Plasma Accelerator Research at the John Adams Institute (JAI)

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University of Oxford

The JAI group

- JAI based in Physics Departments at Oxford & Royal Holloway, London
- 5 faculty working on aspects of laser-driven plasma accelerators
- 5 faculty with accelerator expertise relevant for laser-plasma light source development.
- In total, 15 faculty, 30 graduate students, 12 research staff and about 12 technical staff (part time)
- Significant cross-fertilisation between plasma accelerators, “conventional” accelerators, plasma physics, and novel light sources


Grahame Blaire


Stewart Boogert


Simon Hooker


Armin Reichold


Roman Walczak

Laser accel.


Riccardo Bartolini


Phil Burrows


George Doucas

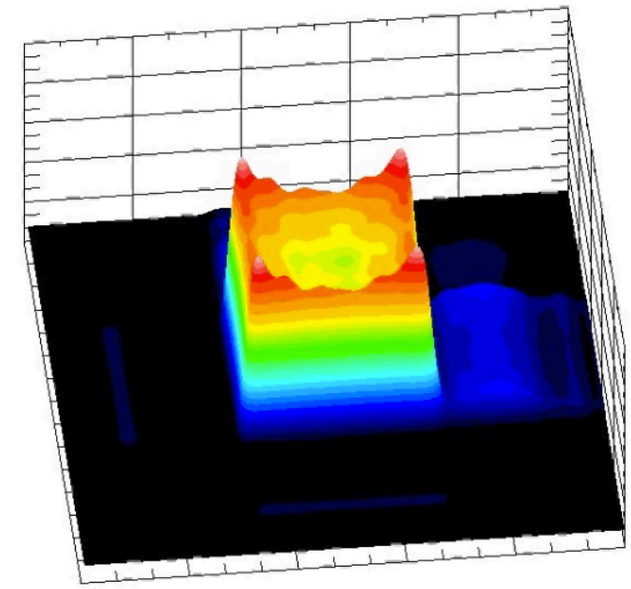

Pavel Karataev

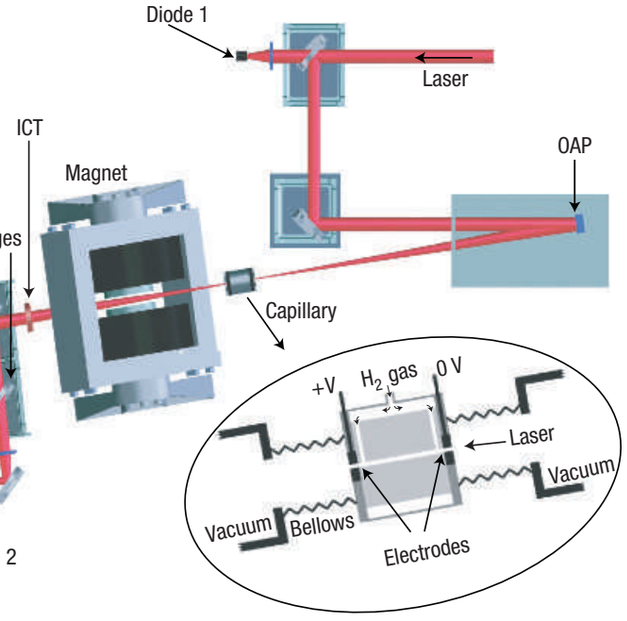

Andrei Seryi

light sources

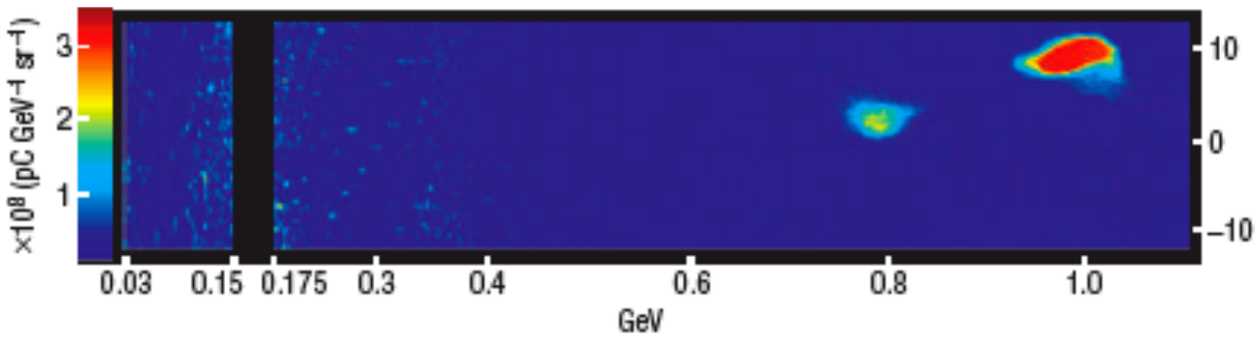
Previous results & collaborations

- Development of novel plasma channel
  - Guided laser pulses with peak intensities of 10^{18} Wcm^{-2} 10s mm
  - *PRL* **89** 185003 (2002), *PRL* **98** 025002 (2007)



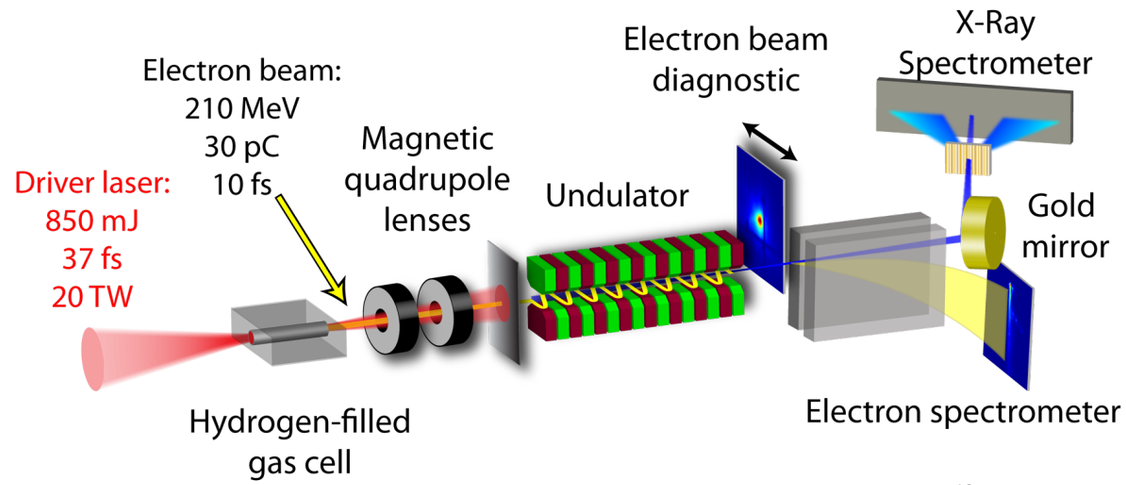


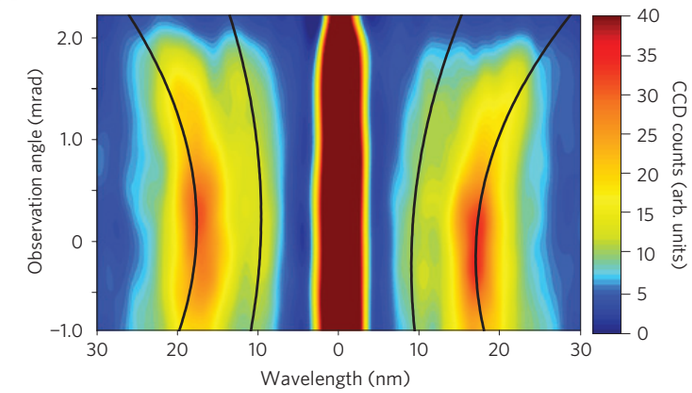
- With LBNL group, first generation of 1 GeV beam
  - *Nat. Phys.* **2** 696 (2006)



