Sketch of a

Muon Collider Targetry R&D Program

at BNL

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

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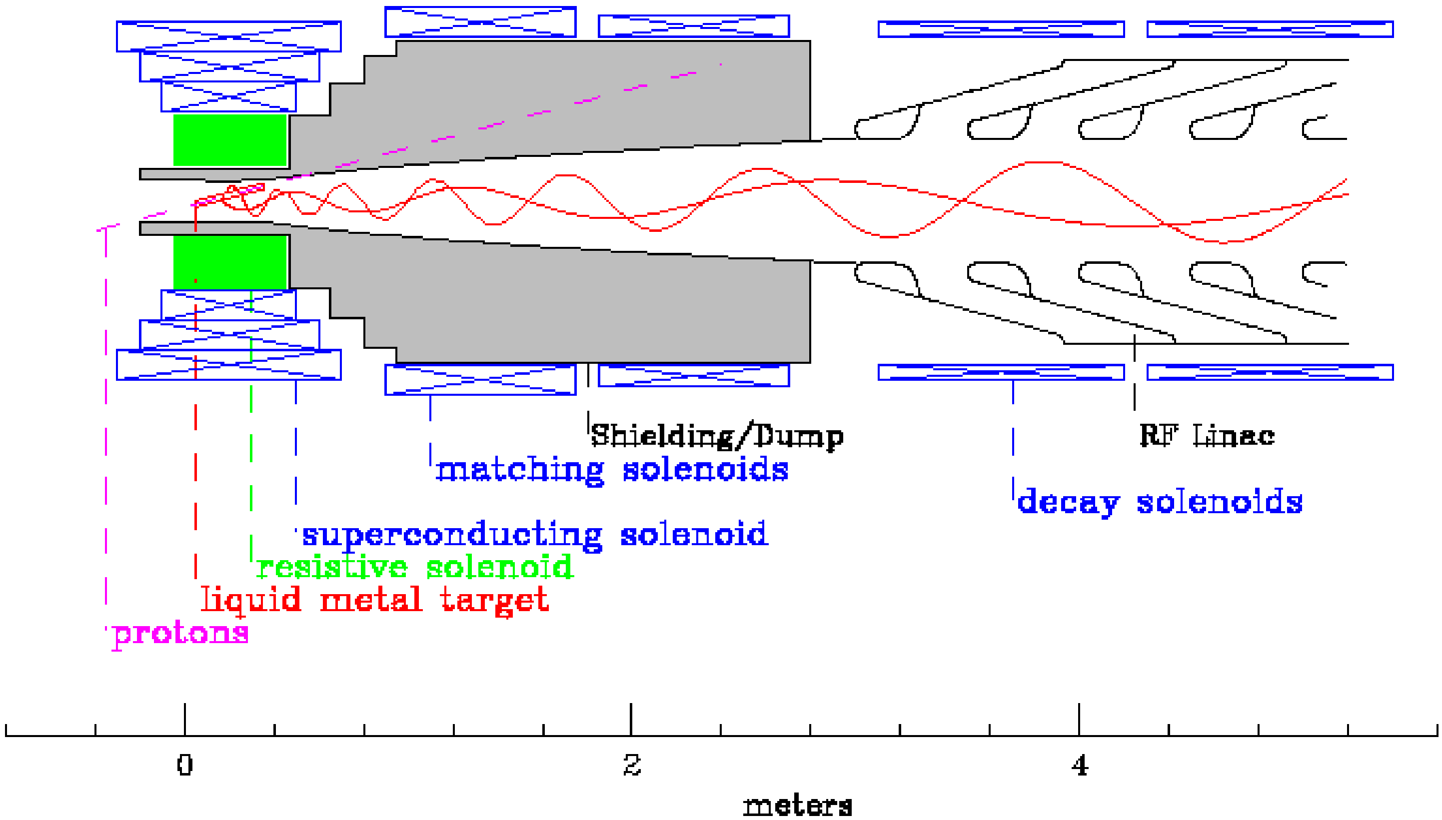
Goals

Long Term: Provide a facility to test key components of the front-end of a muon collider in realistic beam conditions.

