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A DEUTERIUM/TRITIUM GAS TARGET FOR FAST NEUTRONS PRODUCTION WITH d-D AND d-T REACTIONS USING THE ASSOCIATED PARTICLE TECHNIQUE AND A TIME-ZERO DETECTOR

C. Cernigoi, G.V. Margagliotti, C. Tuniz

Dipartimento di Fisica, Università di Trieste, I-31100 Trieste, Italy
INFN, Sezione di Trieste, I-31100 Trieste, Italy

R. Cherubini, A. Varela (*)

INFN, Laboratori Nazionali di Legnaro, I-35020 Legnaro (Padova), Italy

G. Moschini

Dipartimento di Fisica, Università di Padova, I-35100 Padova, Italy
INFN, Laboratori Nazionali di Legnaro, I-35020 Legnaro (Padova), Italy

Abstract: Main features of a deuterium/tritium gas target for fast tagged neutron production, with the d-D and d-T reaction and the associated particle technique is reported. It is described as an improved method in associated particle detection based on a time-zero detector.

(gas target, d-D reaction, d-T reaction, Associated Particle Technique, time-zero detector, microchannel-plate detector)

Introduction

It is well known that the D(d,n)^{3}He and the T(d,n)^{4}He reactions using the Associated Particle Technique (A.P.T.) are widely used as the monoenergetic neutron source in a wide energy range.
Among the effects which influence the monochromacity of the neutron beam, those connected with the target features, are very important. Moreover, the unambiguous identification of the He ions is necessary for a precise neutron flux determination.

In order to produce clean monoenergetic neutron beams of known flux with energy up to 50 MeV, we have designed, constructed and set up at the INFN, Laboratori Nazionali di Legnaro, Legnaro (Padova), Italy, (L.N.L.) a D/T gas target.
The unambiguous identification of the He recoil ions is accomplished by a method based on a combined energy and time-of-flight (tof) measurement, providing an accurate discrimi-nation against the masking presence of other particles, like the scattered deuterons.

