CTF3 Collaboration Technical Meeting

TAIL-CLIPPER KICKER

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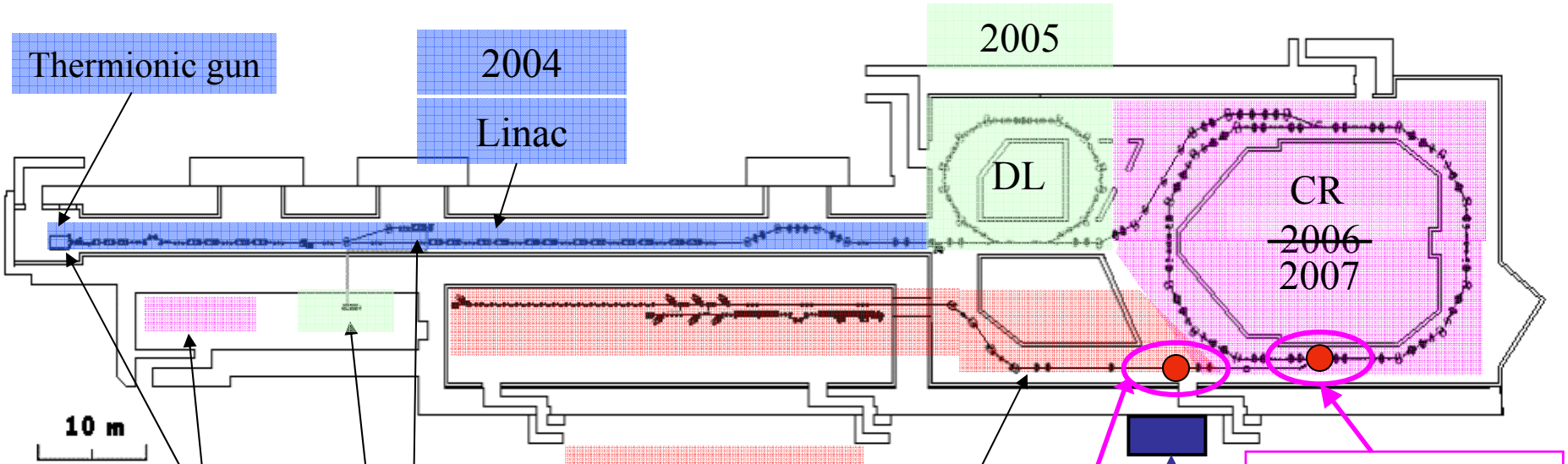
OVERVIEW

- Review of design and status of tail-clipper – several measurements presented;
- Outstanding work for tail-clipper;
- Future kicker systems that would be required for CLIC.

CTF3 Programme



CTF3 & CLIC Stripline Kickers

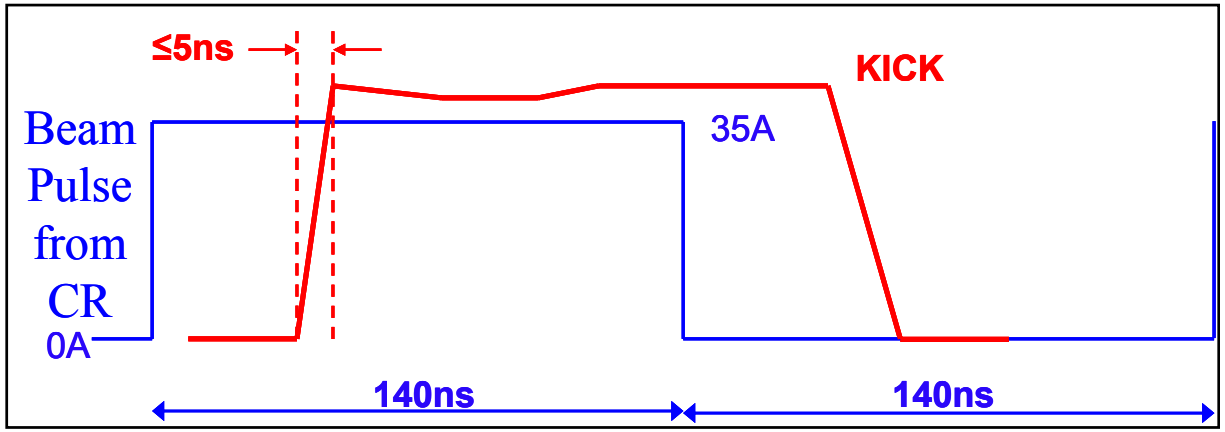
Generator 2007; Striplines 02/2008 → CTF3 CR Extraction

Jan. 2009 → Tail Clipper

		CTF3 CR Extraction	Tail Clipper	
Beam energy		300	200	MeV
Total kick deflection angle ("B" & "E" Fields)		7	1.2	mrad
Stripline plate separation		40	40	mm
Stripline electrical length		1.7	**4** x ~0.295	m
Available length (including transitions)			1.625	m
Field rise time (0.25% to 99.75%)		≤70	≤5 !	ns
Pulse duration		200	Up to 140	ns
Flat-top reproducibility		± 0.1	NA	%
Flat-top stability (including droop)		± 0.25	NA	%
Field homogeneity			± 18	%
Repetition rate	Initial	5	5	Hz
	Nominal	50	50	Hz
Stripline Pulse voltage		±12.6	±2.0 for 1.18m ±2.65 for 0.885m	kV
Pulse current (into 50 Ω load)		±252	±40 for 1.18m ±53 for 0.885m	A
Timing Jitter			≤ 1 rms	ns

