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

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

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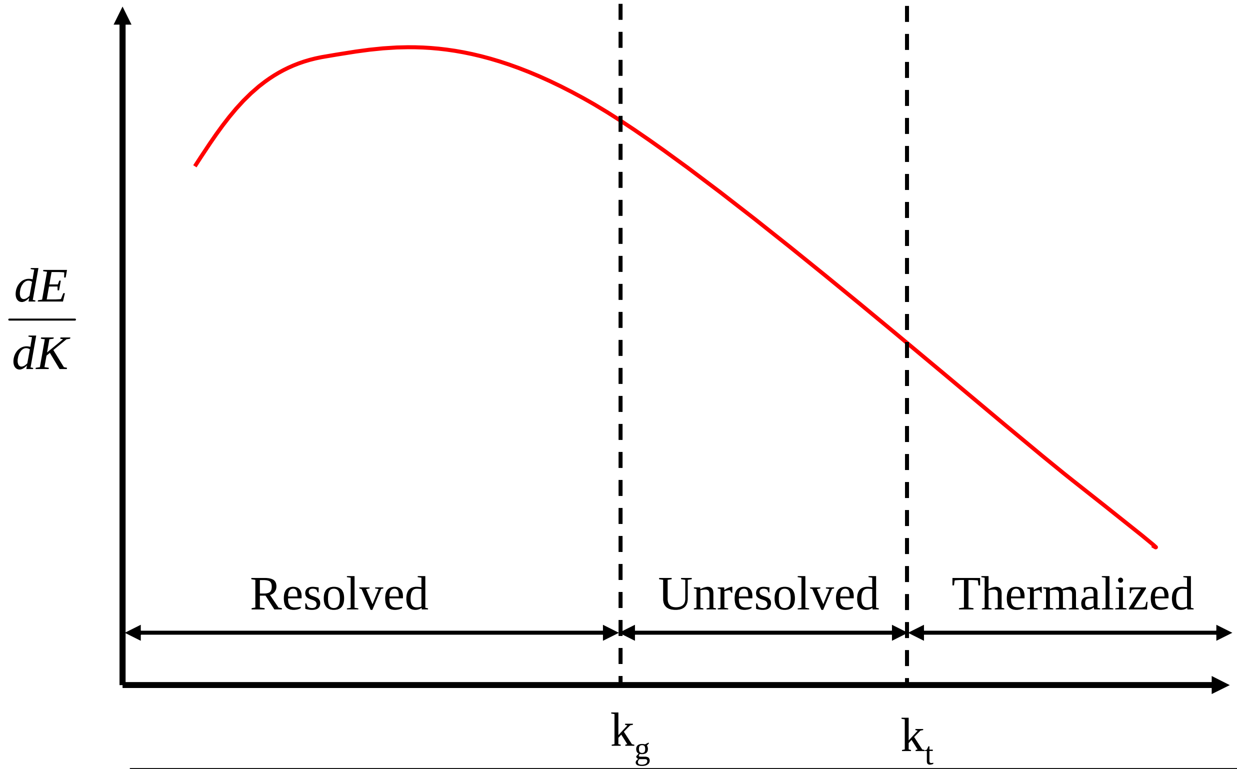
Main Points

- 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

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

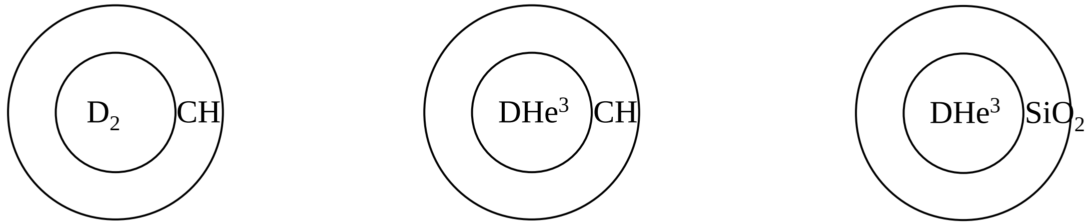
α_B inferred from LEM data is 0.06 rather than 0.07

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

1D Calculations with CALEICF

- 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 => N + He4 reactions in flight
- He3+D => 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:

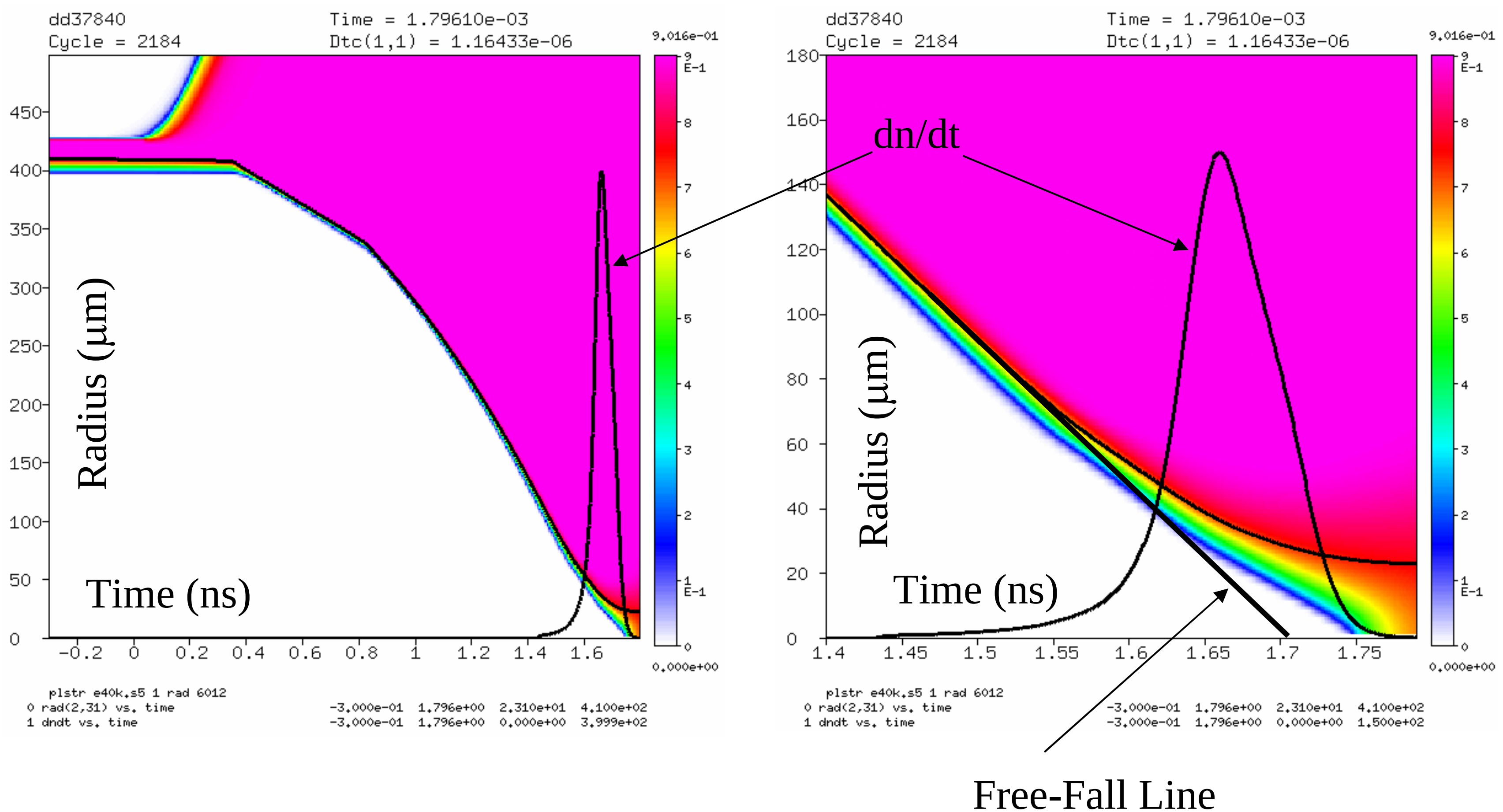
1 Primary DD neutrons and secondary DT neutrons

