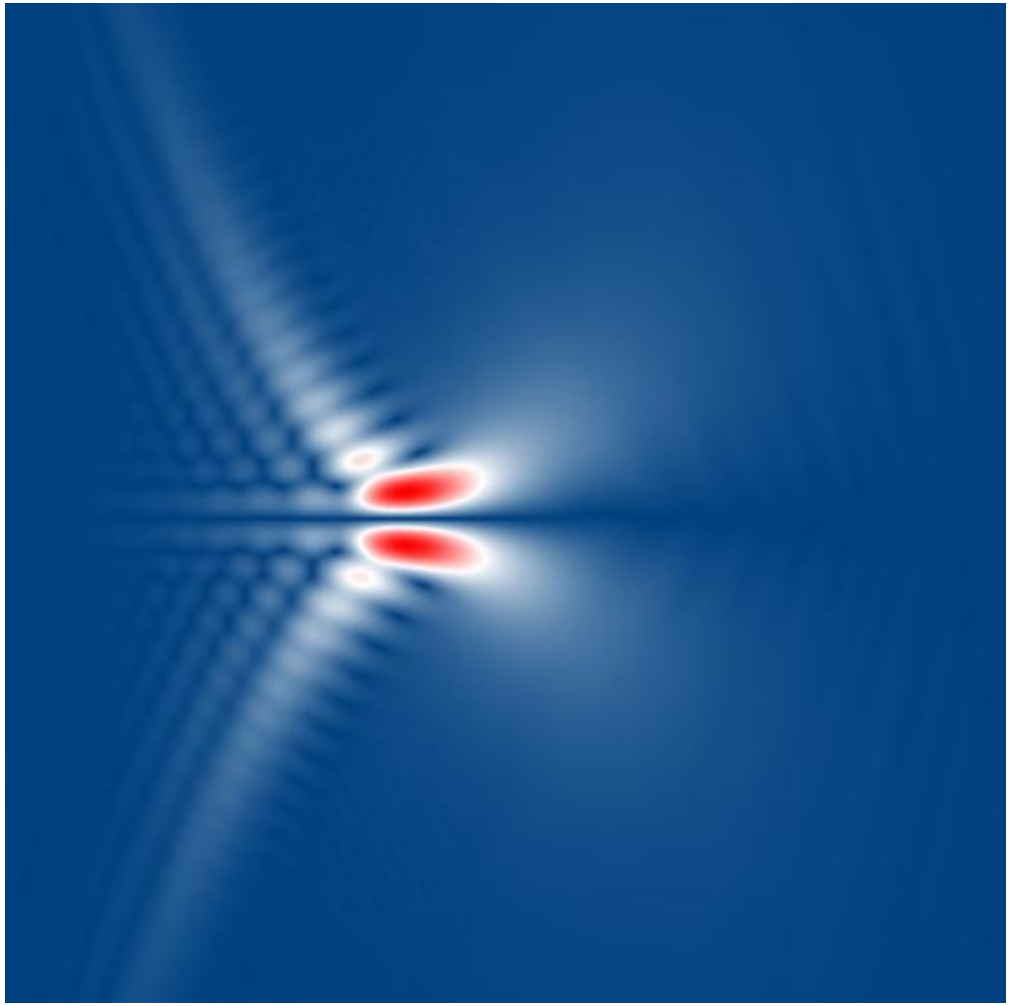
Pulse Focusing with High-Na Lens

Abstract



While for most other types of sources it is often accurate enough to labour under the stationary approximation, ultrashort pulses require a somewhat more nuanced approach, where the correlation between the different spectral modes is taken into account. We investigate here the effects of subjecting one such pulse to propagation through a lens with high numerical aperture, in terms of its spatial, as well as of its temporal, profile.

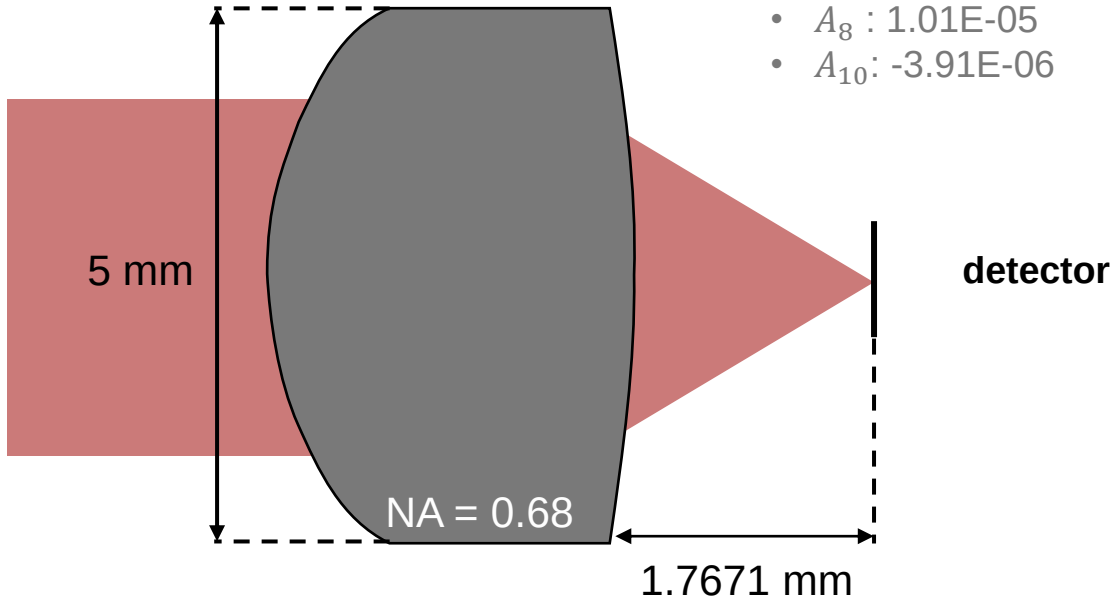
Application Scenario

Application Scenario – System

laser pulse

- collimated gaussian profile
- diameter: 2.5 mm x 2.5 mm
- linearly polarized in x-direction

