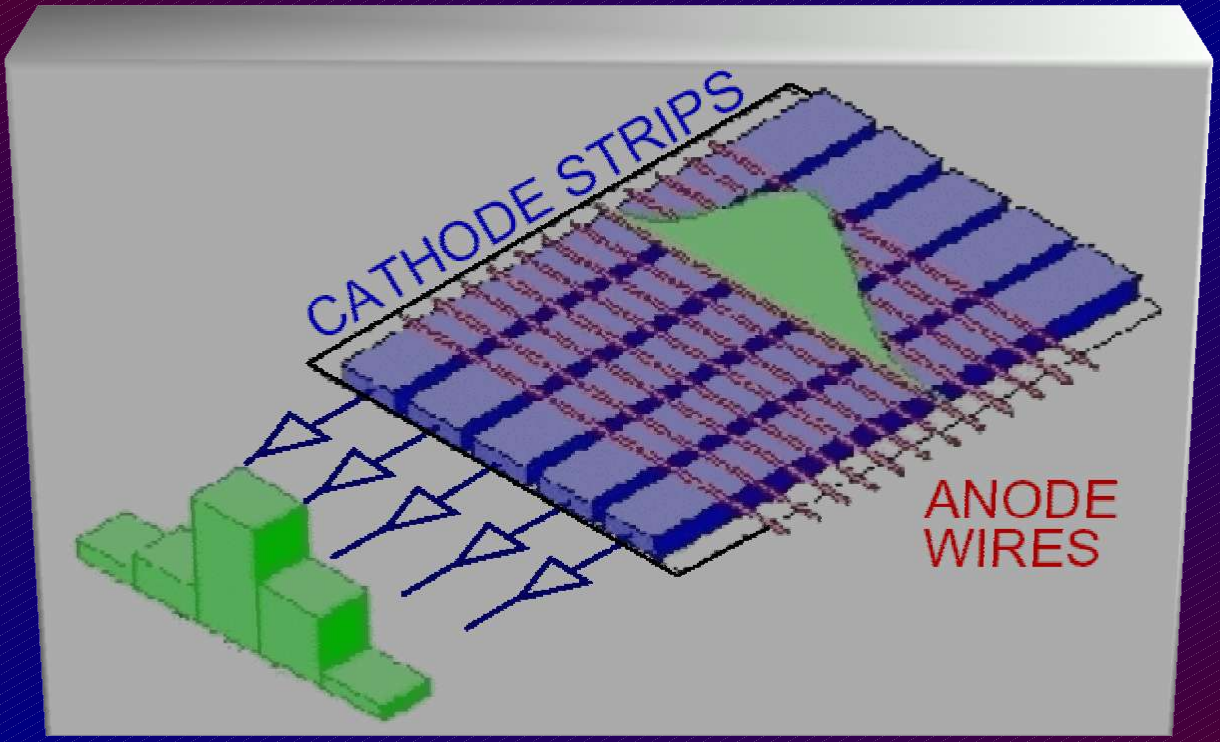
Studies of the FDC using a Struck Flash ADC



