Status Update:

PRECISE MEASUREMENT OF THE $\pi^+ \to \pi^0 e^+ \nu$ DECAY RATE

The PIBETA Collaboration

- Brief review of experiment
- Current status: data and simulation
- Beam request for 2001 and near term plans

PSI, 6 March 2001

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MOTIVATION

Provide precision tests of Standard Model and QCD predictions:

- $\pi^+ \to \pi^0 e^+ \nu_e$ – main goal
  - SM tests from CKM unitarity

- $\pi^+ \to e^+ \nu_e \gamma(ee)$ – included in main run
  - F_A/F_V, π polarizability (χPT prediction)
  - tensor coupling besides $V-A$

- $\mu^+ \to e^+ \nu_e \bar{\nu}_\mu \gamma(ee)$ – included in main run
  - departures from $V-A$ in $\mathcal{L}_{\text{weak}}$

- $\pi^+ \to e^+ \nu_e$ – 2nd phase
  - e-μ universality
  - pseudoscalar coupling besides $V-A$
  - massive neutrino, Majoran, ...

New calculation of pion beta decay radiative corrections in the light-front quark model

W. Jaus, Phys. Rev. D **63** (2001) 053009,

applied light-front quark model to the pion to determine structure-dependent axial-current radiative corrections.

Total RC for pion beta decay:

$$\delta = (3.230 \pm 0.002) \times 10^{-2} \ .$$

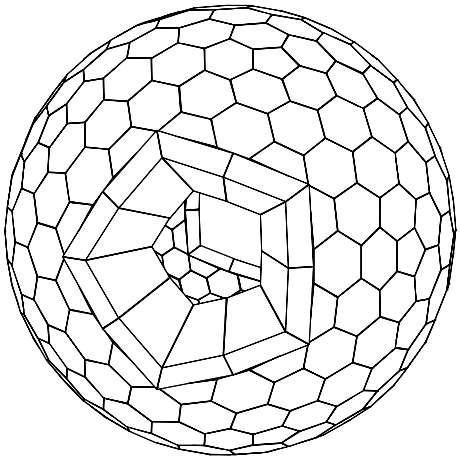
Using nuclear β decay data as input Jaus finds:

