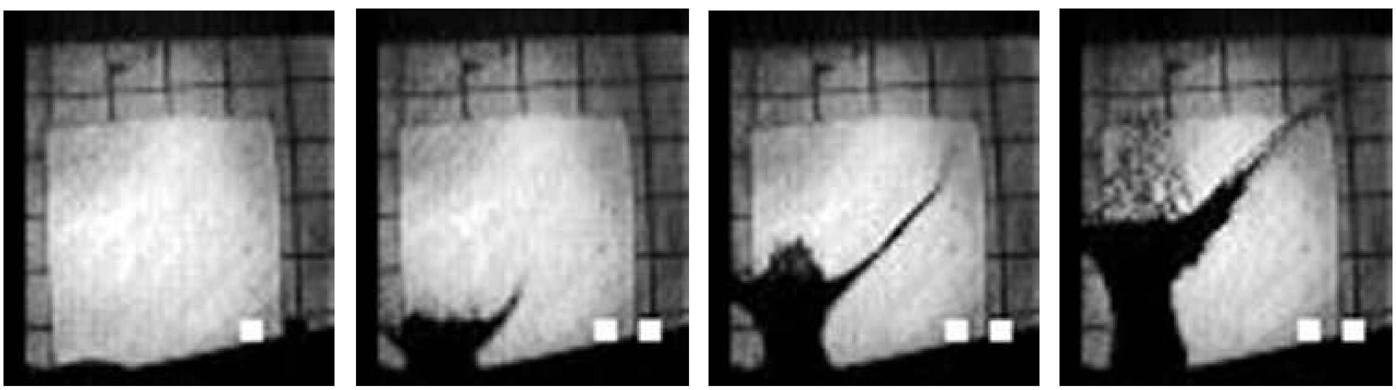
The R&D Program for Targetry and Capture at a Neutrino Factory and Muon Collider Source

(BNL E951)



K.T. McDonald

Princeton U.

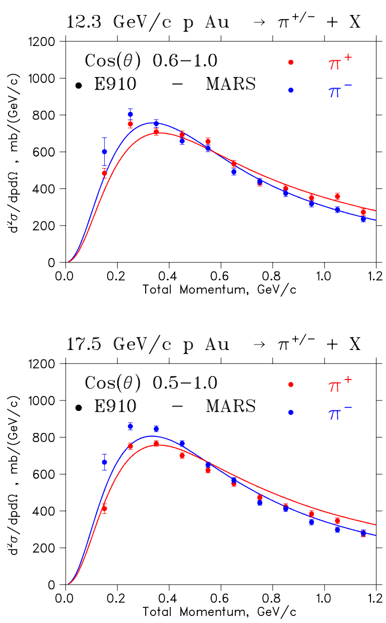
BNL, April 19, 2001

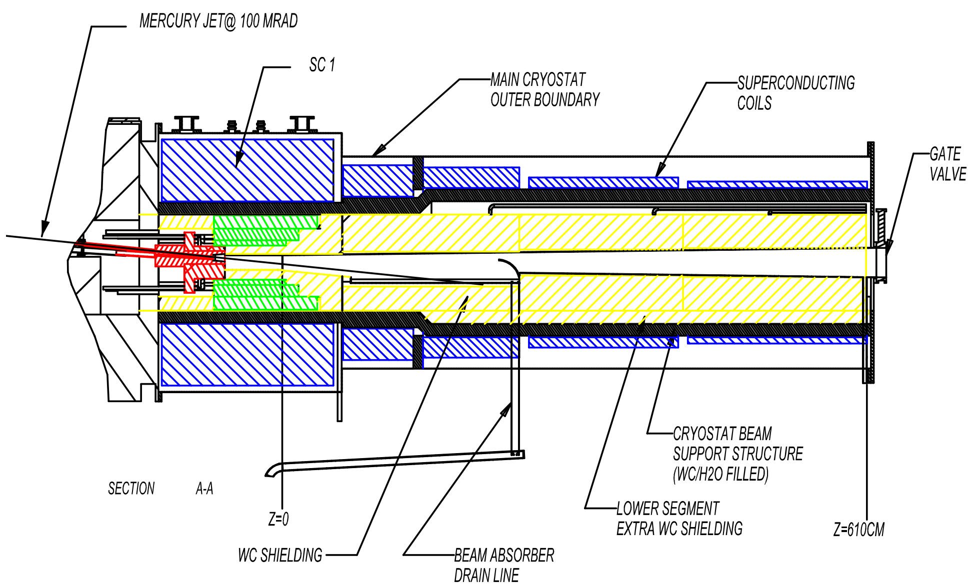
HEPAP Subpanel on Long-Range Plans for US HEP

