Development and test of a segmented Time-of-Flight plastic detector*

M. L. Cortés[†1,2], *H. Schaffner*[2], *I. Kojouharov*[2], *B. Voss*[2], *F. Ameil*[2], *K. Koch*[2], *S. Pietri*[2], *J. Gerl*[2], *N. Pietralla*[1], *P. Bednarczyk*[3], *J. Kotuła*[3], *Z. Sułek*[3], *and the PreSPEC and AGATA collaborations*

[1]TU Darmstadt, Darmstadt, Germany; [2]GSI, Darmstadt, Germany; [3]IFJ PAN, Kraków, Poland

Introduction

Improved SIS primary beam intensities converts directly into higher yields of exotic nuclei. Improvements to the FRS [1] tracking detectors are necessary to allow for higher rates. This concerns in particular the rate at the intermediate focal plane S2 where tracking detectors allowing for rates higher than $10^6 s^{-1}$ are needed.

In September 2010 a first Finger detector made of 15 strips of plastic scintillator, 14 mm wide each, was successfully commissioned and used [2]. As an upgrade from that detector, a new Finger detector was developed consisting of 51 strips, 4.4 mm wide, of BC420 plastic scintillator. This detector is used as a test case for further developments for HISPEC/DESPEC at FAIR.

Setup

Each pair of strips was glued to a bended UV-transparent PMMA light guide using a 2 component silicon glue. The light guides were then optically coupled to Hamamatsu R9880U-01 photo-multiplier tubes (PMTs) using silicon pads. To power up the PMTs, 13 power supplies were used, each one powering up 4 tubes. Independent potentiometers were added to the setup to allow independent adjustment of the voltages. Figure 1 shows the new Finger detector mounted.

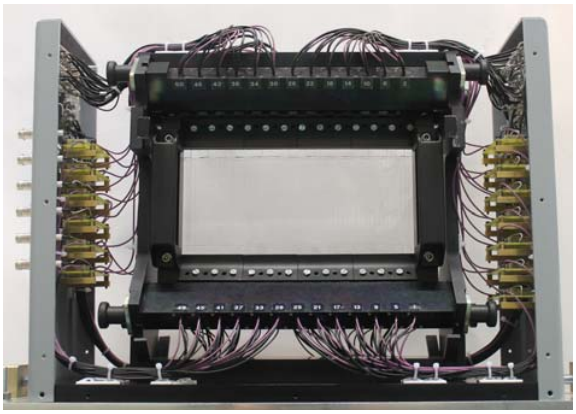

Figure 1: The new Finger detector

The PMTs are read-out using the LANDFEE discriminator. This electronics determines the leading and trailing edges of the incoming PMT pulses as time signals. These two times are then recorded using two CAEN V1290 Multihit TDCs. Using the two times given by the electronics it is possible to obtain, apart from the time of occurrence, the time-over-threshold (ToT) of the signal, which provides a measure of the signal amplitude. TRIPLEX cards [3] are used for the remote control of the thresholds and to obtain an OR signal and an analogue sum of the signals for monitoring. One of the TRIPLEX cards is connected with a network module which makes the system remote controllable via Ethernet by a lab-view program.

In-beam test

The New Finger detector was tested from February to April 2014 as part of the PreSPEC-AGATA setup at GSI [4]. Time and ToT spectra were obtained for Fe and Ni beams with different intensities. The efficiency of the new Finger detector was in average 2% lower than the one of the standard scintillator at S2, mainly because of gaps between the strips. Figure 2 shows a typical ToT spectrum recorded in one of the PMTs. Using these spectra it is possible to decide which strip had the higher charge collection and therefore which was the strip that was hit. Position and timing information from that strip were used for each event and a preliminary analysis was performed. Figure 3 shows the correlation between the strip selected as being hit and the position determined in TPCs. In spite of the clear correlation, background is also present, coming from two different sources: The high rate present as S2, which reduces the performance of the TPCs and the possibility of having

