TRIUMF Experiment E614

Technical Note 65.1

TEC Resolution at 60 and 100Torr (Monte Carlo Drift)

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STR and space resolution for TEC presented in Fig.1 has been calculated in TN-65 at $p = 40Torr$ for surface muons only. Calculation has been done by Runge-Kutta method for TEC with pitch of $1mm$ between sense wires. Present note calculates STR and resolution of new TEC construction with paired wires for positrons, muons and pions. Calculations have been done for DME and ISO gas at 60 and $100Torr$ using Monte Carlo drift of electrons. Diffusion of drift electrons gives a big contribution to drift of electrons in a low pressure gas. Figs. 2-5 demonstrate Runge-Kutta and Monte Carlo drift lines from a track with length of $2mm$ covering two paired sense wires placed at $Y = 0$ and $0.1cm$. In reality the original length of $2mm$ is spreed to $\approx 5mm$ because a diffusion, as one can see comparing Fig.2 and Fig.3. Diffusion changes drift lines behavior at small distances also (Figs.4-5), and even inside multiplication area at $0 < X < 0.6cm$. The diffusion spreads of drift line lengths, and therefore worse a space resolution, especially at small values of d.

Calculations have been done using Monte Carlo drift of electrons.Monte Carlo step size (MCS) of $120\mu m$ has been selected therefore there are not so accurate calculation results. Less value of MCS can not be possible because the GARFIELD allows only a restricted number of Monte Carlo steps. An electron reaches a sense wire from $d = 5cm$ at $MCS \geq 120\mu m$ only. SIGNAL section of GARFIELD has been used. Single electron amplitude was $90mV$. Threshold was $140mV$. Such value of parameters probably is close to real possibility of our front-end electronics.

Data about ionization electron numbers and registration efficiency are presented in Table 1. One can see that a particle in ISO gas produces more primary electrons than in DME gas, and provides therefore a possibility to measure even positron track at $p = 100Torr$. The ISO is more preferable gas than DME one from this standpoint. But the ISO gas is more sensitive to a magnetic field. This effect has been analyzed in TN-65. Magnetic field map on TEC position is needed to do a gas selection. Let me point out next time that we have to use a big value of V_c in order to increase positive ion drift velocity and decrease an influence of a positive ion cloud on TEC drift parameters. This question is discussed in TN-65 with more details.

Table 1: Number N_e of primary electrons per 2mm and registration efficiency $(\varepsilon, (\%))$. Gain of TEC has been selected to have a single electron amplitude equals to $90mV$. Threshold of $140mV$ has been selected.

	ISO gas				DME gas			
	$p = 60Torr$		$p = 100Torr$		$p = 60Torr$		$p = 100Torr$	
	$N_e, (2mm)$	$\varepsilon, (\%)$	$N_e, (2mm)$	$\varepsilon, (\%)$	$N_e, (2mm)$	$\varepsilon, (\%)$	$N_e, (2mm)$	$\varepsilon, (\%)$
$e^+, 30MeV$	2.6	49	4.4	58	1.4	26	2.1	44
$\pi^+, 120MeV/c$	4.8	62	7.4	81	2.2	37	3.7	54
$\mu^+, 29.8MeV/c$	23.7	100	38.3	100	11.1	99.8	18.8	100

STR curves are fitted by function $t_0 = a_0 + a_1 d$, where t_0 is an average drift time from a particle goes at distance of d from grid wires placed at $X = 0.6cm$ (Figs.2-5). Drift velocity depends on gas and V_c. It is $a_1 \approx 18.4ns/mm$ for ISO gas at $p = 100Torr$ (See Fig.6) for positrons, pions and muons. Value of a_0 is $12.1, 10.4, 6.1ns$ for positron, pion and muon respectively.

Space resolution curves are fitted by linear function $\sigma = c_0 + c_1 d$ also in contradistinction to Runge-Kutta calculations where a resolution is fitted by function $\sigma = c_0 + c_1\sqrt{d}$ with a good confidence level (see TN-56). Examples of resolution dependence are presented in Figs.7-8 and in Table 2.

