Fast electron generation and transport in solid targets

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Talk summary

1. Fast electron generation and transport in ultraintense laser-solid interactions

2. Transverse refluxing of fast electrons in thin foil targets

3. SUSSP Laser-plasma summer school

Laser absorption to fast electrons:

Processes identified in the literature:

Brunel; vacuum heating, wave breaking, stochastic heating, anomalous skin layer absorption, anharmonic resonance, ponderomotive vxB,…..

Sensitive to:

Pulse duration;

Polarisation;

Pulse intensity;

Angle of incidence;

Focal spot size;

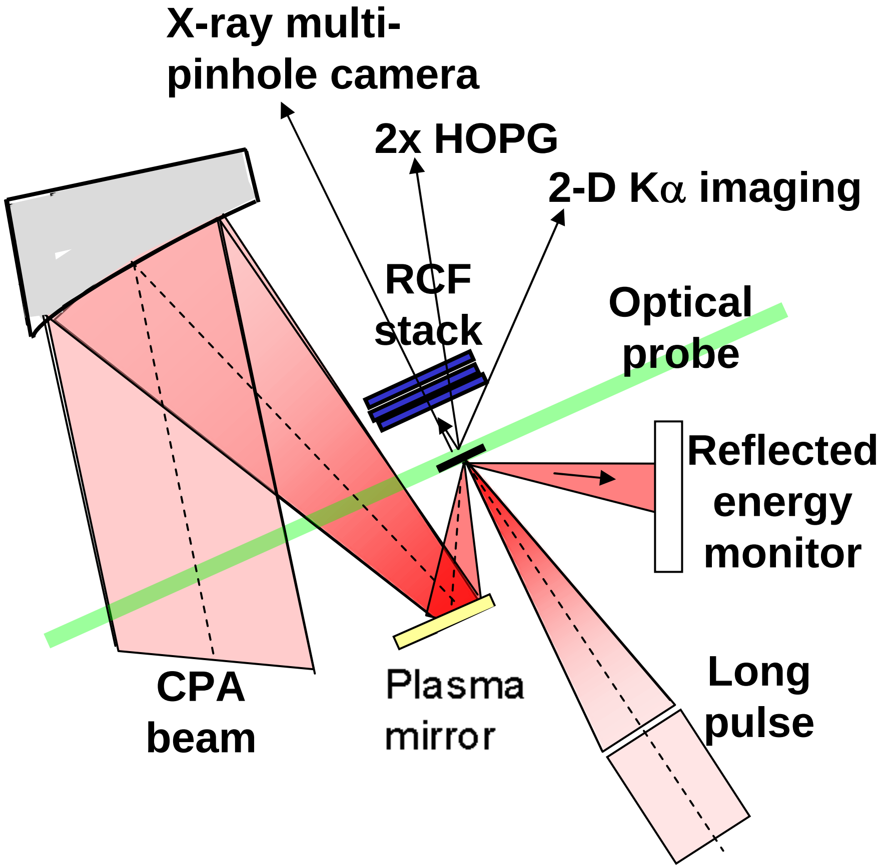
Preplasma expansion;

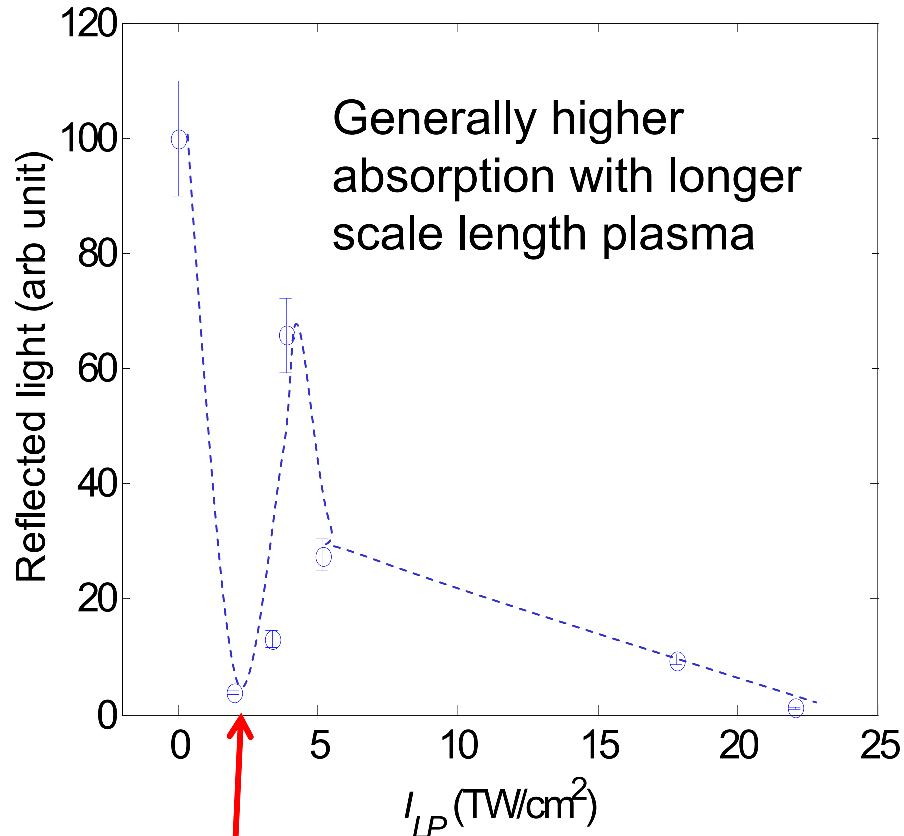
Target Z.

