Skipper CCD Long-Term Vacuum Chamber

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Abstract

The Skipper CCD is a high-sensitivity Charge Coupled Device (CCD) sensor designed at Fermilab that has extremely low readout noise. The Skipper can only be operated at pressures below 10^{-4} Torr (about a millionth of an atmosphere). The purpose of this project was to investigate whether a long-term vacuum chamber could be used for the Skipper CCD, which would require only being re-pumped once a year. This would allow the Skipper to be fully integrated here at Fermilab and then be transported anywhere for immediate use.

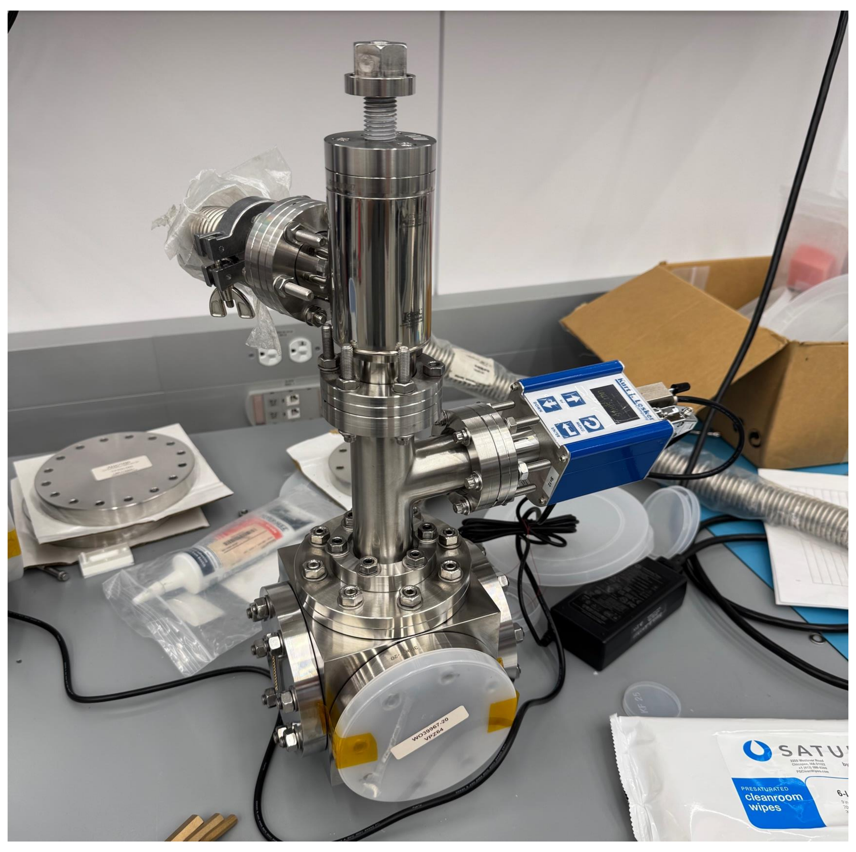


Figure 2: The vacuum chamber with the UHV valve on top, the pressure gauge on the right, and the main body of the chamber at the bottom.

