

Metrology research for External Beam Cancer Therapy

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Topics



- **Overview Therapeutic Ultrasound and HIFU (HITU)**
- **The European Metrology Research Program**
 - **Joint Research Project 'External Beam Cancer Therapy'**
 - **Partner NMI**
 - **Work package 'HITU'**
- **(preliminary) Results**
- **Summary**

Therapeutic Ultrasound - Overview



Typical properties of therapeutic ultrasound fields

Application	Frequency (in MHz)	Intensity (in W/cm ²)	Peak pressure (in MPa)
Physiotherapy	1.0 – 3.0	0.1 - 1	< 0.5
Extr. shock-waves lithotripsy	0.5	very low	> 10
HIFU	0.8 – 2.0	400 – 10 000	10
Haemostasis	1.0 – 10.0	5 000	7
Stimulation of bone healing	1.5	0.03	0.05
Pharmacotherapy (targeted drug delivery)	< 2.0	variable	0.2 - 8

NPL Report DQL AC 015, 2006

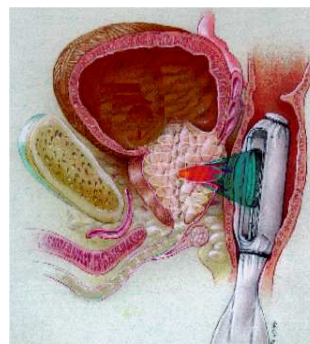
Clinical application of HITU



Therapeutic application:

- Tumor therapy (prostate, liver, breast, brain, ...)
- Opening of the blood brain barrier (temporary)
- Thrombolysis
- Non-invasive sealing of blood vessels (Haemostasis)

Example: prostate



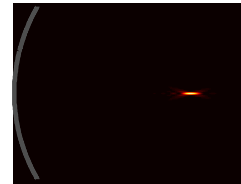
Monitoring of 'hot spot' and lesion is strictly required!

Problems to solve



Basic specification and acoustic calibration of HITU systems and components

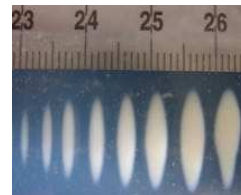
- ▶ Measurement of acoustic output power and efficiency
- ▶ Field characterization in water



J. Soneson - HIFU-Simulator

Treatment planning and monitoring Development of dosimetry techniques

- ▶ Measurement of temperature distributions
- ▶ Detection and quantification of cavitation



Divkovic, Jenne - ISTU 2005

Therapy relevant field parameters



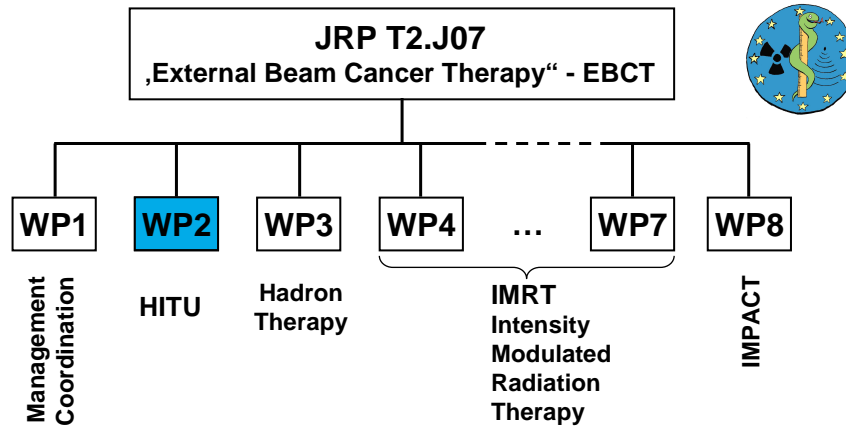
Physiological basis of the Ultrasound Therapy:

- thermal effects
- non-thermal effects (e.g. cavitation)

- Parameters:
- Total output power
 - Intensity distribution
 - Temperature profile (at focal spot)
 - Peak Pressure (p_+ , p_-)

Structure:

EMRP
European Metrology Research Programme
► Programme of EURAMET



<http://www.ptb.de/EURAMET-JRP7/>

Goal:

Improvement of the efficacy, safety and range of applicability of clinical HITU treatments by providing validated methods

for:

- ultrasonic field characterization,
- HITU system performance testing,
- quality assurance
- patient exposure monitoring

EMRP-Projekt JRP7



Achievement by addressing of

- basic calibration and specification of equipment
- repeatable and controllable clinical use of HITU systems

and by

- extending the techniques used for diagnostic and low intensity physiotherapy ultrasound
- sensor development
- computational modeling

Participating National Metrological Institutes



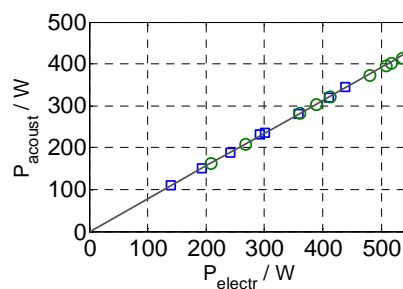
WP 2

Main tasks:

- Measurement of acoustic power output and efficiency
- Field characterization in water
- Measurement of temperature distributions (incl. calibration phantom for MRI)
- Detection and quantification of cavitation

Task 1: Acoustic power output

- set-up of a radiation force balance arrangement usable up to power levels of 500 W (extended uncertainty 4.3 %)
- investigation of the dependency of the measured output power on the target distance
- accomplishment of an interlaboratory comparison of HITU power measurement procedures and capabilities



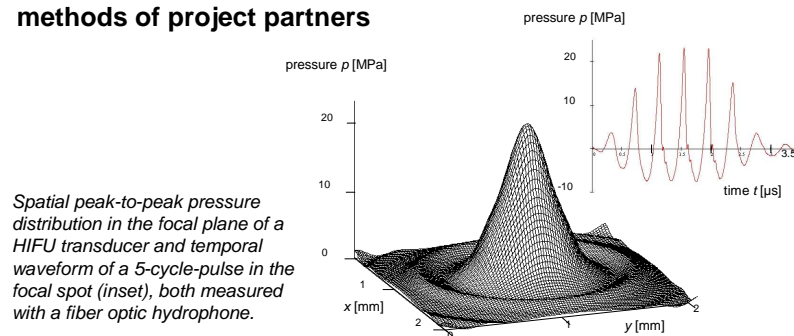
Total acoustic output total of a HITU-transducer measured up to a power level of 420 W using a radiation force balance set-up.

WP2: High Intensity Therapeutic Ultrasound (II)



Task 2: Field characterization

- development and test of fiber-optic measurement set-up
- field test is in progress and an comparison with different methods of project partners



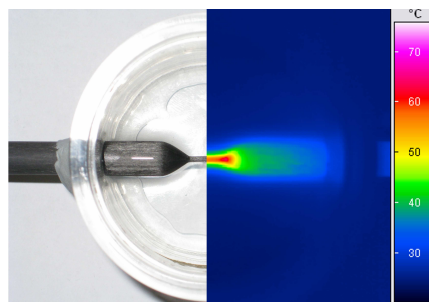
WP2: High Intensity Therapeutic Ultrasound (III)



Task 3: Temperature distribution

- development of an calibration phantom using electrically heated carbon rods
- tests were made with an IR camera and a NTC sensor.
- a first feasibility MR measurement was performed at PTB in Berlin.

Carbon fiber heating phantom for the calibration of Magnetic Resonance Thermometry (left half) and its temperature distribution as measured with a thermal camera (right half).



Interlaboratory comparison



of HITU power measurement techniques and capabilities

frequency range: 0.5 – 3.0 MHz
max. acoustic output power: 150 W

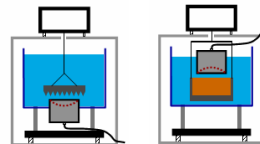
- Goal:**
- Investigation of the comparability of different measurement techniques
 - Estimation of uncertainties
 - Estimation of the degrees of equivalence

Period: June to December 2009

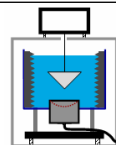
Investigated power measurement techniques



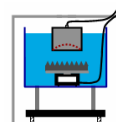
Radiation force balance (RFB)
absorbing target



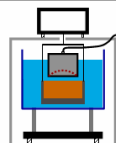
RFB
reflecting target



RFB - submersible load cell
absorbing target



Buoyancy / thermal expansion
absorbing target



Summary



Overview of the content and the achievements in the 'ultrasound part' (work package 2 - HITU) of the metrology research project about 'External Beam Cancer Therapy'

Achievements and preliminary results:

- radiation force balance arrangement suitable for power levels up to 500 W (extended uncertainty of 4,3%)
- accomplishment of a inter-laboratory key comparison (different approaches, up to 150 W)
- set up of a fiber optic sensor system ($p_+ > 30$ MPa)

Acknowledgements



Project partners:

G. Durando, C. Musacchio
Istituto Nazionale di Ricerca Metrologica, INRiM (Italy)

A. Shaw, S. Rajagopal
National Physical Laboratory, NPL (United Kingdom)

B. Karaböce, E. Sadikoğlu
Ulusal Metroloji Enstitüsü, UME (Turkey)

J. Haller, S. Dencks, C. Koch
Physikalisch-Technische Bundesanstalt, PTB (Germany)

The research project is supported by the European Union.

<http://www.ptb.de/EURAMET-JRP7/>