Lab Tests of the Magnetohydrodynamics of Liquid Metal Jets

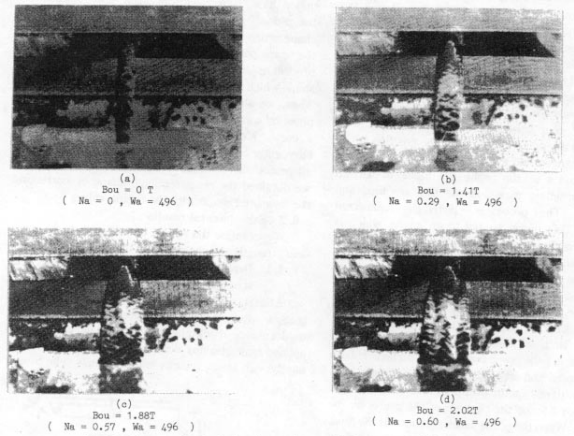

Fig. 9 Photographs of the jet for various applied mag- netic field strengths

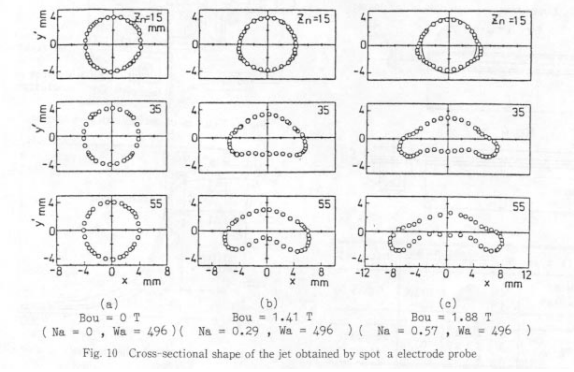

Fig. 10 Cross-sectional shape of the jet obtained by spot a electrode probe

S. Oshima *et al.*, JSME Int. J. **30**, 437 (1987).

K.T. McDonald

Princeton U.

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Issues

A strong magnetic field can damp some hydrodynamic instabilitites of a liquid metal jet:

- Breakup due to surface tension (Rayleigh instability).
- Some of the perturbations due to the proton beam.

But it is difficult to get a metal into a magnet:

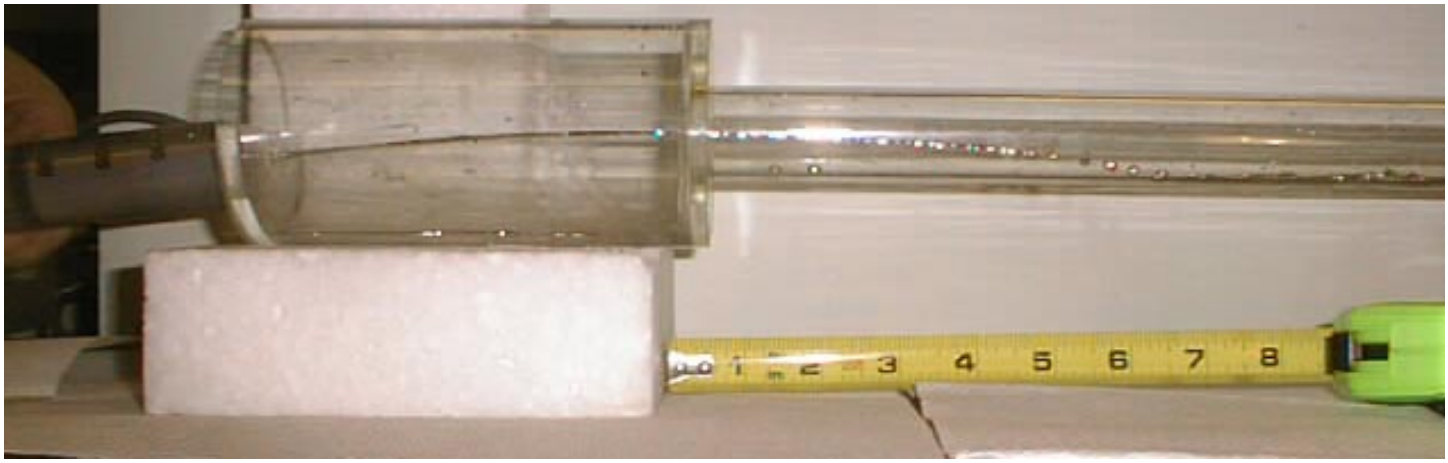
- If conductivity is too high, almost impossible to enter the field.
- Radial pinch on entering a solenoid $\Rightarrow$ increase in internal pressure.
- Axial retarding force on entering and exiting a solenoid.
- Strong shear forces, especially if enter at an angle.
- Quadrupole deformation due to transverse field.

Calculations give some confidence, but laboratory confirmation is needed that a liquid metal jet can enter the solenoid without undue distortion.

A First Test

- Use a 5-T solenoid with 4-cm warm bore, and coil inner diameter of 6 cm.

- Mercury jet via a syringe with 1.5-mm diameter aperture.



