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

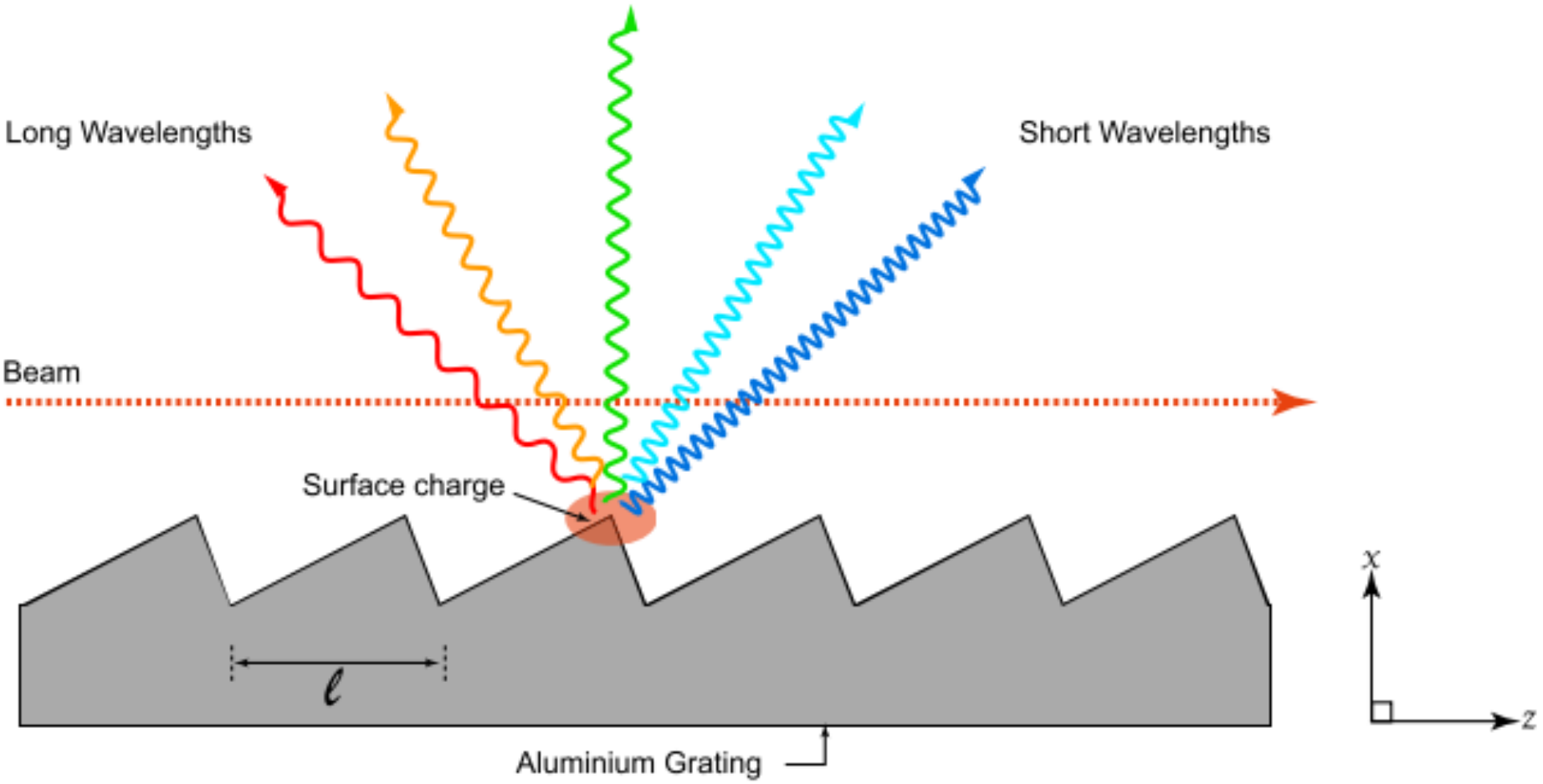
- A *single-shot longitudinal beam profile monitor* using *coherent Smith-Purcell radiation* (cSPr) is being developed.

