Minimizing Residual Pressure within a Windowless Gas Target System - JENSA

*O. Gomez[*A] J. Browne[B,C,D] A. Kontos[C,D] F. Montes[C,D] H. Schatz[B,C,D]*

The JENSA Collaboration

[A]Physics Department, Florida International University, Miami, FL 33199, United States [B]Department of Physics and Astronomy, Michigan State University, Lansing, MI 48823, United States
[C]National Superconducting Cyclotron Laboratory, Lansing, MI 48823, United States [D]Joint Institute for Nuclear Astrophysics

Introduction

Nuclear reactions between light gases and radioactive isotope beams are essential to address open questions in nuclear structure and astrophysics [5]. Pure light gas targets are critical for the measurements of proton- and alpha-induced reactions [1] [5]. Jet Experiments in Nuclear Structure and Astrophysics (JENSA) is the world's most dense (~10^{19} atoms/cm^2) windowless gas target system [1]. Most of the gas flow is localized; however, escaping residual gas creates a pressure gradient which degrades experimental measurements and contaminates the beam line [2]. JENSA contains a differential pumping system to maintain a vacuum. The previous design configuration was not optimized for future experiments (pressure measurements 70 cm downstream from the jet were ~10^{-3} torr; optimal is less than 10^{-4} torr). We have altered the current gas-receiving cone geometry of the differential pumping system to minimize the residual pressure profile within JENSA.

Methods & Materials

Fig 3 shows the experimental configuration of JENSA. ^{4}He was compressed and discharged through a 1.1 mm nozzle into the central chamber. We installed and tested inner and outer catchers of different diameters:

- Inner cone: 10, 15, 20 mm
- Outer cone: 20, 25, 30 mm

We measured the pressures in the system as a function of the pressure of the compressed ^{4}He. The discharge pressure was ranged between 3000 to 16000 torr (about 26 atm at maximum).

