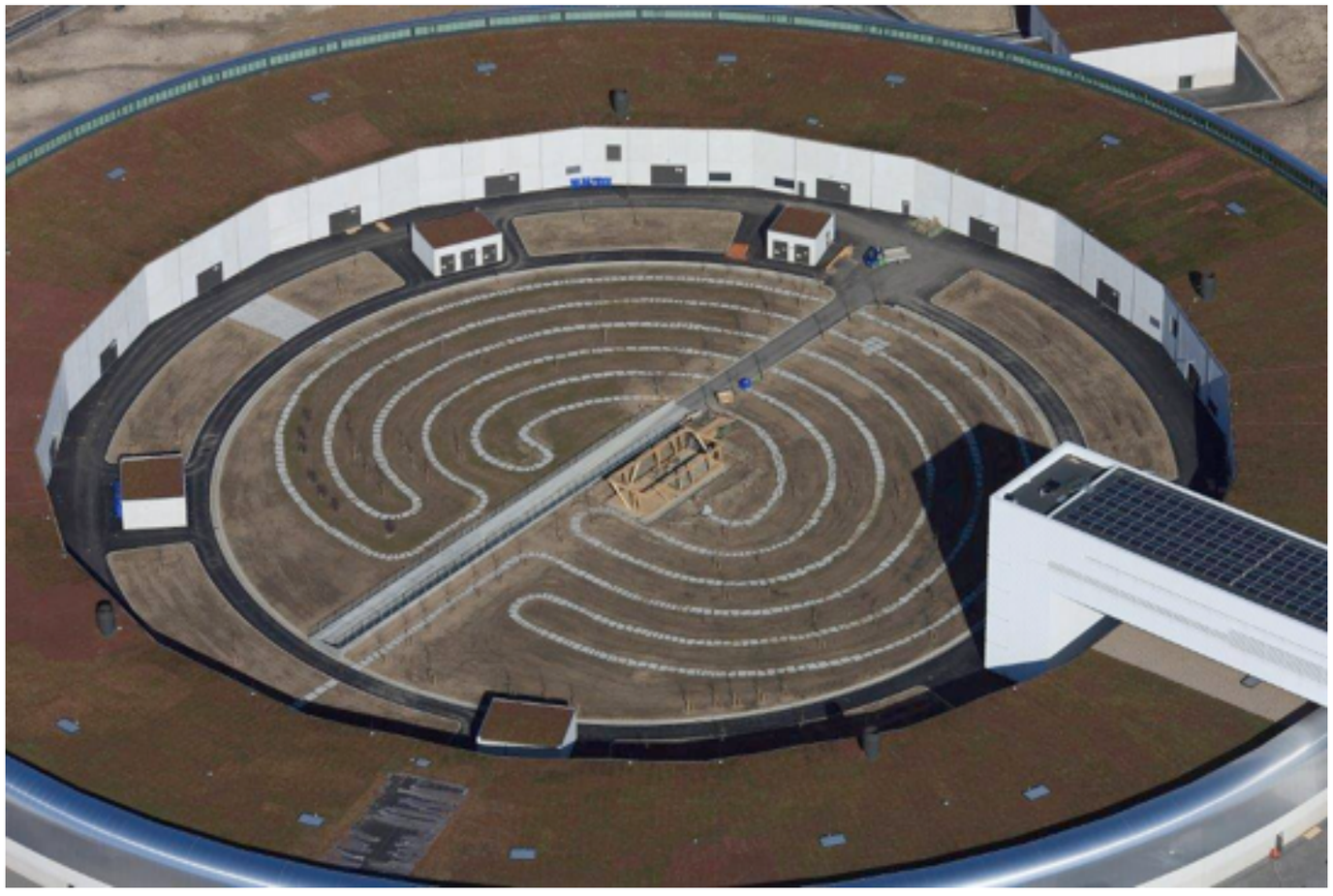
Timing modes for low-emittance storage rings



Stacey Sörensen, Lund University

MAX IV Workshop Lund 25-27 March 2015

A scientific case for timing experiments at MAX IV

The MAX scientific community has been generally satisfied with full multibunch timing modes since the MAX II ring was commissioned in 1997. The laser pump-probe beam line (D611) operates for studies of low picosecond time-resolved x-ray diffraction.

The MAX IV storage ring is designed to achieve the lowest possible electron beam emittance. So far no real effort has been put into alternative filling schemes, and the feasibility of these must be investigated.

