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Revolutionizing Nuclear Engineering Education: Developing Virtual Labs for Neutron Detection, Geiger Counter, and Reactor Experiments

Mr. Jonah Lau

Purdue University, USA

31 January 2024

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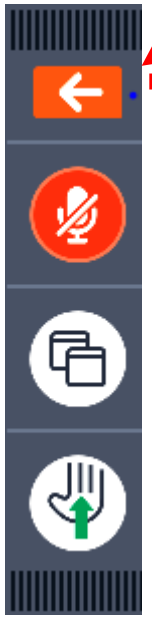

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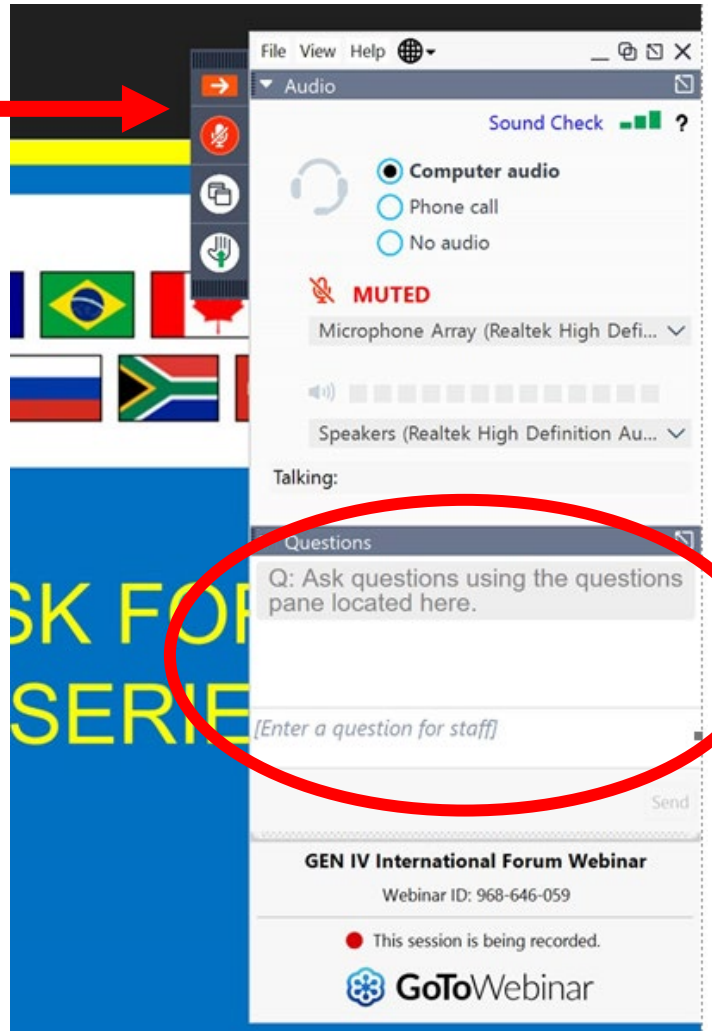

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PURDUE UNIVERSITY

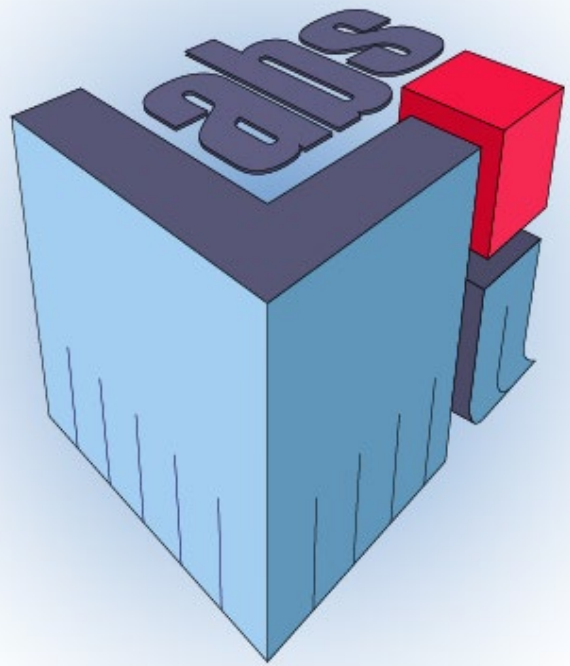
Meet the Presenter

Mr. Jonah Lau, is an undergraduate Nuclear Engineering researcher and student at Purdue University with hopes of starting his own company.

In the past, Jonah has worked at a UAS startup called Avetics, in their R&D department, developing drone applications contracted by companies such as Shell O&G, Petronas, etc.

His current aim is to deliver Nuclear Engineering places where it is needed the most. He likes to read on game theory, metaphysics, and SSRNs

Email: au61@purdue.edu

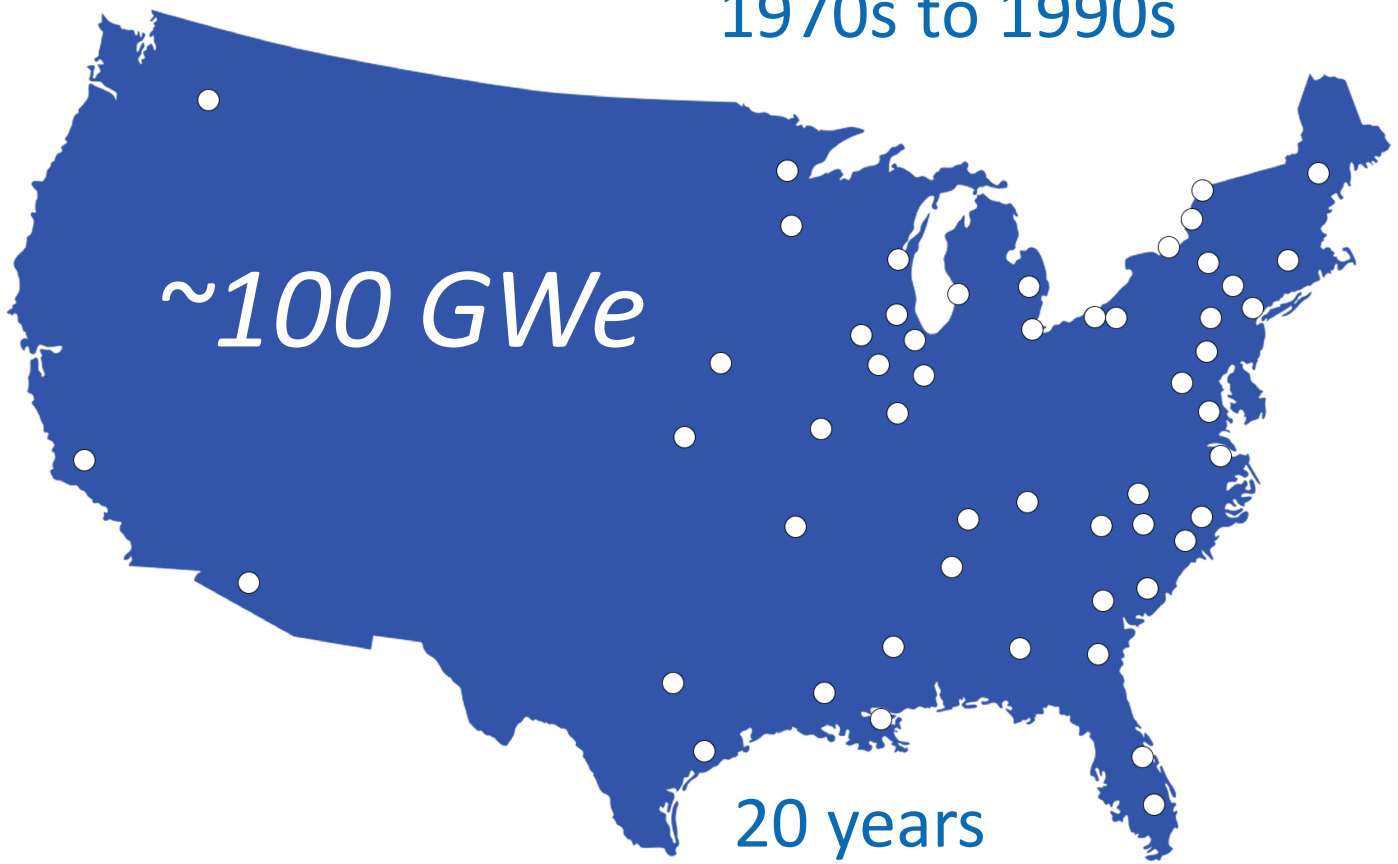

abs

State of Nuclear

COP 28 [1]

