Single shot emittance diagnostic development for AWAKE Run 2c

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Motivation

- Emittance is an important characteristic which must be understood in each accelerator.
- **Single shot, high resolution** imaging methods must continue be developed as beam parameters improve.
- At AWAKE, the existing 18.5 MeV electron injector has an emittance of 2 – 5 µm. The secondary injector will have an energy of 150 MeV, and an emittance of 2 µm[1].
- Current emittance measurements are carried out using a spectrometer fixed in place after the plasma cell[2].
- To improve diagnostics along the beamline, we have been working on **two styles of compact emittance monitors** which could be repositioned when needed.

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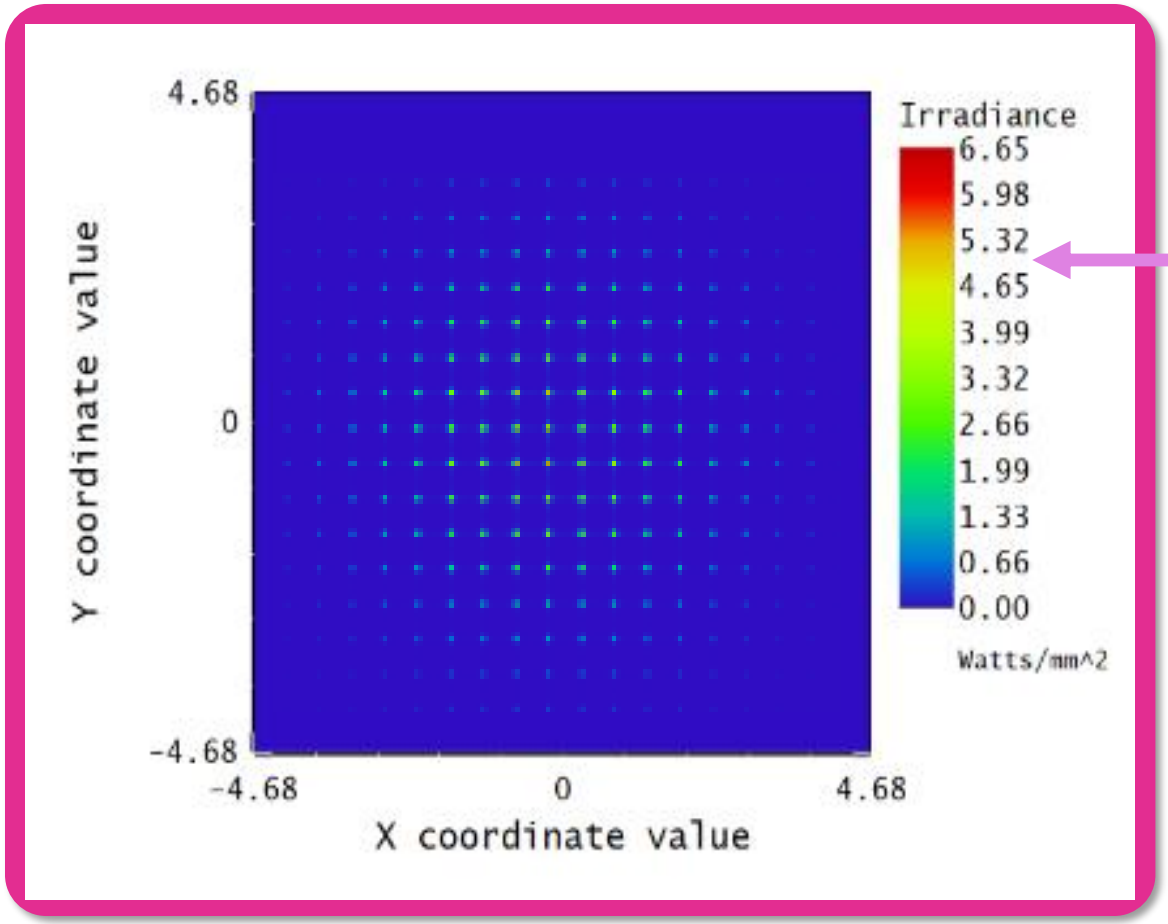
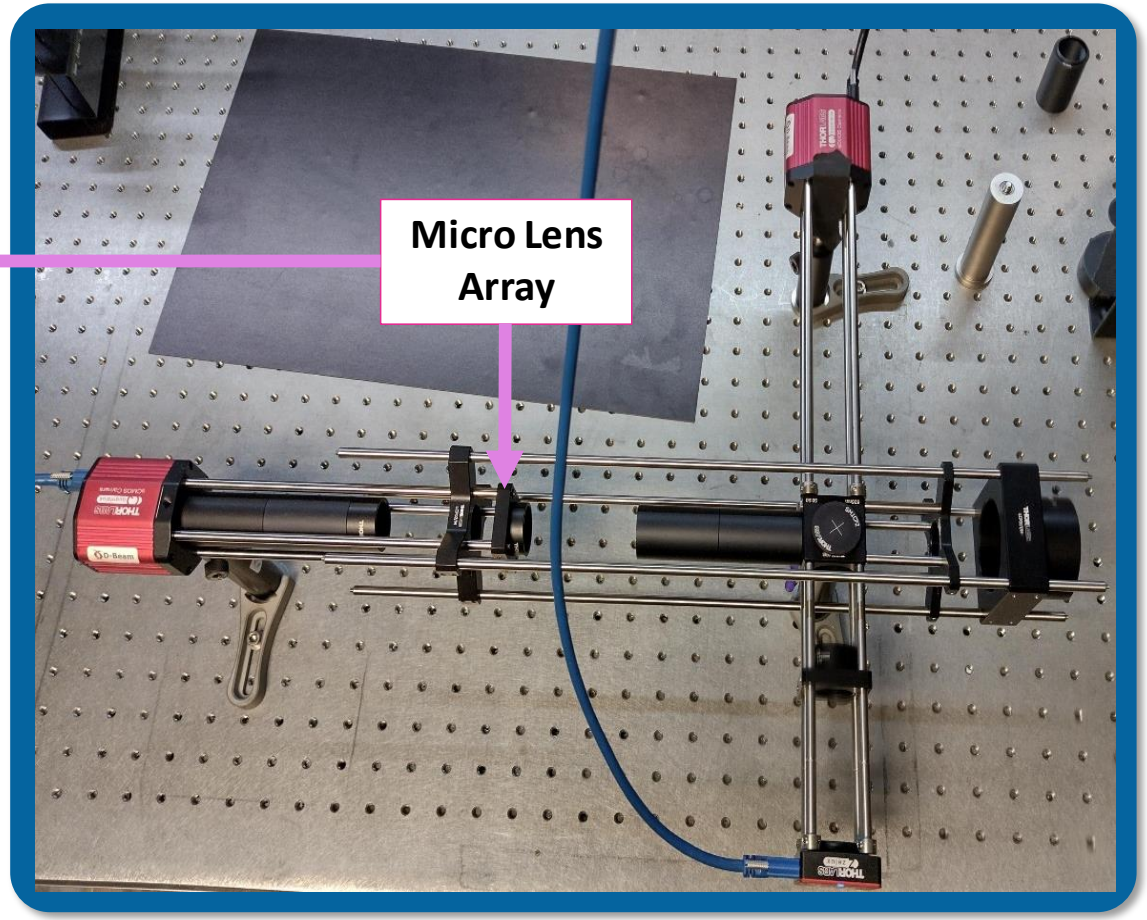
Pepperpot measurements with an MLA

- Optical pepperpots offer single shot emittance measurements **in both planes simultaneously**.
- Capable of masking out **space charge effects**[3].
- Traditionally use foil mask which sits in the beam before a scintillator screen[4].
- MLA – Micro Lens Array.
- MLA setup uses OTR generated by the screen, making this system **less invasive**[5].
- Already works for single shot measurements, we're now improving the resolution.

