Ultra-Fast Hybrid Pixel Detector for Synchrotron Time-Resolved Pump-Probe Diffraction Experiments

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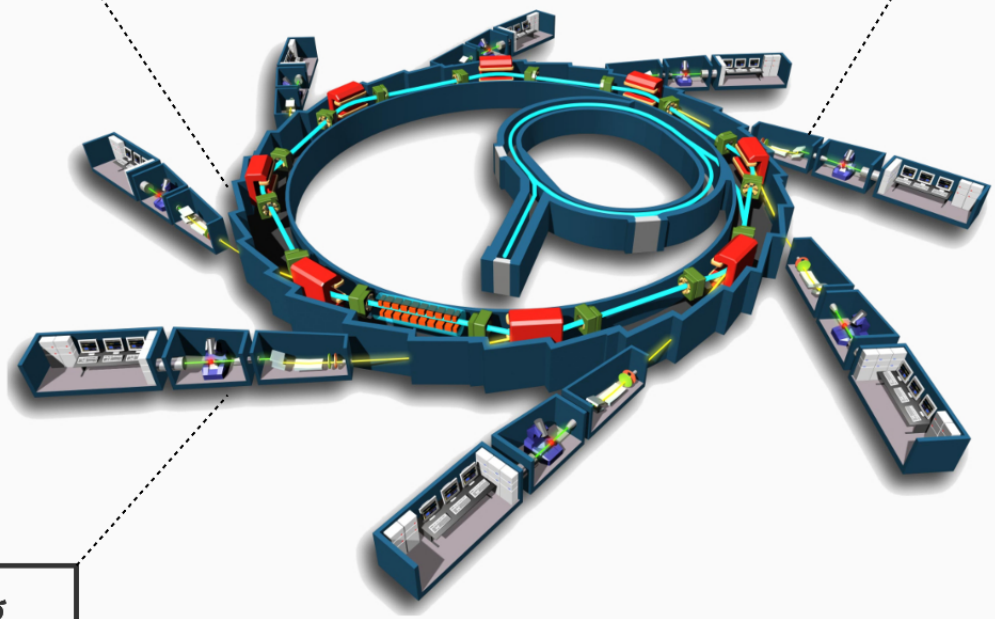
Synchrotron techniques



