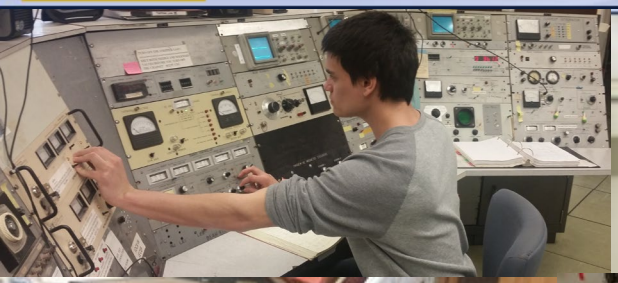
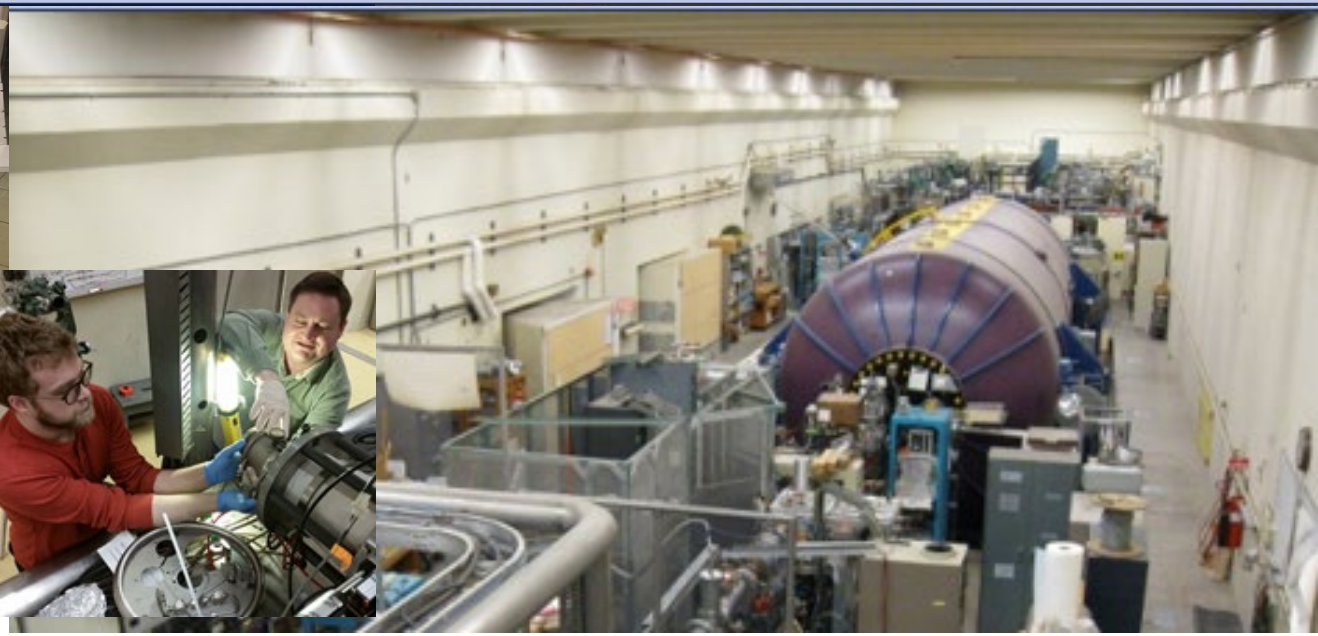
Center for Experimental Nuclear Physics and Astrophysics (CENPA)
University of Washington


Van de Graaff at UW - CENPA

A. Garcia
University of Washington
Center for Nuclear Physics and Astrophysics

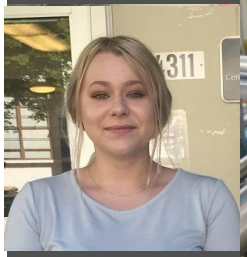
U.S. DEPARTMENT OF ENERGY | Office of Science

