

Design and realisation of a simple, rapid Beam Plotting System for medical ultrasound fields

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NPL

Presentation plan

- The Problem
- Requirements of a Solution
- Our Design & Implementation
- Measurement Procedure
- Testing
- Future Improvements

The Problem (1/3)



- Number of ultrasound scans carried out each year is increasing, systems becoming more complex
- Safety committees recommend QA procedures
- QA of medical ultrasound devices is time consuming and expensive
- Many hospitals find it difficult to undertake QA measurements

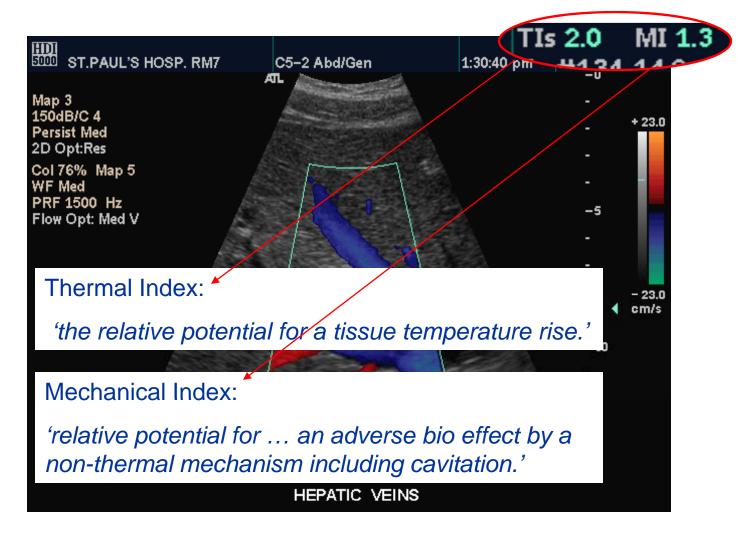




- BMUS Safety Guidelines Recommend periodic checking of acoustic output:
 - 'There should be independent checks that the displayed TI and MI values are accurate'

The Problem (3/3)





System Requirements (1/5)



- Rapid
- Easy to use
- Portable
- Cost effective
- No need to submerge device under test

System Requirements (2/5): Scanned and Non-Scanned Modes





System Requirements (3/5): Mechanical Index



 $MI = \frac{p_{r.3}(\text{at } z_{sp})}{\sqrt{f}}$

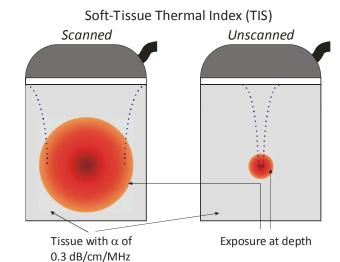
System Requirements (4/5): Thermal Index (Soft Tissue)



Scanned / At Surface Non-Scanned

$$TIS_{as,ns} = \frac{P_{1x1}f_{awf}}{210\,\mathrm{mWMHz}}$$

Below Surface Non-Scanned



$$TIS_{bs,ns} = \min\left[\frac{P_{\alpha}(Z_{s,ns})f_{awf}}{210 \,\mathrm{mWMHz}}, \frac{I_{spta,\alpha}(Z_{s,ns})f_{awf}}{210 \,\mathrm{mW\,cm^{-2}\,MHz}}\right]$$

System Requirements (5/5): Required Measurements

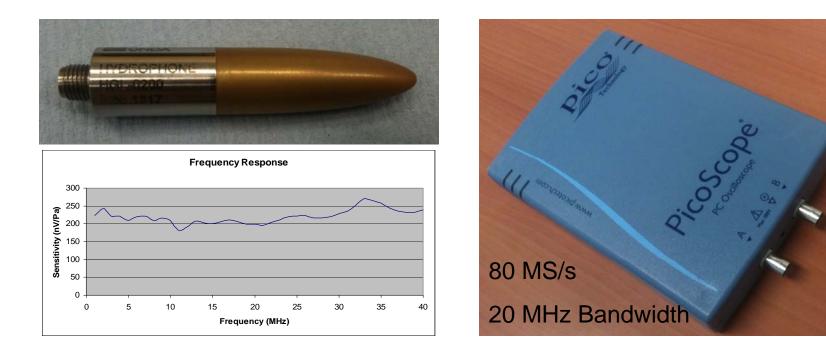


- Axial scan (p_r, I_{ta})
- Pulse repetition rate / frame rate & pulses per frame
- Acoustic working frequency
- Output power and bounded square power

