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The Progress of JUNO Liquid Scintillation（LS） Research

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On behalf of JUNO LS group

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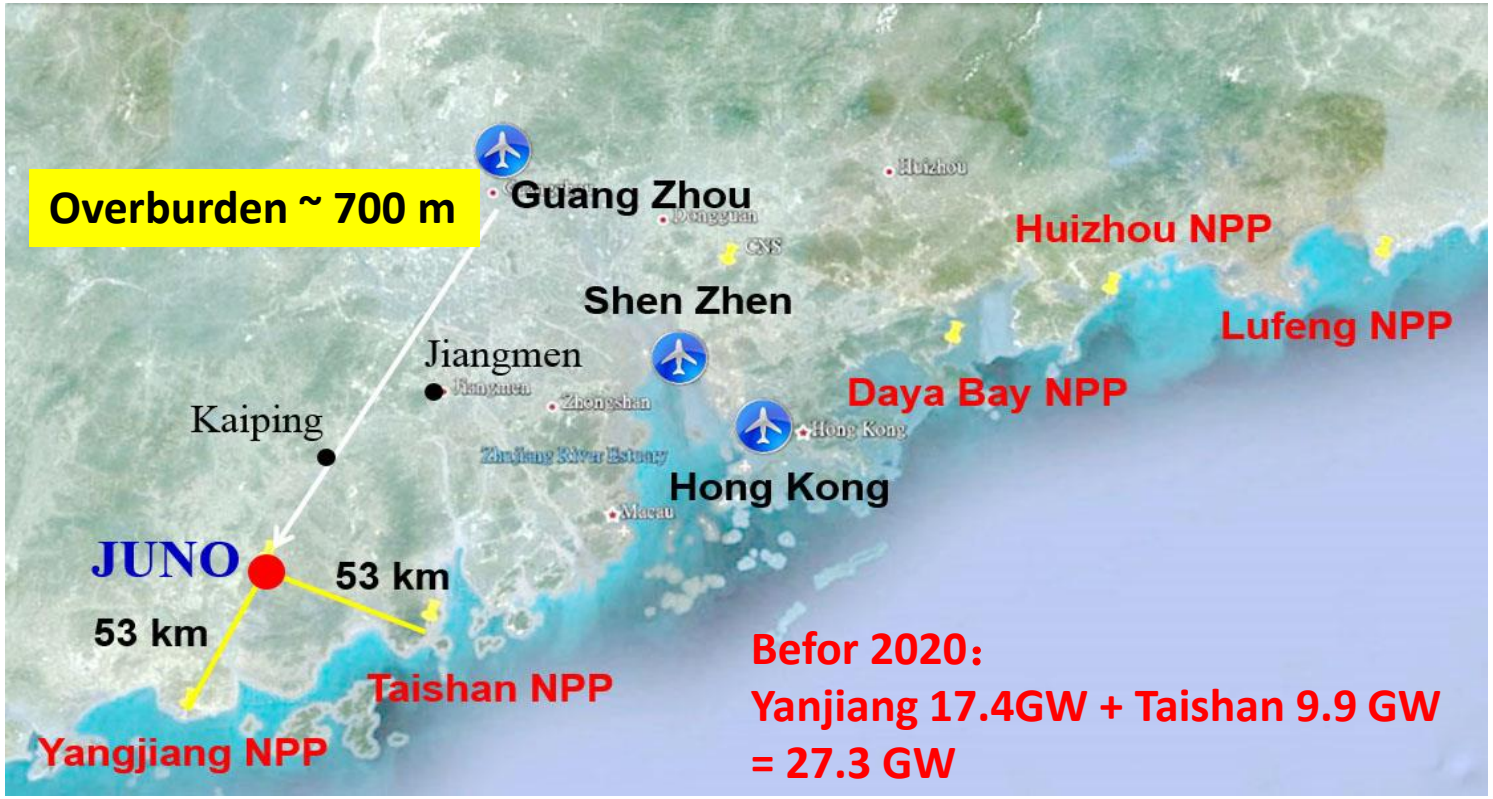
Outlines

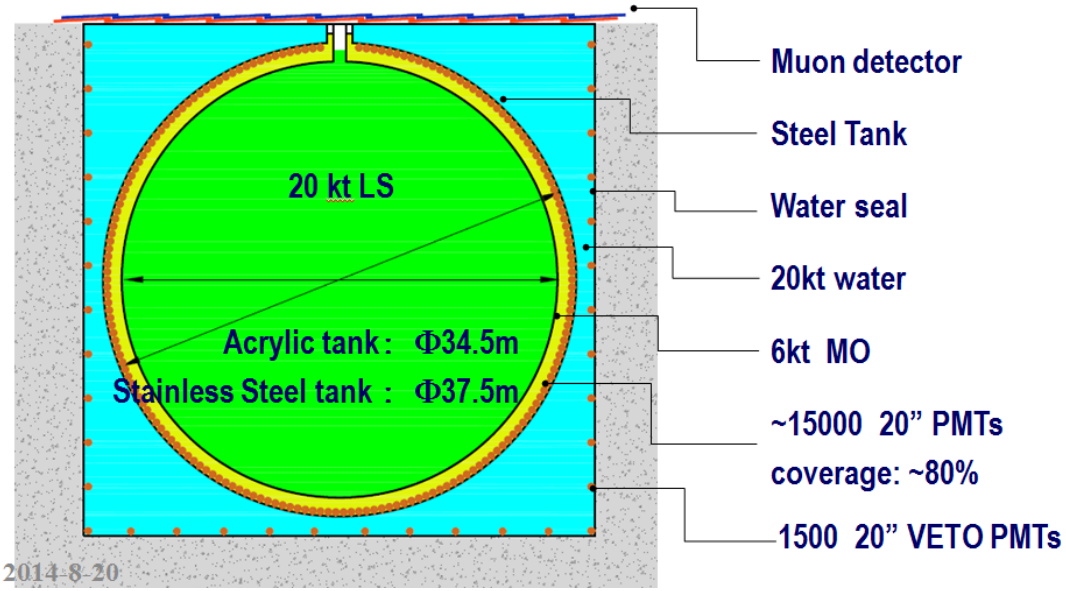
- **Introduction of Jiangmen Underground Neutrino Observatory**
- **LS research work in Laboratory**
  - Study of light yield
  - Optical purification methods
  - Radio-purification
  - LAB/LS Characterization
  - Scintillator response
- **LS Mass production**
  - Flow chat (conceptual design)
  - Civil construction
  - Chemicals: LAB, PPO, bis-MSB, Al2O3, N2, deionized water