http://puhep1.princeton.edu/mumu/target/

Challenges

- Maximal production of soft pions → muons in a megawatt proton beam.
- Capture pions in a 20-T solenoid, followed by a 1.25-T decay channel.



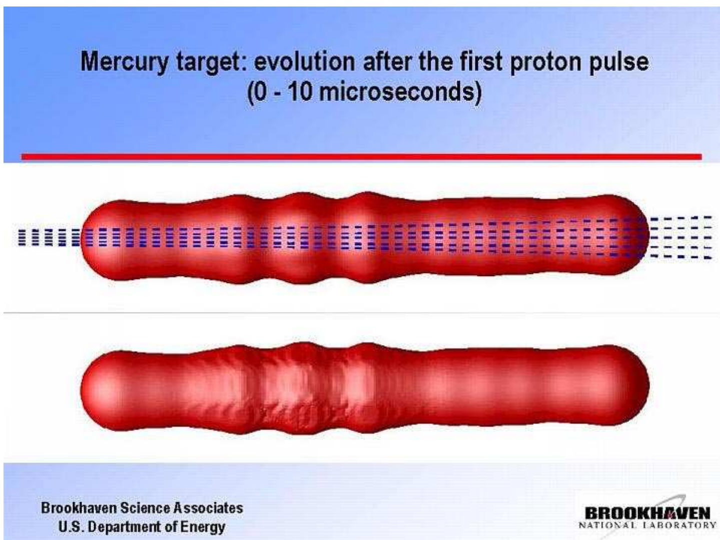


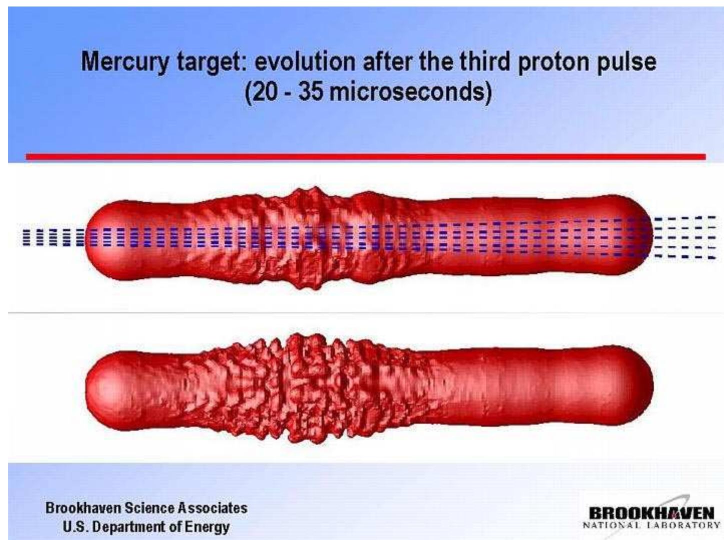
- A carbon target is feasible for $\lesssim 2 \times 10^{13}$ protons/pulse.
- For $E_p \gtrsim 16$ GeV, factor of 2 advantage with high-Z target.
- Static high-Z target would melt, ⇒ Moving target.
- A free mercury jet target may be a viable option, particularly for very intense proton pulses.

