CBC2 CM studies

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some new evidence

some progress in understanding what's going on

workarounds & implications

systems meeting, 13th January, 2015.

CBC2 CM issues

noticeable increased sensitivity to comparator threshold in “electrons” mode

symptoms

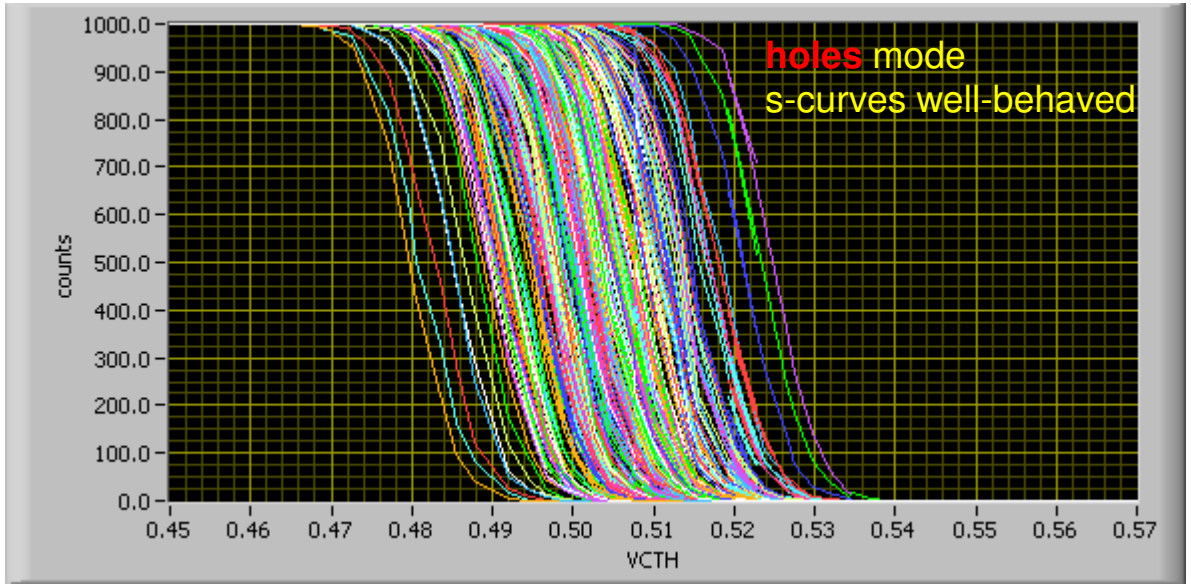
channels start to fire as threshold reduced - as expected

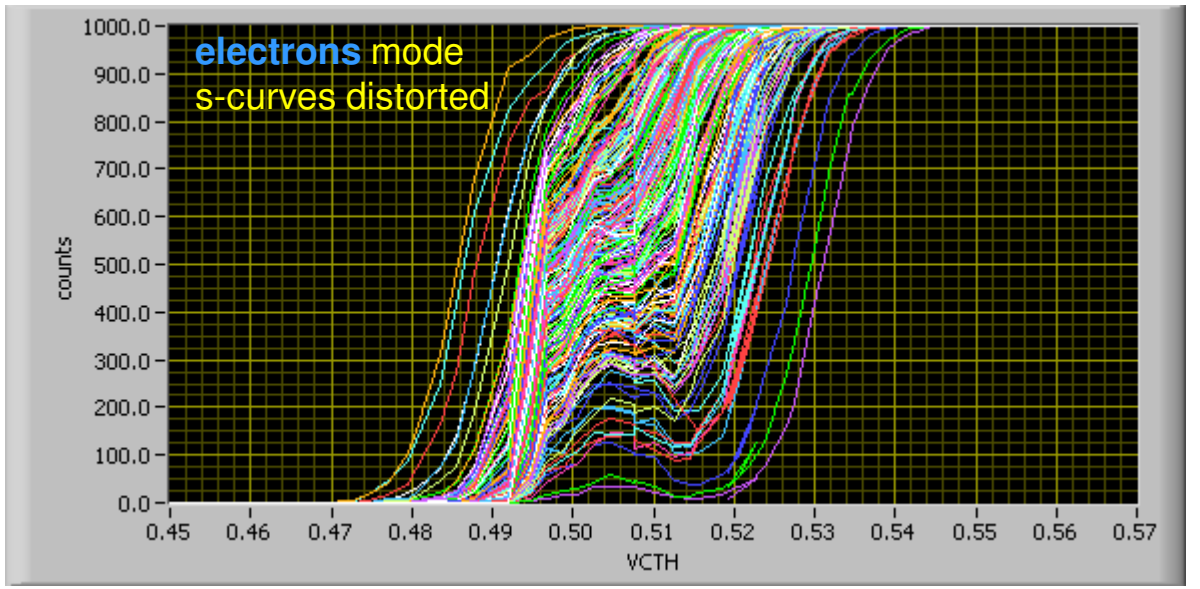
but at some point, when many channels firing, becomes “unstable”
i.e. all channels fire, or no channels fire

this doesn’t happen in “holes” mode

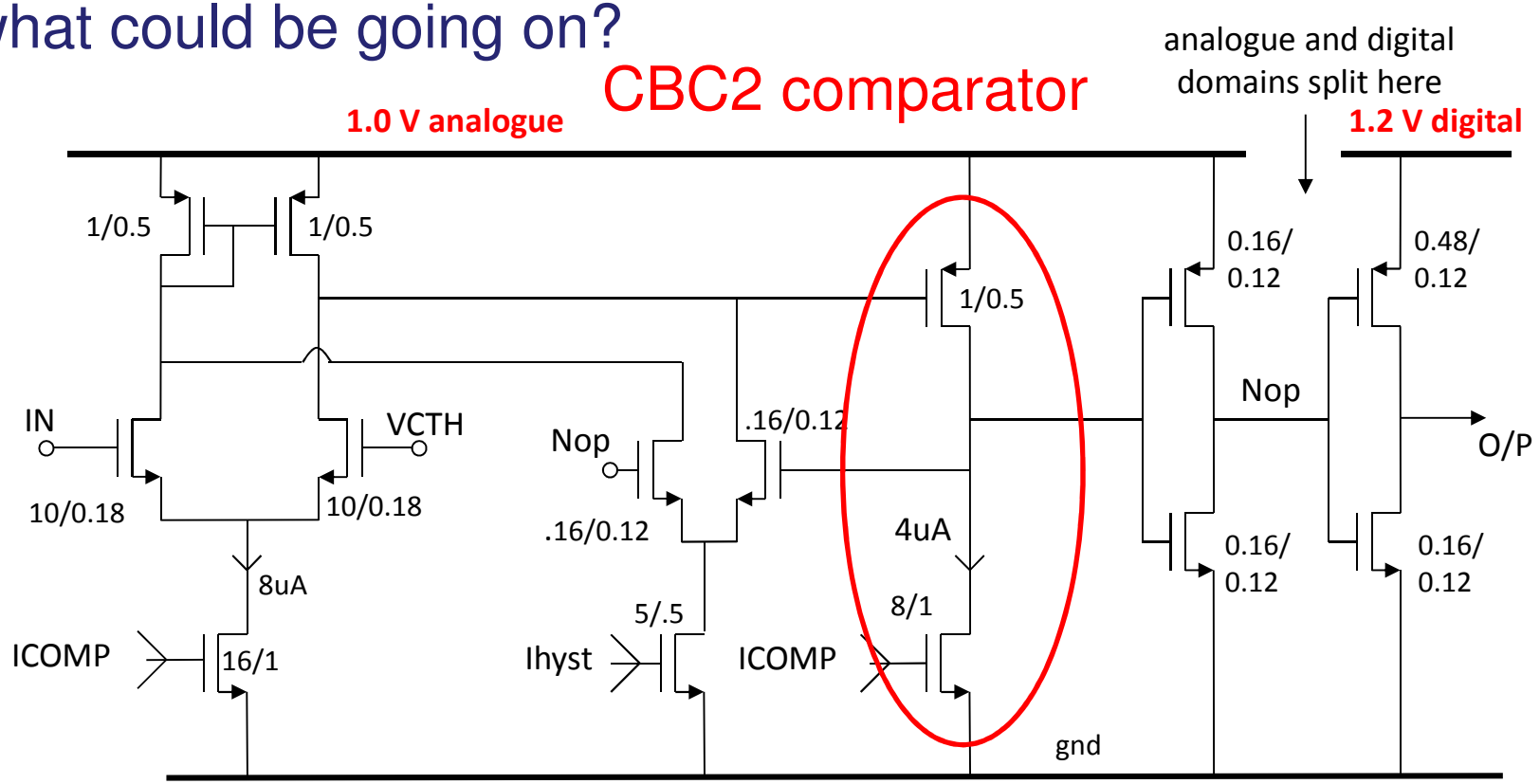
evidence - pedestals s-curves

channel offsets not tuned
plots show raw data
(vs. VCTH in Volts)





what could be going on?



