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UCRL-CONF-216111

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October 12, 2005

47th Annual Meeting of the APS-DPP  
Denver, CO, United States  
October 24, 2005 through October 28, 2005

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# The KL Mix Model Applied to Directly Driven Capsules on the Omega Laser\*

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Prepared for the 47<sup>th</sup> Annual Meeting of the Division of  
Plasma Physics of the  
American Physical Society  
FO2.00003

October 25, 2003

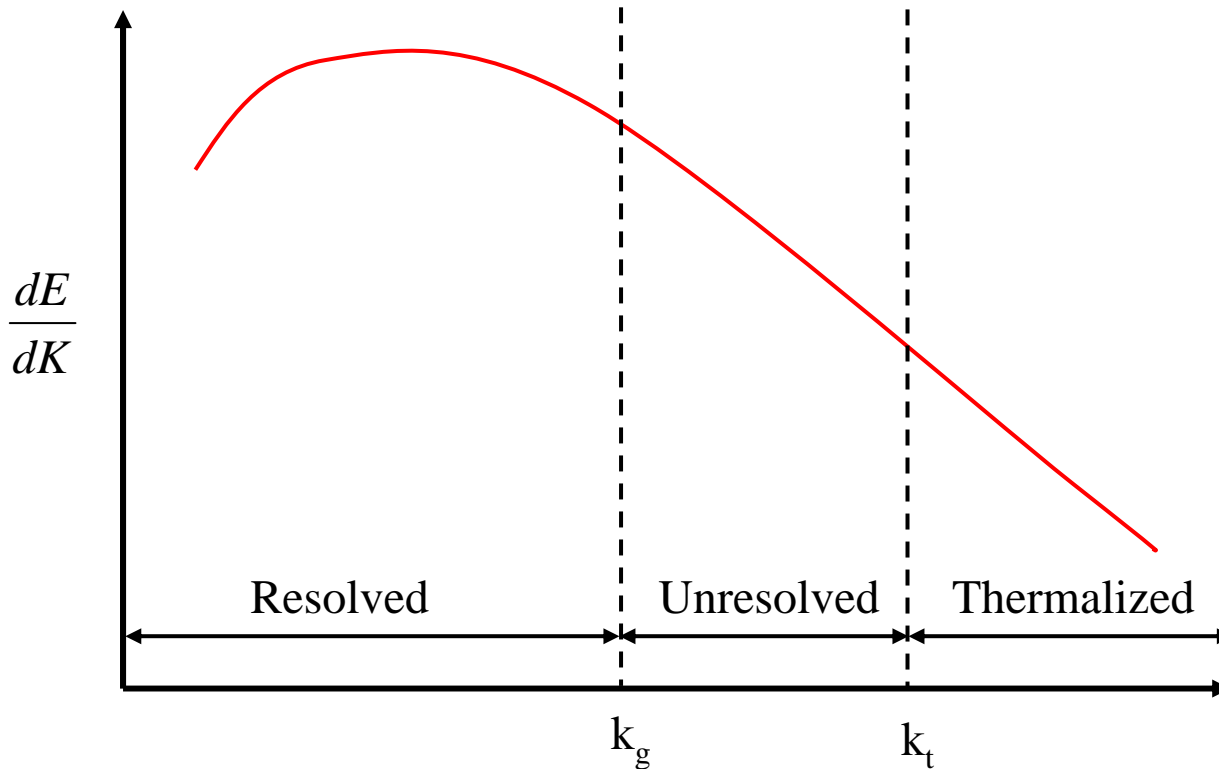
\*This work was performed under the auspices of the U.S. Department of Energy by the University of California, Lawrence Livermore National Laboratory under contract No. W-7405-Eng-48.

# Main Points

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- The coefficients of the KL mix model were set by Dimonte to match RT and RM instabilities as measured on the Linear Electric Motor (LEM).
- The KL mix model has been applied to directly-driven capsule implosions with a variety of laser energies, ablator materials, ablator thicknesses and convergence ratios.
- The KL calculations nearly match the observed  $Y_{DD}$ ,  $Y_{DT}$ ,  $Y_P$ ,  $T_{ion}$  and implosion times for many (but not all) capsules.

# The KL model characterizes sub-grid hydrodynamics with 2 variables



$$K = \int_{k_g}^{k_t} \frac{dE}{dk} dk$$

$L$  is the characteristic eddy size

Please see Guy Dimonte's talk on the KL equations –  
**LO1.00009** 3:36 Wed Oct 26, 2005

# All coefficients of the KL model can be derived from four numbers

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- $\alpha_B = 0.07$  – Young's RT bubble coefficient
- $\theta = 0.25$  – RM exponent
- $f_{PE} = 0.50$  – Ratio of turbulent to potential energy
- $C_c = 0.$  – the compression coefficient in the L eq.

$\alpha_B$  inferred from LEM data is 0.06 rather than 0.07

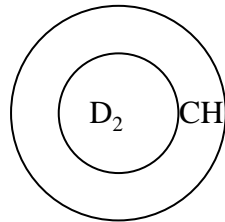
The ideal value of  $C_c$  is 1/3 rather than 0

# 1D Calculations with CALEICF

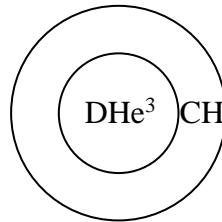
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- Sn radiation transport
- Electron thermal flux limiter of 0.05
- LTE opacities from SHM
- Lee-More thermal conductivities
- Thermonuclear reactions
- MC charged particle transport
- $T+D \Rightarrow N + He4$  reactions in flight
- $He3+D \Rightarrow P + He4$  reactions in flight
- Initialize L field to 50nm on inner surface
- Initialize L field to 50-150nm on outer surface

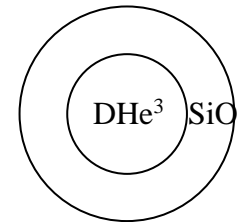
# Three different types of capsules were tested