- Gaussian spectrum
- 800 nm central wavelength
- 5 fs pulse duration



high NA aspheric doublet

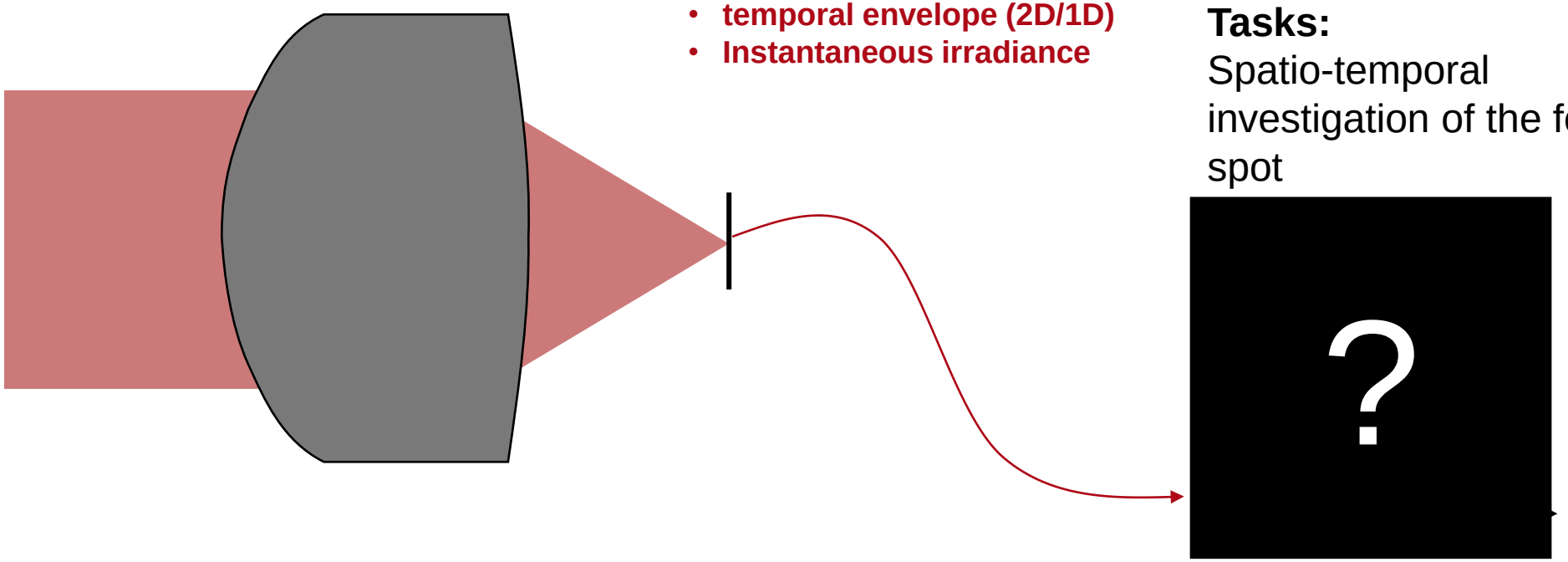
asphere 1:

- radius of curvature: 2.75 mm
- conical constant: -0.61
- asphere coefficients:
  - A_4 : 0.000589
  - A_6 : -1.76E-05
  - A_8 : 1.01E-05
  - A_{10}: -3.91E-06

asphere 2:

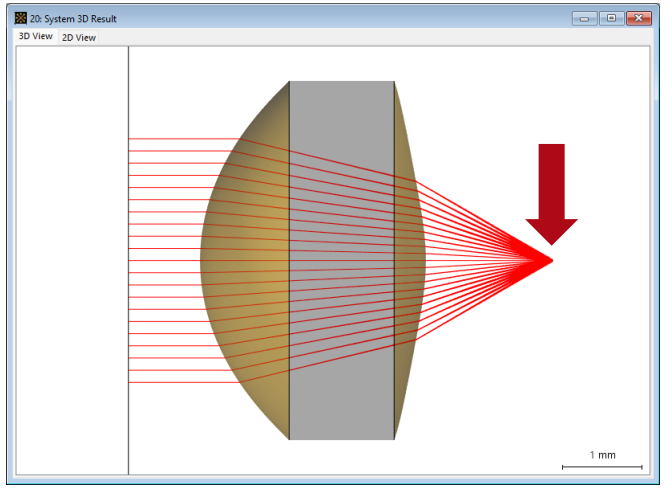
- radius of curvature: -3.19 mm
- conical constant: -12.7
- asphere coefficients:
  - A_4 : 0.0124
  - A_6 : -0.00371
  - A_8 : 0.000512
  - A_{10}: -3.11E-05