Two Classes of Issues

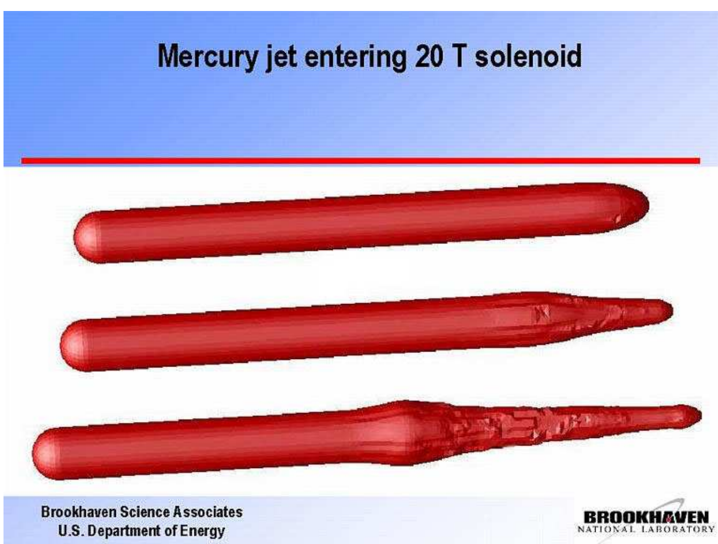
1. Viability of targetry and capture for a single pulse (E951).

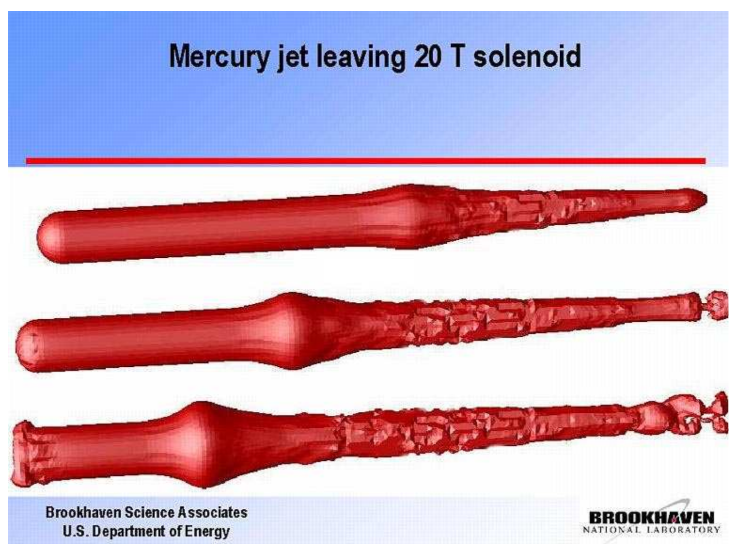
- Beam energy deposition may disperse the jet.



