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Specifications of SVT Global Alignment Package

O.Yu. Barannikova, L. Muresan, G.A.Ososkov, and Yu.A. Panebratsev
Joint Institute for Nuclear Research, Dubna, Russia

C. A. Pruneau, and W. K. Wilson
Dept. of Physics and Astronomy, Wayne State University

S. Margetis
Kent State University

Abstract

The problems of alignment of the SVT as a whole inside the STAR experiment, as well as its relative alignment to the TPC are addressed. The techniques, the algorithms and the software implementation are discussed.

1 Introduction

The installation group of SVT will try its best to place the SVT within a millimeter from its nominal position within the STAR experiment. It is foreseen that by the nature of the mechanical support cone of the SVT, it will be hard to obtain, on hardware installation, a perfect positioning of the detector in its designed place, or a perfect measurement of its actual position after the STAR detector rolls into its data data-taking position. The actual position and orientation will have to be derived from data taken with the detector in-situ. In this document we assume that the problem of the internal SVT alignment has been resolved separately. We focus on the task of software alignment of the SVT in STAR as well as the task of the relative alignment of SVT and TPC. We refer to these tasks as SVT global alignment.

2 General Considerations

The task of the SVT alignment is done in three steps: In the first step the task of the internal SVT alignment is performed using tracking information. The second step refers to the 'positioning' (alignment) of the SVT in the STAR coordinate system [1]. The last step is a check of the relative positions of the SVT and TPC. Here we will discuss the latter two steps only.

It is quite clear that a much better accuracy will be obtained if high transverse momenta tracks are used for alignment as they typically suffer less multiple scattering. Ideally one should aim to do the alignment with magnetic field (field "ON") since it allows a selection of high momentum track. In practice it might be preferable to use tracks recorded in a zero field run. This way, there are no ambiguities in the curvature reconstruction - all tracks are straight lines. However the ability to use a selected momentum range is lost.

Further on, one might chose to select on peripheral rather than central collisions. This would make the track finding and track matching between the TPC and SVT much easier.

3 Alignment Method

The task of alignment should be explicitly separated from the tasks of cluster and track reconstruction. We shall assume in the remainder of this document that the input to the global alignment code should consist of a finite set of heavy ion collision events each including the following data.

- Track parameters of tracks reconstructed in a) the SVT alone and, b) in the TPC alone.
- Estimates of the event vertex position using a) only SVT tracks and, b)only TPC tracks.
- Track–track matching information for SVT and TPC tracks.

The track parameters will be in the format of the nominal track tables, "stk_track", and "tptrack". Likewise the vertex position estimates will be in the format of the nominal global vertex table "dst_vertex".

As we mentioned above the purpose of alignment is twofold:

- Determine the position of the SVT in STAR.
- Determine the relative position and orientation of the SVT and the TPC.

Both the SVT alignment in STAR and the relative SVT/TPC alignment will be expressed by means of 3 space translations and 3 rotations. We choose (according to ref. [1]) the beam direction inside the TPC as the "z" axis of our reference coordinate system. The "x" and "y" axes will be oriented parallel to the ground and vertical respectively. The positive "x" direction will be chosen as pointing radially outward from the RHIC collider. The positive "z" direction will be chosen to be clock-wise looking at the RHIC ring from the sky. The positive y direction will defined such the (x,y,z) triplet forms a right handed coordinate system; i.e. positive y points toward the sky.

The first task, unlike fixed target experiments is not trivial. The size of the interaction diamond is large (RMS$\approx$25 cm longitudinally): an event can occur over a wide range of positions. This implies that one cannot rely on the interaction diamond to provide a stable origin. However, the actual position of the diamond center is somewhat immaterial and inconsequential. It is strictly speaking only a matter of convenience to choose the reference frame origin to be close to the diamond center. This holds in particular if the solenoidal field is very uniform providing some form of "translational invariance". Nevertheless, having the reference frame origin near the detector geometrical center offers much simplification in the track parametrization and visualization of the detector. One would thus hope to be able to determine the origin relative to beam vertex. For this purpose, one should be able to use gamma conversions and hadronic interactions in the beam pipe. These 'secondary' vertices when accumulated over many events will very well outline the beam pipe shape, the orientation of which in the STAR system is assumed to be fairly accurately known. In this indirect way, the orientation and position of the SVT in STAR will be determined in the transverse plane relative to the beam axis. The longitudinal position and azimuthal angle will however still be undetermined given the pipe cylindrical symmetry. It was suggested to use fiducial marks (e.g. copper tape) on the pipe at fixed and known location to provide extra "scattering centers" to be used for alignment along the longitudinal and azimuthal directions. This a task doesn't in principal require extra effort on software development, the standard V0 code is sufficient. Only in the case of field-off runs the V0 code would require some modification in order to be able to be used as a straight line V0 finder. Figure 1 shows the flow chart of the event processing for this alignment task.

