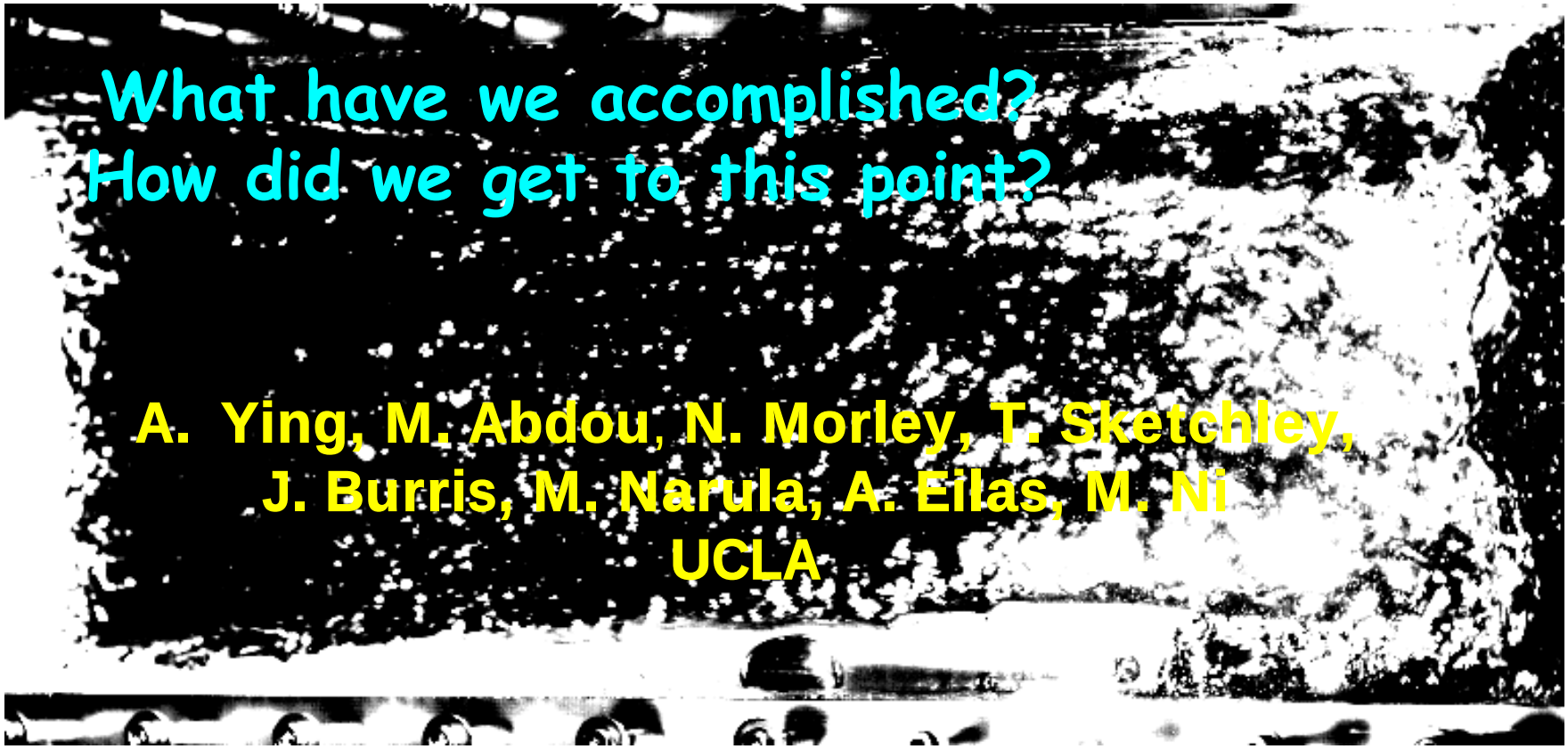
Recent Results on MTOR LM Free Surface Flow



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UCLA

PFC Meeting
May 4, 2004
Urbana, IL

Loop Upgrade (A1: improving flow quality)

Since last November, large effort spent on improving flow loop by incorporating an on-line GaInSn clean-up system

The problem:
GaInSn reacts with oxygen and forms "solid molten chunks", which constantly block the flow

