Impedance Budget Database

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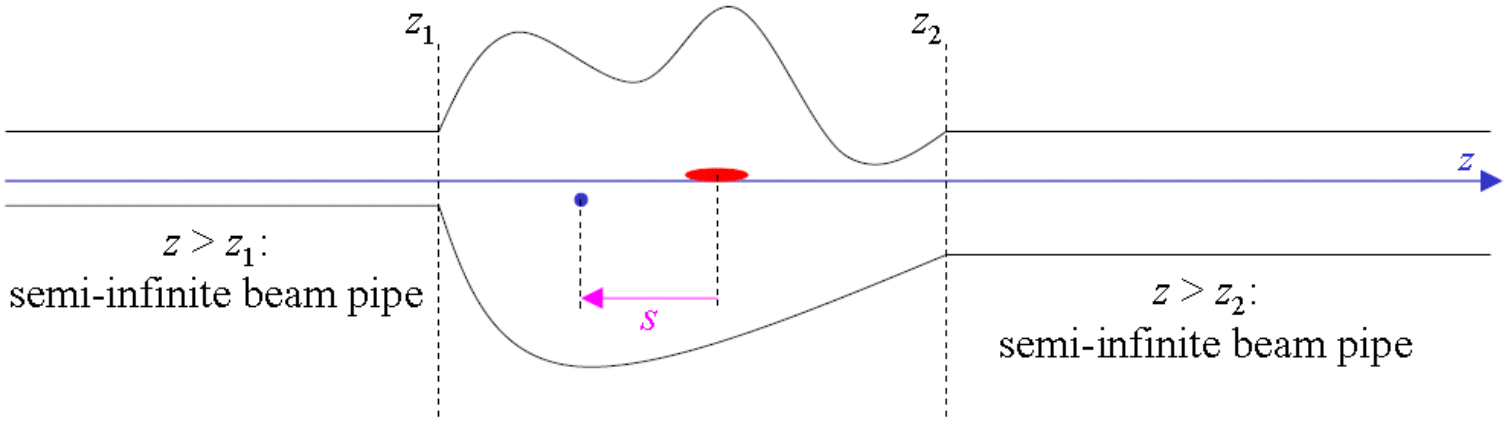
3.11.08

BD meeting, DESY

wake potential



source particle → source distribution

$$W_{||}(s) = -\int_{-\infty}^{s} w_{||}(s-s')\lambda(s')ds'$$

wake (Green) function

Wake function model

$$w(s) = \underbrace{w^{(0)}(s) + \frac{1}{C}}_{\text{regular part}} + \underbrace{Rc\delta(s) - c\frac{\partial}{\partial s}\left[Lc\delta(s) + w^{(-1)}(s) \right]}_{\text{singular part}}$$

singular part
(cannot be tabulated directly)

$$Z(\omega) = Z^{(0)}(\omega) - \frac{1}{i\omega C} + R + i\omega\left[L + Z^{(-1)}(\omega) \right]$$

capacitive: $W \sim \int \lambda(s) ds$

resistive: $W \sim \lambda(s)$

inductive: $W \sim \lambda'(s)$

$$\frac{\partial}{\partial s} w^{(-1)}(s) = o(s^{-1}), \quad s \to 0.$$

it describes singularities $s^{-\alpha}$, $\alpha<1$

Wake potential for arbitrary bunch shape

$$W(s) = -\int_{-\infty}^{s} w^{(0)}(s-s')\lambda(s')ds' - \frac{1}{C}\int_{-\infty}^{s} \lambda(s')ds' - Rc\lambda(s) -$$

$$-c^2 L\lambda'(s) - c\int_{-\infty}^{s} w^{(-1)}(s-s')\lambda'(s)ds'$$

derivative of the bunch shape

We have N normalized charge distributions λ_i :

$$\int \lambda_i(s)ds = 1, i = 1,..., N$$

We can calculate the first two moments of the distributions:

$$\mu_i = \int s\lambda_i(s)ds, \qquad \sigma_i = \sqrt{\int (s-\mu_i)^2 \lambda_i(s)ds}$$

The wake potential of the distribution λ_i can be written in the normalized coordinate p as:

$$\hat{W}(p) = W_i(p\sigma_i + \mu_i).$$

The total wake potential and the averaged bunch shape can be defined as:

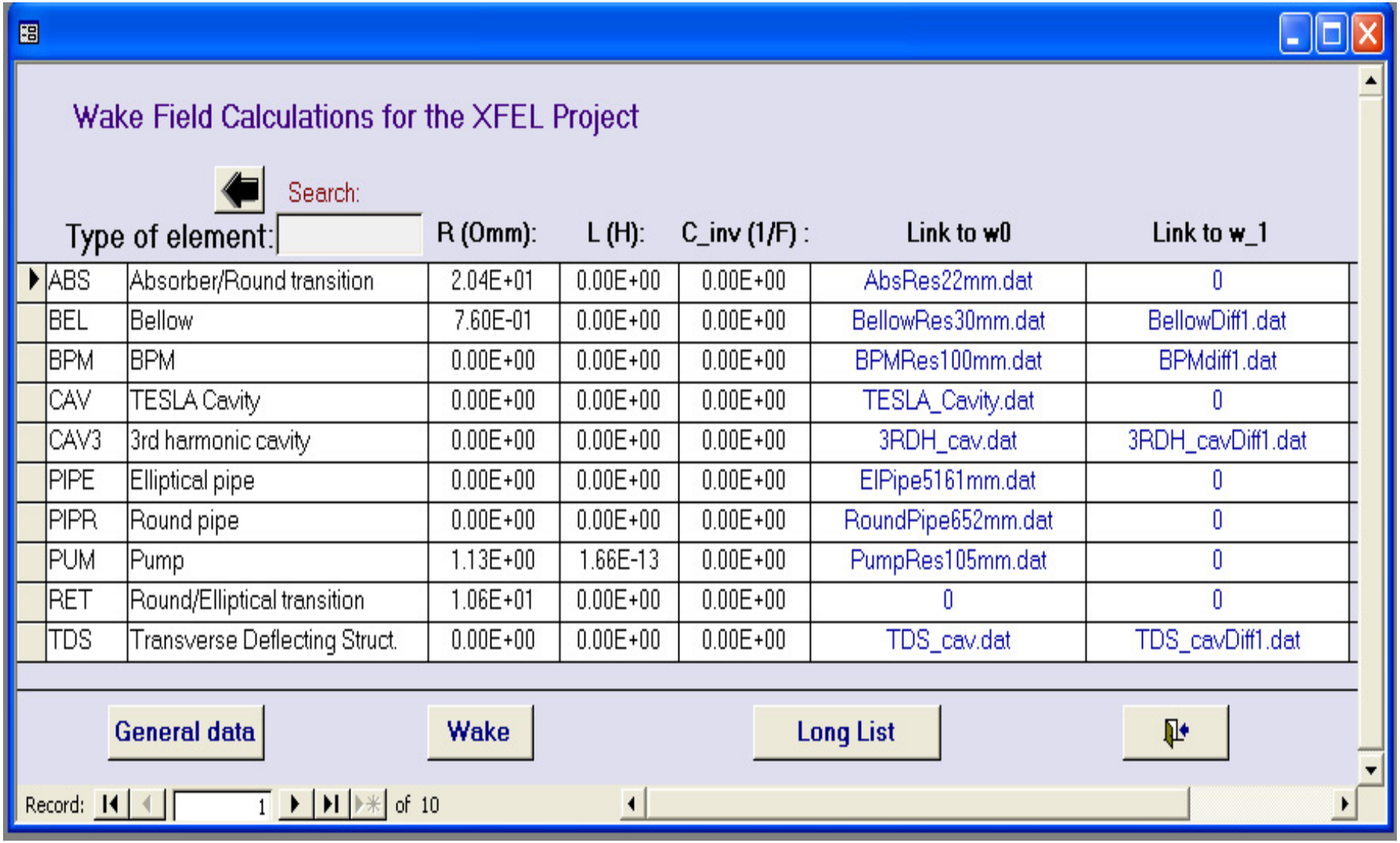
$$\hat{W}(p) = \sum_{i=1}^{N} \hat{W}_i(p) = \sum_{i=1}^{N} W_i(p\sigma_i + \mu_i). \qquad \hat{\lambda}(p) = \frac{1}{N}\sum_{i=1}^{N} \sigma_i \lambda_i(p\sigma_i + \mu_i).$$

Then the loss factor and energy spread can be defined as:

$$Loss = \int \hat{W}(p)\hat{\lambda}(p)dp$$

$$Spread = \sqrt{(\hat{W}(p) - Loss)^2 \hat{\lambda}(p)dp.}$$

The main form of data base application contains a list of element types, parameters R, L, C
and links to tables w0 and w_1.



Wake Field Calculations for the XFEL Project

Search:

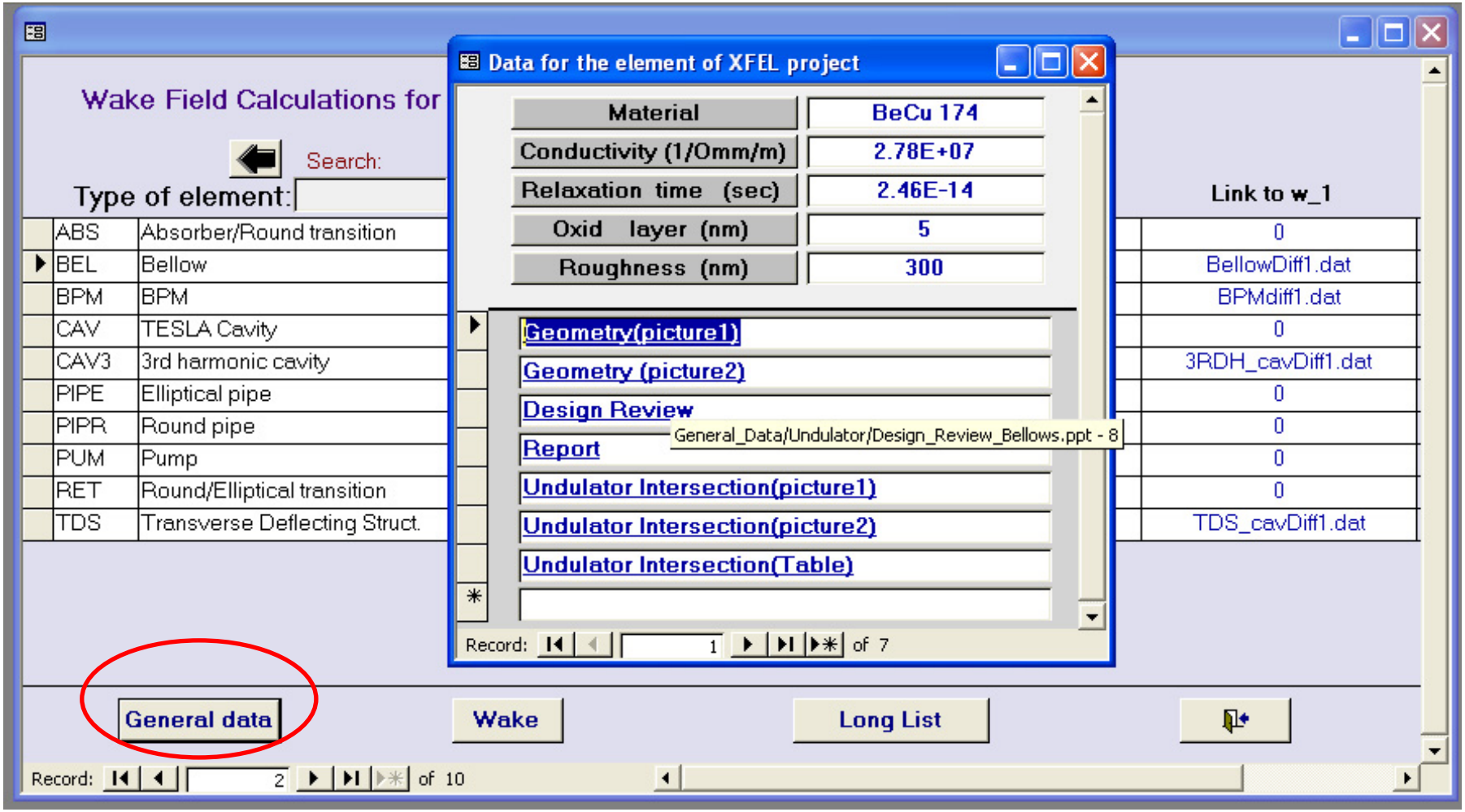
Type of element:

	Type of element:	R (Omm):	L (H):	C_inv (1/F) :	Link to w0	Link to w_1
ABS	Absorber/Round transition	2.04E+01	0.00E+00	0.00E+00	AbsRes22mm.dat	0
BEL	Bellow	7.60E-01	0.00E+00	0.00E+00	BellowRes30mm.dat	BellowDiff1.dat
BPM	BPM	0.00E+00	0.00E+00	0.00E+00	BPMRes100mm.dat	BPMdiff1.dat
CAV	TESLA Cavity	0.00E+00	0.00E+00	0.00E+00	TESLA_Cavity.dat	0
CAV3	3rd harmonic cavity	0.00E+00	0.00E+00	0.00E+00	3RDH_cav.dat	3RDH_cavDiff1.dat
PIPE	Elliptical pipe	0.00E+00	0.00E+00	0.00E+00	ElPipe5161mm.dat	0
PIPR	Round pipe	0.00E+00	0.00E+00	0.00E+00	RoundPipe652mm.dat	0
PUM	Pump	1.13E+00	1.66E-13	0.00E+00	PumpRes105mm.dat	0
RET	Round/Elliptical transition	1.06E+01	0.00E+00	0.00E+00	0	0
TDS	Transverse Deflecting Struct.	0.00E+00	0.00E+00	0.00E+00	TDS_cav.dat	TDS_cavDiff1.dat

