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Managed by Fermi Research Alliance, LLC for the U.S. Department of Energy Office of Science

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

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Supervisors: G. Stancari, A. Romanov

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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;

Design

Resolution:

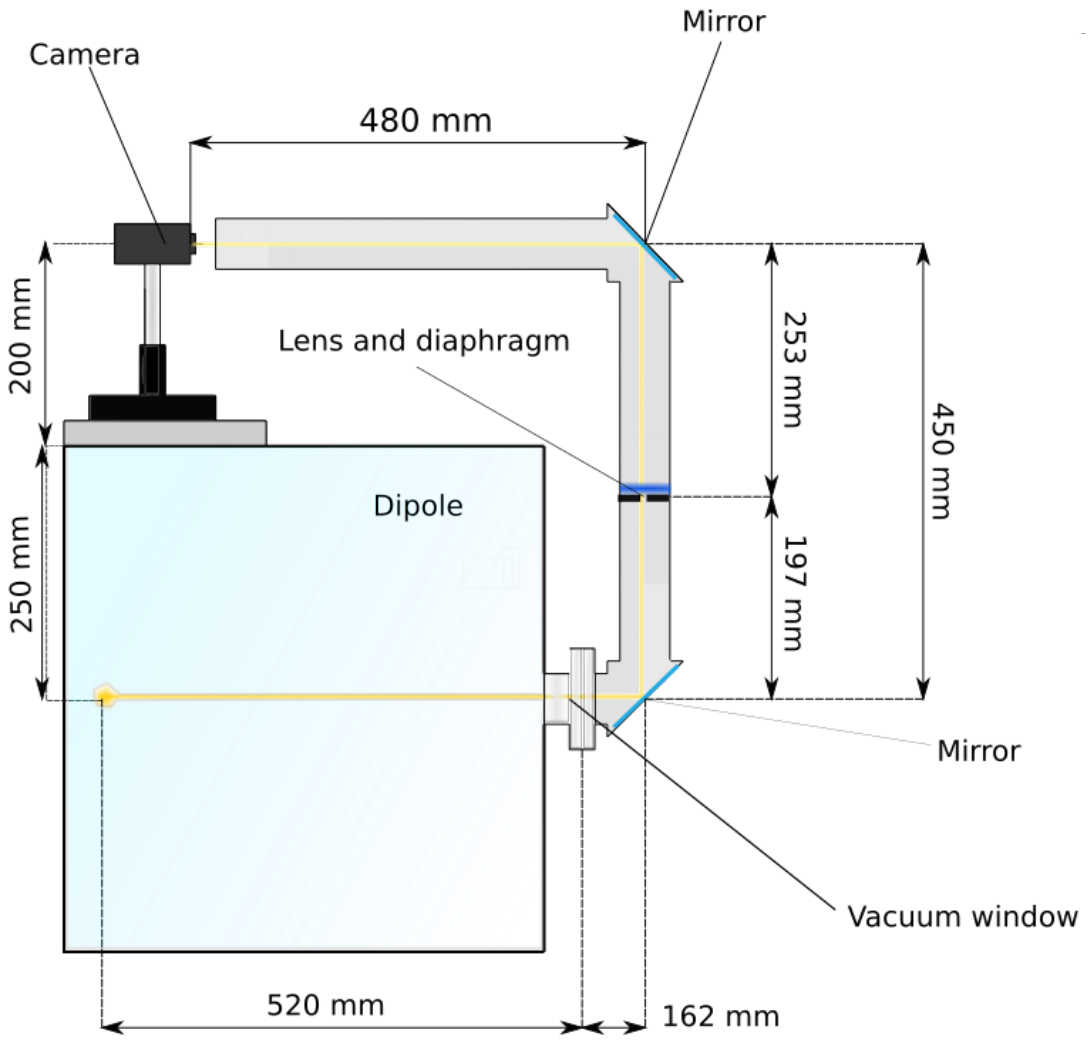
- Characteristic beam size: $\sigma \approx 70$ µm
- Resolution: < 7 µm/pixel
- Camera size: 1920x1200 (5.86 µm/pixel)

