The Target System Baseline

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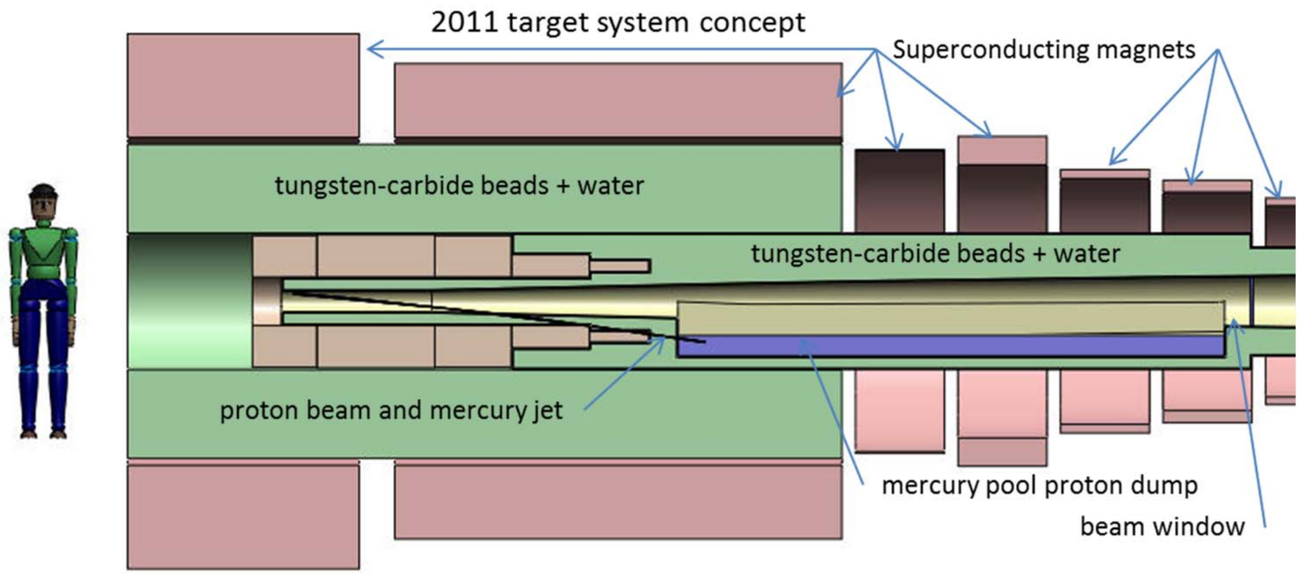
More extensive commentary at
http://www.hep.princeton.edu/~mcdonald/mumu/target/targettrans80.pdf

Baseline Concept

Present baseline concept is described in

http://www.hep.princeton.edu/~mcdonald/mumu/target/target_baseline_v3.pdf

Present Target Concept



Figures related to the baseline configuration are at

http://www.hep.princeton.edu/~mcdonald/mumu/target/baseline_figures.pptx

Figures by Phil Spampinato from Study 2 are at

http://www.hep.princeton.edu/~mcdonald/mumu/target/phil_figs.pptx

Baseline Proton Beam Parameters

Proton-beam energy	8 GeV
Rep rate (Neutrino Factory)	50 Hz
Rep rate (Muon Collider)	15 Hz
Bunch structure (Neutrino Factory)	3 bunches, 240 μsec total
Bunch structure (Muon Collider)	1 bunch
Bunch width	2 ± 1 ns
Beam radius	1.2 mm (rms)
Beam power	4 MW (3.125×10^{15} protons/sec)

The final focus of the proton beam has been little considered, but its configuration must be compatible with the design (and installation with the target system.

Final Focus

Basic specs of final focus:

Proton beam energy = 8 GeV.

Transverse, geometric emittance = 5 μm (rms) = σ^2 / β^*

https://www.ids-nf.org/wiki/FrontPage/Documentation?action=AttachFile&do=get&target=IDS-NF-020-v1.0.pdf (p. 224)

Spot size, σ = 1.2 mm (rms).

β^* = 30 cm.

Beam divergence, $\sigma_\theta = \sigma / \beta^*$ = 4 mrad

Air gap(?) in proton beam between end of final-focus system and target system. Can the radioactive air-handling system deal with the resulting activation of air?

Can this gap be long enough that the target system could be (dis)assembled with the final-focus system in place?

Example: if want last quad at z = - 10 m, beam σ = 4 cm, so a 5-σ clearance requires the bore of the quad to be 40 cm. Is this large bore practical? [Could use a solenoid lens rather than a quad.]

