Schlieren Systems and other Matters

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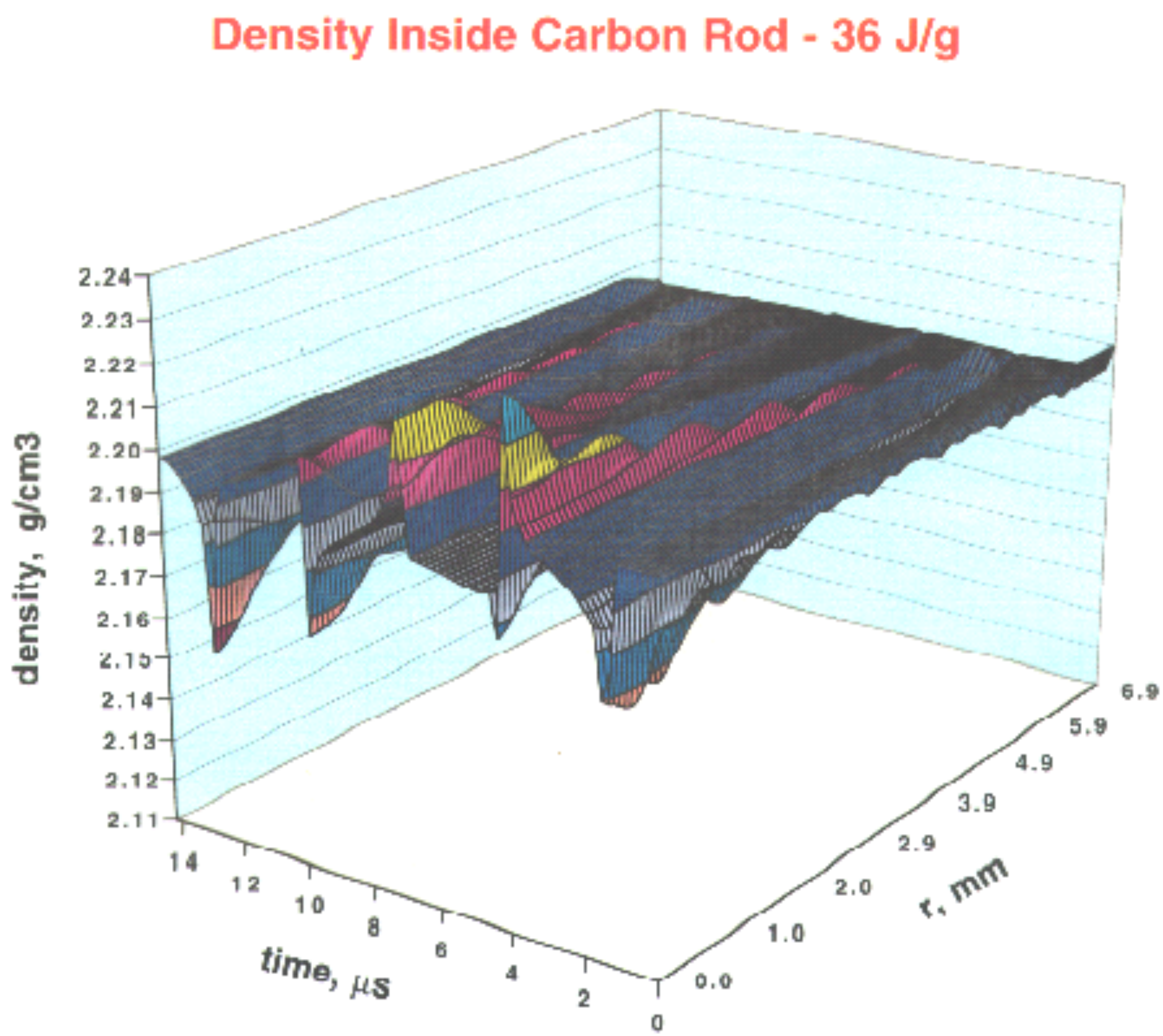
Beam Power Deposition Can Strongly Perturb a Target.



For Carbon Targets Near the Breaking Point . . .