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

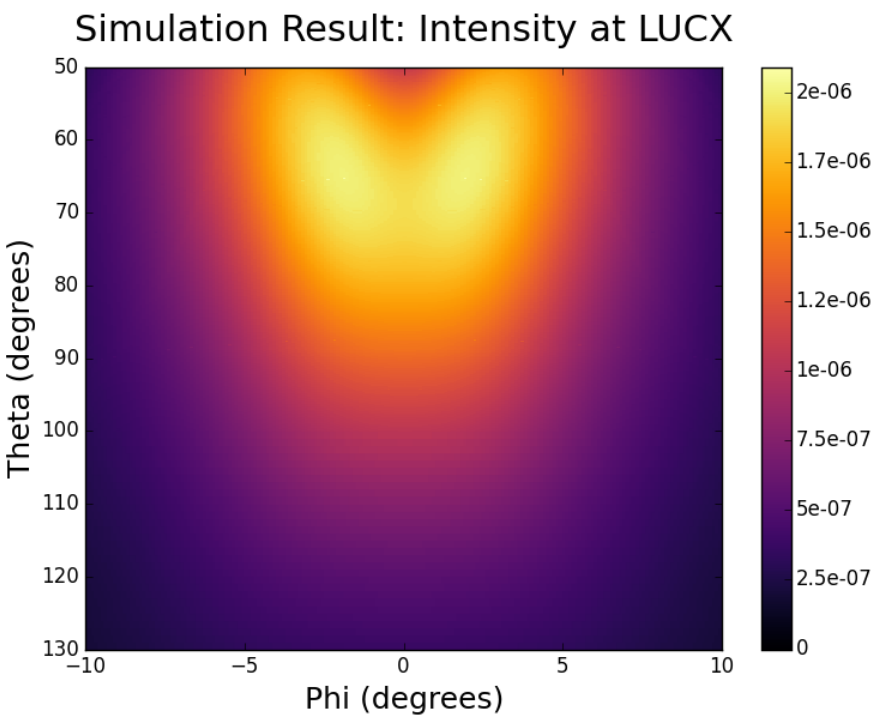
- Theory shows *cSPr to be highly polarized* – it has been proposed that the signal and the background could be separated using polarizers.

