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Developing muon-catalyzed fusion as an abundant new source of energy

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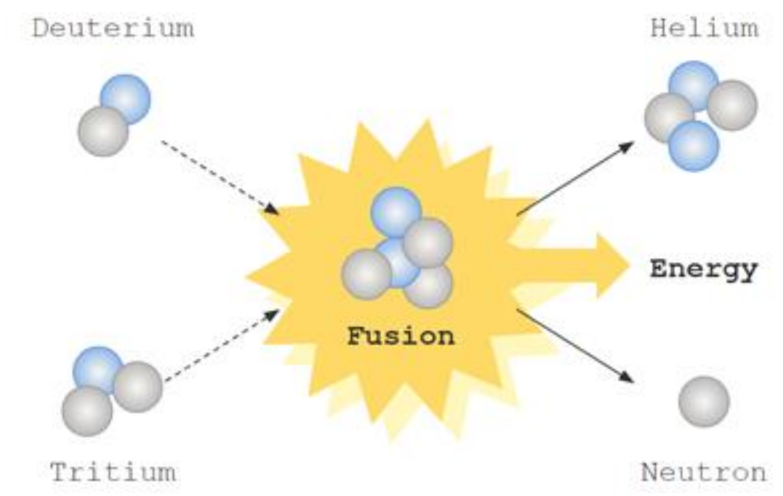
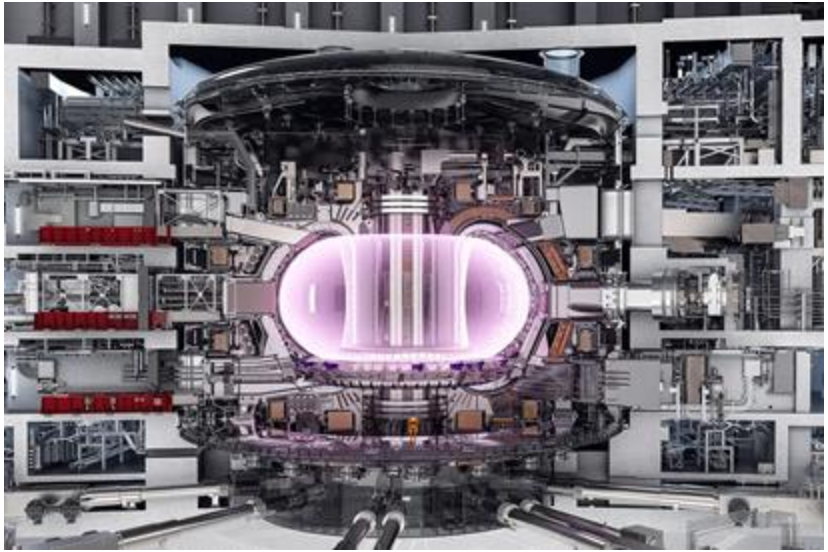
Co-founder and President Acceleron Fusion and NK Labs

ARPA-E Fusion Programs Annual Meeting - July 8-9, 2025

Plasma fusion requires stable 100,000,000 °C plasma



The deuterium-tritium fusion reaction has the highest cross section.



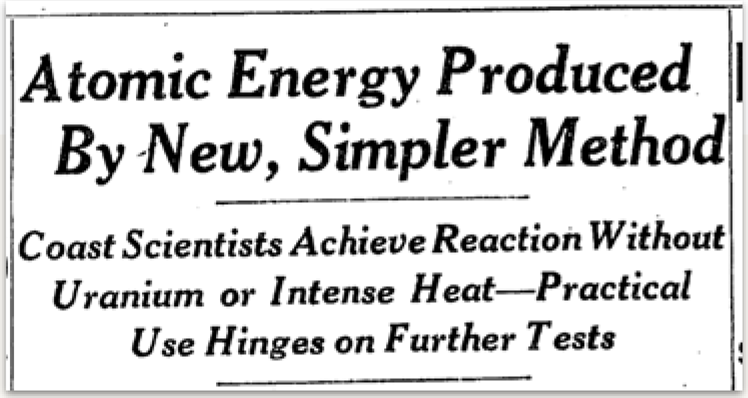
A cutaway view of the ITER tokamak, scheduled to burn DT in 2035.

Our Approach

The science for muon-catalyzed fusion was discovered in the 1950s

1957

Luis Alvarez first discovers muon-catalyzed fusion caused by cosmic rays



Atomic Energy Produced By New, Simpler Method

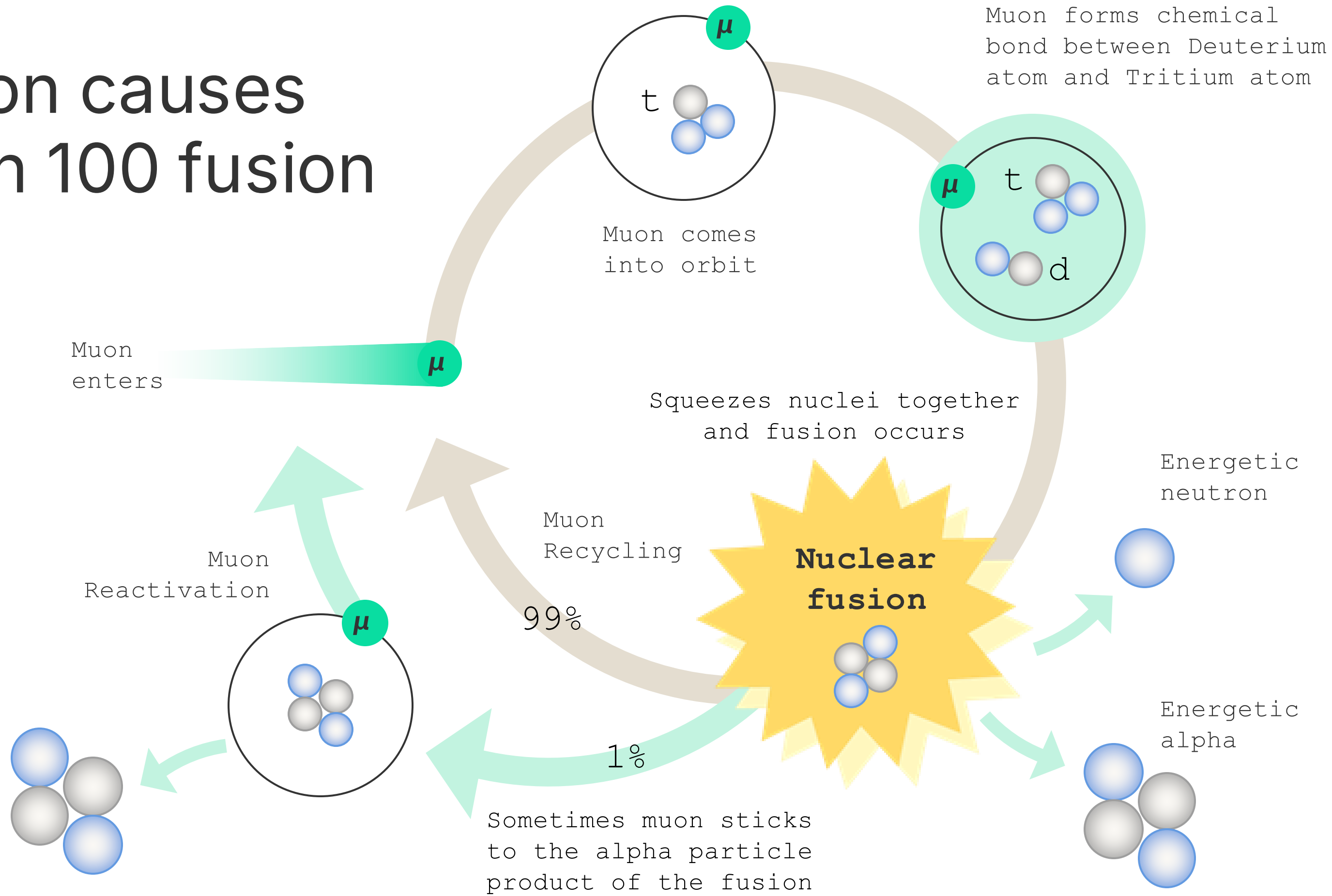
Coast Scientists Achieve Reaction Without Uranium or Intense Heat—Practical Use Hinges on Further Tests

