Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
National Metrology Institute

METROLOGY PARTNERSHIP | EURAMET

Comparison of mass spectrometers for the determination of uranium and plutonium

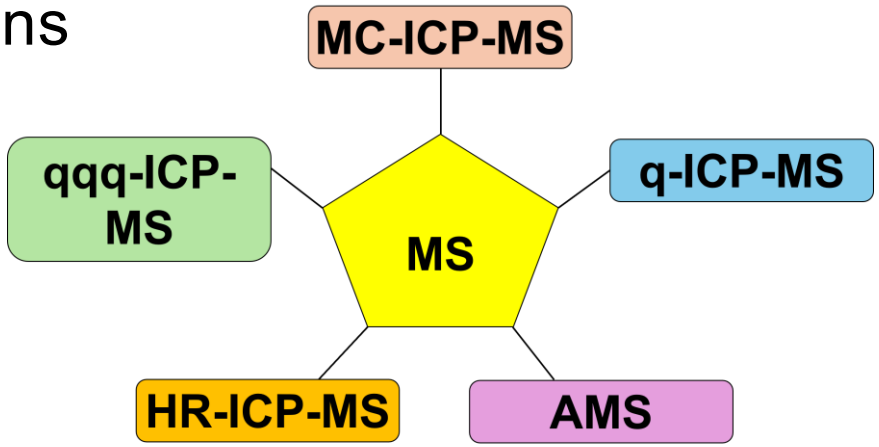
MetroPOEM

Dr. Janine Eberhardt et al.
Environmental Radioactivity

ICRM-LLRMT, Ottawa, Canada, September 14-18, 2026

Introduction

- MetroPOEM: European funded research project (2022-2025)
- 2 new reference materials
  - One solution with a seawater matrix: LRM
  - One synthesized solid with a silicate matrix: SRM
- 2 interlaboratory comparisons
  - 5 types of MS
  - 12 institutes



Scan me for the MetroPOEM website

© PTB, 2026

Important quantities

Isotope ratio R: Natural uranium $n(^{235}\mathrm{U})/n(^{238}\mathrm{U}) \approx 0.0073$ mol/mol

$$R\left({}^{i}\mathrm{E}/{}^{j}\mathrm{E}\right) = \frac{n\left({}^{i}\mathrm{E}\right)}{n\left({}^{j}\mathrm{E}\right)} = \frac{x\left({}^{i}\mathrm{E}\right)}{x\left({}^{j}\mathrm{E}\right)} \quad \text{in mol/mol}$$

Mass fraction w: around 3 ng uranium per g seawater

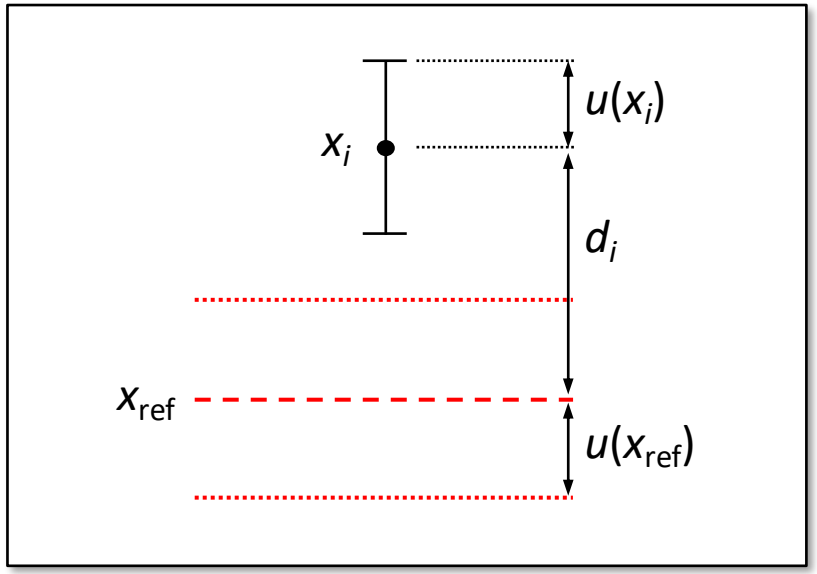
$$w_x = \frac{m_i}{\sum_j m_j} \quad \text{in g/g}$$

