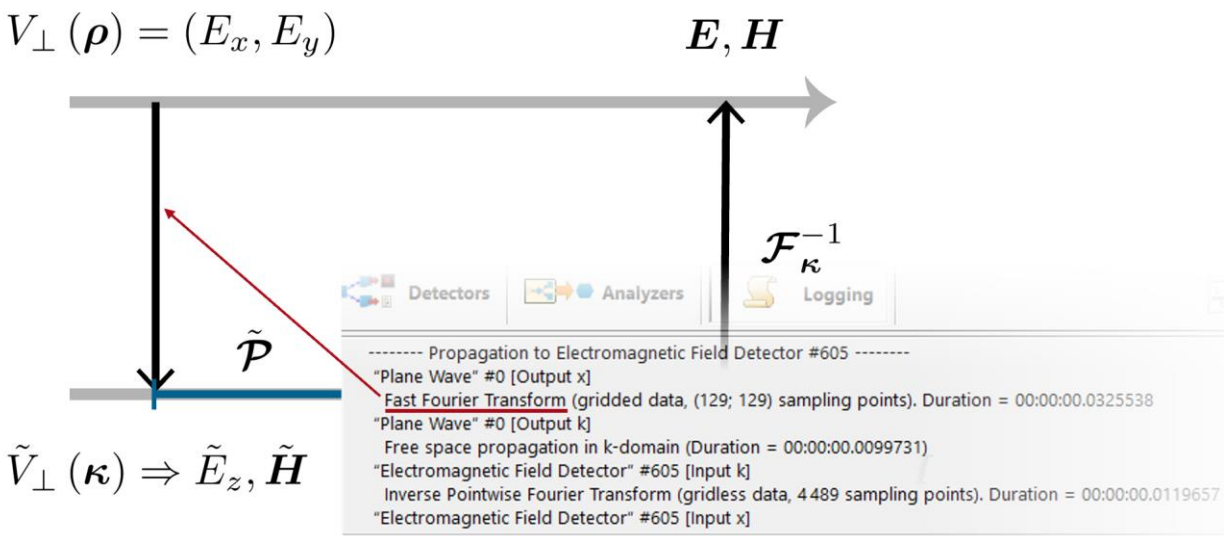
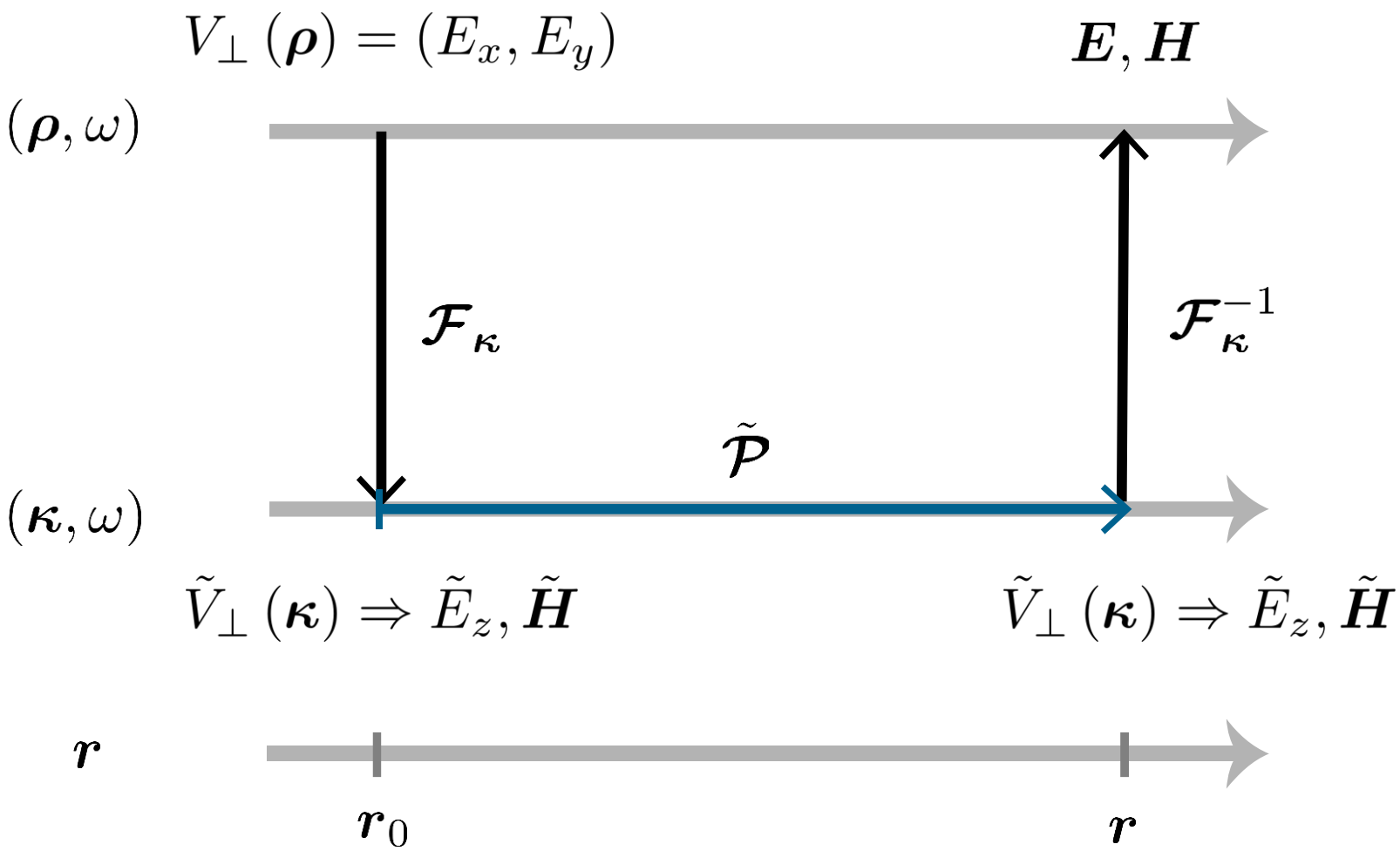
Automatic Selection of Fourier Transform Techniques in Free-Space Propagation Operator

Abstract



Accurate and efficient simulation of the free-space propagation of electromagnetic fields is essential for physical optics modeling and design. For this purpose, VirtualLab Fusion's modeling engine uses a unified free-space propagation concept based on spatial-frequency domain (k-domain) analysis. In combination with different Fourier transform techniques, it delivers numerically efficient solutions for different situations of free-space propagations. The selection of an appropriate Fourier transform algorithm is automatically done according to the specific situation.

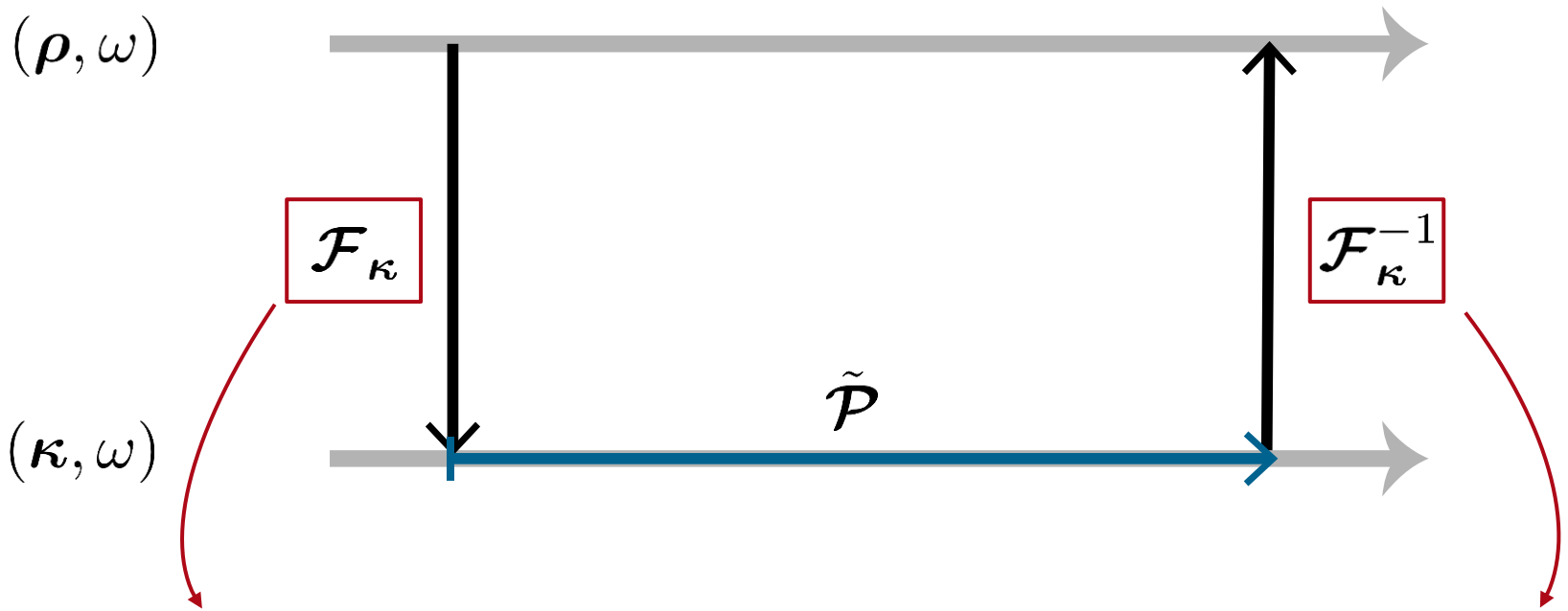
Concept of Free-Space Propagation Operator



