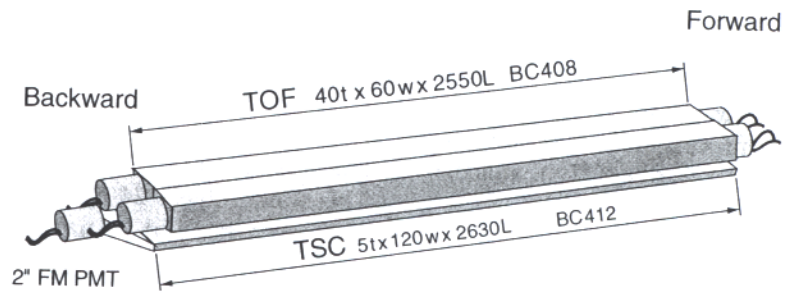


Jan. 2004

M. Jones



# Belle TOF Calibration and Systematics

TOF performance on muons over 4 years

- PMT gain expected to be OK for 40 years, preamps changed Summer 2003
- 1 dead TSC PMT out of 64 + 1 very bad TOF PMT out of 256
- linear decrease in atten. length with time -> 180 cm in 2006
- linear increase in time resol. with time -> 110 ps for muons in 2006
- mystery of sudden TOF timing shifts and resolution changes
- high-momentum muon systematics less than 15 ps after calibration
- small excess at negative  $\Delta t$  values seen - muons near gaps

study of hadron systematics using HadronC,  $D^*$ , and 2-photon events

Why is hadron time resolution 15 ps worse than muon time resolution?

- non-Gaussian tails seen for high momentum tracks in  $D^*$  events
- non-Gaussian tails seen for low momentum tracks in HadronC events

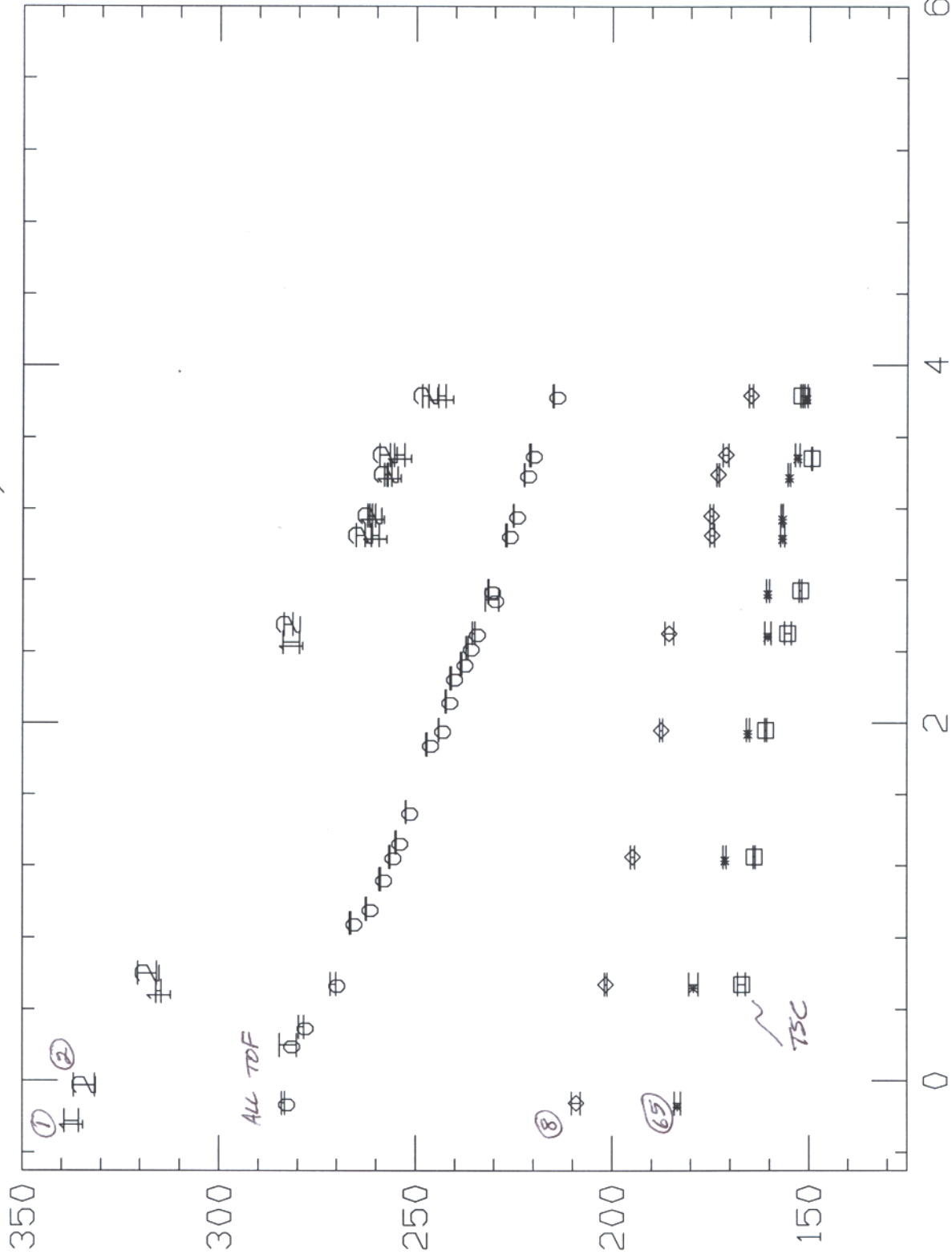
3 effects associated with non-Gaussian tails

