CCAUV/17-57

KRISS
Korea Research Institute of Standards and Science

2017 CCAUV

Activities in KRISS

Wan-Cho Cho

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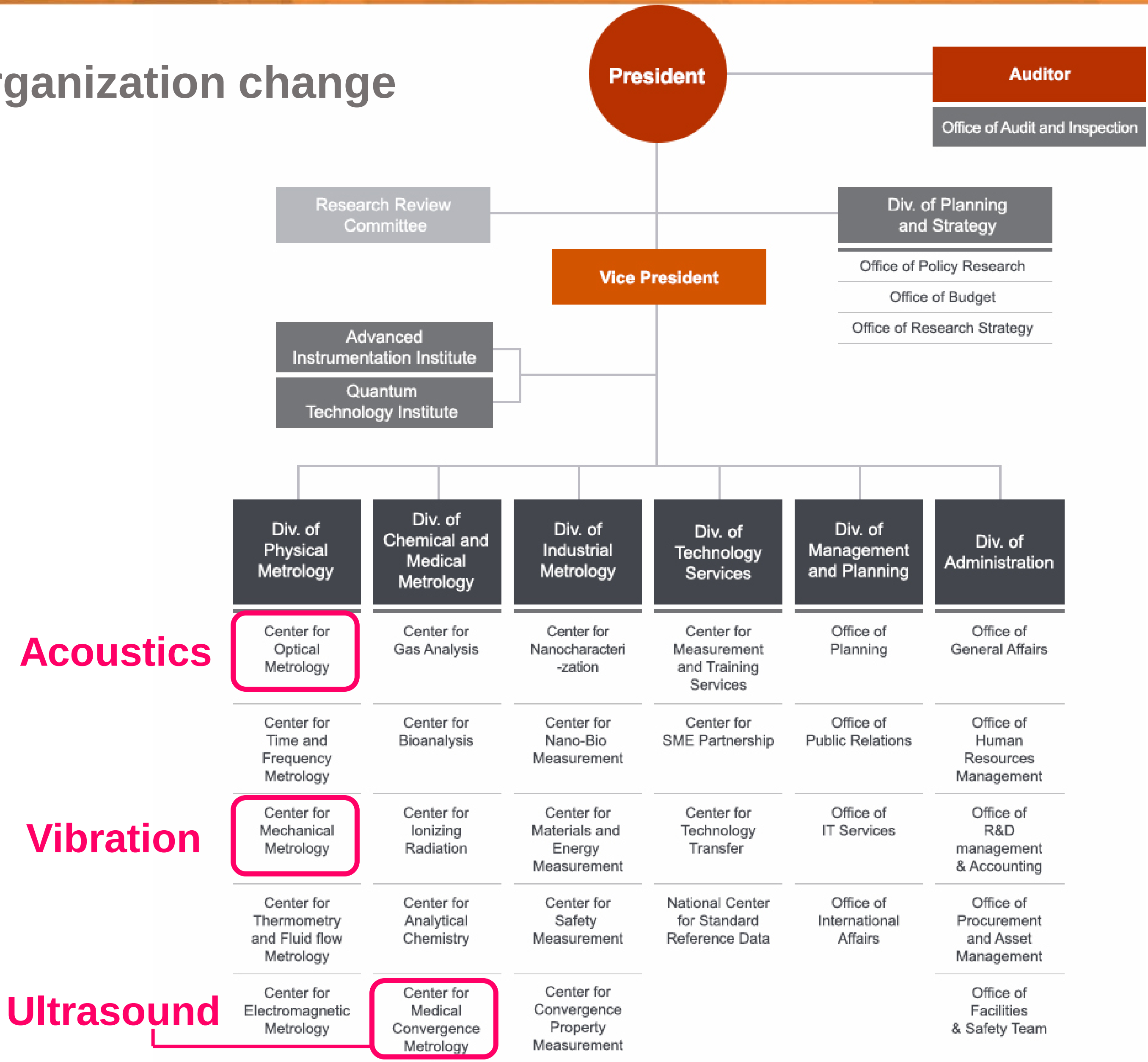
Organization change



General

CMC updates (approved at April 2017)

- Acoustics
  - ✓ Whole previously existing items are re-approved
- Ultrasound
  - ✓ The items of ultrasonic power are newly added
- Vibration
  - ✓ Whole previously existing items of linear vibration are re-approved
  - ✓ The items of angular vibrations are newly added

Peer review

- Acoustics
  - ✓ The items for free-field microphone sensitivity for the frequency range of 1 kHz -31.5 kHz are newly added based on the results of CCAUV.A-K4
- Ultrasound
  - ✓ The items of ultrasonic power are updated and the uncertainties are updated
- Vibration
  - ✓ The frequency ranges of items of linear vibration are extended to 0.5 Hz
  - ✓ The items of angular vibration are updated and the uncertainties are updated

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Sound in Air

- Diffuse-field sensitivity
- Optical measurement method

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Types of sound field

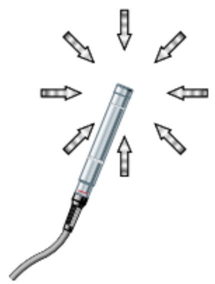
- Pressure field
  - ✓ Uniform pressure, only diaphragm exposed to pressure
  - ✓ Small coupler, cross-section of plane wave duct
  - ✓ High S/N ratio & high stability

Pressure field

- Free field
  - ✓ No reverberant field, SPL distribution satisfy the inverse square law
  - ✓ Direct field + effect of sensor body (infinite rod)
  - ✓ Representing outdoor condition

Free field

- Diffuse field
  - ✓ Uniform pressure, plane wave incidence with same probability for every direction
  - ✓ Representing indoor condition

