

# Xenon from BNL and Xenon Procurement for PIONEER Test at PSI

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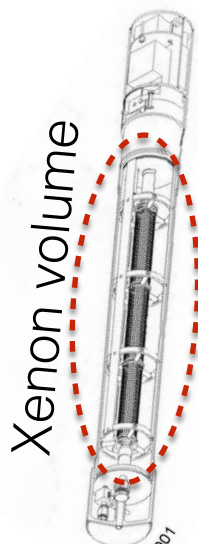
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# Overview

- PIONEER Test at PSI requires 110L of LXe
  - **BNL is going to provide ~20L**
  - KEK is going to provide ~20L
  - **The remaining 70L is expected to be purchased**
- BNL Xenon Inventory and Collection
  - Xenon Inventory
  - Xenon collection and transportation to PSI
- Xenon procurement
  - Global Xenon product and supply
  - Quotes from vendors

# Xe Inventory at BNL

- We conducted a survey via the BNL chemical management system among all Xe owners
- The Xenon is stored inside the 13x Xenon-1001 Gamma-Ray Detectors since 2007 in storage, estimated ~20 L in LXe
- The detector disassembly in progress to extract the Xenon
- We ran a broad purity analysis for all major impurities including, H<sub>2</sub>O, N<sub>2</sub>, O<sub>2</sub>, Ar, Kr, He, H<sub>2</sub>, CO, CO<sub>2</sub>, CH<sub>4</sub>, N<sub>2</sub>O, SF<sub>6</sub>
- Xenon purity is 99.89%, with 0.109% H<sub>2</sub> and 28 ppm of H<sub>2</sub>O, no other impurities
- Gas purity is well maintained after long-term storage and agrees with the specifications
- Constructing a collection system to transfer the Xenon into storage cylinders



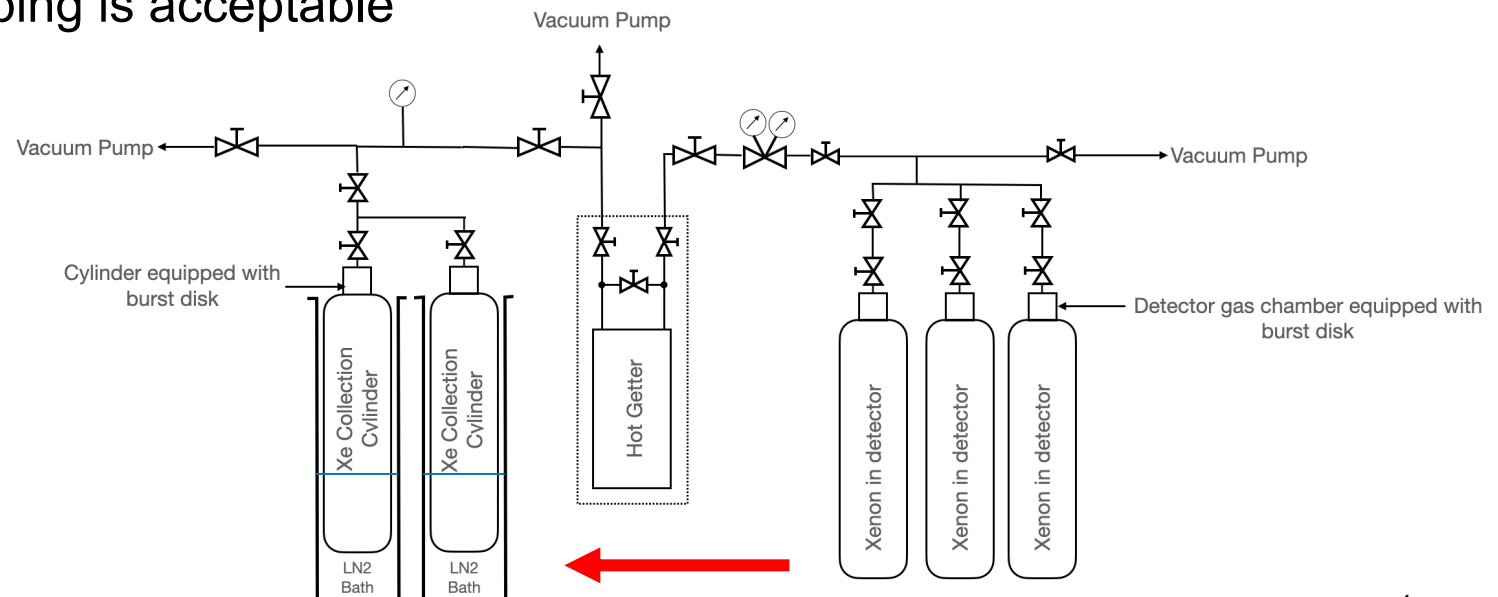
## Xenon Analysis Report

Test Description/Units	Result	DL	
Nitrogen (N <sub>2</sub> , ppm v/v by MS):	-----	nd	4
Oxygen (O <sub>2</sub> , ppm v/v by MS):	-----	nd	4
Argon (Ar, ppm v/v by MS):	-----	nd	4
Krypton (Kr, ppm v/v by MS):	-----	nd	4
Helium (He, ppm v/v by MS):	-----	nd	10
Hydrogen (H <sub>2</sub> , ppm v/v by MS):	-----	1090	10
Carbon Monoxide (CO, ppm v/v by IR):	-----	nd	0.5
Carbon Dioxide (CO <sub>2</sub> , ppm v/v by IR):	-----	nd	0.5
Methane (CH <sub>4</sub> , ppm v/v by IR):	-----	nd	0.5
Nitrous Oxide (N <sub>2</sub> O, ppm v/v by IR):	-----	nd	0.5
Sulfur Hexafluoride (SF <sub>6</sub> , ppm v/v by IR):	-----	nd	0.5
Water (H <sub>2</sub> O, ppm v/v by EH):	-----	28	1
<b>Xenon (Xe, % v/v by difference):</b>	-----	<b>99.89</b>	<b>na</b>