- Unified propagation operator in the k-domain
- Applicable for arbitrarily oriented planes
- Switching between two domains via Fourier transform
- References

- F. Wyrowski, “Unification of the geometric and diffractive theories of electromagnetic fields” Proc. DGaO, (2017)
- Z. Wang *et al*., „Application of the semi-analytical Fourier transform to electromagnetic modeling,“ Opt. Express 27, 15335-15350 (2019)

Available Fourier Transform Techniques in VirtualLab Fusion

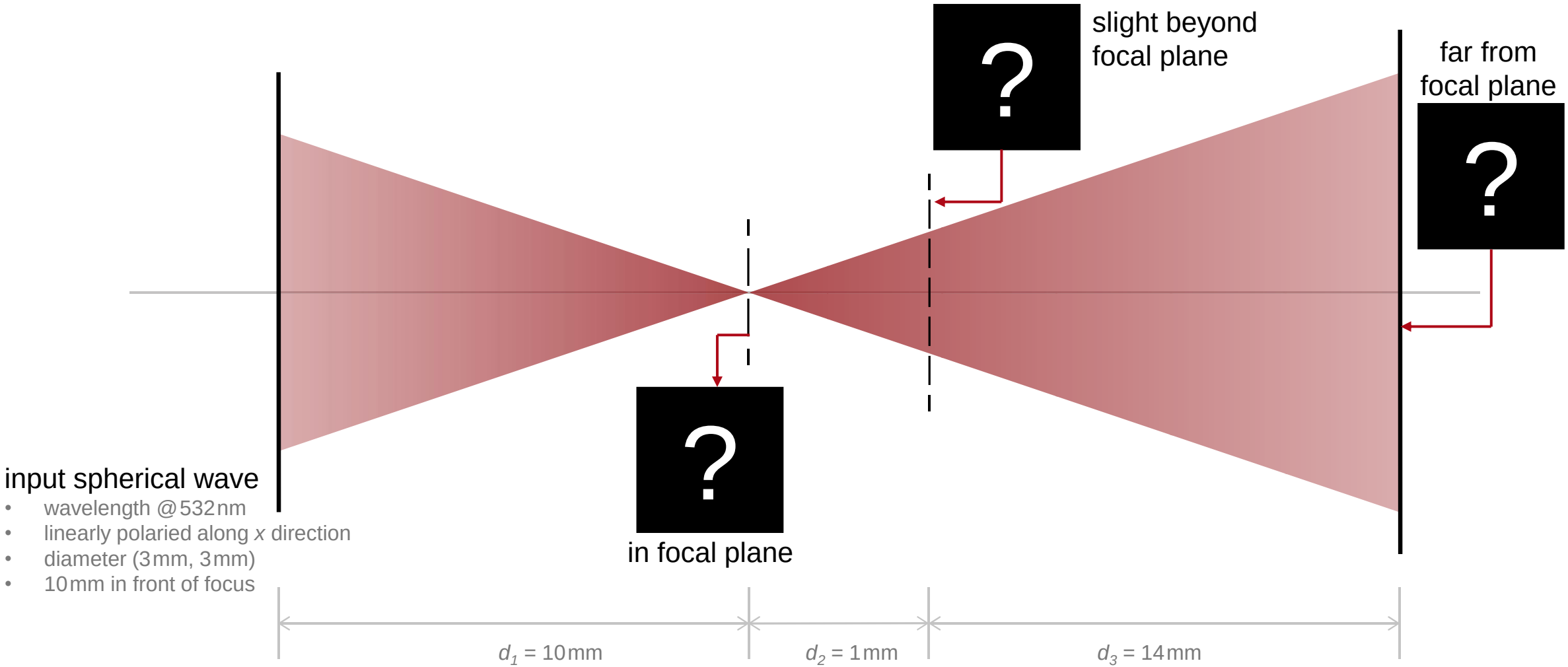


- $\mathcal{F}_\kappa$: fast Fourier transform (FFT)
- $\mathcal{F}_\kappa^{\text{semi}}$: semi-analytical Fourier transform (SFT)
- $\mathcal{F}_\kappa^{\text{p}}$: Pointwise Fourier transform (PFT)

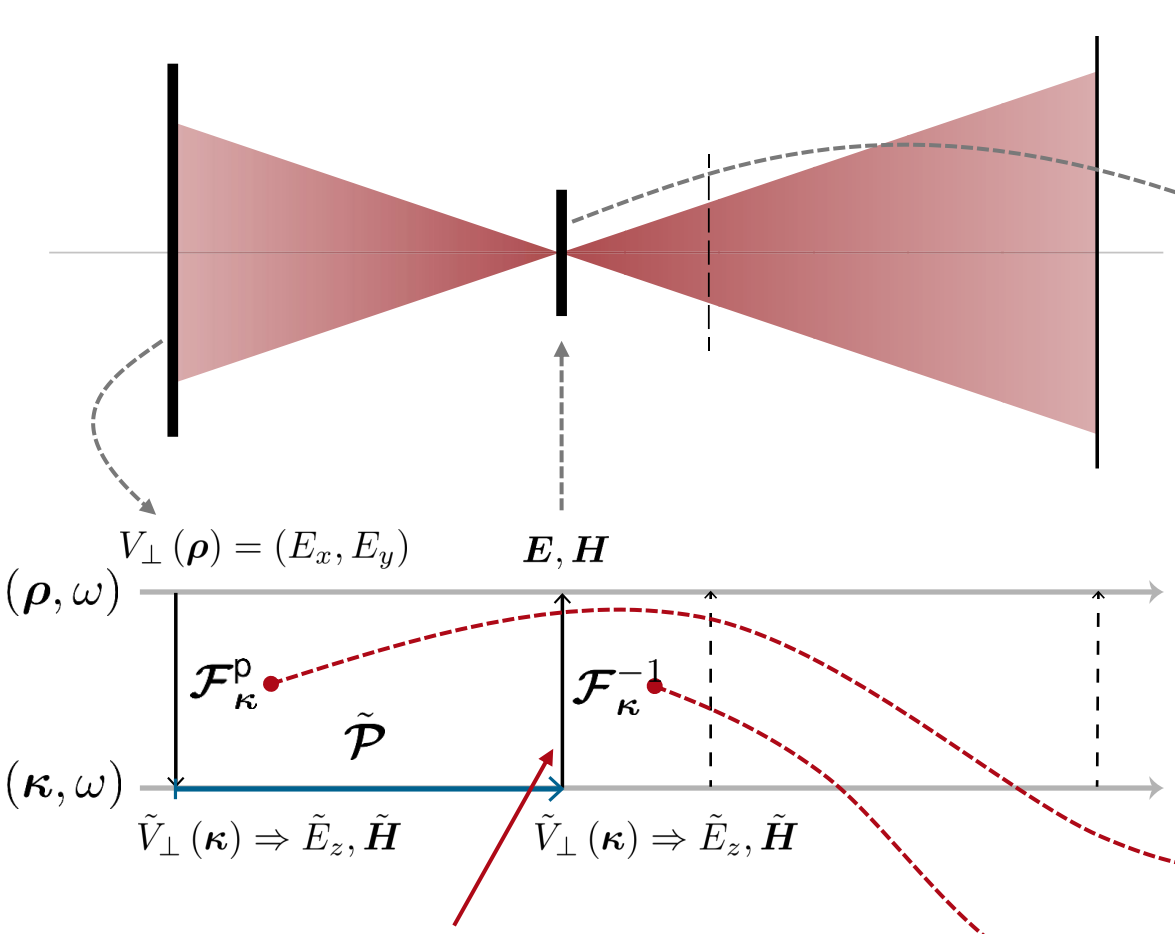
- $\mathcal{F}_\kappa^{-1}$: inverse fast Fourier transform (IFFT)
- $\mathcal{F}_\kappa^{-1,\text{semi}}$: inverse semi-analytical Fourier transform (ISFT)
- $\mathcal{F}_\kappa^{-1,\text{p}}$: inverse Pointwise Fourier transform (IPFT)

