Status of FE Electronics

Arnaud Lucotte

for the experts:

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Thanks to:
K. Borer and M. Hess

Content

32-channel chip (Reminder)

Chip Design

- Complete chip with 32 channels + 2 test channels
  - Technology: AMS 0.8 µm BiCMOS
  - Ch01-32: 32 inputs / 1 trigger + 1 multiplexed output
  - Ch33 : powered separately / intermediate outputs
- Chip area :
  - S=10 mm2
- Package : QFP100

Preamplifier

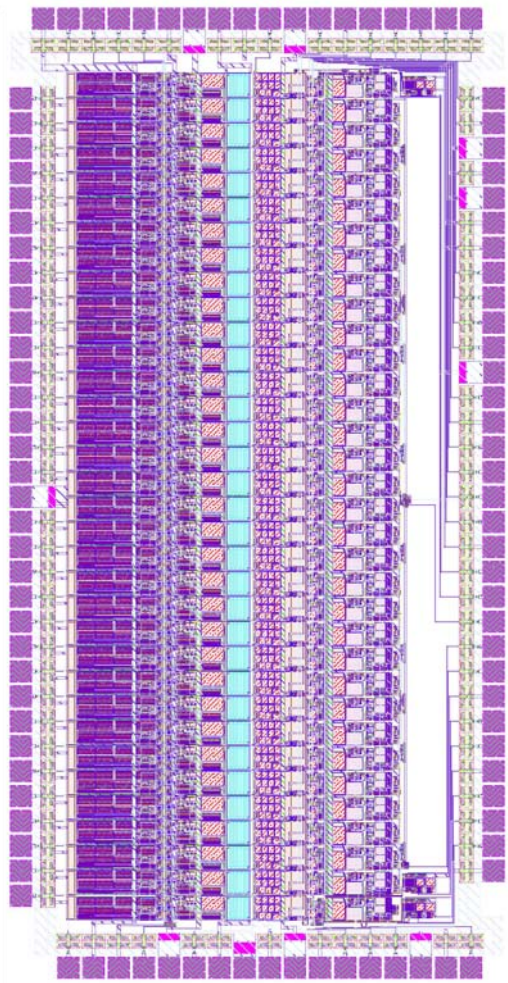
- Variable Gain preamp.
  - Current mirror architecture
  - Gain Range:[1,½,¼,1/8](4bits)

