Getting Ahead with

Compact Models

- Speaker: Yushi Tan
- Start time: 17:00 CET(11:00 ET)
- Audio will be broadcast through your computer speakers or headphones (no need to teleconference)
- In case of audio broadcast failure please use dial-in numbers from your registration email
- There will be no audio until the scheduled start time.
- A recording will be made available, you will be notified by email
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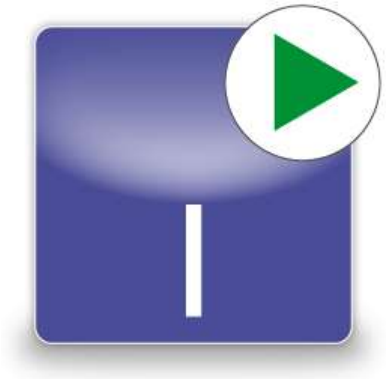
Why time domain?



TLM solver in CST Studio Suite

Motivation

Types of compact models available

Demo: How to create the compact models

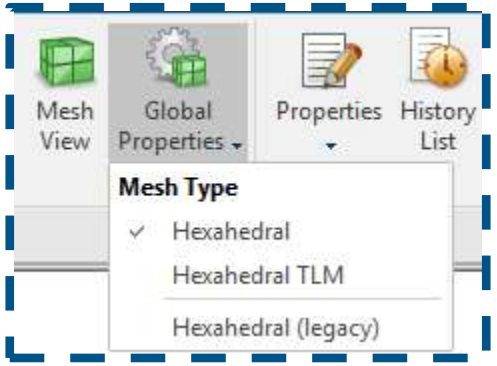
Validation: measured result vs simulation result

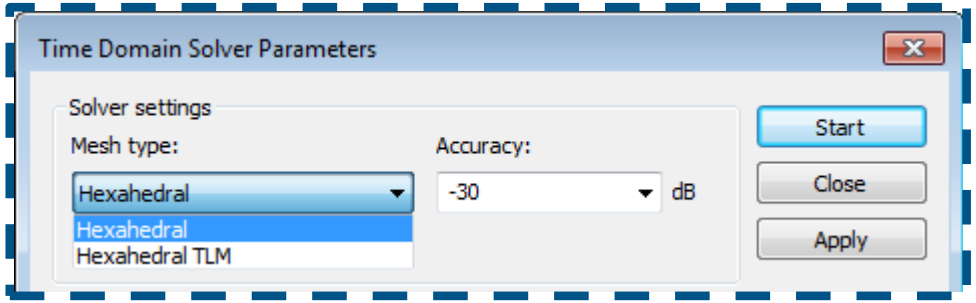
Summary

TLM solver in CST Studio Suite

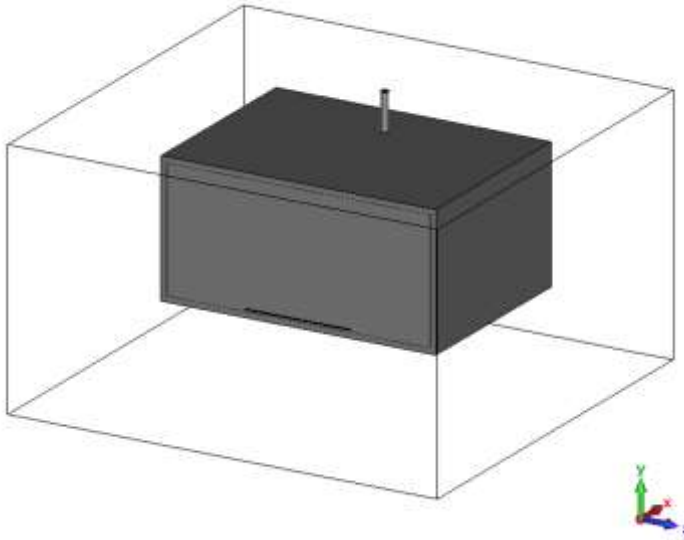
- CST Studio Suite offers two time domain solvers:
  - FIT solver (based on the Finite Integration Technique)
    - PCBs, connectors, antennas
  - TLM solver (based on the Transmission-Line Matrix Method)
    - EMC applications(i.e. enclosures, large structure with tiny details)

