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Example: AI for Targetry at the SNS

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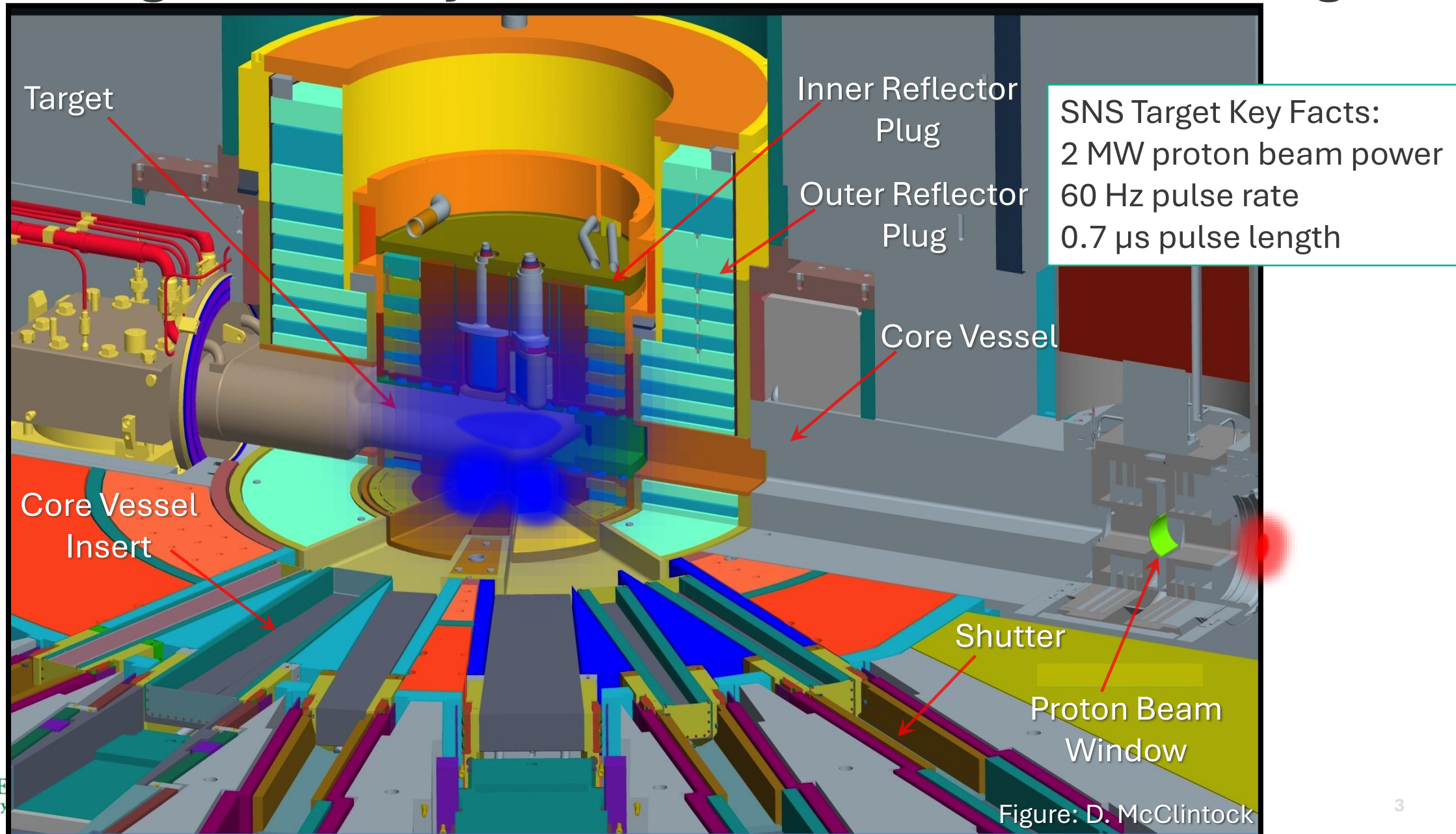
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The Spallation Neutron Source Accelerator is very similar to the proton accelerator part of a muon collider