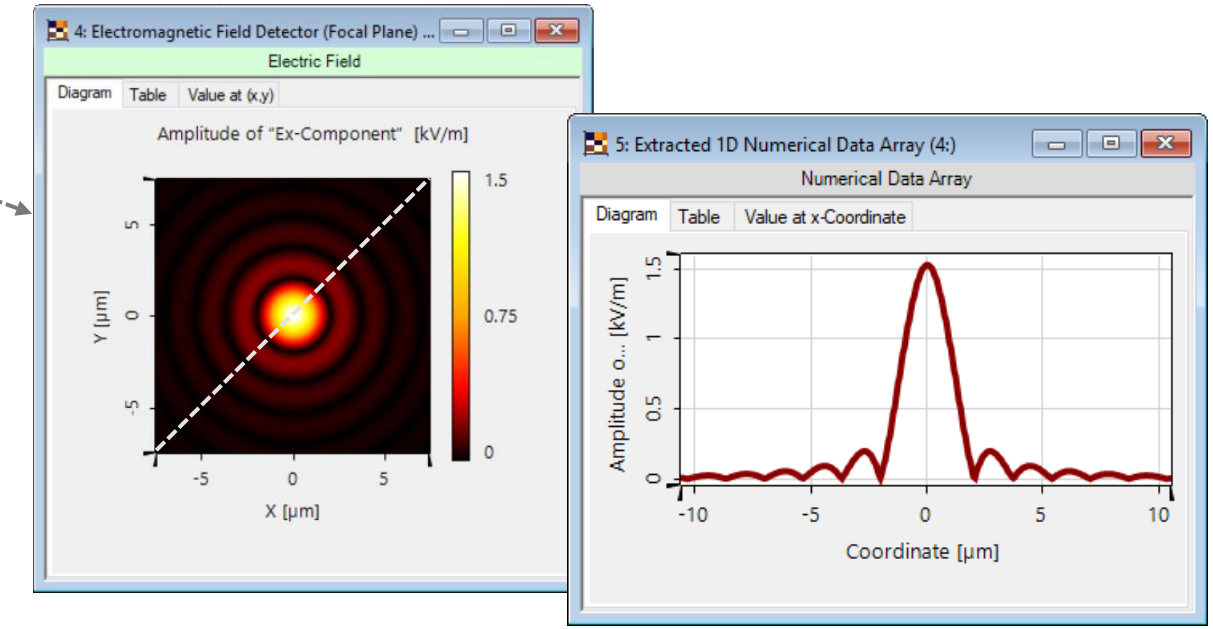
Example 1: Propagation of a Spherical Wave

