ICF Relevant Research at Warwick

Warwick:

Tony Arber - LPI, Code development
Keith Bennett -Senior code developer
Chris Brady - PDRA studying LPI
Dirk Gericke - EOS, alpha stopping and Thompson
Jan Vorberger - EOS
+ 5 PhD students

Warwick & AWE:

Nathan Sircombe - Warwick visiting fellow
Martin Ramsey - Part-time PhD at Warwick
Kelvin Long - Part-time PhD at Warwick
David Chapman - Part-time PhD at Warwick

Overview

- *EPOCH* (PIC) code development.
- Collisions in PIC codes
- LPI studies of filamentation and SRS
- Other projects & Plans

The *EPOCH* Project

A freely available EM PIC code

Principle Investigators

Tony Bell (Oxford)
Roger Evans (Imperial)
Tony Arber (Warwick)

Senior Developers

Keith Bennett (Warwick)
Chris Brady (Warwick)
Holger Schmidz (Imperial)
Chris Ridgers (Oxford)

Based on core algorithm from PSC by Hartmut Ruhl

EPOCH Code and Project

Extendable PIC Open Collaboration (the H is silent!)

EPSRC funded project to develop a UK advanced PIC code.

Core Relativistic EM PIC code is freely available.

Project funds 3 PDRAs to develop the code. These are in Oxford/Imperial/Warwick. Funds for an additional 3 years.

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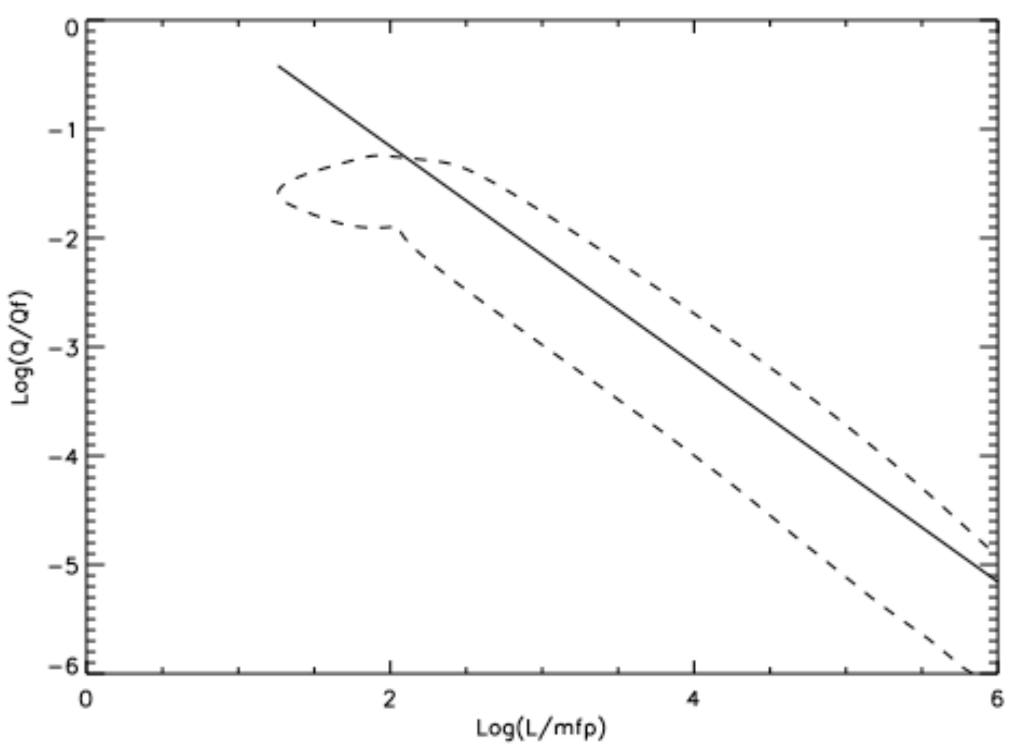
Advanced features will include:

- Collisions
- Radiation
- Ionisation
- QED effects
- Coherent radiation
- Hybrid schemes

Collisions in PIC - Thermal Conductivity

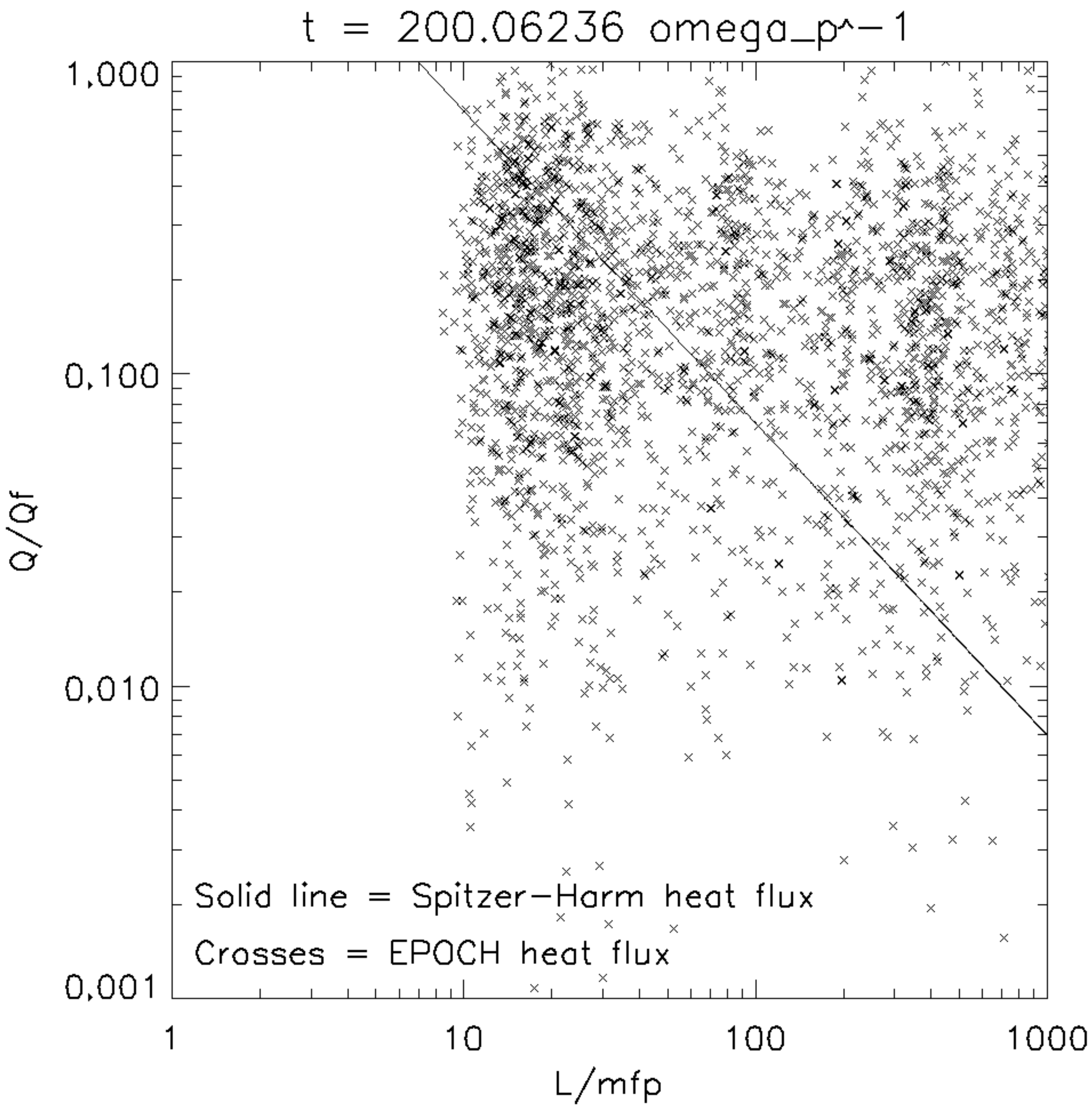
Y. Sentoku and A. J. Kemp, *J. Comput. Phys.*, 227, 6846 (2008) scheme for collisions with variable particle weights in 1D and 2D.