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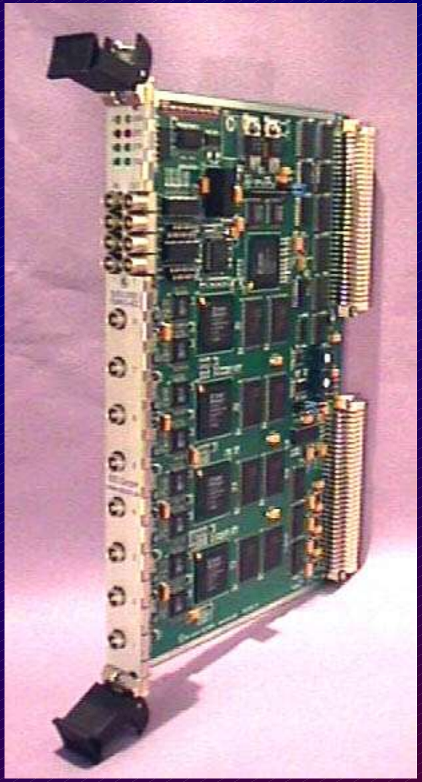
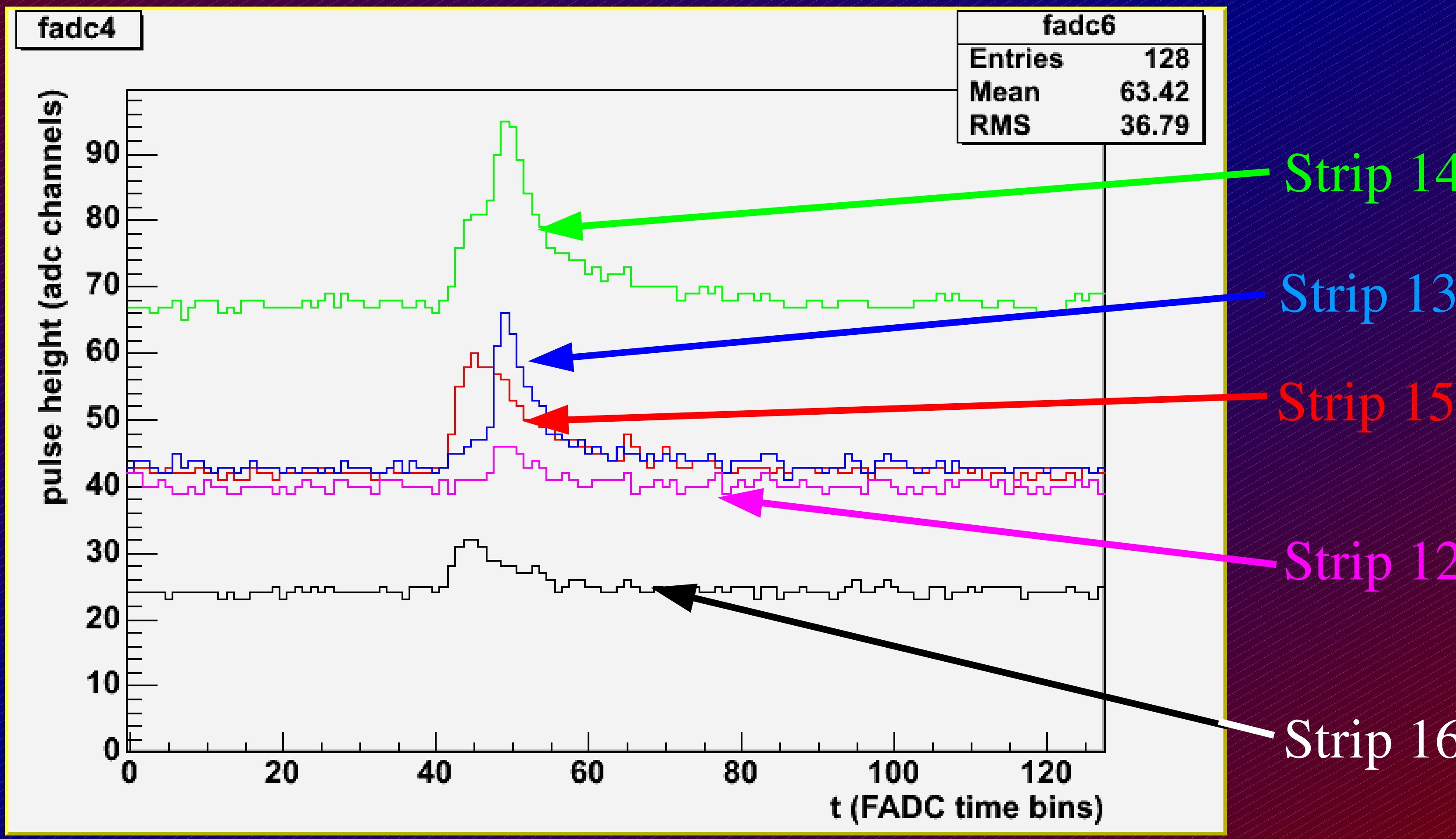
Properties of Struck SIS3300 FADC



- Single width 6U VME card
- 8 channels
- 105 MHz per channel (1 MHz - 105 MHz)
- >80 MHz bandwidth
- Internal/External clock
- 2 banks x 128K samples/channel memory
- Multi event mode
- Pre/Post trigger capability
- Trigger or output (8 individual thresholds)
- A32/D32/BLT32/MBLT64/2eVME
- In field JTAG firmware upgrade capability
- Trapezoidal FIR filter option (firmware major revision 0x11)
- Power consumption: +5V 6A (sampling @ 100 MHz), +12 V 50 mA, -12 V 50 mA

