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Acoustics of Chants, Conch-Shells, Bells and Gongs in Hindu Worship spaces

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Introduction

- **Worship** is the pinnacle of communication between human beings and God in many religions. Worship can be individualistic (or) congregational.

- Congregational worship usually requires dedicated spaces such as temples, gurdwaras, churches, synagogues and mosques.

- Acoustics plays an very important role in worship spaces in all cultures and religions of the world. In Hinduism, acoustics is of major importance in various aspects of life namely spirituality, religion, culture, science, arts etc.

- It is well known that sound plays a very important role in Hindu worship spaces namely homes, community halls and temples.

Lord Krishna with "***CONCH-SHELL***"

Lord Shiva with "***DRUM***"

"ROSARY" as Speech Alphabet Sounds

Goddess Saraswathi with "***VEENA***"

Lord Krishna with "***FLUTE***"

Acoustics and Vedic Tradition

- The **Vedas,** which are the **foundational literature** of Hinduism, are the collection of mantras chanted with **precise acoustical characteristics.**

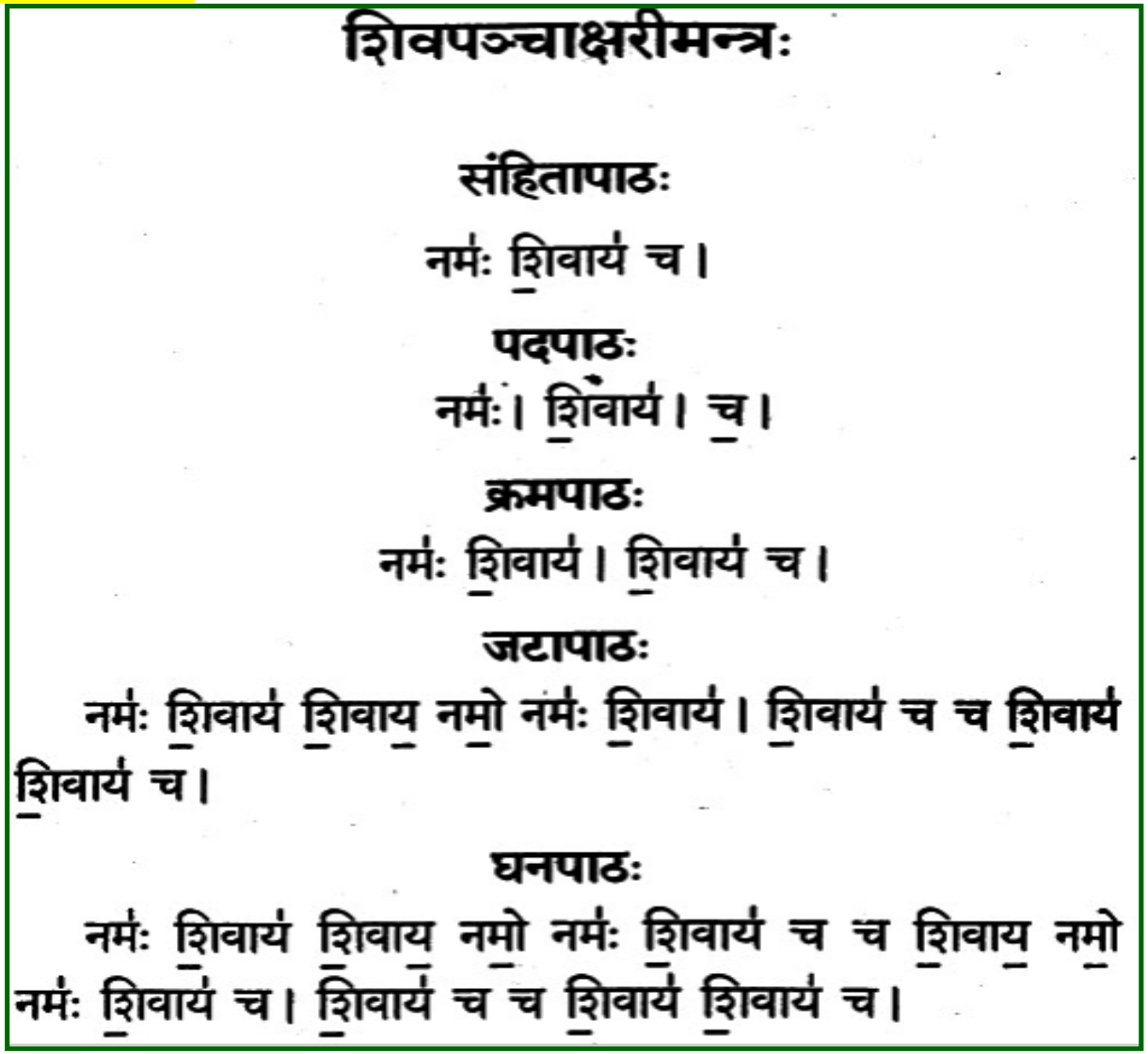
- **Oral tradition** has been very efficient in transmitting the Vedic chanting from master to disciple over generations.

- **Vedic chants** in Hindu worship are well known. In addition to Vedic chants, Instruments such as **Conch-Shells, Bells** and **Gongs** are commonly used to enhance the spiritual experience of the devotees during the worship.

- This study presents **acoustical studies** of **chants** and of **these instruments** sounding individually as well as collectively.

Acoustics and Vedic Chants

Shiva Panchaakshari mantra



शिवपञ्चाक्षरीमन्त्रः

संहितापाठः

नमः शिवायं च।

पदपाठः

नमः। शिवायं। च।

क्रमपाठः

नमः शिवायं। शिवायं च।

जटापाठः

नमः शिवायं शिवाय नमो नमः शिवायं। शिवायं च च शिवायं शिवायं च।

घनपाठः

नमः शिवायं शिवाय नमो नमः शिवायं च च शिवाय नमो नमः शिवायं च। शिवायं च च शिवायं शिवायं च।

Acoustical knowledge of ancient Hindus

"It would form a fascinating chapter of history to try and trace the gradual development of musical instruments and musical knowledge, from the rhythmic chanting of Rig-Veda in the ancient home of the Aryan race to the Indian music of the present day"

-- Sir C. V. Raman (1922)

Conch-Shell, Bell and Gong used for the study

Conch-Shell

Bell

Gong

Vedic Perspectives on Sound

Four Stages of Speech

ना देन व्यज्यते वर्ण: पदं वर्णात्पदा द्वचः
वच्सा व्यवहा रो यं ना दा धी नमतो जगत्

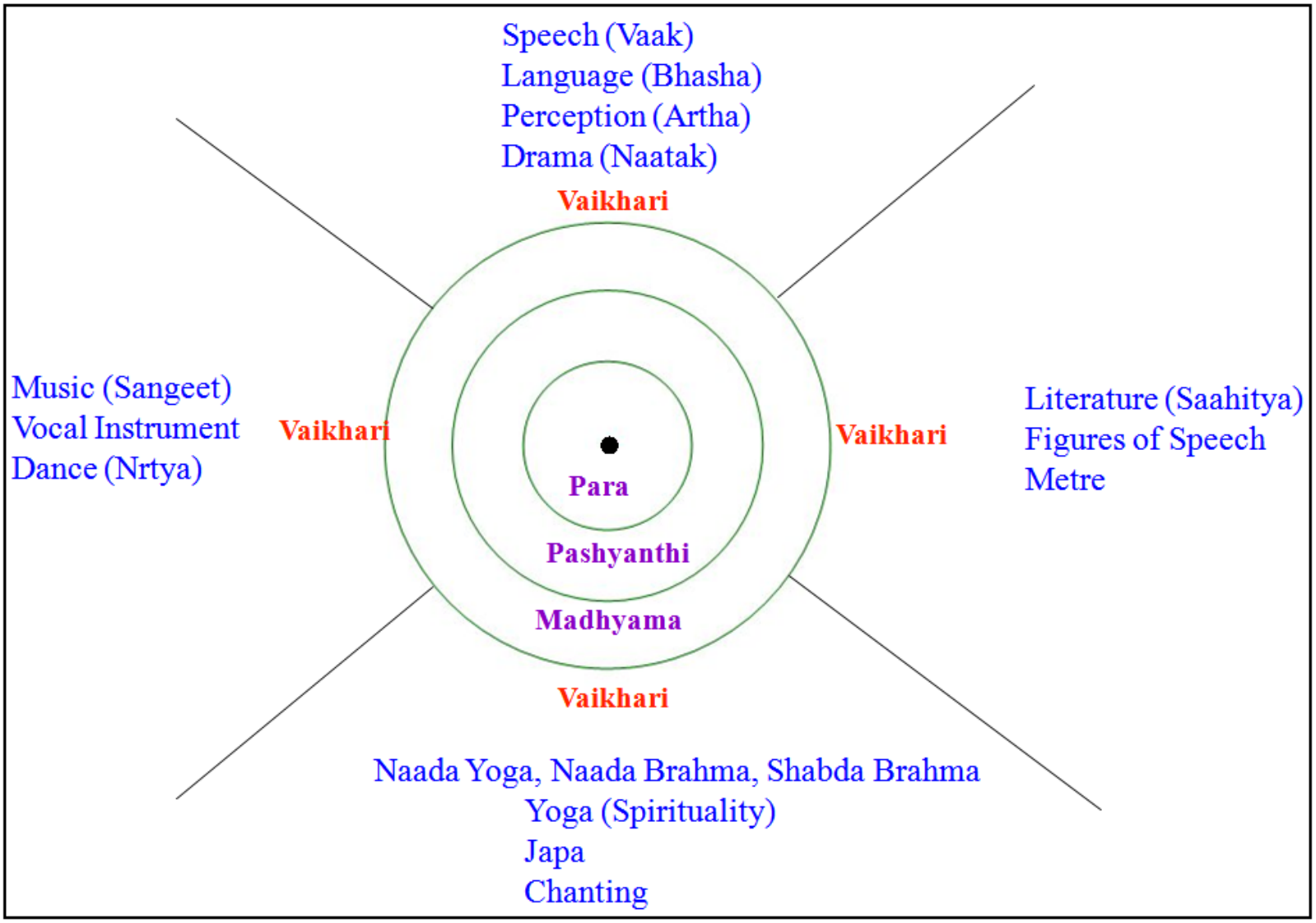
Naada manifests as letters. Words are made from letters, speech is made from words. The life's transactions are through speech. Hence world is dependent on **Naada**

चत्वारि वाक् परिमिता पद्मानितानि विद् ब्रा:मना ये मानिषेण
गु हा त्रीणिनिहिता नेग्यन्नितु रीयं वाचो मनु ष्या वदन्ति

There are four stages of speech. The first three stages are hidden and are only perceptible to Yogis. The last stage is used by all the human beings.

परा	Para (Causal)	●
पश्यन्ति	Pashyanthi (seen)	●
मध्यमा	Madhyama (Through Medium)	●
वै खरी	Vaikhari (Manifested)	●

Representation of the four fields of sound at **Vaikhari level**



The **Order of Correspondence** According to the **Vedic Tradition**

Space	Sound
Air	Touch, Sound
Fire	Form, Touch, Sound
Water	Taste, Form, Touch and Sound
Earth	Smell, Taste, Form, Touch and Sound

Acoustical Aspects of **Hindu Worship** Spaces

Acoustical Aspects of **Hindu Worship** Spaces

- **Temples** (devaalayas or mandirs) as worship spaces have been an integral part of Hindu religion from ancient times.

- **Hindus** also use spaces such as **community halls** and specified space in their **homes** as spaces of worship.

- In addition to the mantras and bhajans, instruments such as **Conch-Shells, Bells** and **Gongs** are also used in the worship.

- The most important space in a Hindu temple is the space where the deity is installed called **"Garbha-Griha"** (or) "**Sanctum-Sanctorum".**

Acoustical Aspects of **Hindu Worship** Spaces

❑ **Agama Shastras** on temple design prescribe that the whole temple is designed based on the size of the deity installed in the Garbha-Griha.