FN Tandem Van de Graaff

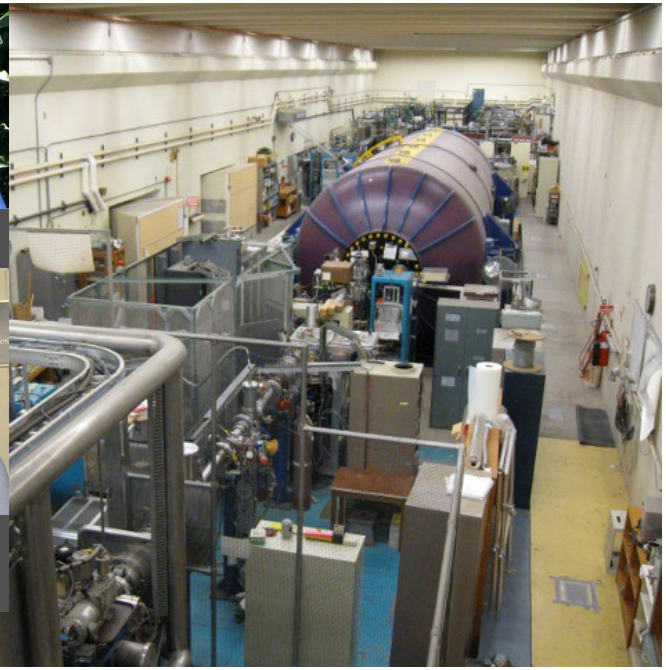
- Eric Smith, resrch engineer
- Brittney Dodson, resrch engineer

Engineers work on Tandem on as-needed basis.

Eric Smith

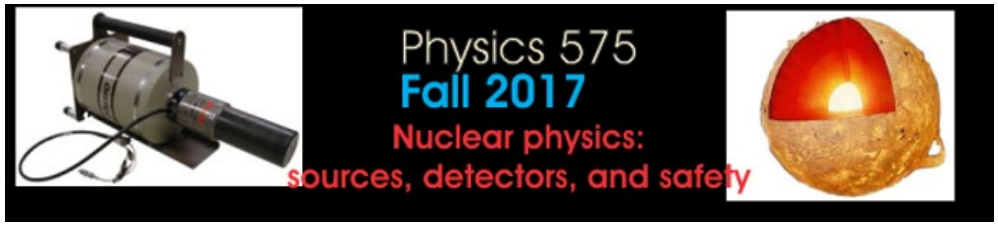


Brittney Dodson

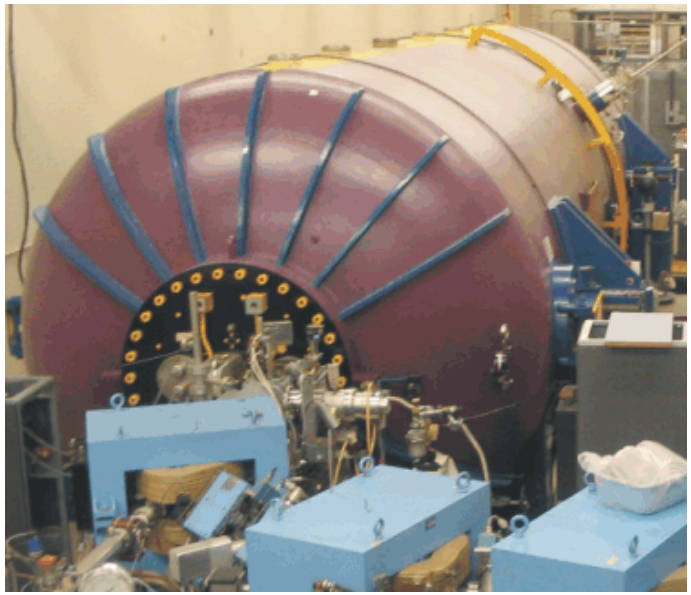


- Recent research:
  ^{6}He + ^{19}Ne production for 6He-CRES
  ^{21}Ne(p,γ) with South Africa group
- Detector studies: ^{40}Ar(^{7}Li,αp)^{42}Ar for **LEGEND and** protons for **PIONEER**
- Accelerator operator training for students