MAGNIFICATION: 0.837

Size of the dipole

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

OVERALL LENGTH > 770 mm



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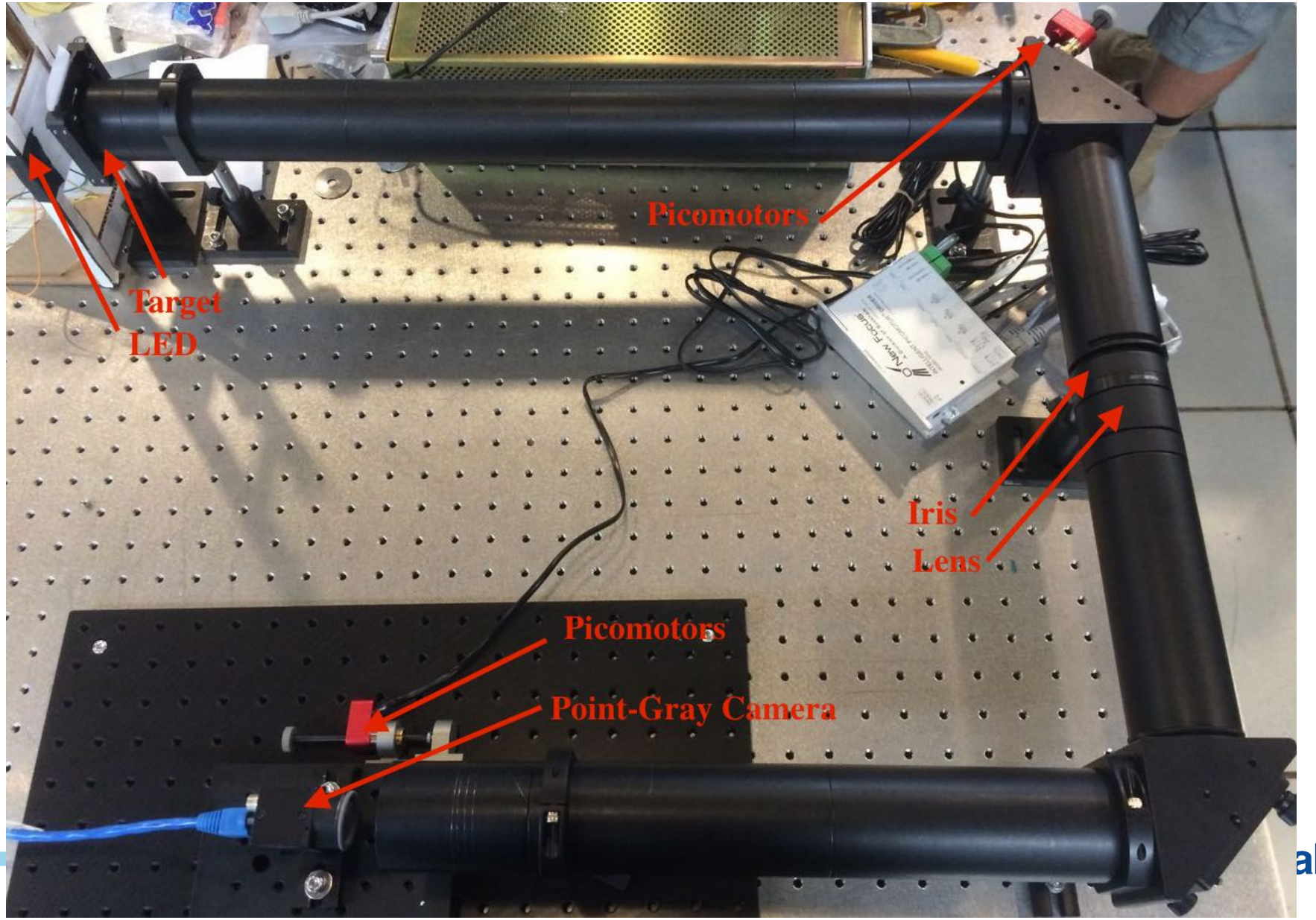
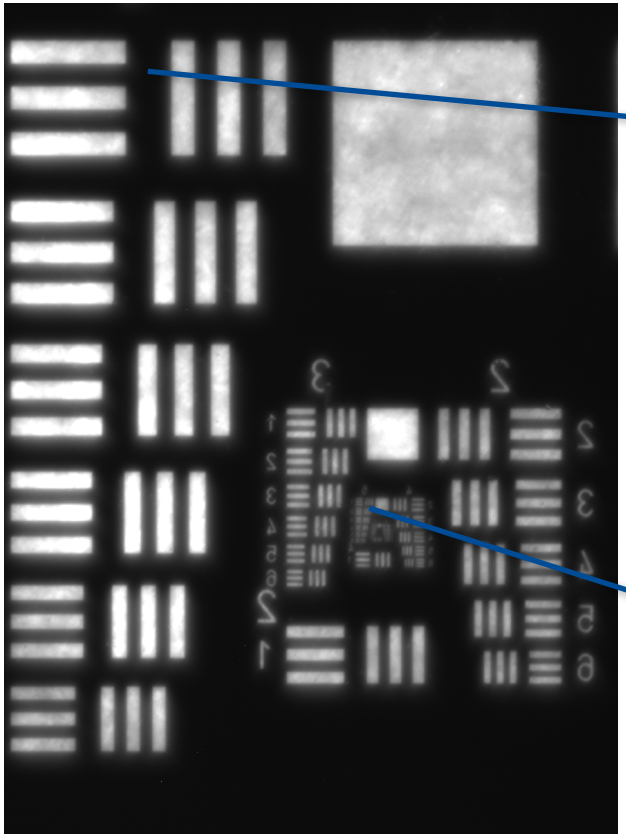
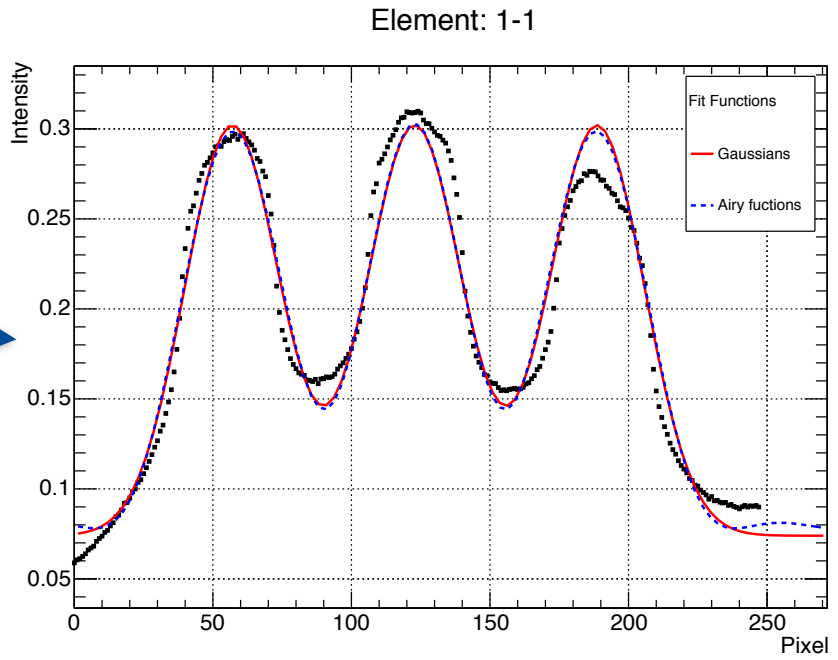
Set Up

