中国计量科学研究院
National Institute of Metrology

# Report on CCAUV.V-K3 low frequency vibration comparison

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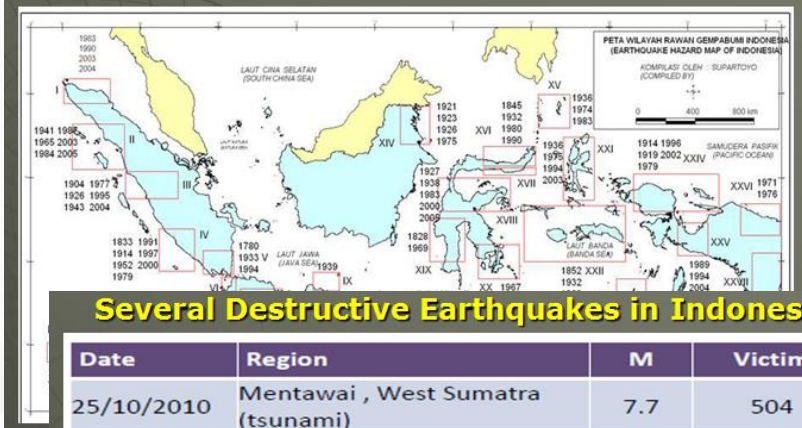
# Contents

- Metrological background of low frequency vibration
- RMO low frequency vibration comparisons
- CCAUV low frequency vibration comparison
- Conclusion

# Metrological Background

## Earthquake Prone Regions in Indonesia




## Eruption of some volcanoes in Indonesia

## Several Destructive Earthquakes in Indonesia

| Date | Region | M | Victim |
|---|---|---|---|
| 25/10/2010 | Mentawai , West Sumatra (tsunami) | 7.7 | 504 |
| 30/9/2009 | Padang, West Sumatra | 7.5 | 1,117 |
| 2/9/2009 | West Java | 7.3 | 81 |
| 12/9/2007 | Bengkulu, Sumatra | 8.4 | 14 |
| 26/5/2006 | Yogyakarta | 6.3 | 5,749 |
| 28/3/2005 | Nias, North Sumatra (tsunami) | 8.6 | 1,313 |
| 06/02/2004 | Nabire, Papua | 7 | 33 |
| 26/12/2004 | Aceh, Sumatera (tsunami) | 9.1 | 227,898 |
| 04/06/2000 | Bengkulu, Sumatra | 7.3 | 99 |
| 29/11/1998 | Mangole & Taliabu, Maluku | 8.3 | 34 |
| 17/02/1996 | Biak, Papua (tsunami) | 8.2 | 108 |

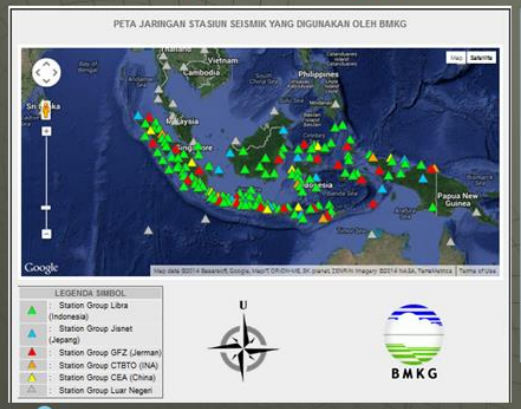
Research Centre for Calibration, Instrumentation and Metrology (KIM-LIPI). Indonesian Institute of Sciences

LIPI

## Indonesian Seismic Monitoring Infrastructure

**Indonesia Tsunami Early Warning System (InaTEWS)**

https://inatews.bmkg.go.id/new/meta_eq.php




**Station Group:**

- Libra (INA): 108
- JISNET (JPN): 17
- GFZ (Germany): 21
- CTBTO (INA): 6
- CEA (China): 11

Research Centre for Calibration, Instrumentation and Metrology (KIM-LIPI). Indonesian Institute of Sciences

LIPI

Source: APMP TCAUV DEC Workshop 2014
by Mr. Suwandi. A, KIM-LIPI

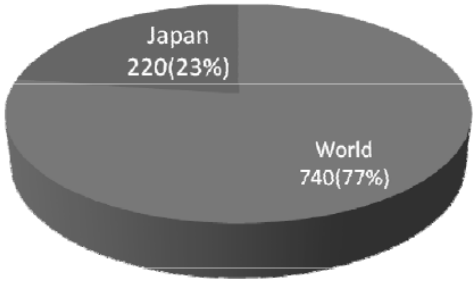
# Metrological Background

APMP TCAUV DEC Workshop(2014)

## Situation of earthquake occurrence

- Occurrence of earthquake in Japan

About 20% of the earthquakes in the world have occurred in and around Japan
(Cabinet Office, Government of Japan document)



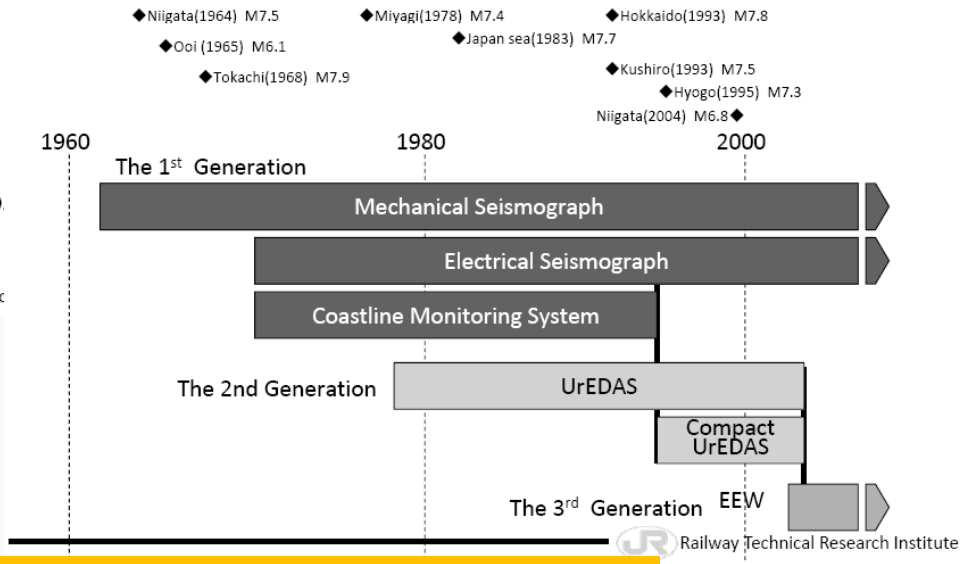

Number of earthquake of magnitude 6.0 or more (199

Railway Tec


APMP TCAUV DEC Workshop(2014)

