

Nanoscale X-Ray Source by High Harmonic Generation in a Capillary

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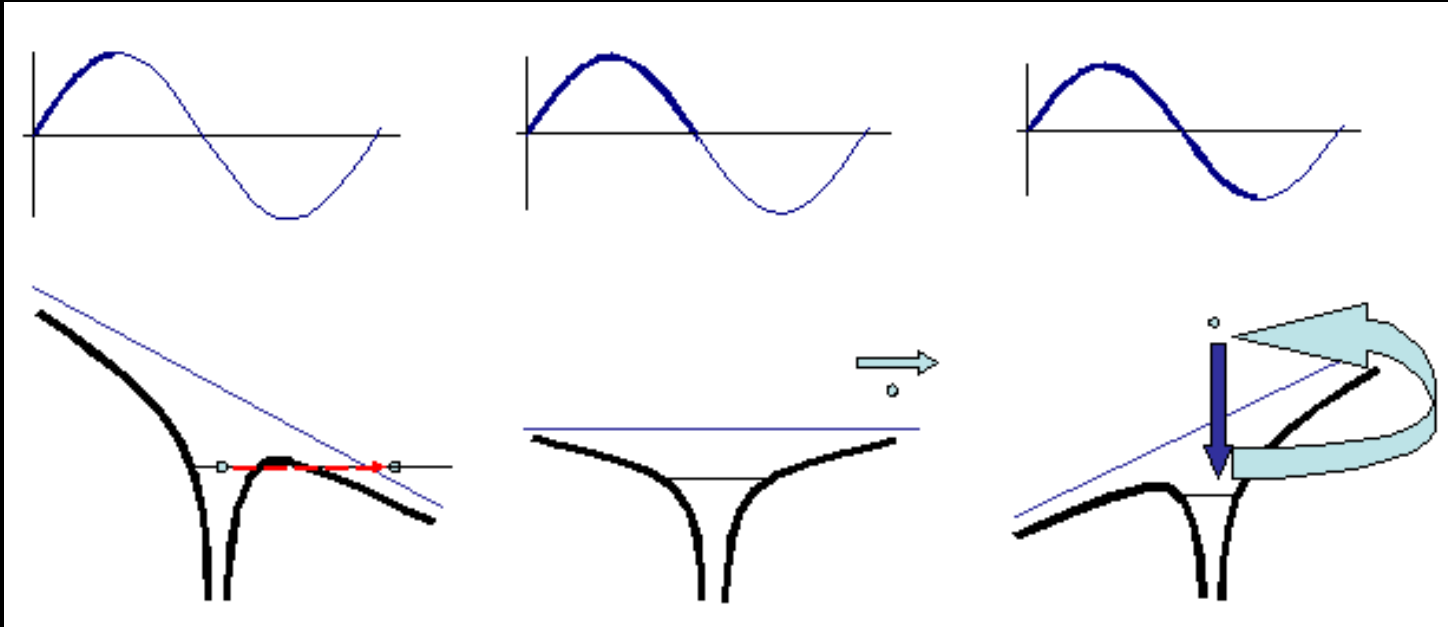
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- Ultimate goal: scattering from single protein molecule.

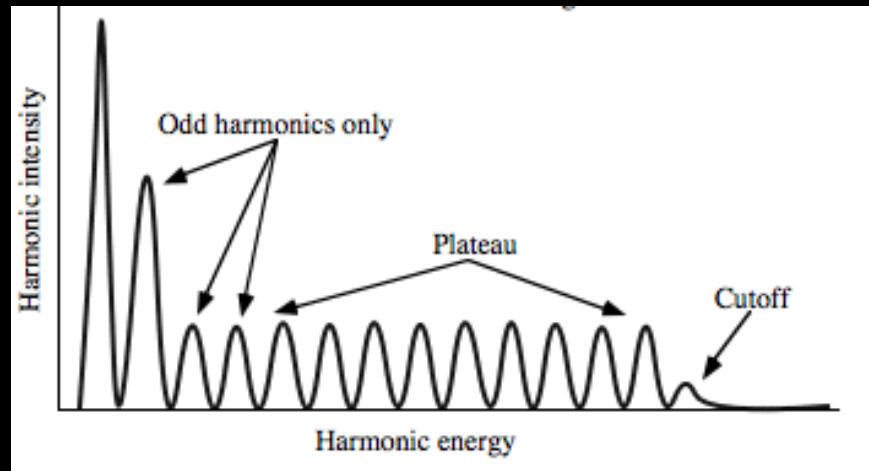
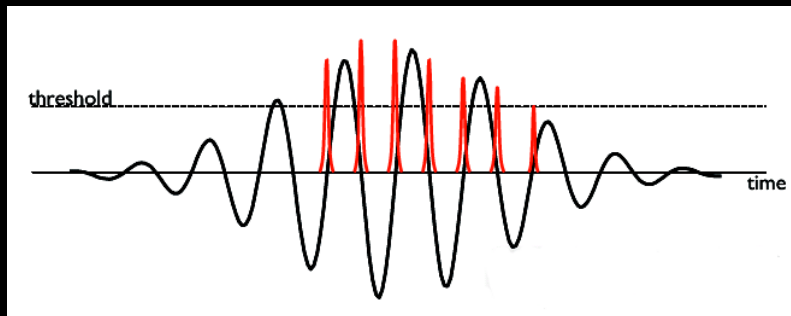
High Harmonic Generation



