# Fiscal Year 2025 One-Time Funding: Purchase of a new compressor/cryopump unit for the Denton electron-beam deposition system

**Proposal Team:** Wenyong Wang (PI), Jifa Tian, and Jinke Tang. Department of Physics and Astronomy

**Total Amount Requested:** $27,444

## Project Description

Our proposal team is currently working on advanced quantum devices based on two-dimensional (2D) materials and is building a world-class research capability at UW, which is closely aligned with the goals of the College's Tier 1 Engineering Initiative, especially the target of achieving world-class research and graduate education. 2D materials, such as graphene, transition metal dichalcogenides, and other van der Waals heterostructures, are at the forefront of quantum materials science and engineering. Research in this area can lead to breakthroughs in electronics, energy storage, sensors, and more. These quantum materials have applications across multiple disciplines, including physics, chemistry, electrical engineering, etc. This interdisciplinary nature will foster innovations across various fields, which aligns well with the goals of a Tier 1 engineering program. High-quality research in this cutting-edge field can attract top-tier graduate students, and the influx of talent is essential for building a robust research environment and achieving Tier 1 status. Such an educational effort will produce highly skilled graduates who are well-prepared for careers in academia, industry, and government, contributing to Wyoming's technological workforce. Our leading research in this field also facilitates collaborations with top universities and national labs, as we have already established collaborations with scholars at UT Austin, Purdue University, Lawrence Livermore National Laboratory, etc., which will enhance the university's reputation and research capabilities. Research in 2D quantum materials is highly competitive and is well-funded by federal agencies including NSF and DOE, and success in securing these grants can provide significant financial resources to support the mission of the Tier 1 Engineering Initiative. Our recent research results have been published in prestigious journals including Nature Communications and Nano Letters, and such high-impact publications and possible future patents can also enhance UW Engineering's academic reputation and ranking, which are key metrics for achieving a Tier 1 status.

Research on 2D materials requires state-of-the-art facilities and equipment, and the Denton electron-beam (e-beam) thin-film deposition system in our lab is one of such crucial instruments. Unlike conventional thermal evaporators that use a resistive heating source to heat the material until it evaporates, an e-beam deposition system uses a focused electron beam to directly heat and vaporize the material. The capability of a thermal evaporator is limited to the maximum temperature achievable by resistive heating and is only suitable for materials with low melting temperatures such as aluminum or gold. An e-beam evaporator, on the other hand, can achieve much higher deposition temperatures due to the concentrated energy of the focused electron beam and is critical for the deposition of high-melting-point materials such as titanium (3,034°F), tungsten (6,192°F), and many others. E-beam evaporators also have other advantages including

lower contamination risk since the material is heated directly and the crucible remains cooler, and can create high quality and more uniform thin films.

The Denton e-beam deposition system in our lab was purchased in 2010 using a DOE fund, and it has been used by our team members for precise thin-film depositions down to the 1 nm scale, a process essential for the fabrication of various device structures including quantum devices based on advanced 2D materials. The compressor/cryopump unit is a vital component of the e-beam system, as it creates a high vacuum down to $10^{-8}$ Torr for the evaporation chamber, which is necessary for high quality thin-film deposition. Unfortunately, after continuous usage for almost 14 years, the current compressor/cryopump unit for the Denton deposition system was completely broken last December and is beyond repair. The failure of the compressor/cryopump unit has brought all functions of the Denton deposition system to a standstill, and the inability to operate the equipment has halted device fabrications for multiple research projects. Without this critical component, we risk falling behind in our research projects, compromising our ability to compete for grants and collaborate with other institutions. Additionally, the educational mission of our department is being adversely affected, as students are unable to access the equipment necessary for their research experiments. Repairing the existing compressor/cryopump unit is not feasible due to its age and the lack of available parts, and a replacement is the only viable solution to restore functionality. To resume our research and educational activities, we are in critical need to purchase a replacement compressor/cryopump unit.

Therefore, for this 2025 One-Time Funding proposal call, we propose the purchase of a new compressor/cryopump unit that is compatible with our Denton e-beam system. This funding will not duplicate previous awards as it is to replace a completely broken unit of an instrument. It will not duplicate existing infrastructure in the College either because, to the best of our knowledge, our Denton system is the only electron-beam thin-film deposition system available at the University of Wyoming. The total cost of a new compressor/cryopump unit is $27,444. This amount is too small to meet the requirement for a Major Research Instrumentation (MRI) funding but is rather large for a typical NSF research grant. Most importantly, this replacement needs immediate funding that cannot be met through standard grant application channels, but it is well suited for this proposal call that requires the awarded fund to be spent by May 31, 2025.

