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CryoCsI R&D for CLOVERS Experiment

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1. The CEνNS Process

The physics of Coherent Elastic Neutrino-Nucleus Scattering (CEνNS) is illustrated by Fig.1. Is is a new method to measure MeV neutrinos. Various aspects of physics would be benefited by studying CEνNS process[1].

1. Standard Model at low momentum transfer.
2. Clearance of the Neutrino Fog of WIMP detection.
3. Outburst of core-collapsed supernova.
4. Spectrum of nuclear reactor neutrinos.

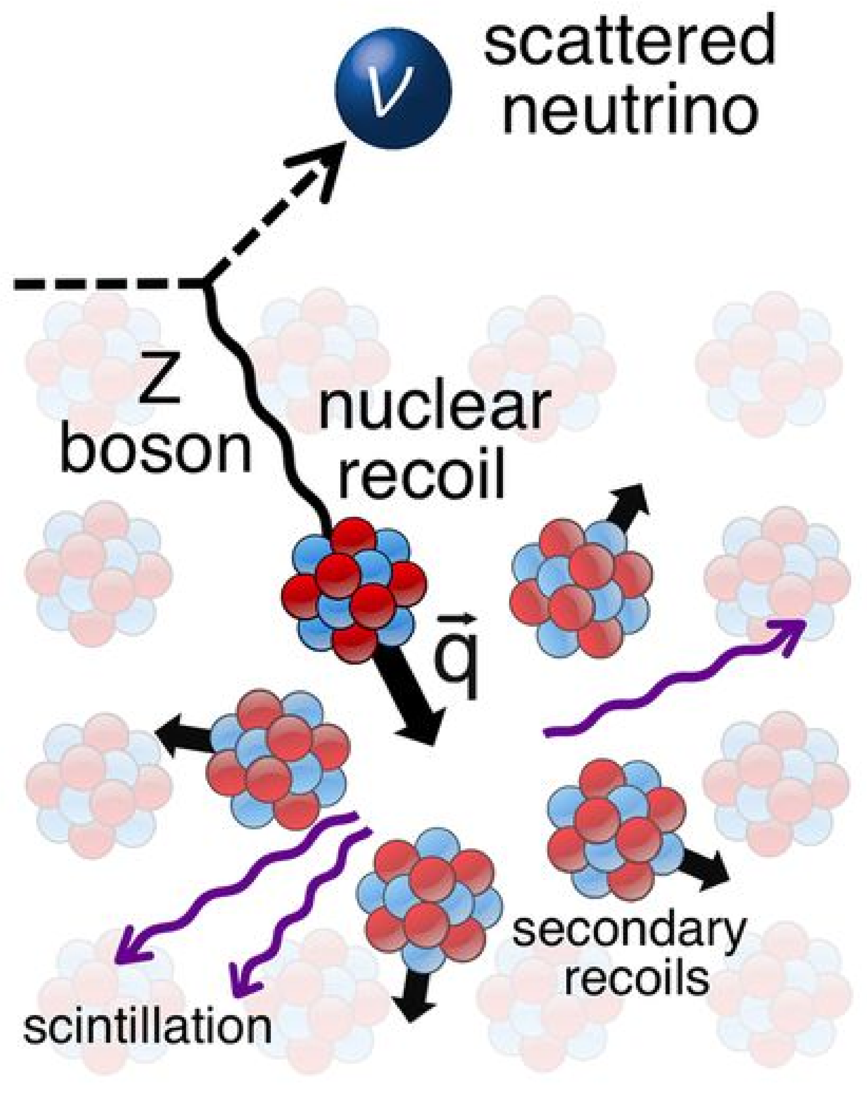

Figure 1: Physics of CEνNS process

2. The CLOVERS Experiment

The CLOVERS represents the "Coherent eLastiv neutrinO(V)-nucleus scattERing experiment at CSNS" [2]. The China Spallation Neutron Source (CSNS) is selected as our neutrino source (Fig.2). Undoped CsI scintillator crystal is selected due to its high light yield and excellent energy resolution at 77K [3, 4].

