

Finnish Centre of Excellence in Inverse Problems Research

Overview of activities 2008-2009



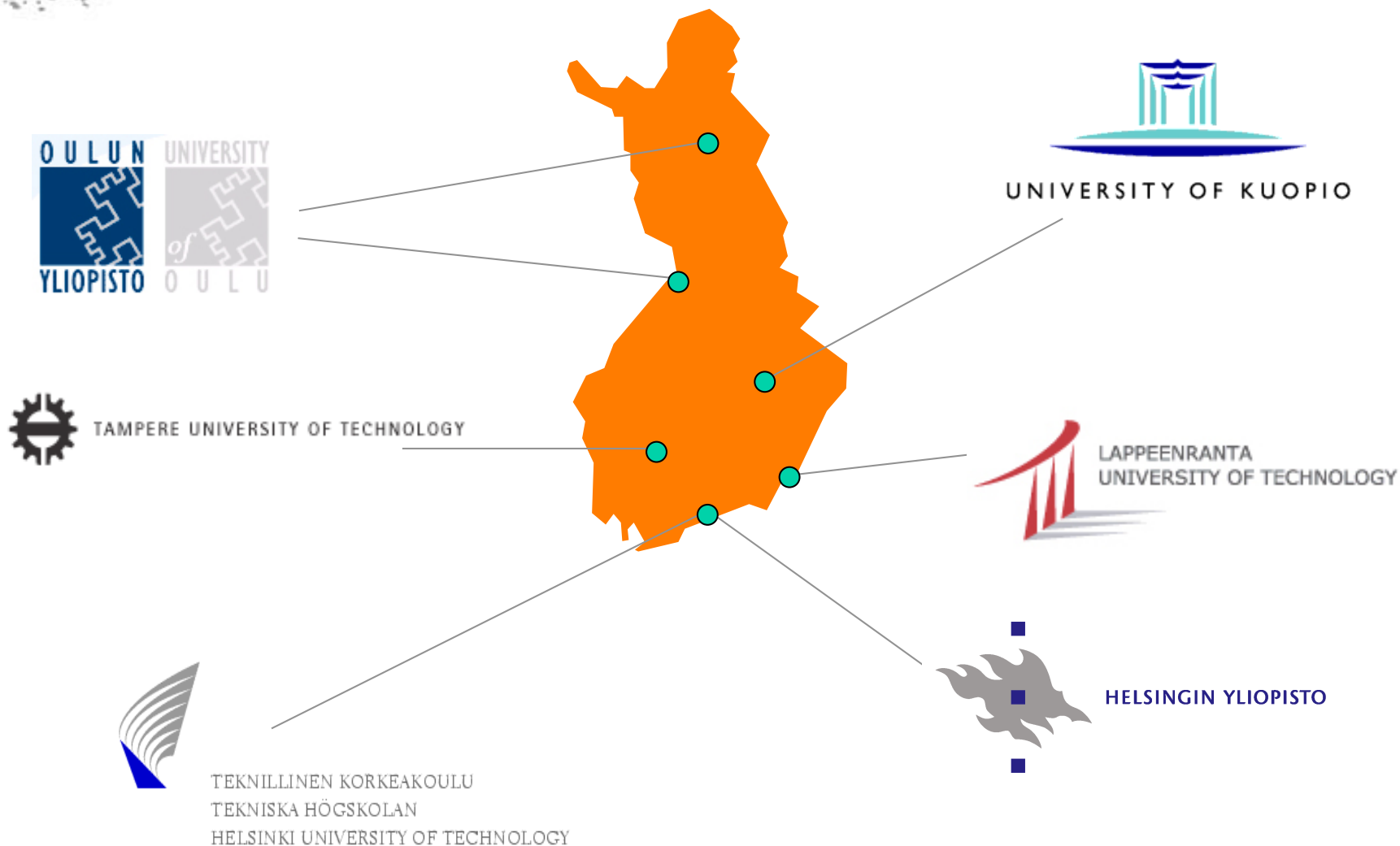
Samuli Siltanen

University of Helsinki

Trilateral workshop, **March 4, 2010**



Finnish Centre of Excellence in Inverse Problems Research



<http://math.tkk.fi/inverse-coe/>

CoE received funding from these sources:

Standard funding was received from universities, Academy of Finland, and Finnish Technology Agency (TEKES).