Application Scenario - Task

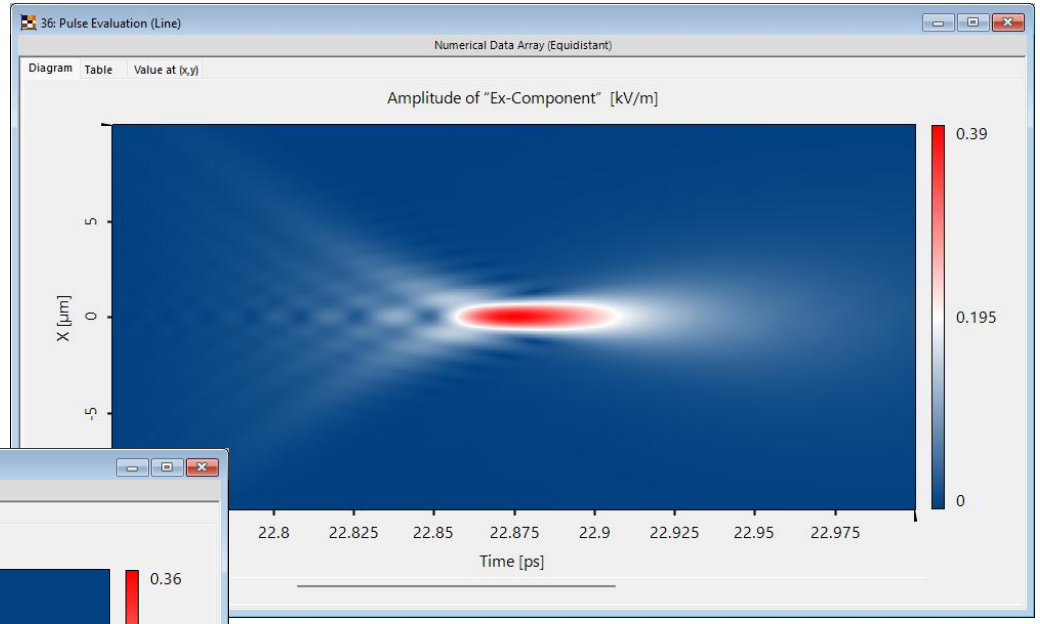


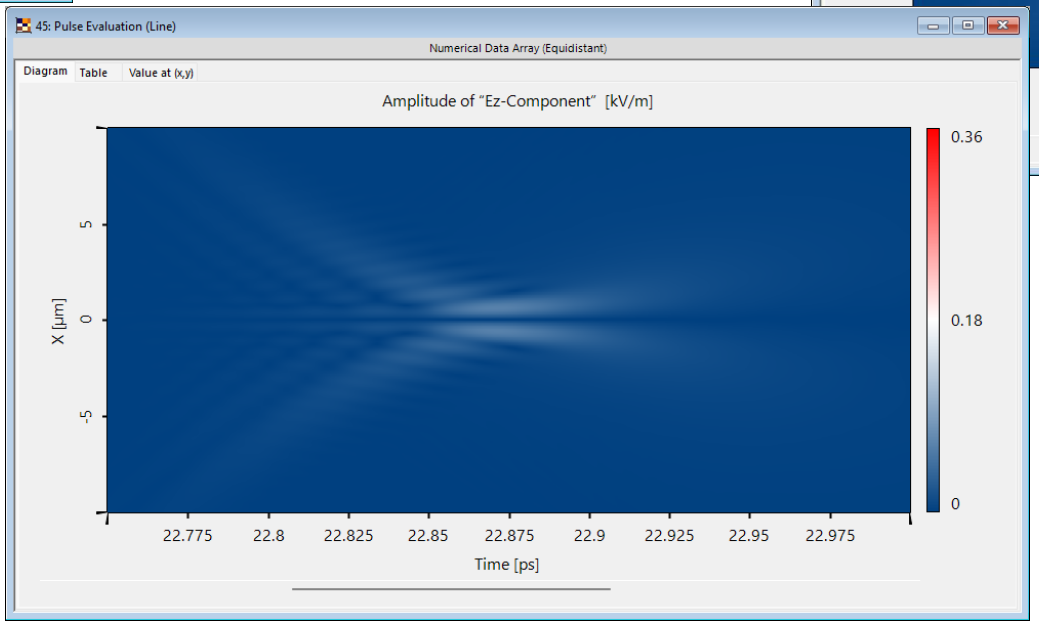
Simulation Results

Temporal Envelope Over Z



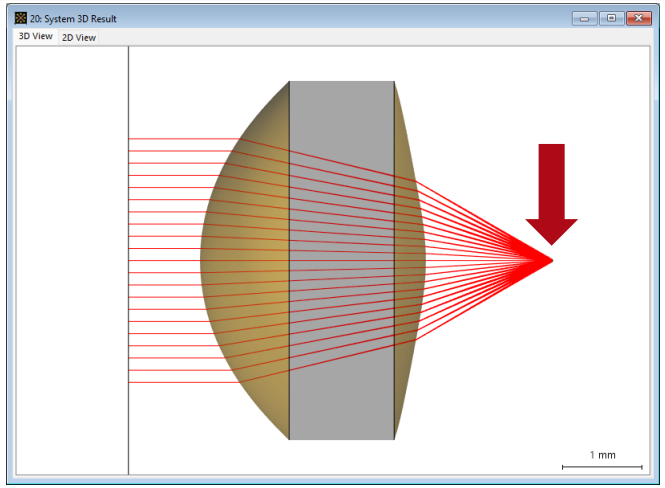
Ex-component



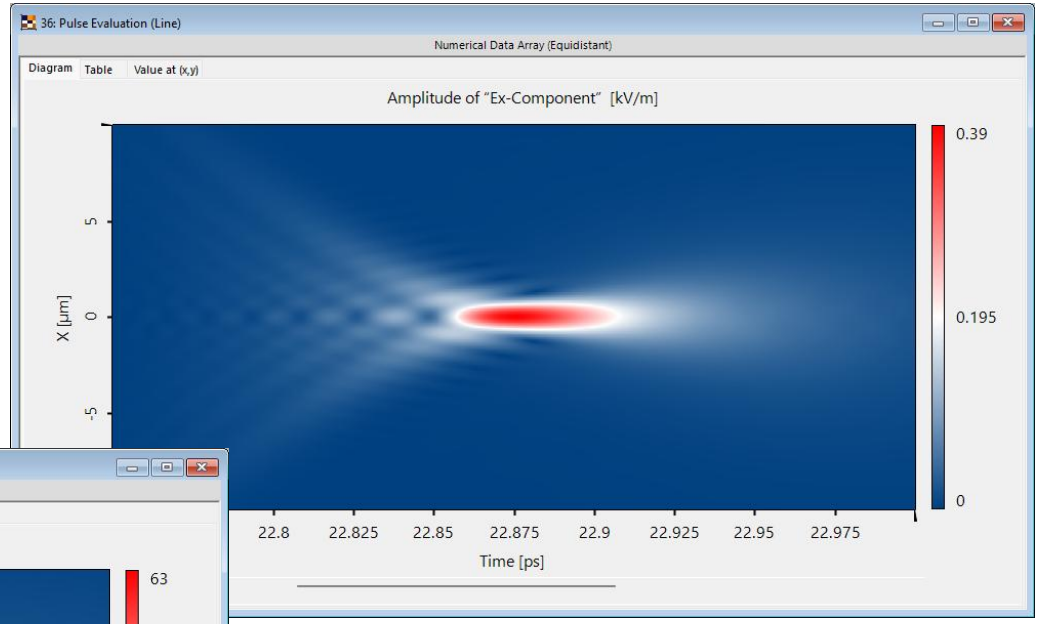


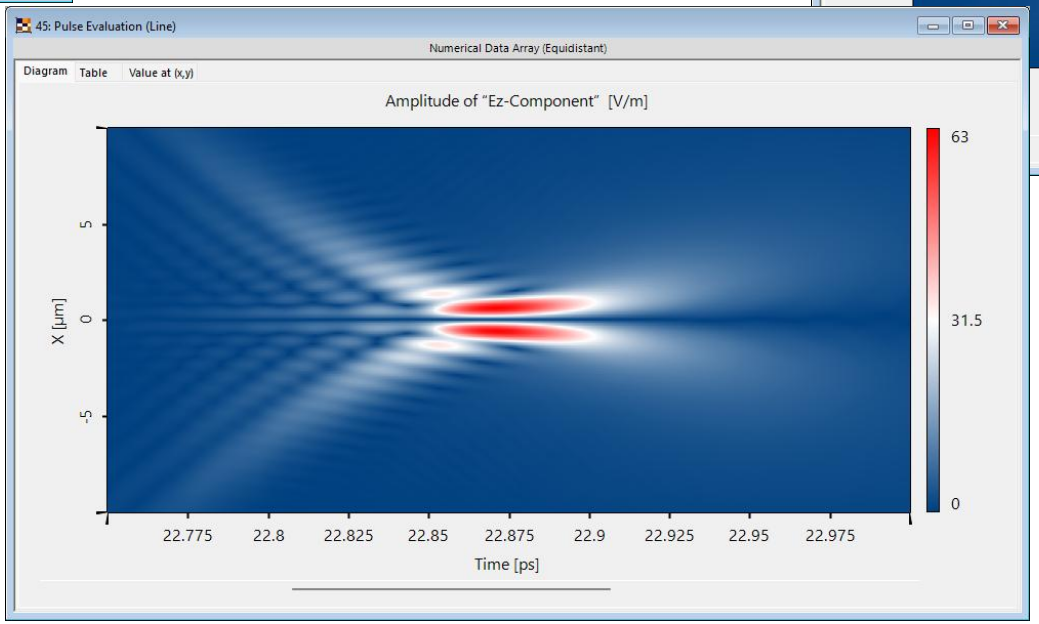
Ez-component