$D_2$  Fuel with  
CH Ablator



$DHe^3$  Fuel with  
CH Ablator



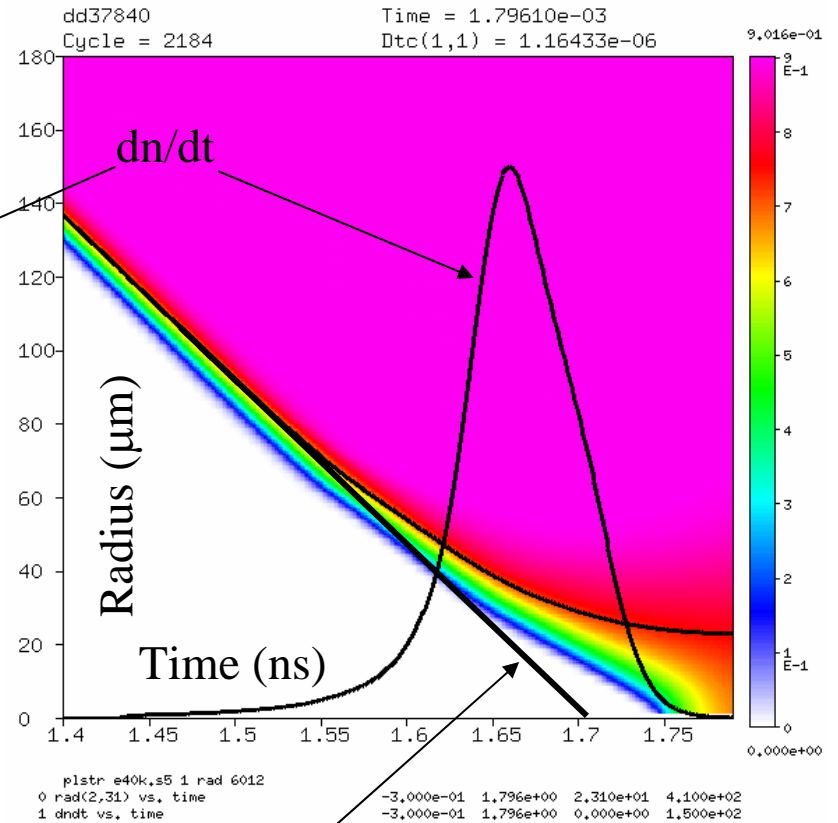
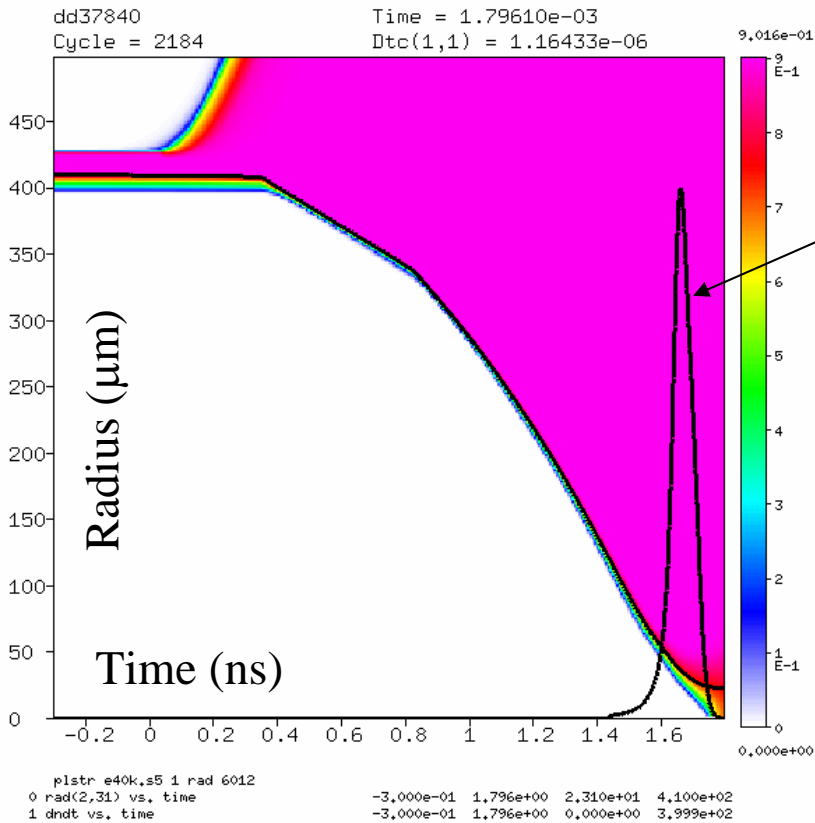
$DHe^3$  Fuel with  
 $SiO_2$  Ablator

Three types of direct drive laser capsules were fired with different fuel pressures, ablator thickness and laser energies. Measured quantities include:

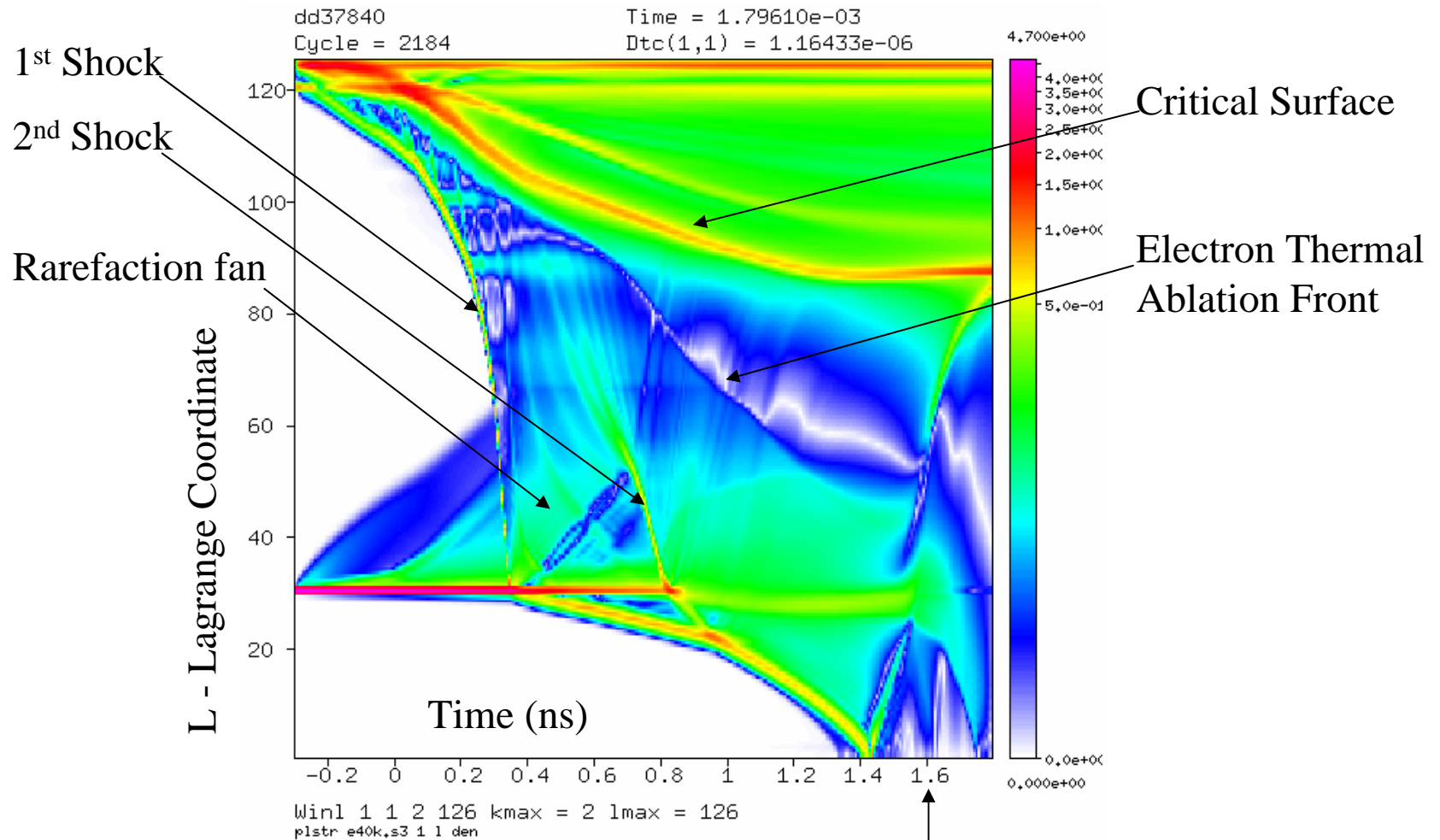
- 1 Primary DD neutrons and secondary DT neutrons
- 2 Primary  $DHe^3$  protons (for  $D_2$  fuels secondary  $DHe^3$  protons were measured)
- 3 Ion temperatures (inferred from TOF spreading of the DD neutrons)
- 4 Implosion Time



