LABORATÓRIO ABERTO DE FÍSICA NUCLEAR

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Proposal	N°
Title: Proposal for in-beam characterization of a new gas tracker prototype for the NUMEN project	
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Telephone:	Skype:
Number of days for experiment:	12
Period planned for the experiment (is the setup ready for beam time?): After November 2023 (no)	

Technical information

Ion source			Accelerator			Experimental Area	
Beam	Cathode	$I_{mín}$	V_{min}	V_{max}	Bunched beam?	Beam line	Target
^{12}C		300 nA	6	7	no	0°	(Tracker)
^{7}Li		300 nA	6.5	7.5	no	0°	(Tracker)

Other relevant/needed information:

Proposal for in-beam characterization of a new gas tracker prototype for the NUMEN project

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Abstract

The aim of the present proposal is to perform a characterization with ion beams of the new gas tracker prototype that has been designed and built at INFN-LNS (Italy) for the focal plane detector of the MAGNEX magnetic spectrometer. The research and development activities of such a prototype are part of the NUMEN (Nuclear Matrix Elements for Neutrinoless Double beta decay) project [1].

The prototype

A new gas tracker for the focal plane detector of the MAGNEX spectrometer based on multiple Thick GEM (M-THGEM) is under development at INFN - LNS. The gas tracker must meet strict requirements for the tracking capability: an angular resolution smaller than 0.5° and a position resolution of 0.5 mm. Moreover, it must be able to handle quite high rate of medium-heavy ions of about 30 kHz/cm [2],[3].

The structure of the gas tracker consists of three main stages:
• a drift region, that is the active volume of the detector, crossed by the reaction ejectiles of interest
• an electron multiplication stage, based on Multi THick Gas Electron Multiplier (M-THGEM)
• a segmented read-out electrode
When an incident charged particle enters the detector leaves a track of ionized atoms and primary electrons in the low-pressure (between 10 and 50 mbar) gas-filled volume. Under the effect of a uniform electric field the electrons drift with a constant velocity toward the multiplication stage.
There the electrons are multiplied in the strong electric field of the M-THGEM. The resulting electron jets are then directed towards the segmented read-out electrode. From the measurements of the drift time of electrons the vertical position and angles are determined, while the horizontal position and angles are measured from the information coming from the charge distribution measured by the segmented anode. From all these information the full track of the ion can be reconstructed (i.e. impact point and angle of incidence at the focal plane).

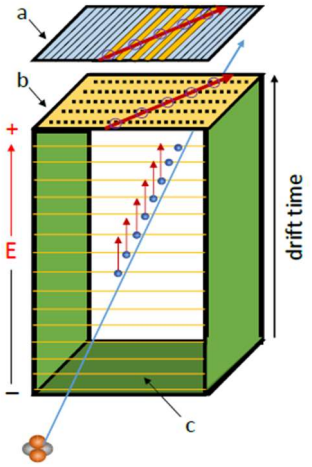

Fig.1 Scheme of the working principle of the NUMEN gas tracker prototype

The proposed in-beam test at LAFN/IFUSP Pelletron facility

The aim of the proposed test at 8UD Pelletron Tandem facility is to characterize

- the position and angle resolution of the tracker
- the dependence of the performances from the angle of the tracker with respect to the incident ion beam
- The tracker response to the beam rate

The **setup** of the proposed experiment is schematically shown in Fig. 2(left). The accelerated beam crosses a thin mylar window (thickness between 1.5 and 6 μm) located in the entrance pipe of the 45 cm diameter scattering chamber installed at the Pelletron facility. The chamber is filled with isobutane (iC4H10) with a of purity 99.95%. Gas pressure ranging from 10 to 50 mbar will be used during the runs. The tracker prototype (Fig. 2(right)) is located in the chamber with a tilt angle θ_{tilt} with respect to the incident beam varying from 0 to 70 degrees in different runs. A Silicon Carbide (SiC) + Cesium Iodide (CsI) telescope detector will stop the beam and provide the timing signal for the measurement of the electron drift velocity. The SiC+CsI telescopes will be used in the particle identification wall designed for the NUMEN experiment at the MAGNEX focal plane within the NUMEN project [2], [3].

