MEASUREMENT OF THE POLARISATION OF COHERENT SMITH-PURCELL RADIATION IN THE SOLEIL LINAC*

Nicolas Delerue, Stéphane Jenzer, Vitalii Khodnevych
LAL, Univ. Paris-Sud, CNRS/IN2P3, Université Paris-Saclay, Orsay, France
Nicolas Hubert, Marie Labat, Jean-Pierre Pollina, Marie-Agnès Tordeux,
Synchrotron SOLEIL, Gif-Sur-Yvette, France

Abstract

SPESO is an experiment installed in the Linac of Synchrotron SOLEIL to study the Coherent Smith-Purcell radiation produced when a grating is approached from the beam. The detectors used to measure this radiation are mounted on 3-translation axis and 2 rotation axis. This allows measurements of the radiation emission map around the grating. In addition a polarizer has been added in 2016 allowing to study the two polarization components of the radiation in this map. Preliminary results of this mapping will be presented.

INTRODUCTION

Coherent Smith-Purcell radiation is produced when a sufficiently short bunch of charged particles pass near a grating [1]. It has been proposed as a beam diagnostic to measure electron bunch profiles [2, 3]. In a bunch diagnostic based on Smith-Purcell radiation a good background rejection is important. Such rejection could be achieved by comparing both polarisation components of the radiation however there have been very few studies on the subject [4].

The Smith-Purcell Experiment at SOLEIL (SPESO) [5, 6] has been designed to allow extensive studies of Smith-Purcell radiation by measuring it parasitically in the SOLEIL Linac [7]. It has been described previously in [5].

The experiment has been upgraded during the summer 2016 with one of the radiation detector replaced with a Gaussian Optics Antenna from Mo-Tech fitted with two radiation detectors, one for each component. This antenna has a 3.5° angular resolution. It is mounted on three translation stages and two rotation stages allowing to move it around the interaction point along 5 degrees of freedom. The experimental setup is shown on figure 1.

PREDICTIONS

The polarisation of Smith-Purcell radiation has been calculated using a code (GFW) based on [1] and the prediction is shown in figure 2. The angle on the x-axis is the azimuthal angle measured from the direction of particle propagation. The degree of polarisation is computed as the ratio of difference between the vertical and the horizontal component divided by their sum. As we can see from the figure 2 the vertical component (parallel to the grating teeth) is dominating. We also notice a specific gap at 40° on this curve. This could be a signature predicted by grating theory [8]

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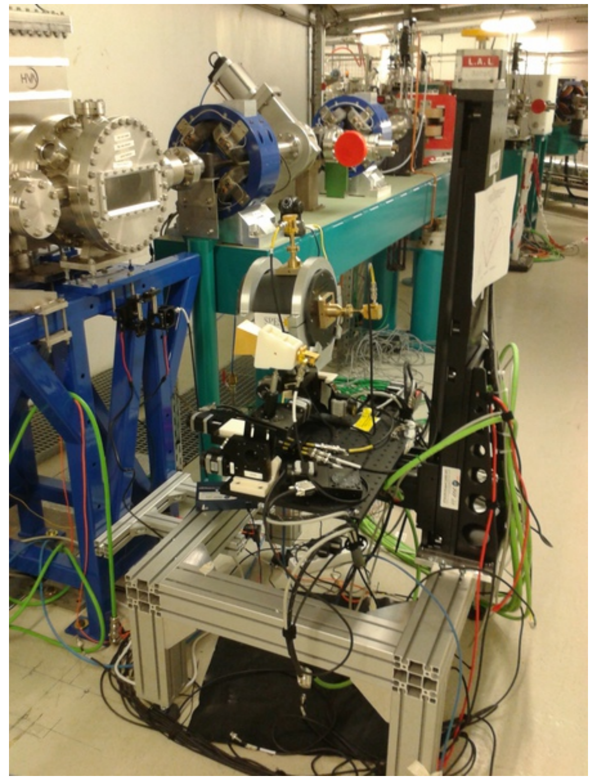

Figure 1: The SPESO experiment in the SOLEIL Linac. The polariser is shown in its rest position on three translation stages. The interaction chamber can be seen on the left of the pictures. The electrons travels from left to right.

for a radiation emitted (or reflected) by a grating such as Smith-Purcell radiation (SPR).

