# Relaxation of PW generated electron beams and ion heating

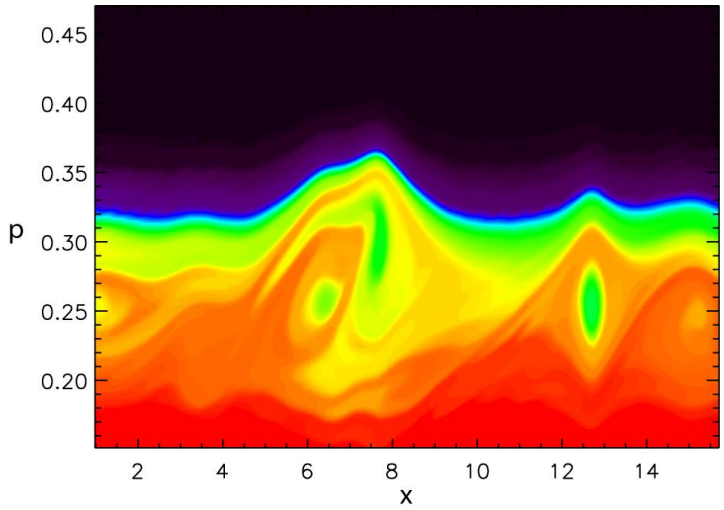
## Experiment concept on OMEGA EP to clarify energy transfer mechanisms in plasmas

Matthew Streeter, Nathan Sircombe, Bob Bingham
Peter Norreys
STFC Rutherford Appleton Laboratory

Tony Arber
University of Warwick

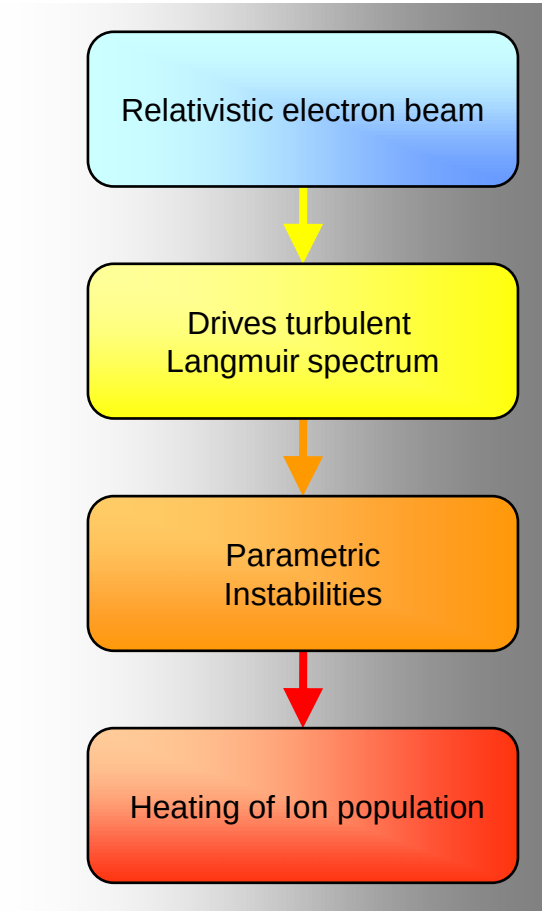
# Relaxation of electron beam and ion heating

- Studies of beam and parametric instabilities [1], using a relativistic Vlasov-Poisson model [2] indicate energy transfer to ions via collisionless processes applicable to fast ignition.
- Rapid growth of electrostatic waves near the electron plasma frequency reaching high amplitudes'
- Parametric decay drives up ion acoustic modes




Phase-space holes form at the high-energy edge of the plateau created by the beam collapse

