Targetry for a Muon Collider or Neutrino Factory

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A key technical issue for both a muon collider or neutrino factory is the production and collection of a sufficient number of muons to render the facility useful. A promising solution has been developed in which copious soft pions of both signs are first produced off a high-Z target, captured in a high-field (≈20 T) solenoid, and then subsequently conducted into a solenoidal decay channel where the muon-decay products from the pions are collected. This strategy possesses many unique features which present challenges to be addressed before such a target system can be implemented. Some key issues include:

1) The target should be high-Z to maximize the production of soft pions of both signs.
2) The target should be long and narrow to maximize showering while minimizing re-absorption of the produced pions.
3) The number of incoming protons required to initiate the process leads to the requirement of a multi-megawatt (2 to 4 MW) beam.
4) A high-Z target coupled with a MW class proton beam leads to high local energy deposition and hence disruption of the target. For a high rep-rate system the target must be continually replaced.

These considerations lead to a solution based on a liquid-jet target. Coupled with the desire for a high-Z target material one is led to consider mercury, or possibility PbBi eutectic alloy, as the target material of choice. The choice of liquid metals, however, leads to the requirement for an evaluation of the dynamics of a moving liquid metal jet in within the confines of a high field solenoidal magnet. These jet-dynamics issues are been addressed through a program of magnetohydrodynamics simulations and experimentation. The experimental program has been headed by the E051 AGS experiment at BNL and the MERIT (nTOF11) experiment at CERN. Key results for these two experiments are:

1) A 20m/s jet velocity is adequate to support a 50-Hz rep-rate.
2) The magnetic field serves to stabilize the surface instabilities of the moving jet.
3) The disruption of the mercury jet resulting from sudden energy deposition from the proton beam/jet interaction is largely transversal in nature and does not extend along the axis of the jet.
4) The disruption is sufficiently slow to support multiple proton bunches over a 350 μs interval without a noticeable loss of pion-production efficiency.
5) Proton beam powers up to 7 MW can be accommodated.

The success of the two beam experiments leads us to declare that the core concept of a high-power target system based on a liquid jet within strong magnetic field has been validated. It now remains to translate this proven concept into a target system which can support the required beam power. The principle remaining technical issues include:

1) Design a shielding system capable of protecting the superconducting coils which are required for generating the 20 T capture field.

2) Design a nozzle system capable of delivering improved performance for a 20m/s jet.
3) Design a mercury handling system capable of sustained CW operations.
4) Design a mercury pool beam dump system capable of intercepting both intense proton beam pulses and the unspent mercury jet.