

# TIMING ANALYSIS OF ANITA-LITE USING CALIBRATION DATA

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- Calibration Measurements at Williams Field
- ANITA-Lite Raw Data and Calibration Runs
- Goal of Timing Analysis
- Method of Analysis
- Results from first look at data
- Web-site of Calibration Data and Analysis at:  
<http://www.ps.uci.edu/~silvestri/ANITA.html>

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March 2004, Pasadena

# TIMING MEASUREMENTS

- Timing Measurements using a Pulser Transmitter
- Frequency used:
  - 375 MHz (mostly)
  - Some events at 350 MHz and 750 MHz
- Bursts sent at different power:
  - (0 db, -10 db and -20 db)
- ANITA Launch 04:08:00 GMT time
- First Burst 04:42:20 GMT time
- Last Burst 14:53:03 GMT time
- GPS Trigger adopted

## ANITA-LITE RAW DATA

- Entire Calibration data set
- Total # of Events 2568, i.e ~ 3.4 files/minute
- Data for 45102 sec, i.e. ~ 12 and a half hours
- A total of 98 events available:
  - 92 events at 375 MHz, 6 events at 350 Mhz
  - ALL THESE 98 EVENTS USED FOR THE ANALYSIS
- About 130 events with huge WF at frequency:  
(375 Mhz, 350 Mhz, and 750 MHz)

## GOAL of TIMING ANALYSIS

- Using Calibration Run to Extract Timing information
- Timing Calculation from Bursts at given Frequency
- Hardware bin digitization 0.5 nsec
- Goals of this analysis:
  - Time resolution limited by digit bin  
( $\sigma \sim 0.25$  nsec)
  - Amplitude dependency
  - Direction, azimuth dependency
  - Frequency dependency

# METHODS of ANALYSIS

- Full data set from USB (1-4) memories
- Scanning by Eye over ~ 3000 files (98 EVENTS)
- Studying features of individual WF (Time domain)
- FFT (Frequency domain) Reconstruction
- Signal about 4 sigmas above noise background level
- Leading Edge identification for all channels
- Fixed Threshold; Threshold channel and event dependent
- Application of Band-Pass Filter
- Distribution of diff. between Leading Edge Times between channels

# NOISE FILTERING

- Raw WF affected by many frequency components
- Filter used for 375 MHz:
  - LOW-PASS Filter: below 400 Mhz
  - HIGH-PASS Filter: above 355 Mhz
  - BAND-PASS Filter: windows [355-400] Mhz
- Filter working well also for other frequencies (350 Mhz and 750 MHz)

# GOOD EVENT at 375 MHz

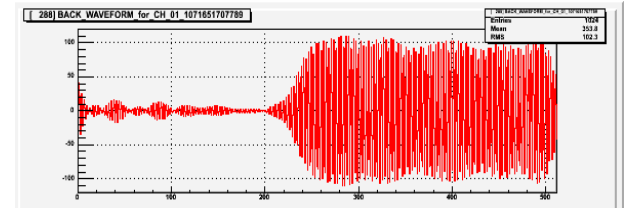
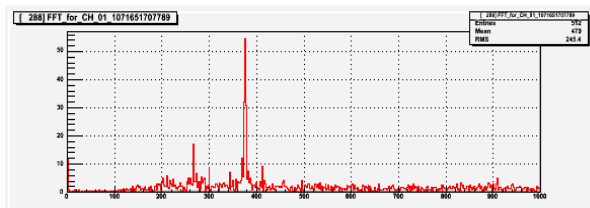
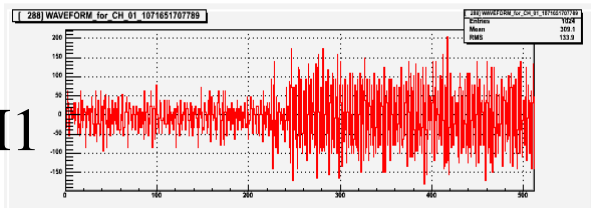
- Typical WF with event at 375 MHz
- Good for timing purpose

RAW

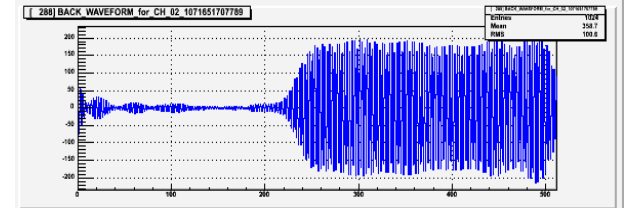
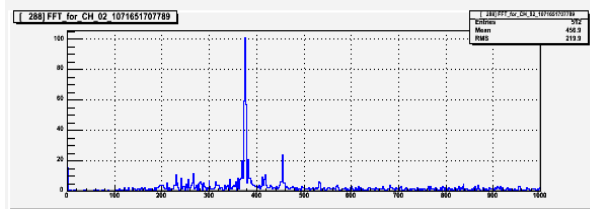
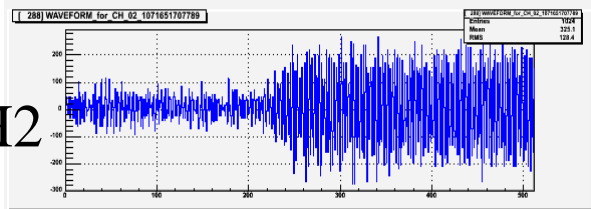
FFT

FILTER

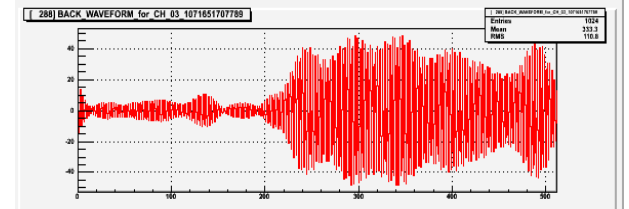
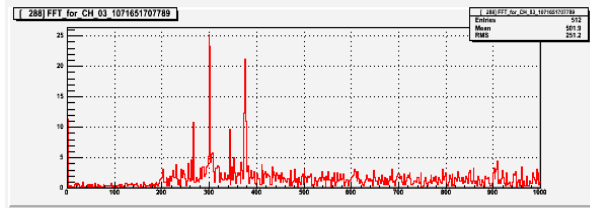
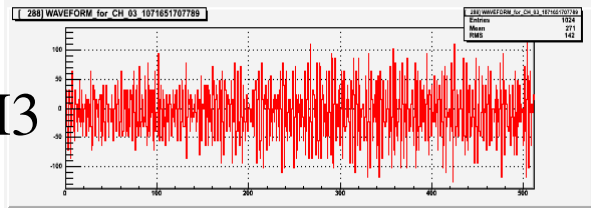
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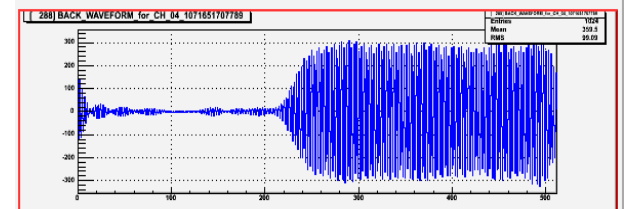
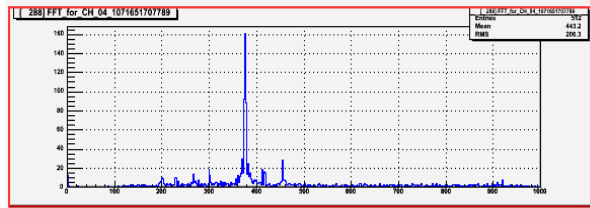
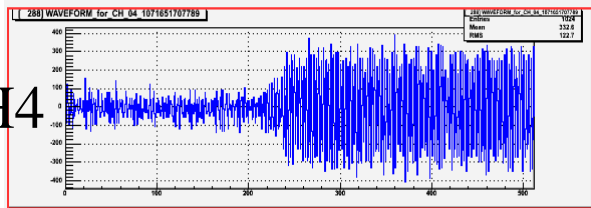
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CH3



CH4



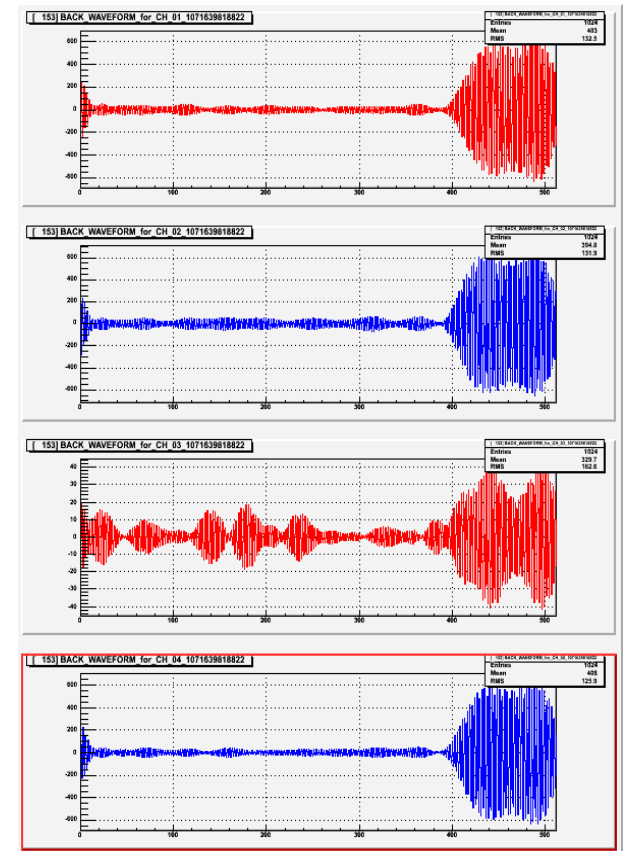
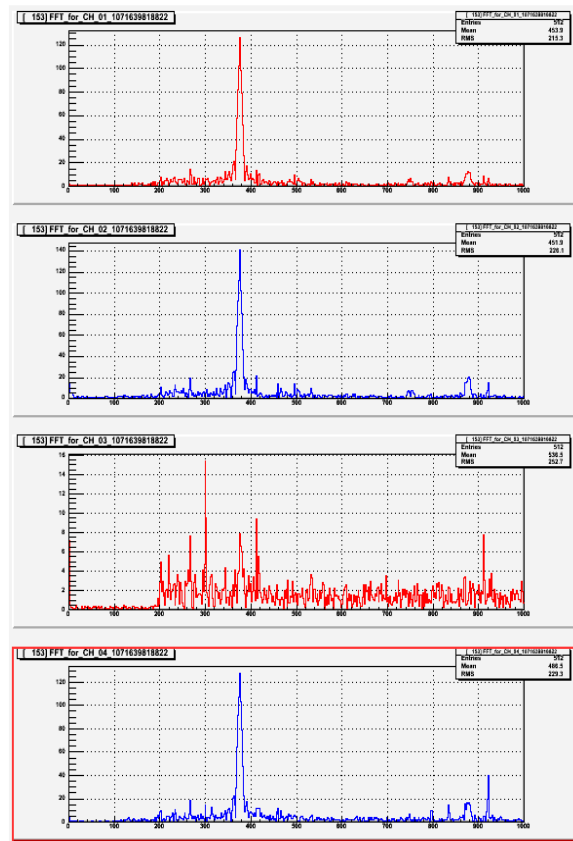
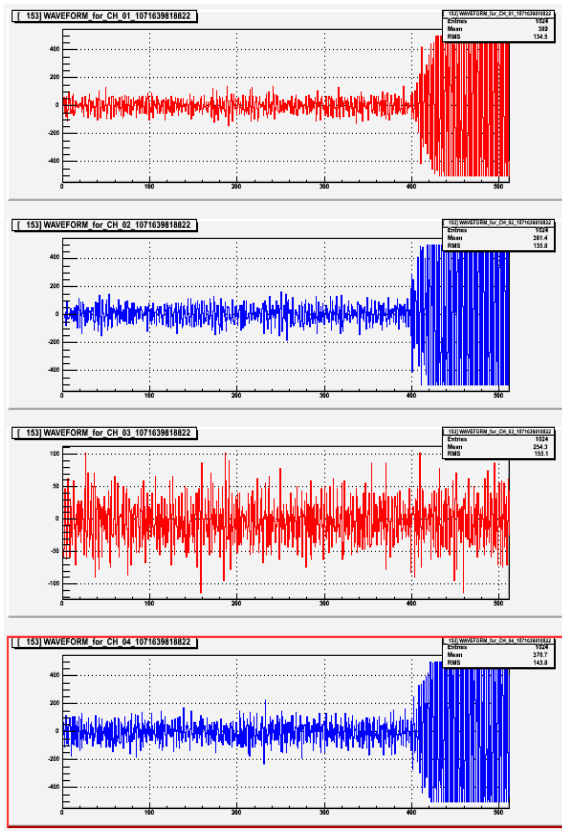
# EVENT at 375 MHz