- Temperature ranged from 100 eV to 400 eV
- Ions Z=4 and A=8
- Plot ratio of heat flux over free streaming limit against scale length over *mfp*
- Scale length estimated from fitting smooth profile through PIC output.

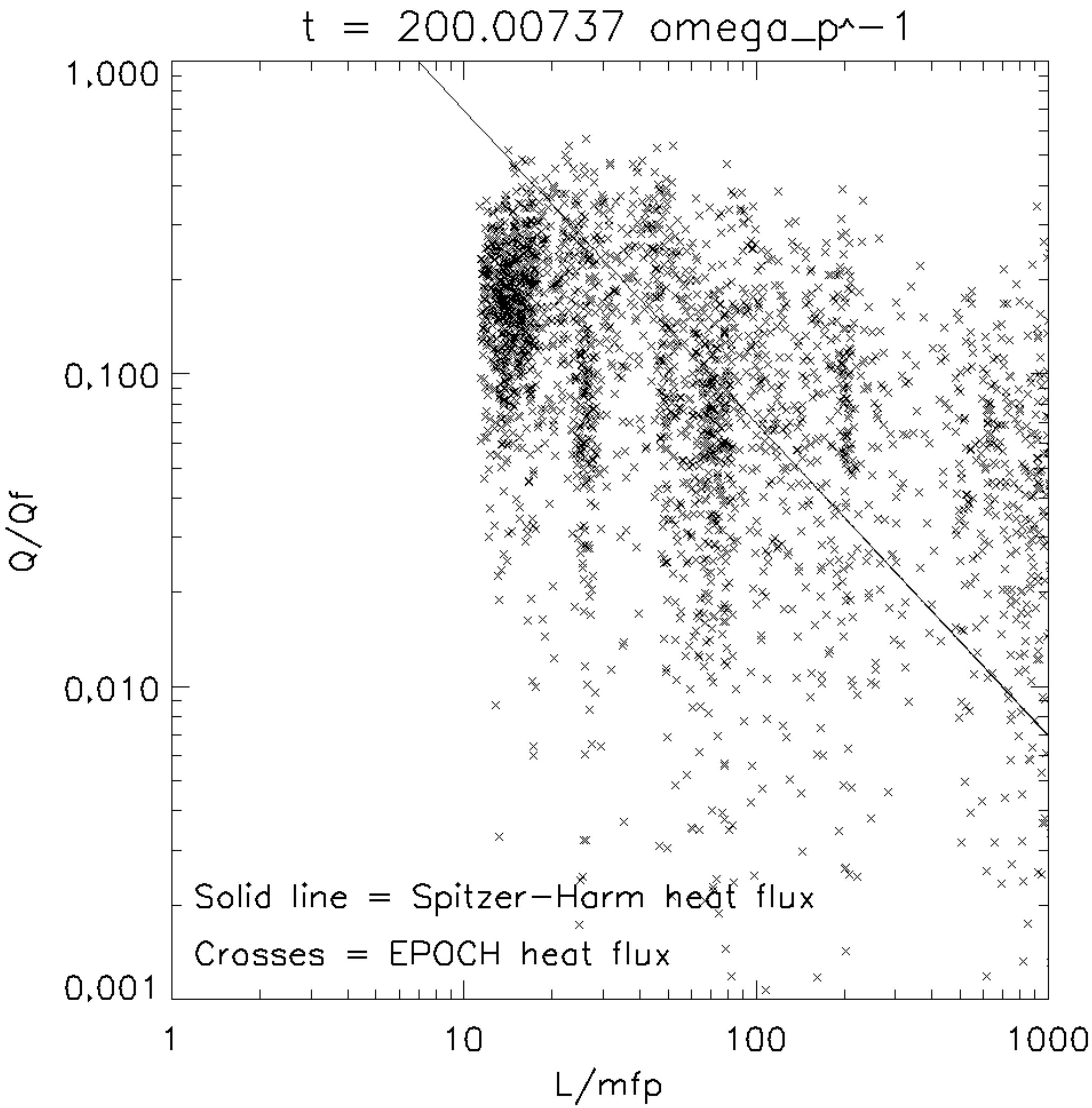


- Fokker-Plank calculation of non-local transport
- Solid line is Spitzer-Harm
- Density ~ 3×10^{26} m^{-3}.
- 8192 cells

