**Introduction**

- One of the most important properties for Neutrino-detectors: signal-to-noise ratio.
- Bigger PMT -- bigger photo-sensitive area.
- But also bigger dark noise.
- SNR mostly unchanged.
- The WOM employs a passive, wavelength-shifting (WLS) coated surface.
- Total internal reflection and trapped by total internal reflection.
- 74.5% of the re-emitted photons are re-emitted isotropically.
- + transparent tube coated with WLS.
- Ideal for Cherenkov-detectors due to UV-sensitivity.

**Building the WOM**

- A transparent tube is dipped in WLS paint and withdrawn at a controlled speed.
- The coated tube is connected to a PMT via a holding structure.
- Optional via an ALG.
- The entire assembly is housed in a quartz vessel with feedthroughs for power and signal cables.
- Coating thickness depends on speed.
- Performance vs. Coating speed on quartz-tubes. High reproducibility and high total efficiency (up to 24.3% per side).

**A dark noise challenge**

- Dark noise measured inside a Faraday cage in a climate chamber (60° to 20°C).
- Dark noise of PMT: 30-50 Hz
- With ALG and WLS tube added: 70 Hz
- Quartz pressure vessel: 800 Hz
- BET: this pressure vessel contains ~150 ppm NH₃.
- Cleaner quartz has been found from Heraeus and Raesch.
- Produce vessel from clean, low activity quartz (HSQ300, SUP310 or HQ200).
- Expected new vessel contribution <10 Hz
- Expected total dark noise <80 Hz.

**Performance**

- Wavelength-scan, one-side-efficiency vs. injected wavelength. Illumination 150 away from tube end. Above 400 nm the UV-light is not absorbed.
- Timing: detection time of single-particle events using a picosecond UV-pulse, depending on illumination point distance from tube end.
- Fit results: WLS-decay time = 1.35 ns
- Photon-attenuation length: \( \lambda_{eff} = 320 \text{ cm} \)

**Testing setup**

- Task: Characterize WLS coating and ensure uniformity of light-guiding efficiency for all tubes.
- Solution: Orbital stage on a linear stage to guide an optical fiber around and along the tube.
- Fiber is connected monochromator and a Xe-lamp.
- Tube efficiency can be measured for all wavelengths and all illumination positions.

**Summary**

- IceCube Gen2
  - The WOM is ideal for experiments that aim to detect UV light with a high SNR.
  - Focus: low noise and high effective area.
  - Main cost driver: quartz pressure vessel for 500 bar
  - Only necessary in ice.
  - A smaller, much cheaper WOM has been developed for SHiP, others may follow. -- Hyper-K?

**Outlook**

- Prototype built.
- 41 ±1.7% avg. efficiency.
- Improve SNR by factor >10 compared to PMT alone.
- Even higher with adiabatic light guide.

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