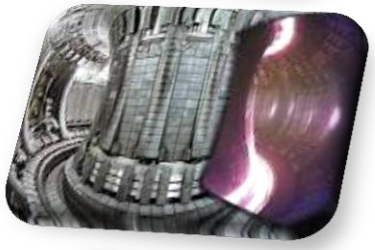
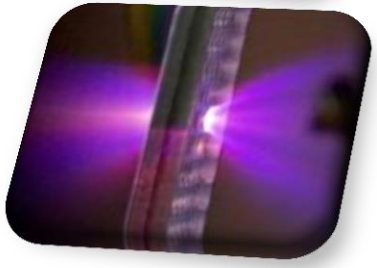
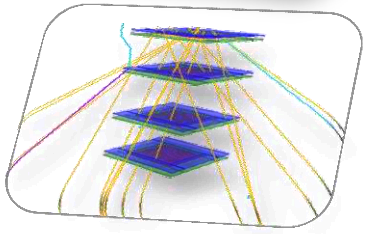






Energy Theme: Research highlights 2014/15

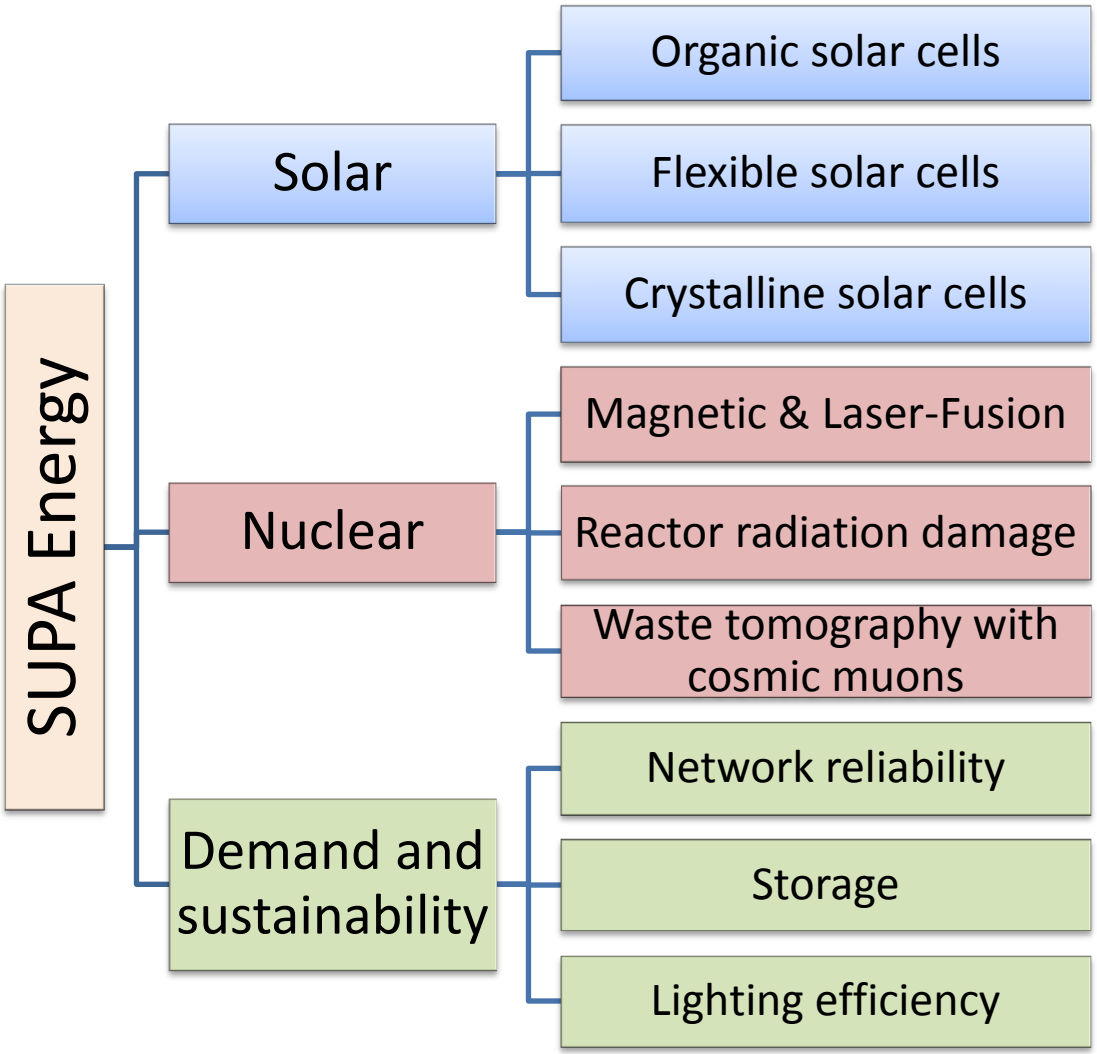
Theme Management Committee:

Paul McKenna (Strathclyde) – Theme Leader

Ifor Samuel (St. Andrews)
Murilo da Silva Baptista (Aberdeen)
Job Thijssen (Edinburgh)
Steve Reynolds (Dundee)
Richard Fu (UWS)
David Hamilton (Glasgow)
Taj O'Donovah (Heriot-Watt)

Theme overview

- ~25 academics, ~30 postdocs, and ~40 PhD students across the 8 SUPA institutions with energy as a core element of their research
- Almost all members of this theme are members of other themes



- Materials for Energy Technologies is a common theme
- Collaborations across SUPA and with EastChem, WestChem and SISOR
- Strong publications leading to new international and collaborative activity
- Developing links to SMEs and international projects to enhance KE and research Impact

Theme overview

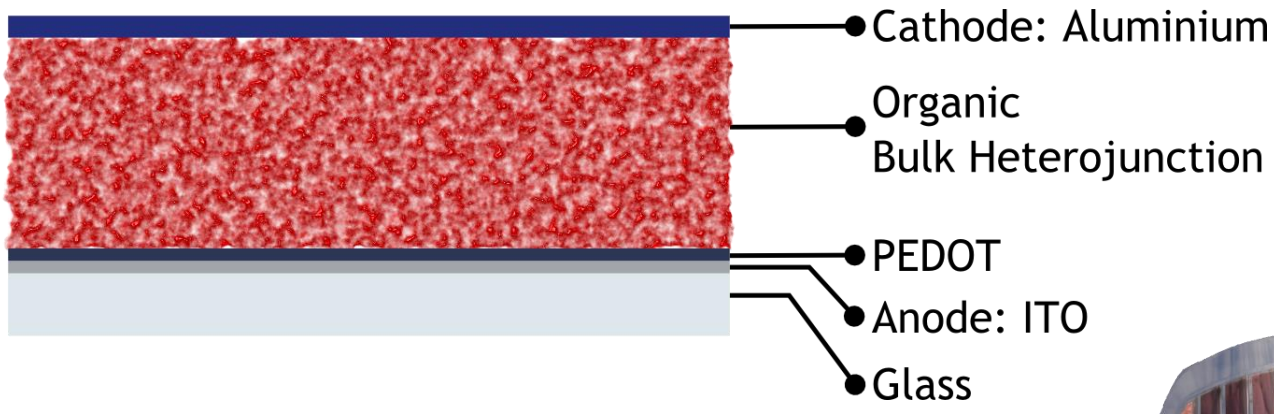
- SUPA Energy
  - Solar
    - Organic solar cells
    - Flexible solar cells
    - Crystalline solar cells
  - Nuclear
    - Magnetic & Laser-Fusion
    - Reactor radiation damage
    - Waste tomography with cosmic muons
  - Demand and sustainability
    - Network reliability
    - Storage
    - Lighting efficiency

Polymer Solar Cells

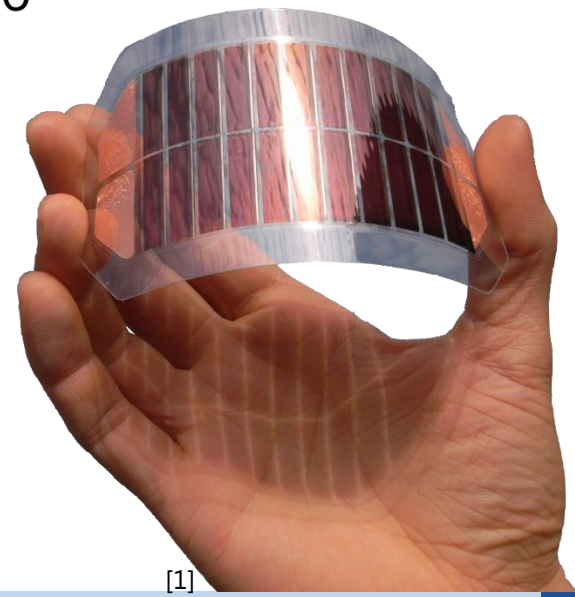
Ifor Samuel (St. Andrews)+ ScotChem

Ward et al, Advanced Materials (At Press)

- Organic Photovoltaic (OPV) devices are a promising source of renewable energy.
- Thin films (~ 100 nm) of a blend of an organic donor and acceptor form a bulk heterojunction and are sandwiched between an anode and cathode.