## History of development of seismograph

- History of development of seismograph for Shinkansen

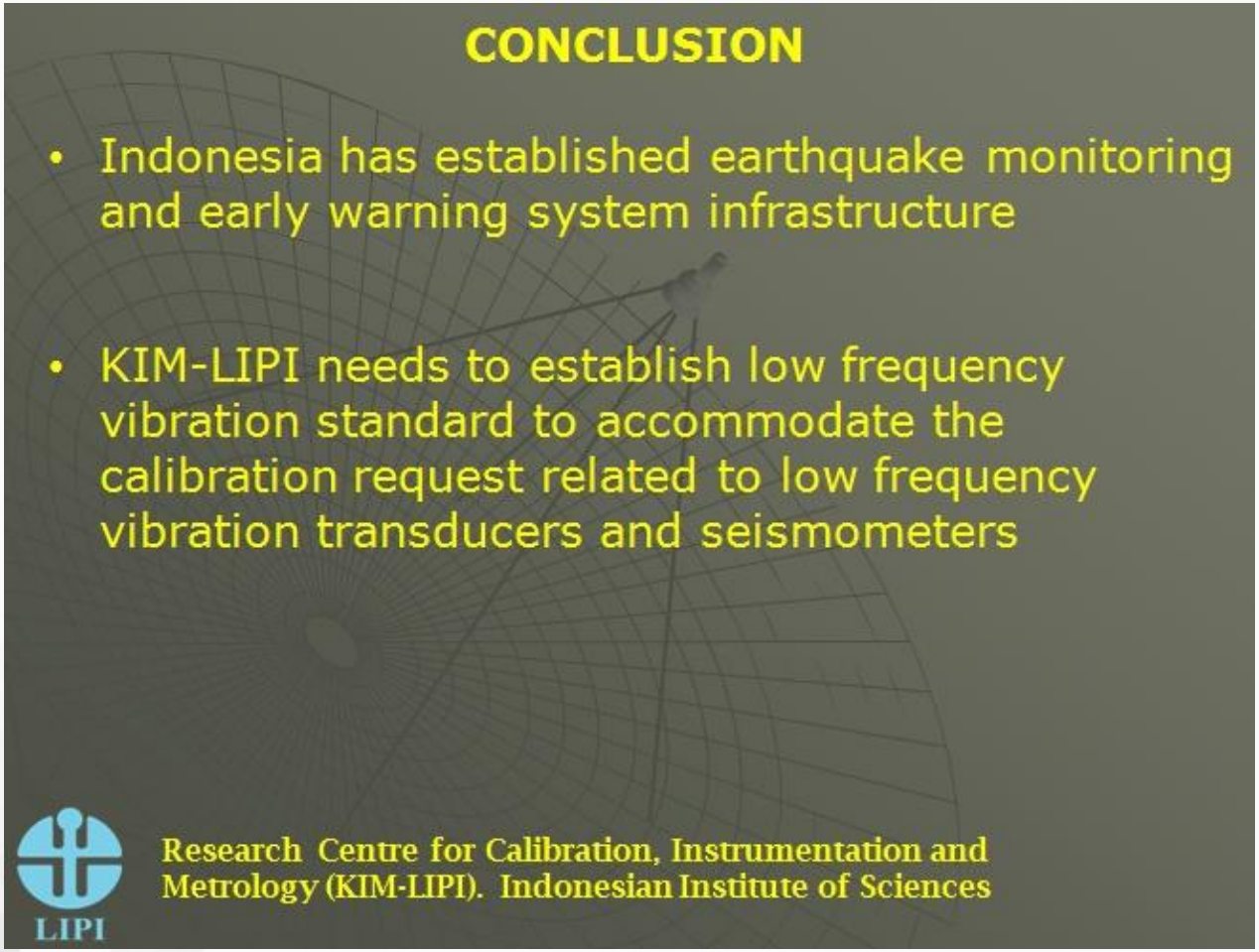



Source: APMP TCAUV DEC Workshop 2014
by Mr. Shinji SATO, Railway Technical Research Institute, Japan

