LENS: Light Transport

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On behalf of the
LENS Collaboration
The LENS Experiment

- Neutrinos captured on $^{115}$In.
- Delayed gammas provide a triple coincidence.
- Beta decay of $^{115}$In is problematic ⇒ detector segmentation needed.
- See J9-5: LENS: Science Scope and Development Stages R. Bruce Vogelaar
- Low index barrier ⇒ total internal reflection (TIR)

\[ \nu_e + ^{115}\text{In} \rightarrow ^{115}\text{Sn} + e^- + 2\gamma \]
The LENS Detector

Thin Container Filled with Liquid Scintillator, typical size of ≈8cm

Container Index of Refraction = $n_1$ (Could be air)

Liquid Scintillator Index of Refraction = $n_2 > n_1$
The LENS Detector

This is called a scintillation lattice (SL)

*Really this is a plane of a SL
Scintillation Lattice

- See D14-6 LENS: μLENS Simulations, Analysis, and Results Charles Rasco
- Current development with single low index films.
  - See J9-7: LENS: Prototyping Program S. Derek Rountree
The miniLENS Prototype

- MiniLENS water tank for rock and PMT shielding.
  - See the next talk: LENS: Prototyping Program
- Maintain channeling through shielding → use light guides (LGs).
MiniLENS LG Design

1. Highly efficient for good energy resolution.
2. Low cost for material and labor.
3. High radiopurity and/or low mass to minimize background.
Construction and Testing of LGs

• Built an LED+diffuser light source.
• Emission not isotropic ⇒ mapped emission distribution via masks on a bare PMT.
• Benchmark to ‘simple’ light guides
Construction and Testing of LGs

• Tefzel and VM2000 were chosen for the initial tests.
• Tefzel film can be heat sealed to create a liquid tight barrier.
• Current tests—LGs sealed with clear water proof tape.
• Purely reflective LGs are made by rolling and taping long seam.
• Clear and multi film LGs can be made.
Construction and Testing of LGs
Continued R&D

• Measured LG transport efficiency differ from the MC.

<table>
<thead>
<tr>
<th>Source Distance (in)</th>
<th>Transport Efficiency</th>
<th>Monte Carlo</th>
<th>MC:Data</th>
</tr>
</thead>
<tbody>
<tr>
<td>5.0</td>
<td>72(3)</td>
<td>81.7(2)</td>
<td>1.13(5)</td>
</tr>
<tr>
<td>7.5</td>
<td>74(4)</td>
<td>83.7(3)</td>
<td>1.13(6)</td>
</tr>
</tbody>
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• Further work includes
  – New light source development.
  – Further characterization of light source.
  – Further MC benchmarking.
  – Building and testing of multi-film LG for the miniLENS prototype.
Acknowledgements

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Extra Slides
Scintillation Lattice

- LAB Scintillator in a Teflon Lattice
  - Teflon: $n_1 = 1.34$, LAB: $n_2 = 0.53$

Direction of Emitted Optical Photon originating from ANYWHERE in Cell
LG Simulation and Benchmarking

- The transport efficiency for LGs is the ratio of the light collected with the guide (B) to a bare PMT (A) where the collection distances (srcDis) are equal.
Some MC Results for LGs

- LGs are simulated using a simple ray tracing Monte Carlo (MC) program.
- LGs of varying shapes and constructions can be modeled.

<table>
<thead>
<tr>
<th>Disk Source Guide Type</th>
<th>Transport Efficiency</th>
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<tbody>
<tr>
<td>Reflective</td>
<td>81.3±0.2</td>
</tr>
<tr>
<td>Film Air Gap</td>
<td>84.9±0.2</td>
</tr>
<tr>
<td>Combination</td>
<td>84.7±0.2</td>
</tr>
<tr>
<td>Acrylic</td>
<td>84.9±0.2</td>
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