Auto-trigger

- Fast Shaper
  - Peak time t_p = 10 ns
  - Gain G ~ 20
- Comparator

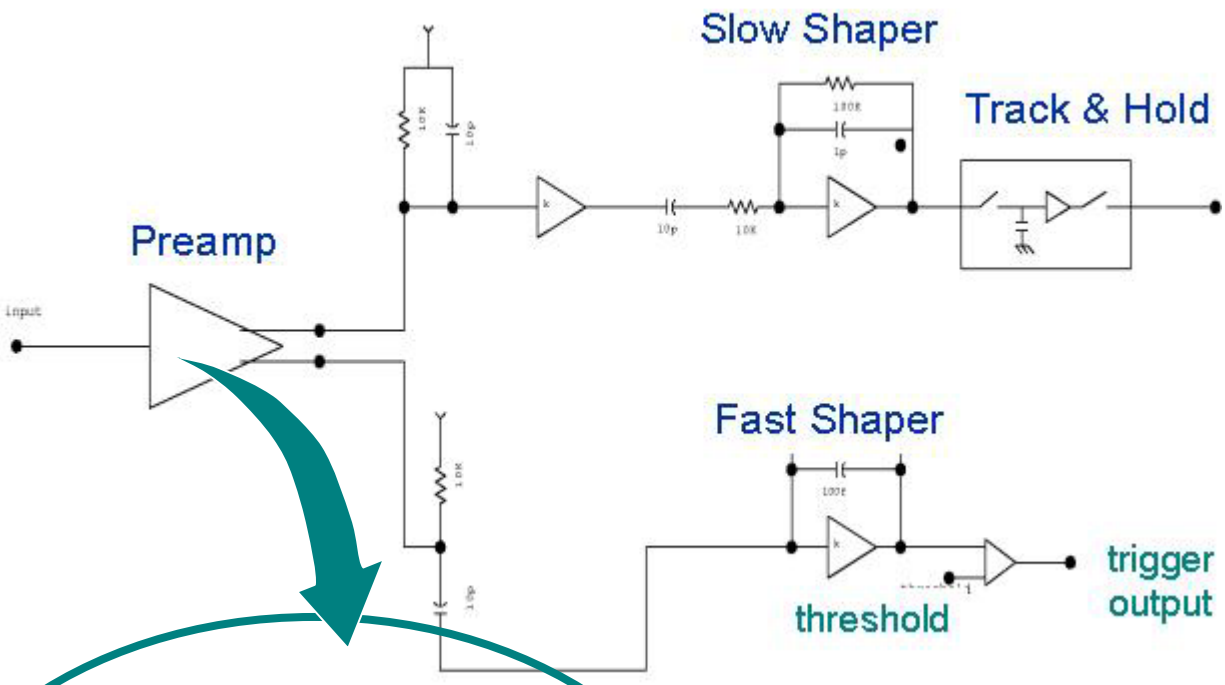
Charge Measurement

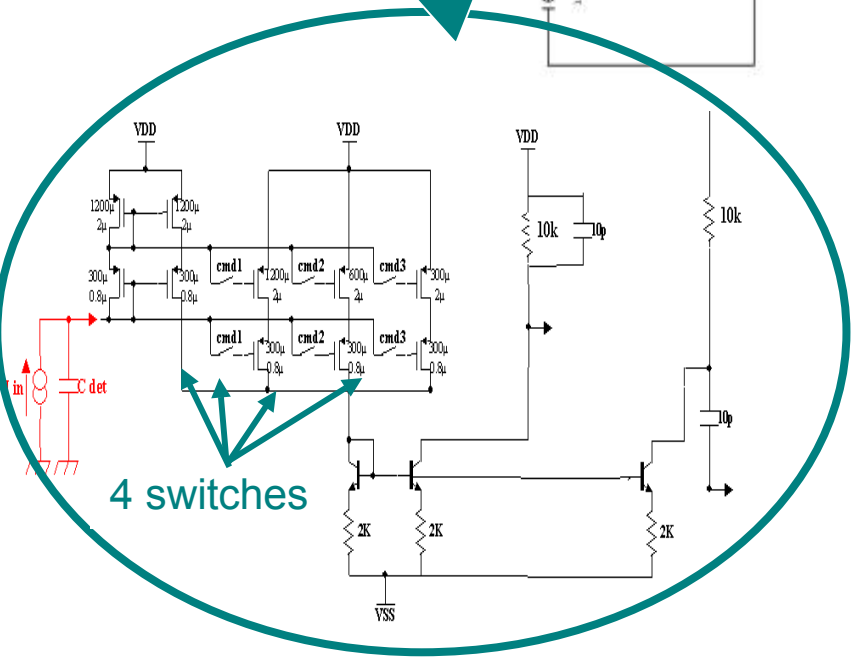
- Slow Shaper:
  - Peak time t_p = 120 ns
  - Gain G ~ 1
- Track & Hold:
  - On chip track and hold
  - Output multiplexer
- Readout Frequency : 5MHz



Submitted FEB-02 / Received JUN-02
Tested JUN to SEP-02 at LAL and at Bern

One channel schematics (Reminder)





Tests performed on:

Preamplifier

Auto-Trigger:

- Fast Shaper
- Comparator

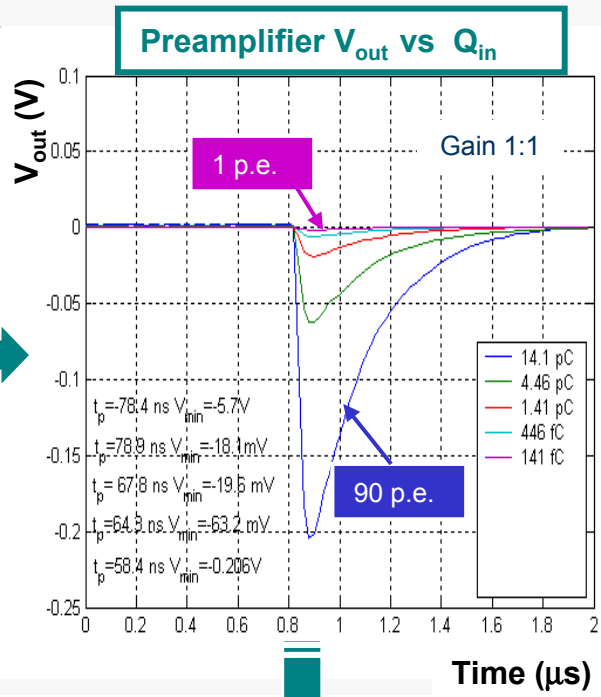
Charge Measurement:

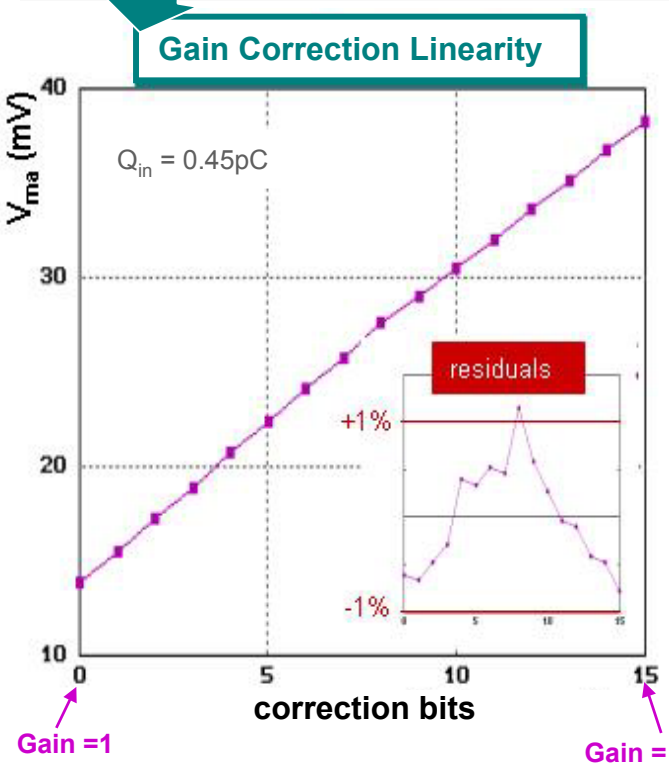
- Slow Shaper
- Track & Hold

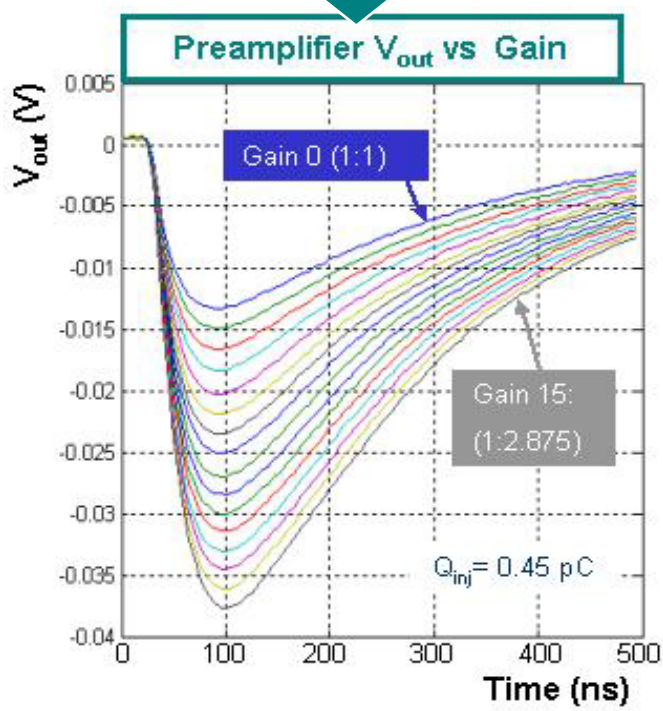
32-channel Chip Tests: Preamplifier

Preamplifier performance

- Preamp. Gain:
  - G ~ 60 mV / pC (#01-32)
  - G = 25 mV / pC (#33)
- Gain Correction:
  - Fully operational over the 1 to 2,875 range
- Gain Correction Linearity:
  - Better than ~1% over the whole range of correction





