Design and Construction of hundred-ton liquid neutrino detector at CJPL II

Benda Xu <orv@tsinghua.edu.cn> on behalf of JNE Collaboration

Department of Engineering Physics & Center for High Energy Physics, Tsinghua University, Beijing, China

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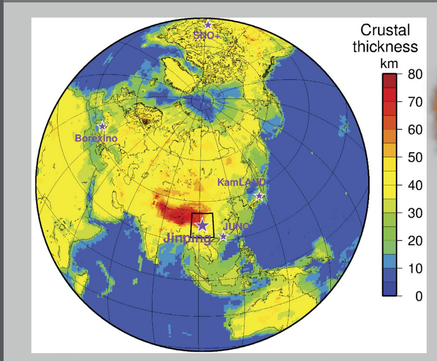
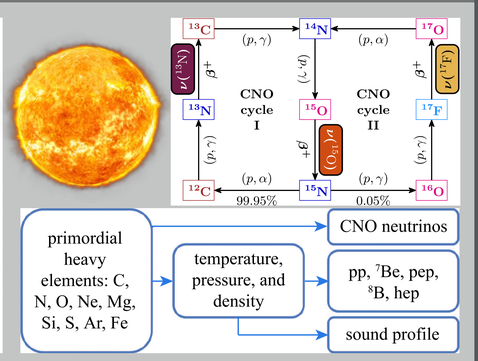
Neutrino as a probe into the Earth and the Sun



from Ondřej et al. 2016



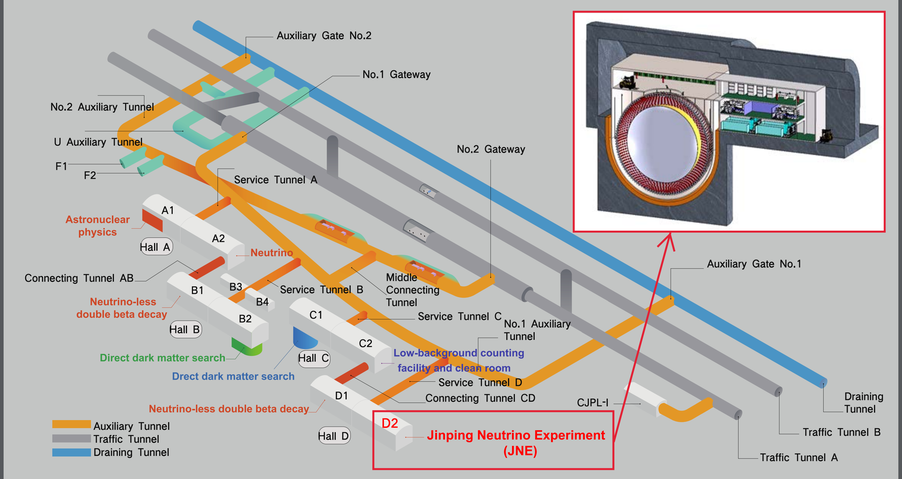
from Borexino (2020) and JNE (2017)

- ^{238}U, ^{232}Th and ^{40}K in the Earth produce heat by β decays with *geo-neutrinos*.
- U and Th enrich in the crust by chemical properties, thus the tibet plateau is the biggest geo-neutrino source on the Earth.
- Get away from commercial nuclear reactor neutrinos.

- The CNO-cycle is sub-dominant in the Sun, but sensitive to the primodial elements heavier than He (*metals* in star evolution).
- Flux of CNO-neutrinos is the key to measure the solar metalicity.
- Go deep underground to shield against cosmogenic backgrounds.

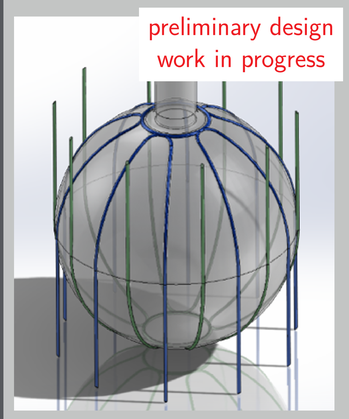
MeV-neutrino physics at the China JinPing underground Laboratory

- Deepest vertical overburden of 2400 m, largest laboratory volume.
- Lowest cosmogenic & reactor backgrounds, see *online poster by Bin Zhang*.



- Rich physics with MeV neutrinos at CJPL II see arXiv:1602.01733, 1612.00133, http://jinping.hep.tsinghua.edu.cn.

