NA62 CFD
Design Review

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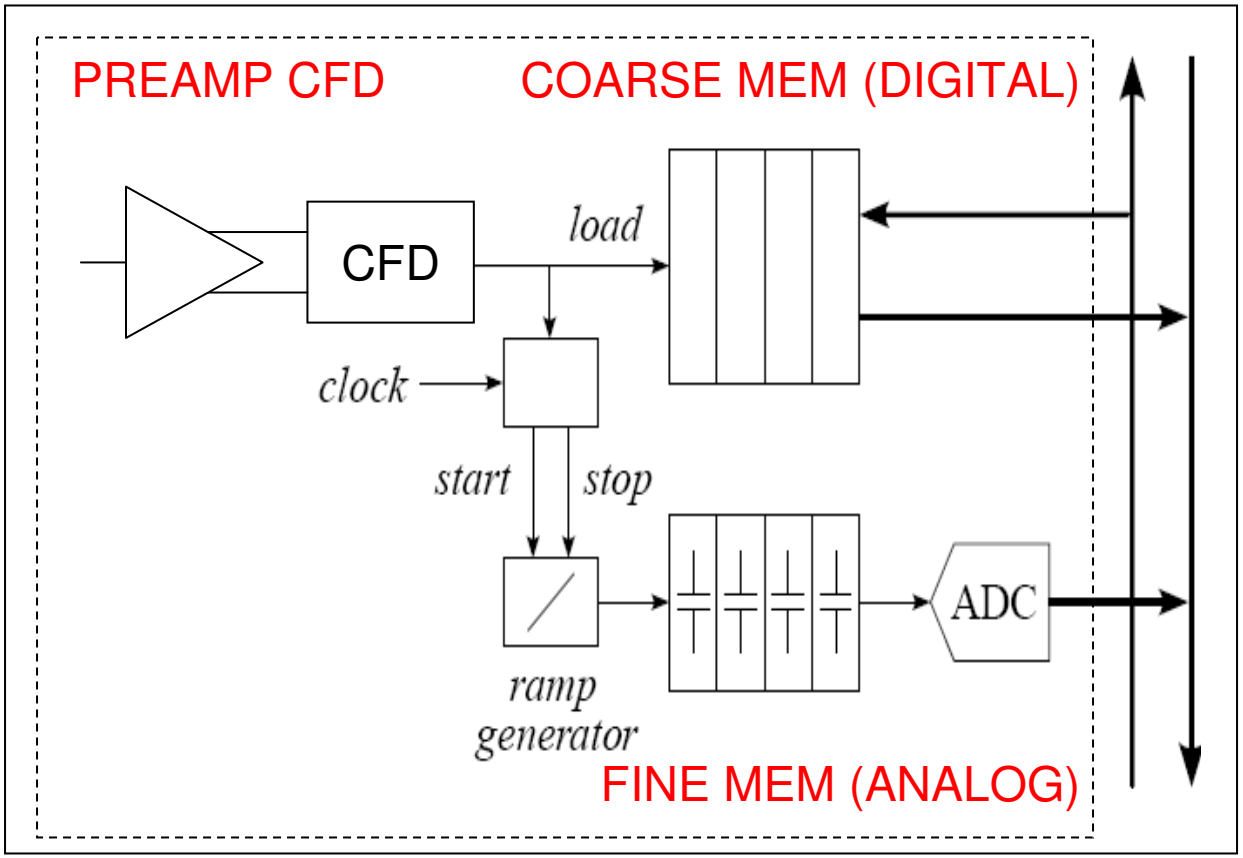
CFD-FE Overview

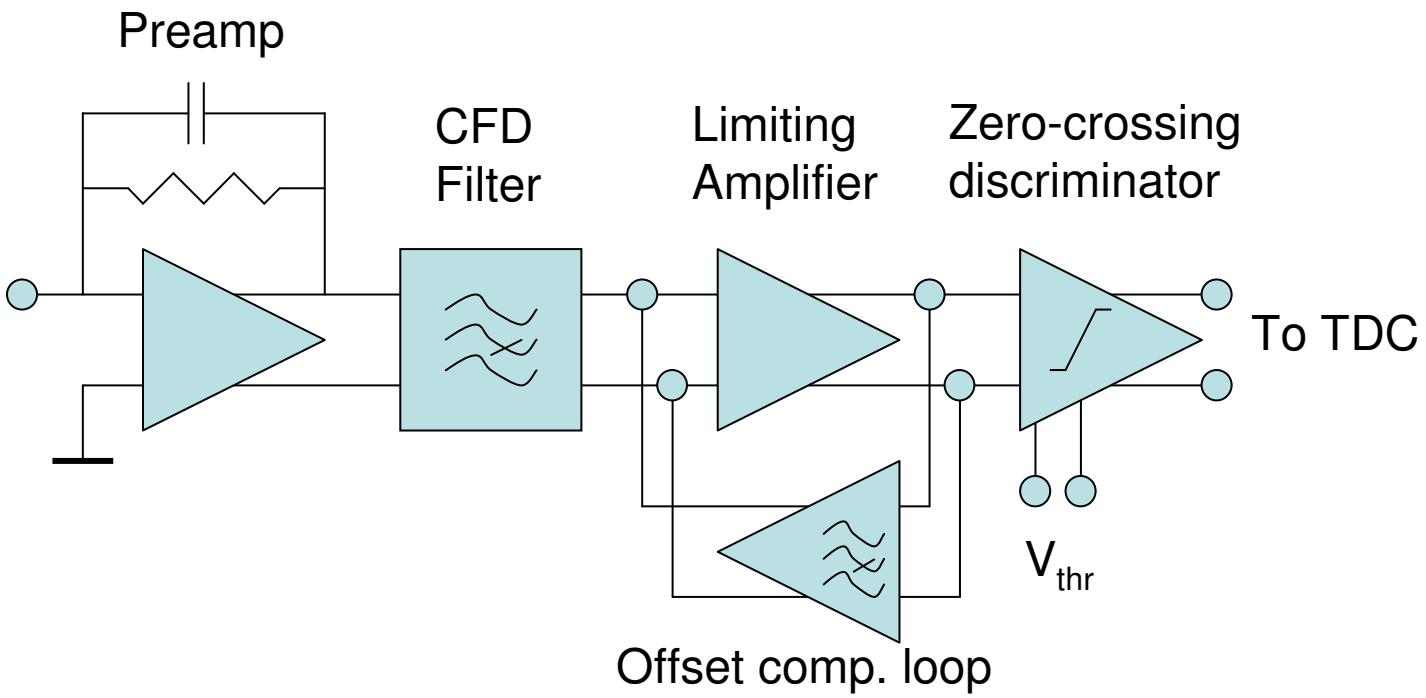


- Efficient de-randomization
- Efficient use of space
- Reduce end-of-column complexity

