Space Mapping, The State of the Art

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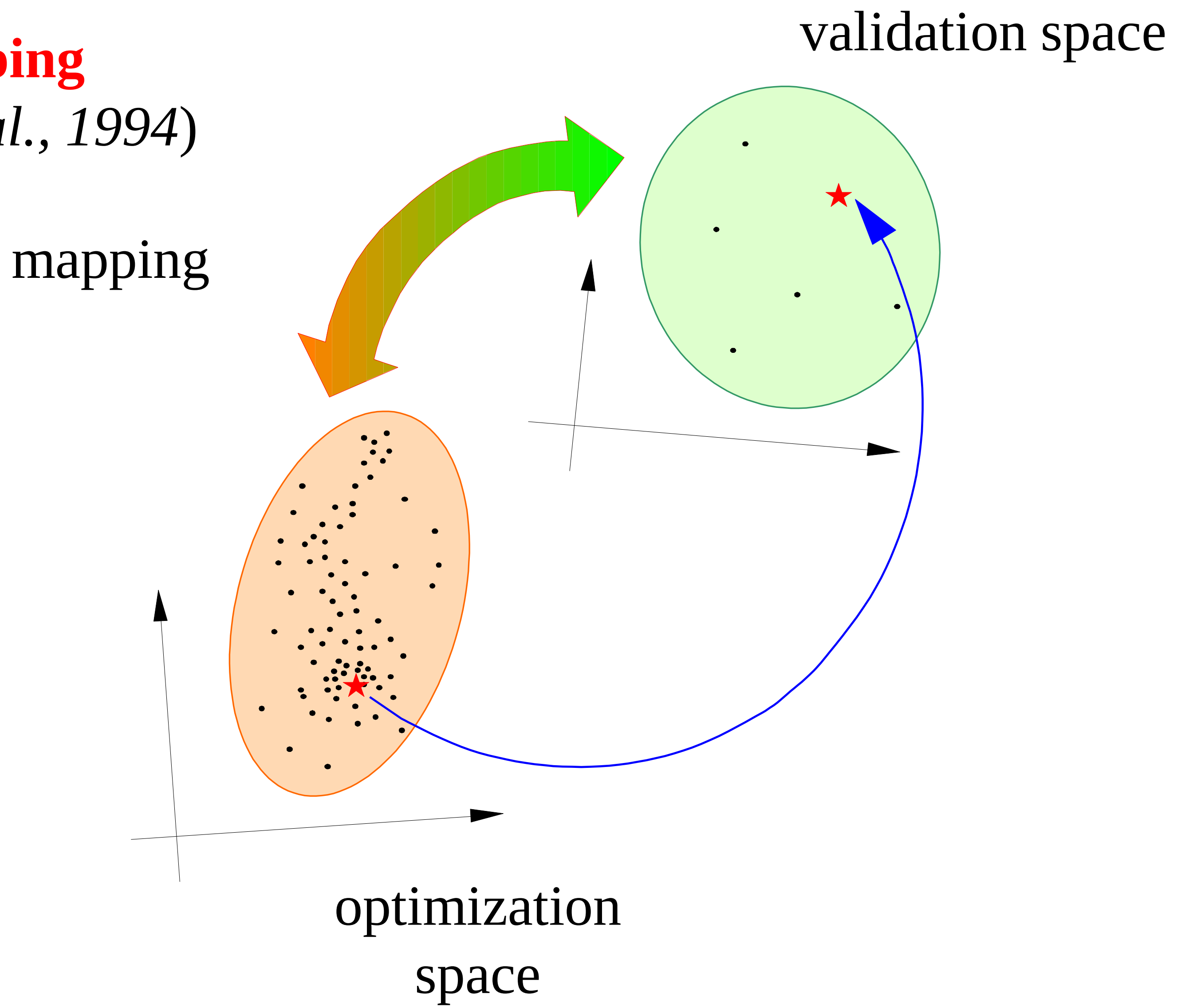
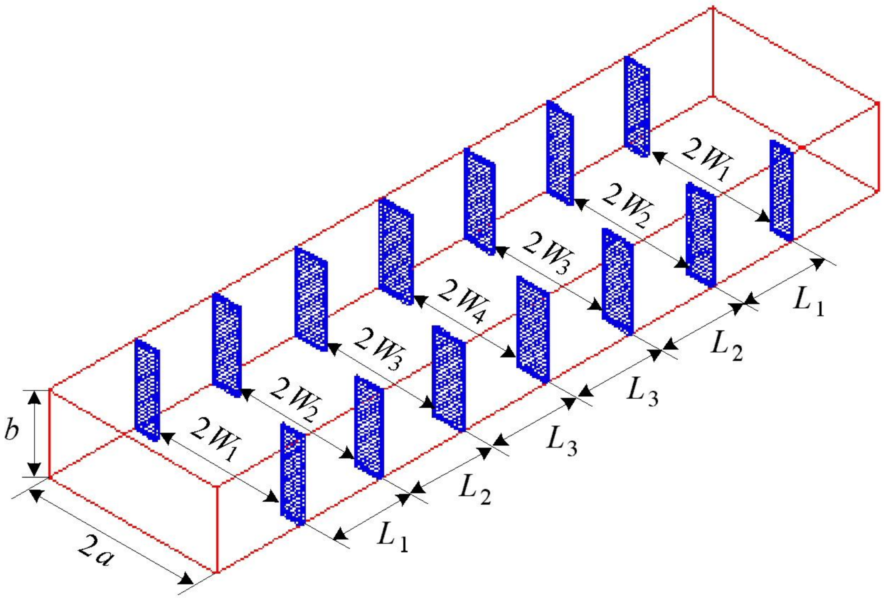
Space Mapping

(*Bandler et al., 1994*)

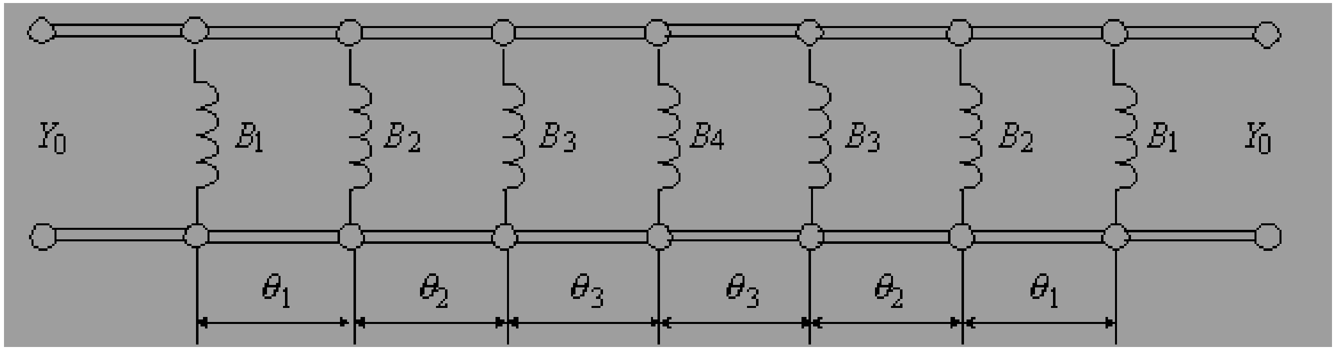


H-plane Waveguide Filter Design (*Young et. al., 1963, Bakr et al., 1999*)

H-plane filter



circuit model (*Marcuvitz,1951*)