Temporal Envelope Over Z



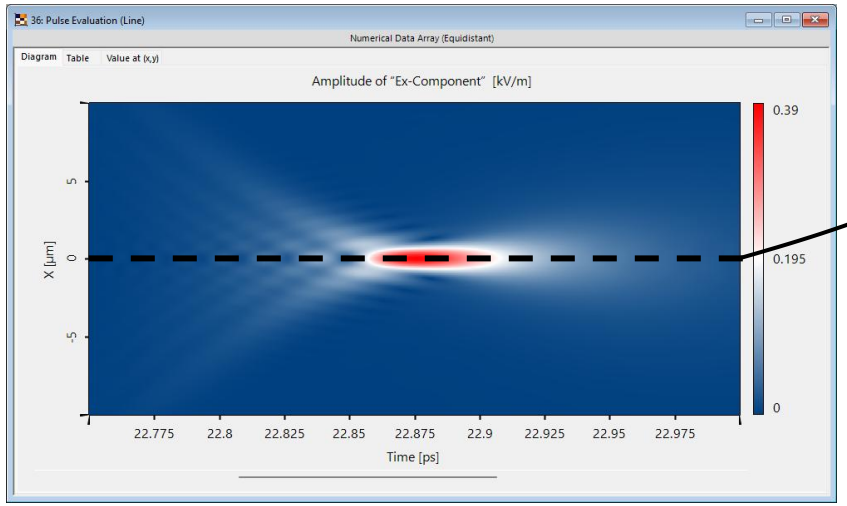
Ex-component

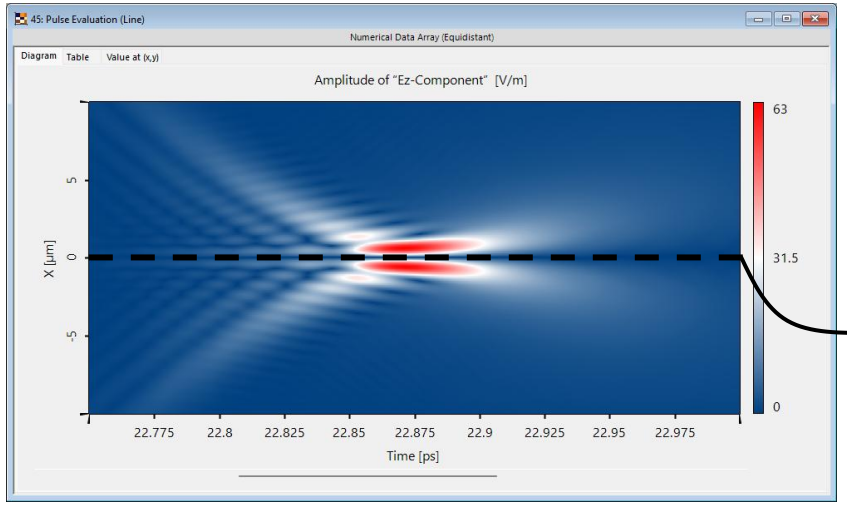




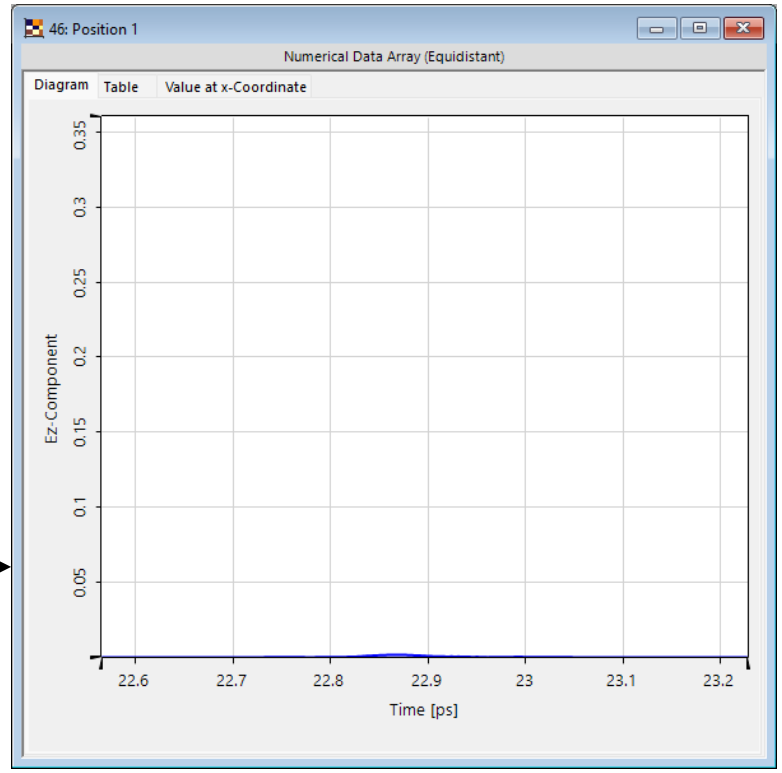
Ez-component

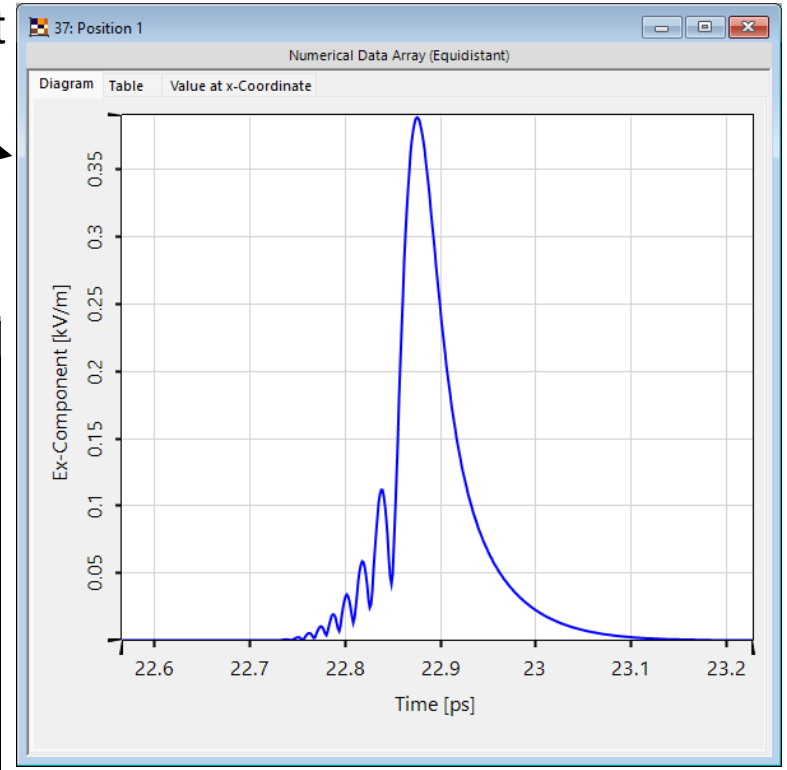
Spatio-Temporal Investigation: On-Axis





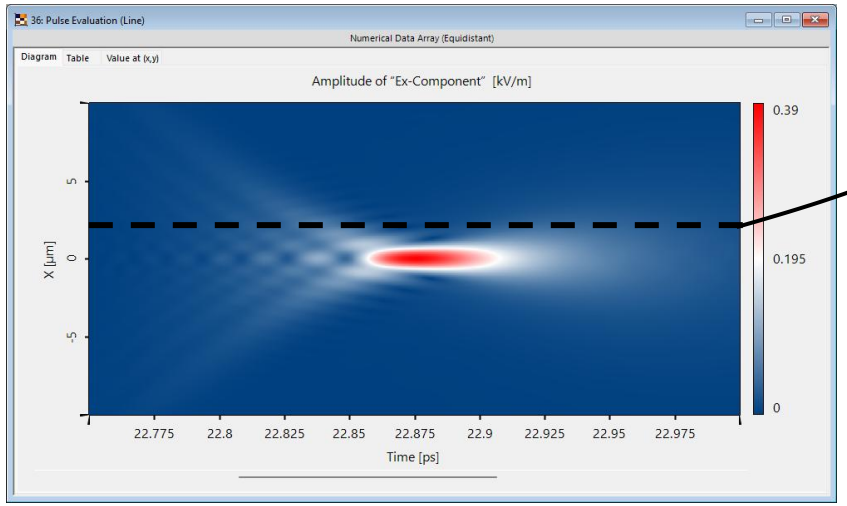