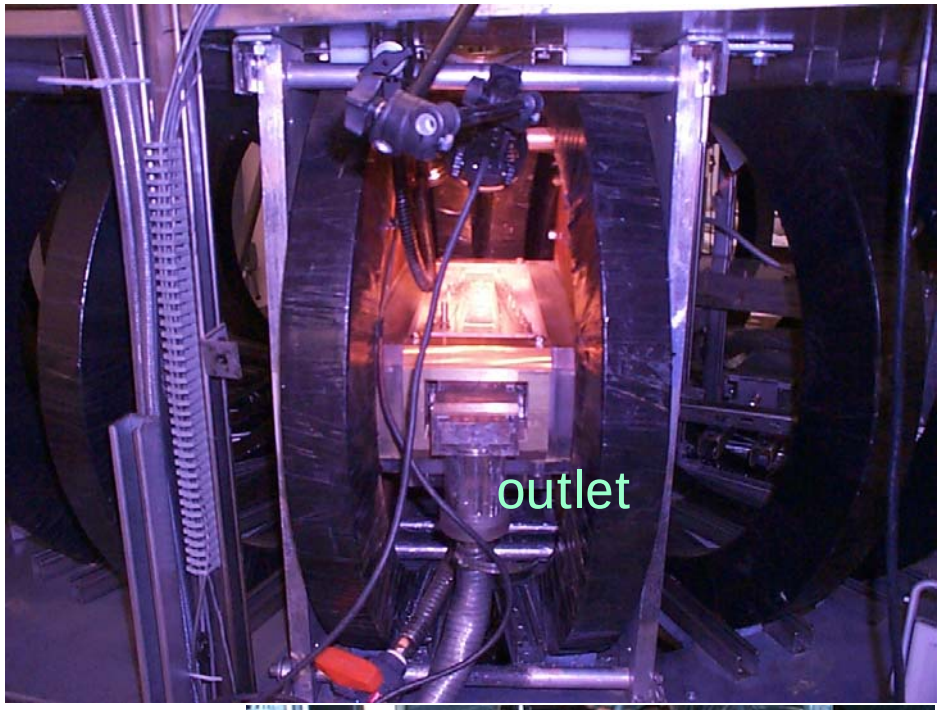
The gallium flowing loop now sits next to rather than under the MTOR (easy to maintain)

The "old" Russian EM pump

MHD experiments in MTOR (using GII conducting walls test article)

