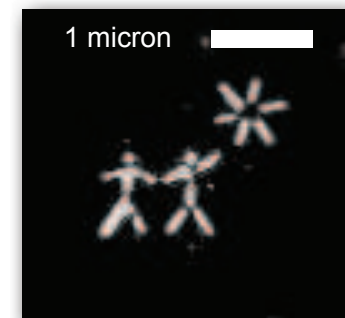
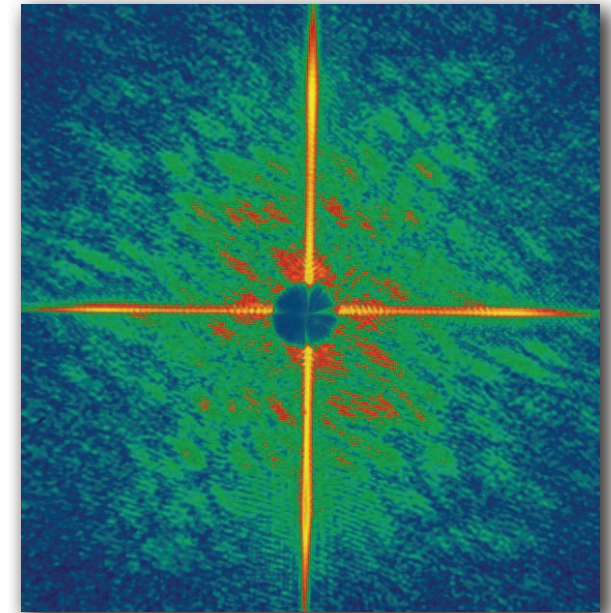
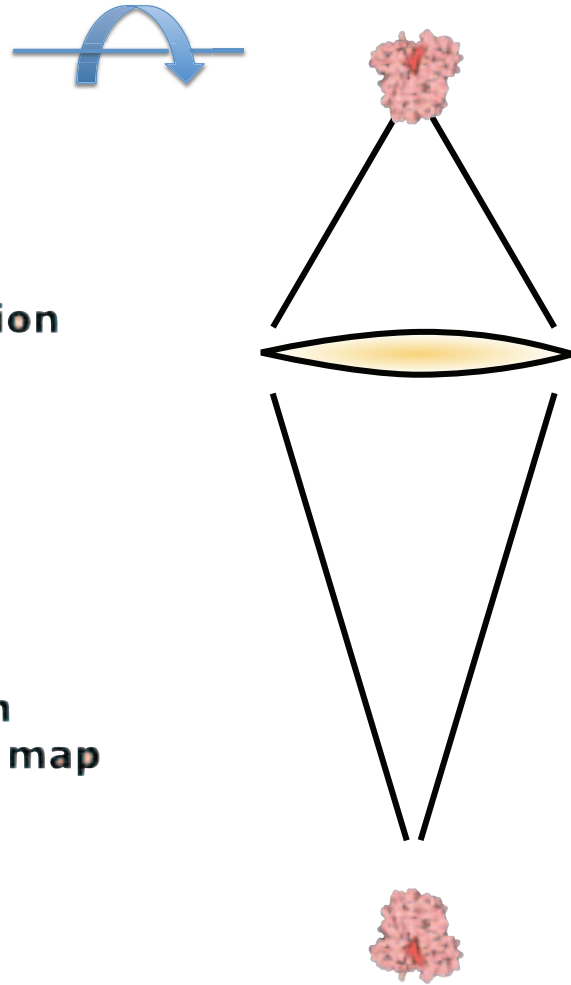
