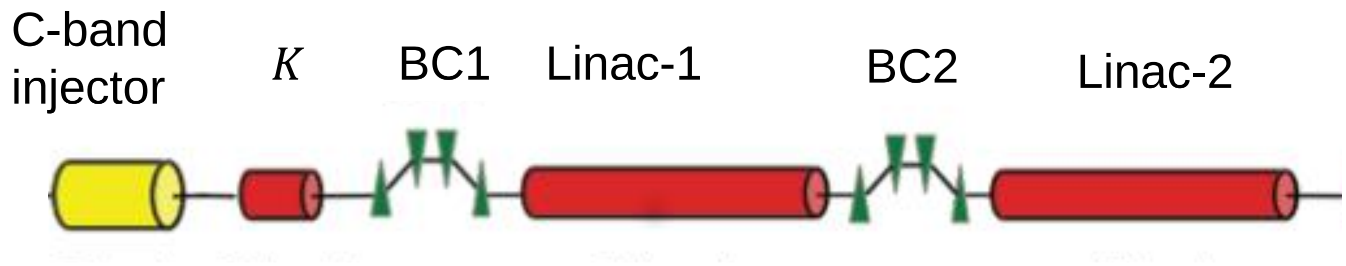
Beam Dynamics Update

On the voltage requirement of the linearizer



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