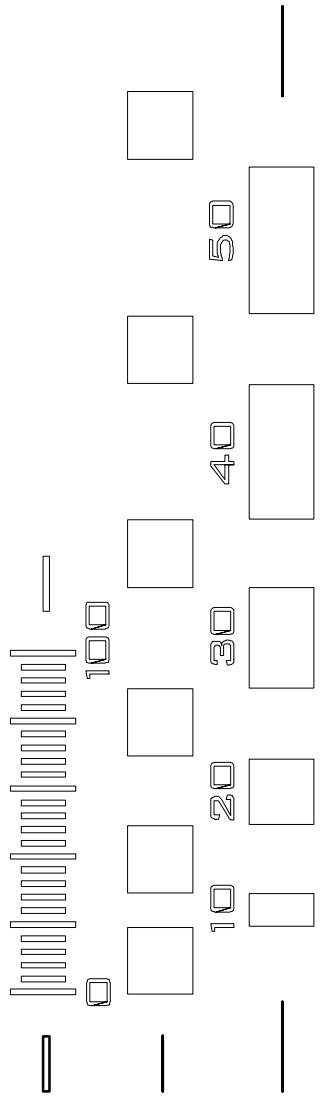
Conference on Microdisplays

Measurement of Microdisplays at NPL



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14th Sept 2001

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Overview

- Displays measurement at NPL
- Why measure microdisplays?
- Measurement challenges for microdisplays
- Current macro display measurement system
- Some solutions for microdisplays measurement
- Further work

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Displays Measurement at NPL

Display screens have been measured at NPL since 1985

We can calibrate both displays screens and measurement instruments

- Luminance 0.01cd/m^2 to 10,000cd/m^2 (<4%)
- Chromaticity (+/- 0.002 CIE units)

We can also measure; correlated colour temperature, contrast, screen uniformity, efficiency of novel display materials, some 3D charateristics...

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Why use microdisplays?

Microdisplays are desirable because they are:

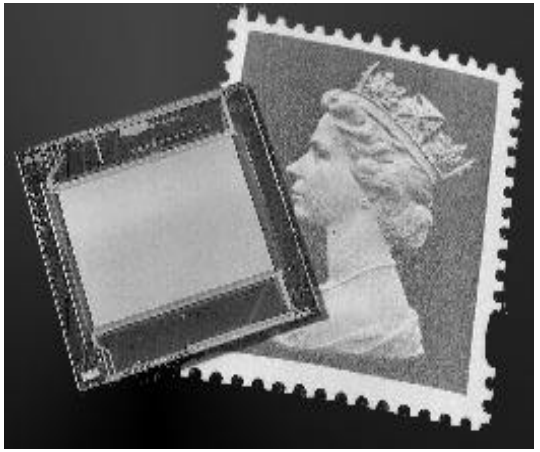
www. micropix.co.uk

Lightweight

Affordable

Power efficient

High resolution



www.microemissive.co.uk

Some applications are; head mounted and close to eye displays, projectors, mobile phones

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Why measure microdisplays?

- Quality control in manufacture
- To meet ‘health and safety’ specifications
- To investigate why some head mounted devices cause eyestrain while others don’t
- To display colours of known chromaticity and luminance
- To enable measurement of text readability/clarity
- To allow microdisplays to be used in experiments on the human visual system

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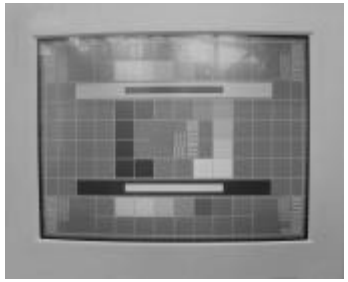
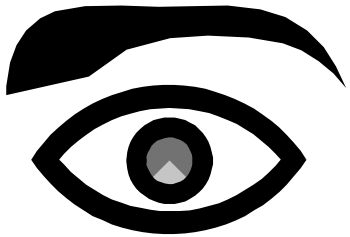
Measuring a display screen