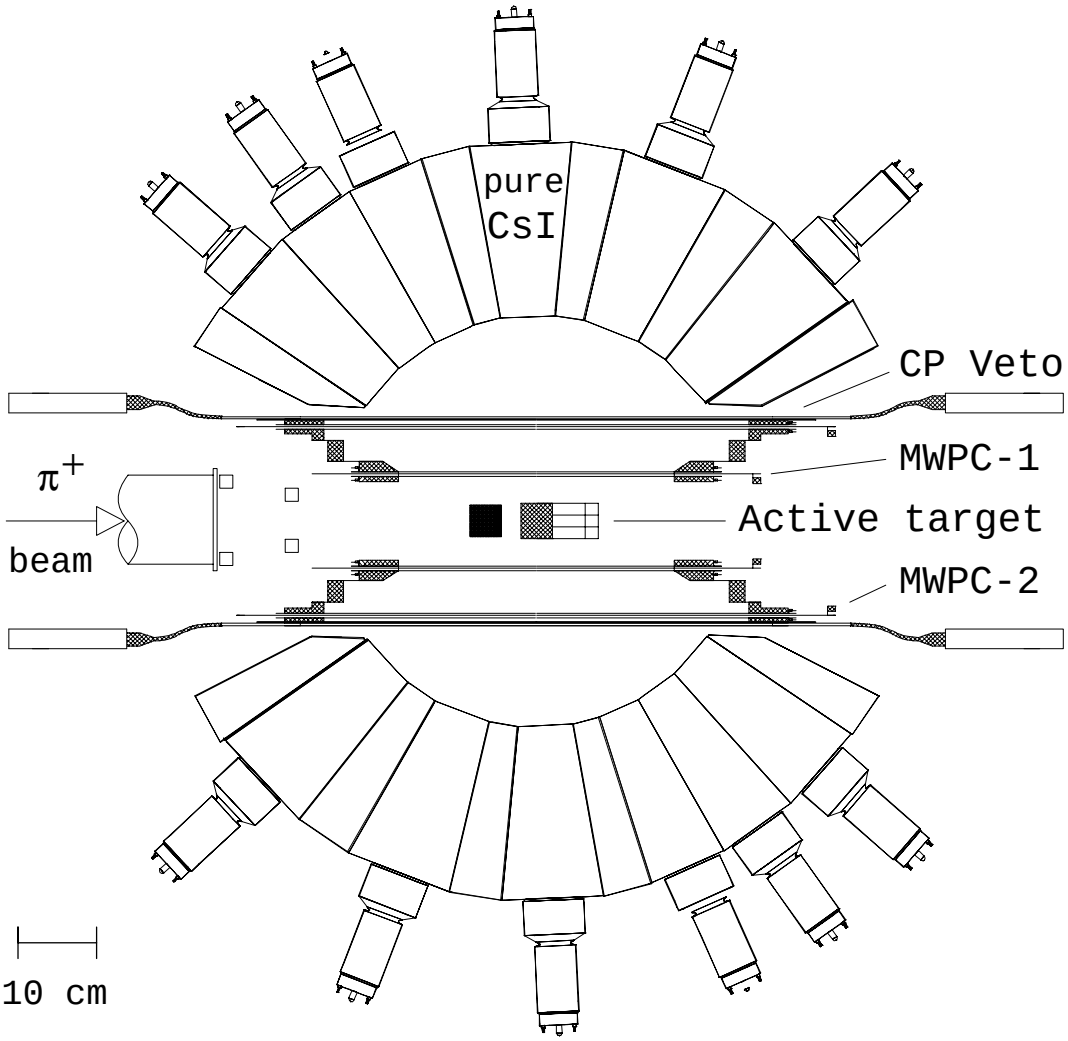
$$V^2 = 0.9956 \pm 0.0011 \ ,$$

i.e., about 4σ violation of unitarity.

PIBETA experiment:

- stopped π^+ beam
- segmented active tgt.
- 240-elem. CsI(p) calo.
- central tracking
- digitized PMT readout
- cosmic μ antihouse
- stable temp./humidity





Main activities in 2000:

- took data at the design π^+ stopping rate of $\sim 0.9\,\mathrm{MHz}$,

- implemented automated routines for detector gain matching and timing offset adjustment,

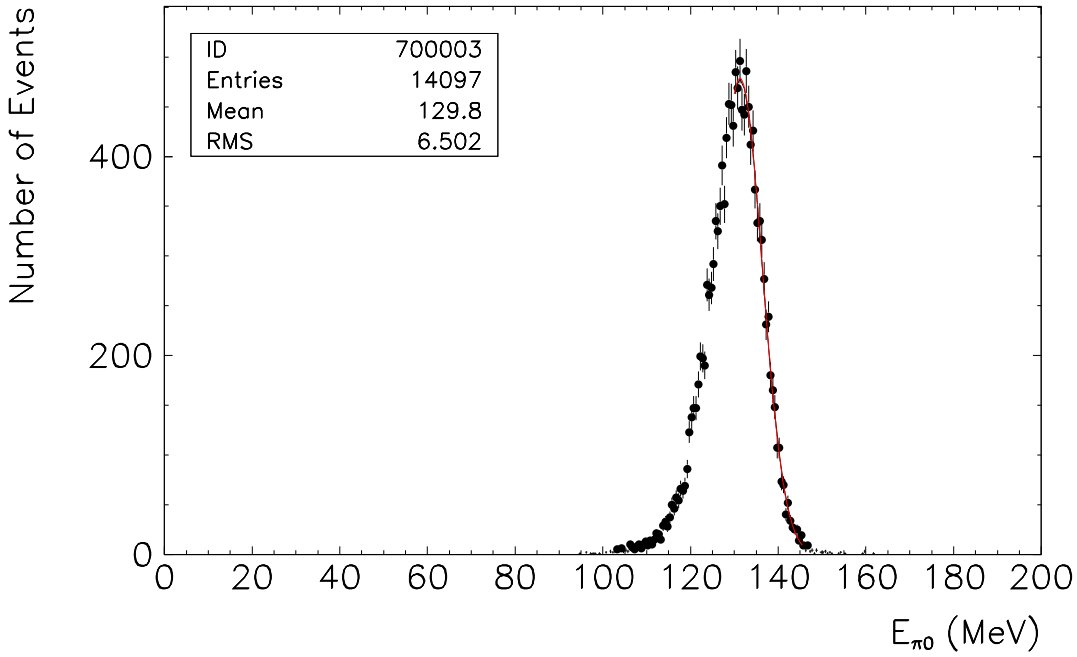
- implemented the DSC sampling readout for all PMT signals, incl. CsI,