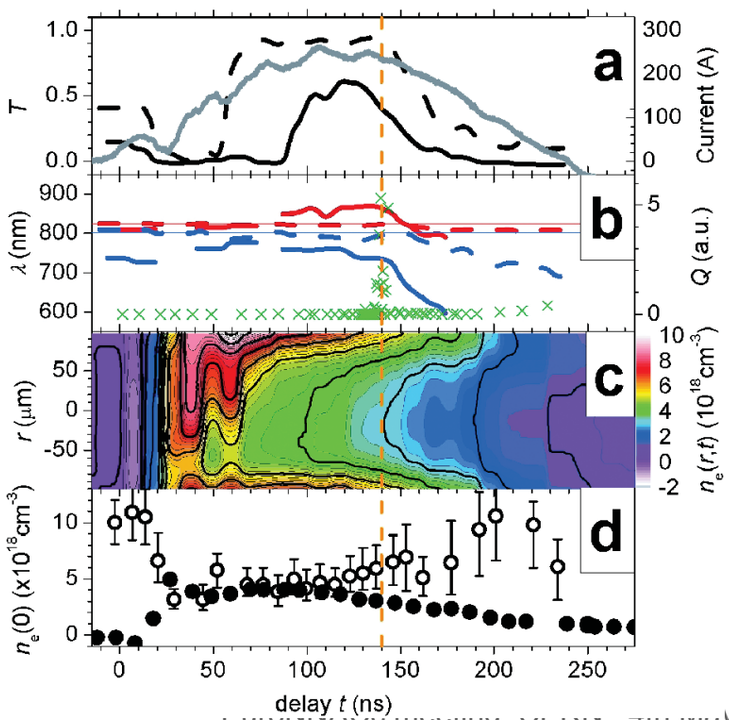
Previous results & collaborations

- With MPQ group, first generation of undulator soft x-rays laser-accelerated beam
  - *Nat. Phys.* **5** 826 (2009)



