

**WATER BASED QUANTUM DOTS
NEUTRINO DETECTOR FOR NEAR-FIELD
NUCLEAR FISSION REACTOR
MONITORING**

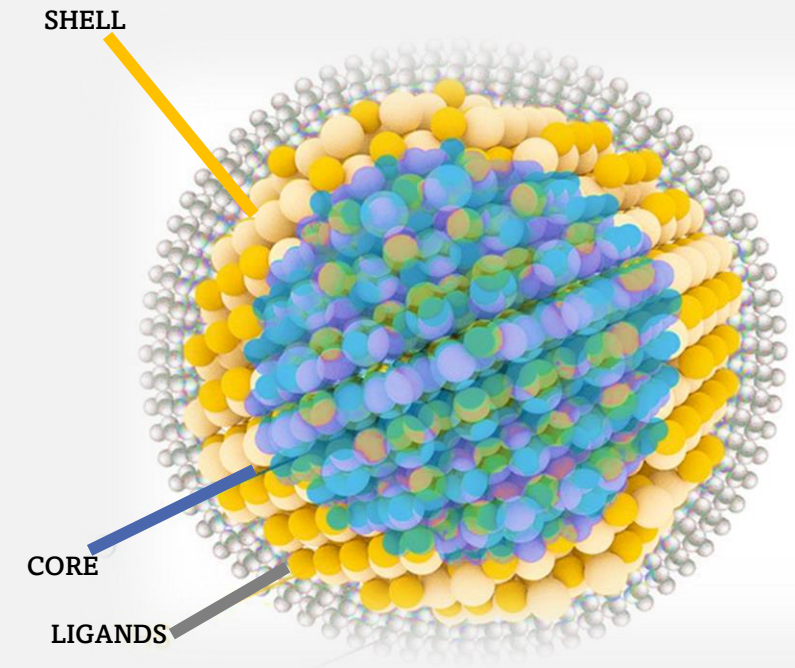
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OBJECTIVES

- Behavior of QDs as water-based liquid scintillators
- Water based liquid scintillator can be a new type of near-field fission reactor monitoring neutrino detector

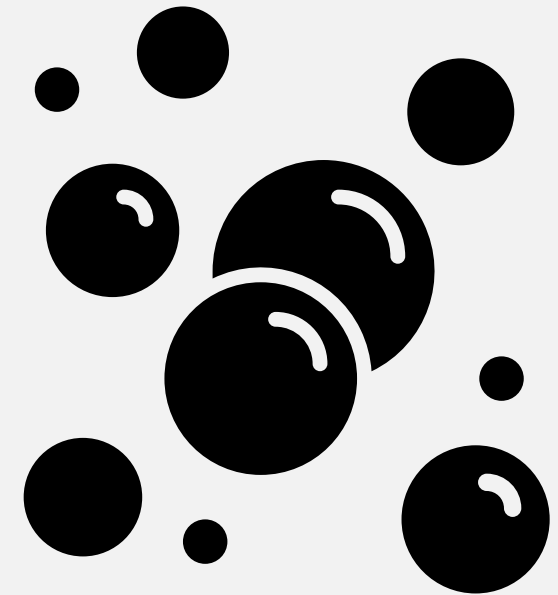
QUANTUM DOTS

- Semiconductor particles
- Size of few nanometers
- Tunable optical properties
- Properties intermediate between bulk semiconductors and discrete atoms or molecules
- Composed of a core, shell and possible encapsulation



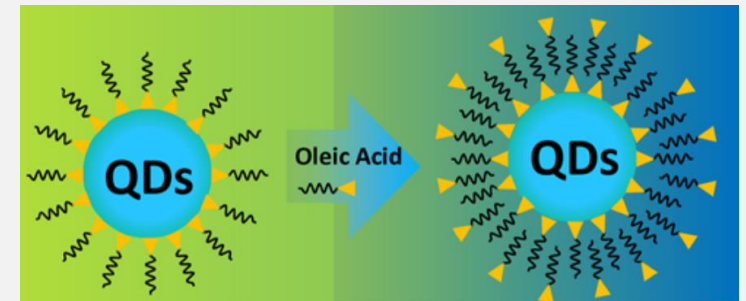
CDS QUANTUM DOTS

- Cadmium Sulfide (CdS) quantum dots (QDs)
- SigmaAldrich manufacturer
- High quantum yield (50%)
- Small size
- Short wavelengths (450nm absorption)
- Oleic acid (OA) encapsulation for water-soluble
- In water solution safe to use near the fission reactors