- tracks hitting near gaps between TOF counters (4% for  $\mu$ , 26% for  $\pi$ )
- tracks with inconsistent Z values (3% for  $\mu$ , 6% for  $\pi$ )
- tracks with hits in adjacent TOF counters (7% for  $\mu$ , >40% for  $\pi$ )
- excess at positive  $\Delta t$  associated with large ADC values

comparison with pions and muons in 2-photon events

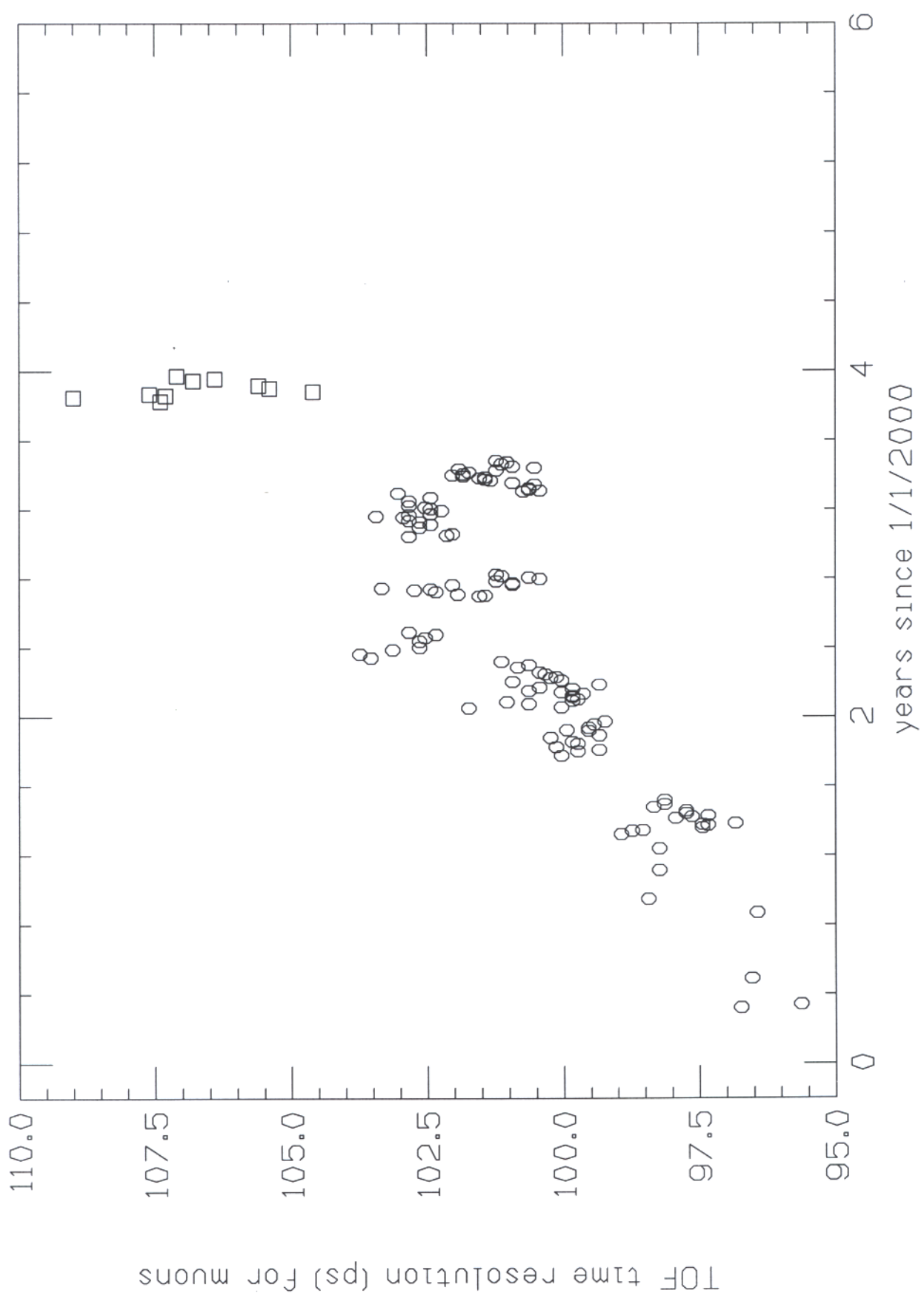
- $\pi$  and  $\mu$  resolutions comparable for  $P > .8$  GeV/c in 2-photon ev.
- resolution for  $\pi$  in HadronC ev. 5-10 ps worse than for  $\pi$  in 2-photon ev.
- systematic time offset for  $\mu$  with  $P < .8$  GeV/c

