Beetle1.2_MA0 submission

The multi-anode pmt (MApmt) tube is the back up solution for the LHCb RICH detector.

A readout chip is required to be able to collect and store signals from the MApmt in a LHCb specific way.

The Beetle chip from Heidelberg conforms to the LHCb specifications but cannot handle the large signal input from a MApmt.

Modifying the Beetle to be able to accept these signals is possible, but which is the best approach. A MPW will be submitted on the 2nd of December 2002 with a modified Beetle1.2 chip (Beetle1.2_MA0) which has three different front end amplifiers.

Introduction

MApmt specifications

The standard simulation test bed used.

A look at the various front end schematics.

A look at the various front end layouts.

Layout of the Beetle1.2MA0 chip and test points.

Can the Beetle pipe line accept the new dynamic range of the FE amp.

The layout checks that have been done.

Some first order simulations.

Beetle1.2_MA0 submission

Specifications for input pulse from MApmt

Single photon signal 300,000e- @ -800V

Pmt capacitance 1.5pF without base

Rise/Fall time 2ns baseline width 5ns

Gain spread 3 (tube to tube 2, pixel to pixel 2)

Signal/pedestal width 40:1

Dynamic range 9 (gain spread x 3 photons)

Beetle noise figure ~ 483e-+45.7e-/pF

Assuming worse case 10pF load so work with noise ~1000e-

Output of amp needs to be 30mV/photon to 270mV/9 photons

Beetle1.2_MA0 submission

All simulations use the following values unless otherwise stated.

300,000e-/photon (delivered by a voltage step across a 3.2pF cap. Rt and Ft =0.1ns, pulse width 10us, Vpeak is –15mV for 300,000e-)

All simulations done on a three channel segment with parasitic extraction and biased by the bias generator.

10pF load

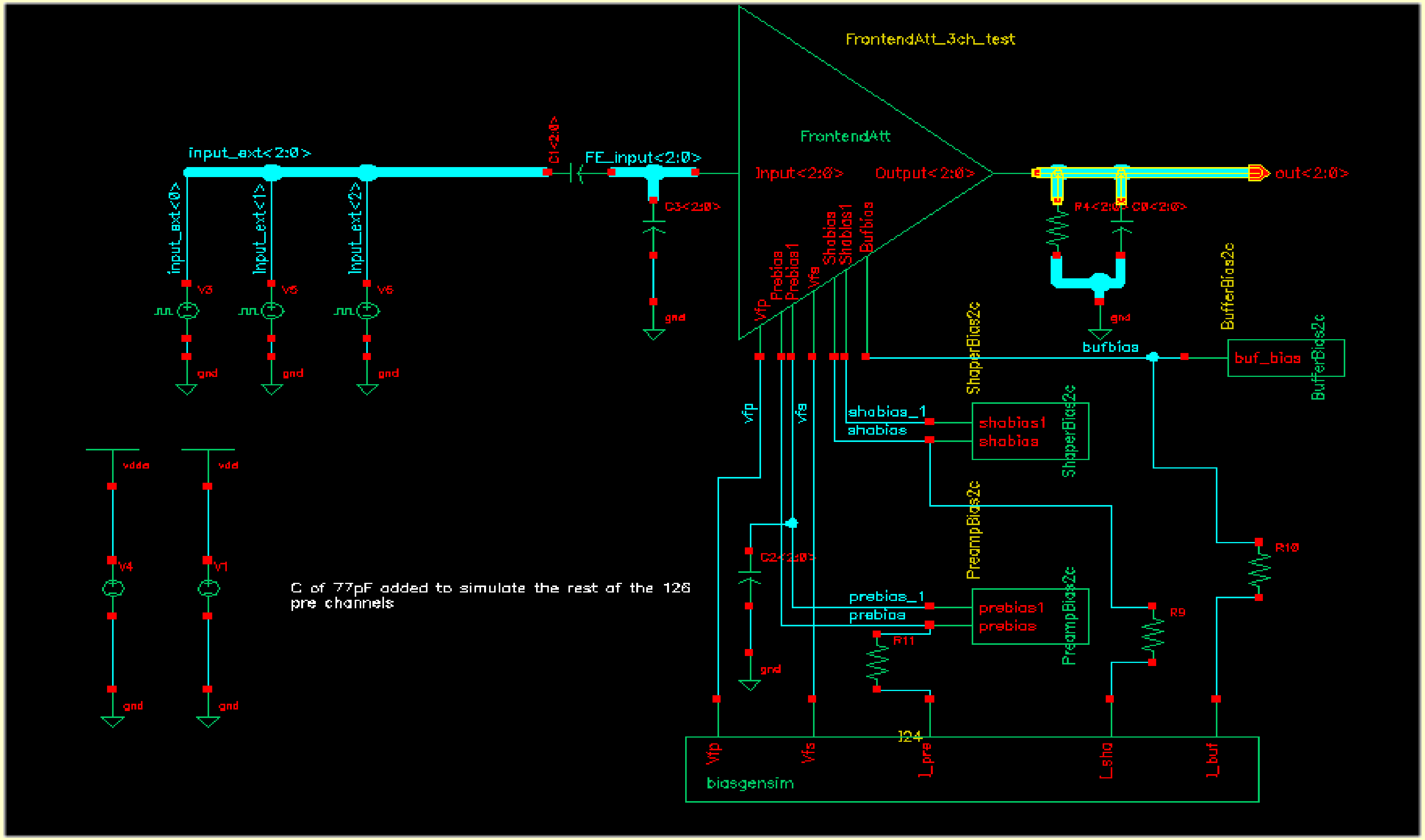
Vfs=0V, Vfp=0V. This gives best rise time and input rate capabilities.

Vfs=0V, Vfp=405mV for the attenuator amp.

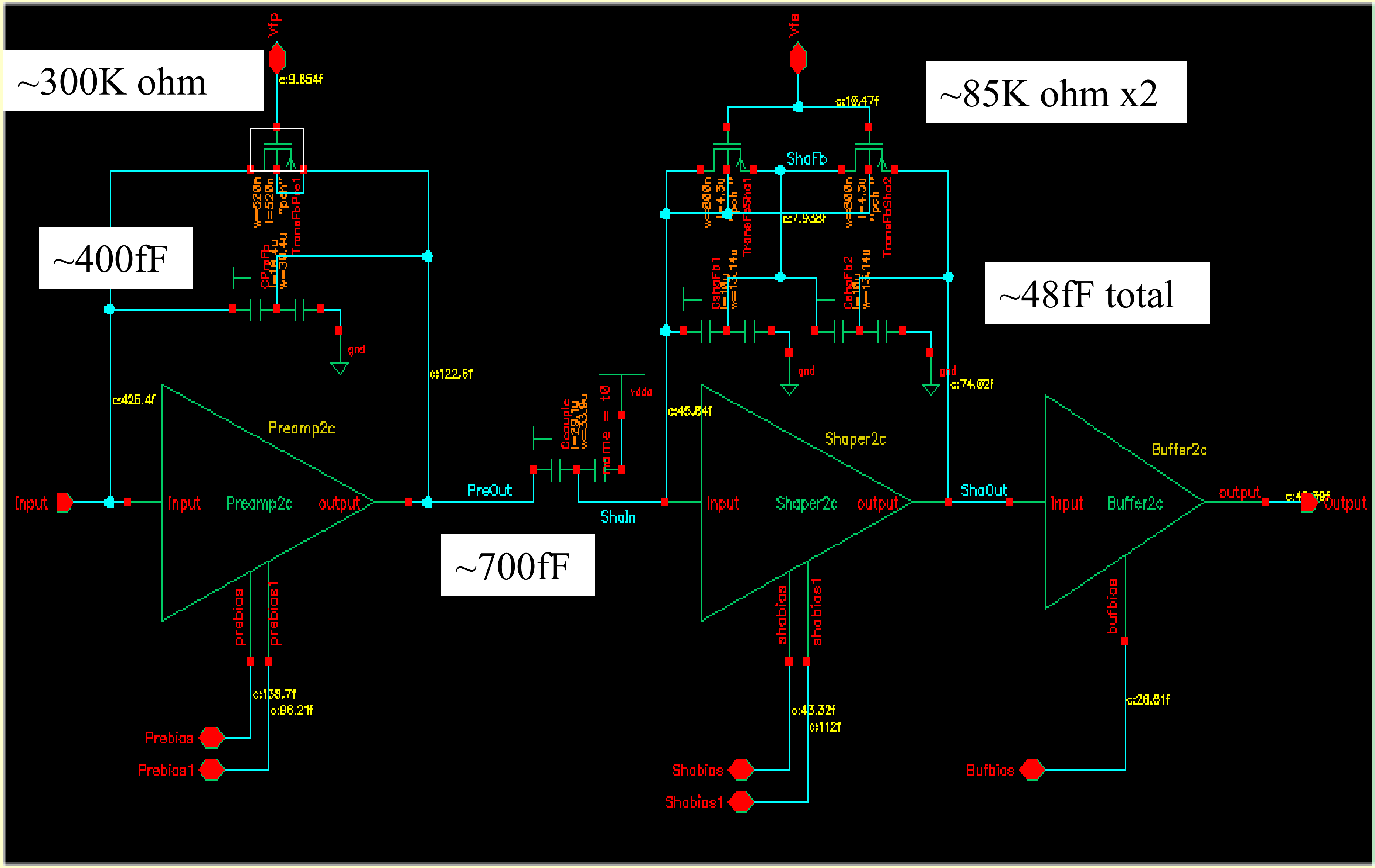
I-shape=78.8uA, I-pre=590.5uA, I-buf=78.8uA. From Beetle bias generators. Standard Beetle1.2 settings.

R=1M//C=1pF on output buffer to give pipeline loading.

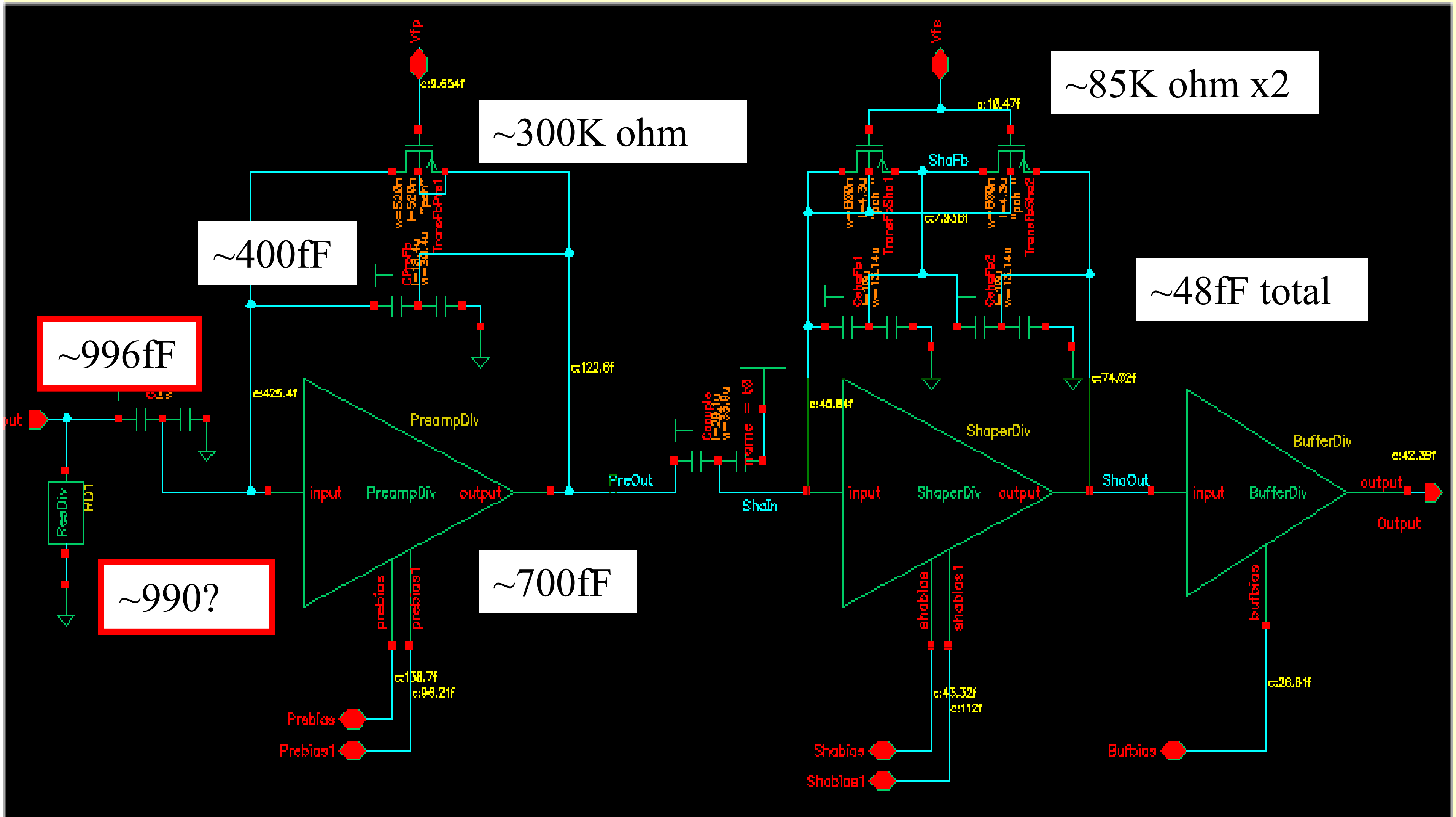
A three channel simulation test bed, allows cross talk measurements.



Standard Beetle1.2 Frontend

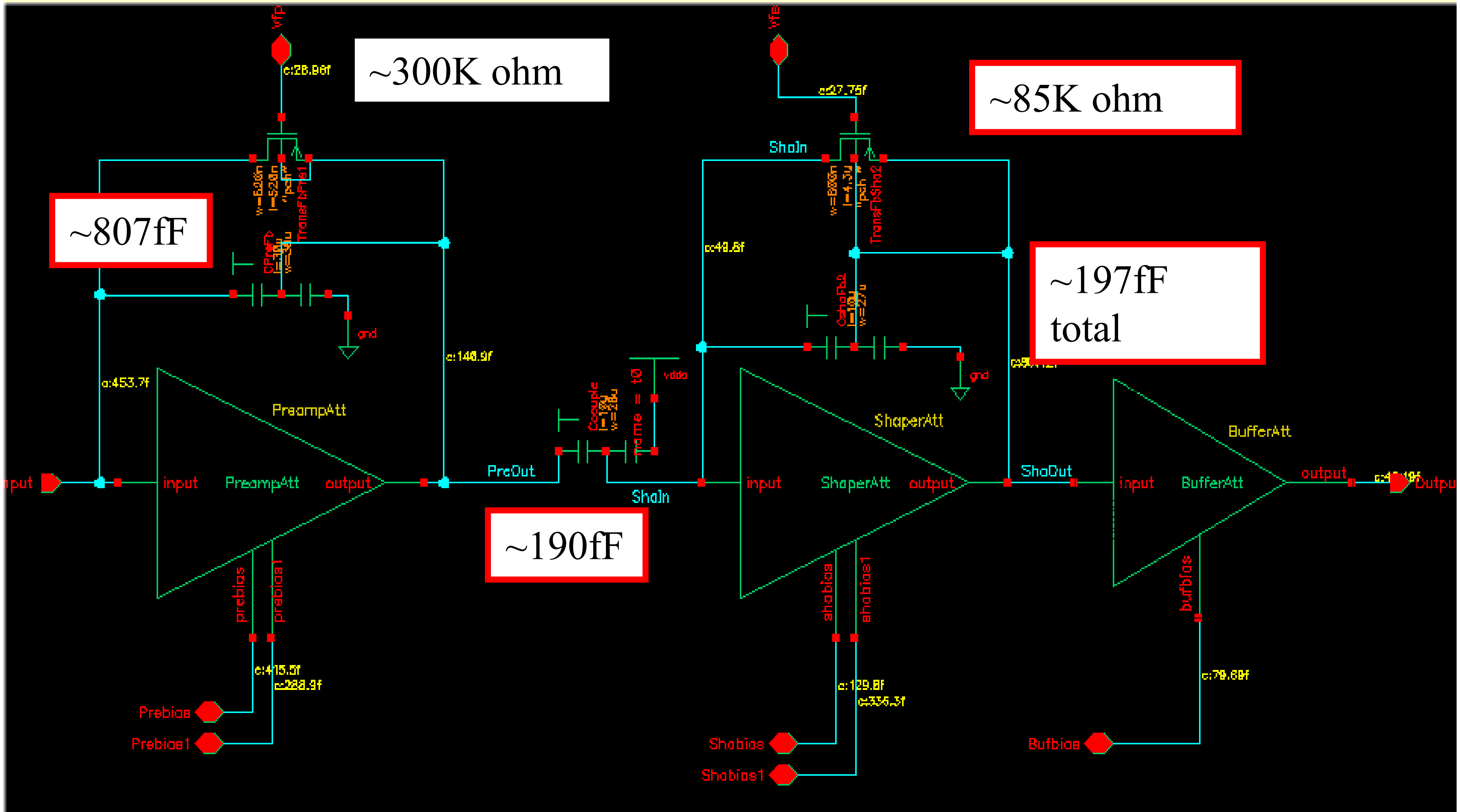


Beetle1.2MA0 FrontendDiv



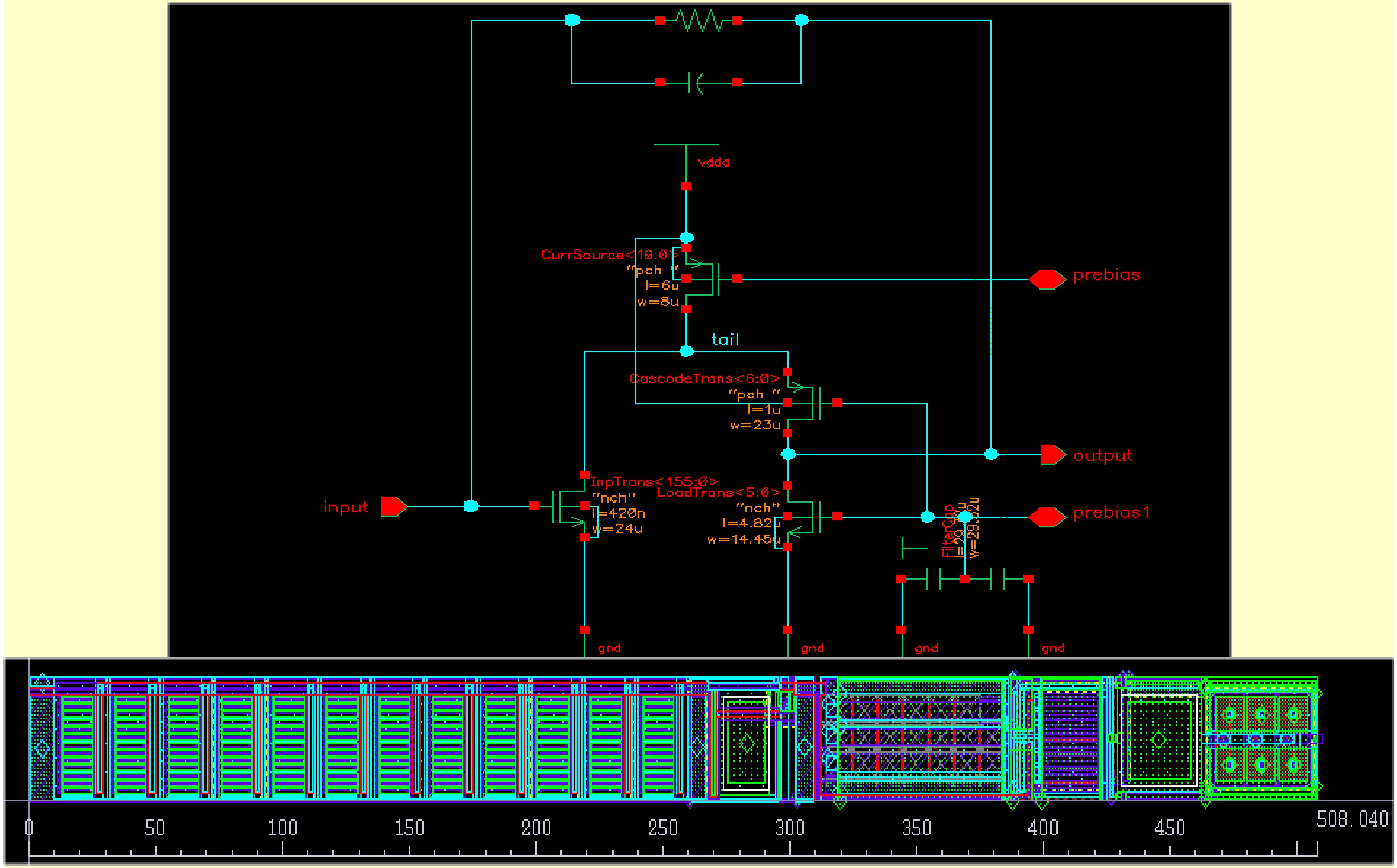
Red box means different to the standard Beetle1.2

Beetle1.2MA0 FrontendAtt

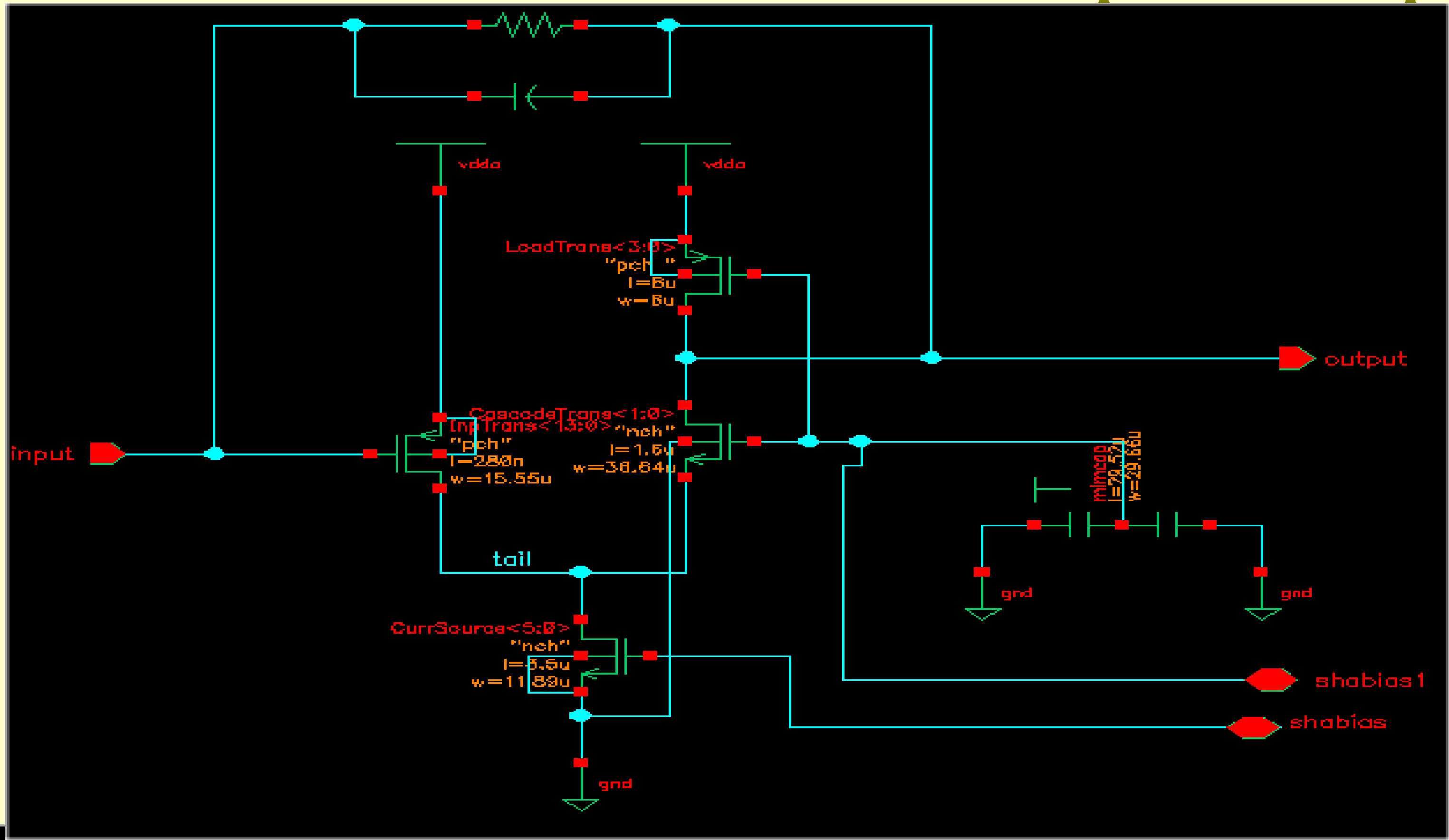


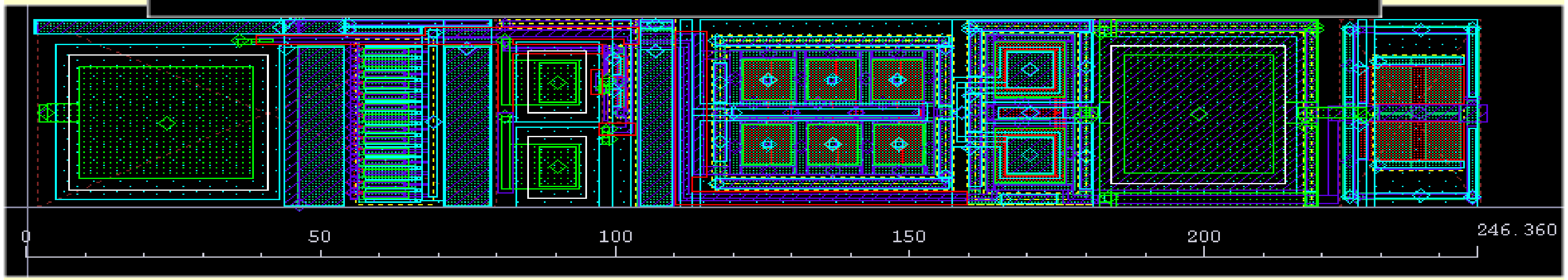
Red box means different to the standard Beetle1.2