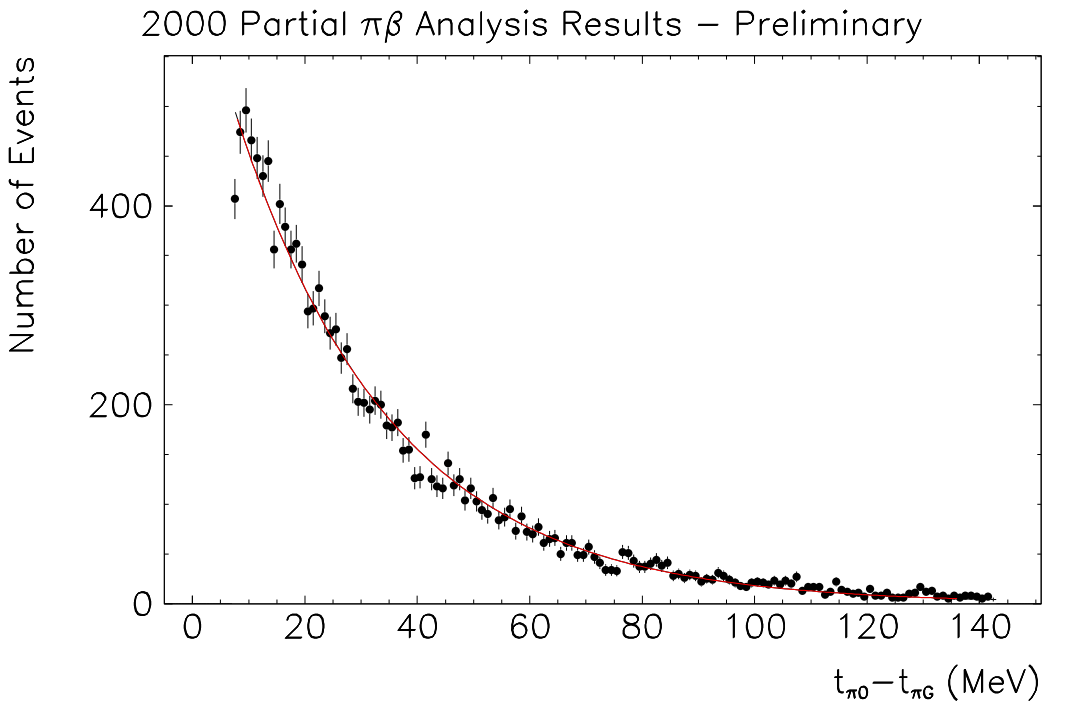
- implemented near-100% run control automation,

- run a series of measurements for calibration of experimental systematics.

