First results from the Imaging Motional Stark Effect diagnostic on ASDEX Upgrade

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J. Svensson[1], R. Wolf,[1] ASDEX Upgrade Team

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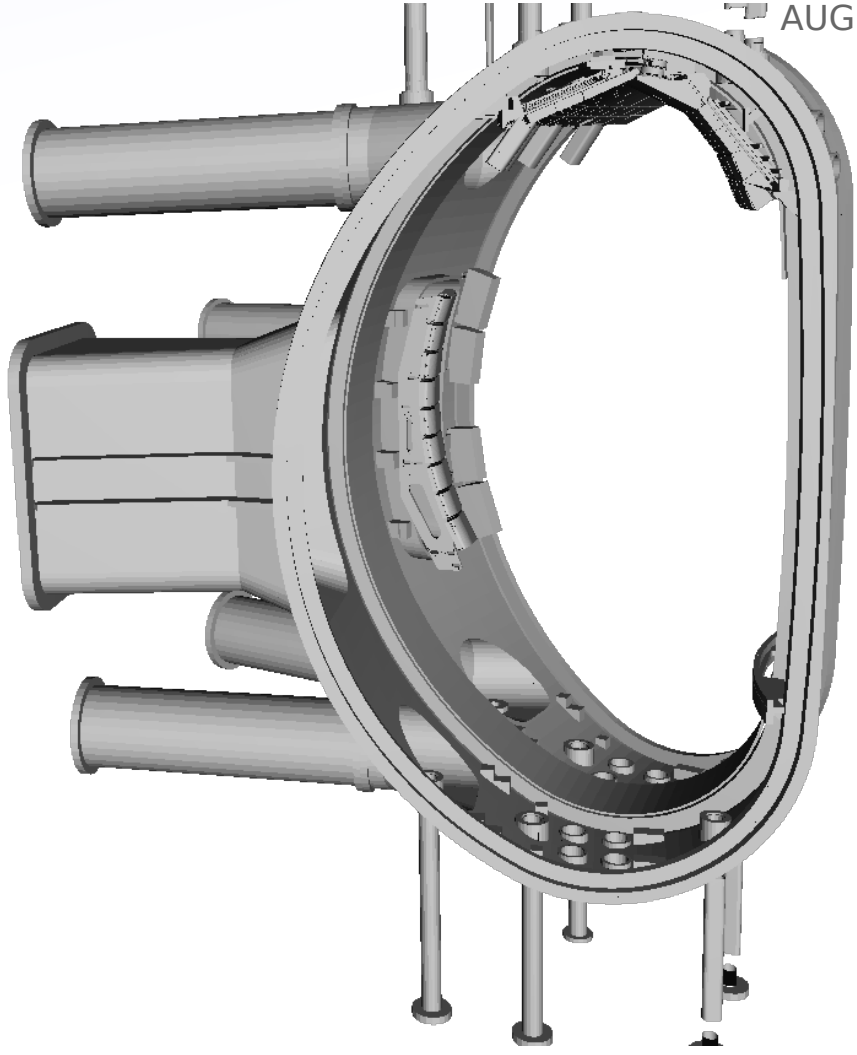
2: Plasma Research Laboratory, Australian National University, Canberra

(Imaging) Motional Stark Effect at AUG

ASDEX Upgrade has an existing 10-channel MSE system.



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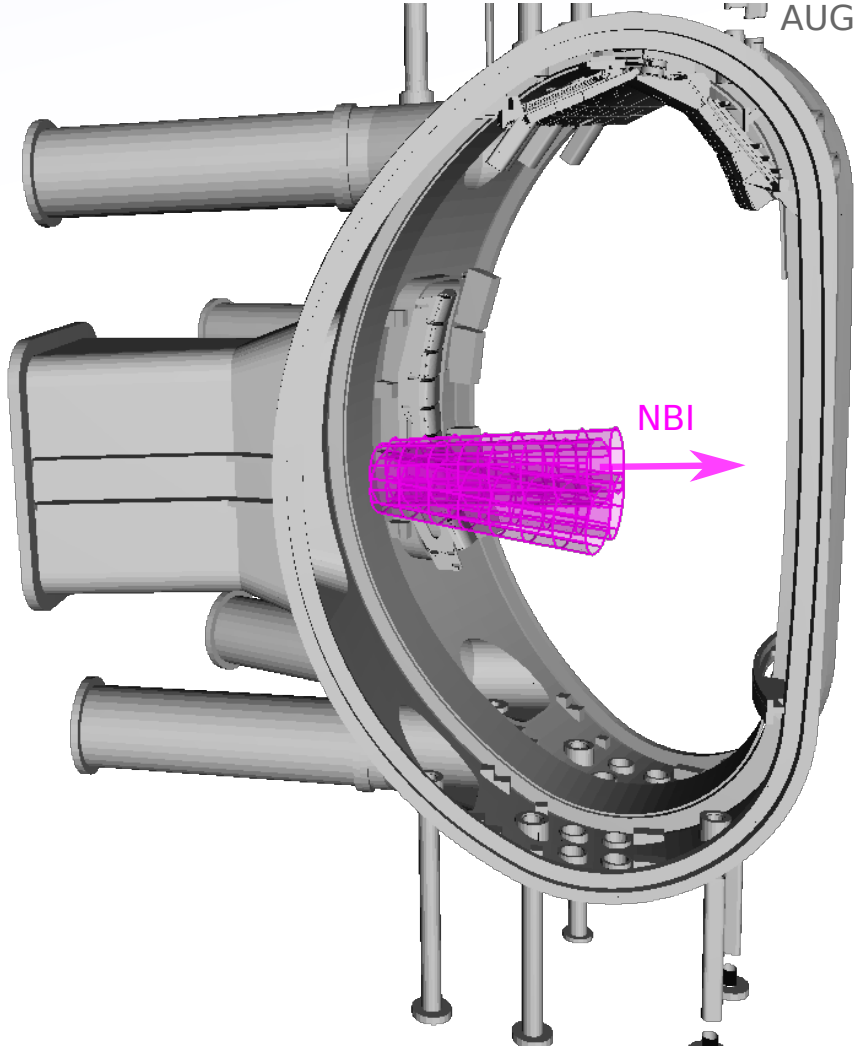

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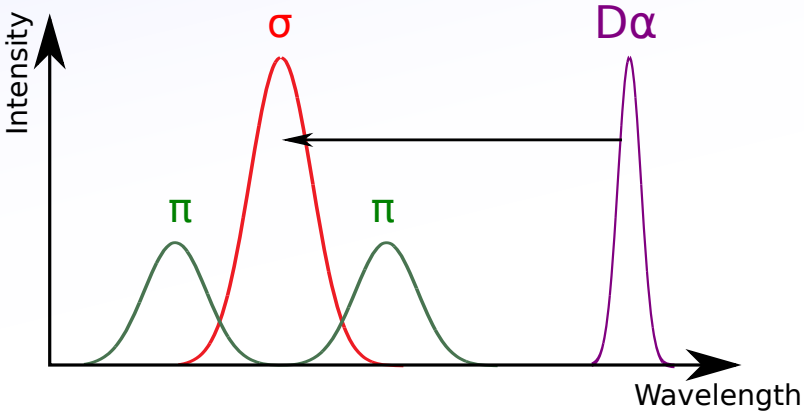
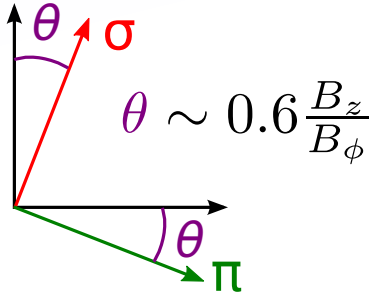
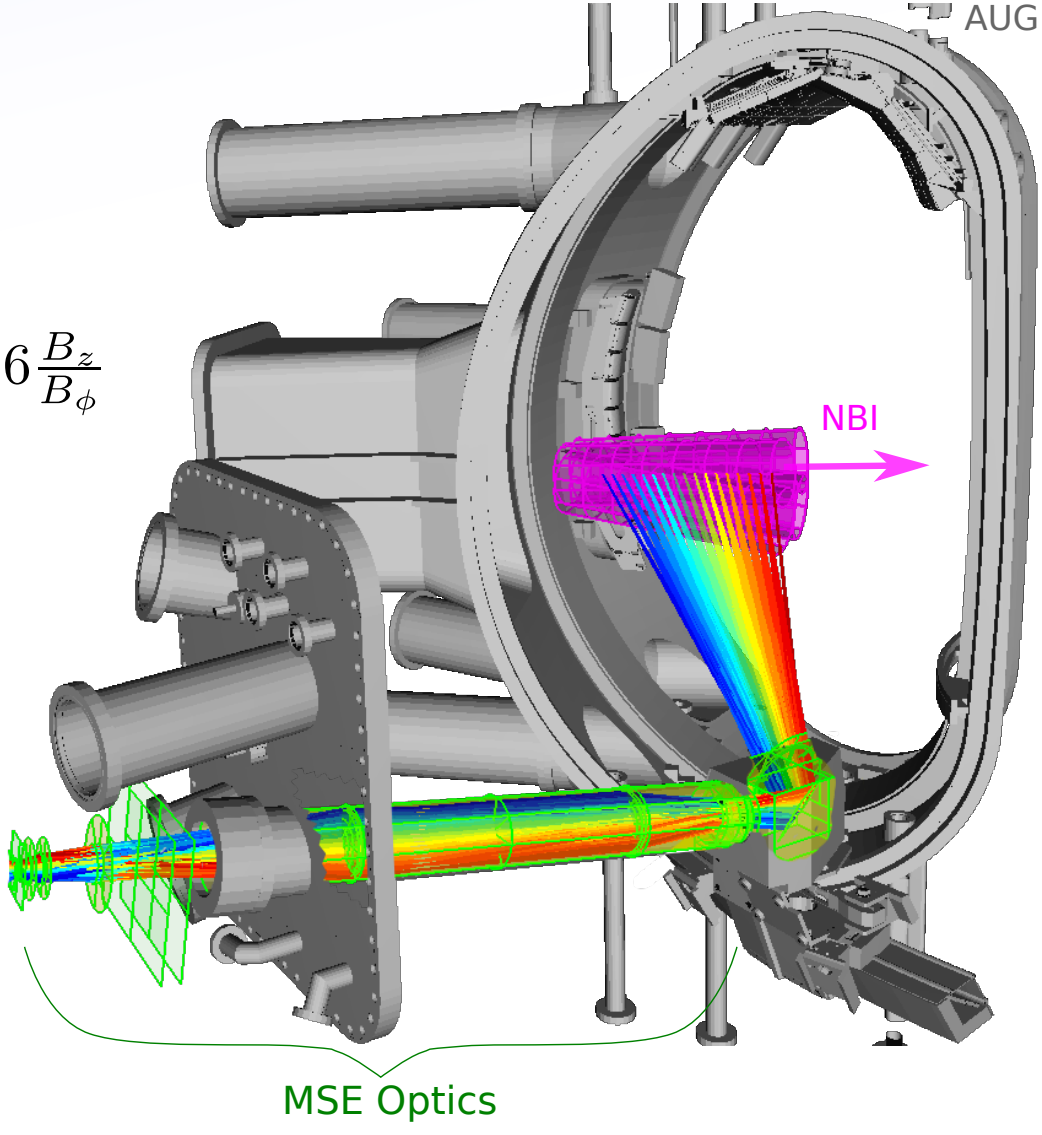




