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Title: FRC FORMATION AND TRAPPING BY COUNTER INJECTION FOR MTF LINER IMPLOSIONS

Author(s): Richard Siemon, P-24, Los Alamos National Laboratory
James Degnan, Air Force Research Laboratory
Michael Frese, Numerex, Inc.
Martin Taccetti, 147103, P-24, Los Alamos National Laboratory

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Form 836 (8/00)

FRC formation and trapping by counter injection for MTF liner implosions

Richard Siemon (Los Alamos National Laboratory), James Degnan (Air Force Research Laboratory), Michael Frese (NumerEx), Martin Taccetti (Los Alamos National Laboratory)

A new simplified design is being developed for injecting and trapping Field-Reversed Configurations (FRCs) into liners, which is compatible with the energetic liner implosions of interest for Magnetized Target Fusion (MTF). Conical theta pinches that inject from each end of the liner region are proposed. The conical angle can be chosen to make axial translation out of the conical theta pinch into the liner region occur on approximately the same time scale as radial compression. Thus no crowbar switch is needed for the high-voltage fast-rising current pulse. The toroidal field from conical theta-pinch injection and/or Z-pinch preionization should rapidly annihilate upon merging of the two oppositely directed FRCs [1]. Two dc coils in a Helmholtz-like configuration are all that are needed to serve the functions of cusp, translation, and mirror fields for trapping in the liner. The mirror strength required for trapping is not as critical as when using one-sided injection because the merging FRCs have no net momentum when they collide. Previously observed damping of axial kinetic energy [2] suggests that viscous damping parallel to B is strong for FRCs with mfp comparable to FRC length, and conversion of directed energy to thermal energy should occur on a time scale comparable to the injection time. The electrical/mechanical details will be described, accompanied by numerical simulations of FRC formation using the MACH2 numerical code.

