Low density plasma experiments investigating laser propagation and proton acceleration

L Willingale, K Krushelnick, A Maksimchuk
Center for Ultrafast Optical Science, University of Michigan, USA
W Nazarov
University of St Andrews, UK
PM Nilson, C Stoeckl, TC Sangster
LLE, University of Rochester, USA
Motivation

- Laser propagation and channeling in near critical densities is important for the **hole boring fast ignition scheme**
- Ion acceleration at near-critical densities has been shown to be an interesting regime for producing **high energy ion beams**

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L Willingale *et al*, PRL, **102**, 125002 (2009)

P Antici *et al*, New Journal of Physics, **11**, 023038 (2009)
Previous work – using proton acceleration to diagnose laser propagation

- Vulcan experiments investigated laser propagation in the relativistic transparent regime, $a_0 = 35$, (500 J, $\tau_L = 600$ fs, 5 $\mu$m focal spot) using proton acceleration as a diagnostic.

- Omega EP experiment is lower intensity, $a_0 = 3$, but longer pulse length, $\tau_L = 10$ ps, where hole boring through the plasma is expected to be important for the channel formation and laser propagation.

**Increasing plasma density = decreasing propagation distance**

$\Rightarrow$ Less proton acceleration
Experimental setup

**Targets:**
Low density foam, CHO
Mounted in 1mm x 1mm x 250μm washers
Made by Wigen Nazarov

Backlighter beam: 1000 J, 10 ps
Focus: 80% of energy within 22 μm radius
Peak intensity = $1.3 \times 10^{19} \text{ Wcm}^{-2}$
$a_0 \approx 3$

Transmitted Scattered Light Imaging diagnostic
TSLID
Filtered at 1053 +/- 10 nm

Proton Film Pack (PFP)

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<table>
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<tr>
<th>Foam density (mg/cc)</th>
<th>$n_e$ ($n_c$)</th>
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<td>3</td>
<td>0.9</td>
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<tr>
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<td>13.5</td>
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<td>30</td>
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Preliminary results
Normalized data

Maximum proton energy observed = 51 MeV

- RCF dose for 28 MeV protons
- Pinhole camera signal
- Transmitted laser energy
- Angular divergence of 28 MeV protons
Summary and Future work

• Summary of data so far:
  – Density scan around the critical density has been shot on Omega EP
  – High energy proton beams were measured
  – Consistent trends observed with different diagnostics

• Future work:
  – Run 2D particle-in-cell (PIC) code for Omega EP conditions
  – Investigate the how much laser energy is transmitted through the foam, but shifted out of the bandwidth of the filter