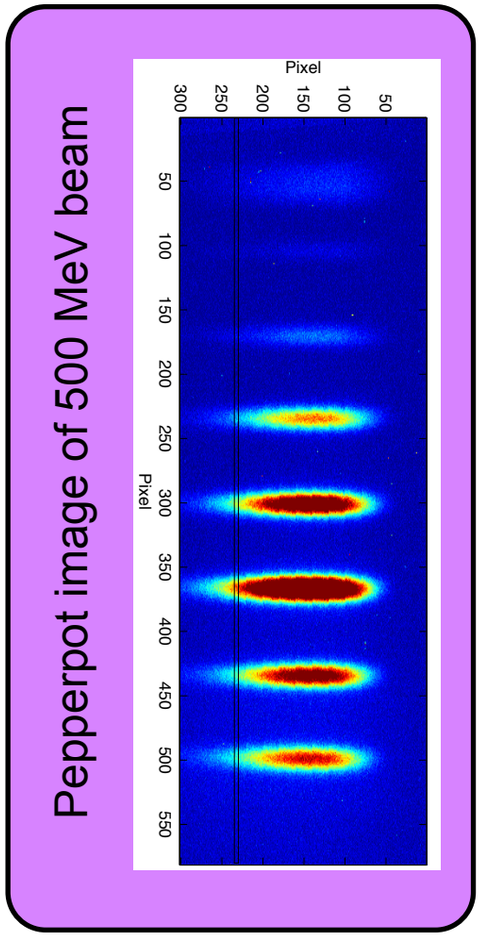


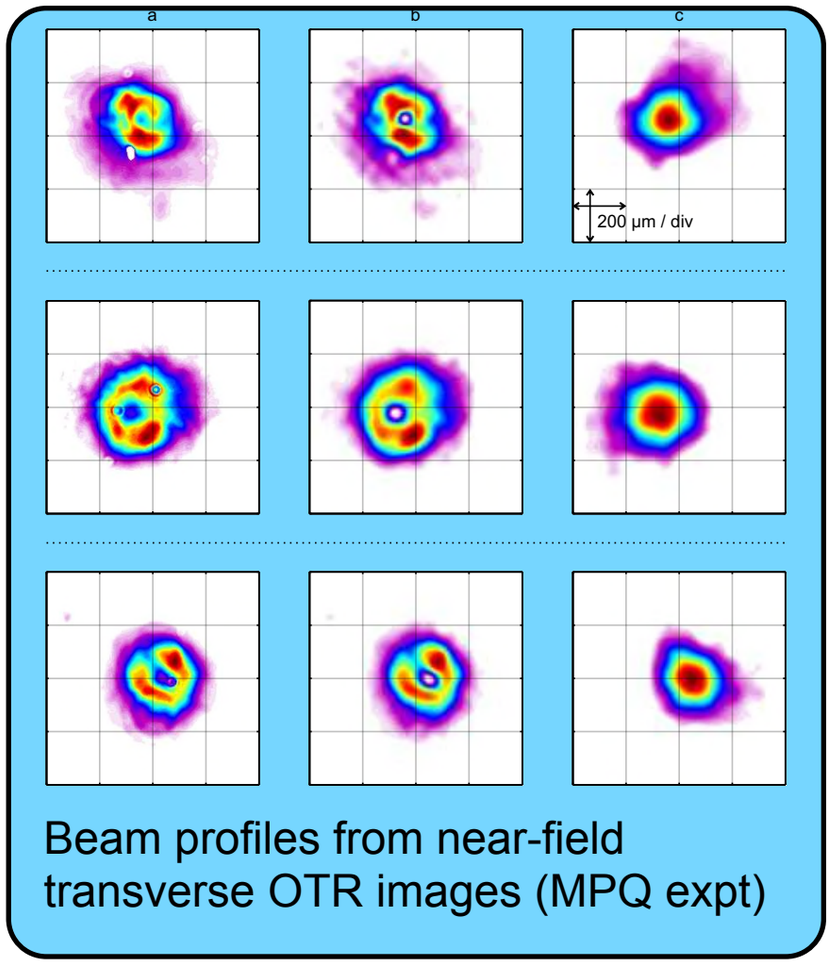
- Identified ionization-induced injection as potential method for controlling electron injection
  - *PRL* **100** 105005 (2008)



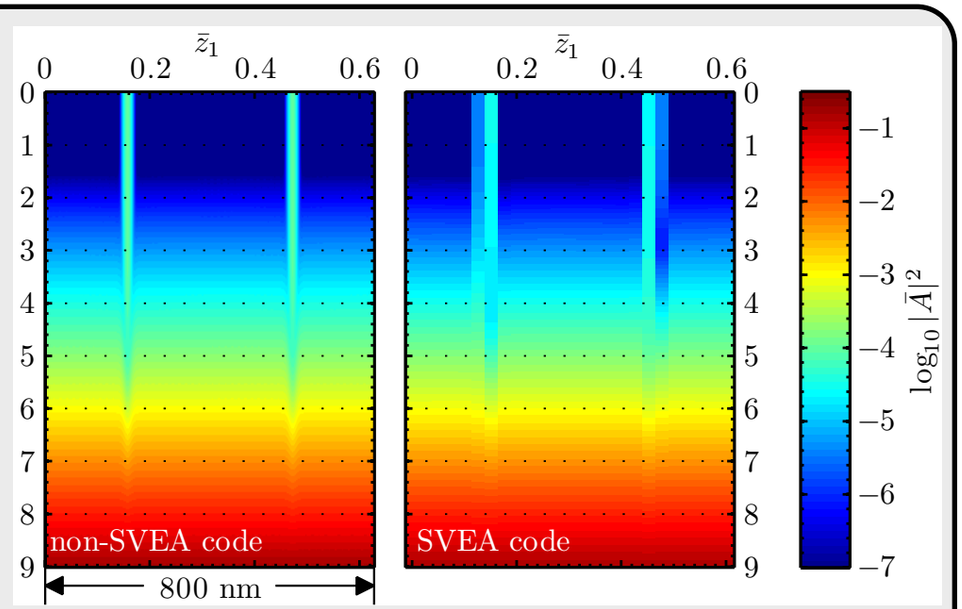
Areas of interest / expertise

- Laser-driven acceleration in plasma waveguides
- Numerical simulations of plasma accelerators
  - VORPAL, EPOCH, WAKE...
- Beam transport
- Beam diagnostics
  - pepperpot, OTR, Smith-Purcell...
- Accelerator-driven radiation sources
- Numerical simulations of free-electron lasers
  - GENESIS, PERSEO
  - Simulations beyond SVEA