$$\theta \sim 0.6 \frac{B_z}{B_\phi}$$



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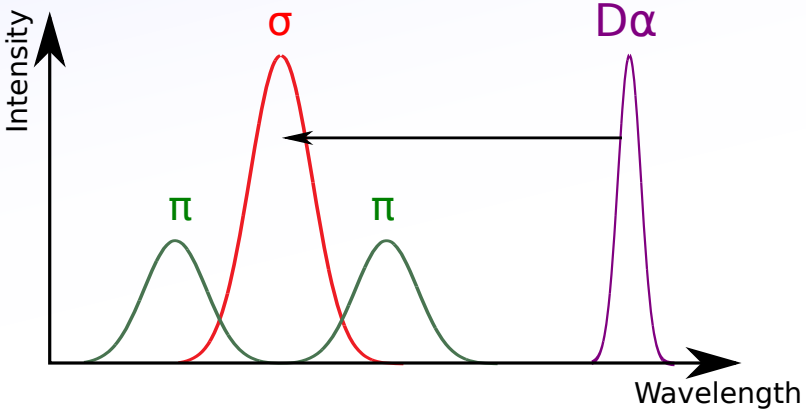

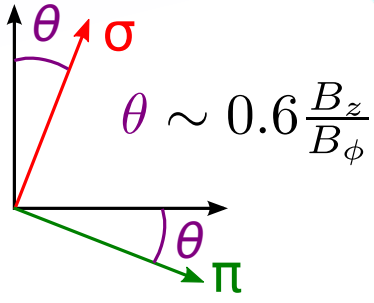

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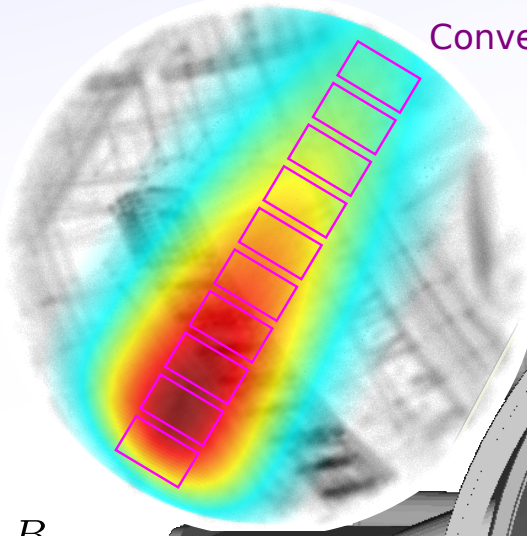
Modelled Image

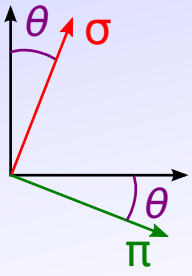


The IMSE observes a full image of the beam emission using a CCD camera, giving > 60x60 *θ* measurements.

As well as the increase in data, the 2D spread can shown to give more information for current inference (tomographic reconstruction)

It replaced the MSE for two short periods of plasma operation this year with the objective of testing the basic principle.

Image Demodulation



Two birefringent plates modulate the image with orthogonal interference patterns. The difference in the wavelength of the σ and π components is exploited to cause their interference patterns to add. Since the measurement of θ is periodic in 90°, the angle θ from each of the σ and π are averaged.

(Details in P6.006 poster, Diagnostics Satellite Meeting, Saturday)

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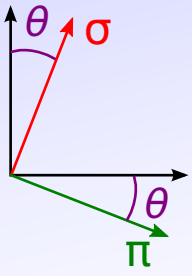

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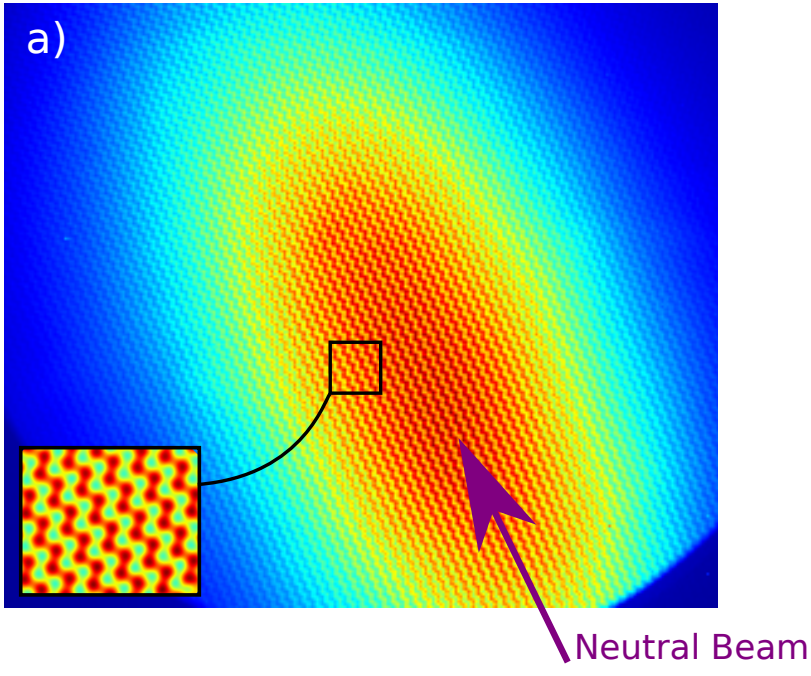
The image produced follows:

$$I \propto 1 + \zeta \cos(2\theta)\cos(x) + \zeta \sin(2\theta)\cos(x+y) + \zeta \sin(2\theta)\cos(x-y)$$



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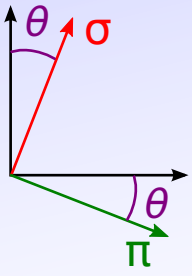

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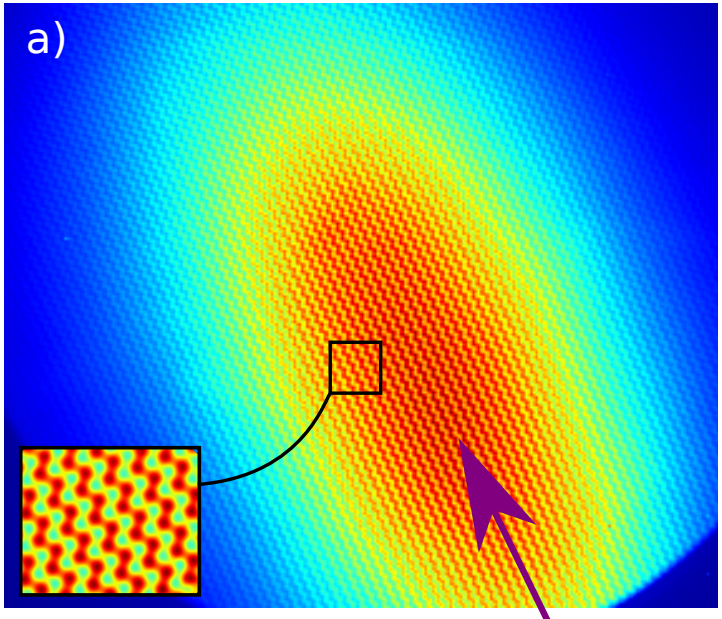
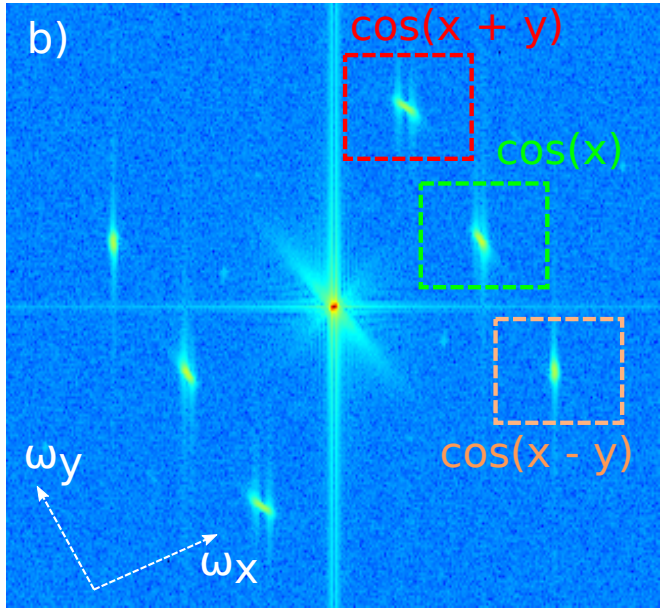
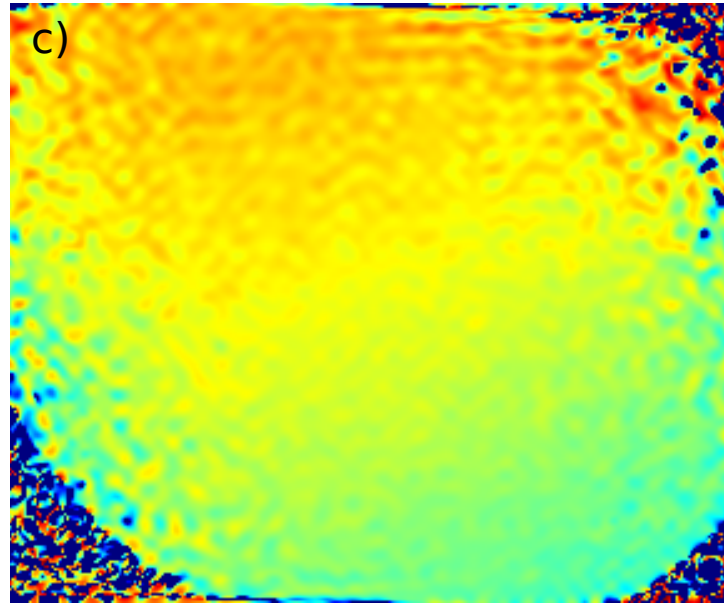
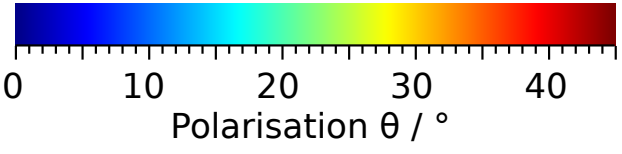