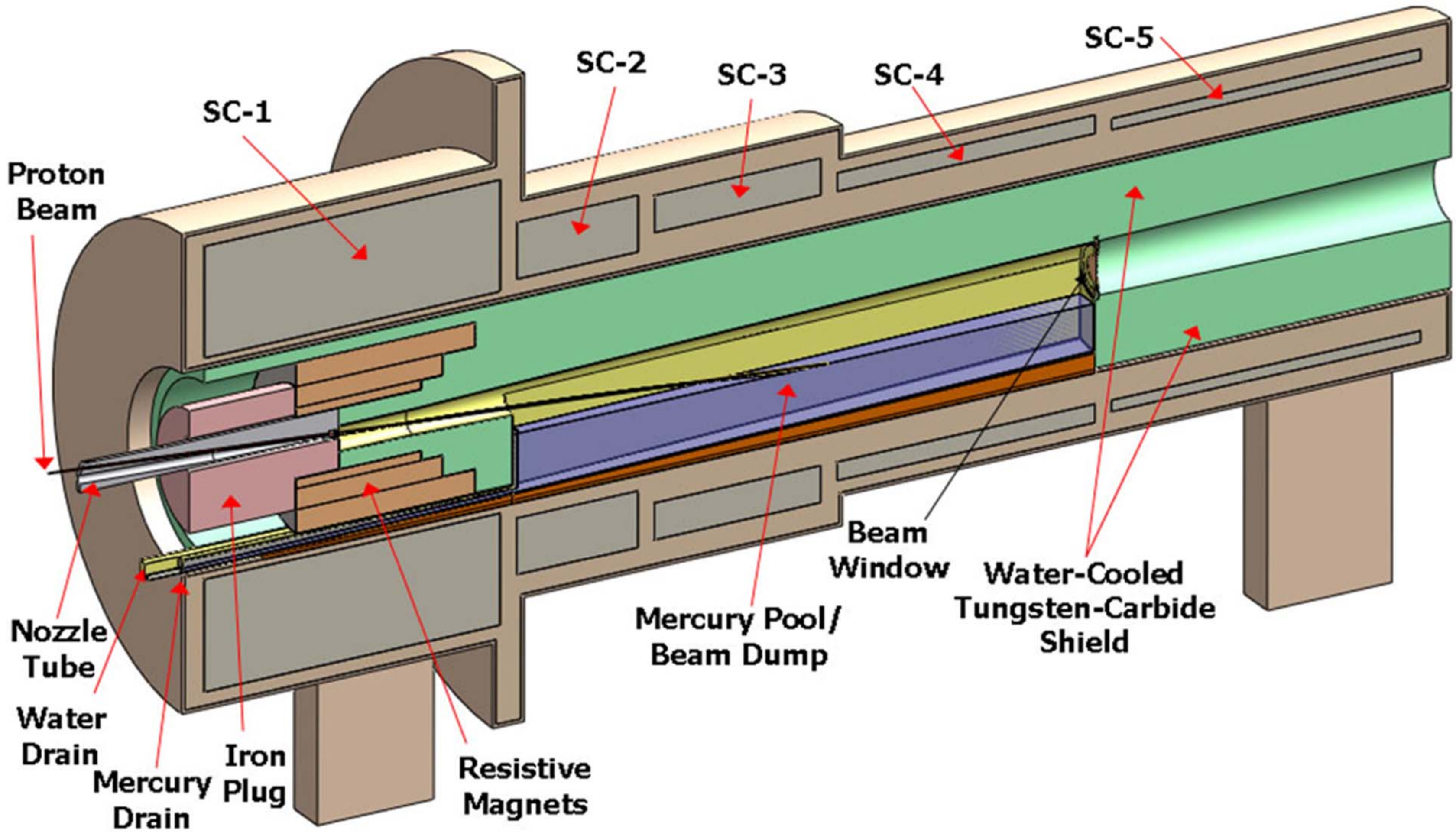
Baseline Target System Parameters

Target type	Free mercury jet
Jet diameter	8 mm
Jet velocity	20 m/s
Jet/solenoid-axis angle	96 mrad
Proton-beam/solenoid-axis angle	96 mrad
Proton-beam/jet angle	27 mrad
Capture solenoid field strength π / μ	20 T
Front-end transport channel field strength	1.5T
Length of transition between 20 T and 1.5 T	15 m

The baseline assumes that a single proton beam impinges on the target.

The option of multiple beams is under consideration.