State of Nuclear

[2]



State of Nuclear

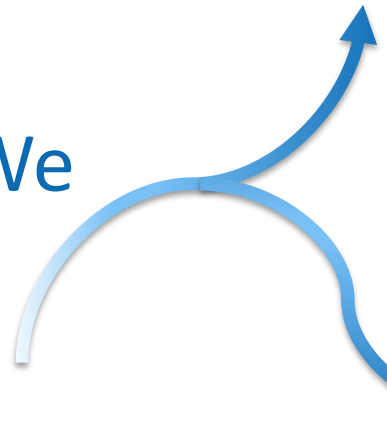
By 2050: ~ 300 GWe

+ 200 GWe ~ 10 Gw/ year

Current: ~ 100 GWe [2]

State of Nuclear

By 2050: ~ 300 GWe



+300 GWe

~ 15 Gw/ year

Current: ~ 100 GWe

- 100 Gwe (decommission)

[2]

State of Nuclear

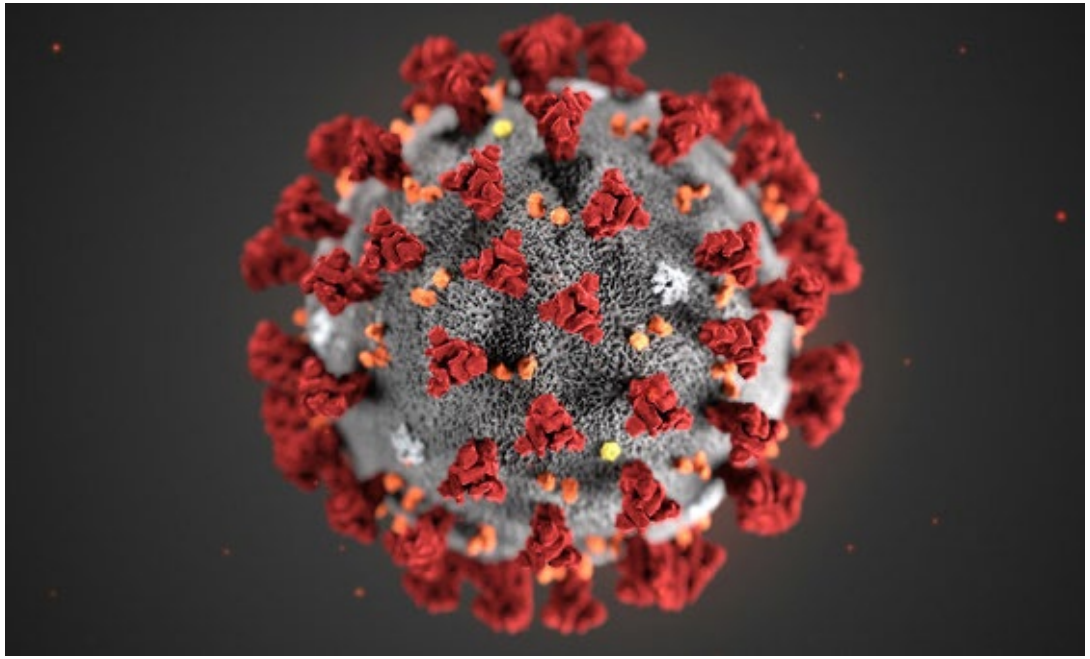
13 GWe per year

Current Nuclear fleet workforce: 100,000

By 2050, 100,000 in operations alone needed

"How are we going to train the amount of new nuclear plant operators in the size of the current nuclear fleet workforce?"

Challenges & opportunities



COVID-19 Pandemic

Dr. Stylianos Chatzidakis

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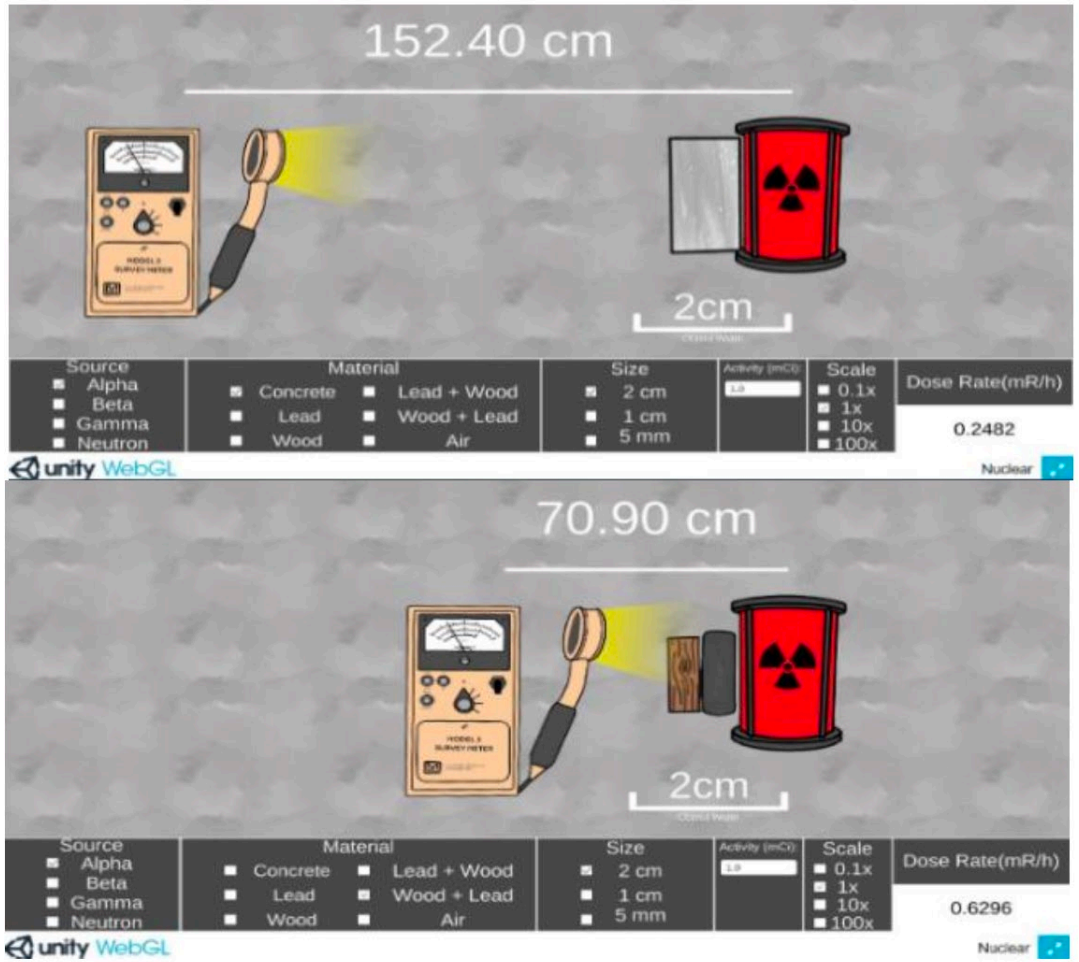
Challenges & Opportunities

- $D_r(r) = 5.15 \times 10^3 \frac{CE}{r^2}$
- $I(\mathrm{x}) = I_0 \exp(-\mu x)$
- Dose Rate, Inverse Square Law, Mass Attenuation, Gamma Sources: Cs-137, Na-22, Co-60

Challenges & Opportunities



Virtual Geiger Counter Lab (First Build)

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A few key questions

- Why is there a need for this tool?
  - How does it fit within normal and abnormal curricula?
- What needs to be expanded on this tool?
  - How do we develop this to cater the broader community?
- Does this tool align with long-term goals and interests?