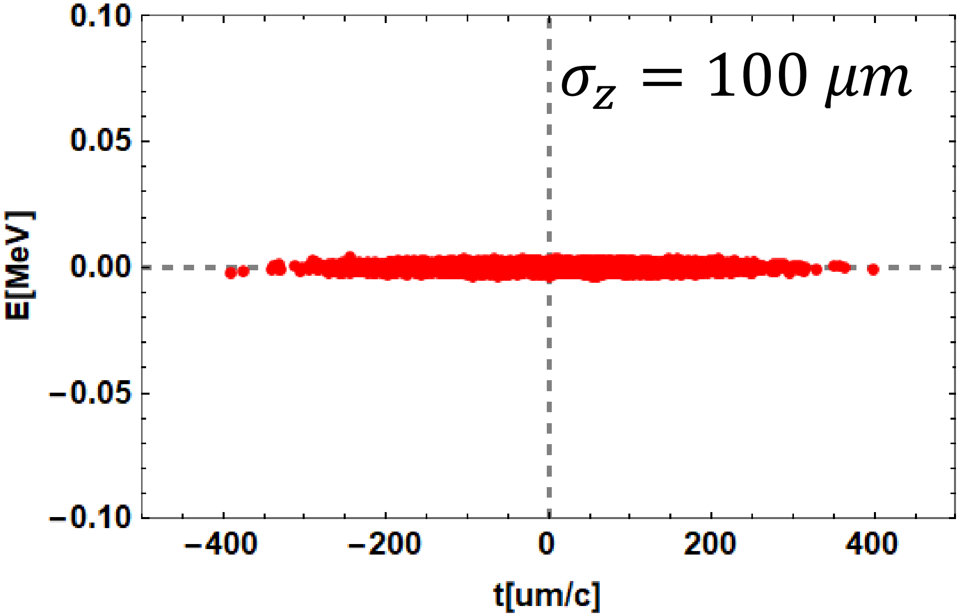
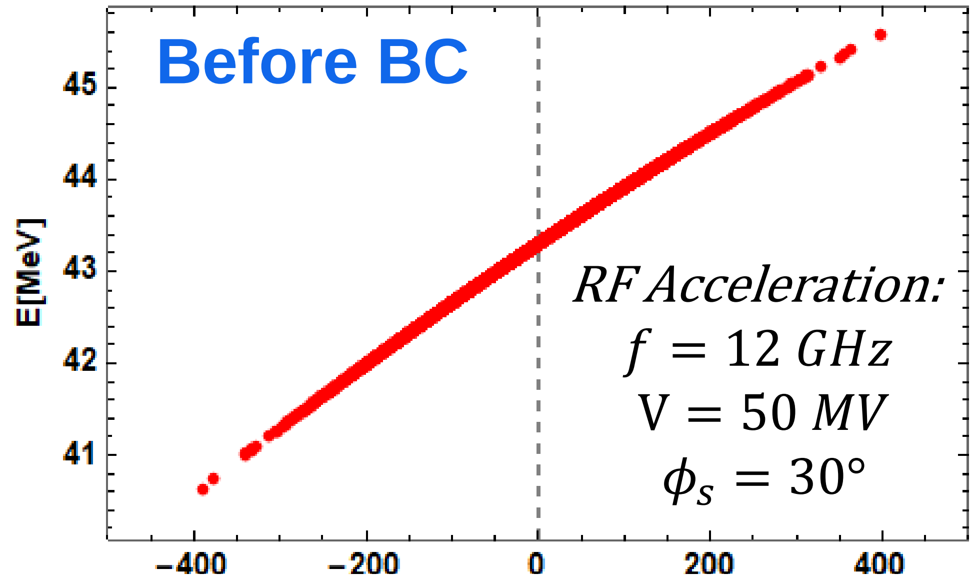
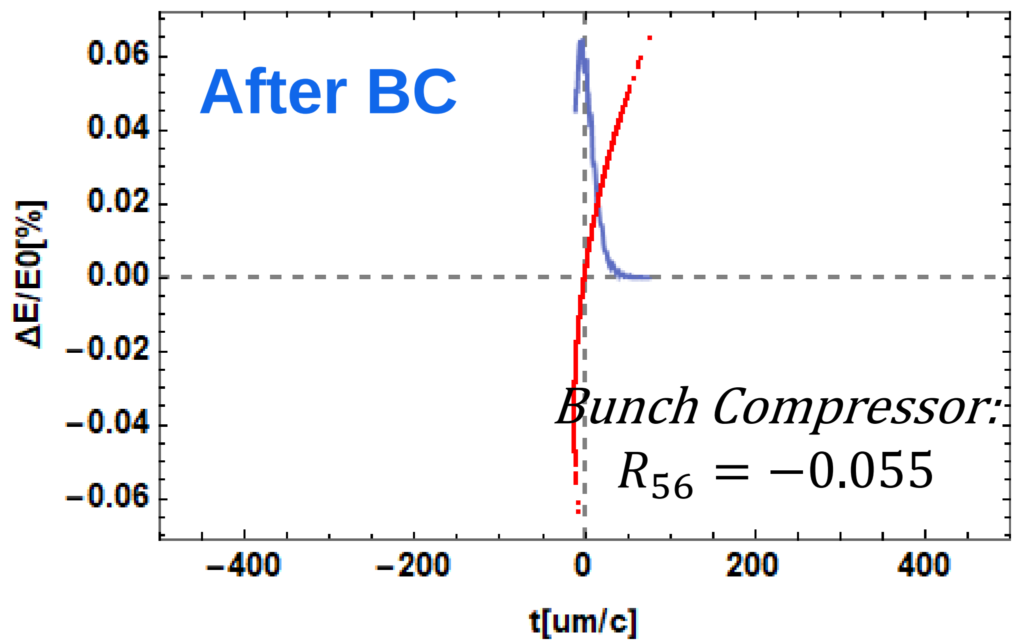
Why we need a Linearizer?







