TRIUMF Experiment E614
Technical Note #47

Monte Carlo Simulation of Muon Stop Distributions in E614 Targets

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Surface muon distributions in a stopping target of E614 detector has been simulated with GEANT/E614/1.2 package for different target materials. A minimal target thickness was selected to provide 70-75% muons stop rate for Li, Be, C, Al, Fe and W. The muon distributions were calculated versus magnetic field value, beam divergence, and momentum spread value.

All elements of E614 detector were involved in the simulation: muon counter (TEC), (Ar +He) degrader, scintillator, PC2 and PDC4 chambers. Scintillator thickness was changed on 50μ maximum to have a symmetrical muons stop distribution along Z axis inside target. Magnetic field maps [1] was also used in simulations.

Minimal Target Thickness

A minimal target thickness is needed for E614 in order to decrease an outgoing positron energy loss inside the stopping target, and to weaken therefore its influence on reconstructed Michel parameters.

Surface muon beam with $\sigma_{\theta_x} = \sigma_{\theta_y} = 6mr$ and $\sigma_x = \sigma_y = 6mm$ was used for the simulation (beam #1). The beam focus was placed at $Z = -140cm$ (before the muon counter). Original muon momentum 29.7MeV/c with spread of $\frac{\Delta p}{p} = 0.5\%$ has been selected. Magnetic field - $B = 2.2T$. The simulation results are shown in Table 1. Typical results of the simulation are shown in Fig.1

One can see that using of the Be target instead of the Al target allows to decrease the total positron energy loss almost in 2 times at 50MeV. The radiative loss is decreased in 3.5 times. On the contrary the total positron energy loss for W target is in 4.5 times more than for Al target.

Muon Stop Distributions vs Beam Divergency.

Proposal exists to make a measurement of ρ and η parameters first of all using a nonpolarised muon beam. Such kind of beam could be provided with so called "mixed" beam consisting surface muons with $P_\mu = -1$ and cloud muons with $P_\mu = +0.4$ in corresponding proportion. Disadvantage of the proposal is a small enough admixture (about 2%,

