



High-Power Targetry R&D for Next-Generation Accelerator Facilities

Frederique Pellemoine

Fermilab ACE Science Workshop

14-15 June 2023

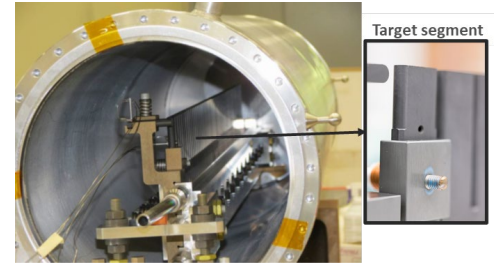
Critical Need for Robust High-Power Targets

Recently, major accelerator facilities have been limited in beam power not by their accelerators, but by target survivability concerns

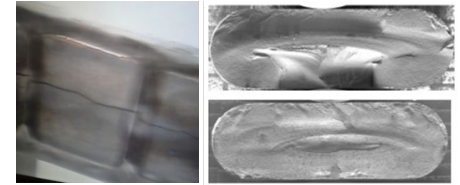
- Timely HPT R&D research is essential to optimize the performance, the reliability and operation lifetimes of target components as beam power and intensity increase
 - High Power Targetry includes all beam intercepting devices (targets, beam windows, beam absorbers, collimators, ...)

The Leading Material Challenges to Address...

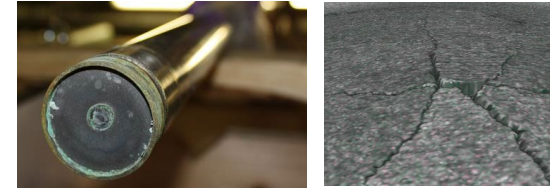
- **Radiation Damage:** affects material properties and target lifetime by disrupting the lattice structure
- **Thermal Shock:** Sudden energy deposition from pulsed beam generates dynamic stress waves that leads to target failure
- **Thermal Fatigue:** Cyclic loading progressively damages the material's microstructure that leads to premature target failure



Graphite neutrino target (NOvA MET series)



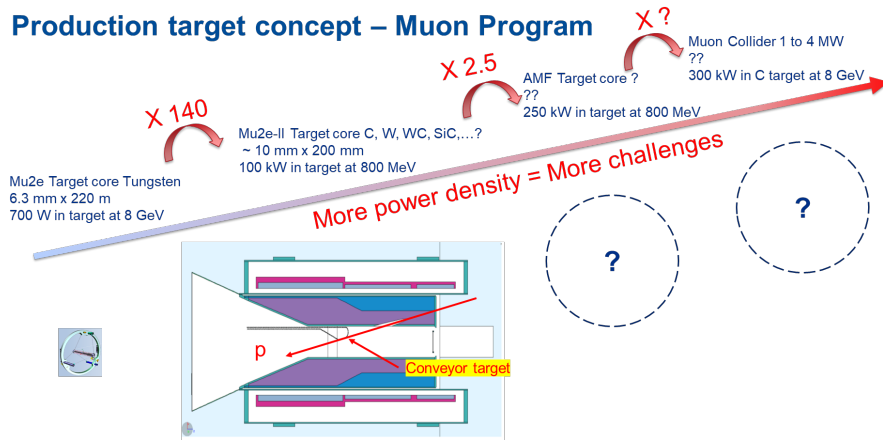
MINOS NT-02 target failure:
radiation-induced swelling (FNAL)



Beryllium window embrittlement (FNAL)

High Power Targetry R&D Roadmap (draft)

Production target concept – Muon Program



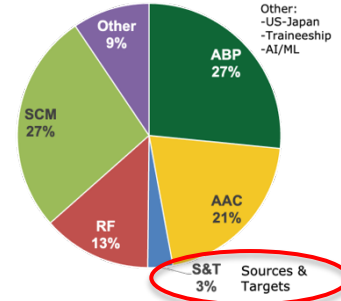
Workshop – April 11-12 2023

- Target can't be directly transferred from one application to another
 - Need specific and significant R&D for each target components
- HPT R&D cycle up to 10 years based on current supports
 - HPT R&D needs to start now with more resources to enable and support future HEP experiments

High Power Targetry Needs

GARD Research By Thrust

\$56.4M



- **Current HPT R&D approach based on 4 topics**
 - Directed R&D to be applied for each projects
 - **In-Beam irradiation**
 - Irradiation time can be very expensive (~\$1M for 4 weeks of irradiation at BNL-BLIP, not enough to replicate radiation dose relevant for future accelerator)
 - Long-term generic R&D that will also benefit other applications
 - **Alternative Methods** to emulate high energy proton irradiations for accelerated and cost-effective material screening
 - **Explore new materials** with enhanced thermal shock and radiation damage resistance
 - **Modeling** to predict fundamental response of various materials to extreme environment and irradiation
- GARD (including US-JP) = \$1.7M (to FNAL: 2.25 FTE + ~\$270k M&S) - **3% of the budget only**
 - **Currently supports only Neutrino Program**
 - Need more support for each project
- **We need to ramp up activities to fully respond to the needs for next generation accelerators**
- **Recommendations to P5 to fully respond to the needs for next generation accelerators**
 - **More resources to fully support R&D:** directed (In-beam studies) and generic R&D (alternative methods, novel materials and modeling)
 - **Develop more capabilities to support HPT R&D:** Post Irradiation Examination (PIE) and irradiation station
 - **Strengthen the high-power target community** through the RaDIATE collaboration and High-Power Targetry workshop.
 - **Develop Synergy with other communities facing similar challenges:** Accelerator Driven Systems and nuclear Energy and Nuclear Physics communities