Design & Implementation (1/5): Pressure Measurement Sensor



- Onda HGL-0200 Hydrophone & AG-2020 Preamp
- PicoTech PicoScope 4224 PC Oscilloscope
- LabVIEW Software on a Laptop PC



Design & Implementation (2/5): Power Measurement



- Thermal method
- Pyroelectric effect of thin (52 μm) pvdf layer
- Backed by a thick, highly absorbent layer (75 dB cm⁻¹ at 1MHz)
- Output proportional to rate of change of temperature of *pvdf*

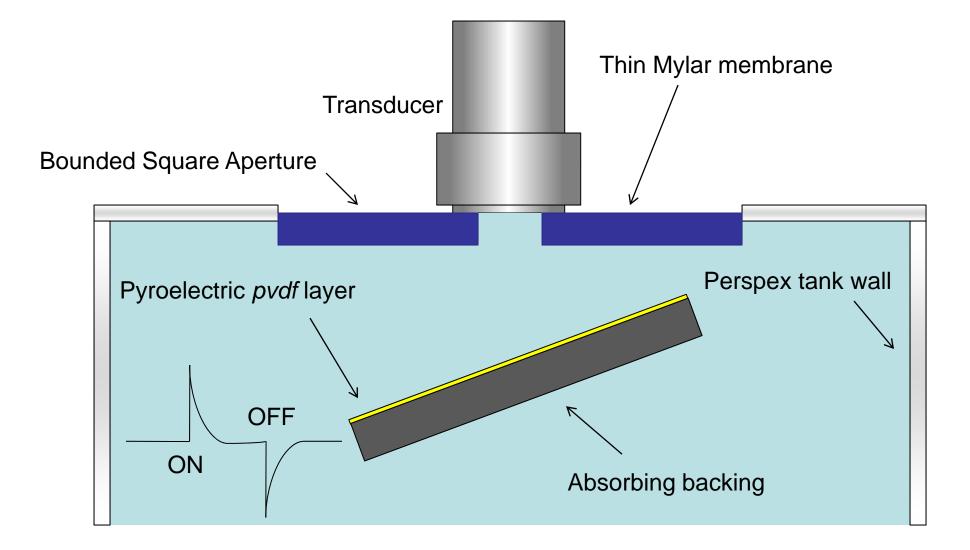




B.Zeqiri, P.N. Gelat, J. Barrie and C.J. Bickley, "A novel pyroelectric method of determining ultrasonic transducer output power: device concept, modelling and preliminary studies," IEEE Trans. Ultrason. Ferroelect. Freq. Control., vol. 54, pp. 2318 – 2330, 2007.

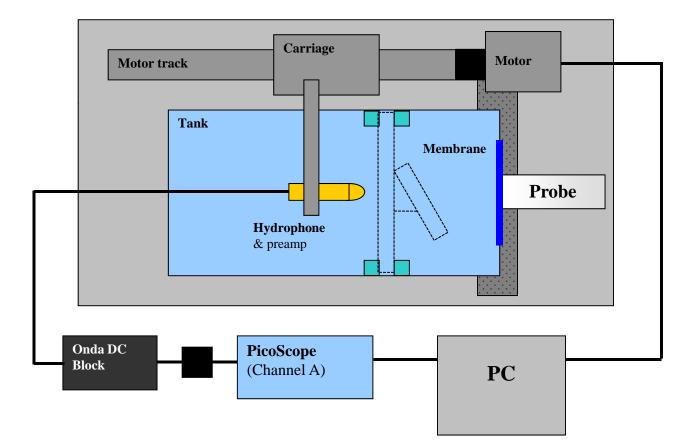
Design & Implementation (3/5): Power Measurement