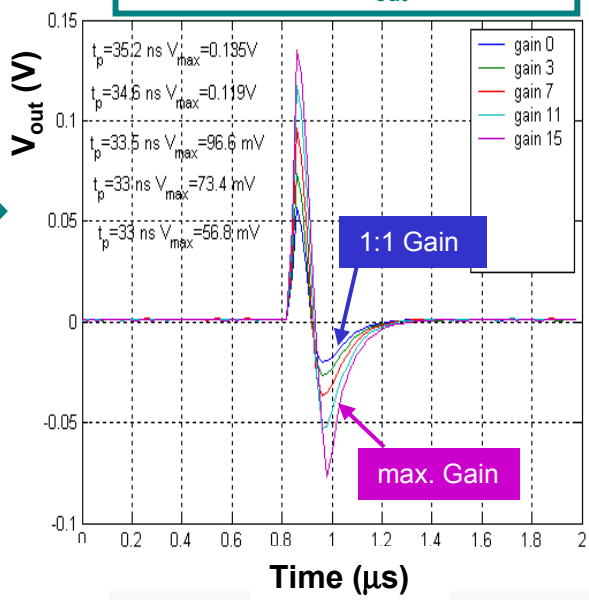


32-channel Chip Tests: Auto-trigger

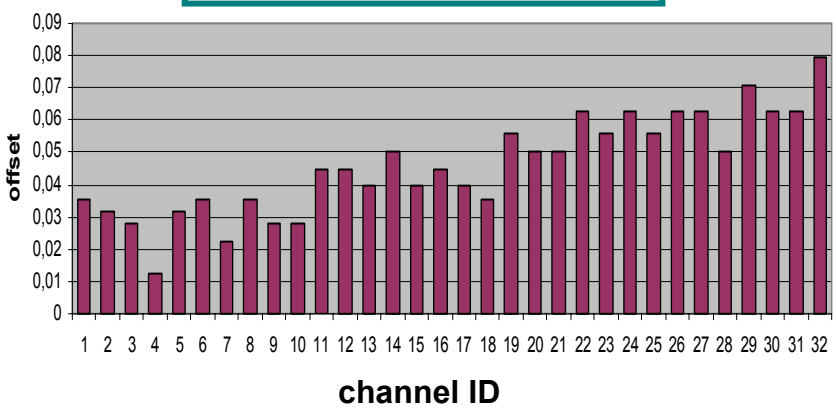
Fast Shaper & Comparator

- Trigger capabilities:
  - ε ~ 100% downto 1/2 p.e.
- Fast Shaper Gain:
  - G ~ 130 mV / p.e.
- Fast Shaper Peaking time:
  - t_P ~ 30 ns (all)

Fast Shaper V_{out} vs Gain



Relative offset vs channel #



- Pedestal spread:
  - ~70 mV
  - 2 main sources:
    Fast shaper (major)
    Comparator (~negl.)
- Noise RMS :
  - ~ 1 mV

Remark

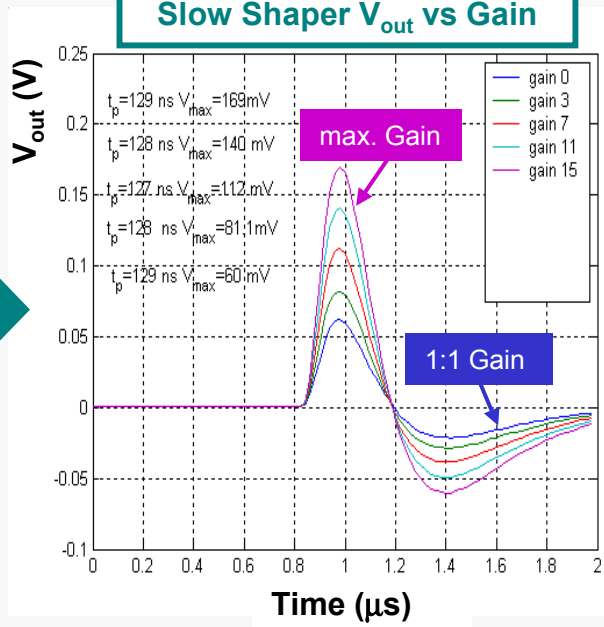
- Comparator issue:
  - Some design problem leads to the use of “ad hoc” fixes
  - This problem is now well identified & understood and will be fully solved with the next iteration (see Vers. 1a)

32-channel Chip Tests: Charge measurement

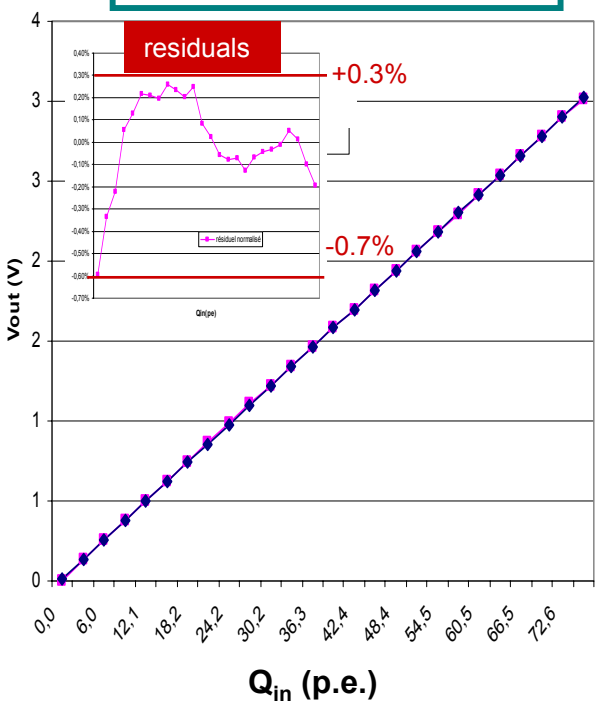
Measured Performance

- Dynamic Range :
  - [0-80]p.e.
- Slow shaper Gain
  - ~15-16 mV / pe (Gain 1)
- Slow Shaper peaking time:
  - t_p ~ 100 ns (#01-32)
  - t_p ~ 130 ns (#33)
- Track & Hold:
  - Fully operational
- Linearity:
  - < 1% over [1-80]p.e.

