

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

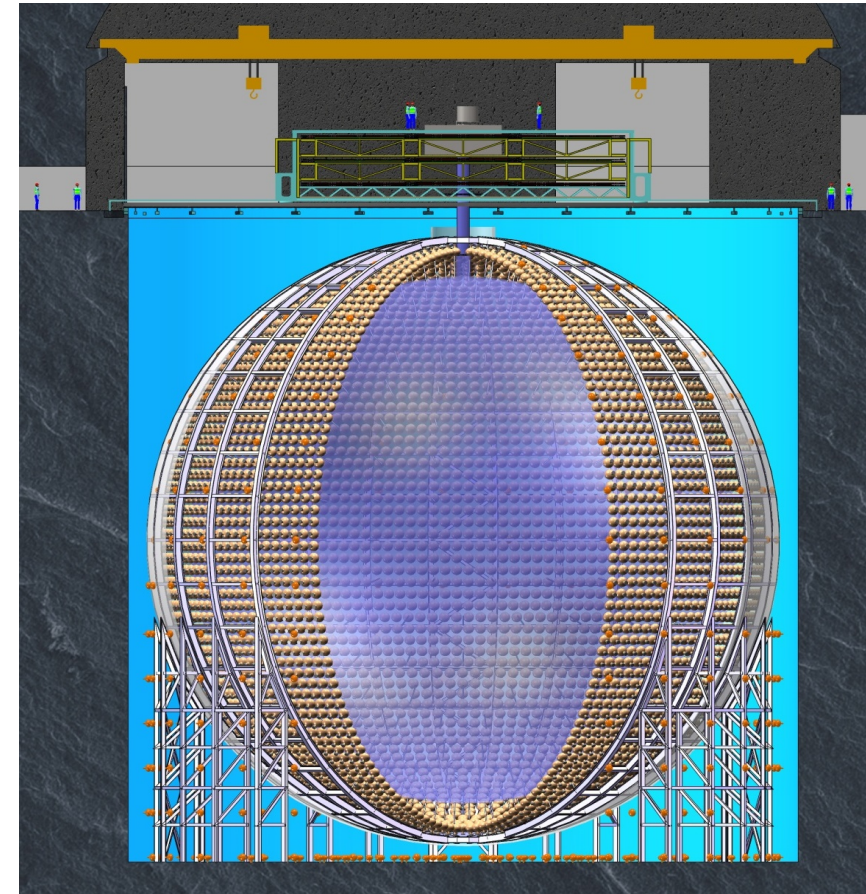
- Linear alkyl benzene (LAB) + 2.5 g/L PPO + 3 mg/L bisMSB

LS optical requirements

- Light output: ~ 10.000 Photons / MeV $\rightarrow \sim 1200$ p.e. / MeV
- Attenuation length: > 20 m @ 430 nm

LS radio-purity requirements :

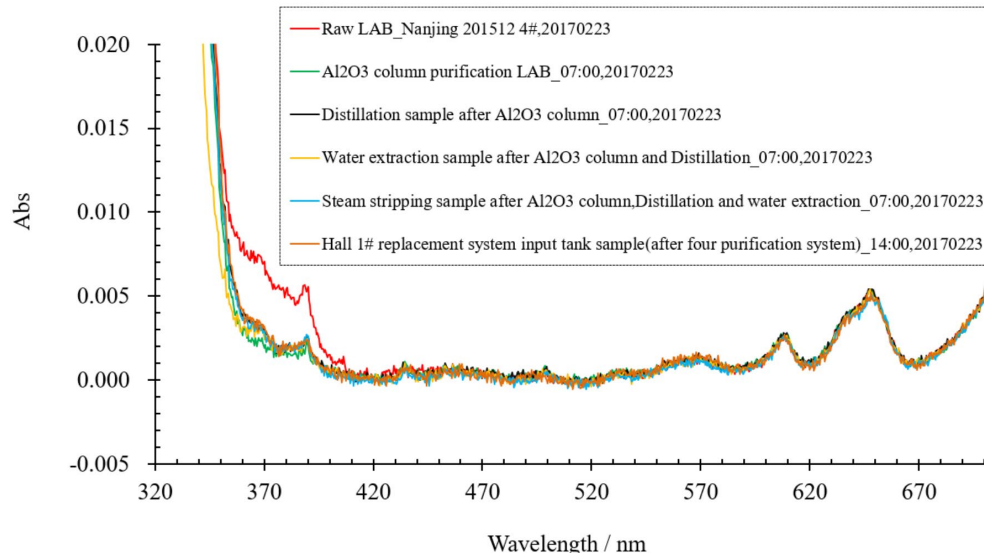
- Reactor anti-neutrino physics: $^{238}\text{U} / ^{232}\text{Th} < 10^{-15}$ g/g, $^{40}\text{K} < 10^{-16}$ g/g
- Solar neutrino physics: $^{238}\text{U} / ^{232}\text{Th} < 10^{-17}$ g/g, $^{40}\text{K} < 10^{-18}$ g/g, $^{14}\text{C} < 10^{-18}$ g/g



