Alternative synchronization approach of external sample environment and neutron data acquisition

A in-situ small angle neutron scattering-photo irradiation experiment setup

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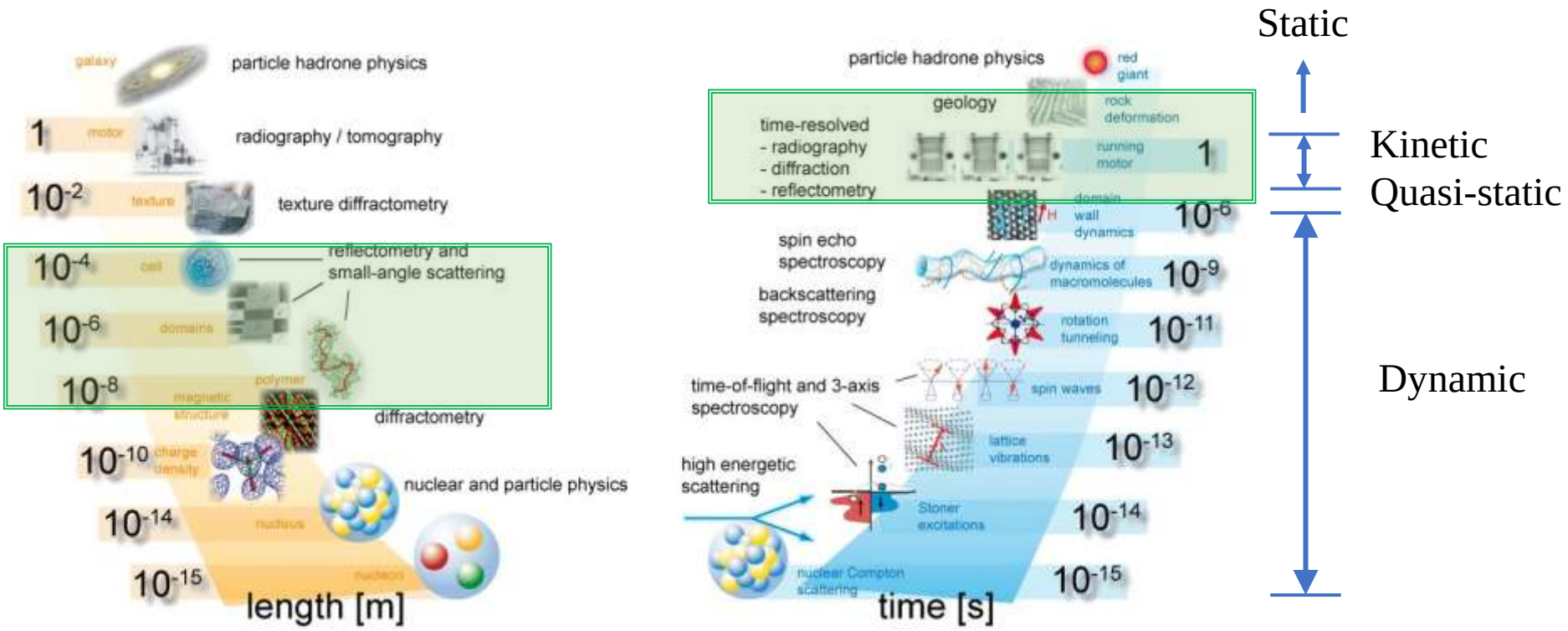
China Spallation Neutron Source

Length and time scale of neutron scattering techniques



(Picture: Karin Griewatsch, Kiel University, KFN)

Capture of kinetic process

Factors affecting time resolution:

- Neutron flux
- Instrument design
  - Beam collimation and aperture
  - Detection electronics
  - Data acquisition protocols
- Sample environment device
- Synchronized control techniques

Cost-efficient improvement

Capture of kinetic process

Coupled with sample environment devices

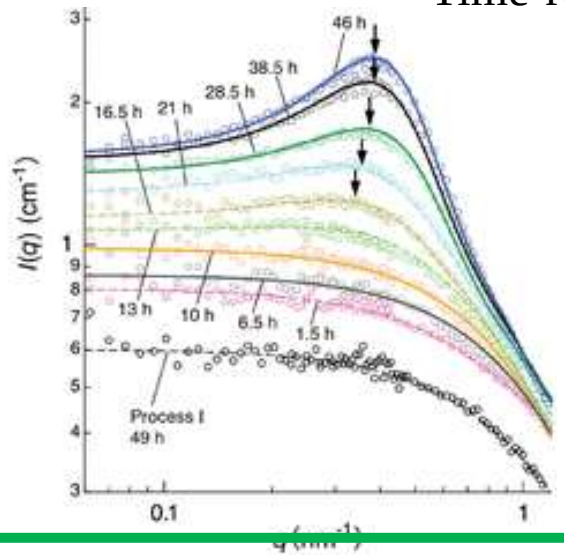
Histogram Sequential measurements with fixed width of time bins
limited by the performance of the detector read-out

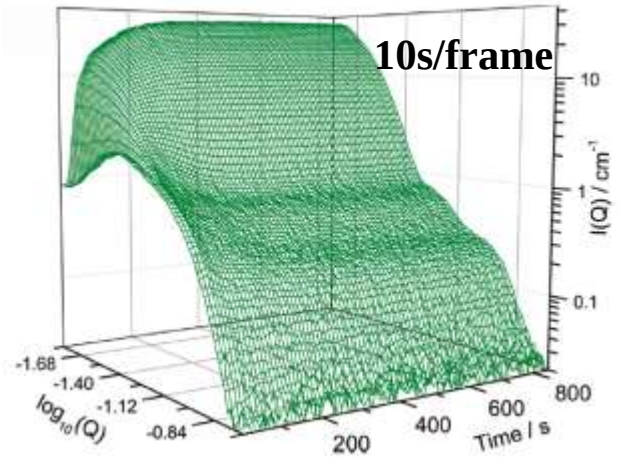
Event mode Time stamps (μs-ns) for each detected neutron

Single-shot measurement
(mins to hours)

Cyclic data acquisition
(sub ms to mins)

Time-resolved SANS

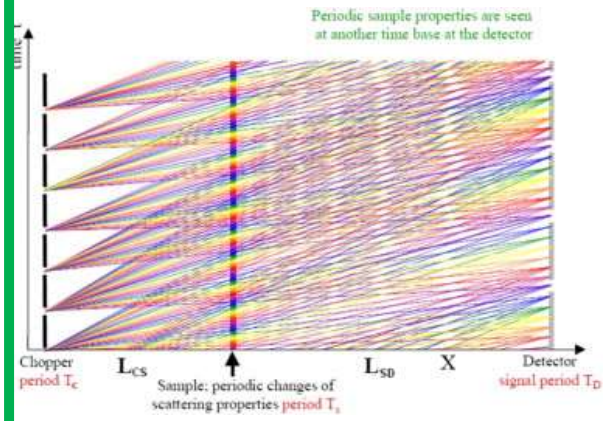




Polymerization process
Macromolecules 2010, 43, 19, 8218−8232

Growth of Silica Nanoparticles
Langmuir 2012, 28, 9, 4425−4433

Time-involved SANS



Physics Letters A 372 (2008) 1541−1546

Capture of kinetic process

Coupled with sample environment devices

Event mode

Sample environment device

Cyclic data acquisition

Time resolution?