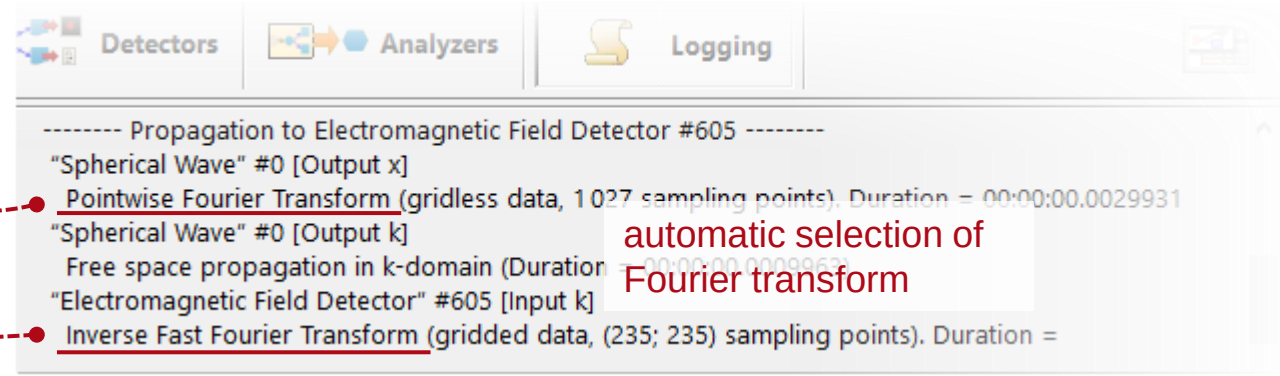
Modeling Task



Simulation Result: in Focal Plane



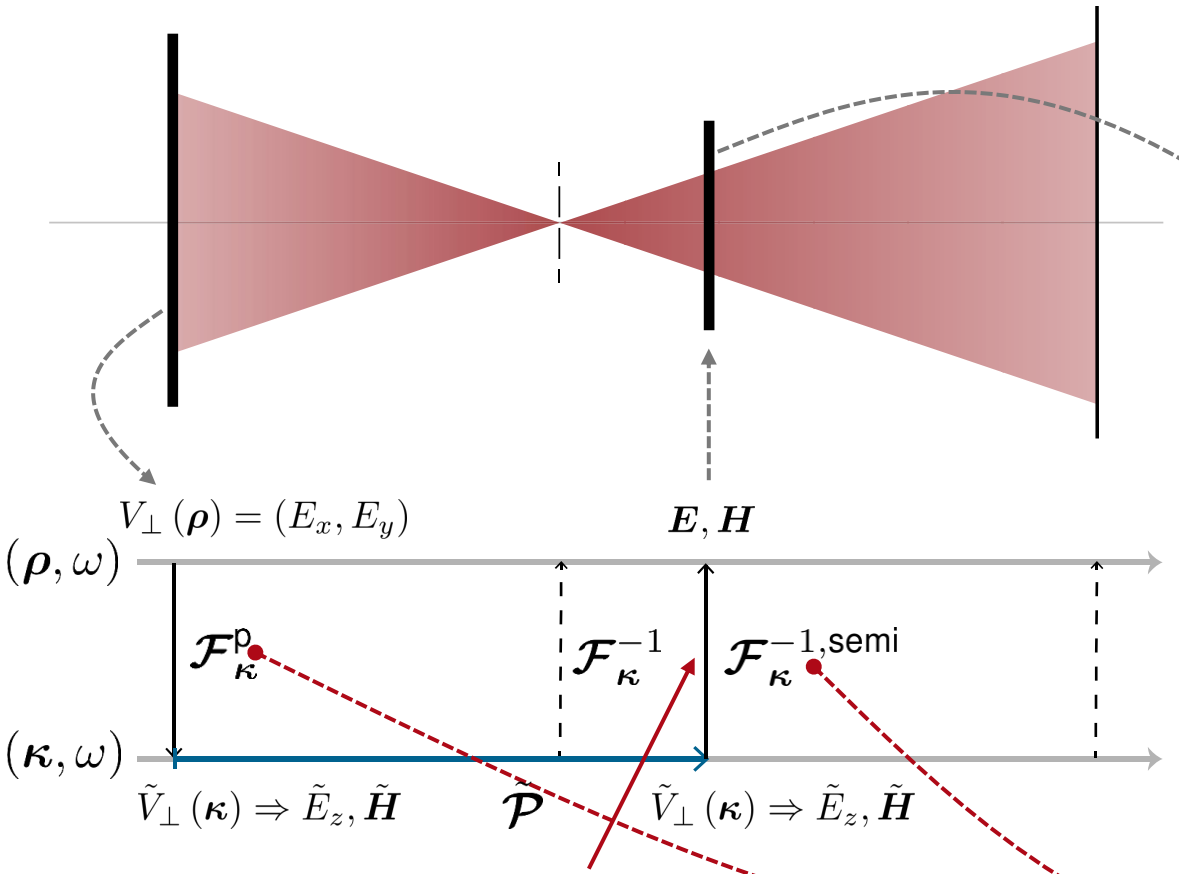


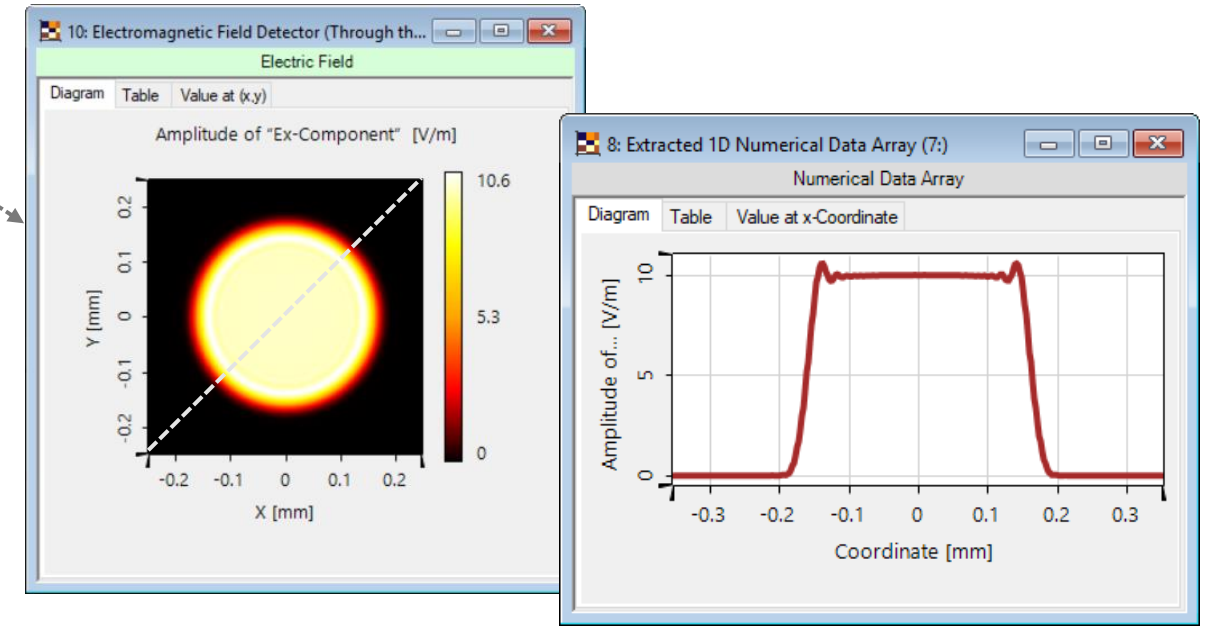


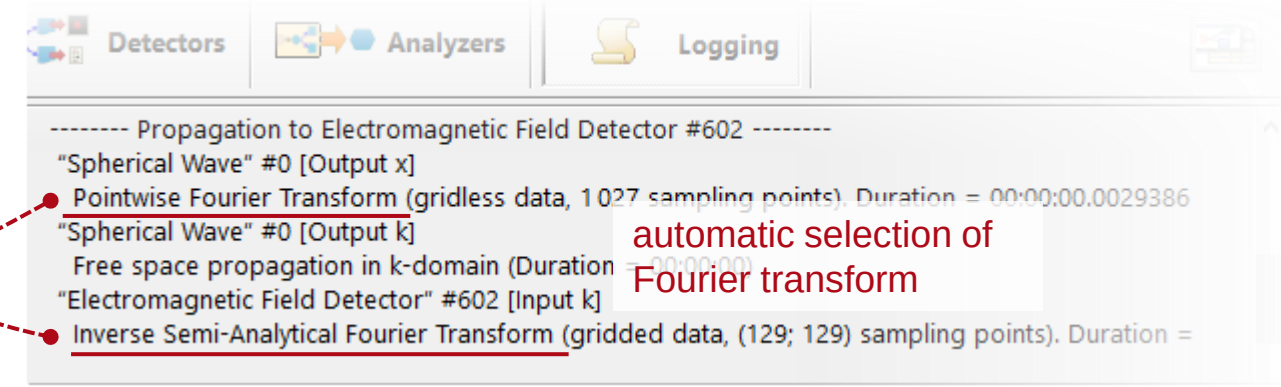
automatic selection of Fourier transform