Activity concentration based on mass fraction

$$a_i = \frac{w_i \times N_A \times \ln(2)}{M_i \times t_{1/2}}$$

Degree of Equivalence (DoE) d_i

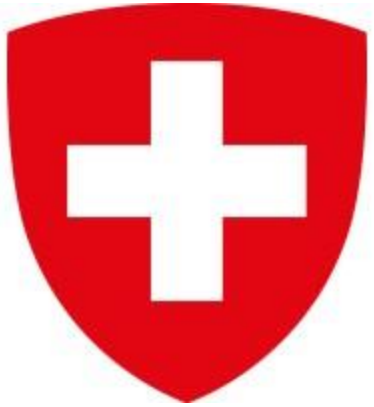
$$d_i = x_i - x_{\mathrm{ref}}$$



Scan me for the CCQM Guidance note

© PTB, 2026

Spiez Laboratory



Physikalisch-Technische Bundesanstalt
Braunschweig und Berlin

HELMHOLTZ ZENTRUM
DRESDEN ROSSENDORF

AGES

DTU

Leibniz
Universität
Hannover

universität
wien

National Institute of
Standards and Technology
U.S. Department of Commerce

ETH zürich

Jožef Stefan Institute, Ljubljana, Slovenia

Measurements at PTB by MC-ICP-MS

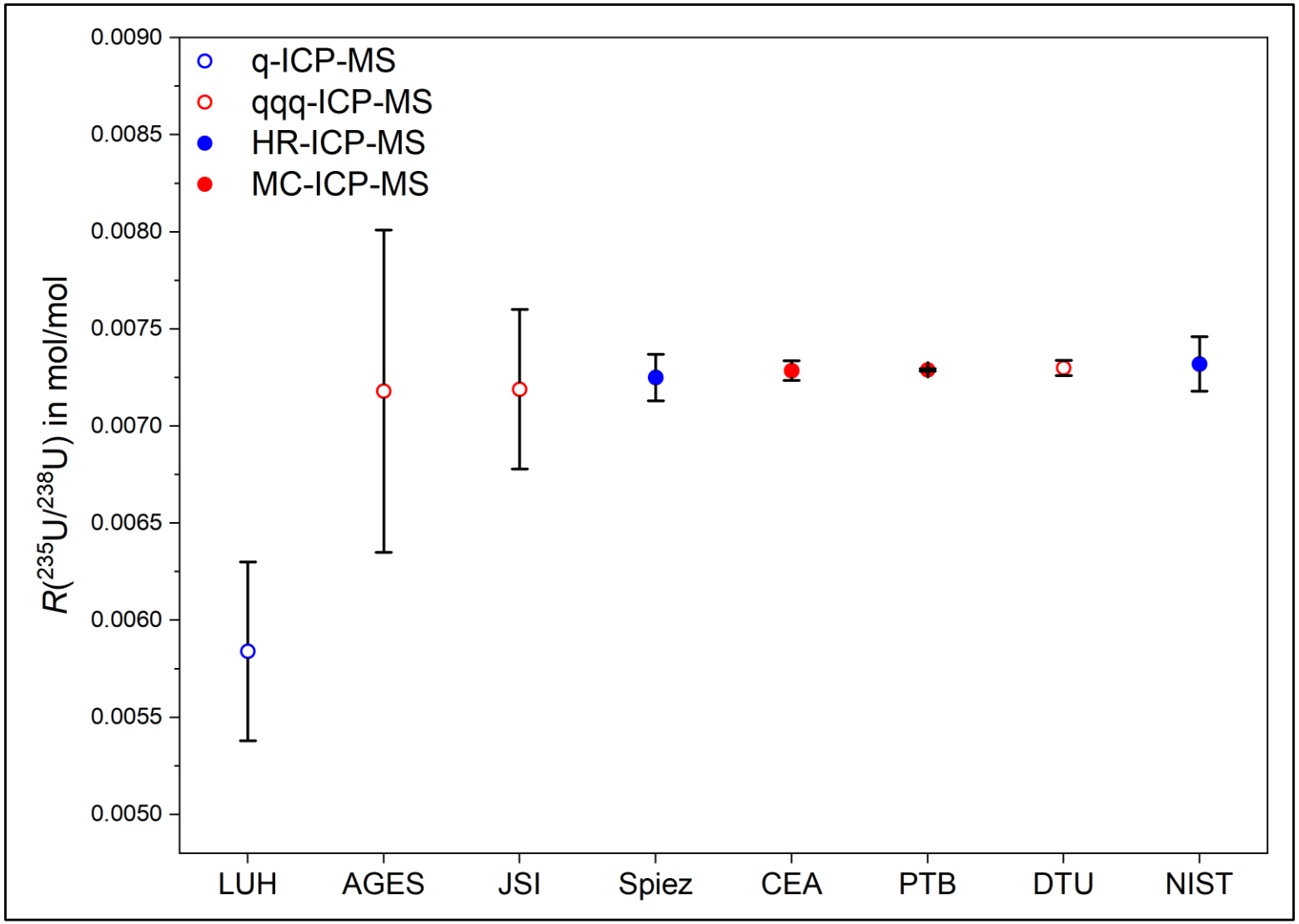
- Uranium
  - Isotope ratios: $\boldsymbol{n(^{234}U)/n(^{238}U)}$, $\boldsymbol{n(^{235}U)/n(^{238}U)}$, $\boldsymbol{n(^{236}U)/n(^{238}U)}$
  - Mass fractions: $\boldsymbol{w(U)}$, $w(^{234}U)$, $w(^{235}U)$, $w(^{236}U)$, $w(^{238}U)$

- Plutonium
  - Isotope ratio $\boldsymbol{n(^{240}Pu)/n(^{239}Pu)}$
  - Mass fractions: $\boldsymbol{w(Pu)}$, $w(^{239}Pu)$, $w(^{240}Pu)$

MetroPOEM
EUROPEAN PARTNERSHIP
Co-funded by the European Union
METROLOGY PARTNERSHIP
EURAMET

© PTB, 2026

$R(^{235}U/^{238}U)$ in the spiked seawater (LRM)

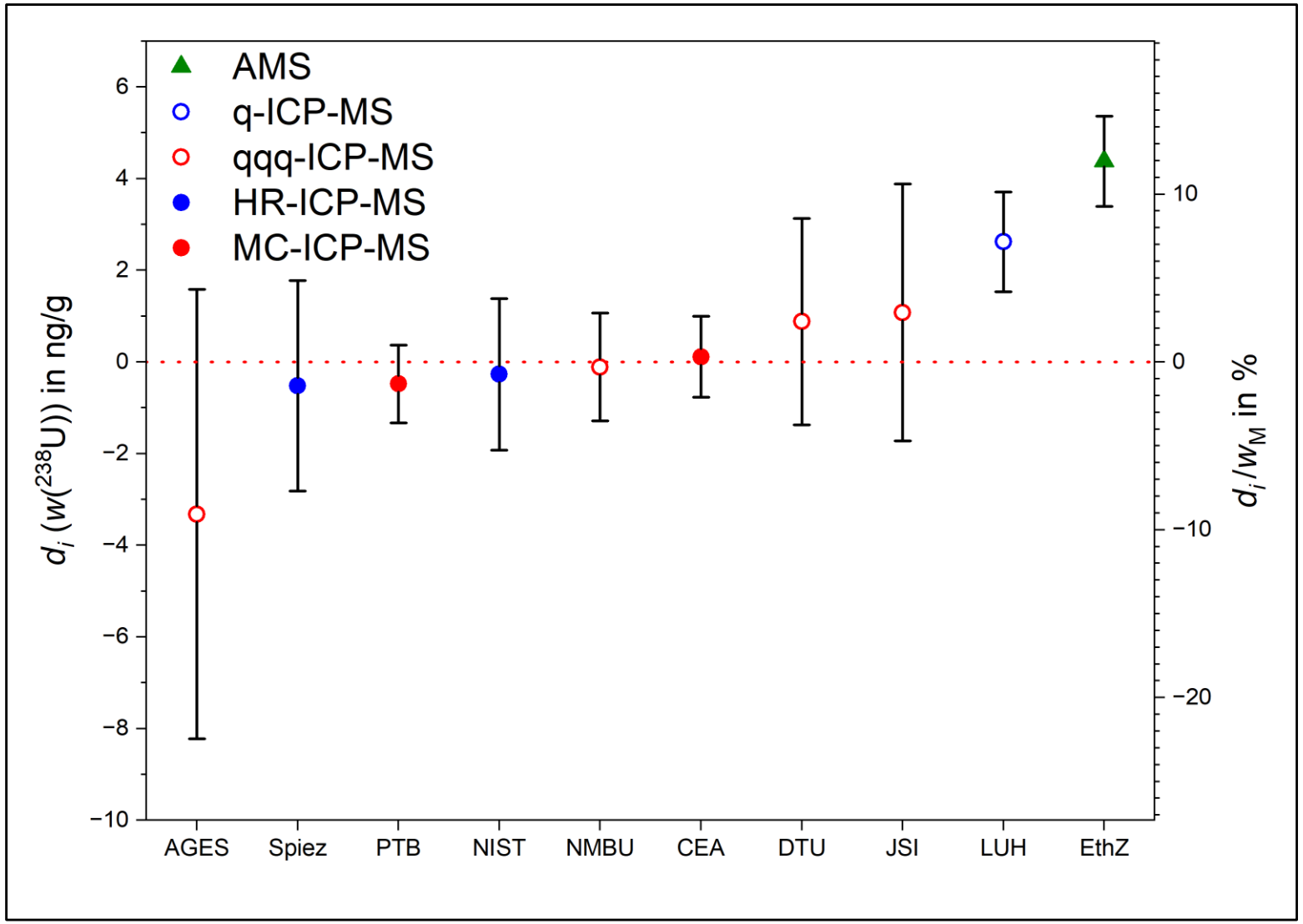


© PTB, 2026

Mass fraction of ^{238}U in the spiked seawater (LRM)

