

# Terahertz Streak Camera as Arrival Time Monitor for SwissFEL

Pavle Juranić, Christoph Hauri, Rasmus Ischebeck, Peter Peier, Volker Schlott

Goals for the SwissFEL photon pulse length and timing stability:

Operating Mode	X-Ray Pulse length	Arrival Time Stability
Standard	20 fs rms	20 fs rms
Short-Pulse	1.5 fs rms	5 fs rms
Attosecond	60 as rms	5 fs rms
Wide Bandwidth	20 fs rms	20 fs rms

Detector requirements

- > Transparent (non-destructive to intensity and wavefront)
- > On-line
- > Resolution sufficient to validate SwissFEL photon beam stability goals

Our current options:

→ X-ray induced reflectivity change

Has been used at SLAC

→ Terahertz streak camera

Pioneered by ultra-short laser groups [1]

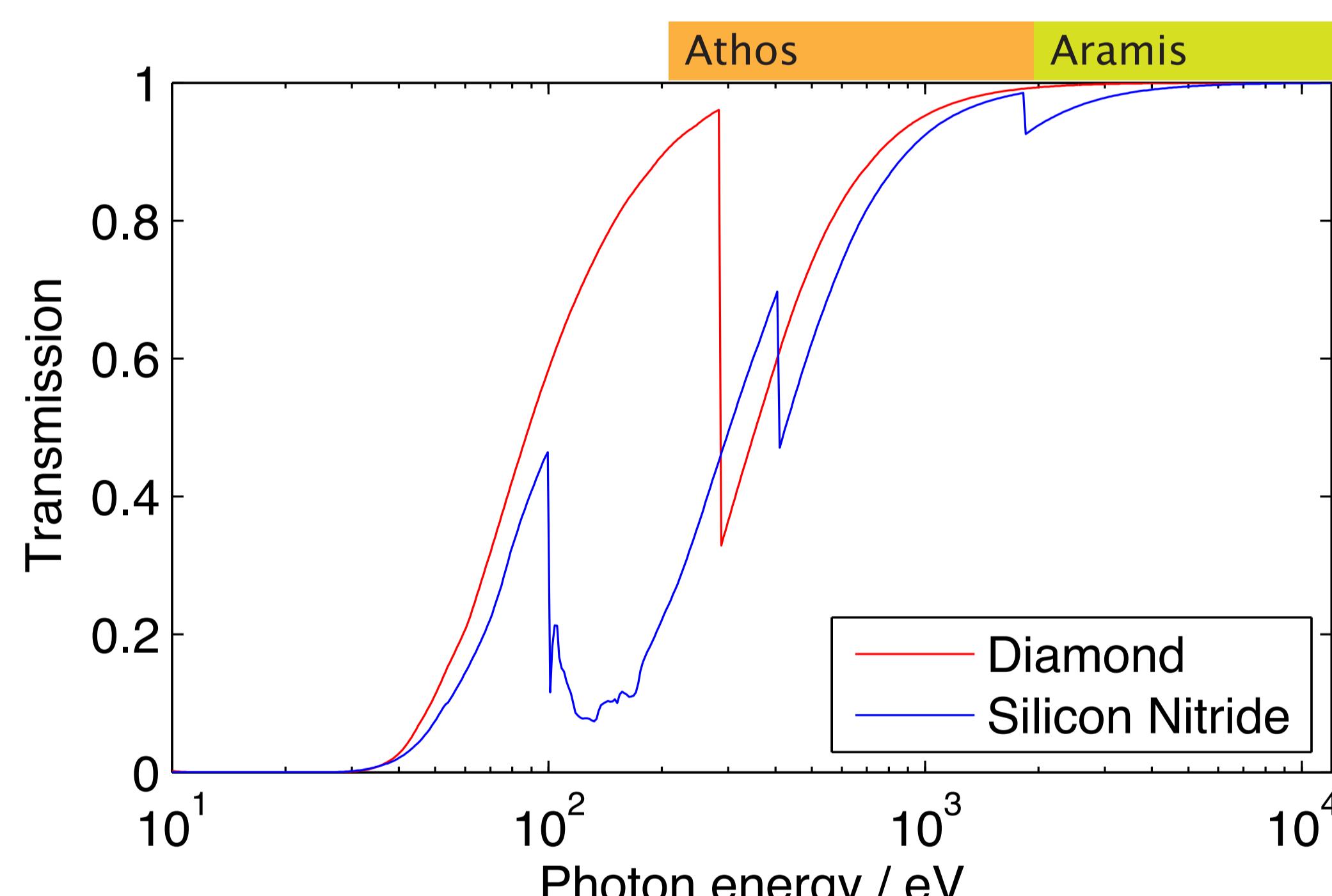
Has been used at FLASH [2] to measure

- > 15 fs pulse length
- > 5 fs arrival time (using THz and X-rays from the same electron beam)