→ No plasma required; can occur in solid, liquid, or gas

→ Happens when muons encounter fusion fuel mixtures

How It Works

Each muon causes more than 100 fusion reactions



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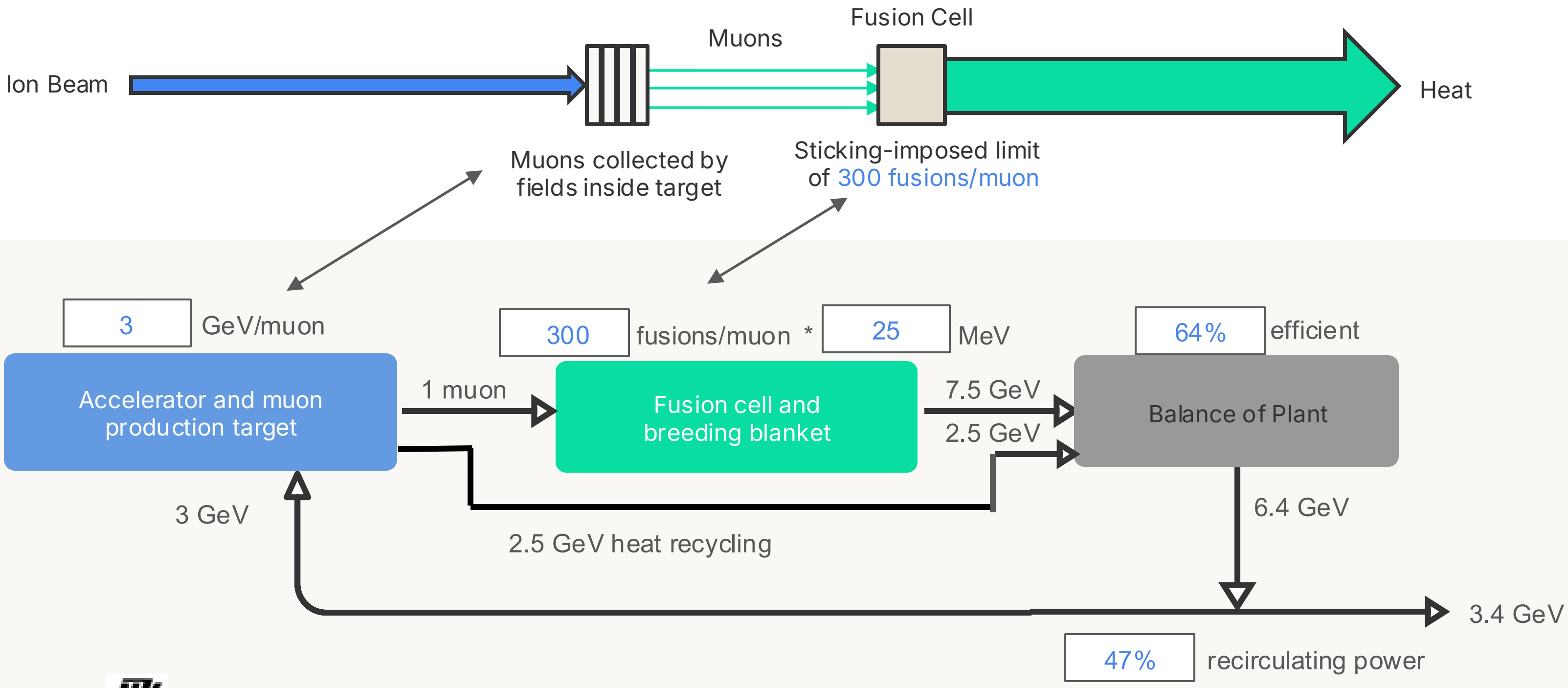
Our Core Innovation

We know how to produce muons cheaply



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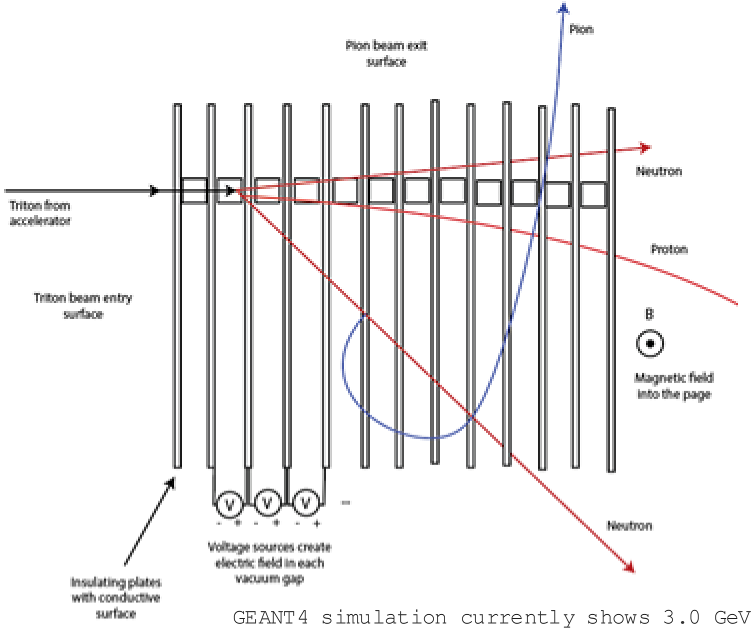
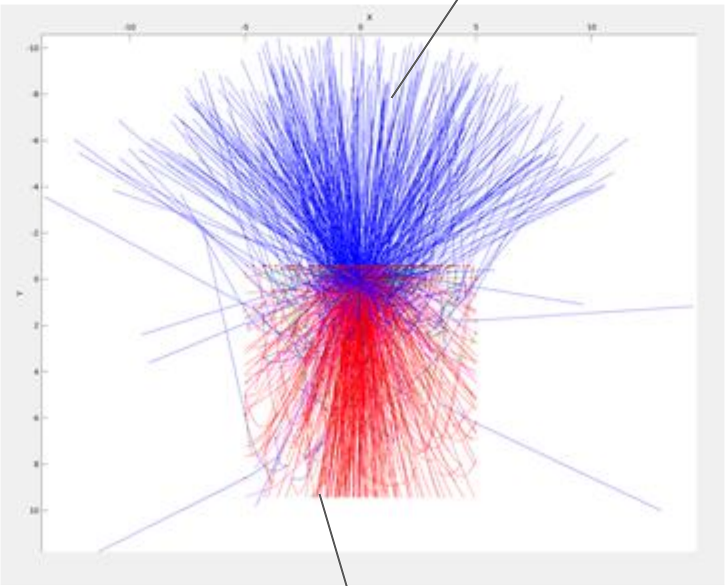
Active-target muon source simulation data



GEANT4 simulation currently shows 3.0 GeV energy per negative pion and muon exiting the target. The design can likely be improved with further engineering.

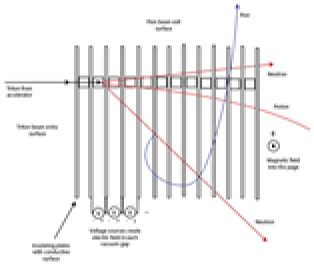
Trajectories of pions and muons, most leaving the target on one side

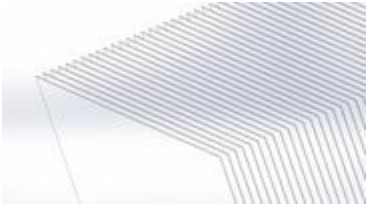


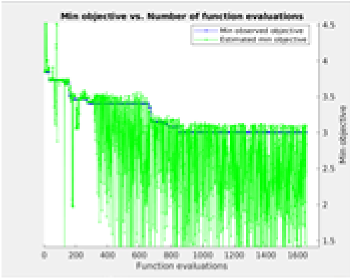
Trajectories of protons and neutrons above threshold for pion production

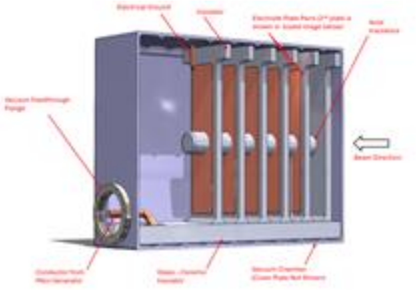
Our approach

We are using Machine Learning to help design the muon source









Human designed concept → Parameterized 3D CAD model (Solidworks) → ML optimization of parameters of particle physics simulation (GEANT4) → Build and test laboratory prototype

