# SPLinac

## simulation of Realistic sc. Linac RF Systems with Beam

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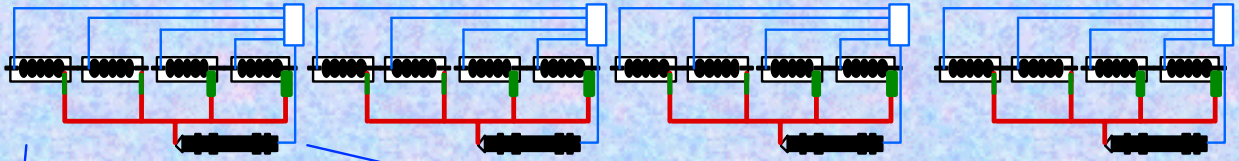
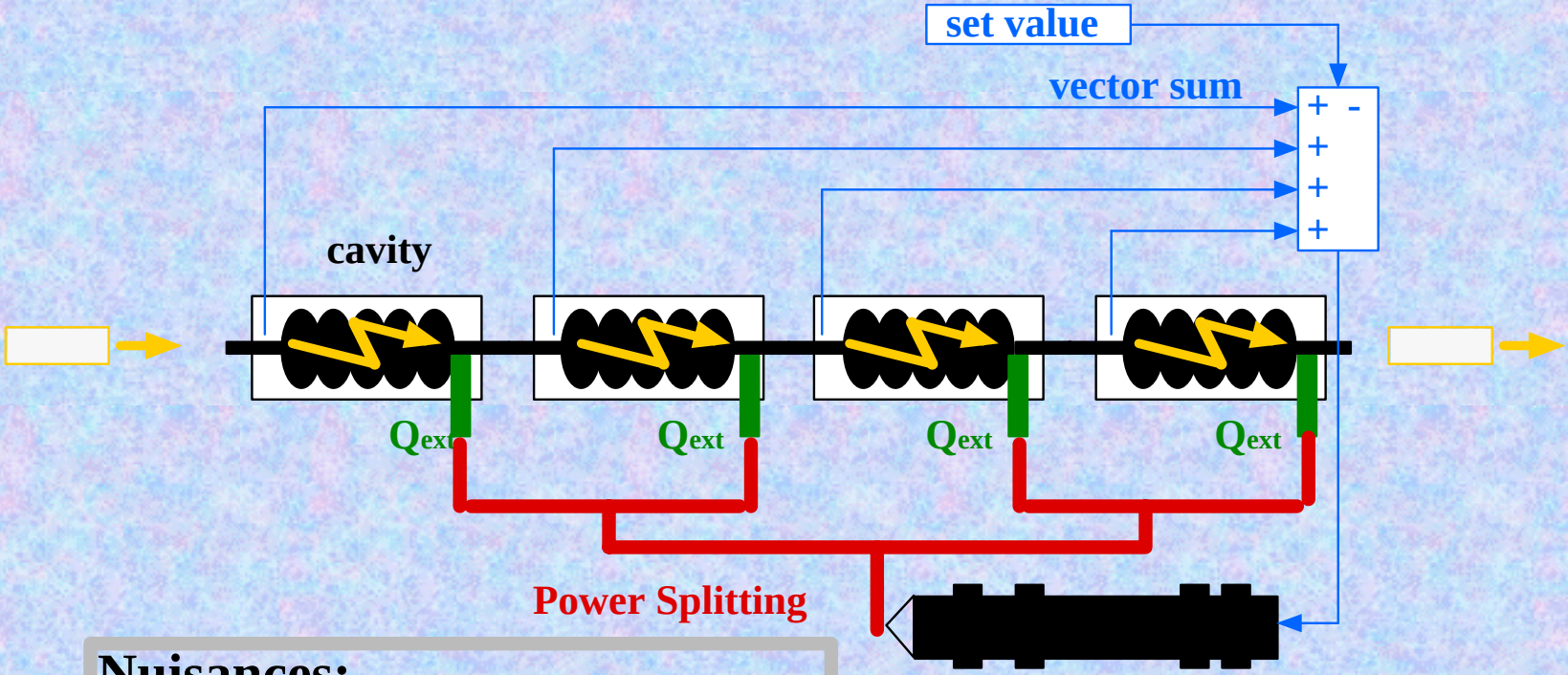
# Split up the 'problem':

**Linac made of different sections**

**Section made of equivalent 'families'**



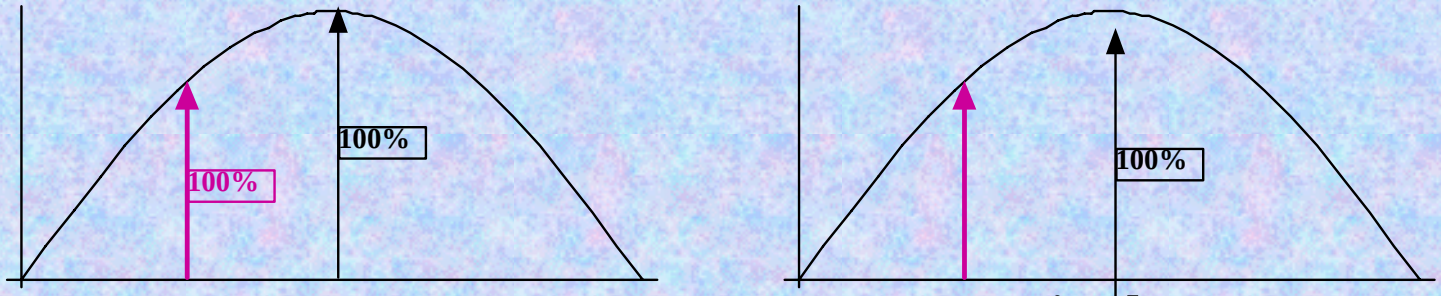
# Family: One transmitter supplies several (or 1) cavities cavity voltage vector sum controls transmitter




## Nuisances:

- Lorentz detuning
- externally driven cavity vibrations
- errors in vector sum
- errors in power splitting
- scatter in $Q_{ext}$
- beamloading

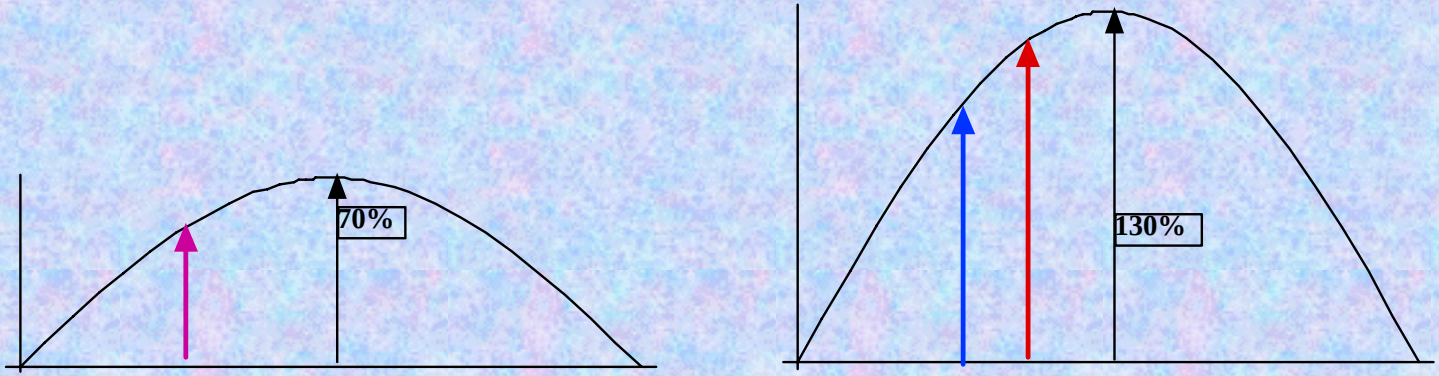
## 2 cavities: 100%+100% excitation: perfect situation