Jiangmen Underground Neutrino Observatory

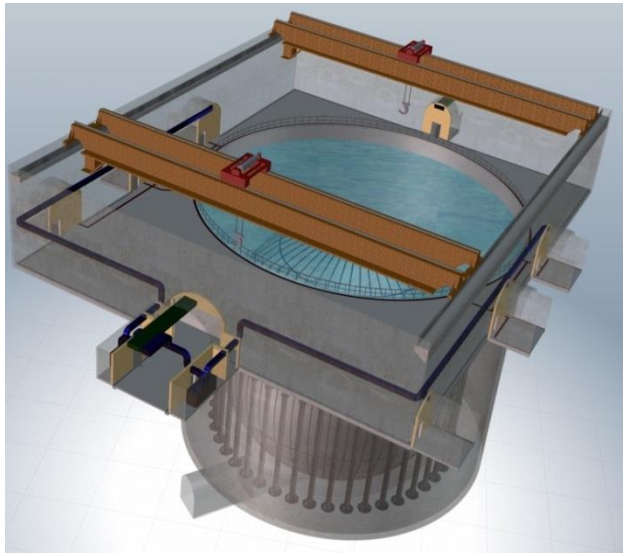


JUNO is located in Kaiping, Jiangmen, in Southern China. It's about 53 km from the Yangjiang and Taishan nuclear power plants, both of which are under construction. When complete in 2020, JUNO is expected to run for more than 20 years, to study the relationship between the three types of neutrino: electron, muon and tau."

The JUNO Experiment

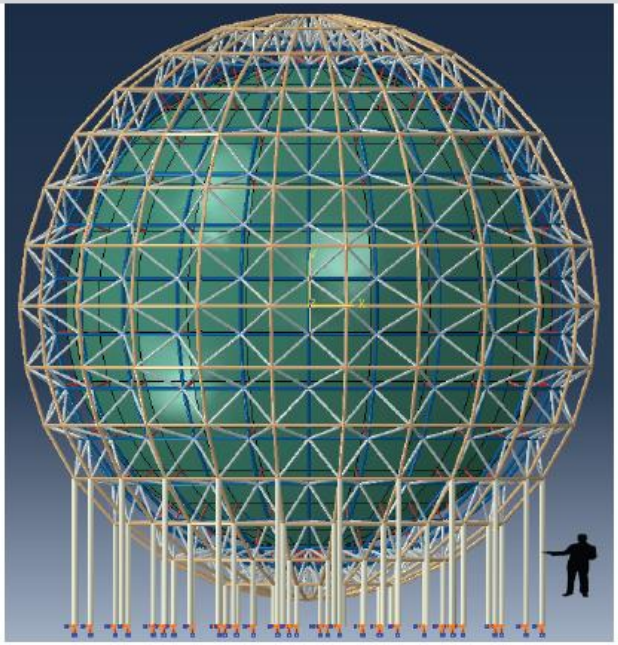


- 20 kton LS detector
- 3% energy resolution
- Rich physics possibilities
  - ⇨ Mass Hierarchy at Reactors
  - ⇨ Precision measurement of 4 mixing parameters
  - ⇨ Supernovae neutrinos
  - ⇨ Geoneutrinos
  - ⇨ Sterile neutrinos
  - ⇨ Atmospheric neutrinos
  - ⇨ Exotic searches