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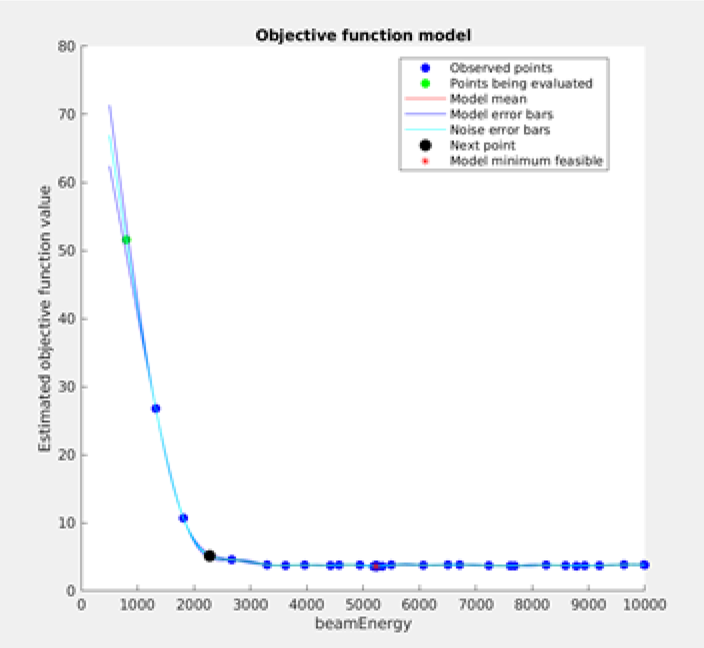
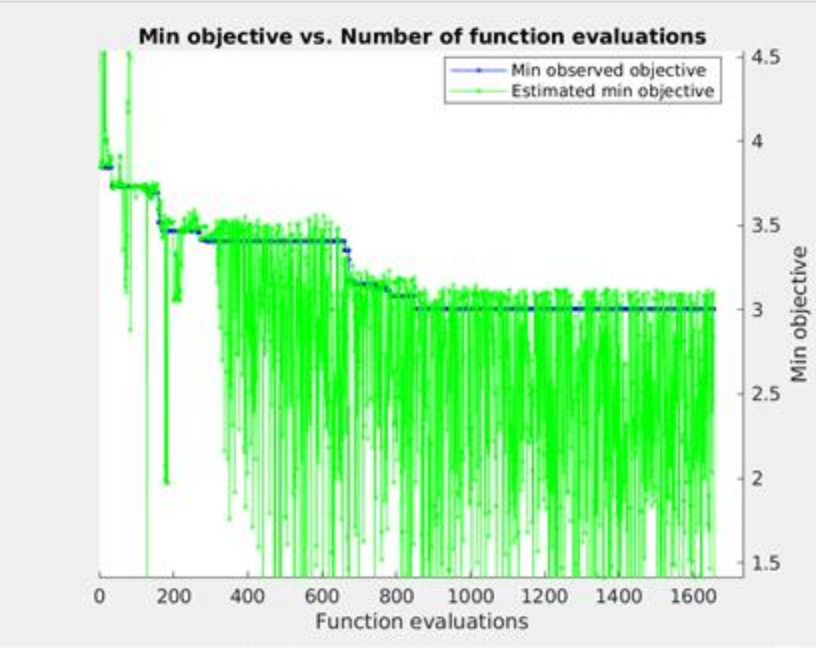
Our approach

We are using ML to help design the muon source

Bayesian optimization of geometric parameters in GEANT4 simulations





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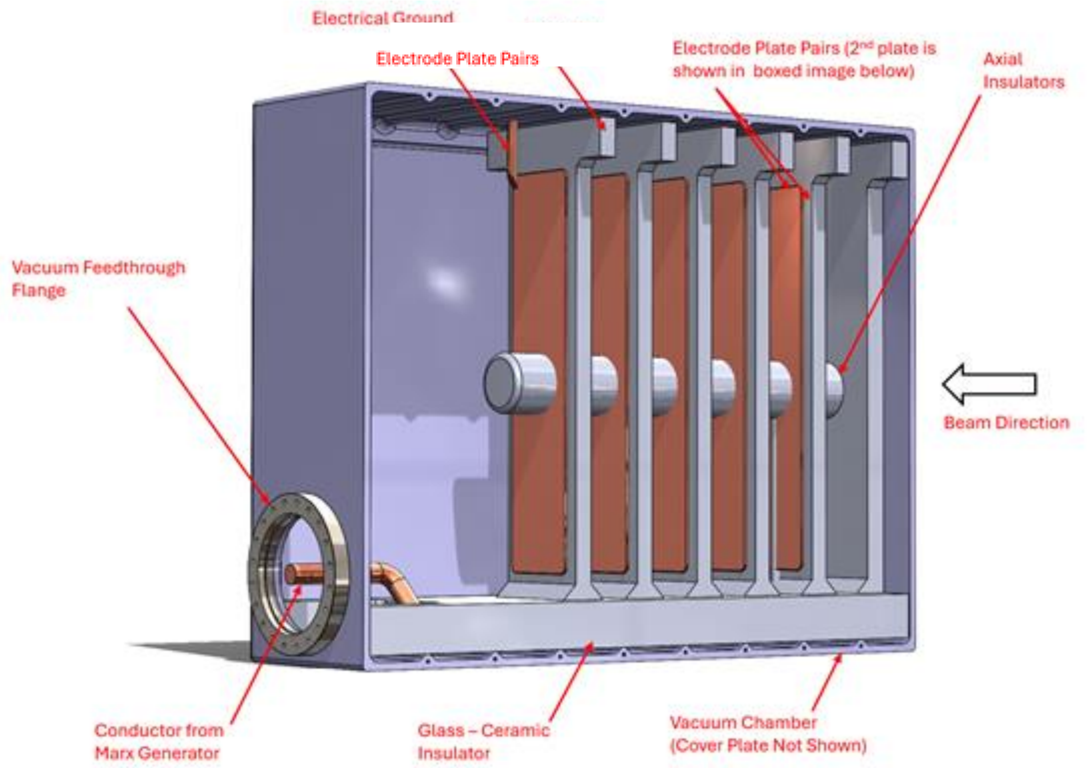
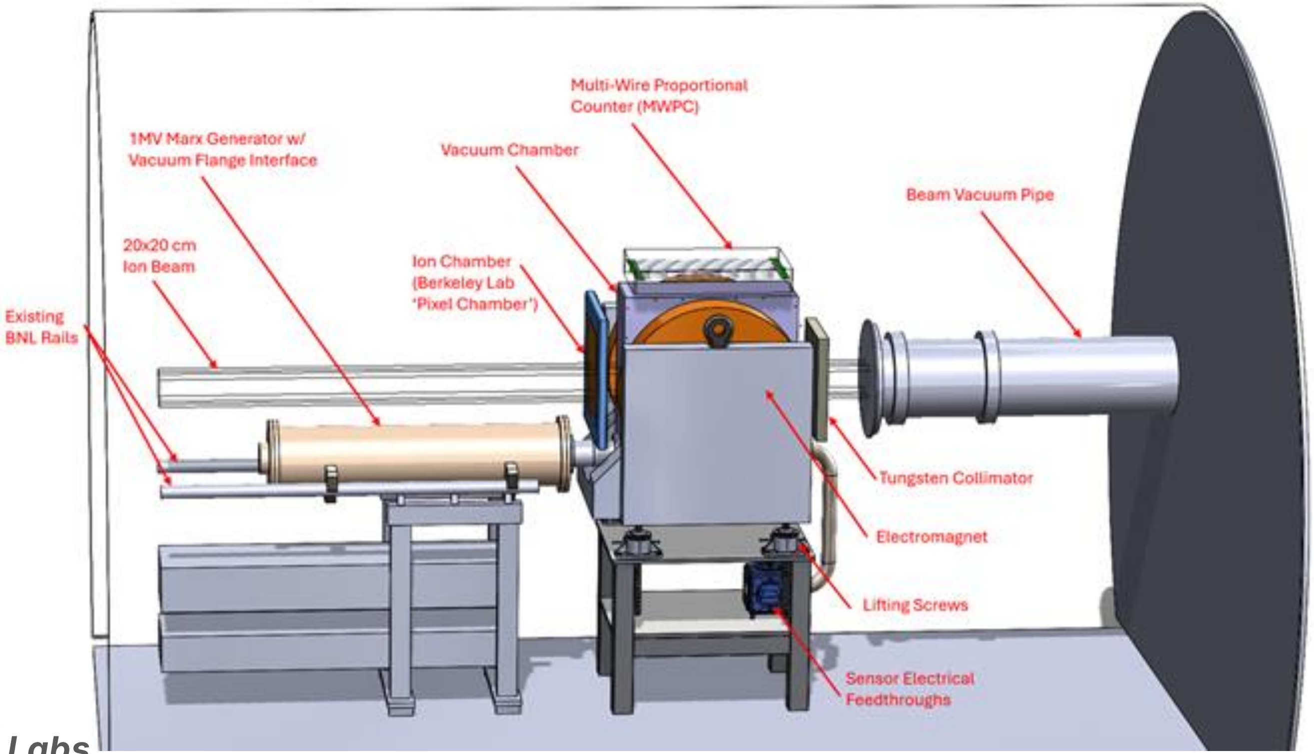
Active Target Design

