CBC deadtime

previously discussed in May 2012 systems meeting

https://indico.cern.ch/getFile.py/access?contribId=0&sessionId=0&resId=0&materialId=slides&confId=191199

repeat some of it here to introduce

add some further information

reminder of issue(1)

the story up to now

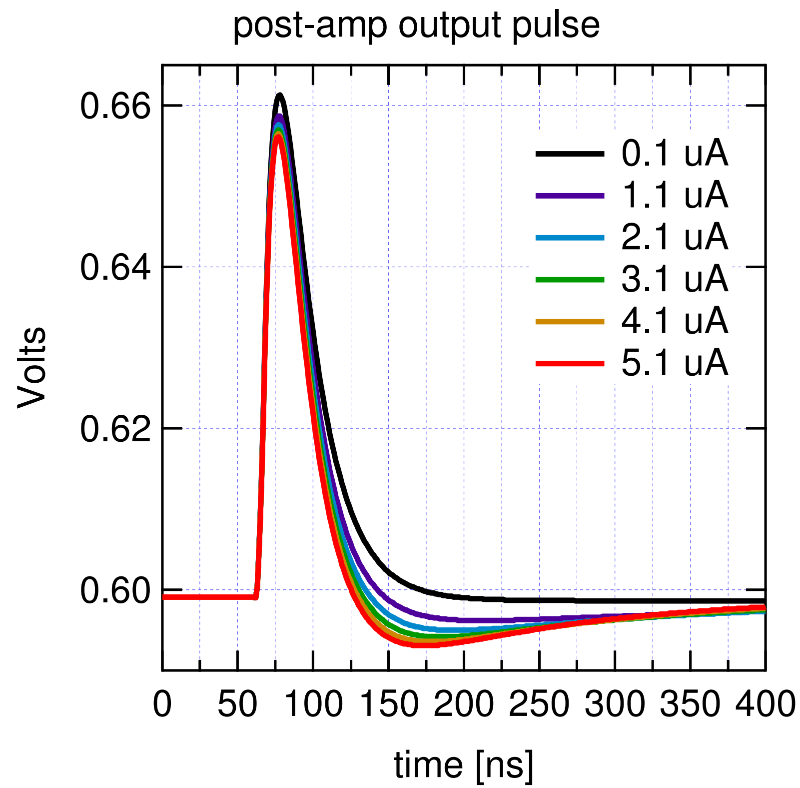
pulse shape longer than single bunch crossing
(can be shortened at expense of undershoot)

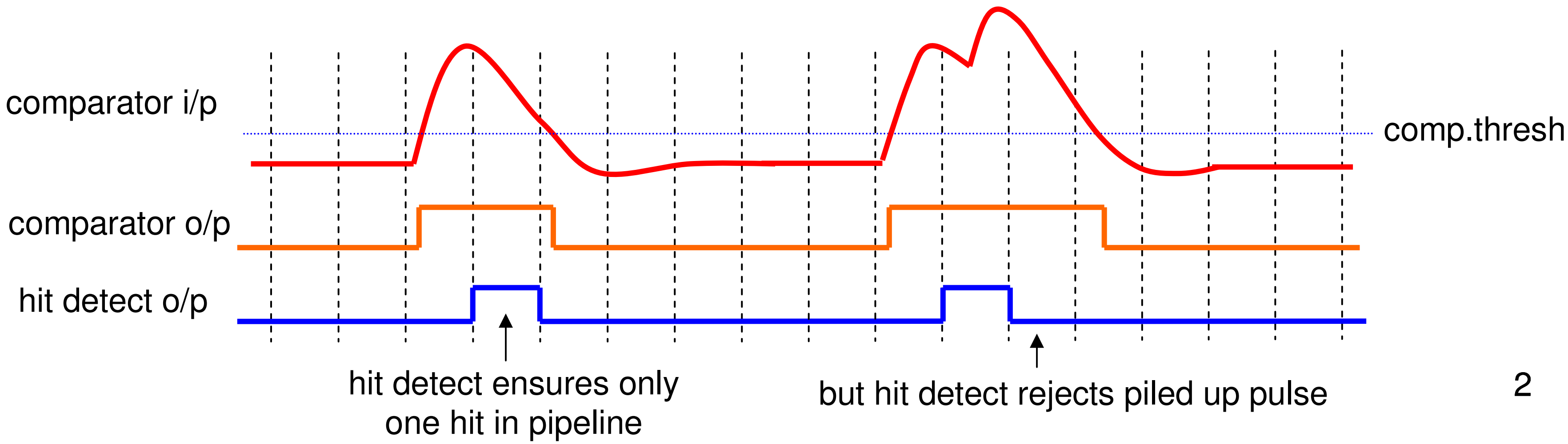
=> comparator output high for > 25 nsec

for CBC1 & 2

“hit detect” circuit ensures that only one ‘1’ is loaded into pipeline
=> when you read out triggered data you don’t get a spurious hit from a previous BX

but a hit from pile-up signal is lost
=> dead-time





reminder of issue(2)

very short pulse shape helps

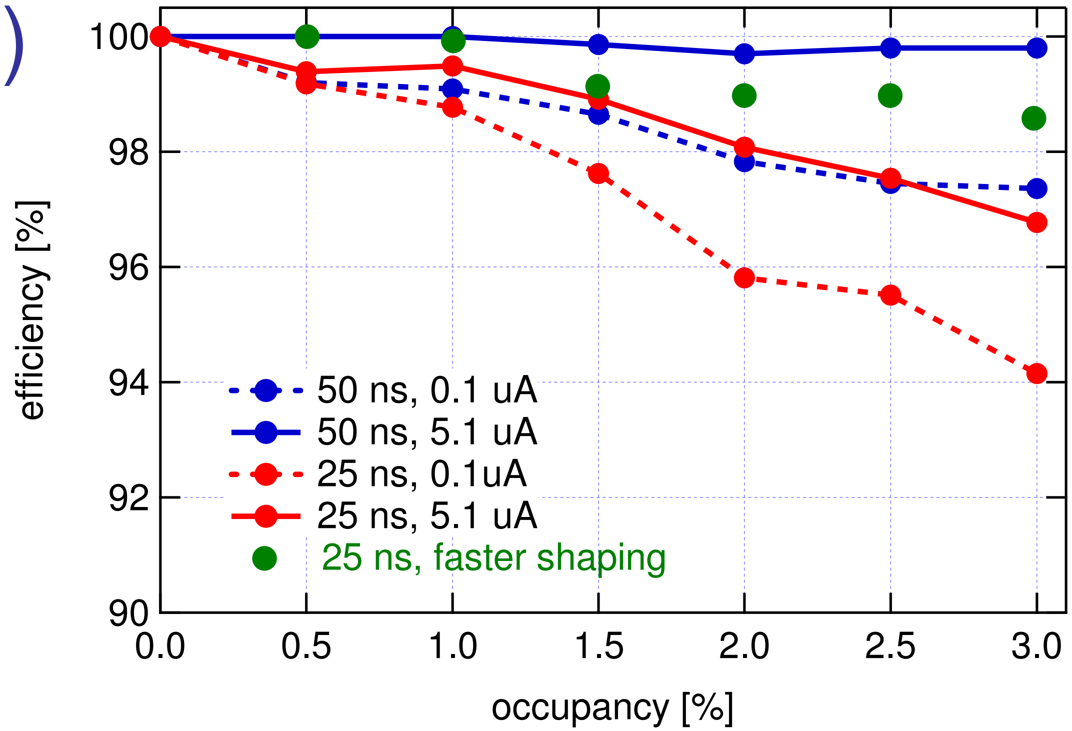
but

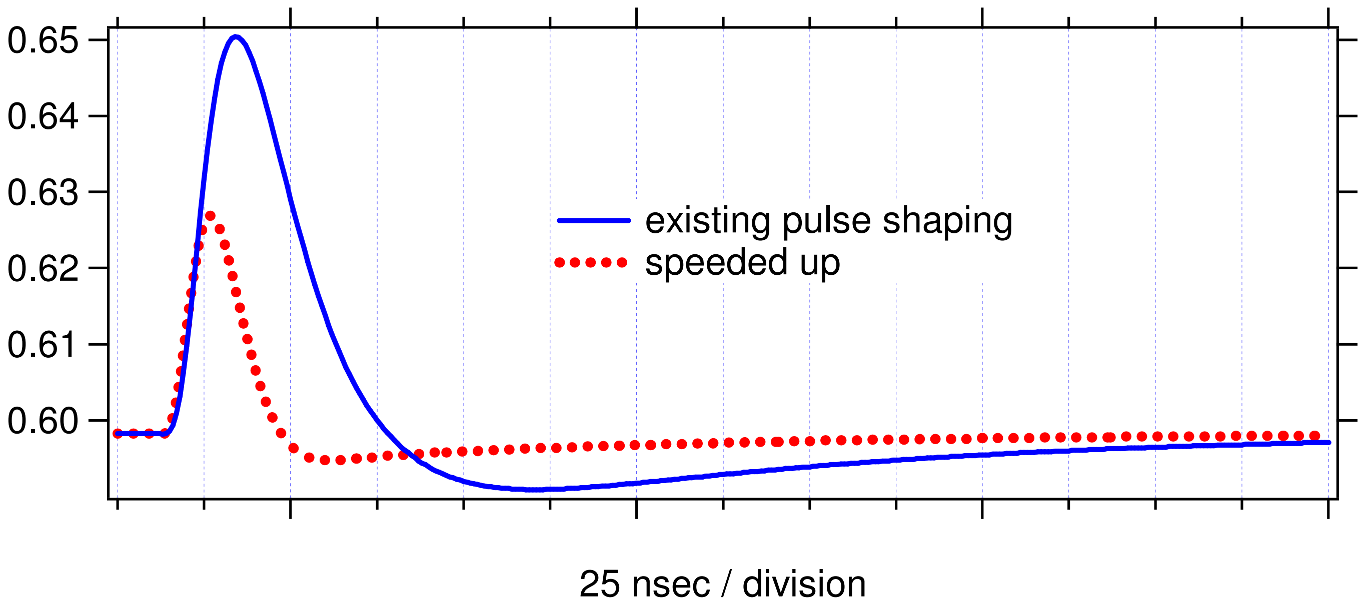
input device current increased
160 -> 210 uA