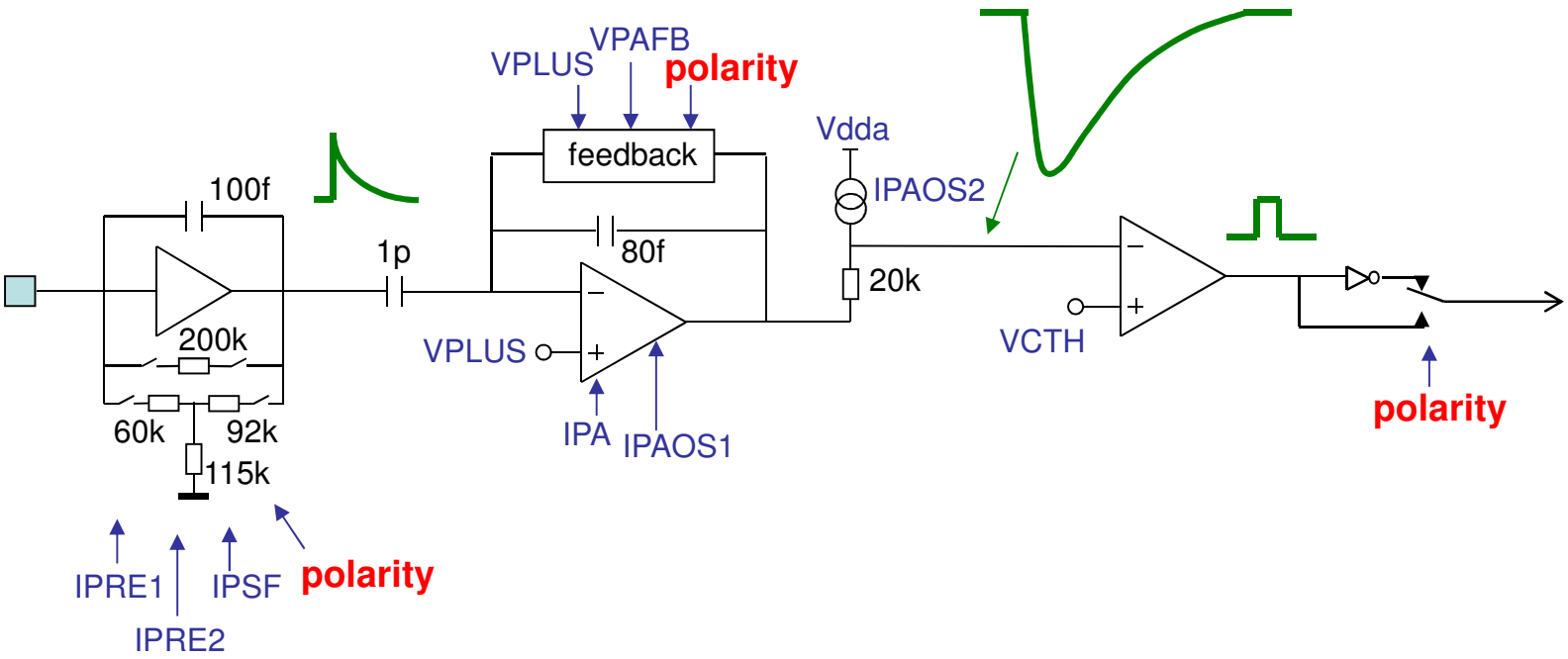
seems reasonable to suspect something associated with the comparator

output stage can cause supply current fluctuations as more and more channels fire

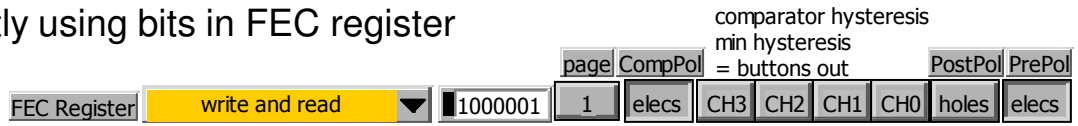
potential for power rail voltage disturbances coupling to other circuits

but why only problems in electrons mode?

CBC2 front end

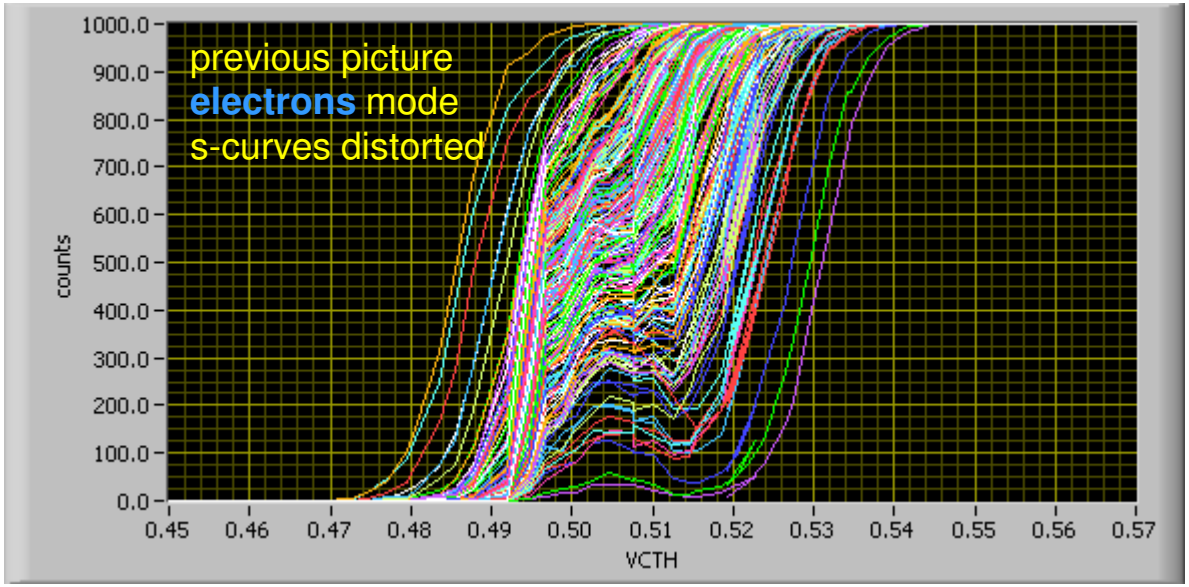


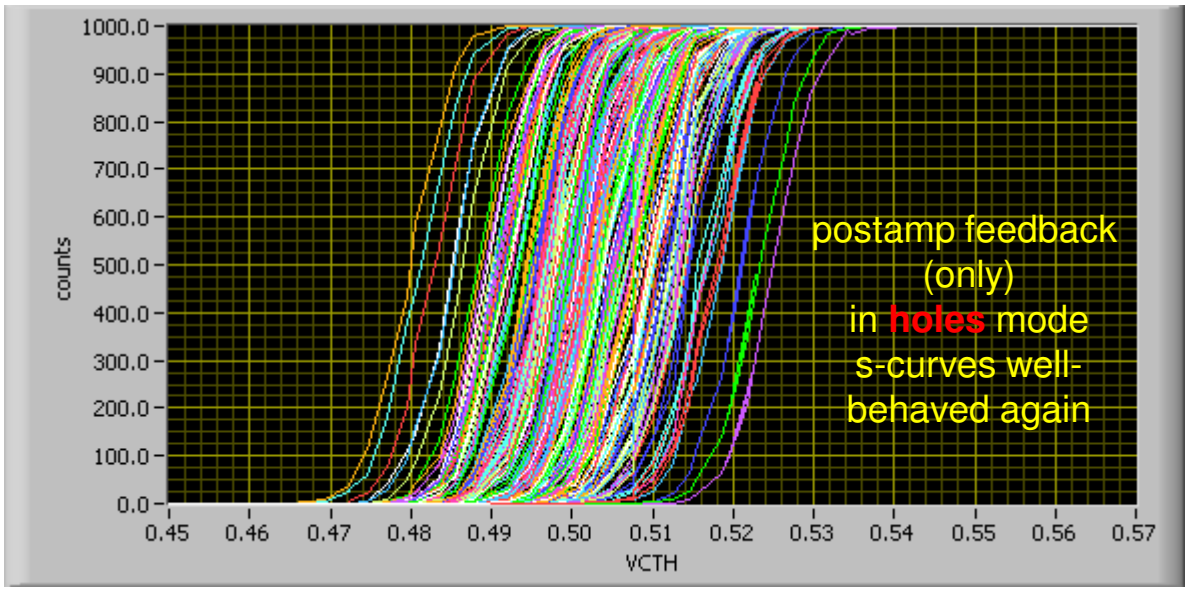
can select polarities independently using bits in FEC register