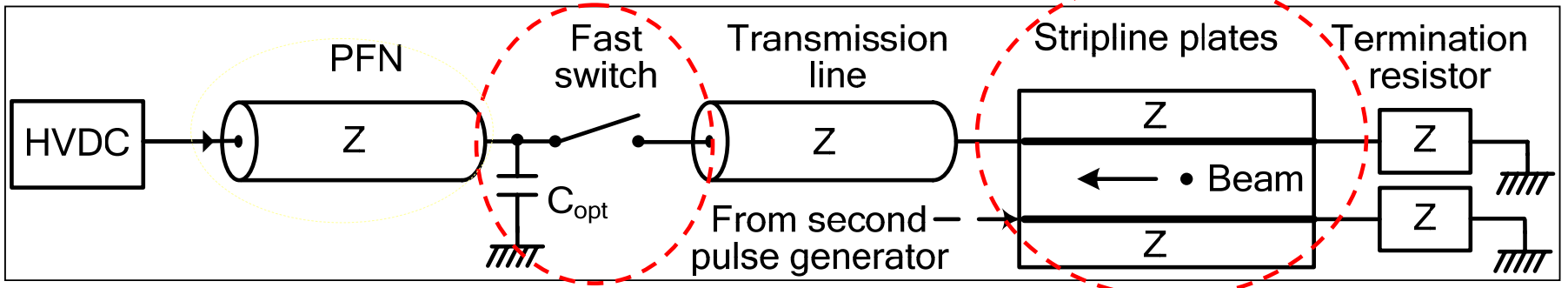
Tail Clipper: Overview

Beam Pulse



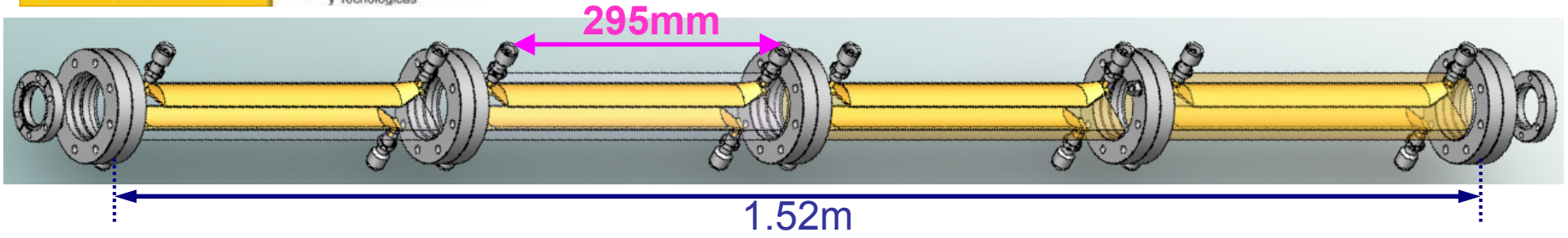
The beam pulse extracted from the CR is 35 A and 140 ns. The tail-clipper must have a fast field rise-time, of 5 ns or less, to minimize uncontrolled beam loss. The flatness of the kick pulse is not important as deflected beam is to be thrown away.

Schematic of Tail-Clipper



Each pulse generator is composed of a 50Ω (Z) Pulse Forming Network (PFN), a fast semiconductor (Behlke) switch, 50 Ω stripline plates and a matched terminating resistor.

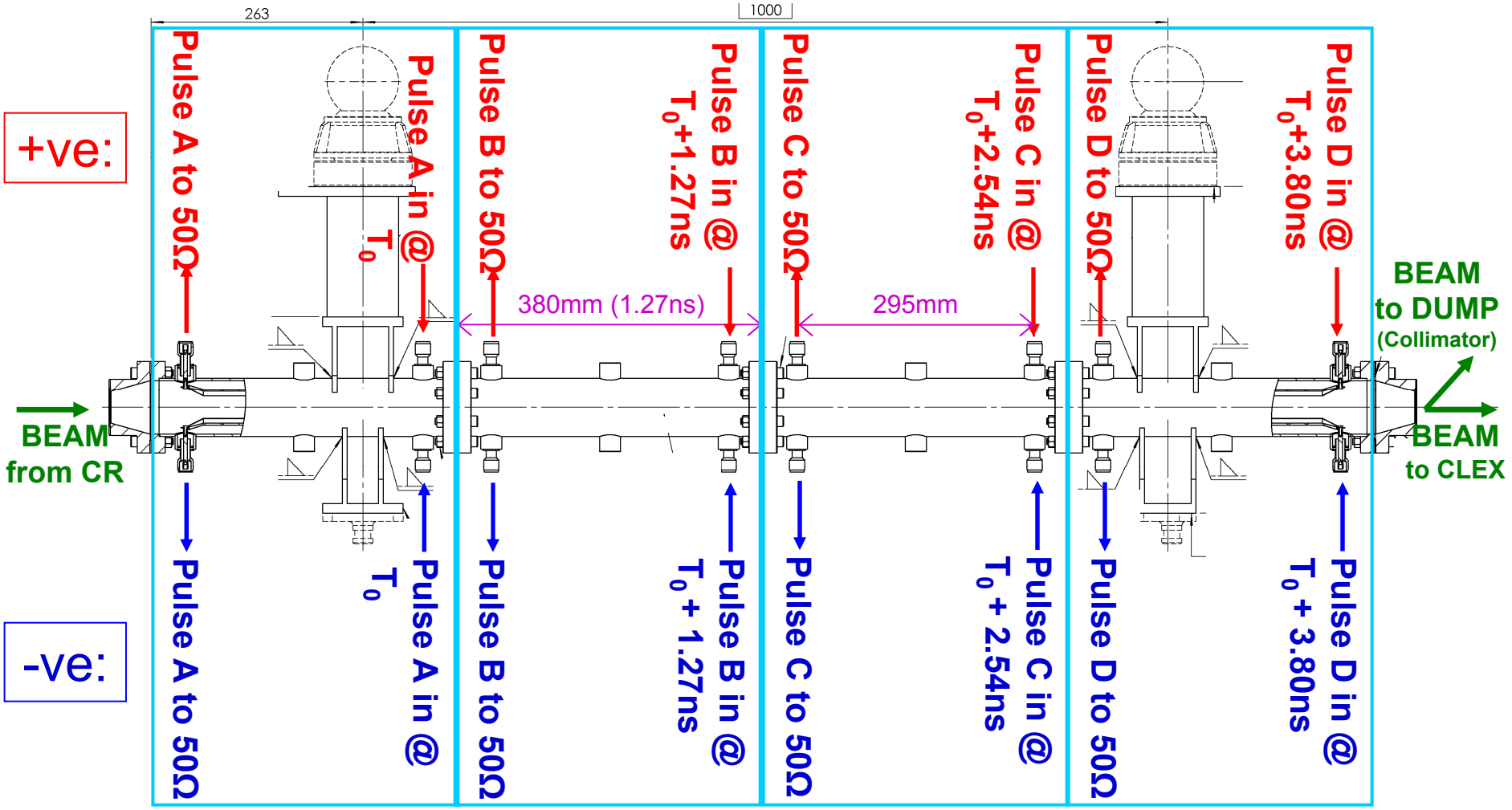
Tail-Clipper Striplines (1)



