CDF/RUN-II/TRIG/SVT/STF/01
Version 1.1
June 25, 1997

SVT Track Fitter with Memory Lookup

T. Nakaya

Abstract

This report describes the possibility of the use of Memory Lookup (MLU) technique for track fitting in the SVT system instead of the use of Digital Signal Processors (DSP). The SVT Track Fitter (STF) with MLU can perform track fitting much faster than that with DSP, and the data stream can be pipelined. As the result, we do not have to worry about the L2 time budget and the saturation of data flow. The main concern of this scheme with MLU is how much memory do we need in the system and what is the performance. In this report, we address these points with the MLU approach. In consequence, it is quite possible to perform track fitting in the SVT with reasonable size of MLU.

1 Introduction

The CDF SVT trigger system is designed to measure the impact parameter (d) of a track with a precision of 35μm in the Level 2 (L2) trigger. The SVT also re-measures the transverse momentum (P_T) and the emitting angle (ϕ) of the track more precisely than those by the XFT. The hits in four SVX layers and the P_T and the ϕ measurements by the XFT are fed into the SVT system to calculate the track parameters. Hereafter, the input to the SVT is denoted by $\vec{x}$, which is a six dimensional vector. The x_1 to x_4 correspond to the hit positions in the four SVX layers and x_5 and x_6 correspond to the curvature (c) and ϕ from the XFT, respectively. The track parameters are also denoted by a three dimensional vector $\vec{p}$ (c, d, ϕ). The system which carries out the process of track fitting is referred to as the SVT Track Fitter (STF).

The original STF was designed to use Digital Signal Processors (DSP STF) to calculate the track parameters with a linear approximation in one SVX wedge which is inside of 30 degrees in ϕ [1]. With the benefit of a linear approximation, we can express the track parameters, $\vec{p}$, with a simple scalar products of hits, $\vec{x}$, like: $p_i = \vec{f}_i \cdot \vec{x} + q_i$. This computation can be carried out by a DSP in less than 100 clock cycles (see TDR [1] Sec. 4.5) which corresponds to 5μsec with a Motorola 9600 DSP which has a 50 nsec clock cycle. The L2 time budget for the SVT system is about 10μsec, most of which will be used by the SVT systems upstream of the STF ($\sim 9\mu$sec). Therefore, the processing time of the entire SVT will exceed the current L2 time budget, and it potentially may cause trigger dead time. In addition, the processing time of the STF depends on how many roads and how many hit patterns are found in the AM system. In order to keep the STF processing time below 5μsec, the design of the AM was fixed with 250μm SuperStrip size. However there is the possibility and risk that the STF processing could saturate if there are more hits coming from the SVX than expected.

As an alternative way to do track fitting, a technique based on Memory Lookup (MLU) was proposed [2] for the SVT (MLU STF). The MLU scheme is much faster than the DSP STF and the data stream in the STF can be pipelined. Therefore we do not have to worry about execution with the DSP STF. In addition, the MLU STF makes the design of the AM more flexible as shown in the later part of this report.

In Section 2, we explain the basic concept of the STF design with MLU. In Section 3, we introduce a stand alone and dedicated SVT Track Fitter simulation which has been developed for the design of the MLU STF. In Section 4, we show how much discretization of the hit positions are needed in the MLU table to maintain good resolution in the SVT system. In Section 5, we show how to form the address of MLU to get track parameters. In Section 6, we show the conceptual design of the MLU STF and presents its performance. In Section 7, we compare the MLU STF with the DSP STF. Finally we give a summary in Section 8.

2 Track Fitting with Memory Lookup

The approach to track fitting with an MLU is well described in the SVT note 72[2]. Therefore we summarize the basic concept of the approach in this section.

At first, as an example, we estimate how much memory we need to make a lookup table to find a track parameter instead of using a DSP. A typical range of the hit x_1 is of order one centimeter, which is the width of one SVX wedge. A typical resolution of the hit position in the SVT system is 15μm. Therefore we need $O(1)\text{cm} \div 15\mu\text{m} = 10^3$ addresses to point the position of the x_1. Since the hits $\vec{x}$ has six dimensions, we need about $(10^3)^6 = 10^{18}$ addresses in a memory. Apparently this is impossible.

However, we have the benefit of the linear approximation described in the SVT TDR Chapter 4 [1]. With the linear approximation, we can express the track parameters as:

$$p_i = \vec{f_i} \cdot \vec{x} + q_i. \tag{1}$$

Here, the coefficient $\vec{f_i}$ and the intercept q_i are common in all roads in a wedge (see TRD Section 3.2.3 [1] for the definition of a road). Since a road corresponds to a real track, we can find a point which satisfies Equation 1 in any road. We use this point as a reference point. The track parameters at the reference point are expressed as:

$$p0_i(r) = \vec{f_i} \cdot \vec{x0}(r) + q_i, \tag{2}$$

where each road has its reference point $\vec{x0}(r)$. With Equation 1 and 2, we can express any tracks in a road as:

$$p0_i(r) + \delta p_i = \vec{f_i} \cdot (x\vec{0(r)} + \vec{d}) + q_i. \tag{3}$$

Here, the equation $\delta p_i = \vec{f_i} \cdot \vec{d}$ is valid in any road since the coefficient $\vec{f_i}$ is common in all roads. As a result, we notice that we need only two MLU tables to describe all tracks: one is for the $p0_i(r)$ and the other is for the δp_i. The number of addresses in the MLU table for the $p0_i(r)$ is same as the number of roads stored in the AM, and it is smaller than 32k patterns (see TDR Sec. 3.2.3). With the AM SuperStrip size of 250μm and the typical resolution of 15μm of the SVT Hit Finder, the number of addresses in the other MLU table is roughly estimated to be $(250\mu\text{m} \div 15\mu\text{m})^6 \sim 20$M patterns where we assume that the dimensions of x_5 and x_6 are same as that of x_1. The number of addresses in the MLU table still looks too large. Before we present a