Display output



x

Response of human eye



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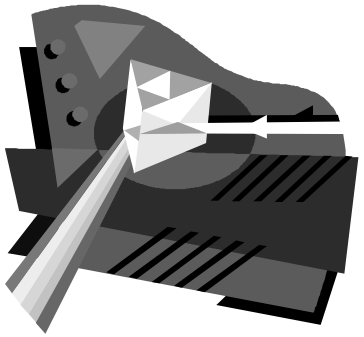
Display measurement



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Spectral Information

phosphors
lamp + filters
OLEDs
laser illuminated…

Environmental Information

Temperature
EM fields
stray light

DISPLAYS CALIBRATION

Temporal Information

refresh rate
flicker
grey-scaling

Spatial Information

pixel size and position on screen
viewing and acceptance angle
polarisation

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Challenges in macro display measurement

- Wavelength error, bandwidth error
- Detector saturation or non-linearity
- Refresh rate of displays (beating with detector)
- Spatial resolution/ pixelation
- Stray light in instrument
- Polarisation sensitivity of instruments
- Alignment of display (spatial & angular uniformity)
- Repeatability
- Traceability

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Extra challenges for microdisplays

- Small areas of measurement
- Low signals
- Accurate positioning of instrument relative to display (requires translations stages, or test charts)
- Illumination
- Refresh rates
- readability (dependent on usage)

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Extra challenges for microdisplay systems

Should we measure the microdisplay in a stand alone way… maybe reflectivity, distortion… to allow a *user* to select the most suitable microdisplay for integration OR.. should we measure the entire microdisplay system?

eg with a projector should we measure the image coming from the microdisplay or from the projector lens or measure the image on the projection screen?

Should we use a standard light source for illumination, or the integrated source?

What about lifetime, power consumtion,shock resistance...

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What I really mean is…

Display measurement is difficult…

BUT …

microdisplay measurement is VERY difficult.

AND…

there are very few specifications, or standard methods of how to do this

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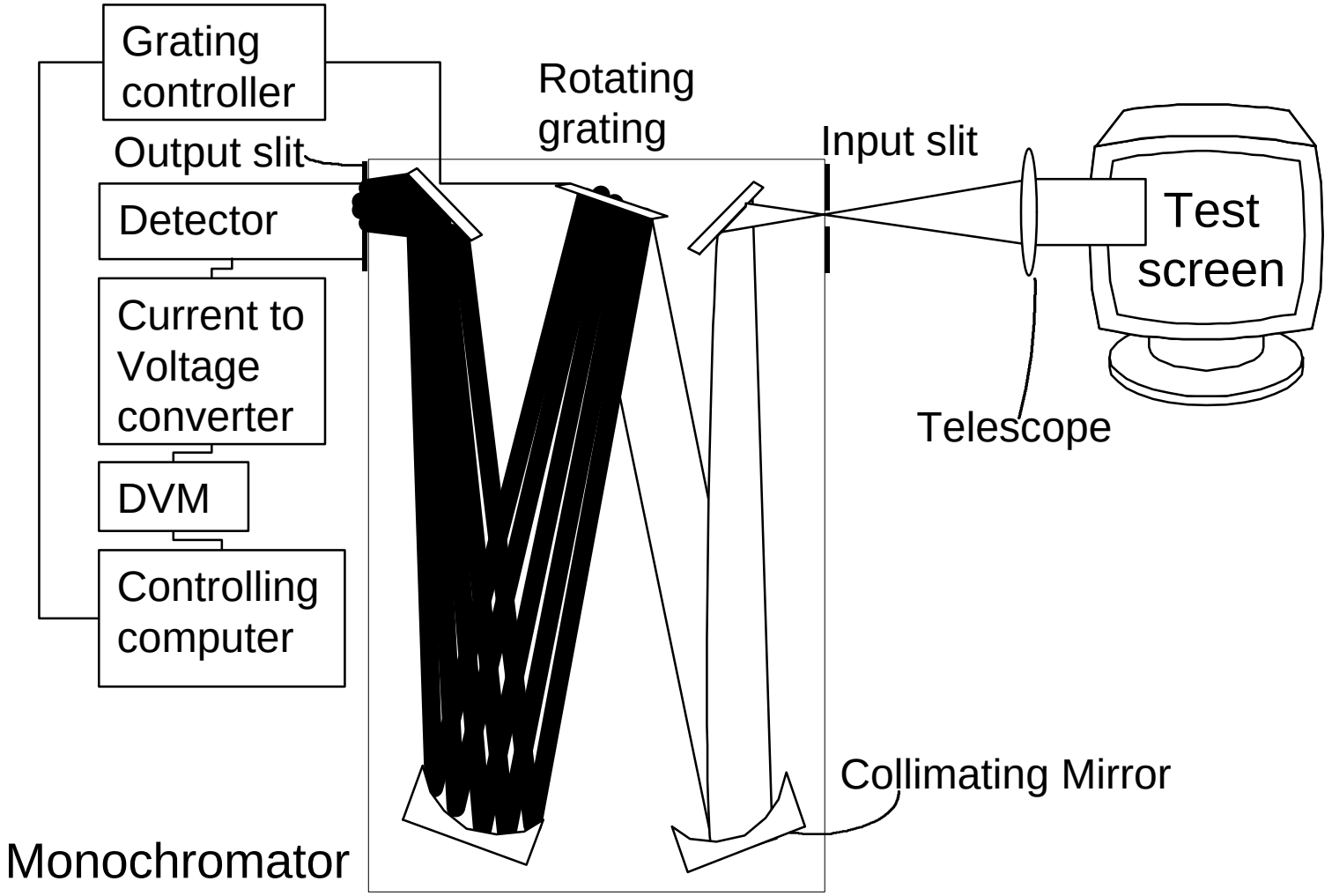
NPL's reference displays system



