

Rectifier-Capacitor Threshold Tracer for mu2e Straw Chamber

Wu, Jinyuan

Fermilab

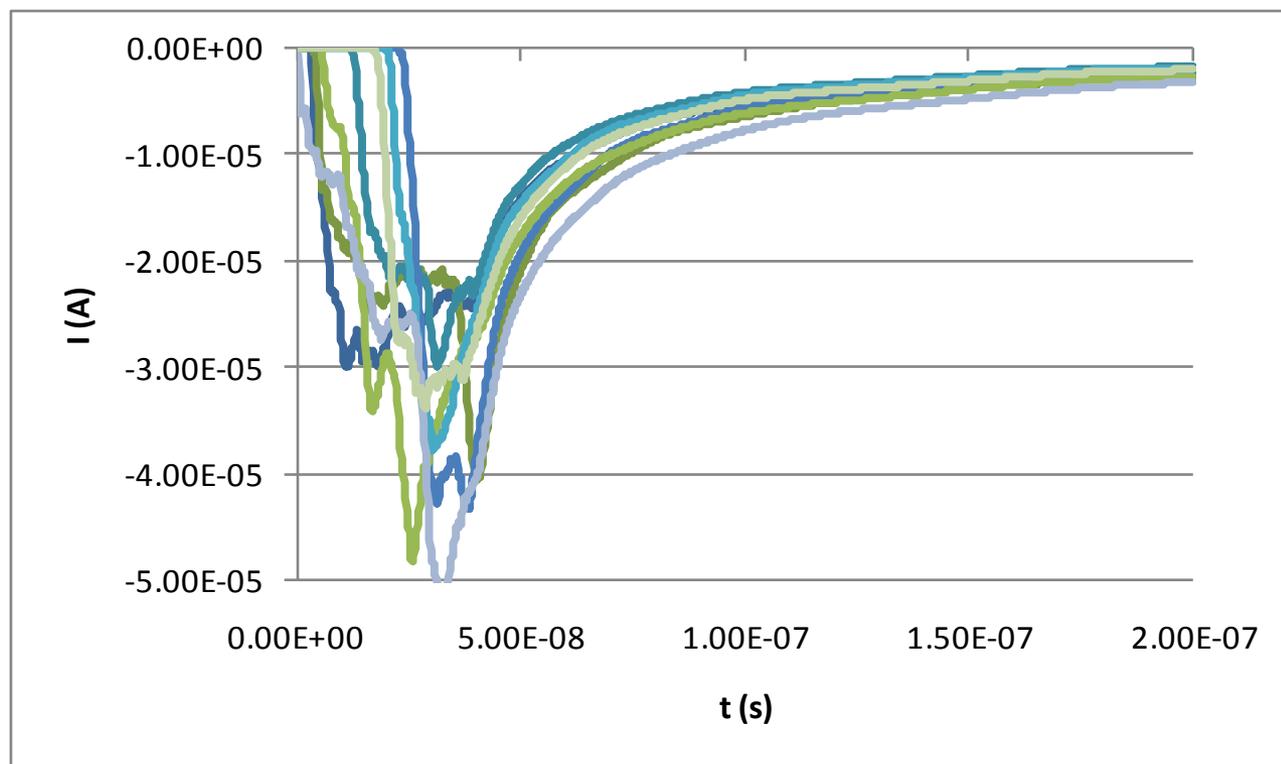
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Introduction