Near Term (1-2 years): Test effects of intense, short proton pulses on liquid metal targets.

Mid Term (3-4 years): Add 20-T magnet to liquid target tests; test 70-90-MHz rf cavity (+ superconducting magnet) downstream of target

Muon Collider Front End



- Proton pulse: 10^{14} in 2 ns at 24 GeV; $\sigma_r \approx 3$ mm.
- 15-Hz $\Rightarrow$ 4-MWatt beam power; 400 kW into target.
- Liquid metal jet target + beam tilted by 10° to axis of the 20-T capture solenoid magnet.
- Matching solenoid (20-T $\rightarrow$ 1.25 T) contains beam dump.
- Phase rotation channel with 70-90 MHz rf inside 1.25-T superconducting magnets.

R&D Issues

- A beam pulse shorter than the transit time of sound across the target will excite a pressure shock wave.

  Will this wave destroy a pipe containing a liquid target? ISOLDE experience says 'yes'.

  Will this wave disperse a liquid jet? If so, will the spray damage the containment vessel?

- To what extent does a strong magnetic field influence the behavior of a liquid metal target?

  Effects of the pressure wave should be damped.

  But eddy currents in a liquid metal jet will perturb its flow.

- Can a low-frequency rf cavity operate near the target?

  Can the cavity have foils that intercept the beam, rather than large irises?

  What is the effect of an axial magnetic field on the cavity?

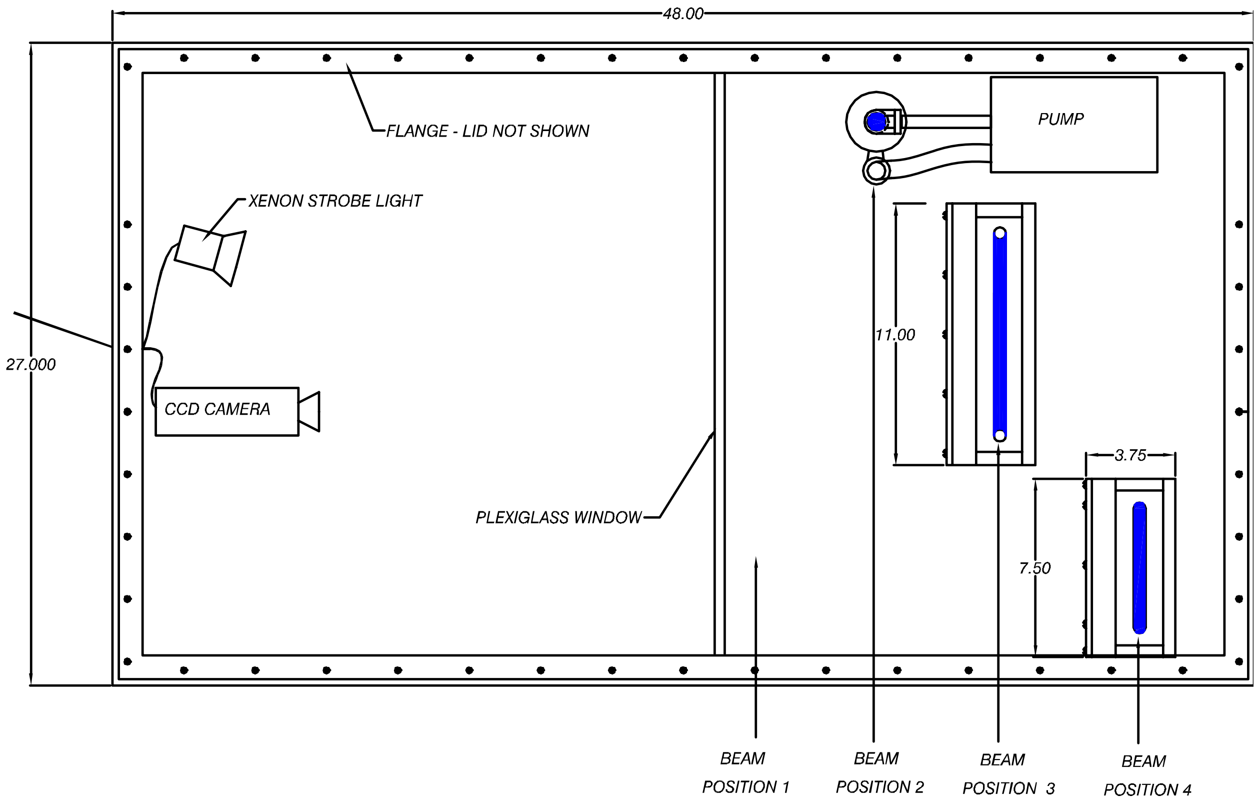
- Can the high-field magnets around the target incorporate a 4-MW beam dump?

