



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

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National Insitute of Metrology, China

2017-09-20

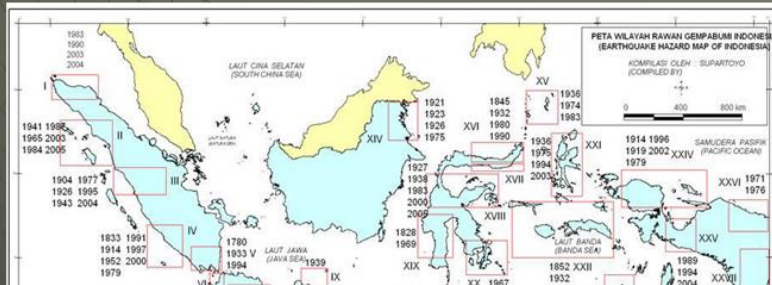
# Contents

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

# Metrological Background

## Earthquake Prone Regions in Indonesia



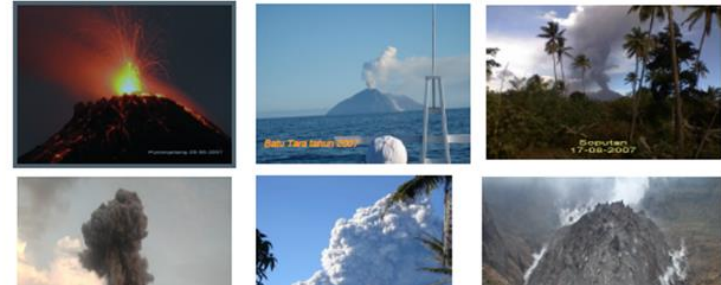
## Several Destructive Earthquakes in Indonesia

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

## Eruption of some volcanoes in Indonesia



## Indonesian Seismic Monitoring Infrastructure

Indonesia Tsunami Early Warning System (InaTEWS)  
[https://inatews.bmkg.go.id/new/meta\\_eq.php](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

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



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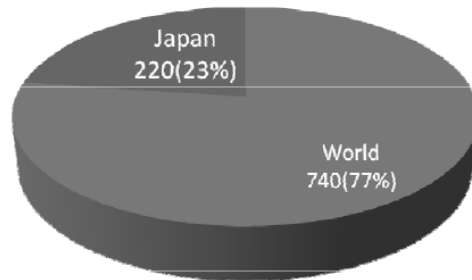
# Metrological Background

## Situation of earthquake occurrence

APMP TCAUV DEC Workshop(2014)

- 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 (1999)

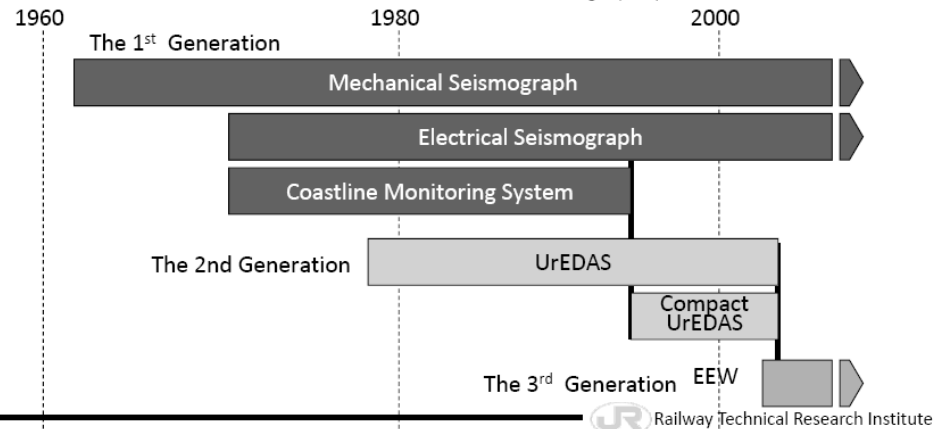


APMP TCAUV DEC Workshop(2014)

## History of development of seismograph

- History of development of seismograph for Shinkansen

- ◆ Niigata(1964) M7.5
- ◆ Ooi (1965) M6.1
- ◆ Tokachi(1968) M7.9
- ◆ Miyagi(1978) M7.4
- ◆ Japan sea(1983) M7.7
- ◆ Hokkaido(1993) M7.8
- ◆ Kushiro(1993) M7.5
- ◆ Hyogo(1995) M7.3
- ◆ Niigata(2004) M6.8



JR Railway Technical Research Institute

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



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# Metrological Background



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

# Metrological Background

## CONCLUSION

- Indonesia has established earthquake monitoring and early warning system infrastructure
- KIM-LIPI needs to establish low frequency vibration standard to accommodate the calibration request related to low frequency vibration transducers and seismometers



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

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.AUV.V-S2**      2 participants    (0.4 to 50) Hz  
*2010 to 2011*



 **APMP.AUV.V-S1**      7 participants    (0.5 to 20) Hz  
*2011 to 2012*



 **EURAMET.AUV.V-S1**      10 participants    (1 to 80) Hz  
*2012 to 2013*



# RMO comparisons




BIPM  
Bureau International des Poids et Mesures

Home    Key and supplementary comparisons    Calibration and Measurement Capabilities - CMCs