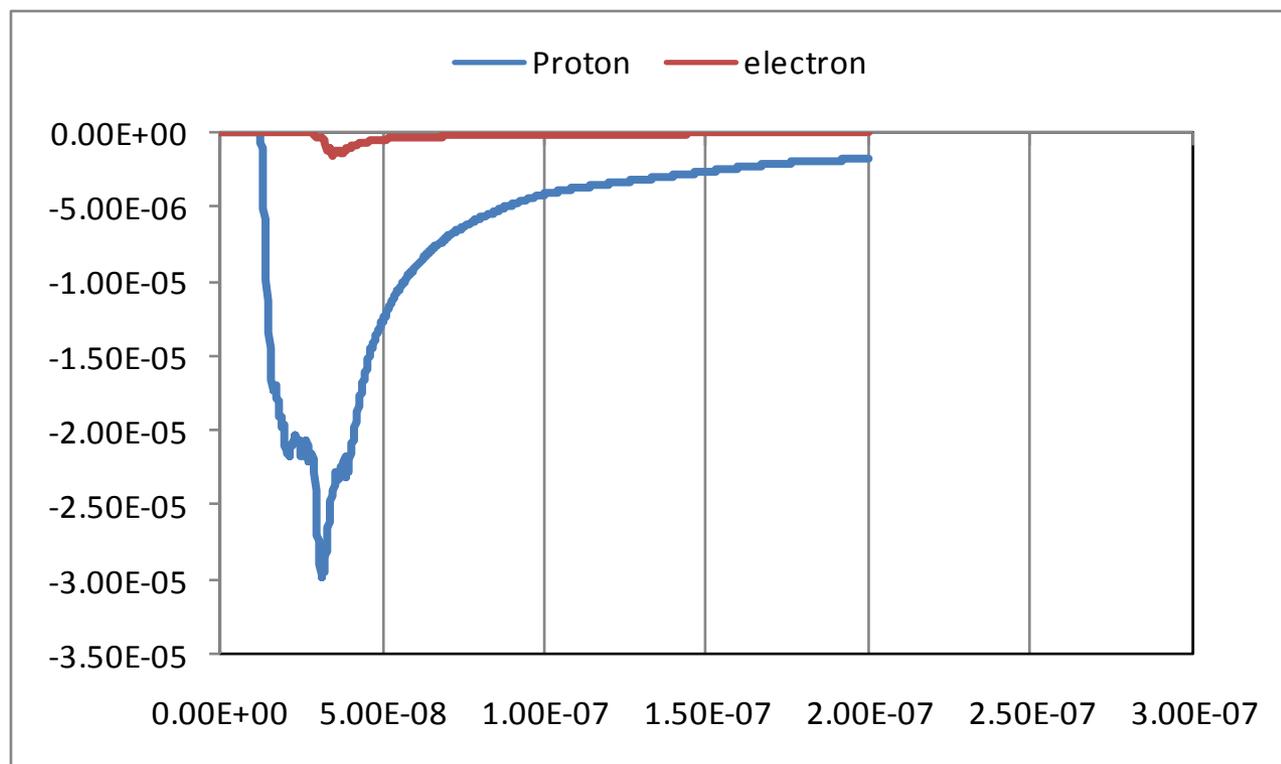
- Proton signals on straw tube chambers are large (20-50uA) and have long ion tails.
- Electron signals are small (0.5-5uA).
- Detecting electron after a proton hit is difficult.
- Usually, a shaper based on linear analog circuit is designed to reduce ion tails, but tuning RC parameters in shaper is challenging.
- A supplemental method, “Rectifier-Capacitor Threshold Tracer”, a nonlinear approach is studied.
- Data files are the outputs of the GARFIELD simulation that Aseet puts in docdb.

Hit Signals of Proton Hits



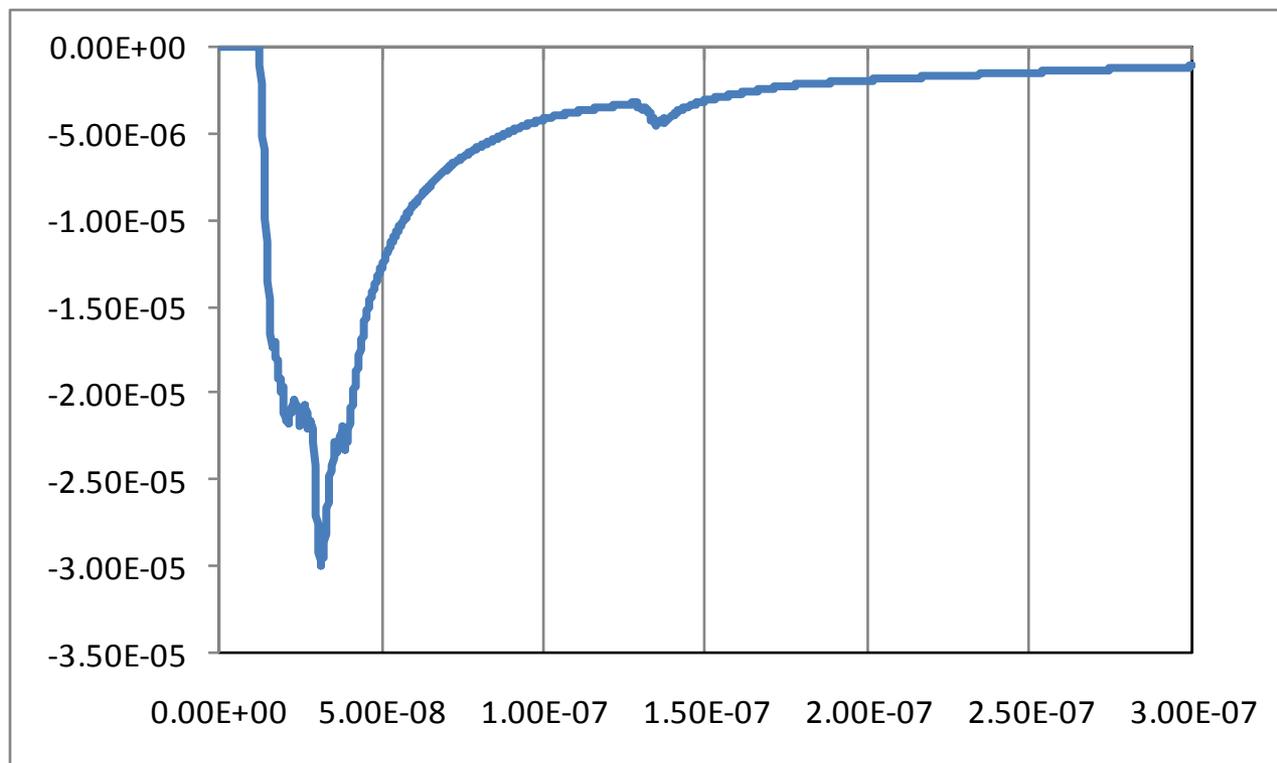
- Signals can be as large as 50 μ A.
- Complicate structure after leading edge.
- Long ion tails with various shapes.