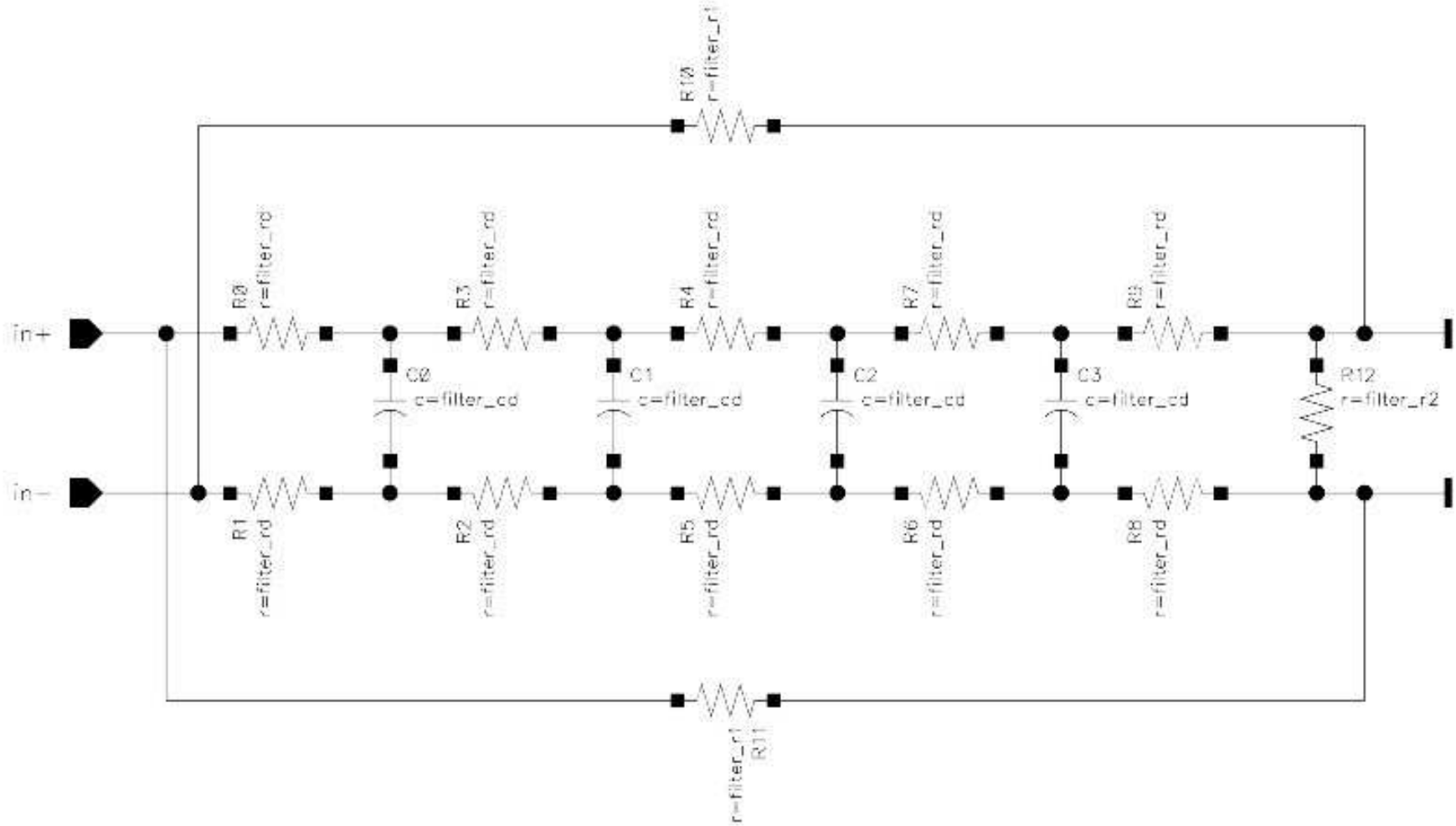
CFD-FE Overview

- Extract 100ps accurate information
- De-randomize
- Convert to digital

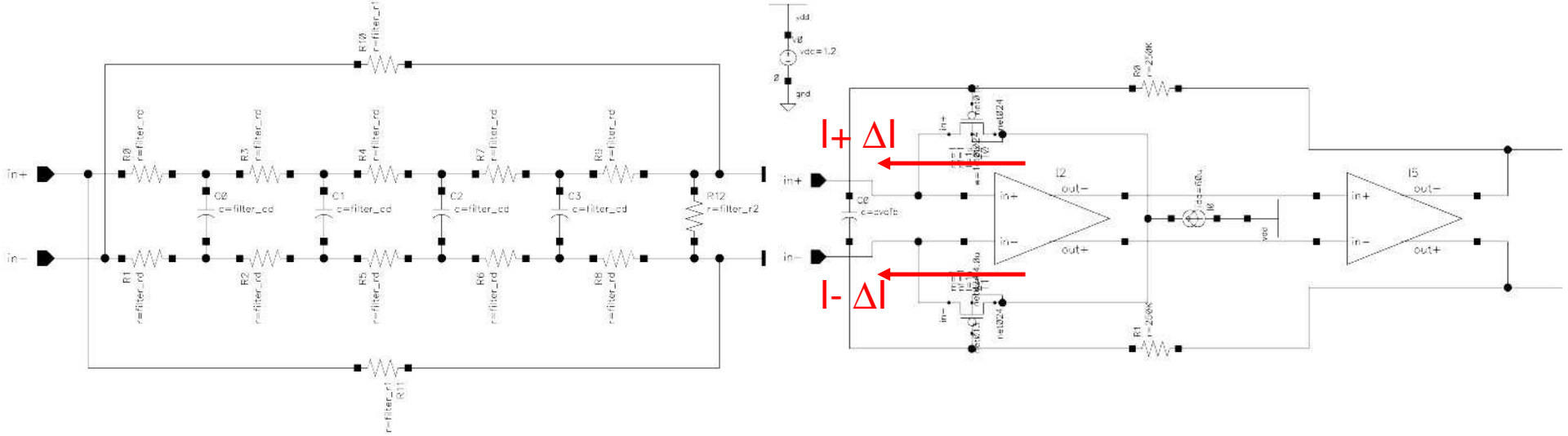
Prototype


Preamp
CFD
Filter
Limiting
Amplifier
Zero-crossing
discriminator
To TDC
V_{thr}
Offset comp. loop