❑ **Garbha-Griha** is generally connected to another space (through its door opening) called **Ardha-Mantapa.**

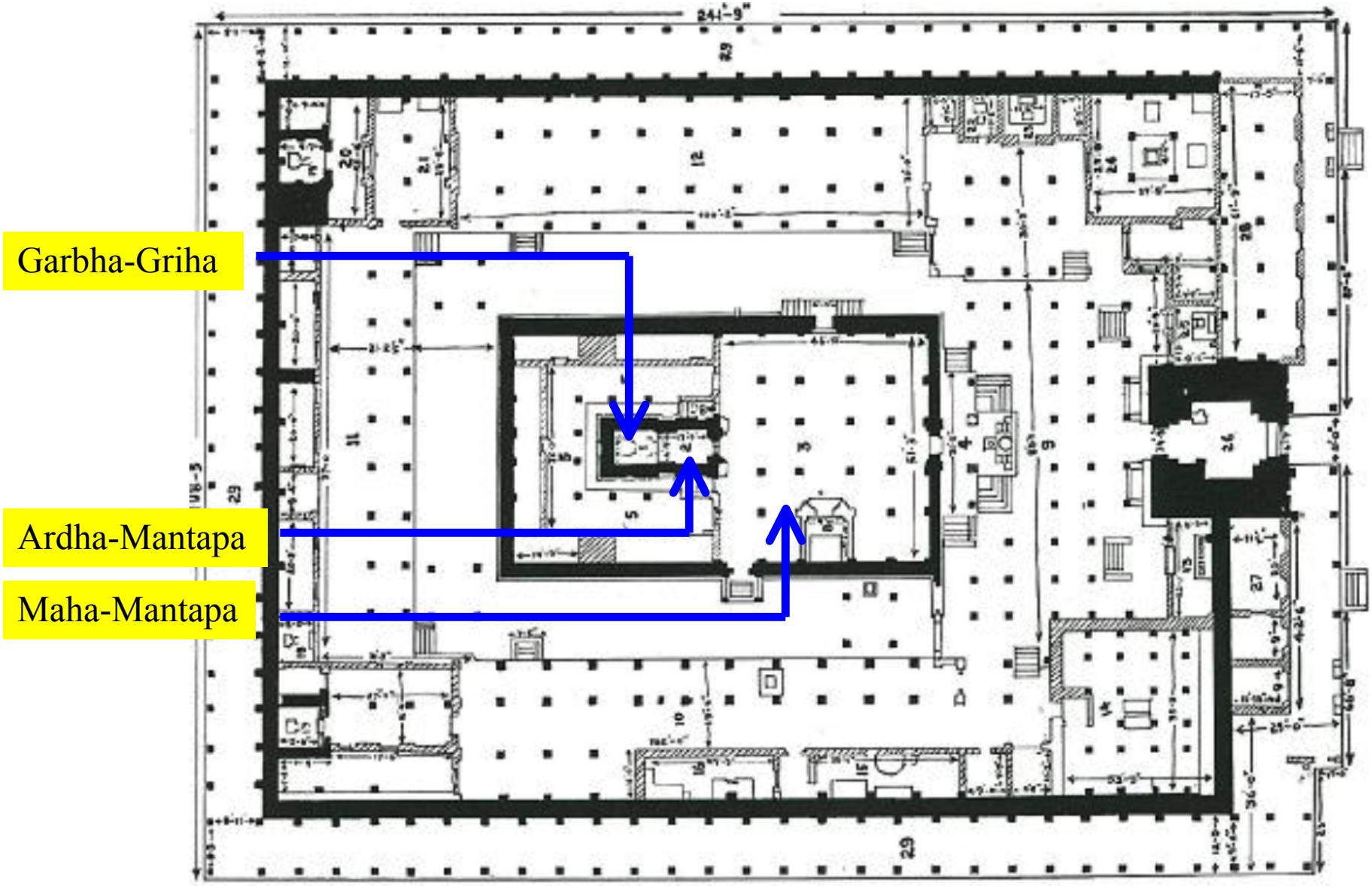
❑ Both the **Garbha-Griha** and the **Ardha-Mantapa** are made of stones and are **highly reflective** with **high reverberation time**.

❑ The acoustical importance of Ardha-Mantapa is that a number of priests in addition to the main priest in the Garbha-Griha chant in unison and also the instruments such as conch-shells, bells and gongs are sounded in Ardha-Mantapa.

❑ The **Ardha-Mantapa** leads to a "main hall" referred as "**Maha-Mantapa**". It is in this Maha-Mantapa where a large number of devotees assemble and participate in the worship.

Acoustical Studies of **Hindu Worship** Spaces

Floor plan of **The Narayanaswami** Temple at Melkote, Karnataka, India

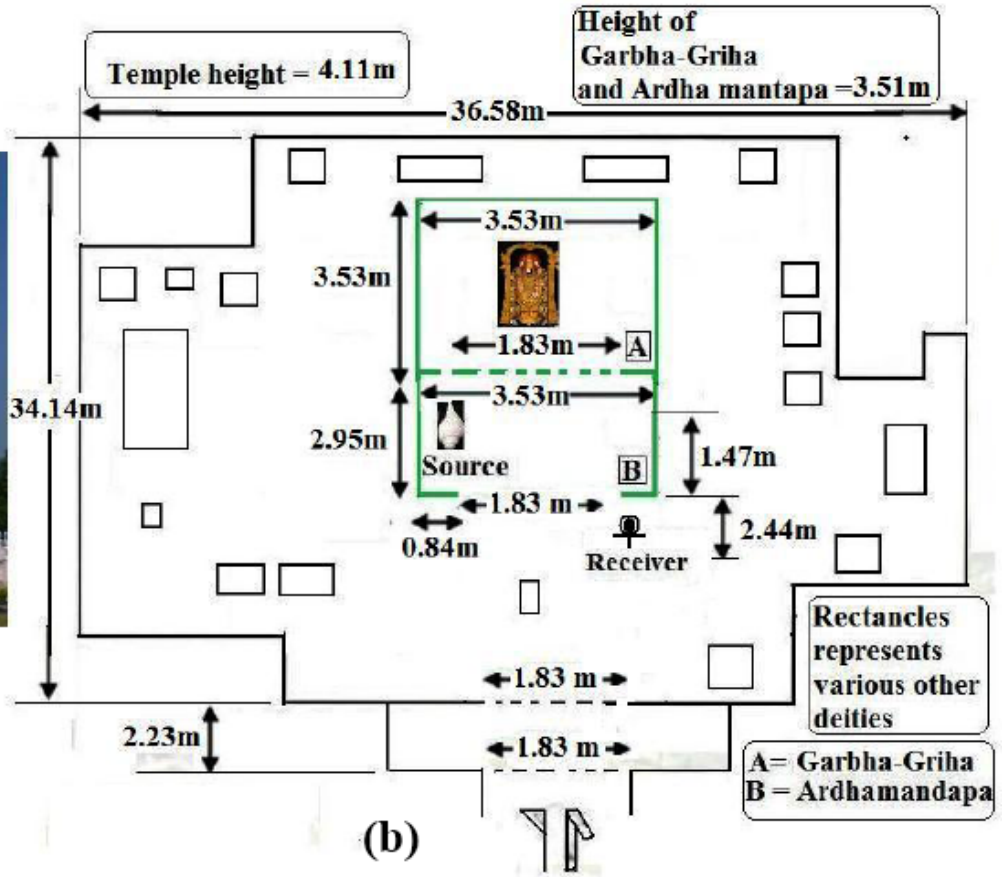


Hindu Temple and Cultural Society in the Bridgewater, New Jersey, USA

Main Deity: Sri Venkateswara

(a)

Temple



(b)

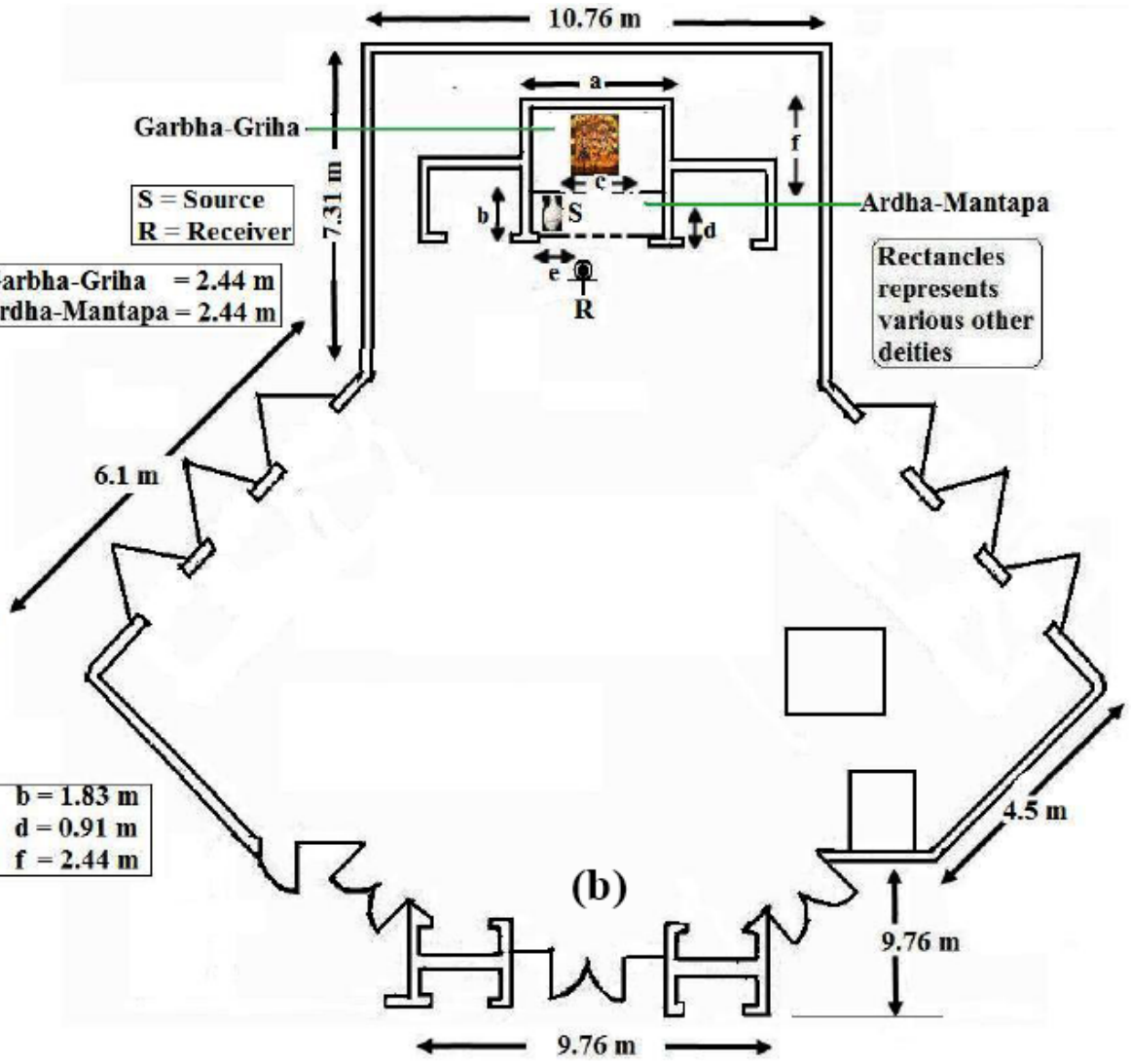
Floor Sketch View

The Hindu Temple Society of Capital District, Albany, NY, USA

Main Deity: Sri Lakshmi - Sri Narayana

(a)

Temple



(b)