Slow Shaper V_{out} vs Gain



Slow Shaper Linearity



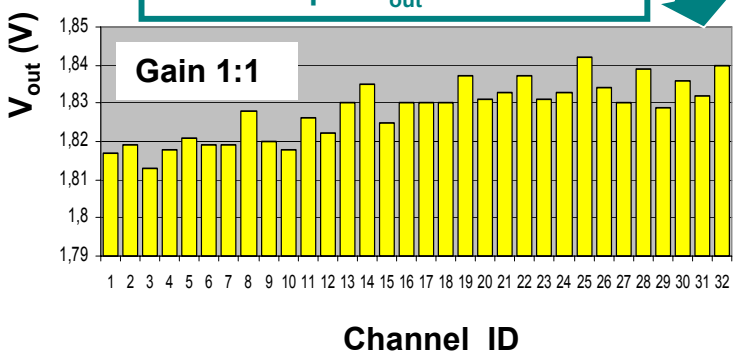
- Noise RMS :
  - RMS ~ 0.5 mV (0.02 pe)
- Pedestal spread :
  - ~ 40 mV (~1 pe)

  Understood:

  ~50% from Shaper ,

  ~50% from Track and Hold

Slow Shaper V_{out} vs channel #

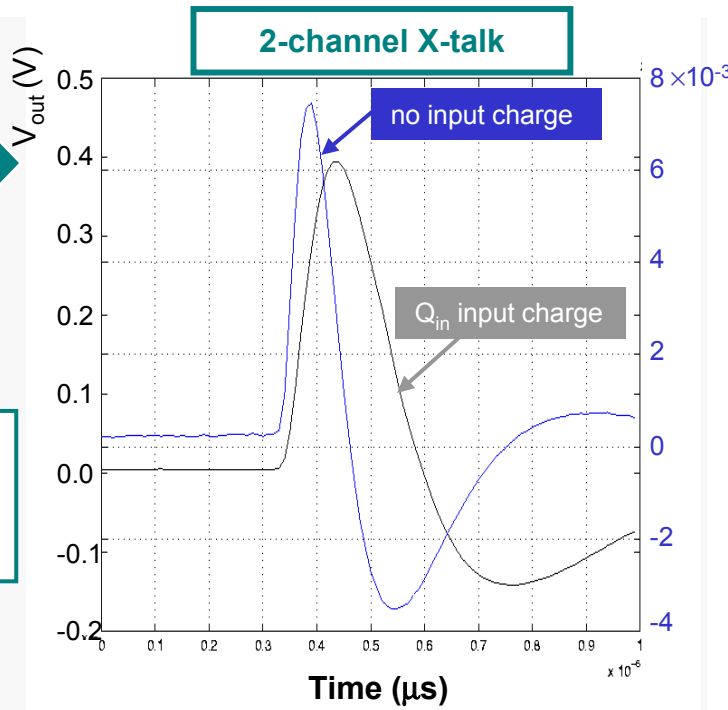


32-channel Chip Tests: Cross-Talk issue

Channel-to-Channel X-talk

- Measurements:
  - ~2%
- Main source:
  - Preamp “large” input Z_{in}~1.5 – 2.0 kΩ

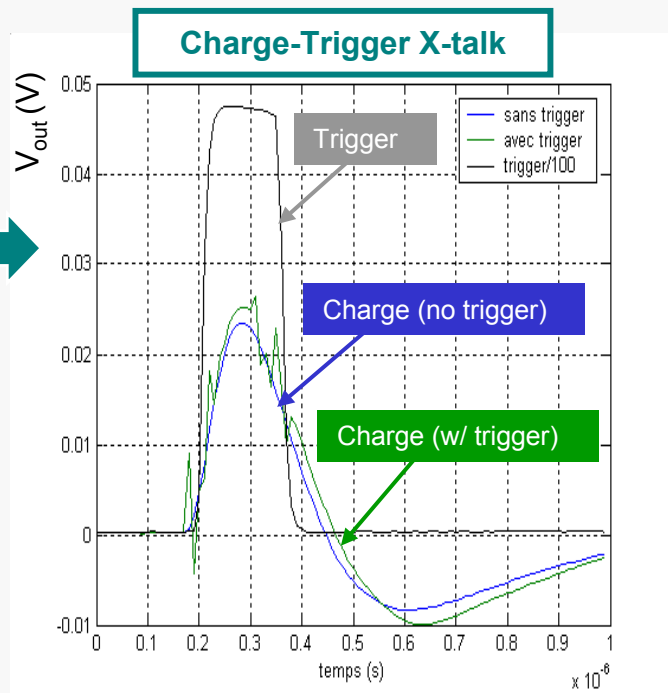
will be improved with reduced Impedance preamp. (see “Mecano” chip)



