Muon Collider Targetry R&D Program

[http://www.hep.princeton.edu/mumu]

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June 1, 1998

Muon Collider Targetry Workshop

Brookhaven National Laboratory

Agenda

1:00-1:30 K. McDonald, Overview of targetry R&D plans

1:30-1:45 A. Carroll, Remarks on the FEB U-line

1:45-2:10 J. Hastings, Plans for spallation target tests

2:10-2:25 B. King, Moving solid targets

2:25-3:00 B. Weggel, The FSU High Field Magnet Lab and other magnet options

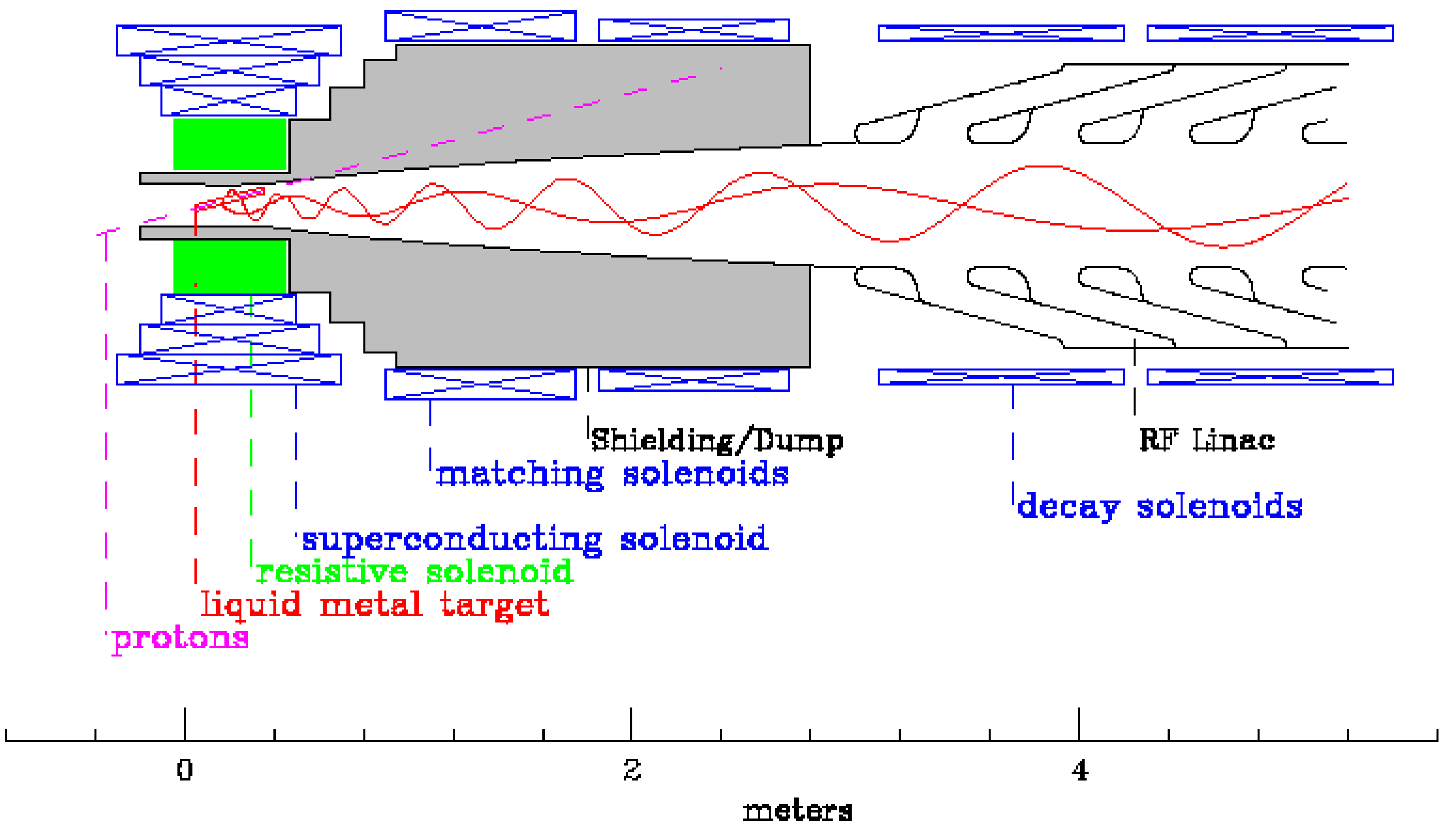
3:00-3:20 Break

3:20-4:00 H. Kirk (+Y. Zhao?) New scenarios for phase rotation; RF test stand for radiation studies