The folded cascode pre-amp

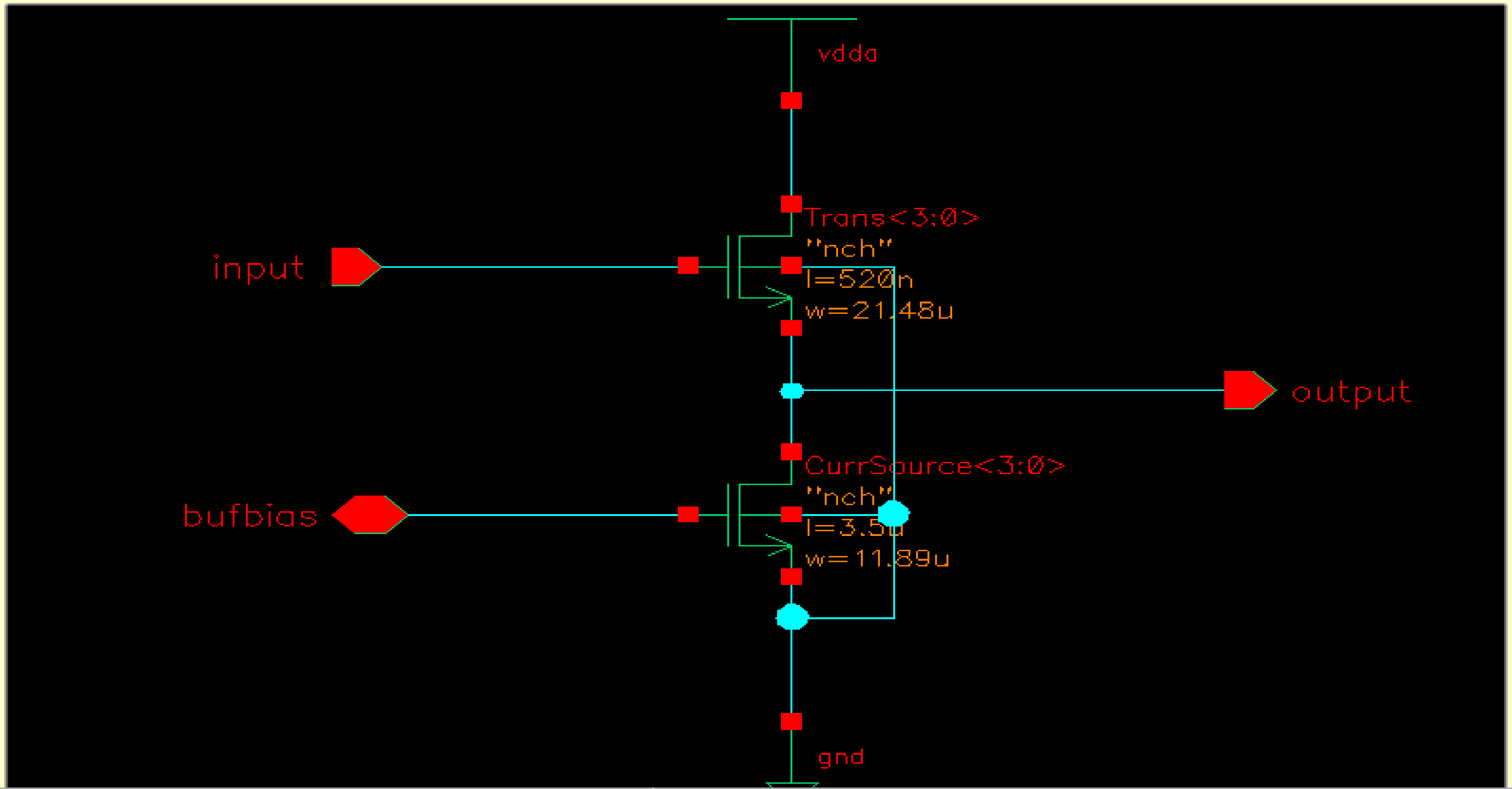


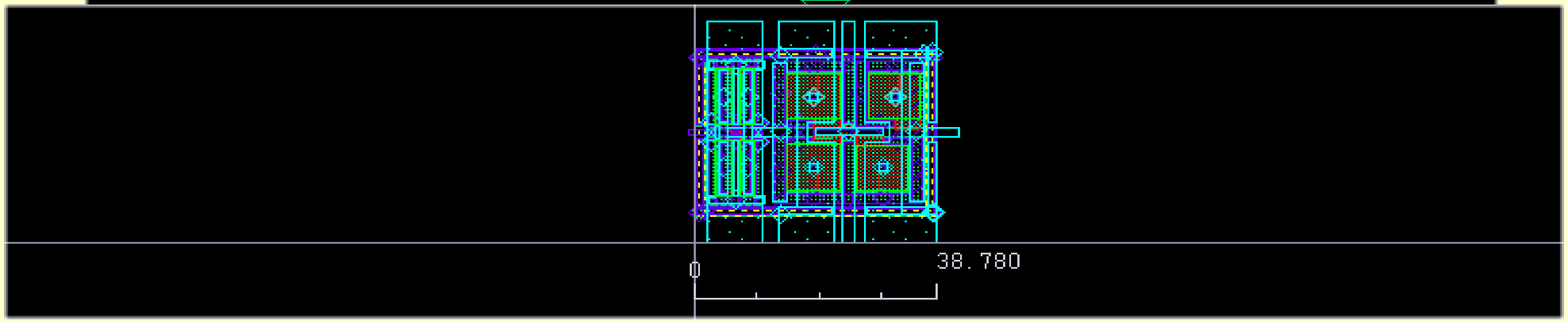
The folded cascode shaper amp



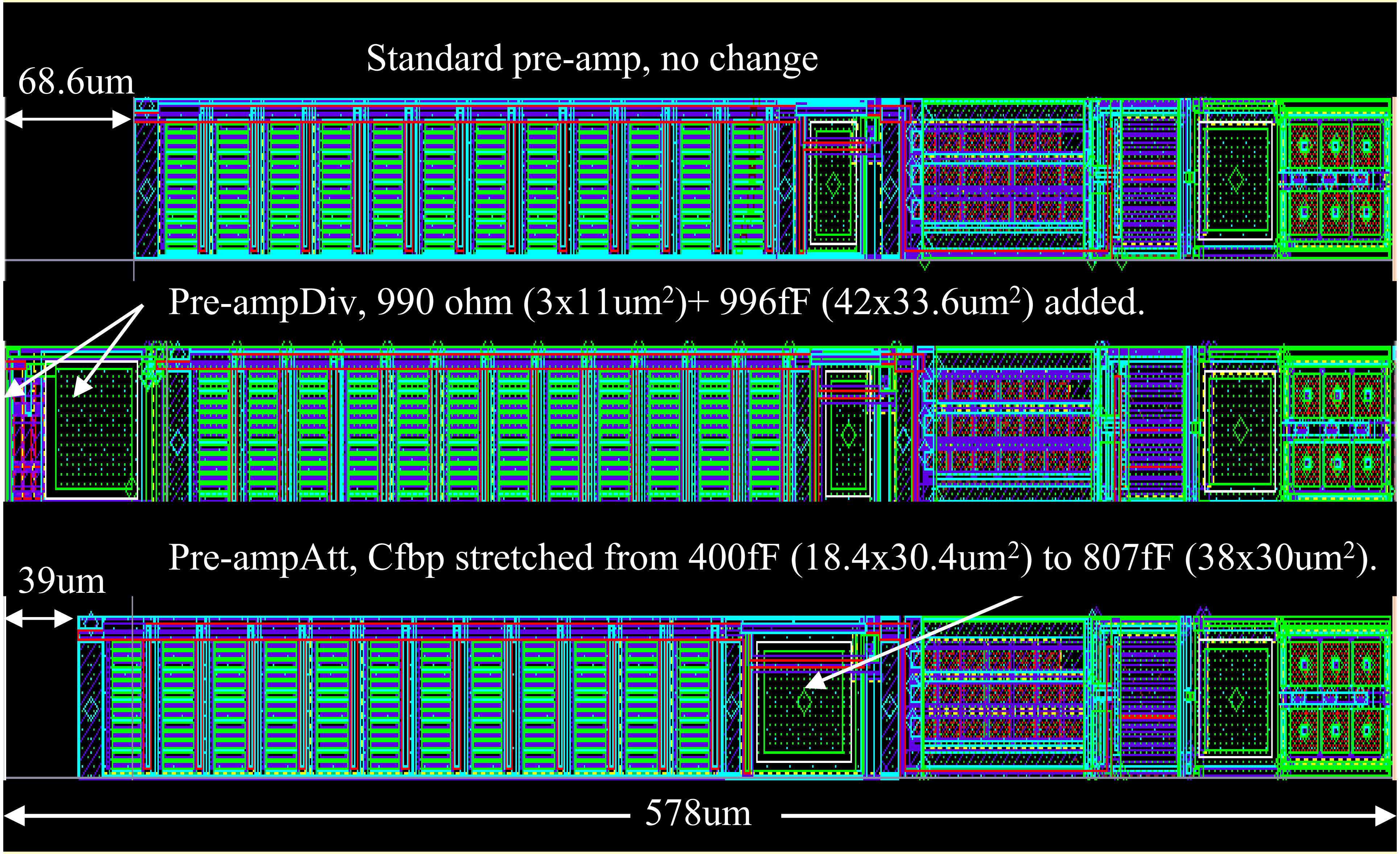


The source follower buffer

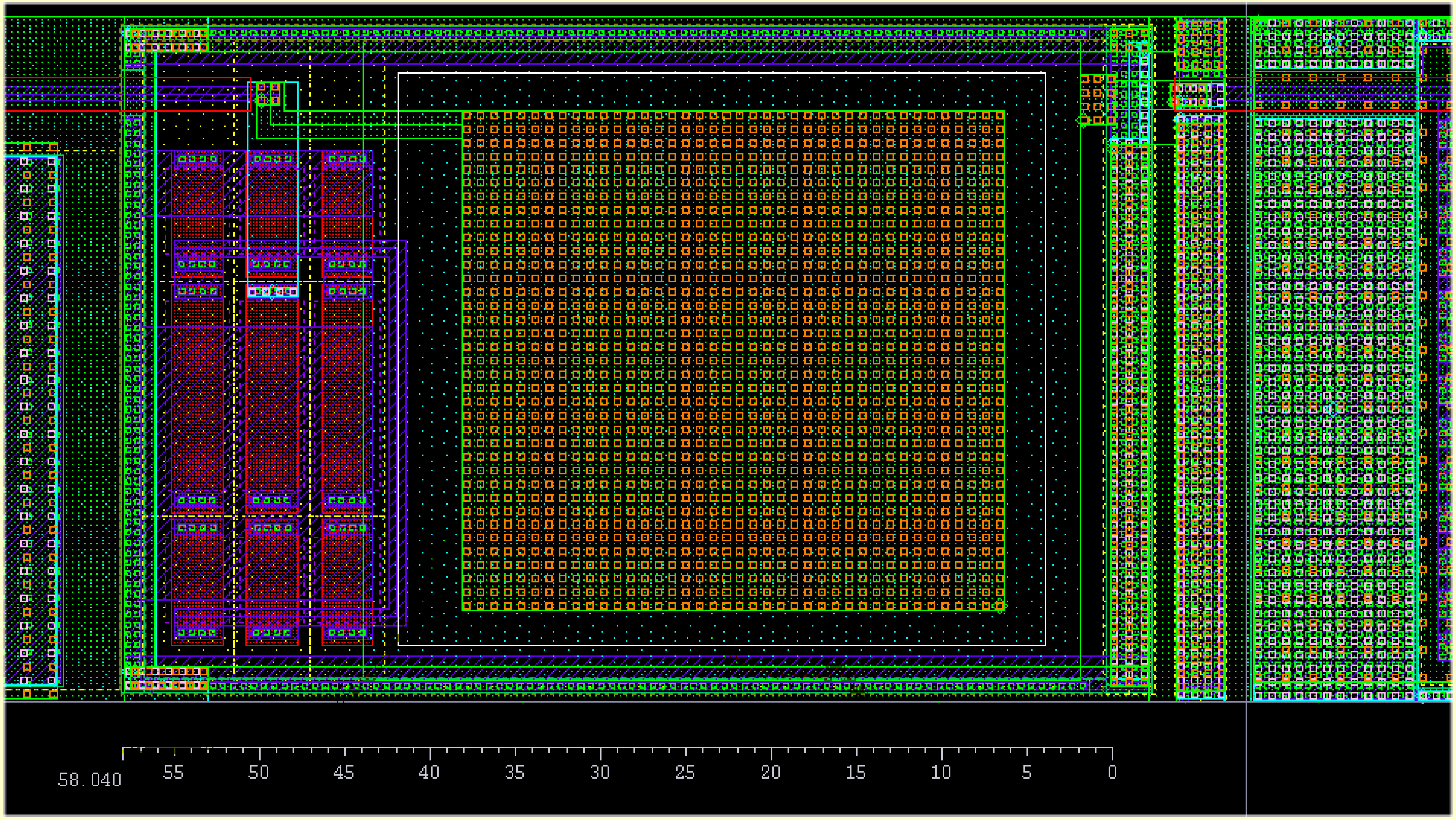




The layout of the three pre-amps

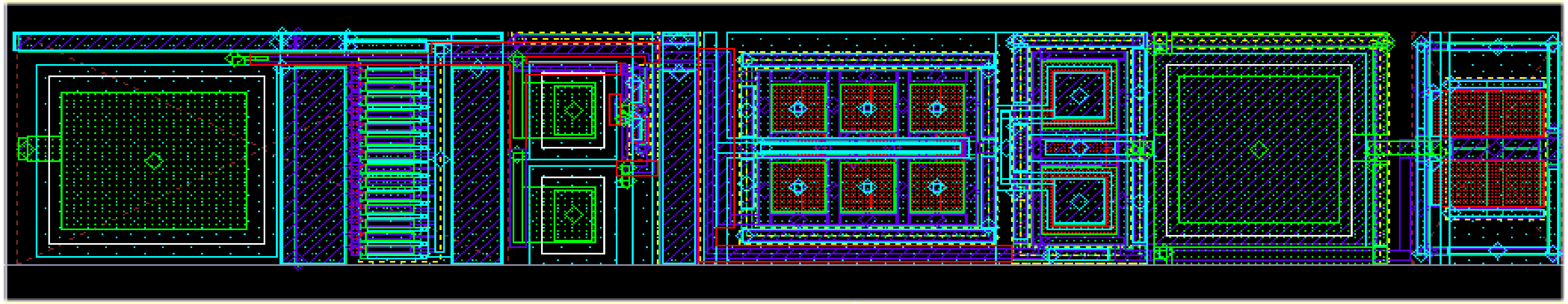


Zoom of the preampDiv RC network



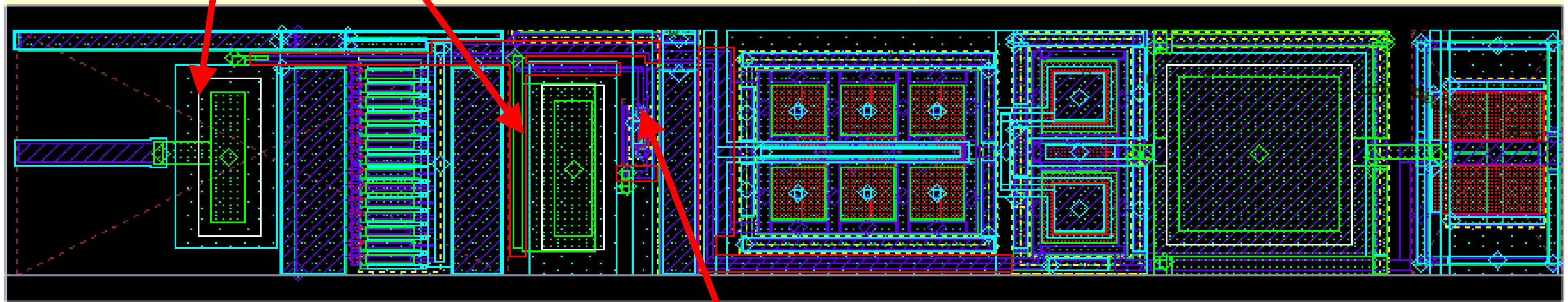
The layout of the three Shaper-amps

Shaper & ShaperDiv have no change.



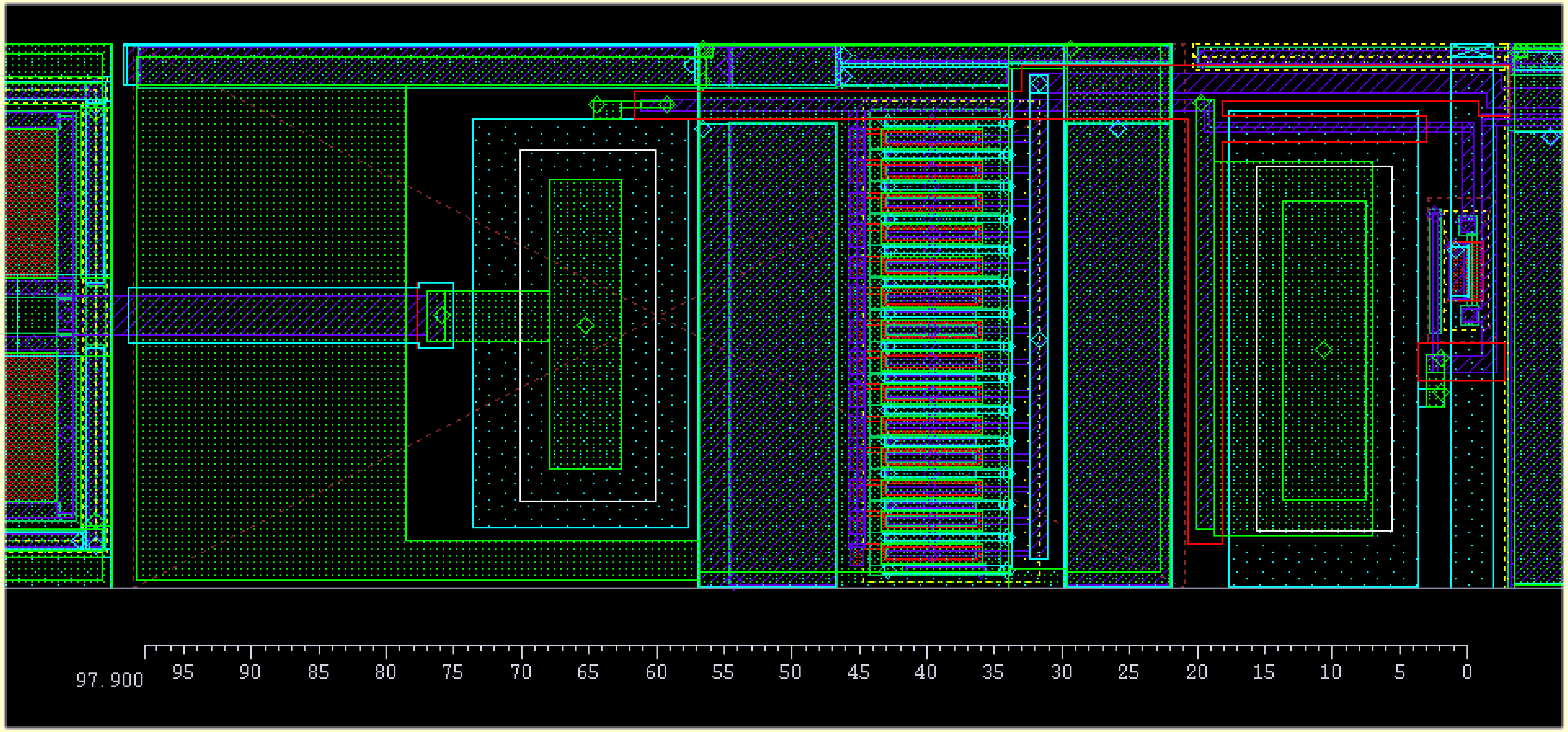
ShaperAtt, coupling C reduced from 700fF (33.9x29.1um^2) to 190fF (26x10um^2) .

Cfbs increased from 48.8fF (2_{caps}x13.14x10um^2) to 197fF (1_{cap}x27x10um^2).