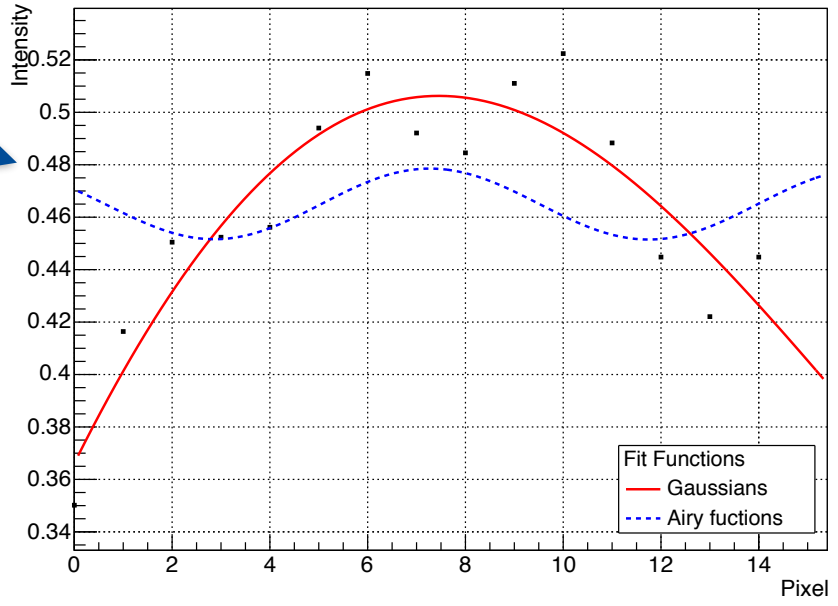

Picomotors
Target
LED
Iris
Lens
Picomotors
Point-Gray Camera

Resolution



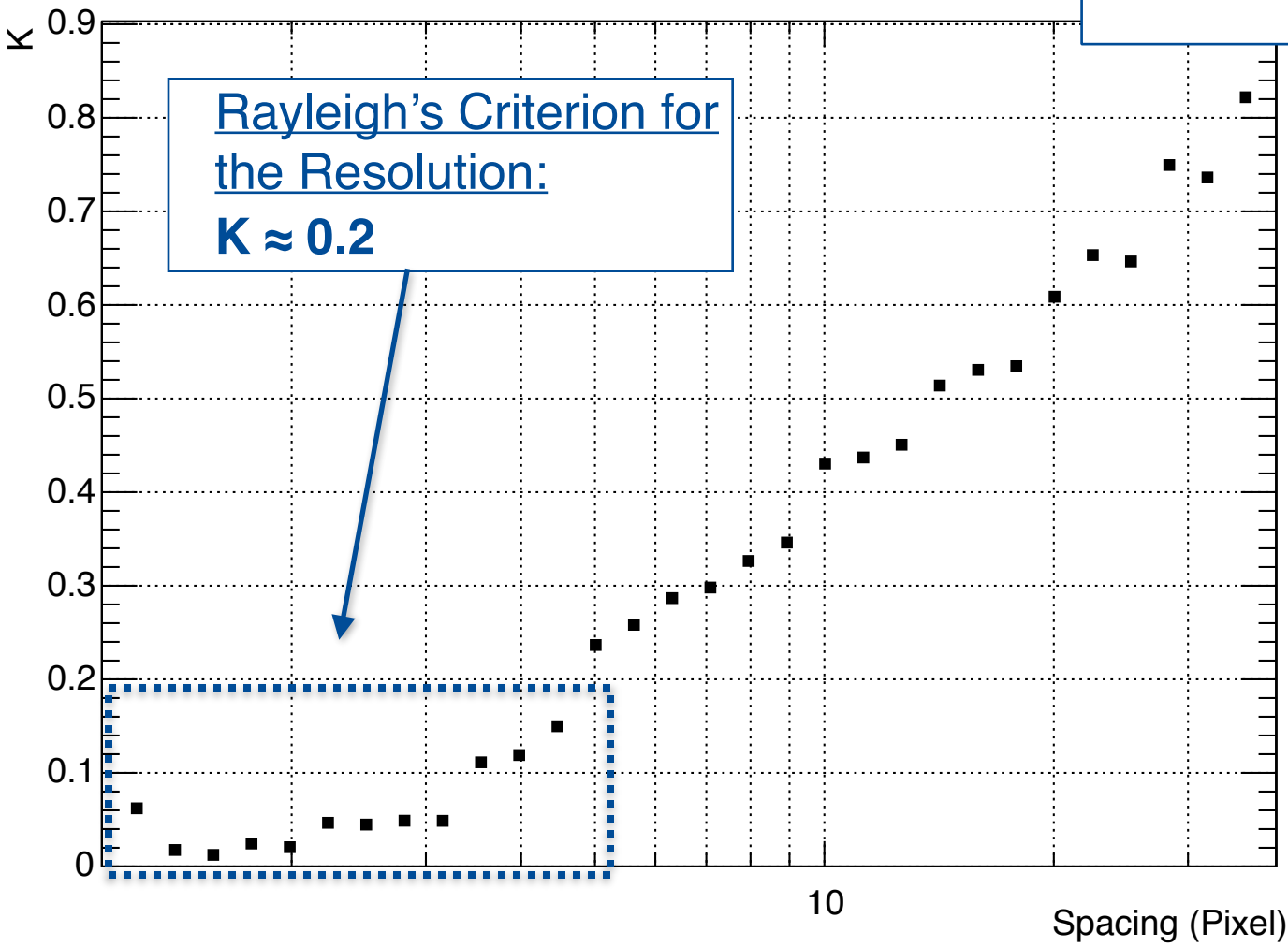
‘USAF target’ Image





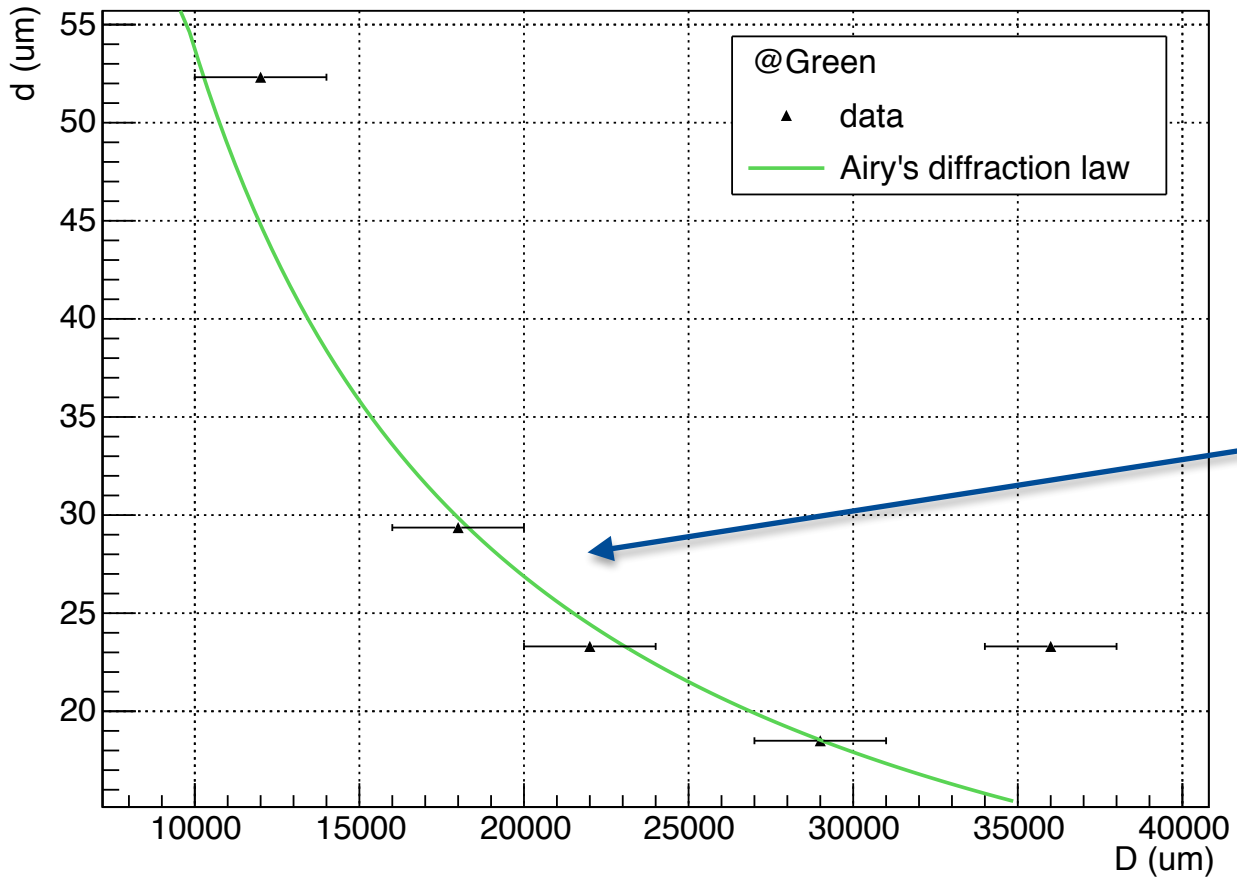
Contrast and Resolution

$$K = \frac{I_{max} - I_{min}}{I_{max}}$$



Diffraction limit

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



$$d_{diff} = 1.22\frac{\lambda l}{D}$$