ISOLDE Liquid Targets Damaged by Short Pulses

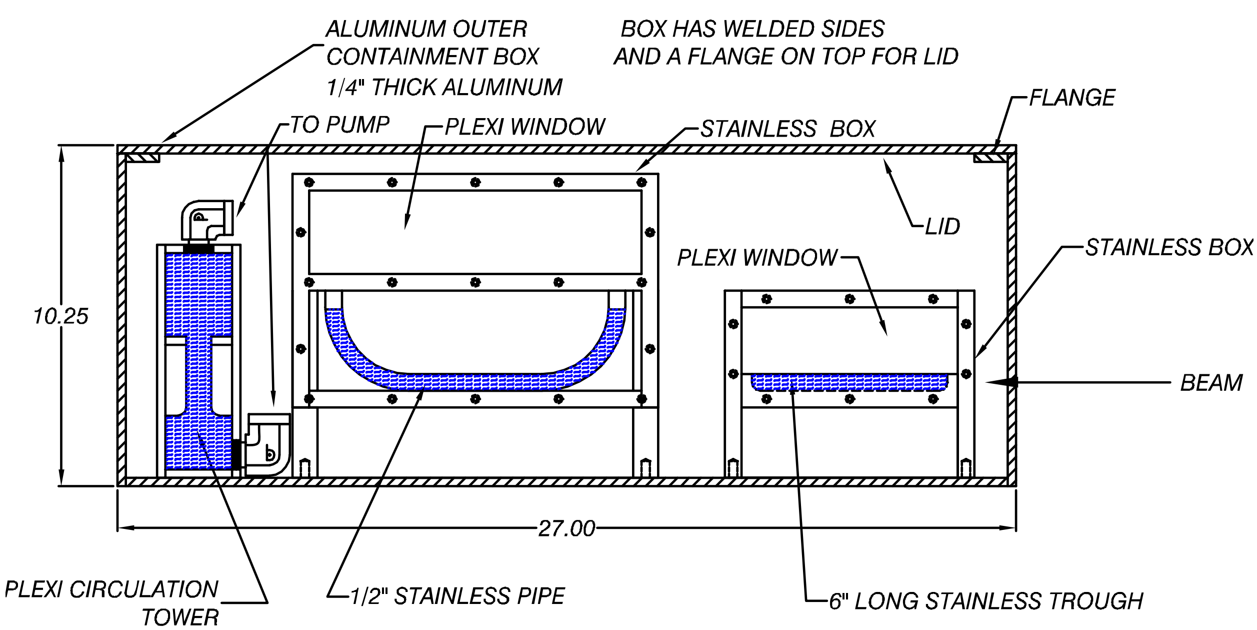
Cracks developed at braised joints and lead sprayed out.