# TOF & TSC atten. length versus time

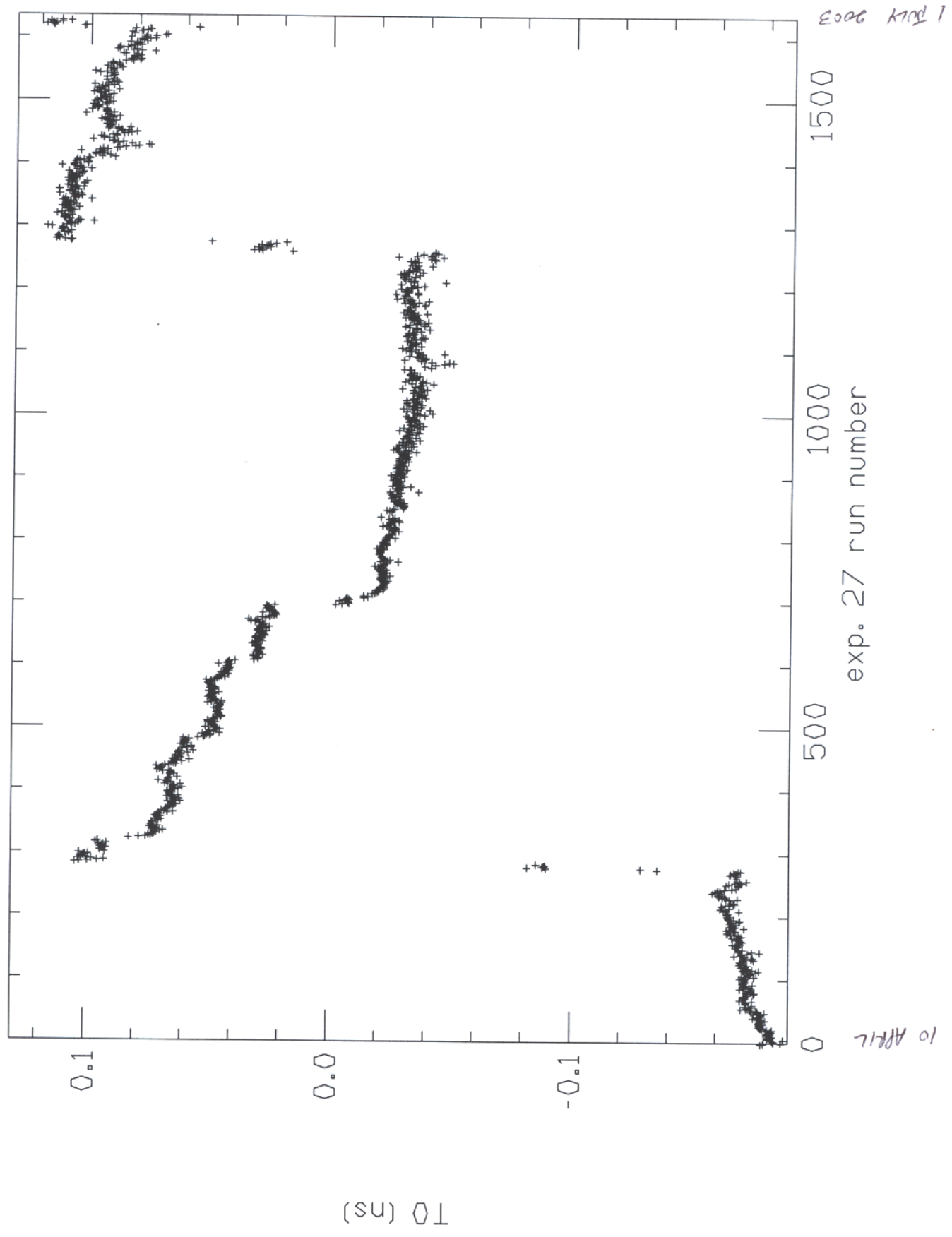


years since 1/1/2000

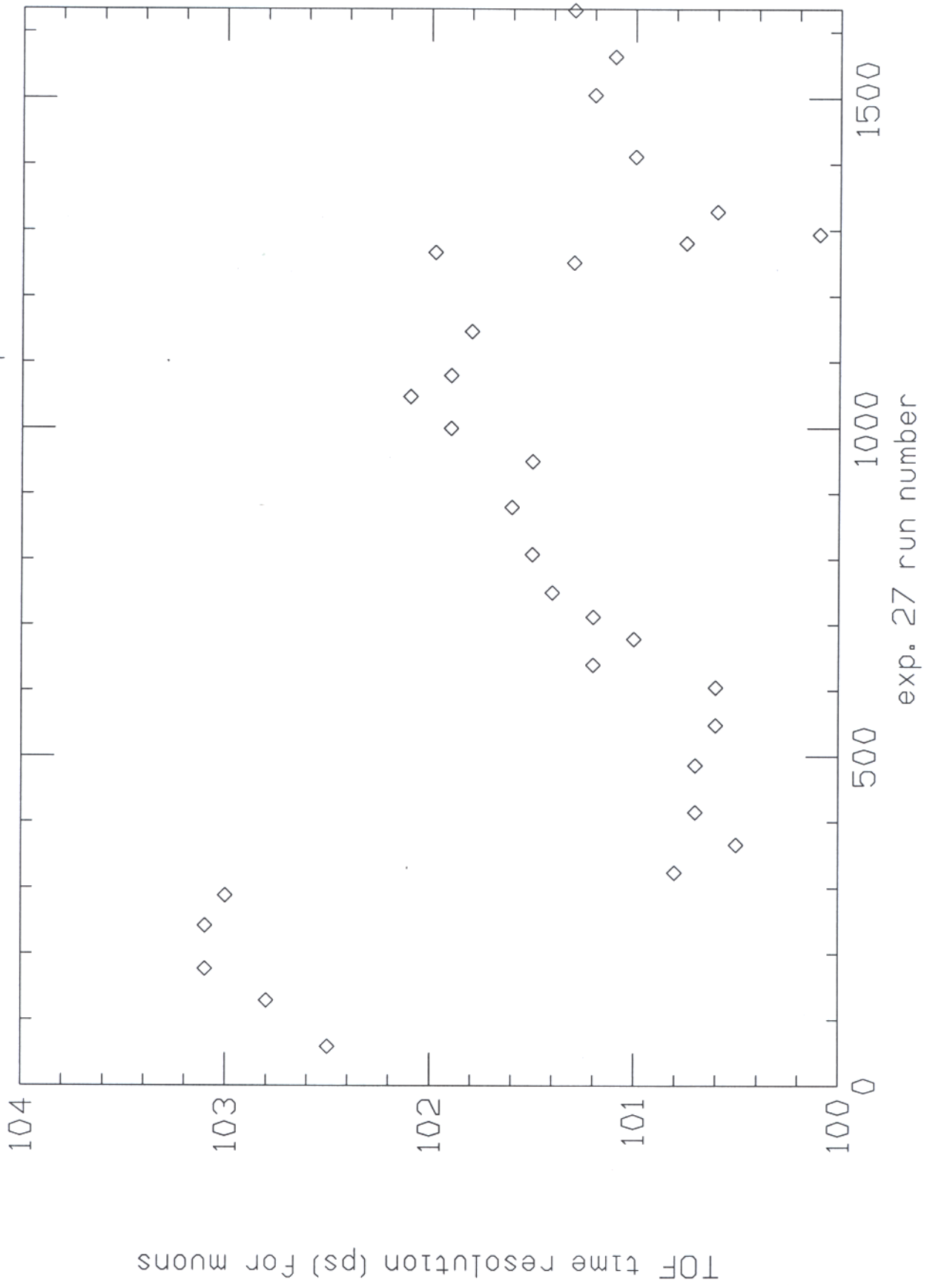
# TOF calibration results



T0 versus run



# TOF calibration results for April-June 2003



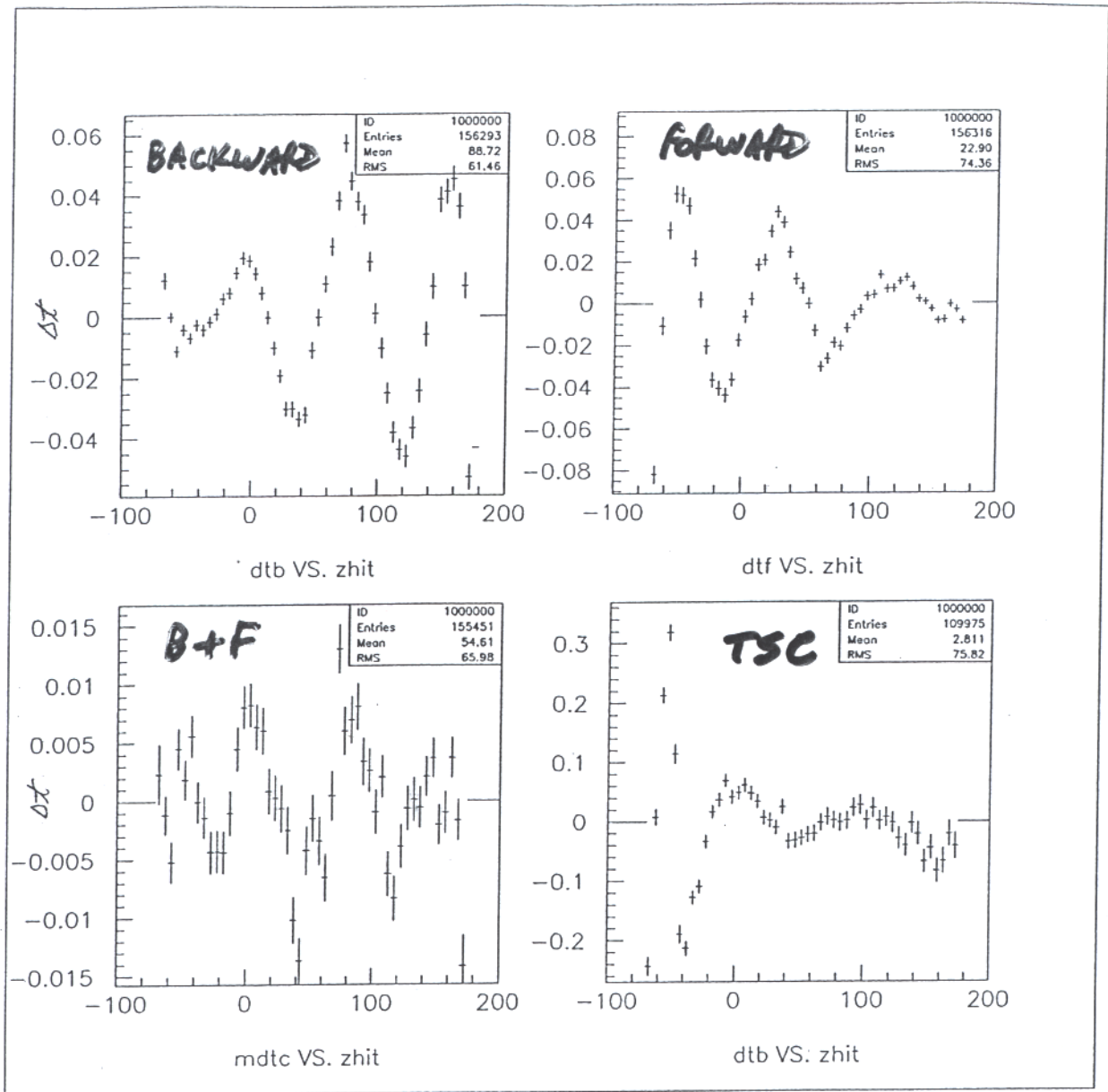


FIG. 2:  $\Delta t$  (ns) as a function of  $z$  (cm) for muons after calibration for the fifth order polynomial function. The  $\Delta t$  is defined as a time difference  $t_{corr} - t_{\mu}$ , where  $t_{\mu}$  is the predicted time of flight of the  $\mu$  track calculated from CDC track parameters and  $t_{corr}$  is the corrected measured time after the calibration. The upper plots are for the TOF backward (left) and forward (right) PMTs; the lower left plot is for the TOF weighted average time. The lower right plot is for the TSC PMTs. The plots are for the data in exp. 19.

