LATEST ADVANCES IN TARGETRY SYSTEMS AT CERN AND EXCITING AVENUES FOR FUTURE ENDEAVORS

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Introduction

- Target systems' comprehensive design and consolidation are vital for supporting CERN's physics program and adhering to radiation protection practices.
- During LS2 (2018-2021), upgrades were done to ensure safe and reliable operations in AD-T and n_TOF facilities, focusing on mechanical system reliability and radiation protection.
- The HI-ECN3 project, to commence TDR in 2024 and operate by 2030, will bring a new high-intensity and high-power target system. One of two candidates from the Physics Beyond Collider Study Group proposals is to be selected.
- This contribution outlines the outcomes of LS2 consolidation for AD-Target and n_TOF Target systems and previews plans for these and upcoming target facilities at CERN.

n_TOF Target

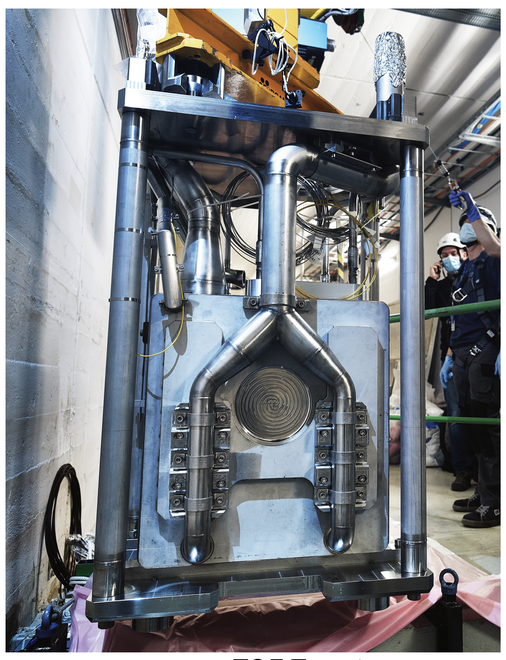
- The n_TOF facility uses about 15% of the complex protons for neutron-induced capture, fission, and cross-section measurements in various scientific domains.

Beam parameters

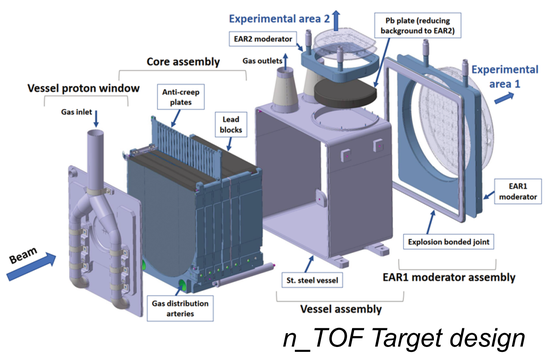
- 10^{13} ppp at 20 GeV/c, 7 ns (1σ) pulse length, 15x30 mm^2 (1σ) beam size, 5.3 kW beam power.

Studies

- Lead operates in cyclic-plasticity at 135 °C.
- Extensive characterisation of the non-linear temperature-dependant kinematic hardening behaviour of pure lead.
- Constitutive model to estimate dynamic stress-strain response and low-cycle fatigue and creep phenomena via FEM analysis.
- Extensive CFD to optimise the target cooling.
- HiRadMat beam irradiation tests.



n_TOF Target



n_TOF Target design

3rd generation design

- Core made of six slices of pure Pb (1.5 tonnes).
- N_2 cooled.
- Aluminium cradle and plates for optimized N_2 flow distribution and to reduce creep.
- Stainless steel vessel.
- Bi-metallic explosion bonding transition to join vessel with moderators.

Plans

- Demand for higher average beam power and precise pulse conditions.
- Potentially liquid lead for the 4th generation. Synergies with (FCCee and IMCC).

AD-Target

- The AD-target area is a dedicated underground facility supplying antiprotons to the Antiproton Decelerator facility, notably the ELENA ring.

AD-Target and Horn trolley systems

Beam parameters

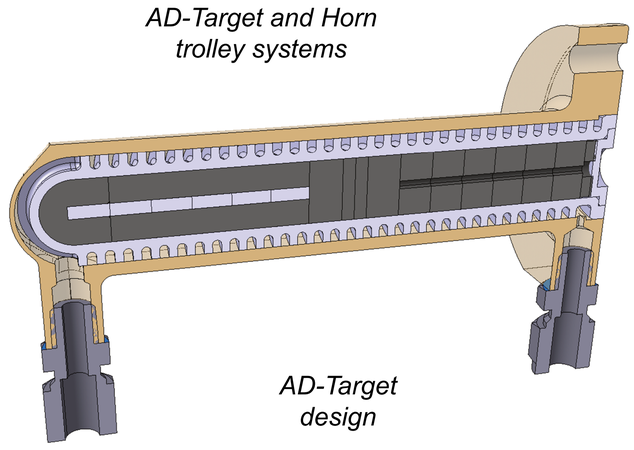
- 1.5x10^{13} ppp at 26 GeV/c, 0.5 μs (1σ) pulse length, 0.5x0.5 mm^2 (1σ) beam size, 1 kW beam power.