The SNS target has many similarities to a muon collider target



Needs vary throughout the lifecycle of a target system

Concept
Design

- Broad optimization

Detailed
Design

- Final optimization
- Control and checking of many interlocking requirements

Operation

- Finding and addressing problems
- Dealing with real world feedback

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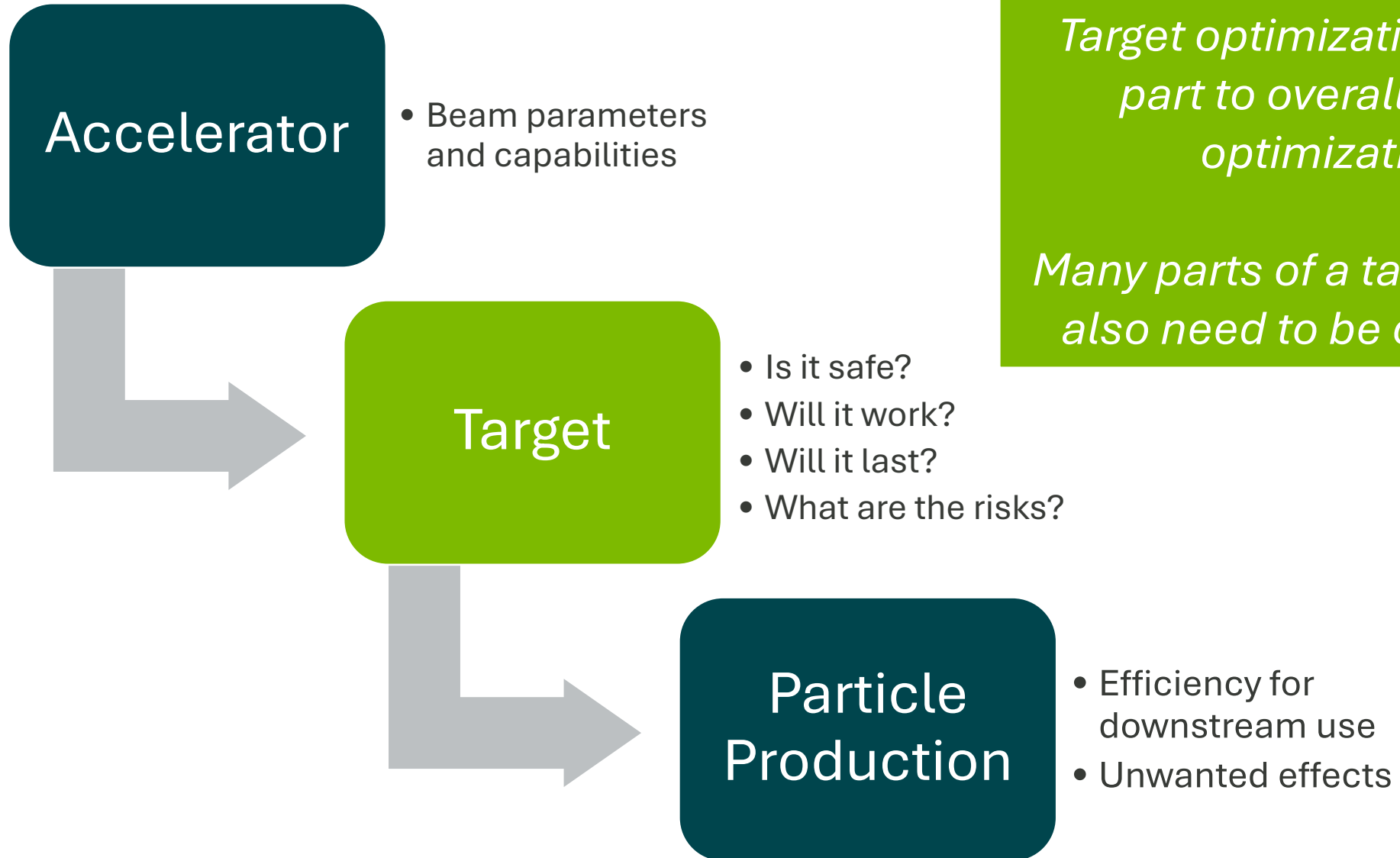
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Optimization of target systems present several challenges