Complex picture!

Experimental results to test / benchmark models of absorption

Specularly reflected laser light

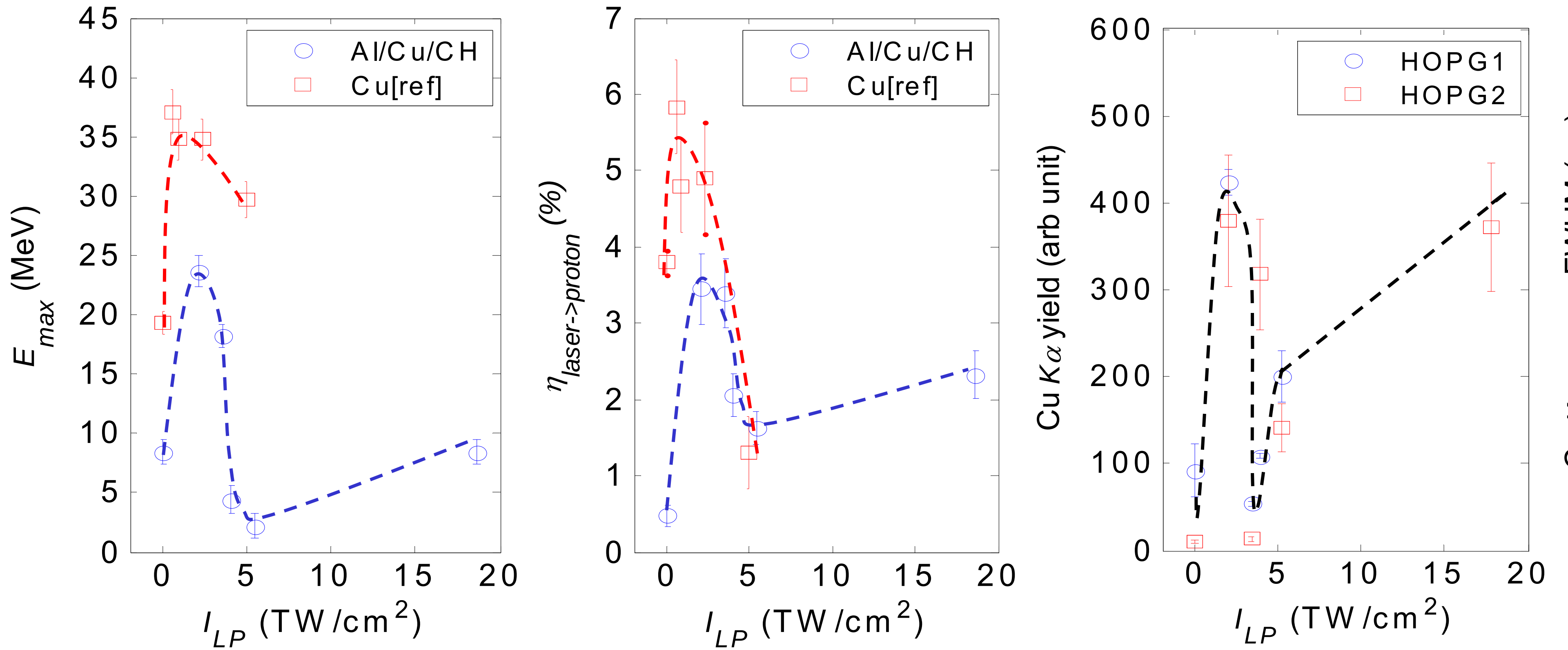




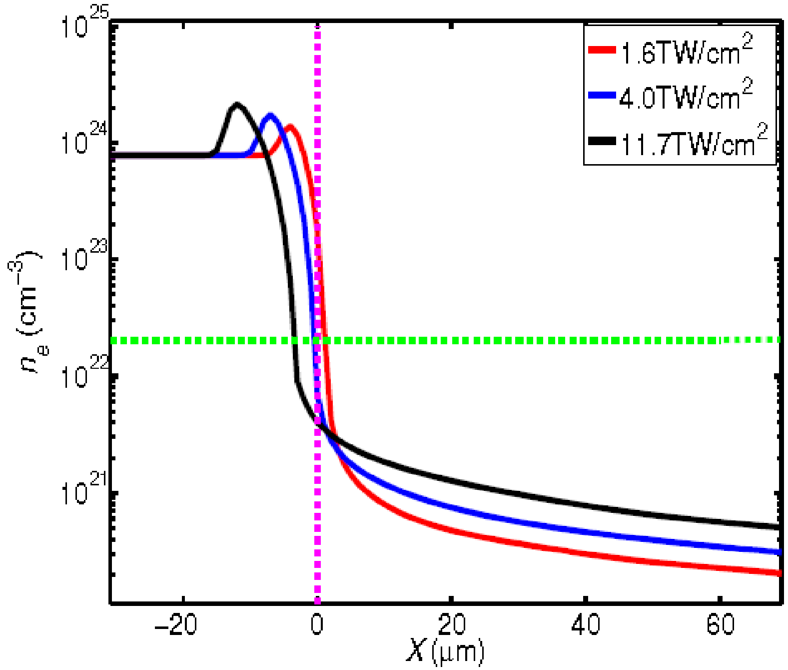
Region of high laser energy absorption

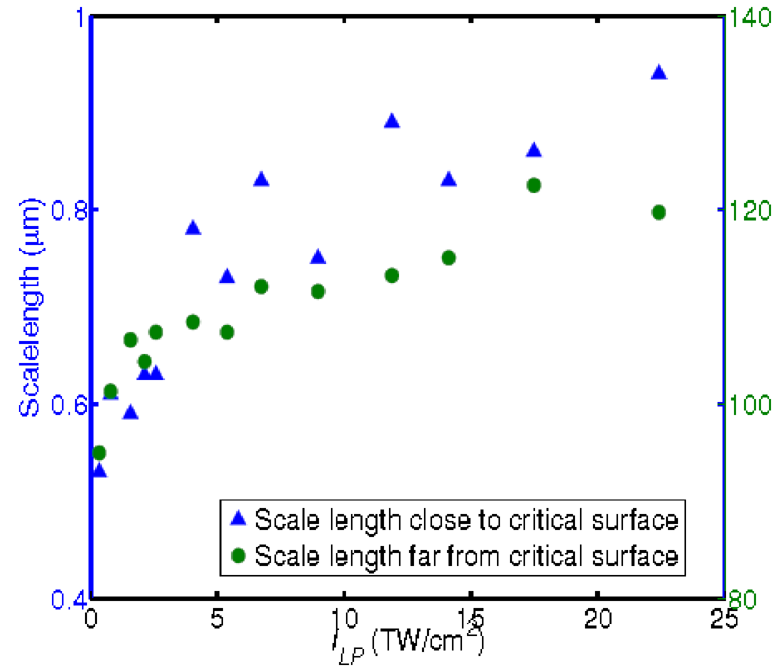