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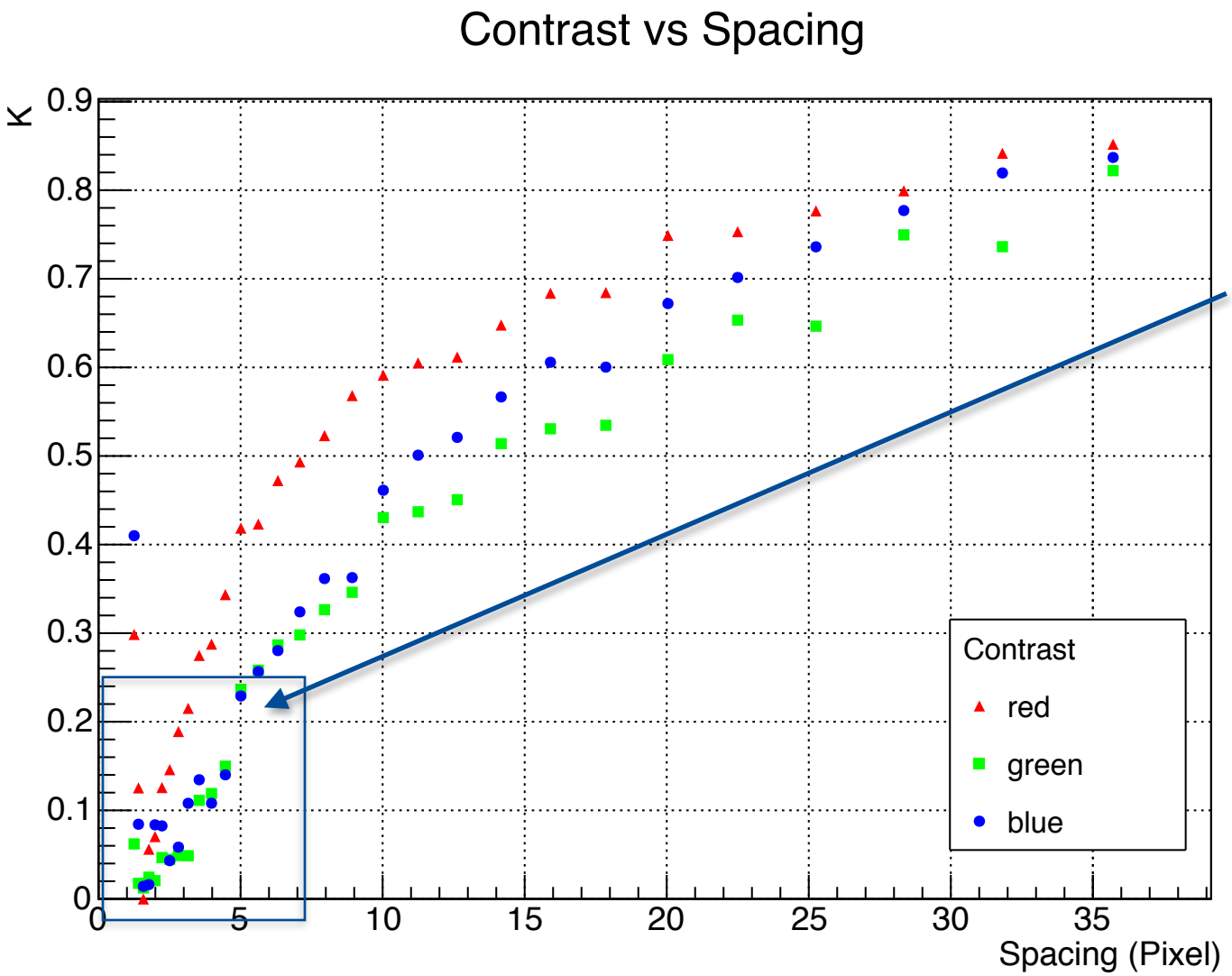
Resolution for different colours



Deviation from the expected law:

- Led brightness
- Lens aberration
- Wrong approximation for the fit function

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Pico-Motors

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

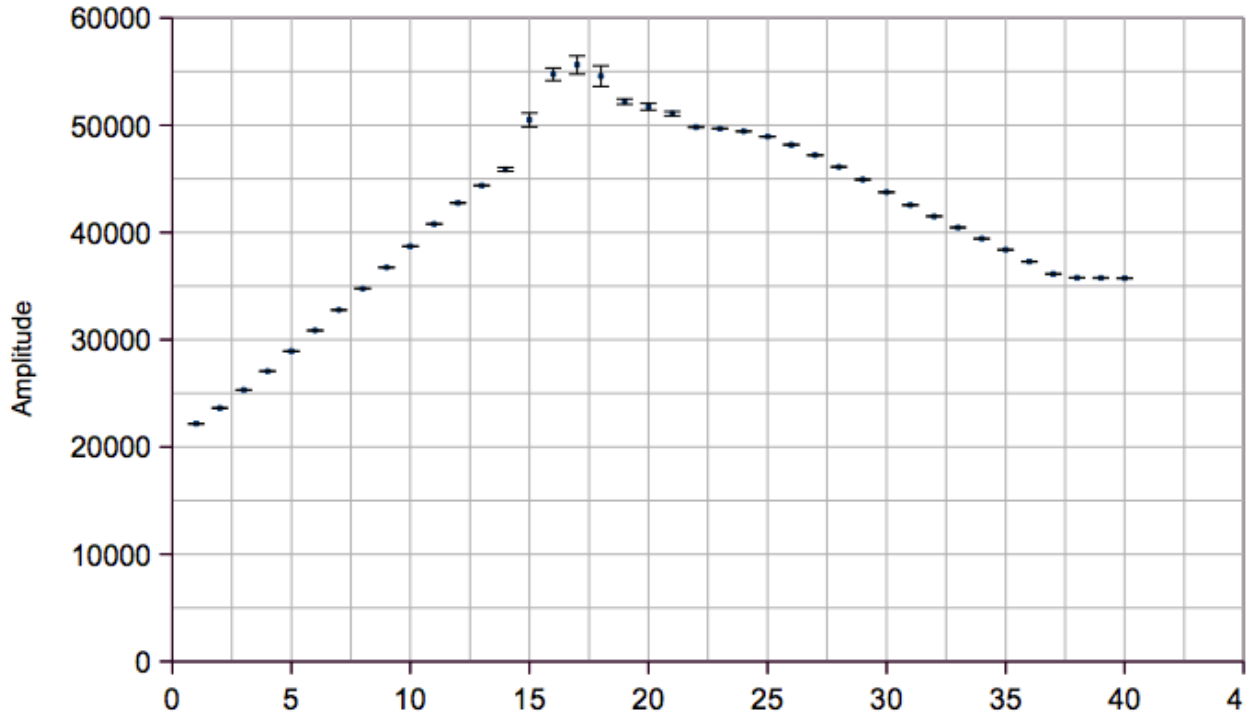
Reproducibility test:

- **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;