A Novel Idea

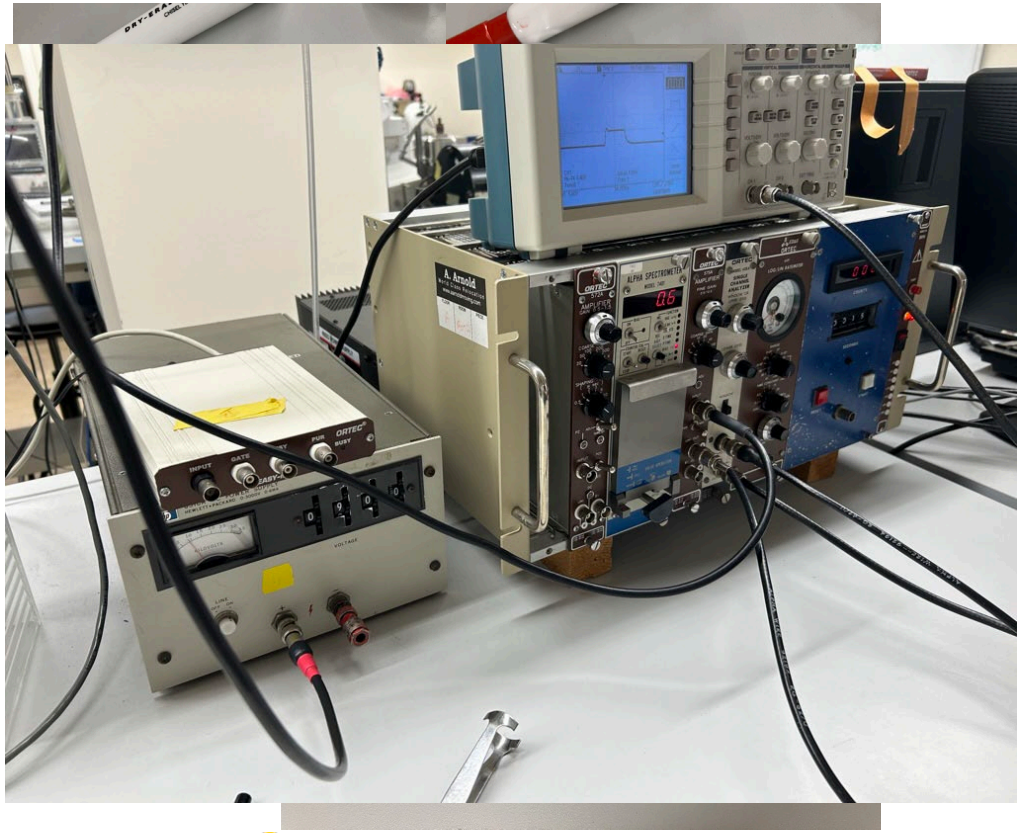
Geiger Counter & Attenuation Lab

Neutron Detection Lab

Reactor Lab

A Novel Idea

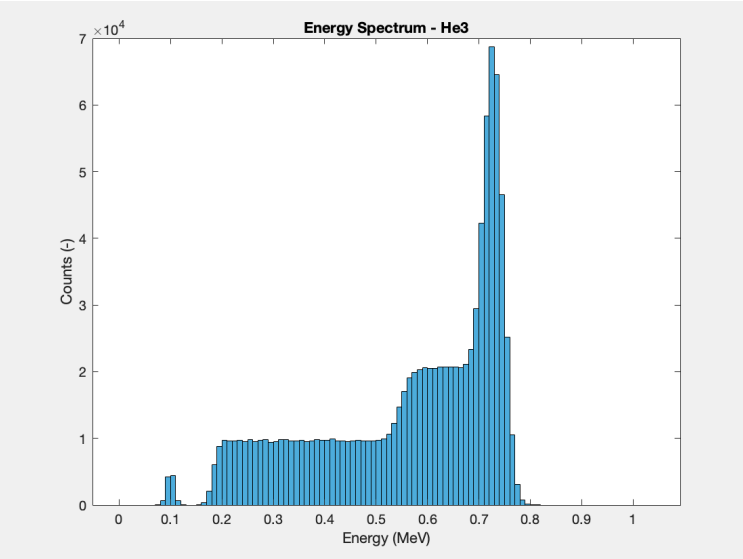
Neutron Detection Lab

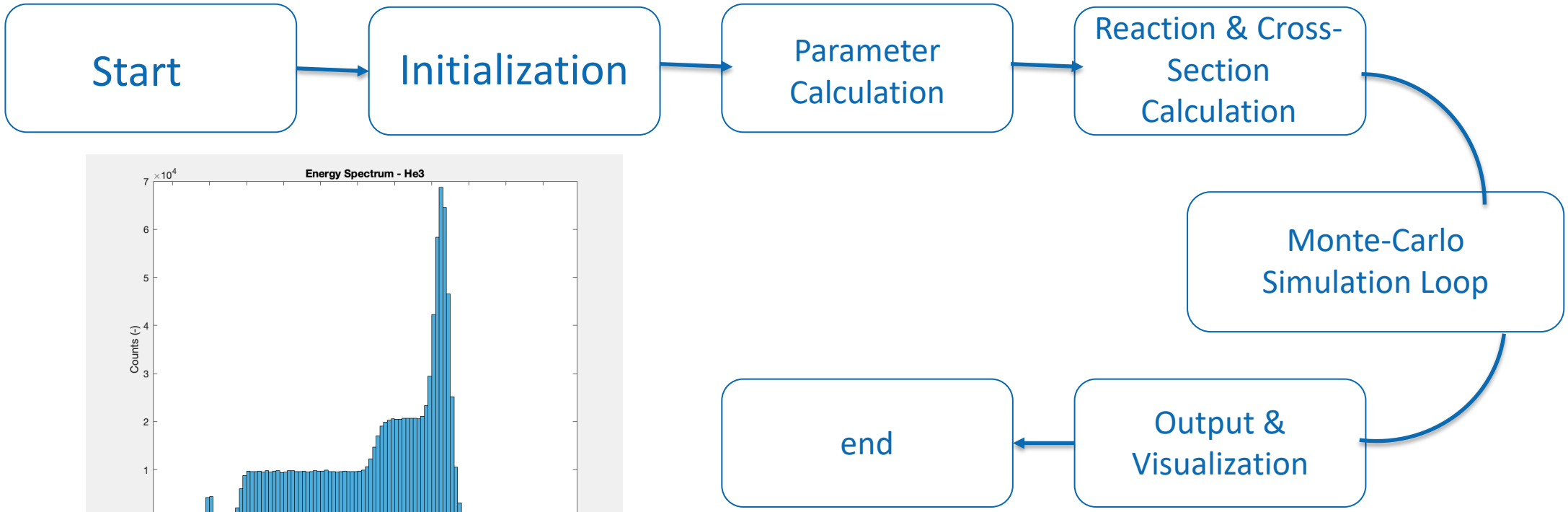


- $E_f = \dfrac{E_i}{1 + (\dfrac{E_i}{m_e c^2})(1 - cos\theta_\gamma)}$
- Variable Sized Gas-filled proportional counters: He-3, BF3, & effects on the spectrum
- Nuclear Electronics operating fundamentals: Preamp, Amp, Oscilloscope, MCA, HVS

