



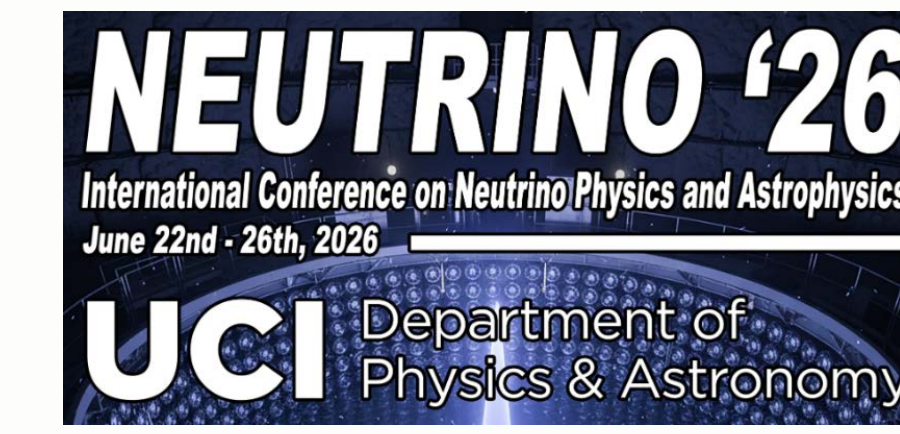
The Production of JUNO Liquid Scintillator



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1 – Introduction

- The Jiangmen Underground Neutrino Observatory (JUNO) is a multi-purpose experiment located in southern China.
- Primary Goals: Determine neutrino mass ordering and perform precision measurements of neutrino oscillation parameters.
- Central Detector: A 35.4 m diameter acrylic sphere containing 20-kt of liquid scintillator (LS).
- Physics Requirements: The LS must achieve a high light yield, long attenuation length, and ultra-low radioactive background.
- Production Milestone: From February to August 2025, 20-kt of LS was successfully produced, purified, and filled at a flow rate of 7 m³/h.

2 – LS Composition & Raw Material Purity

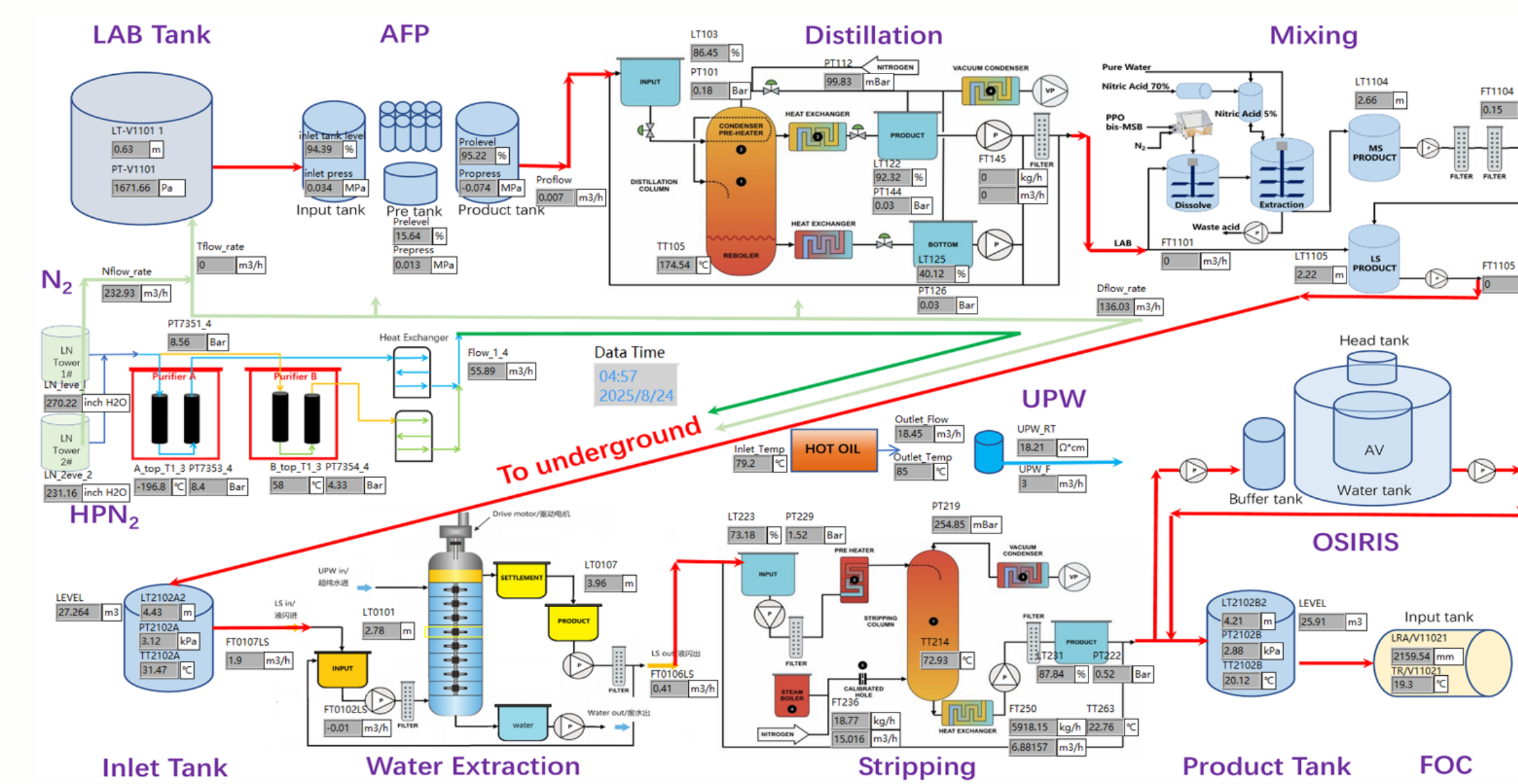
- To meet JUNO's strict requirements, specially manufactured high-purity raw materials were utilized. The baseline LS recipe consists of LAB + 2.5 g/L PPO + 3 mg/L bis-MSB + 50 mg/kg BHT.