reduced amplitude ~ factor 2

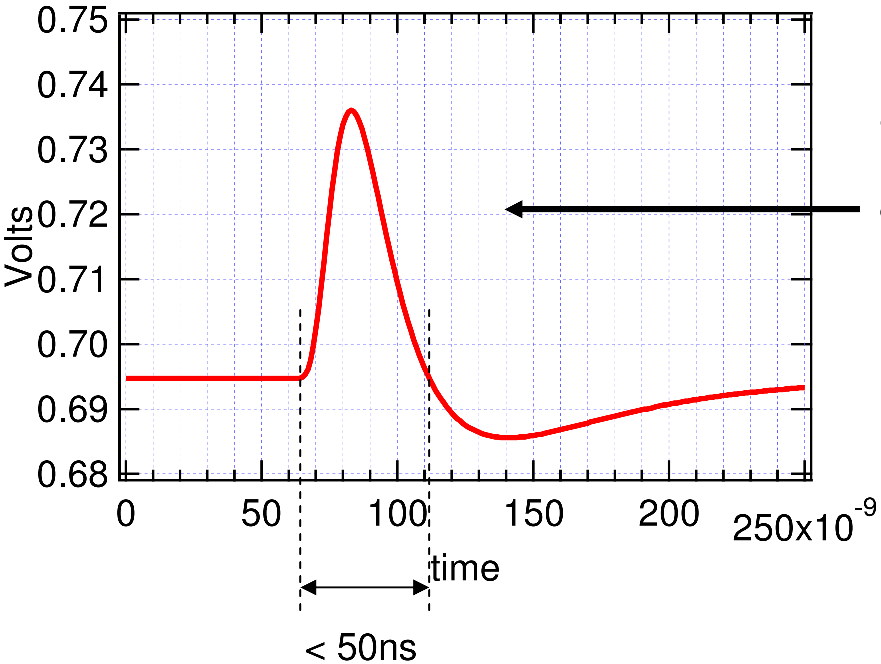
noise increase 890 -> 1200 e

v. sensitive to charge collection time





reminder of issue(3) - optimum pulse shape



but pulse doesn't have to return to baseline within 25 ns,

only within 50 nsec

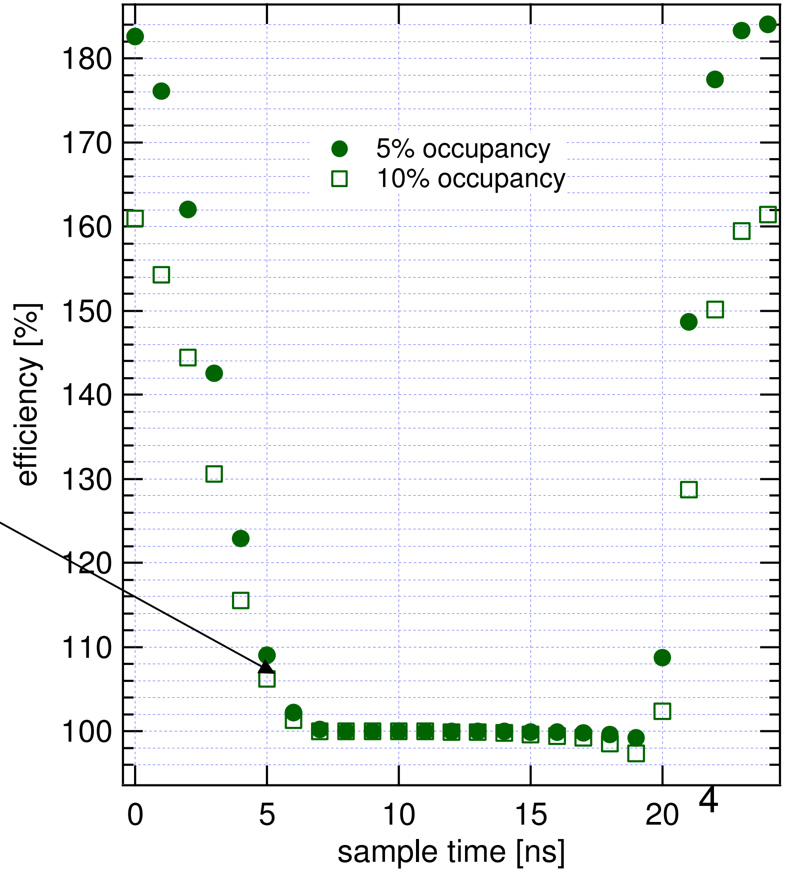
can get this pulse shape by tuning existing CBC front end

noise increase ~ 10% over more unipolar shape
=> 800 -> 880 electrons

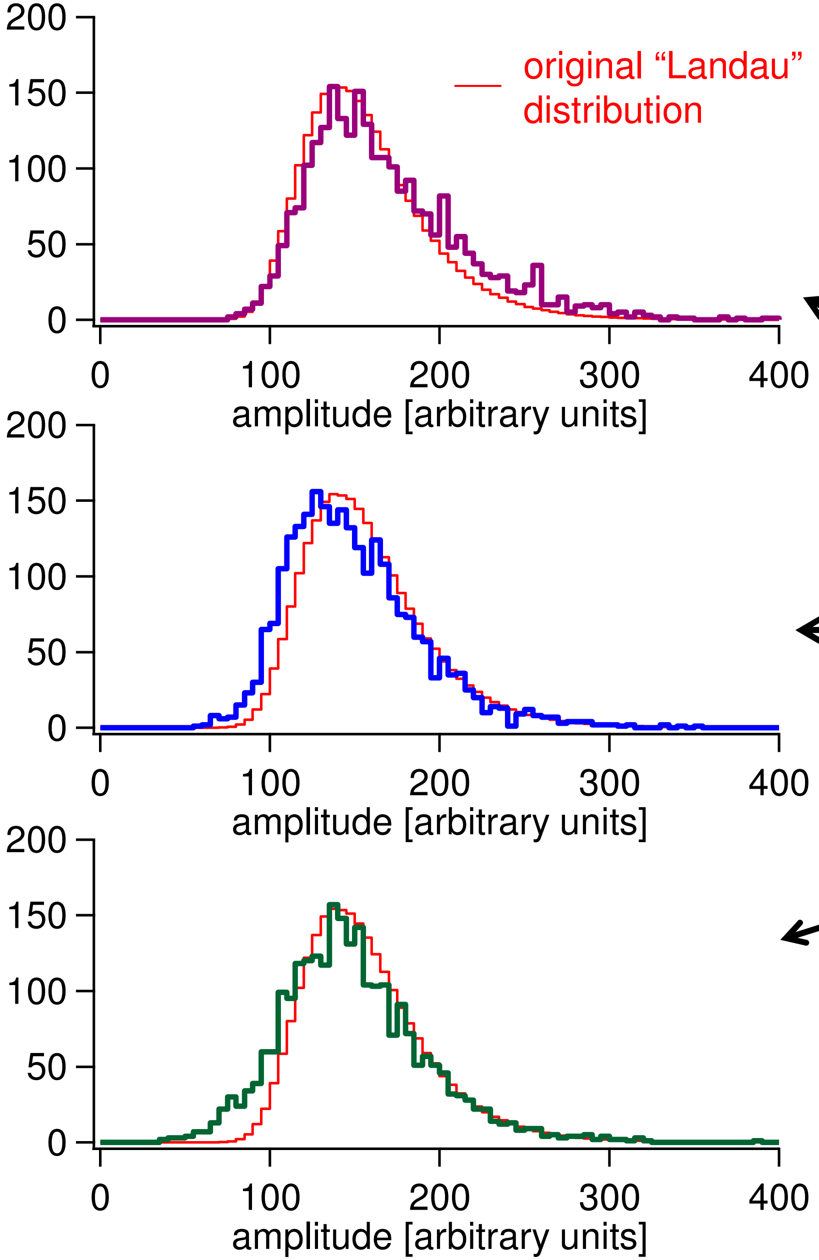
100% efficiency plateau attainable even for very high occupancies

unprocessed comparator used (no hit detect)

get >100% in places because sampling comparator output from same pulse more than once



reminder of issue(4)



effect of "short pulse with undershoot" on pulse height distribution

unipolar pulse (no undershoot)

"landau" skewed to higher amplitudes

very fast pulse (small undershoot)

"landau" skewed to lower amplitudes

"optimum" pulse (undershoot)

"landau" skewed to even lower amplitudes

but had to generate these data with 10% occupancy! to get an observable effect

conclusions from last time

further work needed, but

- seems as though very fast pulse shape may not be required
  - return to baseline within 50 ns is sufficient
- baseline undershoot does not seem to cause a big effect

