The fragmentation trigger of the FOOT experiment

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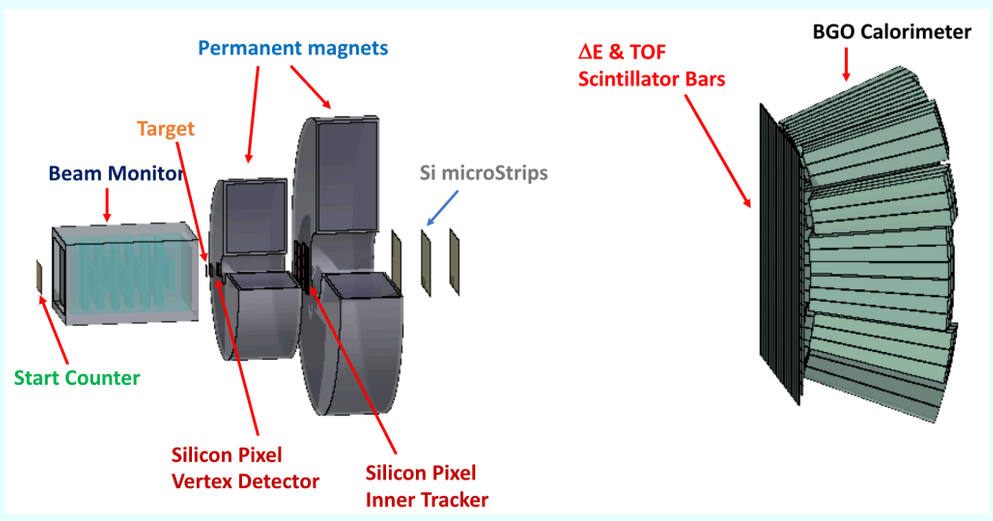
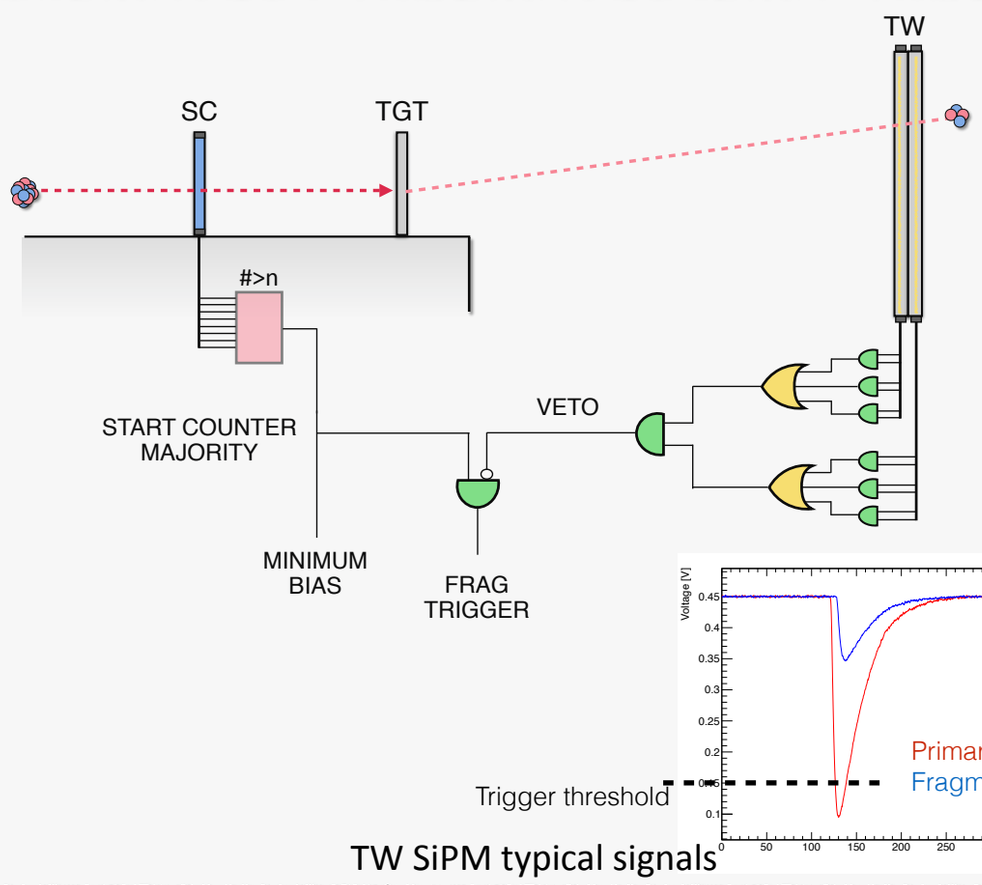
The FOOT experiment