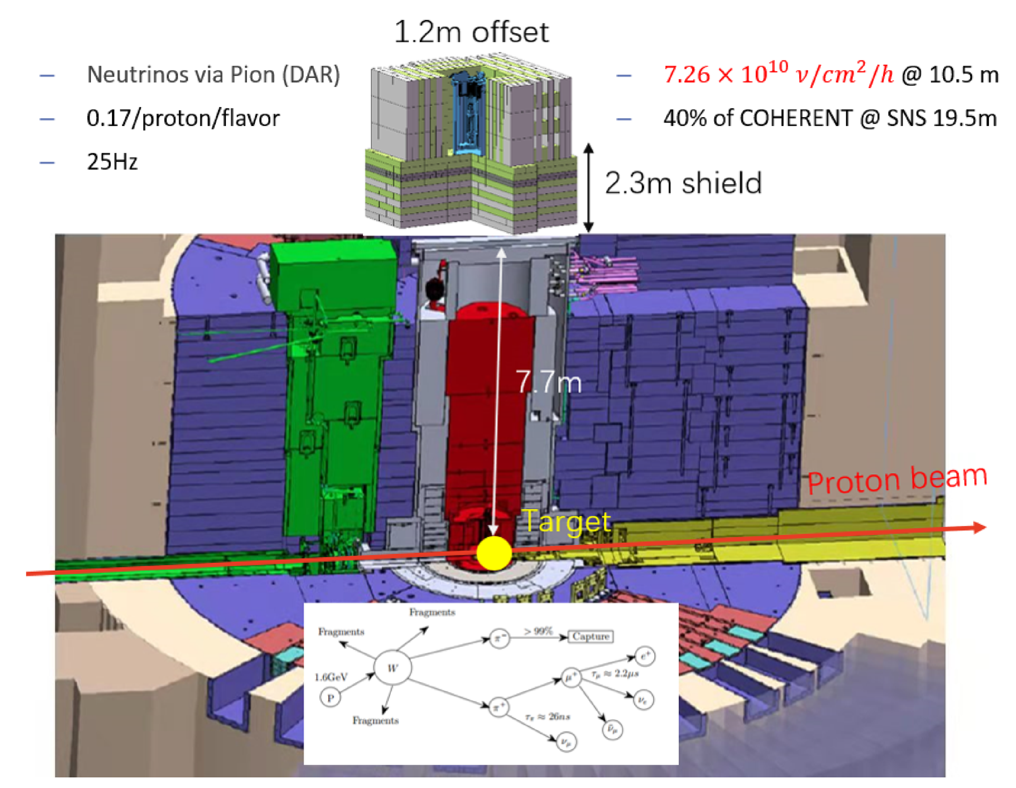

Figure 2: CLOVERS experiment design

3. R&D of CryoCsI detector

3.1 Light yield and energy resolution

The characterization of the CryoCsI was carried out with a $2\times2\times2cm^3$ cubic crystal with all its surfaces polished. The crystal was coupled to a HAMAMATSU R11065 PMT and raped with 4 layers of BC-642 PTFE tapes. At 77K, the light yield of CryoCsI reaches 35.2PE/keVee with an unprecedented energy resolution: 6.9% at 60keV. (Fig.3, 4). [4]

