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MC&A plan for Abilene Christian University's Natura MSR-1 Reactor

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Natura Resources

Abilene Christian University

TEXAS The University of Texas at Austin

Texas A&M University

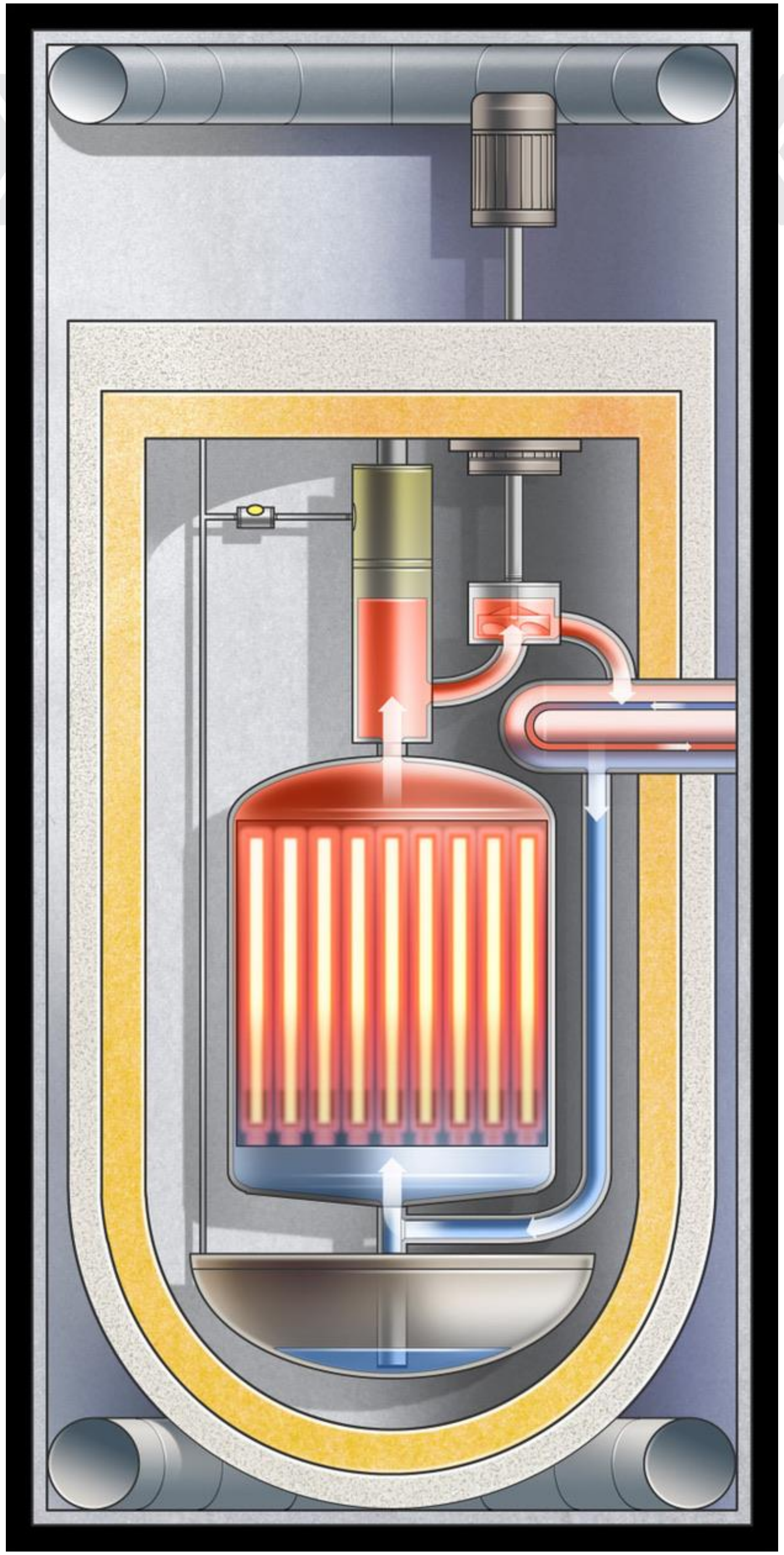
Georgia Tech

Outline

- Molten Salt Research Reactor (MSRR)
- MSRR Timeline
- Material Control and Accounting

Molten Salt Research Reactor (MSRR)