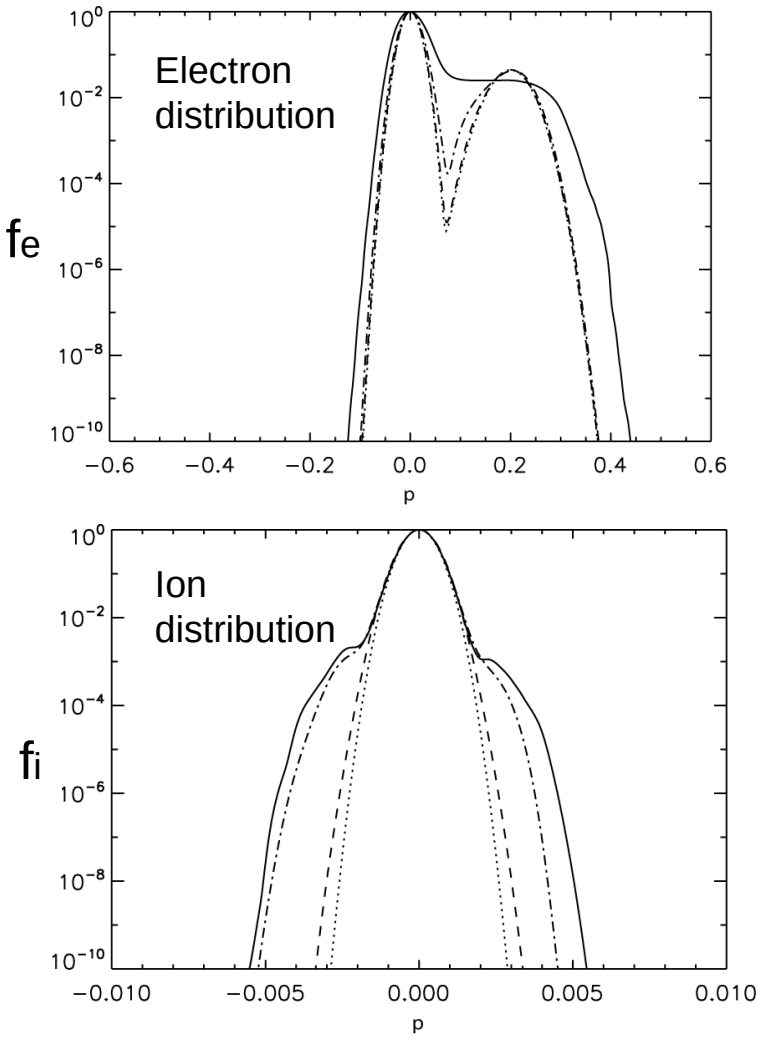
These scatter electrons to higher energies





[1] *Plasma Phys. Control. Fusion, 50, 065005 (2008)*
[2] *Phys. Rev. Lett., 94, 245002*
[3] *Phys. Plasmas, 12, 012303 (2005)*