4:00-5:00 General discussion on R&D

Goal for summer '98: prepare AGS proposal; discuss at HEPAP meeting on Aug. 24.

RevisedBaseline Scenario



New vision of phase rotation channel:

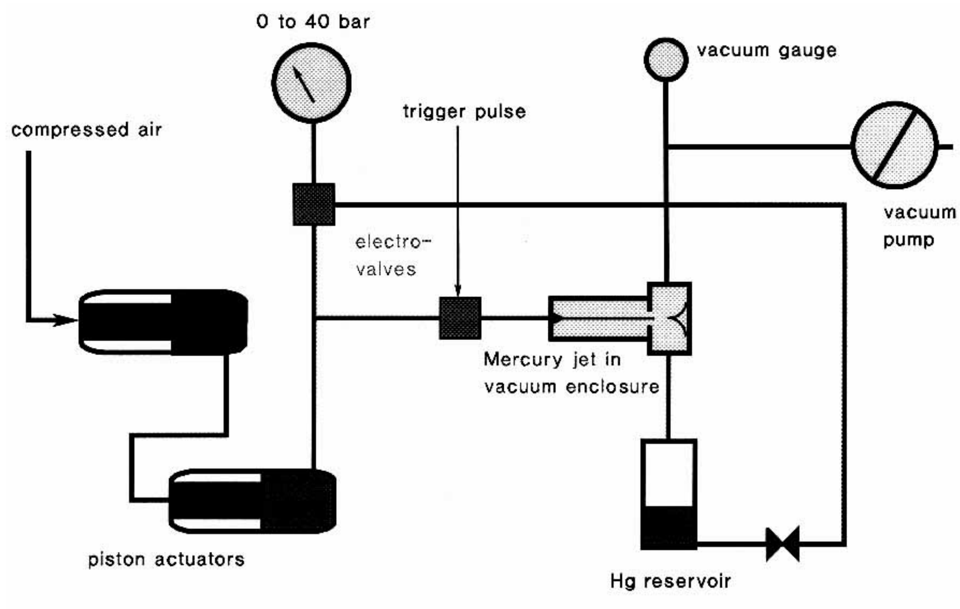
- Folded RF cavities
- Low-field solenoid outside cavities
- Report by H. Kirk + Y. Zhao