Table 2: Spatial resolution of the TEC with IS0 ($(CH_3)_2CHCH_3$) and DME ($(CH_3)_2O$) gases for positron, pion and muon. Particle track was parallel to sense wires plane and orthogonal to wires direction (See Fig.1). d is distance between track and field wires plane. Sense wires placed every 1mm and they are joined in pairs. It means that signals from wires of the pair are summarized one preamplifier input. SIGNAL section and HEED package of the GARFIELD have been used for the simulation. Gain of TEC has been selected to have a single electron amplitude equals to $90mV$. Threshold of $140mV$ has been selected. Monte Carlo drift of an electron in the TEC has been used. Monte Carlo step size (MCS) of $120\mu m$ has been selected therefore there are not so accurate calculation results. Less value of MCS can not be possible because the GARFIELD allows only a restricted number of Monte Carlo steps. An electron reaches a sense wire from $d = 5cm$ at $MCS \geq 120\mu m$ only. V_c is voltage between cathode and field planes of drift part of the TEC (See Fig.1). Function $\sigma(d) = c_0 + c_1 \cdot d$ has been selected for fitting of a $\sigma(d)$ function. The fitted parameters and their errors are presented in the Table. Data for positron in DME at $p = 60Torr$ are not presented because a low statistics.

	ISO gas $\sigma(mm) = c_0(mm) + c_1 \cdot d(mm)$				DME gas $\sigma(mm) = c_0(mm) + c_1 \cdot d(mm)$			
	$p = 60Torr$ ($V_c = -1500V$)		$p = 100Torr$ ($V_c = -2500V$)		$p = 60Torr$ ($V_c = -2000V$)		$p = 100Torr$ ($V_c = -3000V$)	
	c_0	c_1	c_0	c_1	c_0	c_1	c_0	c_1
$e^+, 30MeV$	0.4024 $\pm$0.1136	0.0025 $\pm$0.0036	0.2425 $\pm$0.0217	0.0039 $\pm$0.0007	–	–	0.2313 $\pm$0.0511	0.0064 $\pm$0.0019
$\pi^+, 120MeV/c$	0.3090 $\pm$0.0299	0.0062 $\pm$0.0011	0.2444 $\pm$0.0229	0.0032 $\pm$0.0007	0.2675 $\pm$0.0570	0.0105 $\pm$0.0021	0.1737 $\pm$0.0299	0.0100 $\pm$0.0013
$\mu^+, 29.8MeV/c$	0.1318 $\pm$0.0466	0.113 $\pm$0.0020	0.1798 $\pm$0.0412	0.0033 $\pm$0.0015	0.2912 $\pm$0.0201	0.0083 $\pm$0.0011	0.2194 $\pm$0.0262	0.0059 $\pm$0.0008

Some conclusions:
1.Total drift time in the TEC is $1 - 2\mu s$. It depends on gas (ISO is faster gas than DME) and on V_c value.
2.DME gas is preferably if we wish to measure only surface muons because we can use $p = 60Torr$ or even $p = 40Torr$ to eliminate a scattering. Besides the DME gas is less sensitive to magnetic field.
3.Average space resolution is $\approx 400\mu m$ in center of the TEC.
4. Maximal value of V_c is needed to decrease an influence of an ion cloud on TEC parameters at rate of a few kHz (see TN-56 for details).
5.Crosstalk between paired wires gives a big contribution to a real signal. Really it is a mutual decreasing of useful amplitudes of signals especially for a track going with $\theta \approx 0$. Unfortunately GARFIELD calculates the effect with a low accuracy, seems to me. Compensation capacitors will be useful to eliminate the crosstalk.