- The device architecture is compatible with various printing techniques (e.g. roll-to-roll, screen and spray printing).
- Consequently OPV has the prospect of being utilised in situations where large area and low cost PV is required, but not necessarily exceptional efficiencies.

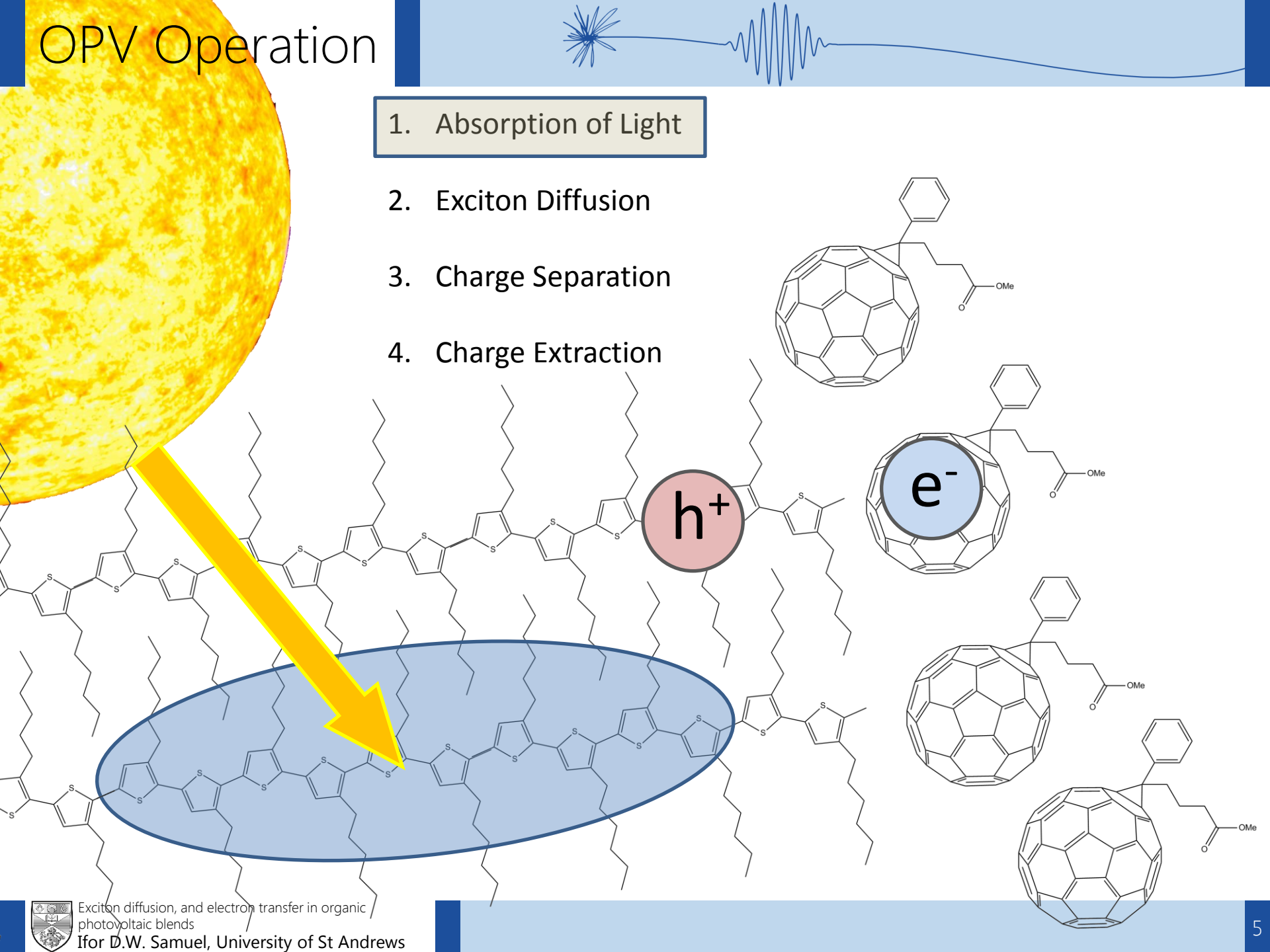


[1]

[1] Photo of organic solar cell from xpsolar.com

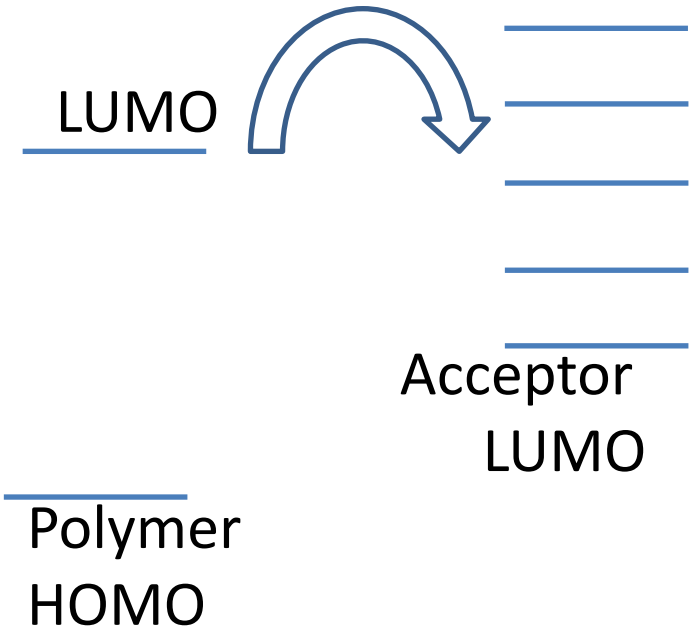
OPV Operation

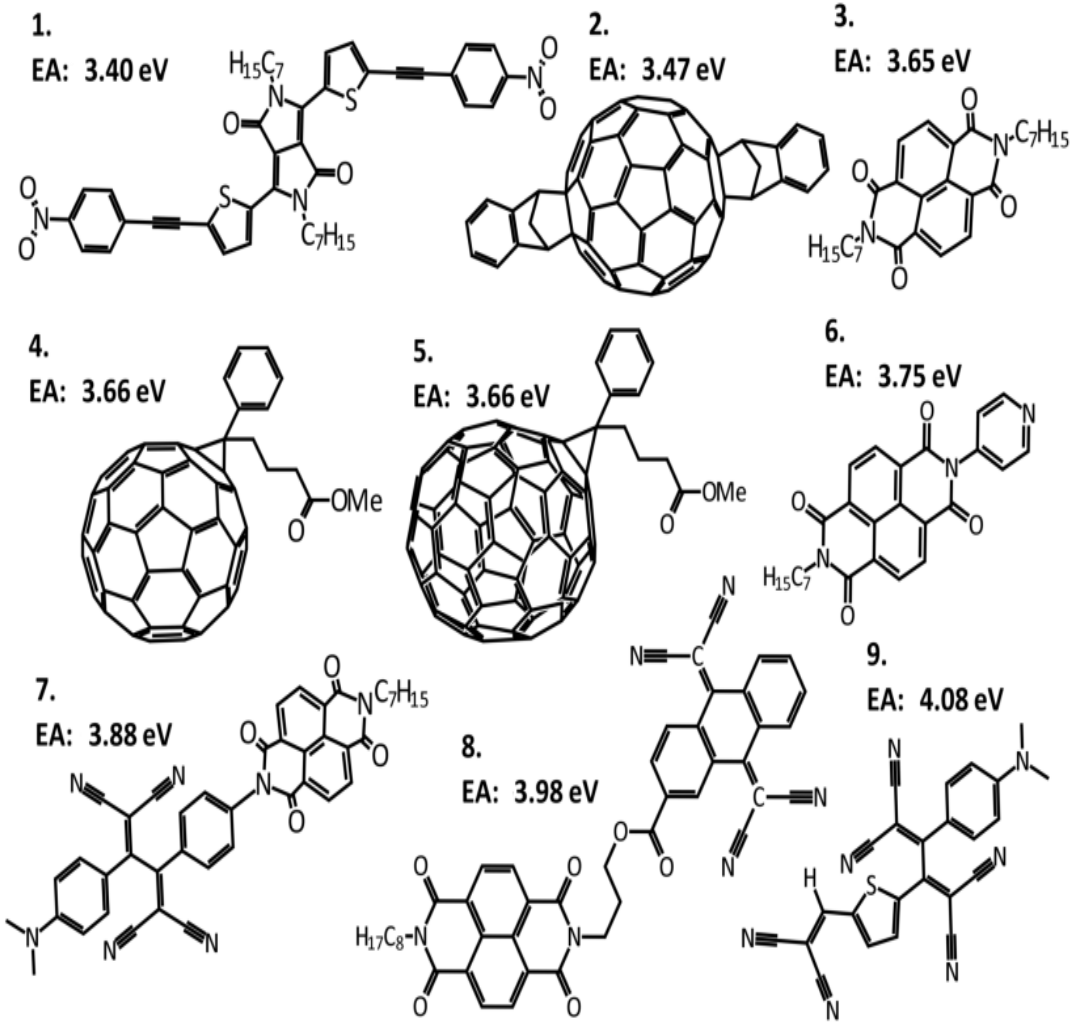
1. Absorption of Light
2. Exciton Diffusion
3. Charge Separation
4. Charge Extraction