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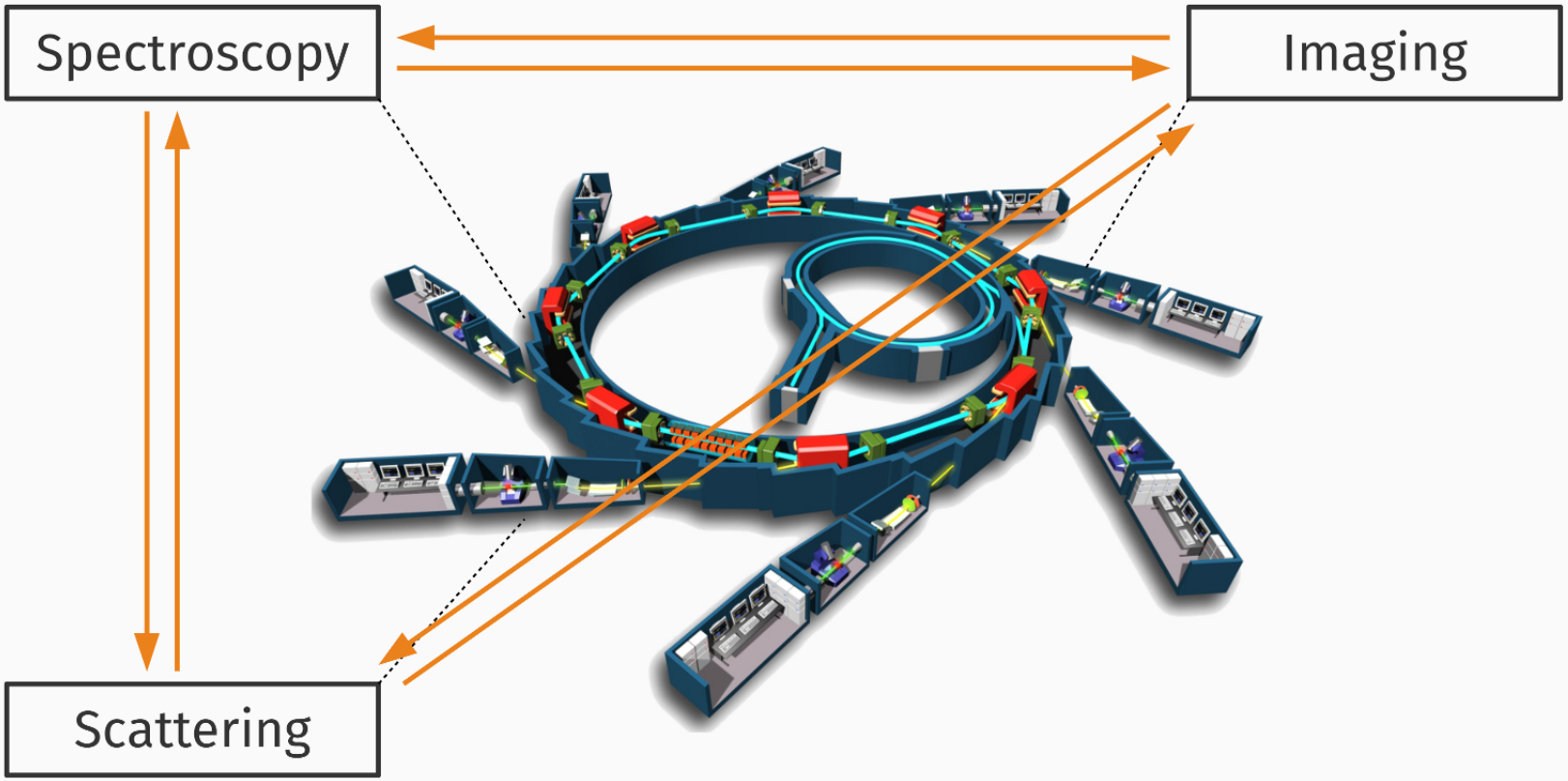