- Signal event not centered in the WF windows

RAW

FFT

FILTER



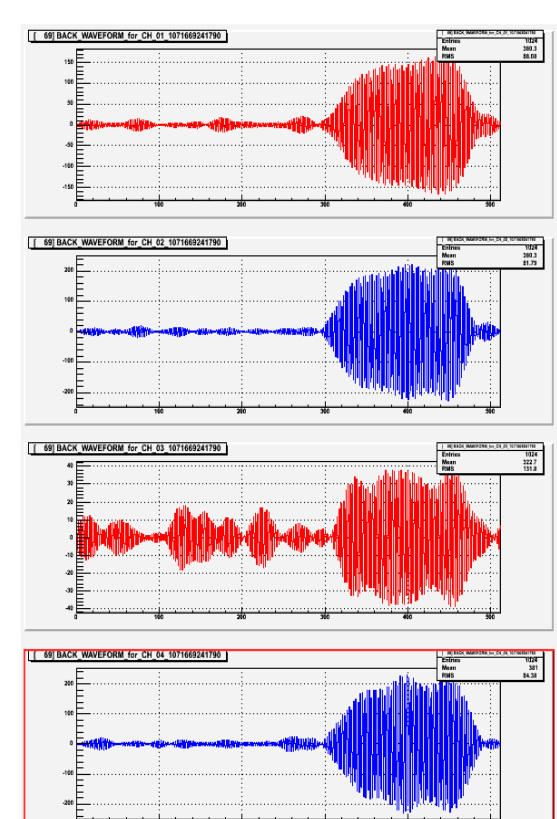
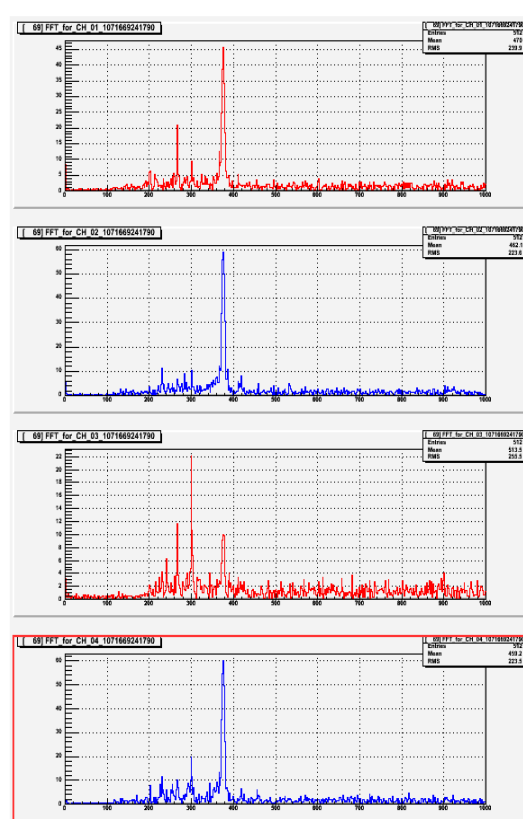
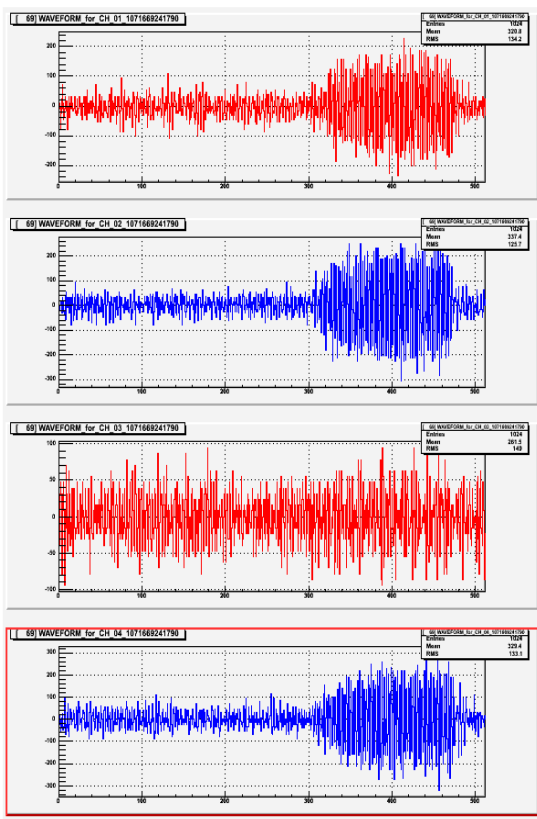
# SHORT PULSE of 150 ns at 375 MHz

- Shorter calibration bursts with 150 ns width

RAW

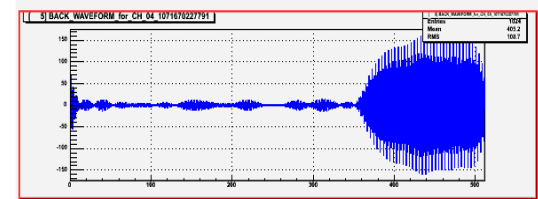
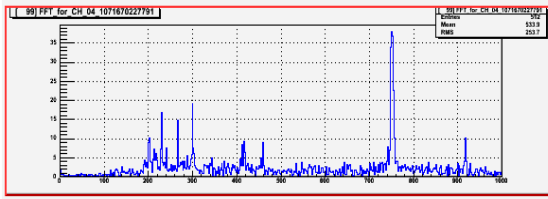
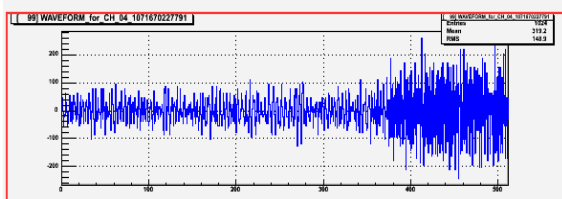
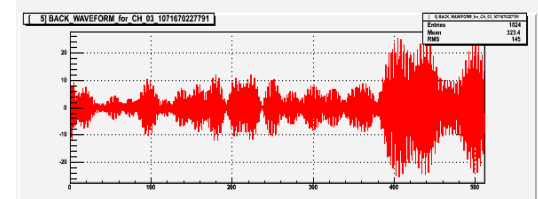
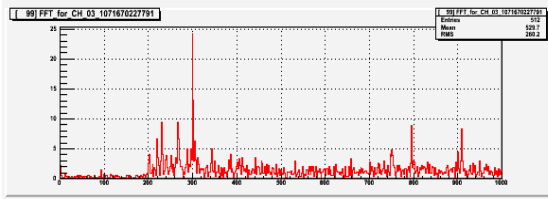
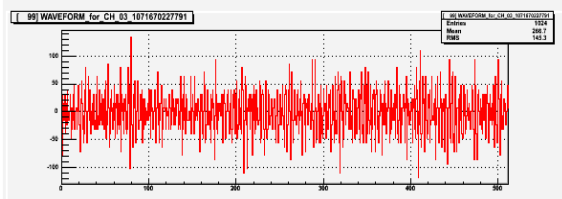
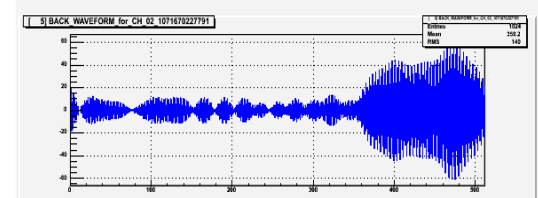
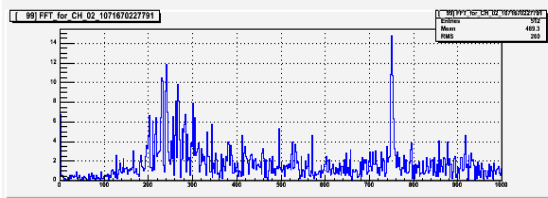
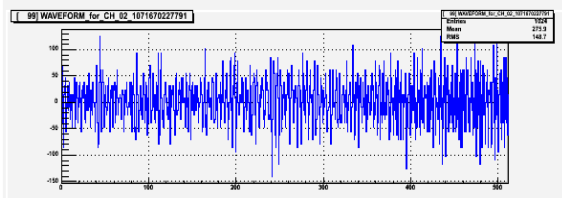
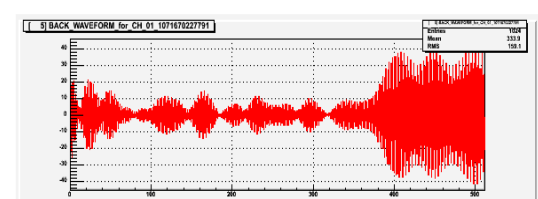
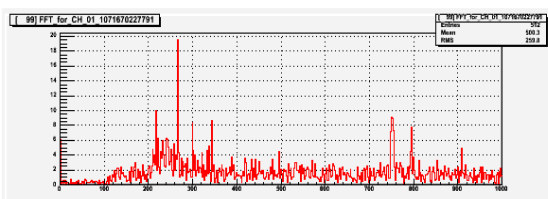
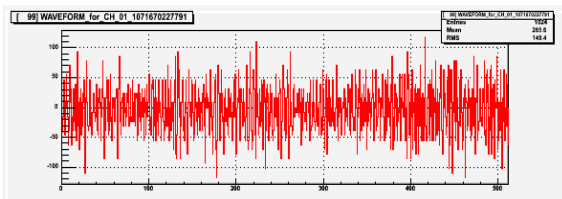
FFT

FILTER



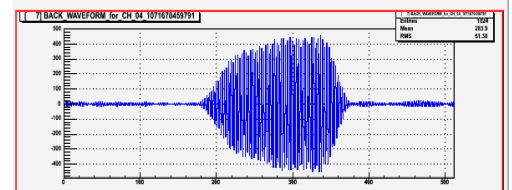
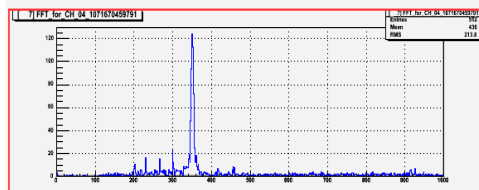
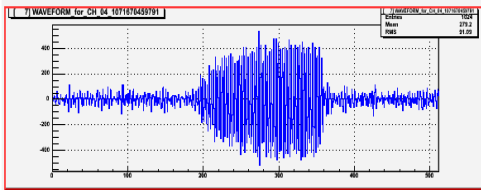
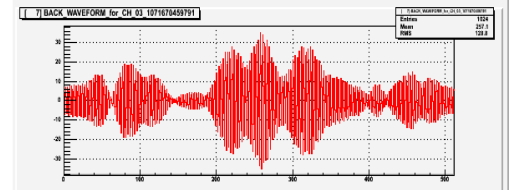
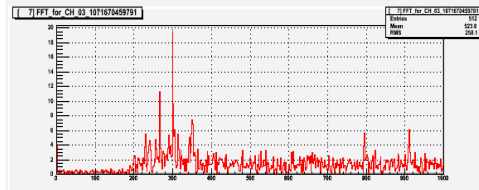
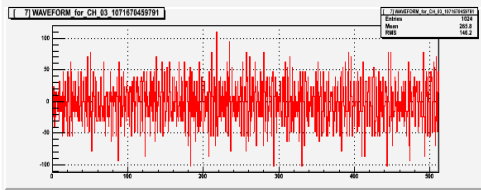
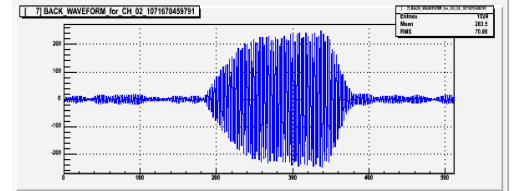
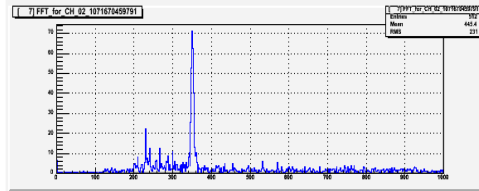
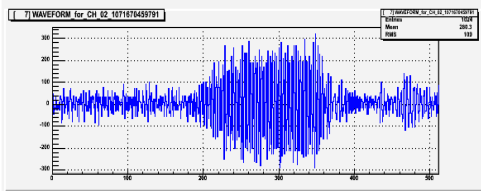
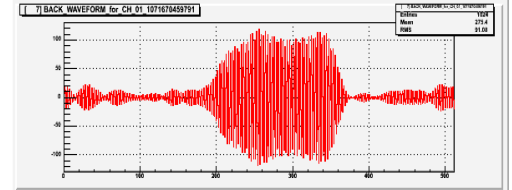
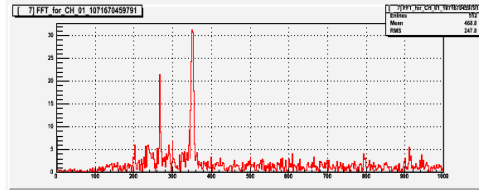
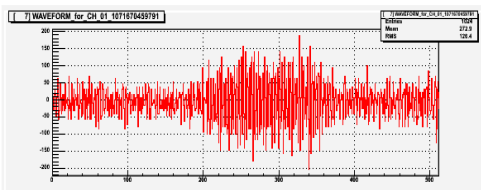
# SHORT PULSE at 750 MHz

