

# Development and animal experiment of variable focusing HIFU system for prostate cancer treatment

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# History of development

## First Step

- Unified therapy and imaging transducer
- Fixed focal length HIFU system

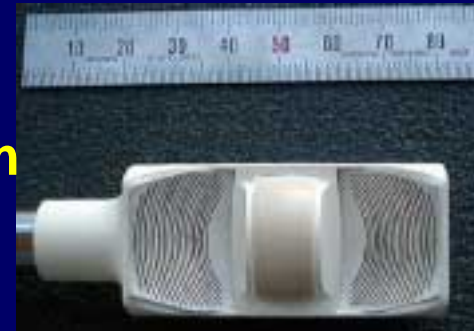
73<sup>rd</sup> Annual meeting of Japan Society of Ultrasonics in Medicine (2000)



## Second Step

- Annular array variable focal length HIFU system

AIUM 45<sup>th</sup> Annual Convention (2001)



## Third Step

- Linear array & cylindrical lens
- 32ch array variable focal length HIFU system

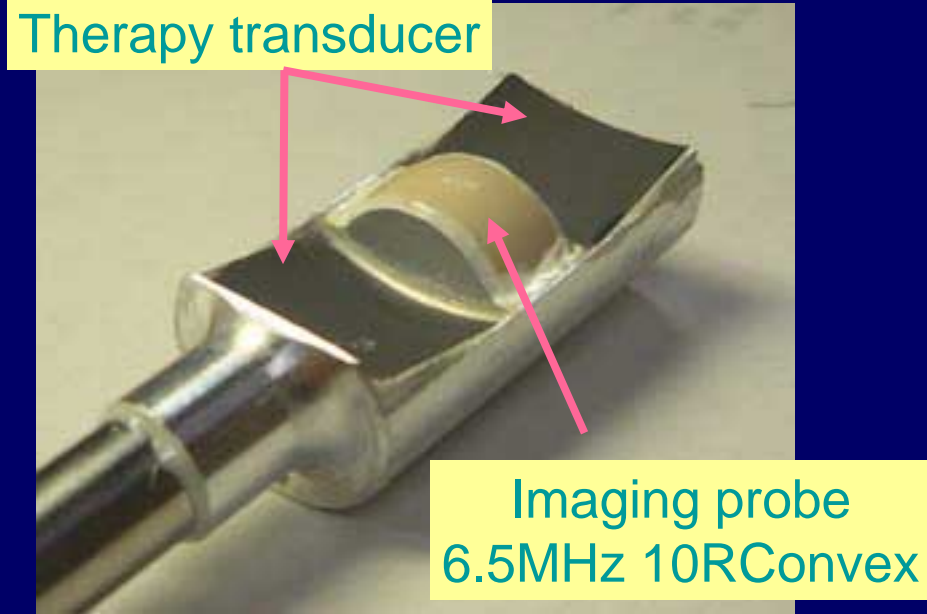
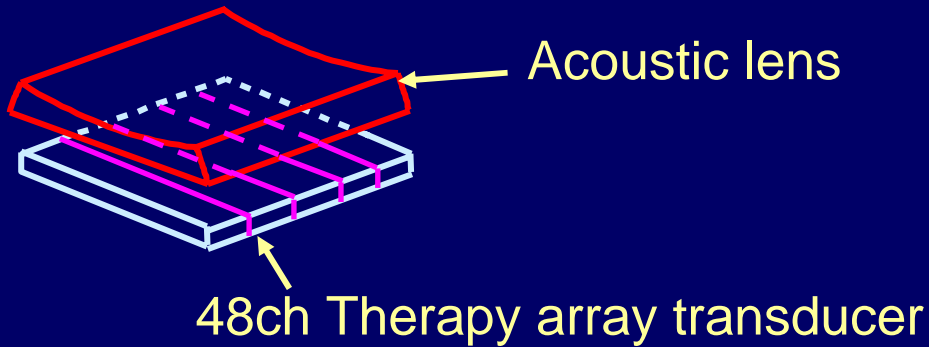
2<sup>nd</sup> ISTU (2002)



# Objective

A prototype variable focal length array transducer system for a high-throughput HIFU (high intensity focused ultrasound) has been developed and animal experiments have been carried out in order to demonstrate an ability to treat prostate through rectum.