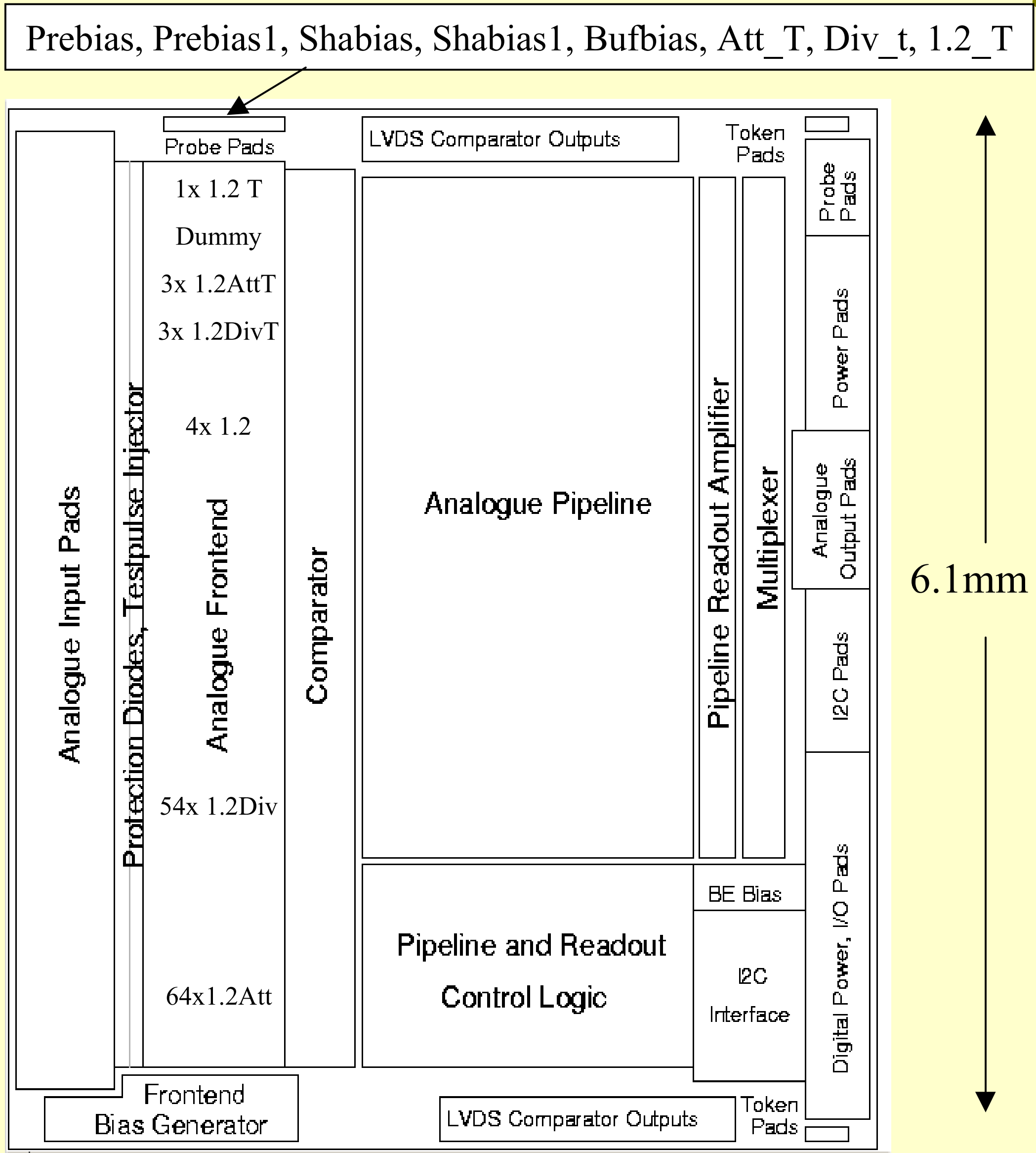


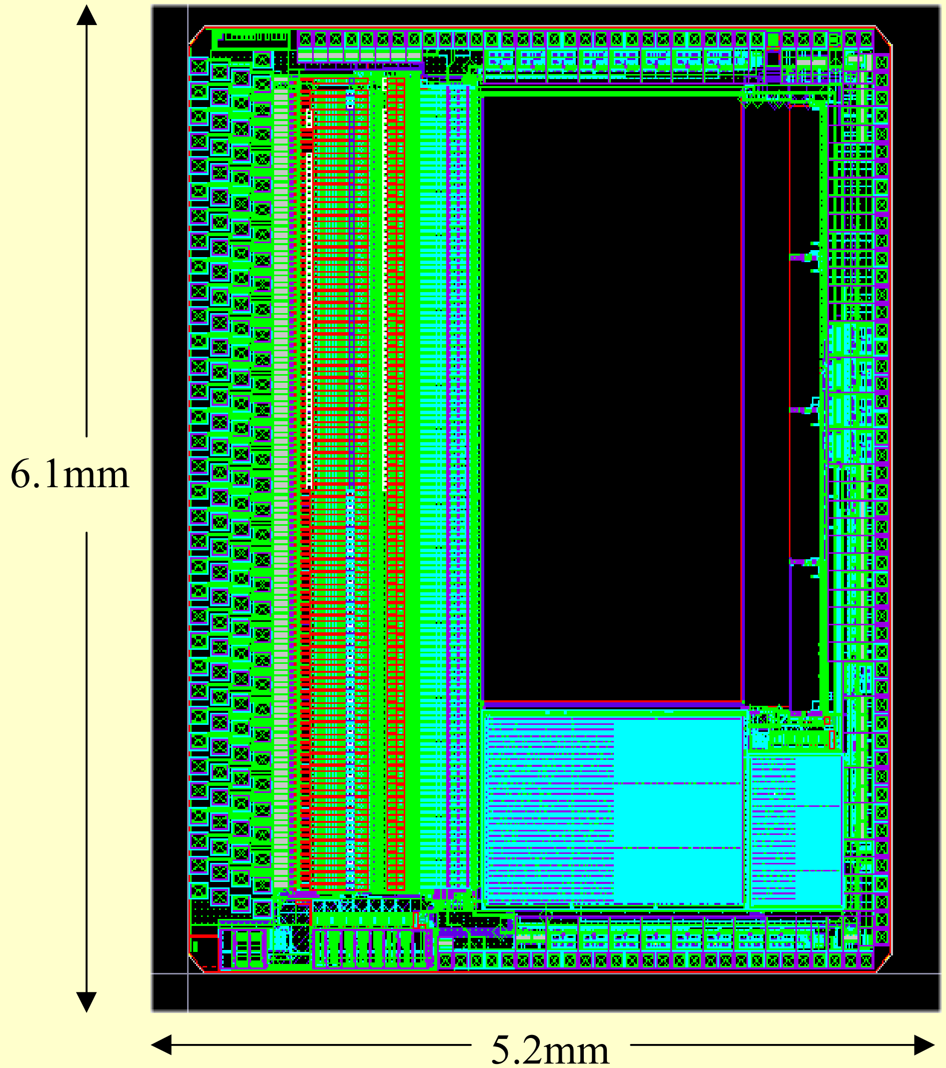
Removed one of the fb transistors

Zoom of the shapampAtt mods

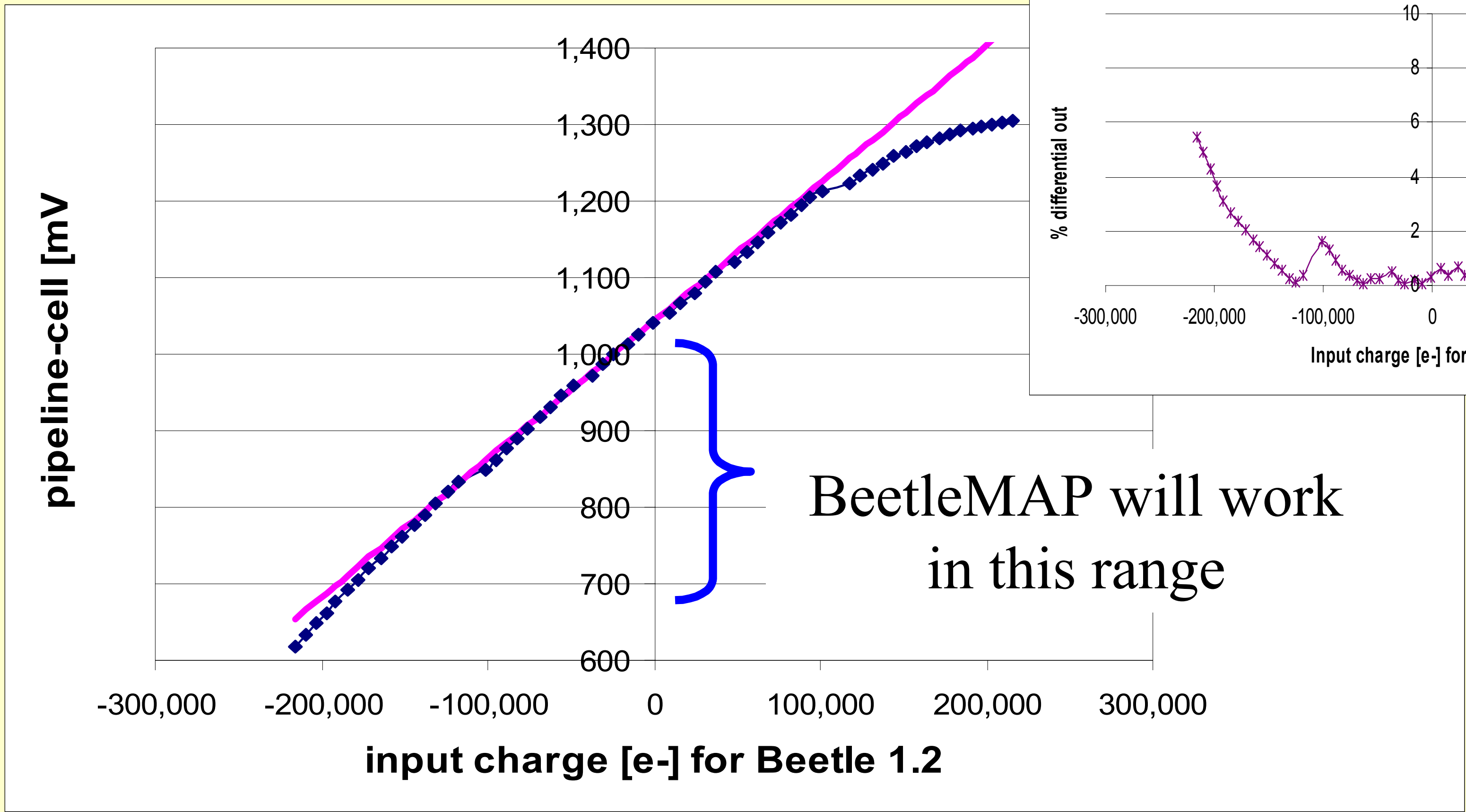


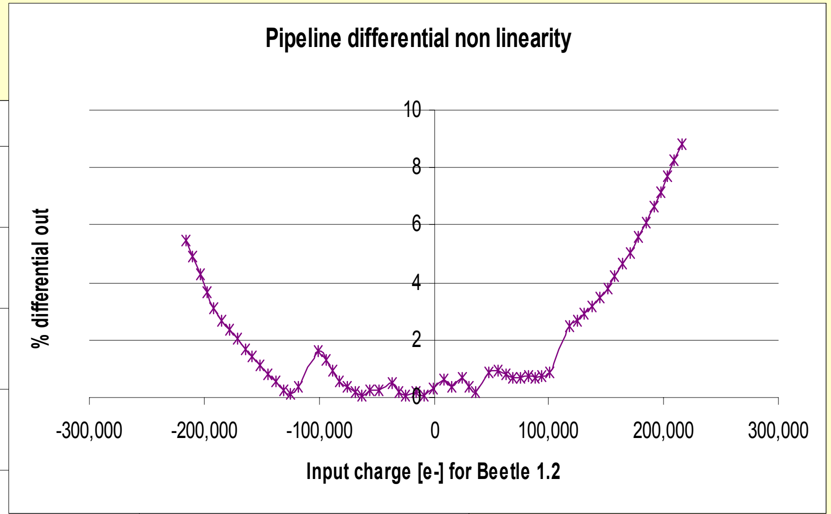
Beetle1.2 MA0 Layout Scheme



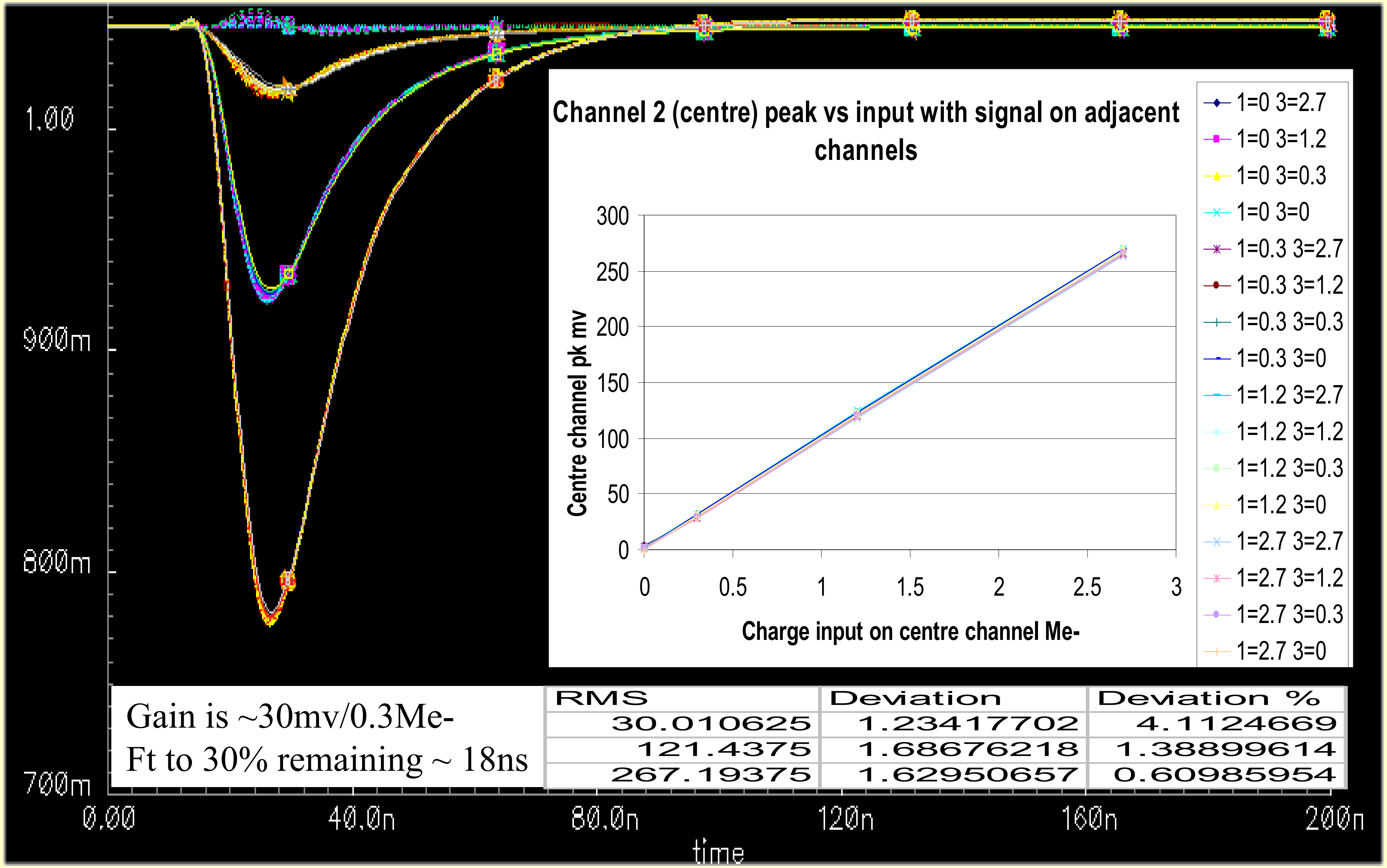


Dynamic input range of the Beetle1.2 pipeline. Plot created by Sven Loechner HD





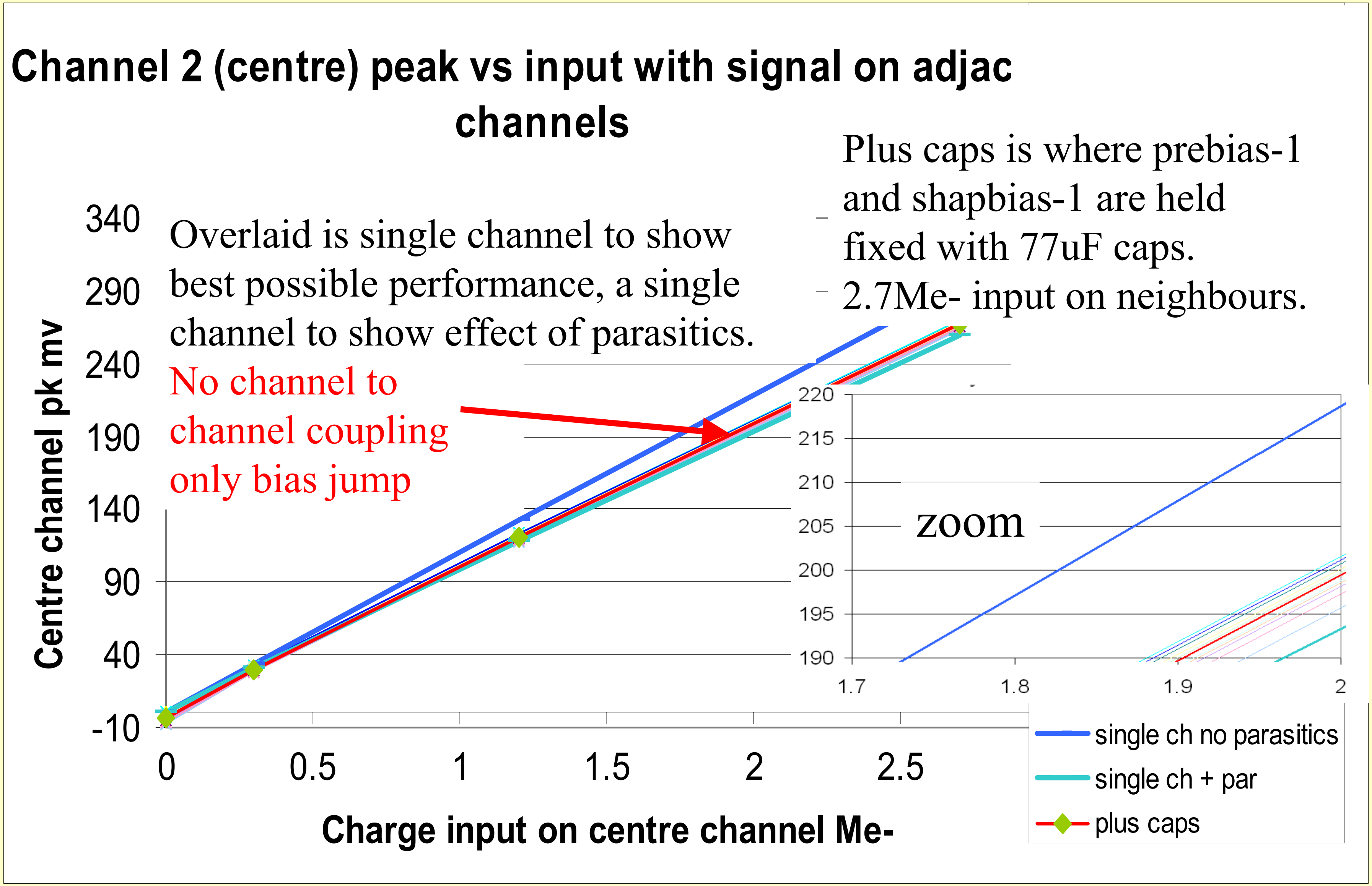
Beetle1.2MA0 FrontendAtt



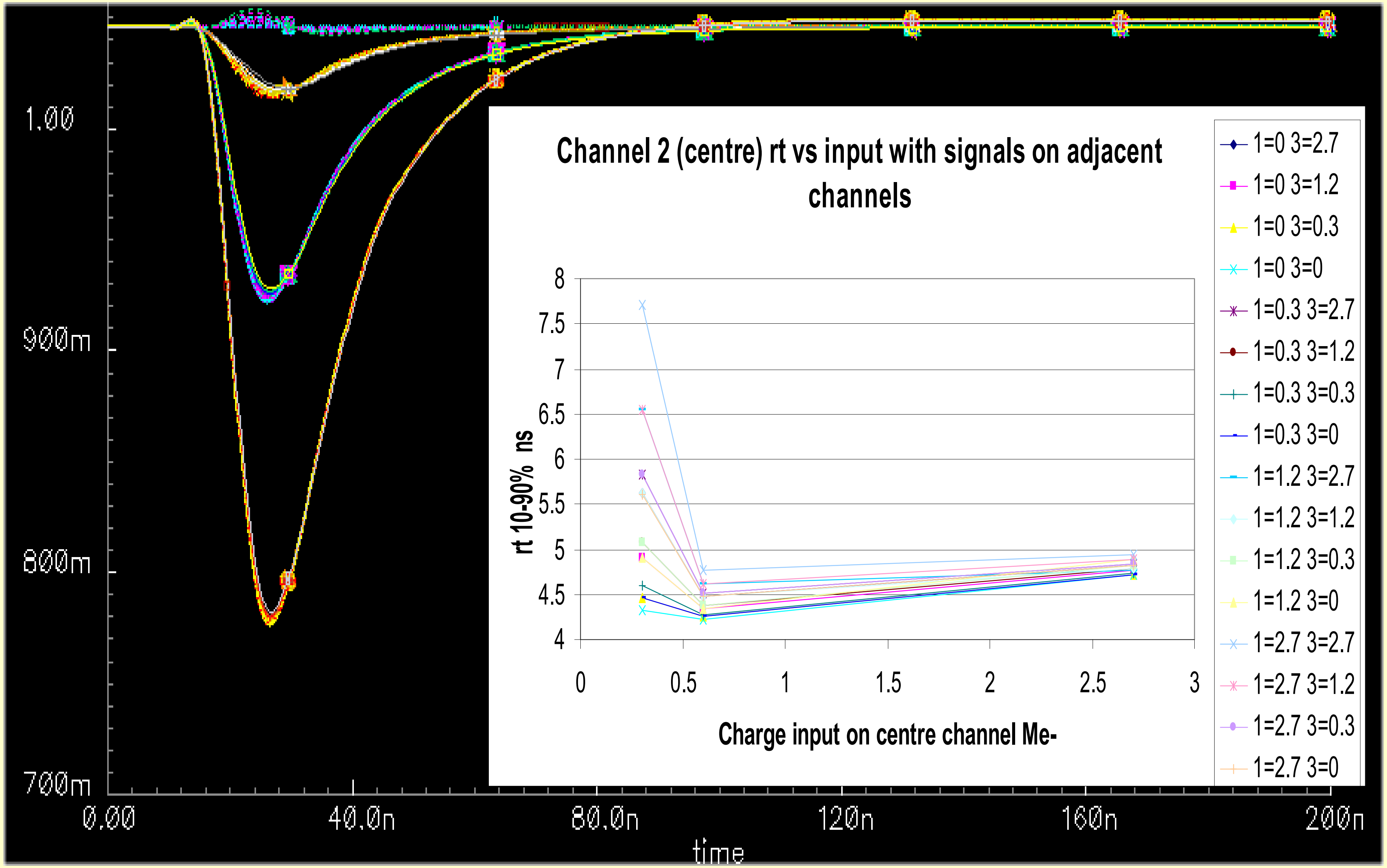
Gain is ~30mv/0.3Me-
Ft to 30% remaining ~ 18ns

RMS	Deviation	Deviation %
30.010625	1.23417702	4.1124669
121.4375	1.68676218	1.38899614
267.19375	1.62950657	0.60985954