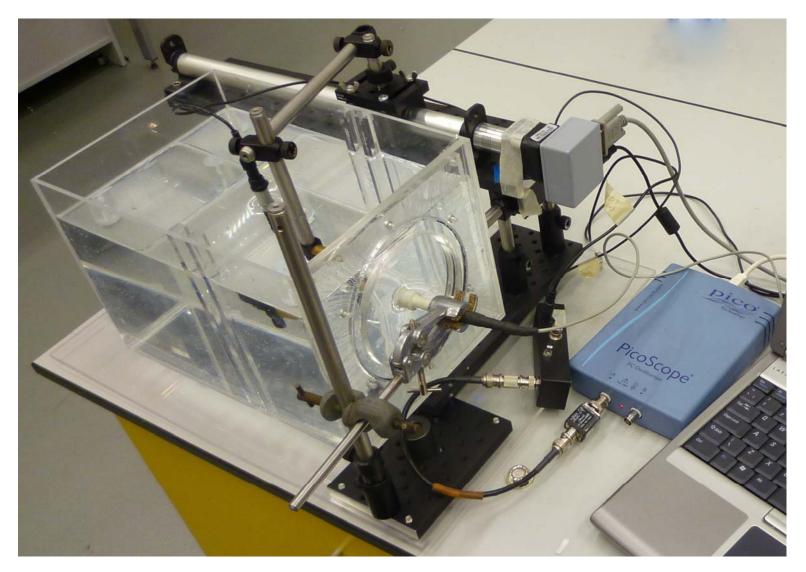
Design & Implementation (4/5): Diagram





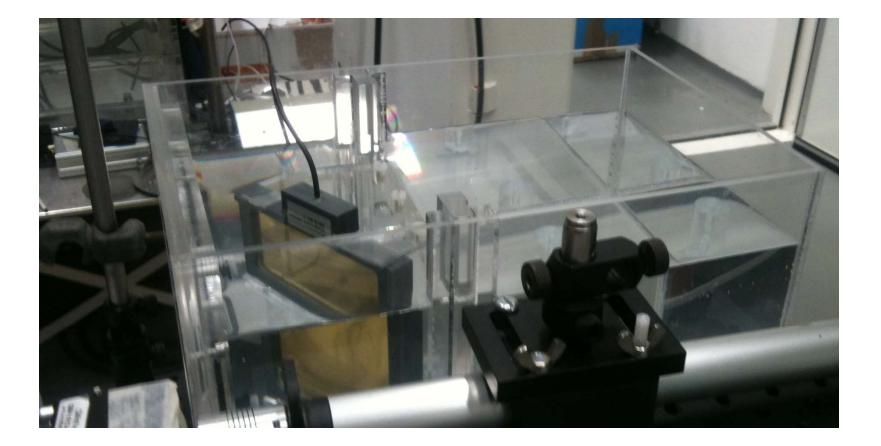
Design & Implementation (5/5): Photos





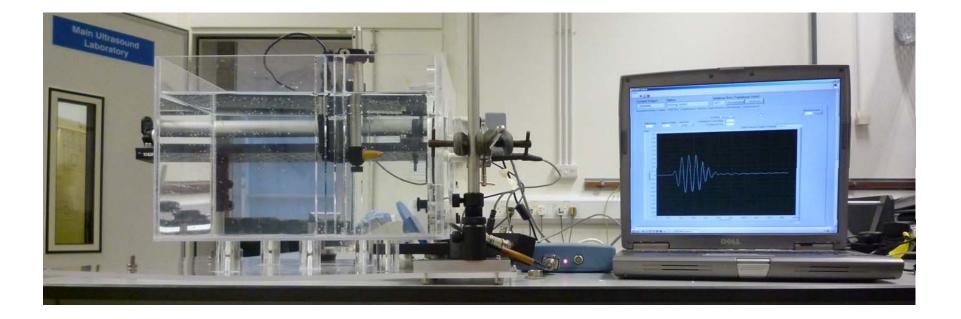
Design & Implementation (5/5): Photos





Design & Implementation (5/5): Photos





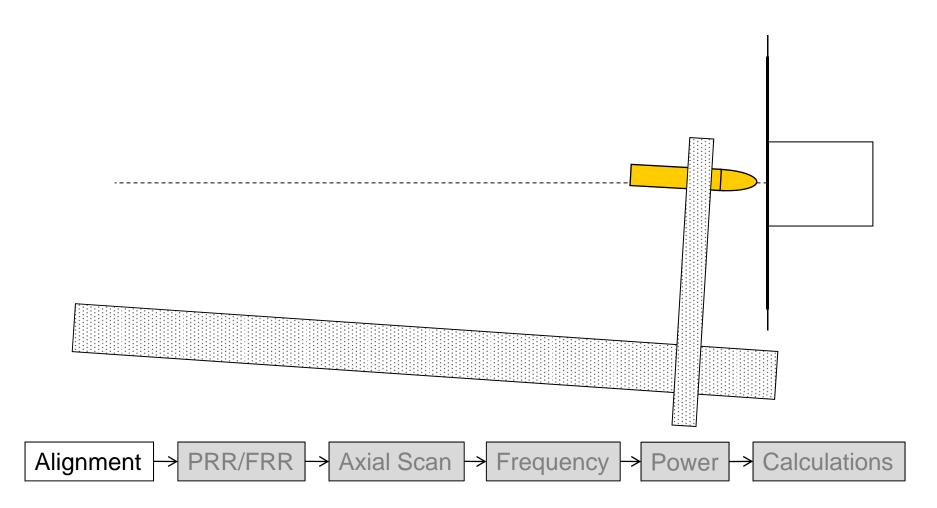