can use this flexibility to help diagnose what's going on

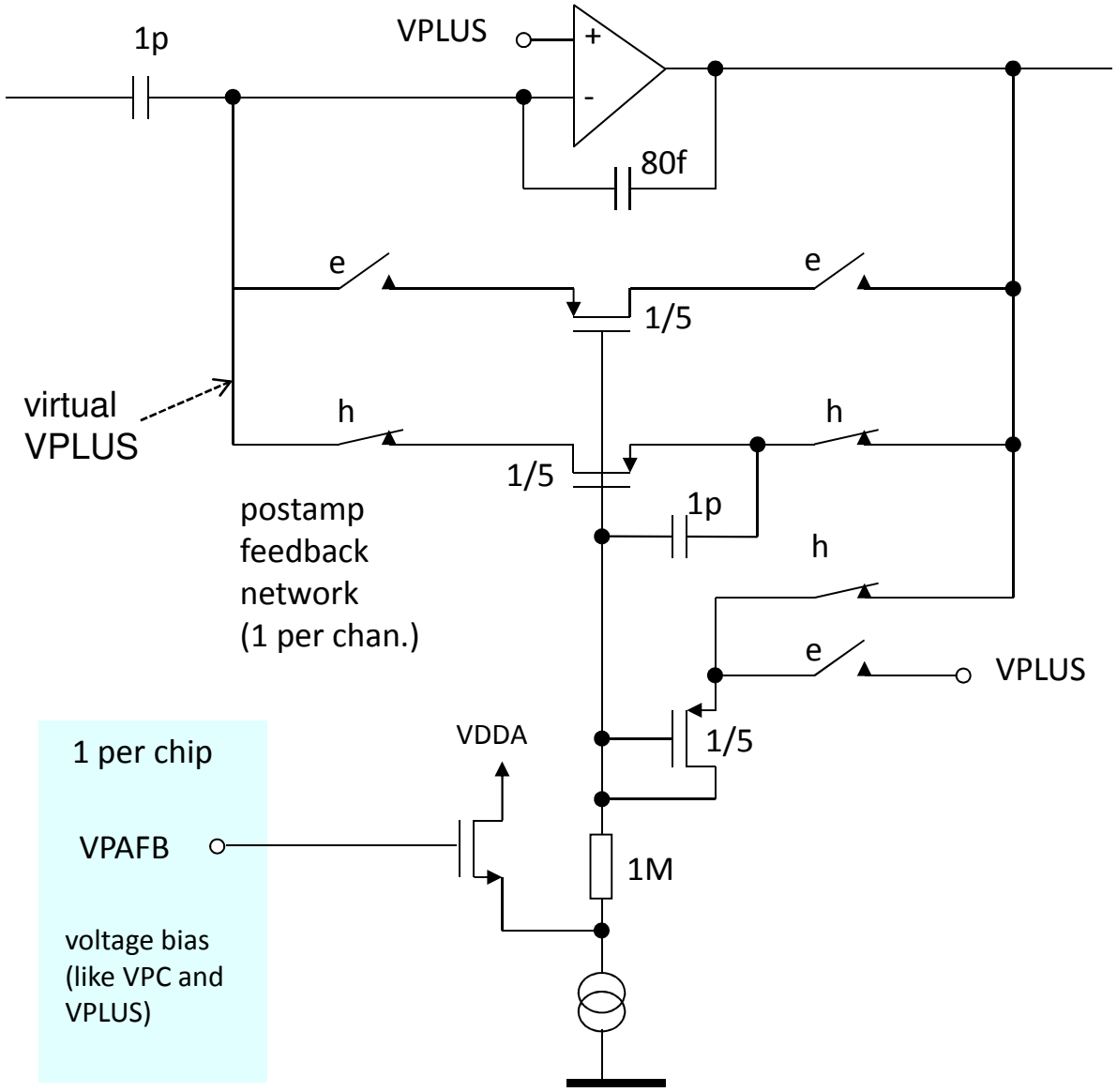
further evidence: stability returns if postamp feedback switched to holes mode





only **postamp** polarity in **holes** mode (preamp and comparator left in electrons)

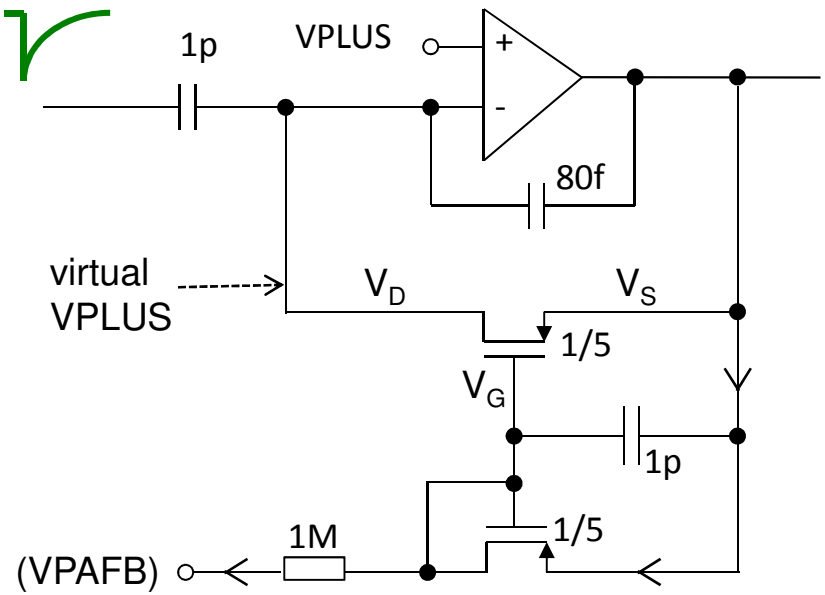
closer look at postamp(1)

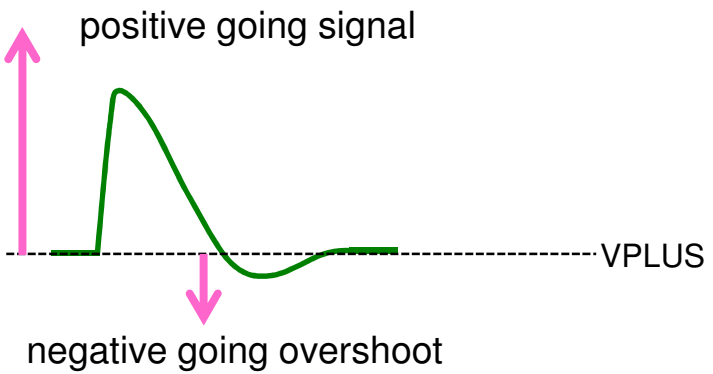


bit complicated - because of need to switch PMOS feedback FET polarity depending on polarity of signal swing (electrons/holes)

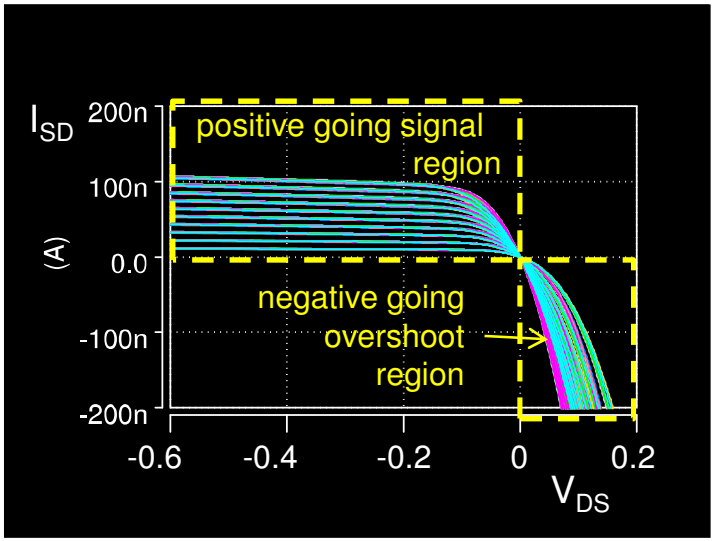
simplify by removing switches and looking at 2 modes separately

