

# Bubble Tests

## Residual Air Bubbles in Liquid Scintillator

- Bubbles form in the filling process
  - Vertical Extrusions: bubbles migrate up and out
  - Horizontal Extrusions: **bubbles are trapped**
- Bubbles may reduce light output
  - On Walls: less reflectivity
  - On Fibers: less absorption
- Is this really a problem?
  - Measurements needed

# Measurements

- Light output with bubbles on walls
  - Not subject of this talk
- Formation and Elimination of Bubbles
  - Report on an initial study
- Two test modules have been built & filled
  - Module 1: Filled with extrusion in vertical orientation
    - Small (1/4 inch) channeling holes; slow fill (50 min)
  - Module 2: Filled with extrusion in horizontal orientation
    - Large volume manifolds ~ 2 inches x 2 inches; fast fill (50 sec)

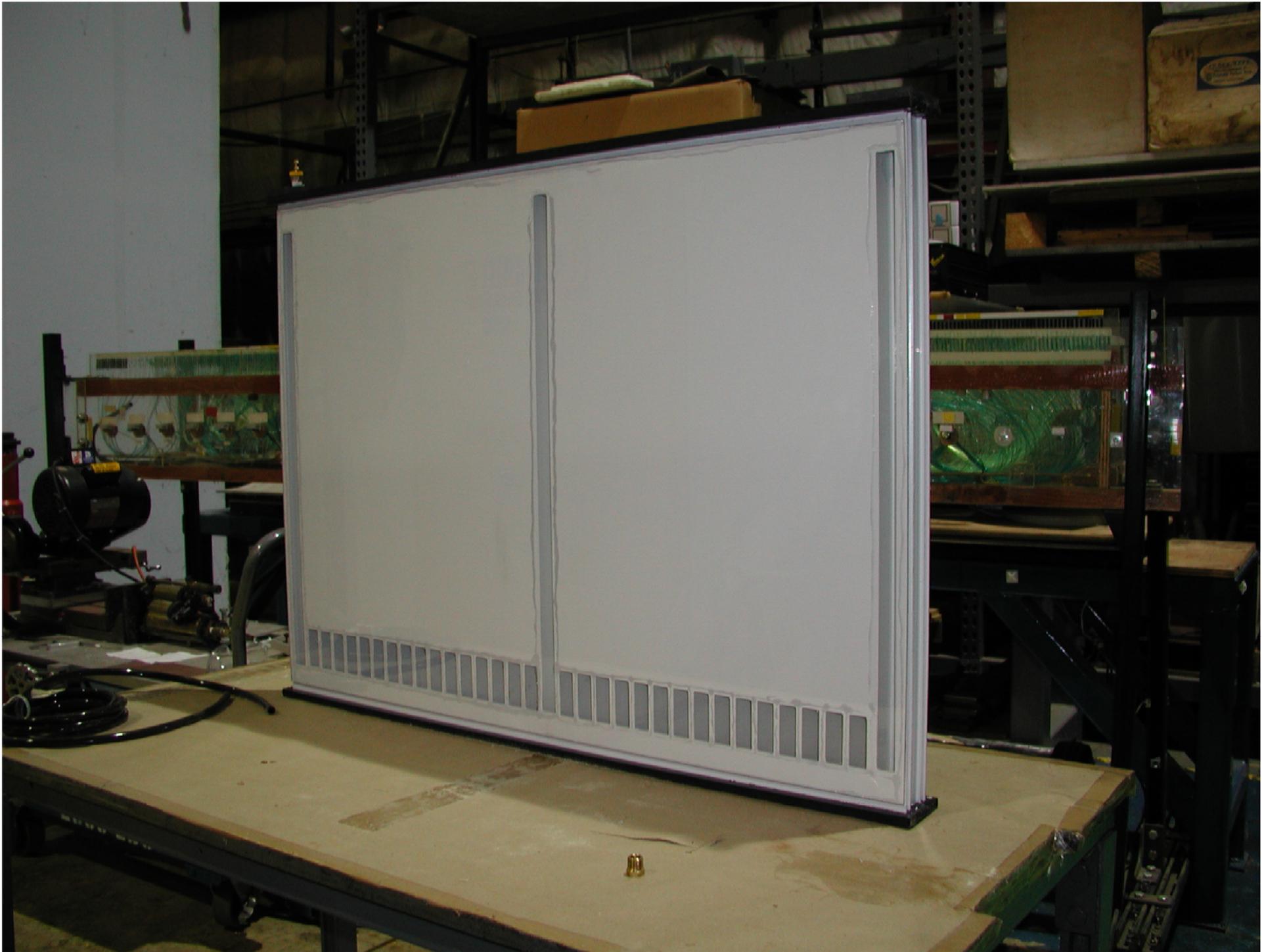
# PVC Extrusions

- Purchased commercial extrusions from
  - Extrutech in Manitowoc, WI
    - 34 cells (34" wide), 27 ft long
- Compare to NOvA Design

	Prototype	TASD	Baseline
Height	8 m	17 m	14.5 m
Inner-wall thickness	0.8 mm	1.0 mm	1.0 mm
Outer-wall thickness	1.6 mm	2.0 mm	1.5 mm
<b>Cell dimensions</b>	<b>2.5 x 4.1 cm<sup>2</sup></b>	<b>3.9 x 4.5 cm<sup>2</sup></b>	<b>2.5 x 4.0 cm<sup>2</sup></b>
<b>Cell cross section</b>	<b>10 cm<sup>2</sup></b>	<b>17 cm<sup>2</sup></b>	<b>10cm<sup>2</sup></b>