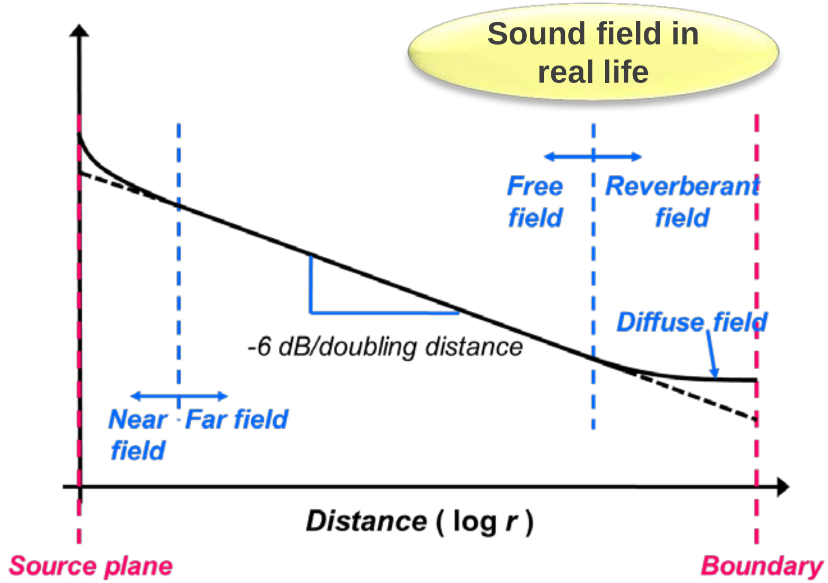


Radom incidence (Diffuse) field

Images from http://www,gras.dk

Diffuse Sound Field

- General definition
  - ✓ Sound field having equal probability of energy flow in all direction and the energy density is uniform in a volume (Jacobsen, DTU Tech. rep., 1979; Nelisse & Nicolas, JASA, 1997)
    - → Summation of infinite-equally spaced plane wave sources
- General characteristics
  - ✓ High reverberation time
  - ✓ Uniform distribution of sound pressure
  - ✓ Spatial correlation is given by sinc function



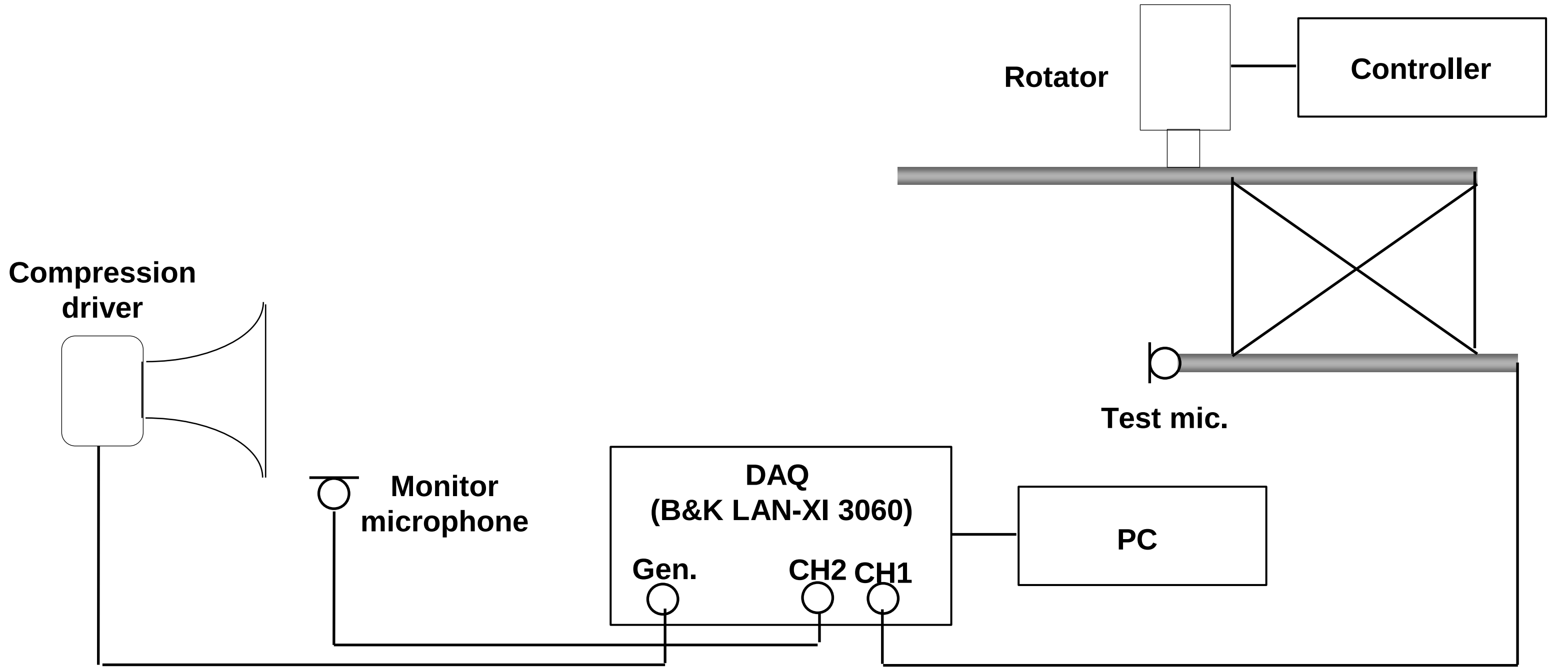
Previous Works

- Standard on the Diffuse Field Sensitivity Calibration
  - ✓ No standard issued for calibrating the diffuse field sensitivity
    - Pressure sensitivity: IEC 61094-2 (Primary), IEC 61094-5 (Comparison)
    - Free-field sensitivity: IEC 61094-3 (Primary), IEC TS 61094-7 (Correction), IEC 61094-8 (Comparison)
  - ✓ No ‘Calibration and Measurement Capabilities’ registered by NMI
  - ✓ No international comparison has been conducted

- Research Works on the Diffuse Field Sensitivity Calibration
  - ✓ Reciprocity method
    - Basic concept & formulation: Diestel, JASA, 1961
    - Measurement method with a scaled reverberation chamber: Barrera-Figueroa et al., JASA, 2008
    - Improved result using diffuser: Milhomem et al., Internoise 2016
  - ✓ Random Incidence method
    - Measurement method result: Barrera-Figueroa et al., JASA, 2007

Measurement System

- System Configuration
  - ✓ Rod: Hollowed pipe, 1 m length, same outer diameter with mic, hanged by fishing line
  - ✓ Rotator: Motor controlled with high precision (0.1 degree resolution)
    Measured with 5 degree step
  - ✓ Sound source: Compression driver + Horn
  - ✓ Data acquisition system: B&K PULSE + LAN-XI 3060 (FFT Analyzer + Generator)
  - ✓ Distance between source and test mic.: 4 m



