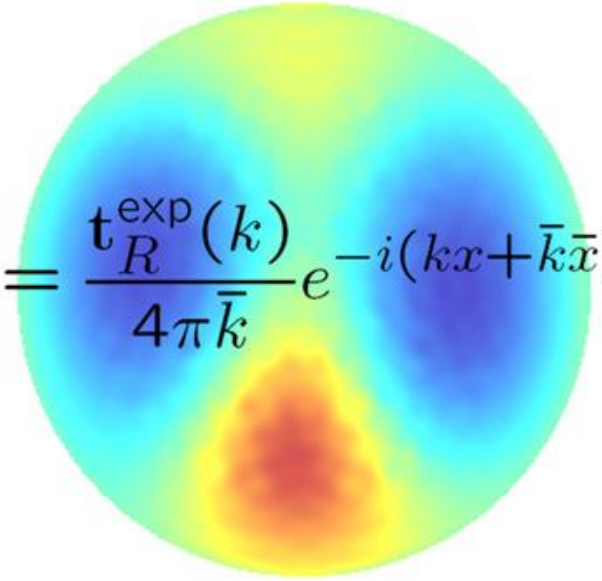
Finnish Centre of Excellence in Inverse Problems Research

Grid computing for the d-bar method for electrical impedance tomography

$$\frac{\partial}{\partial \bar{k}} \mu_R(x,k) = \frac{\mathbf{t}_R^{\exp}(k)}{4\pi \bar{k}} e^{-i(kx+\bar{k}\bar{x})} \overline{\mu_R(x,k)}$$



TAMPEREEN TEKNILLINEN YLIOPISTO

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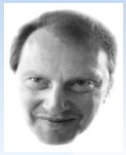
This is a joint work with



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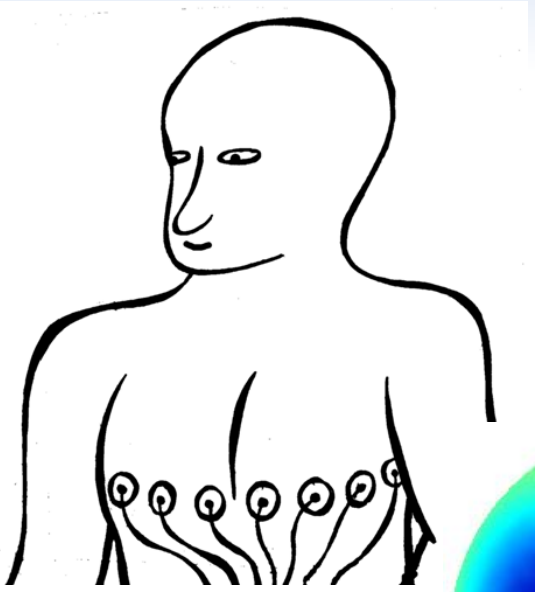
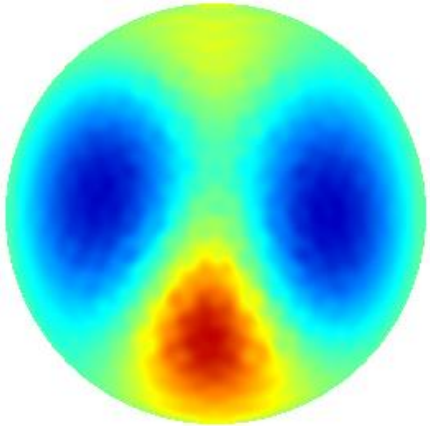
Electrical impedance tomography (EIT) is an emerging medical imaging method

•Feed electric currents through electrodes, measure voltages

•Reconstruct the image of electric conductivity in a two-dimensional slice

•Applications:
monitoring heart and lungs of unconscious patients, detecting pulmonary edema, enhancing electrocardiography