In summary, the Denton e-beam deposition system is a crucial piece of equipment, enabling cutting-edge research and education in the fields of quantum materials and nanoengineering. Without a functional compressor/cryopump unit the system is inoperable. The proposed purchase is essential to restore the functionality of the Denton system and ensure the continuation of our research and educational activities. Given the critical role of this instrument, we believe this expenditure will yield significant long-term benefits for the College that can help accomplish the goals of the Tier 1 Engineering Initiative.

## Budget and justification

The cost of the replacement compressor/cryopump unit is $27,444, which includes

1. New Trillium M350 Helium Compressor: $11,565
2. New cryopump, Cryo-Plex 8, ISO 200, Diode: $11,121
3. Cable, drive, on-board compressor: $734
4. Helium line: $1,024
5. Shipping and Handling: $3,000

Total: $27,444

The original compressor/cryopump unit for the Denton e-beam deposition system was from Oxford Instrument, which was bought by Trillium years ago. The price quote provided by Trillium is attached to this proposal.

# SALES QUOTATION

**Corporate/Remittance Address**
Trillium US
13011 SE Jennifer St
Suite 204
Clackamas, OR 97015

**Shipping Address for This Quote**
Trillium US
1340 Airport Commerce Dr.
Bldg 1 Suite 175
Austin, TX 78741

**Quote Date:** 1/8/2025
**Expiration:** 4/8/2025
**Quote ID:** 130267 Rev C
**Terms:** Net 30 days
**Freight Terms:** ExWorks Trillium
**Lead Time:** 15 - 20 Weeks

**Customer Name/Address**
University of Wyoming
223 Physical Sciences Building
1000 E. University Ave., Dept. 3905
Laramie, WY 82071

**Ship to Address**
University of Wyoming
223 Physical Sciences Building
1000 E. University Ave., Dept. 3905
Laramie, WY 82071

**Customer Contact**
Jifa Tian
Tel:
Email: jtian@uwyo.edu

**Salesperson**
Trillium Inside Sales
Tel: (800) 453-1340 x 1
Email: inside.sales@trilliumus.com

**To Place Orders**
Email PO to: csr@trilliumus.com
Fax PO to: 512-443-6665
Site Phone: 1-800-453-1340
**Please Indicate Shipping Account on PO**

**New M350 Compressor and CP8 ISO Diode**

| Item | Product Description | PN | Price | Qty | Extended |
|---|---|---|---|---|---|
| 1 | **New Trillium M350 Helium Compressor**<br>• Water Cooled<br>• 208V 60Hz 3Ph Operation | 91-00350-000 | $11,565.00 | 1 | $11,565.00 |
| 2 | **NEW Cryo-Plex 8, ISO 200, Diode** | 10227 | $11,121.00 | 1 | $11,121.00 |
| 3 | **Shipping and Handling**<br>• Freight to zip 82071 | | $3,000.00 | 1 | $3,000.00 |
| 4 | **CABLE, DRIVE, ON-BOARD compressor to ASC/CTI standard pump, 10FT,** | 10355-10 | $734.00 | 1 | $734.00 |
| 5 | **HELIUM LINE, 0.5"ID, 10FT LNG, HL-10**<br>• Straight Ends - No 90 deg Elbow | 10418-10 | $512.00 | 2 | $1,024.00 |
| | **TOTAL** | | | | **$27,444.00** |

**WARRANTY**

New Helium Compressors are Provided with a 12 Month Warranty

Trillium Inside Sales via email
**Authorized Signature**

1/8/2025
**Date**

# SALES QUOTATION

## TRILLIUM US, INC. TERMS AND CONDITIONS

**1 SCOPE**

1.1 In these Conditions: **"Sale"** means the sale of Goods or Services by the Supplier to the Buyer.
**"Buyer"** means the party buying Goods or procuring Services.
**"Supplier"** shall mean Trillium US, Inc., a Nevada corporation;
**"Purchase Order"** means an order placed on Supplier by Buyer; **"Goods"** means equipment, equipment components, equipment service, spare parts, and other goods and materials the Supplier has agreed to sell to Buyer.
**"Services"** means any services supplied by Supplier to Buyer.

1.2 These Conditions apply to all contracts for Goods and Services. No modification to these Conditions shall be valid unless in writing and duly signed by a person authorized by Supplier.

1.3 Supplier and Buyer may agree to specific terms, the specific terms shall then apply to and prevail over all other conditions.

1.4 All Purchase Orders are subject to acceptance by Supplier.

1.5 Once accepted the Purchase Order and these Conditions shall constitute the contract **("Contract")** between Buyer and Supplier.

**2 PRICE QUOTATIONS**

2.1 Prices quoted for Goods and Services are valid for 30 days.

2.2 Availability of refurbished goods is subject to prior sale.

2.3 Prices quoted are exclusive of all taxes. All Taxes shall be paid by Buyer unless Buyer provides Supplier with an exemption certificate acceptable to the taxing authority.