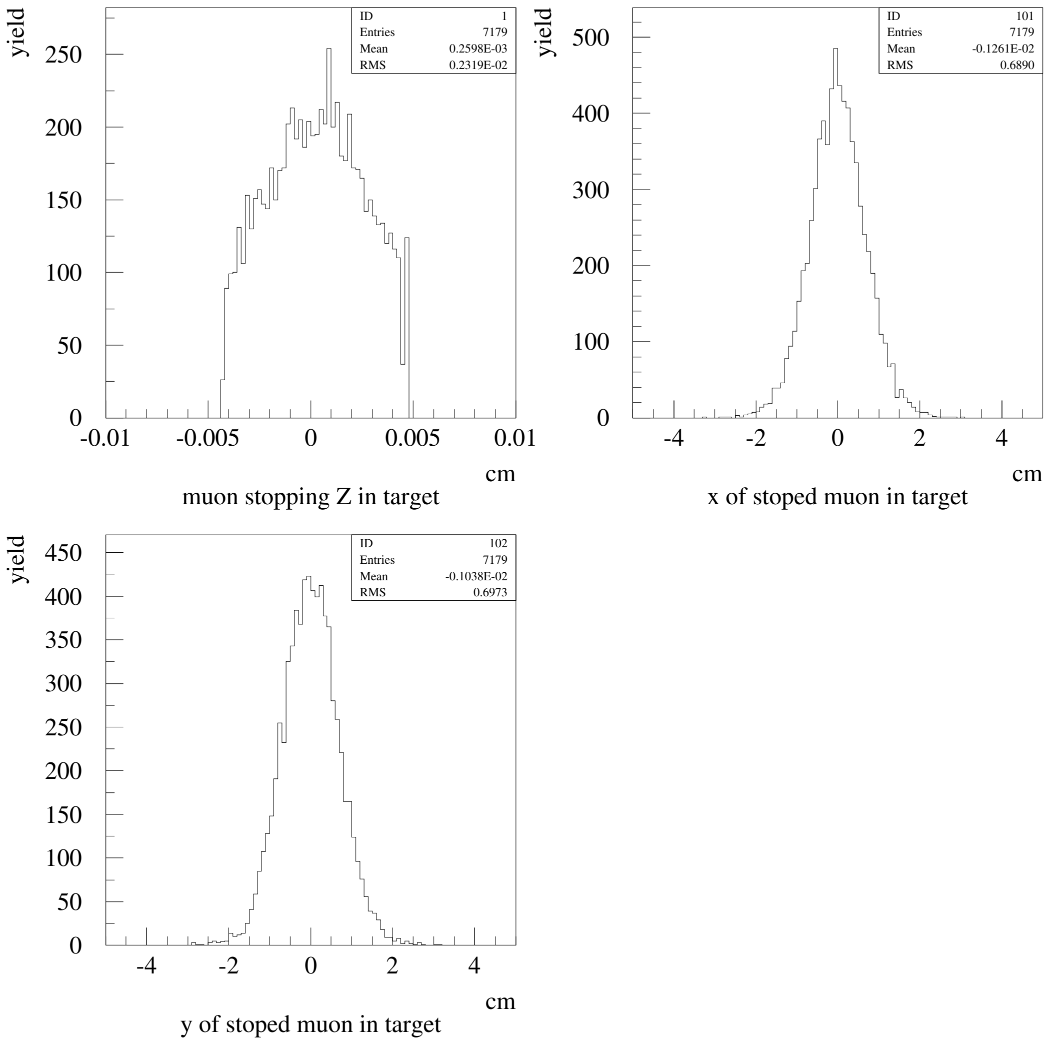

Figure 1: Muon stop distributions for 90μ of Be stopping target at B=2.2T (beam #1). Total 10000 events has been simulated.

Table 1: Selected target thickness, muons stop rate, and positron energy losses

Name	Z	ρ, g/cm^3	Target thickness (mg/cm^2)	Target thickness (μ)	Muons stop rate, (%)	Positron energy loss (KeV/target thickness) $T_e = 20$MeV Coll.	Rad.	Total	$T_e = 50$MeV Coll.	Rad.	Total
Li	3	0.534	16	300	71	26.6	2.7	29.3	27.7	7.8	35.5
Be	4	1.848	16.6	90	72	26.9	3.6	30.5	28.1	10.3	38.4
C	6	2.265	15.9	70	73	28.6	5.4	34.0	29.9	15.3	45.2
Al	13	2.70	20	75	76	34.0	12.8	46.8	35.8	35.2	71.0
Fe	26	7.87	23.6	30	75	36.8	27.1	63.9	38.9	73.9	112.8
W	79	19.30	38.6	20	78	49.0	97.3	146.3	52.5	261.3	313.8

[2]) of the cloud muons around $p_\mu = 29.8MeV/c$. Possible way to increase the beam intensity is an opening of slits placed between Q2 and B1 (F0VJ (vertical jaw) and F0HSL (horizontal slit)). According to Fig.12 of the reference [2] beam flux can be increased in 6-7 times by opening of the horizontal slit only. It means a total gain of flux is about 30-50 times with the jaw and the slit open. Another way is possible for the estimation. Particle flux at $p_\mu = 30MeV/c$ is about $3000s^{-1}$ at $100\mu A$ with all slits and jaws fully open ([2], fig.7) using a 1.45mm carbon target. It means the flux about $20000s^{-1}$ with a 10mm carbon target. Maximal momentum acceptance of the M13 is about 7% with F1 horizontal slit width equals to 15cm ([2], Fig.10). We need to put the F1 horizontal slit width equals to 0.5cm in order to have a beam momentum acceptance equals to 0.5%. It corresponds to a flux decreasing it 10 times ([2],Fig.13). So, we can have cloud muon flux about $2000s^{-1}$ at $\frac{\Delta p}{p} = 0.5\%$, in result. Another disadvantage of the "mixed" beam is a high rate of positrons (about $10^5 s^{-1}$) from beam line. It means we will see nearly always both a positron from beam line and a decaying positron.

Muon stop distributions in a stopping target for a "mixed" beam with a big divergency has been simulated. Simulation result is shown in Fig.2 at $\sigma_{\theta_x} = \sigma_{\theta_y} = 80mr$

One can see that the X and Y stop distributions are acceptable even for the 80mr beam divergency.