Floor Sketch View

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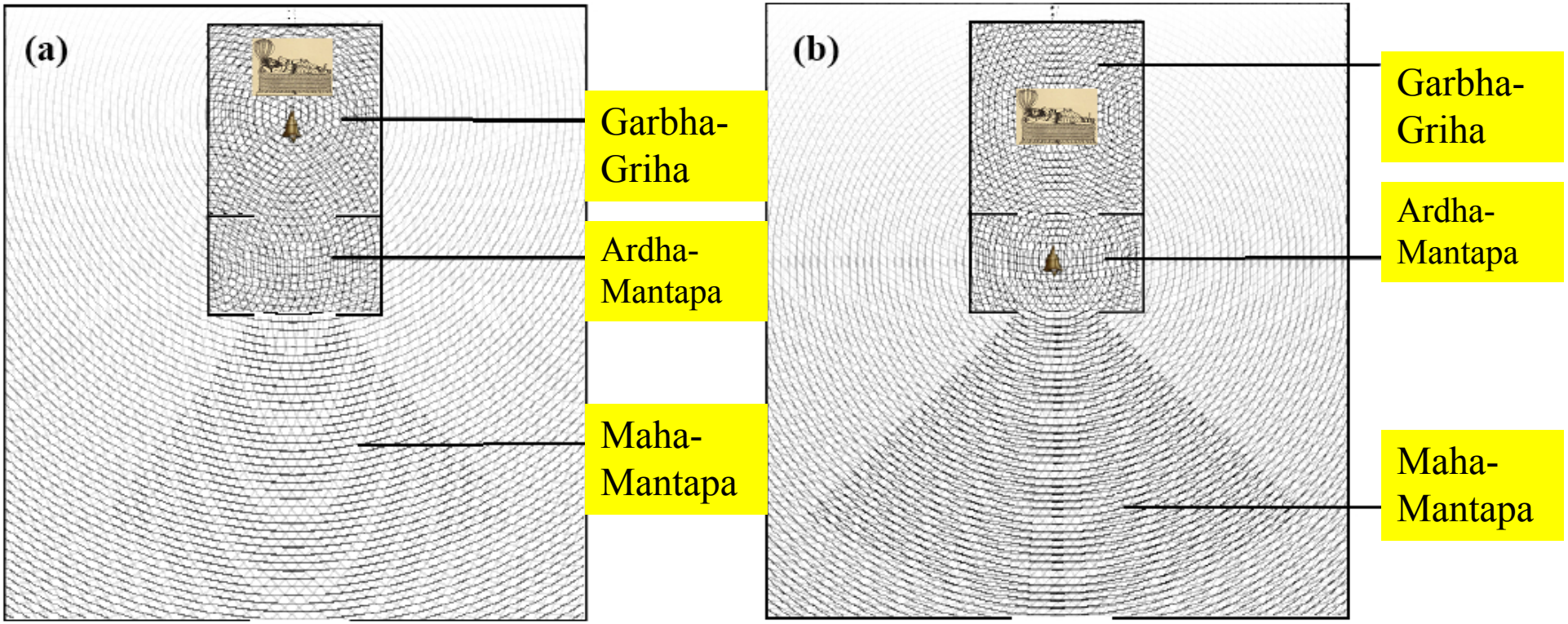
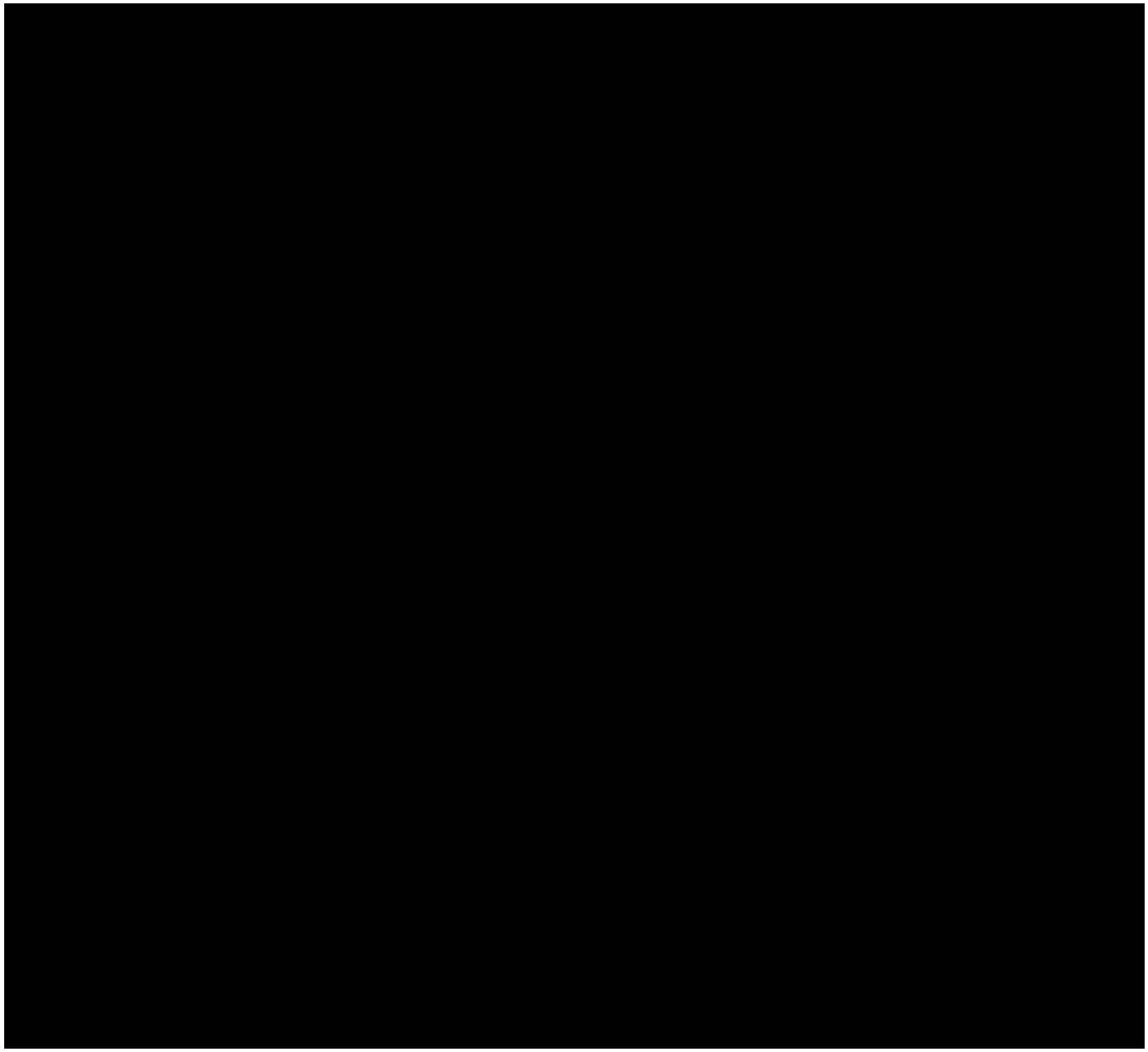
Reverberant Sound Field in **Garbha-Griha** and **Ardha-Mantapa**



Source in Garbha-Griha

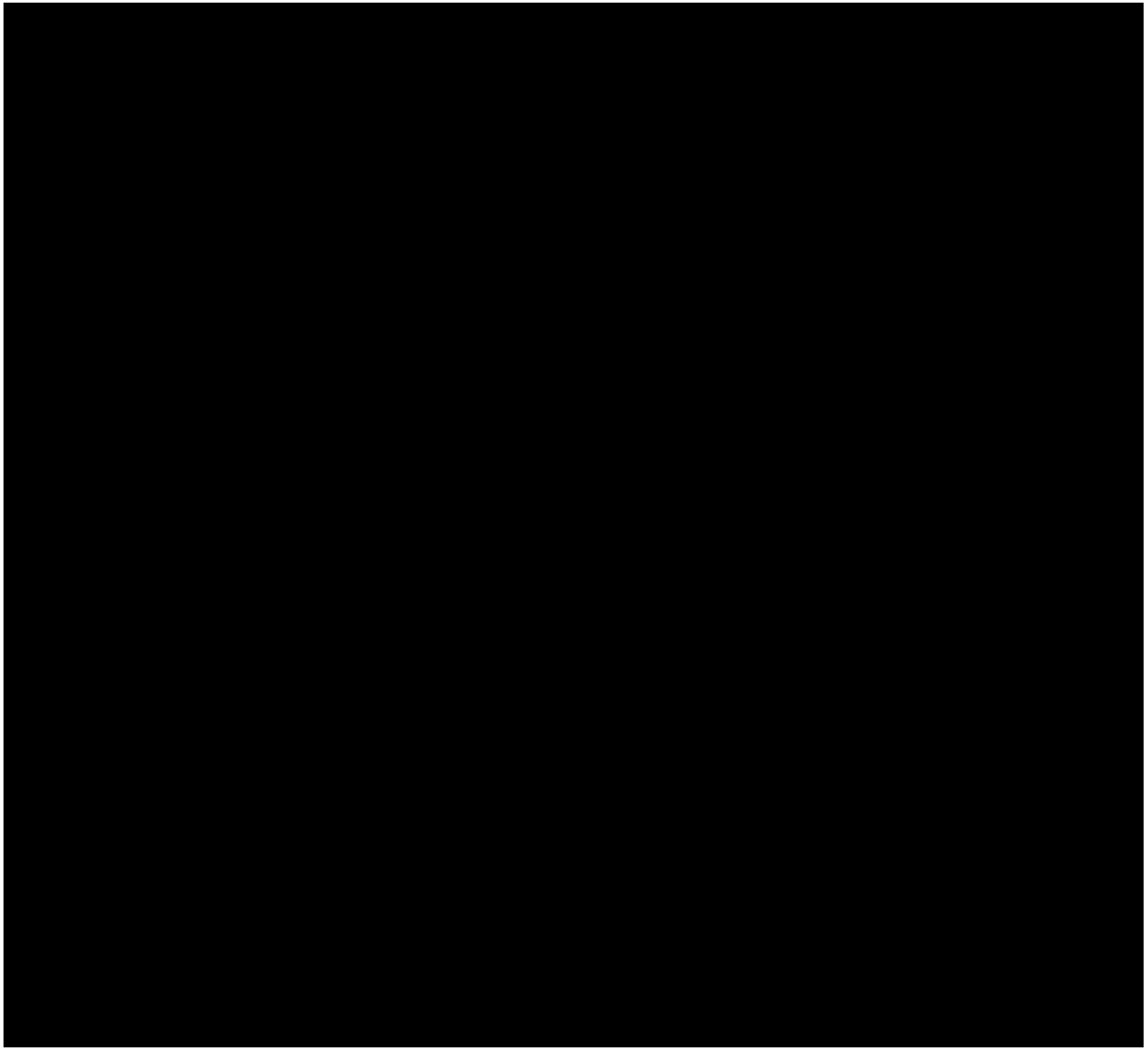
Source in Ardha-Mantapa

Reverberant Sound Field in **Garbha-Griha** and **Ardha-Mantapa**



Source in Garbha-Griha

Reverberant Sound Field in **Garbha-Griha** and **Ardha-Mantapa**



Source in Ardha-Mantapa

Modeling of **Garbha-Griha** and **Ardha-Mantapa**

If we **model** the entire **Garbha-Griha and Ardha-Mantapa** spaces as **highly reflective** and **diffuse field** then the sound pressure level (SPL) at any given point is,

$$L_{P1} = L_w + 10\log\left[\frac{4}{R}\right] \qquad \text{------ (1)}$$

If we **assume** the **space** as entirely **free field** then the sound pressure level at the corresponding point (r), close to Ardha-Mantapa for a given source of sound power level can be written as (L_w)

$$L_{P2} = L_w + 10\log\left[\frac{1}{4\pi r^2}\right] \qquad \text{------ (2)}$$

Subtracting Eqn. (2) from (1), we can obtain the **increase in SPL** of the room space as,

$$\Delta L = L_{P1} - L_{P2} = 10\log\left[\frac{16\pi r^2}{R}\right] \qquad \text{------ (3)}$$

$R = S\bar{\alpha}/(1-\bar{\alpha})$ is the Room constant, m^2

Surface area (S) in m^2, $\bar{\alpha}$ s average absorption coefficient.

Estimated **Reverberation Time** and increase in **Sound Pressure Levels at** various Hindu Temples

	Temple (Bridgewater, NJ)			Temple (Albany, NY)			Temple (Melkote, India)		
	Volume	T_{60}	ΔL	Volume	T_{60}	ΔL	Volume	T_{60}	ΔL
Ardha-Mantapa	36.18	1.09	22.93	10.87	0.58	13.9	24.84	0.92	21.9
Garbha-Griha	43.86	1.14	22.32	19.93	0.68	14.5	18.11	0.61	21.5
Combined	80.02	1.12	19.62	30.80	0.63	11.2	42.95	0.76	18.7

