SUPA Physics Scotland

SUPA Meeting – 11th May 2017

Nuclear and Plasma Physics

Theme Leader Professor Dino Jaroszynski

Speaker: Professor Dave Ireland

Theme: Edinburgh, Glasgow, Strathclyde, and UWS – opportunities to include Dundee and Aberdeen for imaging applications

- Plasma Physics: SCAPA, RAL, ELI, Laserlab Europe
- Laser-plasma based accelerators and radiation sources: compact FEL
- Nuclear physics: nuclear structure & photo-nuclear physics - Jefferson Laboratory and the Mainz Microtron, CERN-ISOLDE, Jyvaslyla,…; NNL & Sellafield (nuclear waste assay)
- Detector development: dark matter (LZ),
- SCAPA as an enabling facility for cross-disciplinary science
- New opportunities at ELI for photo-nuclear physics, high field physics & applications
- Opportunities with NPL and Cockcroft Institute: accelerators & metrology

Existing Scope of Theme

- **Plasma Physics**: high field physics, fusion related physics, laboratory astrophysics,
- **Laser-plasma based accelerators and radiation sources**: compact coherent X-ray, gamma-ray, THz & microwave sources, radiotherapy, imaging
- **Nuclear physics**: hadron structure, hadron spectroscopy, mesons, nucleons and nuclei, nuclear astrophysics, exotic nuclei
- **SCAPA: enabling facility** for cross-disciplinary research
- **Industry engagement**: radiotherapy, radiation damage and imaging for security, defence, health and the environment.

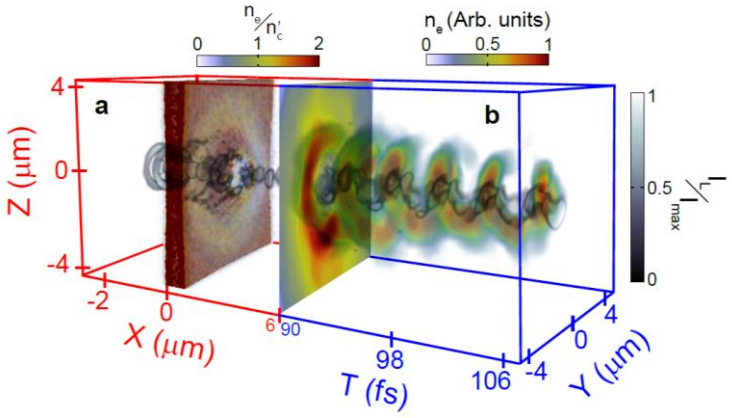
Illustrative Examples

University of Strathclyde Glasgow

Controlling plasma dynamics in intense laser interactions

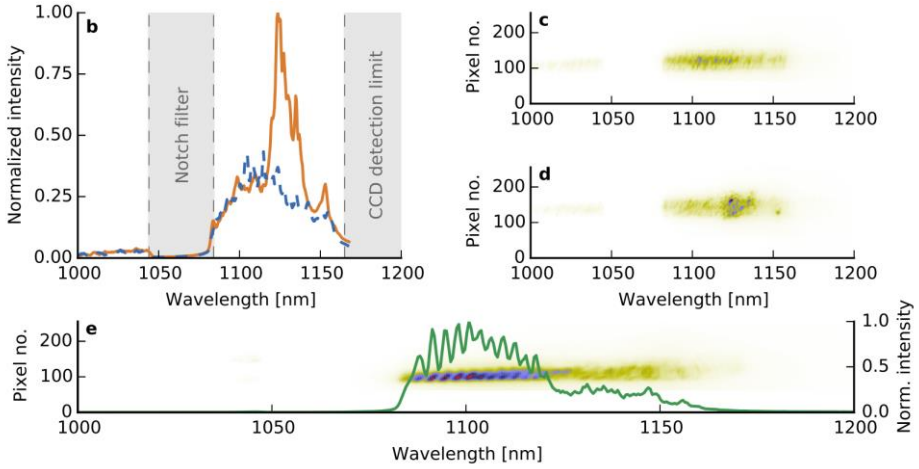
Spiralling plasma jets

B. Gonzalez-Izquierdo et al, Nature Physics, (2016)



Next-generation laser amplifiers

Ultra-high gain Raman-plasma amplifier:
efficiency = 10%, gain >10^8 (100's pJ $\rightarrow$ 0.1 J),
G = 180 cm^{-1}
G. Vieux et al., Sci. Reports (2017)



Scottish Centre for the Application of Plasma-based Accelerators (SCAPA)

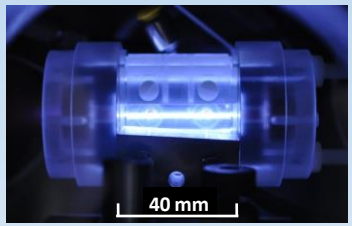
SCAPA

• Expansion of **ALPHA-X** laser-plasma accelerator facilities at Strathclyde with new laboratories.

• In-depth programme of **Applications**.
• Accelerator and source **Research & Development**.
• Knowledge Exchange & **Commercialisation**
• Engagement in European and other large projects.
• **Training:** CDT in the Application of Next Generation Accelerations and several university funded CDTs

• **3 shielded areas** with **7 accelerator/radiation beam lines**.