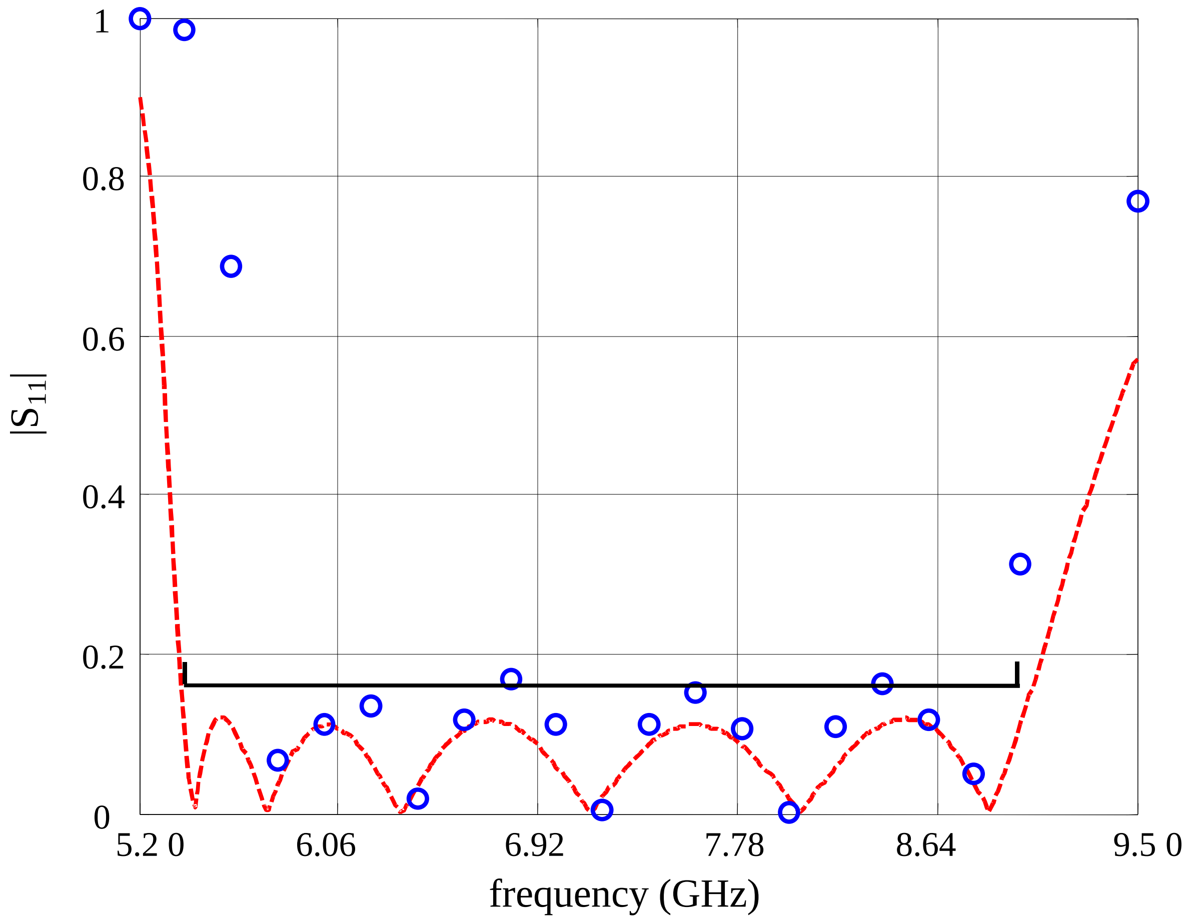


H-plane Waveguide Filter Space Mapping Design

(*Bandler et al., 2004*)

optimal coarse model response (---)

initial fine model* response (○)



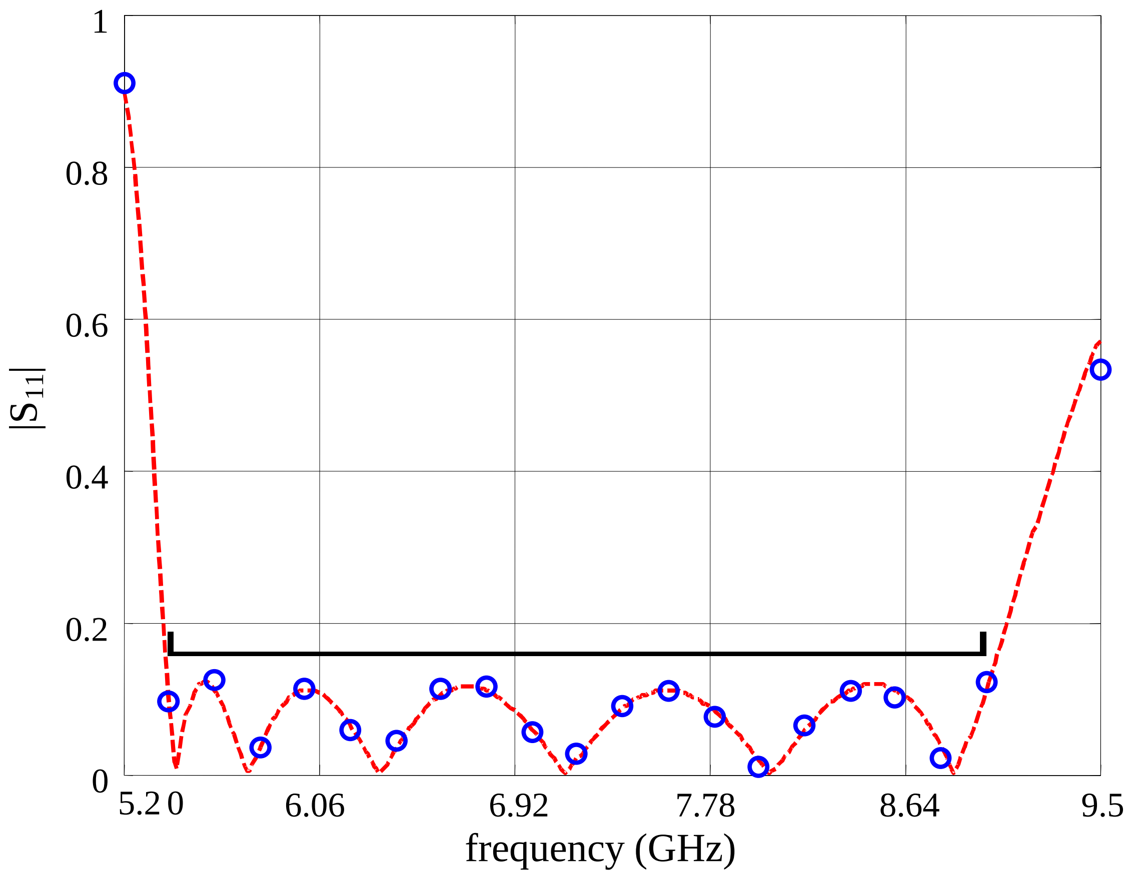
*the fine model exploits Agilent HFSS

H-plane Waveguide Filter Space Mapping Design

(*Bandler et al., 2004*)

optimal coarse model response (---)

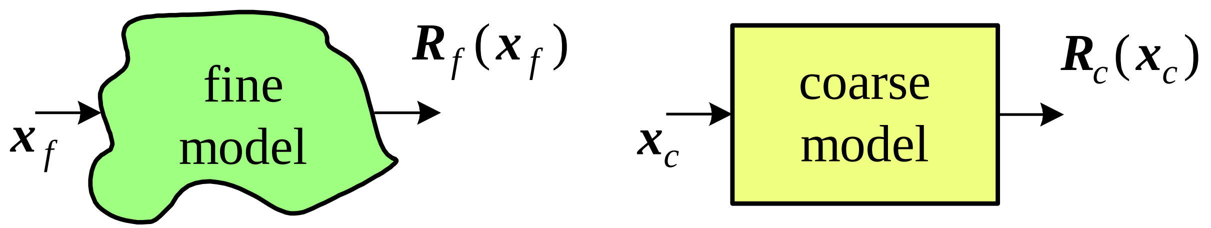
fine model* (○)
SMIS algorithm,
3 iterations,
4 frequency sweeps
(excluding Jacobian estimations)