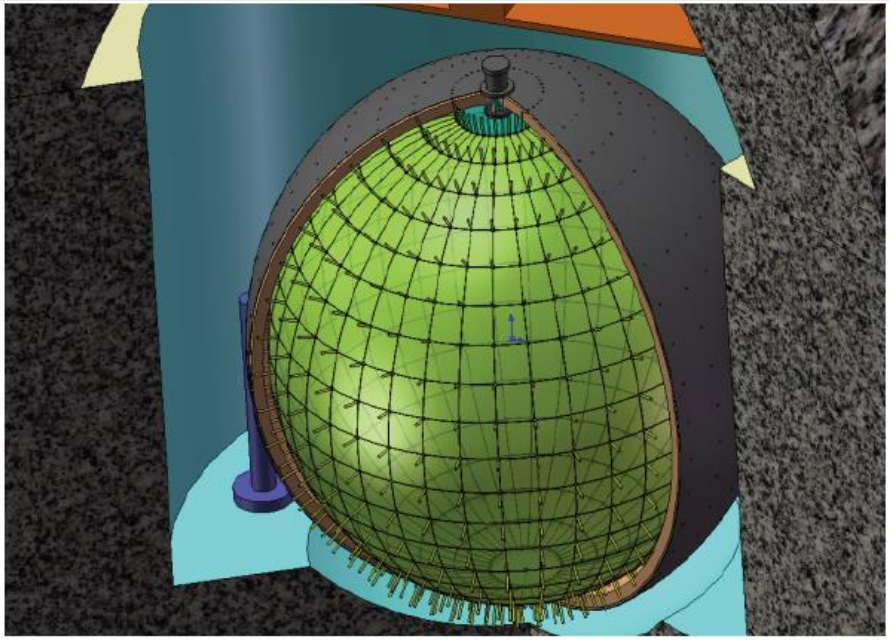


Experimental Hall

Two JUNO Detector Designs



- **Baseline design**: a 35m diameter acrylic sphere holds the LS
- Stainless truss provides mechanical supports to the acrylic sphere and the PMTs
- Designing/Improving details and interfaces with other components
- Independent FEA calculations



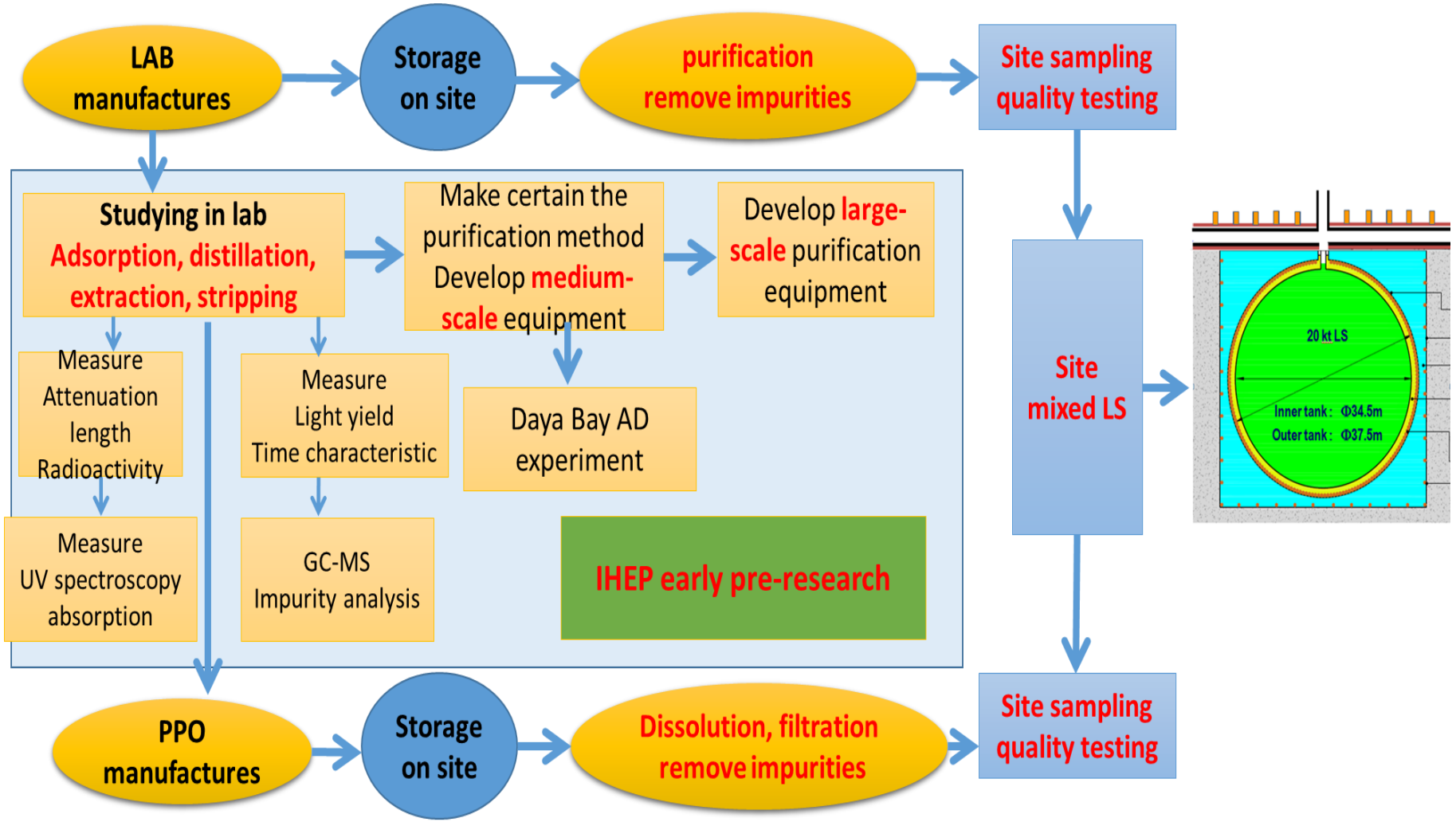
- Balloon holds the LS
- Acrylic panels+stainless steel sphere support the balloon and PMTs
- Better transmittance but bad fraction index matching
- Leakage and dusts are the serious concerns

