The MAP Targetry Program in FY11 and FY12

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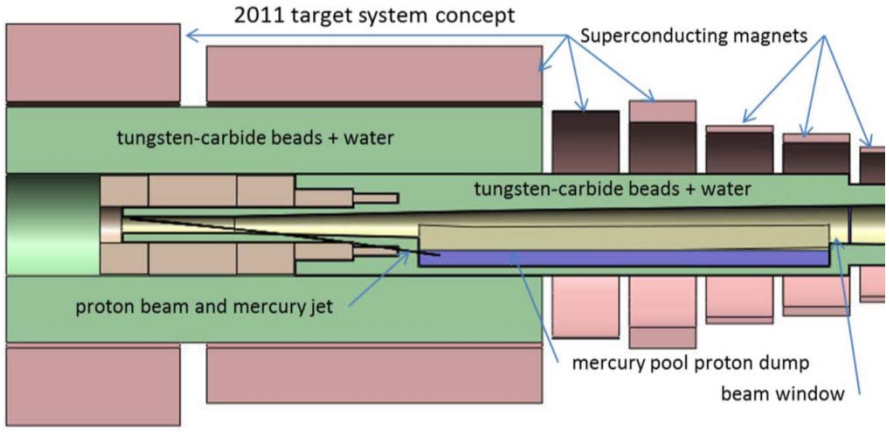
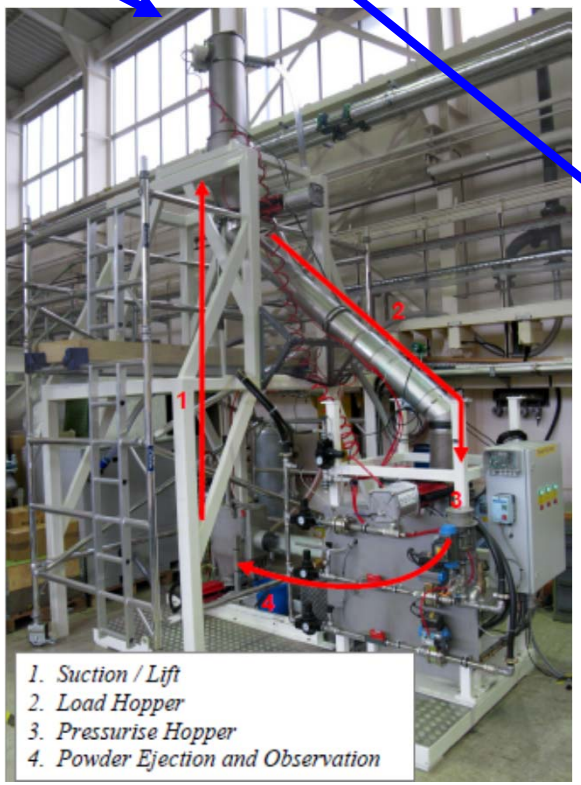
Muon Accelerator Program

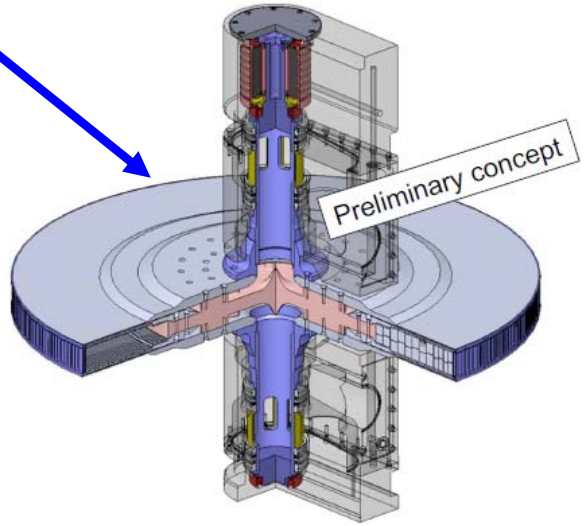
Muon Collider Technical Challenges (3)

- **Target**
  - favored target concept based on Hg jet in 20-T solenoid
    - jet velocity of ~ 20 m/s establishes "new" target each beam pulse
      - magnet shielding is daunting, but appears manageable
  - alternative approaches (powder or solid targets) also being pursued within EUROnu

Hg-jet target (MERIT)







Target and Capture Topology: Solenoid

Desire $\approx 10^{14}$ μ/s from $\approx 10^{15}$ p/s ($\approx$ 4 MW proton beam).