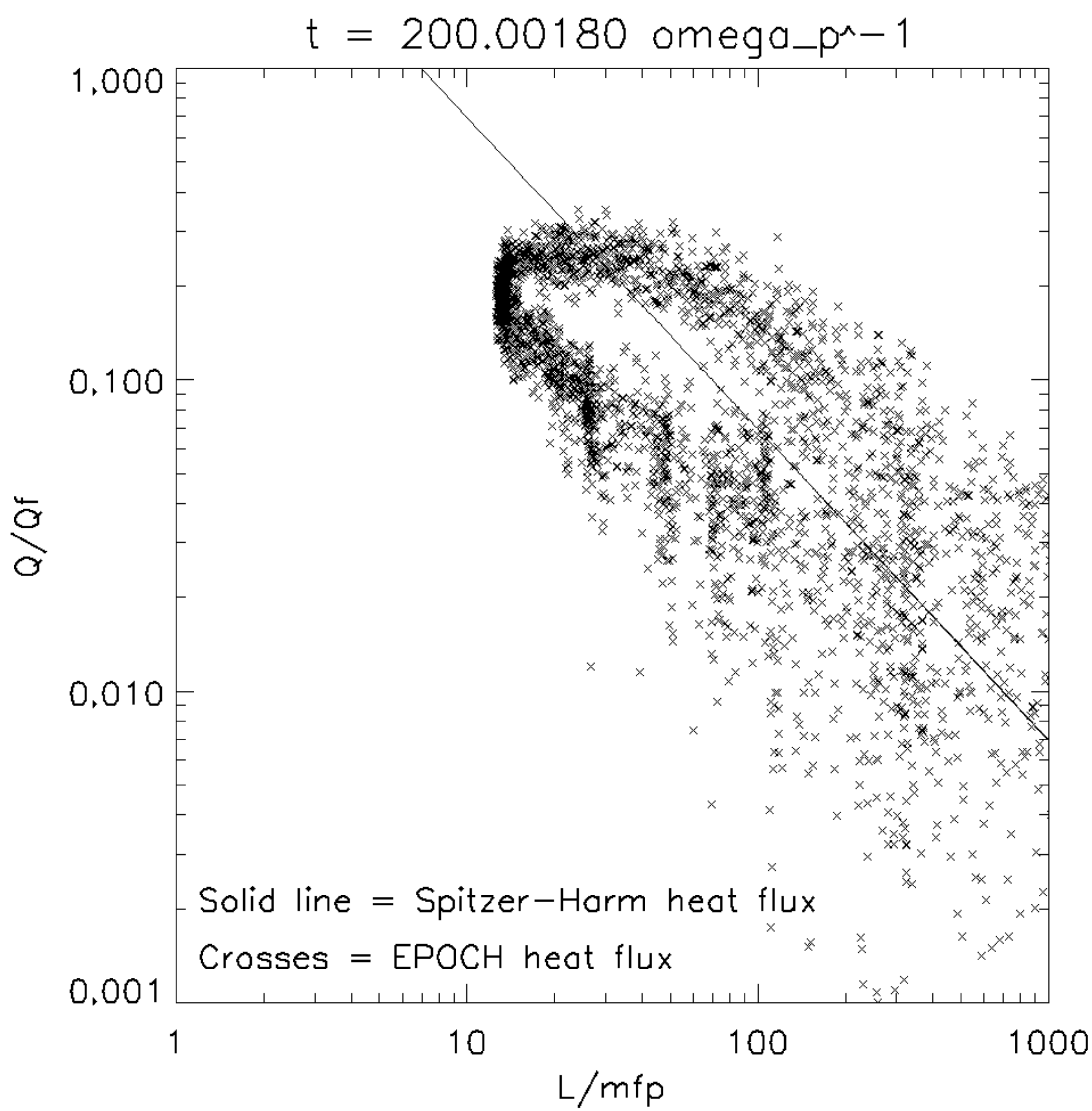
Thermal Conductivity 50ppc



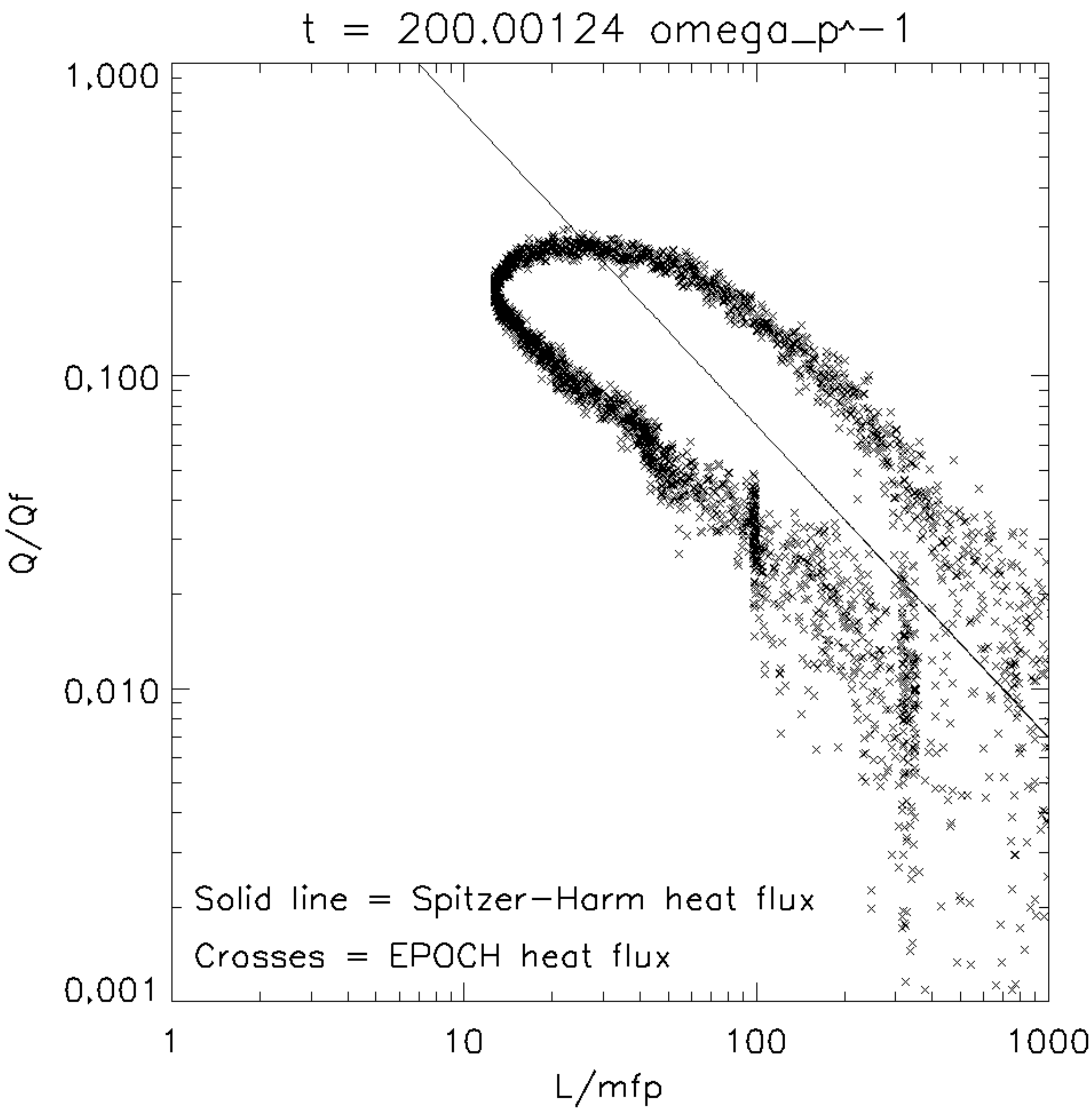
Thermal Conductivity 500ppc



Thermal Conductivity 5000ppc