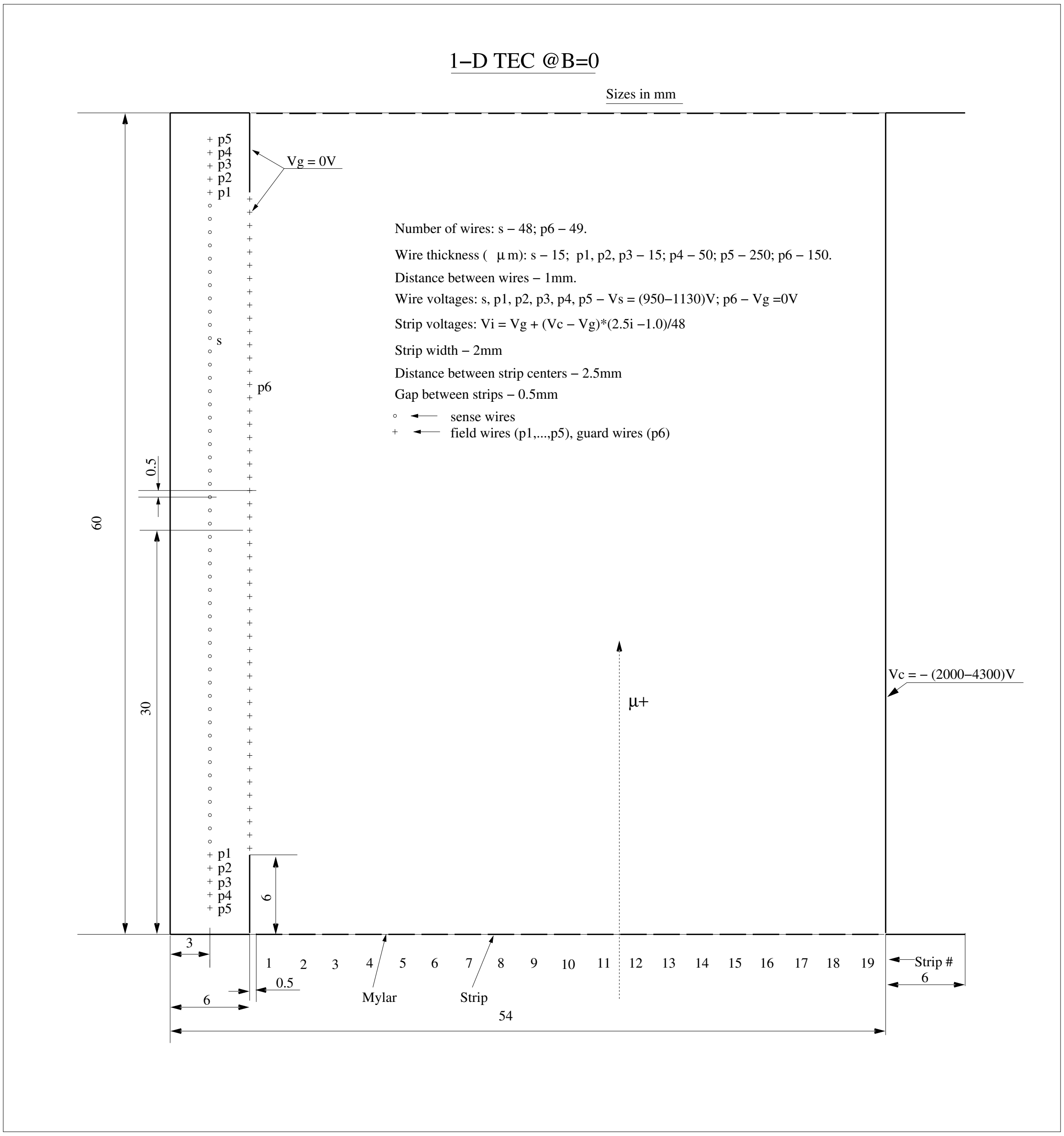

Figure 1: TEC view in XY-plane. Length of the TEC in Z direction is 100 cm.

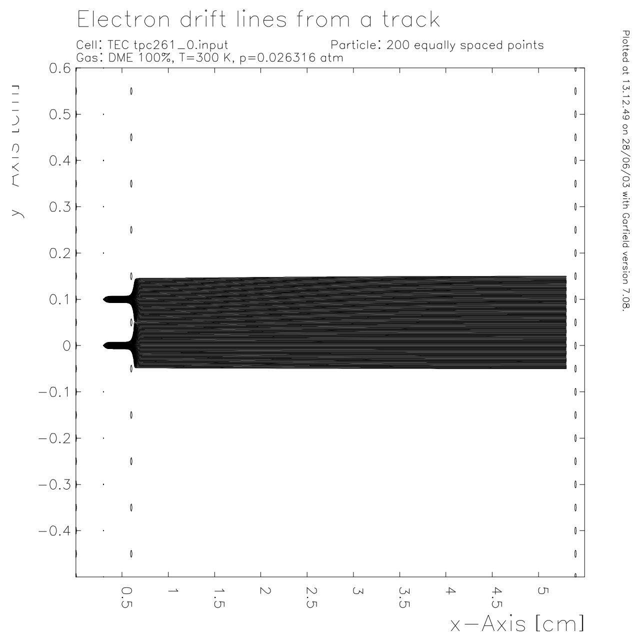

Figure 2: Runge Kutta drift lines of electrons in the TEC. DME gas at $p = 20Torr$.