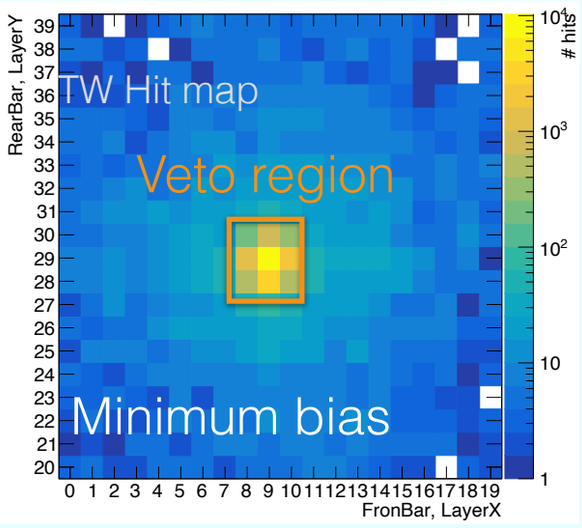
The FOOT experiment aims at measuring the nuclear fragmentation of carbon and oxygen nuclei to characterise the secondary products in hadron therapy. C and O beams of an energy in the range 150-400 MeV/u are shot on thin targets, the emerging fragments are reconstructed by the FOOT detector.
Since the projectile fragmentation occurs in less than 10% of the events a sophisticated trigger logic has been implemented to enrich the data sample with fragments which are distinguished from primaries by looking at the energy deposit in the scintillator detectors.
The Start Counter (SC), the TOF-Wall* (TW) and the BGO calorimeter are readout by means of the WaveDAQ system, an highly integrated trigger and DAQ system. The FOOT physics triggers, based on fast the SC and TW detectors, are generated by the WaveDAQ and then distributed to the general DAQ.
**Contribution ID 351 by M. Morrocchi at this conference*