Avoid the intensity distortion

What the voltage requirement for a Linearizer?

$$V(z) = V_0 \mathrm{Cos}(\phi_s - kz)$$

$$V(z) = V_0 \mathrm{Cos}\phi_s + \mathrm{V0}kz\mathrm{Sin}\phi_s - \frac{1}{2}(kz)^2 V_0 \mathrm{Cos}\phi_s + O(kz)^3$$

$$V(z) = V_h \mathrm{Cos}\phi_h + V_h hkz\mathrm{Sin}\phi_h - \frac{1}{2}(hkz)^2 V_h \mathrm{Cos}\phi_h + O(hkz)^3$$

$$V_h = \frac{V_0 \mathrm{Cos}\phi_s}{h^2}$$ → **Really?**

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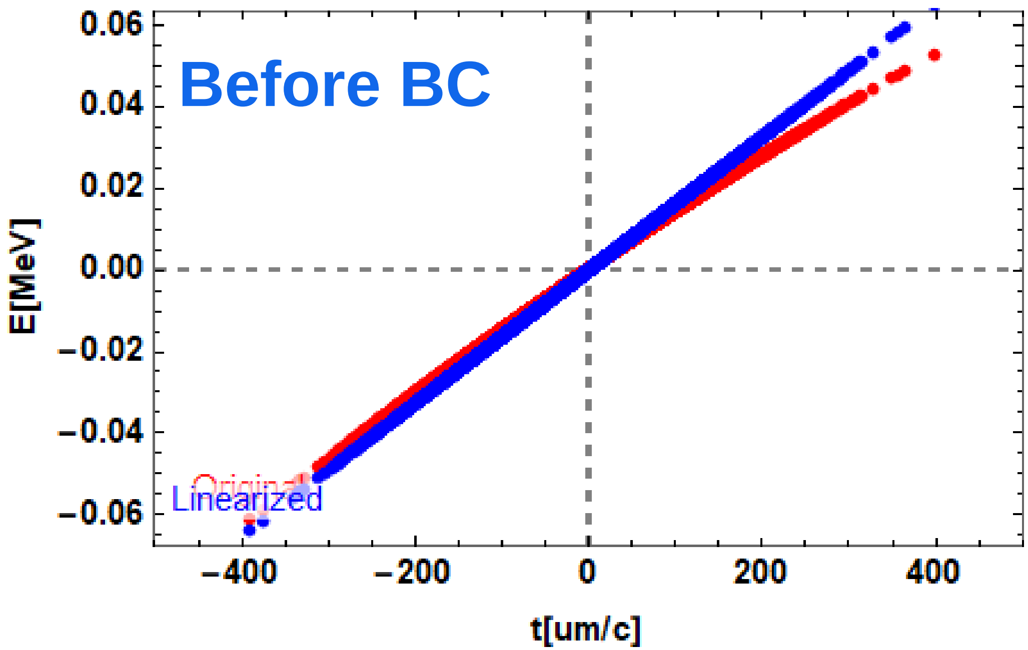
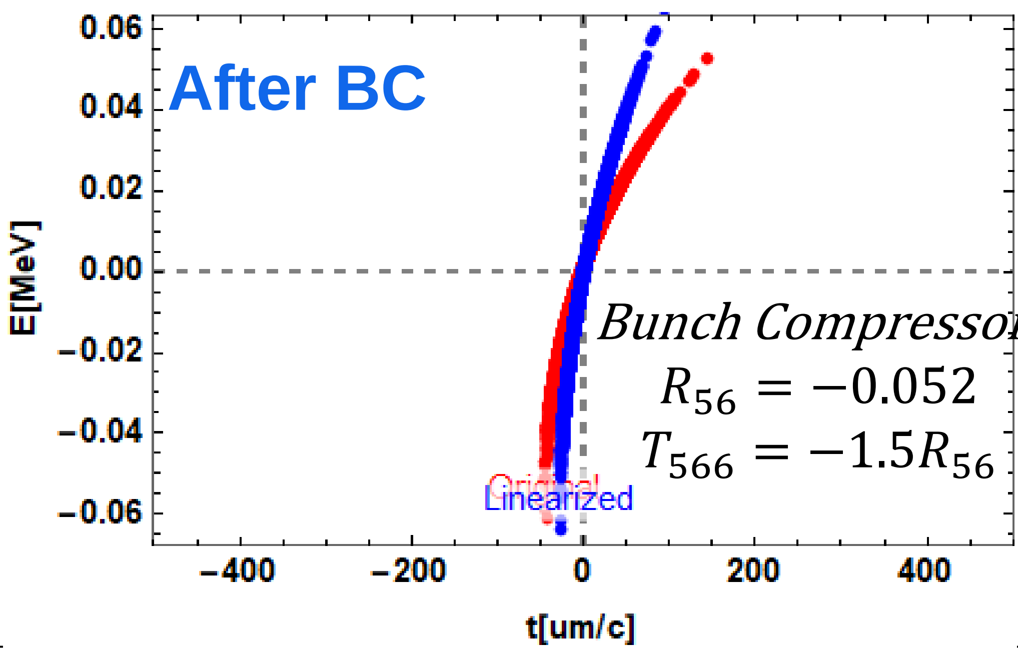