A Novel Idea

Neutron Detection Lab





A Novel Idea

PUR-1 Reactor Lab

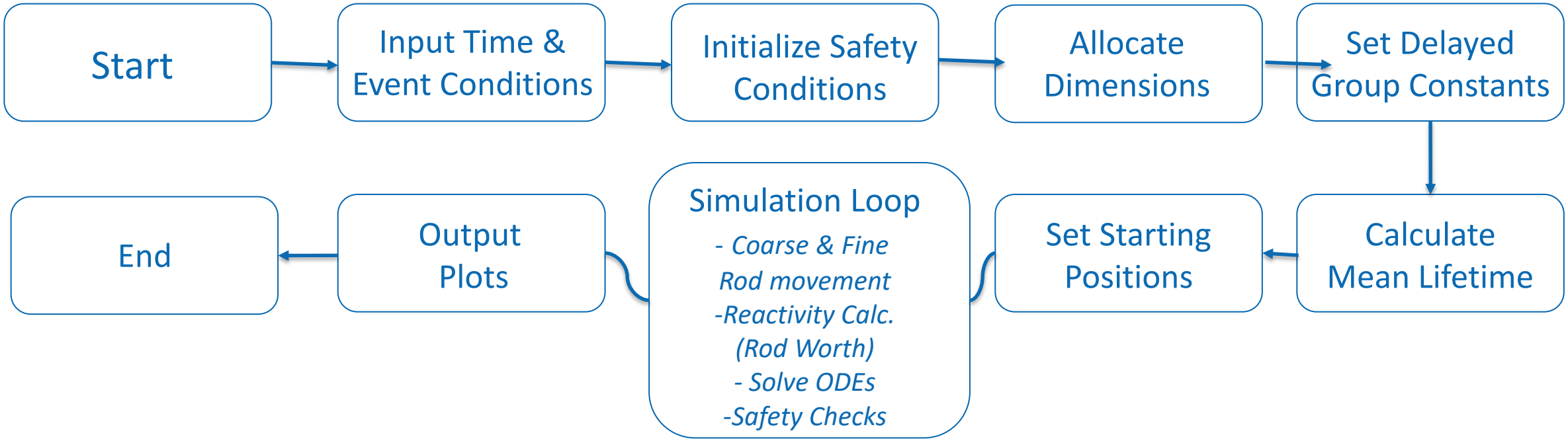
- $\frac{d}{dt}n(t) = \frac{k-1}{l_d}n(t)$

$$n(t) = n_0 \exp\left(\frac{k-1}{l_d}\right)$$

- Reactor Operations
- Data Trends: Subcritical Multiplication, Critical, Supercritical

