UIA 2010

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Realtime acousto-optical QA methods for high intensity fields

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NPL
National Physical Laboratory

Overview

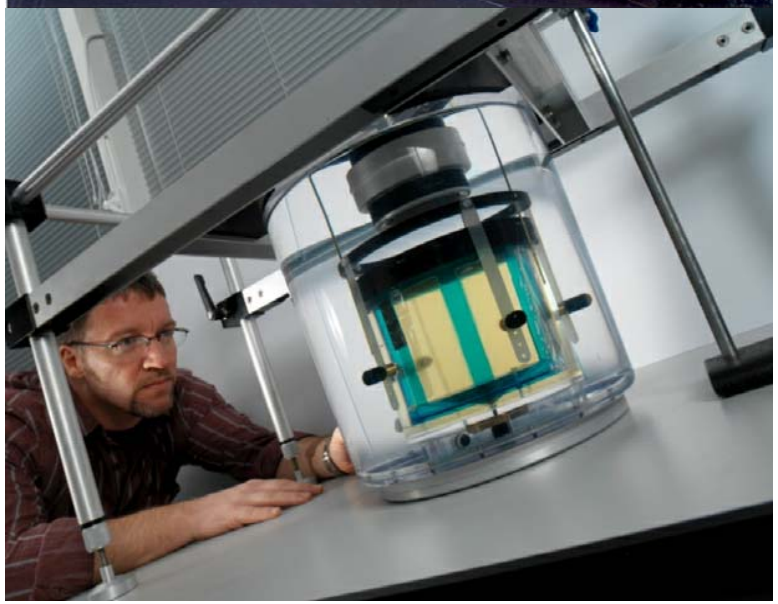
- NPL
- HIFU, and why we need Quality Assurance
- Initial observations
- The effect
- Understanding the effect
- Exploitation
- Conclusions

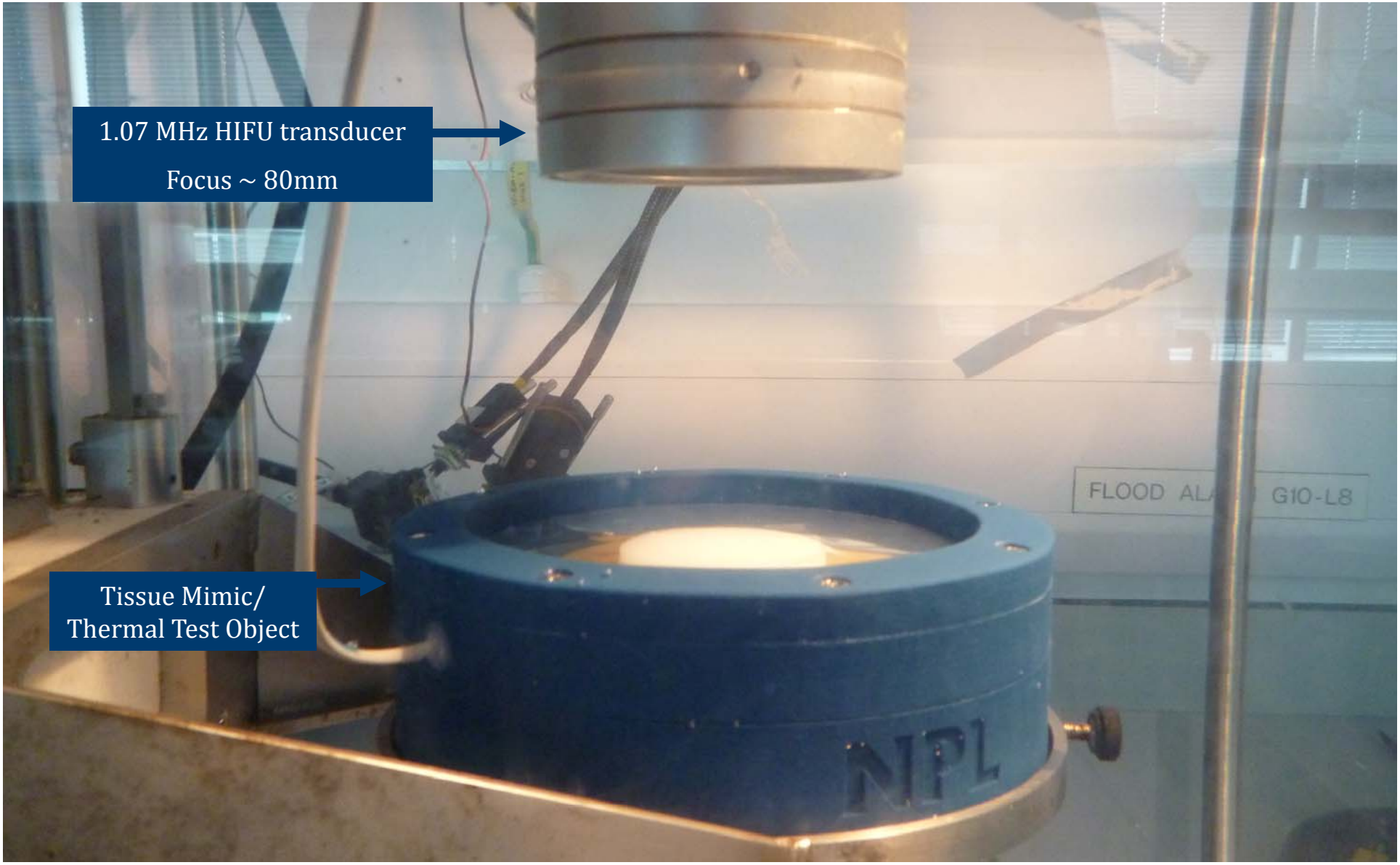
NPL

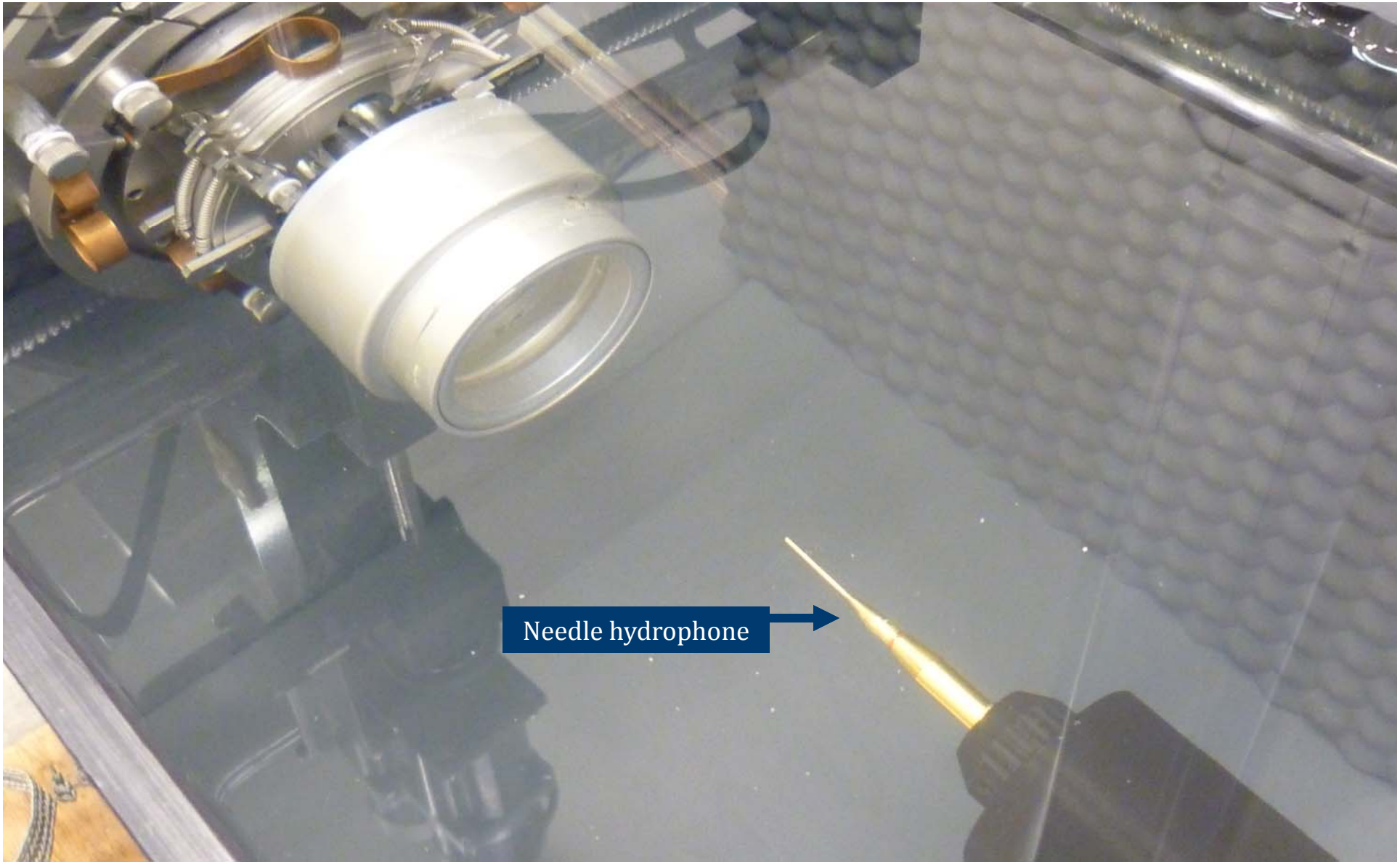
The UK's National Measurement Institute

- A government owned laboratory tasked with provision of primary standards in the physical sciences for UK industry
- Supporting the National Measurement System (NMS)