Liquid Scintillator

- **Requirements & works:**
  - ⇨ **Low background: ➔ No Gd-loading**
  - ⇨ **Current Choice: LAB+PPO+Bis-MSB**
  - ⇨ **Long attenuation length: 15m ➔ >>22m**
    - ✓ **Improve raw materials**
    - ✓ **Improve the production process**
    - ✓ **Purification**
      - – **Distillation, Filtration, Water extraction, Nitrogen stripping…**
  - ⇨ **High light yield：Optimize the concentrations of fluors**
- **Other works：**
  - ⇨ **Rayleigh scattering length**
  - ⇨ **Energy non-linearity**
  - ⇨ **Aging test**
  - ⇨ **Engineering issues: equipment for 20kt**
  - ⇨ **Raw material selection: BKG & purity issues**

JUNO LS group

LS developed process



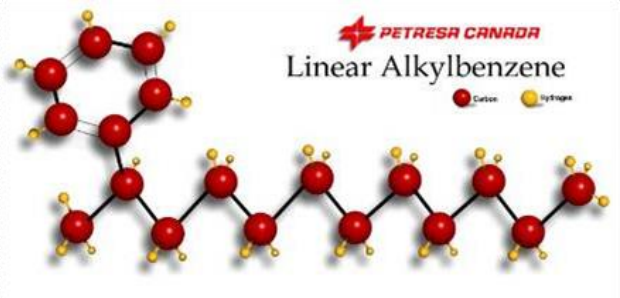
Liquid scintillator for JUNO

Preliminary recipe:

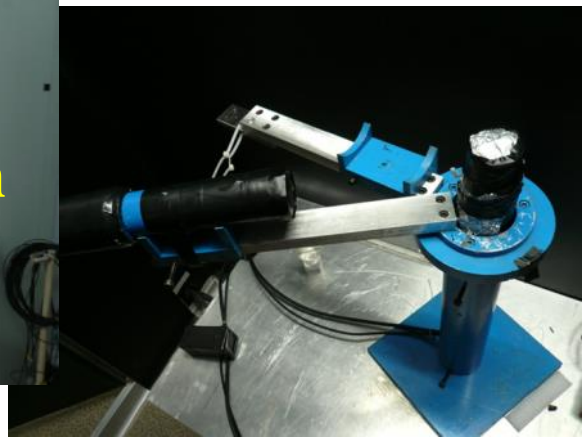
3g/L PPO, 15mg/L bis-MSB in LAB

- Long attenuation length
- High light yield
- Chemical inertness
- Compatible with containers
- High flash point, low toxicity, friendly to environment

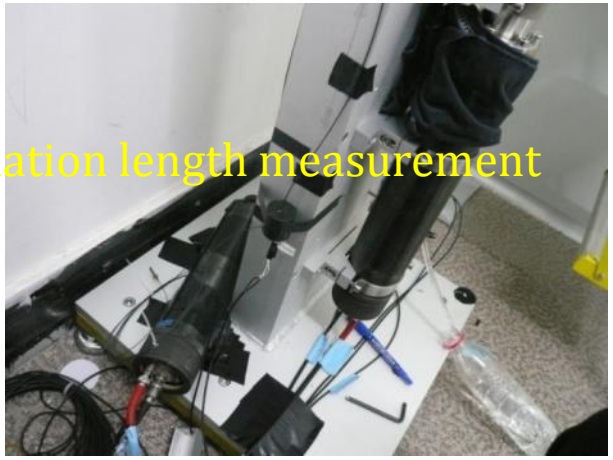
Linear alkyl benzene
- Commercially available
- Relatively cheap
- Transparent
- High light yield
- Biodegradable
- High flash point：130^{o}C



LS performance test equipment

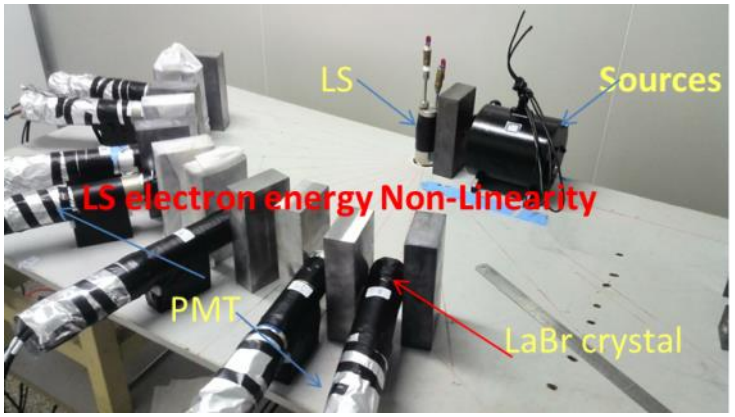


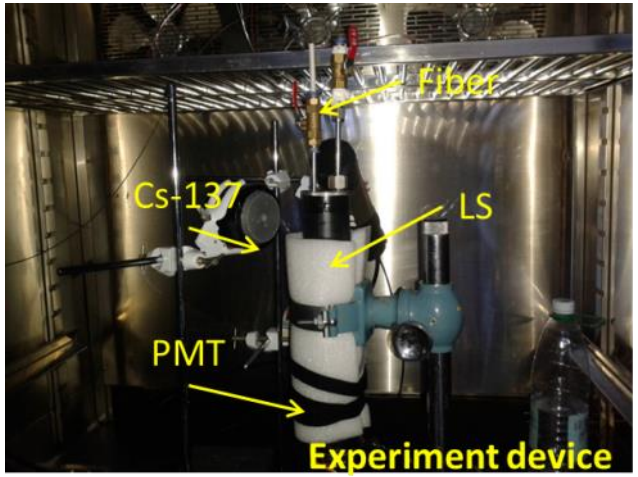
Light out
The attenuation length
Time property
UV-Vis spectra
GC-MS

