Nitrogen removal from liquid argon using Li-FAU, an innovative Brazilian method

Flor de Maria Blaszczyk[5], Sergey Koshelev[5], Alan Hahn[5], **Daniel Correia**[4], Dilson Cardoso[2], Renato Soccol Junior[3], Pedro Bianchi Neto[3], Roza Doubnik[5], Mark Adamowski[5], David Montanari[5], Thiago P. M. Alegre, Ana Amélia Machado[1], Ettore Segreto[1], José Mansur Assaf[2], H. da Motta[4], Dirceu Noriler[3] and P. G. Pagliuso[1].

[1]Instituto de Física "Gleb Wataghin", UNICAMP, Campinas-SP, 13083-859, Brazil, [2]Advanced Materials and Energy Research Center, Federal University of São Carlos, São Carlos, Brazil, [3]School of Chemical Engineering, UNICAMP, Campinas-SP, Brazil, [4]Brazilian Center for Research in Physics, Rio de Janeiro-RJ, Brazil, [5]Fermi National Accelerator Laboratory, Batavia, Illinois, USA.

Background

Liquid argon (LAr) is at the core of Time Projection Chamber used in neutrino experiments. Nitrogen (N_2), oxygen and water are the main contaminants in LAr that compromise the quality of physics a LArTPC can deliver. It is crucial to keep them as low as possible.

- N_2 **absorbs** the LAr scintillation light, restricting the full collection of the light available [1];
- **There is no N_2 adsorbent** being used in LAr detectors up to date;
- **Li^+ Faujasite (Li-FAU)** is an innovative method proposed to remove N_2 from LAr, whose initial tests were performed in the Liquid Argon Purification Cryostat (PuLArC, IFGW/Unicamp) [1,2].

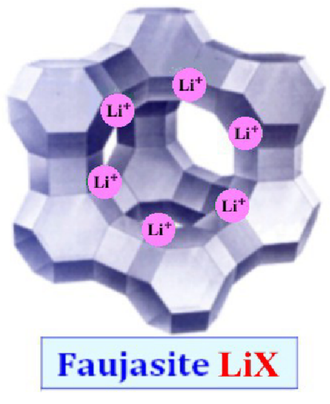

Figure 1: Li-FAU structure. Extracted from [3].

The adsortion mechanism is due to the interaction of N_2 with the lithium cations present in Li-FAU.

- **The method was tested in the ICEBERG** cryostat at the Noble Liquid Test Facility (NLTF, Fermilab);
- **The tests in ICEBERG confirm** previous results from PuLArC, where Li-FAU removed N_2 from LAr down below to sub-ppm.

Experimental Setup

The experimental setup used to explore Li-FAU in the ICEBERG is described below. Fig. 2 illustrates the ICEBERG cryostat.

- 2,625 liters of commercial LAr;
- 3 kg of Li-FAU media;
- 1 gas analyzer: LDetek;
- 70 liters of gas Nitrogen.

Several controlled amounts of N_2 were flushed into ICEBERG (15-25 L each).

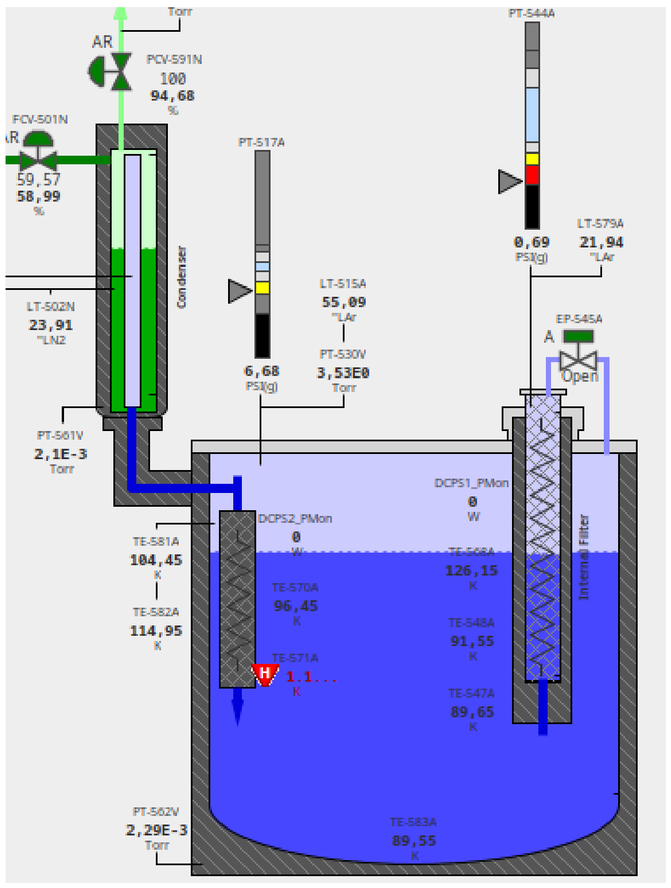

Figure 2: ICEBERG Cryostat at Fermilab.

