SPESO report

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1 Introduction

Coherent Smith-Purcell radiation is produced when a sufficiently short bunch of charged particles pass near a grating ?. It has been proposed as a beam diagnostic to measure electron bunch profiles ??. 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 ?.

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

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^o 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.

1.1 Geometry @ 28/07/2017

Dimension	value
Front of chamber - polarizer split point	30.1 cm
Front of chamber - polarizer front (black shield)	19.2 cm
Front of chamber - polarizer back (black shield)	36.6 cm
Beam-pipe center - ground	120 cm
Polarizer center - ground	122 cm
Front of chamber - front window of DET3	24 cm
Beam-pipe center - Front of chamber	10 cm
DET3-Polarizer	25.5 cm
Front of chamber - Pyro	49.5 cm

Translation stage are manufactured by OWIS

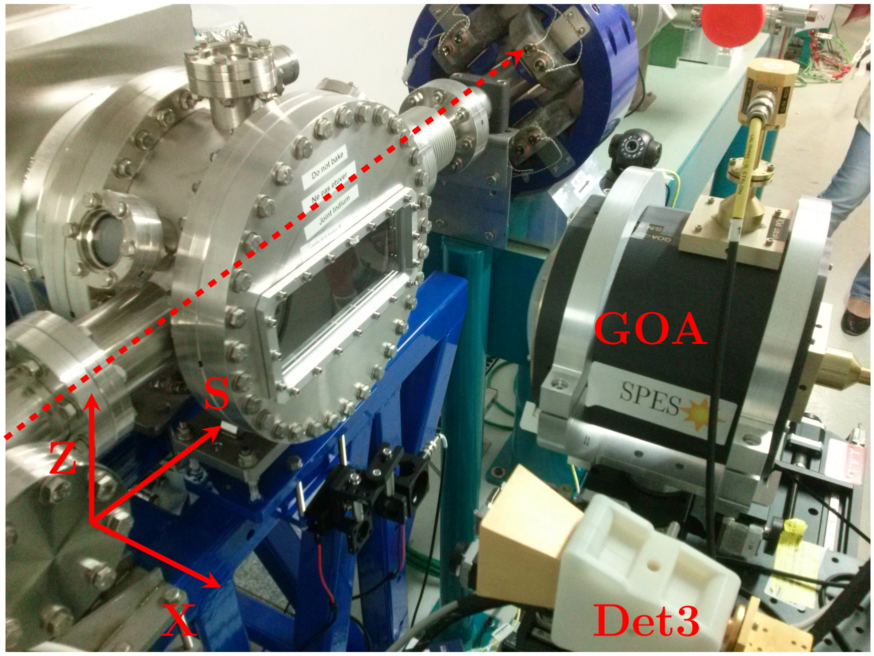
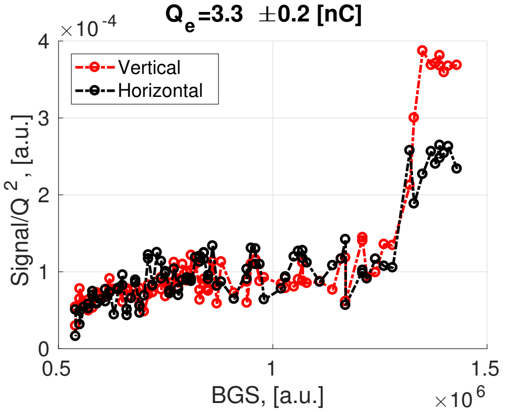


Figure 1: The SPESO experiment in the SOLEIL Linac.

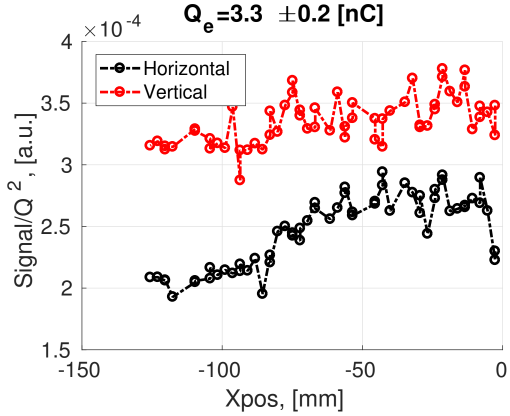
TS	41.123.40 AD
TX	41.123.40 AD
TZ	41.170.60 AG

2 Check of basic properties of SPR

Theory of Smith-Purcell radiation predict exponential increase of radiation with approaching grating to the beam. In figure 2a is shown normalized by square of change signal amplitude as function of beam-grating separation (BGS) for two polarization components. In signal we could determine two components: signal of SPR and background. Observation of this kind od dependences allows to determine background level of the signal.