ENCAPSULATION PROCESS

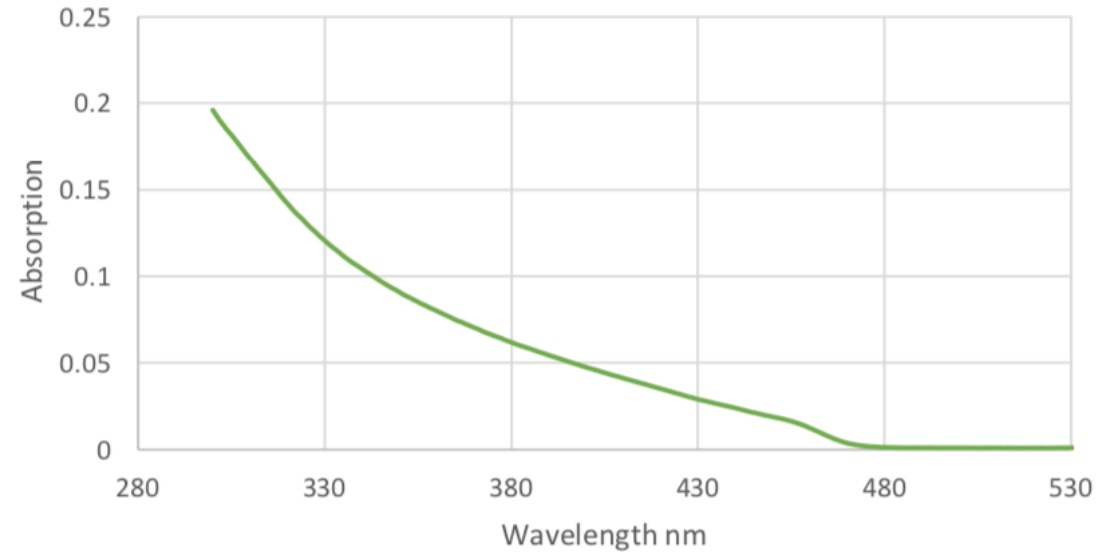
- Dilution in Hexane
- Sonication in Ultrasonic bath
- Addition of OA
- Dilution in deionized water
- Sonication and 24h rest
- Centrifugation
- Filtration



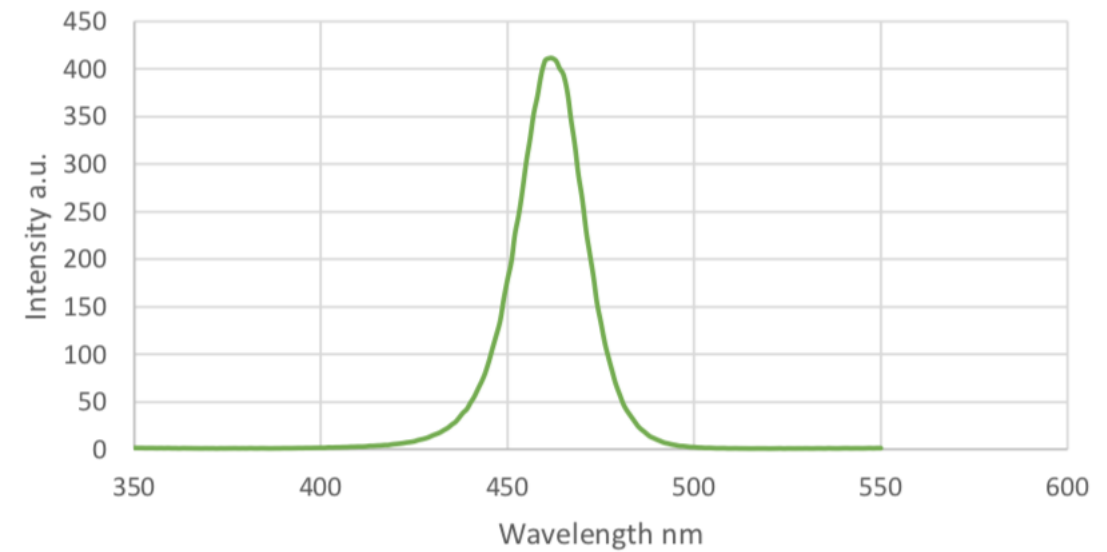
MEASUREMENTS OF ABSORPTION AND EMISSION (TOLUENE)