Proton and Electron Hits



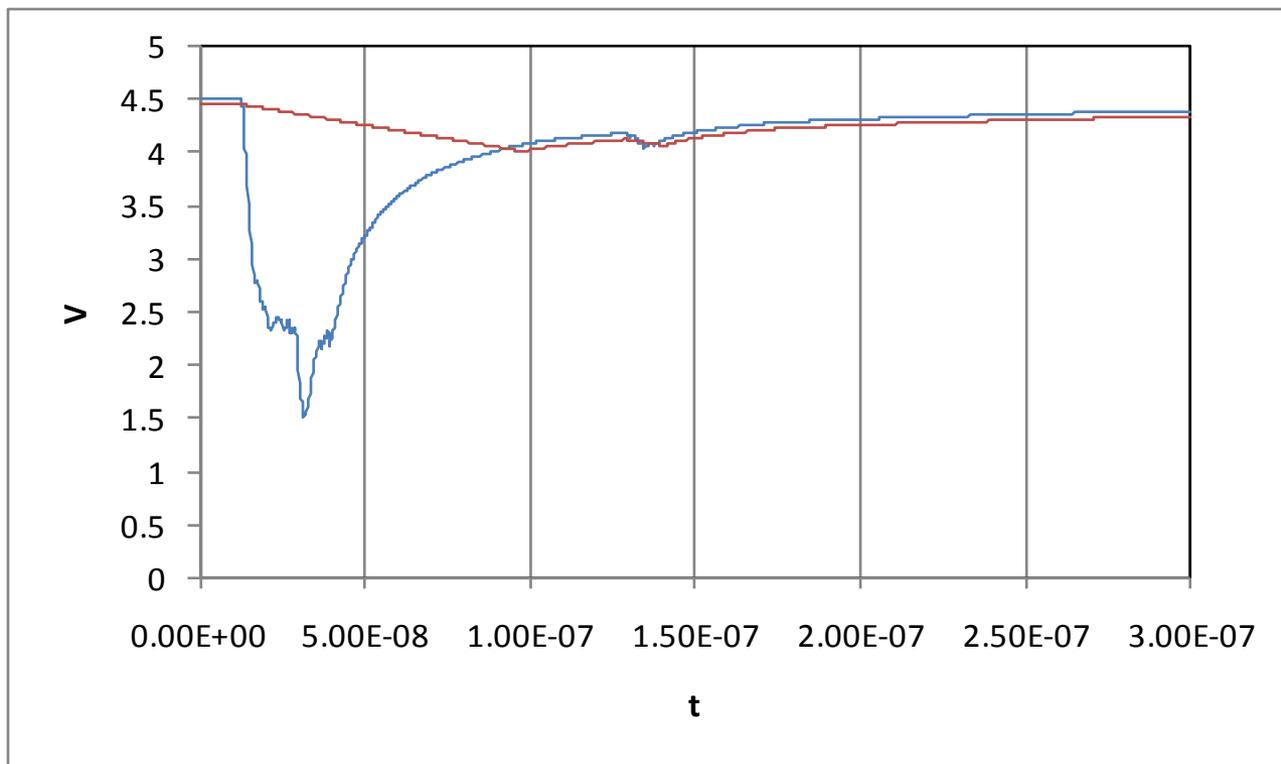
- Electron signals are low. (This one is 1.5uA).
- Electron signal heights are below the ion tails of proton hits for >200ns.
- The proton pulse is not the highest nor the electron pulse is the lowest.