The **required beams** are ^{12}C at ~45 MeV, ^{7}Li at ~28 MeV. The ^{12}C and ^{7}Li beam energies allow to simulate the conditions of the typical NUMEN beams in terms of energy loss in the low-pressure gas volume. Consequently, the charge distribution deposited in the segmented anode of the tracker is expected to be similar to the NUMEN working conditions. In particular, the energy loss in 10 cm thick gas volume (at 20 mbar pressure and 30° angle, also considering energy losses in dead layers) is ~2.3 MeV for ^{12}C beam and ~0.6 MeV for the ^{7}Li beam, thus exploring almost the same range of energy loss as in the NUMEN case. The beams will be well collimated with the collimation system available at the SAFIIRA setup in order to guarantee low emittance (beam spot of 0.3 mm diameter, divergency of 0.2 deg FWHM).

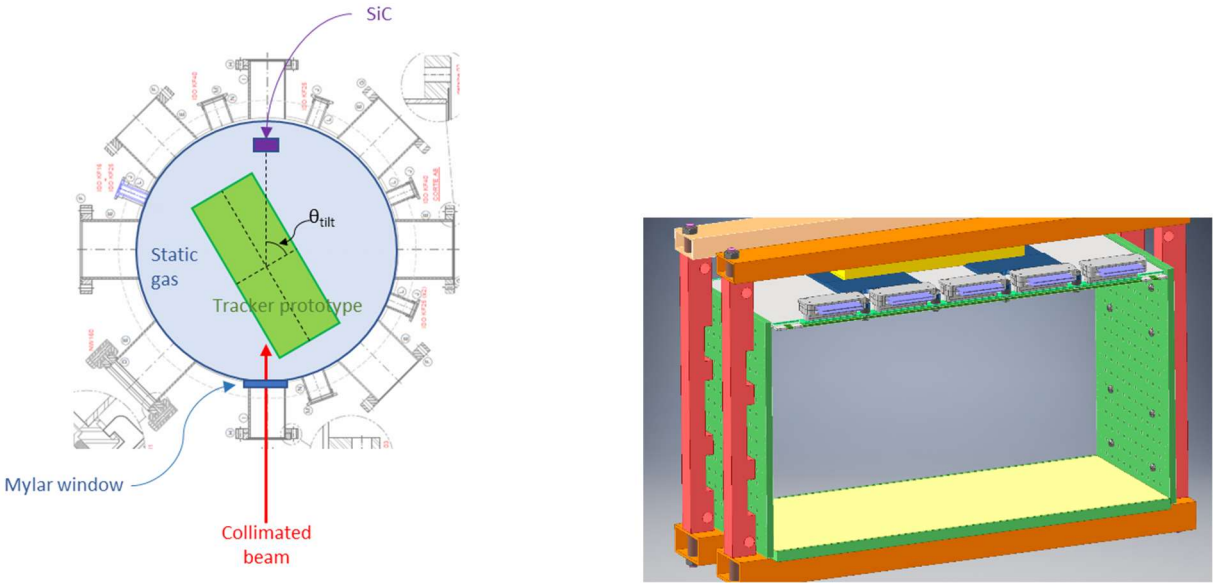

Fig. 2 (left) Schematic setup of the proposed experiment at the 0° Pelletron beam line chamber. (right) Drawing of the tracker prototype

The **beam time** request (1 BTU = 8 hours) is for 18 BTU with ^{7}Li beam + 18 BTU with ^{12}C beam for a total of 36 BTU (12 days) (mechanical installation and accelerator source preparation are excluded) arranged as follows:

- 3 BTU for the ^{7}Li beam transport at controlled rate with collimators and targets along the beam line
- 1 BTU for the setup of the tracker high voltages for ^{7}Li beam
- 14 BTU for the test at increasing rate of the ^{7}Li beam (from 10 Hz to 3 kHz), at four different angular configurations (θ_{tilt} = 70°, 60°, 30°, 0°) and at different high voltage configurations of the gas detector
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References

[1] F. Cappuzzello, et al., Eur. Phys. J. A (2018) **54**: 72
[2] P. Finocchiaro, et al., Universe 6 (2020) 129
[3] F. Cappuzzello, et al., Front. Astron. Space Sci. 8 (2021) 668587