# Metrological Background


Source: APMP TCAUV DEC Workshop 2014
On-site visit, Thailand

# Metrological Background




Source: APMP TCAUV DEC Workshop 2014
by Mr. Suwandi. A, KIM-LIPI

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# RMO comparisons

**Supplementary comparison in 3 RMOs (18 Participants)**

AFRIMETS

AFRIMETS.AUV.V-S2 — 2 participants — (0.4 to 50) Hz

*2010 to 2011*

APMP

APMP.AUV.V-S1 — 7 participants — (0.5 to 20) Hz

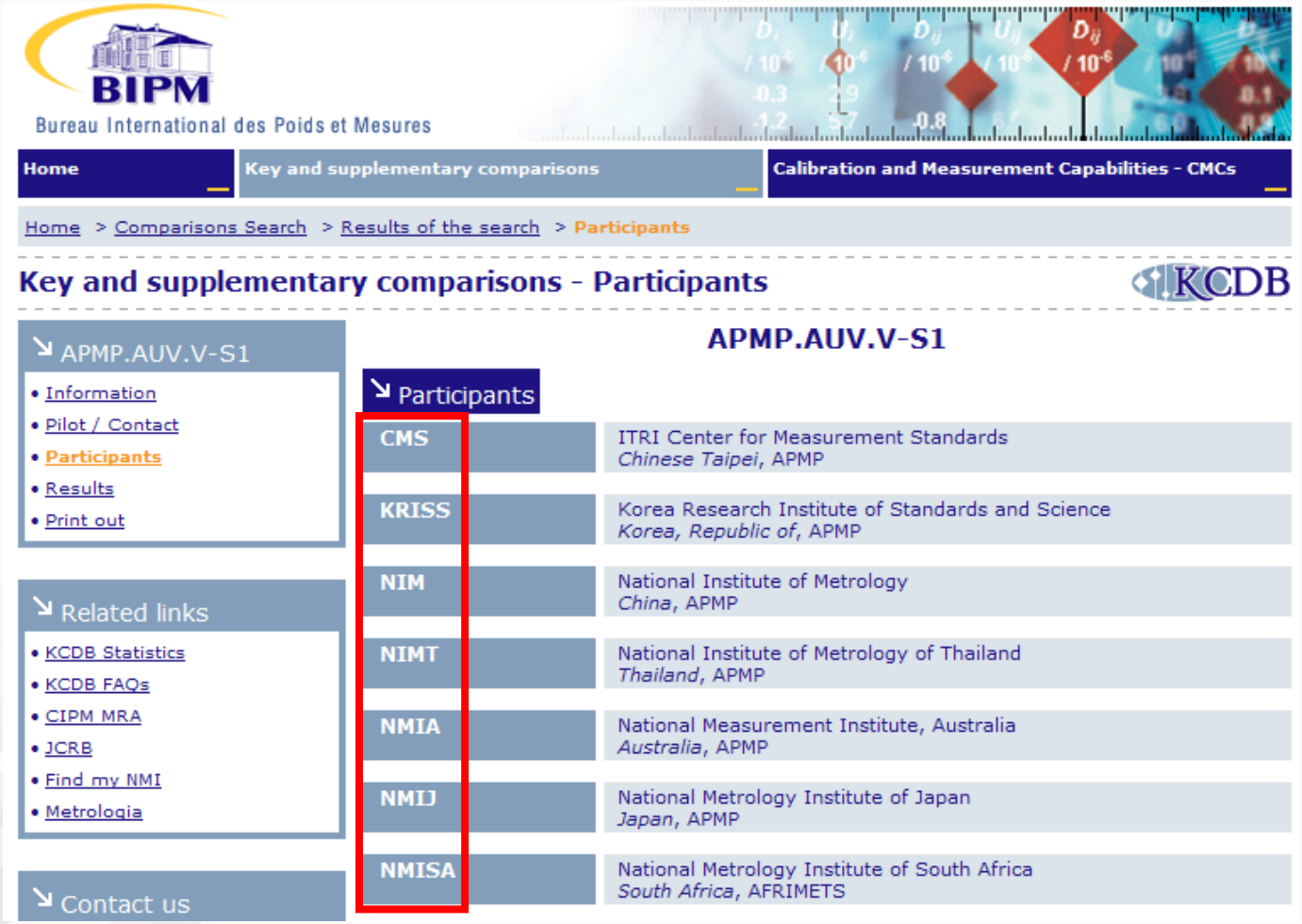
*2011 to 2012*

EURAMET

EURAMET.AUV.V-S1 — 10 participants — (1 to 80) Hz

*2012 to 2013*

# RMO comparisons

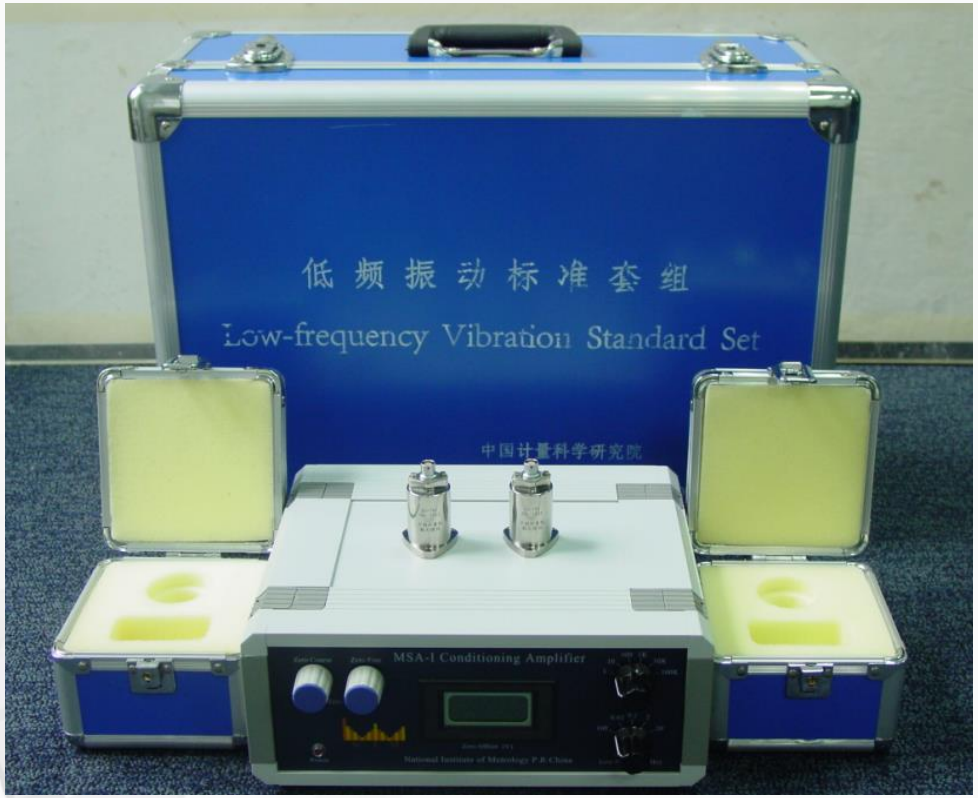


# RMO comparisons

- Monitoring measurements performed *2010-2011*


# RMO comparisons

- Comparison measurements carried out *2011-2012*





Comparison transfer standards (Gw10kg)