An Electron Hit after a Proton Hit



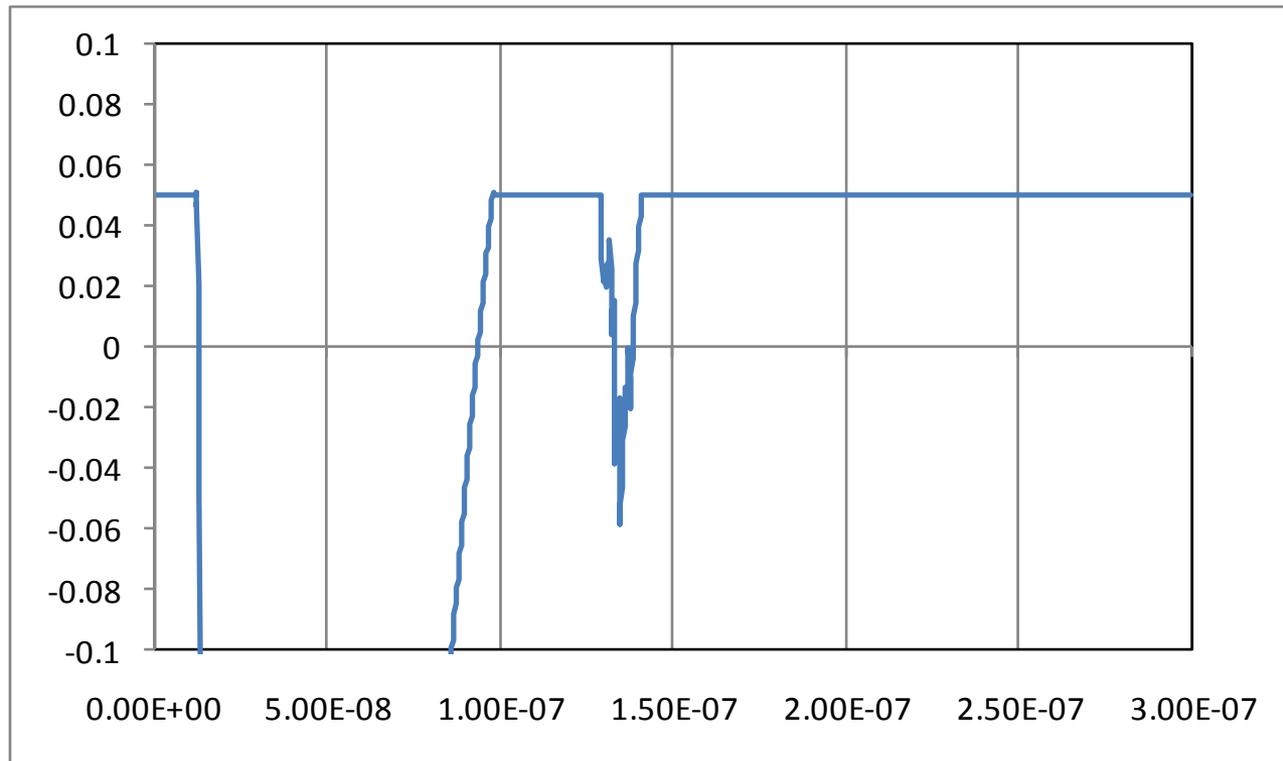
- The electron hit is delayed by 100 ns.