Pepperpot measurements with an MLA





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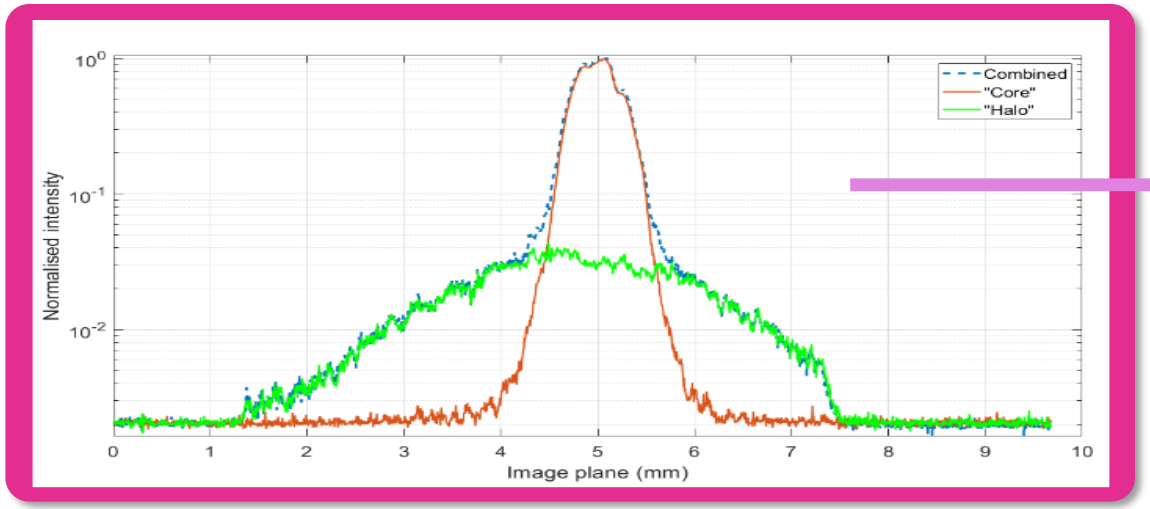

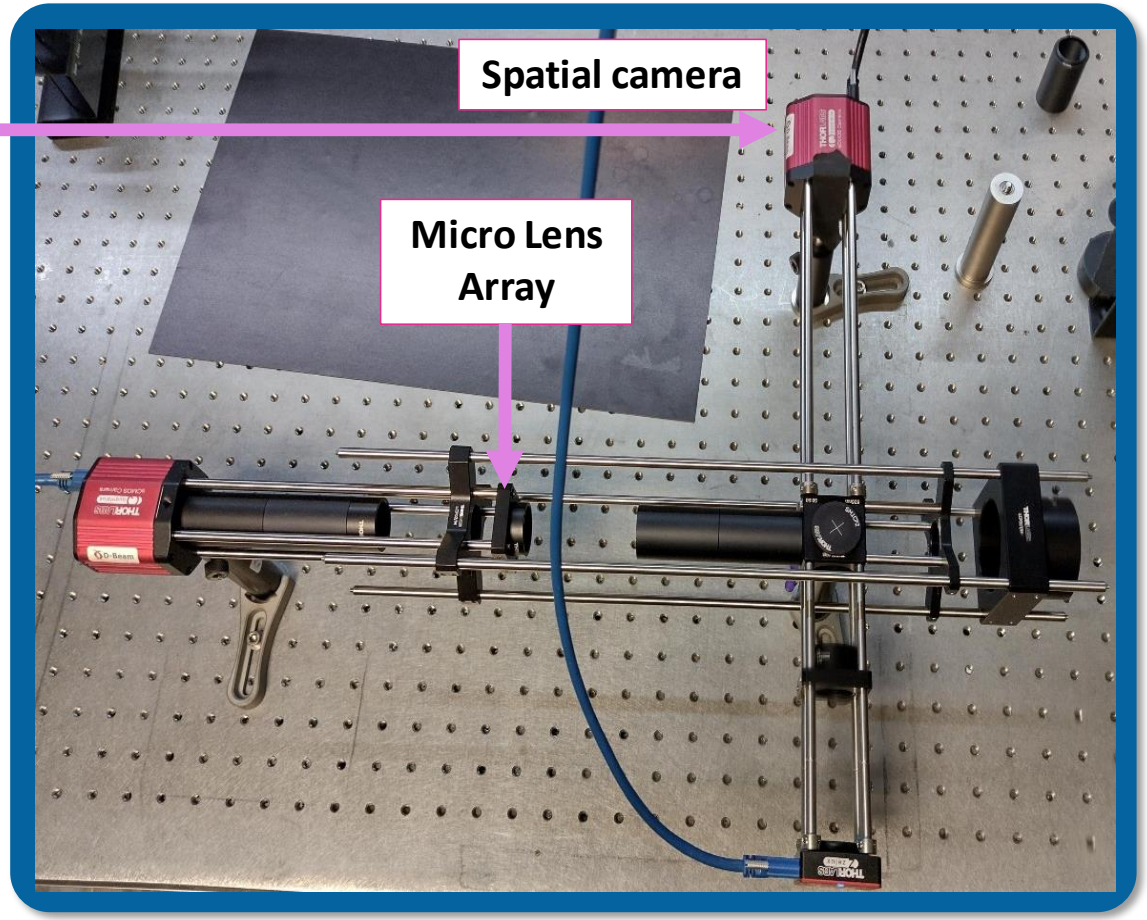

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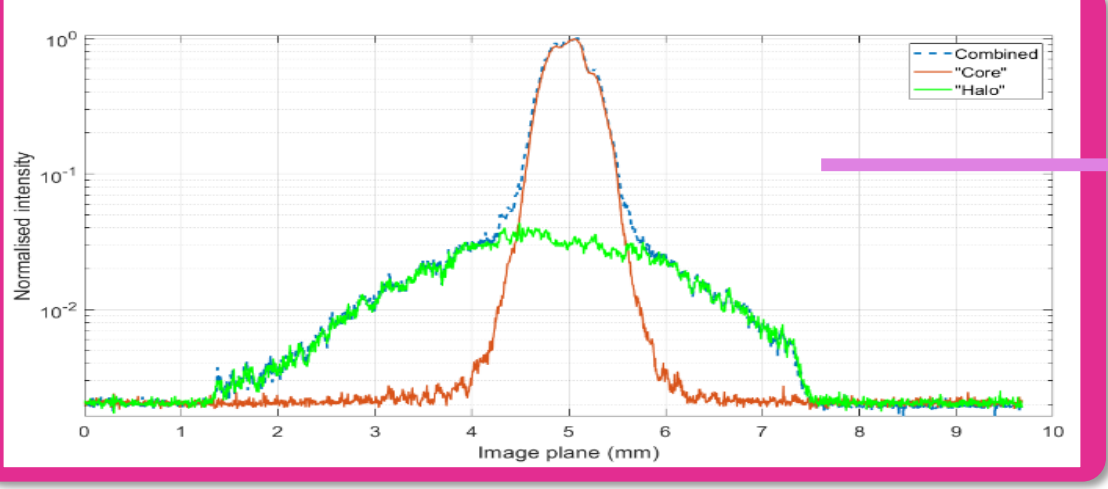
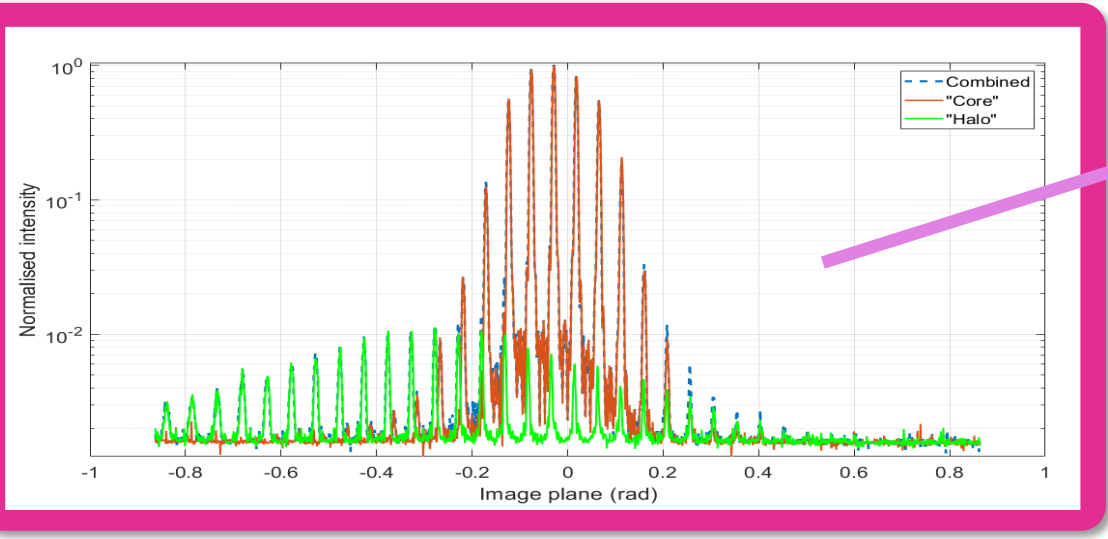
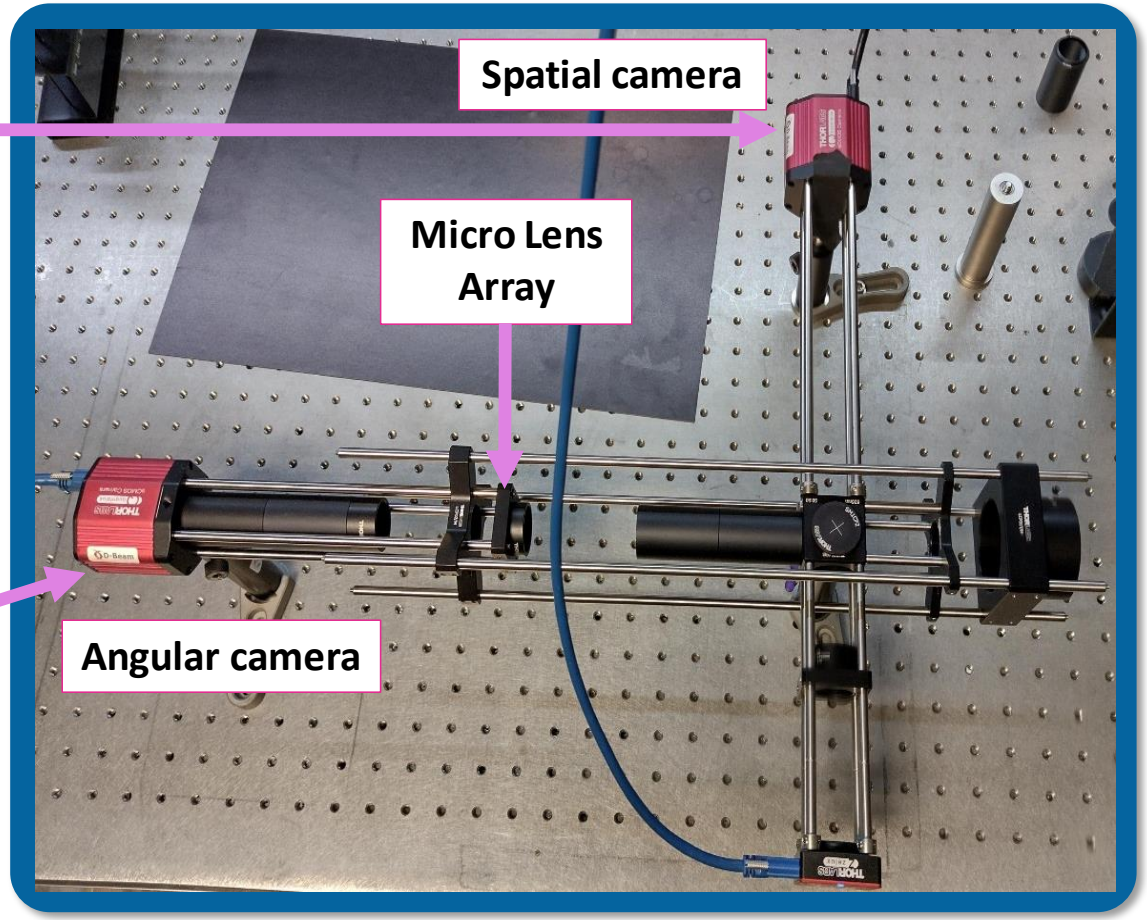