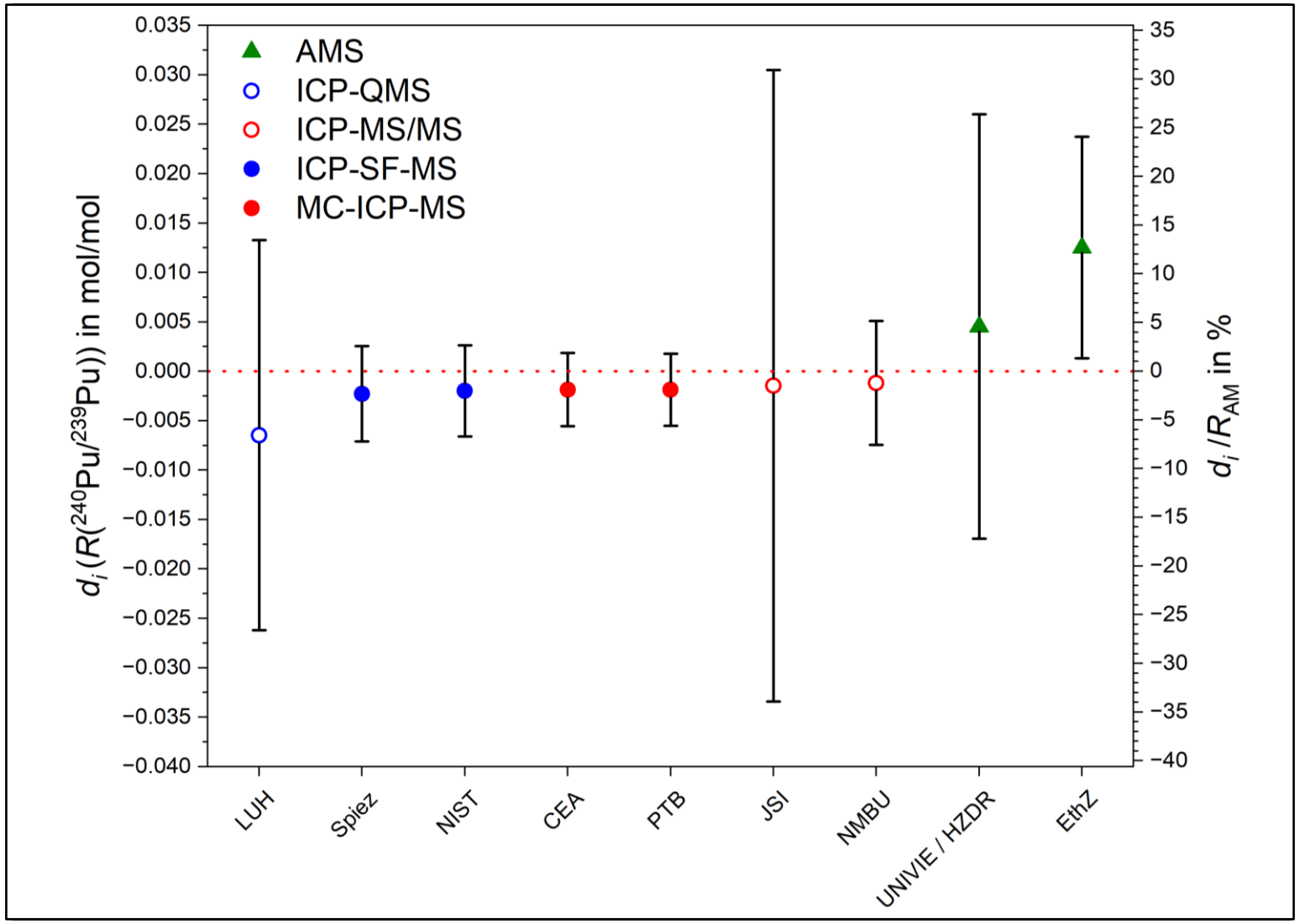
$w(^{238}U)_M$ in ng/g
36.62 ± 0.82

$a(^{238}U)$ in mBq/g
0.455 ± 0.010



© PTB, 2026

$R(^{240}Pu/^{239}Pu)$ in the spiked seawater (LRM)

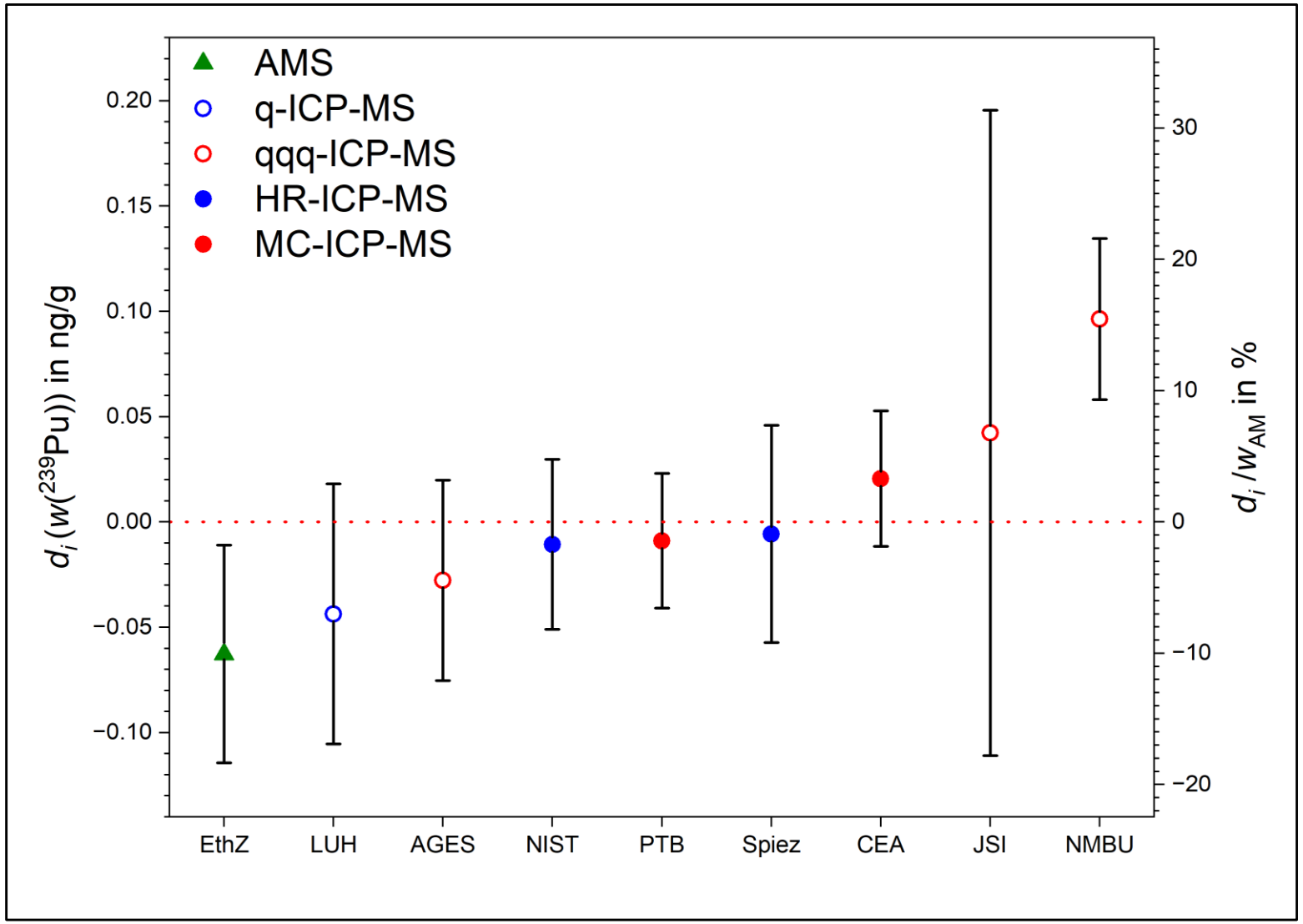


© PTB, 2026

Mass fraction of ^{239}Pu in the spiked seawater (LRM)