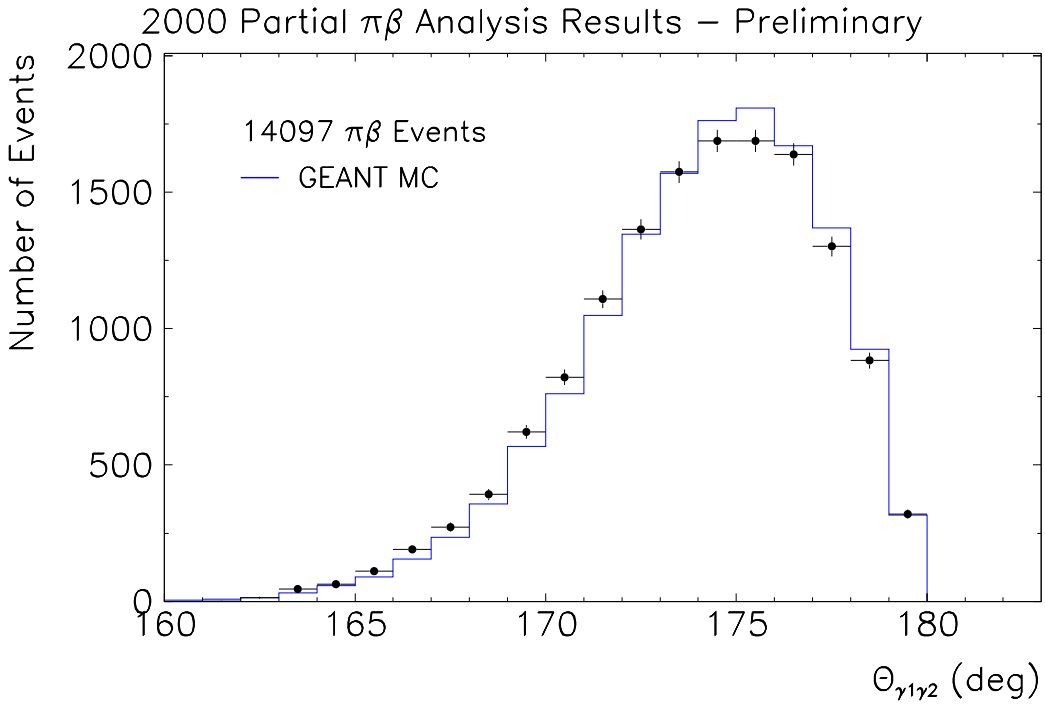
DETECTOR PERFORMANCE

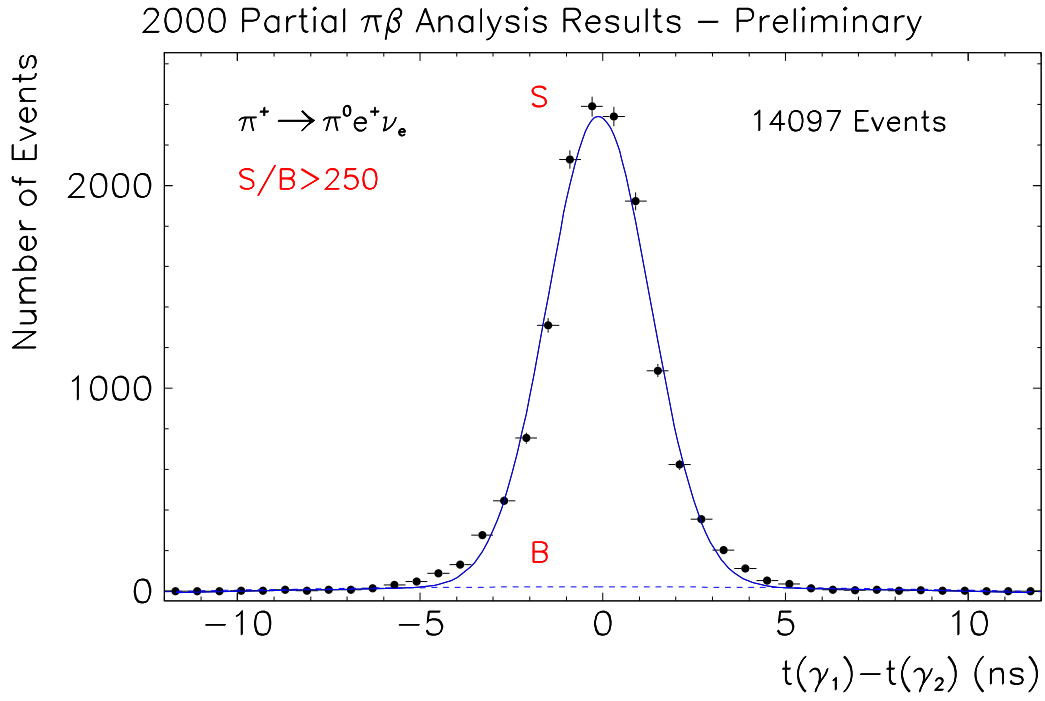
1999/2000 RESULTS: $\pi^+ \to \pi^0 e^+ \nu$