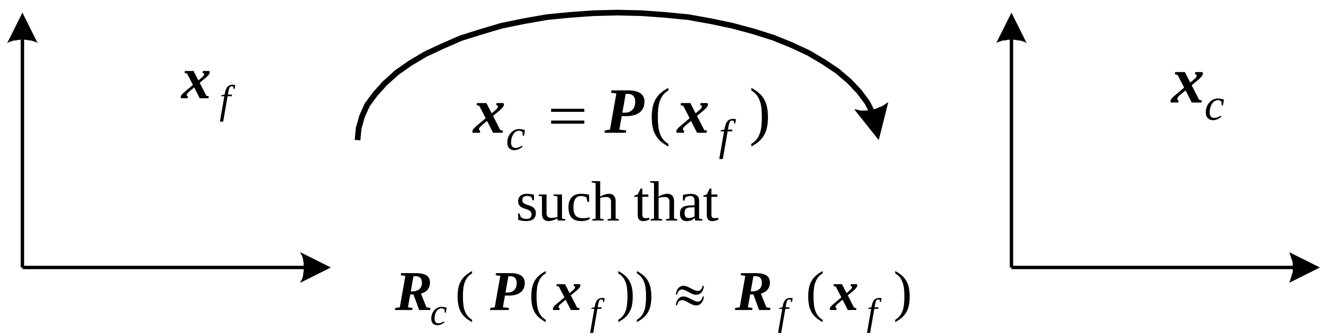


*the fine model exploits Agilent HFSS

The Space Mapping Concept

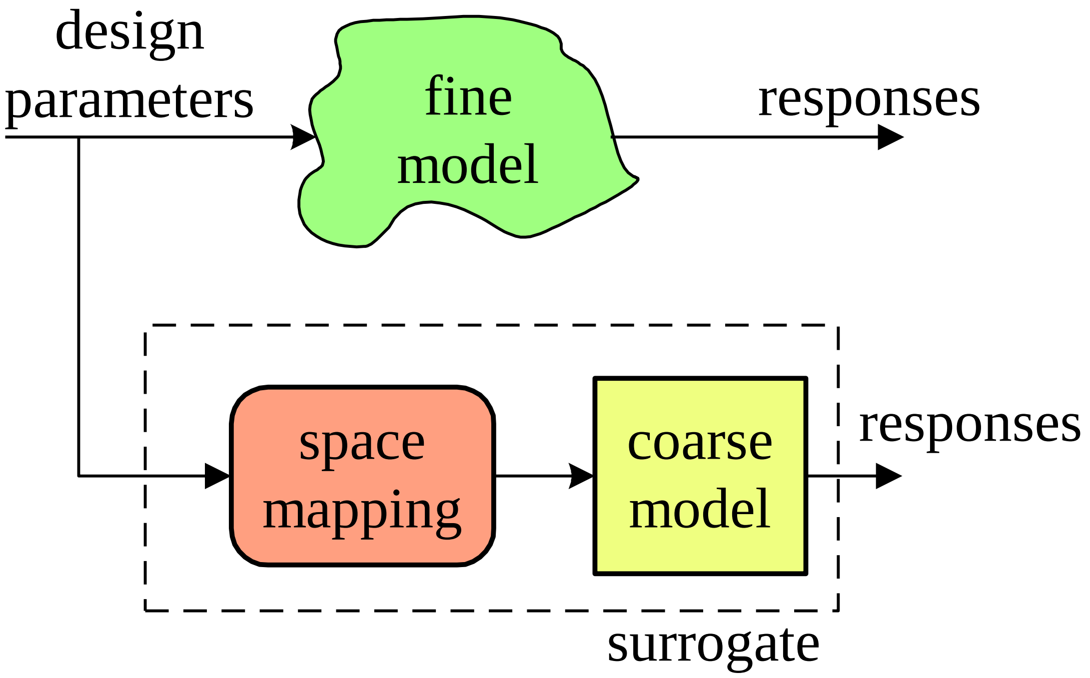
(Bandler et al., 1994-)





Explicit Space Mapping Concept

(*Bandler et al., 1994-*)



used in the microwave industry (e.g., Com Dev, 2003-2004, for optimization of dielectric resonator filters and multiplexers)

Space Mapping: a Glossary of Terms

Space Mapping	transformation, link, adjustment, correction, shift (in parameters or responses)
Coarse Model	simplification or convenient representation, companion to the fine model, auxiliary representation, cheap model idealized model
Fine Model	accurate representation of system considered, device under test, component to be optimized, expensive model

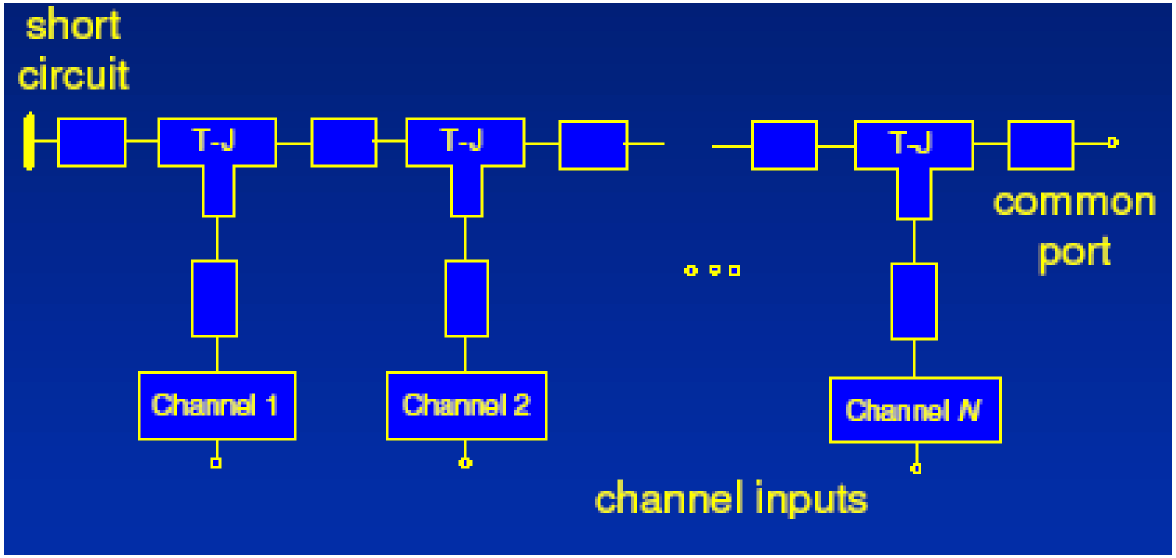
Space Mapping: a Glossary of Terms

Surrogate	model, approximation or representation to be used, or to act, in place of, or as a substitute for, the system under consideration
Updated Surrogate	mapped or enhanced coarse model corrected coarse model
Surrogate Model	alternative expression for Surrogate
Target Response	response the fine model should achieve, (usually) optimal response of an idealized "coarse" model, an enhanced coarse model, or surrogate

Space Mapping Design of Dielectric Resonator Multiplexers

(*Ismail et al., 2003, Com Dev, Canada*)