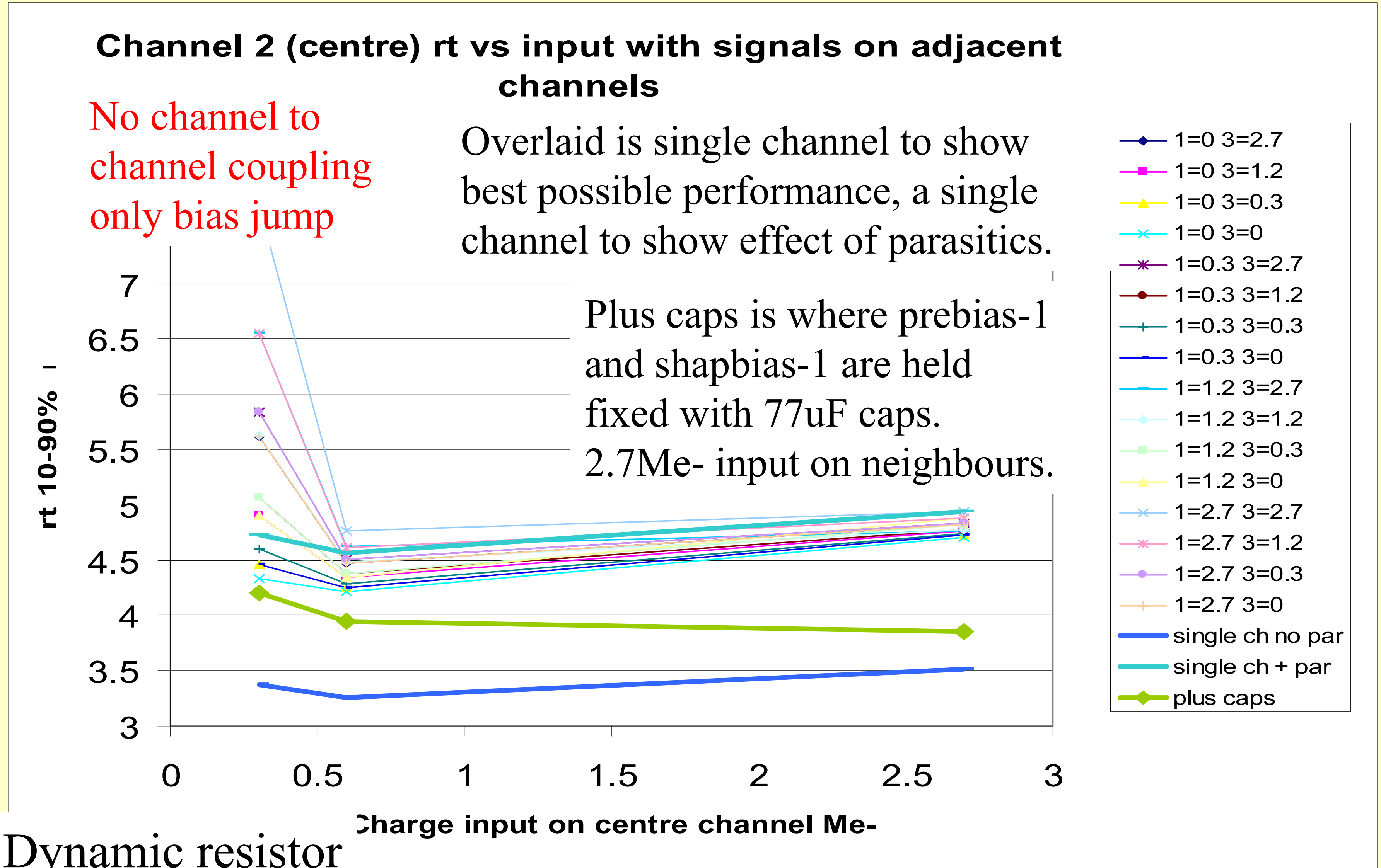
Beetle1.2MA0 FrontendAtt



Beetle1.2MA0 FrontendAtt

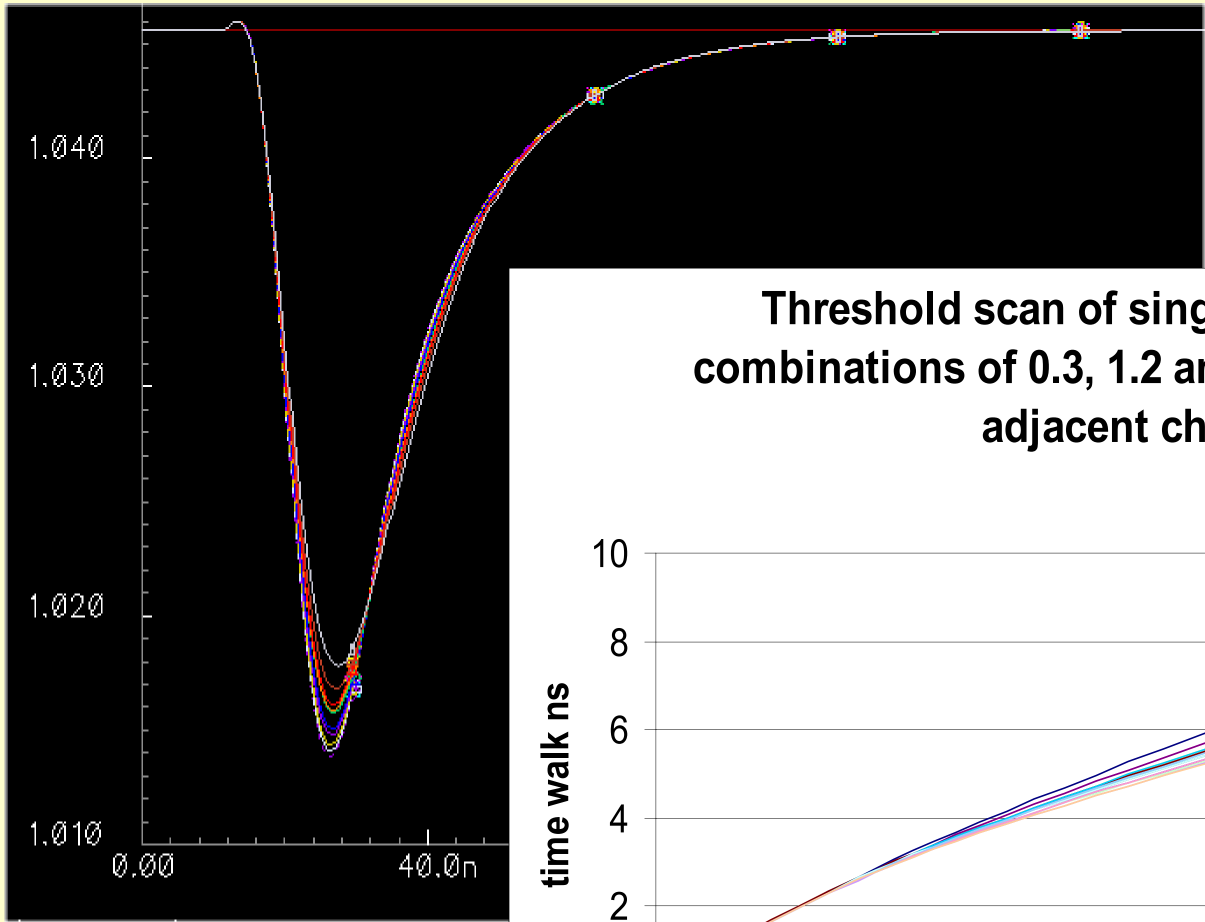


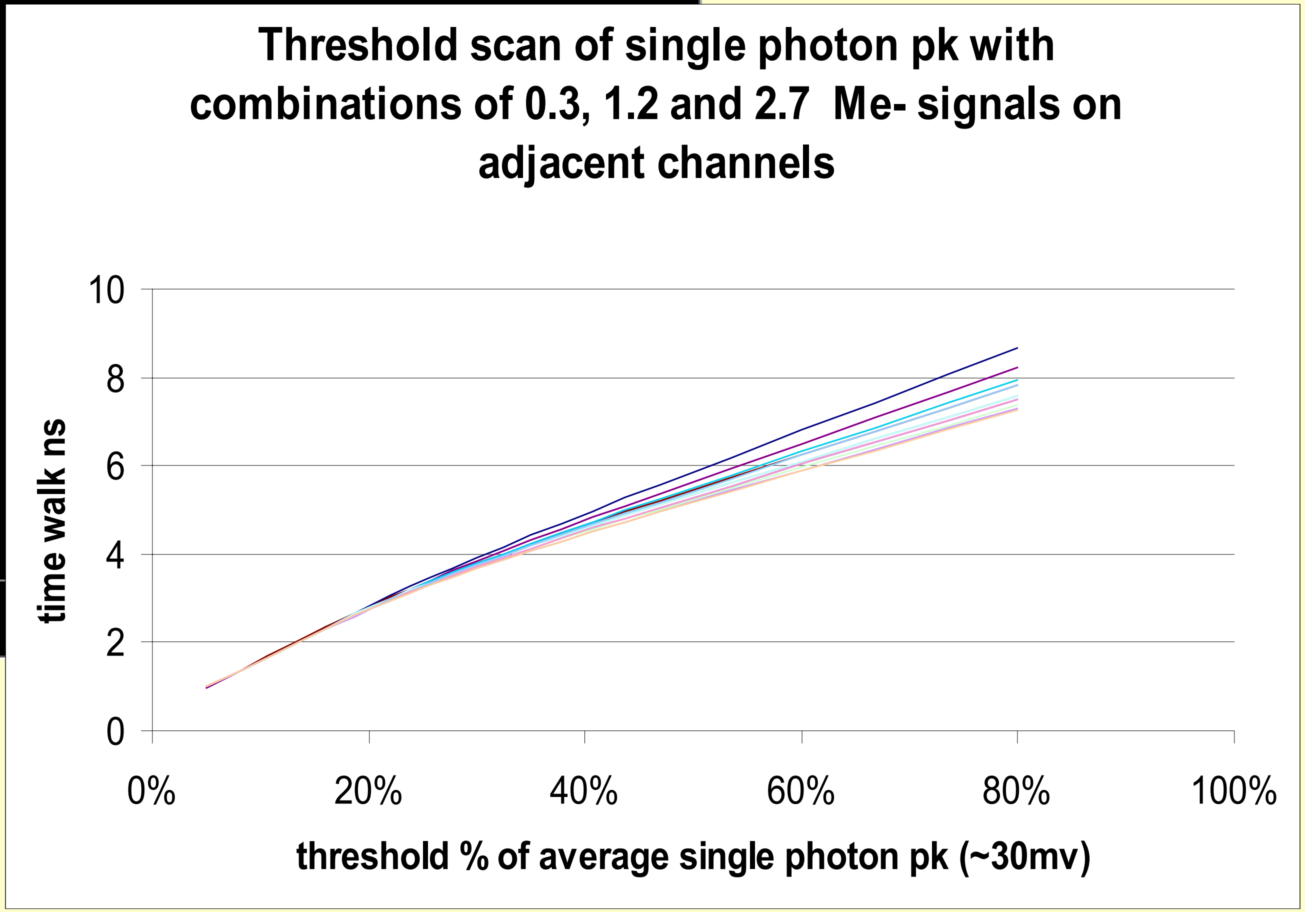
Beetle1.2MA0 FrontendAtt



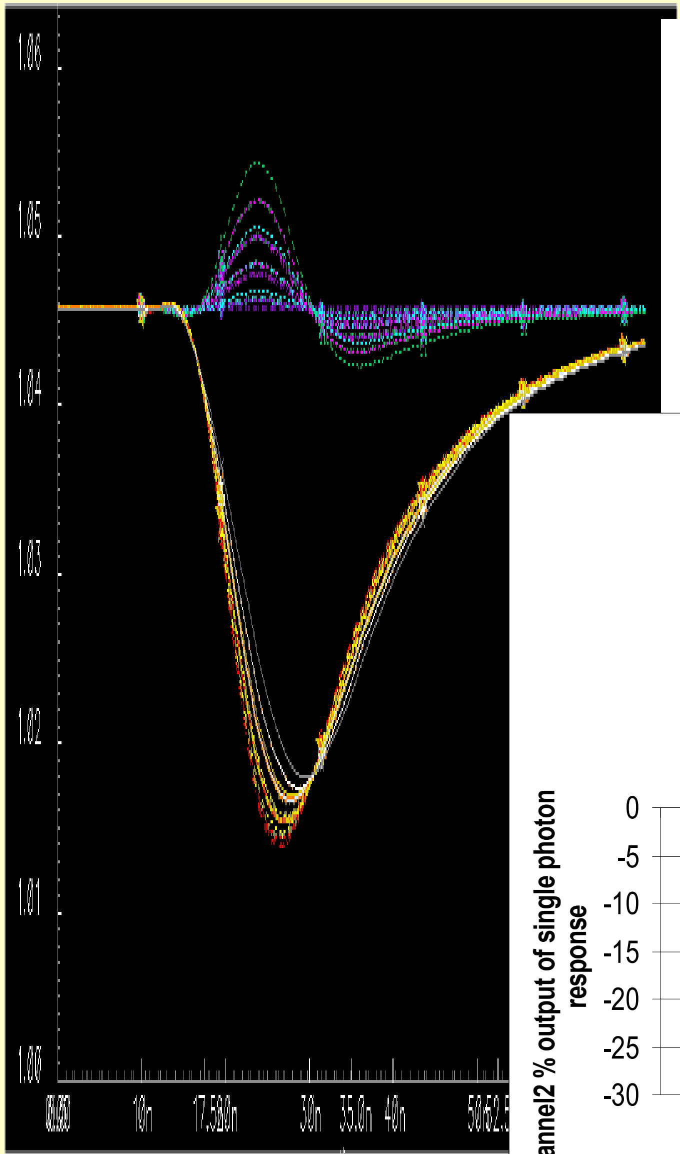
Dynamic resistor

Beetle1.2MA0 FrontendAtt

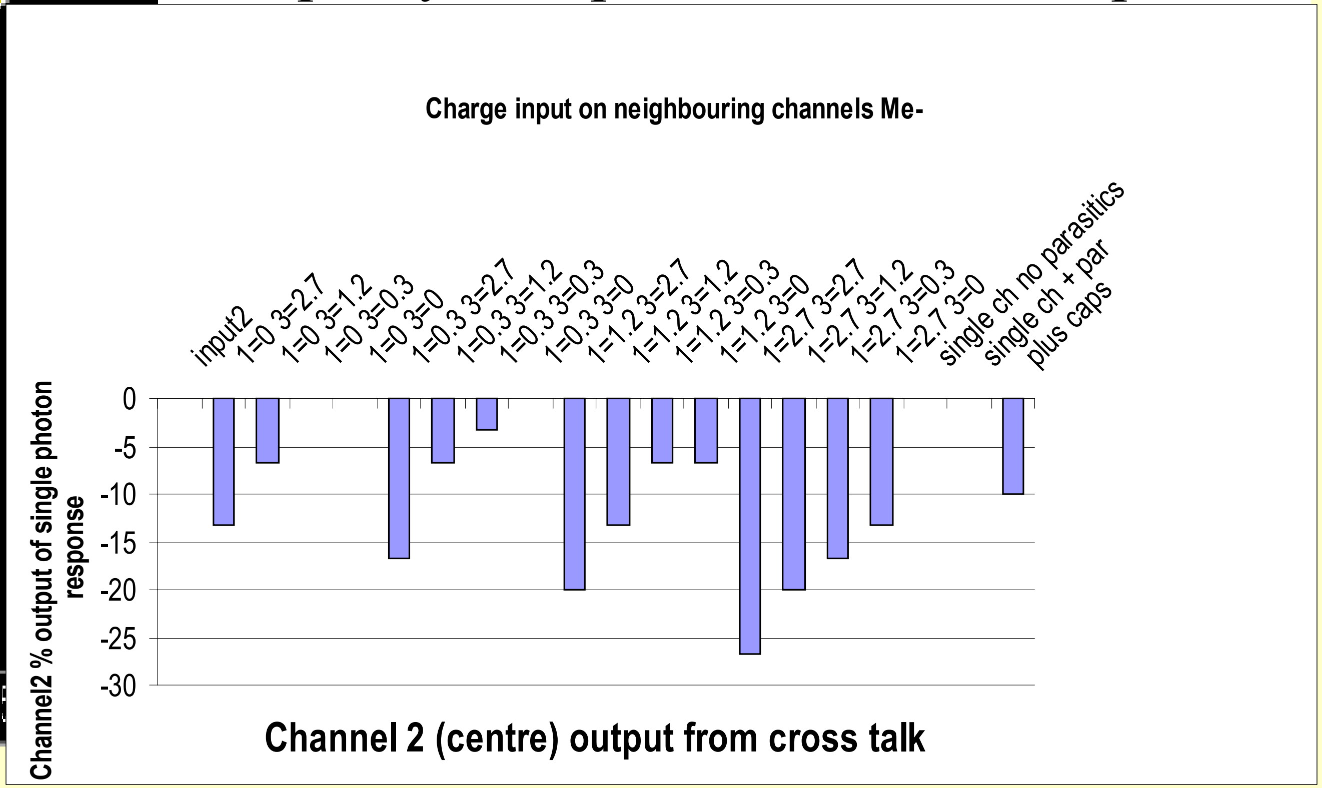




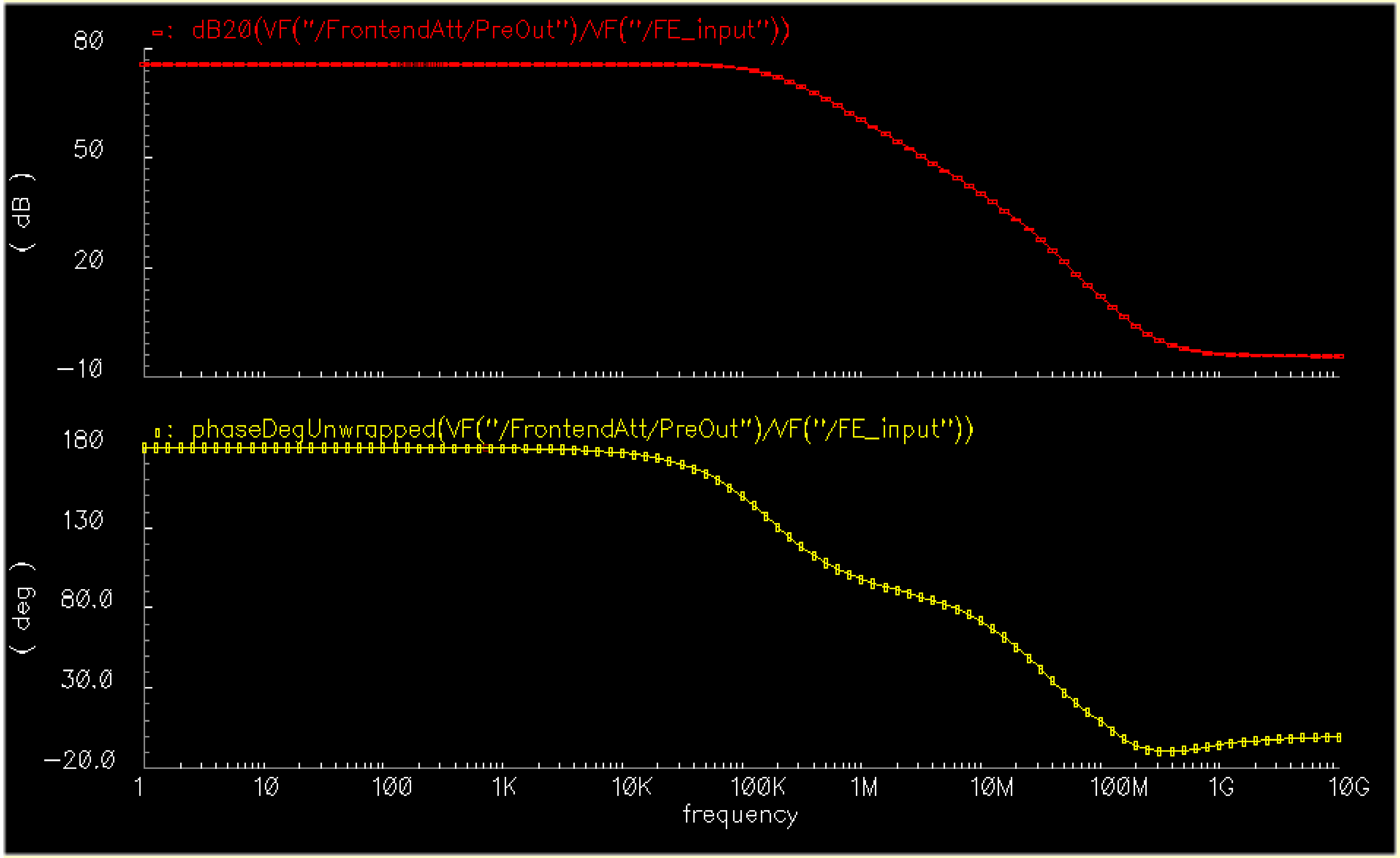
Beetle1.2MA0 FrontendAtt



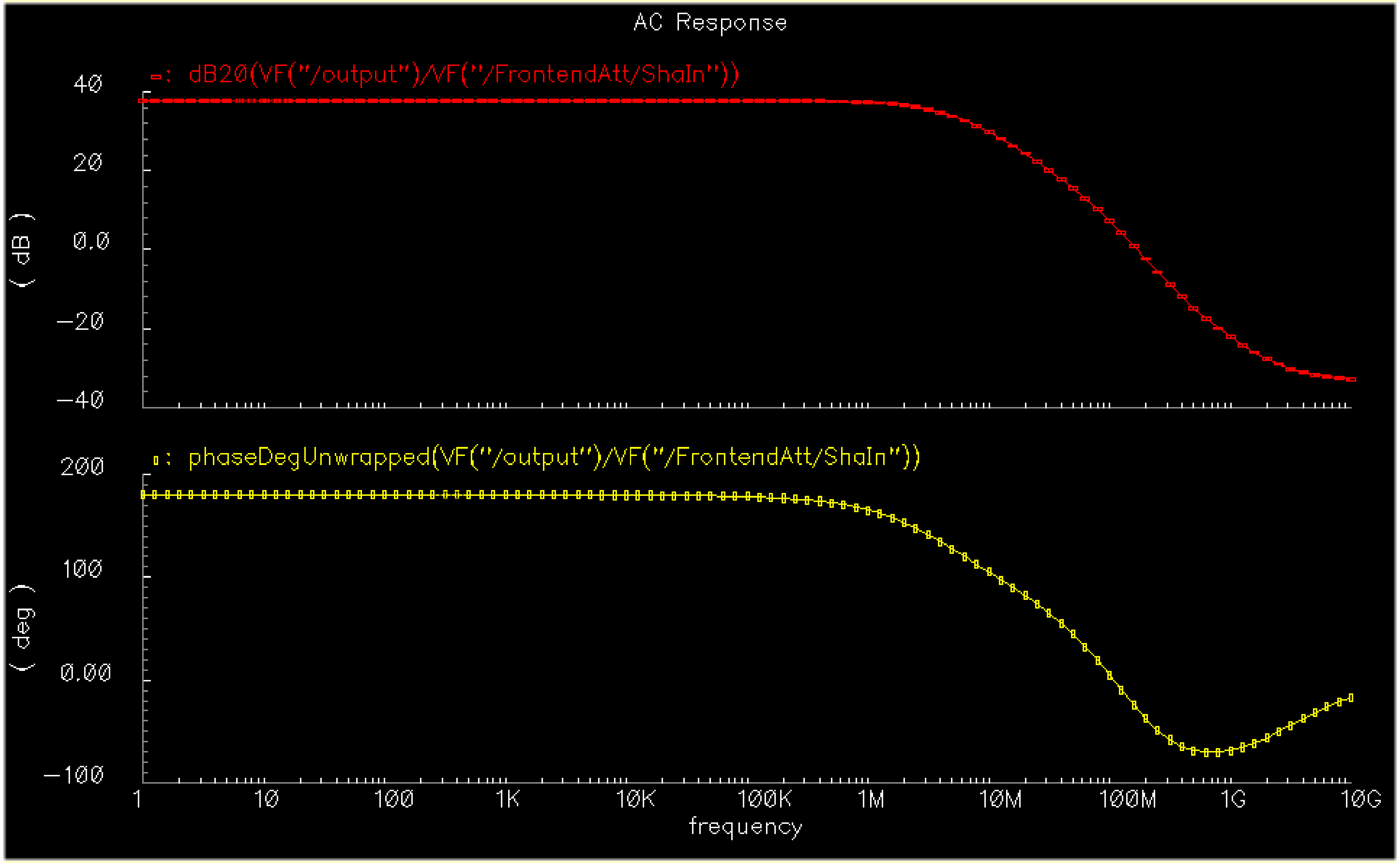
Worst case cross talk (26%) is when neighbour channels have 2.7M-e input. More realistic is .3Me- on neigbours giving <1% cross talk. Depends on occupancy. See previous slide for caps.



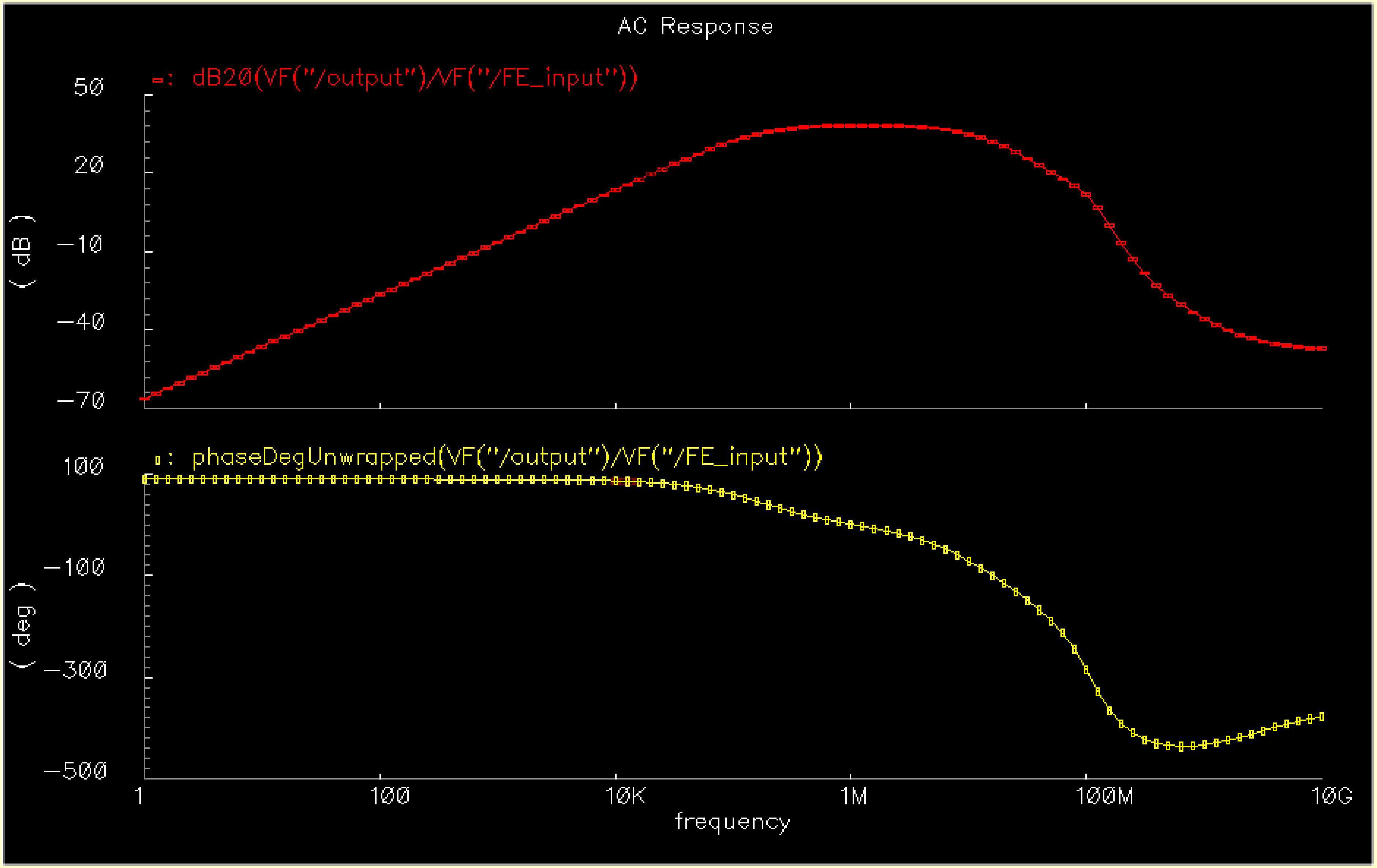
Beetle1.2MA0 FrontendAtt



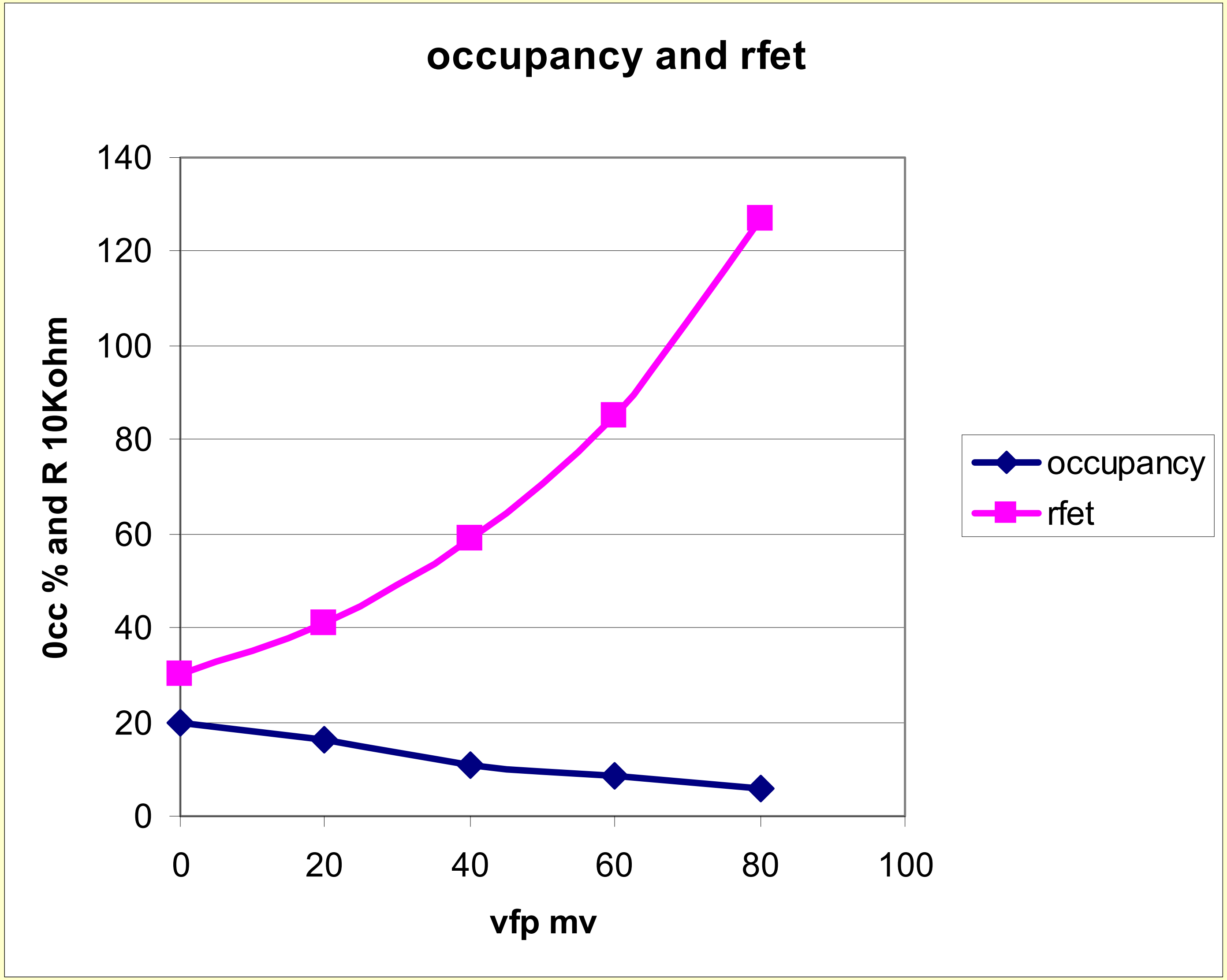
Beetle1.2MA0 FrontendAtt



Beetle1.2MA0 FrontendAtt

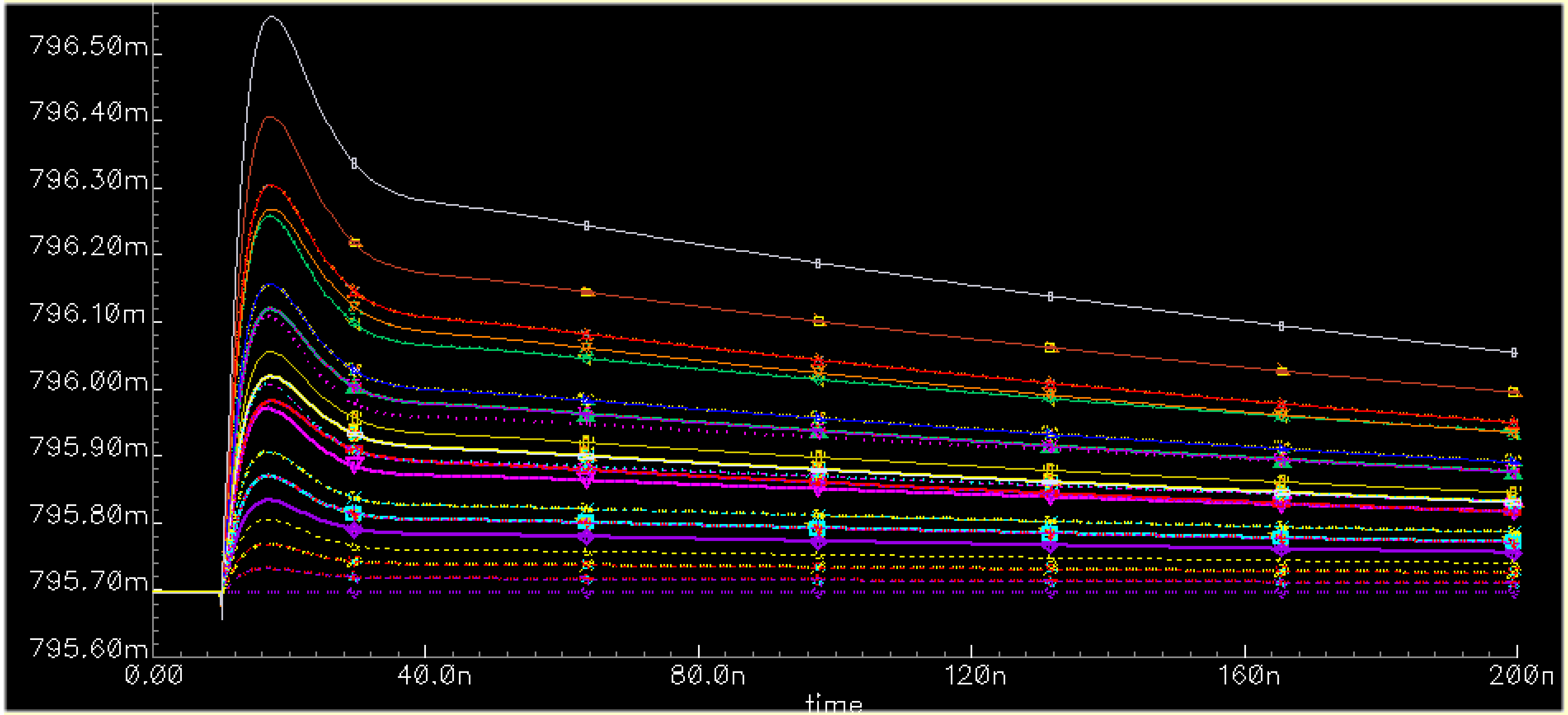


Beetle1.2MA0 FrontendAtt



Beetle1.2MA0 FrontendAtt

Prebias-1 problem

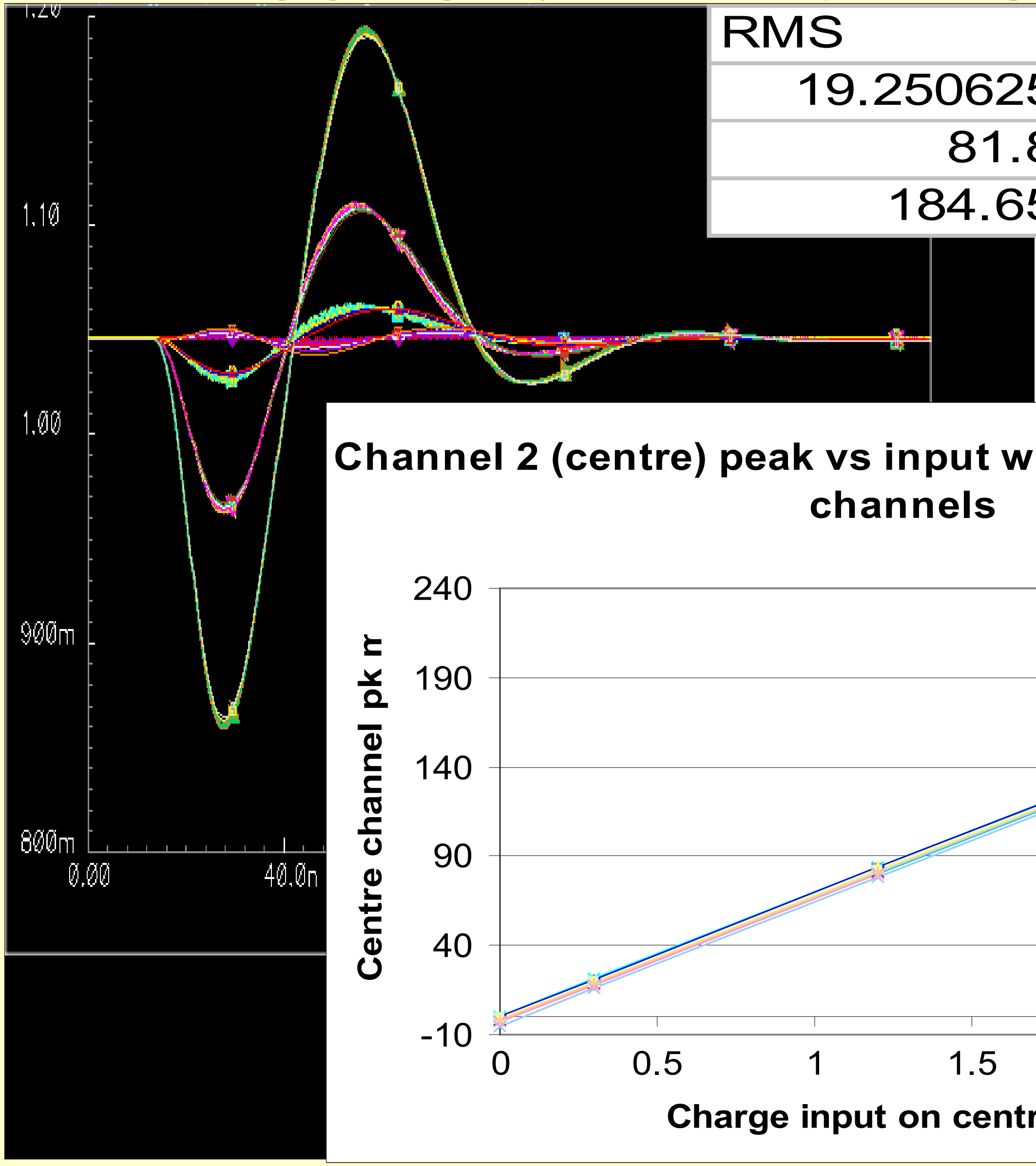


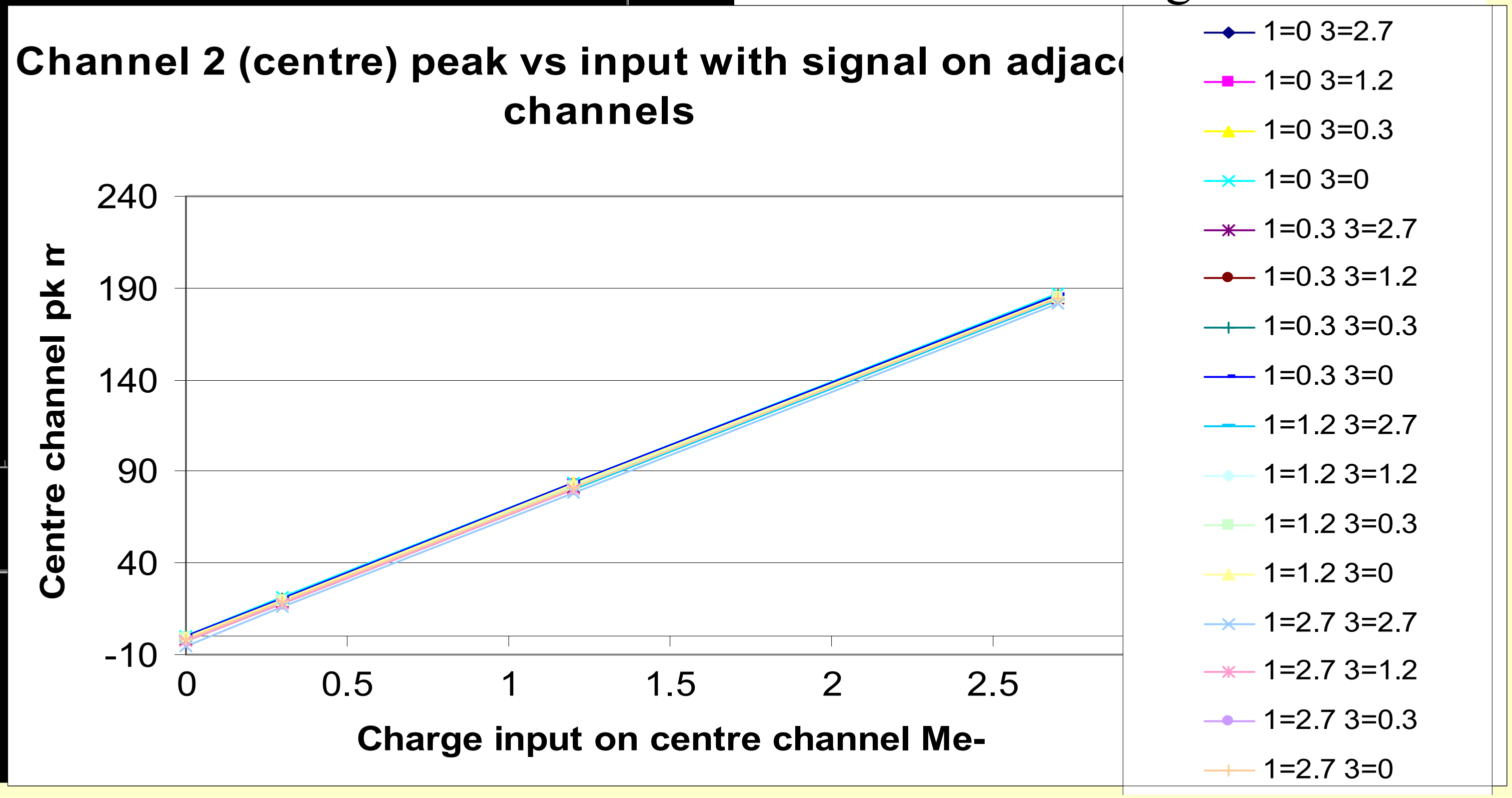
Beetle1.2MA0 FrontendDiv

RMS	Deviation	Deviation %
19.250625	1.41359338	7.34310383
81.8	1.44615352	1.76791384
184.65	1.47648231	0.79961132