# RMO comparisons



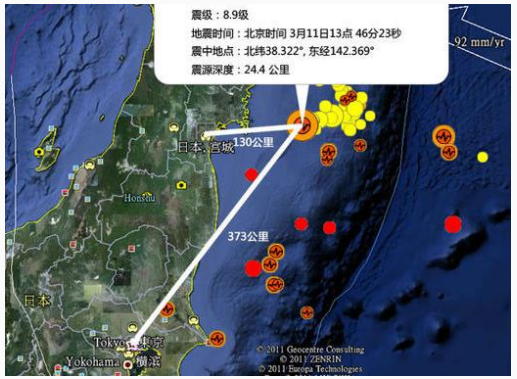


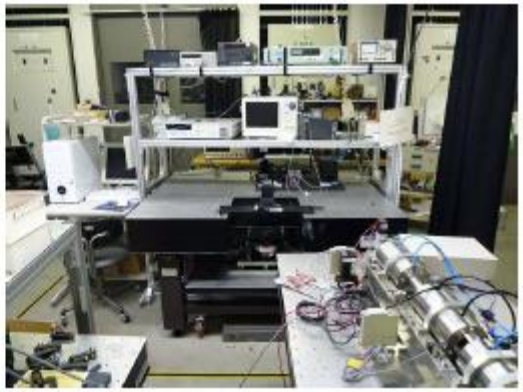
***Planned in 2011***

# RMO comparisons

Connecting Hallway between buildings

Vibration and Hardness section office (5th floor)



Experimental room for vibration standard (ground floor)