## Challenges for Soft X-Rays

Absorption in solids for soft X-rays

→ Use gas-based detectors

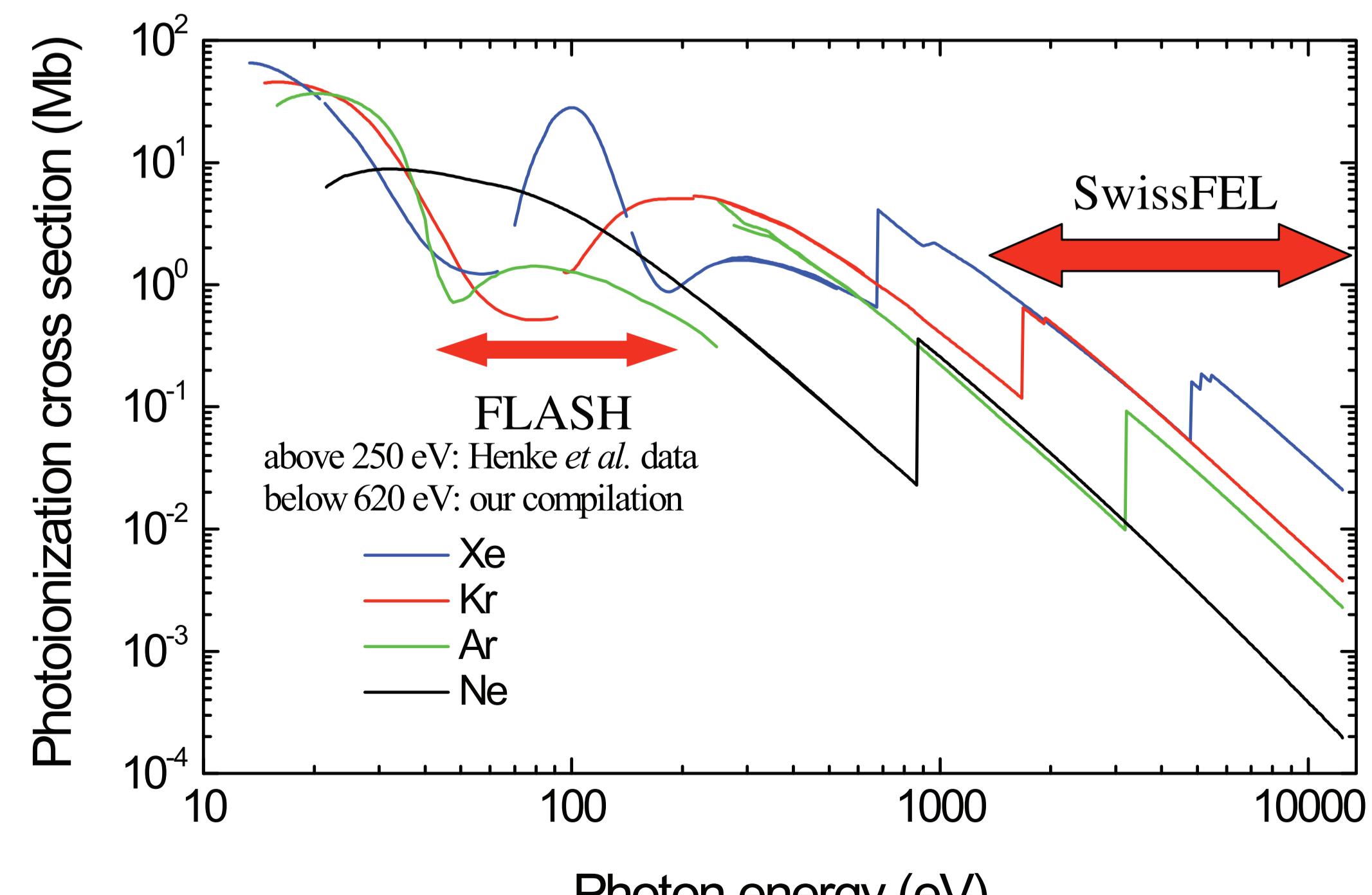


## Challenges for Hard X-Rays