- Only few events found at 750 MHz
- After BAND-PASS filter signal visible



# SHORT PULSE at 350 MHz

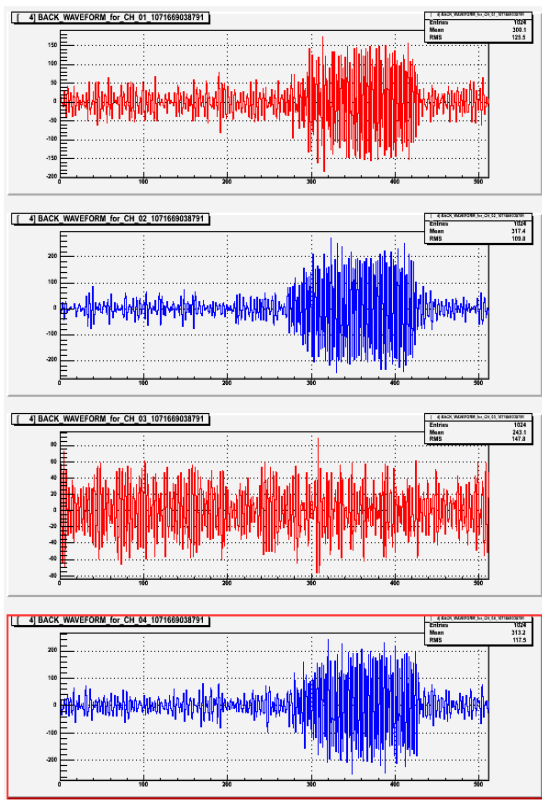
- Few events at 350 Mhz



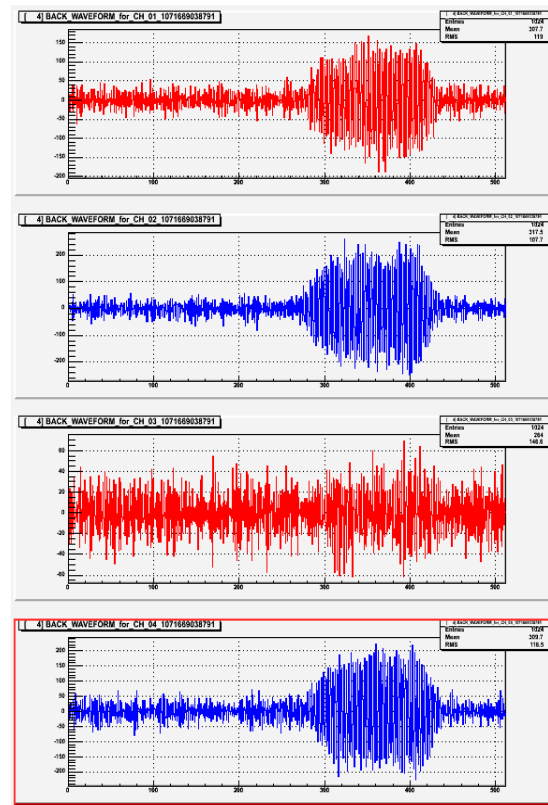
# LOW and HIGH PASS FILTER

- Different frequency filter adopted
- HIGH-PASS; LOW-PASS; BAND-PASS
- Best Windows around 375 Mhz is [355-400] Mhz

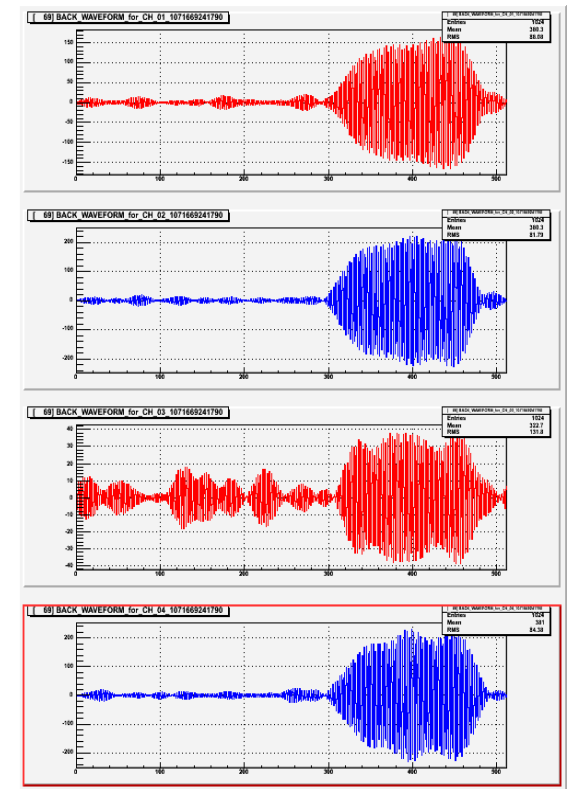
## HIGH-PASS



## LOW-PASS

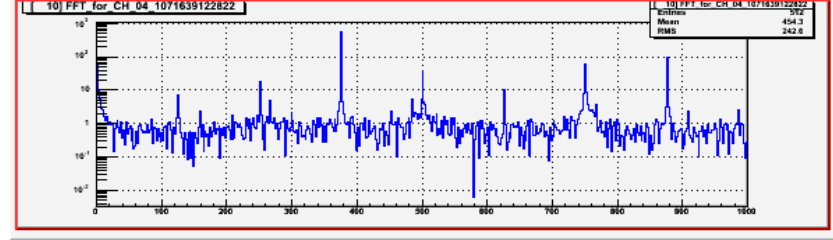
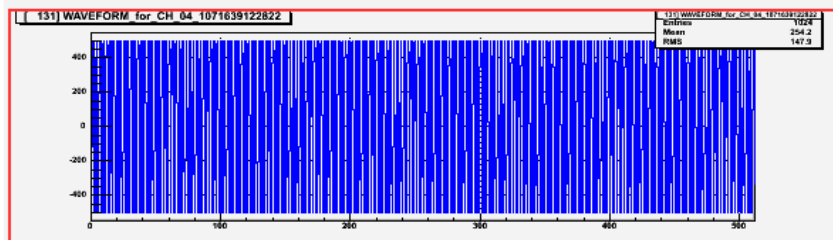
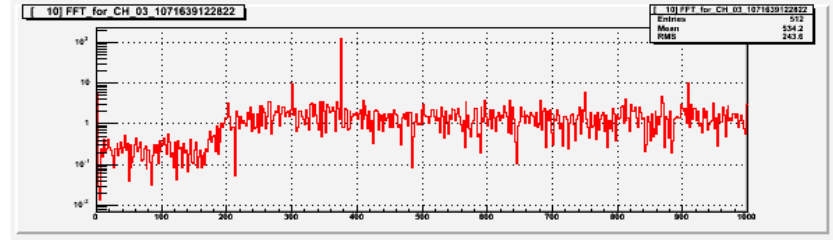
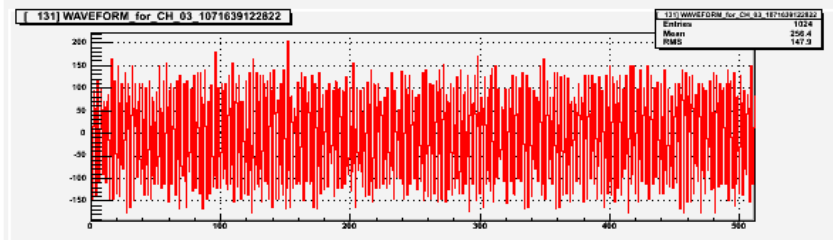
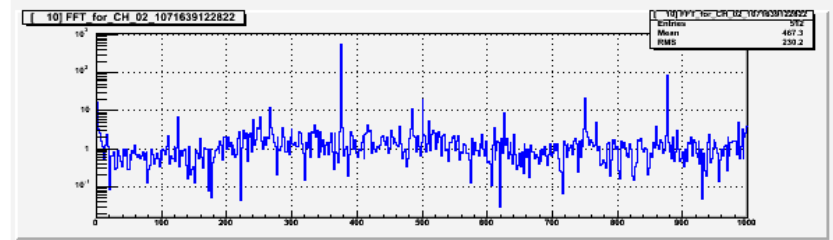
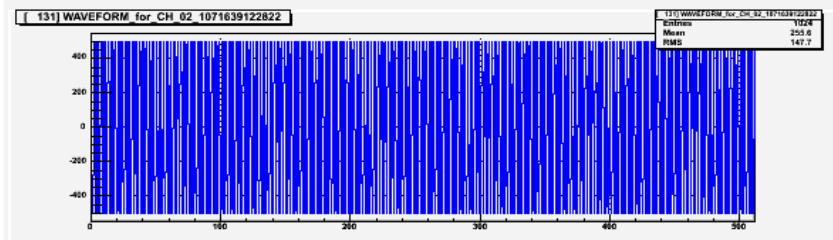
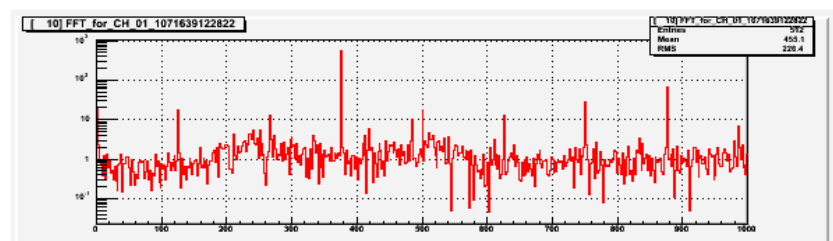
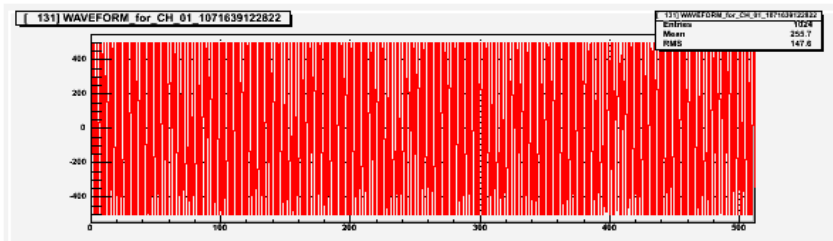