Thermal Conductivity 50,000ppc



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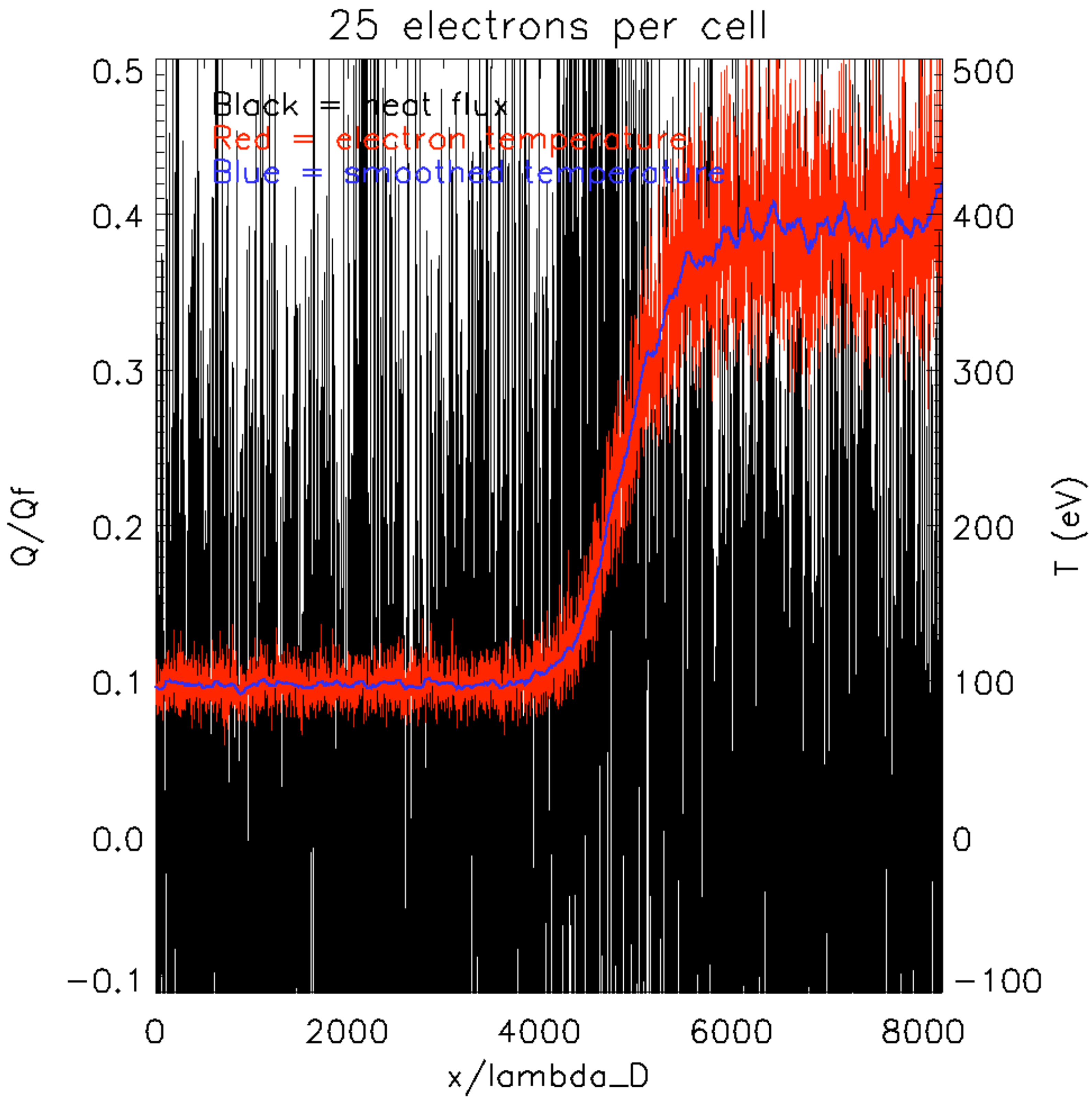
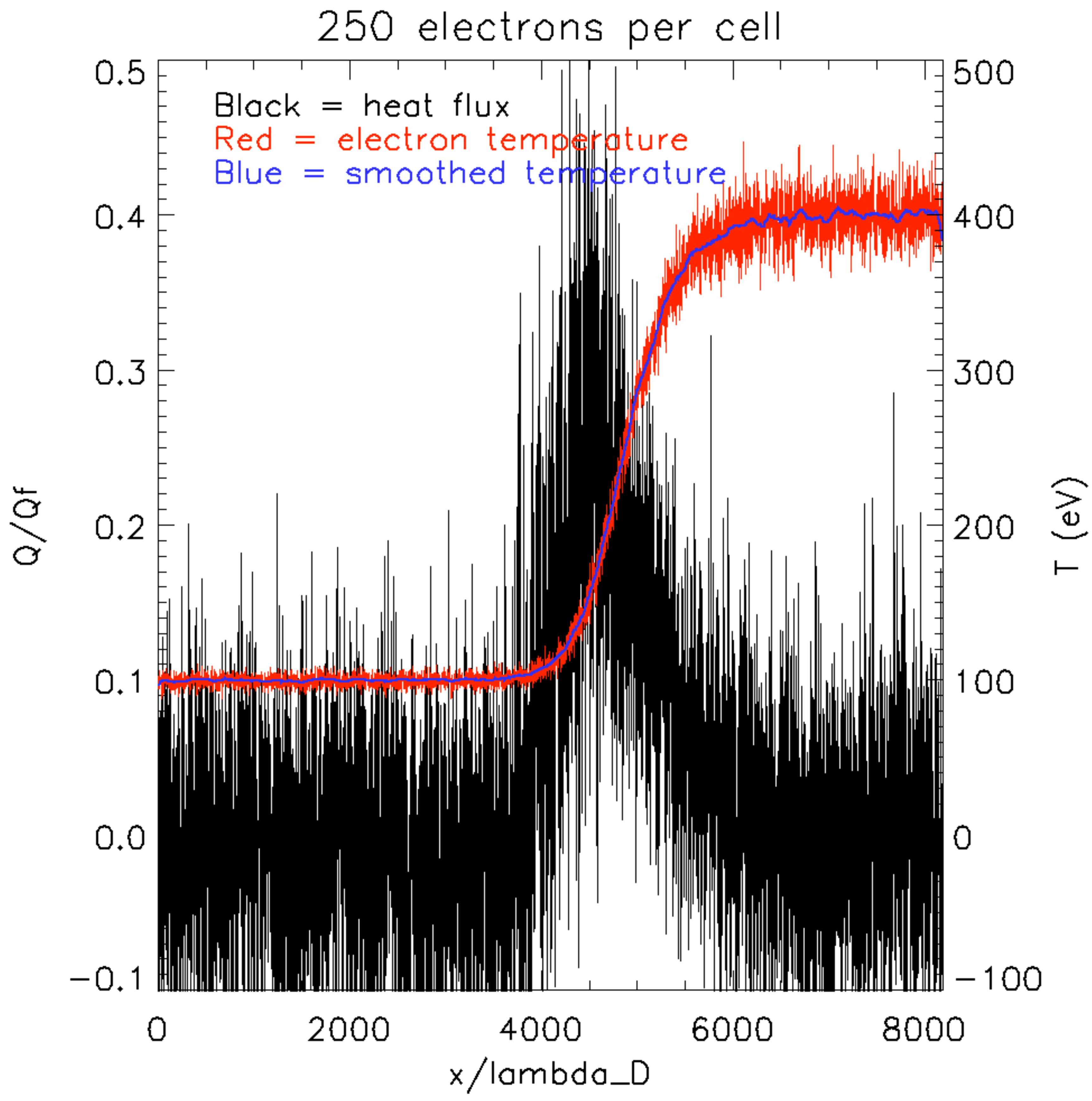
Thermal heat flux 50ppc



