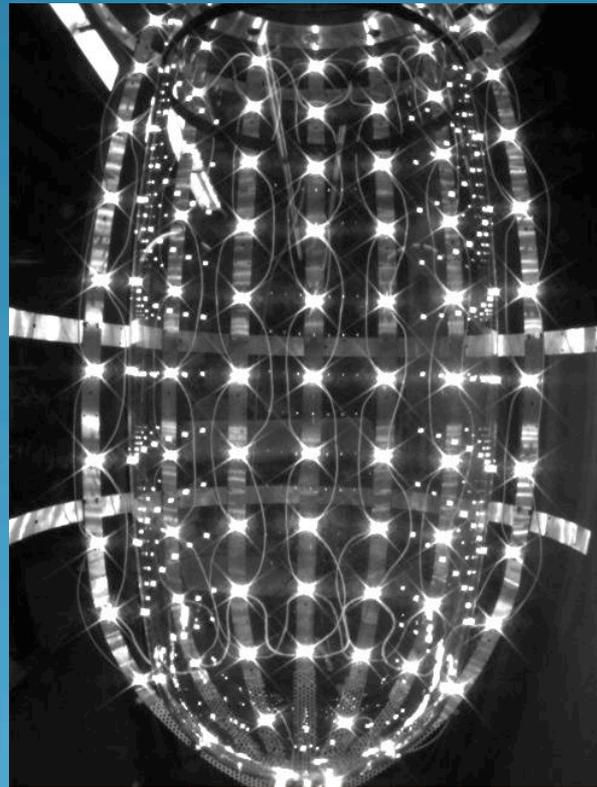
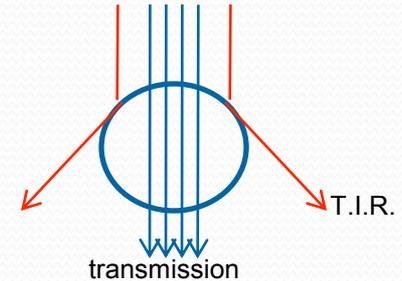