- Supporting industry through metrology
- Measurement and uncertainty




1.07 MHz HIFU transducer
Focus ~ 80mm
Tissue Mimic/
Thermal Test Object
NPL

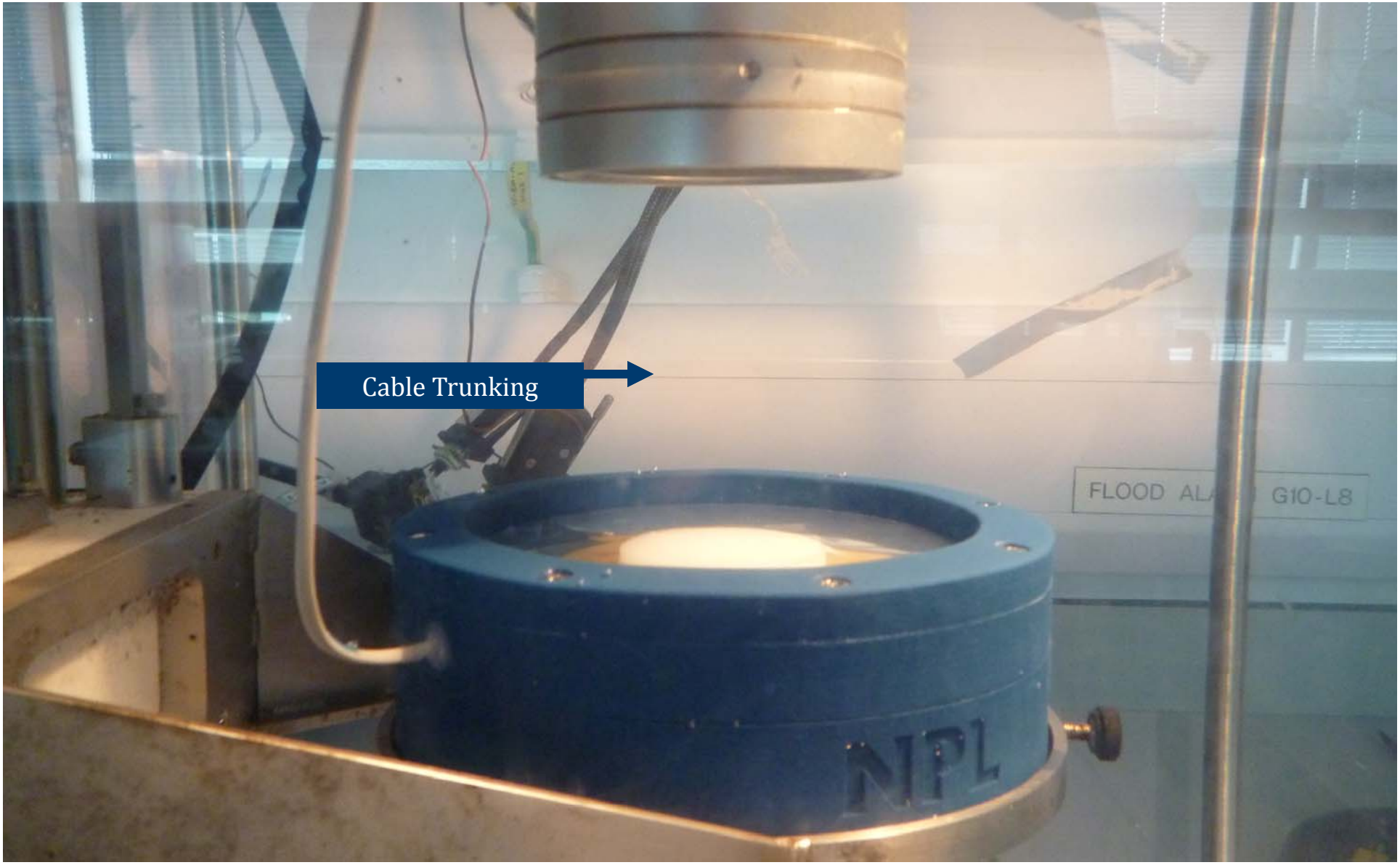

Needle hydrophone

Transducer quality

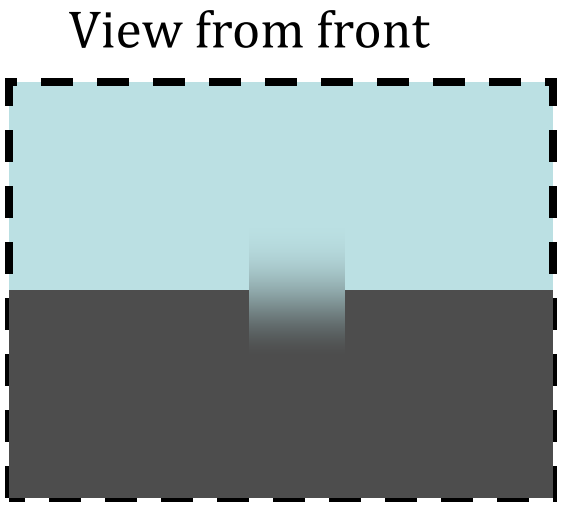
High drive powers and frequent use..

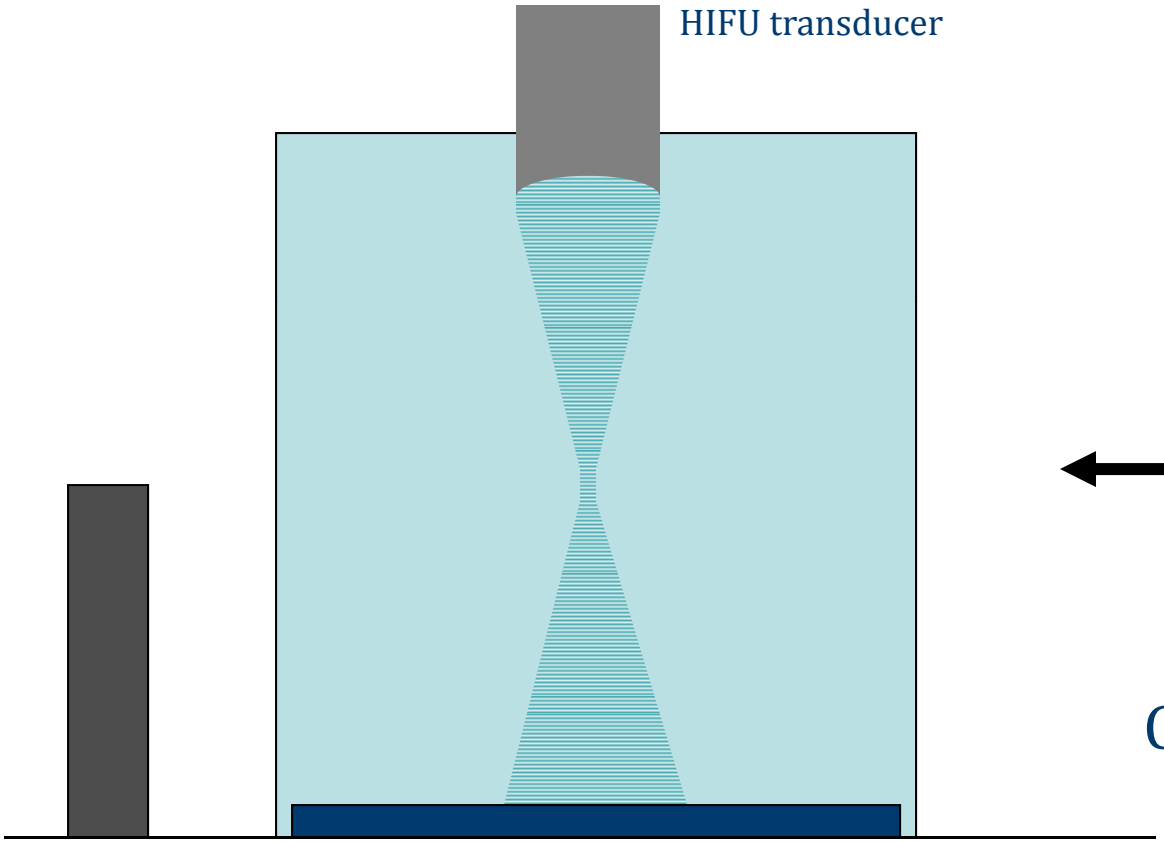
- Has the transducer been damaged?
- Is its performance changing drastically over time?