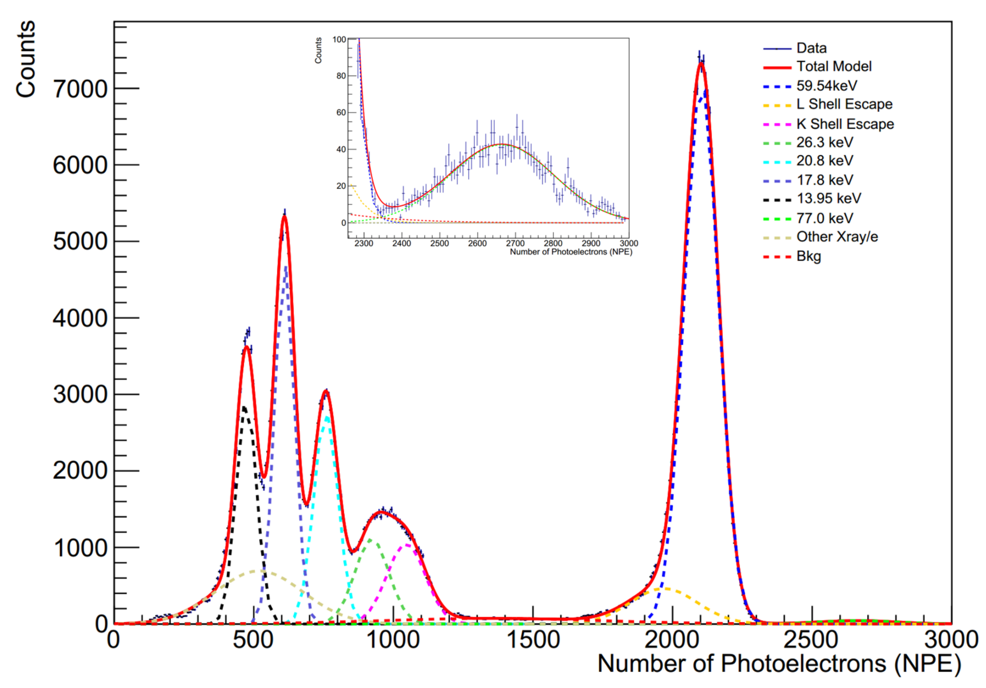

Figure 3: Measuered ^{241}Am spectrum

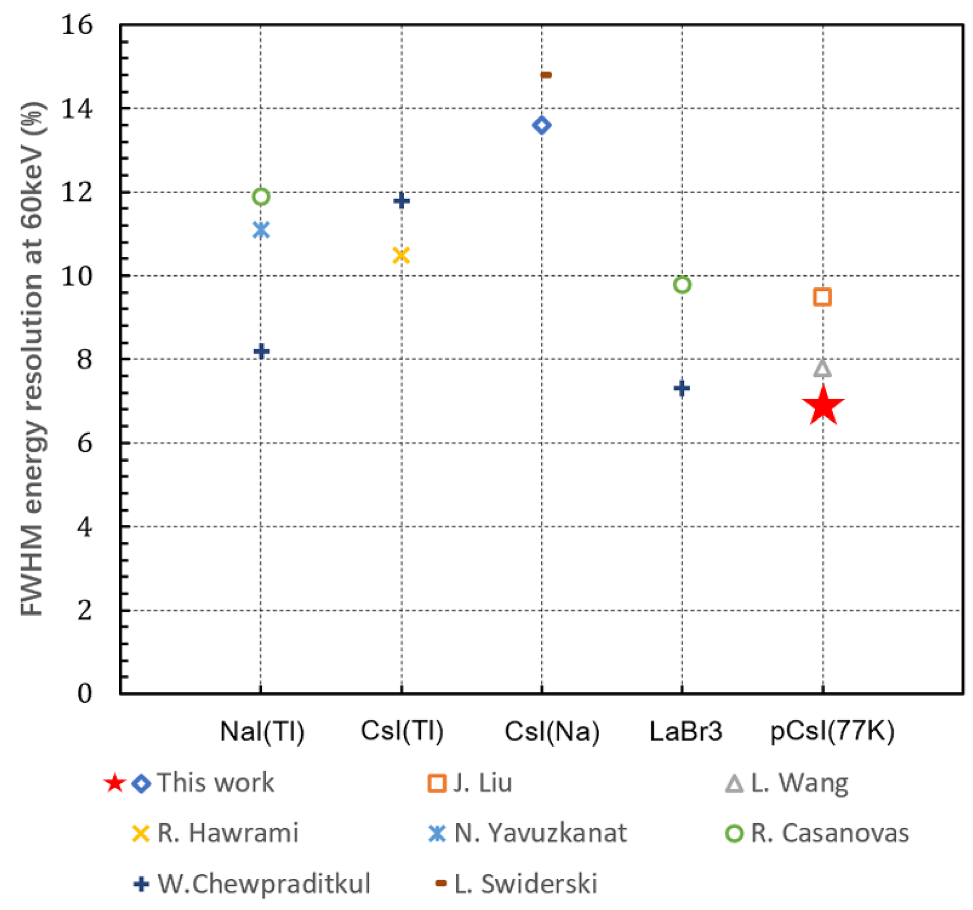

Figure 4: Energy resolution of CryoCsI compared with other scintillators. [3, 5, 6, 7, 8, 9, 10]

3.2 Decay time

The decay time of CryoCsI at 77K was measured to be around 1 μs, much shorter than the 17 μs for CsI(Na) at 293K. Helps to reduce the afterglow background. (Fig. 5)