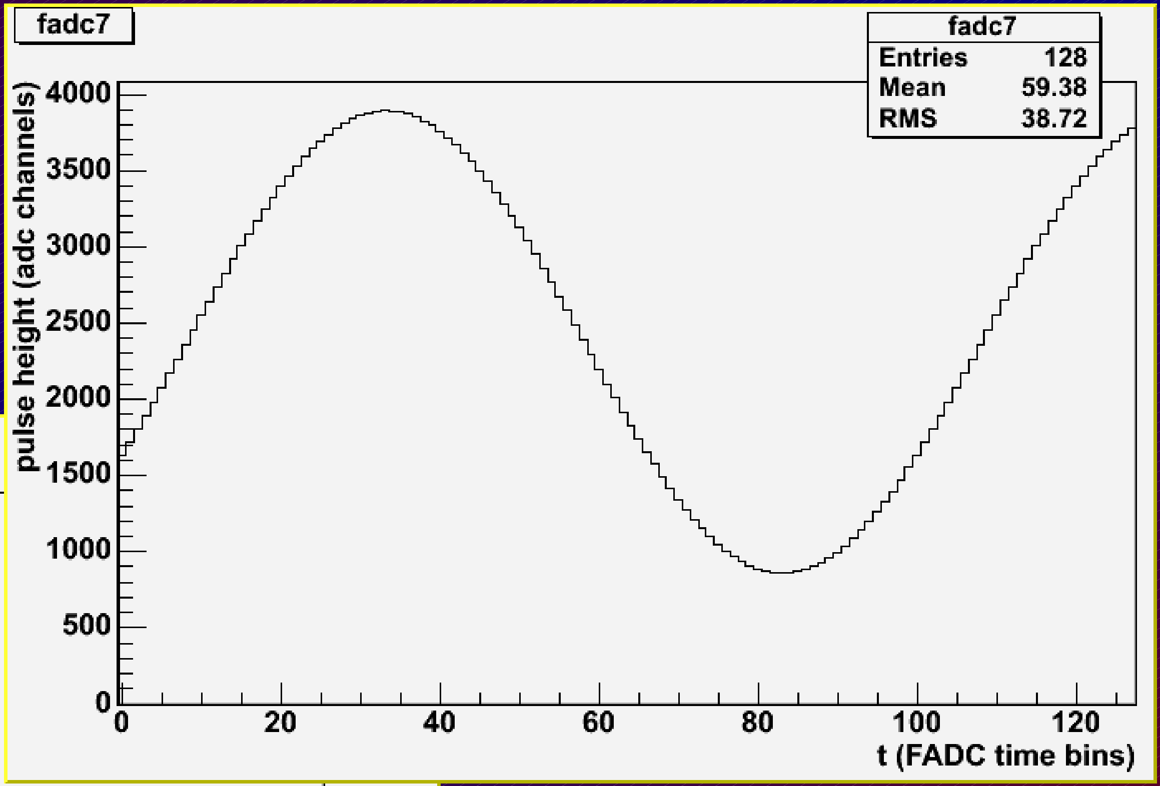
Sample Event

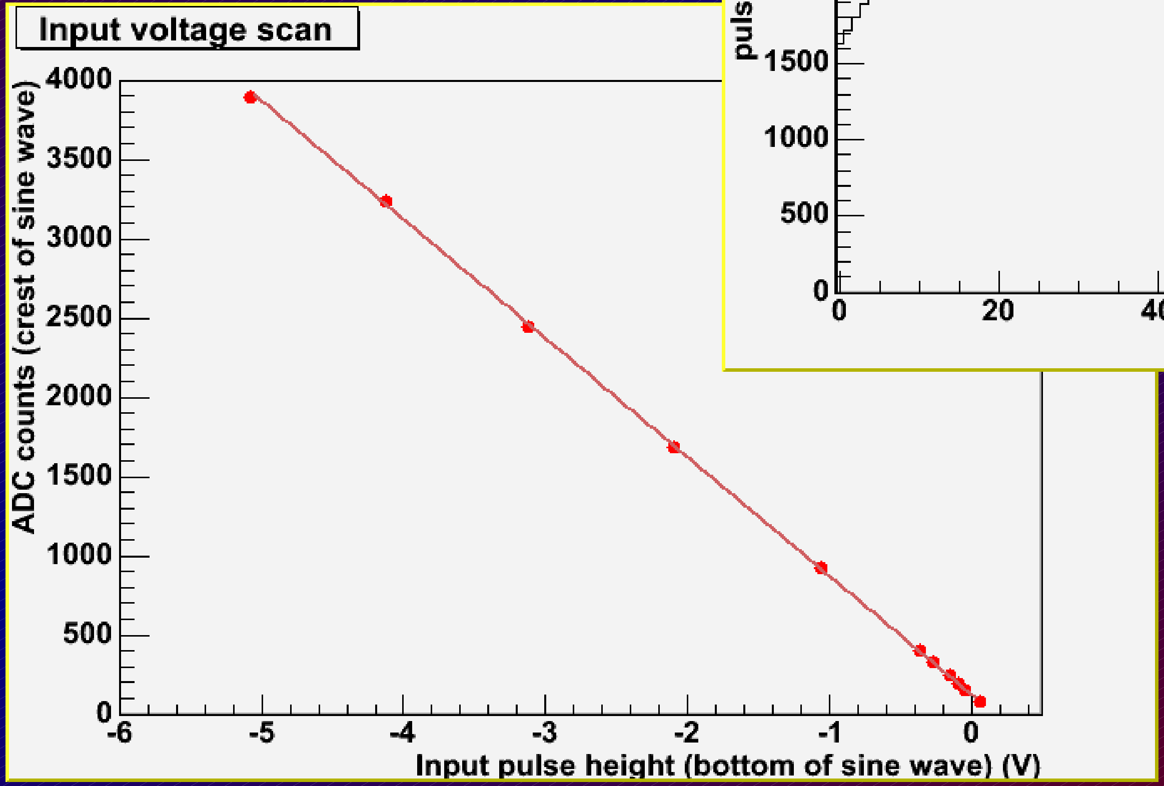
Six adjacent strips (11-16 on bottom view) read out with Flash ADCs.