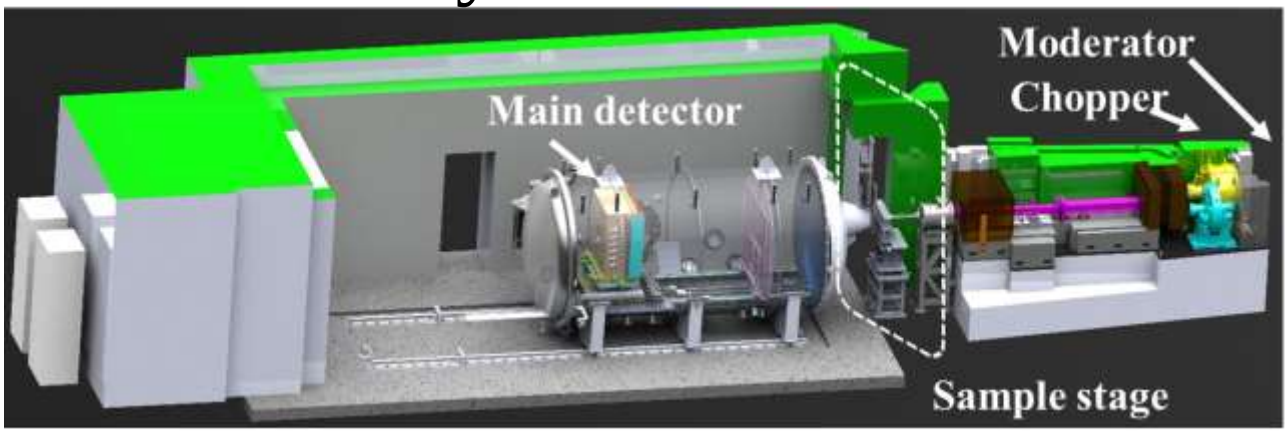
Synchronization/alignment of neutron data from each cycle

Instrument control system <— **Trigger signal** —> Device control system

Time stamp check

SANS @ CSNS

Instrument layout



Moderator	CHM (20K)
Detector area	1000×1000 mm^2
Detector resolution	10×8 mm
Wavelength range	1 -12Å
Neutron brightness	5×10^6 ($n\cdot cm^{-2}s^{-1}$) @100kW
Q-range	0.008-0.1.2 $Å^{-1}$ (SDD=2m) 0.005-0.6 $Å^{-1}$ (SDD=4m)

Data structure

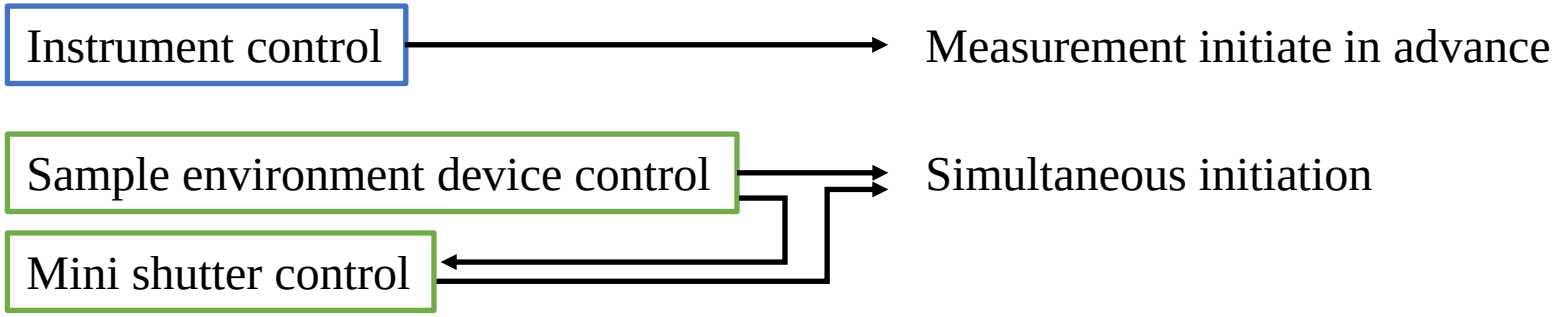
Detector nexus file

Run info	Start/end time in UTC (to second)
Event data	Neutron position, pulse ID, relative time within pulse (**4.56 μs/step**)
Histogram	

Waiting list:

1. More accurate initiation/end time
2. Sample environment data logging

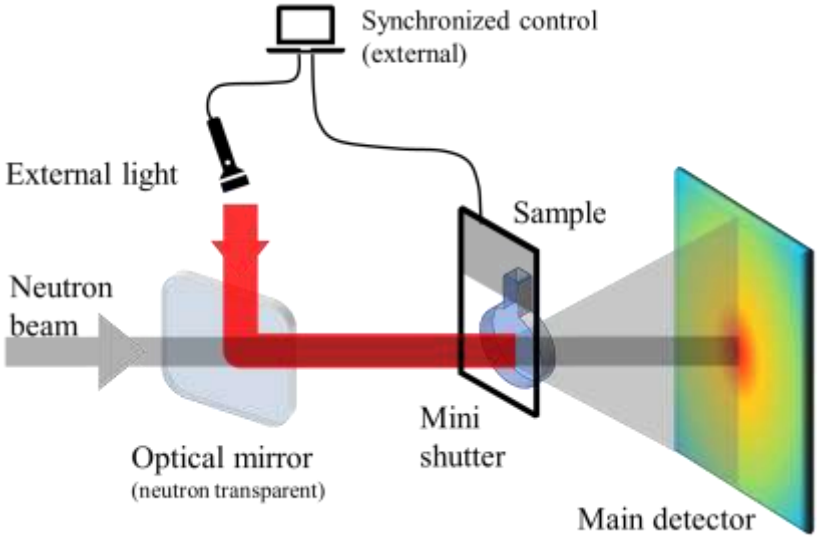
Photo irradiation device setup



Data alignment through detector counts examination

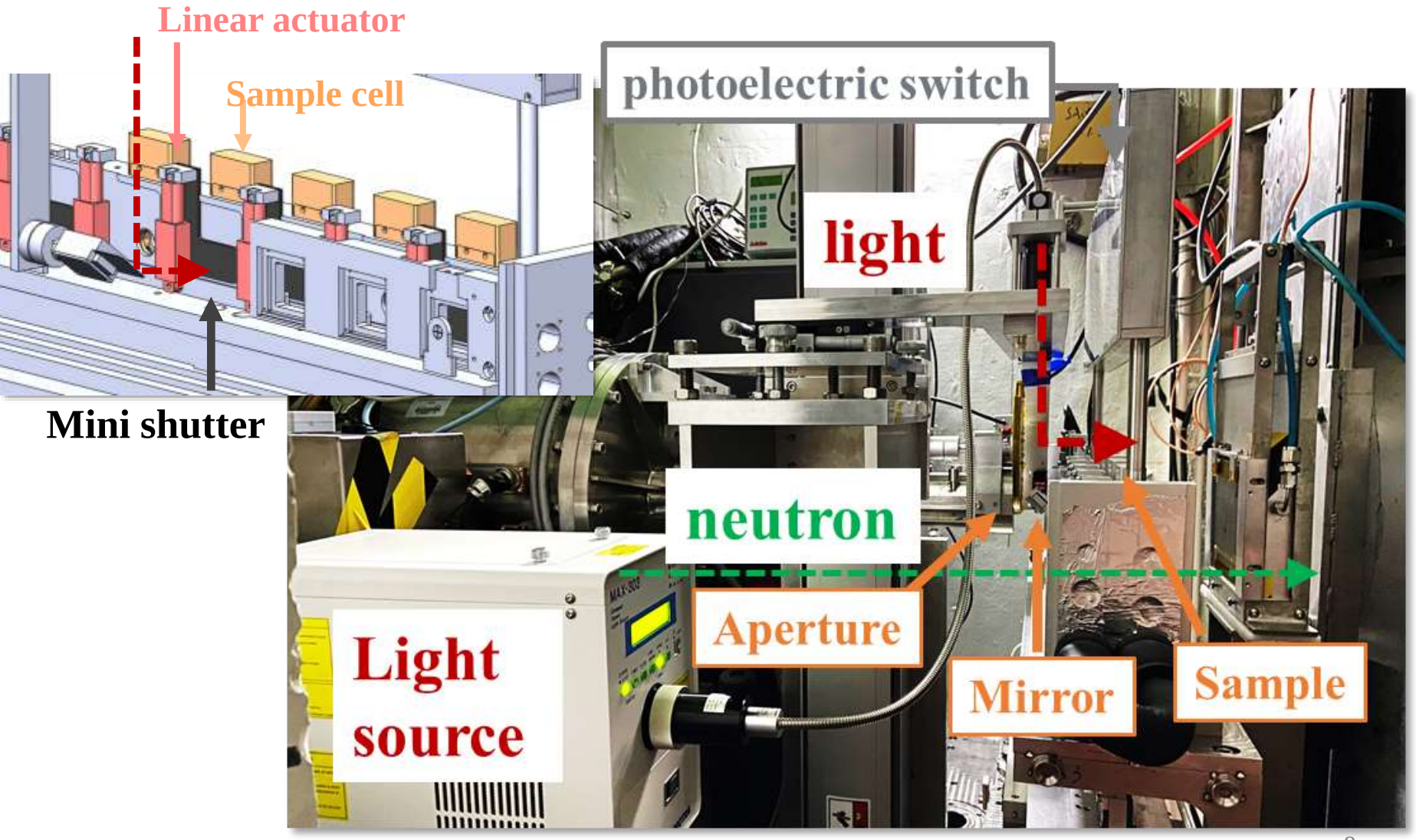
- ✓ Unperturbed instrument protocol
- ✓ Easier synchronization
- ✓ Accurate initiation point

(without requiring absolute timing)

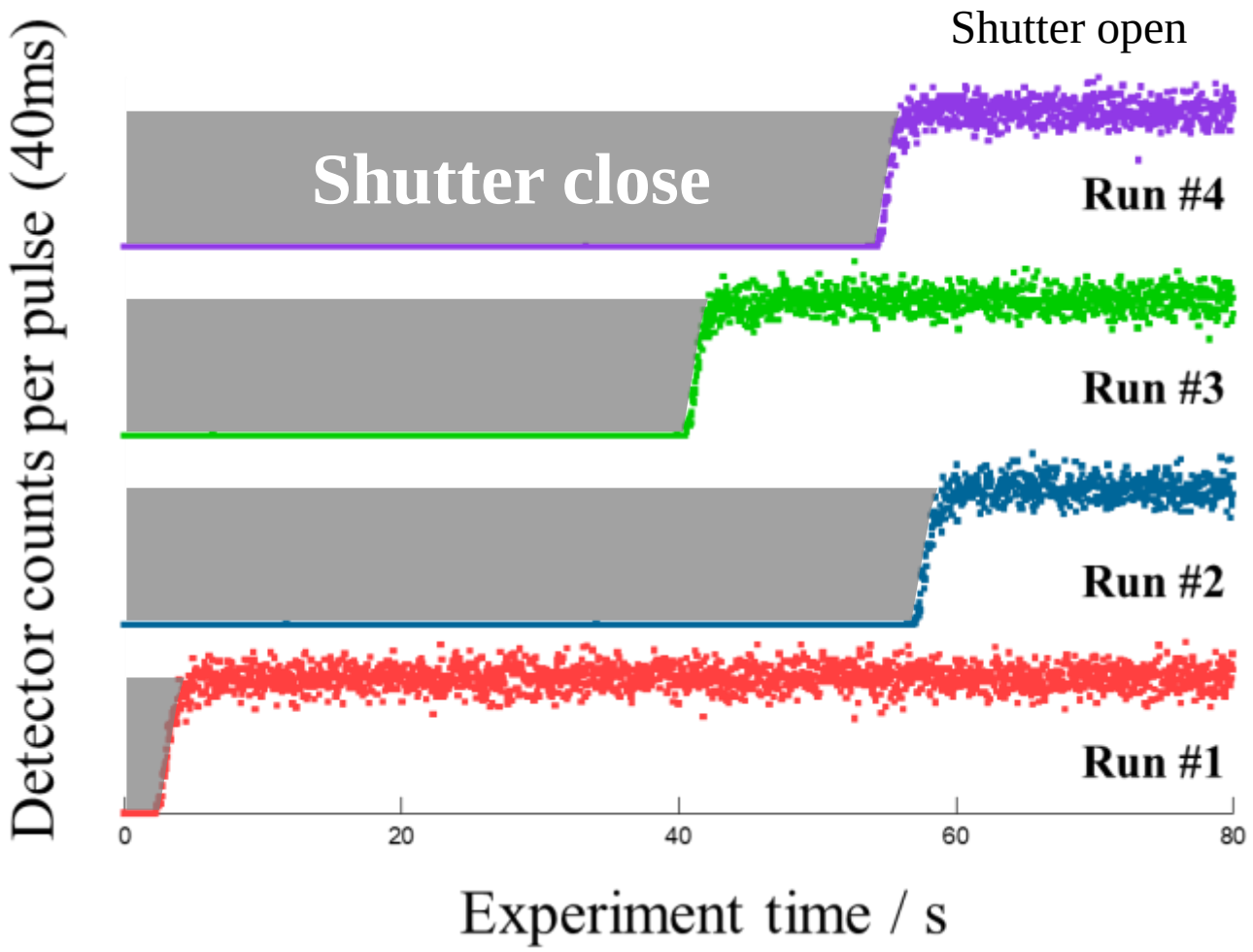


Time resolution = 1 pulse period (40ms)