MEASUREMENTS

Using a Gunn diode on which the radiation is focussed by a horn antena we are able to measure the SPR produced by a 10 mm pitch grating. The radiation is in the range 20 GHz to 50 GHz. In this configuration the polarisation of the detector setup is vertical (parallel to the teeth of the grating). The results of this measurements for long pulse mode (described in [6]) are presented in figure 3. With this spectrum we are able to reconstruct the bunch averaged profile given in [6].

We made a similar study for other directions. In the X direction corresponding to an increase in the beam detector distance (perpendicular to the grating surface), the signal intensity measured decreases with the distance without showing any clear sign of oscillation as would be expected from

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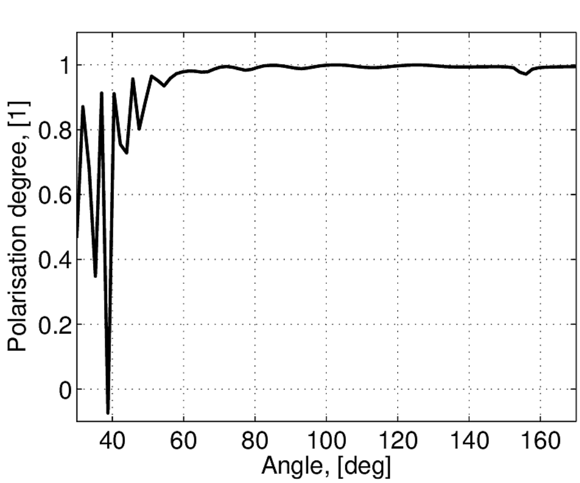

Figure 2: Degree of polarisation as function of angle for a 20 mm × 90 mm grating with 10 mm pitch, and a 20 mm beam-grating separation and for relativistic $\gamma = 200$.

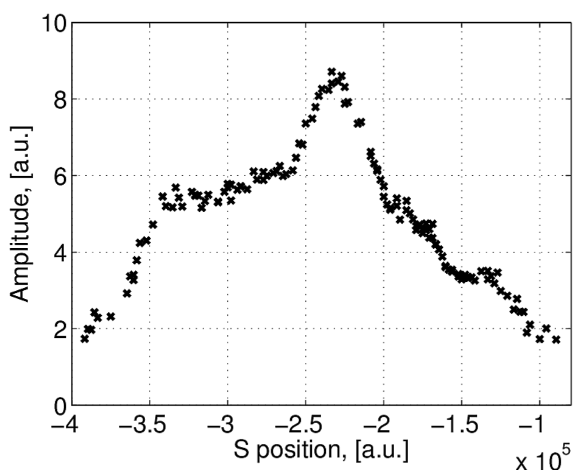

Figure 3: Spectrum of SPR as function of position for a beam charge of 0.5 nC to 0.55 nC. The S-position on the horizontal axis corresponds to a displacement of the grating along the beamline.

some pre-wave models [9] but further investigation is in progress. We have also studied the radiation in the zenithal angle ϕ and found that the distribution of radiation decreases with ϕ, in agreement with previous calculation[6] (see figure 5).

To be able to measure polarisation, we use a Gaussian Optics Antenna on which a mounted a polariser and two detectors measuring each polarisation component. By selecting data where all parameters (rotation angle, position, bunch charge etc.) but the longitudinal position remain constant we measure the degree of polarisation as function of the longitudinal position.

This study has been done both in high charge mode (LPM - 3.0 nC to 3.6 nC) and in low charge mode (SPM - 0.5 nC to 0.55 nC). As we can see there is a remarkable agreement between the two different operation modes.

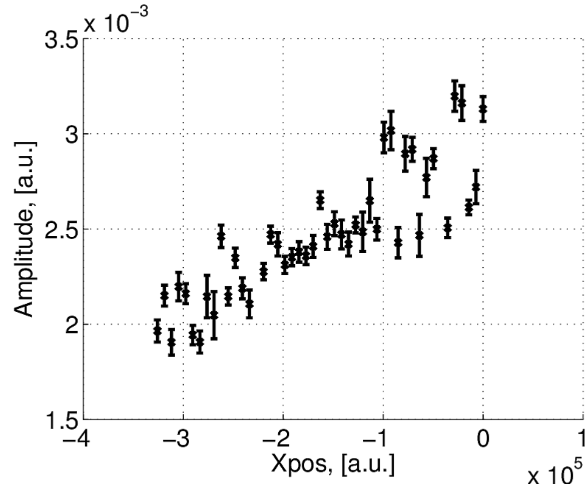

Figure 4: Amplitude of the signal as function of beam-detector distance with a beam charge of 3.0 nC to 3.6 nC with the others parameters unchanged.