- Four sets of striplines.
- Smooth transitions from coaxial feedthru to stripline.
- Tapered electrodes preserving 50Ω characteristic impedance to minimize reflections.
- At a radius of 10mm the deflection is up to 4.3% less than the on-axis deflection.
- For an overall electrical length of 0.885m (3*0.295m), a current of ~53A into 50Ω provides the specified kick of 1.2 mrad.
- A 4th set of striplines provides redundancy.
- "Over-driving" striplines also reduces field rise-time.

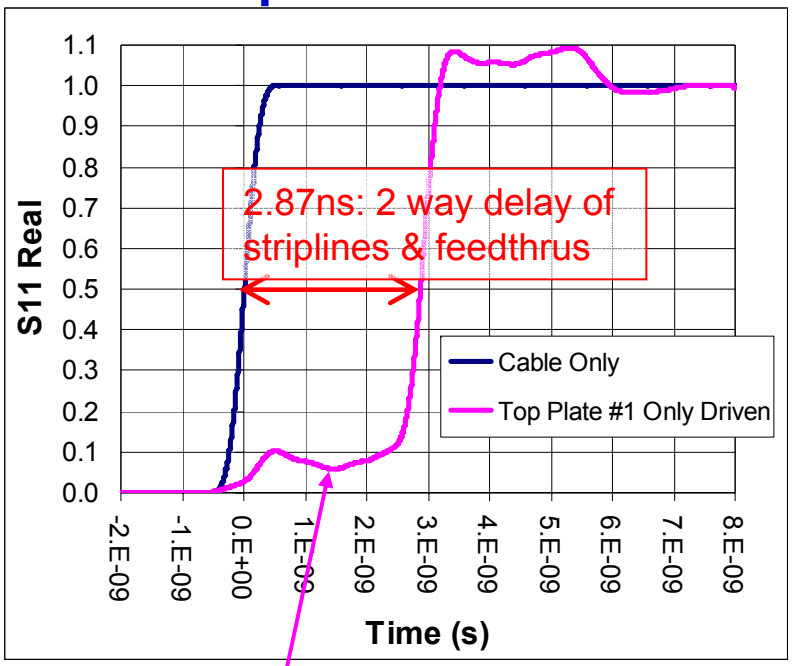
Tail-Clipper Striplines (2)

1.2mrad deflection. Striplines fed from CLEX end.
Pulse voltage: ±2.0kV for 1.18m; or ±2.65kV for 0.885m



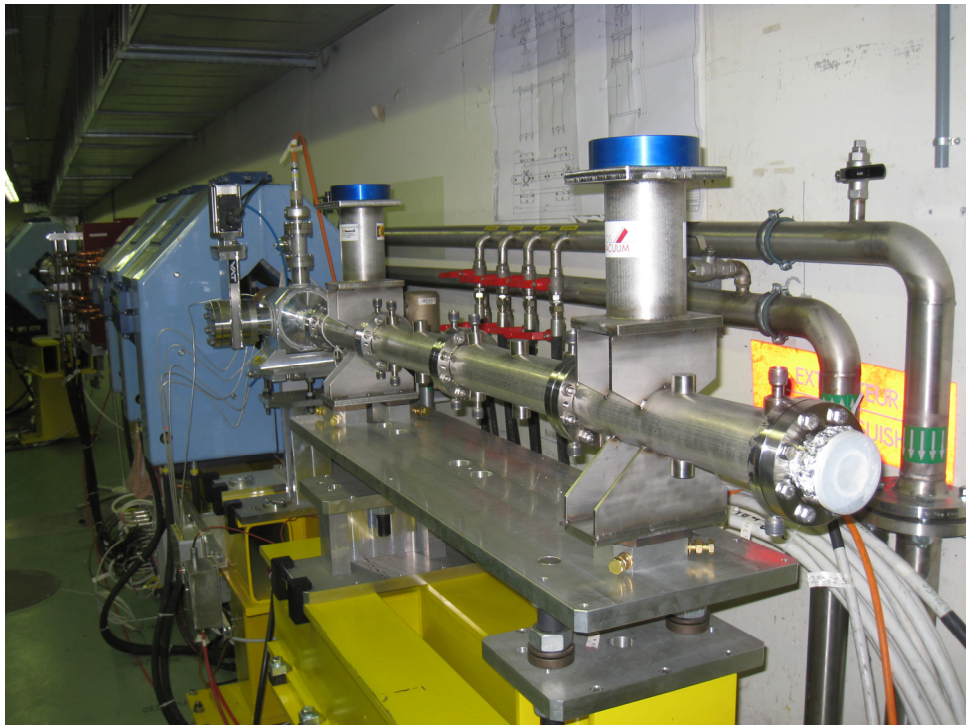
Tail-Clipper Striplines (3)

Measured pulse response with only one plate of a set of striplines driven:

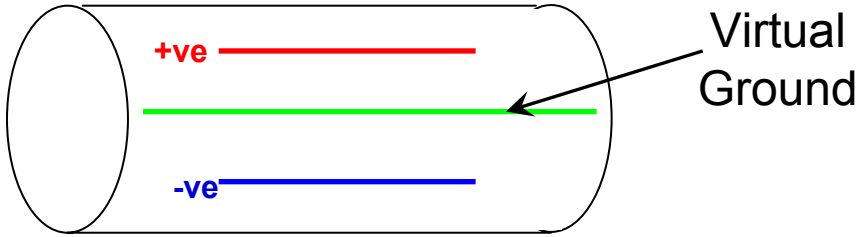


Mismatch (S11=0.06): Z ≈ 56Ω.