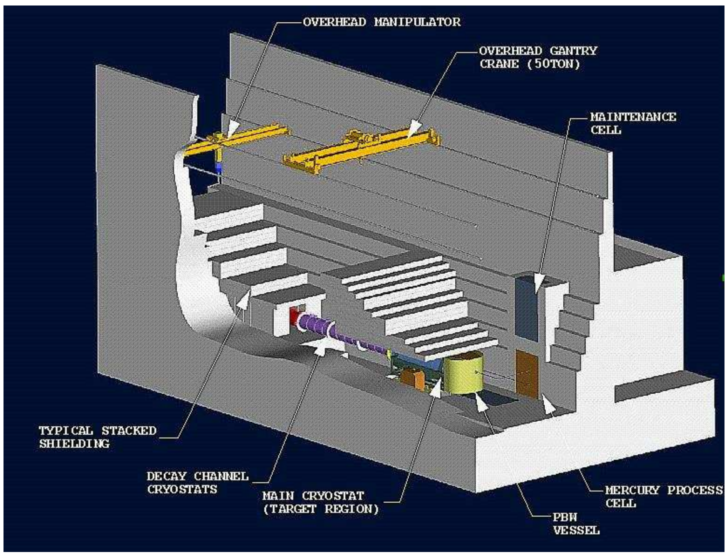


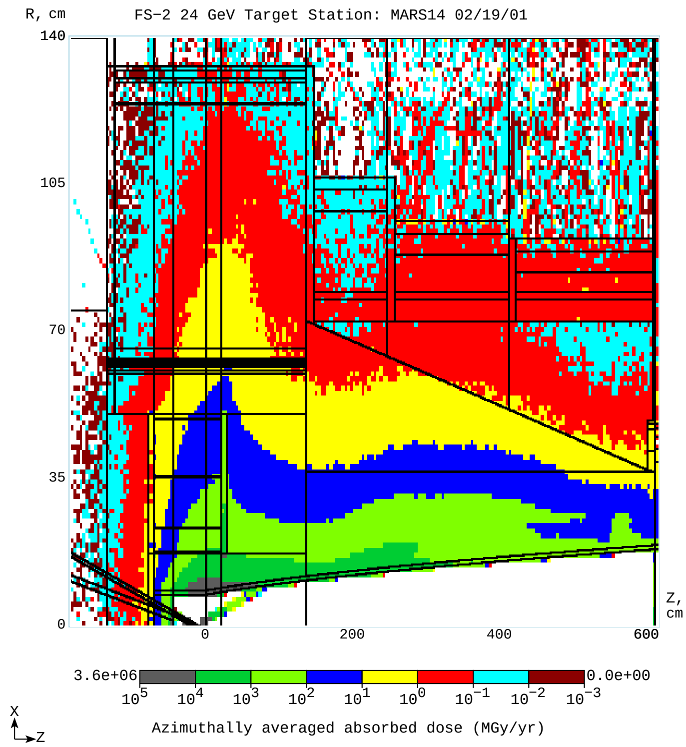
- Eddy currents may distort the jet as it traverses the magnet.





2. Long-term viability of the system in a high radiation area (Feasibility Study 2).





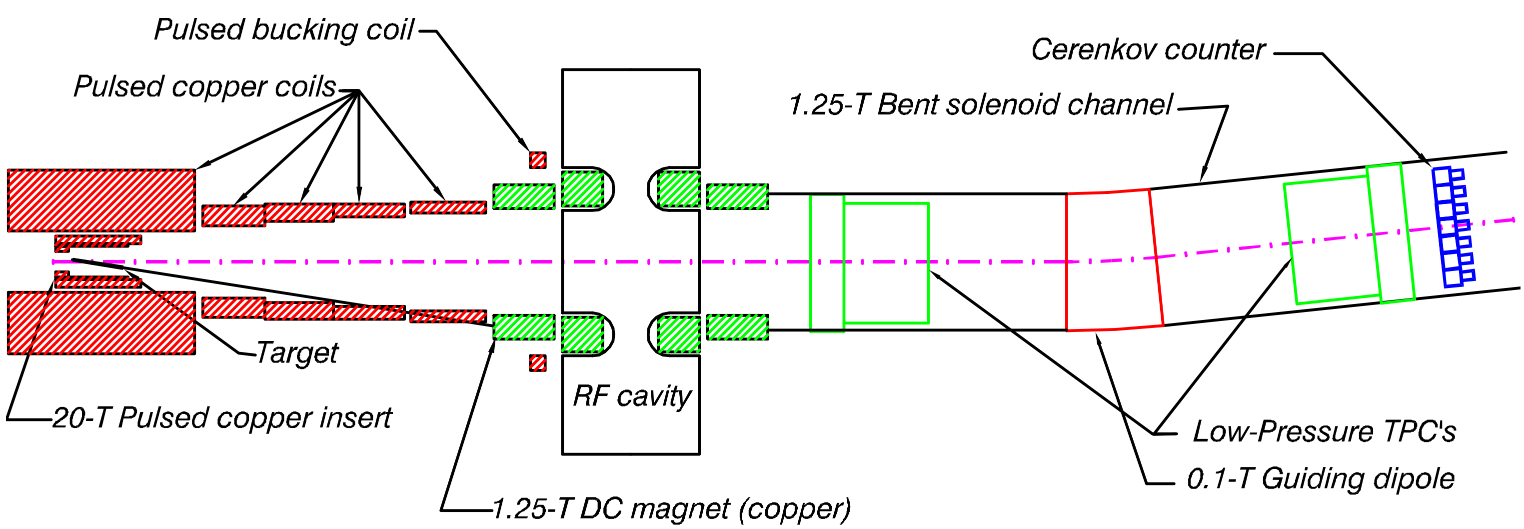
- Heating of superconducting magnets.
- Radiation damage to magnets and support structures (and personnel).
- Activation of solids, liquids and gases.