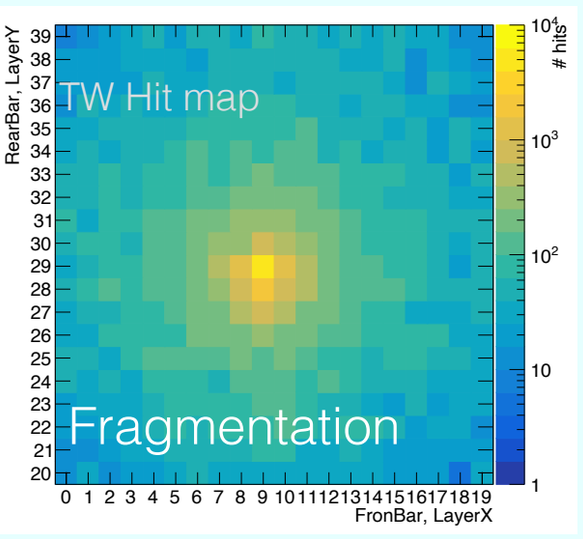
Trigger idea: why and how

The maximum sustainable DAQ rate of the FOOT experiment is about 500Hz, smaller than the usual beam rate available, leading to dead time. Here we present a trigger algorithm to select with full efficiency projectile fragmentation events among the most abundant primarie hits.
The Start Counter (SC) consists of a thin squared foil of EJ-228 plastic scintillator 250 µm thick read by 8 groups of SiPMs. At trigger level SC signals are discriminated and the number of hits are counted; in case they exceed a programmable value (majority) the Minimum bias trigger is generated.
The TOFWall detector (TW) is composed of two layers of 20 plastic scintillator bars (EJ-200), arranged orthogonally, readout by SiPM on both bar ends.
Since primaries enter in the central region of the TW and deposit a larger amount of energy w.r.t. fragments, they can be distinguished just by looking at the central bars on both views of the detector. In practice if the signal pulse height exceeds a programmable threshold a Veto signal inhibits the Minimum bias, otherwise the fragmentation trigger signal is generated.



TW SiPM typical signals



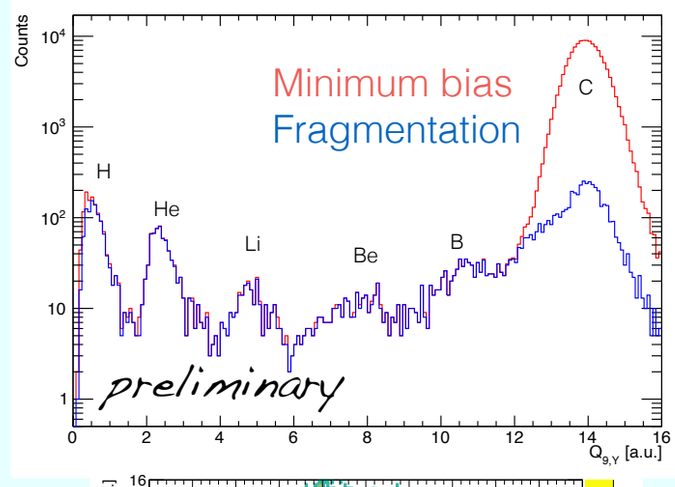


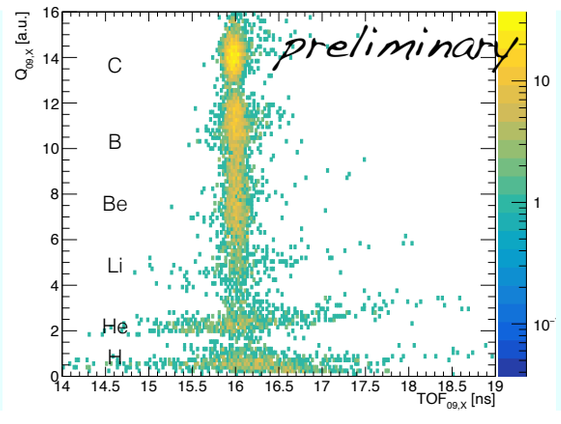
Configuration procedure

1. Minimum bias dataset to check the TW pulse height distribution and compute trigger thresholds
2. Data set with minimum bias trigger to check fragmentation trigger rate and collect a sample for detailed trigger efficiency evaluation *a posteriori*
3. Fragmentation trigger data acquisition

Results

As a result the data acquisition rate is reduced by almost a factor 10 preserving full efficiency on signal selection. The DAQ rate is limited at ~500 Hz which is saturated by both minimum bias and fragmentation trigger peak rates. Thus a factor of about 6 more statistics is actually available in the same beam time, then an improvement of about a factor ~2.5 in cross section measurements is expected.
The fragmentation trigger was successfully used for 2021 DAQ campaigns at GSI on ^{16}O beam in summer and CNAO ^{12}C beam in fall. In the latter case the reproducibility of the method was proven with 4 different beam energies.





E [MeV]	H	He	Li	Be	B
150	100 %	100 %	100 %	100 %	(99.75 ± 0.15) %
200	100 %	(99.84 ± 0.16) %	100 %	100 %	(99.67 ± 0.15) %
300	(99.72 ± 0.28) %	(99.90 ± 0.10) %	100 %	(99.94 ± 0.04) %	(99.60 ± 0.06) %
400	100 %	100 %	(98.93 ± 0.75) %	(99.72 ± 0.28) %	(96.56 ± 0.44) %

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