RF Acceleration:

$$f_x = 12\ GHz$$
$$V_x = 50\ MV$$
$$\phi_x = 30°$$

RF Linearizer:

$$f_k = 36\ GHz$$
$$V_k = \frac{50}{9} Cos30° = 4.81 MV$$
$$\phi_k = -180°$$



Bunch Compressor:

$$R_{56} = -0.052$$
$$T_{566} = -1.5 R_{56}$$

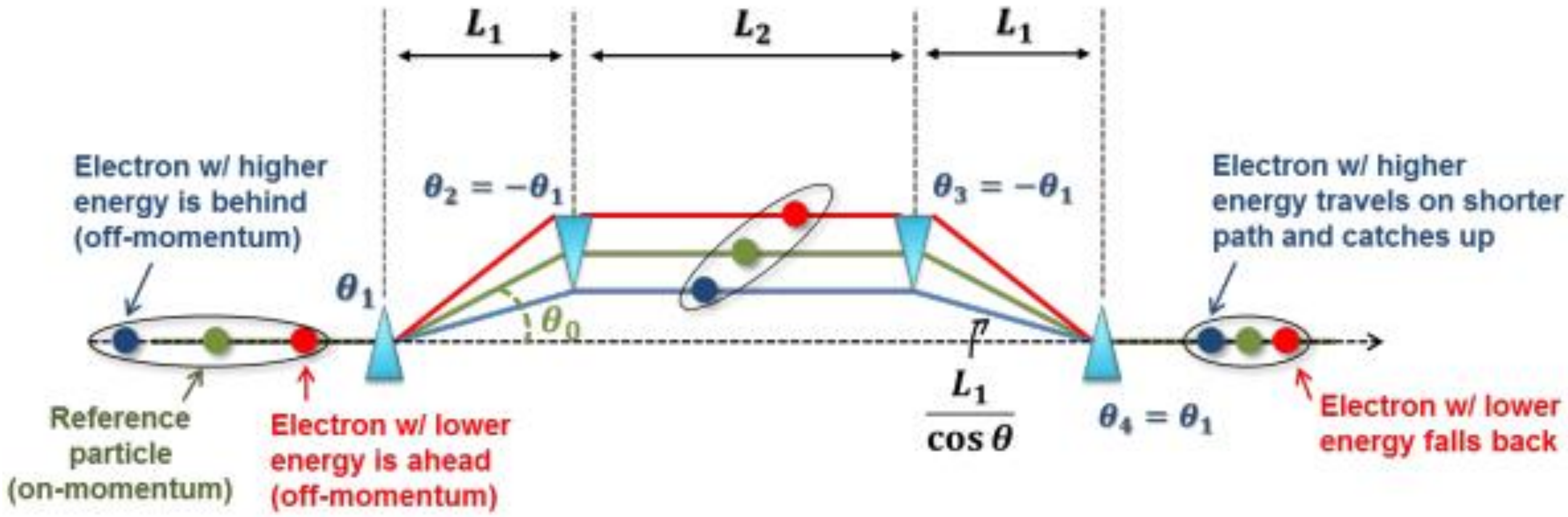
☹ Not really.