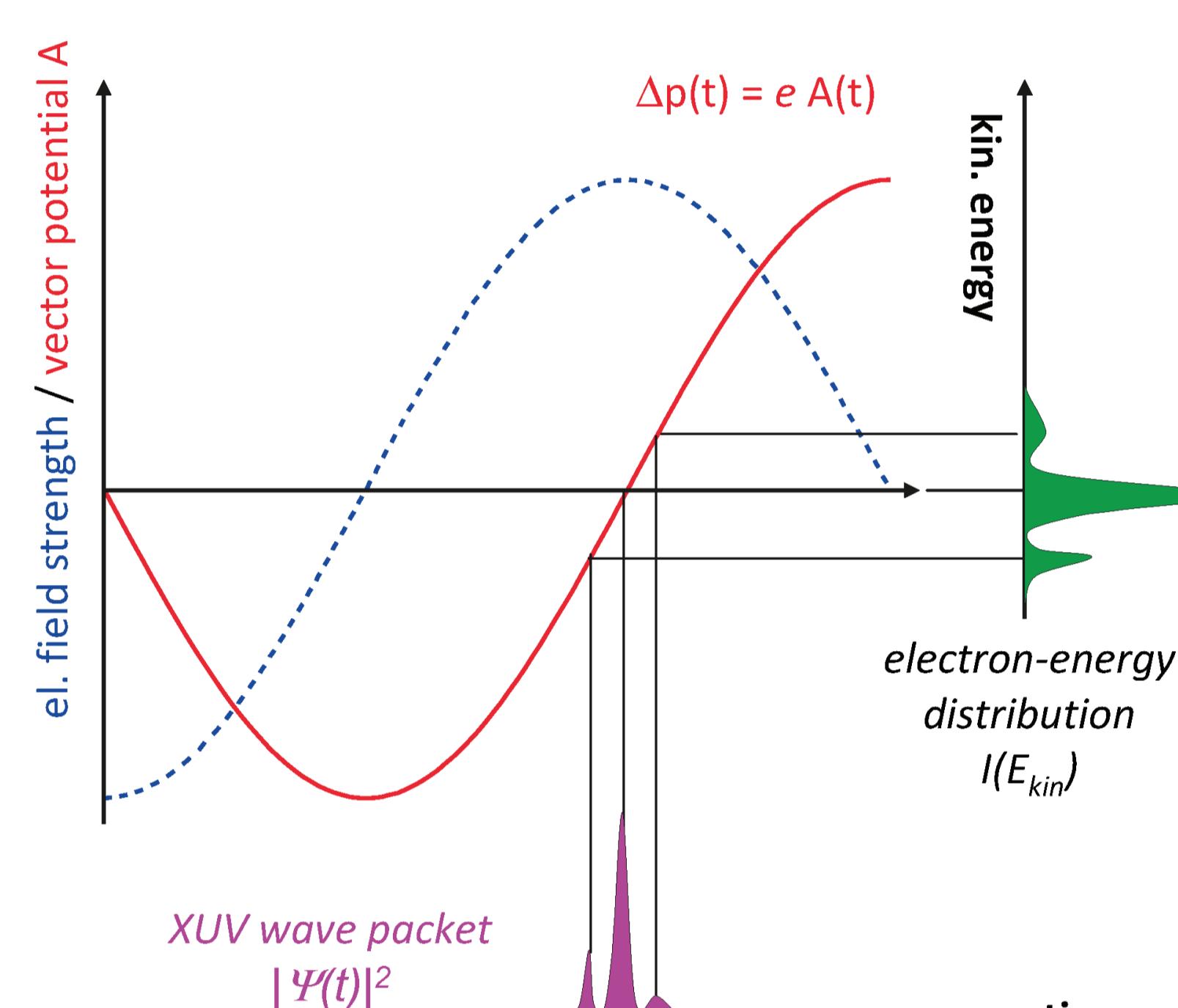
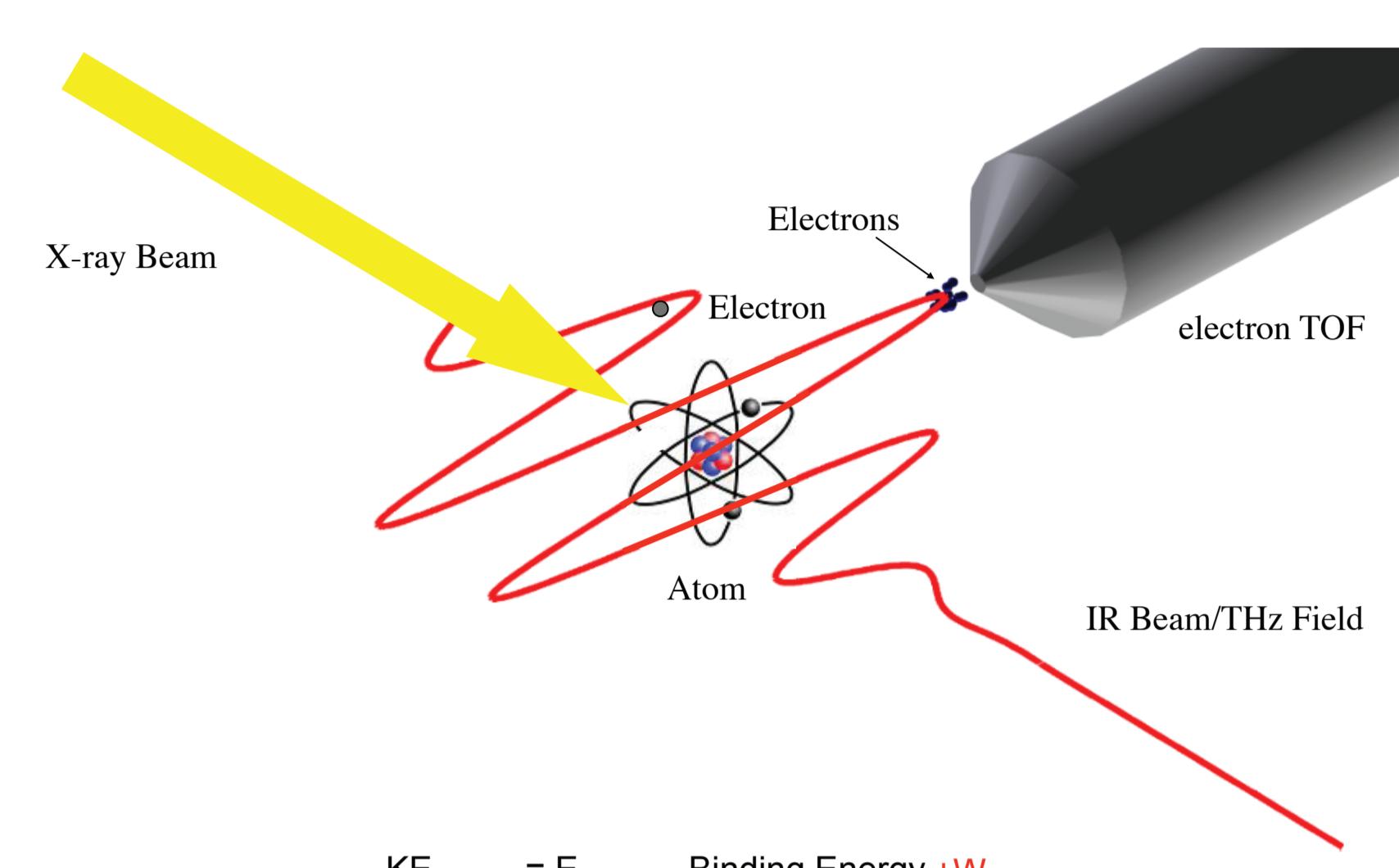
Low cross section in gases