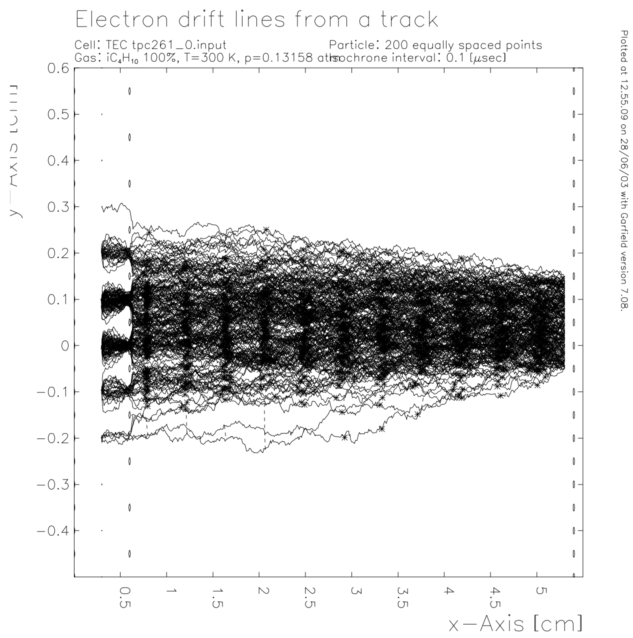

Figure 3: Monte Carlo drift lines of electrons in the TEC. ISO gas at $p = 100Torr$.

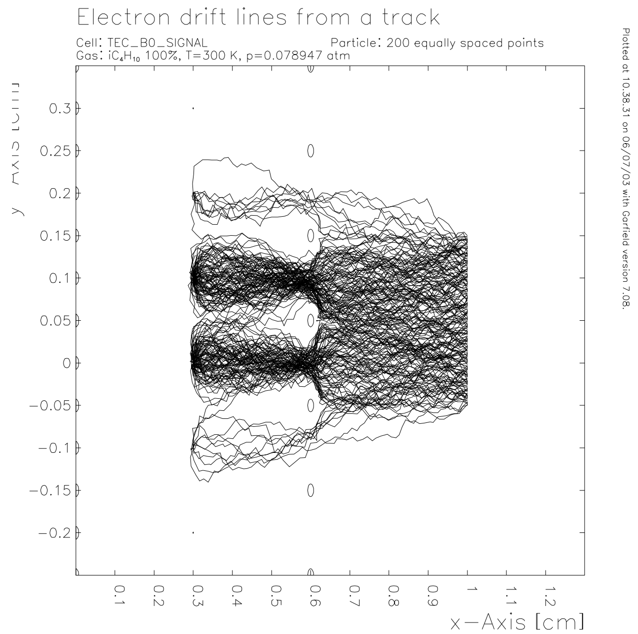

Figure 4: Monte Carlo drift lines of electrons in the TEC from $d = 4mm$. One can see an electron diffusion even between sense wires inside multiplication area ($0 < X < 0.6cm$). ISO gas at $p = 60Torr$.

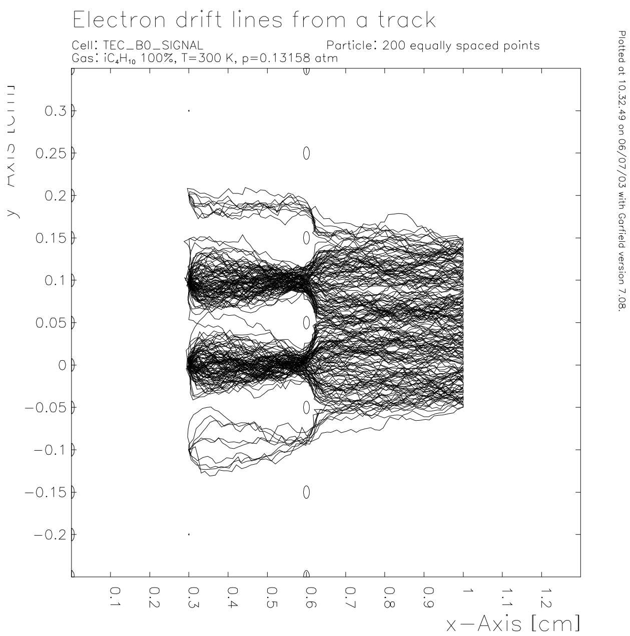

Figure 5: Monte Carlo drift lines of electrons in the TEC from $d = 4mm$. ISO gas at $p = 100Torr$.