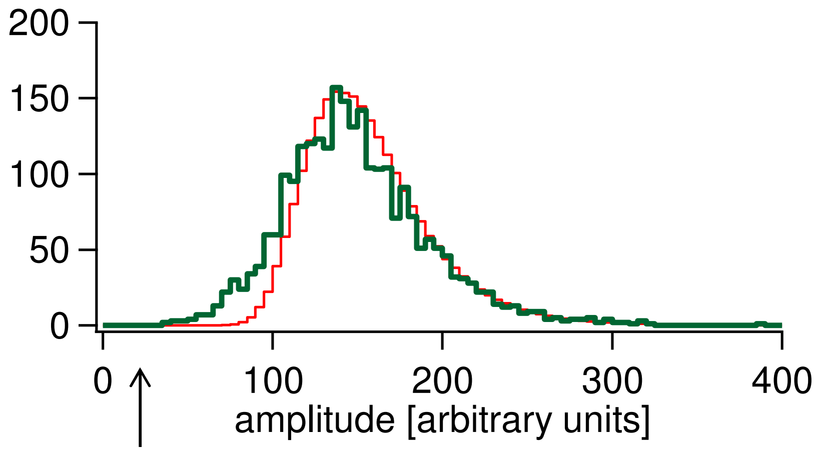
continuing the story

simulations up to now use realistic pulse shapes from SPICE

but no noise

which will affect efficiency and generate fake hits depending on comparator threshold

have made some additions to simulation to study these effects



can position comparator threshold anywhere in this region

have previously used comp threshold of MPV/4

new simulation conditions

occupancy: 2% (pessimistic)

simulated noise added: 1000e

comparator thresholds at 5000e, 4000e, 3000e (5, 4, 3 sigma)

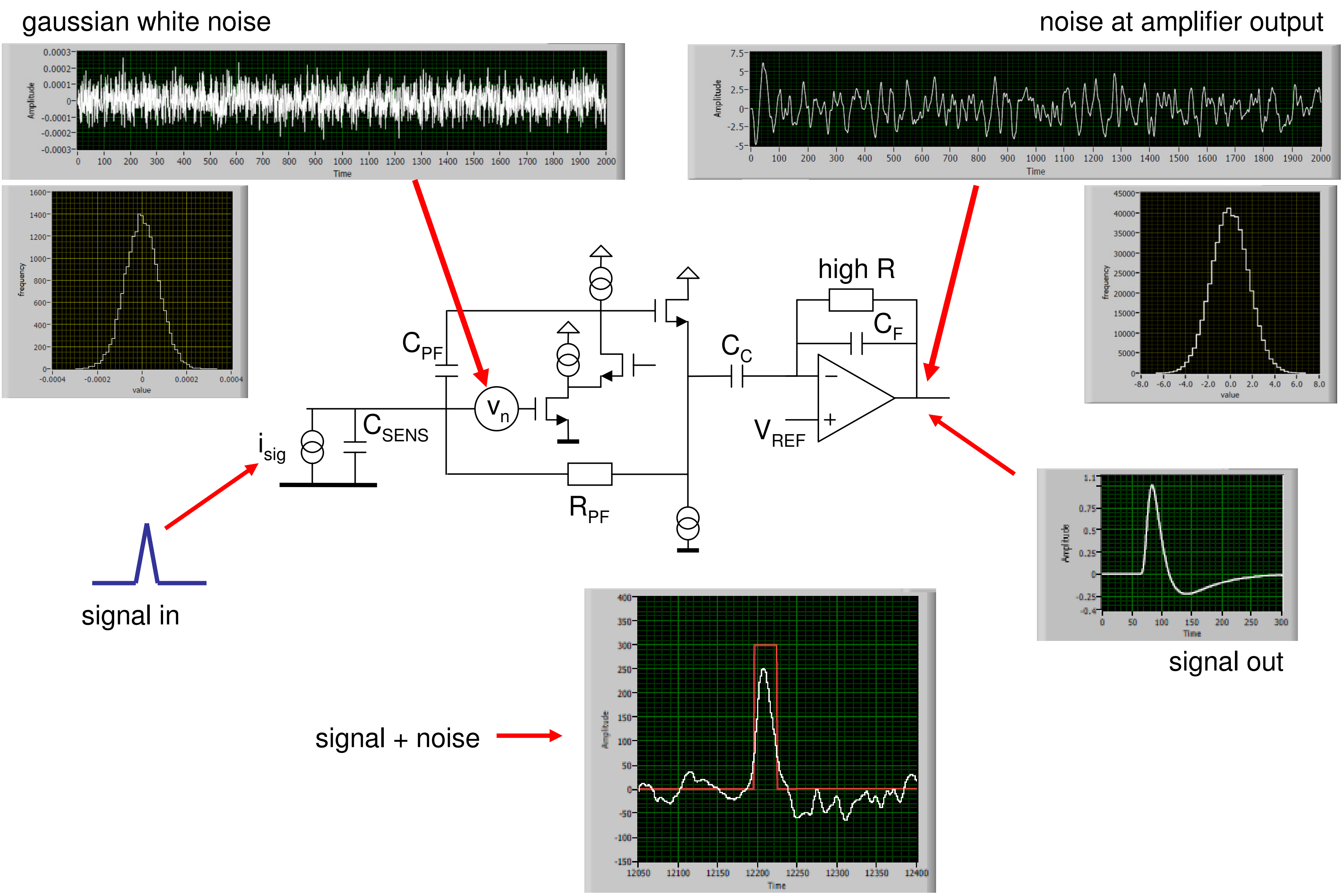
most probable signal level values (MPV):

24,000 e	:	300 um sensor
12,000 e	:	300 um sensor, charge shared
16,000 e	:	200 um sensor
8,000e	:	200 um sensor, charge shared
12,000 e	:	200 um sensor, radiation damaged
6,000 e	;	200 um sensor, radiation damaged, charge shared

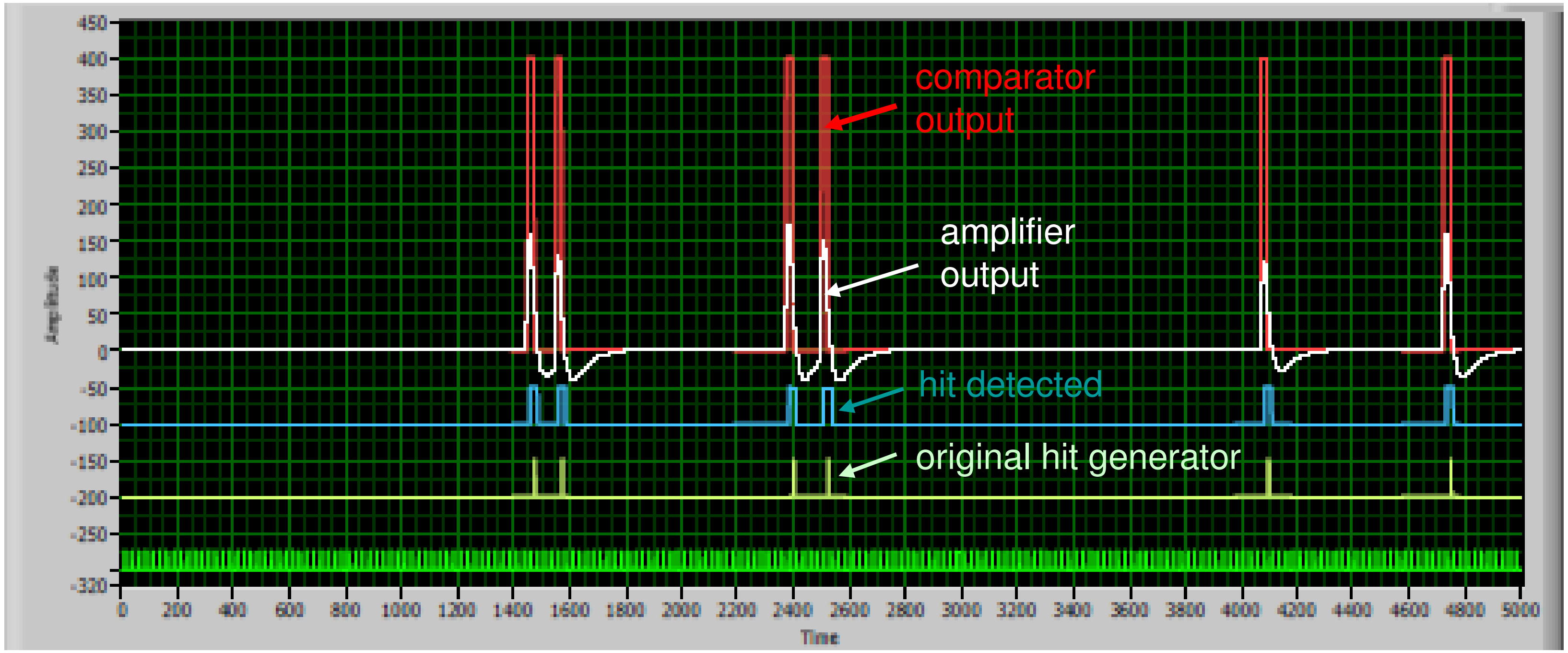
looking at

- % of true hits found
  - hit was randomly generated and subsequently found
- % of fake hits found
  - noise hits found as percentage of total hits found