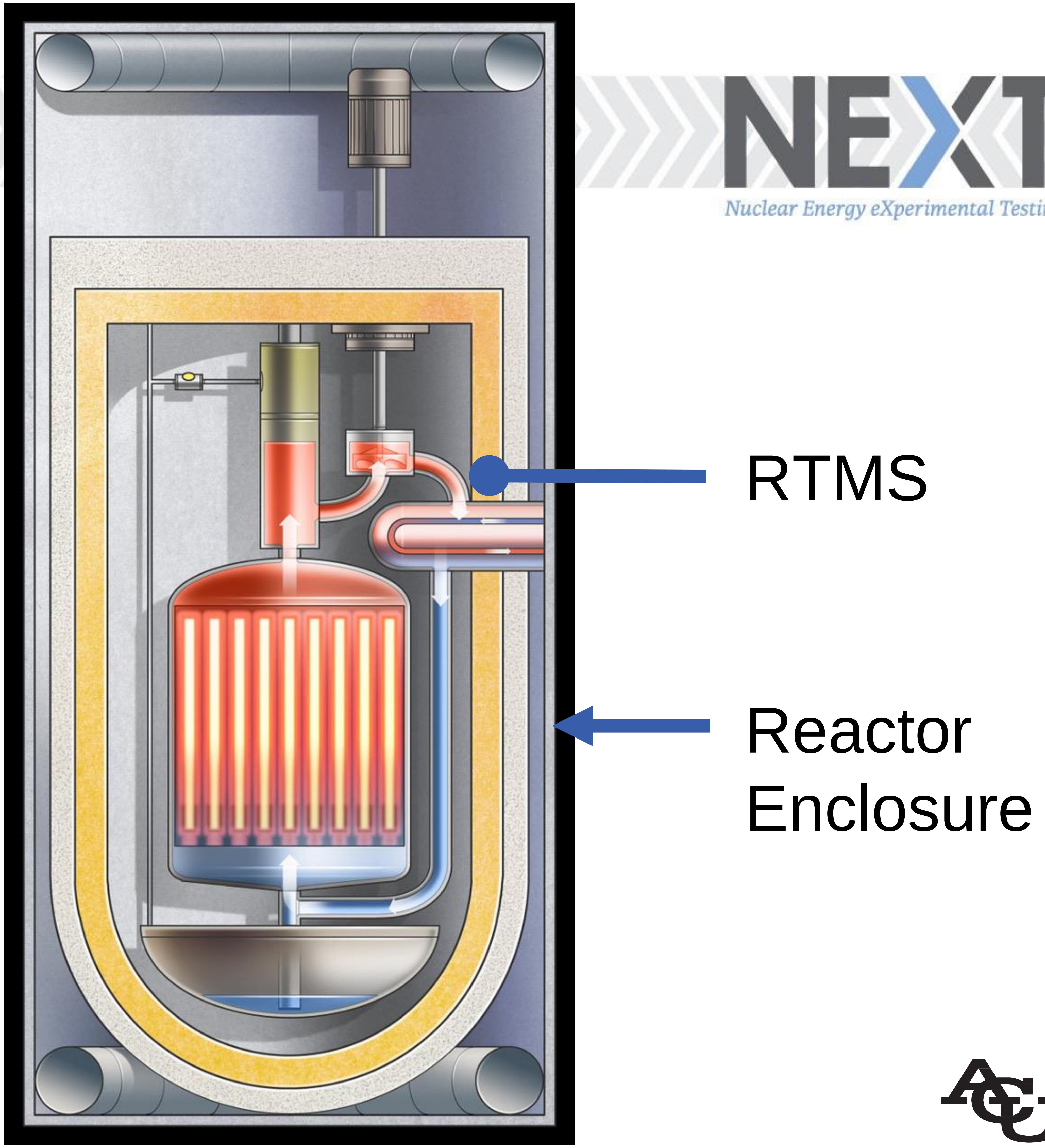
Thermal Output:	1 MW_{th}
Electric Output:	n/a
Fuel:	19.5% enriched HALEU
Moderator:	Graphite
Coolant Salt:	LiF-BeF_2-UF_4 (FLiBe)
Const. Material:	SS 316H
Deployment:	2026
Features:	Passive shut down & cooling Off-site, modular construction
Commercial Benefits:	Demonstrates licensure with NRC Produces experimental data, models & codes



MSRR Layout

MSRR Safety Features

- Multiple barriers:
  - Salt
  - Primary fueled salt loop
  - Reactor Thermal Management System (RTMS)
  - Reactor Enclosure
  - Reactor Cell
- Low pressure system
- Shutdown via core drain
- Passive heat removal during shutdown