$$T_{60} = \frac{0.161V}{S\bar{\alpha}}$$

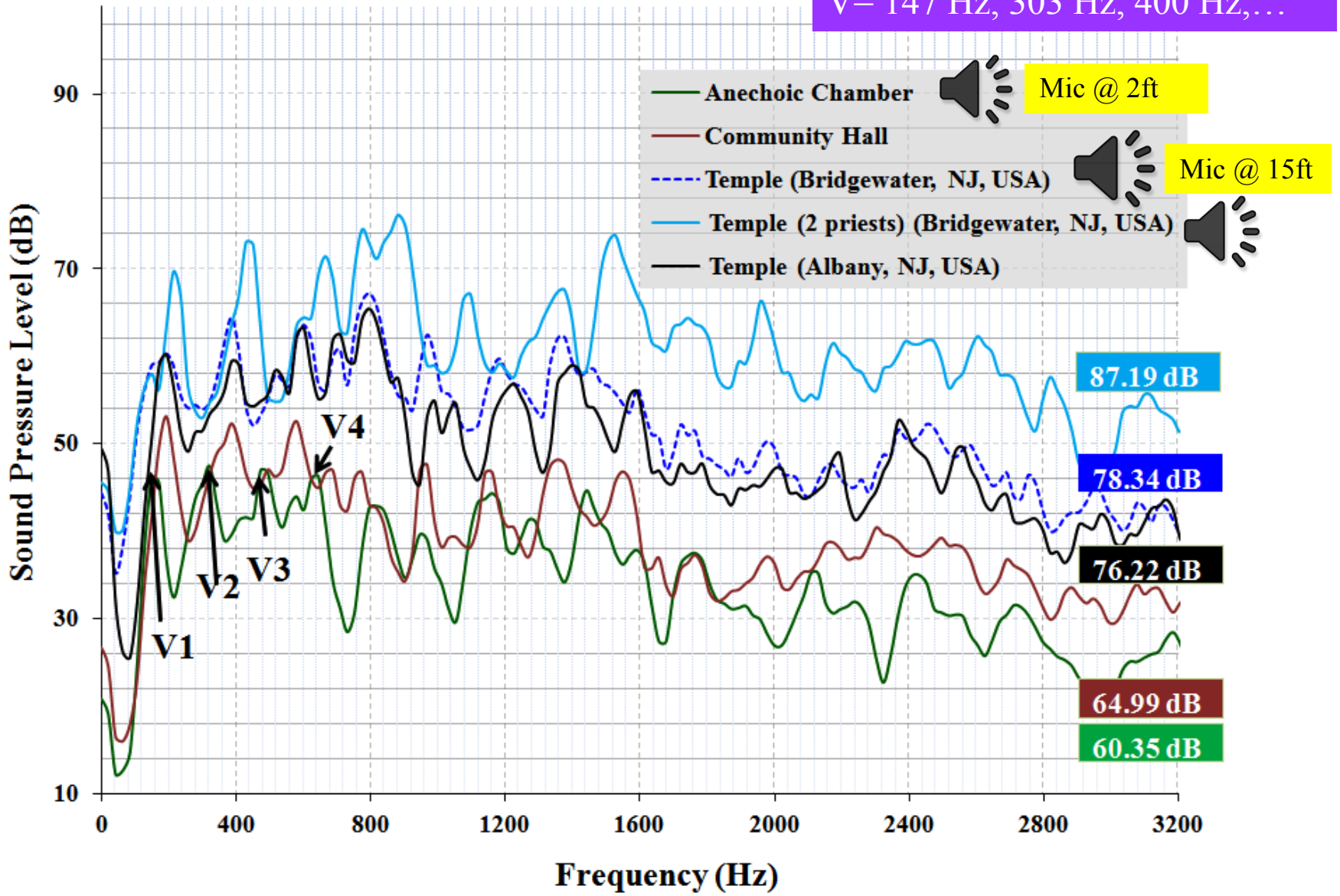
Volume (V) in m^3, T_{60} in sec, ΔL in dB

Surface area (S) in m^2, $\bar{\alpha}$ is average absorption coefficient, 0.015 for granite walls, 0.4 for person

Spectral Analysis of **Vedic Chanting**

Spectra of **Vedic-Chanting** (alone)

V= 147 Hz, 303 Hz, 400 Hz,…



ΔL (measured) = 18 dB, ΔL (theoretical) = 19.6 dB

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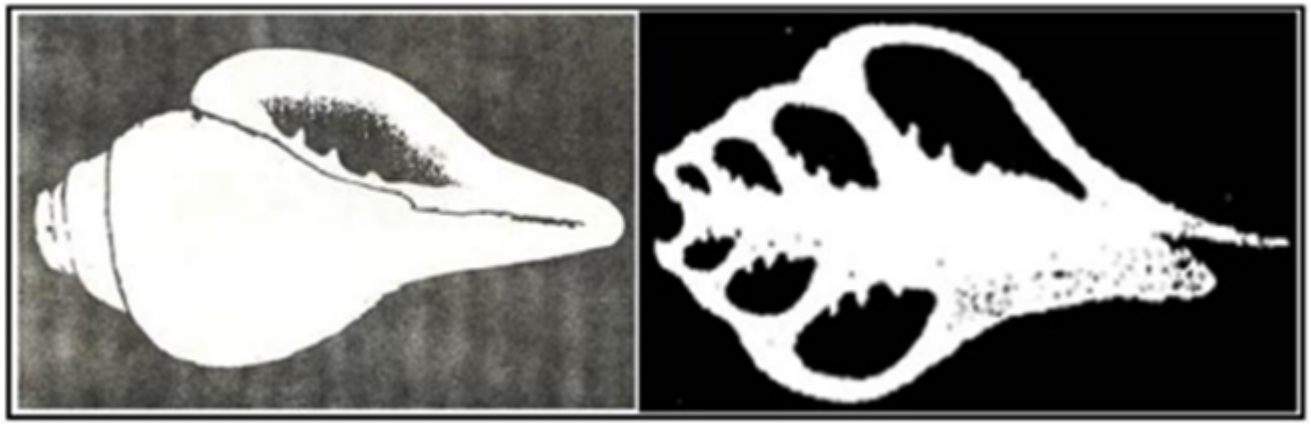
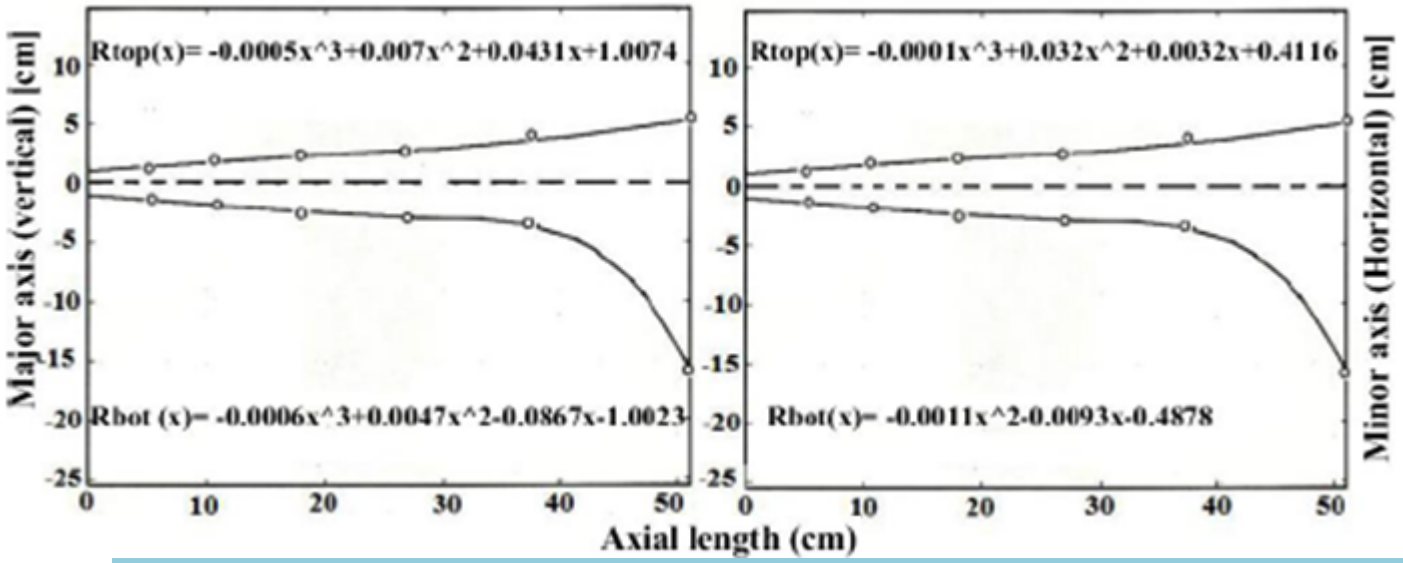
Spectral Analysis of **Conch-Shell**