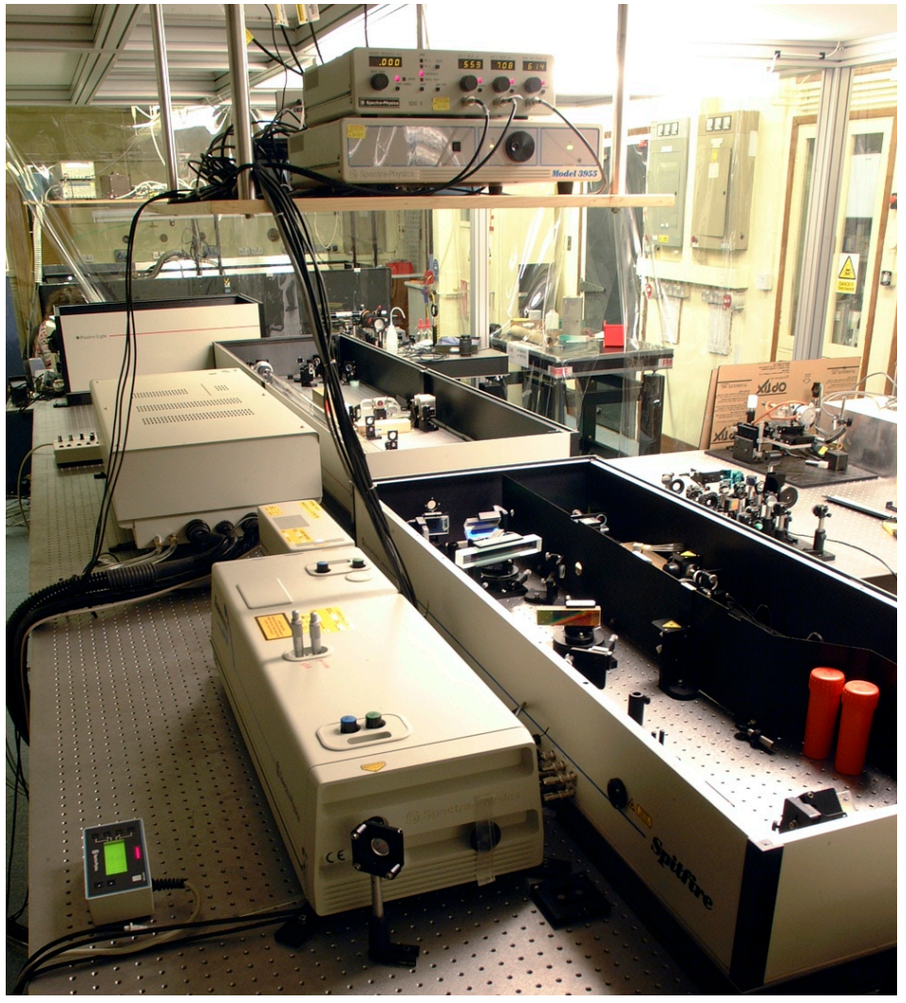
Beam profiles from near-field transverse OTR images (MPQ expt)