Measurement Procedure (1/10): 1) Alignment



Image: NEWUI_main.vi Project Image: New UI_main.vi		
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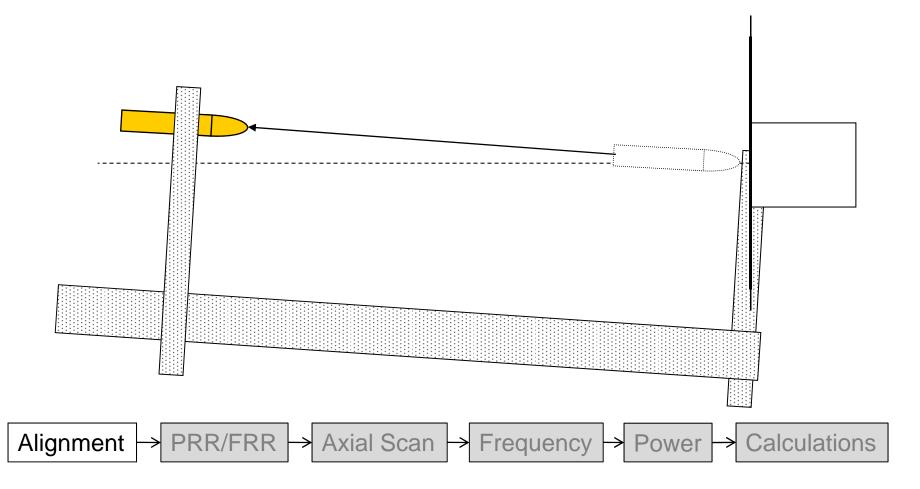
Measurement Procedure (2/10): 1) Alignment





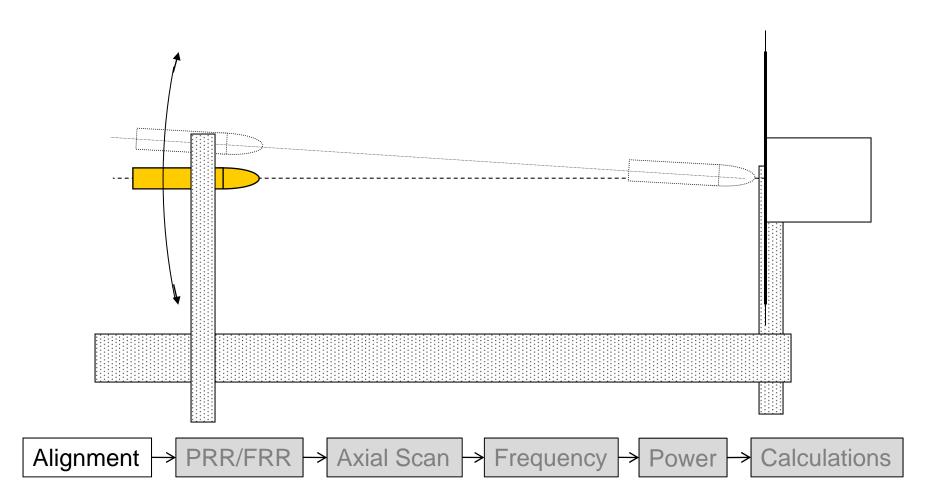
Measurement Procedure (2/10): 1) Alignment