Scope of Targetry R&D Program

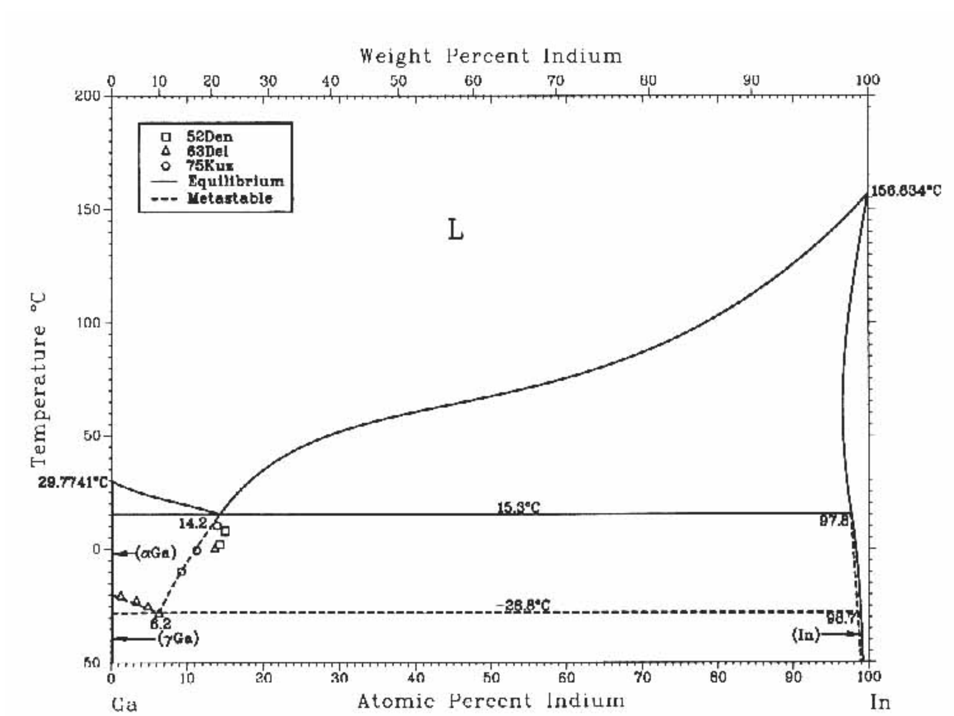
- Build Ga-In liquid jet similar to Hg jet of C. Johnson.
- Test effect of eddy currents on liquid metal jet in 20-T magnet at FSU National High Field Magnet Lab.
- Test effects of short beam pulse on liquids at AGS.
- Test liquid jet in short beam pulse at AGS
- Test liquid jet + 20-T magnet in beam at AGS
- Test rf cavity (+ superconducting magnet) in high radiation downstream of target hit by short beam pulse at AGS.

Ga-In Liquid Metal Jet

Colin Johnson's Hg jet design:



Ga-In 5:1 alloy melts at 15-16°C:



CERN Participation

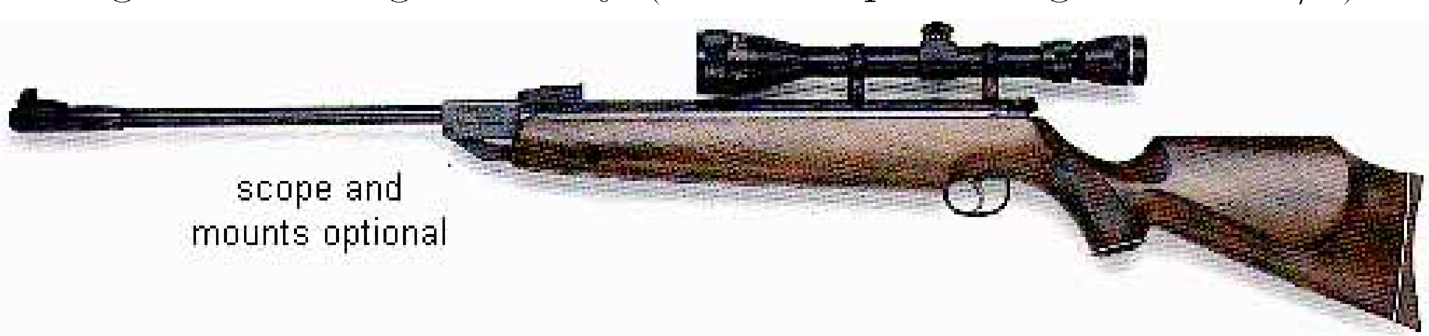
B. Autin, C. Johnson, H. Ravn and others at CERN are very interested in participation in the muon collider project.

The mechanism for formal participation by CERN remains under discussion.

For the time being, C. Johnson gives us advice, but is not actively contructing a liquid jet.

Ex: Simple, single-shot liquid metal or powder jet target (5/29/98)