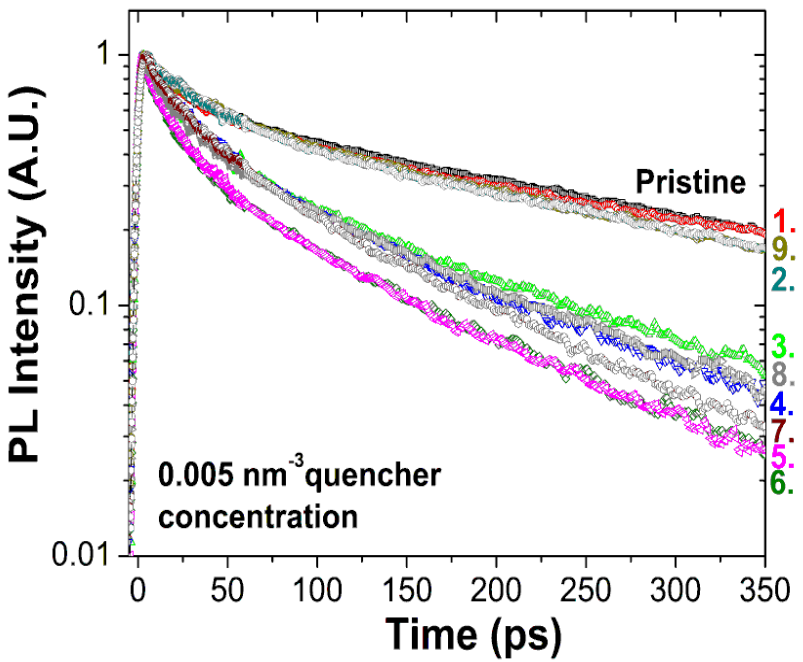
Electron Transfer

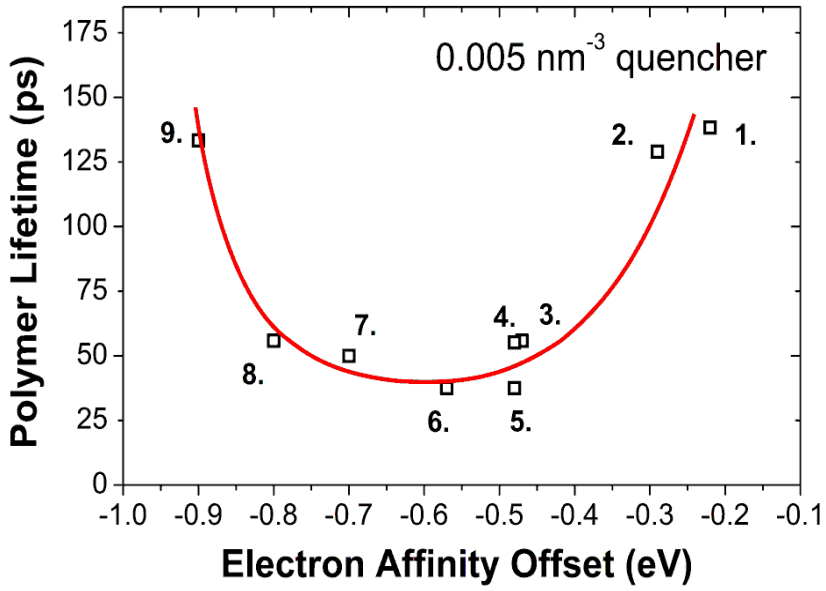
- How does electron transfer depend on energy level offset?

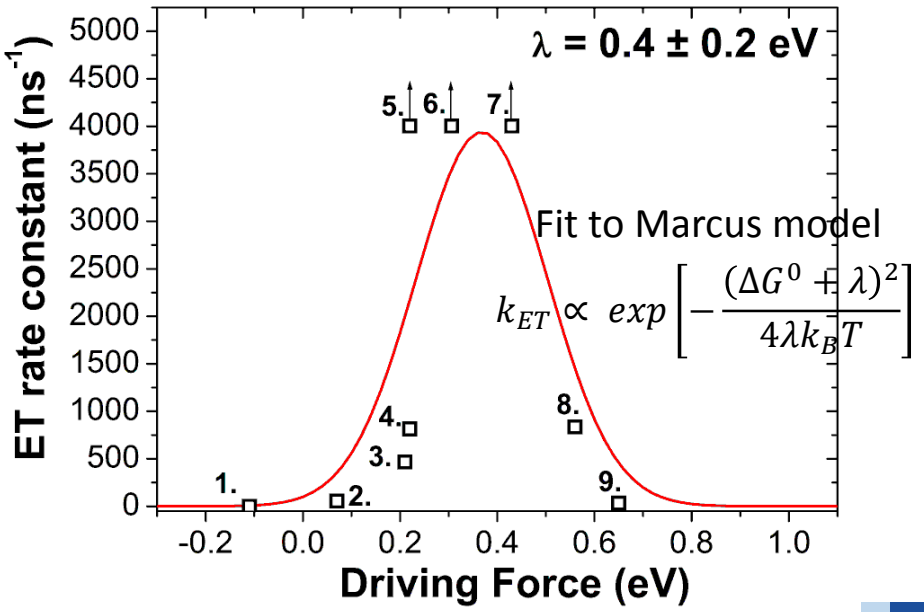




Energy Of Acceptor Affects Electron Transfer Rate





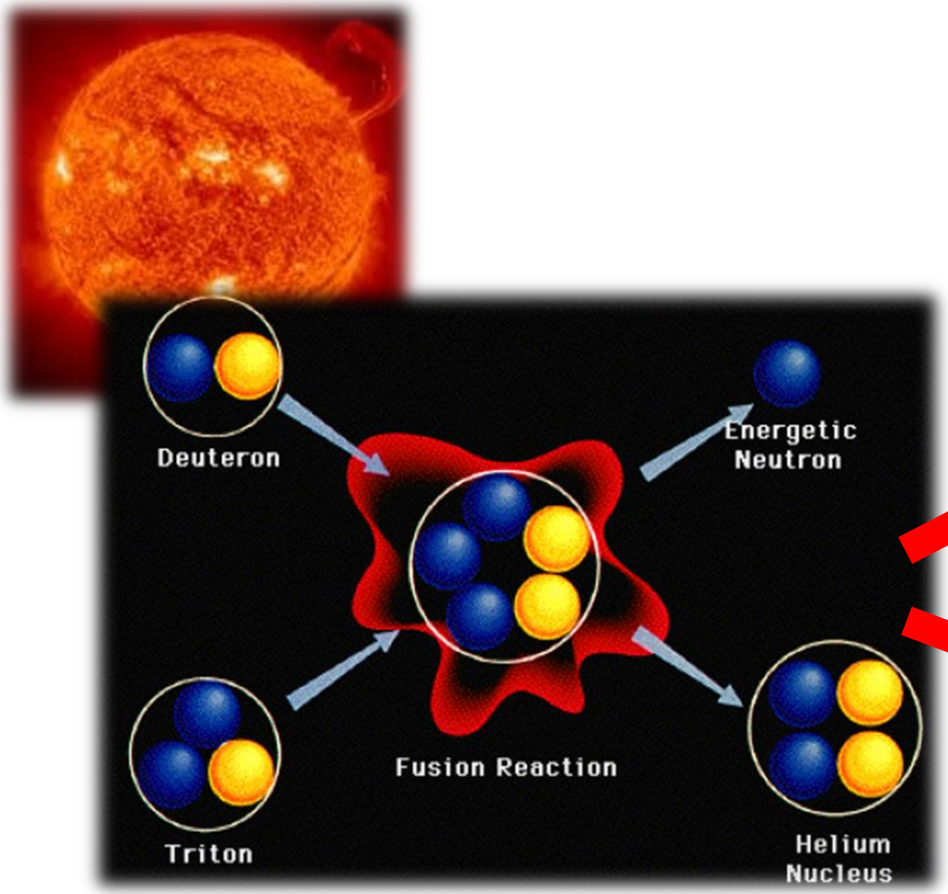


- Small reorganisation energy, λ, of 0.4 eV
- Means small donor-acceptor offset needed
- Voltage loss 1.1 eV in PTB7 and 1.4 eV in P3HT
- Narrower range of suitable acceptors