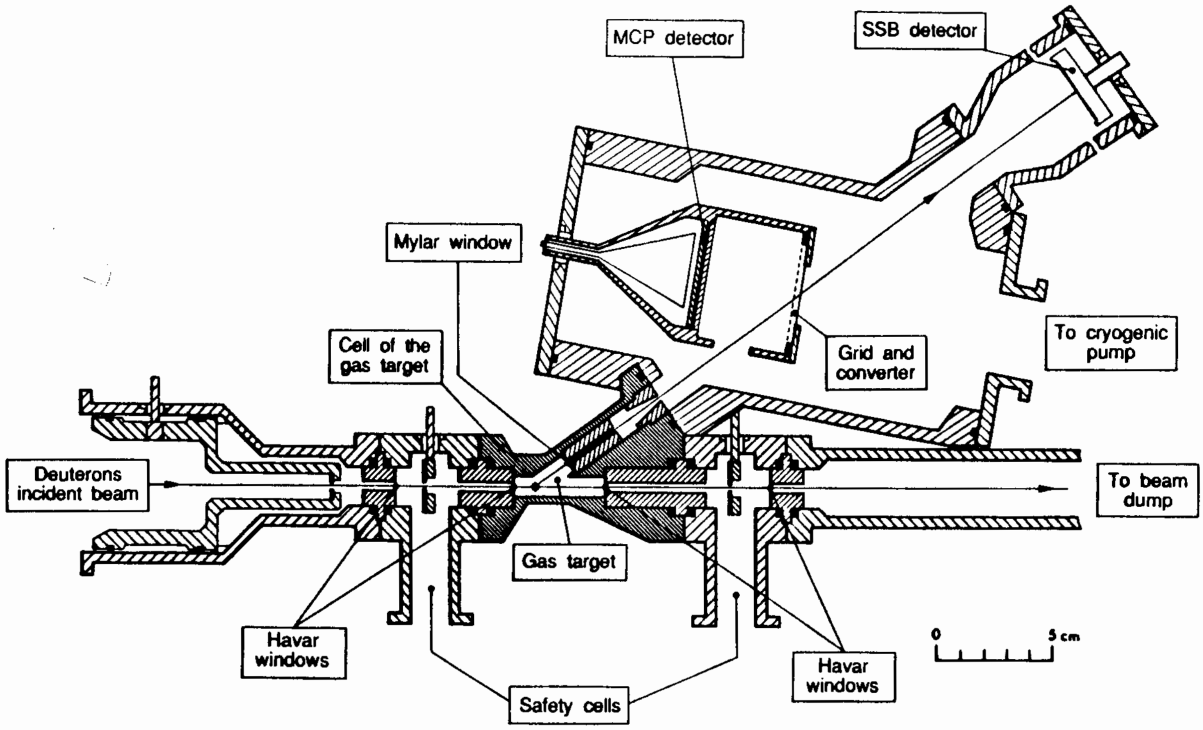

Fig. 1 Schematic view of the D/T gas target and the charged particle detectors telescope

Experimental Apparatus

The schematic view of the target is shown in Fig.1 (for details see ref.1). A gas type target is used to eliminate the well known disadvantages of the D,T solid targets.
With respect to the gas cell, protected by two safety cells, a chamber at 35° or 55° degrees is used to house the charged particle detectors telescope providing the energy and tof signals.
The safety cells are connected to a vacuum system, based on a tritium tight Balzers turbomolecular pump, independently of the system used in conjunction with the accelerator.

The energy measurement is performed by a 900 mm^2 silicon surface barrier detector (SSBD), which furnishes also the stop signal for the tof measurements. The start signal is obtained by a microchannel-plate detector (MCP) impinged upon by the electrons produced in a 20 $\mu gr/cm^2$ gold emitter. The MCP permits an important charged particle discrimination based on the strong dependence[2] of the emitted electron number on the z of the impinging particle. The associated electronics is reported in Fig. 2.