- Physics 575 graduate-level course

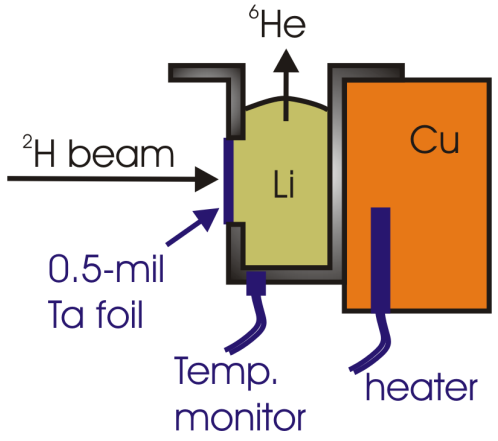


Accelerator/Ion Source Capabilities

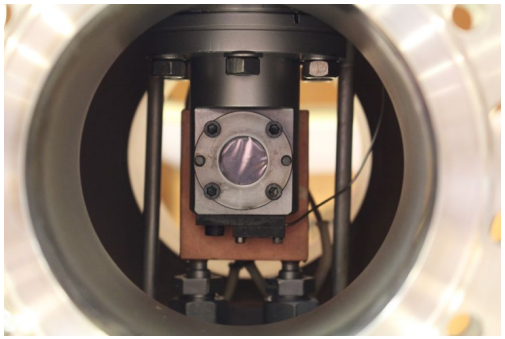


- **High current:**
  - 60 μA protons (100 – 1000 keV)
  - 25 μA ^{3}He (100 – 7000 keV)
  - 20 μA ^{4}He (100 – 7000 keV)
- **High current at high voltage:**
  - 15 μA of deuterium at 18 MeV (into Li target)
  - Allows high-intensity ^{6}He production (> 10^{10}/s)
  - Can deliver **pulsed ion beams** of 30 ns to 250 ns width at maximum rate of 4 MHz
- Implantation of positive and negative beams for special targets
  - ^{3}He, ^{4}He
  - ^{20}Ne, ^{21}Ne
  - ^{23}Na
  - ^{24}Mg
  - ^{28}Si
  - ^{32}S
  - ^{36}Ar
  - ^{113}In

Research with the accelerator: ^{6}He source for 6He-CRES

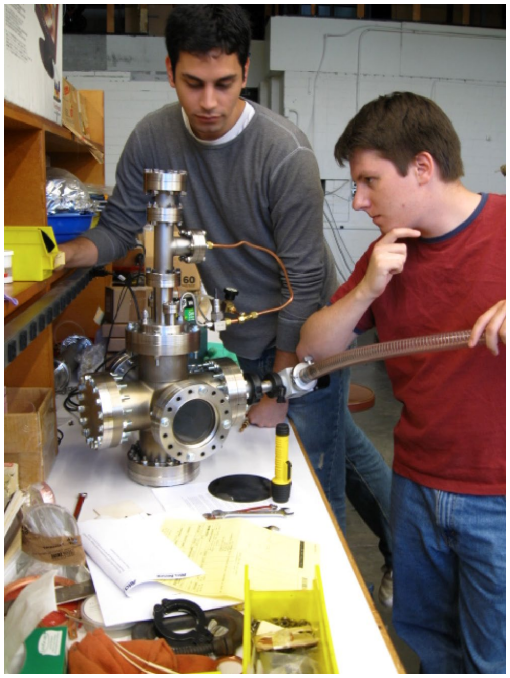


Molten Li target → ^{7}Li(^{2}H, ^{3}He)^{6}He



10^{10} ^{6}He/s to clean lab.