**At cavity 1 all particles see nominal voltage: nominal speed**

**At cavity 2: nominal phase angle for β=1 and β<1: 100% + 100%= 200%**

## 2 cavities: 70%+130% excitation: same (vector) sum: looks OK




**At cavity 1 all particles see lower voltage: β<1 lower speed, β=1 same speed**

**at cavity 2: nominal phase angle for β=1 : 70% + 130 % -> 200 %**

**at cavity 2: larger phase angle for β<1 : 70% + 150 % -> 220%**

# SPLinac:
# The main panel

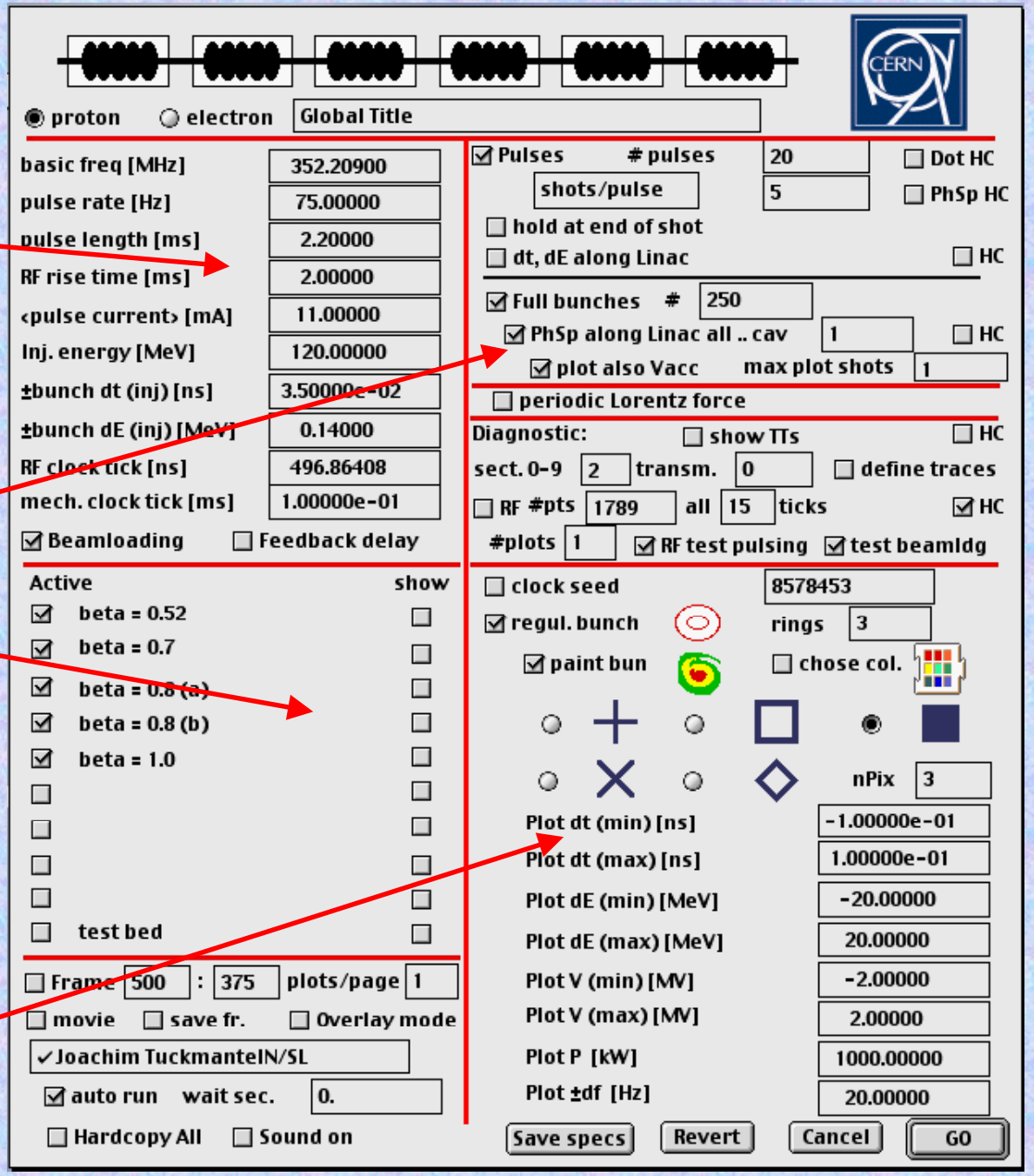
**Global specs:**

($f_0$, $T_{pulse}$, $\langle I_b \rangle$,... )

**What to do:**

**Active sections:**

**Plot scalings**



# RF section panel

modules in section

Cavites / module

Mechanical positioning

Cavity specs:

$f_0$, (R/Q), $Q_{ext}$, $\Delta f$, $V_{acc}$, $\phi_0$, ...

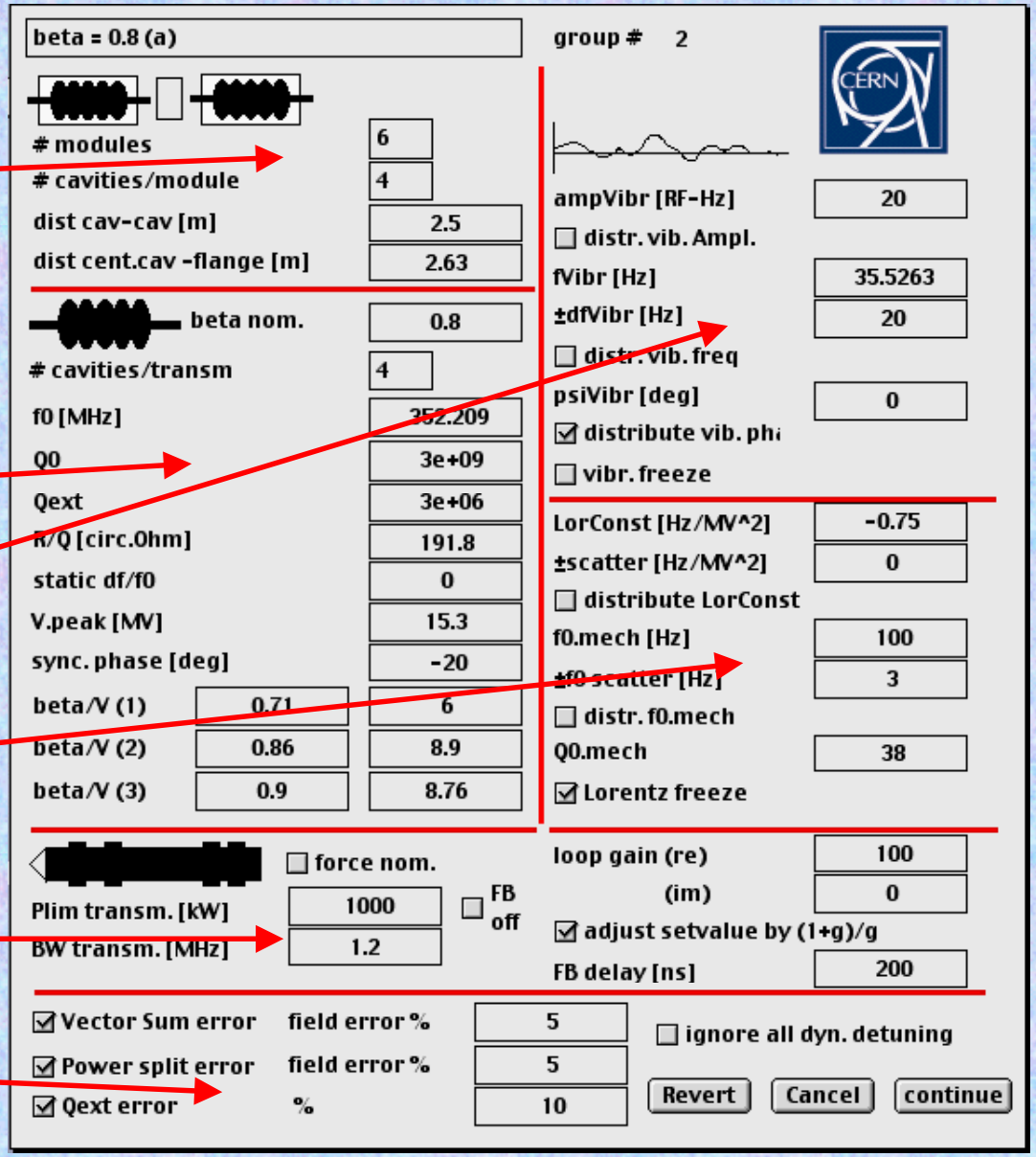
Cavity external vibr.