First Test: Liquid Metal in a Trough, a Pipe and Free Flow

TOP VIEW

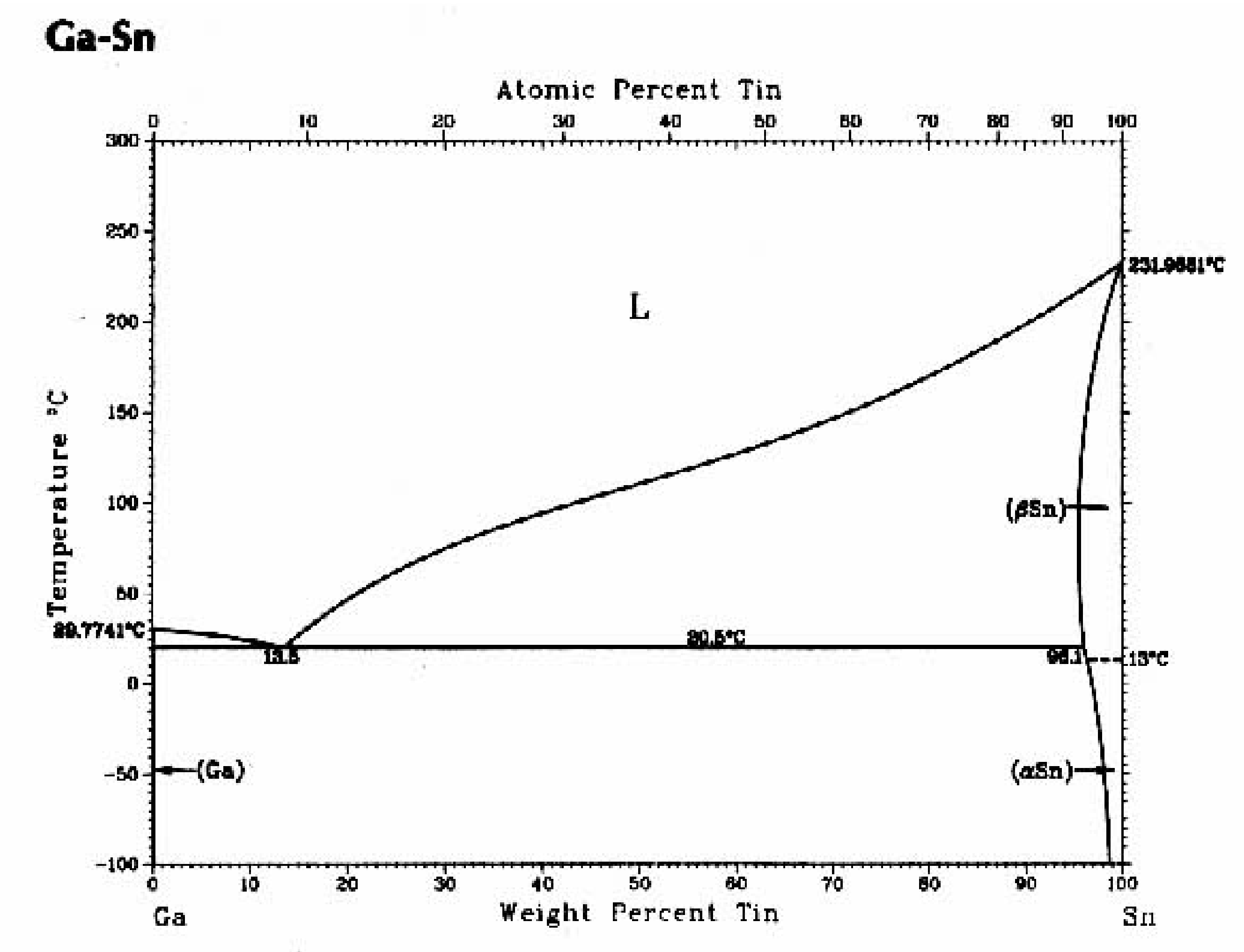


CAMERA VIEW



PIPE AND TROUGH ARE FILLED WITH Ga-Sn EUTECTIC LIQUID METAL

Ga/Sn/Zn Liquid Metal Alloys



Eutectic Ga/Sn alloy melts at 21C.

4% Zn drops melting temp by 4C.

If desire an alloy that is solid at room temperature, add small amounts of tin (or zinc).

About 1 liter of liquid metal will be used in the initial tests.

Instrumentation

CCD camera.