Source: Report of NMIJ to the 11th APMP TCAUV 2011
by Dr. T. KIKUCHI

# RMO comparisons

***rearranged***

# RMO comparisons

## Self-developed systems

*Horizontal* *(0.1 - 20) Hz*

NIM

*Vertical* *(0.1 - 20) Hz*

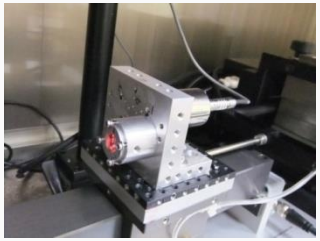
*Horizontal* *(0.5 - 2) Hz*


*Vertical* *(>2 - 20) Hz*

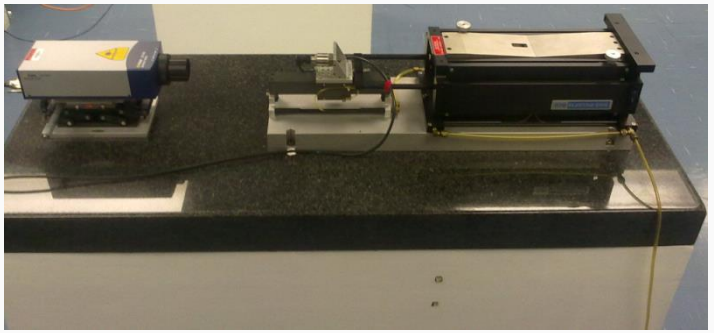
NMIJ

# RMO comparisons

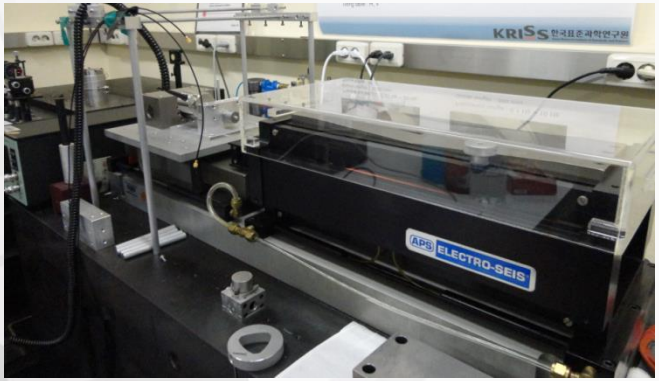
- Commercial systems



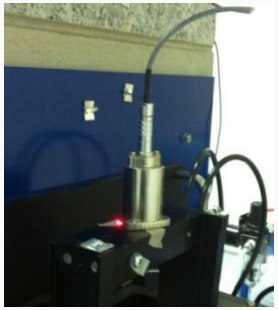
CMS *Horizontal (0.5 - 20) Hz*



NMISA *Horizontal (0.5 - 20) Hz*



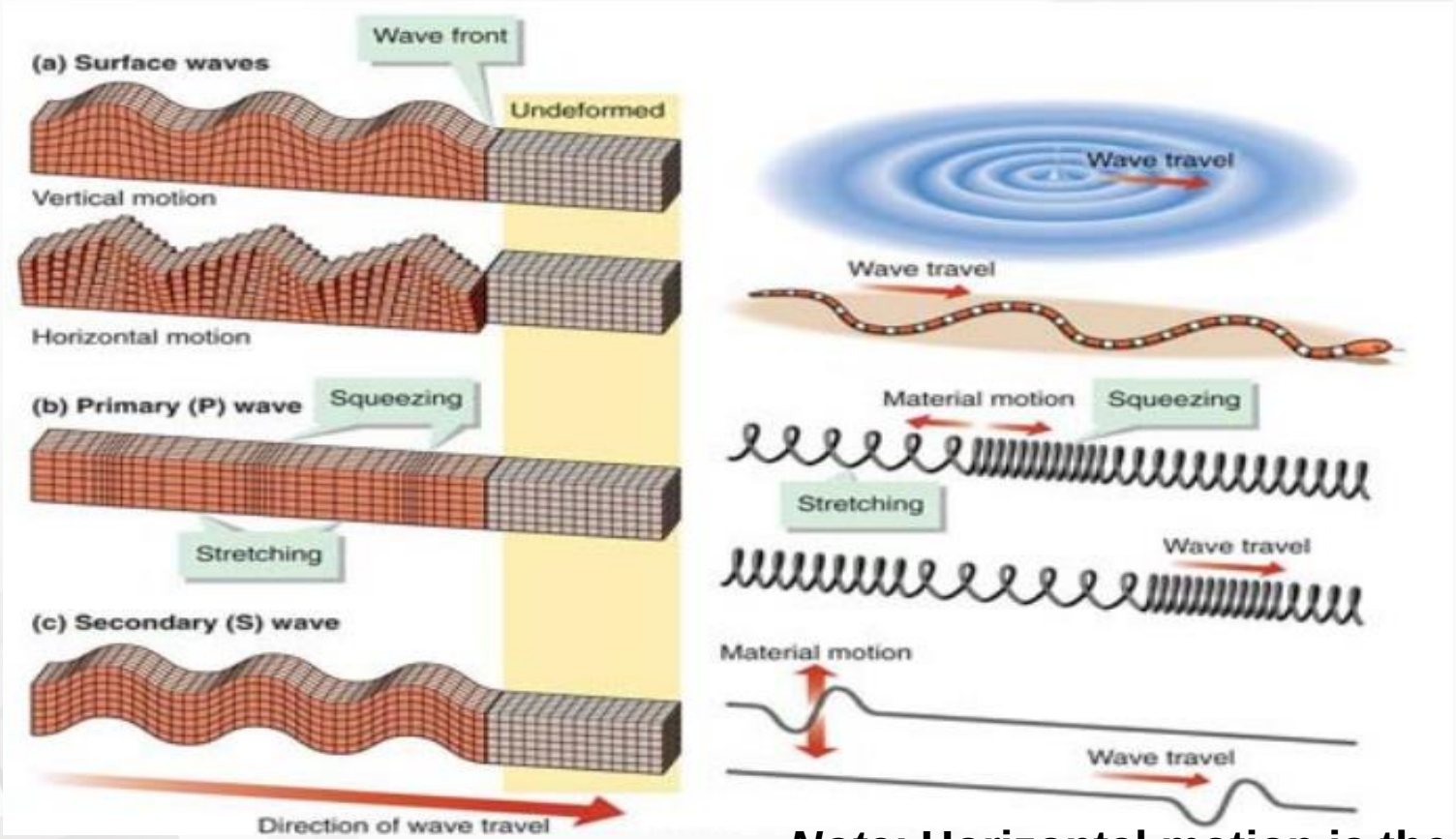

KRISS *Horizontal (0.5 - 20) Hz*



NIMT *Vertical (0.5 - 20) Hz*

# RMO comparisons

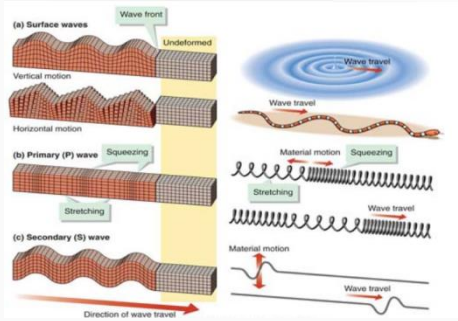
## Installation direction




***Note:*** **Horizontal motion is the main cause of building destruction.**

# RMO comparisons

## Installation direction


***Note:*** **Sensors are tri-axis, but horizontal X and Y axis are very important directions.**


# Contents

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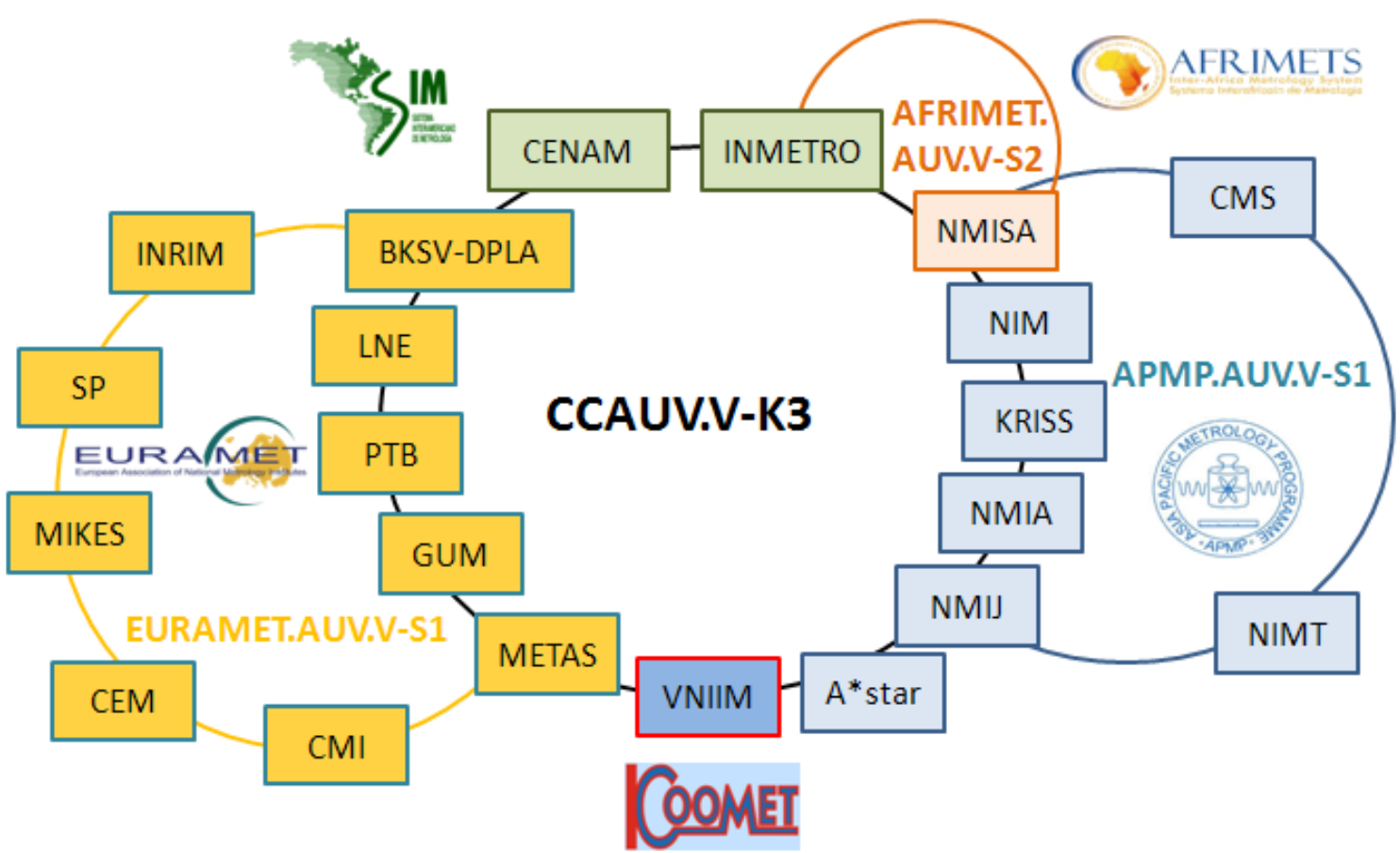
# CCAUV comparison