Component	Quantity	Quality	Th/U Contribution to 20 kt LS	Transportation
Fluor(PPO)	60 t	✓ Optically qualified	✓ 2~3*10 ⁻¹⁶ g/g	3 layers vacuum plastic bags
Wavelength shifter(bis-MSB)	72 kg	✓ Optically qualified	✓ ~1*10 ⁻¹⁷ g/g	
Antioxidant(BHT)	1 t	✓ Optically qualified	✓ 4~7*10 ⁻¹⁸ g/g	brand new Iso-tanks
Solvent(LAB)	20 kt	✓ Optical & U/Th qualified	✓ ~1*10 ⁻¹⁵ g/g	

- Key Target Limits: ²³⁸U and ²³²Th < 1.0 × 10⁻¹⁵ g/g, and average Optical Attenuation Length > 20 m @ 430 nm.

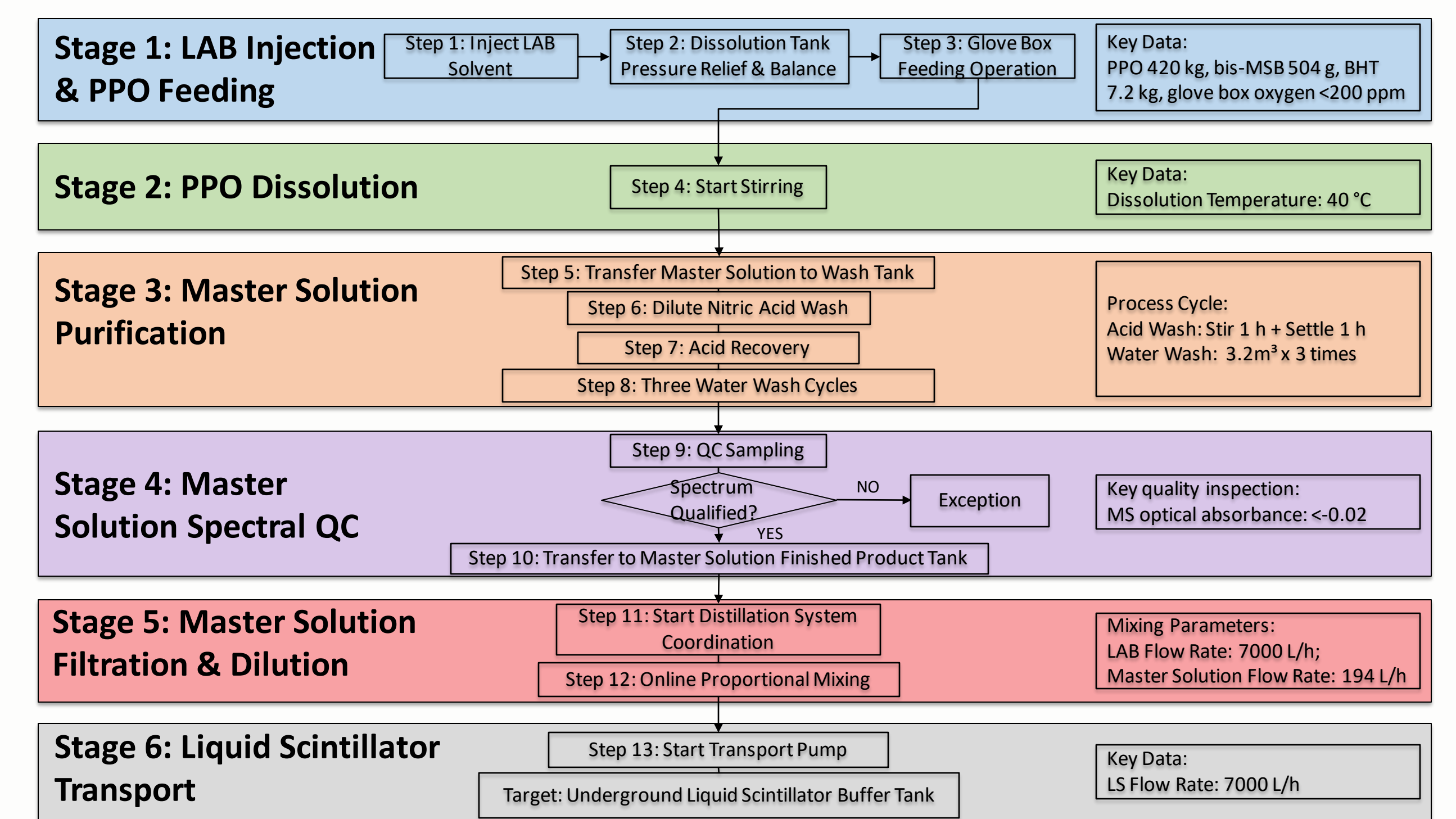
3 – The JUNO LS Purification Chain

- An on-site production line was designed and constructed to achieve these specifications, supported by dedicated ultrapure water and high-purity nitrogen plants.
- The macroscopic purification chain involves: Alumina Filtration → Distillation → Mixing → Water Extraction → Gas Stripping.