Ex-component



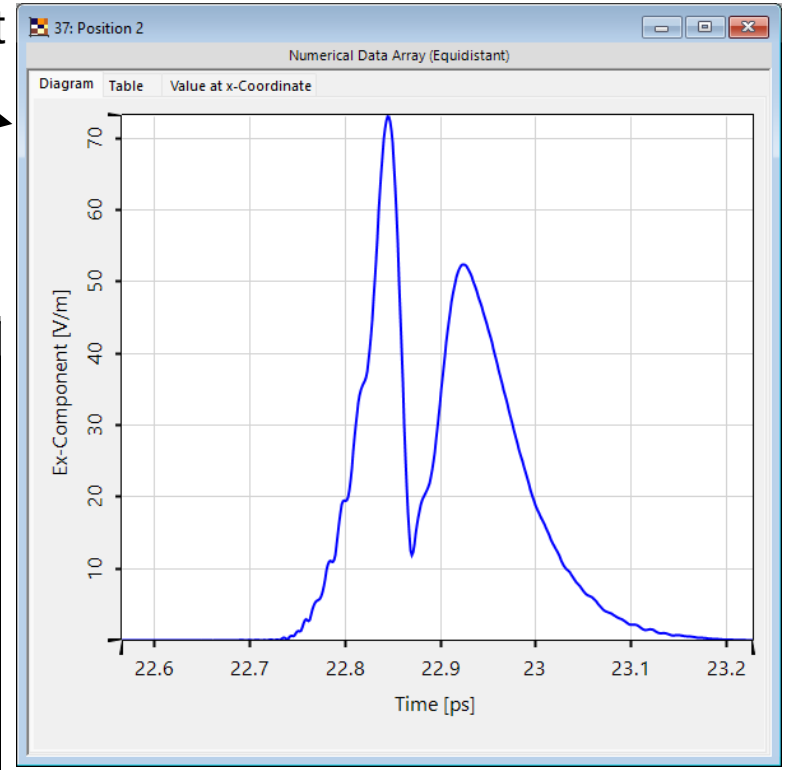


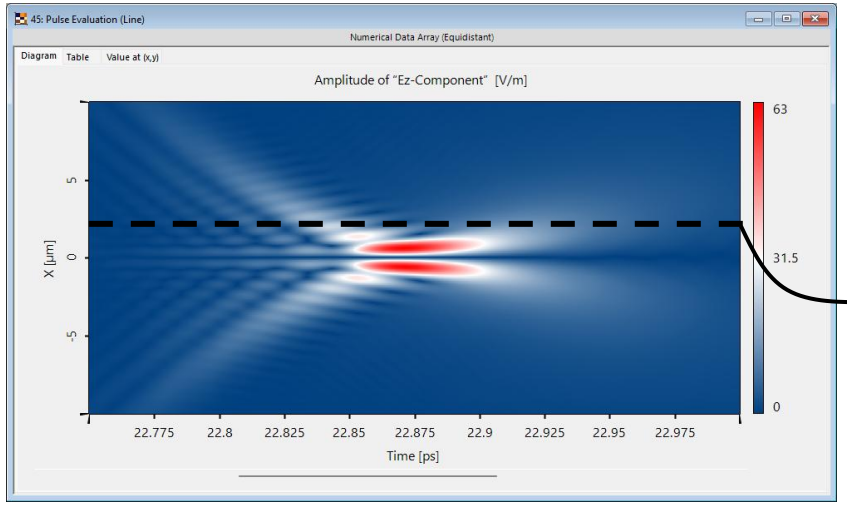
Ez-component

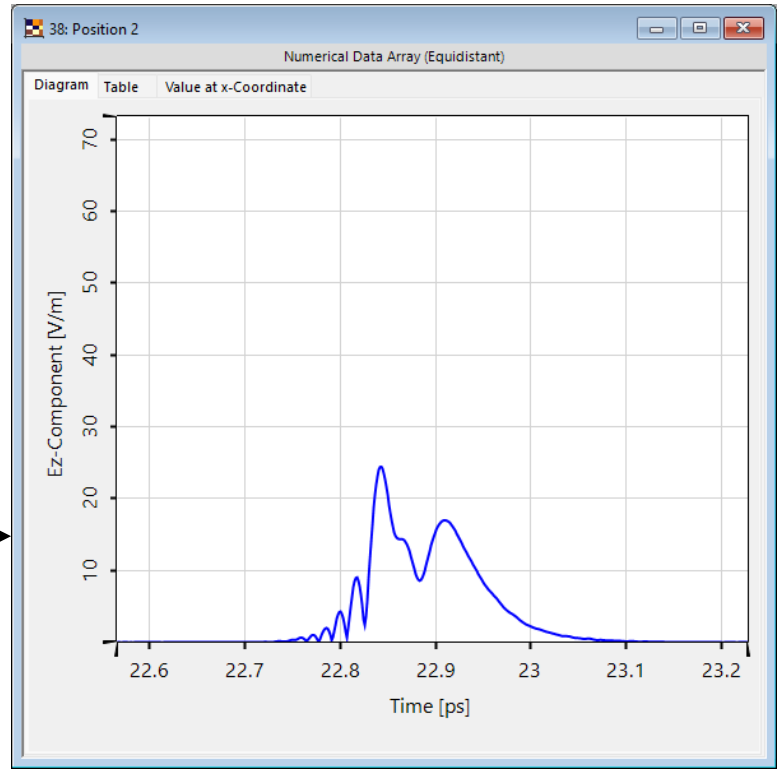
Spatio-Temporal Investigation: Off-Axis



Ex-component

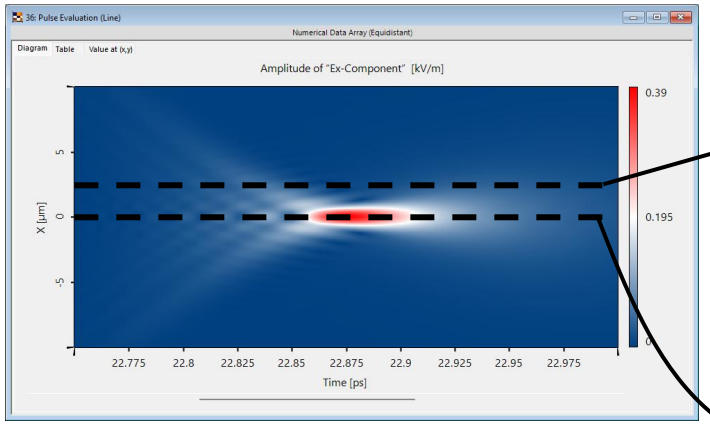


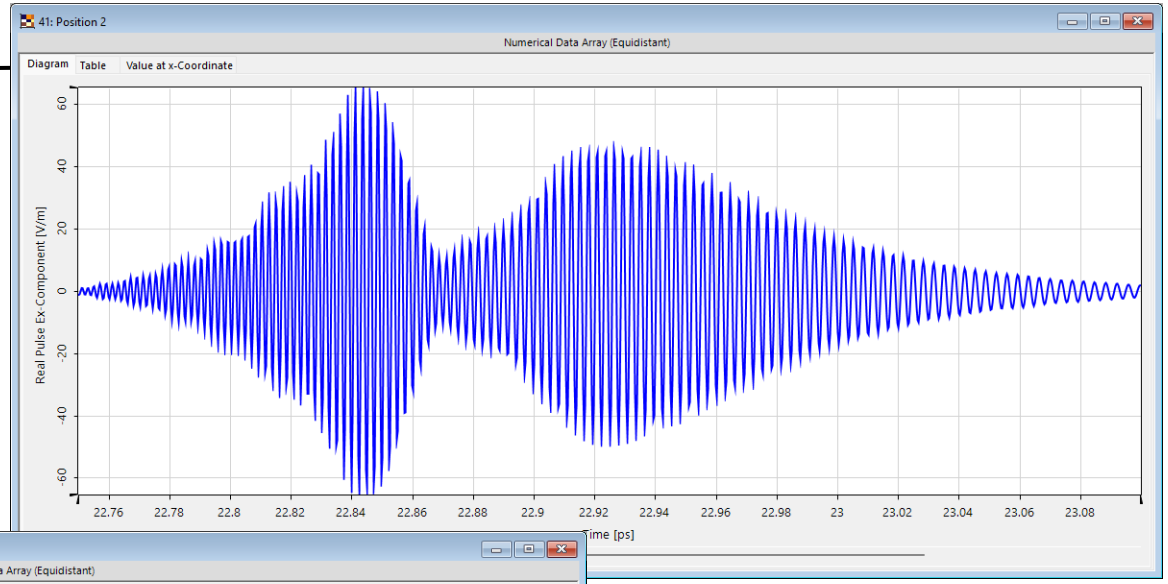