Impedance of 56Ω is due to only one-plate being driven (confirmed from simulations). To do: Double-check using a hybrid.

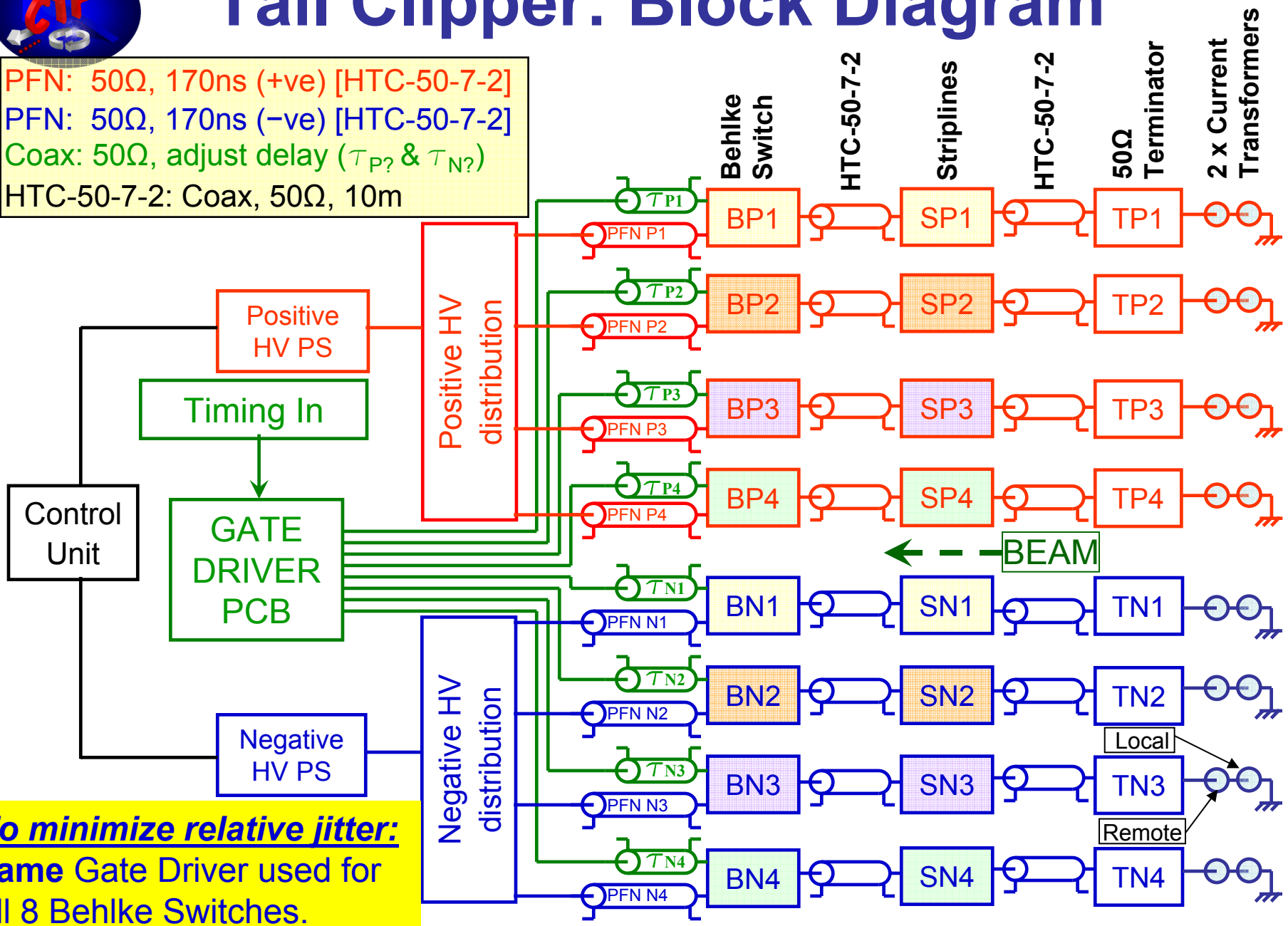


Striplines in situ in TL2



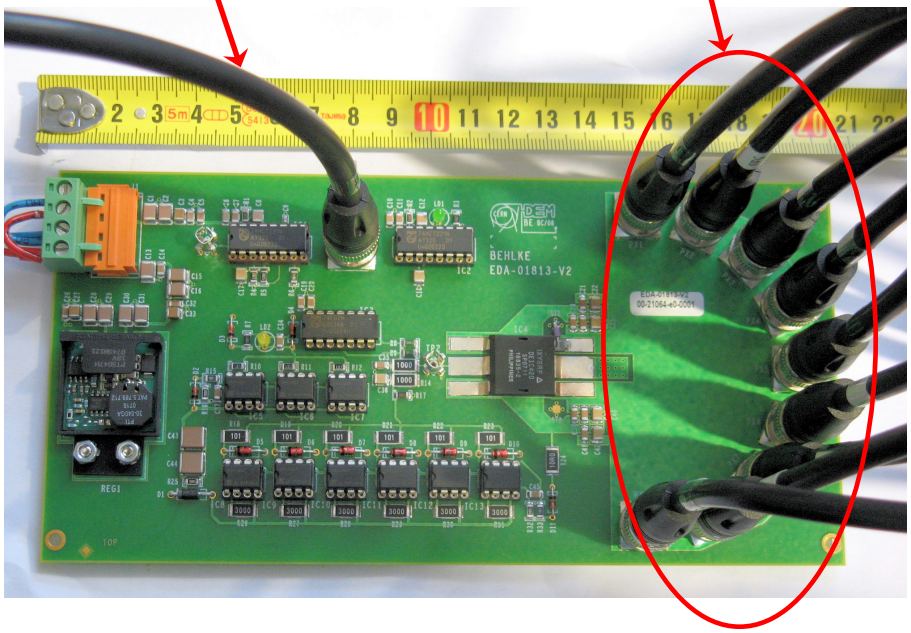
Tail Clipper: Block Diagram

PFN: 50Ω, 170ns (+ve) [HTC-50-7-2]
PFN: 50Ω, 170ns (−ve) [HTC-50-7-2]
