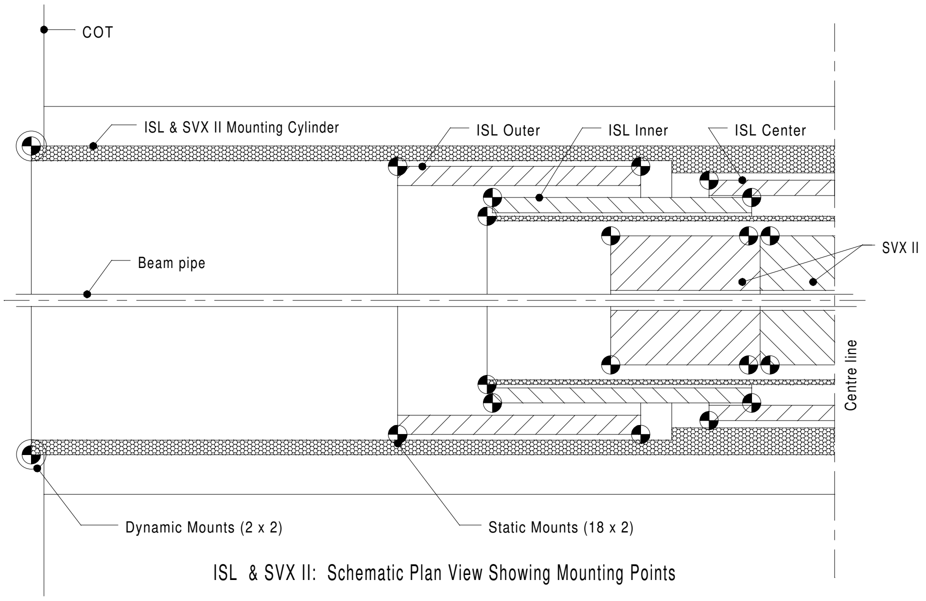

Figure 4: A schematic view of the ISL and SVX II spaceframe assemblies and the locations of the kinematic mounts for each component.

(ii) Dynamic Kinematic Mounts

In order to ensure that the SVT will function independently of beamline position, we propose to design and fabricate a system capable of remotely re-orienting the silicon trackers with respect to the beam. In order to satisfy the SVT trigger requirements the alignment between the detector axes and beamline must be retained within 100 μrad. During Run I, total drifts of the beam with respect to CDF in excess of 2 mrad were observed. Small drifts, up to 200 μrad, can be compensated for by adding small bumps to the beam orbit around the CDF experiment. Beyond this it will be necessary to physically move either the machine or the detector.

We propose to add the ability to reposition the spaceframe holding both the ISL and SVX II to the kinematic mounts that join this frame to the COT (see Fig. 4). While data from the ISL detectors are not currently included in the SVT, adding them is under study as this could extend the η acceptance of the impact parameter trigger significantly. In order to be able to compensate for all reasonable axis shifts, our proposed system has the ability to move each of four points in two transverse dimensions up to a distance of 5 mm. Although we anticipate only infrequent adjustments (less than once per month) this system must be capable of operating in the presence of a magnetic field so that adjustments can be made without ramping down the solenoid. In at least one dimension the devices must be able to lift a significant fraction of the combined weight of the SVX II, ISL and support structures. The mass of these objects is estimated to be 30 kg. To this one must add some fraction of the cable plant that will be dressed along the walls of the support structure. We anticipate that the total load will not exceed 100 kg. Since small misalignments will be compensated for by orbit corrections to the Tevatron this positioning system need have step sizes no smaller than 50 μm– about one quarter of the