Tunneling - The simple model

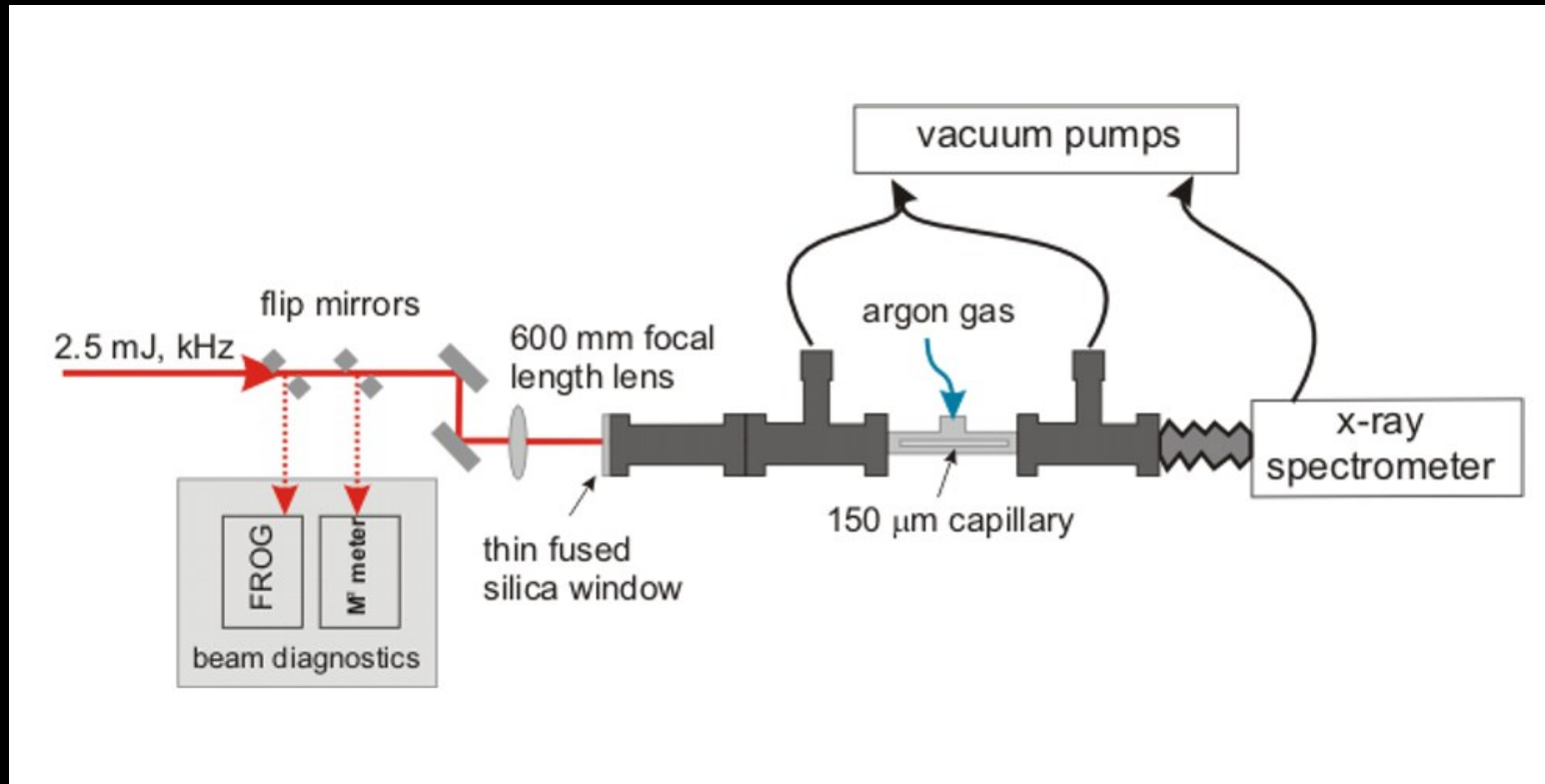
High Harmonic Generation

X-ray emission during a pulse



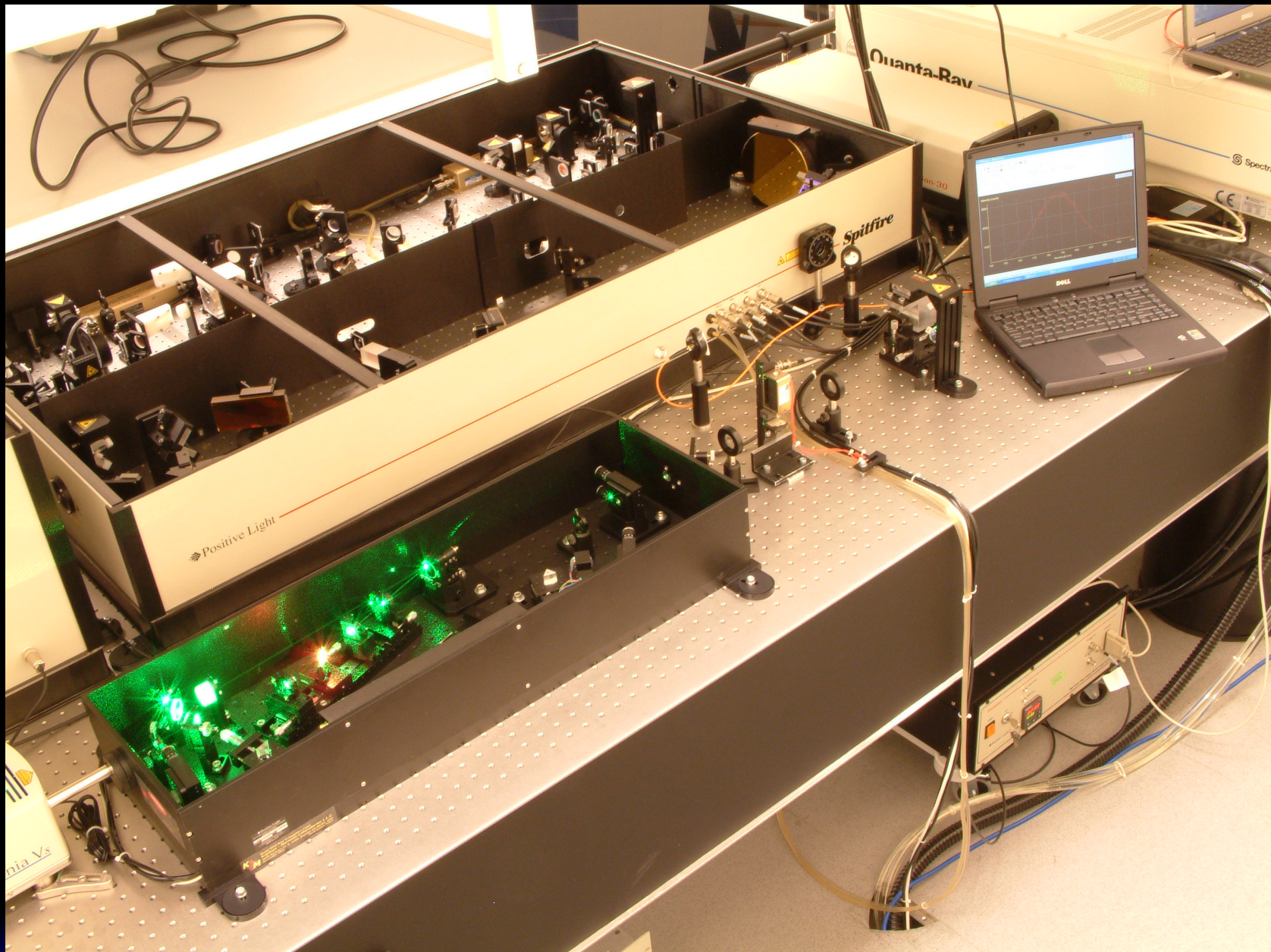
Ionization and recollision repeats every half-cycle and produce a comb of frequencies up to the cutoff