Coax: 50Ω, adjust delay ($\tau_{P?}$ & $\tau_{N?}$)
HTC-50-7-2: Coax, 50Ω, 10m



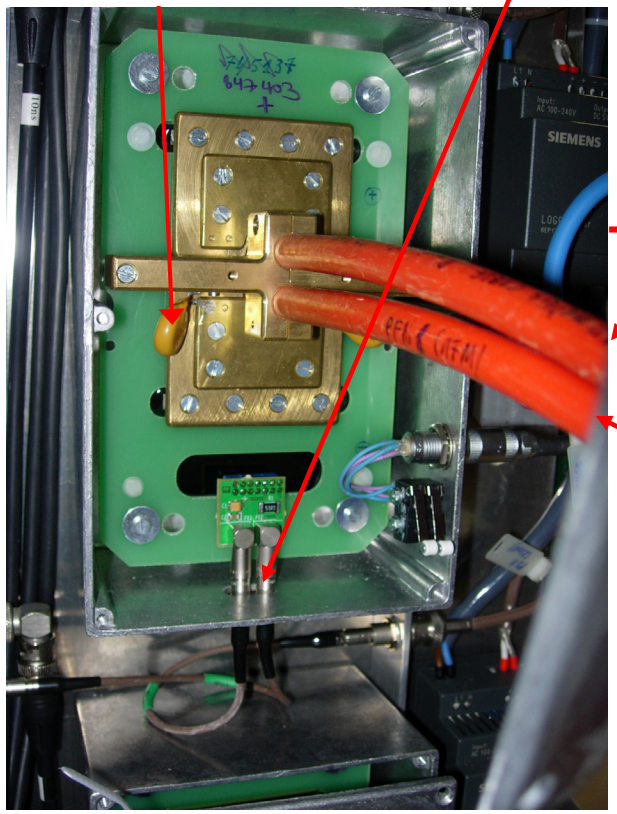
To minimize relative jitter:
same Gate Driver used for all 8 Behlke Switches.

Tail-Clipper Hardware



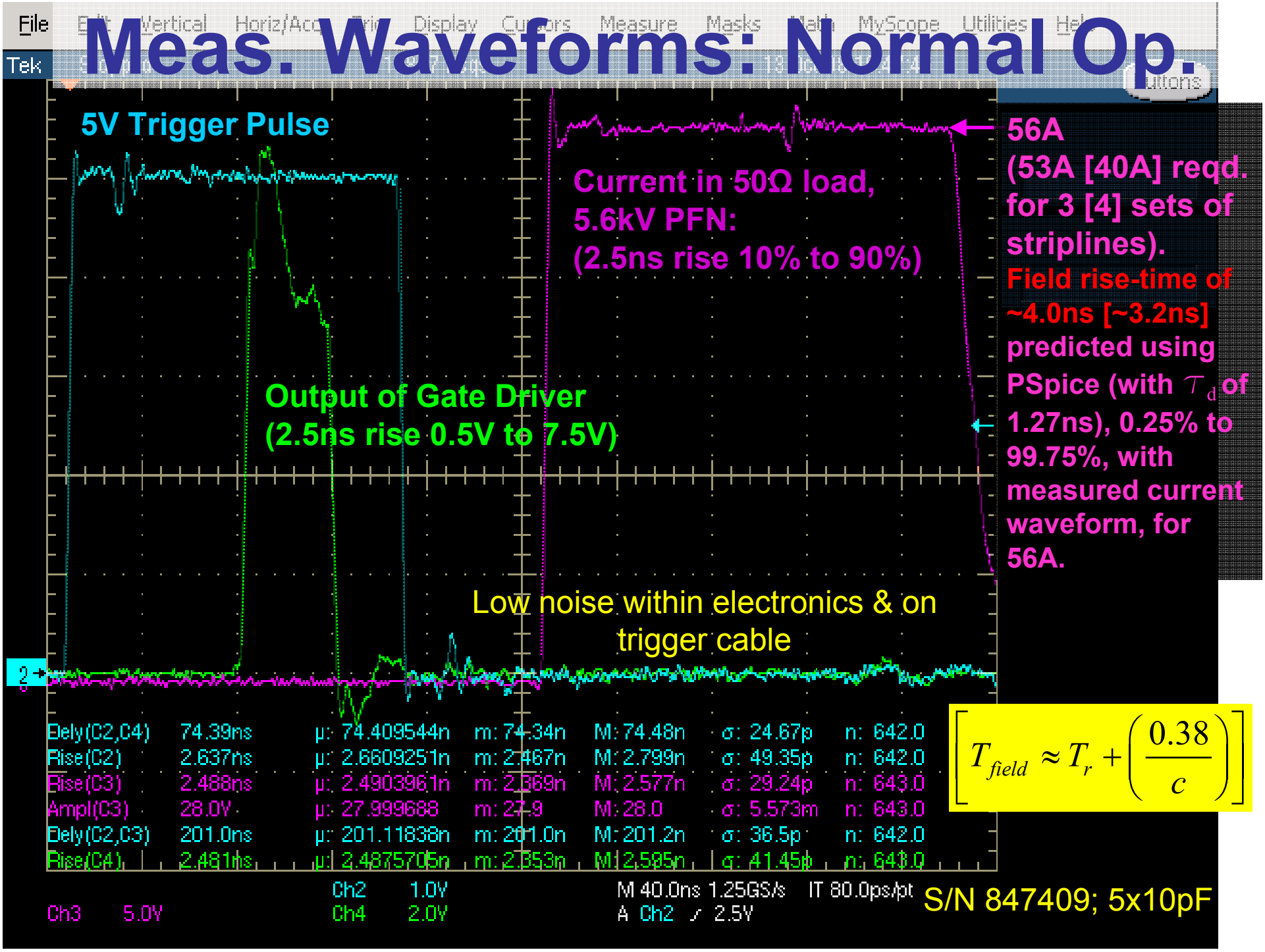
Gate Driver PCB
(9 Parallel 50Ω Outputs
[8 Behlke Switches])