time domain noise generation in SPICE



example - before noise added

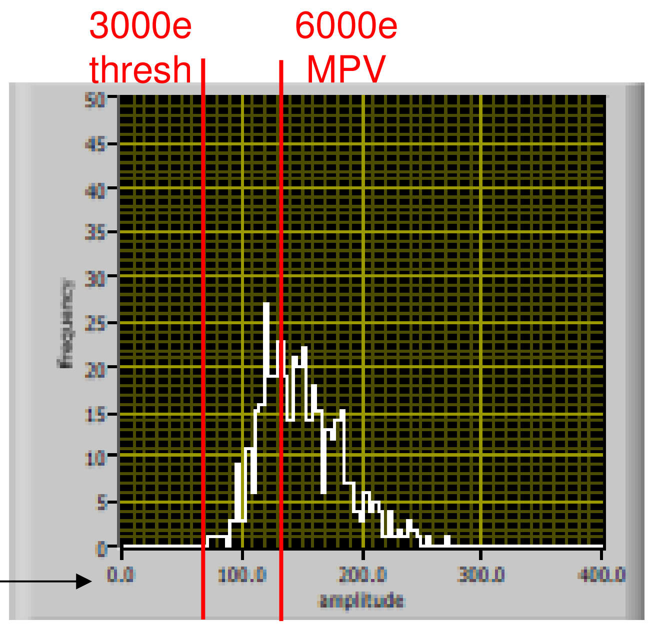


if hit detected corresponds to original hit generated, then “true” hit

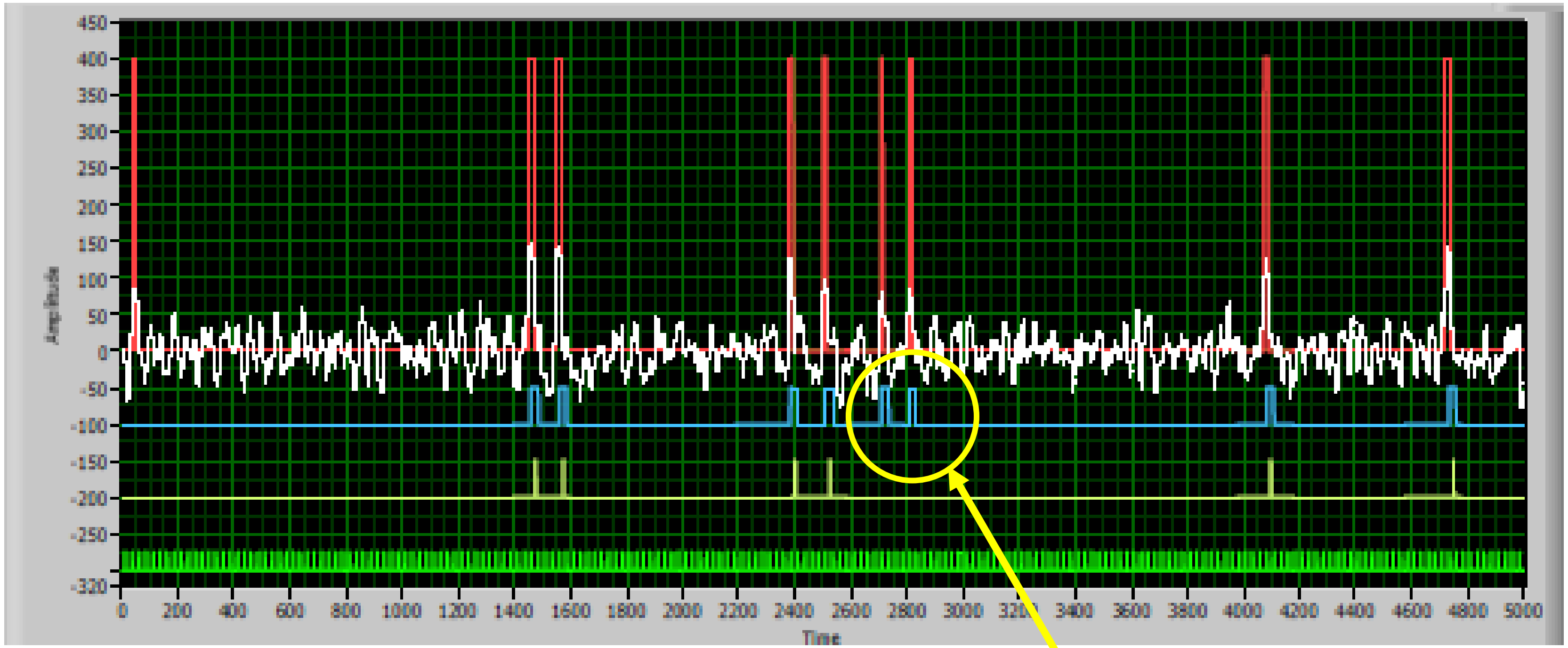
MPV = 6000e
threshold = 3000e

no noise added
~ 100% efficient

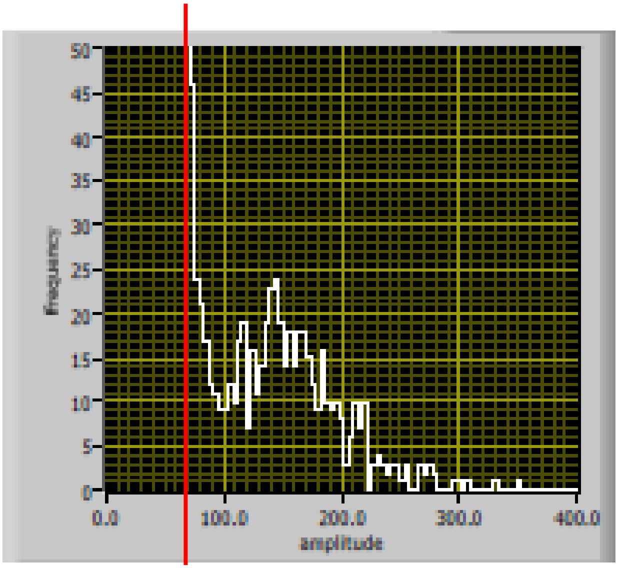
(note: arbitrary scale units here)



example - after noise added



if hit detected doesn't corresponds to original hit generated, then "fake" hit



MPV = 6000e
threshold = 3000e

1000e noise added
~ 98% efficient for true hits
but ~6% fake hits due to noise

results so far

	“Landau” MPV	5000e threshold		4000e threshold		3000e threshold	
		% true hits	% fake hits	% true hits	% fake hits	% true hits	% fake hits
300um	24,000e	100	0	100	0.24	100	7.2
	12,000e	99.8	0	99.8	0.24	100	5.7
200um	16,000e	100	0	100	0.24	100	7.6
	8,000e	95.0	0	98.6	0.24	99.8	5.1
200um + damage	12,000e	99.8	0	99.8	0.24	100	5.7
	6,000e	80	0	91.1	0.26	97.4	5.4

conditions

1000e noise

2% occupancy

20,000 bunch crossings

=> ~ 400 hits
=> statistics not huge
(limited by simulated
noise waveform length)

statistical effect - fakes due to noise shouldn’t depend on signal size

good efficiency and low fake rate for signal MPV > 8,000e and thresholds of 4000e
8000e MPV @ 5000e threshold -> low efficiency for true hits

6000e MPV altogether too low -> low efficiency for true hits at any reasonable threshold

3000e threshold too low -> fake rate too high

extra

slides from previous talk follow

dead-time caused by pile-up

the story up to now

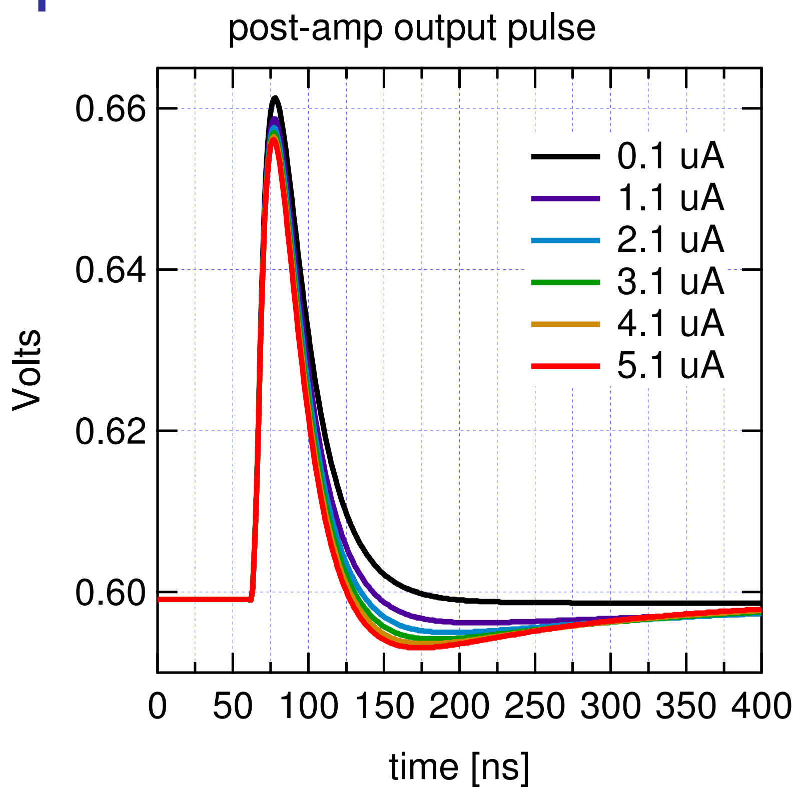
pulse shape longer than single bunch crossing
(can be shortened at expense of undershoot)