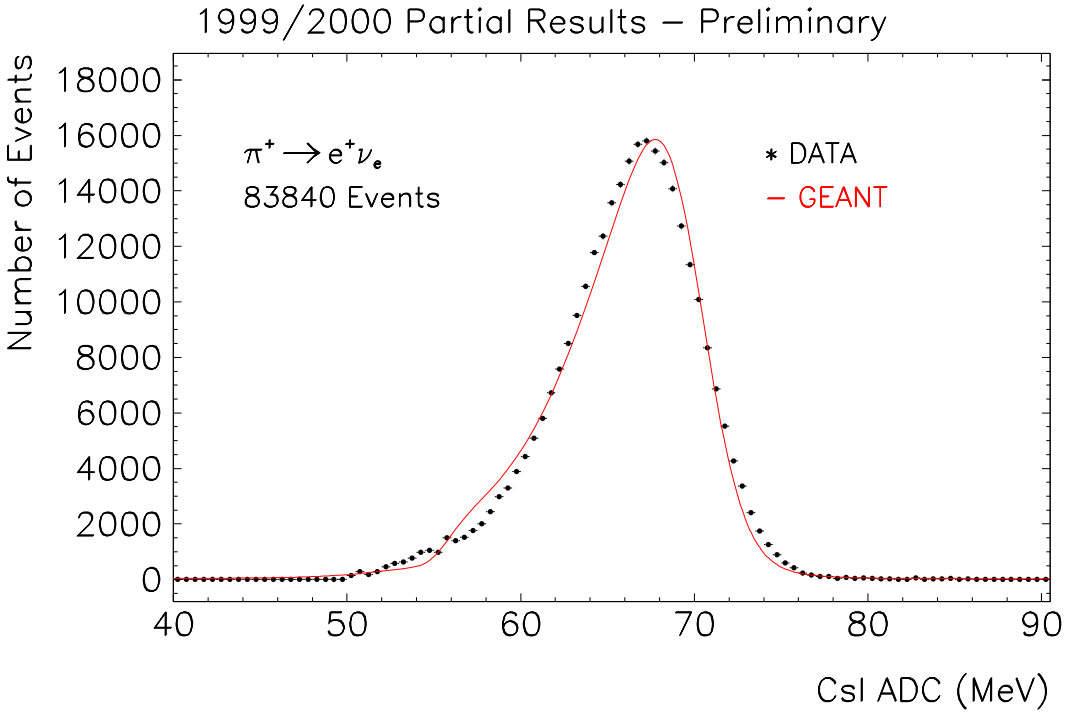


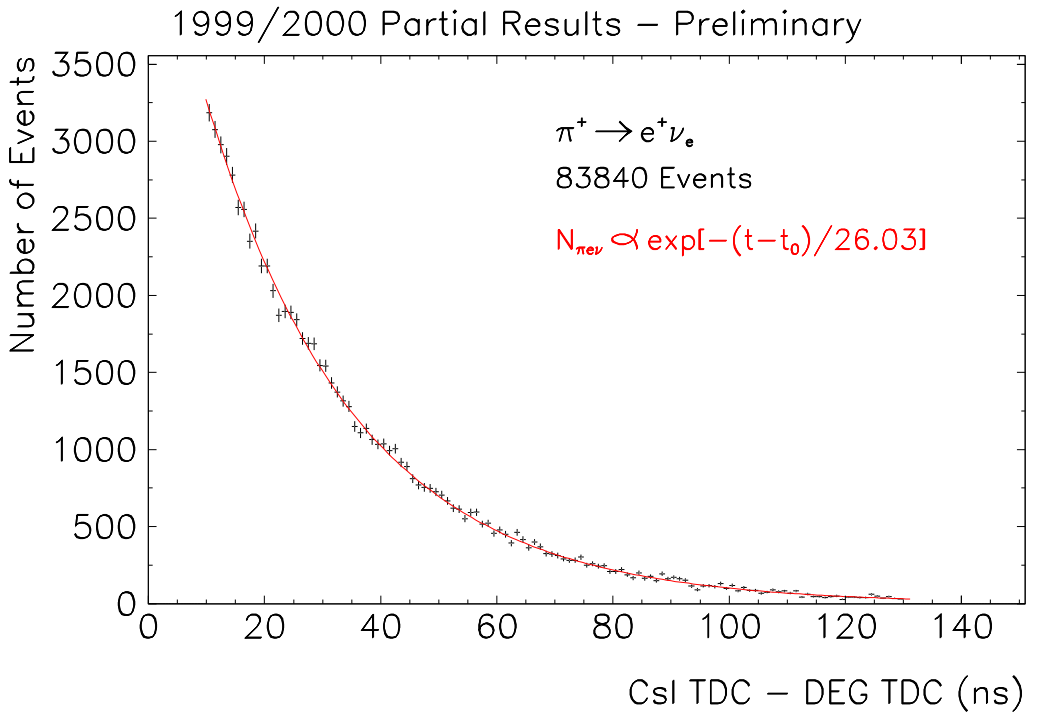
1999/2000 RESULTS: $\pi^+ \to \pi^0 e^+ \nu$