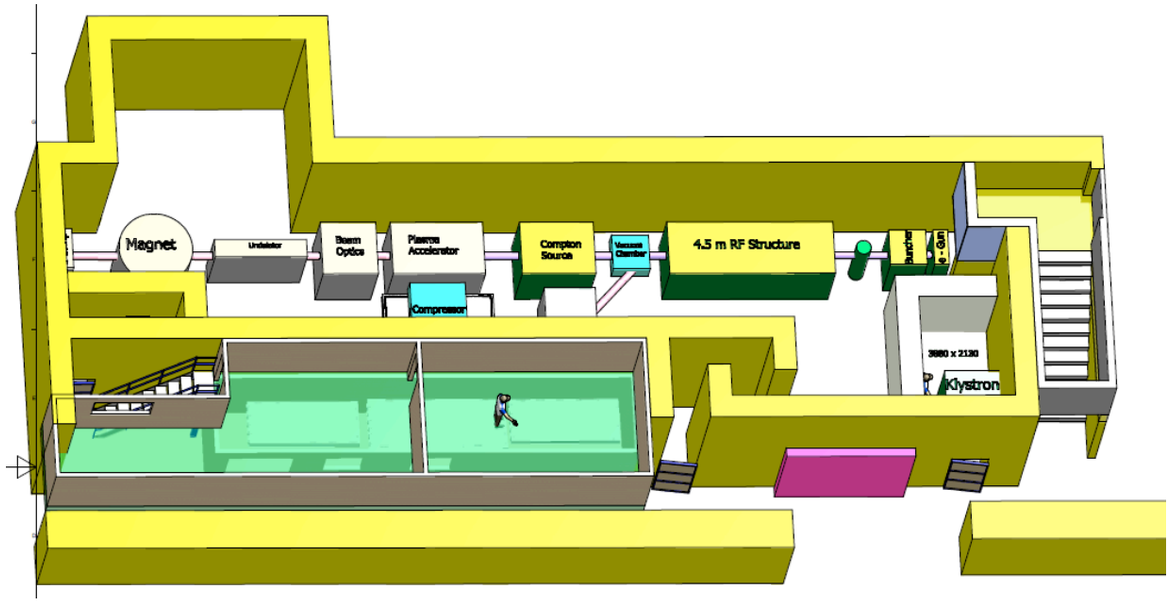


Comparison of SVEA and non-SVEA codes
S. Bajlekov *et al. submitted*

Facilities & plans for development

- Existing facilities:
  - 4 mJ, 35 fs, 1 kHz Ti:sapphire system
  - 120 mJ, 50 fs, 2.4 TW Ti: sapphire laser system
  - used to develop plasma waveguides, plasma mirrors, experiment preparation, training
- Plans to build new Accelerator Science Lab (ASL) in Oxford Physics
  - RF & plasma accelerator beamlines
  - develop improved laser-driven plasma accelerators
  - develop x-ray sources driven by laser-accelerated electrons
  - provide training in laser-based accelerator physics



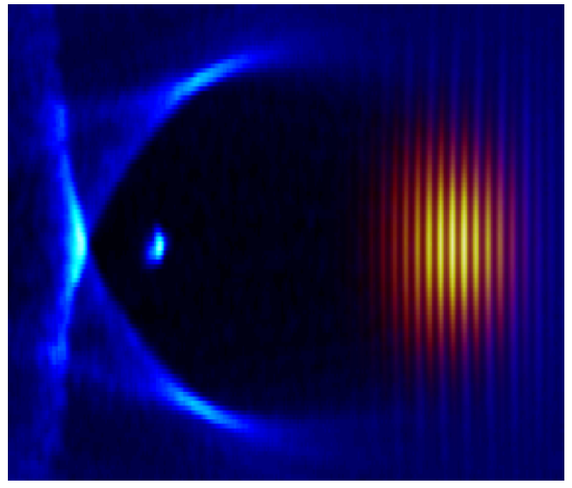


Funding

- Core JAI funding presently €1.2M per year
- In next JAI proposal for the core STFC funding, laser-driven plasma accelerators will be a major direction of JAI research
  - Core funding is expected to be more than doubled by project-related grants

- Current specific project funding of €1.3M
  - Several grants from EPSRC (UK funding council)
  - Leverhulme Trust funding of International Network on fs x-ray sources (Oxford, Berkeley, MPQ)
  - These run for approx. 2 more years; bids to renew this funding will be made

Motivations & research focus



Motivations

- Understand physics of laser-driven plasma accelerators
- Use this to develop accelerators with improved performance
  - higher energies, improved bunch parameters, improved shot-to-shot stability
- Develop the applications of plasma accelerators

