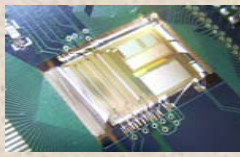
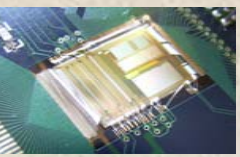
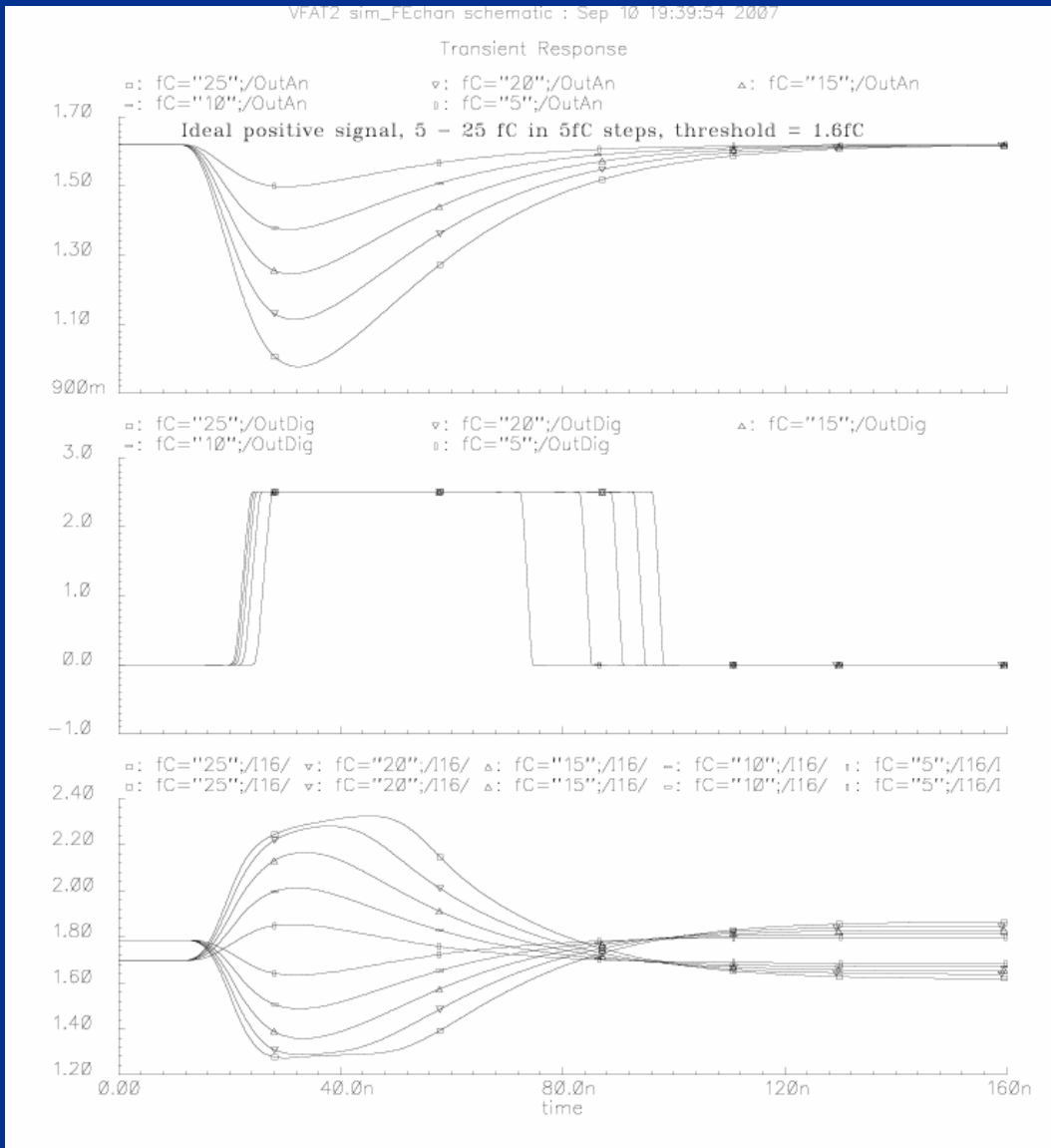
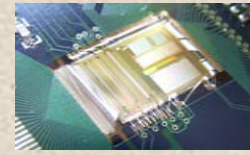
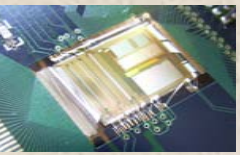


# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	
VFAT Dynamic Range for GEM	
Threshold range	
Trim-DAC range	
Recovery time from very large signals	

# Dynamic range (Ideal positive charge)



Pre-amp output



For Ideal pulses  
From 5 to 25 fC (steps of 5 fC)

Threshold = 1.6 fC



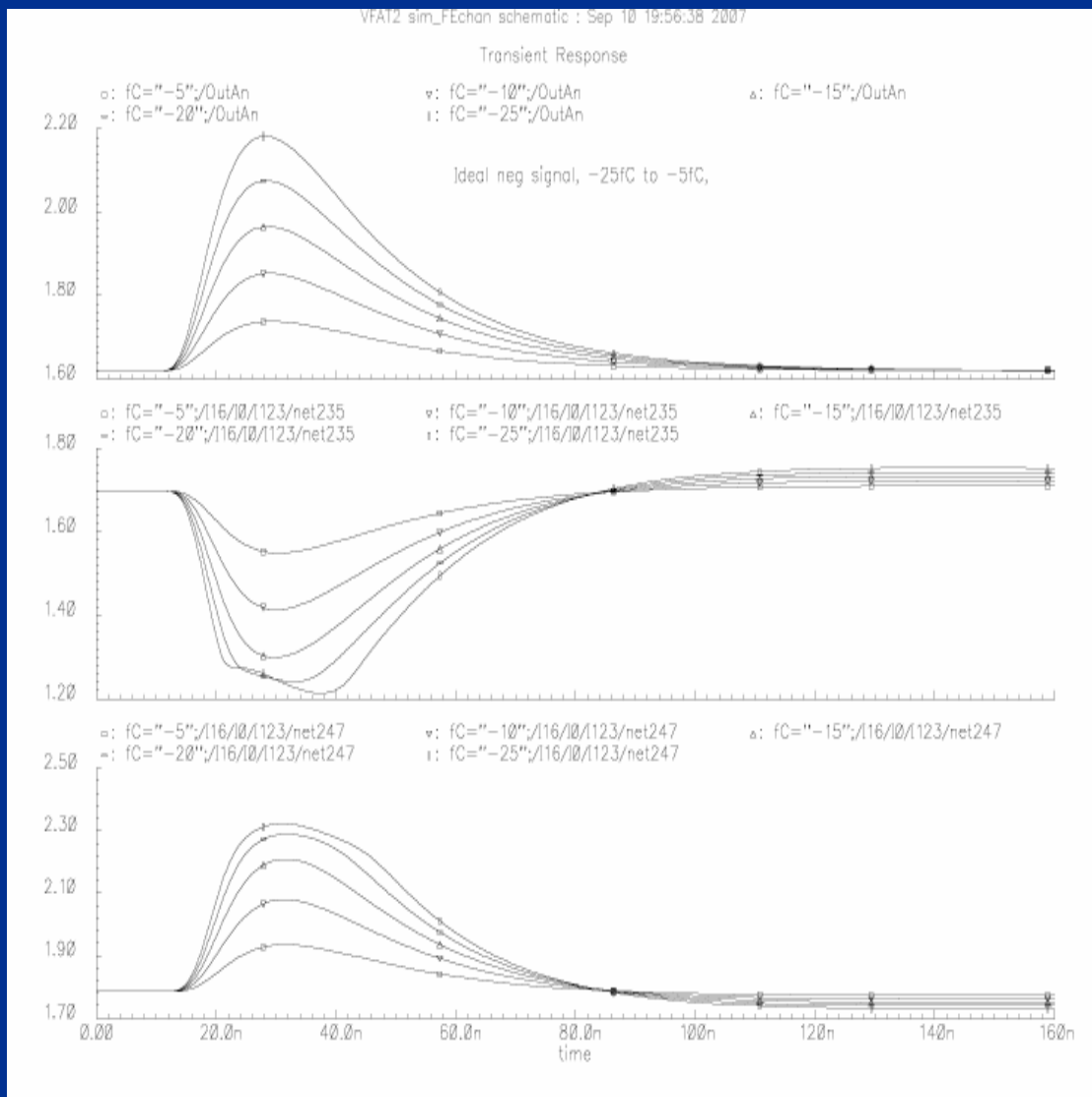
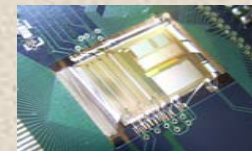
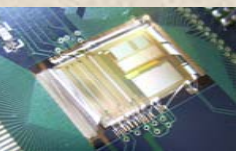
Comparator output