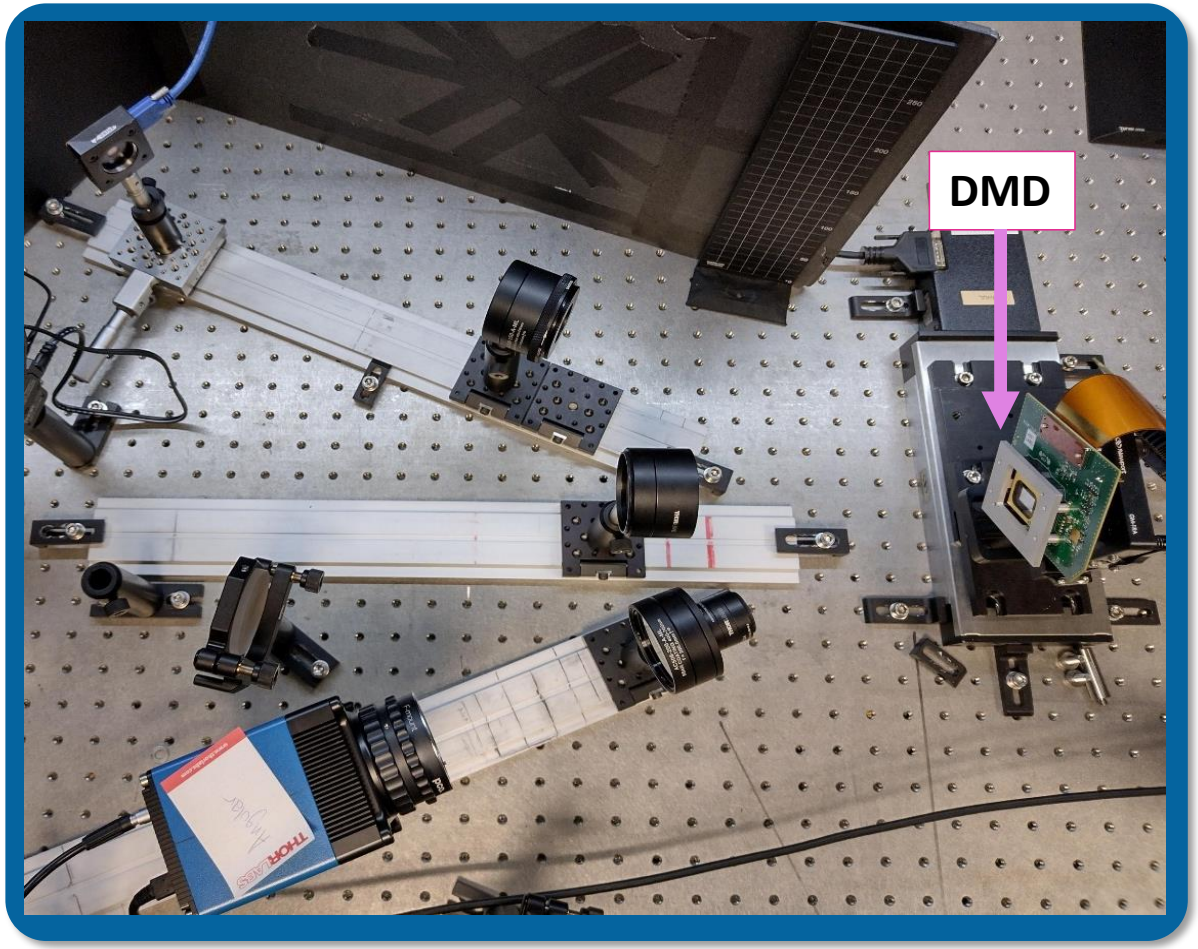




Pinhole measurements with a DMD

- Pinholes are a simple way to measure beam size, position, and emittance[6].
- Traditional pinhole measurements use a thin metal plate in the beam before a screen[7].
- To gain a full picture of emittance, the **pinhole must be scanned across the beam**.
- DMD – Digital Micromirror Device.
- Again, DMD uses OTR and so is **less invasive**.
- Already high resolution, but we're currently exploring single shot capability.

Pinhole measurements with a DMD



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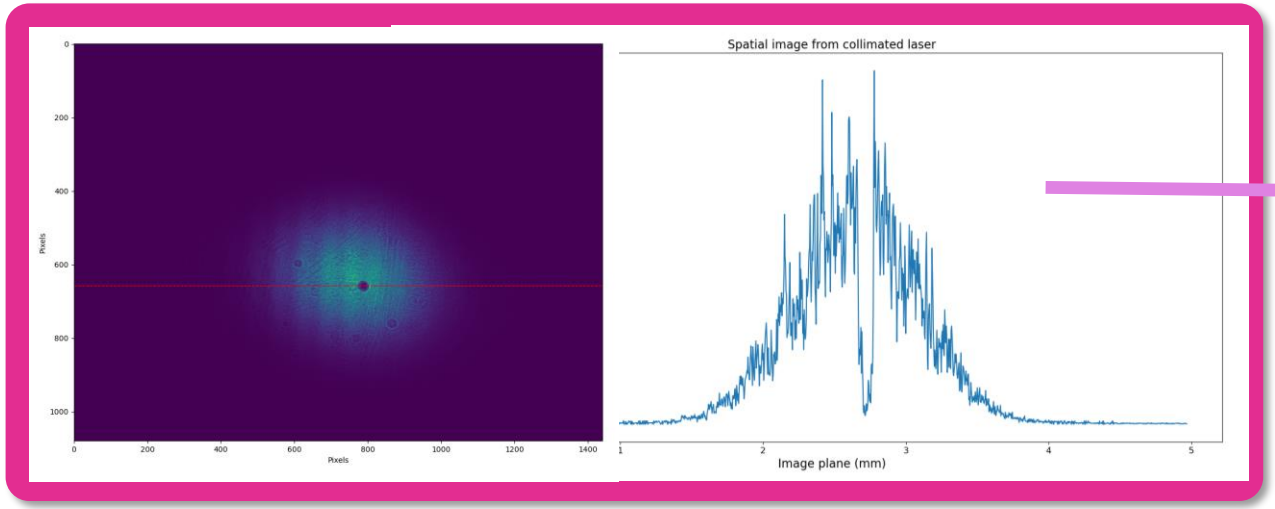

