

Examples Guide

Eight models. Nine reference runs.

A visual tour of the owner-approved EMUZAG example collection: geometry, active options, selected Studio results, field histories and measured execution costs. Includes the separately configured $\beta = 0.8$ companion to the rectangular step-out.

EMUZAG 1.1.2

Hybrid MPI/OpenMP desktop edition

26 October 2026

Companion to the User Guide

This document uses the owner-approved examples. Reference figures retain their recorded settings; current inputs use explicit source and observation lists. It supplements the full *EMUZAG Studio User Guide*; it is not a replacement for the reference manual or a certification of numerical convergence.

How to use this collection

Start with the *Quick Start*, which walks through Example 01. This guide then explains what changes from model to model and what to inspect in each result. The revised illustrations combine owner-supplied Studio screenshots with retained plots from the earlier documentation calculations. The settings tables and timings describe those unchanged reference inputs; screenshot run IDs identify the owner's separate calculations.

Current explicit calculations use Standard conformal treatment. Historical method names in the reference tables and screenshots describe the retained runs: enhanced is now displayed as Standard, while explicit simple inputs now select Standard for a new calculation. The reference plots below have not been recomputed with the new selection policy. Implicit methods offer Simplified and Standard. The supplied YAML is authoritative for new calculations. The owner's 12 September parameter refresh switches Example 04 to stationary execution. Its reference table, plots and timings below continue to describe the earlier moving run; they have not been recomputed for that refreshed input. The 17 September update writes explicit source and absolute observation lists in all nine supplied YAML files while preserving their physical settings. The supplementary N100 case is no longer supplied. Retained screenshots use older Bunch/Additional labels; current Studio shows absolute observation positions.

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The $\beta = 0.8$ companion starts on page 12; the intermediate kicker Field View is on page 29.

Run the supplied case, not a reconstruction

Copy a complete example directory to a writable work folder. Open its `case.yaml`, inspect the geometry and validation, then use **Build Mesh** and **Run**. The parameter summaries here are deliberately rounded for reading; the YAML and referenced STL files remain the exact inputs.

For the companion in directory 02, open `case-finite-beta.yaml` in a *separate copy* of that directory. Its mesh and result directory names are shared with the main case, so do not run both into the same working directory.

Scope of the evidence

Eight main examples plus the finite-speed companion were meshed and solved once each. Successful completion and finite recorded values are checked. These runs are not mesh-convergence studies, cross-code validation, or proof that every physical error is negligible.

Coordinates, components, and active options

All these inputs use millimetres and pC. The bunch travels in $+x$; y, z are transverse. The drive charge is $Q = 1$ pC and the transverse source is a point. The longitudinal profile is Gaussian with the RMS length listed for each model.

Wake and field are different quantities

Current builds save physical voltages. The V/pC reference plots below are derived during analysis. All physical source charges and saved example parameters are unchanged.

The plots of W_x, W_y, W_z show finite-bunch wake potentials in V/pC, as written by Solver. The field panels show the native E_x component in V/m on the XY plane requested at $z = 0$. No Panofsky–Wenzel reconstruction is introduced. The native sample convention is

$$s_i = -5\sigma_x + (i+1)\Delta x, \qquad i = 0, \ldots, N-1.$$

Thus the requested wake *length* is not the final positive lag. Current YAML uses separate explicit source and absolute observation lists. The effective witness coordinates in the plot legends come from the native wake files, after grid selection. Relative offsets in historical tables and screenshots describe the retained runs; add them to the stated source position to obtain absolute witness coordinates. Legend coordinates are rounded for display; values below 10^{-9} mm are displayed as zero, without changing the underlying data.

In Studio Results screenshots, the blue curve is the selected wake, read on the left axis; the orange curve is bunch current, read on the right axis. The component and witness selection are stated in each caption. Small, oscillatory transverse plots near zero are omitted from this guide. No saved curve is smoothed or modified, and omission is not a proof of an exactly zero wake.

For the retained data-rendered moving panels, the field panel follows Studio's coordinate mapping $x_{\mathrm{view}} = x_{\mathrm{STL}} - x_{\mathrm{start}} + N\Delta x$. The initial window precedes the geometry. Geometry-only panels keep authored STL coordinates; field overlays use the mapped coordinates. Stationary panels need no such shift.

Shared settings that remain unchanged

- `initial_field.model: waveguide`; automatic scaled time step and simulation duration; indirect integration enabled.
- Explicit stepping in all nine configurations. Public method names are `dispersion-free` and `FDTD`; the latter is used by the finite-speed companion.
- `live_field`: `electric_x`, XY, $z = 0$, maximum resolution 256×128, maximum 200 frames, `bounded_history` storage.
- PML depth 10 cells, conductivity scale 0.8, complex-frequency shift 20, conductivity order 3, and shift order 1. PML is used only on open boundary sides.

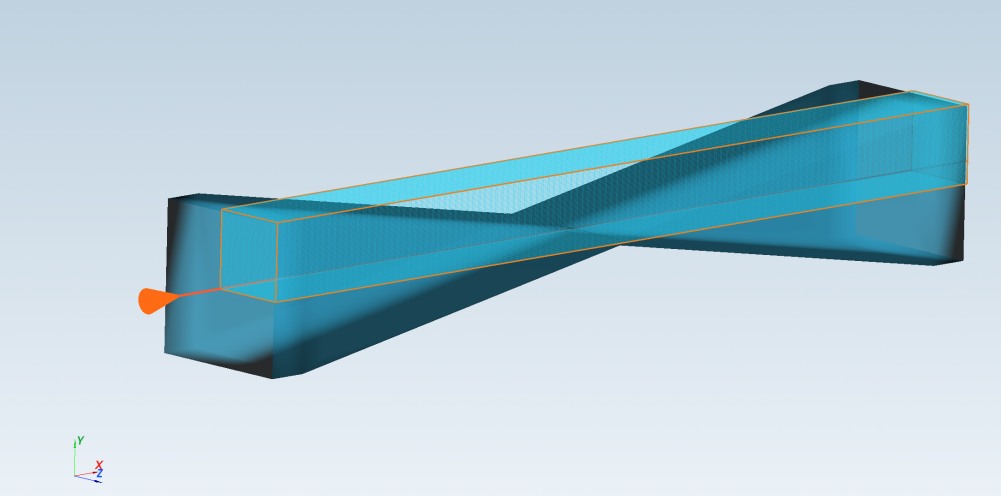
The selected method decides what is active

An `implicit` parameter block does not change an explicit time stepper. Stationary-only parameters do not control a moving window. Likewise, a saved self-correction request must not be confused with the active state reported by Solver. The finite-speed companion in this collection selects stationary standard FDTD; it is not a demonstration of another time-stepping method.

01 / Tapered collimator

`01_TaperedCollimator/case.yaml`

This is the first-run tutorial model. The vacuum aperture narrows and opens inside a PEC background. A moving calculation window follows the relativistic bunch through the full longitudinal geometry.



Owner-supplied 3D view of the collimator, displayed mesh and source marker. The original aspect ratio and axis triad are retained.

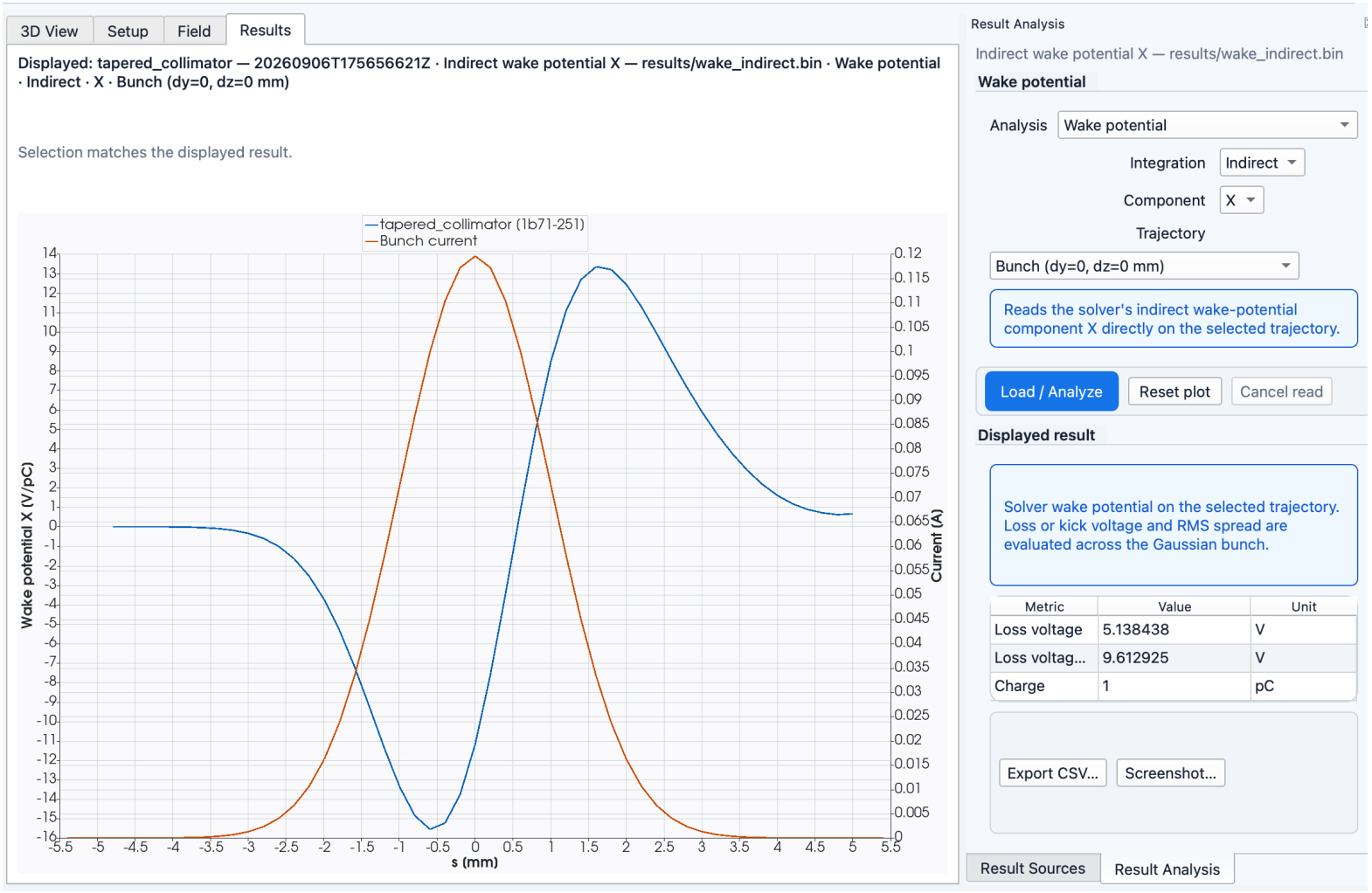
Setting	Saved configuration
Method	Moving, dispersion-free, explicit, enhanced conformal.
Mesh spacing	$(0.2,\ 0.296985,\ 0.296985)$ mm in (x, y, z).
Domain	x : 0–227.8 mm; y, z : 0–19.601 mm.
Boundaries	x: open/open; y, z: PMC/PEC (lower/upper).
Bunch	$\beta = 1$, $\sigma_x = 1$ mm, $(y_q, z_q) = (0, 0)$.
Witness offsets	T0 is the beam; T1: $(0.296985, 0)$ mm.
Wake and execution	10 mm interval; 6 ranks $\times$ 1 thread.