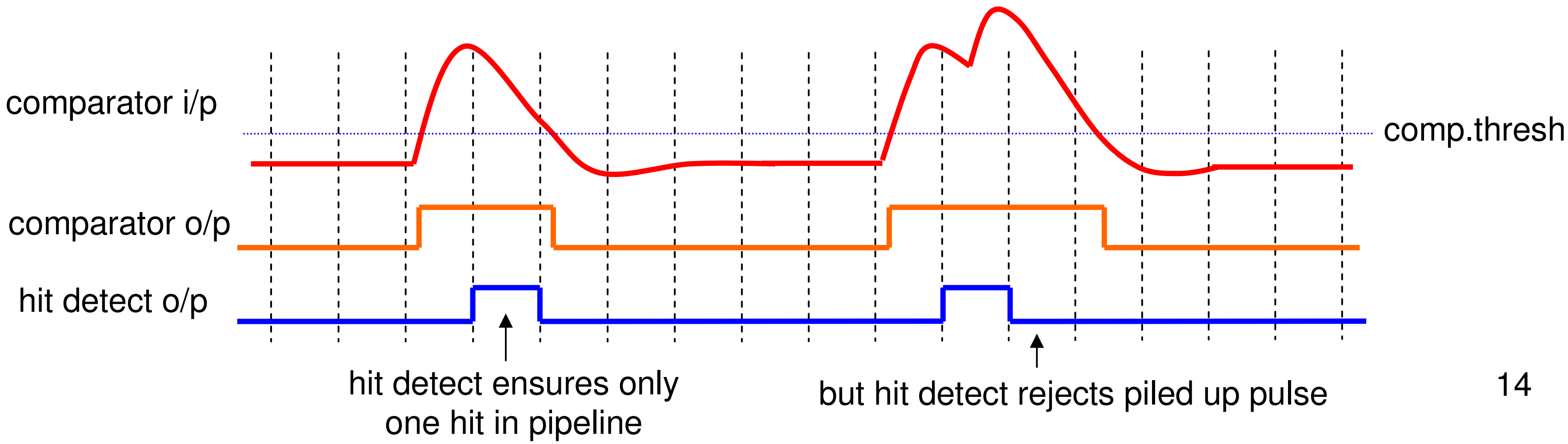
=> comparator output high for > 25 nsec

for triggered readout

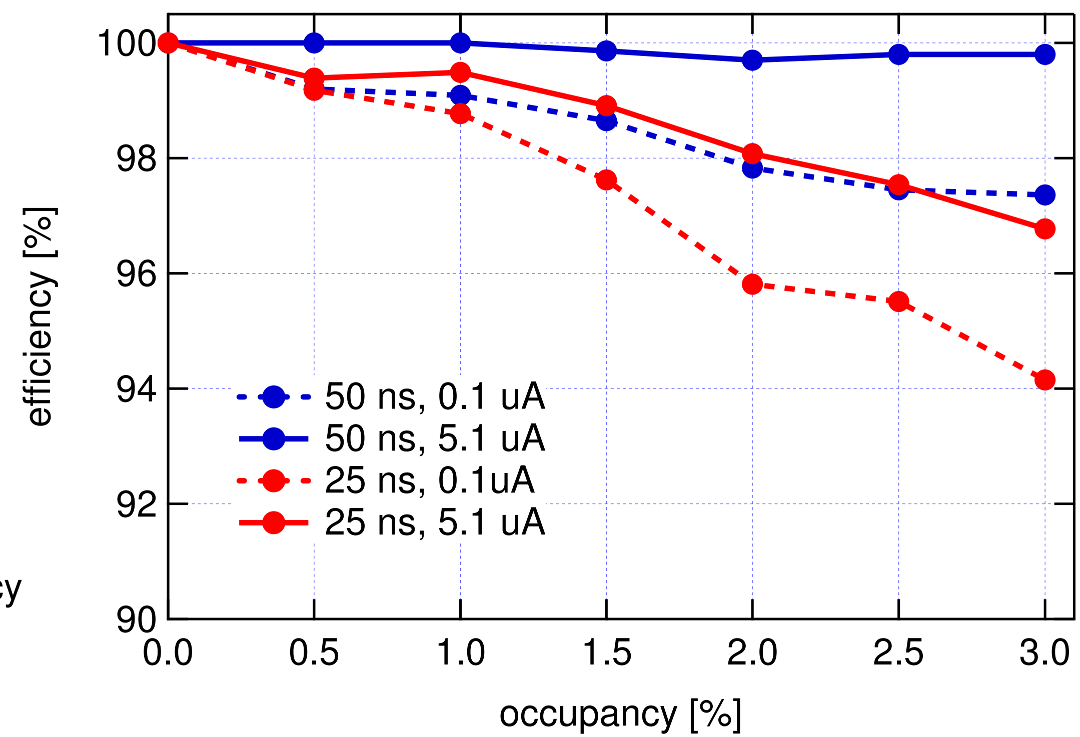
use “hit detect” circuit to ensure that only one ‘1’ is loaded into pipeline
=> when you read out triggered data you don’t get a spurious hit from a previous BX

but a hit from pile-up signal is lost
=> dead-time





effects of dead-time



simulation results from ~3 meetings ago

- random time distribution of hits generated for specific occupancy
- SPICE simulated pulse-shapes
- Landau distributed amplitudes

get loss of efficiency depending on occupancy

- (100% efficient if all hits identified)

shorter pulse shape (with undershoot) gives higher efficiency

~ 100% efficient for 50 ns bunch spacing

efficiency will mostly impact on Pt stub identification

shorter pulse shape?

results from ~2 meetings ago

pushing existing front-end hard
(very preliminary study)

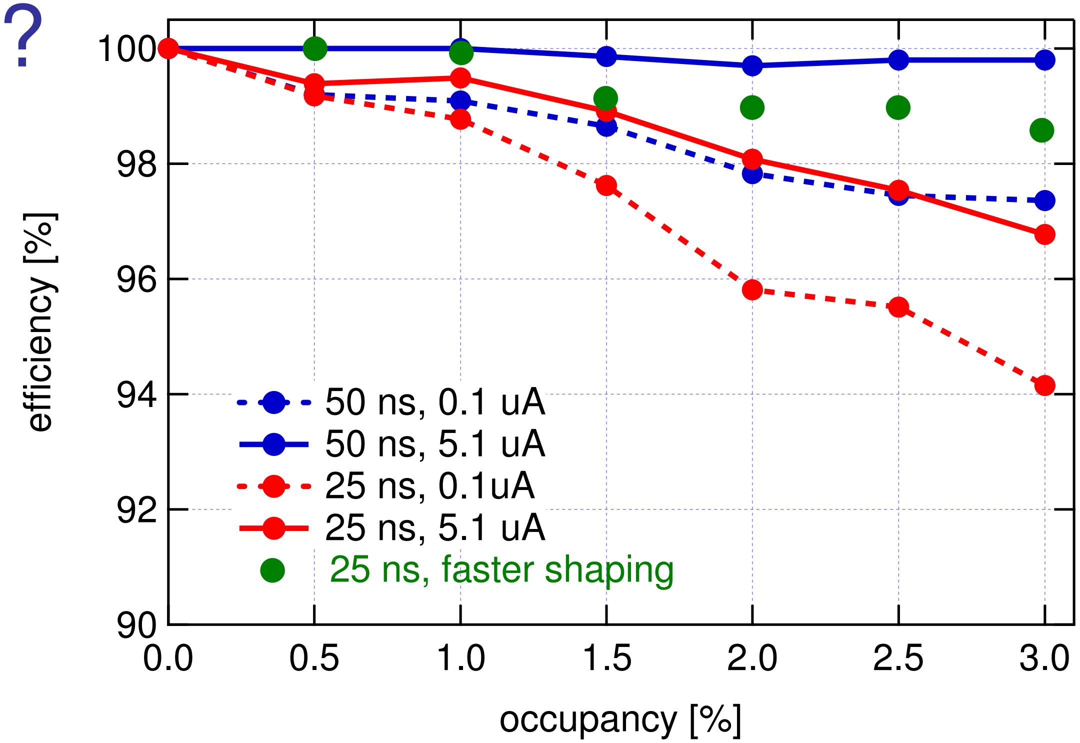
input device current increased
160 -> 210 uA