Figure 4: Photo by author of cones

Figure 5: Photo by author of gauges

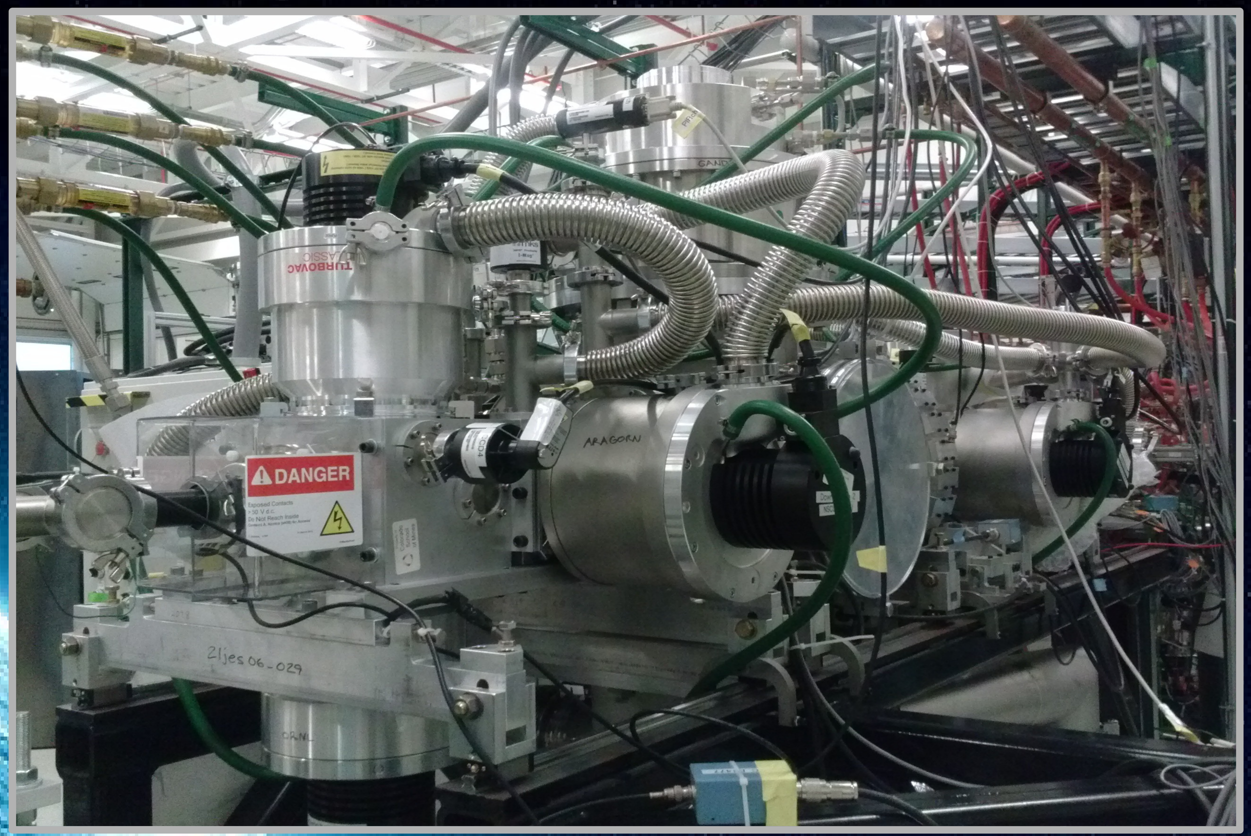


Figure 1: Photo by author of JENSA (Exterior View)