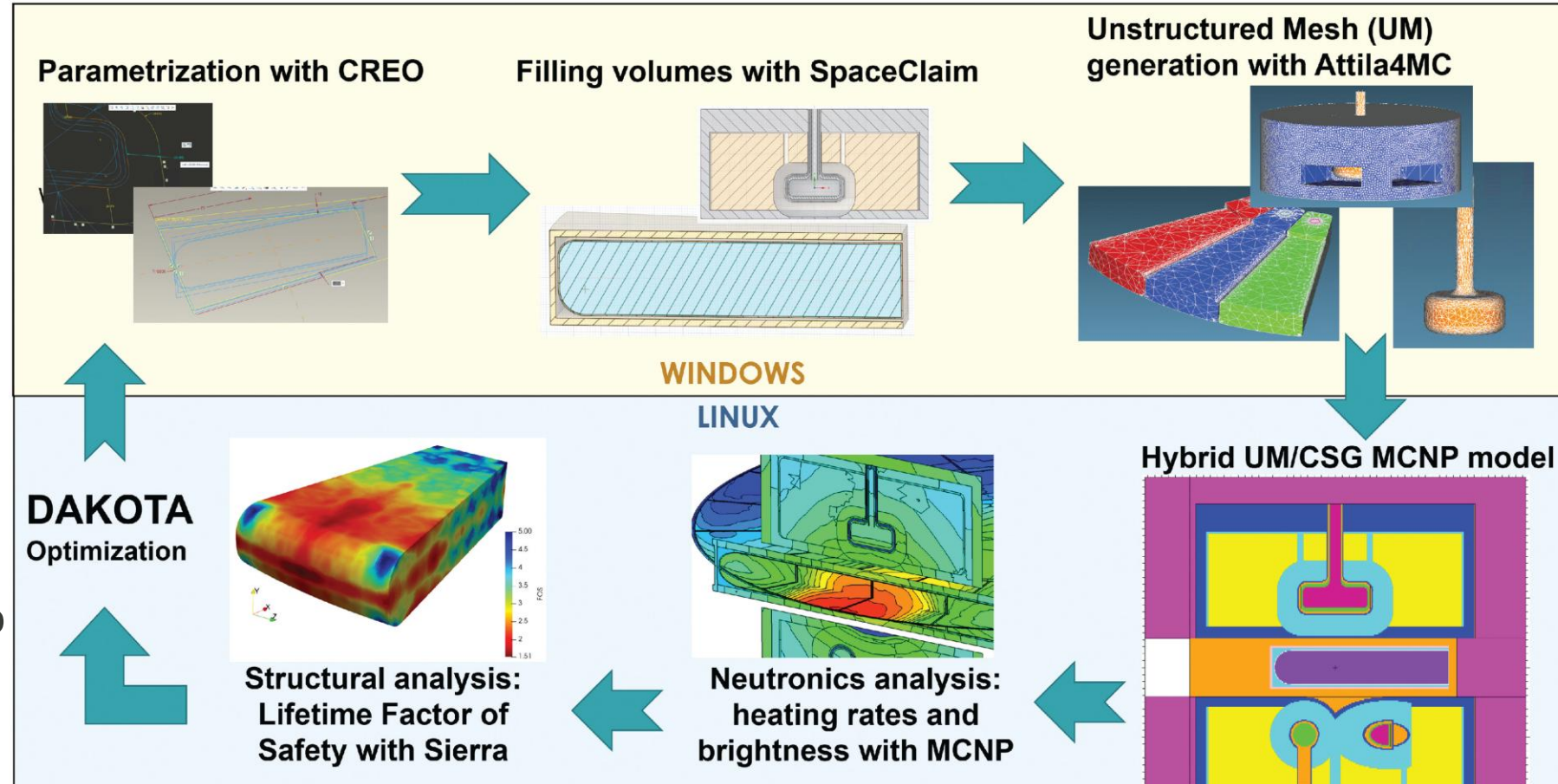
Optimization of target systems present several challenges