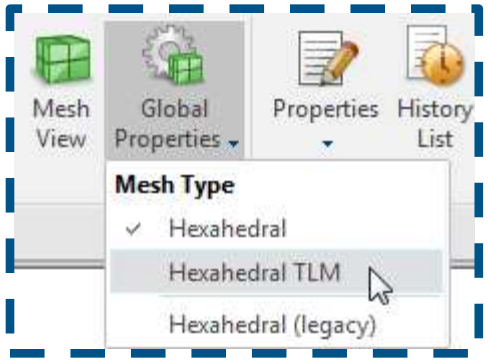
- Time domain discretization
  - Hexahedral
  - Hexahedral TLM

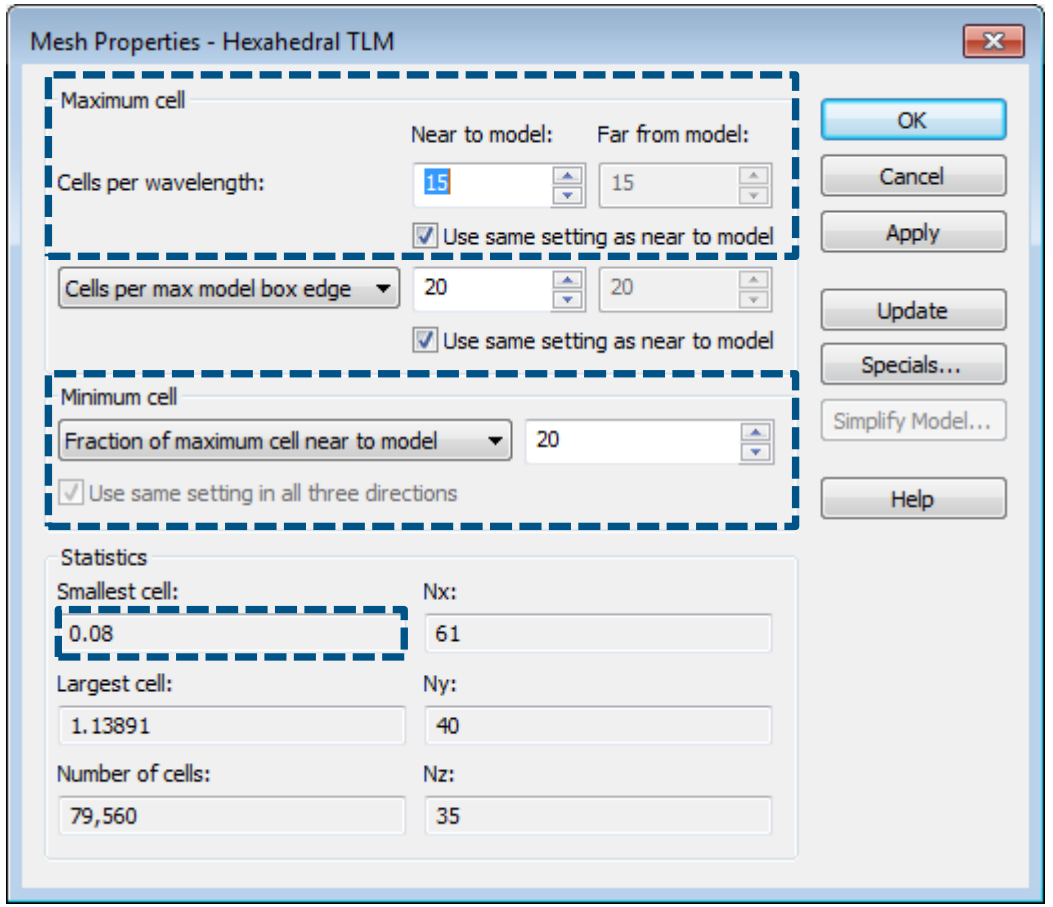




Time domain discretization







Smallest feature of the model

↓

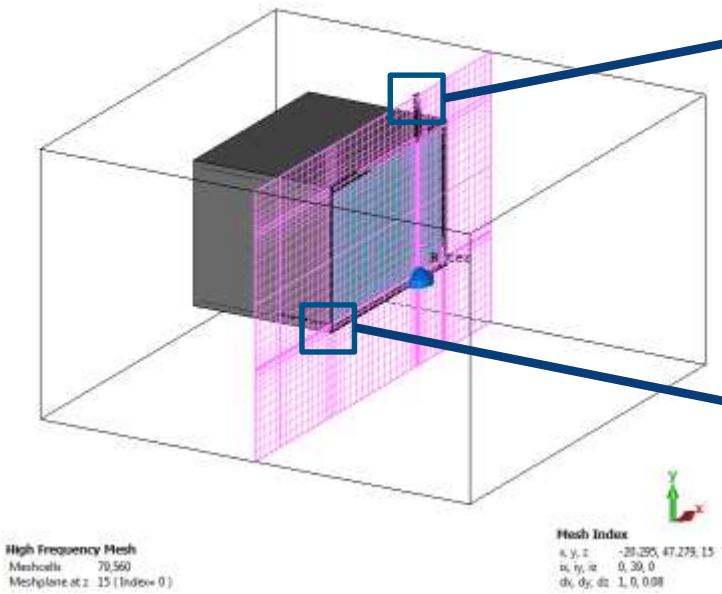
Smallest mesh cell

