A new tri-particle backlighter for radiography and stopping power measurements in HED plasmas at OMEGA and the NIF

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This work is supported by the NNSA MIT Center of Excellence (DE-NA0003868)

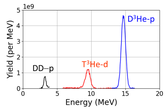
National Nuclear Security Administration

A new tri-particle backlighter platform which extends the capability of the existing D^3He proton backlighter has been developed and tested

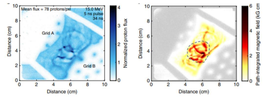
Three probe particles provide additional information required to distinguish:

- **Magnetic fields**
- **Electric fields**
- **Scattering**

$$D + D \rightarrow T + p\ (3.0\ MeV)$$
$$D + {}^3He \rightarrow \alpha + p\ (14.7\ MeV)$$
$$\star\ T + {}^3He \rightarrow \alpha + d\ (9.5\ MeV)$$

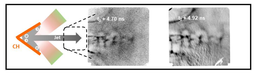


The D^3He backlighter is a unique platform, used extensively for radiography on OMEGA and the NIF



Amplification of magnetic fields in a turbulent plasma

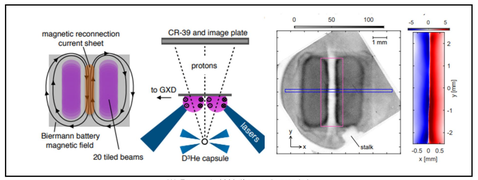
P. Tzeferacos *et al.*, Nature Comm., 2018



Scaled Lab-Astro demonstration of kink instability in the Crab Nebula Jet

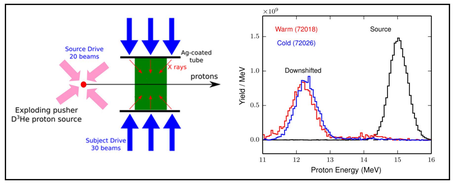
C.K. Li *et al.*, Nature Communications 2016

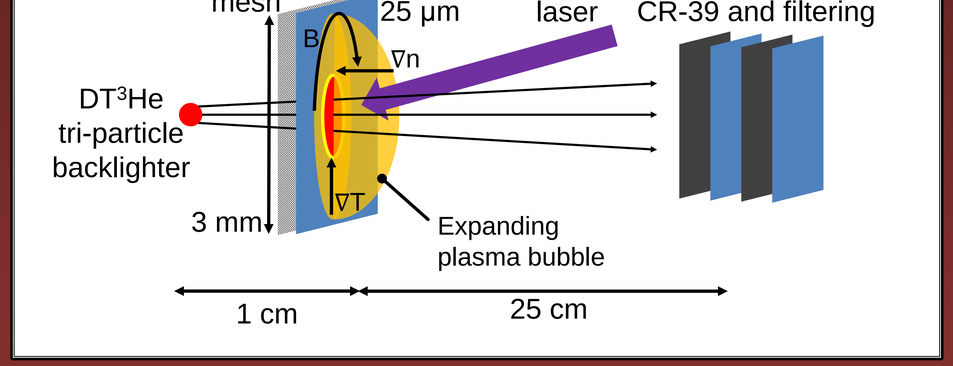
Fast magnetic reconnection in highly-extended current sheets



W. Fox *et al.*, 2020 (from arxiv preprint)

Stopping of D^3He protons in warm dense Beryllium



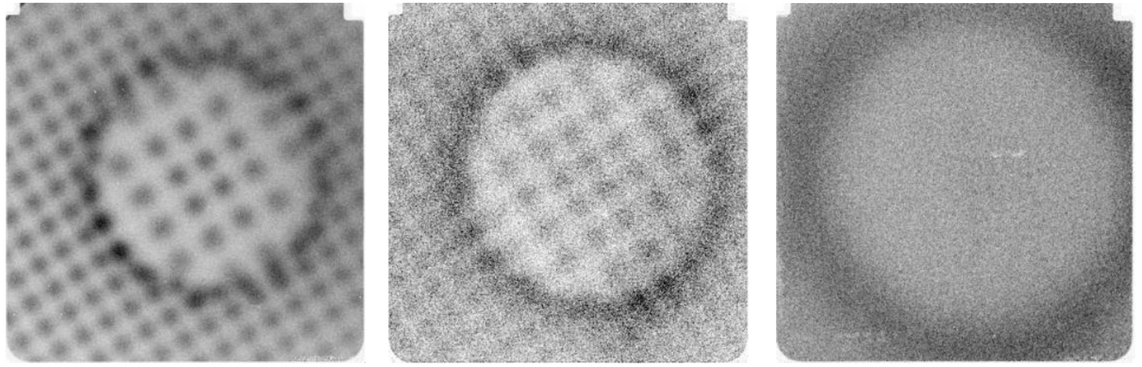


$$\theta_B \propto {qBL}/{\sqrt{mE}}$$

$$\theta_{\mathcal{E}} \propto {q\mathcal{E}L}/{E}$$

$$\theta_{\frac{dE}{dx}} \propto {q^2nL}/{E}$$

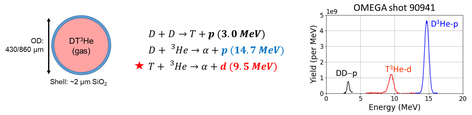
14.7 MeV D^3He-p | **9.5 MeV T^3He-d** | **3 MeV DD-p**



t = 0.49 ns | t = 0.70 ns | t = 0.83 ns

The 9.5 MeV deuteron is ideal in experiments where fields and plasma scattering are too strong for the DD-proton to produce a quality radiograph (for example, hohlraum experiments)

Adding tritium to the backlighter capsule fill introduces a new monoenergetic probe particle



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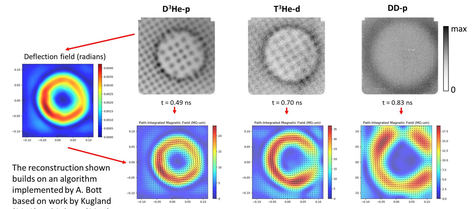
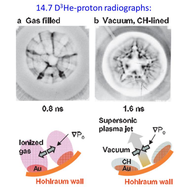
New fuel → New particles → More powerful data

Field reconstruction techniques back out spatially resolved fields from radiographs



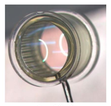
The reconstruction shown builds on an algorithm implemented by A. Bott based on work by Kugland (2012) and Sulman (2011)

The tri-particle backlighter is being used to untangle electric and magnetic fields in hohlraums



Li et al. PRL (2012), Li et al. Nucl. Fusion (2013)

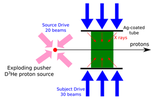
- Work by J. Pearcy and myself deploys the backlighter in vacuum and gas-filled hohlraums



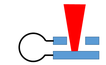
Gas-filled: OMEGA 2020/02/11

Future uses of the tri-particle backlighter

Warm dense matter stopping power experiments using both the D^3He-proton and T^3He-deuteron to make simultaneous stopping measurements



Measurement of fields in laser-driven coils and MIFEDs coils



... and many more!

MIT PhD students work on NIF diagnostics (2nd DTn[1], WRF/SRF[2], PRAD[3], MRS-t[4], PTOF) and fundamental physics (hohlraum x-rays[5] and fields[6])

[1] poster by Patrick Adrian
[2] poster by Tim Johnson
[3] poster by Graeme Sutcliffe
[4] poster by Justin Kunimune
[5] poster by Ben Reichelt
[6] poster by Jacob Pearcy

NIF&PS