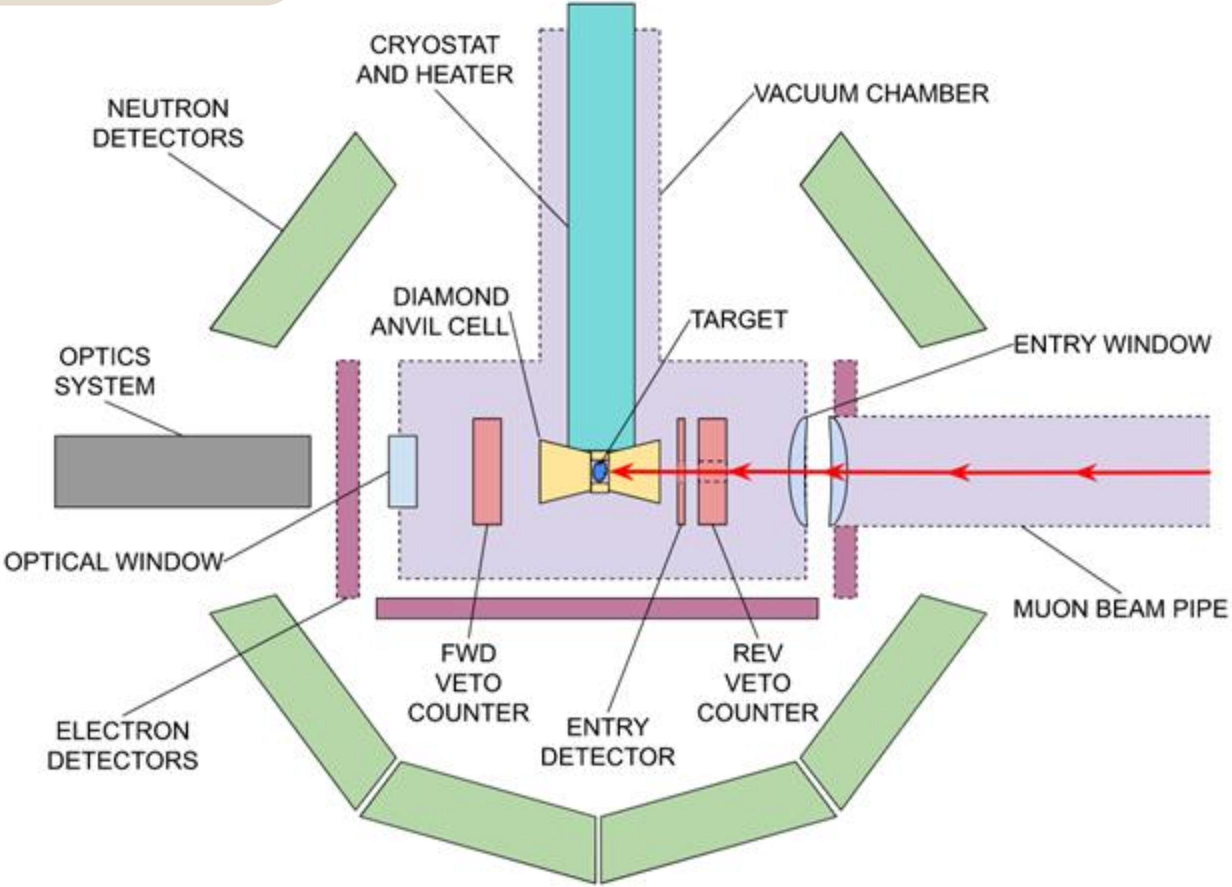
Core Hardware: Muon Generation Vacuum Assembly



