The JUNO Experiment

The Jiangmen Underground Neutrino Observatory (JUNO), with its main purpose to determine neutrino mass hierarchy (MH), is located at Kaiping, Jiangmen in south China. It consists of a central detector, a water Cherenkov detector and a muon tracker. The central detector is a 35.4 meter diameter acrylic ball full filled with 20 kiloton liquid scintillator. In order to reach unprecedented 3%/$\sqrt{E_{MC}}$ energy resolution, “18,000 20”” photomultiplier tubes (PMTs) and “25,000 3” PMTs will be used for photon detection.

The Central Detector

- Acrylic sphere: Inner diameter 35.4m. Thickness 120mm.
- Stainless shell: Inner diameter 40.1m. Divided into 30 longitudes and 23 layers.
- Weight of acrylic sphere: ~600t.
- 590 connecting bars
- 60 pillars
- Acrylic sphere supported by stainless steel shell

Structure of support system-pillars:
- 30 pillars
- 3 horizontal bracing
- 5 cross bracing

Segmentation scheme:
- 23 layers + 2 chimneys
- 291 pieces of acrylic panels in total
- Weight of acrylic sphere: 600t

The liquid scintillator

- Low background: $^{228}U < 10^{-15}$/g, $^{232}$Th $< 10^{-25}$/g, $^{40}$K $< 10^{-40}$/g.
- High light yield: Optimize the concentrations of floors
- Long attenuation length: $>200m$+430mm
- Purification:
  - Absorption, Distillation, Water extraction, Gas stripping.
  - Preliminary recipe: LiBr + Li$^+$PPO + 15mg/l bis-MB

Requirements for LS

- Effects of light emitting substance
- Concentration to light yield and energy nonlinearity
- Check radioactive background
- Which purification method will be used and how to combine them?
- Pre-study for JUNO LS mass production

The PMT System

- “5,000 20” dynode PMT from Hamamatsu
- “15,000 20” MCP-PMT from NNVT
- transmissive photocathode + reflective photocathode
- High CE
- Low background glass shell

SPE Spectrum

Comparison of dynode PMT and MCP-PMT

The Veto Detector

Targets of veto detector (top tracker + water Cherenkov detector)

- Cosmogenic isotope reduction ($^{7}$Li/$^{8}$Li) - requires a precise muon track reconstruction
- Fast neutrons background rejection – passive shielding and possible tagging
- Radioactivity from rock shielding – passive shielding by water.

Top tracker

- 62 plastic scintillator walls in three layers for good muon tracking
- Cover half of the top area of the water pool
- Re-using the OPERA's Target Tracker

Water Cherenkov detector

- 2000 20” PMTs and 35kton ultrapure water
- Detector efficiency expected to be >95%
- Fast neutron background <0.12/day
- Radon control less than 0.28mg/m³
- Earth magnetic field shielding

Physics Reach

The large fiducial volume and precision spectral measurements offer many opportunities for different physics researches.

- Mass hierarchy
- Precision measurement of mixing parameters
- Supernova neutrino
- Geoneutrinos
- Sterile neutrinos
- Atmospheric neutrinos

- The inverse beta decay (IBD) reaction: $p_\nu + p \rightarrow e^+ + n$ generate a prompt signal (positron annihilation) and a delay signal (neutron capture), from which the antineutrino spectrum can be reconstructed.
- Electron antineutrino survival probability in vacuum: $P_{\nu_e} = 1 - \cos^2 \theta_{13} \sin^2 2\theta_{12} \sin^2 2\theta_{13} \cos(2\Delta M_{eff} \pm \phi)$
- + for normal hierarchy
- - for inverted hierarchy

Protection cover and implosion tests

- Sufficient safety factor
- 75% PMT coverage
- Light absorption < 1%
- Compatible with pure water
- Low background

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