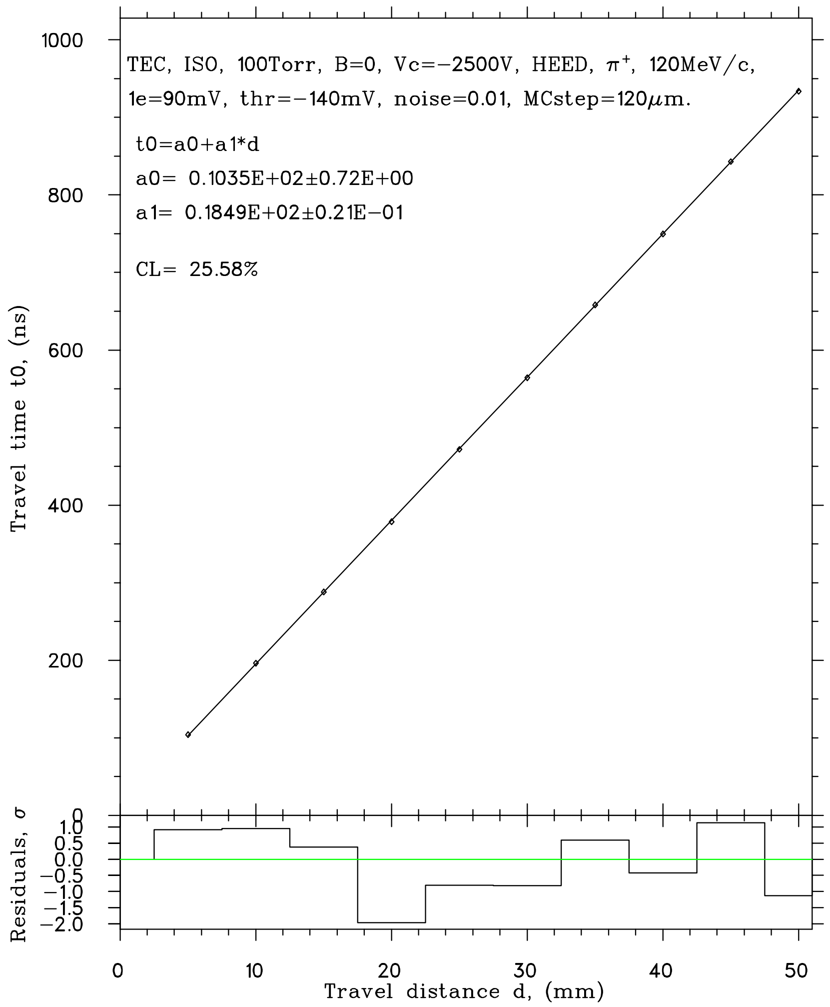

Figure 6: STR for π^+ at $p = 120MeV/c$ in ISO gas at $P = 100Torr$.

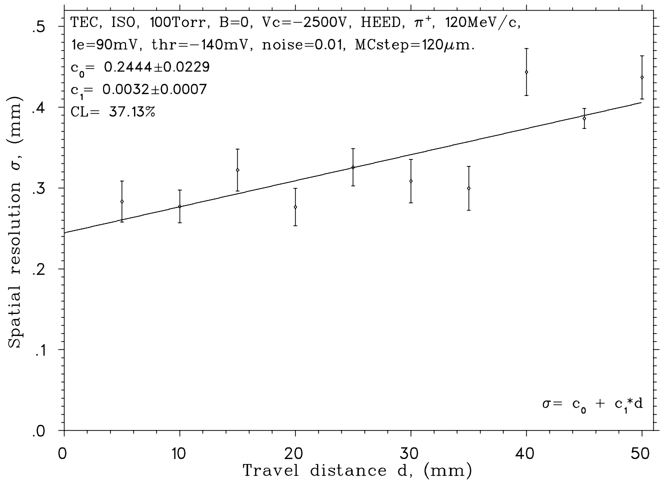

Figure 7: Space resolution for π^+ at $p = 120MeV/c$ in ISO gas at $P = 100Torr$.

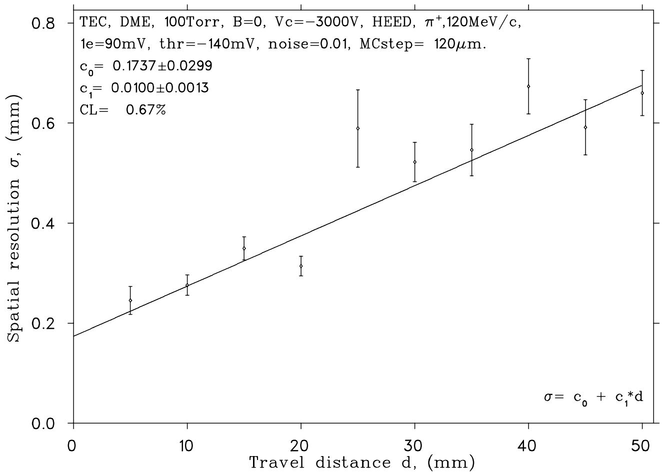

Figure 8: Space resolution for π^+ at $p = 120MeV/c$ in DME gas at $P = 100Torr$.