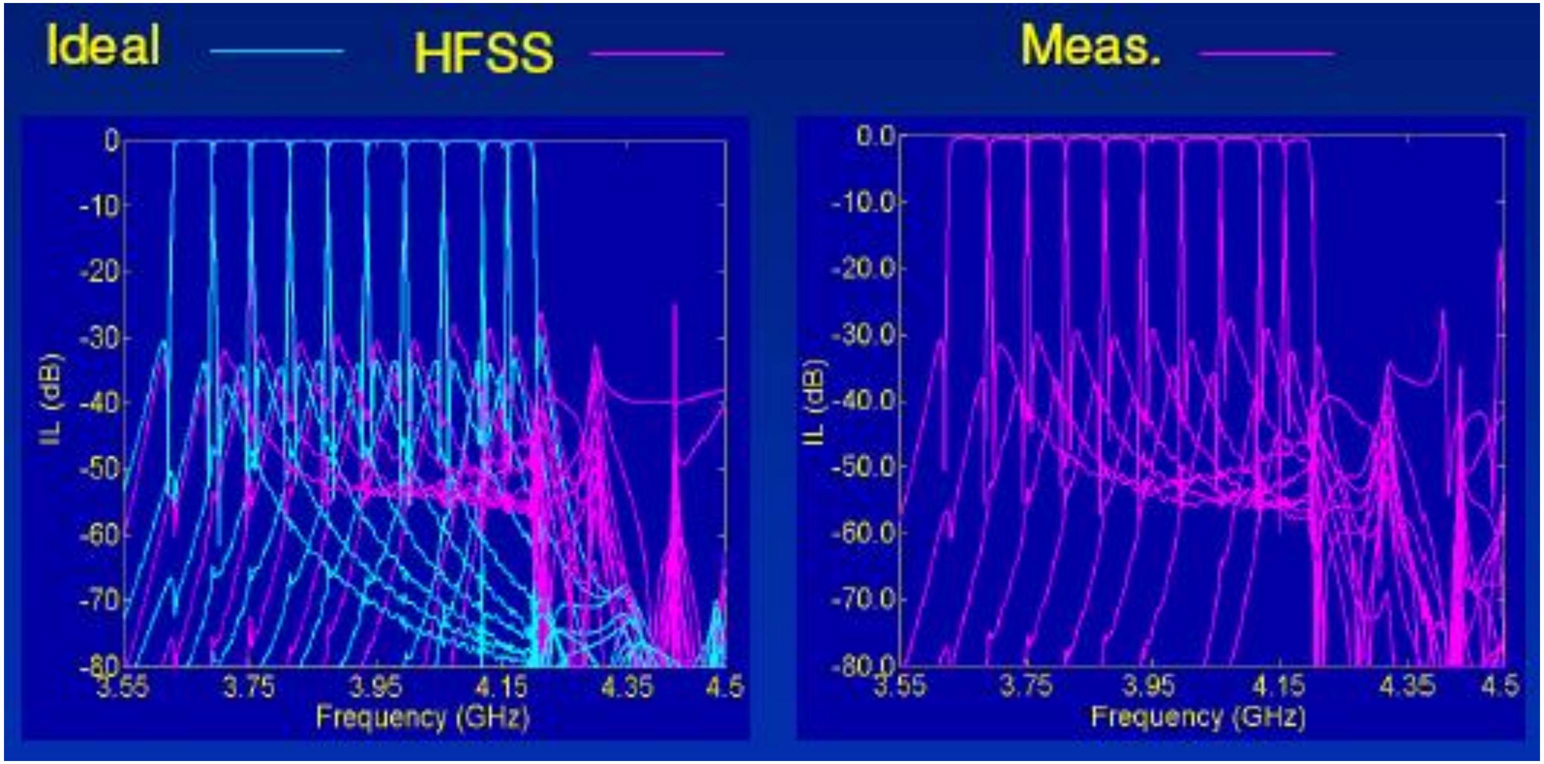
manifold multiplexer: coarse channel model (equivalent circuit)
fine channel model (HFSS finite element)



Space Mapping Design of Dielectric Resonator Multiplexers

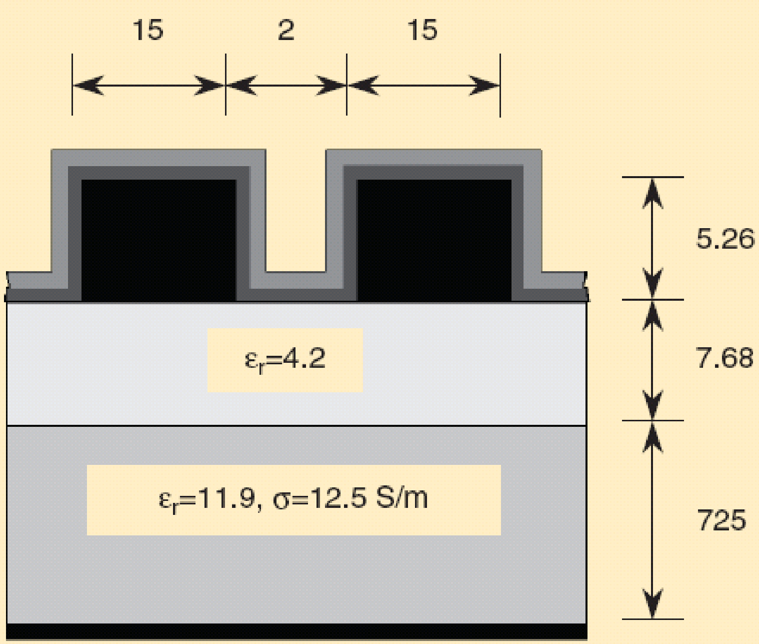
(*Ismail et al., 2003, Com Dev, Canada*)

10-channel output multiplexer

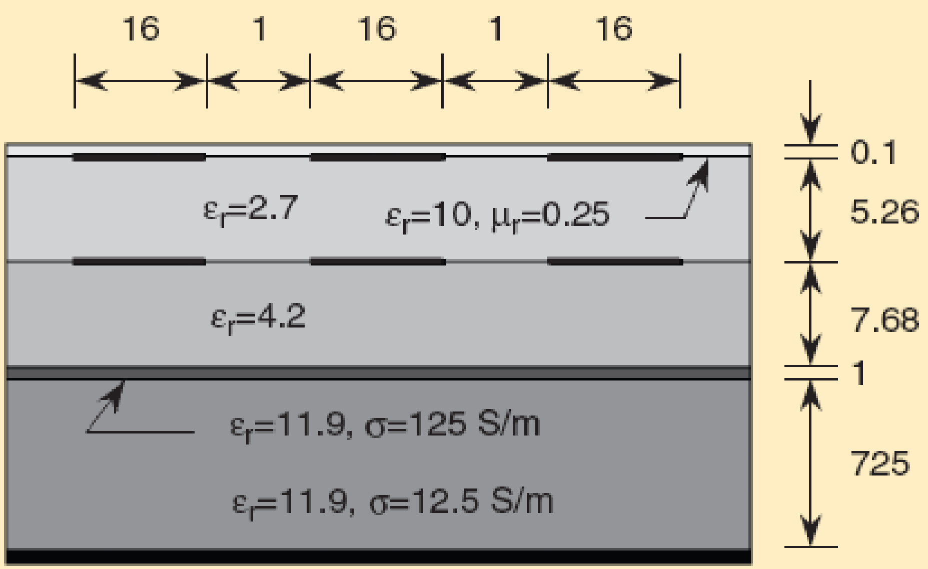


Implicit Space Mapping Design of Thick, Tightly Coupled Conductors (*Rautio, 2004, Sonnet*)

thick, closely spaced conductors
on silicon (fine model)



"space-mapping" (top) layer
(coarse model)



Space Mapping Crashworthiness Design of Saab 9^3

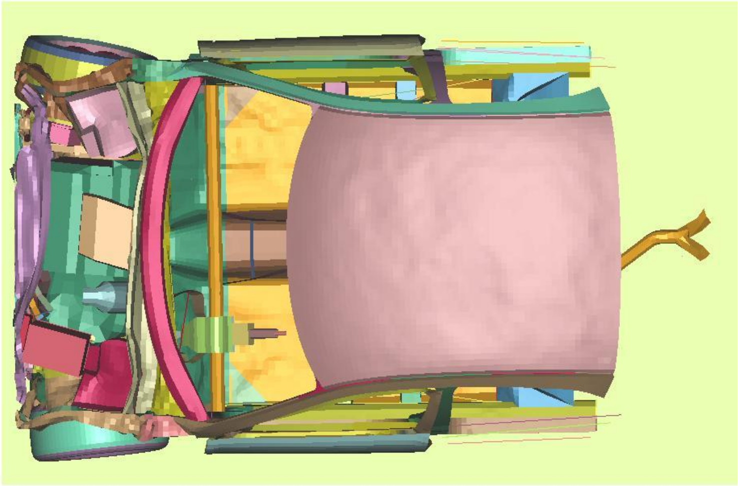
(*Redhe et al., 2001-2004, Sweden*)

[type "saab space mapping" into Google]

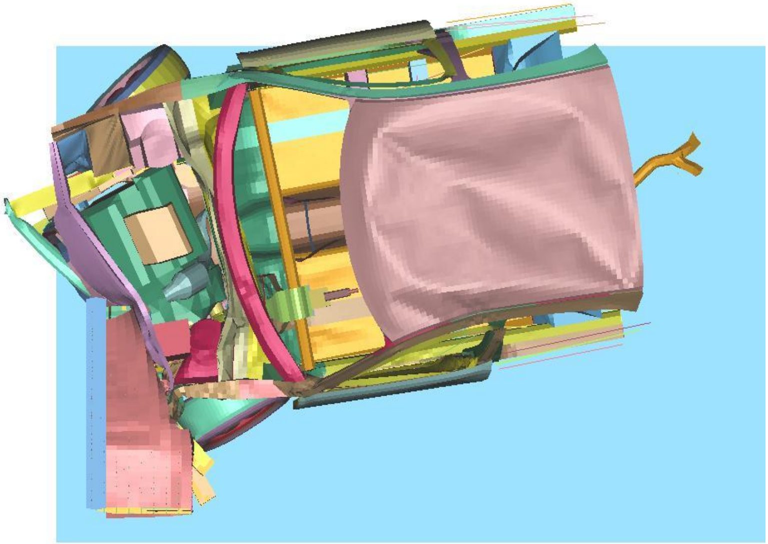
In crashworthiness finite element simulations, each evaluation is expensive. Space Mapping reduces the total computing time to optimize the vehicle structure more than 50% compared to traditional optimization.