## BAND-PASS



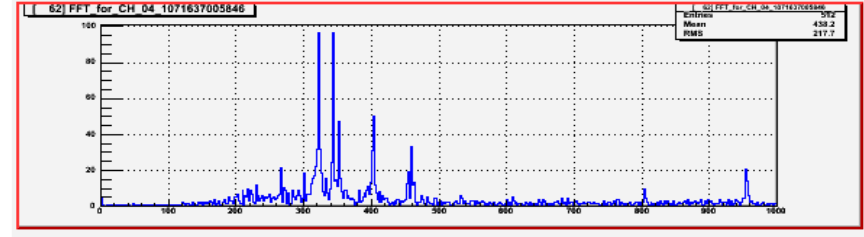
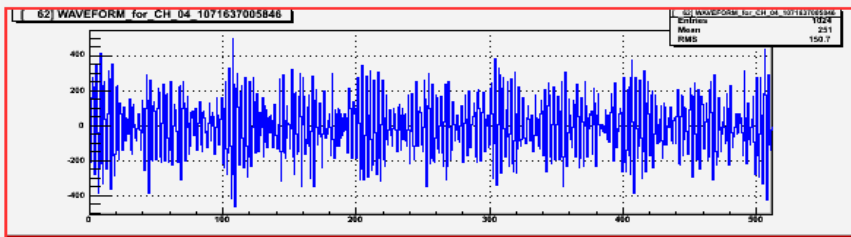
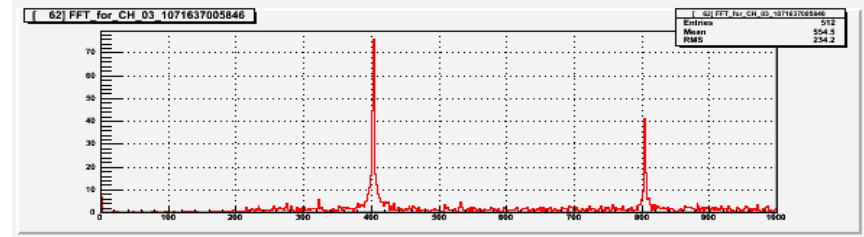
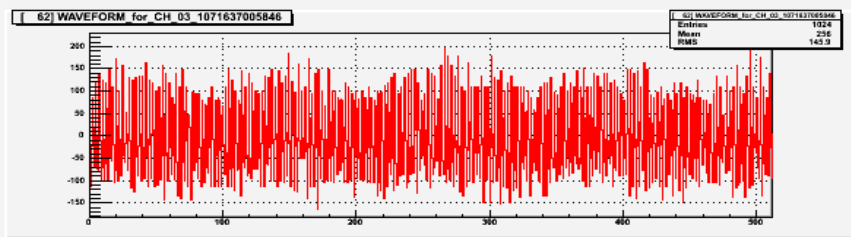
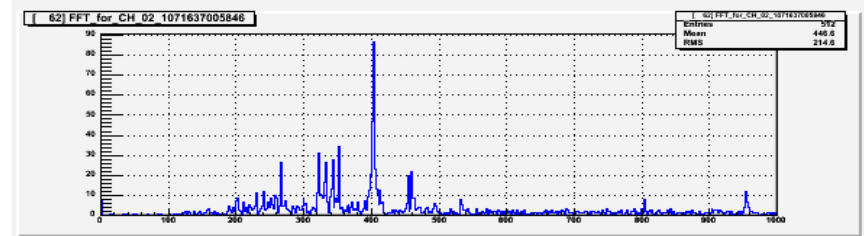
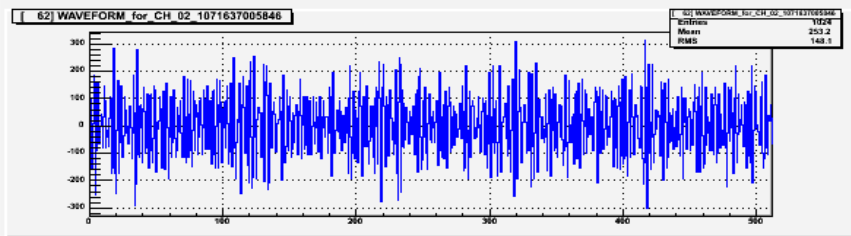
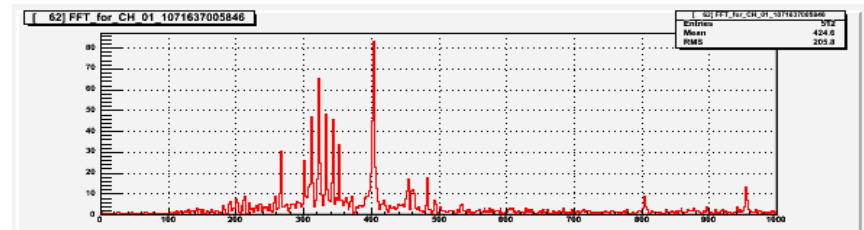
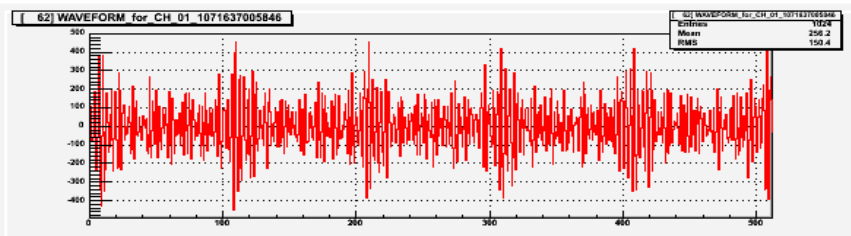
# LARGE SIGNALS

- About 140 events are affected by large amplitude



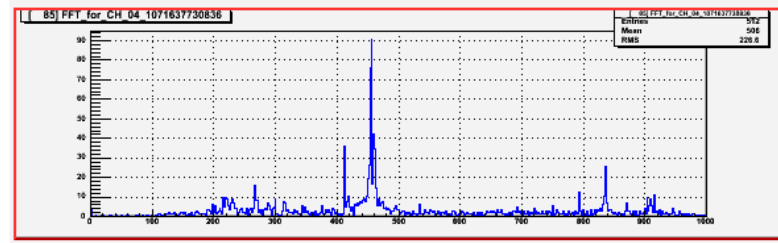
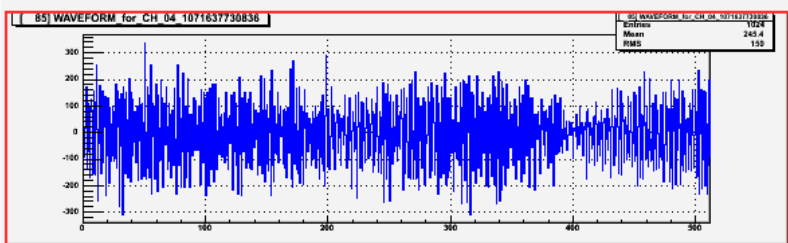
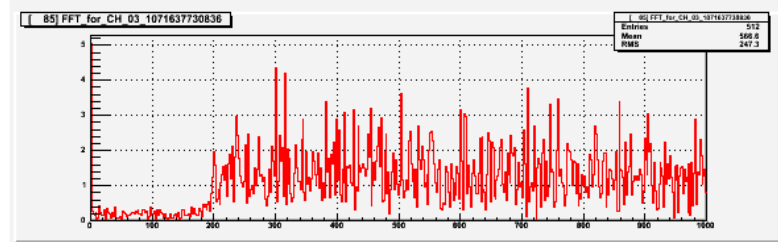
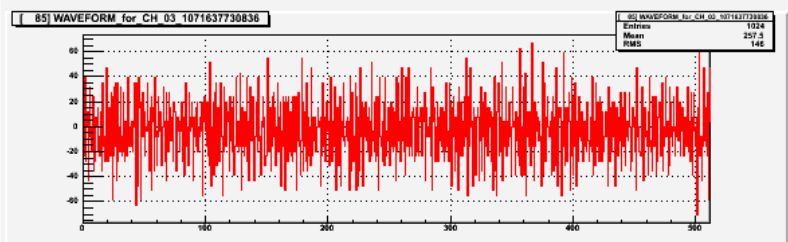
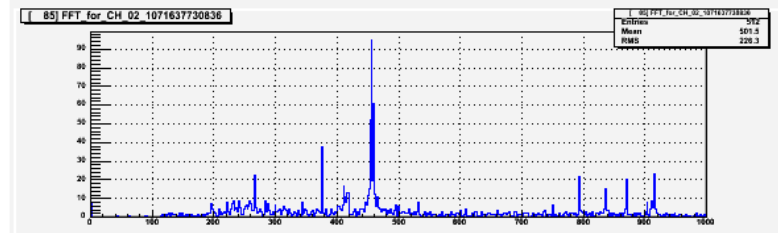
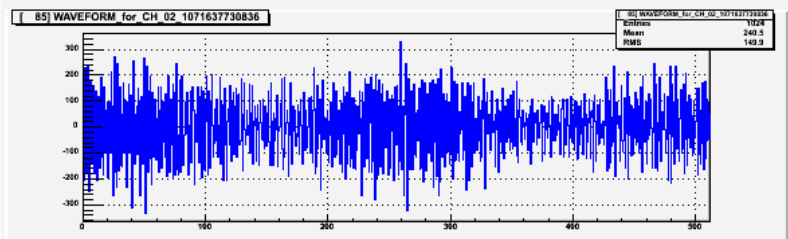
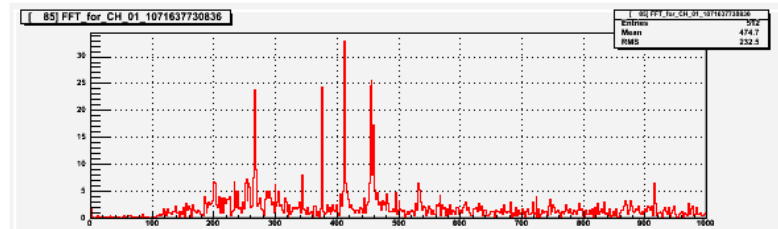
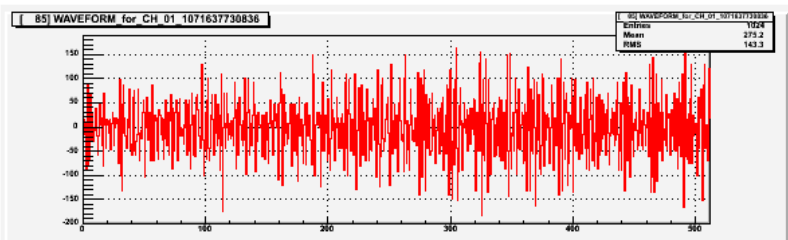
# EVENT at 405 Mhz

- Typical event found at 405 Mhz, packets 30-50 nsec
- Other antenna source(?)