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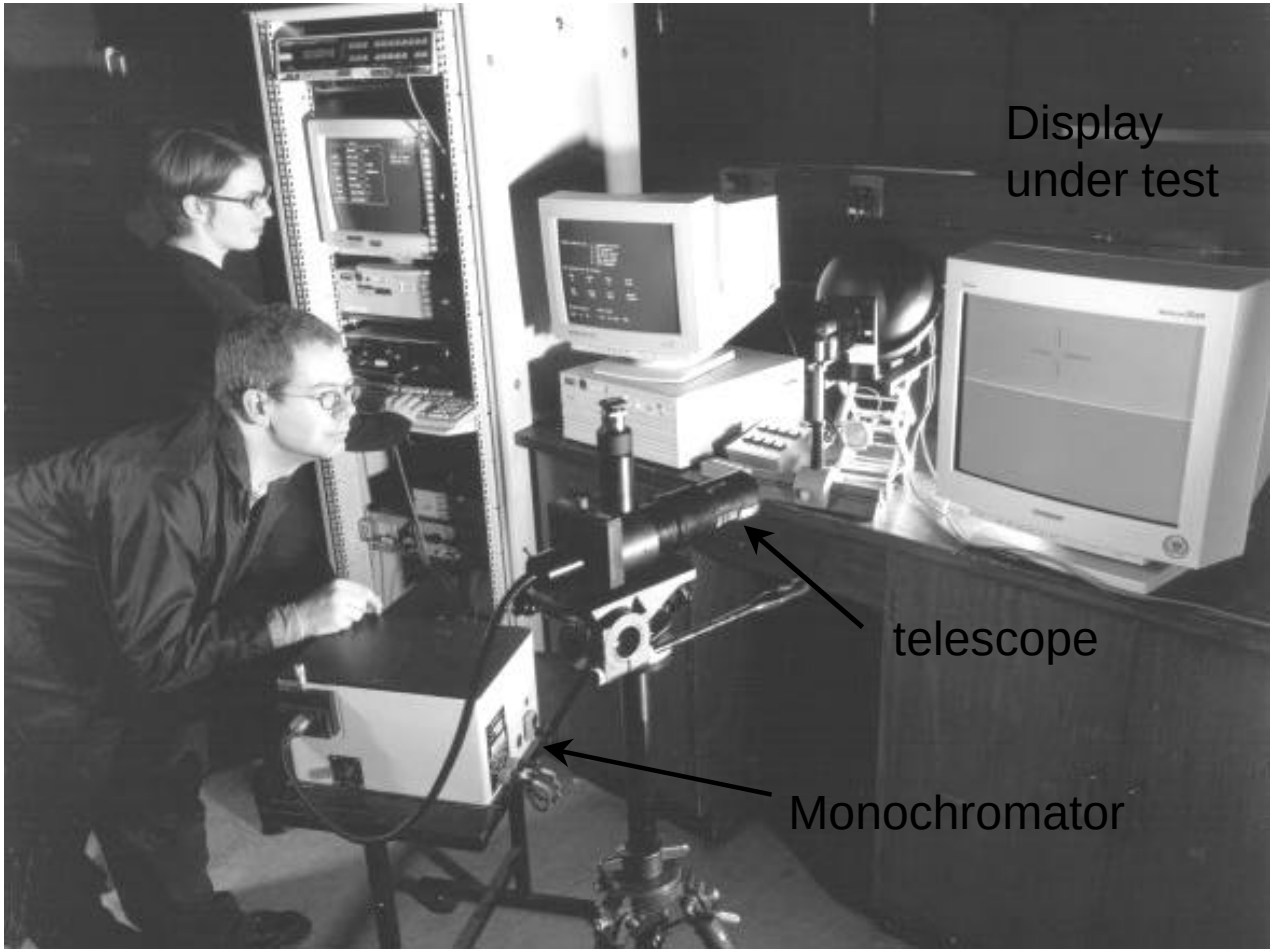
NPL's reference displays system