Trigger-Charge X-talk

- Cross talk Trigger and Charge Channel :
  - Capacitive coupling Injection charge in all channels

X-talk expected to be well reduced with new chip



32-channel Chip Tests: summary

Internal note in preparation

	32-channels chip	mecano chip
Auto Trigger:		
Pedestal spread	80 mV	
Noise RMS	1 mV (<< 1.p.e.)	
Comparator	fixed	
Fast Shaper t_P	t_P=35 ns	
Fast Shaper Gain	130 mV / p.e	
Charge meast:		
Dynamic range	[0-80] p.e.	
Gain Correction	Operational (4 bits)	
Pedestal spread	40 mV	
Noise RMS	0.5 mV (<<1.pe.)	
Slow Shaper t_P	t_P=100 ns	
Slow Shaper Gain	16 mV / p.e.	
Cross-talk	O(2%)	

Chip with extra feature: Mecano Chip

Main new features:

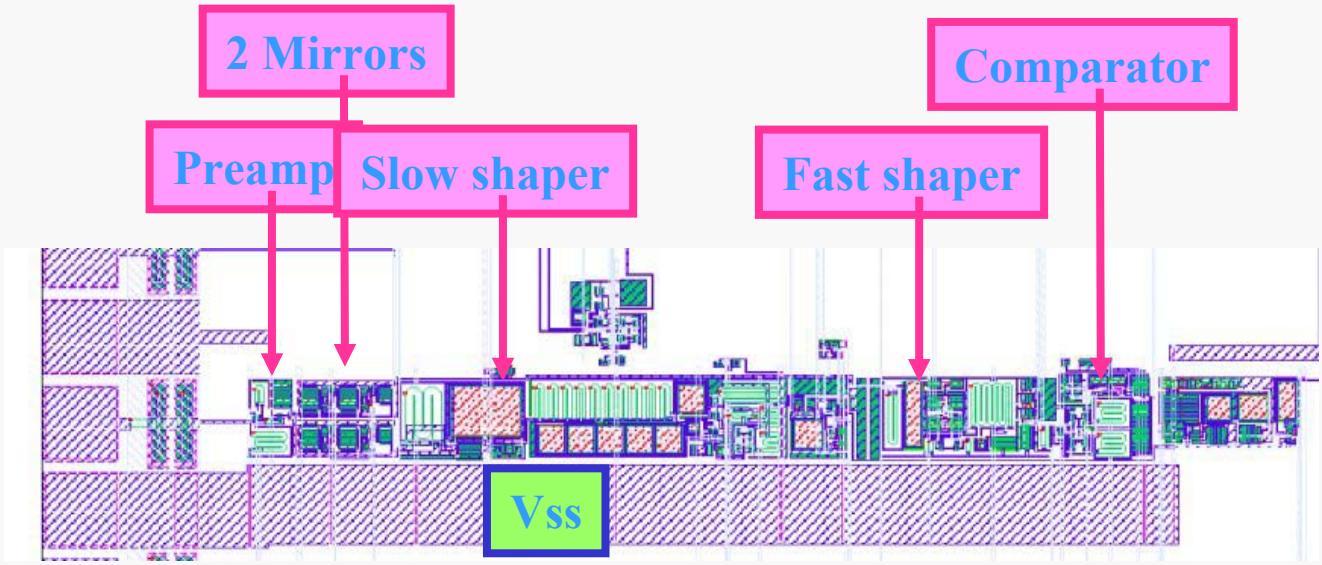
- New variable gain preamplifier :
  - Low Impedance Z_{in}~70 Ω
  - Range 1-3 , 2 bits resolution (1,1/2)

→ reduce current, X-talk

- New Differential PMOS Fast shaper
  - t_p = 10 ns
  - G ~ 20
- New Differential Slow shaper
  - t_p = 120 ns
  - G ~ 1