- Absorption: 458nm
- Emission: 463nm
- Concentration found by Lambert-Beer law: $1.25 \times 10^{-8} \frac{\text{mol}}{\text{L}}$
- Lambert-Beer law: $A = \epsilon CL$

QDs In Toluene Absorption



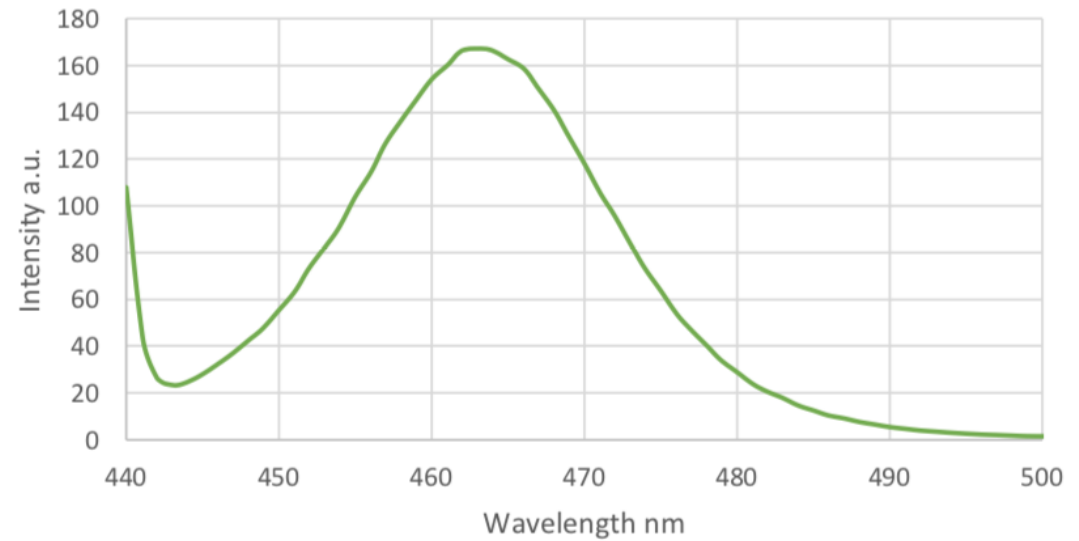
QDs in Toluene Emission Spectra



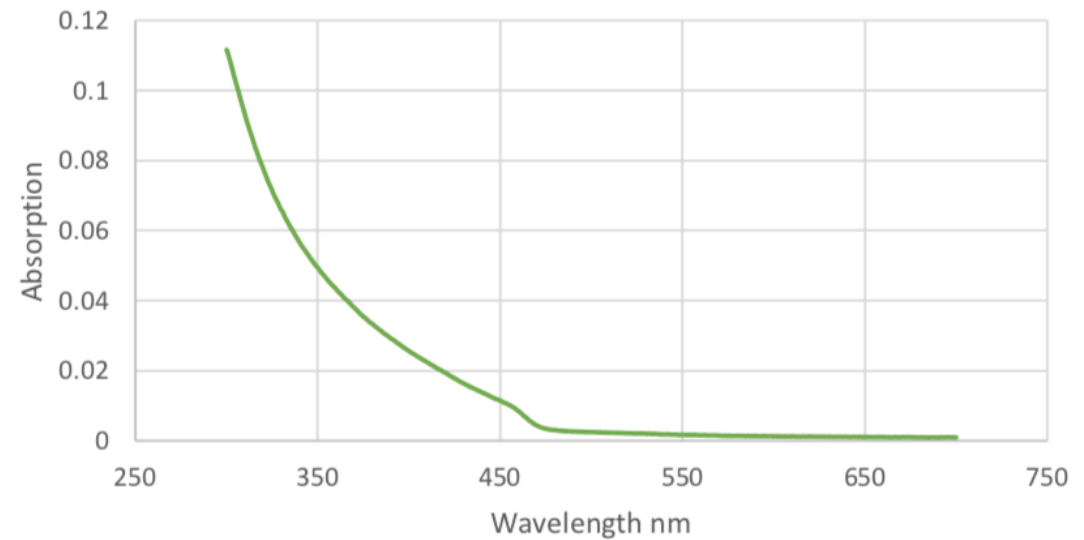
MEASUREMENTS OF ABSORPTION AND EMISSION (WATER)