Conch-Shell Internal Structure

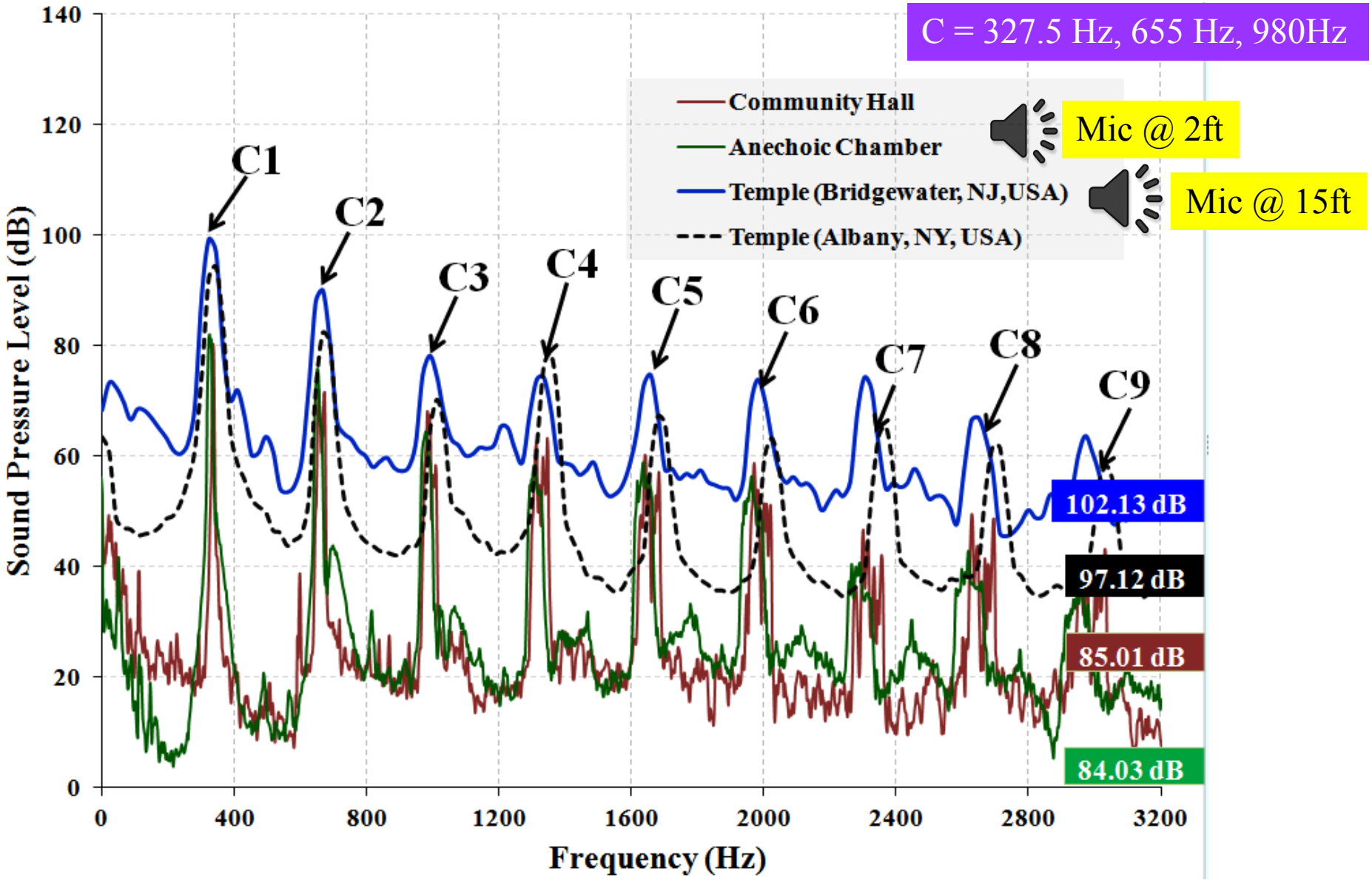


X-Ray tomography



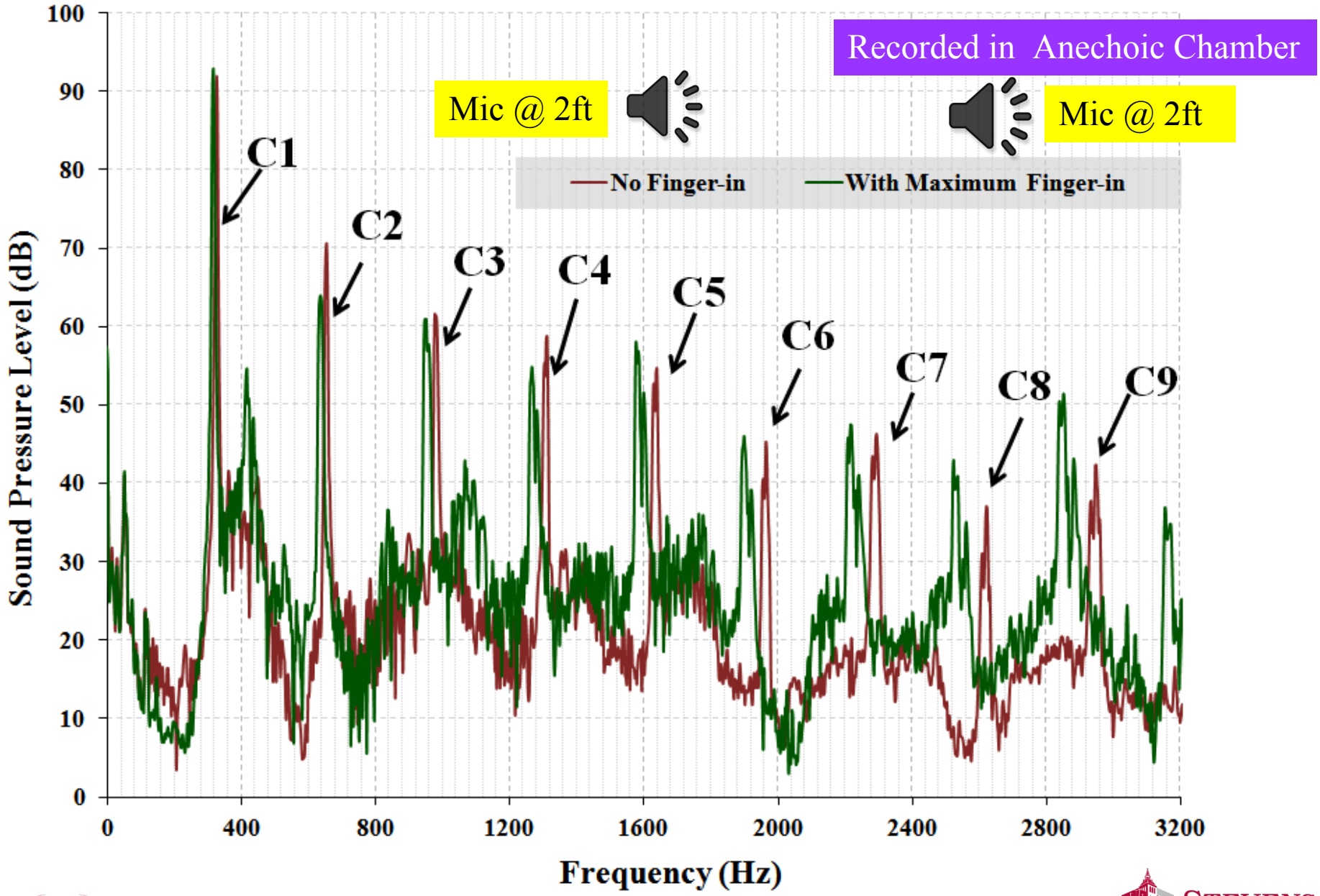
Straightened conch-shell cavity profile (major and minor axis)

Spectra of a **Conch-Shell** (sounded alone)



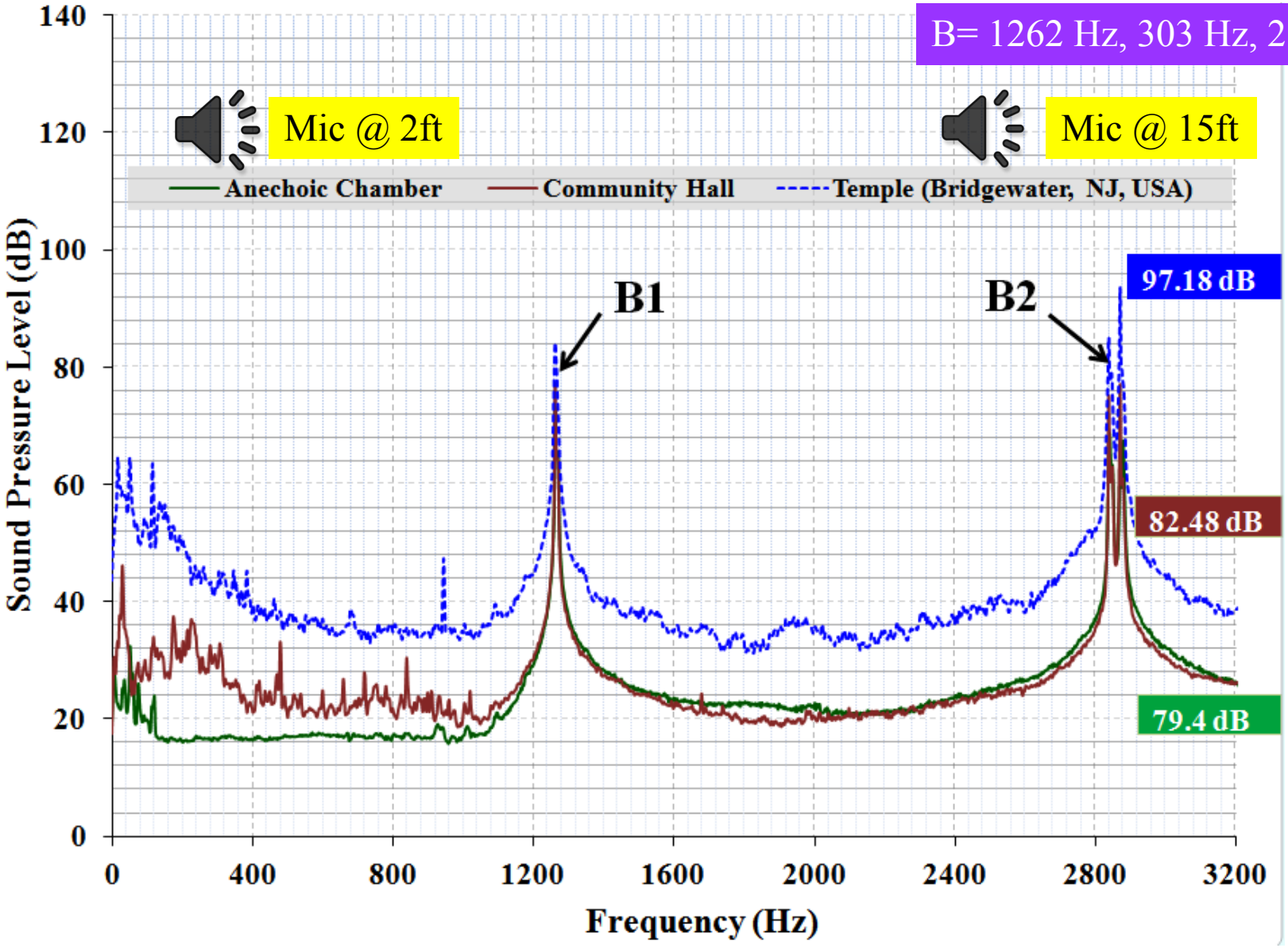
ΔL (measured) = 18.1 dB, ΔL (theoretical) = 19.6 dB

‘Finger-In’ Effect on Conch-Shell Spectra



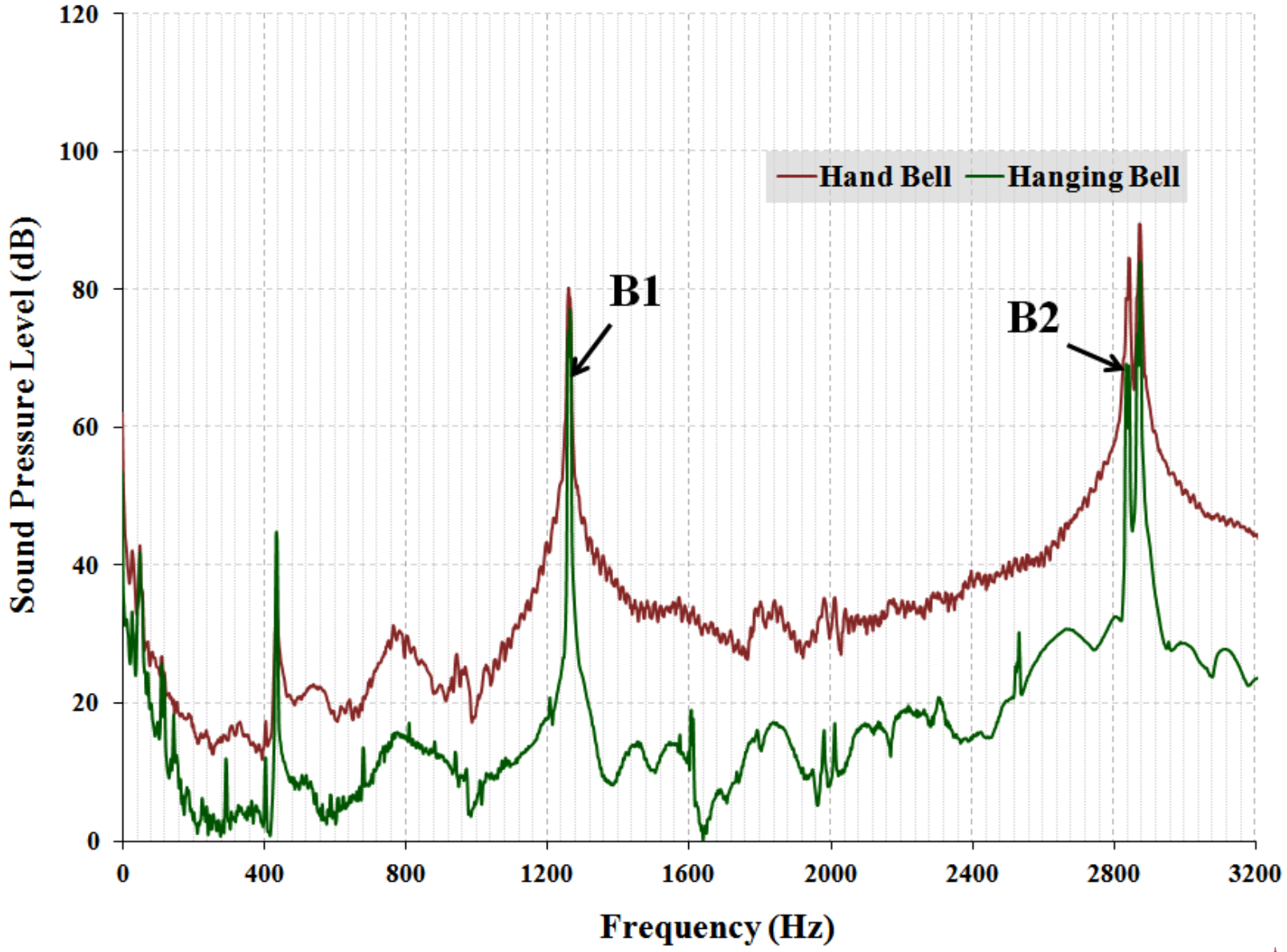
Spectral Analysis of **Bell**

Spectra of a **Hand-Bell** (Sounded Alone)