Knecht et al.
NIM A 660, 43 (2011)



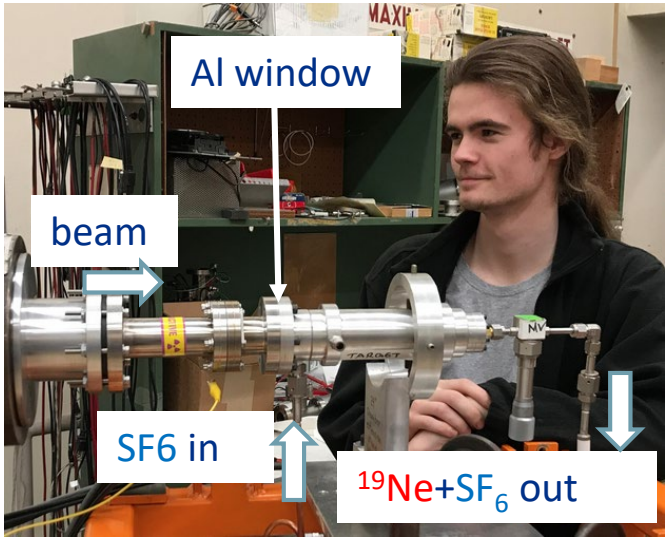
Compare intensities for "precision beta decay studies" to neutron sources

UCN: 10^3 UCN/cc → ≈ 1 (decay/s)/cc
CN: 10^{10} CN/s cm2 → 2×10^5 CN/cc ≈200 (decay/s)/cc
^{6}He: ≈ 2×10^6 (decay/s)/cc

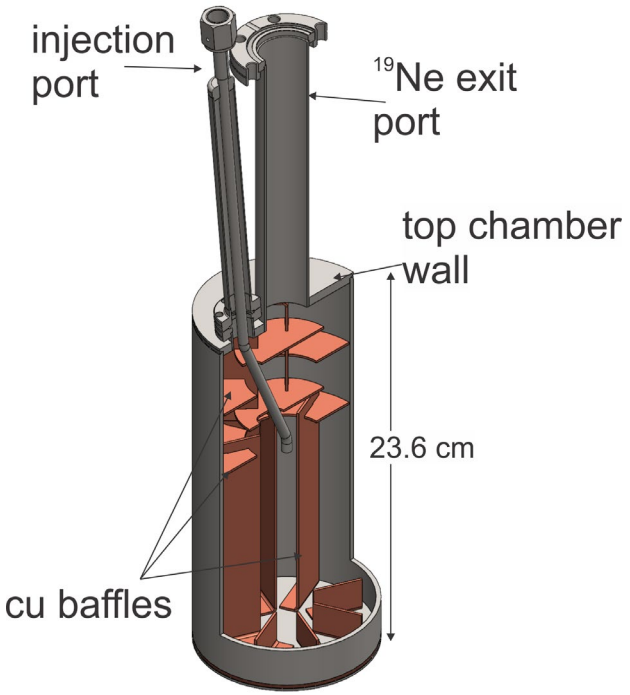
Relevant for using CRES technique in an RF guide.

Research with the accelerator: ^{19}Ne source for 6He-CRES

SF_6 target → $^{19}F(p,n)^{19}Ne$
Similar to Princeton/LBL source developed by Commins/Calaprice

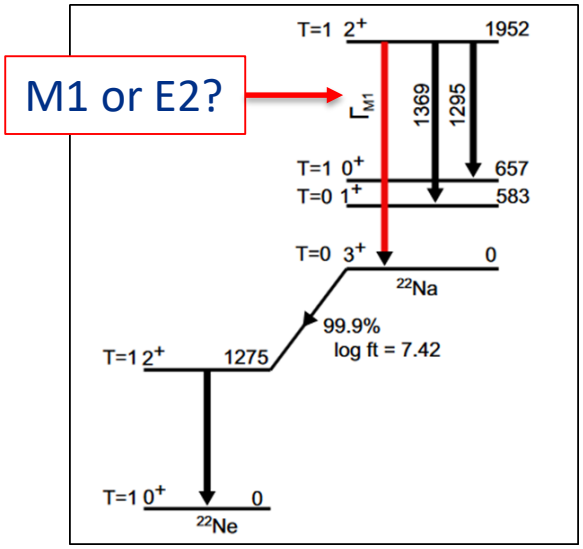


Undergrad Noah Hoppis at SF_6 target



^{19}Ne production at CENPA now stable and sufficient for 6He-CRES needs.
$\sim 5\times10^9$ ^{19}Ne/s to clean lab.