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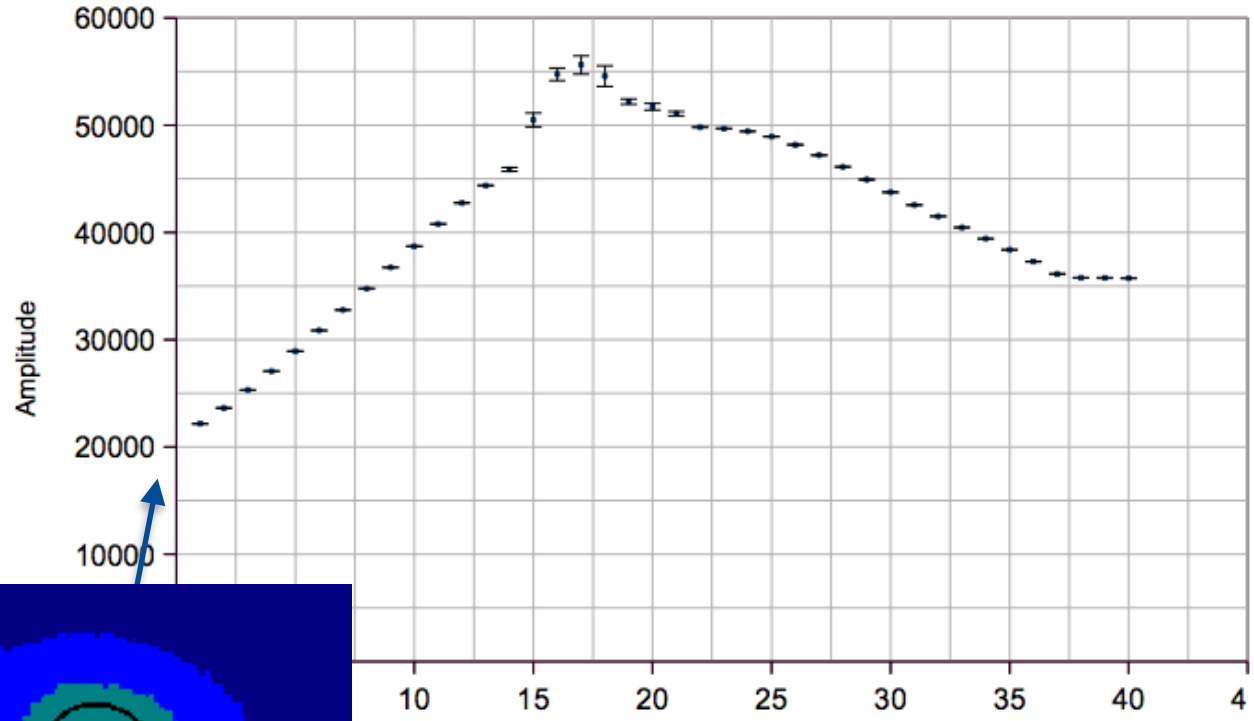

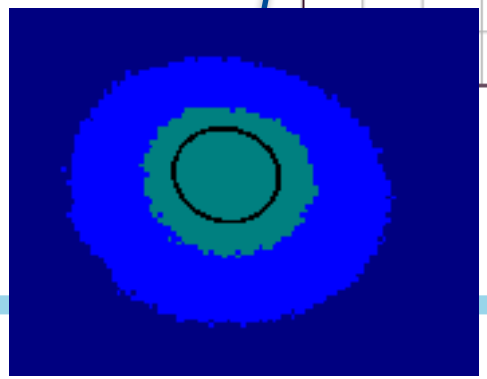

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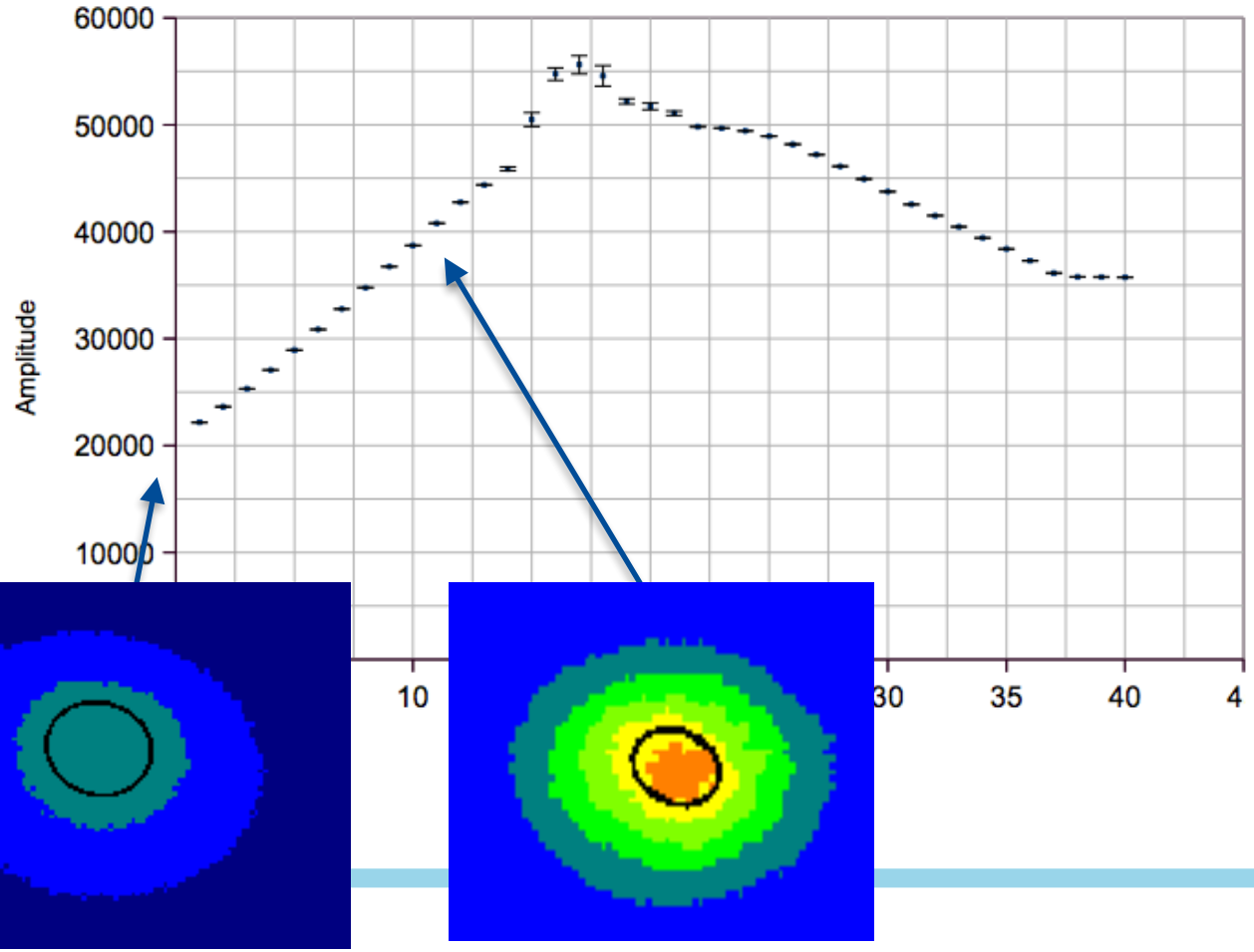