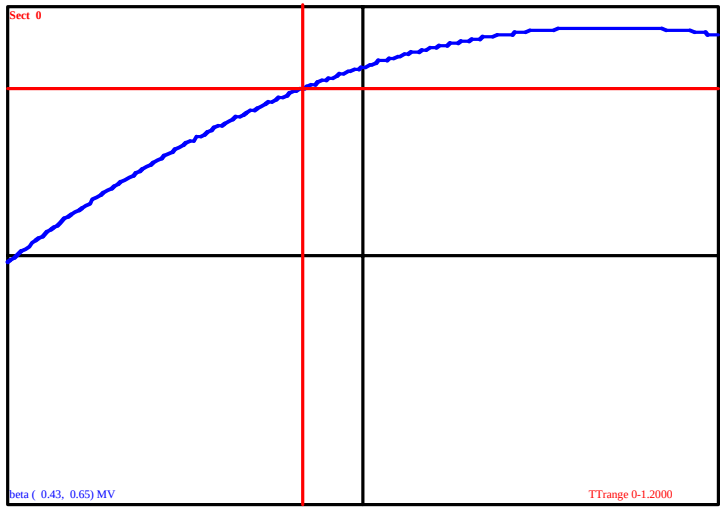
Lorentz detuning data

Transmitter data

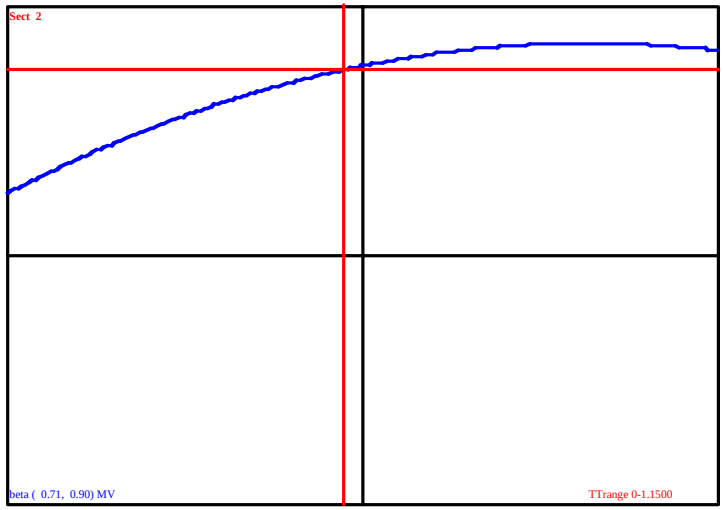
Vector loop data

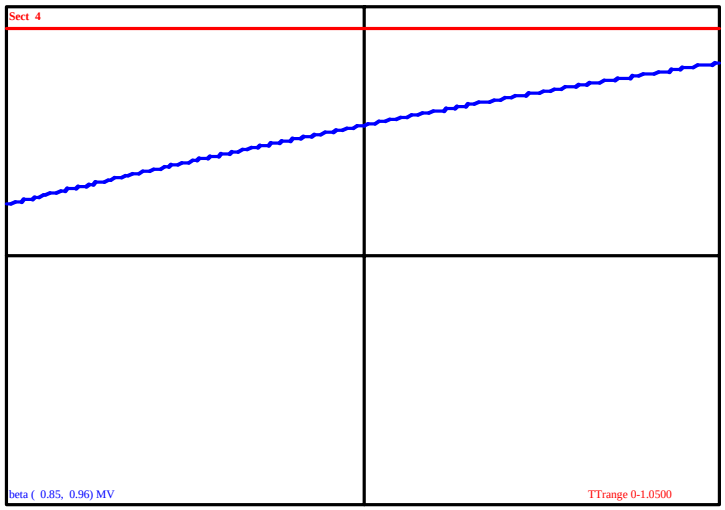
RF system error data

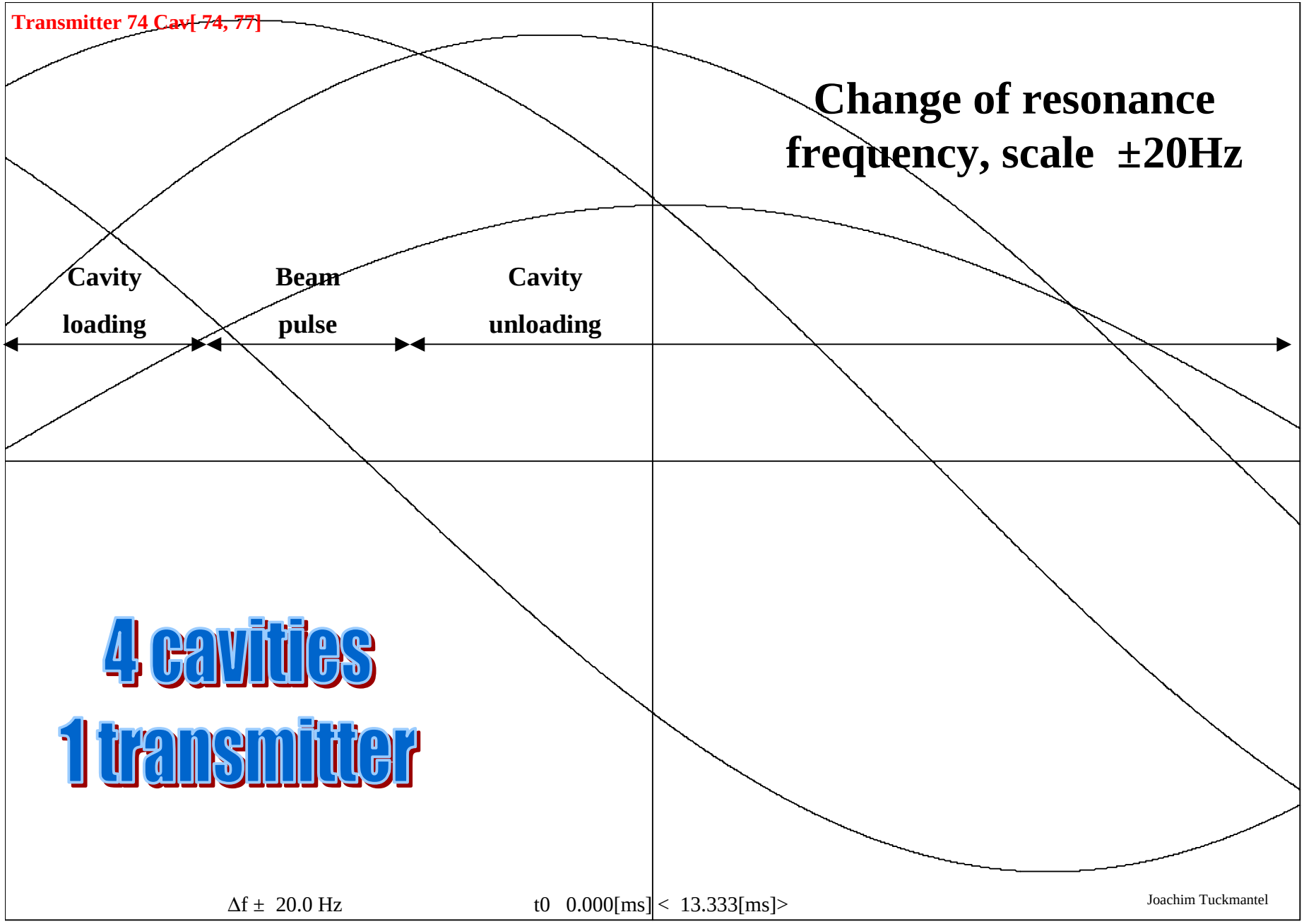


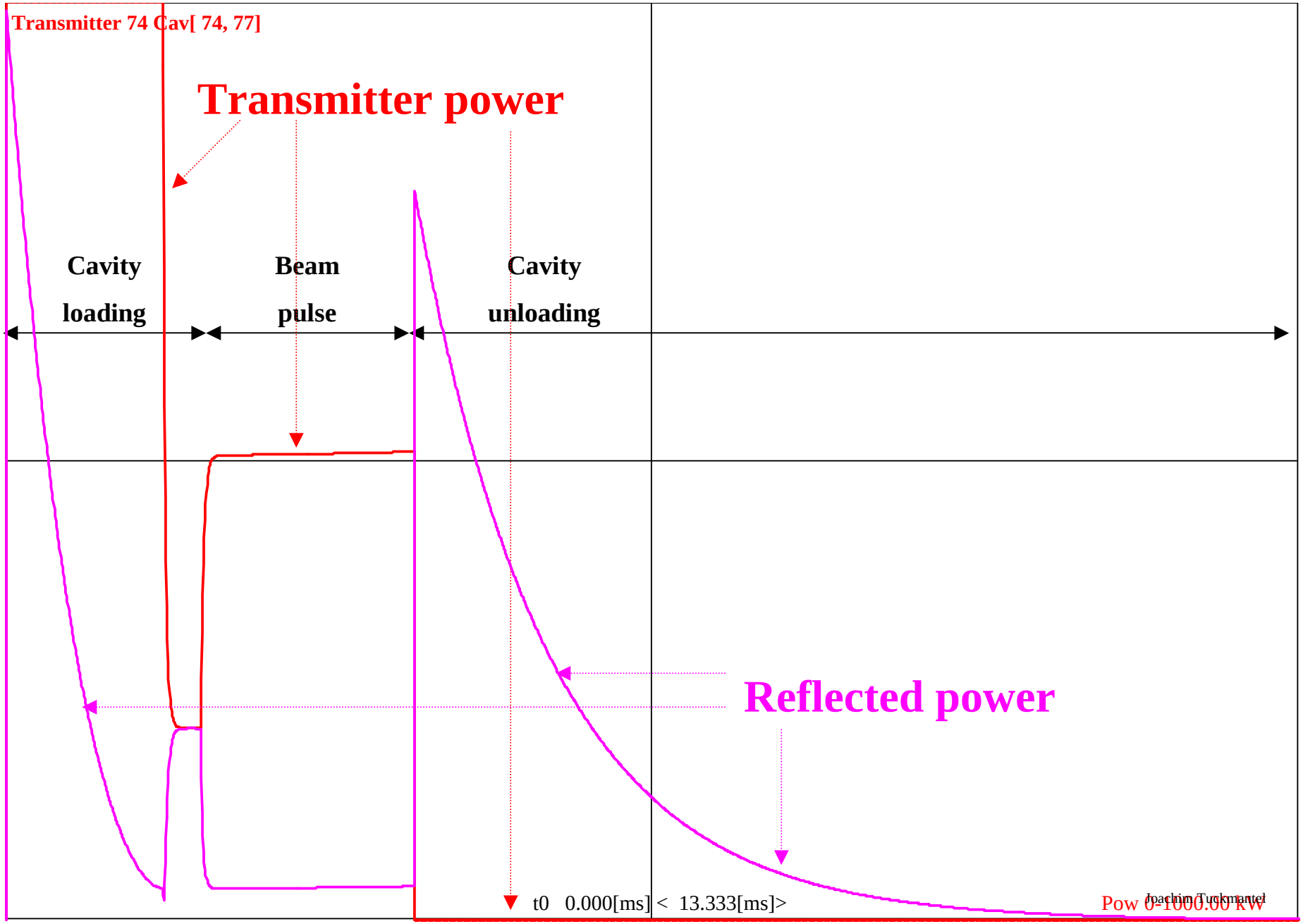

Sect 0
beta ( 0.43, 0.65) MV
TTrange 0-1.2000


Sect 1
beta ( 0.60, 0.80) MV
TTrange 0-1.2000


Sect 2
beta ( 0.71, 0.90) MV
TTrange 0-1.1500


Sect 4
beta ( 0.85, 0.96) MV
TTrange 0-1.0500

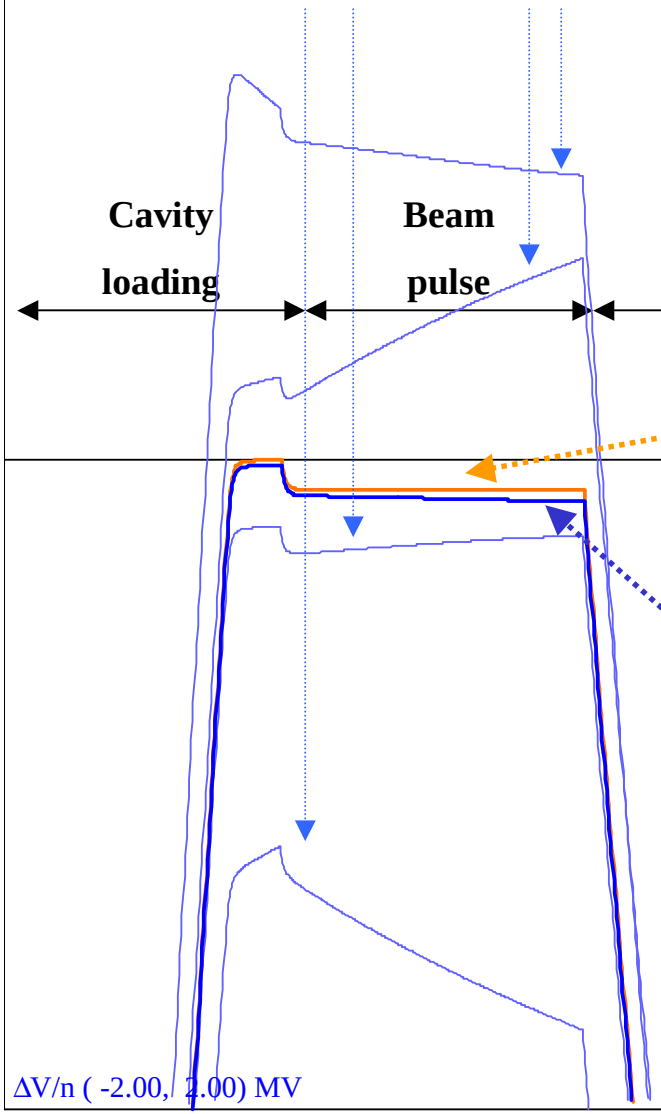

Transmitter 74 Cav[ 74, 77]
Change of resonance frequency, scale ±20Hz
Cavity loading
Beam pulse
Cavity unloading
4 cavities
1 transmitter
Δf ± 20.0 Hz
t0 0.000[ms] < 13.333[ms]>
Joachim Tuckmantel