- Jet velocity up to 3 m/s, determined from sagitta of arc.

- No noticeable difference in jet motion at 0 T and 5 T.

Scaling Up to a Neutrino Factory

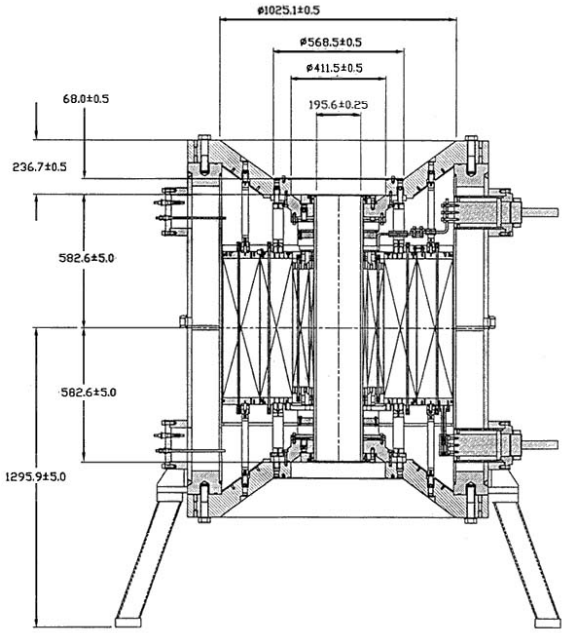
- Axial retardation of the jet as it enters a solenoid scales as

$$\frac{\sigma r^2 B^2}{\rho D} .$$

- For $B = 20$ T, $D = 30$ cm and $r = 5$ mm, the retardation is 320 times larger than in the first test.

- $\Rightarrow$ Need for further test, at parameters close to those for a neutrino factory.

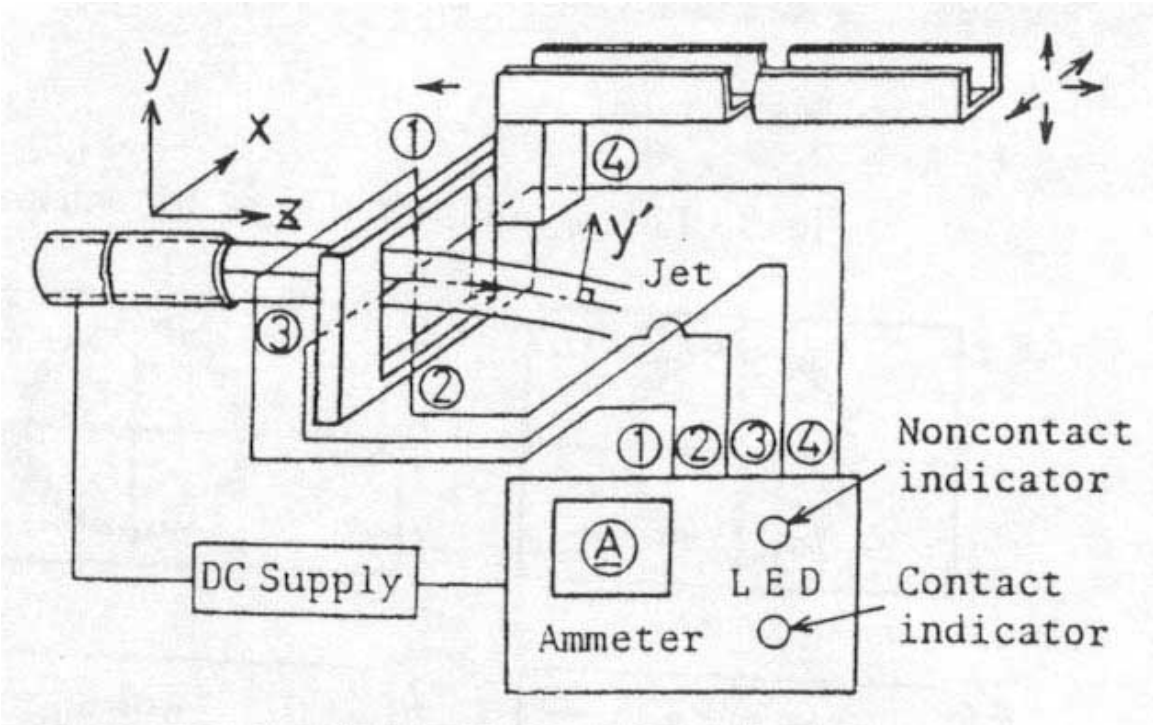
- Best option: 20-T, 20-cm diameter-warm-bore resistive magnet facility at the NHMFL (or similar facility in Grenoble).



Goals of the Test

Characterize the distortion of a mercury jet entering a 20-T solenoid.

- Types of distortion: deflection, shear, quadrupole.
- Dependence on jet velocity, radius, angle to magnetic axis, and proximity of nozzle to the magnet.
- Effect of pulsed *vs.* steady jet.
- Diagnostics: primarily visual; perhaps wire scan in phase 2.



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