Development of a Synchrotron Radiation beam monitor for the Integrabile Optics Test Accelerator

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Goal

A BM based on SR can monitor the beam shape during the IOTA experiments

Have a realistic prototype of beam monitoring system based on synchrotron radiation for IOTA

- Build a table-top prototype of the Synch-Light stand with real measures;
- Characterise the prototype (resolution measurement);
- Design Software tools for searching and focusing the image;
Resolution:
- Characteristic beam size: $\sigma \approx 70 \, \mu m$
- Resolution: $< 7 \, \mu m/pixel$
- Camera size: 1920x1200 (5.86 $\mu m/pixel$)

**MAGNIFICATION: 0.837**

Size of the dipole
- Light path inside the vacuum chamber
- Height of the dipole

**OVERALL LENGTH > 770 mm**
Set Up

- Picomotors
- Iris
- Lens
- Point-Gray Camera
- Target LED
Resolution

‘USAF target’ Image
Contrast and Resolution

Rayleigh’s Criterion for the Resolution:
\[ K \approx 0.2 \]

\[ K = \frac{I_{\text{max}} - I_{\text{min}}}{I_{\text{max}}} \]
Diffraction limit

- Different Iris aperture
- Diffraction law is followed up to the optical resolution limit of the system

\[ d_{\text{diff}} = 1.22 \frac{\lambda l}{D} \]
Resolution for different colours

Contrast vs Spacing

Deviation from the expected law:
• Led brightness
• Lens aberration
• Wrong approximation for the fit function
Pico-Motors

- **PIEZOELECTRIC:** the impulse is different in the two direction, but the time length of the signal is the same
- **OPEN LOOP:** no feedback from the Pico-Motor

Reproducibility test:
- Extremely poor
- Different for each pico-motors
- Fluctuation in the **same direction up to 40%**
- Length difference from **back and forth up to 70%**

Non reproducibility **does not allow to implement a beam searching software** and pose the feasibility question on the focusing software. The beam centring software is not affected
Autofocusing Software

- Position Independent: Maximisation or Minimisation Algorithm
- Gaussian beam: quantities varies according to square of the distance
- Real test: not gaussian Beam;
Auto-focusing Software

- Step Independent: Maximisation or Minimisation Algorithm
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Conclusions

- Design of the BM to fit on the IOTA dipole
- Measured limit resolution for the system around 3-5 pixels;
- Measured resolution for different diaphragm aperture and colours
- Beam centring software done
- Proved the feasibility of the autofocusing software

☐ More solid autofocusing algorithm
☐ More ‘Users friendly’ interface for the software
☐ Build the real optical system
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Backup slides
Software SetUP

- PointGray Camera
- other BMs
- Pico Motors

BM Software Hard

Software Common
- Manage data traffic
- Multivariate data analysis

X, Y, A, B, Amplitude

- Beam Centring
- Autofocus

Steps

ACNET
Power spectrum

Normalized spectra of synchrotron radiation

\[ s(\omega/\omega_c) \]

\[ \omega/\omega_c \]
Power spectrum
Geometry of the SR
Simulation of the SR in IOTA

The observed beam shape is not the real beam shape. Simulations can study systematic effects:

A) **Depth of Field:** the optical acceptance changes the light collected

B) **Diffraction:** the optical acceptance broadens the diffraction pattern