Transmitter 74 Cav[ 74, 77]
Transmitter power
Cavity loading
Beam pulse
Cavity unloading
Reflected power
t0 0.000[ms] < 13.333[ms]>
Pow 0-1000.00 kW
Joachim Tuckmantel

Transmitter 74 Cav[ 74, 77]

# Real part of voltages

## True individual cavity voltages




**Measured sum voltage**

**as seen by the feedback system**

**including vector sum errors**

**True sum voltage**

**As seen by the nominal particle**

**Zero suppressed**

**Scale 13.3-17.3 MV**

ΔV/n ( -2.00, 2.00) MV

t0 0.000[ms] < 13.333[ms]>

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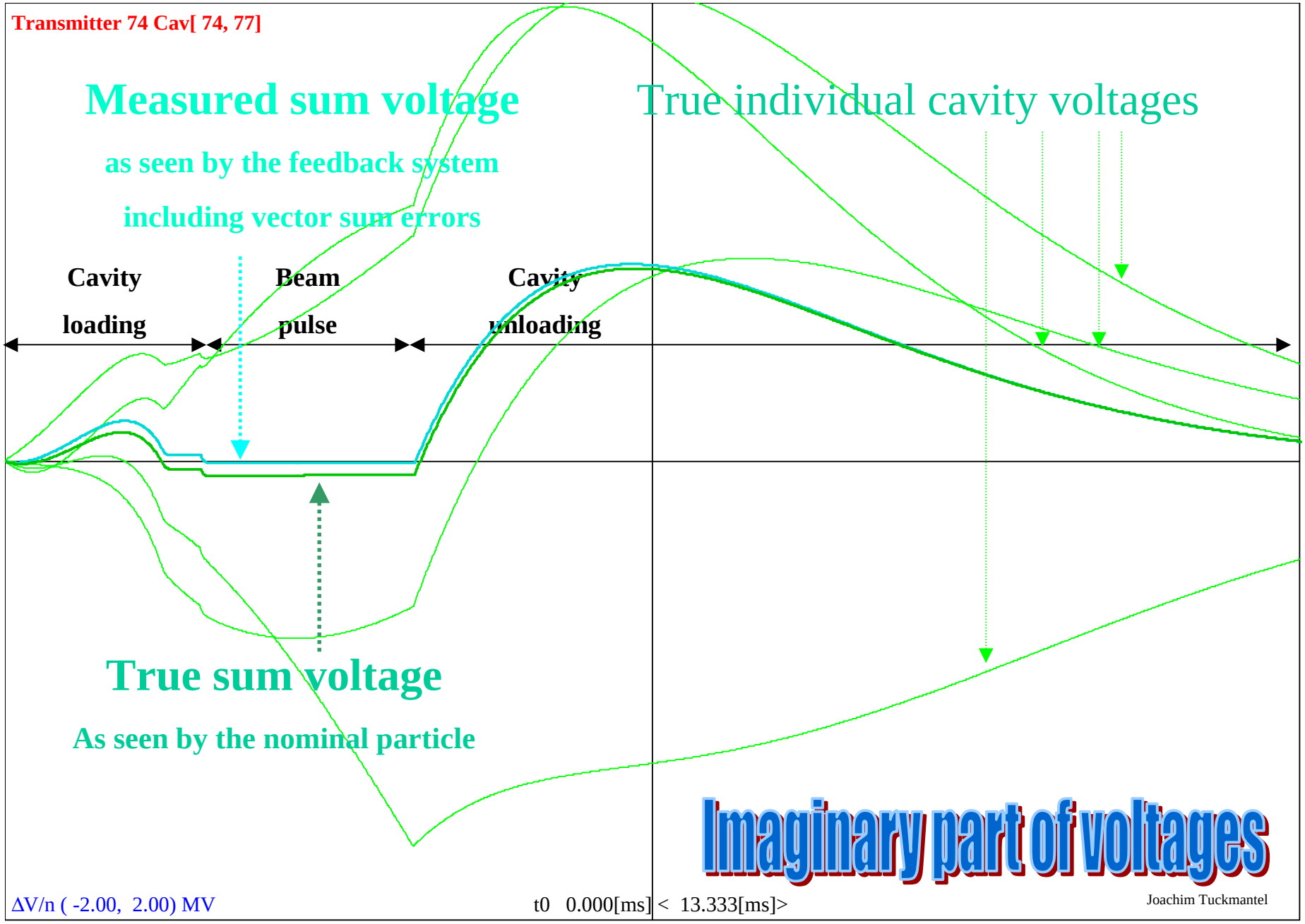
Transmitter 74 Cav[ 74, 77]
Measured sum voltage
as seen by the feedback system
including vector sum errors
True individual cavity voltages
Cavity
loading
Beam
pulse
Cavity
unloading
True sum voltage
As seen by the nominal particle
Imaginary part of voltages
ΔV/n ( -2.00, 2.00) MV
t0 0.000[ms] < 13.333[ms]>
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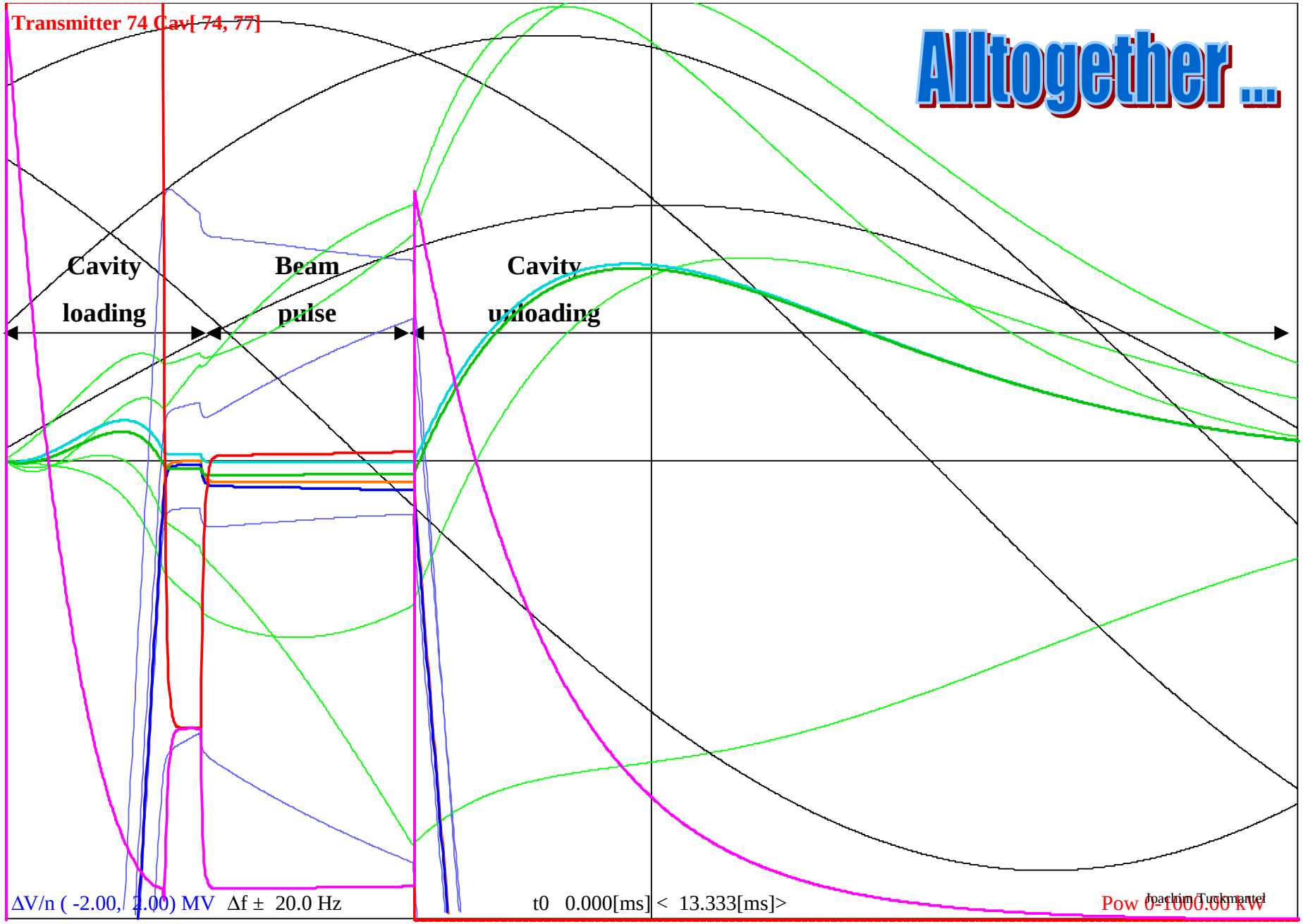
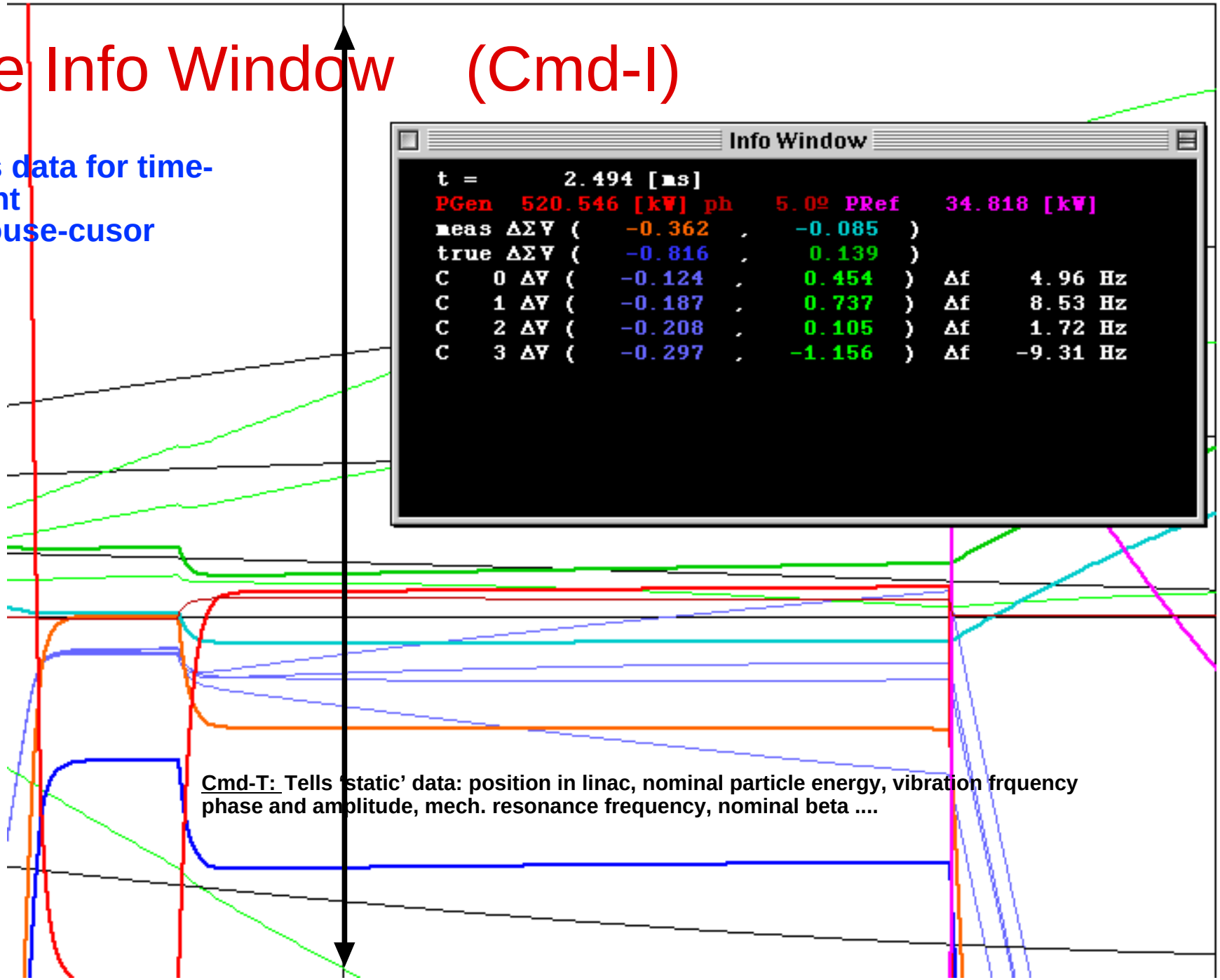