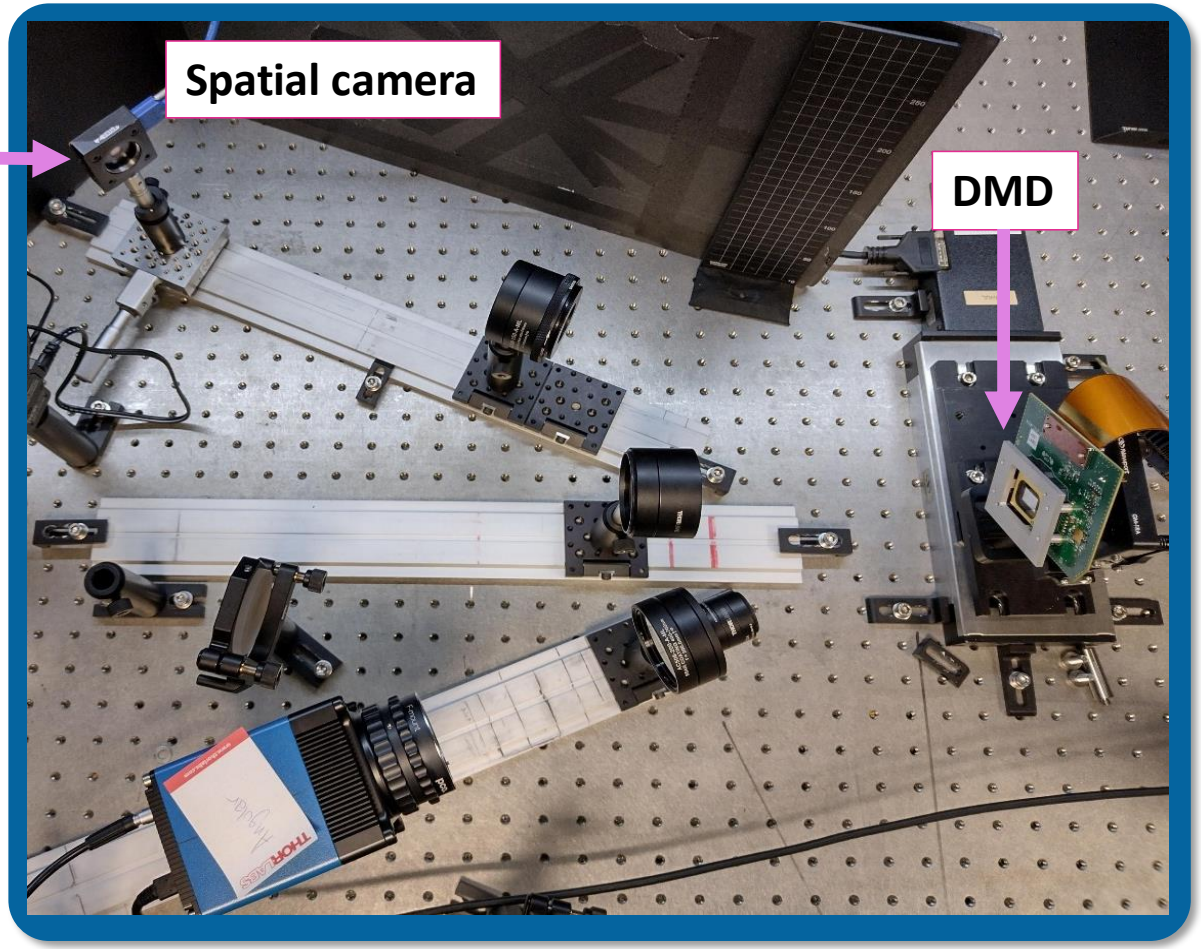

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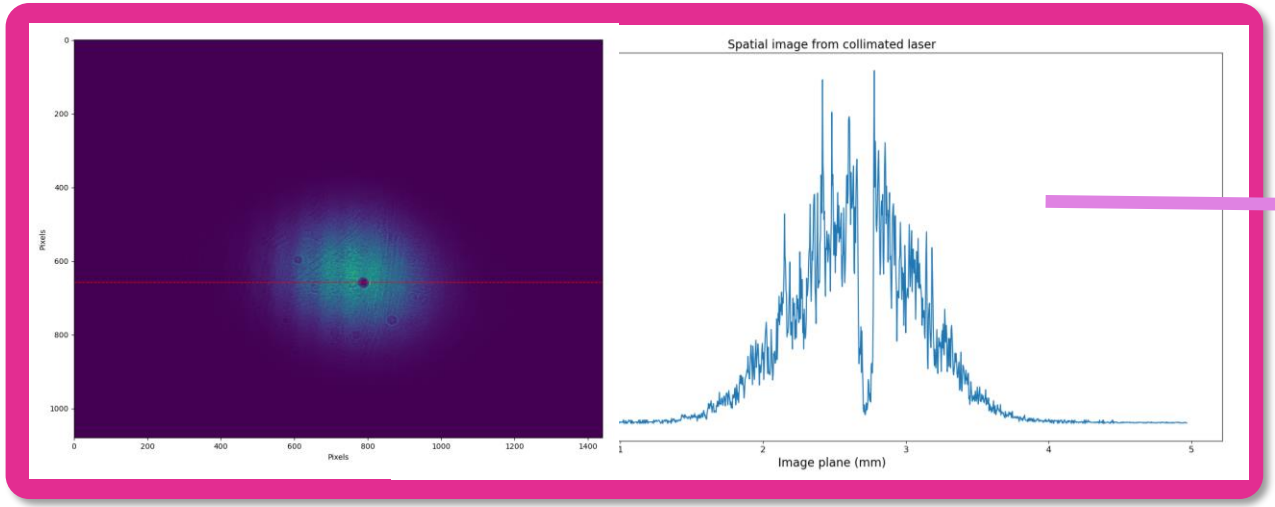