a	b	
Linear [MV/mm]	Second-order [(MV/mm)^2]	E0 [MV]
6.28555	-1.36879	43.3013
6.28556	-0.00319415	38.49
27.9086	-136.703	43.3182
45.4832	-311.146	38.4575

$$Find\ a\ fit:\ a\,z + b\,z^2 + E_0$$

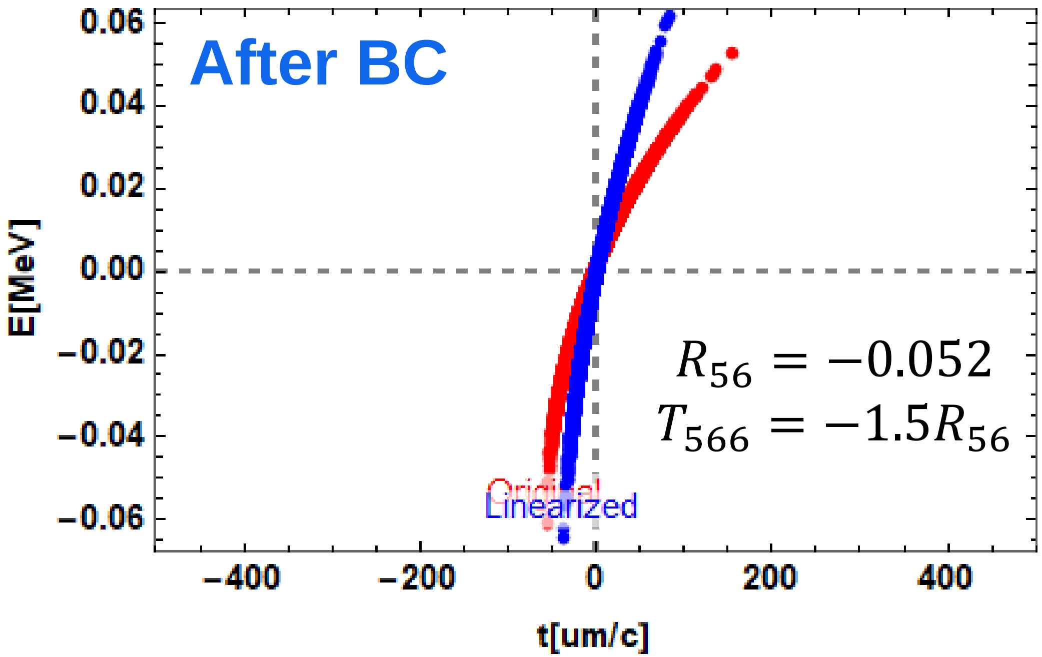
How does a bunch compressor work*?

*XLS Deliverable D3.2: Review report on bunch compression techniques and phase space linearization