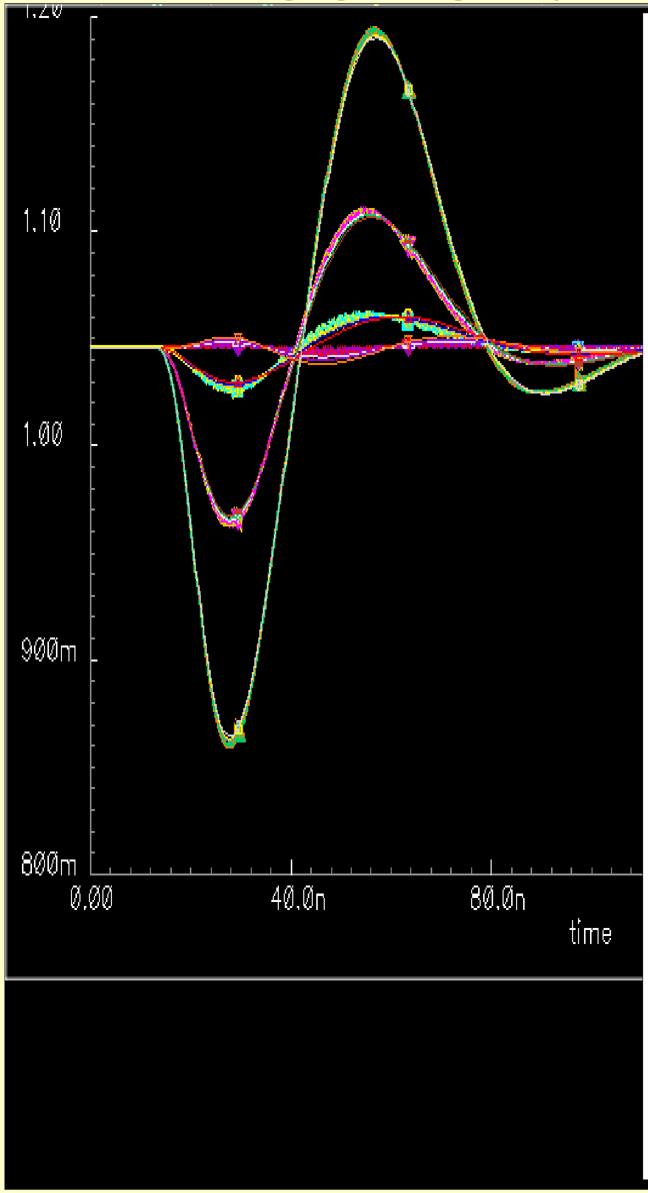
Gain is ~20mv/0.3Me-

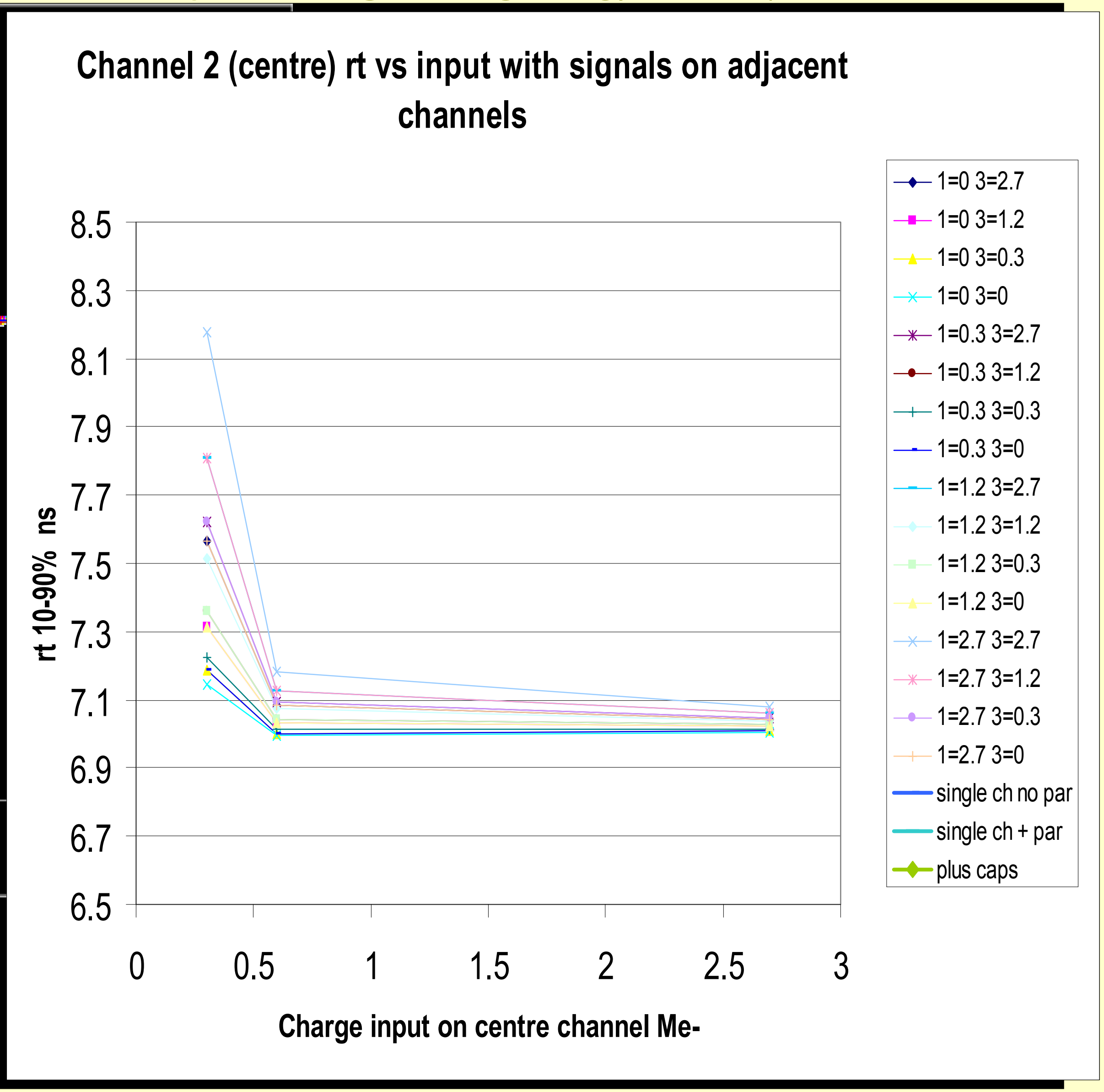
Ft to 30% remaining ~ 9ns



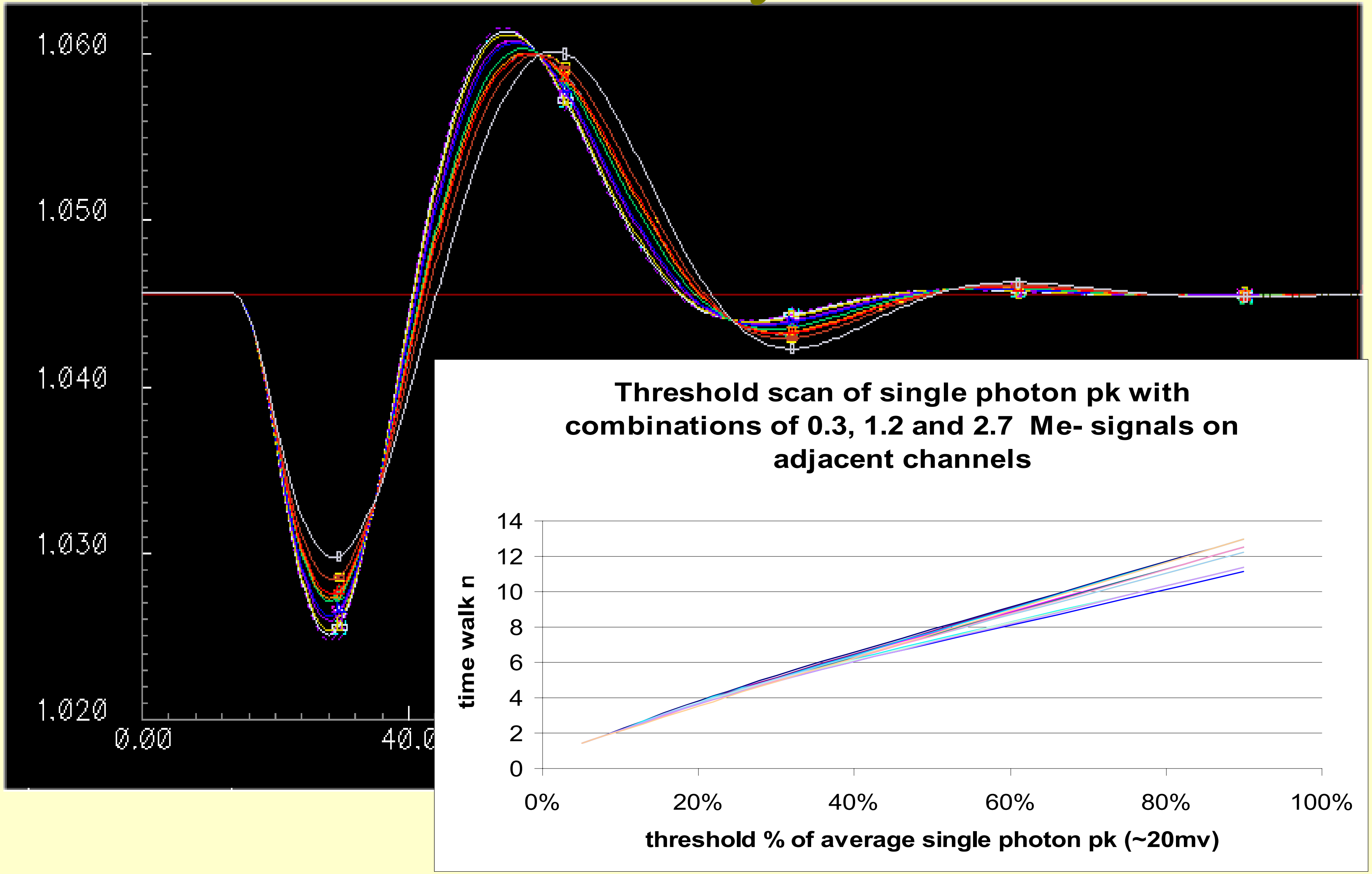


Beetle1.2MA0 FrontendDiv

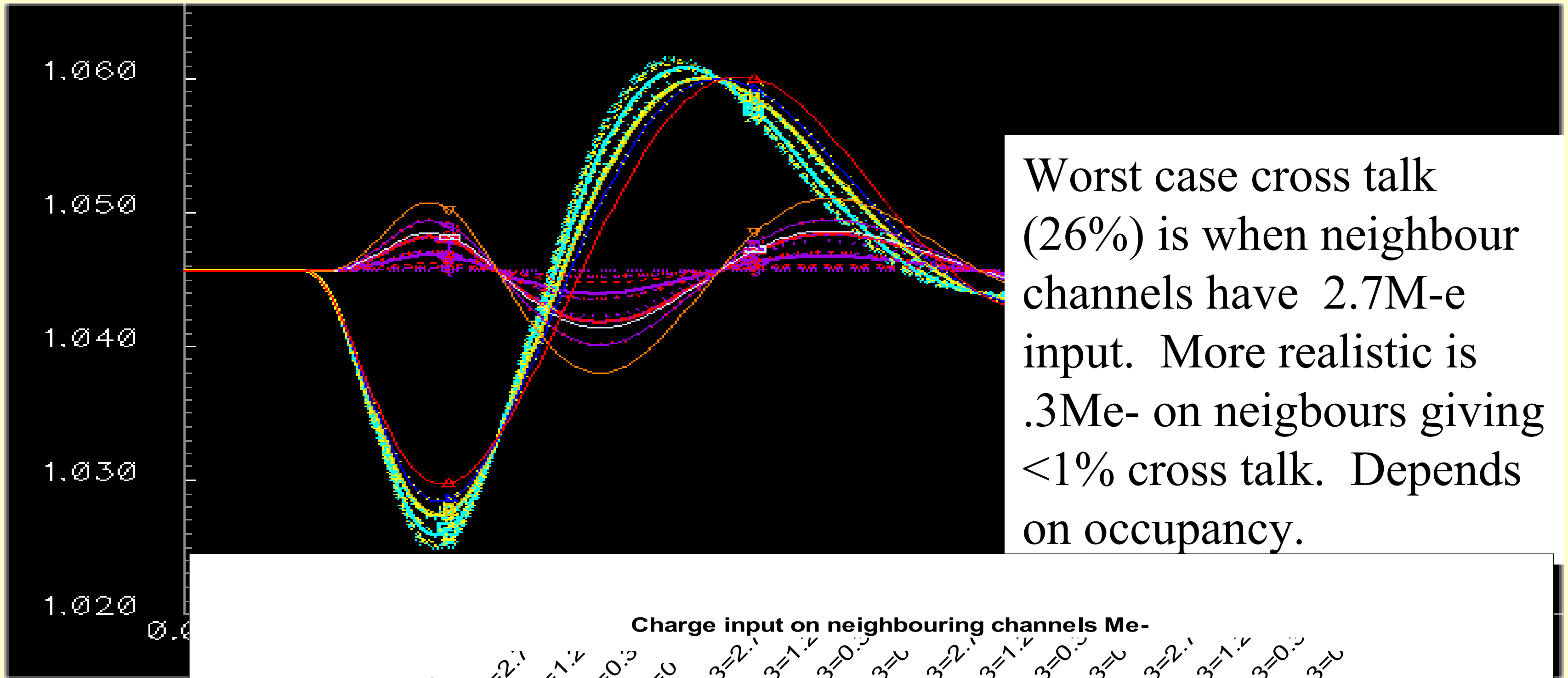




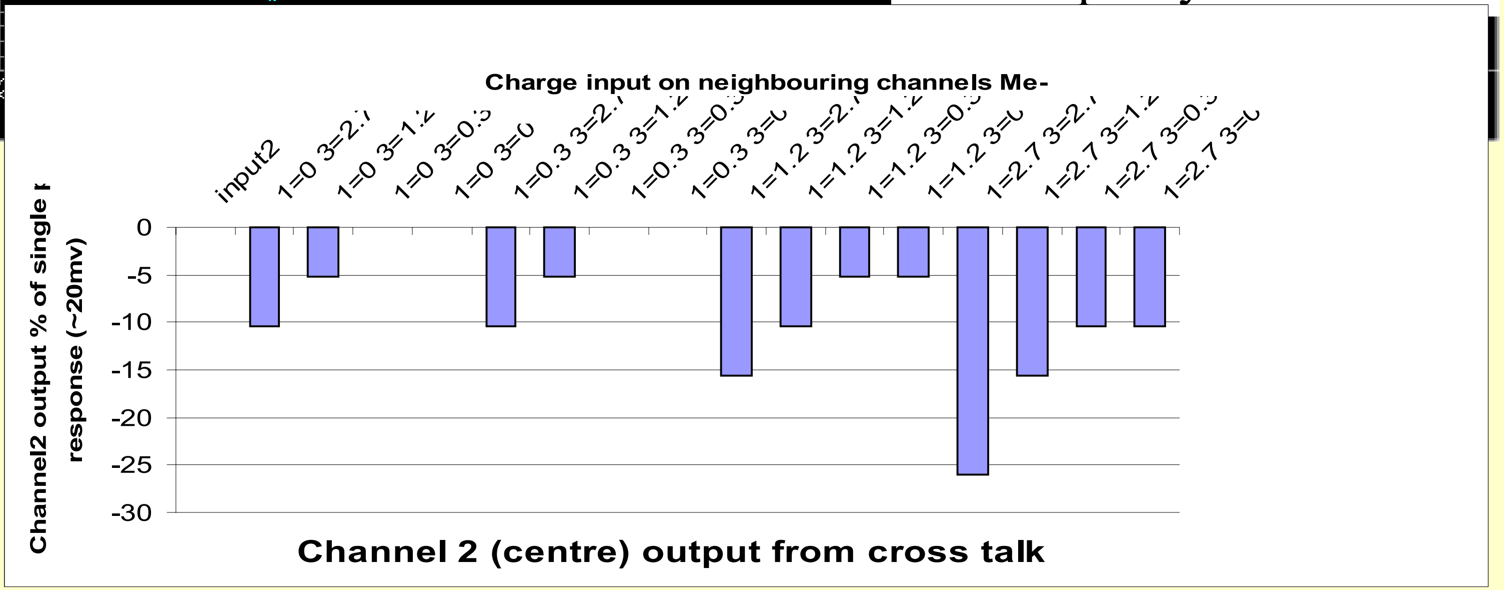
Beetle1.2MA0 layout checks



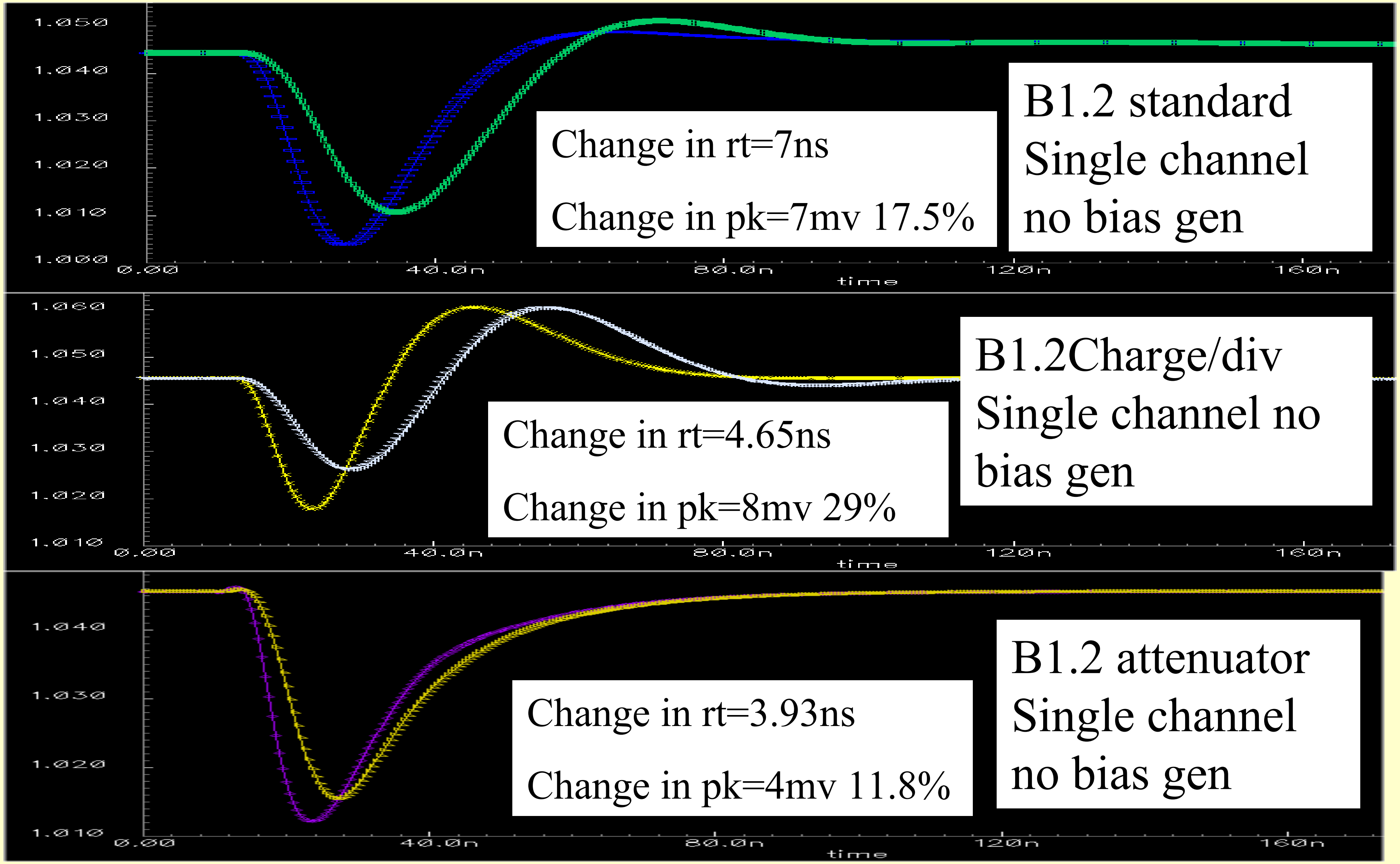
Beetle1.2MA0 FrontendDiv



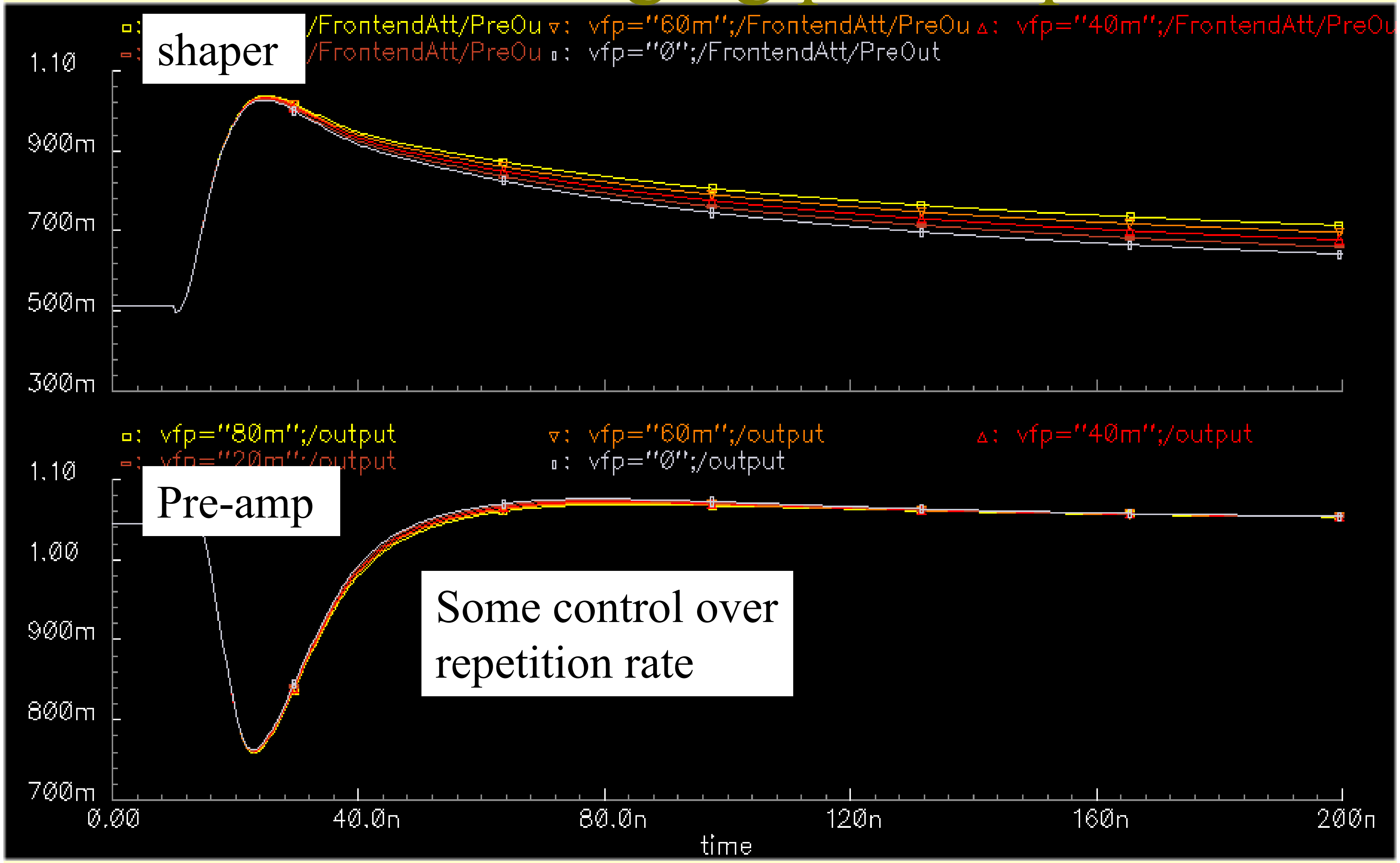
Worst case cross talk (26%) is when neighbour channels have 2.7M-e input. More realistic is .3Me- on neigbours giving <1% cross talk. Depends on occupancy.



With and without Parasitic extraction



The effect of changing pre-amp bias Vfs



Beetle1.2MA0 layout checks

Three adjacent channels for both Div and Att have passed DRC, extraction and LVS.

Simulations look o.k for a first order for both, and are as expected.

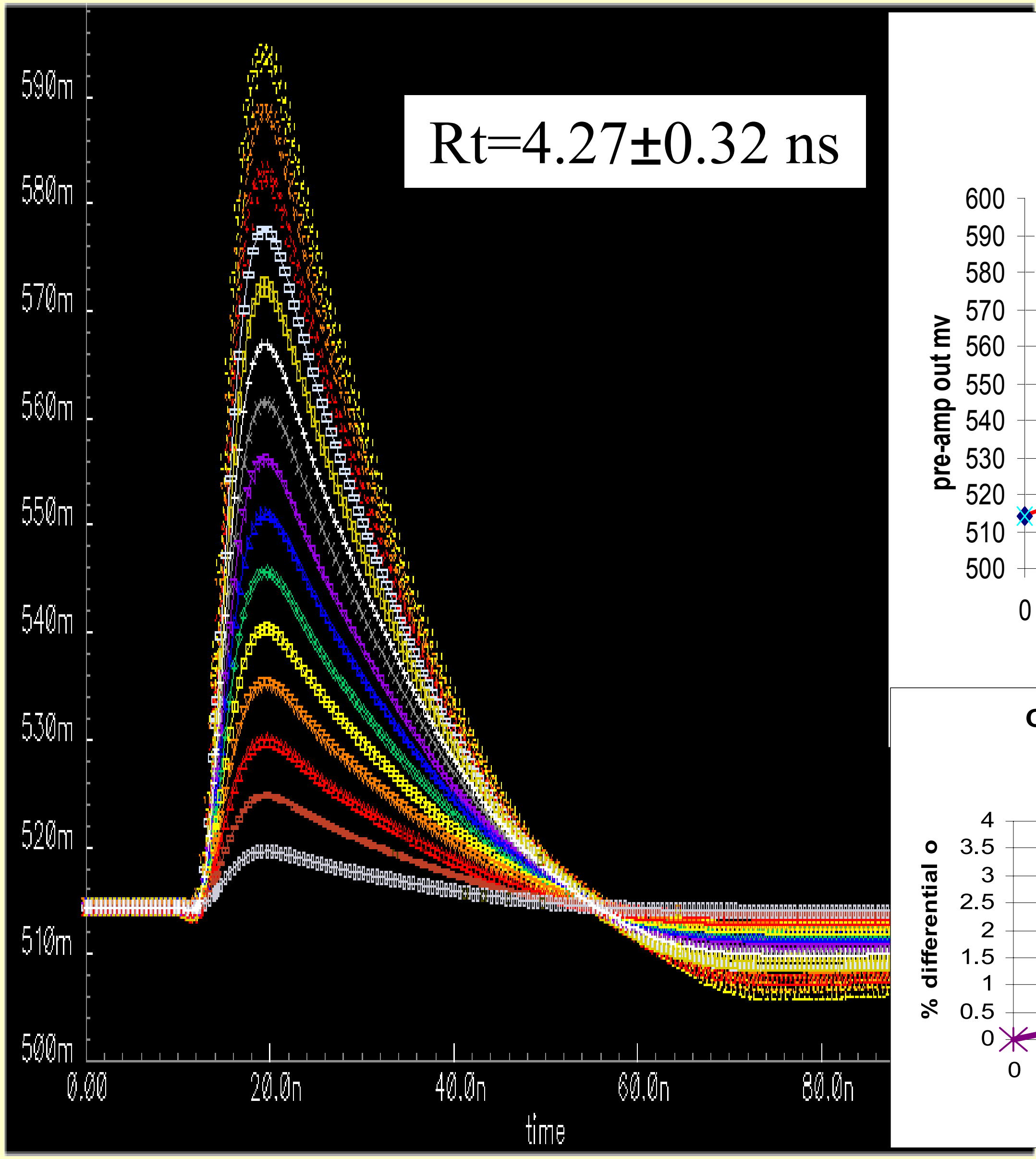
Sven has incorporated these into a full chip structure, and completed extraction and LVS. Since this time the Div has had a modification made to the resistor block. The resistor has been surrounded by dummies.

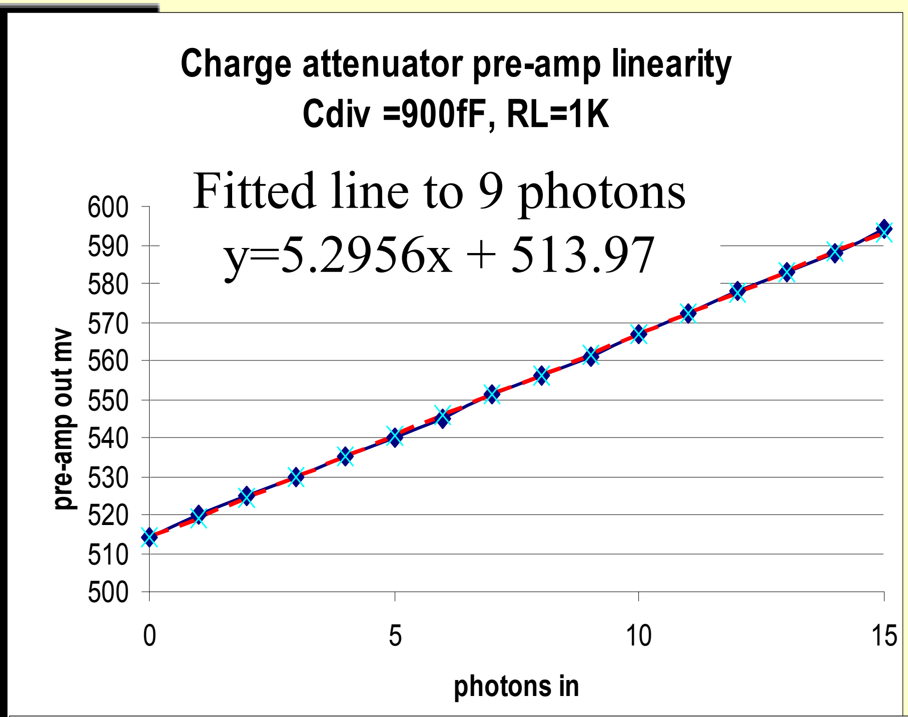
Sven will do another full test when he is back and generate the gdsII file.

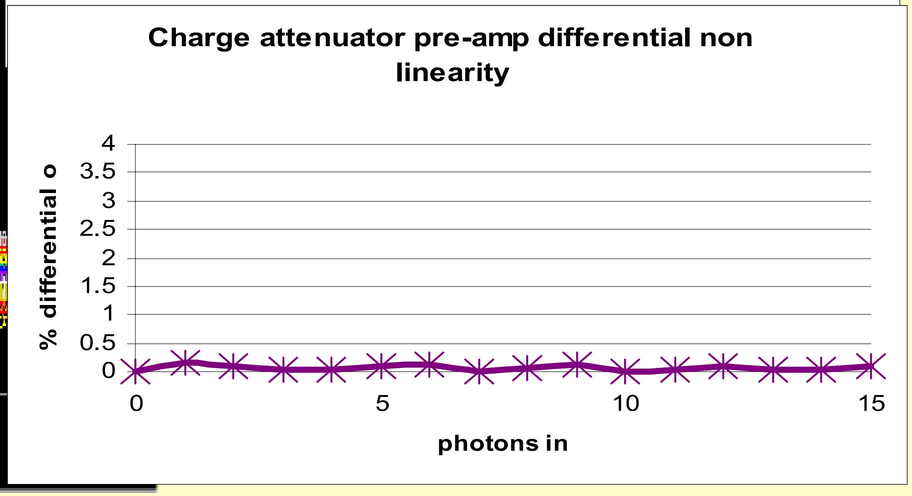
Consideration of changing a track width.

There was one warning in the DRC.