2 Primary DHe^3 protons (for D_2 fuels secondary DHe^3 protons were measured)

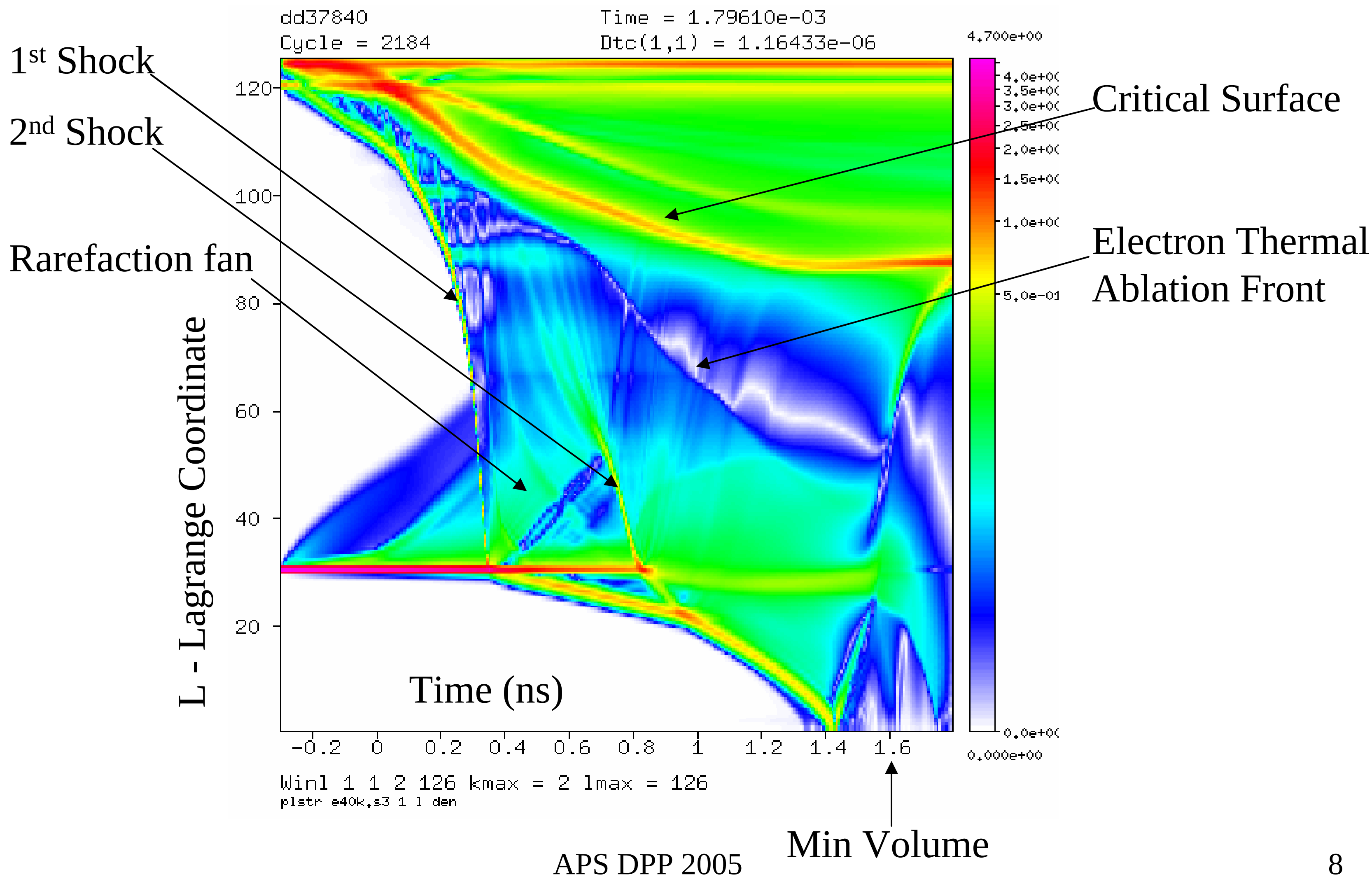
3 Ion temperatures (inferred from TOF spreading of the DD neutrons)