Additional and external funding:

Forest Cluster Ltd. project funding,

Three academy research fellow positions,
Academy postdoctoral projects,

Academy programme on computational science,

TEKES programme “modelling and simulation”,
Individual TEKES projects with industrial support,
Graduate schools (inverse problems, **computational science**),
Grants from various foundations.

Scientific output of the CoE in 2008-2009:

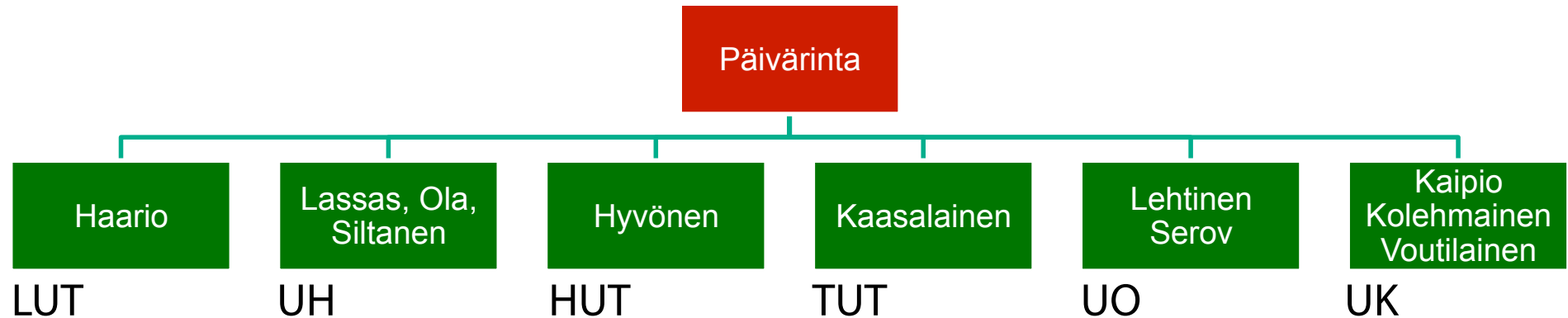
125 peer-reviewed publications, with **44** more submitted,

5 PhD theses,

4 international conferences or minisymposia, and

2 patents.

Management of the CoE network is organized this way:

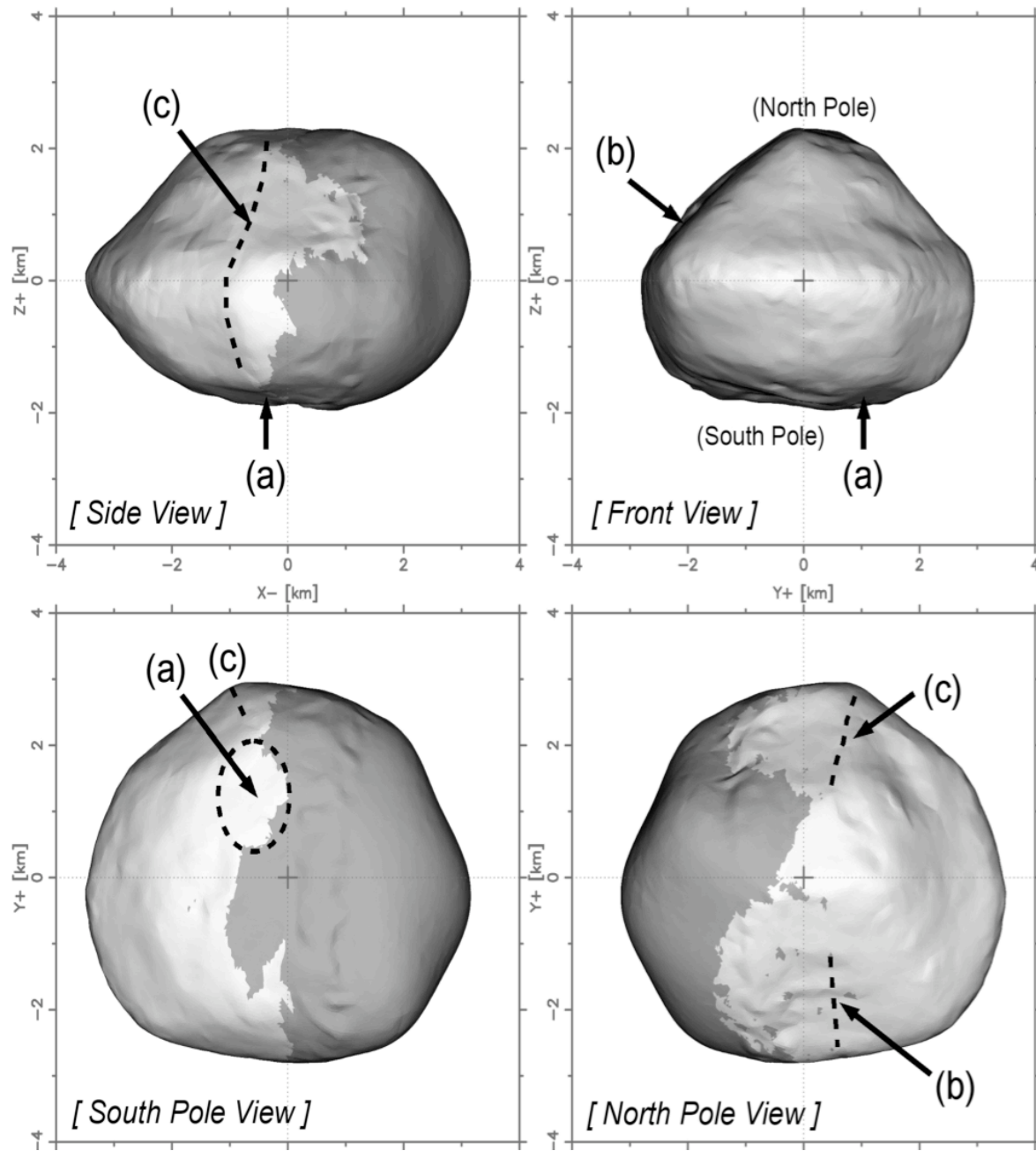


Responsibility areas of board members:

Päivärinta:	general planning and management, SAB relations
Kaipio:	budget and legal issues
Lehtinen:	rapid response and IPR issues
Haario:	Tekes projects and their documentation
Kaasalainen:	internal communications and documentation
Lassas:	meetings, visitors
Ola:	budget
Siltanen:	public relations and external communications

Lassi Päivärinta was appointed as a member of the Research Council for Natural Sciences and Engineering of the Academy of Finland for the period 2010-2012.

Science article by Kaasalainen et al.



Transmission Eigenvalues

Lassi Päivärinta and John Sylvester, SIAM Journal on Mathematical Analysis 40 (2008).

A body has a transmission eigenvalue if there is an incoming wave with zero scattering.

Similarly to the usual eigenvalues, which are clearly visible in near-field measurements, transmission eigenvalues cause high peaks in scattering observations, such as radar measurements.

Transmission eigenvalues lead to non-elliptic equations and their existence is now proven under general conditions.

Invisibility results by Lassas *et al.* were widely featured. Here Nature:

OPTICS

Watch your back

Kosmas L. Tsakmakidis and Ortwin Hess

A proposal for transporting photons invisibly between two unconnected points in space seems worthy of a *Star Trek* plot. But it is in principle wholly realizable, and could open up new vistas — literally.

