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PICKUP ELECTRODE ELECTRODYNAMICS INVESTIGATION WEPC26

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ABSTRACT

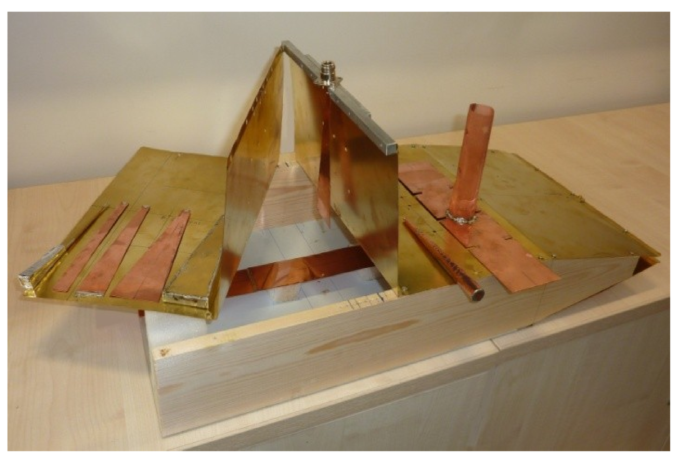
We conducted a model-based investigation of wave excitation and propagation in pickup electrode structures up to the times of the order of gap length over c. A short pulse in a TEM line was used to model a bunch. We developed a capacitive-probe-based technique for wave electric field measurements. The probe signals were measured by a 20GHz oscilloscope. We introduced an elementary electrode structure as a one-gap transverse flat thin electrode. It was found that in the gap between the electrode and wall, a shorter-than-gap bunch excites a TE-like packet which length is of the order of gap length over c. The packet propagates forward along the electrode to a coaxial connector. At this low impedance common point the packet partially reflects back and partially passes into the opposite gap. The voltage appearing at the impedance excites two TEM-wave packets: one propagates backwards, another one propagates forward through connector. The three packets propagating backwards reflect at the electrode end and come back to the summing point and generate output in a similar way. The same processes occur in a two-gap electrode. This phenomenological picture can be used as a guide in pickup design and simulation.

NO ANALYTICAL MODEL AVAILABLE

No analytical models is there in this time domain, to be a guide in development of real devices. This work is an initial step to get some qualitative understanding of the wave processes in the system pickup electrode – vacuum pipe. When the whole conception of the device is laid then the available simulation packages become useful.

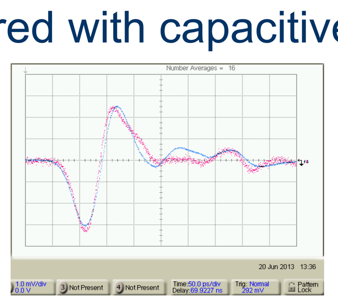
PICKUP LARGE SCALE MODEL

Bunch length 5.4mm. It is to be << than electrode/gap size. It lays down a model scale >5:1 as regards to a typical pickup. Electrode size range 10mm to 50mm. Gap length range 5mm to 25mm. Linear arrangement.



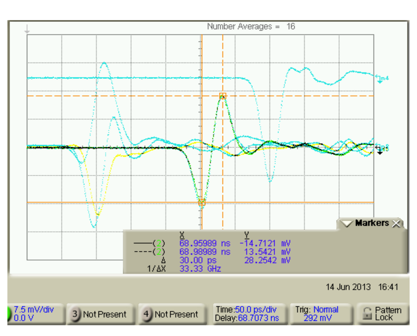
MEASUREMENT TECHNIQUE

- 20GHz (17ps) oscilloscope
- Output signal was measured directly
- Wave electric field was measured with capacitive probe



The probe output is proportional to derivative. We integrated not the output but the beam. For probe the beam was a step (12ps), for electrode output the beam was a pulse (18ps) obtained with a differentiator. In the plot above: the electrode output with pulse is blue, the same signal with step and probe is red.

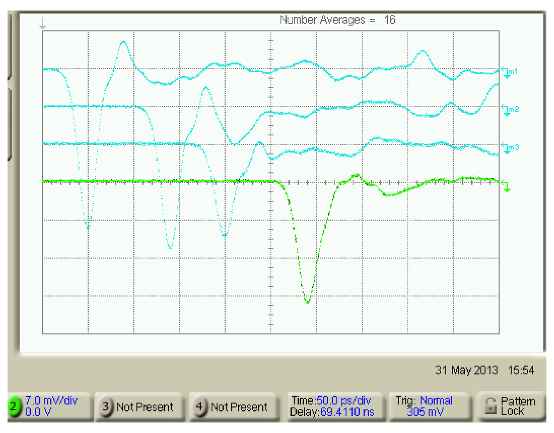
- We tried also an inductive probe to measure magnetic field. Electric shielding was a problem.

