The measurement of ^{25}Mg (p, γ)^{26}Al and the origin of interstellar ^{26}Al

Hydrogen is the most abundant element in the universe, and the reactions it involved are of crucial importance in stellar evolution. Comparing with the capture reactions of heavy-ion, the proton capture reactions with smaller Coulomb barrier can take place more easily, and therefore play very important roles in the early evolution of stars. In the numerous hydrogen involved reactions, ^{25}Mg (p, γ)^{26}Al reaction is very distinctive. It is one of the key reactions of Mg-Al chain hydrogen-burning, and the main production mechanism for ^{26}Al in astrophysical scenarios like W-R or AGB stars. The ^{26}Al ground state decays to an excited state of ^{26}Mg though β-emission with a half-life of 7.2X10^5 years. The excited state decays to the ground state of ^{26}Mg by emitting a 1.809 MeV γ-ray, the measurement of this γ-ray can be used to study the history of recent galactic nucleosynthesis activity.

In 1984, the 1.809 MeV γ-ray was first detected by Mahoney et al. by the spacecraft HEAO-C [1], this evidence that ^{26}Al nucleosynthesis is still active in the Galaxy. Afterwards, the COMPTEL telescope on board of the CGRO satellite obtained the distribution of the 1.809 MeV γ-ray emissions in the Galaxy. The Galaxy is relatively transparent to such gamma-rays, and emission has been found concentrated along its plane, as shown in Fig.1. A total ^{26}Al mass of 2.8 M$_\odot$ [2] were derived through the analysis of the measured gamma spectra. ^{26}Mg, the decay production of ^{26}Al, was also found excess in the Allende meteorite [3]. Nowadays, the origin of ^{26}Al in the galaxy was increasingly concerned.

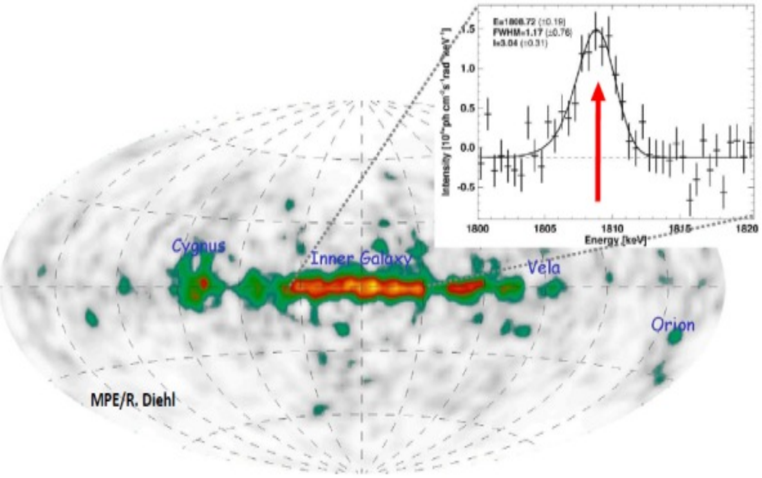

Fig.1 the Galactic 1.809 MeV line emission observed with COMPTEL

The reaction ^{25}Mg(p, γ)^{26}Al is the main way to produce ^{26}Al in the galaxy and its cross section are dominated by isolated resonances although the high level density of ^{26}Al. The energy range of astrophysical interests is 100 ± 44 keV, so the levels between 50 keV and 150 keV are more important in the study of galaxy ^{26}Al. Many experiments have been performed to study the ^{25}Mg(p, γ)^{26}Al reaction sine 1970 [4-15], but the experiment on the surface of earth ground can only reach to 190 keV energy level due to the small cross section and large background effects of the cosmic rays. In 2012, LUNA group in Italy measured the resonance strength at 92 keV with the help of high shielding conditions in the underground laboratory [16, 17]. The cross section of

$^{25}Mg(p, \gamma)^{26}Al$ is very small at the energies less than 90 keV, and it is very difficult to measure the resonance strength for lower levels in the shielding conditions of LUNA experiments. The underground laboratory of Jinping in China covered with the marble rock of 2500 meters, the shielding conditions are much better than LUNA experiment. By utilizing the high intensity proton beam of 10 mA and the high efficiency 4π BGO gamma detector shown in Fig. 2, the 58 keV resonance strength of $^{25}Mg(p, \gamma)^{26}Al$ can be measured at Jinping underground nuclear astrophysics (JUNA) laboratory. Fig. 3 shows the expected measuring spectra for the 92 and 58 keV levels at JUNA with a 10 mA proton beam, the high shielding conditions of JUNA, and 38% coincident gamma ray detective efficiency of BGO detector.

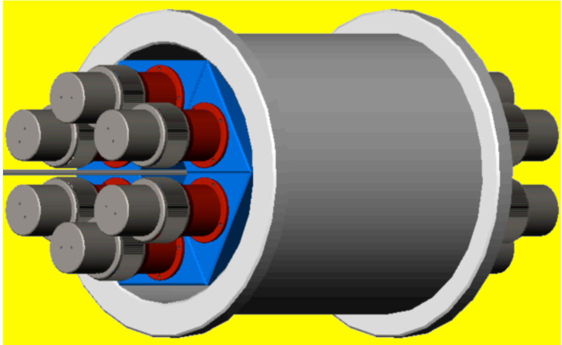

Fig. 2 4π BGO gamma detector

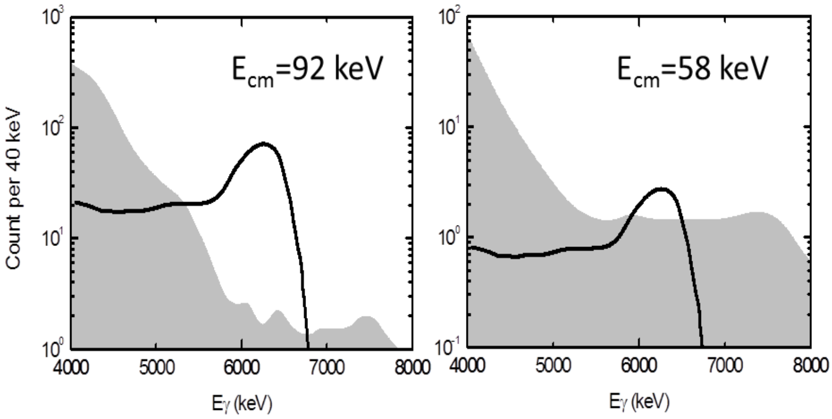

Fig. 3 The estimation results of $^{25}Mg(p, \gamma)^{26}Al$

The project consists of 4 sub-projects: the target manufacture and constituent analysis, the development of BGO detector, the background measurement and shielding design, and the measurement of the $^{25}Mg(p, \gamma)^{26}Al$. The first three sub-projects will be done at the end of 2017. We will performance the measurement for reaction and background in 2018, and publish the results in 2019. In this year, we will measure the background in the both underground and ground conditions, and select the material of shield and BGO detector. The component of enriched ^{25}MgO target will be analyzed by measuring the angular distribution of ^{7}Li+target elastic scattering with Q3D spectrometer. The level width of 58 keV in ^{26}Al will also be deduced from the angular distribution of $^{25}Mg(^{7}Li, ^{6}He)^{26}Al$.

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