Next Steps in DIRC Shipping

- Comments from Review
- Questions to Answer
- Discussion

It may be of value to use an acceptable quartz bar at SLAC and perform a road test to evaluate any damage.

- A road test with a single bar as opposed to a bar box?
  - Not clear what one is trying to study with a single bar on the road
  - Would it be better stress a single bar in a controlled way? Glue joints seem most critical - this single bar would need old glue joints for such a test to be useful.
- *A bar box could be used for a road test in the vicinity of SLAC and then returned for testing.*

The use of helical springs may be of value by eliminating the need to monitor air pressure in the shipping crate dampers.

- Opinion (for discussion):
  - Helical springs tend to have a very linear spring rate. The amount of displacement they experience produces a very predictable force response.
  - Air springs, on the other hand, have a flatter initial force response that progressively becomes stronger with displacement. They tend to allow more travel initially while producing an ever increasing force response.
  - This factor allows for air springs to soak up initial displacements without producing as much reaction force, that in turn gets transmitted to the bar box. They "ease in" to the reaction force.
  - Air springs also have some inherent damping qualities that helical springs do not. For these reasons we would like to continue the development of the shipping crate using the air spring system.

Use of existing studies and specifications to determine expected shock and vibration levels should be investigated.

- We agree that data exist on expected shock for various environments. This is in addition to the data that we have collected directly with the crate.
- The problem is not anticipating what type of shock we might expect, but instead estimating what a safe shock tolerance is on the bar box. As far as we know, there is no data to reference for this.

Given the fact that bar boxes are 15 years old, were exposed to radiation, possibly suffering from button friction or deformation, were never designed for a trip across the country, one has to be very cautious. We suggest careful planning and continued testing of the transportation mode for the bar boxes, potentially to include such things as local trips, cross-country trips, and multi-terrain trips, with thought to crate instrumentation.

- Yes - radiation damage and button degradation are wild cards
- Do we want to test with a local trip around SLAC? A single bar box cross country (~$15K) first?
- Crate instrumentation has included 3-axis accelerometers with continuous readout, which limits data size and recording time.
- GPS enabled, triggered accelerometers are an option
- Should we investigate live monitoring in transit? An equipped lead vehicle to sniff out rough roads?

Transport testing to date has been done by university collaboration members. Consider enlisting subject matter experts at SLAC and JLab to further develop and test the transport plan.

- Yes! We're all ears.
- Tim has experience with moving fragile cryomodules.

It would be worthwhile to look for any unusable or incomplete quartz bar (already damaged or dismissed demo) for defining the minimum acceptable shock parameter and the initial trip tests.

- Reviewers seemed to hone in on static vs. dynamic loading. How to shock a bar in a quantifiable, repeatable way?
- Likely the glue joints, not the bar itself are most fragile.
- Is there a problem with repetitive low-amplitude vibration? How to test? Our instrumentation suggests the inner crate experiences continuous low amplitude vibration in the 10 Hz range.

It would be wise to exploit as much as possible tools and experience available at SLAC for the movement and installation of the quartz bars.

- We plan to replicate the key features of the tooling used to pick up and orient the bars for installation.

- Transportation at SLAC from assembly to installation was done in a fashion that seems impossible to easily replicate for large distance scales: large flexible boom with human intervention to steady and damp oscillations.

Recommendation: Continue the development of the transportation plan, enlisting subject-matter-experts wherever possible, to further minimize risk including considerations of both static and dynamic loads.

- How to consider dynamic loads? Is the time structure or repetition that is potentially problematic?

- The key problem seems to be quantifying the design specs of the crate which, in principle, is tailored for this device, with all of its glue joints, radiation damage, deformed buttons, etc.

  - Have asked all the subject-matter-experts we know on this topic and the response is that it is unknown and such considerations were never made in design.

  - Have ample access to subject-matter-experts in aiding in the design of low vibration crates. The question is: what is the target we are shooting for?

Open Questions - Details

- What is the best route to travel?
  - I-80 or I-10: I-10 longer but less elevation change.
  - Should we consider driving routes end-to-end to scout road conditions using an instrumented test load? Could combine with trip to SLAC.
- How steep are the road grades? What is the maximum pressure differential allowed to avoid rupturing the destructive over-pressure valve? Does the box breathe fast enough?
  - This can probably be calculated to estimate. If close, tests can be done to measure the conductance of the box.
- How does Al honeycomb respond to altitude change?
  - Test with sample in a bell jar?
- Do we need flush with LN2 during transit?
  - Other options: bottle, sealed bag (leakage problematic for pressure differentials)
- Is there a way to test robustness of nylon buttons and springs inside the box?

Big Questions - Summary

- Can we quantify an acceptable limit for repeated dynamic loads (vibration and shock)? Are FEA studies based on static loads sufficient?
- Do we ship all four boxes at once or try one first?
  - Try one: how extensively? A few hours around the bay area or make the full trip to JLab?
- Route:
  - Drive roads in advance
  - Live monitoring: lead vehicle
  - Instrument and test upon arrival
- Need: another visit to scrutinize individual bar boxes at SLAC and select the bar boxes that we want to use.