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# Warsaw Active-Target TPC: a new detector for photonuclear reactions studies at astrophysical energies

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An active-target time-projection chamber (TPC) optimized for studying nuclear reactions of astrophysical interest has been developed by the University of Warsaw in collaboration with University of Connecticut and ELI-NP/IFIN-HH. The experimental program focuses on $(\mathrm{p},\gamma)$ and $(\alpha,\gamma)$ reactions that regulate the ratio of carbon and oxygen and those that burn $^{18}$O and, therefore, regulate the ratio between $^{16}$O and $^{18}$O in the Universe. In particular, the benchmark reaction of $^{12}\mathrm{C}(\alpha,\gamma)^{16}\mathrm{O}$ can be studied at energies down to 1 MeV in the centre-of-mass reference frame.

The cross-sections of time-reverse processes are measured using TPC detection technique by reconstructing energies and angular distributions of the charged products of photo-disintegration reactions induced by intense, monochromatic and collimated gamma-ray beams. Different reactions can be studied by tuning composition and density of the gaseous target for particular energy of the gamma beam.

The Warsaw TPC detector has an active volume of about $33 \times 20 \times 20\,\mathrm{cm}^3$ that is centered around the beam axis. The micro-pattern structures are employed to amplify the primary ionization induced by charged particles produced in reactions in the gaseous target. The 3D kinematics of charged particles in the event are reconstructed from signal strips, arranged into 3-coordinate redundant system. A total of about $10^3$ channels is read out by digitizing front-end electronics based on the Generic Electronics for TPCs (GET).

In years 2021-22 two pilot experiments were carried out to study $^{16}\mathrm{O}(\gamma,\alpha)^{12}\mathrm{C}$ reaction using low-pressure $CO_2$ gas target and monochromatic gamma-ray beams at the Van der Graaf accelerator at IFJ-PAN, Cracow, Poland and at the High Intensity Gamma-Ray Source (HI$\gamma$S) facility, TUNL, Durham (NC), USA. The gamma beam energies ranged from 13.9 MeV down to 8.51 MeV ($\mathrm{E}_{CM}$ from 6.7 MeV down to 1.35 MeV, respectively). In this work the principles of detector operation and basic track reconstruction methods will be discussed, together with preliminary results.

**Primary authors:** Dr CWIOK, Mikolaj (University of Warsaw (PL)); Prof. DOMINIK, Wojtek (University of Warsaw (PL)); Dr FIJALKOWSKA, Aleksandra (University of Warsaw (PL)); Mr FILA, Mateusz (University of Warsaw (PL)); Prof. JANAS, Zenon (University of Warsaw (PL)); Dr KALINOWSKI, Artur (University of Warsaw (PL)); Dr KUICH, Magdalena (University of Warsaw (PL)); Dr MAZZOCCHI, Chiara (University of Warsaw (PL)); Mr ZAREMBA, Marcin (University of Warsaw (PL)); Prof. GAI, Moshe (University of Connecticut (US)); Mr SCHWEITZER, Deran (University of Connecticut (US)); Ms STERN, Sarah (University of Connecticut (US)); Prof. BALABANSKI, Dimiter (IFIN-HH / ELI-NP (RO))

**Presenter:** Dr CWIOK, Mikolaj (University of Warsaw (PL))

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