Home > Comparisons Search > Results of the search > Participants

## Key and supplementary comparisons - Participants



### APMP.AUV.V-S1

- [Information](#)
- [Pilot / Contact](#)
- [Participants](#)
- [Results](#)
- [Print out](#)

### APMP.AUV.V-S1

#### Participants

CMS	ITRI Center for Measurement Standards <i>Chinese Taipei, APMP</i>
KRISS	Korea Research Institute of Standards and Science <i>Korea, Republic of, APMP</i>
NIM	National Institute of Metrology <i>China, APMP</i>
NIMT	National Institute of Metrology of Thailand <i>Thailand, APMP</i>
NMIA	National Measurement Institute, Australia <i>Australia, APMP</i>
NMIJ	National Metrology Institute of Japan <i>Japan, APMP</i>
NMISA	National Metrology Institute of South Africa <i>South Africa, AFRIMETS</i>

#### Related links

- [KCDB Statistics](#)
- [KCDB FAQs](#)
- [CIPM MRA](#)
- [JCRB](#)
- [Find my NMI](#)
- [Metrologia](#)

#### Contact us



# RMO comparisons



Monitoring measurements performed 2010-2011



# RMO comparisons

☀ Comparison measurements carried out 2011-2012



Comparison transfer standards (Gw10kg)

m s K cd  
kg mol A



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# RMO comparisons



*Planned  
in 2011*

m s K cd  
kg mol A



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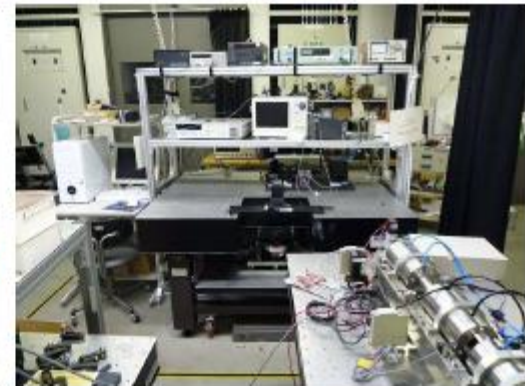
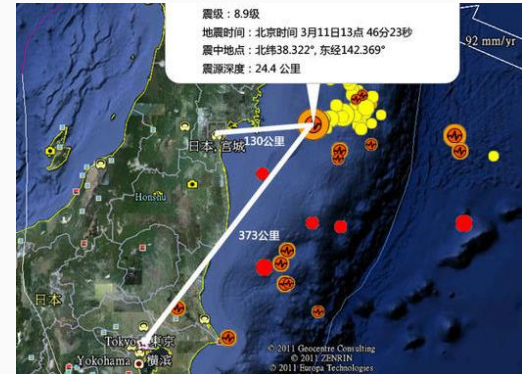
# RMO comparisons



Connecting Hallway  
between buildings



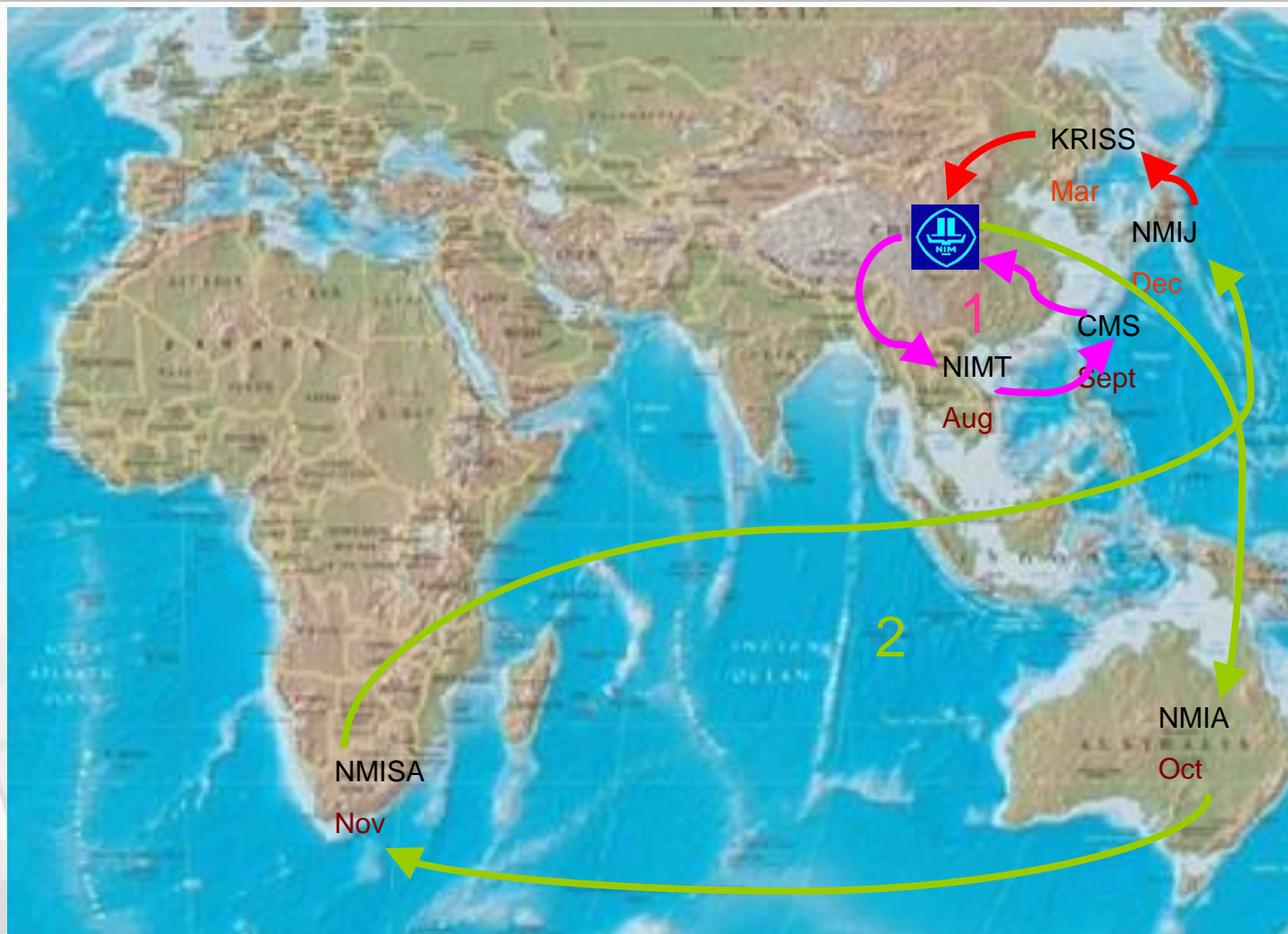
Vibration and Hardness section  
office (5<sup>th</sup> floor)