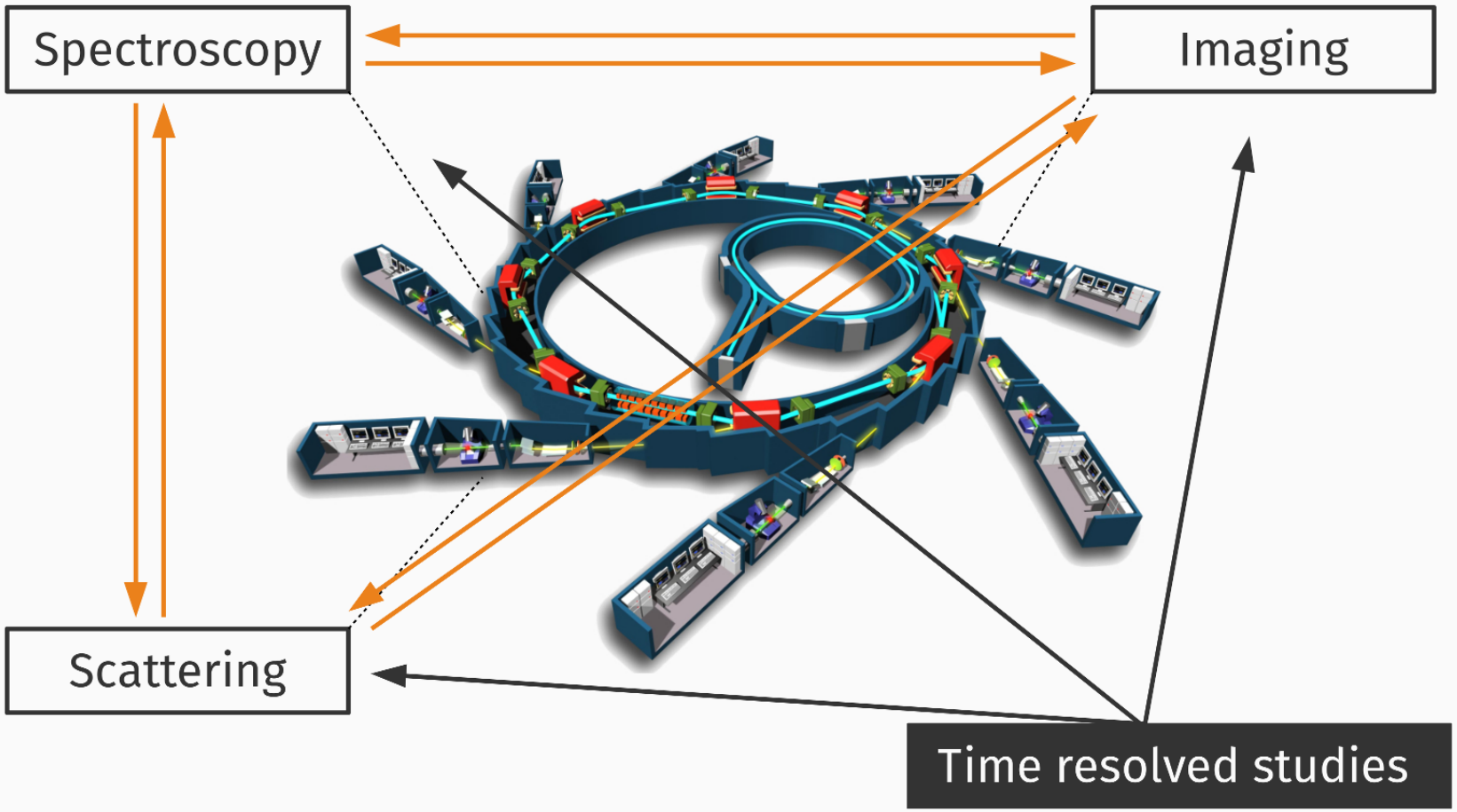
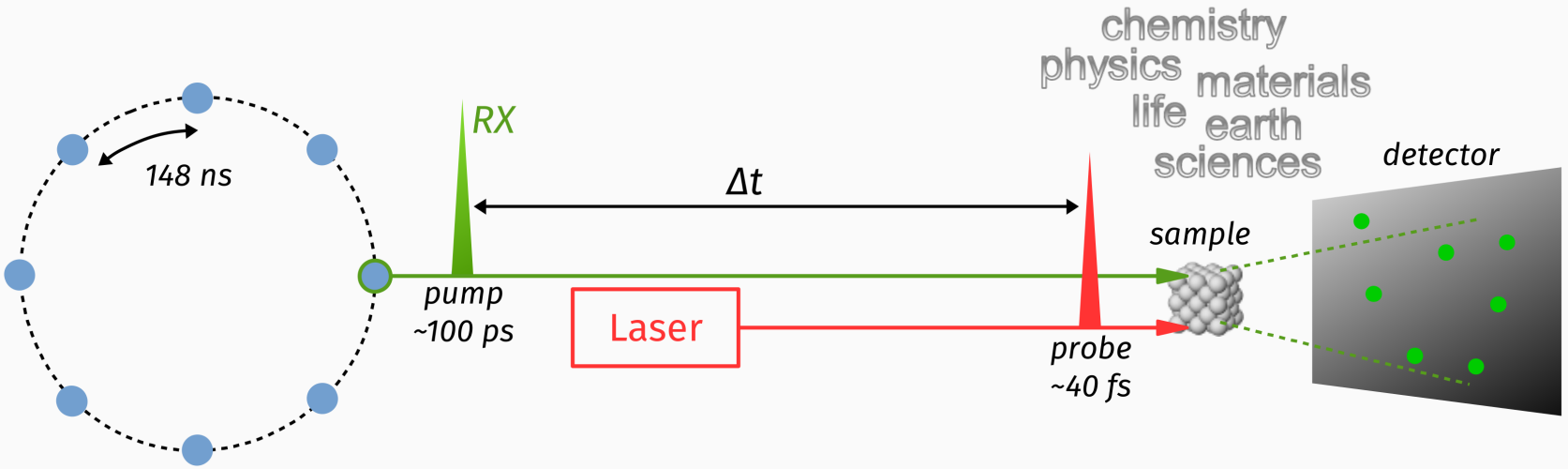