What this case teaches

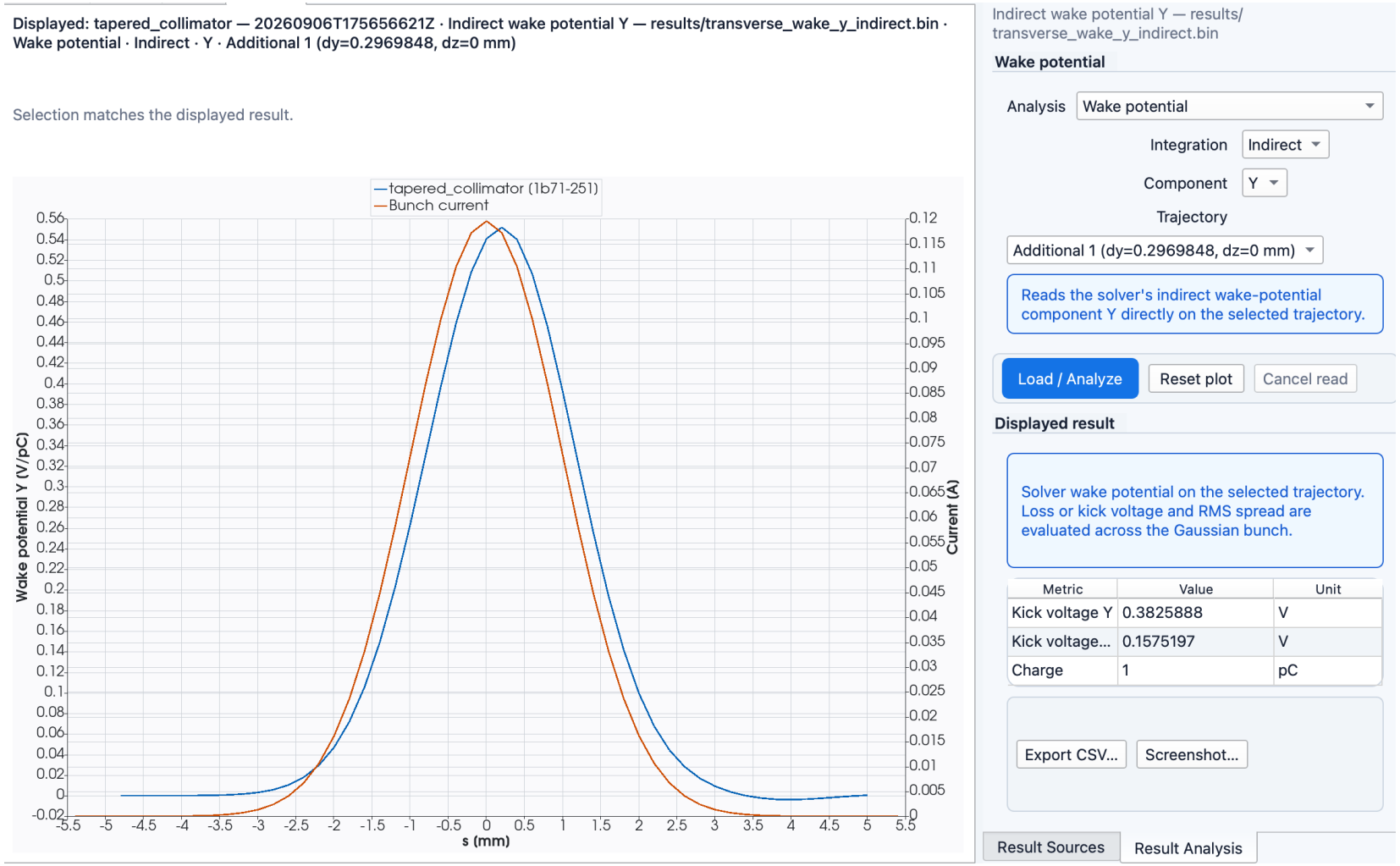
The enhanced conformal option addresses cut geometry, while the moving mode limits the active field window. Those are separate choices. The off-axis witness provides a transverse kick measurement without moving the source off its axis. The selected transverse illustration shows W_y at the off-axis witness; zero and small transverse curves are not drawn as additional results.

Observed in this run

1191 completed steps; 50 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -4.8 to 5 mm. Across the recorded trajectories, W_x ranges from -15.59 to 13.4 V/pC.

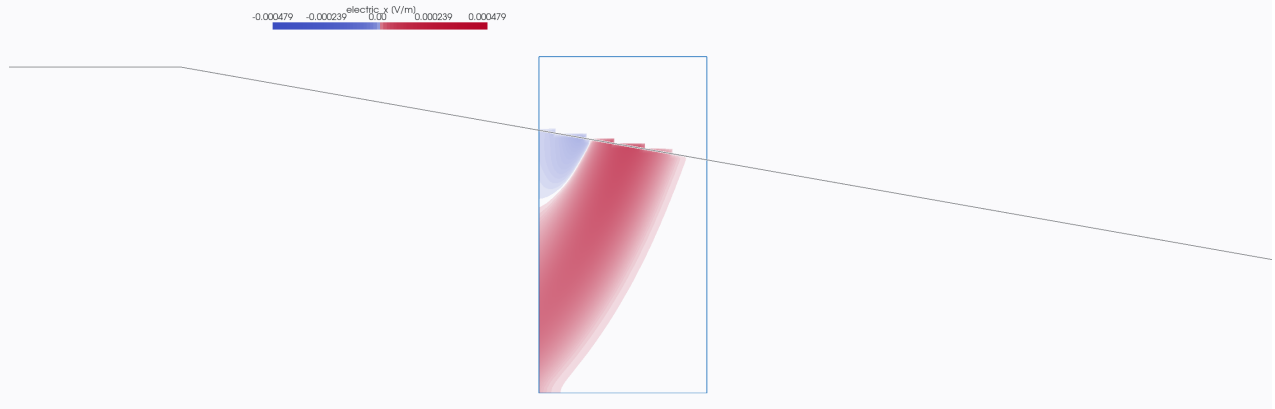


Indirect W_x on the Bunch trajectory. The blue curve is the wake in V/pC; the orange curve is bunch current in A. The screenshot identifies the owner's selected run and retains its original axes and metrics.



Indirect W_y at Additional 1, with beam-relative offset $(dy, dz) \simeq (0.296985, 0)$ mm. The peak is about $0.55\,\mathrm{V/pC}$. This is a selected witness wake, not an automatically offset-normalized coefficient.

01 / Field View



Owner-supplied E_x Field View in the moving window. The colour scale is in V/m. No step or time is visible in this image, so a timestamp from another recording is not assigned to it.

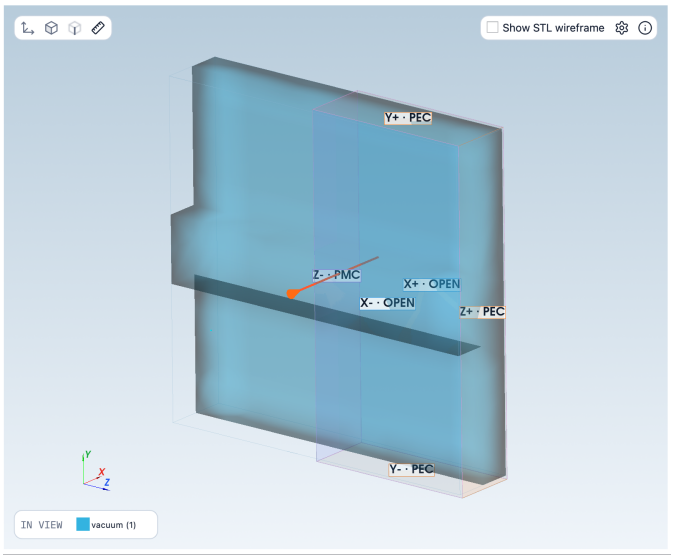
Read the field separately from the wake

The field view is an instantaneous slice in the moving calculation window. The wake is an integral along a witness trajectory. Their shapes and units are therefore different. Use the **Field** timeline to inspect the available recorded frames, and compare the numerical colour limits as well as the colours.

02 / Rectangular step-out

`02_RectangularStepOut/case.yaml`

An abrupt increase of rectangular aperture provides a compact stationary geometry. The supplied main case uses a positive-y source offset and a second witness on the transverse axis.



Owner-supplied 3D view with the boundary labels. The main case includes both signs of y and only non-negative z; it is not a quarter-domain case.

Setting	Saved configuration
Method	Stationary, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.2,\ 0.4,\ 0.4)$ mm.
Domain	x : -10–9.6 mm; y : ± 50.8 mm; z : 0–50.8 mm.
Boundaries	x: open/open; y: PEC/PEC; z: PMC/PEC.
Bunch	$\beta = 1$, $\sigma_x = 2$ mm, $(y_q, z_q) = (0.4, 0)$ mm.
Witness offsets	T1: $(-0.4, 0)$ mm; its absolute position is $(0, 0)$.
Wake and execution	40 mm interval; 6 ranks $\times$ 1 thread.

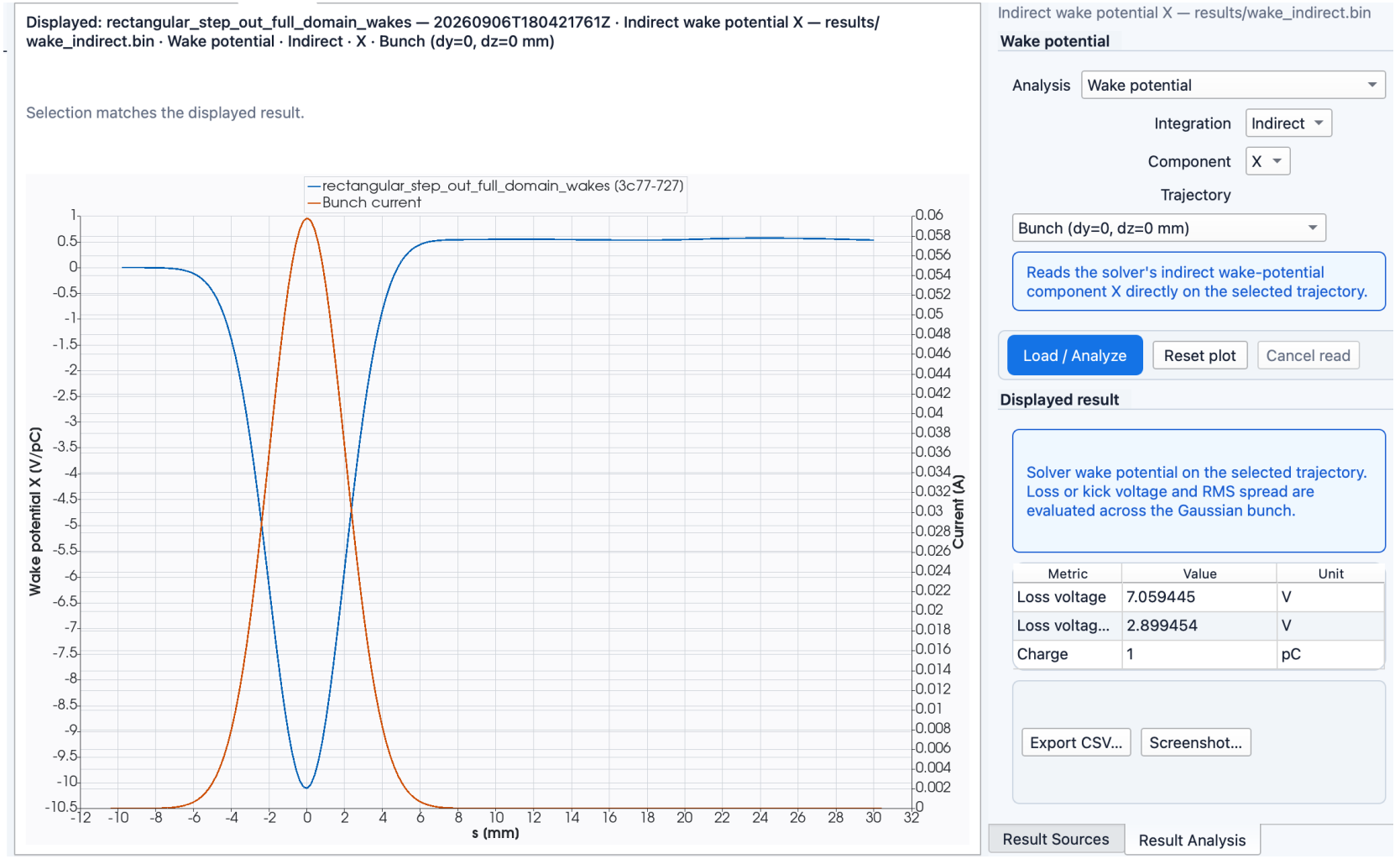
What to compare inside this run

T0 samples the source-offset trajectory and T1 the on-axis witness. Their transverse curves need not agree. Keep the source fixed when comparing them. The indirect files shown here are distinct from the finite direct integral; choosing a different source in Results changes the quantity being displayed.