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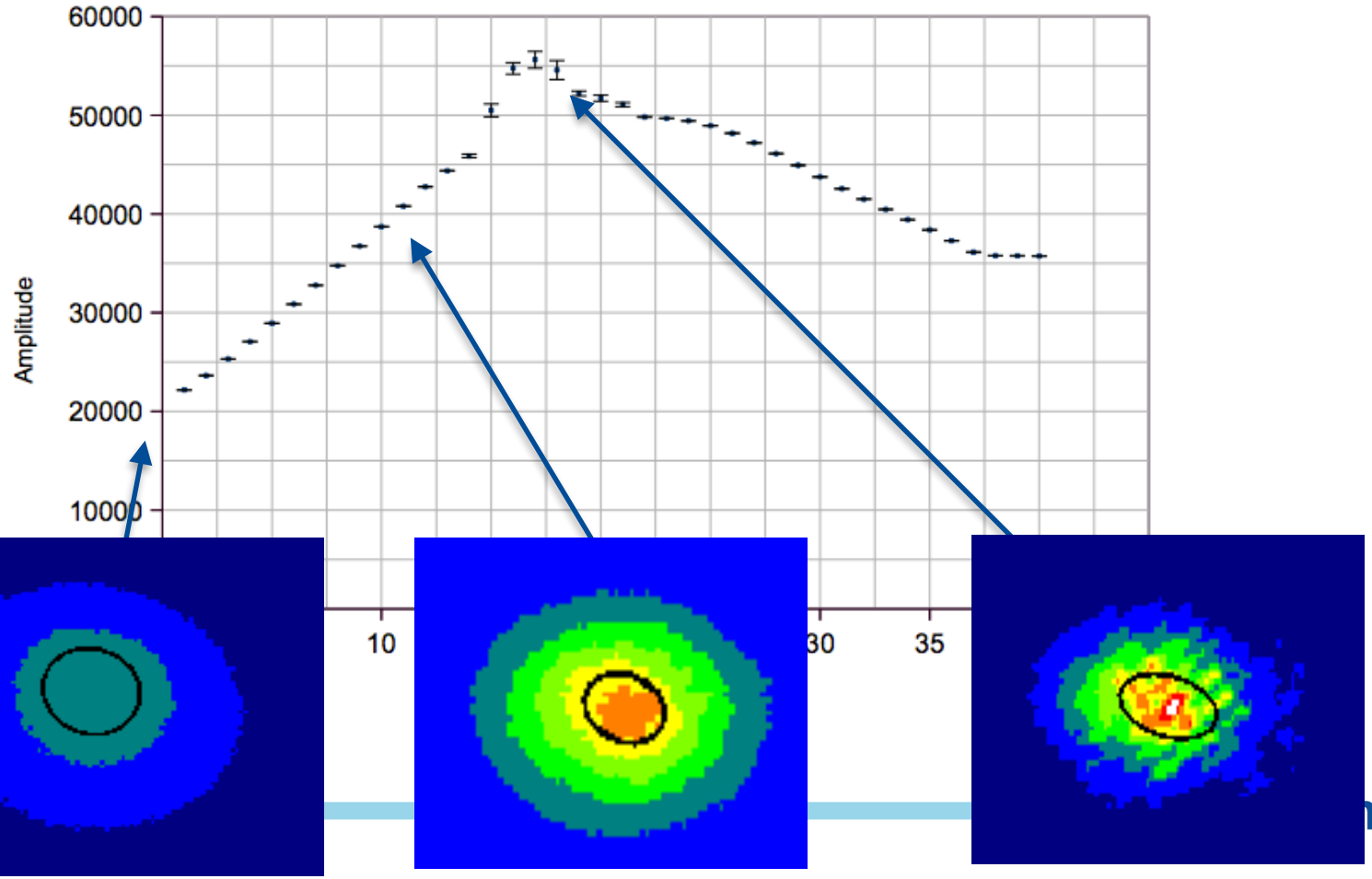

Conclusions

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

- [ ] More solid autofocusing algorithm
- [ ] More ‘Users friendly’ interface for the software
- [ ] Build the real optical system

Acknowledgments

A special thank for following me in my jobs and answering to my dull questions goes to my supervisor but also to:

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Thanks for your attention!