# Optics for COUPP 60 kg Detector



## Goal and method

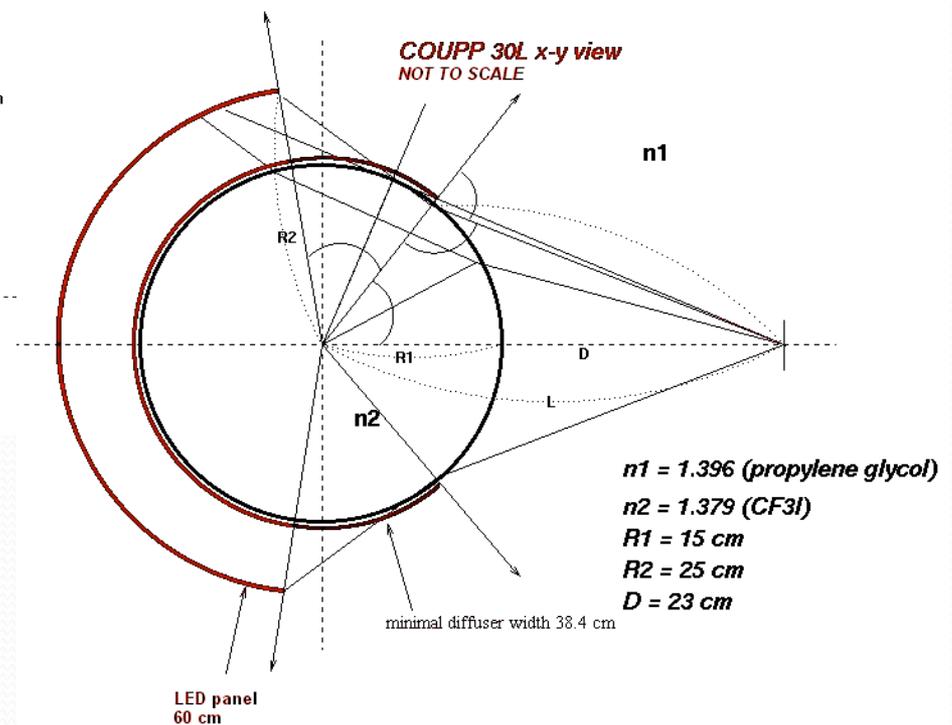
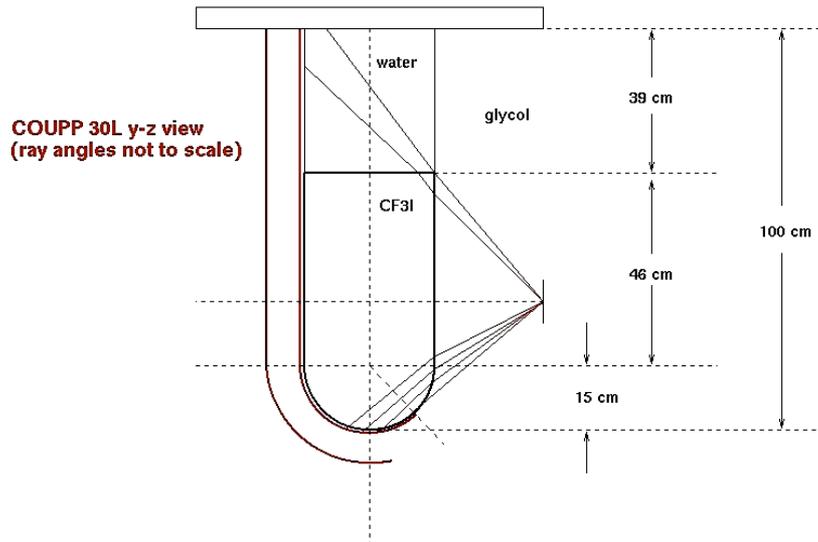
- Small angle stereo with back lighting
  - Back lighting provides the best possible resolution and contrast
  - Small angle stereo as a result of pressure vessel constraint
- Basler eXite cameras
  - Mono CMOS sensor, frame rate 176 Hz, 656 x 491 resolution , 3.5mm focal length lens
  - Quantity of light needed based on Exposure time and F-stop
- Lumens per pixel determined from experimentation; factor of 2 margin designed in
- Use Luxeon III red LED's (627 nm, 4 watts, 140 lumens)



A bubble seen from above or below

# Geometry

-- Dealing with different indices of refractions --



# Scope

- LED grid
  - Done
- Power supply and management
  - Done
- Light diffuser and optics
  - Done
- Camera programming and tests
  - 50% done

# Status

- Prototype (partial coverage) finished in March, 2008
  - Obtained experience with LED grid immersion in propylene glycol
- Prototype installed and started operating in pressure vessel by July 15<sup>th</sup> , 2008
  - Obtained good test results during engineering run
- Construction of final lighting grid finished in November
  - Diffuser out-sourced to **Acrylic Design Works** of Chicago
  - Outstanding job; \$550, mold exists for spares
- Power supply/management in finished
  - Tested for 2 months, performed well after minor tweak
- Camera programming and tests in progress