Muon Stop Distributions vs Momentum Spread

Additional possibility to gain the "mixed" muon flux is increasing of beam momentum spread. The results of GEANT simulation are shown in Fig.3. One can see that the results are not so good because muon rate drops rapidly with the momentum spread growth.

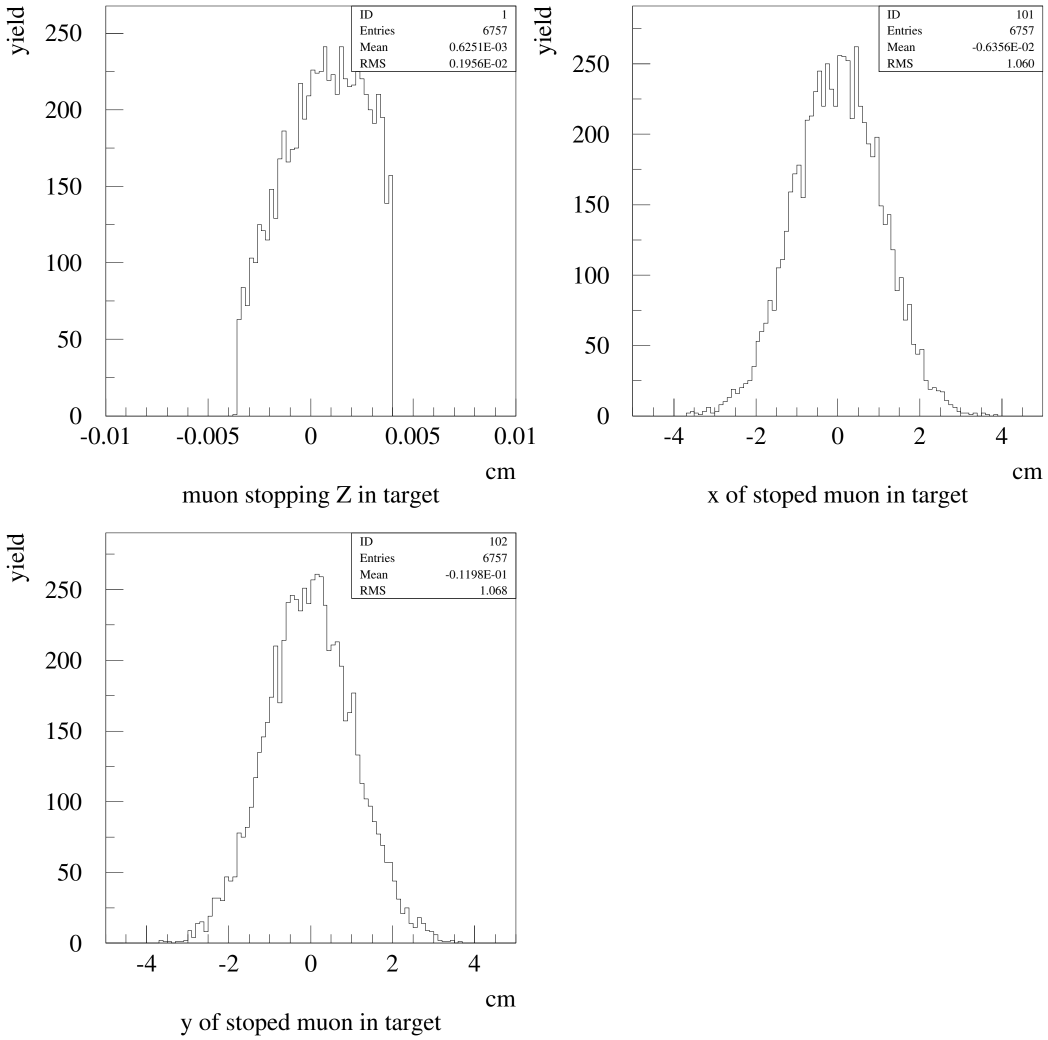

Figure 2: Muon stop distributions for 75μ Al stopping target at the beam divergency equals to 80mr (beam #2, focus plane at $Z = -140cm$, B=2.2T). Total 10000 events has been simulated.