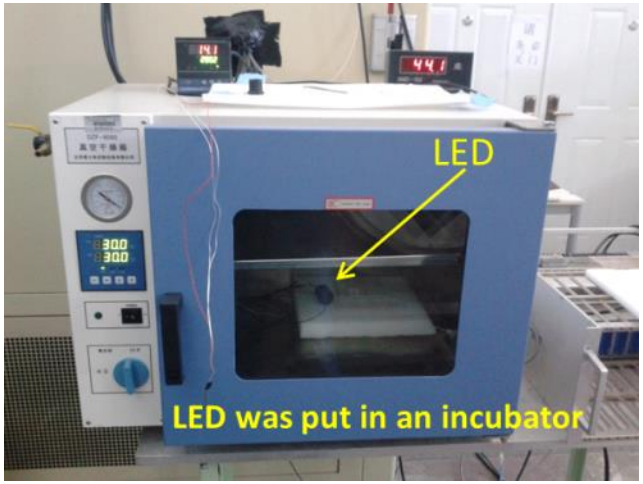


Performance measurements of LAB and LS

LS light out varies with temperature — detector design
LS light out varies PPO contents — LS final Formula
LS electron energy Non-Linearity — MC parameter
LS ageing test

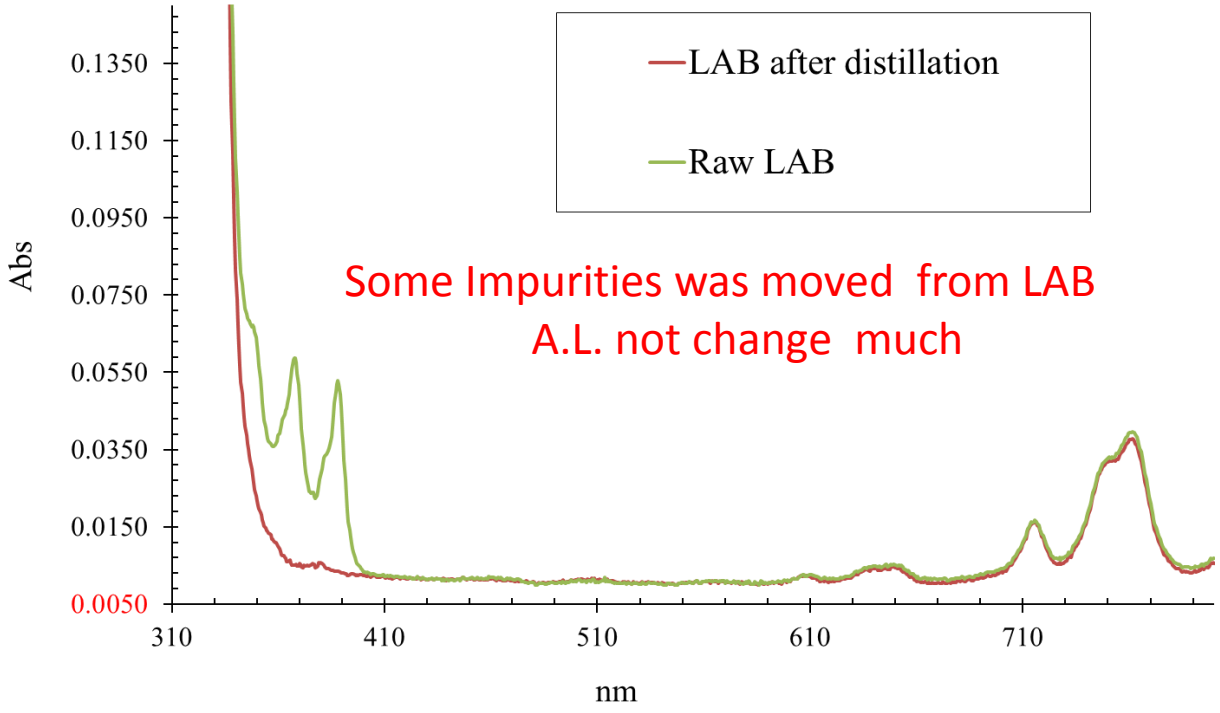






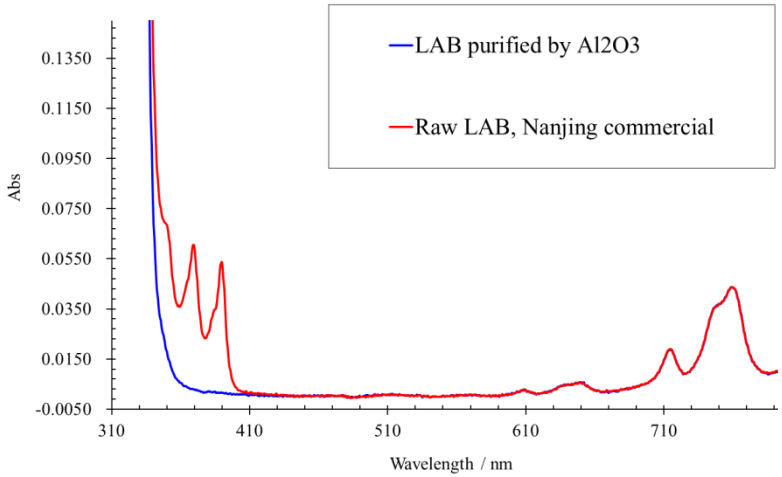
Distillation

- A small vacuum distillation system in the lab
- The distillation temperature, vacuum degree was optimized to get high quality distillate