- Absorption: 460nm
- Emission: 465nm
- Concentration: $6.96 \times 10^{-9} \frac{\text{mol}}{\text{L}}$

QDs OA coated in Water Emission Spectra

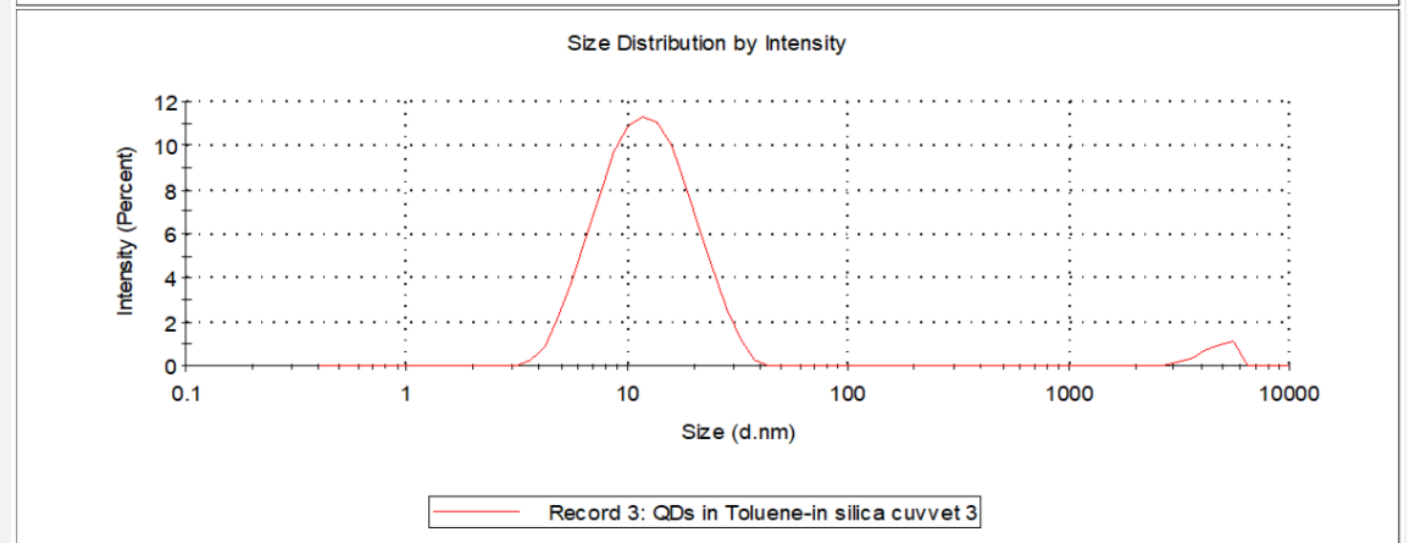
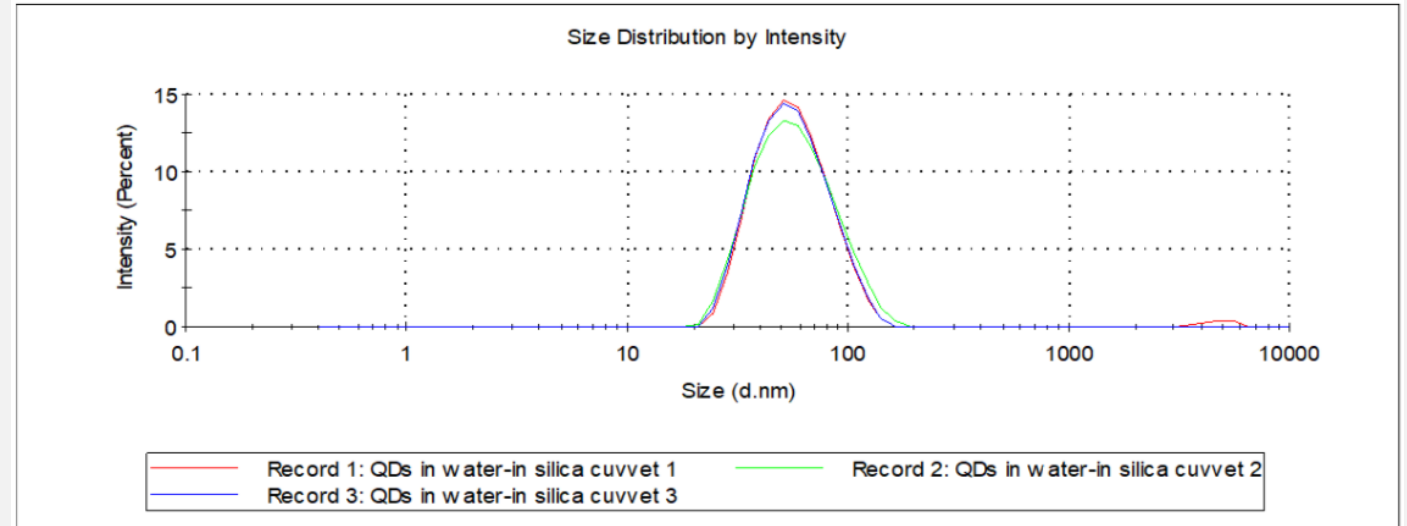