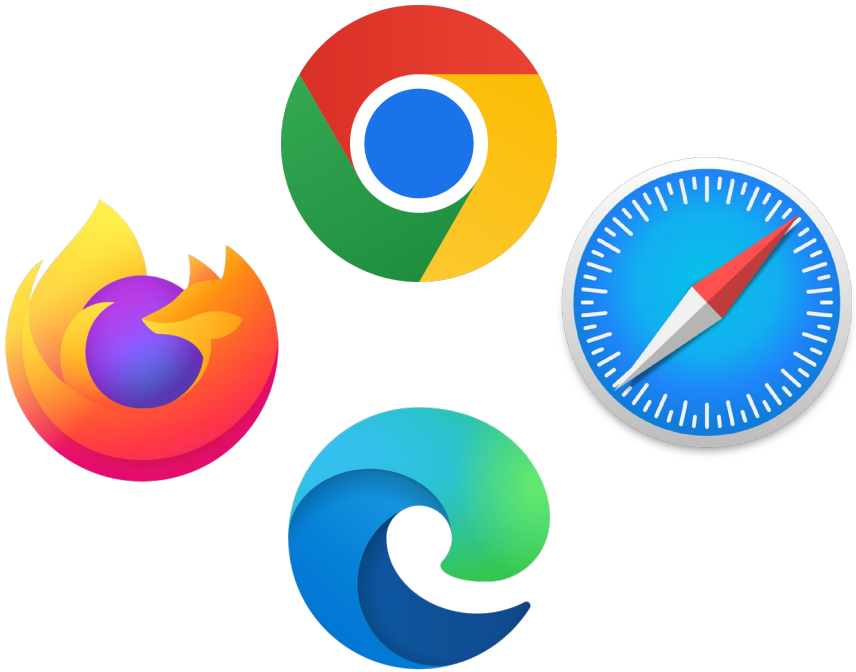
A Novel Idea

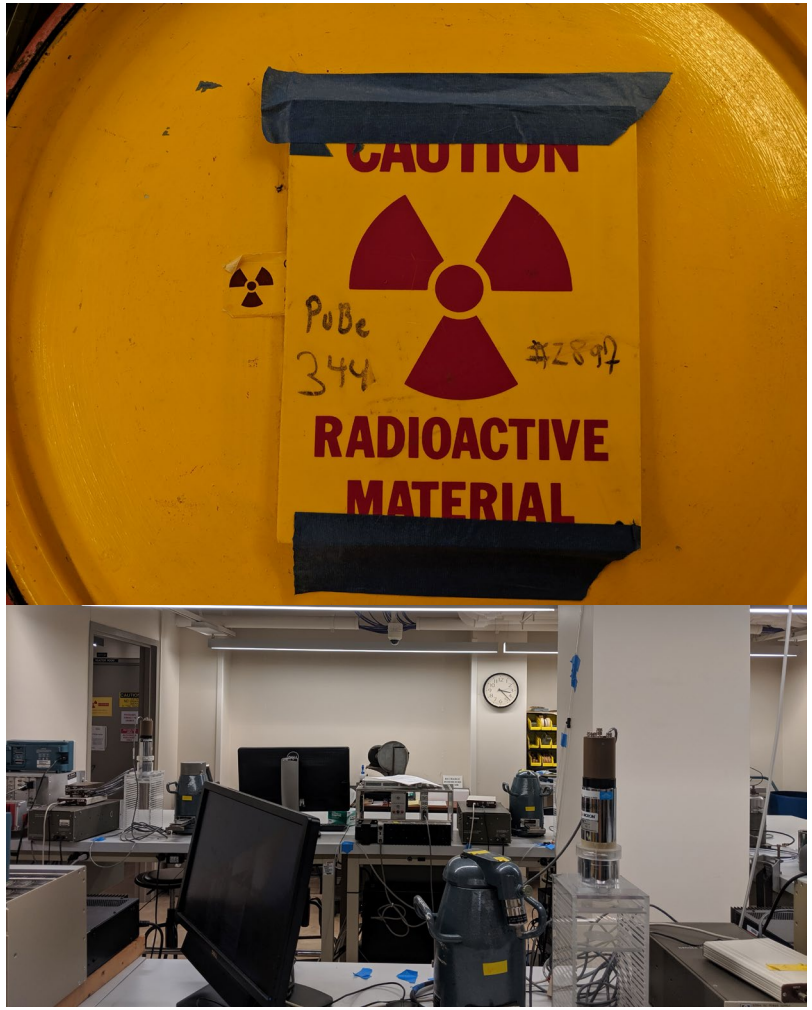
PUR-1 Reactor Lab



A Novel Idea

A Novel Idea

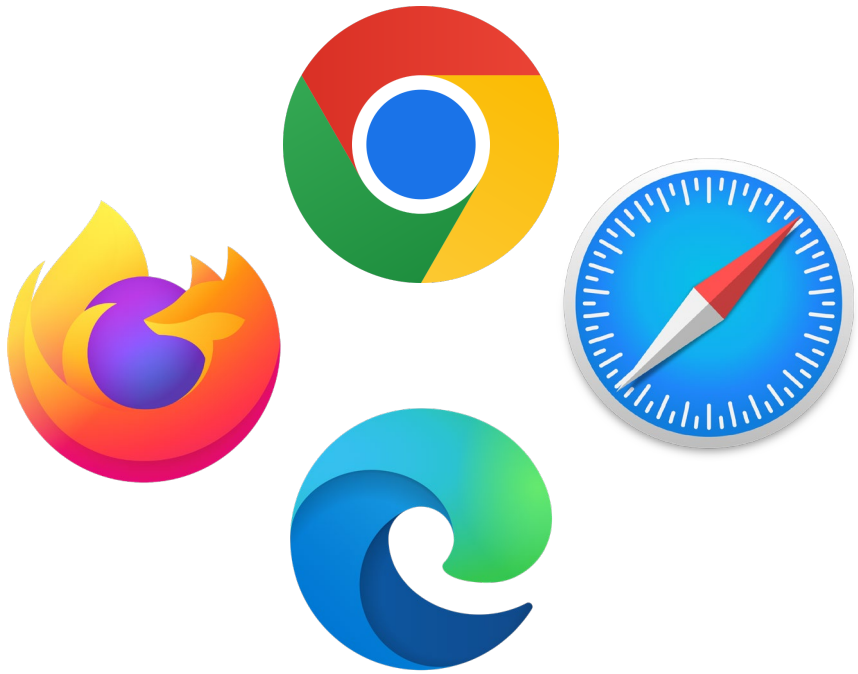


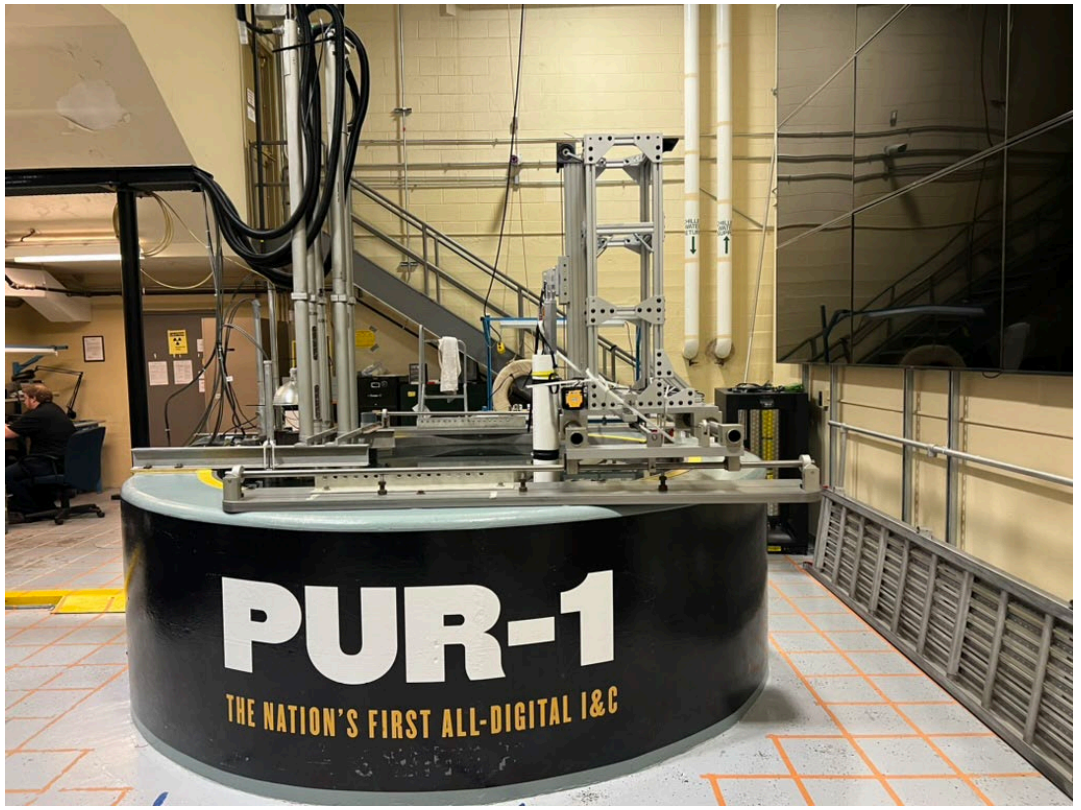


Virtual Neutron Detector Lab

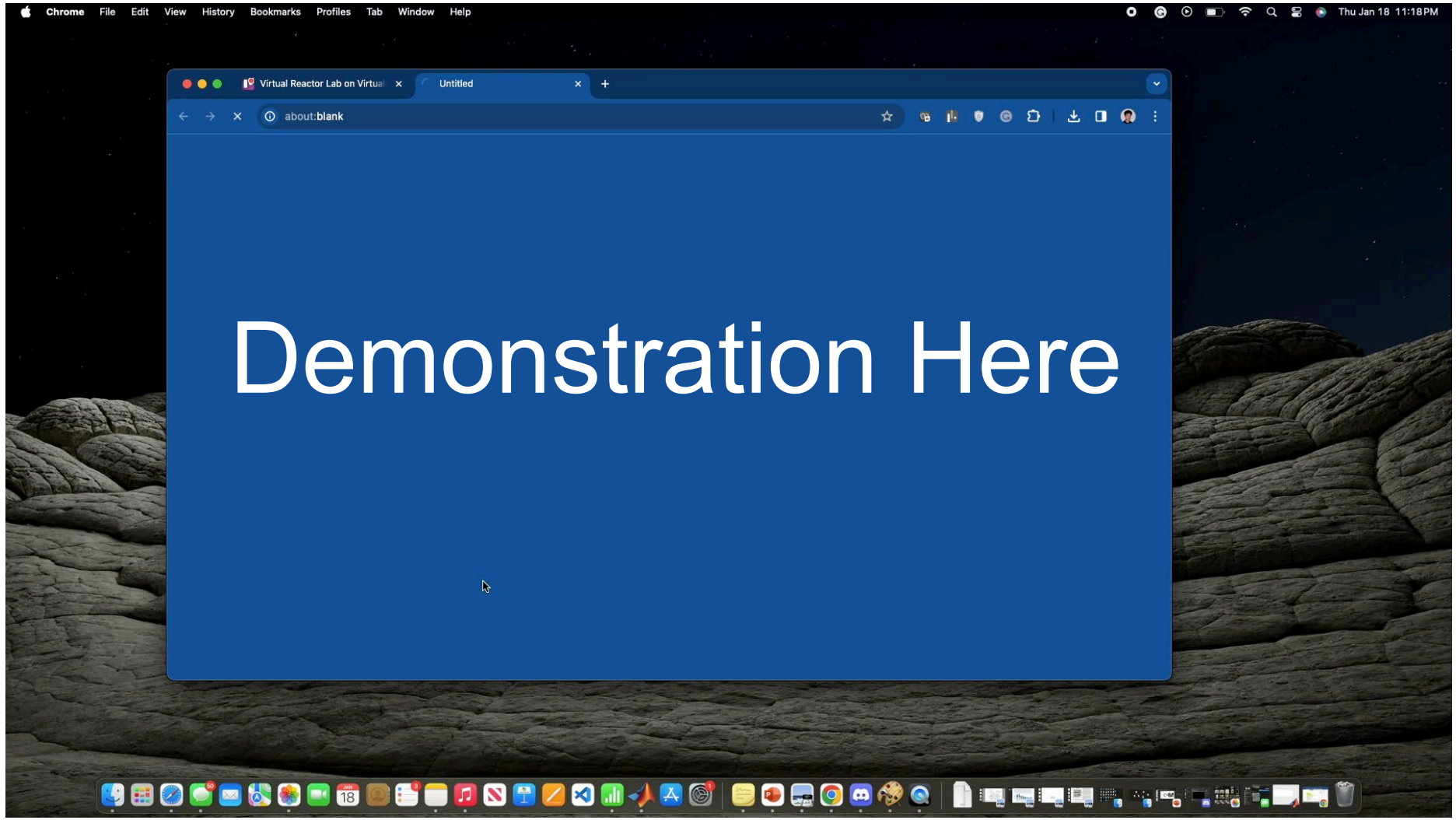

Demonstration Here

A Novel Idea





Virtual Reactor Lab (PUR-1)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Virtual Reactor Lab on Virtua