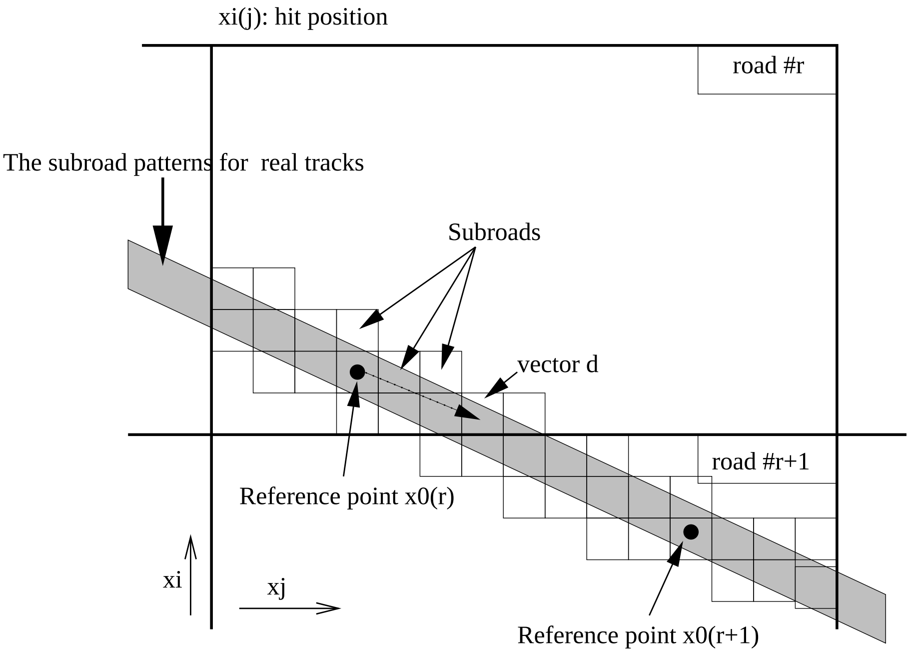


Figure 1: Road and Sub-road Patterns

more reliable size for the MLU table, we introduce the idea of a sub-road. The allowed range in the hit position of each dimension is divided into small pieces. For a given track, the hit position is discretized and falls into one of the pieces. A combination of allowed pieces in six dimensions defines one sub-road. Apparently, a sub-road is a lower level structure of a road defined in the SVT TDR Section 3.2.3 [1]. Therefore, a real track falls into one sub-road in a road. The number of sub-road patterns is the number of addresses needed in the MLU table for the δp_i. In the above example, we adopt 15μm as the sub-road size. We can also adopt a larger sub-road size of 30μm instead of 15μm without disturbing the performance much since the resolution of 15μm is not a FWHM, but a sigma. In that case, the number of addresses in the MLU table for the δp_i is dropped to $20\text{M} \times (0.5)^6 = 300\text{k}$ patterns. This is a reasonable size for an MLU table using a Static RAM. In addition, we do not have to cover all possible sub-road patterns in a road since a real track is limited to certain sub-road patterns in a road as shown in Figure 1.

In consequence of the above investigation, it is possible to make the STF system with the MLU technique (MLU STF). The conceptual diagram of the MLU STF is

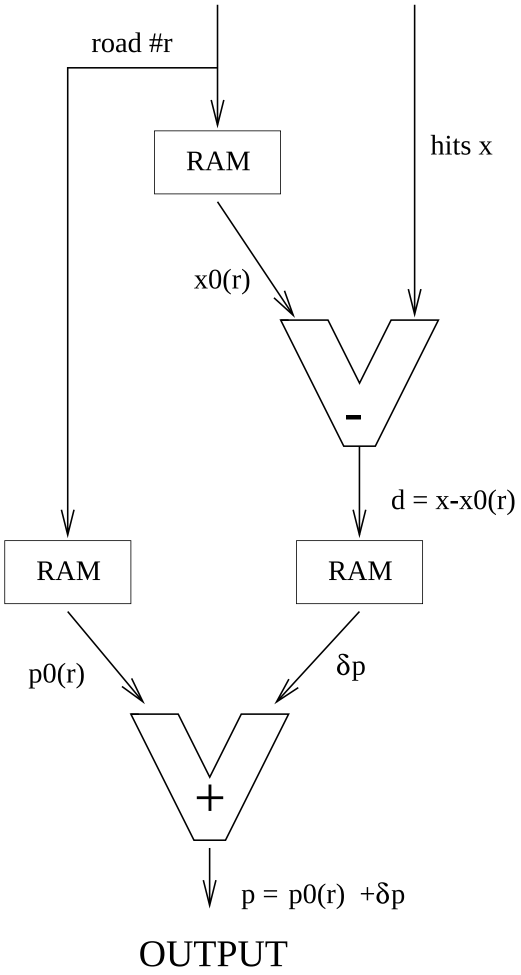


Figure 2: Conceptual Diagram of MLU STF

shown in Figure 2. Definitely it is important to study how many sub-road patterns we need for the MLU STF and what is its performance. We address these points in the following sections.

3 SVT Simulation

A SVT simulation independent of SVTSIM was developed for the dedicated purpose of the design of the MLU STF. In this section, we introduce the simulation package. The simulation consists of two parts. In the first part, a track is generated and traced

Table 1: Material in the STF simulation

Material and Detector	Radiation Length (%)	Inner radius (cm)
Beam Pipe	0.14	1.35
Inner Screen	0.17	2.05
SVX1	0.32	2.77
SVX2	0.32	4.35
SVX3	0.29	6.77
SVX4	0.32	8.47
SVX5	0.29	10.37
ISL	2.0	21.0
COT	1.0	47.0

through the detectors. Then, the SVX hit positions and the XFT measurements of the track are recorded. We named this part "SVTHIT". The second part is dedicated to track fitting and performs a couple of different track fitting approaches. We called this part "SVTFIT".

3.1 SVTHIT Simulation

In the simulation, tracks are generated uniformly from a radius r between 0 and 2mm with an azimuth angle ϕ between 0 and 2π. Currently z is always at 0, and the range of η is uniform between -1 and 1. The distribution of the momenta of tracks follows the function $1/\mathrm{P_T}$ and the range is selected between 2 and 40 GeV/c. The ranges and the distributions of the track parameters are shown in Figure 3.