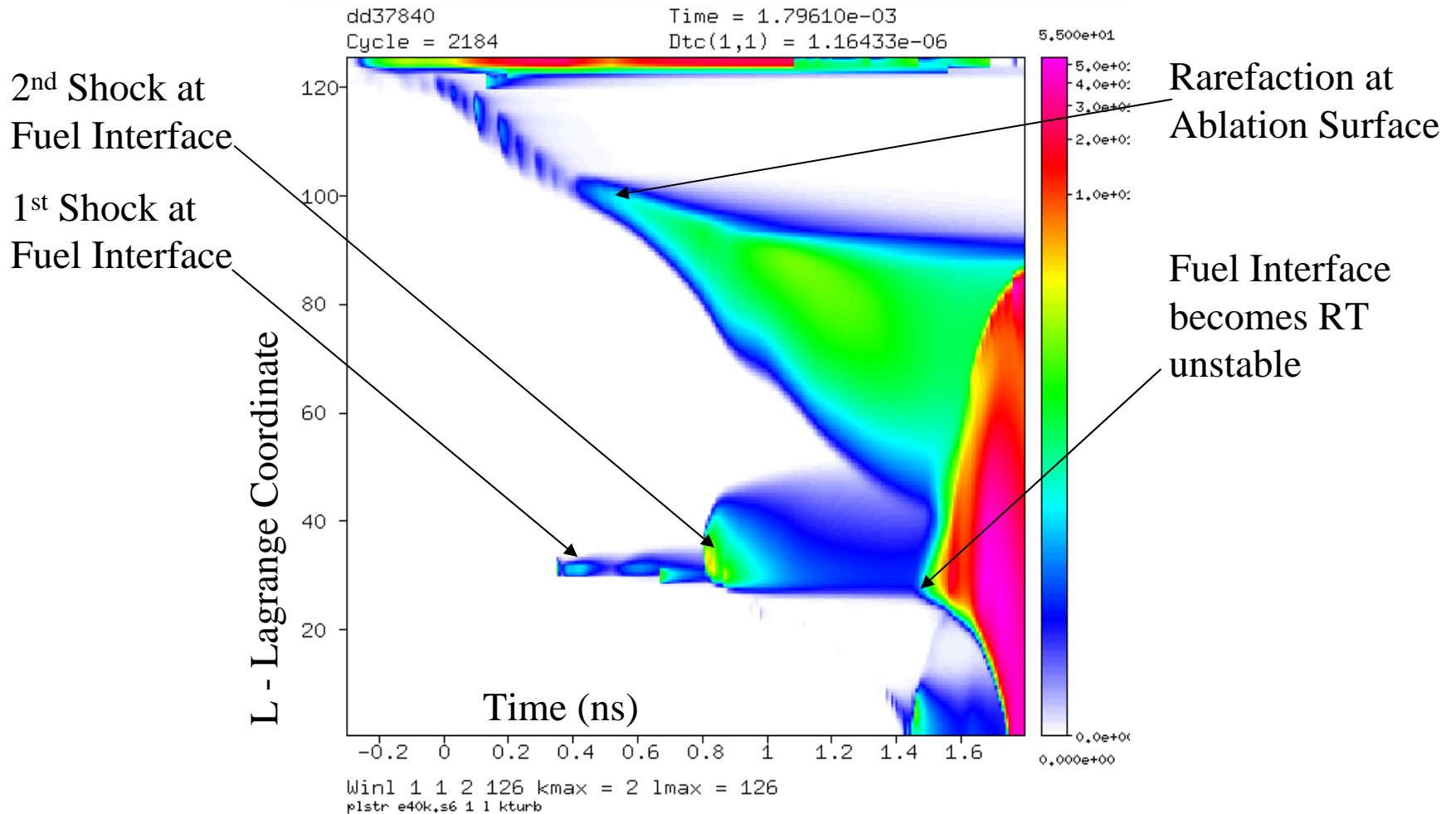
# Carbon mass fraction front nearly follows the free-fall line