A definite need for a simple and immediate assurance of quality


Cable Trunking
FLOOD
G10-L8
NPL

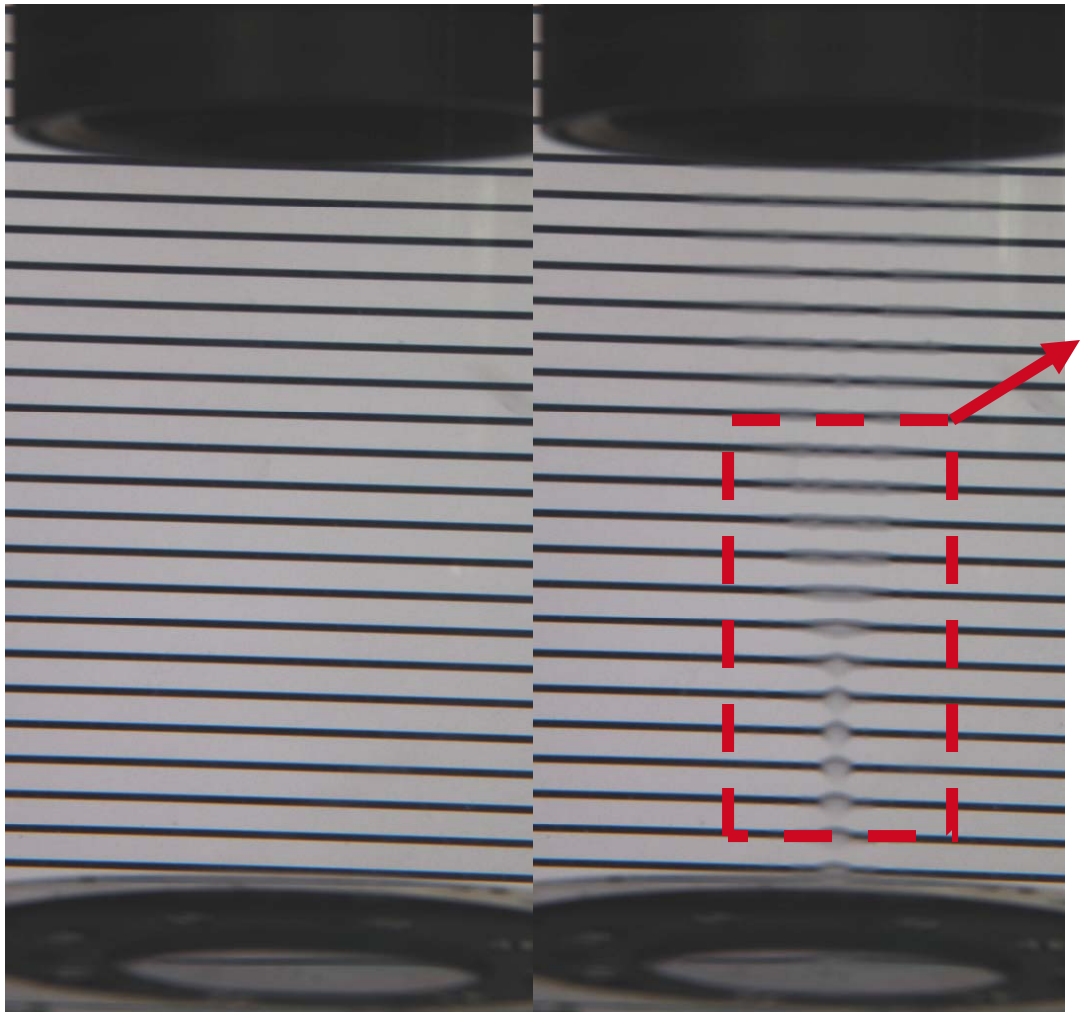
Initial observations

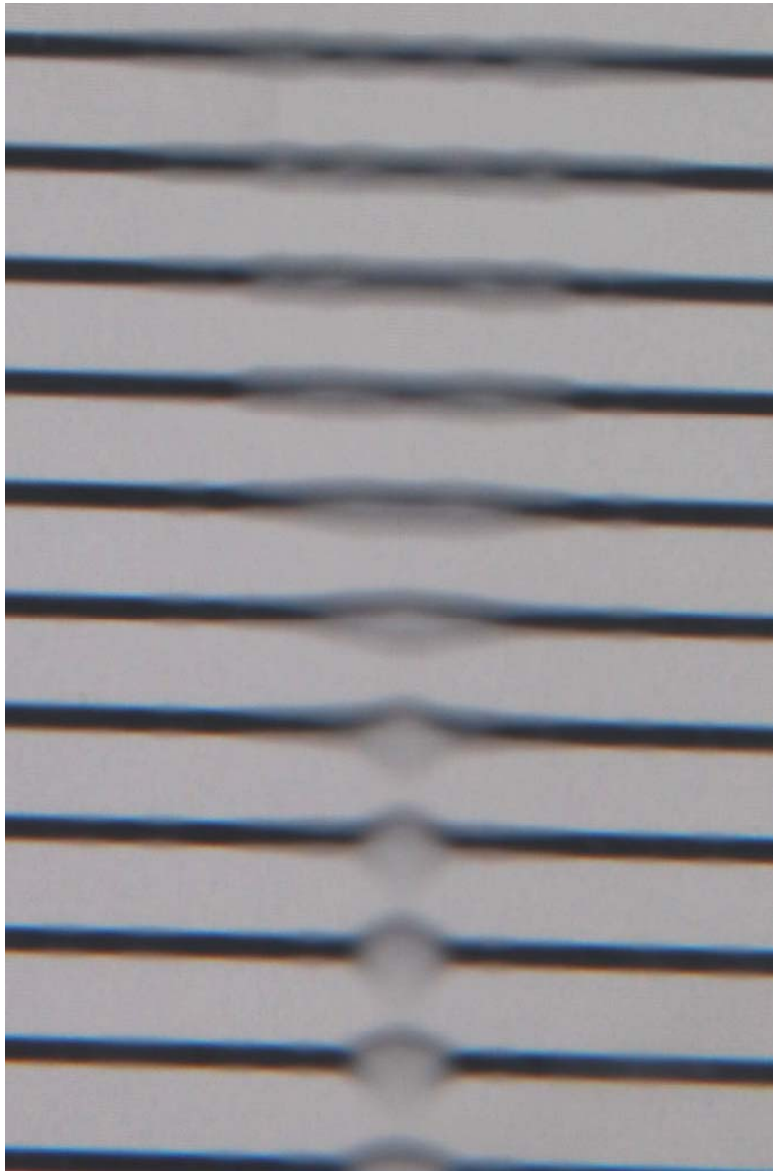




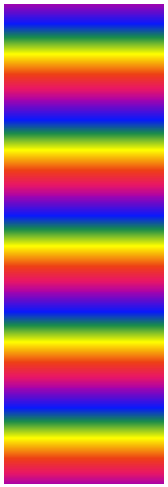
Can we exploit this?