Two distinct absorption processes?

Proton and Cu Kα measurements



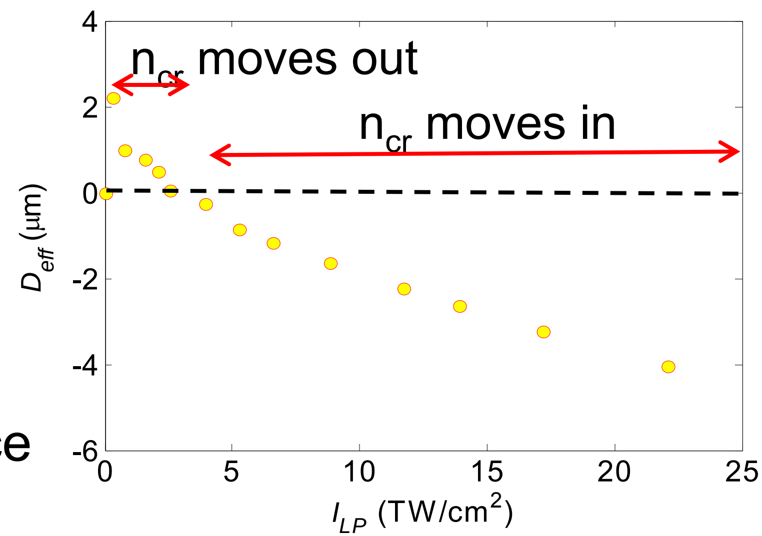
POLLUX – density variations





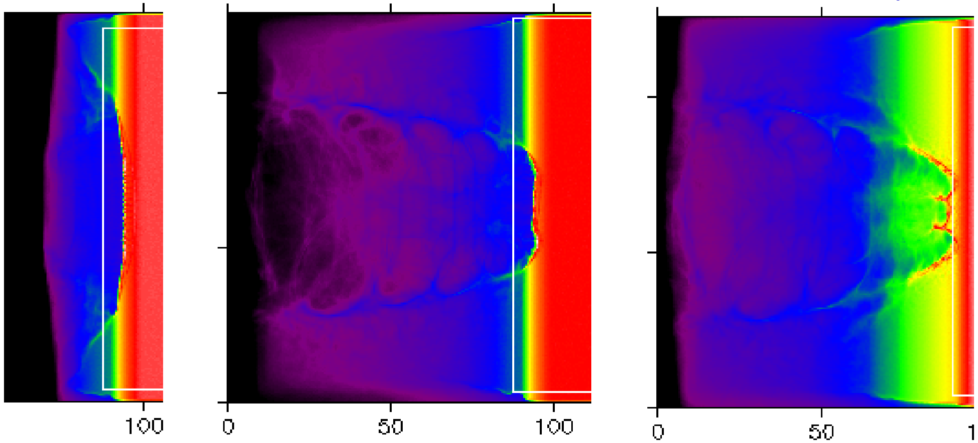
Absorption physics is complex because of two regions with density gradients