Comparator Input

Distortion occurs at ~18 fC

# Dynamic range (ideal neg. charge)



Pre-amp output



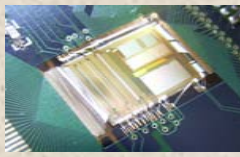
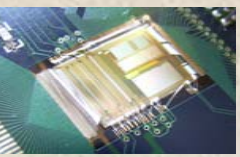
For Ideal pulses  
From -5 to -25 fC (steps of -5 fC)



Comparator Inputs

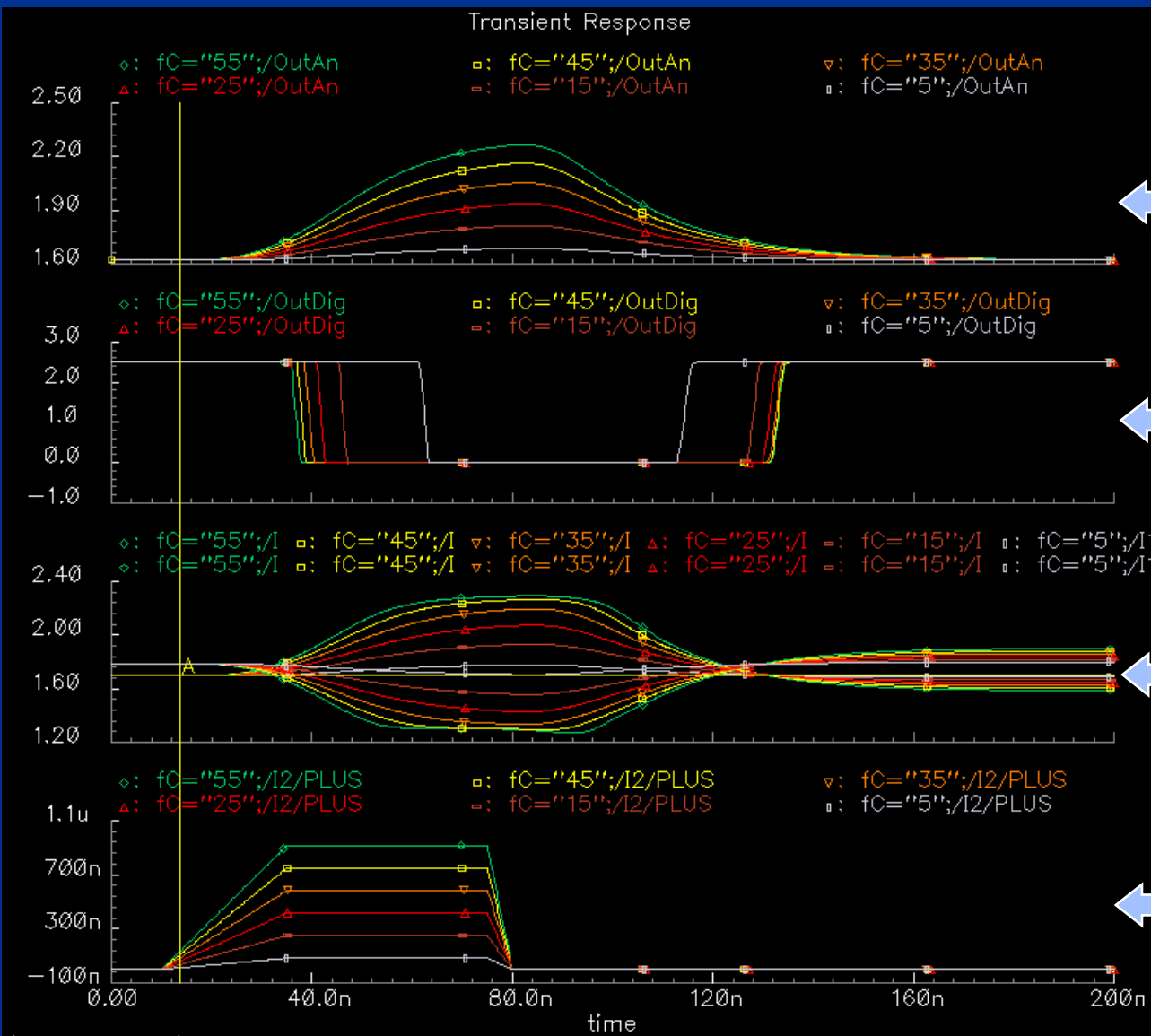
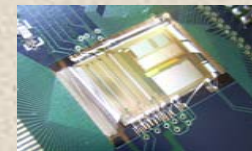
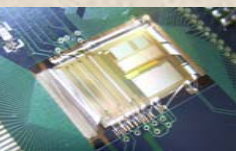
Distortion occurs at ~ -18 fC

# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	$\sim 18 \text{ fC}$ ( $\sim 5 \text{ MIPs}$ )
VFAT Dynamic Range for GEM	
Threshold range	
Trim-DAC range	
Recovery time from very large signals	

# Dynamic range (GEM signal)



Pre-amp output

For GEM neg. pulses  
From 5 to 55 fC  
(steps of 10 fC)

Comparator output

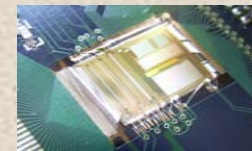
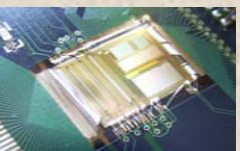
Threshold =  $-1.7fC$   
Time walk on both edges

Comparator Inputs

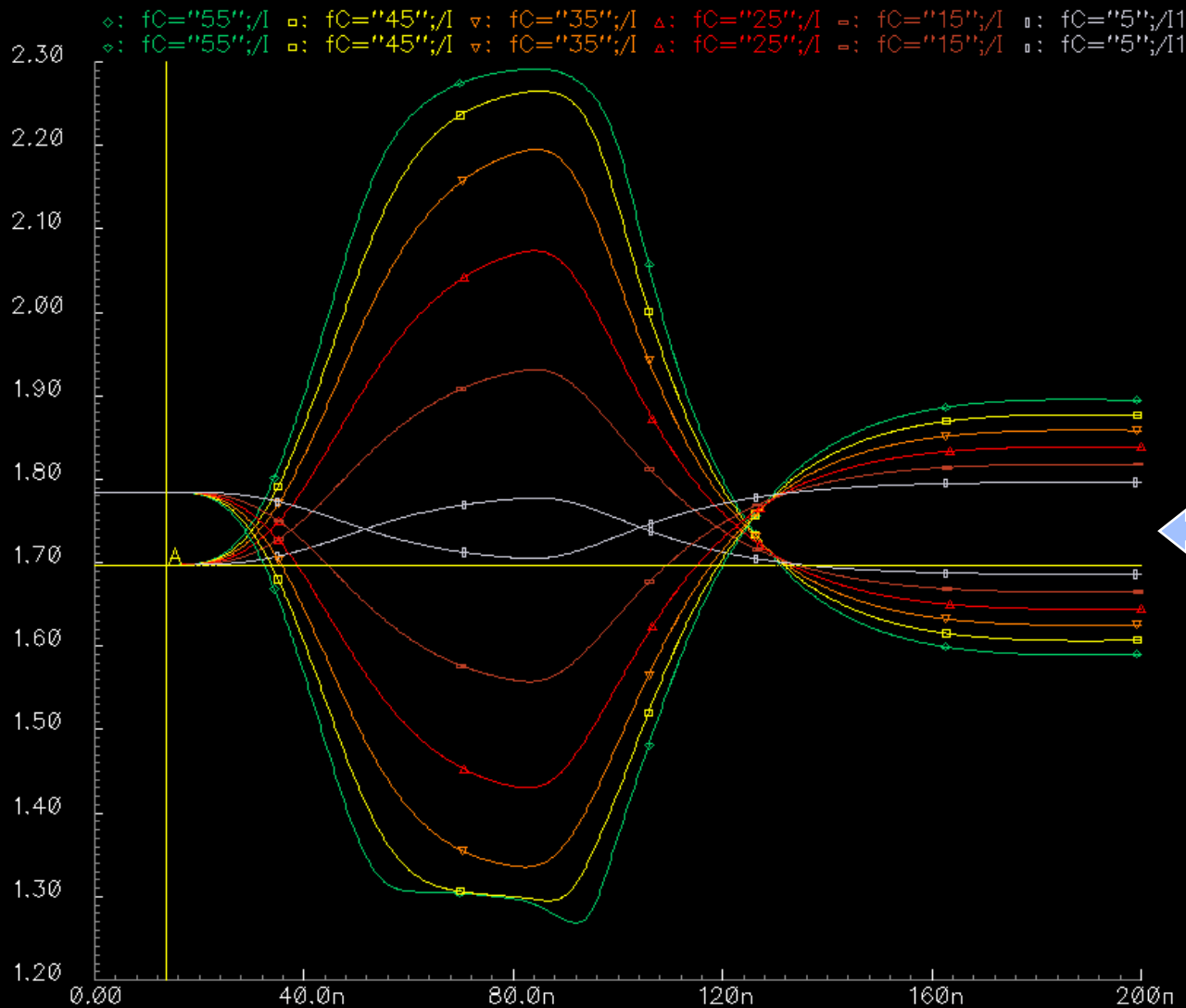
Distortion occurs between  
35fC and 45fC