The material in the simulation is shown in Table 1, with the thickness and the inner radius given. The SVX detectors are segmented into 12 sectors in ϕ. Therefore each SVX detector covers 30 degrees in ϕ. In this simulation, we do not care about the z coordinate. Therefore, all materials have an infinite length in the z axis.

Once a track is generated, it is propagated through all detector elements using the uniform magnetic field (1.4T) of the solenoid magnet. When the track passes a material layer, the direction of the track is affected by multiple scattering. The effect

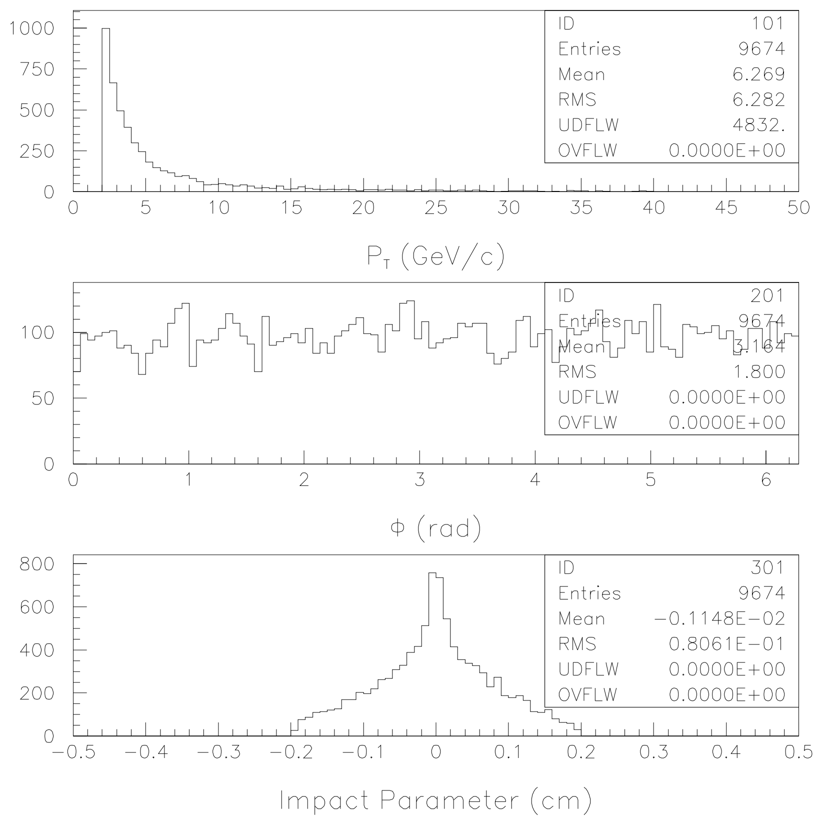


Figure 3: Track Parameter distributions in SVTHIT

of the multiple scattering is formalized with an average scattering angle of:

$$\delta\theta = 0.0136/\mathrm{P_T(GeV/c)} \times \sqrt{\mathrm{x}} \times (1 + 0.038 \times \log(\mathrm{x})), \tag{4}$$

where the x is in radiation lengths. When the track passes through the SVX, the hit positions are recorded with a resolution of 15μm. Then, the track enters the region of the COT; the momentum and ϕ are recorded with the proper XFT resolution. Since the measurement of curvature and ϕ by the XFT are correlated, the assumption of $\delta\mathrm{P_T} = \alpha \times \delta\phi \times (\mathrm{P_T})^2$ is used. The parameter α is tuned to be 4.0, so that the ϕ resolution of 3.0 mrad reproduces the 1.1% of $\delta P_T/P_T^2$ resolution.

Finally, the hits from the SVX detectors at the inner most four layers and the P_T and the ϕ measurements by the XFT are recorded and pass to the program "SVTFIT".

3.2 SVTFIT Simulation

The package "SVTFIT" performs several kinds of track fitting approaches. The basic approach is to fit a track with a linear approximation in one SVX wedge as presented in the SVT TDR. The SVT resolution from this simulation is shown in Figure 4. We get 0.28% for the $\delta\mathrm{P_T}/\mathrm{P_T^2}(1/(\mathrm{GeV/c}))$ resolution, 1.0mrad for the ϕ resolution, and 24μm for the impact parameter resolution for the full momentum range of tracks. The numbers which we get here is consistent with or slightly better than the result presented in the SVT TDR where the resolutions are measured with 2GeV/c $\mathrm{P_T}$ tracks. The result also shows the reliability of this simulation. We expect this performance with the DSP STF for a perfect linear system as assumed in Equation 1. Since the study of non-linearity was done in the SVT TDR, we do not study it again in this report. The main purpose of this simulation is to study the MLU STF.

4 Sub-road Size

As we introduced in Section 2, the number of sub-road patterns is a key parameter for the design of the MLU STF. The number of addresses in the MLU table for the δp_i (see Section 2) depends on the size of a road and that of a sub-road. The size of a road presented in the SVT TDR is: 250μm for x_1 to x_4 (hit positions in the

