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Design of the 2-Stage Laser Transport for the Low Energy RHIC electron Cooling (LEReC) DC Photogun

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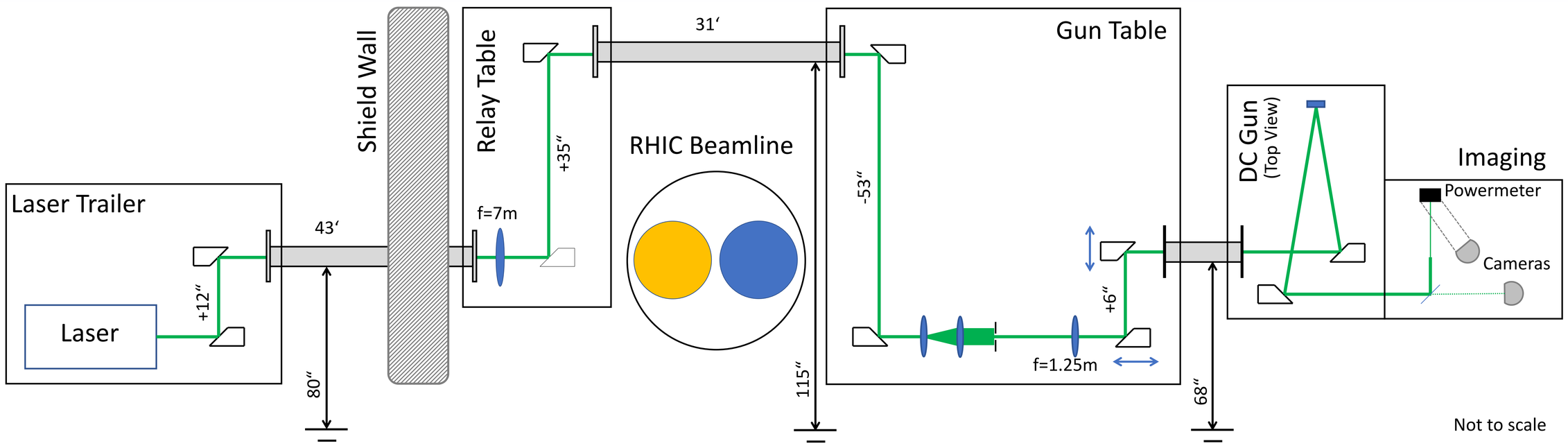
BROOKHAVEN NATIONAL LABORATORY