Absorption is sensitive to details of the plasma surface

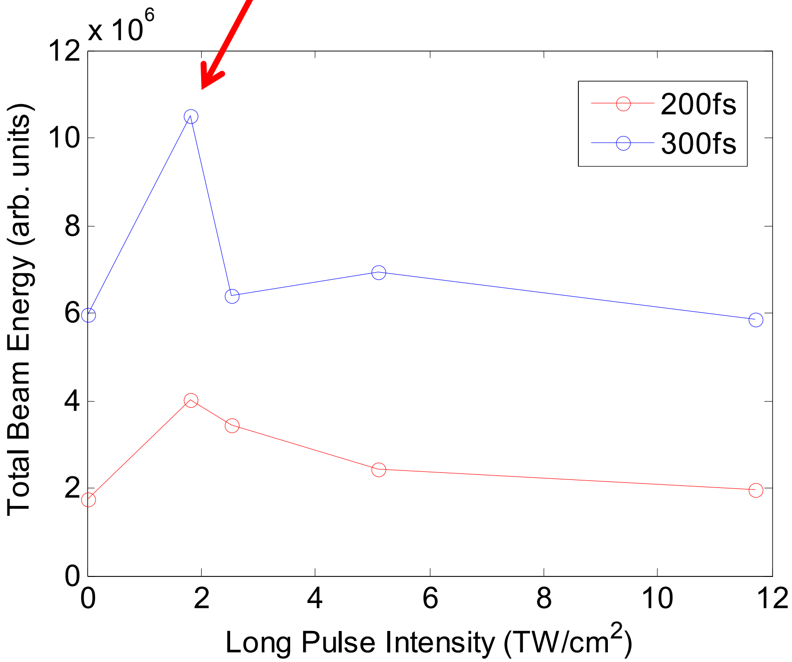


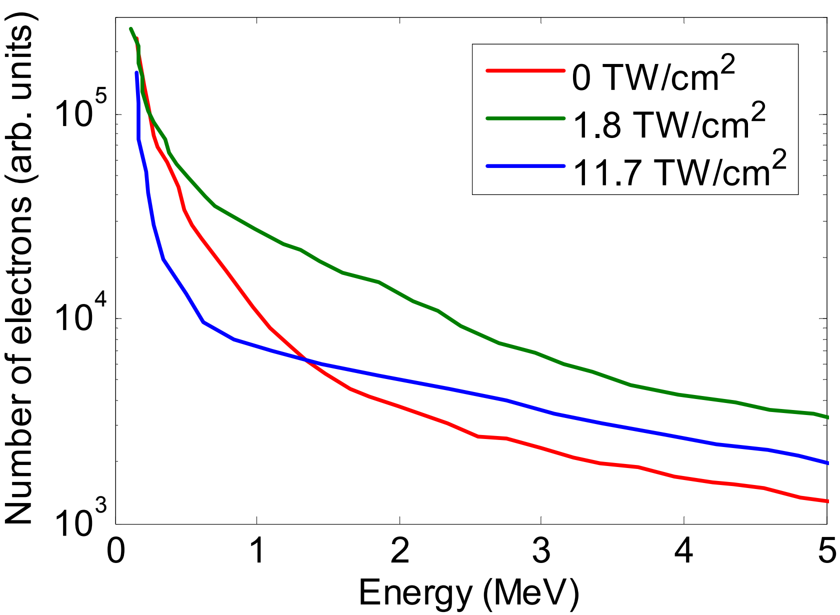
Simulations with 2D OSIRIS – by Roger Evans