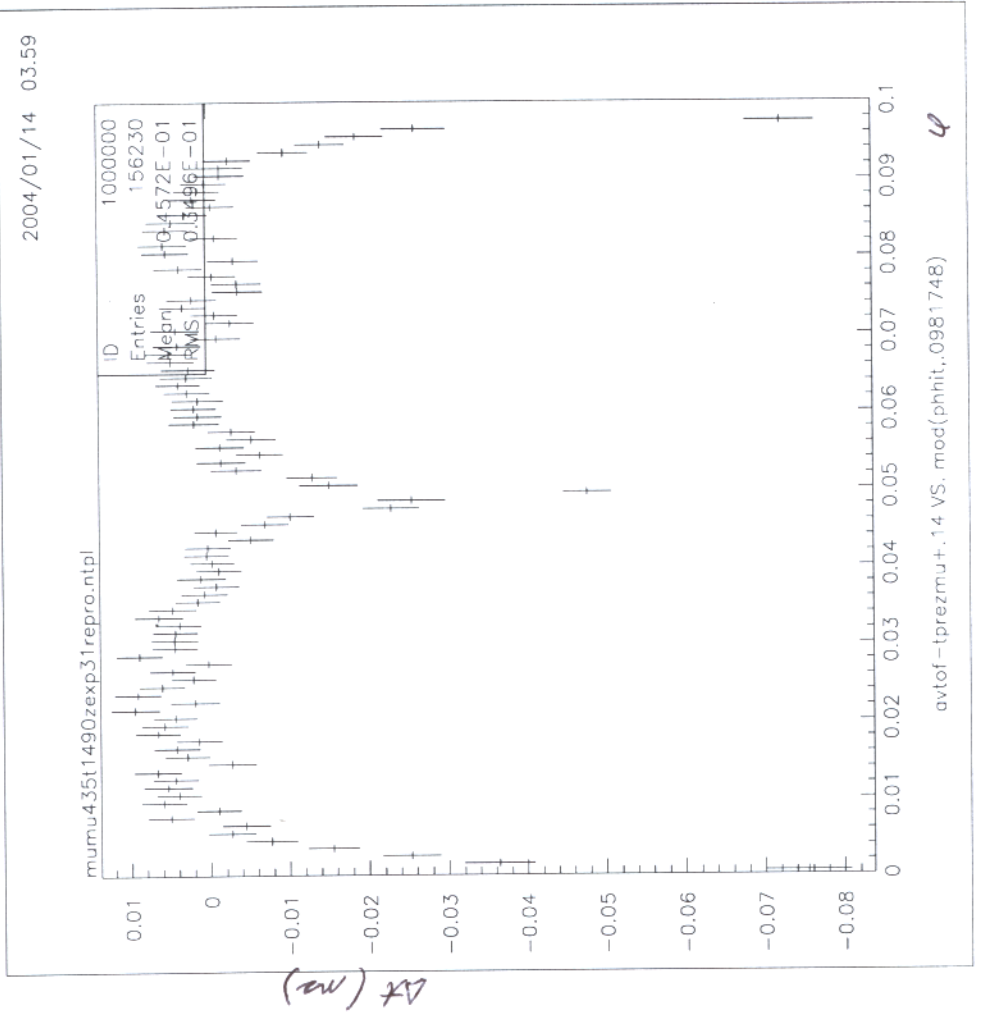
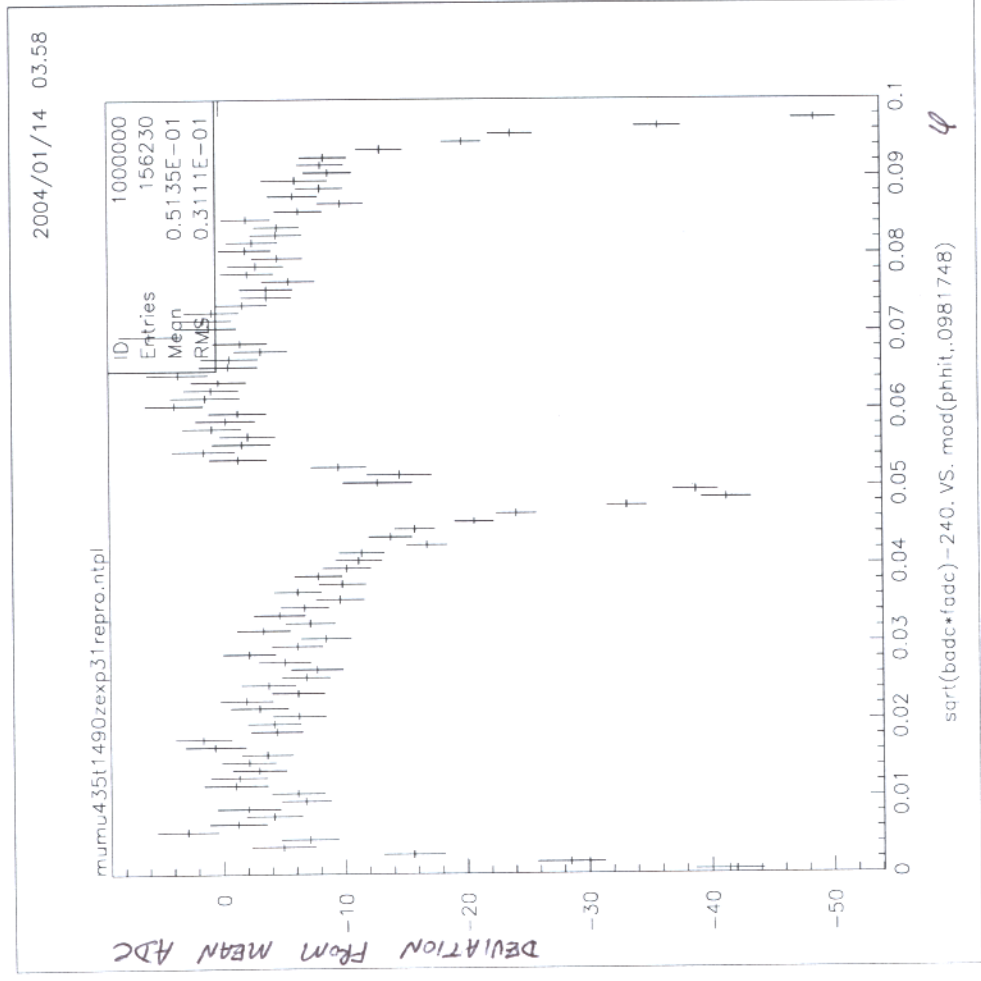
### B. Time Walk Calibration

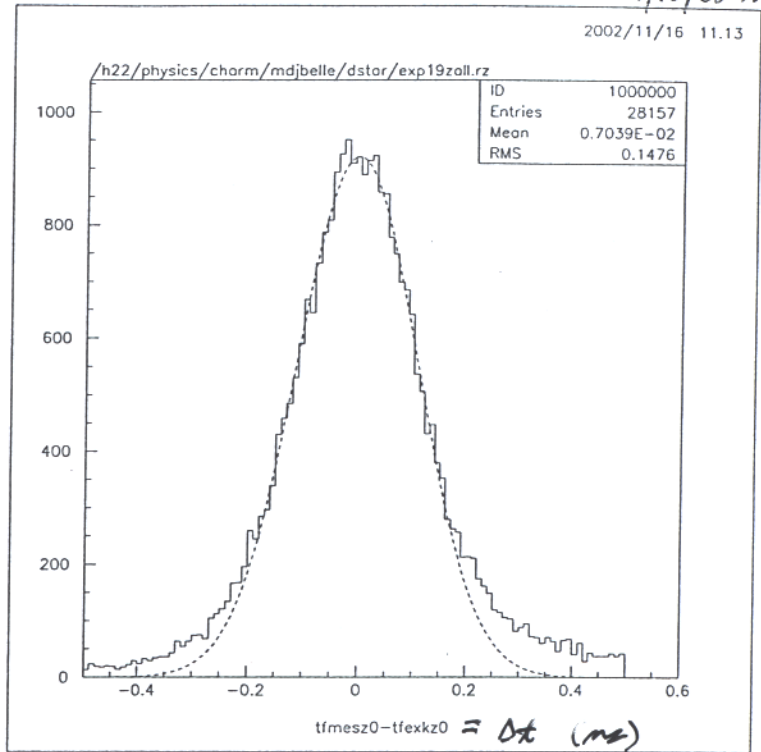
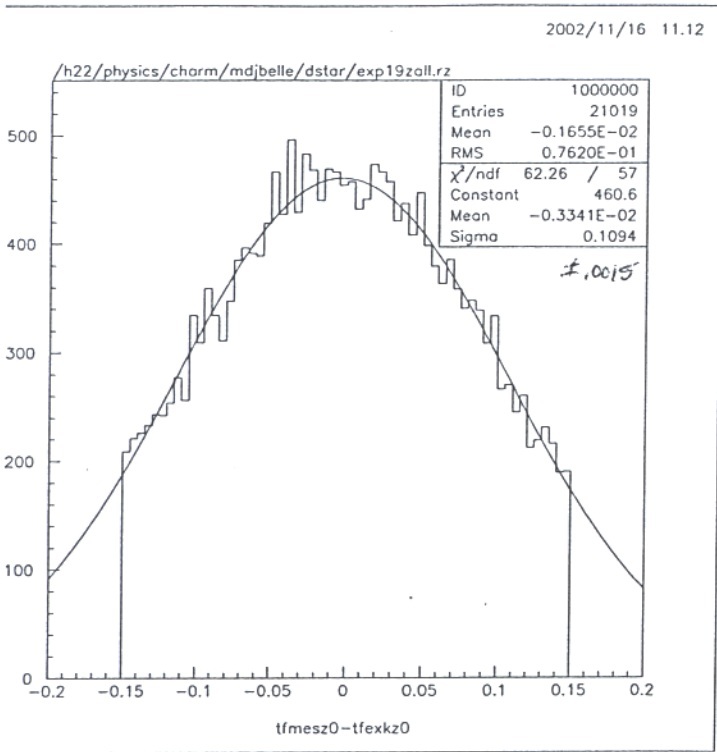
After run-by-run T0 values are determined and installed into the T0 database, a calibration of the TOF and TSC counters is done using dimuon events. Typically, a calibration uses 50-100 runs and 2000 muons per TOF counter. The TOF forward and backward PMTs and the TSC PMTs are fit independently. The first step in the calibration is a two-dimensional fit to the time difference  $\Delta t$  defined by