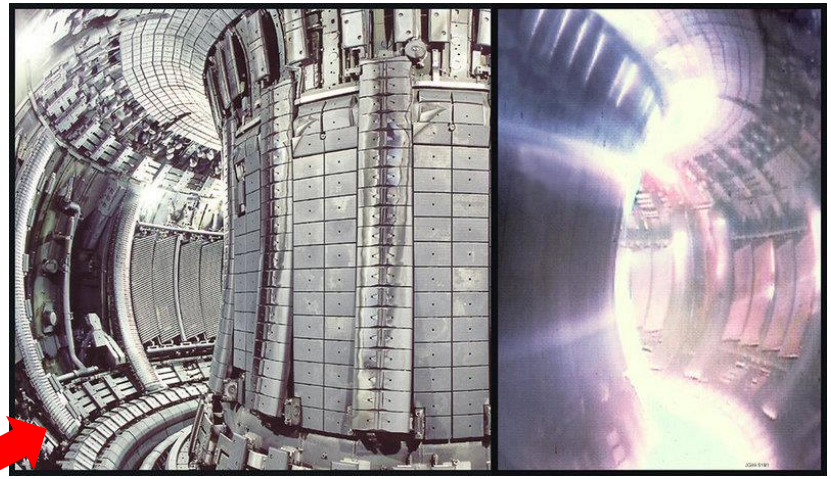
Ward et al, Advanced Materials (At Press)

- SUPA Energy
  - Solar
    - Organic solar cells
    - Flexible solar cells
    - Crystalline solar cells
  - Nuclear
    - Magnetic & Laser-Fusion
    - Reactor radiation damage
    - Waste tomography with cosmic muons
  - Demand and sustainability
    - Network reliability
    - Storage
    - Lighting efficiency

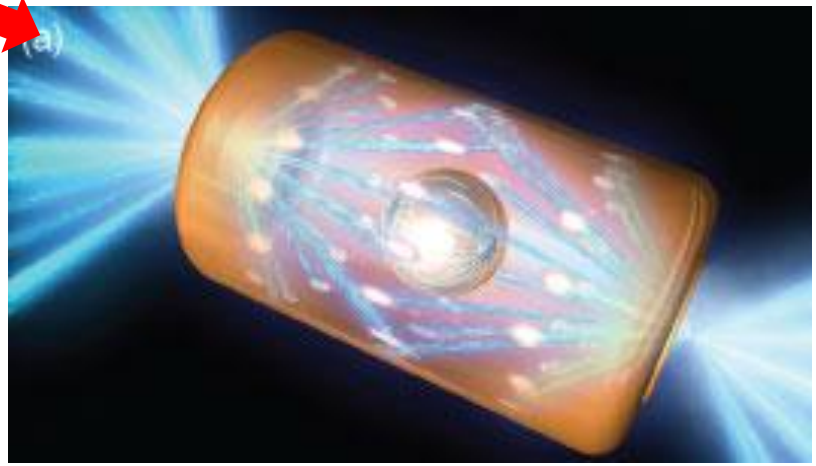
SUPA contributions to fusion research



Magnetic confinement (JET, Culham; ITER)

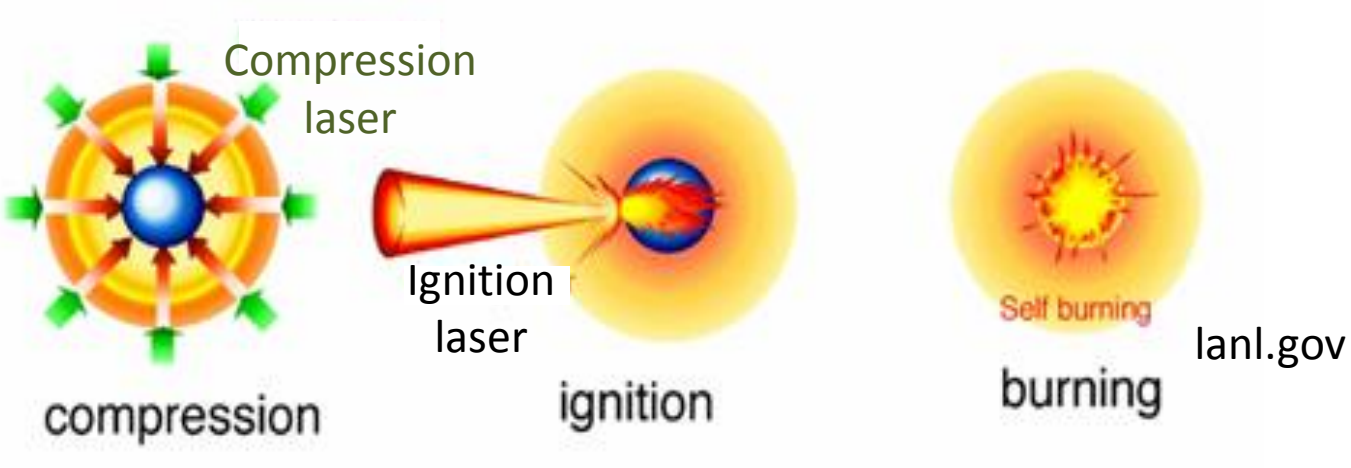


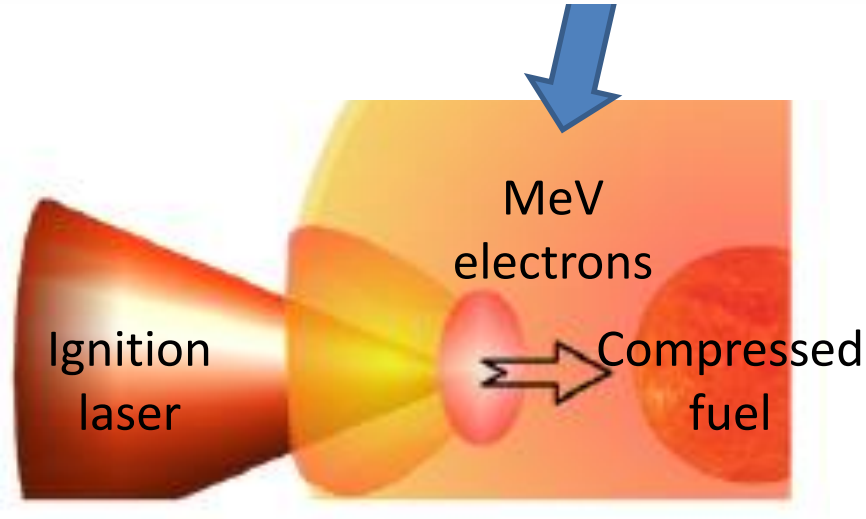
Inertial confinement (NIF; HiPER)

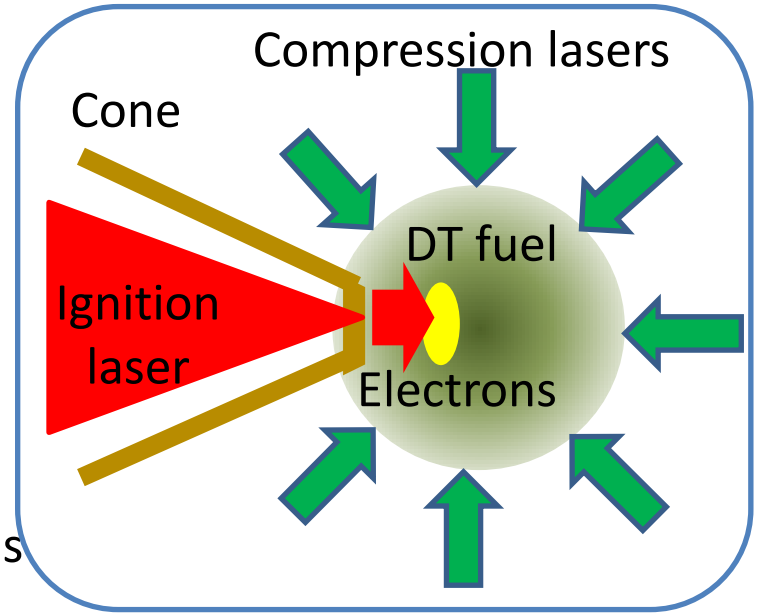


Fast Ignition scheme for Inertial Confinement Fusion

The fast ignition concept is a variant of inertial fusion in which the compression and ignition steps are separated.