Space Mapping has been applied to the complete FE model of the new Saab 9^3 Sport Sedan. Intrusion into the passenger compartment area after the impact was reduced by 32% with no reduction in other crashworthiness responses.

Space Mapping Crashworthiness Design of Saab 9[3] Frontal Impact (*Nilsson and Redhe, 2005, Sweden*)

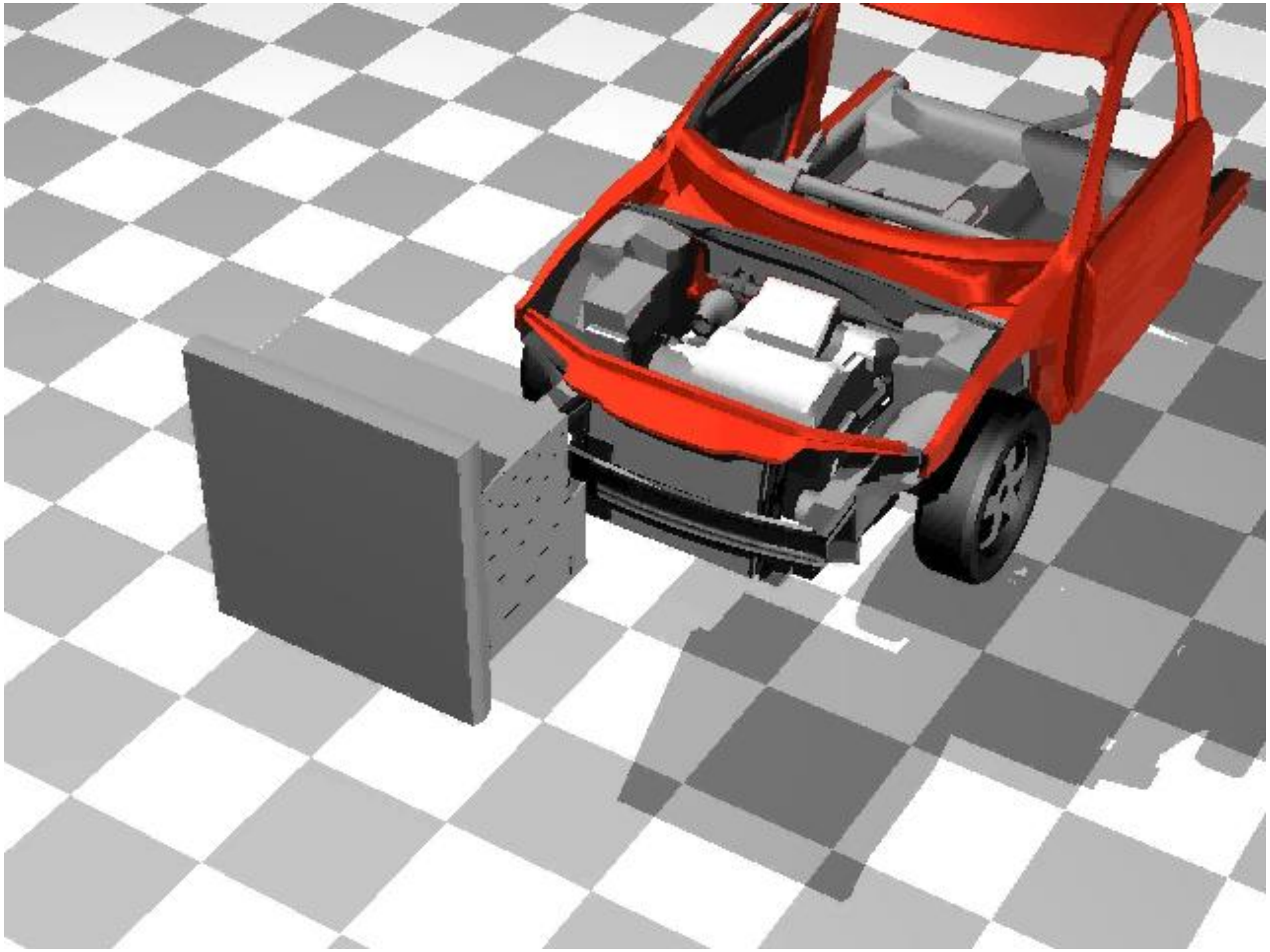


US-NCAP



EU-NCAP

Space Mapping Crashworthiness Design of Saab 9^3 Frontal Impact (*Nilsson and Redhe, 2005, Sweden*)



Space Mapping Crashworthiness Design of Saab 9[3]

(*www.studyinsweden.se, 2005*)

Space Mapping cuts calculation times by three fourths compared with traditional RSM optimization methods

driven straight into a steel barrier at 56 km/h

penetration of the passenger space by the material was reduced by 32 percent

Space Mapping Crashworthiness Design of Saab 9[5]

(*Redhe et al., 2005*)

structural optimization problem

a complete FE vehicle model,
consisting of 350,000 shell elements
and a computing time of 100 hours

intrusion into the passenger
compartment area was reduced by 16%

computing time reduced by 57% relative to traditional
RSM optimization

Space Mapping Implementation and Applications 2005

SIAM Conf. on Optimization, Stockholm, Sweden, May 15-19, 2005;
Space Mapping: A Knowledge Based Engineering Modeling and Optimization Methodology Exploiting Surrogates (*Bandler and Madsen*, *Organizers*)

K. Madsen, "Introduction to Space Mapping"
S. Koziel, "On the Convergence of Space Mapping Optimization Algorithms"
J.W. Bandler, "Optimal Design of High-Fidelity Engineering Device Models Through Space Mapping"
L. Nielsson, "Optimization using Space Mapping, with Application on Contact and Impact Mechanical Problems"
Q.J. Zhang, "Neuro-Space Mapping for Nonlinear Electronic Device Modeling"
F. Pedersen, "Modeling Thermally Active Building Components Using Space Mapping"
D. Echeverria, "Multi-Level Optimization with the Space-Mapping Technique"
D. Lahaye, "Space-Mapping Applied to Linear Actuator Design"