(a) Normalized by square of change signal amplitude as function of beam-grating separation for two polarization components. Short pulse mode, $QICT_1 = 3.37 \pm 0.02$, $QICT_2 = 1.23 \pm 1.24$, $RS_1 = 2$, RS_2 = -45, $RS_3 = 0$, $RS_4 = 0$, XPOS = 0, ZPOS = -145000, SPOS = -670000



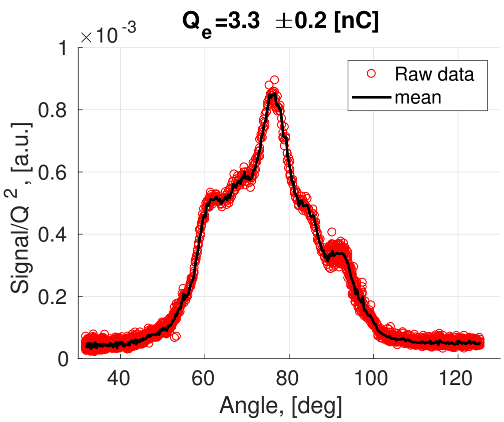
(b) Decay of the signal as function of detector-grating separation for two polarization components. Short pulse mode, grating position = 1450000, $QICT_1 = 3.4 \pm 0.01$, $QICT_2 = 0.87 \pm 0.96$, $RS_1 = 2$, RS_2 = -45, $RS_3 = 0$, $RS_4 = 0$, ZPOS = -145000, SPOS = -670000

Figure 2: Experimental data

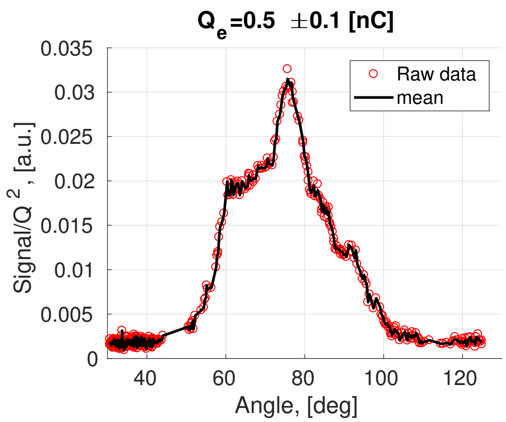
One of the competitions of measuring SPR is to measure spectrum in wide angle with many detectors (each detector measure only one frequency component). Up to some limit, increase of detectors will increase quality of profile reconstruction. Main restriction is detector size and absorption of the radiation in medium. Last problem could be solved by installing detector close to the grating, but from other side this will limit number of detectors. We made measurements of decay signal amplitude as function of detector-grating separation. Results of this measurements You could see on the figure 2b.

3 Spectrum of SPR in Long Pulse Mode

Except polarizer on SPESO was insalled also detector with Horn anthena. Anthena increase sensitivity of the detector and we can see signals in long pulse mode (LPM). This spectrums for low and high charge are presented on figure 3.



(a) Spectrum of SPR for high charge. Long pulse mode, grating position = 1450000, $QICT_1 = 3.2 \pm 0.05$, $QICT_2 = 3.11 \pm 0.07$, RS_1 = 2, RS_2 = -45, RS_3 = 0, RS_4 = -3, XPOS = 0, ZPOS = -145000, SPOS is changing.



(b) Spectrum of SPR for low charge. Long pulse mode, grating position = 1450000, $QICT_1 = 0.51 \pm 0.01$, $QICT_2 = 2.44 \pm 1.13$, RS_1 = 2, RS_2 = -45, XPOS = 0, ZPOS = -145000, RS_3 is changing during measurements, but as its belong to other detector, there is no cut. RS_4 change one time during measurement (almost no change) and SPOS are changing.

Figure 3: Experimental results

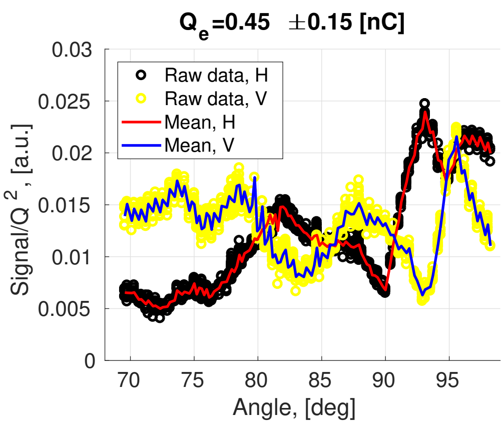
This data set for this detector is not really correct, as there was no detector rotation. Also there was no shots in LPM with low charge. So figure 3b have only error information inself. Figure 3a contain horn anthena angular acceptance information convoluted with detector sensitivity.