**3 INSPECTION AND TESTING**

3.1 All Goods are inspected by Supplier before supply to Buyer and tested where appropriate.

3.2 An additional charge will be made for tests carried out at Buyer's request.

**4 SUPPLY**

4.1 All delivery dates given by Supplier are estimates only. Supplier will use reasonable efforts to supply Goods and Services within the estimated time requested and in any event within a reasonable period. Supplier will not be liable for any losses or expenses caused directly or indirectly by any delay or failure to deliver the Goods or Services.

4.2 The Buyer will be entitled to terminate the Contract if a delay exceeds 80 days.

4.3 Unless otherwise agreed in writing all shipments shall be made FCA (Incoterms 2000) Supplier's production and/or distribution facilities.

4.4 Buyer will provide Supplier with delivery instructions promptly on notification the Goods are ready for shipment. If instructions are not received within 10 days after notification, the Supplier will invoice the Buyer for the Goods and make arrangements for storage at the Buyers expense.

4.5 Buyer agrees to comply with all applicable laws including export certifications that may be required in connection with its purchase of Goods.

4.6 Goods will be supplied and paid for as available. Each shipment shall be considered an independent transaction. Supplier may suspend shipment of the balance of the Contract if Buyer fails to meet their obligations under the Contract.

4.7 All Goods and Services supplied will be deemed accepted unless Buyer promptly notifies Supplier in writing that is the Goods are not in compliance with the Contract. Any damaged Goods and packaging must be kept for inspection by Supplier.

4.8 Supplier may modify the specification of Goods without notice provided that the modification does not materially affect the performance, form or fit of the affected Goods or Service.

4.9 Installation and commissioning are not included in the purchase price for the Goods.

4.10 Buyer shall be responsible for shipment of any product requiring Services to Supplier. Supplier shall notify Buyer following discovery of any such product as unsuitable for the performance of Services.

**5 PAYMENT**

5.1 All payments are to be made in US Dollars.

5.2 Unless otherwise stated, full payment must be made to Supplier within 30 days of the date of invoice. Invoices will normally be issued on the date of delivery of the Goods or completion of the Services. Any invoice disputes must be raised by Buyer within 15 days from date of invoice, or the invoice shall be considered to be accepted by Buyer.

5.3 All Purchase Orders are subject to credit approval before shipment.

5.4 If any payment is overdue Supplier shall be entitled, without prejudice to any other right or remedy, to charge interest on any amount overdue at the rate of 10% per annum compounding daily.

**6 RETENTION OF TITLE**

6.1 Goods shall remain Supplier's property until Buyer has made full payment to Supplier. Buyer's goods the subject of Services by Supplier shall remain Buyer's property at all times.

6.2 If payment becomes overdue, Supplier may, where permitted by law, and after giving notice to Buyer, enter upon any premises in Buyer's control where Supplier reasonably believes Goods to be to recover Goods.

**7 INTELLECTUAL PROPERTY**

7.1 Supplier shall retain all rights and ownership of any know-how, technical information, drawings, specifications or ideas, developed or created by the Supplier. All such information shall be kept confidential by Buyer. Such information may not be used by Buyer for any purpose other than for the purpose of using any Goods supplied under the Contract without Supplier's prior written consent.

7.2 Supplier's trademarks and names and those of its associated companies shall not be used otherwise than as applied by Supplier to Goods, Services or associated documentation.

**8 WARRANTY**

8.1 Seller hereby undertakes to repair or replace at Seller's option any Equipment supplied to Buyer if a defect in materials or workmanship arises under conditions of normal and proper use and maintenance (fair wear and tear, and consumables excepted) provided that:

a) the Equipment was purchased and used for a purpose for

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## TRILLIUM US, INC. TERMS AND CONDITIONS

which it was suitable, was operated and maintained in accordance with the operating instructions, and was not used in a way which was unsuitable;
b) the claim is first notified promptly in writing to Seller;
c) unless otherwise agreed, or specified by Seller, in writing, the defect occurs within eighteen months from the date of shipment of the Equipment or within twelve months from the date of installation of the Equipment, whichever is earlier:
d) the Equipment has not been repaired or modified by anyone other than Seller or at Seller's direction;
e) in the case of Equipment or parts not of Seller's own manufacture, unless otherwise required by law, Seller's responsibility shall be limited to passing on to Buyer the benefit of any guarantee or warranty given to Seller by the manufacturer of such Equipment;
f) in the case of a replacement, Buyer returns, at its cost, the defective Equipment, which is being or has been replaced, to Seller within ten (10) days of delivery of the replacement Equipment by Seller.
g) The defect does not arise from Buyer's specification or instructions
h) Buyer has paid the purchase price for the Equipment in full.
8.2 Any repaired or replaced Equipment will continue to be warranted for the unexpired period of the warranty.
8.4 Failing satisfactory repair or replacement, Seller may satisfy Seller's liability by reducing the purchase price or refunding the purchase price and retaking the Equipment.
8.5 EXCEPT AS EXPRESSLY WARRANTED ABOVE, ALL WARRANTIES, CONDITIONS AND OTHER TERMS WHICH MAY HAVE BEEN IMPLIED ARE EXCLUDED.