postamp feedback FET biasing - holes mode





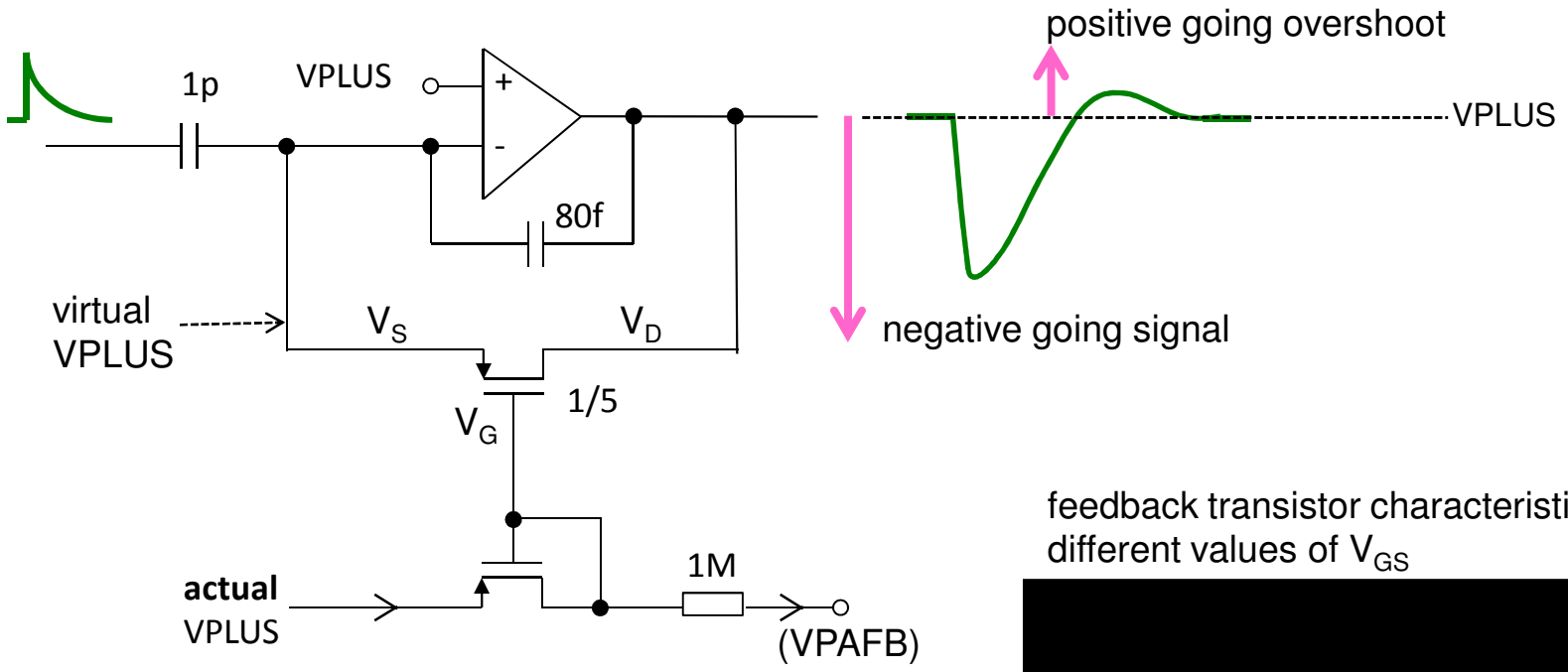
feedback transistor characteristics for different values of V_{GS}



"current mirror" biasing technique allows to exploit FET characteristic to get high resistance in signal direction and lower for overshoot (quicker restoration to baseline)

postamp output supplies current mirror bias current

postamp feedback FET biasing - electrons mode



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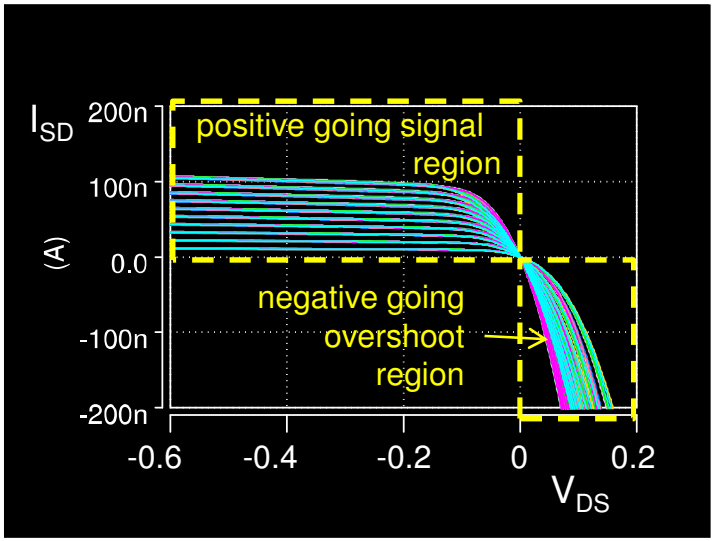
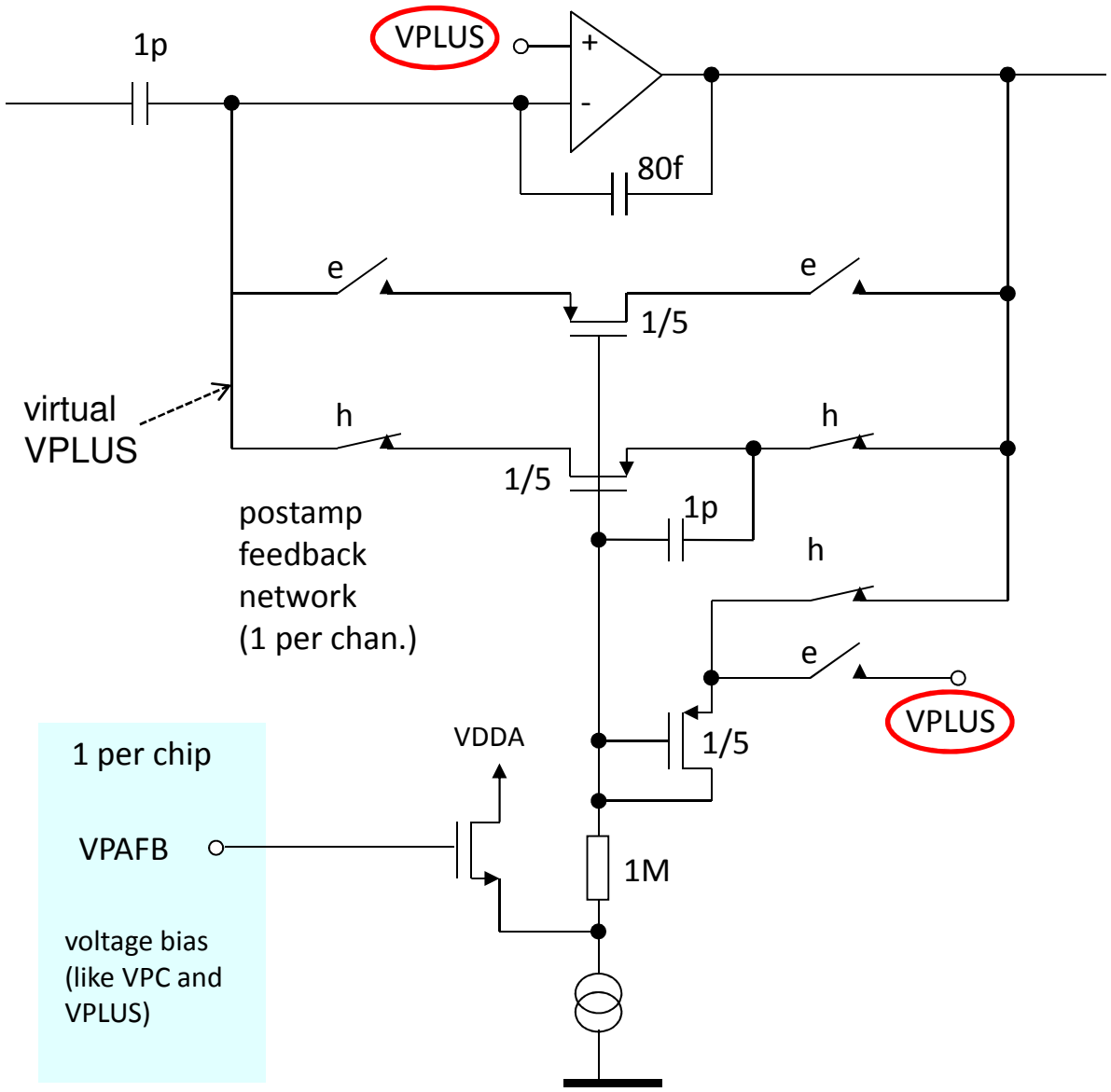


same technique in electrons mode but use actual VPLUS for mirror transistor source node (virtual node cannot supply DC current)

closer look at postamp(2)



suspect mirror transistor connection to actual VPLUS in electrons mode could be cause of problem

possibility for VPLUS to be affected by disturbance on VPAFB source follower node

(1M/254 = 4k)