For miniature displays, the test area was too large and the resulting signal too weak.

The fibre link was removed, and lock in amplification used.



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An improved solution for miniature displays

- Increase the magnification of the input optics using an achromatic long focal distance microscope
- Increase system throughput by removing optical fibre link.
- Increase the signal to noise ratio of the detection system by using lock-in amplification

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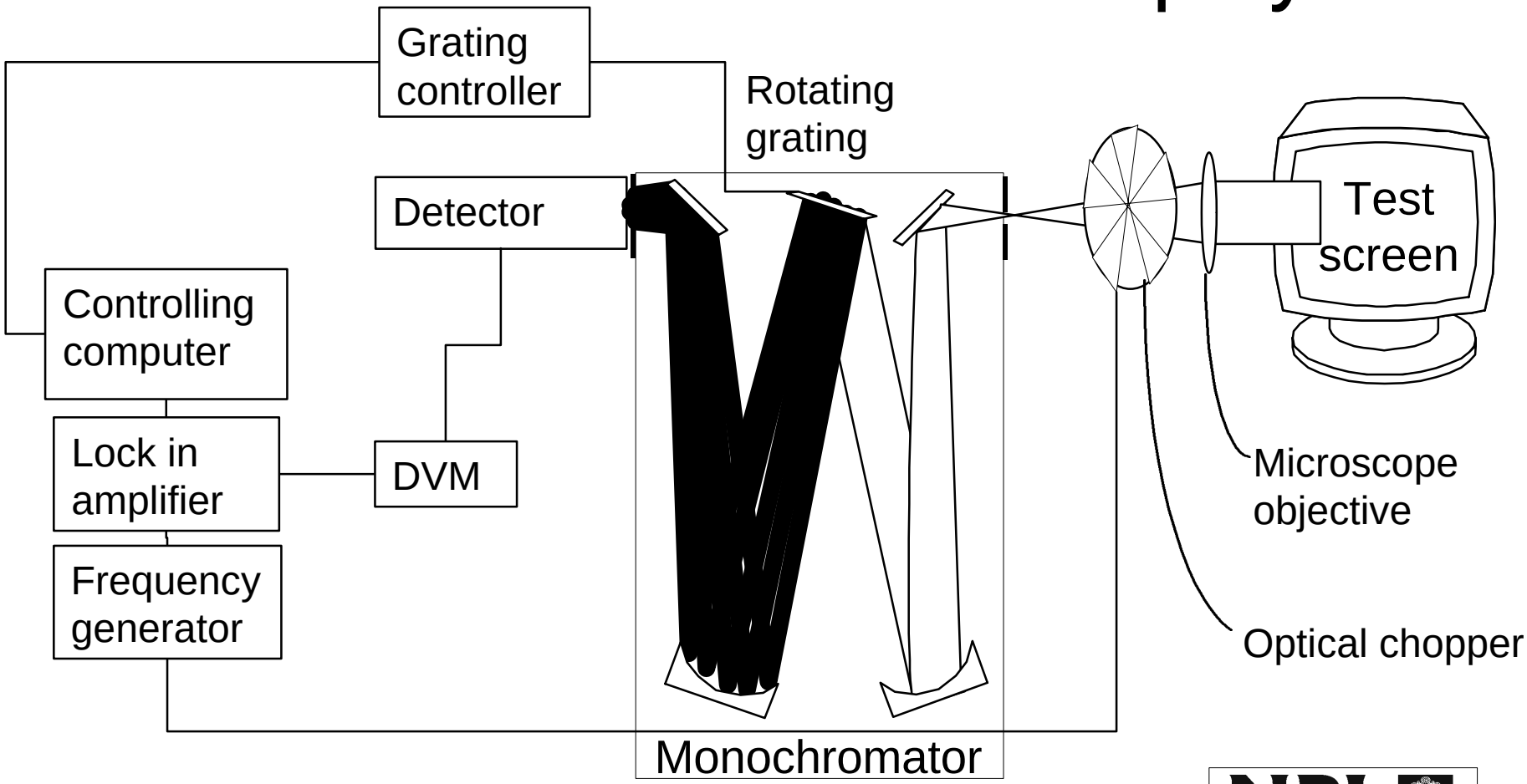
An improved solution for measurement of miniature displays