$w(^{239}Pu)_{AM}$ in pg/g
624 ± 32

$a(^{239}Pu)$ in Bq/g
1.433 ± 0.073



© PTB, 2026

Summary for the spiked seawater (LRM)

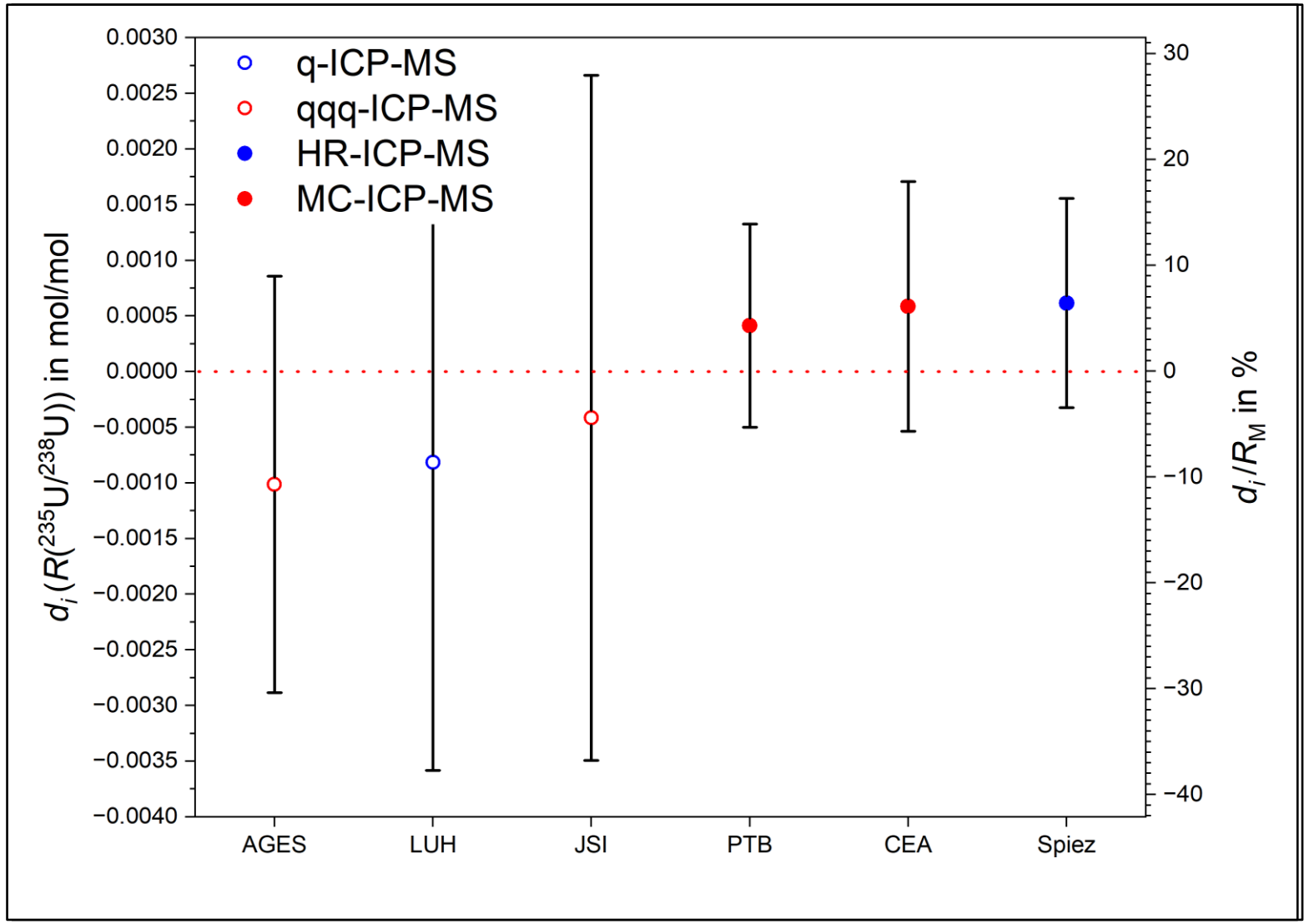
- Sample preparation: easy, lot of submitted values
- MS-instrument: overall good agreement, except for AMS and q-ICP-MS
- Expertise of the institutes



Scan me for the MetroPOEM website

© PTB, 2026

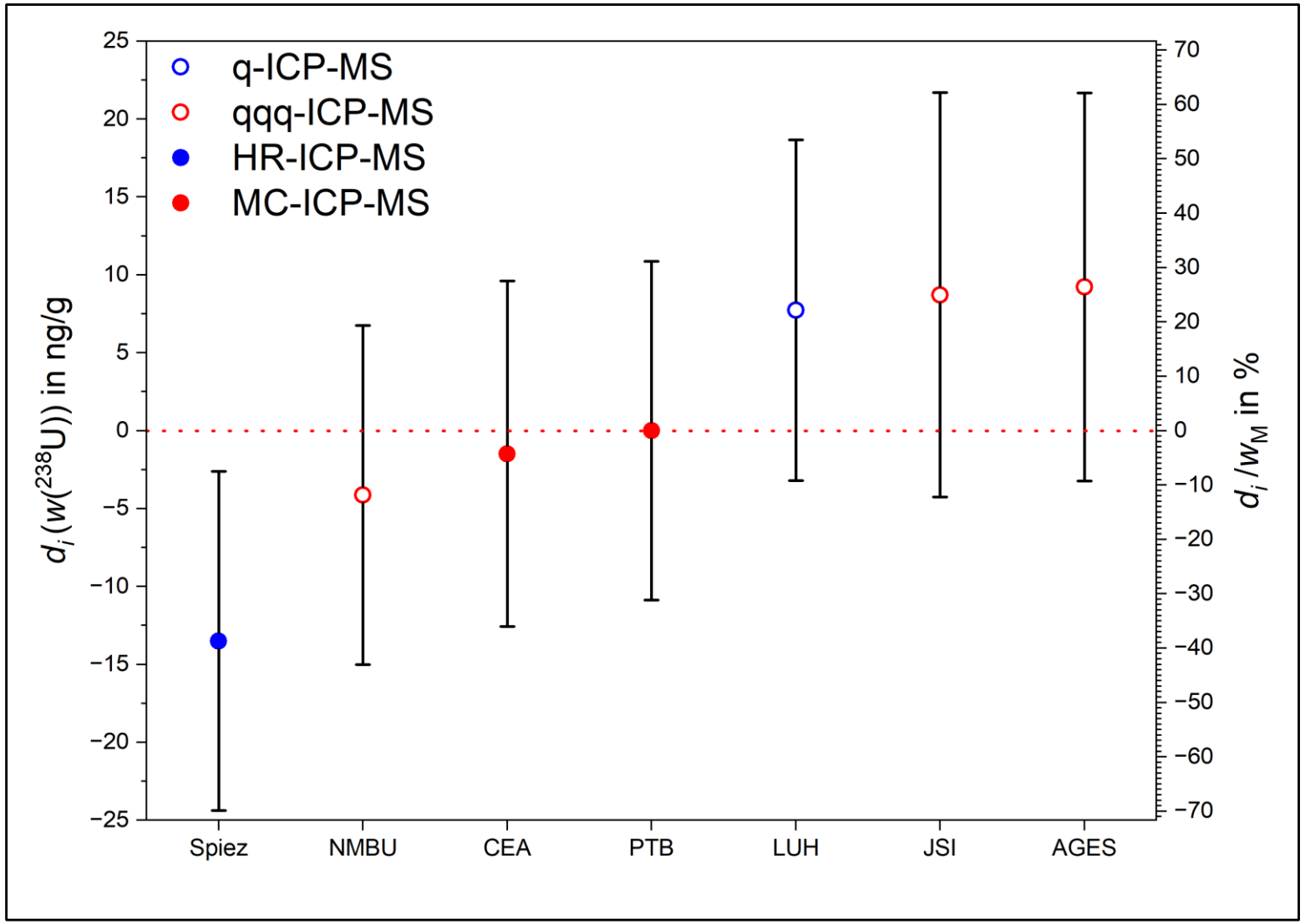
$R(^{235}U/^{238}U)$ in the spiked silicate (SRM)