=> possibility to affect non-inverting node of op-amp

in holes mode this is not the case

VPAFB generated by current through resistor to ground

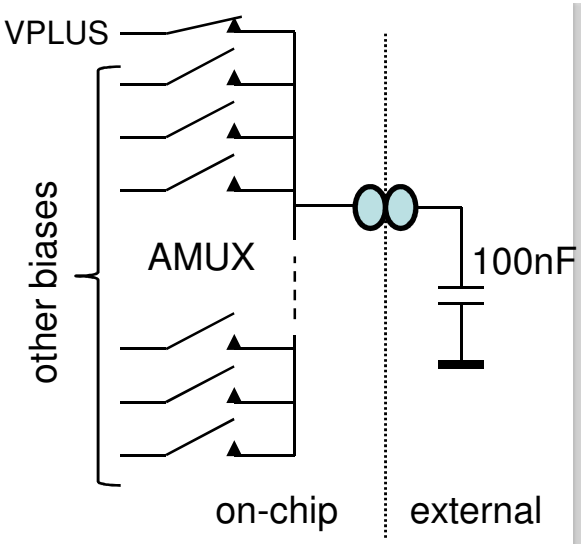
=> susceptible to disturbance on ground

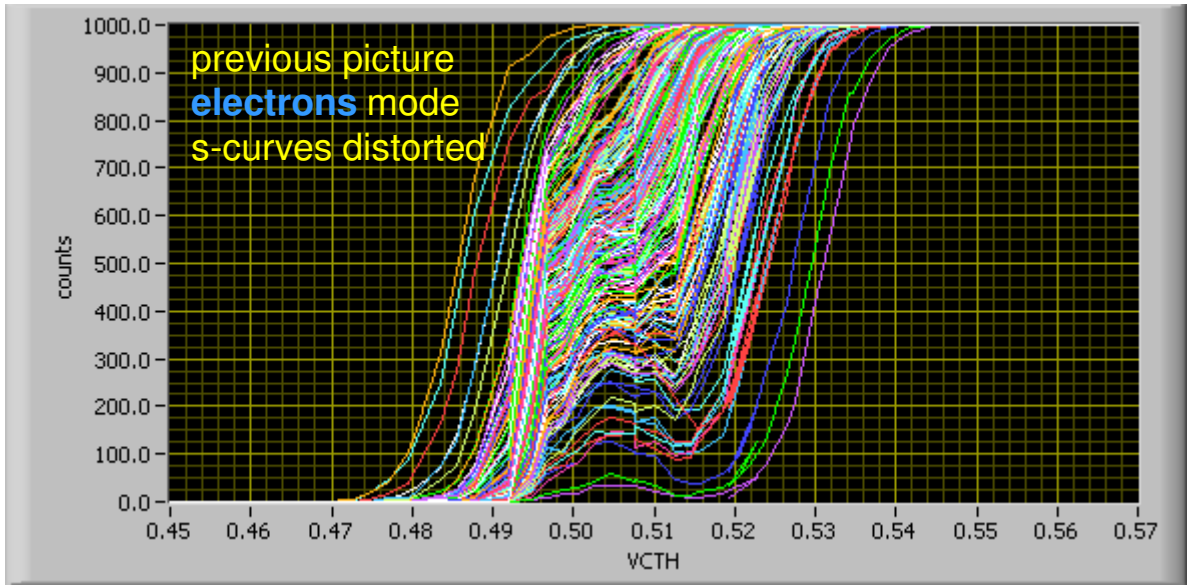
could this be the culprit?

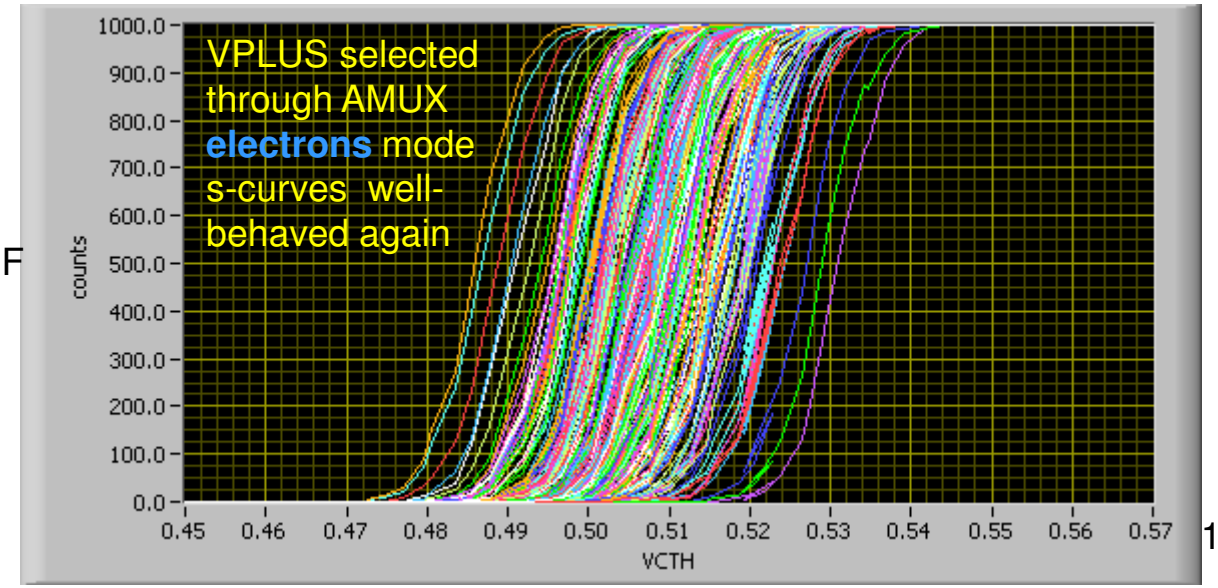
even further evidence: stability returns if VPLUS externally decoupled

program Analog MUX to select VPLUS. AMUX O/P is decoupled to GND by 100nF capacitor on 2CBC2 support board

(set 5 bit AMUX field in TP Cntrol & Analog Mux register to b00001)







summary so far

CM effect appears when a lot of comparator channels start to fire

there will be transient currents in comparator power rails when this happens

=> likely to produce disturbance to power/GND rail

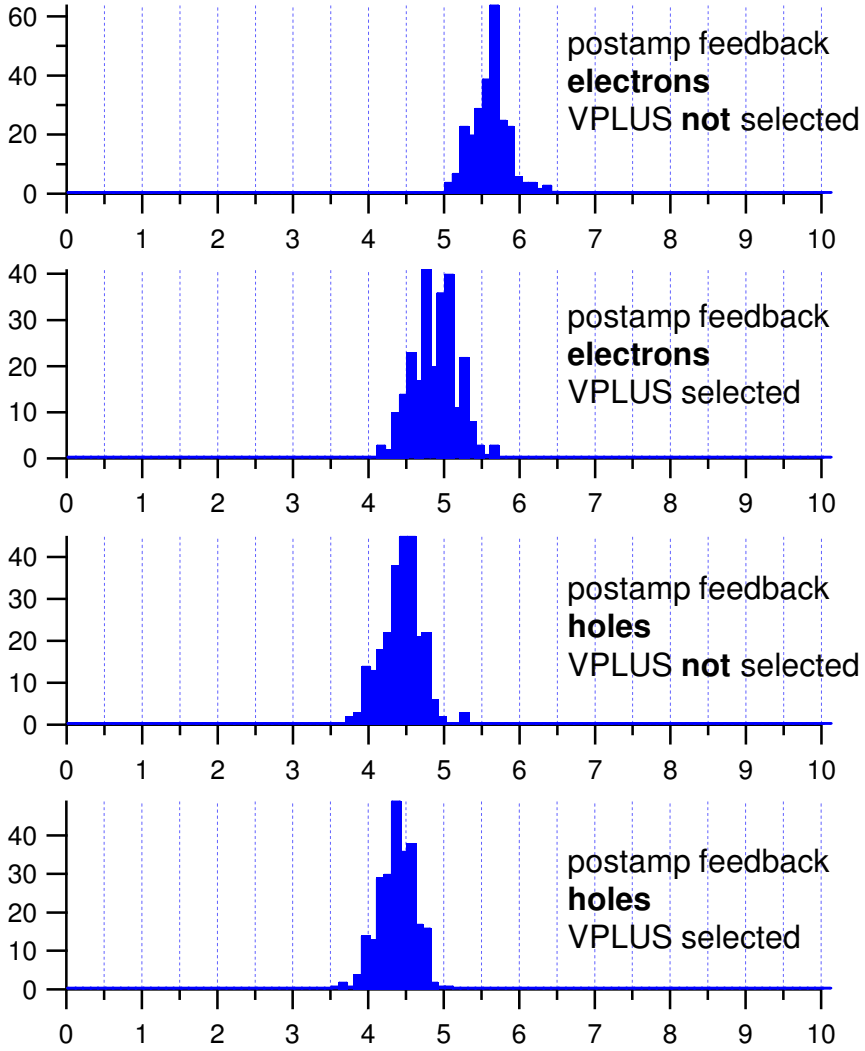
experimental evidence points to postamp feedback circuit implicated

only see effect when this switched to electrons mode

there is potential for VPLUS to be disturbed when circuit in electrons (not holes) mode

effect goes away if VPLUS selected through analog mux
(and therefore decoupled by external capacitor)

“normal” noise measurements



“normal” noise = noise determined from s-curves measured 32 channels at a time (VCTH translated to mV)

postamp in electrons mode

decoupling VPLUS by selecting through AMUX gives ~10% improvement

=> 32/254 channels occupancy enough to cause excess noise

postamp in holes mode

noise appears slightly less when postamp in holes mode (but pulse shape may be slightly different)

decoupling makes no difference

pulse shape measurements

possible workaround: could run postamp in holes mode for electrons polarity signals

but what happens to pulse shape?