Transmitter 74 Cav[ 74, 77]
Alltogether ...
Cavity
loading
Beam
pulse
Cavity
unloading
ΔV/n ( -2.00, 2.00) MV Δf ± 20.0 Hz
t0 0.000[ms] < 13.333[ms]>
Pow 0-1000.00 kW
Joachim Tuckmantel

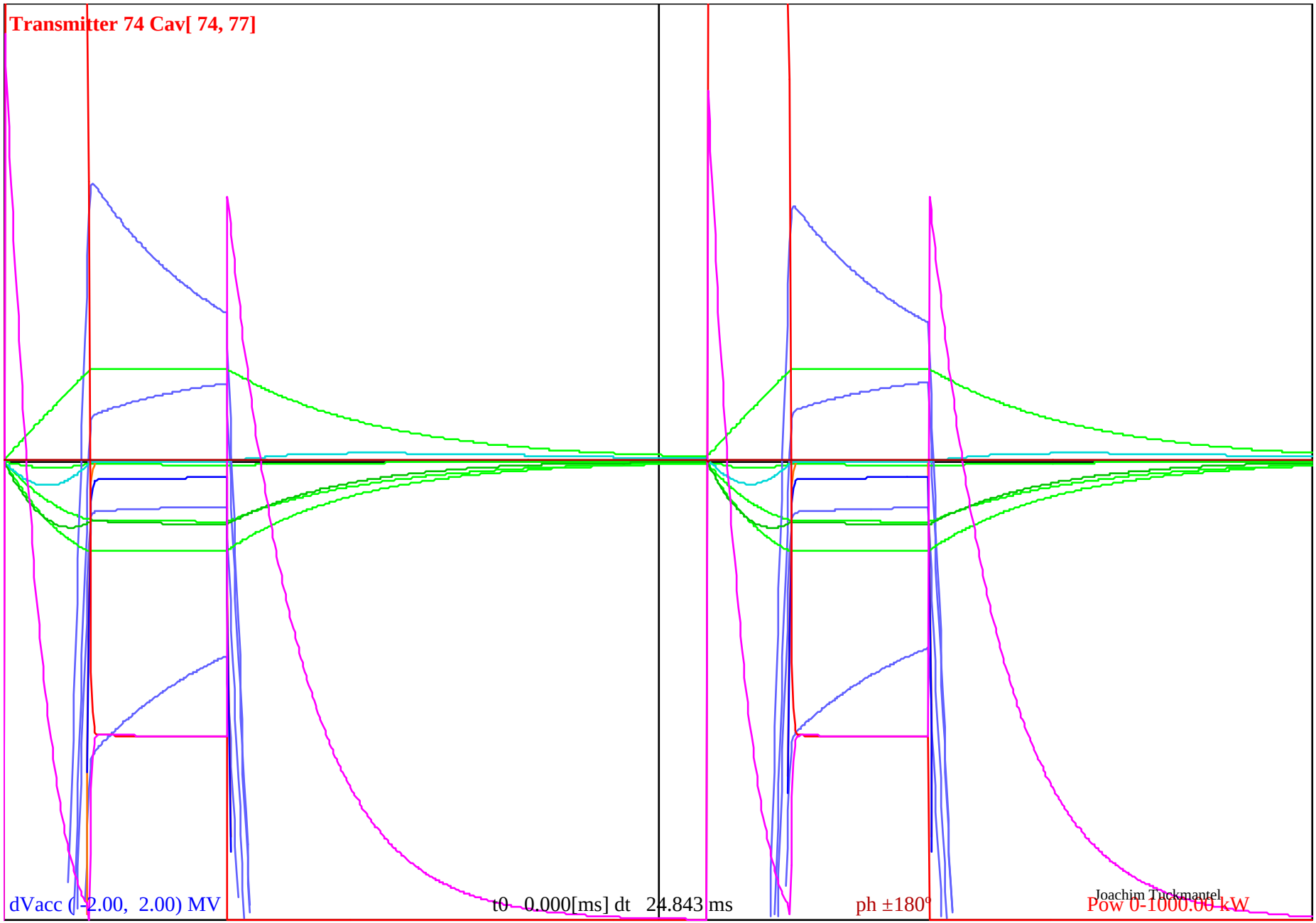
# The Info Window (Cmd-I)

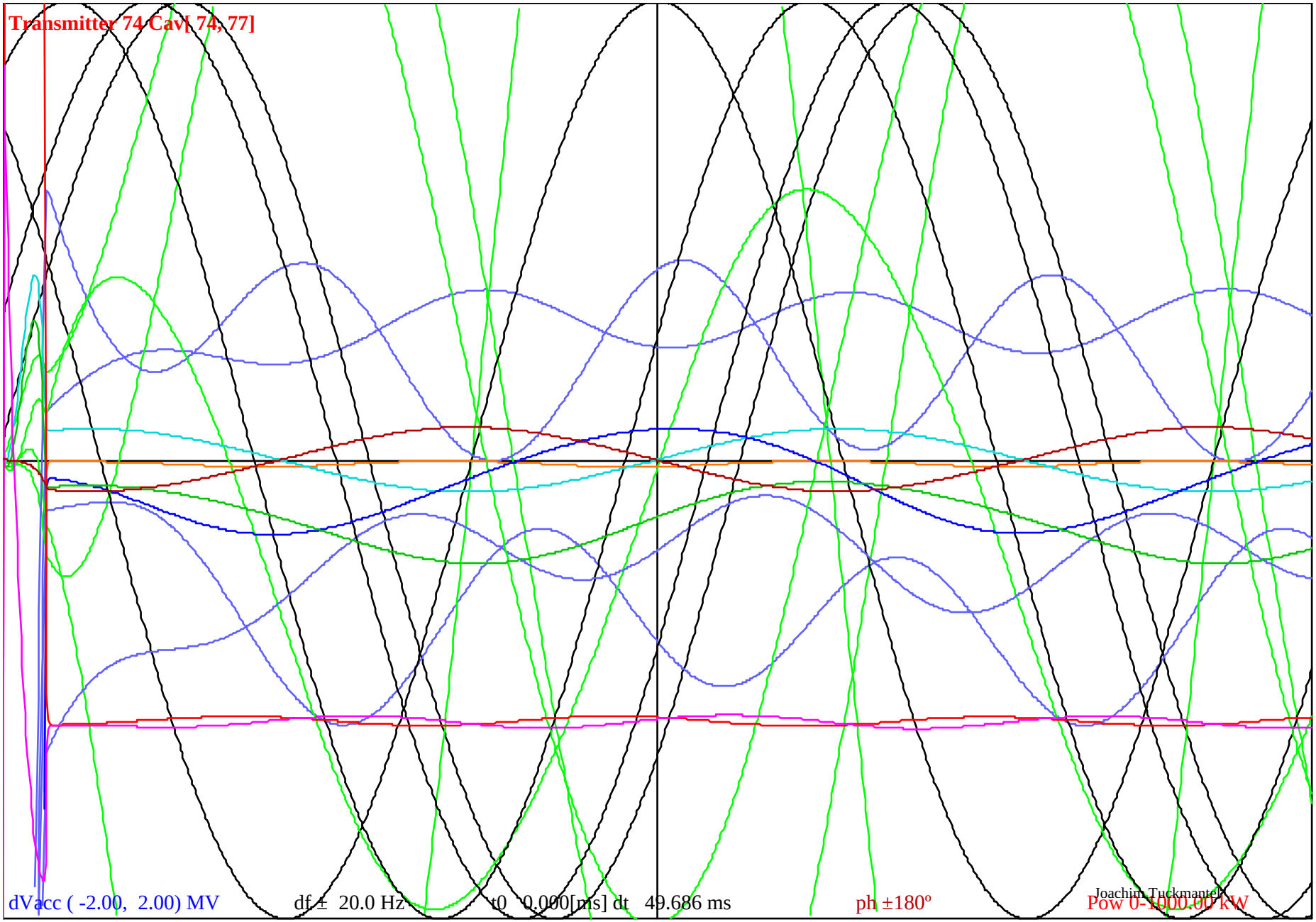
**Gives data for time-instant of mouse-cusor**




**Cmd-T:** Tells 'static' data: position in linac, nominal particle energy, vibration frquency phase and amplitude, mech. resonance frequency, nominal beta ....