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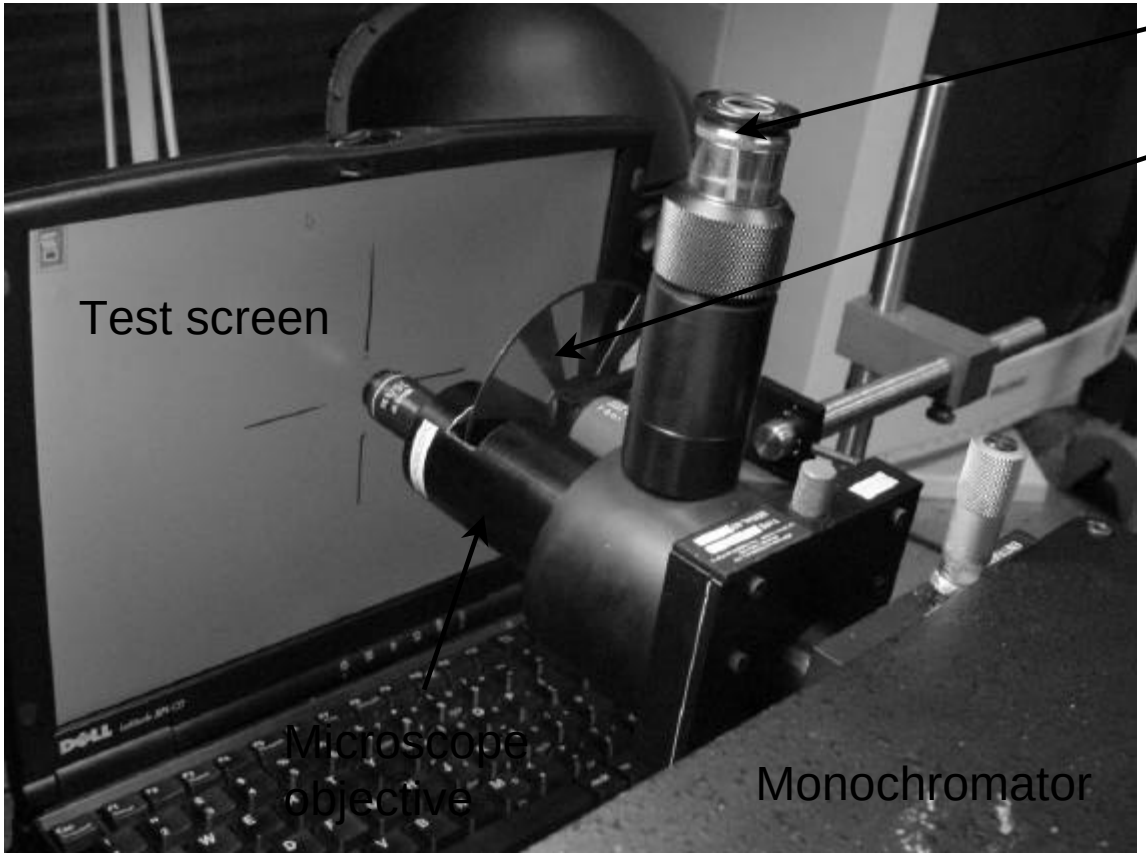
An improved solution for measurement of miniature displays