4 Implosion Time

Carbon mass fraction front nearly follows the free-fall line



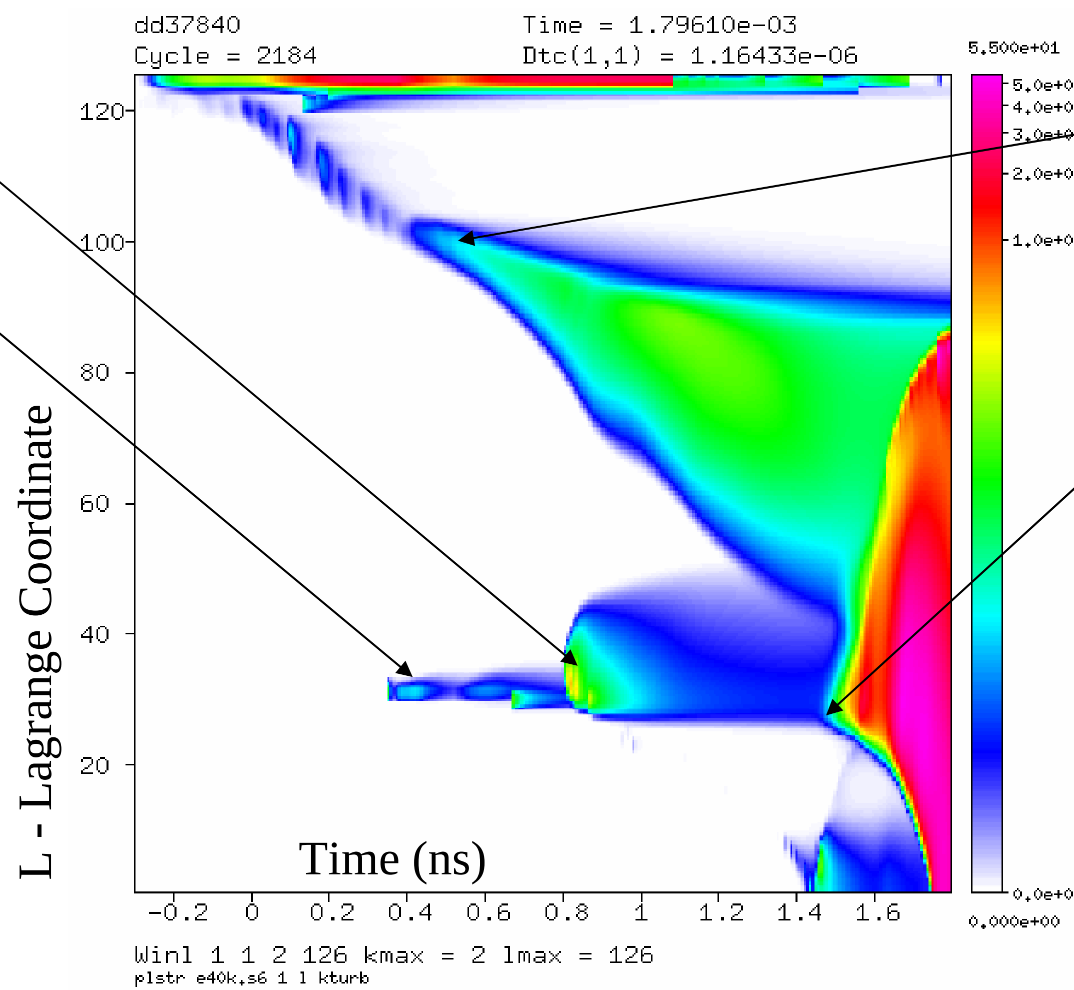
Streak plot of d log(ρ)/dL shows shocks, rarefactions and ablation fronts



