Physikalisch-Technische Bundesanstalt
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Reliability of Key Comparison Results for Validation of Calibration and Measurement Capabilities

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Outline

- Short introduction to the situation
- Key comparison with random instabilities of transfer standard
- Quantification of reliability of DOEs in terms of explanatory power
- Explanatory power for design of key comparisons

Introduction: Uncertainties in CMC vs. Comparison

- In fluid flow measurement we are finally interested in the amount of fluid at the location of metering.
  => Our CMCs shall express our capabilities to determine the amount of fluid at the location of device under test (DuT).
- We always depend on the sensor performance of the DuT, we never can measure the identical amount again or compare it among Labs.
- In definition of CMC, repeatability of (best available) DuT is included.
- In comparisons, long term stability (reproducibility) of DuT (transfer standard TS) has to be considered as an additional uncertainty u_{TS}.

$$u_{Lab,Comp} = \sqrt{u_{Lab,CMC}^2 + u_{TS}^2}$$

Uncertainties in CMC vs. Comparison
Numbers to illustrate

	Liquid	Gas
CMC		
typical	0,05 %	0,1 %
best	0,02 %	0,04 %
Repeatability (included in CMC)	≤ 0,005 %	≤ 0,01 %
Reproducibility		
typical	0,05 %	0,05 %
best	0,01 %	0,02 %

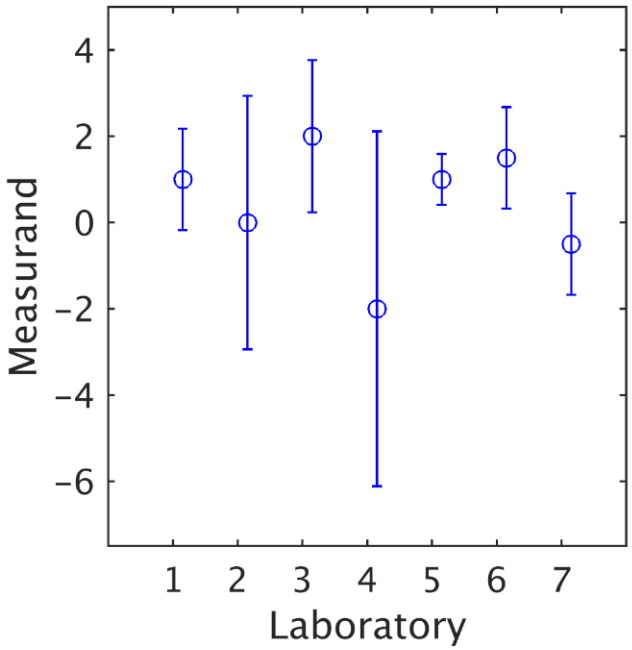
$$u_{Lab,Comp} = \sqrt{u^2_{Lab,CMC} + u^2_{TS}}$$

In practice of inter comparisons, best CMC meets quite often typical Reproducibility!

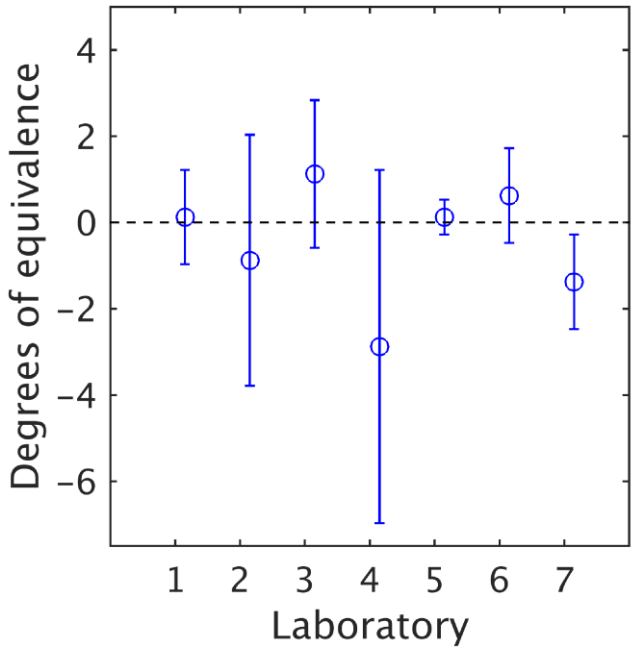
Approval of calibration and measurement capabilities (CMCs)