4 Spectrum of SPR in Short Pulse Mode

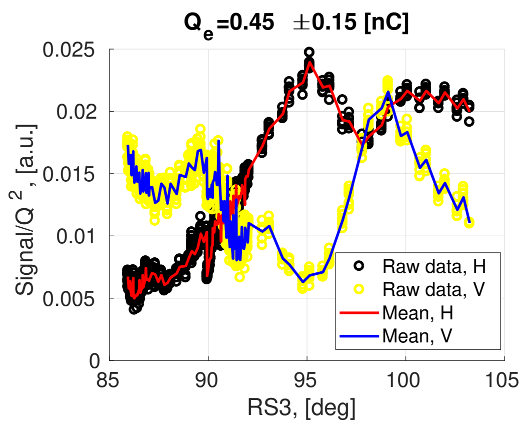
Pulses only in SPM mode are visible with polarizer. Experimental results are presented on figure 4 and 5.

During measurements of this spectrums, we change position of detector and turn angle in horisontal plane (RS3). When detector is not rotated, detector see only one frequency and small change of the borders of the grating (discussed in appendix). With 3.5^o angular acceptance of polarizer (efficiently small) we have exactly this situation. That case presented on figure 5a. Here angle is calculated in Θ terms of theory of Smith-Purcell radiation with respect to shift from center of the grating. Same units was used for figure 4a. But this time RS3 is also is changing. From other side, we could present spectrum in units of RS3 turn.

Results of degree of polarization for this two data sets are presented on figure **??**

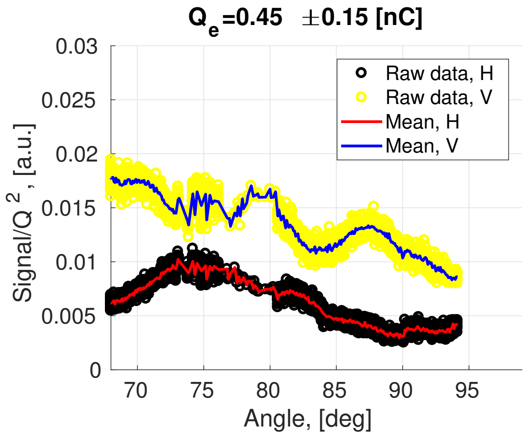


(a) Measured SPR spectrum from the end of April to current date as function of angle calculated from detector position. Short pulse mode, grating position = 1450000, $QICT_1 = 0.44 \pm 0.18$, $QICT_2 = 0.53 \pm 0.59$, $RS_1 = 2$, RS_2 = -45, $RS_4 = 0$, XPOS = 0, ZPOS = -145000, RS_3 and SPOS are changing.



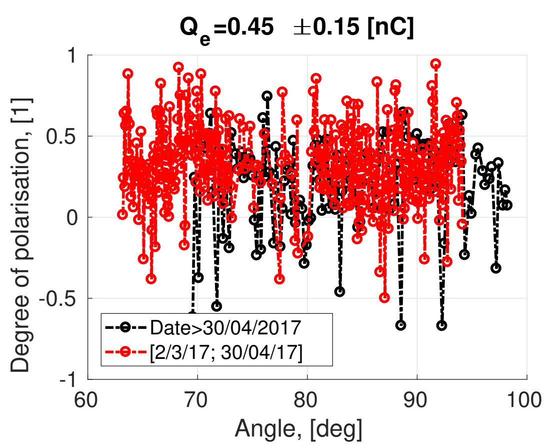
(b) Measured SPR spectrum from the end of April to current date as function of angle calculated from detector rotation RS3. Short pulse mode, grating position = 1450000, $QICT_1 = 0.44 \pm 0.18$, $QICT_2 = 0.53 \pm 0.59$, $RS_1 = 2$, RS_2 = -45, RS_4 = 0, XPOS = 0, ZPOS = -145000, RS_3 and SPOS are changing.

Figure 4: Experimental results.