Mass fraction of ^{238}U in the spiked silicate (SRM)

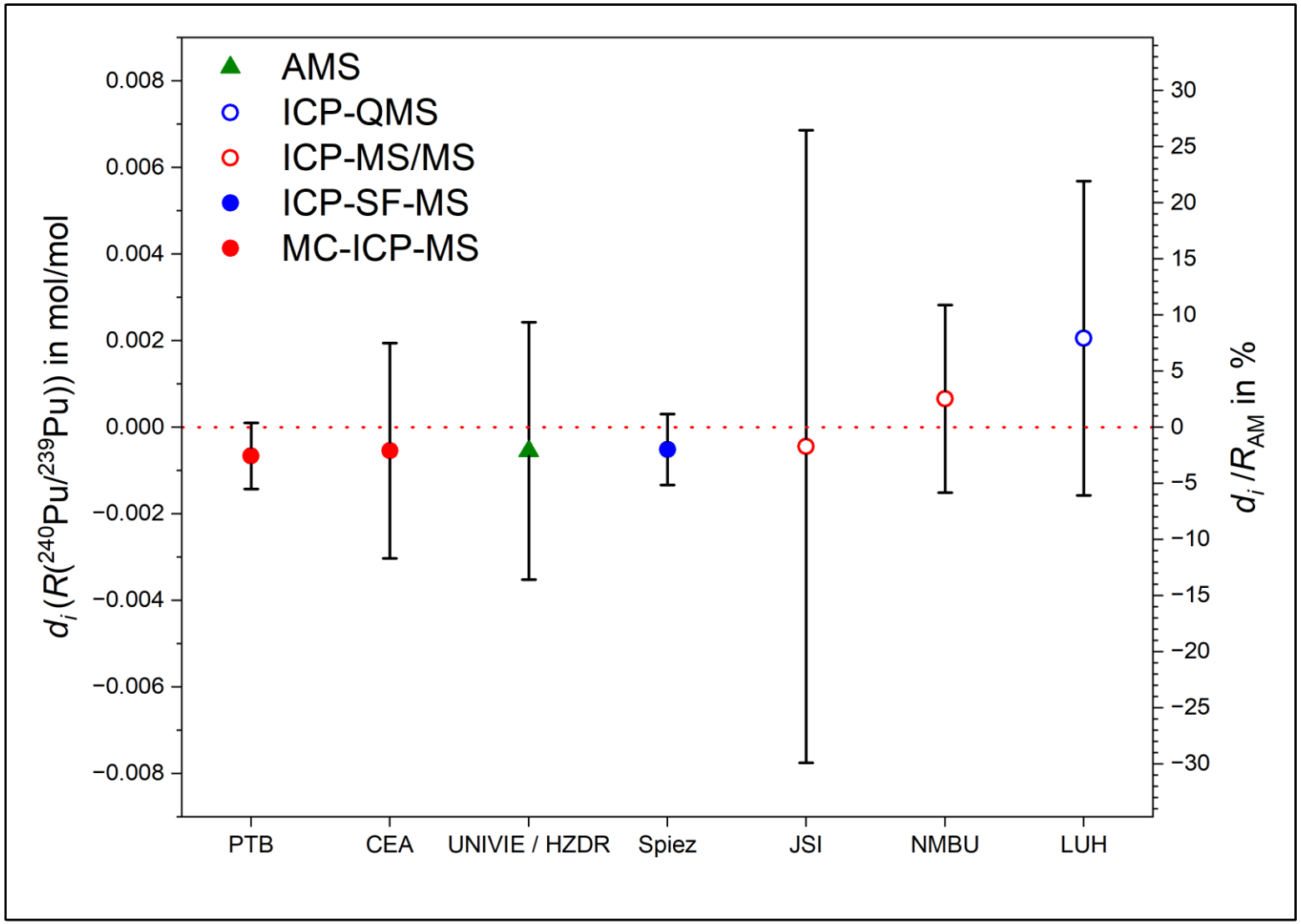
$w(^{238}U)_M$ in ng/g
35 ± 11

$a(^{238}U)$ in mBq/g
0.43 ± 0.14



© PTB, 2026

$R(^{240}Pu/^{239}Pu)$ in the spiked silicate (SRM)