Thermal heat flux 500ppc



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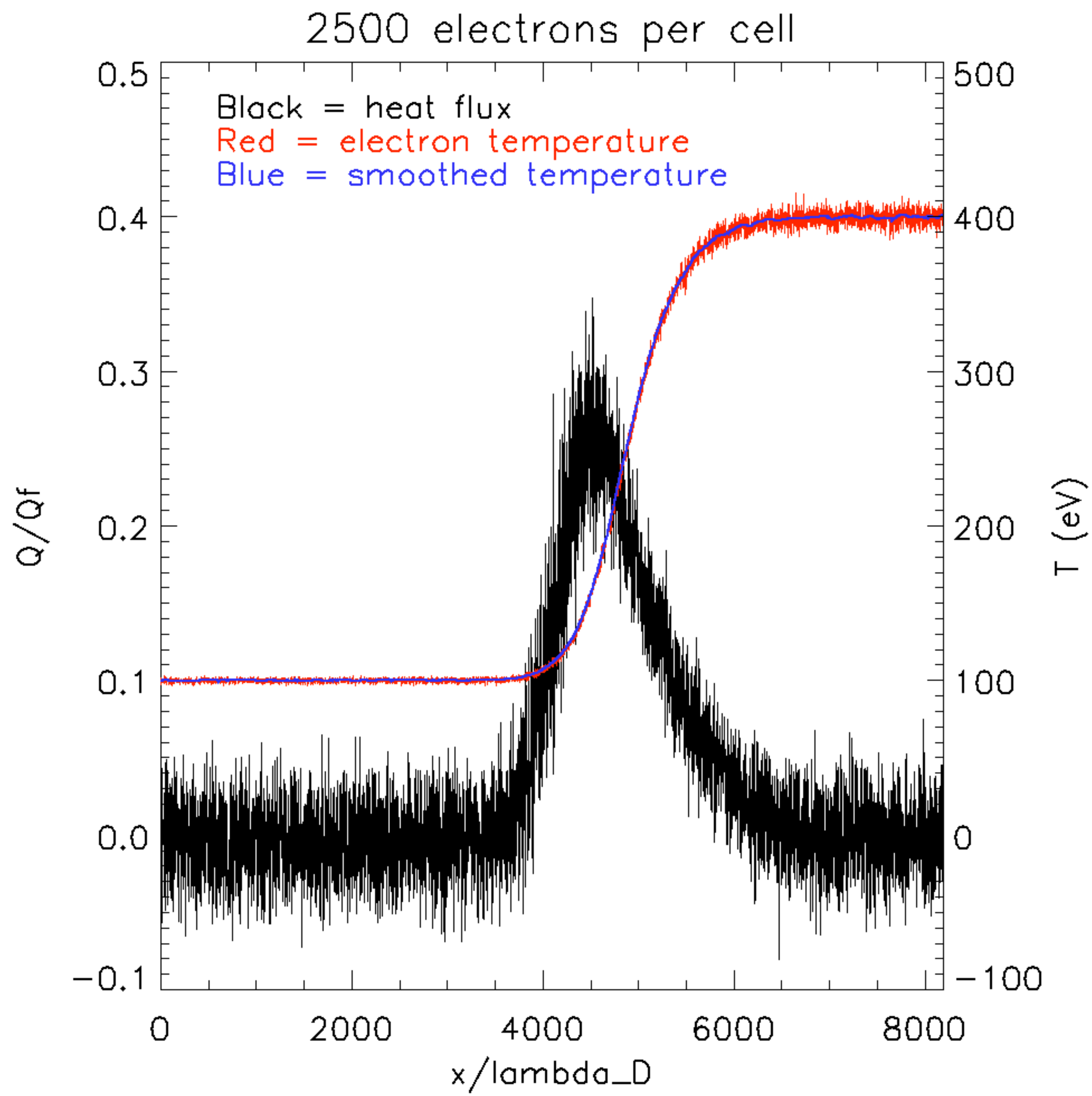
Thermal heat flux 5000ppc



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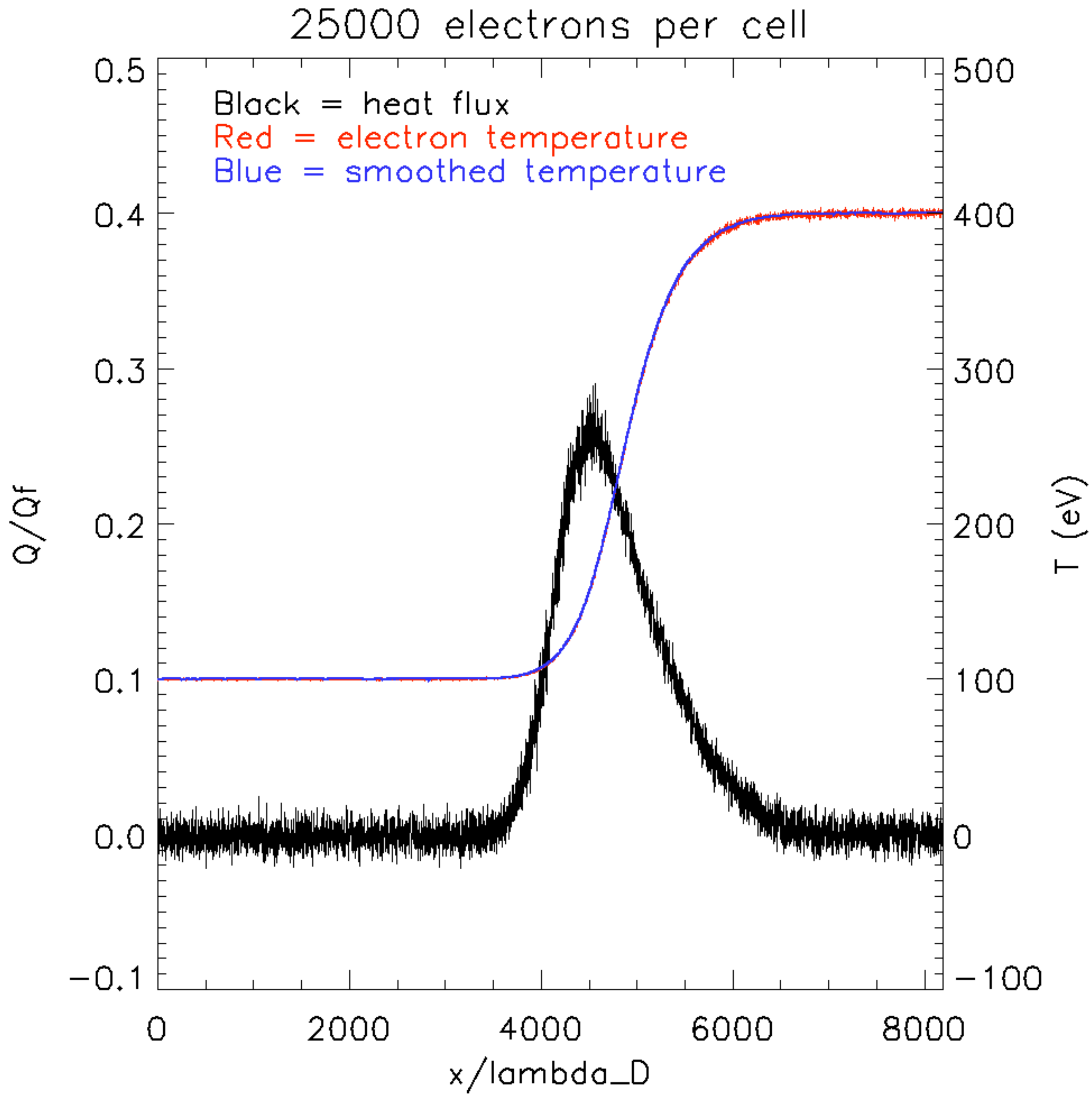
Thermal heat flux 50,000ppc



CFSA

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Cone Fast Ignition Igniter Pulse