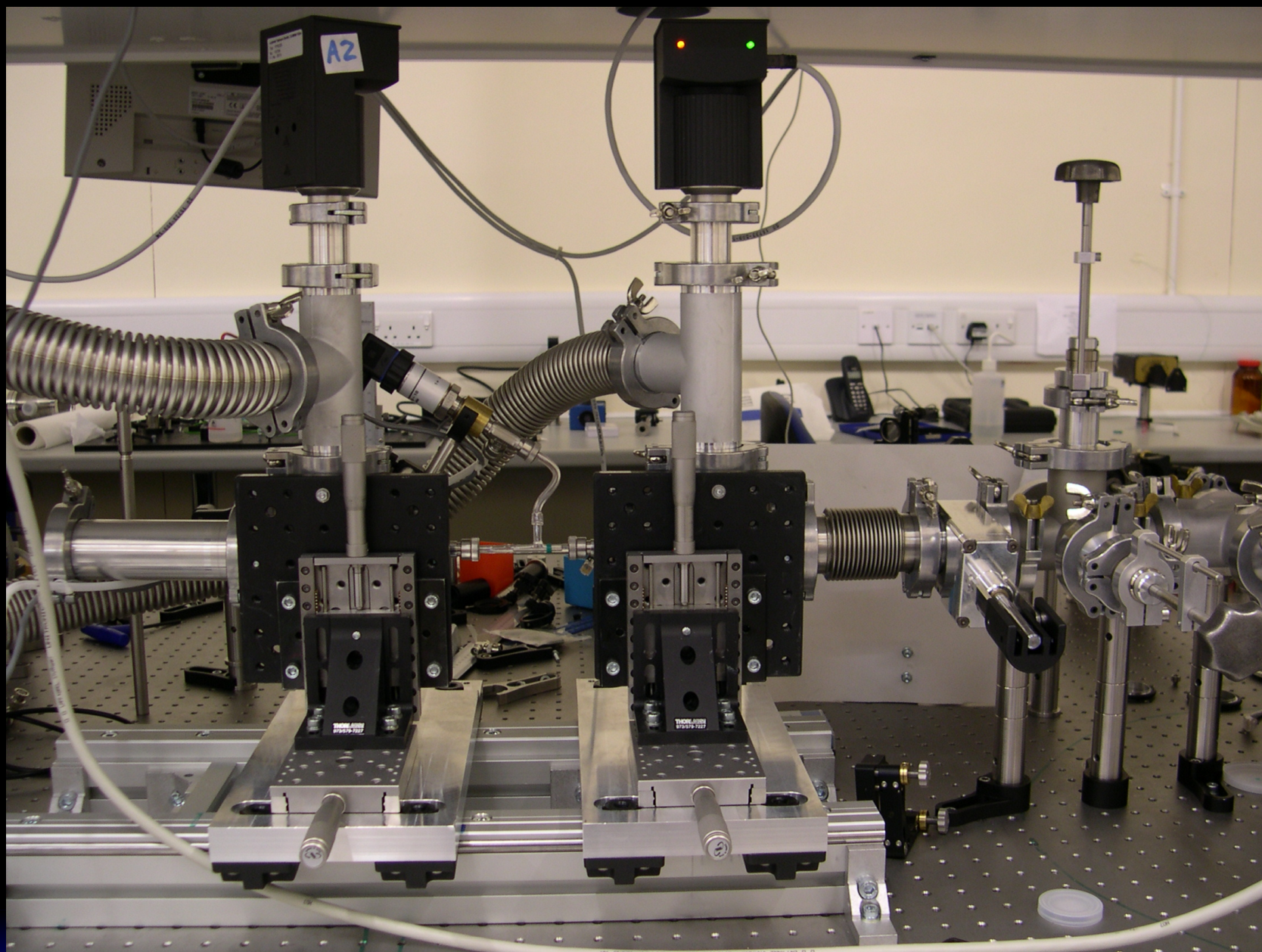
Experimental set-up



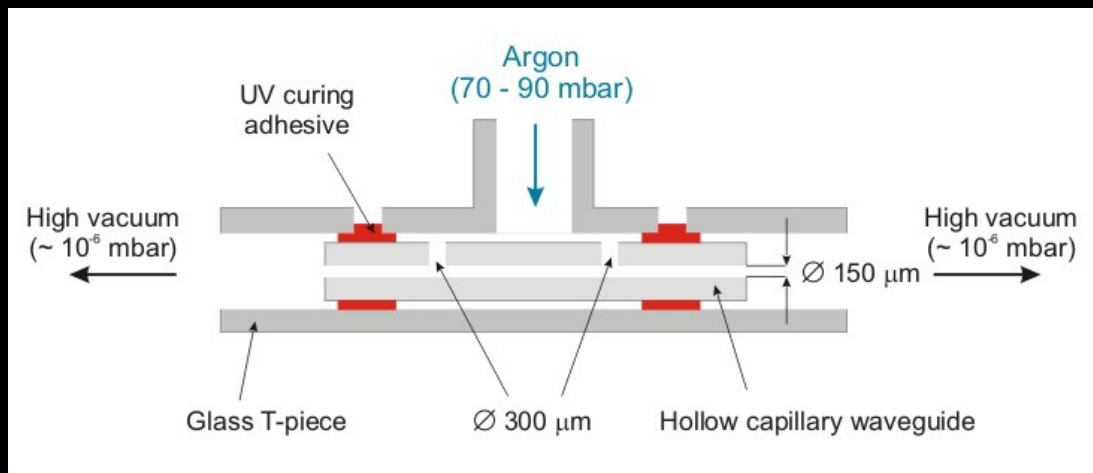
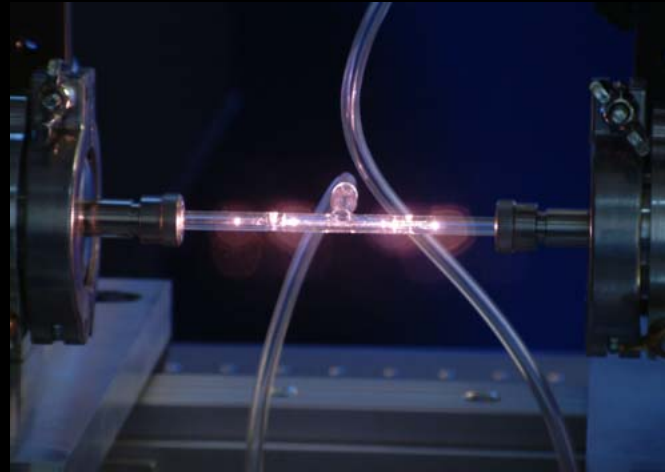