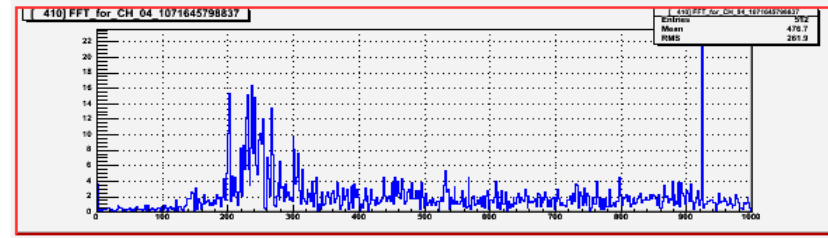
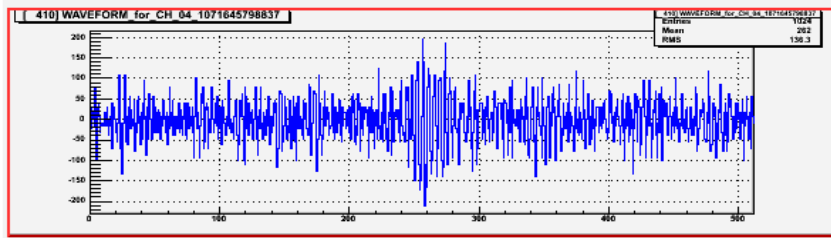
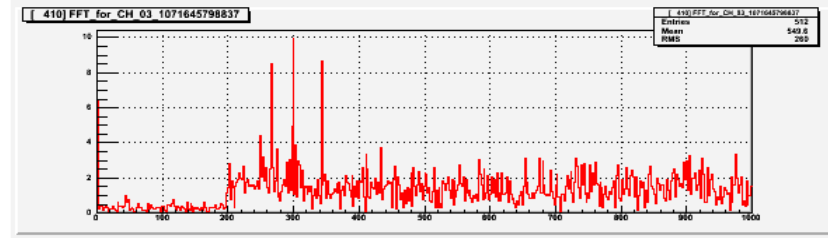
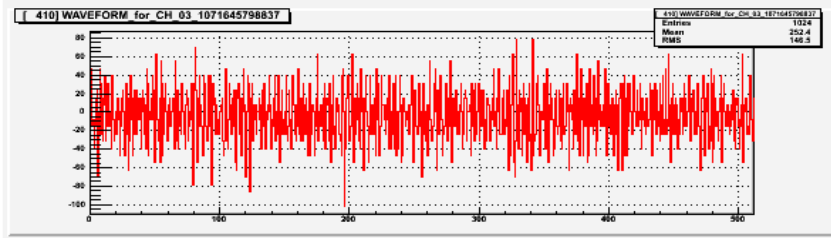
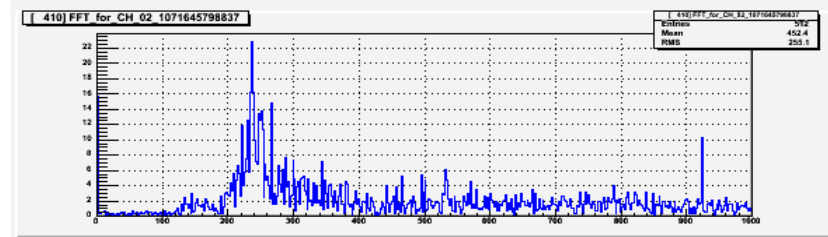
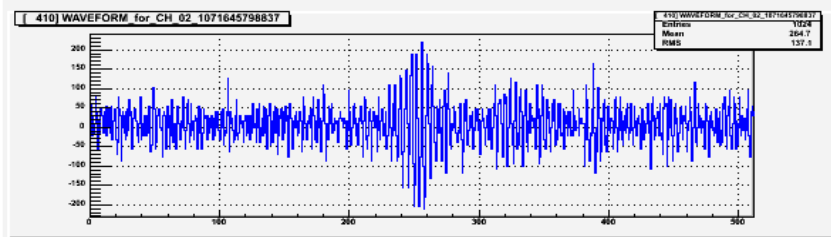
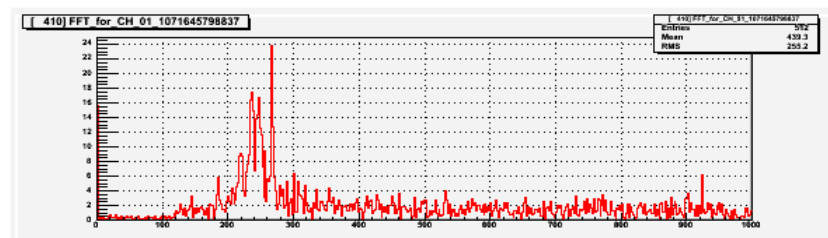
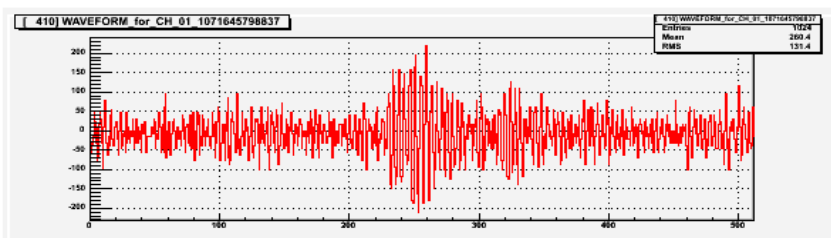
# EVENT at 460 MHz

- Larger modulation at 460 Mhz
- Other sources (?)



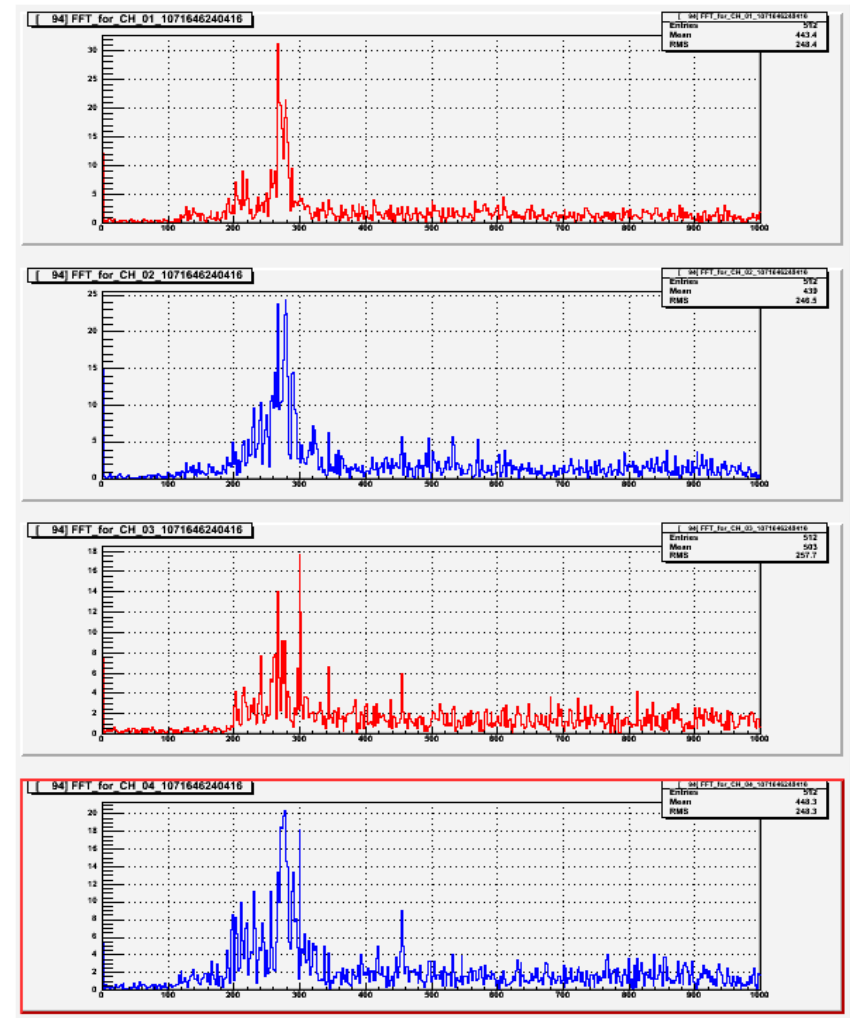
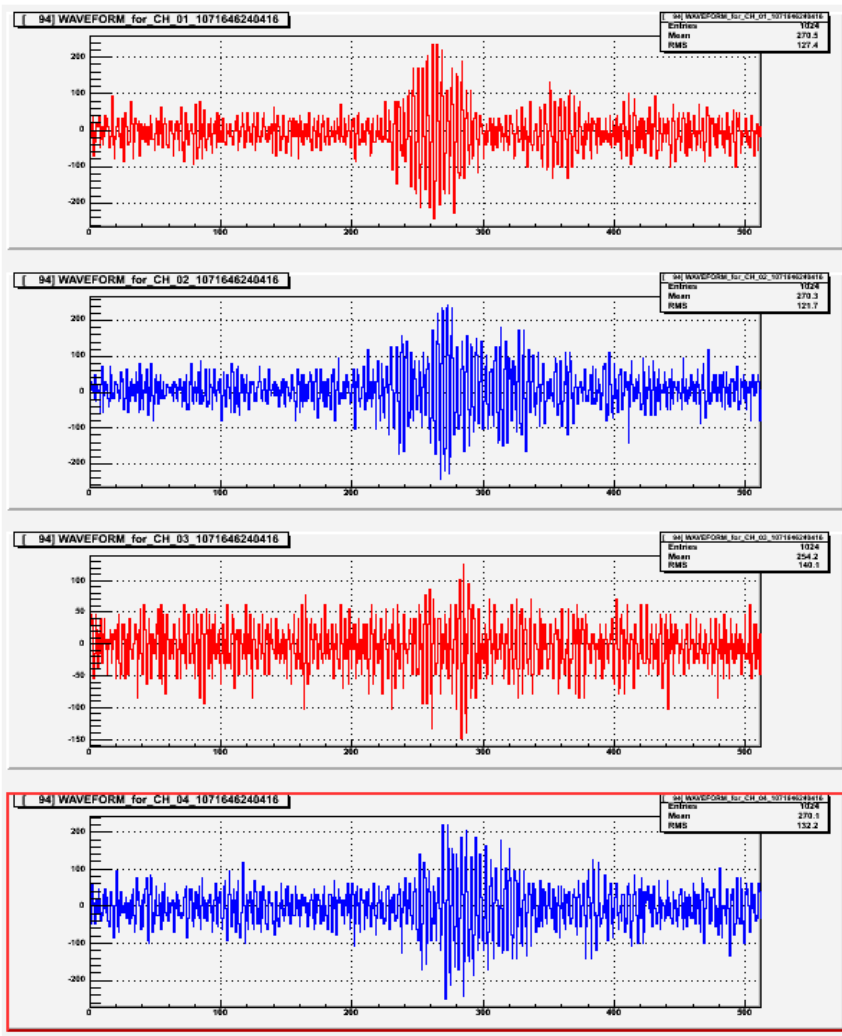
# BROAD PEAK at 250 MHz

- Broader peaks around 250 MHz
- Probably internal electronic noise



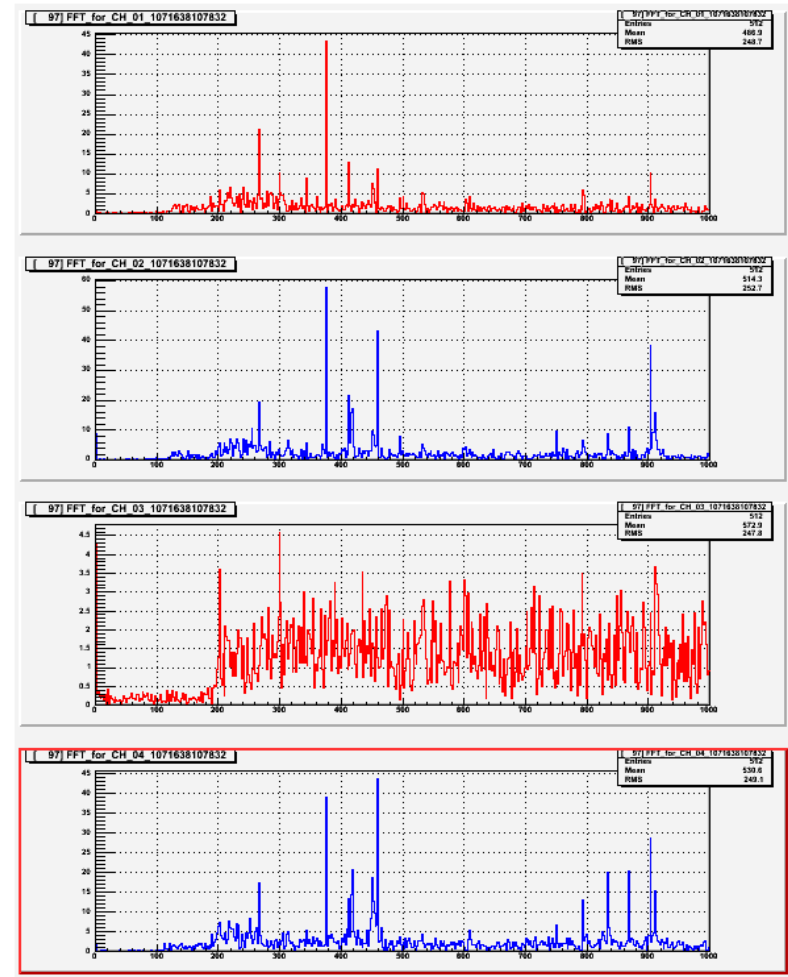
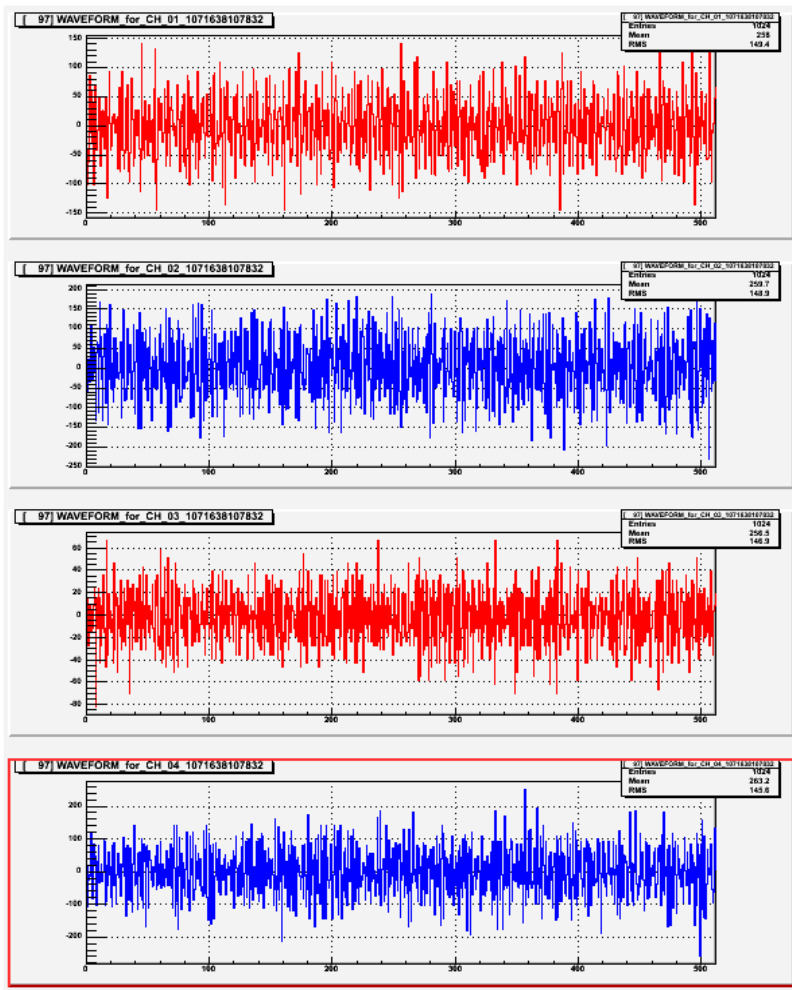
# BRAOD PEAK at 275 MHz