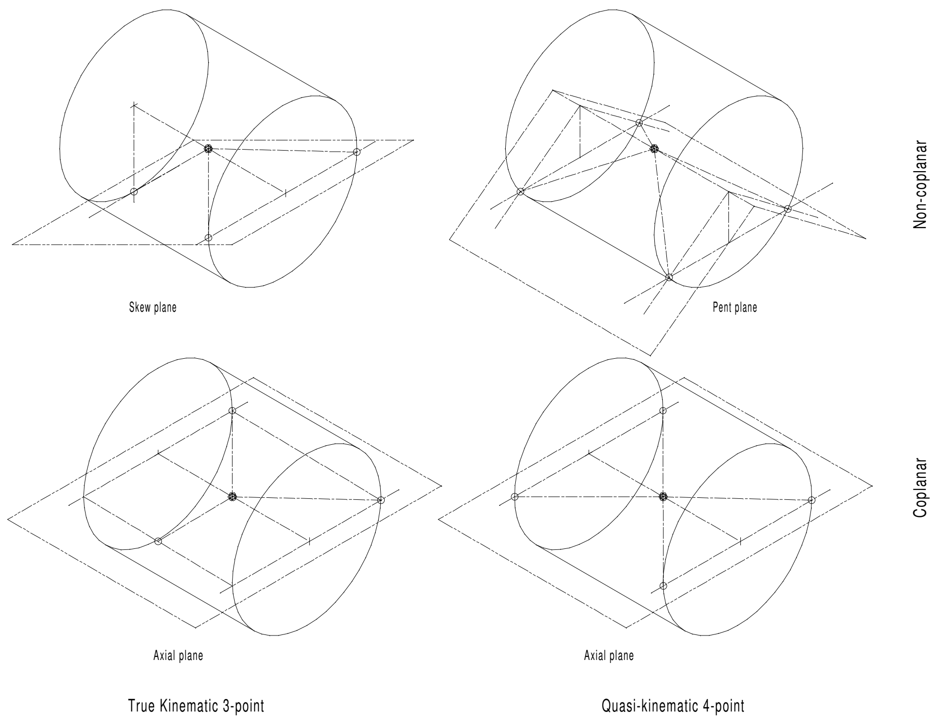

Figure 5: Four possible configurations of kinematic mounts to support a cylindrical detector. The planes illustrate the surface that the mount points are constrained to move along under expansion or contraction of the cylinder. The bottom-right configuration results in the most symmetrical motion of the entire detector.

accelerator's full compensation range. Finally the system must be compact in order to fit into the overall structure of the COT/silicon mechanical package and not introduce excess material in the acceptance of the endcap calorimeters.

With these requirements in mind, we have designed a set of inchworm stepping devices that use piezoelectric cells to move along a precise reference bar. Each inchworm consists of a carrier made of two machined frames connected by a piezoelectric cell, as shown in Fig. 6. Each frame has its own piezoelectric cell that, when expanded, will cause the frame to release its grip on a precision machined rail. In this way the quiescent state of the device is to be locked in position attached to the rail – in case of a power failure, the device will not move. The piezoelectric cells operate cyclically in order that the carrier move along the rail, alternately gripping the rail with one of the two carriers, and then expanding or contracting the central piezoelectric cell. The piezoelectric devices we are currently studying, capable of lifting in excess of 200 kg, will make 5 μm steps. An application-specific driver circuit should be able to excite the 3 cells of a single inchworm at frequencies in excess of 10 Hz. Thus the full range of motion could be covered in about one minute.

Our conceptual design of the inchworm occupies a volume of $20 \times 20 \times 70$ mm^3. We

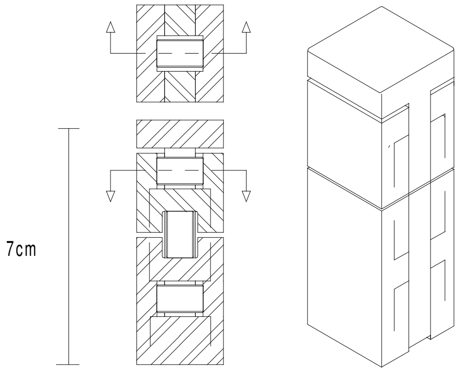

Figure 6: Schematic design for inchworm dynamic positioning devices.

intend to couple these devices in pairs to be able to dynamically correct all possible degrees of freedom transverse to the beam. We anticipate equipping four support points between the silicon detector space frame and the COT endplates with such devices. We are therefore requesting funds for 10 inchworms (this includes two spares).

(iii) Position Monitoring System

The silicon detector systems in use in high energy physics experiments today are all smaller and more compact devices than those proposed to upgrade CDF for the next run. All previous detectors have relied on the overall rigidity of the mechanical mounting structure and precise construction tolerances to achieve an initial alignment suitable for further refinement using charged particle tracks. Several experiments [9, 10] have implemented independent position monitoring of their vertex detectors and the associated support structures. These systems measure the relative positions of the detector elements during data-taking – typically the position of the silicon support structure with respect to the inner-wall of the adjacent gaseous tracking detector. This has the drawback that any observed shift could be either due to the movement of the vertex detector or the reference surface.

In order to overcome this problem, we propose a system which, in addition, has the ability to make **absolute** distance measurements on an over-constrained geodetic grid. A set of scanned laser interferometric distance measurements will allow us to pinpoint changes in the locations of individual grid nodes that are fixed to the vertex detector support structure. A series of LED light sources rigidly attached to the laser grid will illuminate several of the silicon detectors, thereby relating their relative position with respect to the grid. This will provide a measurement of the silicon sensor positions