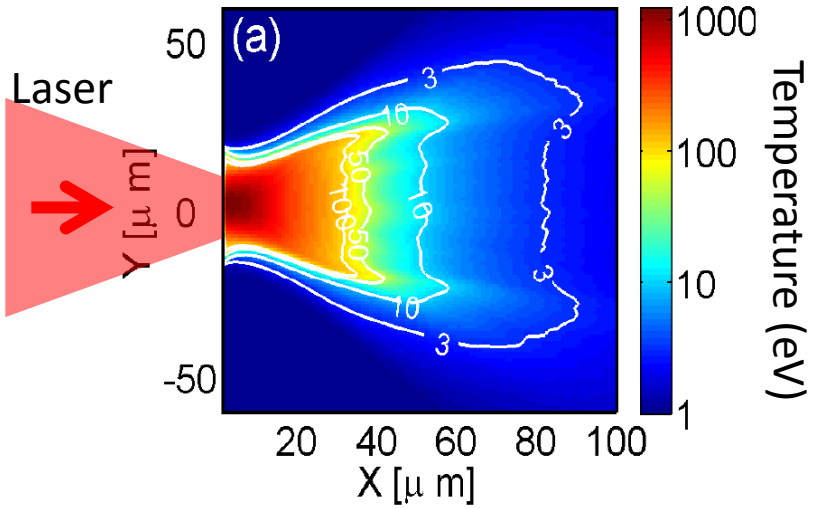


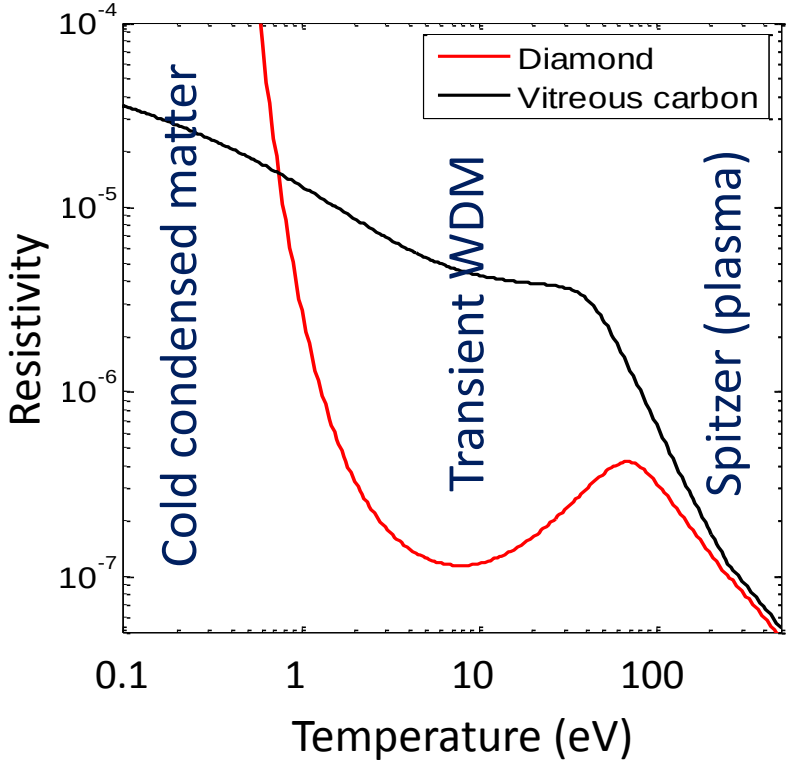




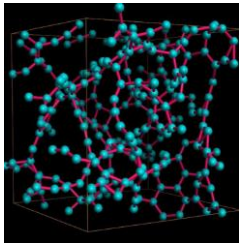
Relies on propagation of GA current of MeV electrons over ~200 μm in dense plasma to compressed fuel

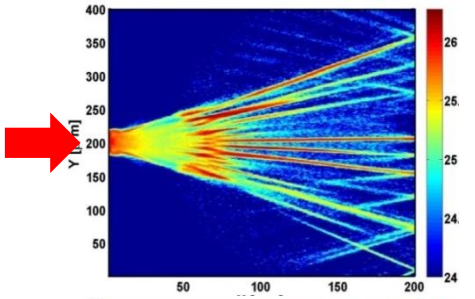
On the role of lattice structure in the transport of multi-MA currents of fast electron - McKenna (Strathclyde)



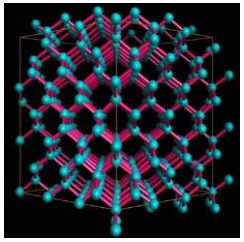


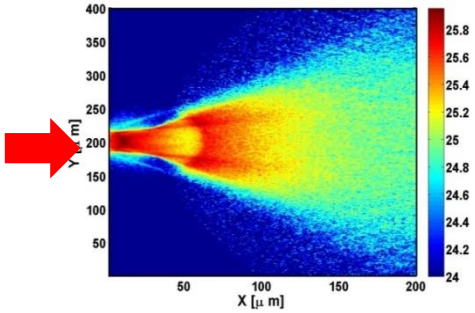
Disordered





Ordered

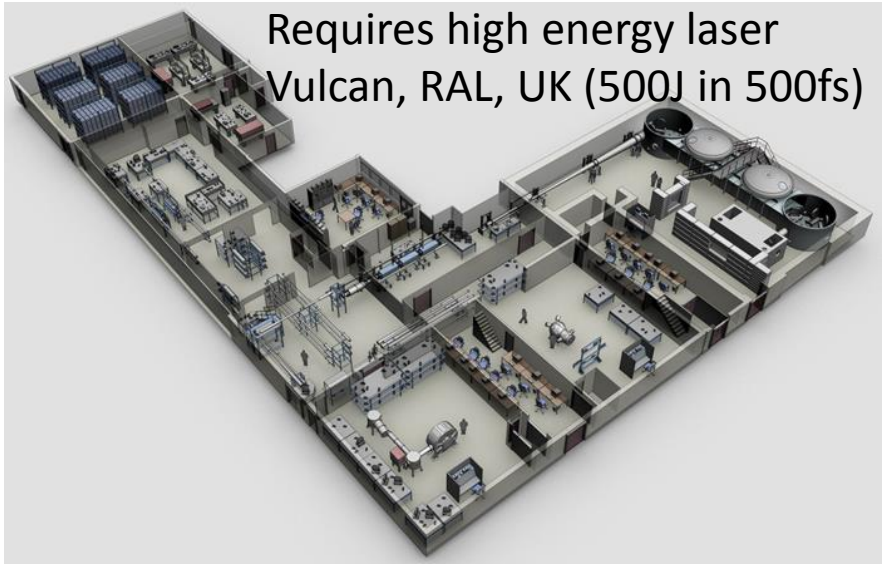


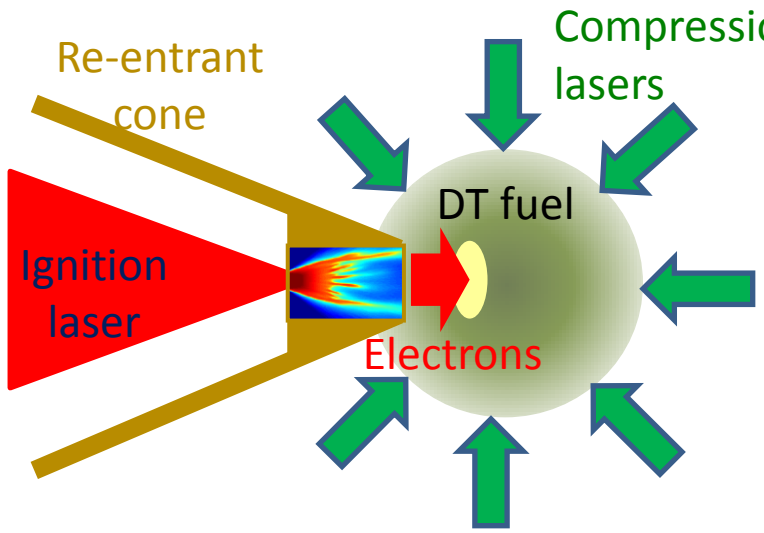


1. Lattice structure effects on transient WDM
   McKenna *et al* , Phys. Rev. Lett. 106, 184004 (2011)
2. Shape of the resistivity-temperature profile
   MacLellan *et al*, Phys. Rev. Lett. 111, 095001 (2013)
3. Effects of temperature and resistivity gradients
   MacLellan *et al*, Phys. Rev. Lett., 113, 185001 (2014)

Using resistivity gradients to control electron transport

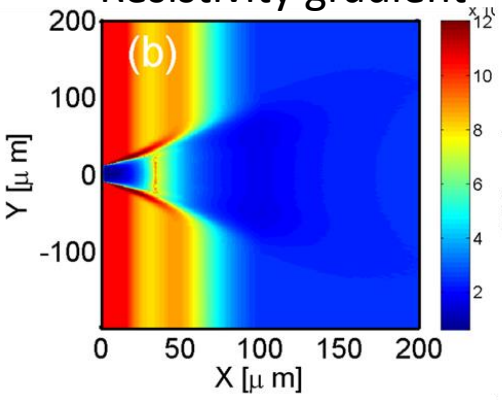
MacLellan,…, McKenna, Phys. Rev. Lett., 113, 185001 (2014)



