SLAC MEMORANDUM

October 1, 2002

To: Persis Drell and Ewan Paterson

From: BaBar Support Tube Review Committee

Subject: BaBar Detector Support Tube Installation Review

Last Thursday morning the Committee* heard presentations by the PEPII and BaBar staff* outlining preparations for reinstallation of the support tube into BaBar. The review was precipitated by damage to the Be wall of the BaBar drift chamber during removal of the support tube for modification 31 July 2002. This was the first removal of the support tube from BaBar. Although the drift chamber has been patched and the detector appears fully functional, the accident's potential consequences for PEPII/BaBar have brought home the seriousness of the work on installation day.

The staff presented a very complete list of short term improvements to the installation procedures which the committee finds adequate to proceed with reinstallation. That list follows with comments.

Short Term Improvements

1. **Remove protrusions from Support Barrel**: Protruding bolts with washers were the cause of the damage. These reduced an 11 mm radial clearance down to less than 4 mm. Replacement of protruding tooling ball sockets, gas fittings and removal of unused hinged wire alignment sensors will also ensure the maximum clearance during installation and removal.

2. **Install 4 proximity sensors**: Visual observation of clearance has proved inadequate. Sensors are necessary to monitor trajectory of the joint between support tube and installation beam. Before reinstallation of support tube, this sensor array should be proven by use during prealignment of the installation beam's trajectory through the detector. The far end of the support tube entering the detector is always visible but the committee feels this clearance should also be measured, maybe with dial indicators.

3. **Laser beam alignment of crane hook trajectory**: This will help the crane operator to guide the free end of the support tube into the the detector. Nevertheless, a large multi ton bridge crane up under the roof of the experimental hall is a difficult tool to guide the support tube with millimeter precision. The risk of error may be too great to place on any operator.

4. **Gauge clearance with plastic ribbon or tubing**: If done often enough and if gauge is thick enough, this should give warning of hard impact between support tube and drift chamber bore. A soft gauge impact is better than direct impact but it would be best if trajectory could be controlled to insure clearance. Clearance between support tube and drift chamber has been reduced by a permanent "sniffer tube" attached to the patch. Any ribbon or tubing used as gauging should not run the risk of getting tangled with this sniffer tube or reopening the wound in the drift chamber wall. At a minimum the sniffer tube should be covered by a continuous layer of tape to the Be wall of the drift ch.

5. **Provide for Survey Alignment of Tooling**: Some of the removal difficulties can be traced back to misalignment of the installation beam. (Without an empty tunnel through the drift chamber, there was no way to check.) During reinstallation, the installation beam should be given fiducials referenced to monuments so next removal can start with proper alignment. Horizontal alignment between the support tube axis and the installation beam axis at their joint should also be checked. A small kink angle here could significantly misalign the support tube. Without a horizontal pivot there it is necessary to make adjustment to the forward installation beam roller supports as well as the rear to keep support tube aligned during motion.

6. **Stiffen Winch system for Installation Beam**: This will make the installation more controllable. The smaller the stored elastic energy released when static friction is overcome the smaller the jumps. For the future, the beam static and rolling frictions could be reduced.

7. **Presence of Martin Nordby and maybe others who did the 1st installation**: A sense of when something is wrong comes only from experience. Having people present with past experience will help. On the other hand, the presence of non-participants will not contribute to focus on the work at hand. Support tube removal/installation is so infrequent that safety must depend mostly on the design of equipment and procedures. Keeping a log of numerical readings and each action taken will help repeat it safely in the future. A video of the work might capture details not written. Before reinstallation it would be good to go over the stress levels in critical load bearing components such as the beam support rollers. Any item designed close to its limits should be proof tested. All adjusting screws and slides should be lubricated.

The first installation of the support tube went without incident. The accident occurred on the first removal. The committee considers the upcoming reinstallation easier than removal because the beam's trajectory can be checked beforehand. Some felt pulling the support tube into the detector was more stable than pushing it out which might have a tendency to 'jack knife' if resistance was felt but if motion is properly aligned, no resistance should be present.

The 2nd removal is 3 years in the future. The radial design clearance before the accident was 11 mm. The committee feels that such a close clearance and the potential for serious damage warrants design of equipment and procedures capable of guiding each end of the support tube to ± 1 mm transverse. A number of long range improvements were discussed during the review and are listed below. The committee urges the staff to commit to any changes they consider practical improvements now. Three years from now these will be forgotten and too late.

Long Range Improvements

1. **Straighten Installation Beam**: An installation beam sagitta of 12 mm was measured by Knut Skarpaas. To first approximation the beam is bent to a radius of 0.9 km. Traveling the full length of the detector on this arc the beam end would move 25 mm off detector axis if not periodically realigned. This motion could be straightened by bolting sole plates on bottom and top of the beam which are aligned by optical survey and locked.

2. **Remove Crane**: The present installation requires one end of the support tube to be guided (in elevation) by the IR2 bridge crane. This is tedious work with serious consequences. A bridge rail on the forward end of BaBar could guide one end of the support tube and remove this danger.

3. **Support Tube to Installation Beam Coupling**: The present coupling is a trunnion which insures moment-free simple support of the support tube in the vertical plane but prevents pivoting in the horizontal plane. A 'trailer hitch' ball pivot could remove this constraint. Support pivots would be mounted above support tube CG to stabilize it. With full pivot, each end of the support tube could be guided independently. The possibility of built-in misalignment would be avoided.

* *Review Committee*	*BaBar & PEPII Staff*
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Tim Thurston	Stuart Metcalfe
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