Study of the Polarization Properties of Coherent Smith-Purcell Radiation at the LUCX (KEK) facility

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Introduction

• Motivation
• Experiments
• Results and Analysis
• Conclusions and Future Work
Motivation

• A single-shot longitudinal beam profile monitor using coherent Smith-Purcell radiation (cSPr) is being developed.

• The previous, proof-of-principle, multi-shot Smith-Purcell monitor (E203, SLAC) had to deal with high levels of background radiation.

• Theory shows cSPr to be highly polarized – it has been proposed that the signal and the background could be separated using polarizers.
Smith-Purcell Radiation

\[ \lambda = \frac{l}{n} \left( \frac{1}{\beta} - \cos \theta \right) \]
Simulations (LUCX)

Simulation Result: Intensity at LUCX

Simulation Result: Polarization at LUCX
Experimental Setup

- A study of the polarization of cSPr was carried out
- Comparison of theoretical predictions and experiment
- Experiment to measure polarisation of cSPr carried out at the LUCX facility
- Aluminium sawtooth grating with 1mm periodicity
Interferometry

According to dispersion relation for Smith-Purcell radiation:

\[ \lambda = \frac{l}{n} \left( \frac{1}{\beta} - \cos \theta \right) \]

For \( \theta = 90^\circ \rightarrow \nu = 300\text{GHz} \)

Comparison of narrowband cSPPr and broadband transition radiation produced at LUCX
Rotation Scans

• To measure polarization:
  – Detector and polarizer attached to rotating stand
  – Signal measured in 2° for approximately 360° rotation
  – Angle between polarizer and detector was constant throughout rotation.

• Only one frequency of radiation (300GHz) was measured during this experiment
• Signal at minima and maxima is not consistent
• Peaks are not spaced 180° apart
• Detector not centred on rotating stand
Result

- Minima and maxima are consistent
- Peaks and troughs equally spaced

\[
p \perp g = G \perp \parallel - G \perp \perp / G \parallel \parallel + G \perp \perp
\]

- Comparison of signal at minima and maxima give degree of polarization as \(0.73 \pm 0.04\)
Discussion

• Current Limitations
  – Unknown Noise Floor of the detector
  – Unknown acceptance of detector
  – Single Frequency result

• Next Steps
  – Multi frequency experiment, by changing detection angle with respect to the grating
  – Comparison with theoretical predictions
  – Decision on using this method for background elimination
Conclusions

• Proposal to use the polarization of cSPr to separate it from background radiation in a planned longitudinal beam profile monitor
• Measurements of polarization of cSPr at a single frequency have been made
• Results so far show polarized radiation
• For comprehensive comparison with theoretical predictions measurements will be needed at different frequencies
• Further experiments are being planned to complete this study
Thanks

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• For more detailed explanations please see our IBIC proceedings (TUPG54)
• Thank you all for listening!