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Tests of CALIFA Barrel modules at CCB in Kraków

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CALIFA (CALorimeter for In-Flight gamma-ray and pArticle detection) [1] is dedicated to the detection, tracking and energy determination of light charged particles and γ rays emerging from R^{3}B experiments. Significant progress has been made on the Barrel section [2] of CALIFA, which consists of ~2000 CsI(Tl) scintillator crystals that provide a high angular resolution needed for effective Doppler corrections.

For the Phase-0 experiments at GSI in 2018, a substantial part of the CALIFA Barrel detectors will be installed and operated in the Demonstrator [3] configuration. An extensive preparatory work in detector performance, stability and data acquisition is required to provide a sound and effective experimental campaign at GSI. To that end, in-beam tests at the Bronowice Cyclotron Center (CCB) at IFJ PAN in Kraków were carried out. The cyclotron at CCB provided proton beams with energies up to 225 MeV, which enabled experiments for (p,2p) quasifree scattering (QFS) reactions on stable targets.

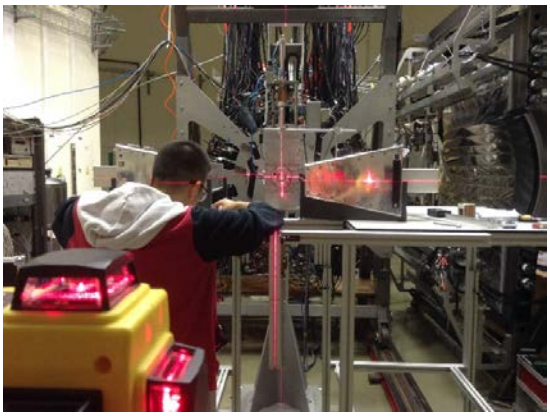

Figure 1: Detectors seen during mounting at CCB for the (p,2p) experiment. Three CALIFA Barrel petals (one placed below the target later), two DSSSD tracking detectors, and one CEPA4 detector were tested.

The experimental setup at CCB is shown in Fig. 1. Two petals were positioned on a horizontal plane with a polar angular coverage of 25° < θ < 58° to detect the scattered particles. One petal was deployed at its nominal CALIFA position (43° < θ < 82°) to detect γ rays. Two double-sided silicon strip detectors (DSSSDs) were also employed as particle trackers. A CEPA4 [4] prototype detector for the CALIFA Forward Endcap was placed at θ ~ 11° for its performance test. Data from the petals and the DSSSD trackers were read out with the MBS system featuring FEBEX3B cards [5]. The calibration data from a ^{60}Co γ-ray source was analysed with the UCESB/R^{3}BRoot software [6].

A laminar water jet, with a small diameter of 0.46 mm was used to provide well-defined tracking correlations for the reactions at the target, and give an energy straggling below the expected resolution limit for the total energy reconstruction of the scattered protons with CALIFA. Other targets such as graphite, polypropylene, ^{112,124}Sn and ^{208}Pb were also irradiated. The proton beam energy was 200 MeV for over 95% of the total beam time. Other beam energies ranged from 70 to 225 MeV.

A preliminary analysis of (p,2p) data from the water target revealed a γ-ray peak at 6.3 MeV (see Fig. 2), corresponding to the known transition from the first excited 3/2$^-$ state to the 1/2$^-$ ground state in ^{15}N. More sophisticated energy calibration, event selection cuts and simulations are being developed to refine and extend the analysis to the data from other targets. We acknowledge the local support at CCB with logistics and beam delivery.

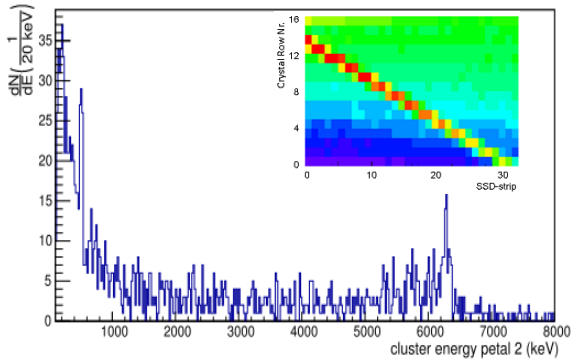

Figure 2: γ-ray energy spectrum following (p,2p) reactions on the water target. The 6.3-MeV transition in ^{15}N is clearly visible. The inset shows the proton tracking data from a DSSSD-petal pair used in the event selection cut.

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