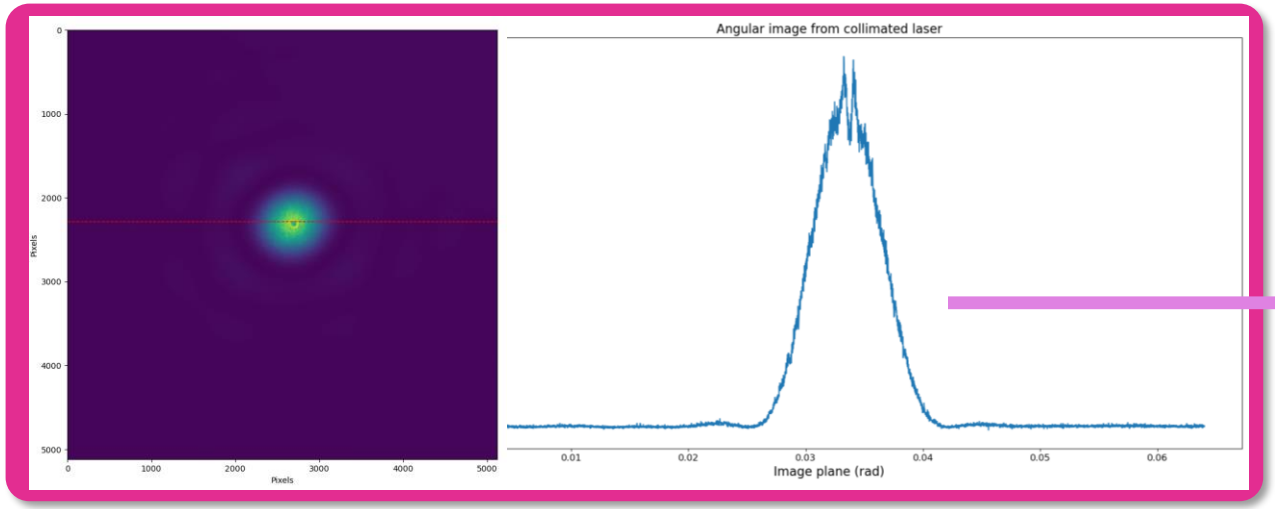

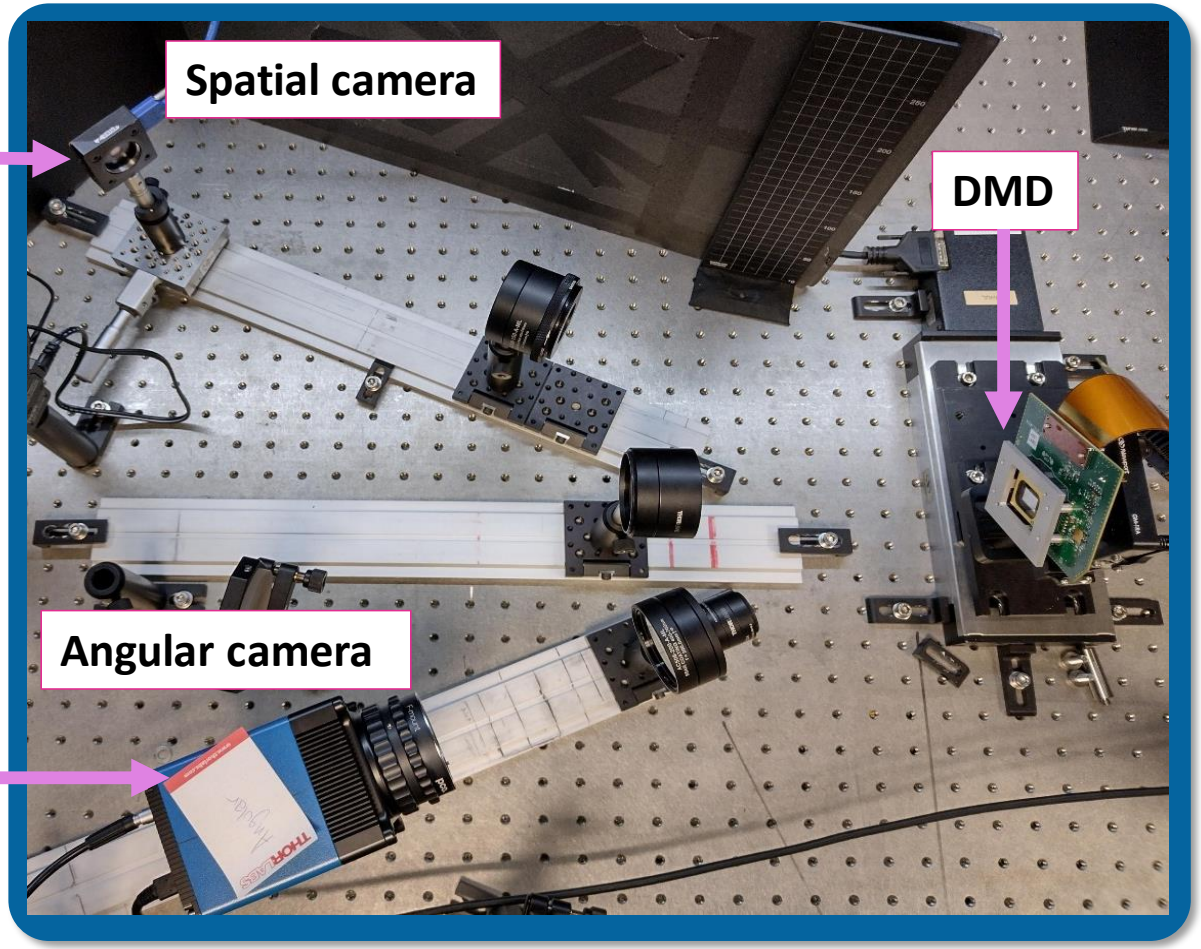

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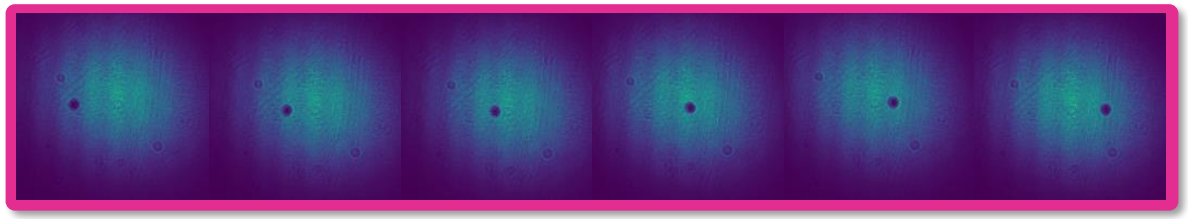

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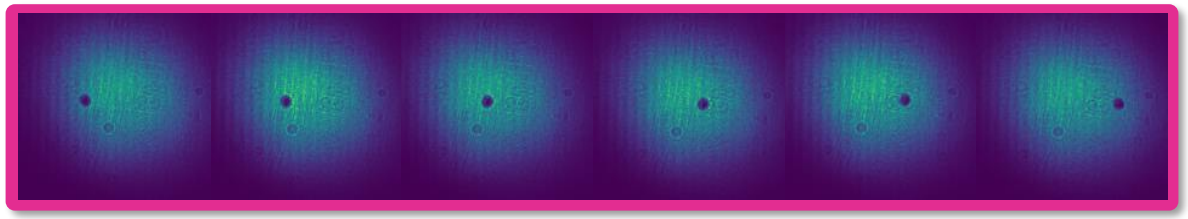
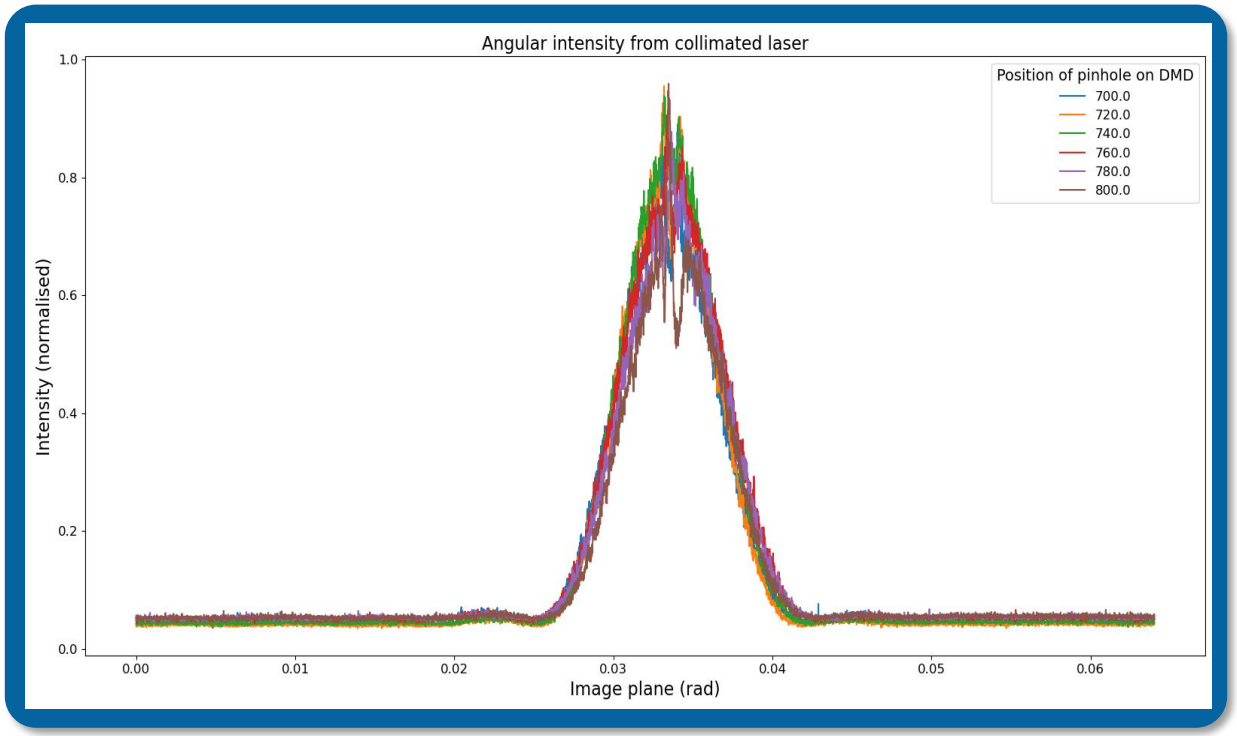
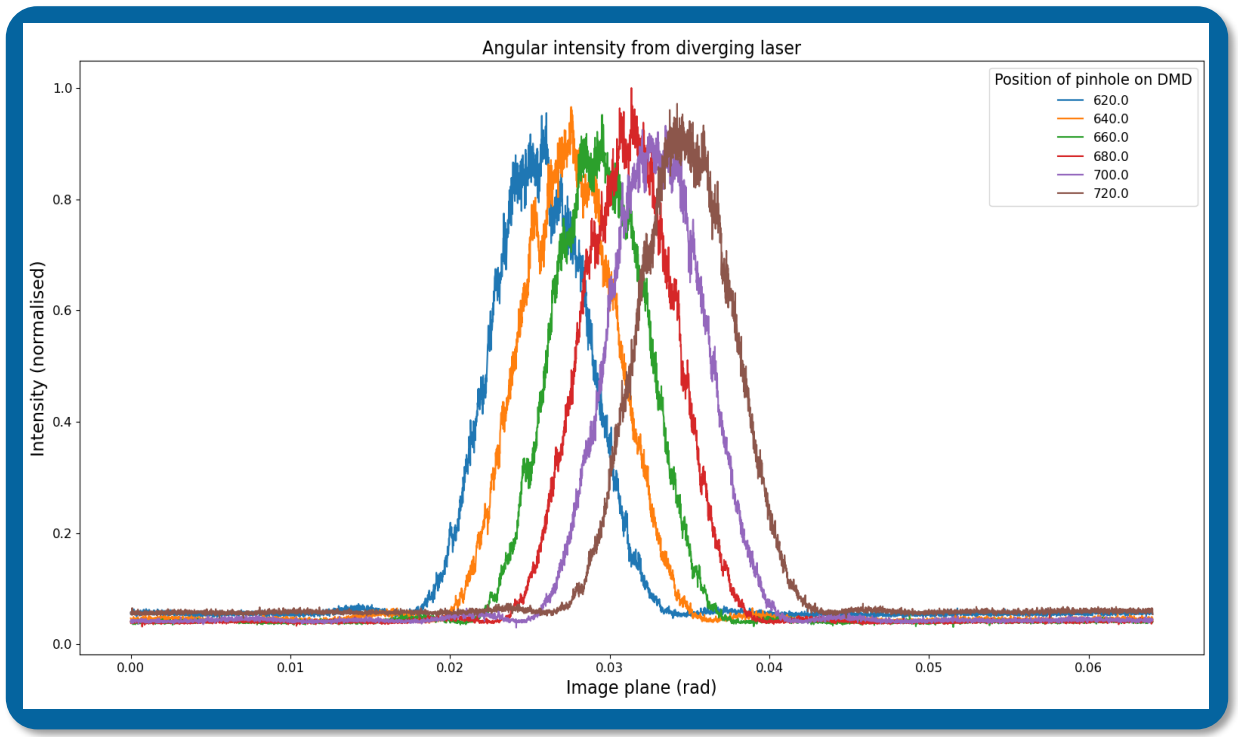