Previous measurements on Behlke switches show need for fast rising (few ns) trigger pulse ≥ 7V.



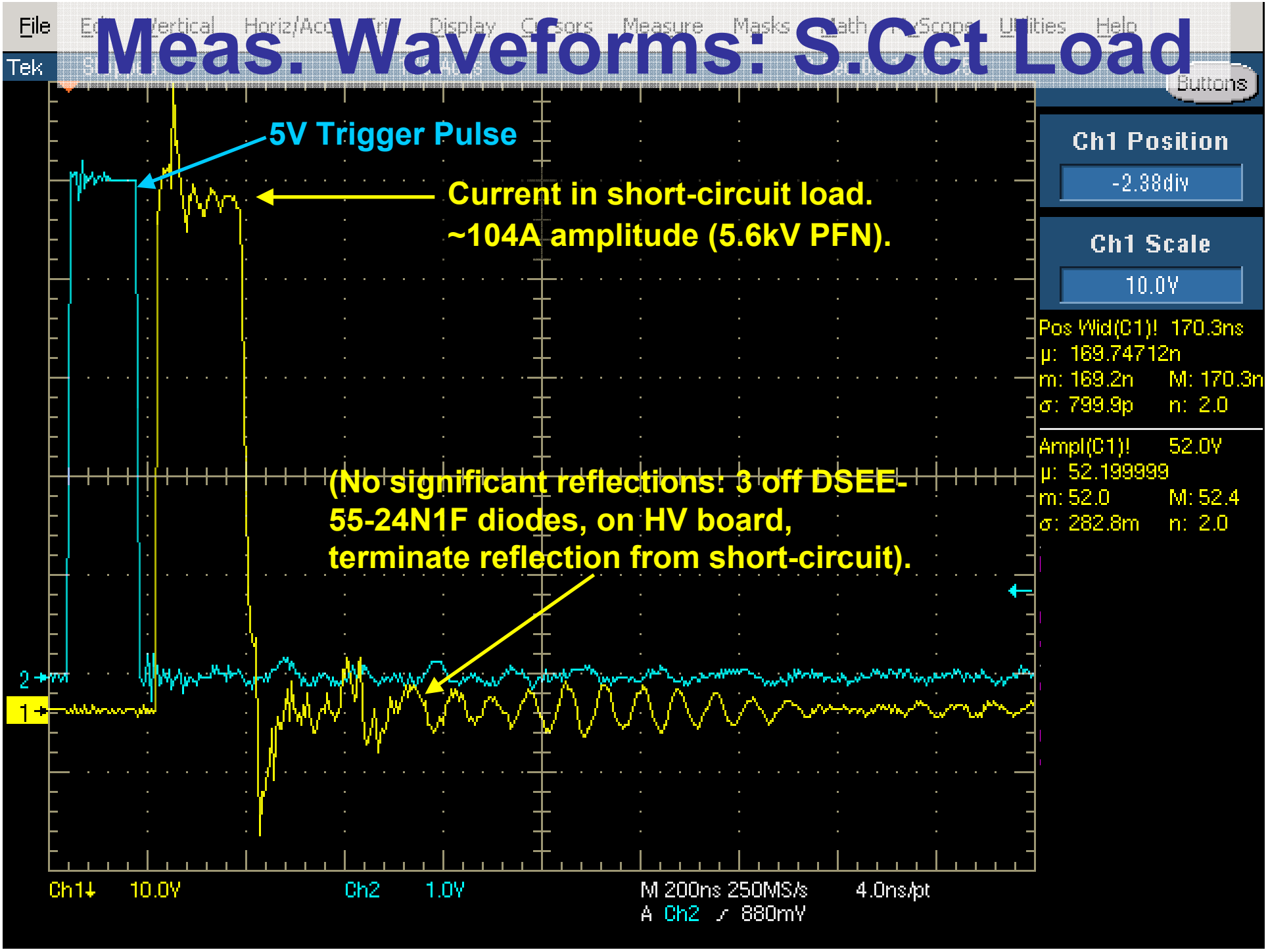
Behlke Switch: Very Low Inductance Connections

Meas. Waveforms: Normal Op.