# Prototype – March 2008

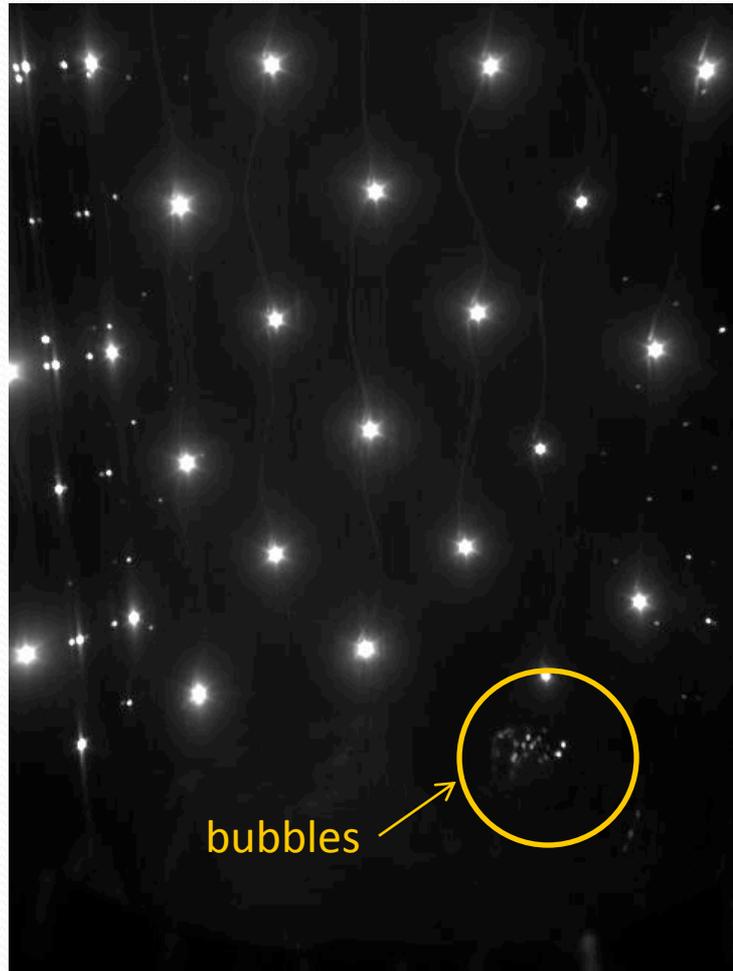
Without and with test diffuser



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Martin Hu

# Prototype grid (28 LED's) inside pressure vessel

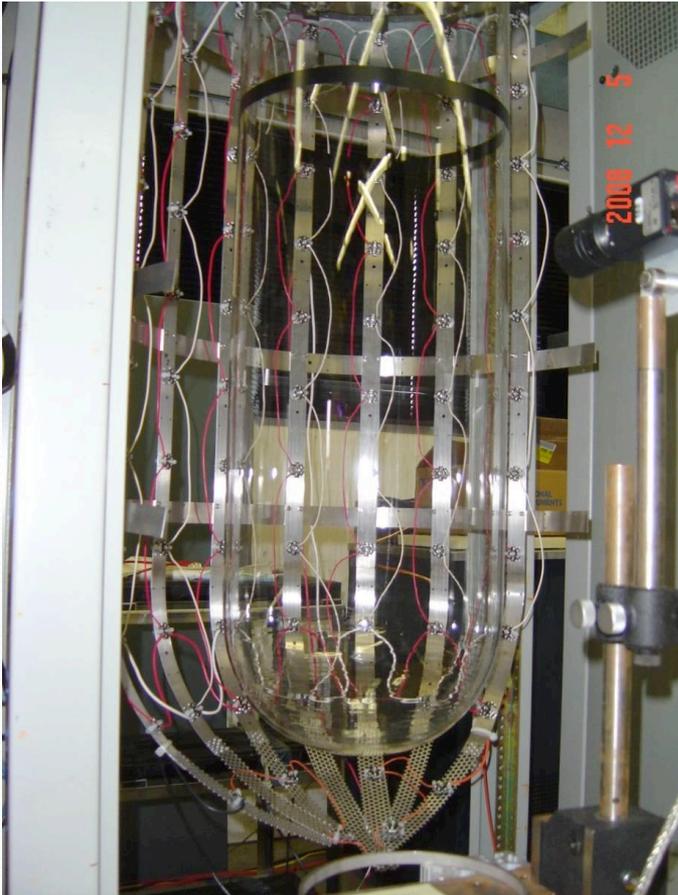
Immersed in propylene glycol, max. pressure 200 psi