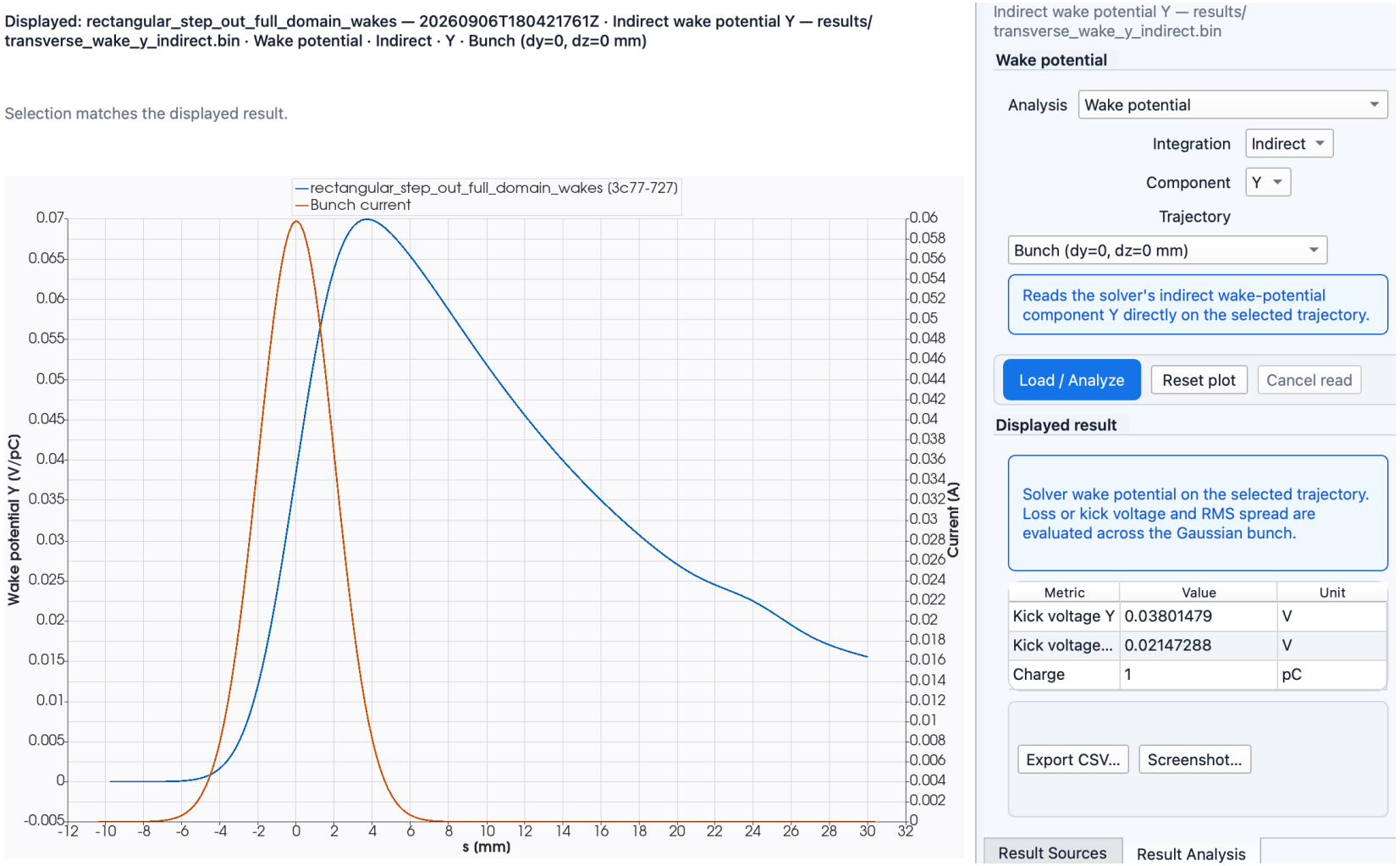
The YAML requests stationary beam self-correction, but the run reports it **disabled** for this stationary dispersion-free method. The saved request is not evidence that a correction was applied.

Observed in this run

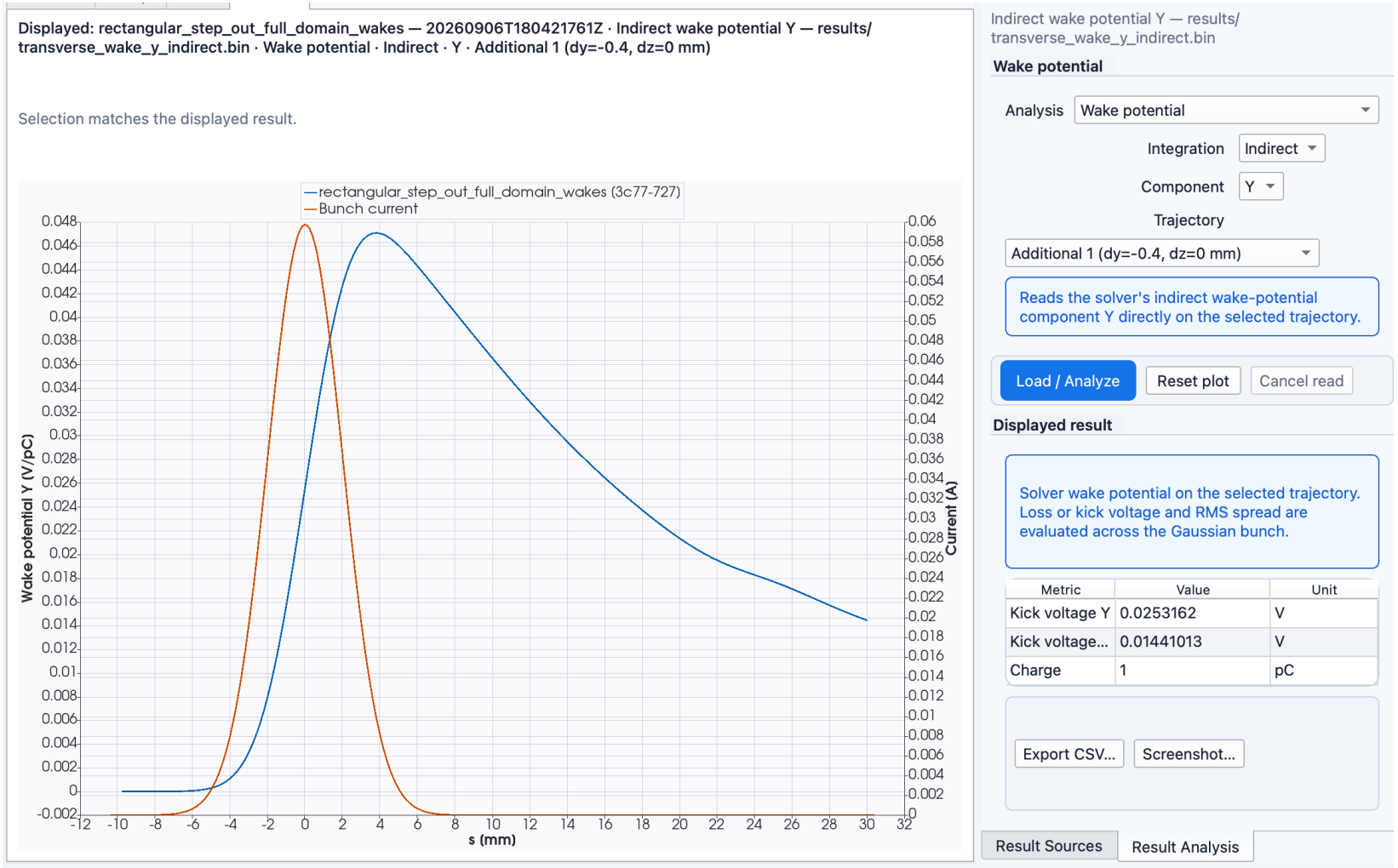
314 completed steps; 200 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -9.8 to 30 mm. Across the recorded trajectories, W_x ranges from -10.11 to 0.5705 V/pC.



Indirect W_x on the Bunch trajectory for the main step-out case. The source is at $(y_q, z_q) = (0.4, 0)$ mm. Read wake and current from their separate axes.



Indirect W_y on the Bunch trajectory: source and witness are both at $(y, z) = (0.4, 0)$ mm. The peak is approximately $0.070\,\mathrm{V/pC}$.

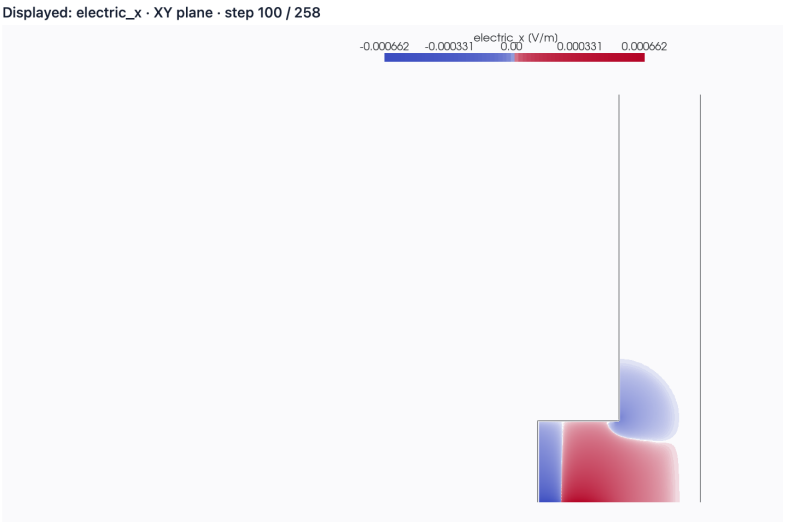


The same source run, with Additional 1 selected: $(dy, dz) = (-0.4, 0)$ mm places the witness at $(y_w, z_w) = (0, 0)$. Its peak is approximately $0.047\,\mathrm{V/pC}$. Changing the witness does not change the exciting bunch.

02 / Finite-speed companion, $\beta = 0.8$

`02_RectangularStepOut/case-finite-beta.yaml`

This separate input exercises stationary FDTD at finite bunch speed. It uses the same authored STL as the main step-out, but several physical and numerical settings are different. Treat it as a separate example, not a beta-only scan.



Owner-supplied E_x Field View for the finite-speed companion, step 100 of 258. The companion uses non-negative y and an on-axis source.

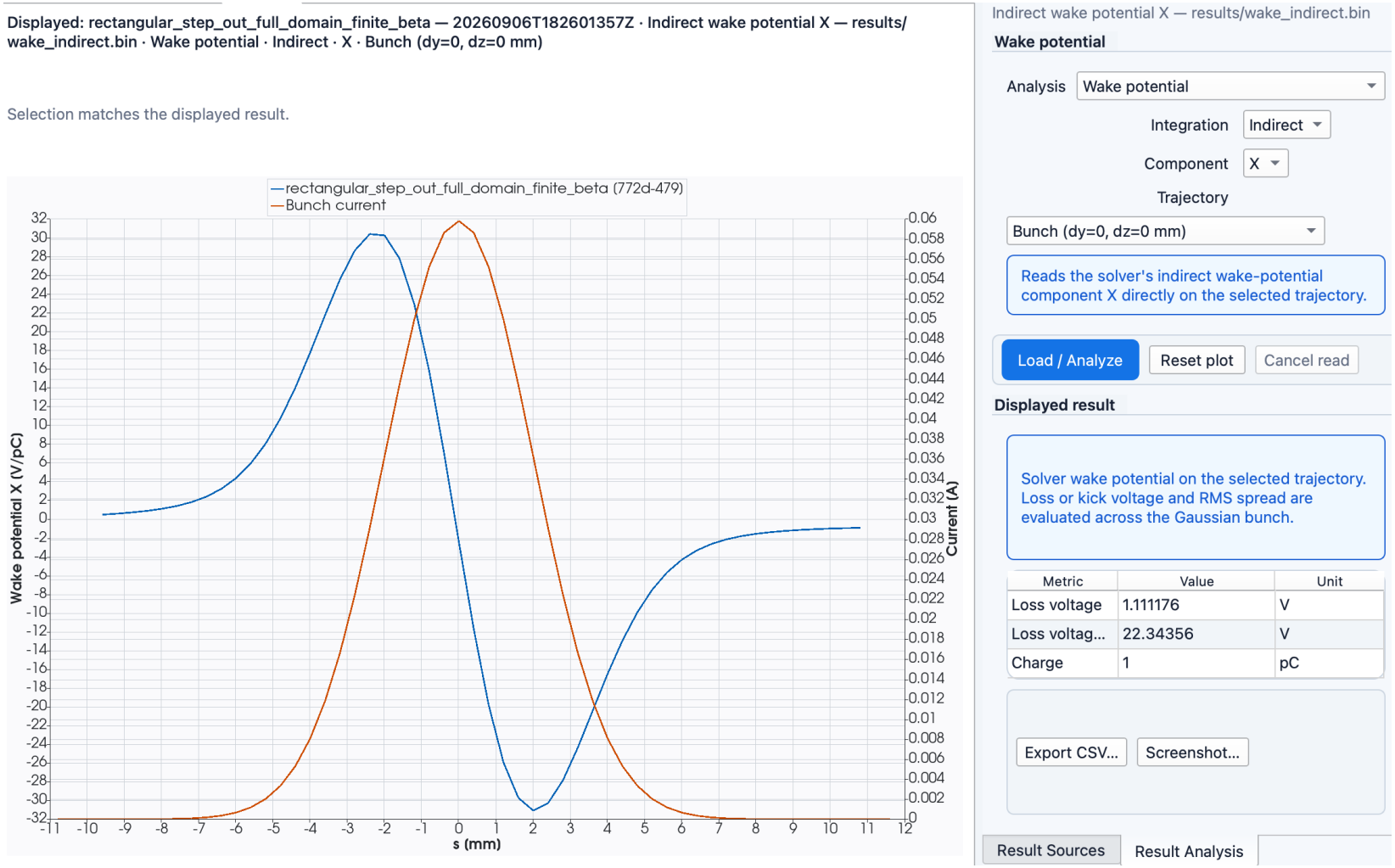
Setting	Saved configuration
Method	Stationary, FDTD, explicit, simple conformal.
Mesh spacing	$(0.4,\ 0.4,\ 0.4)$ mm.
Domain	x : -10–10 mm; y, z : 0–50 mm.
Boundaries	x: open/open; y, z: PMC/PEC.
Bunch	$\beta = 0.8$, $\sigma_x = 2$ mm, $(y_q, z_q) = (0, 0)$.
Witnesses	Beam trajectory only; no additional offsets.
Wake and execution	20.8 mm interval; 6 ranks $\times$ 1 thread.

Self-correction is reported **enabled**. The finite-speed reference field and indirect treatment belong to the supported stationary FDTD path selected by this input. This example does not test another field method or a moving finite-speed window.

Symmetry makes the transverse wake on the axis vanish in this configuration. That does not mean the finite-speed algorithm lacks transverse output; it means this particular saved witness does not test an off-axis transverse kick.