in a focal plane, a rigorous (inverse) Fast Fourier Transform is required

Simulation Result: Slightly beyond Focal Plane



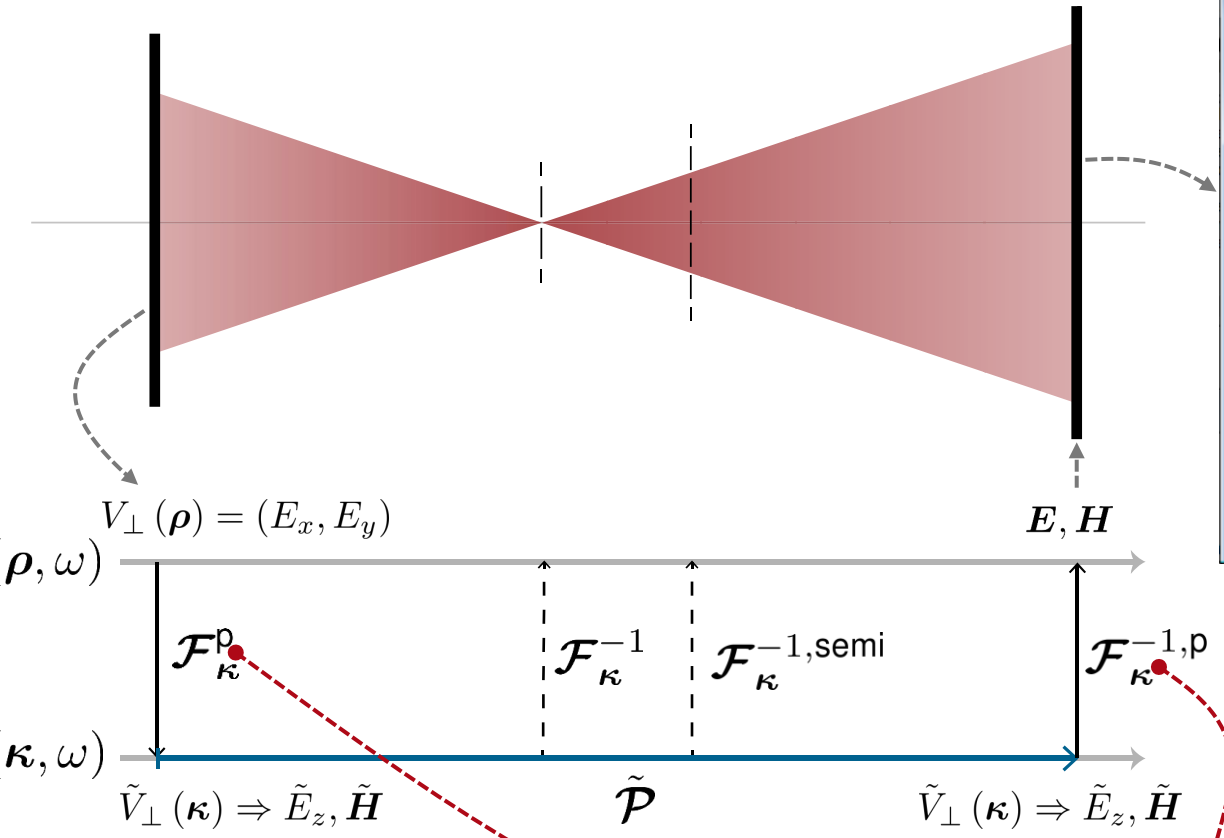


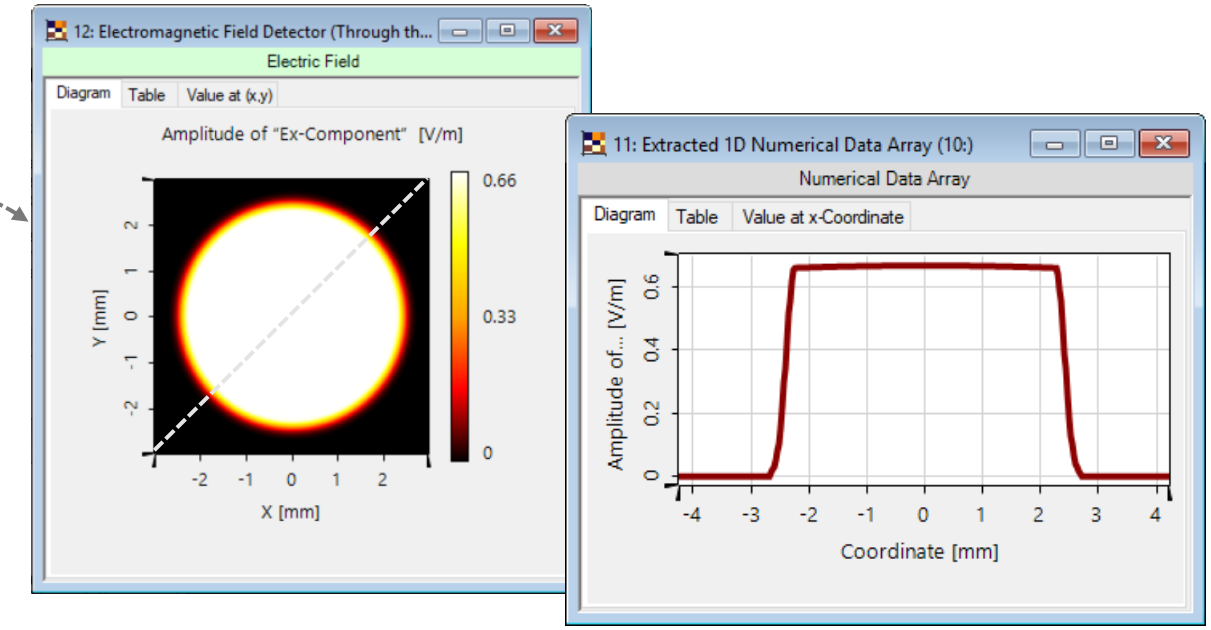


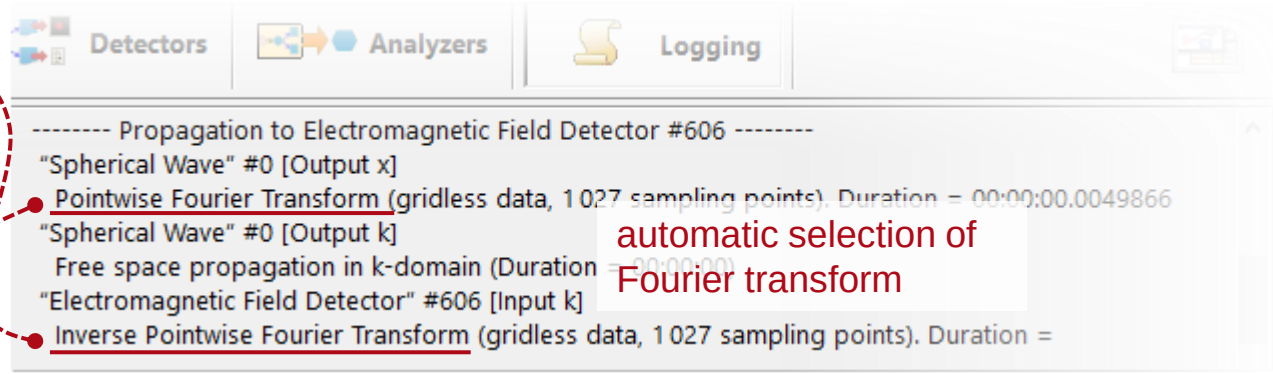
automatic selection of Fourier transform

close to a focal plane, the proper Fourier Transform depends on the NA of the field, here: rigorous inverse SFT is chosen

Simulation Result: Far from Focal Plane







automatic selection of Fourier transform

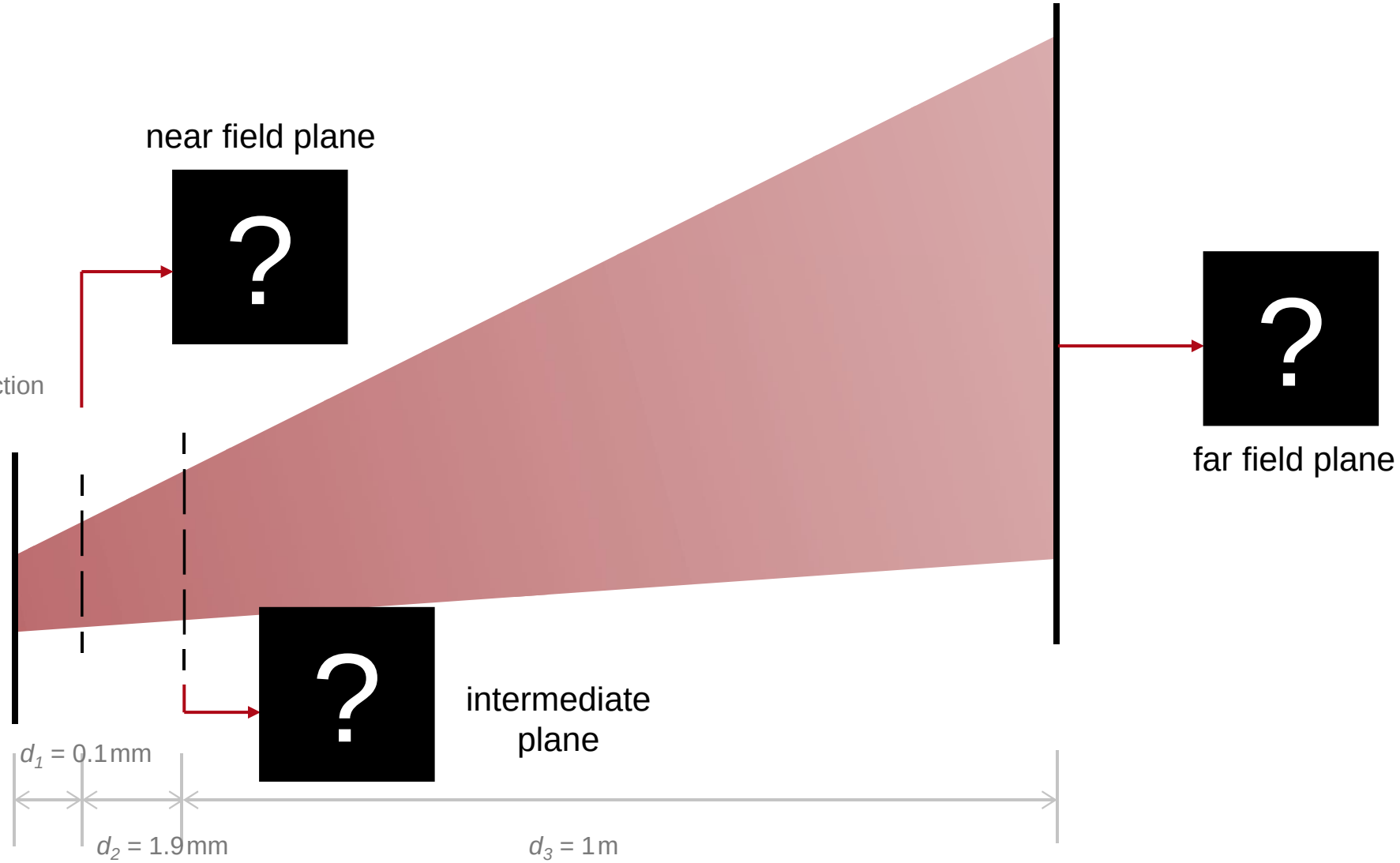
in the far field, a pointwise Fourier transform provides sufficient accuracy