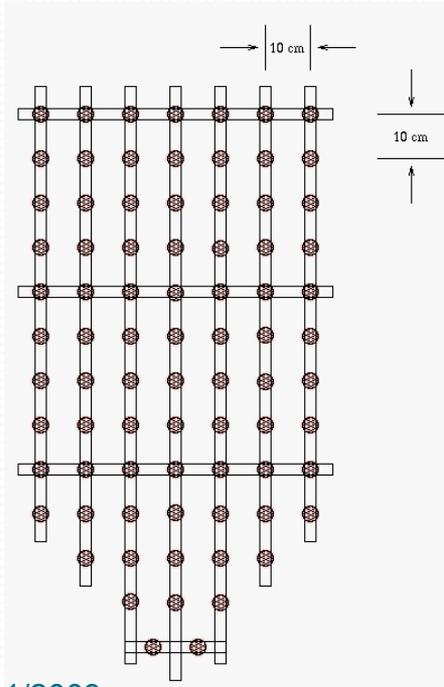
## Test results

- LED grid survived test, but some corrosion on metal parts could be seen
- We made the choice of Dynalene
  - It is “PG with proprietary anti-corrosion agent”
  - Optically quite transparent (vs Dowfrost HD)
  - No similar long-term immersion test done

# Final lighting grid

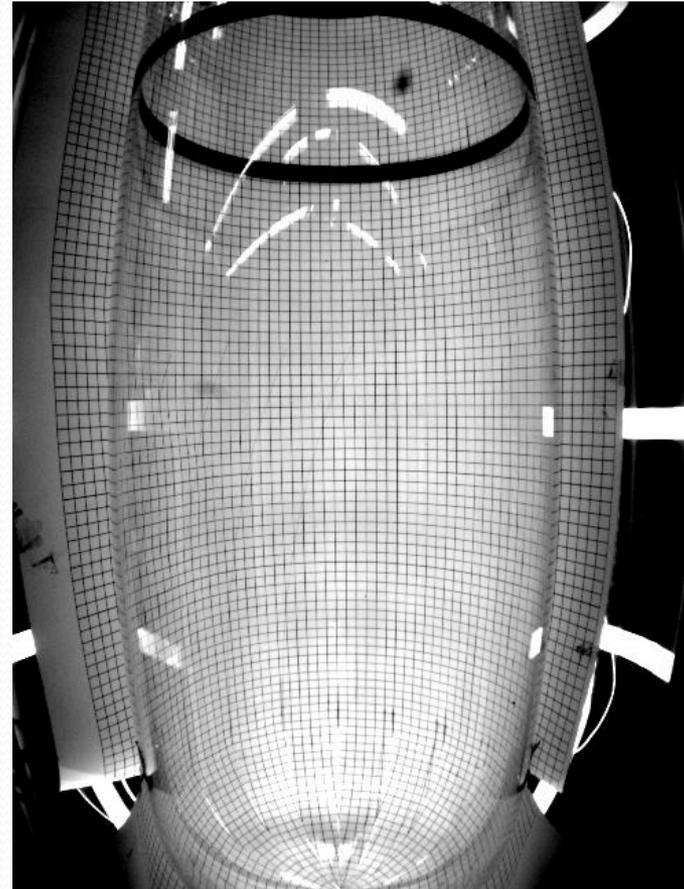
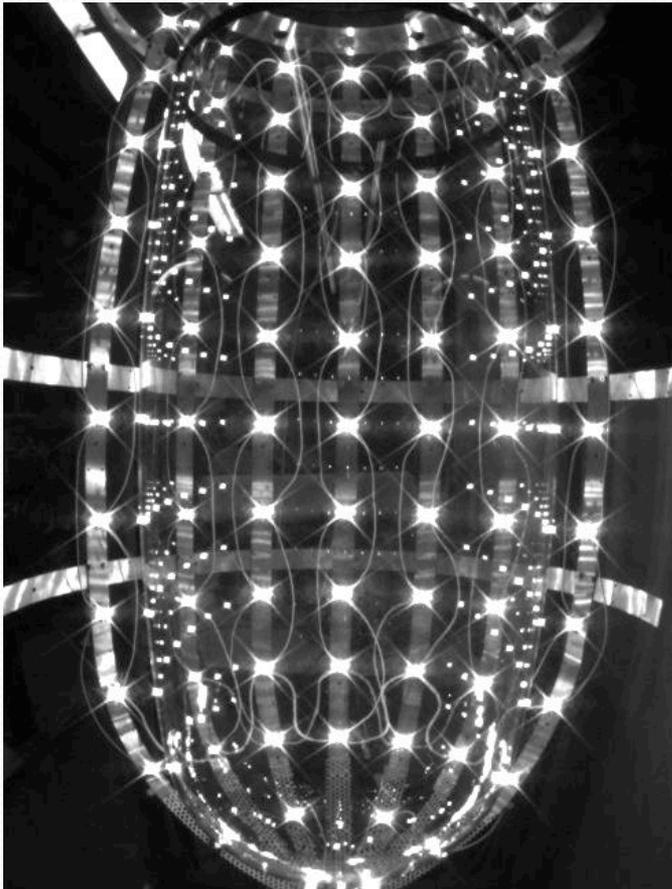