➔ Unilateral degrees of equivalence (DOE) not significantly different from zero

KC data



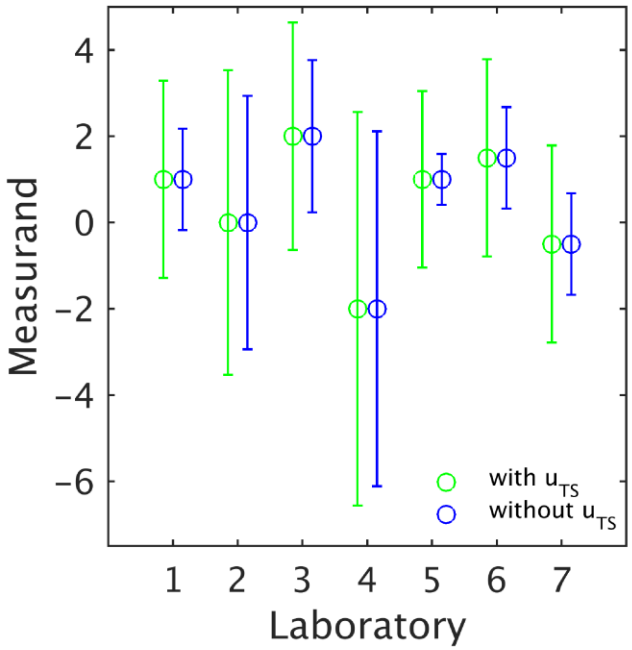
DOE



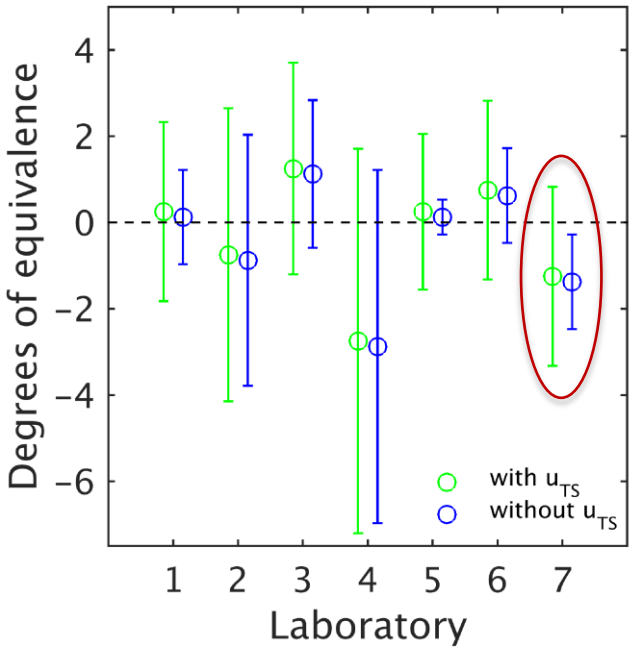
Transfer standard exhibiting random fluctuations