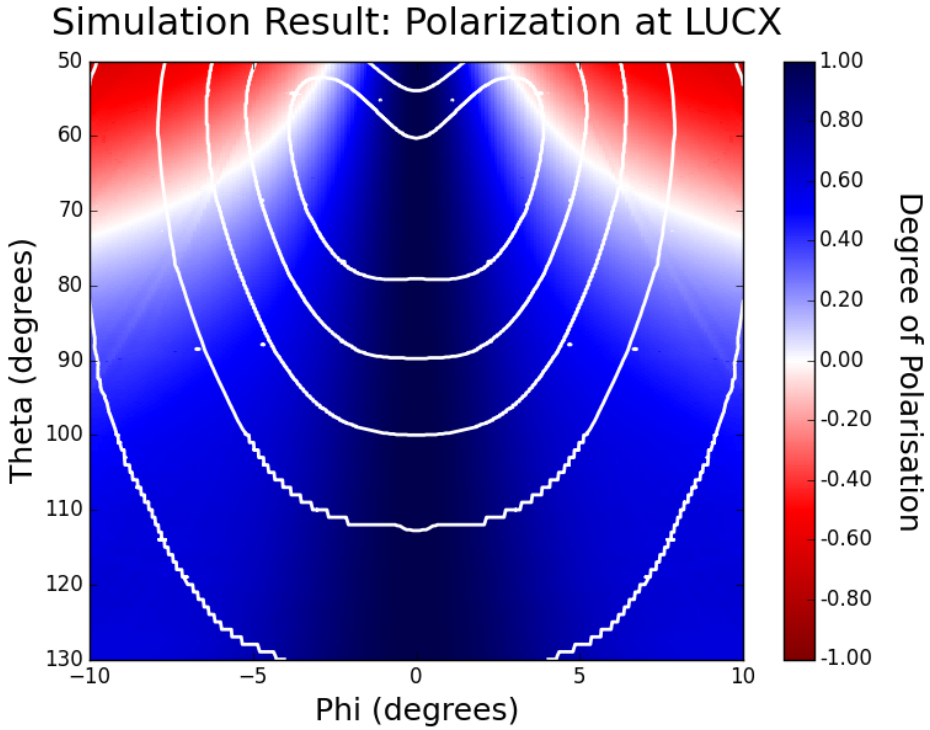
Smith-Purcell Radiation

$\lambda = l/n\ (1/\beta - \cos\theta)$

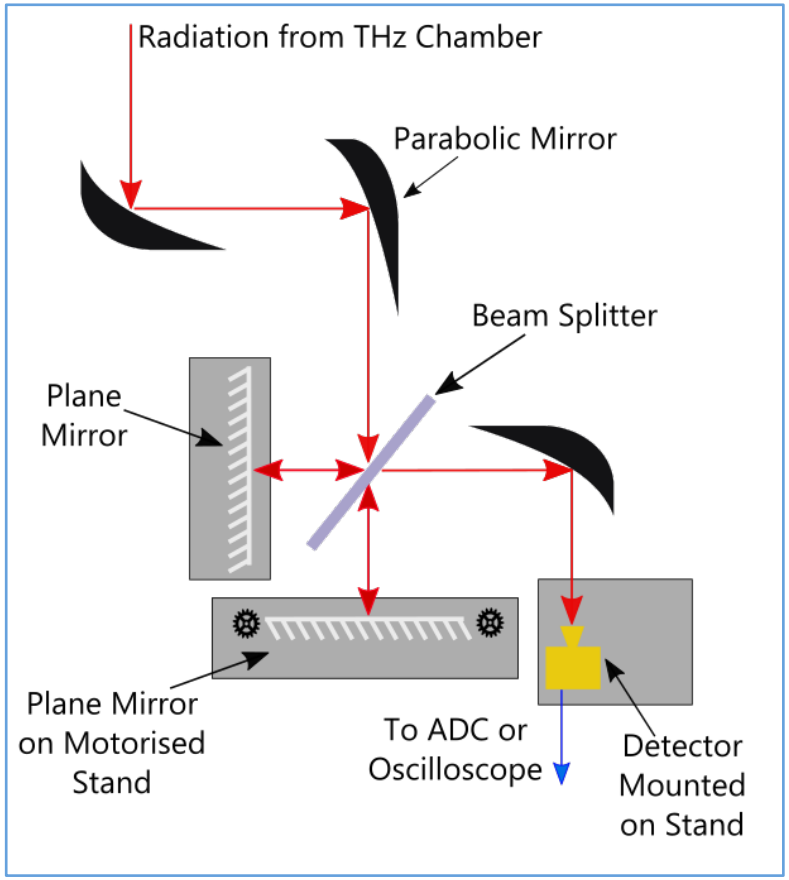


Simulations (LUCX)