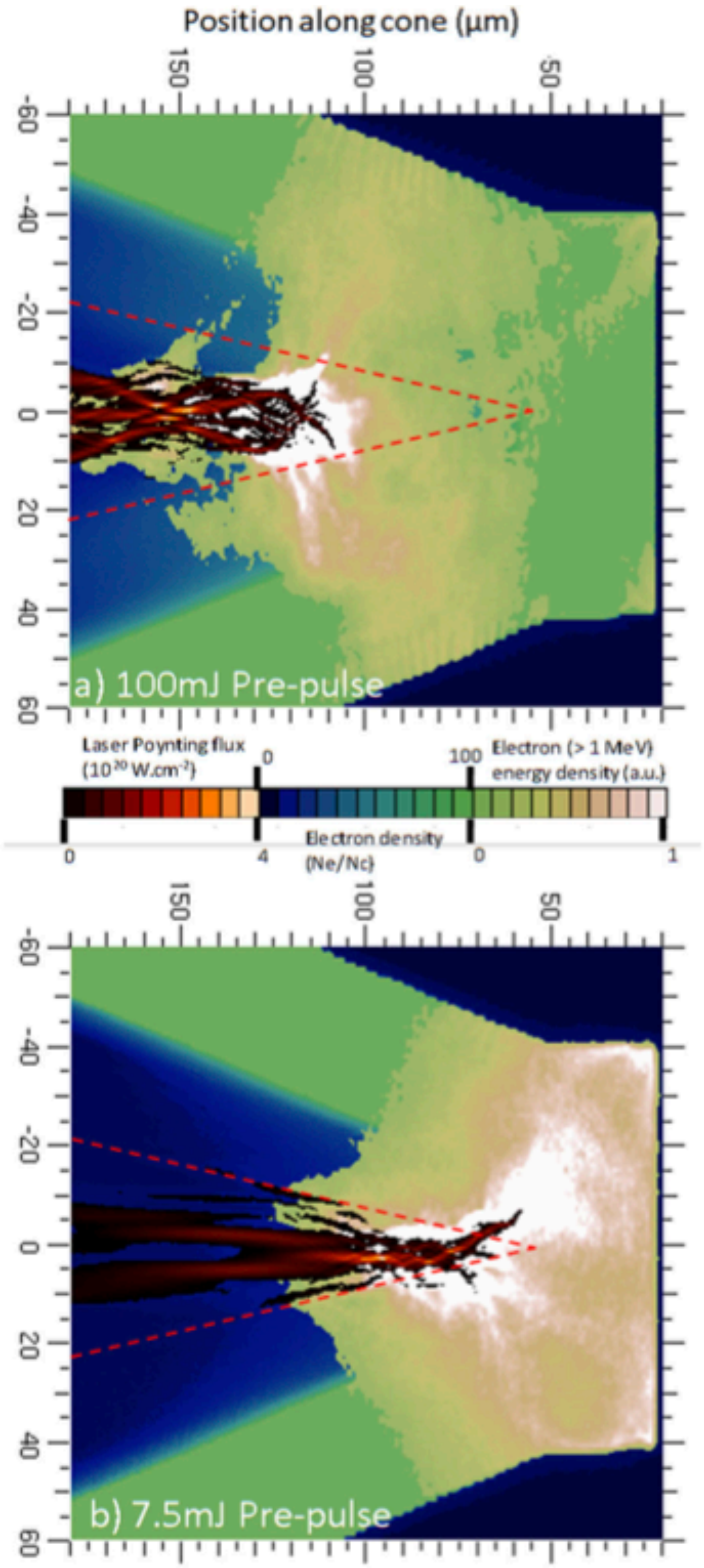


FIG. 3 (color online). Overlay of laser Poynting flux and electron density maps 1 ps after nominal peak fluence on target: (a) 100 mJ prepulse, (b) 7.5 mJ prepulse.

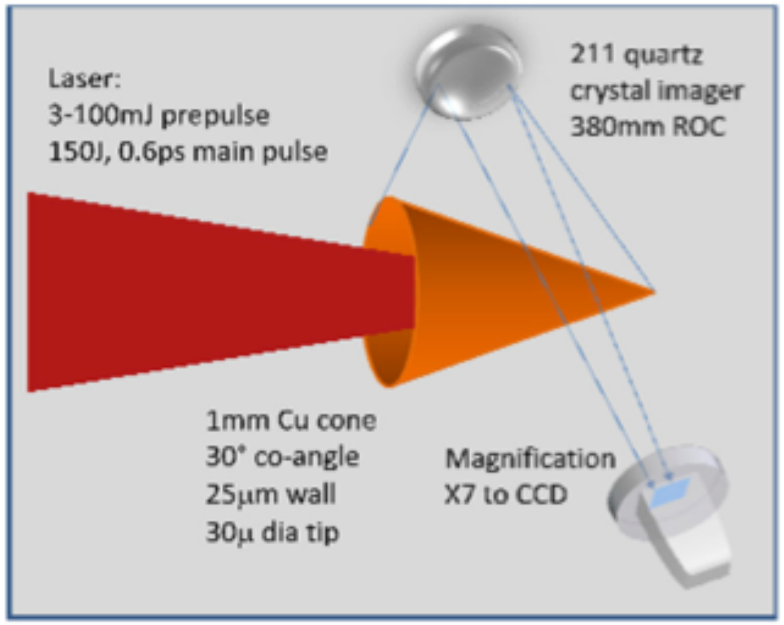
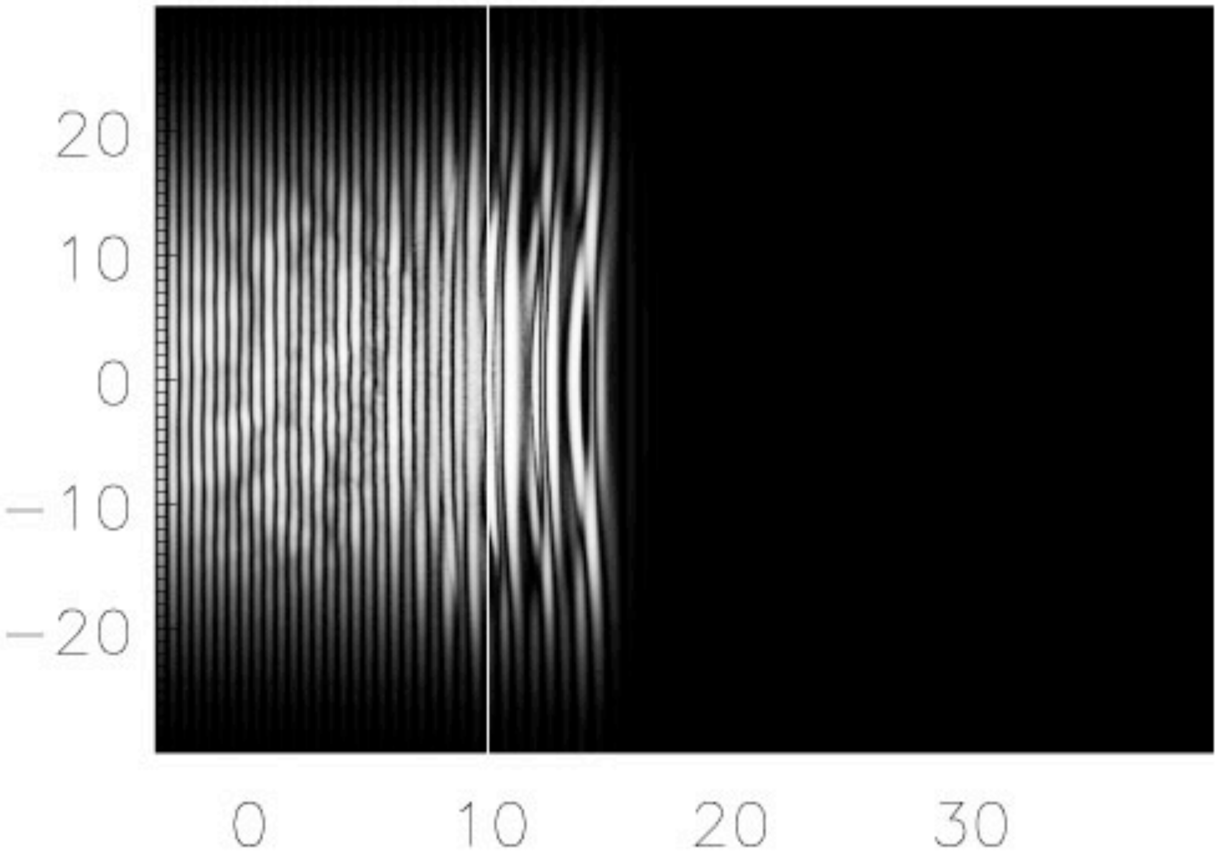