The Signal and the Threshold



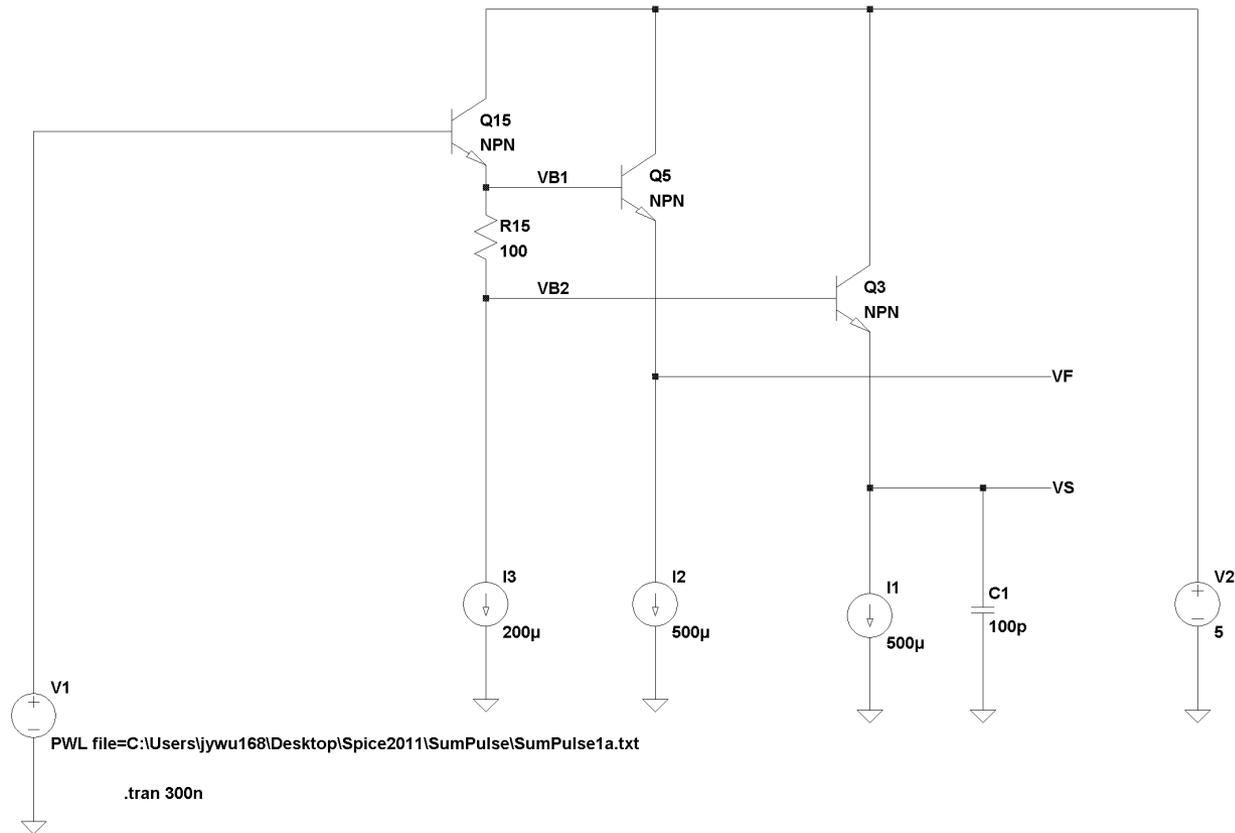
- The current is amplified and converted into voltage ($V = 100k \cdot I$).
- If a (moving) threshold as shown can be generated, then both the proton and the electron hits can be detected.
- The threshold traces tail ramp only while allows leading ramp to pass through.
- Time-over-threshold (TOT) can be used to distinguish protons and electrons.