$$\Delta t = T_{raw} - T_{pred} - \frac{z}{v(i)} - S(i)/\sqrt{q} - t(i) \quad (1)$$

*From EXTRAPOLATION TO TOF*

where  $T_{raw}$  is the raw measured time from the PMT,  $q$  is the pulse height value from this PMT,  $T_{pred}$  is the flight time predicted for the muon hitting the TOF,  $z$  is the displacement along the TOF/TSC scintillator (-72.5 cm to 182.5 cm for TOF counters),  $v(i)$  is the effective





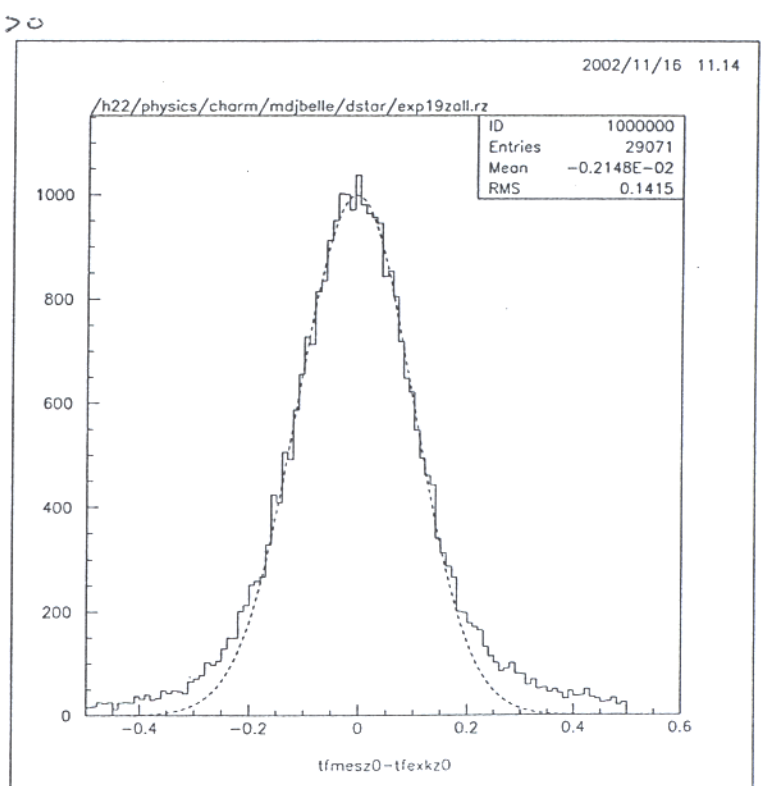
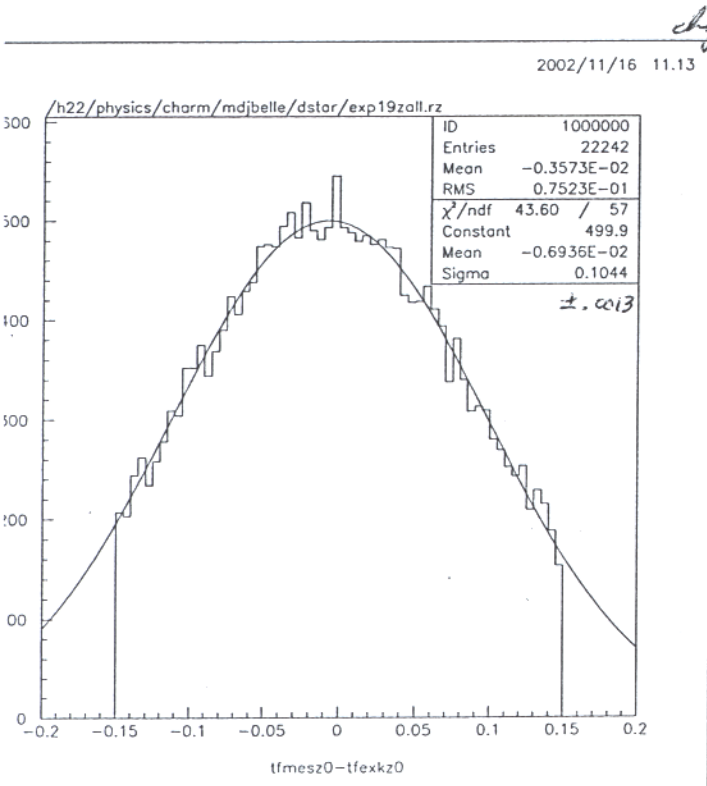
$dk - \phi < 0$