“CMOS” Differential Implementation

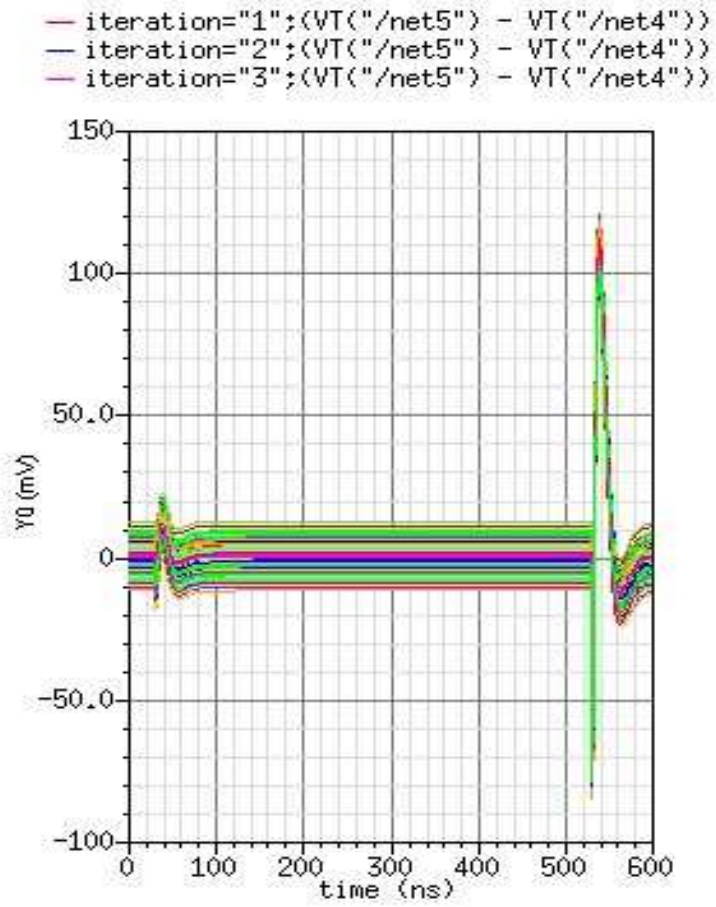


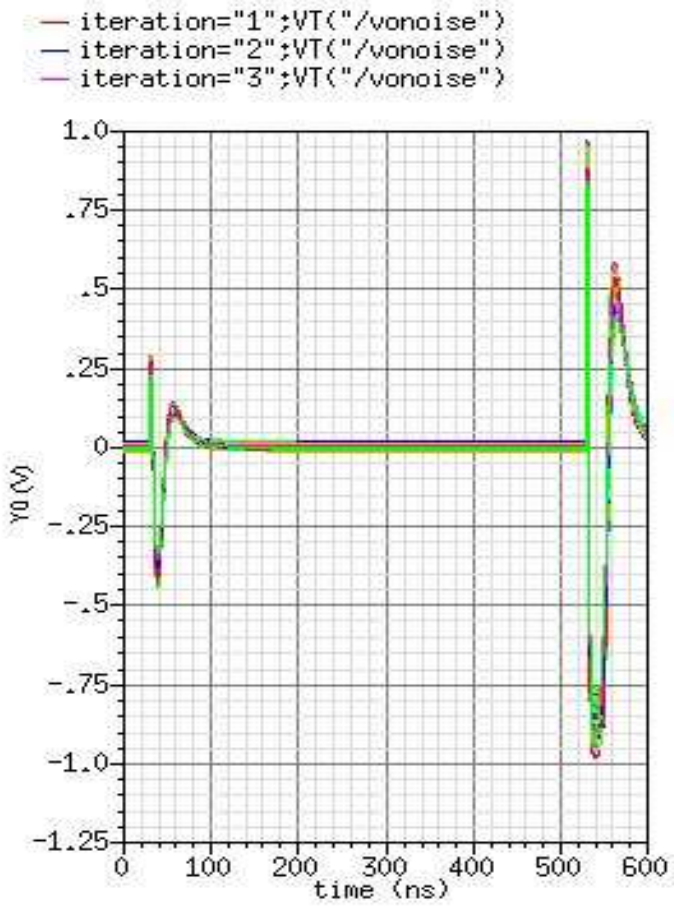
Dynamic Offset Compensation



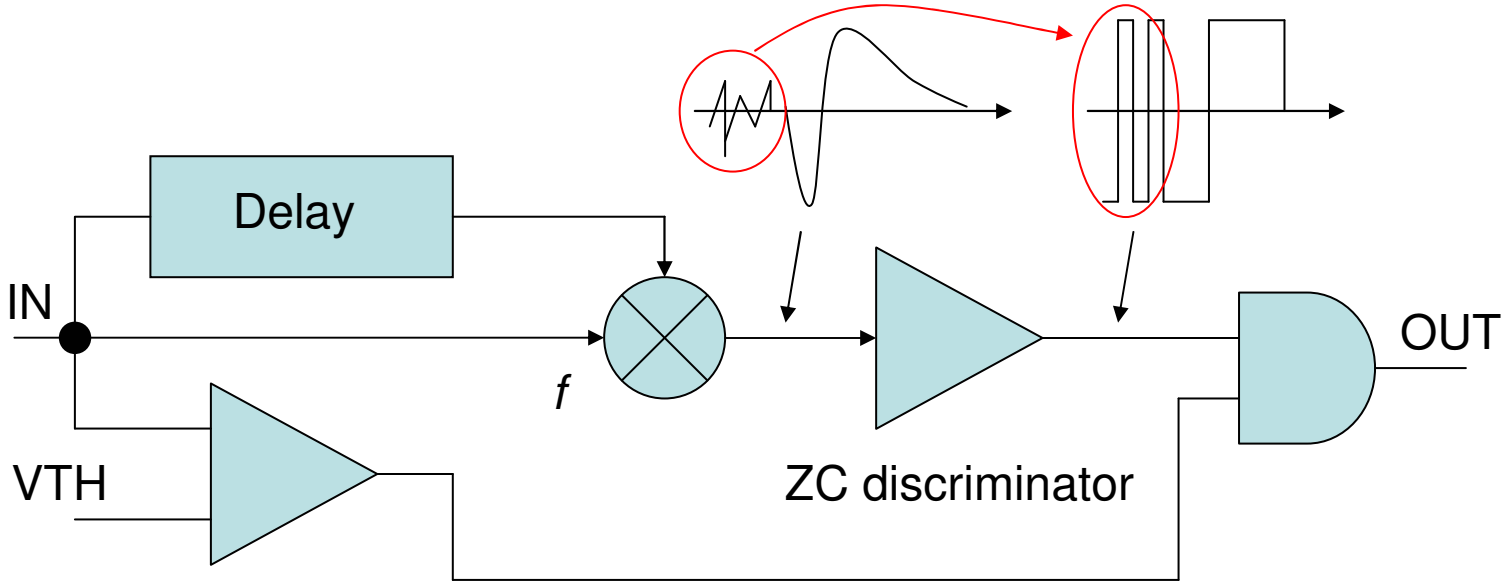
- Offset cancellation
- Low-pass feedback => high-pass overall transfer
  => reduce low-frequency noise (1/f noise)