Visual inspection

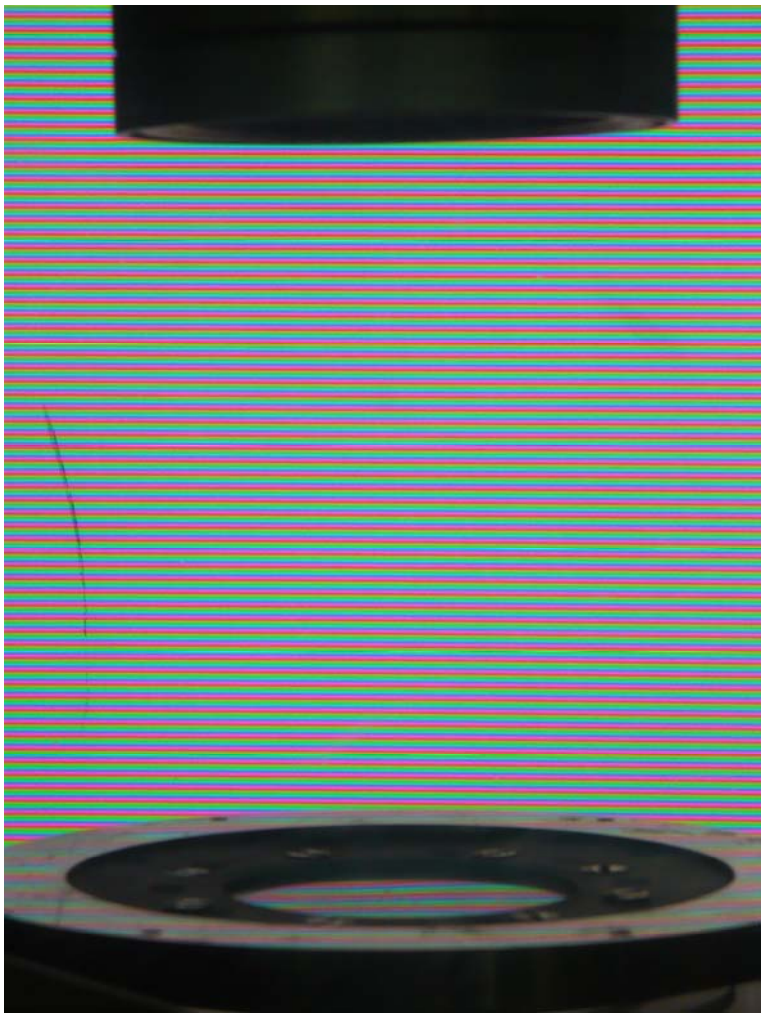




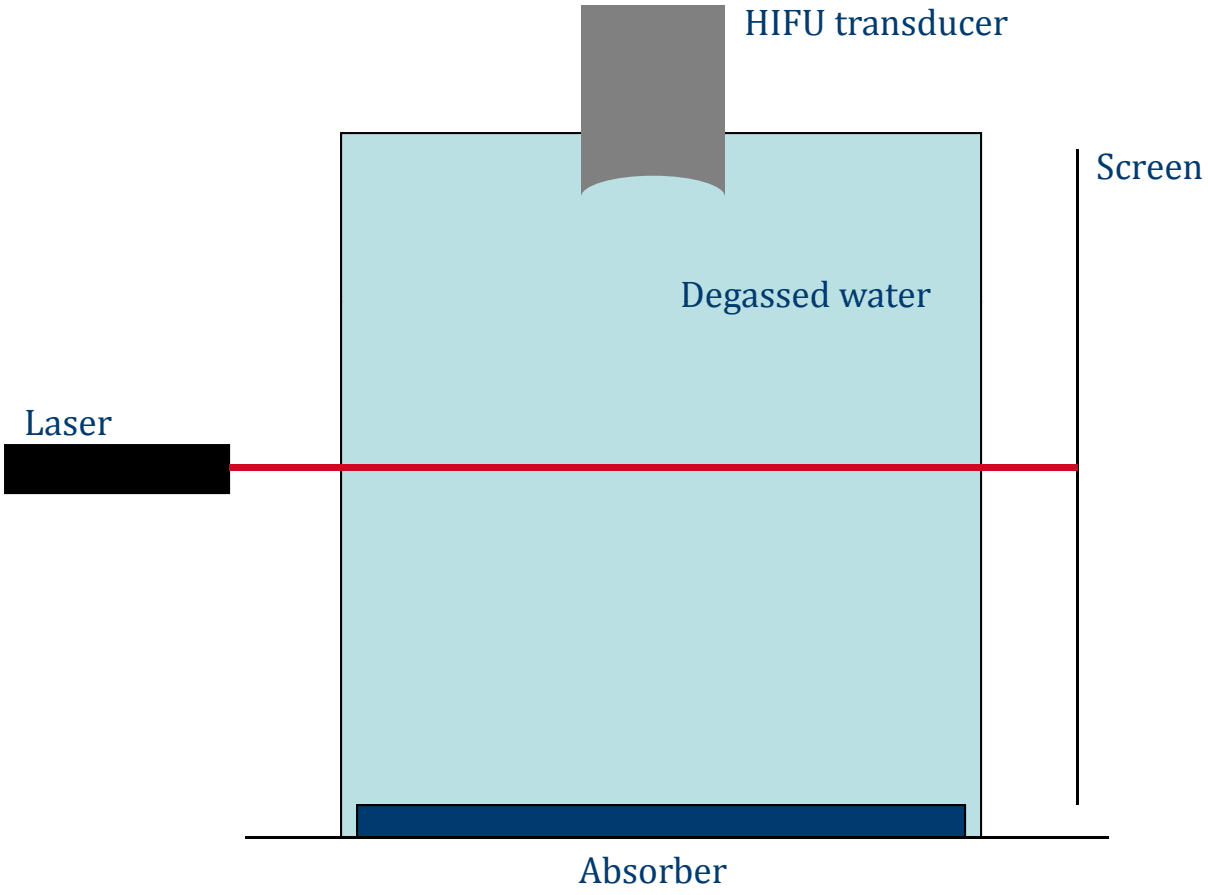
Visual inspection



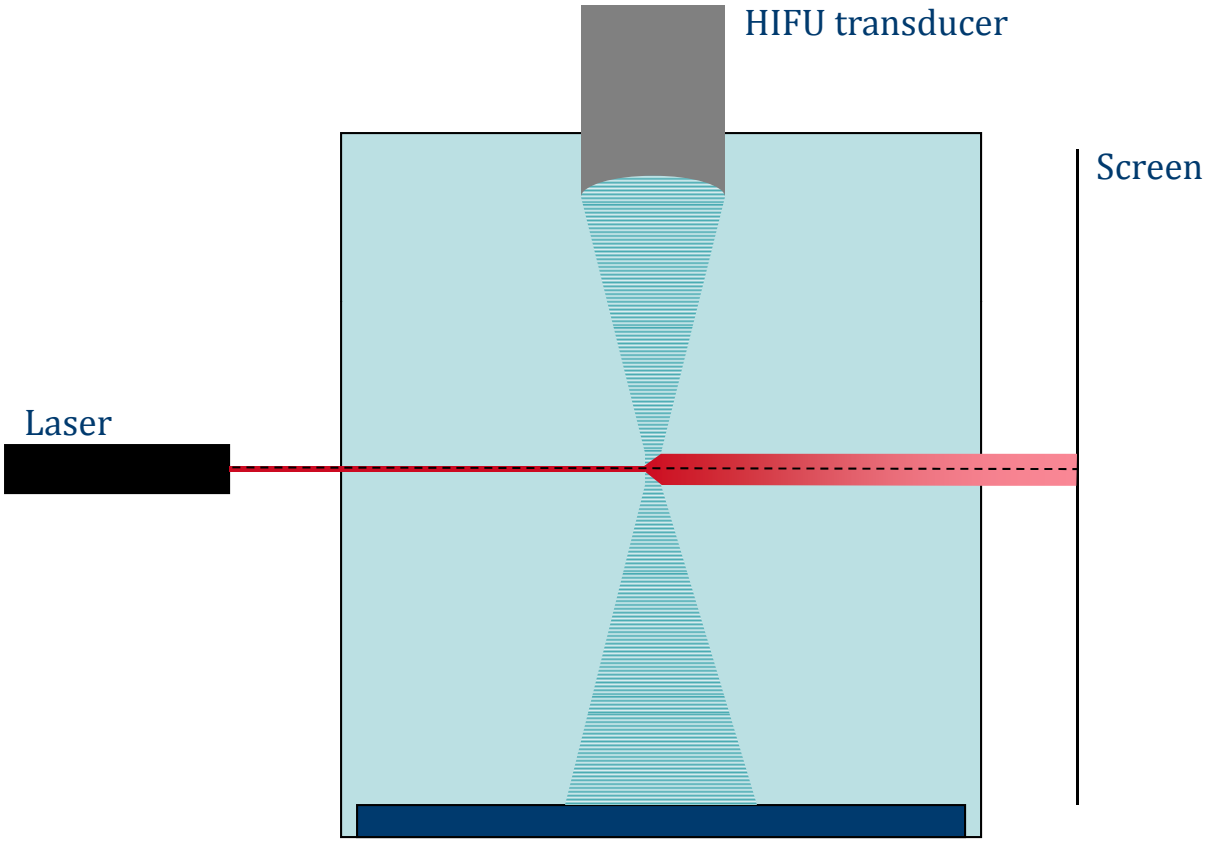
4mm



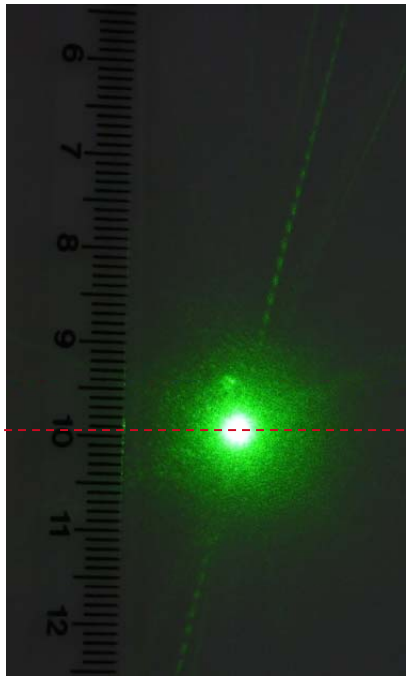
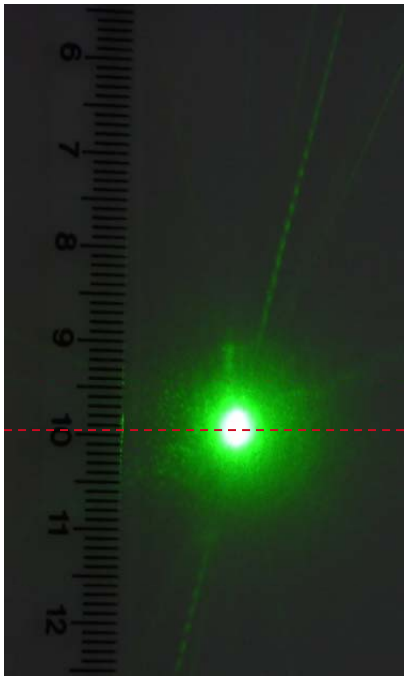
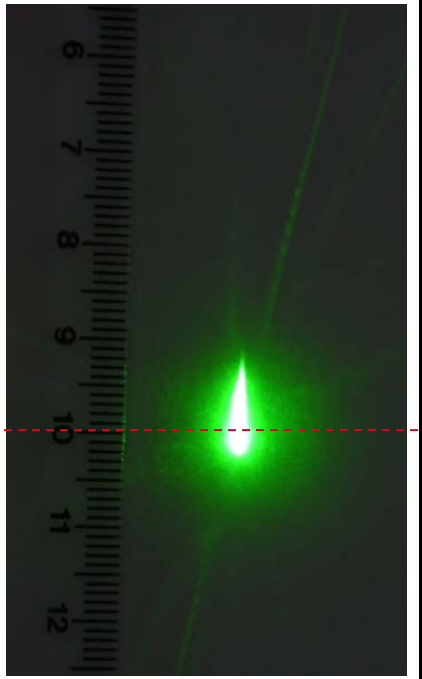
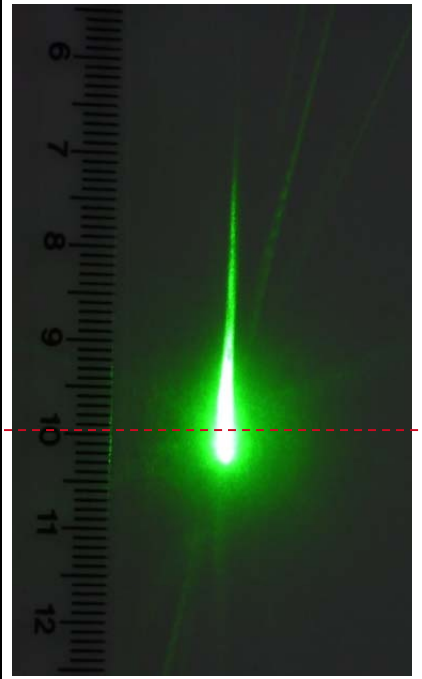
The Schlieren effect



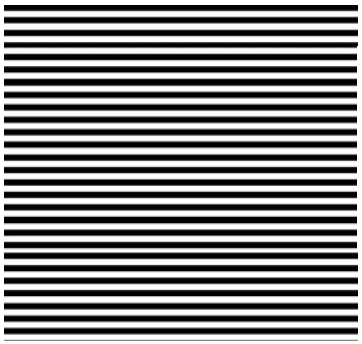
The Schlieren effect

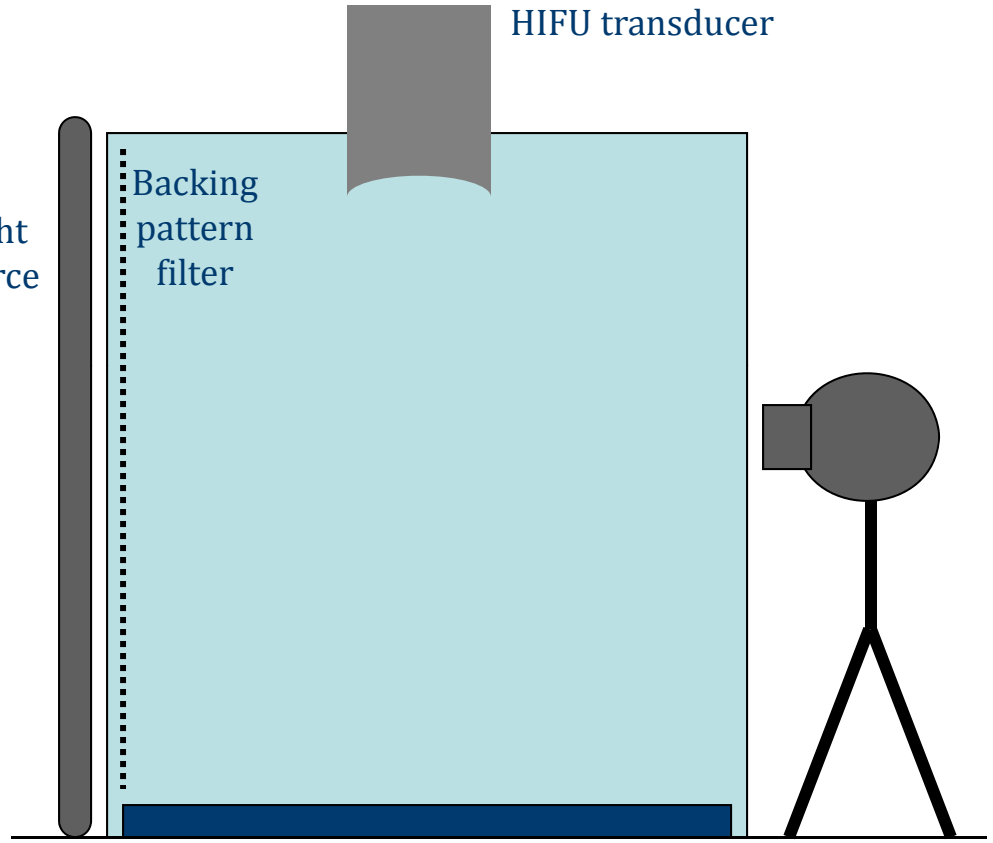


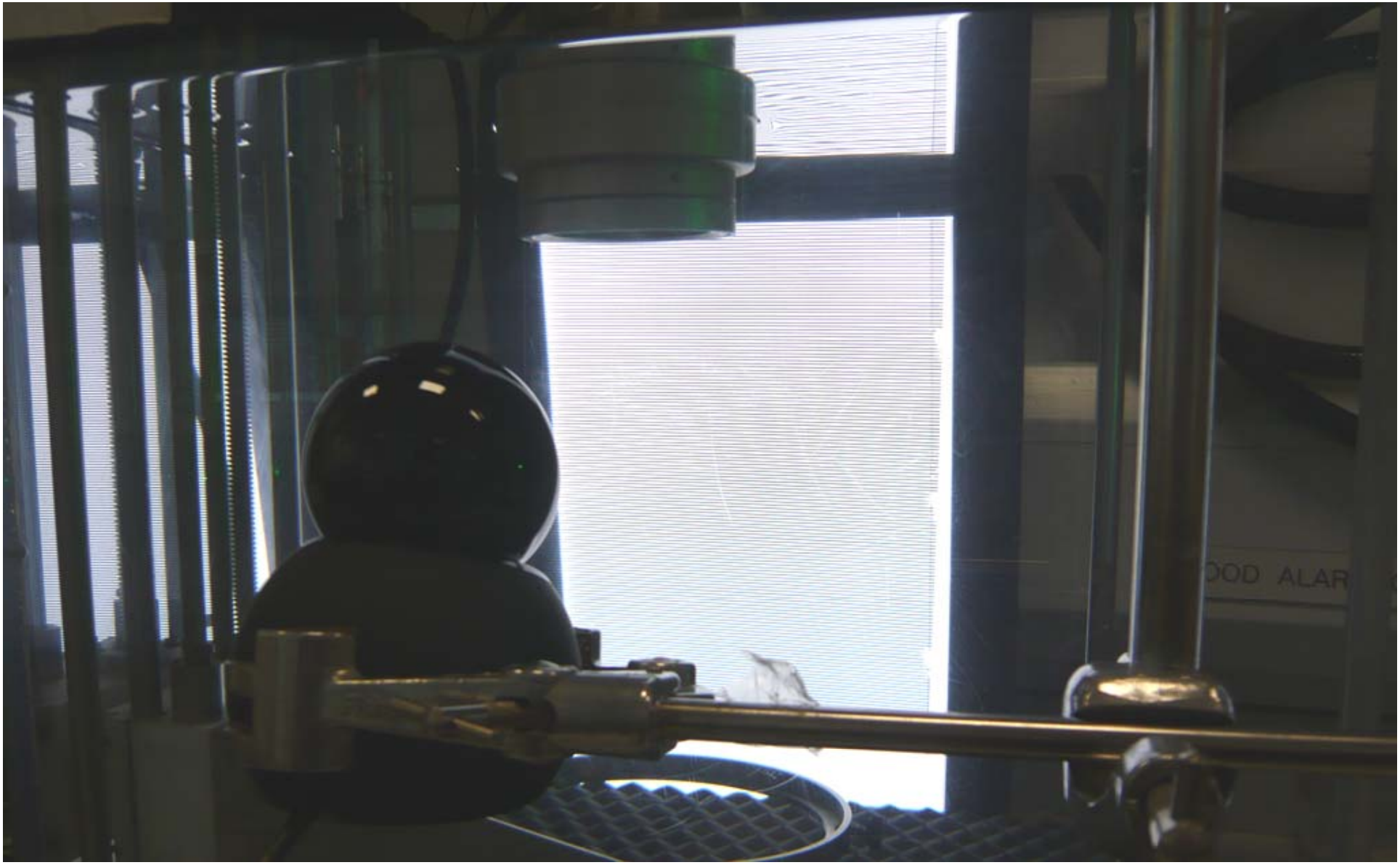
The Schlieren effect

			
Off	$Power \approx 4.5W$ $p_{peak} \approx [-1.2 \quad 1.5]MPa$ $I_{focus} \approx 70Wcm^{-2}$	$Power \approx 40W$ $p_{peak} \approx [-3.2 \quad 8]MPa$ $I_{focus} \approx 700Wcm^{-2}$	$Power \approx 73W$ $p_{peak} \approx [-3.8 \quad 15]MPa$ $I_{focus} \approx 1200Wcm^{-2}$