The second task, the relative alignment of the SVT and TPC, is by far more important from the physics analysis point of view. Both detectors should report the same event vertex position and the 'same' track parameters for a given particle. Since the SVT vertex and angular resolution is expected to be superior to that of the TPC, one should use the vertex and orientation data of the SVT as reference and make sure that the SVT reported vertex and track positions lie inside the TPC positions/errors. Since in both tasks an alignment action is taken according to various comparisons and calculations, one should make sure that these actions are consistent.

The relative alignment of the SVT and TPC will be determined by using (matched) tracks and reconstructed event vertex positions.

Consider first the alignment problem in the absence of a magnetic field. We use the following line (track) representation:

$$\vec{P} = \vec{a} + \lambda \hat{e} \tag{1}$$

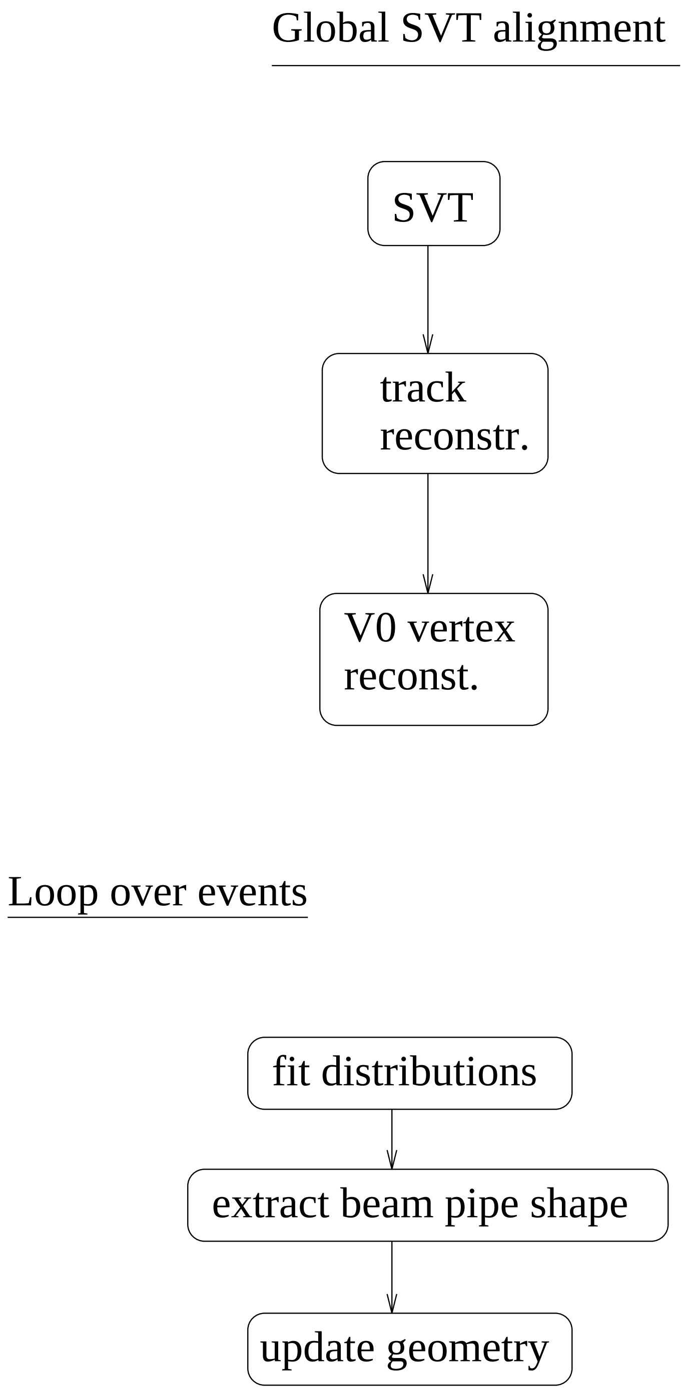

Figure 1: Analysis flow-chart for the SVT alignment in STAR

The vector $\vec{P}$ represents the position of an arbitrary point on a track. The vector $\vec{a}$ corresponds to a given point on the line from the origin, λ is a real number, and ê is a unit vector pointing along the track. In practice ê is calculated as a two element vector ($\tan\lambda = p_z/p_T$ and $\psi = \mathrm{atan}(p_y/p_x)$). The track reconstruction leads, for each track, to two sets of track parameters $\vec{\beta}_t = (\vec{a}_t, \hat{e}_t)$, $\vec{\beta}_s = (\vec{a}_s, \hat{e}_s)$ for the TPC and SVT respectively. From these two sets one can calculate the corresponding primary vertex position $\vec{V}_{s,t}$. At this point we can make a selection, i.e. only consider tracks which are compatible with the main vertex within some track impact parameter range (e.g. ± 5 mm). One should then proceed to analyze a large number of events and for each calculate: a) the SVT and TPC primary vertex ($\vec{V}_t$, $\vec{V}_s$), and b) the tracks three directional cosines ($\hat{e}_s \cdot \hat{e}_t$).