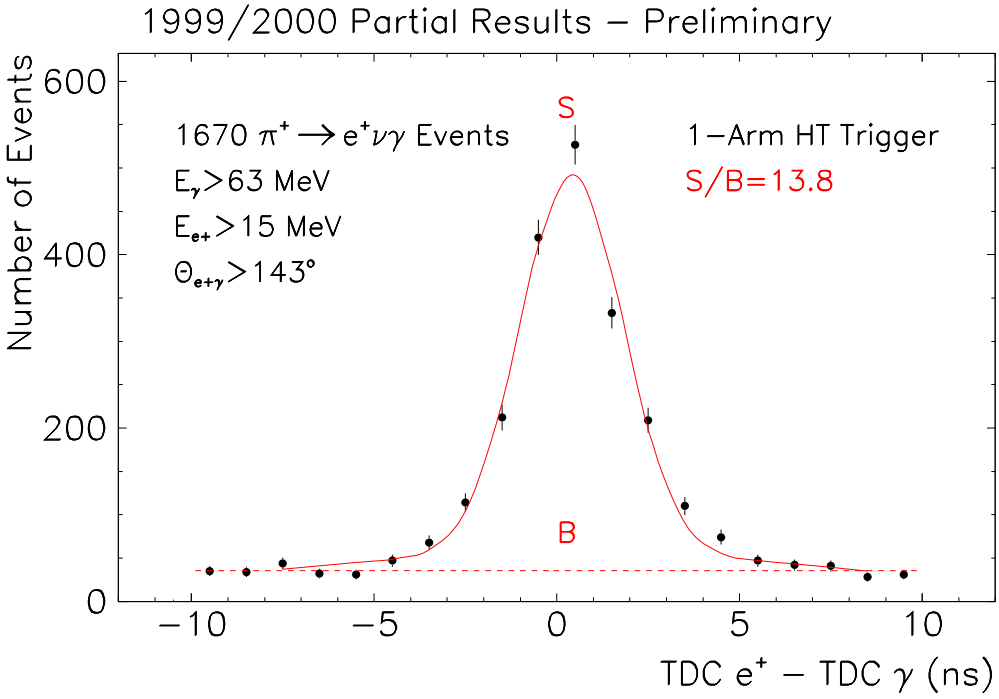


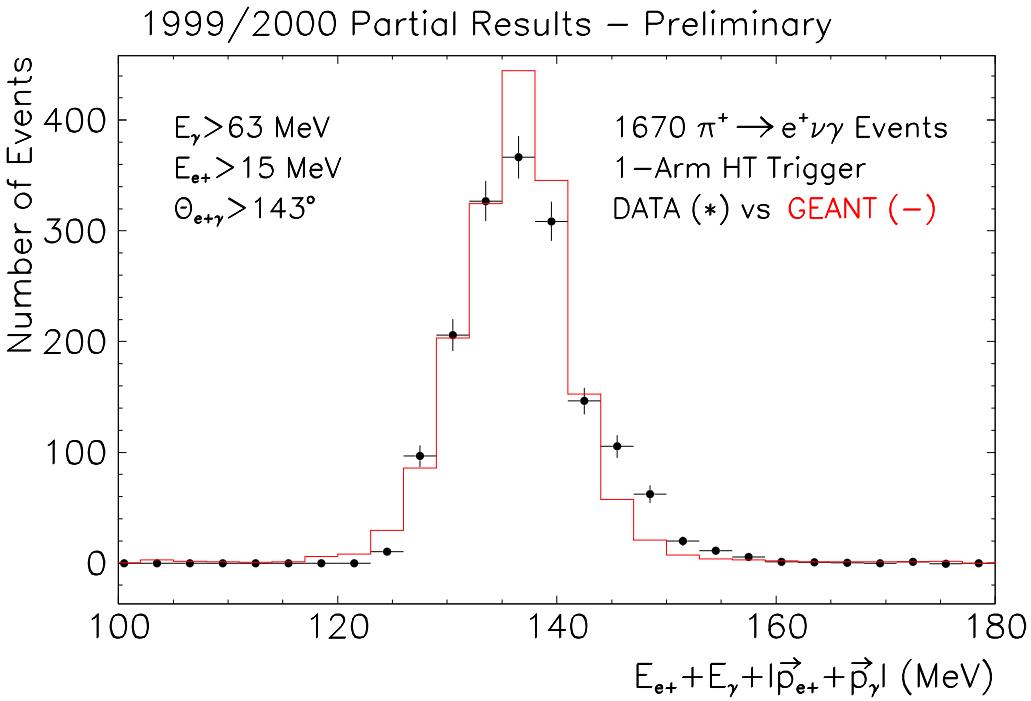