The Difference of the Signal and the Threshold



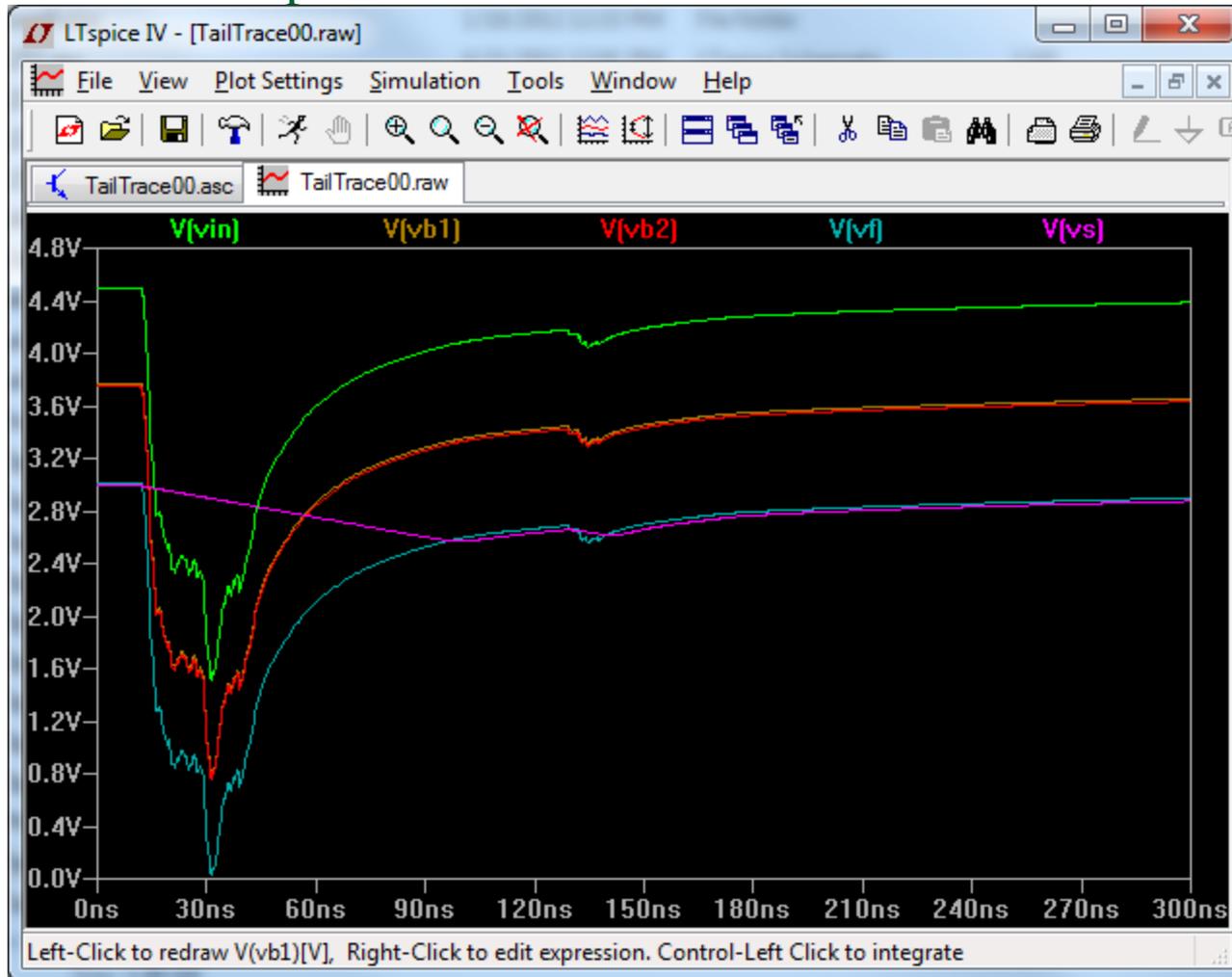
- The curve is the difference of the signal and the threshold shown in previous slide.

Circuit for Spice Simulation



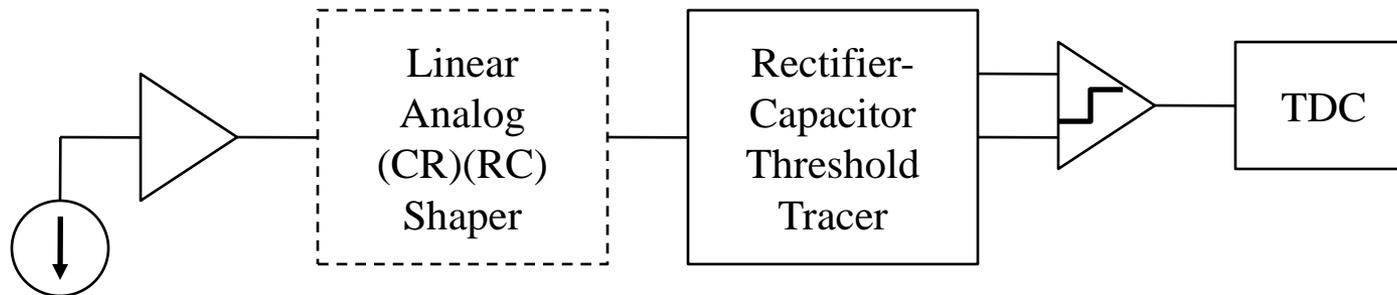
- Two stages emitter followers are used.
- Threshold is adjusted with $I3 \cdot R15$.
- The signal VF follows input on both leading and trailing ramps.
- The node VS only follows the trailing ramp. (Q3 turns off when input going negative.)

Outputs from Spice Simulation



- Top trace: input voltage.
- Middle traces: emitter follower outputs with 20 mV difference.
- Lower traces: signal and threshold, inputs to a comparator.