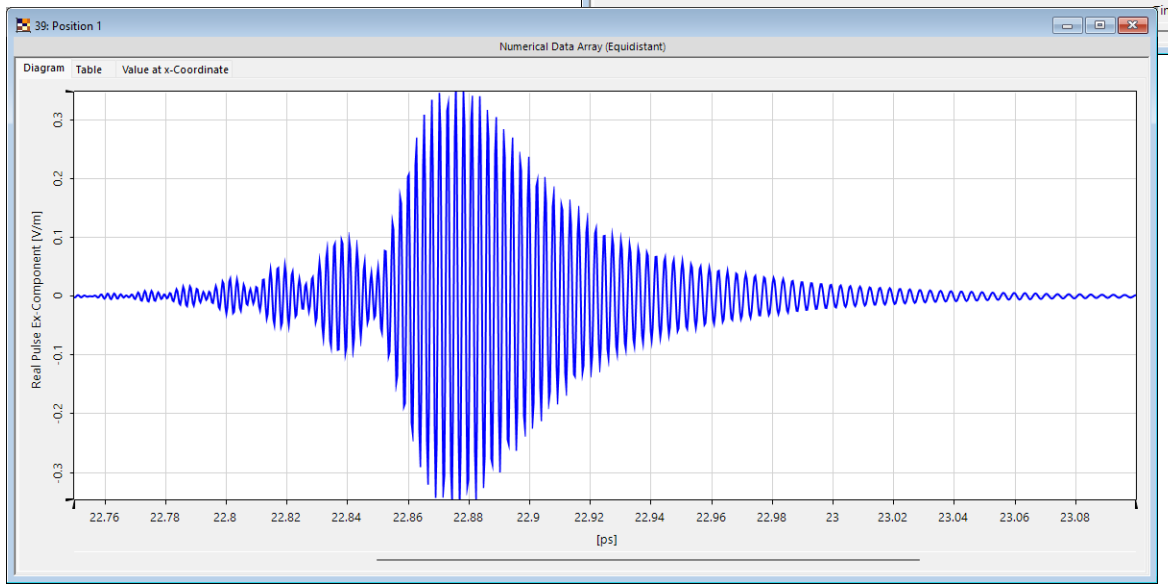
Ez-component

Real Pulse with Carrier Envelope

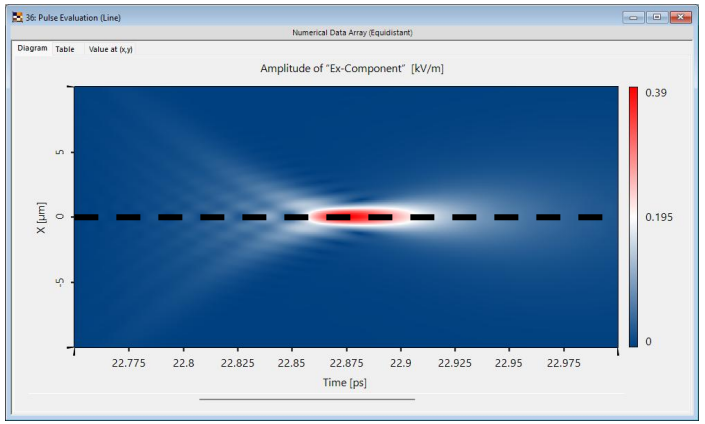




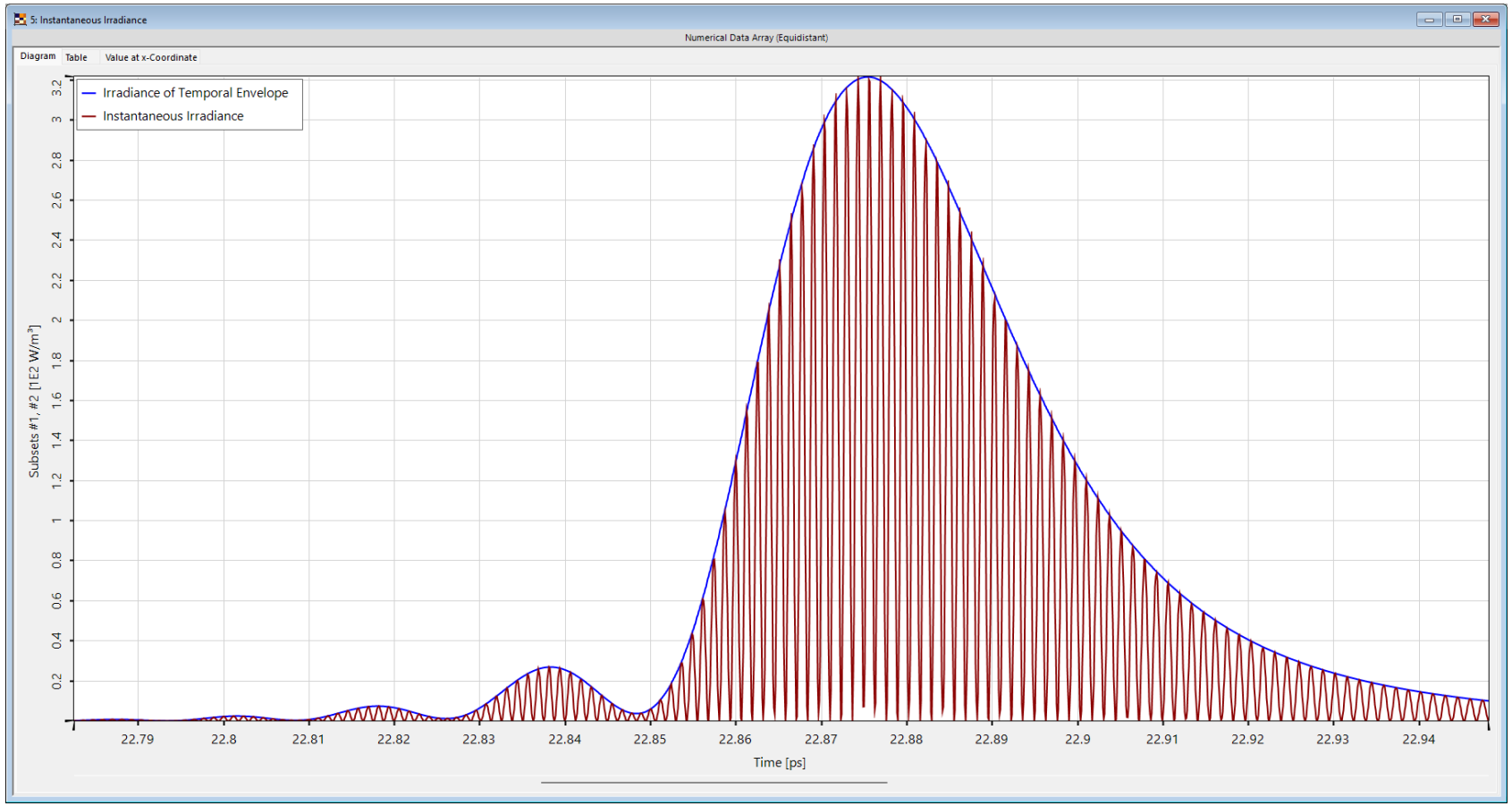
VirtualLab Fusion can also calculate the real pulse (including carrier frequency) which might be necessary for accurate calculation of energy values.