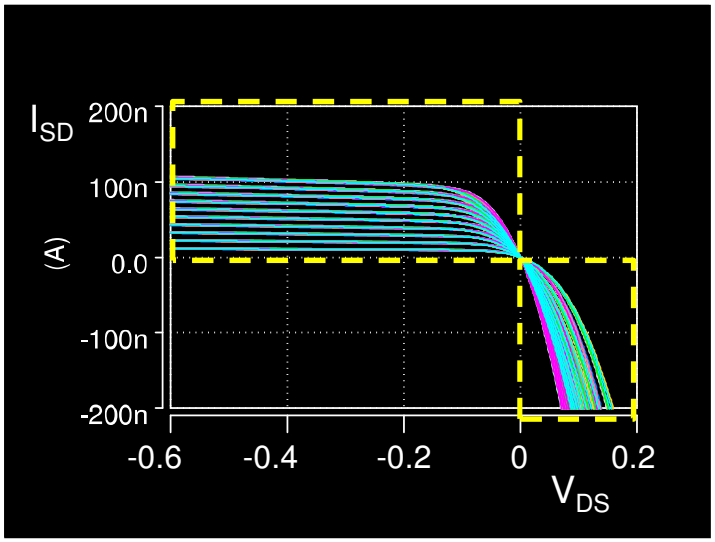
feedback resistance will be:

lower for signals -> can expect amplitude reduction

but higher for overshoot region -> expect overshoot amplitude to be higher

can we measure pulse shape?

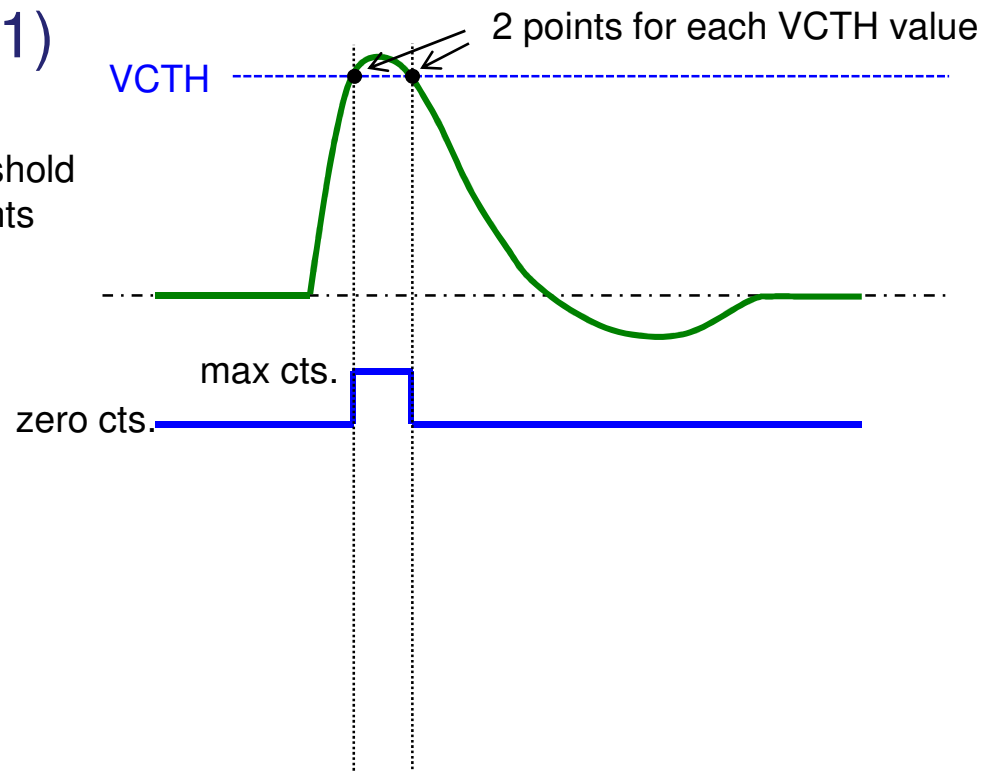
yes - but have to digress to explain measurement technique



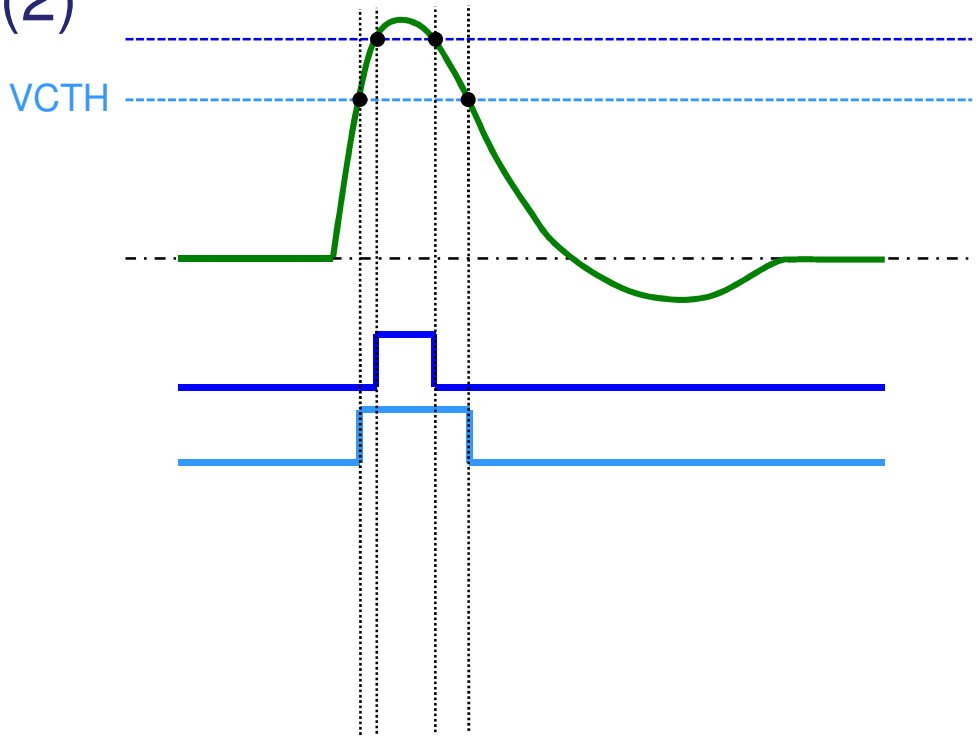
pulse shape measurement(1)

can measure pulse shape by sweeping time of charge injection for different values of threshold VCTH, recording transition times of zero counts to max. counts and vice-versa

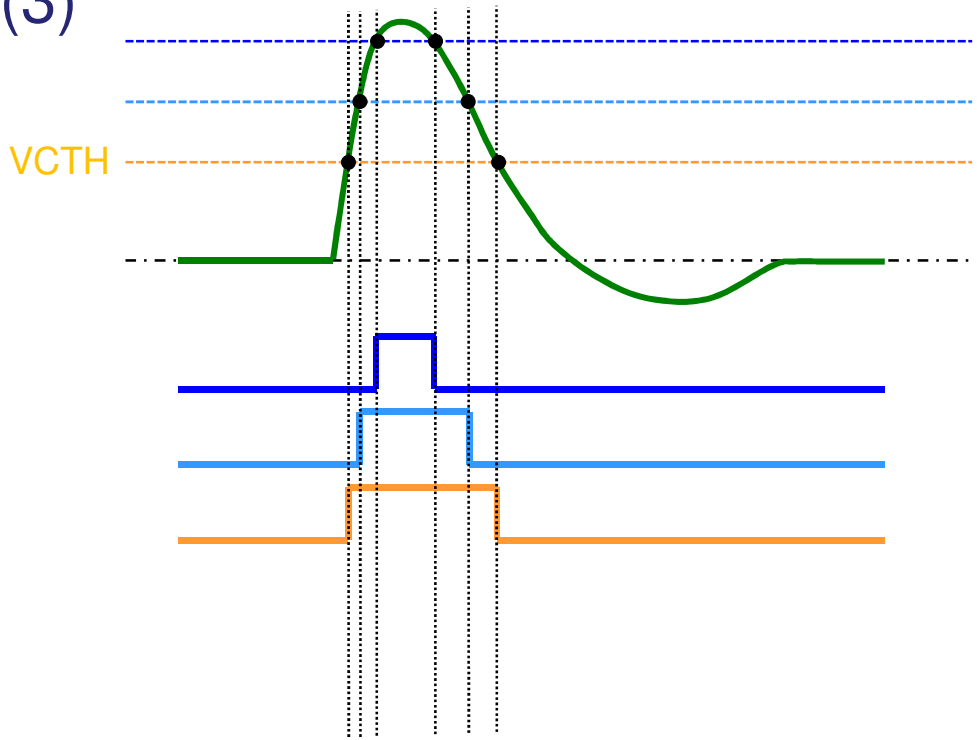
for each value of VCTH get 2 points on pulse shape