$$\left[T_{field} \approx T_r + \left(\frac{0.38}{c} \right) \right]$$

Meas. Waveforms: S.Cct Load

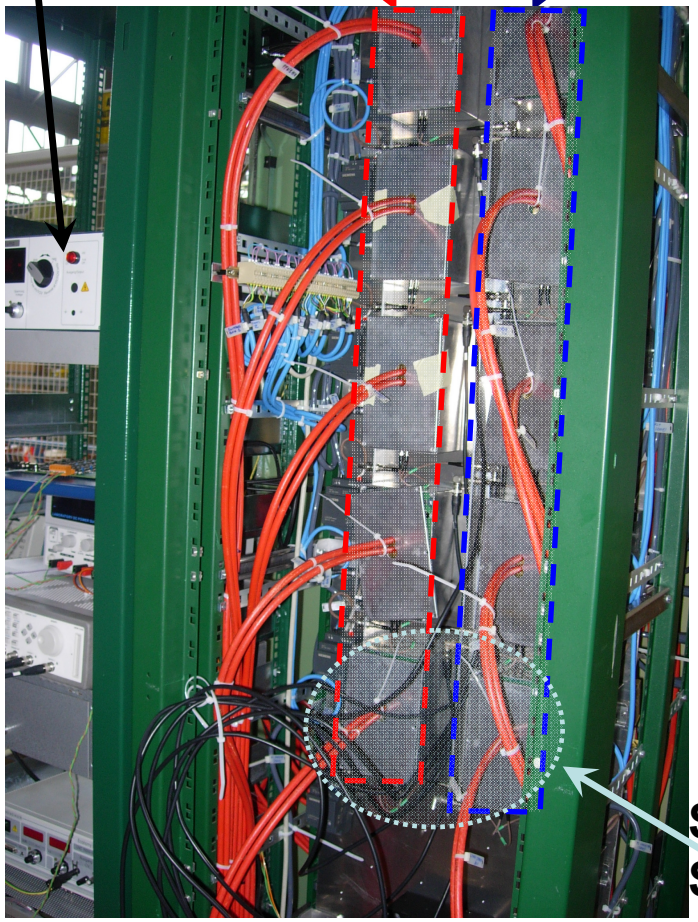


Kicker Cabinet During Assembly

HVPS

5 x Positive Polarity Switches

5 x Negative Polarity Switches



Spare Switches

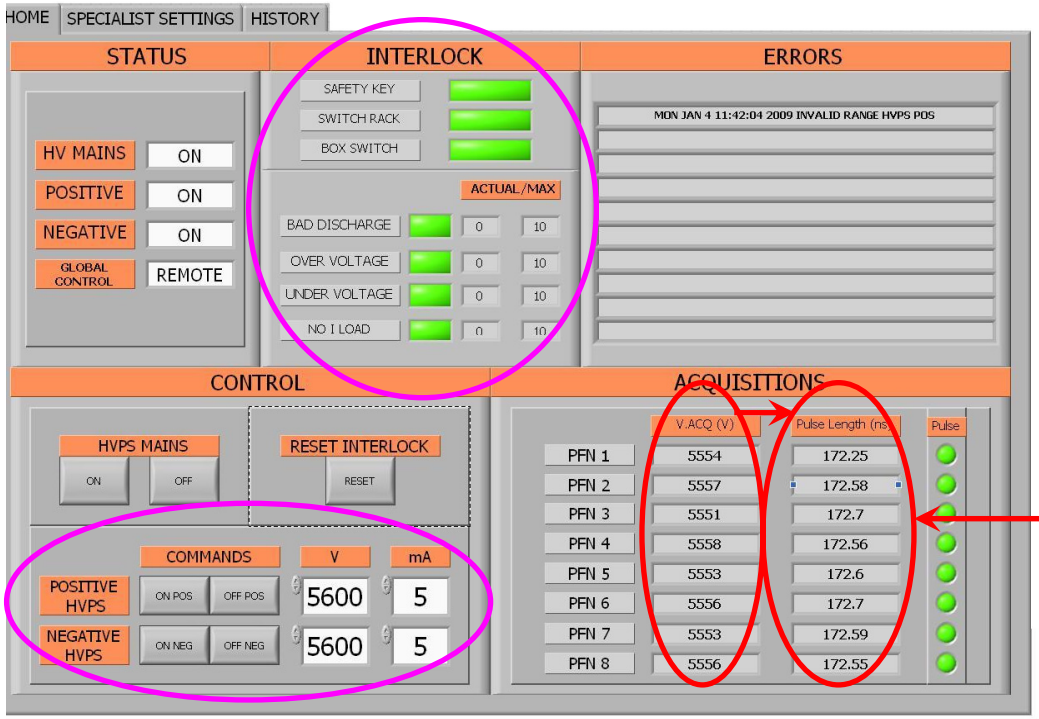
"Top" CT to Control Room

"Bottom" CT to Integrator or Local Diagnostics

FRONT VIEW

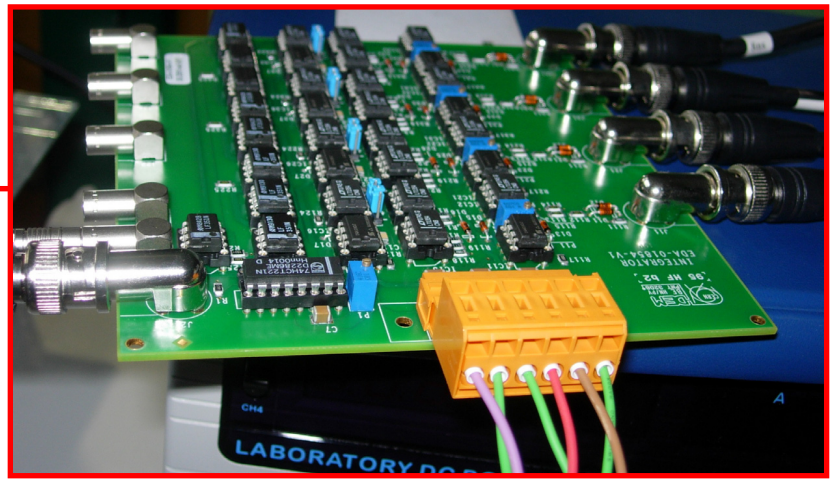
BACK VIEW

Diagnostics & Controls



Screen-Dump: Local Controls

(courtesy of Jan Schipper)