# Streak plot of $d \log(\rho)/dL$ shows shocks, rarefactions and ablation fronts

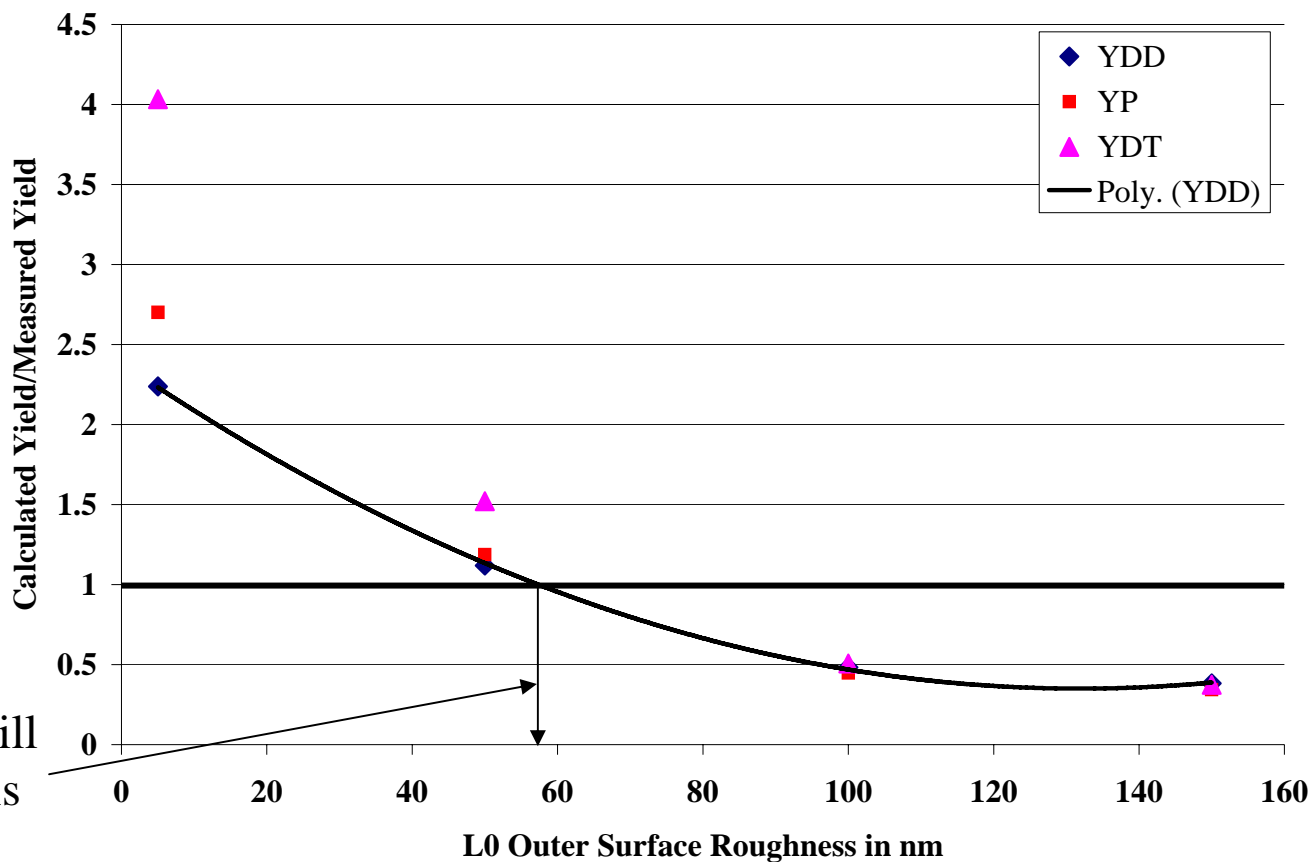


# Streak plot shows turbulent energy feeds through from thermal-ablation front to fuel surface



# KL model predicts instabilities near laser absorption will degrade performance. Outer surface roughness can be adjusted to match data

## L0 Study for Shot 37840

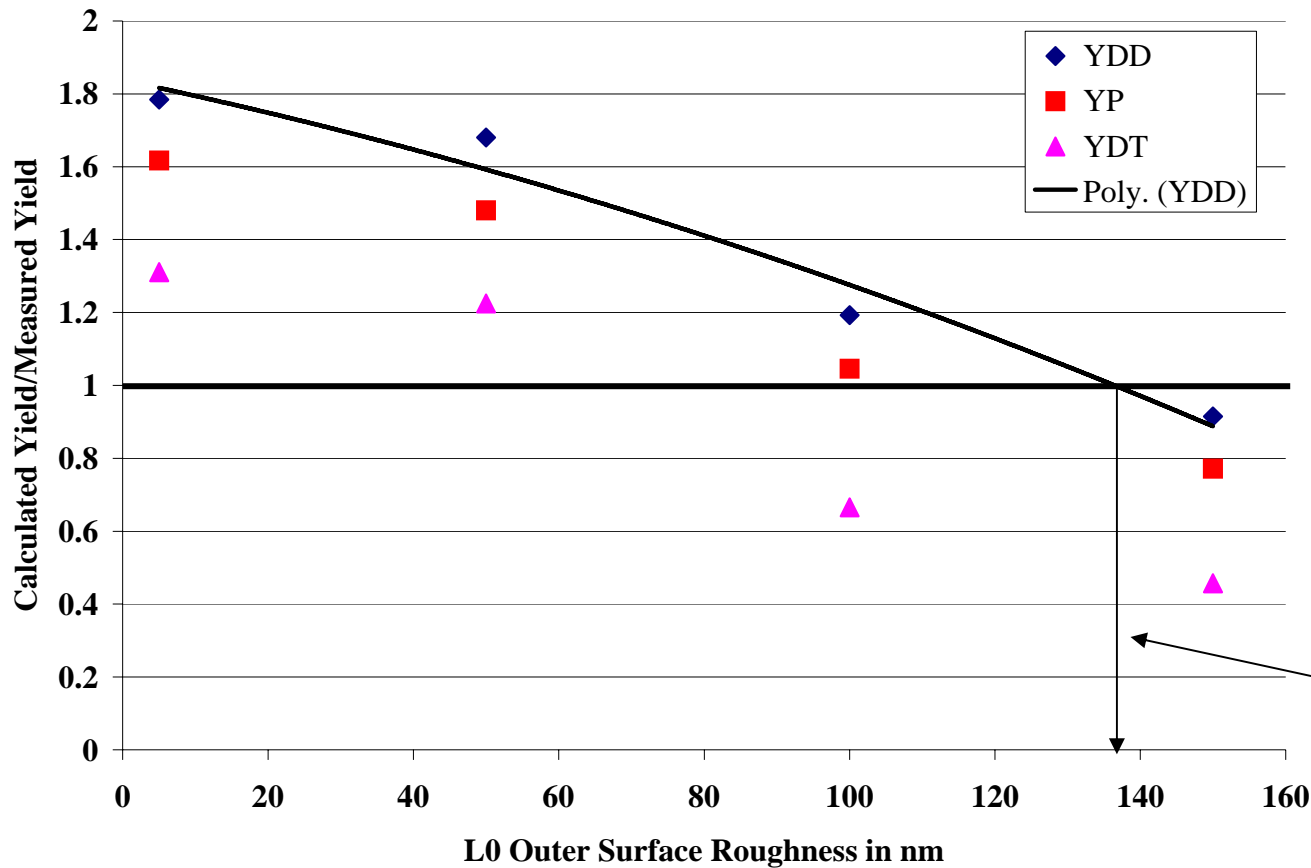


$L_0 = 57\text{nm}$  on the outside surface will match data for this capsule

A surface roughness of 50-70nm gives good results for most capsules however, some require 150nm