Dynamic range of FADC

- Nominal input range 0 to -5 V
- 12 bit resolution
- Study with sine wave input

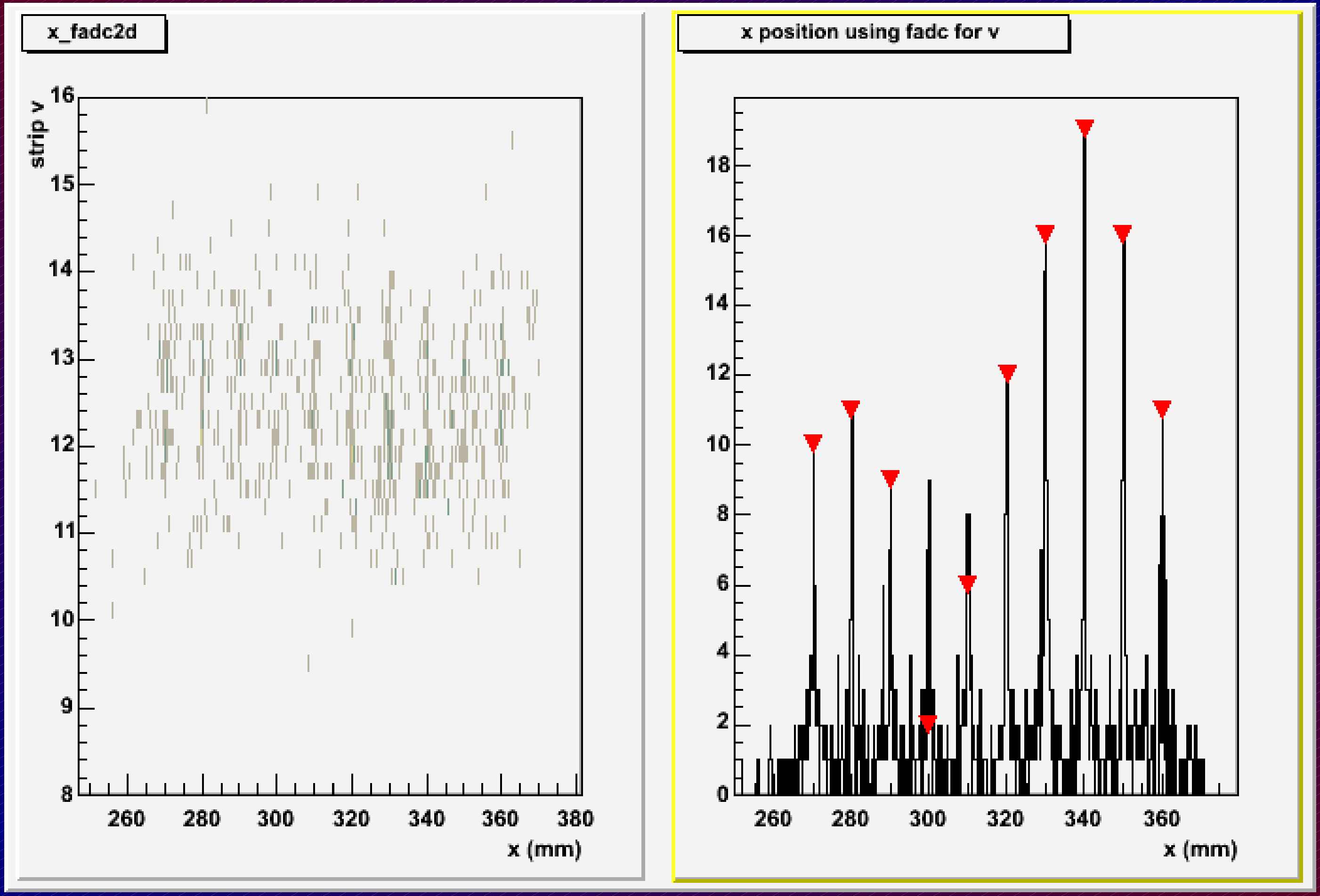




Very linear response – but we are only using a small fraction of the dynamic range...