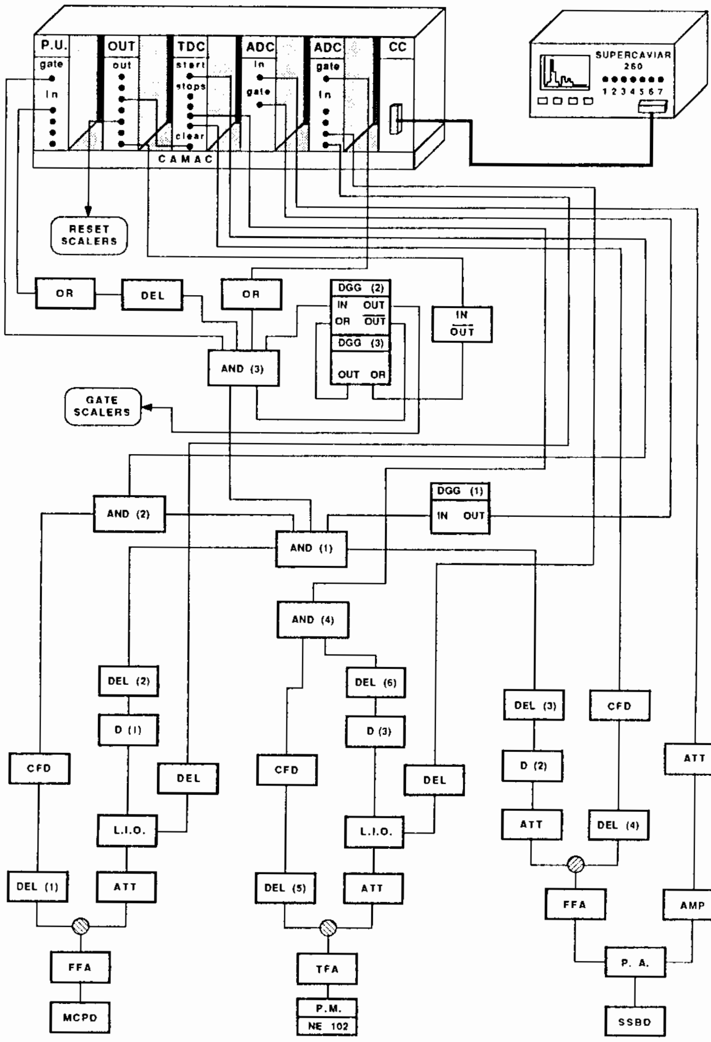

Fig.2 Block diagram of electronics (FFA=fast filter amplifier, P.A.=pre-amplifier, DEL=delay, ATT=attenuator, D=discriminator, CFD=constant fraction discriminator, AND=fast coincidence, DGG=dual gate generator, P.U.=pattern unit, OUT=output register, TDC=time-to-digital converter, ADC=anolog-to-digital converter, CC=crate controller)

By the use of a fast discriminator on the MCP signals, almost all the z=1 particles can be rejected. This action clearly manifests itself in a comparison of Fig. 3 with Fig. 4, displaying the linear energy spectrum for D(d,n)^{3}He at a deutron energy of 3.5 MeV.

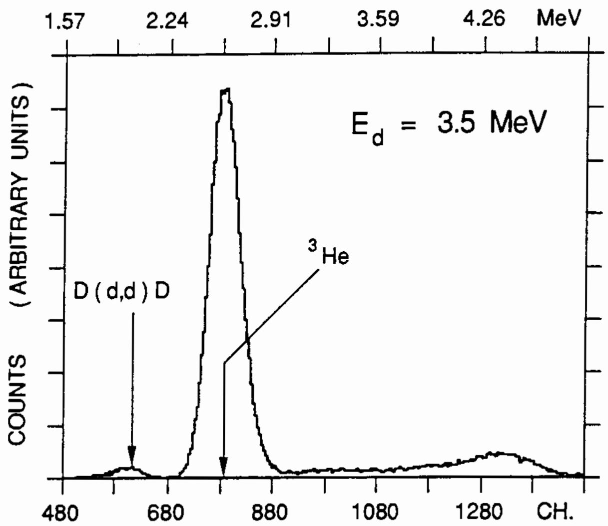

Fig. 3 Energy spectrum of charged particles from the SSBD gated by the MCP (see text)

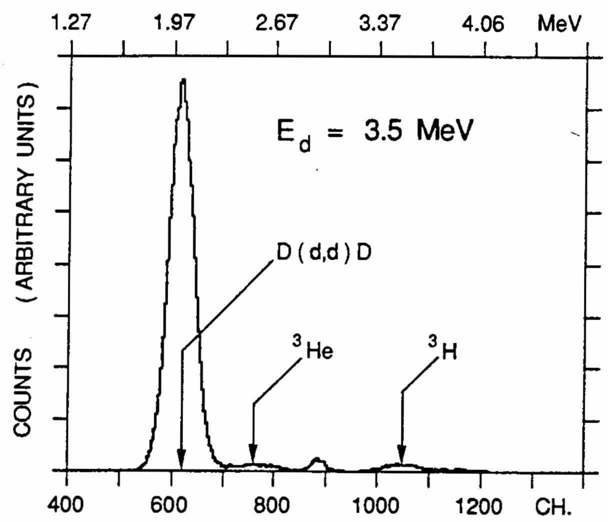

Fig. 4 Linear energy spectrum of charged particles from the SSBD

The SuperCaviar minicomputer is working in such a way to accept, by an appropriate supporting software, only the charged particles which satisfy the kinematic conditions to be identified as ^{3}He or ^{4}He.

Experimental results

The above described apparatus has so far been used for the D(d,n)^{3}He reaction at the 7 MV Van de Graaff CN accelerator of the L.N.L. in the deuteron energy range from 2.5 to 6.5 MeV.

A typical tof spectrum, obtained with a NE-102A scintillator, for a neutron of 3.5 MeV, is given in Fig. 5.

No n-γ discrimination is necessary.