Research focus

- Techniques for controlling electron injection
  - ionization-induced injection, density ramps
- Techniques for staging plasma accelerators
  - coupling of stages by plasma mirrors
- Development of electron beam diagnostics
  - pepper-pots, OTR screens, Smith-Purcell radiation
- Application to radiation generation
  - undulator experiments
  - numerical studies of HHG seeding

Acceleration and application goals

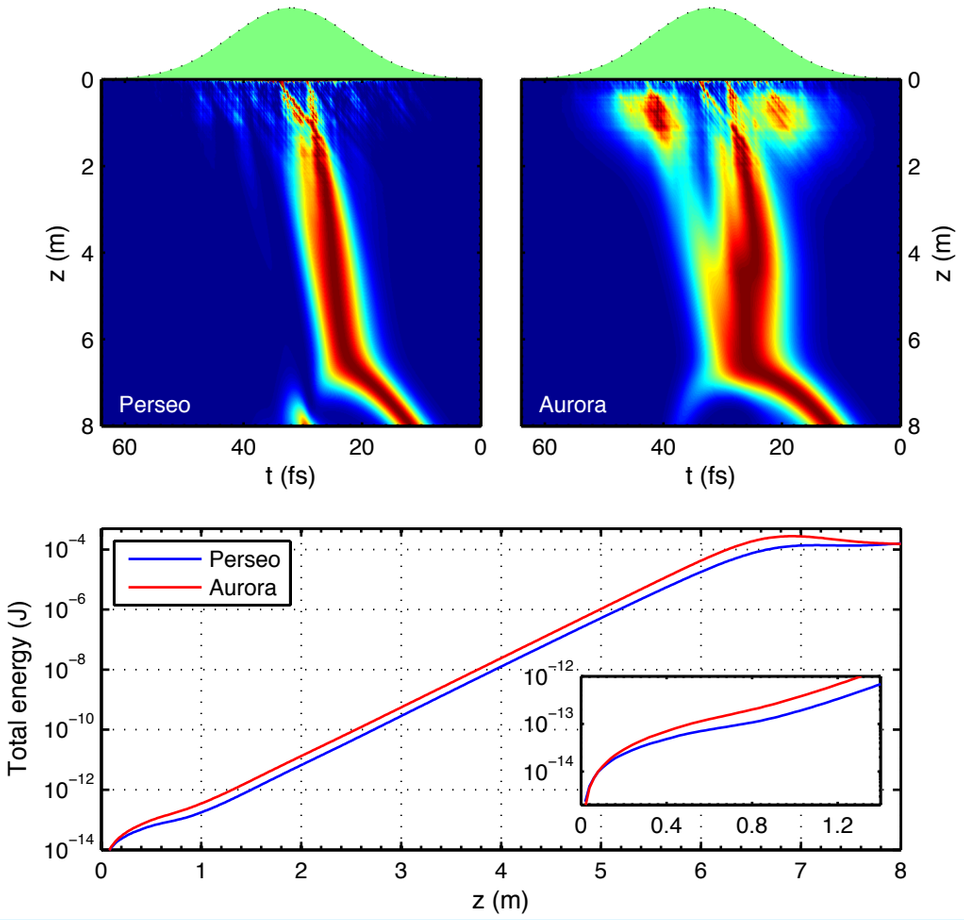
- Compact, ultrafast incoherent x-ray sources
  - undulator radiation
  - betatron radiation

- Free-electron lasers driven by plasma accelerators

Parameter	R.M.S.
beam energy	1-2 GeV
energy spread	< 0.5%
energy stability	better than 0.5%
bunch charge	> 100 pC
charge stability	better than 5 %
bunch duration	< 2 fs
normalized emittance	< 1 mm mrad

Expectations of network

- It should stimulate cross-fertilization between groups working on:
  - experiments and simulations
  - acceleration experiments and diagnostics
  - laser- and beam-driven plasma accelerators
  - light sources driven by conventional and plasma accelerators
- Collaboration with relevant industries should be explored
- It should enable dissemination of progress to all network members



Comparison of SVEA and non-SVEA FEL codes