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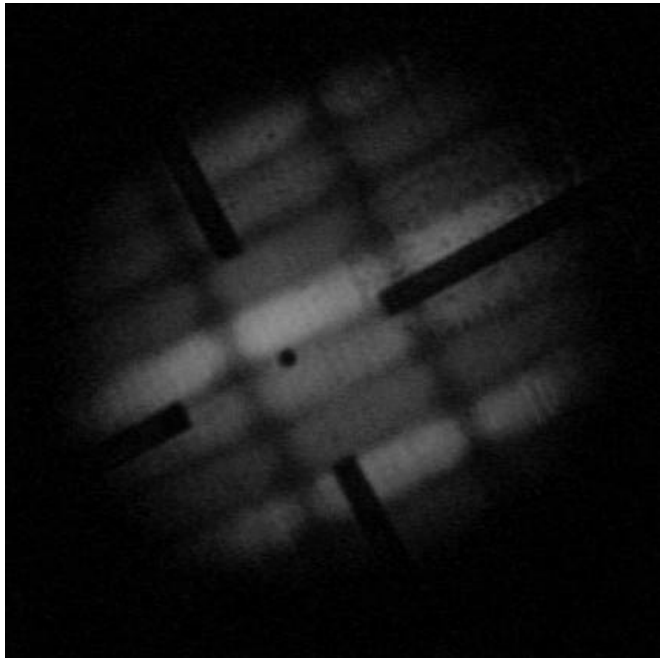
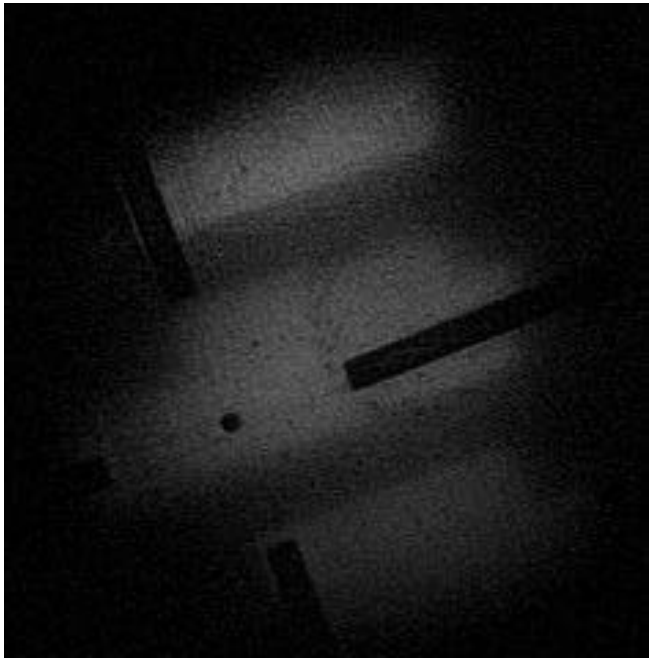
View though the eyepiece



x 50



x 160

- Spot size versus signal
- Microscope depth of focus (CRT Glass)
- Which frequency to chop at?

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Deciding on a chopping frequency

A 50/50 chopper with 12 blades was used.

The chopping frequency was selected by choosing prime numbers which were NOT multiples of either 60 Hz (the refresh rate) or 50 Hz (mains voltage)

733 Hz was used

67	103	139	211	269	307	373	409	521	613	733	821	919
71	107	157	223	271	311	379	431	523	617		823	929
73	109	163	227	277	313	383	433	563	619		877	977
79	113	167	229	281	317	389	439	569	631		881	
83	127	173	233	283	331		461	571	673			
89	131	191	257	293	337		463	577	677			
97	137	193	263		367		467	587	683			