Harmonic generation in low-pressure argon gas in a hollow capillary waveguide



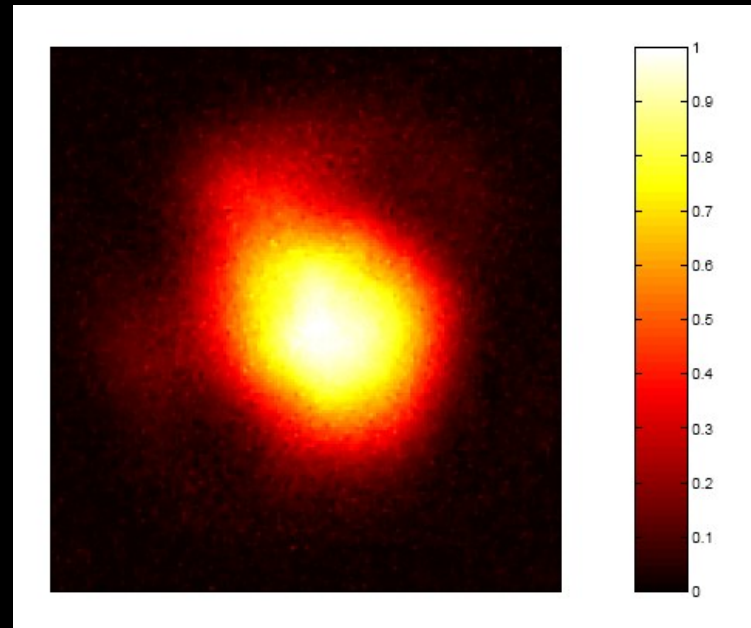
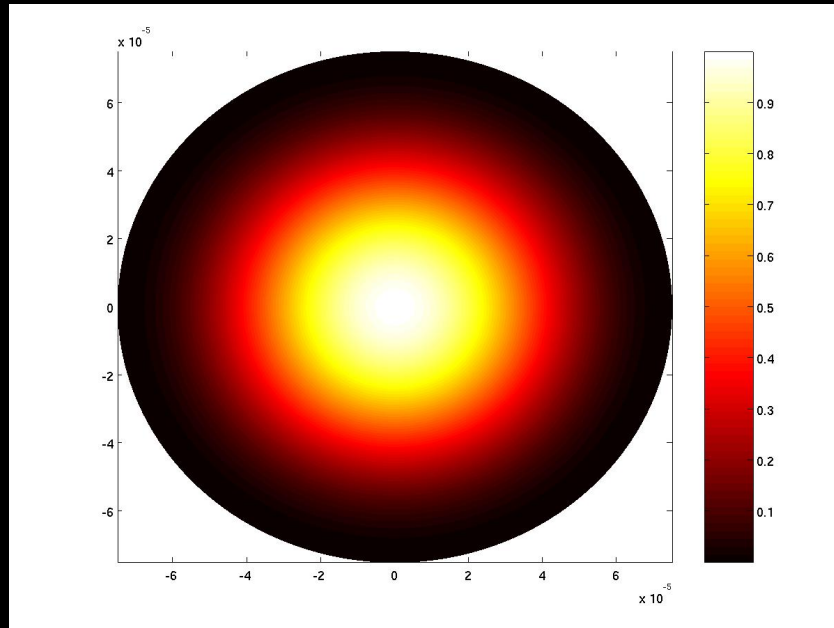