Neutral Beam



The polarisation angle relates directly to magnetic field pitch angle.

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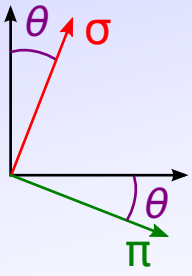

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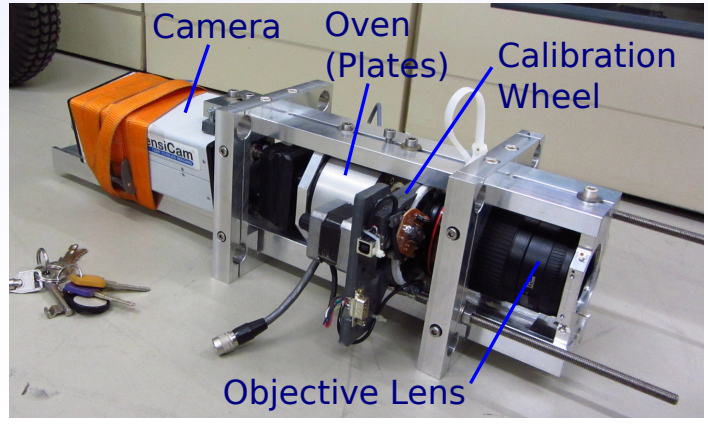

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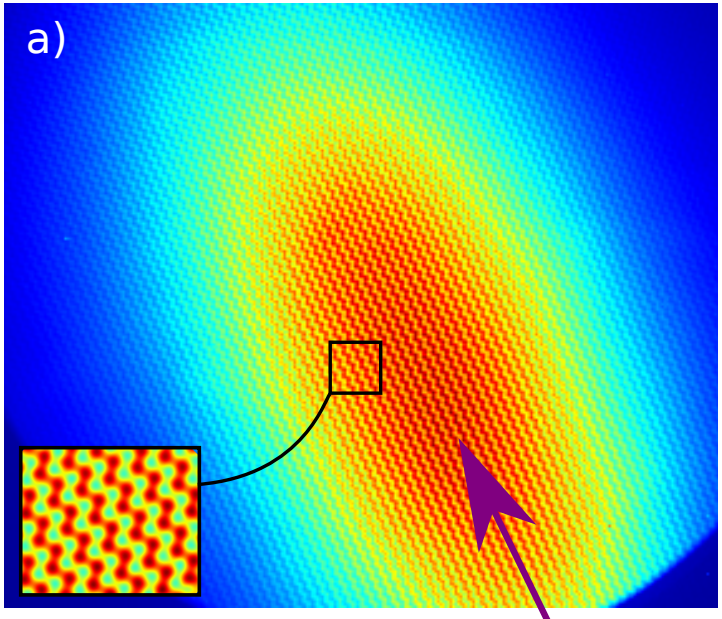

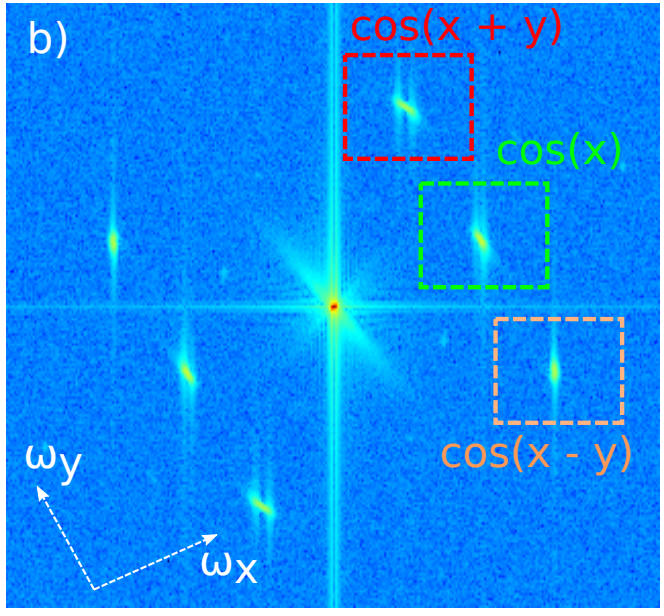

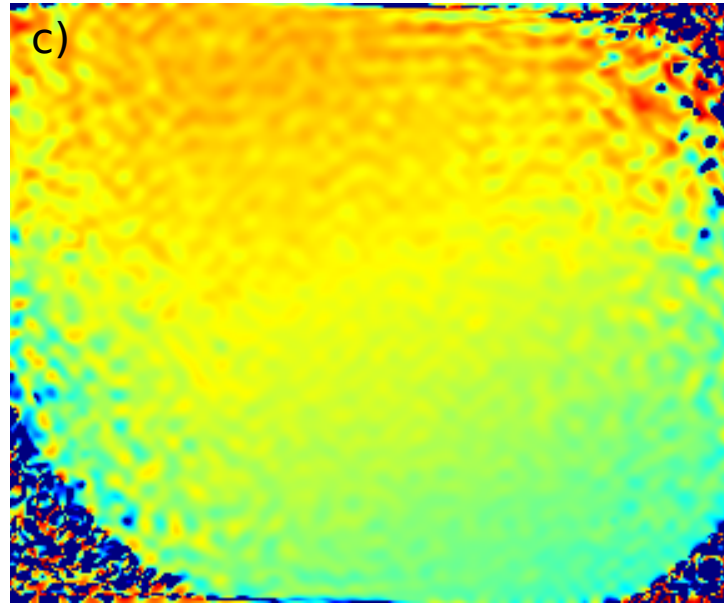

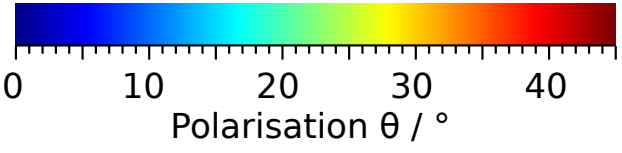

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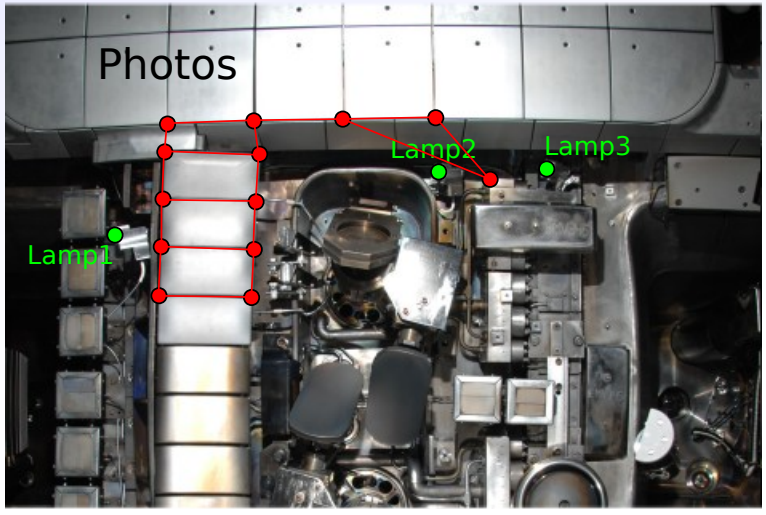

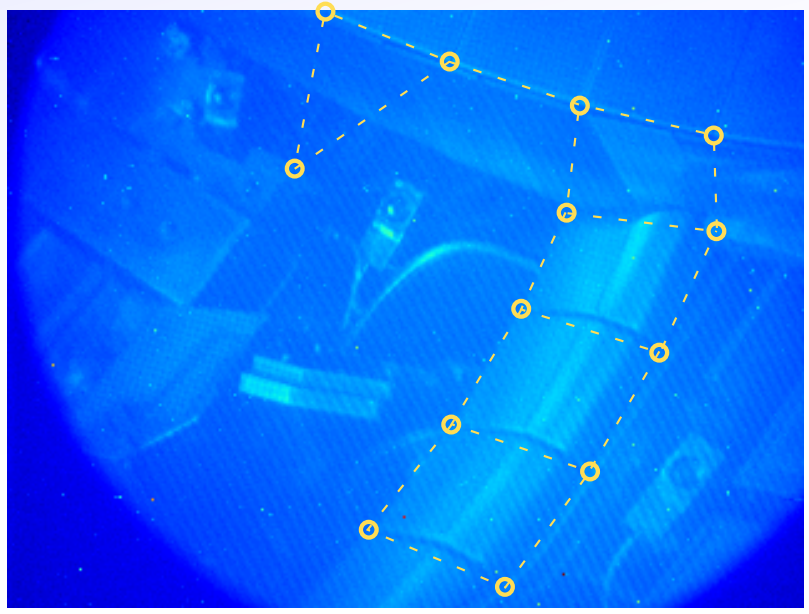

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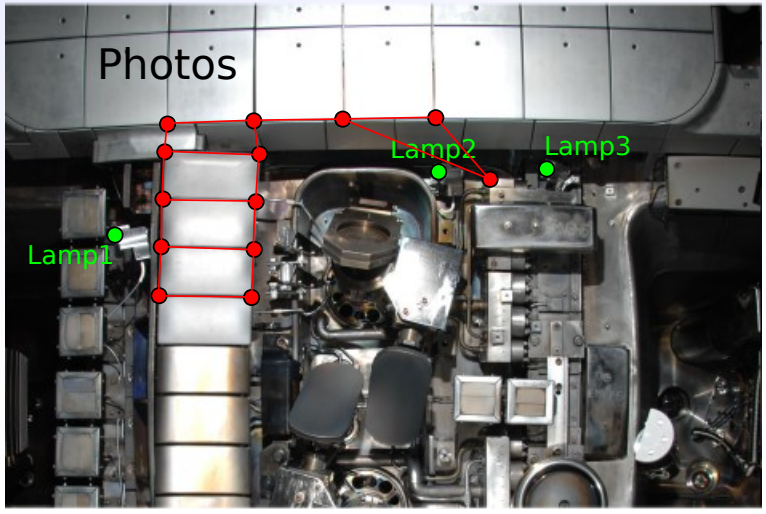

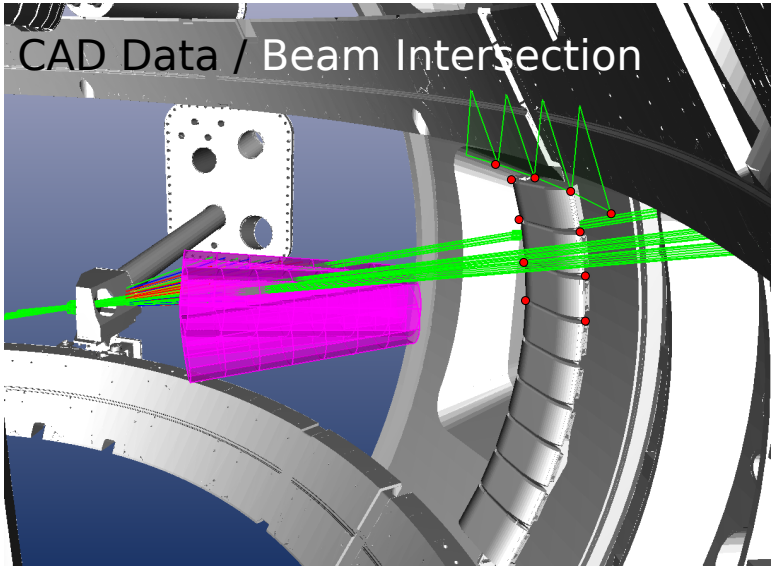

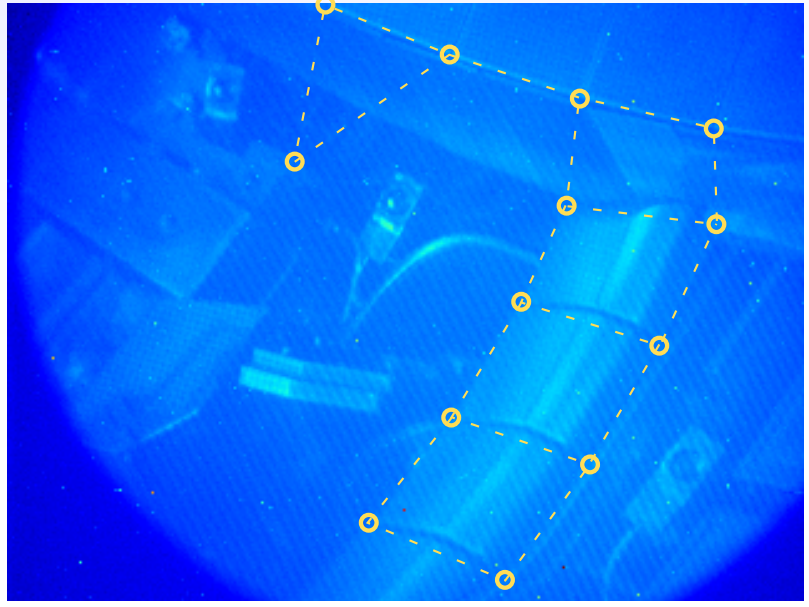

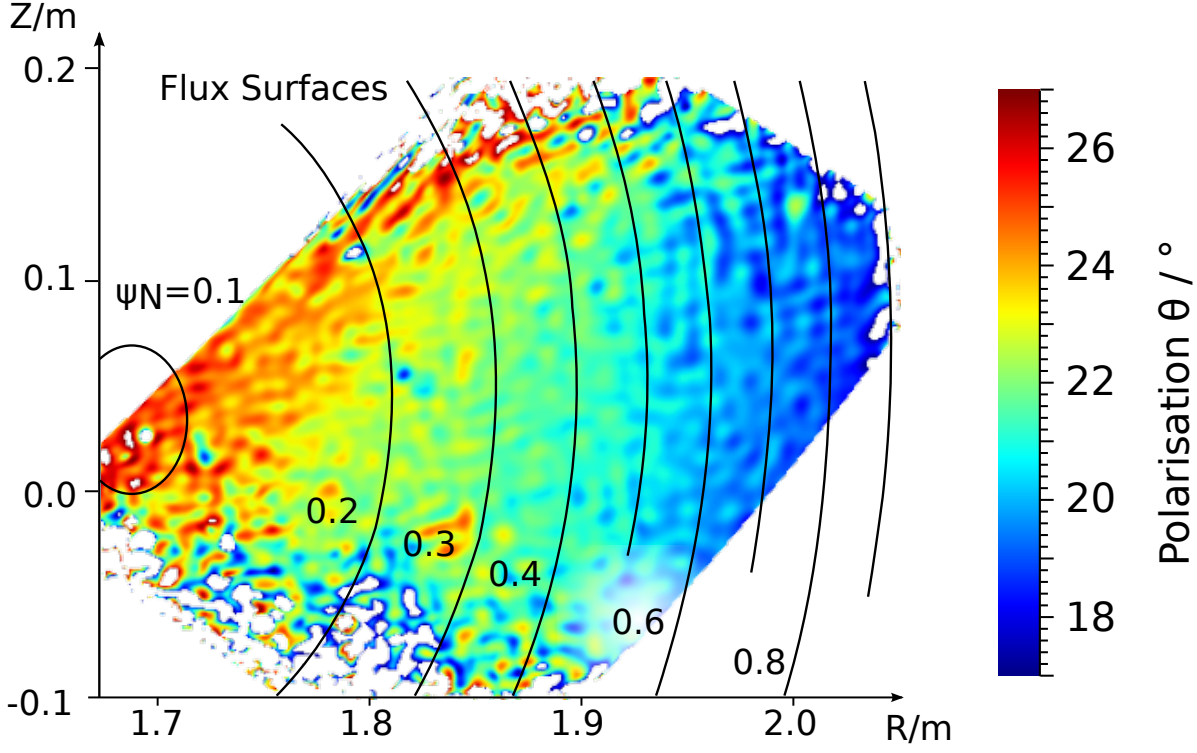

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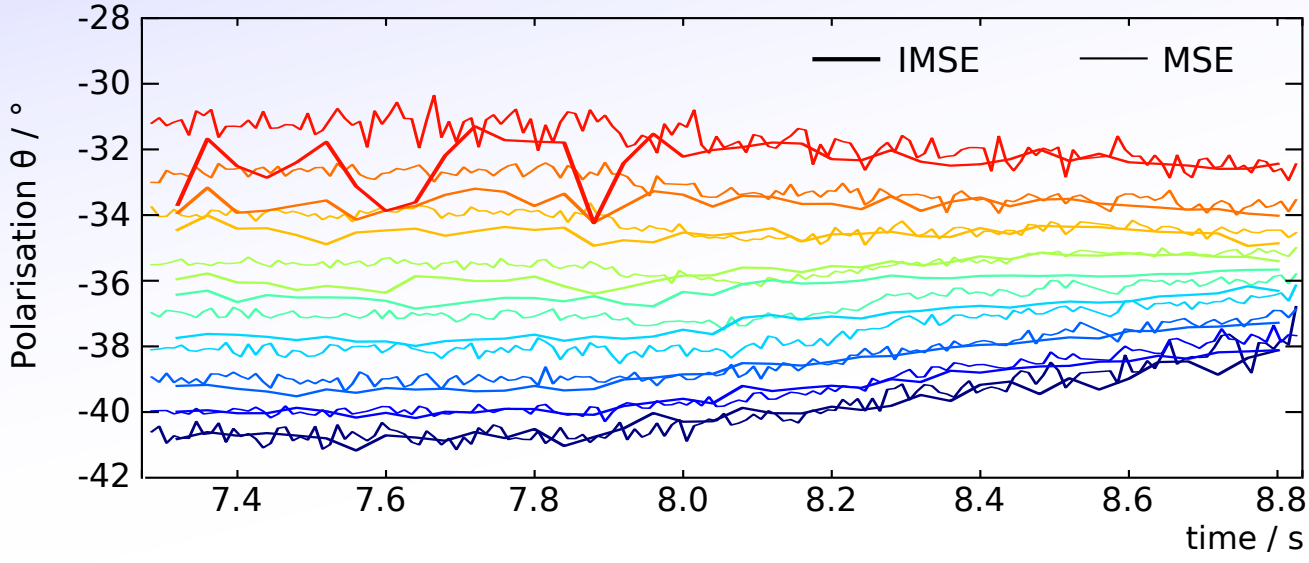
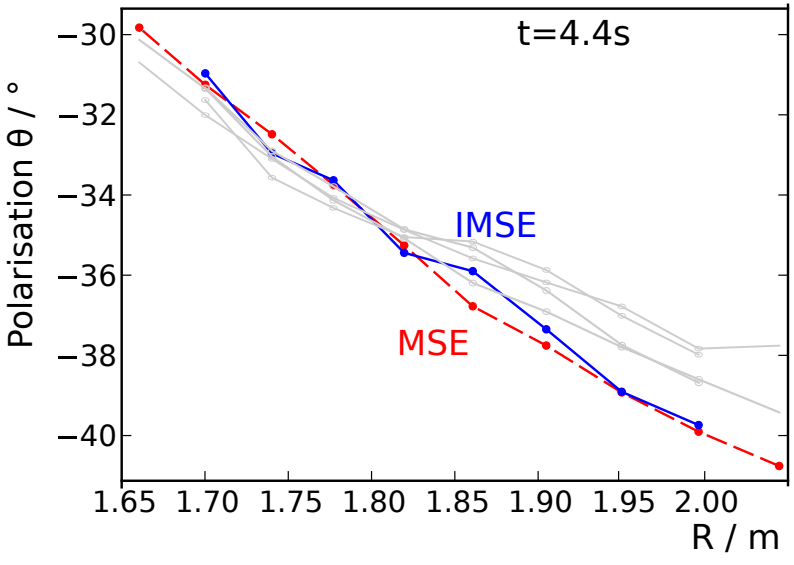
To compare the IMSE and MSE systems directly, the same plasma shot was run with the MSE system in the following week. Except for a 1.1° offset, the agreement is good:





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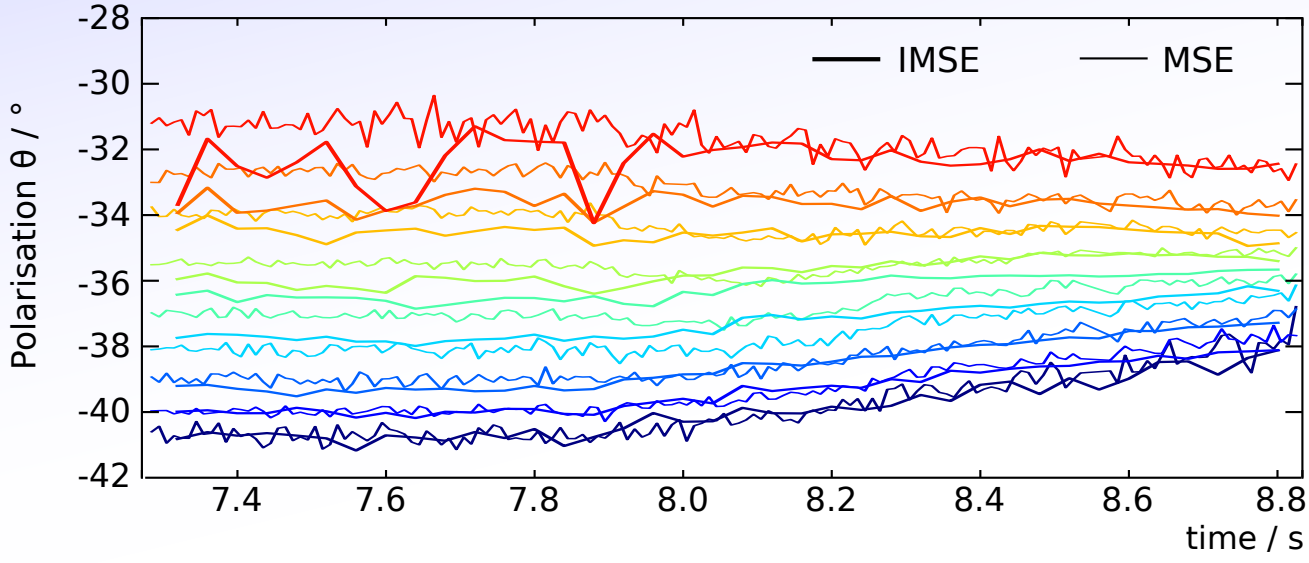

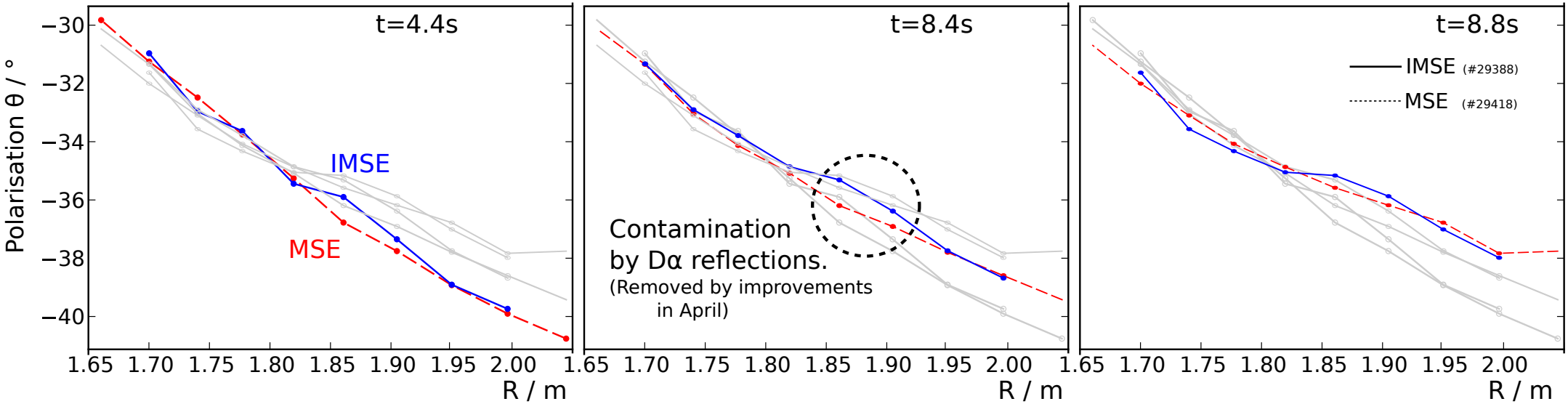

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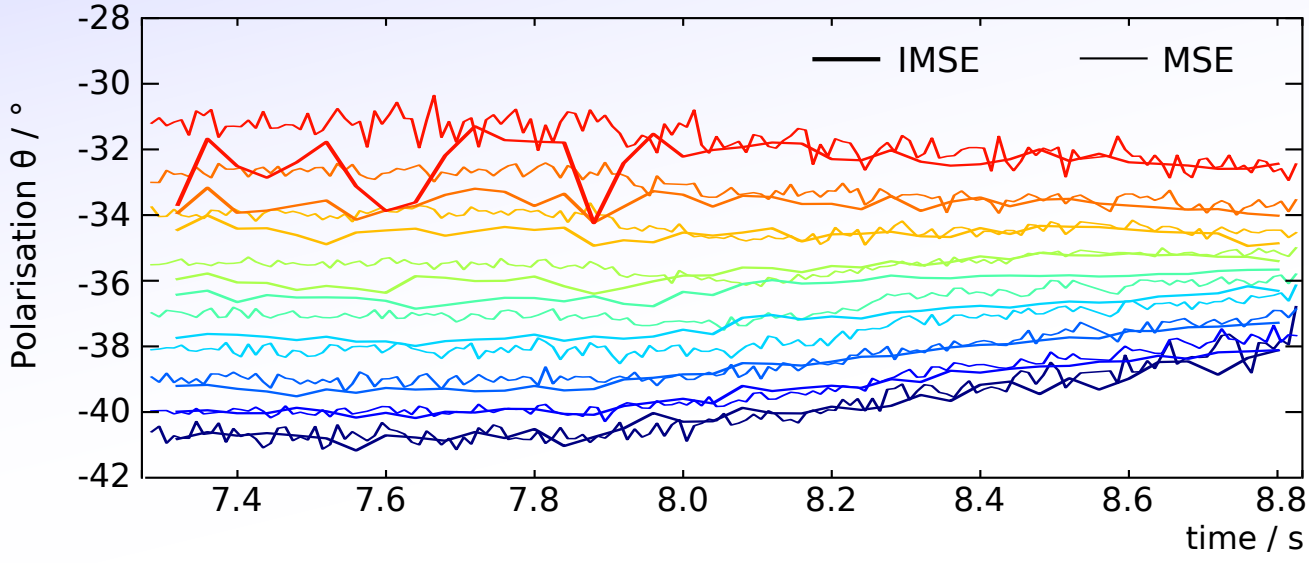

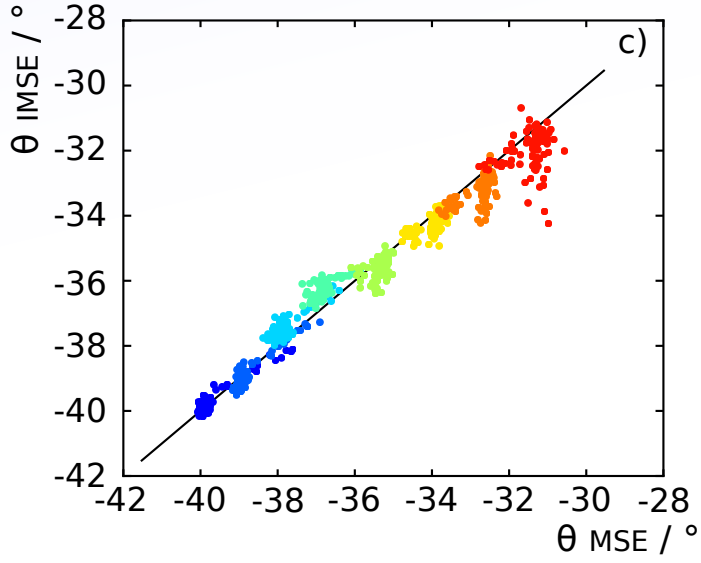

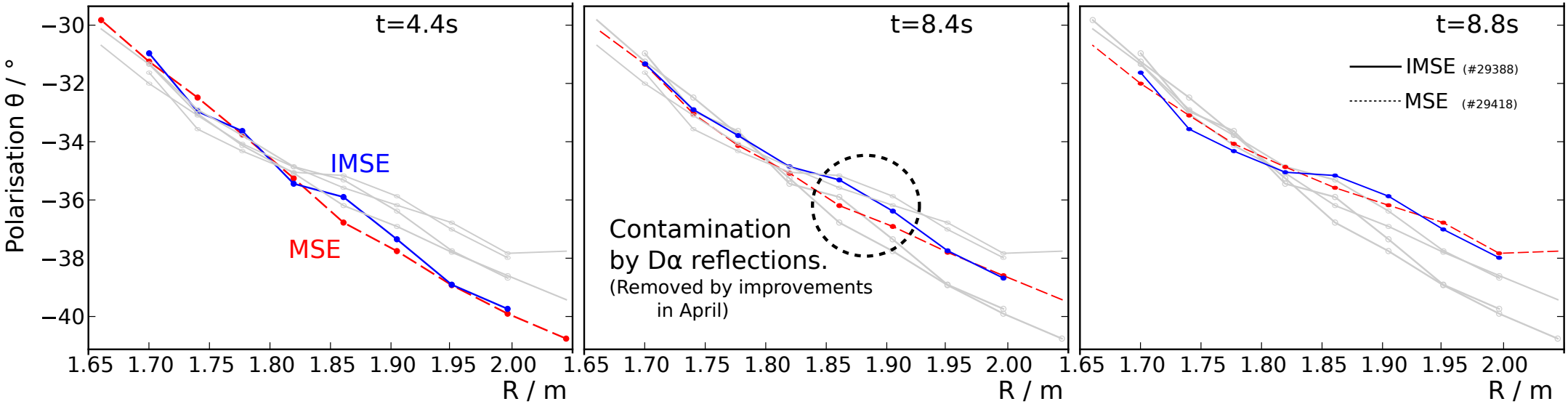

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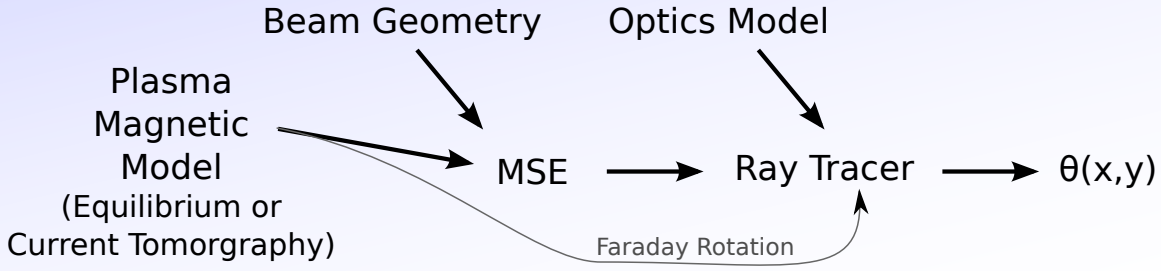

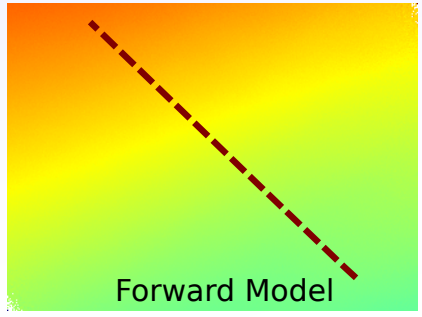

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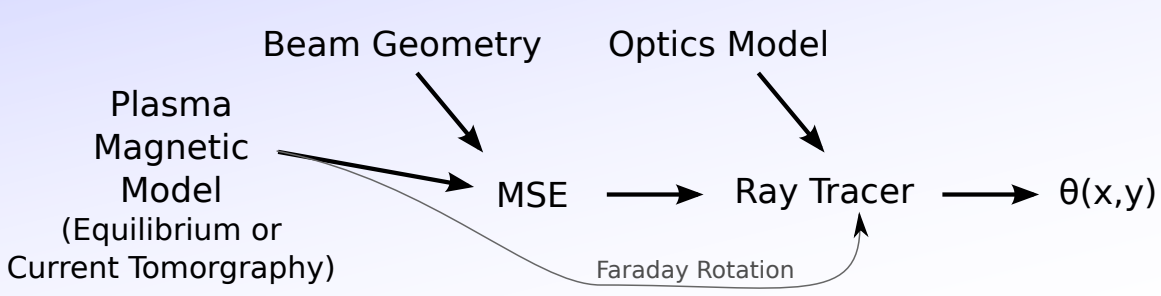

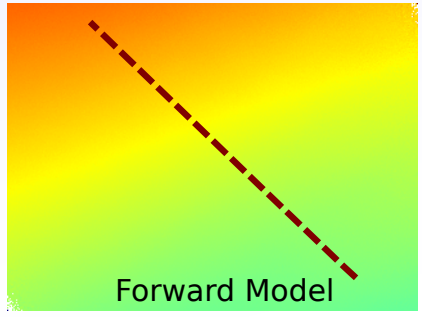

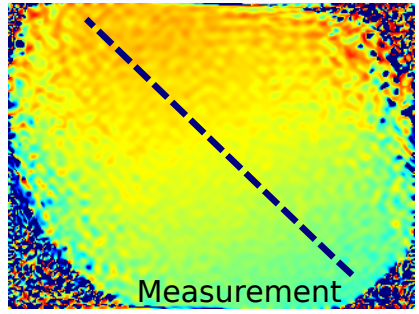

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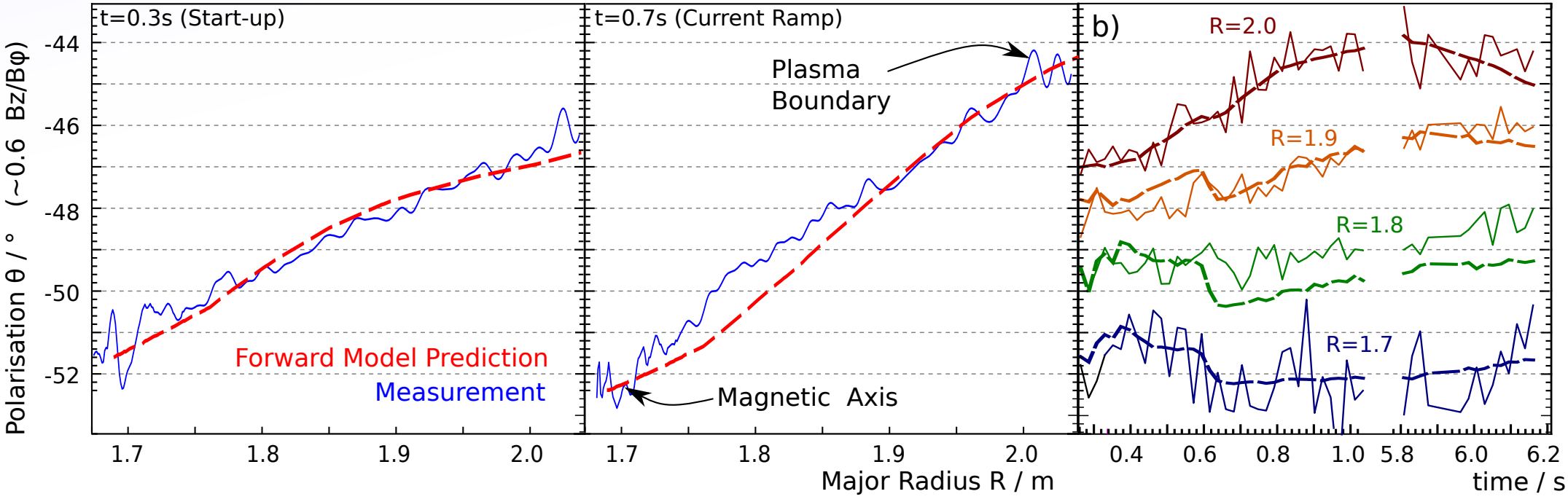

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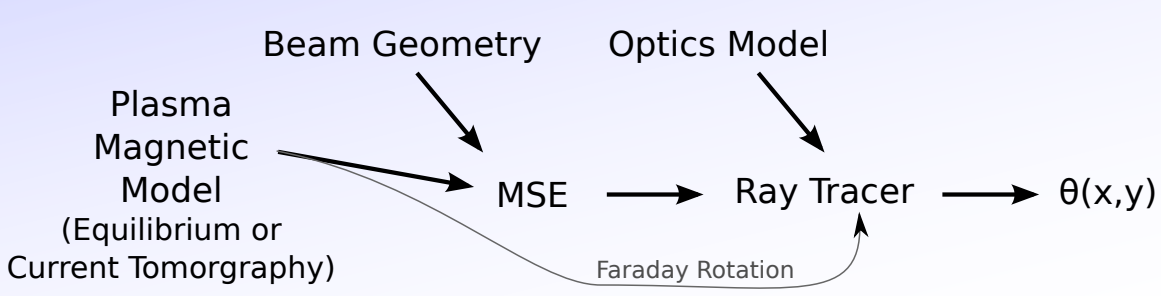