Reconstruction of wire positions

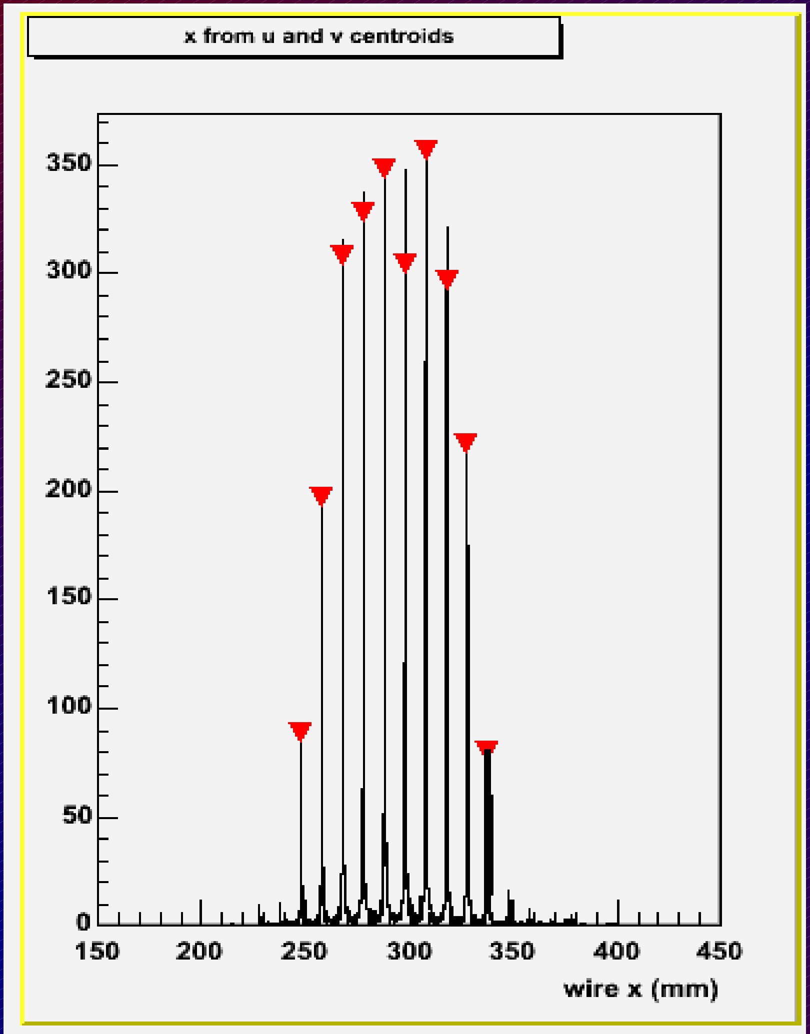
Centroid from one view using FADC, other view using CAEN ADC



Peak position (mm):	270.2	280.1	290.1	309.8	230.0	330.1	340.1	350.1	360.2
Resolution (microns):	412.7	339.6	281.7	693.5	386.0	431.9	272.6	206.2	356.3