TiO <sub>2</sub> content	8%	10-15%	10-15%

# Module 1

- Vertical Orientation
- Slow: 10 minutes/gallon filling time
- Small (1/4") holes in ribs limit flow rate
- Module is rotated 90 degrees → horizontal
- Oil percolates through 1/4" holes
  - Bubbles are formed
- Tested at 0, 1 and 2 degrees
- Long-term test at 1 degree (> 1 month) in progress
- More tests are planned









December 22 '04 Angle = 1 degree



December 23 '04 Angle = 1 degree



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January 4 '05 Angle = 1 degree



January 28 '05 Angle = 1 degree



## Module 1 Conclusions

- “Fizzy” bubbles (fill column) clear quickly
- Fibers have no bubbles (slow fill)
- Vibrations (hand-sander) have **no effect** on bubbles (2 degrees)
- 1 degree incline reduces bubbles slowly
  - Long-term study going on now

## Module 2

### Major Differences from Module 1

- Horizontal Orientation
- Large 2" x 2" side manifolds
  - No limit to flow rate
- Fast fill rate: 10 **seconds** per gallon
  - Gravity feed, 4 feet above top of module
- Tested at 0 degrees (so far)
- More tests are planned, including
  - Slower filling
  - Filling under vacuum

Module 2 January 26 '05

Deep manifold



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# Module 2 Fast Fill down Left Manifold