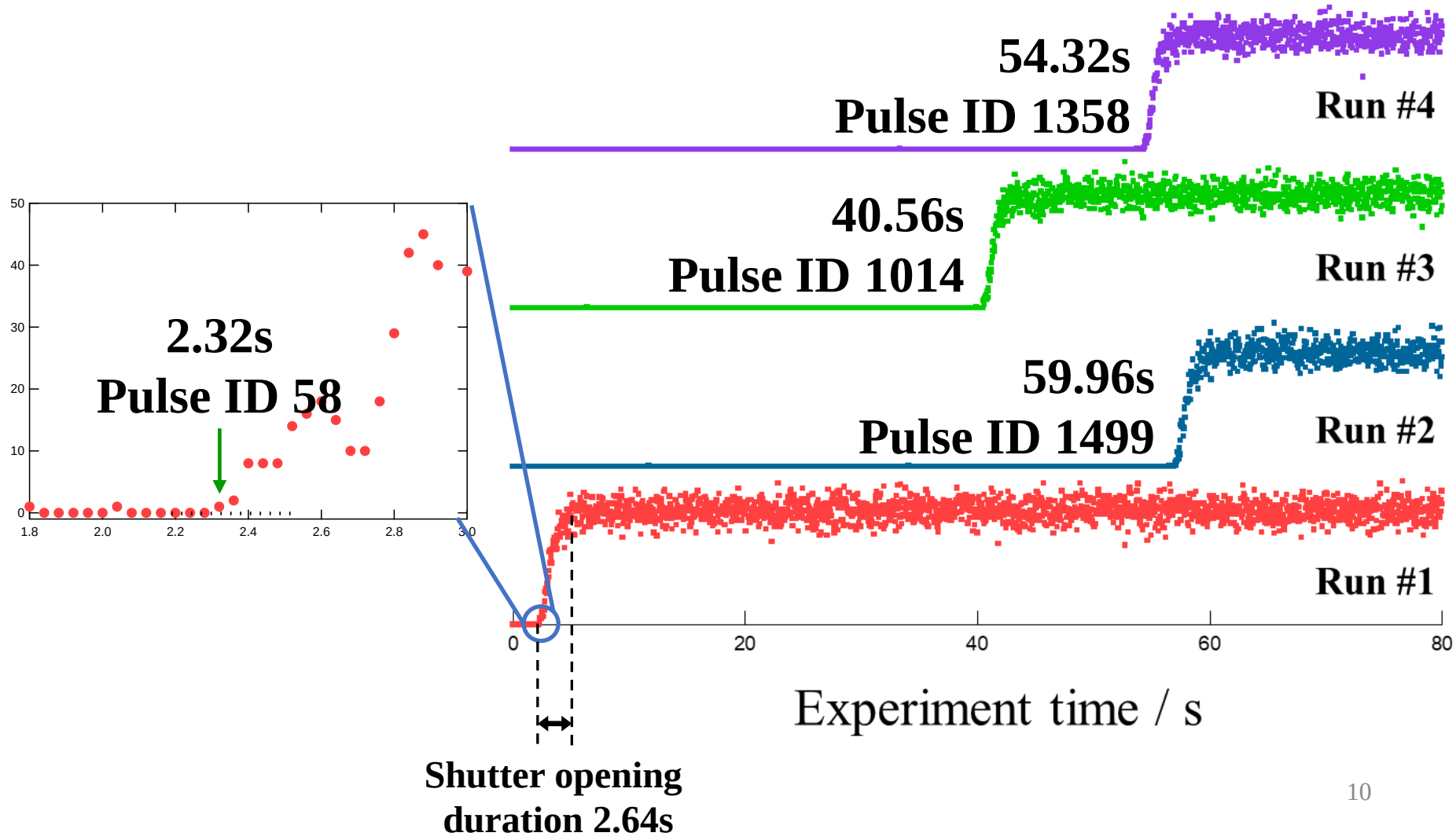
Photo irradiation device setup



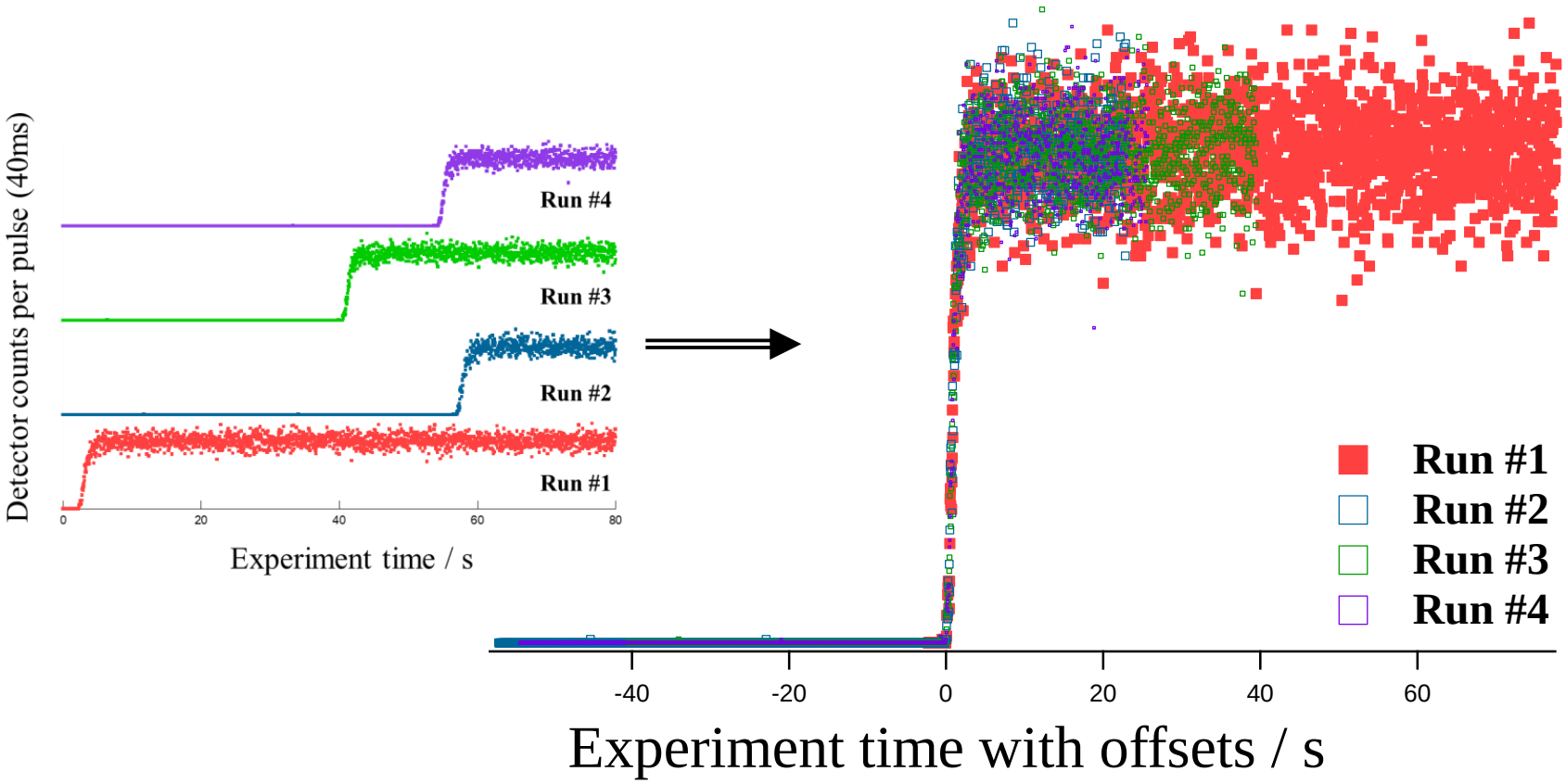
Shutter test



Shutter test

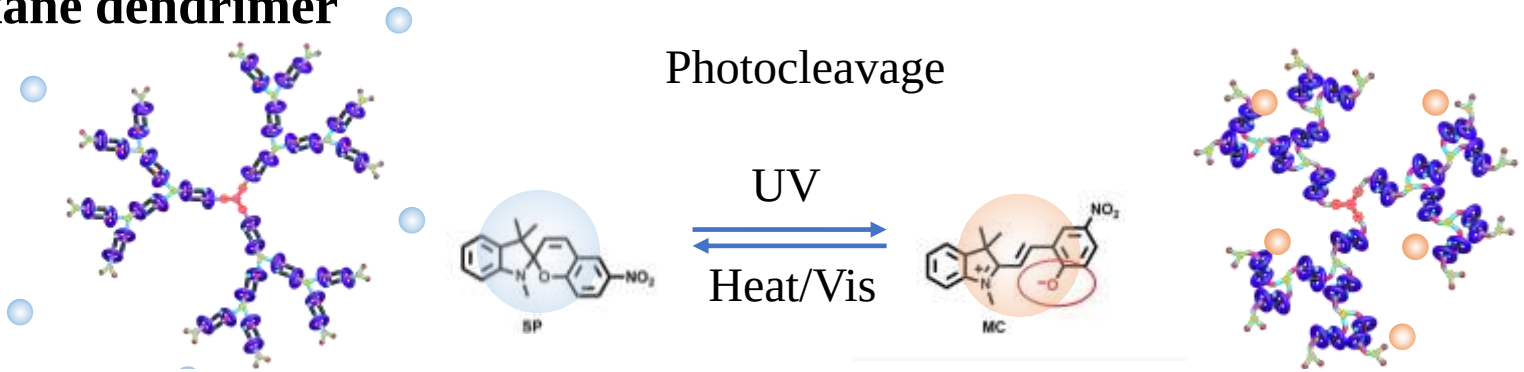


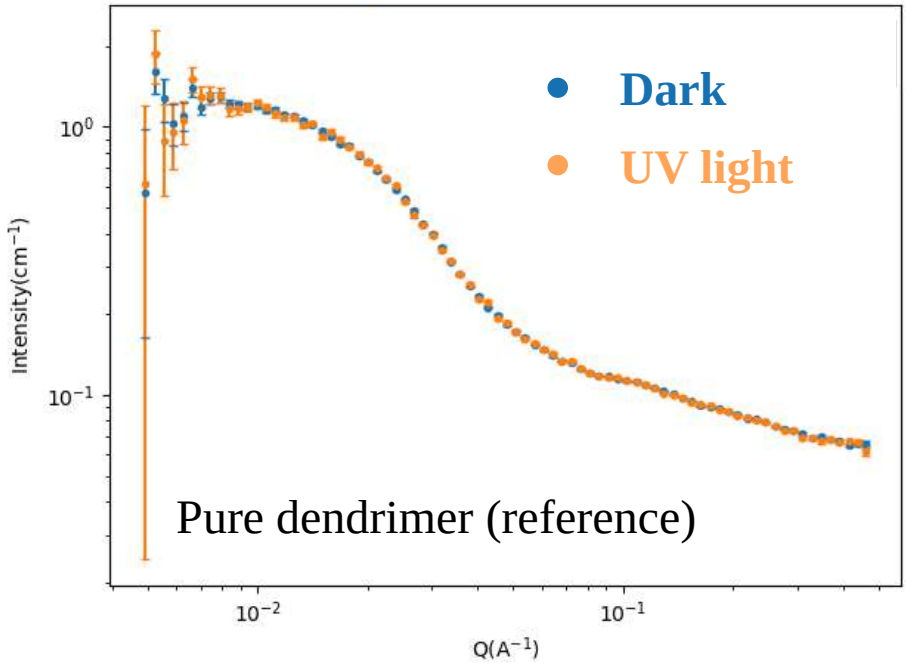
Shutter test

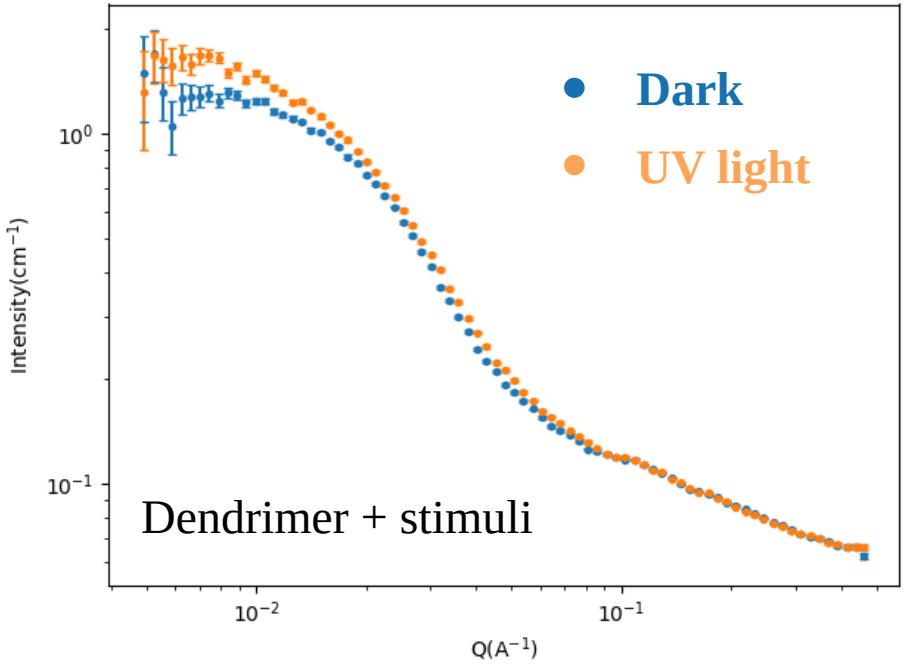


Experiment results

Rotaxane dendrimer





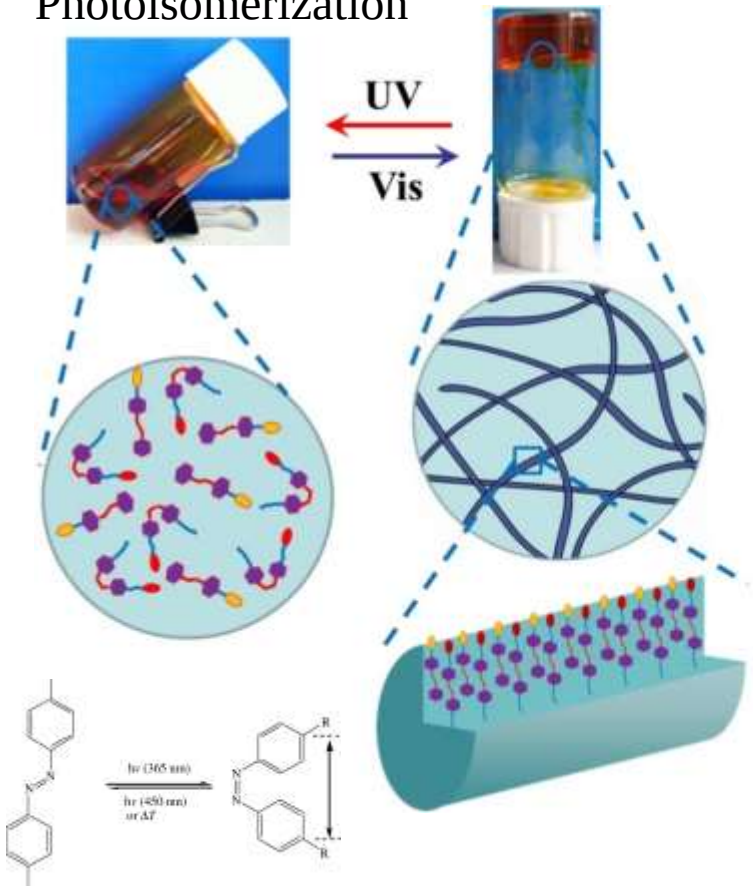


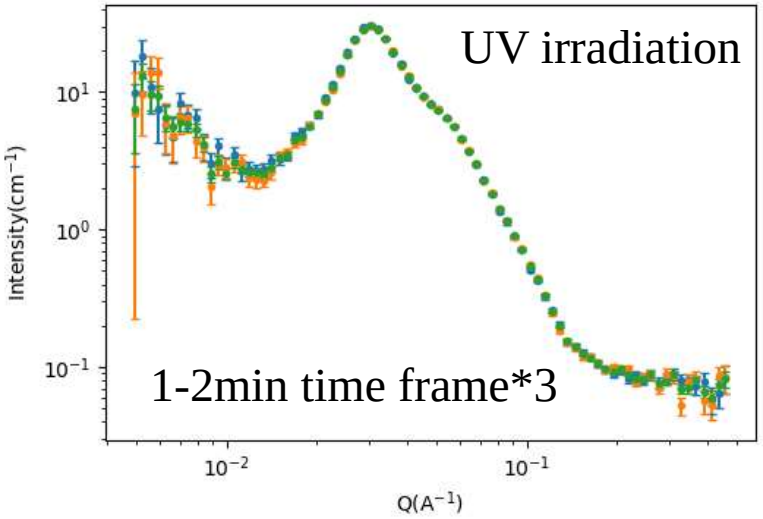