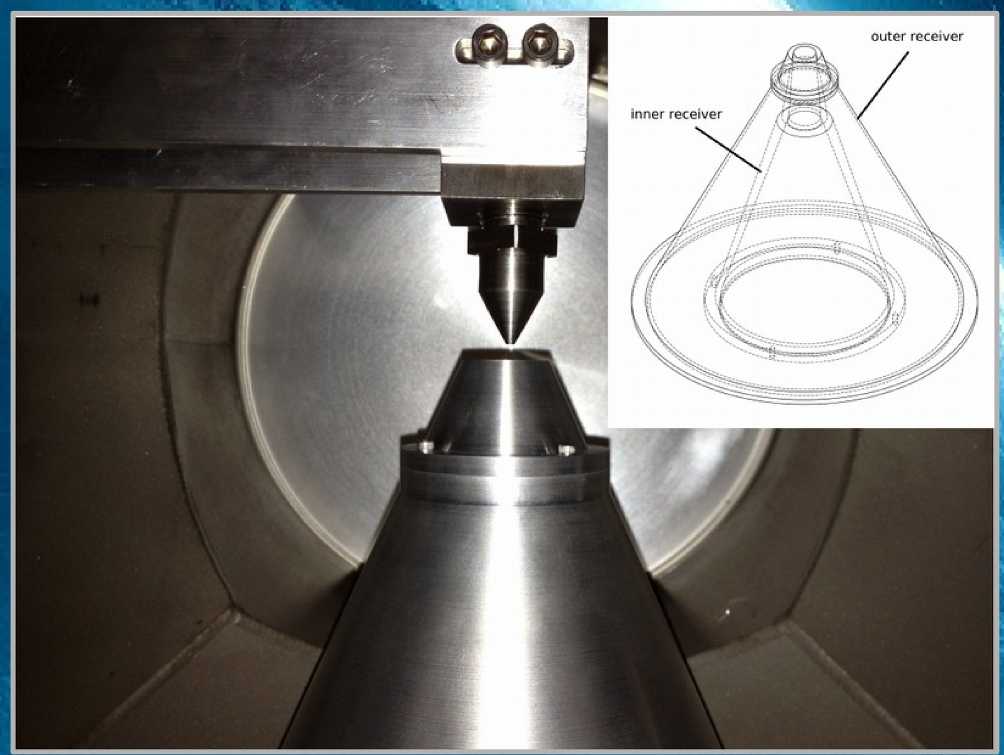


Figure 2: Photo by K.A.Chipps of Central Chamber

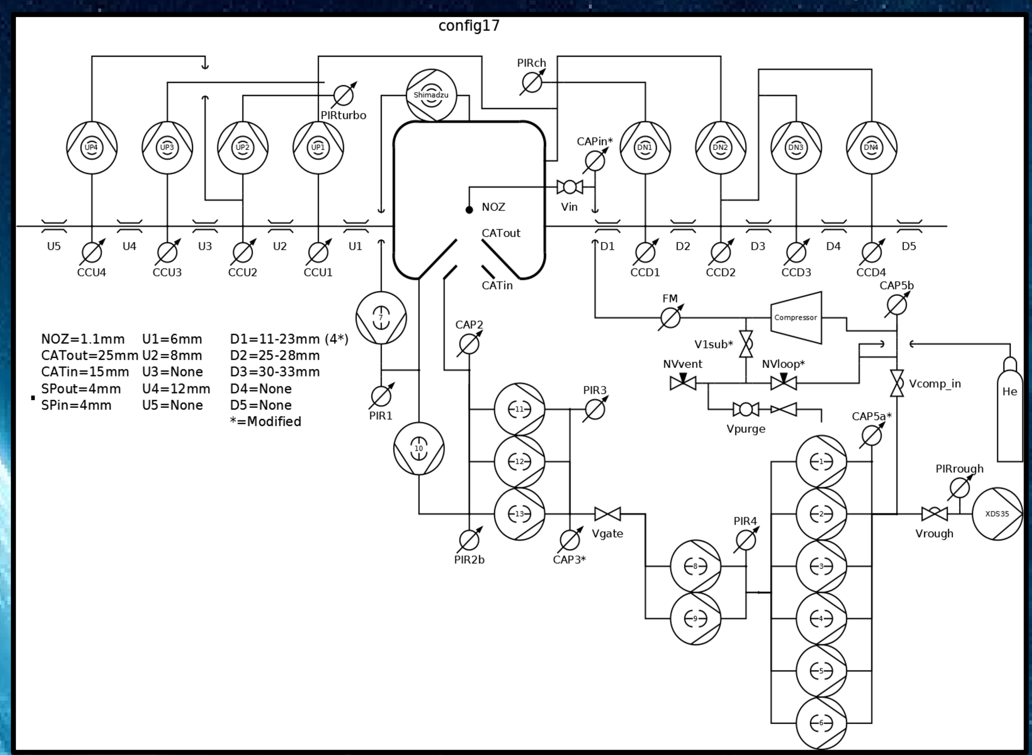


Figure 3: Diagram by J. Browne of JENSA Gas Flow

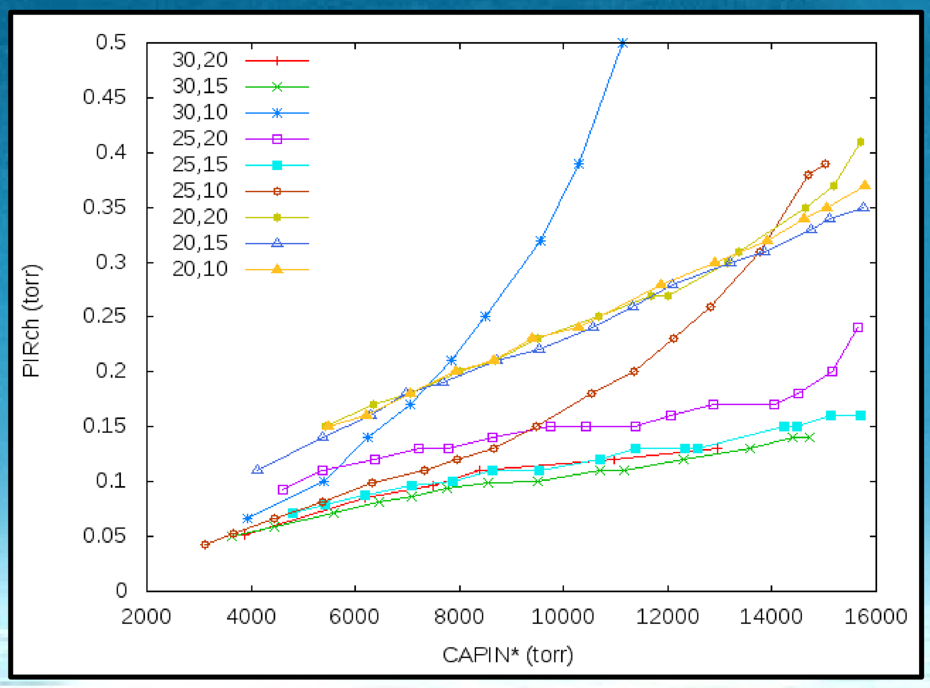


Figure 6: Results of Central Pressure of each combination.