- Stainless steel support with nylon stand-offs, nuts and bolts (Mark Ruschman)
- Made with 80 Luxeon III red LED's
- Maximum total power consumption ~ 400 watts
- Maximum total output ~ 10,000 lumens
- System will operate at ~10% duty cycle



# LED lighting without and with (test) diffuser

Square spacing = 10mm; line thickness = 1mm; fiducial volume shown ~ 40 liter

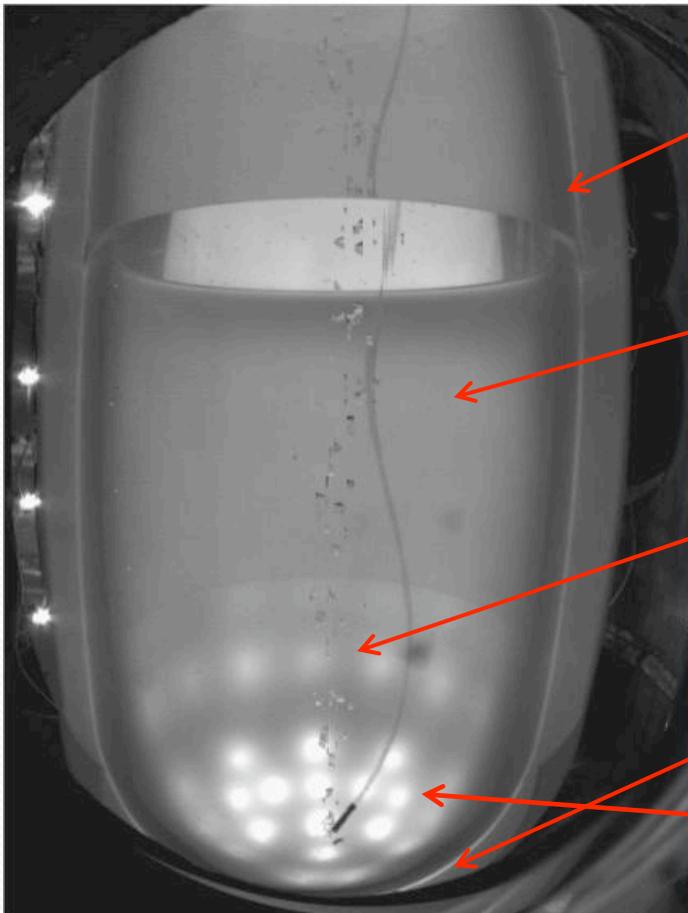


## Diffuser and LED grid fitted to inner assembly



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# Actual image with fluids and lensing effect



PG only filled up to the viewport

Quartz inner vessel filled with water

Acquarium pump makes bubbles  
(Image captured using test program)

Bottom of vessel not blocked

Bottom lighting less uniform due to  
small deviation in specification of test  
setup (will be fixed in final version)