Steady state test User experiment (Prof. Yang Haibo, Dr. Li Weijian)

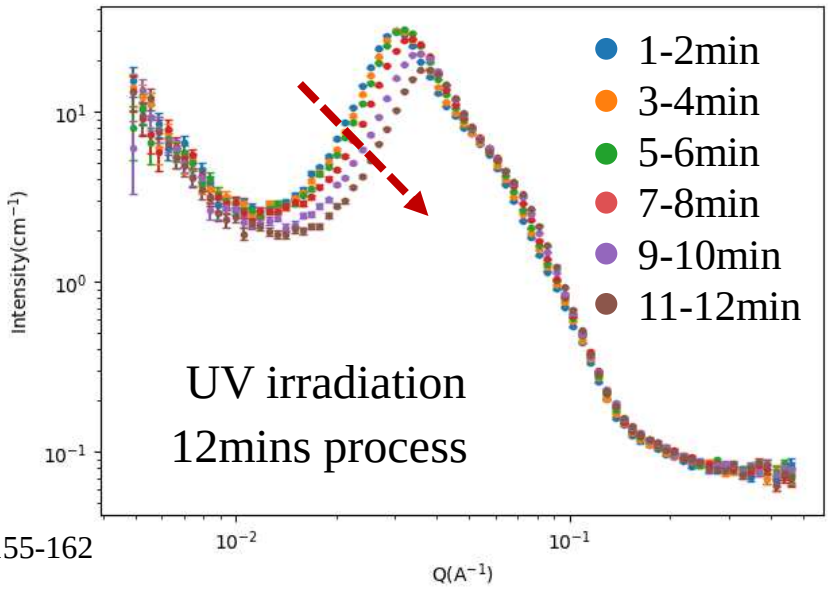
Experiment results

Azobenzene based surfactant

Photoisomerization







Sample provided by Prof. Jiang Jianzhong

Colloids and Surfaces A: Physicochem. Eng. Aspects, 2018,543:155-162

Future plan

- **Optimization of mini shutter: shape, speed, material**
- **Automization of data reduction process**
  - Allocation of shutter opening point
  - Truncation and superposition of neutron data
- **Decipher faster kinetic process**

Acknowledgement

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Long-term user and collaborator

Dr. Li Weijian

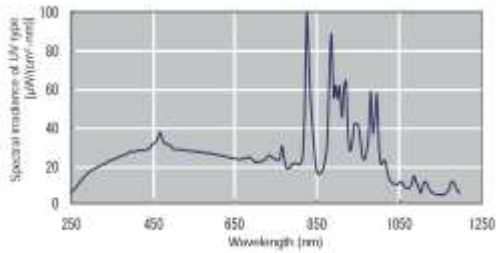
Jiangnan University

Prof. Jiang Jianzhong

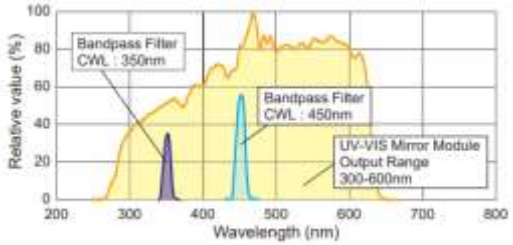
Thank you!