GEM current pulse shape

# Dynamic range (GEM signal)



Transient Response



For GEM neg. pulses  
From 5 to 55 fC  
(steps of 10 fC)

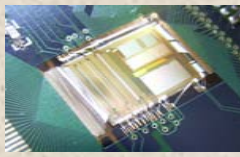
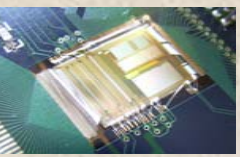
Comparator Inputs

Distortion occurs between  
35fC and 45fC

GEM charge for 1 MIP

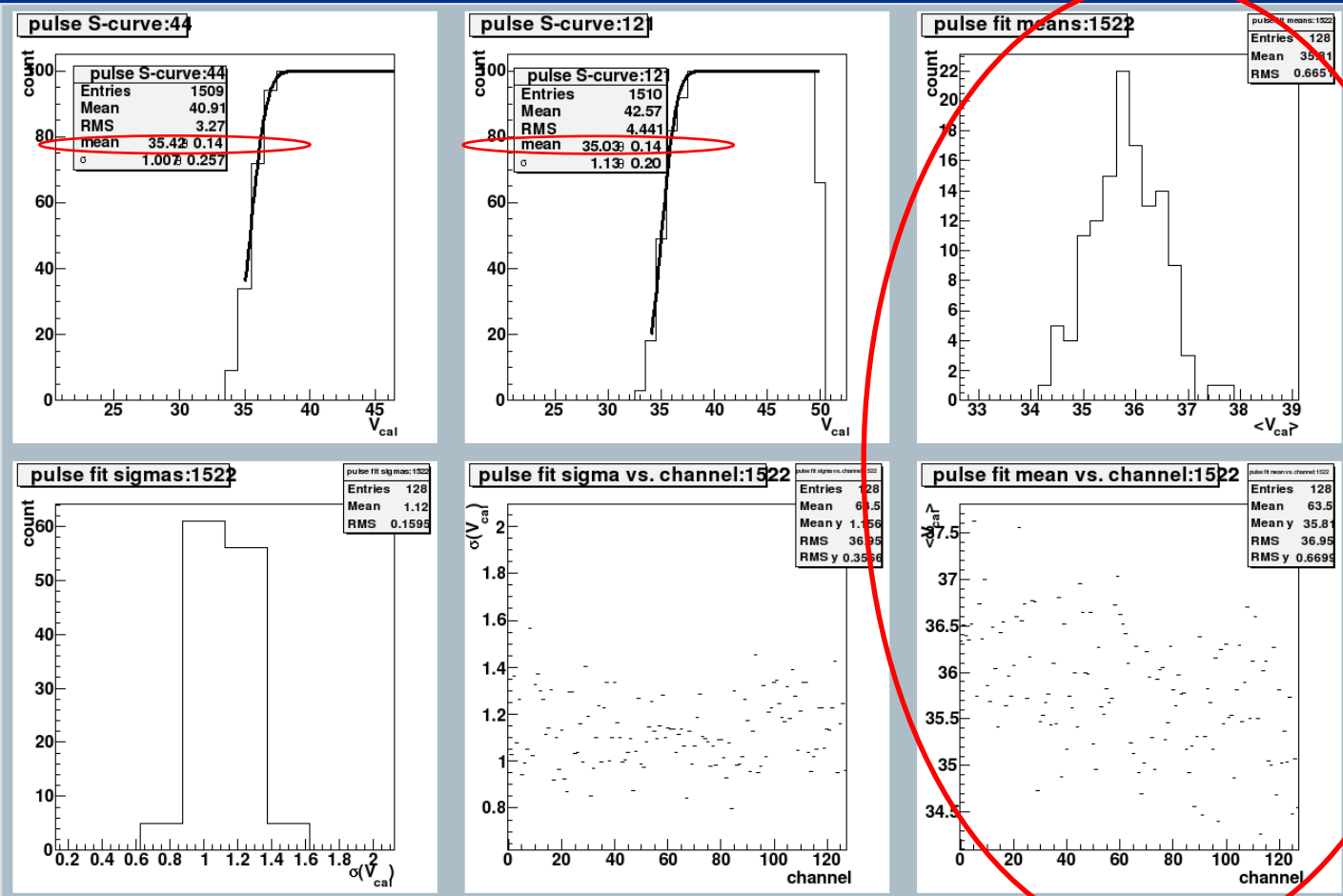
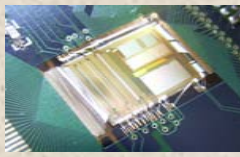
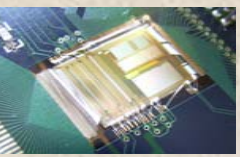
PADs = 19.2 fC (120 000e)  
Strips = 6.4 fC (40 000e)

# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	~ 18 fC (5 MIPs)
VFAT Dynamic Range for GEM	35fC to 45fC (~ 2 MIPs pads, ~ 6 MIPs strips)
Threshold range	
Trim-DAC range	
Recovery time from very large signals	

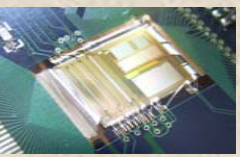
# Measuring thresholds



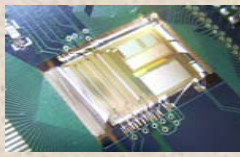
The S-curve mean is the threshold.

**Note :  $V_{cal}$  is on the x-axis in order to be able to express threshold in terms of input charge needed to go through the threshold.**





# VFAT2 Thresholds (1)



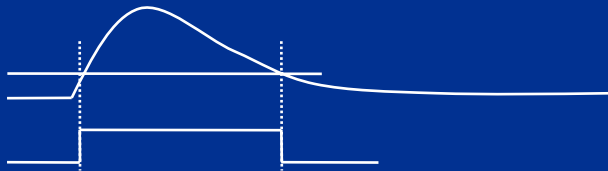
VFAT has one main threshold control which is common for all channels.

Main threshold controlled by the difference between two voltages VT1 & VT2.