Fiberoptic interferometric strain gauges:

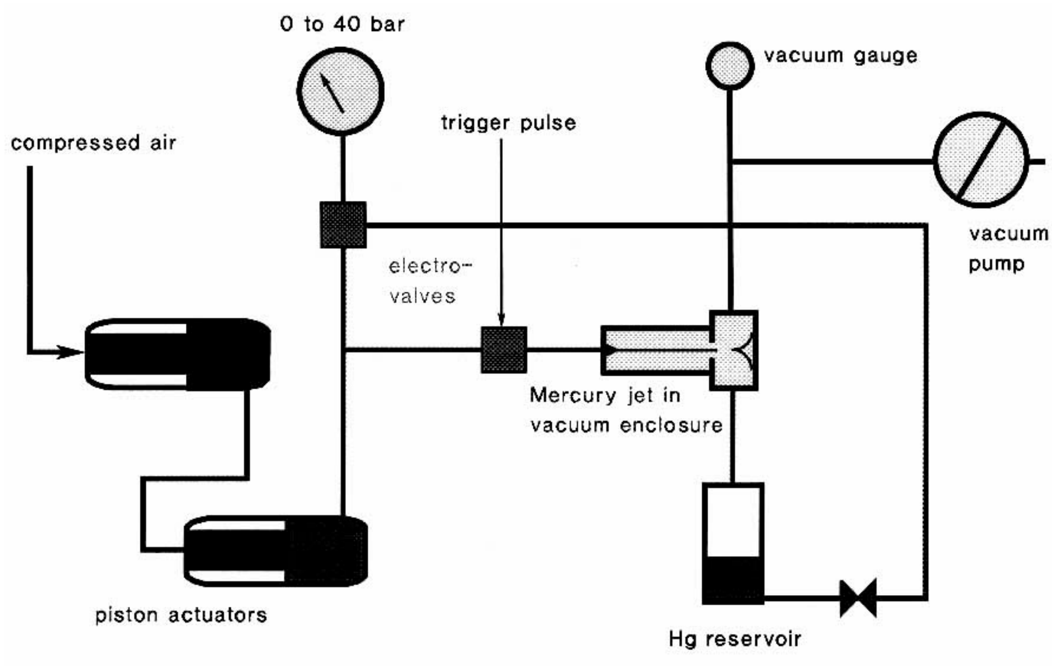
(from Fiber and Sensor Technologies)

Optical readout immune from rf interference from beam pulse.

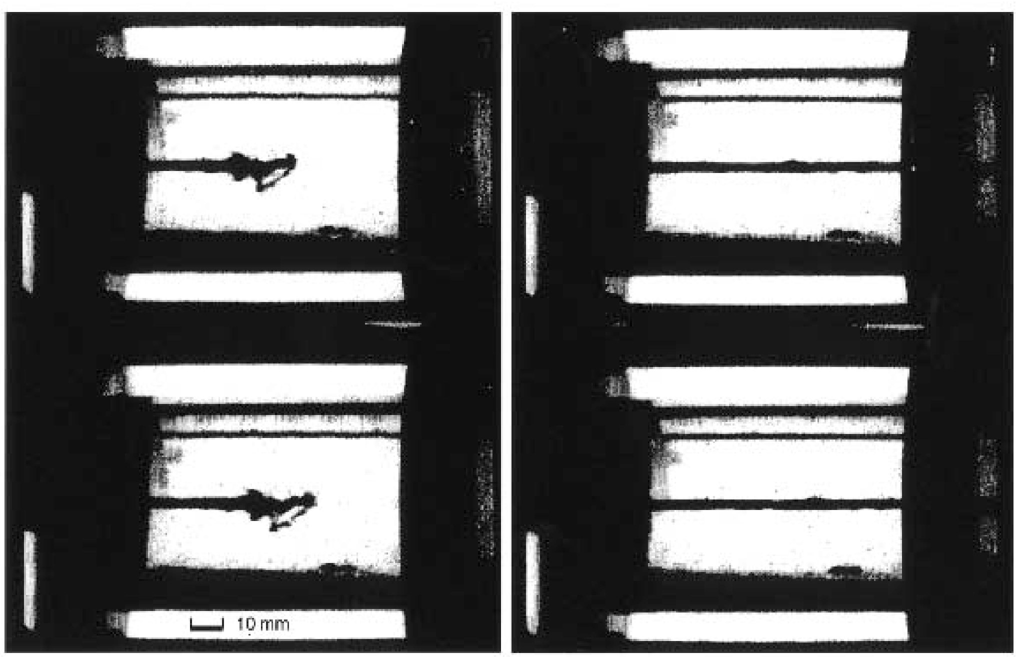
Used in spallation target test (Duncan Earl, 423-576-0869).

