

# Fast Waveform Digitizer

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- **Plan of my talk**
  - Need
  - Approaches
  - Present status
  - Future plans

# Need of pulse profile

- Pulse capture and processing is the present day demand in Particle physics and Astroparticle physics experiments
- Sample the waveform in real time and record digitized data only on a event
- Accuracy depends on the sampling frequency , digitization resolution, process noise removal etc.

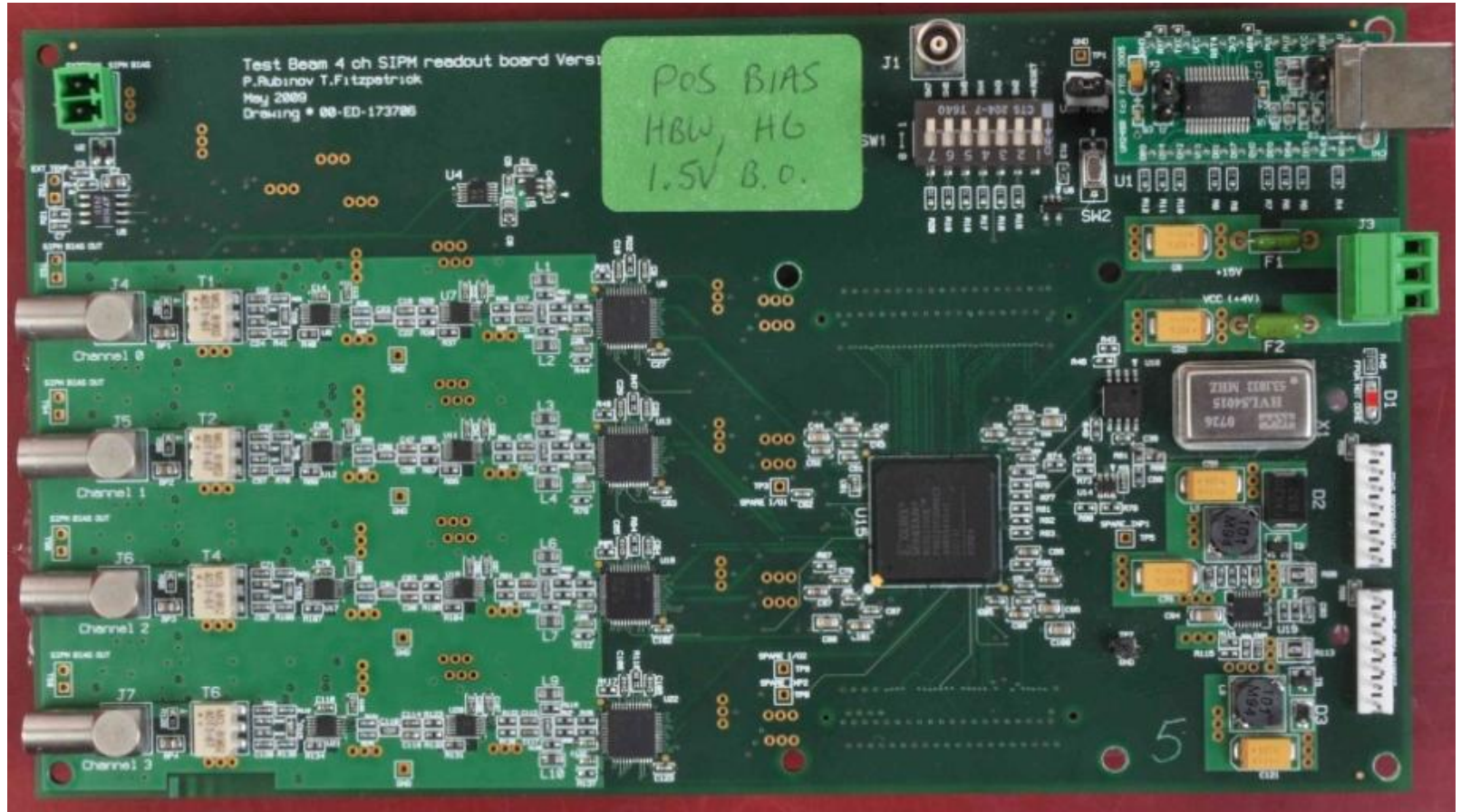
# Basic approaches

- Sample the wave form at optimum sample rate for proper reconstruction of original wave form
- Few Techniques
  - **Flash ADC**
    - Concurrent Sampling and Digitization
    - Long sampling depth (limited by memory size)
    - Better accuracy and stability
    - Max resolution is fairly low;
    - Commercial fast digitizers exploit this technique.
  - **Pipelined ADC**
    - Multiple Flash stages
    - Achieve higher resolution than flash Adc for a given no of comparators
    - Same throughput as Flash ADC
  - **Switched Capacitor Array**
    - Analog Sampling at higher speed, but slow digitization
    - Self calibration needed for correction
    - Lower power and Cost at low sampling depth
    - Need an external trig to get digitized data