Light source

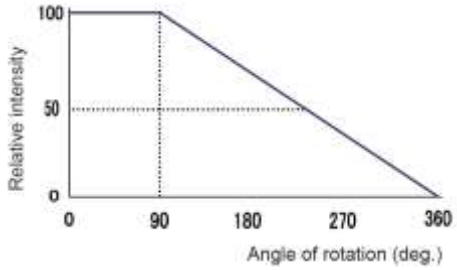
Full Spectrum
Xenon lamp (Full Spectrum)



Monochromatic light
Band pass filters×8



Adjustable intensity
Neutral density filter



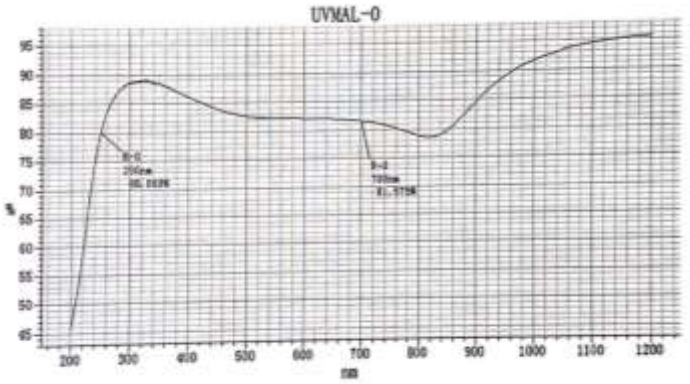
Optical mirror

Material survey

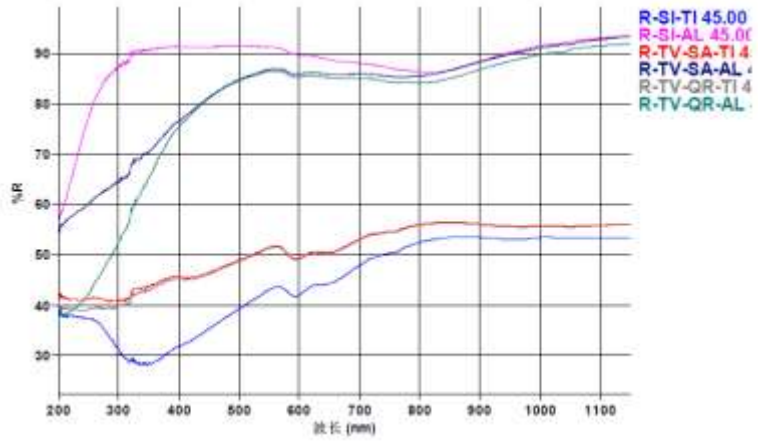
30*30mm

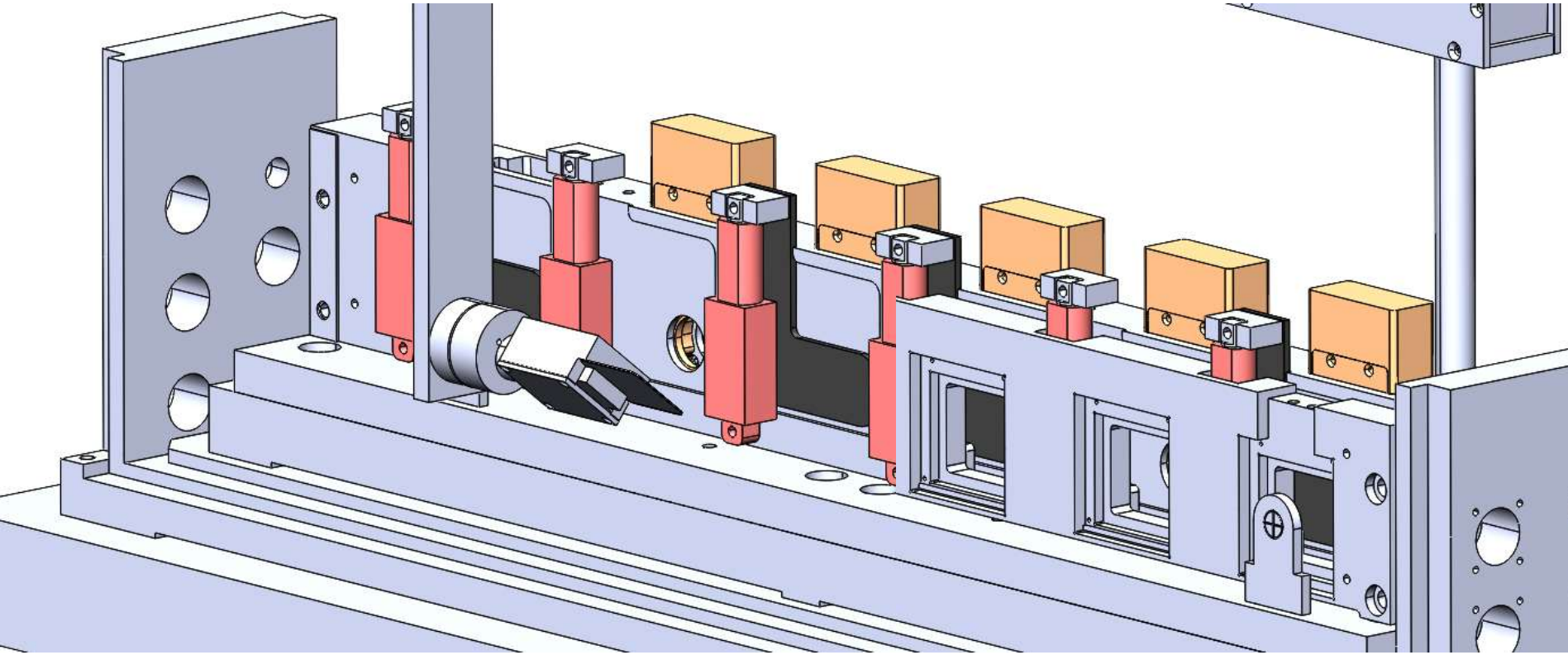
Mirror base/0.5mm	Coating （~100nm）
Quartz	**UV-Enhanced Aluminum**
	Aluminum
	Titanium
Sapphire	Aluminum
	Titanium
Silicon wafer	**Aluminum**
	Titanium