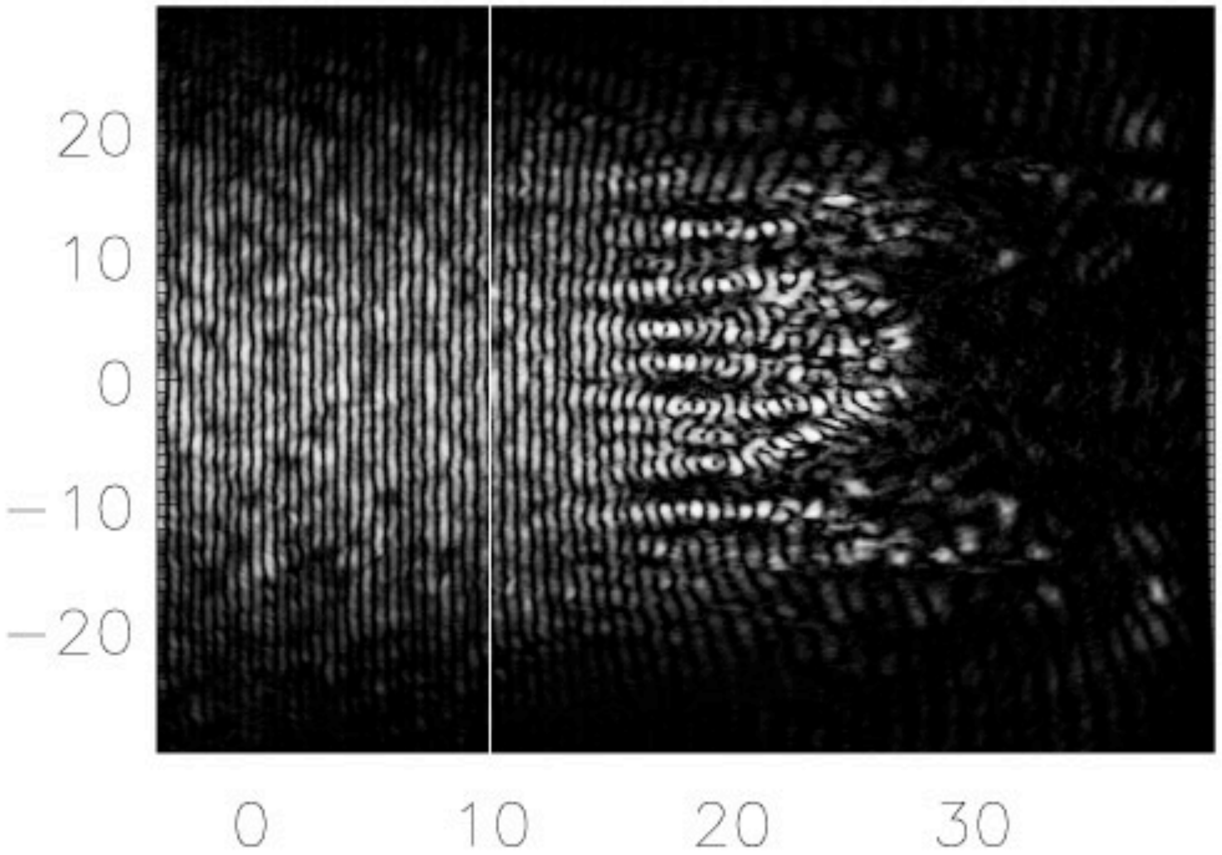
FIG. 1 (color online). Target detail illustrating K_α imaging geometry.

Results from MacPhee et al. PRL, **104** (2010) suggest that beam filamentation may prevent igniter pulse reaching cone tip.

What physics determines filament formation?

Short pulse filamentation

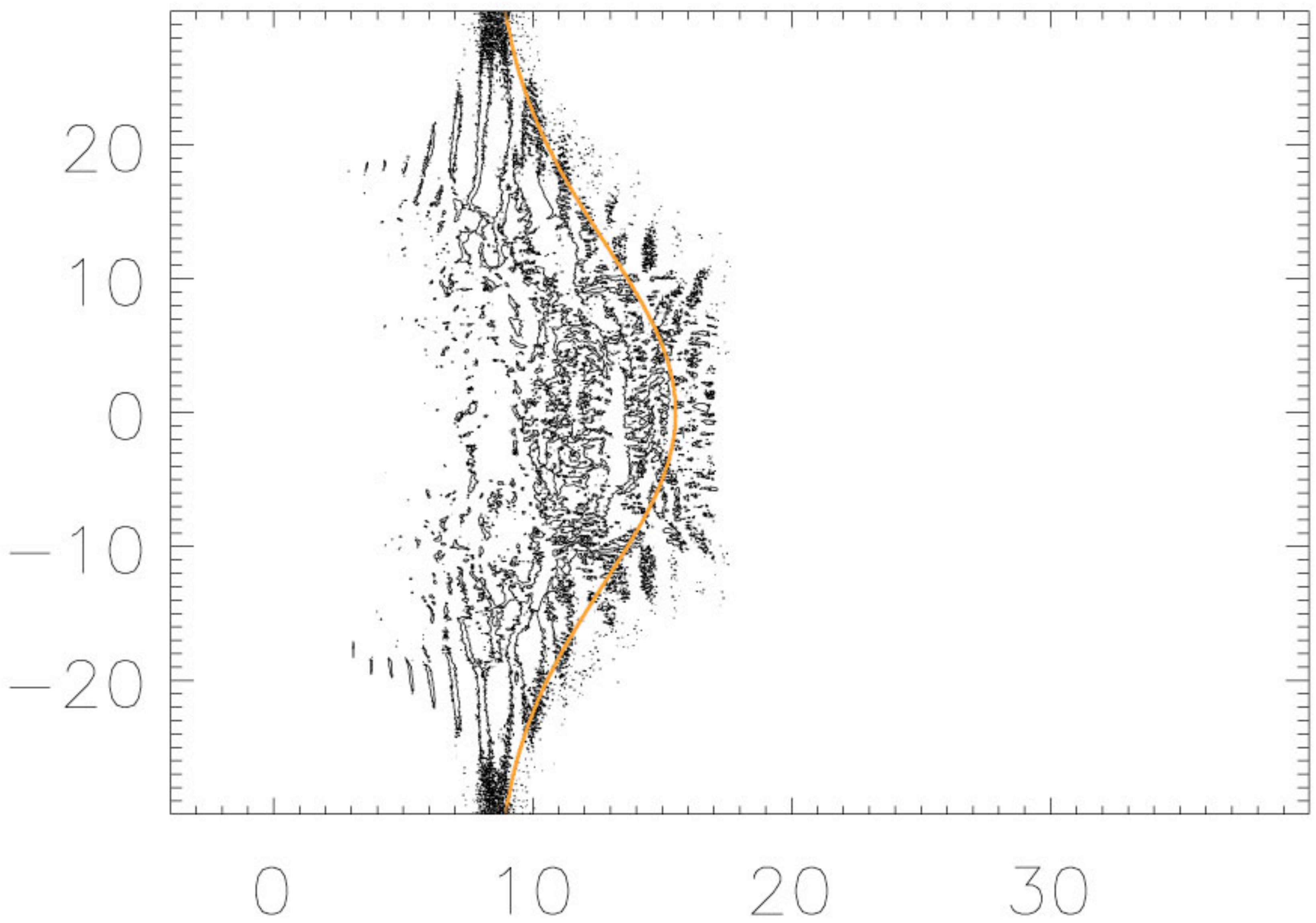




Lasers with intensity > 5×10^{17} W/cm^2 propagating up density ramp filament at the 1/4 critical surface.