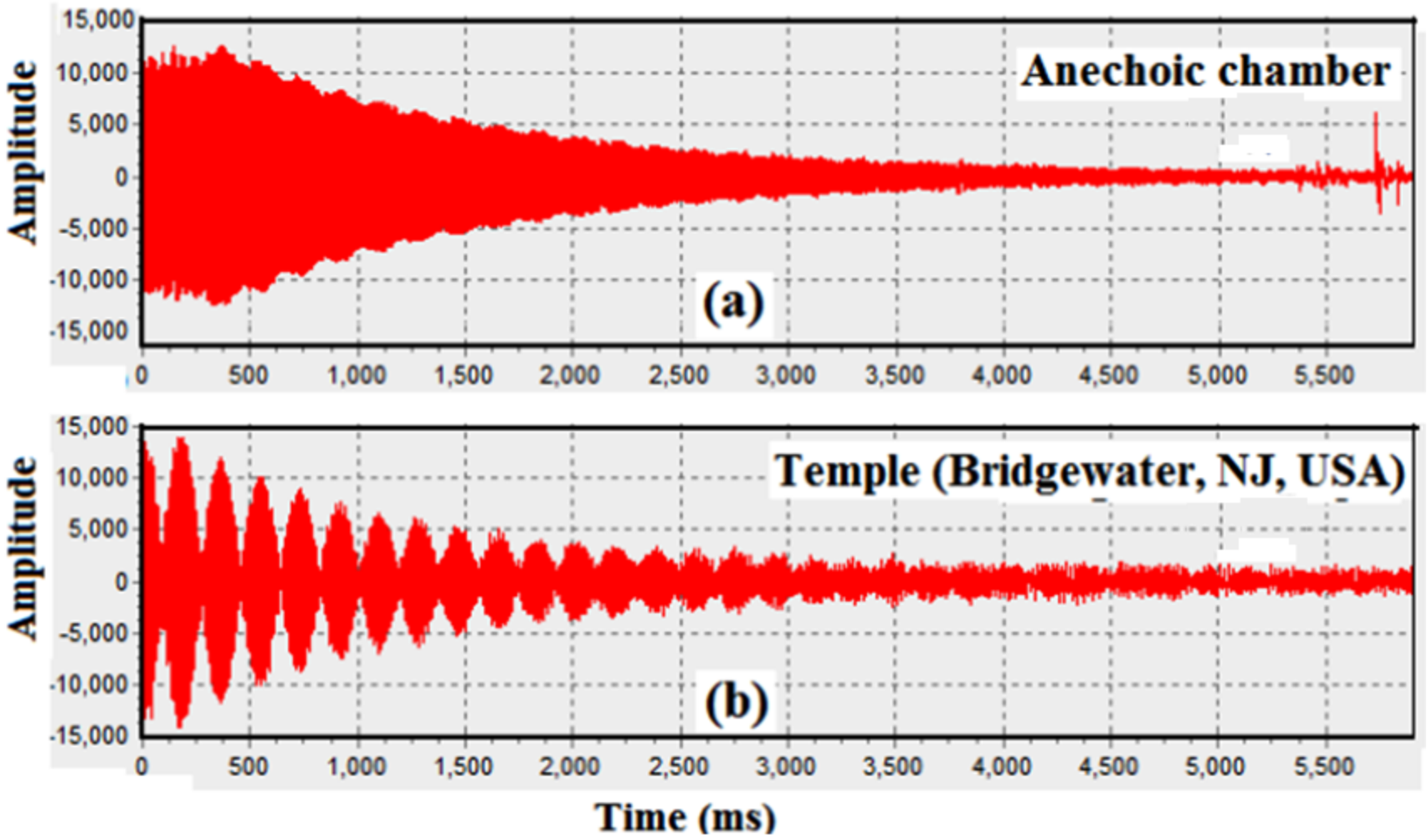


ΔL (measured) = 17.8 dB, ΔL (theoretical) = 19.6 dB

Spectra of **Hand** and **Hanging**-Bells

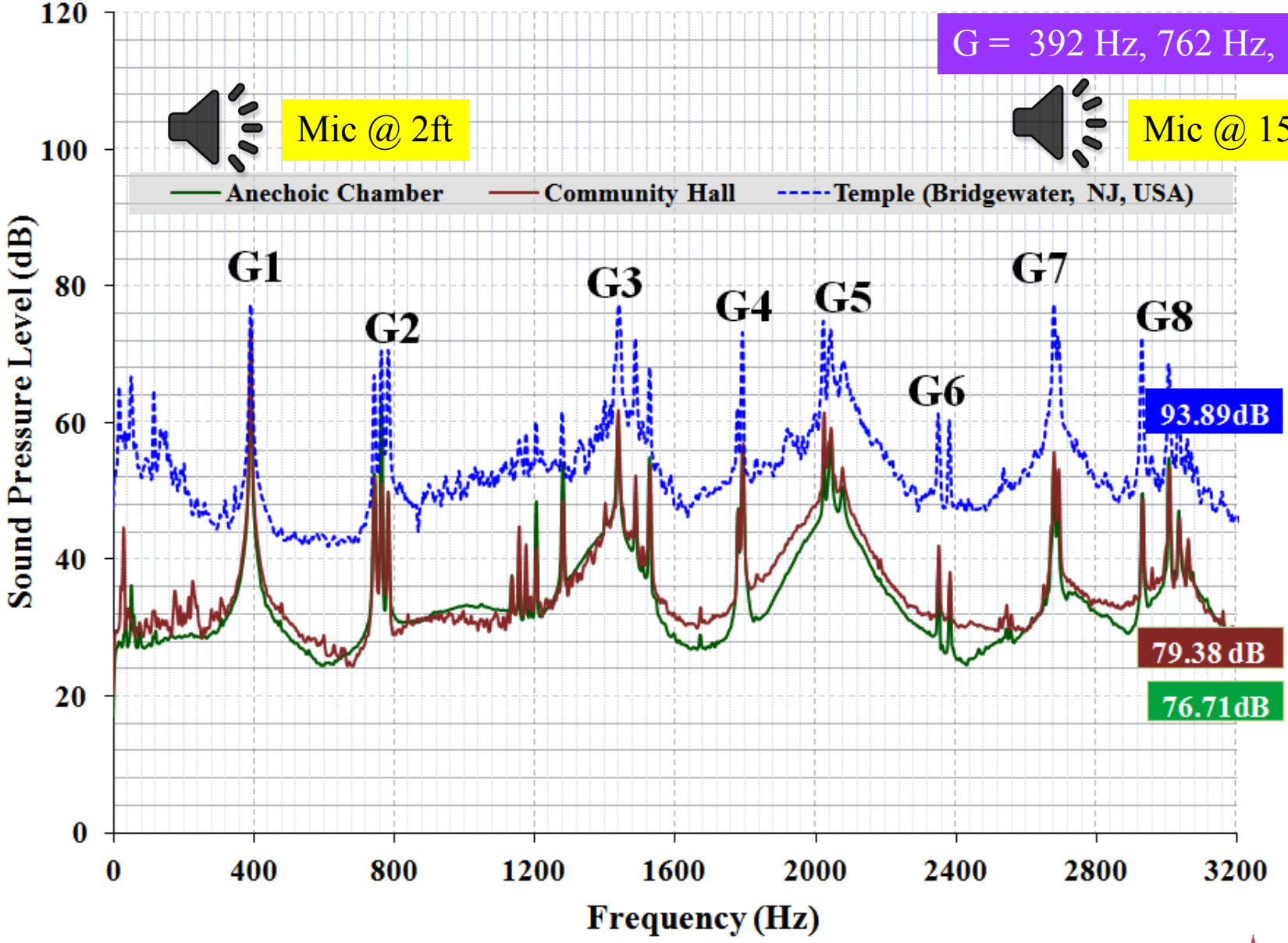


Impulse Response of **Hand-Bell**



Spectral Analysis of **Gong**

Spectra of a **Gong** (Sounded Alone)



ΔL (measured) = 17.2 dB, ΔL (theoretical) = 19.6 dB

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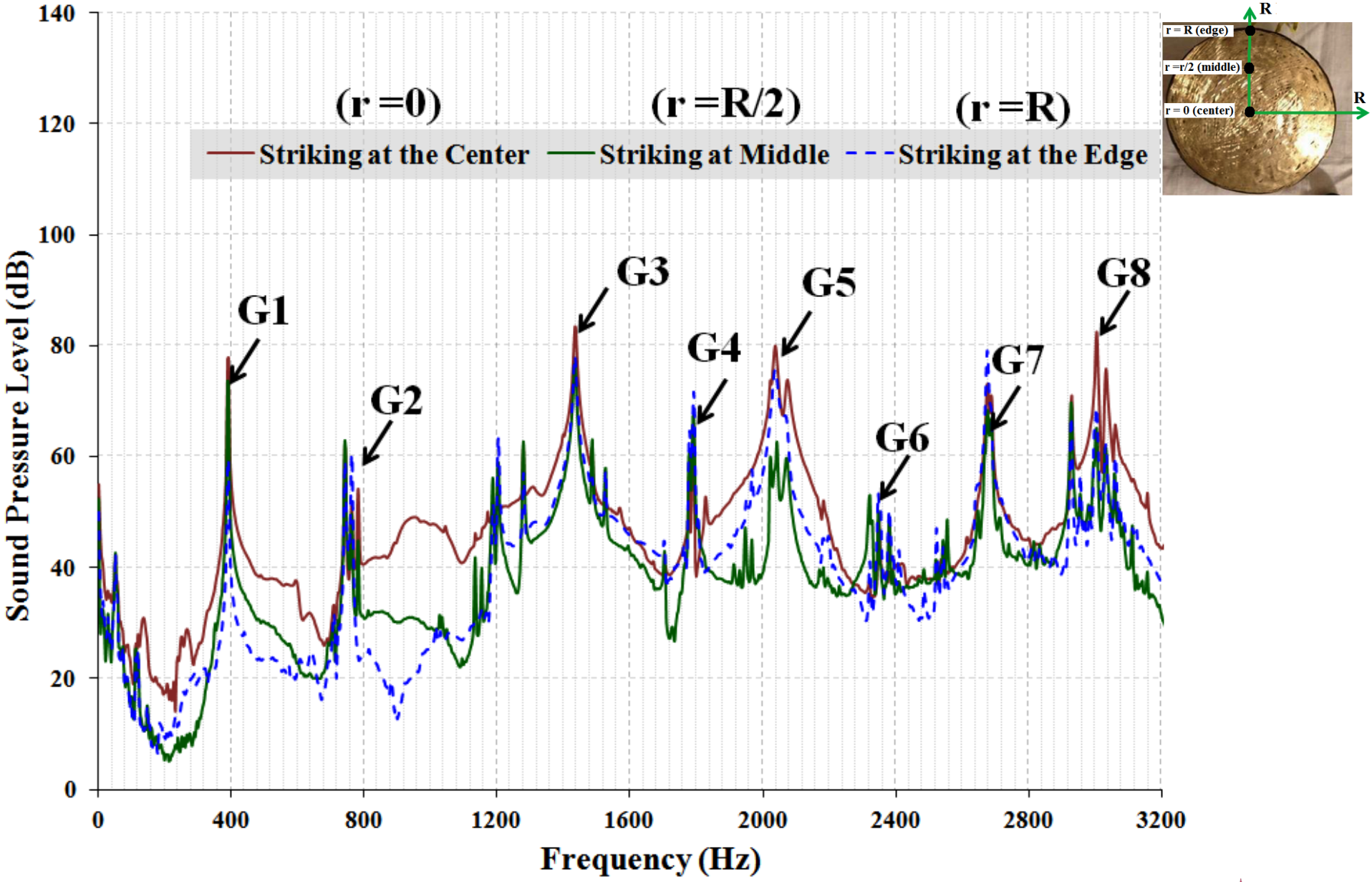
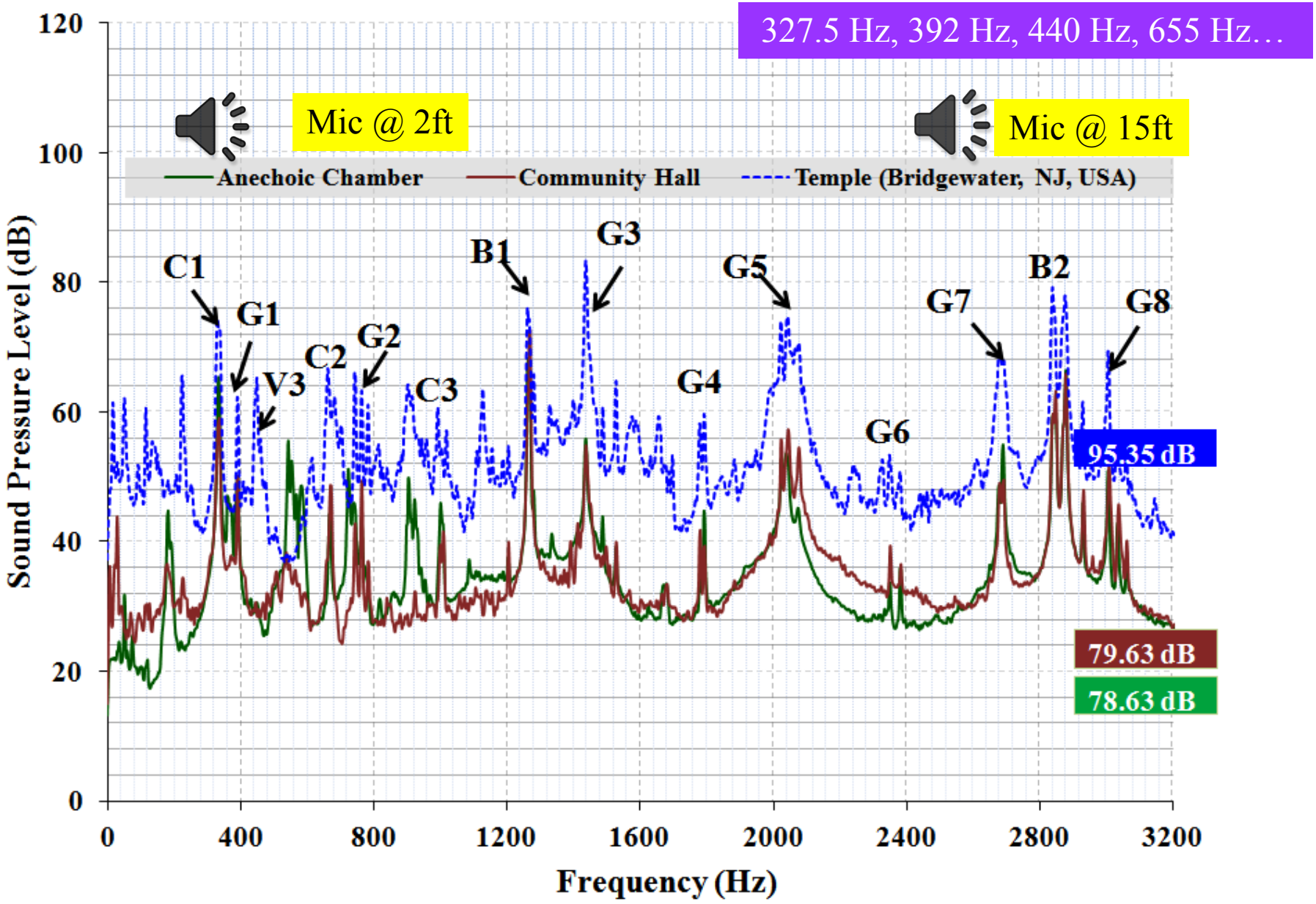
Spectra of a Gong when Stroked at Different Places



Spectral Analysis of **Chant**, **Conch-Shell**, **Bell** and **Gong**

Spectra of **Chant**, **Conch-Shell**, **Bell** and **Gong** (Simultaneously Sounded)



ΔL (measured) = 16.7 dB, ΔL (theoretical) = 19.6 dB

Summary of Observed Sounding Frequencies

Type of Instrument	Observed Frequency (Hz)
Vedic chant (alone)	147.5, 302, 440
Conch-Shell (sounding alone)	327.5, 655, 980, 1302.5, 1637, 1965, 2292.5
Bell (sounding alone)	1262.5, 2877.5
Gong (sounding alone)	392, 762, 1437, 1792, 2070, 2350, 2675, 3002
Simultaneous sounding of Vedic chant, Conch-Shell, Bell and Gong	327.5, 392, 440, 655, 762, 980, 1262.5, 1437, 1792, 2070, 2350, 2675, 2877.5, 3002

Conclusions

- **Sound** plays a very important role in **Hinduism** and **Hindu worship spaces**.