→ reduce Offset (pedestal) to 0 at 1st order

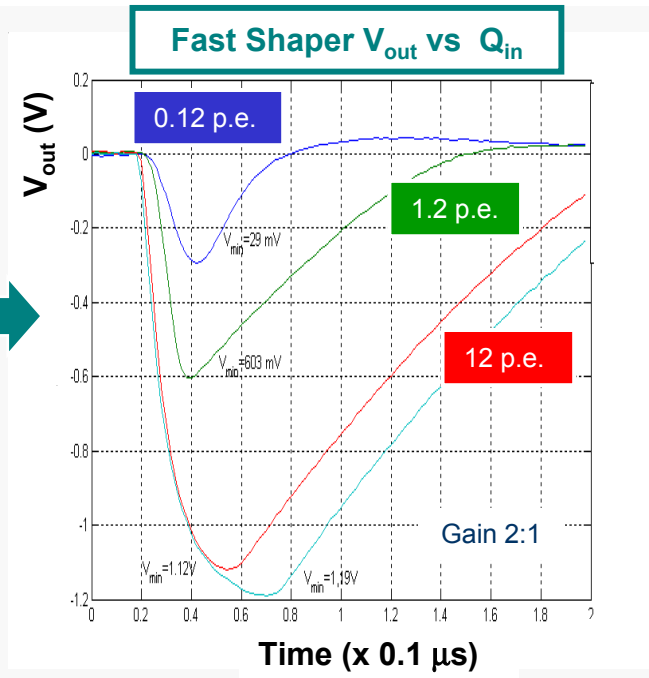
- On chip Track & Hold and output multiplexer
  - Power consumption : 1.6 mW

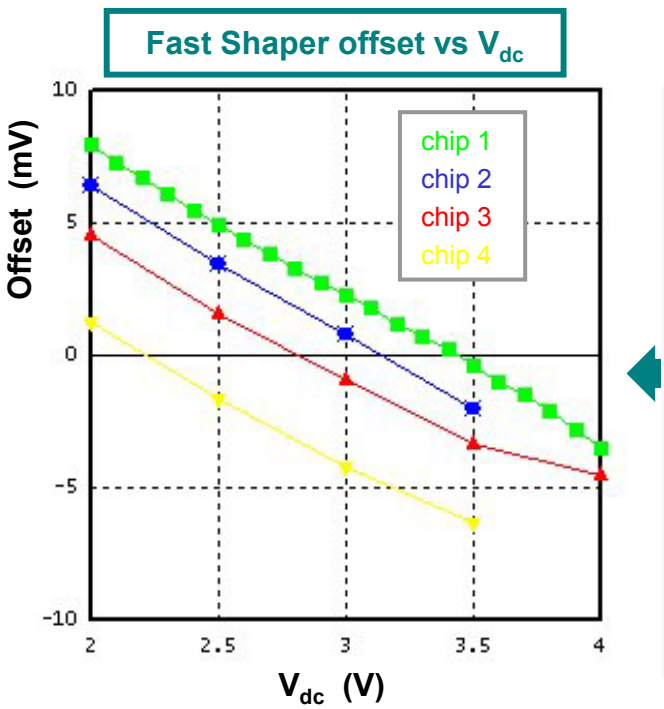


Mecano chip: Auto-Trigger

Fast Shaper:

- New Architecture:
  - Differential configuration
  - PMOS input transistor
  - Designed for V_{DC} = +3V
- Gain:
  - 250 mV / p.e.
- Speed
  - Rise time t_R~ 12 ns
  - Peak time t_P ~ 20 ns





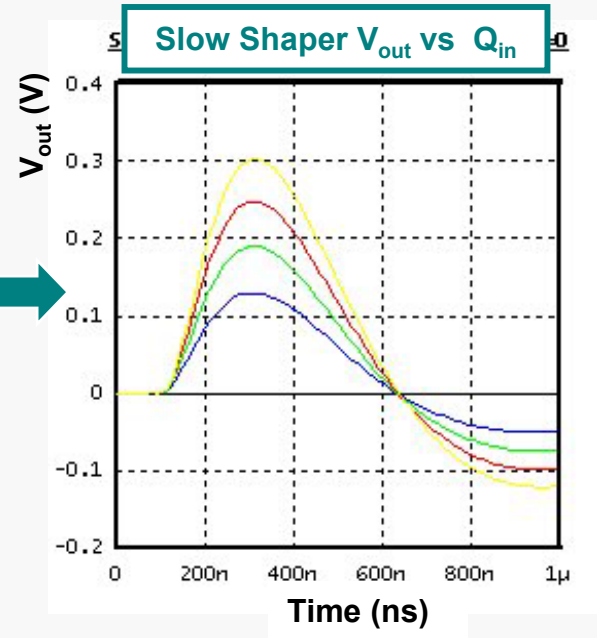
- Noise
  - G = 1 : 420 µV
  - G = 2.5 : 850 µV
- Offset spread
  - 4 chips tested
  - Offset slope : 6 mV / V
  - Spread at 3V : -4 / +3 mV (≠ chips !)