Highest rate μ^+ beam to date: PSI μE4 with $\approx 10^9$ μ/s from $\approx 10^{16}$ p/s at 600 MeV.

$\Rightarrow$ Some R&D needed!

R. Palmer (*BNL*, 1994) proposed a solenoidal capture system.

Low-energy π's collected from side of long, thin cylindrical target.

Collects both signs of π's and μ's,

$\Rightarrow$ Shorter data runs (with magnetic detector).

Solenoid coils can be some distance from proton beam.

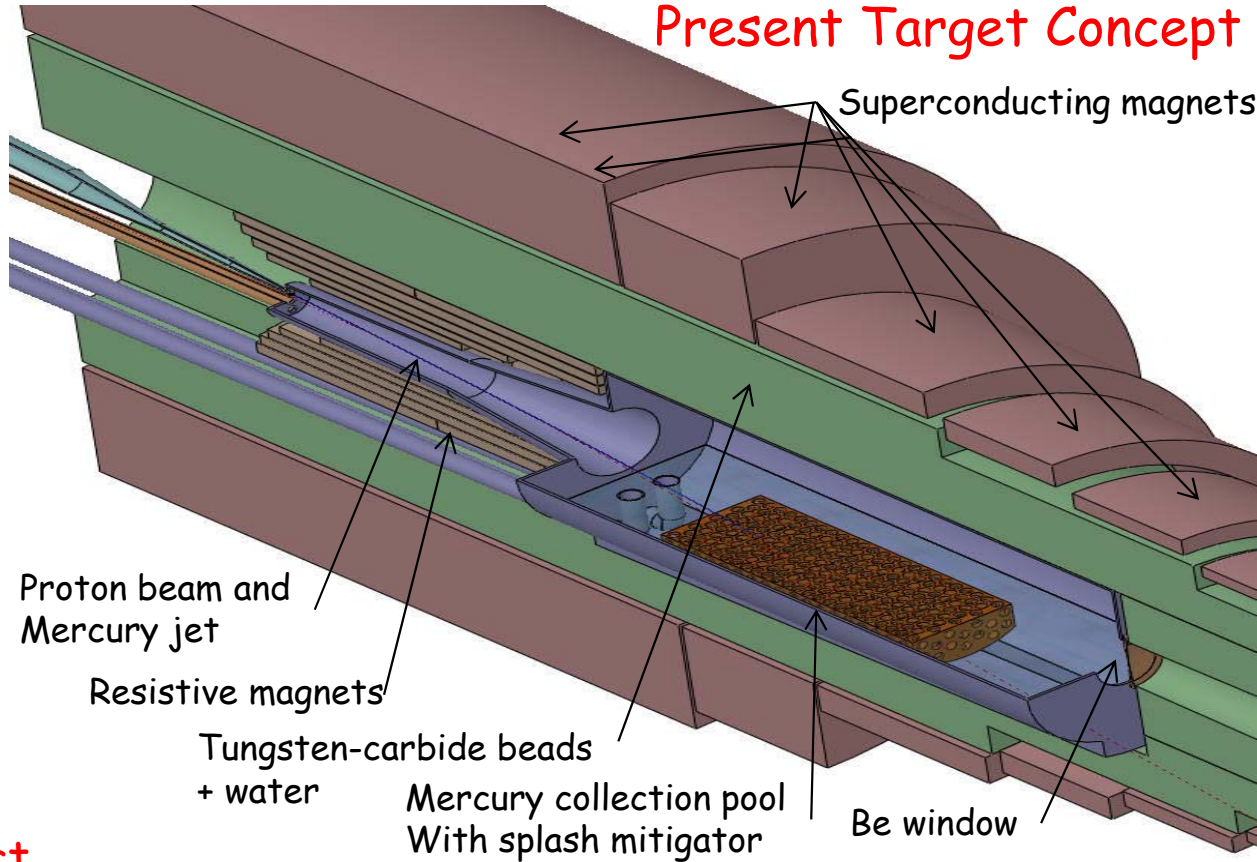
$\Rightarrow$ $\geq$ 4-year life against radiation damage at 4 MW.