Quartz base coated with **UV-Enhanced Aluminum**



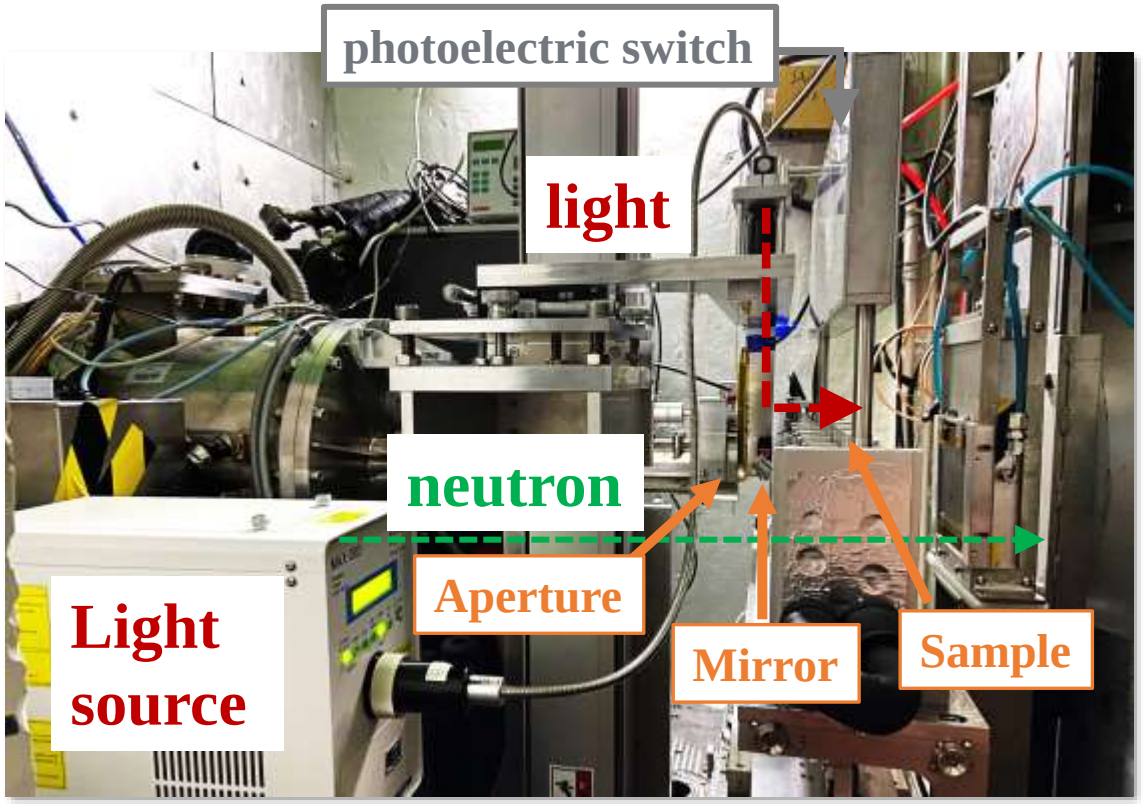
Silicon wafer base coated with **Aluminum**



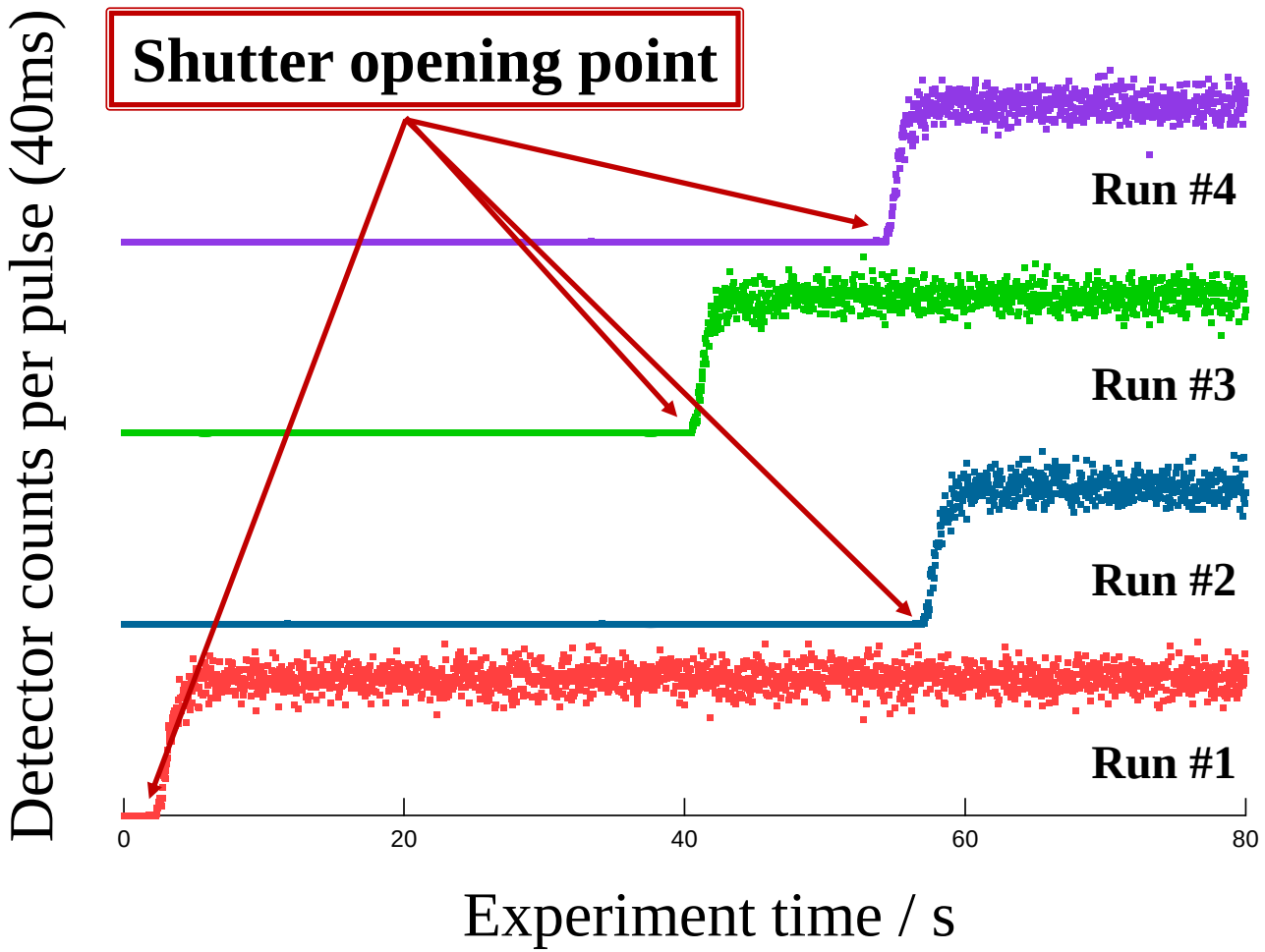


Capture of kinetic process

Coupled with sample environment devices



during operation (external stimulatio


Shutter opening point
Run #4
Run #3
Run #2
Run #1
Detector counts per pulse (40ms)
0
20
40
60
80
Experiment time / s