Design of a dual-purpose chamber for the gas cells of the *p*/He-LIG facility

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The low-energy RIBs for TAMUTRAP facility will be delivered by a new He-LIG facility. Last year, most of the effort was dedicated towards designing the gas cell chamber, its support structure and the extraction section, and detailed SIMION simulations of the He-LIG system to help design and optimize the LSTAR mass separator using the program COSY INFINITY. More details on simulations and designs of the He-LIG and mass separator are discussed in our other reports [1]. Here we describe in more detail the chamber to service the existing *p*-LIG system as well as the new He-LIG system.

The chamber is designed with the aim to: (a) have easy access to work around the chamber; (b) be compatible with the *p*-LIG and He-LIG facilities; (c) be able to easily and quickly switch between proton and ^{3}He modes of operation; and (d) provide a strong support structure for the gas cell chamber to allow precise alignment and ensure mechanical rigidity. Fig. 1 shows the assembled design of the *p*/He-LIG facility consisting of a gas cell chamber, extraction sides of *p*- and He-LIG facilities, and coupling of the K150 and beam-dump sides to the chamber.

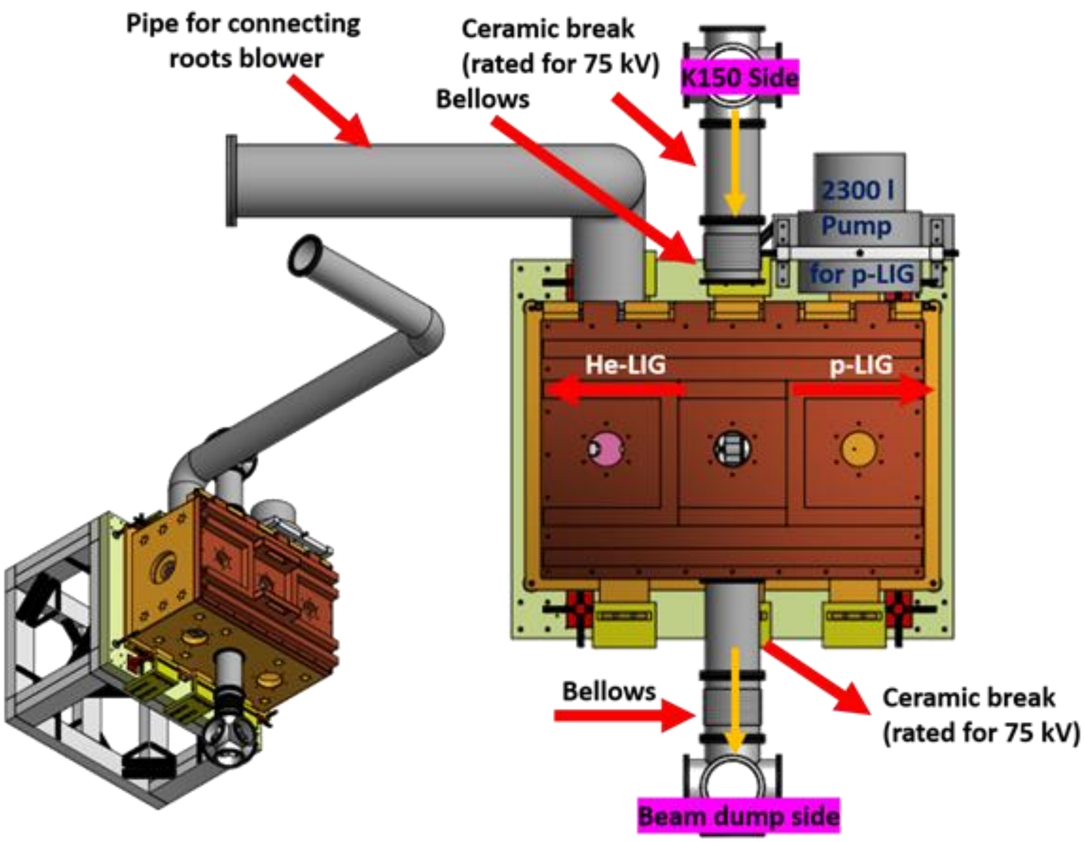

Fig. 1. The design of a gas cell chamber and coupling of the chamber to beam dump and K150 beam line.