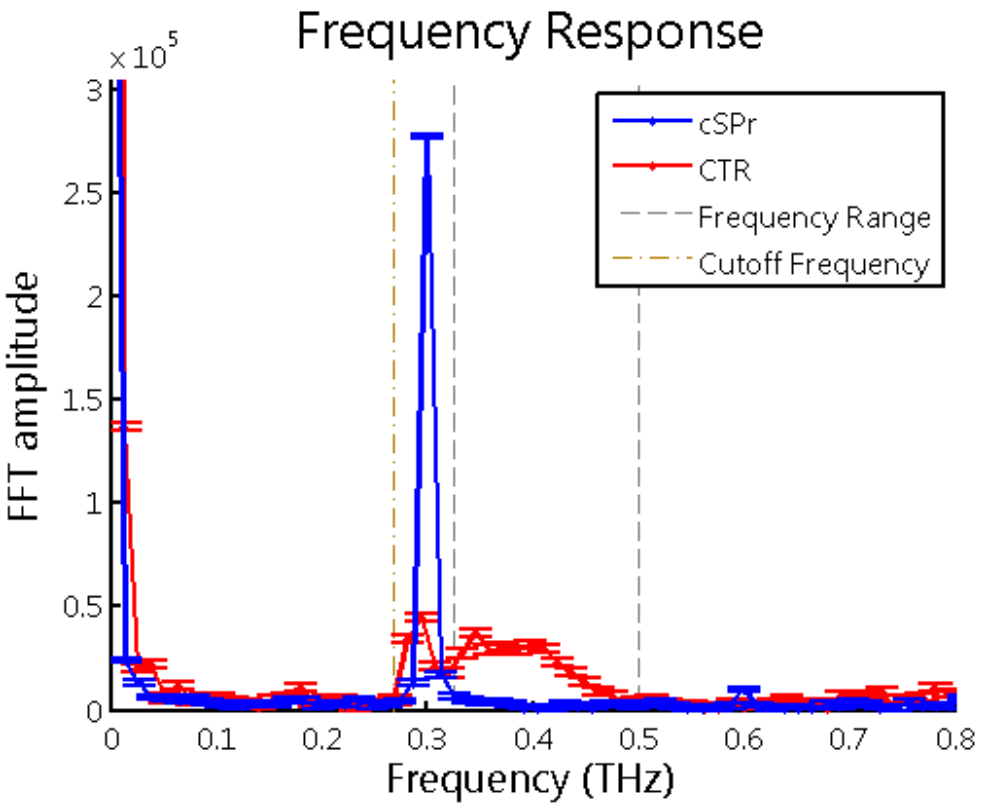


Experimental Setup



- 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



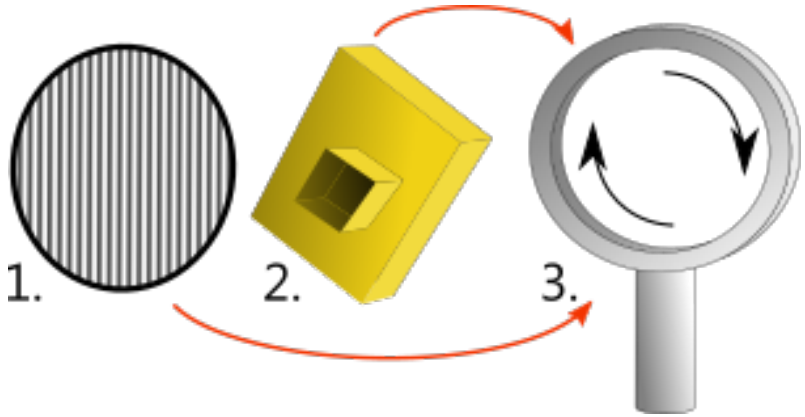
According to dispersion relation for Smith-Purcell radiation:

$$\lambda = l/n \ (1/\beta - \cos\theta)$$

For θ = 90° → ν = 300GHz

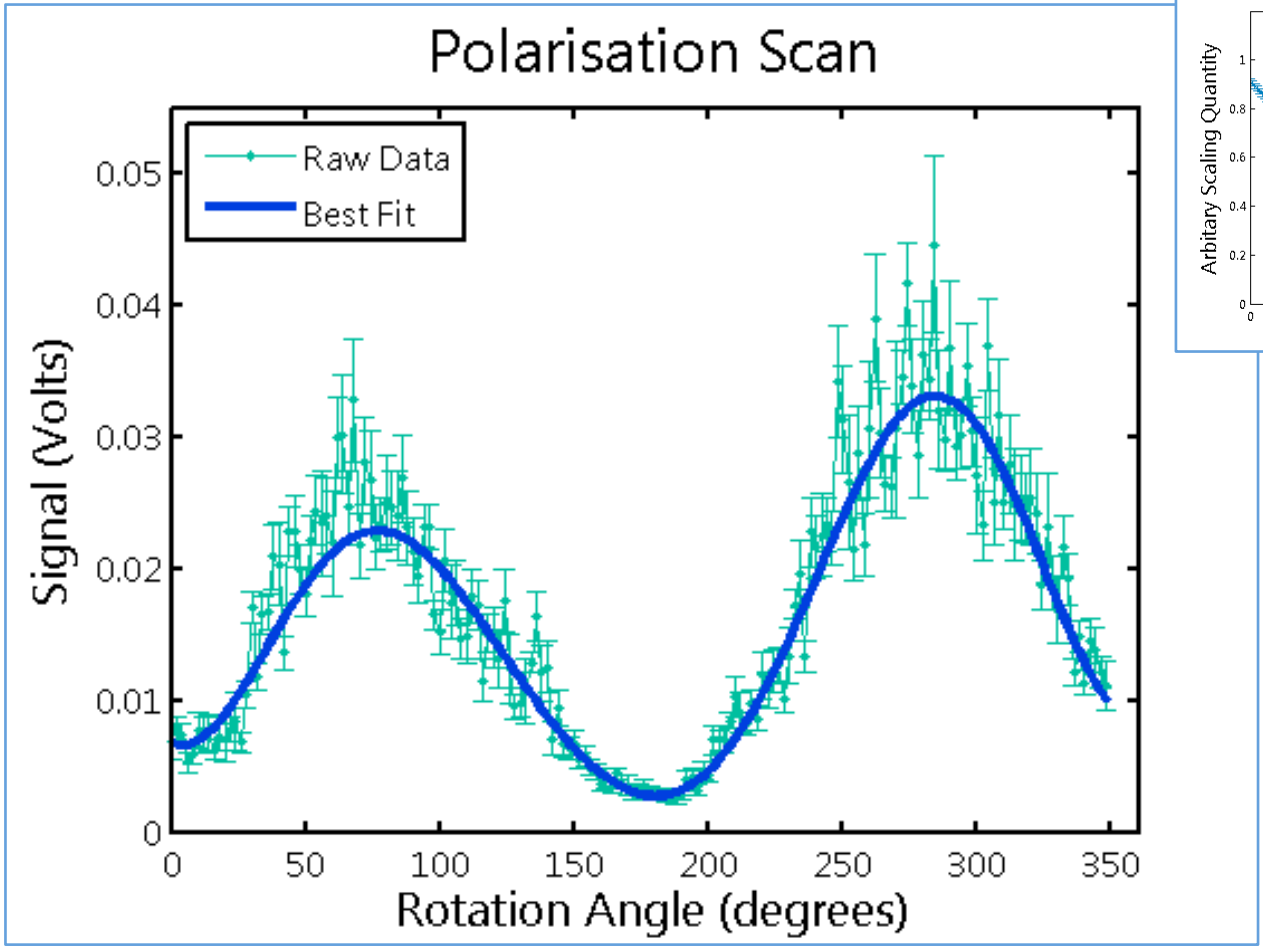
Comparison of narrowband cSPr and broadband transition radiation produced at LUCX