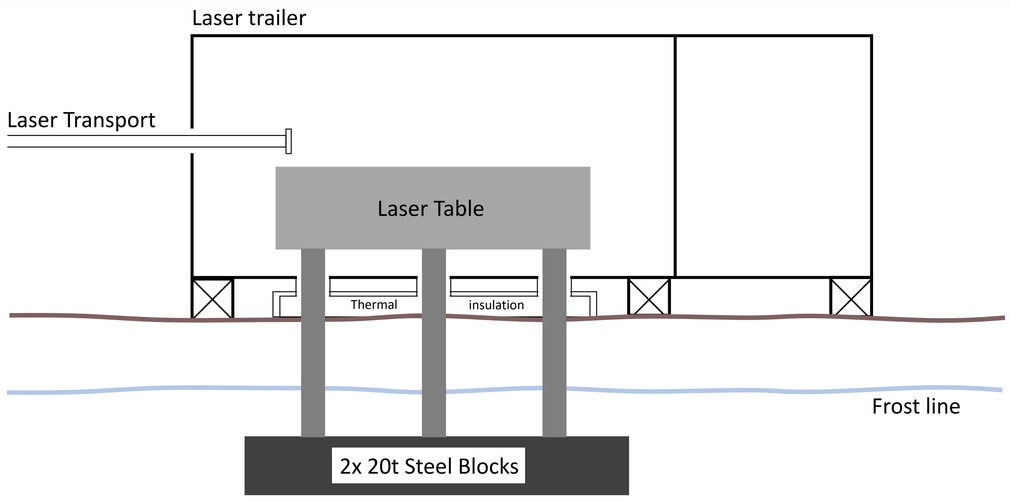


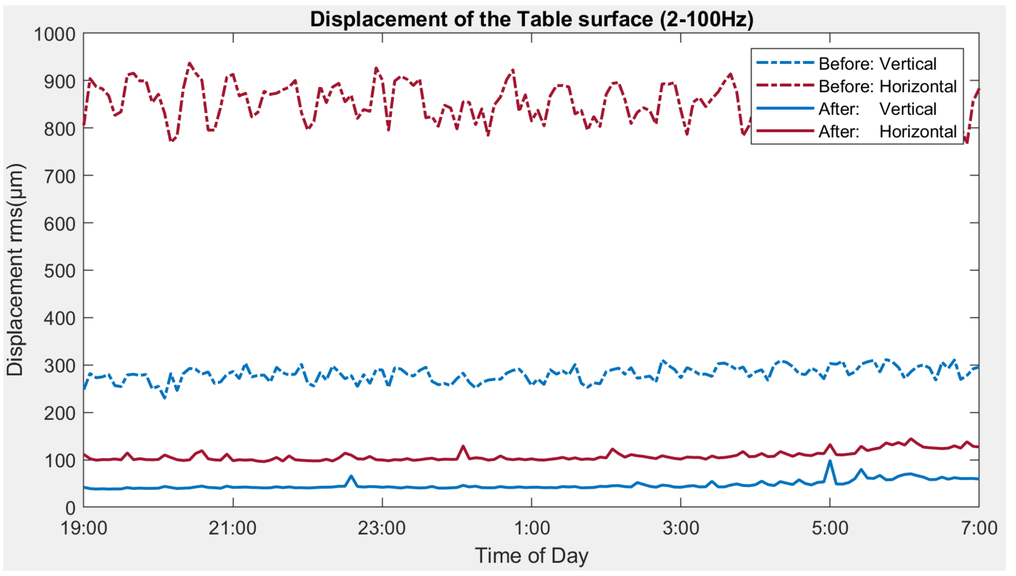
Abstract:

The electron beam for the recently constructed Low Energy RHIC electron Cooler (LEReC) at Brookhaven National Laboratory is generated by a high-power fiber laser [3] illuminating a photocathode. The pointing stability of the low-energy electron beam, which is crucial to maintain within acceptable limits given the long beam transport, is highly dependent on the center-of-mass (CoM) stability of the laser spot on the photocathode. For reasons of accessibility during operations, the laser itself is located outside the accelerator tunnel, leading to the need to propagate the laser beam 34m via three laser tables to the photocathode. The challenges to achieving the required CoM stability of 10 microns on the photocathode thus requires mitigation of vibrations along the transport and of weather- and season-related environmental effects, while preserving accessibility and diagnostic capabilities with proactive design. After successful commissioning of the full transport in 2018/19, we report on our solutions to these design challenges.