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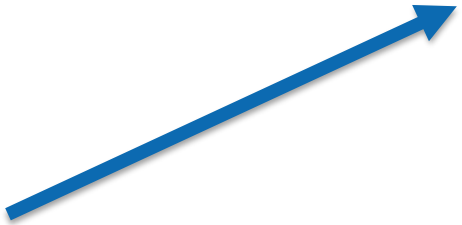
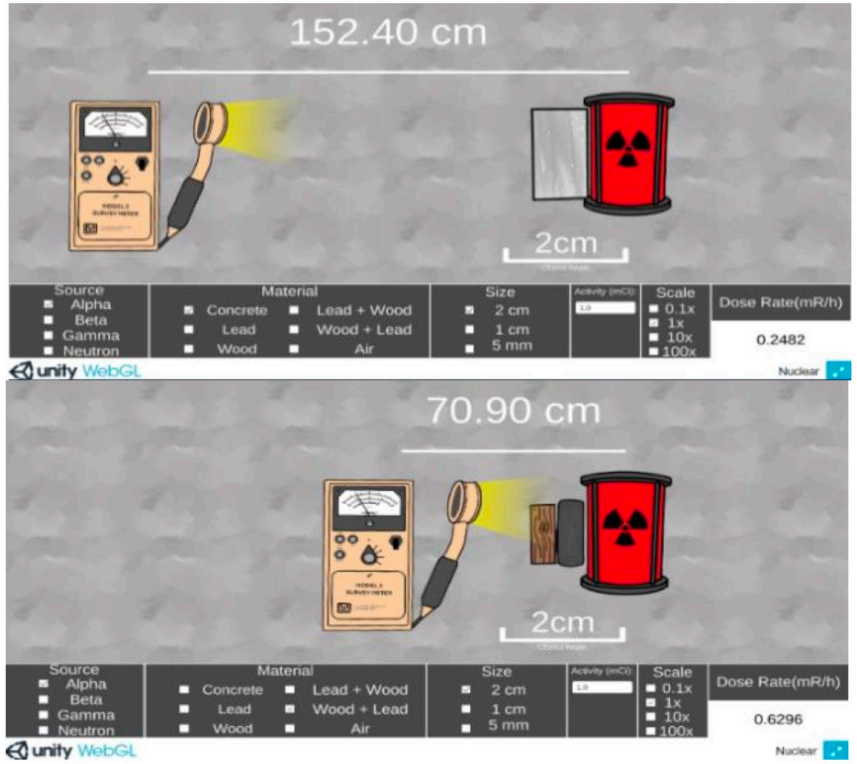
Demonstration Here

Virtually Integrated Labs

Proof of Concept



Virtually Integrated Labs

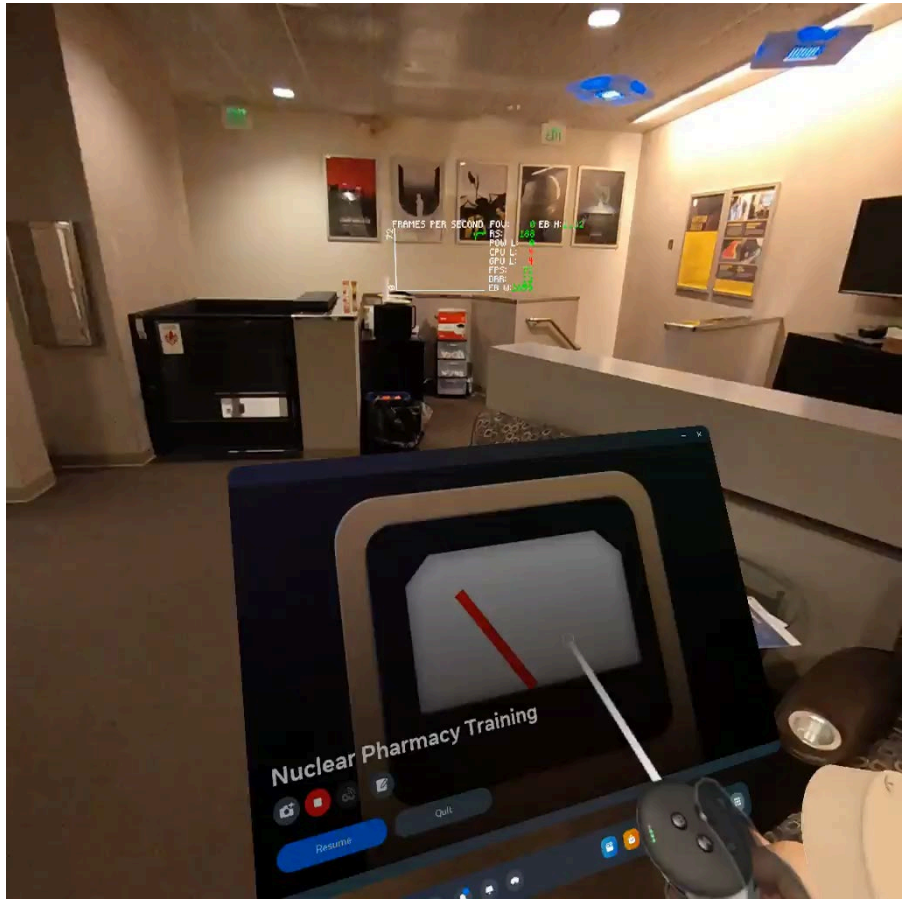


Virtually Integrated Labs

Julian Triveri (Envision Center)
Jonah Lau (N.E.)