# TB4 Digitizer Tests

- FNAL group provided TB4 waveform Digitizer used in Test beam activities at FNAL
  - Flash ADC based digitizer
  - 4 channel, 14 bit, bipolar 210 MSPS digitizer
  - input range : ~30mV full scale
  - Built in amplifier stages
  - Memory depth of 4k samples/channel
  - USB interface
  - Built in Bias generator for SiPMs

# TB4 board (Developed by FNAL)



# TB4 GUI components...

The image displays two windows from the TB4 GUI. The main window, titled 'FTE11F15', contains the following components:

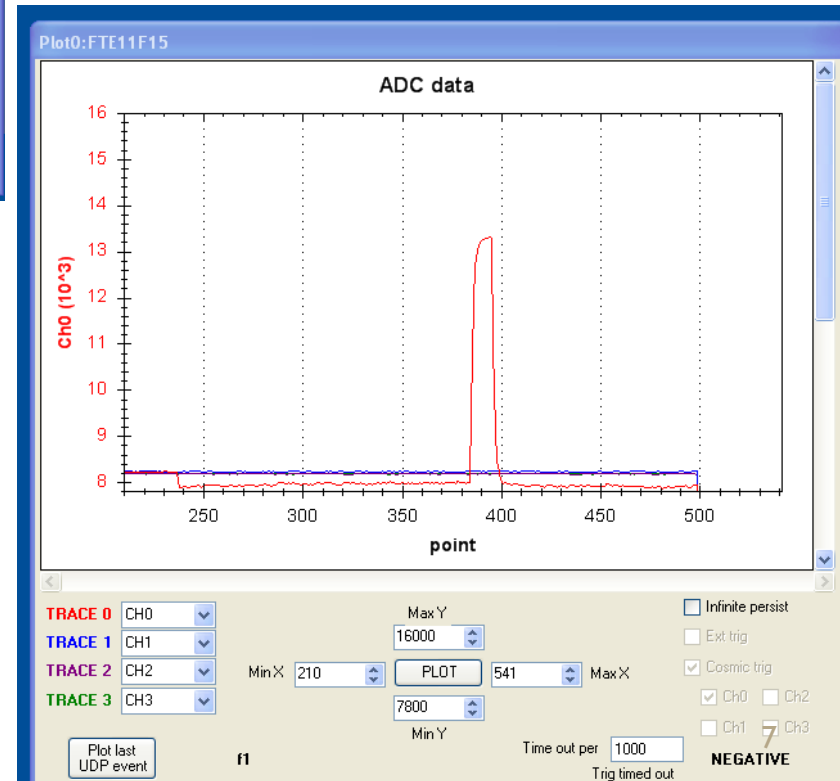
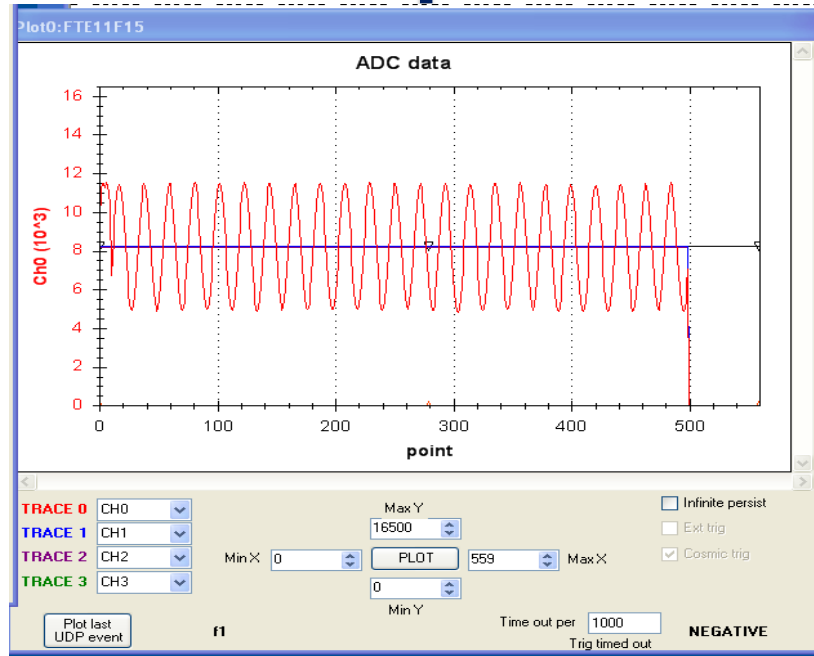
- USB Interface:** A 'ListDevices' button, a dropdown menu showing '1', and 'Open', 'Close', and 'Status' buttons. The status is 'OK'.
- INIT FILE:** A text field containing 'B4\Setups\USB\_SELF\_TRIG\_EXAMPLE\_v300.tb4' and a 'BROWSE' button.
- RUN DATA FILE:** A text field containing 'C:\TB4\DATA\waveform\_screen\_shot.dat' and a 'BROWSE' button.
- Run Parameters:** Three input fields for 'Run Num' (value: 2), 'Max Events' (value: 500), and 'Max Time' (value: 1000000).
- Control Buttons:** Three large buttons labeled 'STOP' (red), 'INIT' (yellow), and 'RUN' (green).
- Status Log:** A text area showing '15/06/2011 13:11:49 Done'.
- Progress Bar:** A bar at the bottom showing '241 taken 13:11:49 15/06/2011' with a green progress indicator.