Target analysis requires the use of many different pieces of specialized software

- Much of this does not play well with others

Simulation time, even for “simple” models, can be significant

- 1.5 hours for structural loop
- 1.3 hour for moderator loop



K. Ghoos, L. Zavorka, J. Tipton, and I. Remec, "Designing the Second Target Station with a Coupled Neutronics-Mechanical Optimization Workflow," *Nuclear science and engineering : the journal of the American Nuclear Society.*, pp. 1-12, 2024, doi: 10.1080/00295639.2024.2383099.

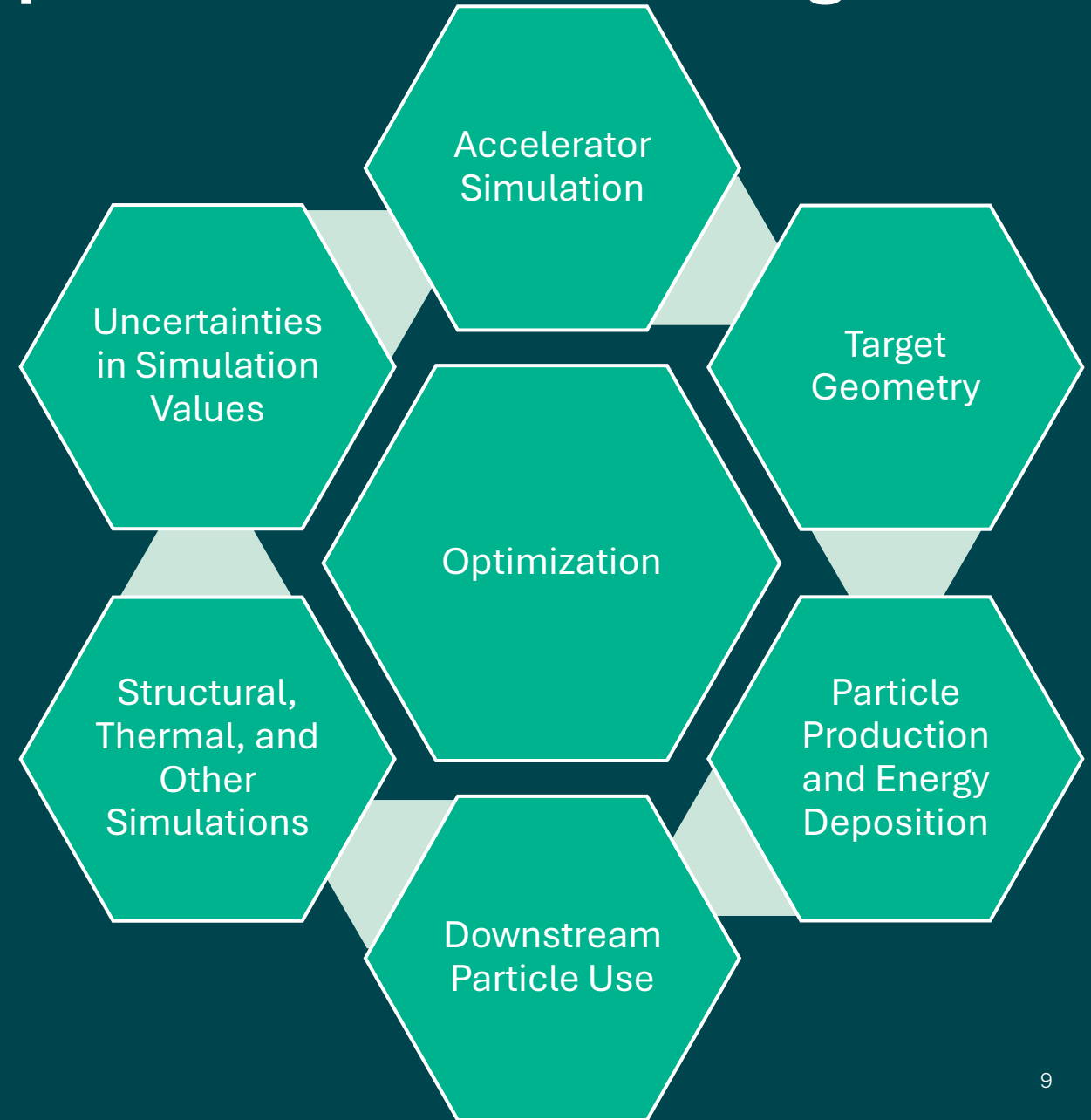
Much of a successful target system is outside of the beam interaction zone