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

2nd Shock at Fuel Interface

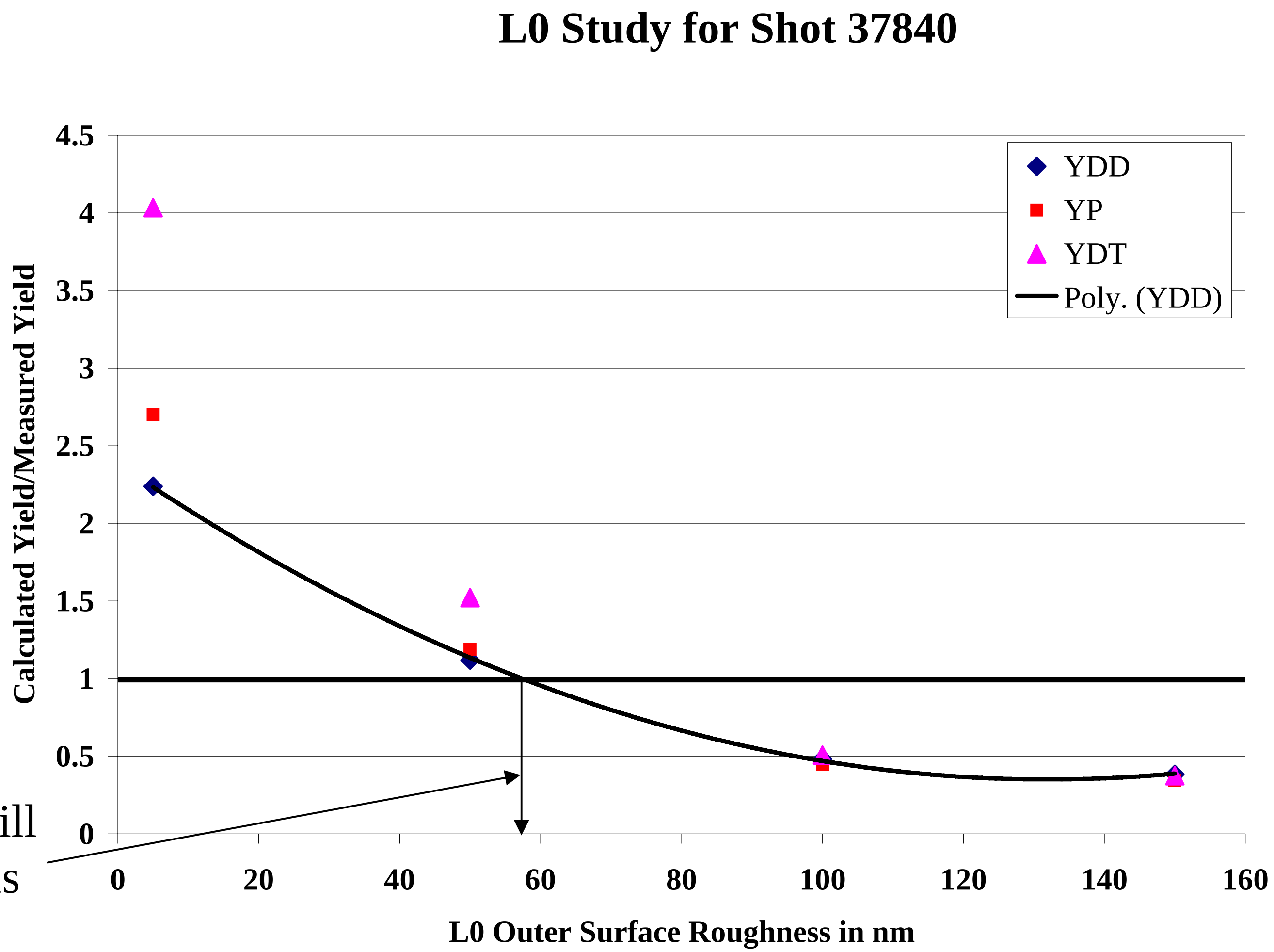
1st Shock at Fuel Interface



Rarefaction at Ablation Surface

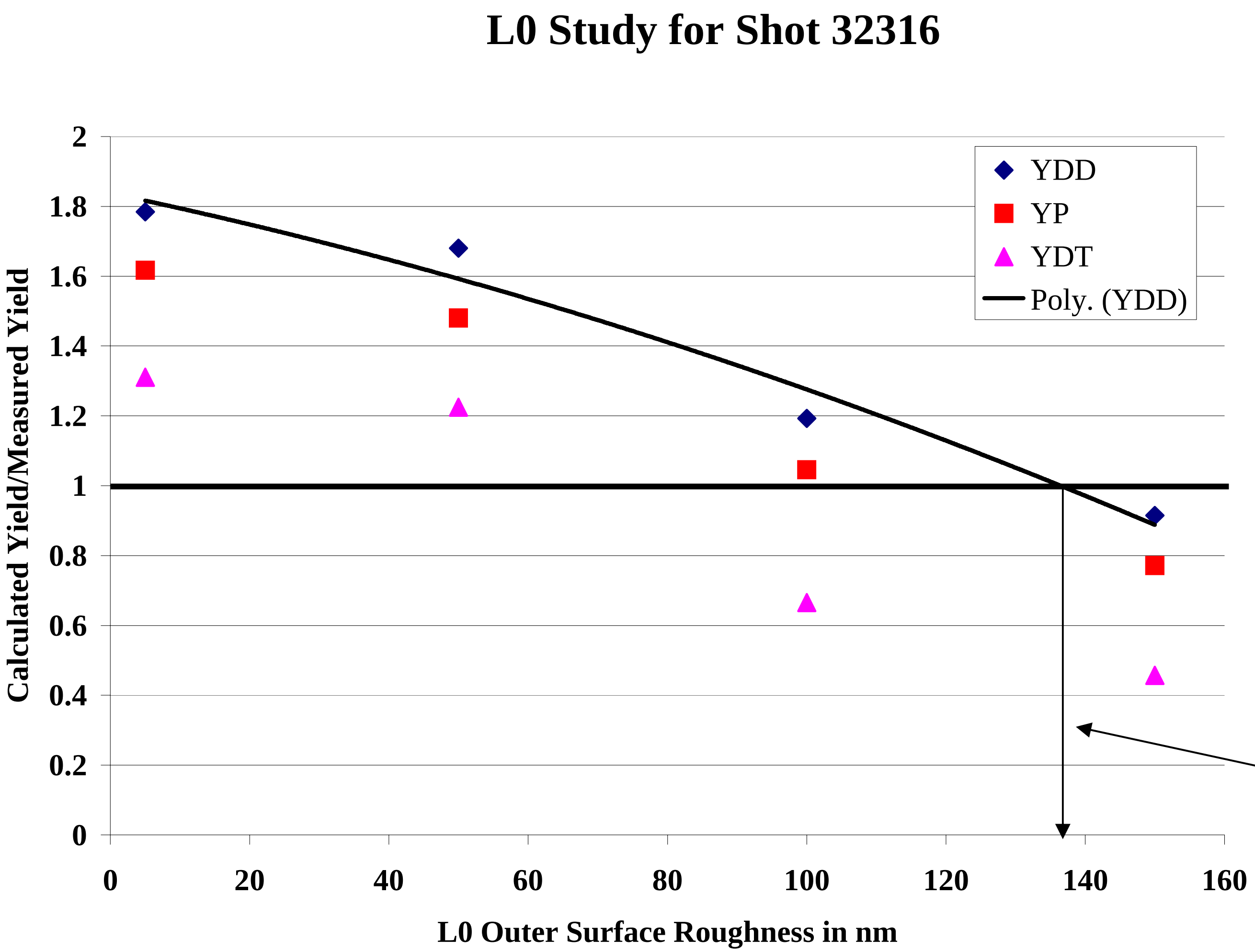
Fuel Interface becomes RT unstable

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



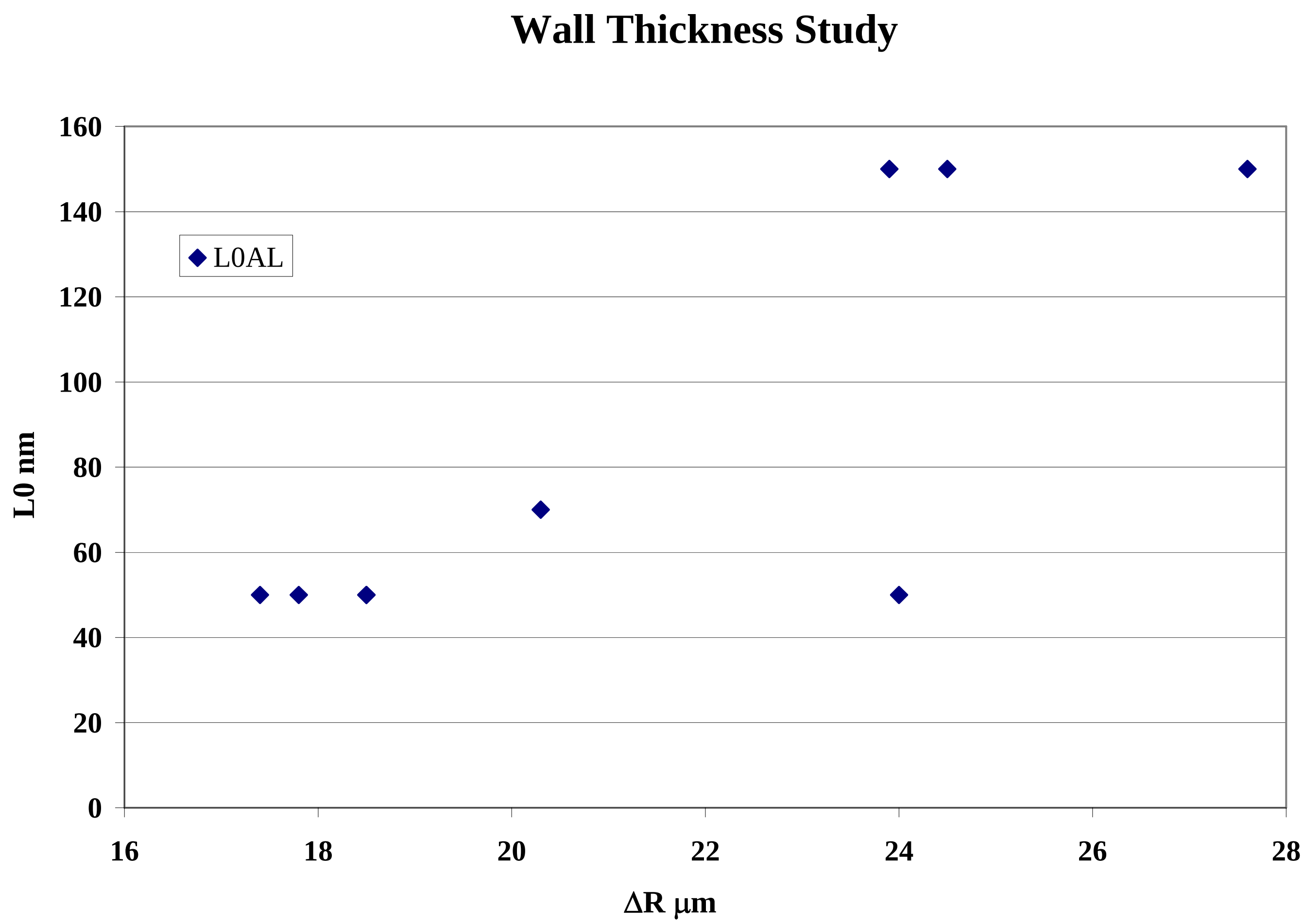
L_0 = 57nm on the outside surface will match data for this capsule

