NEW AND EMERGING TECHNOLOGIES: NOVEL PHOTODETECTORS

DISCUSSION SESSION

2 PHOTODETECTORS

DETECTION DEVICES

- PMTs
- SiPMs
- Di-SiPMs
- APDs

PHOTODETECTION ENHANCEMENT

- ABALONE
- ARAPUCA
- LHM

PRIMARY CONCERNS

- Cost – Best quantified as $/area to compare devices -> For SiPMs, $/area can be enhanced with ABALONE and ARAPUCA type devices , but cost of granularity is important as well
- Restrictive Characteristics: Dependent on the detector goals, for DM search: DCR, PDE and radiopurity are critical points for SiPMs
- For large neutrino experiments, massive surface area requires cost effective light collection technique
- For Xenon, VUV sensitive PMT’s already a good solution, but SiPMs can offer a high granularity as well as fast timing, useful for position and time resolution

OPEN QUESTIONS

- VUV vs VIS SiPMs, removal of dependence on WLS for LAr detectors is an attractive concept
- VUV SiPMs : How do they survive the LAr environment? Thermal cycling? Sensitivity to handling? Can be optimized more, Currently just removed quartz window.

  -> Operational Characteristics need to be determined at detector conditions
- Di-SiPMs: Same as VUV SiPMs, need to characterize, but attractive due to simplified readout, high SNR, and SPAD level resolution, Cons: High DCR

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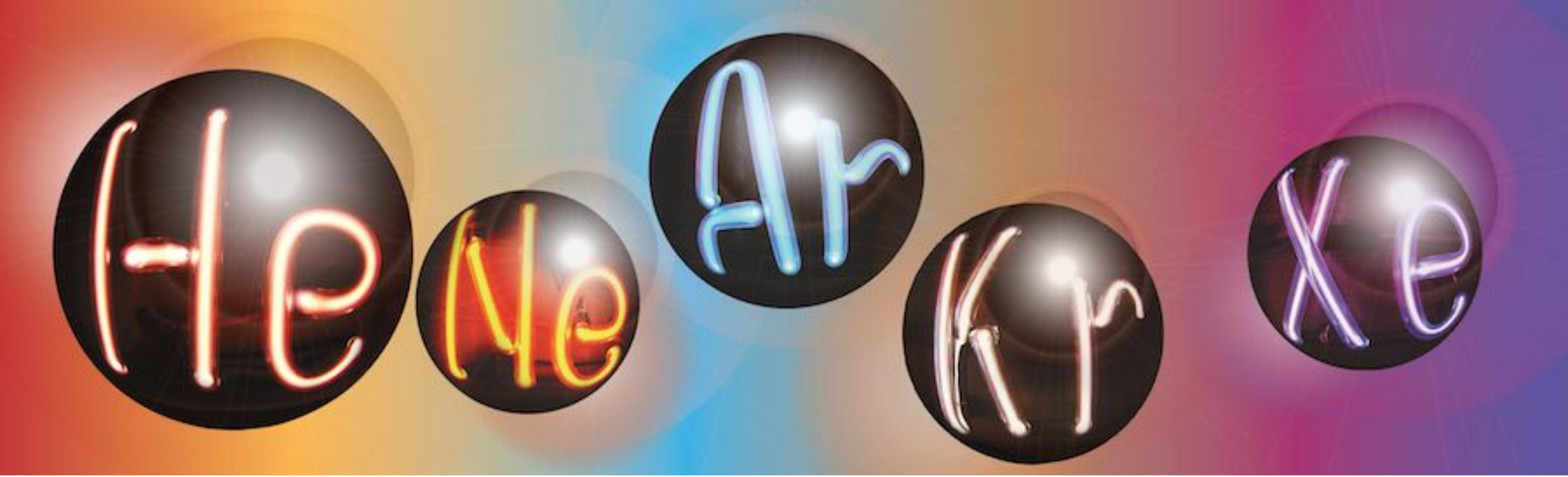
SOME TAKEAWAY

- Diverse requirements of the field requires a diverse portfolio of photodetection options
- DM Search experiments have different needs from neutrino baseline experiments for example.. Many tools allows for more flexibility and better optimization to needs
- There has been improvement over recent years, options such as Di-SiPMs, VUV SiPMs and devices like ABALONE and ARAPUCA are a boon
- More characterization of new technology at relevant operating conditions for experiments needs to be done and will allow for more informed selection
- Some challenges like dynamic range, effective cost can be answered with informed design of FE electronics and area enhancement