# ‘Long term’ pulsing and .... (no vibrations)




Transmitter 74 Cav[ 74, 77]
dVacc ( -2.00, 2.00) MV
df ± 20.0 Hz
t0 0.000[ms] dt 49.686 ms
ph ±180º
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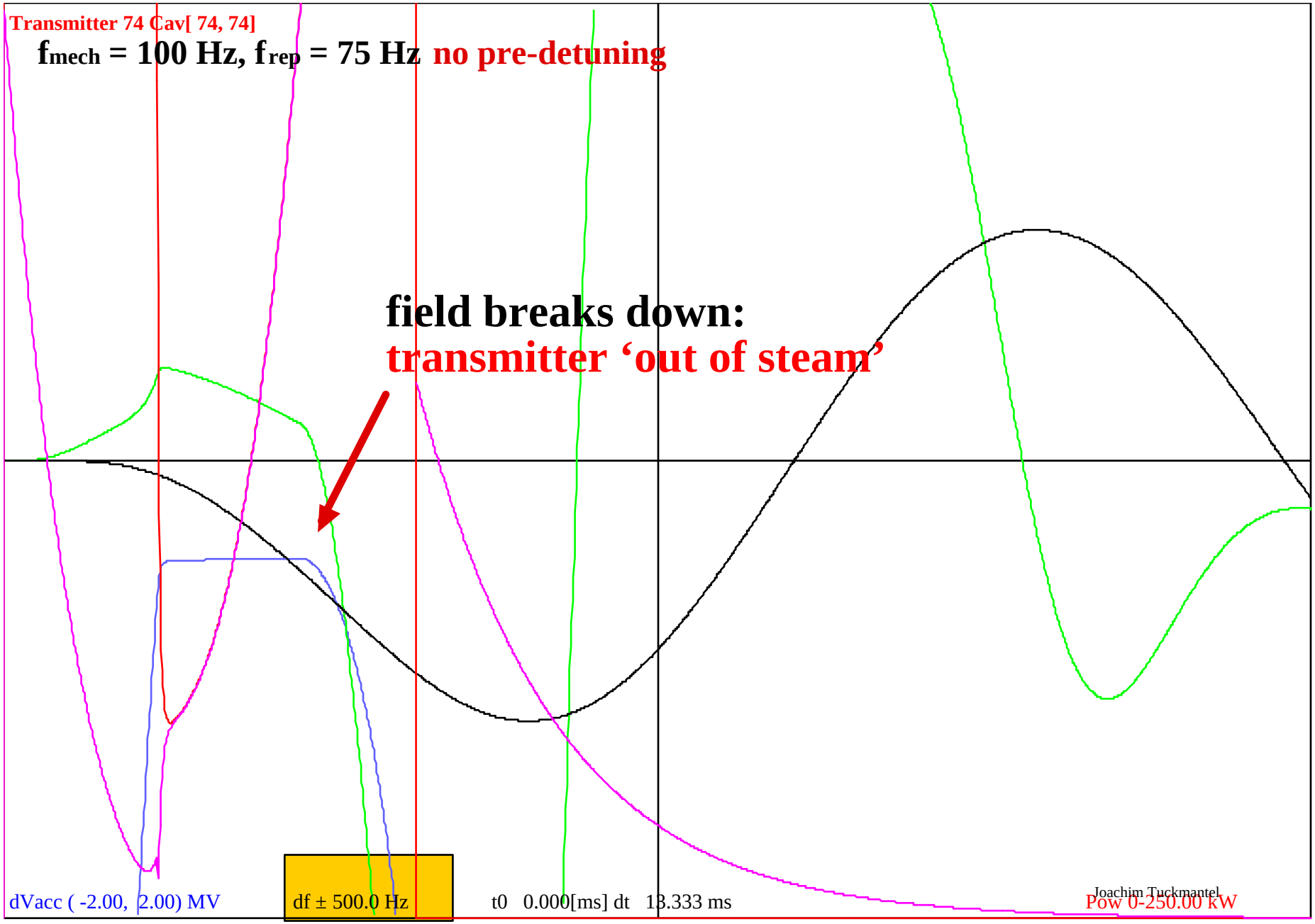
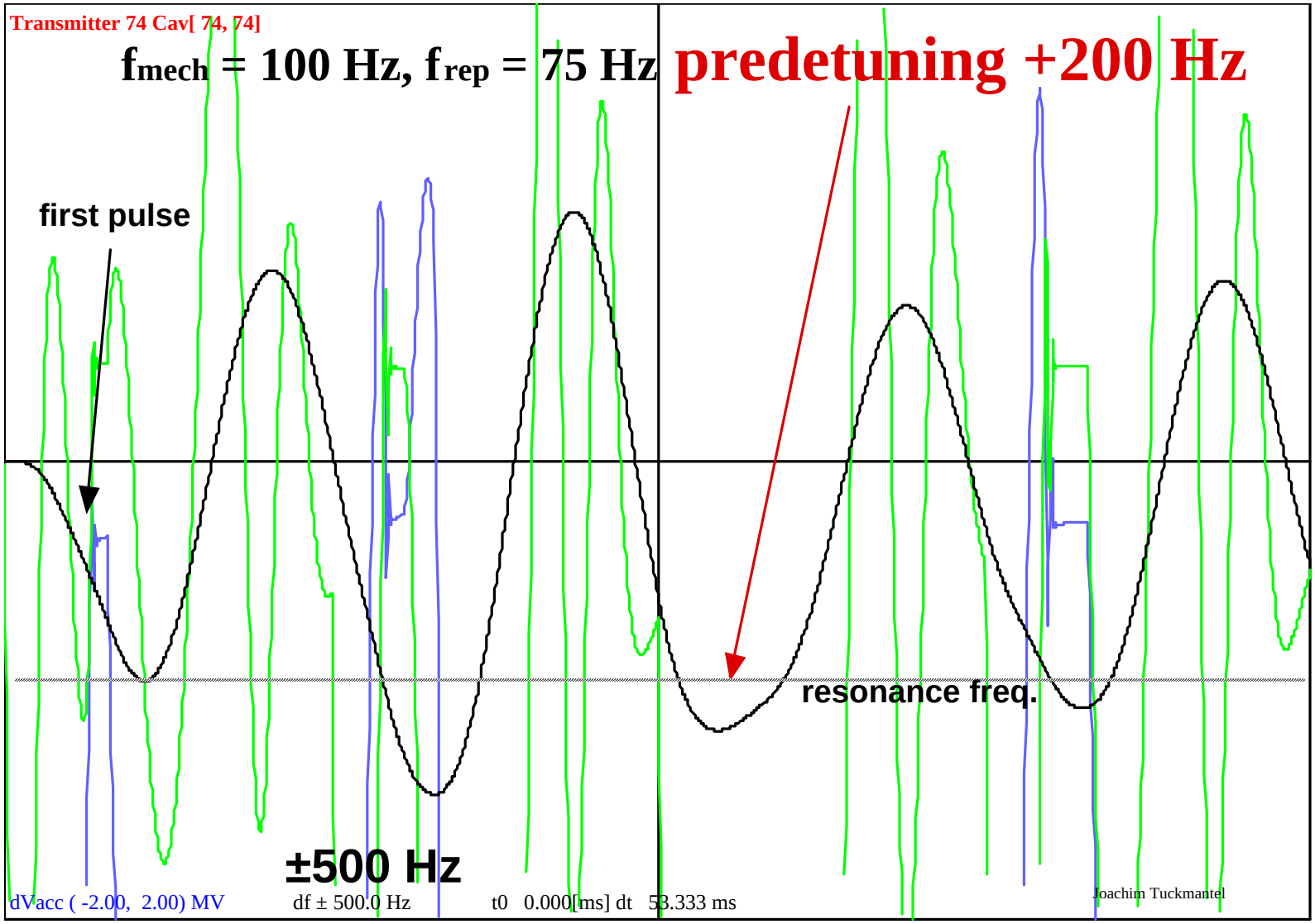
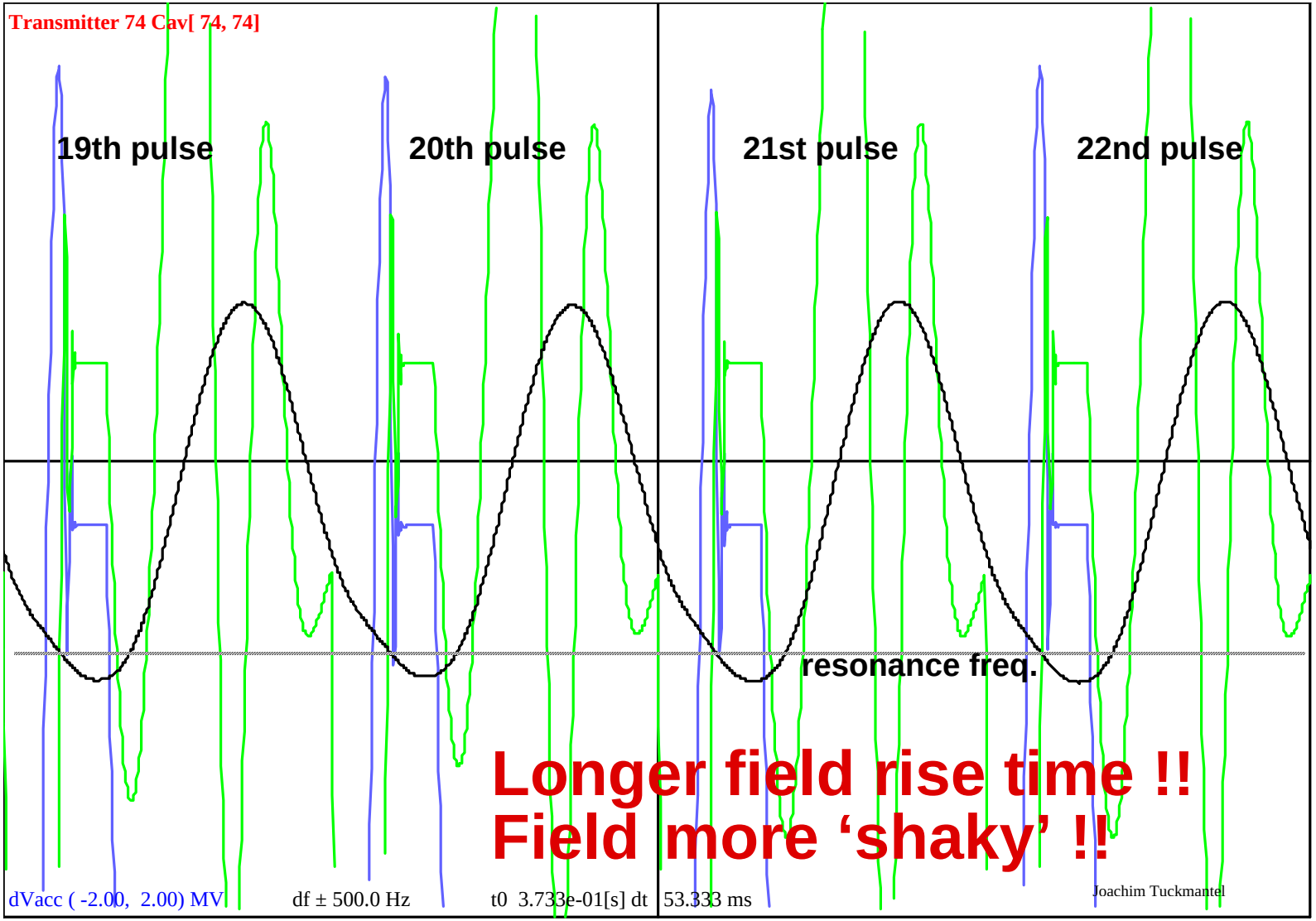
Pow 0-1000.00 kW

