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DESIGN AND CONSTRUCTION OF THE VACUUM SUITCASE FOR CARIE

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Abstract

This paper describes the design of the load locks and vacuum suitcase for the Cathodes And Radio-frequency Interactions in Extremes (CARIE) C-band high gradient photoinjector test facility at Los Alamos National Laboratory (LANL). High quantum efficiency (QE) photocathodes require ultra-high vacuum (UHV) conditions, typically 10^{-10} Torr vacuum to maintain their efficiency. A vacuum transport device is required to move them from where they are manufactured to anywhere that they will be used or tested. This is typically done with a custom vacuum suitcase. The CARIE project has had two iterations of a vacuum suitcase design as the project has evolved. We describe both designs, their trade-offs, and why two designs were pursued. We also describe the load-locks for the growth system and the photoinjector, all of which were designed to ensure interoperability. We expect to build the vacuum suitcase and load locks this year and begin routinely transferring photocathodes next year.

INTRODUCTION

High quantum efficiency photocathodes require ultra-high vacuum (UHV) conditions, typically 10^{-10} Torr, to maintain their efficiency. CARIE will be using a variety of high QE cathodes, with candidate materials including CsTe and CsSb [1]. As these materials are not produced directly in the photoinjector, a vacuum transport device is required to move them from where they are manufactured to anywhere that they will be used or tested [2]. This is typically done with a custom vacuum suitcase–the unique needs of each project and lack of standardization of photocathode insertion devices has made it difficult for the community to develop a common transport system. The CARIE project has had two iterations of a vacuum suitcase design as the project has evolved, both of which are described here. We expect to build the second vacuum suitcase this year and start transferring photocathodes next year.

INITIAL DESIGN

The first version of the suitcase design is shown in Fig. 1. The suitcase was based on fittings with a 6” conflat (CF) flange, the largest size that the growth chamber load lock would accommodate. This size flange was selected for two reasons: first to transfer a removable back plate, which was still being considered for the CARIE photoinjector, and second, to accommodate a wide variety of future plug and photocathode substrates. This was also the reason for including independent pumping, i.e. a turbo and ion pump on the suitcase. The large flange size and included pumping are the most significant changes between the initial and current designs.

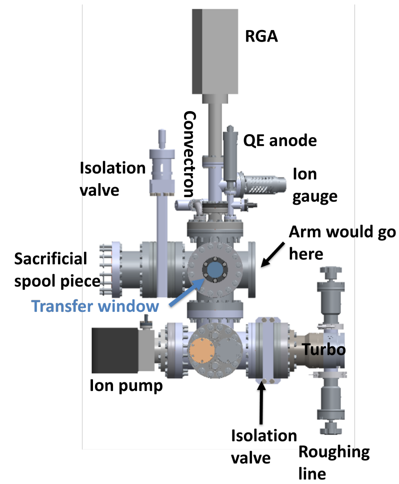

Figure 1: CAD model of the initial CARIE vacuum suitcase design.

The large flange size and pumping has several implications. First, there are significantly fewer requirements on the growth system and photoinjector load locks. However, the weight difference (and size of the mechanical support of this design was relatively complicated as a result. Alignment of a heavy vacuum suitcase can take multiple hours and it is easy to damage the vacuum system (e.g., denting a flange knife edge). The design does include sacrificial spool pieces to mitigate these risks, but these challenges, combined with the decision to not use a removable cathode back plate were the reason that a second design was ultimately pursued.

CURRENT DESIGN

The current vacuum suitcase design for CARIE is shown in Fig. 2.

As previously mentioned, it is both smaller, has fewer elements, and is much lighter. The only pumping is a NEG pump, which will not need power during operation. There is no transfer arm, only a cathode securing arm. The RGA has also been removed, with only an ion gauge for monitoring. Finally, the entire system is on a 2.75” conflat, which is just large enough for the half size plug that we intend to use in the CARIE photoinjector but not the standard INFN plug. Table 1 shows the weight comparison for the initial design and the flange sizes considered for the second iteration. Even going to a 3.33” or 4.5” significantly increases the weight, though it does allow for a larger plug. We will use the 2.75” flange size as it can accommodate our plug design and can safely be hand-carried by a single person.

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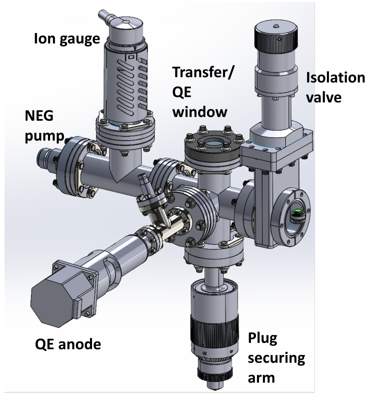

Figure 2: CAD model of the current CARIE vacuum suitcase design.

Table 1: Weight and Max Photocathode Size for Various Suitcase Sizes

Suitcase version	Weight (lb)	Max cathode size (in)
V0	270	4
V1 (2.75")	30	1.5
V1 (3.38")	45	2
V1 (4.5")	60	2.5

LOAD LOCKS

Growth Chamber

Attaching the vacuum suitcase to the existing load lock minimizes disruption to other users of the ACERT photocathode growth chamber, and reduces risks associated with vacuum excursions. However, any changes to the load lock must maintain the existing functionality, in particular the ability to hand insert substrates.The upgraded load lock seen in Fig. 3 has several new features.

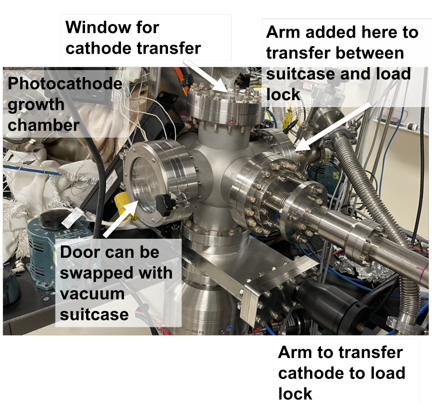

Figure 3: The photocathode growth chamber load lock.

First, the door is on a conflat flange, rather than being integral to the chamber. The door can be removed when use of the vacuum suitcase is planned. It also enables users to insert samples by hand and reach UHV conditions when needed by installing a blank CF flange. A top window was also added for visibility during sample transfer. The only remaining component to be added is the arm that will move the photocathode into the suitcase from the load lock.

Photoinjector Load Lock

A model of the photoinjector load lock is shown in Fig. 4. The design of the photoinjector itself is described here [3]. The photoinjector and load lock are isolated by a UHV-rated gate valve and have independent pumping systems. We will have a 3 arm setup to avoid long arms overhanging the optical table that could impede egress. The load lock arm that inserts the plug into the photonijector will be isolated and pumped separately to accommodate different plug styles, including the full and half INFN plugs.

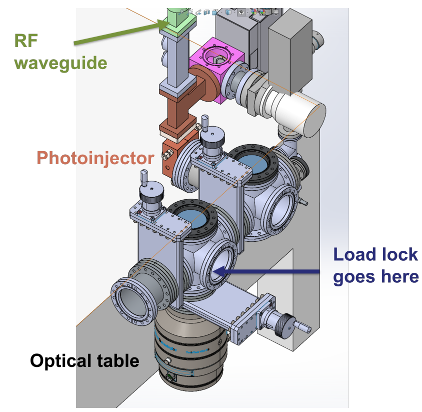

Figure 4: A model of the photoinjector load lock.

CONCLUSION

The vacuum suitcase, photoinjector load lock, and growth system load lock have been designed. The growth system load lock is largely complete and the suitcase and photoinjector load lock will be built this year. We expect to begin transferring photocathodes routinely in FY 2025.

ACKNOWLEDGEMENTS

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