Random Incidence Sensitivity Method

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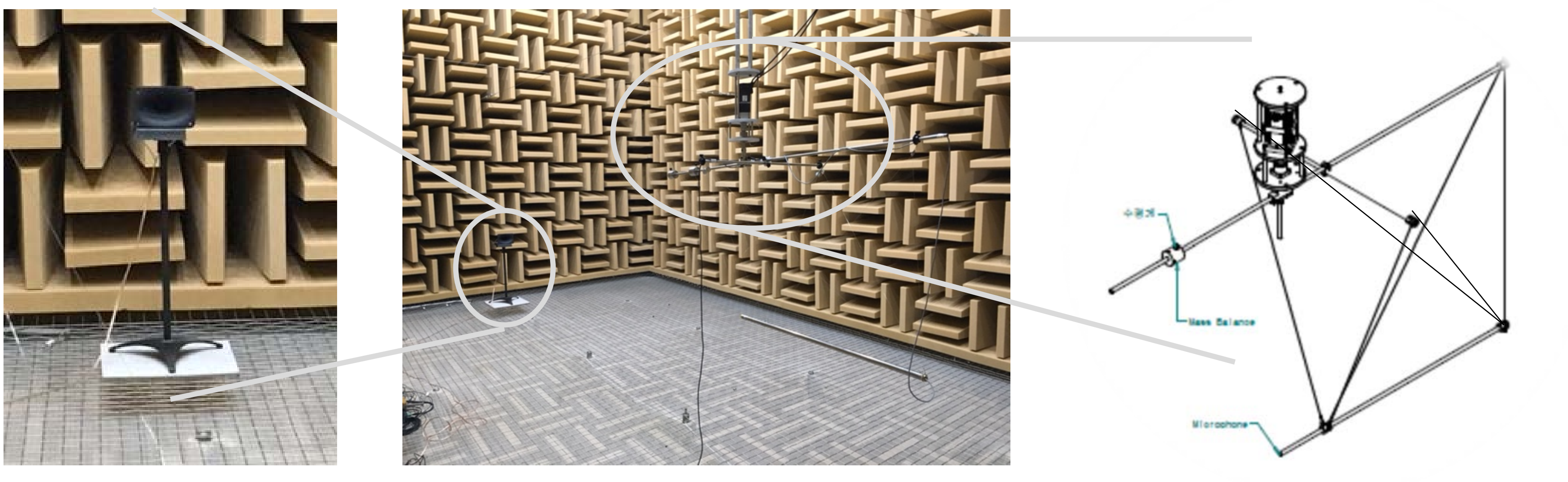
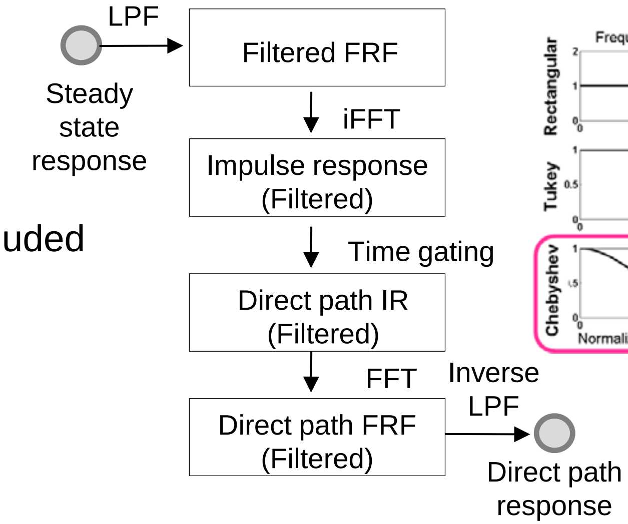
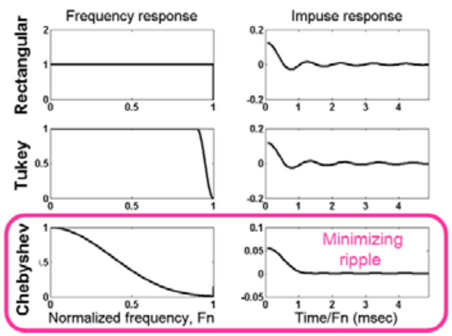


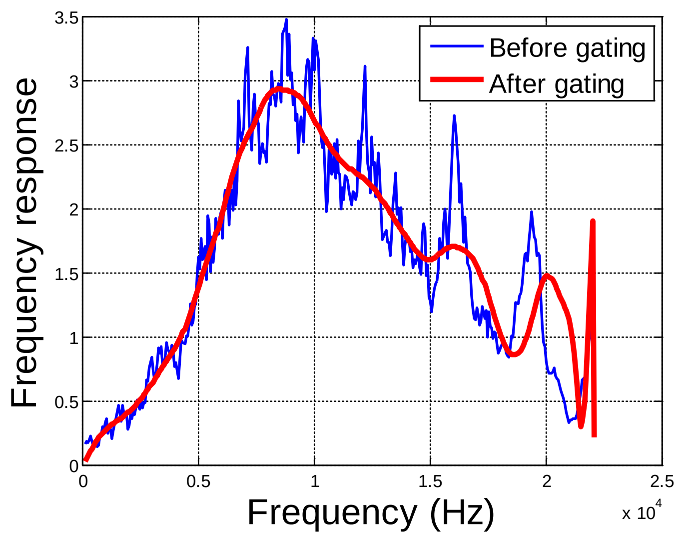
Random Incidence Sensitivity Method

Signal Processing

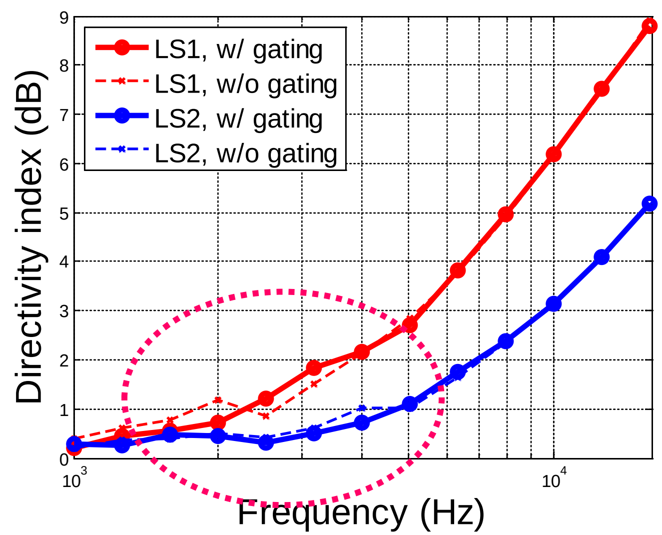
- Gating Process
  - ✓ Various reflection & scattering effects are included
    - → Reflection removal should be applied
    - → Applying low-pass filtering for stabilizing impulse response (Kwon & Cho, JASA, 2013)
    - → Fluctuation in 2 kHz – 5 kHz is reduced







Frequency response at frontal direction (4160.1792662)

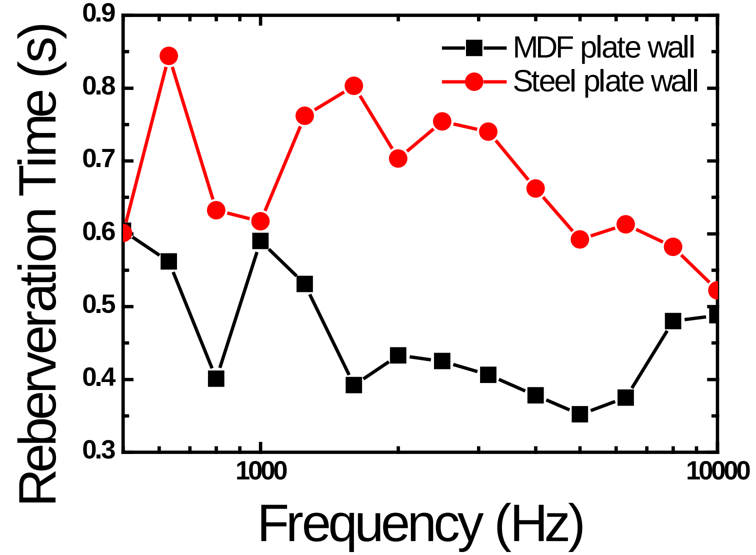


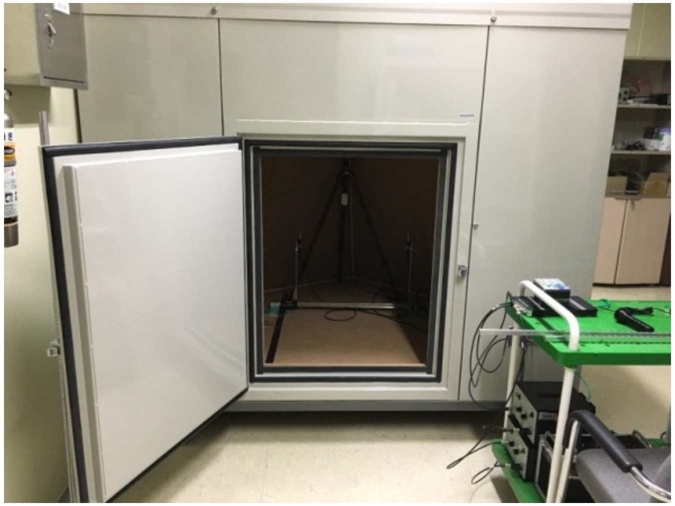
Averaged measured directivity with 3 microphones

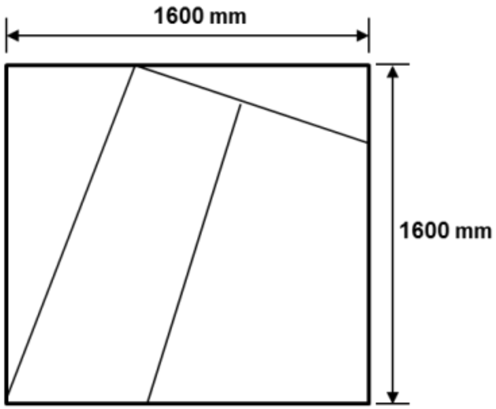
Reciprocity Method

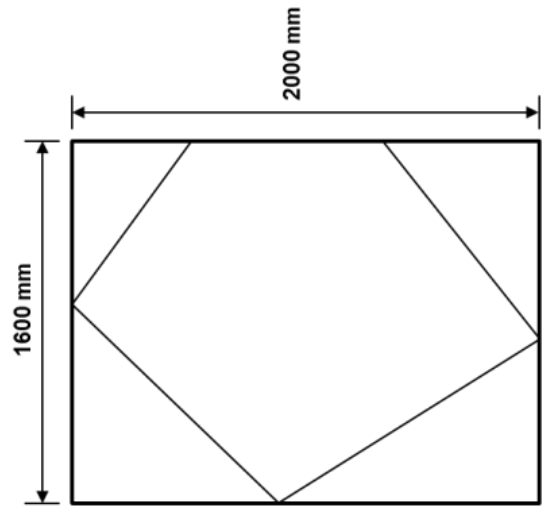
Measurement System

- Scaled Mini Reverberation Chamber
  - ✓ Non-paralleled walls of aluminum plates
  - ✓ Volume: 2.8 m^3
  - ✓ Transmission loss of door: 30~45 dB
  - ✓ Reverberation time:
    - MDF plate wall: 0.38 ~ 0.60 s
    - Steel plate wall: 0.52 ~ 0.84 s



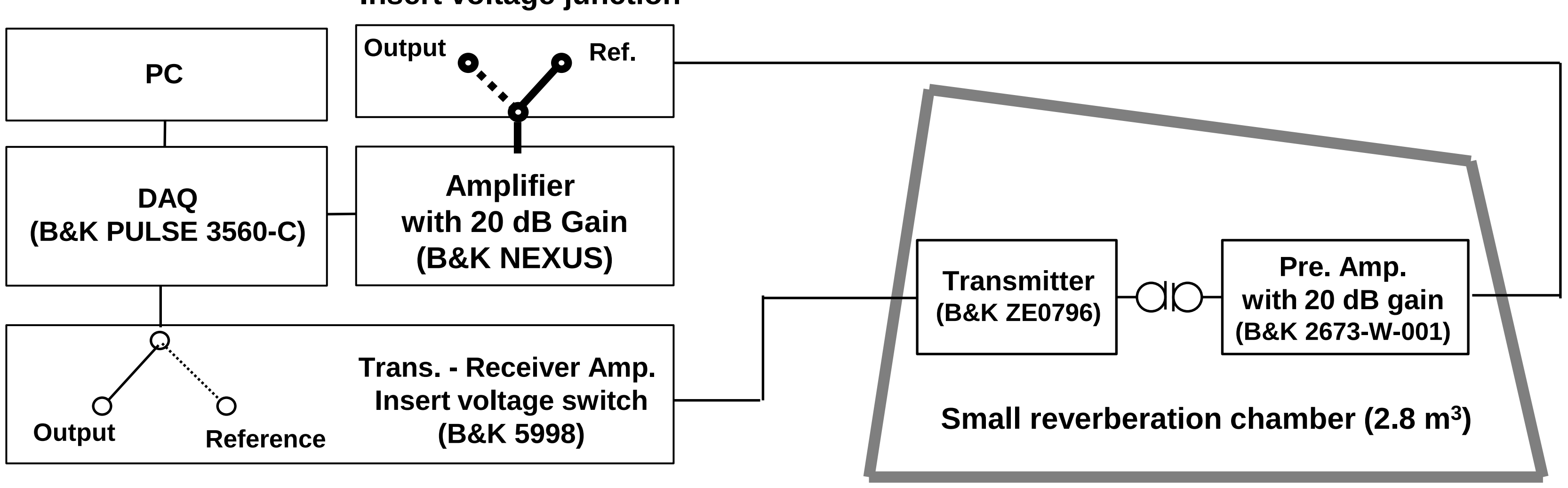






Measurement System

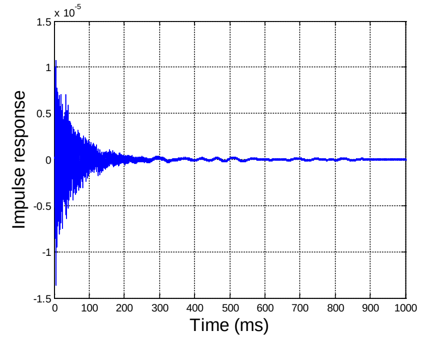
- Voltage ratio measurement
  - ✓ Same to the free-field reciprocity measurement system
    - Insert voltage method
    - Isolating the channels of transmitter and receiver to suppress cross-talk
    - 20 dB preamp. gain to increase S/N ratio
- Acquisition process
  - ✓ FRF with Random noise

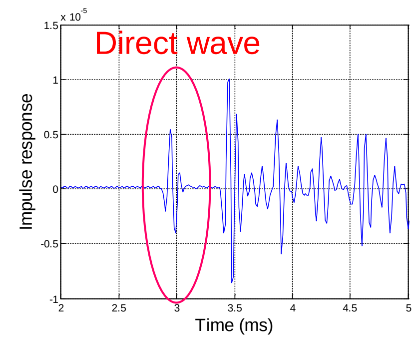


Reciprocity Method

Signal Processing

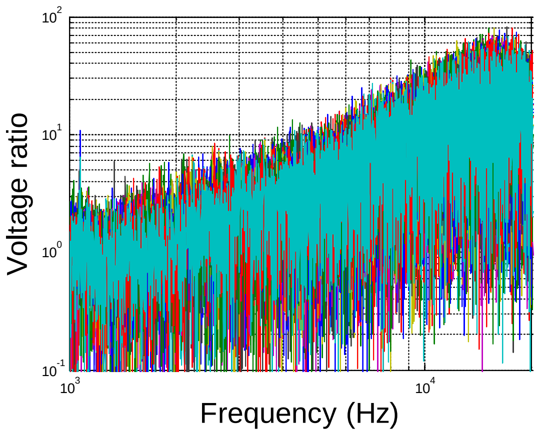
- Contribution of direct wave
  - ✓ For the face to face configuration, contribution of frontal direction become larger than other directions
  - ✓ To apply the removal process
    - → Freq. step smaller than (1/RT) Hz is required



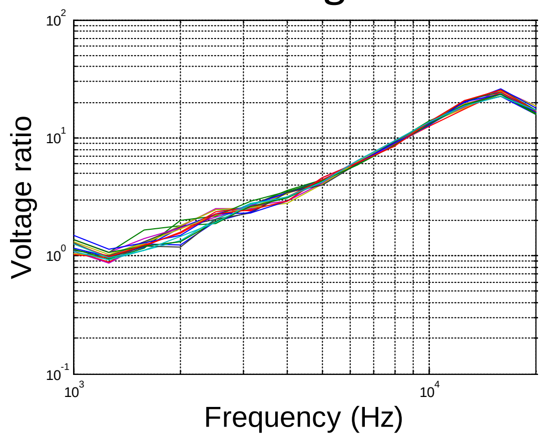


- Averaging process
  - ✓ Frequency band average: 1 Hz → 1/3 octave band
  - ✓ Spatial averaging: 18 separated points (no face to face configuration)

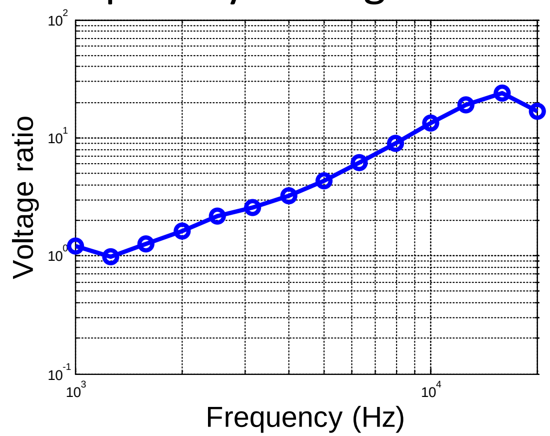
Raw data



Band averaged data



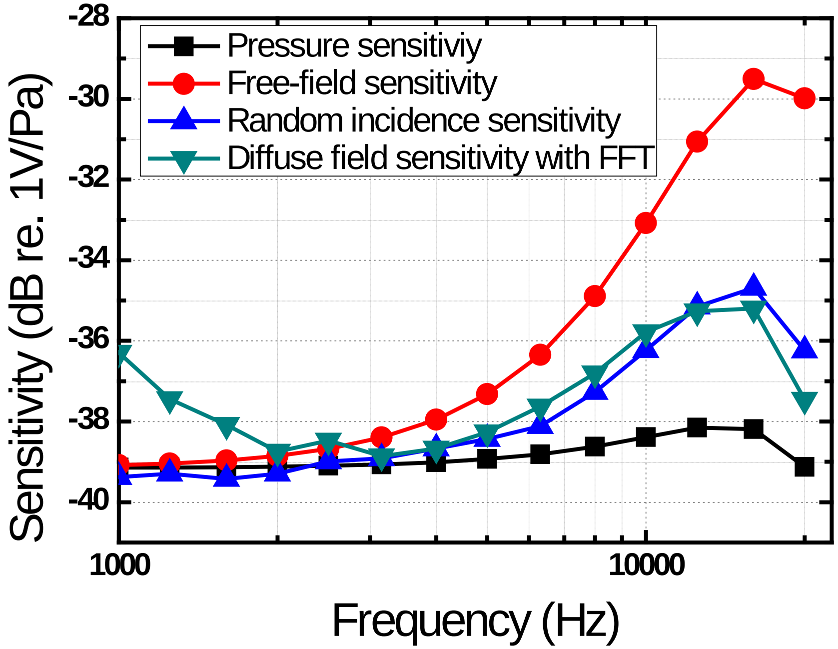
Spatially averaged data



Results comparison

- Comparison with the sensitivities in other types of sound fields
  - ✓ Diffuse-field sensitivity estimated by the different methods are placed in between the pressure and free-field sensitivity

4180.2341431



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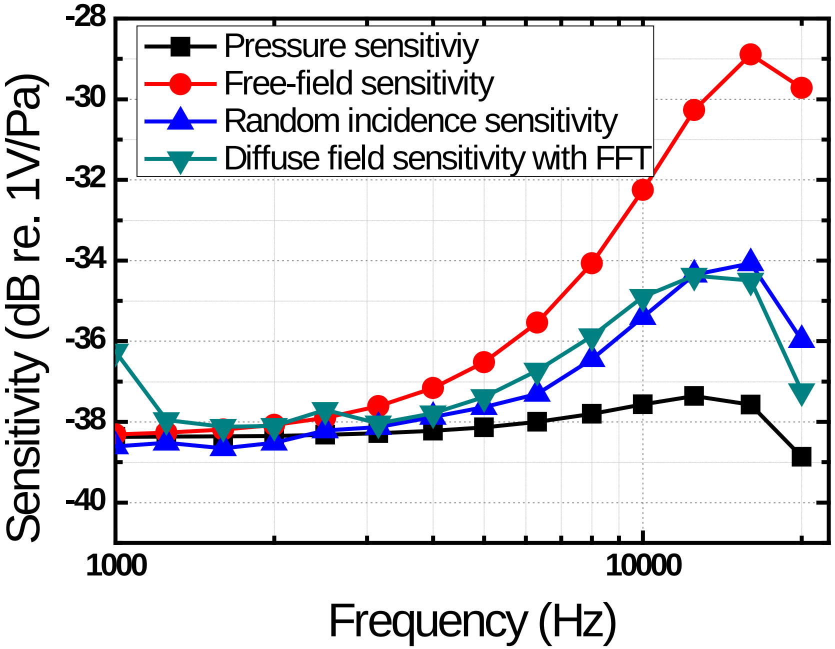
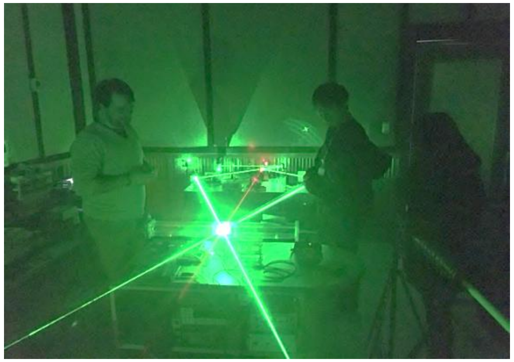
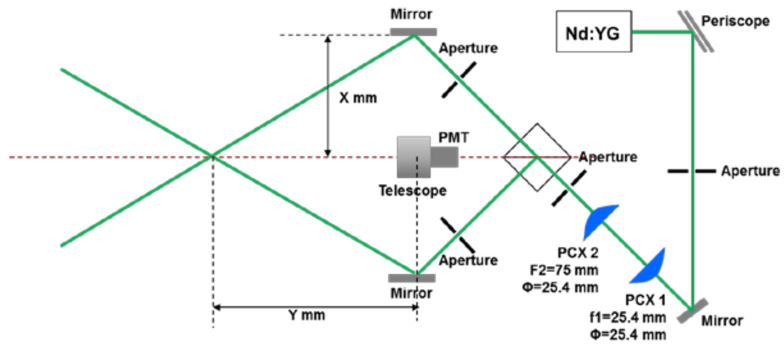


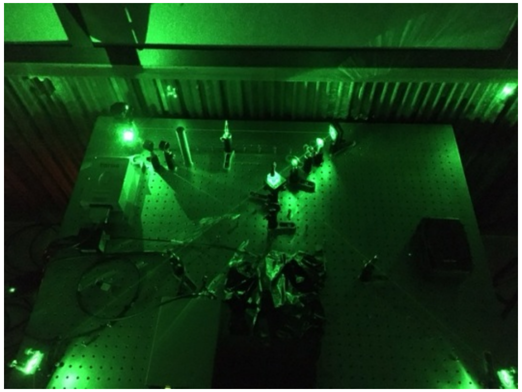
Measurement system with gated photon correlation method

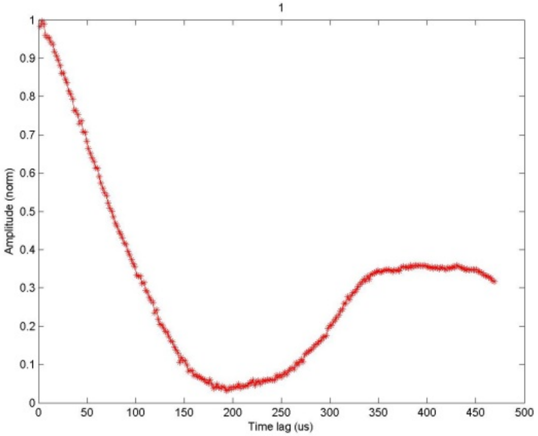
- System setup
  - ✓ Feasibility test with sine-wave tube
  - ✓ Installation of free-field measurement system
  - → Collection of measurement data and the detailed investigation are on-going

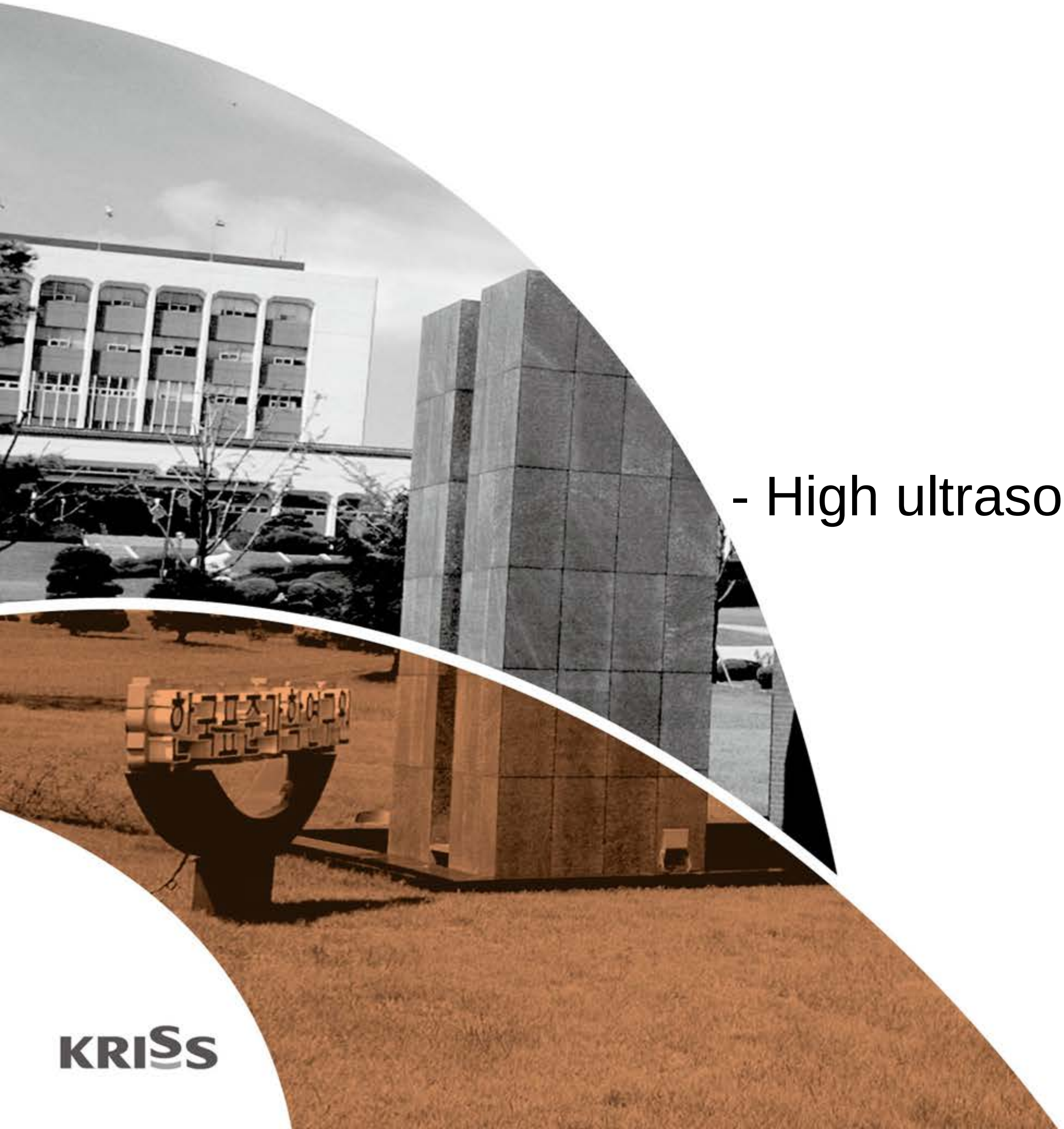
This works was conducted by
collaborating with Dr. T. Koukoulas
a former principal research scientist at NPL











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Ultrasound

- High ultrasonic power measurement

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Ultrasound

Contact point

- Name: Dr. Yong Tae Kim
  (Head, Center for medical convergence metrology)
- Email: ytkim@kriss.re.kr

Recent activities

- Ultrasound power
  - ✓ **<u>Development absorbing target available to RFB method up to 300 W</u>**
  - ✓ **<u>High power measurement system construction</u>**
  - ✓ Fabrication of high power transducers (1 MHz, 3 MHz)
  - ✓ Pilot study for comparison with NMIJ, NIS (2 MHz – 15 MHz)
    Report is submitted to SCI journal.
  - ✓ HIFU Transducer using meta-acoustic lens
  - ✓ HIFU phantom research for histotripsy

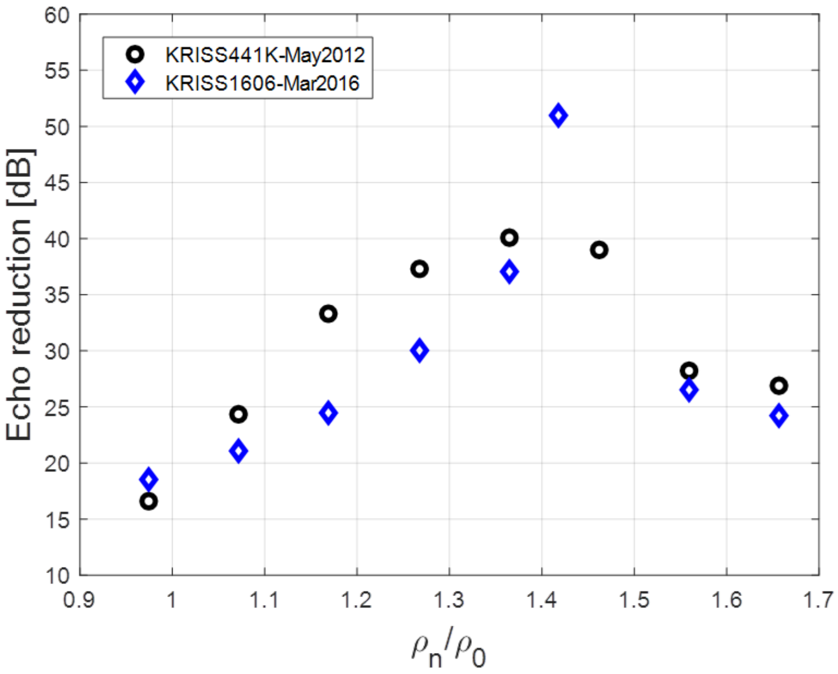
Future Plan (2018 -)

- Pilot study high power measurement comparison in APMP
- APMP.U-K1 RMO KC (2018)