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

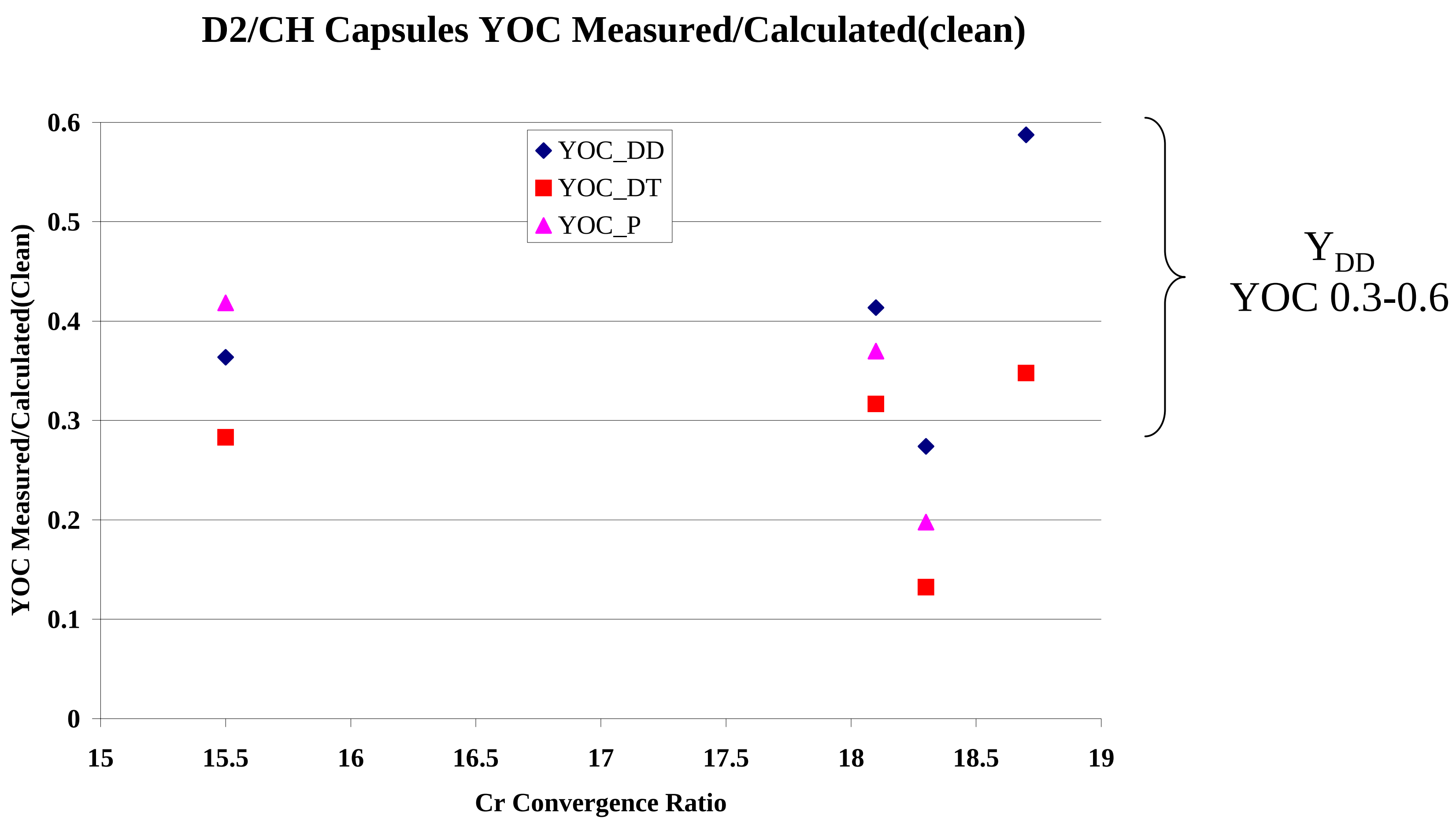


L_0 = 135nm on the outside surface will match data for this capsule