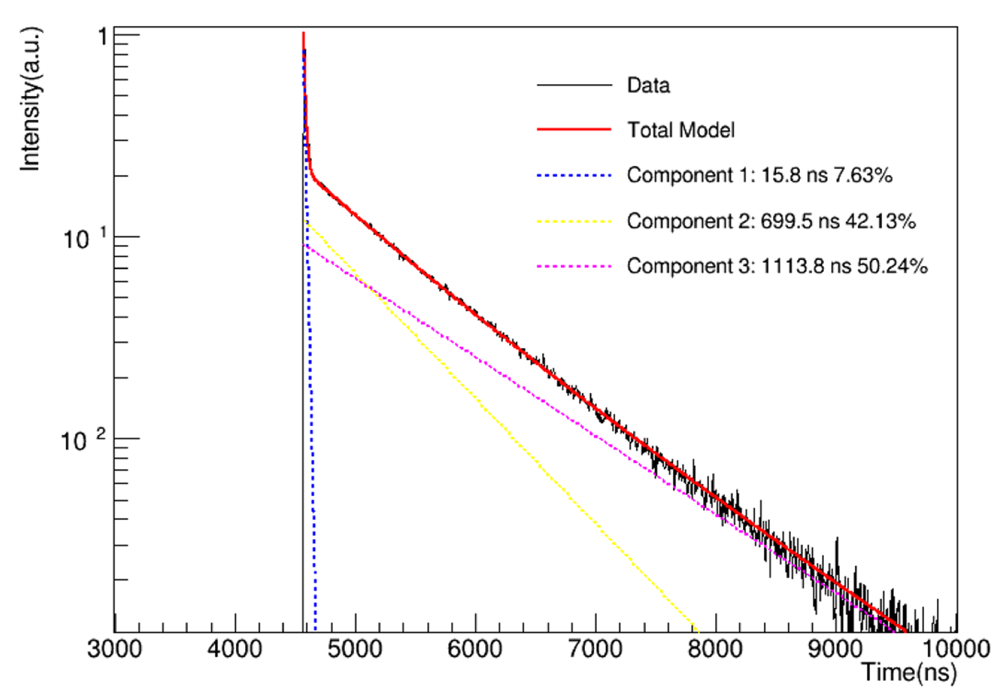

Figure 5: Decay time fitting of CryoCsI

3.3 Temperature dependence of light yield

The dependence of light yield to temperatures was also investigated down to 6K (Fig.6). It peaks at around 20K, and drops for lower temperature. It does not change much from 100K to 77K, making using LAr as cooling mattering and anti-veto detector possible.

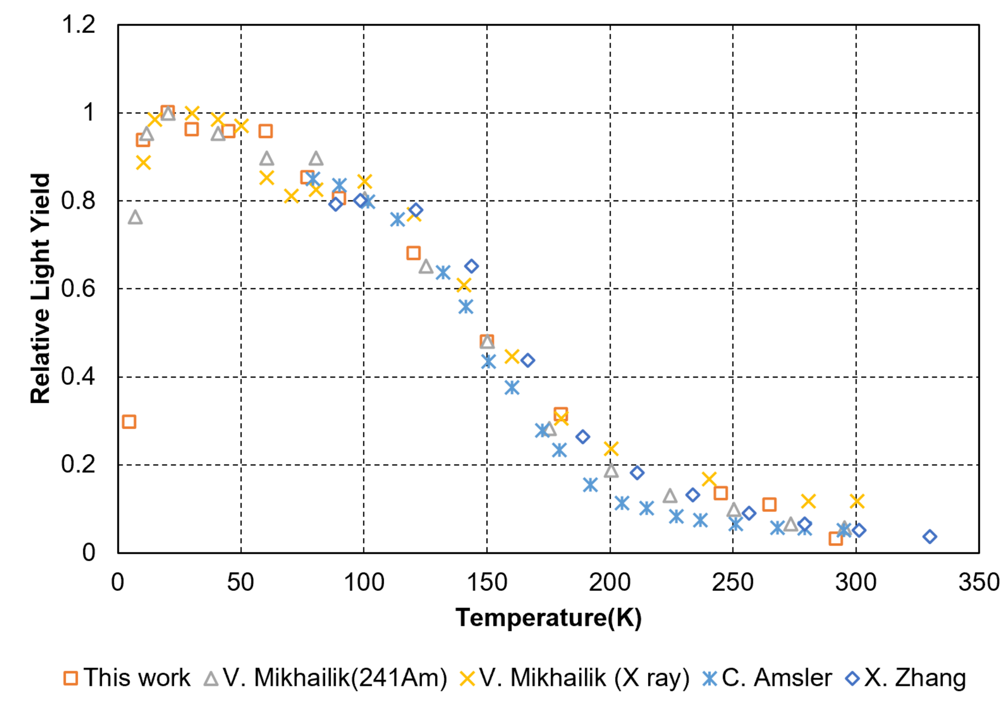

Figure 6: Temperature dependence of light yield. [11, 12, 13]

3.4 Influence of surface treatment and crystal shape

The influence of surface treatment and crystal shape to light yield was also investigated to optimize the detector performance. (Tab.1 and 2). Polished surfaces increase the light yield significantly while the shape of the crystal has minor influence.

Experiment	pCsI(A)	pCsI(B)	pCsI(C)	pCsI(D)
R_{ly}(293K)	0.68	0.62	0.63	0.68
R_{ly}(77K)	0.70	0.68	-	-

Table 1: Ratio of the light yield (R_{ly}) between ground and polished crystals for different experiments.

Crystal	LY(PE/keV$_{ee}$)	FWHM(%)
Cubic (polished)	35.2	6.9
Cubic (ground)	24.8	7.8
Cylindrical (polished)	33.9	7.1
Cylindrical (ground)	22.3	7.9

Table 2: Comparison of the light yield and energy resolution of crystals with different shapes and surface treatment.

4. Summary

A remarkable light yield of 35.2PE/keV$_{ee}$ and an unprecedented energy resolution FWHM 6.9% at 60keV has been achieved for CryoCsI detector. Making it a promising low threshold detector for CEvNS detection.

References

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