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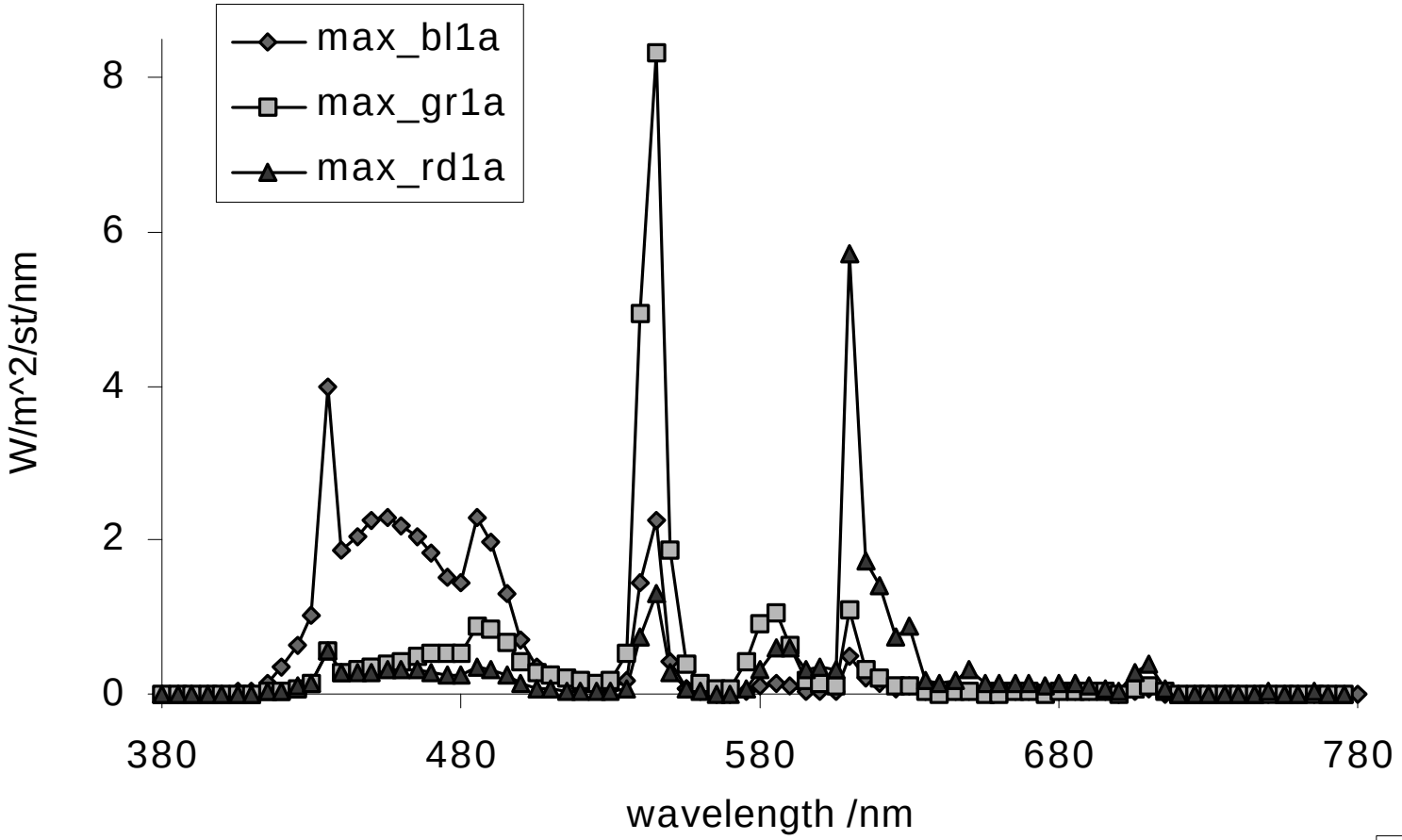
Results

The miniature displays system is working but there is a degree of leakage between the channels, so further work on the optics and detection is needed



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Conclusions

- Measuring microdisplays is difficult
- Using lock in amplification can help detection at low signal levels
- Combinations of techniques may be necessary for full characterisation of a microdisplay system
- Recommendations and standards for microdisplay measurement are required.

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Further work

- Evaluation of minimum signal levels measurable using the NPL microdisplays system
- Collaboration with other centres measuring microdisplays
- Further testing of the microdisplay ***systems*** using real microdisplays
- Comparison of results with other centres

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