The gas-cell chamber will be coupled to the K150 and beam dump beamlines using a combination of bellows and ceramic breaks which are rated for 75 kV. When operating in ^{3}He mode, the gas-cell chamber will be floated to a high voltage ranging between 50–70 kV, while in the proton mode it will only be floated to 10–15 kV. The roots blower and a turbo pump for the *p*-LIG will be connected to the chamber from the side (see Fig. 1) providing easy open access to the inside of the chamber from the top.

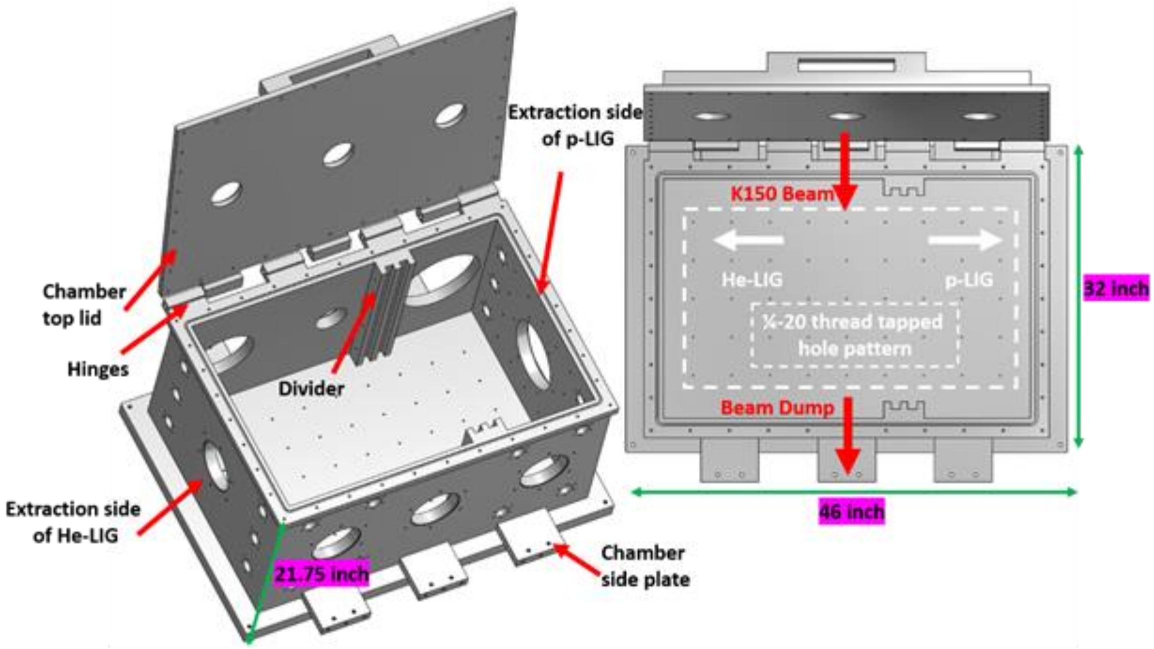

Fig. 2. The design of the gas-cell chamber for servicing both the proton and ^{3}He modes of operating the LIG facility.

