The Liquid Scintillator of JUNO

Presented by
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On behalf of the JUNO collaboration

XIX International Workshop on Neutrino Telescopes 2021, ONLINE (ZOOM)
Neutrino Masses and Mixing Parallel Session

February 24th, 2021
Central detector:
• Acrylic sphere with 20 ktons liquid scintillator (LAB+fluors)
• 17571 large PMTs (20-inch)
• 25600 small PMTs (3-inch)
• 78% PMT coverage

Water Cherenkov muon veto:
• 2400 20-inch PMTs
• 35 ktons ultra-pure water

LS Recipe
• Linear alkyl benzene (LAB) + 2.5 g/L PPO + 3 mg/L bisMSB

LS optical requirements
• Light output: \( \sim 10,000 \text{ Photons / MeV} \rightarrow \sim 1200 \text{ p.e. / MeV} \)
• Attenuation length: > 20 m @ 430 nm

LS radio-purity requirements:
• Reactor anti-neutrino physics: \(^{238}\text{U} / ^{232}\text{Th} < 10^{-15} \text{ g/g, } ^{40}\text{K} < 10^{-16} \text{ g/g}\)
• Solar neutrino physics: \(^{238}\text{U} / ^{232}\text{Th} < 10^{-17} \text{ g/g, } ^{40}\text{K} < 10^{-18} \text{ g/g, } ^{14}\text{C} < 10^{-18} \text{ g/g}\)
LIQUID SCINTILLATOR PURIFICATION TEST at DAYA BAY

Absorbance Spectrum

- Raw LAB Attenuation Length (A.L.) 20 m
- LAB A.L. after Alumina treatment 23.3 m
- LAB A.L. after distillation 25.4 m
- LAB A.L. after water extraction 24.6 m
- LAB A.L. after steam stripping 24.4 m
- Stripping efficiency 95.8% ± 1.1%

Stripping efficiency: 95.8% ± 1.1%

Abusleme et al. - Optimization of the JUNO liquid scintillator composition using a Daya Bay antineutrino detector - NIM A, 988, 164823 (2021)
Purification of LAB in 4 Steps:

- **Al₂O₃ filtration column**: improvement of optical properties
- **Distillation**: removal of heavy metals, improvement of transparency
- **Water Extraction**: removal of radio isotopes from uranium and thorium chain and furthermore of ^{40}K (underground)
- **Steam / Nitrogen Stripping**: removal of gaseous impurities like ^{39}Ar, ^{85}Kr, and ^{222}Rn (underground)
Status of the alumina filtration plant:
- All tubes were connected
- The cabinets were completed
- 8 pumps were tested
- The columns were tested at a P = 19 bar
- under construction and will be ready for installation later in March

Status of the distillation plant
- Equipment and piping production and cleaning is completed
- All equipment installed inside skids
- Helium leak test finished
- completed and delivered at JUNO site

Alumina filtration process parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Height [m]</td>
<td>2.6</td>
</tr>
<tr>
<td>Height/Diameter</td>
<td>3:1</td>
</tr>
<tr>
<td>N° Columns</td>
<td>8</td>
</tr>
<tr>
<td>Pressure [bar]</td>
<td>&gt;10</td>
</tr>
<tr>
<td>Scint. Flux [l/h]</td>
<td>7000</td>
</tr>
<tr>
<td>Bed Volume [l]</td>
<td>500</td>
</tr>
<tr>
<td>Filters [nm]</td>
<td>220/50</td>
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</tbody>
</table>

Distillation process parameters

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Value</th>
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</thead>
<tbody>
<tr>
<td>Height [m]</td>
<td>4</td>
</tr>
<tr>
<td>Height/Diameter</td>
<td>4:2</td>
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<tr>
<td>N° Trays</td>
<td>6</td>
</tr>
<tr>
<td>Pressure [mbar]</td>
<td>10</td>
</tr>
<tr>
<td>Temperature [°C]</td>
<td>200</td>
</tr>
<tr>
<td>Scint. Flux [l/h]</td>
<td>7000</td>
</tr>
<tr>
<td>Max Gas flow [kg/h]</td>
<td>50</td>
</tr>
</tbody>
</table>
Status of the Water Extraction plant:
- Finished production of the columns and its internal parts
- Finished the welding of the four tanks
- Heat exchanger will be manufactured in March
- Under construction and will be ready for installation in July

Status of the steam stripping plant:
- Equipment and piping production and cleaning is completed
- All equipment installed inside skids
- Helium leak test finished
- Completed and delivered at JUNO site
Thank you.

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Thank you
Thank you
BackUp
MOTIVATION FOR LIQUID SCINTILLATOR PURIFICATION

Liquid scintillator: 20 kton of Linear Alkyl-Benzene

Purification of LAB in 4 Steps:

• **Al₂O₃ filtration column:** improvement of optical properties
• **Distillation:** removal of heavy metals, improvement of transparency
• **Water Extraction:** removal of radio isotopes from uranium and thorium chain and furthermore of ⁴₀K (underground)
• **Steam / Nitrogen Stripping:** removal of gaseous impurities like ³⁹Ar, ⁸⁵Kr, and ²²²Rn (underground)

**Solvent:**
Linear alkylbenzene (LAB)

**Fluor**
2.5 g/l PPO

**Wavelength Shifter:**
3 mg/l Bis-MSB