Number and location of filaments easily predicted by considering the 1/4 critical surface to be a partially reflecting mirrot

1/4 Critical Surface



Growth rate of SRS backscatter

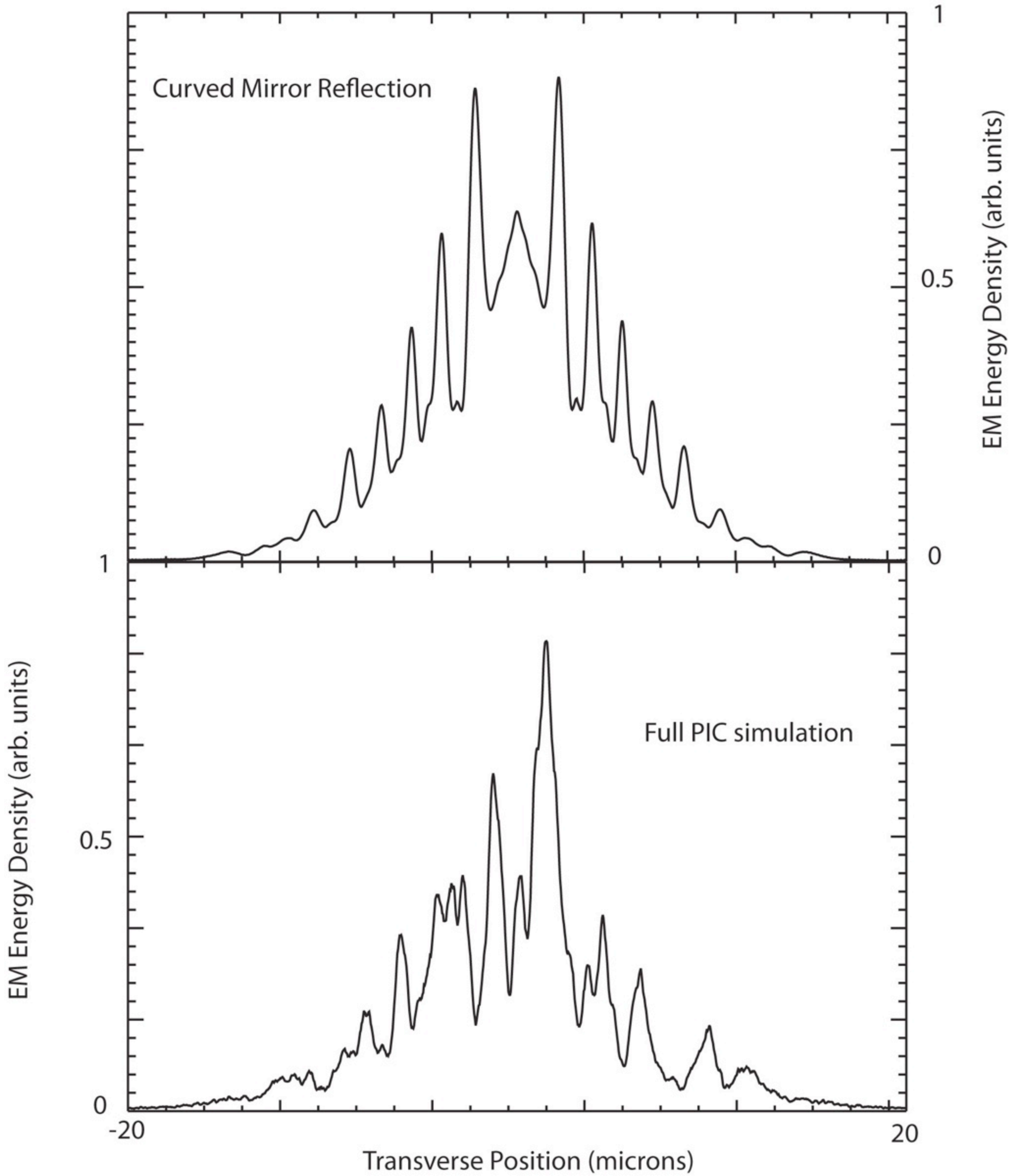
$$\gamma \propto \frac{\omega_{pe}^2}{\omega_0}\frac{u_{os}}{c}$$

Increasing growth rate with plasma frequency localises SRS near the 1/4 critical surface

Dependence of growth, and hence SRS backscatter, on laser intensity means at higher intensity reflectivity localised near 1/4 critical.

1/4 critical surface deformed by laser profile.

SRS interference patterns



Above 5×10^{17} W/cm^2 contrast in reflectivity means 1/4 critical acts as a partially reflecting mirror.

Increasing intensity deforms 1/4 critical surface.

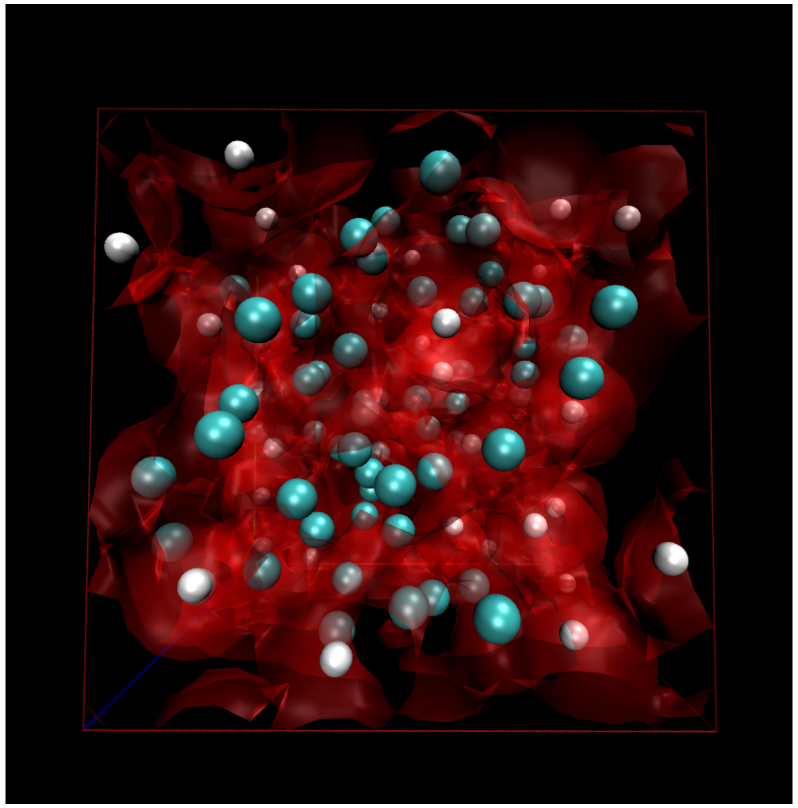
Interference pattern below 1/4 critical leads to localised E^2 which seeds filamentation.

Number of filaments scales with wavelength, pulse cross-section and intensity as expected from this simple model.

EOS, WDM & Diagnostics

Dirk Gericke - Warwick

- Alpha particle stopping in ICF - collaboration with Steve Rose (Imperial)
- Plasma diagnostics - Thompson Scattering - collaborations with Gianluca Gregori (Oxford)
- Strongly coupled plasmas
- Warm dense matter



Other Projects & Plans

- **Ionisation models:** included tunnelling, multi-photon and BSI models in EPOCH.

- **Direct Vlasov solver:** developed EM Vlasov solver (Valis)with BGK collisions for comparison with VFP. Study FI non-local transport.

- **Rad-hydro ALE code:** EPSRC funding for project in collaboration with Imperial.

- **LPI:** concentrate on LPI issues using EPOCH and Valis.

- **Non-Classical:** EOS, Thompson Scattering and Alpha-stopping