Increasing density gradient



Peak at same S.L. as observed experimentally



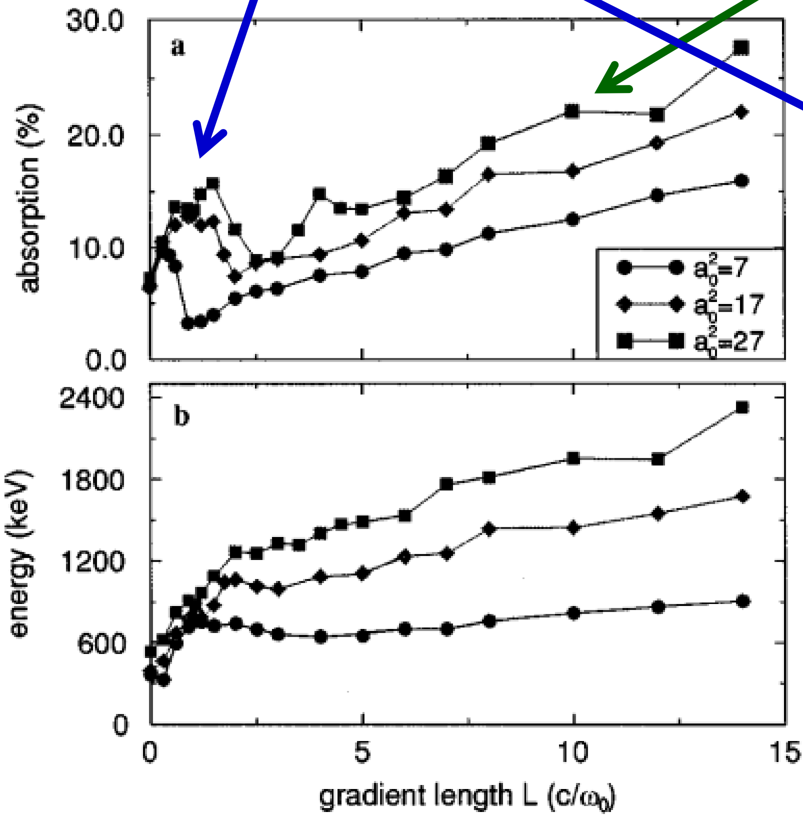


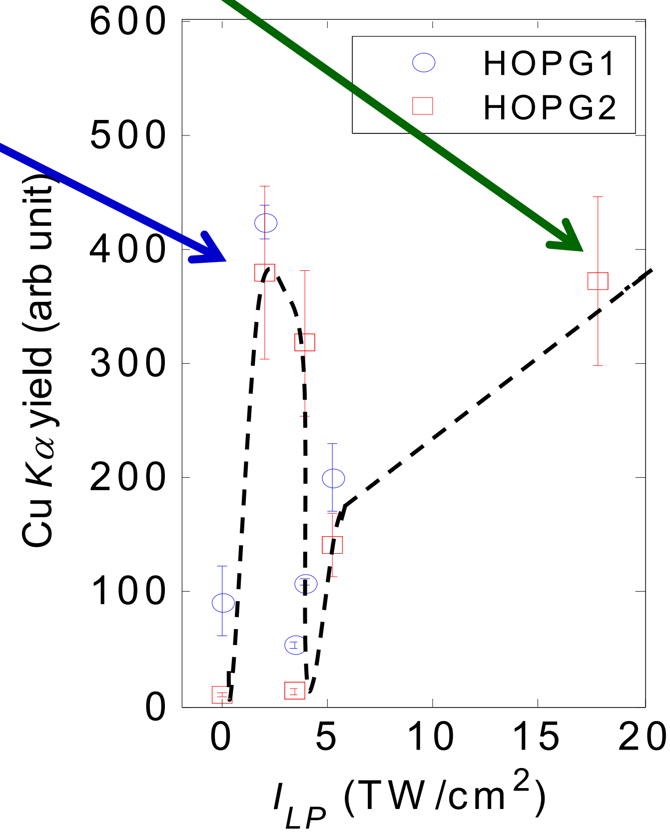
Enhanced energy coupling to electrons and changes to the electron spectrum are predicted

Picture emerging…..

1. Absorption sensitive to details of the plasma surface

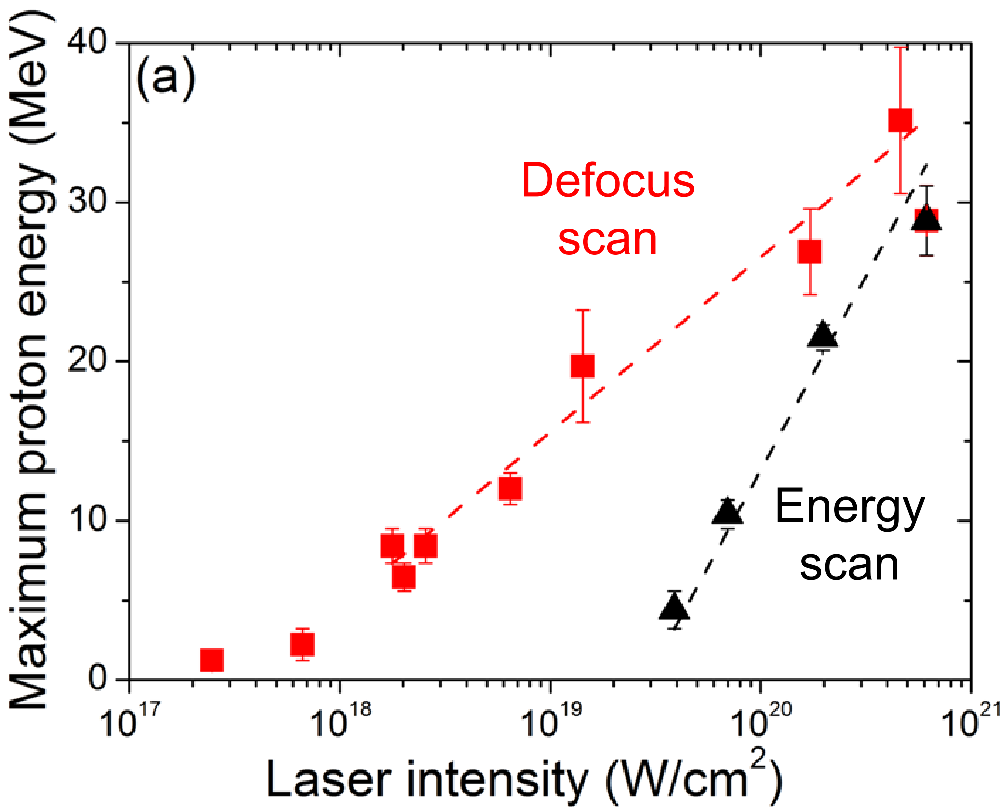
2. Volume heating when enough underdense plasma

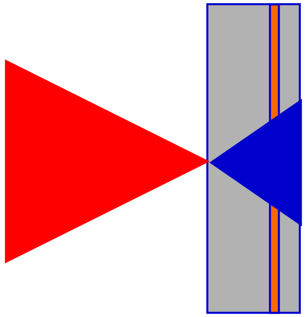




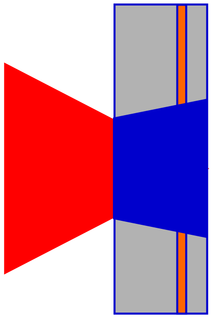
E. Lefebvre et al, PRE 55,1011 (1997)
Nonlinear electron heating in ultrahigh-intensity-laser plasma interaction

Transition from tight focus to 1D geometry





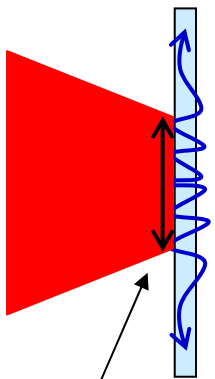
Tight focus: large divergence



1D geometry

Effects of refluxing/recirculating electrons

(1) Reheating due to refluxing?