Column purification (Al_2O_3)

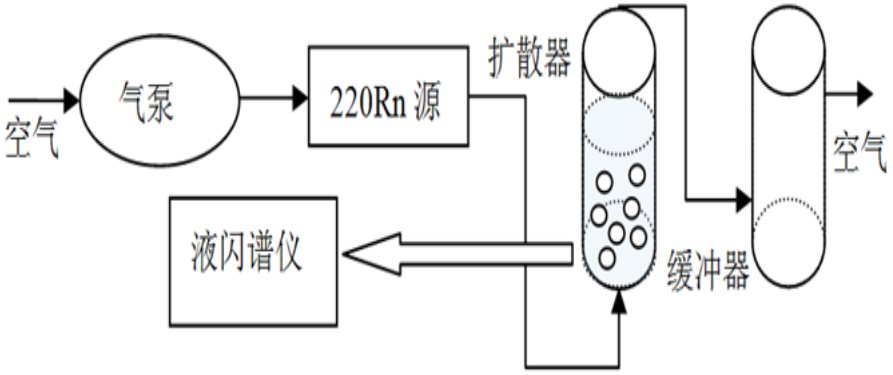
- Al_2O_3 column purification can greatly improve the A.L. and spectra of various LABs
  - Optimization parameters such as particle size, Al_2O_3-types, flow rate (pressure/vacuum)
  - Absorption spectrum and attenuation length, light yield
- Radio-impurities in alumina hydroxide



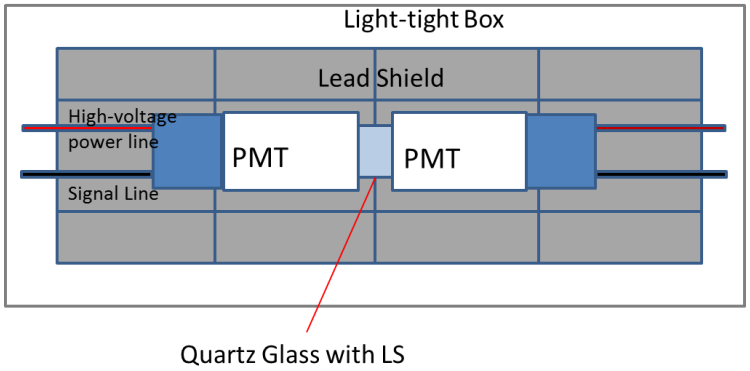
Linear Alky Benzene	Atte. L(m) @ 430 nm
RAW	14.2
Vacuum distillation	19.5
SiO_2 coloum	18.6
Al_2O_3 coloum	22.3
LAB from Nanjing, Raw	20
Al_2O_3 coloum	25

Study of radioactive purification

- Jiangmen neutrino experiment requires the radioactive background below 10^{-15}g/g
- the radioactive loading method be used in the LAB , filtration, distillation, water extraction the efficiency was measured