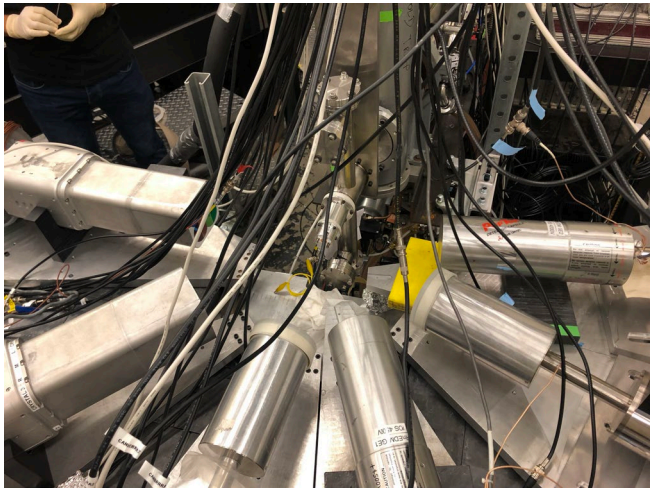
Research with the accelerator: ^{21}Ne(p,γ)



Led by Triambak et al. from South Africa – TRIUMF/Gluelph.

Data under analysis by PhD student Bhivek Singh (South Africa)

Angular distrib. of gammas: Borrowed detectors from Gammasphere & TRIUMF



Research with accelerator: recent publications

Charge-state distribution of Li ions from the decay of laser-trapped ^{6}He atoms
R. Hong et al.
Phys. Rev. A **96**, 053411 (2017)

Isospin mixing and the cubic isobaric multiplet mass equation in the lowest T = 2, A = 32 quintet Editors' Suggestion Letter
Kamil et al. (Triambak et al., South Africa + TRIUMF/Guelph group)
Phys. Rev. C **104**, L061303 (2021)

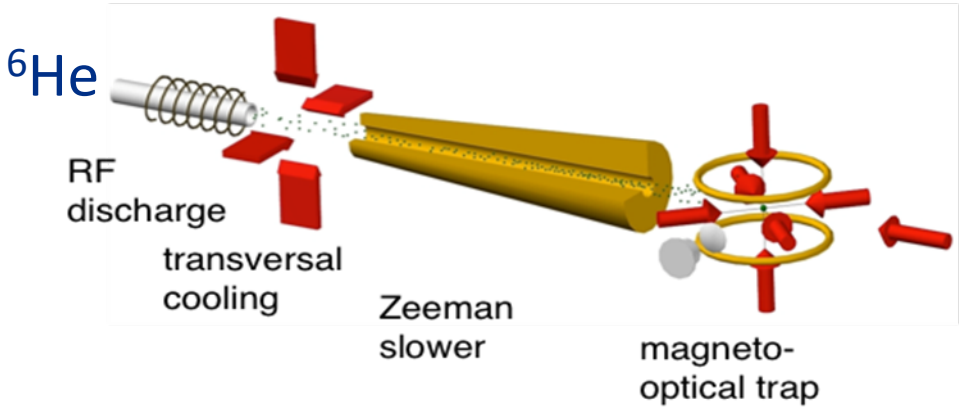
β-*nuclear-recoil correlation from ^{6}He decay in a laser trap*
P. Müller et al.
Phys. Rev. Lett. **129,** 182502 (2022)