Preliminary Announcement

SECOND INTERNATIONAL WORKSHOP ON SURROGATE MODELING AND SPACE MAPPING FOR ENGINEERING OPTIMIZATION

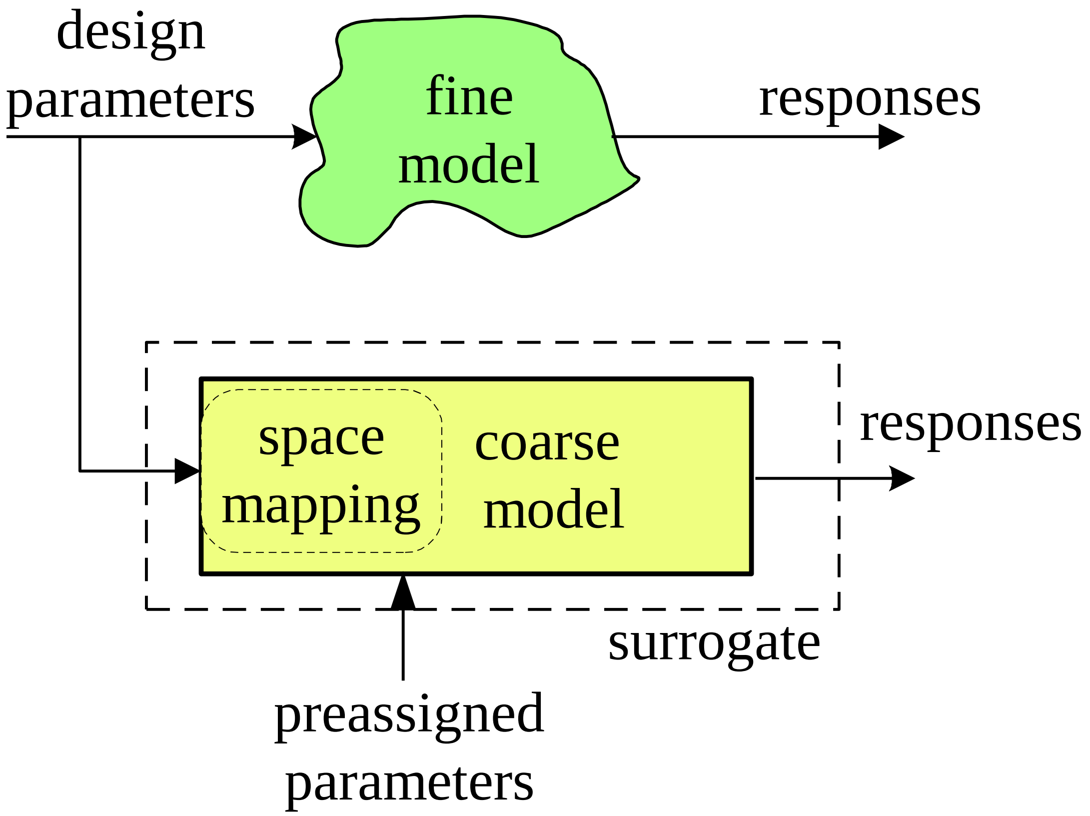
John Bandler and Kaj Madsen, Organizers

Thursday, November 9 to Saturday, November 11, 2006
Technical University of Denmark
Lyngby, Denmark

Invited speakers to be announced

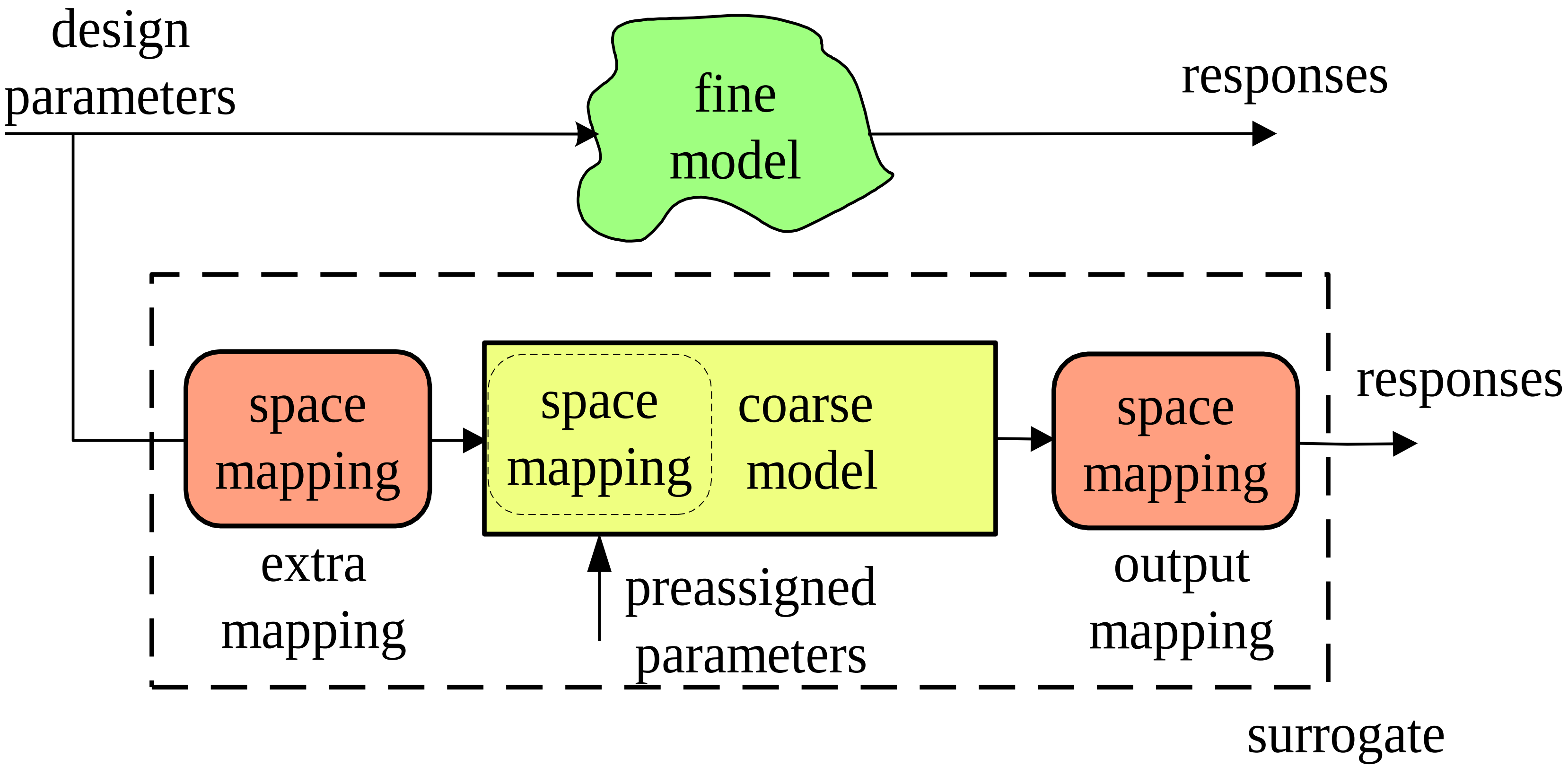
Implicit Space Mapping Concept

(*Bandler et al., 2004*)



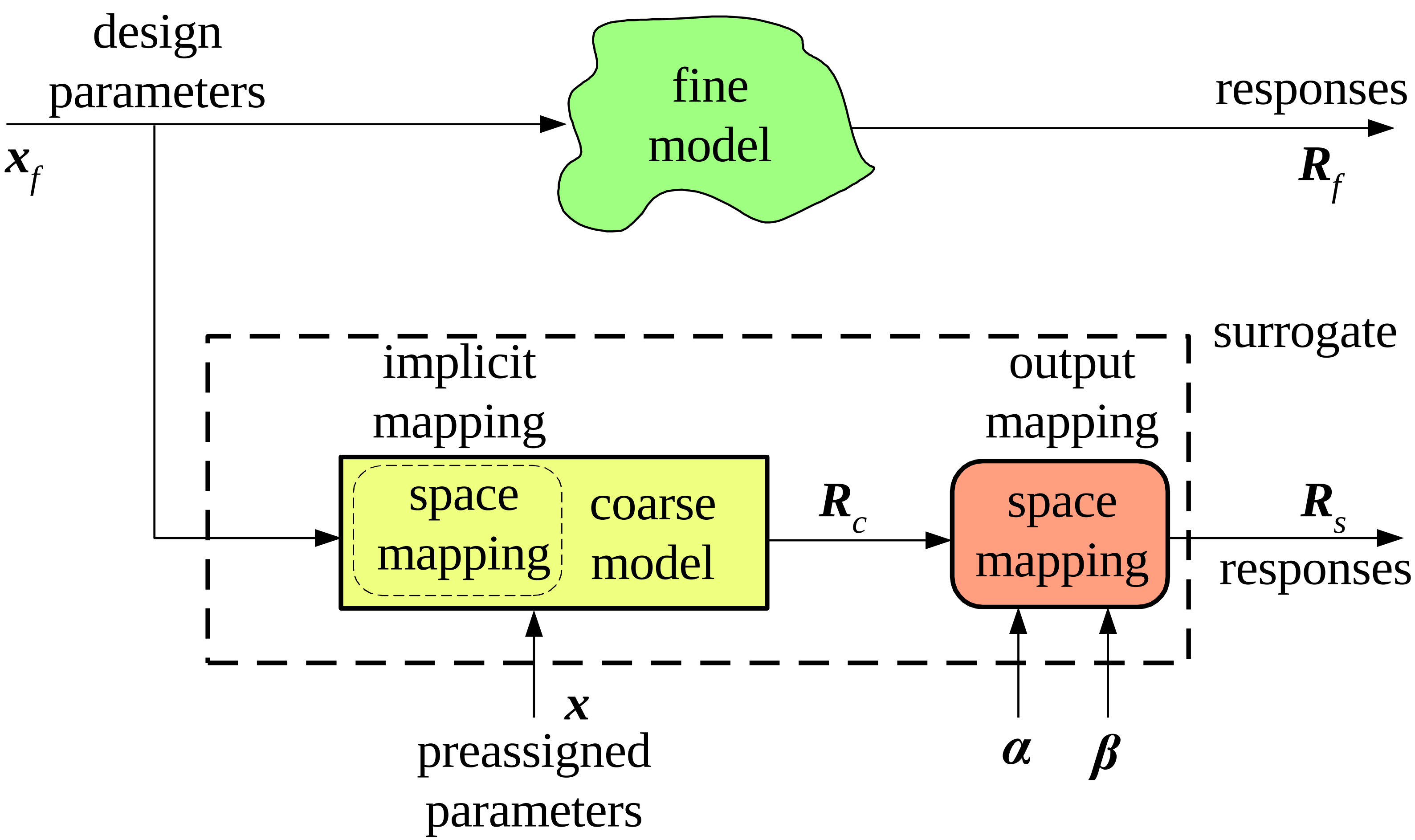
Implicit, Extra and Output Space Mappings