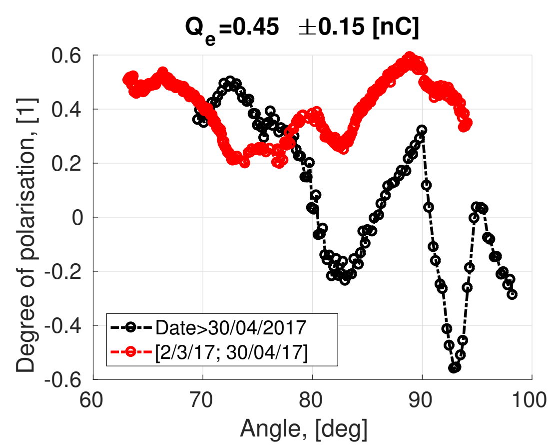


(a) SPR spectrum with change only of position of detector, without rotation. Short pulse mode, grating position = 1450000, $QICT_1$ = 0.47 ± 0.16, $QICT_2$ = 0.49 ± 0.37, RS_1 = 2, RS_2 = -45, RS_3 = 0, RS_4 = -3, XPOS = 0, ZPOS = -145000, SPOS is changing

Figure 5: Experimental results.



(a) Polarization of SPR background

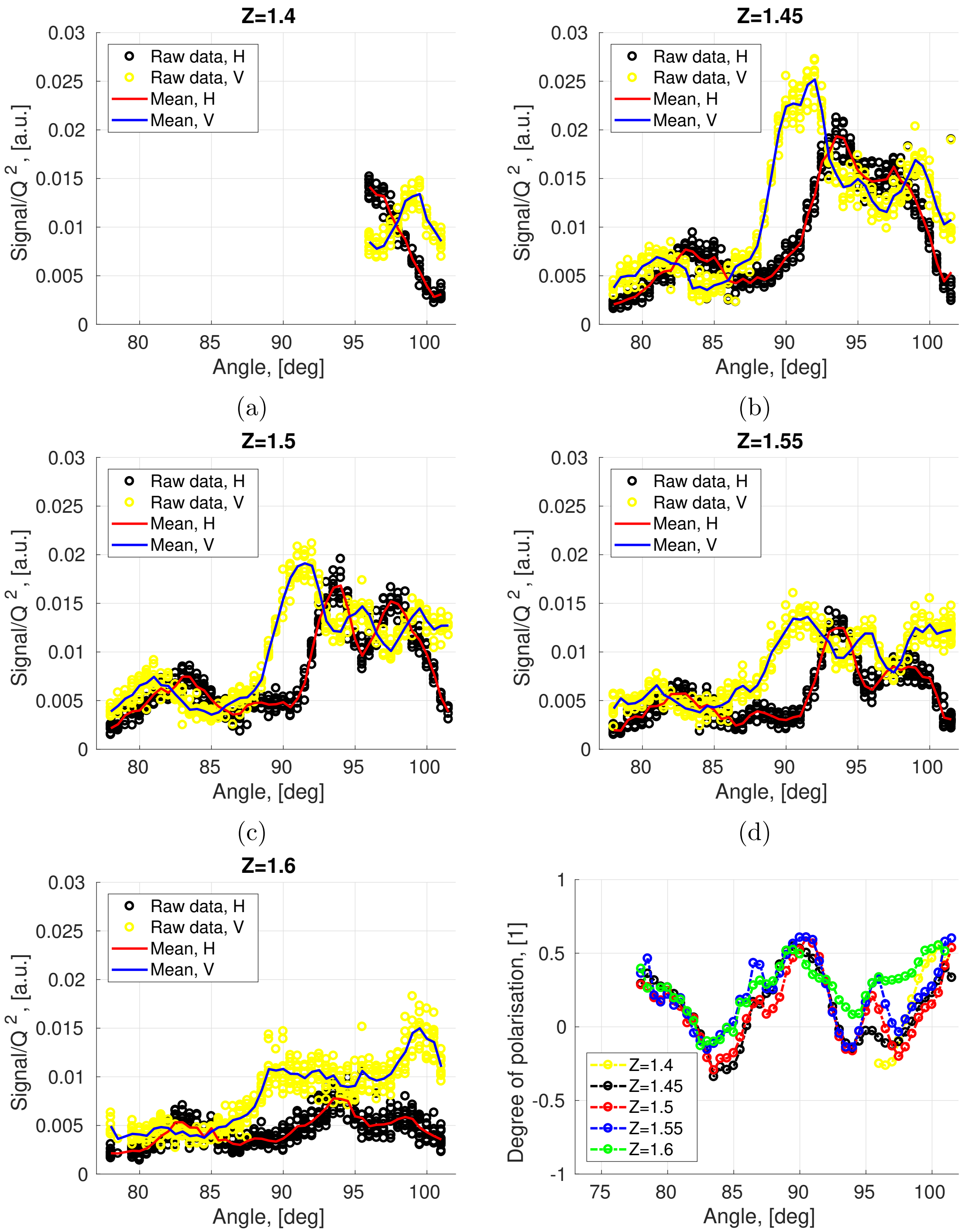


(b) Polarization of SPR

Figure 6: Experimental results. Polarization

5 Z axis (ϕ)

Same corrections as for S axis, could be applied to Z axis (see Appendix). As grating is not wide, boundary effects are strong and we could observe change of spectrum with change of detector height. Increase of height cause decrease of signal amplitude and change of spectral components, while polarization is almost constant (see fig. 7f).



(a) (b) (c) (d) (e) (f) Polarization

Figure 7: Experimental results. SPR spectrums as function of vertical detector displacement.Short pulse mode, grating position = 1450000, $QICT_1$ = 0.41 ± 0.01, $QICT_2$ = 0.36 ± 0.02, RS_1 = 2, RS_2 = -45, RS_4 = -3, XPOS = 10000, ZPOS, RS_3 and SPOS are changing.

6 Next steps

- Decrease DET3 amplification.
- Check dimensions of setup and all main sizes – done!
- Change script for detector rotation
- Check pyrodetector.
- ????

7 Appendix