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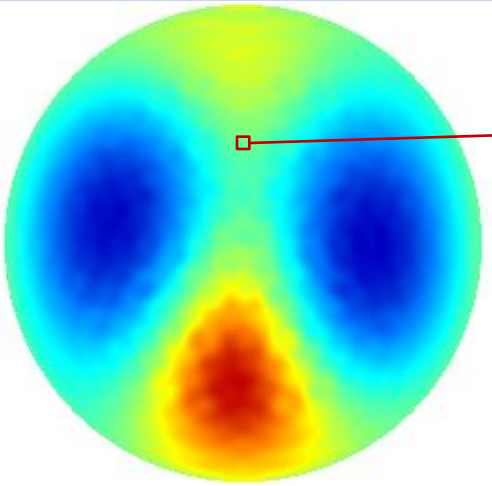
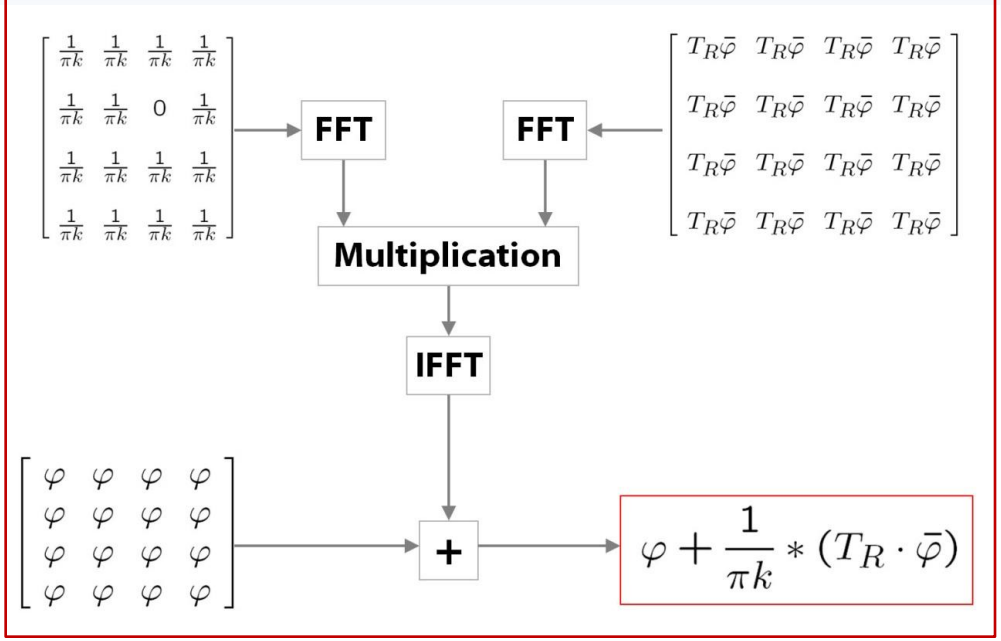
For each pixel in the image, one has to solve a d-bar equation

(possible to do in “embarrassingly” parallel way)



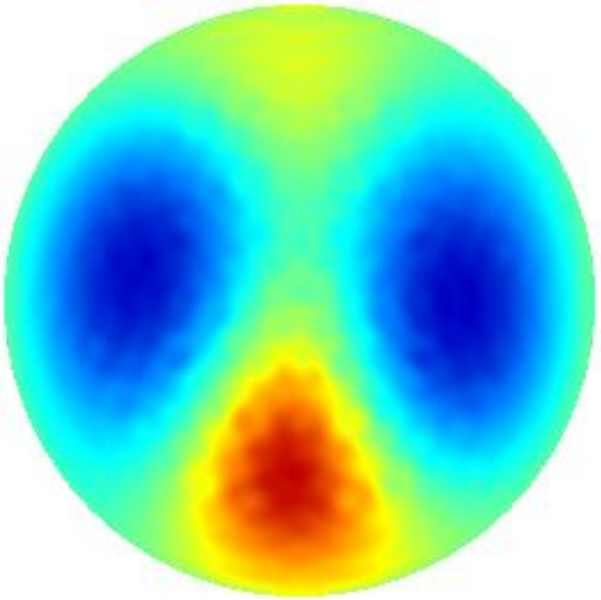
$$\mu_R(x,k) = 1 + \frac{1}{(2\pi)^2} \int_{\mathbb{R}^2} \frac{\mathbf{t}_R^{\varepsilon}(s)}{(k-s)\bar{s}} e_{-x}(s) \overline{\mu_R(x,s)} ds_1 ds_2$$