Diverging





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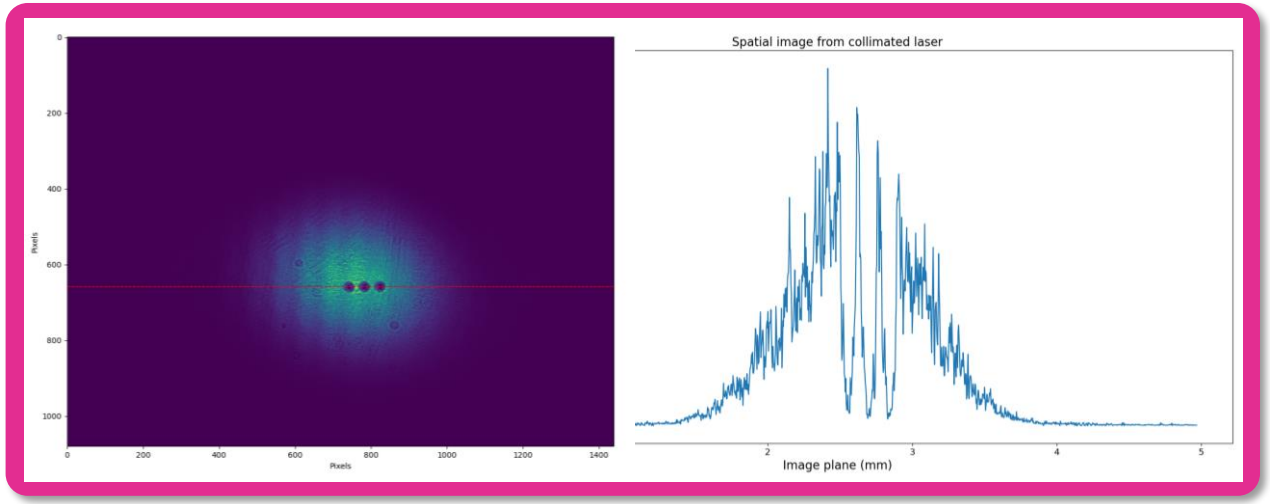