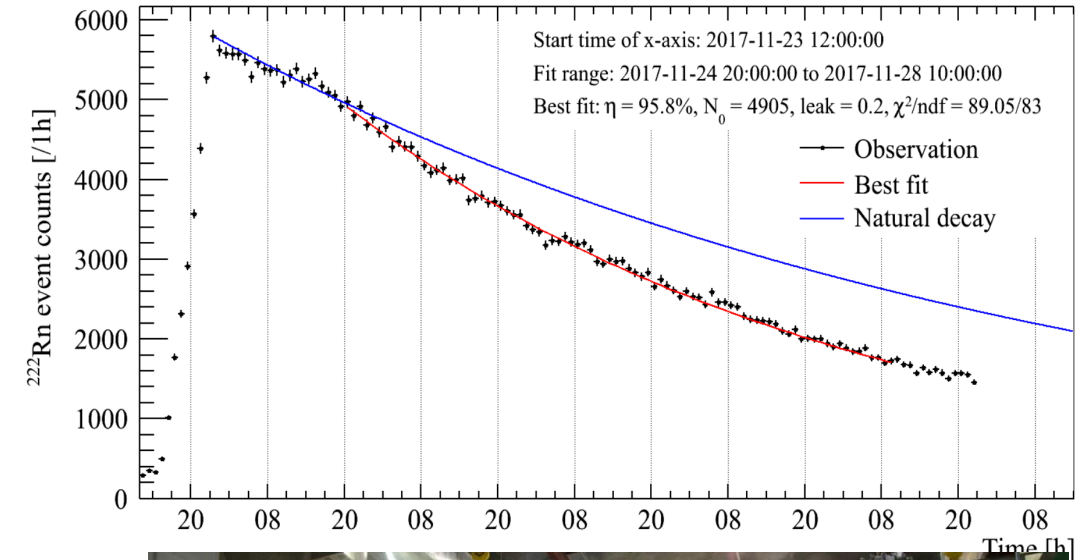
Technological Challenges

- Constant delivery of purified LS
- Underground laboratory
- Minimize the contamination of LS