- In addition to **Vedic chants**, musical instruments such as **Conch-Shells, Bells** and **Gongs** are also very commonly used to **enhance the spiritual** experience of the devotees during the worship.

- The measured spectra of chants and instruments show that the frequencies are spread across the active hearing range, which **helps focusing of mind** and further contribute to the spiritual experience of the devotees.

- The study shows that the highly reverberant characteristics of both **Garbha-Griha** and **Ardha-Mantapa** significantly enhance the acoustical environment and also enrich the spiritual experience of the devotees in Hindu Temples.

Acknowledgement

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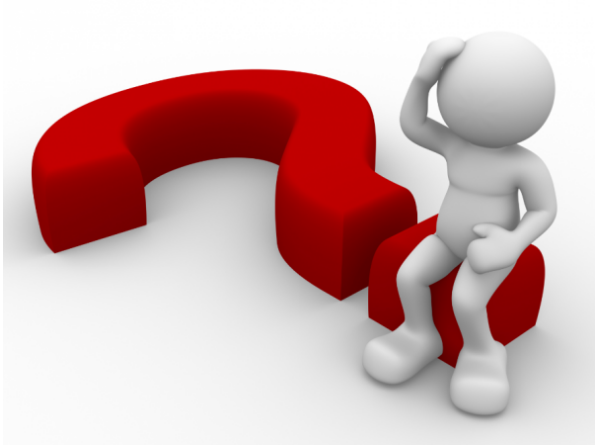
- The authors thank **Sri Vivek Vasanth**, Sri **Sunil Iyengar** and Prof**. Robert Harari** (at Stevens Institute of Technology, Hoboken, NJ) for their help and discussions.
- The authors also thanks **Sri Siva Lakshmanarao Kakarala**, **Sri Naidu Bonthu** and the priests **Vidwan Pramod Acharya** and **Vidwan Sriram Acharaya** of the Hindu Temple and Cultural Society in **Bridgewater, New Jersey** and **Sri Mattur Balakrishna** of the Hindu Temple Society of Capital District in **Albany, New York** for their help in making acoustic measurements.

Thank You!



Additional Slides

Role of Acoustics in Vedic Hindu Tradition and Philosophy

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Acoustical knowledge of ancient "Hindus"

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Shiva Panchaakshari mantra

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क्रमपाठः

नमः शिवायं। शिवायं च।

जटापाठः

नमः शिवायं शिवाय नमो नमः शिवायं। शिवायं च च शिवायं शिवायं च।

घनपाठः

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Two Bramhans (Two Manifestations of GOD)

द्वे ब्रह्मणीवेदितव्ये शब्दब्रह्म परम् च यत्
शब्दब्रह्मणि निष्णातः परं ब्रह्माधिगच्छति
ॐ तत्सत्

There are two manifestations of GOD (Bramhan) to be realized: Shabda (Sound) and Param Bramhan (Light). One who has realized and is well versed in Shabda Bramhan will realize Param Bramhan ...

(Amrita Bindu Upanishat)

Consciousness

चैतन्यं सर्व भूतानां शब्द ब्रह्मेति मे
मतिः

Consciousness (Chaitanya) in all beings is Shabda Bramhan according to me ...

Lakshmana Deshika in Sharada Tilaka

चैतन्यं सर्व भूतानां विवृतं जगदात्मना
नाद ब्रह्मतदानन्दं अद्वितीयमुपास्महे
संगीत रत्नाकर (सारन्गदेव)

We worship the "Nada Bramhan" second to none which is blissful and is in all beings as consciousness and has expressed (manifested) itself as universe ...

Sangita Ratnakara (Saranga Deva)

चत्वारि वाक् परिमिता पदानि
तानि विद् ब्राःमना ये मानिषेण
गुहा त्रीणिनिहिता नेग्यन्ति
तुरीयं वाचो मनुष्या वदन्ति

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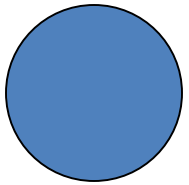
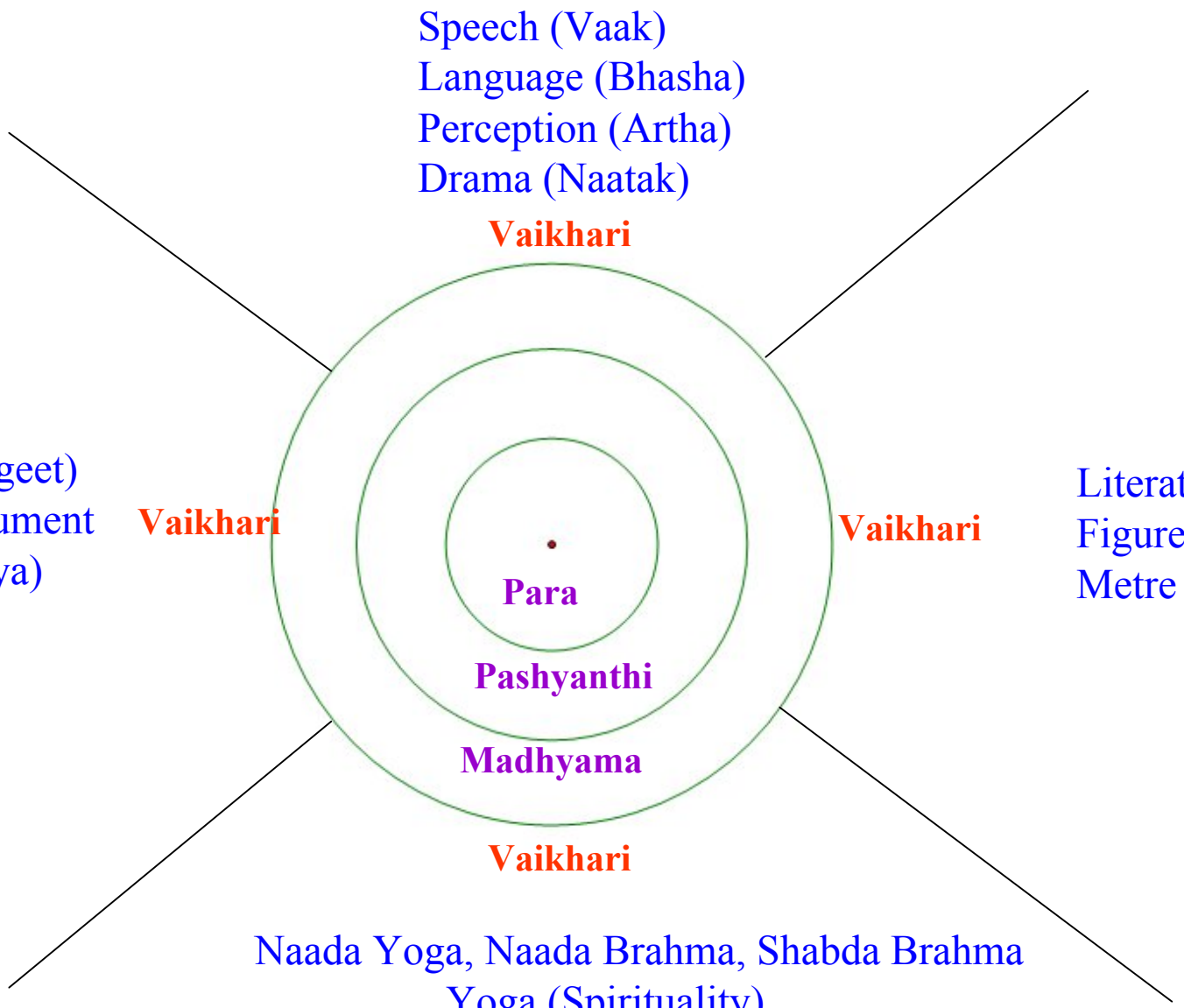
वैखरी	Vaikhari (Manifested)	

Speech, Music, Literature and Yoga



How Sound of Speech Manifests

आत्मा विनक्ष्माने यं मन प्रे षयति मनः
नाभि स्य वन्नि मादन्ति स प्रे रयति मारु तं
ब्रह्मग्रन्थि स्थितो नादः क्रमादुघ्र्ने पाये चरन
नाभि द्रु त कण्ठ मु र्ध म् ये दन्तिर्भ वति त ध्वनिम्

An individual (soul) with a desire to speak encourages the mind. The mind strikes the heat (fire) center at the navel, which then pushes the air (wind). the sound (NADA) energy then gradually moves up through stomach, heart, throat, mouth as audible sound...

Ganarahasya Prakashini

Manifestation of Sound

वैखरी शब्द निष्पत्तिः मध्यमा स्मृति गोचराः
द्योतिकार्थस्य पश्यन्ती सूक्ष्मा ब्रह्मैव केवलं

Vaikhari is word manifestation. Madhyama is at memory level. Pashyanti is intentive level. Pure causal is Para.

मूलाधारात्प्रथाम मुदितो यस्तु भावः पराख्यय

पश्यात्पष्यन्तमय दुदयगां बुद्धियु द्ध्यमा
वक्त्रं वैखार्य यरु दिष्तांरस्य जन्तो सुषुम्ना
बदस्तस्मात्प्रति पवन प्रेरितो वर्णसन्घः

The manifested air driven letters and assemblies first are caused at Mulaadhaar, then at heart as Pashyanti, then at intelligence as Madhyama (before it manifests) then as Vaikhari. All this happens in Sushumna of beings

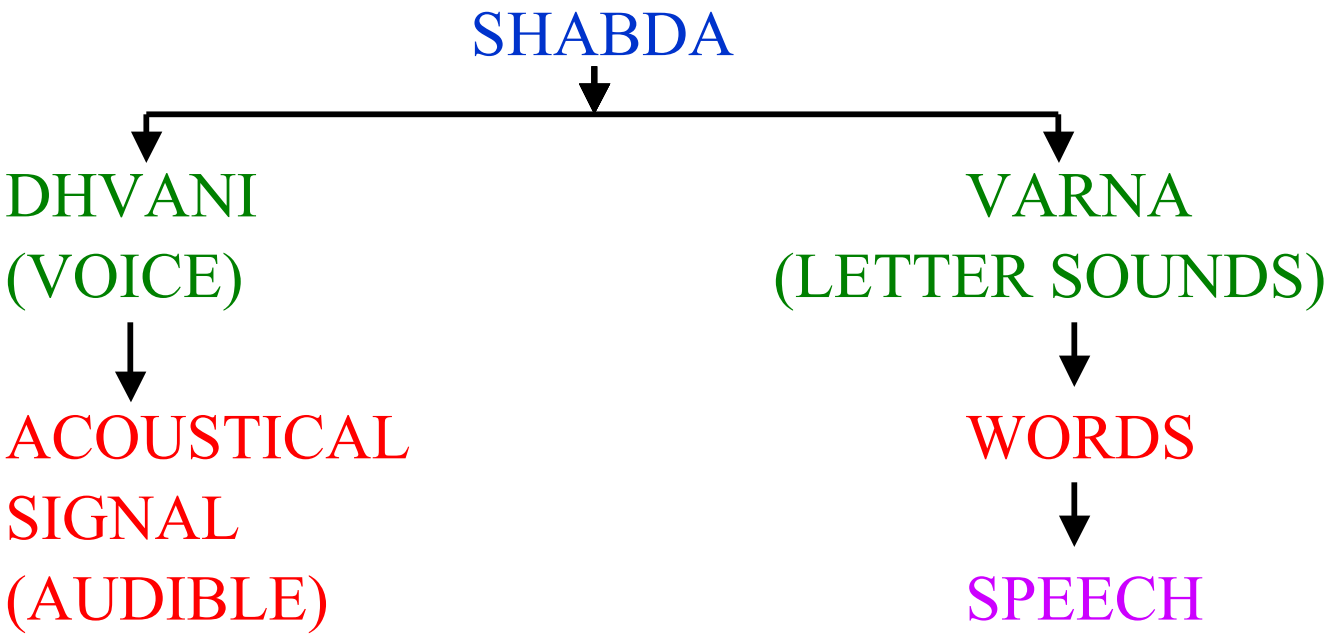
परावाङ् मूलचक्रस्था पश्यन्ती नाभिसंस्थिता
हृदिस्था मध्यमा ज्ञेया वैखरी कण्ठदेशगा:

The Para stage of speech is at base of the spine. Pasyanthi stage is at the navel. Madhyama stage at the heart and Vikhari is at the throat.