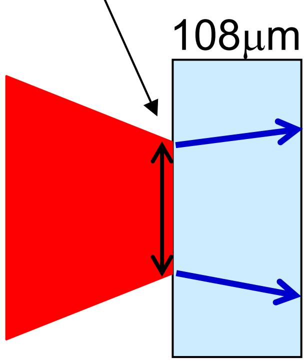


A similar effect observed previously with 5 μm-thick targets

$\phi_L >> L$

Refluxing could account for better energy coupling in thin targets

$\phi_L = 160\mu m$ for 10^{18} W/cm^{-2}



But here the target is thick!

$\phi_L \sim L$

(2) Increase in acceleration time?

Laterally spreading electrons take longer to 'escape' the sheath

$$Escape = \frac{150\,\mu m}{c} = 450\ fs$$

Refluxing does not explain the observed enhancements

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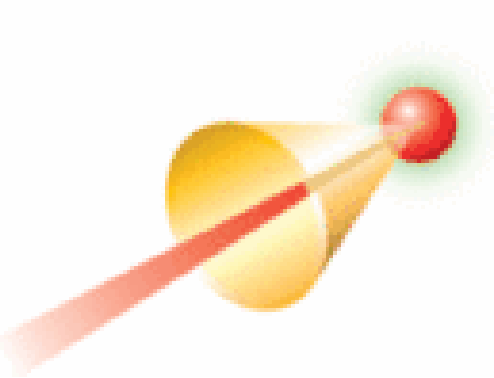
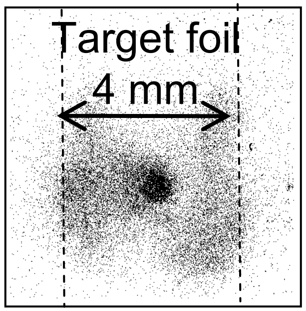
Lateral fast electron transport in thin foils

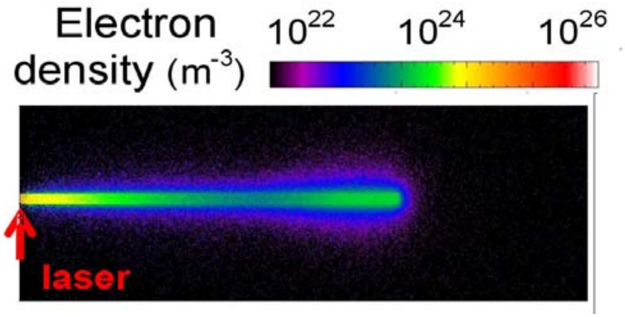


Motivation:

- Fast electron guiding along cone walls
- Important for the optimisation of TNSA ions

Previous study:

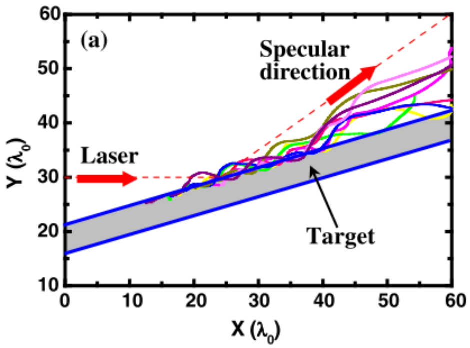




McKenna et al, Phys Rev Lett (2007)

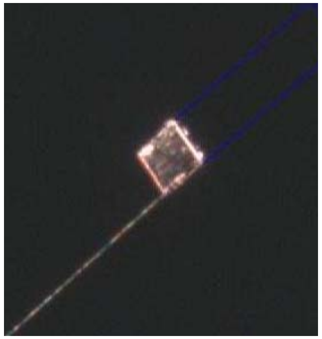
Lateral transport can arise due to:

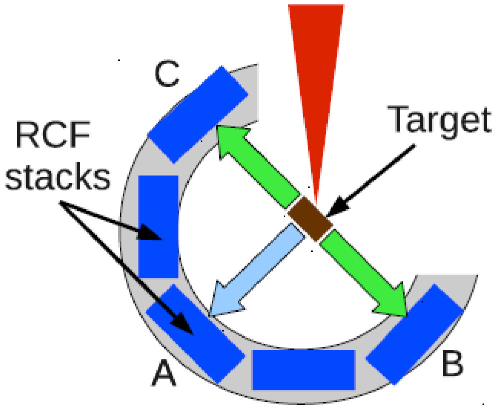
1. fields confine electrons in a potential well along the surface
2. hot electron refluxing within target