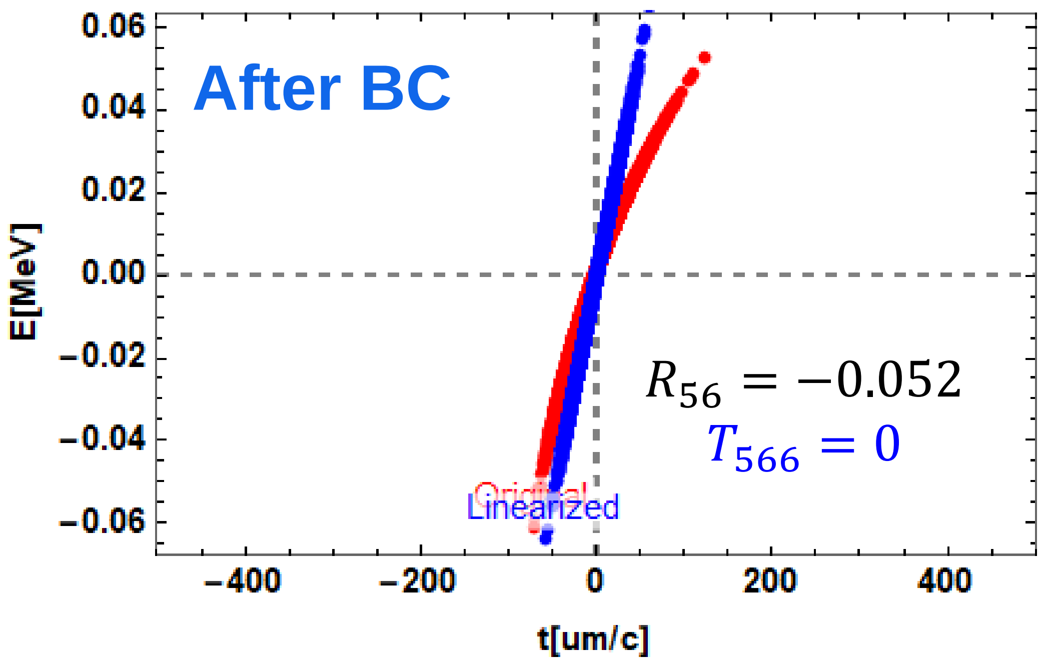


$$\Delta z_2 = \Delta z_1 + R_{56}\delta + T_{566}\delta^2 + O(\delta)^3$$

A "non-linear" relation ship between Δz and δ, T_{566}



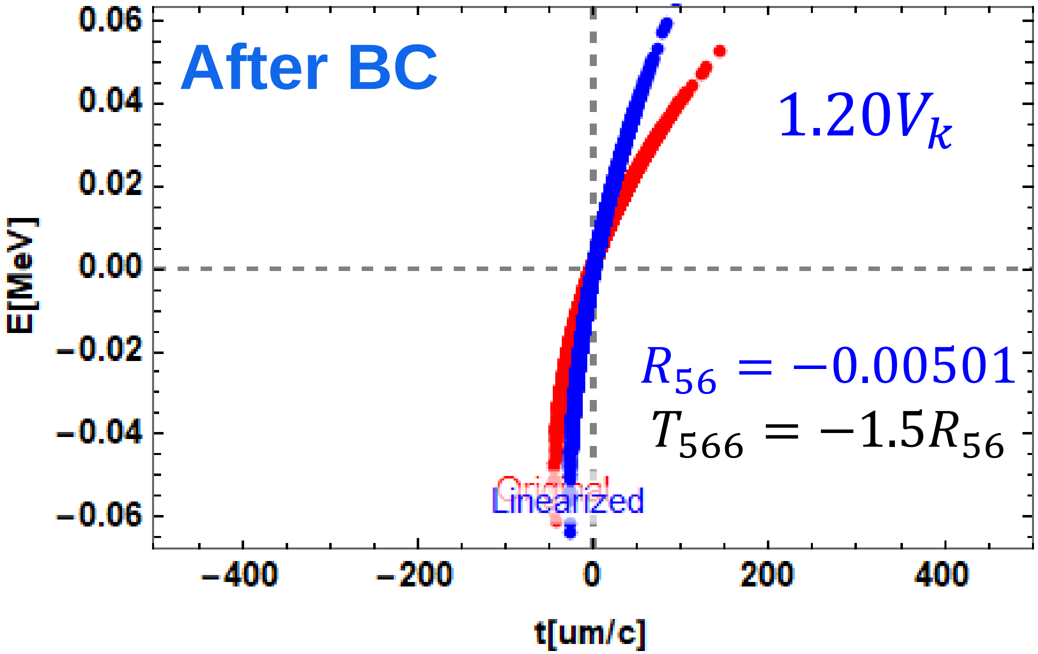
Linear[MV/mm]	Second-order[(MV/mm)^2]	E0[MV]
27.9086	-136.703	43.3182
45.4832	-311.146	38.4575
26.2731	-88.7487	43.3343
41.6635	-0.934987	38.4787