Beamline Test Setup & Instrumentation



Fusion yield measurement



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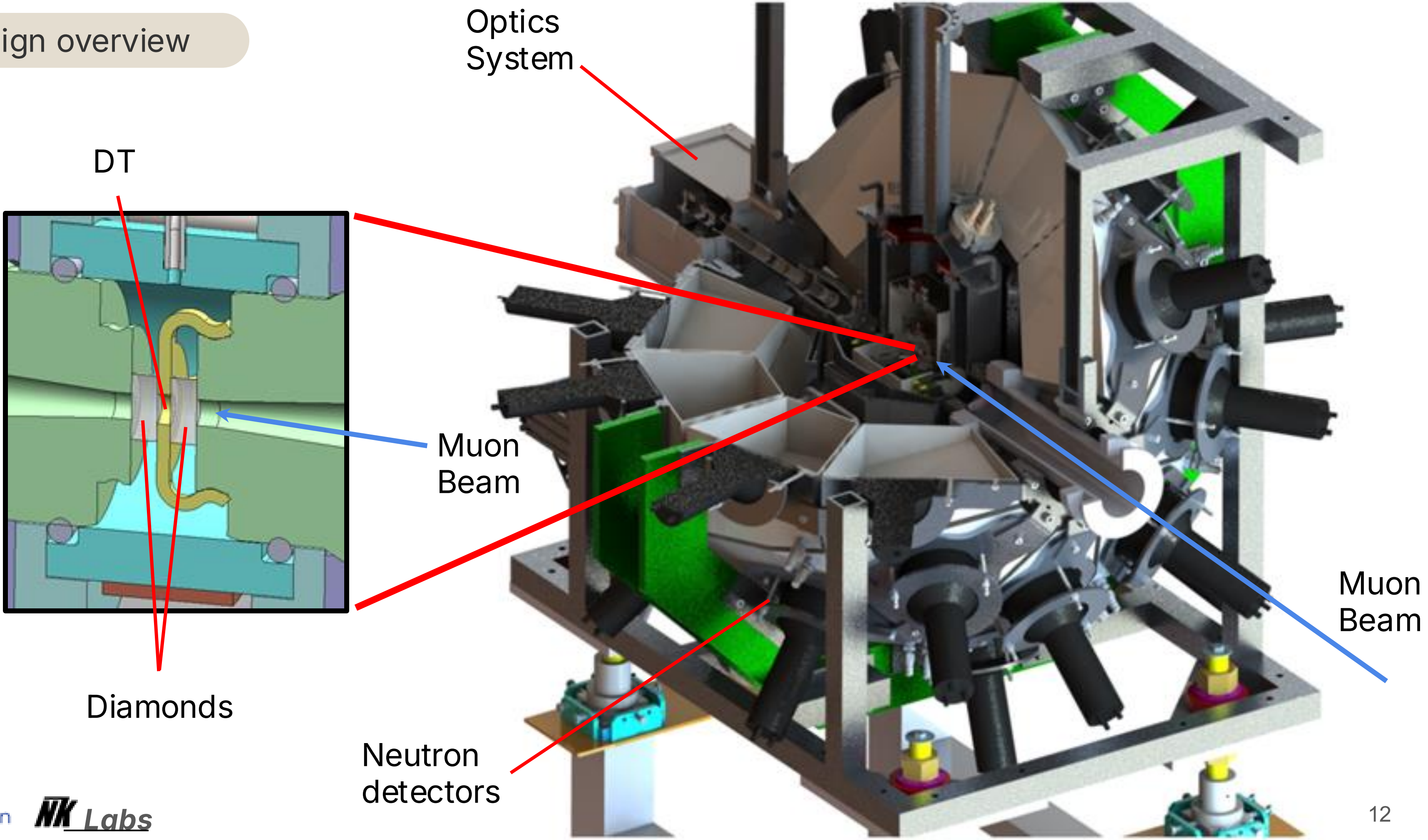
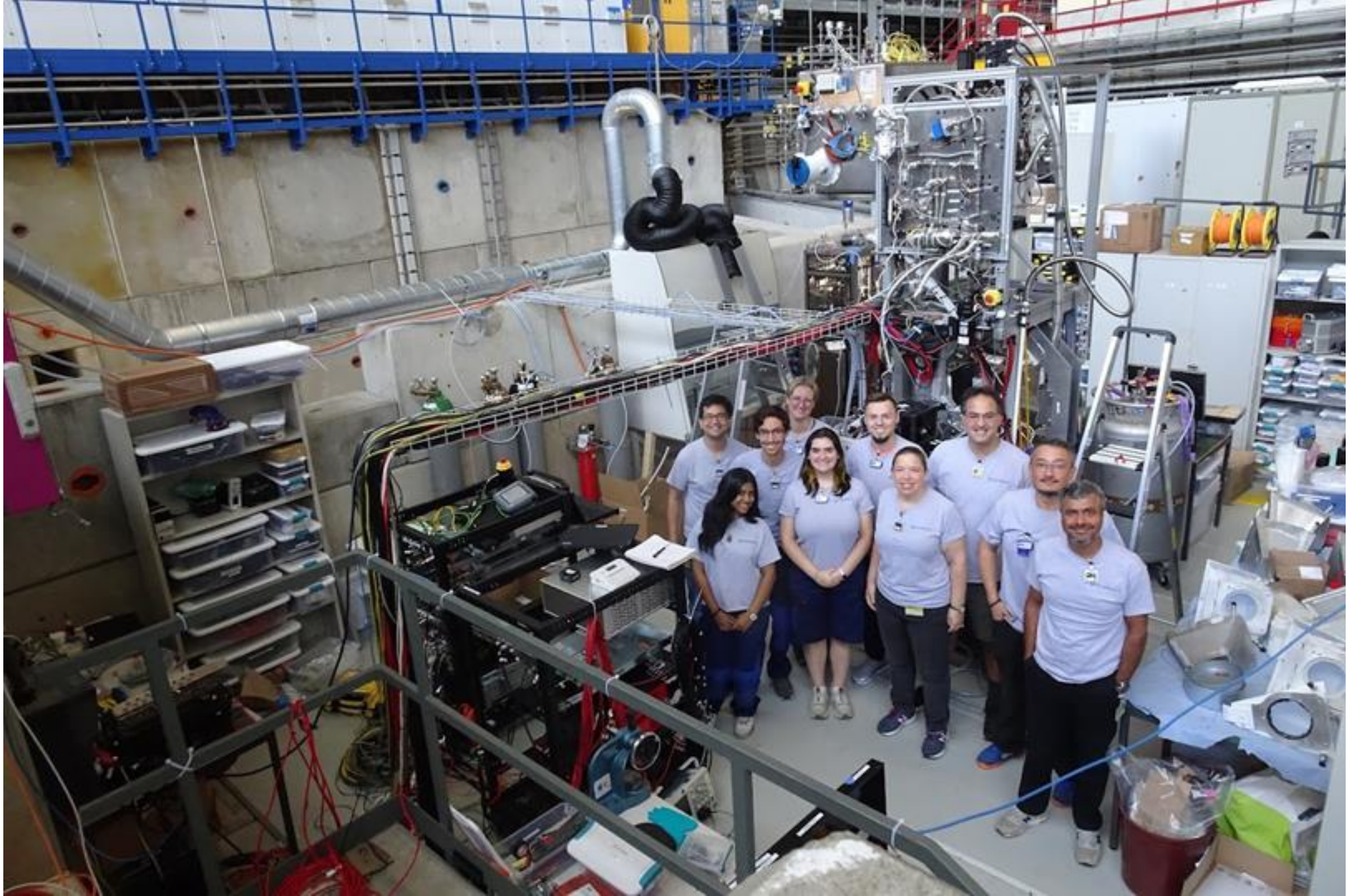
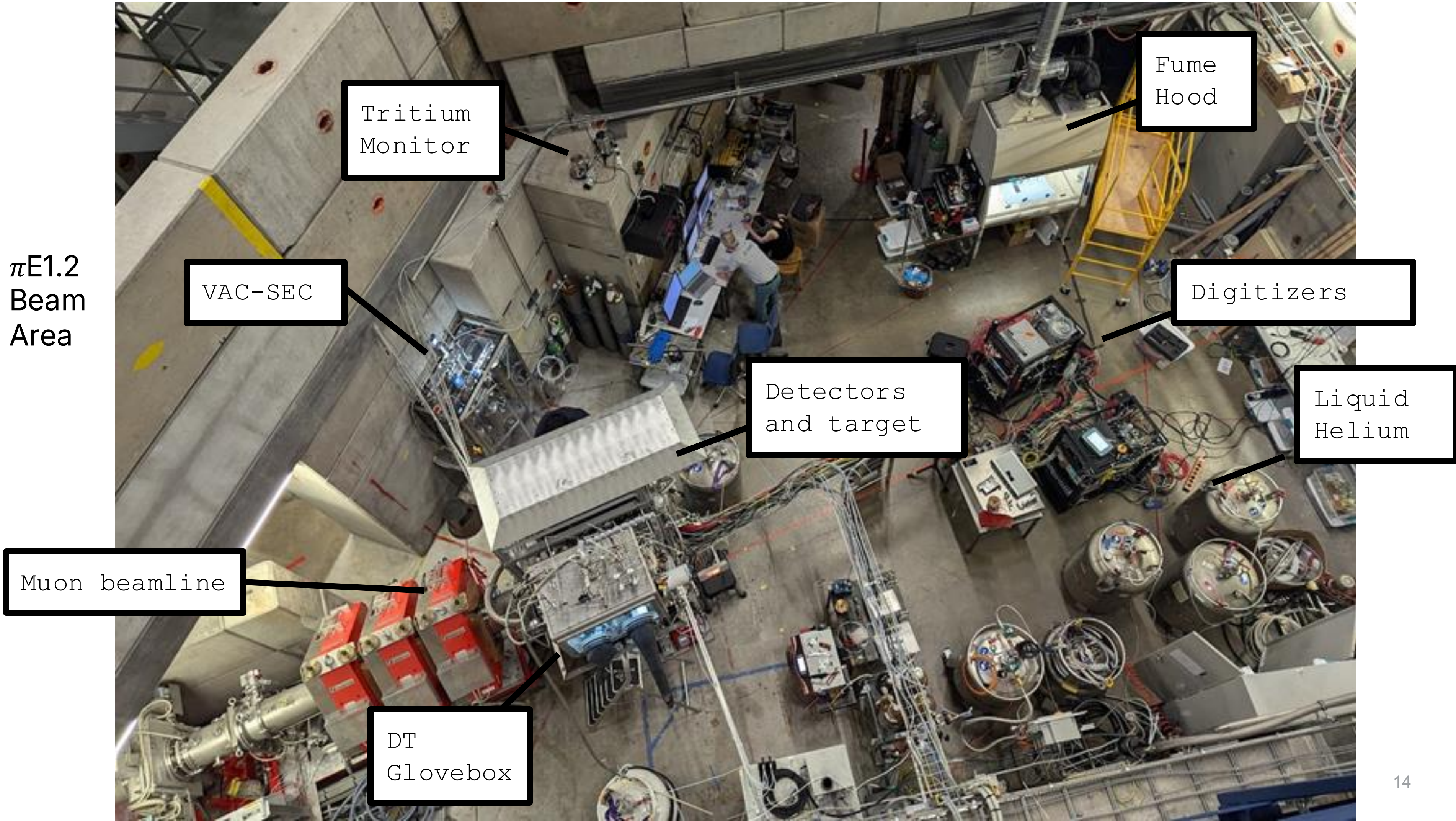
Design overview