• High-intensity femtosecond laser systems:
  a) 350 TW (with provision for PW) @ 5 Hz,
  b) 40 TW @ 10 Hz,
  c) sub-TW @ 1 kHz.
• High-energy **proton, ion and electron** bunches.
• High-brightness fs duration **X-ray & gamma-ray** pulses.
• Neutrons



Compact GeV electron accelerator and gamma-ray source

APPLICATIONS

• Radiobiology
• Ultrafast Probing
• High-Resolution Imaging
• Radioisotope Production
• Detector Development
• Radiation Damage Testing

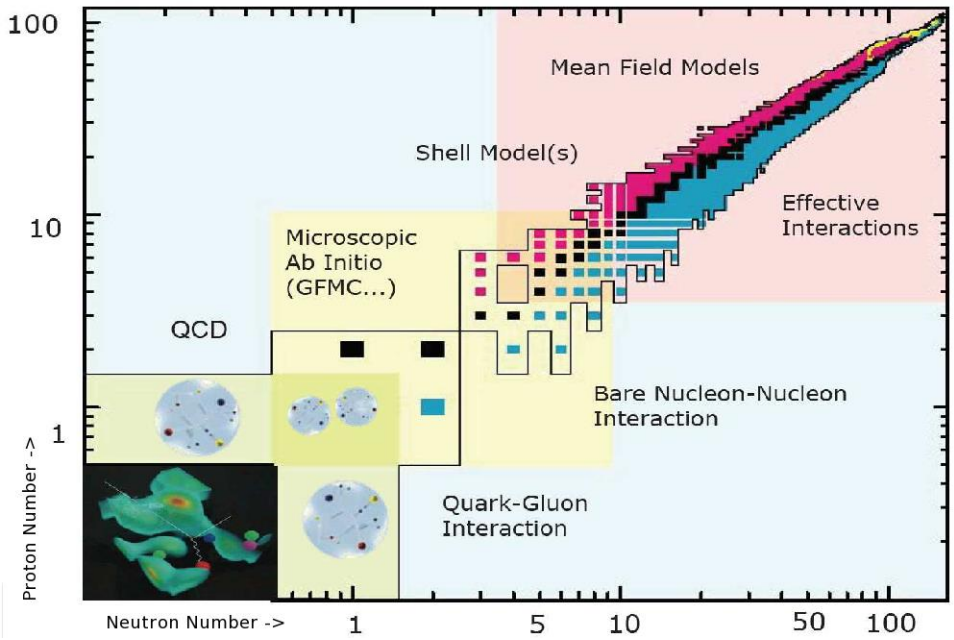
Potential Areas for Development

- **SCAPA**: beamlines (funded by SUPA, Strathclyde, Cockcroft, EPSRC and STFC) for nuclear, plasma & applications of particle beams and incoherent and coherent radiation (THz – gamma-rays)
- **CDT** radiotherapy – focussed on advanced radiotherapy e.g. VHEET
- **ELI**: high field physics and gamma ray detector development
- Nuclear physics facilities
- Coherent XUV radiation source applications: cross Theme and cross Pooling
- Imaging collaboration through SINAPSE
- Cockcroft Institute collaboration on novel accelerators and radiation sources – bring together new and old concepts

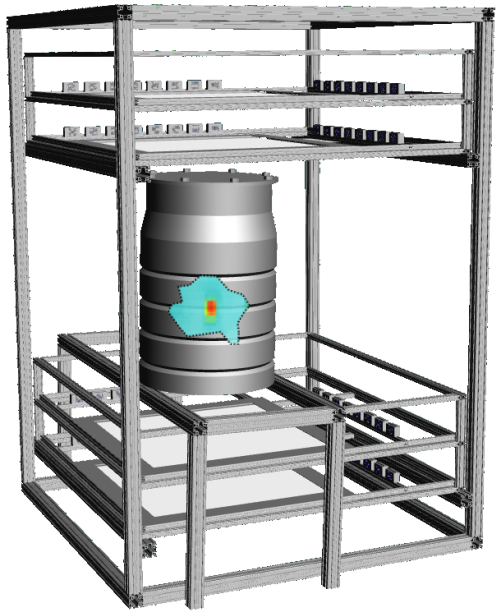
Concluding Remarks (Laser-Plasma)

- **Basic laser-plasma:** plasma instabilities (analogues of astrophysical gamma ray bursts, jets, cosmic rays), collective processes (laser-beam-radiation interactions)
- **Laser-wakefield accelerators:** ultra-compact next-generation accelerator: attosecond bunch acceleration, high energies
- **Compact radiation sources:** ultra-compact replacement for the free-electron laser (ion channel laser), THz sources, attosecond to zeptosecond coherent X-ray sources, gamma rays
- **High field physics:** radiation reaction (QED, non-perturbative, non-linear), highly radiating systems
- **Applications:** radiotherapy, medical imaging, medical radio-isotope production, Raman and Compton amplification
- **Laser-driven high energy density physics** (e.g., laboratory astrophysics, physics for advanced fusion concept)
- **New ion acceleration schemes** based on laser radiation pressure and relativistically induced transparency
- **Radiation damage**: Space radiation reproduction and testing of electronics & space radiobiology
- **Ultra-fast science:** attosecond coherent X-ray radiation sources

Nuclear Physics



University of Glasgow



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