Dynamic Offset Compensation



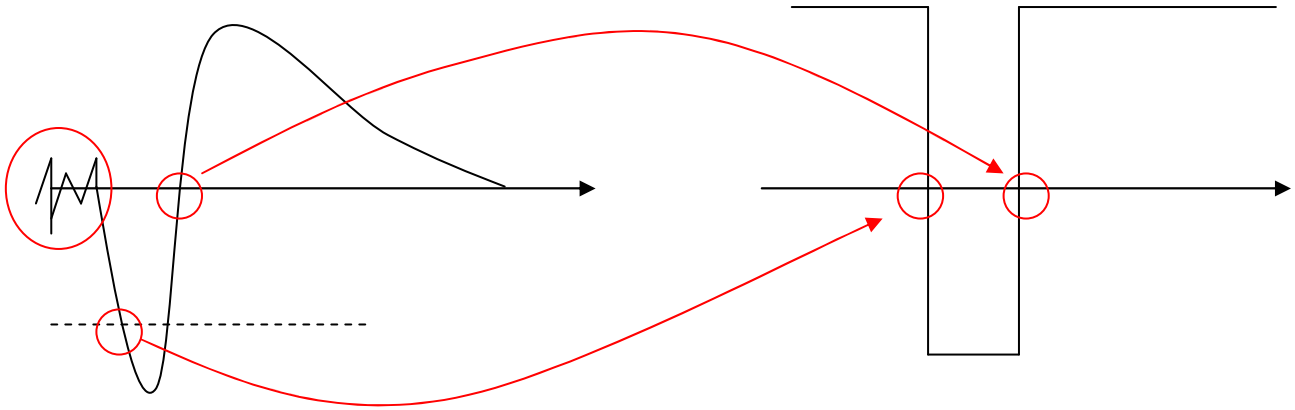


Coincidence discriminator

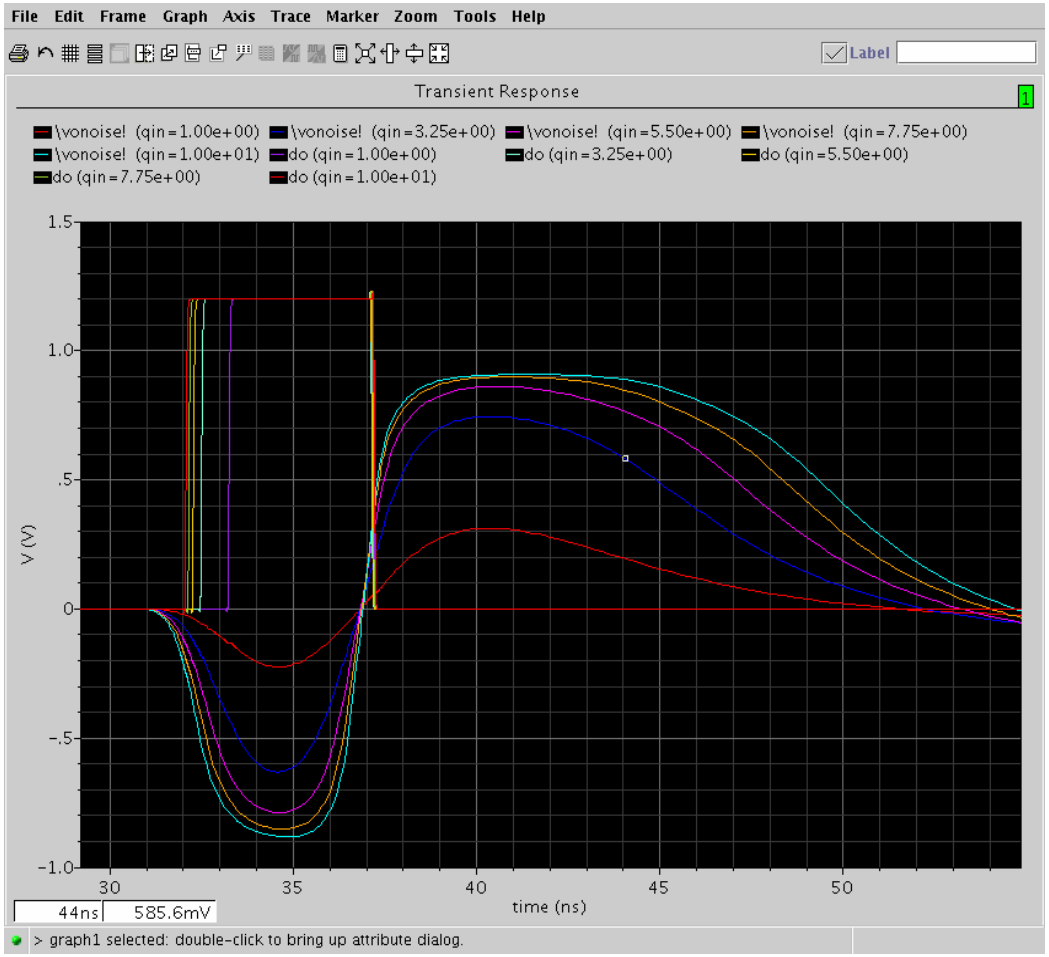


- Noise produces inherent noise switching at output of ZCD
- Need parallel leading-edge discriminator to mask noise switching
- Noise switching is not eliminated

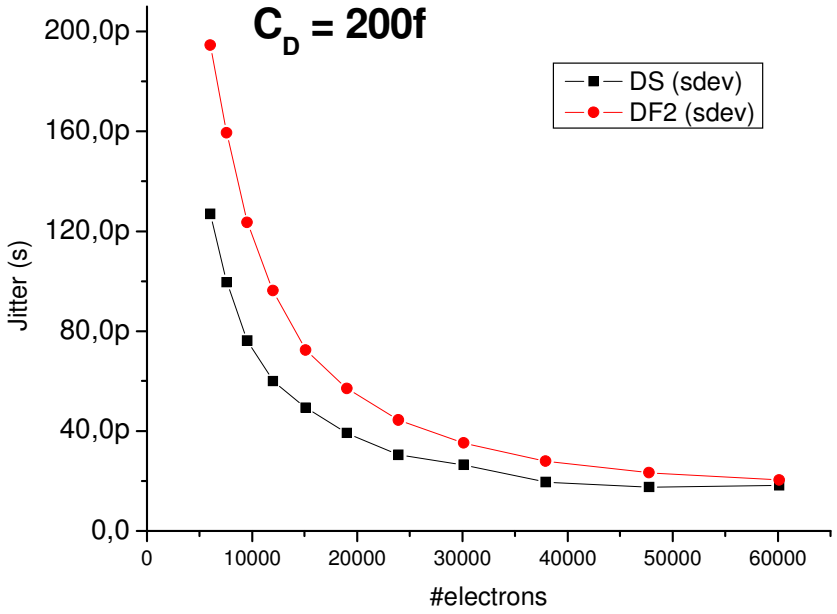
ZCD w/ hysteresis

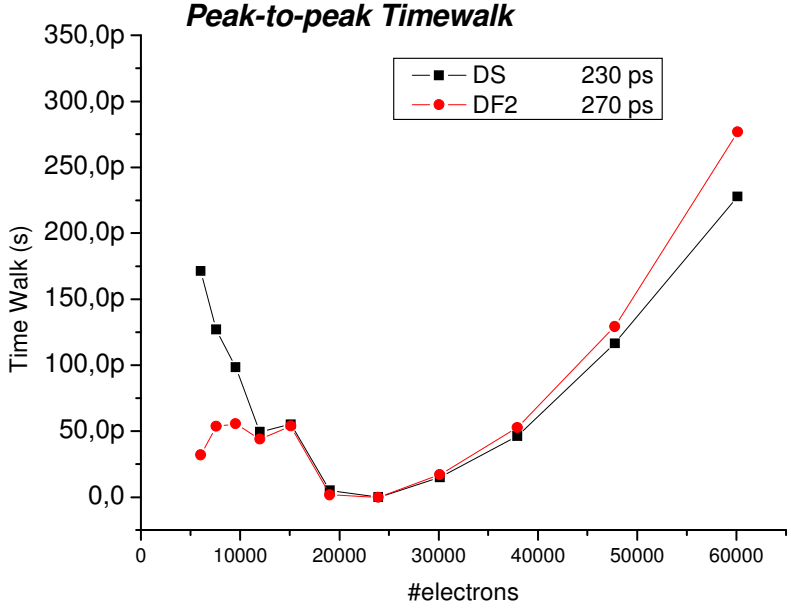


- ZCD “arms” when the bipolar signal crosses a certain threshold
- Switching noise is eliminated
- Additional fast block w/o offset compensation => may introduce some time walk


File Edit Frame Graph Axis Trace Marker Zoom Tools Help
Label
Transient Response
1
\vonoise! (qin=1.00e+00)
\vonoise! (qin=3.25e+00)
\vonoise! (qin=5.50e+00)
\vonoise! (qin=7.75e+00)
\vonoise! (qin=1.00e+01)
do (qin=1.00e+00)
do (qin=3.25e+00)
do (qin=5.50e+00)
do (qin=7.75e+00)
do (qin=1.00e+01)
1.5
1.0
.5
0
-.5
-1.0
V (V)
30
35
40
45
50
time (ns)
44ns
585.6mV
> graph1 selected: double-click to bring up attribute dialog.