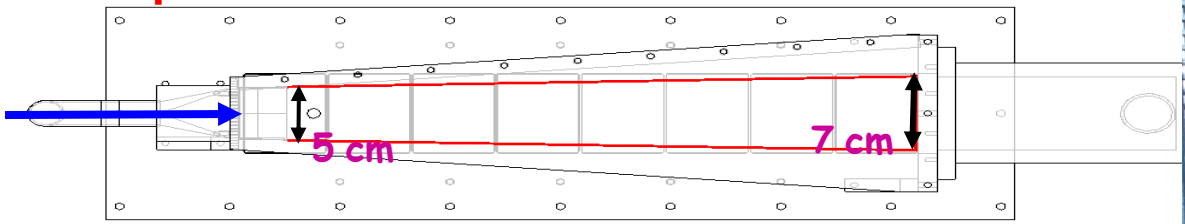
A2: provided data from the effect of

- MHD due to gradient toroidal field
- flow expansion; and
- up-hill flow

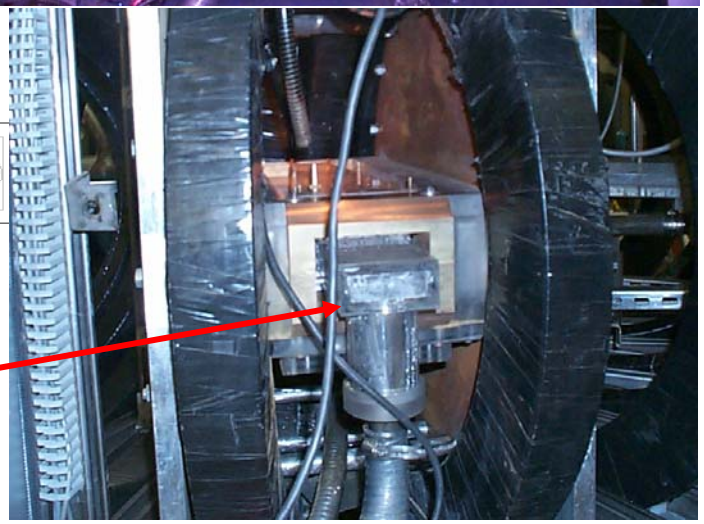


Flow path 45 cm

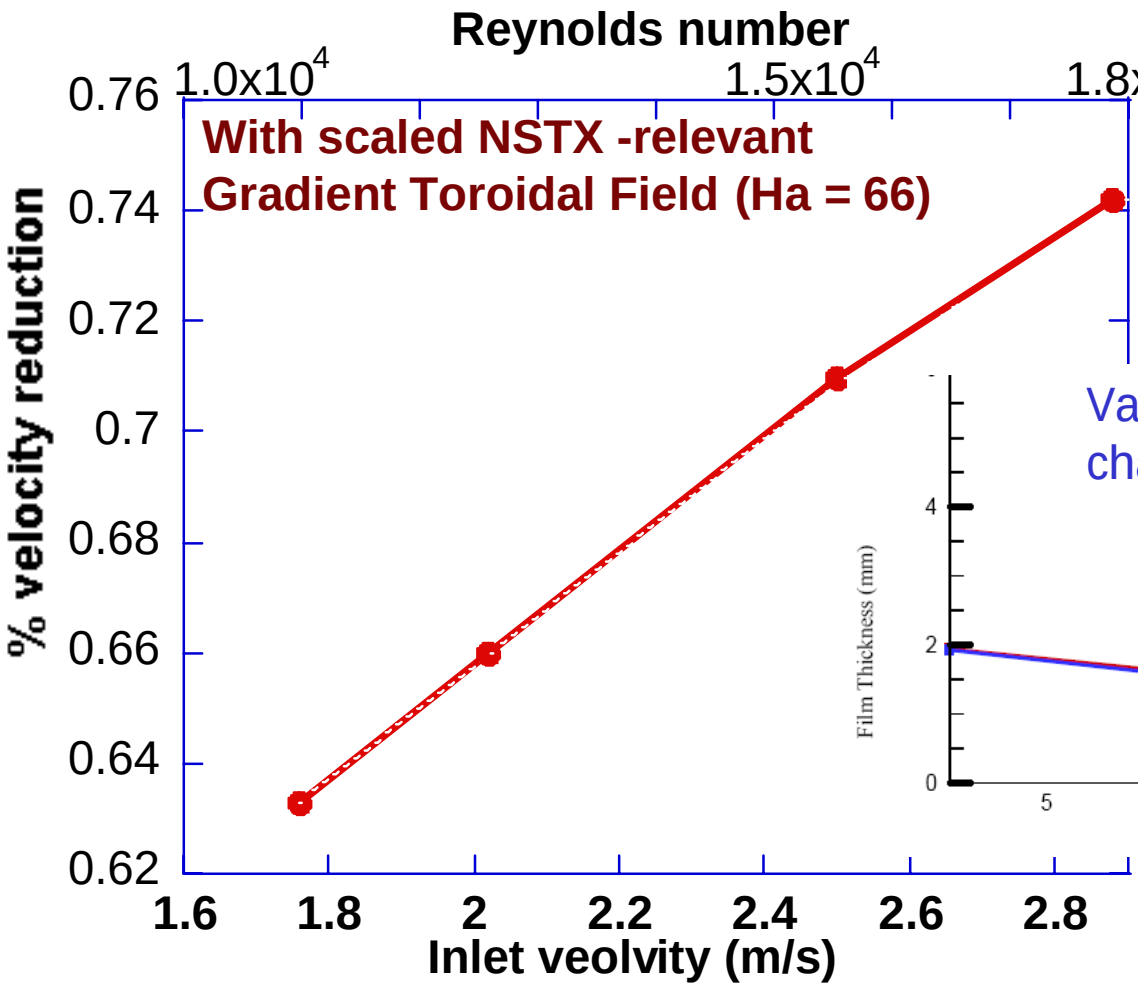
Top view



A large outlet pipe used to provide adequate drain capability

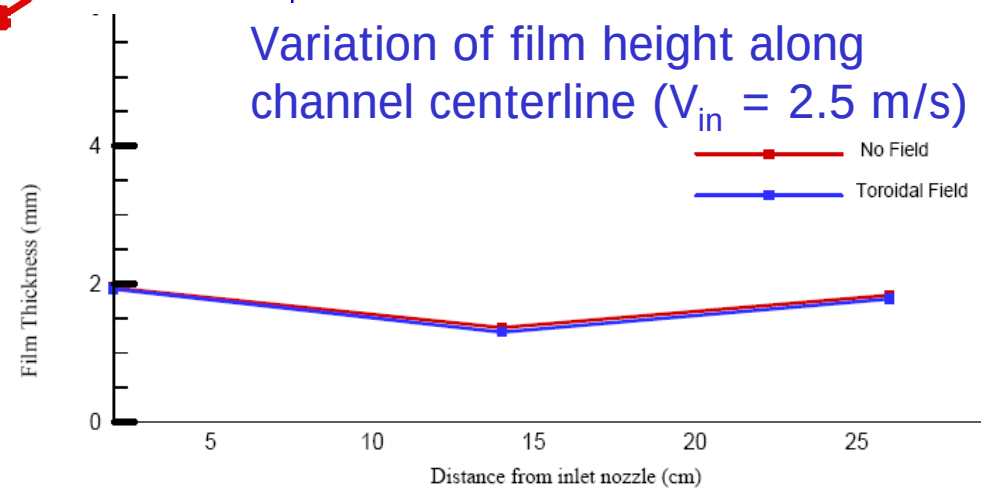


The predominant effect of the toroidal field is reducing the average velocity as a whole and not the velocity in certain regions