Capillary

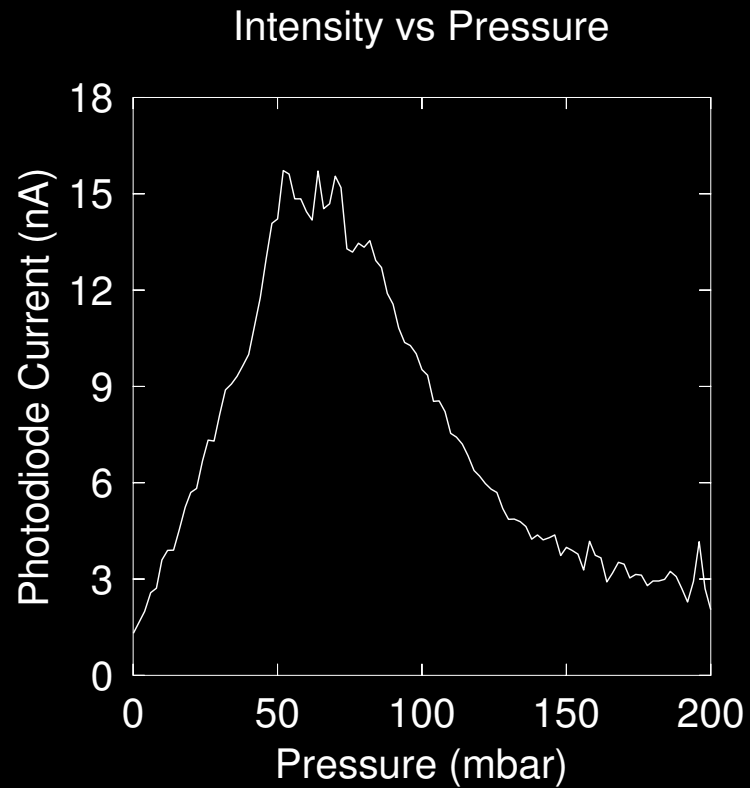


Capillary Modes

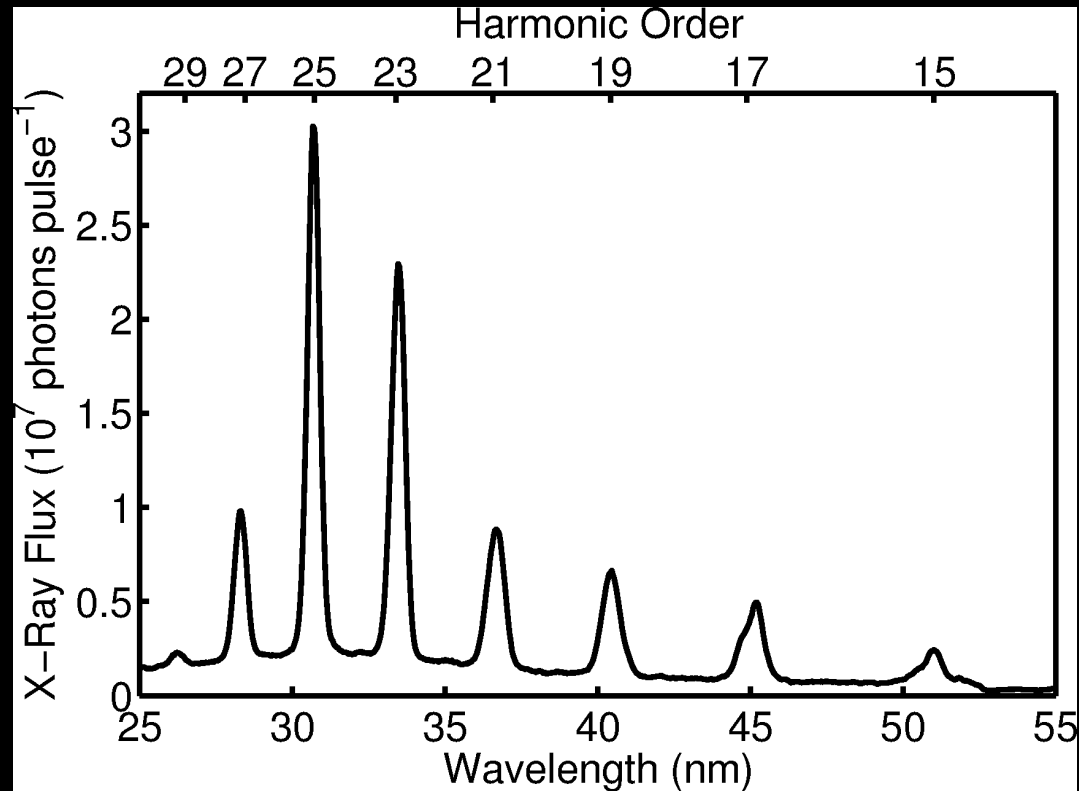


Theory and Experiment

Phase Matching

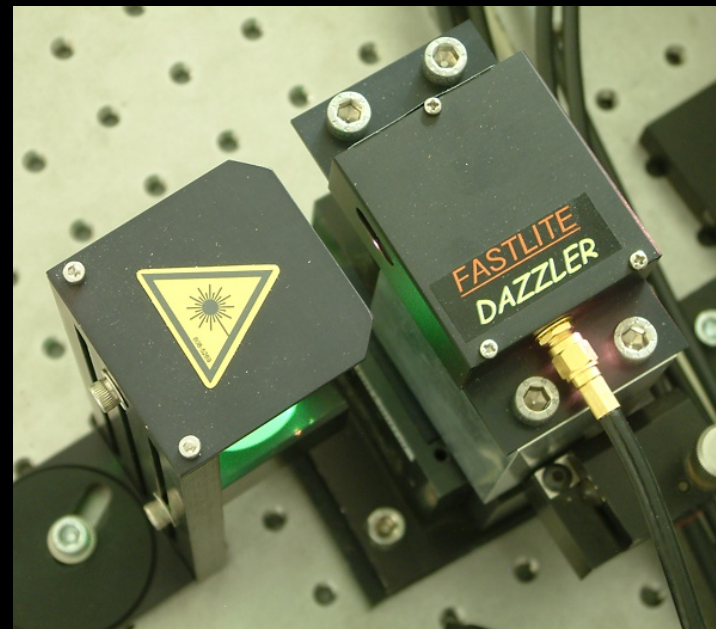
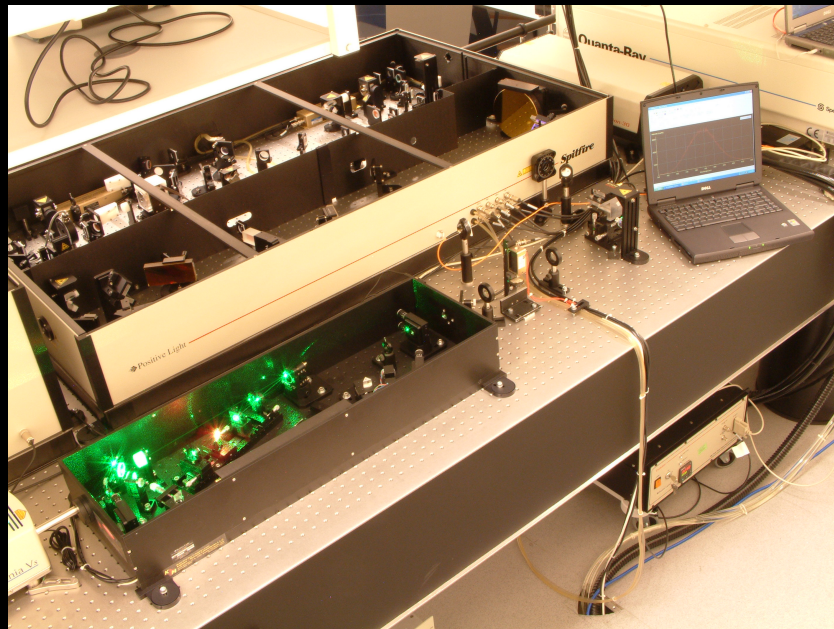