The production rate is about 300neutrons/sec.srad.nA.atm.

By a change in the angle of the associated particle chamber (a very simple operation), and the use of the d-D and d-T reaction with the deuteron beams furnished by the CN (2-7 MeV) as well as XTU-tandem (12-32 MeV) accelerators, the neutron energy should in principle be expected to be in a very wide range (see Fig. 6).

Conclusive Considerations

We hope that this fast tagged neutron source would contribute to improve significatly our knowledge in the field of neutron physics, especially for neutron cross-sections measurements in the energy region not yet extensively explored.

Also absolute efficiency calibration of neutron counters can be performed with a great precision.

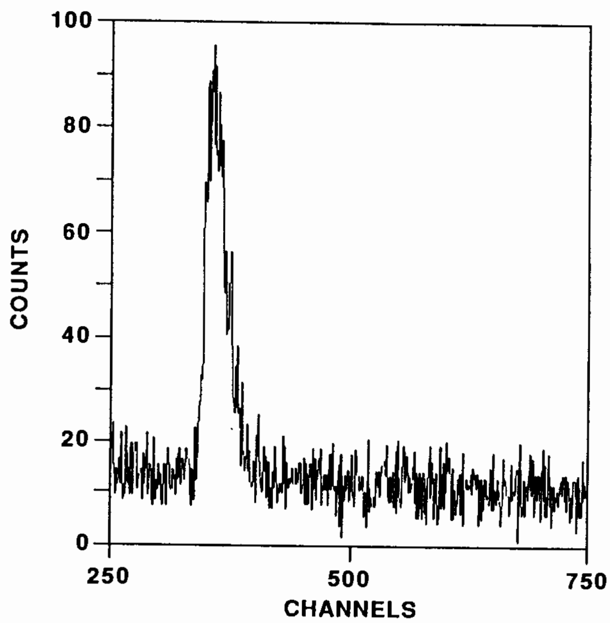

Fig. 5 TOF spectrum for a neutron of 3.5 MeV

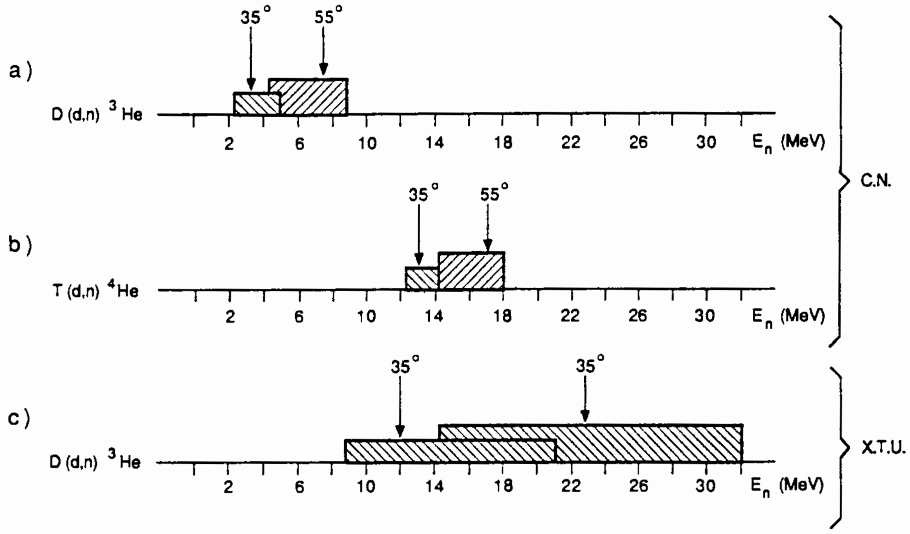

Fig. 6 Neutron energy range for deuteron energy 2-7 MeV and 12-32 MeV and detection angles of associated charged particle of 35° and 55° degrees.

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1. C. Cernigoi et al.: Nucl. Instr. and Meth.(accepted for publication, 1988)

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(*) On leave: ININ, Mexico D.F. and Fellow of the ICTP-Trieste, Italy