Example 2: Propagation of a Truncated Plane Wave

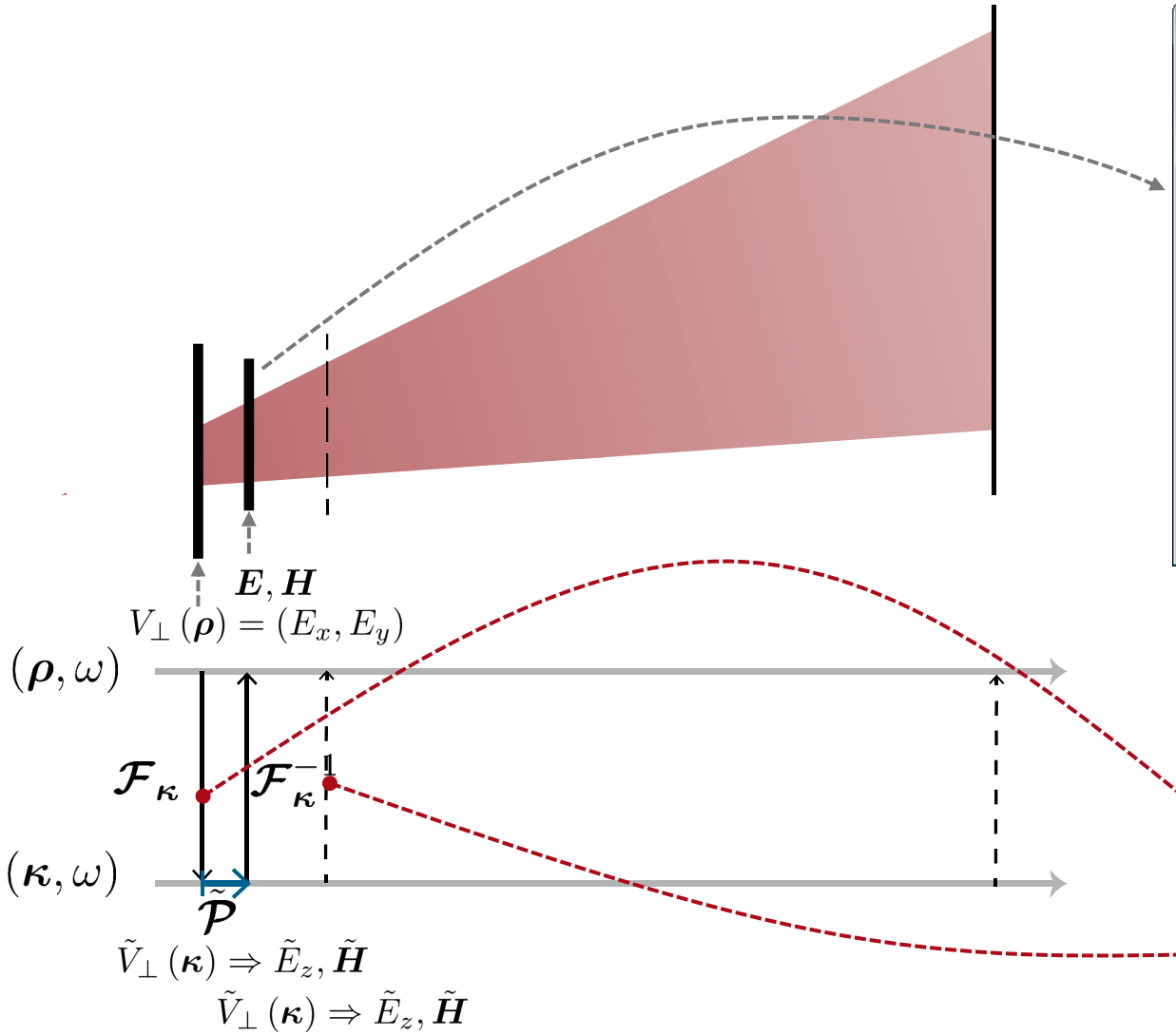
Modeling Task

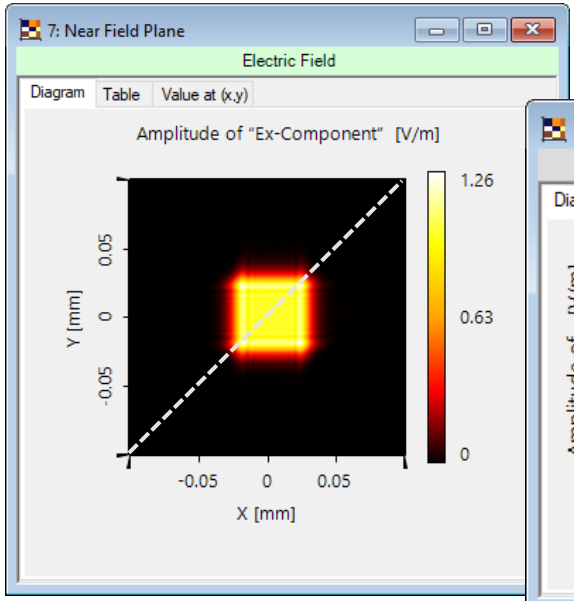
truncated plane wave

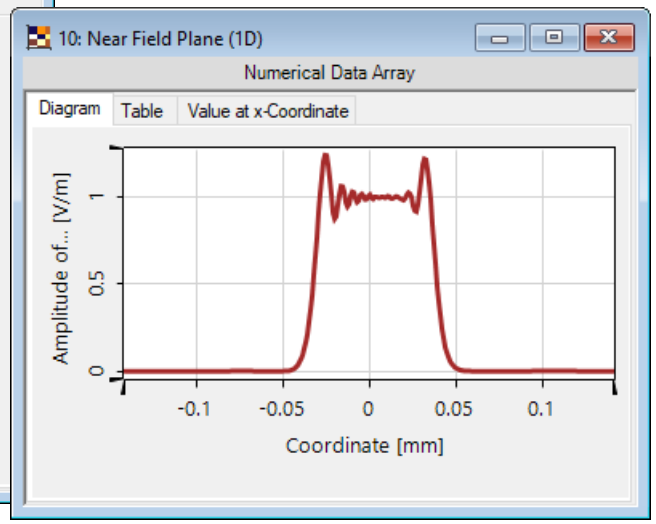
- wavelength @532nm
- linearly polaried along *x* direction
- shape: rectangular
- diameter: (50um, 50um)
- inclination(10°, 20°)