## Roman Pot silicon

Positive signal charge  
Requires a positive threshold

$$VT2 - VT1 > 0$$



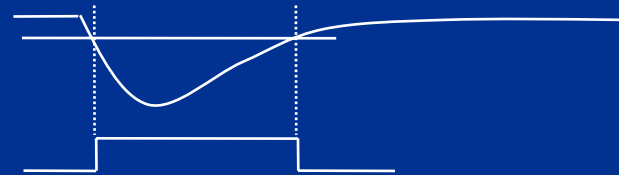
**To increase threshold w.r.t. signal :**

**Increase DAC value (VT2-VT1)**

## GEM and CSC

Negative signal charge  
Requires a negative threshold

$$VT1 - VT2 > 0$$

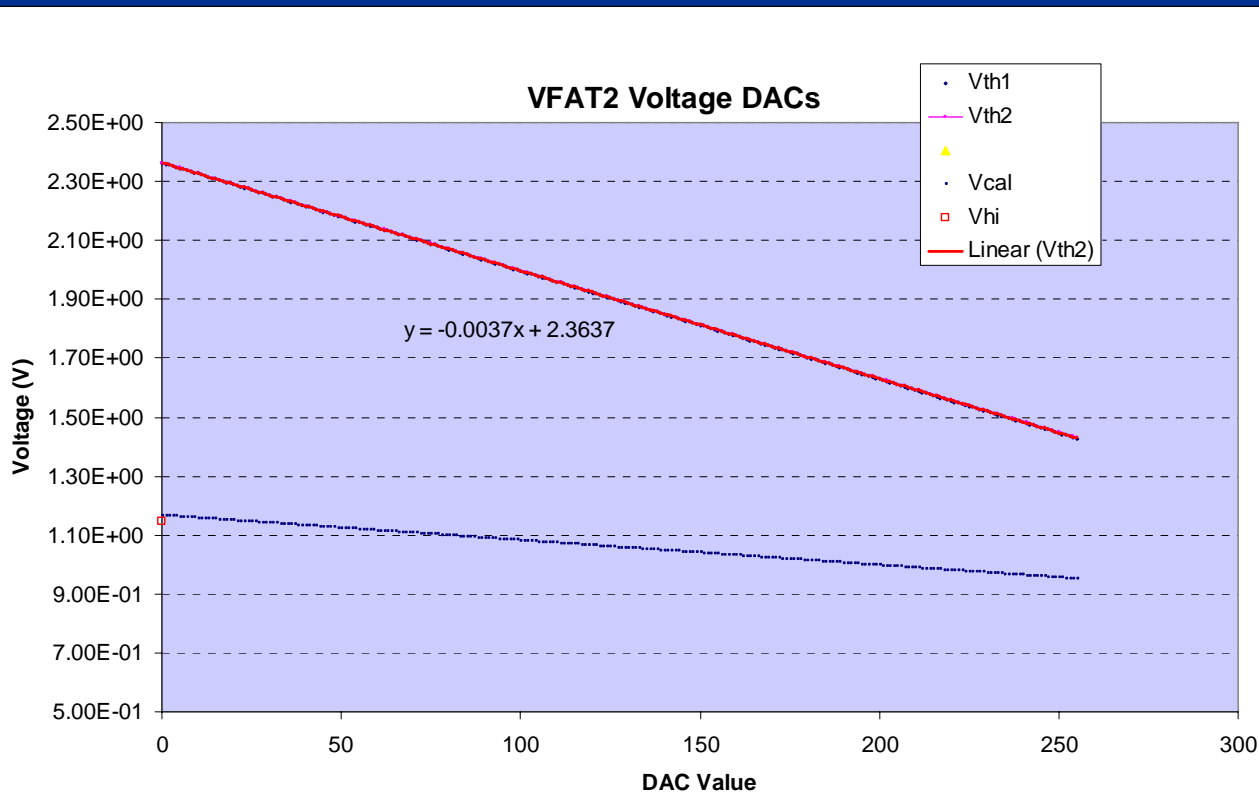


**To increase threshold w.r.t. signal :**

**Increase DAC value (VT1-VT2)**

# Calibrating VCal & Threshold range

Measure VCal, VT1 and VT2 DAC response via DCU



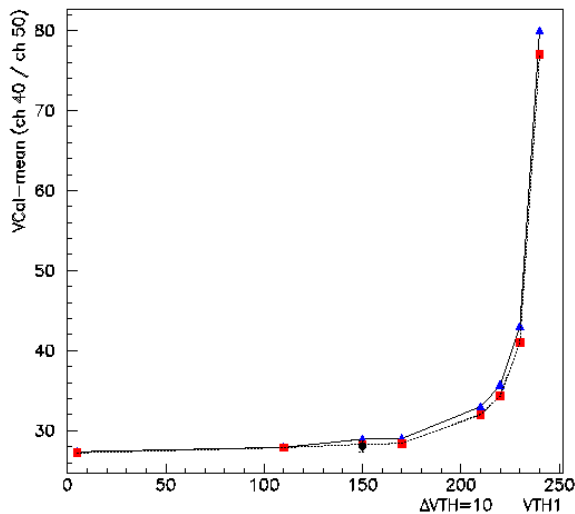
Vt1 and Vt2 DAC response

Total range of VT1 or VT2 = 0.9472 volts

# Thresholds

Question : Does a given  $\Delta VT$  always give the same threshold irrespective of  $VT1$  and  $VT2$  absolute values ???

Answer : No !!

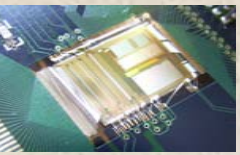


For signals of positive charge :

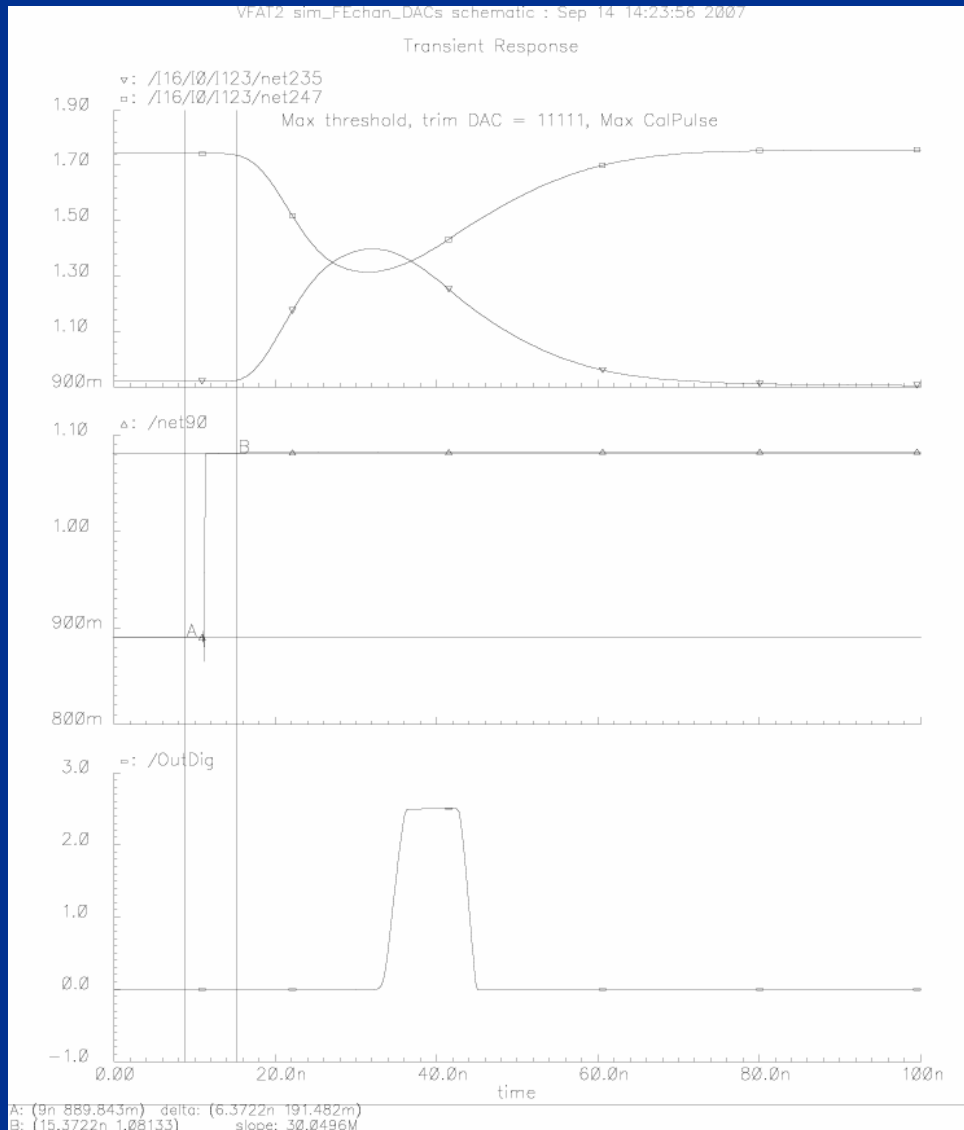
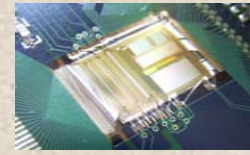
$VT1 = 0$  constant,  $VT2$  variable

For signals of negative charge :

$VT2 = 0$  constant,  $VT1$  variable



# Max Threshold simulated with DACs



## Simulation including the DACs

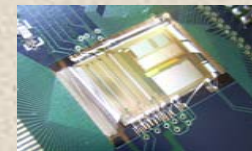
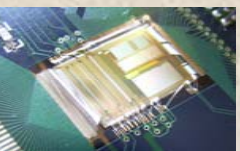
Input charge from CalPulse, VCAL = FF  
Input charge = 19.15 fC

Max Threshold  
VT1 = 00, VT2 = FF  
TrimDAC = 11111

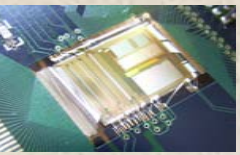
Threshold seen to be just below peak  
value, hence around 18 fC

The measured max threshold in the lab  
was 18.69 fC.

