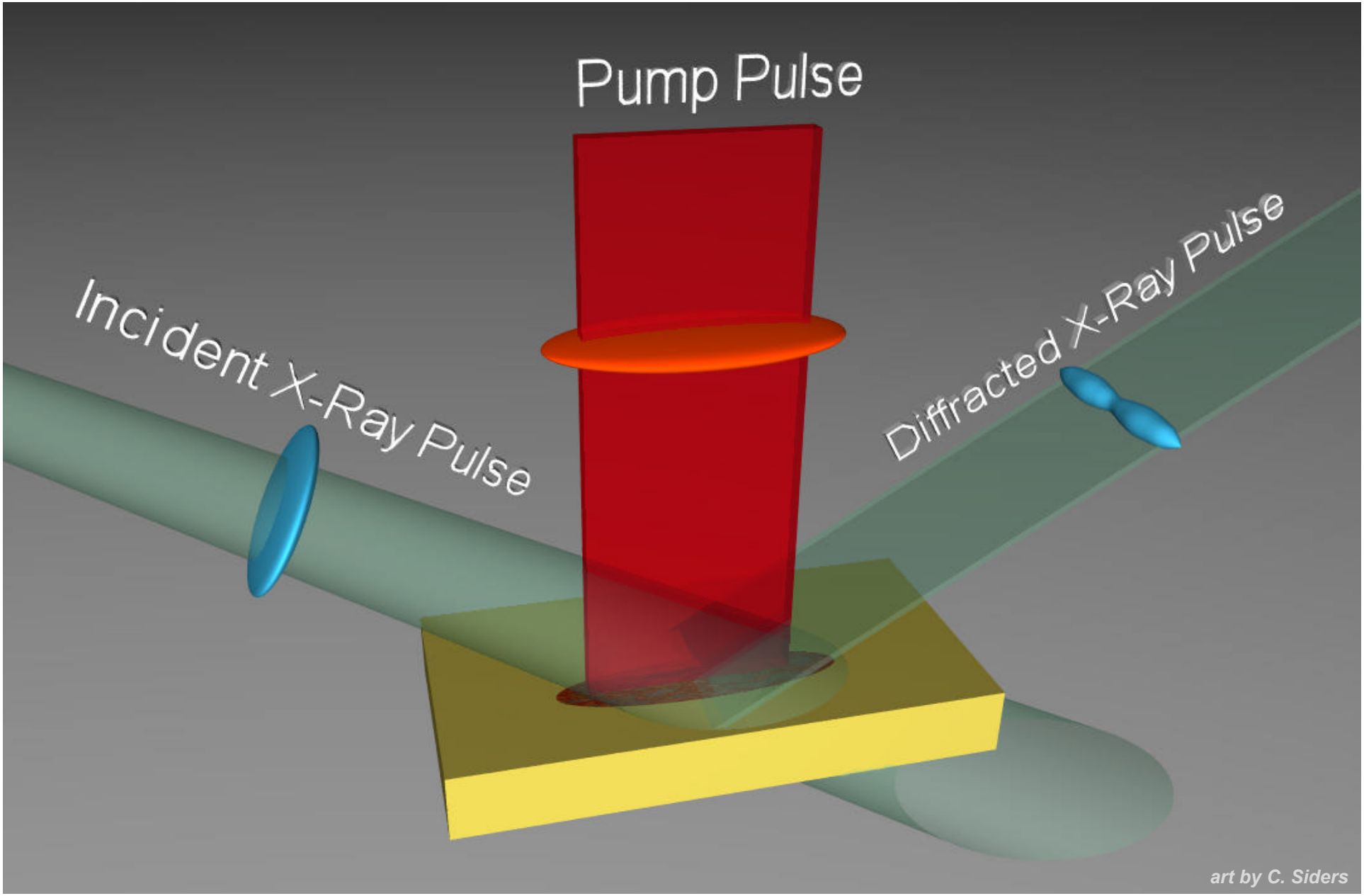
Structural Dynamics

Time-resolved measurements
of collective material responses

Optical excitation, x-ray diffraction probe



Optical excitation, x-ray diffraction probe

"Detection of Nonthermal Melting by Ultrafast X-ray Diffraction"

C. W. Siders, A. Cavalleri, K. Sokolowski-Tinten, Cs. Tóth, T. Guo, M. Kammler, M. Horn von Hoegen, K. R. Wilson, D. von der Linde, C. P. J. Barty

This paper should be published with high priority. It is a seminal paper – marginal data, barely enough to support the main conclusions … but at present an experimental *tour de force* and a clear indicator of what is to come. When it does come in earnest, it will come in simpler form with better data, higher signal/noise, and so on – but this will remain the seminal paper that showed that it was really possible. The use of ultrafast hard x-ray pulses to do x-ray diffraction from non-thermally rearranging materials is a dream that has finally been realized, if in crude form. This will be a landmark publication in *Science*.

Optical excitation, x-ray diffraction probe

Excitation can drive:

- Strong electronic excitation
- Acoustic waves, shock waves
- Optic phonons
- Thermal melting
- Nonthermal melting
- Solid-state phase transitions

Probing able to monitor these & other responses

- Probe pulse intensity, duration, synchronization are important issues

Optical excitation: $q \approx 0$
X-ray diffraction probe: high q

Works because sample response to low-q excitation couples to high-q response

- Optical excitation (low-q) leads to changes in lattice order (high-q)

Also of interest: full range of wavevectors q across entire Brillouin zone

- Not just lattice wavevectors but correlation lengths & their relations to correlation times
  - Are short structural correlation lengths in polymers & other complex materials associated with fast dynamics, and long correlations lengths with slow dynamics?
- X-ray inelastic scattering now providing partial access

Time-resolved measurements will require

Coherent x-ray excitation, x-ray probe

to drive high-q responses directly

- Demands intense, ultrafast x-ray excitation pulse
- X-ray time-resolved four-wave mixing now being attempted with HHG
- Will be possible with 4^{th} generation sources, hard x-rays
- Entire Brillouin zone will be ours!