Next Phase: Ga-Sn Liquid Metal Jet

Colin Johnson's Hg jet design:



Produced 3-mm jet at 20 m/s, but never exposed to beam.



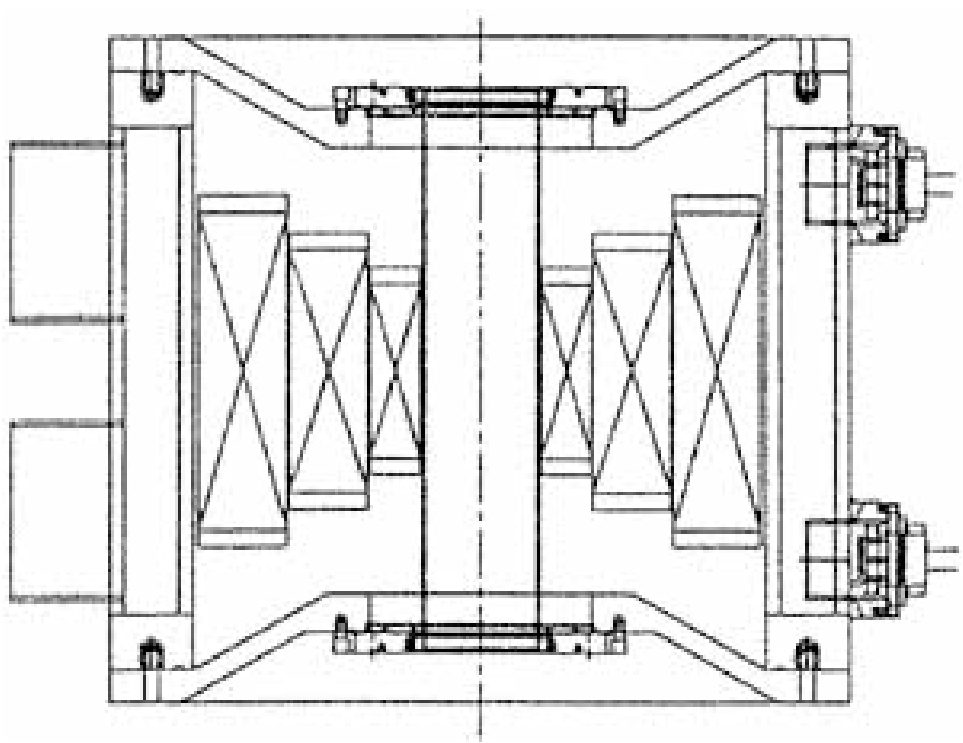
High-speed photographs of mercury jet target for CERN-PS-AA. (laboratory test)
4,000 frames per second, Jet speed: 20 ms^{-1}, diameter: 3 mm, Reynold's Number: >100,000
A. Poncet