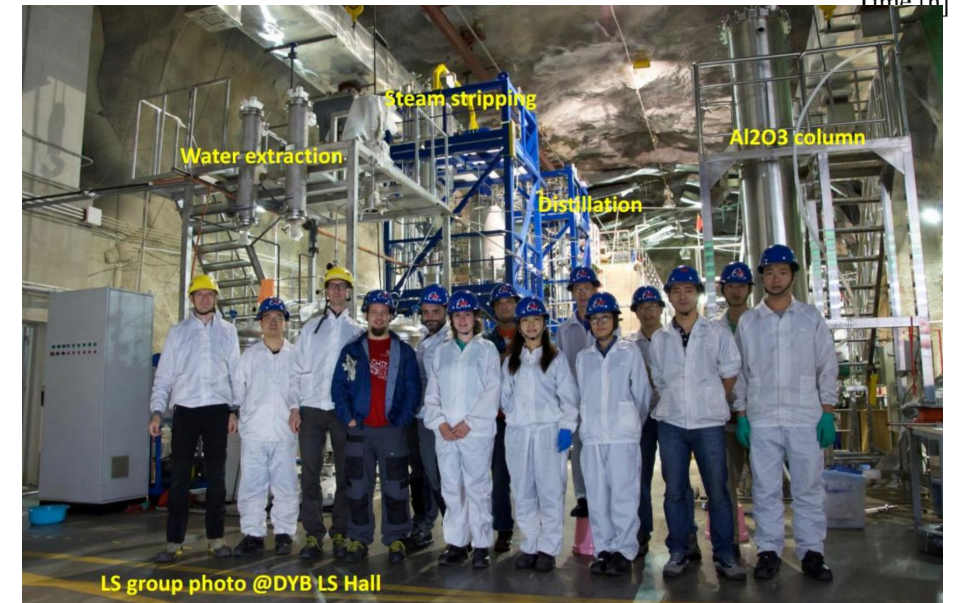
Absorbance Spectrum



Rn removal with Stripping pilot plant

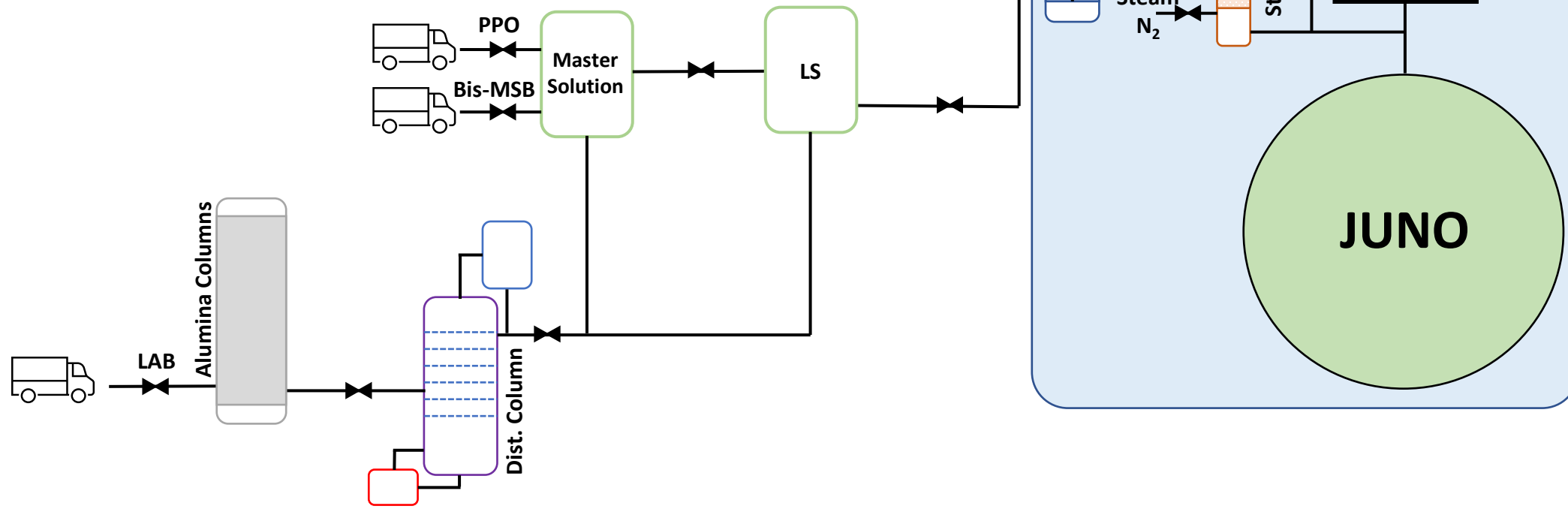


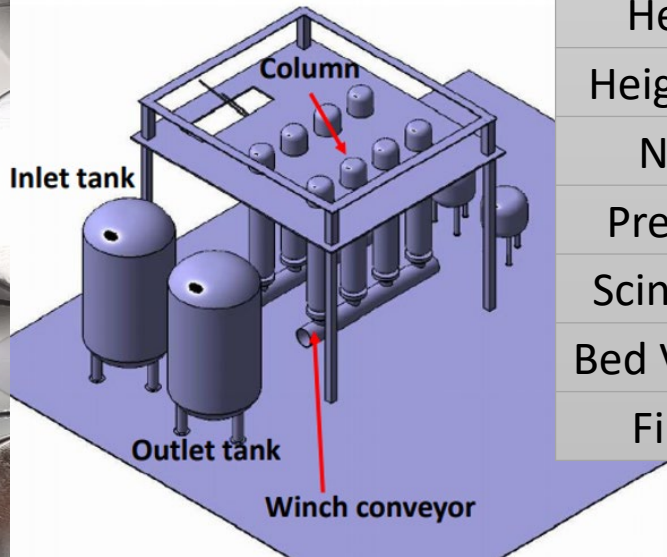
Raw LAB Attenuation Length (A.L.)	20 m
LAB A.L. after Alumina treatment	23.3 m
LAB A.L. after distillation	25.4 m
LAB A.L. after water extraction	24.6 m
LAB A.L. after steam stripping	24.4 m
Stripping efficiency	95.8% ^{+1.1%} _{-0.9%}



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**)