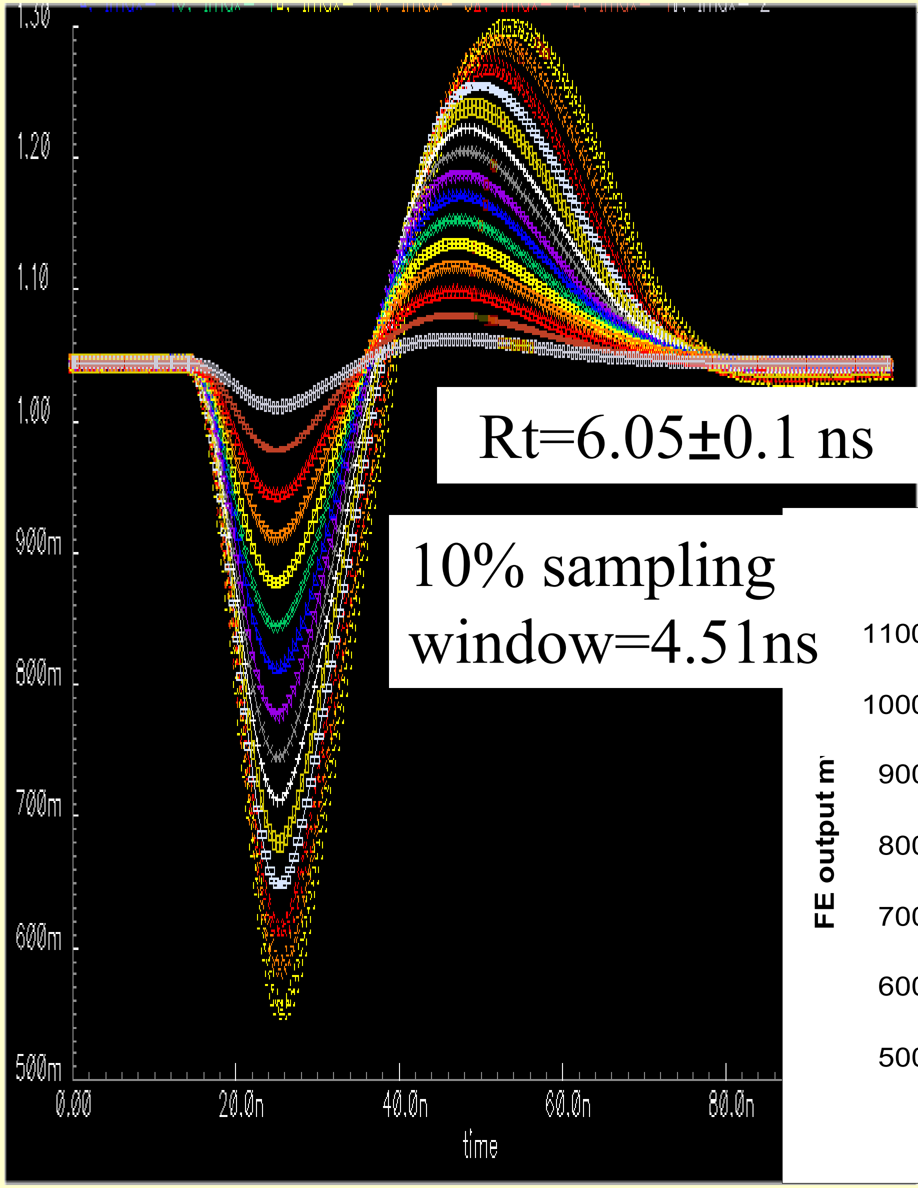
Charge attenuator Pre-amp, RL=1K,Cdiv=900fF,

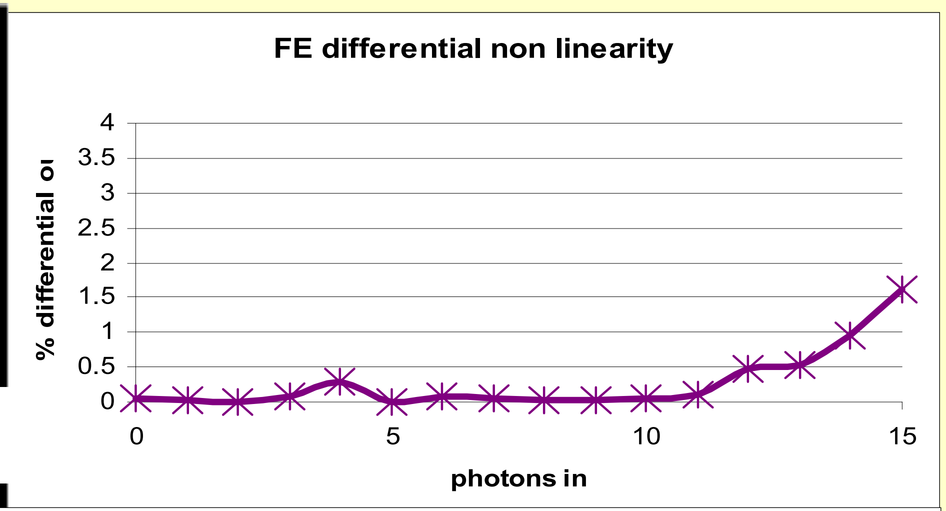


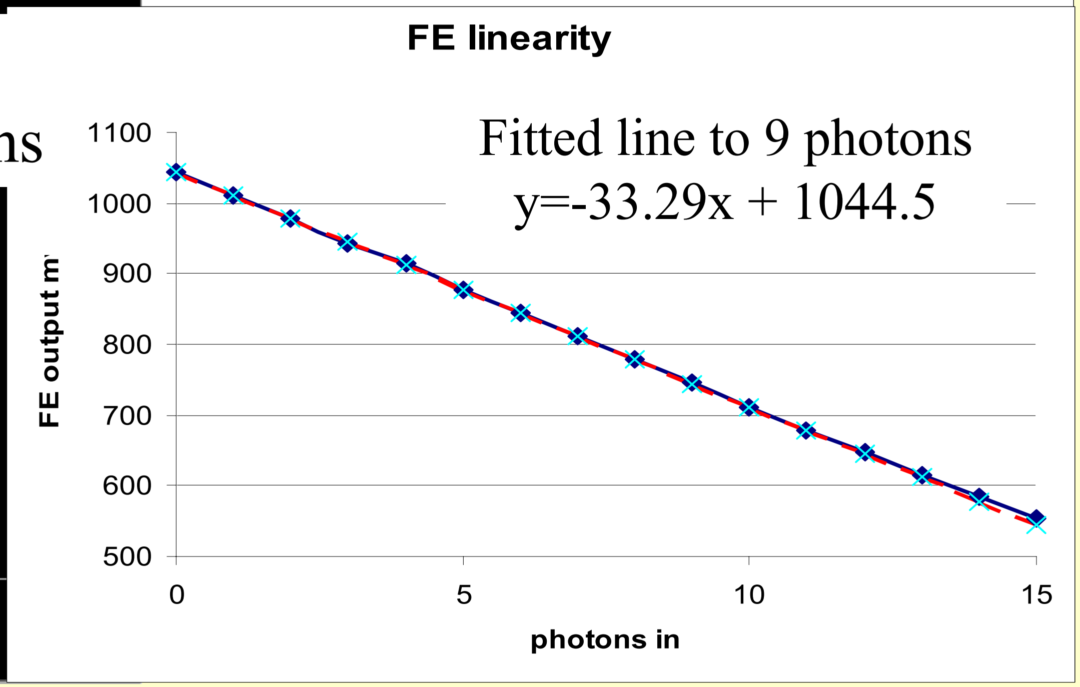




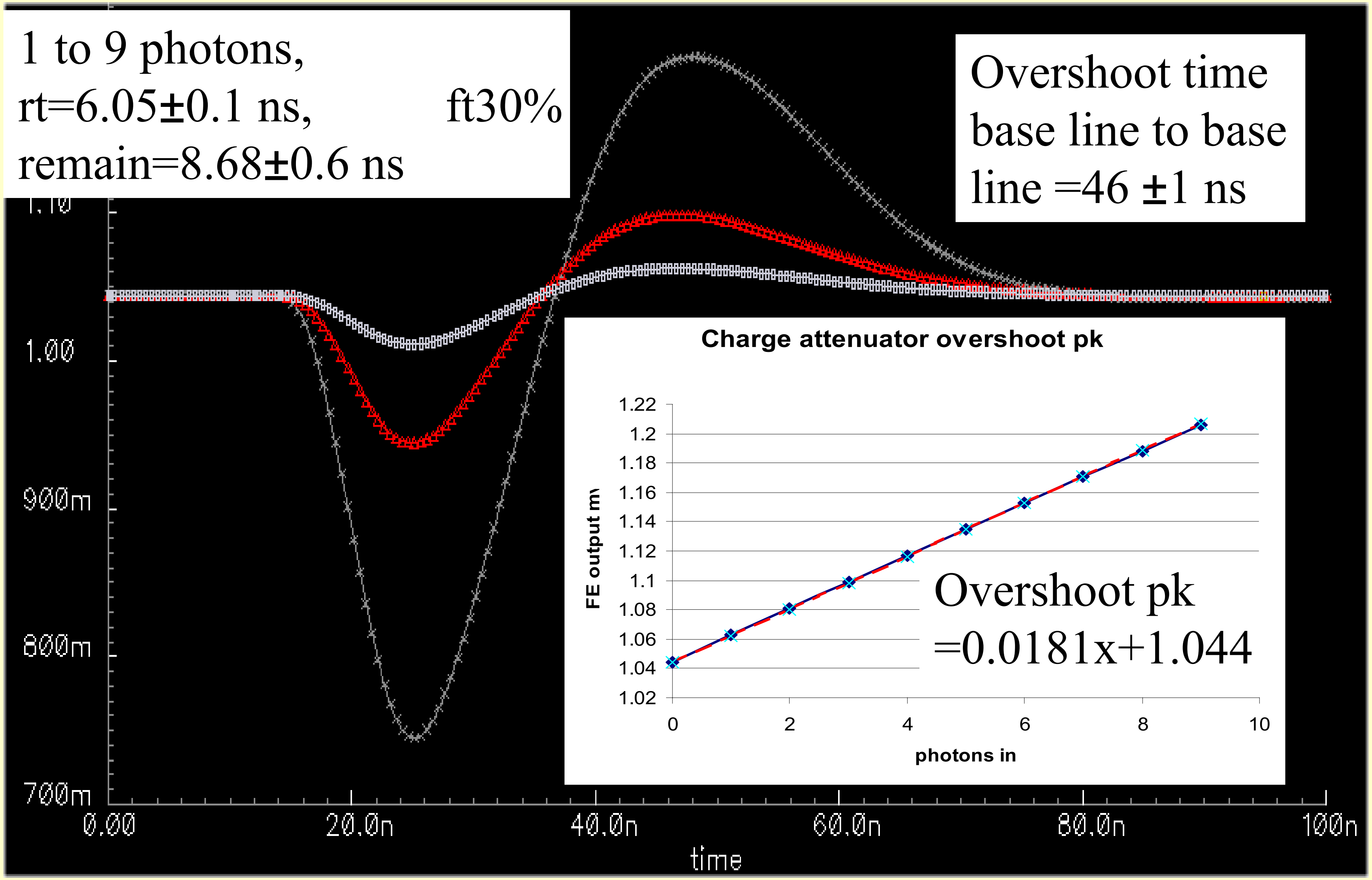
Charge attenuator FE-amp, RL=1K,Cdiv=900fF,



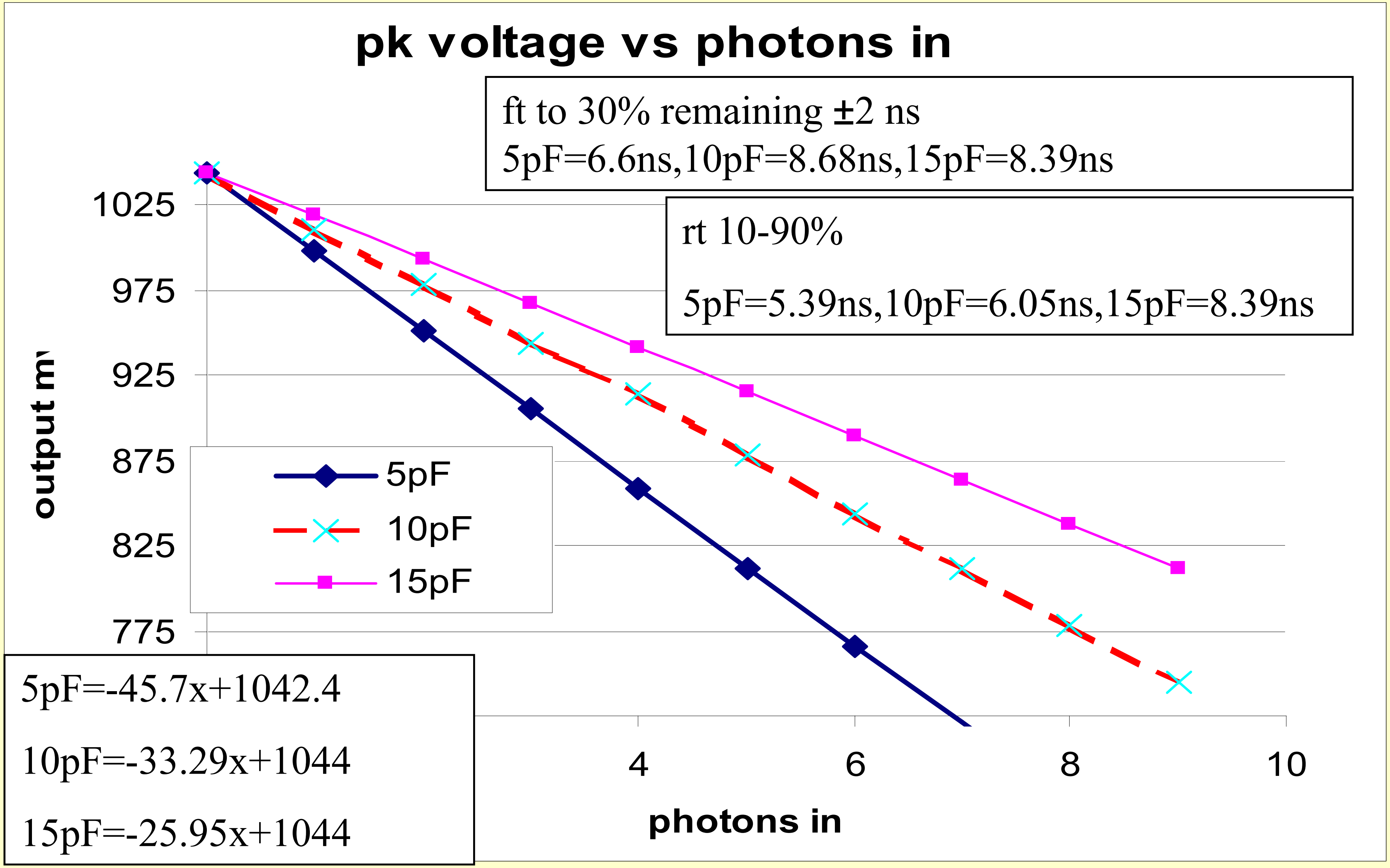




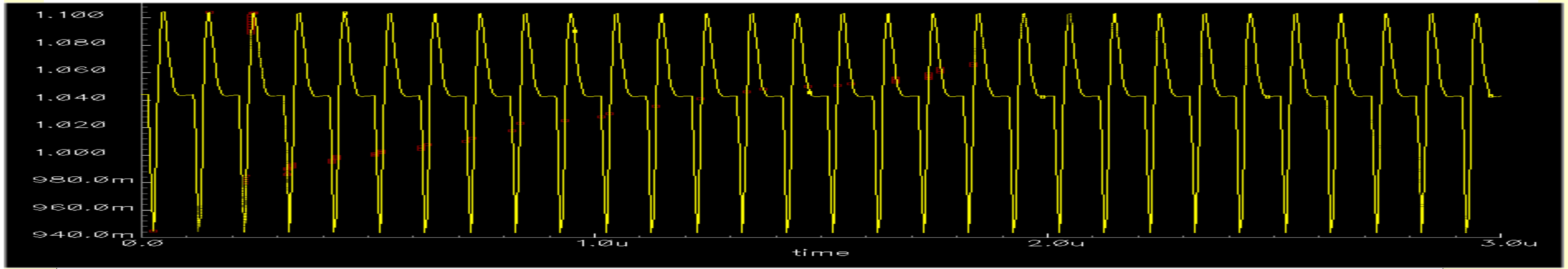
Charge attenuator FE-amp, RL=1K,Cdiv=900fF,

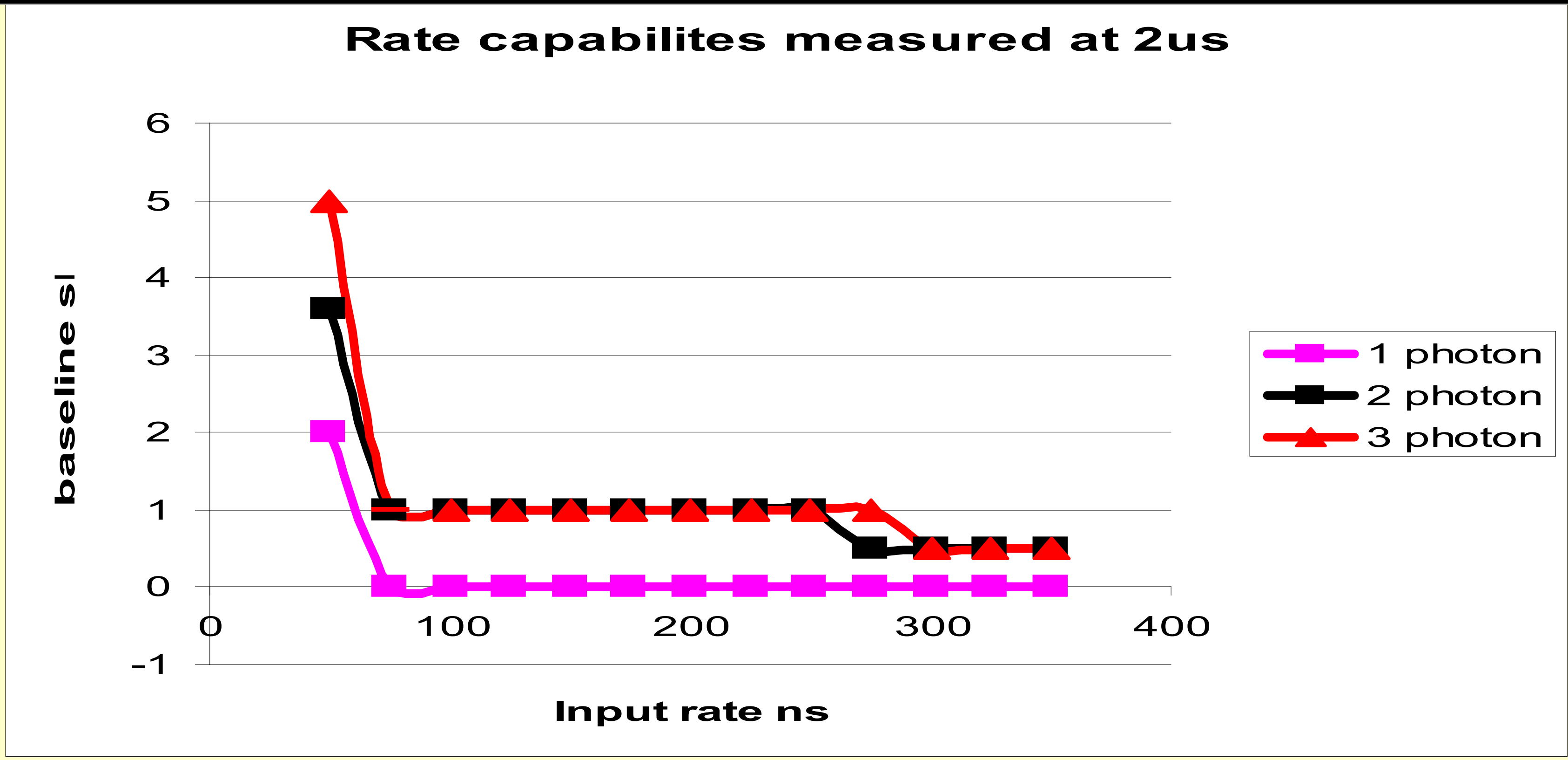


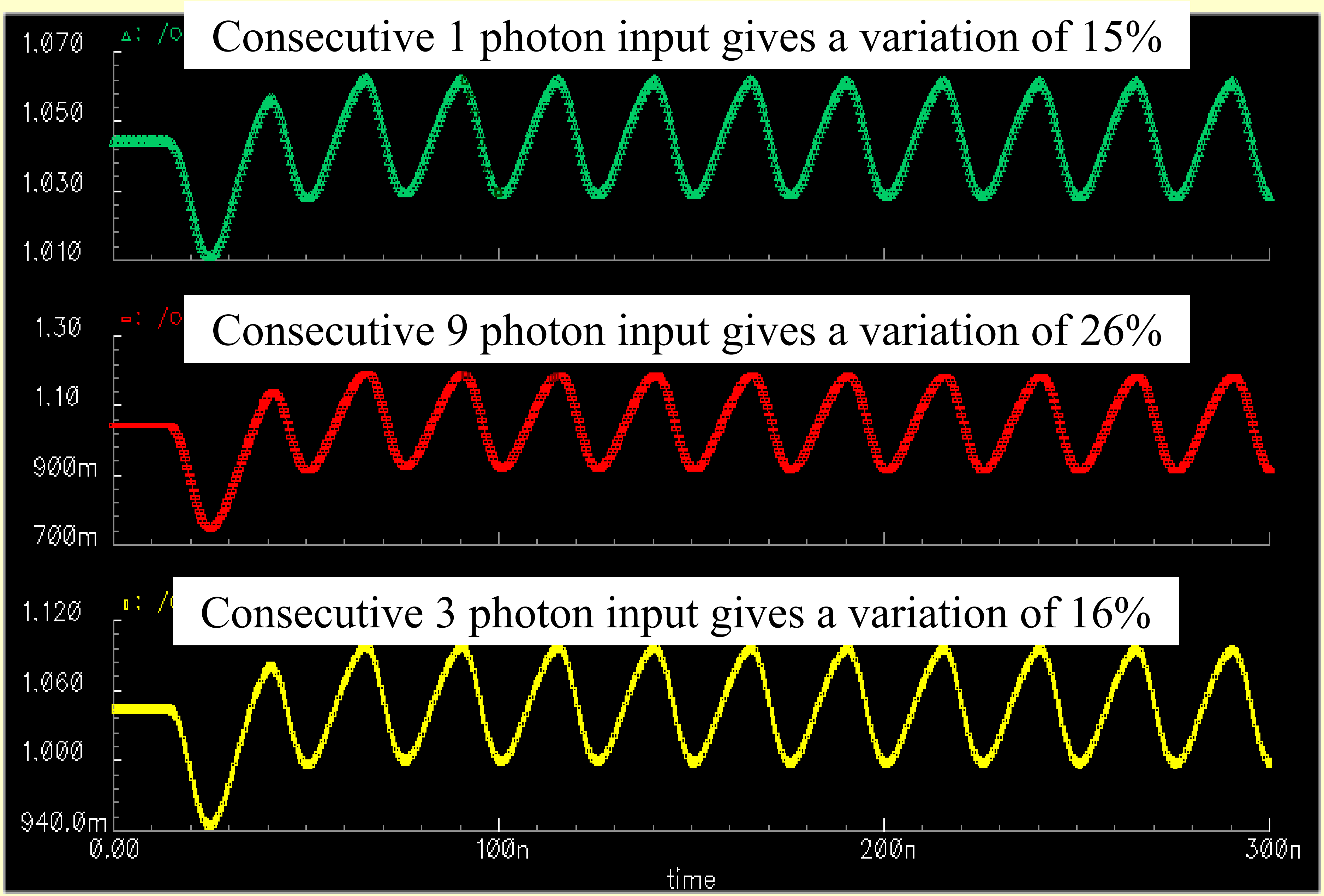
The effect of load capacitance



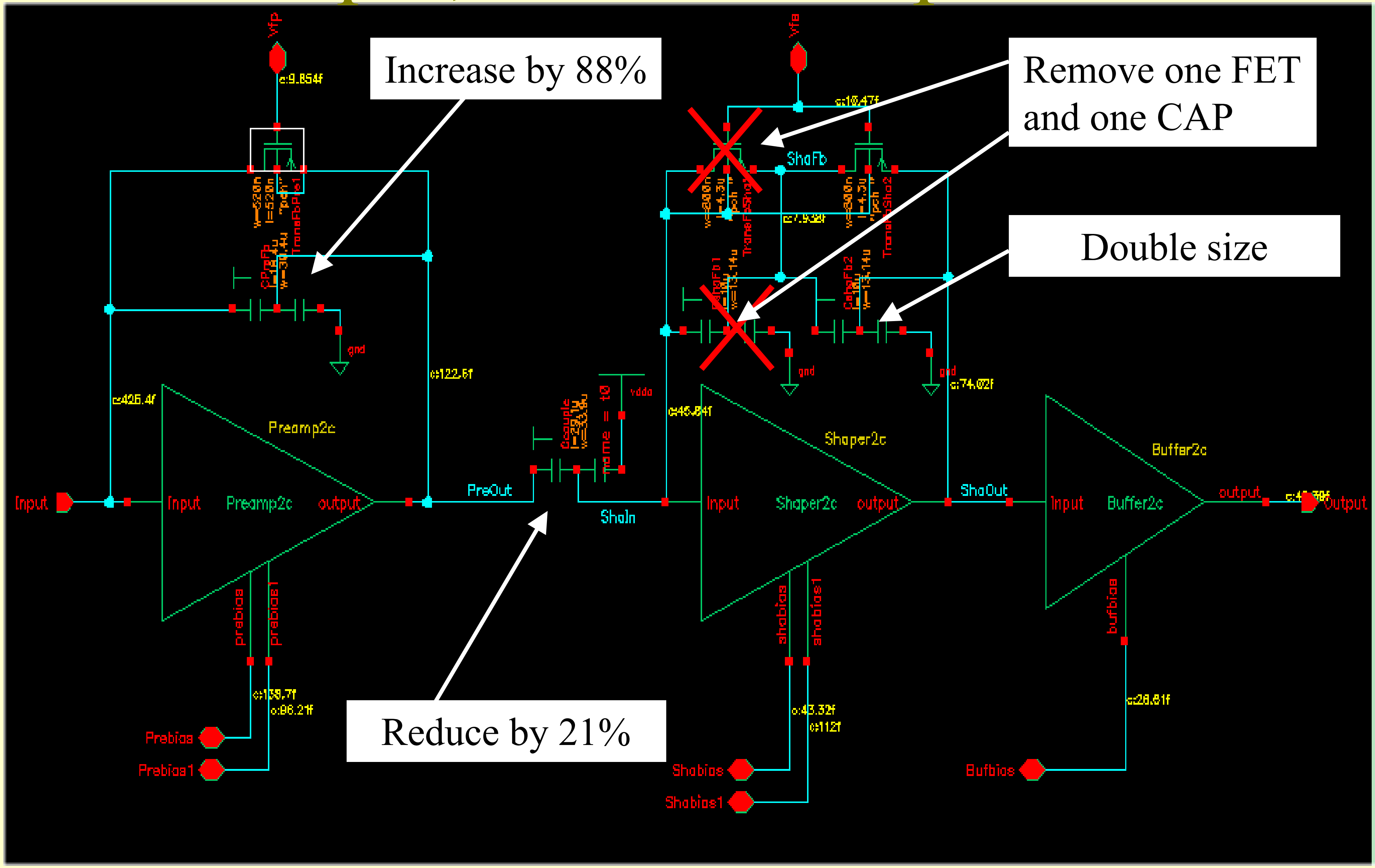
3 photon input at 50ns rate gives a 5.1mv baseline shift



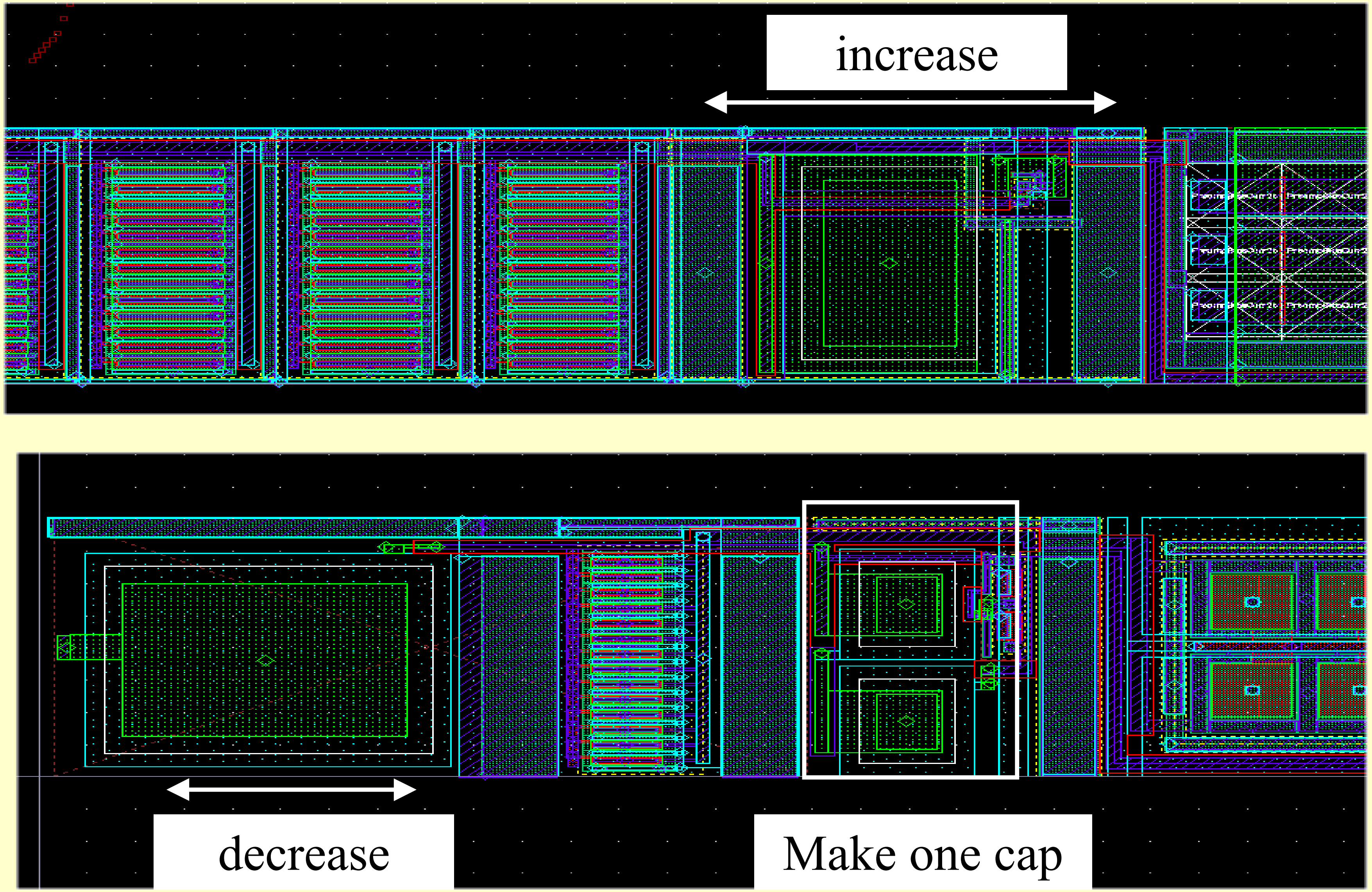



Consecutive 1 photon input gives a variation of 15%
1.070
1.050
1.030
1.010
Consecutive 9 photon input gives a variation of 26%
1.30
1.10
900m
700m
Consecutive 3 photon input gives a variation of 16%
1.120
1.060
1.000
940.0m
0.00
100n
200n
300n
time