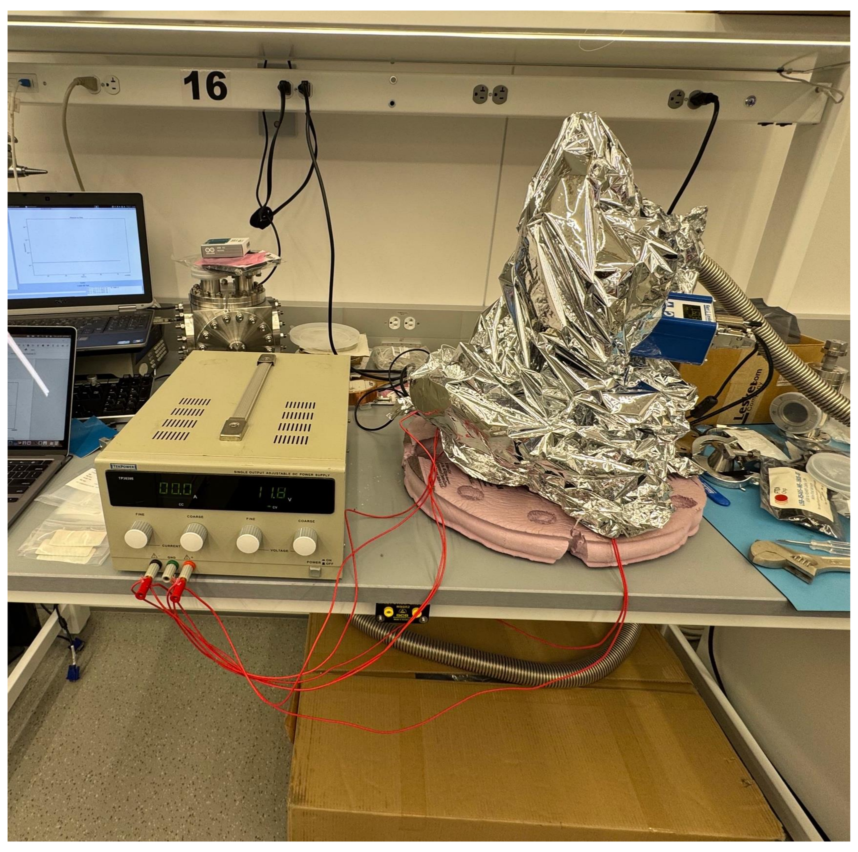


Figure 3: The bake-out setup with a multiple heaters on the chamber, wrapped in a thermal blanket, sitting on a foam pad, and the power supply to the left.