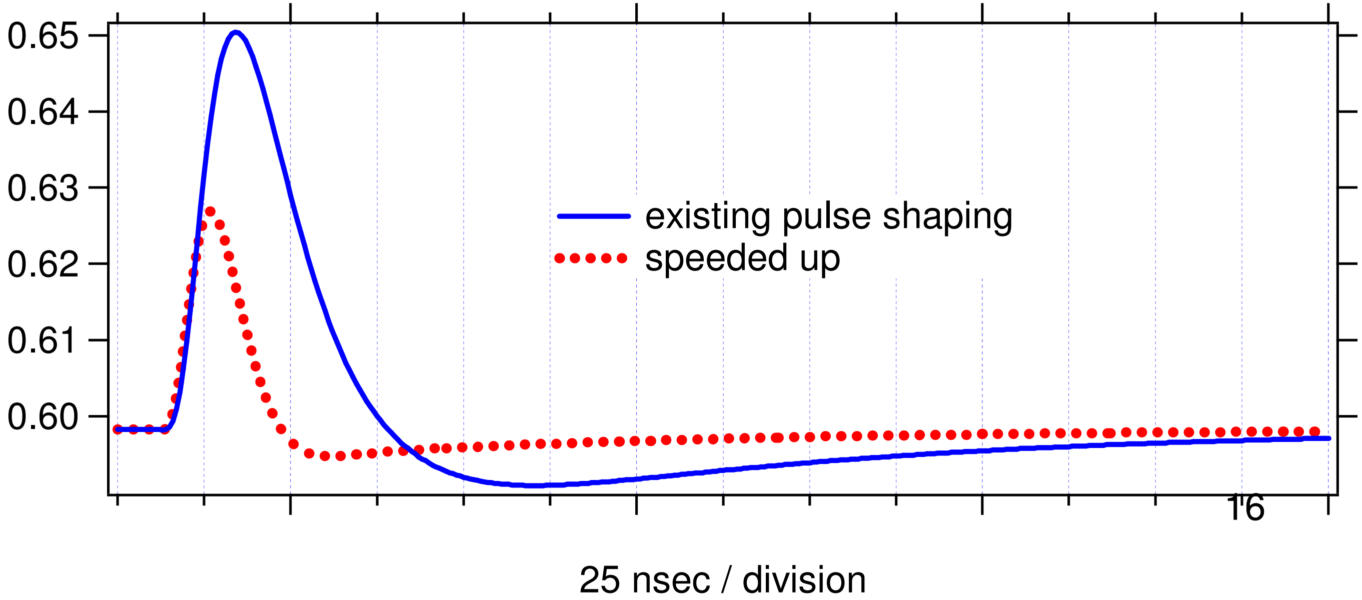
reduced amplitude ~ factor 2

noise increase 890 -> 1200 e

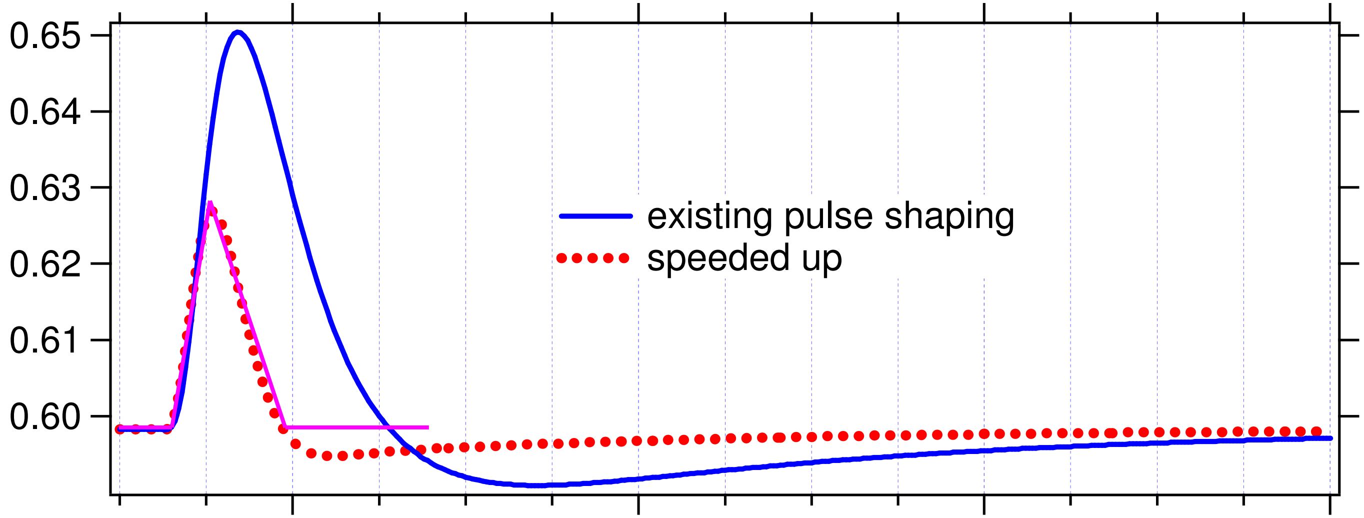
10 ns charge collection in sensor assumed
(will be sensitive to this)

but efficiency improved



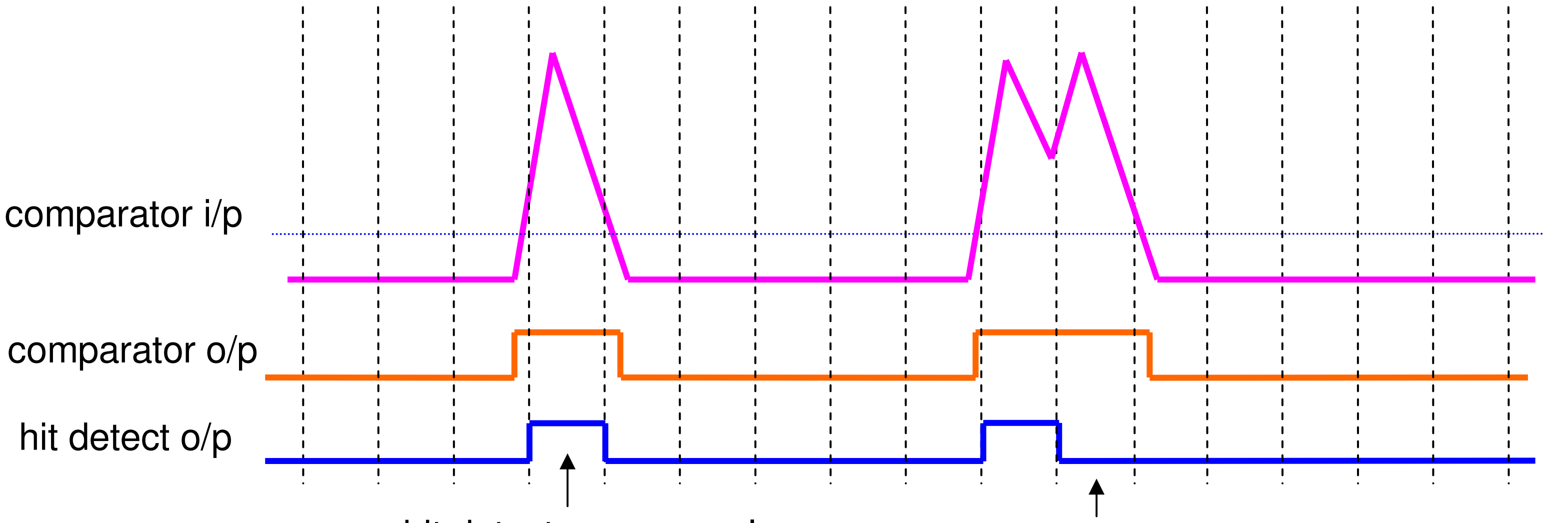


why is short pulse shape not 100% efficient?



can understand basic behaviour
using crude triangular approximation to pulse shape
ignore undershoot for now (will come back to later)

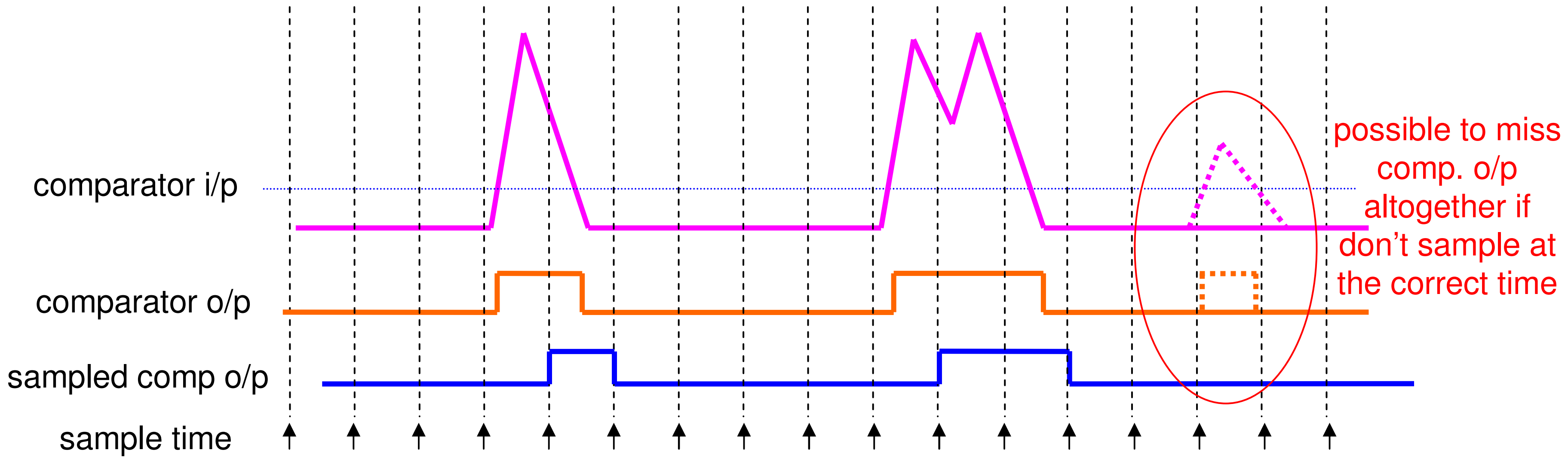
25 nsec / division



hit detect ensures only one hit in pipeline

but hit detect rejects piled up pulse

but what if don’t use “hit detect” ?



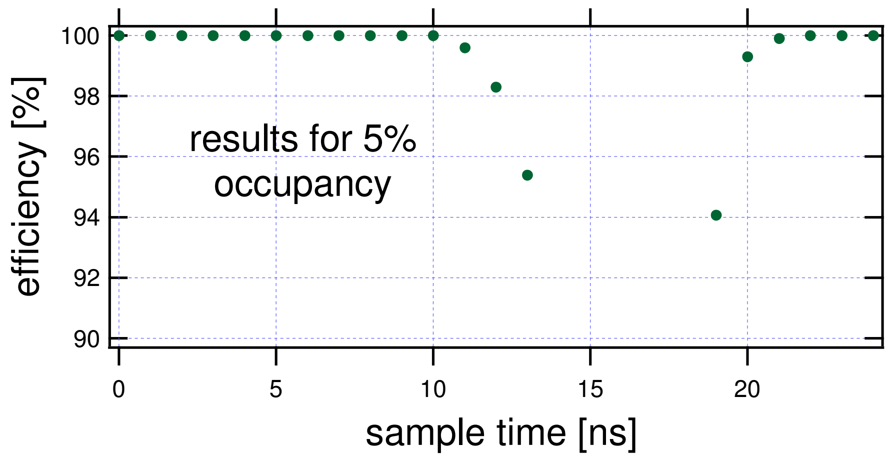
just sample the comparator output at the right time