E951 Studies the Single Pulse Issues

Overall Goal: Test key components of the front-end of a neutrino factory in realistic single-pulse beam conditions.

Near Term (1-2 years): Explore viability of a liquid metal jet target in intense, short proton pulses and (separately) in strong magnetic fields.

Mid Term (3-4 years): Add 20-T magnet to beam tests; Test 70-MHz rf cavity (+ 1.25-T magnet) 3 m from target; Characterize pion yield.



The E951 Collaboration

Audrey Bernadon,[d] David Brashears,[i] Kevin Brown,[b] Daniel Carminati,[d] Michael Cates,[i] John Corlett,[g] F Debray,[f] Adrian Fabich,[d] Richard C. Fernow,[b] Charles Finfrock,[b] Yasuo Fukui,[c] Tony A. Gabriel,[i] Juan C. Gallardo,[b] Michael A. Green,[g] George A. Greene,[b] John R. Haines,[i] Jerry Hastings,[b] Ahmed Hassanein,[a] Michael Iarocci,[b] Colin Johnson,[d] Stephen A. Kahn,[b] Bruce J. King,[b] Harold G. Kirk,[b,1] Jacques Lettry,[d] Vincent LoDestro,[b] Changguo Lu,[j] Kirk T. McDonald,[j,2] Nikolai V. Mokhov,[e] Alfred Moretti,[e] James H. Norem,[a] Robert B. Palmer,[b] Ralf Prigl,[b] Helge Ravn,[d]

Bernard Riemer,[i] James Rose,[b] Thomas Roser,[b] Roman Samulyak,[b] Joseph Scaduto,[b] Peter Sievers,[d] Nicholas Simos,[b] Philip Spampinato,[i] Iuliu Stumer,[b] Peter Thieberger,[b] James Tsai,[i] Thomas Tsang,[b] Haipeng Wang,[b]

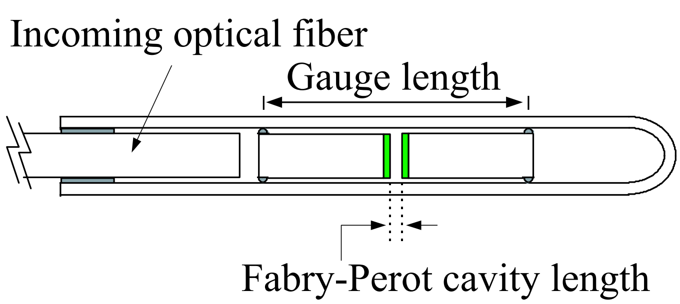
Robert Weggel,[b] Albert F. Zeller,[h] Yongxiang Zhao[b]