## Module 2 Fast Fill Down Left Manifold



Module 2 January 26 Angle = Zero degrees

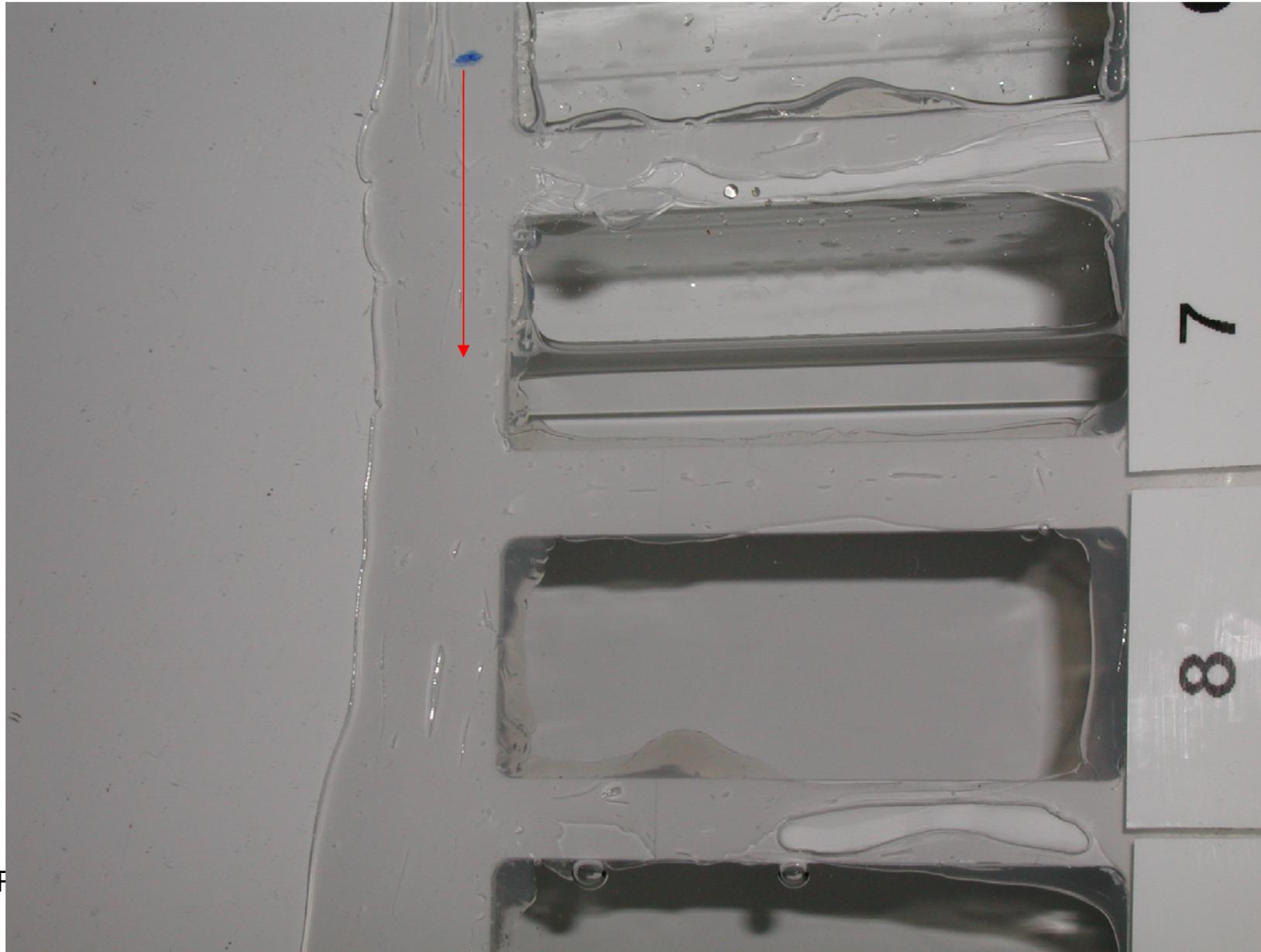


Module 2 January 27 '05 Angle = Zero Degrees



Module 2 January 27 '05 Zero Degrees

**Oil level drop 23 mm: fewer bubbles**



Module 2 January 27 '05 **Well, almost Zero Degrees**



# Preliminary Conclusions & Future Plan

- Bubbles escape
  - Over time
  - At larger angles
- Scintillator level will drop as bubbles escape
  - Add more scintillator at a later time?
- Additional Studies
  - Goal: Reduce or eliminate bubbles with the least inclination
    - Flow rate
    - Vacuum
    - Other ideas
- Do bubbles really reduce light yield?
  - A study is needed