appropriate adjustment of this time is important

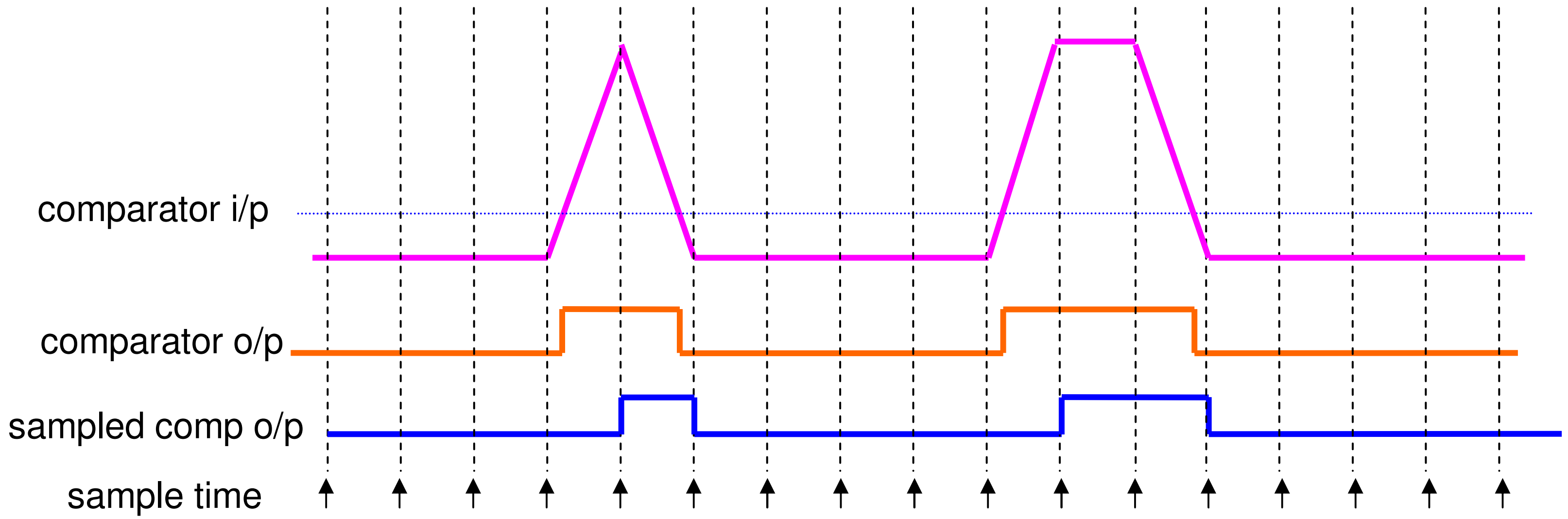
but 100% efficiency is now possible

can we get this without going for so short a pulse?

how long can pulse actually be?



optimal length pulse

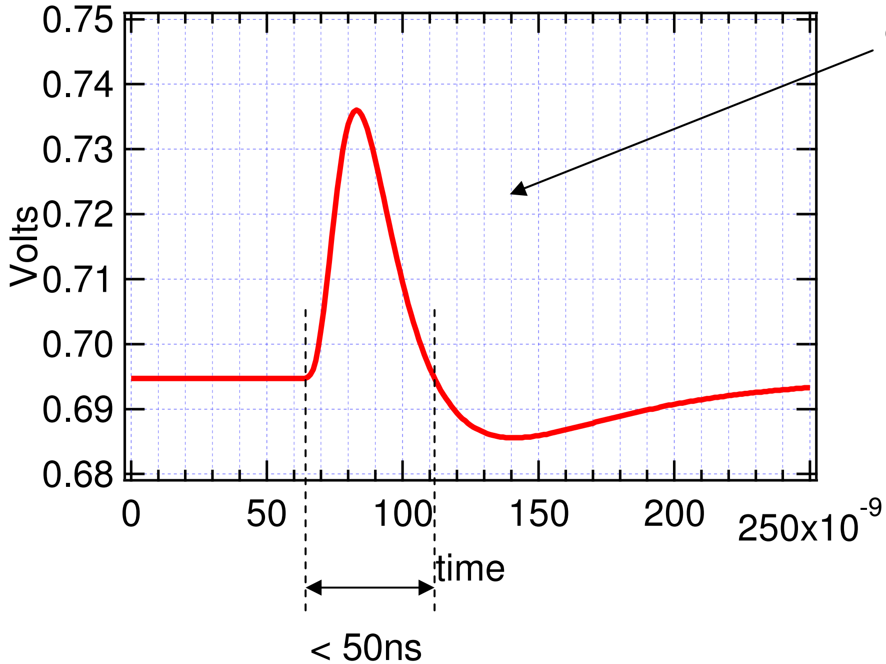


intuitively can be seen that optimum pulse shape rises, peaks and returns to baseline within 50 ns
(actually what we have in the APV after deconvolution)

if this condition met then pile-up is **not** an issue

=> very fast pulse shape is **not** required (I think)

close-to-optimum pulse shape?

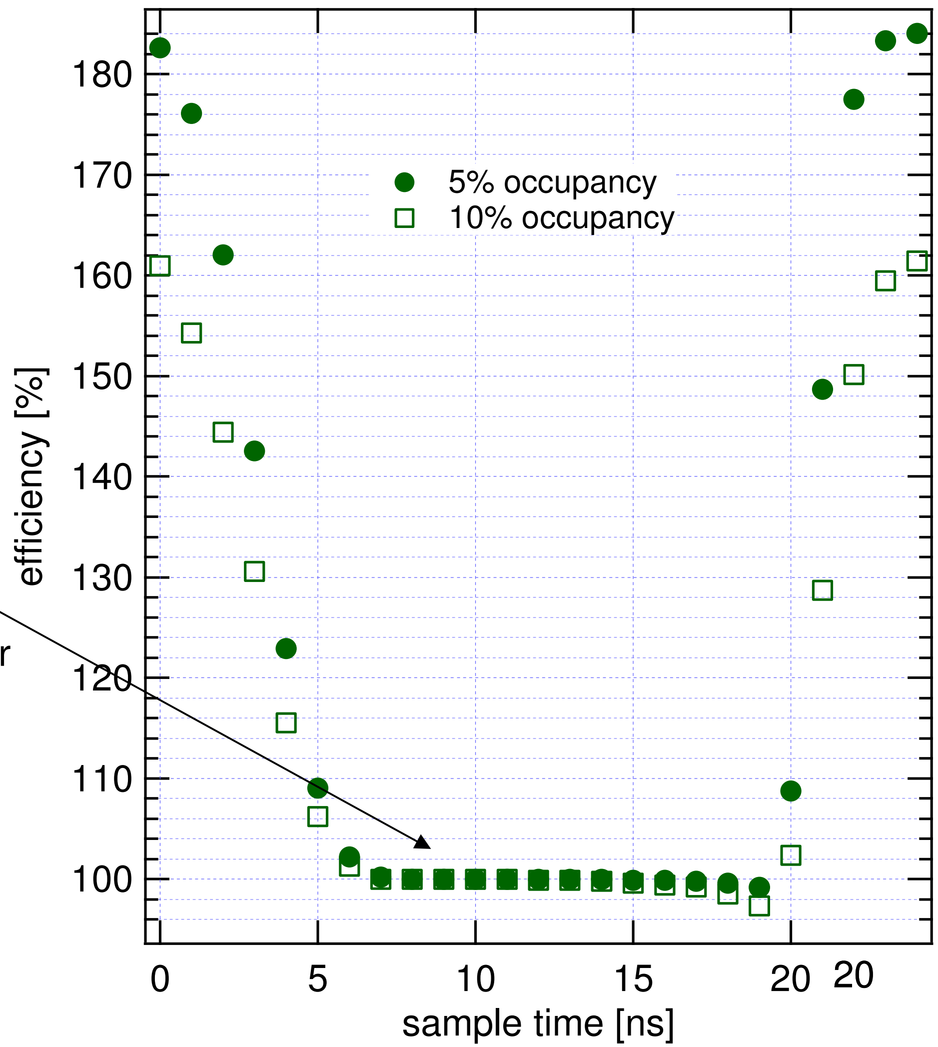


can get this pulse shape by tuning existing CBC front end

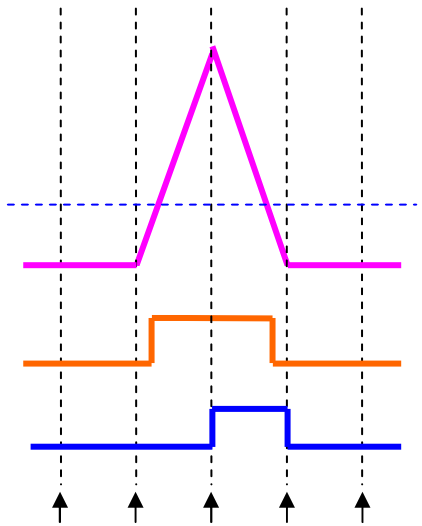
(note: noise increase ~ 10% over more unipolar shape but maybe we can live with that)

100% efficiency plateau attainable even for very high occupancies

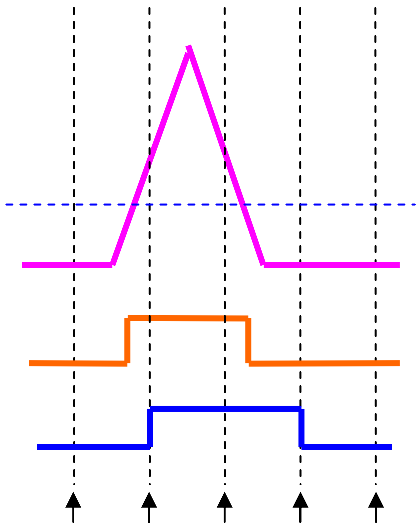
get >100% in places because sampling comparator output from same pulse more than once