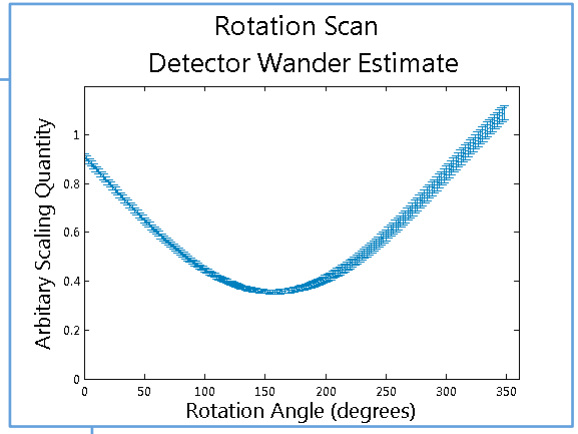
Rotation Scans



- 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

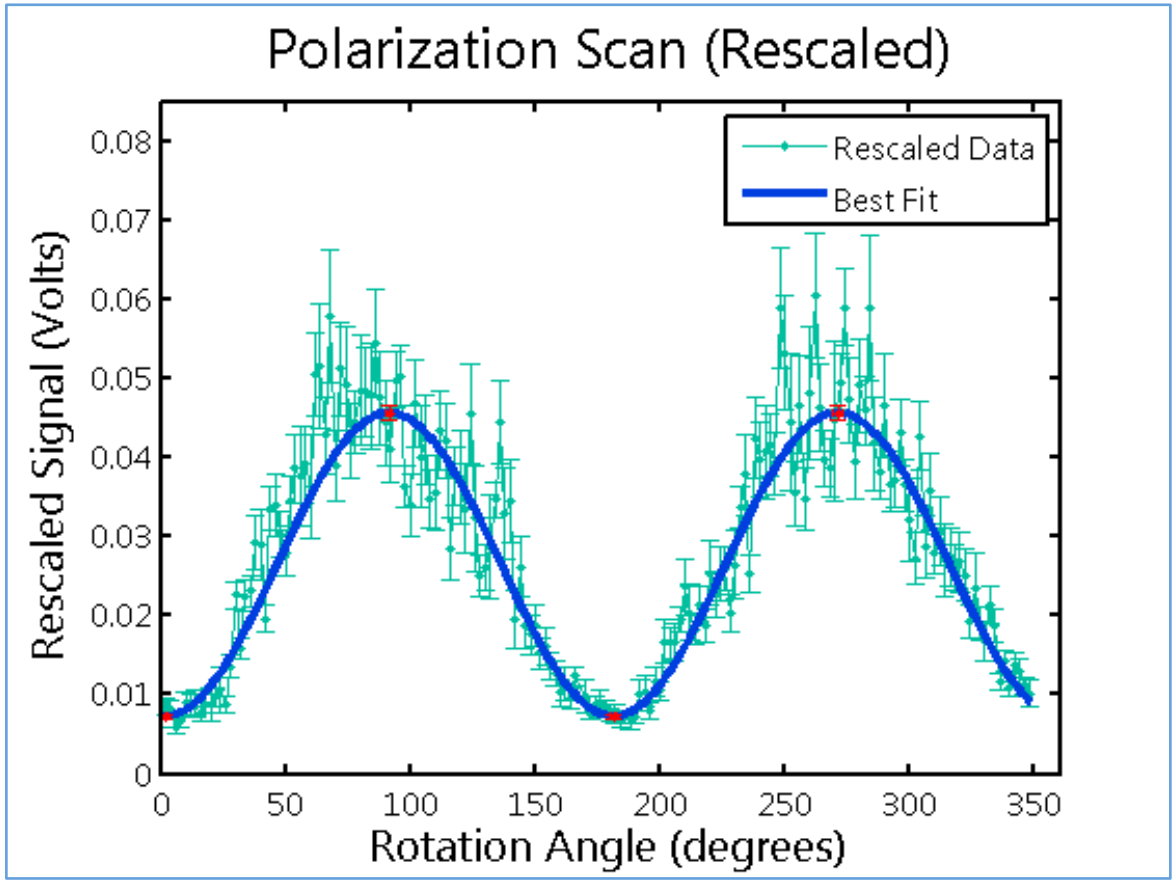
Raw Data





- 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

$$p\downarrow g = G\downarrow\| - G\downarrow\perp / G\downarrow\| + G\downarrow\perp$$

- Comparison of signal at minima and maxima give degree of polarization as ***0.73±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

- Many thanks the STFC and Leverhulme trust for supporting this work.
- With thanks to our collaborators at LUCX for their time and expertise.
- Personal thanks to the STFC and John Adam Institute for supporting this DPhil Project.
- For more detailed explanations please see our IBIC proceedings (TUPG54)
- Thank you all for listening!