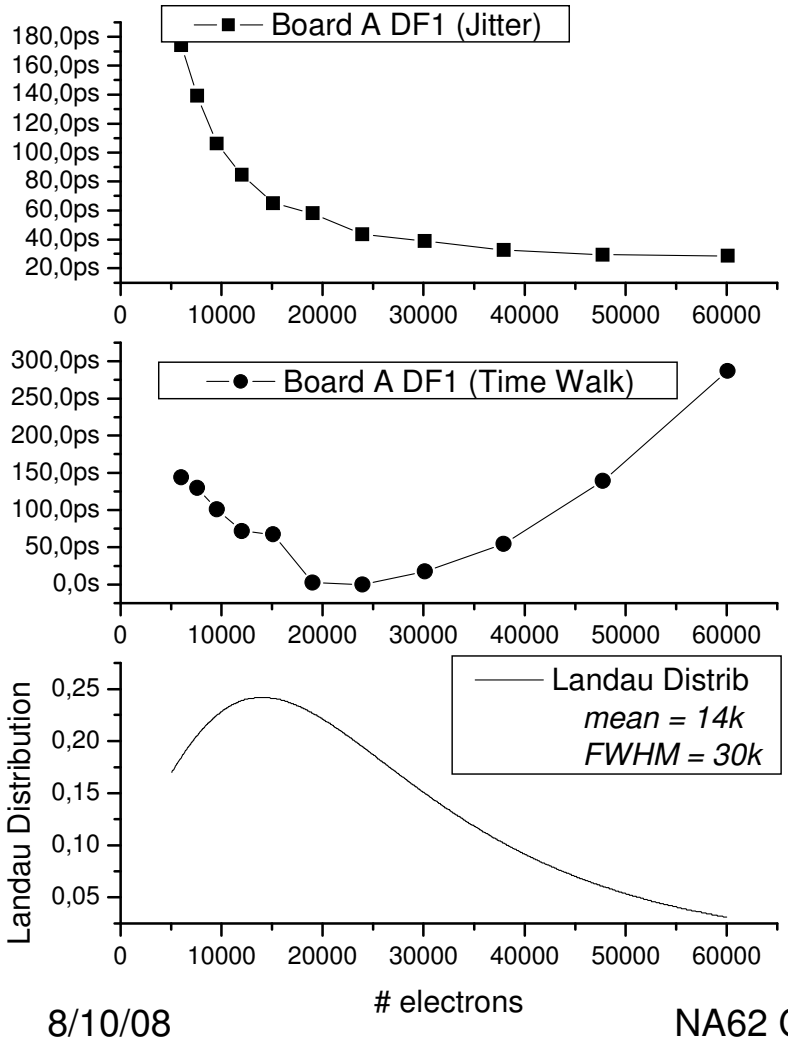
Measurements

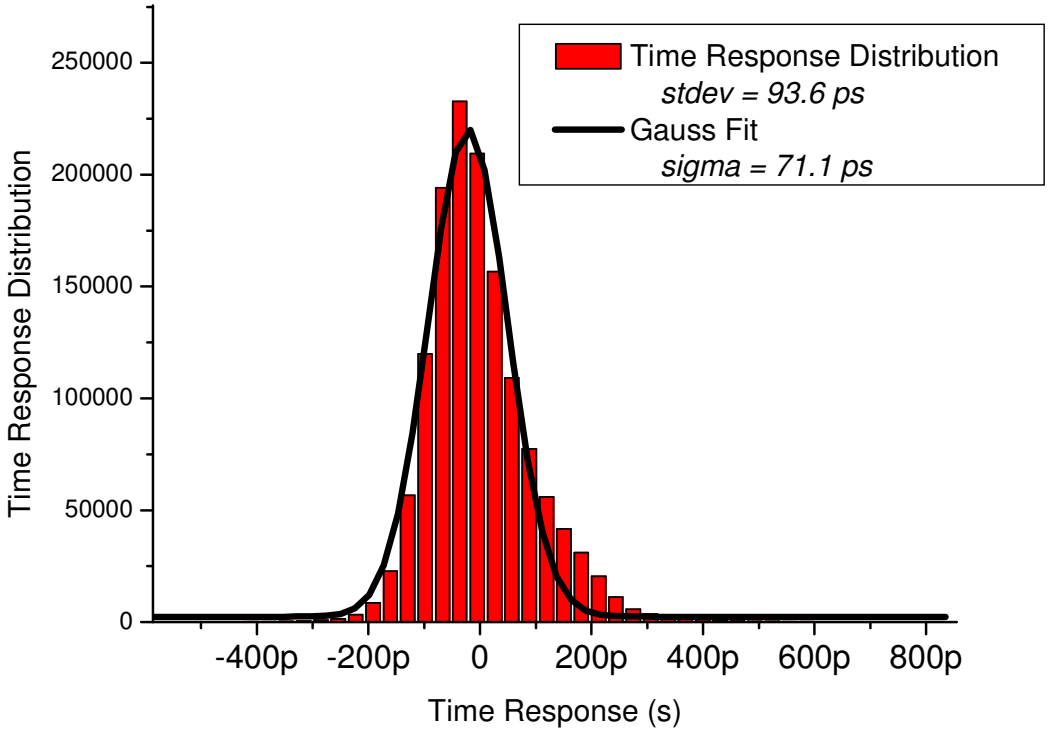




	Jitter @14ke (ps)	Jitter @6ke (ps)	TW(p-p) (ps)	LandauStd @22ke (ps)	LandauStd @14ke (ps)
DF1	73	195	277	92	93,7
DS	50	127	228	73,5	75,02