The 'Registers: FTE11F15' window is open on the right, showing a list of registers with their addresses and names. Each register has a value field and 'R' (Read) and 'W' (Write) buttons.

Address	Name	Value	R	W
30100000	CSR			
34400000	TRIG_THRESHOLD_CH0			
34500000	TRIG_THRESHOLD_CH1			
34600000	TRIG_THRESHOLD_CH2			
34700000	TRIG_THRESHOLD_CH3			
34800000	TRIG_POST_STORE			
34d00000	TRG_AND_BITS			
34e00000	TRIG_WINDOW			
34f00000	TRIG_HYSTERESIS			
35000000	EVENT_SIZE			
36000000	READ_POINTER_OFFSET	500		
3fd00000	FIRMWARE_VER			

Below the registers window, a vertical menu titled 'FTE11F15' contains buttons for: RUN, REGISTERS, ARRAYS, SCOPE, FLASH, and MB LVDS.

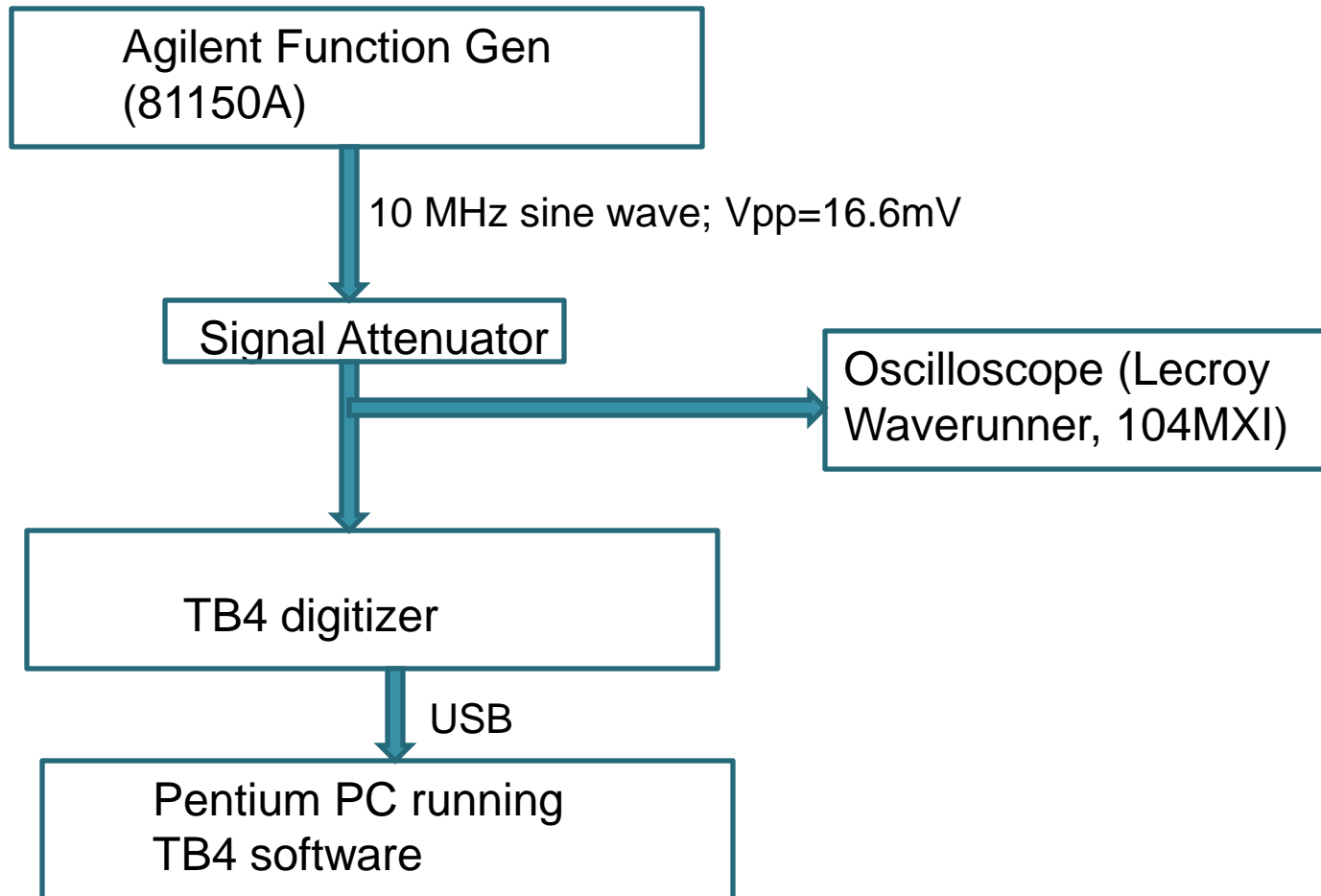
# Captured waveforms in TB4



6/17/2011



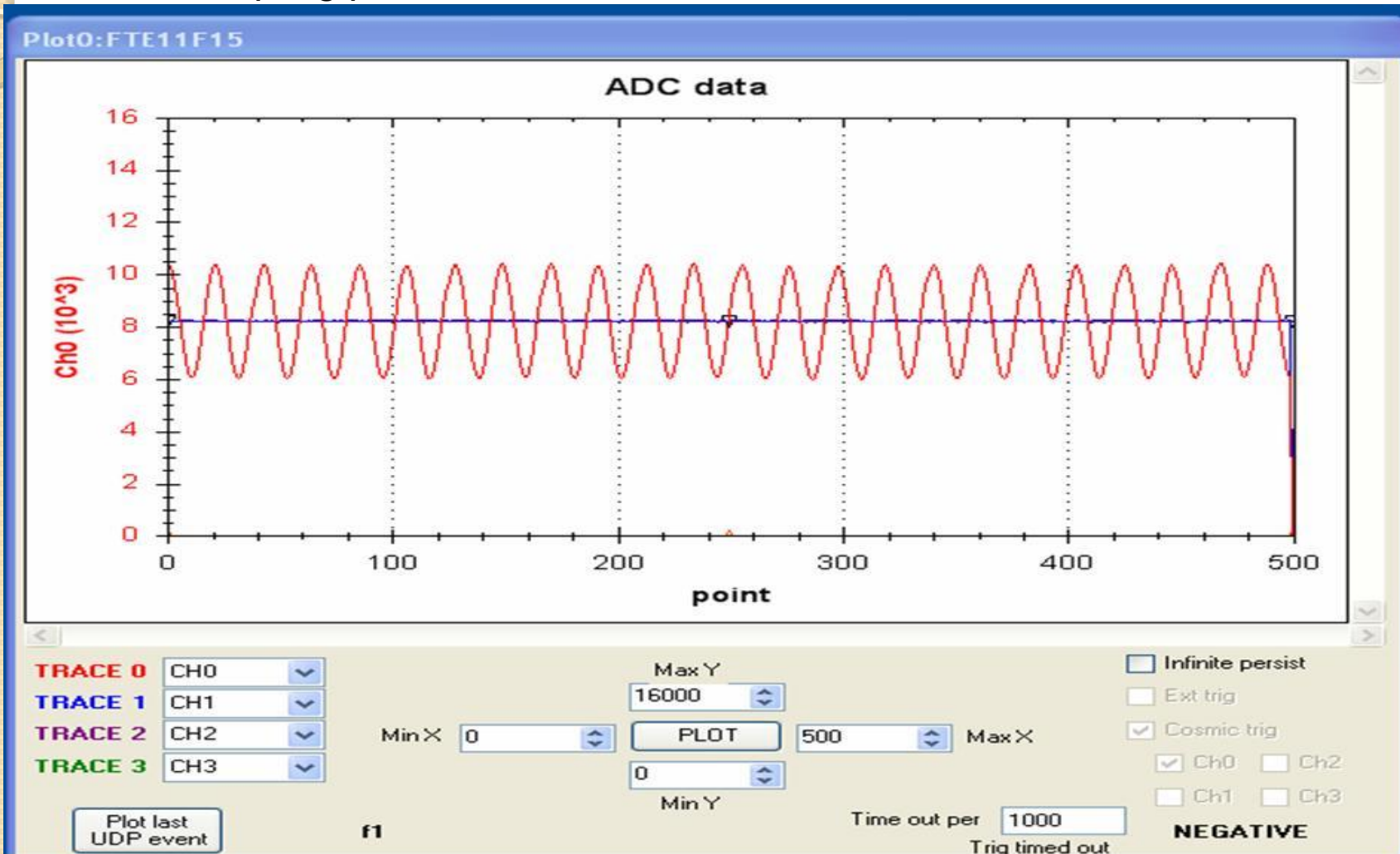
# Gain Linearity Test set-up



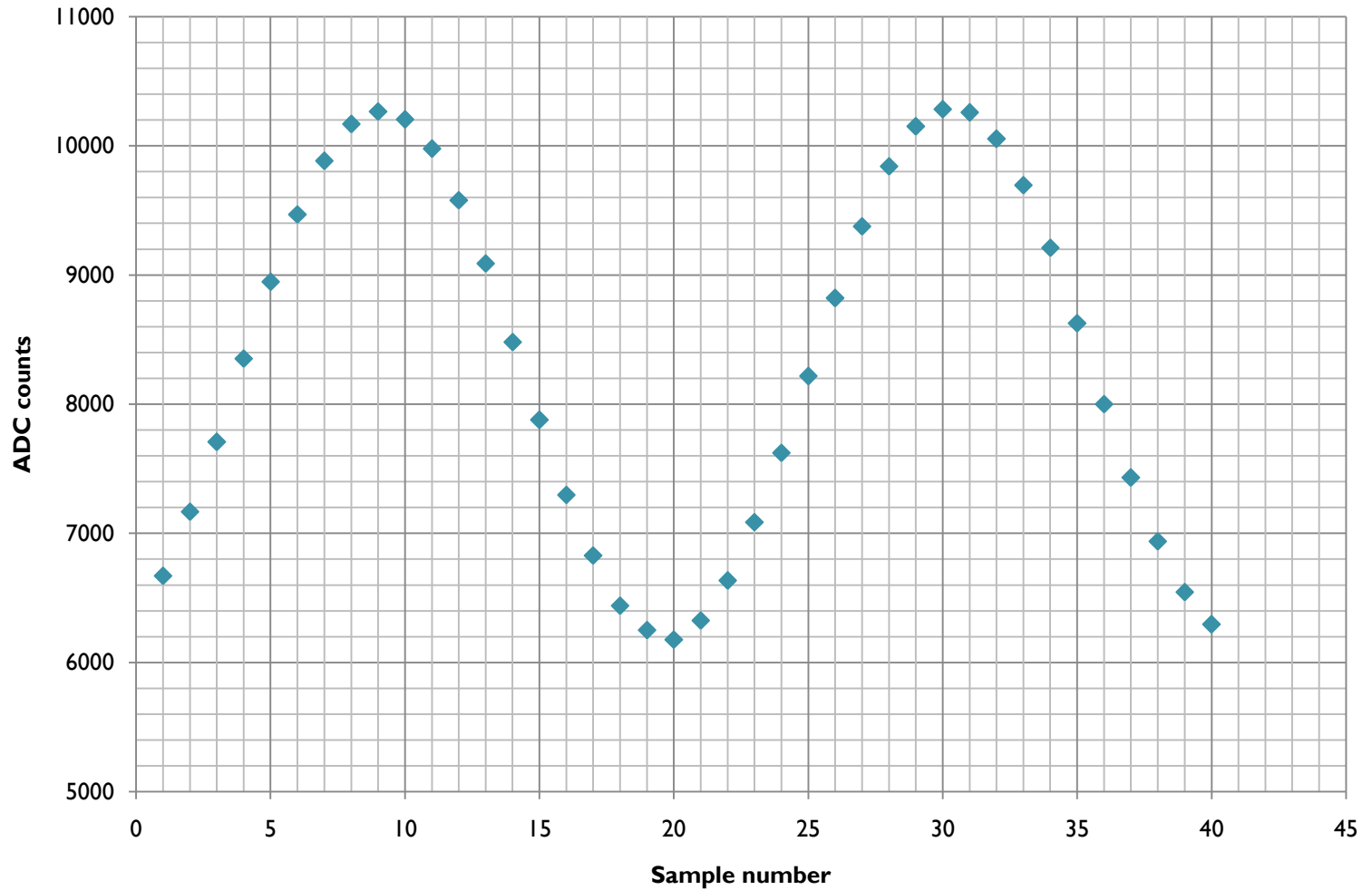


# TB4 tests... waveform reconstructed by TB4...

Input: 10 MHz sine wave;  $V_{pp} = 16.6$  mV ;  
Sampling period: 4.76 ns