Average resolution = 375.6 microns

Wire positions using all CAEN ADCs

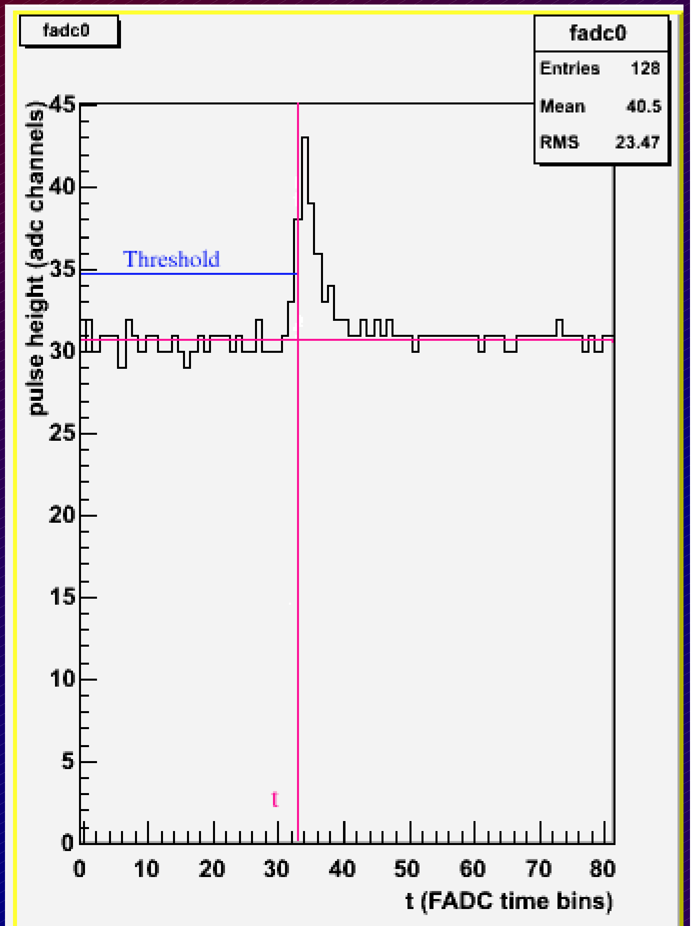


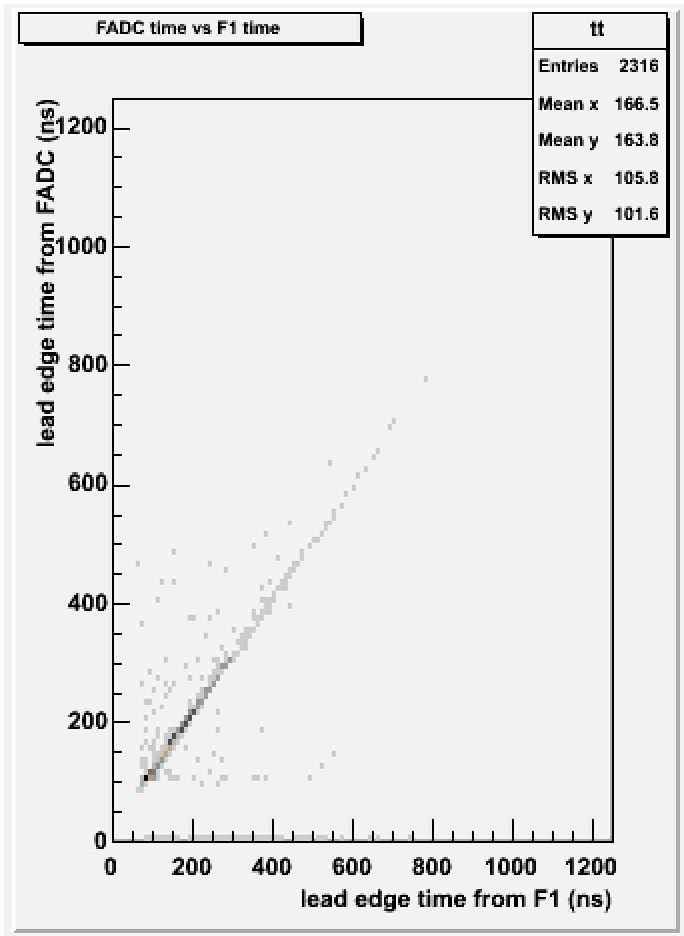
Peak position (mm)	Resolution (microns)
270.1	154.0
280.2	169.5
290.2	158.1
300.1	178.6
310.2	165.1
320.2	177.9
330.2	162.2
340.2	175.6
350.2	174.7
360.2	187.4

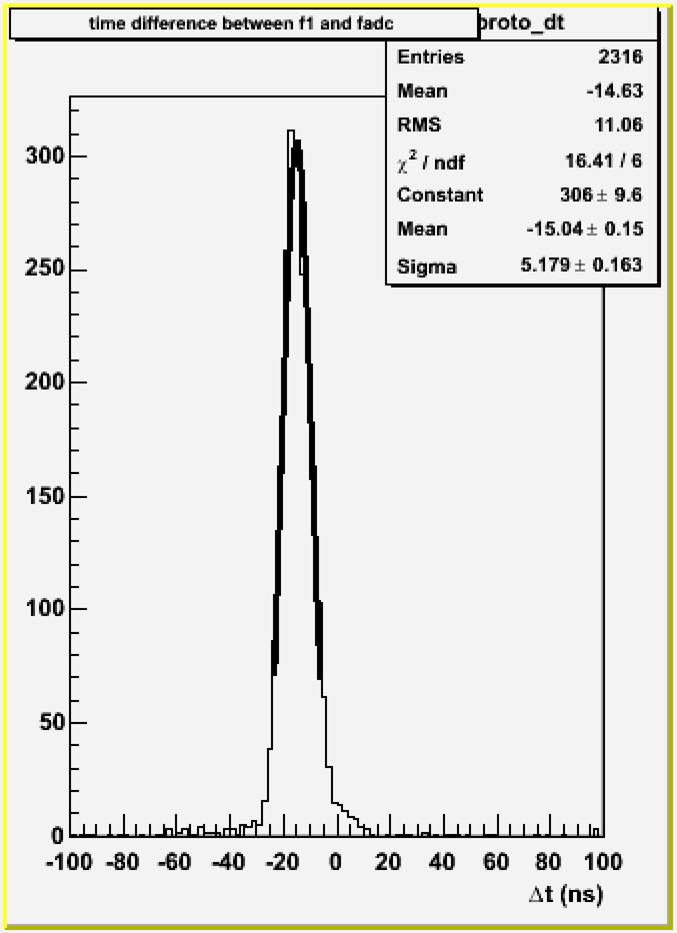
Average resolution:
170.3 microns

Leading-edge timing for Wire 11

- Flash ADC time: center of bin at which pulse height exceeds 4 counts above background.
- Compare to time from F1 TDC using leading-edge discriminator