Implementation of timing modes requires a new perspective on low-emittance storage ring operation and design.

MAX IV timing today

	3 GeV ring	1.5 GeV ring	SPF
Revolution period	1760 ns	320 ns	
Bunch separation	10 ns	10 ns	5 µs
Bunch length (σ)	170 ps	200 ps	
Bunch length (FWHM)	390 ps	470 ps	100 fs
Bunch length (σ) without damping	30 ps	40 ps	

with passive Landau cavities

Summary of user discussions so far

Timing pulses:

- pulse length
- photon intensity
- interval between pulses
- synchronization with laser, chopper
- photon energy - wide range, interest for both MAX IV rings

Overview of timing modes

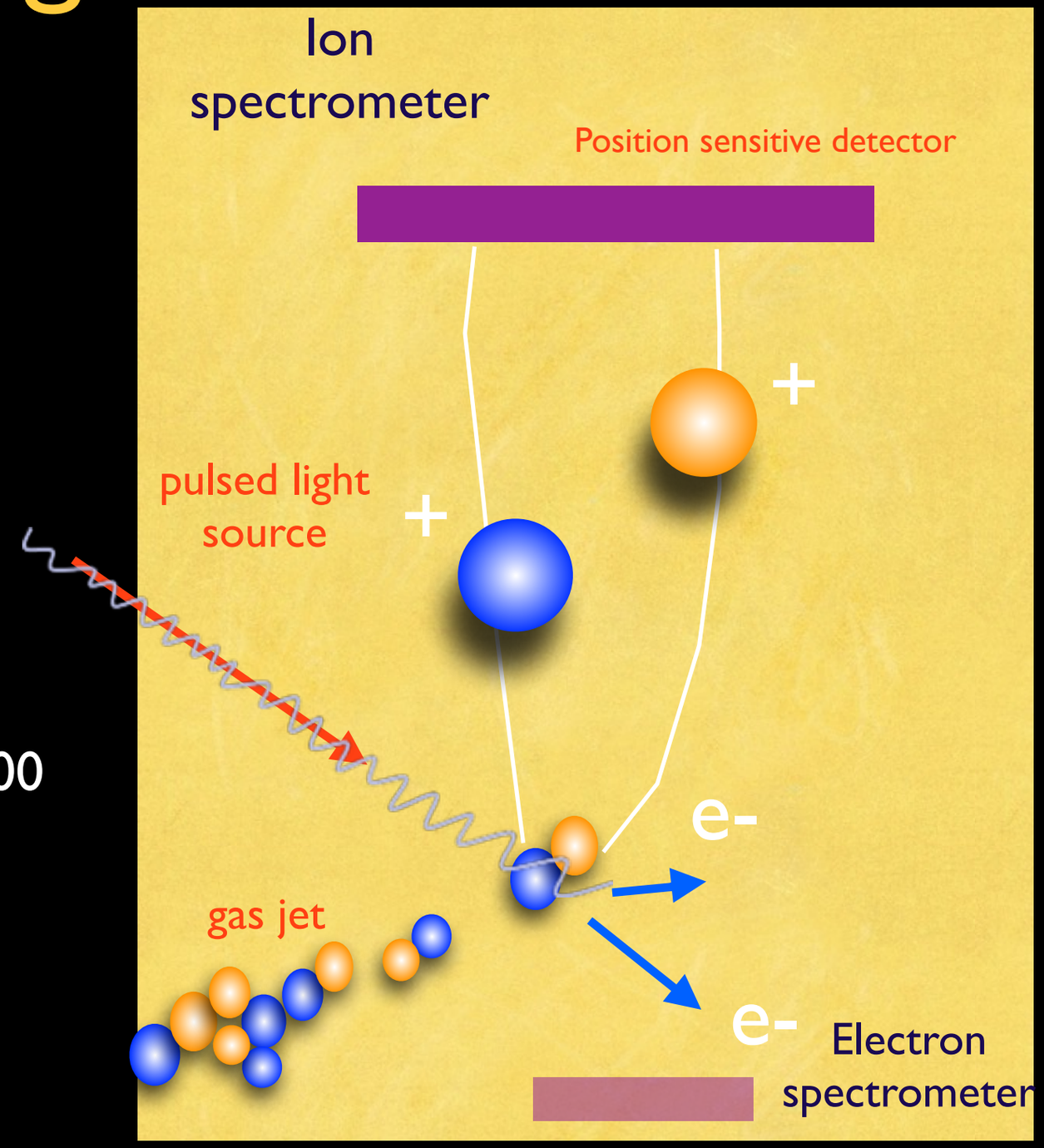
Users specify the type of experiments, and basic requirements for timing modes.