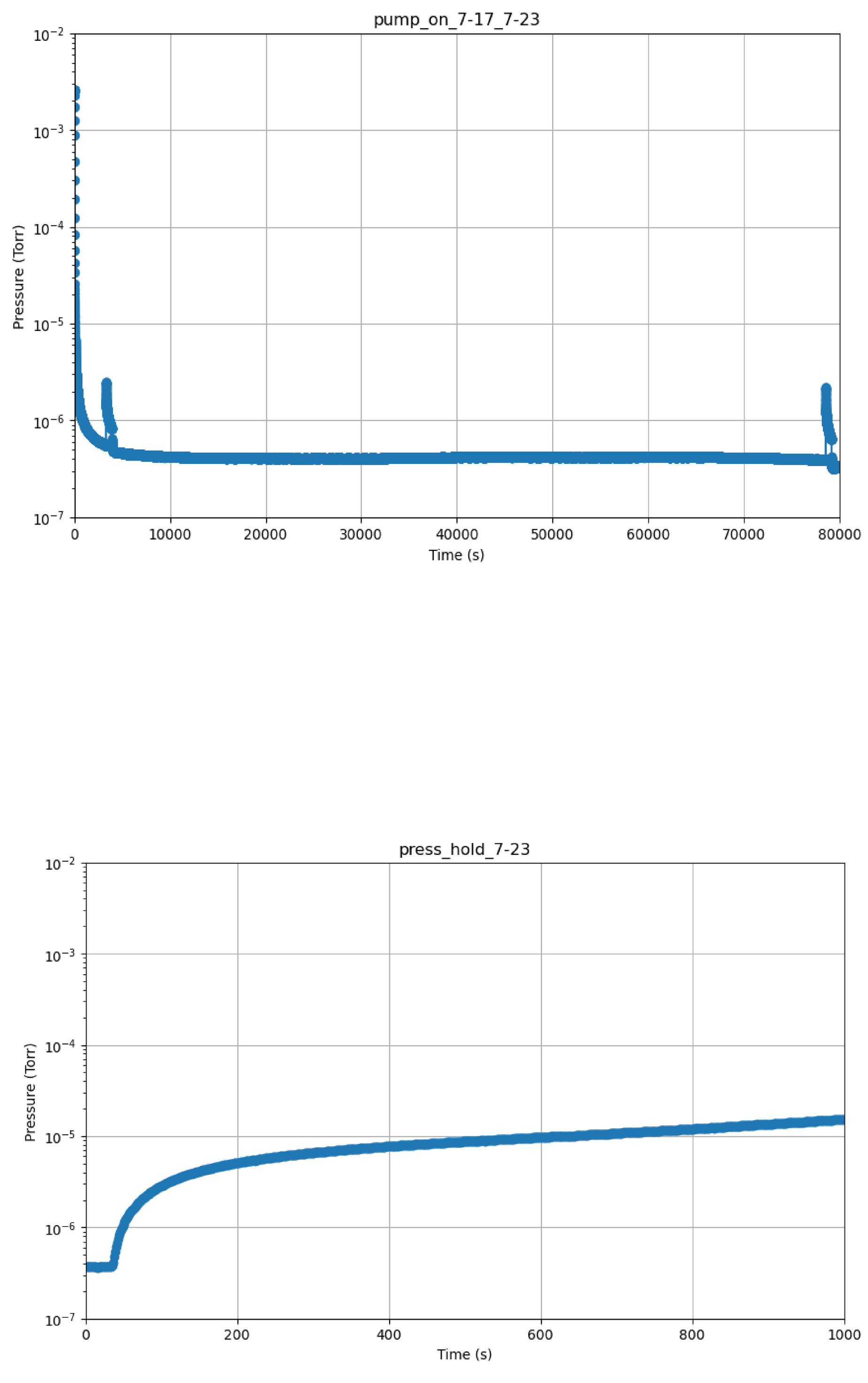


Figure 4: Shown here are two charts of the chamber's pressure vs time. Pressure is logarithmic. The first shows the pressure after roughly a day. The two random spikes are from the gauge's degas subroutine. The second chart shows the result of a closed-valve pressure hold test lasting 1000 seconds before any bake-out.

The chamber was evaluated for leaks using a standard helium leak check. The process involved using a turbopump with a helium detector, and spraying helium around the chamber (especially in problem areas). No leak was detectable above 10^{-9} Torr/s. This is what led us to believe the primary driver of the rising pressure was off-gassing. Heating the chamber to roughly 100 C allows us to speed up the off-gassing to be done within a day rather than taking weeks at ambient with the pump running.

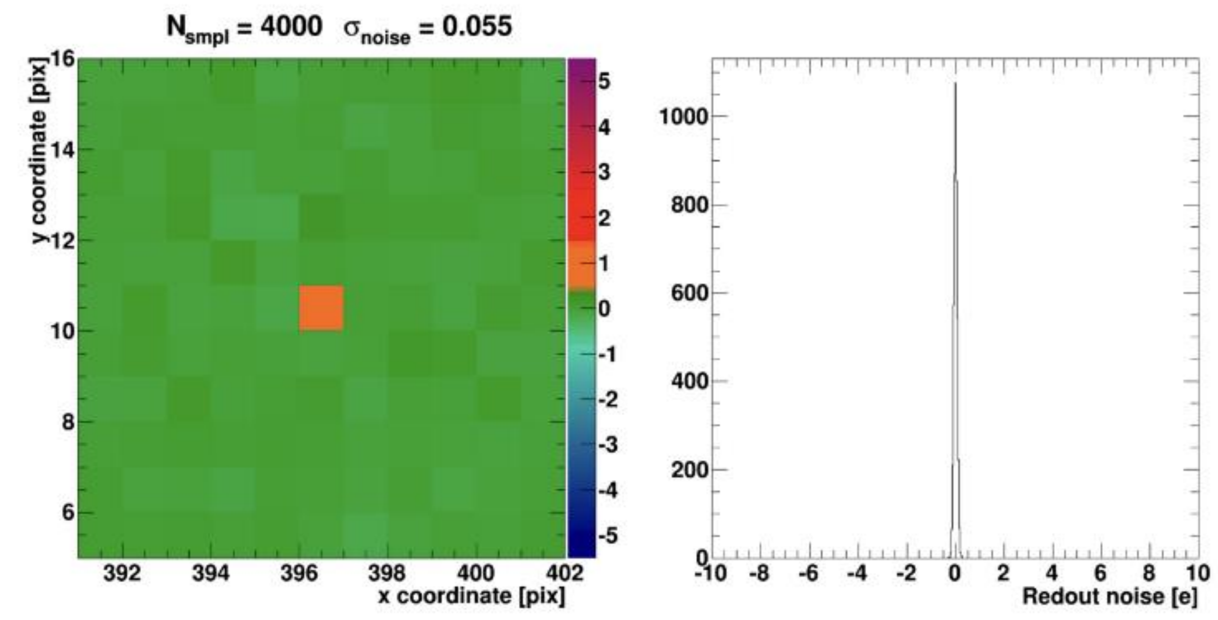
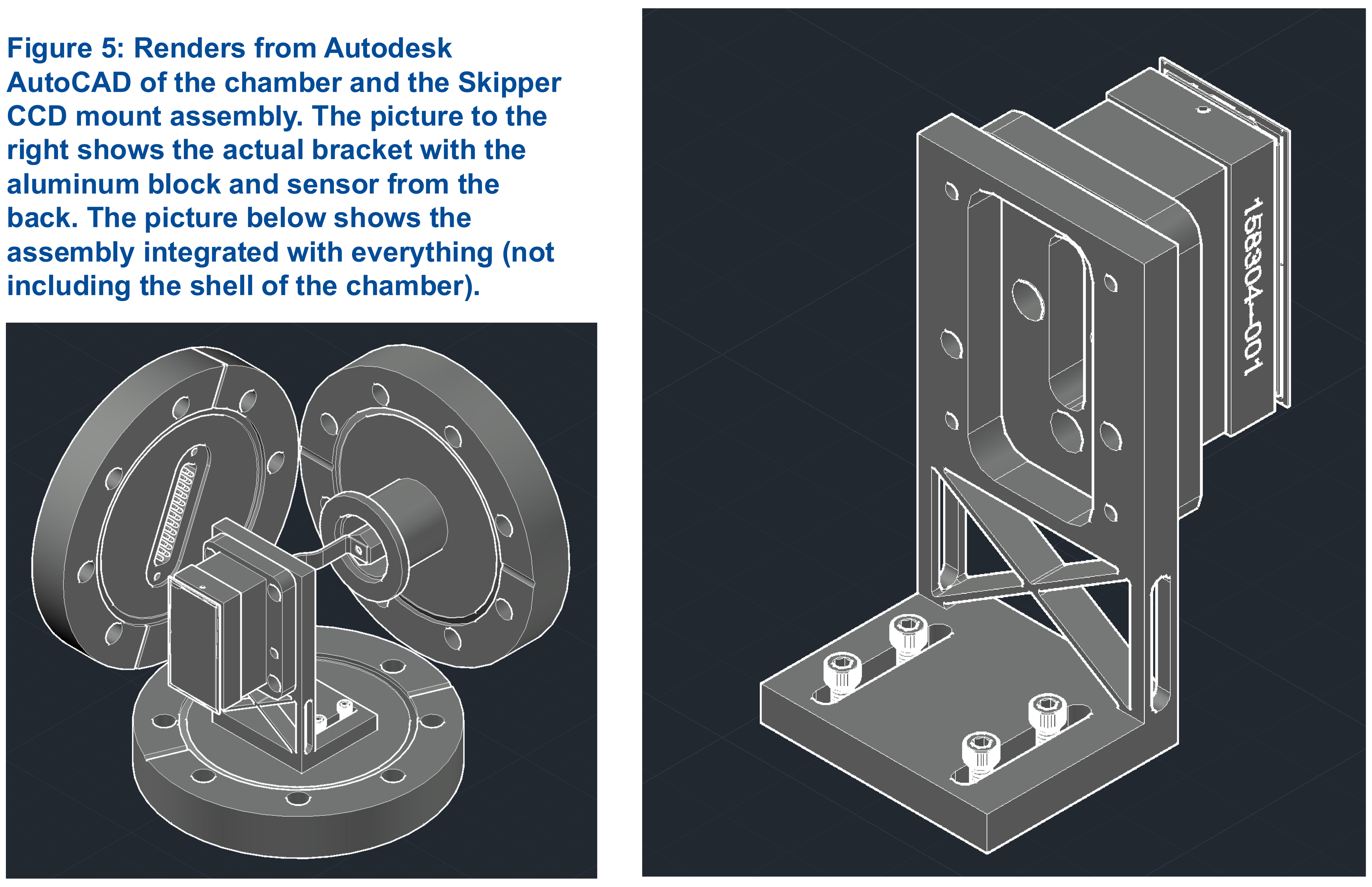