QDs OA coated in Water Absorption



MEASUREMENTS OF SIZE

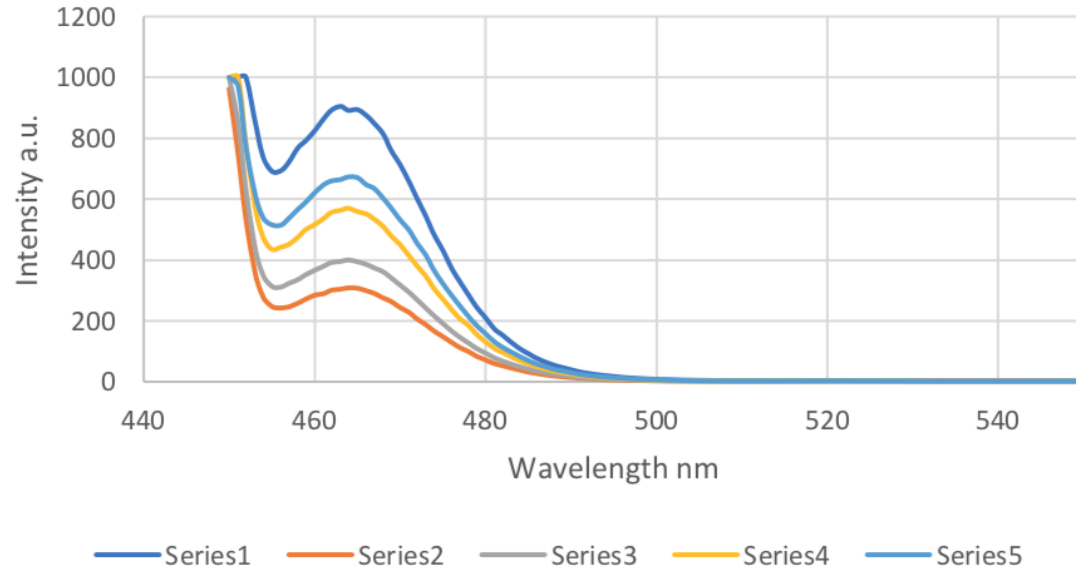
- Measured through dynamic light scattering
- Calculations carried out by the software
- QDs in Toluene: 13.46nm
- QDs in Water: 59.1 nm
- Literature value: 5nm