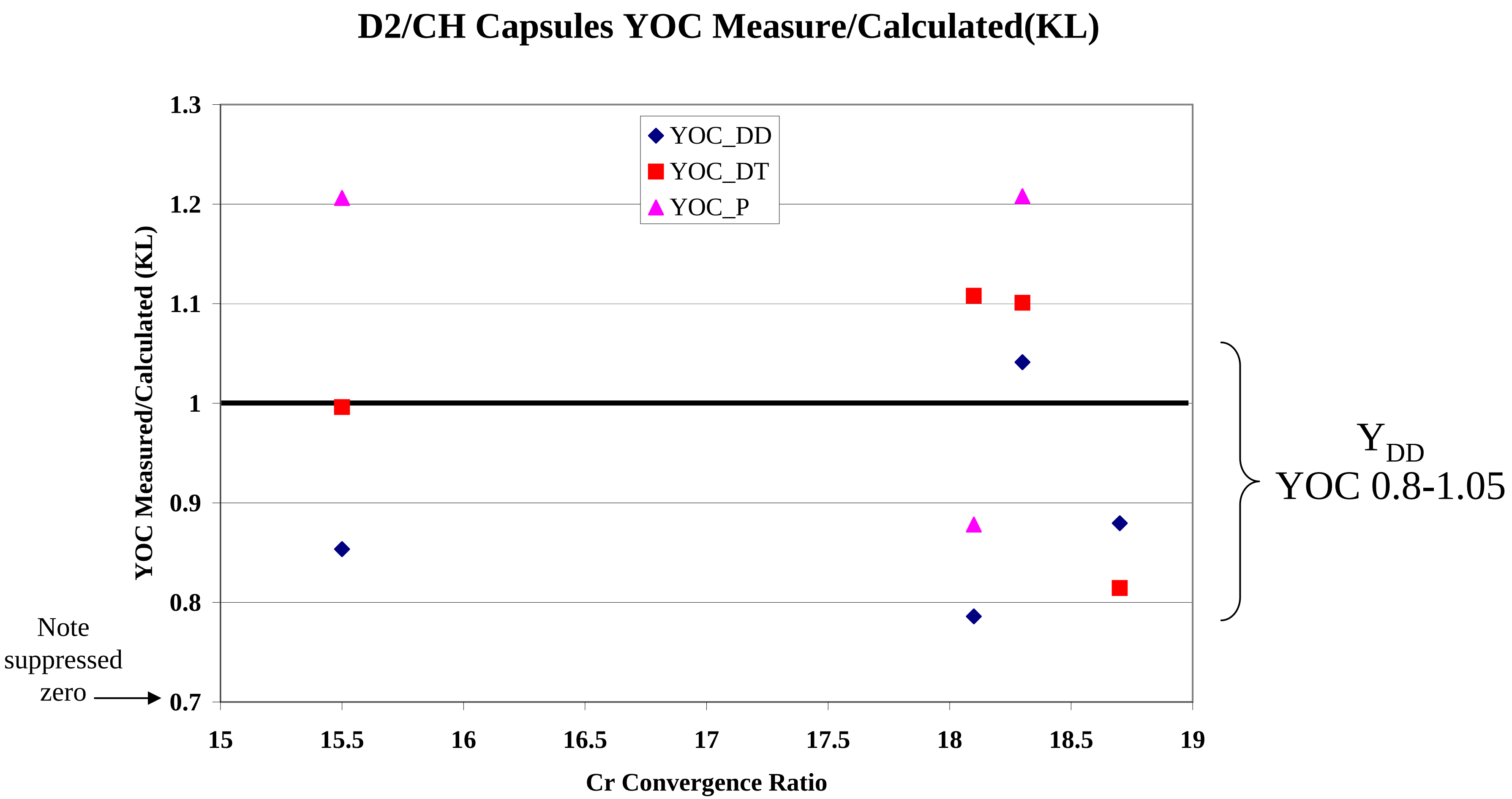
Thin capsules need L0 = 50 nm
Thick capsules need L0 = 150 nm



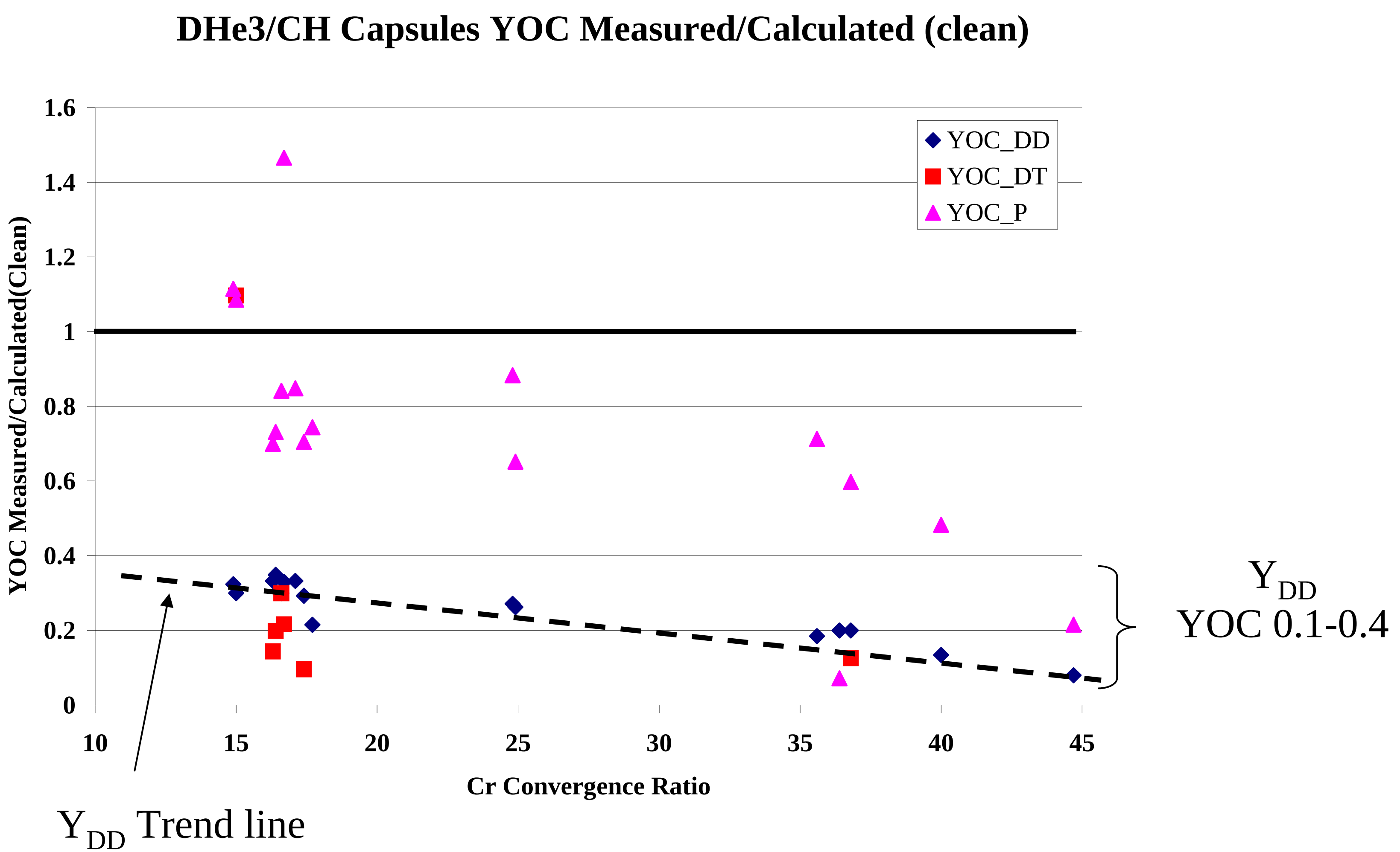
Y_{DD} from D_2/CH Capsules gave YOC(Clean) ~ 0.3-0.6