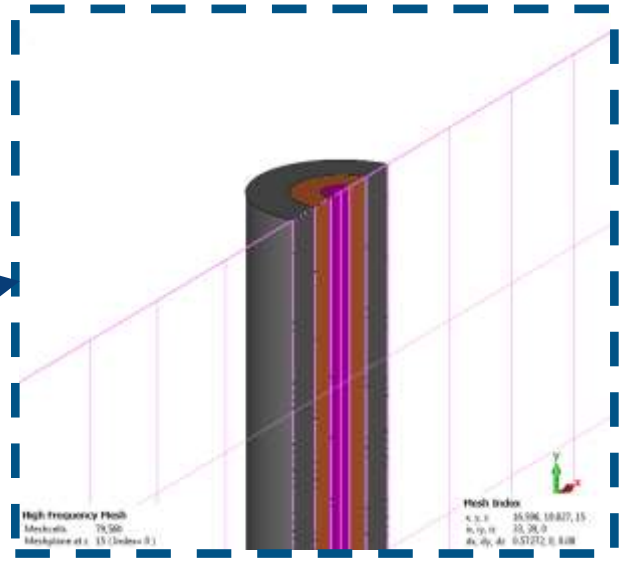
↓

Smallest time step

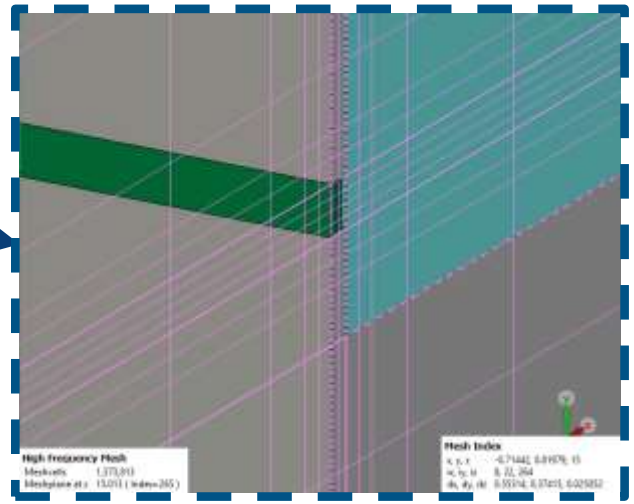
Time domain discretization

Smallest feature determines the smallest mesh cell





Detailed coaxial feed



Detailed slot

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Detailed 3D models vs compact models