## Participants List

| No. | NMIs | low limit | Direction |
|---|---|---|---|
| 1 | NMISA | 0.4 | Horizontal |
| 2 | KRISS | 0.1 | Horizontal |
| 3 | NIM | 0.1 | Horizontal |
| 4 | NMIJ | 0.1 | Horizontal |
| 5 | BKSV-DPLA | 0.1 | Horizontal |
| 6 | NMIA | 0.1 | Horizontal |
| 7 | LNE | 0.4 | Horizontal |
| 8 | METAS | 0.4 | Horizontal |
| 9 | PTB | 0.4 | Horizontal |
| 10 | INMETRO | 0.4 | Horizontal |
| 11 | CENAM | 0.1 | Horizontal |
| 12 | A*STAR | 0.1 | Horizontal |
| 13 | VNIIM | 0.1 | Horizontal |
| 14 | GUM | 0.4 | Horizontal |

# CCAUV comparison

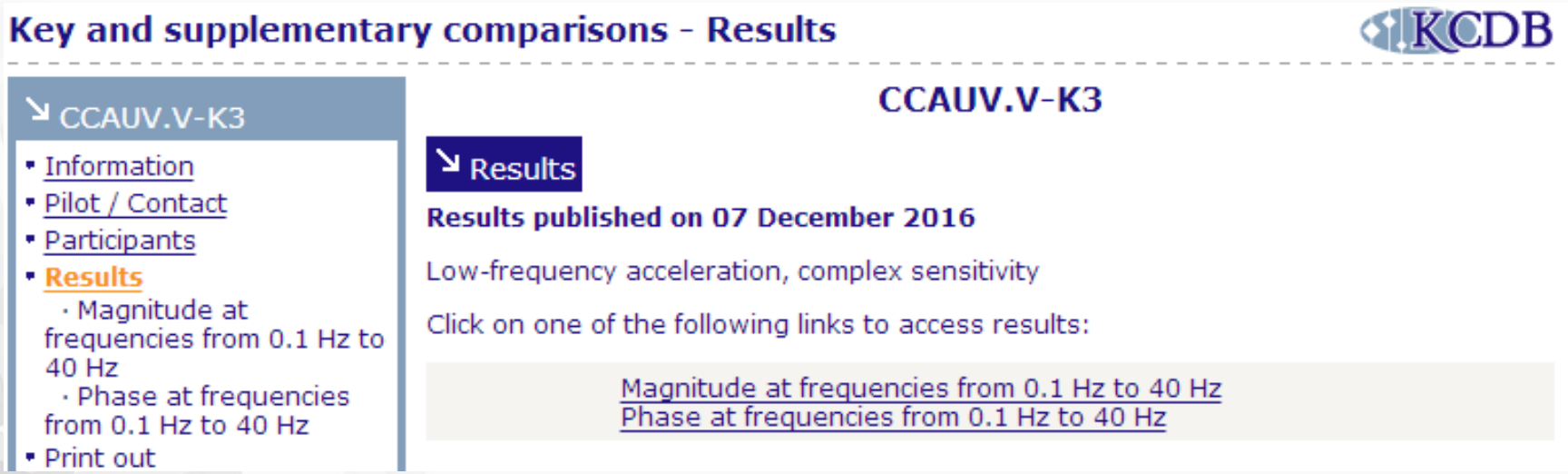


# CCAUV comparison

**CCAUV.V-K3** 2013-2015 *time of measurement*

BKSV-DPLA , CENAM, GUM, INMETRO, KRISS, LNE, METAS, NIM, NMC, NMIA, NMIJ, NMISA, PTB and VNIIM (14).