1. Yamada et al., Phys. Rev. Lett. 65, 721 (1990).
2. 2. Rej et al., Phys. Fluids 29,. 852 (1986).

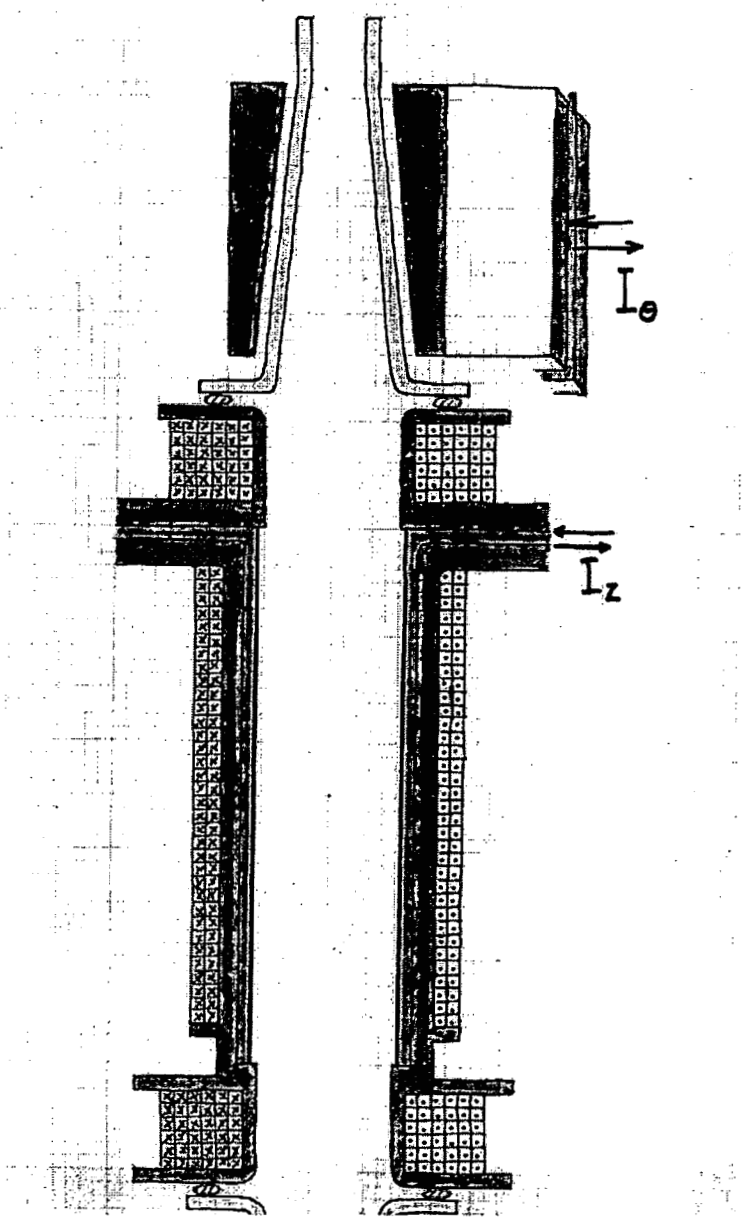
Purpose of design effort

- Main goal is to develop a hardware design that is compatible between FRC injection and operation of Shiva-Star liner implosion hardware.
- Theta pinch injector can be operated without a crowbar; less costly equipment and more reliable operation.
- Values of guide field and mirror field during injection are not as critical as with one-sided injection because the net axial momentum is close to zero; allows choice of field values that maximize plasma lifetime after injection.
- System is compatible with an option of z-pinch preionization.
- Toroidal field expected from conical theta pinch and z-pinch if used, is expected to be annihilated during merging according to observations of spheromak merging experiments.
- Flows parallel to B are likely to result from injection process, and these may help FRC stability.