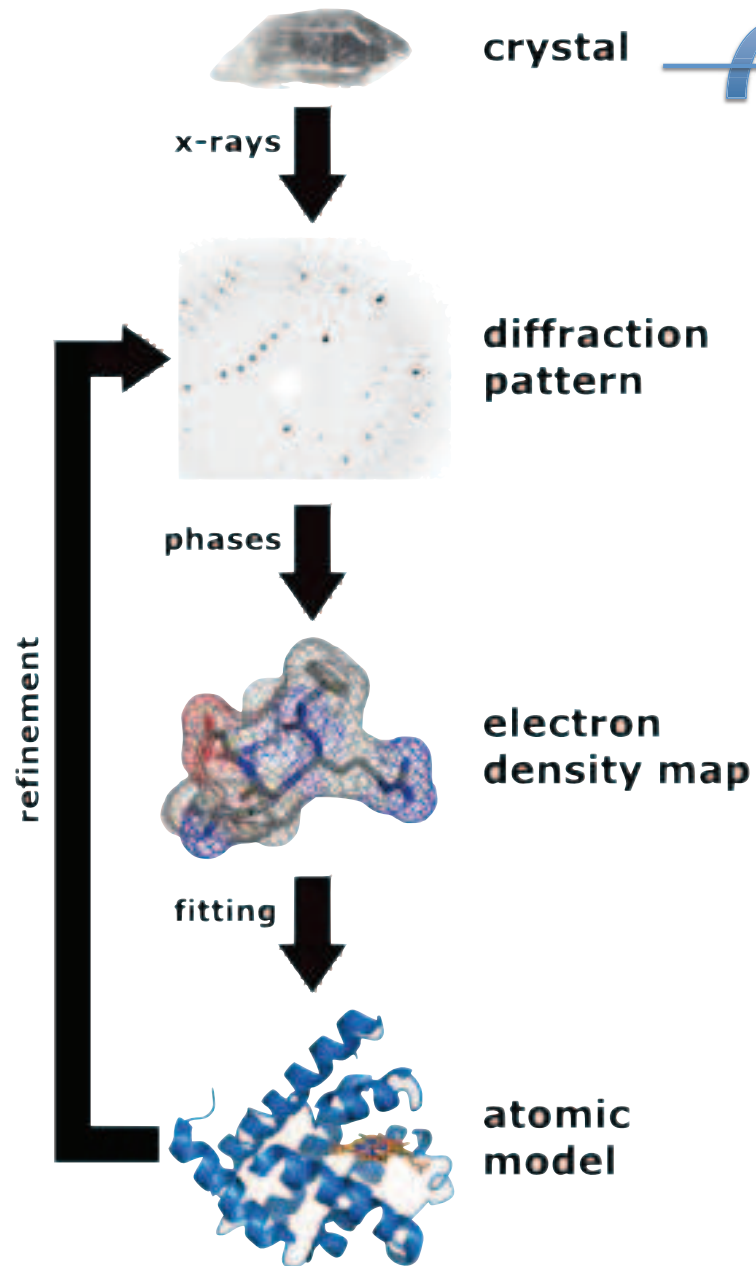
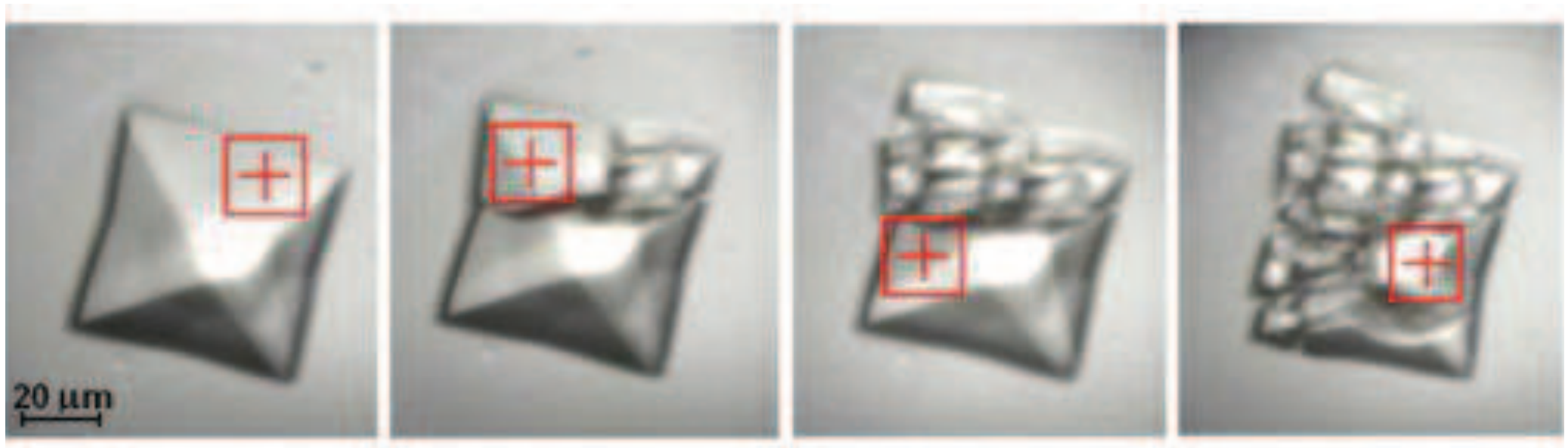


