High-Power Targets for a Neutrino Factory

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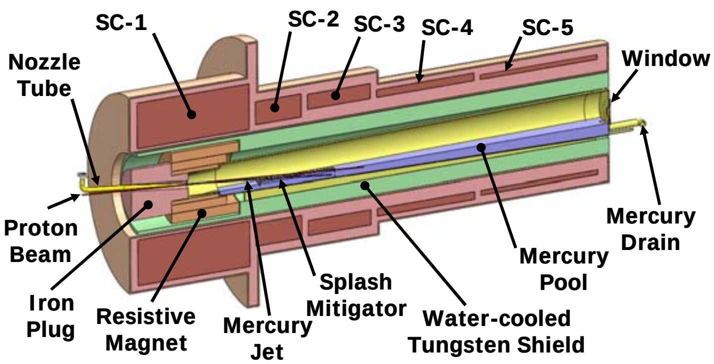
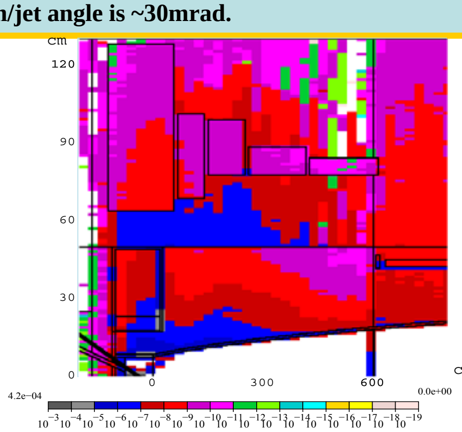
While the principle of a liquid-metal jet target inside a 20-T solenoid has been validated by the MERIT experiment for beam pulses equivalent to 4-MW beam power at 50 Hz, substantial effort is still required to turn this concept into a viable engineering design. We are embarking on a multi-year program of simulation and technical design for a 4-MW target station under auspices of the International Design Study for a Neutrino Factory.



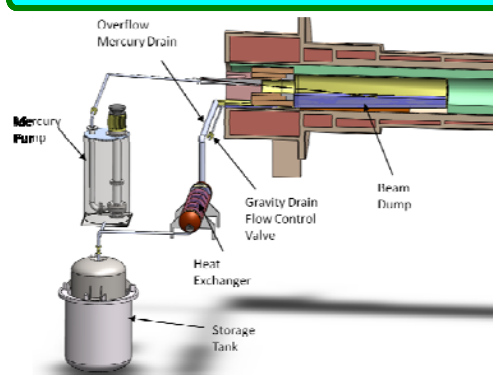
Concept of a continuous mercury jet target for an intense proton beam. The jet is tilted by 100mrad with respect to a 20-T solenoid magnet that conducts low-momentum pions into a decay channel. The beam/jet angle is ~30mrad.



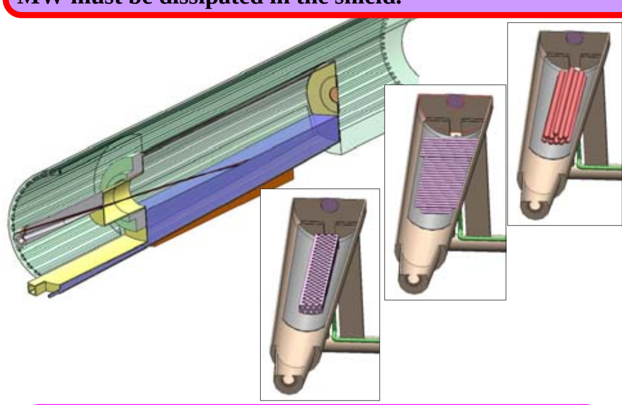
Above: Energy deposition in the superconducting magnet and the tungsten-carbide shield inside them. Approximately 2.4 MW must be dissipated in the shield.

Item	Neutrino Factory IDS	Comments
Beam Power	4 MW	No existing target system will survive at this power
E_p	5-15GeV	π yield for fixed beam power peaks at ~ 8GeV
Rep Rate	50 Hz	Lower rep rate could be favorable
Bunch width	~ 3 ns	Very challenging for proton driver
Bunches/pulse	3	3-ns bunches easier if 3 bunches per pulse
Bunch spacing	~ 100 μs	Disruption of liquid target takes longer than 200 μs
Beam dump	< 5 m from target	Very challenging for target system
π Capture system	20-T Solenoid	High field solenoid "cools" rms emittance
π Capture energy	$40 < T_\pi < 300$MeV	Much lower energy than for ν Superbeams
Target geometry	Free liquid jet	Moving target, replaced every pulse
Target velocity	20m/s	Target moves by 50 cm ~ 3 int. lengths per pulse
Target material	Hg	High-Z favored; could also be Pb-Bi eutectic
Target radius	4 mm	Proton beam σ_r = 0.3 of target radius = 1.2 mm
Jet angle	≈ 100mrad	Jet Angle is relative to the axis of the solenoid
Beam angle	≈ 30mrad	Beam/jet angle of 30mrad, ⇒ 2 int. lengths
Dump material	Hg	Hg pool serves as dump and jet collector
Magnet shield	W-C beads + water	Shield must dissipate 2.4 MW; could be Hg

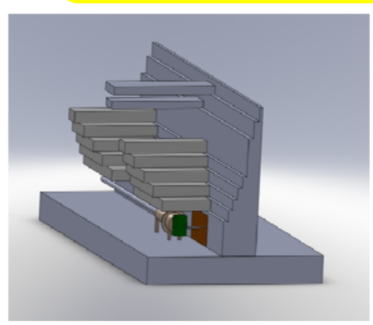
Above: Baseline Parameters for the target system.

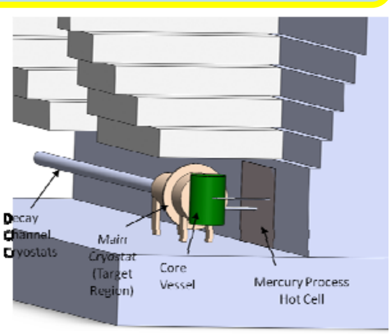


Above: A major challenge is incorporation of the proton beam dump Inside the superconducting magnet cryostat. The mercury collection pool can serve as this dump.



Above: Splash mitigation options for the mercury collection pool/beam dump, which will be disrupted by both the proton beam and mercury jet.





Above : The major cost driver of the target system is the civil construction of the target vault – with hot cells and remote handling manipulators.