Knudsen, Mueller and Siltanen, Journal of Computational Physics **198** (2004)

Grid computation makes practical EIT imaging with the d-bar method possible

- Computation time with one modern PC would be ~3 hours, but with the Techila PC grid it is only 3 minutes.
- **This difference is crucial from the point of view of future research and development of the d-bar method for EIT.**
- The difference is even more crucial from the point of view of the doctor making a diagnosis!



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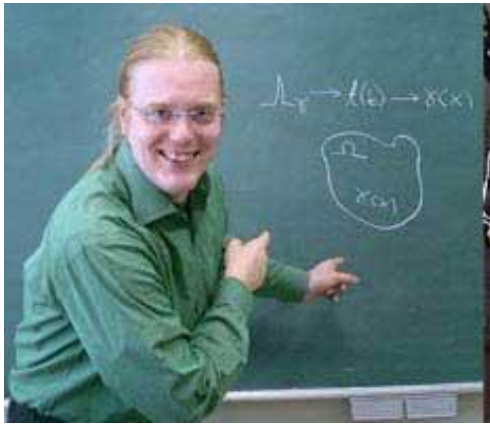
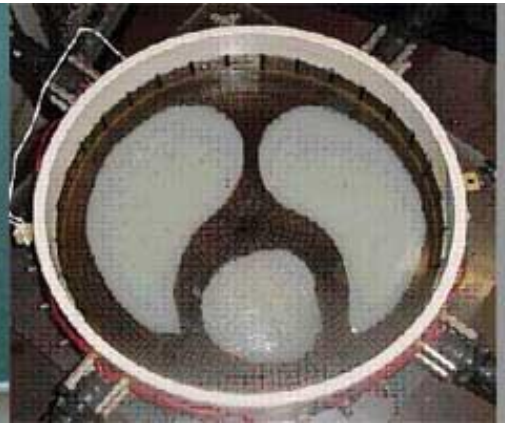
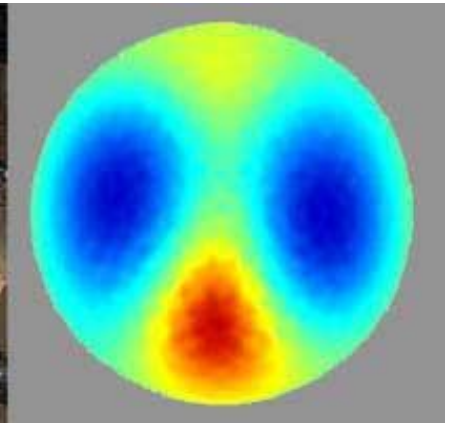
Examples of ongoing computational Projects 1/2

We wanted to know results when using 36 different truncation radii
→ 36 projects.

- Total wall clock time consumed : 41m 25 s
- Total CPU time consumed :128h 40m 9s
- On average 192 desktop PC were utilized
- 186,4x speed was gained

Examples of ongoing computational Projects 2/2

The more you get the more you consumed. We have started more revolutionary research were a single calculation:

- consumed 63d 18h 51m CPU time,
- only 3h 48m wall clock time was needed,
- on average 249 desktop PCs were utilized.

The speed would be even better if the computation would have been executed outside office hours when most of the desktop PCs were used by students and researcher in their daily work.

Future of d-bar computation

In 2003, professors Kari Astala and Lassi Päivärinta from University of Helsinki made a breakthrough in EIT research. They used a Beltrami equation to show how to make electrical imaging of tissue boundaries; this was so far unknown.
See Annals of Mathematics 163 (2006). Development of a practical algorithm is on its way.

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Computation of transport matrix:
64 days CPU time, 3 hours wall-clock time