- Electron time of flight, multicoincidence
- Ion time of flight, multicoincidence
- Short x-ray pulses for electron ARToF experiments
- Pump-probe experiments with laser synchronization
- Time-resolved experiments implementing gated detectors
- Time-resolved luminescence experiments (life times from ns to microsecond scale)

Ion-electron imaging time-of-flight studies

- Multicoincidence ion experiments
- 10-20 kHz single-pulse frequency
- 250-500 ps pulse duration
- minimum 10^5 photons/pulse
- broad range of photon energies 20 eV-10 keV
- well focused beam is essential (<< 100 micrometer)

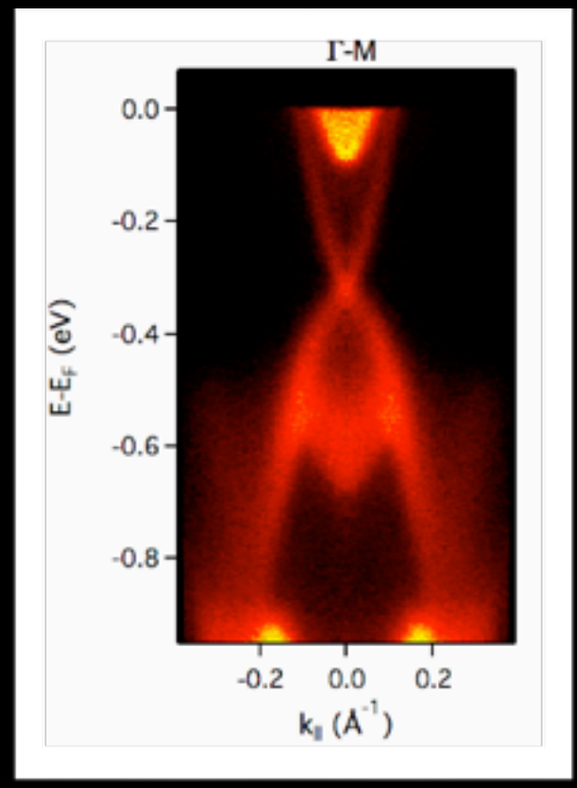
Ion TOF on the order of tens of microseconds, electron TOF 100 ns