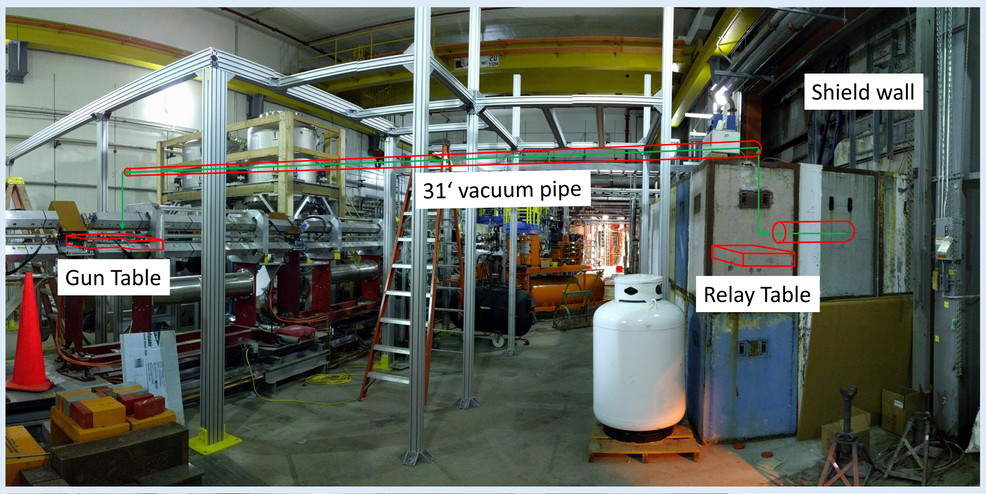
2016: Laser Trailer Modifications

- Vibration measurements show strong amplification of ground vibrations to the table surface
- Damping would decouple the table from the transport, introducing relative motion
- Rigidly mounting the table to steel blocks below ground eliminates amplification and couples the table to the RHIC tunnel foundation
- Mounting the Table on the Steel blocks reduced vibrations on the table surface 7-8 fold

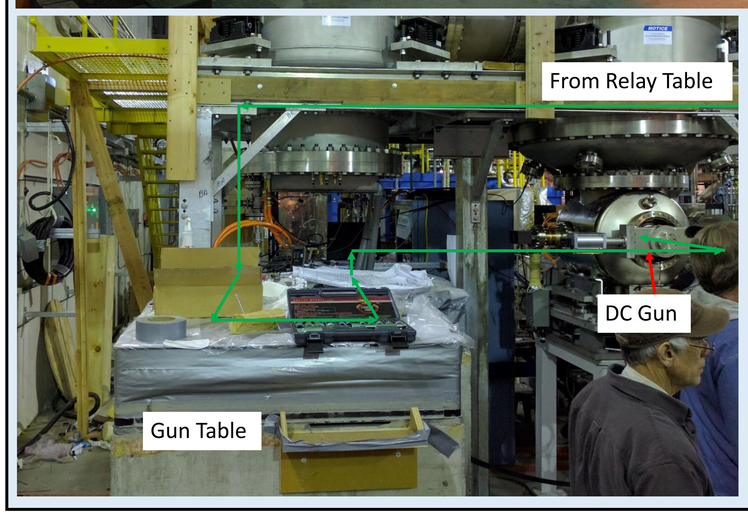


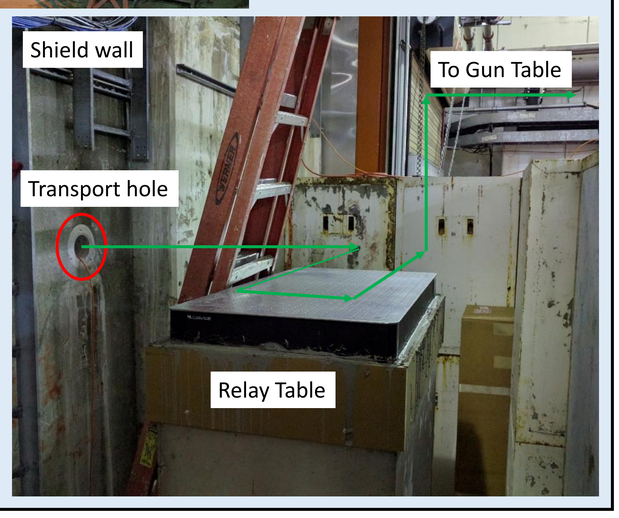


2016: Transport Construction

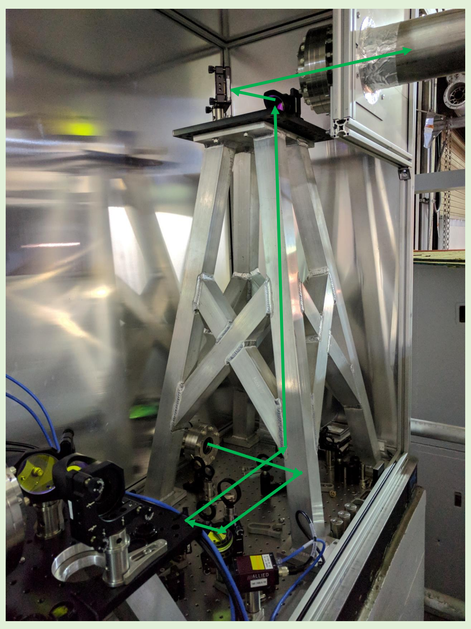


- 5” diameter hole gets drilled through the 8 feet thick RHIC concrete shield wall.
- Gun and Relay Tables get rigidly attached to concrete blocks to prevent amplification or damping of vibrations present in the ground, also affecting the DC gun
- Evacuated Transport pipes get installed, mechanically decoupled from the optical tables