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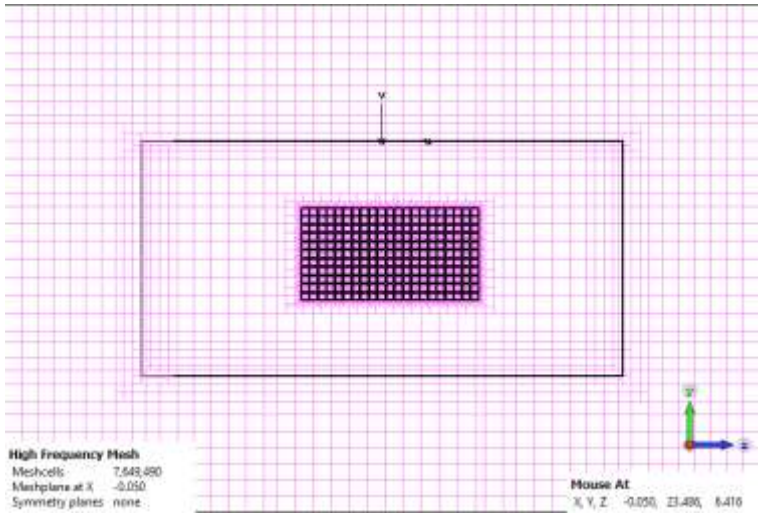
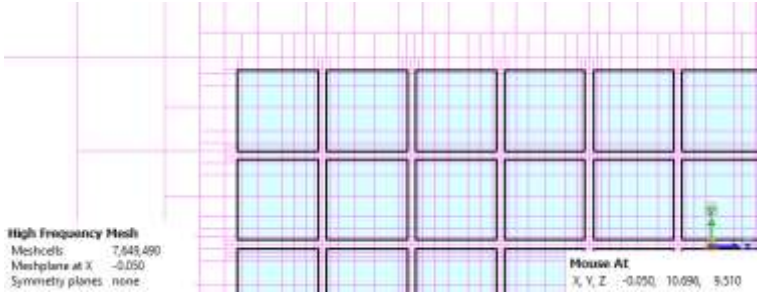
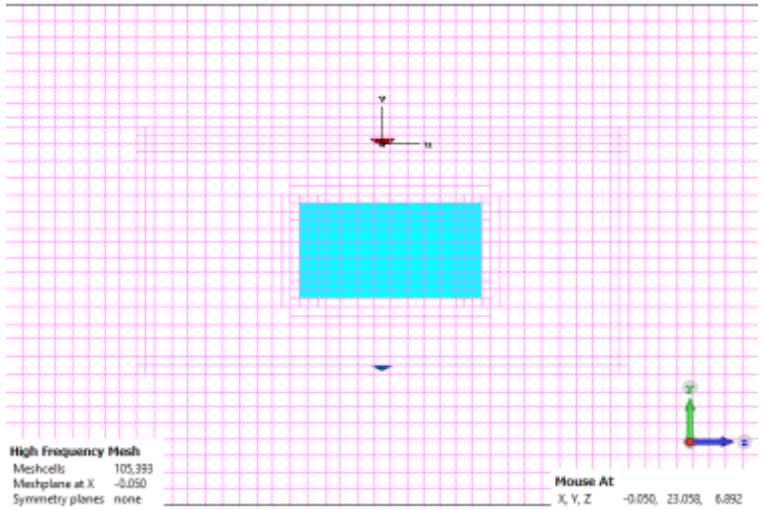
- We want
  - Fast simulation, meaning -> big time step -> big mesh step -> equivalent model
- To make simulation run faster, we need to maximize the time step
- We need to capture the details while at the same time maximizing the time step

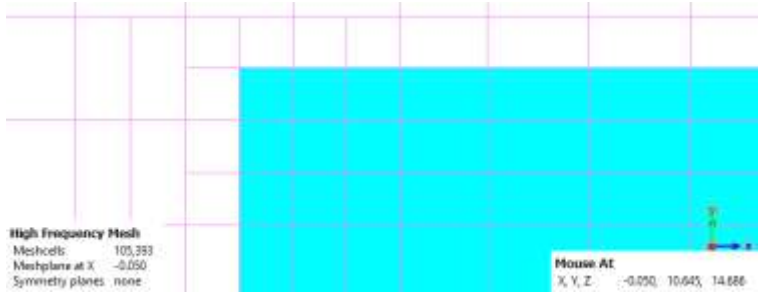
Any way to simplify the model?