Imagine walking down a footpath, staring unconcernedly at the clear track in front of you. Suddenly, you stumble over an object. You look down, but there is nothing to be seen on the ground. You step back and try a different angle of view, again without success. But you know something must be there, because you can feel it.

This situation is brought a step closer to reality with a device dreamt up by Greenleaf *et al.*¹ and described in *Physical Review Letters*. The authors propose a way of creating an 'invisible tunnel' through which photons, the elementary particles of light, can propagate between two seemingly unconnected points. To an observer standing where they emerge from their tunnel, the photons seem to come from nowhere. To an external viewer, they seem to be teleported from one place to the other. And anything within the tunnel cannot be seen by anyone. In analogy to the infamous 'wormholes' — a prediction in general relativity of tunnels through space-time that connect distant areas of the Universe — the authors call their

brainchild an electromagnetic wormhole.

The wormhole works (in theory) by neatly combining concepts from differential geometry, general relativity, electromagnetism and the theory of 'metamaterials'². Metamaterials are composite, nanostructured materials with specifically tuned electromagnetic properties. The authors construct the tunnel wall of their wormhole using a metamaterial layer that is designed to bend light waves around it without reflection, much as water waves bend around a tree branch or similar obstruction lying just below the surface of the water. This layer thus renders whatever is inside it invisible. The idea draws on techniques proposed^{3,4} for the creation of an 'invisibility cloak' (Fig. 1a) — a device that has already been constructed and proved viable, at both microwave⁵ and optical⁶ wavelengths.

The advance in Greenleaf and colleagues' scheme¹ is that a cloaked object can 'see' into the outside world at the end of the tunnel, because photons are also free to propagate through it. The tunnel 'deceives' photons into

(other than staying on the surface of the cup) for getting from the one place to the other.

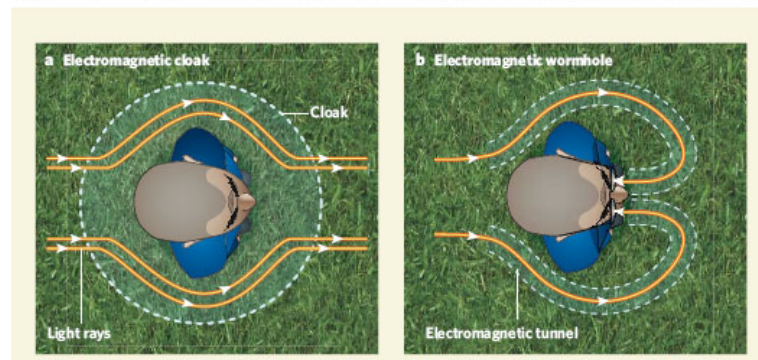
The key to the realization of this scheme is that this new photon-space does not naturally exist in real space. Rather, using suitable coordinate transformations, the authors tweak Maxwell's equations — the set of equations that describe the workings of electromagnetic waves — to simulate it. The equations retain their form on passing from the real to an artificial photon-space; the only thing that is required to complete the deception of the photons is to modify the values of the electric permittivity and magnetic permeability (numbers that codify the degree to which a material allows electric and magnetic fields to pass).

Such a concealed communication channel could be deployed for military purposes for the secret transmission of information or stealth technologies. But it might also find its way into civilian applications: rerouting mobile-phone signals around obstacles, for example, or shielding sensitive medical devices from interference by magnetic resonance imaging scanners. But the possibilities don't end there. Two of Greenleaf and colleagues' invisible electromagnetic tunnels, built into the frame of a pair of special half-moon spectacles, would effectively 'glue' the photon-space behind the head to the photon-space in front of the eyes, allowing one literally to watch one's back (Fig. 1b).