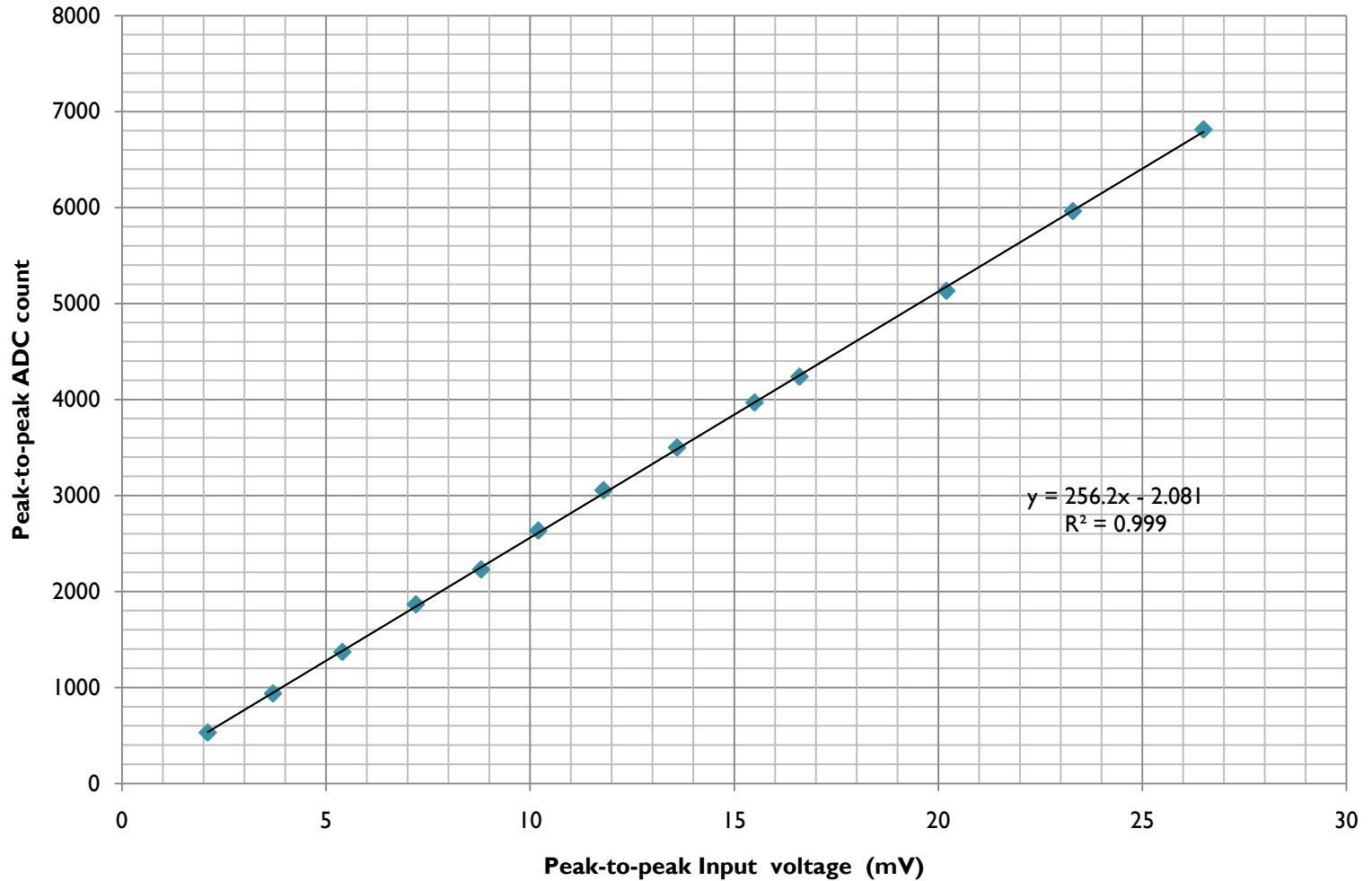


# Digitized Output Data



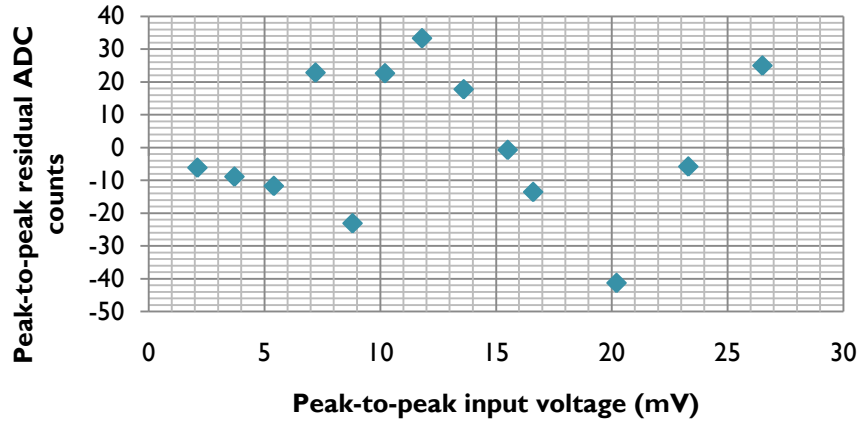
# Gain Linearity Test Result

## ADC Count Vs Input signal voltage

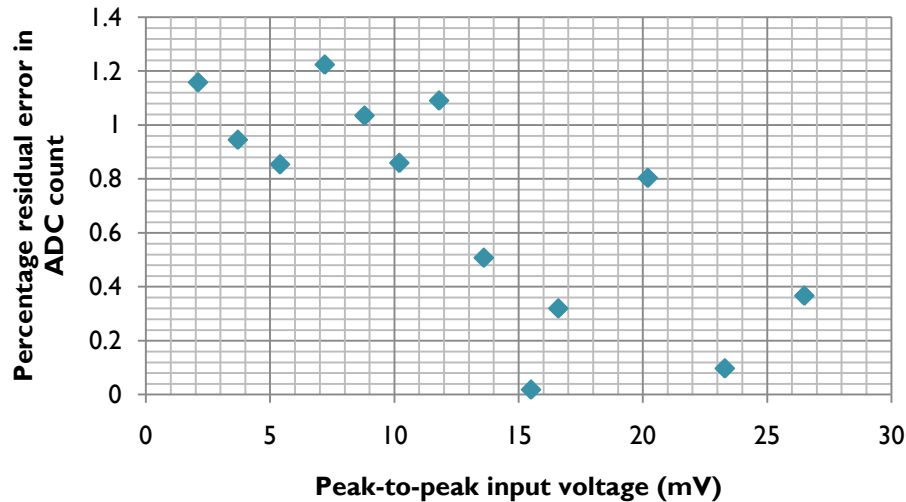


# Gain Linearity Test result

## Residual ADC counts (absolute) Vs Input voltage



## Percentage error in ADC counts Vs Input voltage



# Future plan

- Detailed understanding of TB4 board
- Propose to design 4/8 channel board in collaboration with FNAL/ANL, USA
  - Higher sampling freq with enough sampling depth
  - Standard interfacing for control and data transfer
  - Flexibility and scalability
  - The architecture may be used for project X experiments