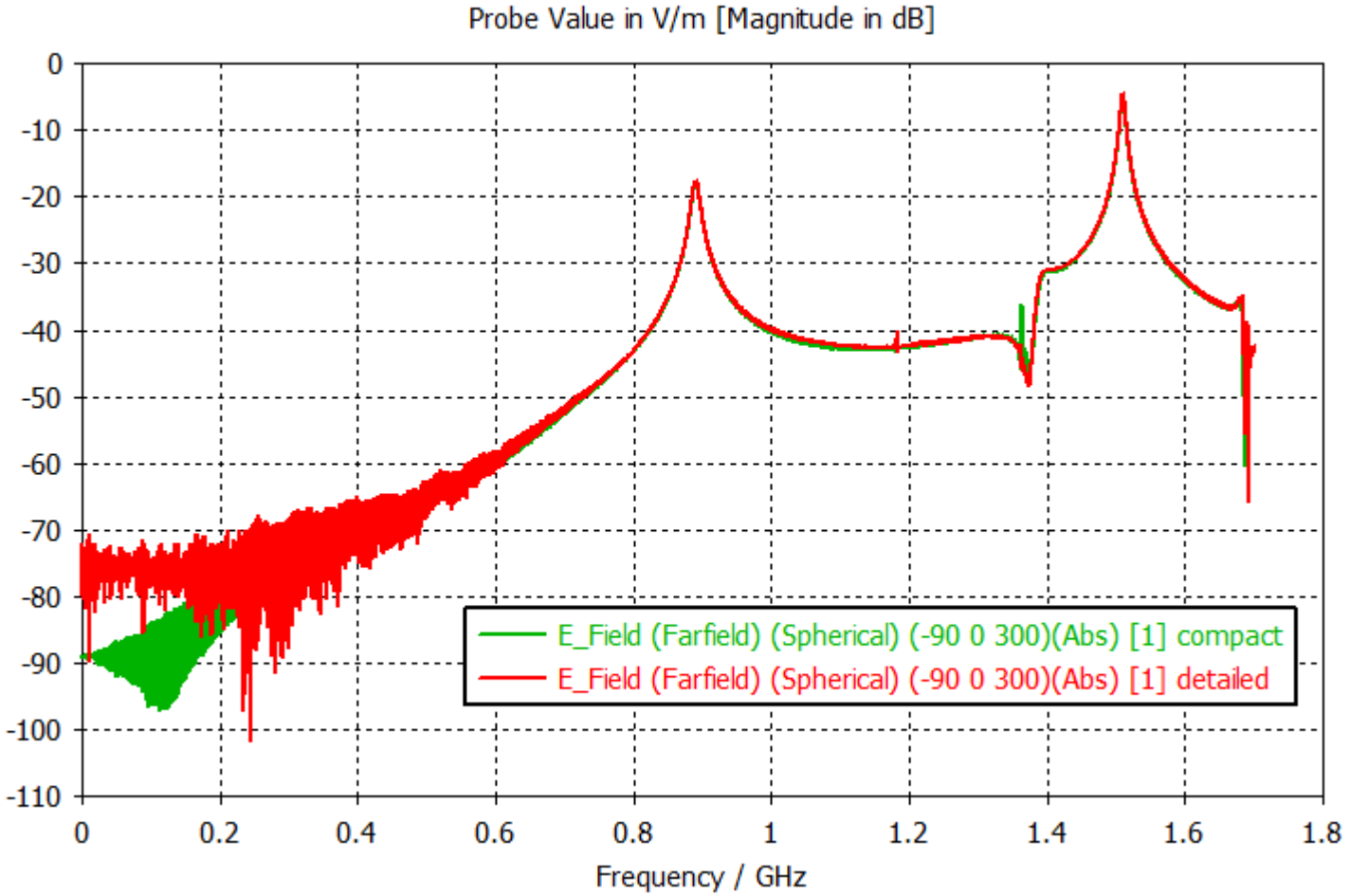
7.5 million -> 157k after lumping





105k -> 55k after lumping

Detailed model vs compact model



Detailed model: 34 minutes

Compact model: 1.5 minutes

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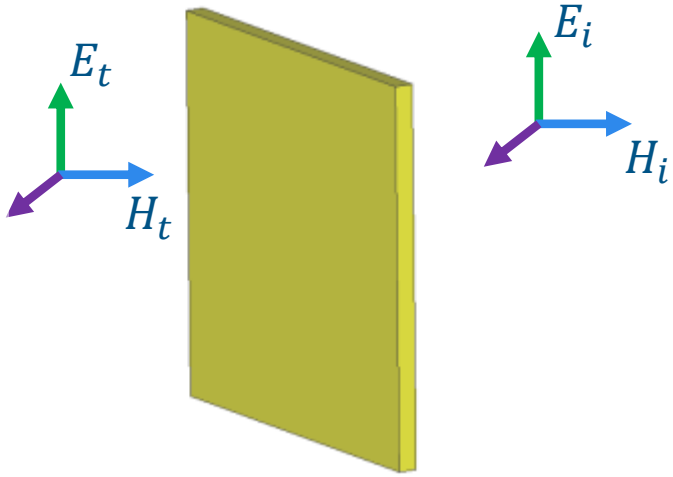
Summary