- Similar behaviour at 275 MHz



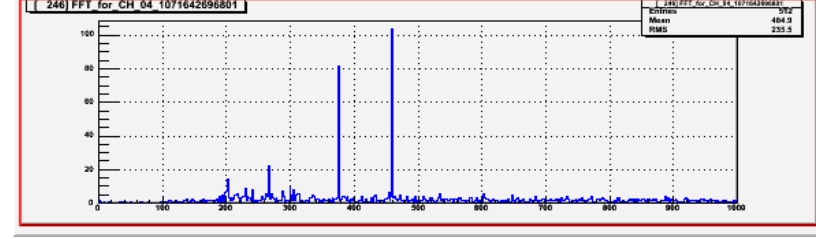
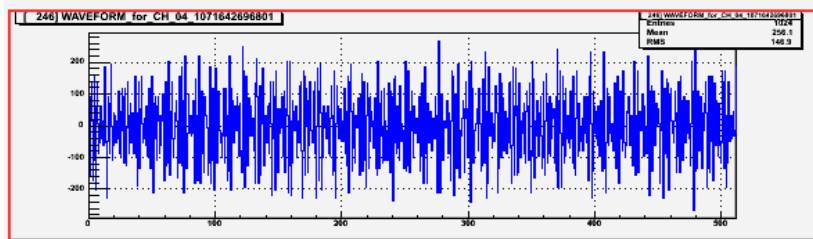
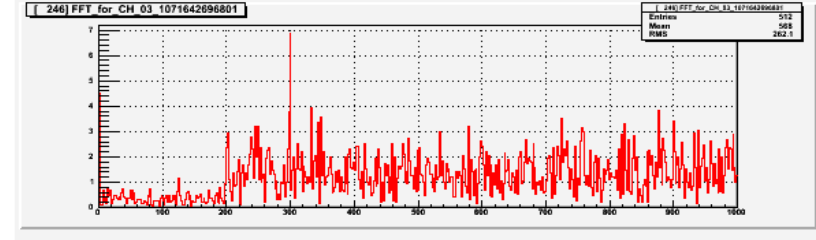
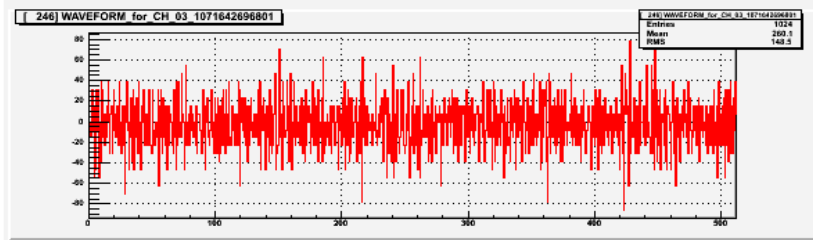
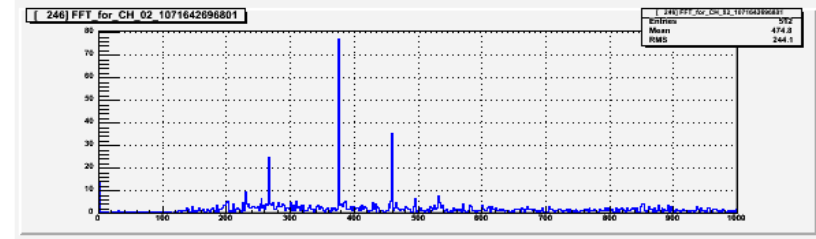
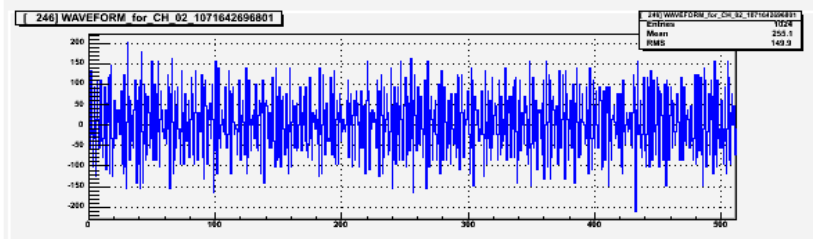
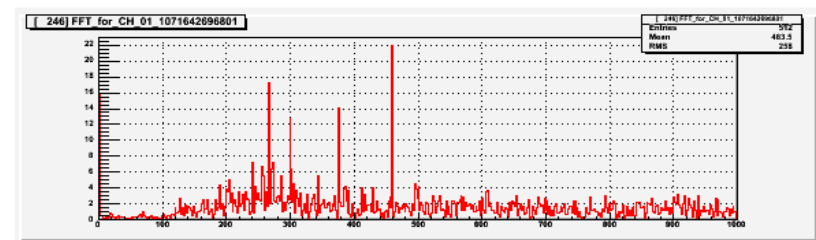
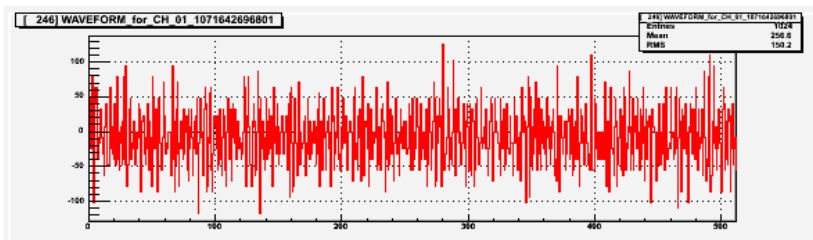
# SIGNAL at 375 Mhz at 909 MHz

- FFT shows signal at 375 Mhz, but still too weak
- Additional component at 909 Mhz



# SIGNAL 375 MHz and NOISE 460 MHz

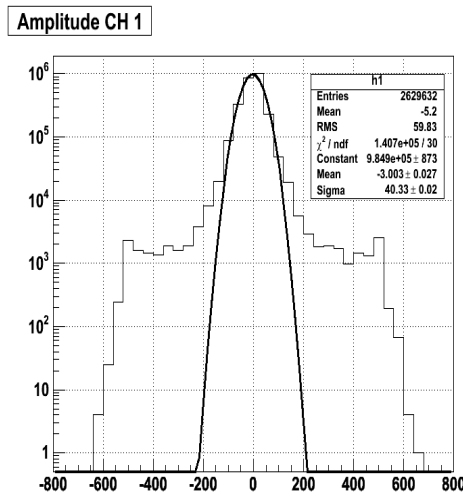
- Typical WF with signals and additional components



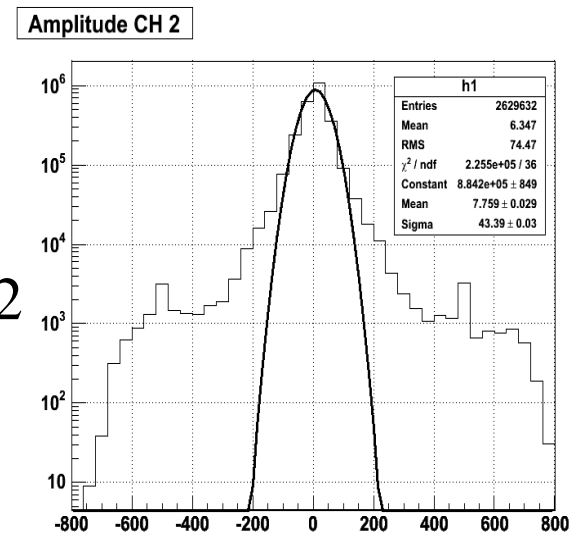
# AMPLITUDE DISTRIBUTION

- Distributions of all data analyzed (2568 events)
- Gaussian distribution expected for Noise Background
- Much broader and flatter distribution for Signal