Application of the Rectifier-Capacitor Threshold Tracer



- Straw tube signal is amplified.
- A linear shaper can optionally included in the design (perhaps in gain stage).
- The Rectifier-Capacitor Threshold Tracer produces a emitter follower version of input signal and a threshold.
- The signal and the threshold are send to a comparator to generate logic pulse.
- Both of the leading and trailing edge times are digitized in TDC.

Comments

	Linear Shaper	Rectifier-Capacitor Threshold Tracer
Ion tail shapes	Matter	Don't matter
Over- or under-shooting	Possible	No
Slowing down leading edge	Possible	No
EMI from 60 Hz, High Voltage, AM broadcast	Matter	Don't matter
Baseline drifts due to temperature	Matter	Don't matter

To DO

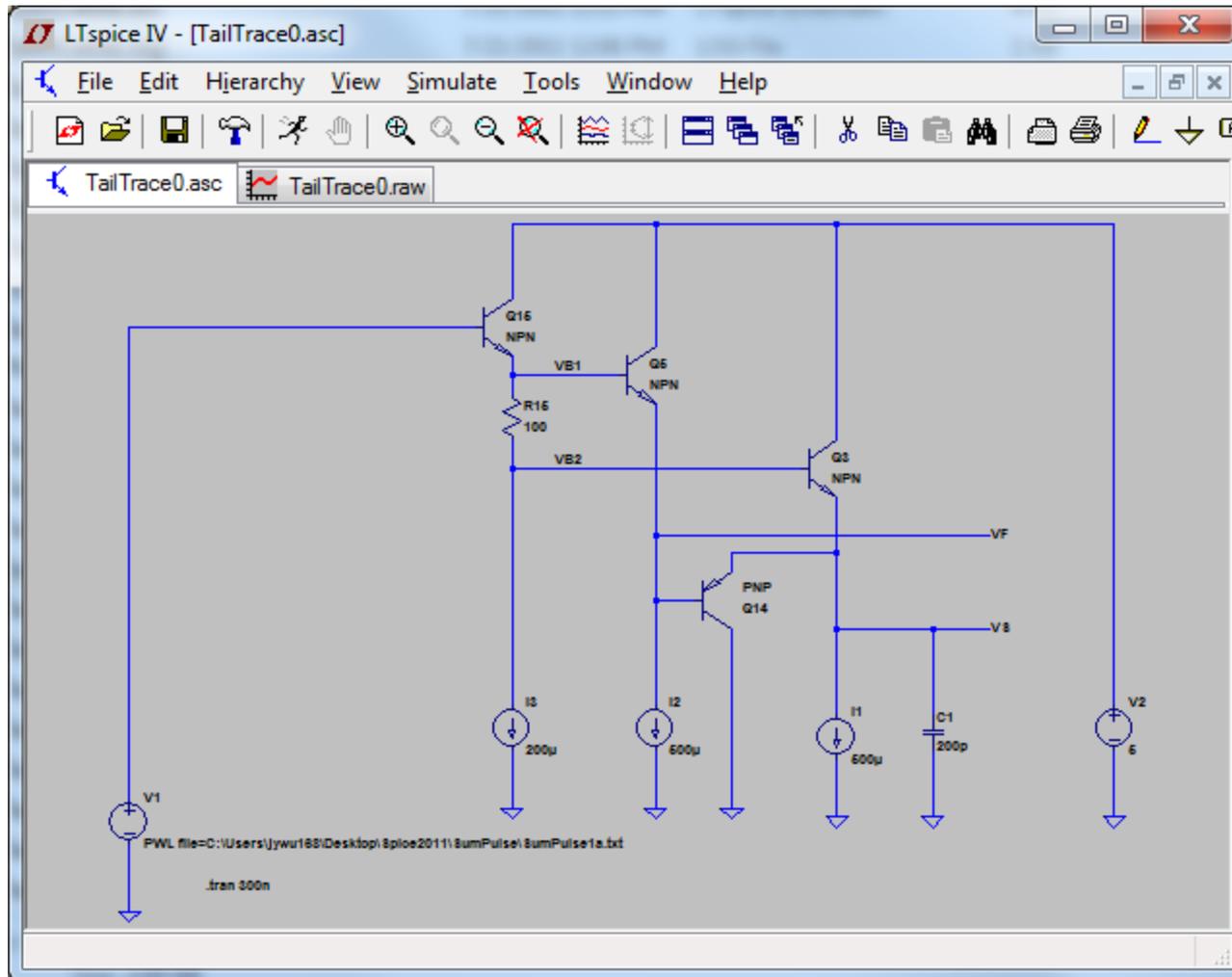
- More simulations using GARFIELD files.
- A test card for total dose radiated FPGA will be made. A test circuit of the Rectifier-Capacitor Threshold Tracer will be carried on this card and tested.
- This circuit is suitable not only for implementing with discrete components, but also for implementing in ASIC. Is this possible to try this circuit in our ASIC?