DOEs calculated taking random fluctuations of transfer standard into account

KC data



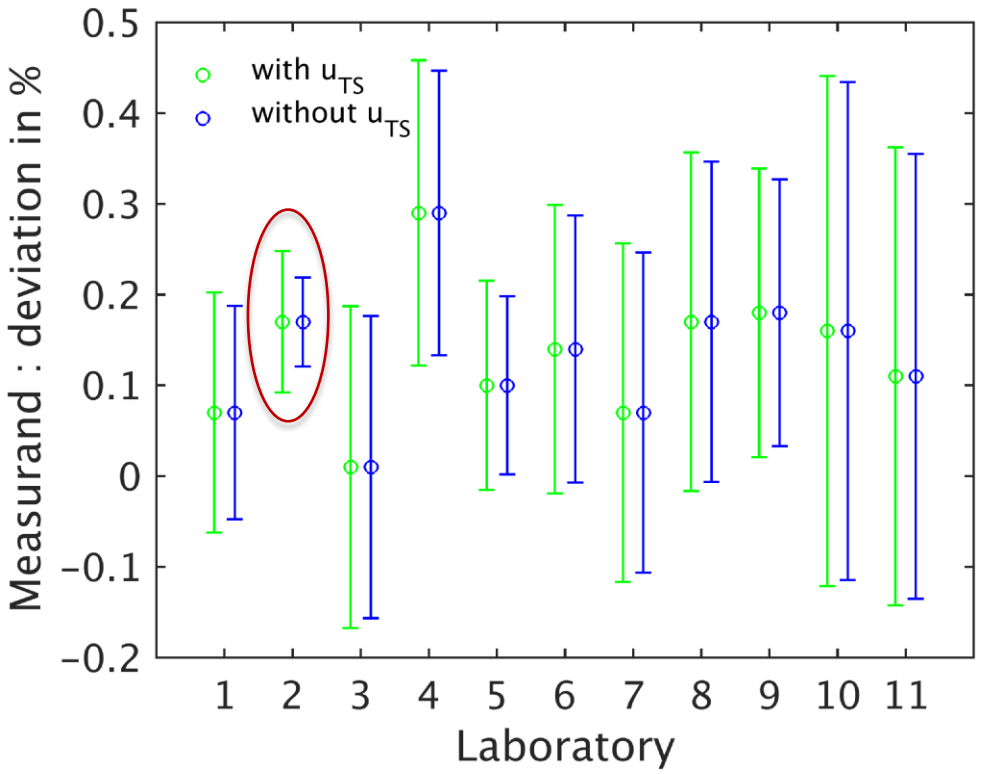
DOE



Challenge : Reliability of DOEs unclear

u_{TS} standard deviation of random fluctuation of transfer standard

Key comparison CCM.FF-K6.2011

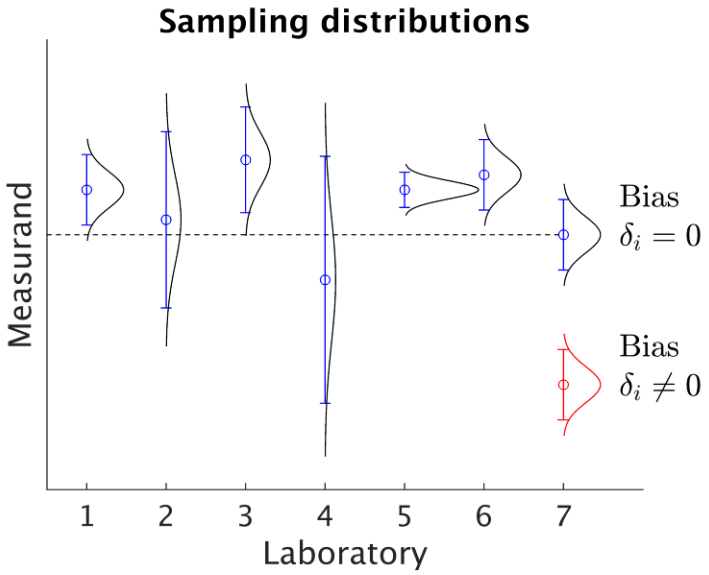


Similar problems in*

- EURAMET.M.FF-K6
- COOMET.M.FF-S2

*) Wright, Toman, Mickan, Wübbeler, Bodnar, Elster, 9th ISFFM (2015)