Types of compact models available

- Thin panel material(electrically thin conductive materials)
  - Can have multiple layers with different thickness and rotation angle



- Slot and seam
  - can be attached to infinitely thin conductive panel
- Wire model
  - wire detail do not have to be meshed
  - Shielded cable(extension of the wire model), a coax cable based on the transfer impedance
- Perforations
  - Vent
    - Hole shape: square, round staggered, hexagonal staggered
  - Wire mesh
    - Hole shape: diamond, circular, rectangular aligned, rectangular staggered

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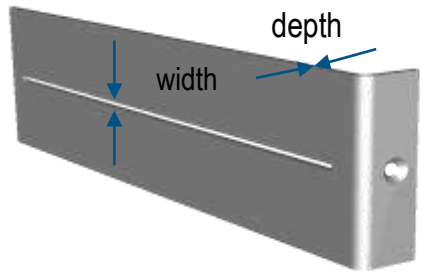
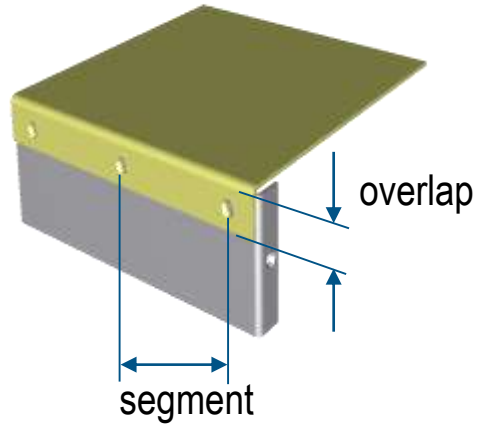
Slots



Seams



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Wire model

Shielded cable

- **Wire model**
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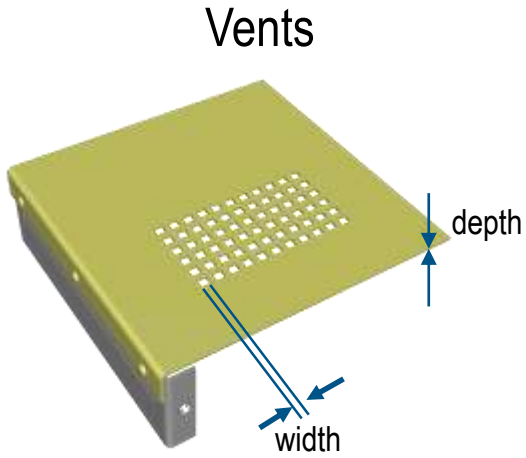

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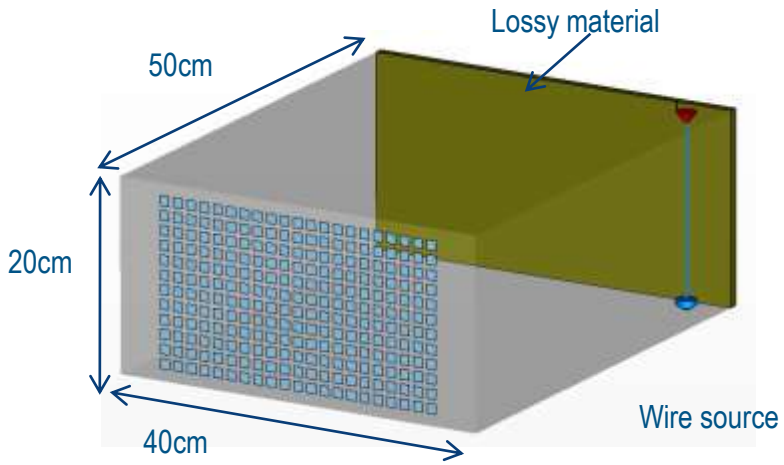
Detailed vs compact models