Landau Correction 14ke$^-$

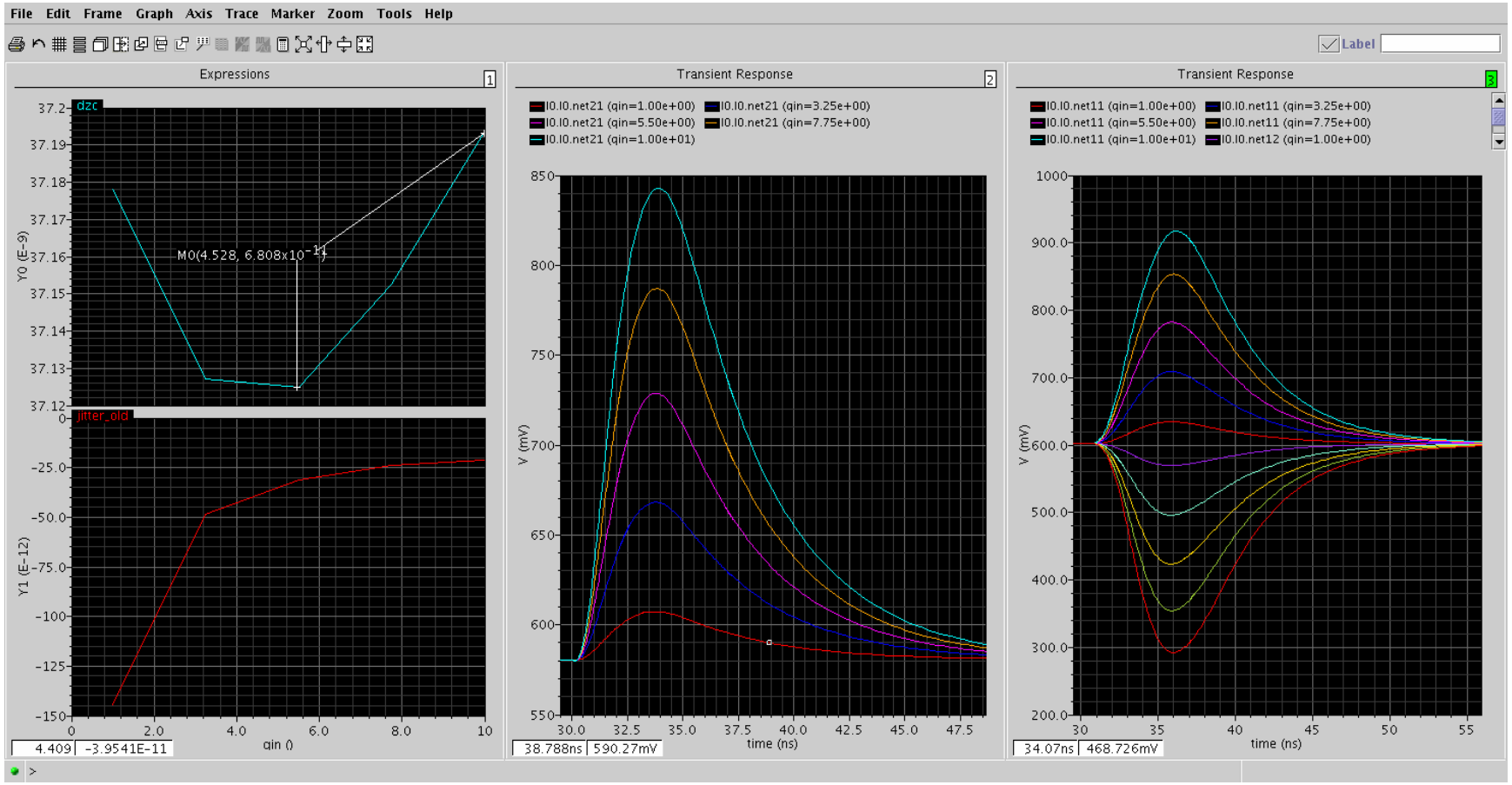




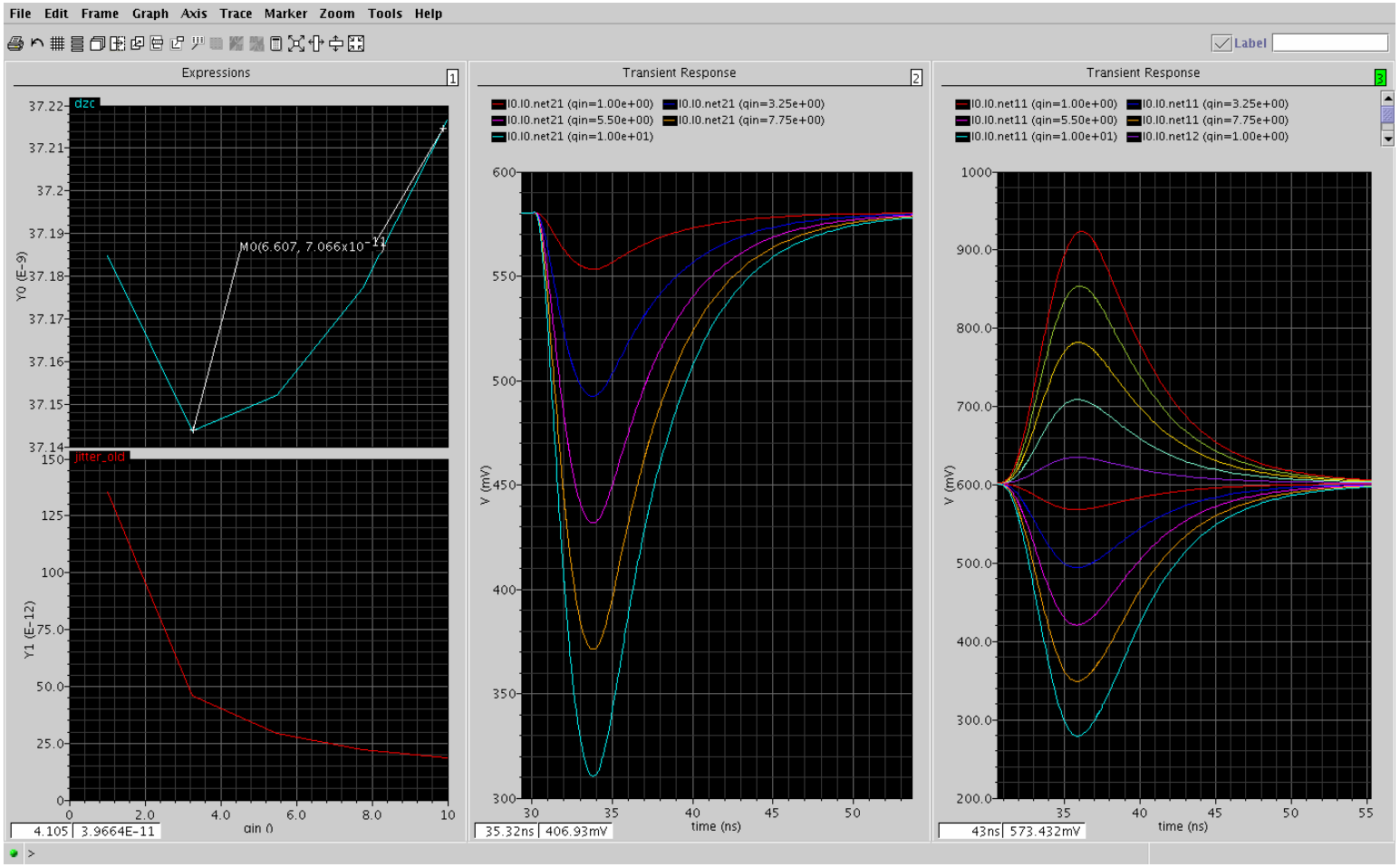
New Prototype

- LP input transistor
  - Bipolarity
  - Noise penalty
- Fully differential preamplifier
- Leakage current compensation

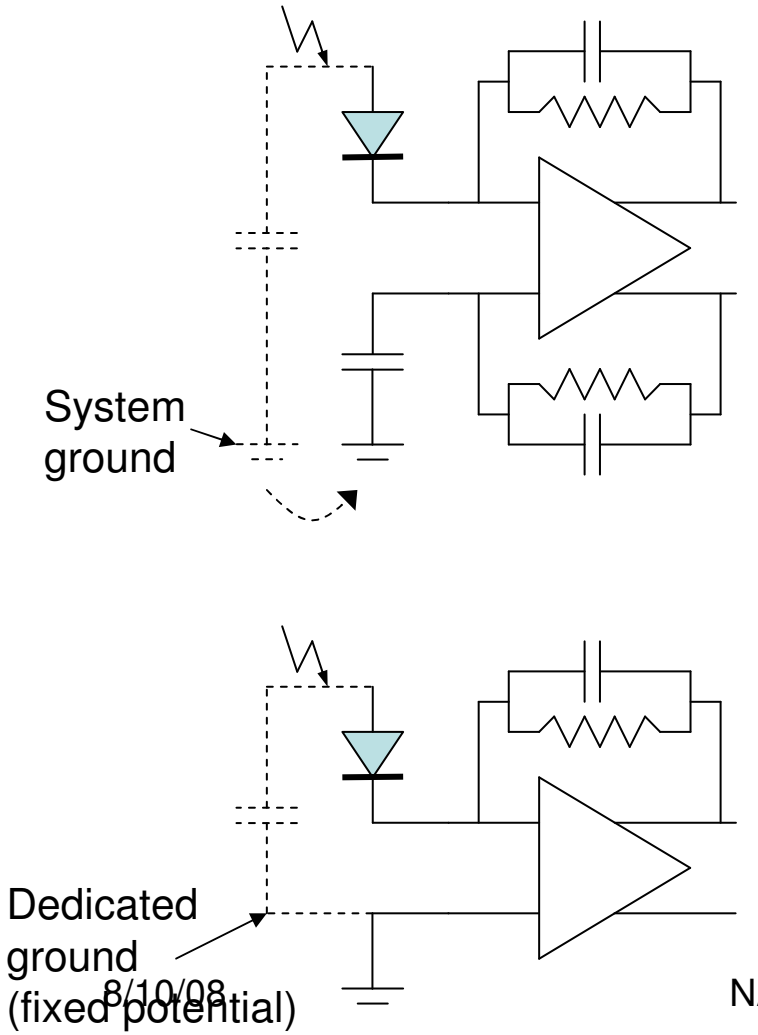
SE Preamp I


File Edit Frame Graph Axis Trace Marker Zoom Tools Help
Label
Expressions
dzc
M0(4.528, 6.808x10^-11)
Y0 (E-9)
jitter_old
Y1 (E-12)
qin ()
4.409 -3.9541E-11
Transient Response
I0.I0.net21 (qin=1.00e+00)
I0.I0.net21 (qin=3.25e+00)
I0.I0.net21 (qin=5.50e+00)
I0.I0.net21 (qin=7.75e+00)
I0.I0.net21 (qin=1.00e+01)
V (mV)
time (ns)
38.788ns 590.27mV
Transient Response
I0.I0.net11 (qin=1.00e+00)
I0.I0.net11 (qin=3.25e+00)
I0.I0.net11 (qin=5.50e+00)
I0.I0.net11 (qin=7.75e+00)
I0.I0.net11 (qin=1.00e+01)
I0.I0.net12 (qin=1.00e+00)
V (mV)
time (ns)
34.07ns 468.726mV