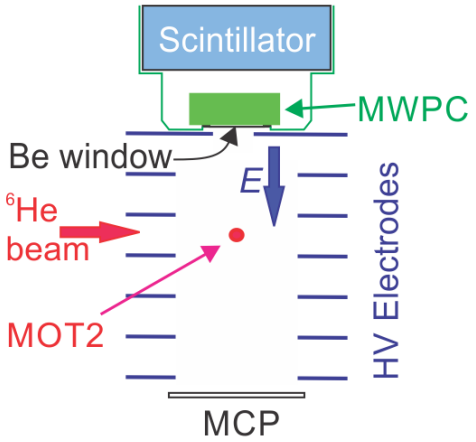
First observation of cyclotron radiation from MeV-scale $e^{\pm}$ following nuclear beta decay
W. Byron et al.
https://arxiv.org/abs/2209.02870
Submitted to Phys. Rev. Lett.

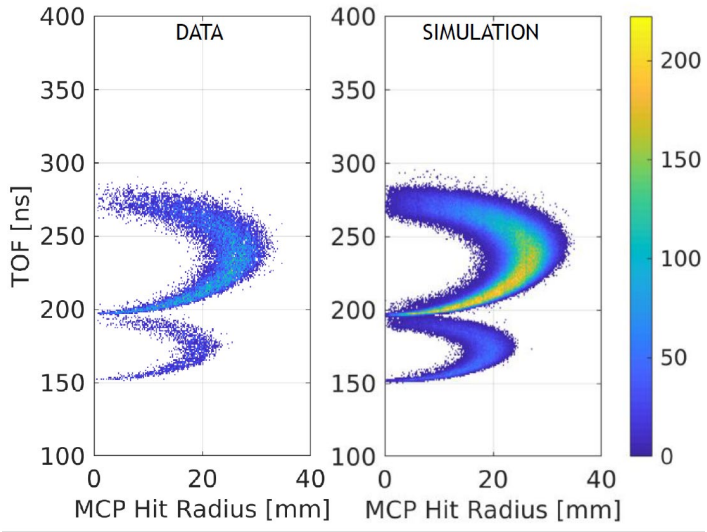
PHYSICAL REVIEW LETTERS 129, 182502 (2022)

β-Nuclear-Recoil Correlation from ^{6}He Decay in a Laser Trap

P. Müller,[1] Y. Bagdasarova,[2] R. Hong,[2] A. Leredde,[1] K. G. Bailey,[1] X. Fléchard,[3] A. García,[2] B. Graner,[2] A. Knecht,[2,4] O. Naviliat-Cuncic,[3,5] T. P. O'Connor,[1] M. G. Sternberg,[2] D. W. Storm,[2] H. E. Swanson,[2] F. Wauters,[2,6] and D. W. Zumwalt[2]







Distribution vs TOF → extract correlation

$$\hat{a} = -0.3268(46)_{\text{stat}}(41)_{\text{syst}}$$

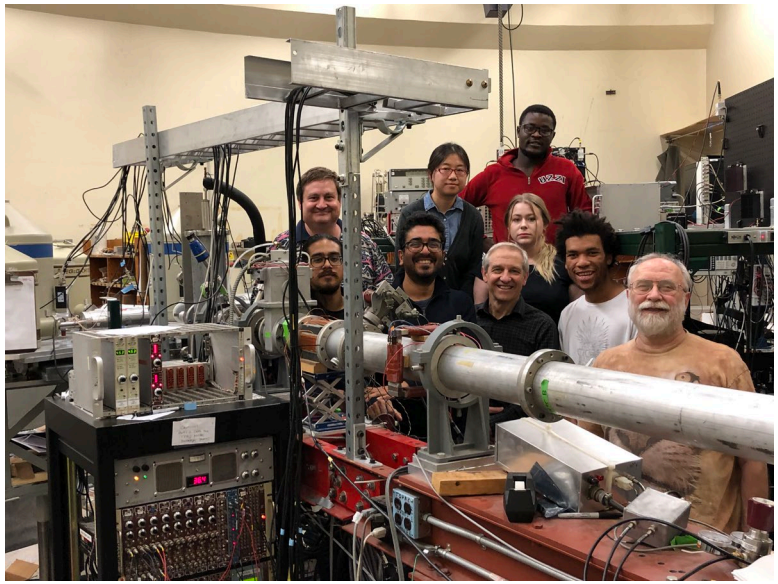
Beam use

Year (March to March)	Tandem running days
2019	80
2020	14
2021	20
2022	25[a]