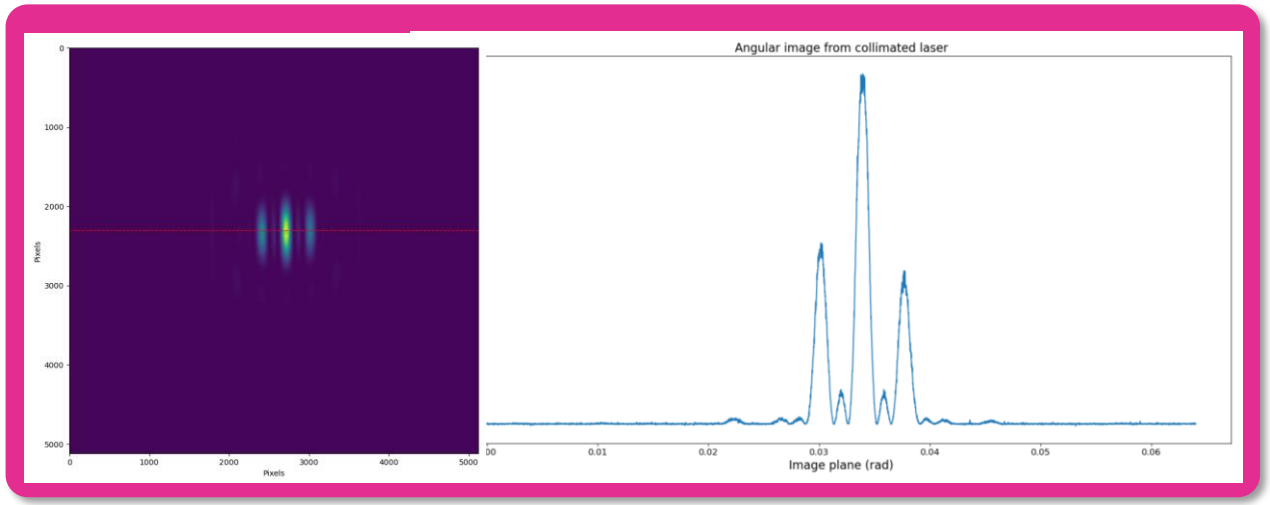

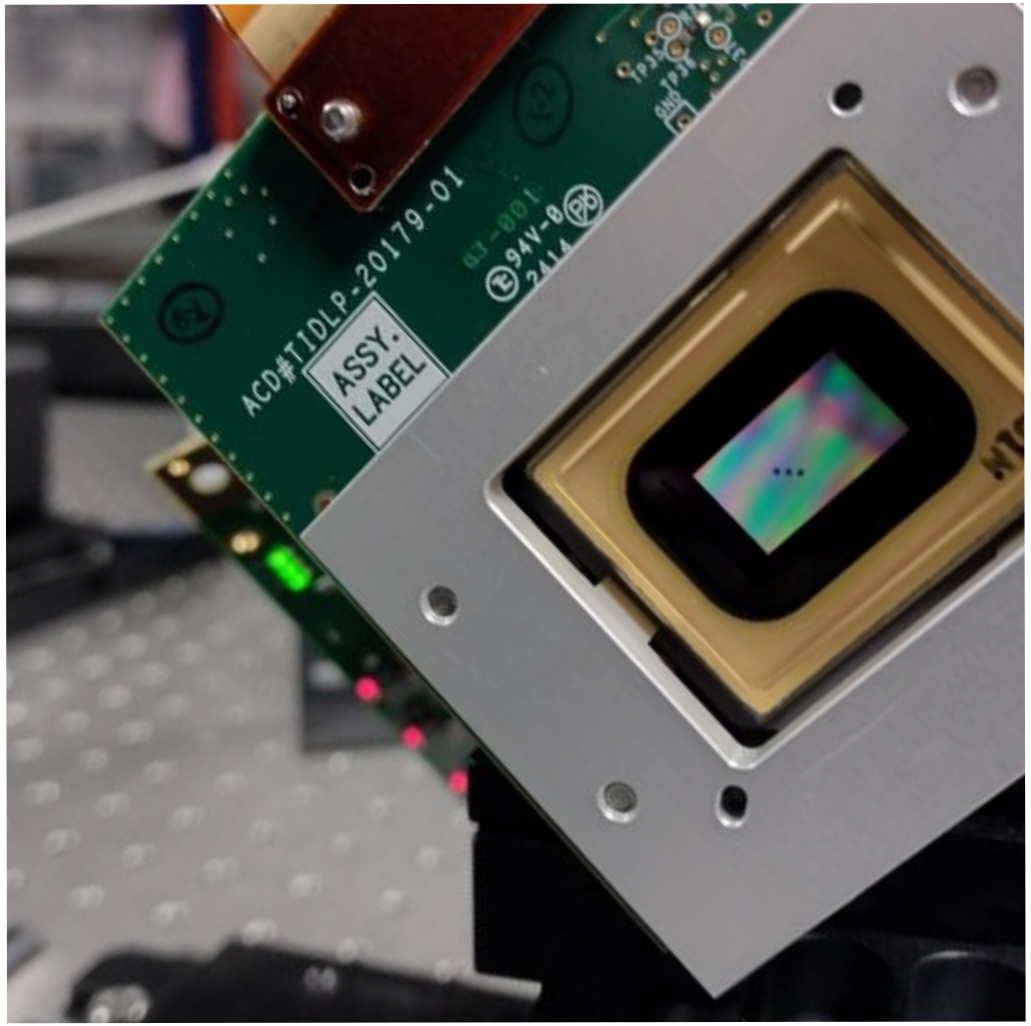

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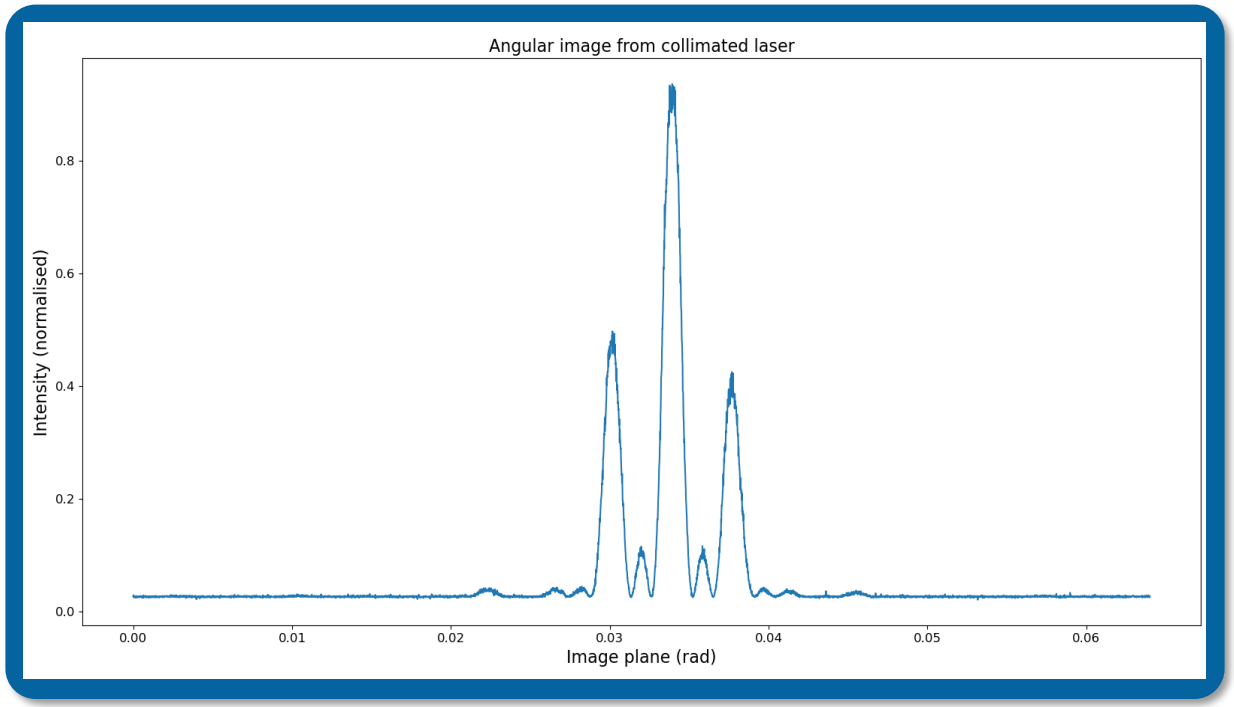

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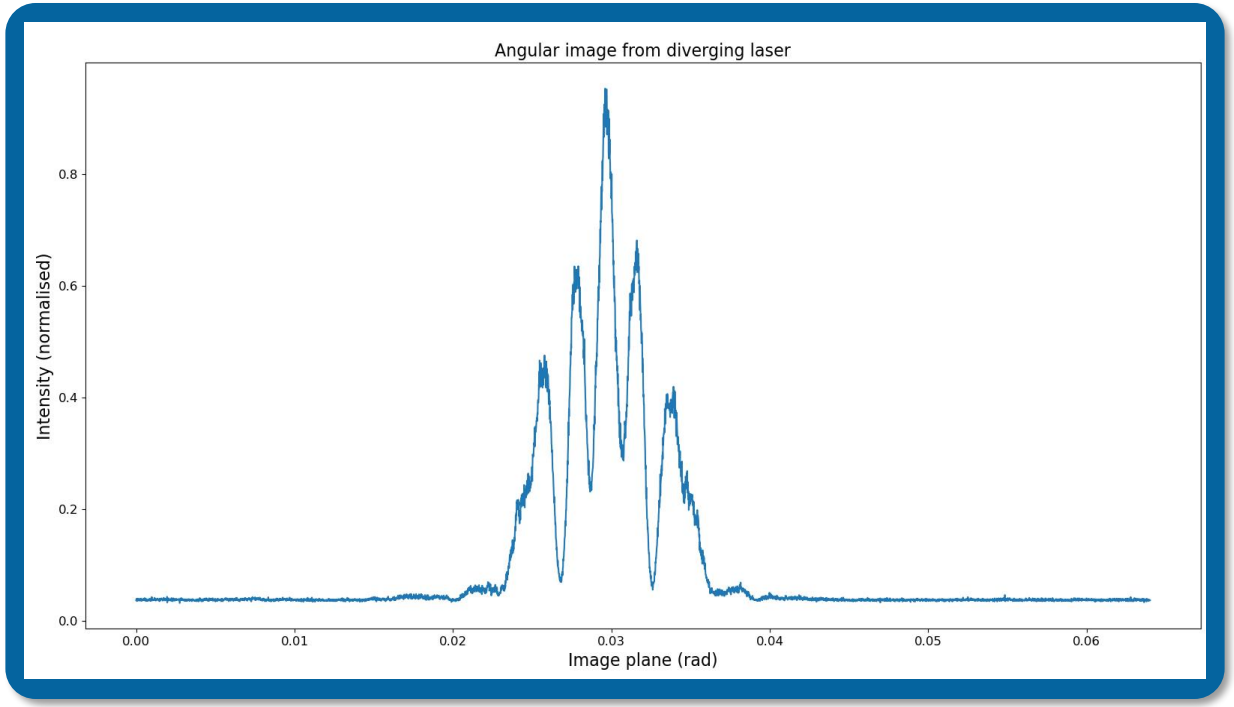