X-ray spectrum

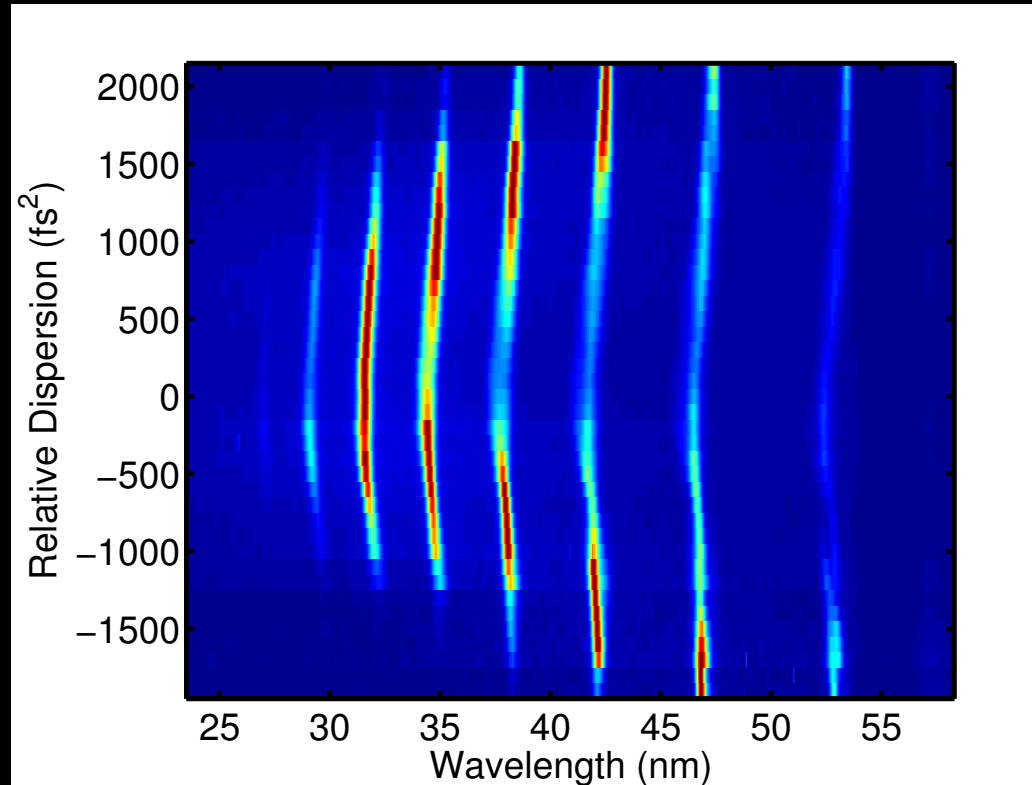


High harmonic spectrum measured with grazing incidence spectrometer using a multi-channel plate detector. A 200 nm Al foil is used to filter laser. Optics Letters, in press.

