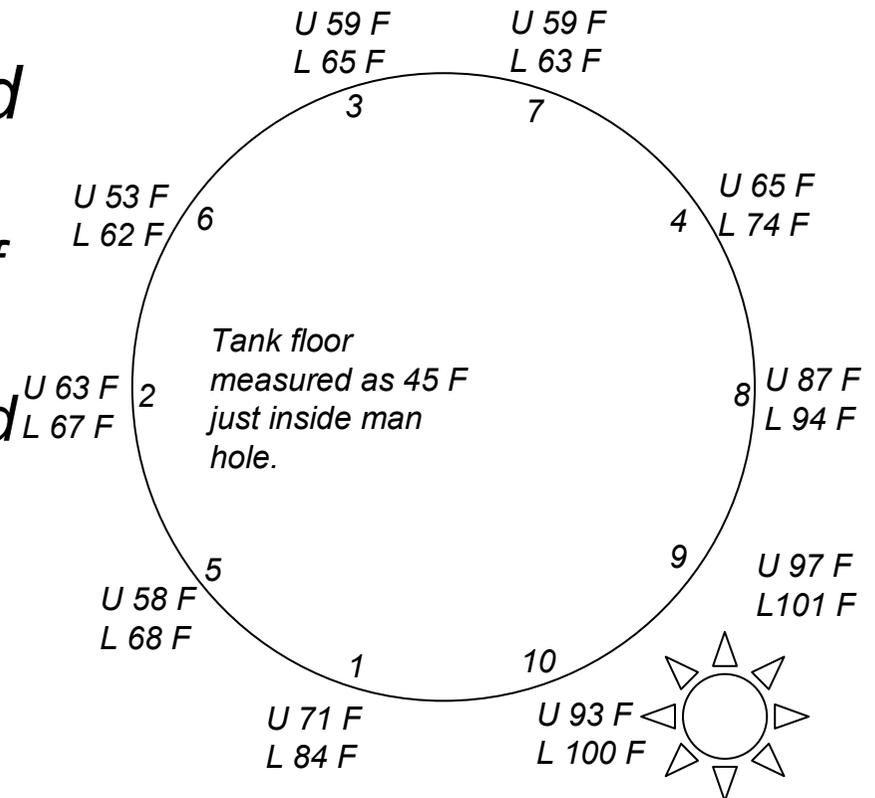
# Village Tank

- 40,000 ft<sup>3</sup> decommissioned water tank
- Current condition....