# Relaxation of electron beam and ion heating

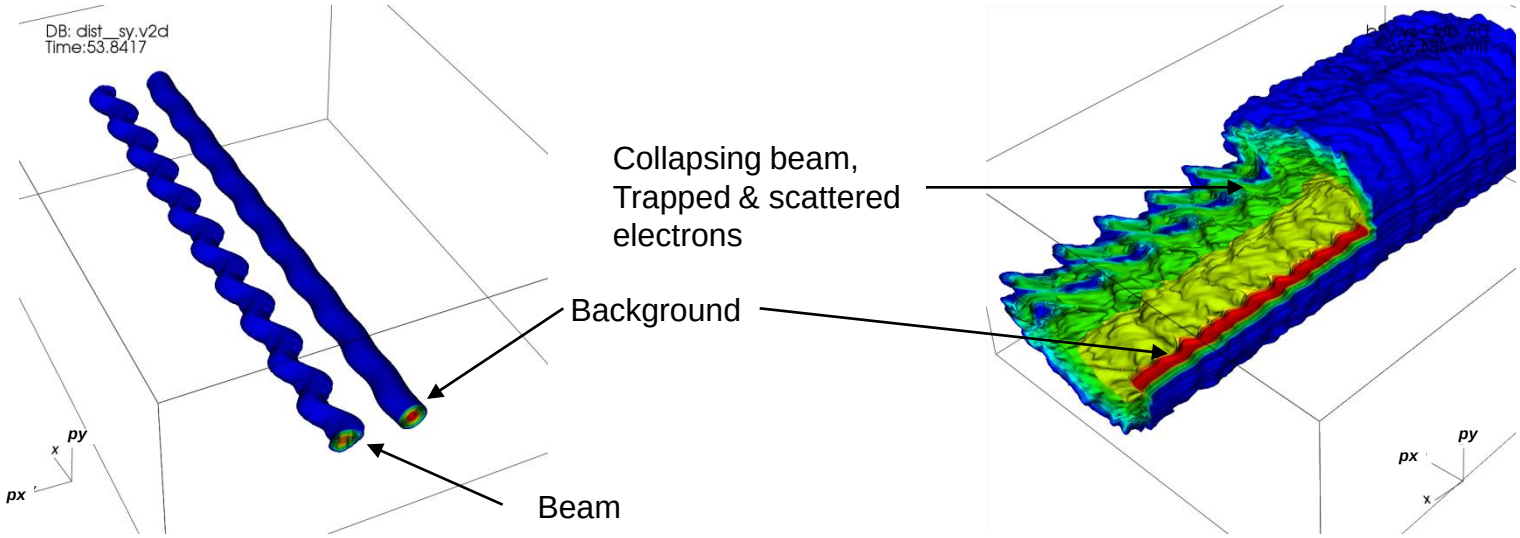



- Waves are responsible for the thermalisation of the electron beam and acceleration of the tail of both electron and ion distribution functions.
- As the system begins to saturate, moving into a non-linear phase, the unstable mode drives other modes parametrically from the background noise dissipating its energy in the process.
- Energy then transferred from the turbulent electron plasma wave spectrum into the ion population via the modulational and parametric instabilities
- Ion acoustic waves responsible for energetic ion tails

Integrated electron (top) and ion (bottom) distributions for of *Tbeam = 500*eV at *t = 0* (dotted line), *40* (dashed line), *480* (dot-dashed line), *1200* (solid line). Initial beam velocity is 0.2c

Plateau in fe formed by the relaxation of the beam is clearly visible, in addition to high energy tails on both the electron and ion distributions.

# 2D effects may also be important

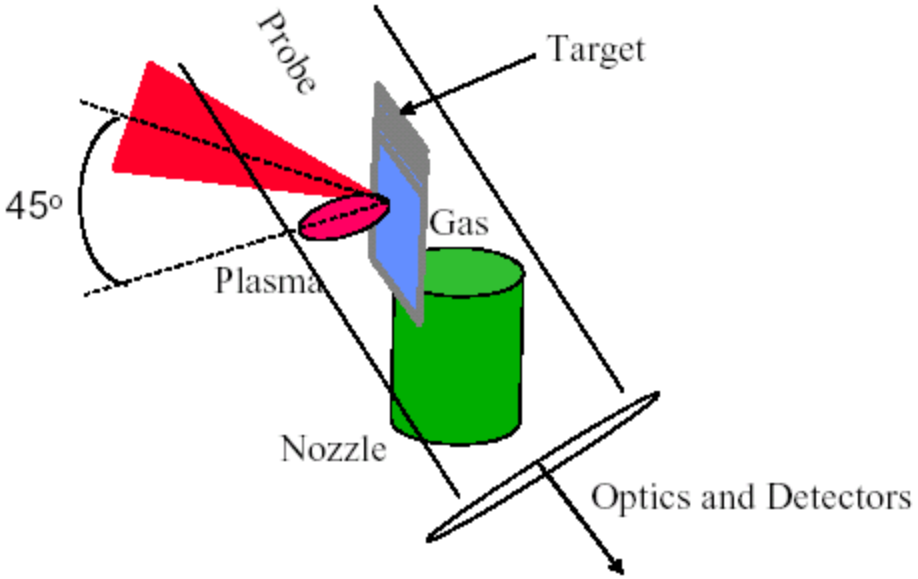


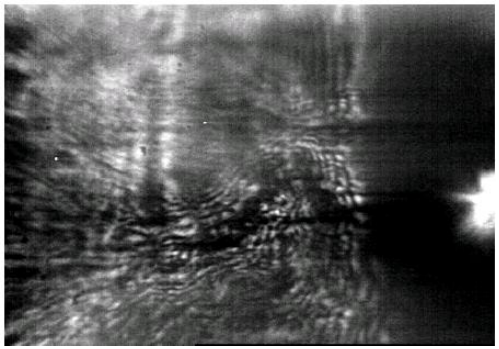

- Additional instabilities [4] can influence the heating of the background
- Prelimenary study of 2D instabilities [5], with immobile ions, conducted. Shows transverse filamentation and significant heating in transverse direction
- Simulations conducted using 2D2P direct Vlasov solver '**VALIS**' [6]
  - Now extended to deal with multiple species
  - Work underway to include some collisional effects
- Simulations of ion heating from electron beams in 2D planned


[4] *Phys. Rev. Lett., 94, 115002 (2005)*
[5] *CLF Annual Report 2007-2008*
[6] *J. Comp. Phys, Accepted, (doi:10.1016/j.jcp.2009.03.029 )*

# Instabilities seen with 1 ps $e^-$ beams

**ultra-intense laser pulses generated multi-MA electron beams propagating through the plasma atmosphere are both subject to a host of plasma instabilities**