[a] ends 03/30/2023

Accelerator runs when needed.
Examples:

- 2019: 70 days of continuous running (with ~1 day of interruption every week) for ^{21}Ne(p,γ).
- 2022: 1 week ^{6}He production
  1 week ^{19}Ne production

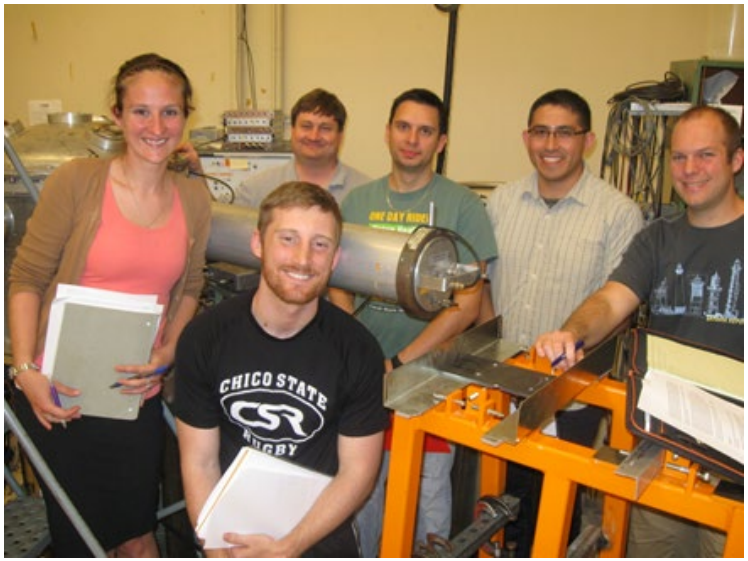


A class on nuclear physics using the accelerator

A class on nuclear physics using the accelerator

Audience/Grade Level: medical or bioscience systems technicians or engineers, medical paraprofessionals.

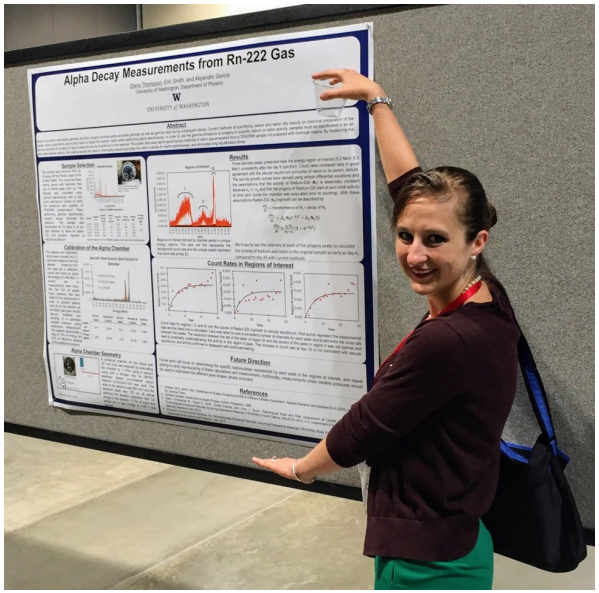
Students get practical training in experimental physics and learn about nuclear science.



Lab experience: students tune beam through the accelerator, learn high-vacuum techniques, electronics, accelerator physics.