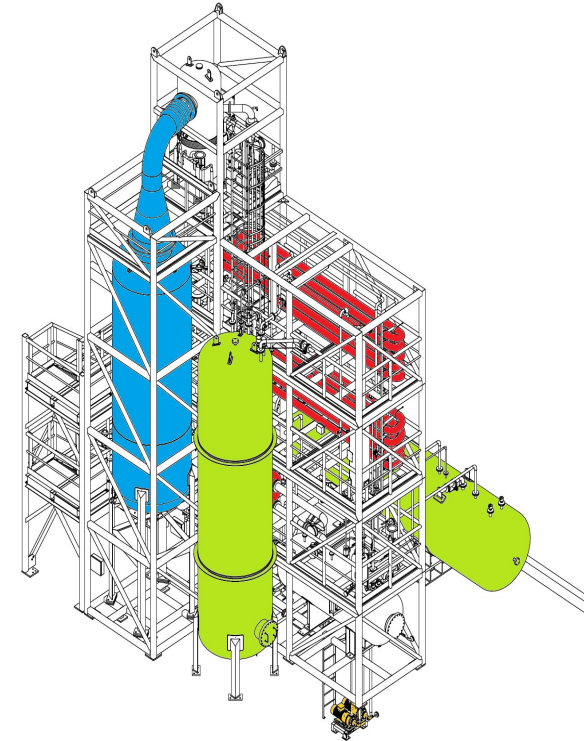


Alumina filtration process parameters

Height	[m]	2.6
Height/Diameter		3:1
N° Columns		8
Pressure	[bar]	>10
Scint. Flux	[l/h]	7000
Bed Volume	[l]	500
Filters	[nm]	220/50

Distillation process parameters

Height	[m]	4
Height/Diameter		4:2
N° Trays		6
Pressure	[mbar]	10
Temperature	[°C]	200
Scint. Flux	[l/h]	7000
Scint. Reflux	[l/h]	2000
Max Gas flow	[kg/h]	50

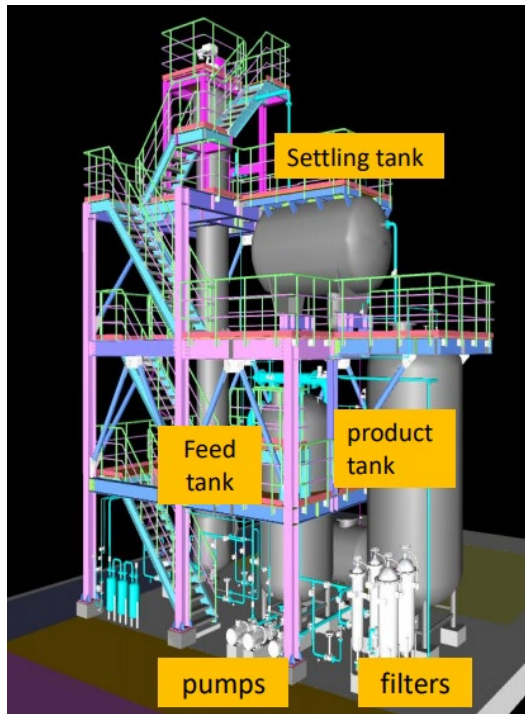


Status of the alumina filtration plant:

- 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

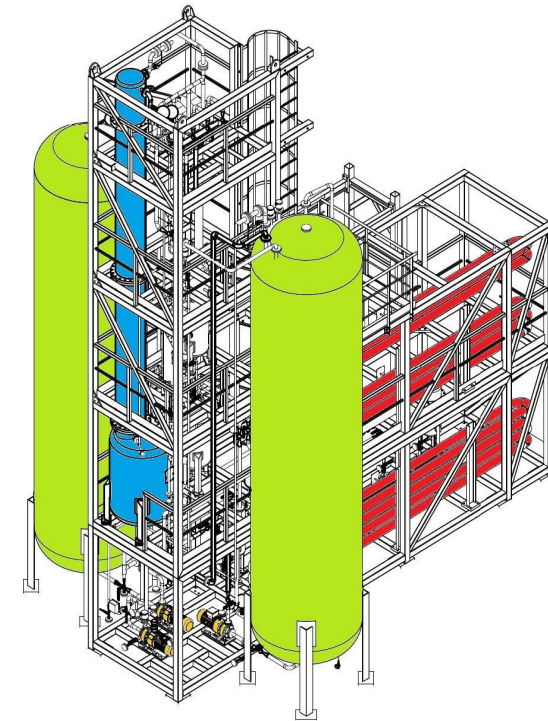


Water Extraction process parameters

Height	[m]	13
Diameter	[m]	1
N° T-Stages		>=5
Temp.	[°C]	80
Scint. Flux	[l/h]	7000
Water Flux	[l/h]	2300
Max Gas flow	[Nm ³ /h]	50

Steam stripping parameters

Height	[m]	6
Diameter	[m]	0.45
Unstructured Packing		
Pressure	[mbar]	300
Temp.	[°C]	90
Scint. Flux	[l/h]	7000
Steam Flux	[kg/h]	25
Gas flow	[kg/h]	60



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.

Contact:

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Istituto Nazionale di Fisica Nucleare

Thank you



Thank you



BackUp



MOTIVATION FOR LIQUID SCINTILLATOR PURIFICATION

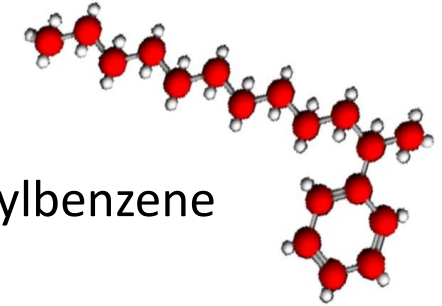
Liquid scintillator: 20 kton of Linear Alkyl-Benzene

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Solvent:

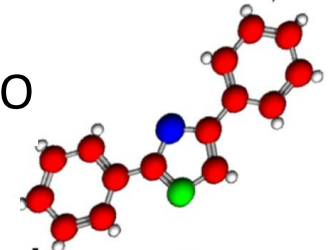
Linear alkylbenzene
(LAB)



non-radiative
→ 280nm

Fluor

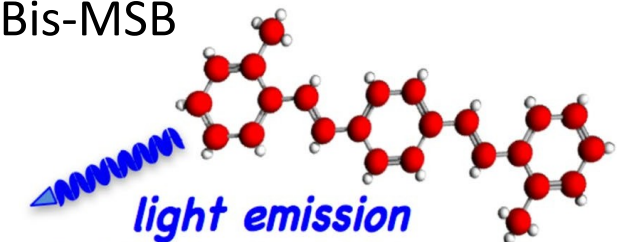
2.5 g/l PPO



non-radiative
→ 390nm

**Wavelength
Shifter:**

3 mg/l Bis-MSB



light emission
→ 430nm, $\tau \approx 4.4$ ns