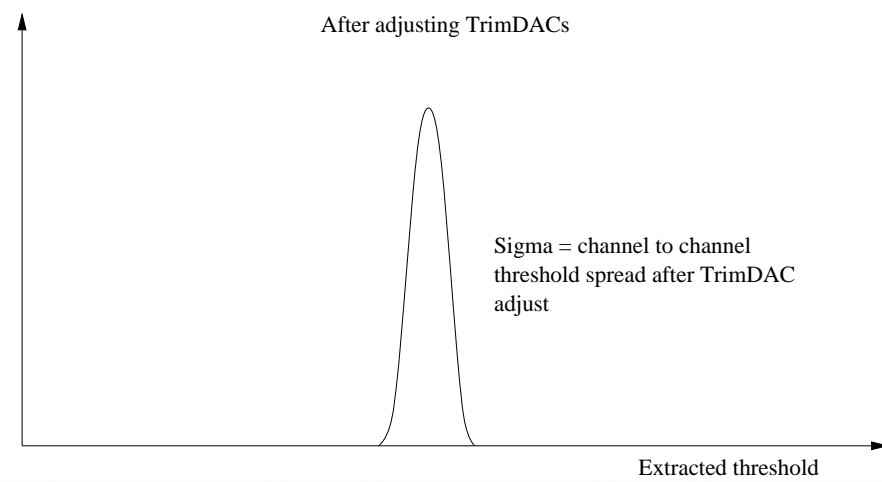
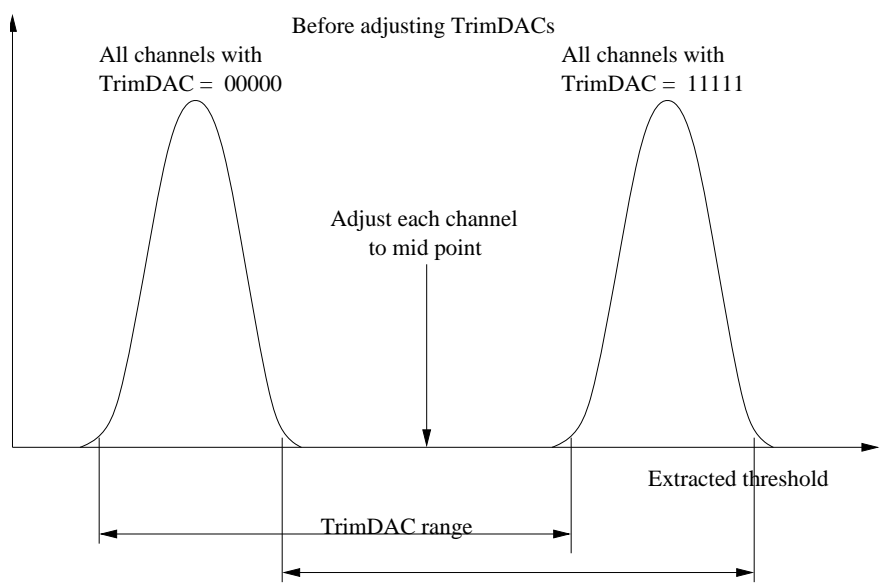
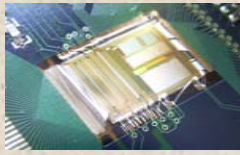
# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	~ 18 fC (5 MIPs)
VFAT Dynamic Range for GEM	35fC to 45fC (~ 2 MIPs pads, ~ 6 MIPs strips)
Threshold range	RP ~ 18 fC Gem ~ 30 fC
Trim-DAC range	
Recovery time from very large signals	



# Trim-DAC functionality



5 bit TrimDAC for each channel

3 bits for TrimDAC range settings

## Constant threshold :

- 1, Measure thresholds for all channels with TrimDACs = 00000 & 11111
- 2, Select TrimDAC range to have the smallest gap possible between the two histograms.
- 3, For each channel, adjust TrimDAC to central point.

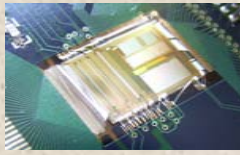
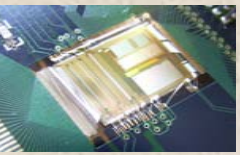
OR

## Constant clarity :

- 1, Adjust TrimDAC for each channel to achieve constant

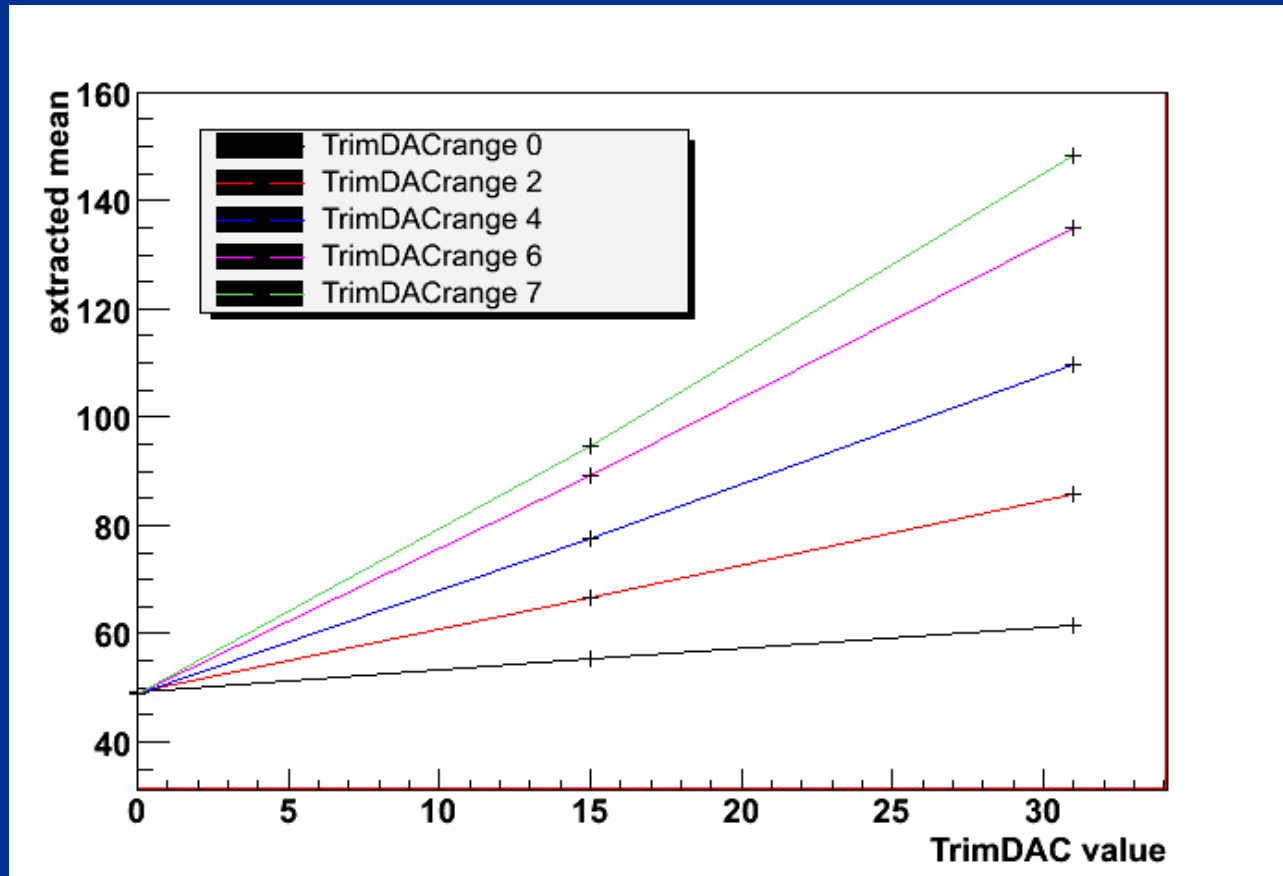
Threshold / (S/N)

Within limits, depends on the S/N variations of the detector.