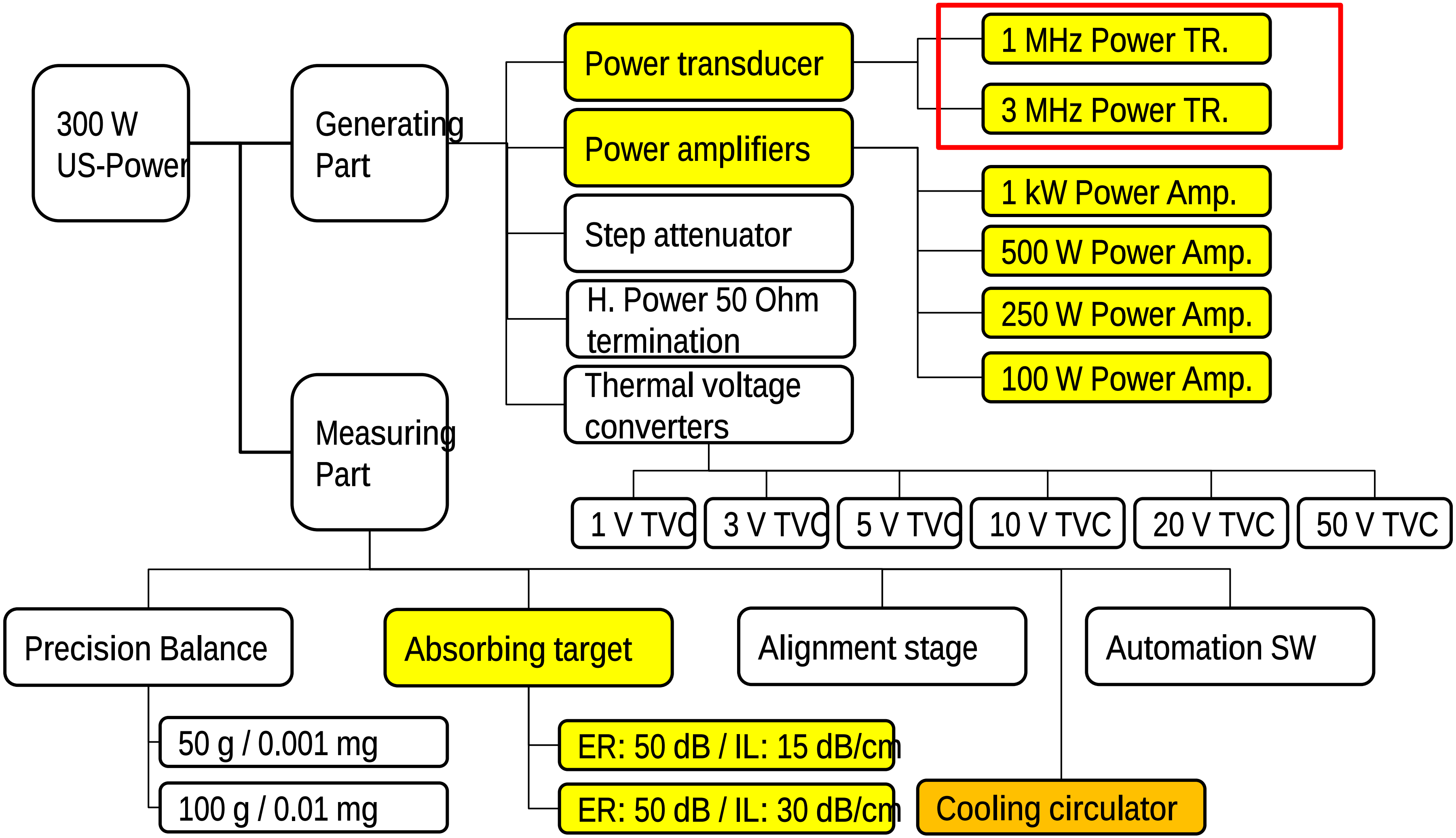
High ultrasonic power measurement

High power target

- Requirement
  - ✓ Echo Reduction: 50 dB (sufficient)
  - ✓ Single layer
- Characteristics of the developed target
  - ✓ Specific Insertion Loss: 15 dB/cm
  - ✓ 3 cm-thickness → IL = 45 dB



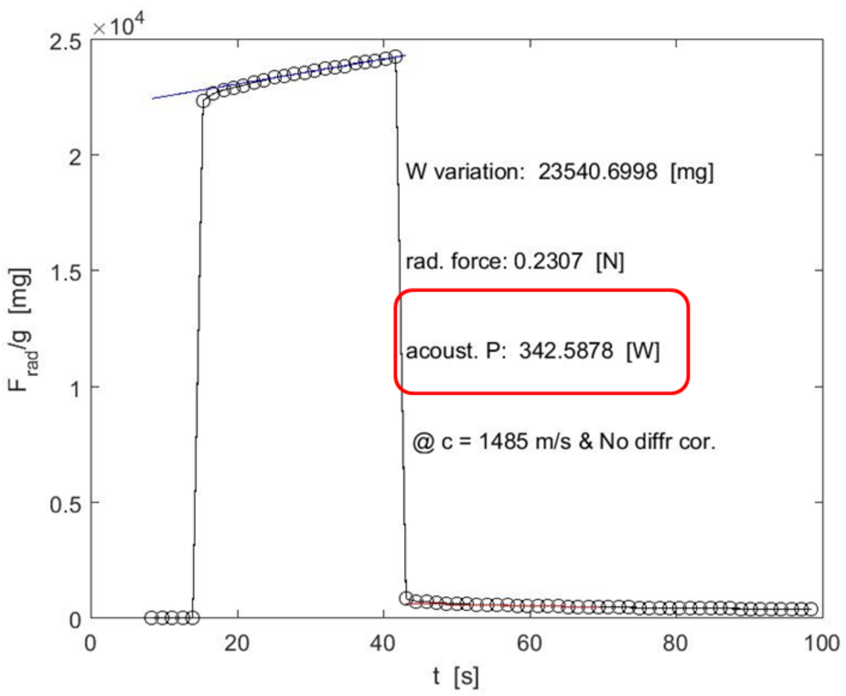
System configuration

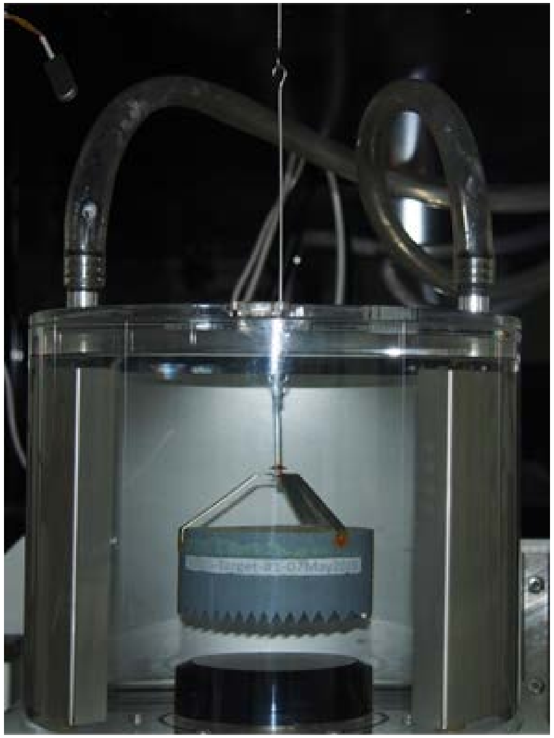


High ultrasonic power measurement

High power measurement and water temperature problem

- Water temperature continues to rise after measurement.
- Difficult to maintain water temperature: (21.5 ± 2.0) ℃
- New water tank with Cooling circulator
- Water temperature can be controlled





Summary

KRISS AUV

- Re-organization
  - ✓ Role, activities and research area are **not changed**

AUV are still in KRISS!

On-going Research Works

- Acoustics
  - ✓ Diffuse-field sensitivity
  - ✓ Optical method for the future primary standard
- Ultrasound
  - ✓ High power measurement method
  - ✓ Related topics to HIFU
- Vibration
  - ✓ Research on the national seismic monitoring system to make it traceable to the international metrology standard

Better Standards, Better Life!

Thank you

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