(*Bandler et al., 2003*)



Implicit and Output Space Mappings

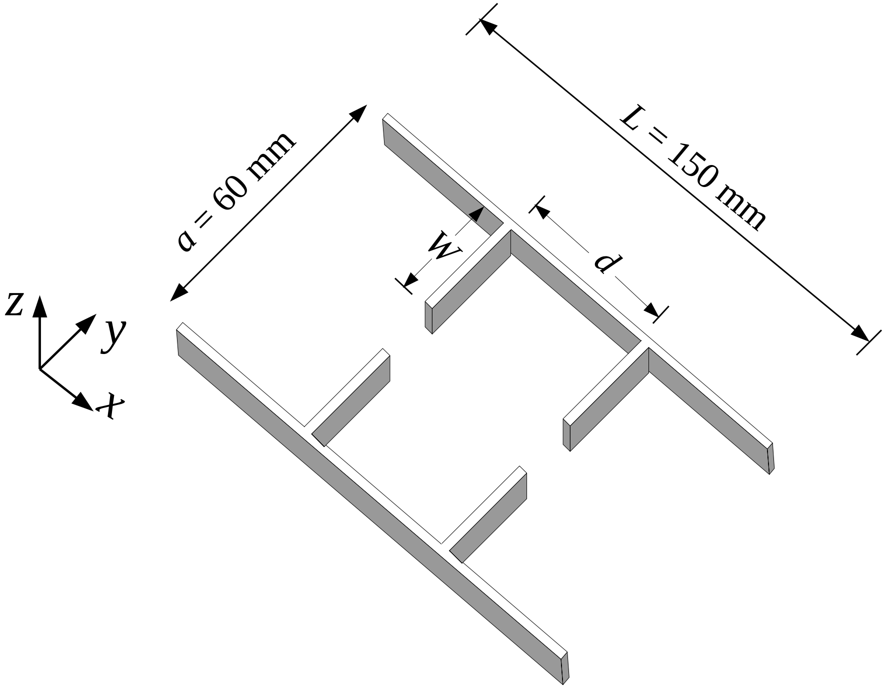
(*Bandler et al., 2003*)



Single Resonator Filter (*Bakr et. al, 2002*)

design of *d* and *W* with the waveguide dimensions fixed
(*a* = 60 mm and *L* = 150 mm)

Matlab implemented 2D TLM simulator is used (*Bakr 2004*)



Single Resonator Filter SM Design (*Bandler et al., 2005*)

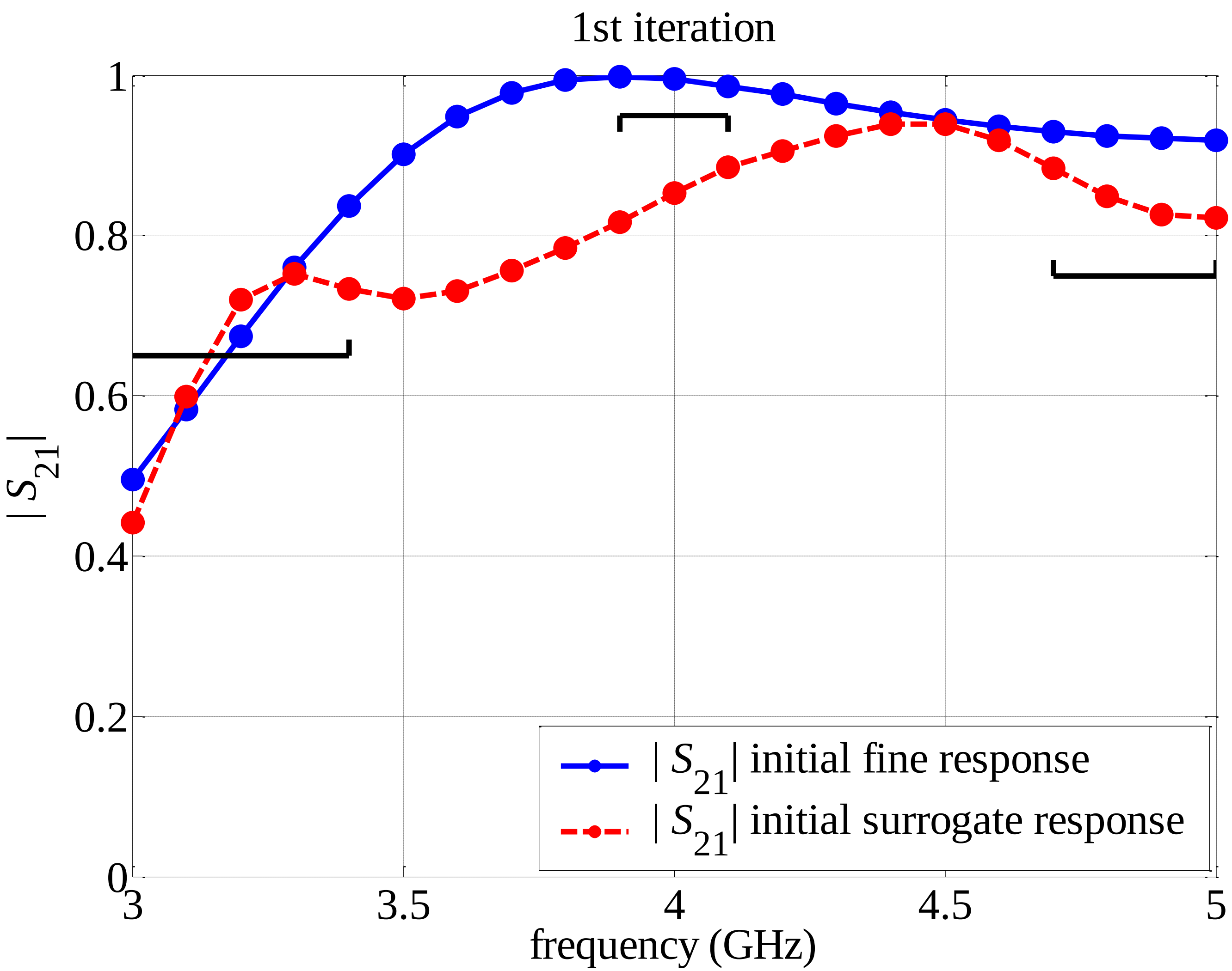
3.0 GHz $\leq \omega \leq$ 5.0 GHz with 0.1GHz step (21 points)