The End

Thanks

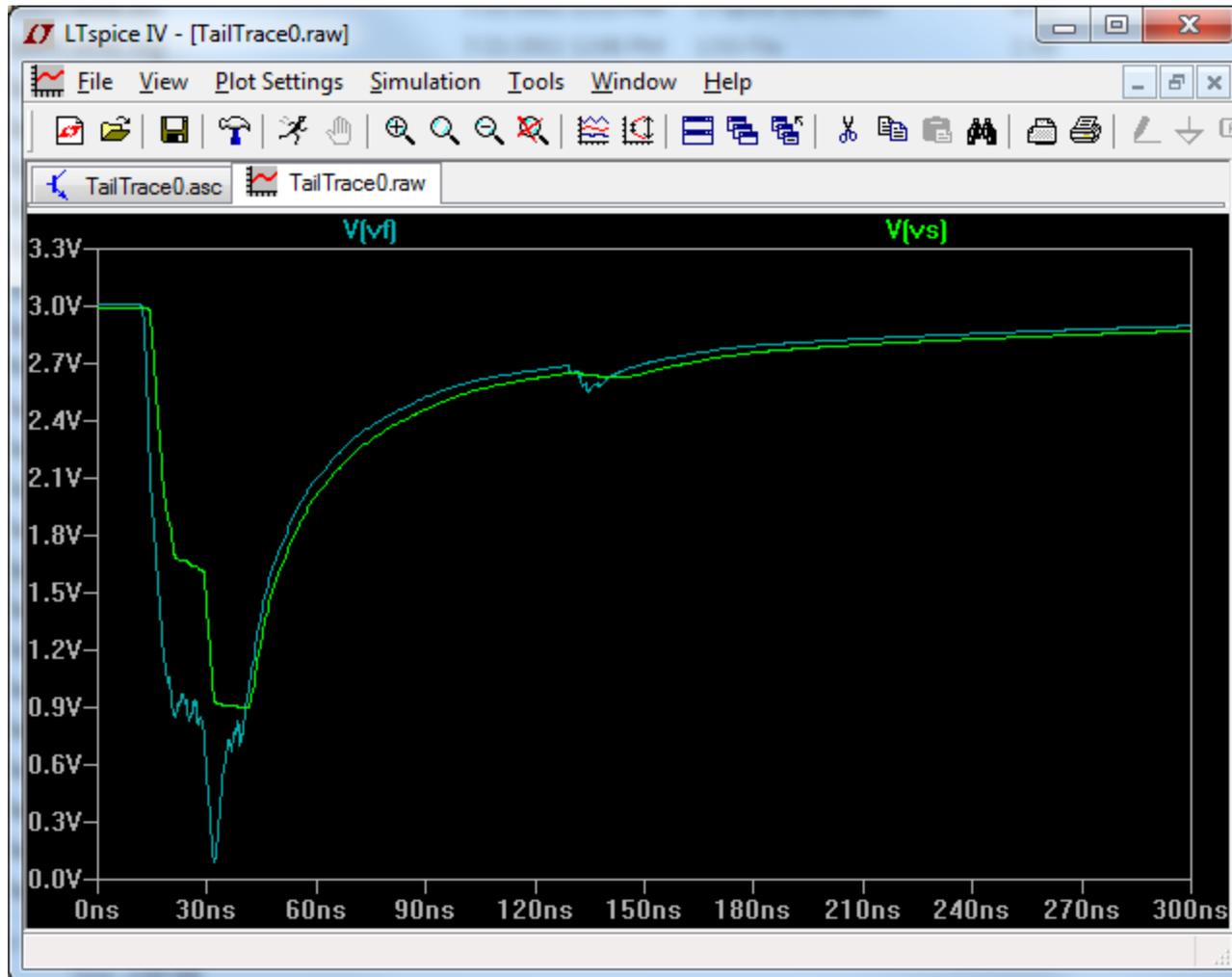


Adding a PNP Emitter Follower



- A PNP emitter follower is added to the node VS.
- There is a crossover (high impedance) region $\sim 0.7V$ for VS.

Outputs from Spice Simulation



- VS also follows on leading edge.
- More tail region can be used to detect close up electron pulses.