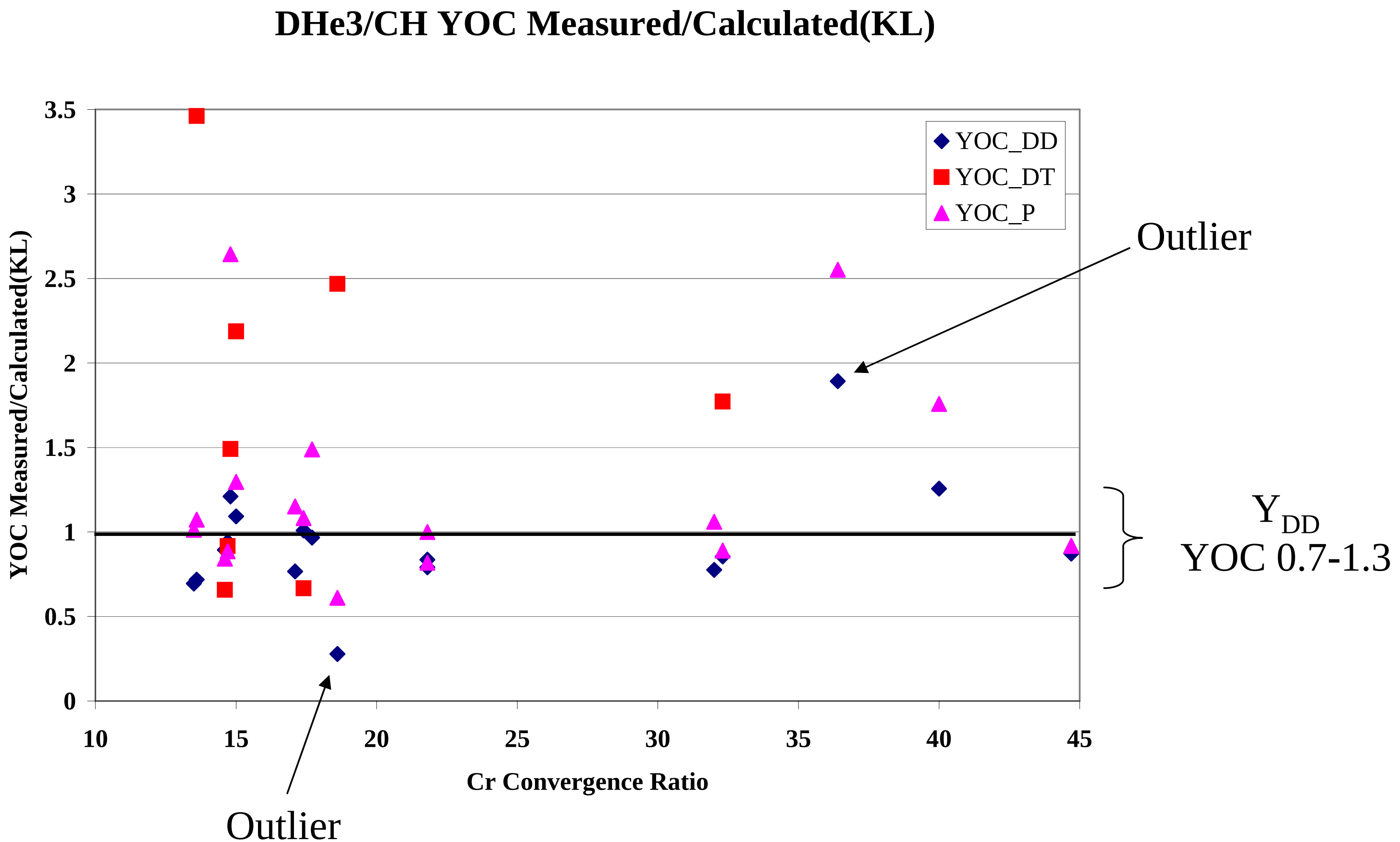
Y_{DD} from D_2/CH Capsules gives YOC(KL) ~ 0.8-1.05