> 100% efficiency explanation

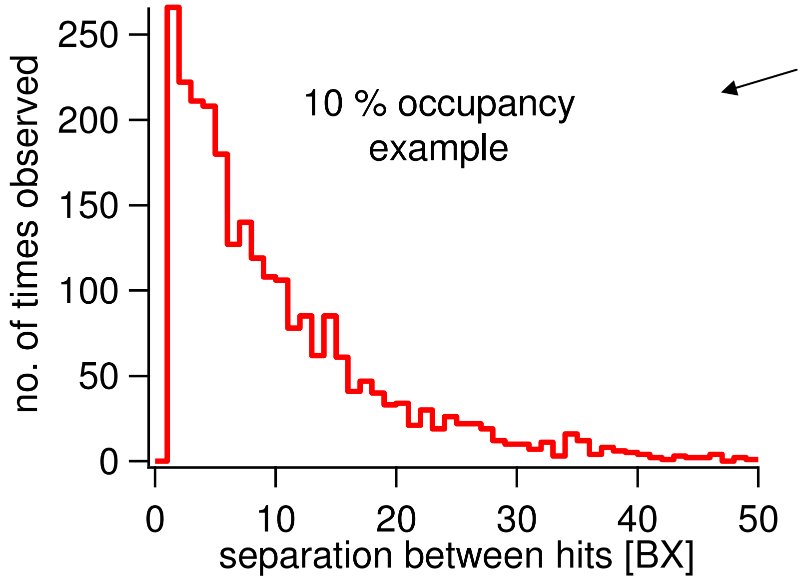


optimal sampling



non-optimal sampling

what about undershoot effect?



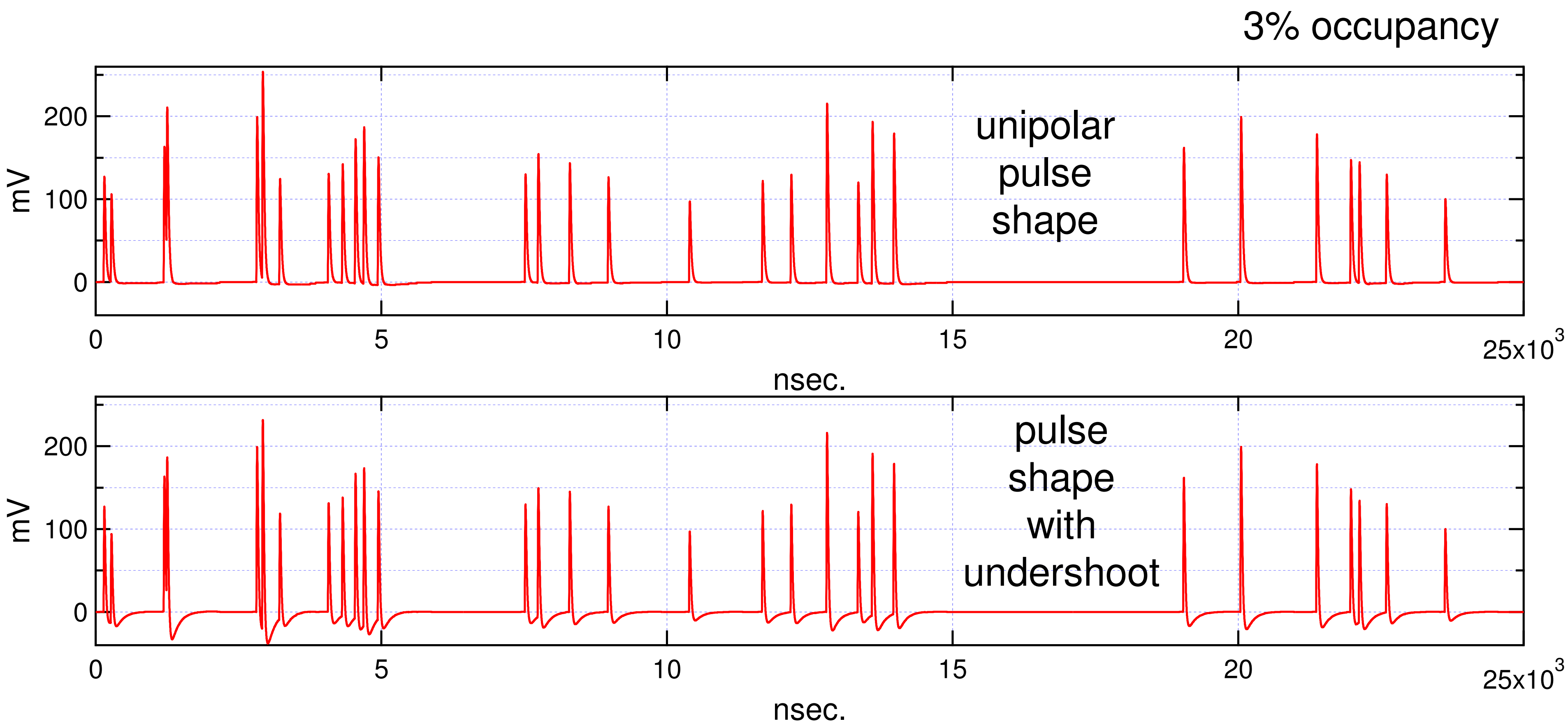
plot shows frequency of observing a particular separation between hits generated randomly

average interval is 10 (for 10% occupancy)
but more likely to see a shorter interval than a longer one

the higher the occupancy the more likely a following pulse will sit on the undershooting tail of the previous pulse

will have a distorting effect on the pulse height distribution

reminder of pulse generation method



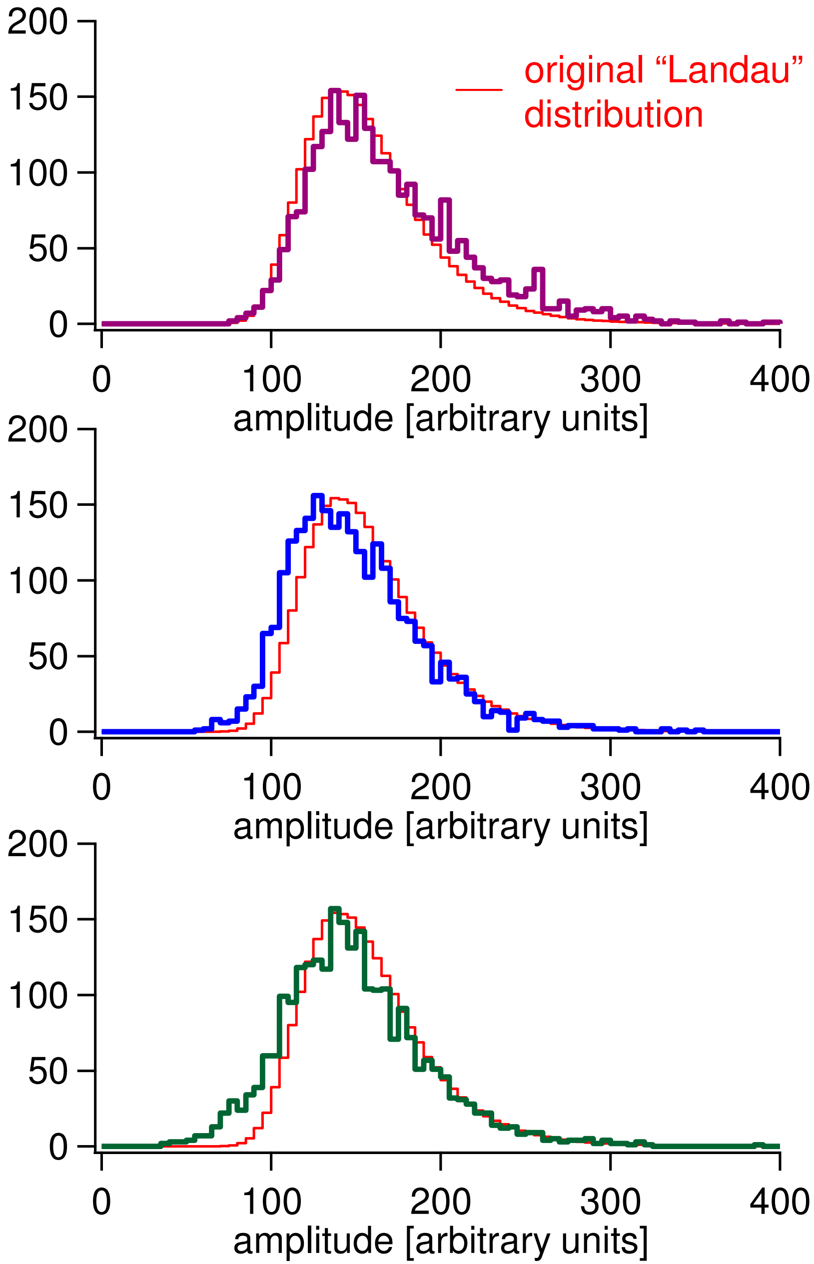
randomly generate time distribution of hits with desired occupancy

for each hit generate an output pulse shape (from SPICE) scaling the amplitude using a value randomly sampled from a "Landau-like" distribution

combine into single data stream

can now re-generate pulse height distribution from single data stream and compare with original Landau

undershoot effect on pulse height distributions



unipolar pulse (no undershoot)

"landau" skewed to higher amplitudes

very fast pulse (undershoot)

"landau" skewed to lower amplitudes

"optimum" pulse (undershoot)

"landau" skewed to even lower amplitudes

notes:

these results are for 10% occupancy
to exaggerate effect

no electronic noise included

dead-time effects summary

further work needed, but

- seems as though very fast pulse shape may not be required
  - return to baseline within 50 ns is sufficient
- baseline undershoot does not seem to cause a big effect