# TrimDAC range (measured)

Y-axis is  
VCal

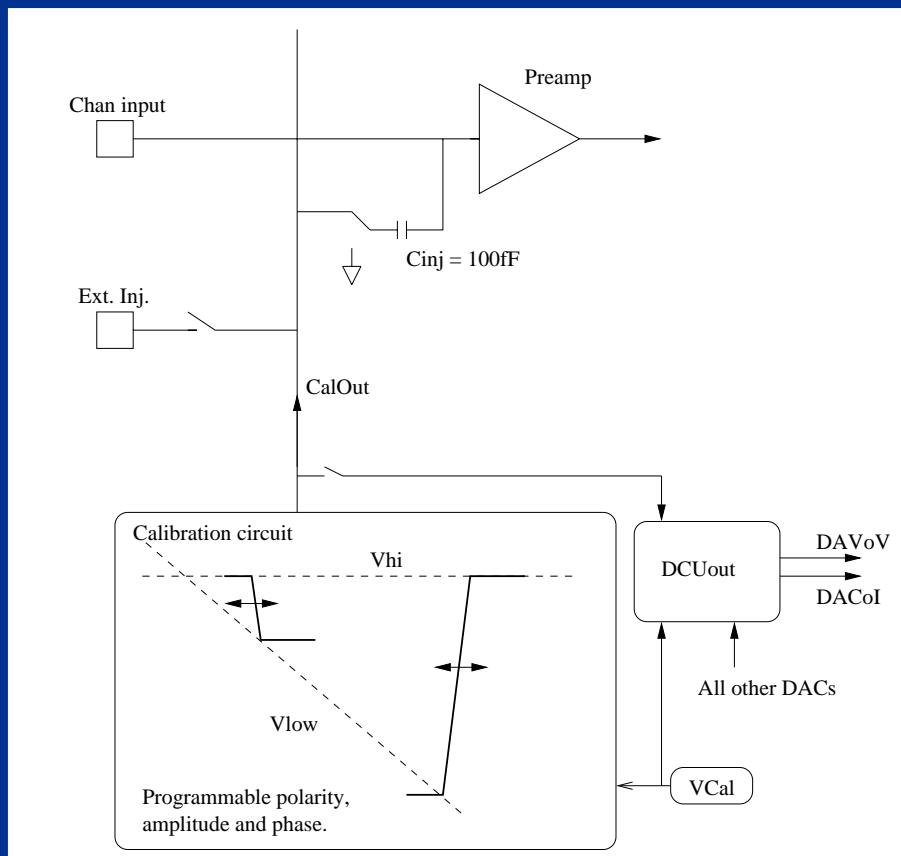


TrimDAC range 7,  $\Delta V_{cal} = \sim 100 \rightarrow 100 * 8^{-17} = \sim 8$  fC for RP signals  
(or  $\sim 40\%$  of dynamic range)

TrimDAC range 0,  $\Delta V_{cal} = \sim 5 \rightarrow 5 * 8^{-17} = \sim 0.4$  fC

# Calibration of VCal for RP

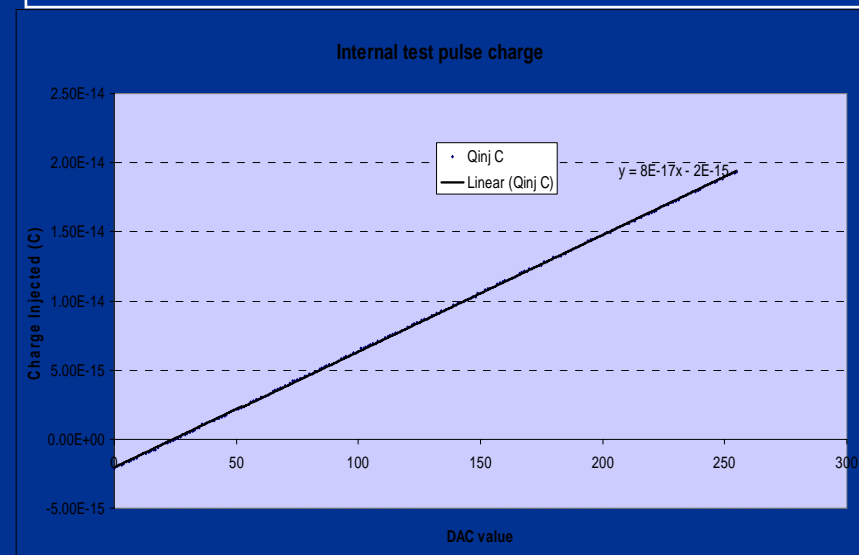
## Calibration circuit



8 bit range

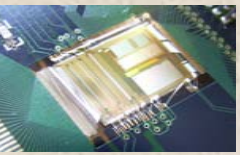
$$\text{Linear fit } Q\text{-inj} = 8^{-17}x - 2^{-15}$$

$$\text{Linear fit } Q\text{-inj (e)} = 526.25^{-17}x - 12927$$

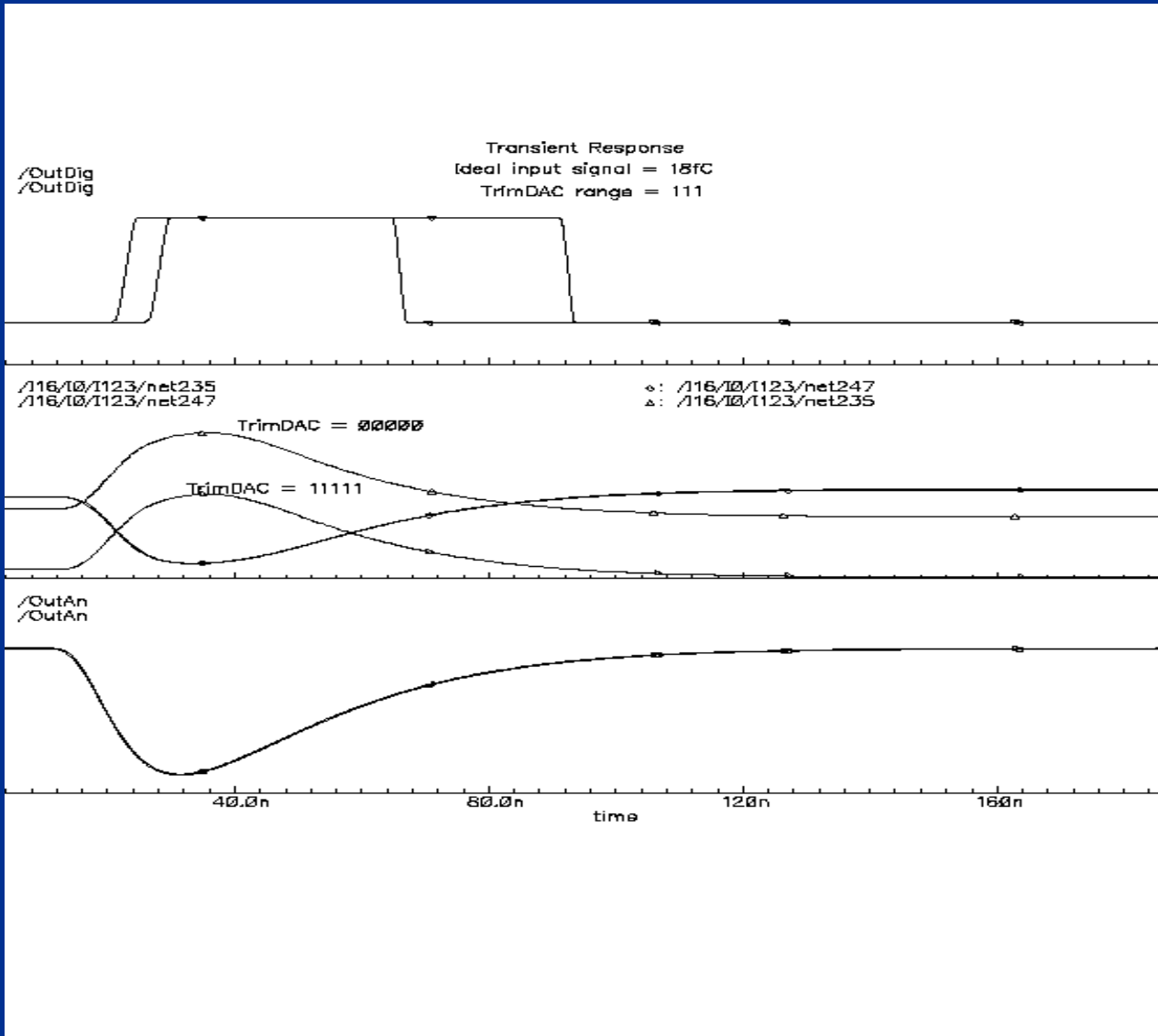
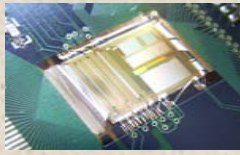