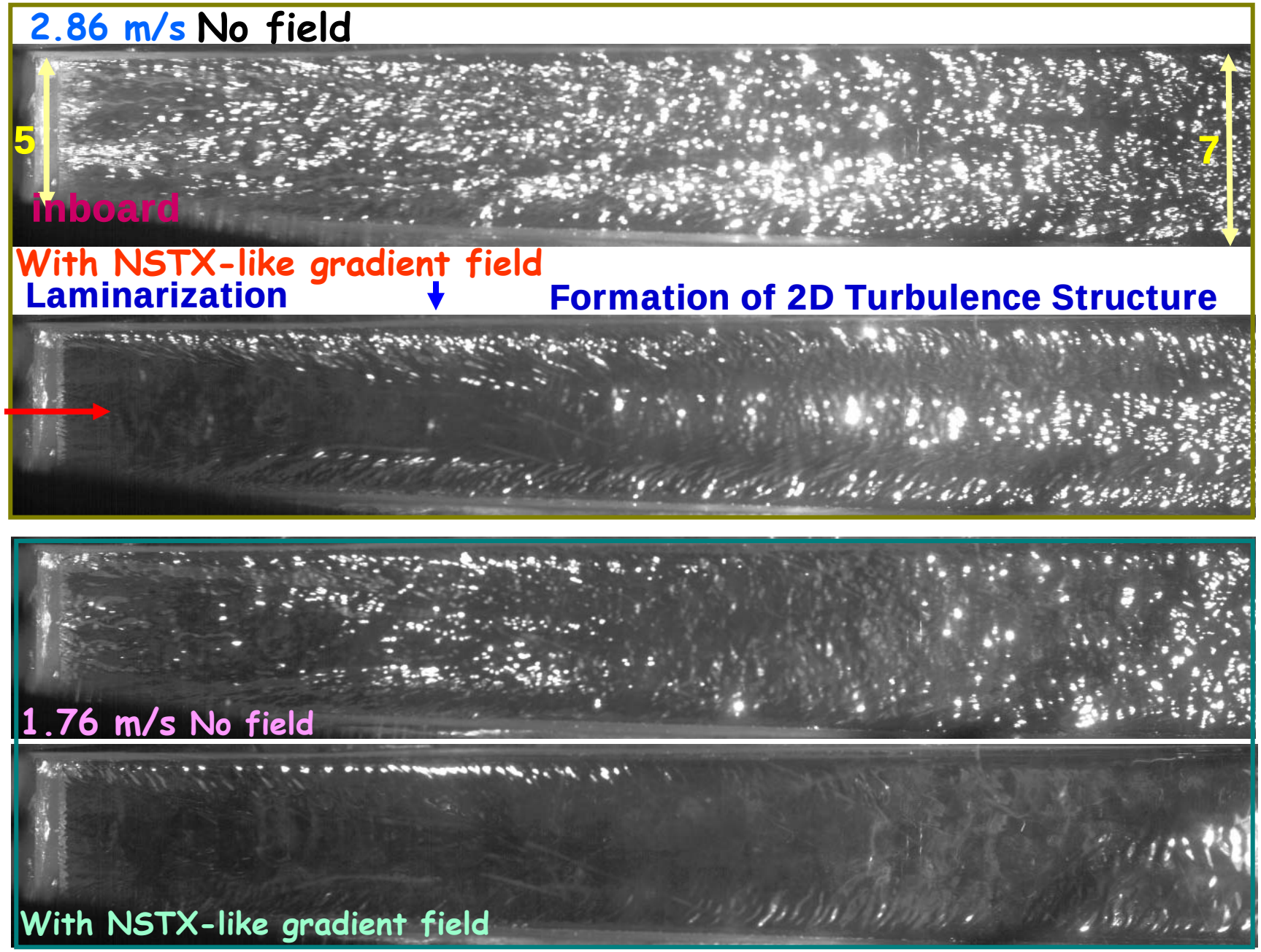


At the same inlet velocity, toroidal field appears not to alter film height profile