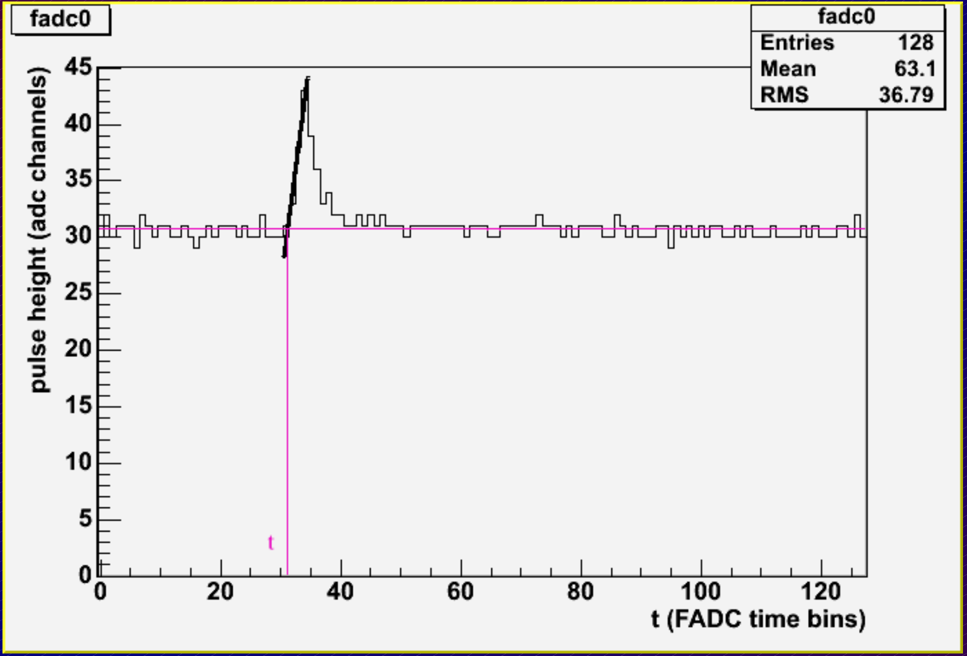


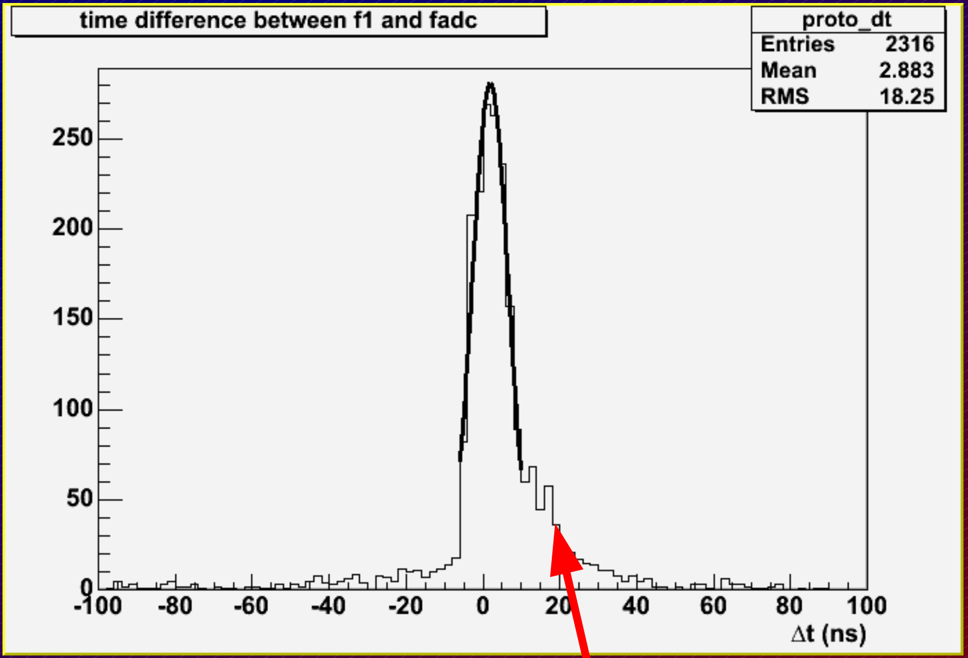


Resolution of timing peak ~ 5.2 ns...