# Village Tank

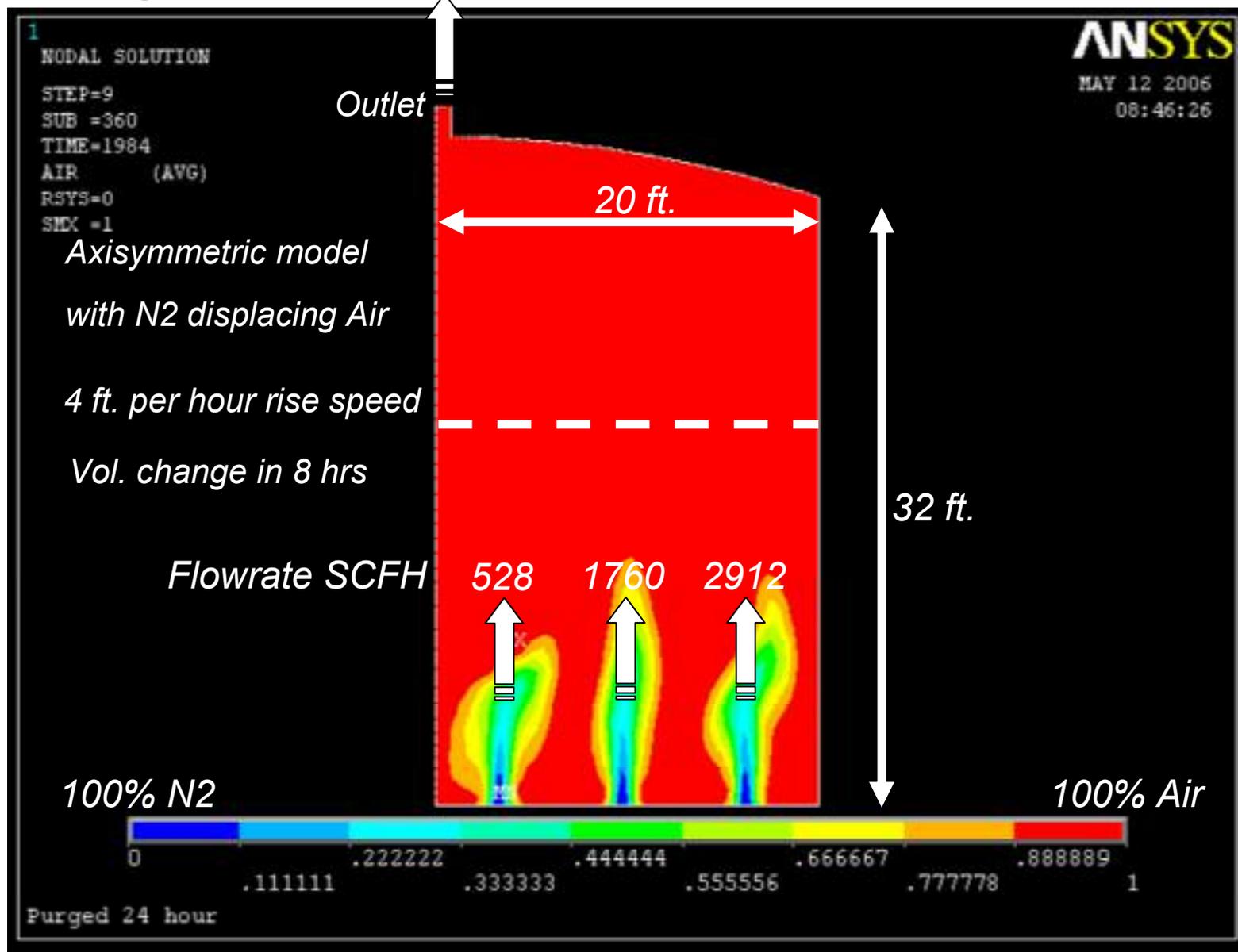
- *Constructed of  $\frac{1}{4}$  steel*
  - *Walls and roof are thin and poor thermal conductors*
  - *Large temperature gradient measured on sunny day*
- *Large cryogenic tank would be well insulated*
  - *Need to understand effect of thermal gradient on test*
  - *Do convection cells form and cause mixing?*
- *Possible solutions*
  - *Introduce cold gas*
  - *Cool tank walls with water*



