THE MICE BEAMLINE PID INSTRUMENTATION FOR A PRECISE EMITTANCE MEASUREMENT

The MICE experiment at RAL aims at a systematic study of a section of the cooling channel of the proposed US Study 2, attaining a 10% effect for a 6π·mm rad beam. The 5.5 m long cooling section consists of three liquid Hydrogen absorbers and eight 201 MHz RF cavities encircled by lattice solenoids. As conventional emittance measurement techniques reach barely a $\sim 10\%$ precision, a novel method based on single particle measurements has been envisaged. Particles are measured before and after the cooling section by two magnetic spectrometers complemented by TOF detectors. For each particle x,y,t,p_x,p_y, E coordinates are measured. In the first step of MICE (STEPI) a preliminary measure of the beam emittance has been obtained using only the TOF system to validate the procedure. A precision of a few per-cent has been obtained.

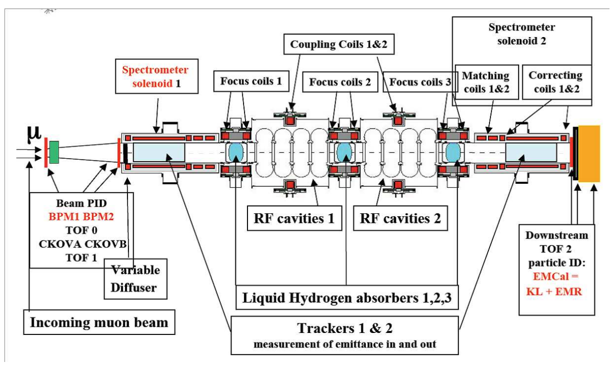

Figure 1: 2-D layout of the MICE experiment at RAL. The cooling section is put between two magnetic spectrometers and two TOF stations (TOF1 and TOF2) to measure particle parameters.

The driving design criteria for MICE detectors are robustness to sustain the severe background conditions in the vicinity of RF cavities and redundancy in PID in order to keep beam contaminations (e, π) well below 1% and reduce systematics on the emittance measurements.

PID is obtained upstream of the first tracking solenoid by two TOF stations (TOF0/TOF1) and two threshold Cerenkov counters (CKOVa/CKOVb), that will provide π/μ separation up to 300 MeV/c.

Downstream the PID is obtained via a further TOF station (TOF2) and calorimeters (EMCAL), to separate muons from decay electrons. All TOF detectors are used to determine the time coordinate (t) in the measurement of the emittance.

All the TOF stations share a common design based on fast 1” scintillator counters along the X/Y directions (to increase measurement redundancy) read at both edges by conventional R4998 Hamamatsu photomultipliers.

The downstream calorimeters (EMCAL) consist of a Pb-scintillating fiber calorimeter (KL), of the KLOE type, with 1-mm diameter blue scintillating fibers glued between 0.3 mm thick grooved lead plates followed by an electron-muon ranger (EMR), made of a 1 m^3 fully sensitive segmented scintillator block. This “spaghetti” design for KL offers the possibility of fine sampling and optimal lateral uniformity. The expected resolution $\sigma_E \simeq 5\%/E$ is fully dominated by sampling fluctuations and is linear for electrons or photons in the range 70-300 MeV. In the EMCAL while KL will measure electrons, the EMR will measure precisely the muon range.

The TOF detector timing resolution can be measured by using the time difference Δt_{XY} between the vertical and horizontal slabs in the same station (see figure 2). The obtained resolution on the difference is $\sigma_{XY} \sim 100\ ps$, that translates into $\sim 50ps$ resolution for a full time-of-flight detector with crossed horizontal and vertical slabs.

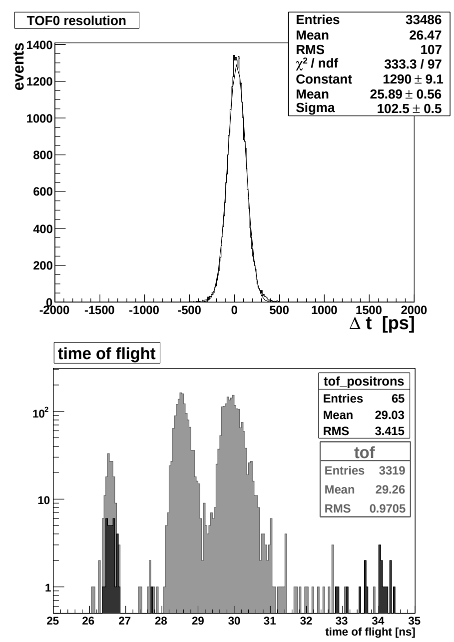

Figure 2: *Top panel: time difference Δt_{XY} between vertical and horizontal slabs in TOF0 (top panel). Bottom panel: time of flight between TOF0 and TOF1 for the $positron$ (black) and $pion$ (grey) beams.*

Figure 2 shows, as an example, the distribution of the time-of-flight between TOF0 and TOF1 for the 300 MeV/c pion beam and a positron beam. The first peak which is present in both distributions (pion and positron beam) is considered as the $time\ of\ flight$ of the positrons and is used to determine the absolute value of the time in TOF1. A natural interpretation of the other two peaks is that they are due to forward flying muons from pion decay and pions themselves.

Using the combined informations from the TOF system and the KL calorimeter, the pion contamination in the MICE muon beam has been estimated $\sim 1\%$.