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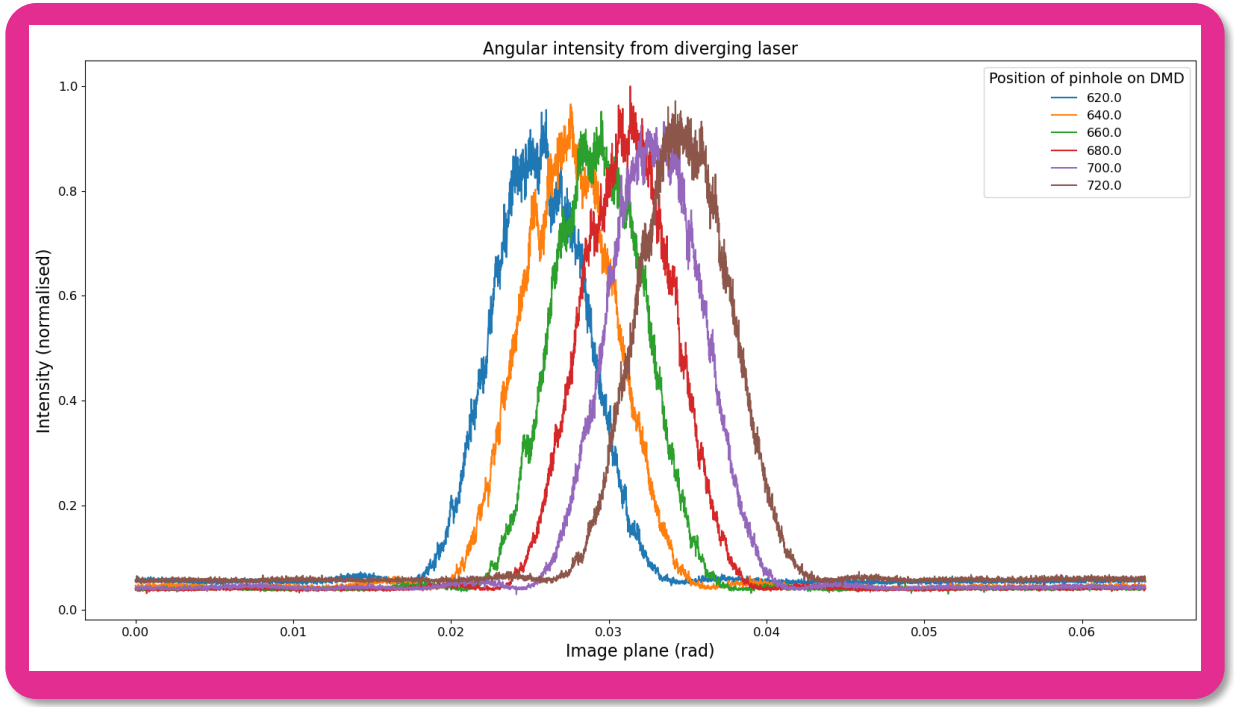
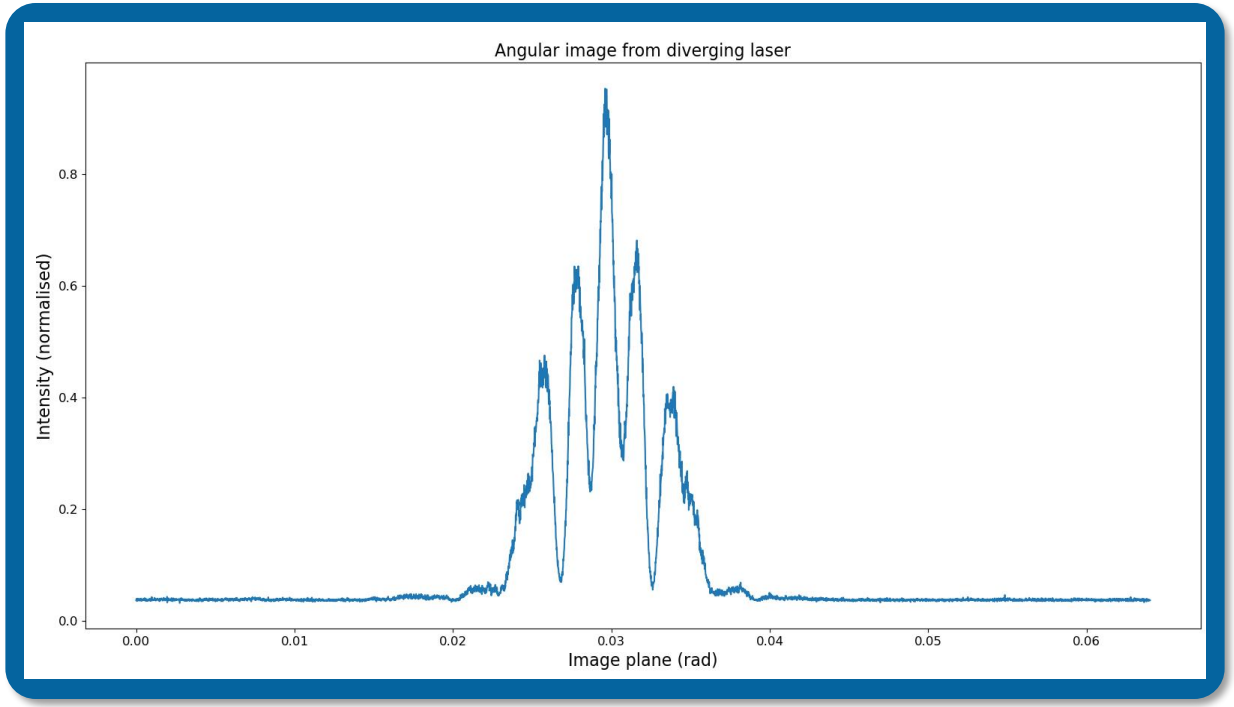
Pinhole measurements with a DMD

Single pinhole scan



Multiple pinholes



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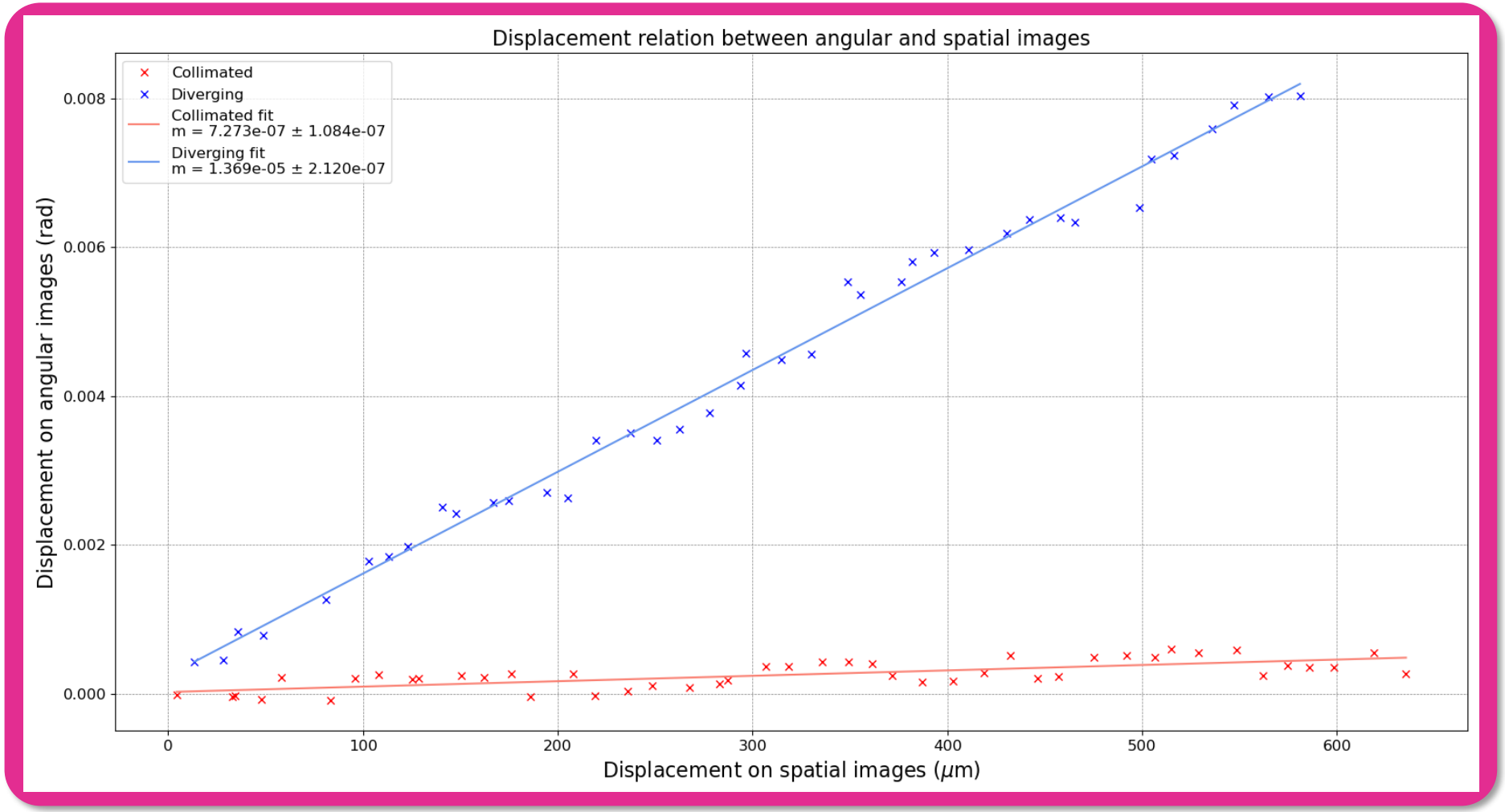

Summary

- **Compact, high resolution, single shot emittance measurements** are an important development within diagnostics, especially for novel accelerators.
- Both systems currently being tested fulfil two of these criteria, and the current improvements being made will allow them to fulfil all three.
- These setups also offer **less invasive methods** than their traditional counterparts.
- There are plans in place to test both setups on **CLARA FEBE and SPARCLab**.

Thanks for listening, any questions?

[1] S. Doebert, (2022), AWAKE collaboration meeting
[2] J. Chappell, et. al., (2019), 10th Int. Particle Acc. Conf., pg 3742 - 3745
[3] O. Apsimon, et. al., Nucl. Instrum. Methods Phys. Res., vol. 943
[4] J. Pitters, et. al., (2019), Nucl. Instrum. Methods Phys. Res., vol. 922, pg 28-35
[5] F. G. Bisesto, et. al., (2018), Methods Phys. Res., vol. 909, pg 364 – 368
[6] Y. B. Leng, et. al., Beam based calibration of X-ray pinhole camera in SSRF
[7] K. R. Ye, et. al., (2013), IBIC2013, pg 539 - 542

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