Wire 11 timing, method 2

Linear fit starting at time bin containing maximum amplitude and 2 bins before, extrapolate to point where line crosses background level.





Asymmetric tail...

Resolution ~ 4.7 ns, no better than simple leading edge method

Cathode charge after amplification

$$\mathcal{Q} = N_{ion} \cdot F_{att} \cdot F_{ind} \cdot F_{sh} \cdot \mathcal{G}_{amp} \cdot \mathcal{G}_{gas} \cdot 1.60 \times 10^{-19}\ \mathrm{C/e.}$$

- Estimate from Sauli: $N_{ion} = 94$ ion pairs/cm (minimum ionizing particles)
- $1-F_{att}$ = fraction of drift electrons lost due to reattachment to chamber gas molecules. Assume $F_{att}=1$ (pure $ArCO_2$ gas)
- $F_{ind} = 0.5$, fraction of anode charge induced on one cathode plane
- F_{sh} = fraction of anode charge collected for a given pre-shaping time
  - Assume $F_{sh}=1$ (no pre-shaping currently used)

- Electronic amplification: assume postamps have gain of 1.

Preamp gain: $$\mathcal{G}_{amp} = 2.2\ \mathrm{mV}/\mu\mathrm{A} \cdot \frac{1}{50\ \Omega} = 44$$

Estimate of gas gain

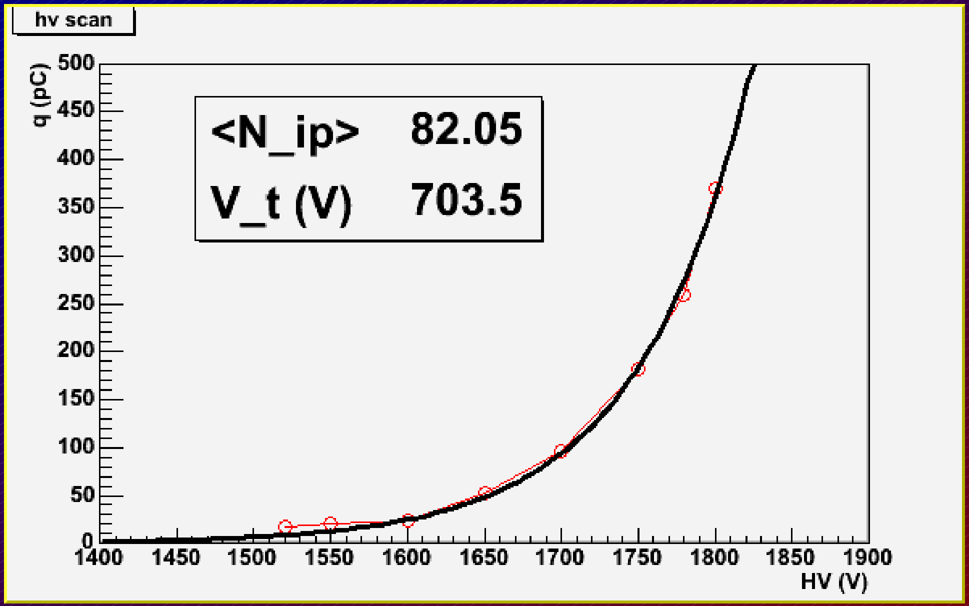
$$\mathcal{Q} = N_{ion} \cdot F_{att} \cdot F_{ind} \cdot F_{sh} \cdot \mathcal{G}_{amp} \cdot \mathcal{G}_{gas} \cdot 1.60 \times 10^{-19}\ \mathrm{C/e}.$$

Gas gain from Sauli and fit to prototype data:

$$\mathcal{G}_{gas} = \exp\left[2\sqrt{\frac{kNCV_0 a}{2\pi\epsilon_0}}\left(\sqrt{\frac{V_0}{V_T}} - 1\right)\right]$$

- V_0=operating voltage=1.8 kV
- V_T=threshold voltage

- a=0.001 cm = anode wire radius
- k=1.8 $\times 10^{-17}$ cm^2/V
- N=2.42 $\times 10^{19}$ molecules/cm^3 (30^{o}C)
- ε_0= 8.85 pF/m
- C= 8.34 pF/m



Gas gain = 4.7 $\times 10^5$

Cathode charge before amplification

$$Q_{cathode} = N_{ion}\ F_{ind}\ G_{gas} \times 1.6 \times 10^{-19}\ C = 94 \times 0.5 \times 4.7 \times 10^{5} \times 1.6 \times 10^{-19}\ C$$

$$= 3.53\ pC$$

(after preamp/postamp = 155.3 pC)

Assuming that most of charge is distributed over 3 adjacent strips:
Estimate for “typical” charge on a strip for single tracks = 1.18 pC