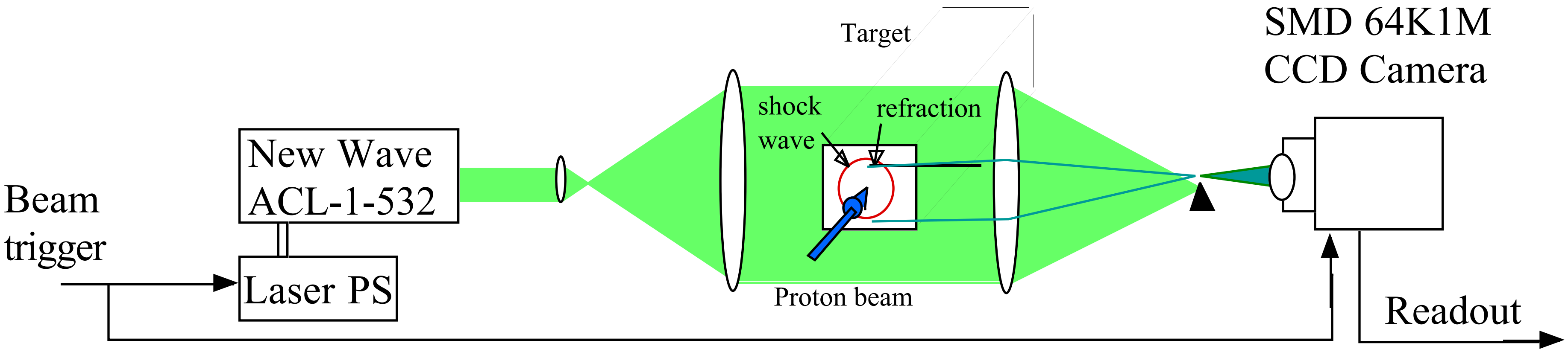
Surface motion	> 6 m/s, 6 μ/μs
Surface pressure	~ 1 katm
Internal pressure	± 10 katm
Surface density fluctuations	$\delta\rho/\rho \sim 0.002$
Internal density fluctuations	$\delta\rho/\rho \sim 0.02$
Sound velocity	~ 2000 m/s

Liquid metal targets may have even more extreme parameters.

Strain Measurements Seem to Require Instrumentation With . . .

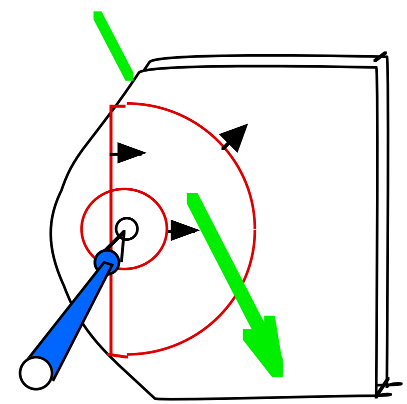
Direct measurements at the surface and interior
High data rates
Insensitivity to proton beam itself (EM, thermal, etc.)
Good dynamic range, good sensitivity
Insensitivity to shock pulse
Digital output
Ability to look at solids and liquids
Measurements over a large area would also be nice

A Schlieren / Ronchi System for Measuring Shock Fronts In and On Targets



The system should be able to measure

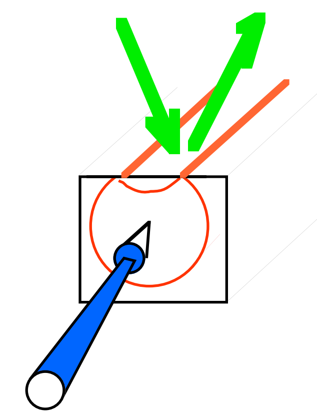
- The beam profile
- Immediate response (~10 ns) of beam in/on target
- Shock fronts & reflections in transparaent materials
- Surface displacements for all materials



Resolution

- trigger jitter ~1 ns
- $\sigma_t \sim 6$ ns, $\sigma_x \sim \sigma_y << 1$ mm

A variety of geometries are possible.