Observed in this run

258 completed steps; 52 wake samples per trajectory; 1 trajectory/trajectories. The sampled lag spans -9.6 to 10.8 mm. Across the recorded trajectories, W_x ranges from -30.95 to 30.61 V/pC.

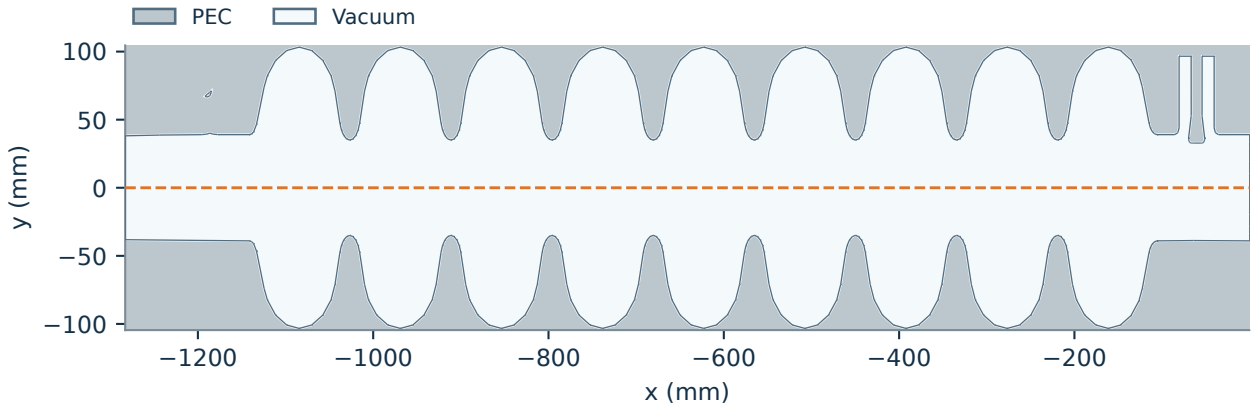


Indirect W_x on the axis for the $\beta = 0.8$ companion. This saved case differs from the main step-out in mesh, source, symmetry and wake interval as well as beta; the two screenshots are not a controlled beta-only comparison.

03 / TESLA cavity

`03_TeslaCavity/case.yaml`

The multi-cell cavity demonstrates a moving calculation through a longer, repeatedly varying aperture. Its vacuum STL sits inside a PEC background.



Longitudinal section of the supplied multi-cell geometry. Negative x coordinates are authored positions, not a reversed beam direction.

Setting	Saved configuration
Method	Moving, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.8,\ 1.18794,\ 1.18794)$ mm.
Domain	$x : -1282.942$–-0.542 mm; $y, z : \pm 104.539$ mm.
Boundaries	x: open/open; y, z: PEC/PEC.
Bunch	$\beta = 1$, $\sigma_x = 4$ mm, $(y_q, z_q) = (0, 0)$.
Witnesses	Beam trajectory only.
Wake and execution	83.2 mm interval; 6 ranks $\times$ 1 thread.

How to read the results

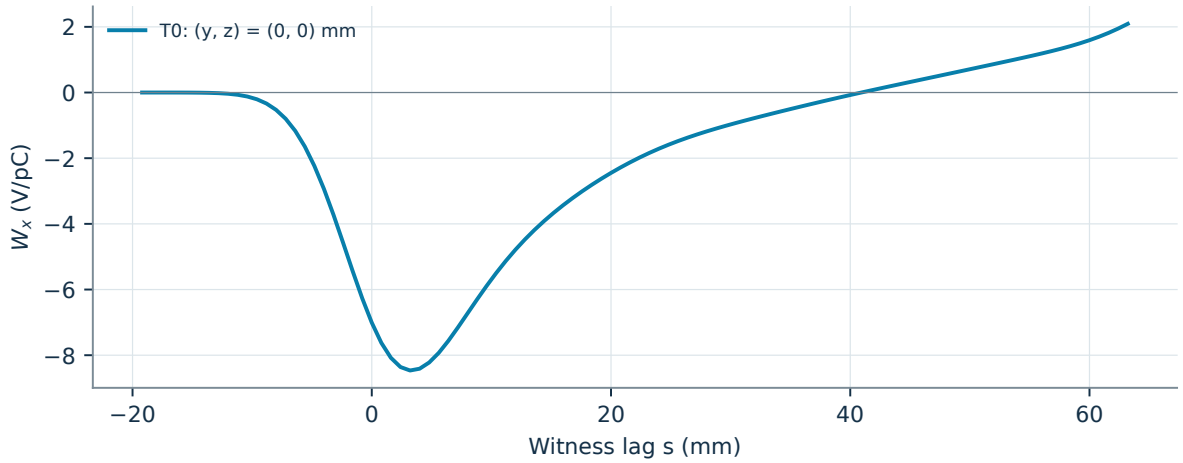
The field panel follows the bunch window; it is not a simultaneous image of all cells. The on-axis longitudinal wake is the main observable shown here. Transverse traces are omitted from this overview, not forced to zero in the stored results. An on-axis source alone does not establish exact transverse symmetry of the authored STL and its discretization.

The geometry can sustain resonant response, but the saved short wake interval is not a high-resolution eigenmode or high-Q measurement. No long-time quality factor is inferred from this run.

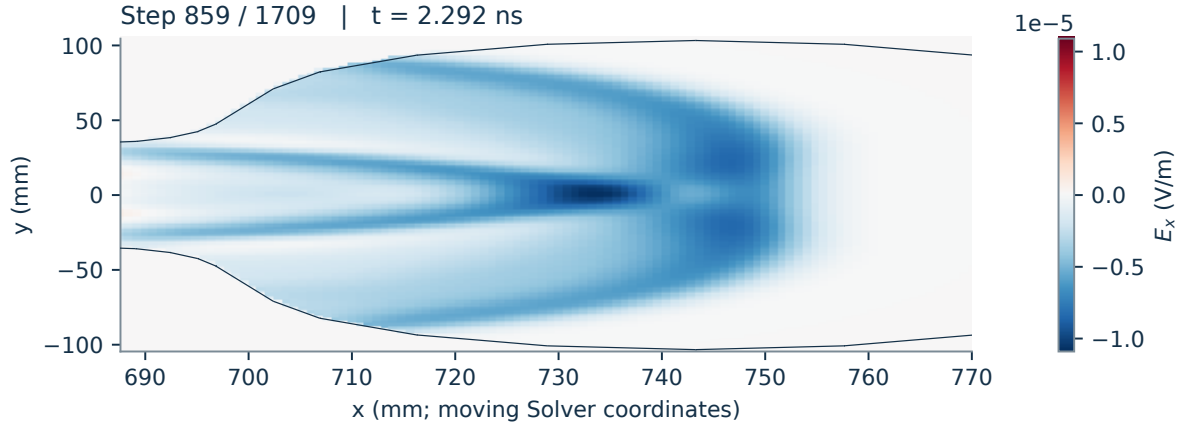
Observed in this run

1709 completed steps; 104 wake samples per trajectory; 1 trajectory/trajectories. The sampled lag spans -19.2 to 63.2 mm. Across the recorded trajectories, W_x ranges from -8.466 to 2.092 V/pC.

03. TESLA cavity / Results



Selected indirect wake potentials from the reference run. T0 is the source trajectory; higher labels identify the additional witnesses. The legend uses effective native coordinates. Small transverse traces are omitted from this guide, not set to zero in the data.

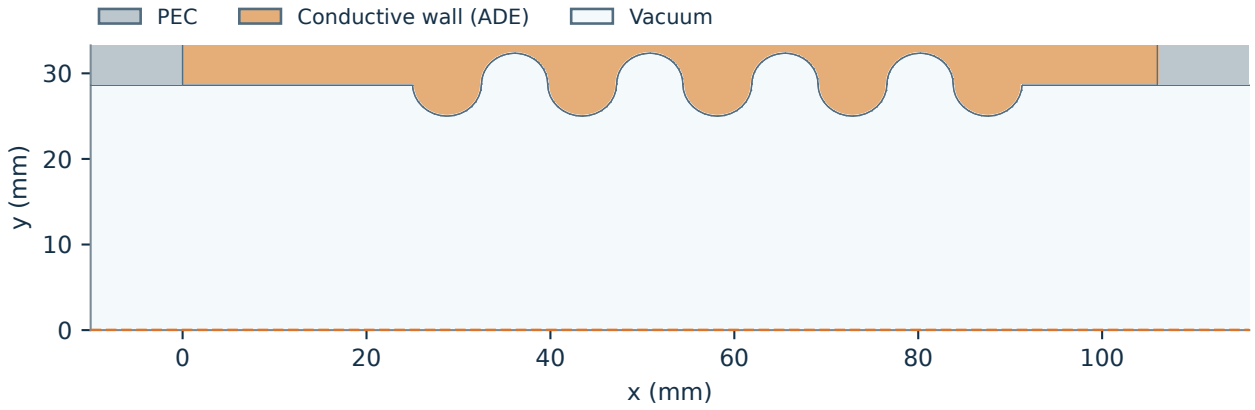


Recorded E_x near the middle of the run, at step 859 and $t = 2.2923$ ns. The geometry outline is overlaid on the actual sampled XY plane. Colour limits are local to this panel; the axes are stretched for readability, not shown at equal aspect ratio.

04 / Lossy bellows

`04_LossyBellows_PowerLoss/case.yaml`

Two intersecting authored objects distinguish the vacuum aperture from the wall region to which finite conductivity is assigned. The surrounding background remains PEC.



Vacuum aperture and assigned copper wall region. Material priority selects the effective material where the authored objects overlap.

Setting	Saved configuration
Method	Moving, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.2,\ 0.296985,\ 0.296985)$ mm.
Domain	x : −10–116 mm; y, z : 0–33.2623 mm.
Boundaries	x: open/open; y, z: PMC/PEC.
Wall	Copper, $\sigma = 5.8 \times 10^7$ S/m; thick-wall ADE model.
Bunch / witnesses	$\beta = 1$, $\sigma_x = 1$ mm; source $(0, 0)$; T1 offset $(0.2, 0.2)$ mm.
Wake / loss monitor	50 mm; power sampled every step; symmetry factor 4.
Execution	4 ranks × 4 threads per rank.

ADE is not a depth-resolved line

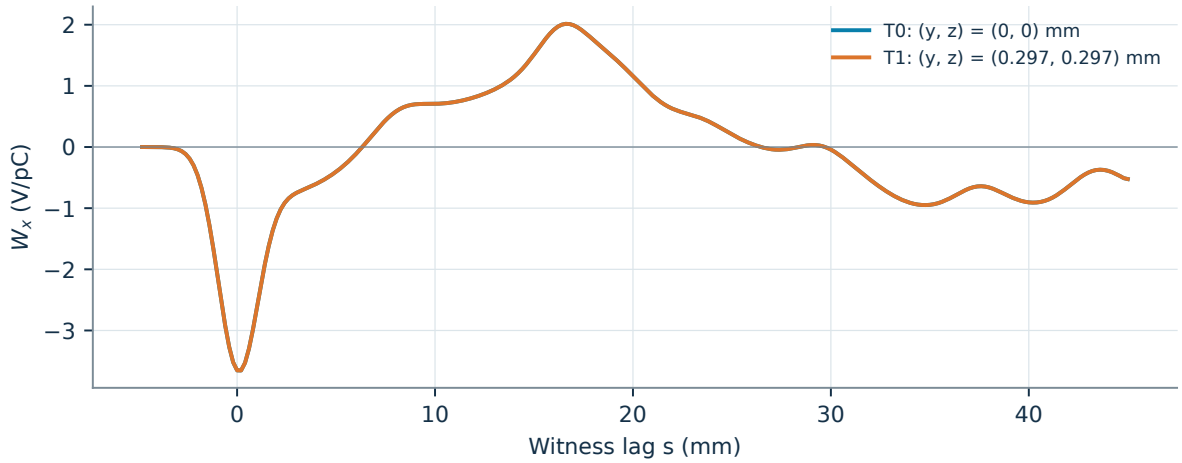
The saved `surface_impedance_model: ade_good_conductor` uses the compact thick good-conductor surface response. It does not select the homogeneous 1-D depth-line model, and no maximum-depth-cell setting is involved here.

The witness request is snapped to native positions; use the result legend for the effective coordinates. The owner-supplied Results screenshot below shows the material-power recording for the selected bellows run.