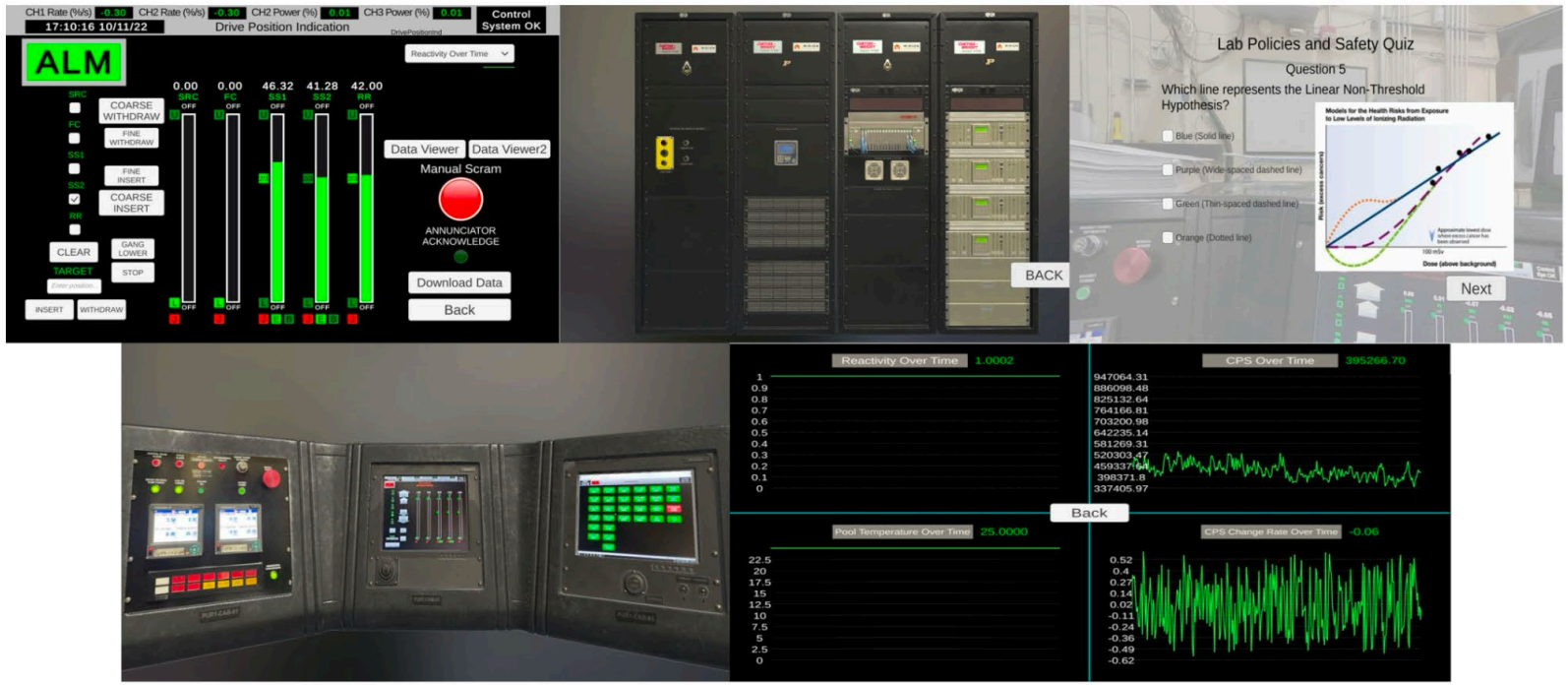
Augmented Reality (AR) GM Counter Lab

Virtually Integrated Labs



Virtually Integrated Labs

Virtually Integrated Labs



Multi-Monitor Simulator (PUR-1)

Virtually Integrated Labs

Joyce Zhou (Envision Center)
Zenen Enrqiuez (E.C.E)
Shea Ruthe (N.E.)
Robert Beatty (N.E.)
Jonah Lau (N.E.)
Preston Kilzer (N.E.)

Current Industrial Simulators

Virtually Integrated Labs

Joyce Zhou (Envision Center)
Zenen Enrqiuez (E.C.E)
Shea Ruthe (N.E.)
Robert Beatty (N.E.)
Jonah Lau (N.E.)
Trent Bloor (N.E.)
Preston Kilzer (N.E.)

Inexpensive

Flexible Hardware

Effective Education

Beginner Friendly

Current Industrial Simulators

Virtually Integrated Labs

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Preston Kilzer (N.E.)