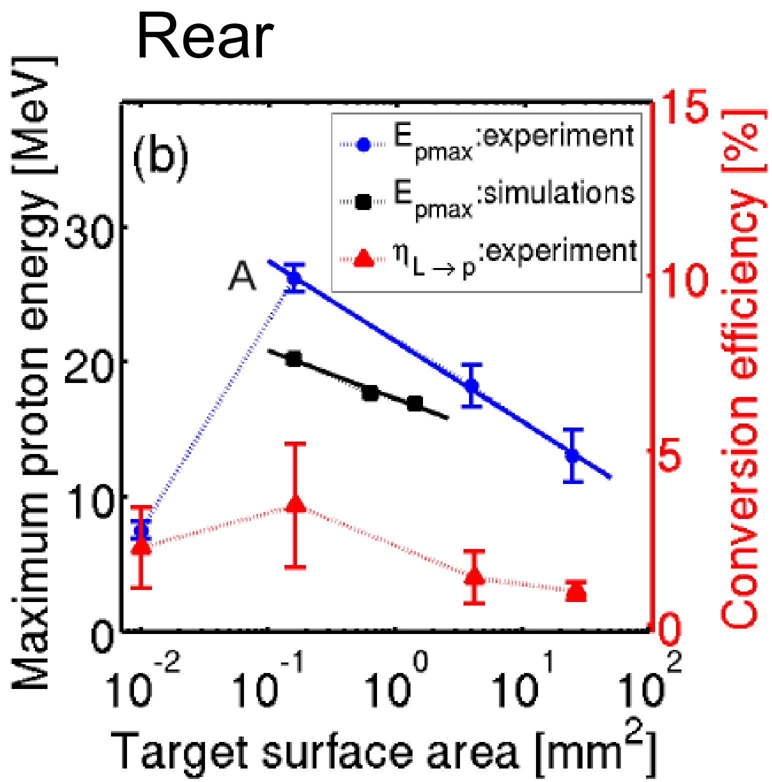


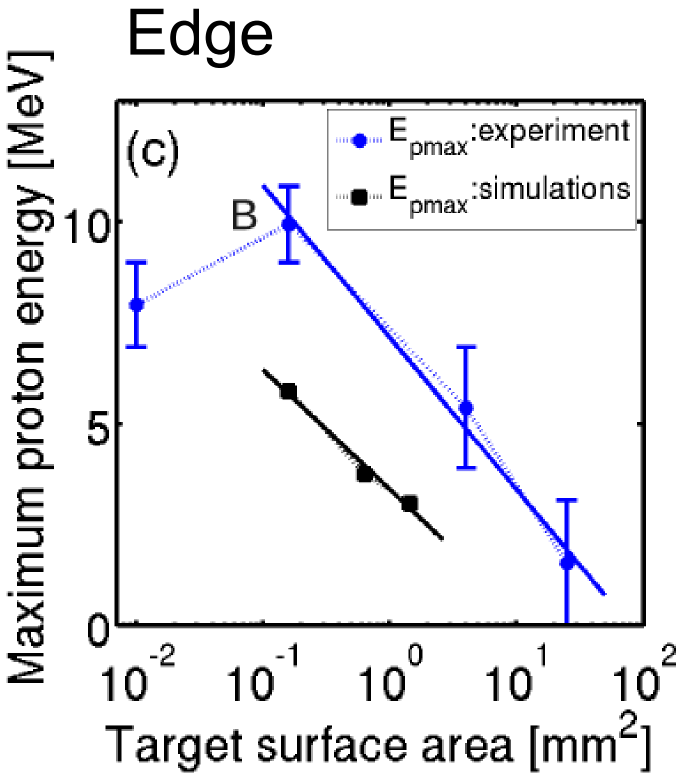
Li *et al* Phys. Rev. Lett. **96**, 165003 (2006)