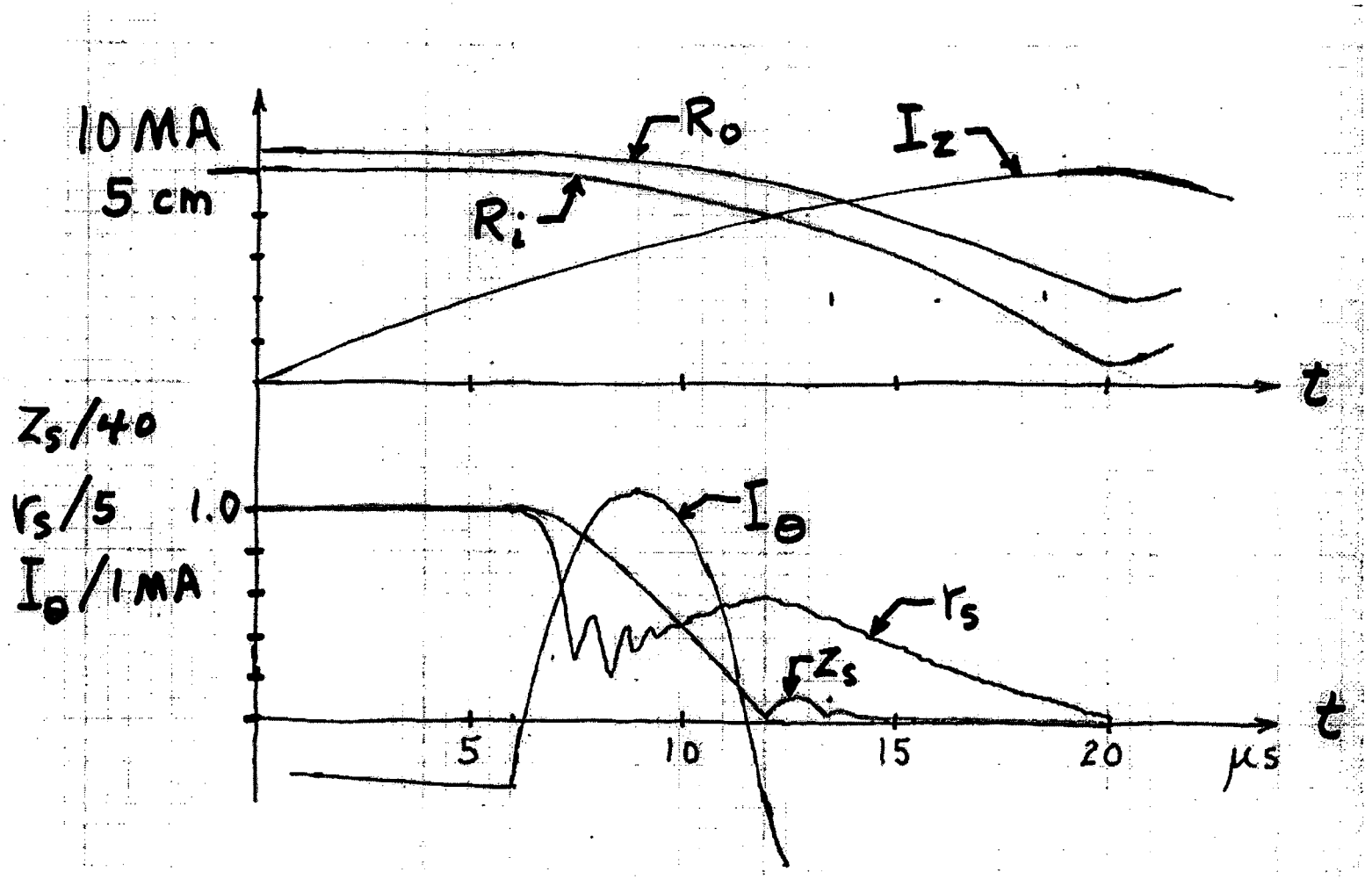
Tools being used

- FLUX2D for initial field profiles using realistic coil properties.
- MACH2 for 2D analysis of liner implosions and FRC plasma injection
- A combined FRC injection and liner implosion calculation is being developed.