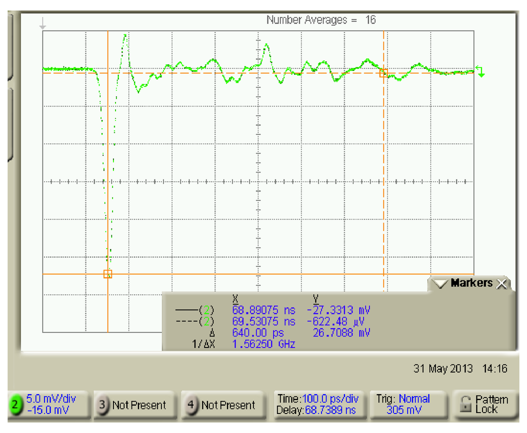


BEAM CHARACTERISATION

- Propagation along the beam line was measured at four points over the line axis: 10cm and 1cm before the gap front edge and 1cm and 10cm after the gap rear edge. Gap length was 20mm.
- **No short pulse reflection occurs!**

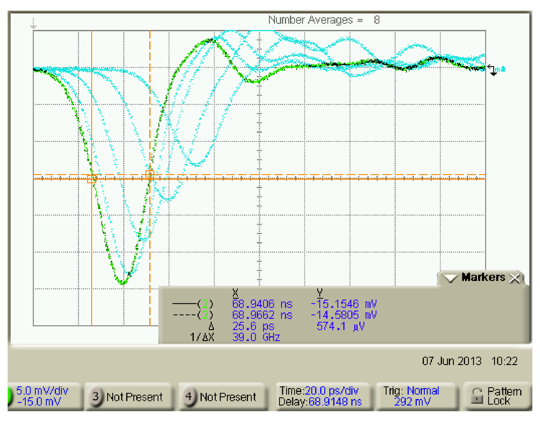
  Short pulse and long gap.





- A wave of a strip placed between two conductive planes decays with distance from the strip. **For a broad electrode this effect reduces effective pulse magnitude.**

  Strip 45mm, interval 20mm along the gap front edge;



- Constant phase surface is not a plane but a convex centred at the transition coax-circular to coax-flat. **For a broad electrode this effect increases effective bunch length.**

ONE-GAP ELECTRODE

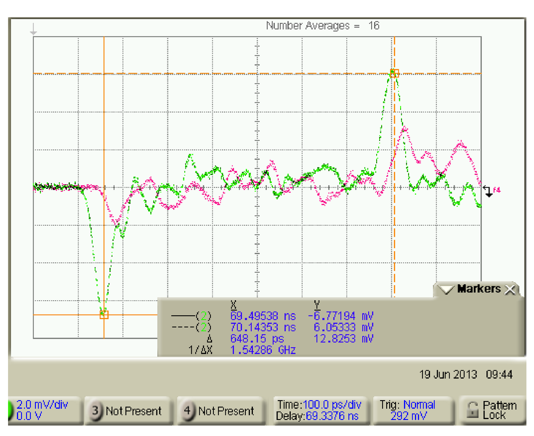
- **We introduced an elementary electrode structure: one-gap transverse flat thin electrode.**

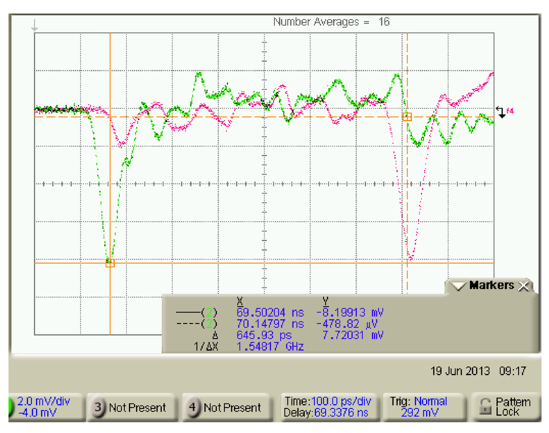
Two gaps, on each side. One only gap interrupts the wall current induced by beam (active gap). Another one is short-circuited (passive gap).

