Focal Plane Detector Optical Readout

an alternative solution for high rate tracking for the NUMEN Project

G. Gallo[1,2], for the NUMEN collaboration

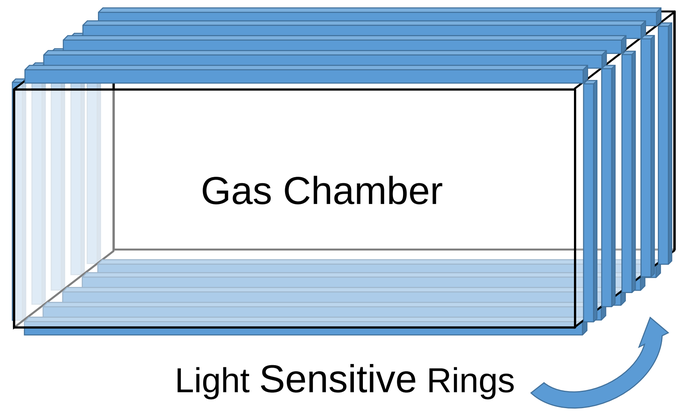
[1] University of Catania, Italy – Department of Physics and Astronomy
[2] INFN - Laboratori Nazionali del Sud, Catania

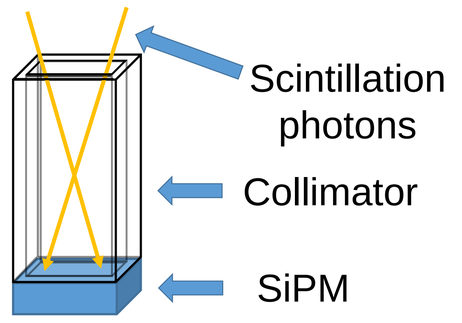
Abstract

A preliminary study of a solution for the optical detection and tracking of the ions in the MAGNEX [1] focal plane detector for the NUMEN project is presented [2]. The track of the ions is sampled by means of the light emitted traversing a scintillating gas and collected by arrays of Silicon PhotoMultiplier suitably arranged. A complete Geant4 simulation is under development to correlate the geometry, the characteristics of the gas filling the chamber and the light collection efficiency.

Design of the detector

The detector is originally designed as a series of light sensitive rings that surround the gas chamber of the focal plane detector. Each ring is composed of four linear arrays of square SiPMs. In front of each SiPM is placed a collimator in order to reduce its field of view. The internal walls of the collimator could be made reflective to improve the photon collection efficiency.





Digital read-out

It consists in registering just which light sensors are hit by the scintillation light, disregarding how many photons strike each sensor. In practice, it could be considered equivalent to a measure of the width of the light cone over a sensitive array. Starting from this measurement on two facing array, a geometric reconstruction algorithm can find the coordinate of the ion on the plane identified by the two arrays.

Main Features

Compared with the standard solution for ions tracking like drift chamber, the optical read-out presents some advantages, such as:

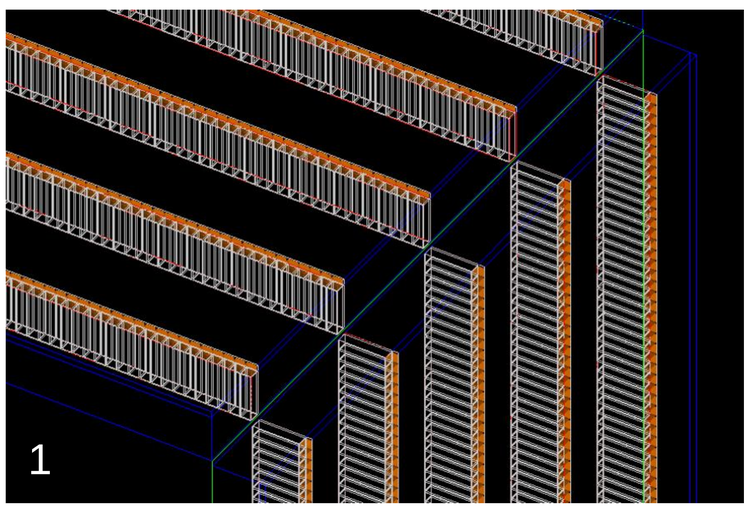
- low operating voltages limited to SiPMs bias;
- uniformity due to no electric field distortion;
- high spatial resolution;
- high counting rate up to 300 MHz;
- reduced data stream.