### L0 Study for Shot 32316



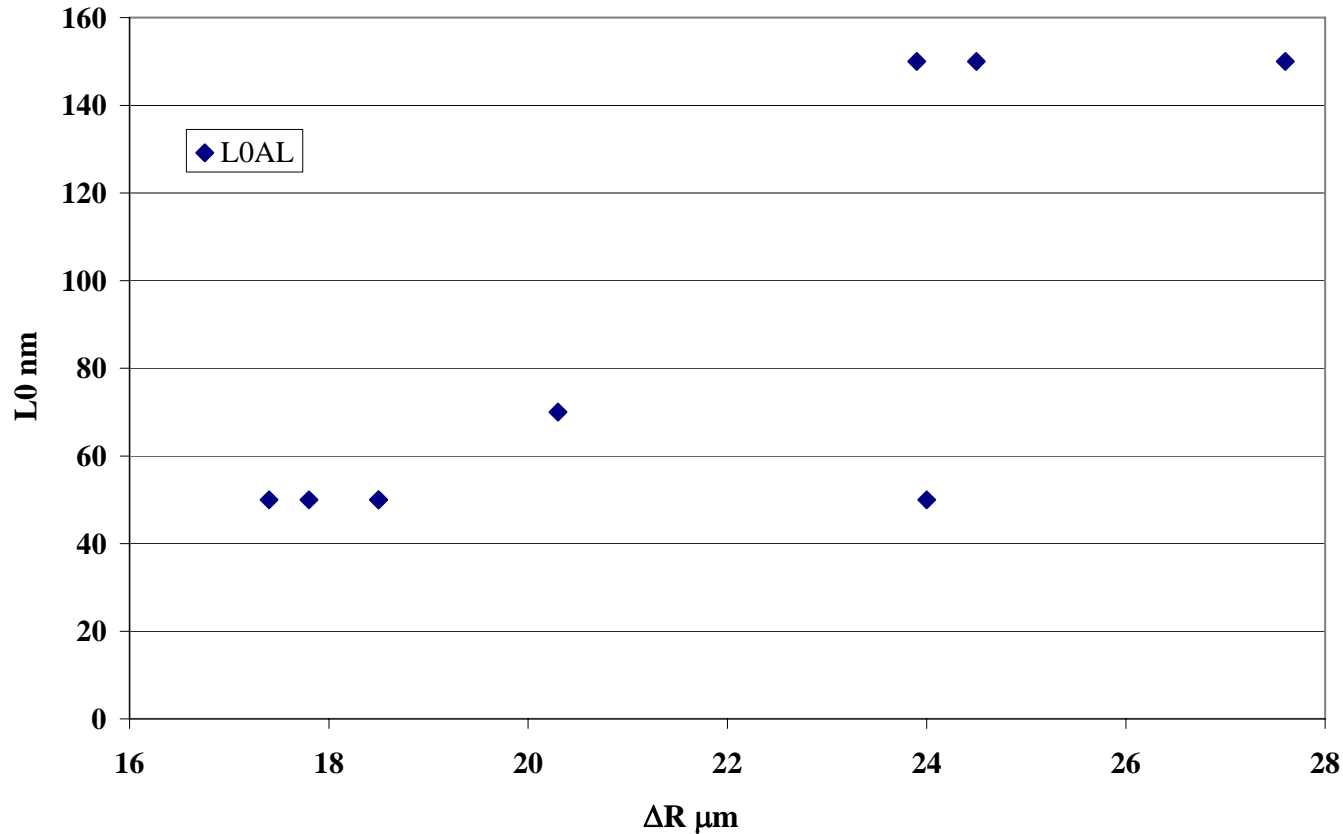
$L_0 = 135\text{nm}$  on the outside surface will match data for this capsule

# Thin capsules need $L_0 = 50$ nm

# Thick capsules need $L_0 = 150$ nm



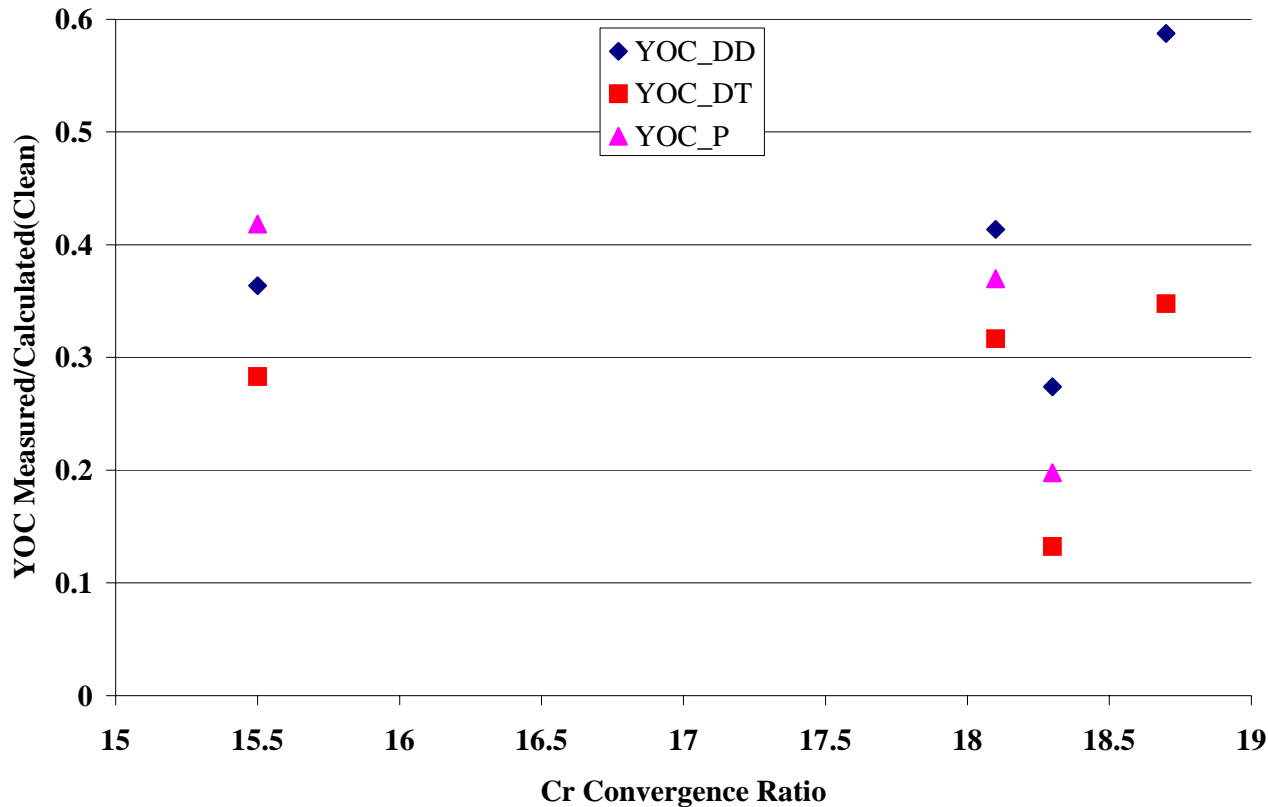
Wall Thickness Study



# $Y_{DD}$ from $D_2/CH$ Capsules gave YOC(Clean) $\sim 0.3-0.6$



D2/CH Capsules YOC Measured/Calculated(clean)