Visualising the field







Synthetic Schlieren

Sutherland et al.(2000)

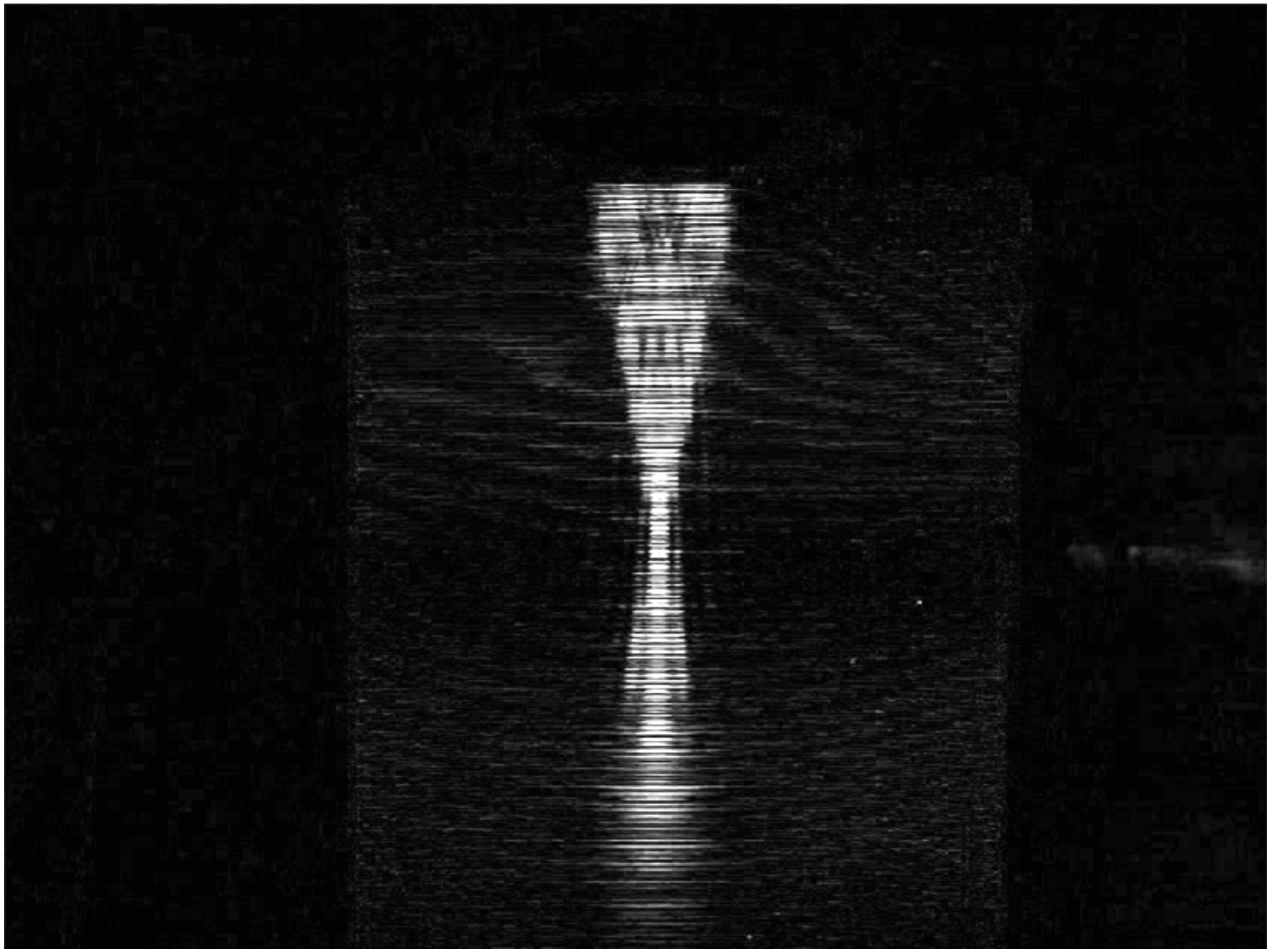
A process that is used to visualize the flow of a fluid of variable refractive index