Transverse refluxing of fast electrons

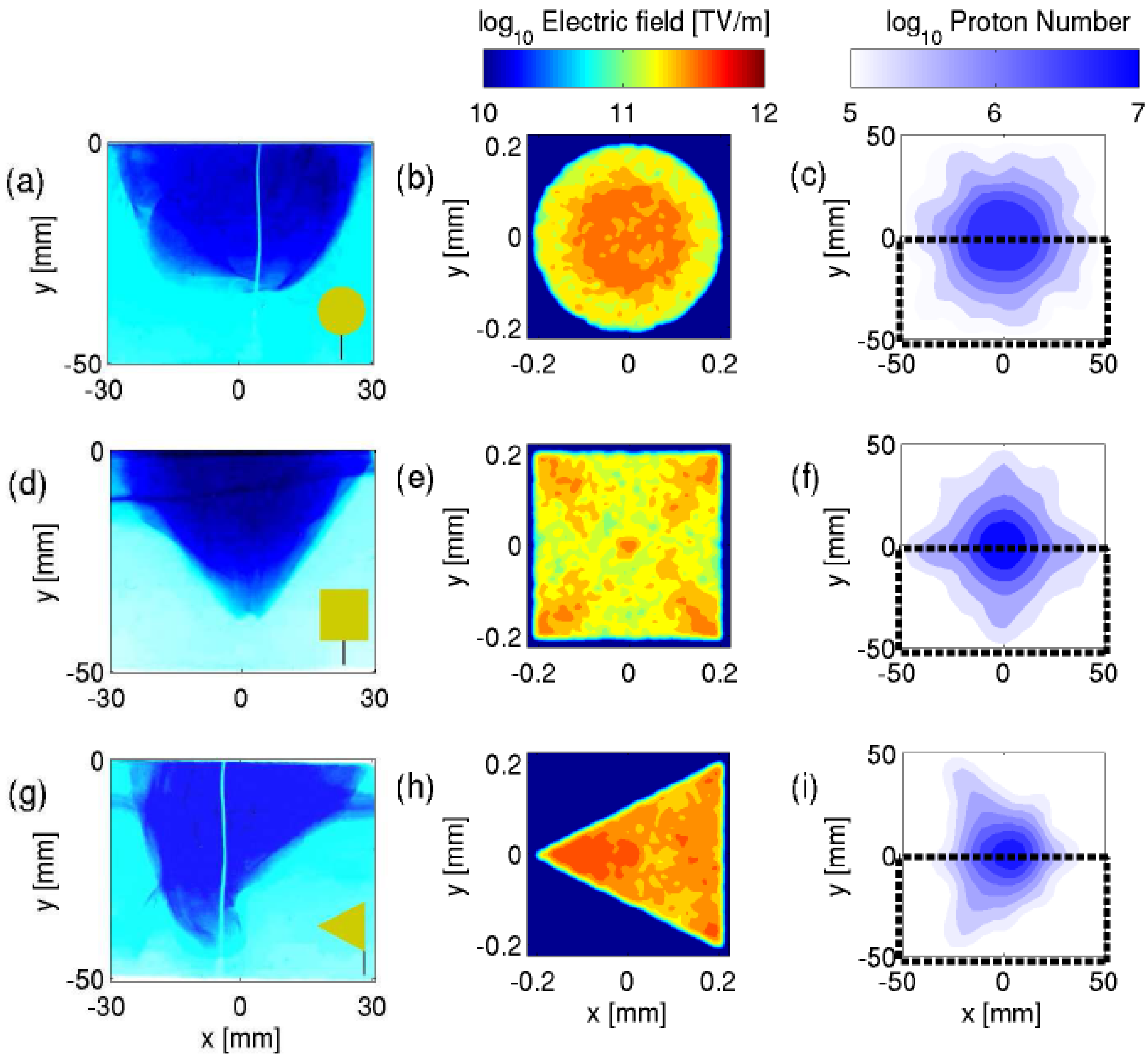








Shaped targets for 'shaped' proton beam



Contributors

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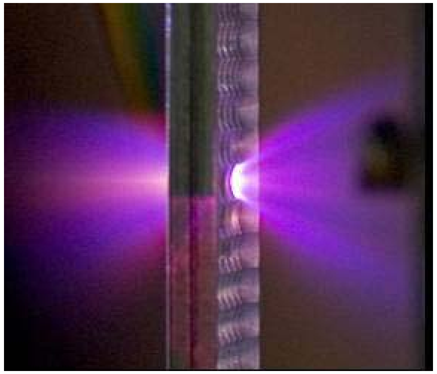
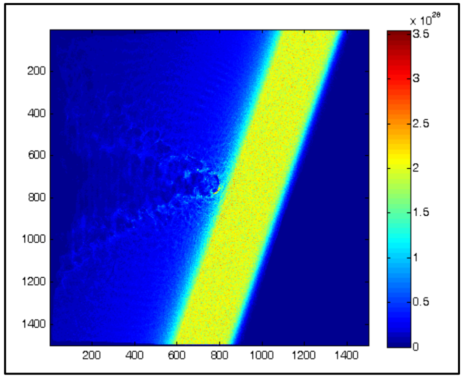
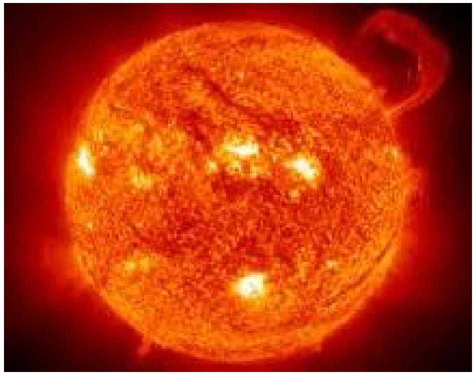
SUSSP68 International Summer School
& NATO Advanced Study Institute
Laser-Plasma Interactions and Applications

14th - 27th August 2011



Deadline for bursary applications has passed (28 February 2011)

Applications process remains open for self-financing students

http://sussp68.phys.strath.ac.uk

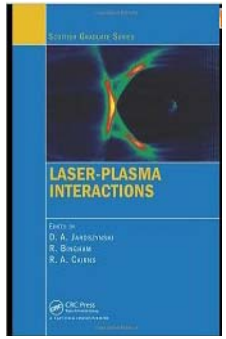
Thank you for your attention!

Distinguished lecturers and guest speakers:

Introduction to laser-plasma interactions :	Prof. B. Bingham
Theory of laser-plasma interactions :	Prof. A. A. Andreev & Prof. L. Silva
Plasma wave electron acceleration :	Prof. V. Malka & Prof. G. Shvets
Undulator and betatron photon sources :	Prof. D. A. Jaroszynski
High harmonic generation :	Prof. M. Zepf
Ion acceleration :	Prof. M. Roth & Dr. P. McKenna
Shock waves and equation of state :	Prof. S. Eliezer
Inertial Confinement Fusion :	Prof. M. Rosen & Prof. W. Kruer
Fast Ignition & implosion hydrodynamics :	Prof. S. Atzeni & Dr. J. Pasley
Modelling techniques and simulations :	Dr. A. P. L. Robinson
Materials at high energy density :	Prof. S. Rose
Applications, diagnostics and targetry :	Prof. D. Neely & Mr. M. Tolley
High power laser projects :	Prof. J. Collier & Dr. T. Goldsack
Public lecture: Prospects for IFE :	Prof. M. Dunne

Dissemination:

Lecture notes will be published as a textbook



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