Sketch of apparatus

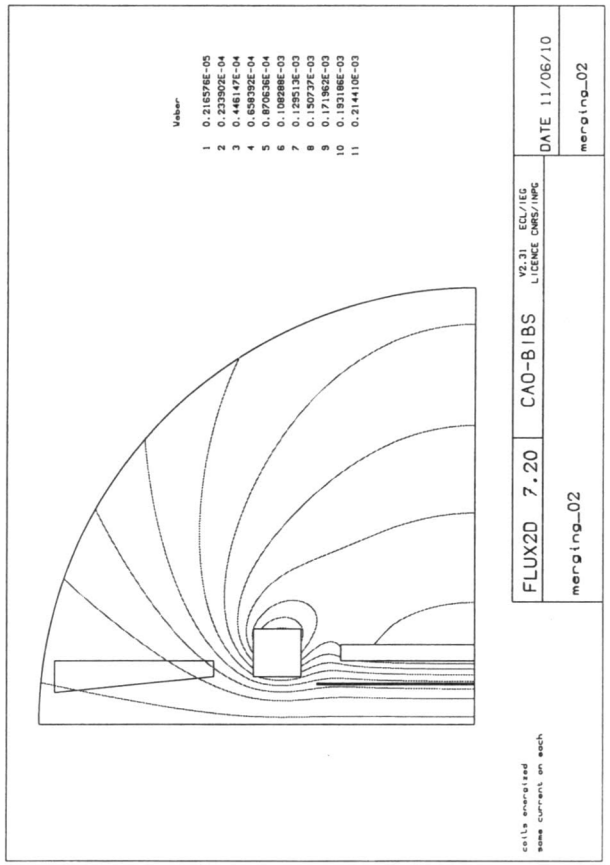


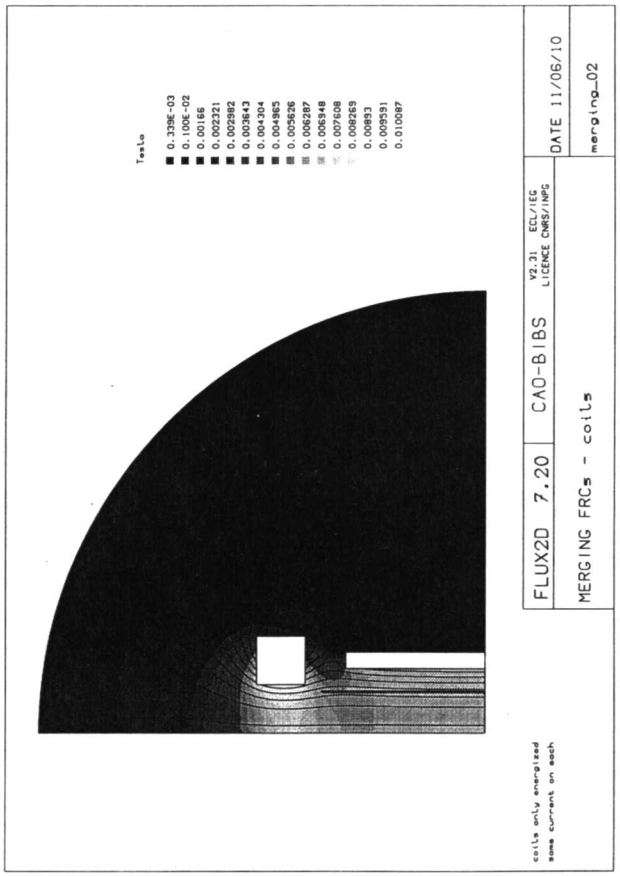
Time sequence of currents and plasma position



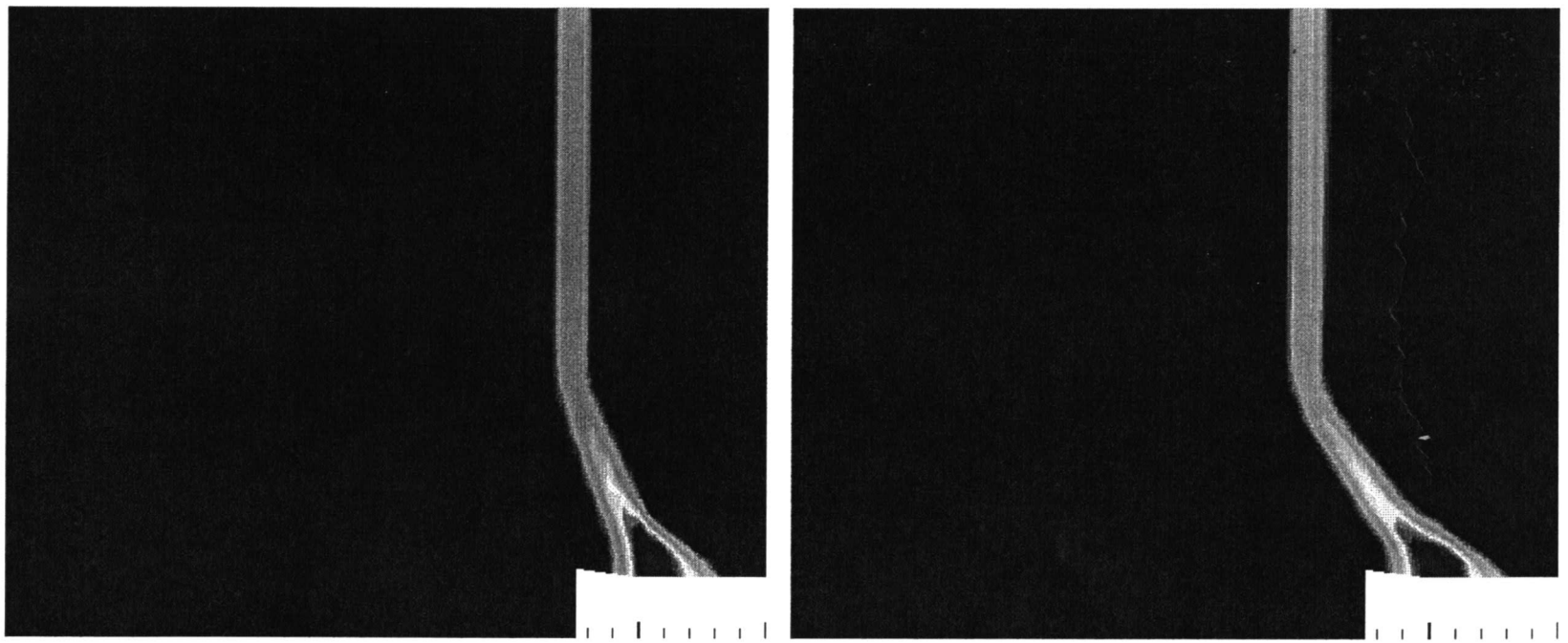
Sketch of mag field at time of PI, initial implosion, and injection