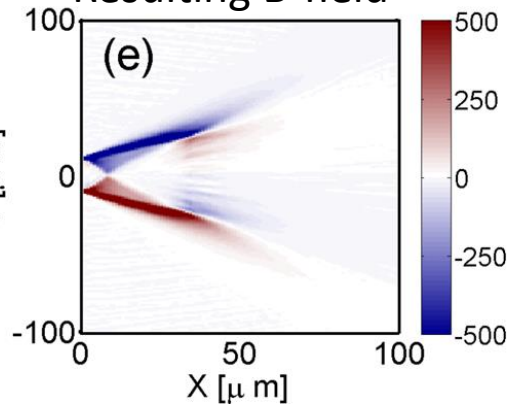


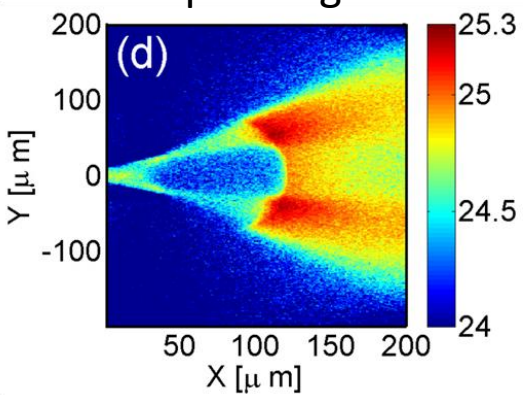
Annular fast electron beam can halve the required ignition laser energy!

Resistivity gradient



Resulting B-field





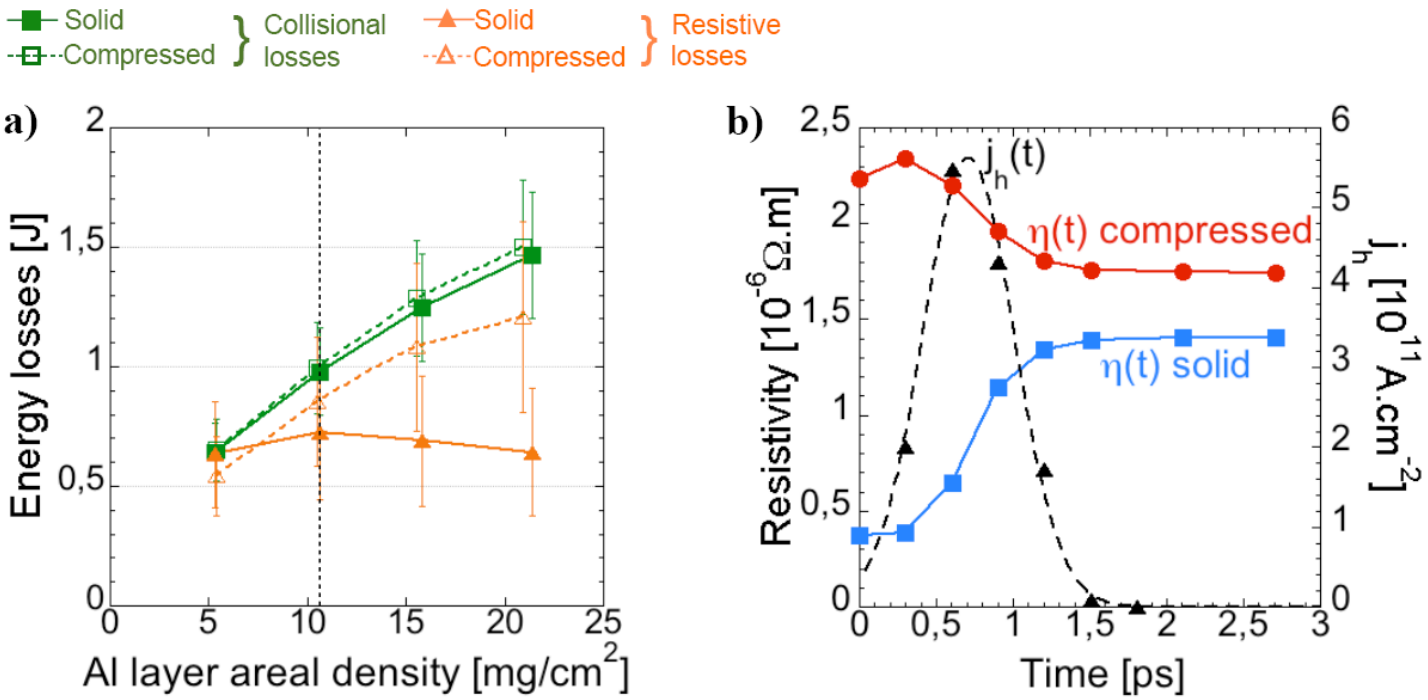
- Invited talks at the International Fast Ignition Conference (2014) & the European Plasma Physics Conference (2015)
- 2015 Culham thesis Prize for Dr David MacLellan (a SUPA Prize student)

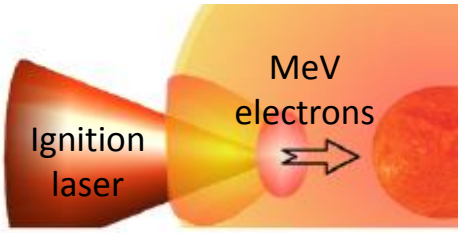
Enhanced relativistic-electron beam energy loss in warm-dense matter – McKenna (Strathclyde)

Vaisseau et al, Phys. Rev. Lett., 114, 095004 (2015)

Measured increase in electron resistive energy loss in warm-dense compared to cold-solid samples of identical areal mass

Titan, LLNL, USA





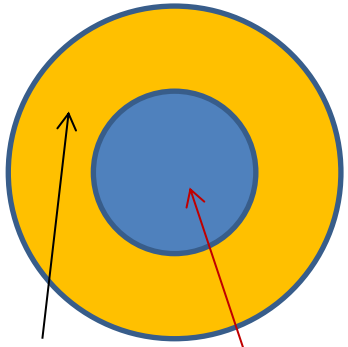
Increased electron energy loss in compressed fusion fuel

Integrated simulation approach to laser-driven fast ignition – Sheng (Strathclyde)

Wang et al, Phys. Rev. Lett. 114, 015001 (2015)

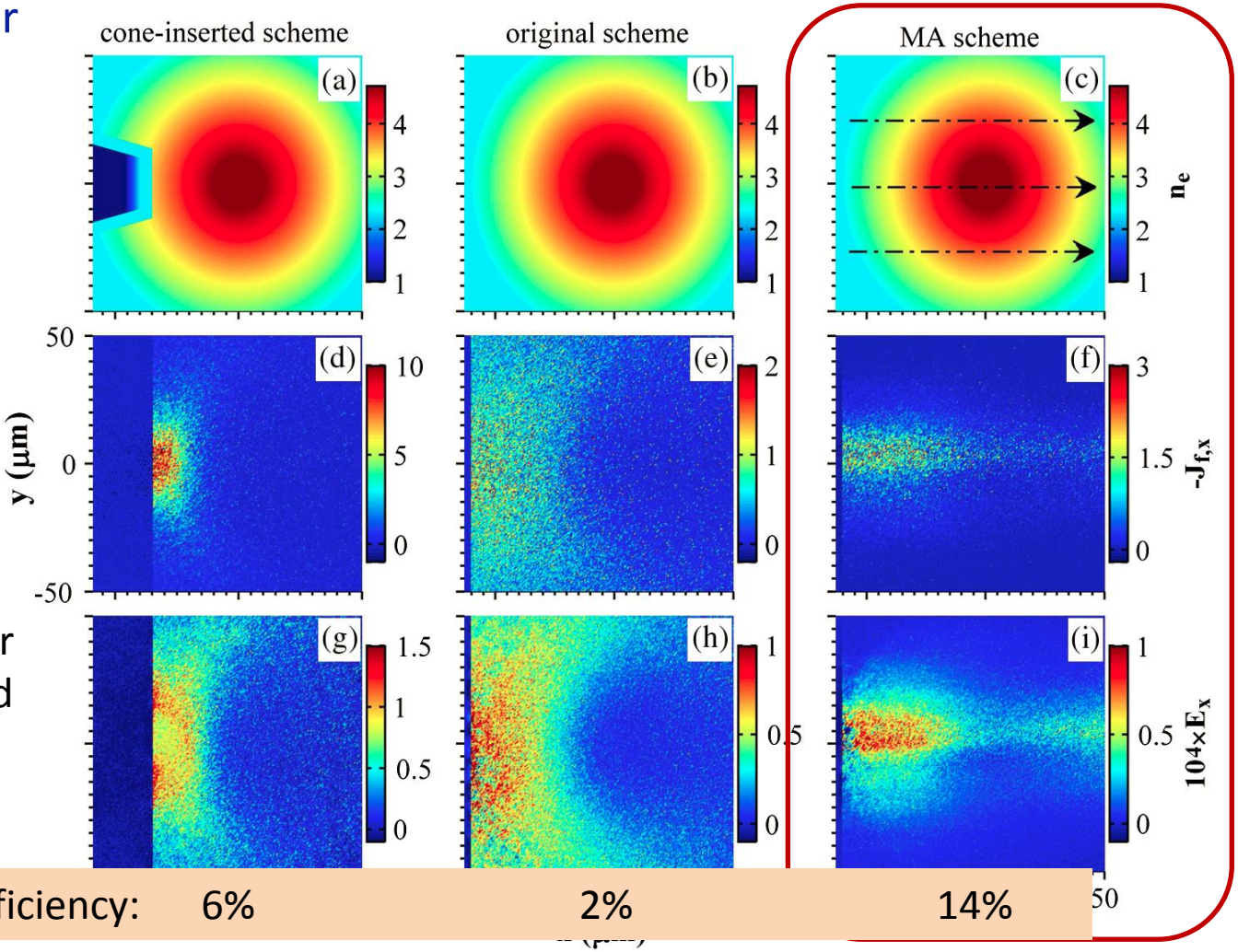
Comparison of three schemes of electron heating