Synchrotron techniques



Scientific Motivation - experiment principle

Generic Pump–Probe Scheme



Time Resolved Studies at Synchrotron Light Sources

- pump–probe method: exploiting pulsed synchrotron beam for studies of induced structural dynamics by a very short laser pulses (fs range)
- time resolution depends on:
  - temporal convolution of pump and probe pulses (~100 ps range)
  - precision of the probe relative delay Δt

Scientific Motivation - challenges

A pixel detector dedicated and optimised for time-resolved studies

GATEABLE shutterless operation, count for few tens of ns

UNIFORMITY of gating over whole pixel matrix - few ns (bunch spacing)

PROBE Δt individually triggered fast counters (few) and fast readout

PHOTON FLUX above 10^9 photons/second per mm^2

ENERGY detection efficiency up to 40 keV $\Rightarrow$ **hybrid approach**

DETECTION several thresholds

SIZE small pixels ($\sim 20 \times 20$ μm^2) and large surface ($\sim 10 \times 10$ cm^2)

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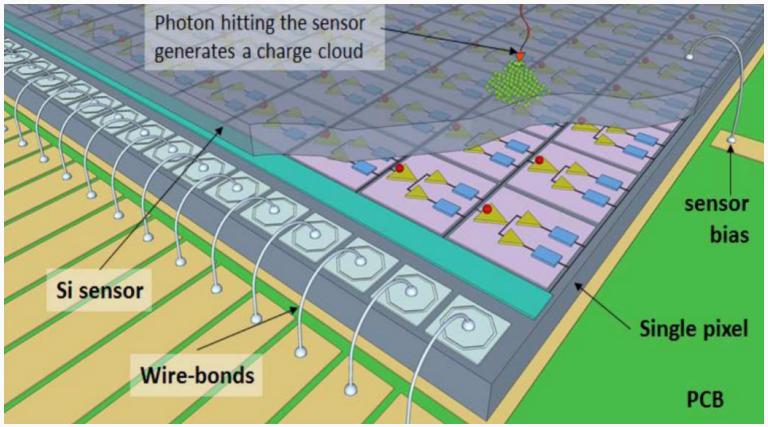
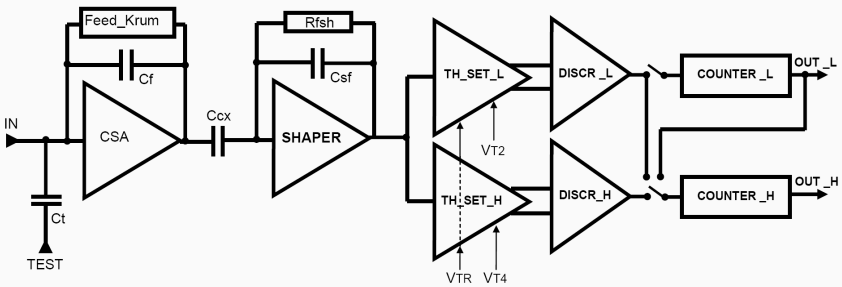
Such a detector does not exist yet

Preliminary Developments at Synchrotron SOLEIL

Detector prototype concept, main parameters





- hybrid, photon counting detector
- moderate pixel size (75 µm pitch)
- ~32k pixels in matrix
- two discriminators, two counters
- frames rate up to 50 kHz
- min. counting time ~100 ns

⇓

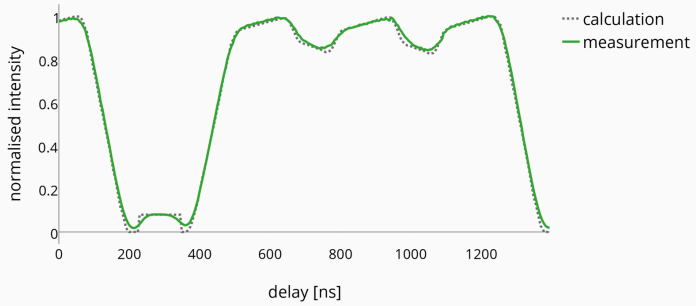
- implementation of the pump-probe-probe technique

Preliminary Measurements with Prototype Detector

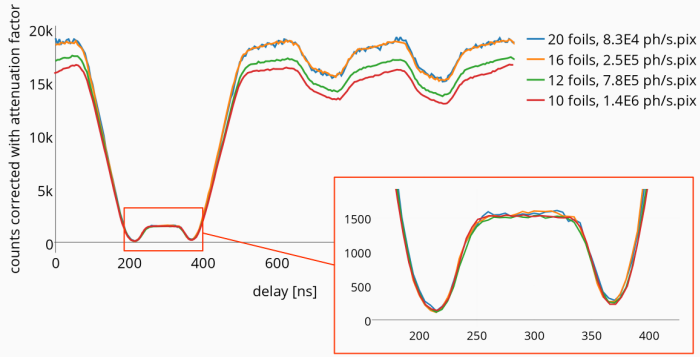
Synchrotron Filling Mode Scans

mapping of the storage ring filling mode by scanning the delay between the detector trigger and the machine reference signal

good matching with expected profile



withstands high photon flux (>10^8 ph sec^{-1} mm^{-1})



Pump-Probe-Probe tests

simultaneous acquisition of images with two different Δt - probing the sample before and after excitation

measured temporal uniformity ≈50 ns

Summary

Short Term Development

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  - use innovative and emerging technologies: interconnections, 3D electronics, TSV, new sensor materials
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Thank you !