design parameters $x_f = [d \;\; W]^T$

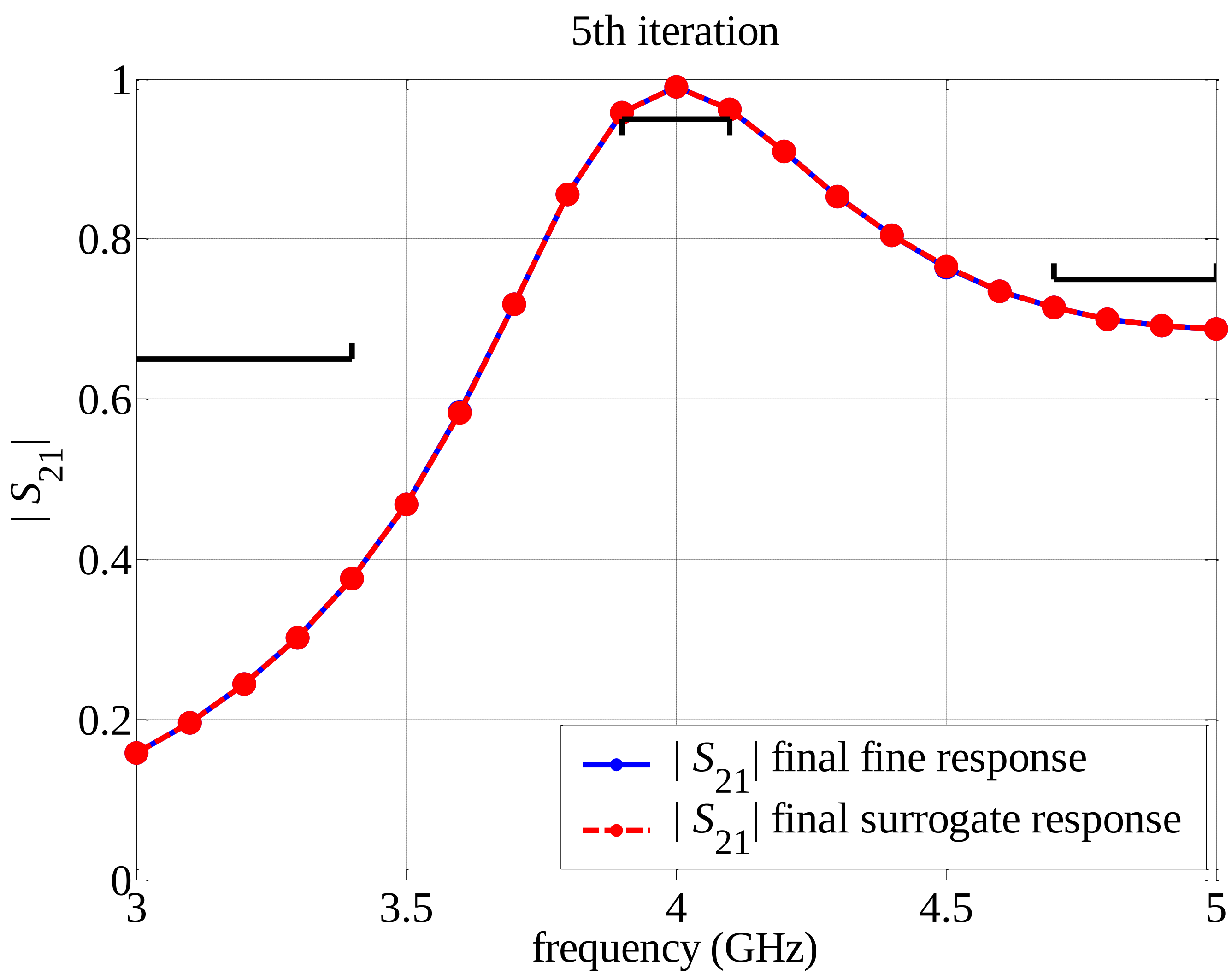
preassigned parameter $x = \varepsilon_r$

Fine Model	**Coarse Model**
$dx = dy = 1$ mm	$dx = dy = 5$ mm
$\Delta d = 2dx$, $\Delta W = dy$	$\Delta d = 2dx$, $\Delta W = dy$
$Nx = 150$	$Nx = 30$
$Ny = 30$	$Ny = 6$
Johns boundary	absorbing boundary at 4 GHz

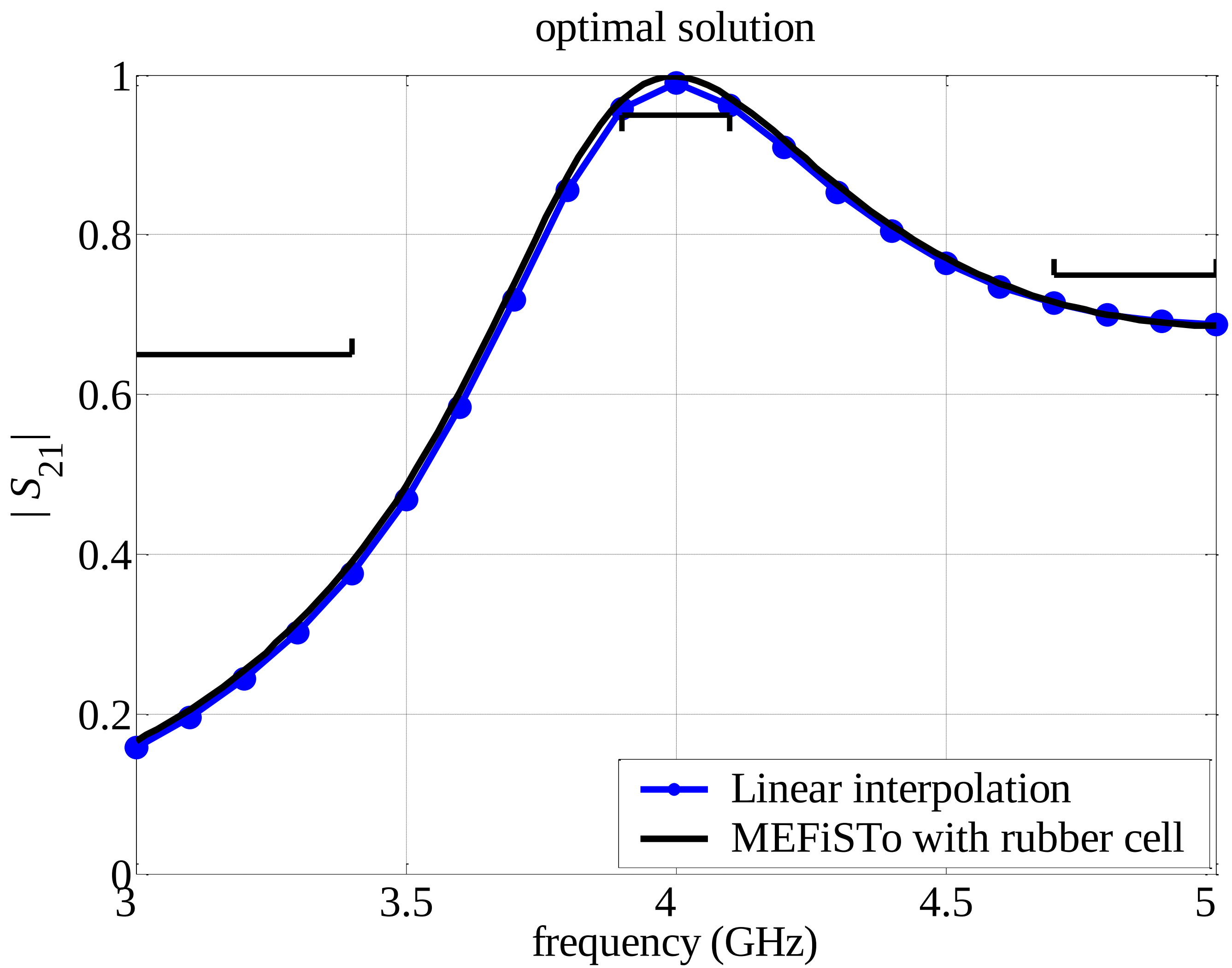
Single Resonator Filter SM Design (*Bandler et al., 2005*)



Single Resonator Filter SM Design (*Bandler et al., 2005*)



Single Resonator Filter Final SM Design (*Bandler et al., 2005*)



Work in Progress: Convergence Theory, Algorithms, User-Friendly Software for SM-based Modeling and Optimization

convergence results for the original, output and implicit SM optimization algorithms

unified SM formulations and algorithms

new and robust SM optimization algorithms

advanced SM modeling methodologies

commercially-available, user-friendly software engine for SM optimization/modeling with sockets to drive popular simulators (*Bandler Corporation, 2005*)

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