radioactive loading



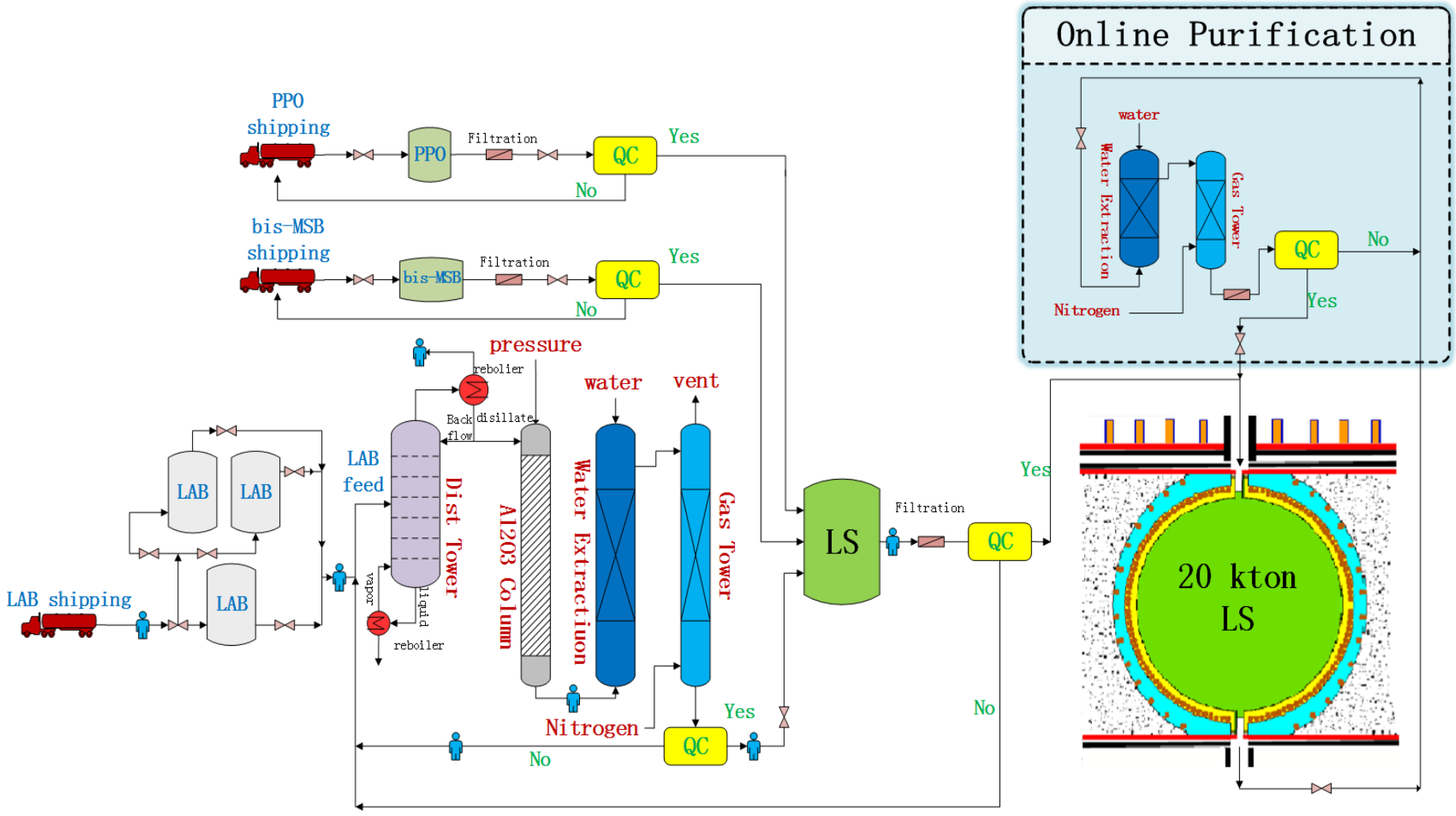
Measurement Device

Efficiency of different radio-purification methods

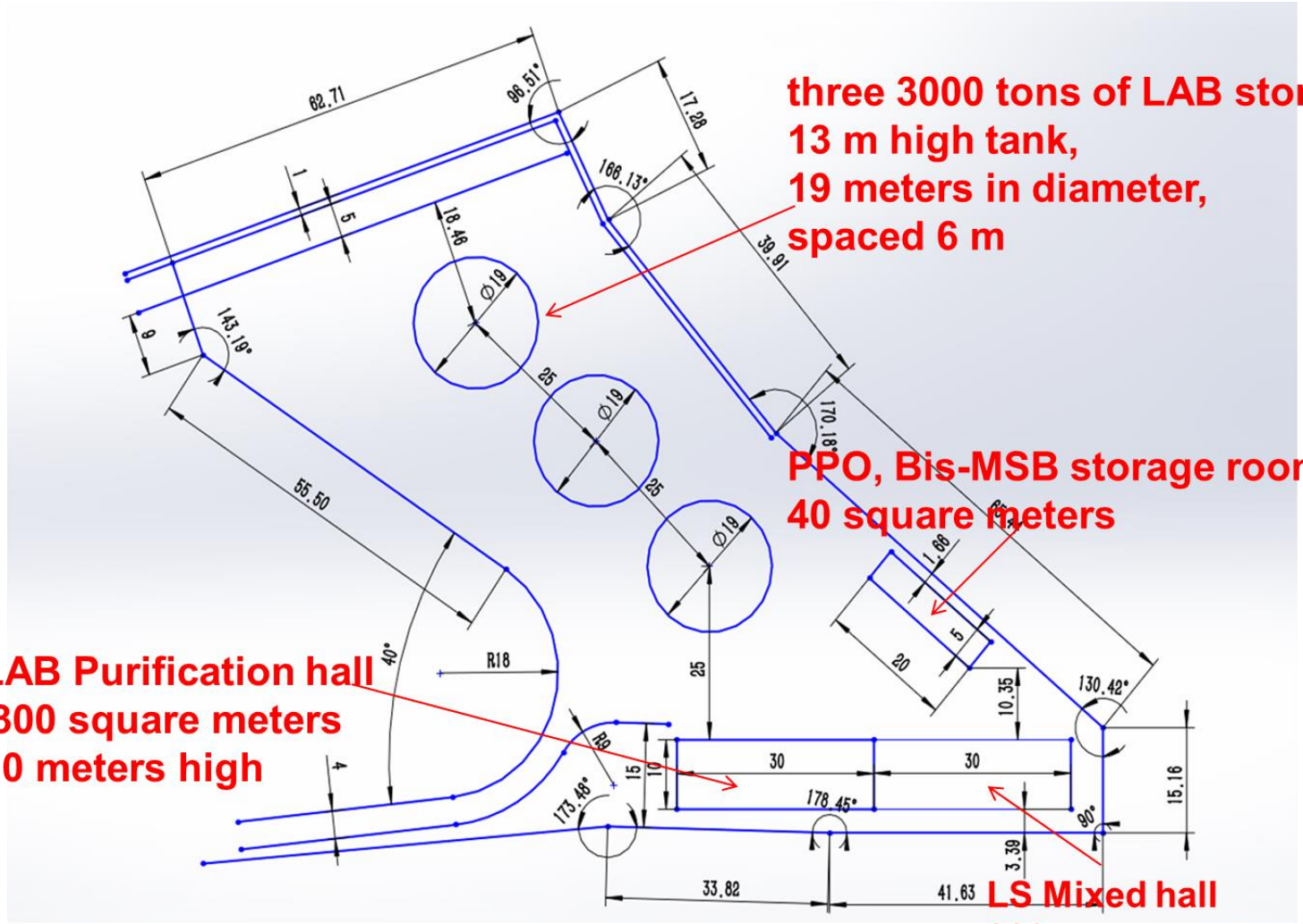
- – Al2O3 column: 99.41%
- – Vacuum distillation: 99.64 %
- – Water extraction: 88.67%
- – Gas stripping: in progress