THANK YOU



Large future detectors: Maximizing light collection

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Overview

- Introductions and background
- Experimental motivations:
  - Why is light collection needed?
  - Requirements for Neutrino (esp Astrophysics) and Dark Matter studies.
- Problems in light collection:
  - Propagation in Liquid Noble Elements
  - Material reflectivity requirements and measurement challenges.
- Future Discussions
  - Light detection
  - Suitable materials
  - Long term stability of light collection

Problems in Large Detectors

- Surface effects/reflection:
  - Measuring the material **VUV reflectivity of photons in the liquid** - more needed!
  - Including the need for VUV black materials.
  - Fluorescence and contribution to ‘Dark Count’ rate.
- Bulk effects/contamination:
  - Studying transportation of electrons in bulk liquid with TPB contamination.
  - Do VUV photons affect rate at which TPB dissolves into the bulk liquid?
  - Absorption due to contamination in bulk liquid.
  - Rayleigh scattering measurements and whether we need more?
  - Photoionisation (light producing charge)
- Often neglected sources of extinction:
  - Electrodes (fill factor & reflectivity)

Future Discussions

Light Detection

- Sensors QE and cost per unit area.

Material measurements:

- VUV reflectivity, total reflectance and angular reflectivity.
- Possible materials: G10, stainless steel, titanium, PEEK.
- Rayleigh Measurements should include statement on purity.

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Discussion Section Summary

Simulation and Reconstruction of Light Signals (in Large Detectors Volumes)

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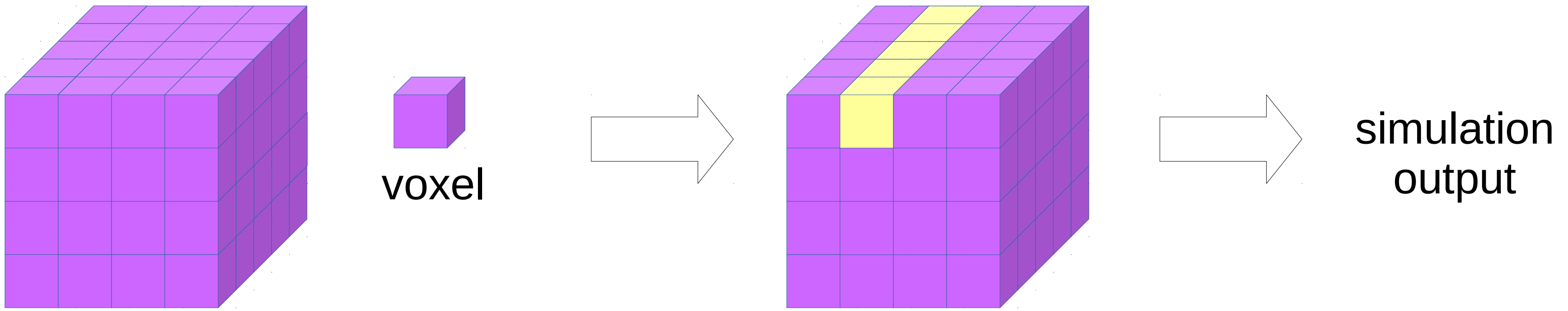
- Simulation is commonly either **compared to data** to try to understand what is being observed and to improve our simulation, or used to **predict and check** expected behaviors.
- There are two kinds: **full and fast** light simulation.

Full simulation: consists of generating and tracking each photon from its creation until its detection or absorption.	✓ Easy to modify ✗ Requires lots of time and memory
Fast simulation: calculates the probabilities based on an **optical library.**	✓ Requires less time and more memory ✗ Hard to modify
Full + Fast simulation: Usage of GPU	



- Light simulation should be **accessible** and **precise**…
- Use light to do physics
- Large detectors generate large libraries
- Energy ranges → which simulation is better?

Fast *versus* Precise

Thank you for your attention!

Noble gas microphysics

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Unknowns for the noble liquid detector

- Single photon background in LAr detector
  Can it happen in LXe aswell?
- Single electron background in surface LXe detector
- What is the proper theoretical framework to understand charge screening?
- Recombination models
- How does the impurities affect both charge and light signal?

Key measurements that should be performed

- What is the process to transfer the fast component in Xe doped LAr? 150nm line of Ar-Xe dimer is reduced (disagree)
- Ratio light/charge, singlet/triplet, number of ions produces in liquid not properly understood. Contradictory statements from the literature
- Rayleigh scattering length, index of refraction
- Drift velocity of charges