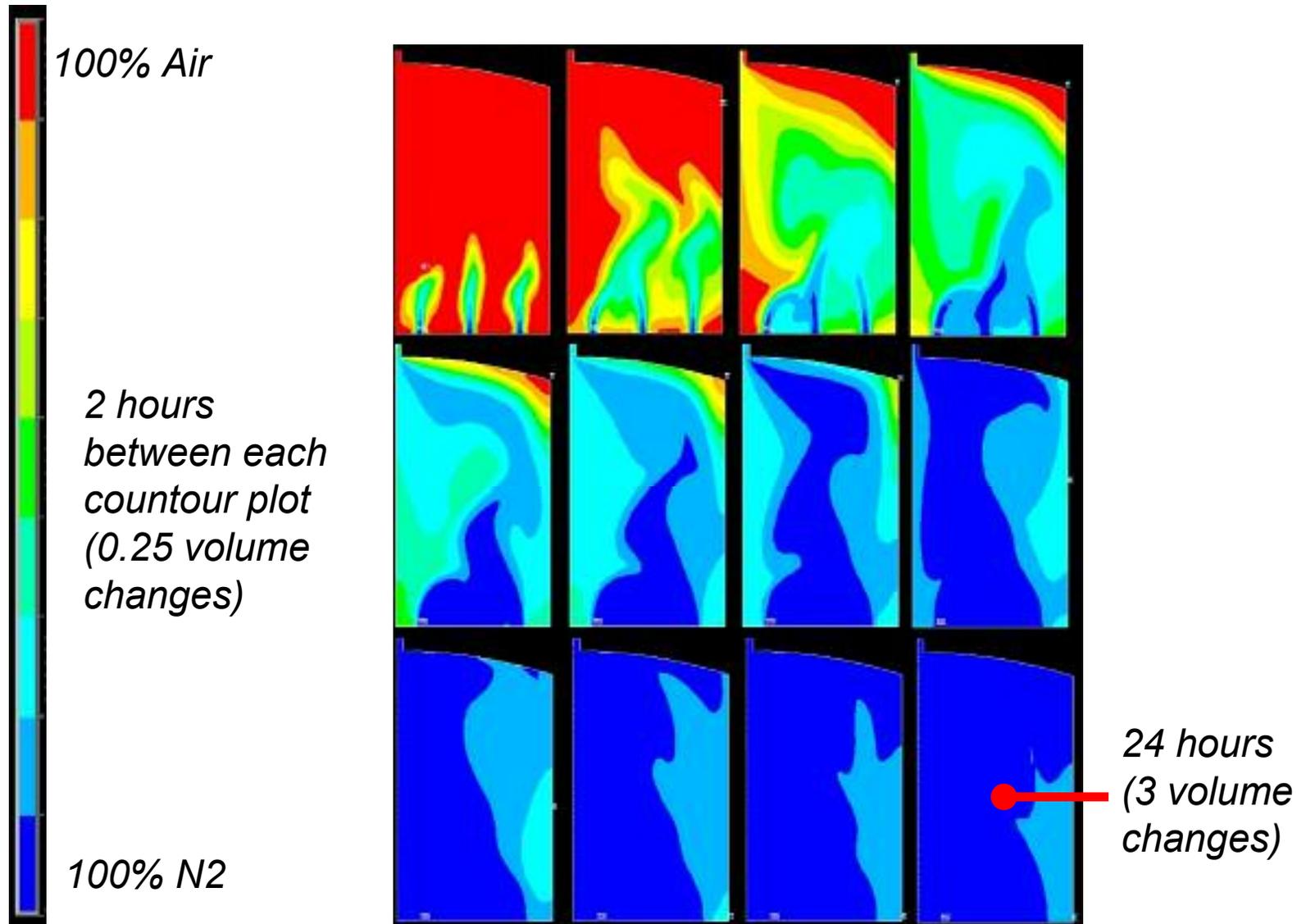
# Village Tank

- *Village tank purge testing will allow*
  - *Development of practical scheme for diffusing the gas introduced into a large cryogenic tank*
  - *Development of computer model*
  - *Characterization of the level of tank cleanliness needed to reach the purge spec?*
    - *Purity test station will help develop spec for N<sub>2</sub>, H<sub>2</sub>O*
- *As a 1<sup>st</sup> step an axisymmetric CFD model of the village tank has been solved with N<sub>2</sub> displacing air*
  - *Tests will be performed 1<sup>st</sup> with N<sub>2</sub> because Argon is much more expensive*