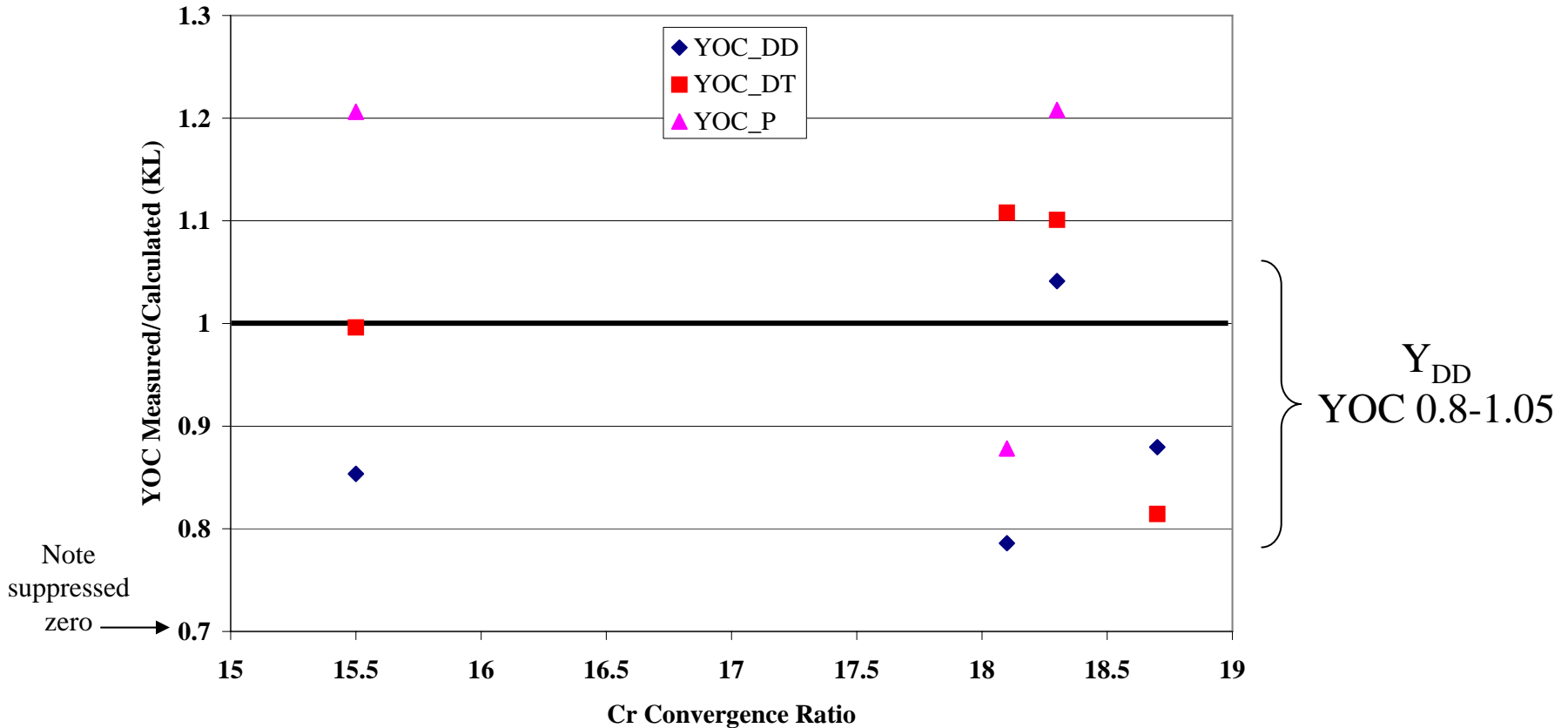


$Y_{DD}$   
YOC 0.3-0.6

# $Y_{DD}$ from $D_2/CH$ Capsules gives $YOC(KL) \sim 0.8-1.05$



D2/CH Capsules YOC Measure/Calculated(KL)