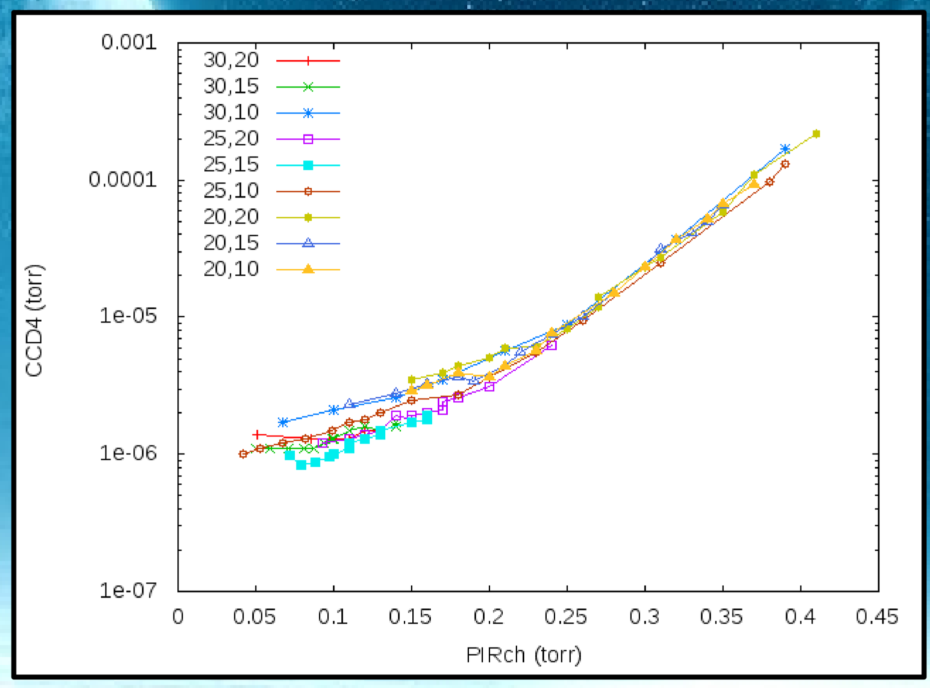
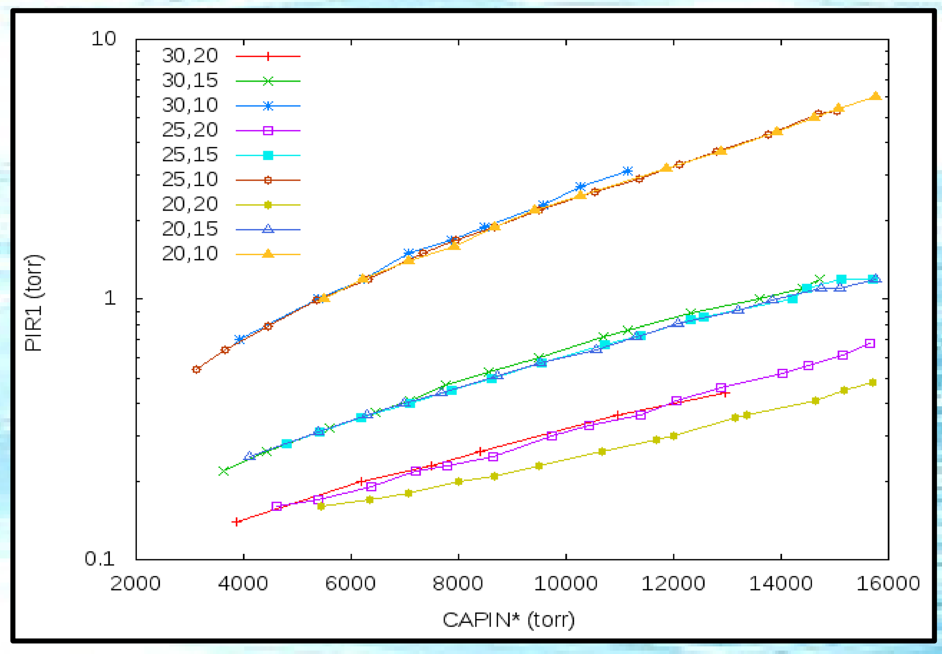