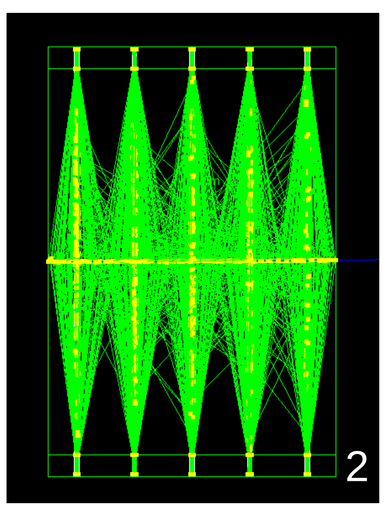
These last two features will be achieved only if the information needed to accurately reconstruct the position of the ions can be obtained by a full digital read out of the SiPMs.

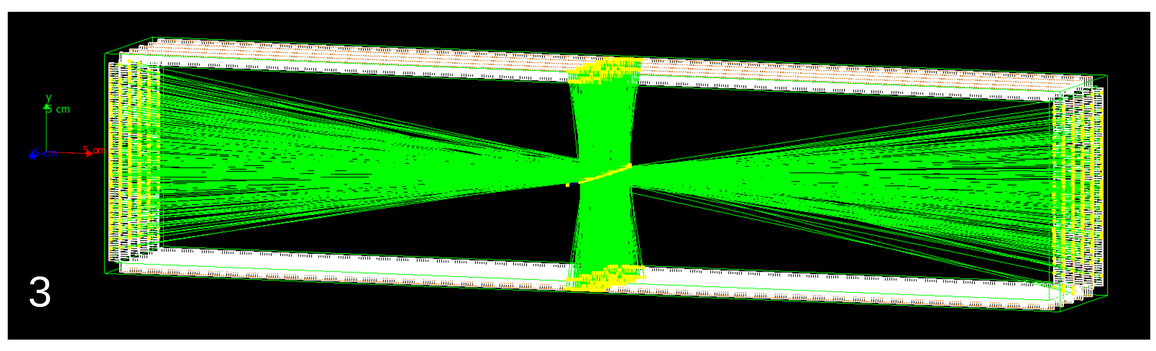
Geant4

To verify the feasibility of an optical tracker with these characteristics and to study its performance, a detailed Monte Carlo simulation is under development by means of the Geant4 toolkit [3]. The parameters of the simulation are:

- scintillating gas and pressure;
- number, sizes and position of the SiPMs;
- collimator size and optical properties.