Shabda

शब्दो ध्वनिश्च वर्णाश्च मृदङ्गादिभावो ध्वनिः
काष्ठ संयोग जन्मनो वर्णास्ते कादयो मतः

भाषा परिच्छेद



Hierarchy of Elements, Senses and Perception

ATMAN

↓

SPACE	SOUND	EARS
↓		
AIR	TOUCH	SKIN
↓		
FIRE	SIGHT	EYES
↓		
WATER	TASTE	TONGUE
↓		
EARTH	SMELL	NOSE

' SOME CONCEPTS '

* SOUND IS A PROPERTY OF SPACE

* AIR IS CARRIER OF SOUND

* SOUND (WITH FORM) IS LETTER

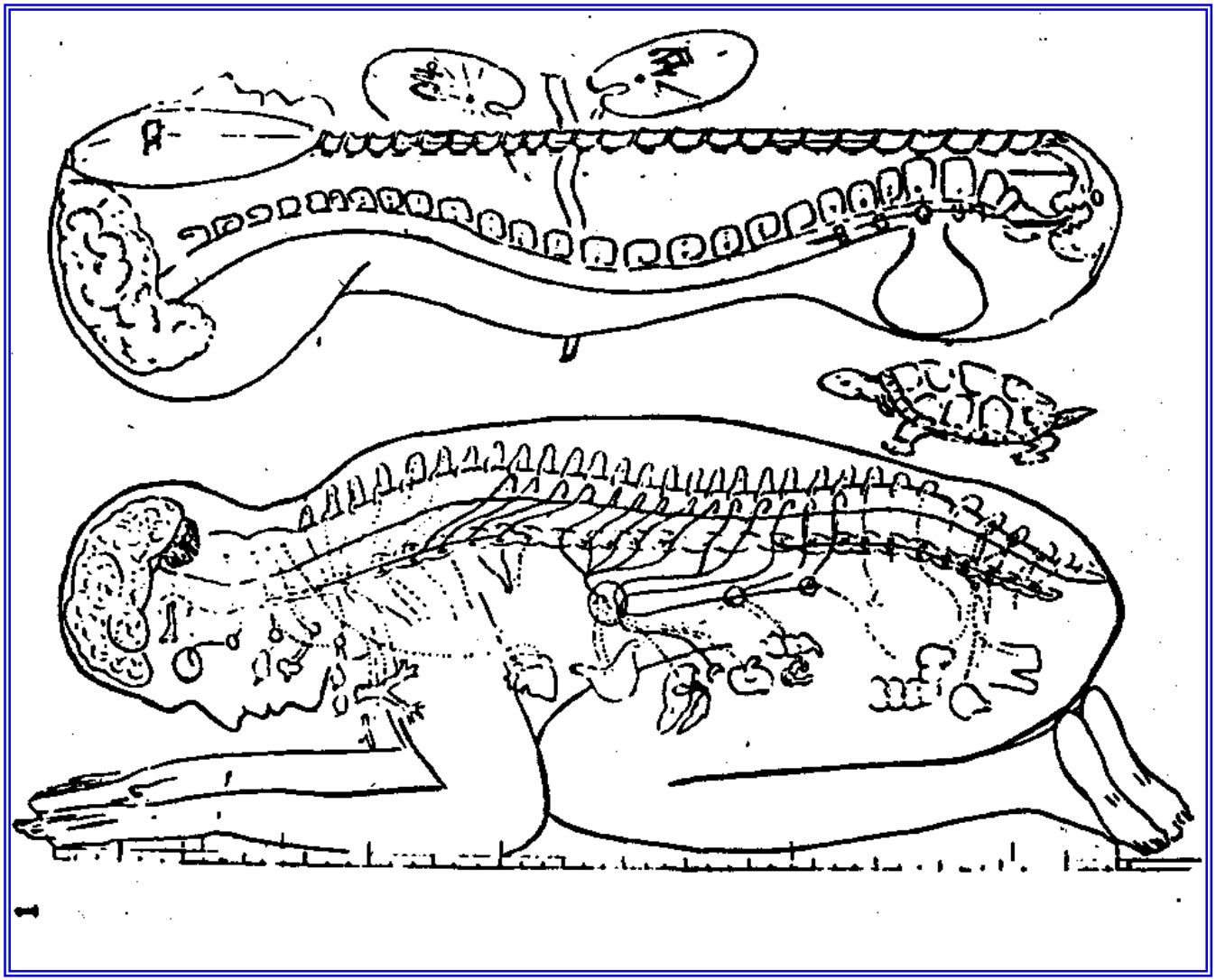
* SOUND (PHYSICAL) IS GENERATED THROUGH HEAT-AIR UNISON

* SPEECH IS THE FOURTH STAGE IN SOUND PRODUCTION

* SOUND PROPAGATES SPATIALLY

* SOUND (NAME/WORD) AND MEANING ARE INSEPARABLE

Human Body as a Musical Instrument VEENA



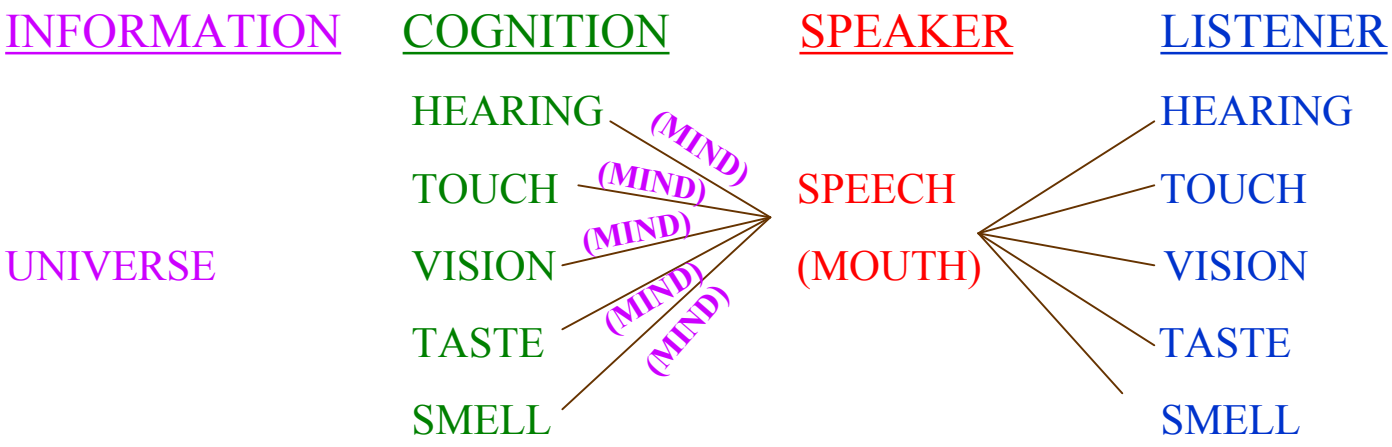
Ref: Sriranga sadguru in “Amaravani”

Cognition and Listening

FIVE ORGANS OF COGNITION
EMANATING FROM THEIR SOURCE, THE
MIND, LIKE FIVE RIVERS SPEED ONWARD
TO SPEECH. THE FLOWING SPEECH, IN
ITS DWELLING PLACE, THE MOUTH
BECOMES FIVE FOLD.

YAJURVEDA XXXIV-II

पञ्चाद्यः सरस्वती मपि यन्ति सस्रोतसः
सरस्वती तु पञ्चधा सो देशो भवत्सरित



Sound as an Effective means for Spiritual Development

सदा शिवो कानि सपादलस लया व धानानि वसन्ति लोक
नादानु सन्धान समाधि मेकं मन्यामहे मान्यतमं लयानप

There are innumerable approaches to attain spiritual development and bliss. However its our view that the approach through sound is most effective.

सर्व चिन्तां परित्यज्य सावधानेन चेतसा
नाद वानु संधे यो योग साम्रा ज्य मिच्छ्हता

The one who wishes to achieve excellence in yoga should concentrate attentively on “sound” by overcoming distractions.

योग तारावली शङ्करा चार्य
(Ref : Shankaracharya in “yoga taravali”)

Concluding Remarks

- The four fold description of sound production in Vedic Hindu literature can be used to describe the Consciousness

- Sound plays a major role in spiritual development of human beings in addition to its important role in arts and culture

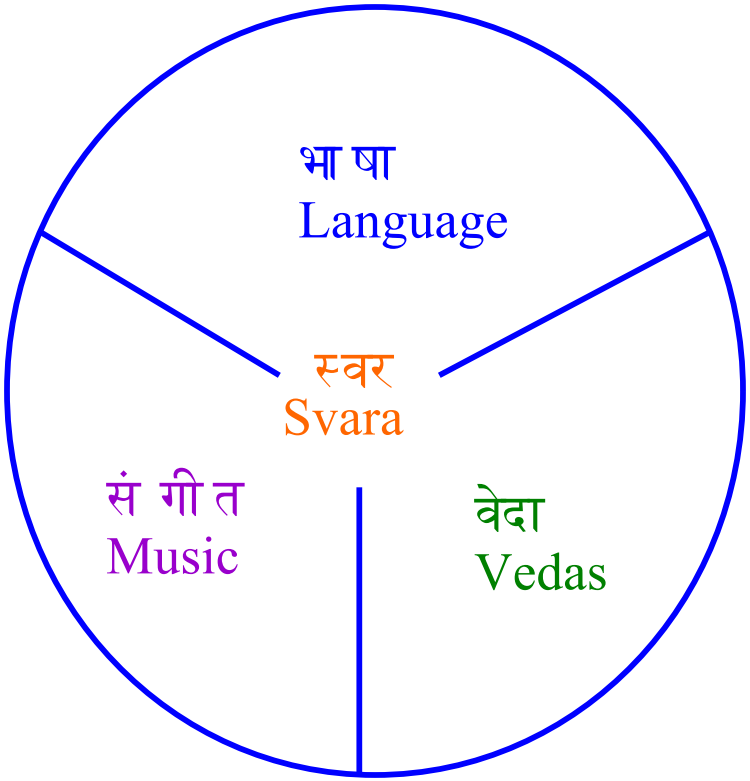
- Further work is needed to investigate the relationship of acoustics to Consciousness

Thank You!

Veda Mantras

- *Mantras (chants) are orally transmitted from teacher to disciples.*
- *Precision in intonations and phonetics.*
- *Intrinsic pitch difference can be overridden*
- *Provides experience and meaning.*
- *Oral transfer of knowledge through ages through memory*

Notes or Intonation or Vowels in Music language and Mantras



स्वर्य ते इ ति स्वर
It Sounds, So it is Svara

Matra Laxanam
मा त्रा लक्षणम

Sabda Bramha

ॐ
नित्यानन्द वपु र्निसन्तर्ग ल्रात पत्र्याष्दर्ने : क्रमात्
व्याप्तं ये न चराचरात्मकमिदं शब्दार्त : रूपं जगत
शब्द ब्रह्म यद्दि चरं सु कृ तिनः चै तन्यमन्तर्ग तं
तद्वो नादनिषं शशाङ्क सदनं नायांधीषं महः
शारदा तिल्क तन्त्रं
लद्मण देसिकेन्द्र

May the great one, which has perennial corten bliss as its body, which has pervaded all the animate and inaniate universe through word and meaning from alphabets continously flowing from it, which is inner consciousness (Chiathnaya) in the physical bodies refered as “Shabda Bramha” by the blessed ones, that (great one) controller (Lord) of speech, residing in moon protect all of

Sharda Tilaka Tantraman

Lakshmana Lessikama