More than 30 interlocking system spanning 4 stories and 1 outbuilding are required to support the target systems.



Optimization of target systems present several challenges

- Optimization needs to take place at several levels
- All are useful, but normal practices result in individual choices at many levels to add safety and redundancy
- It's important not to over-promise from “optimized” systems that have missed key requirements



Optimization of target systems present several challenges

High power target systems
must work at all time scales

μs to ms

- Pulses
- Dynamic response

Seconds

- Thermal time constants

Days to months

- Radiation damage
- Mechanical Damage

Years

- On-going operations
- Facility lifetimes

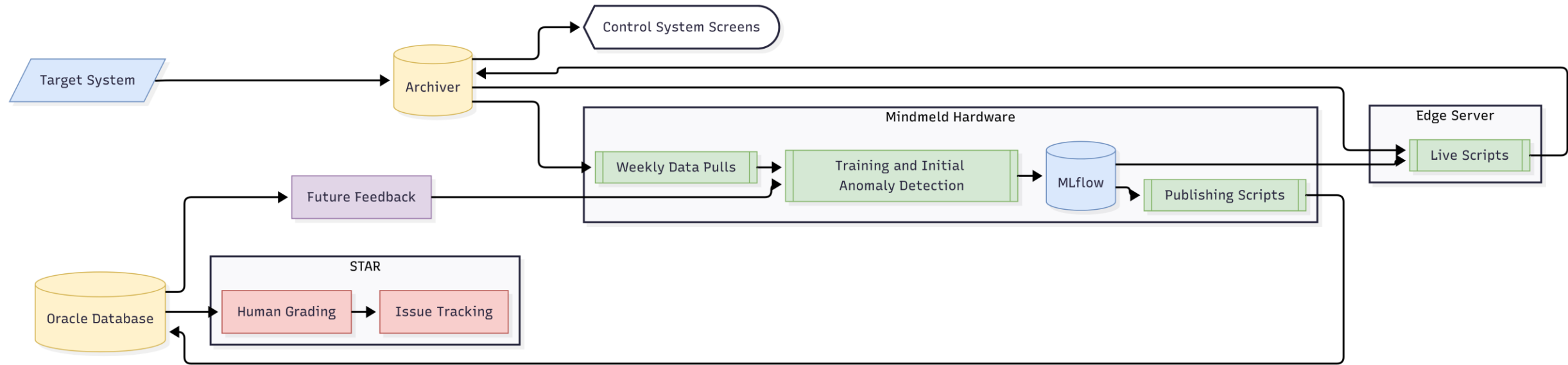
*Anything can be a target for a short time, but a
successful muon collider will need to be reliable*

Real target systems often don't behave as we would expect

- Operators are watching multiple systems for problems, and can't see everything
- Help finding and addressing problems when they are small would help reliability
- Problems include dirty data, lack of labels for data, many mismatched systems where different data is kept



SNS Anomaly Detection system points out potential problems to humans and collects labeled data for future improvements



Targets are important to facility success and provide an interesting area ripe for improvements using AI

Thank you and I look forward to the discussion.