Liquid mercury jet target replaced every pulse.

Proton beam readily tilted with respect to magnetic axis.

$\Rightarrow$ Beam dump (mercury pool) out of the way of secondary π's and μ's.

Present Target Concept



Shielding of the superconducting magnets from radiation is a major issue.

Magnet stored energy ~ 3 GJ!

Use of "magnetic bottles" around production targets proposed by Djilkibaev and Lobashev,
http://puhep1.princeton.edu/~mcdonald/examples/detectors/djilkibaev_aipcp_372_53_95.pdf

Targetry Activities in FY11

FY11 Targetry Budget: $410k

- BNL $350K (subcontracts to Ladiende ($50k), Samulyak ($50k), Souchlas $50k, Weggel $100k; Travel)
- ORNL $50k (Complete decommissioning of MERIT expt., begin engineering on baseline mercury flow loop. *Funding only available July 2011*)
- Princeton $10k (Travel)

The major activities in FY11 were related to the realization that the shielding of the superconducting magnets around the target as foreseen in Study 2 would be very inadequate to protect the magnets from radiation damage.

- Mitigation of this issue requires substantially greater shielding, which in turn requires the inner radii of the magnets to be very large (≈ 1.2 m) and the stored energy to be very large (≈ 3 GJ).
- A new baseline document incorporating preliminary understanding of this was released Feb 4, 2011, http://www.hep.princeton.edu/~mcdonald/mumu/target/target_baseline_v3.pdf
- Roughly 100 technical notes/talks expanding on targetry issues were produced in FY11, available at http://www.hep.princeton.edu/~mcdonald/mumu/target/

Supporting activities:

- Particle productions simulations using MARS15 (Ding, Kirk) and FLUKA (Back).
- Energy Deposition/shielding studies using MARS15 (Kirk, Souchlas)
- Magnet and shielding design studies (Weggel)
- Mercury loop design (Graves)
- Mercury pipe flow simulations (Ladiende, Zhan)
- Simulation of interaction of mercury jet with proton beam and magnetic field (Guo, Samulyak, Simos)

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Targetry Activities in FY12

FY11 Targetry Budget: $486k [Distribution 1 = $278k, Distr. 2 = $193k]

- BNL $311K (subcontracts to Ladiende ($50k), Samulyak ($50k), Souchlas $50k, Weggel $100k; New postdoc $100k; Travel)
- FNAL $15k (Mokhov group)
- ORNL $150k (Engineering studies on baseline system, integrating magnet, shield and mercury systems.)
- Princeton $10k (Travel)

The major activities in FY12 will be refinement of the baseline design via engineering studies, to provide cost estimates for the IDS-NF Reference Design Report.

Substantial progress here depends on funding to ORNL (Graves) and Weggel, and would be significantly less if the Distribution 2 funds are not released to the targetry effort.

- While we anticipate that lab tests will be needed to validate the new designs of the mercury nozzle and collection pool (including splash mitigation), we are unlikely to be ready for such tests in FY12.
- The final focus of the proton beam needs a design – with awareness of coupling constraints to the target system.

In addition to elaboration of the baseline design, we should consider alternative scenarios including

- Lower (or higher magnetic field around the target (with possible change in the front-end magnetic field as well). Note that the target magnets provide transverse cooling via emittance exchange.
- Alternative target materials such as liquid gallium or Pb-Bi eutectic, as well as graphite targets. (Tungsten powder and rod targets are under study at RAL).
- Multiple proton beams (perhaps more relevant for a Muon Collider than for a Neutrino Factory).
- High-T_c superconducting magnet around the target.
- *Reconsider low-power options, perhaps including a toroidal horn target system.*