Measurement Procedure (2/10): 1) Alignment

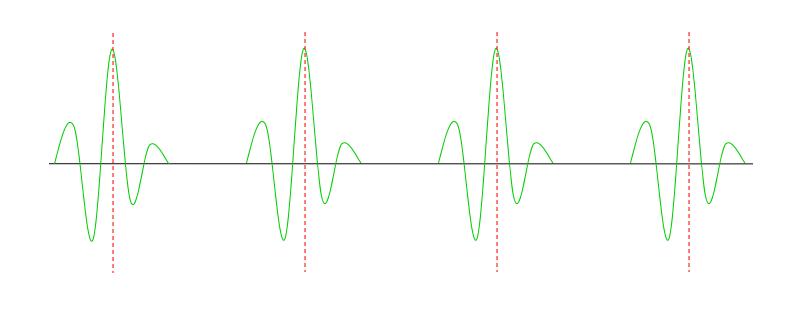


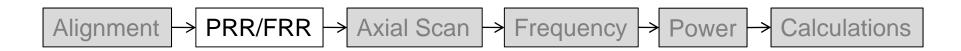


Measurement Procedure (3/10): 2) Pulse / Frame Rate Measurement



Non-Scanned Mode

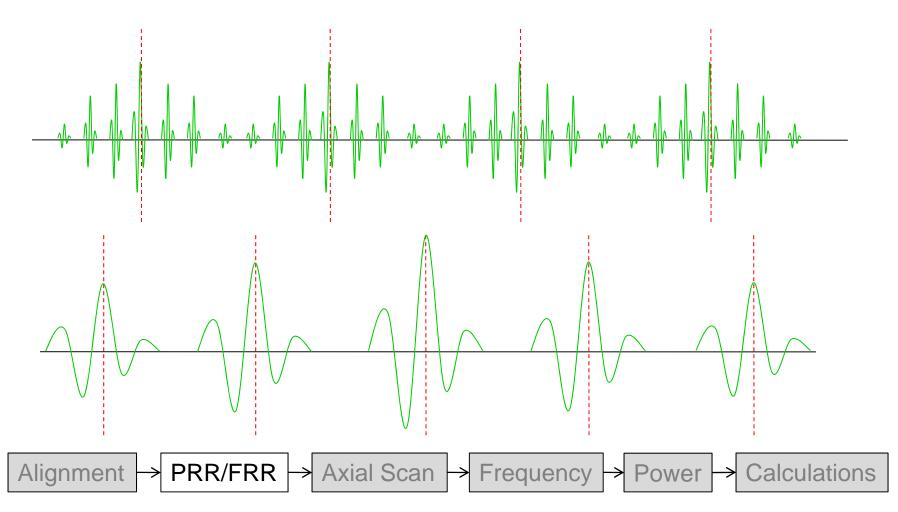




Measurement Procedure (4/10): 2) Pulse / Frame Rate Measurement



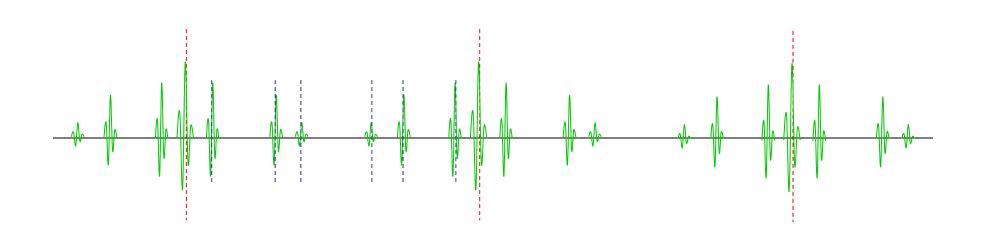
Scanned Mode with Constant Pulse Rate

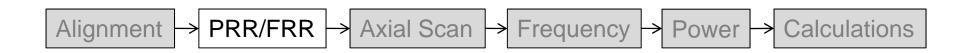


Measurement Procedure (5/10): 2) Pulse / Frame Rate Measurement



Scanned Mode with Varying Pulse Rate





Measurement Procedure (6/10): 2) Pulse / Frame Rate Measurement

Alignme



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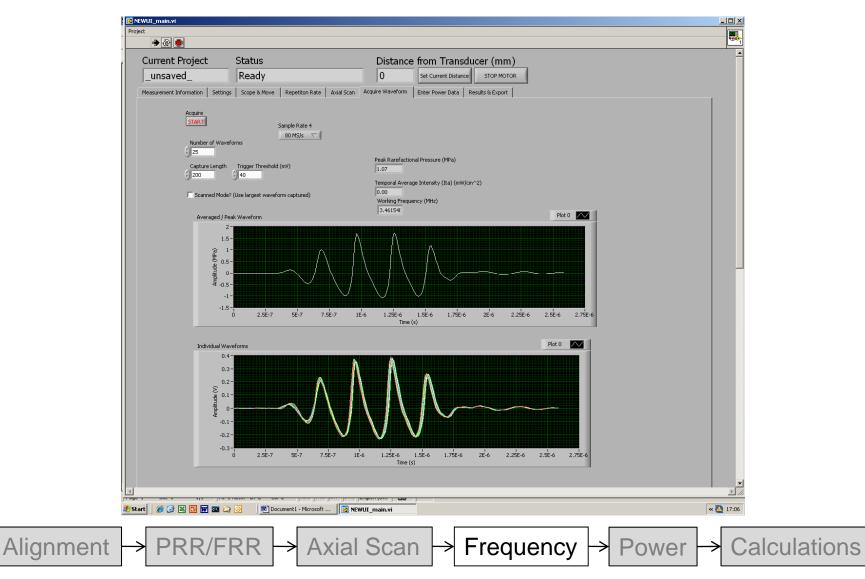
Measurement Procedure (7/10): 3) Axial Scan



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Measurement Procedure (8/10): 4) Frequency Measurement