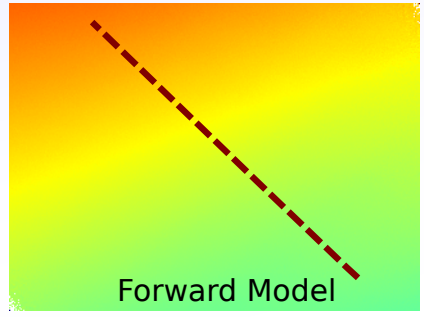

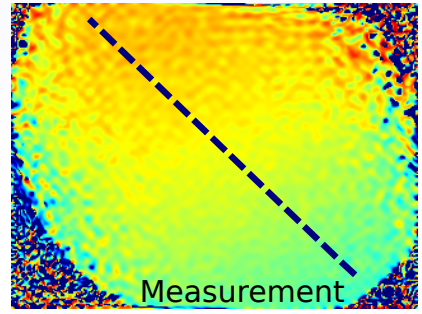

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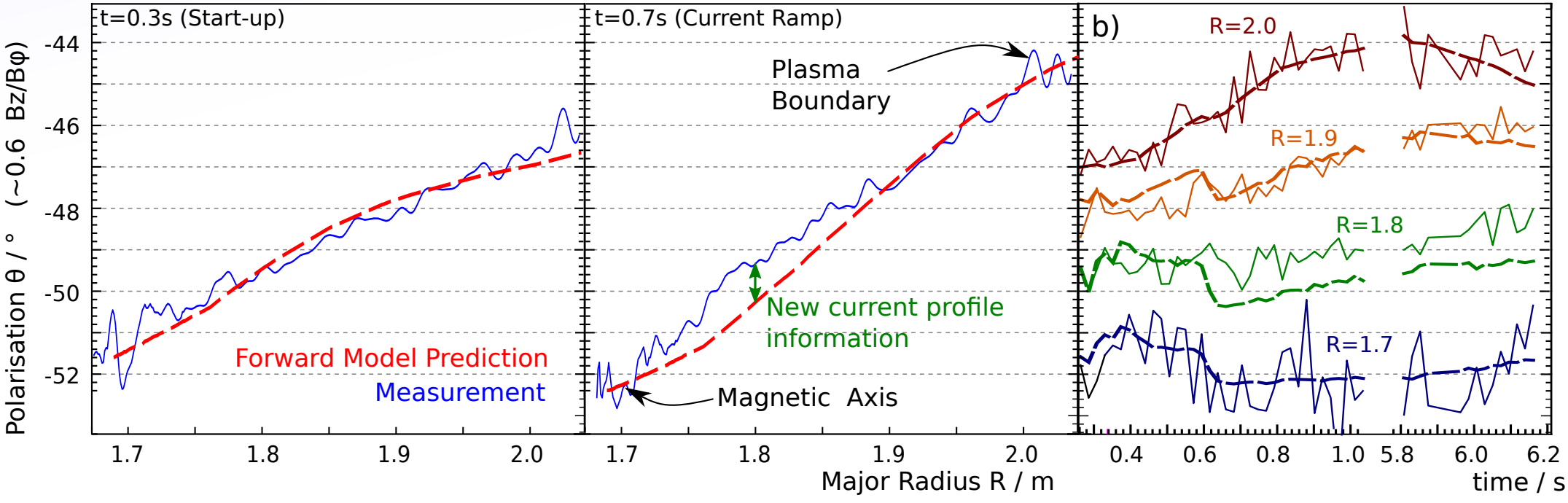

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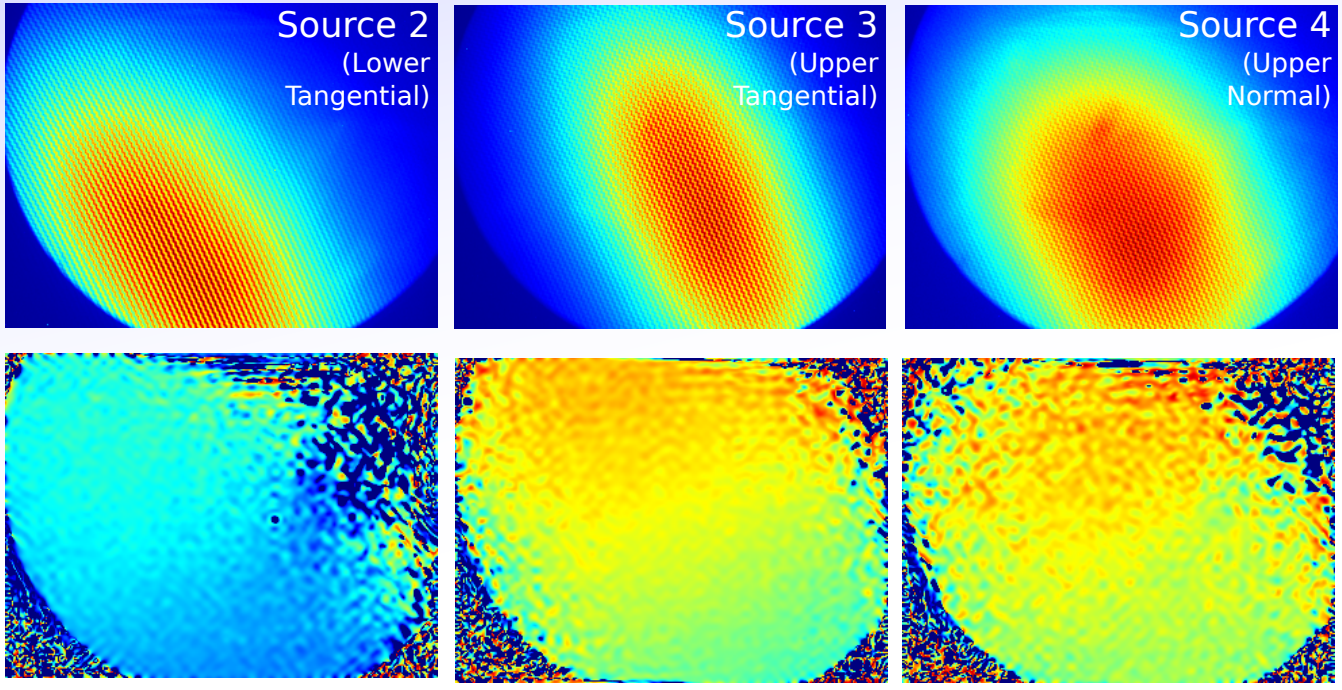
The disagreement at mid-radius is useful information that will be used to constrain the current profile.

Oliver Ford
IPP Greifswald

Beam Configuration Insensitivity

IMSE is insensitive to the spectrum so works on all 4 beam sources with both Deuterium and Hydrogen fuel:



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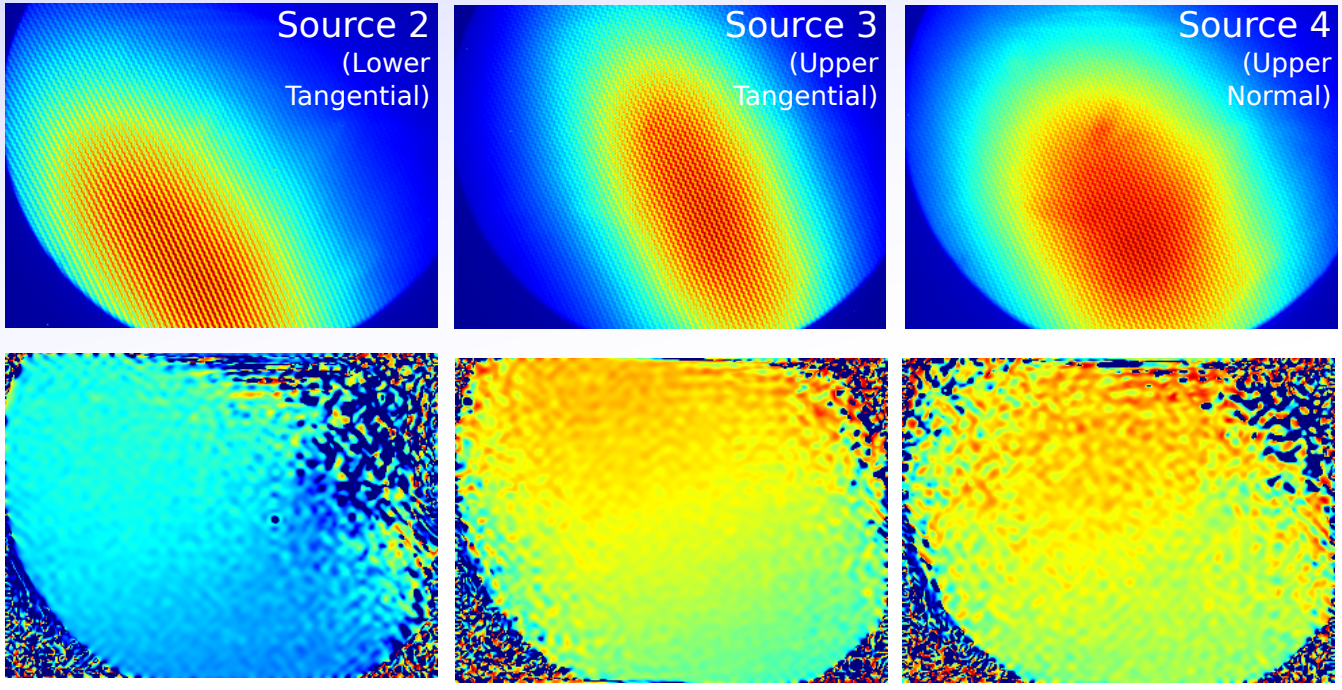

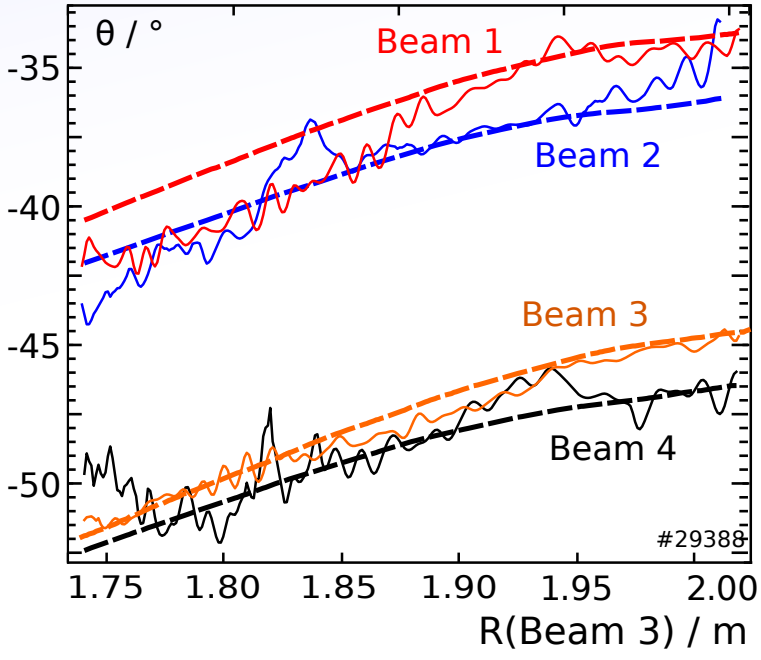

$\theta_3 - \theta_1$ is a fixed geometry value, so the agreement confirms the diagnostic linearity and beam geometry.
$\theta_3 - \theta_4$ (or $\theta_2 - \theta_1$) relate directly to Bz/Bφ and are unaffectd by fixed offset errors.