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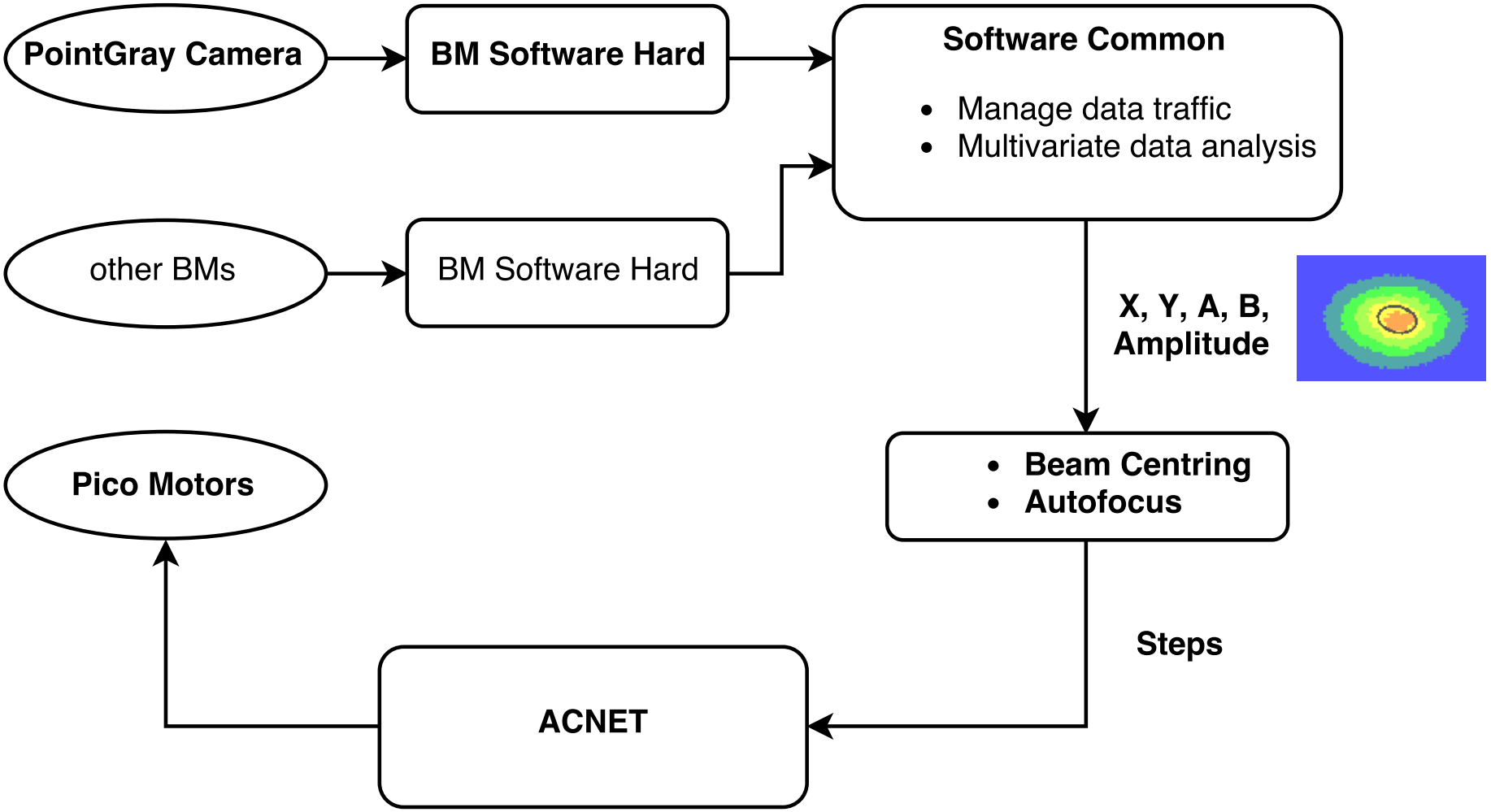
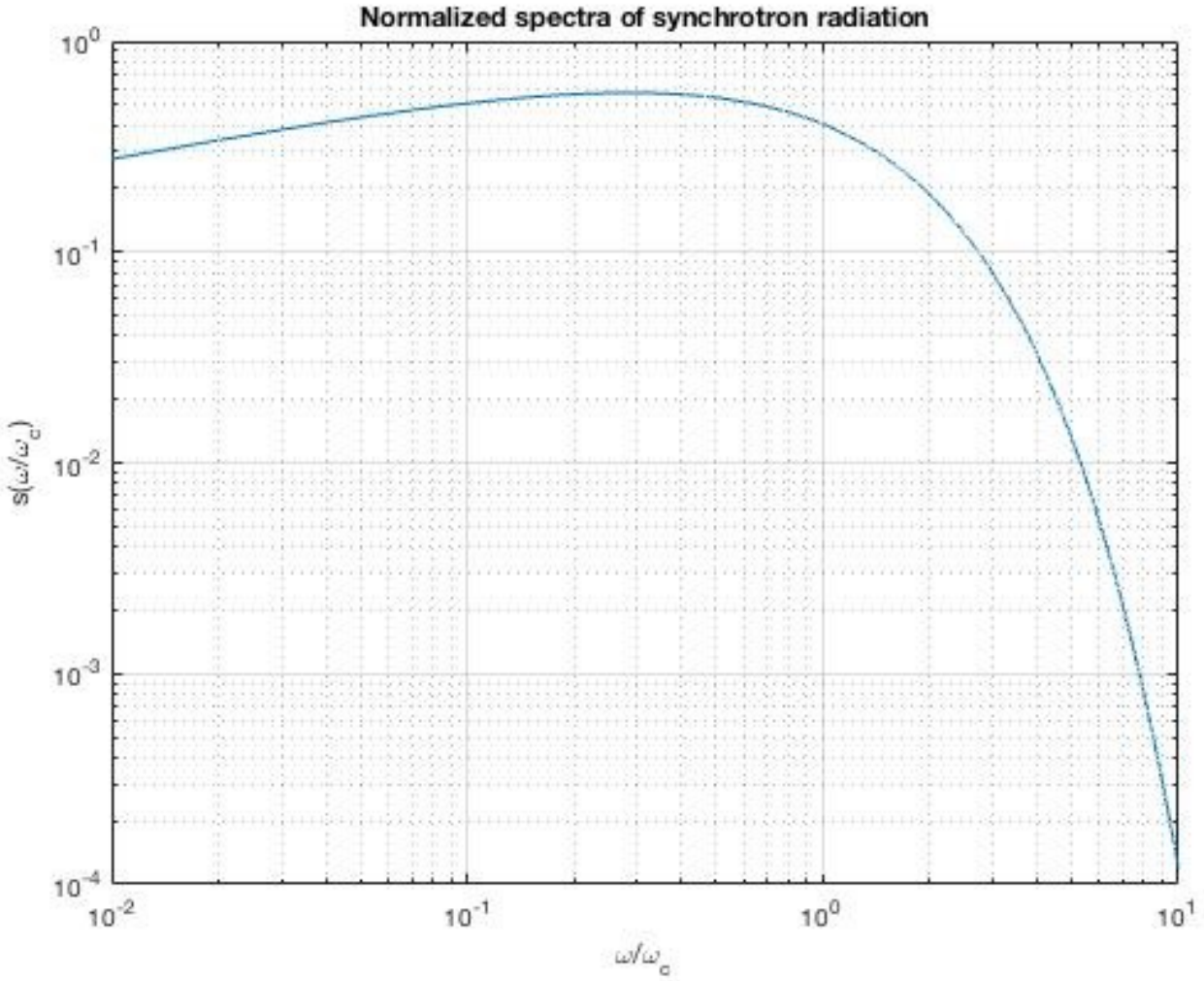
Backup slides