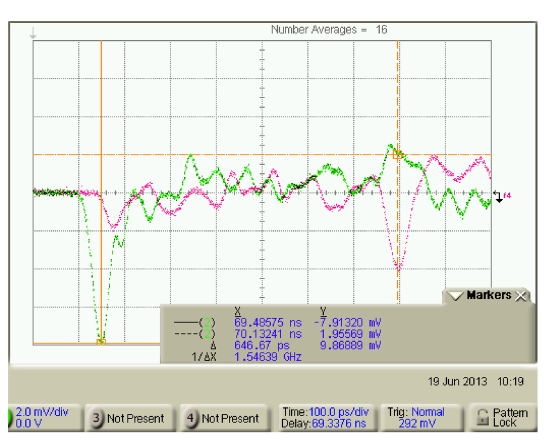
- An example: one-end-short-circuited strip line pickup. The rear gap is screened by the strip itself.

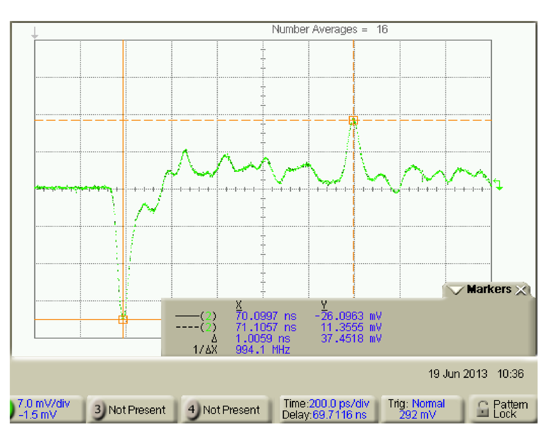
A button pickup is the superposition of two one-gap structures.

- **The waves excited in a one-gap electrode structure were measured at either gap** at four points: at 1cm, 5.5cm, 10cm, and 14.5cm distance from the electrode edge. To identify the waves, **the electrode end was made short, open, and connected to a output coax connector pin.** The last plot is the output.
- The electrode width was 30mm tapered down to 10mm at the connection point. Each gap length was 15mm tapered down to 5mm at the end.
- **Packets at the point three, active/passive gap is green/red.**









Observations:

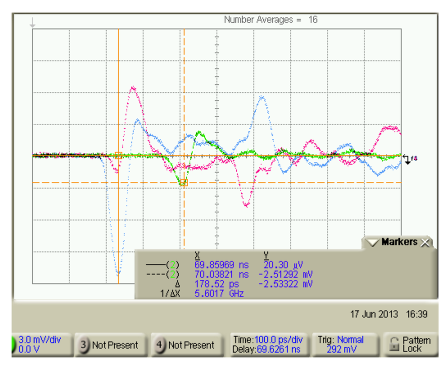
- **The waves propagated as TE-like compact packets guided by the electrode.**
- **The packet length was about gap length over c.**
- **Some residue coupling of the passive gap and beam took place.**
- **At the connection point the active gap principally can't be matched.**

At this point, **four lines** are interconnected: an active gap excited by beam, a passive gap , with its own impedance, an output 50Ohm coax line, and one more, internal coax line with the electrode as a central wire.

TE-like wave packet **converts** to TEM-output at the connection point. Two TE-like wave packets and one TEM packet are reflected and **go back** to the electrode edge.

TWO-GAP ELECTRODE

- Two-gap electrode has each gap open and active.
- The rear gap is excited by beam **later** than the front gap. For a thin electrode **the delay** is minimal and equal to **gap over c.**
- Packet propagation and reflection occur analogously to one-gap electrode.
- **As a novel pickup for bunch arrival time monitor, the two gap pickup is considered in [5].**



SUMMARY

We attempted a model-based investigation of wave excitation and propagation in pickup electrode structures up to the times of the order of gap length over c. A short pulse in a TEM line was used to model a bunch. We developed a capacitive-probe-based technique for wave electric field measurements.

We introduced a one-gap transverse flat thin electrode as an elementary electrode structure. It was observed that in this structure a shorter-than-gap bunch excites TE-like waves that propagate along the electrode as a compact packet of the length of gap length over c. This packet converts to a TEM output signal at the interconnection of the electrode and coaxial connector. We discovered that at this point the packet is principally unmatched which causes multiply reflection.

We investigated also a two-gap structure which represents a button pickup. The output is a superposition of two opposite polarity one-gap electrode signals spaced by an interval which minimal value is gap length over c.

The results can be used as a guide in pickup design and simulation.

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