Currently, metamaterial technology allows the construction of invisibility cloaks that work well for only a limited range of frequencies. The electromagnetic wormhole in its present form can also be only short, otherwise the image of an object being transmitted through it becomes noticeably distorted. The true potential of such schemes will become clear in future experimental tests. What is plain now is that innovations are coming thick and fast in this burgeoning world of 'transformation optics'.

Kosmas L. Tsakmakidis and Ortwin Hess are at the Advanced Technology Institute and the Department of Physics, University of Surrey, Guildford GU2 7XH, UK.
e-mail: o.hess@surrey.ac.uk

1. Greenleaf, A., Kurylev, Y., Lassas, M. & Uhlmann, G. *Phys. Rev. Lett.* **99**, 183901 (2007).



The Kuopio group has produced two spin-off companies

Kuava: Computational engineering

COMPUTATIONAL TECHNOLOGY SERVICES

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KUAVA

Kuava Ltd provides computational and software development services based on physical and statistical modelling, optimisation and inversion techniques. We optimise our clients' competitive edge by providing computational tools that make processes and products more accurate, environmentally friendlier and more effective.

Kuava's expertise is applied to a wide range of fields, including paper making, health care, mobile communications, environment technology and iron and steel production.

The company is a part of an expertise network coordinated by Numerola Ltd. The network provides computational technology services throughout several companies. At the moment the network consists of Kuava Ltd, Numerola Ltd and Promastia Ltd.

News

13.03.2008
Kuava delivers high performance computing for x-ray imaging [read more...]

21.01.2008
Waveller used for simulating the head related transfer function (HRTF) [read more...]

15.11.2007
Kuava delivers a solution for coupling noise modeling to a geographic information system [read more...]

Increasing competence

Numcore: Process control solutions

NUMCORE
INSIGHT INTO SOLUTIONS

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Electrical Impedance Tomography (EIT) in Industrial Process Control and Optimization

Many process industries rely on mixing processes where solids, fibers, or gases such as air, are mixed with fluids. Good process control requires the knowledge of the progress of the mixing and the density distribution in the mixing product. Inhomogeneity in the mixing distribution is an indicator of problems in the process.

Electrical Impedance Tomography (EIT) has been developed to allow monitoring of density, air bubble, fiber and solid content etc. distribution within an industrial process, thus allowing for improved process optimization. EIT is extremely well suited for monitoring slurries and high-viscosity fluids while low-viscosity processes do not benefit so much from EIT.

Examples of EIT in various processes:

- In pharmaceutical manufacturing processes it is important to know when solids are completely dissolved in fluids.
- In paper and pulp industry and non-wovens industry, fibers are mixed to fluid and the density has to be uniform.
- In food processing industry, homogeneity of the product is important and in waste water processing the solid content needs to be monitored.
- In mining industry, sedimentation levels in a flotation process are difficult to measure using traditional measurements, but EIT suits there well.