Figure 1: The Skipper CCD can provide sub-electron readout by resampling each pixel, in the case here 4000 times, providing a sufficiently high signal-to-noise ratio to detect something as small as a single electron being excited.

Evaluating the Chamber

The chamber components are provided by Ideal Vacuum. The flanges use a copper seal to ensure minimal pressure loss and off gassing compared to rubber seals. The pressure gauge has a range of 10^{-2} Torr to 10^{-9} Torr, and a custom script had to be made to operate it and evaluate the performance of the chamber. The chamber features an UHV valve to hold the vacuum for the desired period. We determined through pressure-hold tests that bake-out was required, and we performed several test bake-outs.

Figure 5: Renders from Autodesk AutoCAD of the chamber and the Skipper CCD mount assembly. The picture to the right shows the actual bracket with the aluminum block and sensor from the back. The picture below shows the assembly integrated with everything (not including the shell of the chamber).



Designing the Skipper Mount

A custom mount was needed for the Skipper. It needed to provide rough focusing, sufficient thermal isolation from the rest of the chamber, minimal pockets for air to get trapped (which would cause virtual leaks), and protection of the skipper during installation. The mount consists of three parts: The bracket, the aluminum block, and the cover. The first is made of stainless steel, the second is aluminum, and the third is plastic. The bracket has a window in the center for the skipper's QIS cable and a cutout on the side for the cryocooler strap. It is expected the design of all of these parts will be completed before August 8th.

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