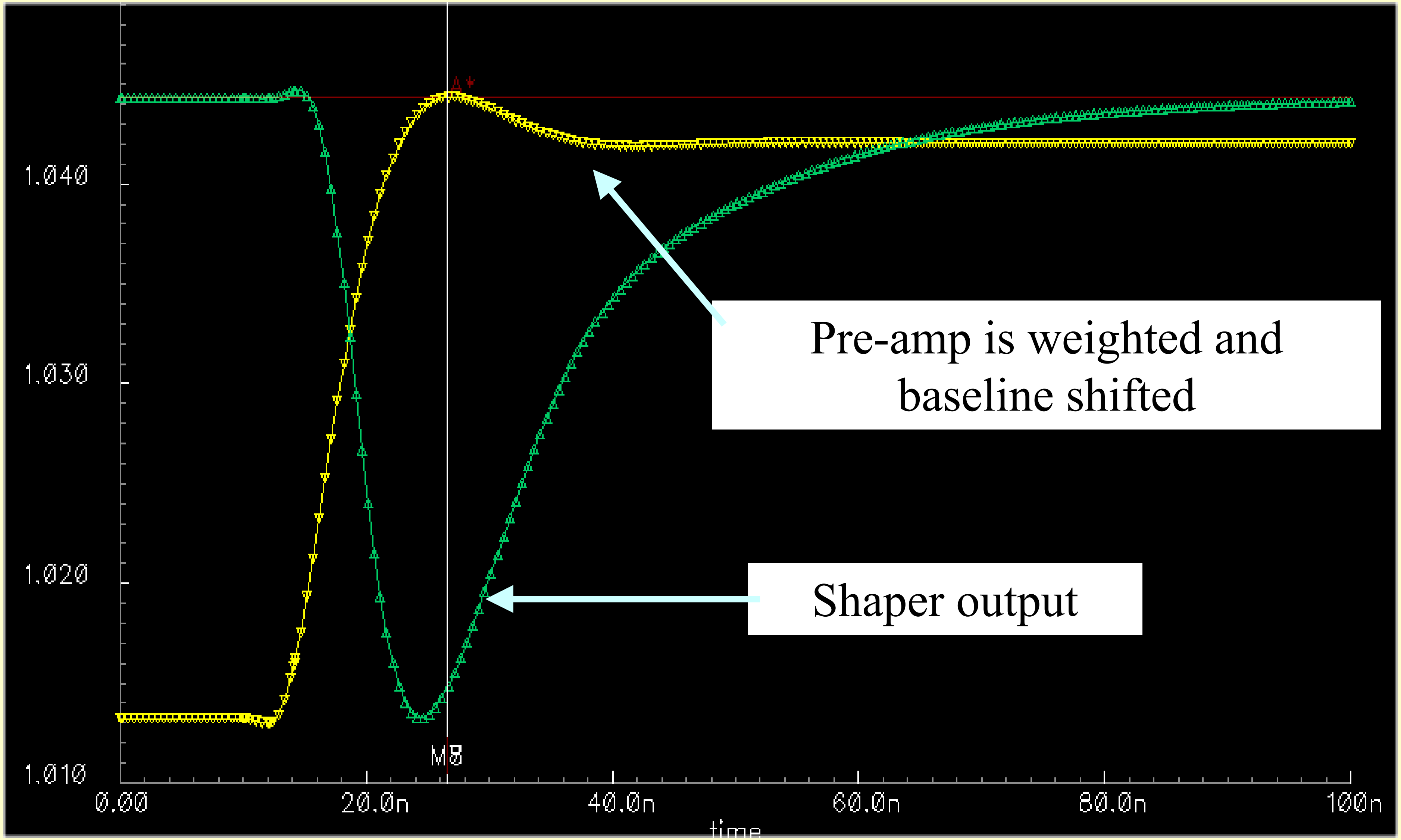
The Cpre,Cd and Cshap mod FE



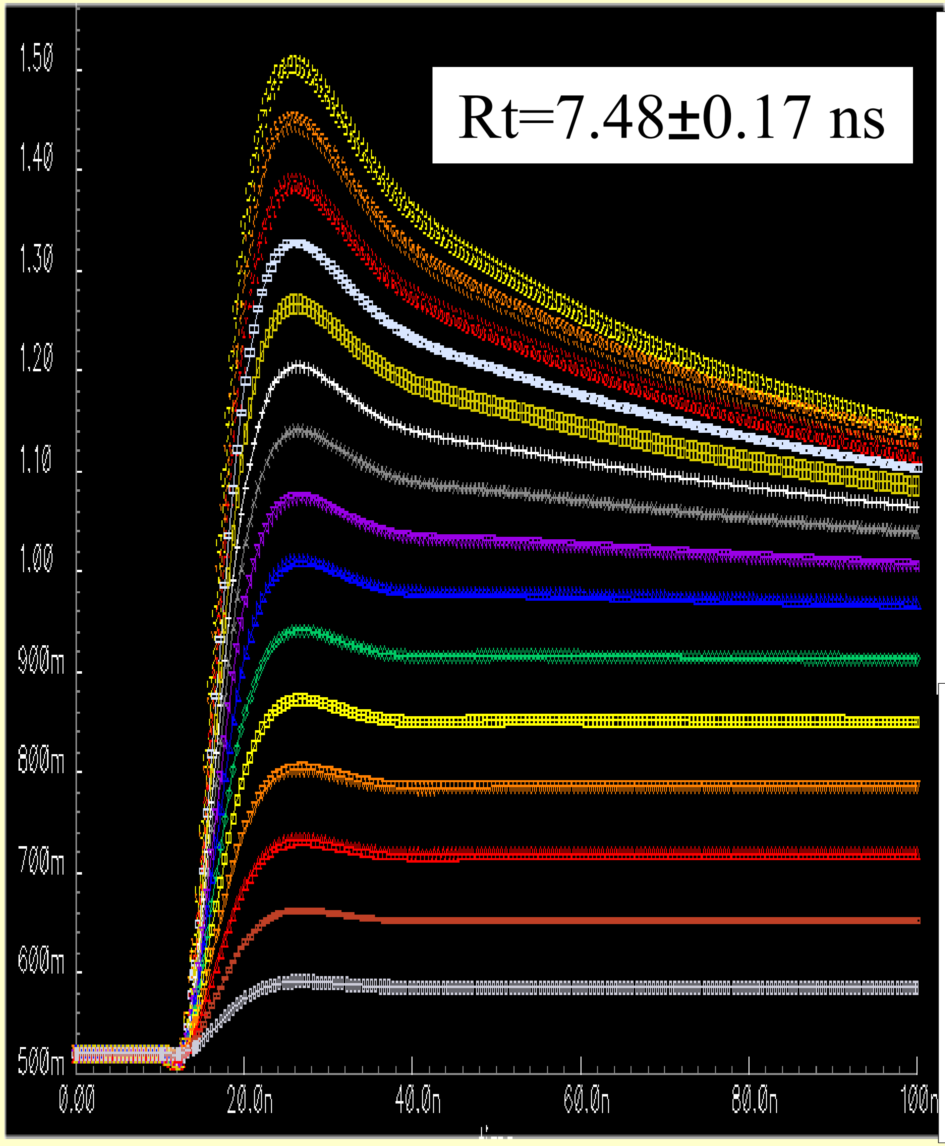
In layout terms

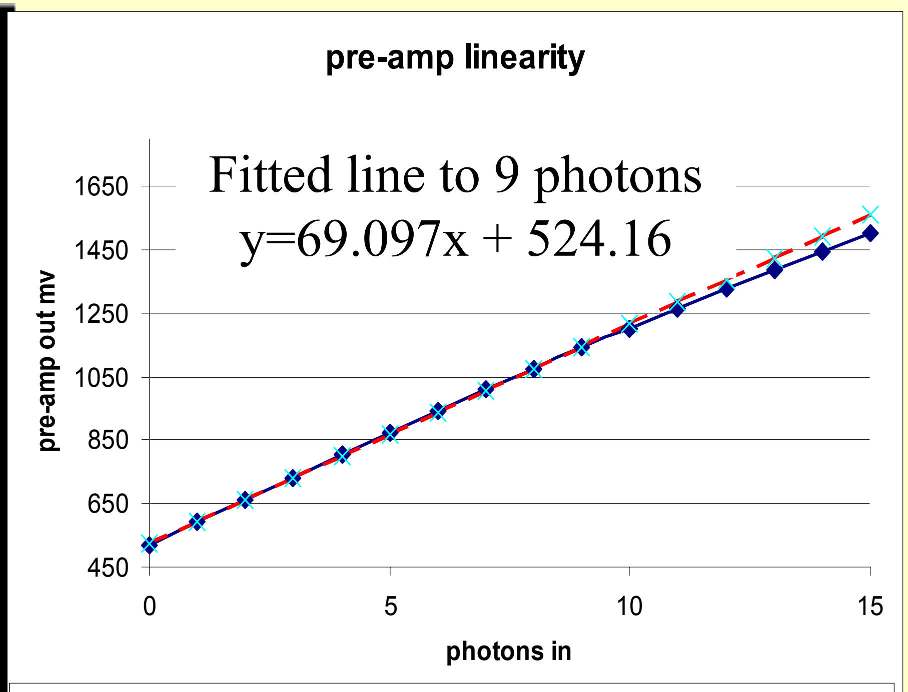


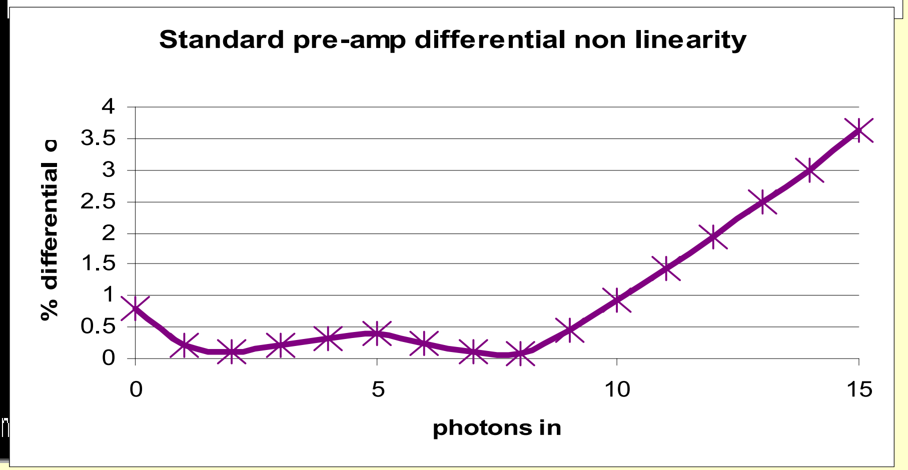
The pre-amp and shaper output



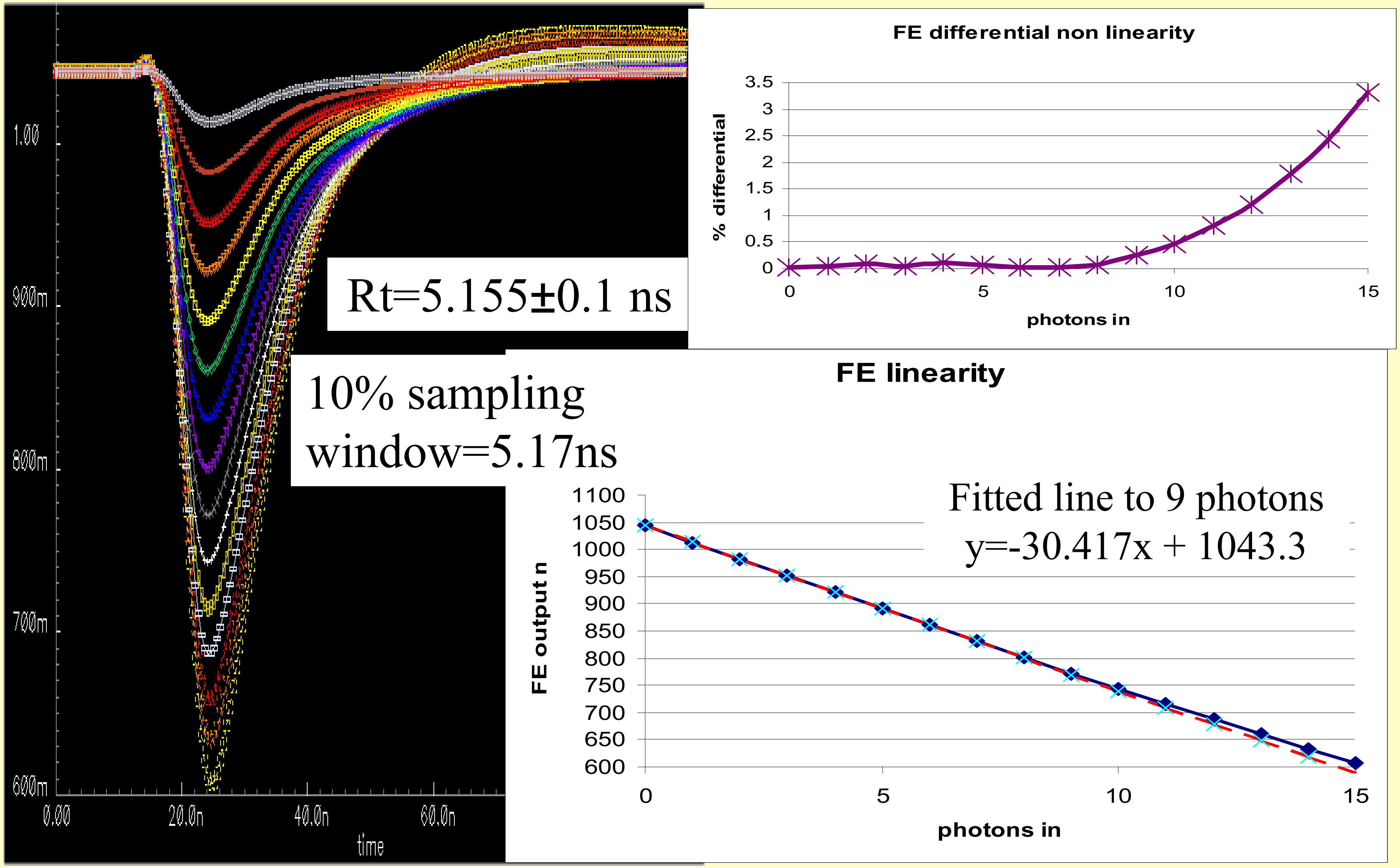
Pre-amp, vfp=400mv,Cfp=735fF,Cfs=192fF,Cd=147fF



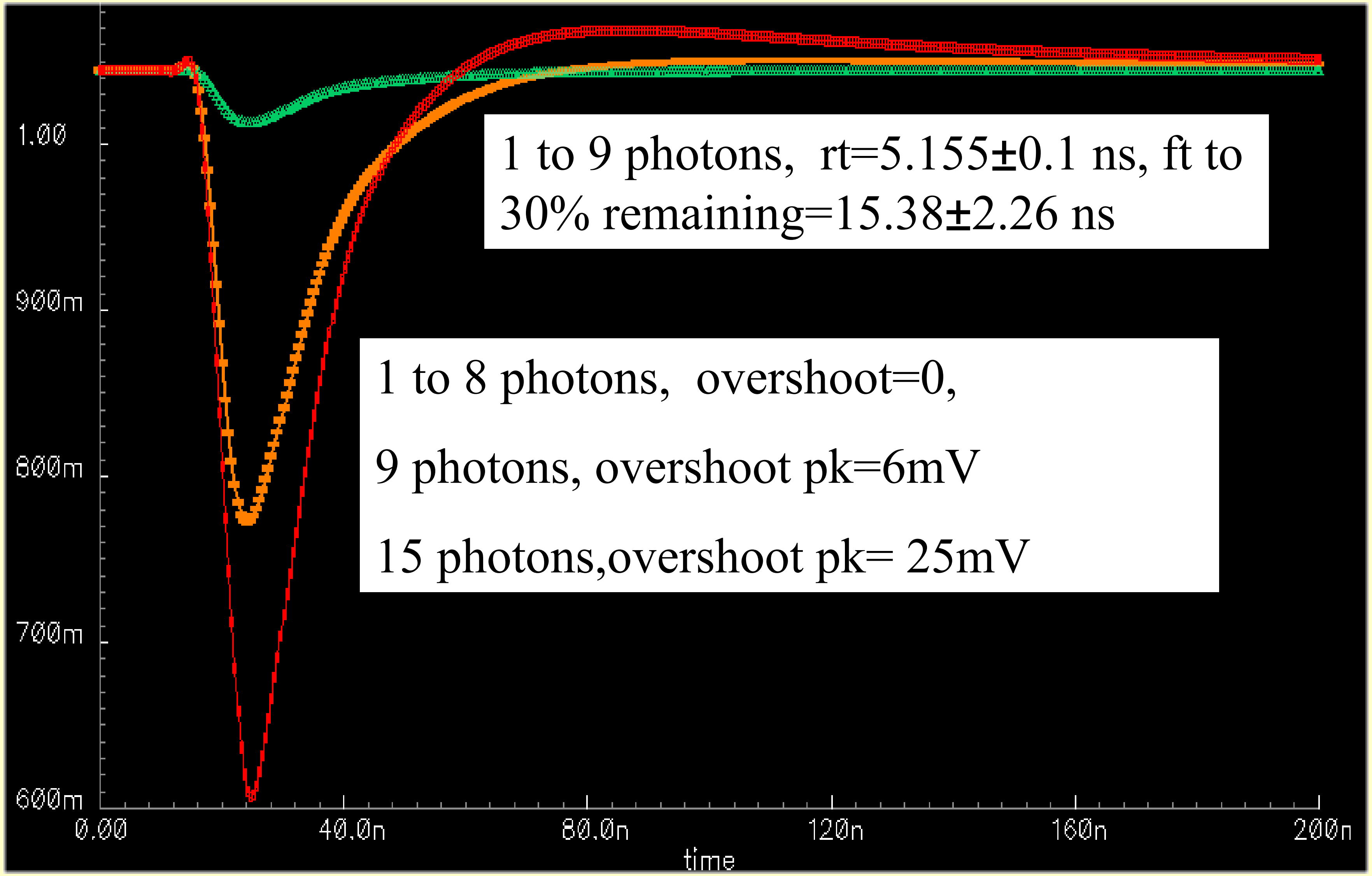




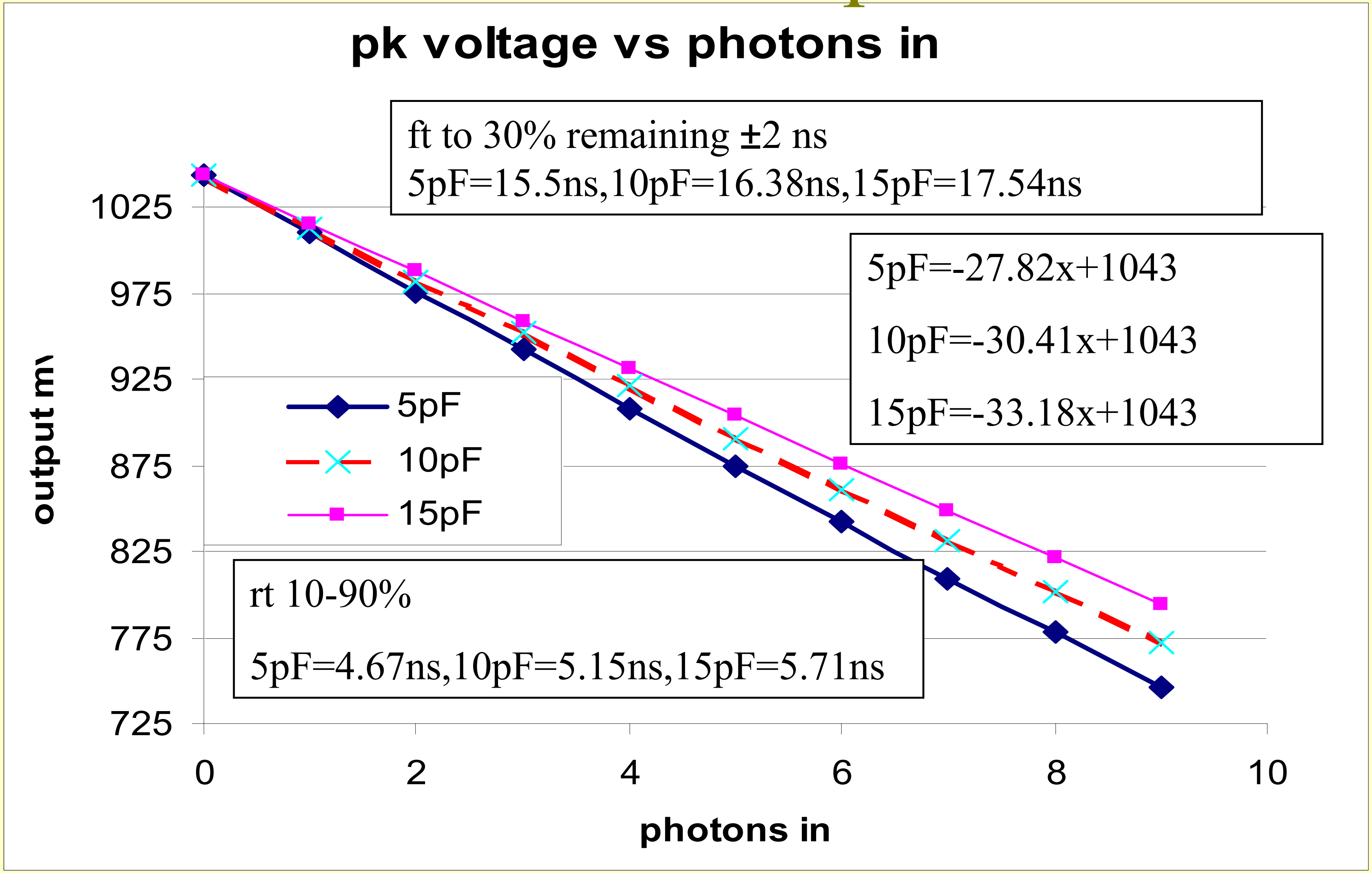
FE-amp, vfp=400mv,Cfp=735fF,Cfs=192fF,Cd=147fF



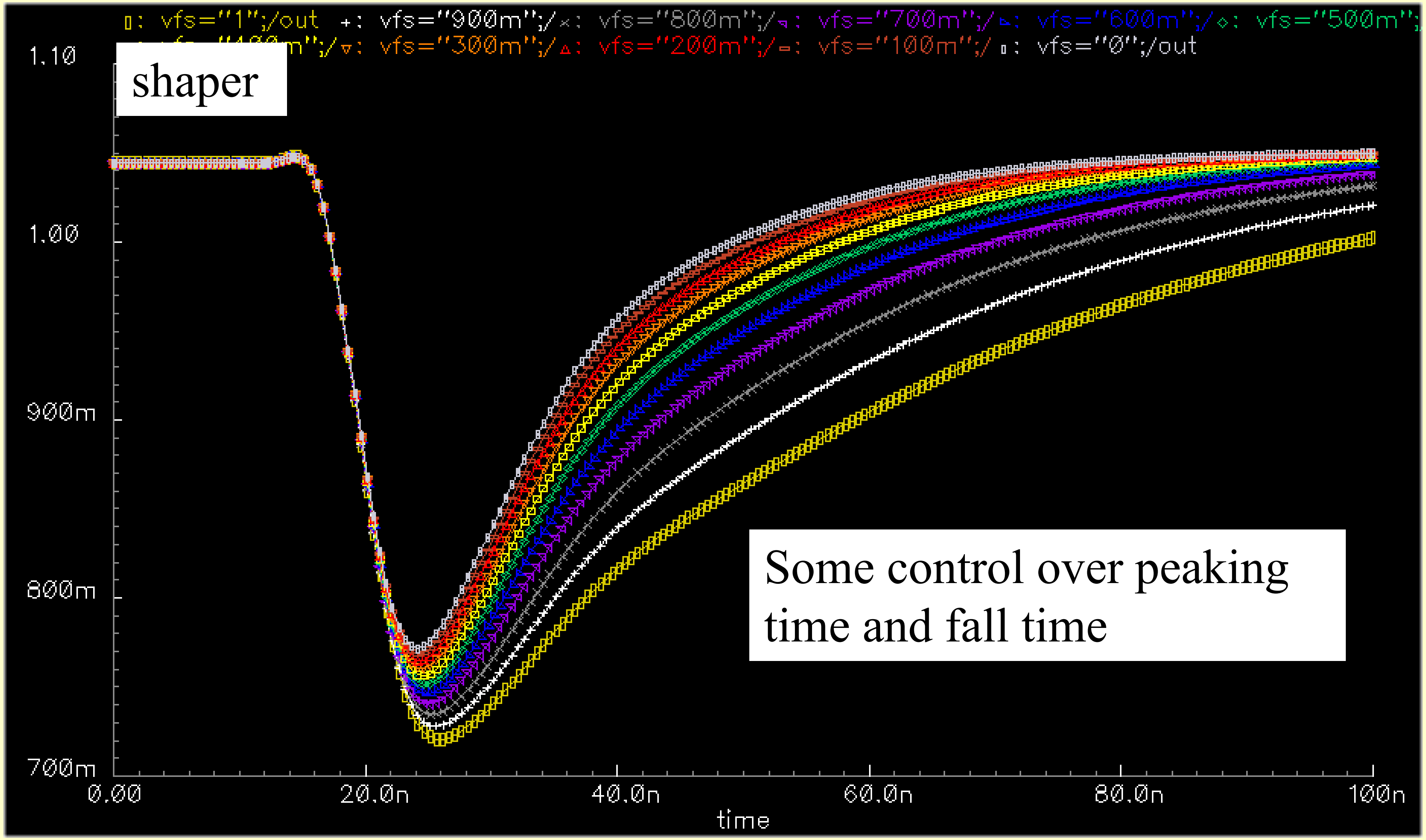
FE-amp, vfp=400mv,Cfp=735fF,Cfs=192fF,Cd=147fF