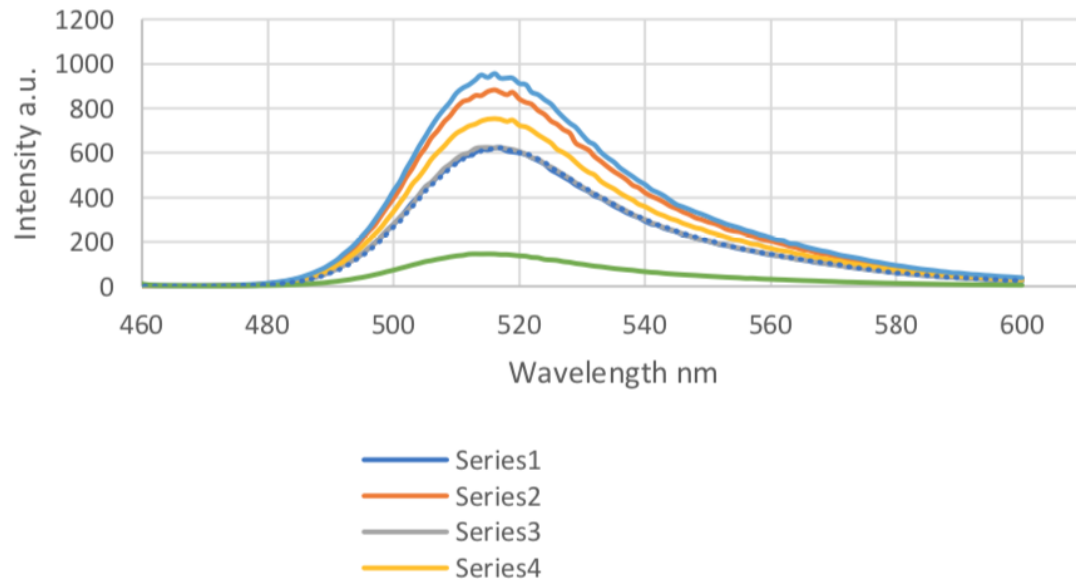
MEASUREMENTS OF QUANTUM YIELD

- Compared with AF488 Dye
- Comparative method based on fluorescence
- $Q_s = Q_r \times \left(\frac{m_s}{m_r}\right) \times \left(\frac{n_s}{n_r}\right)^2$
- Result: 55%
- Reported value by manufacturer: 50%