SE Preamp II


File Edit Frame Graph Axis Trace Marker Zoom Tools Help
Label
Expressions
dzc
M0(6.607, 7.066x10^-11)
Y0 (E-9)
jitter_old
Y1 (E-12)
4.105 3.9664E-11
gin 0
Transient Response
I0.I0.net21 (qin=1.00e+00)
I0.I0.net21 (qin=3.25e+00)
I0.I0.net21 (qin=5.50e+00)
I0.I0.net21 (qin=7.75e+00)
I0.I0.net21 (qin=1.00e+01)
V (mV)
35.32ns 406.93mV
time (ns)
Transient Response
I0.I0.net11 (qin=1.00e+00)
I0.I0.net11 (qin=3.25e+00)
I0.I0.net11 (qin=5.50e+00)
I0.I0.net11 (qin=7.75e+00)
I0.I0.net11 (qin=1.00e+01)
I0.I0.net12 (qin=1.00e+00)
V (mV)
43ns 573.432mV
time (ns)

Differential Preamp



2 possible grounding schemes:

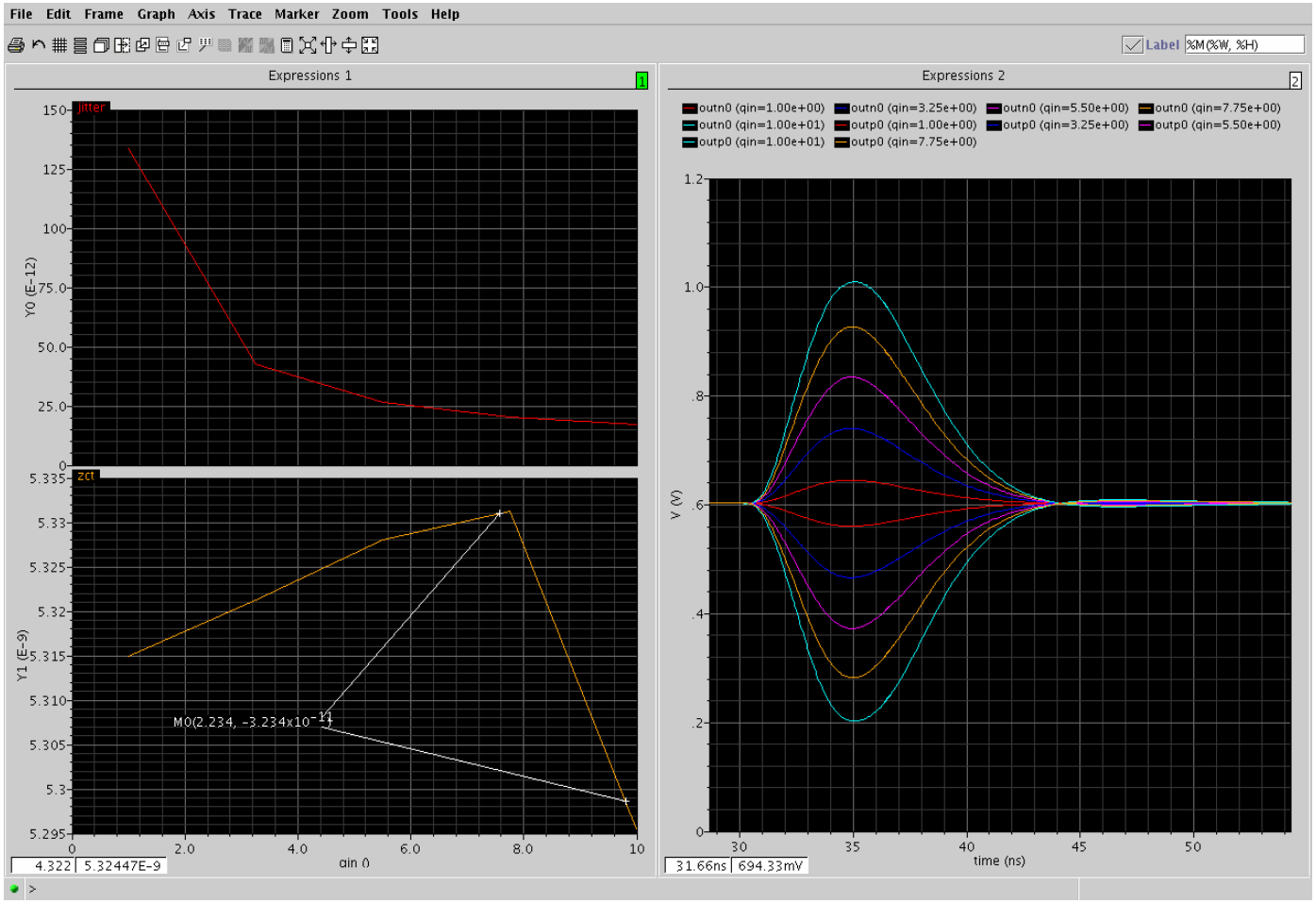
a) System ground
- Local spur-noise injection
- HV separation

b) Dedicated ground
- Potential HV risk
- Better performance (speed and noise)