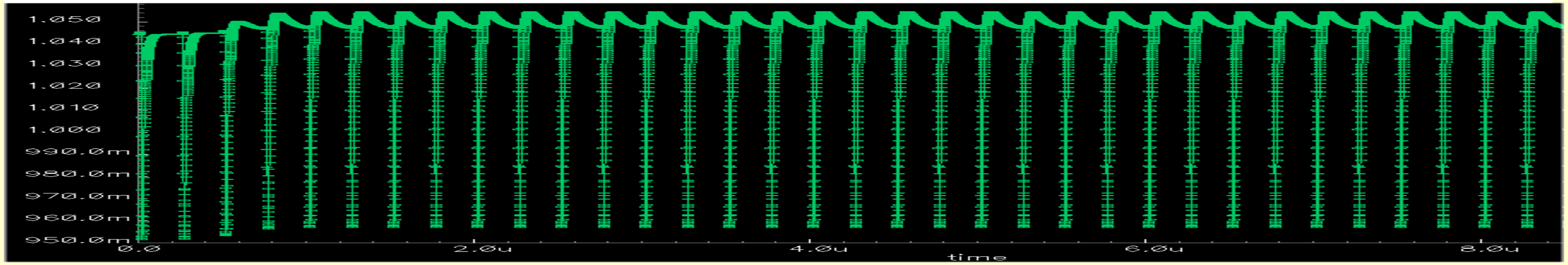
The effect of load capacitance

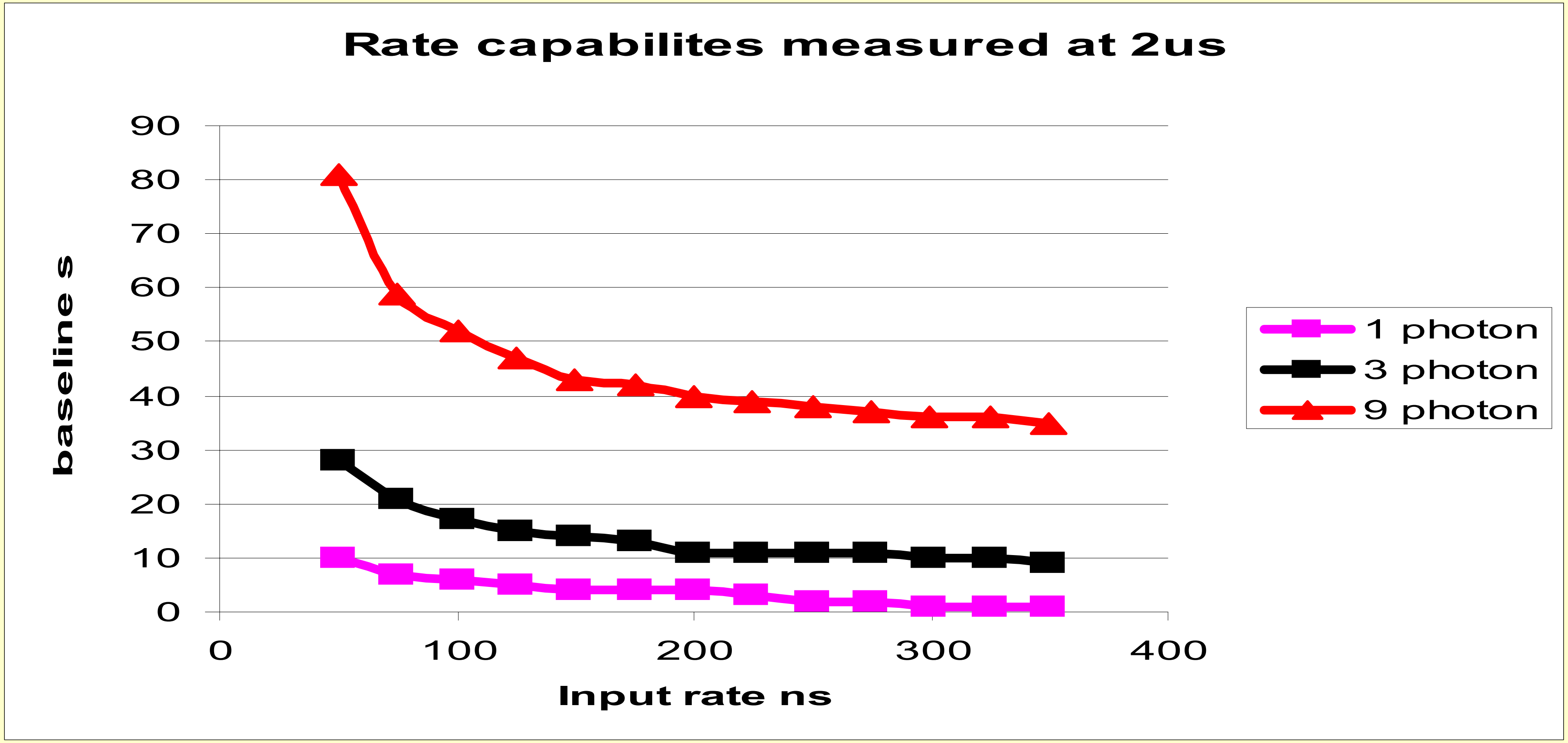


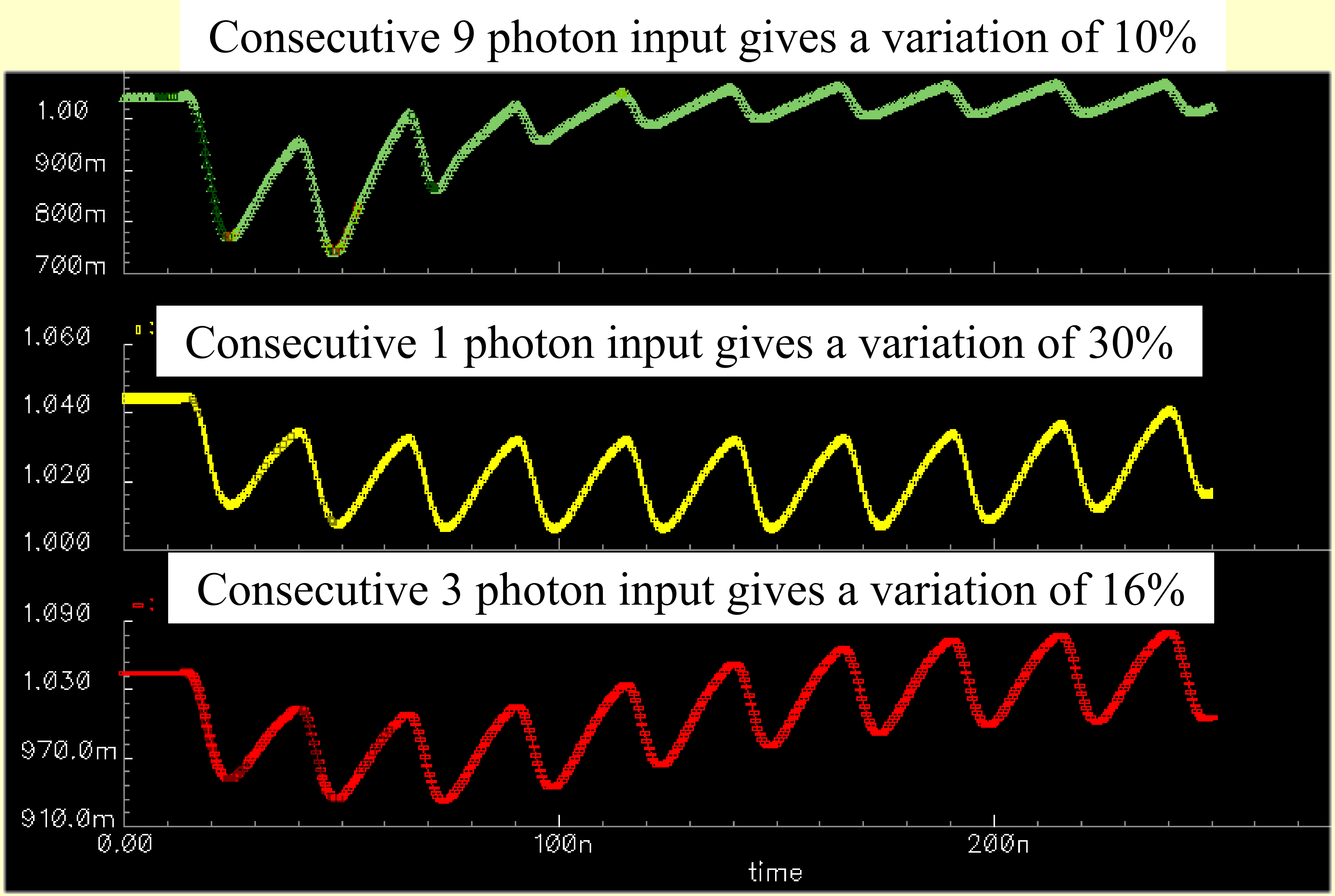
The effect of changing shaper bias Vfs



3 photon input at 250ns rate gives a 10% baseline shift






Consecutive 9 photon input gives a variation of 10%
1.00
900m
800m
700m
Consecutive 1 photon input gives a variation of 30%
1.060
1.040
1.020
1.000
Consecutive 3 photon input gives a variation of 16%
1.090
1.030
970.0m
910.0m
0.00
100n
200n
time

Conclusions and questions outstanding

•Beetle1.2 is in good condition, other than bug in control logic. Should we submit with new or old logic.

•Only three amplifiers are worth considering for the RICH option

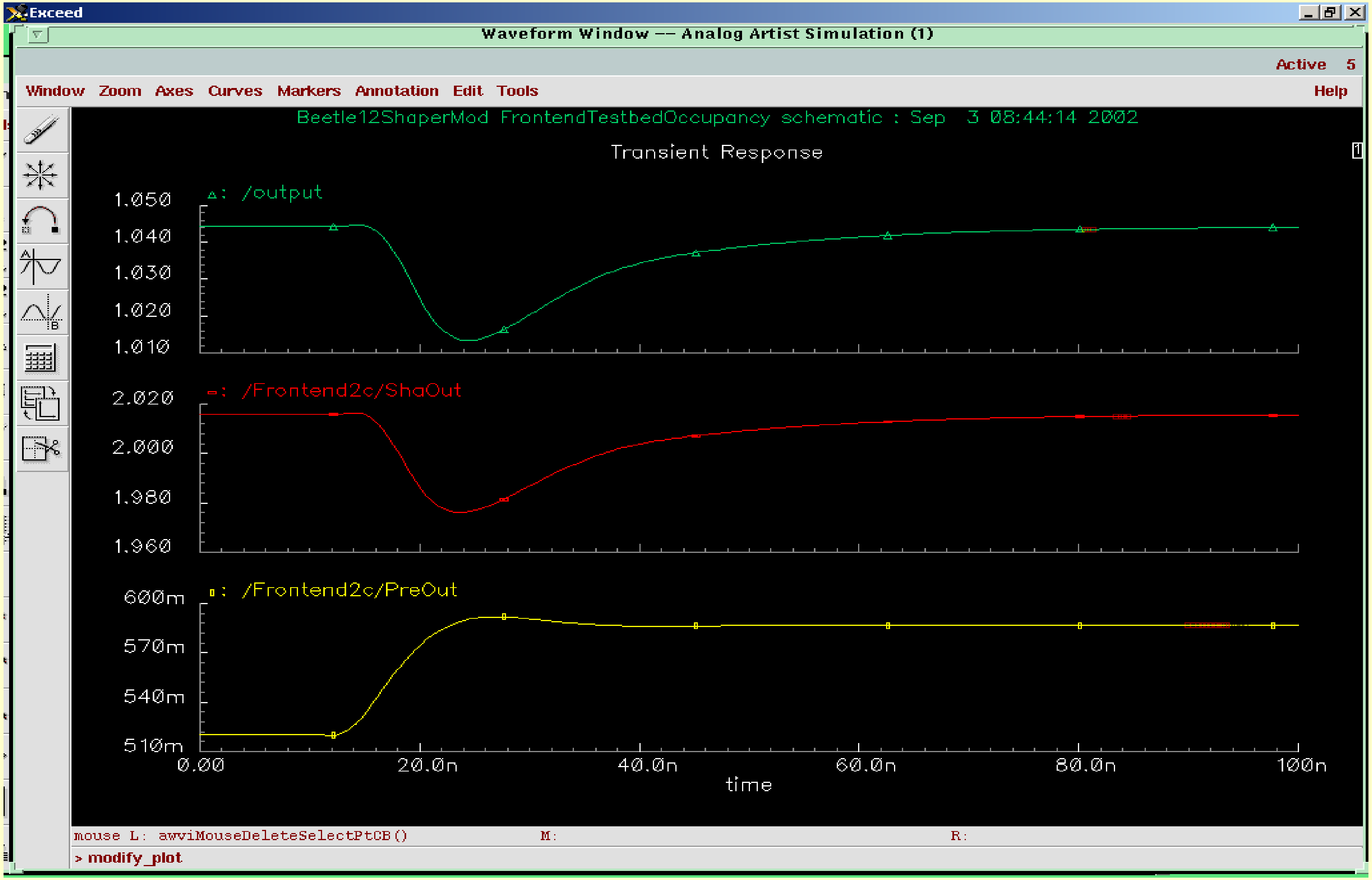
> The preferred is the C modified FE, the charge division is a definite contender if ac coupling is required, the op-amp needs consideration.

•Detailed study of how these amplifiers really fit into the rest of the Beetle1.2 architecture now needs to be studied. Real parasitic capacitance and inductance needs to be added to simulation when layout is complete.

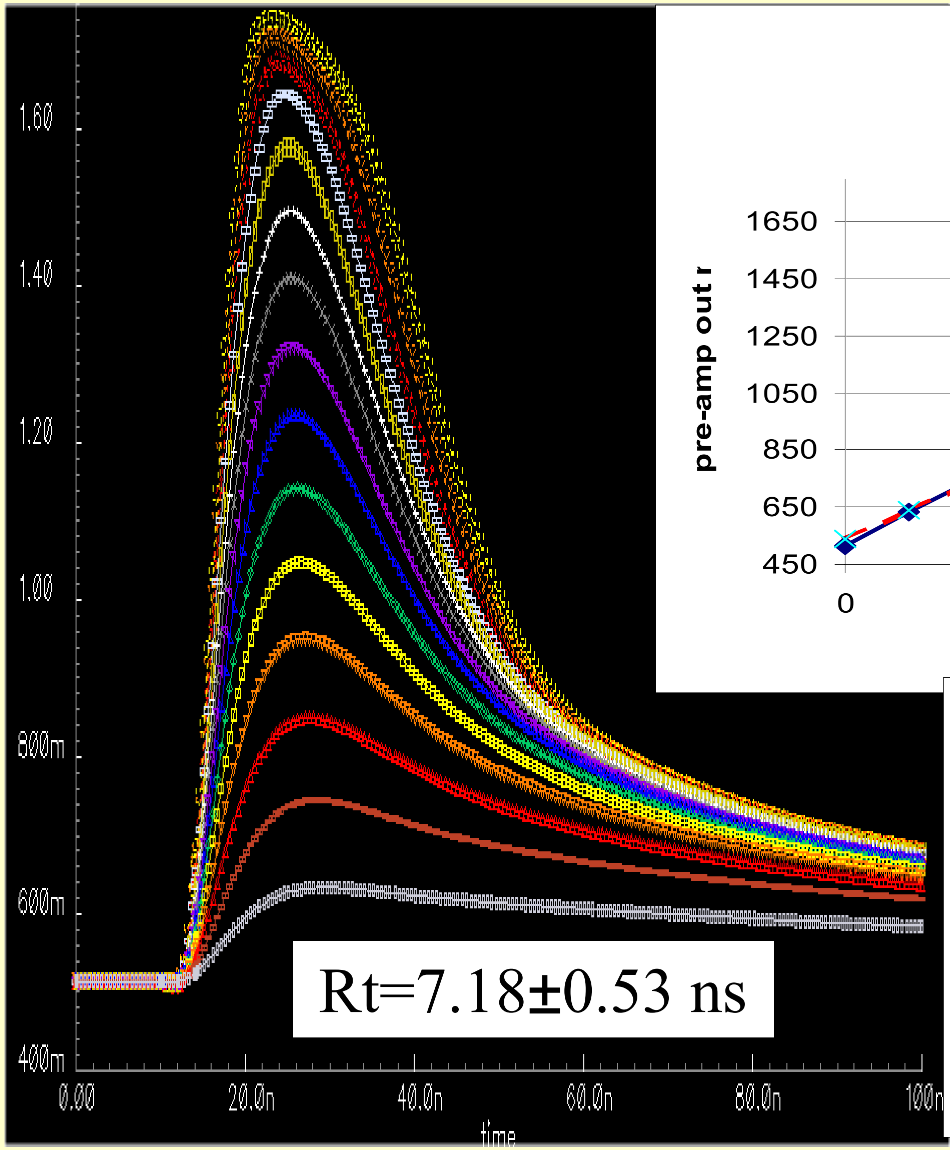
•Detailed look at the binary comparator compatibility with the new amps needs to be studied.

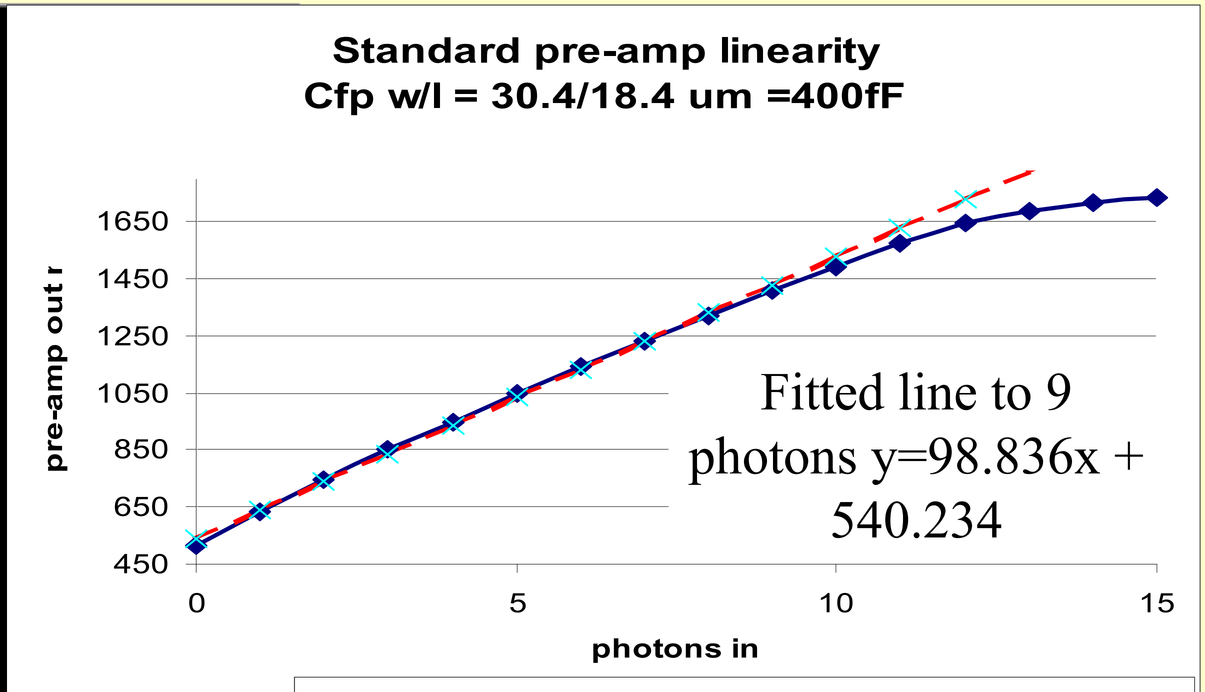
Extra slides

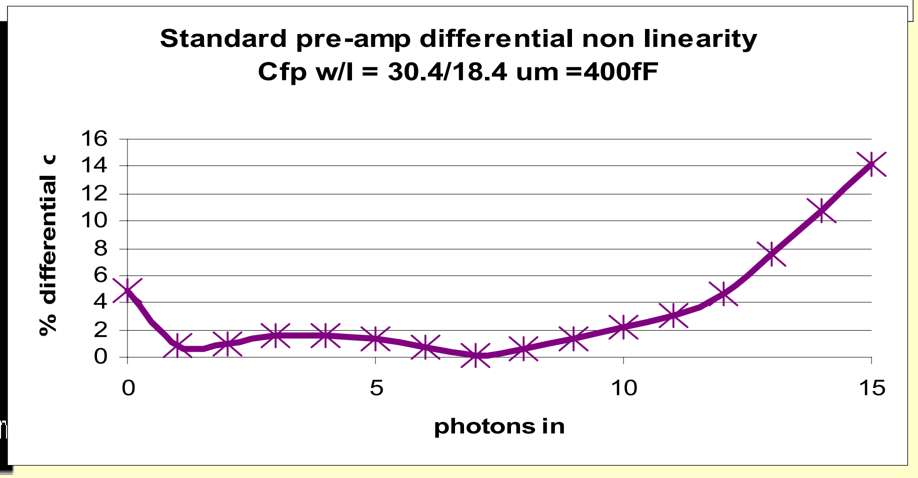
For the shaper mod with vfb at 400mv etc, put here because interesting that shaper out is at 2v



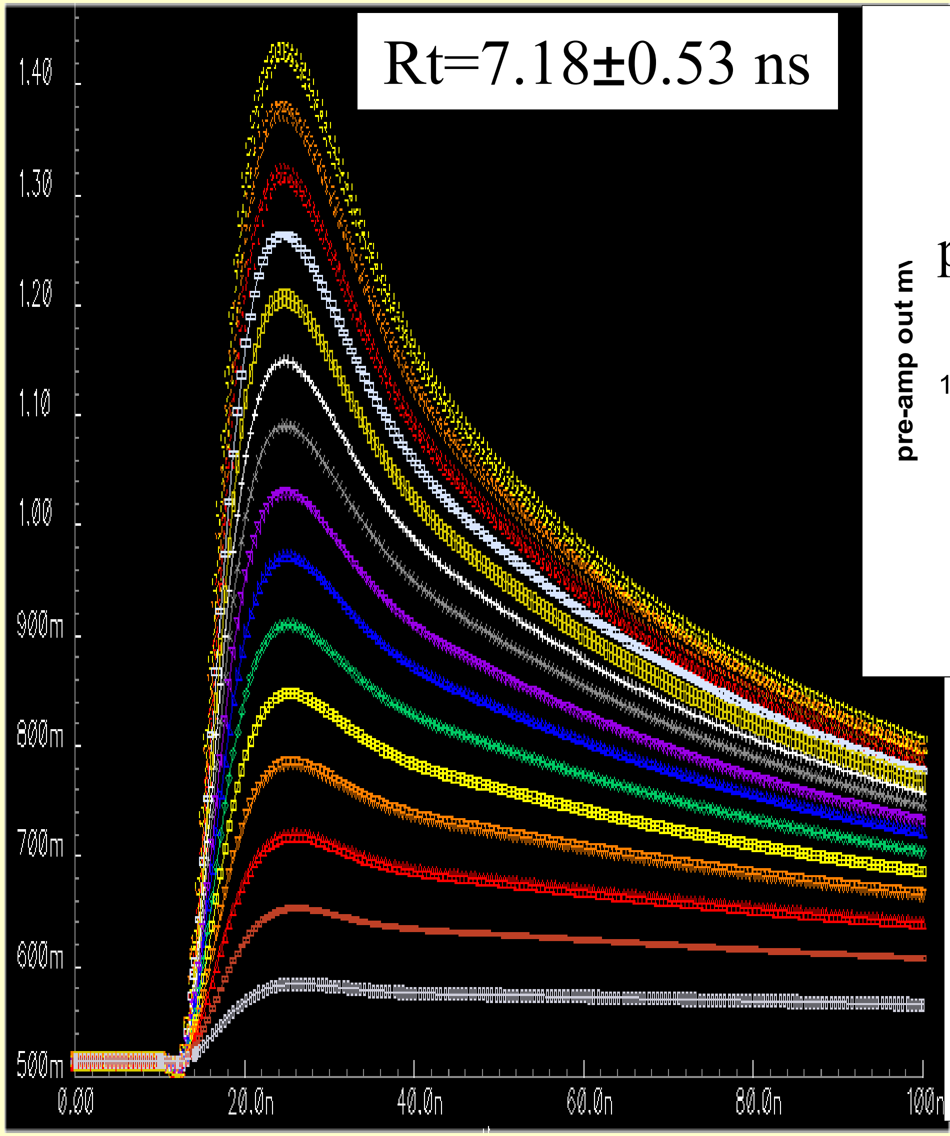
Reference FE pre-amp

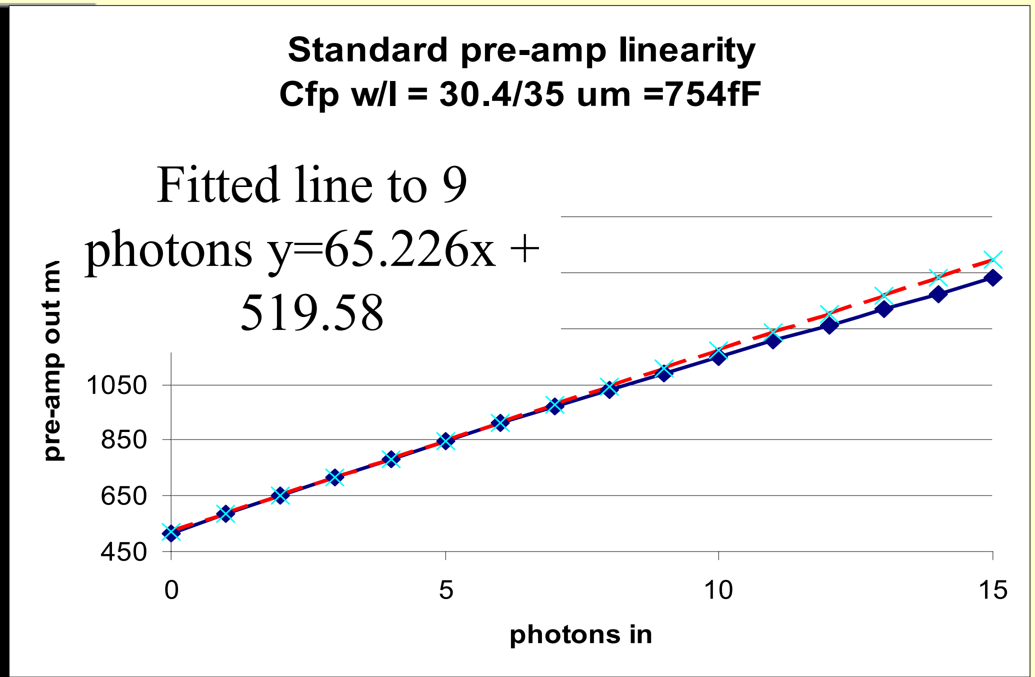


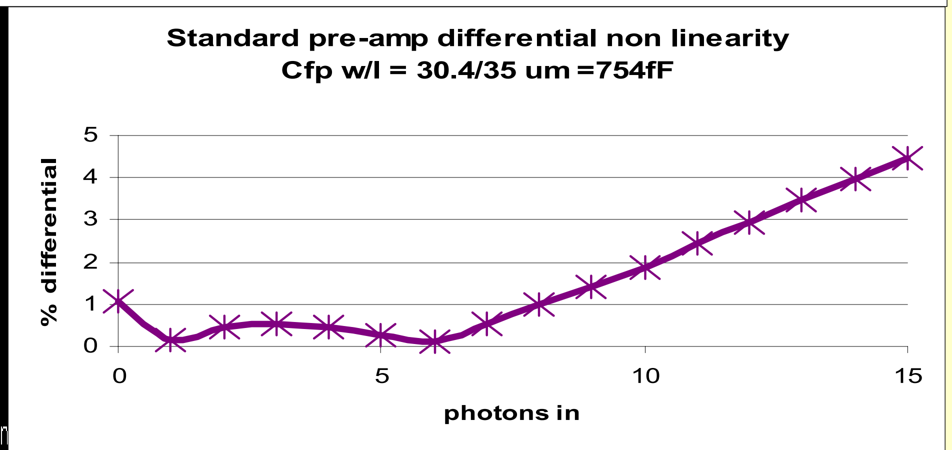




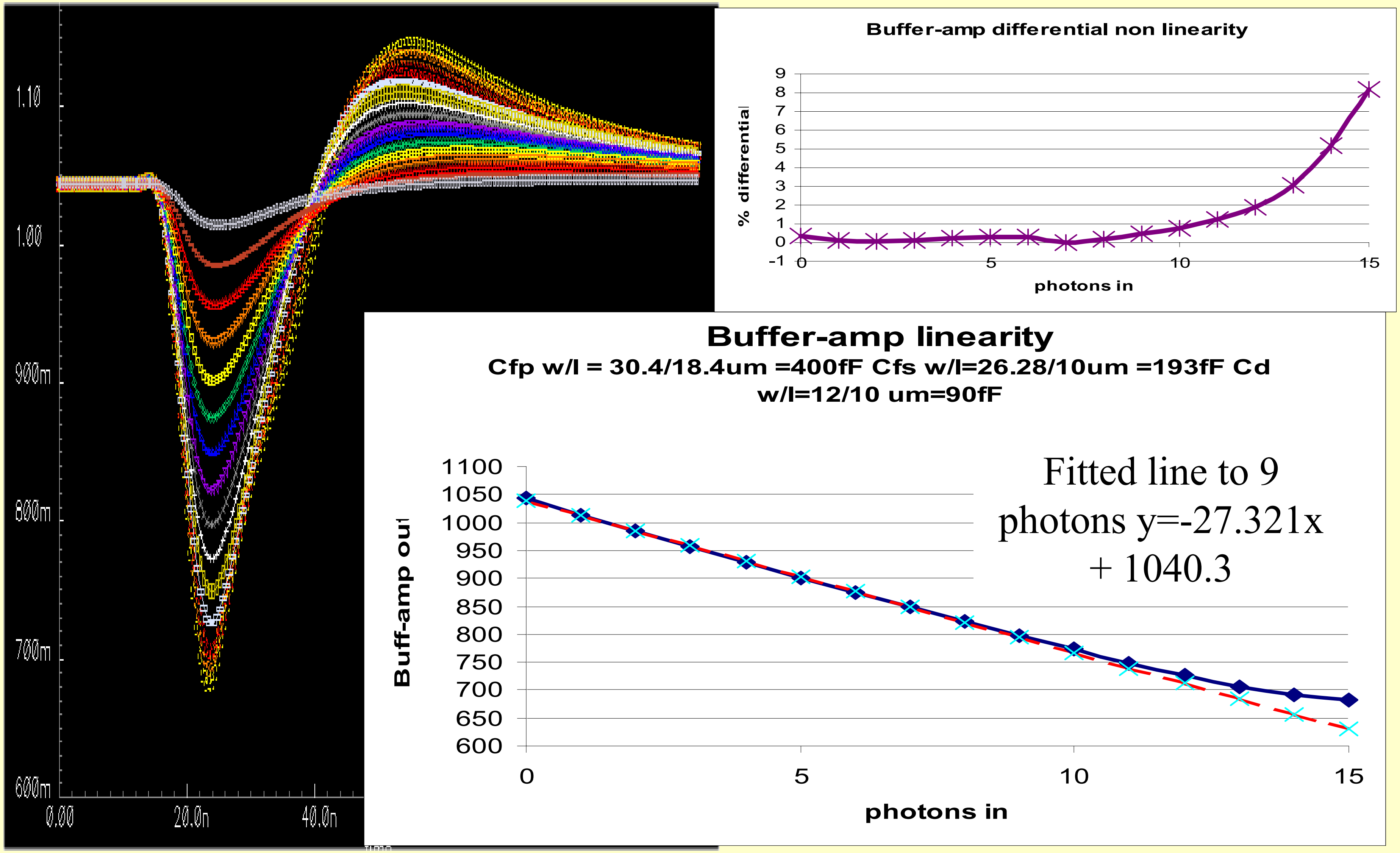
Cfb made larger on Pre-amp







Buf-amp with Cd & Cfs adjusted



Buf-amp with Cfp, Cd & Cfs adjusted