Mecano Chip: Slow Shaper

Slow Shaper

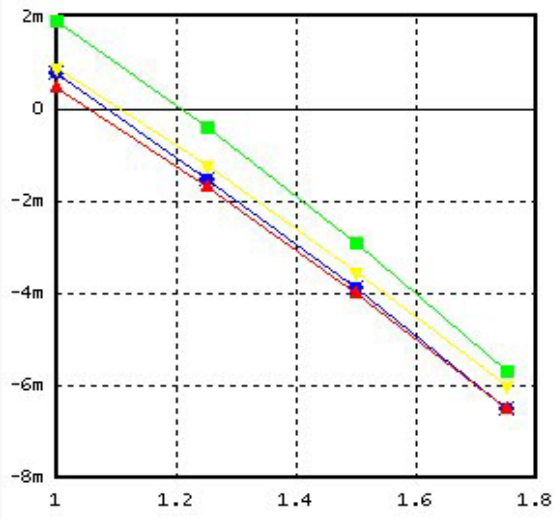
- New Architecture:
  - Differential configuration
  - NPN input differential pair
- Gain
  - G=1 : 10 mV / p.e.
  - G=2.5 : 24 mV / pe
- Speed:
  - Peaking time t_P=187 ns
  - idem for G=1 and G=2.5
- Noise:
  - ~ 500 µV
- Pedestal spread:
  - 4 chips tested
  - Offset slope: 10 mV/ V
  - Spread at 1.1 V: +/- 800 µV

Slow Shaper V_{out} vs Q_{in}

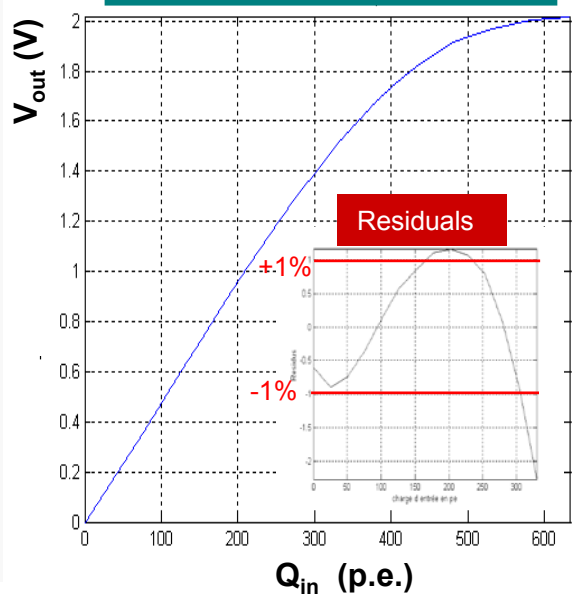


- Linearity:
  - 1% over [1-300] p.e.

Slow Shaper offset vs V_{dc}



Slow Shaper Linearity



Mecano Chip Tests: Summary

Internal note in preparation

	32-channels chip	mecano chip
Auto Trigger:		
Pedestal spread	80 mV	< 4 mV
Noise RMS	1 mV (<< 1.p.e.)	0.5-0.8 mV
Comparator	will be improved	
Fast Shaper t_P	t_P=35 ns	t_P=20 ns
Fast Shaper Gain	130 mV / p.e	250 mV / p.e.
Charge meast:		
Dynamic range	[0-80] p.e.	[0-300] p.e
Gain Correction	Operational (4 bits)	Operational (2 bits)
Pedestal spread	40 mV	< 1 mV
Noise RMS	0.5 mV (<<1.pe.)	0.3 mV (<<1.pe.)
Slow Shaper t_P	t_P=100 ns	t_P=190 ns
Slow Shaper Gain	16 mV / p.e.	10 mV / p.e.
Cross-talk	O(2%)	--

Pedestal reduced

Increased dynamic range

...on the way to the Final Design

Version 1a Chip

- Conservative Version:
  - no significant change wrt present 32-ch. chip design
- Improvements in the Comparator Design:
  - Separate Voltage alim. (analog / digital)
  - Re-size transistors etc...
- Adjusted parameters in the Shaper
  - No change in the Design
  - Increase t_P (Bern suggestion)

Baseline Version conservative

→ – Submitted 27-SEP
– Expected JAN-03

Version 2 (improved) Chip

- Significant improvements:
  - Reduced predestal spread
  - Reduced X-talk
  - Improved for lower signal
- Main new features included:
  - Version 1a comparator
  - Mecano Fast Shaper
  - Mecano Slow Shaper
  - Improved Track & Hold
  - Masking of “dead” channel (not only at trigger level)
  - Register to ID the triggerred channel

mostly all the features tested on the mecano chip

→ – Submitted JAN-03 (NOV-02 ?)
– Expected MAY-03