QDs OA coated Emission Spectra

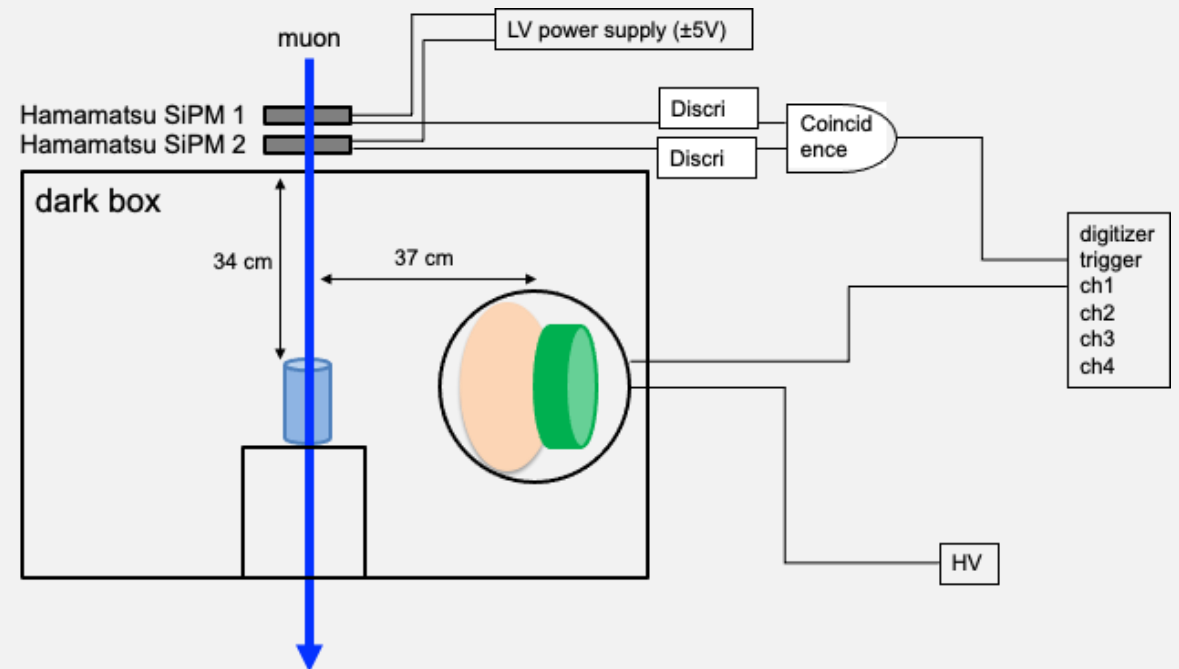
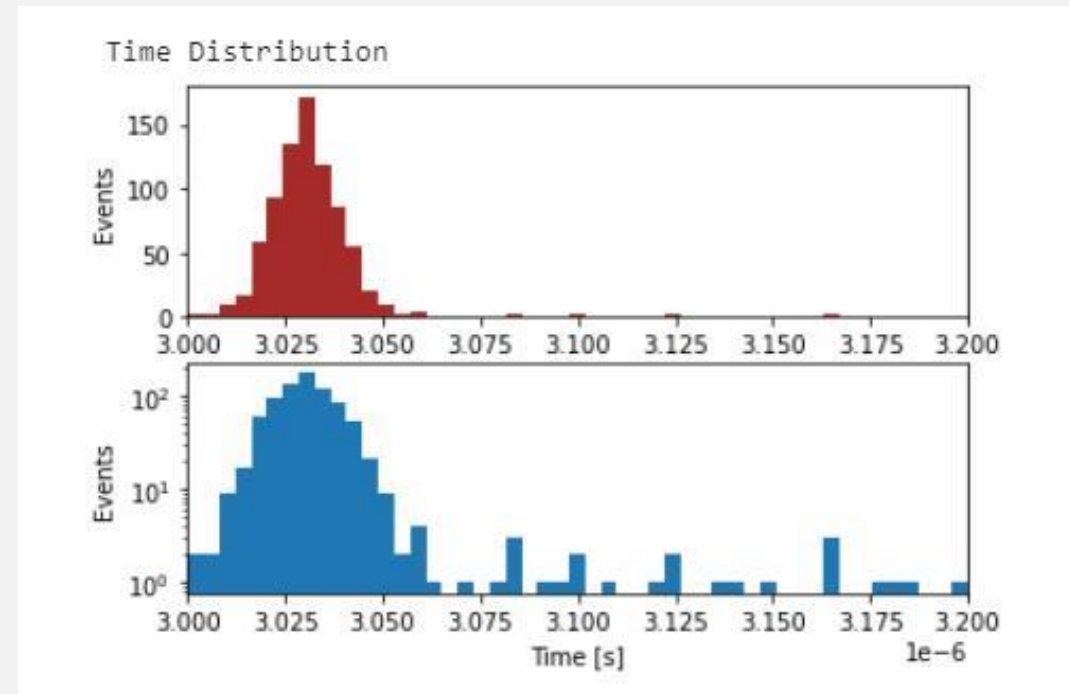
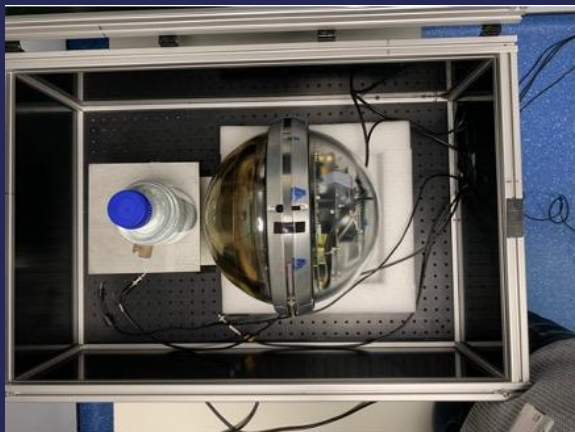


AF488 Emission Spectra



COSMIC RAY TESTING

- 2 cosmic ray taggers
- 10-inch PMT to record emission
- Time and charge distribution (<50ns)



CONCLUSIONS

- OA encapsulation is made to make water-based liquid scintillator
- We confirmed optical properties are not damaged by OA coating
- Cosmic rays are successfully measured by water-based CdS QDs

Acknowledgements

We thank Steve Po and Miao Zhao in helping us to produce and maintain the QDs sample. We thank Dipanjan Mitra in helping us to set up the cosmic ray test system at the EPAP lab. We thank Dipanjan Mitra, Mahdi Taani, and Pratyaksha Purohit for the help on cosmic ray data analysis.