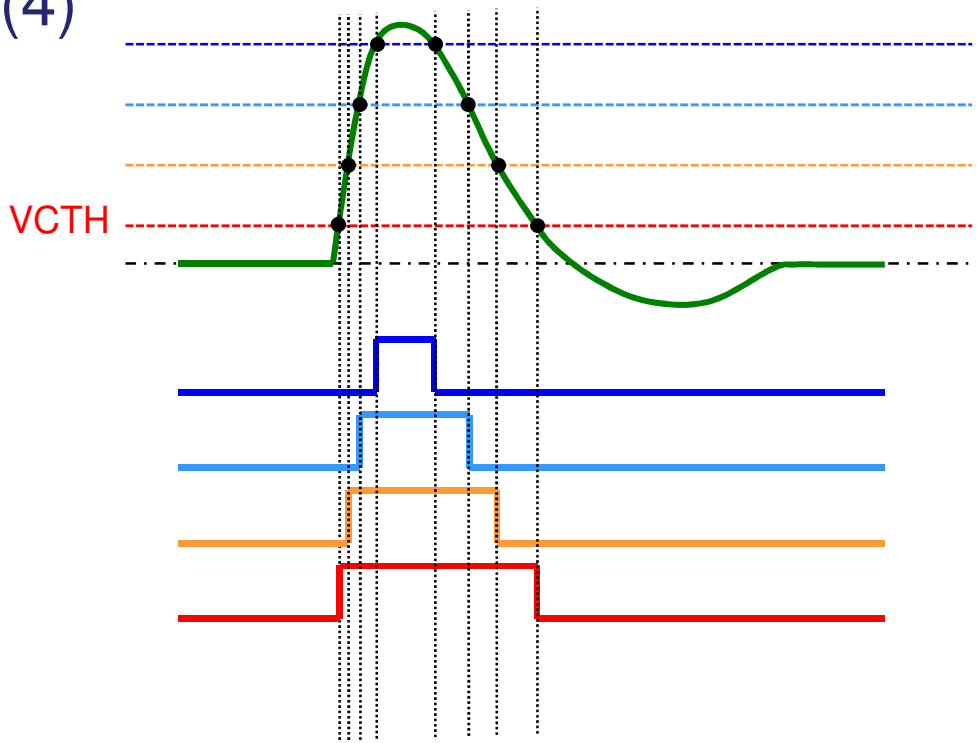
pulse shape measurement(2)



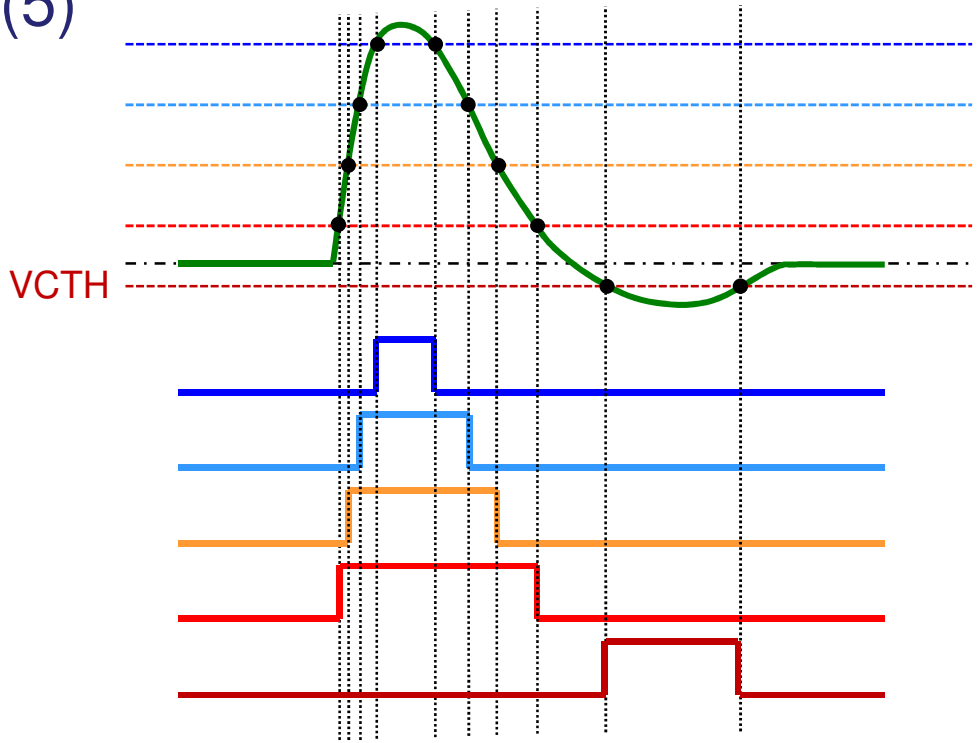
pulse shape measurement(3)



pulse shape measurement(4)

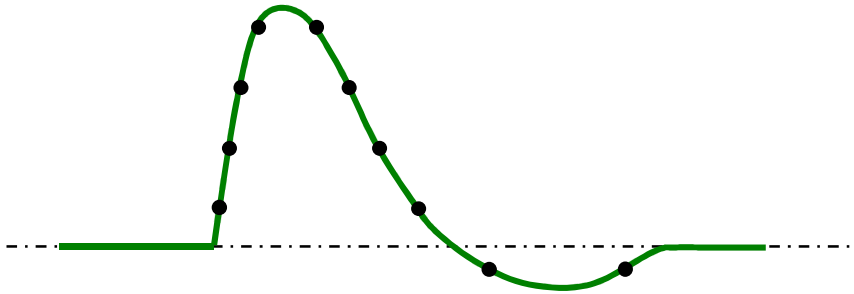


pulse shape measurement(5)