Pulse shape control

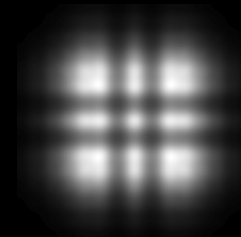
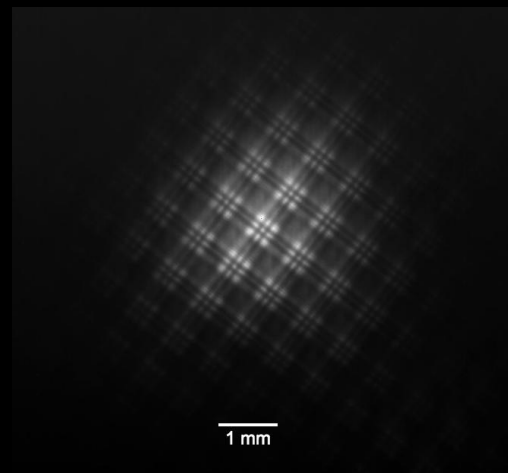
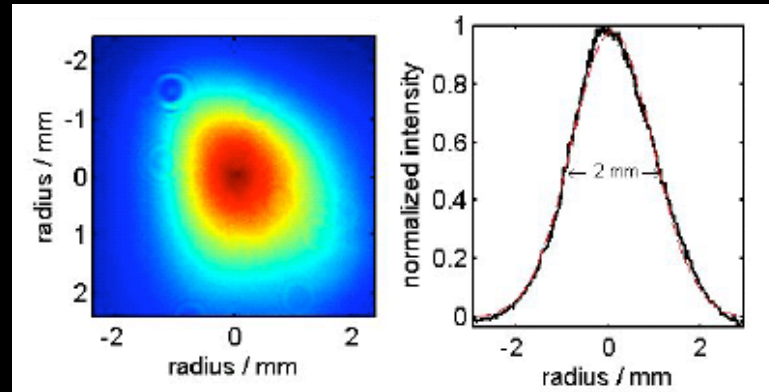


Spectrum control



Optimisation of the X-ray harmonic spectrum by pulse shaping using an acousto-optic programmable filter.