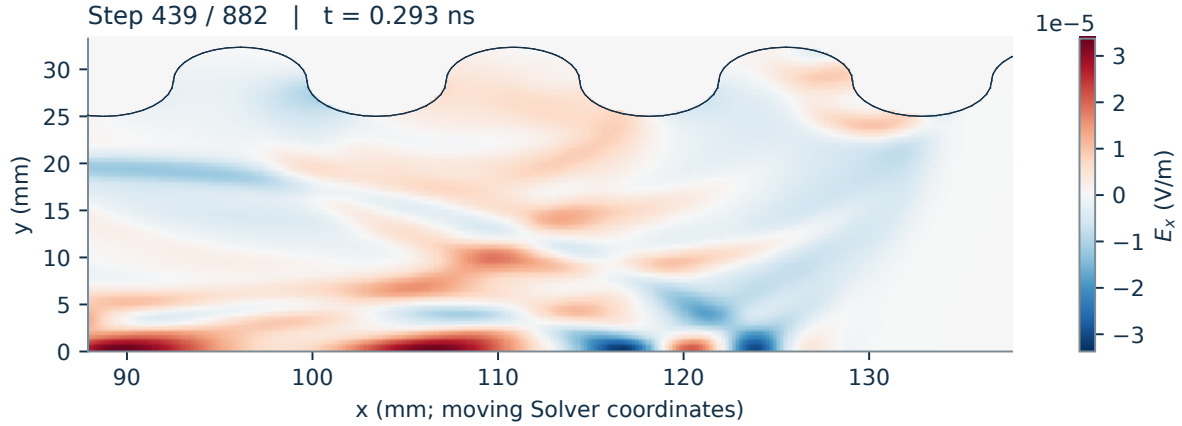
Observed in this run

882 completed steps; 250 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -4.8 to 45 mm. Across the recorded trajectories, W_x ranges from -3.654 to 2.014 V/pC.

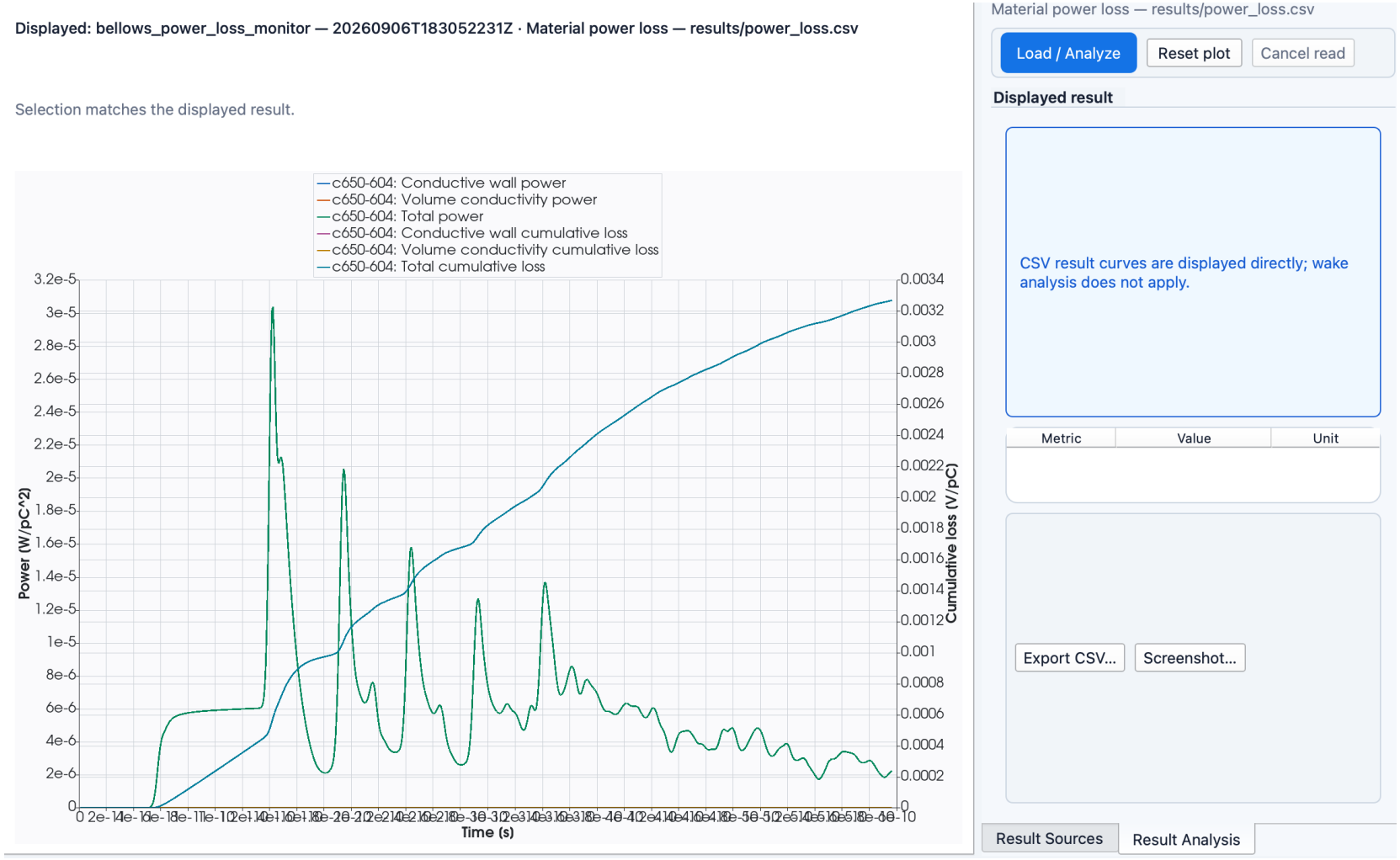
04. Lossy bellows / Results



Selected indirect wake potentials from the reference run. T0 is the source trajectory; higher labels identify the additional witnesses. The legend uses effective native coordinates. Small transverse traces are omitted from this guide, not set to zero in the data.



Recorded E_x near the middle of the run, at step 439 and $t = 0.2929$ ns. The geometry outline is overlaid on the actual sampled XY plane. Colour limits are local to this panel; the axes are stretched for readability, not shown at equal aspect ratio.

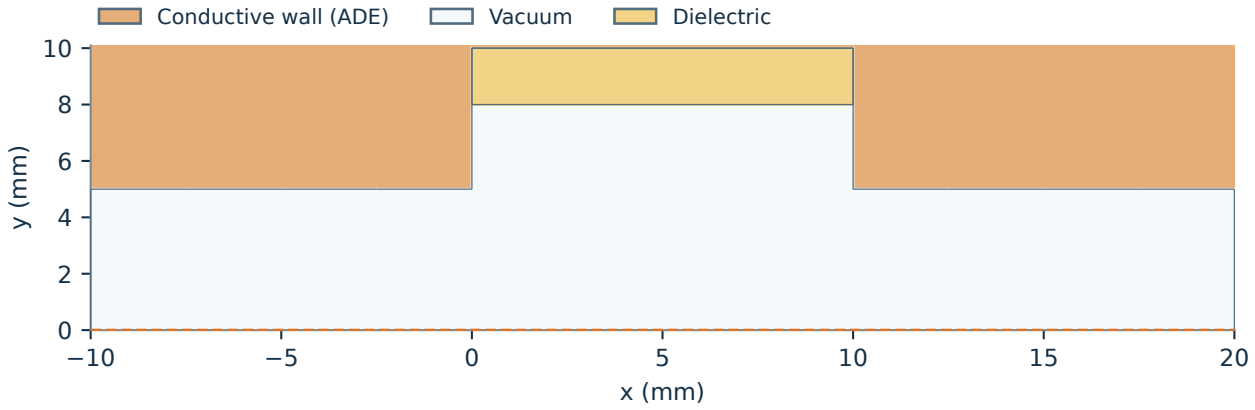


Owner-supplied Results view for the bellows: power on the left axis, cumulative loss on the right. This figure belongs to Example 04; there is no separate material-loss analysis section in this guide.

05 / Lossy pillbox

`05_LossyPillbox_PowerLoss/case.yaml`

This case combines a finite-conductivity wall with a conducting dielectric annulus. It demonstrates two dissipative channels in one physical model.



The background is a conductive wall, not PEC. The higher-priority dielectric annulus occupies part of the cavity's nominal vacuum region.

Setting	Saved configuration
Method	Stationary, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.1,\ 0.148492,\ 0.148492)$ mm.
Domain / boundaries	x : −10–20 mm; y, z : 0–10.0975 mm; x: open/open, y, z: PMC/PEC.
Wall	Thick-wall ADE, $\sigma = 5.8 \times 10^7$ S/m.
Dielectric annulus	$\epsilon_r = 4$, $\mu_r = 1$, $\sigma = 2$ S/m.
Bunch / witnesses	$\beta = 1$, $\sigma_x = 0.5$ mm; source $(0, 0)$; T1 offset $(0.25, 0.25)$ mm.
Wake / loss monitor	500 mm; power sampled every 4 steps; symmetry factor 4.
Execution	6 ranks × 1 thread.

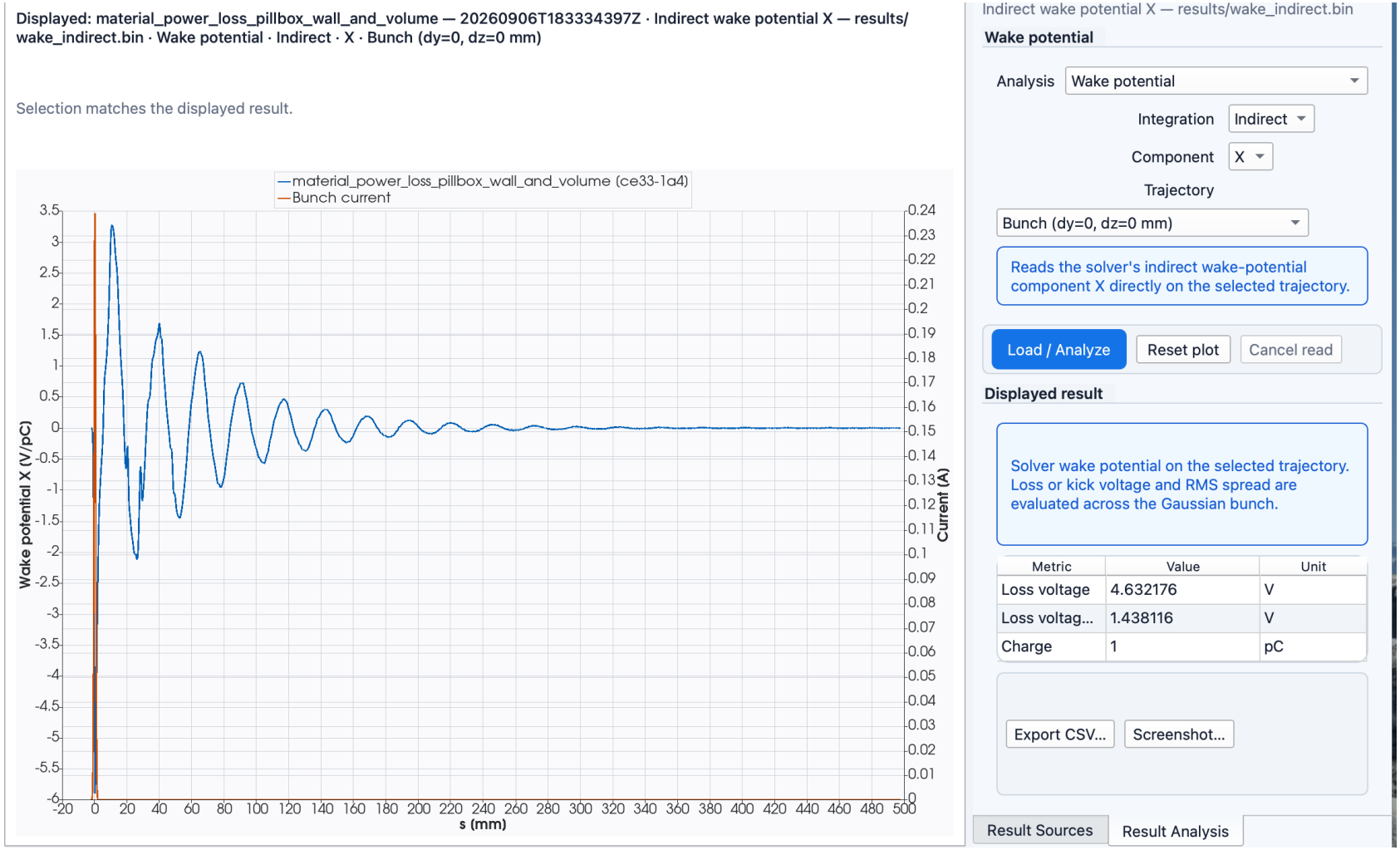
A longer ring-down record

The relatively long wake interval permits observation of the oscillatory tail after the bunch passes the compact geometry. The field near the middle of the run is therefore not necessarily a picture of the driving bunch in the cavity.