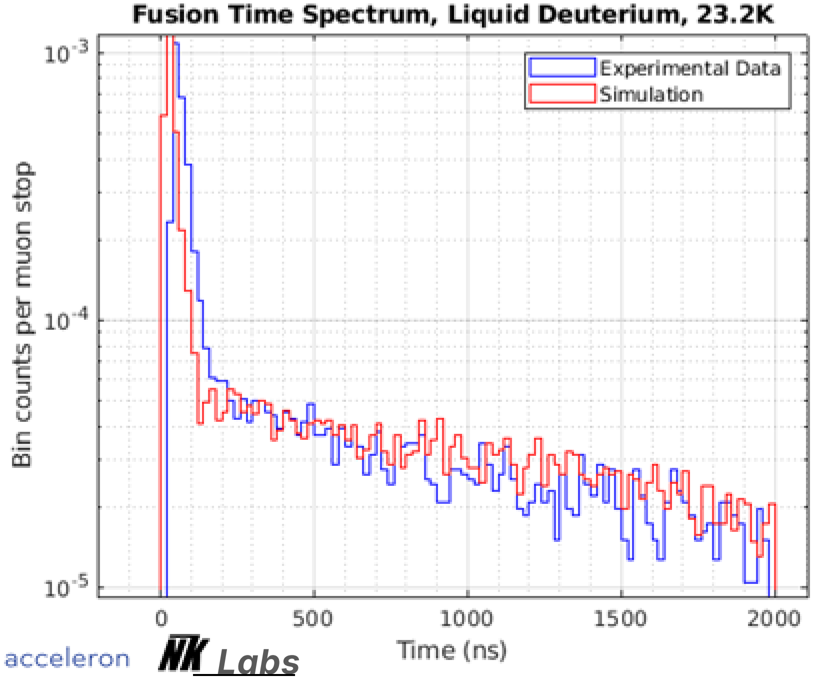


πE1.2 Beam Area

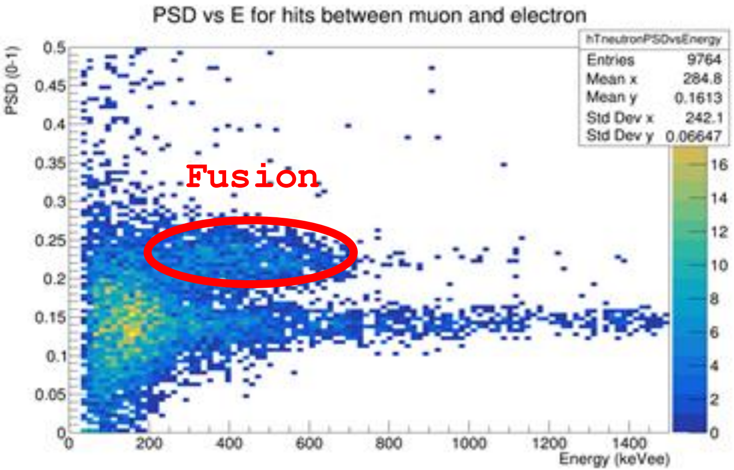


Results

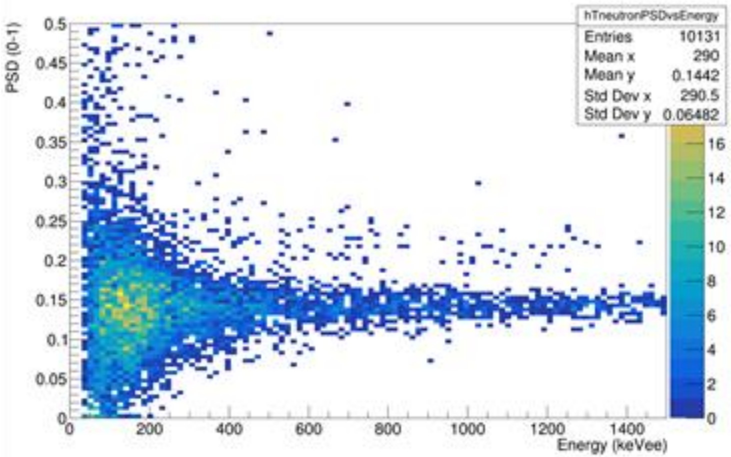
Neutron detection between the muon and electron



Liquid Deuterium



Liquid Hydrogen



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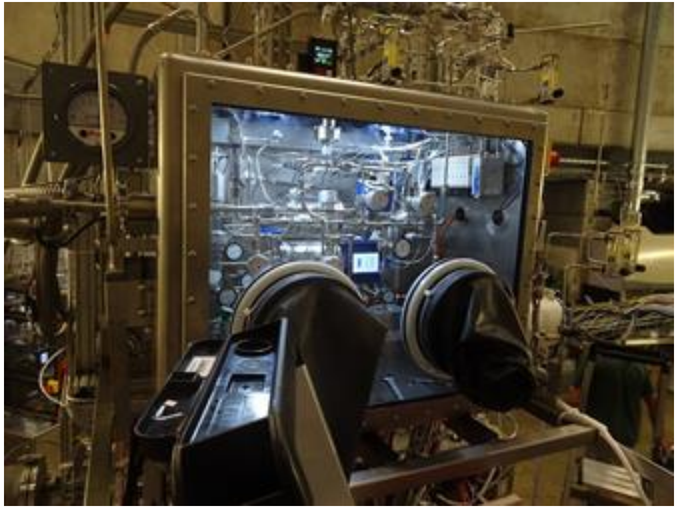
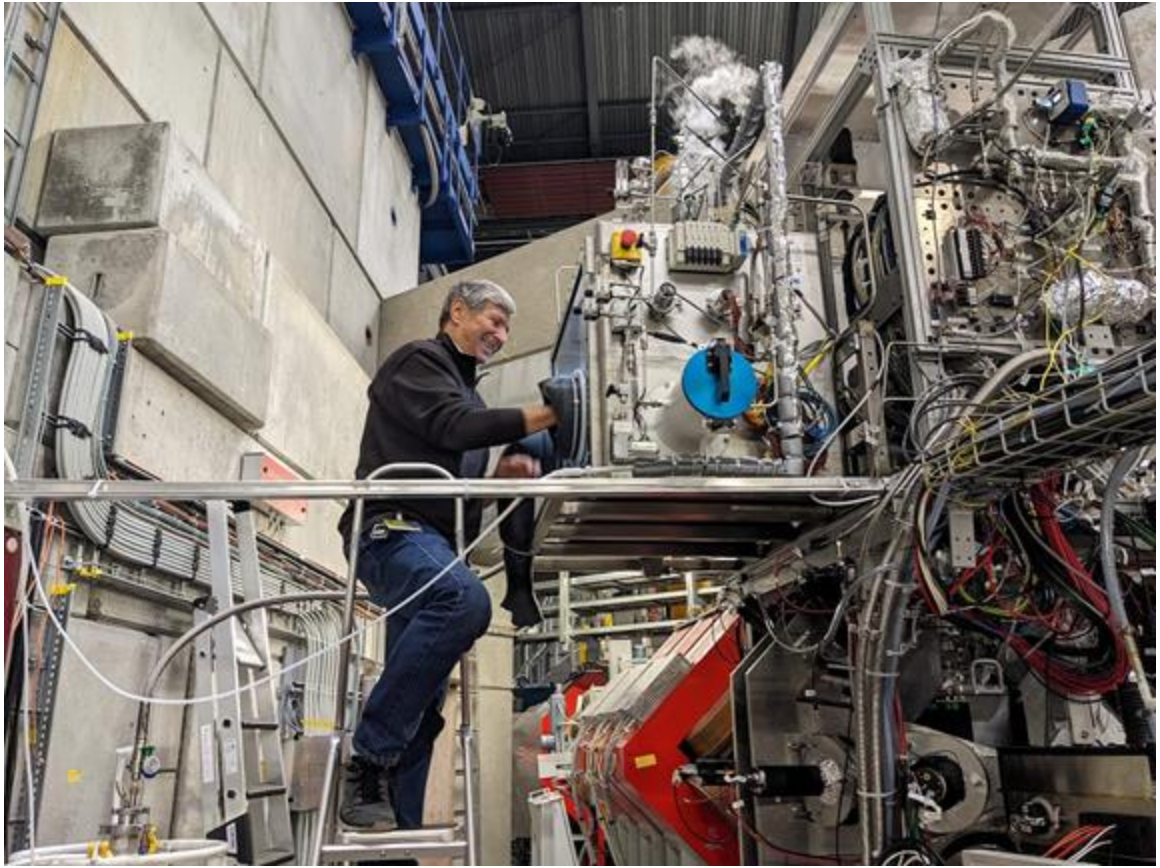
Materials and Methods