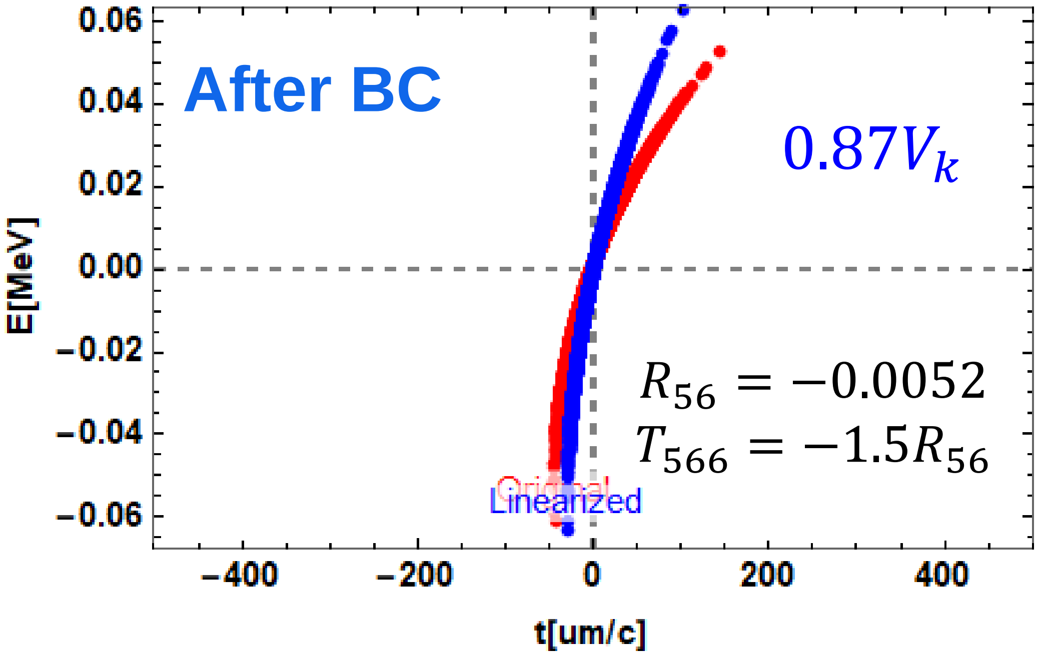
$$V_h = \frac{V_0 \mathrm{Cos}\phi_s}{h^2}$$

☺ Really works.

Targeting same “linear slope”



Linear[MV/mm]	Second-order[(MV/mm)^2]	E0[MV]
24.7341	-102.433	43.3193
→ 41.5091	-221.611	37.4917
27.9086	-136.703	43.3182
→ 41.6762	-267.063	39.0938



If $T_{566} = -1.5R_{56}$, a different set of (V_k, R_{56}) can provide the same slope but the “curvature” stays

Summary: Why it is hard to decide the linearizer voltage?

- In case of "**completely**" linearize the beam distribution:
  - $T_{566} = -1.5R_{56}$: the simple relationship doesn't work
  - $T_{566} = 0$ (which will complicate the lattice design): $\boldsymbol{V_k}$ **can be simply determined**

✓ In case of "**partially**" linearize (as in CompactLight's Case* where down-stream x-band structures serve as passive linearizer due to longitudinal short-range wake fields) :

- $T_{566} = -1.5R_{56}$ (most of design cases), the simple relationship doesn't work, $\boldsymbol{V_k}$ **can be higher or lower depending on the choice**
- $T_{566} = 0$: V_k will be lower

* e.g. See X.Liu's presentation at 2nd XLS Annual Meeting, https://indico.cern.ch/event/867582/

Follow-up studies

- Voltage dependence on:
    - the distribution from the injector
    - two-stage compression scheme (BC1 - BC2) with longitudinal short-range wake fields
- Design comparison on the choice of T566

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Thank you!