- Uses a backing pattern and camera
- Doesn't rely on expensive optics

Wikipedia:Chrisjohnson

Visualisation of a buoyant plume of air rising from a flame

Difference imaging



HIFU transducer

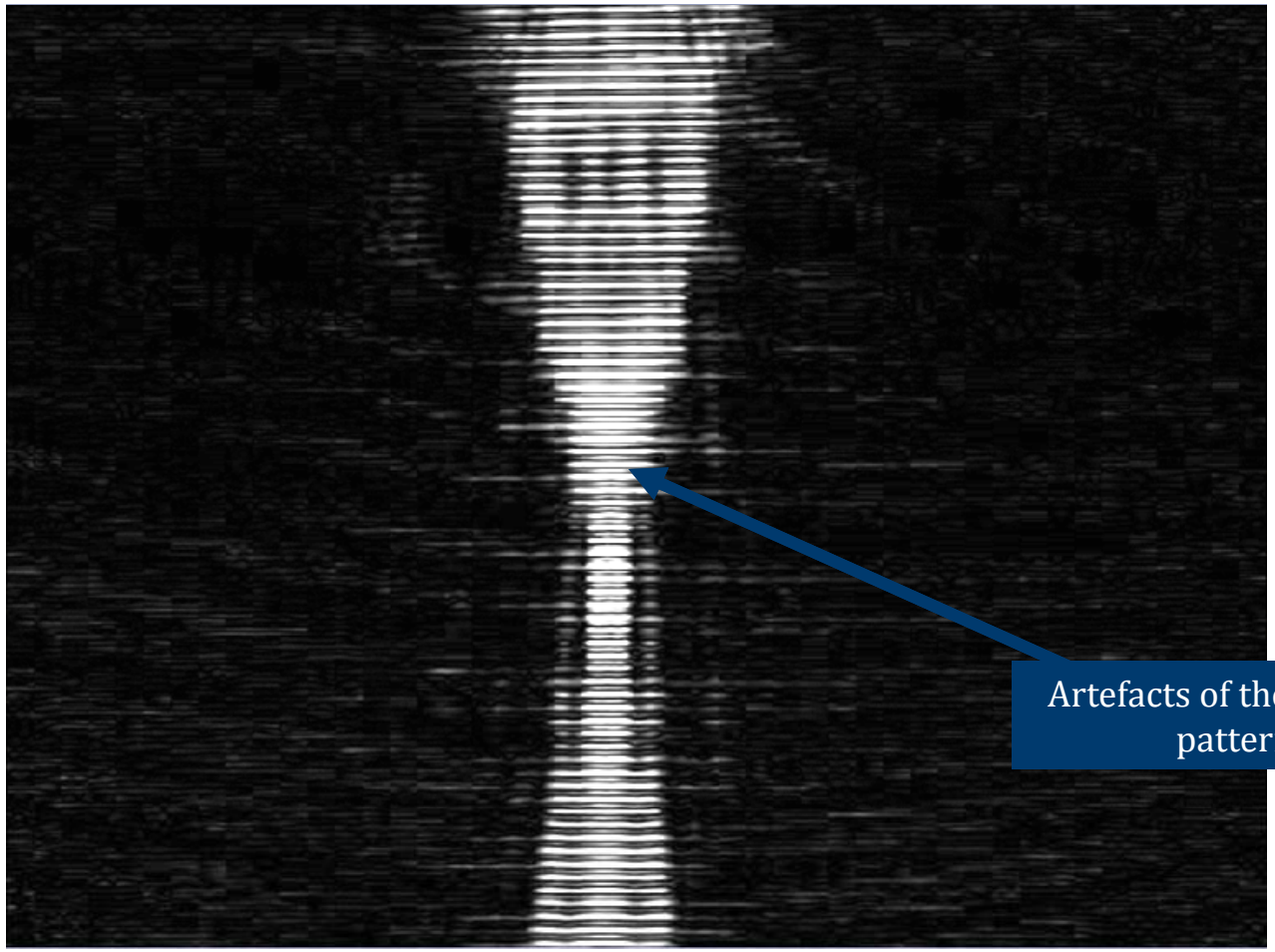
$$f = 1.07 MHz$$

$$Power \approx 73W$$

$$p_{peak} \approx [-3.8 \quad 15] MPa$$

$$I_{focus} \approx 1200 Wcm^{-2}$$

Difference Imaging



HIFU transducer

$$f = 1.07MHz$$

$$Power \approx 73W$$

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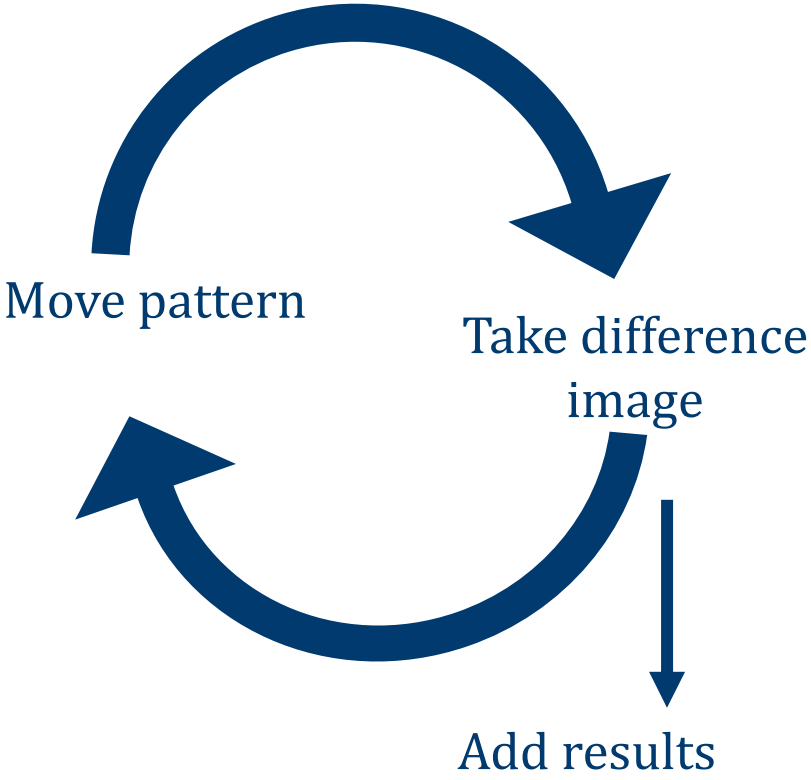
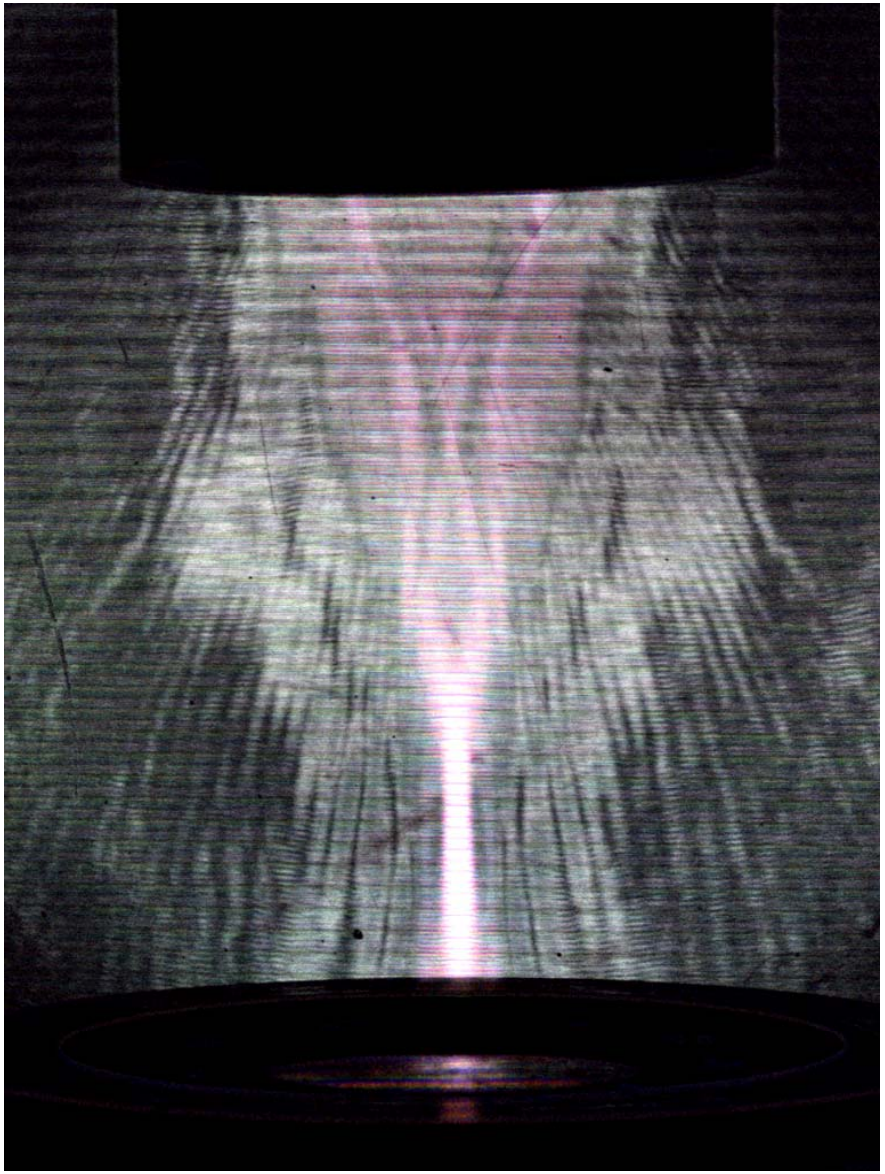
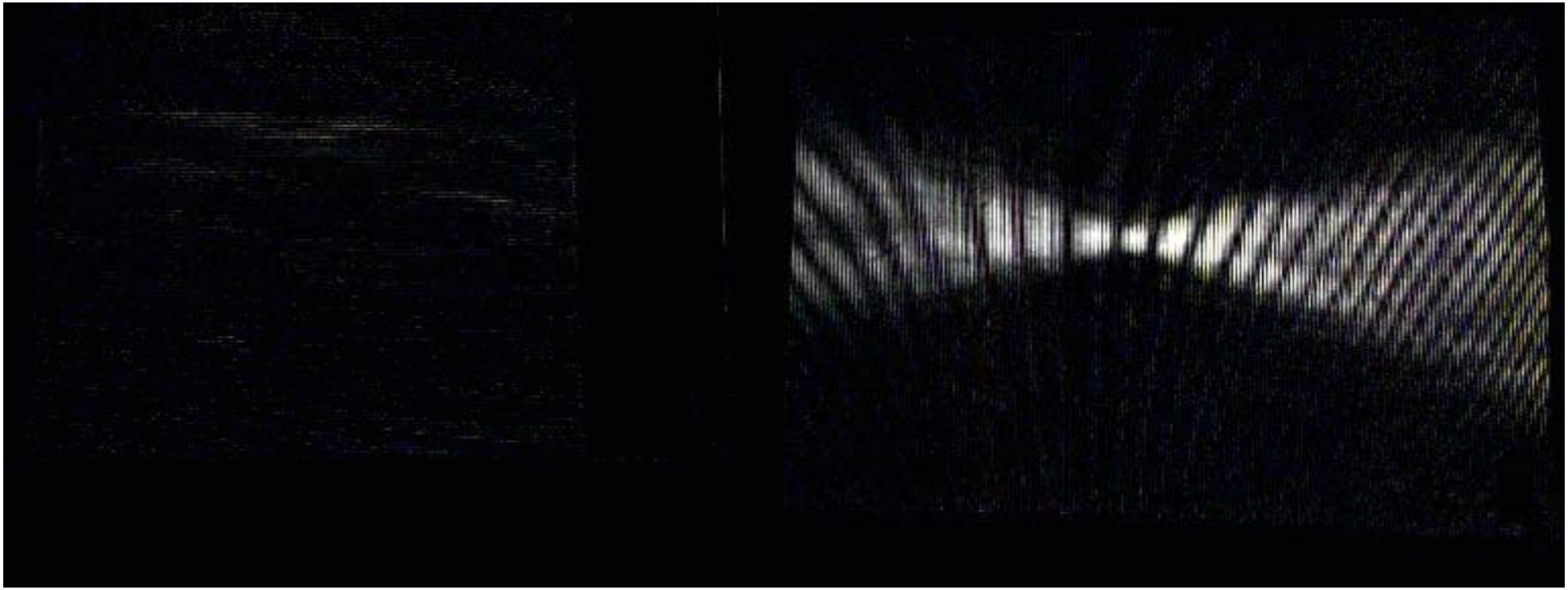
Removing artefacts





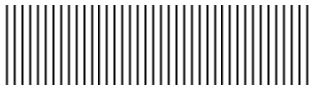
Quantitative measurements?

Pattern orientation

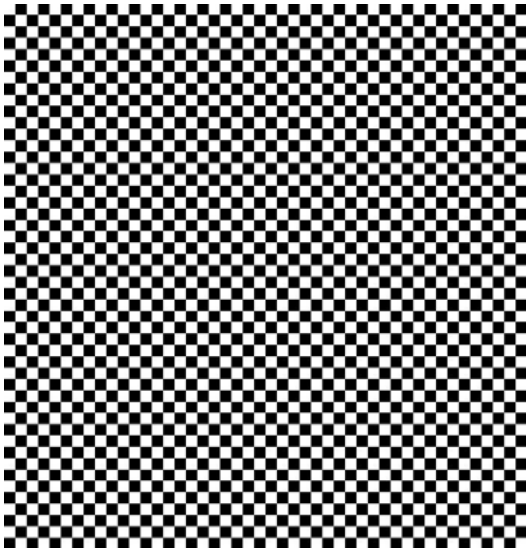


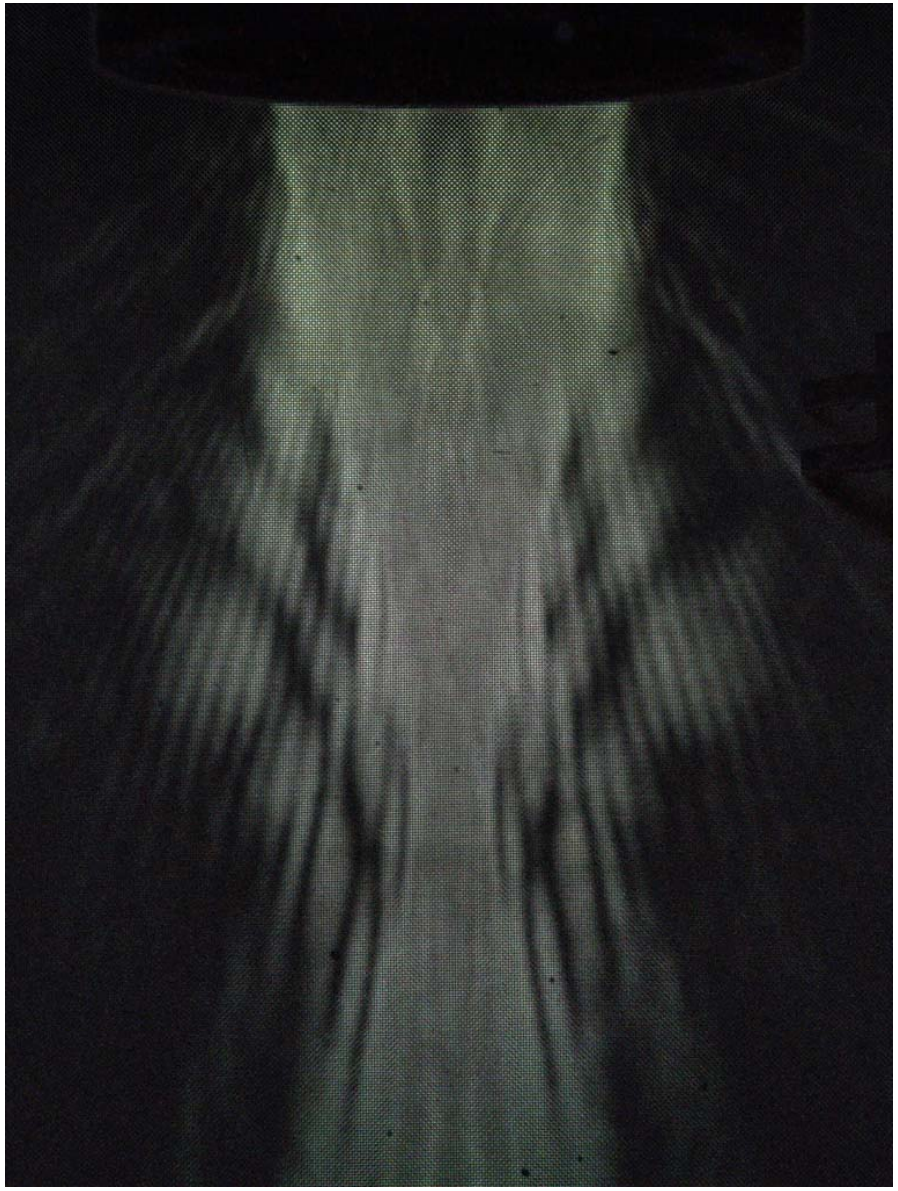
In-line with field

Perpendicular



The easier option..





- Fewer pattern artefacts
- Sensitivity varied by square size
- Reduced ‘dynamic range’

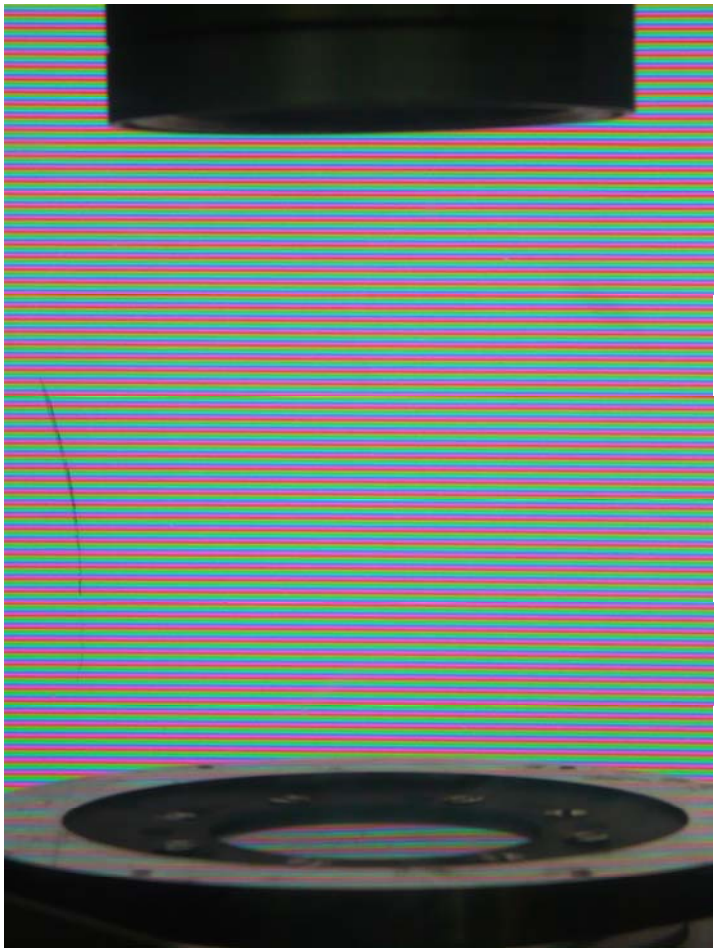
As a Quality Assurance tool..

The need for HIFU Quality Assurance

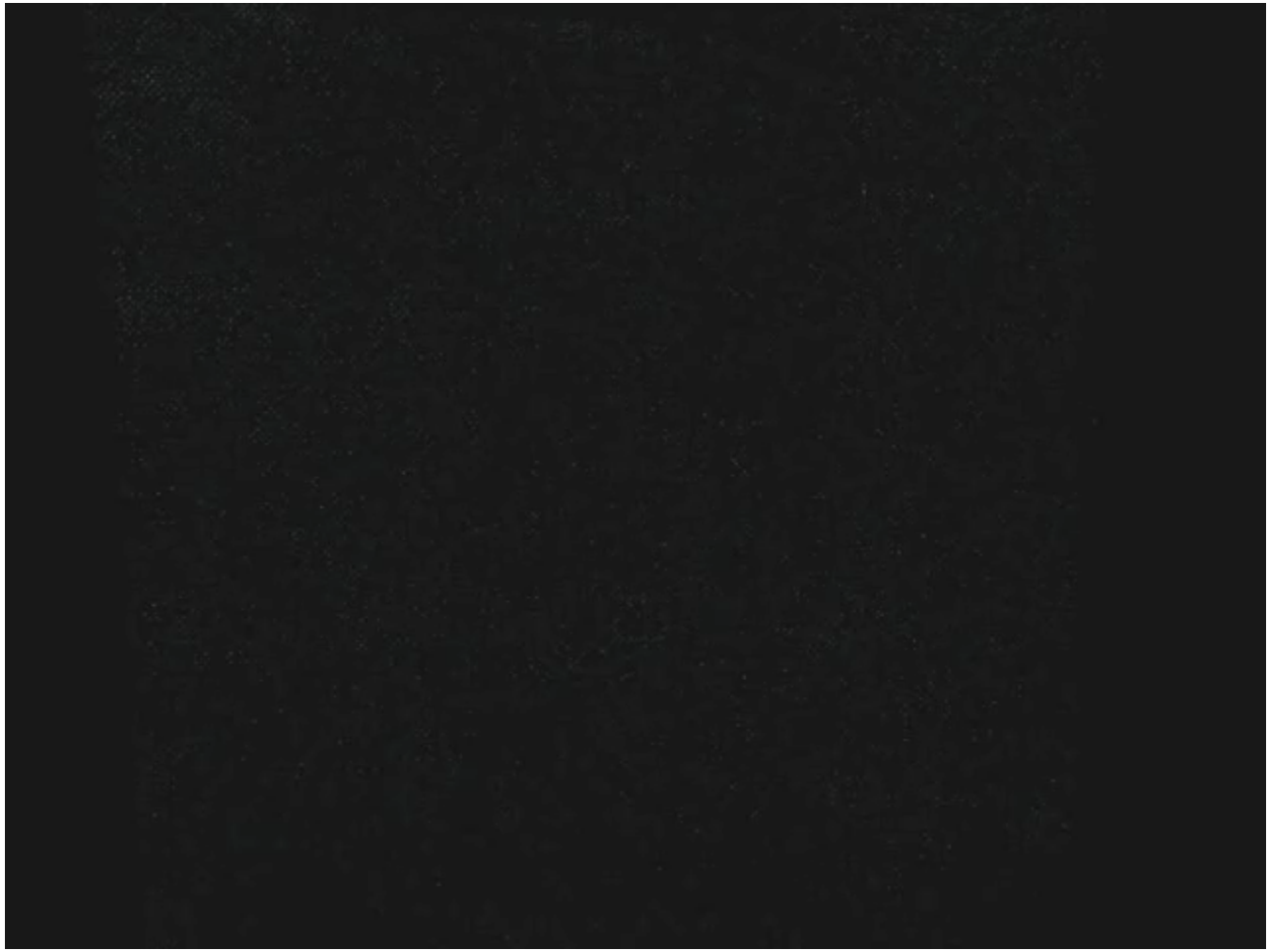
- Is the HIFU field symmetrical?
- Is the transducer being driven at resonance?
- How is our test object interfering with the field?

- Is the transducer on?

QA - Is the transducer on?



QA - Is the transducer being driven at resonance?



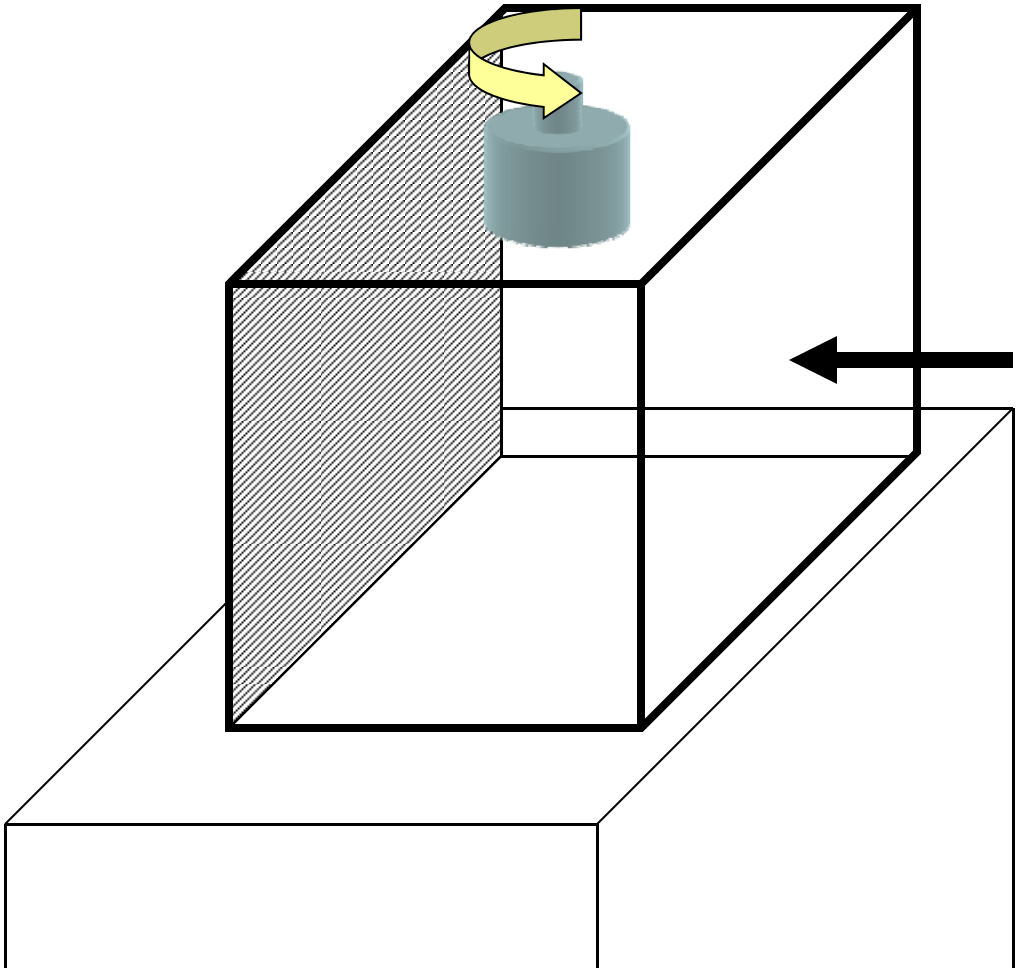
HIFU transducer

$Power \approx 40W$

(at 1.07 MHz)

1.3 to 1 MHz
at 10 kHz steps

QA - Is the field symmetrical?



- Planar symmetry
- Cylindrical symmetry

QA - How is our test object interfering with the field?

HIFU transducer

$$f = 1.07 MHz$$

$$Power \approx 40W$$

$$p_{peak} \approx [-3.2 \quad 8] MPa$$

$$I_{focus} \approx 700 W cm^{-2}$$

QA - Is the field stable?