# LED electrode corrosion problem

-- Observed during the 2L vessel test--

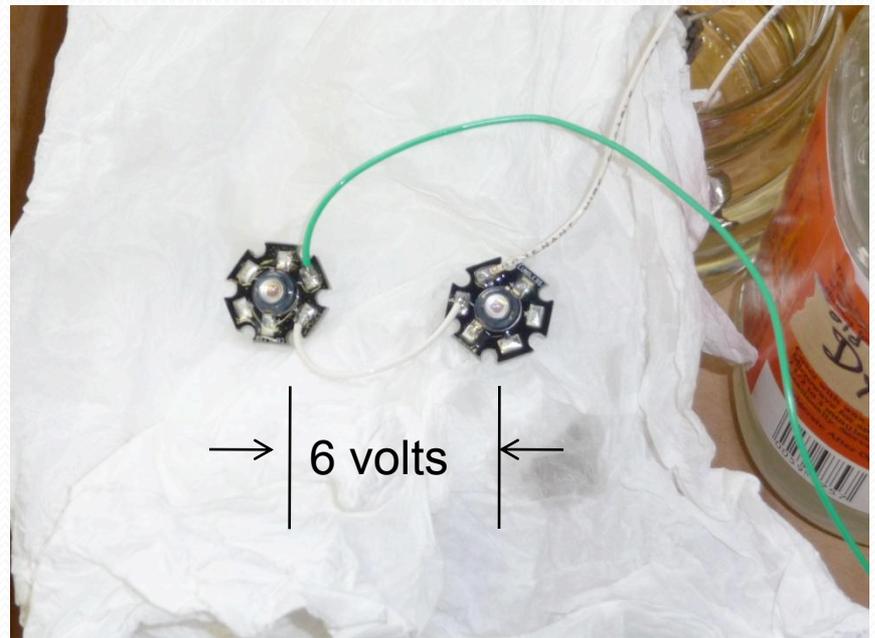
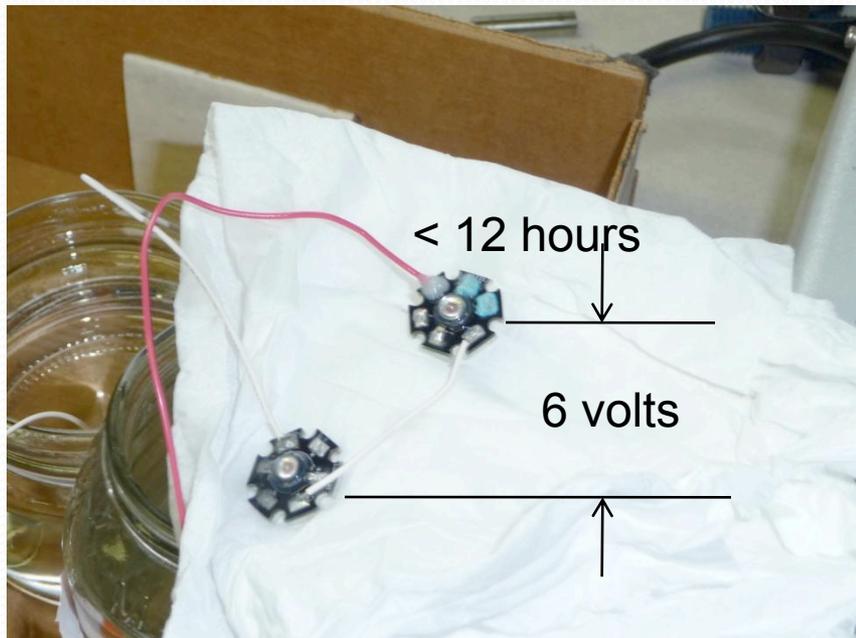


# Pressure vessel fluid compatibility

-- tests at PAB following 2L grid problem --



## Results – Dynalene is the problem



LED's immersed in Dynalene jar developed blue Cu<sup>++</sup> substance with or without water contamination

LED's immersed in propylene glycol look clean after a week, even with water contamination

## Following the initial test...

- The 60 kg grid was pulled out after ~4 hours of running at 10% duty cycle
- No blue  $\text{Cu}^{+2}$
- Cleaned and will be re-used in pure glycol
- LED DC torture test in pure glycol now over 1 week; still OK so far

## Next...

- Slight fine-tuning before freezing lenses and camera mount
- CTIC box being programmed; CLIM already working
- Camera programming and tests will continue
  - Triggering on actual bubbles
  - Bubble position reconstruction