Two-system approach for integrated FI simulation



Region 1: Low density, full PIC simulation

Region 2: Higher density, reduced Maxwell solver



Energy coupling efficiency: 6% 2% 14%

Energy coupling is highest with Magnetically Assisted Fast Ignition

University of Glasgow | School of Physics & Astronomy

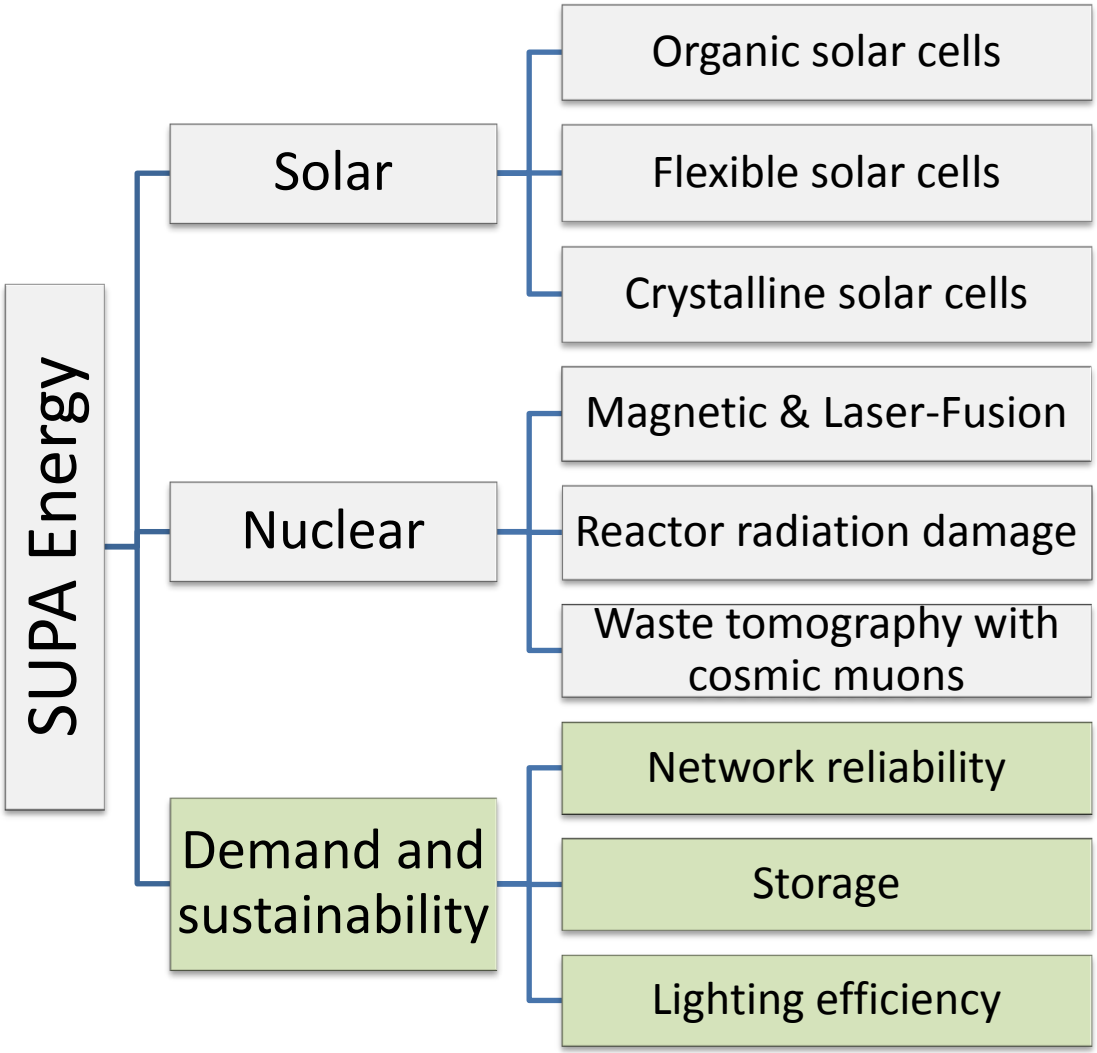
National Nuclear Laboratory

NDA Nuclear Decommissioning Authority

Sellafield Ltd

Muon Tomography Project

- Multi-million pound R&D project led by the University of Glasgow Nuclear Physics group
- Industrial collaboration with National Nuclear Laboratory and Sellafield Ltd., funded by the UK Nuclear Decommissioning Authority
- Small-scale prototype cosmic-ray muon tomography system successfully demonstrated in Glasgow by imaging nuclear materials within shielded, concrete barrel
- Full-scale, industrial system under construction in 2015

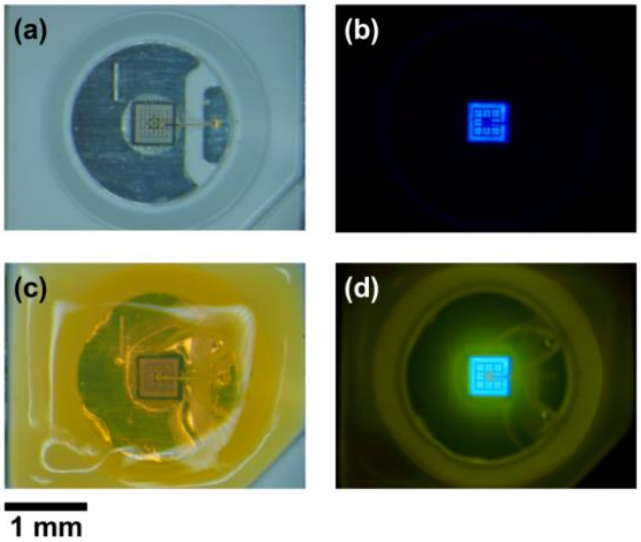

SUPA Energy
Solar
Organic solar cells
Flexible solar cells
Crystalline solar cells
Nuclear
Magnetic & Laser-Fusion
Reactor radiation damage
Waste tomography with cosmic muons
Demand and sustainability
Network reliability
Storage
Lighting efficiency

Organic Down-Converter Molecules for White Light Emission

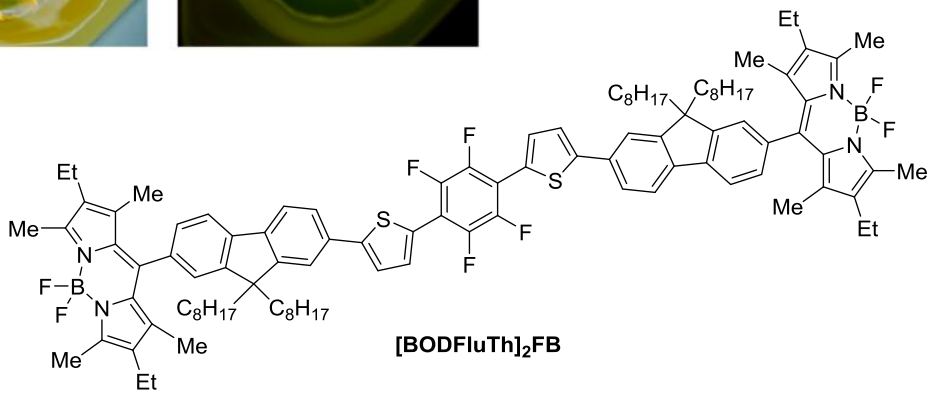
Rob Martin et al (Strathclyde)

Advanced Materials **2014**, *43*, 7290

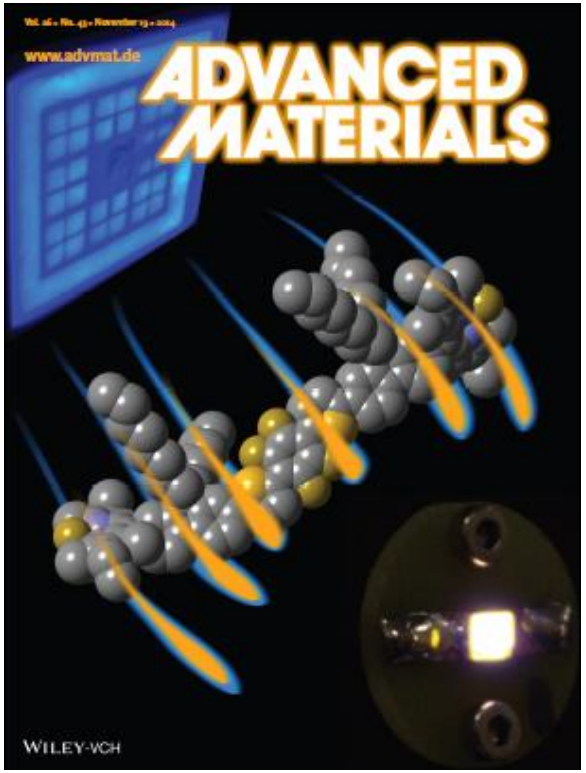
Tailorable white LEDs fabricated using colour-converting molecules based on “Bodipy” emitter units – efficiently absorbing in the blue and emitting in yellow.