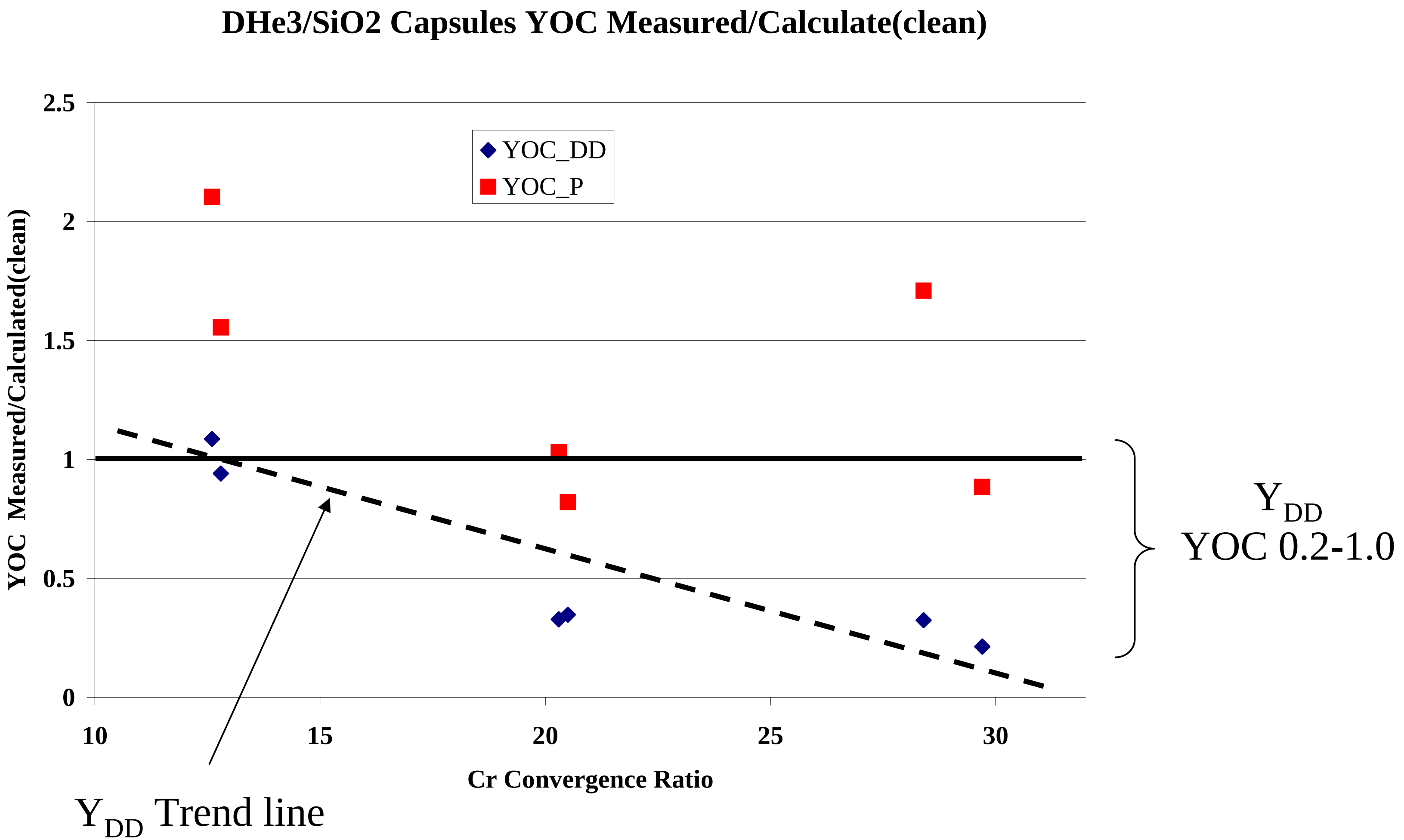
Y_{DD} from DHe^3/CH Capsules gave YOC(Clean) ~ 0.1-0.4



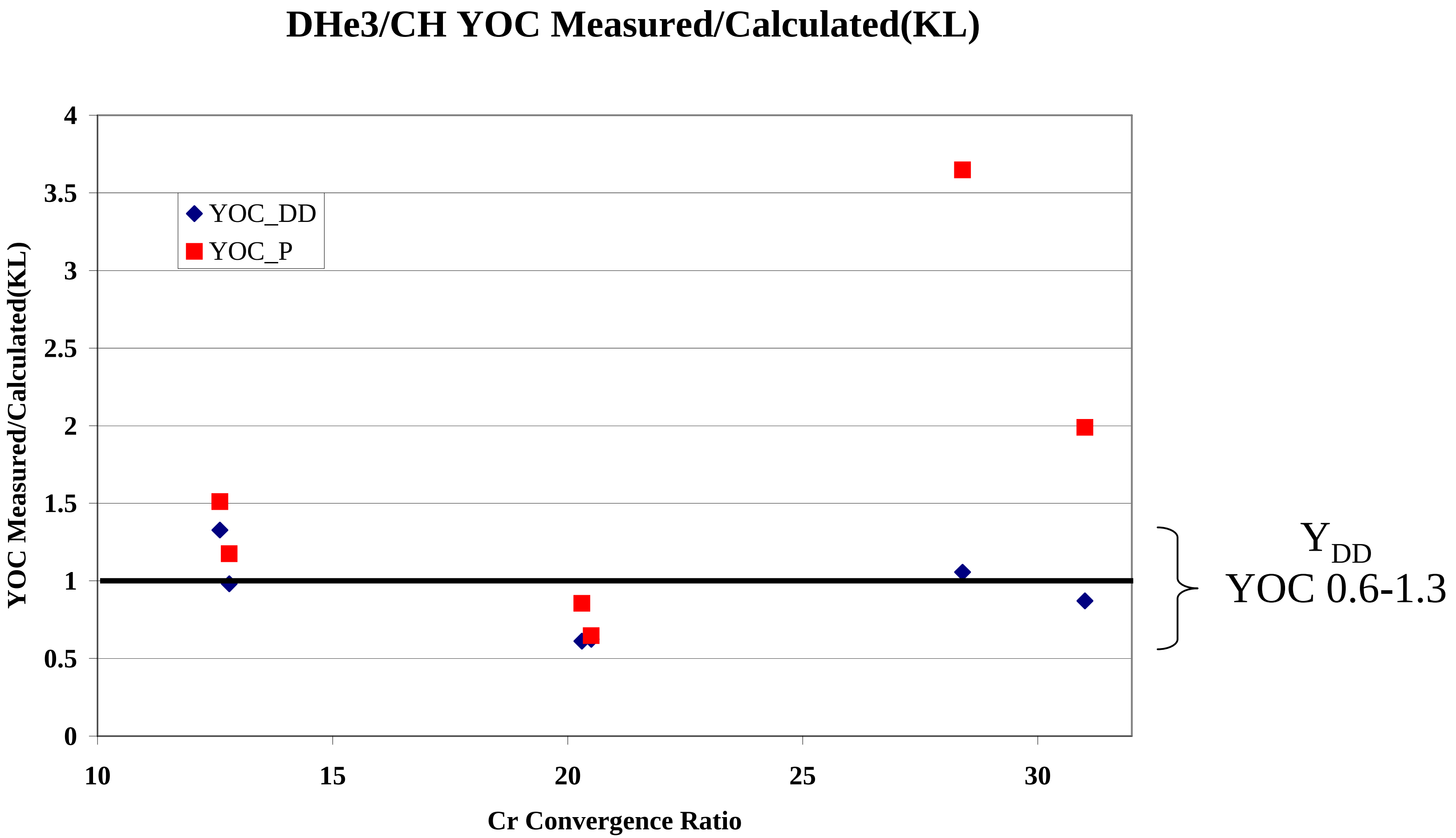
Y_{DD} from DHe^3/CH Capsules gives YOC(KL) ~ 0.7-1.3



Y_{DD} from DHe^3/SiO_2 Capsules gave YOC(Clean) ~ 0.2-1.0



Y_{DD} from DHe3/SiO_2 Capsules gave YOC(KL) ~ 0.6-1.3



Summary

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