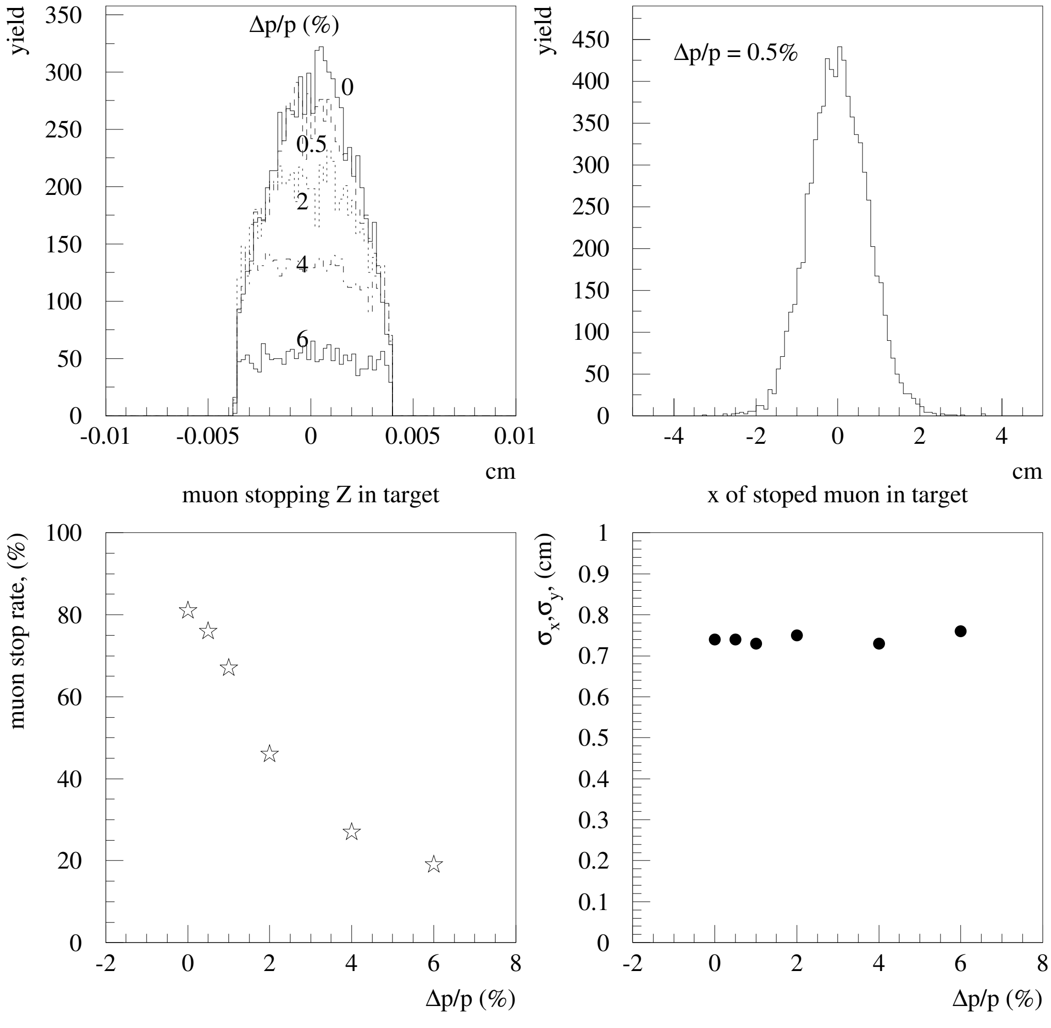

Figure 3: Muon stop distributions for 75μ Al stopping target at different muon momentum spread $\Delta p/p$ (beam #1, focus plane at $Z = -140cm$, B=2.2T). Total 10000 events has been simulated.