Next: Add 20-T Magnet around the Target

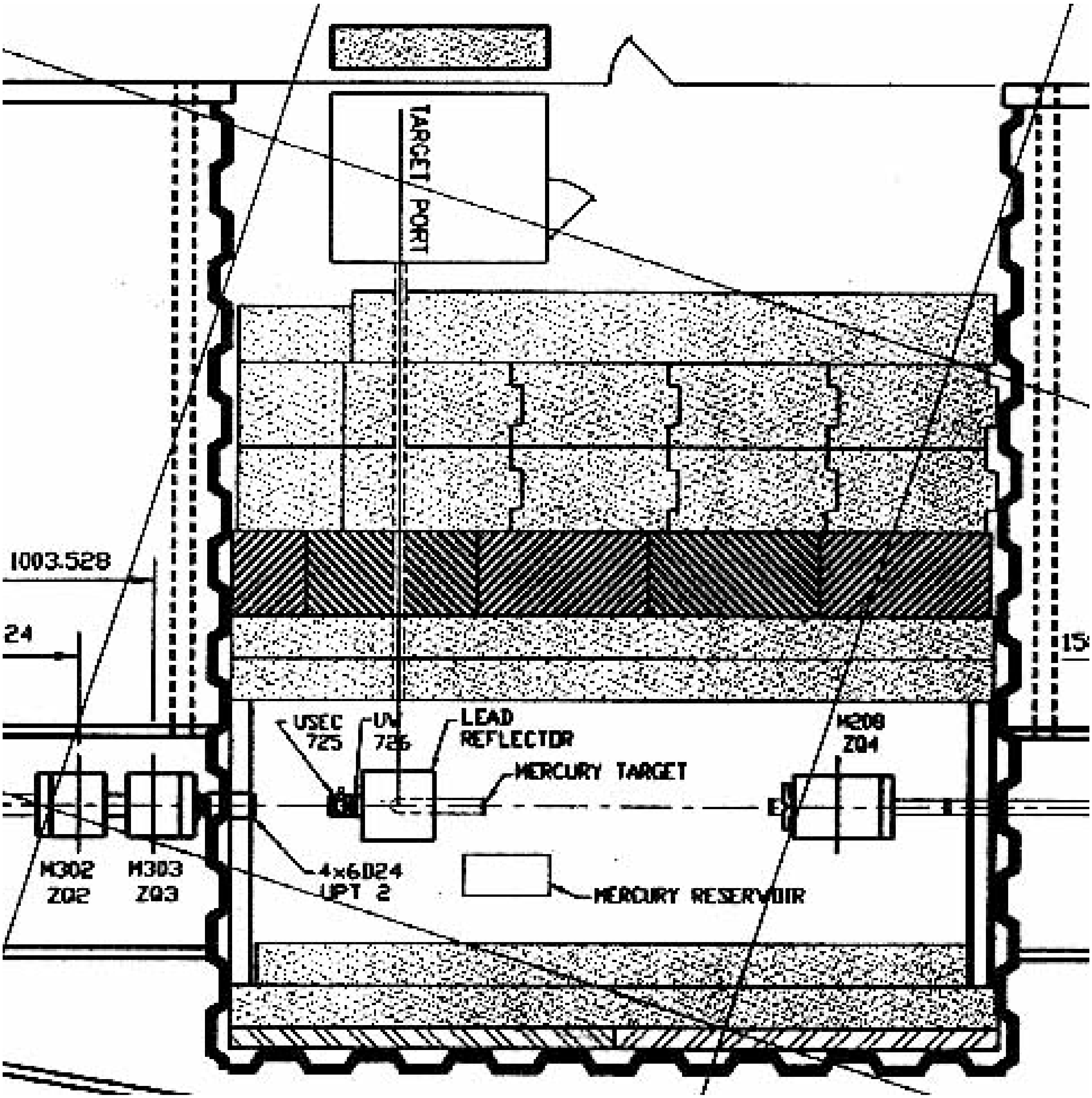
LN_2-cooled, pulsed magnet would need at least 4 MW.

DC resistive magnet would require 20 MW.