Explanatory power



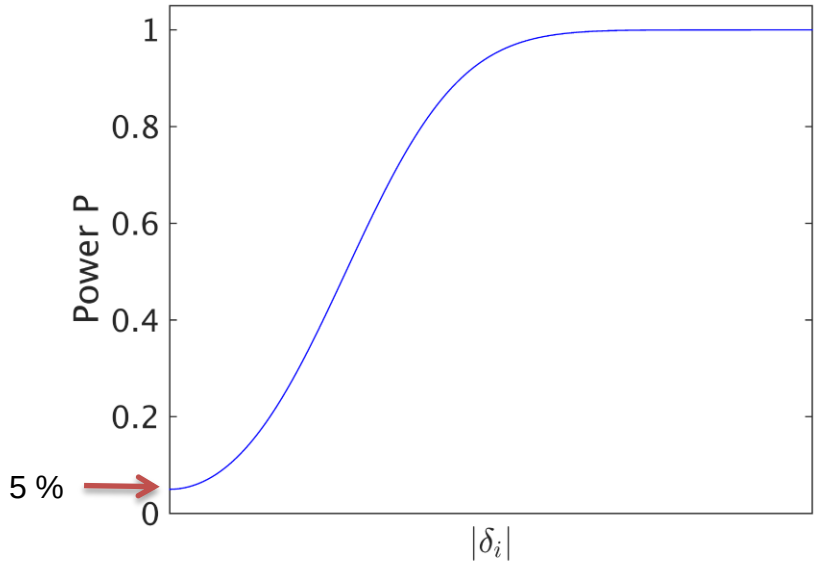
Hypothesis test

$H_0 : \delta_i = 0$ against $H_1 : \delta_i \neq 0$

Power

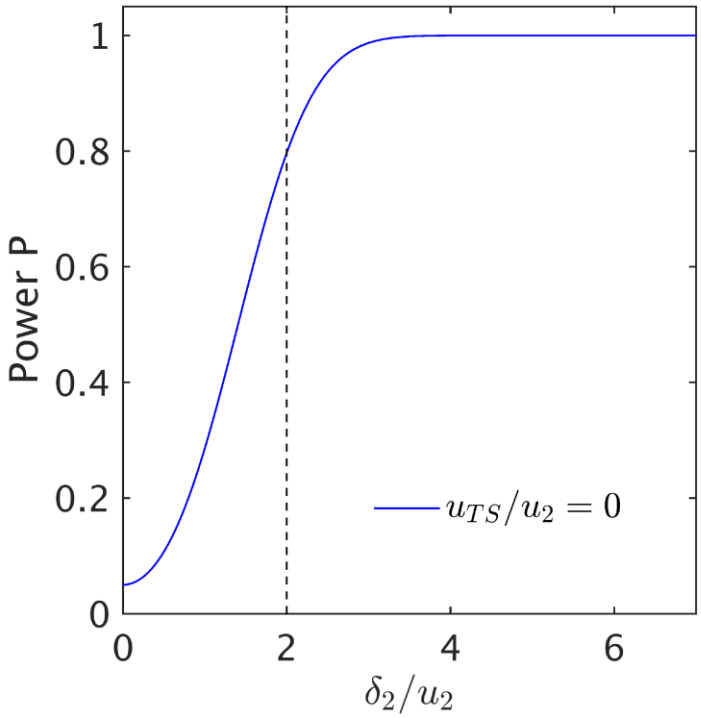
Probability* to reject H_0
when it is violated ($\delta_i \neq 0$ here)

*) before the data have been observed

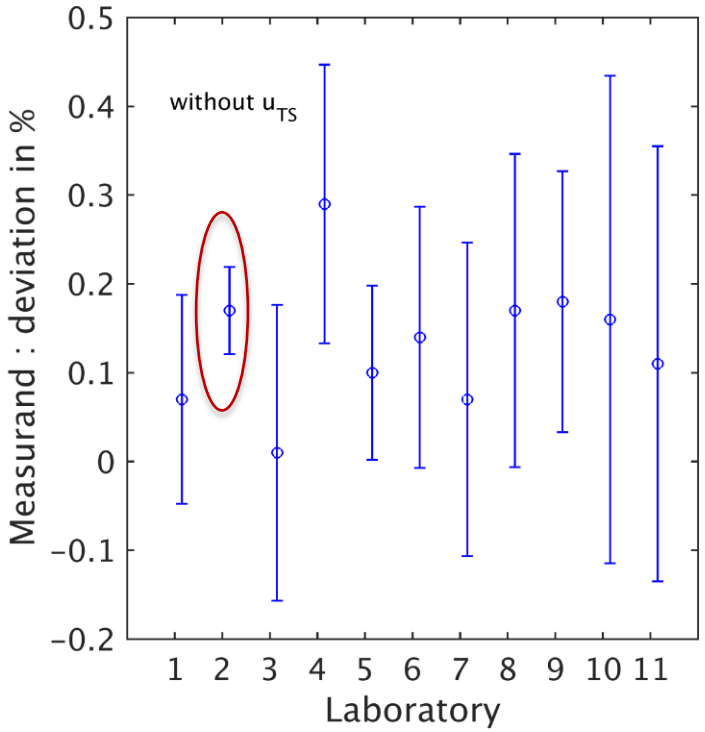


Reliability of DOEs in terms of explanatory power

Power for laboratory 2



CCM.FF-K6.2011



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Reliability of DOEs in terms of explanatory power