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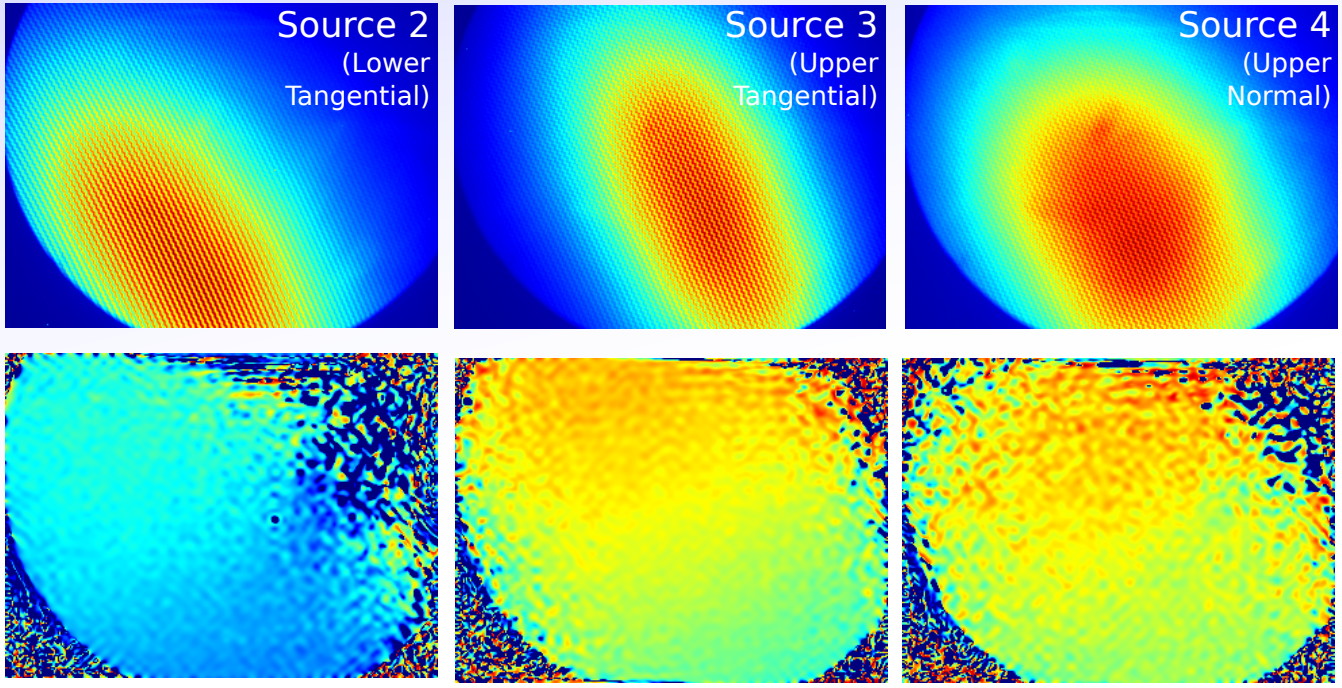

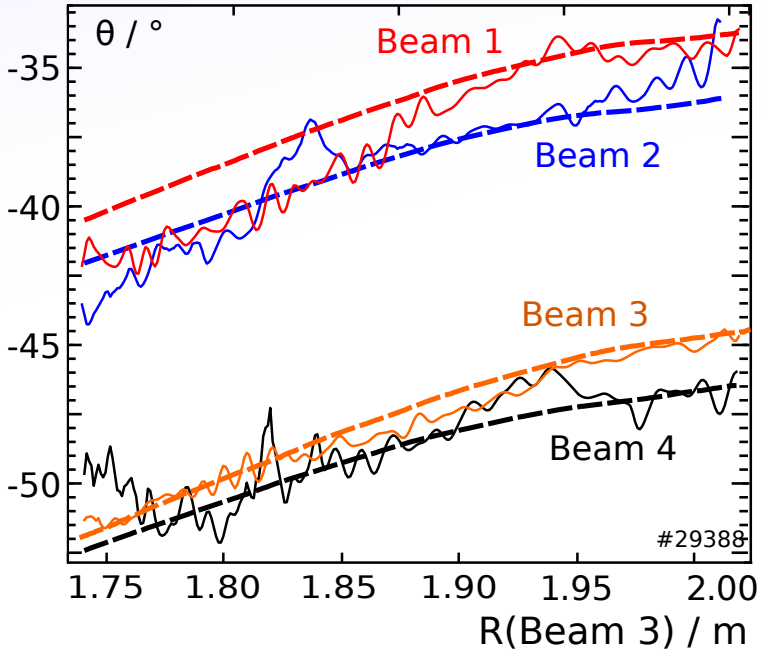

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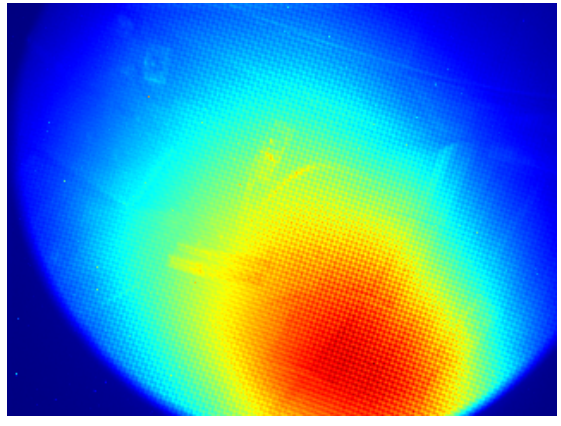
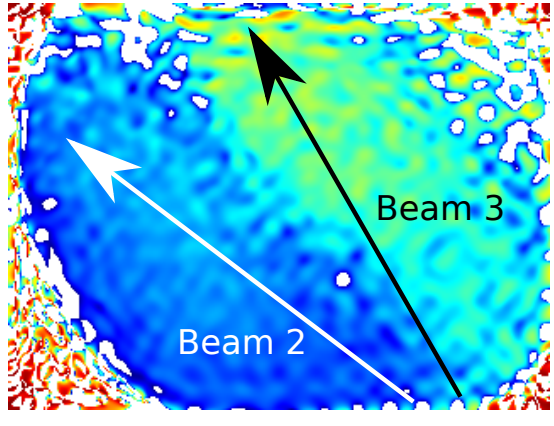
In principle, it is also possible to use data when multiple beams are on. The data is a complex average but can be analysed with the forward model if the beam geometry model is accurate.





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Summary

Conclusions:

- ✓ 2D MSE measurements increase the data quantity and also the information per data point.
- ✓ An IMSE diagnostic has been designed, constructed and operated at ASDEX Upgrade.
- ✓ Polarisation angle images were recorded over two periods with Hydrogen and Deuterium beams.
- ✓ Initial analysis shows agreement with conventional MSE for a repeated plasma.
- ✓ Forward modelling shows agreement with expected polarisation at the diagnostic, well within expected uncertainty. This implies there are no significant unexpected effects in forward optics.
- ✓ Evaluation of different beams confirm measurement linearity and provides a cross-check of pitch angle when absolute calibration is unavailable.

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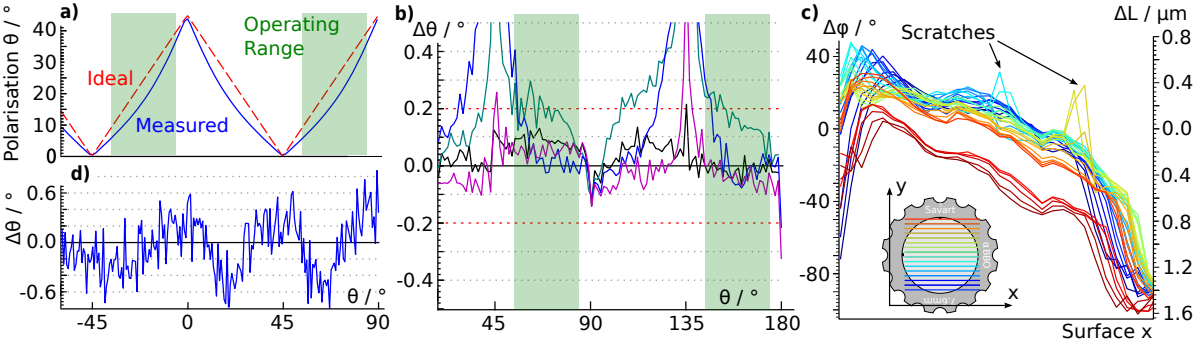
Next steps:

- Analysis of data with Current Tomography (±equilibrium assumption).
- Further improvements to signal/noise, temporal resolution.
- A calibration method is required to determine the single fixed offset with ~0.1° precision.


a)
Polarisation θ / °
Ideal
Measured
Operating
Range
d)
Δθ / °
θ / °
b)
Δθ / °
θ / °
c)
Δφ / °
ΔL / µm
Scratches
Surface x
y
x
Sensor
Chip
Lamp