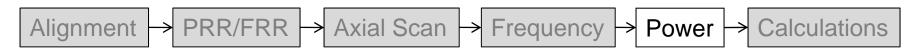




Measurement Procedure (9/10): 5) Power Measurements

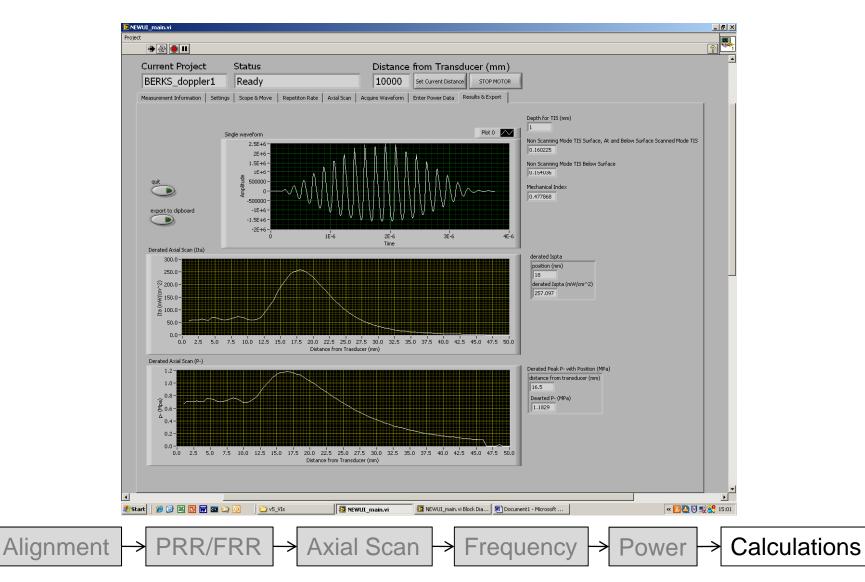






Measurement Procedure (10/10): 6) De-rating and MI TI Calculation















Summary



- Portable system
- Simple alignment of hydrophone to beam axis
- Automatic beam plotting
- Simple power measurement as part of same system
- Automatic calculation of MI and TI





Future Work



- Easier alignment
- Reduce effect of vibration on power sensor
- More portable
- Comparison with existing systems

Acknowledgments

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The National Measurement System delivers world-class measurement science & technology through these organisations



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National Measurement System



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