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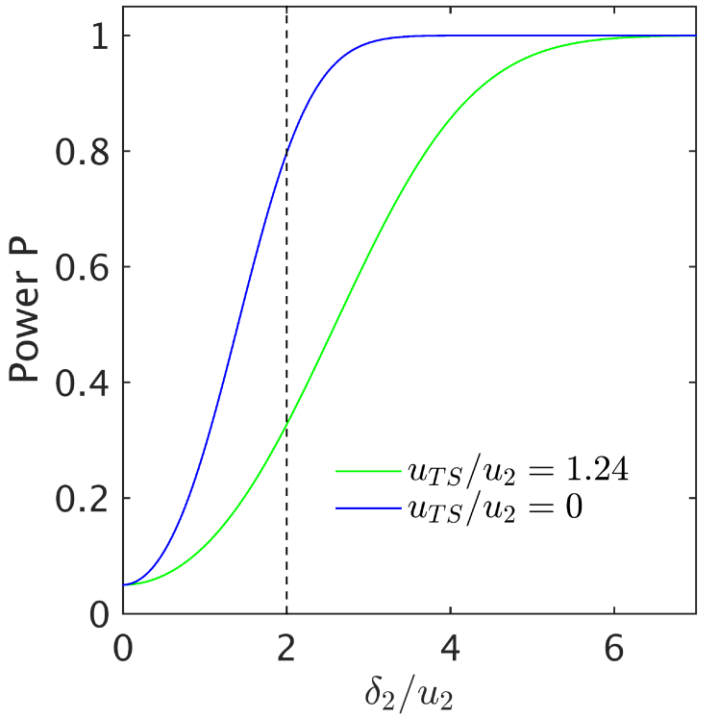
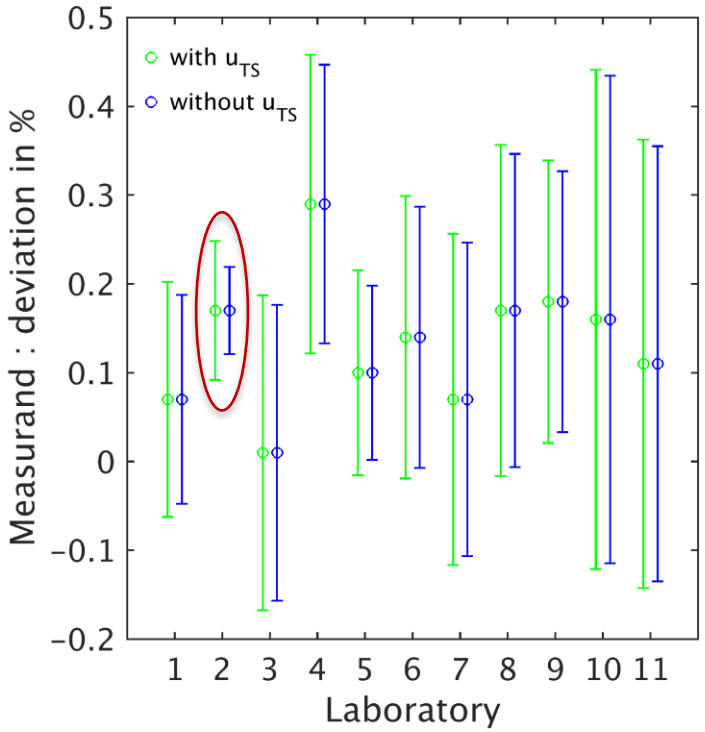