Analysis

- **Analysis:** mean and standard deviation of the mean computed for 10-secs measurements at each 3 hour of purification.

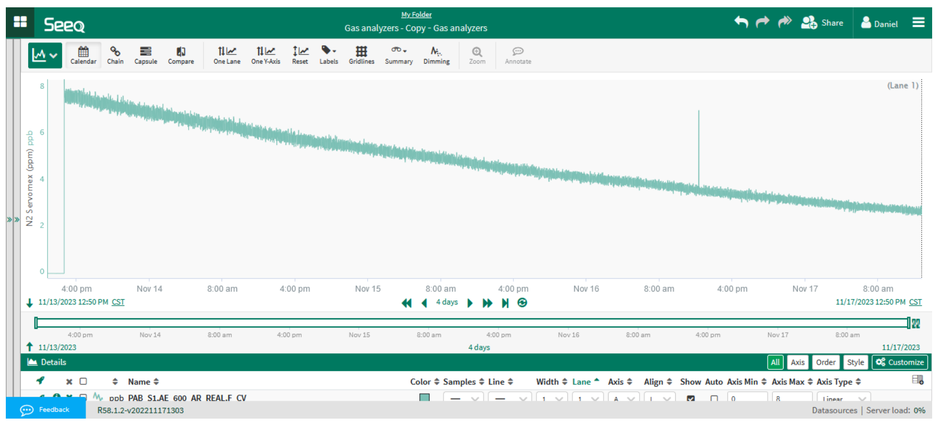

Figure 3: N_2 concentration (ppm) for 4 days of purification through Li-FAU.

Results

Tab. 1 contains the mean values of the initial and final N_2 concentrations.

Table 1: Initial and final N_2 concentrations (ppm).

Tests	t=0 h	t=96 h
Run1	5.68 ± 0.10	0.84 ± 0.04
Run2	4.84 ± 0.07	0.71 ± 0.03
Run3	7.54 ± 0.14	2.50 ± 0.07

Fig. 4 shows the evolution of N_2 concentration (ppm) *vs.* purification time (h).

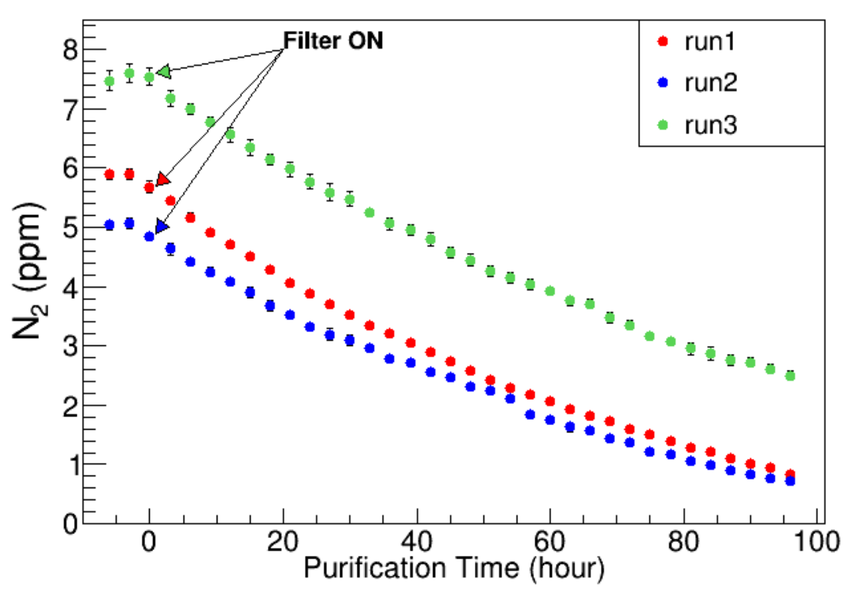

Figure 4: N_2 concentration as function of purification time.

Conclusions

An innovative method to remove N_2 from LAr, Li-FAU, was tested in ICEBERG at NLTF (Fermilab). The experiment shows that Li-FAU is able to reduce the concentration of N_2 injected multiple times into 2,625 L of LAr down to sub-ppm in cycles of 96 hours. The tests confirm the preliminary results obtained in PuLArC at IFGW/Unicamp.

Acknowledgments

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References

[1] Technical Note CRYOFRABR010/2023, *Innovative Proposal for N_2 Capturing in Liquid Argon Using the Li-FAU Molecular Sieve*;

[2] D. Cardoso *et al.*, *Innovative proposal for N_2 capturing in Liquid Argon using the Li-FAU molecular Sieve*, submitted to JINST;

[3] Technical Note CRYOFRABR003/2021, *Determination of nitrogen physisorption properties by zeolites for argon purification*.