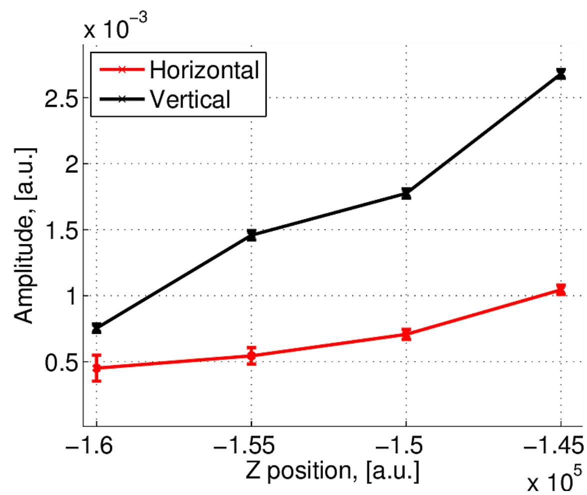

Figure 5: Amplitude of the signal as function of vertical displacement (along the teeth of the grating) for vertical and horizontal components measured with the polariser mounted on the Gaussian Optics Antenna.

The fact the the radiation is not fully polarized can be interpreted by the presence of unpolarized background radiation in our measurement as seen also in [4]. Apart from that reduced polarisation we see that the expected dip is present albeit wider than expected.

CONCLUSION

We have made a first measurement of the polarization of Smith-Purcell radiation. The results are promising but require further investigations that are on-going.

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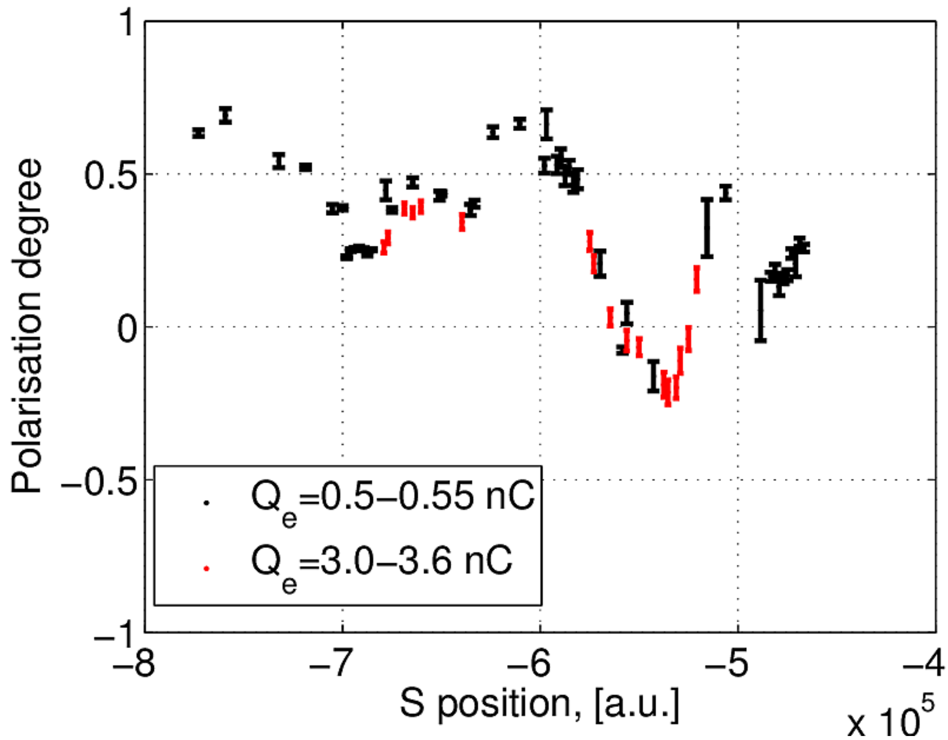

Figure 6: Degree of polarisation as function of the longitudinal displacement (along the beam propagation axis).

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