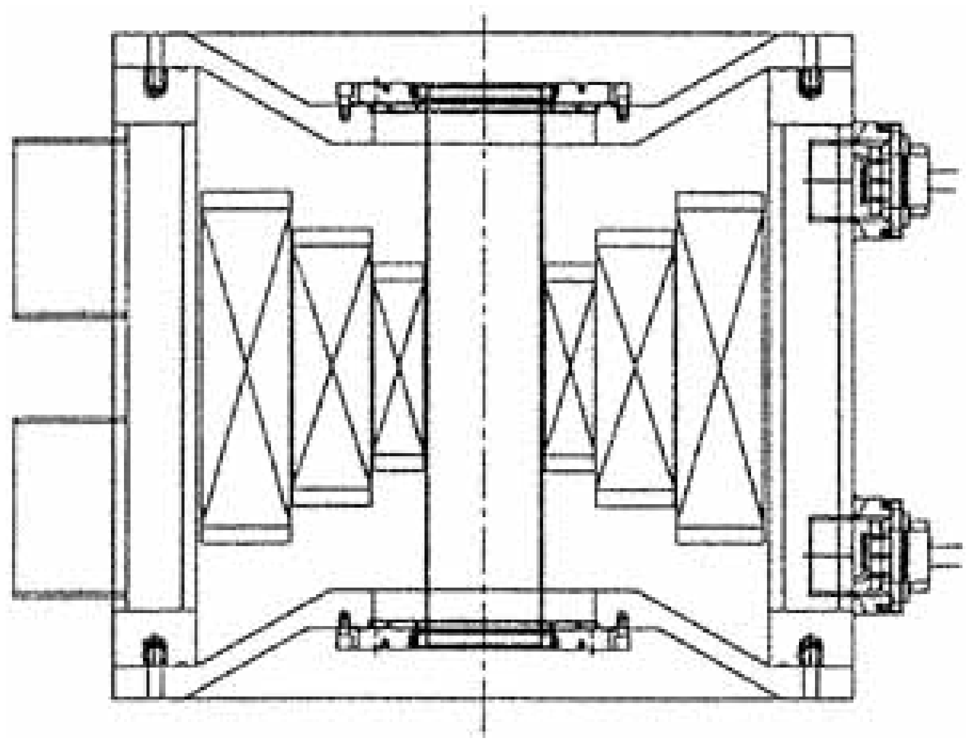
Coupling the output from the gun actuator via a tampon to a 8 mm x 100 mm tube filled with W powder or liquid metal and pulling the trigger produces a fairly well-formed jet of low divergence and high velocity (in the required region of 5 m/s).



http://www.airgunsusa.com

20-T, 20-cm-Bore Resistive Magnet at FNHMFL

http://www.magnet.fsu.edu



Aim jet near vertical downward into magnet.

Record trajectory with Hadland IMACON 790 streak camera ($1/\mu$s/frame).

Contactperson: Bruce Brandt: 850-644-0311

Will get acquainted via test of microchannel-plate PMT gain and timing in high fields.

Effect of a Short Beam Pulse on a Liquid?

Will shock heating disperse the target violently?

Simple model to estimate magnitude of shock pressure wave:

Beam energy heats liquid (no heat flow);

Liquid expands causing strain (shock wave);

Liquid 'tears' if pressure exceeds tensile strength.

Fact: tensile strength (TS) is about $0.002E$ (Young's modulus) in most metals.

$$P = F/A = E\Delta L/L = E\alpha\Delta T = \frac{E\alpha\Delta U[\mathrm{J/gm}]}{C_P[\mathrm{J/gm\text{-}K}]}.$$

Trouble when $P = TS$:

$$\Delta U[\mathrm{J/gm}] = \frac{TS}{E}\frac{C_P}{\alpha}.$$

For Ga and In, $\alpha \approx 2 \times 10^{-5}$/K, $C_P \approx 0.3$ J/gm-K.

So liquid 'tears' (at speed of sound) when $\Delta U \approx (0.002)(0.3)/(2 \times 10^{-5}) \approx 30$ J/gm.

This is roughly the nominal energy deposition in the target!

Even if liquid doesn't tear violently, it may disperse into drops as pressure wave bounces around inside.