Nuclear Energy eXperimental Testing

Gayle and Max Dillard
Science and Engineering Research Center

Abilene Christian University – September 2023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Molten Salt Research Reactor
ABILENE CHRISTIAN
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The Molten Salt Research Reactor (MSRR) is the first advanced university research reactor.
– Reactor Trip Valves
– Access Vessel
– Pump
– Heat Exchanger
– Reactor Core
– Shielding
– Insulation
– Reactor Enclosure
– Drain Tank
– Helium Tank (one of two)
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MSRR Project Status

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The Natura Resources Research Alliance is leading the way in MSR development and deployment.

1. ACU received a Construction Permit from the Nuclear Regulatory Commission on September 16, 2024.
2. ACU has completed the SERC to house the Molten Salt Research Reactor (MSRR).
3. We are on a path to be the first operating molten salt reactor in the nation since the MSRE.

Material Control and Accounting

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- Material Control and Accounting program is currently under development.
- General plan is to take a material balance approach.
- Quantify material inputs and outputs.
  - Goal is to have redundant measurement methods.
  - Replicates
  - Need to be able to address uncertainty.
  - Refueling procedures under development.
  - Output measurements supported by computation.
- Robust control and surveillance within material control areas.

MC&A Relevant Design Parameters

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Pre-Irradiation → Irradiation → Post-Irradiation

Pre-Irradiation

Fuel Receiving

A. HALEU (19.7%)
B. Solid salt in discrete containers.
C. UF_4 and UF_4 in FLiBe
D. 500 kg U
E. Low radioactivity

Initial Fuel Salt

A. HALEU (19.7%)
B. Liquid at reactor temperature. Solid at room temperature.
C. UF_4 in FLiBe
D. 300 kg U
E. Low radioactivity

Makeup Fuel Salt

A. HALEU (19.7%)
B. Solid at reactor and room temperature.
C. UF_4
D. 200 kg U
E. Low radioactivity

Irradiation

Reactor

A. HALEU (19.7%) with Pu from ^{238}U transmutation
B. Liquid at reactor temperature. Solid at room temperature.
C. UF_4 in FLiBe
D. 300 kg U
E. Very High activity after irradiation

Post-Irradiation

Off-Gas

A. HALEU (19.7%)
B. Gas and solid
C.U and Pu in fluoride chemical forms.
D. < 1 g U and Pu expected
E. Very high radioactivity

Salt Samples for SSL

A. HALEU (19.7%)
B. Solid salt in discrete samples.
C. UF_4 and PuF_4 in FLiBe
D. ~ 0.1 g of fuel-salt per sample. ~ 100 samples over life of reactor.
E. High radioactivity

Used Fuel Salt in Fuel Handling System

A. HALEU (19.7%) with Pu from ^{238}U transmutation
B. Liquid at reactor temperature. Solid at room temperature.
C. . UF_4 and PuF_4 in FLiBe
D. < 300 kg U and < 0.5 kg Pu
E. Very High activity after irradiation

Used Fuel Salt in Shipping Containers

A. HALEU (19.7%) with Pu from ^{238}U transmutation
B. Solid at room temperature.
C. UF_4 and PuF_4 in FLiBe
D. < 300 kg U and < 0.5 kg Pu
E. Very High activity after irradiation