	Injection Range	LSB	$\sigma$ (LSB)
Q	-2 fC to 18.5 fC	0.08 fC	0.3 fC





# TrimDAC range (simulated)



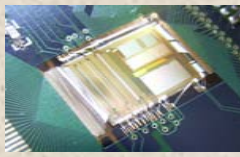
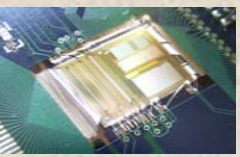
Ideal input signal ~ 18fC

Max TrimDAC range

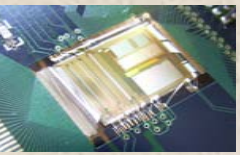
Simulated at  
TrimDAC = 00000  
&  
TrimDAC = 11111

Threshold changes by  
~40% of signal range

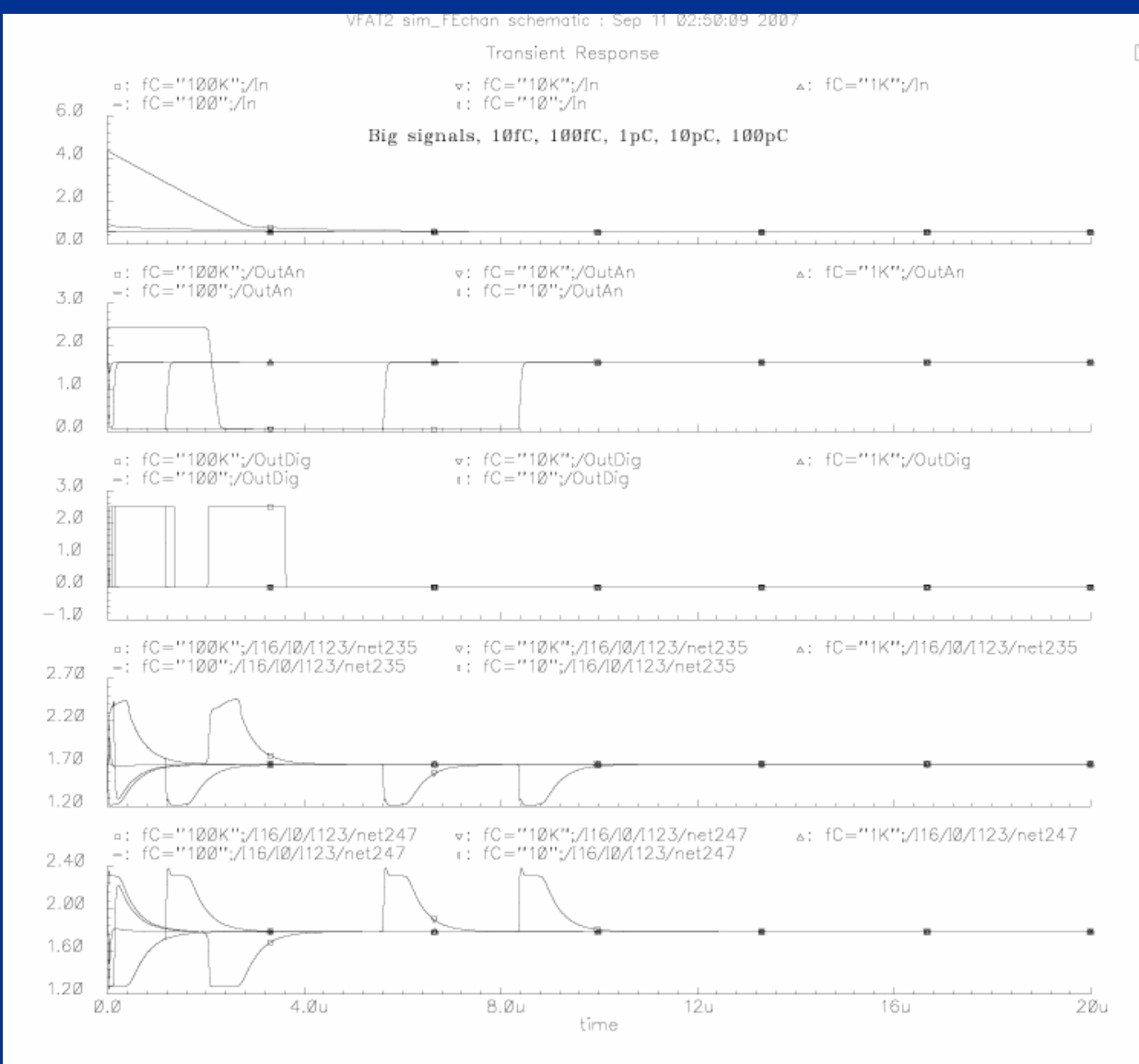
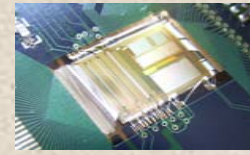
# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	$\sim 18 \text{ fC}$ (5 MIPs)
VFAT Dynamic Range for GEM	35fC to 45fC ( $\sim 2$ MIPs pads, $\sim 6$ MIPs strips)
Threshold range	RP $\sim 18 \text{ fC}$ Gem $\sim 30 \text{ fC}$
Trim-DAC range	$\sim 40\%$ of dynamic range
Recovery time from very large signals	