Software SetUP



Power spectrum



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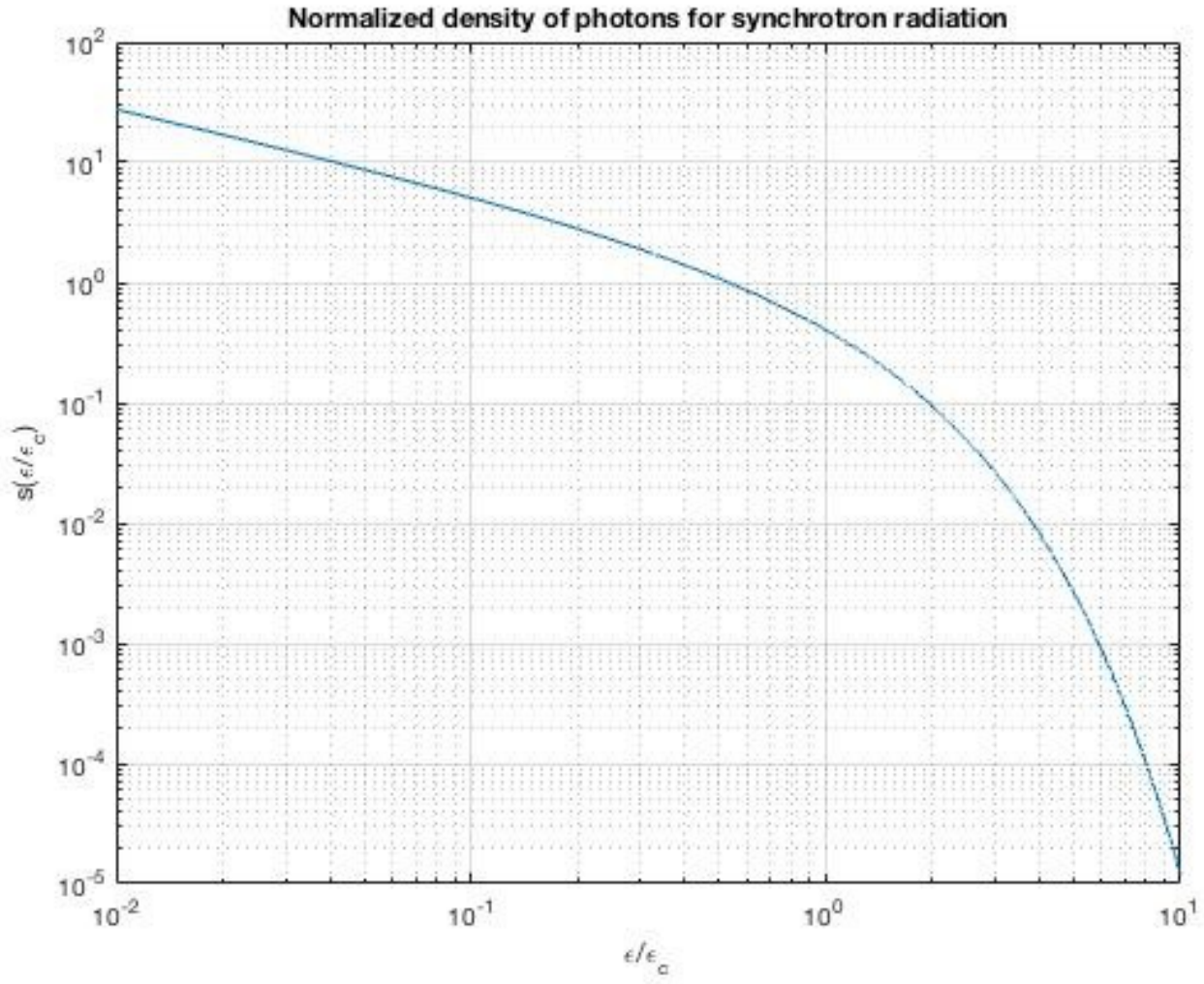
Power spectrum



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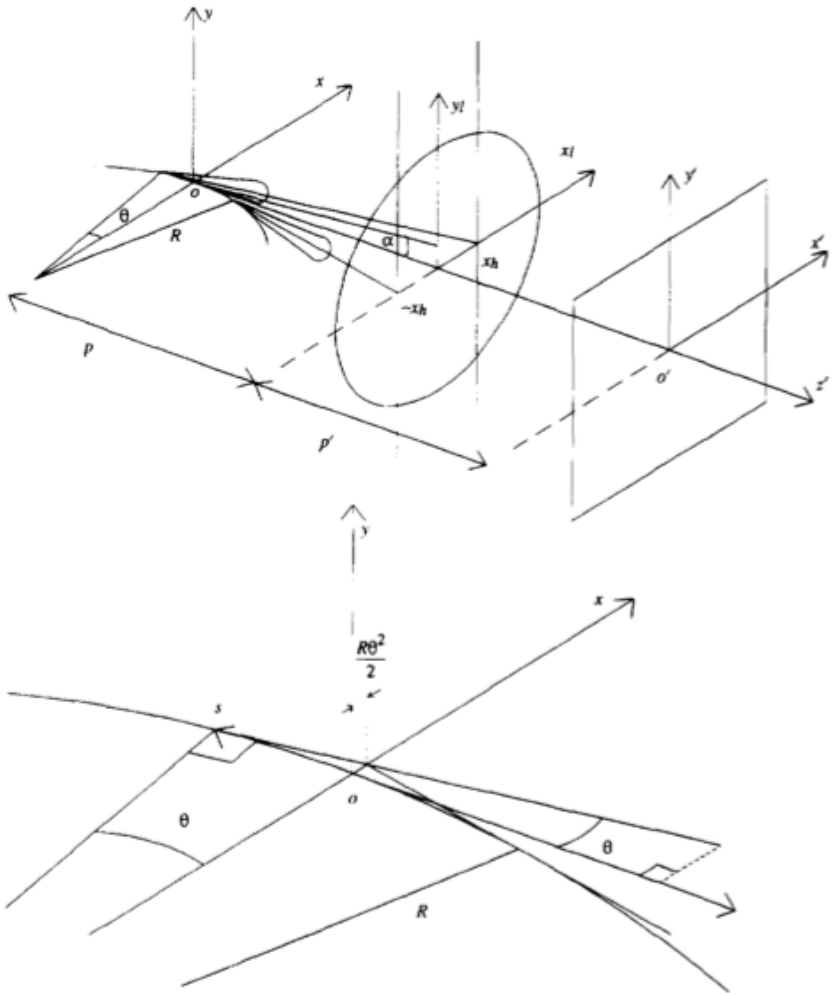
Geometry of the SR



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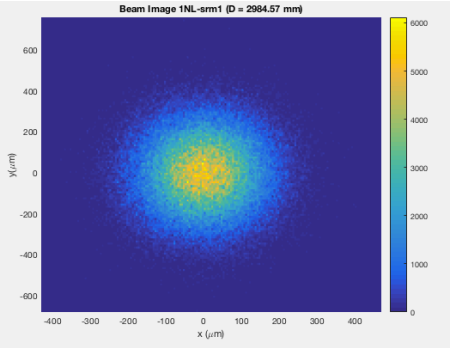
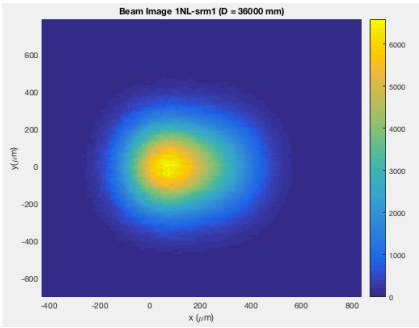
Simulation of the SR in IOTA

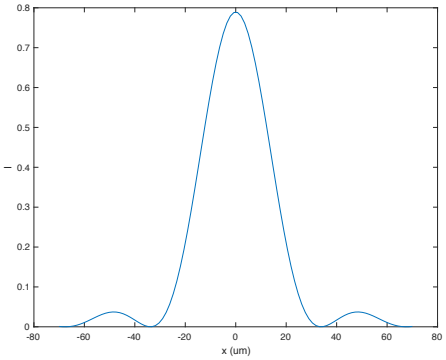
The observed beam shape is not the real beam shape. Simulations can study systematic effects:

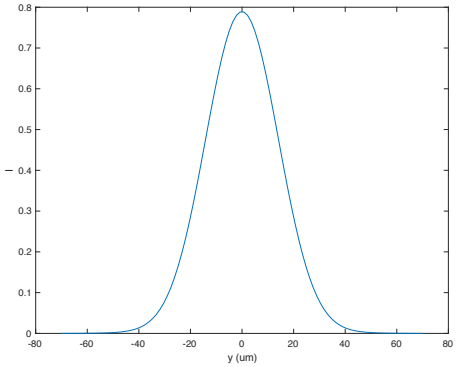
A) Depth of Field: the optical acceptance changes the light collected





B) Diffraction: the optical acceptance broadens the diffraction pattern





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