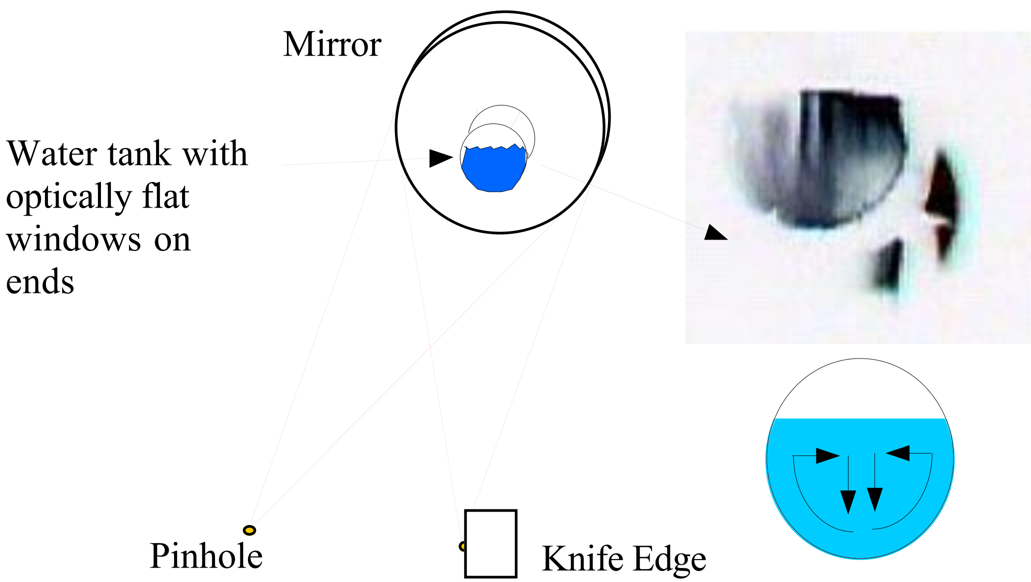


The Ronchi method replaces a pinhole & edge with slit & grid and produces an image with lines which can be used for quantitative measurements.

Foucault, Schlieren, Ronchi . . . . .

The Schlieren system can be very sensitive. It is based on the Foucault method of testing optics, which for years (since 1859) has been *the* standard method. It is a very cheap, fast and precise, (surface variations ~ 1/8 - 1/10 λ), way of measuring the local radius of curvature of a zone of an optical system.   (It was *not* used to test the Hubble mirror.)

A Demonstration of this Method

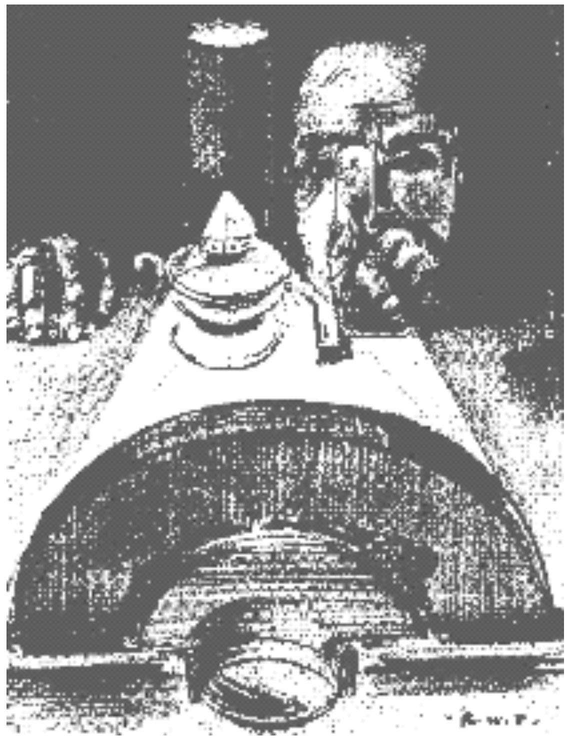


This Demo was designed to see if this technology could be used to look at beam excited turbulence in Liquid Hydrogen Absorbers

After the water is stirred, and the visible eddies die down, there is no structure. After about two minutes a plume forms from the top. This seems to be due to water cooled by evaporation moving to the center and dropping to the bottom. This plume sharpens with time.

Measuring shock waves *in* materials should be a rather straightforward extension of this method. However the time resolution of the light must be short $\delta t < \delta x / v_s$, and the system should be able to make quantitative measurements over a large, and adjustable, dynamic range, since the density fluctuations should be large. A two dimensional field of view is also desirable.