CCM.FF-K6.2011



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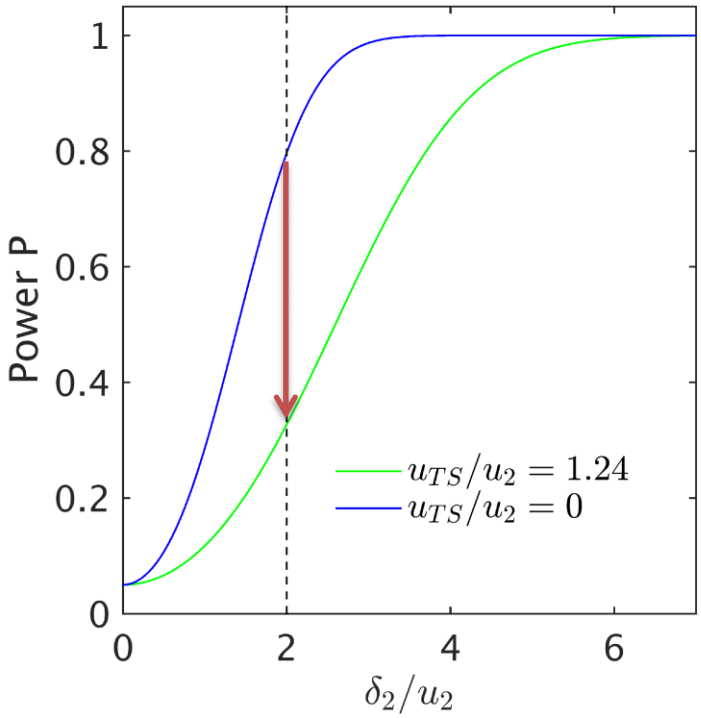
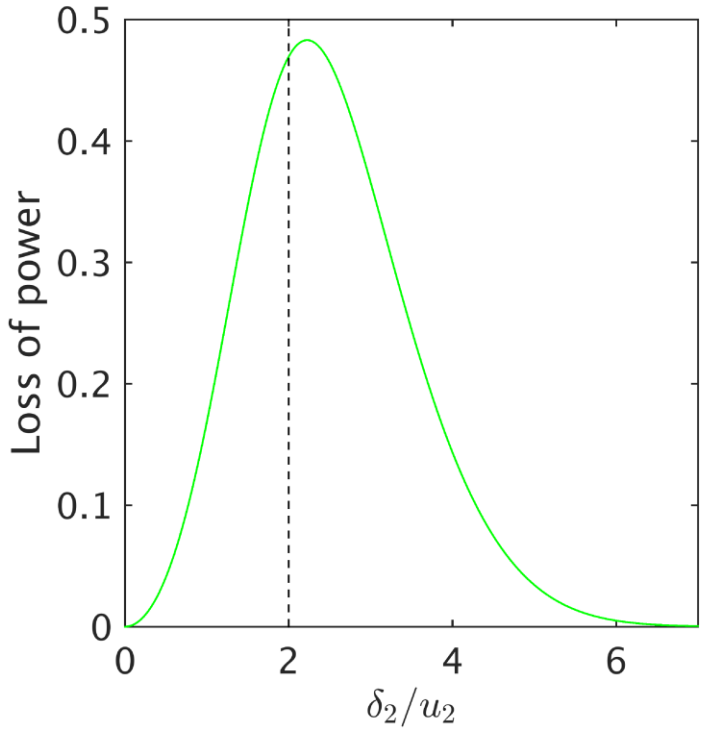
Reliability of DOEs in terms of explanatory power

Power for laboratory 2



Loss of power for laboratory 2



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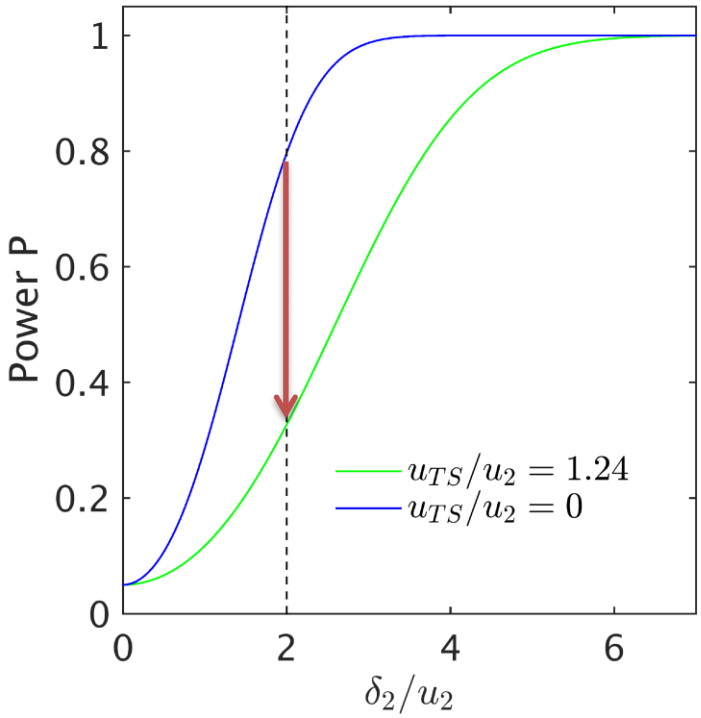
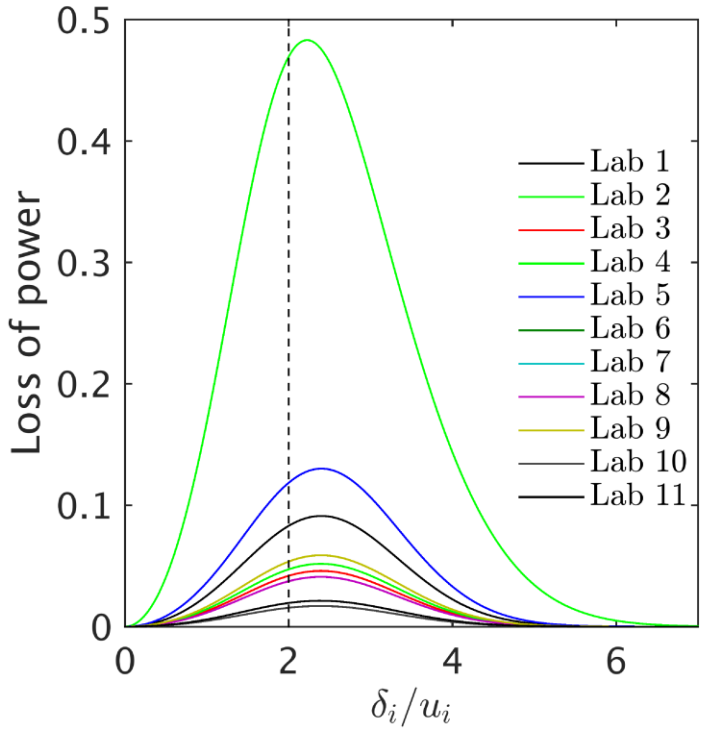
Reliability of DOEs in terms of explanatory power