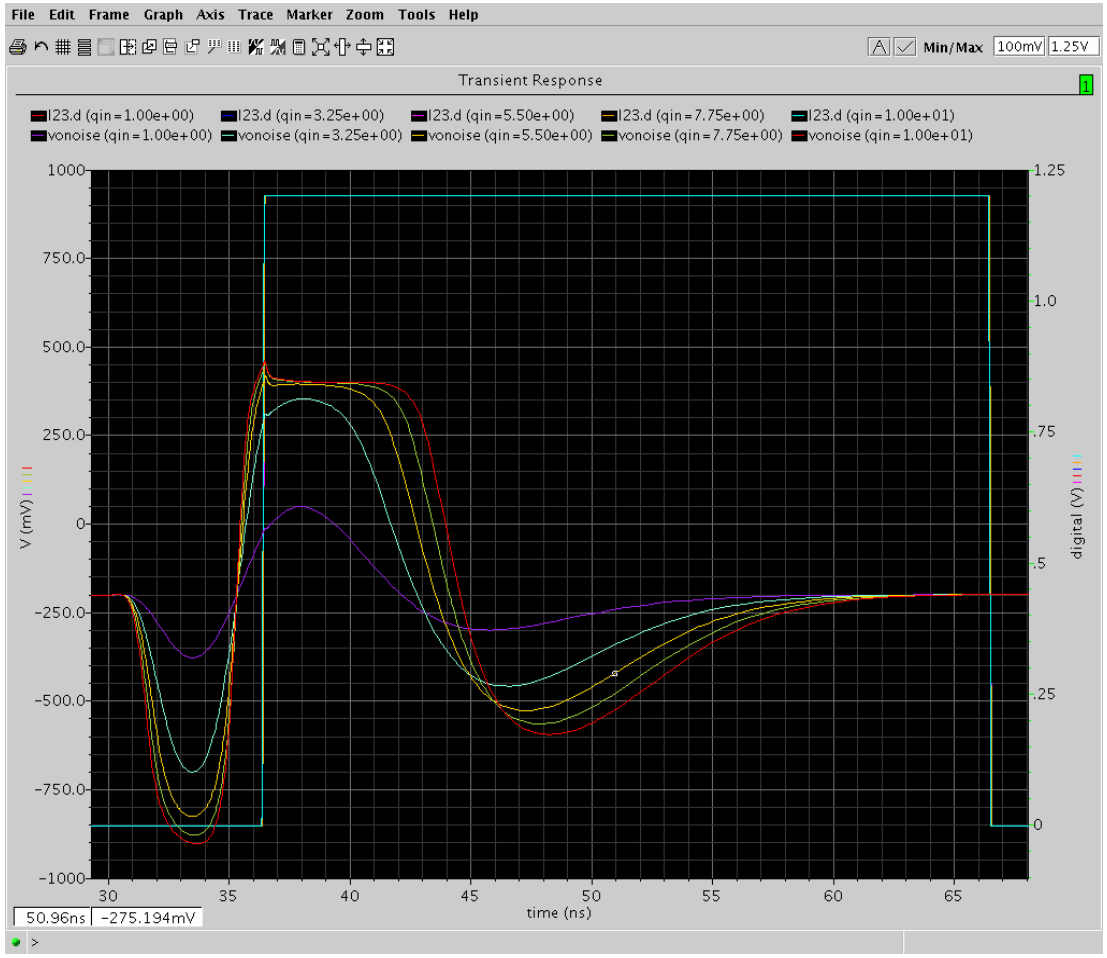
Differential Preamp

- Under-compensated
  - Still stable without detector
- Class-AB
- Low CMFB phase margin (40 - 50 deg)
- Leakage compensation slow servo-loop

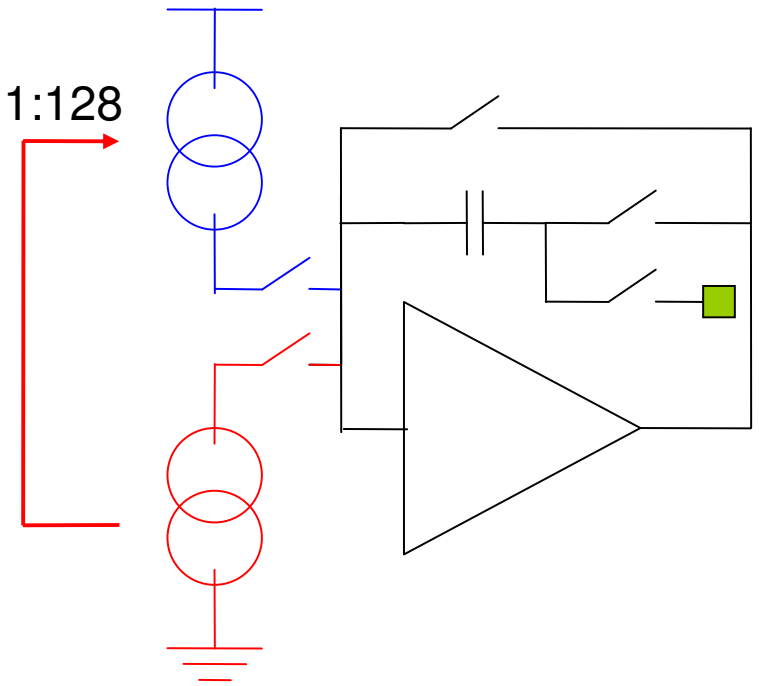
Differential Preamp



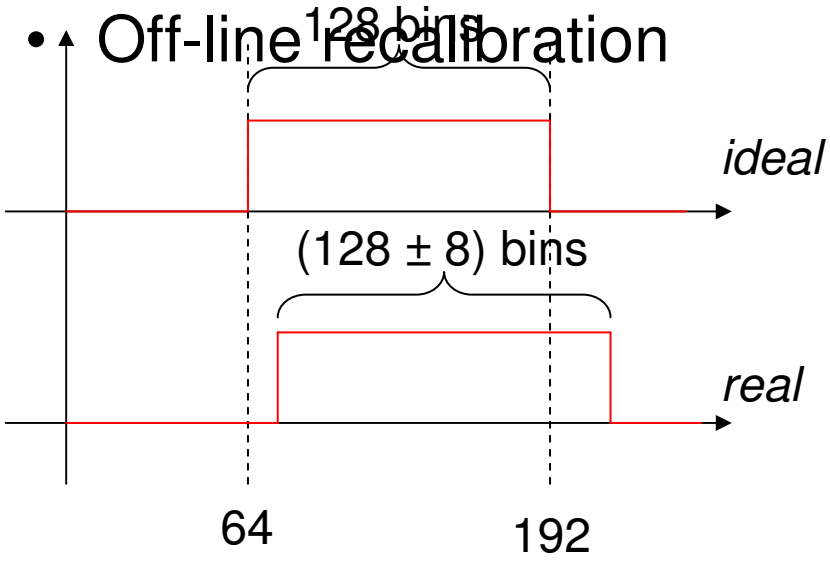
Tail Cancellation



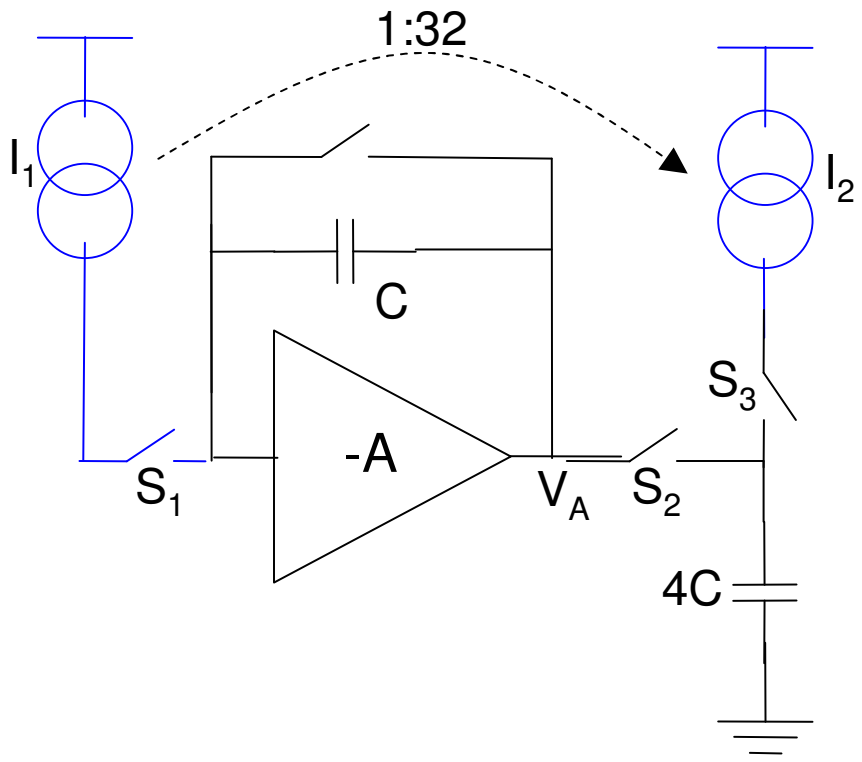
Wilkinson TDC



- ~16 LSB range mismatch (p-p)
- 4-5 bit calibration DAC
- Off-line recalibration



TDC



Modified Wilkinson TDC:

1. S_1: I_1 charges C for t_x
2. S_2: V_A potential transferred to 4C (charge transferred to 4C is 4 times the charge stored on C)
3. S_3: I_2 charges 4C to the initial voltage

Advantages:

- Current ratio is reduced by the capacitor ratio
- Better matching of same polarity current sources

Power Consumption

	I_{DD}	Power
Preamp	360 uA	430 uW
CFD + Limiting Amp + ZCD	120 uA	144 uW
TDC	80 uA	100 uW
Total	560 uA	0.67 mW