**9 LIABILITY AND INDEMNIFICATION**

9.1 THE FOLLOWING PROVISIONS SET OUT THE ENTIRE LIABILITY OF SELLER (INCLUDING ANY LIABILITY FOR THE ACTS OR OMISSIONS OF ITS EMPLOYEES, AGENTS, OR SUBCONTRACTORS) TO BUYER IN RESPECT OF:
(A) ANY BREACH OF THESE CONDITIONS; OR
(B) ANY REPRESENTATION, STATEMENT OR TORTIOUS ACT OF OMISSION INCLUDING NEGLIGENCE ARISING UNDER OR IN CONNECTION WITH THESE CONDITIONS.
9.2 NOTHING IN THESE SALE CONDITIONS EXCLUDES OR LIMITS THE LIABILITY OF SELLER FOR DEATH OR PERSONAL INJURY CAUSED BY SELLER'S NEGLIGENCE OR FRAUDULENT MISREPRESENTATION
9.3 PHYSICAL DAMAGE TO PROPERTY TO THE EXTENT THAT IT RESULTS FROM BREACH OF CONTRACT OR SELLER'S NEGLIGENCE IN CONNECTION WITH THE PERFORMANCE OF THE CONTRACT, SUBJECT TO AN OVERALL LIMIT OF THE AMOUNT RECEIVED BY SELLER FROM BUYER UNDER THE CONTRACT.
9.4 IN NO CIRCUMSTANCES SHALL THE SELLER HAVE ANY RESPOSIBILITY FOR CONSEQENTIAL DAMAGES

**10 FORCE MAJEURE**

10.1 Neither Buyer nor Supplier shall be liable for failures in performance resulting from acts or events beyond its reasonable control.

**11 CANCELLATION**

11.1 No Contract may be cancelled or altered by Buyer except with Supplier's written agreement and upon terms and conditions acceptable to Supplier.
11.2 Buyer shall be liable for all costs of work done and materials purchased or provided up to the time of cancellation.

**12 TERMINATION**

12.1 If Buyer commits any act of bankruptcy then all sums due to Supplier under the Contract shall immediately become due and payable and Supplier may terminate the Contract forthwith by written notice.
12.2 Supplier may terminate the Contract with immediate effect in the event of a failure by Buyer to comply with any material provision of these Conditions if the failure continues for more than 14 days after Buyer has been given written notice.
12.3 Termination shall be without prejudice to any prior right of either party.

**13 MISCELLANEOUS**

13.1 Buyer may neither assign nor transfer any or all of its rights under the Contract without the prior written consent of Supplier.
13.2 All drawings, descriptive matter, technical specifications, capacities, performance rates, descriptions and other particulars given in respect of Goods (whether in catalogues or advertisements or accompanying or referred to in the Contract) are
stated by Supplier in good faith based on Supplier's experience as being correct within acceptable tolerances but are not binding in detail and do not form part of the Contract unless specifically stated to do so. Unless agreed otherwise in writing, it is Buyer's responsibility to ensure that Goods are sufficient and suitable for Buyer's purposes.
13.3 Buyer hereby acknowledges that relevant safety and training literature relating to the Goods and Services will be supplied by Supplier to Buyer free of charge.
13.7 All environments at Buyer's premises and all Goods returned to Supplier must be free from risks to health and safety (save to the extent notified to Supplier in writing and specifically accepted by Supplier).

**14 GOVERNING LAW AND DISPUTE RESOLUTION**

14.1 The Contract shall be governed by and construed in accordance with the laws of the State of Nevada.
14.2 Buyer and Supplier agree that the courts of the State of Nevada shall have the exclusive jurisdiction to settle any disputes, which may arise in connection with the Contract.
14.3 Supplier shall have the option to bring suit before the Courts of the domicile of Buyer when the claim is for or related to payments due from Buyer.

**15 CONFIDENTIALITY**

15.1 This quotation is the property of Trillium US Inc and contains confidential information.
15.2 The contents of this proposal, including but not limited to pricing and structure, shall not be disclosed outside the customer or disclosed in whole or in part for any purpose other than to evaluate the quotation.
15.3 Upon award, the terms of the award will remain confidential.