	Detailed model		Compact model	
	Mesh cells	Time	Mesh cells	Solver Time
Panel	4.8 million → 260k	7 minutes	105k → 55k	0.5 minute
Slot	1.3 million → 67k	14 minutes	75k → 50k	1.5 minutes
Square vent	7.6 million → 186k	34 minutes	105k → 55k	1.5 minutes
Round staggered vent	2.1 million → 205k	98 minutes	105k → 55k	2 minutes

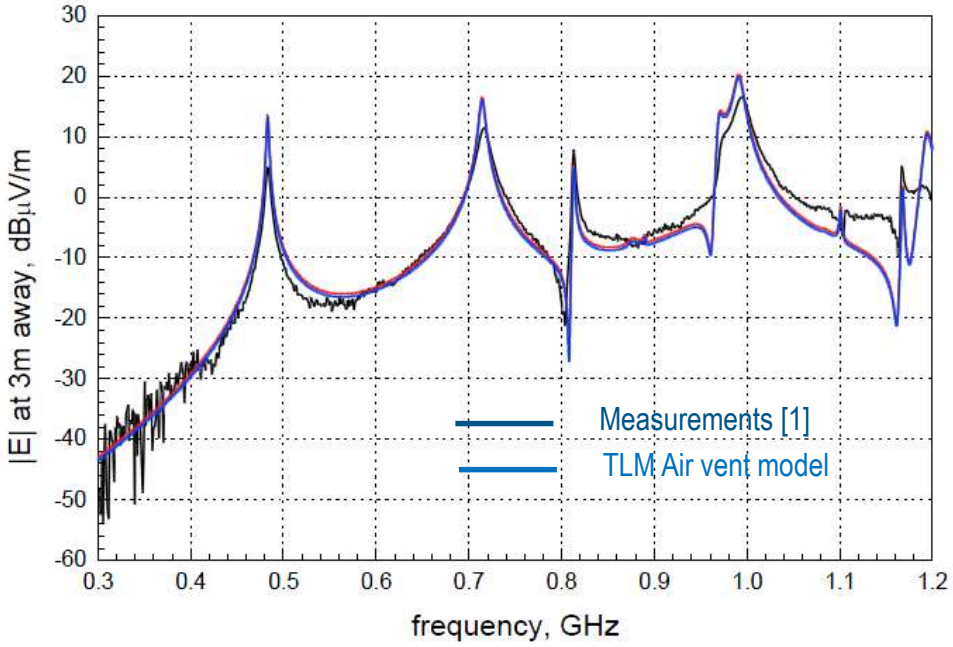
Note: all models ran on the same machine with 2 x K40c GPUs.

Validations

Ref: M. Li, J. Nuebel et. al, "EMI from Airflow Aperture Arrays in Shielding Enclosures", *IEEE Trans. EMC, Vol. 42, No. 3, pp. 265-275, 2000*



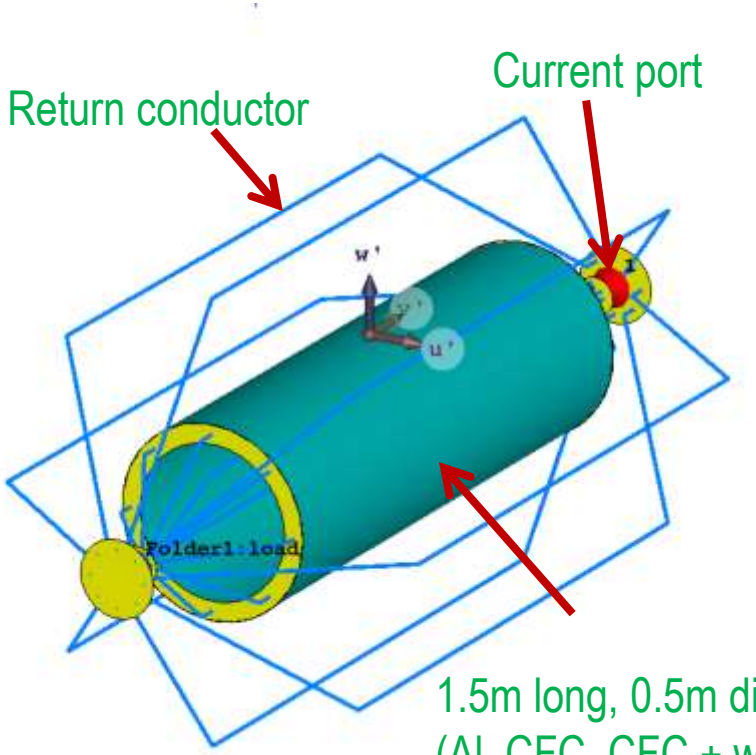
- 1.65mm thick Al plate
- Aperture size 10mm
- Edge-to-edge space 5mm
- 252 apertures