LS production-purification flow chart

(The conceptual design)



Civil construction (surface design)



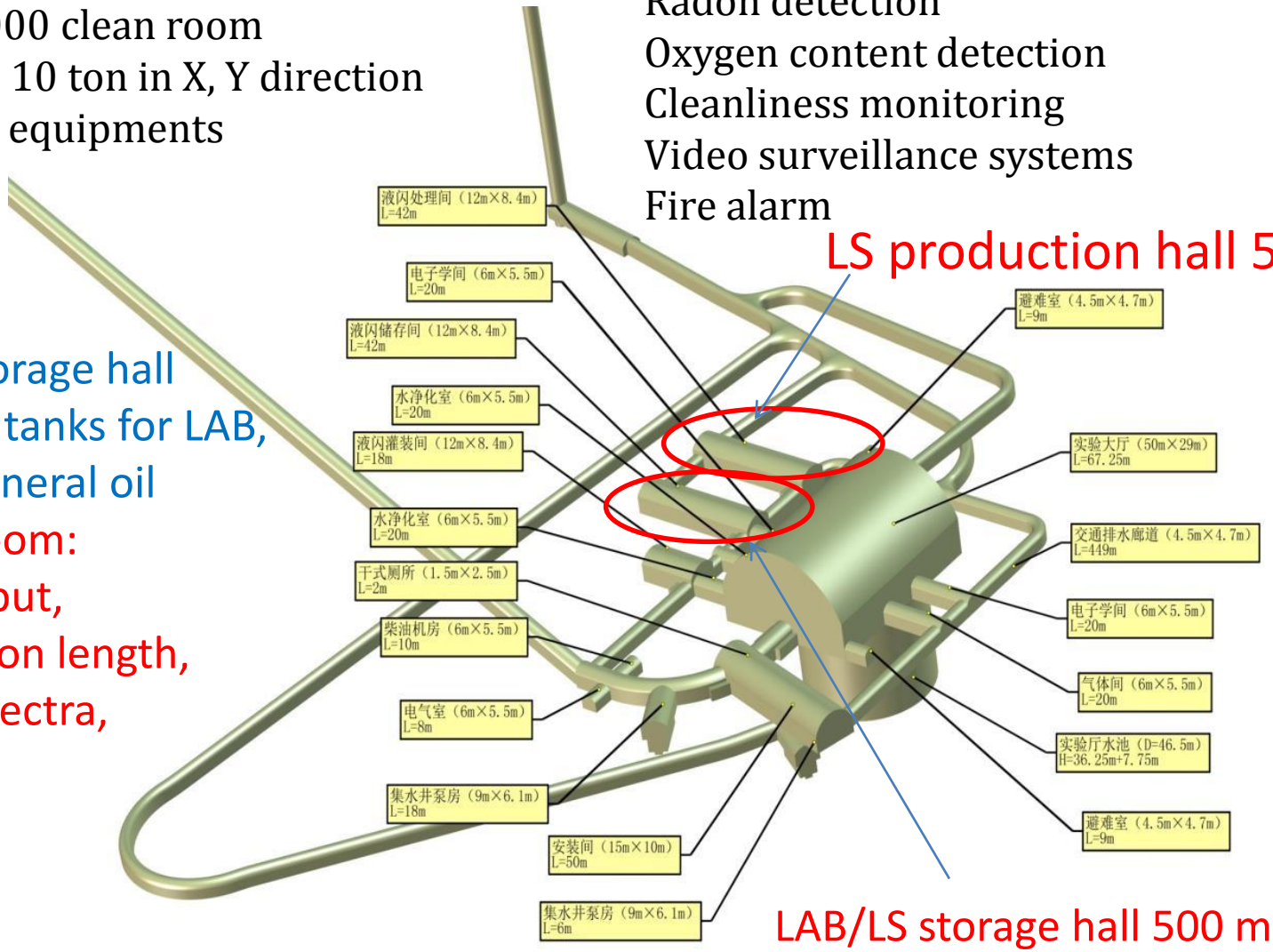
Civil construction
Two underground halls for LS

LS produced hall
Class 10,000 clean room
the crane: 10 ton in X, Y direction
LS mixing equipments

Radon detection
Oxygen content detection
Cleanliness monitoring
Video surveillance systems
Fire alarm

LS production hall 500 m²

LAB LS storage hall
4 storage tanks for LAB,
LS and mineral oil
QA/QC room:
Light output,
Attenuation length,
UV-Vis spectra,
GC-MS



LAB/LS storage hall 500 m²

Aerial view of JUNO

Summary

- JUNO experiment is making good progress
- LAB purification methods (column, distillation, water extraction, gas stripping) had been studied , no final decision yet, further study is needed
- Some basic properties of LS had been measured within LS group
- Conceptual design for LS mass production is in progress
- Build good relationship with suppliers of LAB and fluors

Thanks !