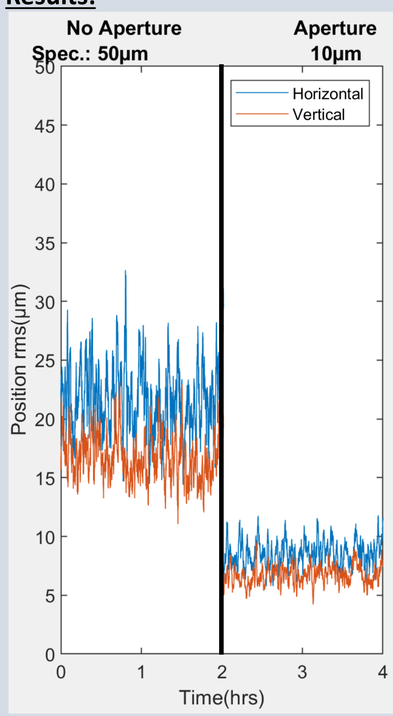
Finished Gun Table with light-tight enclosure and incoming Transport pipe



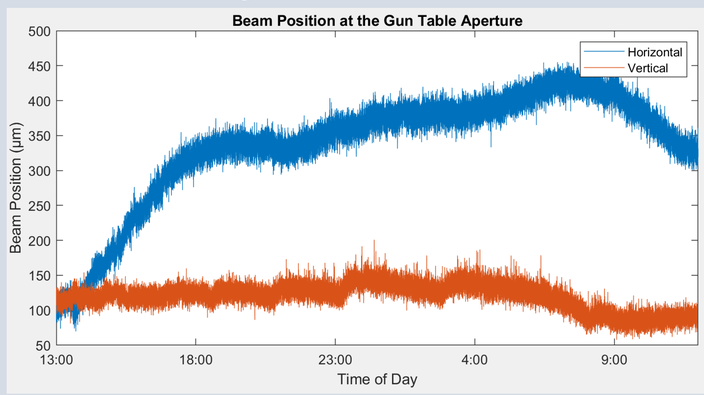
Inside of the Relay Table with incoming Transport pipe, visible A-Frame to lift the beam and outgoing Transport pipe

- Light tight enclosures protect from dust and air currents disturbing the transported beam.
- Rigid A-Frames mitigate amplification and damping of vibrations present in the table surface to prevent relative motion between optics.

Results:



- Measurements show the rms position stability of an alignment laser transported to the gun table is within the specification for LEReC.
- 24hr Measurements reveal slow drifting of the Transport. Further investigations showed this is due to weather and seasonal changes.
- A slow camera-based Feedback [4] was installed 2018 to mitigate these drifts .



Summary:

The Engineering solutions of mounting the optical table in the Trailer on steel blocks below ground, as well as attaching the transport tables rigidly to the foundation of the RHIC enclosure provide a quiet laser transport for LEReC.
The installation of a slow position feedback system to combat the weather and season related drifts of the transport produced good results in run19, successfully completing commissioning of the system.
Maintenance of the system throughout the year is minimal, limited to regular checks for damage of optical surfaces and occasional cleaning

References:

[1] D. Kayran *et al.*, “First results from commissioning of low energy RHIC electron cooler (LEReC)”, in *Proc. 10th Int. Particle Accelerator Conf. (IPAC2019)*, Melbourne, Australia, May 2019, pp. 770-772. doi:10.18429/JACoW-IPAC2019-MOPRB085
[2] A.V. Fedotov *et al.*, “First electron cooling of hadron beams using a bunched electron beam”, this conference.
[3] Z. Zhao *et al.*, “Generation of 180W average green power from fiber laser”, Optics Express 8138, V. 25, No. 7, 2017.
[4] L.K. Nguyen et al., “Active Pointing stabilization techniques applied to the Low Energy RHIC electron Cooling laser transport”, this conference