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Stråhlman, Christian; Sankari, Rami; Nyholm, Ralf

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LUND UNIVERSITY

PO Box 117
221 00 Lund
+46 46-222 00 00

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Possibilities of Timing-Based Spectroscopies at High Brilliance Storage Rings

Christian Stråhlman[1], Rami Sankari and Ralf Nyholm

MAX IV Laboratory, Lund University, P.O. Box 118, SE-221 00 Lund, Sweden

Synopsis Timing based spectroscopy instrumentation in most cases require pulsed light sources, thus limiting their use at storage rings to dedicated accelerator modes. However, recent developments in accelerator technology, chopper designs and instrument gating schemes allow for simultaneous running of high-intensity experiments and timing-based experiments. We will discuss how these advances can be combined to facilitate use of timing-based spectroscopy at storage rings.

Time-of-flight (TOF) based spectrometers remain indispensable tools in electron and ion spectroscopies. In electron-TOF a significant step forward has been taken with new angle-resolved time-of-flight spectrometers with much increased resolution and very high transmission [1]. Other advancements have come in the area of magnetic bottle spectrometers [2]. These instruments often demand pulsed light sources much below typical storage ring frequencies, thus limiting their use.

It is possible to increase the use of TOF-instrumentation considering recently expanded capabilities of storage rings: creating for example local single-bunch pulse structures for instruments with timing-requirements, while other beamlines simultaneously can benefit from high intensity, quasi-continuous light.

In addition to requiring pulsed light source, high precision timing instrumentation puts demands also on the length of the light pulse. As current developments in storage ring design have a strong focus on increasing brilliance it is unlikely that future storage rings will be optimized for timing-based experiments. Even so, it is of great interest for the spectroscopy community to utilize these new high brilliance light sources for timing based experiment.

We propose that solutions for adapting timing based experiments can be sought following four lines:

1. *Accelerator adaptations*, which include the use of hybrid modes either to be used in combination with choppers or to allow for pseudo-single-bunch (PSB). In the latter, a displacement or excitation of a hybrid bunch causes light to be emitted spatially separated from the multi-bunch train [3,4]. In this approach the disturbances to beam stability must be carefully considered. With present technology, hybrid mode is an absolute requirement.

2. *Choppers*, where new solutions with very small opening times have emerged. The Jülich MHz-chopper [5] represents to this day the shortest available opening time (150 ns). Paired with a 1.25 MHz repetition rate, it can be run together with hybrid modes in larger rings. These are ideal conditions for e.g. electron TOFs. MHz-choppers allow single-bunch instrumentation to be used at dedicated beam lines while all other experiments can use the light from the multi-bunch structure. Also smaller storage rings can benefit from this chopper when paired with single-bunch operation.

3. *Spectrometer gating*, where timing demands are met by blocking the emitted particles by means of pulsed electric fields. Within the development collaboration for the ArTOF, we have shown that operation with hybrid modes can be achieved with detector gating [6]. We have also proposed a scheme for gating close to the sample position [7].

4. *Coincidence measurements*, where a detection of some other emitted particle is used as a start trigger for a time-of-flight measurement.

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[1] E-mail: Christian.Strahlman@maxlab.lu.se