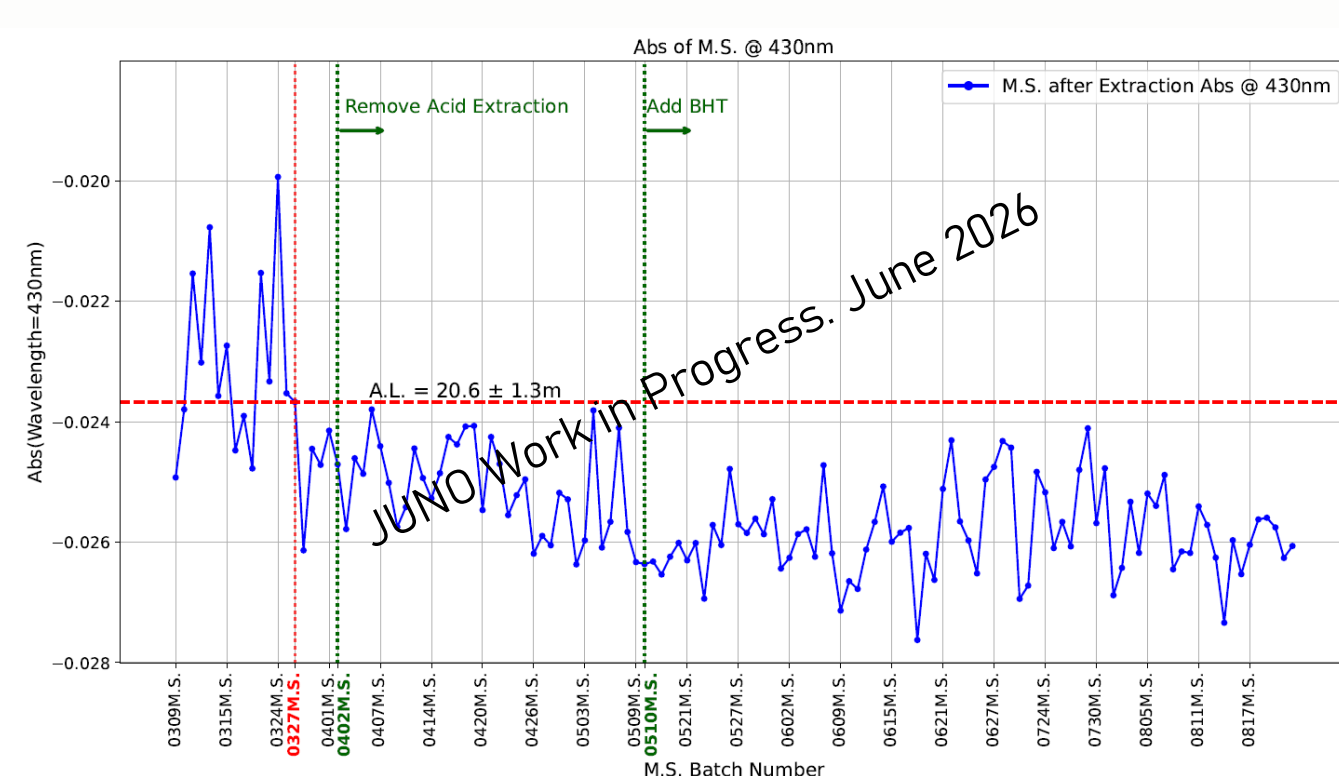
4 – The Mixing Flowchart

- The LS mixing was executed across six rigorous stages.

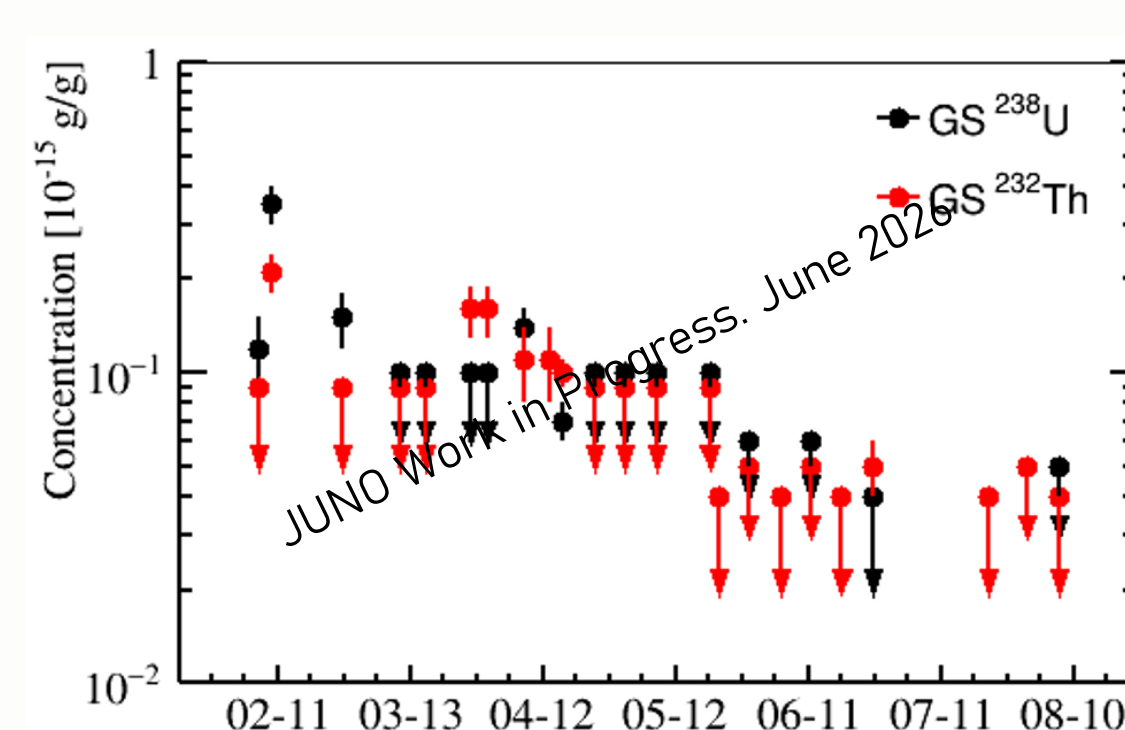


5 – The Quality Control

- Dynamic Tiered Strategy:** A two-tiered QC program continuously monitored standard parameters to ensure process stability, supported by rapid crisis management protocols.
- Continuous Monitoring:** Continuous batch-by-batch Master Solution absorbance inspections, alongside U/Th concentrations were verified via ICP-MS.