Packaged LEDs (from Plessey) before and after coating with organic material, with structure as below



[BODFluTh]$_2$FB



WestCHEM

SUPA
Scottish Universities Physics Alliance

Energy-efficient LCDs – Self-assembly of switchable colloid blue-phase composites – D. Marenduzzo, J Thijssen (Edinburgh)

Stratford…Marenduzzo, *Nat. Comm.* **5**, E3954 (2014)

The University of Edinburgh: simulations prove switching between meta-stable states using an electric field:

Energy needed only to switch pixels and not to maintain them!

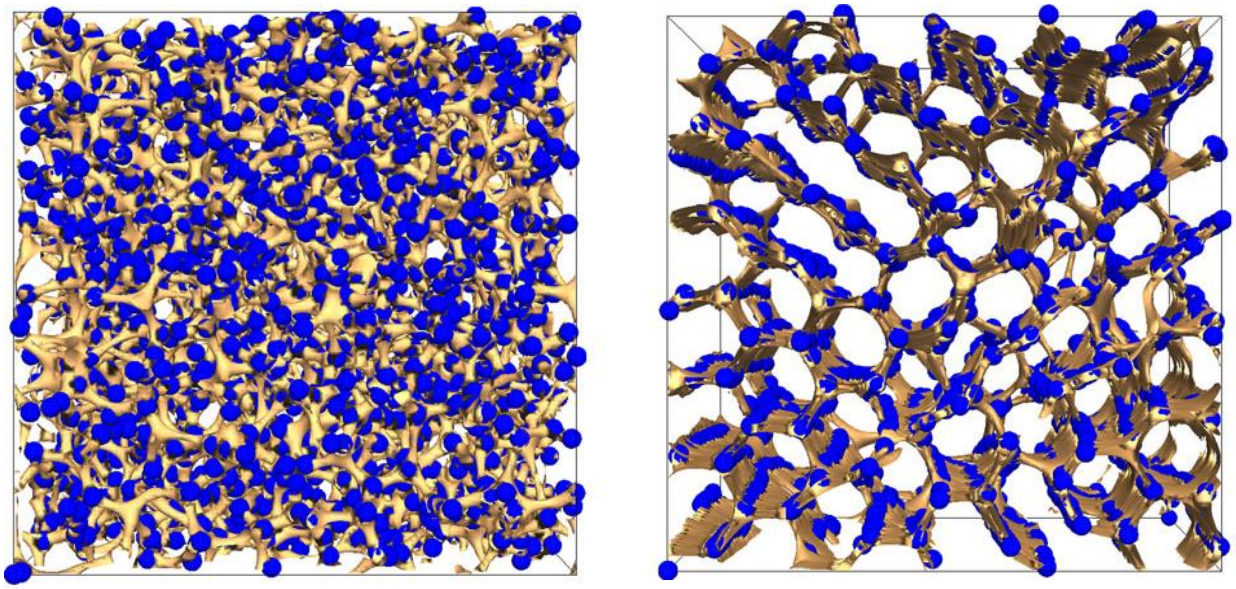
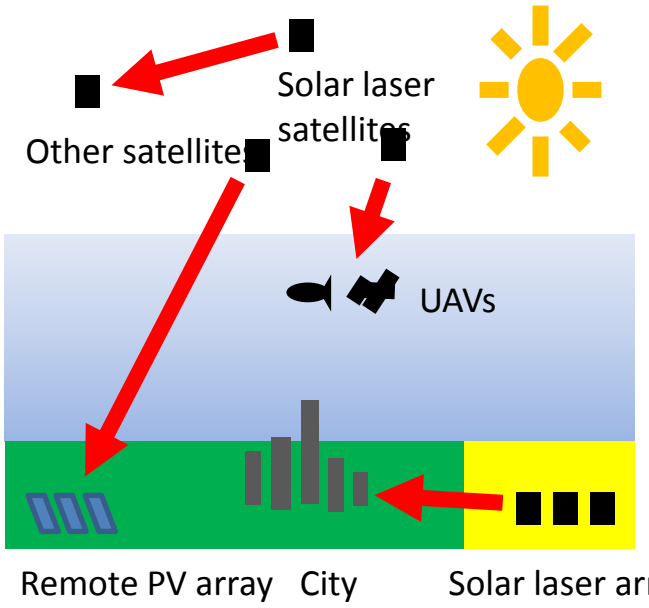


Figure: simulation snapshots of colloid blue-phase composite prepared (left) without and (right) with electric field.

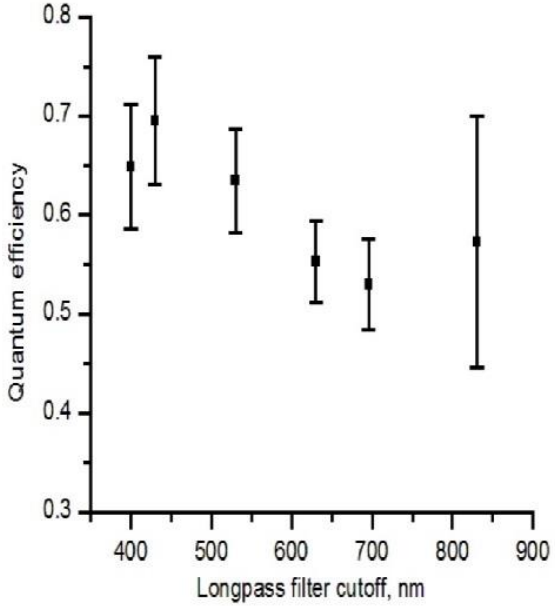
Solar-pumped semiconductor lasers

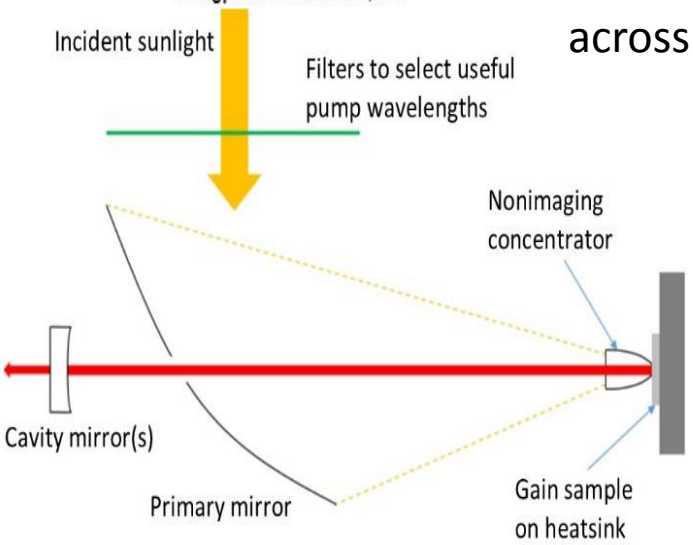
Adrian Quarterman et al (Dundee)

A.H. Quarterman and K.G. Wilcox, Optica 2(1) 56 (2015)



- Various power beaming applications for solar-pumped lasers
- Currently limited by low efficiency of solid-state solar lasers
- Semiconductors predicted to do much better





SPSL work at Dundee:

To modify existing optically-pumped semiconductor lasers for solar pumping

Pumping efficiency measured to be excellent across solar spectrum

Currently working towards first demonstration of a solar-pumped semiconductor laser

Summary of 2014/15

- High impact publications across our energy research activities
- Collaborative work across SUPA in solar, lighting and nuclear; Links to several international projects and networks
- Strong links to the EastCHEM, WestCHEM and SISER research pools
- Building new links to SMEs; Engagement with large fusion projects