NEWS

12.03.2008
Numcore keeps up the good work (Venture Cup, 2nd stage)

05.03.2008
Mr. Anssi Lehtikoinen nominated as CEO of Numcore

05.03.2008
Venture Cup (1st stage - Cleantech)

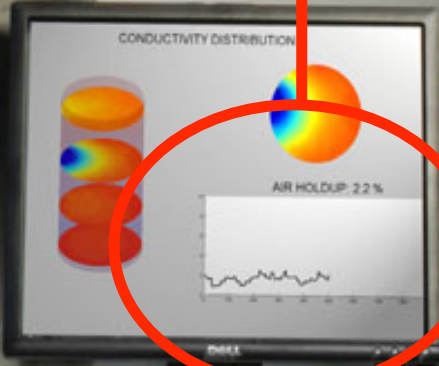
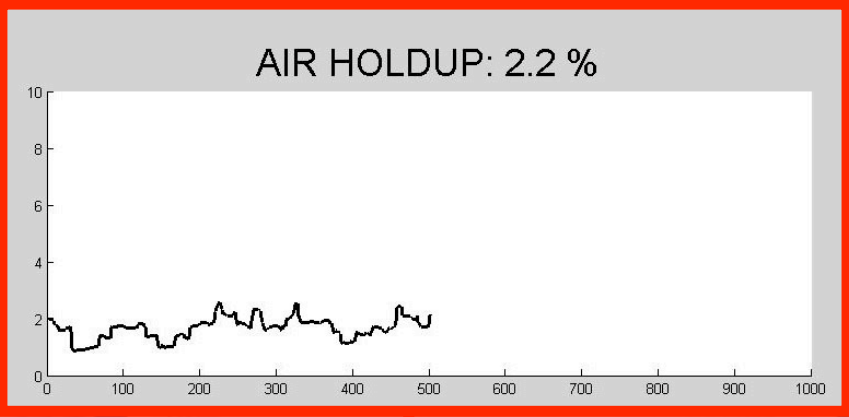
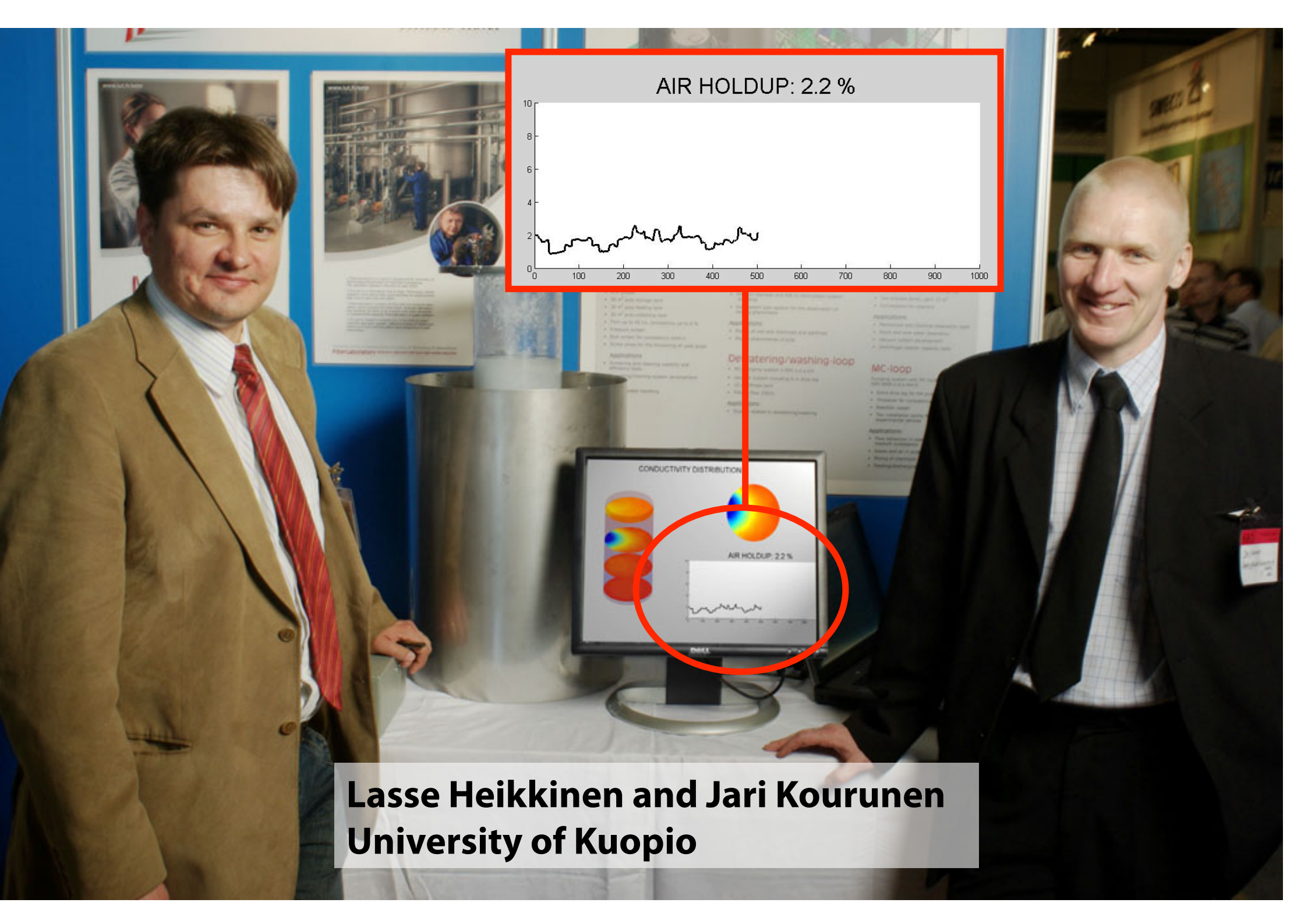
04.03.2008
Numcore excels in Venture Cup (1st stage)