**Approved for equivalence, Results available**



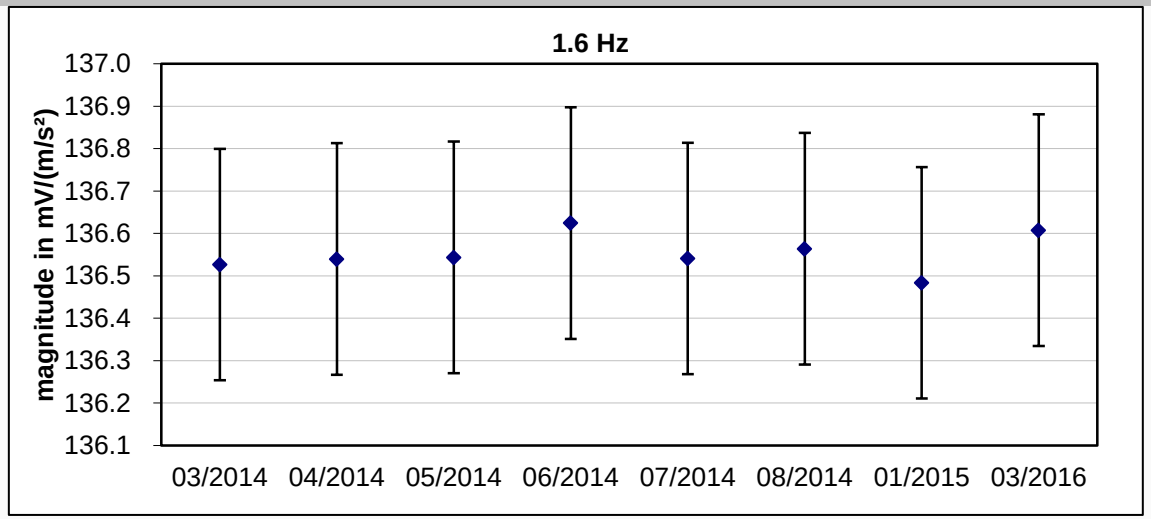

*Metrologia*, 2017, 54, *Tech. Suppl.*, 09001

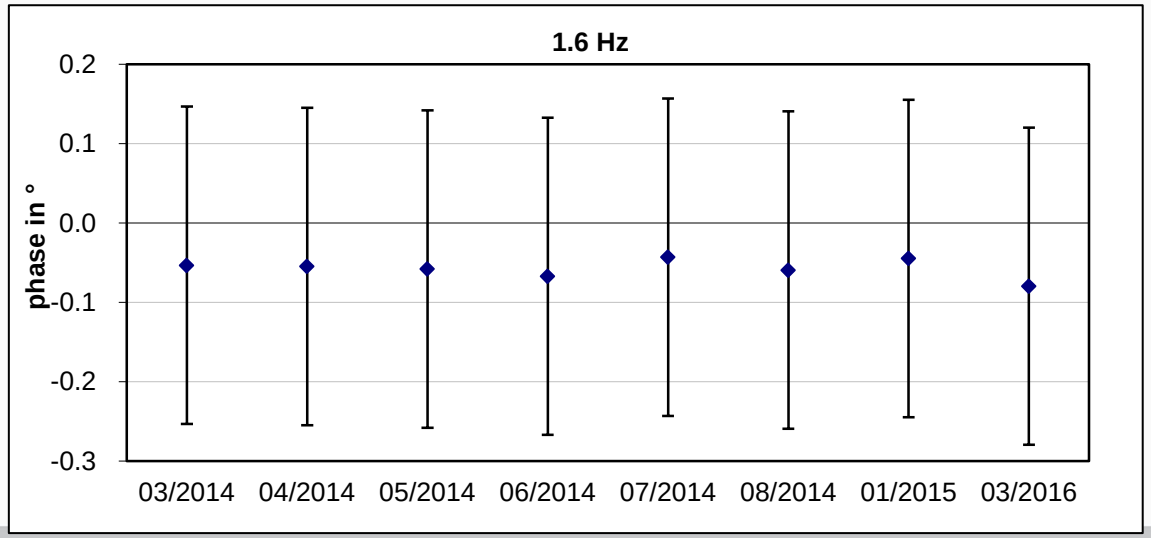
# CCAUV comparison

**Key comparison CCAUV.V-K3**

**DEVICE : Low-frequency vibration comparison transfer standard**
**MEASURAND : Acceleration complex sensitivity covering magnitude and phase**
**FREQUENCIES : 0.1 Hz, 0.125 Hz, 0.16 Hz, 0.2 Hz, 0.25 Hz, 0.315 Hz, 0.4 Hz, 0.5 Hz, 0.63 Hz, 0.8 Hz, 1 Hz, 1.25 Hz, 1.60 Hz, 2 Hz, 2.5 Hz, 3.15 Hz, 4 Hz, 5 Hz, 6.3 Hz, 8 Hz, 10 Hz, 12.5 Hz, 16 Hz, 20 Hz, 25 Hz, 31.5 Hz, 40 Hz**