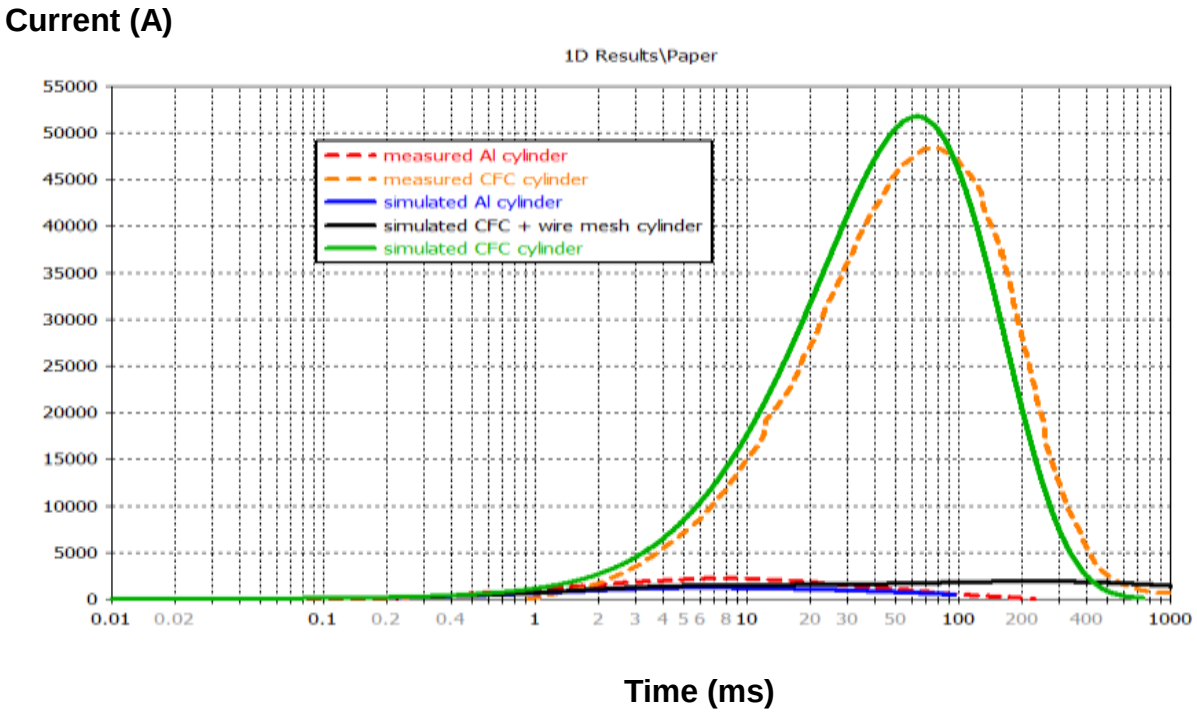
Radiated E field at 3m

Validations

Ref: “Lightning induced currents in aircraft wiring using low level injection techniques”, E Stevens (ERA) & D Jordan (RAE), NASA Technical report 19910023380.



1.5m long, 0.5m diameter test cylinders
(Al, CFC, CFC + wire mesh)



Compact model rule of thumb

Skin depth(δ) of conductive material

- $\delta = \frac{1}{\sqrt{\pi f_{max} \mu \sigma}}$

- Panel thickness(d), its conductivity, highest frequency(f_{max}) of interest determine what material should be used,
  - d < δ: EM fields can penetrate the panel, use thin panel material
- Compact models can only be applied to zero-thickness objects
- Compact model dimension < 40% of cell size
- If accurate field result near the feature is required, use detailed model