Sample calcs using Flux2D





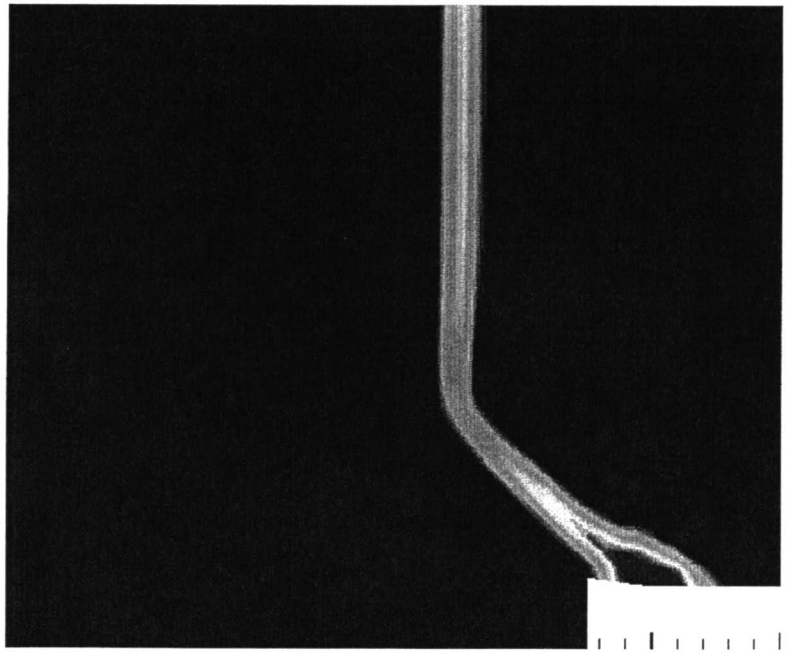
Mach2 liner simulation (liner density)