# Very large signals



VFAT2 response for 10 fC, 100 fC, 1pC and 10pC of input charge



Input node voltage



Preamp output

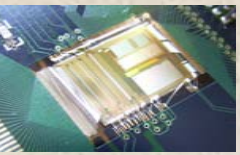


Comparator output

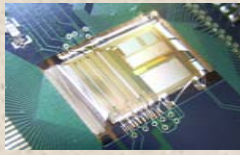


Comparator input

Normal operation returns after ~10us following 10pC of input charge

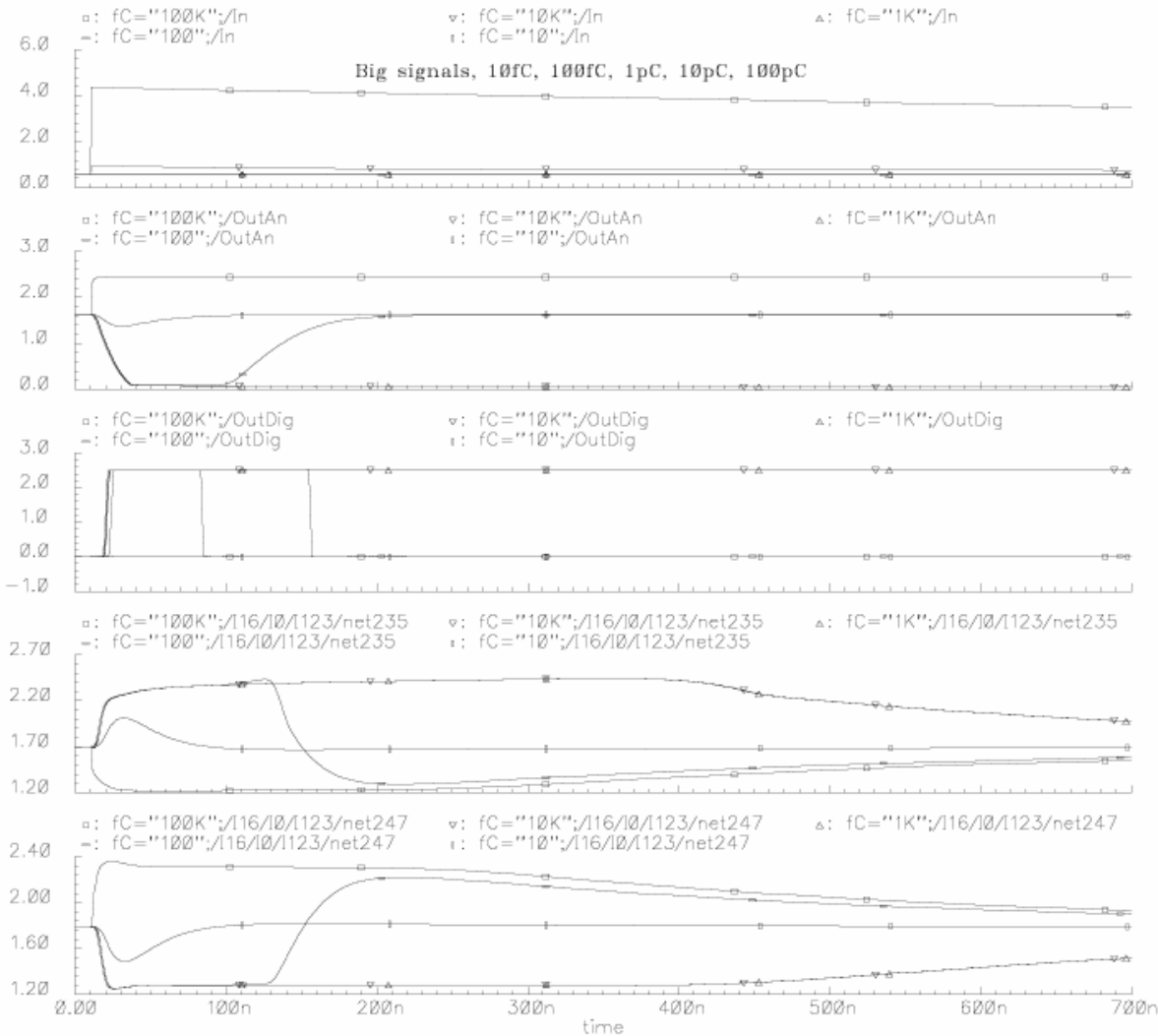


# Very large signals (zoom)



VFAT2 sim\_FEchan schematic : Sep 11 02:50:09 2007

Transient Response



VFAT2 response for 10 fC, 100 fC, 1pC and 10pC of input charge

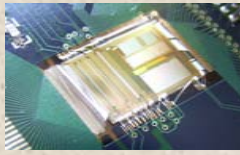
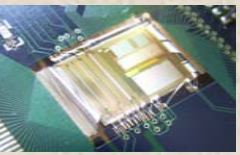
← Input node voltage  
Input voltage ok up to 1pC

← Preamp output

← Comparator output

← Comparator input

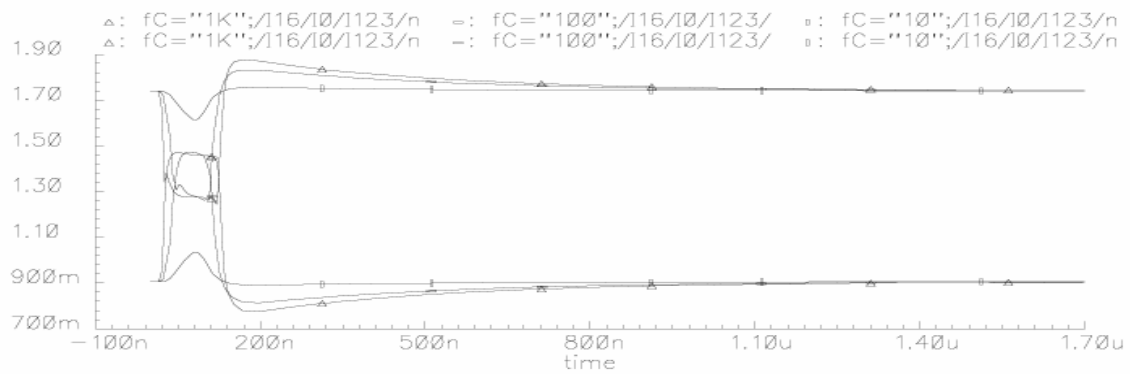
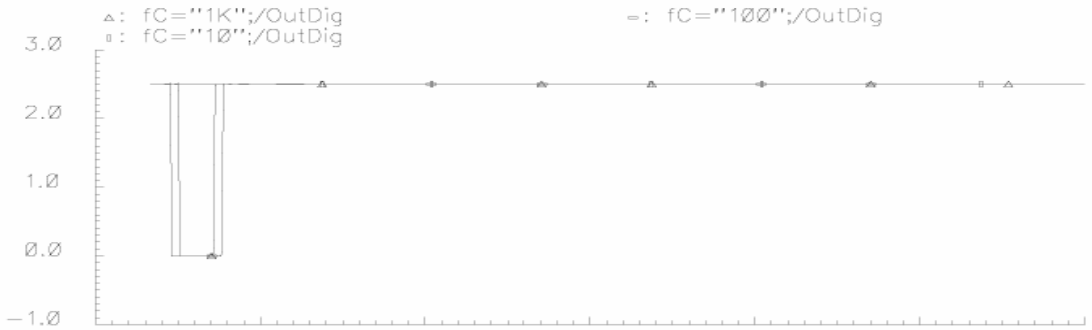
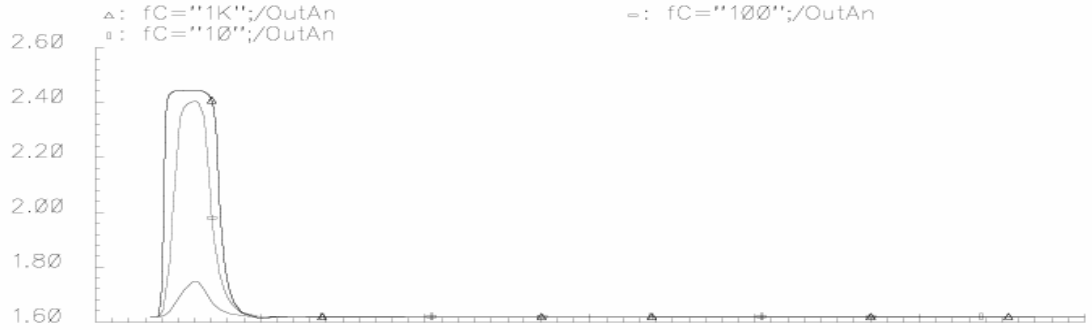
Recovery after 1us with a 100fC input signal.



# Very large GEM signals

VFAT2 sim\_FEchan schematic : Sep 14 17:07:59 2007

Transient Response



VFAT2 response for 10 fC, 100 fC and 1pC of GEM input charge



Preamp output



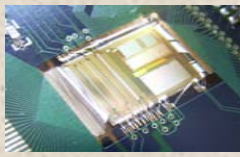
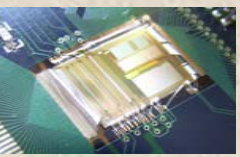
Comparator output



Comparator input

Normal operation returns after  $\sim 0.8 \mu s$  for 1pC of GEM input charge

# Simulations of VFAT dynamic range issues



VFAT Dynamic Range for RP	$\sim 18 \text{ fC}$ (5 MIPs)
VFAT Dynamic Range for GEM	35fC to 45fC ( $\sim 2$ MIPs pads, $\sim 6$ MIPs strips)
Threshold range	RP $\sim 18 \text{ fC}$ Gem $\sim 30 \text{ fC}$
Trim-DAC range	$\sim 40\%$ of dynamic range
Recovery time from very large signals	$\sim 1\mu\text{s}$ with a 100fC ideal input signal. $\sim 10\mu\text{s}$ following 10pC of ideal input charge  $0.8\mu\text{s}$ for 1pC of GEM input charge