Loading the tritium into the U-beds





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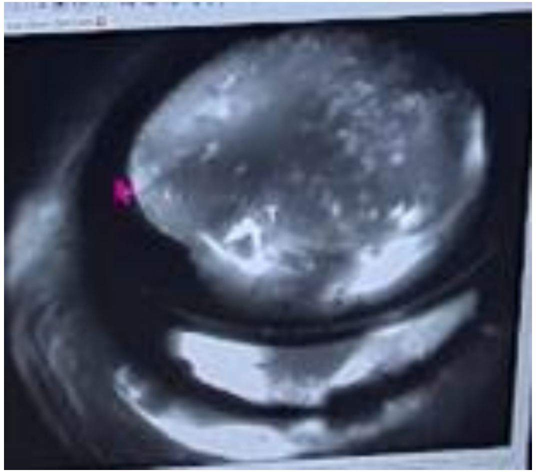
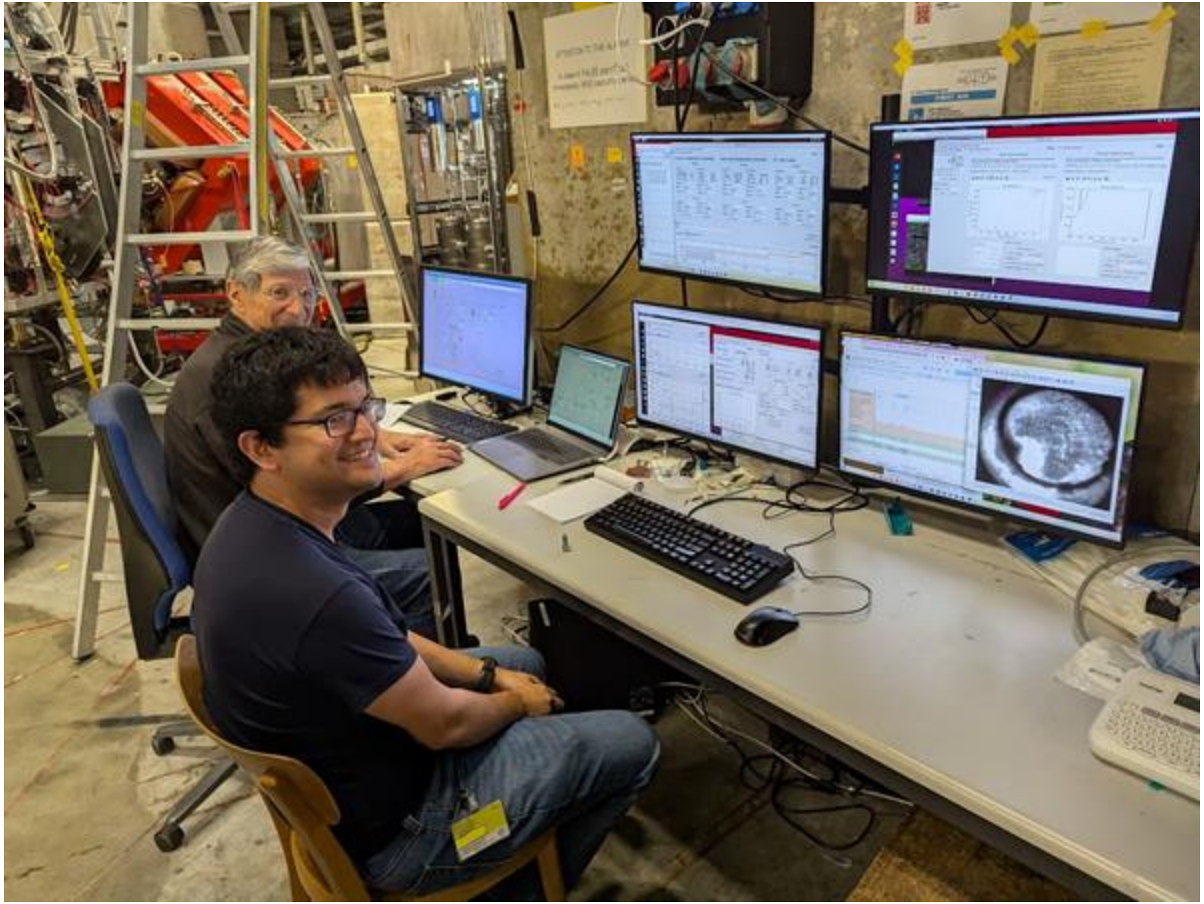
Materials and Methods

Loading the cell with liquid DT





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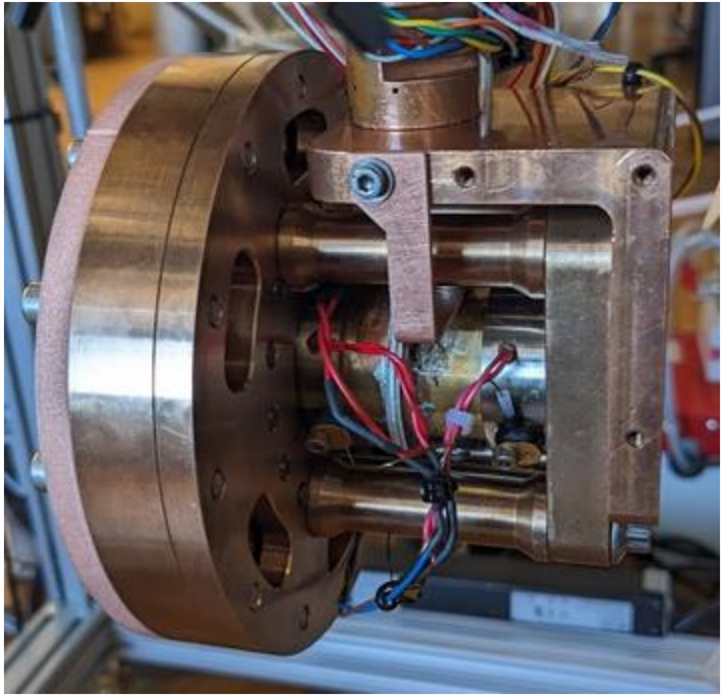
Results

In-system compression of **liquid hydrogen** (2024)

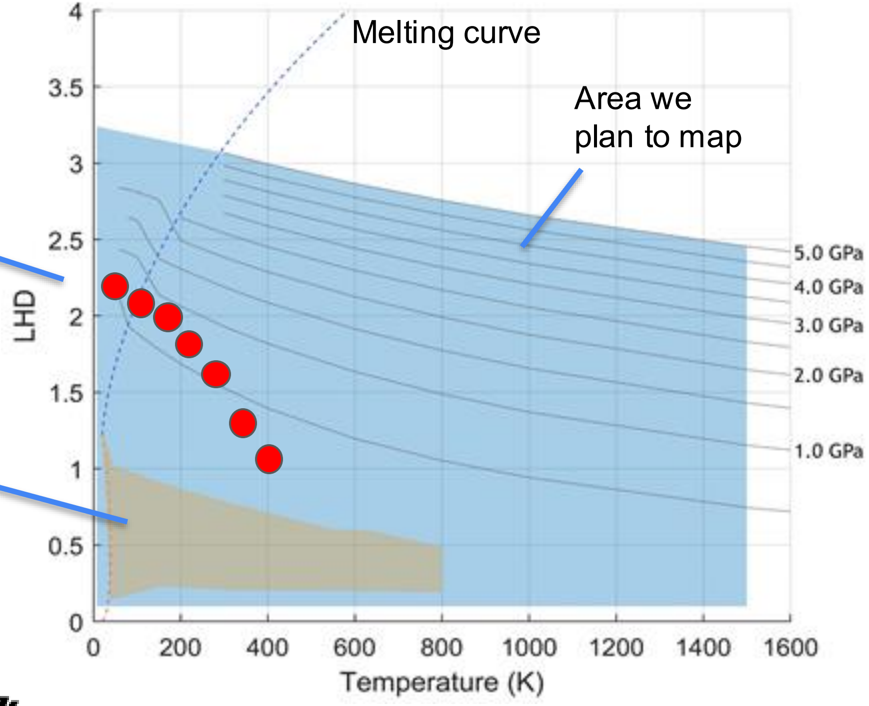
- Compression of the liquid DT to a solid
- Heat the DT sample under pressure to return it to a high density fluid