Batch-by-batch absorbance quality inspection of Master Solution



Monitoring of U/Th in filling LS by ICP-MS

6 – Operational Standardization

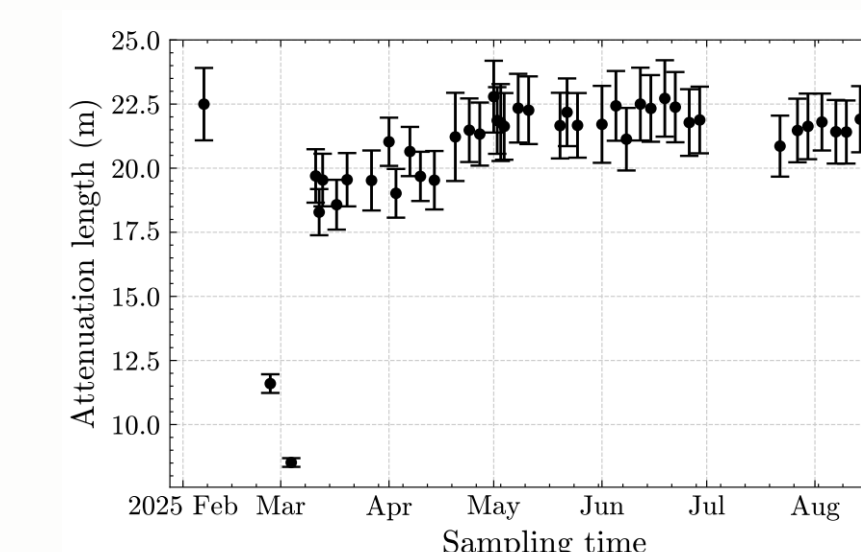
- Impeccable Execution:** Comprehensive Standard Operating Procedures (SOPs) were developed and strictly enforced. Thanks to rigorous training, there were zero critical operator errors throughout the entire 209-day production period.



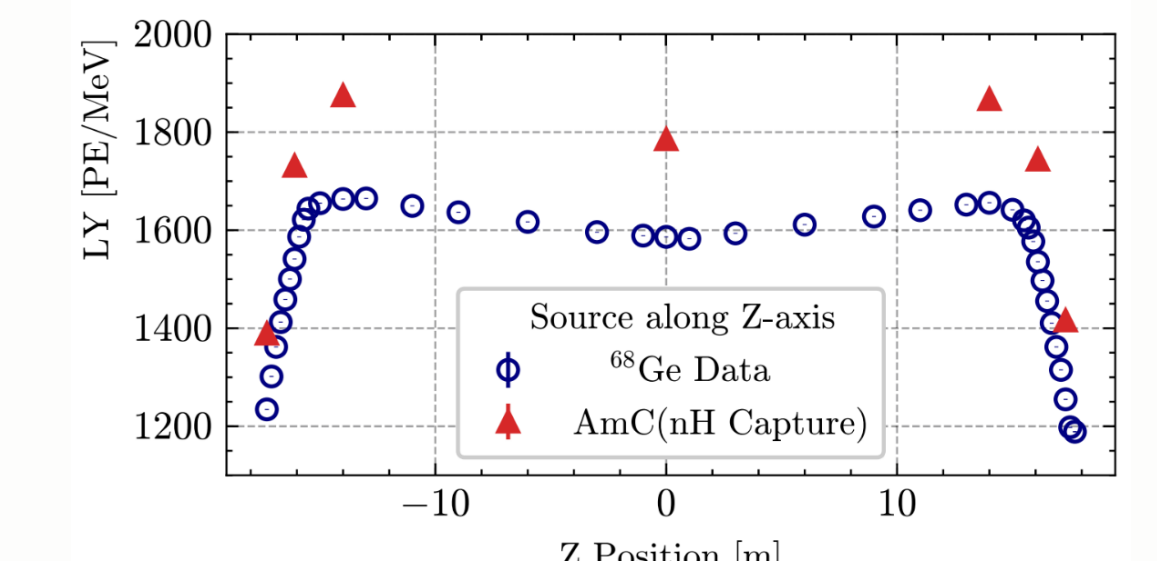
Group photo of the entire team involved in the LS production campaign

7 – Final LS Performance

- Radiopurity:** Achieved ultra-low contamination levels of (7.5 ± 0.9) × 10⁻¹⁷ g/g for ²³⁸U and (8.2 ± 0.7) × 10⁻¹⁷ g/g for ²³²Th measured by CD. [1]
- Attenuation Length:** Reached an average of > 20 meters, with final measurements yielding 20.6 m @ 430 nm, thoroughly fulfilling critical physics requirements. [1]
- Light Yield:** Achieved a high light yield of 1785 PE/MeV at the center of the detector, exceeding initial expectations. [1]



The LS attenuation length was measured throughout the six-month filling phase @430 nm [1]



LY measured with the ⁶⁸Ge and the AmC sources by CD [1]
Reference: [1] Angel Abusleme et al 2026 Chinese Phys. C 50 043001.