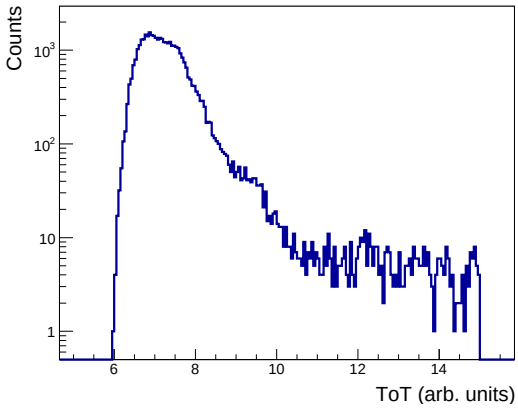

Figure 2: Time-over-threshold spectrum

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† m.l.cortes@gsi.de

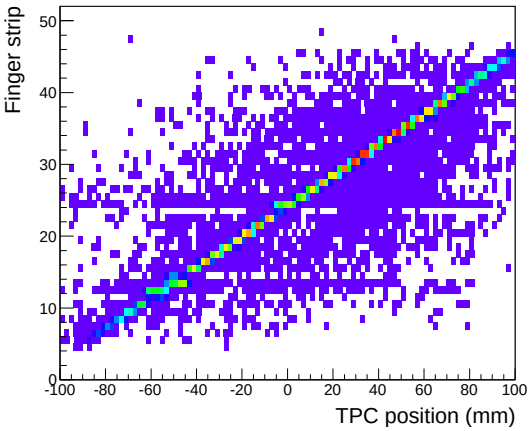

Figure 3: Strip number vs. position projected from TPCs

two particles hitting the Finger detector during the same trigger, which gives the possibility of a wrong strip selection. To study this effect, the number of PMTs fired per event was calculated. When all fired PMTs are consecutive they are considered as coming from a single particle interaction. When they are not consecutive, a second particle could have produced the signals. The number of this sets of consecutive PMTs is called cluster multiplicity. Figure 4 shows the number of clusters recorded versus the number of PMTs fired. We can see that for the case of one particle

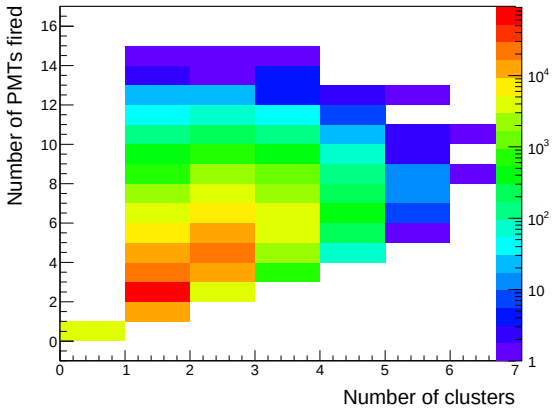

Figure 4: Cluster multiplicity vs. PMT multiplicity

the most likely is to have two PMTs fired, corresponding to one strip. The rest of the events can be properly reconstructed with more detailed analysis.

Using the timing information given by the strip selected, the Time-of-Flight (ToF) between the new Finger detector and the scintillator placed in the last focal point of FRS (S4) was calculated. Figure 5 shows the ToF versus the atomic number of the particles obtained from the MUSIC ionization chambers.

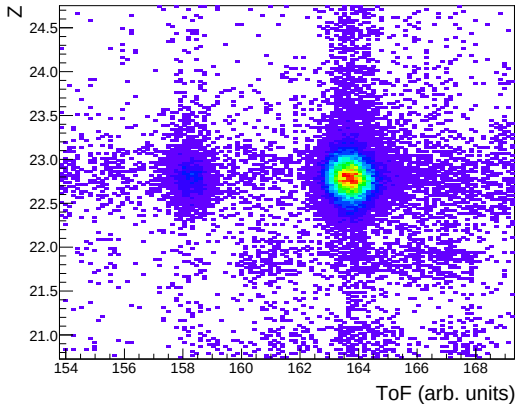

Figure 5: Time of flight vs. atomic number

This plot presents a preliminary identification plot and can be further improved by a more detailed analysis which includes strip selection, considering multiple particles and proper calibrations.

Outlook

A new Finger detector with higher count rate capabilities was developed and tested. ToT technique to select the strip was proved to be feasible. The preliminary analysis of the data obtained during the PreSPEC-AGATA campaign 2014 show a reasonable efficiency and the possibility to characterize multiple particles hitting the detector. The outcome of this study will be used to optimize further developments for a Time-of-Flight detector at the Super FRS.

References

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