# Structure of Variable Focus HIFU probe

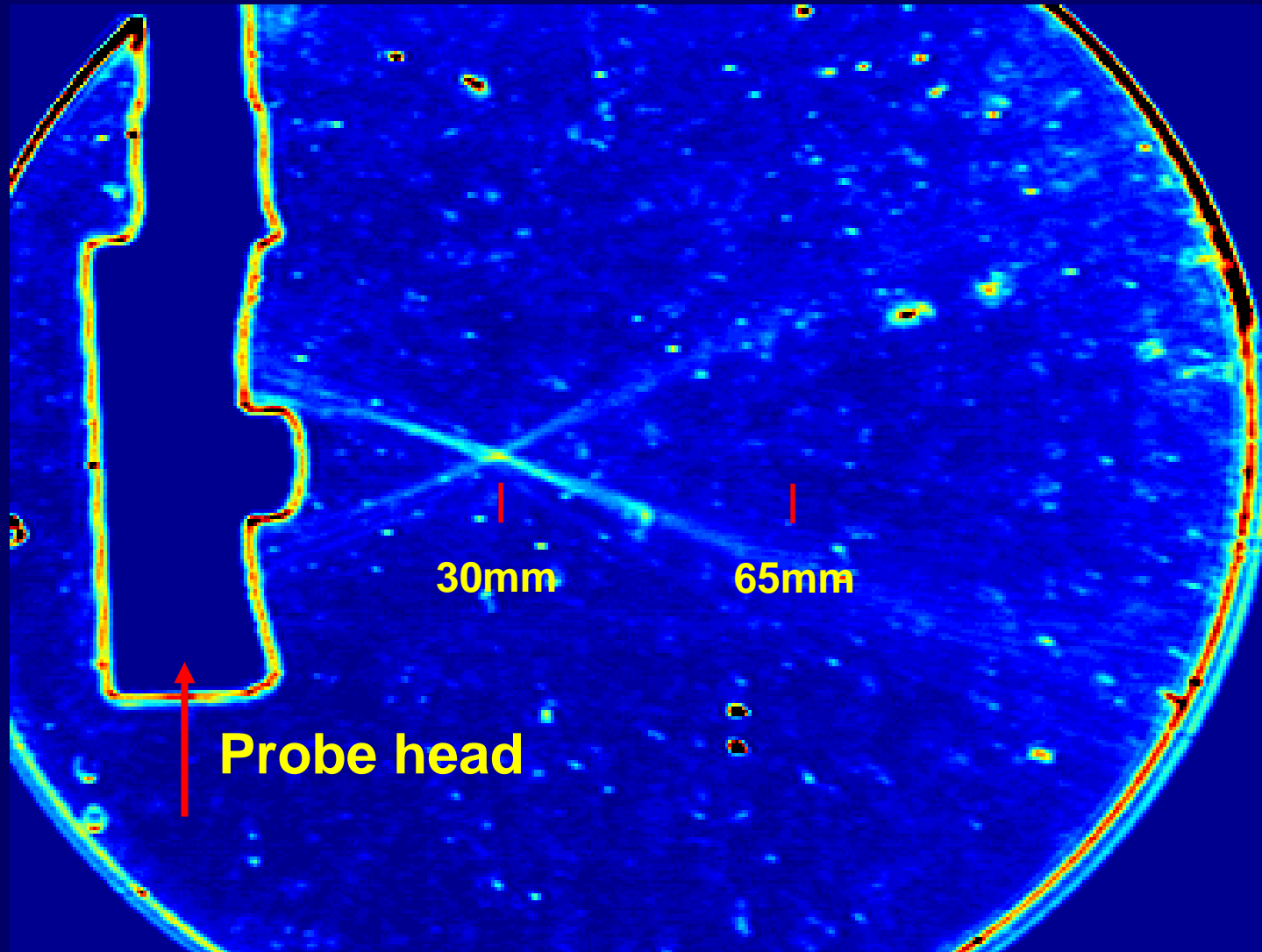


Therapy head part

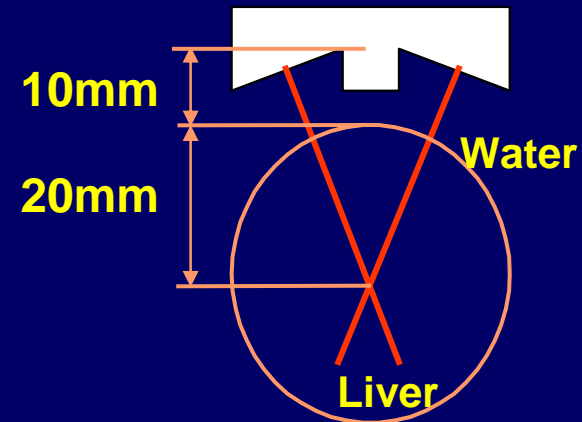
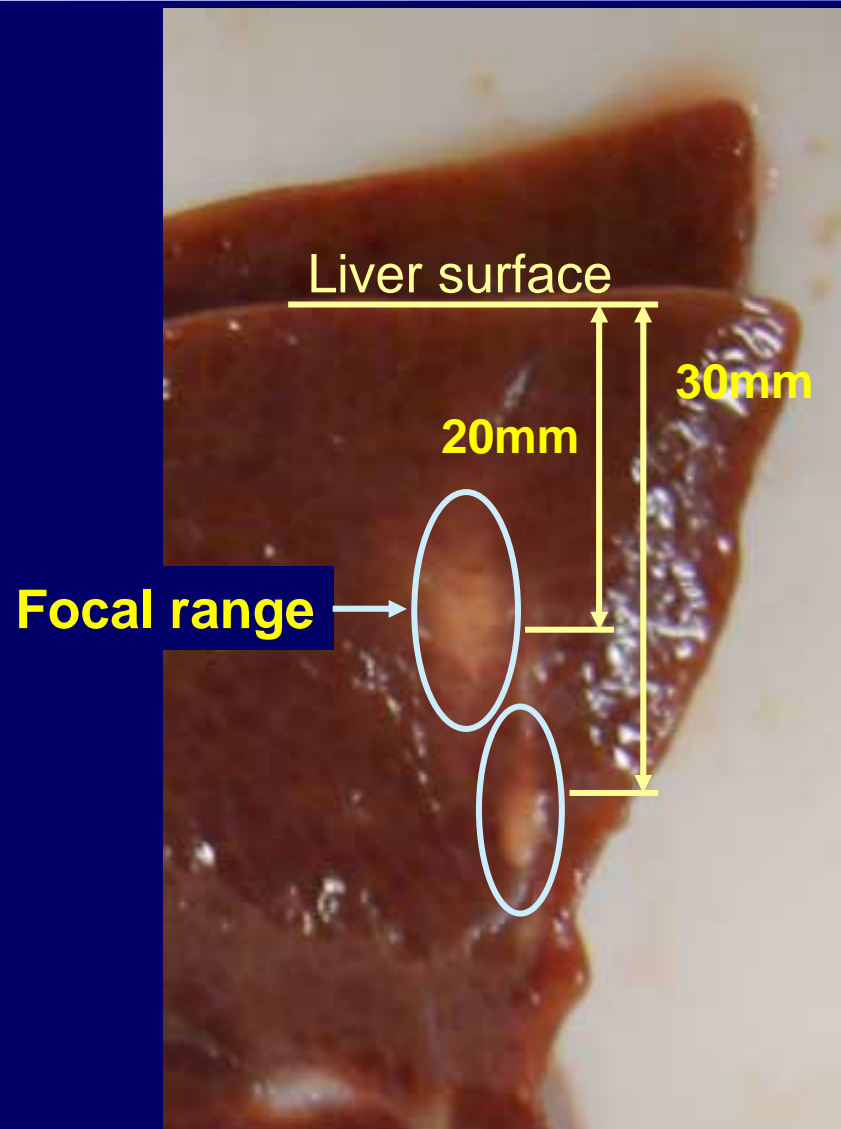


# Schlieren image of the variably focused beam

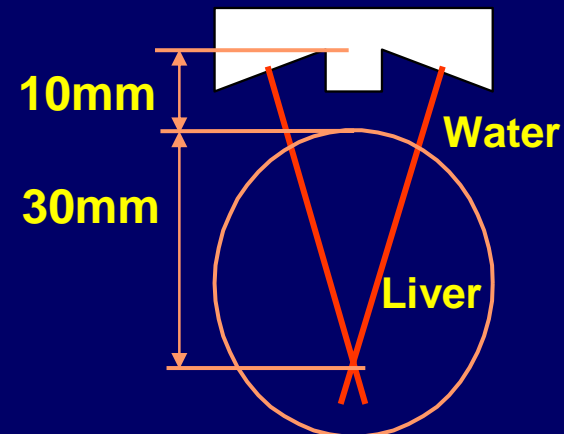
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# HIFU lesion of extracted liver



TAP: 30W, Irradiation time: 3s



TAP: 25W , Irradiation time: 3s

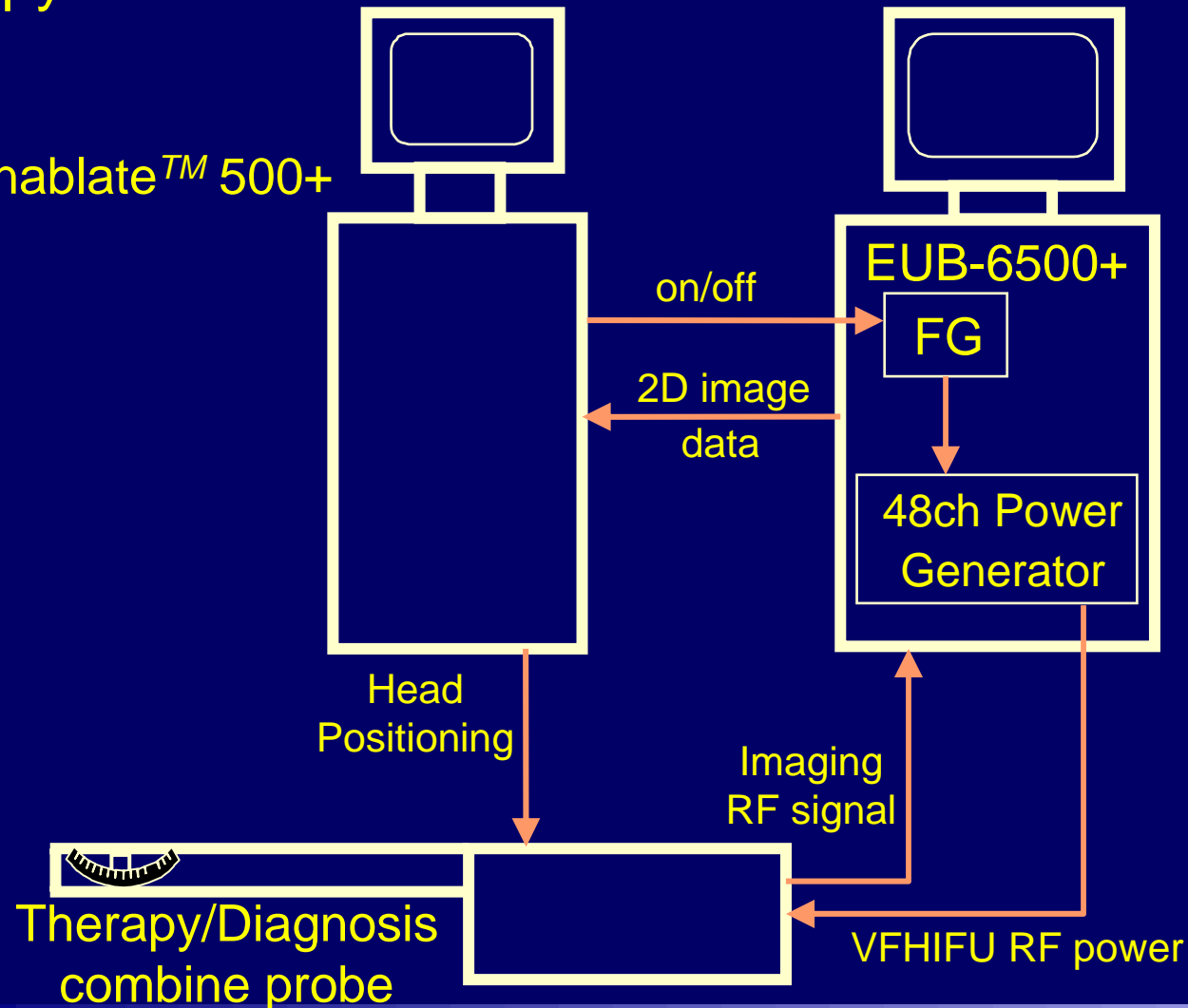
TAP: Total Acoustic Power

# Construction of Therapy System

Therapy control unit

Ultrasonic diagnostic device

Sonablate™ 500+



# Outline view of Therapy System

Ultrasonic diagnostic device  
EUB-6500+

Therapy probe

48ch Power amplifier

Therapy control unit  
Sonablate<sup>TM</sup> 500+



# Protocol of the animal experiment

1. Measurement of position and size of prostate gland with the imaging transducer
2. Transfer of results to Sonablate™ 500
3. Treatment Planning
  - Setup irradiation time and treatment scan pitch
  - Setup irradiation position and power
4. Operation of a chiller unit
5. Irradiation
6. Euthanasia after the operation
7. Removal of a prostate and rectum
8. Formalin immersion, sectioning, and comparison with the treatment plan

# Appearance of Animal Experiment

## Summary of the protocols

Number of sector	Number of liner	Focal length	TAP
5	3	30mm	55W
5	3	35mm	62W
4	3	40mm	68W
4	3	45mm	75W

On/Off time=4/8s Sector Pitch=3deg. Liner Pitch=3mm