pulse shape result

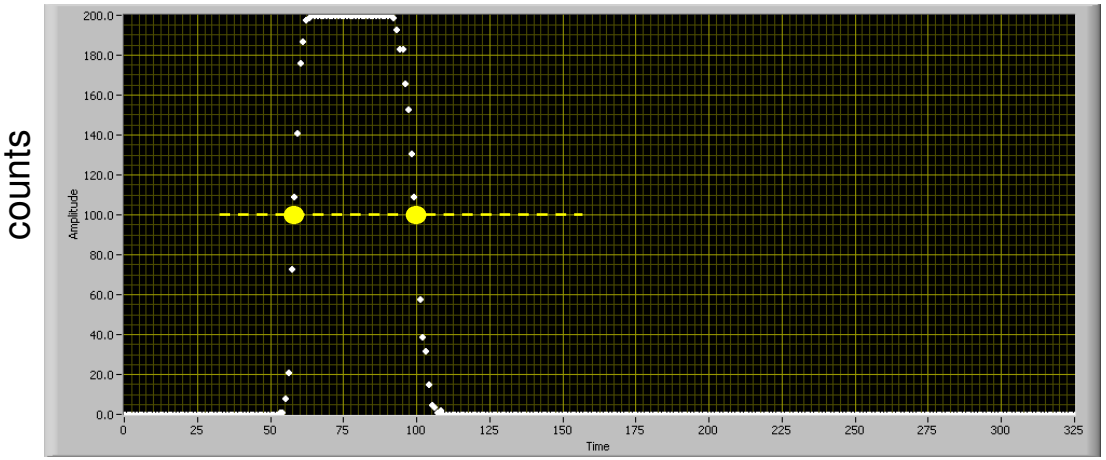
join up the dots



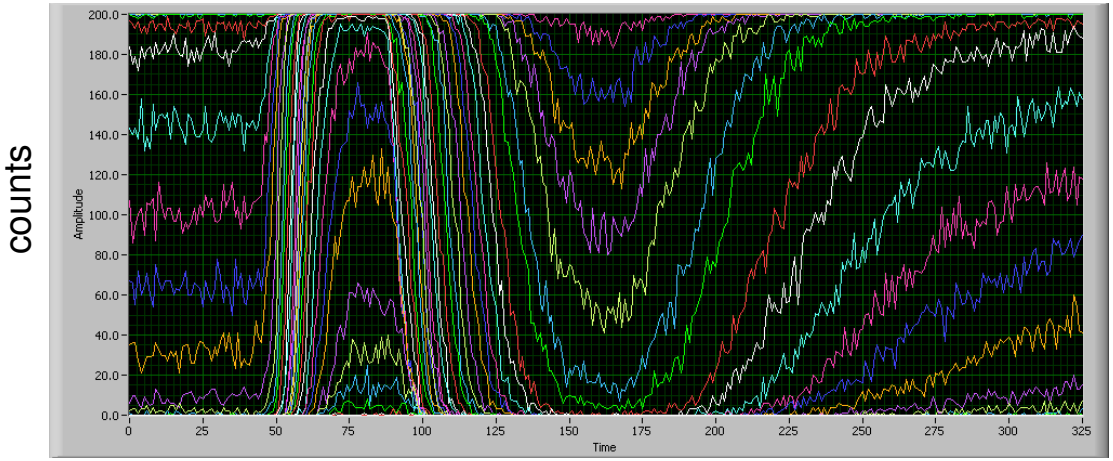
pulse shape measurement reality

charge injection time sweep for one VCTH value

noise affects transition times
take 50% points



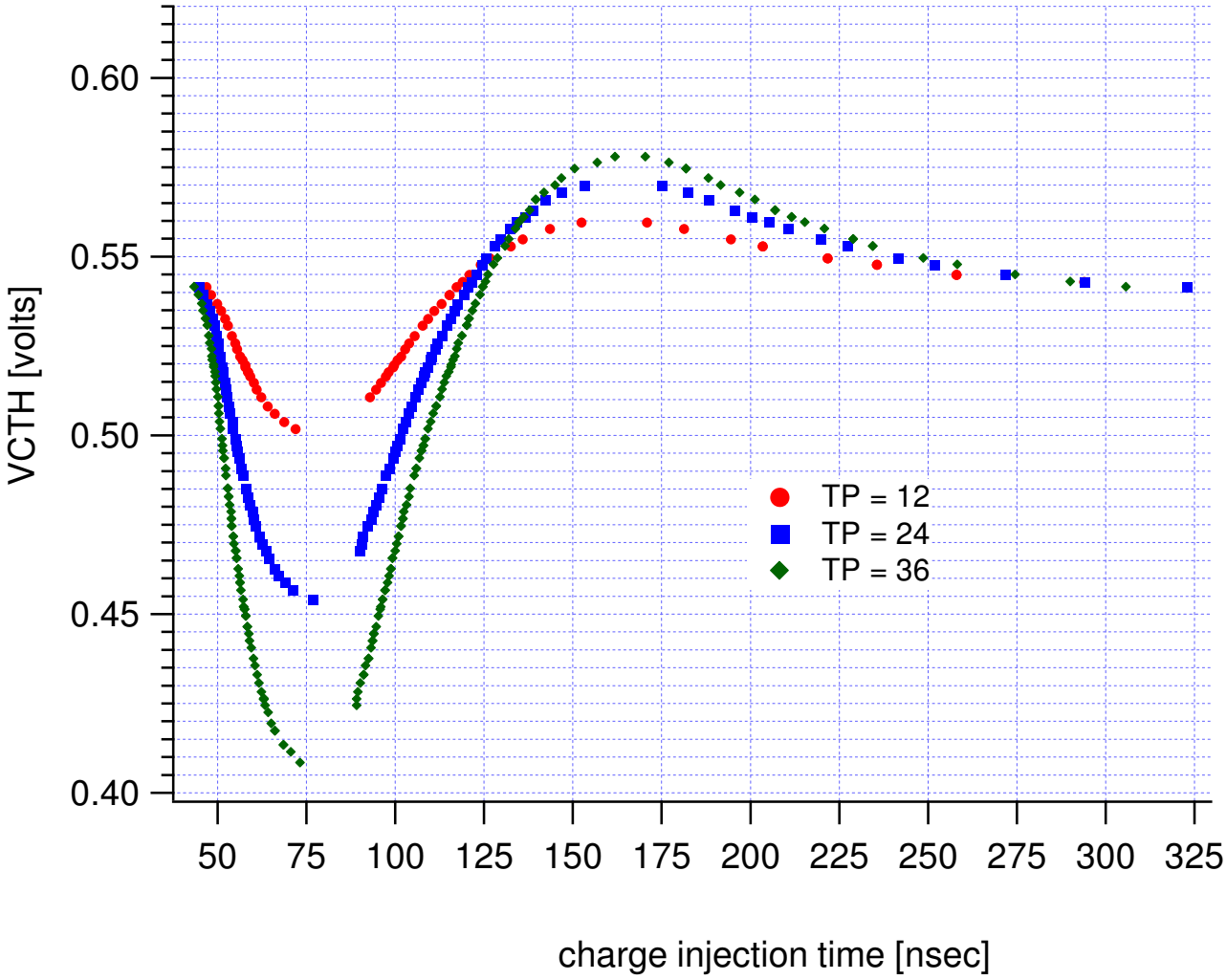
complete set of charge injection time sweeps
for range of VCTH values



method fails where no 0 - 100%
transition - e.g. where VCTH set
to near peak of pulse

=> lose some points in these regions

pulse shape measurement - **electrons** mode

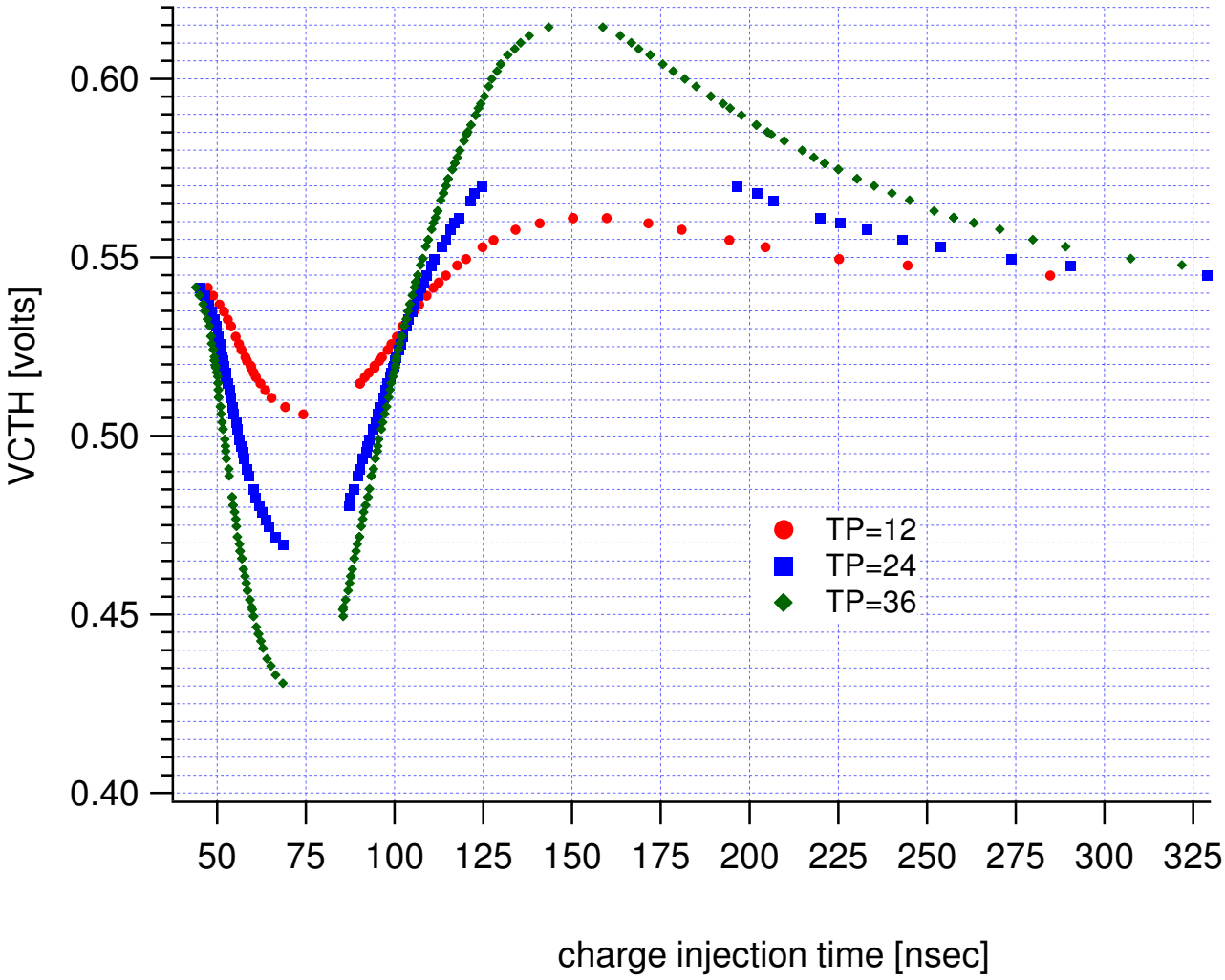


electrons polarity signals

postamp feedback in **electrons** mode

overshoot limited (cf holes measurement on next slide)

pulse shape measurement - **holes** mode



electrons polarity signals

but postamp feedback in **holes** mode

reduced signal amplitude

signal duration reduced

significantly more overshoot

but no reason why chip can't be used in this mode

overall summary

some progress in understanding origins of differences in CM effects in holes/electrons modes

strong evidence that postamp feedback implicated

some options for CBC2 operation for electrons polarity signals

1) do nothing (preamp/postamp/comparator all in electrons mode)

chip still works ok for normal occupancies
CNM sensor module in DESY test beam was operated in this mode

2) select VPLUS using analog mux, and couple to external capacitor

CM instability goes away
capacitors present for both chips on 2CBC2 system
not on 8CBC2flex system unless can add on support board (using test connector?)

3) switch postamp feedback **only** to holes mode

CM instability goes away
increased overshoot should not be a problem for normal signal occupancies