Discussion of Instantaneous Irradiance



For the calculation of energy quantities, such as the irradiance, the carrier frequency needs to be considered. Though when the time-dependent phase changes slowly in comparison to the carrier frequency, the envelope of the instantaneous irradiance is the instantaneous irradiance of the temporal envelope of the pulse.

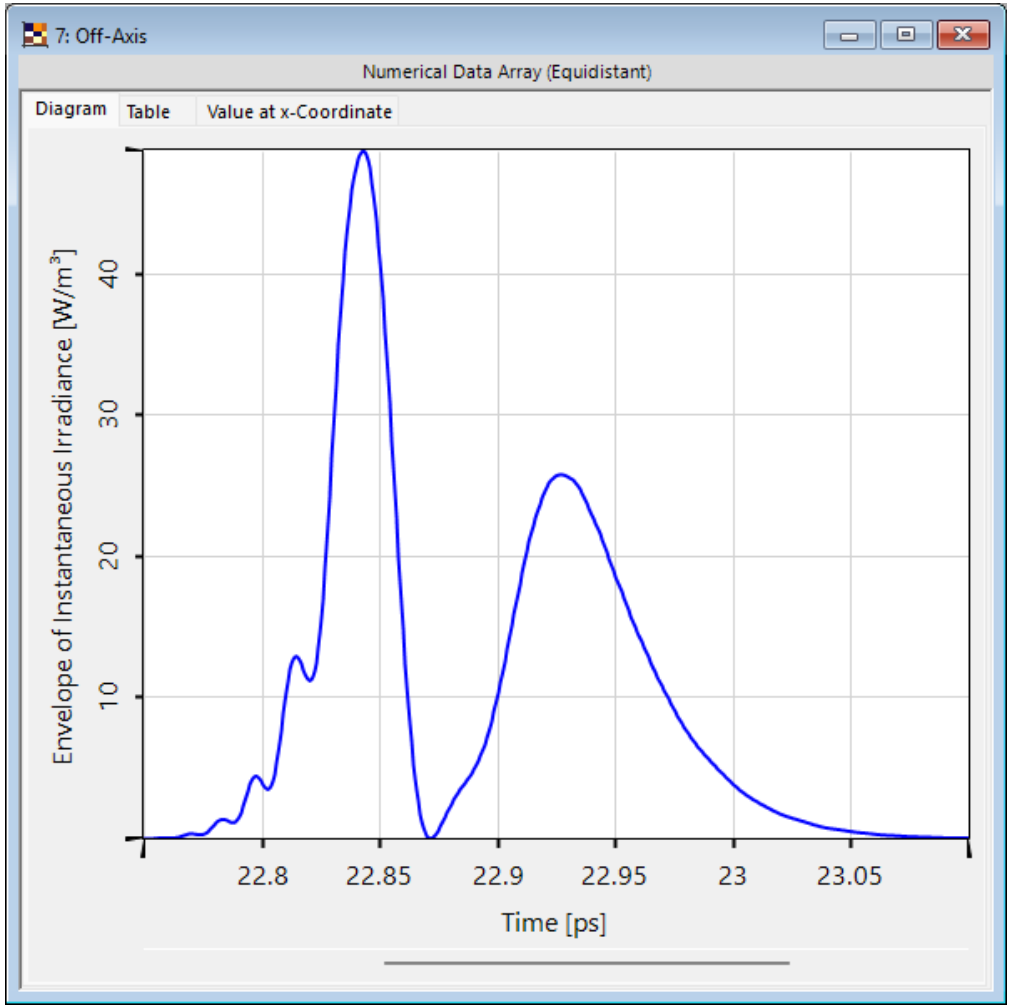


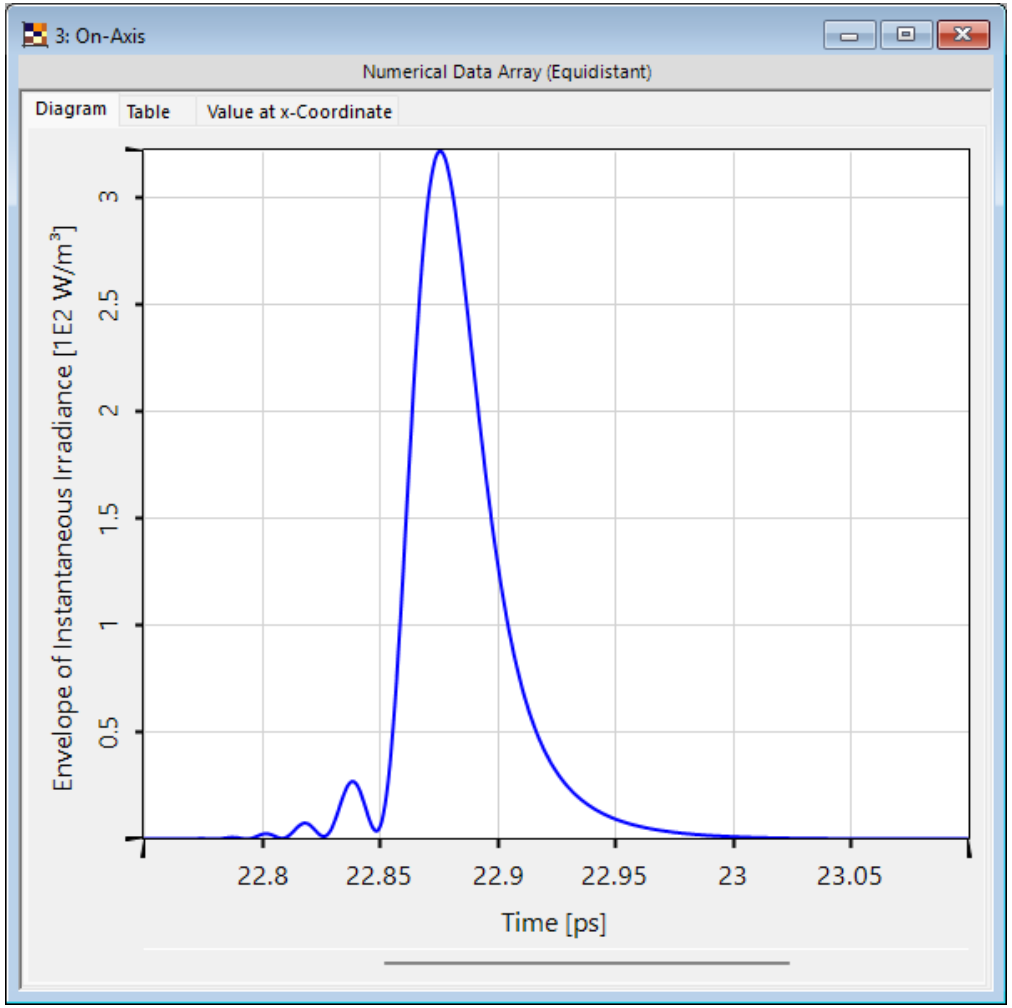
Irradiance (integration over time):

- Real pulse – $6.5e^{-12}\ J/m^2$
- Only Envelope – $1.3e^{-11}\ J/m^2$

Envelope of Instantaneous Irradiance for On- and Off-Axis Spot

Off-axis





On-axis

Note: For visualization purposes, we show the envelope of the instantaneous irradiance only.