03.03.2008
Numcore webpages published

MAKE REQUEST

Numcore Oy, Mikrokatu 1, PL 1188, 70211 Kuopio, Finland.
Copyright Numcore 2008

**Winner of Venture Cup
main award 2008**



Lasse Heikkinen and Jari Kourunen
University of Kuopio

Medical imaging project 2001-2007 produced a new dental X-ray product



VT - ESSENTIAL INFORMATION FOR IMPLANTOLOGY

EASY NAVIGATION OF SLICES

EXCELLENT IMAGE QUALITY

PATIENT WELLBEING

EFFICIENT AND EASY OPERATION

CONTACT

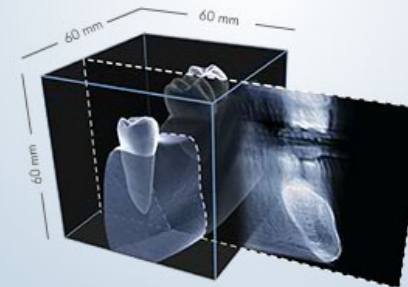
CLINICAL CASES



[Open OP200 -presentation >](#)

VT – essential information for implantology

VT option is a Narrow Beam Volumetric Tomography (NBVT) imaging tool that provides digital tomography with reliable measurements and excellent image quality for implant site evaluation.



What does VT do?

One VT image covers a cubical area of ~ 60 mm per side, producing 256 cross-sectional slices with a minimum slice thickness of 0,23 mm.

How does VT do this?

The resulting 3D model is reconstructed from a set of projection images targeted only on the region of interest. The reconstructed, wide volumetric view offers 256 slices, from which the optimal slice or any number of slices can be viewed.

[SPIN THE CUBE](#)

Traditional panoramic X-ray device is used in a radically novel way



VT - ESSENTIAL INFORMATION FOR IMPLANTOLOGY

EASY NAVIGATION OF SLICES

EXCELLENT IMAGE QUALITY

PATIENT WELLBEING

EFFICIENT AND EASY OPERATION

CONTACT

CLINICAL CASES



[Open OP200 -presentation >](#)

Efficient and easy operation

An innovative positioning system allows easy and consistent patient positioning. Selection of the region of interest is guided by five pre-selected positions, eliminating the need for lengthy and cumbersome patient positioning. The OP200 D SmartNav controller software allows an easy selection of imaging parameters and has helpful patient positioning animations.

VT -the cost effective solution

The Orthopantomograph OC200 model with Orthoceph and VT offers you all the important imaging tools in one premium quality unit. There is no need to learn to use several different products and software when one unit can fulfill all your needs. Cost effective VT option field upgrades are available for most existing Orthopantomograph units.



SPIN THE CUBE

универсальное решение для панорамной рентгенографии

Spin-off company from Lappeenranta: Arbonaut for forest inventory service

Bayesian estimation turns laser scanning data into estimates of forest parameters, such as timber volume, species distribution, tree height and stem count