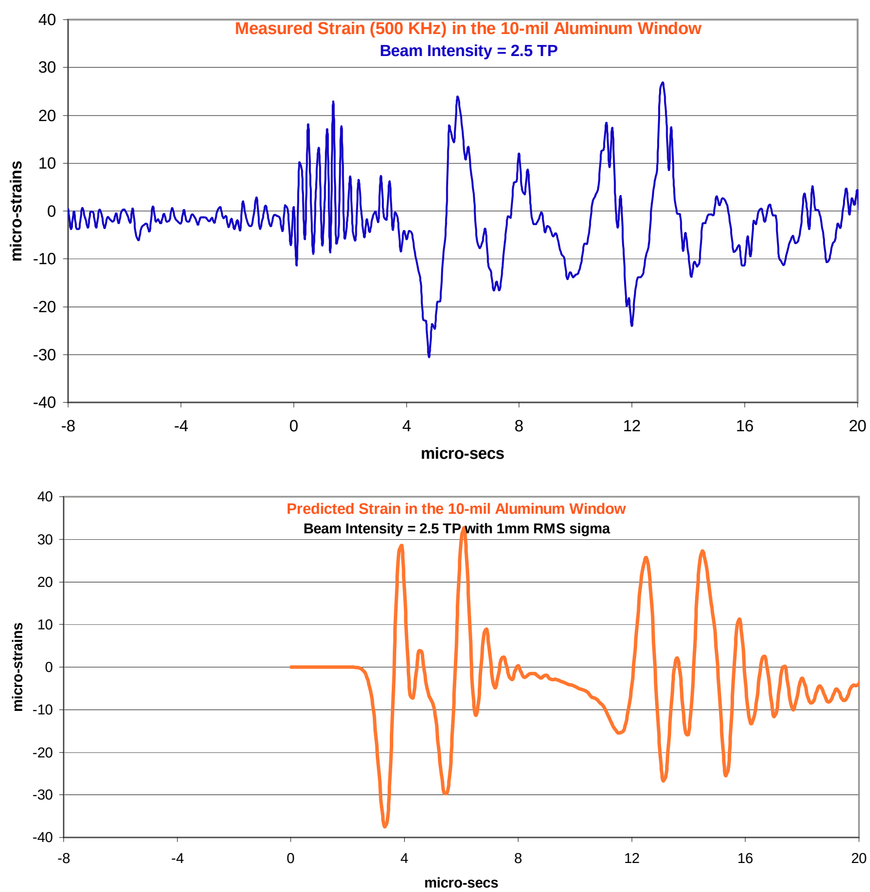
[a] *Argonne National Laboratory, Argonne, IL 60439*
[b] *Brookhaven National Laboratory, Upton, NY 11973*
[c] *University of California, Los Angeles, CA 90095*
[d] *CERN, 1211 Geneva, Switzerland*
[e] *Fermi National Laboratory, Batavia, IL 60510*
[f] *Grenoble High Magnetic Field Laboratory, 38042 Grenoble, France*
[g] *Lawrence Berkeley National Laboratory, Berkeley, CA 94720*
[h] *Michigan State University, East Lansing, MI 48824*
[i] *Oak Ridge National Laboratory, Oak Ridge, TN 37831*
[j] *Princeton University, Princeton, NJ 08544*

[1] Project Manager. Email: hkirk@bnl.gov
[2] Spokesperson. Email: kirkmcd@princeton.edu

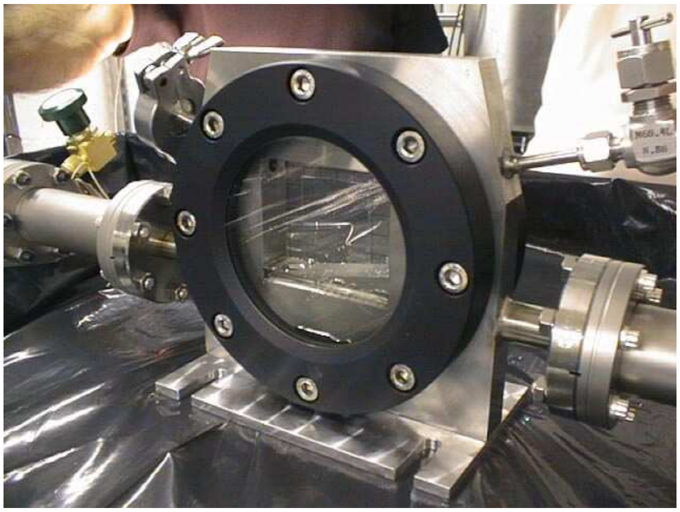
Solid Target Tests (5e12 $p$pp, 24 GeV, 100 ns)