Power for laboratory 2



Loss of power for all laboratories

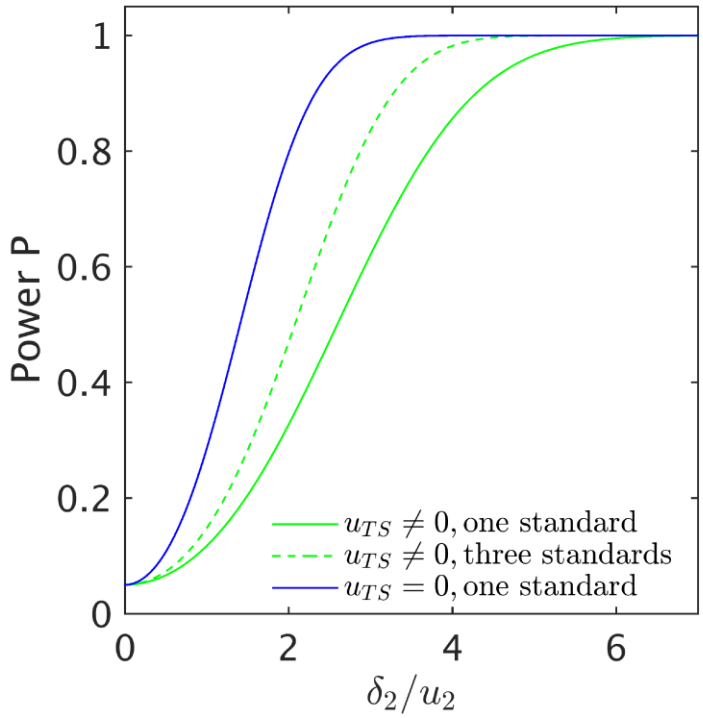


Bias δ_i unknown ➔ reliability criterion based on maximum tolerable loss of power (e.g. 0.3) *