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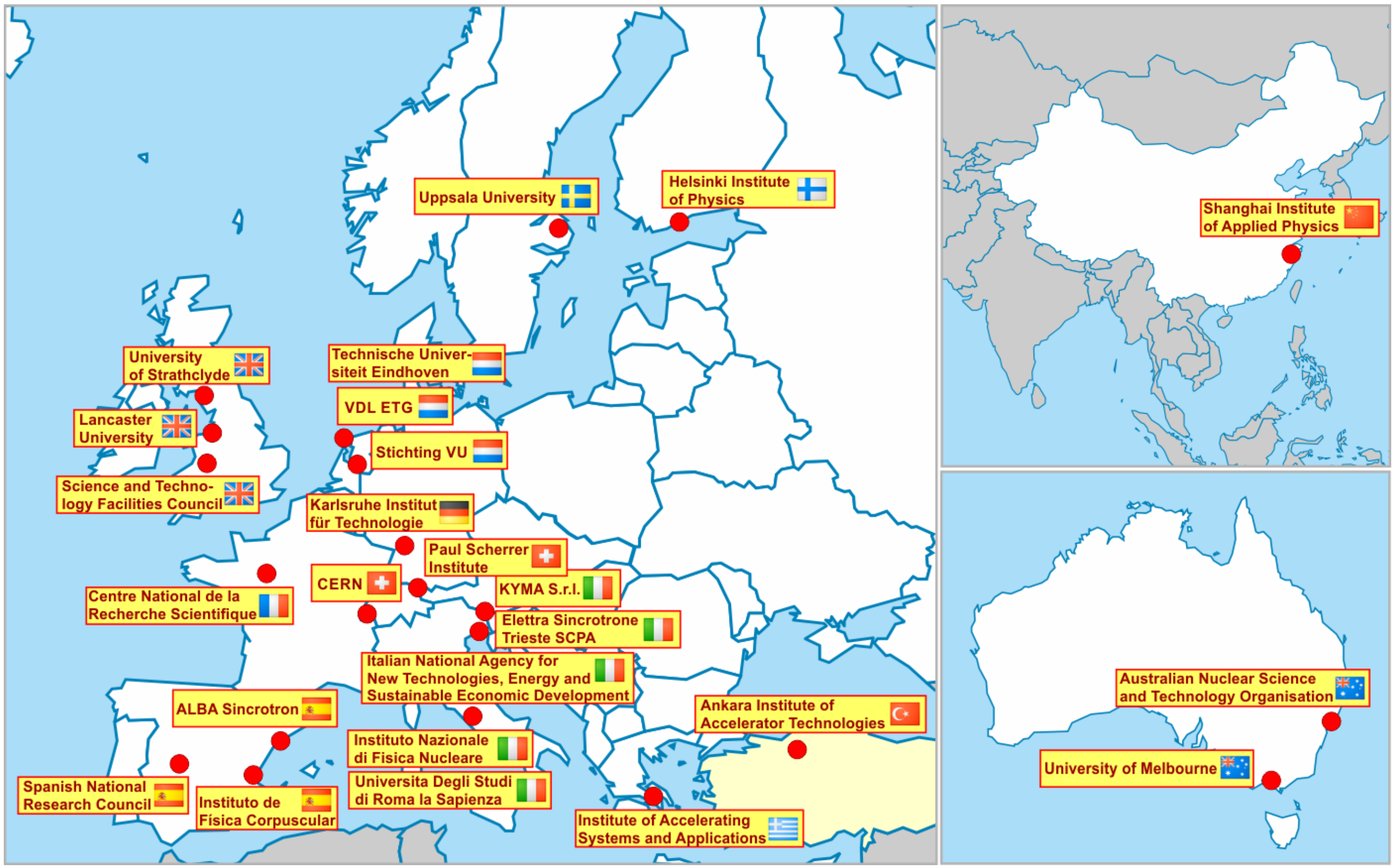

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