http://www.magnet.fsu.edu/magnets/index.html



Beam Tests in BNL F.E.B. U-Line

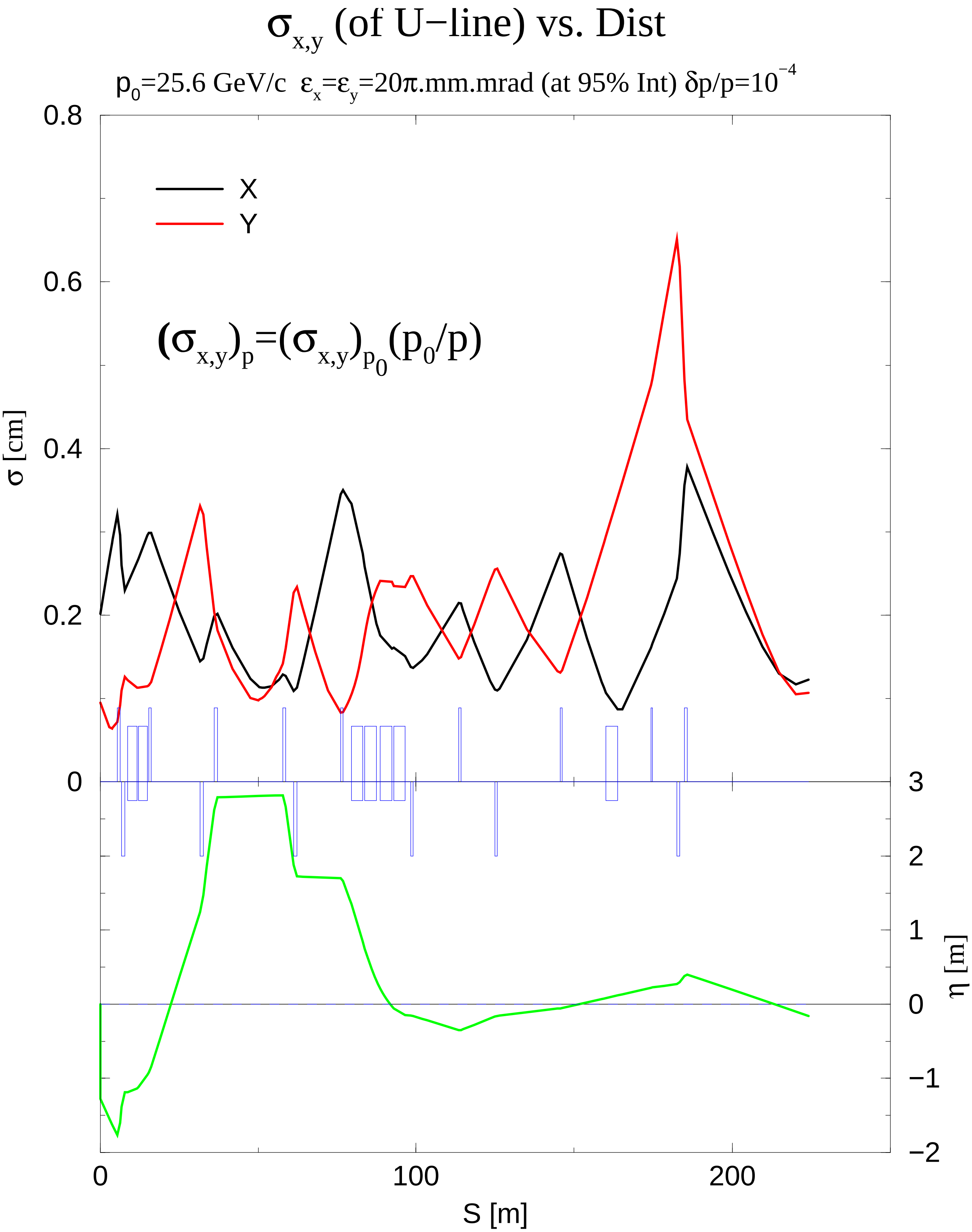


Area previously used by Hg spallation target test.

Beam Requirements

- 24-GeV proton beam.
- Single turn extraction.
- All 8 bunches needed for some tests $\Rightarrow$ Must upgrade AGS extraction system ($100k, 6 months).
- Pulse width $\approx 1/4$ rf cycle desirable for rf cavity test.
  (Tom Roser: 5ns possible)
- Variable spot size: $\sigma_x \approx \sigma_y = 1$-5 mm.
  (Can be achieved with existing quads: Nick Tsoupas)
  $\Rightarrow$ **Study spot size in Sept. '98.**

Quad Tune for Small Spot Size in FEB U-Line



Facility Requirements

Near Term:

- ≈ 2 m along beam.
- Horizontal mover for target box.
- Beam monitors: optical flags, intensity, profile monitors.
- Access ports for RF power, HV and LV electrical cables....
- Personnel trailer.
- Access to spallation target group strain-gauge readout system.

Longer Term:

- 4 MW (10 desirable) power for pulsed magnet.
- 300 gpm cooling water, if water-cooled magnets.
- LN2, LHe dewars inside tunnel.
- Shed for RF power station outside tunnel.