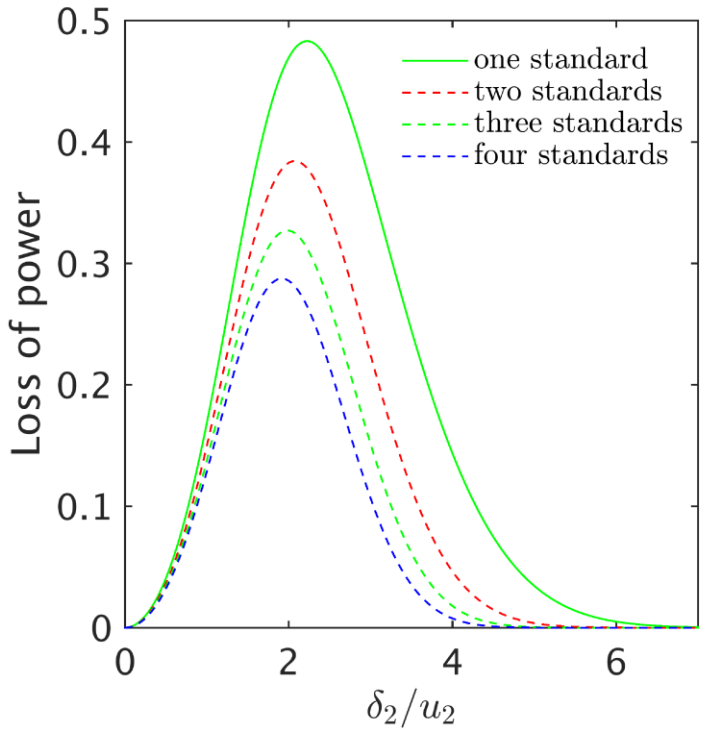
*) to be specified by CCs

Design of key comparisons: multiple transfer standards

Power for laboratory 2

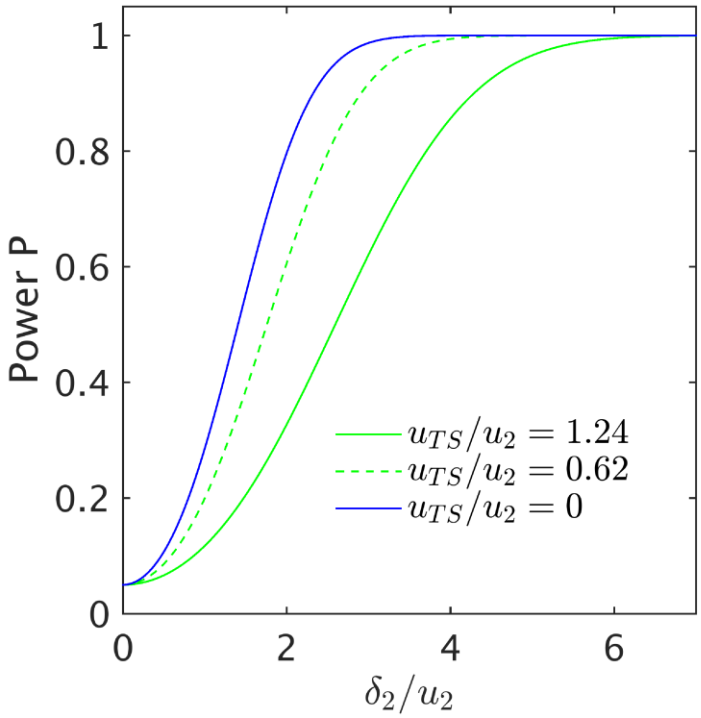


Loss of power for laboratory 2

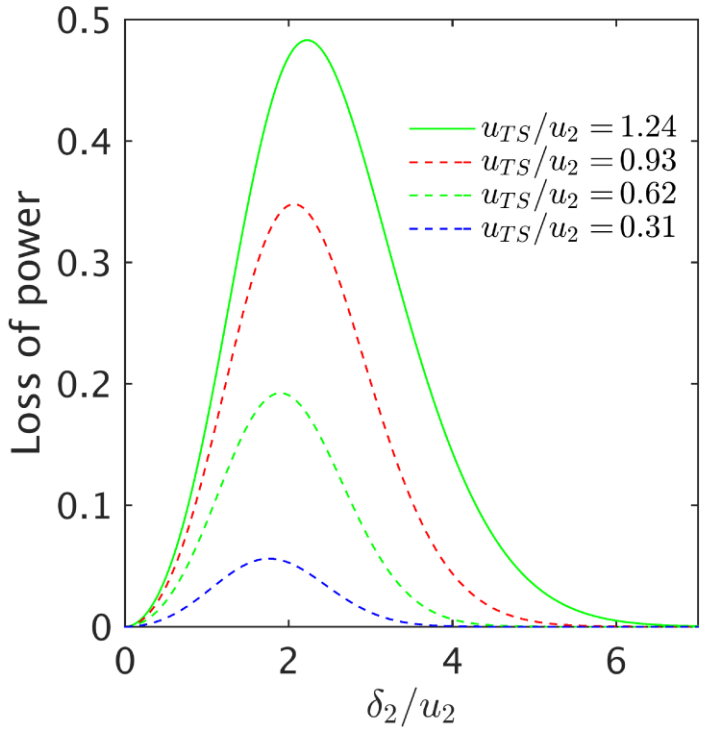


Design of key comparisons: more stable transfer standard

Power for laboratory 2



Loss of power for laboratory 2



Summary and conclusions

- Relevance of DOEs deteriorates in the presence of random instability of transfer standard.
- Explanatory power enables a quantitative assessment of this deterioration.
- Explanatory power can be applied for the design of key comparisons.
- Loss of power can be used in terms of an assessment of CMCs.
- Quantification in terms of power is just the first step; further considerations should follow to improve our situation.

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