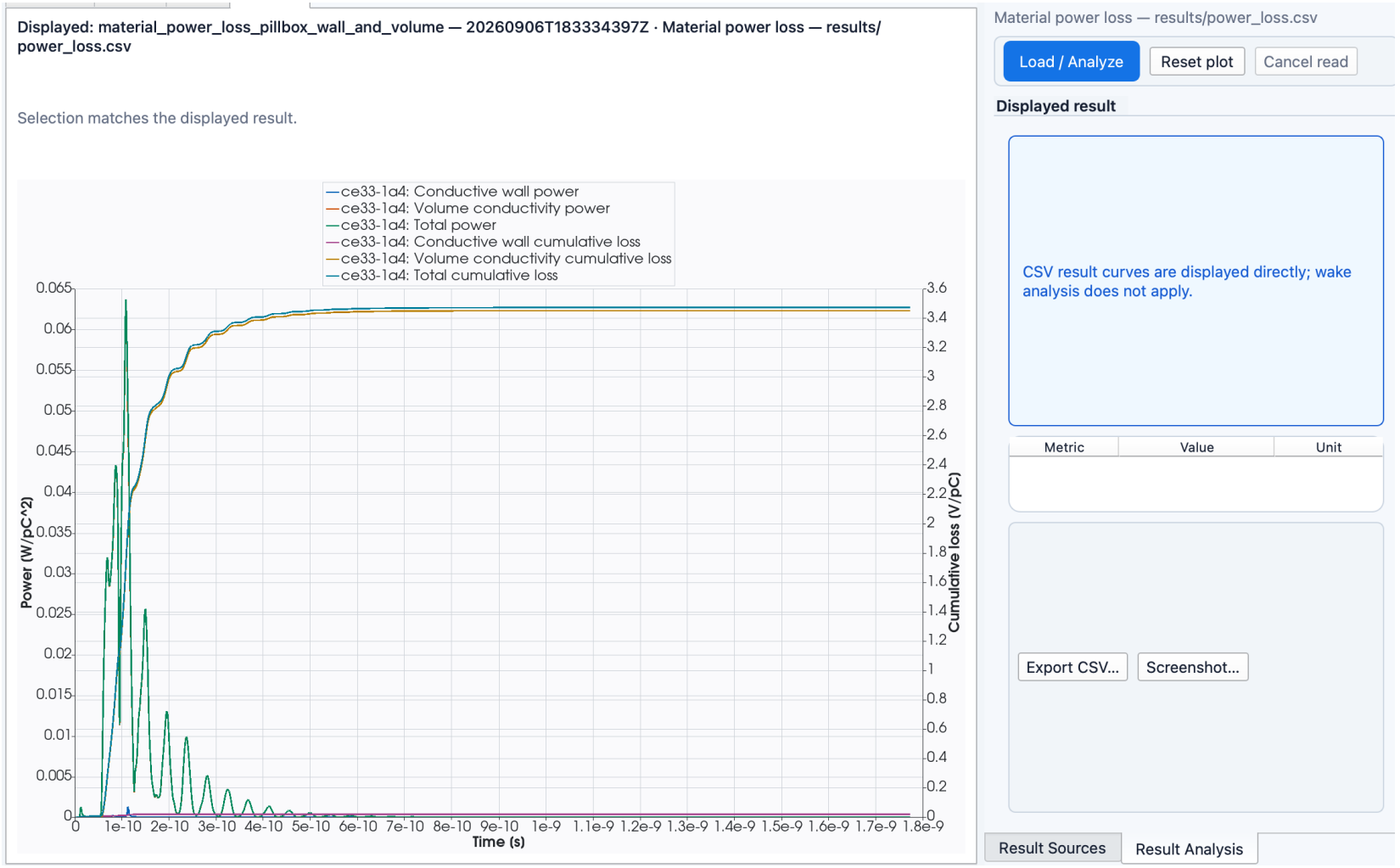
Wall and volume channels are already separated in `power_loss.csv`; no second control calculation is part of this example. The supplied screenshot shows both recorded channels and their total.

Observed in this run

5314 completed steps; 5000 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -2.4 to 497.5 mm. Across the recorded trajectories, W_x ranges from -5.908 to 3.279 V/pC.



Indirect W_x on the Bunch trajectory in the owner's selected pillbox run. The long record shows an oscillatory tail. The small transverse plots from the earlier guide are omitted; this longitudinal curve is reproduced unchanged.

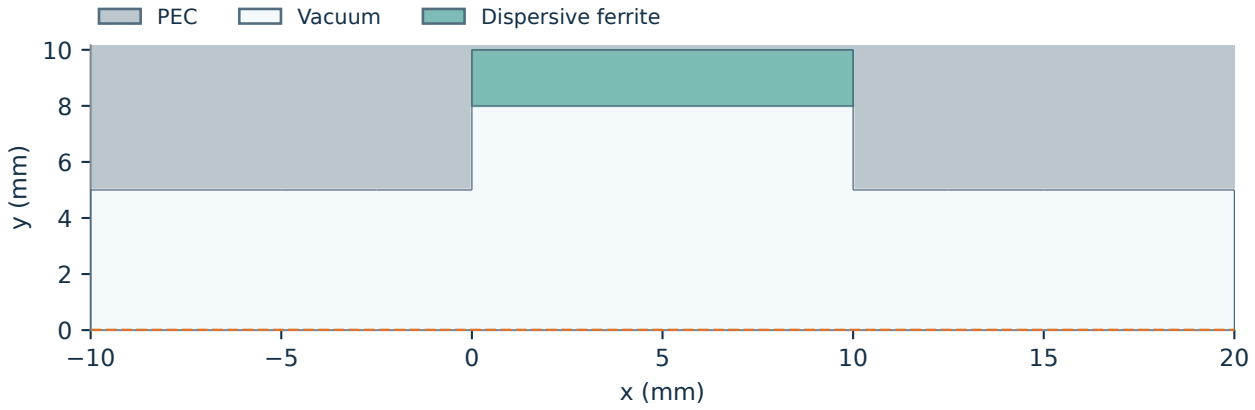


Owner-supplied Results view for the pillbox. Wall, volume and total traces are distinguished by the original legend; power and cumulative loss use different vertical axes. The authored symmetry factor is already included.

06 / Ferrite pillbox with a Lorentz pole

`06_FerritePillbox_Lorentz/case.yaml`

The pillbox annulus now has a dispersive magnetic response while the surrounding wall is PEC. This is one configured material example, not a material-subtraction pair.



Vacuum cavity, magnetic annulus, and PEC background. The Lorentz pole describes the material response; it is not a separate geometric solid.

Setting	Saved configuration
Method	Stationary, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.12,\ 0.178191,\ 0.178191)$ mm.
Domain / boundaries	x : −10–20 mm; y, z : 0–10.1569 mm; x: open/open, y, z: PMC/PEC.
Material background	$\epsilon_r = 1$, high-frequency $\mu_\infty = 1$.
Magnetic pole	$\Delta\mu = 1$; $f_0 = 12$ GHz; $\gamma = 1.507964474 \times 10^{10}\ \mathrm{s}^{-1}$.
Bunch / witnesses	$\beta = 1$, $\sigma_x = 0.6$ mm; source $(0, 0)$; T1 offset $(0.4, 0.4)$ mm.
Wake and execution	300 mm; 6 ranks × 1 thread; no power-loss monitor.

For one pole, with $\omega_0 = 2\pi f_0$, the authored material law is

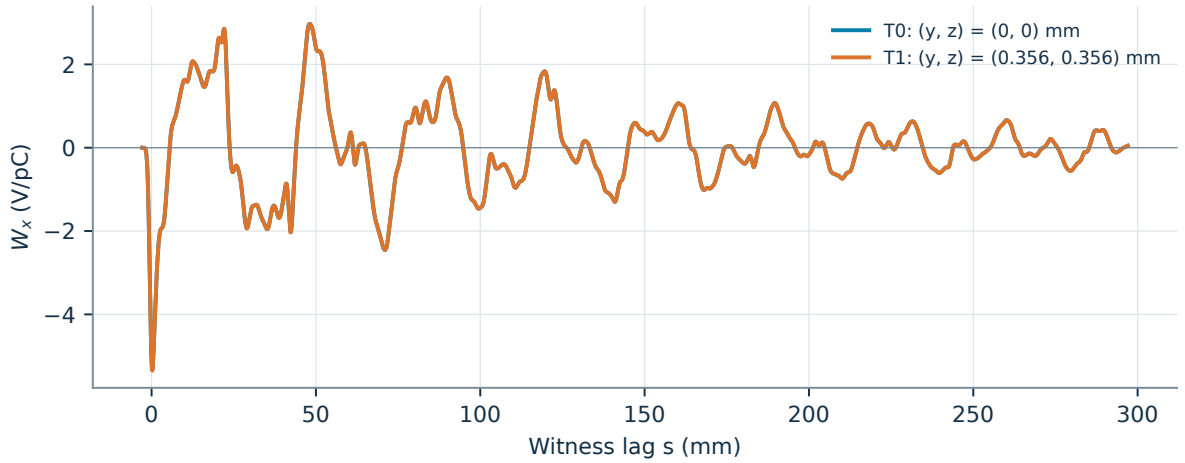
$$\mu_r(\omega) = \mu_\infty + \frac{\Delta\mu\,\omega_0^2}{\omega_0^2 - \omega^2 + i\gamma\omega}.$$

Here $\mu_r(0) = 2$, not 1. The damping input is already a rate in s^{-1}; no extra factor 2π is applied to it. A structure's wake-spectrum peaks need not coincide with the material pole frequency. No external-code agreement is claimed from the reference notes shipped in the directory.

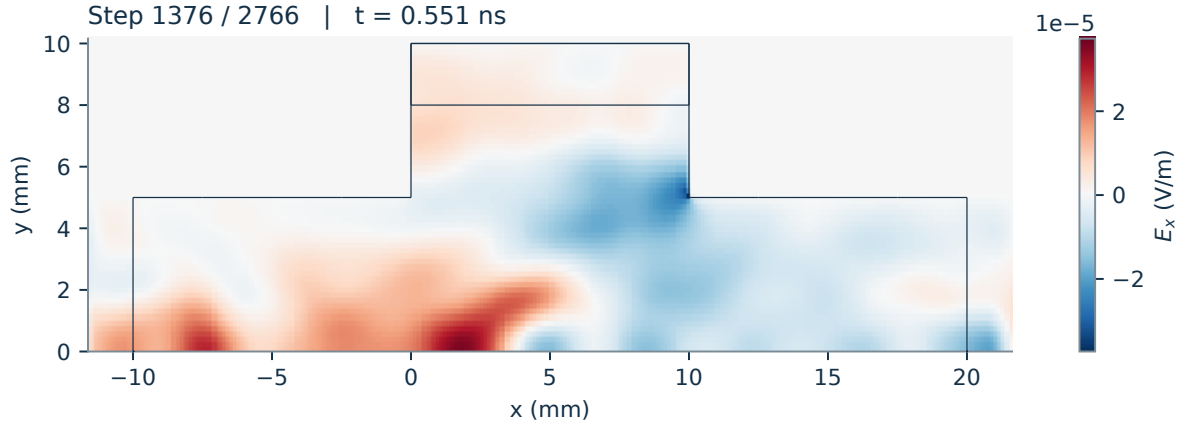
Observed in this run

2766 completed steps; 2500 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -2.88 to 297 mm. Across the recorded trajectories, W_x ranges from -5.347 to $2.974\,\mathrm{V/pC}$.

06. Ferrite pillbox / Results



Selected indirect wake potentials from the reference run. T0 is the source trajectory; higher labels identify the additional witnesses. The legend uses effective native coordinates. Small transverse traces are omitted from this guide, not set to zero in the data.

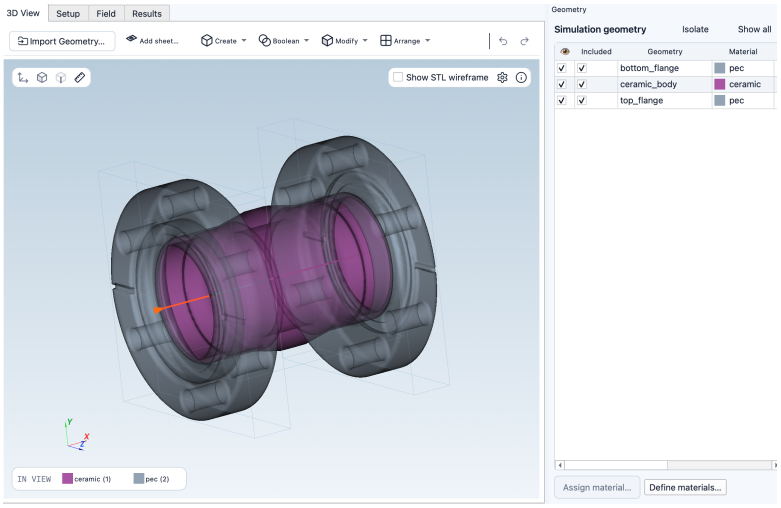


Recorded E_x near the middle of the run, at step 1376 and $t = 0.5508$ ns. The geometry outline is overlaid on the actual sampled XY plane. Colour limits are local to this panel; the axes are stretched for readability, not shown at equal aspect ratio.

07 / Ceramic break

`07_CeramicBreak_Dielectric/case.yaml`

This model reverses the background convention used in most earlier cases: the background is vacuum, with PEC flange objects and a dielectric ceramic body.



Owner-supplied Studio geometry view: the two PEC flanges and the ceramic body. The geometry list retains the original object and material IDs.

Setting	Saved configuration
Method	Stationary, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.2,\ 0.296985,\ 0.296985)$ mm.
Domain	x : −32–31.6 mm; y, z : 0–35.6382 mm.
Boundaries	x: open/open; y, z: PMC/open.
Materials	Vacuum background, PEC flanges; ceramic $\epsilon_r = 11$, $\mu_r = 1$.
Bunch / witnesses	$\beta = 1$, $\sigma_x = 1$ mm; source $(0, 0)$; T1 offset $(0.5, 0.5)$ mm.
Wake and execution	150 mm; 6 ranks × 1 thread; no power-loss monitor.