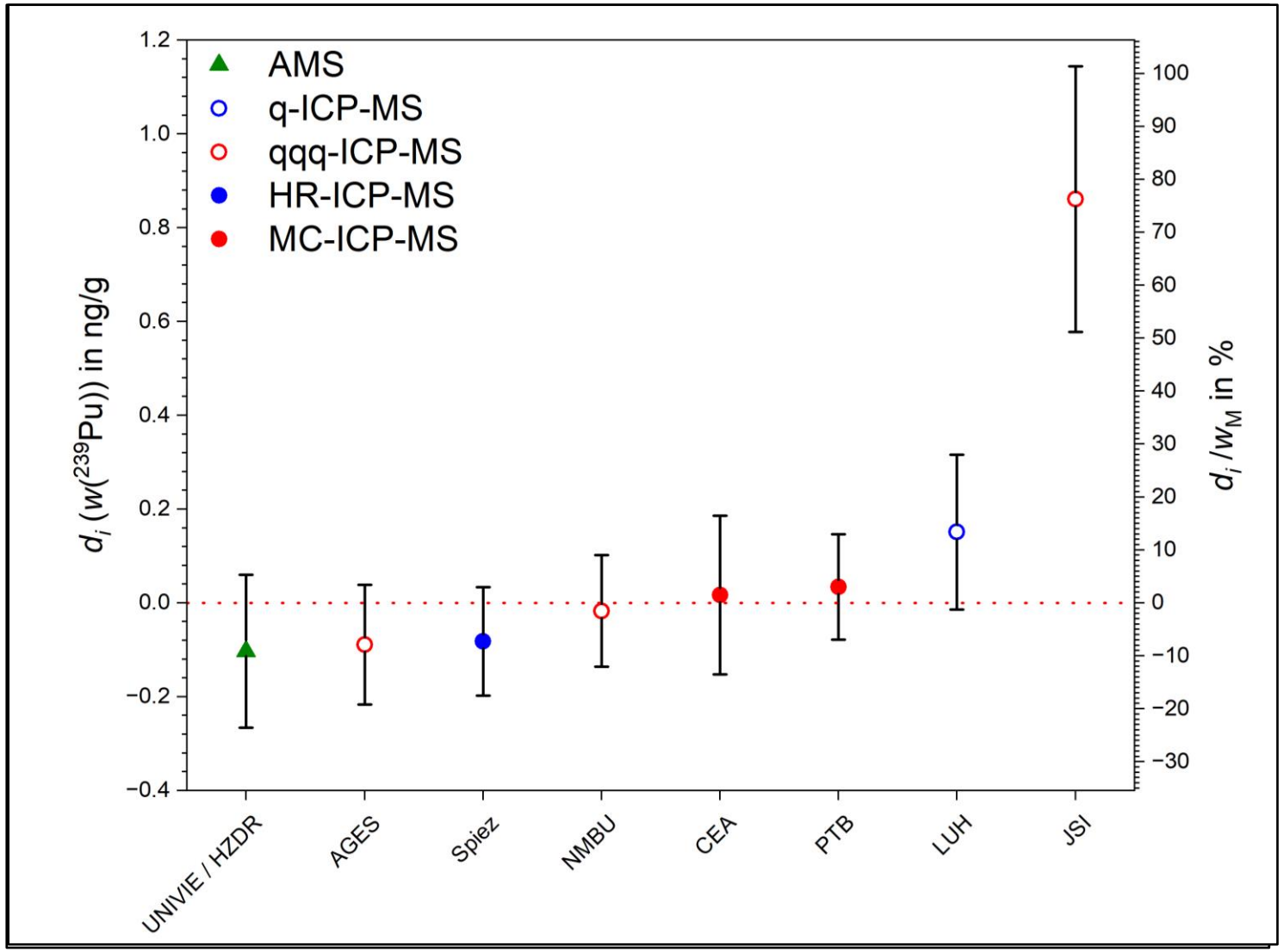


© PTB, 2026

Mass fraction of ^{239}Pu in the spiked silicate (SRM)

$w(^{239}Pu)_M$ in ng/g
1.13 ± 0.11

$a(^{239}Pu)$ in Bq/g
2.59 ± 0.13



© PTB, 2026

Summary spiked silicate (SRM)

- Sample preparation: challenging, not as many submissions
- MS-instrument: agreement better than expected
- Expertise of the institutes



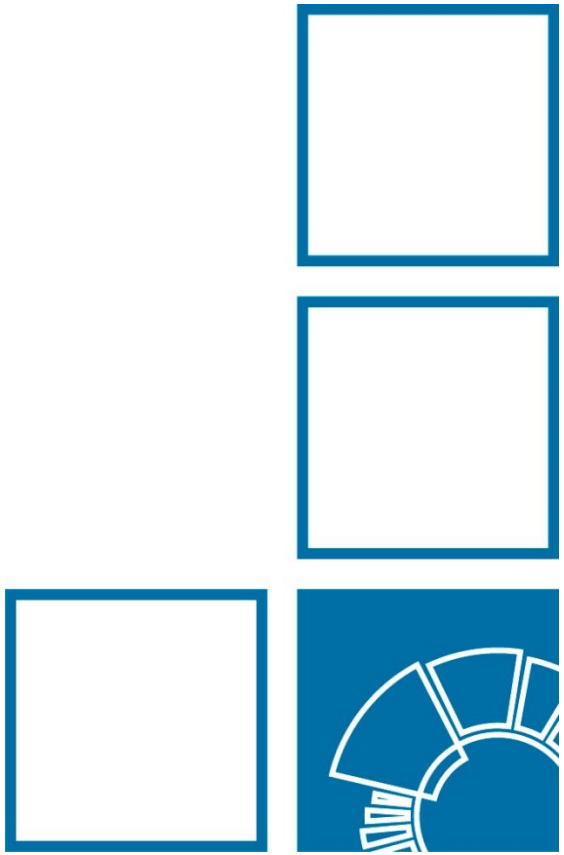
Scan me for the MetroPOEM website

Acknowledgements

“The project 21GRD09 MetroPOEM has received funding from the European Partnership on Metrology, co-financed from the European Union’s Horizon Europe Research and Innovation Programme and by the Participating States.”

- Funder name: European Partnership on Metrology
- Funder ID: 10.13039/100019599
- Grant number: 21GRD09 MetroPOEM