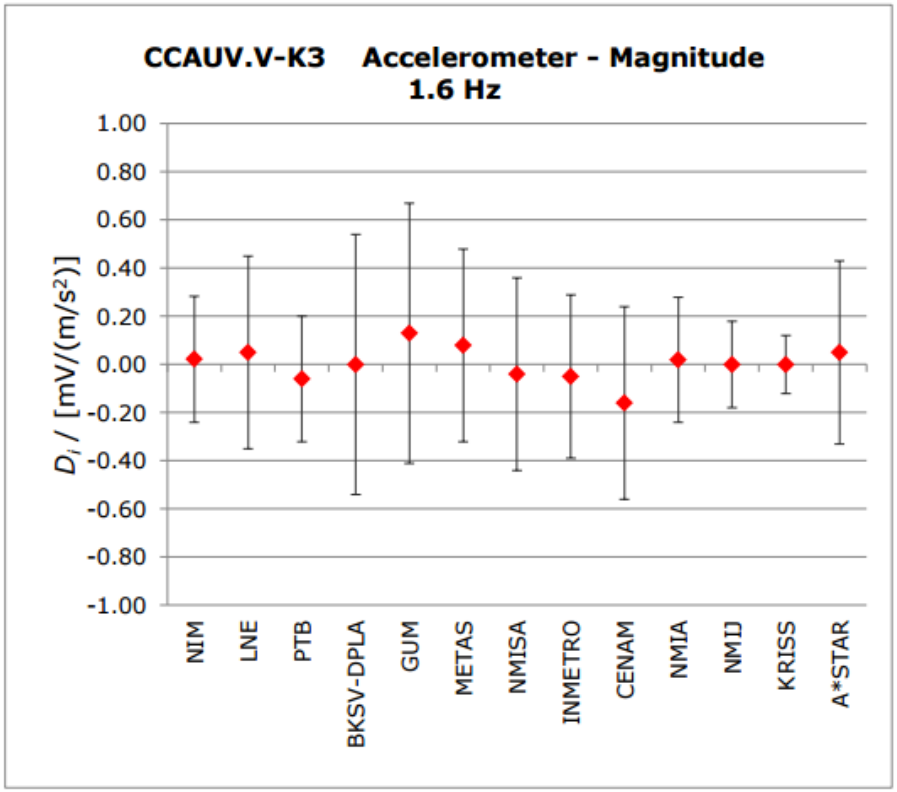
# CCAUV comparison

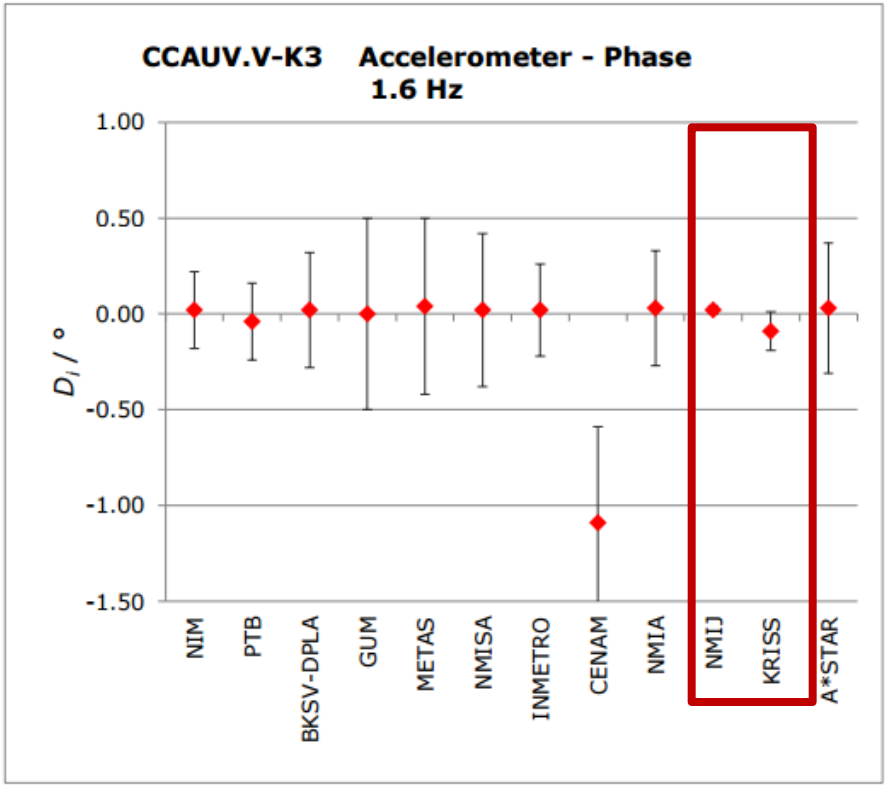



# CCAUV comparison

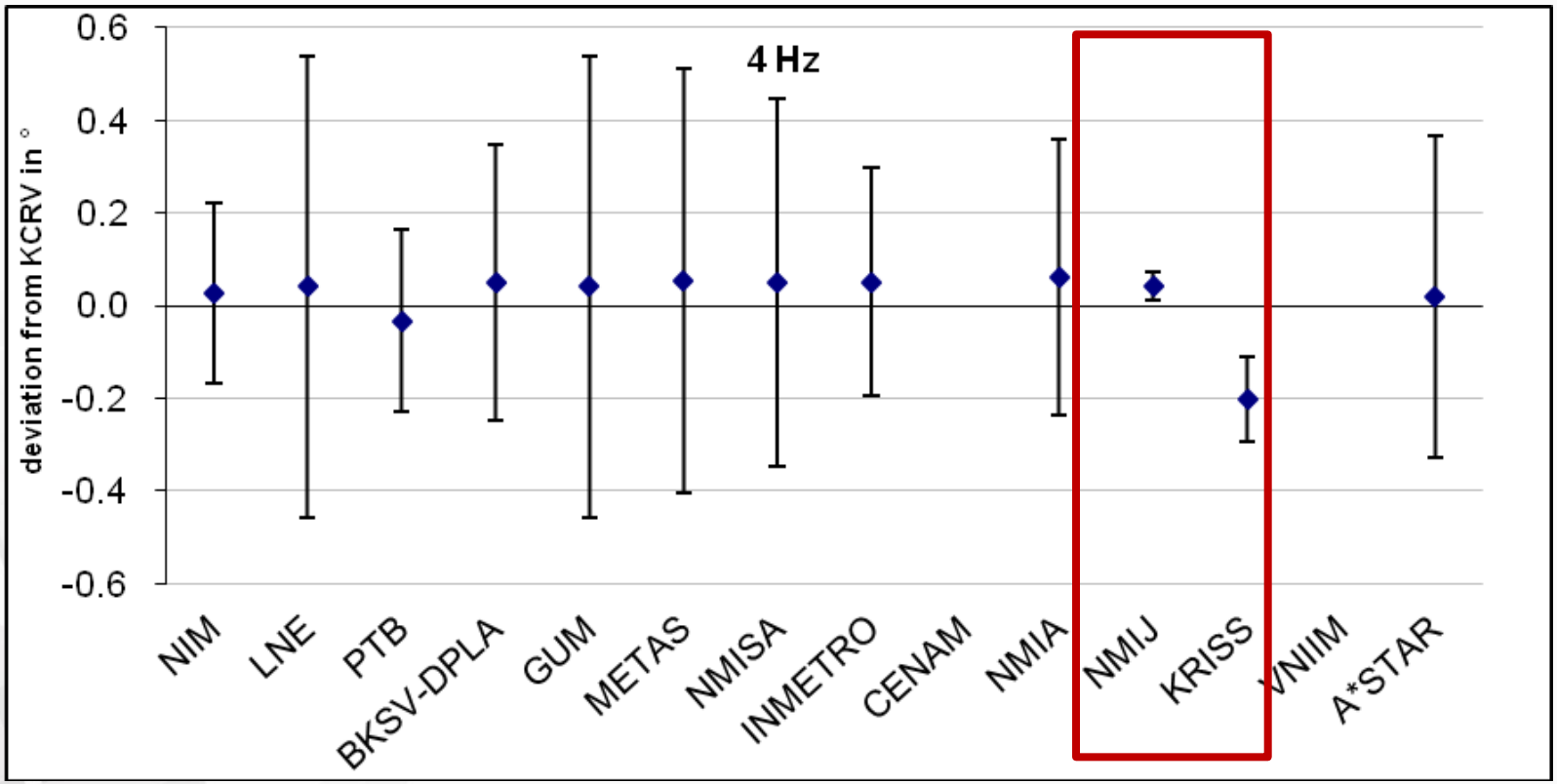
## Comparison results



# CCAUV comparison

## Comparison results



# Contents

# Conclusion

- The first low-frequency CIPM key comparison CCAUV.V-K3 in vibration revealed the current calibration capabilities of the 14 participants of 5 RMOs. 13 participating laboratories provided their calibration results, which were mostly consistent within their declared expanded uncertainties.
- For magnitude results, only 2 participants failed to contribute to the KCRV values calculated for 5 frequencies out of a total of 27 comparison frequencies.
- For phase shift, 3 participants could not contribute to the calculation of the KCRV values in a total of 16 frequencies. Better understanding of their calibration devices and more reasonable evaluation of their calibration uncertainties will provide more accurate and reliable measurement results in the future.

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# Thank you for your attention!

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