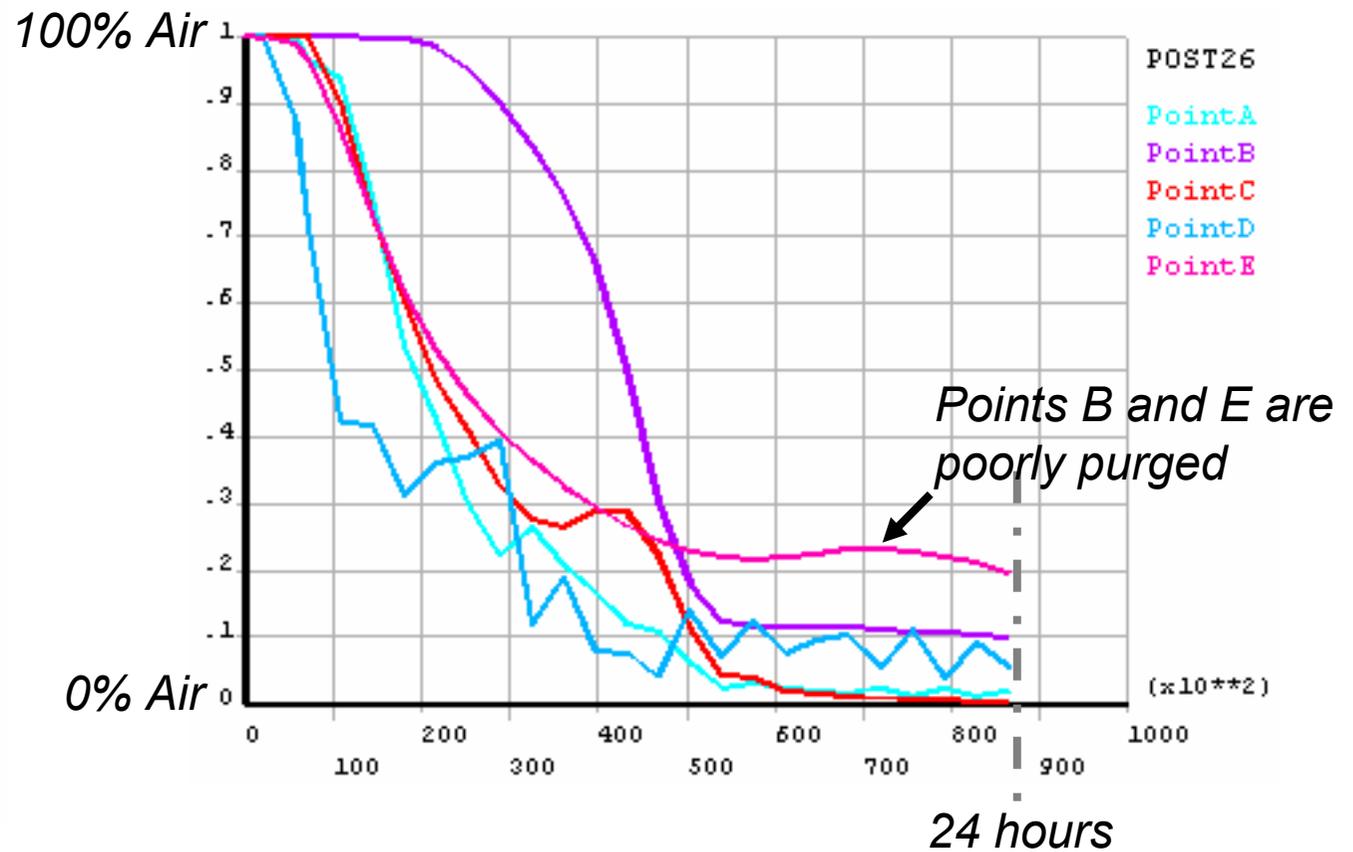
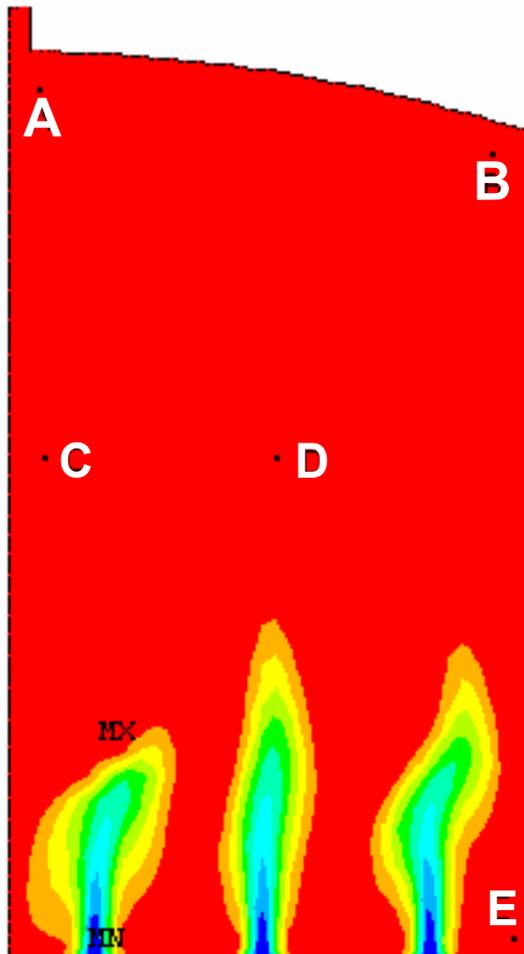
# Village Tank – 1<sup>st</sup> ANSYS Model



# Village Tank – 1<sup>st</sup> ANSYS Model



# Village Tank – 1<sup>st</sup> ANSYS Model



# *Village Tank – Future Work*

- *Plan for village tank*
  - *Improve ANSYS model with PAB setup*
    - *Run test with Nitrogen*
    - *Run test with applied temperature gradient*
  - *Use ANSYS to develop tank purge test*
    - *Determine village tank diffuser locations*
    - *Understand effect of wall temperature gradient*

# *Village Tank – Future Work*

- *Task list*
  - *Remove muck from tank floor and pressure wash walls*
  - *Instrument tank with O<sub>2</sub> and temperature sensors*
  - *Fabricate internal argon manifold*
  - *Prepare site to produce gas from a liquid cryogenic trailer*
- *Future-Future*
  - *Purge microTPC cryostat and reach high purity liquid without evacuation?*