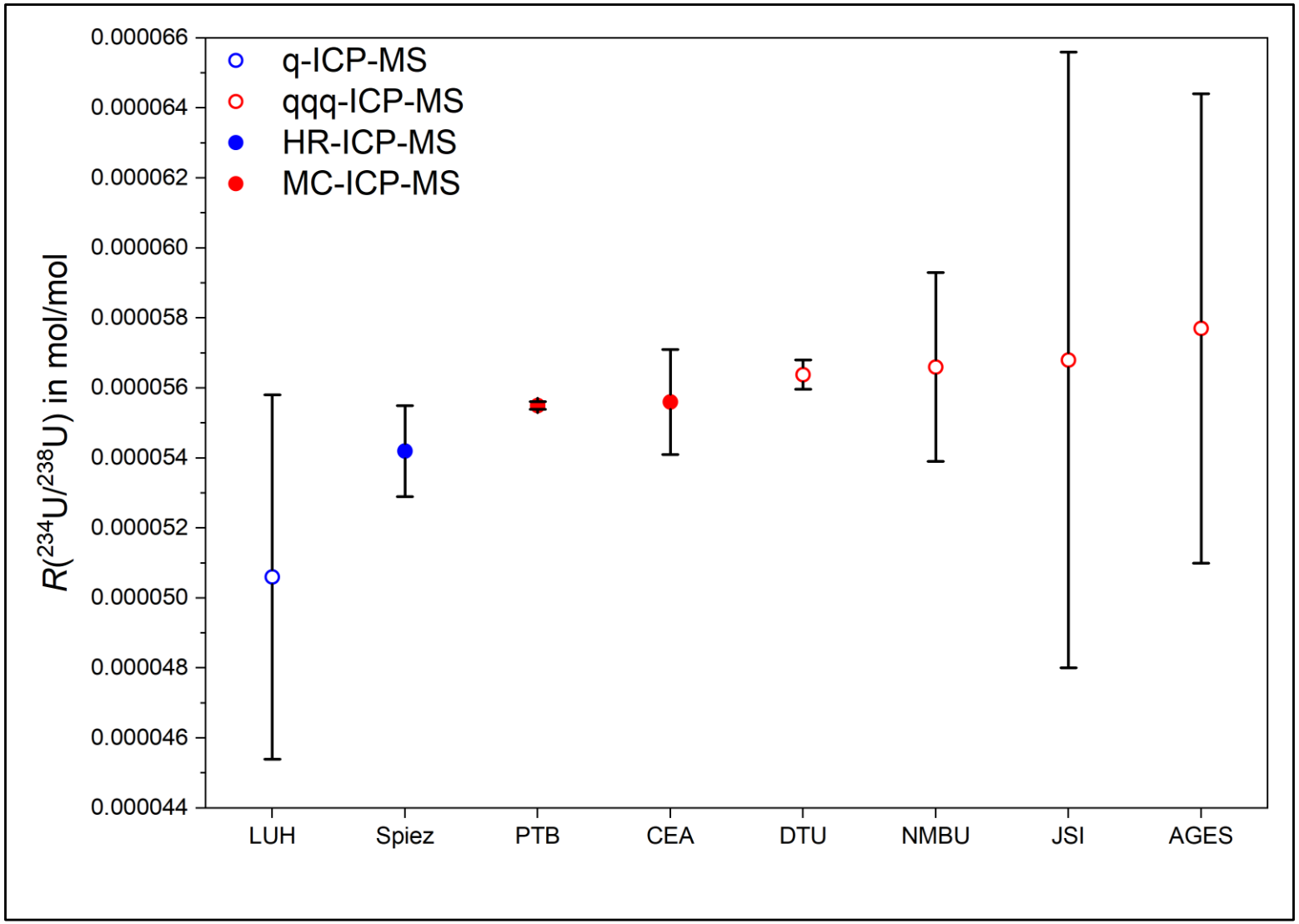
© PTB, 2026



Physikalisch-Technische Bundesanstalt
Braunschweig and Berlin
Bundesallee 100
38116 Braunschweig

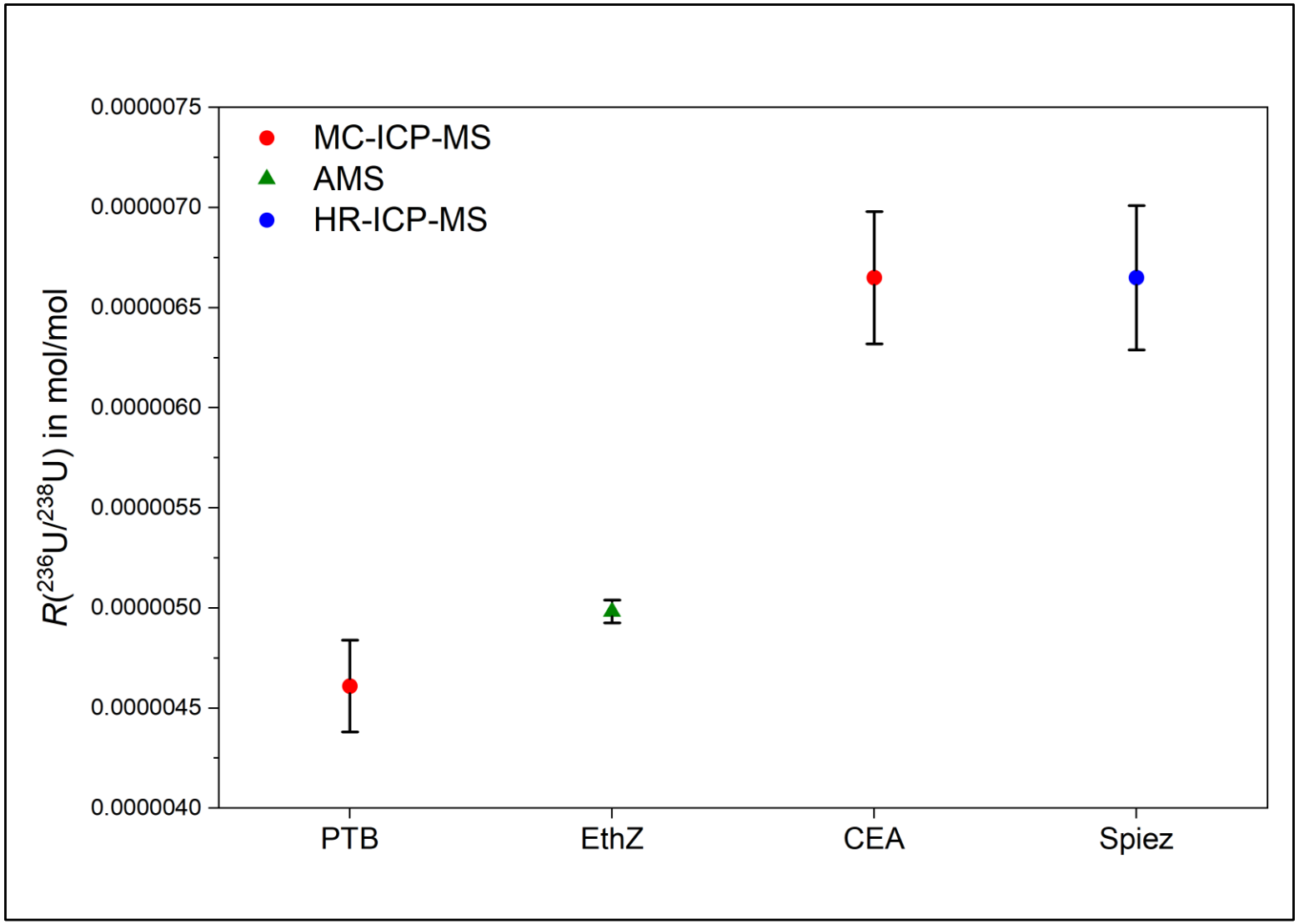
Janine Eberhardt
Phone: +49 531 592 6121
E-Mail: janine.eberhardt@ptb.de
www.ptb.de

$R(^{234}U/^{238}U)$ in the spiked seawater (LRM)