X-ray beam profile

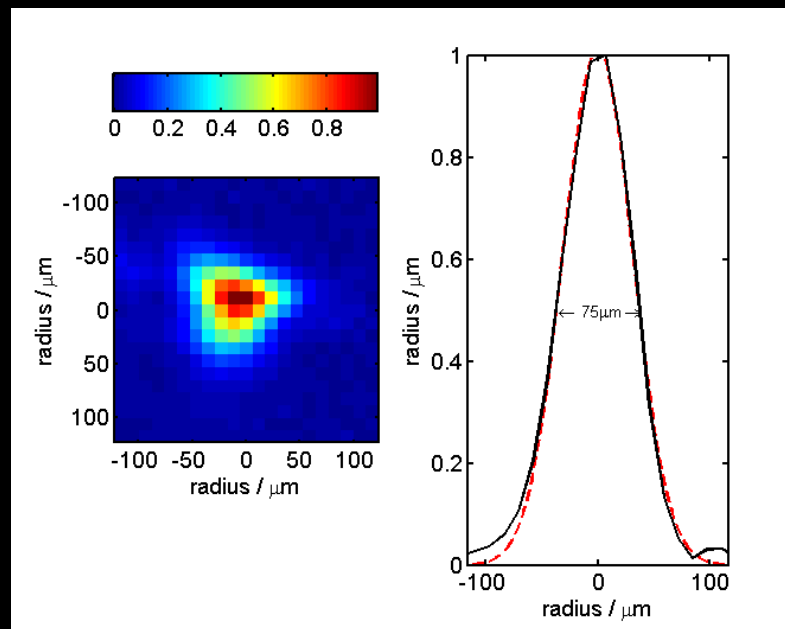


Focusing with parabolic taper

Initial results

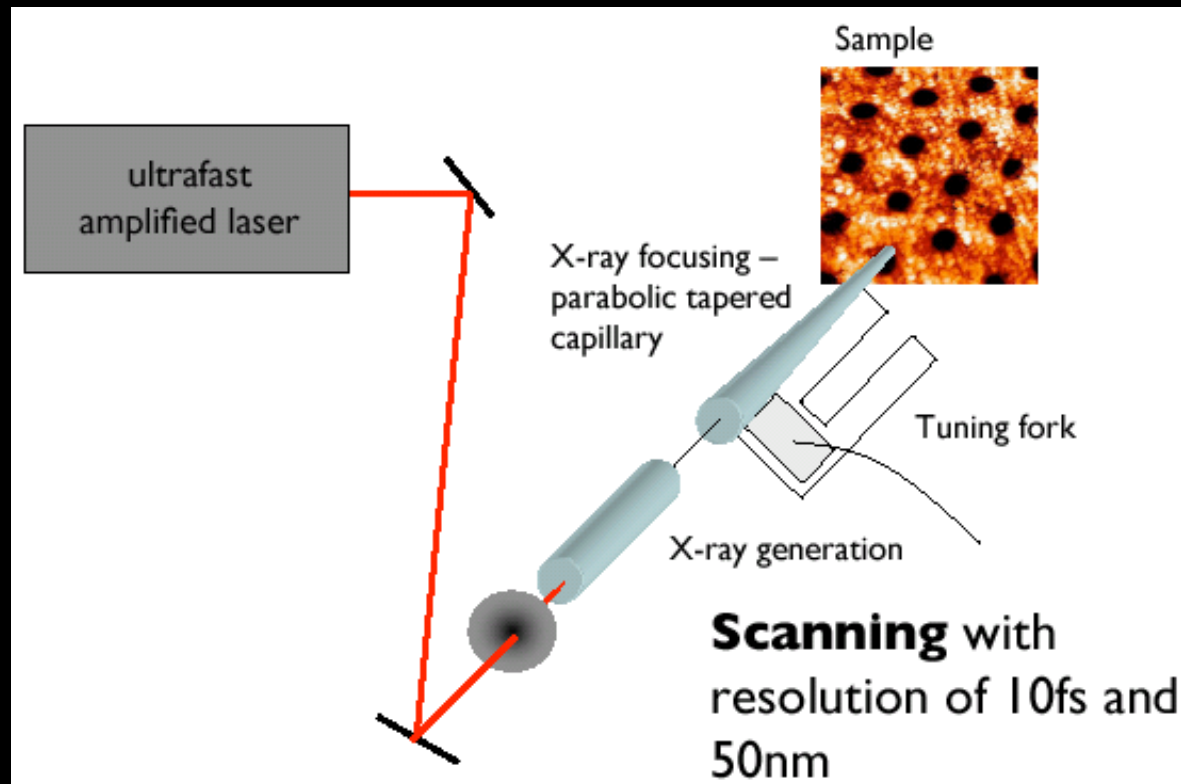
Fabricated a large bore taper (500 μm - 100 μm)

X-ray spot through taper, 75 μm FWHM



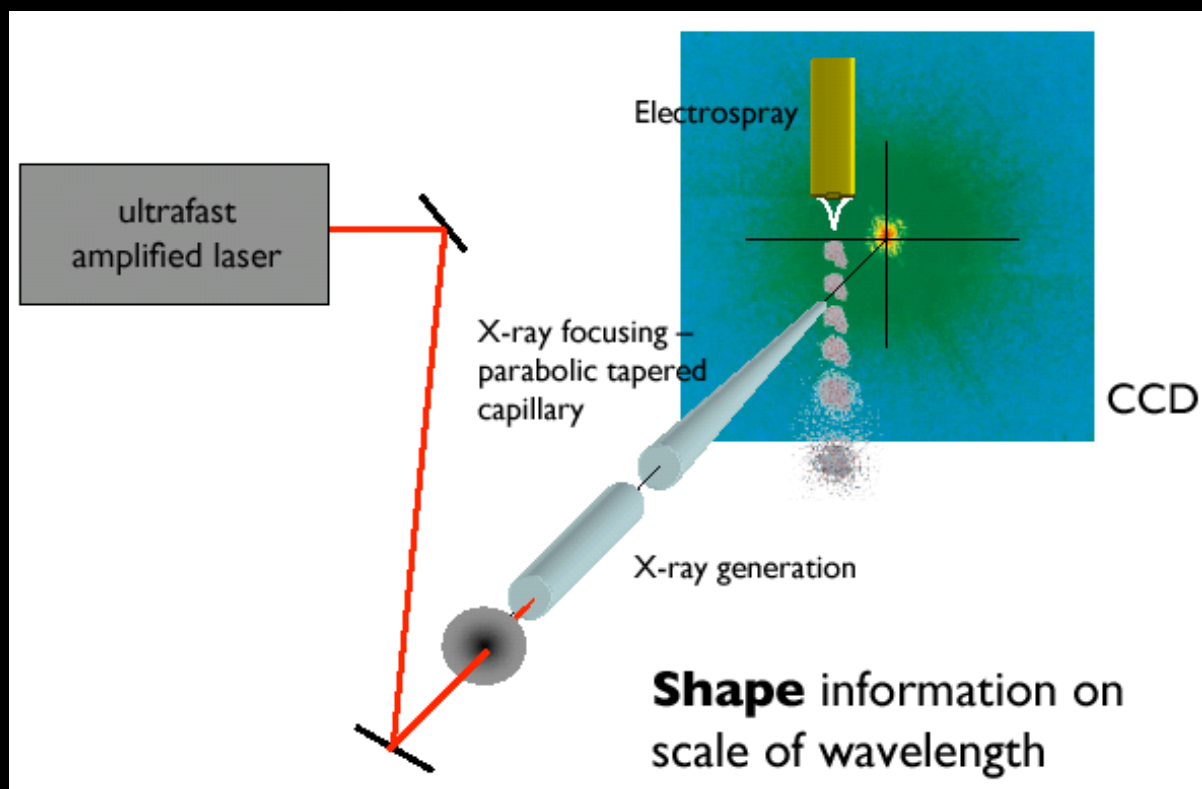
Scattering experiments

Scanning nano-size samples



Scattering experiments

Scattering from isolated molecules



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- Working capillary generation system;
- Generating X-rays to 25 nm, 10^8 photons per pulse;
- Wavelength tuning by laser pulse shaping;
- Potential for generation down to 2 – 4 nm.

New technology for a nanoscale X-ray source: Towards single isolated molecule scattering

Jeremy Frey, Chemistry

Jeremy Baumberg, Physics

Bill Brocklesby, ORC

Chris Froud

Edward Rogers

Matthew Praeger

Sarah Stebbings

Dave Hanna, David Richardson, Jonathan Price, ORC

Rutherford Appleton Laboratory

Basic Technology grant, Research Councils UK