Variation of film height along channel centerline (V_{in} = 2.5 m/s)



Effect of Toroidal Fields



Experimental schemes proposed to resolve uncertainties found in previous results

Uncertainties

- Strong wall effect on LM surface flow profile
- Impact of chute width on MHD effects

Ideal scheme:

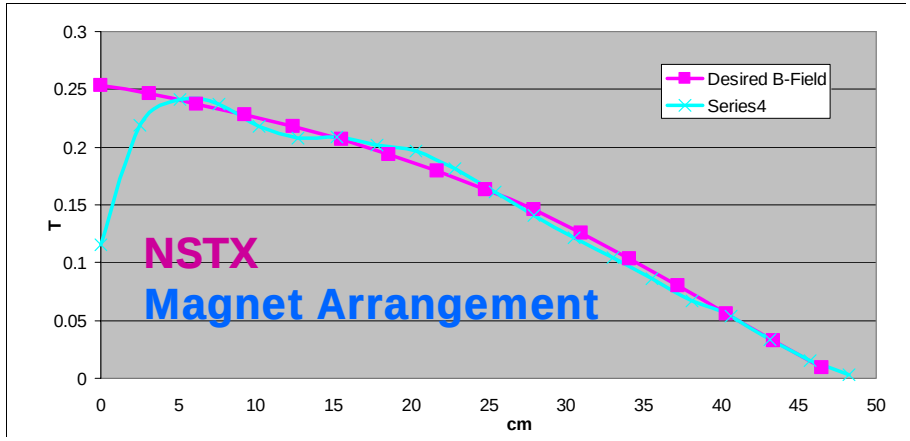
- to proceed with a wider channel in MTOR ASAP
  - MTOR upgrade needs careful planning with adequate resources not to idle MTOR

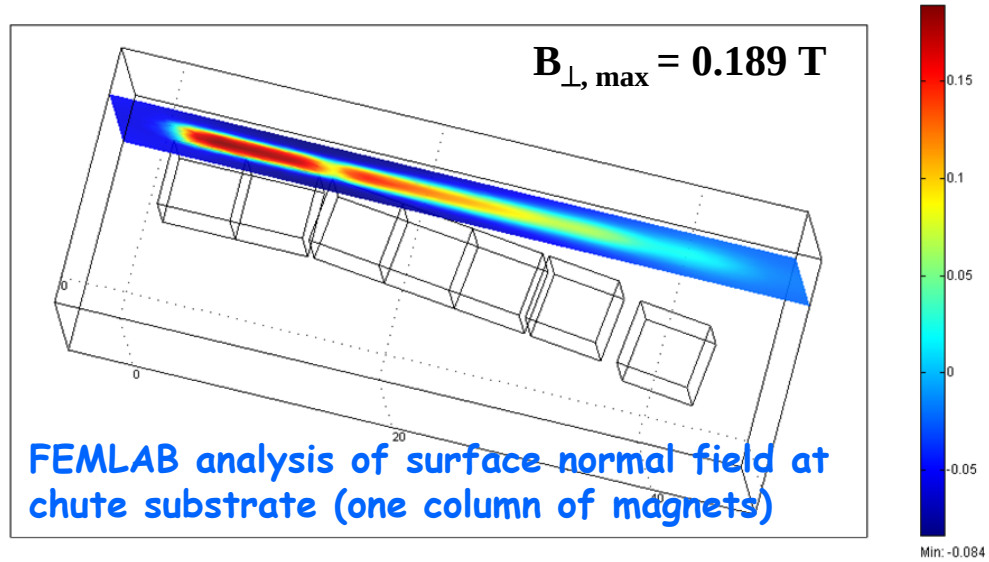
    (a full current of 3600 A operation or a reduced test volume with filled irons)