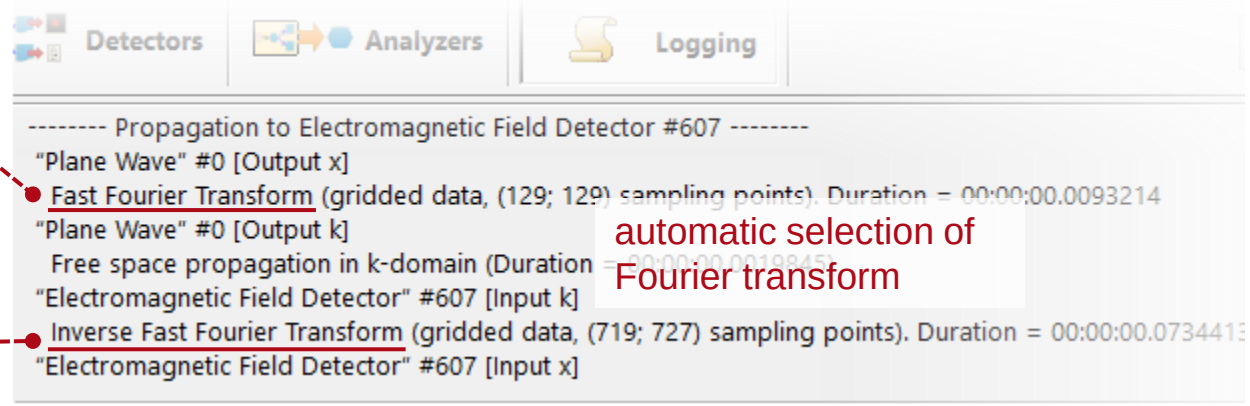


Simulation Result: Near Field Plane



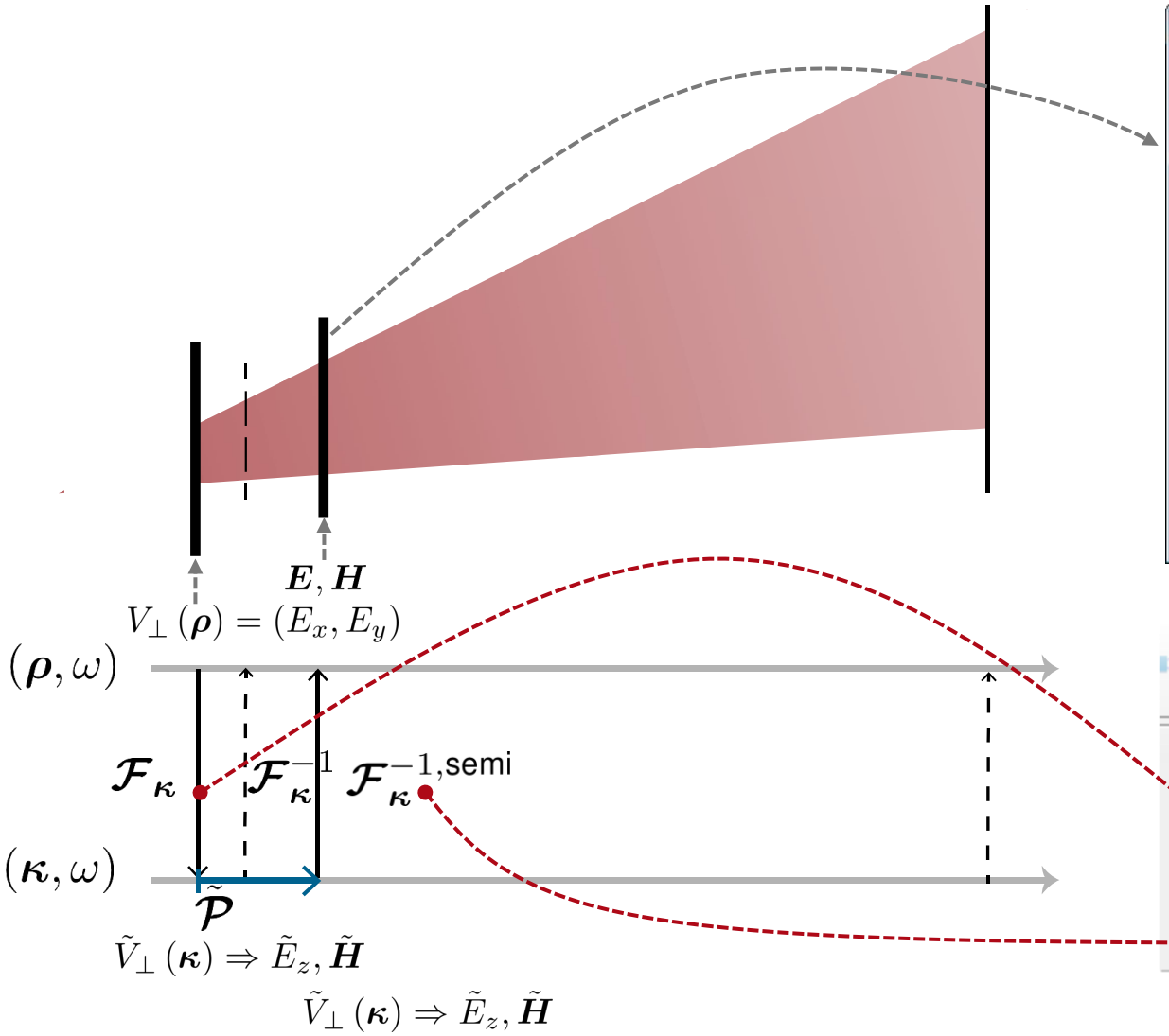


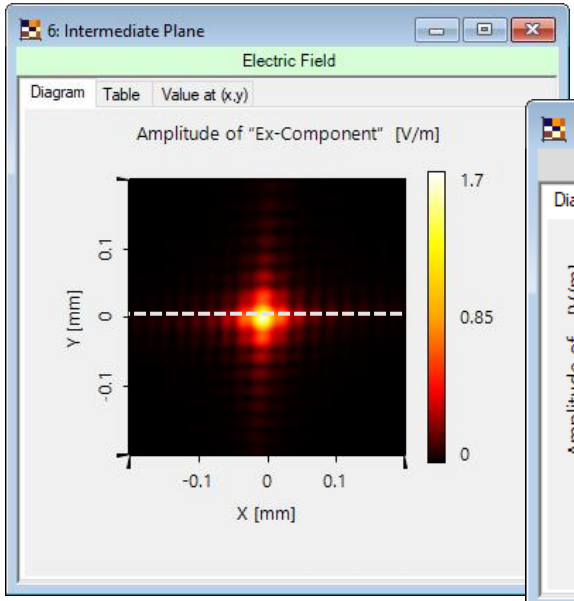


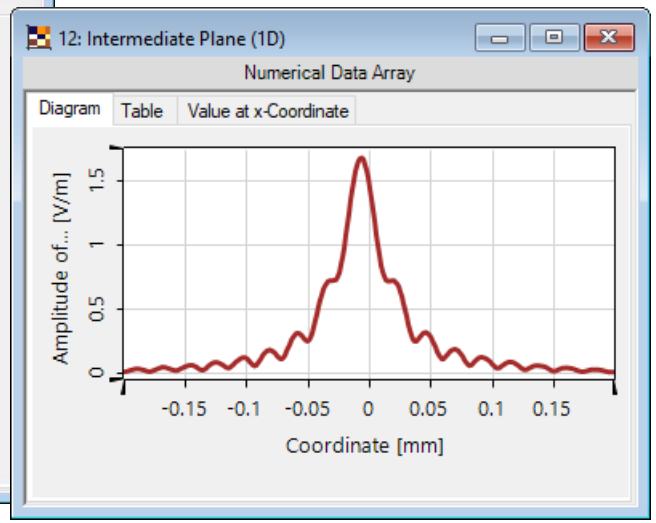


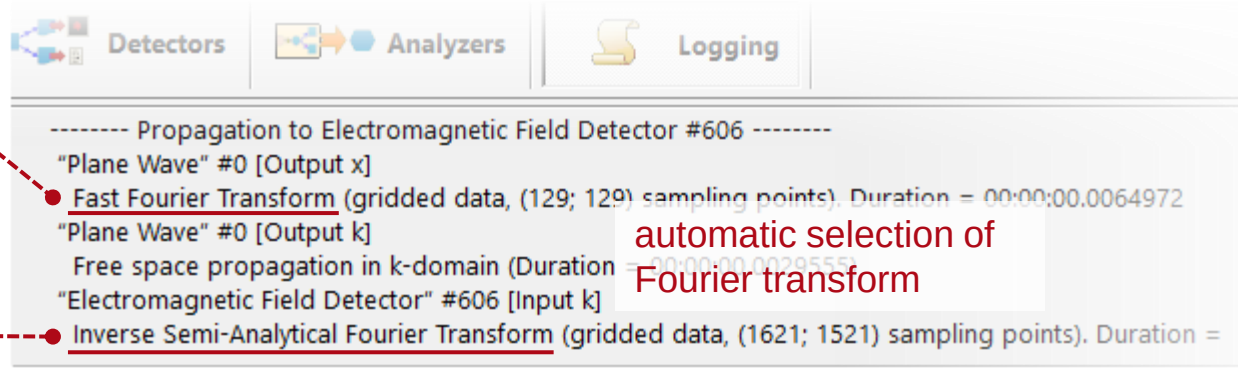
automatic selection of Fourier transform