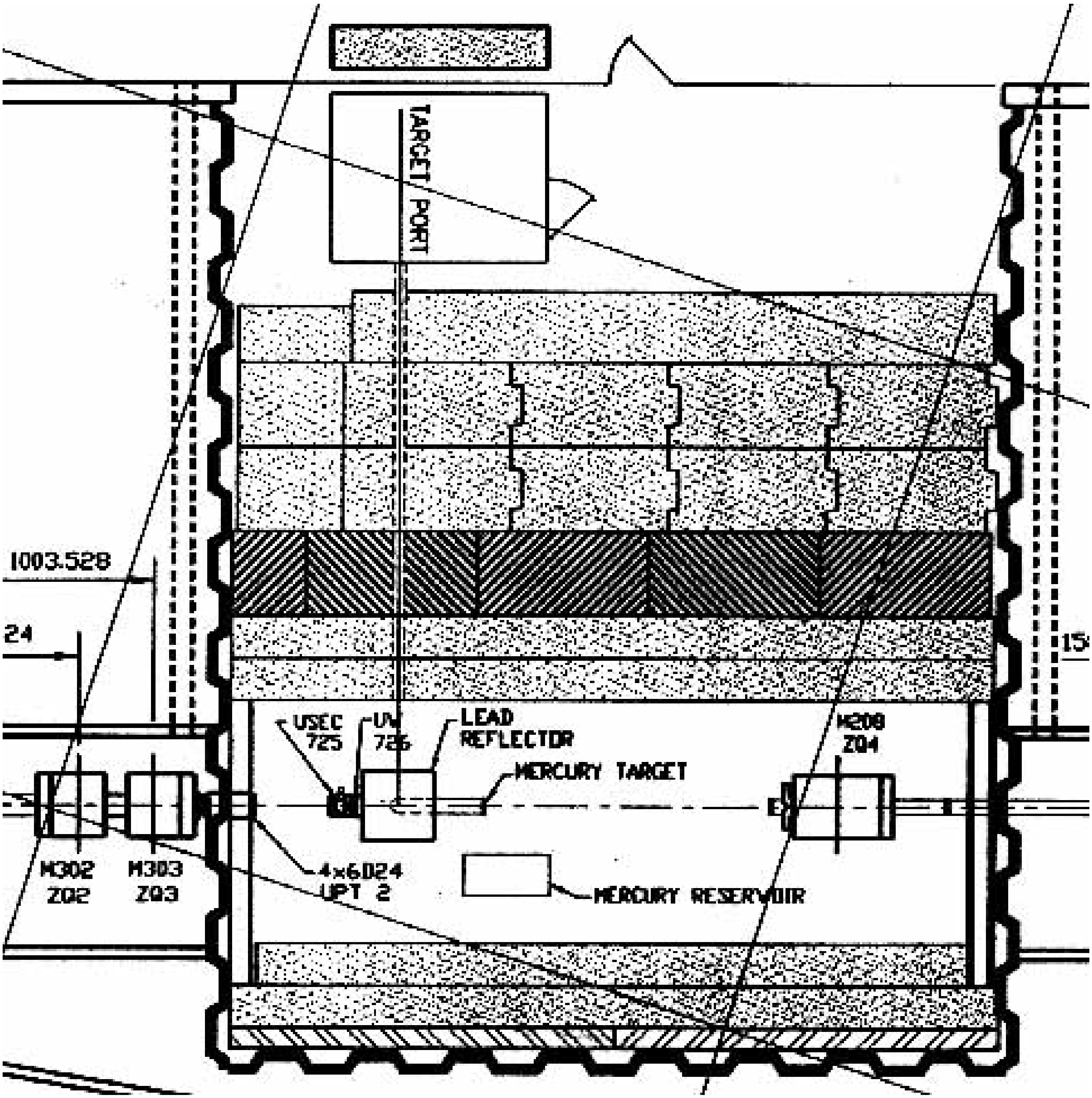
Leftoever dops from previous pulses might absorb pions.

Strong magnetic field will damp effects of shock wave.

Simulation: ANSYS/LSDYNA (Paul Montanez).

Need beam tests.

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



Area previously used by Hg spallation target test.