Alternate: A3

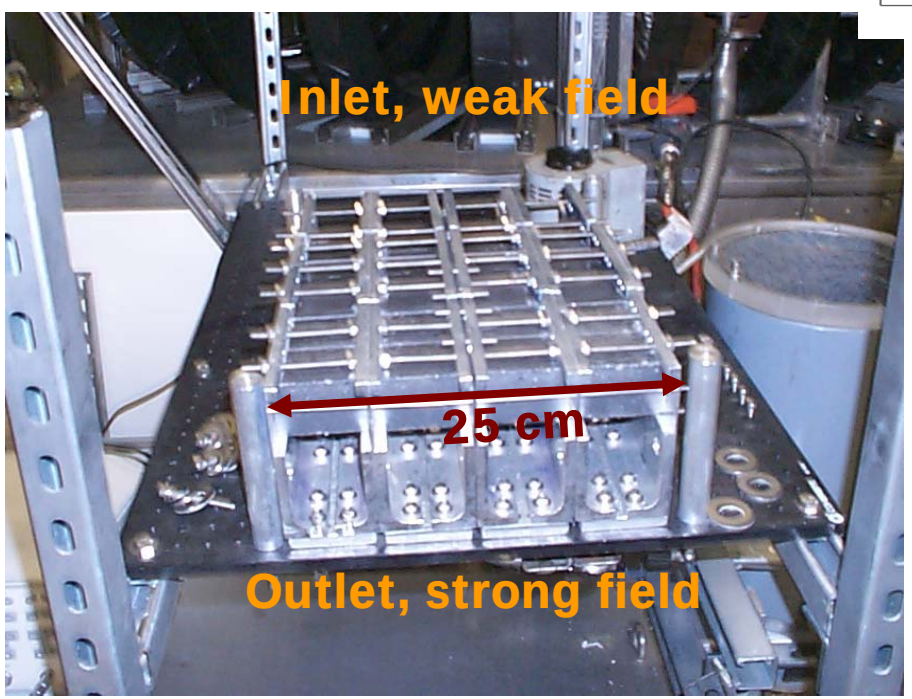
- to conduct experiments outside MTOR using permanent magnets
  - limited to gradient surface normal field only

Proceeded to a larger test article outside MTOR using permanent magnets (cost effective)

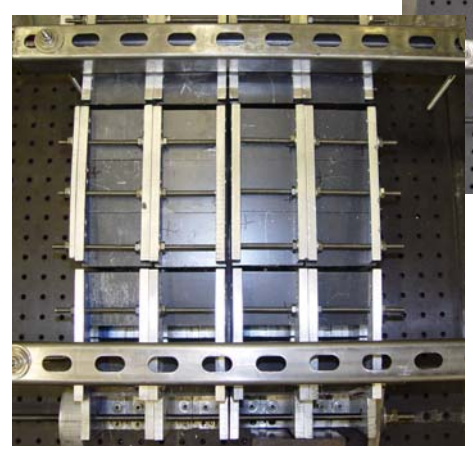


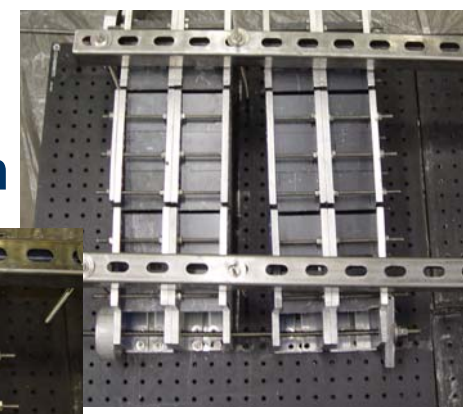


FEMLAB analysis of surface normal field at chute substrate (one column of magnets)



Flow channel dimensions:
20 cm x 45 cm



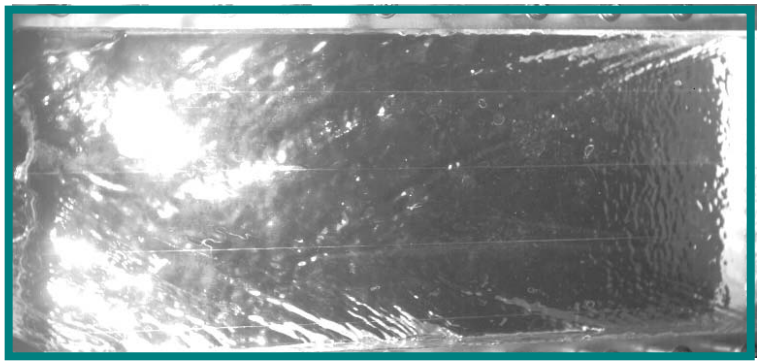


Brut forces applied in order to bring the magnets together

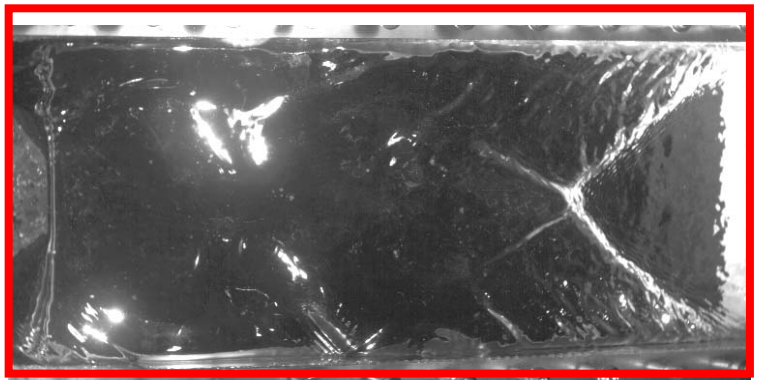
Axial (return) current density increases as velocity increases, which results in unfavorable, stronger MHD effects