Four Channel Integrator Card, for "Online" Local Diagnostics

Tail-Clipper Status

Striplines received at CERN early December 2008:

- Shock detector activated during shipment !, but no problems apparent;
- Impedance checked: 1 plate of a pair driven ⇨ 56Ω (as per predictions);
- HV pulses applied to striplines **in air** (6kV pulses to one plate at a time; ±5.6kV pulses to both plates of a stripline, simultaneously). No breakdowns;
- Results from Jan Hansen, re vacuum:
  - Leak rate $<1\times10^{-10}$mbar•l/s;
  - 8.8×10^{-8}mbar pressure on downstream gauge after 72 hours pumping; ⇨ expected pressure in TL2 line of ~1×10^{-7}mbar downstream of the kicker with the taper installed and using a standard CTF3 pumping port;
  - 3.4×10^{-9}mbar pressure on downstream gauge 5 days after a 120°C bake out for 24 hours ⇨ expected pressure in TL2 line of ~7×10^{-9}mbar downstream of the kicker with the taper installed and using a standard CTF3 pumping port (no bake out of striplines foreseen in the machine).
- Situated in TL2.
- **Fruitful collaboration with CIEMAT on BOTH TL2 Tail Clipper & CR Extraction kicker !**

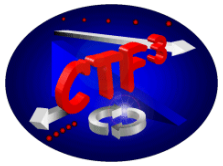
Tail-Clipper Status & Ongoing Works

- **Tests on TL2 Pulse Generator:**
  - **show excellent (fast) rise-time;**
  - **system has been reliable**
  - **low noise levels within pulse generator.**
- **Kicker cabinets installed in building 6102, January 2009.**
- Method developed to measure relative timing of Behlke Switches: method to be applied and, if necessary, relative timing modified.
- Radiation will be higher than originally appreciated, therefore cable connecters with ceramic insulators ordered (to replace existing connecters with plastic insulators).
- Cables between cabinets & striplines to be made, pulled & relative timing of pulses at striplines checked (before week 11 !!).
- FID (Fast Ionization Dynistor) expected delivery in 2 months time!! – will be evaluated.

Future Kicker Requirements

- **DRIVE BEAM**
  - Combiner Ring #1 Extraction (**2.4GeV**; ~830kHz burst rate for 63 pulses; 100Hz rep-rate; 240ns flattop; **voltage may be very high?? – depending on aperture**).
  - Combiner Ring #2 Extraction (**2.4GeV**; ~320kHz burst rate for 42 pulses; 100Hz rep-rate; 240ns flattop; **voltage may be very high?? – depending on aperture**).
  - Decelerating ring kickers (extraction into decelerating structure) – 42 systems!; **Pulse to pulse stability may be important**.
  - Phase feedback kickers (<100ns latency) – 96 kickers per side!.
- **MAIN BEAM**
  - Injection and Extraction. Extraction requires a **high stability flattop**.
  - Inter-train feedback kickers at intersection points (**pulse to pulse correction**). 1TeV, 1nrad, **<40ns latency (10ns preferred).**
  - Beam Abort Kickers?? (e.g. 1 kicker per drive beam sector, **21st (final)** kicker per side (1.5 TeV) ⇨ **1T•m**, 150Hz: R.W. Assmann, F. Zimmermann, "Efficient Collimation And Machine Protection For The Compact Linear Collider", EPAC06).
- **DAMPING RING EXTRACTION**
  - **High precision (e.g. ±1x10^{-4}),** 2.9GeV, 50Hz, 160ns pulse width, 1μs rise & fall, ~5mm aperture.

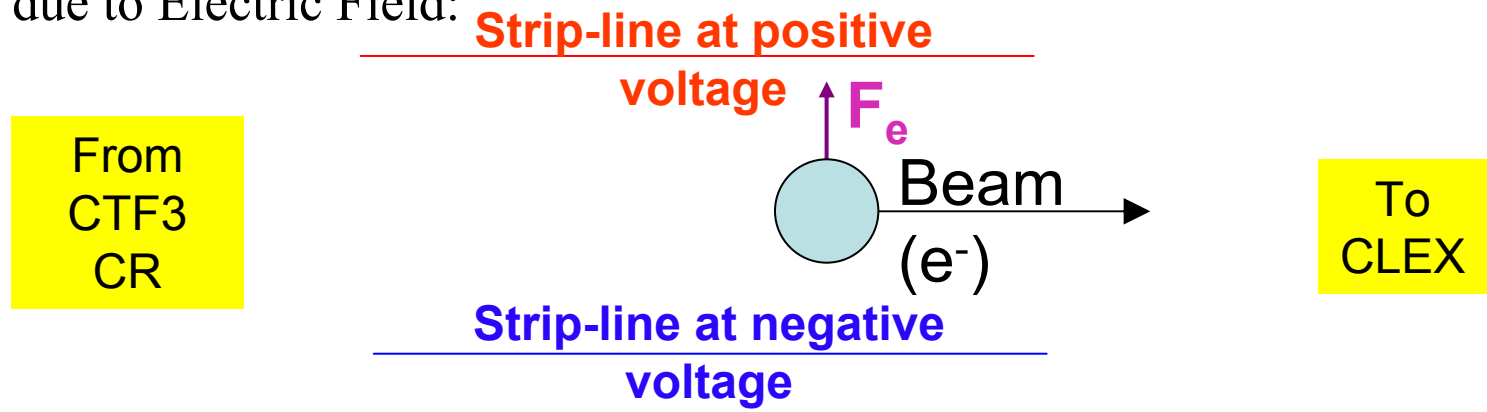
Table of preliminary parameters, for above, to be presented to kicker group, for discussion, in next couple of weeks ! – important for our input into CDR.



Questions ???

Tail Clipper: Deflection

Deflection due to Electric Field:



Deflection due to Magnetic Field: