PHENIX Time-of-flight detector West (TOFW) – Detector Basics

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(Based on pointers provided by Julia Velkovska)

Purpose, technology, dimensions

The momentum (p), charge sign and flight path length (L) of charged hadrons is measured with the Drift Chamber (DC). Identification of long-lived charged hadrons (π, K, p) is done with one of three dectectors: the Time-of-flight (TOF), the Ring Imaging Cherenkov Detector (RICH) and the aerogel detector (AGEL). The three detectors are effective in distinguishing between pions and kaons, and kaons and protons in different p_{T} ranges (see Fig. 1).

		Pion-Kaon separation	Kaon-Proton separation
TOF	σ~100 ps	0 - 2.5	- 5
RICH	n=1.00044 γth~34	5 - 17	17 -
Aerogel	n=1.01 γth~8.5	1 - 5	5 - 9

FIG. 1. Charged hadron identification ranges of various PHENIX detectors (source: Conceptual Design Report, June 2005)

An approximately 100 ps resolution, scintillator-based time-of-flight detector in the East Arm (TOF or TOFE) was installed already for Run-1. In 2005 another TOF detector was proposed for the West Arm, the TOFW, with better timing resolution and azimuthally back-to-back with TOFE, in order to improve particle identification and make the measurement of back-to-back particle correlations possible.

The time-of-flight detector in the West arm of PHENIX (TOFW) is located at a radial distance of 4.81 m from the interaction point, having a pseudorapidity coverage of $|\eta| < 0.35$

and azimuthal coverage of 22^o in two separate sections. The individual elements are multigap resistive plate chambers (MRPCs). Each MRPC has six 230 μm gas gaps separated by five 550 μm thick glass plates. On each side of the outermost glass plates (1.1 mm thick) are carbon tape electrodes held at +7 kV on one side and -7 kV on the other side for a total bias voltage of 14 kV. When charged particles traverse the detector, the gas between the plates is ionized and the image charge is collected at each side of the chamber on four copper readout strips. Each strip has dimensions 37*2.8 cm^2 with a separation of 0.3 cm between them. The strips are oriented lengthwise along the azimuthal direction. Each strip is read out from both top and bottom so that the time difference between them can be used to determine the hit position along the length of the strip with resolution of order 1 cm. The TOFW system is composed of a total of 128 MRPCs, 512 strips, and 1024 readouts. The total timing resolution, which includes the uncertainty in the start time from the BBC, is 84 ps in Au+Au collisions. In d+Au collisions it is 95 ps, where the slightly poorer resolution is due to the lower resolution of the start time determination from the BBC.

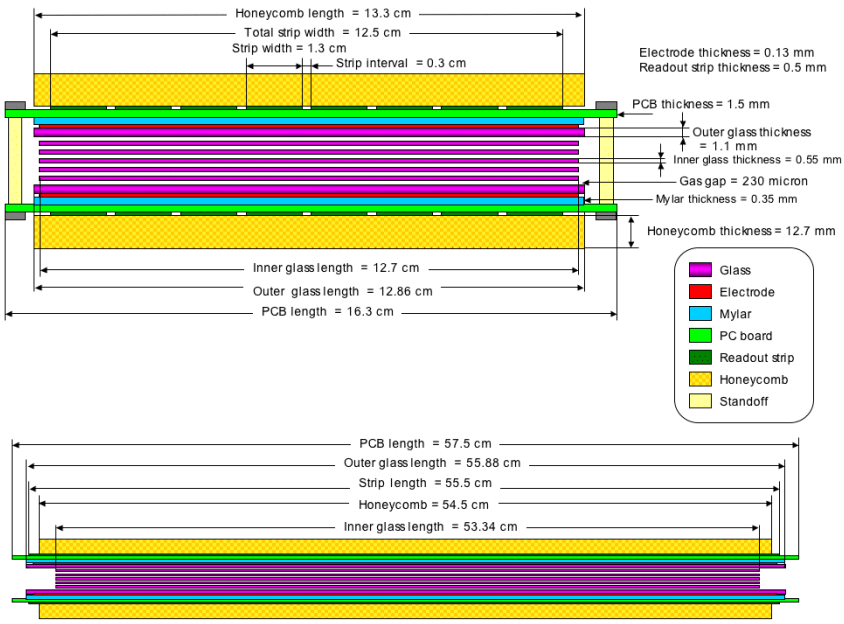

FIG. 2. TOFW drawing with dimensions (source: Conceptual Design Report, June 2005)

The drawing of the TOFW is shown in Fig. 2, and the testbeam performance (particle separation) is shown in Fig. 3.

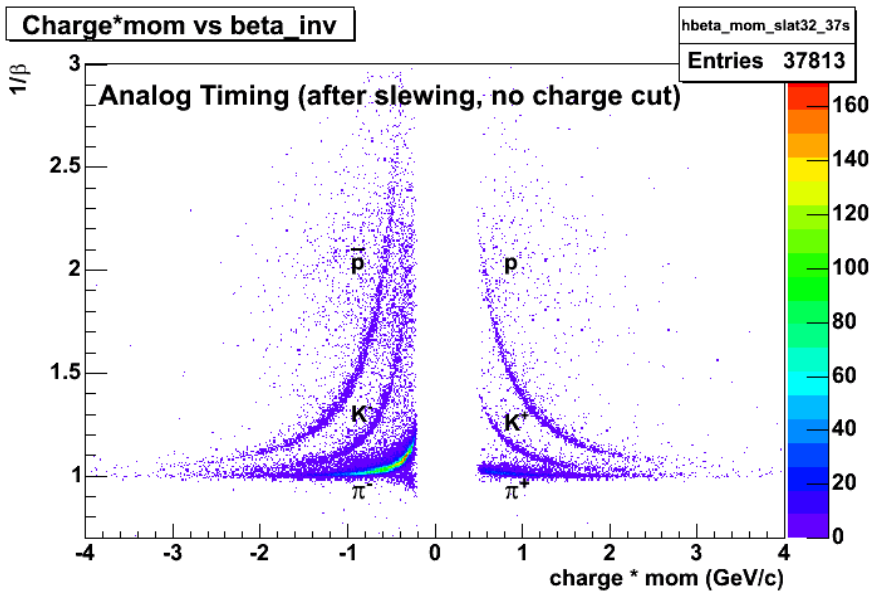

FIG. 3. TOFW testbeam performance (source: Conceptual Design Report, June 2005)

Physically, the four TOFW boxes are located in sectors W1 and W2, one box each on the North and South sides. They cover the full DC pseudorapidity range, but only half the azimuth (11.25^o) of each sector. The front-end module (FEM) provides TDC and ADC values for each readout channel, in order to make slewing correction possible. An example of the timing distribution for pions, kaons and protons is shown in Fig. 4.

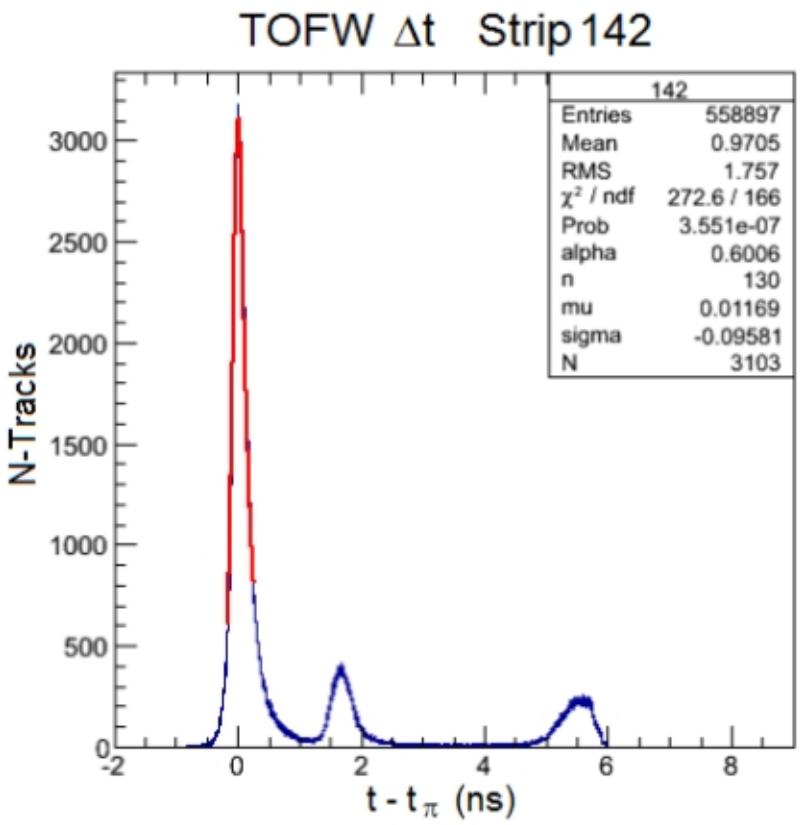

FIG. 4. Example of a TOFW strip timing distribution after slewing correction and subtracting the expected pion time-of-flight, i.e. shifting the pion time to zero. The p_{T} range is 1.0-1.1 GeV/c. The pion, kaon and proton peaks are well separated. (source: Brennan Schaefer, thesis, 2016)