The average difference between the vertices $\vec{V}_t$ and $\vec{V}_s$, accumulated over a large sample of events, determines the spacial translation of the two systems relative to one another. The analysis of the average three components of the SVT-TPC track directional differences provides information about the relative orientation of the two detectors.

Figure 2 shows the flow chart of the event processing for this alignment task.

References

[1] STAR – Geometry, Starnote-229

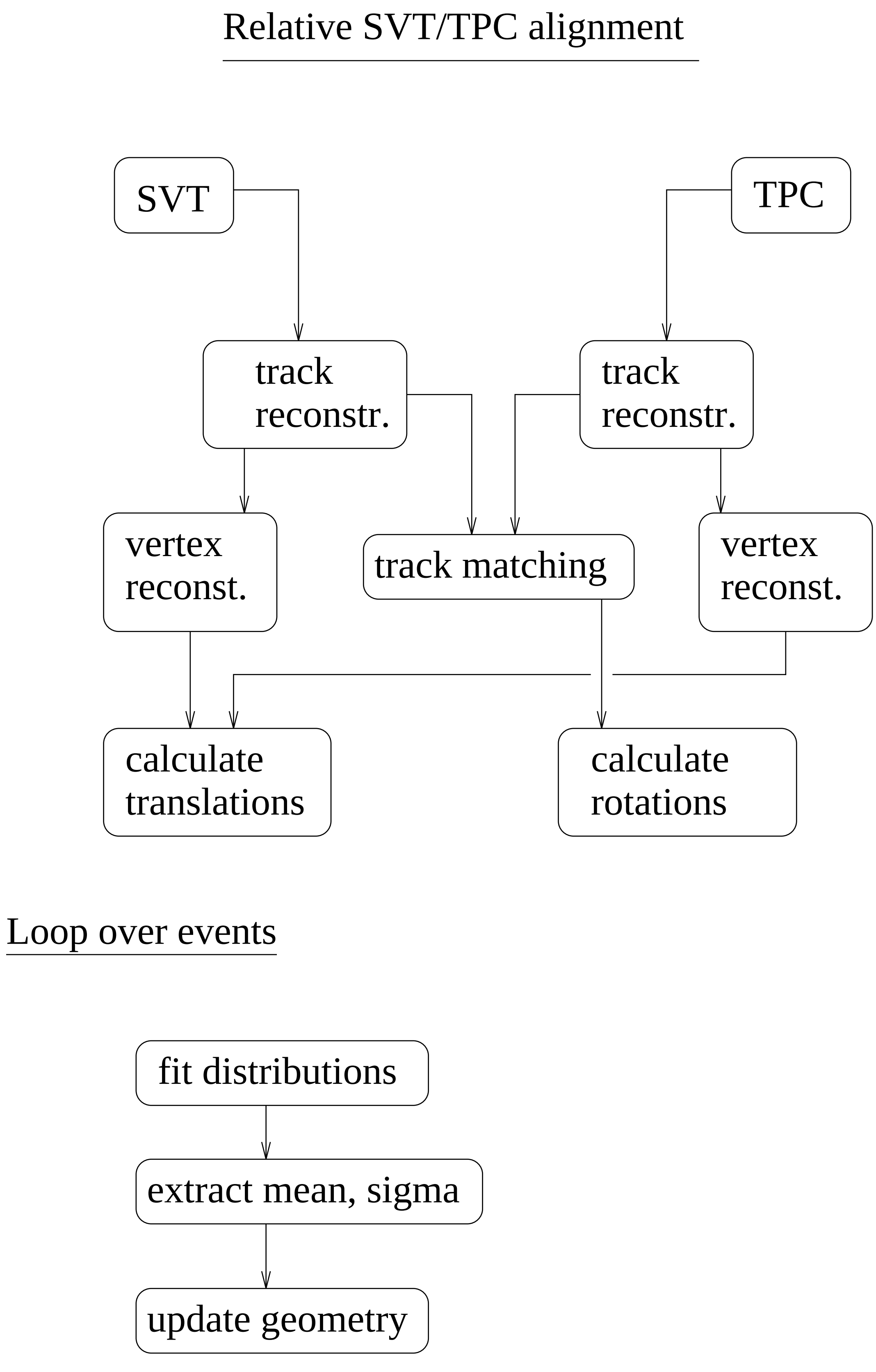

Figure 2: Analysis flow-chart for the relative SVT/TPC alignment