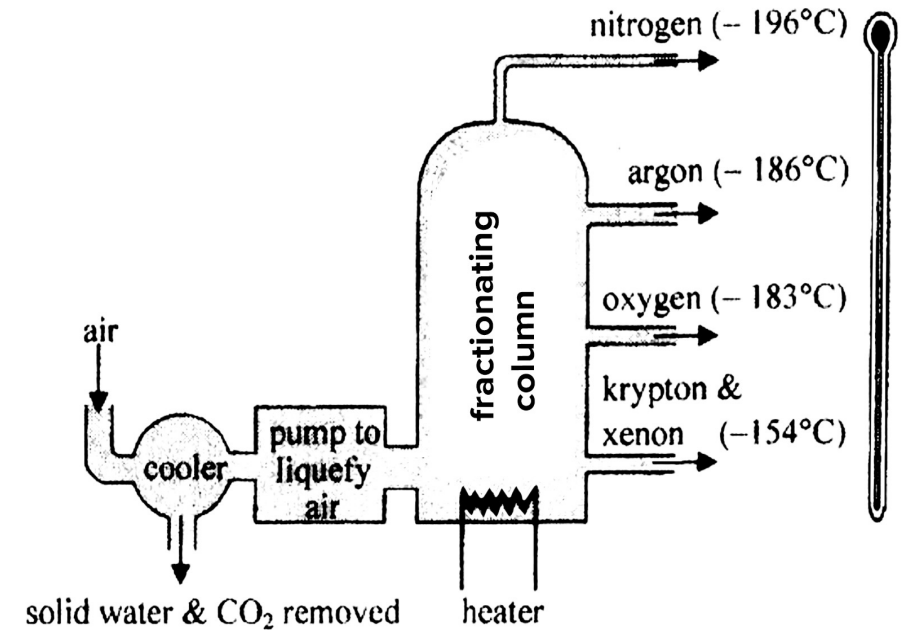
# Xe Collection and Transportation to PSI

- Xe collection with cryo-pumping.
  - Transfer driven by negative pressure produced by the LN2 bath condensing in the Xe collection cylinders
  - The Xe will be purified through a hot getter while filling into the gas cylinders
  - We had discussions with the BNL lab safety. The concept design of the Xenon collection system is approved
  - We are purchasing 88 ft<sup>3</sup> Aluminum gas cylinders Thunderbird LLC via, the same type of cylinders used by XENON experiment
- Xe transportation to PSI
  - We had discussions with PSI safety
  - The DOT stamp cylinders are acceptable at PSI
  - DOT regulation compliance shipping is acceptable



# Brief Introduction of Xenon production

- Xenon is produced commercially as a byproduct of the separation of air by fractional distillation
- Liquid O<sub>2</sub> contains small quantities of Kr and Xe. Xenon is extracted by further processing
- Ukraine produced ~30% of global UHP Xe, from raw Xe with a purity of ~60-70% from Russia. The supply chain is now gone and it caused a global price spike.
- Chinese suppliers expand the production
- We found suppliers in China with the help of our colleagues



# Quotes for 70 L (220kg) LXe

- Quote from CERN in June (20 kg each cylinder, 3.3m<sup>3</sup> at STP)
  - **\$2.7 per gram**, *high quality with certified content of SF<sub>6</sub> below 0.01 ppm*
- Xenon pricing from China (10 m<sup>3</sup> each cylinder, 4 pieces in total)
  - Xenon price is 10 times less than the same time last year and at a historically low level
  - Wuhan Iron and Steel Corporation can offer **\$1.8 per gram\***. They have supplied Xenon to SJTU, Columbia, and UCSD. They have sufficient Xenon in stock for shipping right now.
  - Fuhaicryo offered **\$1.62 per gram\***. They have also sold to the US previously. They have sufficient Xenon in stock for shipping right now.
  - Price slightly increased from the last time we reported to the collaboration (Wuhan \$1.62/g, Fuhaicryo \$1.38/g)
- Xenon pricing from domestic suppliers
  - Praxair/Linde (US) **\$12.35 per gram\*** 2023, **\$16.15 per gram\*** in 2024
  - Airgas/Air Liquide can't even provide a quote for Xenon due to being in Force Majeure with Xenon supply in the next 4-5 months, the previous informal quote was **\$18 per gram\***

\*Shipping and custom duties excluded. Estimated cost of shipping is in the order \$10k-20k

# Potential arrangement at BNL

- DUNE Far Detector II needs 178 kg Liquid Xenon for enhancing light collection efficiency
- BNL purchases Xenon for PIONEER and later sell it back to DUNE
  - in process of negotiating with DUNE
- Concerns from BNL
  - Under the provision of Buy American Act, BNL needs a waive to purchase Xenon from China. A difference of 25% in price can initialize a request for the wavier.
  - **Bidding process is required. Do Chinese companies want to register their information at BNL?**

# Summary

- BNL has located about 20 L Liquid Xenon
- We are in process of collecting the Xenon and transporting to PSI
- Cylinders and transportation plan approved by PSI
- The current best option is to order the remaining 70L LXe from CERN or China
- Purchase by BNL must go through a bidding process