Carbon, aluminum, Ti90Al6V4, Inconel 708, Havar, instrumented with fiberoptic strain sensors.

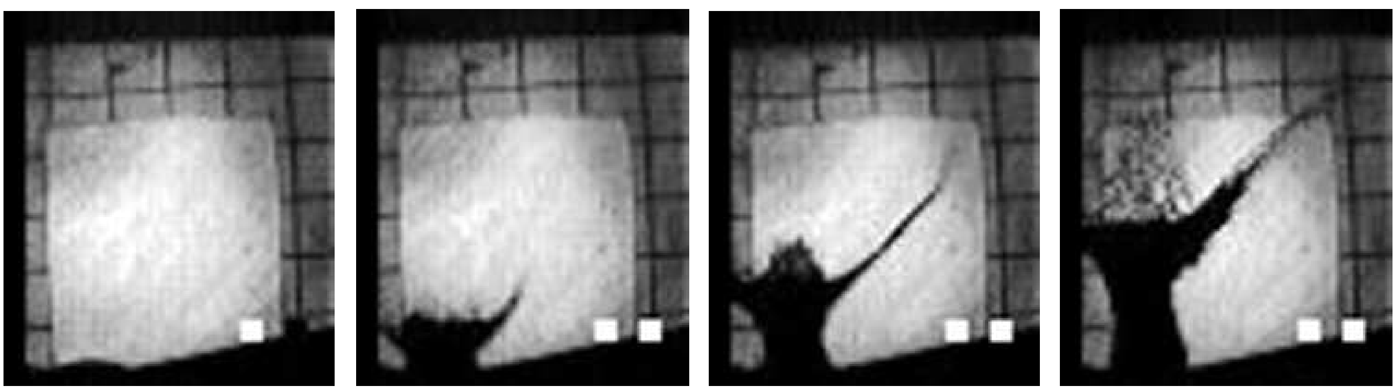




Passive Mercury Target Tests

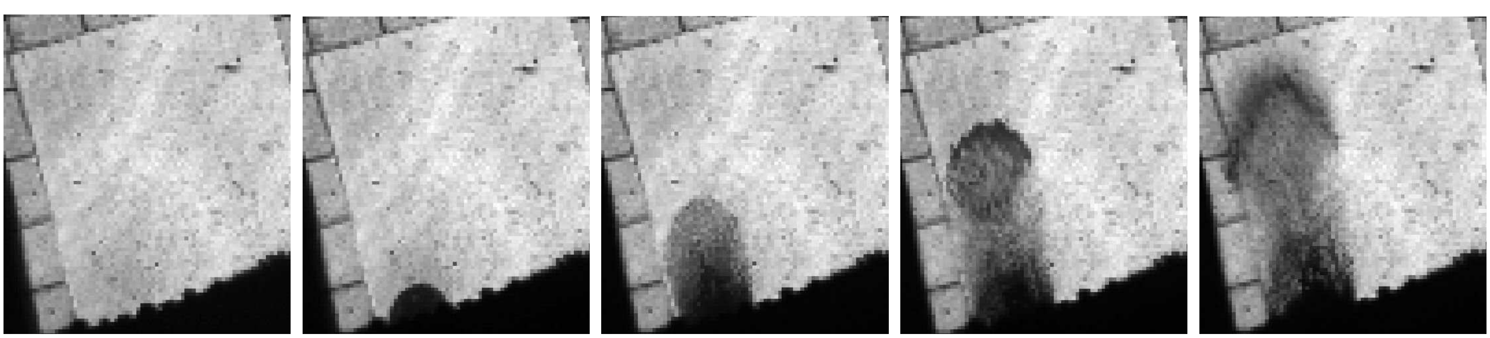


Exposures of 25 μs at
$t = 0, 0.5, 1.6, 3.4$ msec,
$\Rightarrow v_{\text{splash}} \approx 20 - 40$ m/s:



Exposures of 150 ns at $t = 0$, 0,2, 0,4, 0,6 and 0.8 msec,

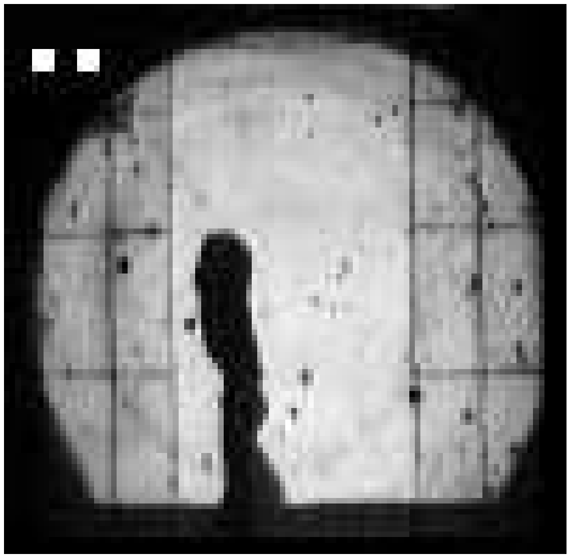
4e12 protons, $\Rightarrow v_{\text{splash}} \approx 75$ m/s (then slowed by air drag):



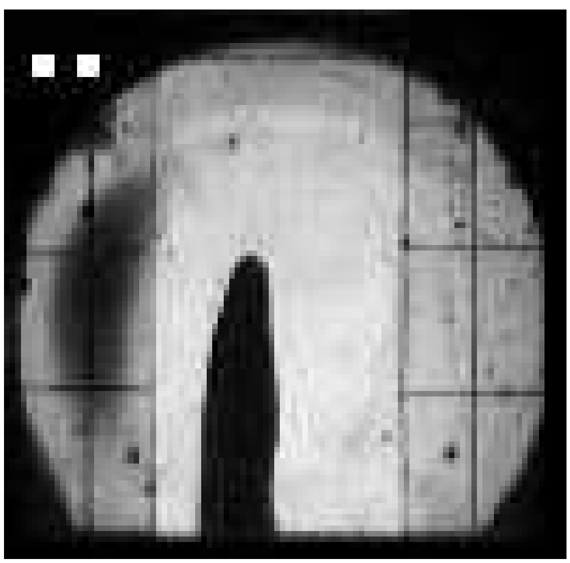
Tests of a Mercury Jet in a 13 T Magnetic Field

(CERN/Grenoble High Magnetic Field Laboratory)

1 cm diameter jet, $v = 4.6$ m/s, $B = 0$ T:



1 cm diameter jet, $v = 4.0$ m/s, $B = 13$ T:



⇒ Damping of surface tension waves (Rayleigh instability).

Continuing R&D Program

- Continue tests of targets in beam, and mercury jets in high magnetic fields.
- Complete tests of sublimation of carbon in helium atmosphere.
- Test mercury jet in beam + 20 T magnetic field.
  $\Rightarrow$ Build 20-T pulsed magnet system at BNL.
- Study alternative concepts such as rotating band target.
- Study issues of fabrication of 20-T hybrid superconducting/resistive solenoid for use in a high-radiation area.
- Validate neutron fluxes above 20 MeV via beam tests.
- Validate pion production yields in the target system.
- Study use of rf cavities very near target for phase rotation.