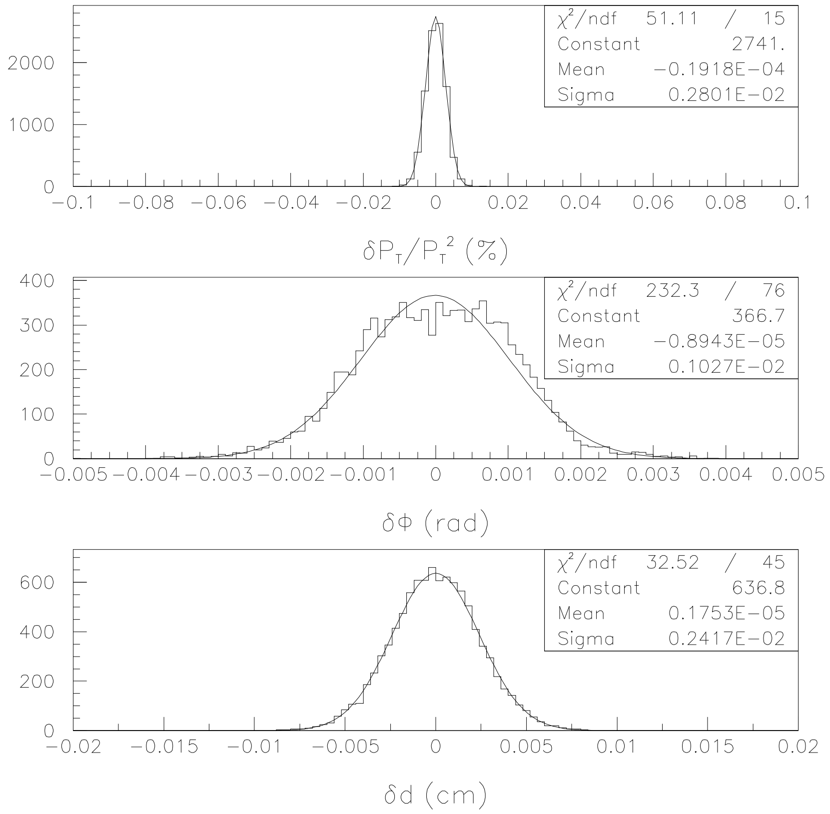


Figure 4: Resolutions of Track Parameters for the SVT Track Fitter

SVX), 50mrad for x_5 (the ϕ measurement by the XFT), and no restriction for x_6 (the curvature measurement by the XFT). The sub-road size proposed in the SVT note 72[2] is: 15μm for x_1 to x_4, 2 mrad for x_5, and 0.064 ($10^{-3}cm^{-1}$) for x_6. In units of $10^{-3}cm^{-1}$ for x_6, 2 GeV/c $\mathrm{P_T}$ corresponds to $x_6 = 2.1$ for the 1.4T magnetic field, and 40 GeV/c $\mathrm{P_T}$ corresponds to $x_6 = 0.105$. This sub-road size is proposed as an approximate 1 sigma resolution for $\vec{x}$. This level of discretization has the effect of increasing the standard deviation of each measurement over the full linear calculation by 4%, which is almost negligible in the measurement of the track parameters. The number of memory addresses with this sub-road size is:

$$(250\mu\mathrm{m}/15\mu\mathrm{m})^4 \times (50\mathrm{mrad}/2\mathrm{mrad}) \times (2.1/0.064 \times 2) = 1.3 \times 10^8 \mathrm{patterns}, \qquad (5)$$

where the factor of 2 in x_6 corresponds to positive and negative values of x_6. The 1.3×10^8 patterns are too large for the number of addresses in a MLU table. In SVT note 72, the number of the patterns of valid sub-roads which corresponds to real tracks is estimated to be roughly in the range of 10^5 to 10^6. Before we determine this number, we study the impact of sub-road size on the measurement of the track parameters.

4.1 Impact of sub-road size on the track parameters

In the view of the design of the MLU STF, the sub-road size should be as large as possible to save memory size without loosing performance in the track parameter measurement. Several kinds of sub-road size were studied, and the results are shown in Table 2. As shown in Table 2, fine sub-road size for x_1 to x_4 is not so important, but fine size for x_5 and x_6 is important. In addition, the most important track parameter measured in the SVT is the impact parameter. Therefore we should keep the best performance possible for the measurement of the impact parameter. For the impact parameter, the hit position at the most inner layer plays an important role. Therefore, we select the sub-road size: 25μm for x_1, 50μm for x_2 to x_4, 2.5 mrad for x_5, and 0.064 for x_6. As shown in Table 2, we can maintain good SVT performance with this sub-road size. In addition, we need only 1.6M addresses in a MLU table, which fits in the size of currently available SRAM.

Table 2: Sub-road size and the resolution of track parameters.

Sub-road Size	Address Space	$\delta P_T/P_T^2(\%)$	$\delta\phi$ (mrad)	$\delta d(\mu m)$
No Sub-road (DSP calculation)	∞	0.28	1.0	24
$(15\mu m)^4 \times 2mrad \times 0.064$	1.3×10^8	0.39	1.0	24
$(30\mu m)^4 \times 2mrad \times 0.064$	7.9×10^6	0.39	1.0	27
$(15\mu m)^4 \times 4mrad \times 0.064$	6.3×10^7	0.45	1.0	25
$(15\mu m)^4 \times 2mrad \times 0.128$	6.3×10^7	0.56	1.0	25
$(15\mu m)^4 \times 2mrad \times 0.032$	2.5×10^8	0.33	1.0	25
$(50\mu m)^4 \times 2mrad \times 0.064$	1.0×10^6	0.40	1.1	31
$(25\mu m) \times (50\mu m)^3 \times 2.5mrad \times 0.064$	1.6×10^6	0.39	1.0	27

5 Addressing the MLU

As the consequence in Section 4, we need only 1.6M addresses in the MLU table. This is a minimum, and the real number of addresses is more than that number. For example, to express the address of x_1, we need at least four bits which can express a number up to 15 ($> 250/25 = 10$). With the above sub-road size, we may need:

$$(250/25)\times(250/50)^3\times(50/2.5)\times(4.2/0.064) < 16\times8^3\times32\times128 = 33\text{M patterns.} \quad (6)$$

The addresses for the MLU table grows to 33M patterns, but we need only 1.6M addresses. This problem is solved by making another Memory Lookup stage for the addressing the main MLU table as shown in Figure 5. We find that we need 4k and 8k address MLU tables to address the main MLU table. In this scheme, we need 4M addresses in the main MLU table, which is currently available. We can further reduce the number of the addresses in the main MLU table by requiring valid sub-road patterns.

5.1 Valid Combinations of Sub-roads in MLU

As shown in Figure 1, a real track makes a certain pattern in the space of the sub-roads. Therefore, we do not have to keep all combinations of sub-roads. Examples of

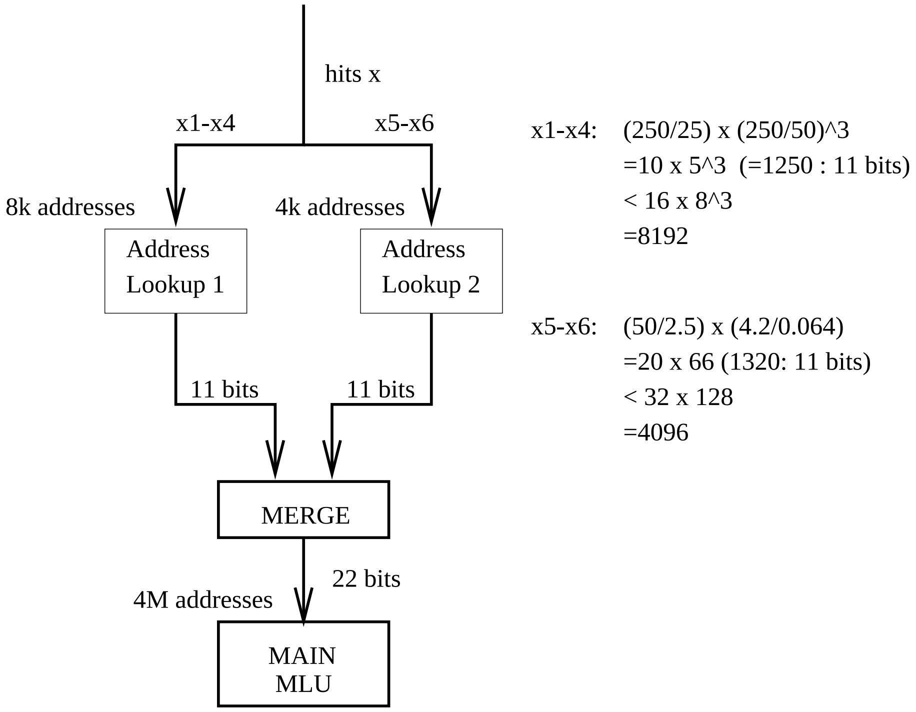
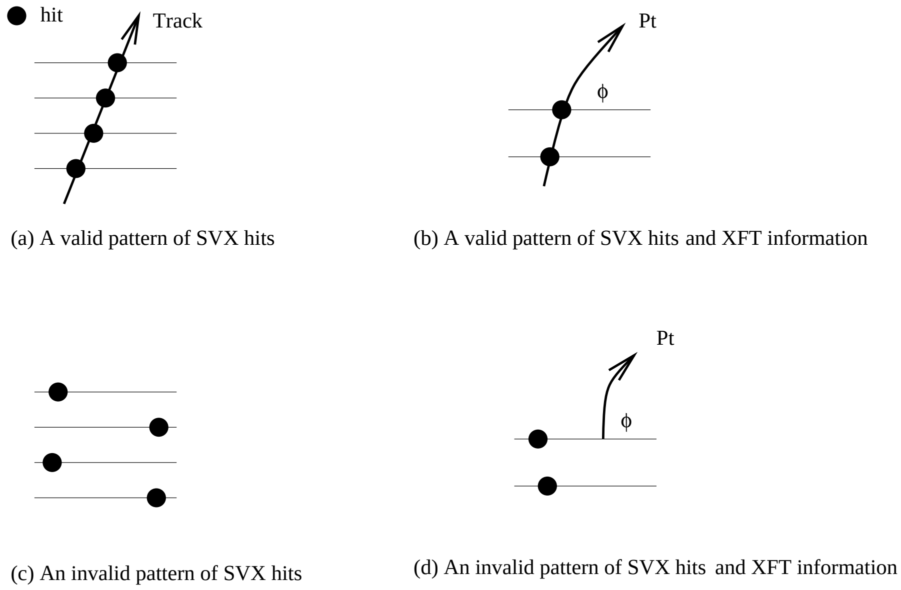


Figure 5: Addressing the main MLU table



(a) A valid pattern of SVX hits

(b) A valid pattern of SVX hits and XFT information

(c) An invalid pattern of SVX hits

(d) An invalid pattern of SVX hits and XFT information

Figure 6: Valid and Invalid patterns of sub-roads

valid and invalid patterns of sub-roads are shown in Figure 6. Definitely, we do not have to keep addresses in the main MLU table that correspond to invalid sub-roads. The invalid sub-roads can be thrown away when the MLU table address is determined in Figure 5. With the simulation, the fraction of valid sub-roads is estimated to be 30% in the x_1 to x_4 space. Therefore, we need:
$(250/25) \times (250/50)^3 \times 0.3 = 375$: 9bits,
to express the x_1 to x_4 address in the main MLU. As the result, we use only 1M addresses in the main MLU. The conceptual diagram of the MLU STF with only valid sub-roads is shown in Figure 7. By contrast to the reduction of the size of the main MLU table, the number of addresses in the address Lookup 2 table grows to 500k patterns. The fine tuning of these parameters is discussed later.

6 SVT Track Fitter with Memory Lookup (MLU STF)

Finally we can design the SVT Track Fitter with Memory Lookup. From many investigations in the previous sections, we find that it is possible to keep the amount

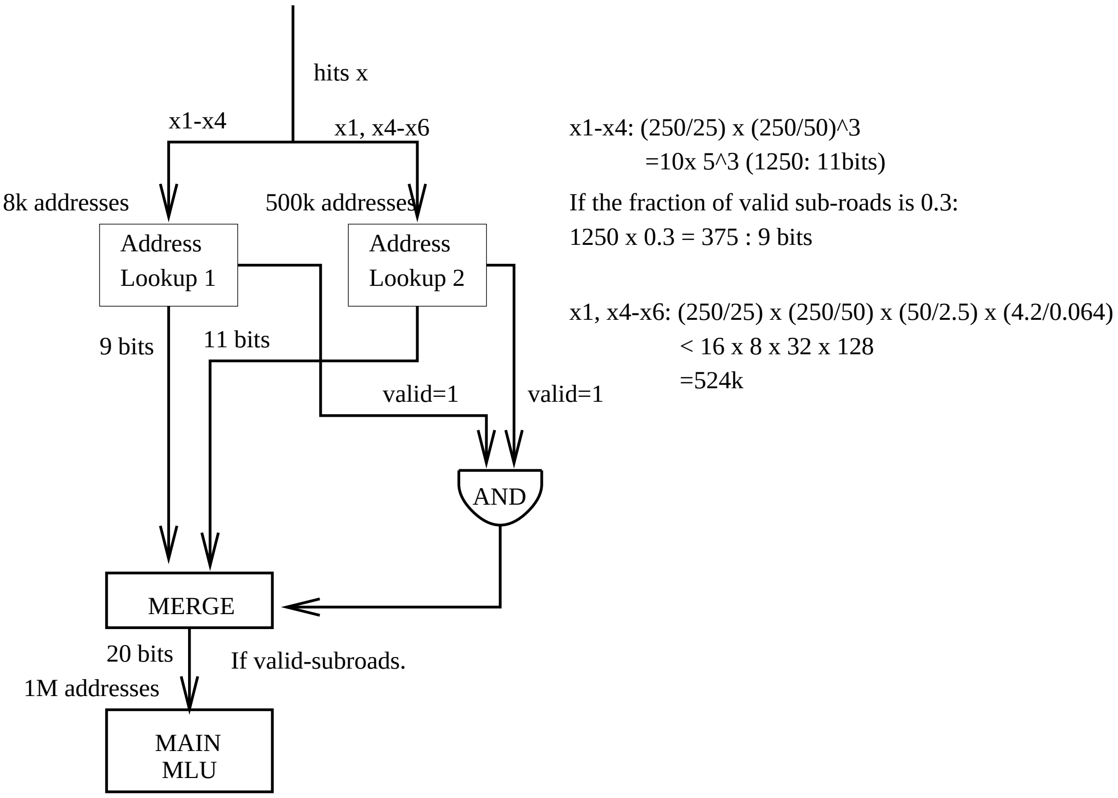


Figure 7: Addressing the MLU table with valid sub-roads. The output of Address Lookup Table 1 has been reduced by two bits relative to Figure 5.

of the MLU memory within a realistic size. The final diagram of the MLU STF is shown in Figure 8. Each RAM is named in Figure 8, and we will used the names in the text, too. The parameters for each RAM is listed in Table 3. In this section, we

Table 3: RAM size in MLU STF.

RAM	Addressing	Output bits	Description
ROAD HIT RAM	$32\text{k} \times 6$	16	AM size $\times$ 6 hits
ROAD TRACK RAM	$32\text{k} \times 3$	16	AM size $\times$ 3 parameters
SVX RAM	131k	$12+1$	$> (500/25) \times (500/50)^3$
XFT RAM	1M	$10+1$	$> (500/25) \times (500/50) \times (50/2.5) \times (2.1/0.064)$
STF RAM	4M	$8 \times 3 + 1$	22 bits = 4M

will explain the diagram in Figure 8, and explain how the parameters in Table 3 are chosen.

6.1 MLU STF Diagram

In Figure 8, the data is flow from top to bottom. The "ROAD HIT RAM" gets the road number from the SVT Hit Buffer and the layer ID of the hits. The "ROAD HIT RAM" passes the position of the reference point hit by hit. Then the deviation of the hit position from the reference point is evaluated, and is denoted as $\vec{d}$. Since there is a possibility that more than one hit is recorded in one layer in the road, we need a "Permutation Generator" to make all possible combinations of the hits. Then the components d_1 to d_4 provide the address to the "SVXRAM", and the components d_1 and d_4 to d_6 provide the address to the "XFTRAM". In these RAM's, we check whether the combination of the hits is valid or not. The "SVXRAM" generates the upper 12 bits of the address to the "STFRAM", corresponding to the combination of d_1 to d_4. The "XFTRAM" generates the lower 10 bits of the address to the "STFRAM", corresponding to the combination of d_5 and d_6. If the combination of hits is invalid, we will not push the output. In case of a valid combination, the $\delta\vec{p}$ in the "STFRAM" is pushed out and summed with the track parameter, $\vec{p0}(r)$, at the reference point from "ROAD TRACK RAM". Finally, the output from the STF is

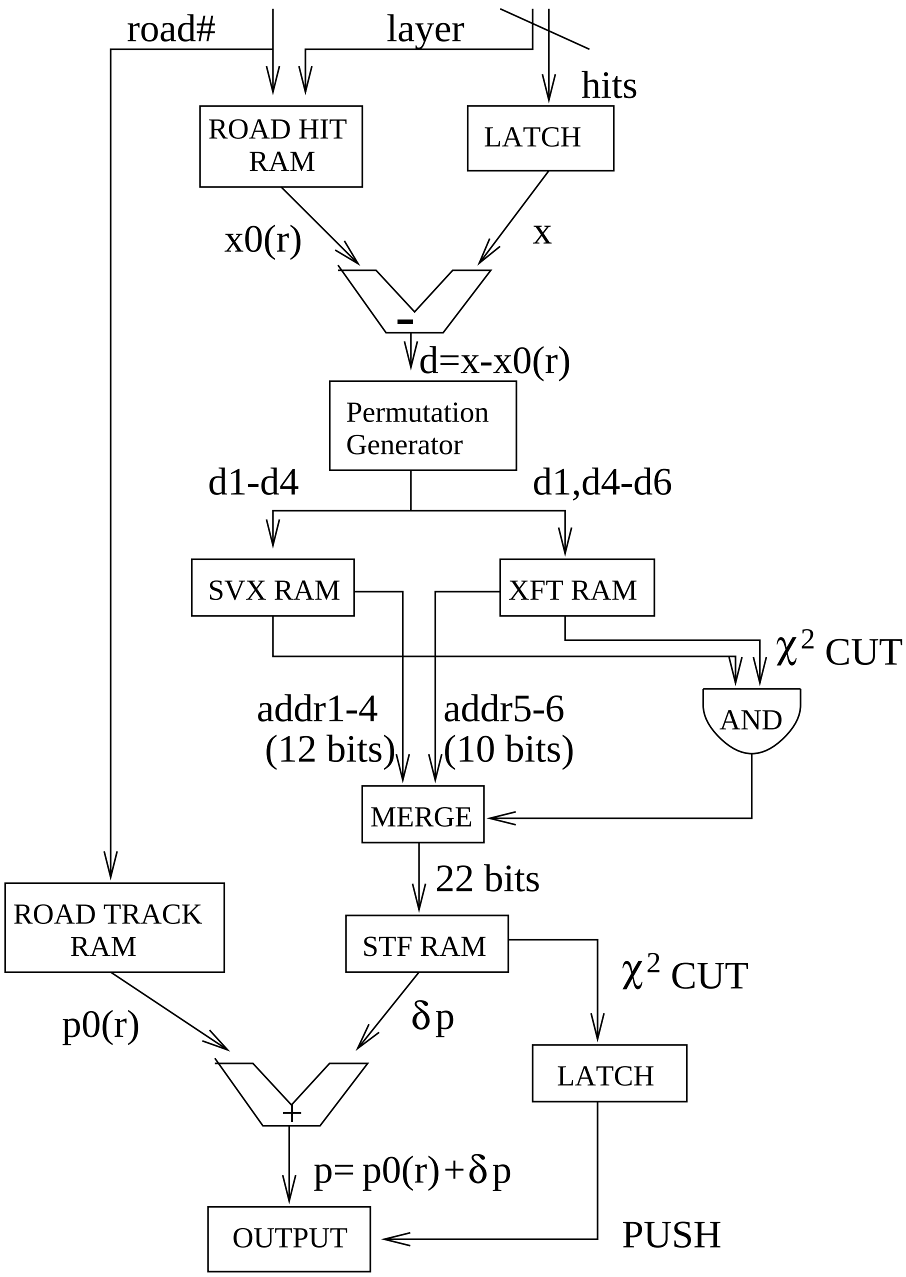


Figure 8: MLU STF

the track parameter, $\vec{p} = \vec{p0}(r) + \delta\vec{p}$.

6.2 MLU STF Parameters

The most critical parameter in the MLU STF system is the number of addresses in the "STFRAM". As shown in Section 5, we need 1M addresses in the "STFRAM". In Table 3, the number of the addresses in the "STFRAM" is shown to be 4M patterns, which is the largest currently available size of a FlashFile Memory (INTEL DD28F032SA with 32-Mbits, makes 4Mbits addressing and 8 bits output). Since the larger number of addresses makes the SVT system more flexible, we assign the maximum size of the memory to the "STFRAM". With 4Mbits addressing, we could avoid checking the validity of the sub-road. Or, if we do check the sub-road validity, we can potentially handle a wider SuperStrip Size in the AM, such as $500\mu m$, which reduces the number of required AM chips and thus the overall cost of the SVT system itself. In order to handle a $500\mu m$ AM SuperStrip Size, the addressing spaces of the "SVXRAM" and the "XFTRAM" are designed to be 131k and 1M bits address, respectively. For example, with the $500\mu m$ AM SuperStrip Size, we need: $(500/25) \times (500/50)^3 = 20 \times 10^3 < 32 \times 16^3 = 131$k addresses in the "SVXRAM". However, simulation shows that only 15% of the combinations are valid. Therefore we can keep the number of addresses in the "SVXRAM" to be: $(500/25) \times (500/50)^3 \times 0.15 = 3$k, which can be expressed by the 12 bits address lines in Figure 8. For the address lines from the "XFTRAM", we assign only 10 bits which is independent of the AM SuperStrip size. With the simulation, we find that we need $(50/2.5) \times (2.1/0.64) = 656$ patterns as the combinations of d_5 and d_6, which is expressed with the 10 bits. In comparison to Equation 5, the factor of 2 in d_6 has disappeared. With the SVTFIT simulation, we found that the sign of the momentum is included in the "ROAD TRACK RAM"; we only have to take care of the deviation of the curvature over the range of 2.1 shown in Equation 5. The number of addresses in the "XFT RAM" grows to 1M patterns, but we can use the same kind of FlashFile Memory as that in the "STFRAM". In addition, we could reduce the "XFTRAM" size to 500k patterns if we use the hit from the second inner most layer (4 bit address) instead of the hit from the inner most layer (5 bit address). As a result, all parameters for the MLU STF are fixed in a reasonable range.

6.3 MLU STF Performance

We performed the simulation of the MLU STF with the same logic as shown in Figure 8. As the reference point in a road, we picked up the closest point to the road center when we made the patterns for the AM. In this simulation, the nominal road size is chosen as: $(250\mu\mathrm{m})^4 \times 50\mathrm{mrad}$. In the AM memory, we kept about 30k patterns for which we generated more than 1,000,000 tracks. The reference points and the track parameters are also kept in the MLU tables where the reference points are selected as close to the road center as possible. The MLU table for the "STFRAM" was created with the linear approximation of Equation 3. Then we fit a sample of tracks independent from those used for making the AM roads. The performance of the track fitting is shown in Figure 9.

The resolution is 0.45% for $\delta\mathrm{P_T}/\mathrm{P_T^2}(1/(\mathrm{GeV/c}))$, 1.1 mrad for ϕ, and 30μm for the impact parameter. The resolutions are quite good, but slightly worse than our expectation in Table 2 for the following reason. Since the reference point in a road is not exactly at the center of the road, the deviation of the hit position from the reference point is sometimes larger than half of the road size as shown in Figure 10. Since the "STFRAM" data is the same for all roads, it covers a region symmetric about the reference point as shown by the lightly shaded region in Figure 10. In the case that a sub-road is beyond the region covered by the Lookup table, we used the table entry closest to the sub-road. As the result, the resolution of the track parameters with the MLU STF are slightly worse than expected, but are still very good. This problem will be solved either if we iterate more tracks to find reference points closer to the road center, or if we widen the range of the track hits in the MLU table. However, since the measured resolution is nearly consistent with those shown in Table 2, we do not have to enlarge the size of MLU tables.

As a result, the performance of the MLU STF is quite satisfactory as an alternative design to the DSP STF.