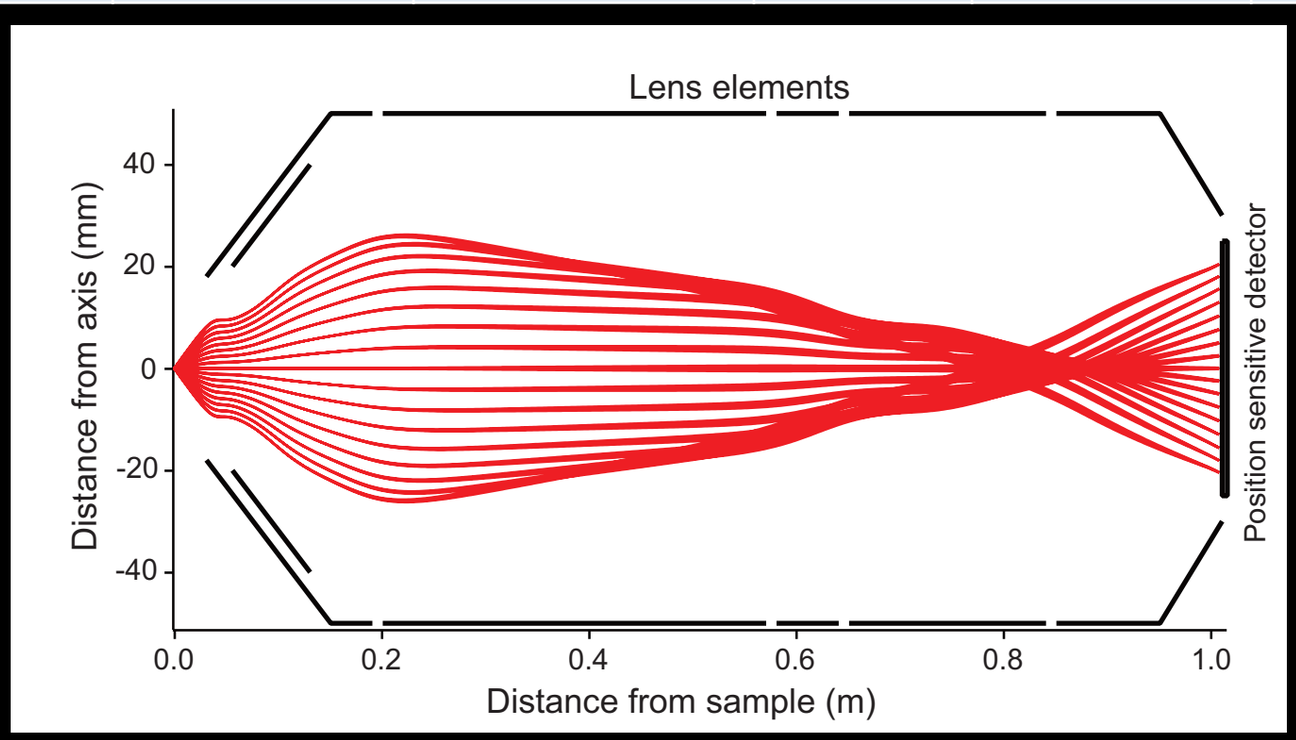


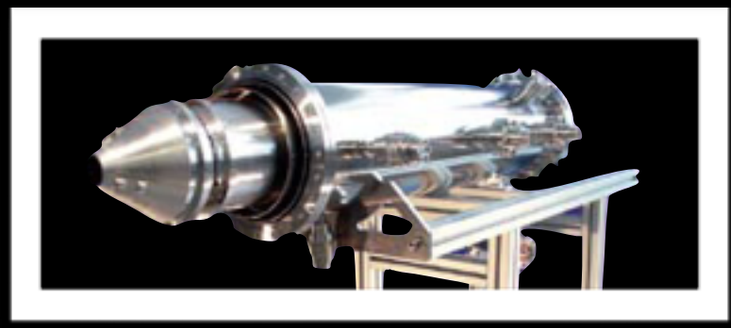
Short pulses for single-particle time-of-flight studies

User specs

Rep rate	Pulse length	Photons/pulse	Energy range		Focus size
100 kHz-3 MHz	5 ps (super), but 50ps works	10^5	Up to 2.5 keV	at least 500 ns between pulses	50x50 micron