Experimental room for vibration standard (ground floor)

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

# RMO comparisons



rearranged

m s K cd  
kg mol A





# RMO comparisons



## Self-developed systems



*Horizontal*  
(0.1 - 20) Hz

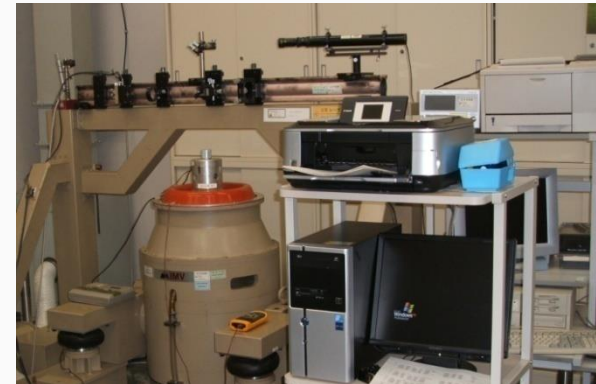
NIM

*Vertical*  
(0.1 - 20) Hz

*Horizontal* (0.5 - 2) Hz



*Vertical* (>2 - 20) Hz



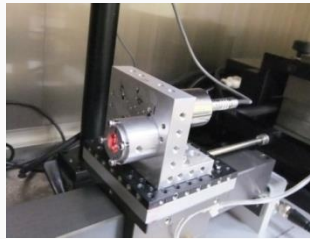
NMIJ



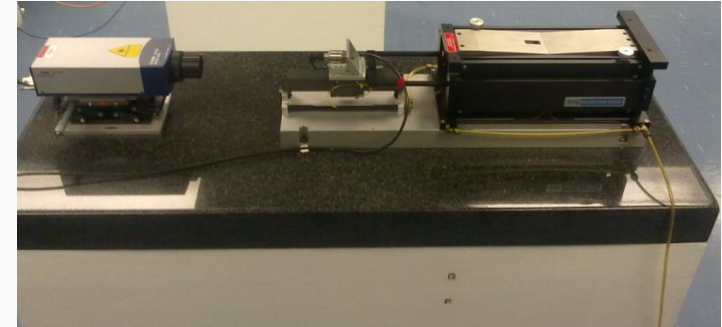