Current experimental setup require careful geometrical correction. First step, is taking into account limit size of grating (see fig. 8). We divide the problem in two parts: when both sides of detector see the grating (green lines) and when only one half of detector saw it (red lines). So in case detector move parallel to the grating, angles of grating borders are changing respectively to observation point. United for both cases result present on figure 9. Here α_1 and α_2 are angles from which detector saw grating borders when it move along S axis (real SPESO dimention was taken into account).

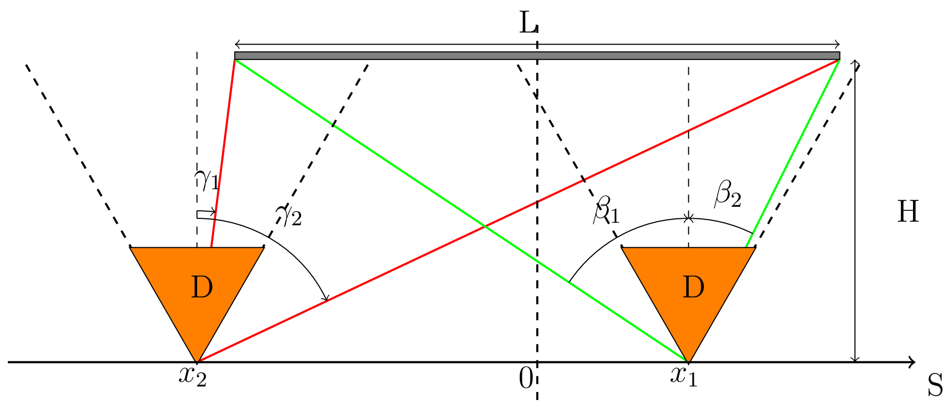


Figure 8: Geometrical corrections

Second step is to take into account angular acceptance of detector when its not rotating (green, dashed lines on fig. 9). Rotation of detector change angular acceptance and integrated region of frequencies in signal integral. Reared should note, that without rotation and with small angular acceptance, this frequency region will be the same along all grating, up to grating borders. From other side, current model is for infinite grating and exact impact of finite grating size should be investigated.

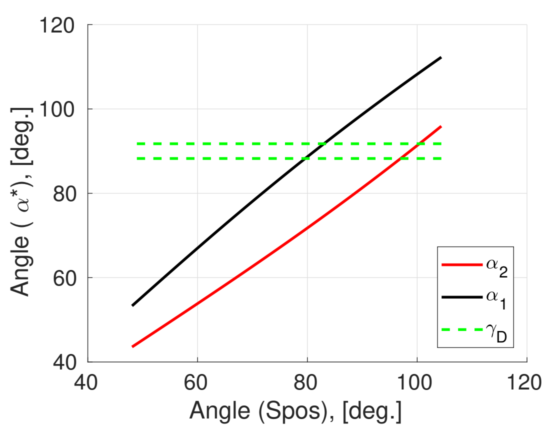


Figure 9: Geometrical corrections

Third step is taking into account grating rotation, which is simple shift in angular acceptance.

Using all this correction, we are able to calculate correctly signal of SPR from current (gfw) model