Workflows

LP Mode Source

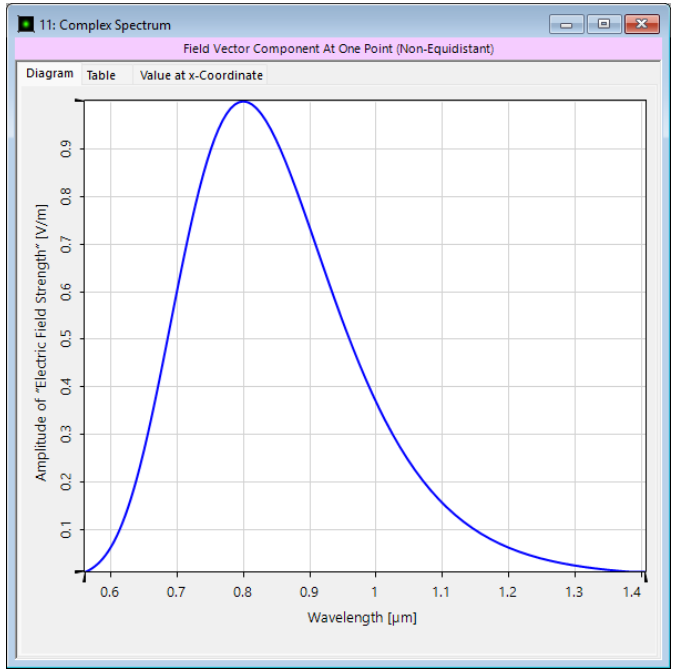
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Gaussian Source
- Include Spectrum into Source



Gaussian spectrum of an ultrashort pulse

System Setup

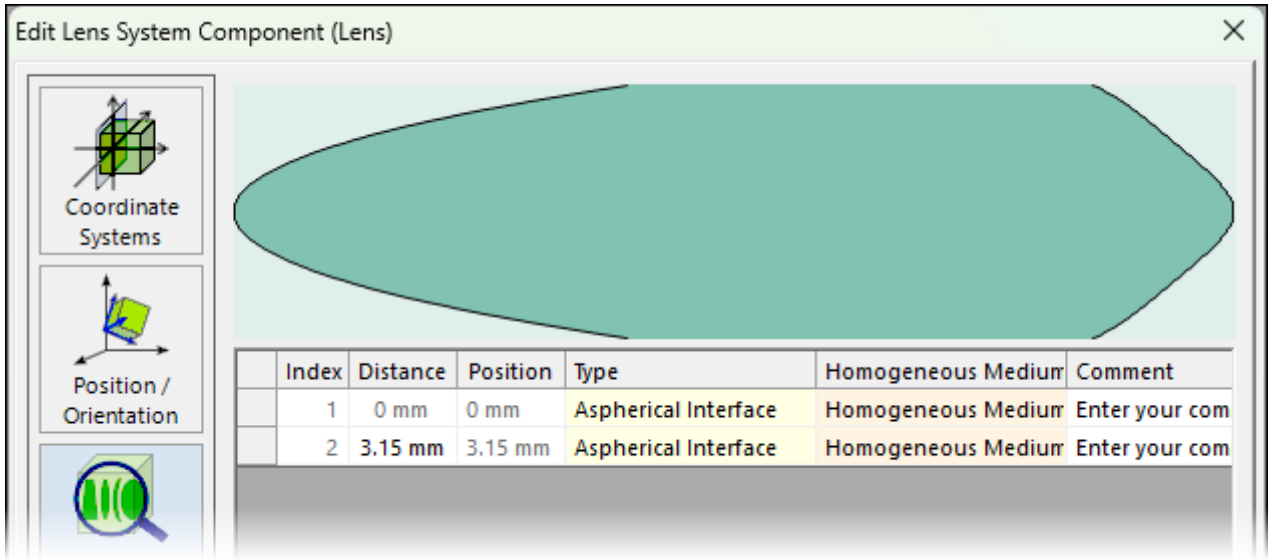
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Import Lens File



Detector Selection

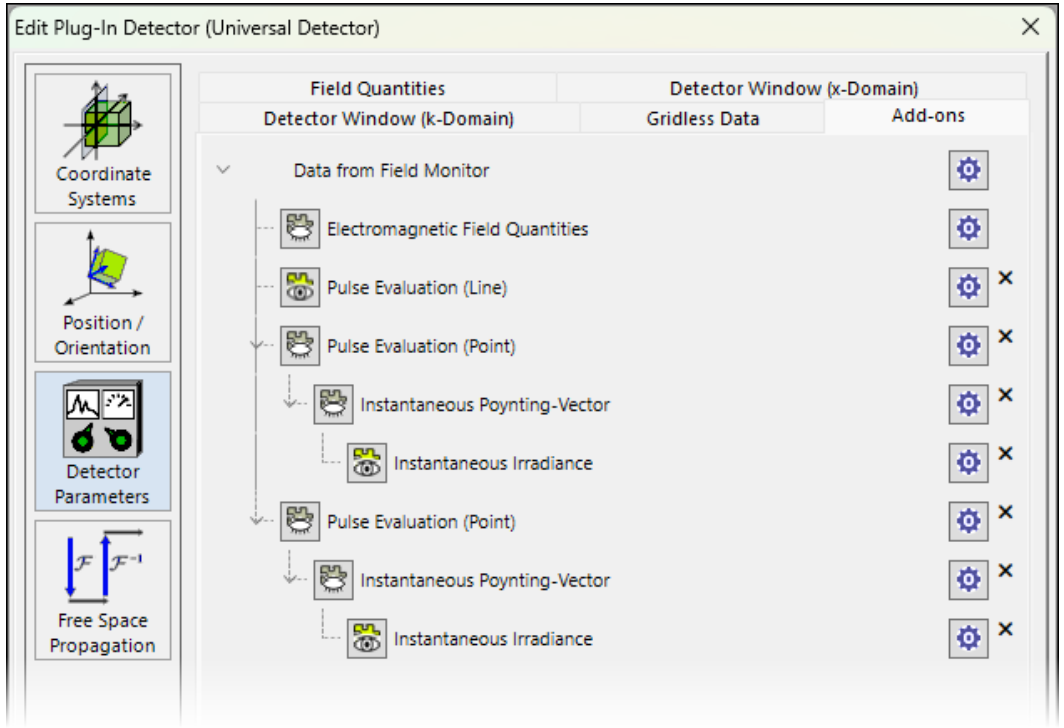
Source selection

System setup

Detector selection

Getting it done in VirtualLab Fusion:

- Pulse Evaluation



Document Information

Title	Pulse Focusing with High-NA Lens
Document code	USC.0123
Publication date	08.07.2025
Required packages	-
Software version	2025.1 (Build 1.172)*
Category	Use Case
Further reading	- Femtosecond Pulse Propagation through Dispersive Seawater - Focusing of Femtosecond Pulse by Using a high-NA off-Axis Parabolic Mirror - Grating Stretcher for Ultrashort Pulses

** The files attached to this document require the specific version or later.*