Target-System Concept from Neutrino Factory Study II

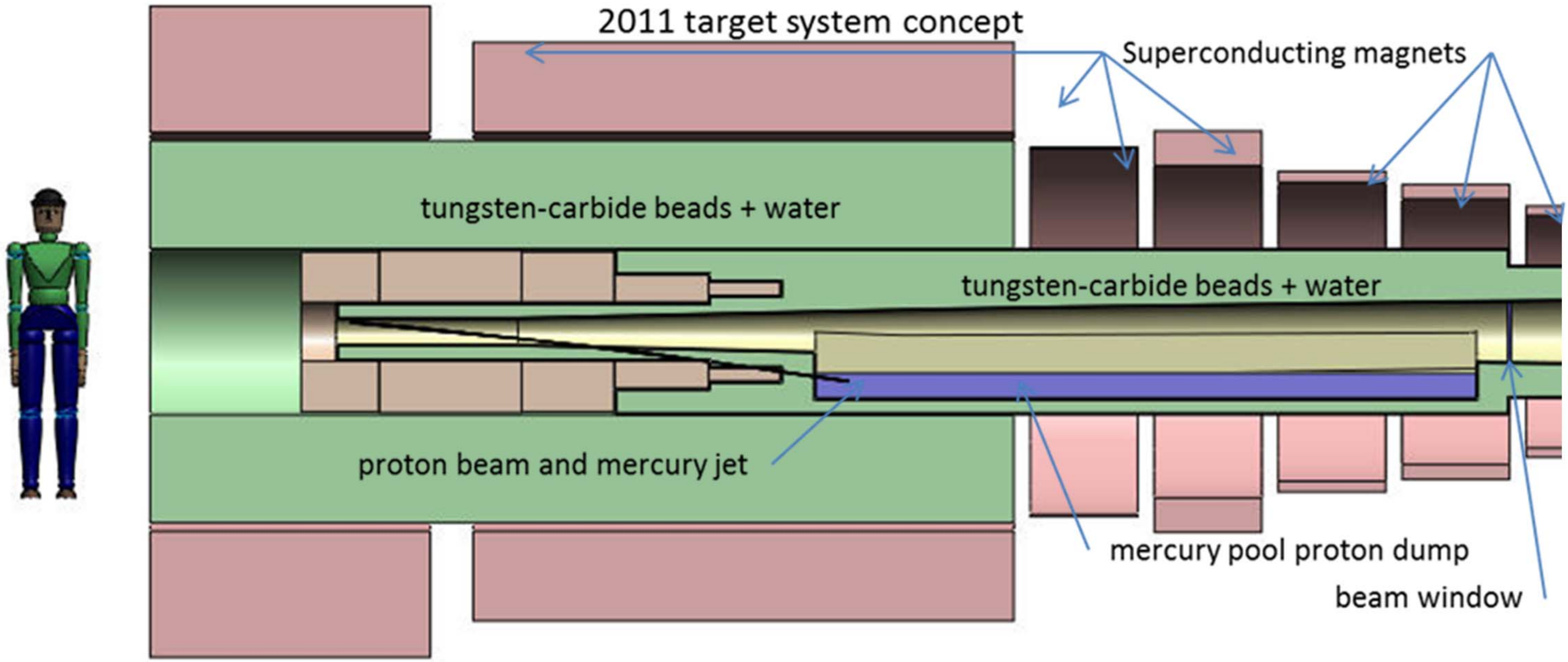


Concept basically sound, but:

Insufficient shielding of superconducting magnets from radiation.

Upstream iron plug to smooth magnetic field makes mechanics of mercury loop very difficult

Present BaselineTarget-System Concept



Much more tungsten carbide shielding.

No iron plug., but longer copper magnet to generate uniform 20-T field on target.

Overview of Mechanical Issues

1. Layout of final-focus (quads, x-y correctors, beam pipe/window).

2. Layout of superconducting magnets and their cryostats (+ quench-protection circuit).

3. Layout of tungsten-carbide (WC) shielding (+ cooling water).

4. Layout of the 6-T copper magnets (+ cooling water and electrical feeds).

5. Layout of the mercury system (nozzle, containment vessel, downstream window, mercury flow return, ….

How do these items fit together? How can they be removed for repair? (Remote handling mandatory.)

No lubricants viable in high-radiation area!

Superconducting Magnets

How are the coils arranged inside cryostats?

Braces against the strong intermagnet forces are simpler if at 4K, $\Rightarrow$ Many coils per cryostat, but then must replace many coils if one fails.

Where will the substantial quench protection system be located?

Will radiation compromise the superinsulation/magnet vacuum?

WC Shields

The WC shields are very massive, and their containment vessels must be reinforced to minimize deformations.

The shields must be assembled inside the magnet cryostat by some kind of sliding support system. However, lubricants must be avoided in the high-radiation environment of the target system.

The cooling-water flow paths must be defined.

6-T Copper Magnet

Can all services (electrical leads and cooling water connections) be on the upstream face of the coils (layer wound)?

How little shielding can there be inside the inner radius of the copper magnets?

N. Mokhov quotes limit of 10^{10} Gy = 100 mW/g for 10 "years" of 10^{7} s each.

http://www-ap.fnal.gov/users/mokhov/papers/2006/Conf-06-244.pdf

How are the copper coils supported?

Mercury System

Needs both primary and secondary containment vessel.

Can the secondary containment vessel be the inner surface of the WC shield?

Need gas between primary and secondary vessel to permit monitor of possible Hg leak ⇒ No water cooling of the primary vessel, ⇒ Need substantial He gas flow!

What is the configuration of the Hg pool, including splash mitigation?

What is the Hg exit flow path?

What is the layout of entrance and exit beam windows?

Removable Target Module

Present thinking is that the mercury vessel must be removable replacement if necessary.

The tapered primary containment vessel is trapped by the copper magnet and WC shield.

⇒ Must be able to remove the mercury vessel, copper magnets, and some/all of the upstream WC shield as a unit, which I call the target module.

Could/should the upstream WC shield consist of concentric subunits, with only the inner subunit being part of the target module?

Could the target module be removed directly upstream, without interference with the final-focus system (which might be removed first)? Or, should some substantial portion of the target system be first movable transversely, followed by axial disassembly?

Should the target module include the entire mercury recirculation system (as at JPARC) or have mercury disconnects (as at SNS)?