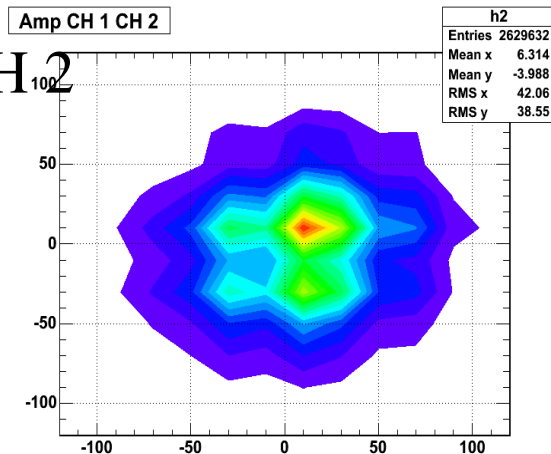
CH 1



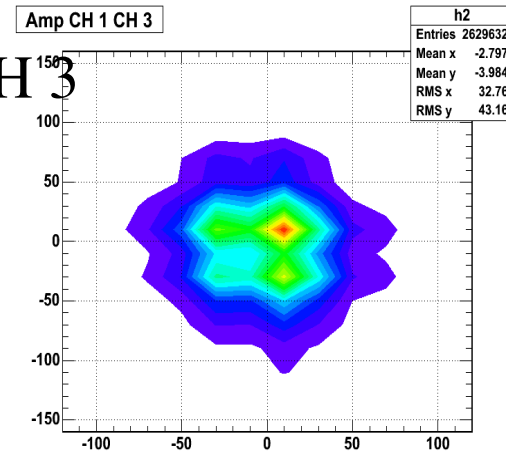
CH 2



CH1 vs CH 2



CH 1 vs CH 3

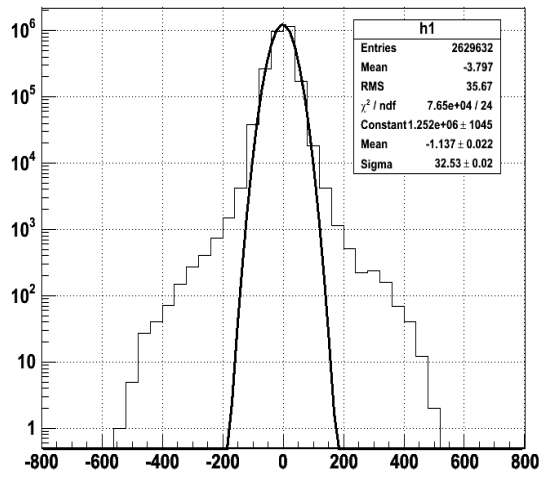


# AMPLITUDE DISTRIBUTION

- Distributions for CH 3 and CH 4
- Amplitude of CH 3 reduced by  $\sim 60\%$

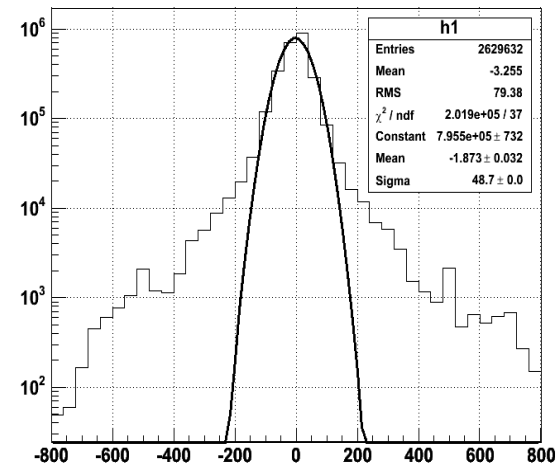
Amplitude CH 3

CH 3



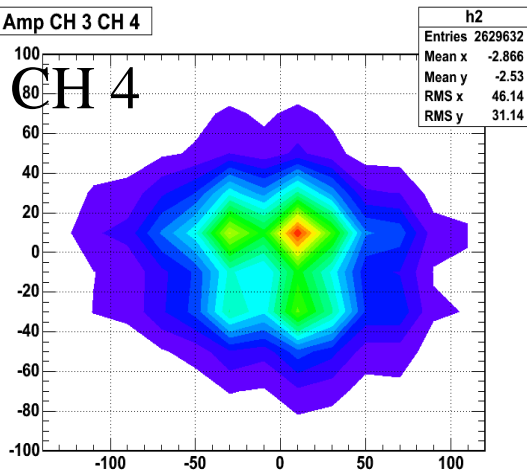
Amplitude CH 4

CH 4



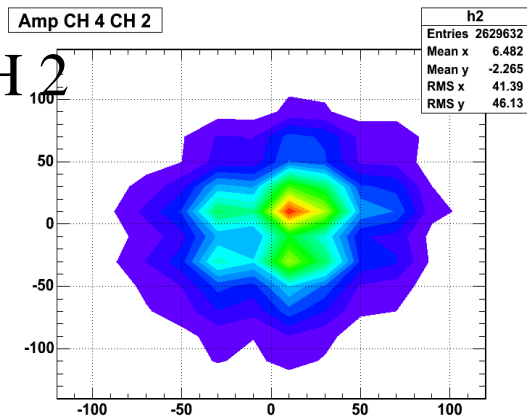
Amp CH 3 CH 4

CH 3 vs CH 4



Amp CH 4 CH 2

CH 4 vs CH 2

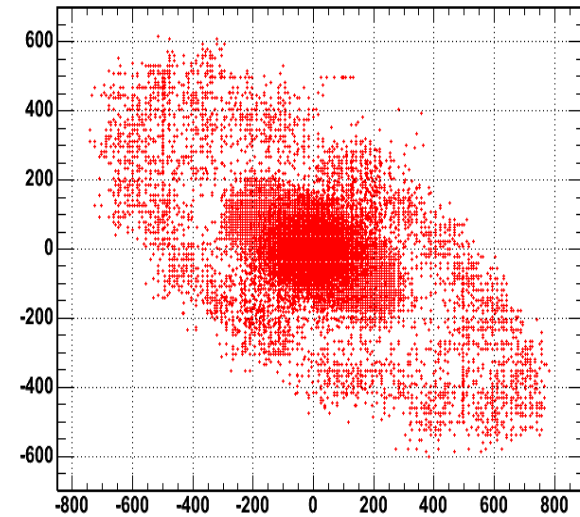


# AMPLITUDE CORRELATION

## CH 1 vs CH 2

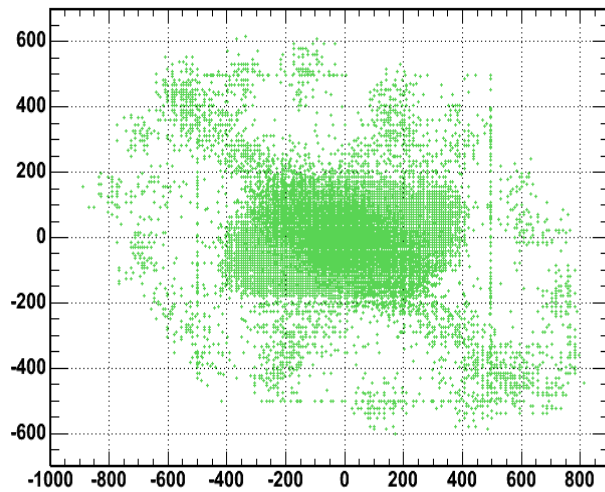
- Correlation in amplitude for signal events

Amplitude1:Amplitude2



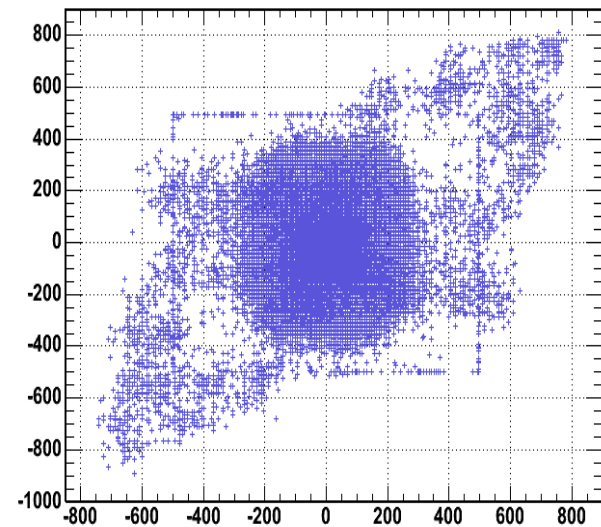
## CH 1 vs CH 4

Amplitude1:Amplitude4



## CH 4 vs CH 2

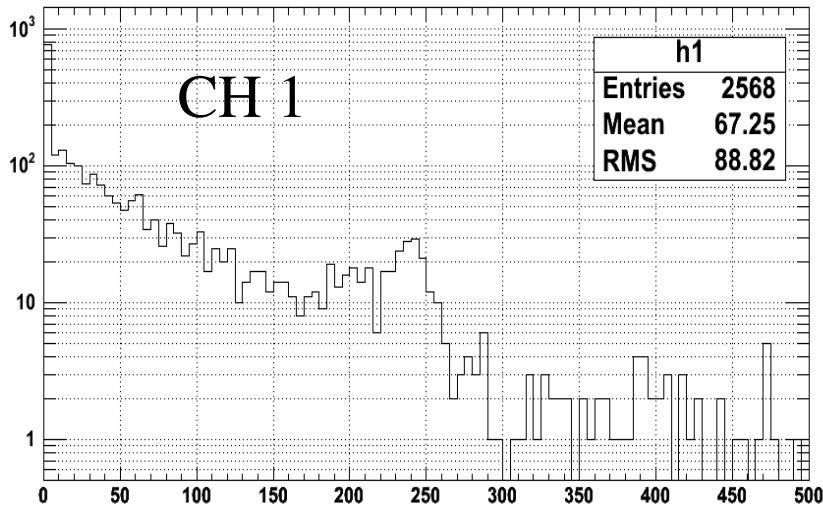
Amplitude4:Amplitude2



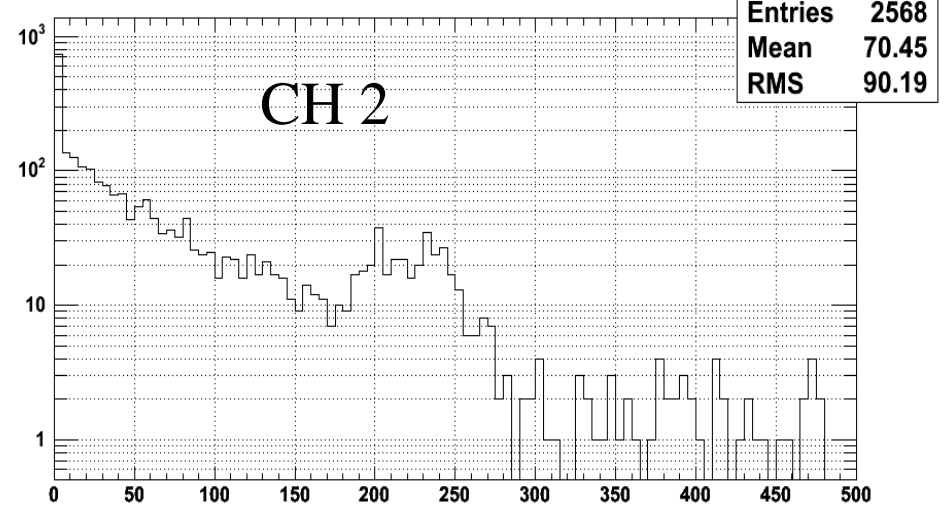
# Leading Edge Distribution

- Exponential decay for LE Background distribution
- Peaks in LE distr. due to threshold requirement