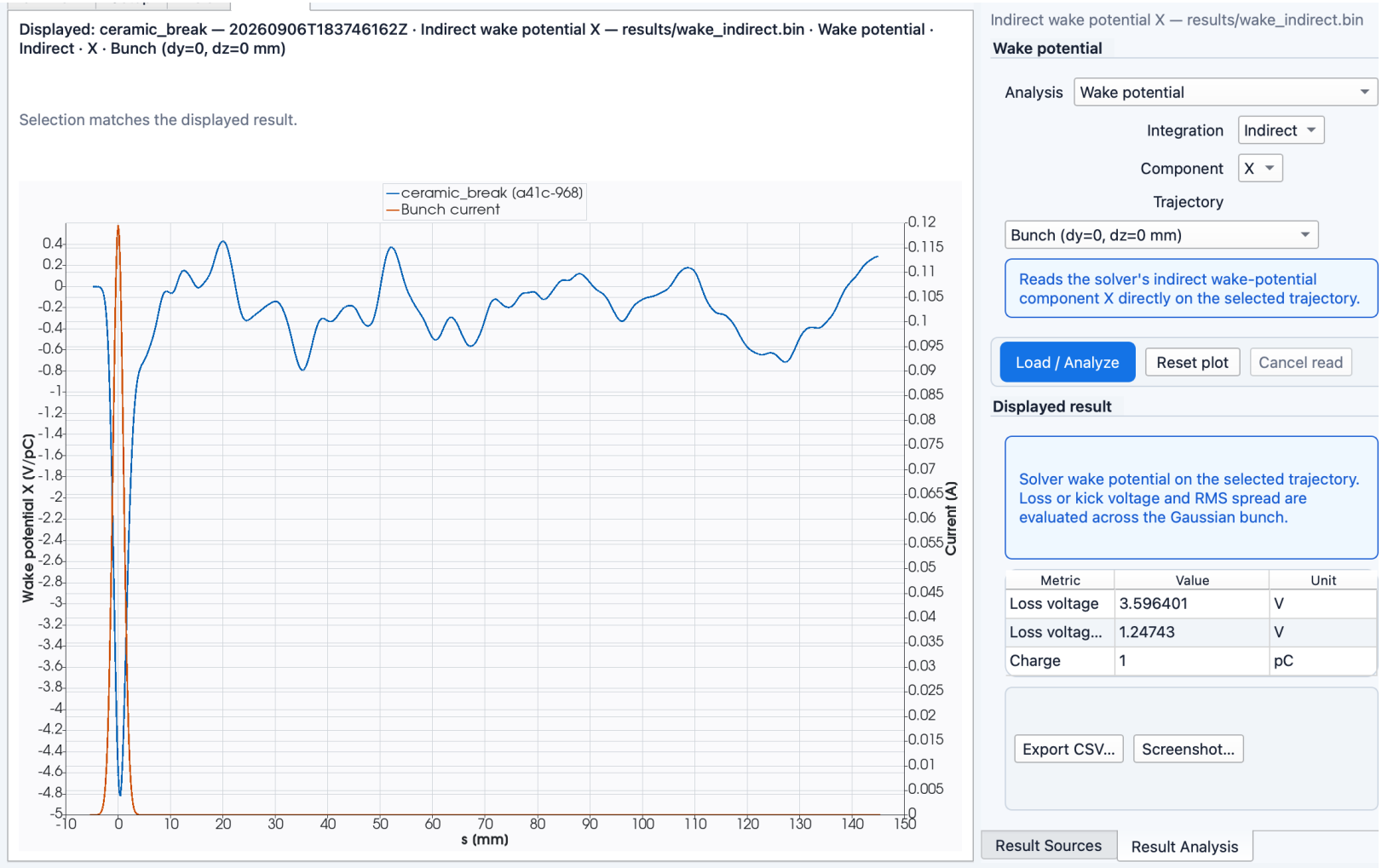
Open transverse boundaries are intentional

The upper y, z faces are open and use PML; they are not a PEC enclosure. The field preview can extend into the recorded exterior padding. Fields beyond an authored geometry boundary do not, by themselves, indicate a material leak.

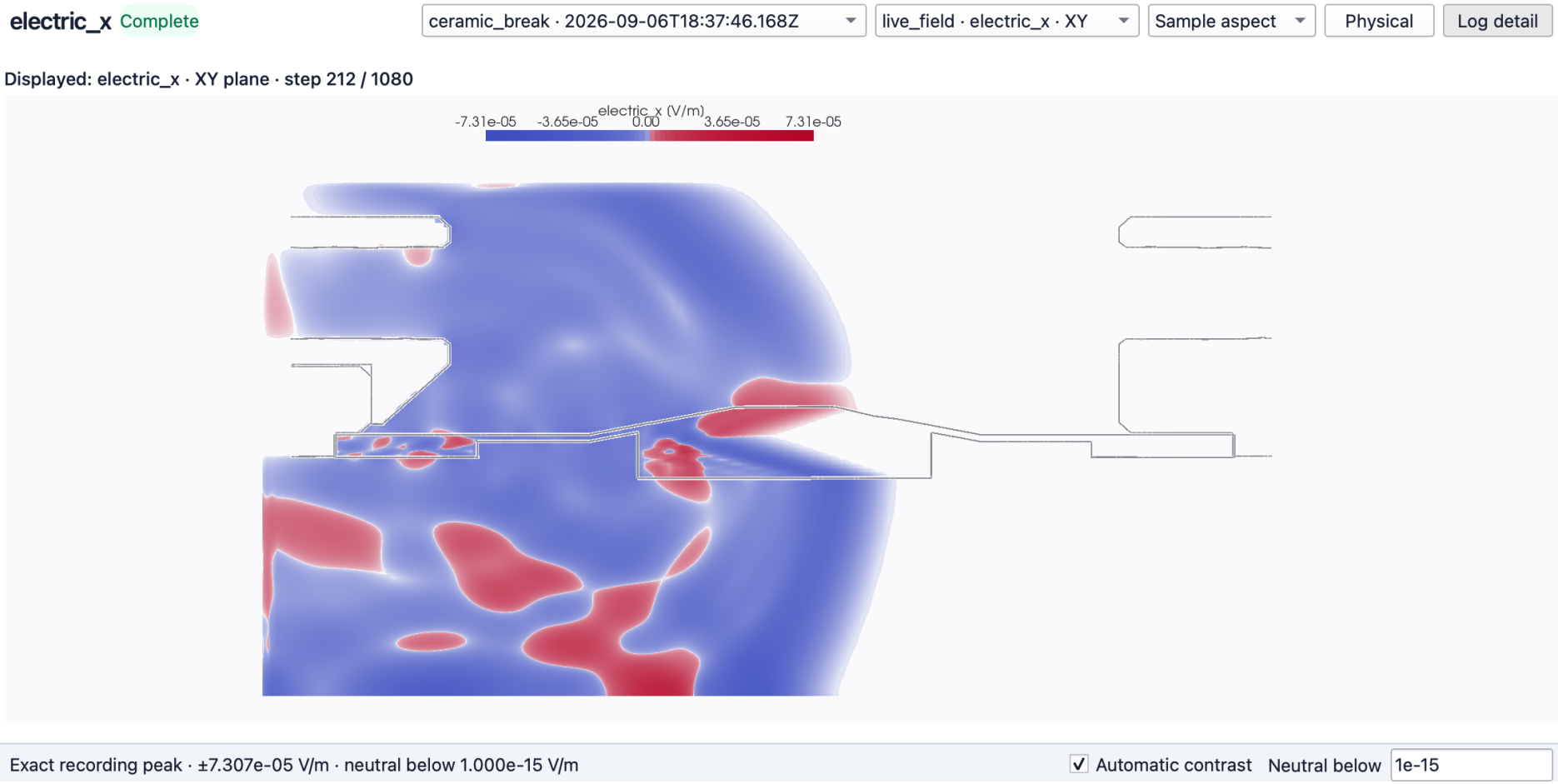
The saved dielectric is lossless, but energy can still leave through open boundaries. Absence of a material-power CSV is not a claim of zero wake effect or zero radiation. Inspect the native field scale and the wake independently.

Observed in this run

1080 completed steps; 750 wake samples per trajectory; 2 trajectory/trajectories. The sampled lag spans -4.8 to 145 mm. Across the recorded trajectories, W_x ranges from -4.824 to 0.431 V/pC.



Indirect W_x on the Bunch trajectory. This is the owner's selected ceramic-break run. Small transverse plots around zero are omitted from the guide.

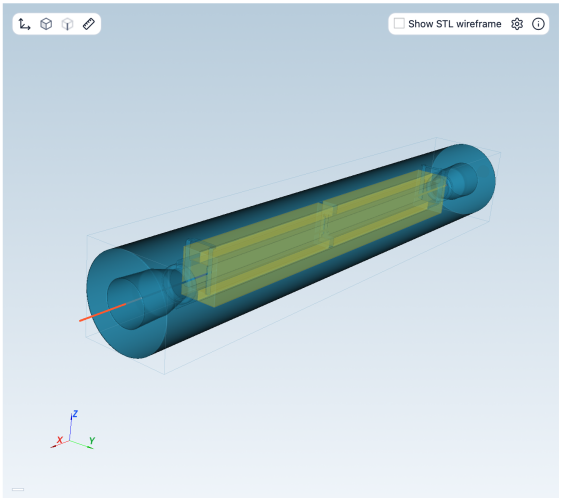


Recorded E_x on the XY plane, step 212 of 1080, in the owner's ceramic-break run. The image includes the geometry overlay and the original colour scale; the open transverse region is part of this example.

08 / Ferrite kicker

`08_FerriteKicker/case.yaml`

The largest model combines a long vacuum region with a dispersive ferrite object. Two additional witnesses sample the transverse directions separately.



Owner-supplied 3D view of the kicker, with transparent outer geometry, the internal object and the source marker. The original aspect ratio and axis triad are retained.

Setting	Saved configuration
Method	Stationary, dispersion-free, explicit, simple conformal.
Mesh spacing	$(0.8,\ 1.18794,\ 1.18794)$ mm.
Domain / boundaries	x : 0–1728 mm; y, z : 0–133.049 mm; x: open/open, y, z: PMC/PEC.
Ferrite background	$\epsilon_r = 12$, $\mu_\infty = 1$, $\sigma = 5 \times 10^{-5}$ S/m.
Magnetic pole	$\Delta\mu = 500$; $f_0 = 150$ MHz; $\gamma = 2 \times 10^{10}$ s^{-1}.
Bunch / witnesses	$\beta = 1$, $\sigma_x = 4$ mm; source $(0, 0)$; T1 $(1.18794, 0)$ mm, T2 $(0, 1.18794)$ mm.
Wake and execution	200 mm; 8 ranks $\times$ 1 thread; no power-loss monitor.

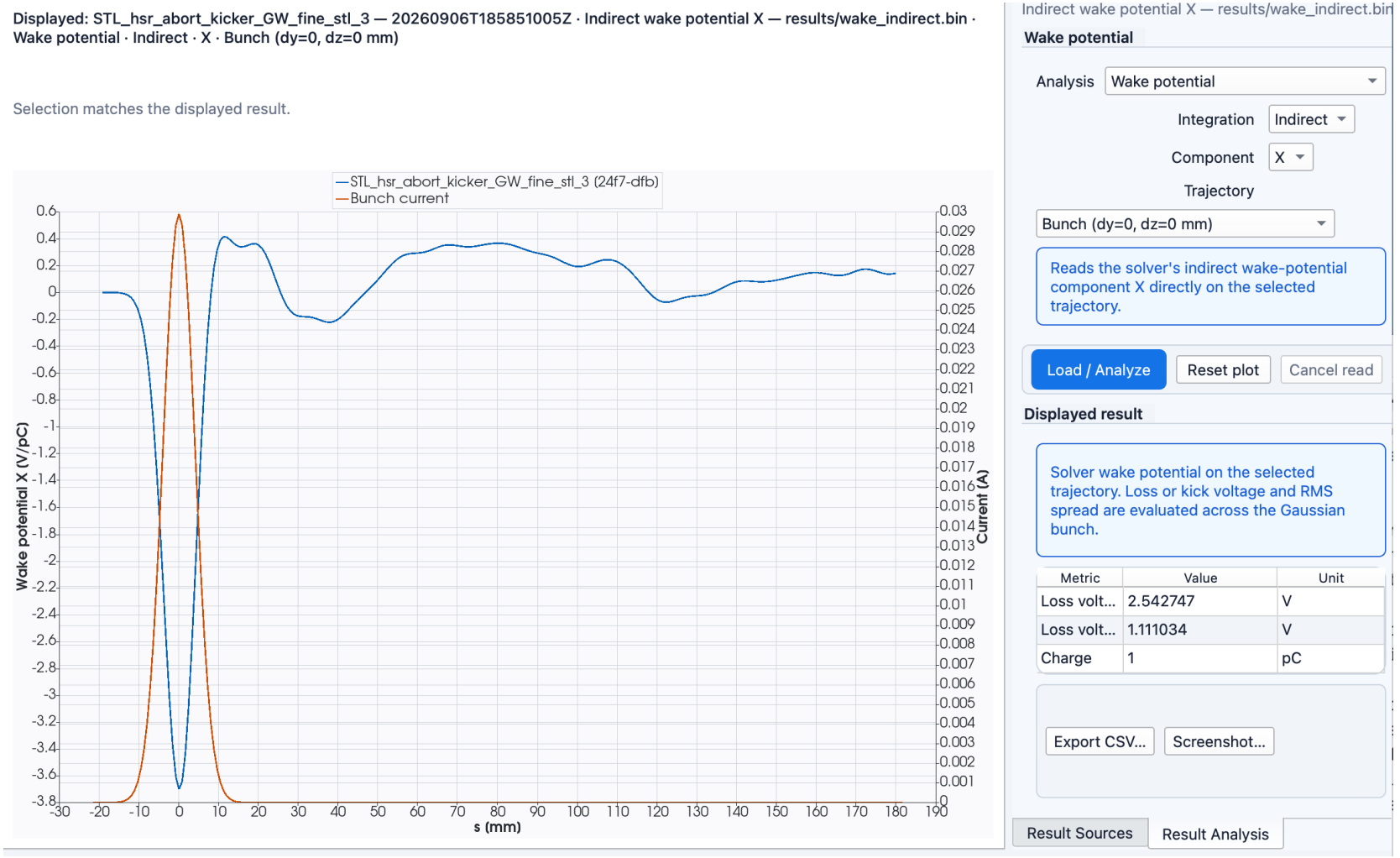
Do not read the permeability as a constant

The background value 1 is the high-frequency term. With the saved Lorentz pole, $\mu_r(0) = 501$. The large damping rate is part of the authored material law; this guide does not replace it with a fitted or constant permeability.