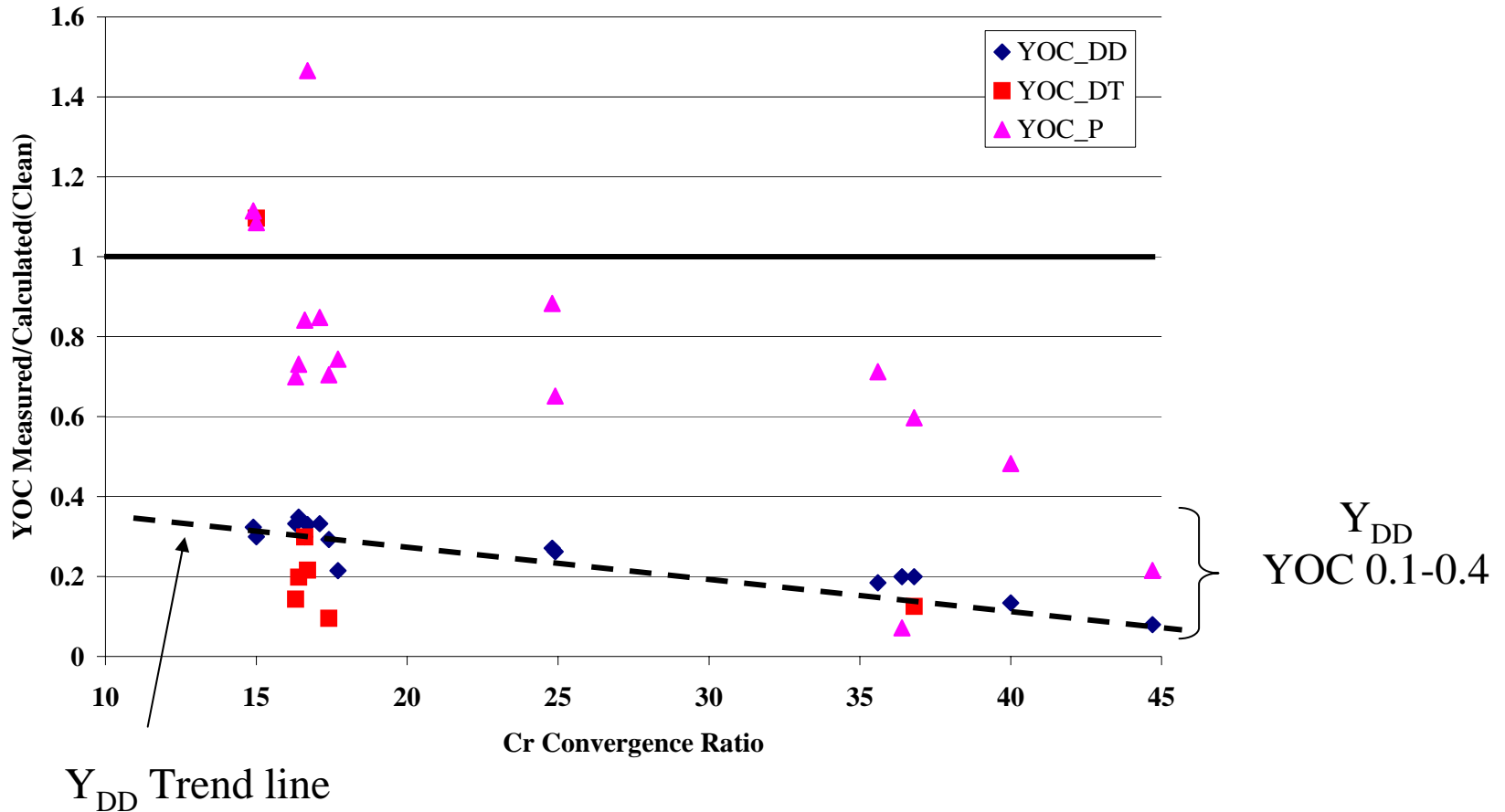




# $Y_{DD}$ from DHe<sup>3</sup>/CH Capsules gave YOOC(Clean) ~ 0.1-0.4

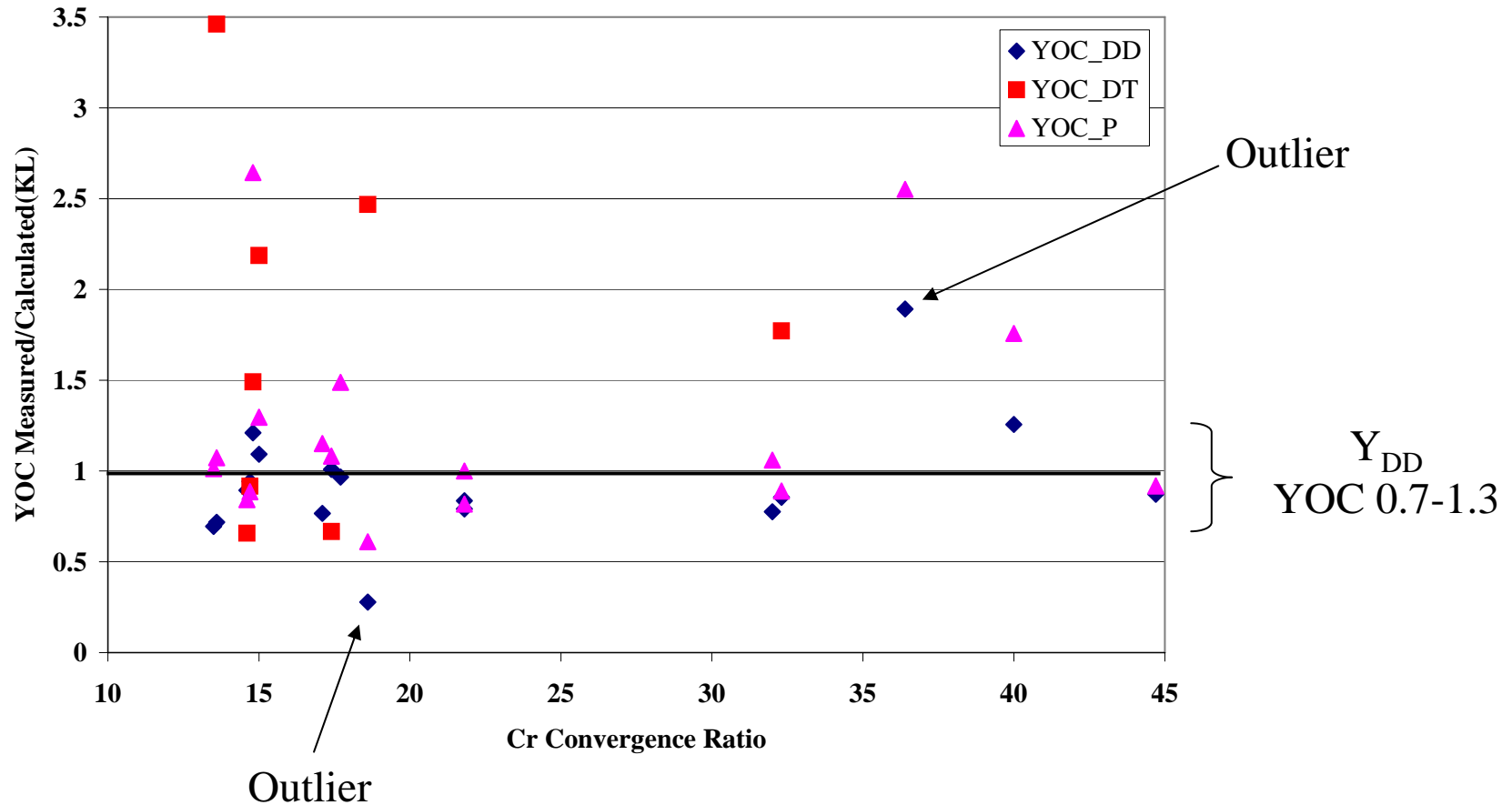


DHe3/CH Capsules YOOC Measured/Calculated (clean)