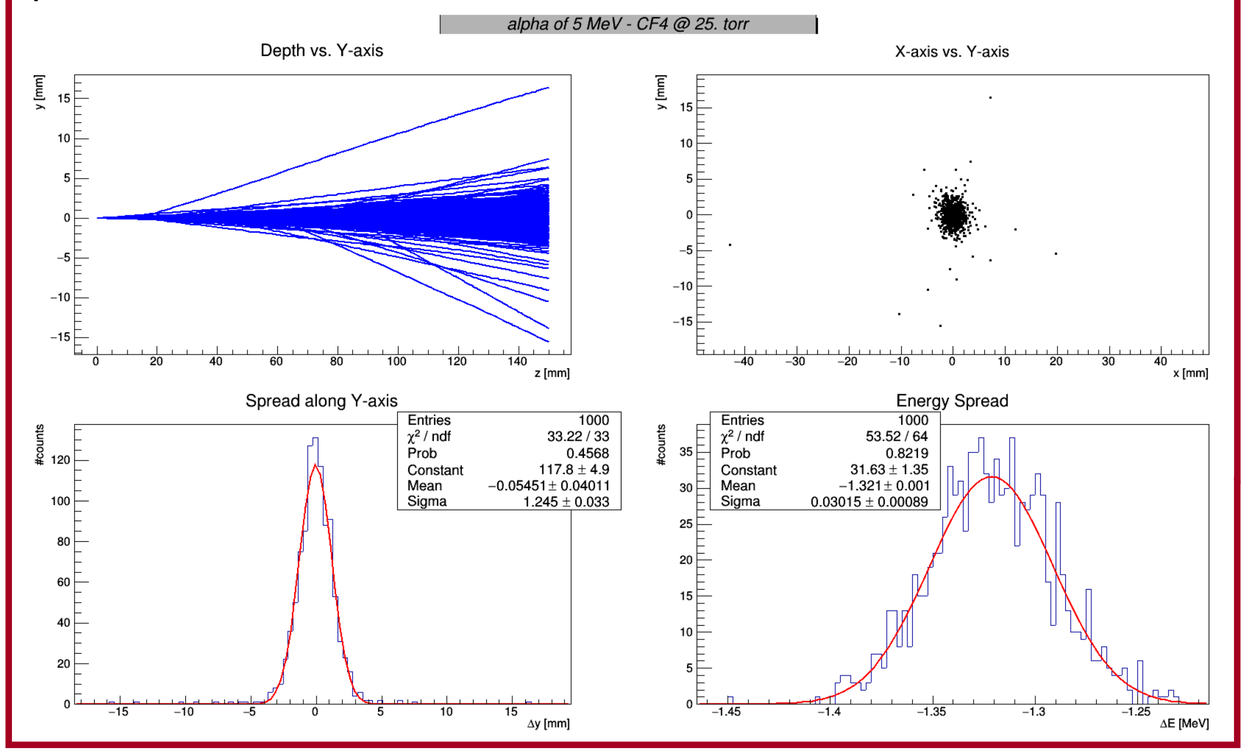




Some screenshot of the Geant4 GUI. Figure 1 shows the arrangement of light sensors (orange) and collimators (white frame) on a corner of the gas box that represents the FPD volume. Figure 2, 3 show the scintillation photons produced by an alpha particle of 5.0 MeV traversing the FPD filled with CF_4 at 25 torr. Photons are radiated isotropically, but it is possible to display only that ones that strike a SiPM.

Preliminary results

Once the number of rings has been set, the first step of the simulation is to calculate the angular straggling and the energy lost by the ions. The figure below shows an example for 1000 alpha particles of 5.0 MeV passing through 150 mm of CF_4 at a pressure of 25 torr.



Conclusions

The next steps of this work include the definition of the ions that could be really detected at the FPD during the NUMEN experiments, find the best parameters to maximize the number of photons collected and the implementation of the algorithm to reconstruct the position of the ions through the detector. This simulation platform will help to design other detectors with similar requirements.

References

[1] F. Cappuzzello, et al., *The MAGNEX spectrometer: Results and perspectives,* Eur. Phys. J. A 52 (6) 167 (2016), DOI: 10.1140/epja/i2016-16167-1.

[2] https://web.infn.it/NUMEN/

[3] Agostinelli S., et al., *Geant4 - a simulation toolkit*, Nuclear Instruments and Methods in Physics Research Section A: Accelerators, Spectrometers, Detectors and Associated Equipment, Volume 506, Issue 3, 1 July 2003,

Pages 250-303, ISSN 0168-9002, https://doi.org/10.1016/S0168-9002(03)01368-8.

For further information please send an e-mail to
giuseppe.gallo@ct.infn.it

Scan the QR code to download a digital copy of this poster