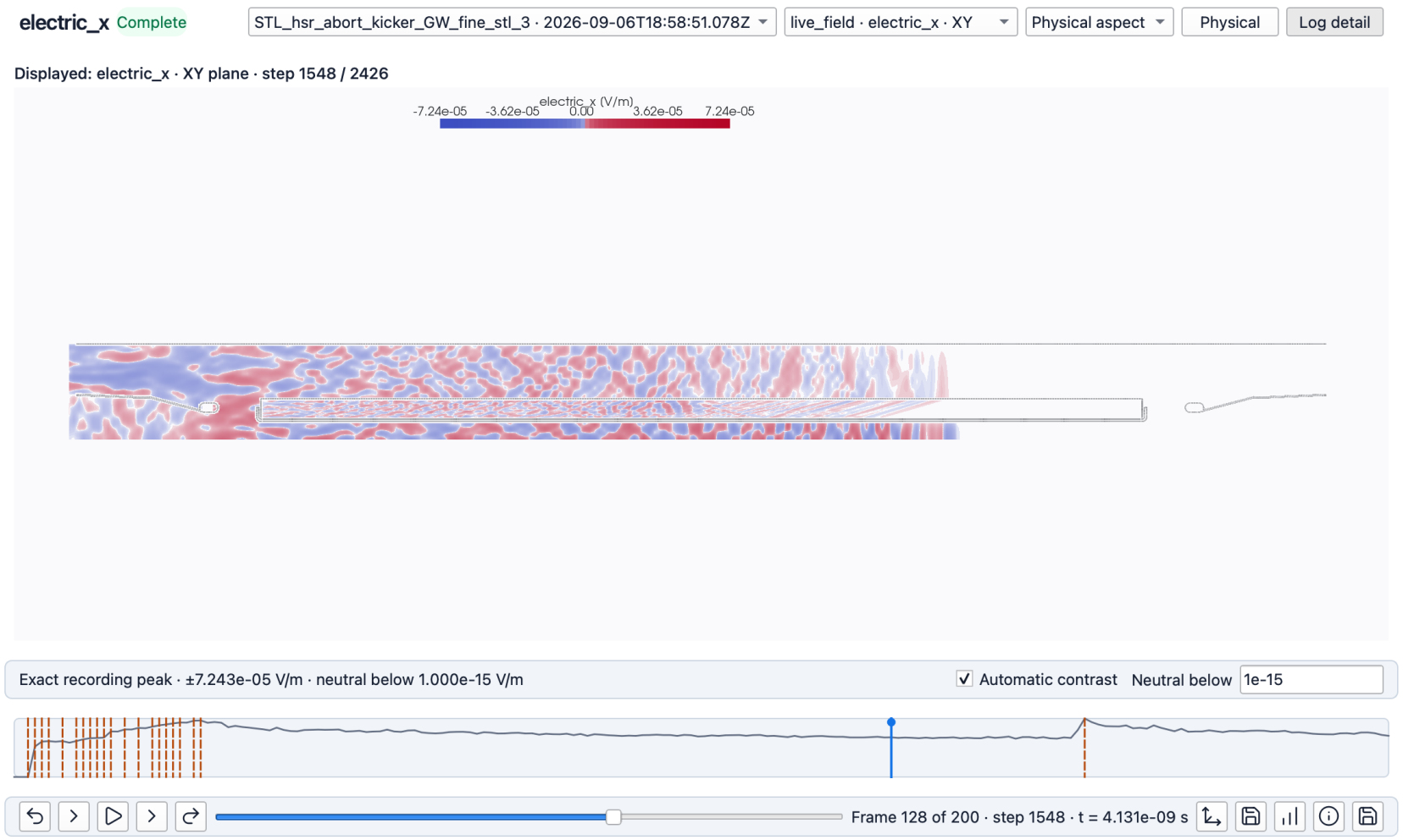
The stationary self-correction request is reported **disabled** for the selected method. The two additional witnesses are passive observations, not two extra bunches. The next pages show the owner's longitudinal wake on the Bunch trajectory and an intermediate Field View frame. Transverse wake plots are not included in this selection.

Observed in this run

2426 completed steps; 250 wake samples per trajectory; 3 trajectory/trajectories. The sampled lag spans -19.2 to 180 mm. Across the recorded trajectories, W_x ranges from -3.704 to 0.4159 V/pC.



Indirect W_x on the Bunch trajectory, $(dy, dz) = (0, 0)$, in the owner's selected kicker run. The blue curve is the wake in V/pC; the orange curve is bunch current in A. The original axes, run identity and result metrics are retained.



Owner-supplied E_x on the XY plane, step 1548 of 2426, $t = 4.131$ ns, frame 128 of 200. The screenshot retains physical aspect ratio, the geometry overlay, timeline and original colour scale. In Studio, select **Field**, choose `live_field`, and move the timeline to the desired retained frame. Read the numerical colour limits when comparing frames.

Create a dipole study

The supplied examples keep their single-source physical setups. To study a driving dipole, make a separate project copy and use **Create dipole pair** in **Excitation Source**. The pair has opposite charges, a common Gaussian profile and velocity, and independently authored observation trajectories.

1. Use geometry and a transverse domain that contain both source positions. A half- or quarter-domain example represents a symmetry sector; its cut cannot be removed without supplying the missing physical geometry and correct boundaries.
2. Enter the pair centre, full separation along Y/Z and charge magnitude. No separate normalization charge is entered.
3. Keep the observations fixed in absolute coordinates. For a driving coefficient on the reference orbit, observe the pair centre; an observation does not automatically follow a source edit.
4. Run and select the separate **dipole coefficient** result source. The primary response is in V; the coefficient is in V/pC/m and already includes division by the effective full separation. Export the coefficient as CSV when needed.
5. Check several resolved separations and mesh refinement. The finite pair cancels the source-independent term, but retains higher odd source terms. An asymmetric geometry is allowed; a pure azimuthal-mode interpretation is not implied by the name dipole coefficient.

The Physics Guide derives the normalization, source-direction dependence and small-separation limit, and distinguishes this full-structure pair from the single-source PEC symmetry method. The User Guide describes the source table, pair preset and result controls. These instructions do not turn the retained single-source figures or timing tables into new dipole measurements.

Measured execution costs

Each configuration was run once, sequentially, using its saved MPI and OpenMP settings. No warm-up, repetition, median selection, or parameter tuning was used. The field-history output was enabled exactly as authored in every run.

Example	Ranks × threads	Mesh (s)	Solver (s)	Rank peak (MiB)	Sum peaks (MiB)
01	6×1	0.74	1.41	33.7	188.7
02	6×1	0.49	5.94	259.0	908.0
02 ($\beta = 0.8$)	6×1	0.20	4.14	257.1	1134.6
03	6×1	6.57	17.48	111.2	644.0
04	4×4	3.79	74.52	362.5	1161.2
05	6×1	0.75	56.23	304.2	1657.7
06	6×1	0.31	24.71	52.1	277.6
07	6×1	0.98	35.27	237.3	978.8
08	8×1	8.51	694.39	1126.6	6788.2

What the columns mean

Mesh is elapsed wall time for the entire mesh command, including MPI launch and shutdown. **Solver** is Solver's own `timing_total_seconds`; it is not the external command wall time and does not include a separate meshing command. The raw collection also preserves the external solve duration and each available phase timer.

Rank peak is the maximum rank-local peak resident memory reported for the solve. **Sum peaks** adds the rank-local peak values; those peaks need not occur simultaneously, and shared pages can be counted more than once. It is not a measurement of unique physical memory at one instant. MiB means 2^{20} bytes.

The reference machine is macOS arm64 with 48 GiB physical memory. These values describe these complete cases on that machine. They are not a controlled scaling study: mesh sizes, materials, duration, MPI layouts, and thread counts differ.

Do not infer a beta-only speed comparison

The two saved step-out configurations differ in more than β: field method, mesh spacing, transverse domain and symmetry, source/witness positions, and wake length also differ. Their timings and curves must not be presented as a controlled comparison in which only beam speed changed.

Provenance, checks, and reproducibility

Inputs and executable

This manual accompanies EMUZAG 1.1.2. The figures and numerical timing tables retain the earlier reference runs identified below; they have not been relabelled as new 1.1.2 measurements. The current package source pair is in `MANIFEST.json`.

The reference-run source was the owner-approved example inventory installed in the recorded unified macOS arm64 hybrid evaluation package. All nine YAML files and their referenced assets were hash-checked before and after the calculations. No parameters, material assignments, witness offsets, preview options, or execution counts were edited. The current `examples/snapshot.json` records the later explicit-list migration; it does not claim byte identity with the earlier YAML or a new timing measurement.

Item	Recorded identity
Package	EMUZAG 0.1.1, macOS arm64 hybrid, owner-examples evaluation
Solver source	`2ce2ab62eb5936f9cfa20756b536c38a4ba0376b`
Studio source	`98c35afde5a01348a9777d90b24c7808feaa4398`
Execution	Packaged external Solver, bundled MPI launcher, packaged native postprocessor
Retained illustrations	Authored STL sections and native wake and field data
Revised illustrations	Owner-supplied Studio screenshots from `Figures_Examples`
Brand asset	Approved EMUZAG logo supplied by the project owner

What was checked

For each run: successful mesh and solve exits; six finite native wake artifacts; completed preview status; finite values in every retained frame; unchanged input hashes. Impedance output and enabled power-loss CSV data were checked for finite values. Wake storage order and longitudinal coordinates follow the current Studio reader contract, not an inferred array layout.

Rebuild the documents without rerunning Solver

The LaTeX source includes the shared style, figures, measured reference data and provenance metadata. Build this document with `build.command -document examples-guide`. Figure generation and calculation collection are separate actions; document compilation never starts a calculation. Earlier source archives predate this screenshot revision and are not an updated source bundle.

The reference-run identity and per-figure source-frame hashes are recorded in `figures/figure-data.json` and the companion collection manifest. Rebuilding these guides uses the reviewed figures and recorded reference data; it does not require retaining or recreating historical calculation directories. The new screenshot inventory and its byte-preserving copies are documented in `EXAMPLES-SCREENSHOTS.md`. Screenshot metrics are not substituted for the earlier run's measurements.

Relationship to the full User Guide

The supplied User Guide documents the broader UI, including Windows setup. These companions describe the current saved example set and macOS reference runs. They do not change licence conditions, promise identical runtime on Windows, or claim a notarized public macOS release.

Geometry representation

The eight approved models retain their supplied geometry and physical settings. The reference figures and costs in this guide remain the recorded observations; their inclusion in the 1.1.2 documentation does not relabel them as new runs.

For a separate CAD study, Studio supports STL, curved surfaces and explicit per-body hybrid choices. Native volumes and supported CAD screens share the ordinary Build Mesh and Run workflow. The supplied examples are not a catalogue of every admitted CAD contact or a convergence certificate for another design. Use the User Guide for representation, screen topology and recovery limits.

Release 1.1.2 uses indexed conducting-wall and thin-screen mesh records. Rebuild older affected meshes when Solver requests it. Keep historical jobs and results, and use a fresh calculation if an earlier checkpoint is rejected after remeshing. The supplied source geometry and saved inputs remain the starting point; a mesh-format upgrade is not a request to change the model.

When comparing representations, preserve physical dimensions, materials, priorities, domain, mesh spacing and retention. Vary calculation STL tolerances separately from grid resolution and compare both face-area policies explicitly if the area choice matters to the requested observable. Keep each run's immutable inputs and report the settings with the result. A better-looking preview alone does not demonstrate improved calculation accuracy.