Fig. 2 shows the design of the gas-cell chamber which will be fabricated out of aluminum in the coming year. It is a rather large rectangular chamber: 46”×32”×21.75”. The wall thickness of the chamber sides is 1.5” and the bottom plate has thickness of 1.75”. The bottom plate of consists of a ¼-20 tapped bolt pattern to mount the support structure for the gas cell. The beam entrance and exit ports consist of ISO 100 and ISO 160 type flanges, respectively. The *p*-LIG and He-LIG extraction sides consists of ISO 160 and ISO 200 type flanges, respectively. In total, the chamber consists of 4 ISO 100 ports, 4 ISO 160 ports, 2 ISO 200 ports, 1 ISO 250 type port, and 14 NW40 KF-type flanges. NW40 KF flanges will be used for feeding the UHP He gas to the gas cell and the electrical feedthroughs for the various electrostatic and electrodynamic components. The ISO 200 and ISO 250 ports will be used to connect the roots blower and HiPace 2300 l/s turbo pump, respectively. One of the critical parts of the chamber is the divider slot which will be used to install a plate with a differential pumping diaphragm for isolating the *p*-LIG section for better vacuum when extracting RIB to the right (proton mode), and vice-versa when extracting to the left (^{3}He mode). The chamber has side plates (see Fig. 2) to securely bolt the chamber to the support structure after it has been precisely aligned. The top lid and the gas chamber have one complete side hinged. A stainless-steel threaded rod extends through an elongated slot in the hinge arm allowing to lift the top lid from one side. The chamber will be fabricated out of aluminum and all the sides of the chamber will be vacuum welded from the inside.

Apart from the design, a stress analysis of the chamber was performed to study the behavior of the assembled gas-cell chamber when exposed to atmospheric pressure (14.7 psi) using Autodesk inventor (2015 version). This study was used to determine the thickness of the chamber walls needed to keep deformations (in all three direction) from causing misalignment. Atmospheric pressure was applied to all sides of the chamber with the corners and tapped holes as fixed constraints, with Fig. 3 showing the output of the analysis. No significant deformation was observed, and the safety factor of the assembled chamber was as high as 15 (Fig. 3(d)). The maximum displacement of 0.08 mm was observed for the bottom flange.

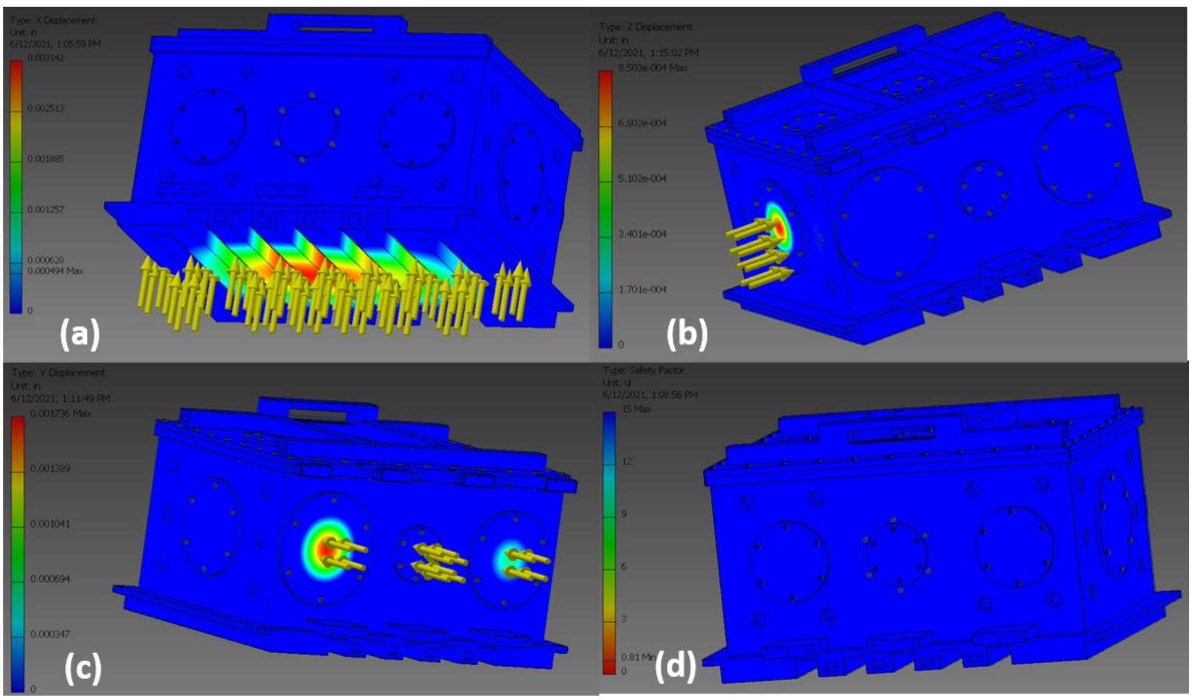

Fig. 3. Stress analysis of the gas cell chamber. (a), (b) and (c): Displacement observed on different sides of the chamber. (d) safety factor of the chamber.

The gas cell chamber support structure will be constructed from solid, double-quad 80/20 aluminum extrusions (6” in height and 3” in width). Fig. 4 shows the design of the support structure. The chamber will be bolted on swivel leveling mounts from all corners and the levelling mounts (red circle in the left image Fig. 4) will be used to adjust the height of the chamber and align it with respect to the beam axis. The left/right and front/back adjustment will be done using swivel-Tip set screws (blue circle on the right side of Fig. 4). After aligning, the chamber side plates will be bolted to the support structure using L-brackets (highlighted as a black circle in Fig. 4).

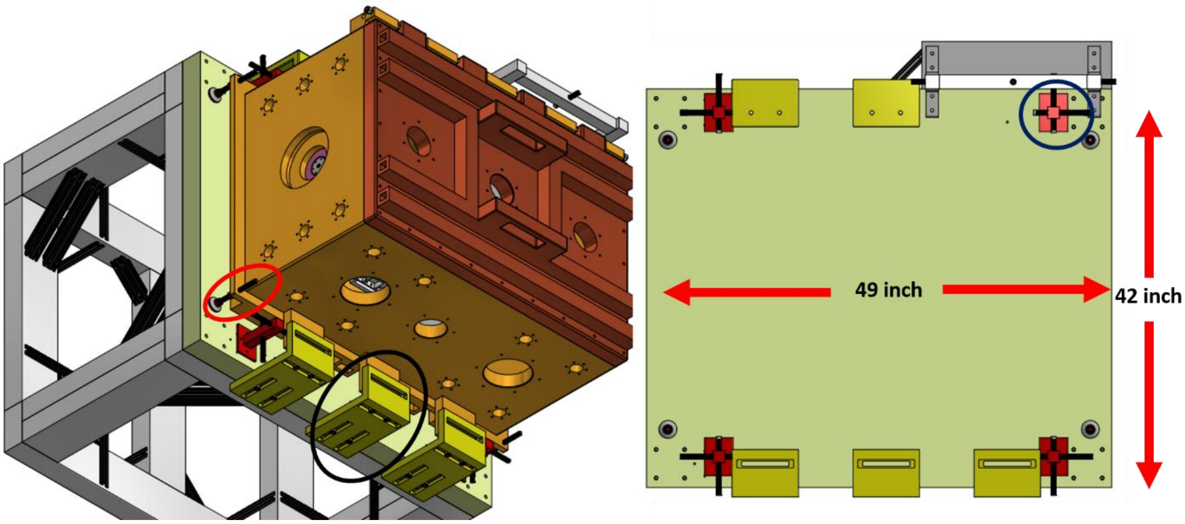

Fig. 4. Support structure for the dual-purpose chamber. Fine-tune adjustments in all three directions is possible with the threaded-rod feet on the corners (height adjustment) as well as threaded rods pressing against the chamber wall and side plates (horizontal adjustment).

The technical drawings are completed and we are in the process of soliciting bids to fabricate the chamber. The chamber will be installed and aligned in the fall of 2021.

[1] D. Melconian *et al.*, LSTAR facility, 2020-2021, *Progress in Research*, Cyclotron Institute, Texas A&M University (2020-2021), p. V-71.

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