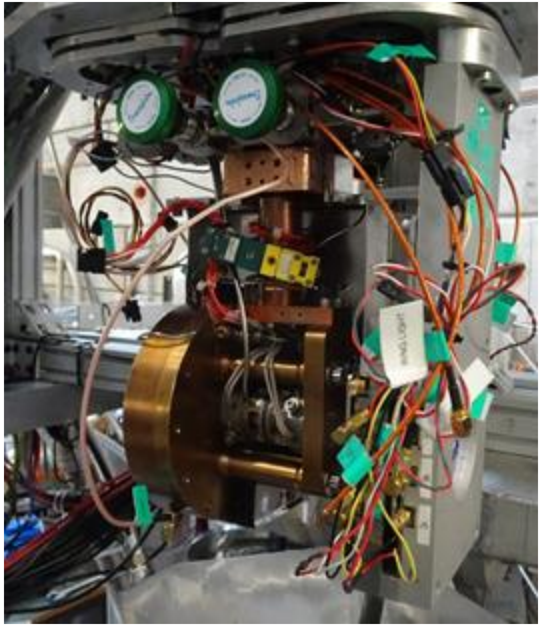


Pressure and temperature reached

Oct 2024 run with 60/40 DT

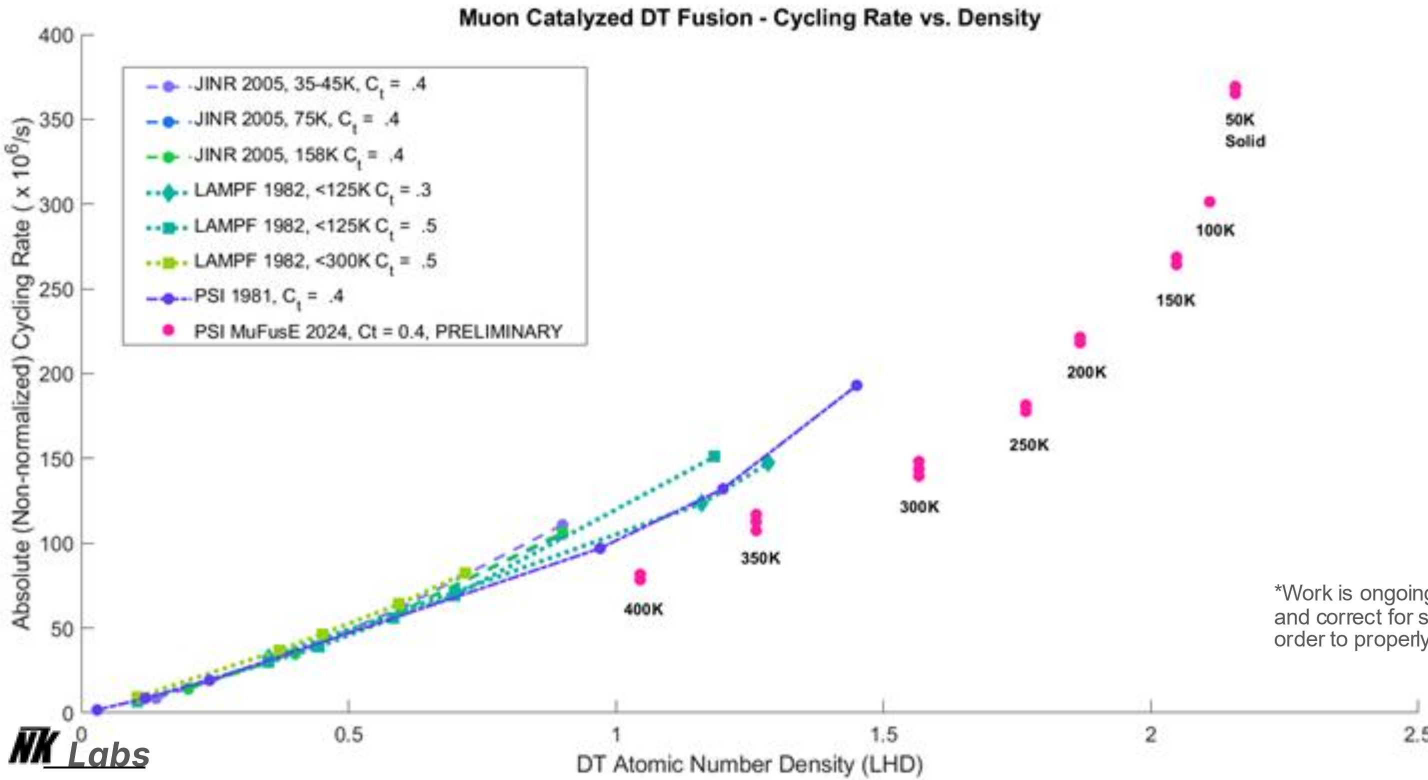
Range previously measured





Diamond anvil cell

PRELIMINARY data on DT cycling rate to 2.2 LHD (2024)

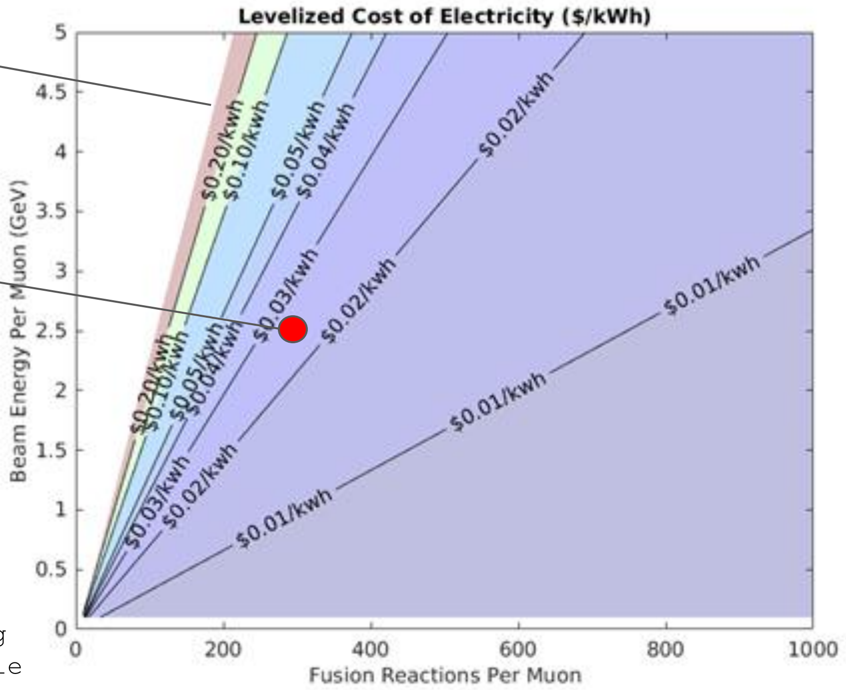


*Work is ongoing to characterize and correct for systematic errors in order to properly size the error bars

Cost of electricity versus physics parameters

Engineering breakeven

Target operating point for a reactor



(Using a superconducting accelerator, Brayton cycle balance of plant, and revenue from heat sales.)

Cost of baseload power by source, $/kWh (1)

Coal
$0.089
Biomass
$0.077
Nuclear fission
$0.071
Gas:
$0.043

Target operating point:
Fusion (?):
$0.025

(1) Levelized Costs of New Generation Resources in the Annual Energy Outlook 2023, US Energy Information Administration, Document #AEO2023

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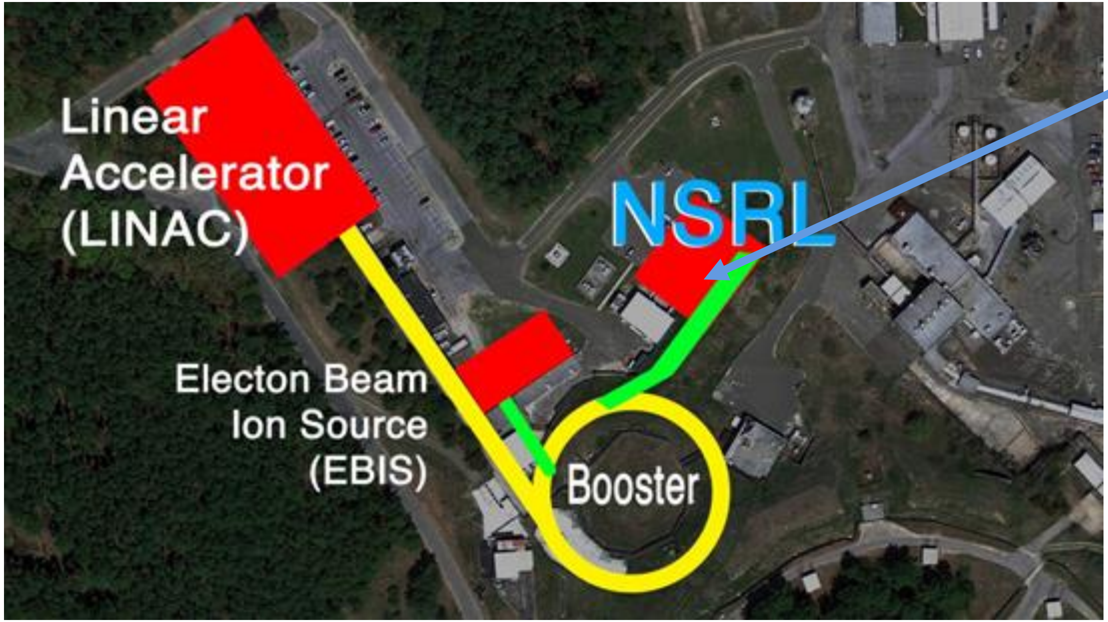
Energy breakeven test at Brookhaven in five years



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