Inexpensive

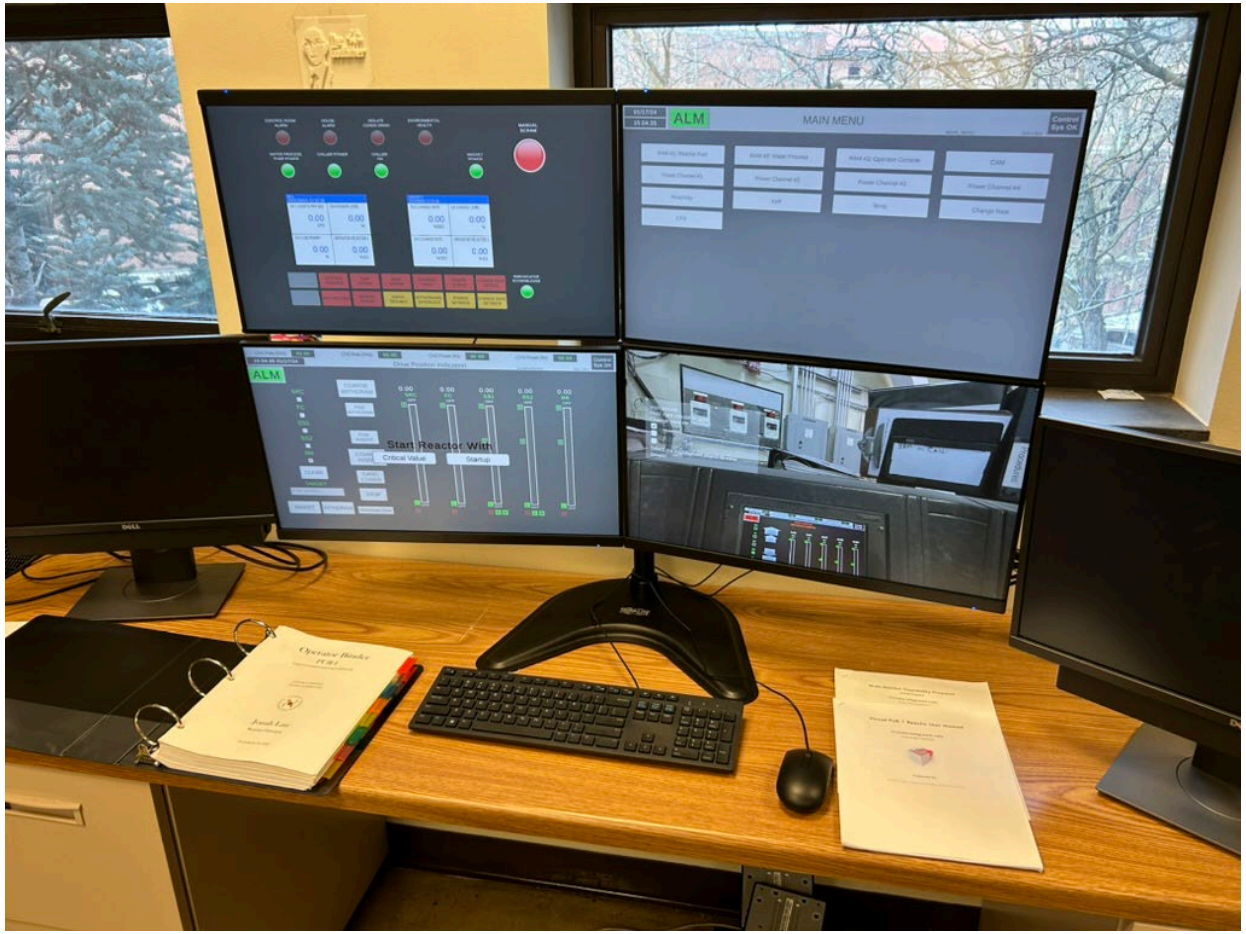
Flexible Hardware

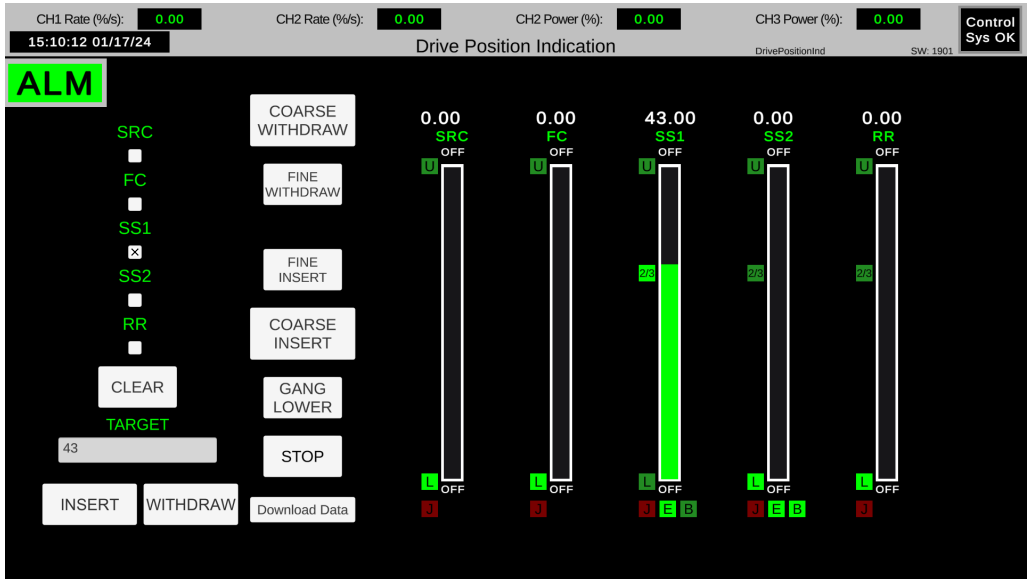
Effective Education

Beginner Friendly

Virtually Integrated Labs
Multi-Monitor Reactor

Multi-Monitor PUR-1 Simulator





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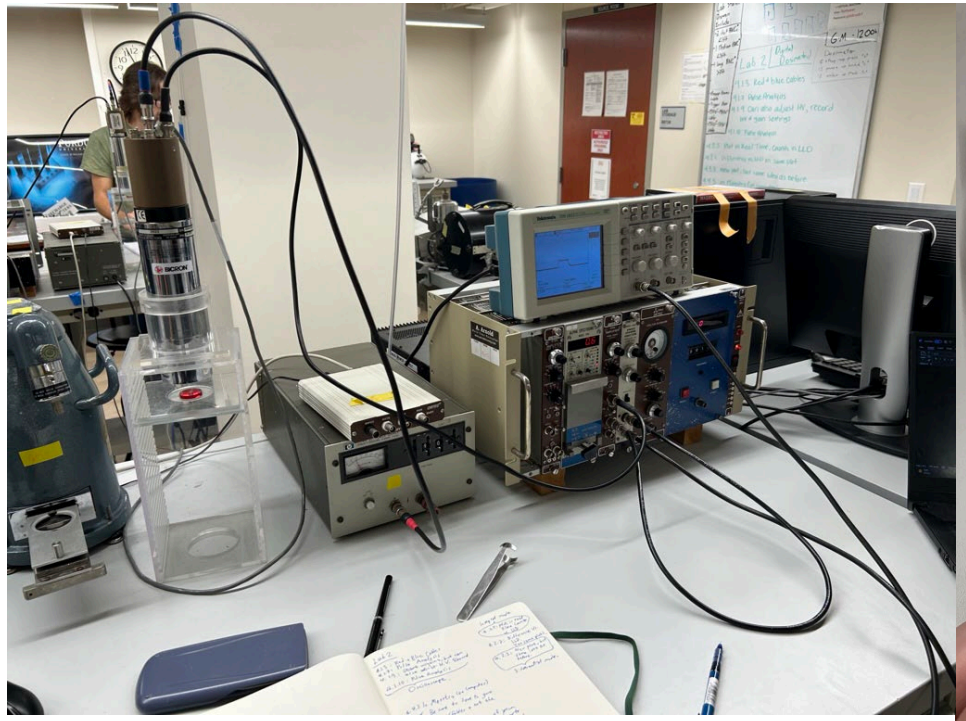
Virtually Integrated Labs

What's Next?

Virtually Integrated Labs

A hint:



Virtually Integrated Labs

Virtual Radiation Labs (UX In-Dev.)

Julian Triveri (Envision Center)
Trent Bloor (N.E.)
Jonah Lau (N.E.)
Robert Beatty (N.E.)

- All Undergraduate labs
- Modular Nuclear Electronics
- G.M., He-3, BF3, NaI detectors
- Modes (Sandbox, lab, Challenge)

What's Next

Potential Collaboration:

Reach out to lau61@purdue.edu

Key Takeaways

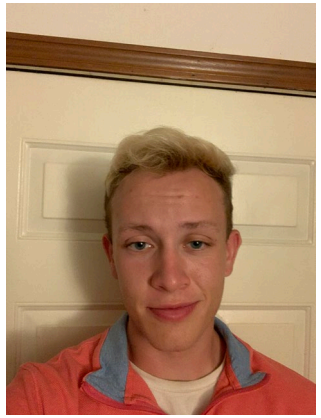
Revolutionizing Nuclear Engineering Education is a Community-Wide Effort

"Have fun while at it!"

Meet the Team

Jonah Lau (N.E.)

Zenen Enriquez (E.C.E)



Robert Beatty (N.E.)

Trent Bloor (N.E.)

Shea Ruthe (N.E.)

Julian Triveri (Envision)

Joyce Zhou (Envision)

Dr. Chatzidakis (PI) (N.E.)

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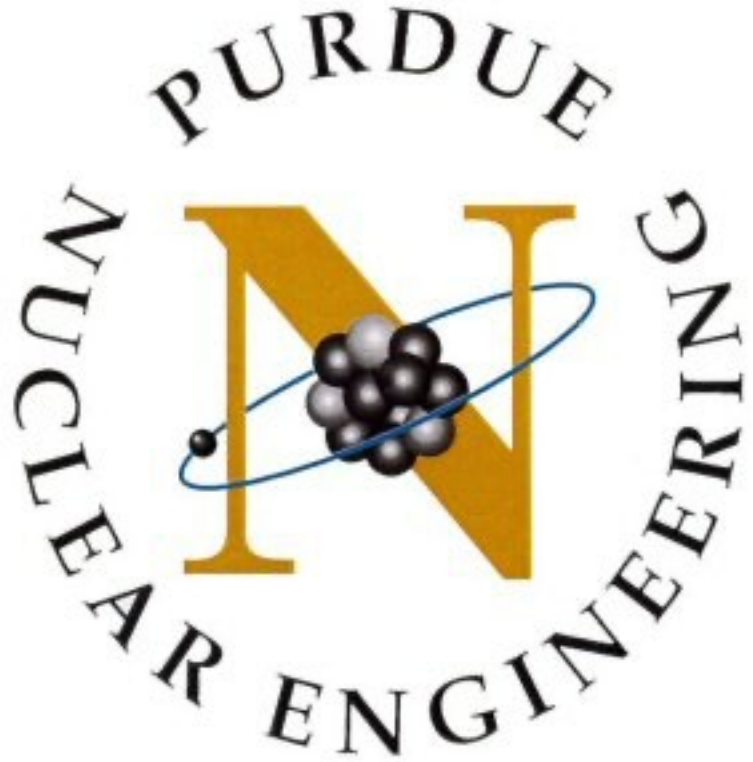
Special Thanks



References

- [1] *At COP28, countries launch declaration to Triple Nuclear Energy Capacity by 2050, recognizing the key role of nuclear energy in reaching net zero*. Energy.gov. (n.d.). https://www.energy.gov/articles/cop28-countries-launch-declaration-triple-nuclear-energy-capacity-2050-recognizing-key
- [2] *Advanced nuclear*. Pathways to Commercial Liftoff. (2023, December 19). https://liftoff.energy.gov/advanced-nuclear/

Upcoming Webinars

Date	Title	Presenter
28 February 2024	The Analysis of the Reactivity Loss of the Phenix Core Cycles for the Experimental Validation of the DARWIN-FR Code Package	Victor Viallon, CEA, France
20 March 2024	Overview of Canadian R&D Capabilities to Support Advanced Reactors	Lori Walters, CNL, Canada
17 April 2024	Multiphysics Depletion & Chemical Analyses of Molten Salt Reactors	Samuel Walker, INL, USA