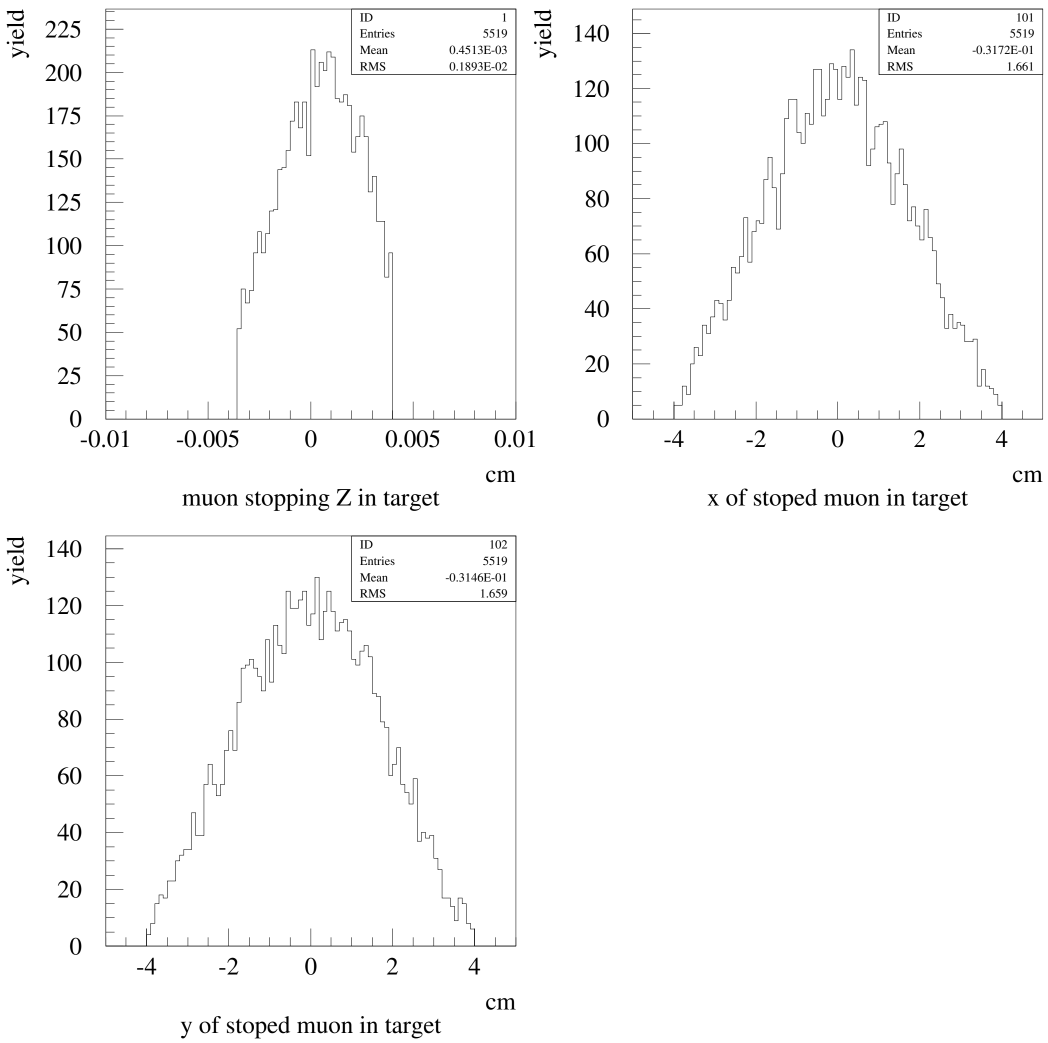

Figure 4: Muon stop distributions for 75μ Al stopping target (beam #2, beam divergency is 19mr, focus plane at Z=0, B=0.6T). Total 10000 events has been simulated.

Muon Stop Distributions at B=0.6T

Measurement of η parameter could request of a smaller magnetic field value because the η is more sensitive to small positron energies. Results of simulation are shown in Fig.4.

Focus plane of the beam was placed at Z=0 (inside the stopping target) to decrease a beam scattering by chambers placed before the stopping target. One can see that the muon stop rate is 55% only, and $\sigma_x = \sigma_y = 1.66cm$ at B = 0.6T instead of $\sigma = 0.75cm$ at B=2.2T (Fig.1, for example). The above distributions are not change actually for beam focus position at $Z = -140cm$. It means the B = 0.6T is too small value to compress beam during a muon scattering by E614 detector.

References

[1] R.Ramadanovic, D.H.Wright, TN-31, 17 May 1999

[2] C.J.Oram, J.B.Warren, G.Marshall, J.Doornbos, D.Ottewell, TRIUMF preprint TRI-80-1, May 1980