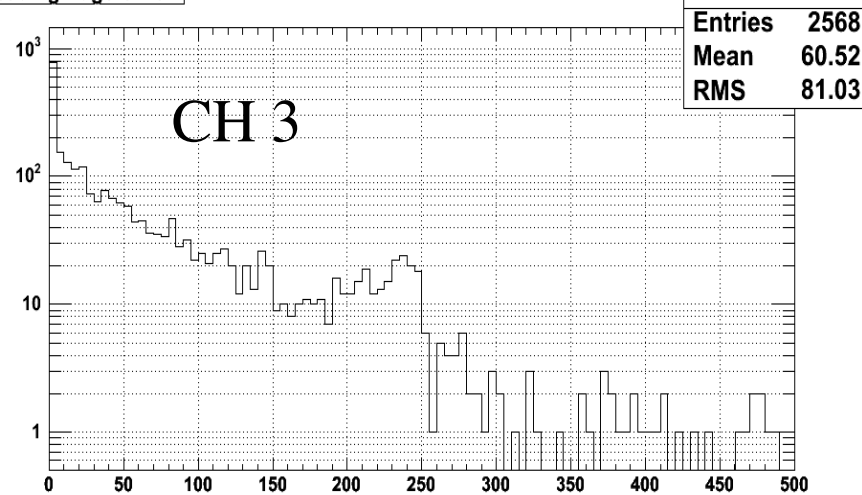
Leading Edge CH 1



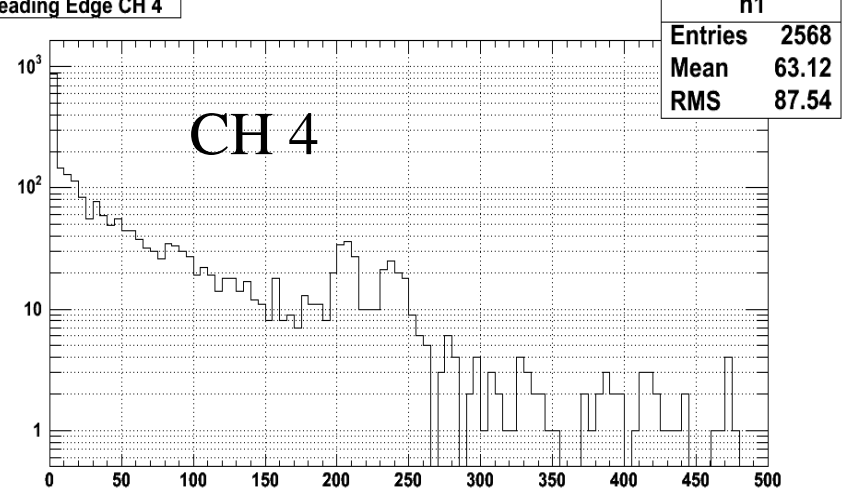
Leading Edge CH 2



Leading Edge CH 3



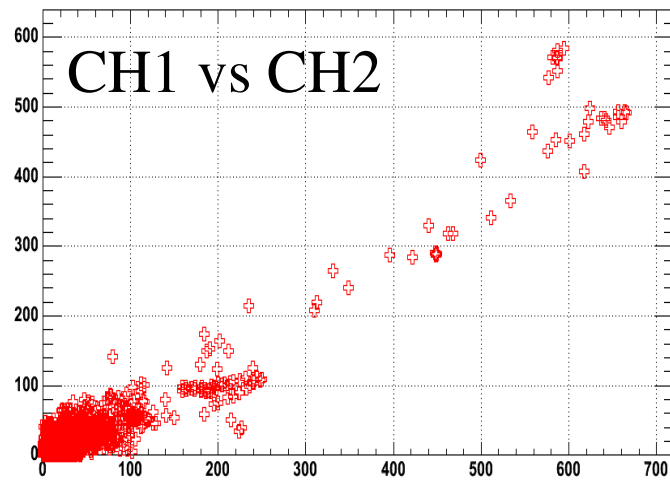
Leading Edge CH 4



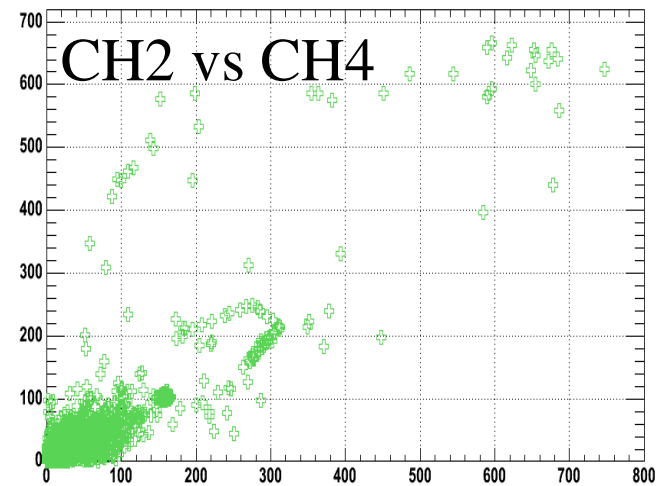
# FFT POWER of diff. CHANNELS

- Expected correlation for working channels
- CH 3 weaker in Amplitude by a factor five

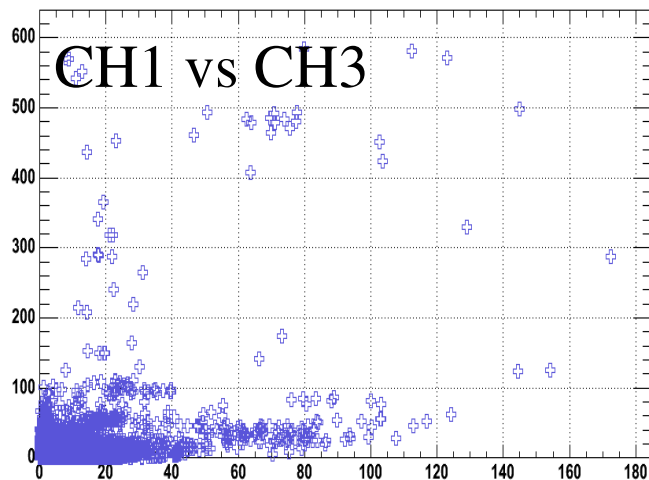
FFTPower1:FFTPower2



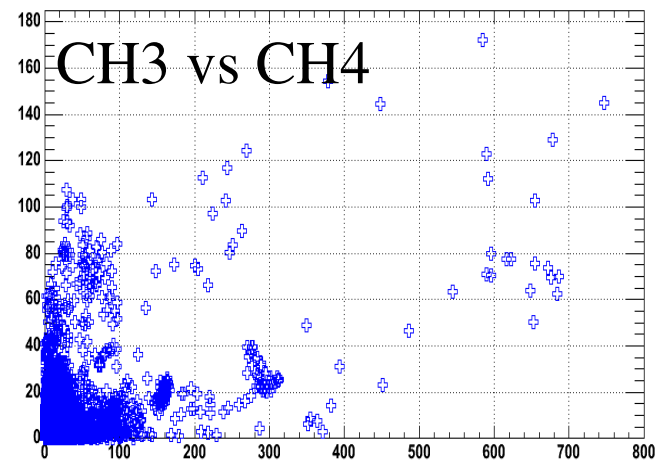
FFTPower2:FFTPower4



FFTPower1:FFTPower3



FFTPower3:FFTPower4

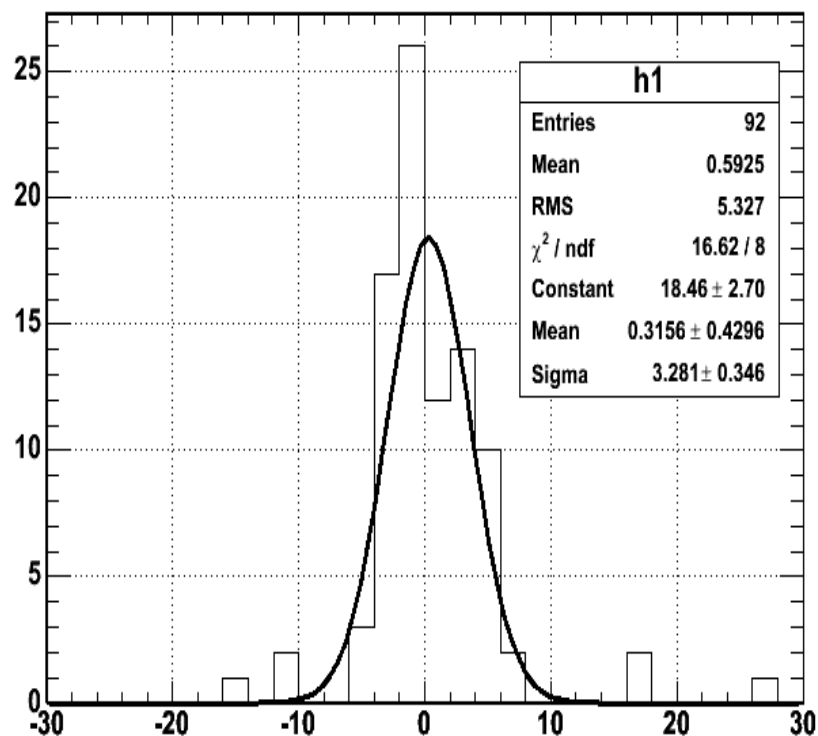


# TIME RESOLUTION

- Current resolution of  $\sim 3\text{ns}$   
(OF COURSE TO BE IMPROVED)

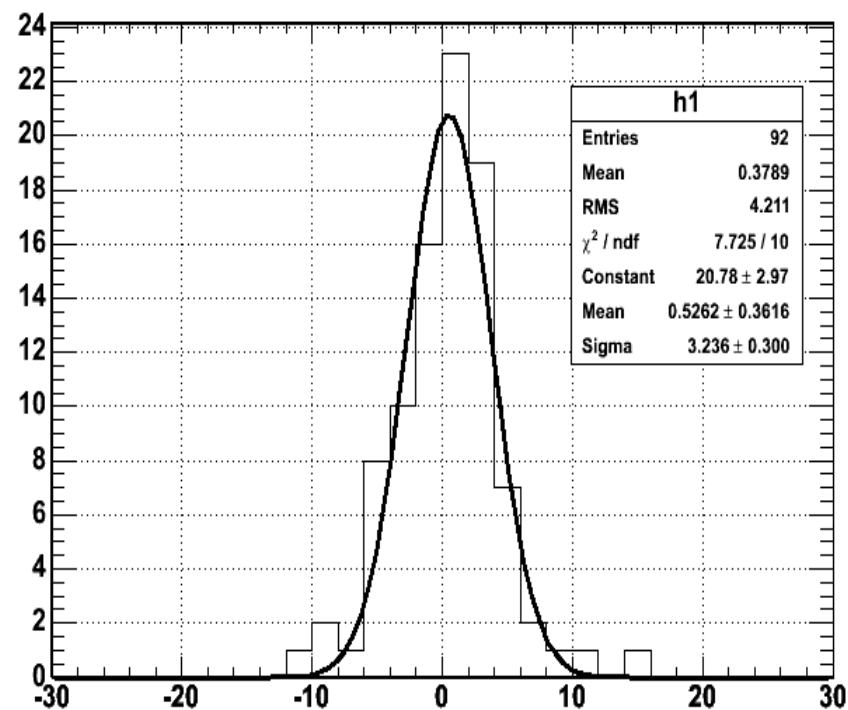
Delta LE(1-4)

LE(ch1)-LE(ch4)



Delta LE(2-4)

LE(ch2)-LE(ch4)



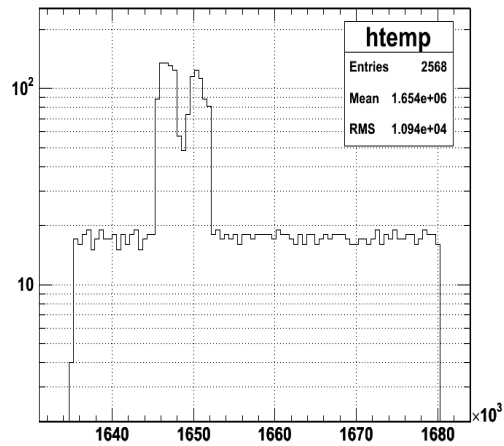
## CONCLUSION and LESSON LEARNED

- Ensure higher data rate during LOS
- Feedback information to be available quickly
- Calibration system fully tested prior next mission
- Even limited current data set, system is reliable
- Operation of amplifier should not modulate the signal pulse
- Plenty of power even at high altitude
- First look at ANITA-Lite calibration data
- Developing first method for timing analysis

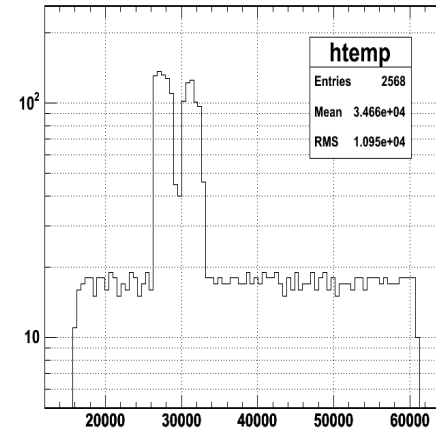
# GMT and GPS TIME

- GMT and GPS distributions strongly correlated
- Internal feature found in both distributions

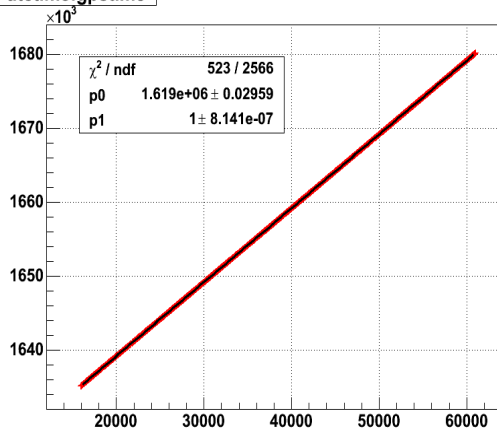
uttime



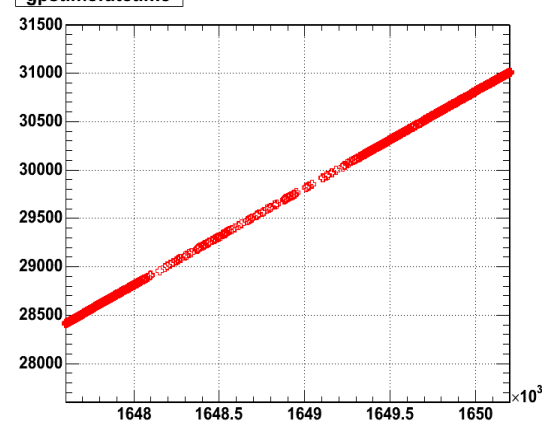
gpstime



uttime:gpstime



gpstime:uttime



# UTC-GPS TIME

- FOR ONLY 98 EVENTS