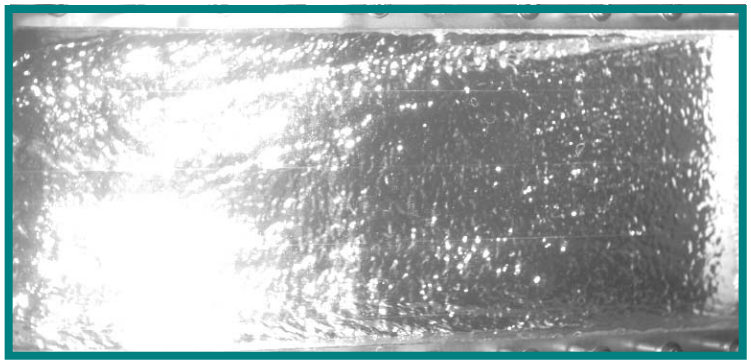
No field

With gradient surface normal field



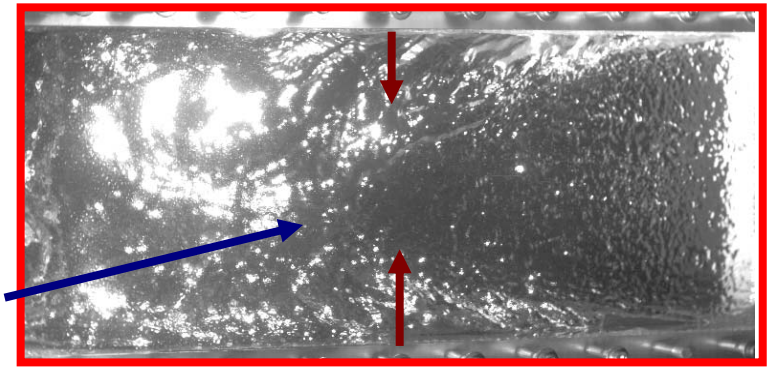
1 m/s

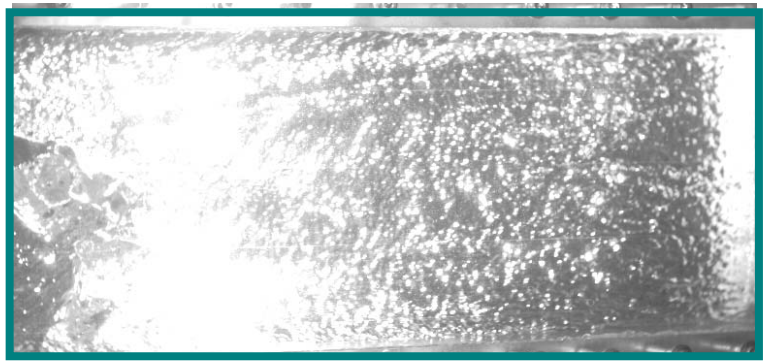




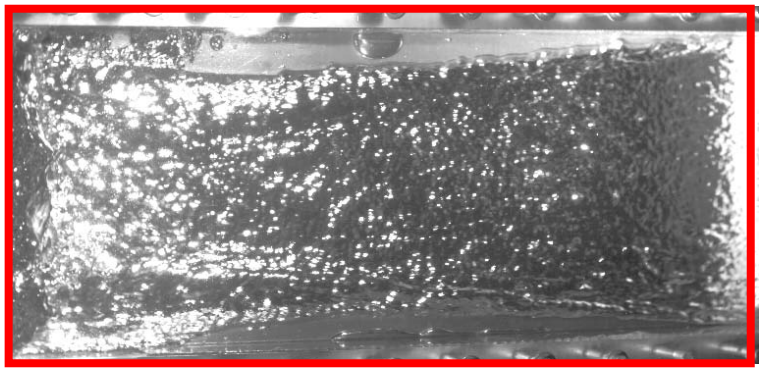
2 m/s

Pinch-in forces begin to appear



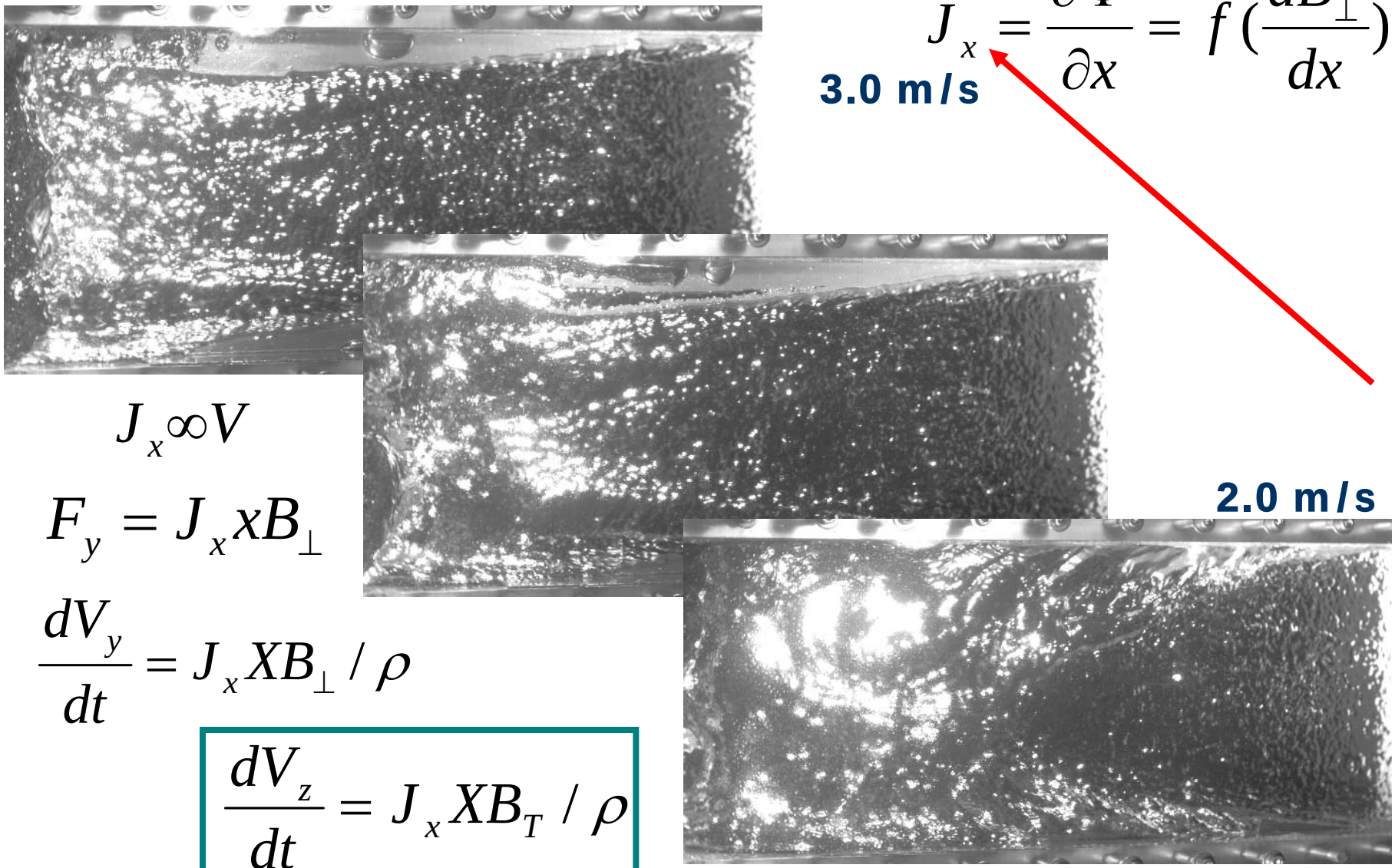


3 m/s



Bare zones appear as MHD pinch-in forces become bigger

$$J_x = \frac{\partial \Phi}{\partial x} = f\left(\frac{dB_\perp}{dx}\right)$$



$$J_x \propto V$$

$$F_y = J_x x B_\perp$$

$$\frac{dV_y}{dt} = J_x X B_\perp / \rho$$

$$\frac{dV_z}{dt} = J_x X B_T / \rho$$

Plans for the remaining FY04

- Solidify “MTOR Upgrade Scheme”
  - **Power upgrade vs test volume reduction**
- Obtain film height profiles for the current wide-channel test article based on inductive probes approach and a laser illumination scheme (under development)
  - **Identify schemes to eliminate problems of bare zones**
  - **Provide schemes to install a wide channel into MTOR**
- HIMAG simulations of MTOR film flow geometries
- Present results at the TOFE meeting