Simulation Result: Intermediate Plane

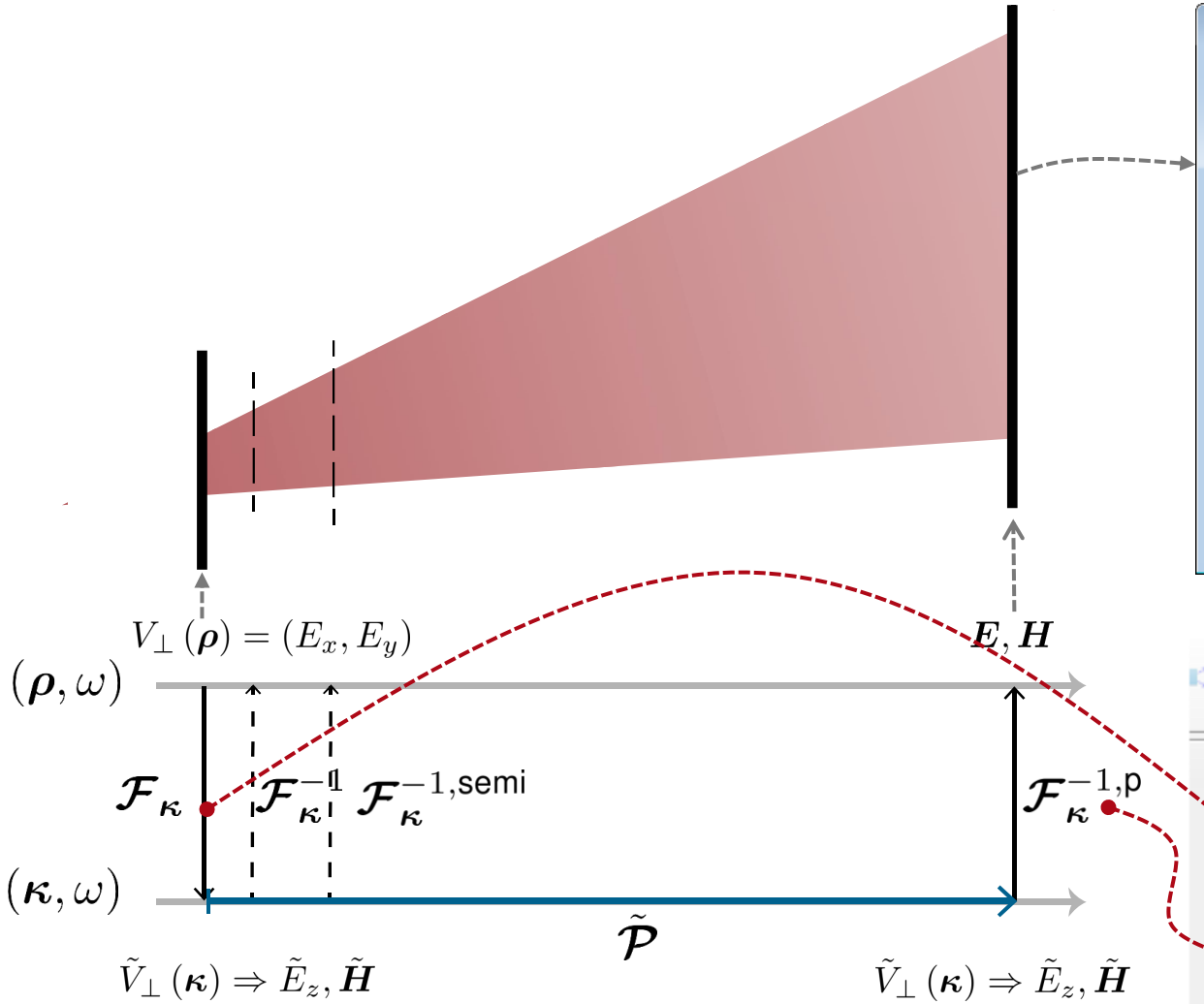


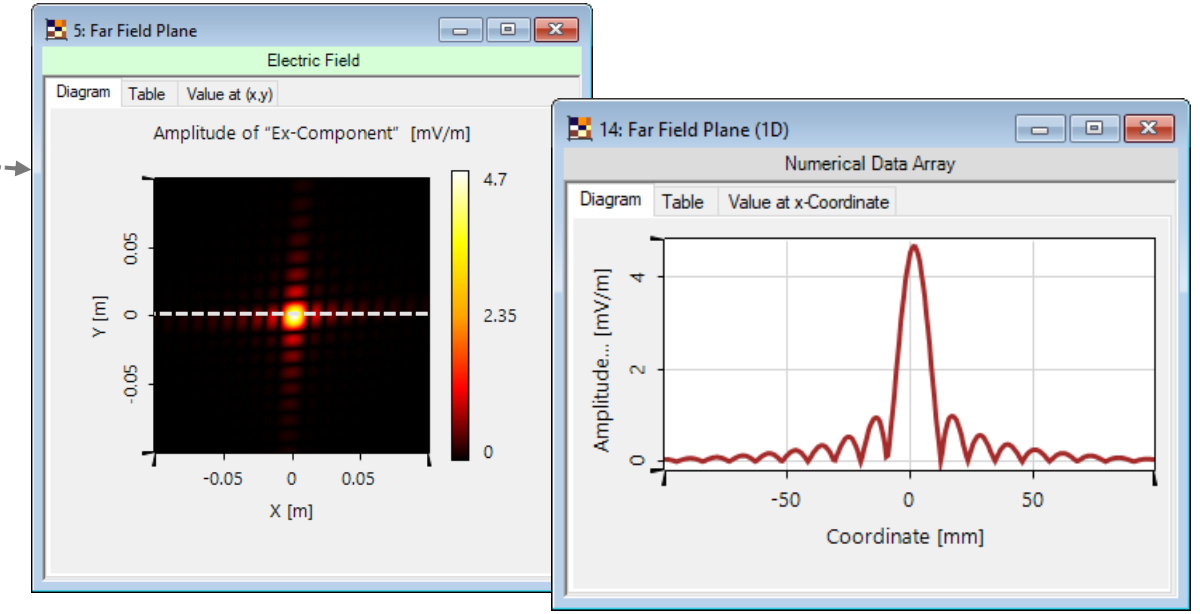


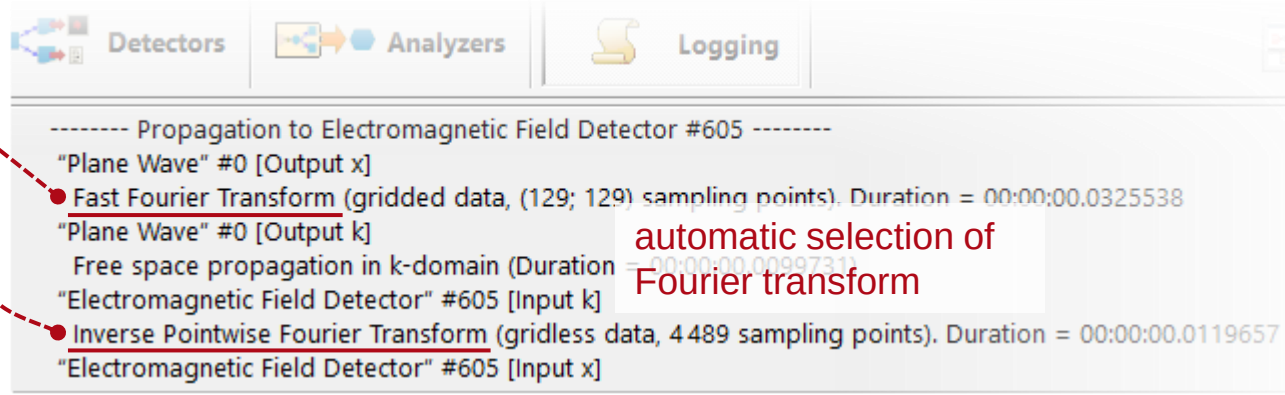




Simulation Result: Far Field Plane







Document Information

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