Figure 7: P-P plot of Central vs Outer Chamber



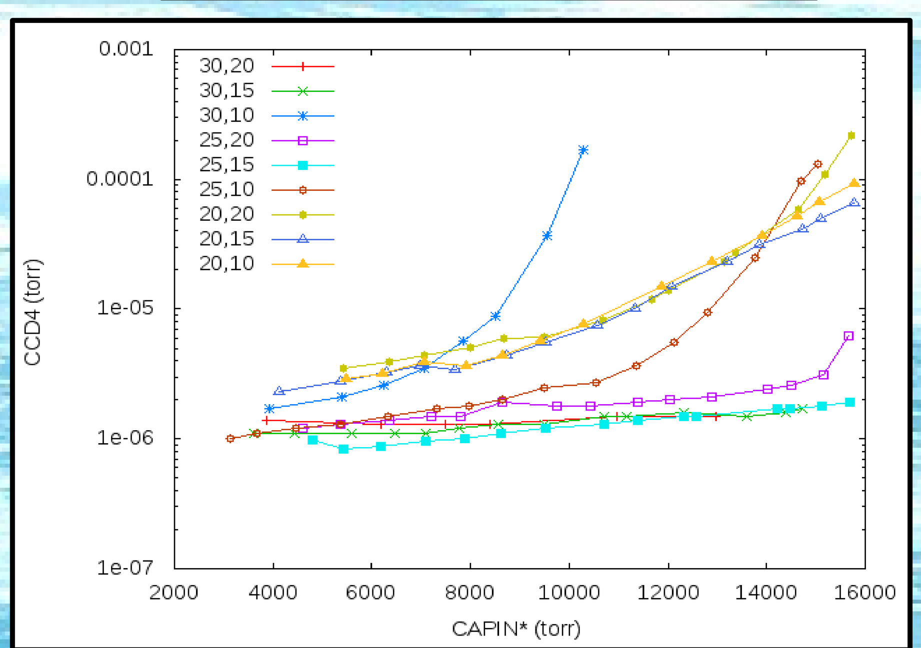


Figure 8 & 9: Pressure-Pressure plots at different stages of JENSA. Fig 7 is downstream and Fig 8 is below central chamber.

Results

The criteria for the best configuration is the one that minimizes pressure within all stages of JENSA.

- Configurations (30,20), (30,15) and (25,15) generated the minimum central and downstream pressures as shown in figures 6 & 9.
- Configurations (30,20) (25,20) and (20,20) generated the minimum pressure in outer receiver as shown in figure 8.

Configuration (30,20) fits all the criteria to best minimize residual pressure.

Future Research

- Characterization of Jet Density.
- Two-stage chiller system to further condense the gas (higher density)
- Optimization of recirculation of gas, needed for expensive gases (^{3}He) and explosive gases (H).

Conclusion

Minimizing the residual pressure profile has allowed operation of JENSA for more sensitive experiments and for the future expansion of a mass recoil separator (SECAR). JENSA is the most advanced windowless gas target system in the world and will host the next generation of radioactive beam experiments.

Acknowledgments

I would like to thank the following people for their assistance, guidance, and support throughout this project: Justin Browne, Dr. Brian Raue, Dr. Fernando Montes, Dr. Antonios Kontos, and my family. I would also like to thank the McNair Post-Baccalaureate Achievement Fellowship Program at Florida International University, the Summer Research Opportunities Program at Michigan State University, and the Joint Institute for Nuclear Structure & Astrophysics for the opportunity to conduct this amazing research.

Funding: NSF grant No. PHY08-22648

References

[1] K.A. Chippsa, U. Greife, D.W. Bardayan, J.C. Blackmon, A. Kontos, L.E. Linhardt, M. Mato, S.D. Pain, S.T. Pittman, A. Sachs, H. Schatz, K.T. Schmitt, M.S. Smith, and P. Thompson, The Jet Experiments in Nuclear Structure and Astrophysics (JENSA) Gas Jet Target, et al, to be published (2014)..
[2] A. Kontos, D. Schurman, C. Akers, M. Couder, J. Gorres, D. Robertson, E. Stech, R. Talwar, and M. Wiescher, Nucl. Instr. and Methods A 664, 272 (2011).
[3] Oerlikon Leybold Vacuum, Fundamentals of Vacuum Technology, 00.200.02, Kat.-Nr. 199 90
[4] A. Kontos, R. deBoer, J. Browne, et al, to be published (2013).
[5] P.D. O'Malley, Nuclear Physics Reactions Important for Astrophysics (2012