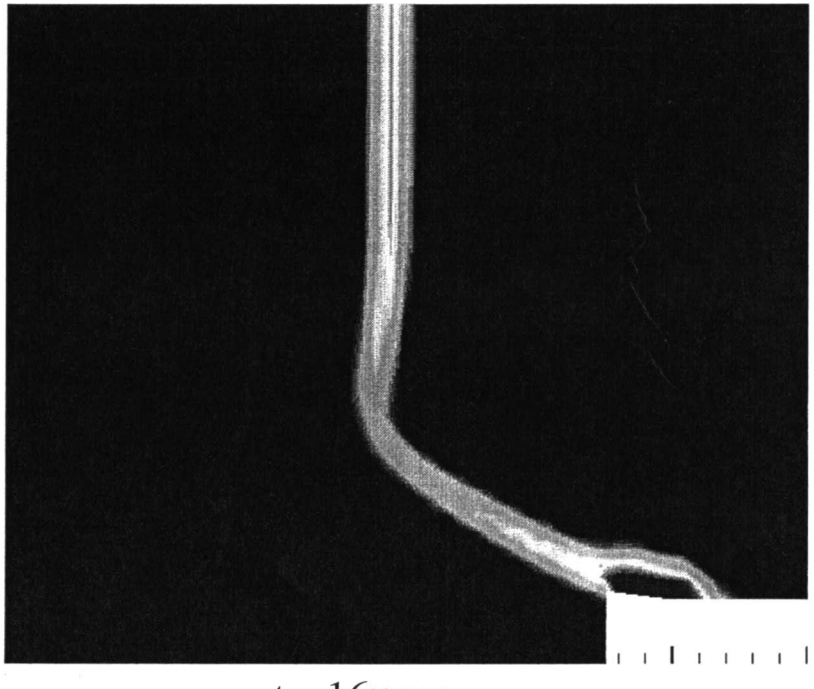
t = 10μsec

t = 12μsec

Deformable Liner

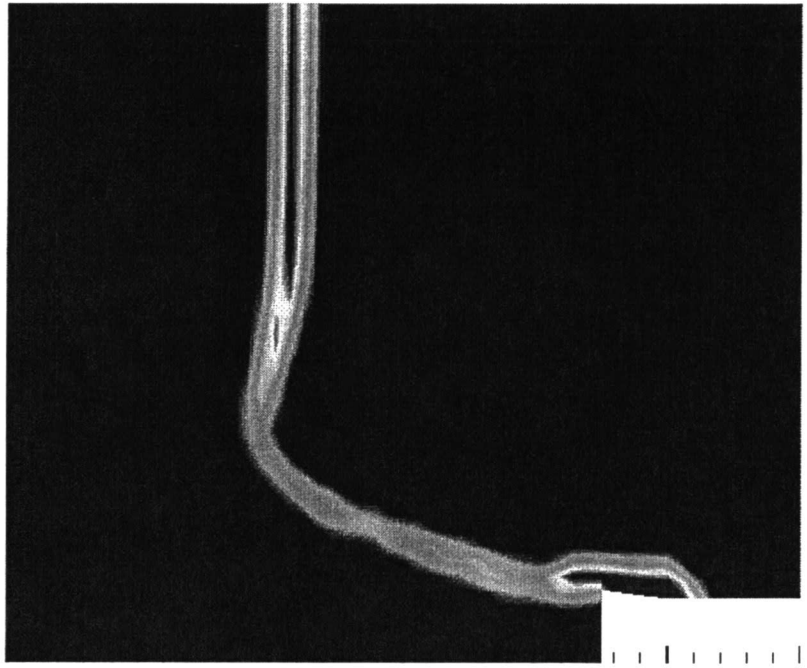


$t = 14\mu sec$

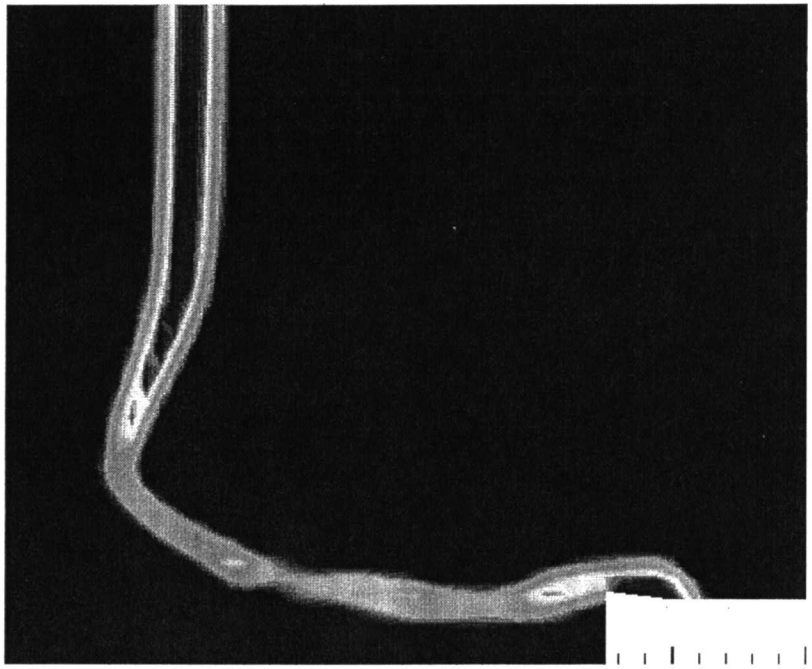


$t = 16\mu sec$

Deformable Liner

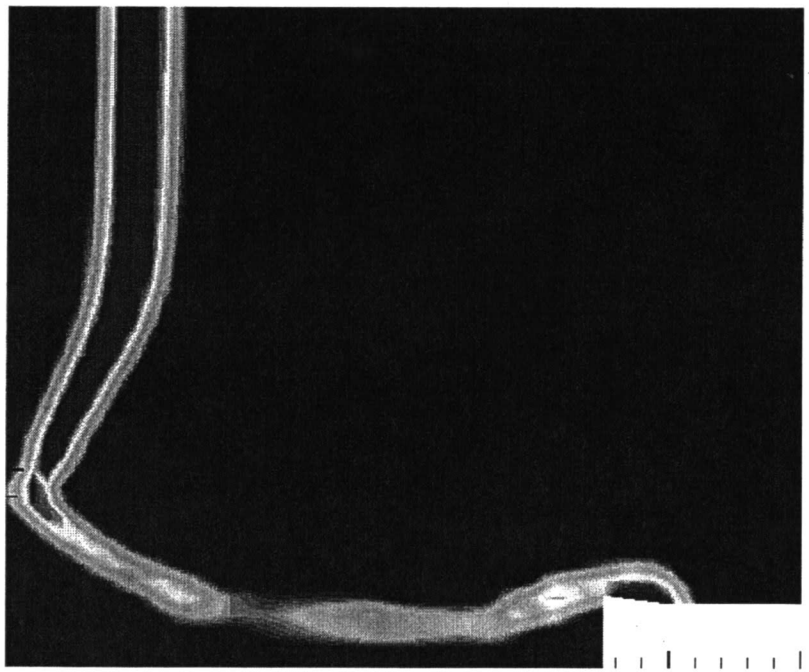


t = 18μsec

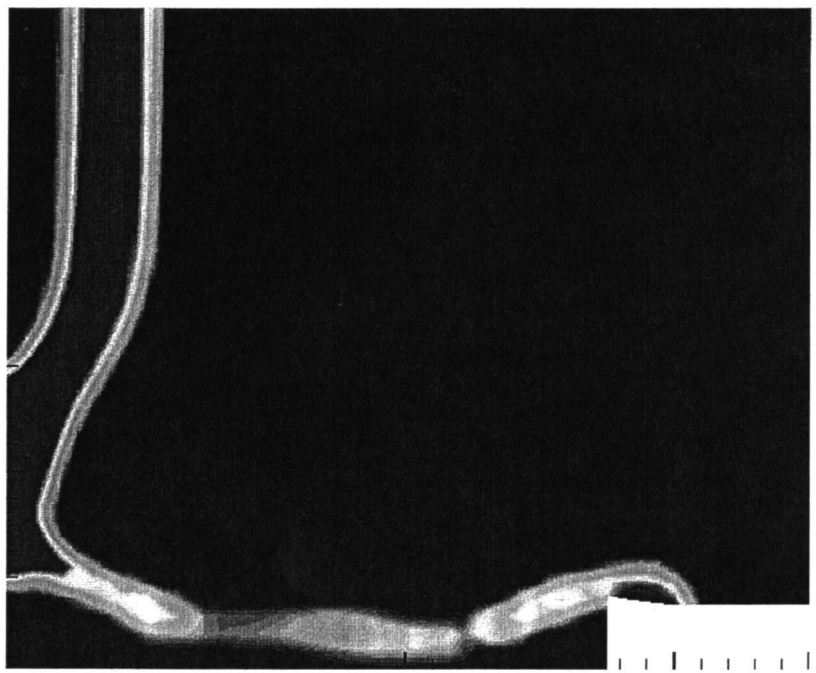


t = 20μsec

Deformable Liner arriving on axis



t = 20μsec



t = 21.5μsec

Sample calcs using Mach2 for FRC formation (Frese)

Conclusions

- A concept has been developed that appears to meet the constraints of available hardware and present understanding of FRC formation.

- Quantitative analysis remains to be done.