6.4 MLU STF with wider AM SuperStrip size

We also examined the MLU STF simulation with a 500μm AM SuperStrip size. In this case, we only needed 10k road patterns to be kept in the AM. By contrast, we need more sub-road patterns in the "STFRAM" in Figure 8. With the χ^2 CUT output

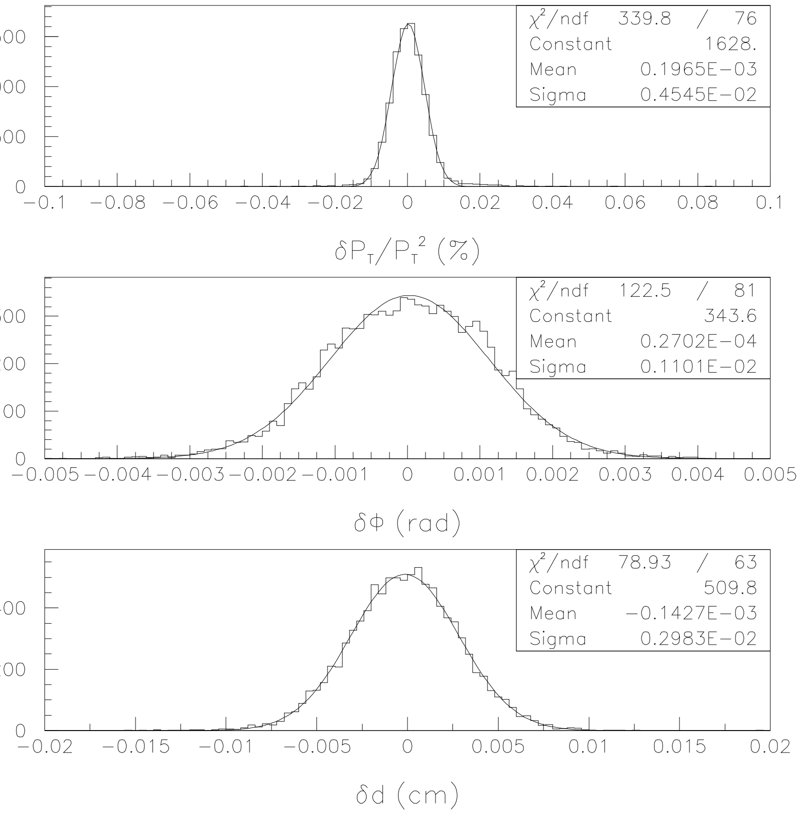


Figure 9: MLU STF Performance

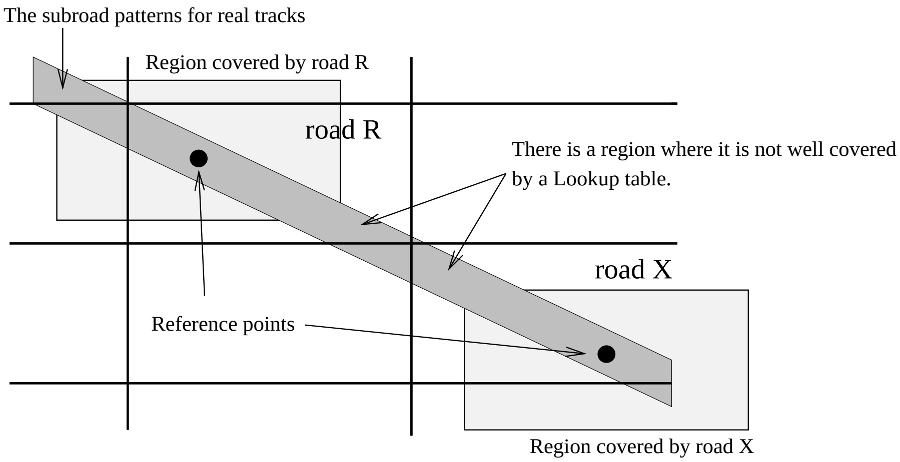


Figure 10: The sub-road which is not covered by Lookup Tables

from the “SVXRAM”, the 12 bits of addressing of d_1 to d_4 are sufficient to specify the valid sub-roads. The resolutions with the wider AM SuperStrip size are exactly same as those of the standard AM SuperStrip size shown in Figure 9. Therefore it is quite possible to handle a wider AM SuperStrip size with the scheme of this MLU STF.

The rate of wrong hit combinations into the STF from the AM system will be increased with the wider SuperStrip size. We will study the effect of wrong hit combinations with the SVTSIM simulation after including the MLU STF design.

7 Comparison of the MLU STF with the DSP STF

7.1 DSP STF

In 1997, Texas Instruments released the new generation DSP [3]. The DSP, TMS320C6x, has 1600 MIPS computing power with 200 MHz clock operation. It is an order of magnitude faster than any other DSP. If we use this DSP, it is possible to keep the track processing time of Equation 1 below 1 μsec. Therefore, the processing speed of the MLU STF is no longer such a critical advantage. We should make a decision which STF scheme can perform track fitting more robustly when non-linear effects are included.

7.2 Non-linearity Problem

Non-linearity in the evolution of track parameters will affect the performance of the SVT. In the DSP scheme, there is no way to compensate non-linearity effects in the STF system. However, with the MLU STF, we can compensate non-linear effects in the "ROAD TRACK RAM" in Figure 8 to first order since we can down-load the offline values of the track parameters at the reference point into the RAM, which is free from the non-linearity. Then, we use a linear approximation in the "STF RAM" to measure the value of $\delta\vec{p}$, which is the deviation of the track parameters from the reference point. Therefore, only the value of $\delta\vec{p}$ will be affected by the non-linearity, and the track parameters measured by the MLU STF should be closer to reality that those by the DSP STF.

A systematic study of non-linear effects in both STF schemes is the next important step in the design of the STF.

8 Conclusion

With a stand-alone simulation of the SVT Track Fitter, we found that the Memory Lookup technique is a viable alternative to the use of a DSP. In addition to faster processing, it can handle first order non-linearity in the track parameters. Therefore, this idea is quite attractive.

For the DSP STF, a new generation of DSP makes the DSP STF faster by an order of magnitude than the design in the SVT TDR. Therefore, the final decision of the STF design should be fixed based on the performance and robustness of the track fitting with full CDF RUN-II simulation and with real data from CDF RUN-I.

References

[1] S. Belforte *et al*, *"SVT Silicon Vertex Tracker TECHNICAL DESIGN REPORT"*, CDF NOTE. 3108 (1996).

[2] G. Punzi, *"DAMN FAST TRACK FITTING"*, SVT NOTE. 72 (1995)

[3] http://www.ti.com/sc/c6x