Beam Requirements

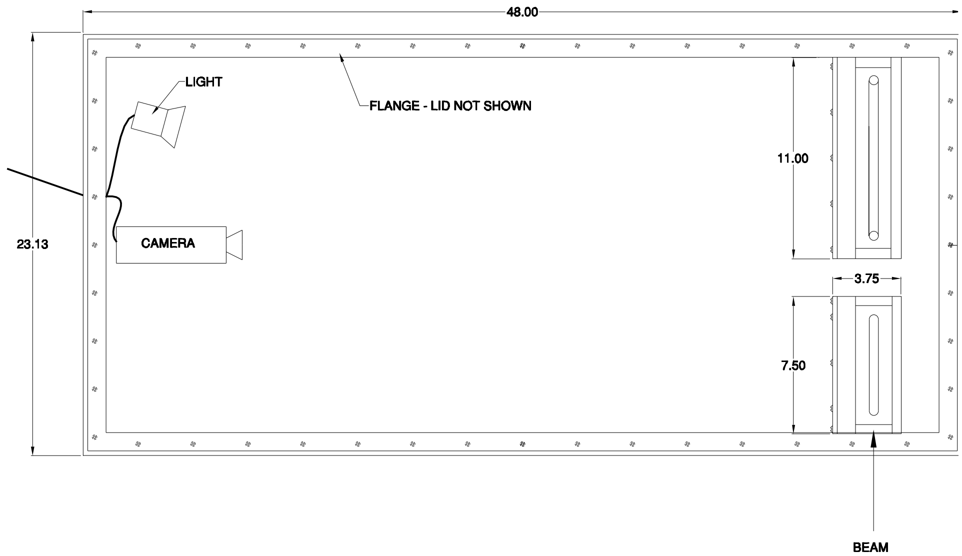
- 24-GeV proton beam.
- Single turn extraction.
- All 8 bunches needed for some tests.
- Pulse width $\approx 1/4$ rf cycle desirable for rf cavity test.
  (Tom Roser)
- Variable spot size: $\sigma_x \approx \sigma_y =$ 1-5 mm.
  (May need new quads: Alan Carroll, Nick Tsoupas)

Facility Requirements

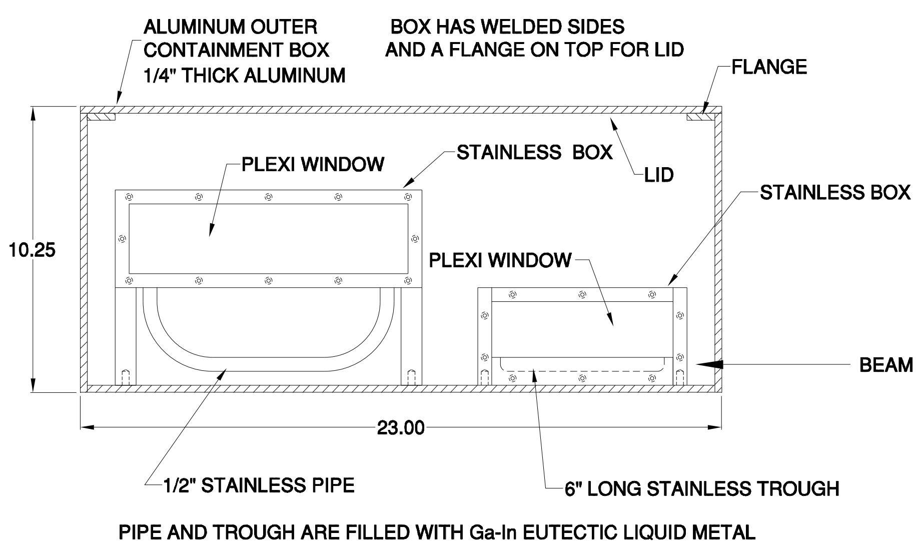
- ≈ 5 m along beam.
- 4 MW (10 desirable) power for pulsed magnet.
- 300 gpm cooling water, if water-cooled magnets.
- LN2, LHe dewars inside tunnel.
- Access ports for RF power, HV and LV electrical cables....
- Shed for RF power station outside tunnel.
- Personnel trailer.
- Access to spallation target group strain-gauge readout system.

First Test: Liquid Metal in a Trough and in a Pipe

TOP VIEW



CAMERA VIEW



Could also have recirculating free vertical column of liquid.

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).

$400 per sensor + fiber optic cable.

$4000 for FOSS1 2-ch interface box.