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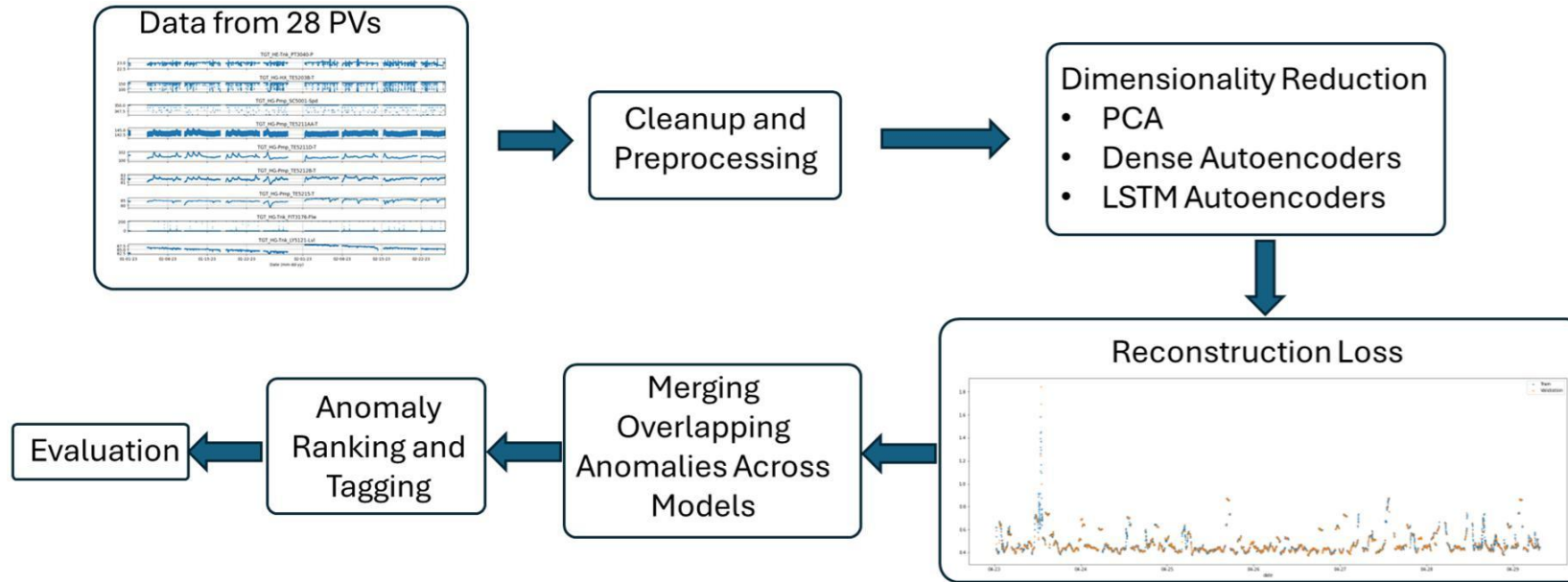
SPALLATION
NEUTRON
SOURCE



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Further details on the SNS system are available, we are glad to collaborate.



A. Raj et al., "Platform for Automated Anomaly Detection in the Mercury Process System at the Target System in the Spallation Neutron Source," *Data Science in Science*, vol. 5, no. 1, p. 2608400, 2026/02/13 2026, doi: 10.1080/26941899.2025.2608400.