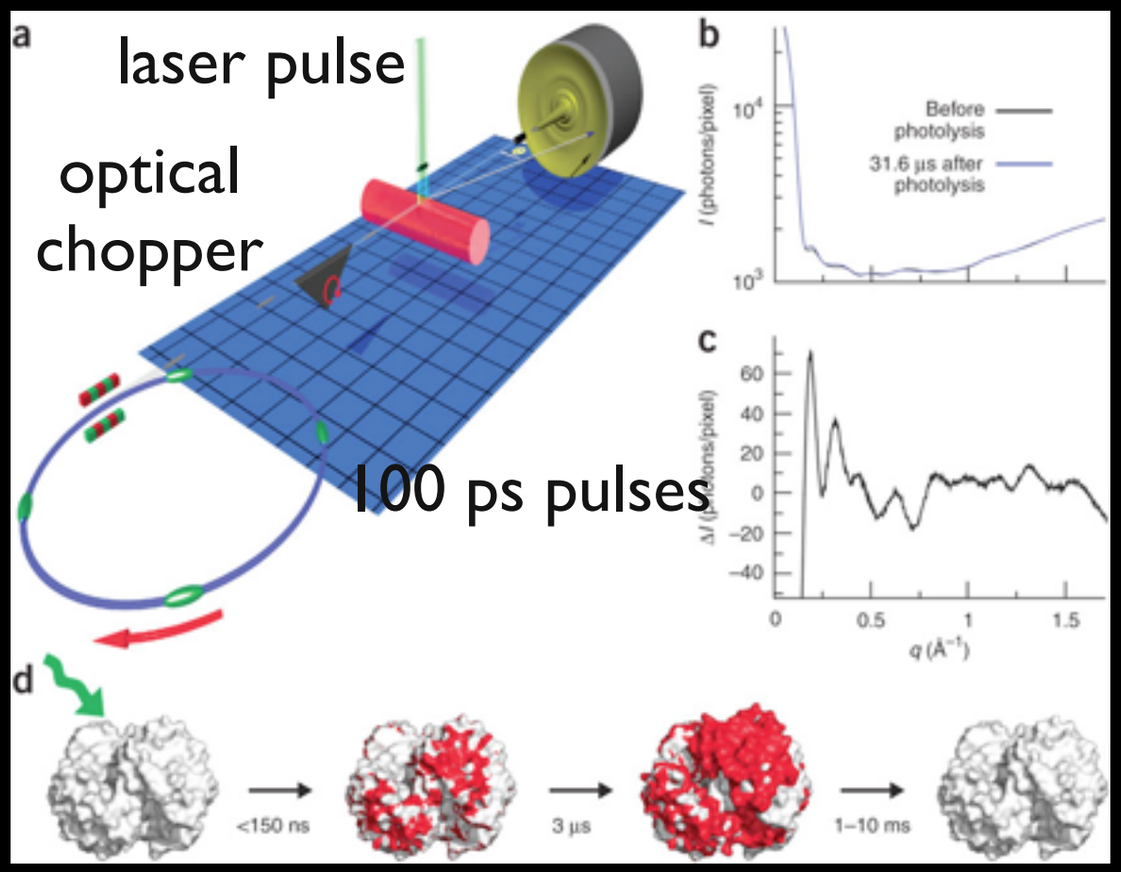




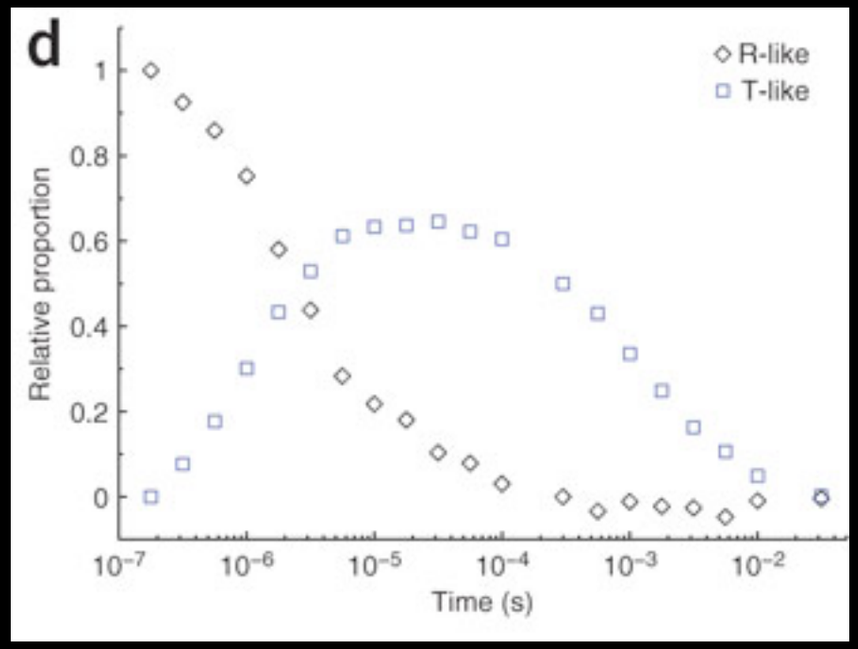


Scientific examples for laser-synchrotron timing experiments

TIME-RESOLVED WAXS: X-RAY SCATTERING STUDIES OF LASER EXCITED TRANSIENT STRUCTURES IN BIOMOLECULES



Hemoglobin and solvent heating contribution: R-like vs T-like species



Cammarata, Nature Meth 5, 881 (2008)

Towards timing @ MAX IV

- Timing workshop for users March, 2014
- Session at MAX User's meeting in September, 2014
- Report to MAX IV directors October, 2014
- Workshop focused on accelerator solutions, March 2015
  - Resonant pulse picking
  - Pseudo single bunch
  - choppers, etc

Summary

New possibilities at laboratories worldwide drive development of methods that require shorter pulses, variable timing pulses, etc

- Is there a scientific case for timing modes at MAX IV?
- Is there a scientific case for investigating solutions for low-emittance rings similar to MAX IV?
    - Which accelerator schemes are feasible to implement at new low-emittance storage rings?
- Workshop……
    - Discussion, summaries
    - Friday: brainstorming and roadmap for development?