# Exp. 19 DA EV.

$|\Delta t_{mes} - \phi - \Delta t_{ex} - \phi| < 1.5$

$\Delta t_{mes} - \phi \neq 1.5, \Delta t_{ex} - \phi > 1.3$

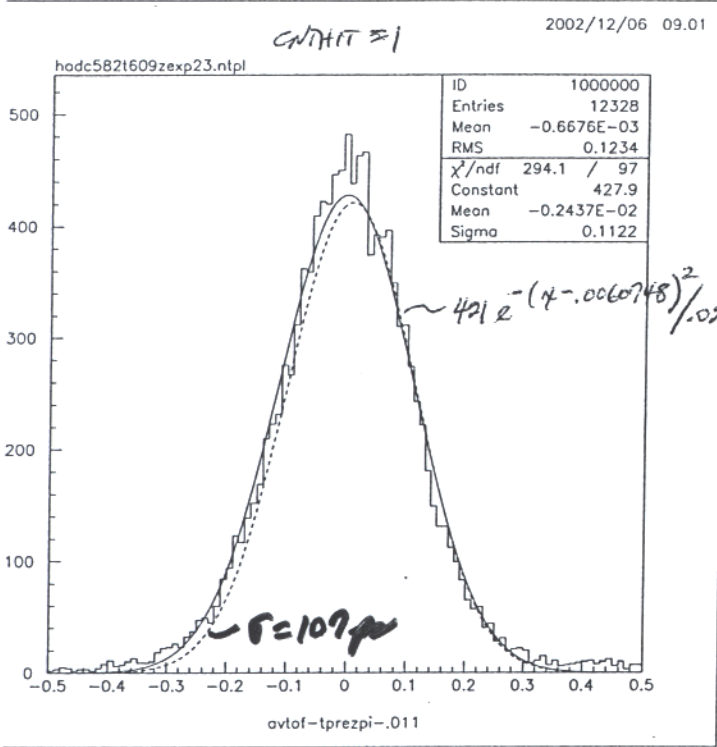
$|\Delta t_{mes} - \phi - \Delta t_{ex} - \phi| < 1.5$



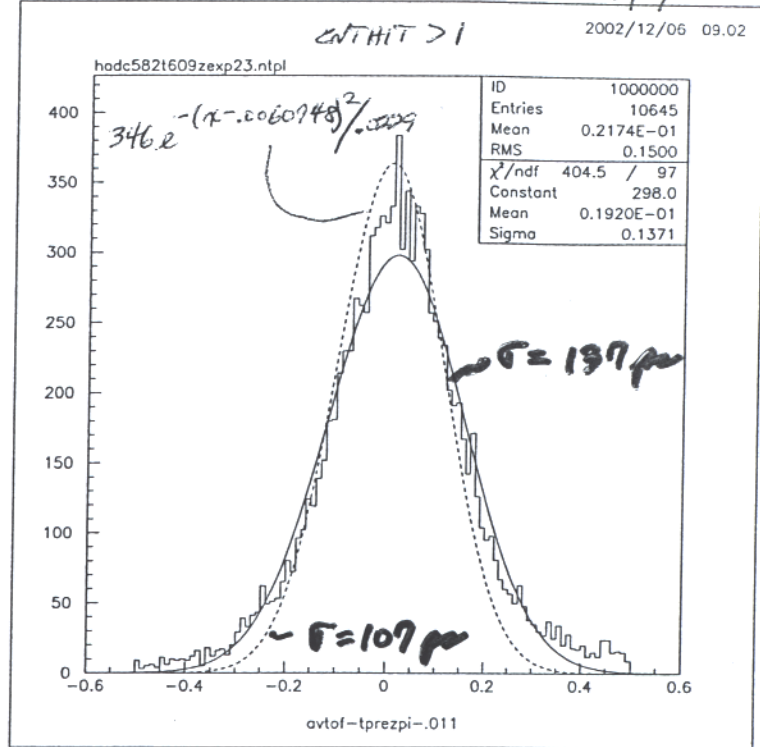


EXP. 23  $\pi^\pm$  .3 < p < .8 GeV/c

12/5/02 a



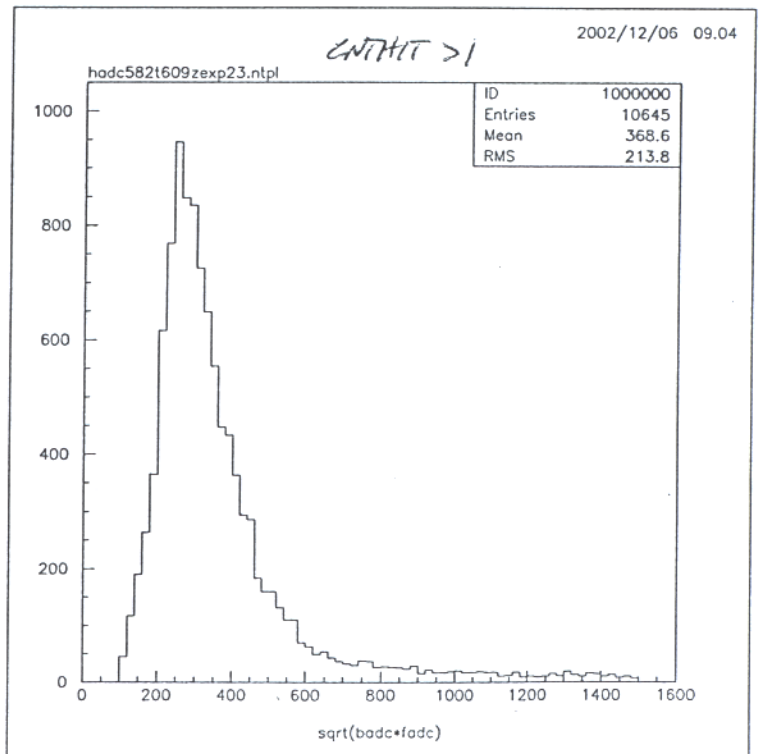
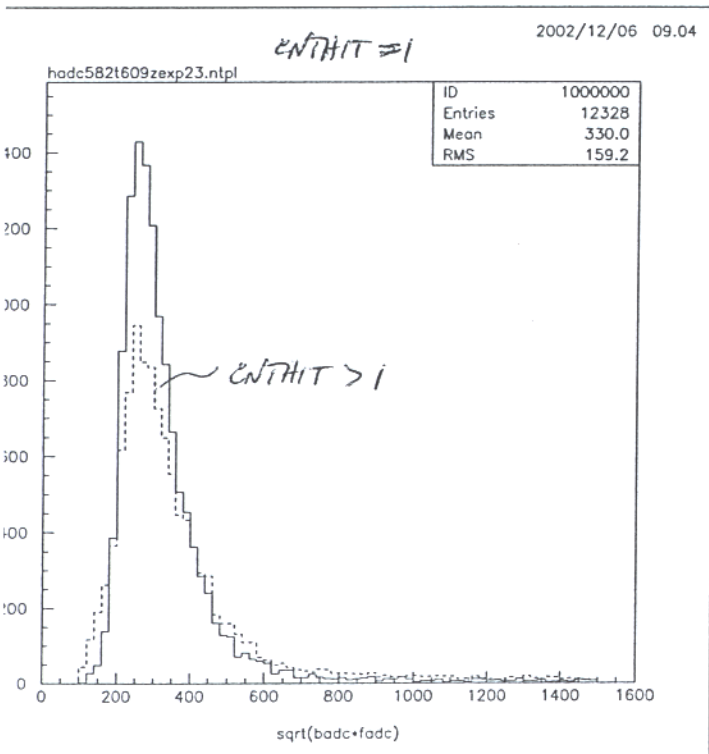
NO ADJACENT HITS