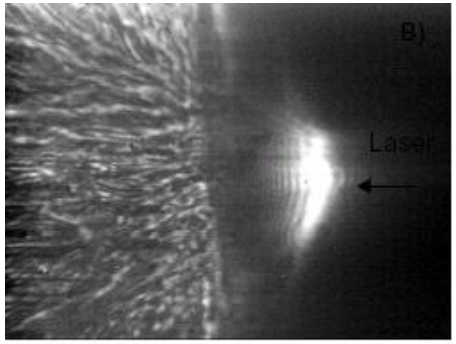


Fire-hose type instability

laser

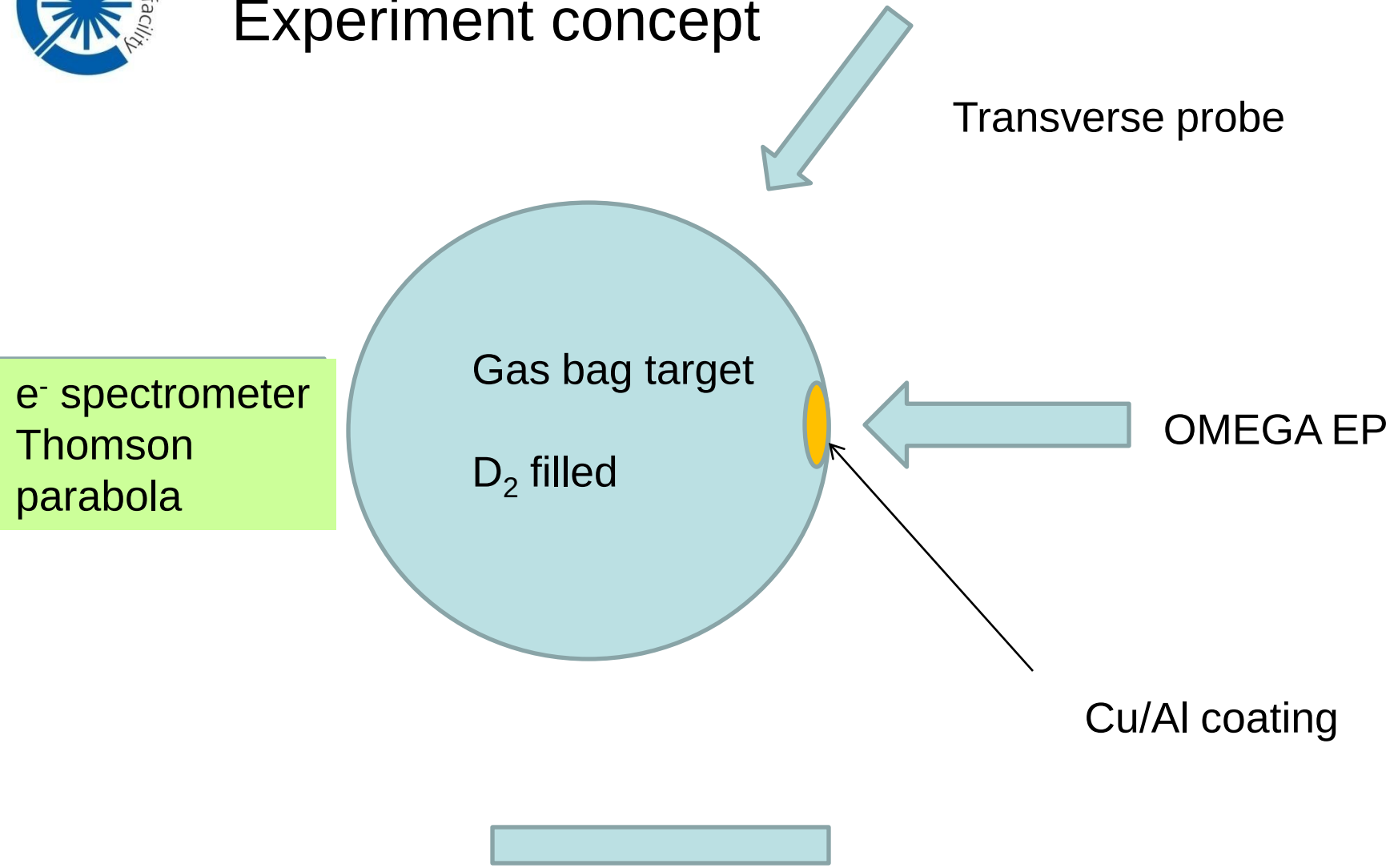
filamentation-or Weibel- type instability




laser

M.Tatarakis *et al.* Phys. Rev. Lett. (May 2003).

# Experiment concept




CR-39 nuclear track detector for 3 MeV d,d proton fusion product