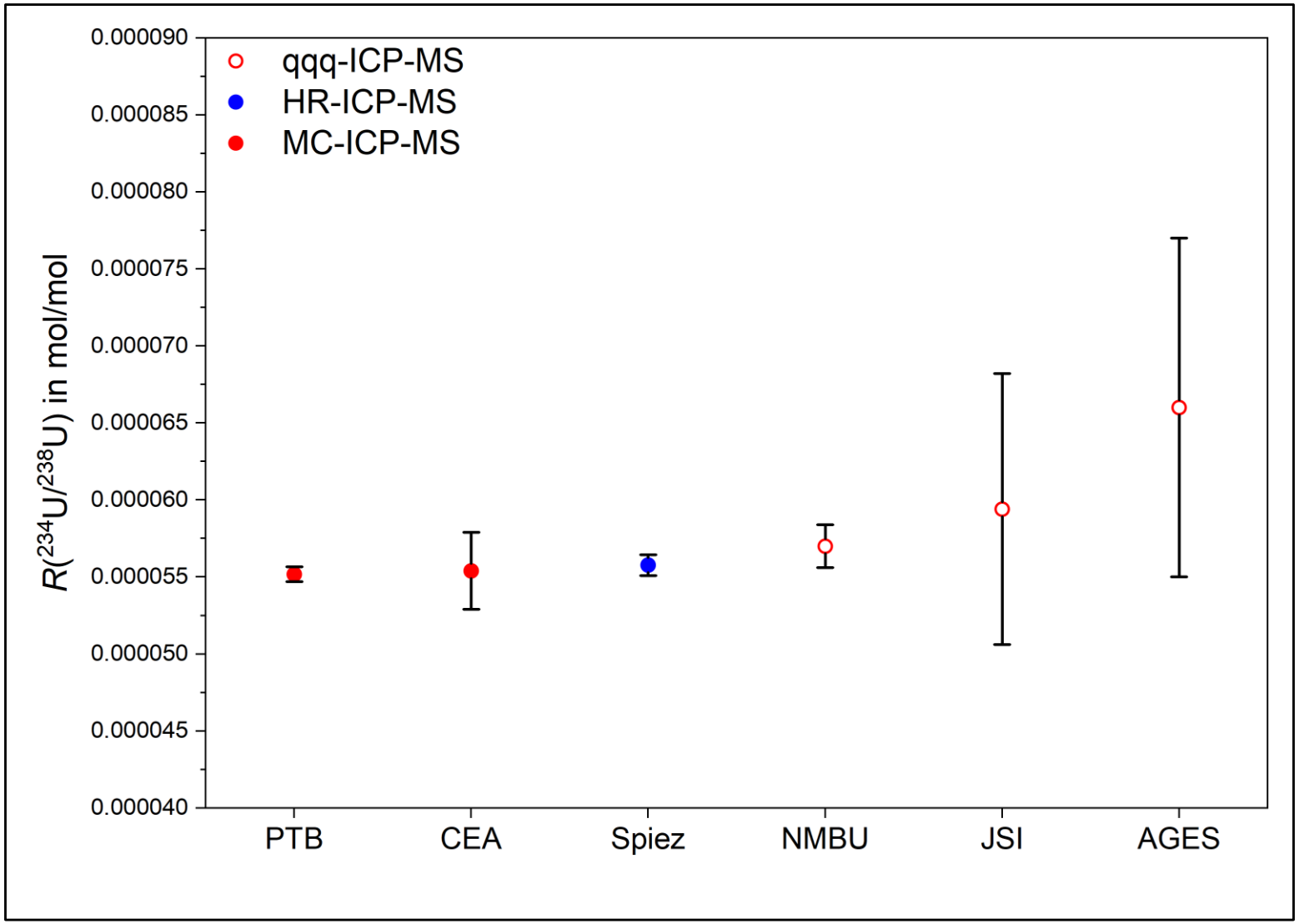


© PTB, 2026

$R(^{236}U/^{238}U)$ in the spiked seawater (LRM)

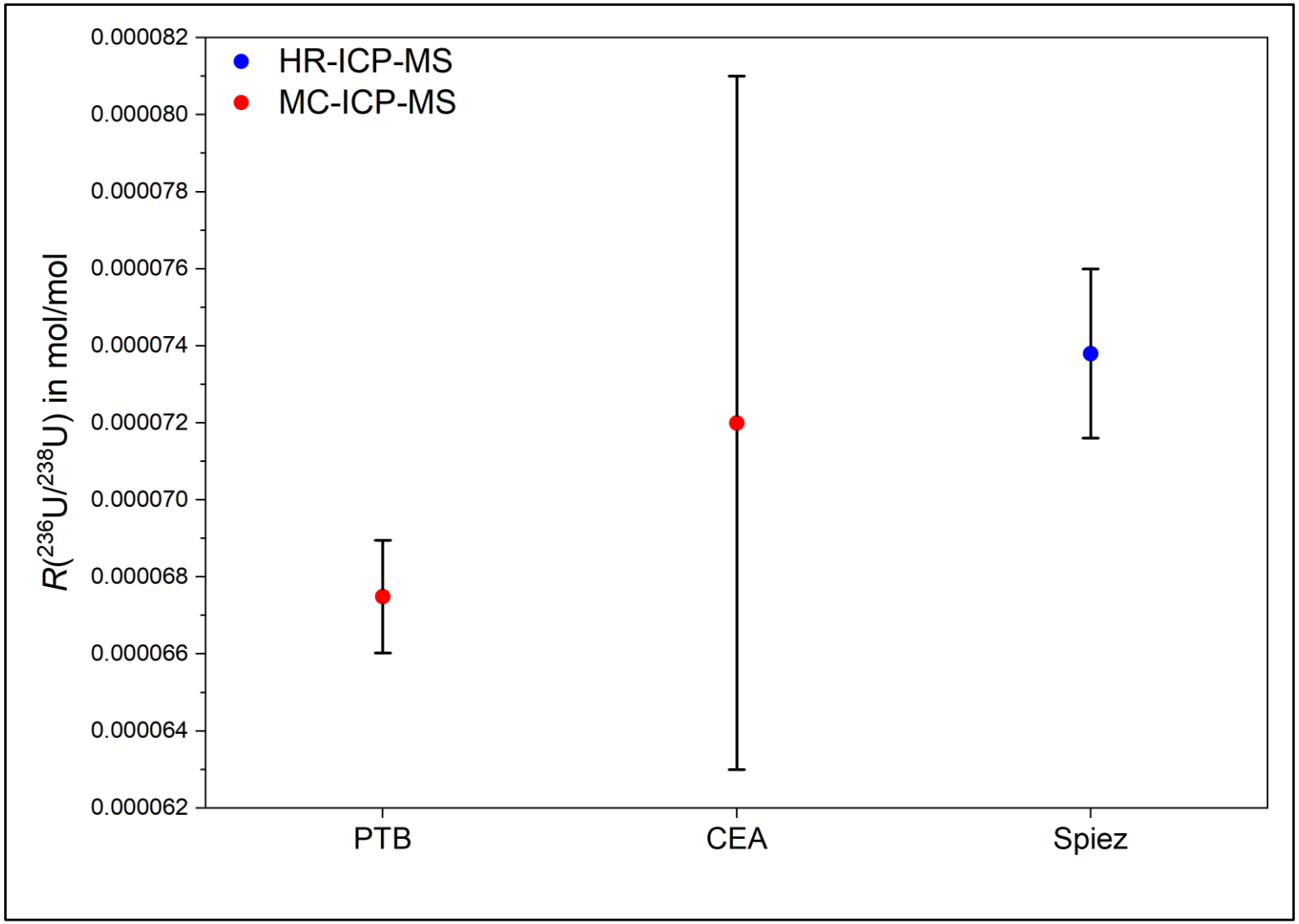


$R(^{234}U/^{238}U)$ in the spiked silicate (SRM)



© PTB, 2026

$R(^{236}U/^{238}U)$ in the spiked silicate (SRM)



© PTB, 2026