→ Use Xenon

→ Pulsed gas jet for high pressures

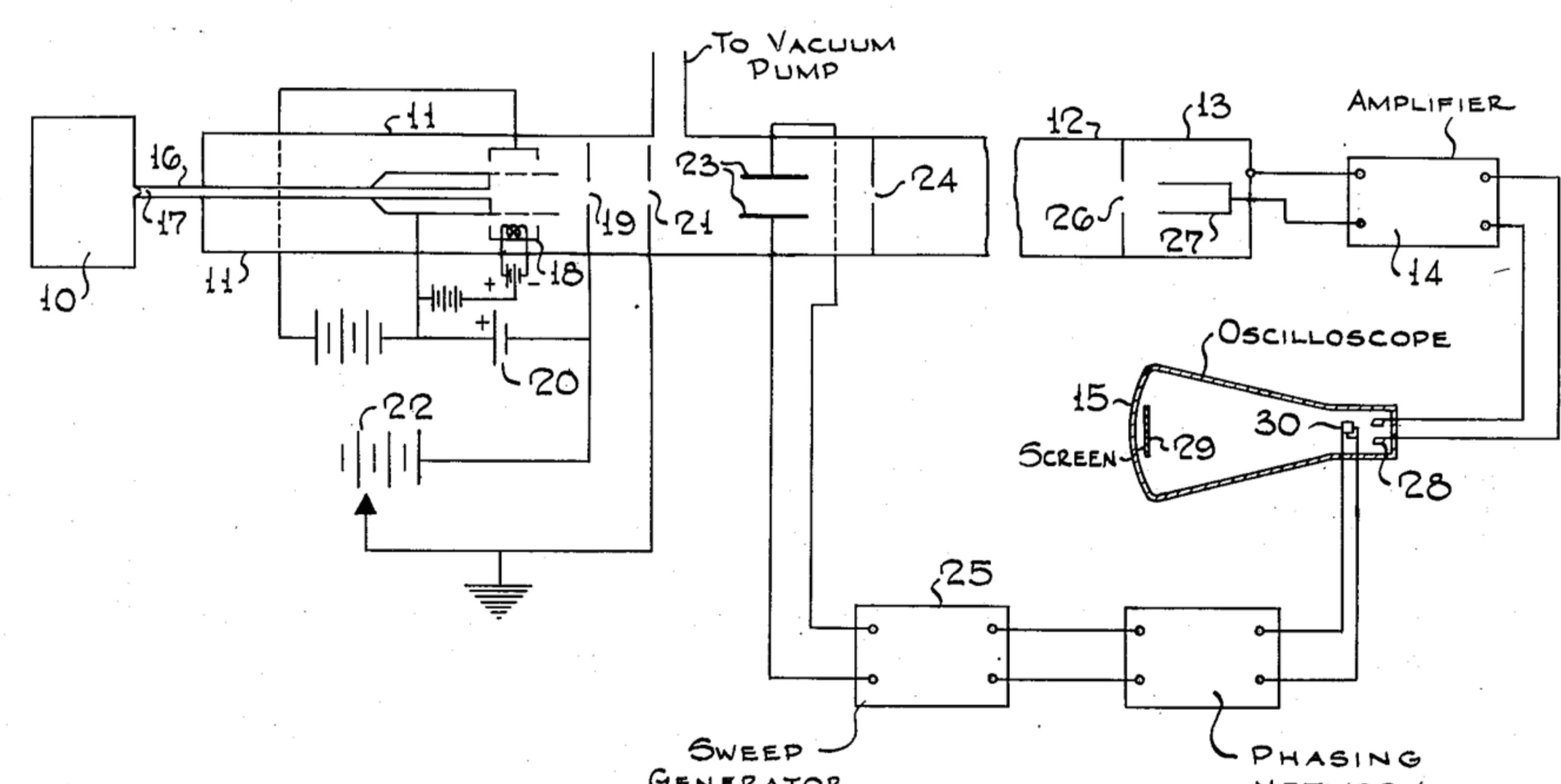


## From Electron Energy to Arrival Time



Illustrations courtesy of Ulrike Fröhling

## Electron Time-of-Flight Spectrometer



Invented by William Stephens (1952)

[1] Drescher, M. et al. X-ray pulses approaching the attosecond frontier. *Science* 291, 1923–1927 (2001)

[2] Fröhling, U. et al. Single-shot terahertz-field-driven X-ray streak camera. *Nature photonics* 3, 523–528 (2009)

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## Next Steps

Need to extend the method to the hard x-ray region and compensate for the smaller atomic cross section by using pulsed gas jet valves.

Need to build a dedicated photon arrival time chamber as on-line instrumentation for the SwissFEL photon beam front end—such a thing currently does not yet exist in other FEL facilities around the world.

Prototyping for extensive testing and parameter optimization in 2012.

Final engineering for SwissFEL from 2014 on.