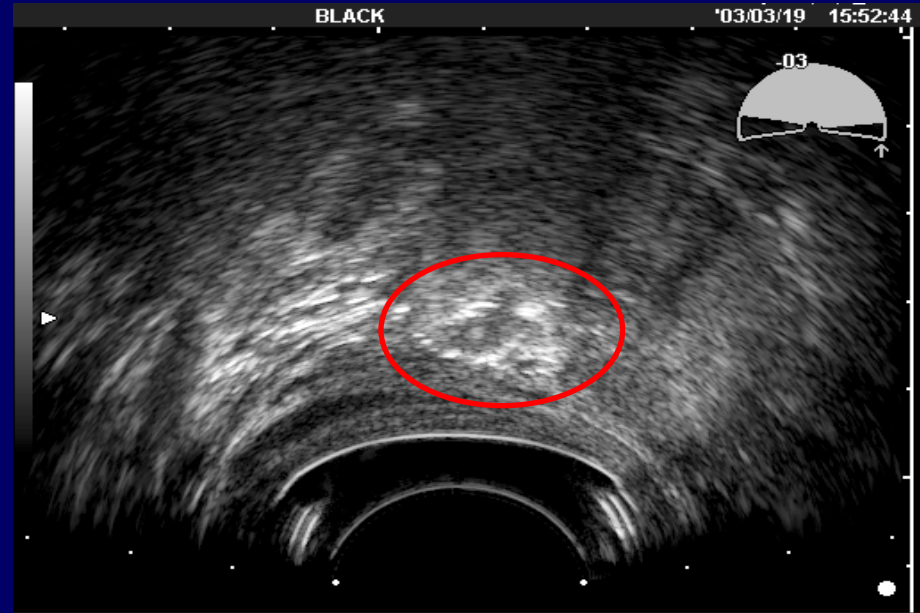


# Ultrasound Imaging during HIFU Therapy

# Real Time US Images in HIFU Therapy



**Before irradiation**



**After irradiation**

# Result of variable focusing HIFU (results of an autopsy of hound dog)

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Thermal metamorphic facies



Side view of  
prostate



Prostate viewed  
from rectum



Cut section of  
the prostate

# The result of irradiation (Cut segments)



Irradiation direction ↑

**Whole prostate**  
( ↓ Rectal side)



**Lesion**



**enlarged views** ( ↓ Rectal side)

# Results

It was confirmed that we successfully enlarge the irradiated area up to 25mm from 10mm (fixed focus case). This is due to move the focal depth from 30mm to 45mm by electrical variable focusing HIFU system.

# Conclusions

Our variable focusing HIFU system with acoustic lens for coagulation therapy was successfully demonstrated to coagulate prostate tissue by ultrasound beam focused at several distances in tissue from the rectum surface without exchanging applicators.

# Acknowledgments

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- We express thanks to Ms. Motoyama of System for Information Technology Inc. who bring out finite element modeling skill to complete transducer simulation.