# RMO comparisons



## 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

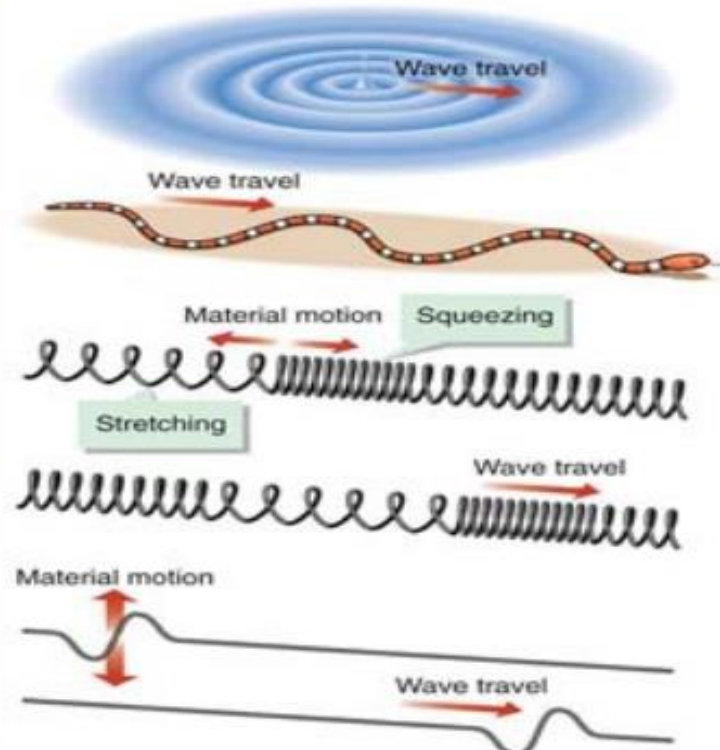
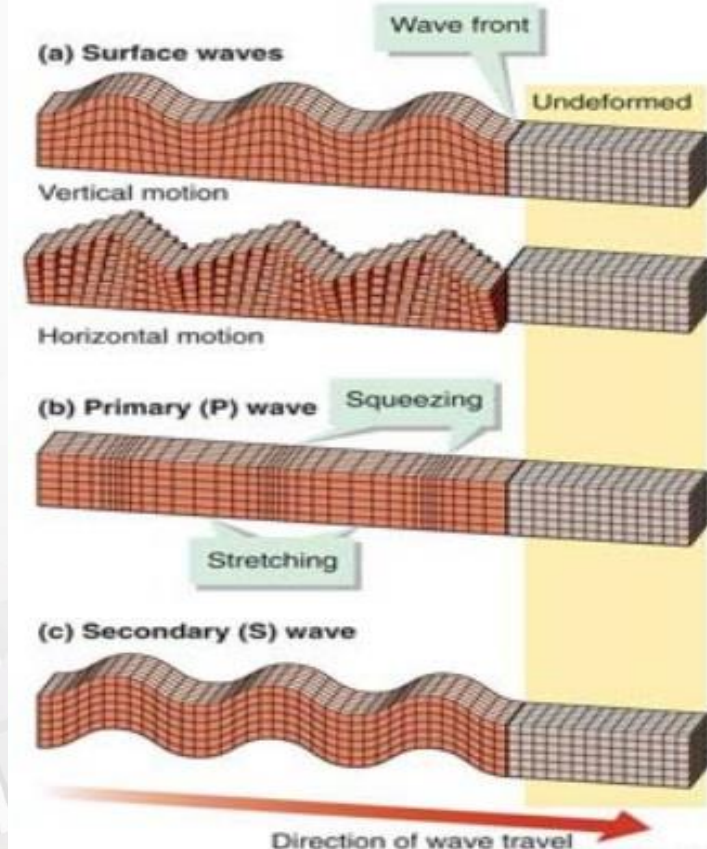
m  
s  
kg  
K  
mol  
A  
cd





# RMO comparisons

## Installation direction



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

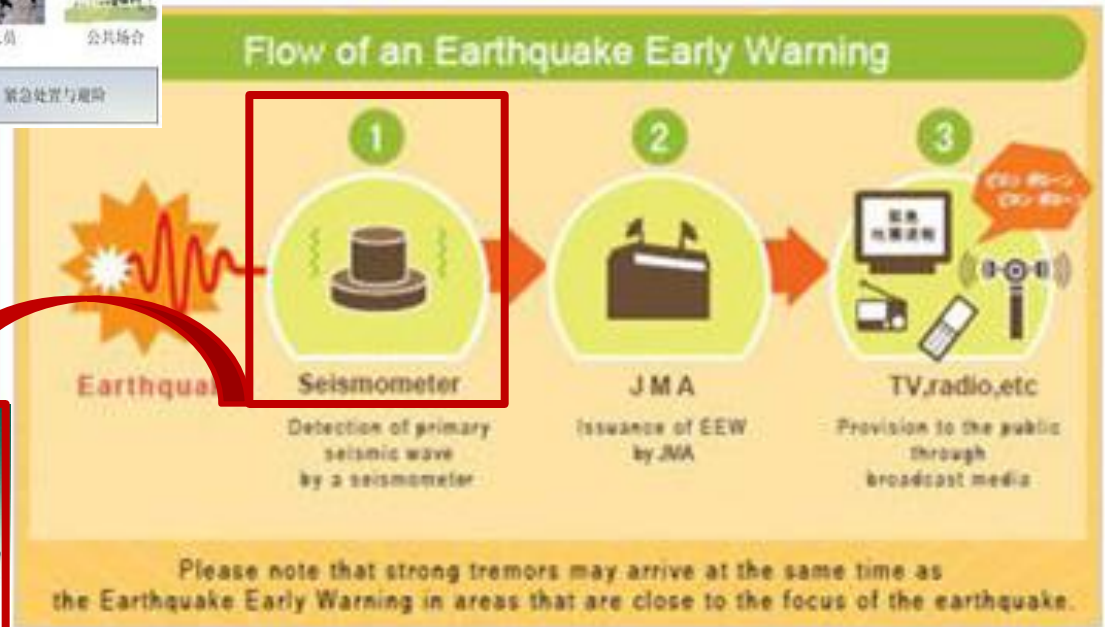
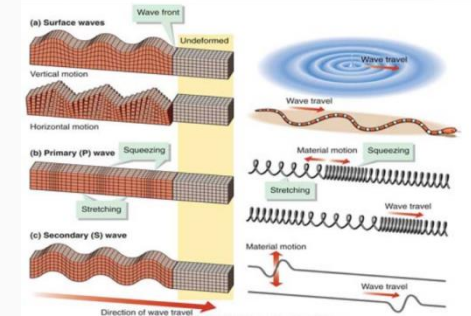
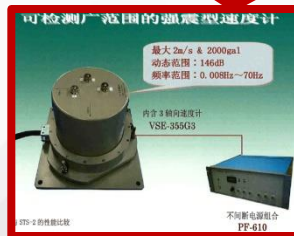
# RMO comparisons



## Installation direction



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



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# CCAUV comparison

## Participants List

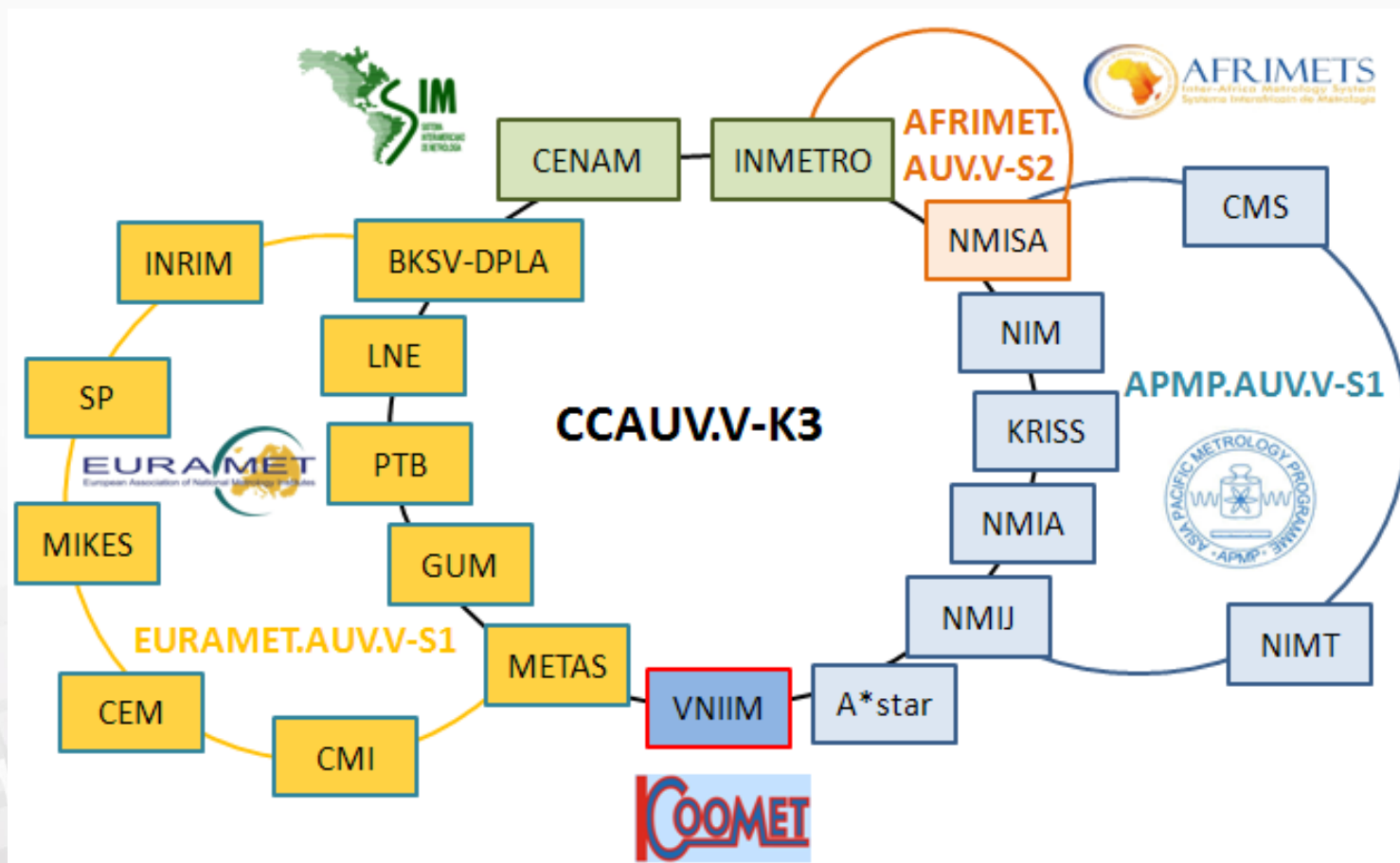


No.	NMIs	low limit	Direction
1	NMISA	0.4	Horizontal
2	KRISS	0.1	Horizontal
3	NIM	0.1	Horizontal
4	NMIJ	0.1	Horizontal
5	BKSV-DPLA	0.1	Horizontal
6	NMIA	0.1	Horizontal
7	LNE	0.4	Horizontal
8	METAS	0.4	Horizontal
9	PTB	0.4	Horizontal
10	INMETRO	0.4	Horizontal
11	CENAM	0.1	Horizontal
12	A*STAR	0.1	Horizontal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

### Key and supplementary comparisons - Results



#### CCAUV.V-K3

- Information
- Pilot / Contact
- Participants
- Results**
  - Magnitude at frequencies from 0.1 Hz to 40 Hz
  - Phase at frequencies from 0.1 Hz to 40 Hz
- Print out

#### CCAUV.V-K3

##### Results

Results published on 07 December 2016

Low-frequency acceleration, complex sensitivity

Click on one of the following links to access results:

[Magnitude at frequencies from 0.1 Hz to 40 Hz](#)  
[Phase at frequencies from 0.1 Hz to 40 Hz](#)

[Metrologia, 2017, 54, Tech. Suppl., 09001](#)



# CCAUV comparison

## Key comparison CCAUV.V-K3

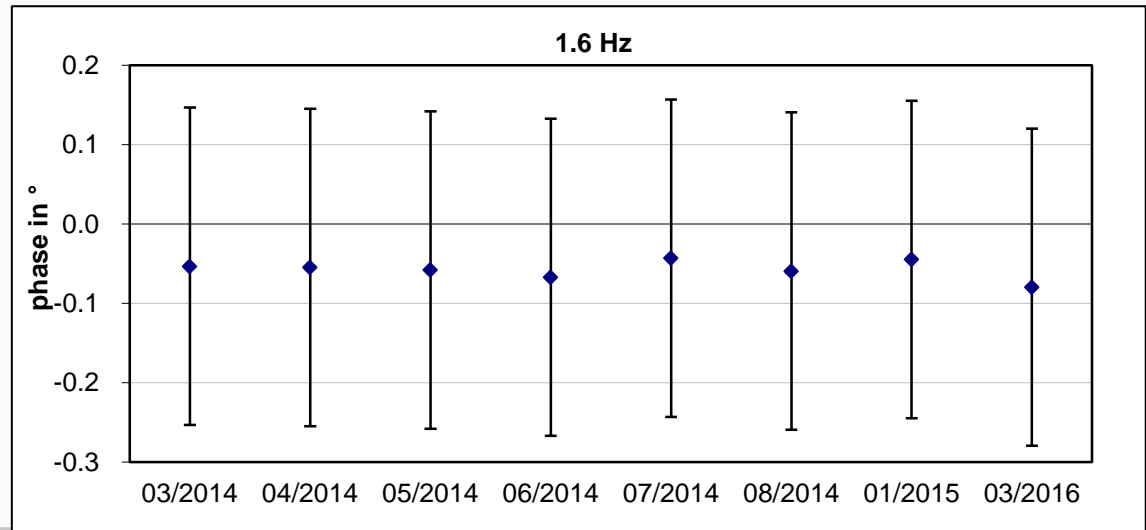
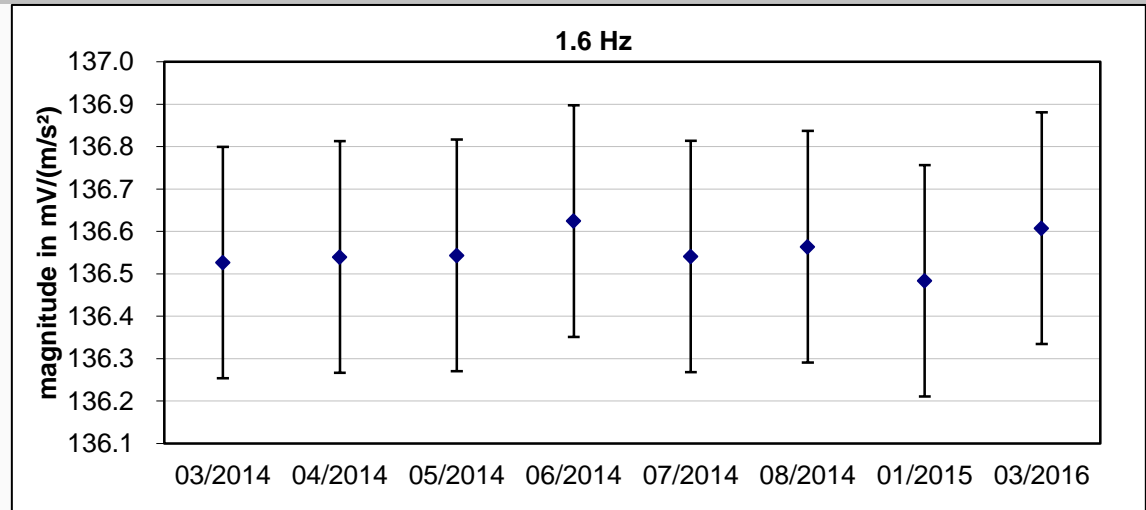
**DEVICE** : Low-frequency vibration comparison transfer standard

**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



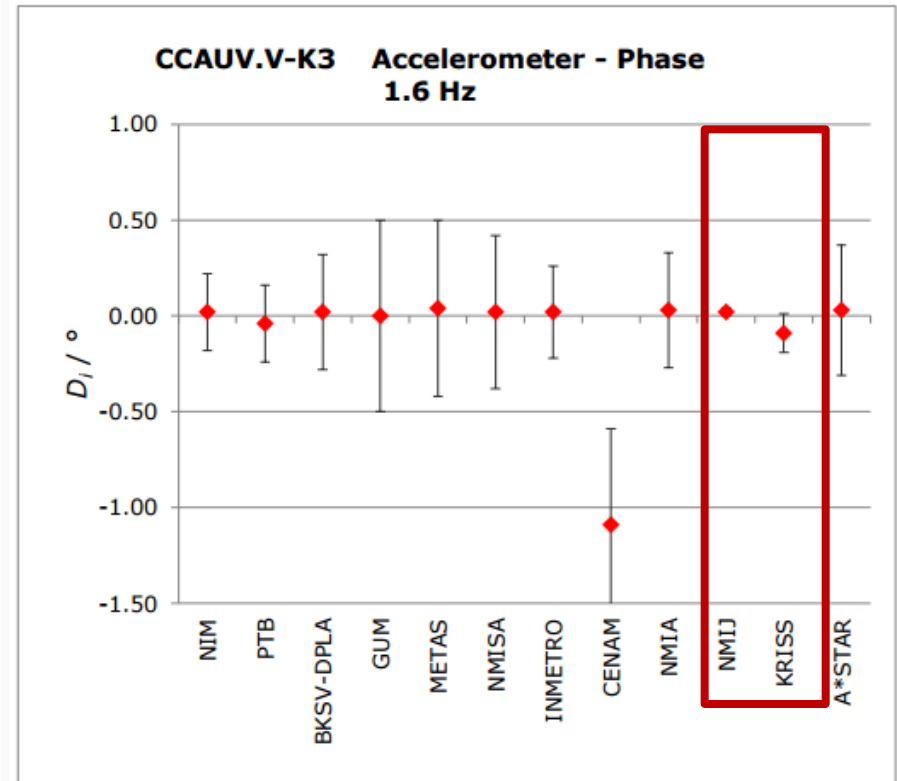
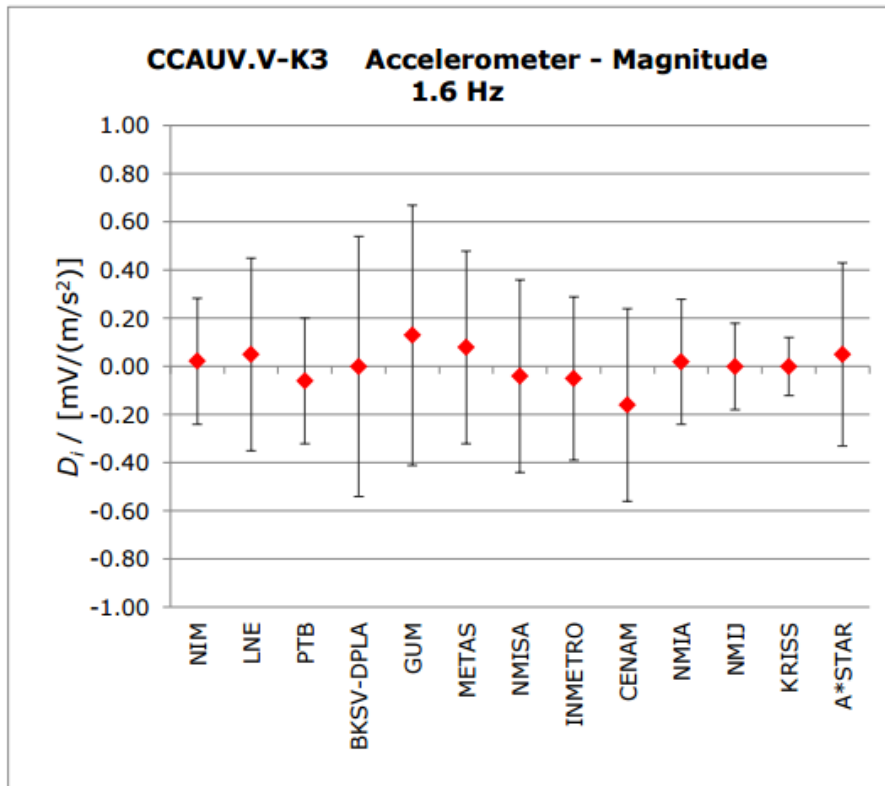
# CCAUV comparison





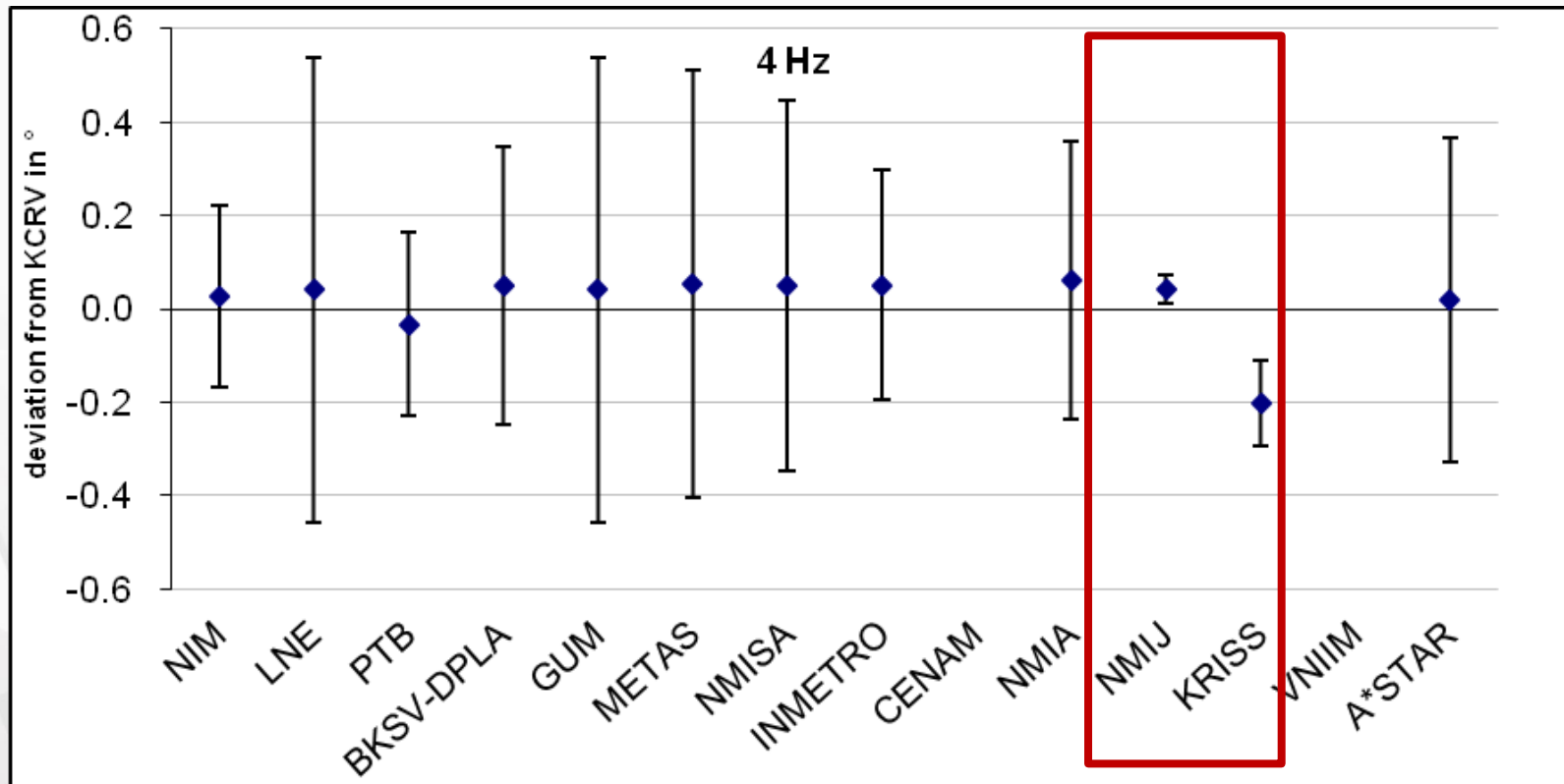
# CCAUV comparison

## Comparison results



# CCAUV comparison

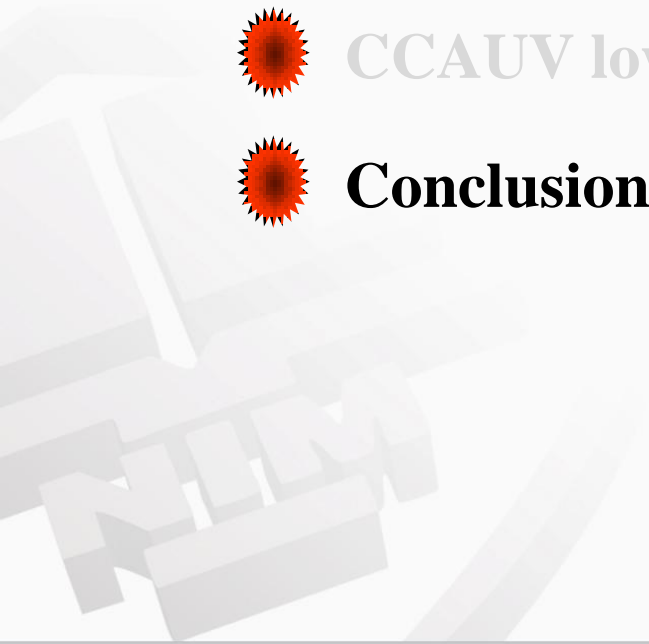
## Comparison results



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# 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.



**Thank you for your attention!**

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