1 Gravity-buoyancy tolerant acrylic vessel

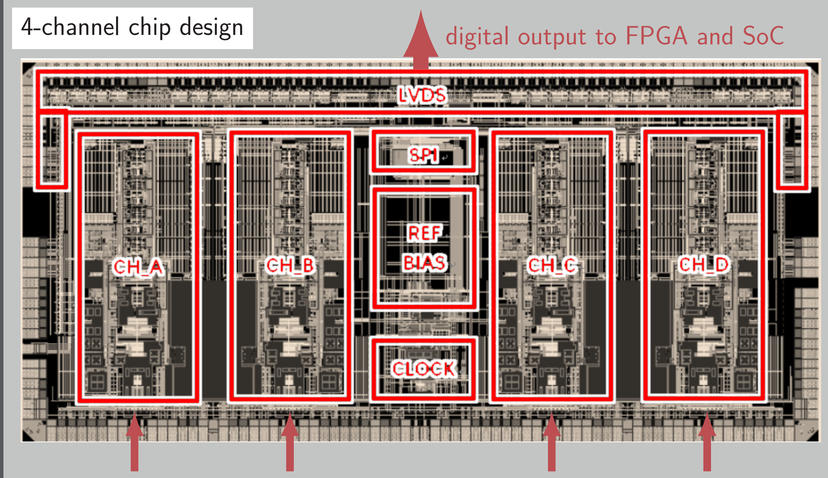


- Strings pulling upwards and downwards.
- Allowance of up to 20% density difference between inner and outer liquid media.
- Pure water for ^{8}B solar neutrino with low cosmogenics.
- multiple possible detecter-target media upgrades without refurbishment:
  - LiCl-water solution, see arXiv:2203.01860.
  - Slow liquid scintillator with Cherenkov readout, see arXiv:1708.07781, 1607.01671, 1511.09339.
  - Liquid scintillator doped with ^{71}Ga, see arXiv:2002.11971.
- 1 t prototype study of mechanics and radioisotops at arXiv:1703.01478 and *online poster by Yiyang Wu*.

2 Low-power-consumption 12-bit 1Gsps waveform digitizer

- Analog-to-digital converter chip from JUNO for full PMT waveform readout, revised with much lower chip power consumption of 0.35 W/channel.
- 4 channels integrated on one chip, 8-channel model under development.
- Scheduled to tapeout with 65nm MOSFET node.
- Frontend electronic board prototype ready.

4-channel chip design



FPGA: Field Programmable Gate Array. SoC: System-on-chip. SPI: Serial Peripheral Interface.

MOSFET: metal–oxide–semiconductor field-effect transistor. LVDS: Low-Voltage Differential Signaling.

3 High-quantum-efficiency low-background PMT

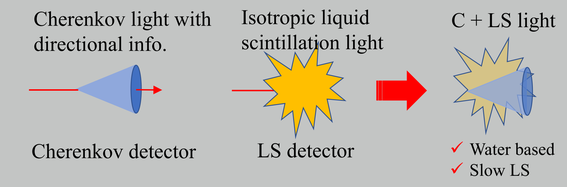
- ⌀20 cm microchannel plate (MCP) PMT design goal: balance of timing ($\sigma_{TT} < 1.5$ ns) and detection efficiency (∼30 %).
- Material and manufacturing process screening for ^{238}U, ^{232}Th and ^{40}K contaminations.

PMT glass bulbs

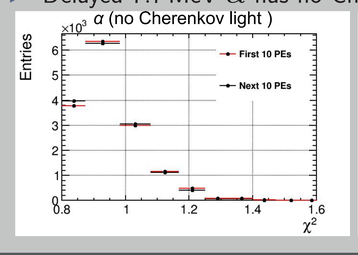
MCP-PMT after potting

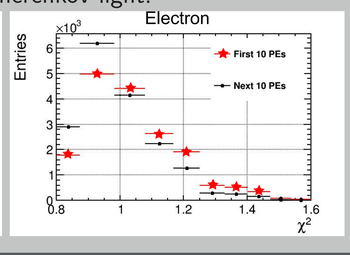
- Waveform analysis suitable to the characterstics of new PMT.
  - GPU acceleration in *online poster Yuyi Wang*.

4 Cherenkov and scintillation light dual readout



- Separate atmospheric ν events from supernova ν.
- Direction of solar ν and ^{40}K Geo-ν.
- Slow liquid scintillator with 1-t prototype detector.
- ^{214}Bi-^{214}Po decay demonstrates dual readout:
  - Prompt 2 MeV β emits Cherenkov light;
  - Delayed 7.7 MeV α has no Cherenkov light.





Summary and Outlook

- CJPL is ideal for MeV neutrino physics, for which JNE collaboration constructs hundred-ton neutrino detector by 2026.
  1. Gravity-buoyancy tolerant acrylic vessel.
  2. New 12-bit 1Gsps waveform digitizer.
  3. Much improved ⌀20 cm MCP-PMT.
  4. Slow liquid scintillator with Cherenkov readout.