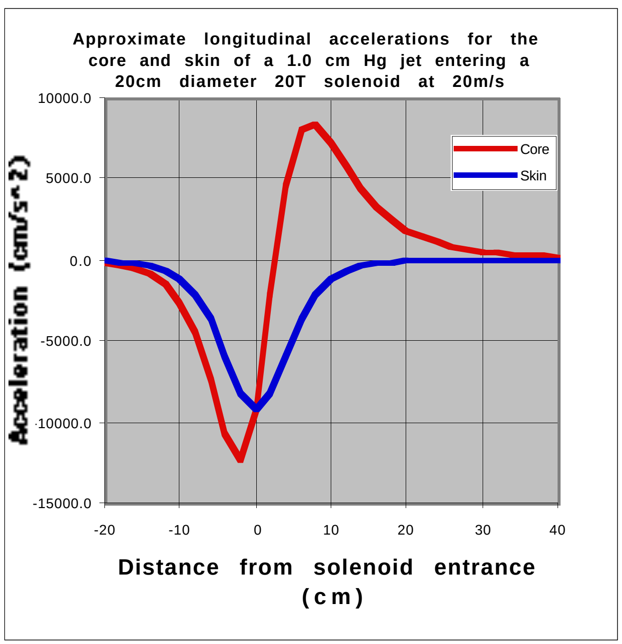
How the Hubble mirror should have been figured . .



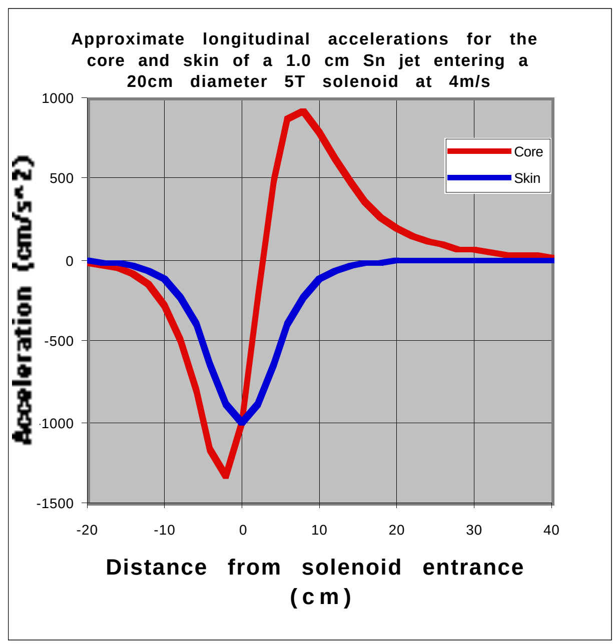
Injecting Metals into a Magnet

One of the major uncertainties involved in the use of a liquid mercury target is the dynamics of the liquid in the fringe field of the magnet.

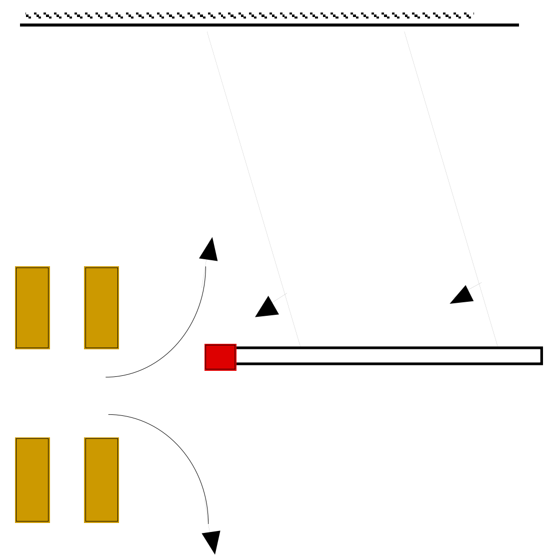
While the magnet in Lab G of Fermilab is only 5 T, 1/4 of the proposed target magnet, it should be possible to do some simple, but relevant, tests of fringe fields using simple samples in air. A pendulum can produce velocities around 4 m/s, only 1/5 of the Hg jet velocity, but since the conductivity of the samples can be higher one can produce the same sort of induced currents, deflections and deformations.



Mercury, 20 m/s, 20 T



Tin, 4 m/s, 5 T



Summary

Schlieren optics seems to offer a good way of mesuring strain in and
on the surface of a variety of solid targets

A demo system shows good sensitivity, can be combined with a 11k laser to
give good time resolution.

A Ronchi system should give data that is easier to digitize and one is under
construction