# Lorentz detuning: normal k



# Lorentz detunig: with ‘normal’ k




Transmitter 74 Cav[ 74, 74]
19th pulse
20th pulse
21st pulse
22nd pulse
resonance freq.
Longer field rise time !!
Field more 'shaky' !!
dVacc ( -2.00, 2.00) MV
df ± 500.0 Hz
t0 3.733e-01[s] dt 53.333 ms
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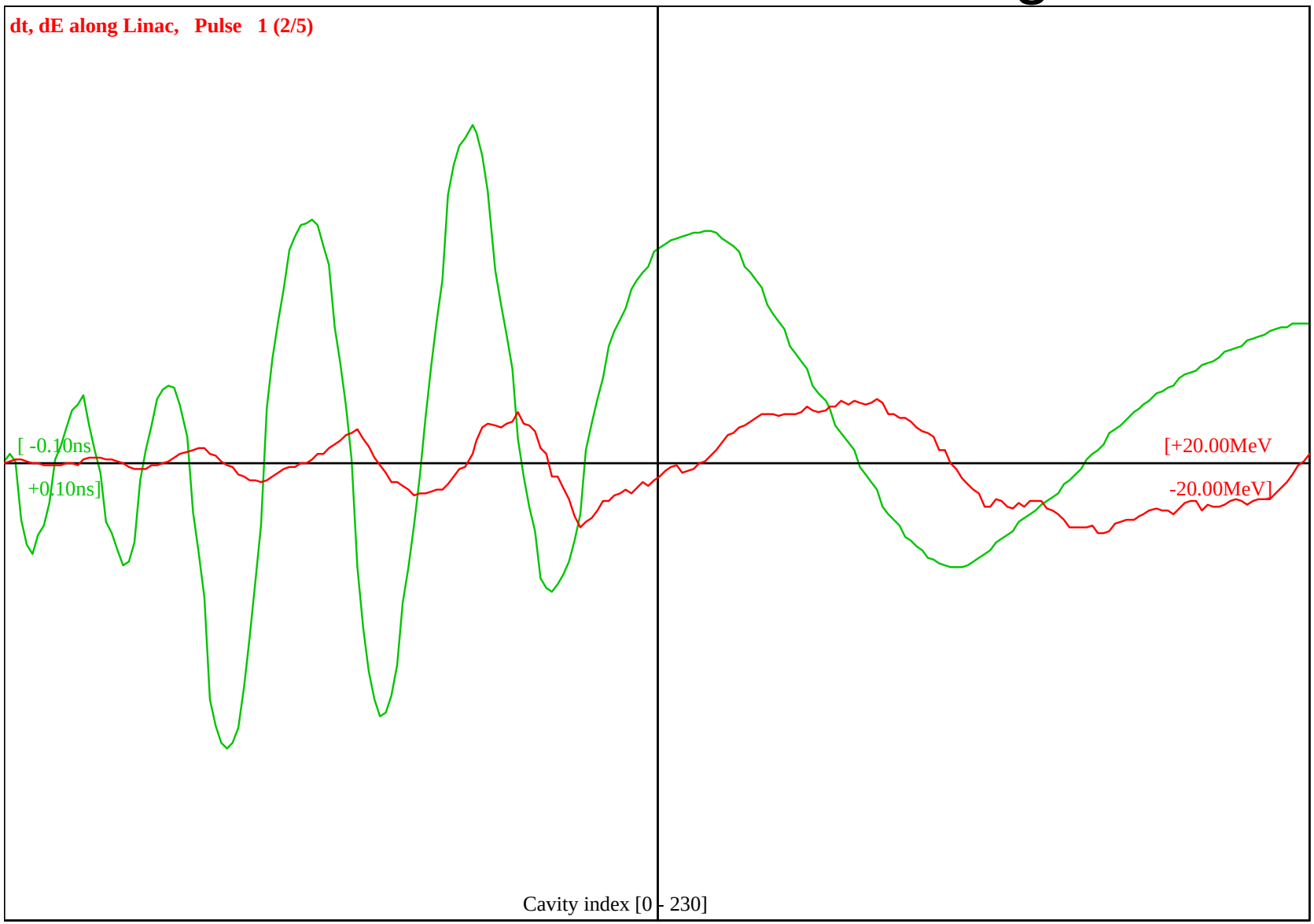
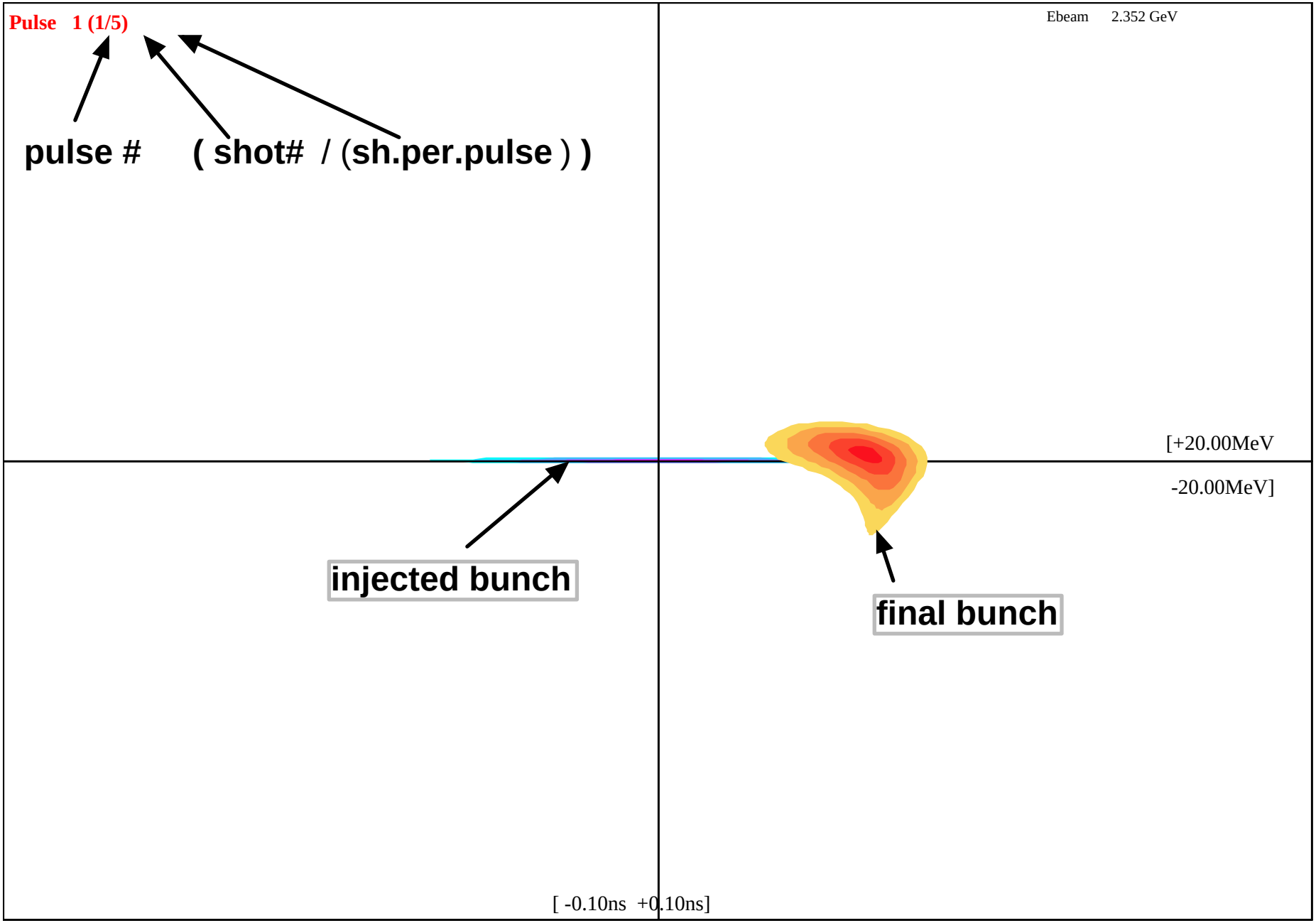
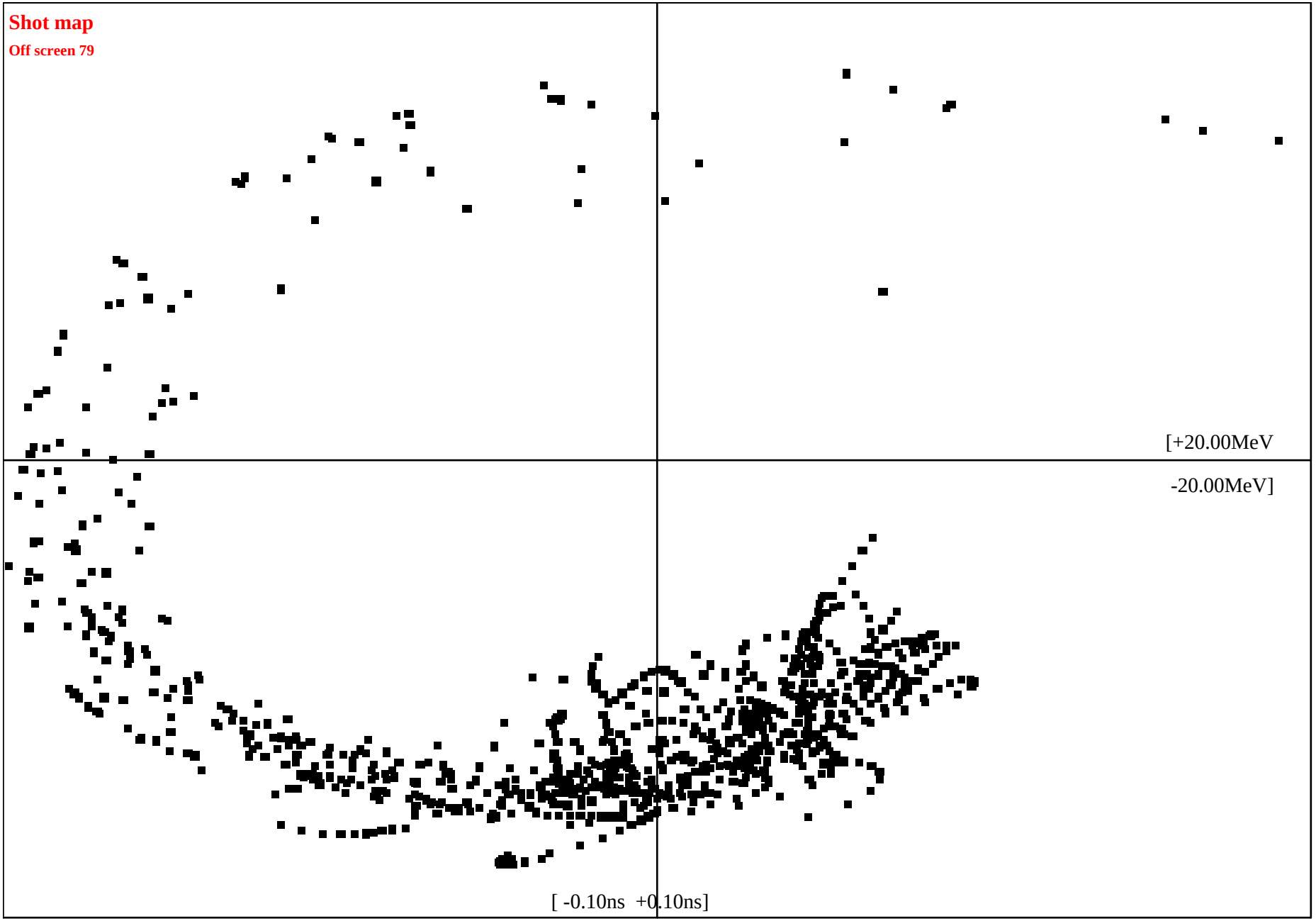
# dt and dE of center of bunch along the linac



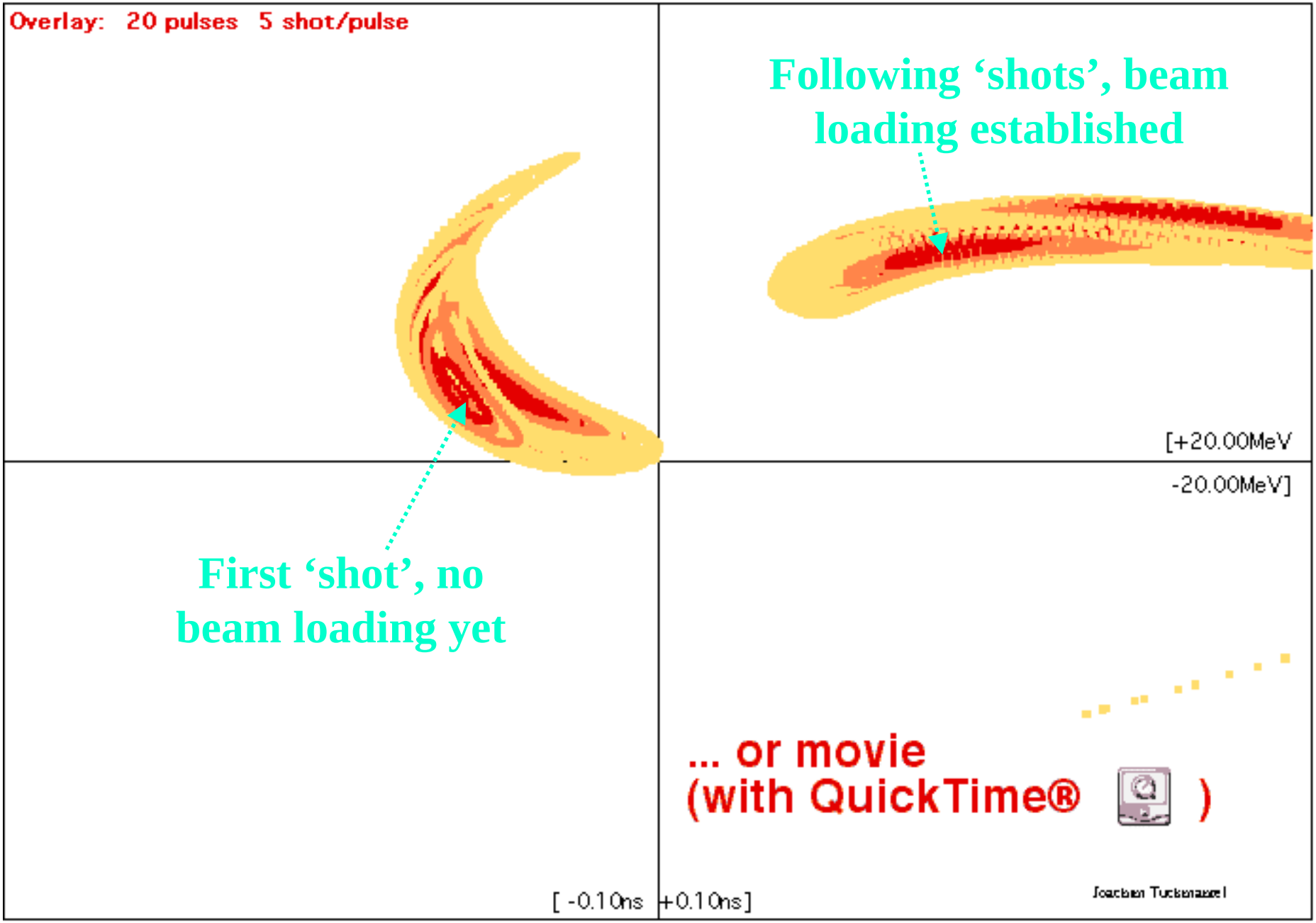
# Bunch in phases space, injected and exit



# Center of bunches at end of linac, 50 pulses, 5 shots each



# Overlay plot of many phase space images



# SPLinac can simulate RF systems with

- β-dependent T.T. factor
- vector (sum) feedback (opt. with delay)
- transmitter power limit and BW limit
- microphonics (different modes of perturb.)
- Lorentz detuning, mechan. resonance
- vector (sum) feedback errors
- power splitter errors
- $Q_{ext}$ errors
- bunch in point or phase space representation

# SPLinac displays phase space plots

- for each bunch along the linac
- for consecutive bunches at the end of the linac
  - ‘dot maps’ for centroids
  - dE, dt along the linac

## Internal parameters of each transmitter family

## Precise numbers or

## Overlay plots or movies

More information may be found at
http://cern.ch/joachim.tuckmantel/

• More detailed porgram description / user guide
SL-2000-053.pdf

• Application example (for CERN's SPL study)
SL-2000-054.pdf

• Some descriptions of the algortithms can be found in
Download phc07.pdf (*)

• … and some QuickTime movies

For movie display on Mac or PC:
QuickTime® can be downloaded free of charge at
(careful: Mac or IBM compatible version)

at http://www.apple.com/quicktime/download/.

(*)HEACC2001 contribution which describes another program made for LHC but uses partly the same cavity descriptions.
Historically this program is the 'mother', SPLinac the 'child'