# $Y_{DD}$ from DHe<sup>3</sup>/CH Capsules gives YOOC(KL) ~ 0.7-1.3

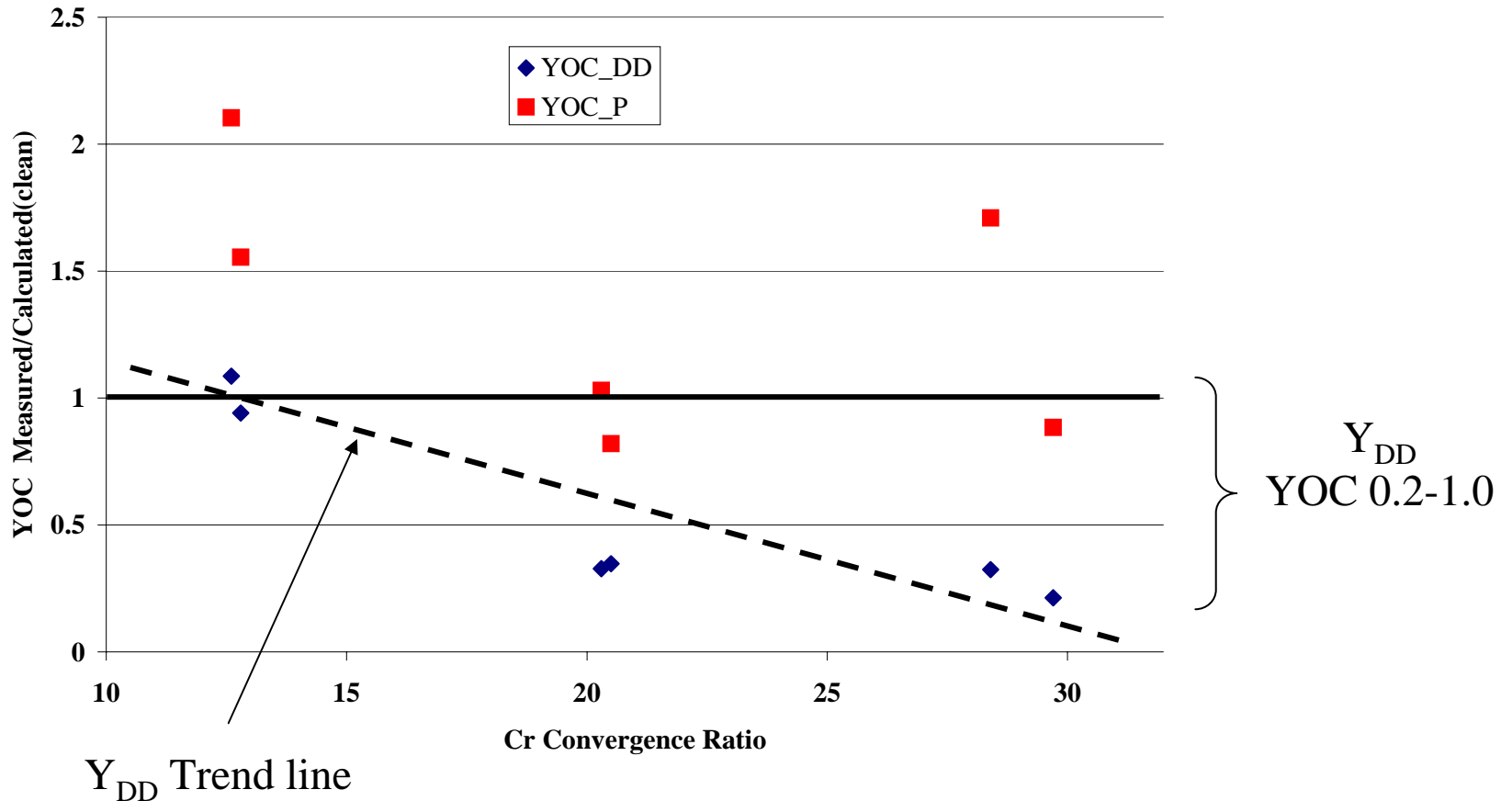
DHe3/CH YOOC Measured/Calculated(KL)



# $Y_{DD}$ from $DHe^3/SiO_2$ Capsules gave $YOC(\text{Clean}) \sim 0.2-1.0$



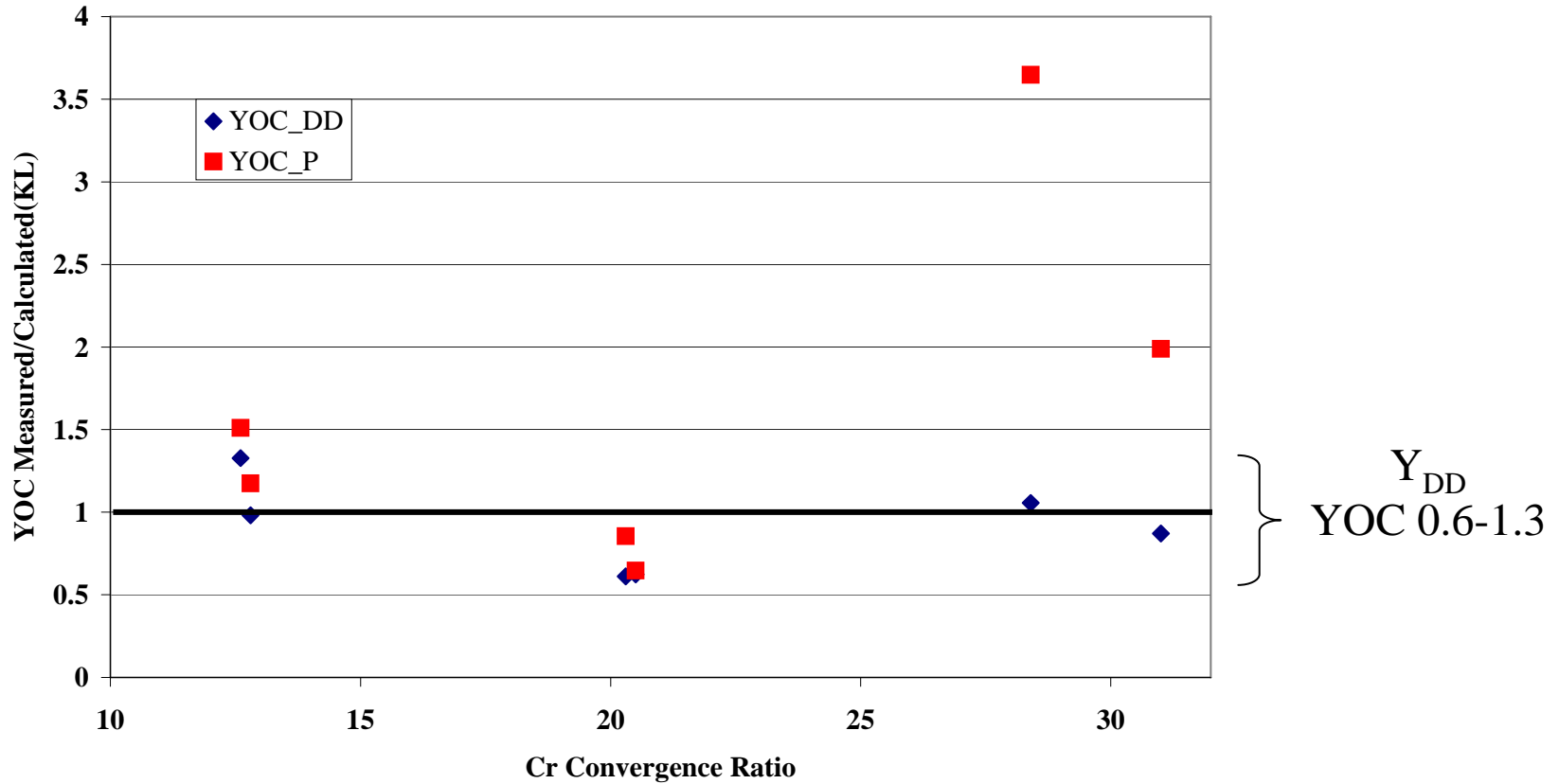
DHe3/SiO2 Capsules YOC Measured/Calculate(clean)



# $Y_{DD}$ from DHe3/SiO<sub>2</sub> Capsules gave YOCC(KL) ~ 0.6-1.3



DHe3/CH YOCC Measured/Calculated(KL)



# Summary

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- The coefficients of the KL mix model were set by Dimonte to match RT and RM instabilities as measured on the Linear Electric Motor (LEM).
- The KL mix model has been applied to directly-driven capsule implosions with a variety of laser energies, ablator materials, ablator thicknesses and convergence ratios.
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