We present the results of some photon-in, photon-out experiments performed at the SPring-8 Compact SASE Source SCSS. The SCSS was constructed as a test facility for the SACLA X-ray free electron laser (FEL), and provided SASE (self-amplified stimulated emission) pulses at a fundamental wavelength variable between 50 and 60 nanometres, a pulse length of around 30 fs, and a pulse energy of up to 100 μJ [1].

Compared to charged particle spectroscopy techniques, photon detection can offer the advantages of high sensitivity, low noise, and allows higher target densities to be used, due to the absence of space-charge effects.

These advantages are typified in the recent observation of superfluorescence (collective spontaneous emission) at a wavelength of 501.6 nm following excitation of high densities of helium atoms to the 1s3p state using FEL pulses at a wavelength of 53.7 nm [2]. The irradiation of argon clusters (N~1000) with a similar wavelength led to the emission of shorter wavelength radiation (as short as ~20 nm) following electron-ion recombination in the intra-cluster nanoplasmas created by the absorption of multiple photons by individual clusters [3]. Radiation at wavelengths shorter than that of the incident pulses was also observed in neon, following two-photon resonant, three-photon ionization via a doubly-excited state [4]. Using the 3rd-order radiation at wavelengths near 20 nm, we have also demonstrated coherent control of the quasi-chaotic SASE pulses using propagation through high densities of helium gas due to double-excitation resonance effects [5].