Design

- Iridium core (D3 mm).
- Graphite matrix (D15 mm).
- Air cooled.

Studies

- Maximum temperature of 2000 °C.
- compression-to-tensile pressure waves, potentially above the material spall limit.
- FEM modelling with hydrocodes.
- HiRadMat beam irradiation tests.



AD-Target design

Plans

- Increase of the PS pulse intensity, profiting from the LIU upgrades.
- Due to challenging conditions, it is foreseen to exchange the production target on yearly basis with other refractory based advanced design concepts.
- PIEs to understand the behaviour and support design improvements.
- New horn designs and testing aiming at increasing the antiproton yield.

High Intensity ECN3

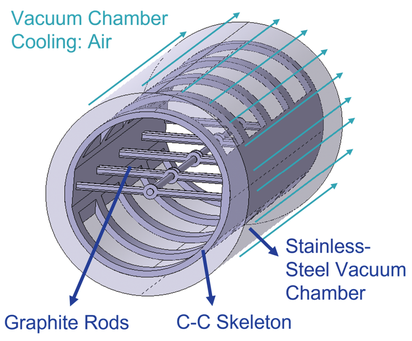
HIKE/SHADOWS

Explore kaon beams and beam dump physics.

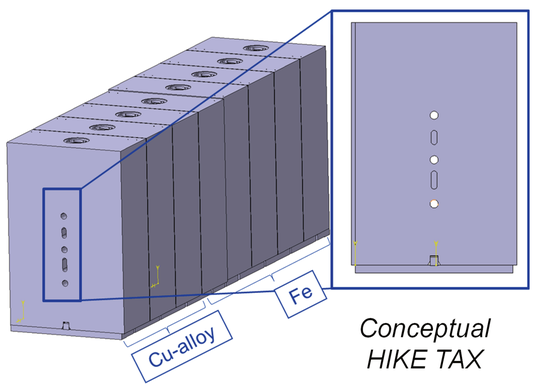
- 100 kW range target complex
- 2.0x10^{13} ppp at 400 GeV/c every 14.4 s.

Production Target & TAX

- Radiation-cooled graphite target or He-cooled beryllium for the production of hadrons.
- TAX (Target Attenuator for eXperimental areas) system. Series of Cu-alloy and Fe blocks, designed with various aperture configurations and the capability to serve as a beam dump or collimator, depending on the operational setting.
- TAX requires enhanced cooling system, possibly a CuCrZr absorber with SS Hot-Isostatically-Pressed (HIPed) cooling pipes, resembling CERN's SPS Internal Dump (TIDVG5).



Conceptual HIKE Target



Conceptual HIKE TAX

Systems

- ALARA driven, shielding volume about 150 m^3 of cast iron and 600 m^3 of concrete and marble, spanning about 27 m.
- Possibility of reusing already activated blocks from different spent CERN facilities, aligning with CERN's sustainability goals.
- Maintenance and handling capabilities, including full remote handling of components.

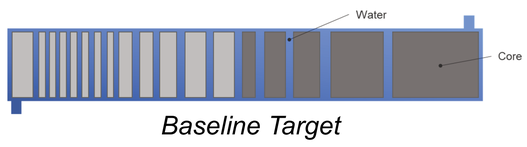
BDF/SHiP

Production of charmed mesons and other weakly interacting particles for hidden sector physics.

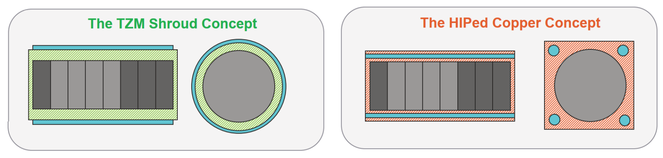
- 350 kW range beam dump / production target.
- 4.0x10^{13} ppp at 400 GeV/c every 7.2s. 4.0x10^{19} p/year.

Production Target

- Refractory core made of discs of TZM (Mo-alloy) and W.
- (*Baseline design*) Discs cladded with Ta2.5W via HIP to avoid erosion, corrosion, and embrittlement when in contact with the water cooling.
- Target housed in a He-filled vessel for leak detection.
- (*Alternative designs*) Ongoing studies aiming at maximising the amount of tungsten in the core. Possibly compact configuration where cooling is done on the outer diameter via an external mechanically robust shroud. Besides advantage of reduced target length.



Baseline Target



Alternative concepts

Systems

- Hadron absorber and magnetic muon shield positioned downstream of the target to minimise background particles to the experiment.
- The overall shielding assembly incorporates about 180 m^3 of cast iron and 360 m^3 of concrete and marble. Special effort to reuse activated blocks at CERN.
- Both the target and the proximity shielding inside the tank can be remotely extracted via a trolley system.
- Proximity shielding and target are housed within a primary vacuum tank to reduce air activation and radiation accelerated corrosion.

Conclusions

- The next few years will see the operation of new-generation targets alongside consolidated infrastructure at the n_TOF and AD-T facilities at CERN.
- Extensive design studies, material characterisations, computational modelling, and benchmarking through beam tests have been conducted to guarantee their operational reliability.
- Studies for future upgrades and a new high-power fixed target will ramp up.

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