Crystallography is a tomographic imaging technique for macromolecules



High radiation dose causes changes in molecular structure



Crystal of Bovine enterovirus 2 (BEV2) after
subsequent exposures of 0.5 s, 6×10^8 ph/ μm^2
300 kGy dose
Room temperature

Cryogenic cooling gives 30 MGy tolerance

Axford et al. Acta Cryst. D68 592 (2012)
Diamond Light Source (courtesy Robin Owen &
Elspeth Garman)

$$1 \text{ Gy} = 1 \text{ J/kg}$$

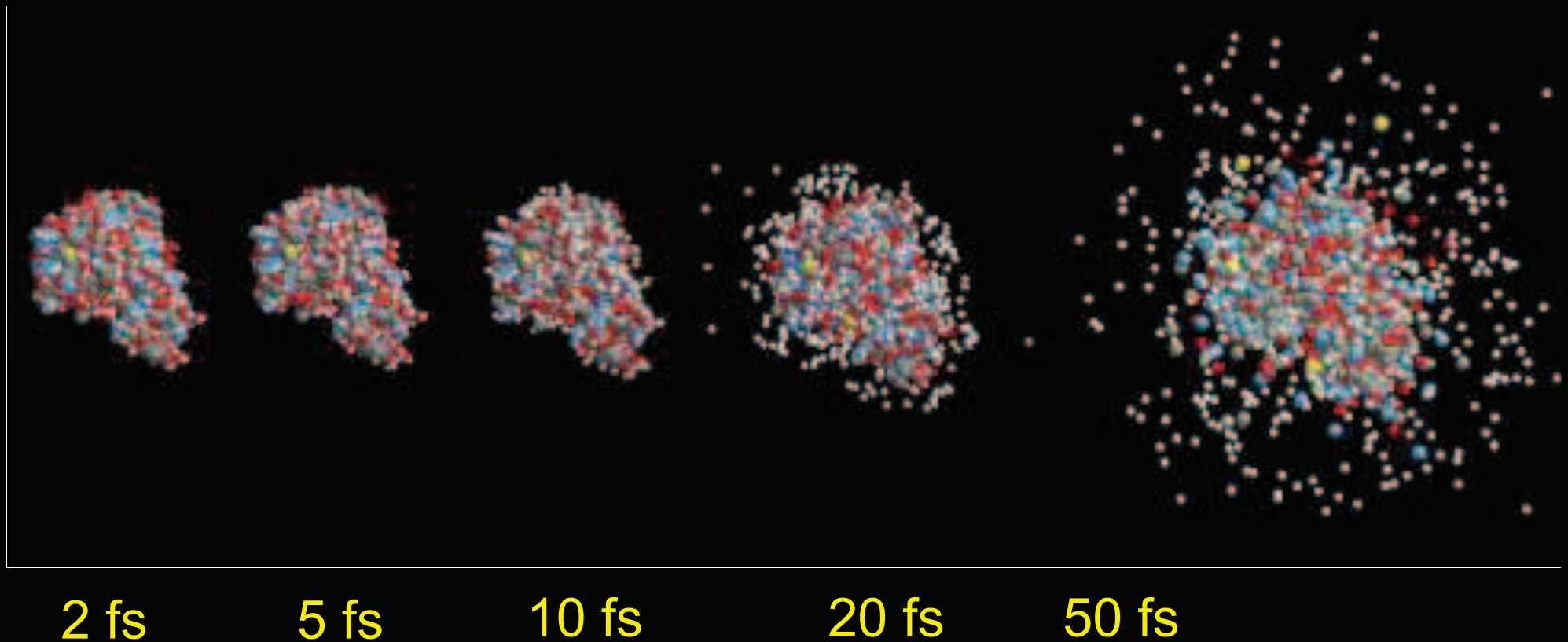
$$1 \text{ MGy} \approx 1 \text{ eV / Da} \quad \text{absorbed} \\ \approx 0.16 \text{ eV / atom}$$

(about one ionization per
10 amino-acid residues)

$$\approx 2 \times 10^9 \text{ ph}/\mu\text{m}^2$$

(assuming we need 25 eV to ionize)

X-ray free-electron lasers may enable atomic-resolution imaging of biological macromolecules



R. Neutze, R. Wouts, D. van der Spoel, E. Weckert, J. Hajdu, *Nature* **406** (2000)

Time is frozen with a short light pulse



Harald Edgerton
Cutting the Card Quickly
1964