# Compensation Controls for an Elliptically Polarising Undulator

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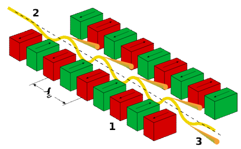
## What is an Undulator?

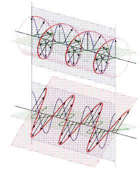
An undulator generates a beam of photons from a beam of electrons via an undulating magnetic field. An Elliptically Polarising Undulator (EPU) may generate photons of Elliptical Phase ($\Phi_E$) and Linear Phase ($\Phi_L$).

**Undulator Operation**

1. Magnets
2. Electron Beam
3. Photon Beam

λ Spatial Phase



**Photon Polarisation**

$\Phi_E$ Elliptical Polarisation

$\Phi_L$ Linear Polarisation

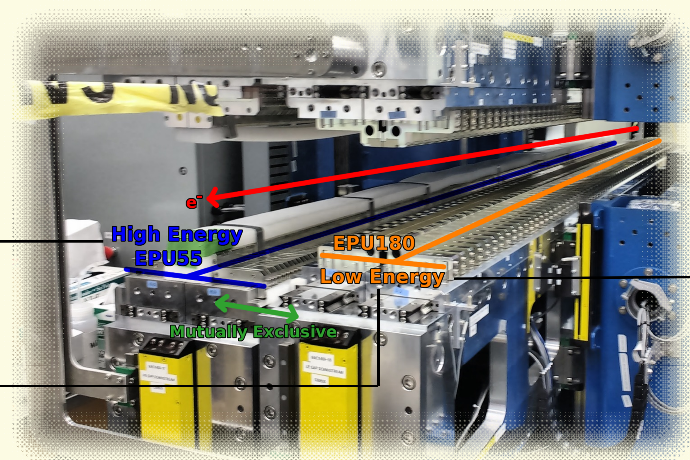
## Why is This Undulator Different?

- Dual-undulator for the Quantum Materials Spectroscopy Centre beamline, consists of two undulators EPU55 and EPU180.
- EPU180 poses two challenges:
  1. Generates photons from an arbitrary superposition of $\Phi_E$, $\Phi_L$, and Gap (three degrees of freedom).
  2. Interferes with electron beam injection.

  which require compensations to the stored electron beam, using Correction Coils and Current Strips.

**Standard EPU** / **This EPU**

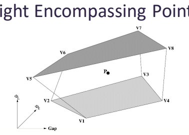
**Two Degrees of Freedom → Three Degrees of Freedom**




### 3D XML Table

### Binary Search

Eight Encompassing Points

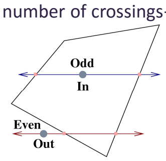


### Search Validation

**Point in Polygon via Ray Casting**

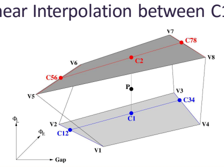
**Conducted on each polygon**

- Odd number of crossings—inside.
- Even number of crossings—outside.




### Trilinear Interpolation

1. Bilinear Interpolation on two planes.
2. Linear Interpolation between C1 & C2.



**Kick**

**Offset**

Σ

### Correction Coils (4)

**First and Second Magnetic Field Integrals**

**Upstream and downstream on electron storage ring**

### Universal Mode

Mathematical Modeling

$$\Phi(x,y,z) = \left(\int_{-\infty}^{y} B_x(x,y',z)dy'\right)^2 + \left(\int_{-\infty}^{y} B_z(x,y',z)dy'\right)^2$$

$$J_{m,x}(x,z) = \frac{1}{I_m}\int_{-\infty}^{\infty} B_{m,x}(x,y,z)dy$$

$$J_{m,z}(x,z) = \frac{1}{I_m}\int_{-\infty}^{\infty} B_{m,z}(x,y,z)dy$$

$$K_x(x,z) = -\frac{\alpha^2}{2}\int_{-\infty}^{\infty}\frac{\partial\Phi}{\partial x}(x,y,z)dy$$

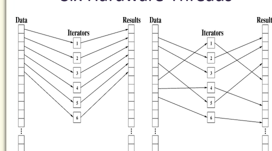
$$K_z(x,z) = -\frac{\alpha^2}{2}\int_{-\infty}^{\infty}\frac{\partial\Phi}{\partial z}(x,y,z)dy$$

$$\begin{bmatrix}\alpha K_x(x_i)\\ \alpha K_z(x_i)\end{bmatrix} = \begin{bmatrix}J_{m,z}(x_i,0)\\ J_{m,x}(x_i,0)\end{bmatrix}\begin{bmatrix}I_m\end{bmatrix}$$

$$\alpha[1/Tm] = \frac{0.299792458}{E[GeV]}$$

### Parallelisation

Six Hardware Threads




Initial Subsequent

**Skew Quadrupole**

**Normal Quadrupole**

**Multipole**

**User Directed**

Σ

### Current Strips (24)

**Dynamic Focusing**

**Upstream and downstream on electron storage ring**

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