A class on nuclear physics using the accelerator

Recent students, eventual positions



Diana Thompson, MS, CHP, RRPT
Present position:
Health Physicist/Licensing Consultant
Sulas Radiation Safety Consultants, LLC
Chicago, IL

Atnativos Zeleke, RHP/MDE
Present position:
Health Physicist,
Maryland Regulatory Body

He6-CRES – Major Equipment

Ensure accelerator system operation protecting against major debilitating failure:
Complete CSX & satellites (HE, LE, DECK, Radiation) computer controls upgrade to replace VAX, 286/DOS, 8186, and Q-BUS :

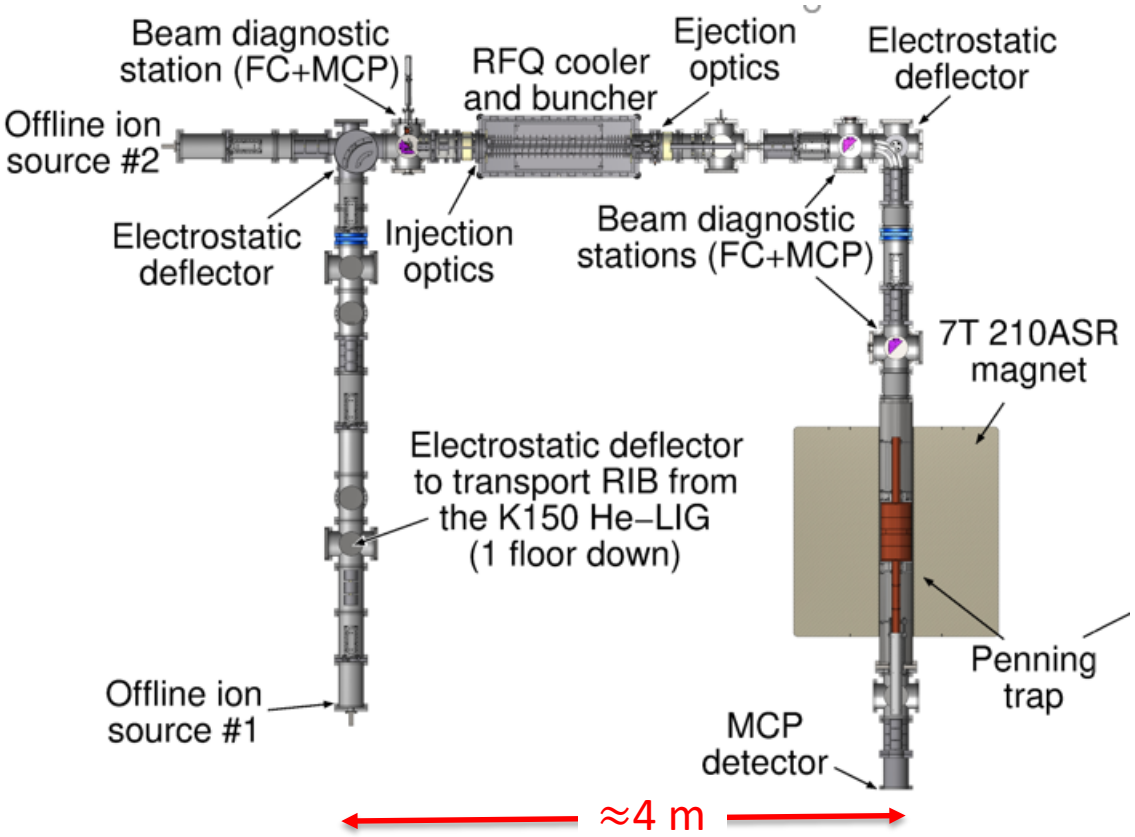
- current PC's, touchscreens, knob box encoders
- LabVIEW programming
- new DAQ devices
- new wire scanners signal display and capture capabilities

He6-CRES – Major Equipment

- ECR Ion source (Argonne National Lab)
- Ion trap (Texas A&M)

Needed for Phase-III of He6-CRES, with radioactivity trapped, so no betas reach the guide surface.

Ion-trap setup at Texas A&M (Melconian)
A similar system would be installed at CENPA



Conclusion UW Van de Graaff

- Ideal tool for our needs for carrying out the local research program
- Engineers work on tandem on as-needed basis.

- Excellent hands-on training environment for undergrad and grad students

Tandem accelerator a big plus with modest expense.