LEGEND

A. Type of Nuclear Material
B. Physical Form
C. Chemical Form
D. Quantity of SNM
E. Radioactivity of material

Process Monitoring

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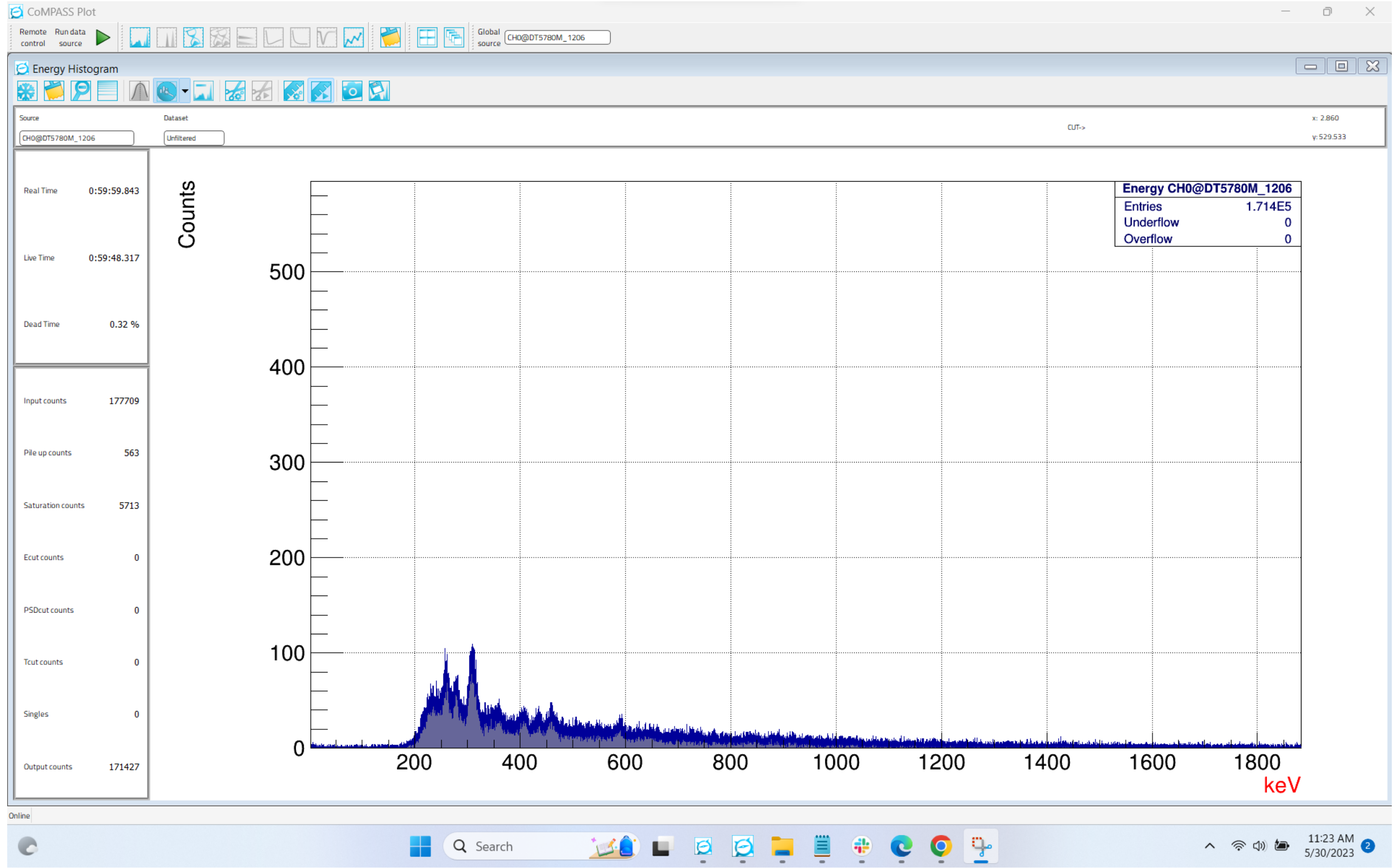
- Process monitoring is not currently planned.
- Initial measurements show that this is not practical and reliable with current commercially available technology.
- Challenges with:
  - High temperatures
  - Radiation levels
  - Complexity of signal



CZT spectra of short-lived fission products

Burn-up Modeling

- Burn-up modeling will predict ^{235}U depletion and the production of ^{239}Pu.
- These models will be periodically validated throughout the operation of the reactor.
- Material outputs may be compared to predicted compositions.
- Uncertainty from these models may be too high for adequate application to a Material Control and Accounting plan.
- Information gained may lead to a better understanding on how to implement computational models for future reactors.

MSRR Benefits from MC&A Perspective

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- There are many aspects of a molten salt reactor that provide benefits from a MC&A perspective:

1) Multitude of physical barriers.
2) Difficulty to remove material from reactor system.
3) Relative homogeneity of fuel-salt makes quantification of composition easier.
4) Any breach of reactor system is easily detected once the fuel salt has been irradiated.
5) Many safety benefits (e.g., strong negative temperature coefficients of reactivity, low operating pressure, low excess reactivity, etc.).
6) High burn of transuranic fuel elements within the fuel.

Testbed Opportunity

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- The MSRR may provide an opportunity to examine the utility of different Material Control and Accounting technologies.
- Temperatures and radiation levels may affect suitability of equipment and methods for implementation.
- Measurement method accuracy and detection limits may be assessed.
- Data may be utilized to support development of a digital twin.

THANK YOU

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Georgia Tech