3 1 ADJACENT HIT

$\sigma_1, |dx| < .5, .3 < |p_{trans}| < .8, |p_{w-h} - p_{w-p}| > .5, \sqrt{\text{index} \cdot f_{dc}} < 1500, .001 < \text{mod}(\text{ghit}, .0490894) < .04$

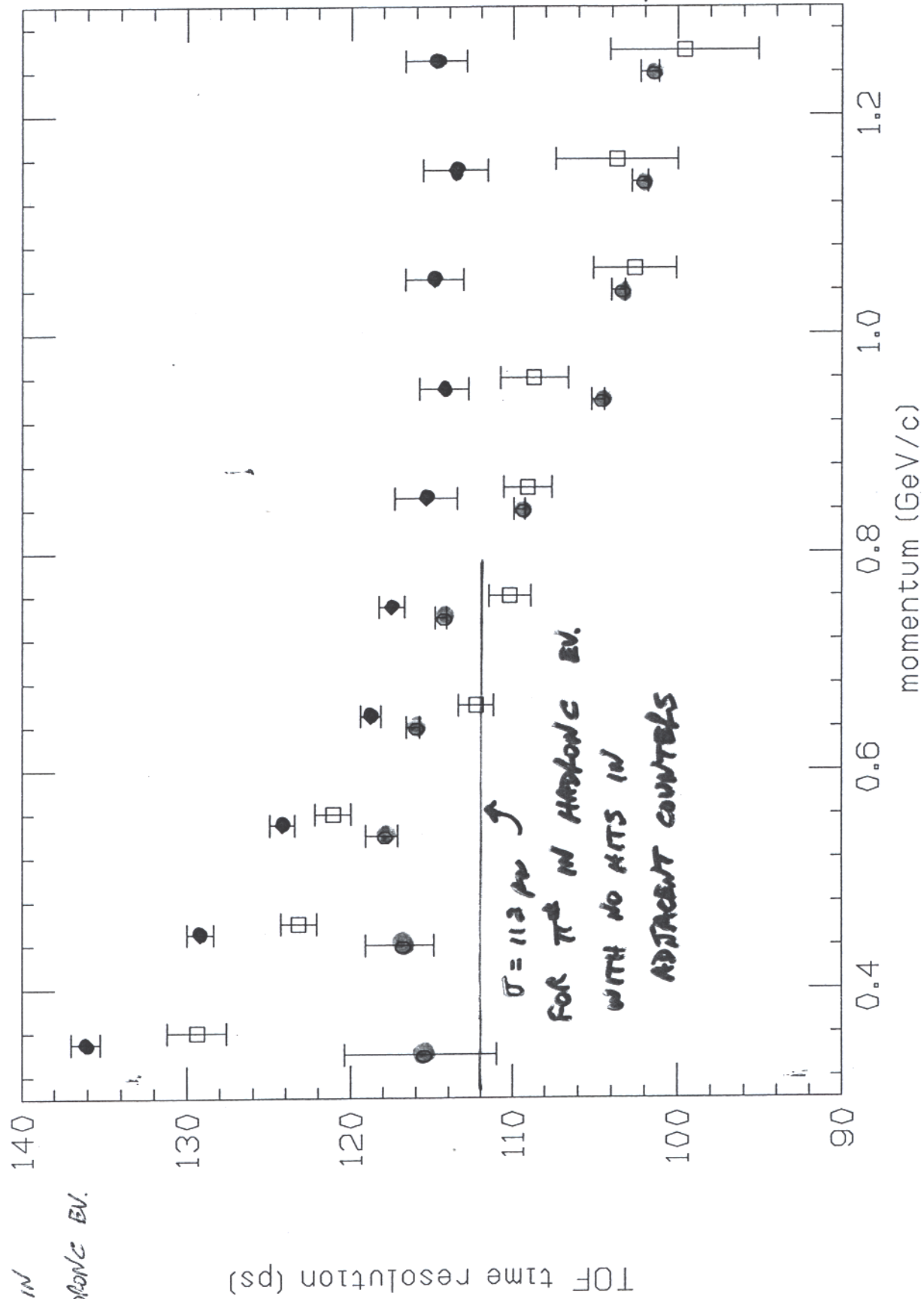
(102 | 410) → CONSISTENT 2'S



●  $\mu^+$  IN 2-8 EV.  
 □  $\pi^+$  "  
 ●  $\pi^+$  IN  
 HADRONIC EV.

3/4/03

TOF time resolution versus momentum for positive particles



Jan. 2004

# Belle TOF extrapolation to $10^{35}$

extrapolation of present TOF performance

TOF online hit rate increase to 10 MHz from .22 MHz

TOF background rate increase to 2 MHz from .15 MHz

TOF inefficiency increase to 10% from 4%

How will higher hit rate affect event T0 determination?

How will higher hit rate affect time resolution?

How will timing stability be affected?

Will continuous injection give comparable efficiencies and resolutions?

new segmented TOF with 1 m length scintillators

faster readout to reduce deadtime to 100 ns from 300 ns

(K. Inami and H. Kichimi at Sept. 2003 Shuzenji Workshop)