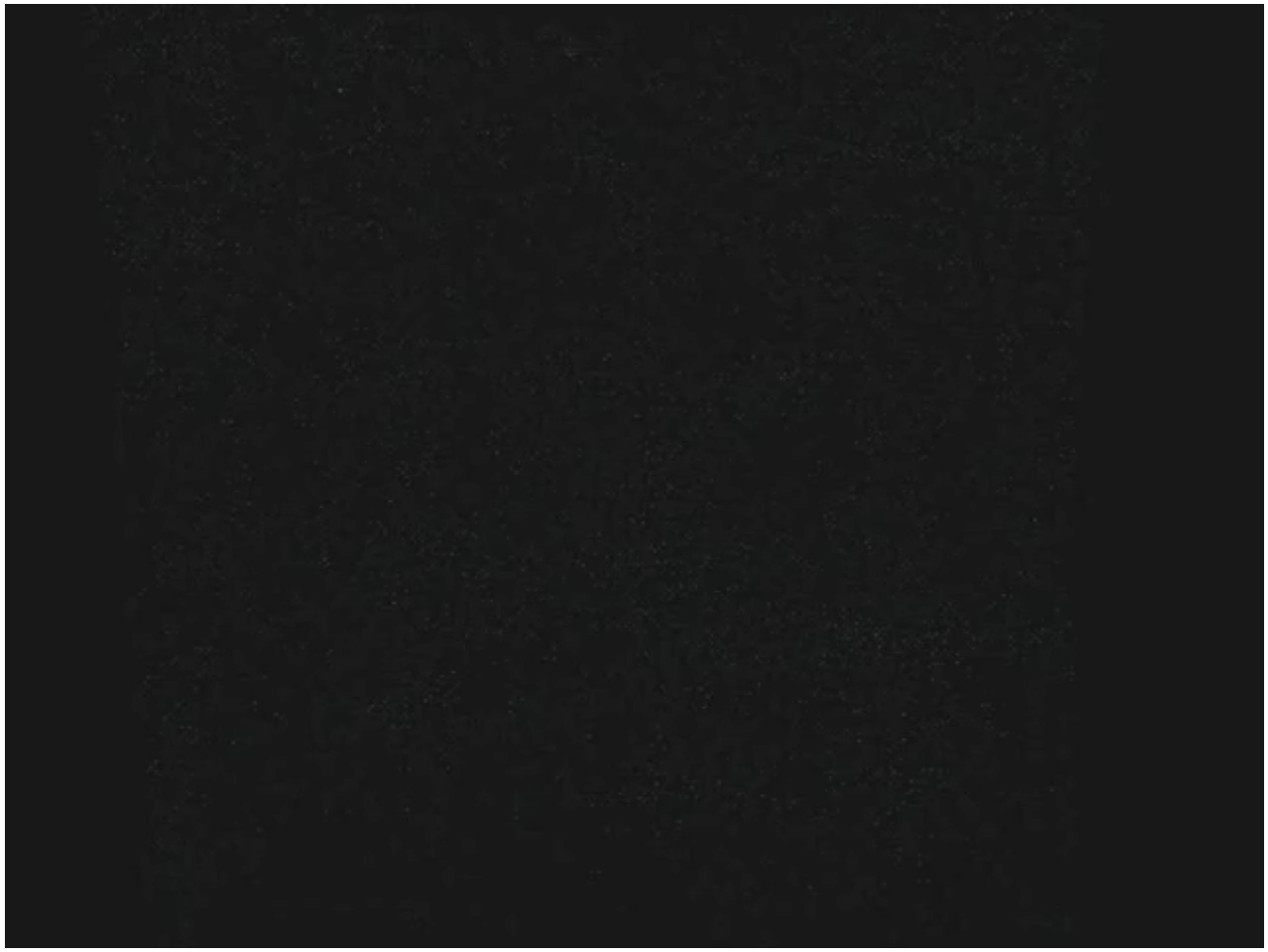
HIFU transducer

$f = 1.07 MHz$

$Power \approx 40W$

Degassed water, left in open tank for 3 days

Limitations – Varying power



HIFU transducer

$$f = 1.07 MHz$$

$$Power \approx 4.5 - 73 W$$

Linear change in input voltage

Saturation occurs

Applications

Laboratories

- Reducing setup time

Hospitals

- A quick and simple equipment check.

Training

- Valuable visualisation of HIFU fields

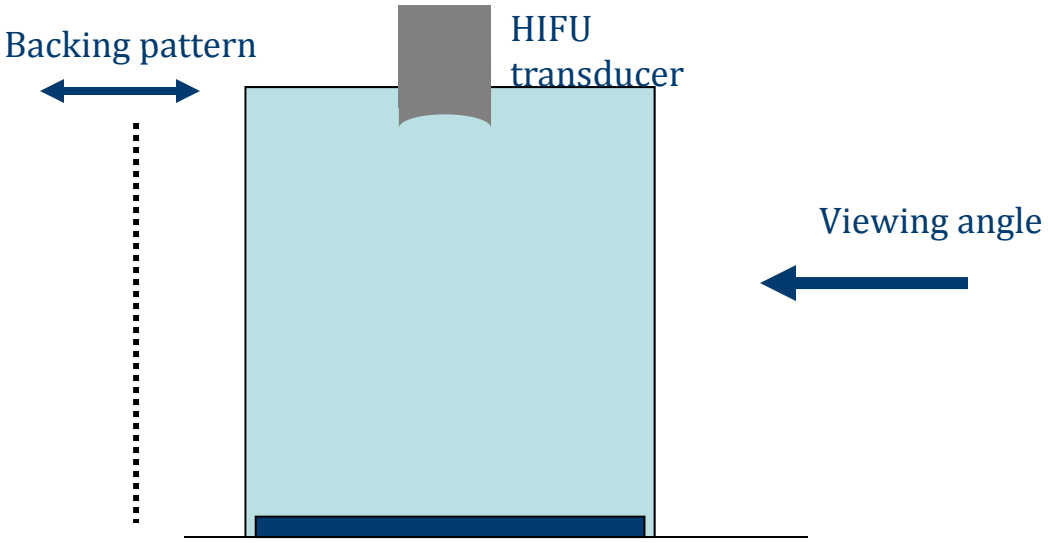
http://medicalphysicsweb.org/cws/article/research/41244

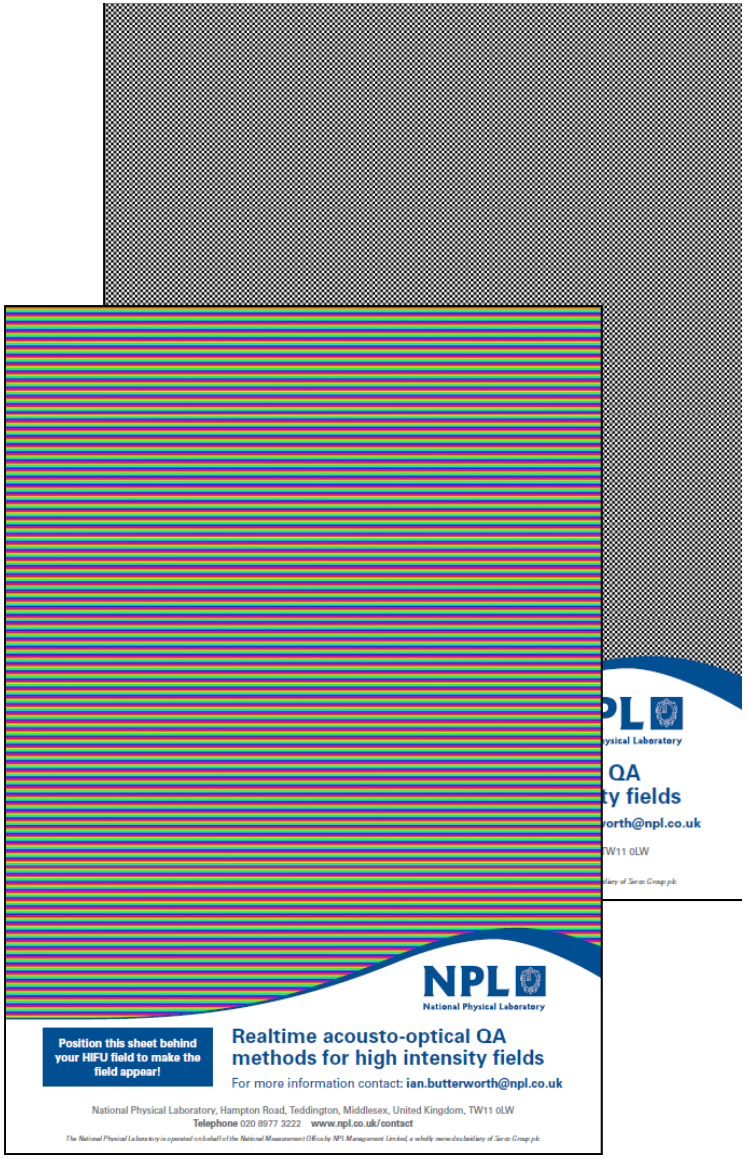
Conclusions

- Inexpensive
- Visible inspection by the naked eye
- A simple training tool
- Image processing for recording quality of transducer
- Not quantitative

Further work

- Optimisation of patterns for visual inspection and image processing
- Inspection of multi-element fields
- Transparent tissue phantoms?
- 3D?

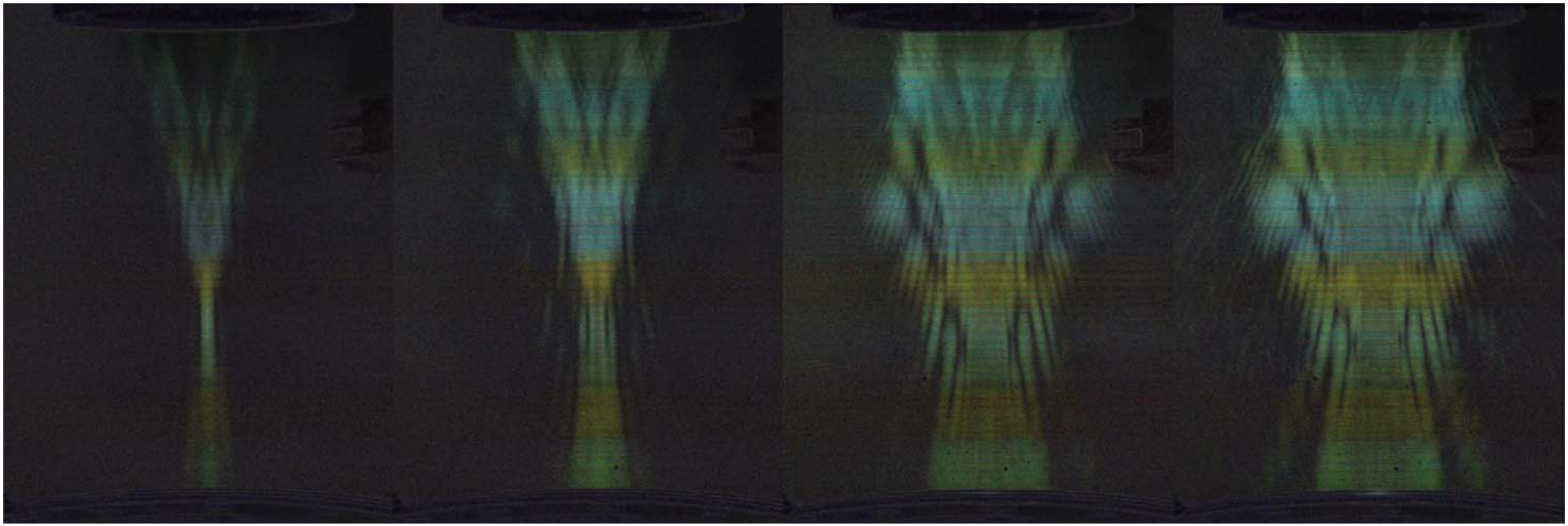




Thank you

Adam Shaw - NPL
Ian Rivens, John Civale, Sreekumar Kaiplavil – ICR

The financial support of the National Measurement Office



2W 4W 40W 78W

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