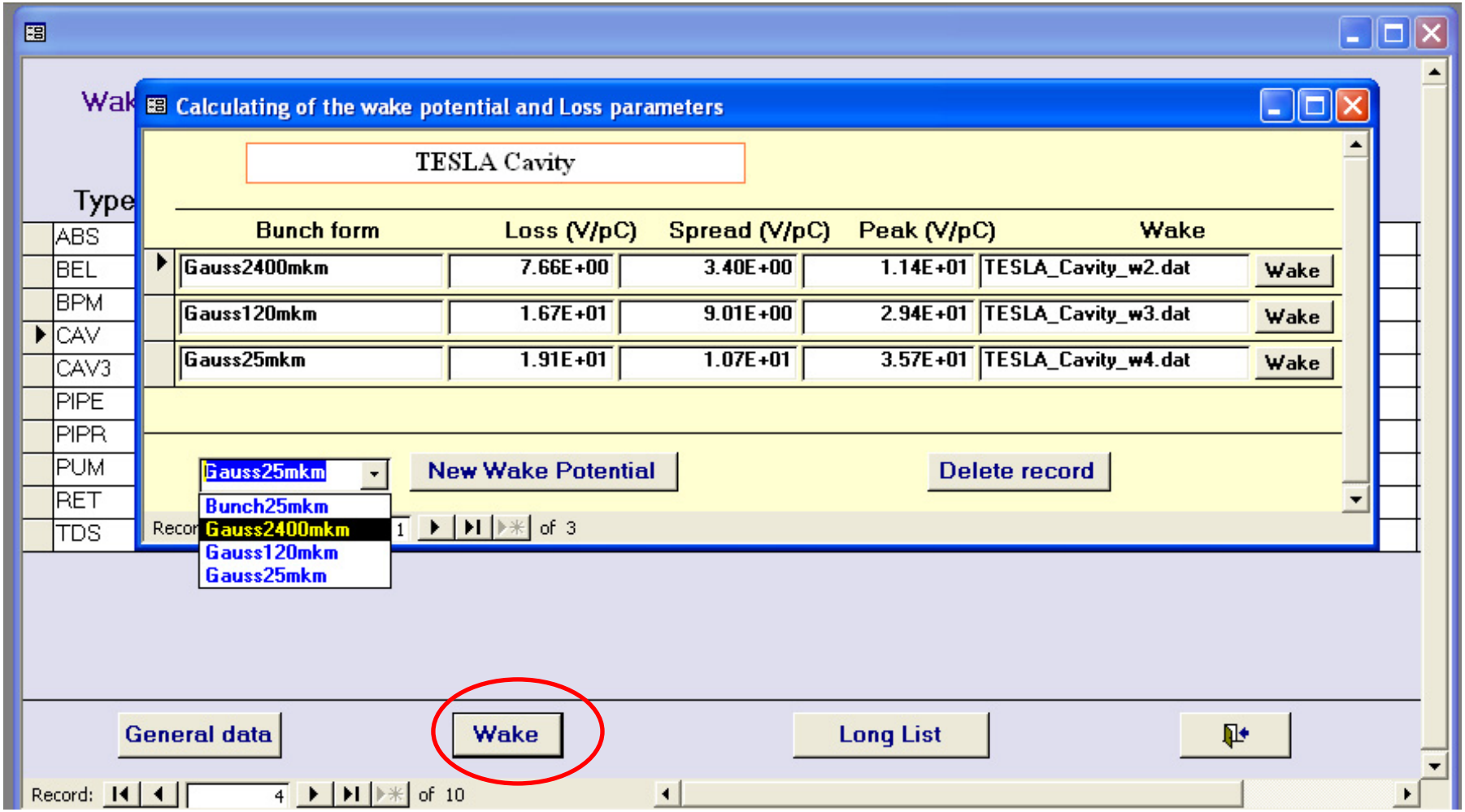
General data | Wake | Long List

Record: 1 of 10

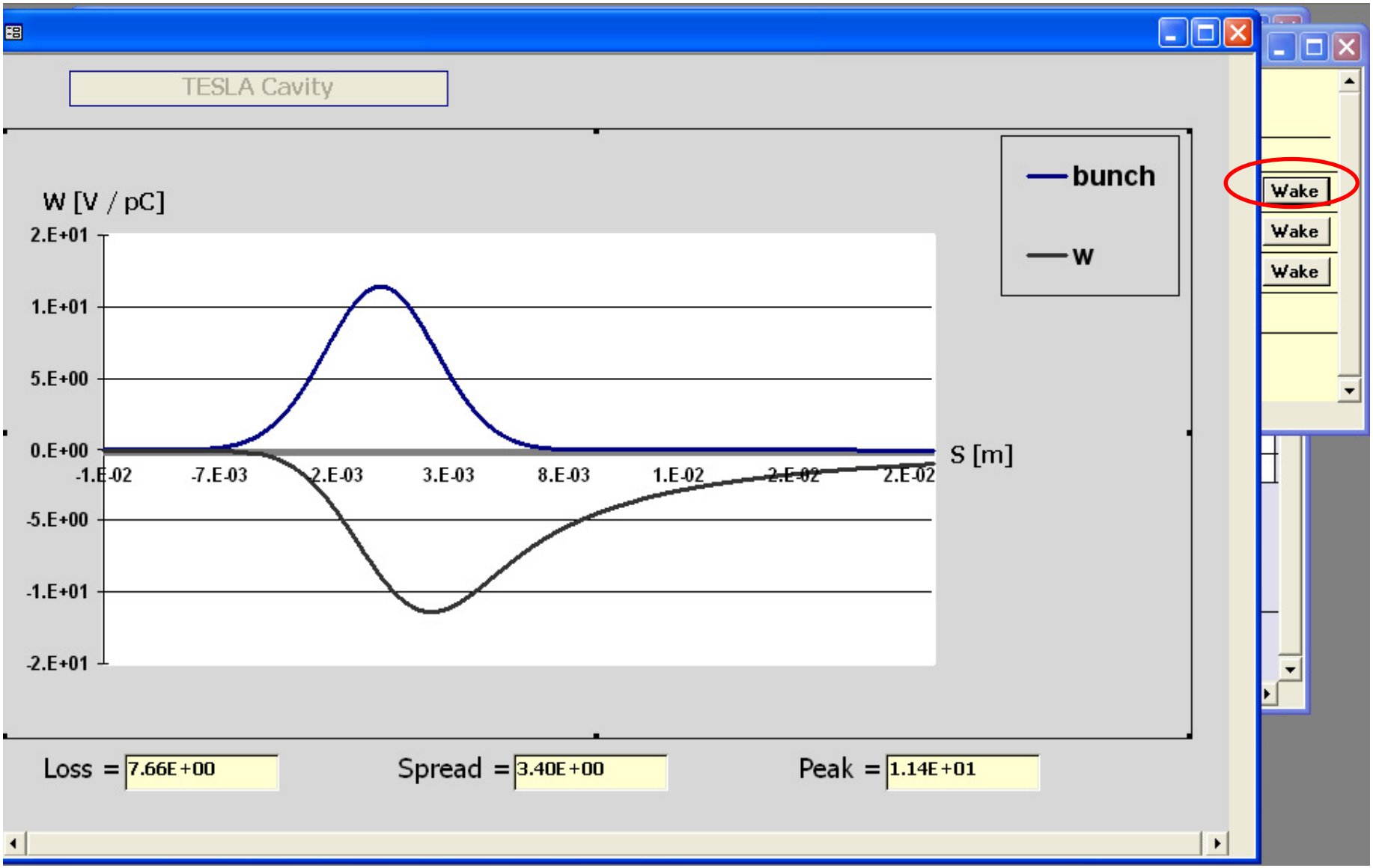
The click on button „General data” opens a description of the current element. This table can contain a reference to additional material: geometry description, input files for wake field calculations, reports.



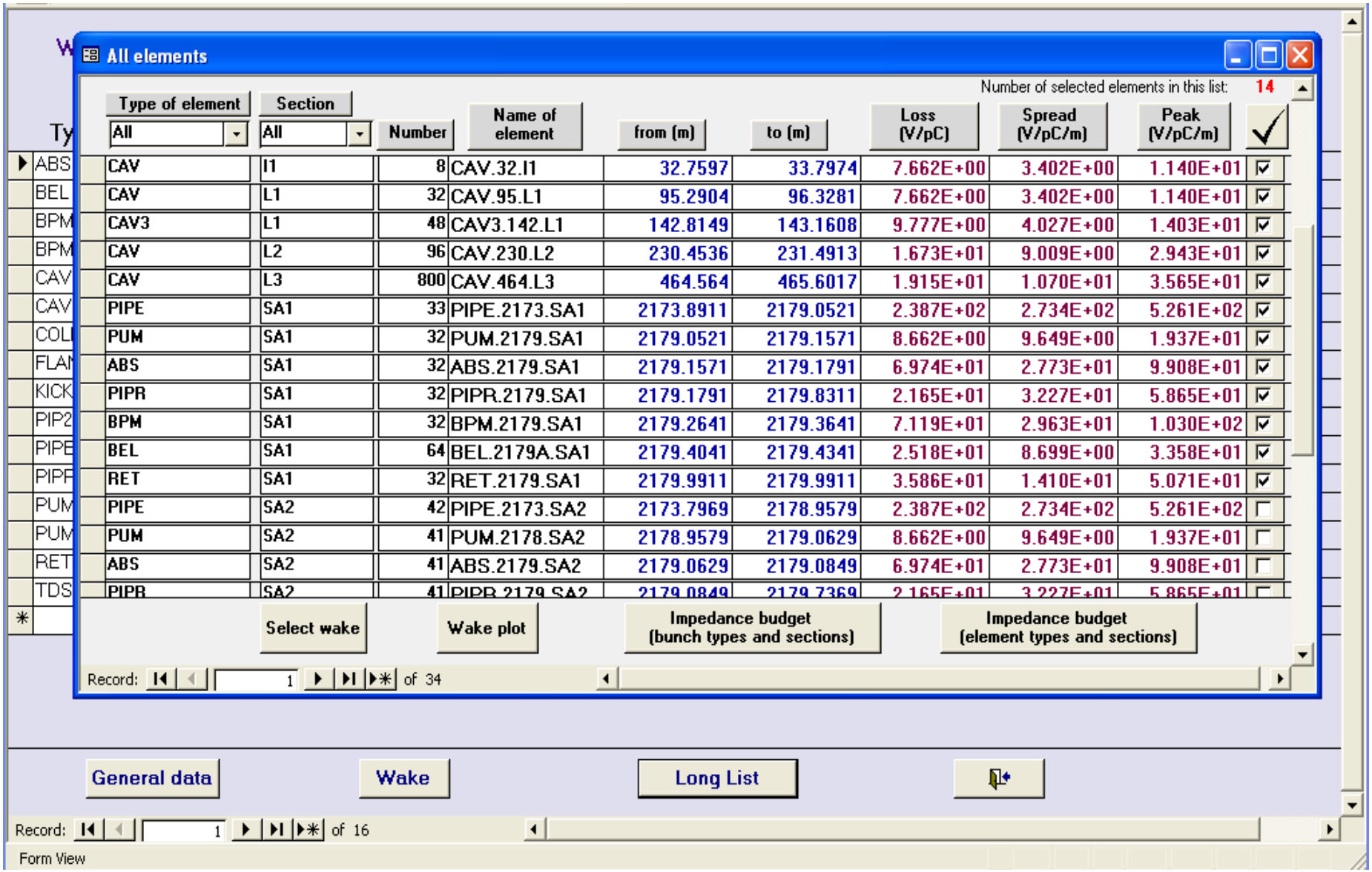
The same element types can appear several times along the beam line. Hence, we need to have all combinations of this element with different bunches.
The click on button „Wake” opens a form to assign a bunch to the current element and to calculate the wake potential for all possible combinations



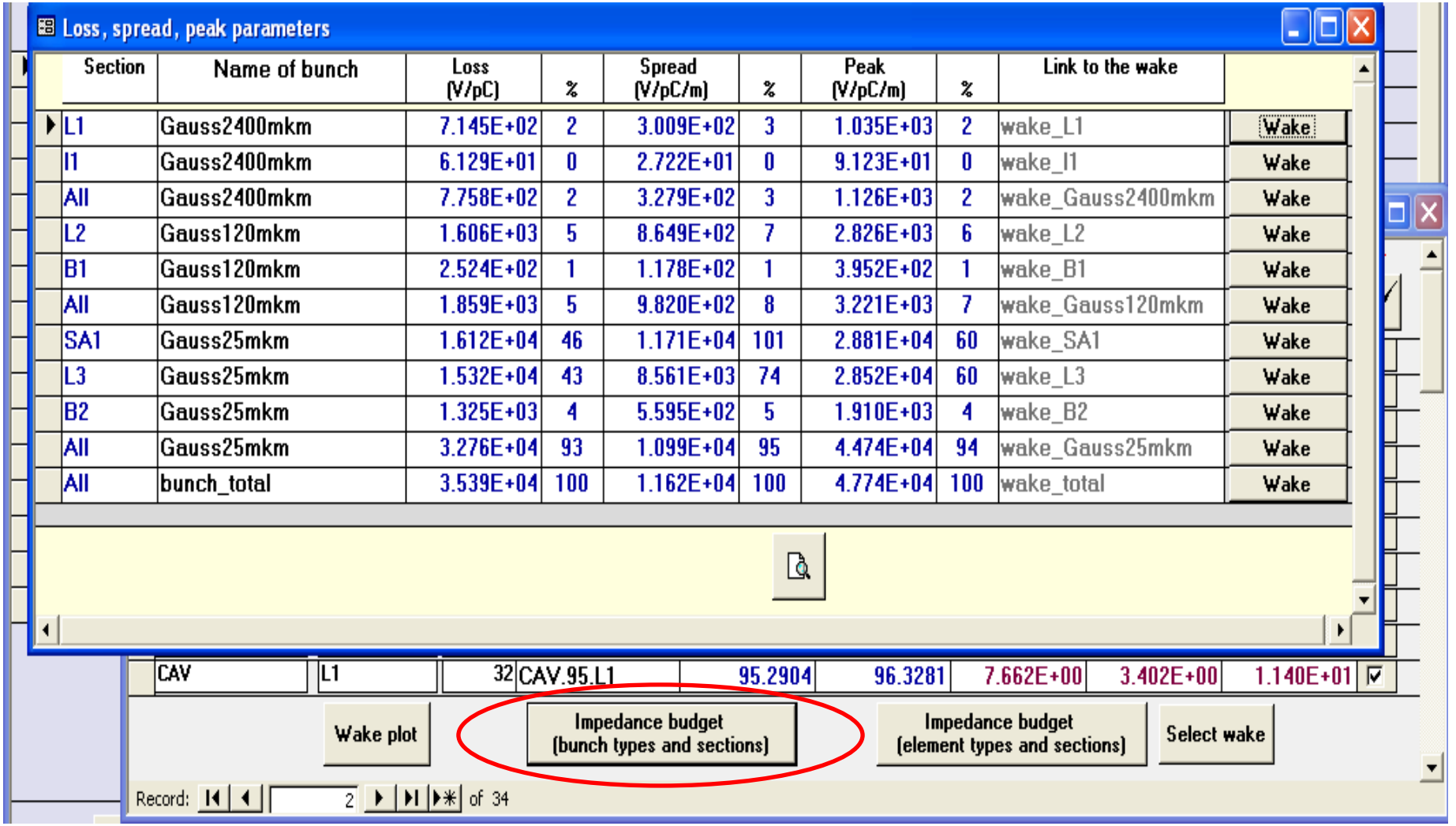
Plot with wake potential of the current element with selected bunch shape can be seen.



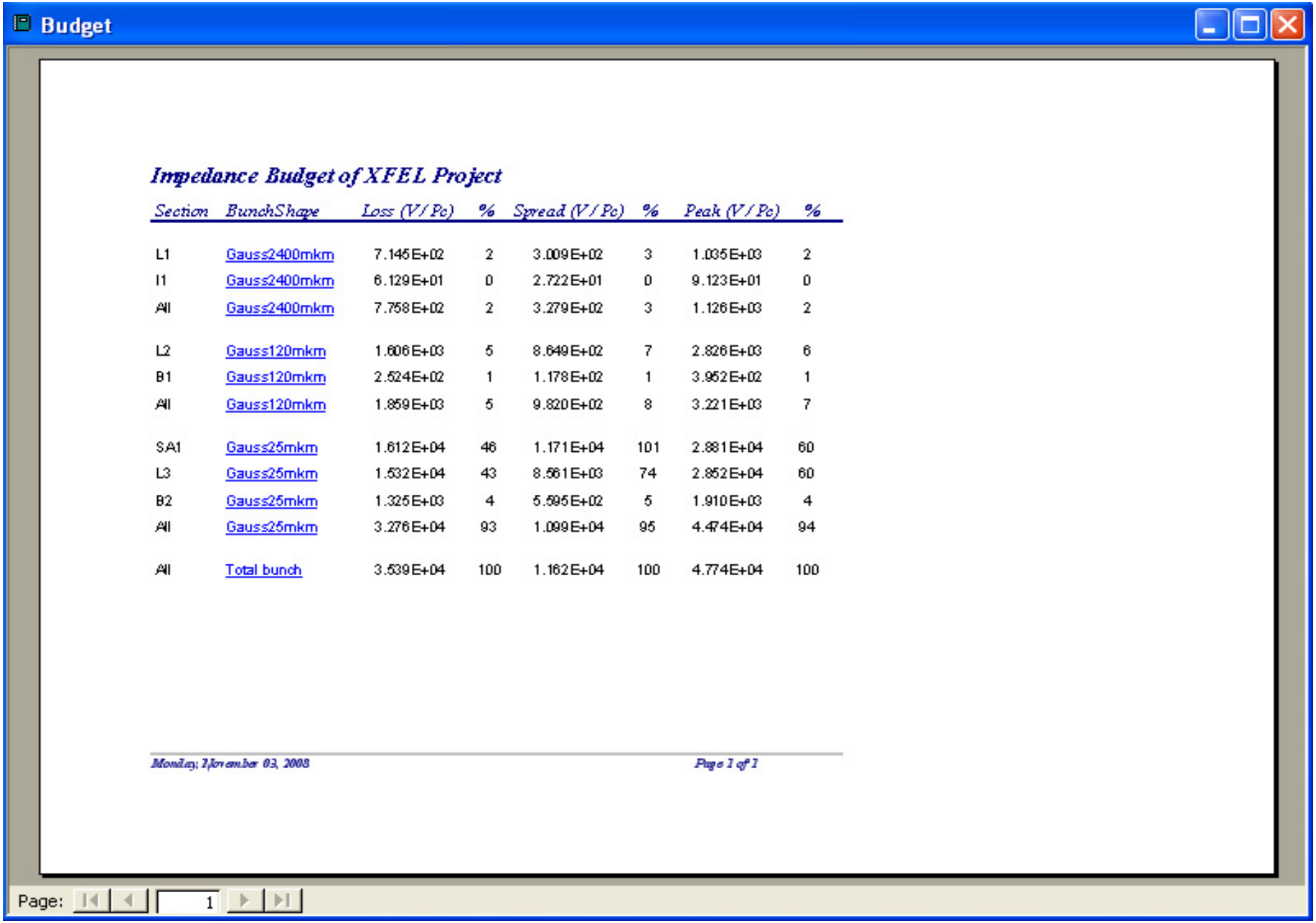
The next table shows a long list of unique elements and integrated wake field parameters for each of them.



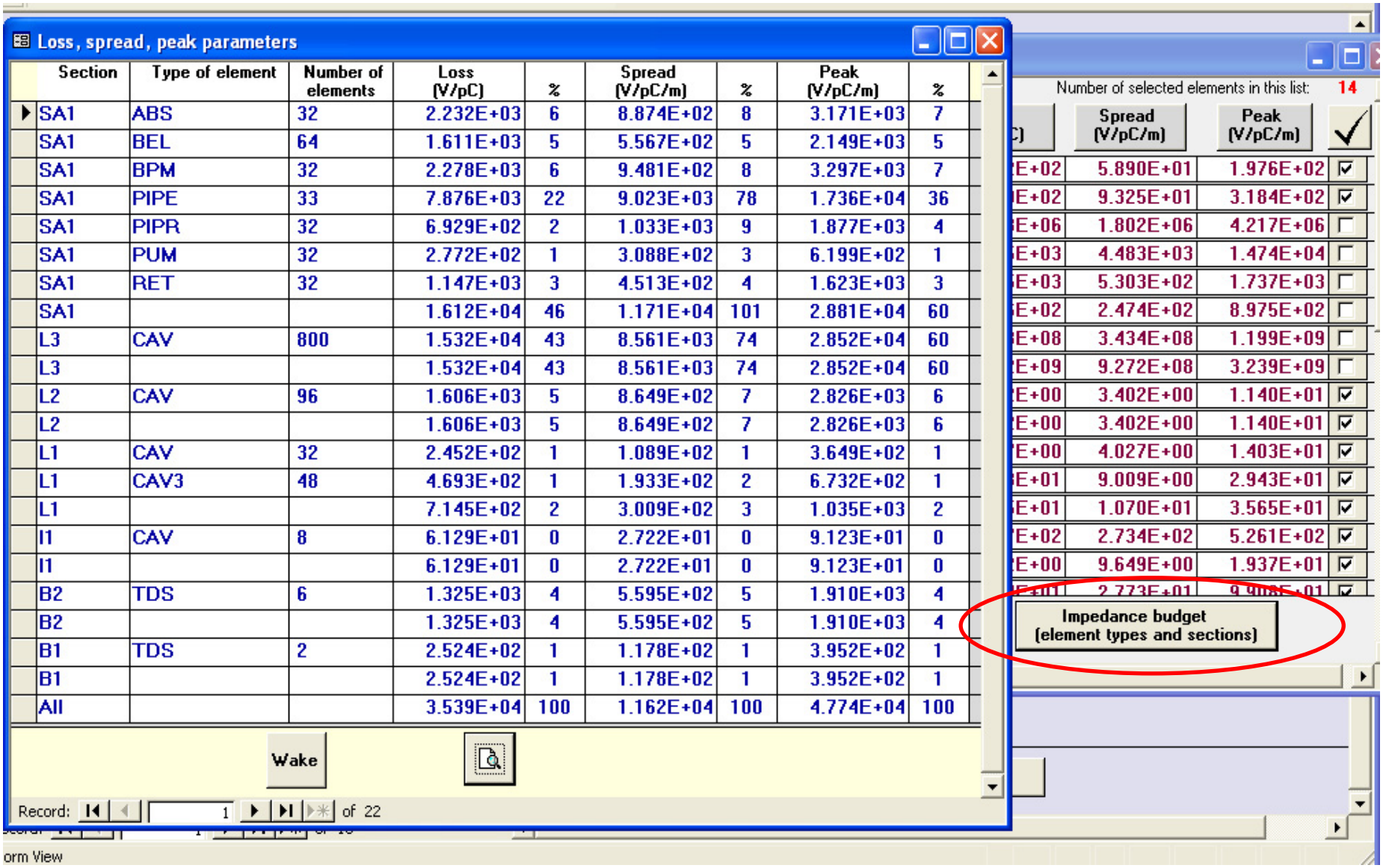
The click on button „Impedance Budget” opens a report with total impedance budget of the selected elements. This table presents the summary results for different sections and bunch shapes.



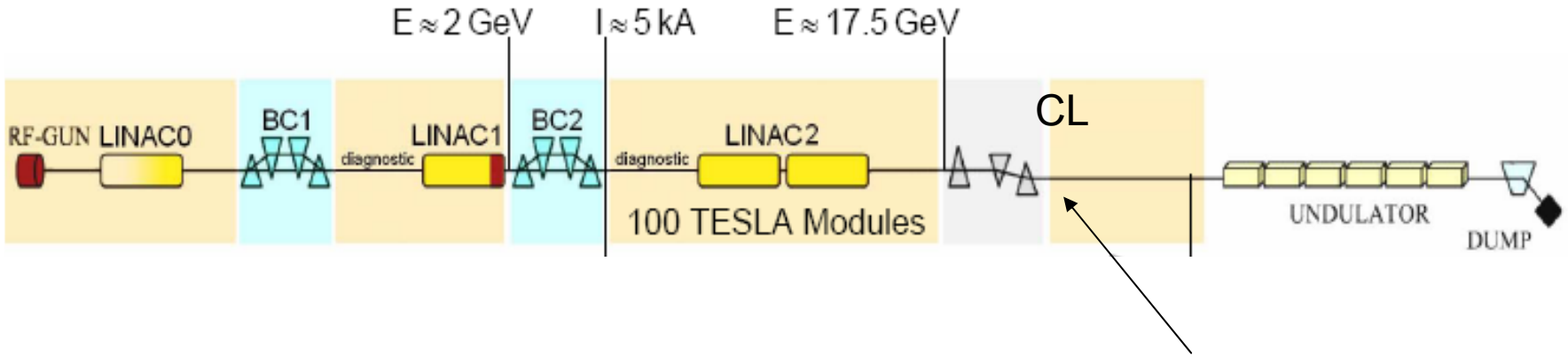
Print version of the summary results.



This table presents the summary results for different sections and types of elements.



European XFEL:



12 cavity BPMs
with step from R=20.25 mm
to R=5mm

Impedance budget

Section	El. type	Num.	Loss (V/pC)	%	Spread(V/Pc)	%	Peak(V/Pc)	%
L3								
	CAV	800	1.53E+04	34	8.56E+03	50	2.85E+04	46
			1.53E+04	34	8.56E+03	50	2.85E+04	46
L2								
	CAV	96	1.61E+03	4	8.65E+02	5	2.83E+03	5
			1.61E+03	4	8.65E+02	5	2.83E+03	5
L1								
	CAV	32	2.45E+02	1	1.09E+02	1	3.65E+02	1
CL								
	BPMCL	12	7.66E+03	17	2.97E+03	17	1.08E+04	17
			6.13E+01	0	2.72E+01	0	9.12E+01	0
CL								
	BPMCL	12	7.66E+03	17	2.97E+03	17	1.08E+04	17
	COLL	4	5.72E+03	13	2.77E+03	16	8.59E+03	14
	FLANG	500	1.42E+03	3	5.73E+02	3	2.00E+03	3
	KICK	4	4.94E+03	11	2.09E+03	12	7.15E+03	11
	PIP20	1	5.40E+03	12	3.95E+03	23	9.25E+03	15
	PUMCL	78	5.96E+02	1	2.41E+02	1	8.43E+02	1
			2.57E+04	57	1.17E+04	69	3.79E+04	61
B2								
	TDS	6	1.33E+03	3	5.60E+02	3	1.91E+03	3
			1.33E+03	3	5.60E+02	3	1.91E+03	3
B1								
	TDS	2	2.52E+02	1	1.18E+02	1	3.95E+02	1
			2.52E+02	1	1.18E+02	1	3.95E+02	1
All								
			4.50E+04	100	1.70E+04	100	6.25E+04	100

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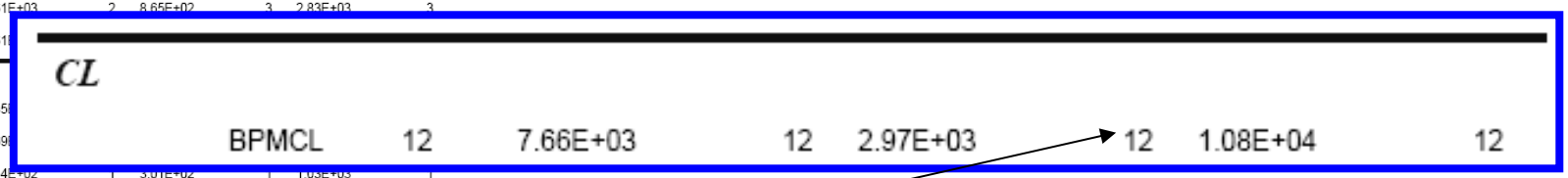
Impedance budget without undulator sections

12 cavity BPMs
with step from R=20.25 mm
to R=5mm produce 17 %
of the energy spread
in impedance budget
from injector to undulator

Impedance budget

Section	El. type	Num.	Loss (V/pC)	%	Spread(V/Pc)	%	Peak(V/Pc)	%
SA2								
	ABS	41	2.86E+03	4	1.14E+03	5	4.06E+03	4
	BEL	82	2.06E+03	3	7.13E+02	3	2.75E+03	3
	BPM	41	2.92E+03	4	1.21E+03	5	4.22E+03	5
	PIPE	42	1.00E+04	15	1.15E+04	46	2.21E+04	24
	PIPR	41	8.88E+02	1	1.32E+03	5	2.40E+03	3
	PUM	41	3.55E+02	1	3.96E+02	2	7.94E+02	1
	RET	41	1.47E+03	2	5.78E+02	2	2.08E+03	2
			2.06E+04	31	1.49E+04	59	3.68E+04	40
L3								
	CAV	800	1.53E+04	23	8.56E+03	34	2.85E+04	31
			1.53E+04	23	8.56E+03	34	2.85E+04	31
L2								
	CAV	96	1.61E+03	2	8.65E+02	3	2.83E+03	3
			1.61E+03	2	8.65E+02	3	2.83E+03	3
L1								
	CAV	32	2.45E+02	0	1.31E+02	0	4.30E+02	0
	CAV3	48	4.69E+02	1	3.01E+02	1	1.03E+03	1
			7.14E+02	1	3.01E+02	1	1.03E+03	1
I1								
	CAV	8	6.13E+01	0	2.72E+01	0	9.12E+01	0
			6.13E+01	0	2.72E+01	0	9.12E+01	0
CL								
	BPMCL	12	7.66E+03	12	2.97E+03	12	1.08E+04	12
	COLL	4	5.72E+03	9	2.77E+03	11	8.59E+03	9
	FLANG	500	1.42E+03	2	5.73E+02	2	2.00E+03	2
	KICK	4	4.94E+03	8	2.09E+03	8	7.15E+03	8
	PIP20	1	5.40E+03	8	3.95E+03	16	9.25E+03	10
	PUMCL	78	5.96E+02	1	2.41E+02	1	8.43E+02	1
			2.57E+04	39	1.17E+04	47	3.79E+04	41
B2								
	TDS	6	1.33E+03	2	5.60E+02	2	1.91E+03	2
			1.33E+03	2	5.60E+02	2	1.91E+03	2
B1								
	TDS	2	2.52E+02	0	1.18E+02	0	3.95E+02	0
			2.52E+02	0	1.18E+02	0	3.95E+02	0
All								
			6.56E+04	100	2.51E+04	100	9.28E+04	100



Impedance budget with SASE 2 included

12 cavity BPMs
with step from R=20.25 mm
to R=5mm produce 12 %
of the energy spread
in impedance budget
from injector to undulator