1999/2000 RESULTS: $\pi^+ \to e^+\nu$



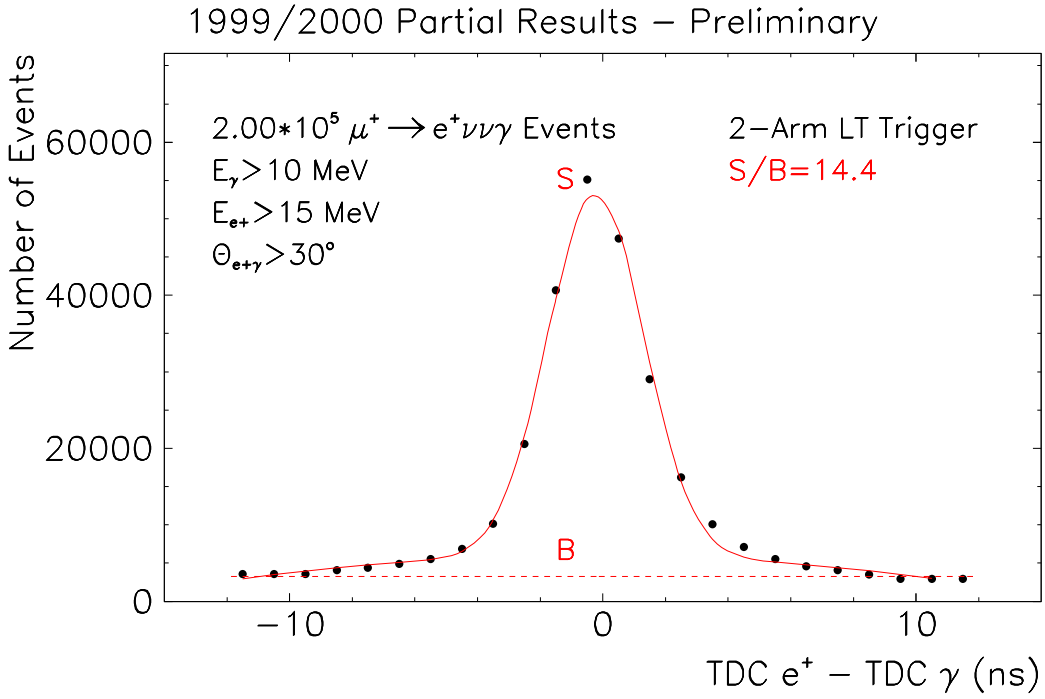


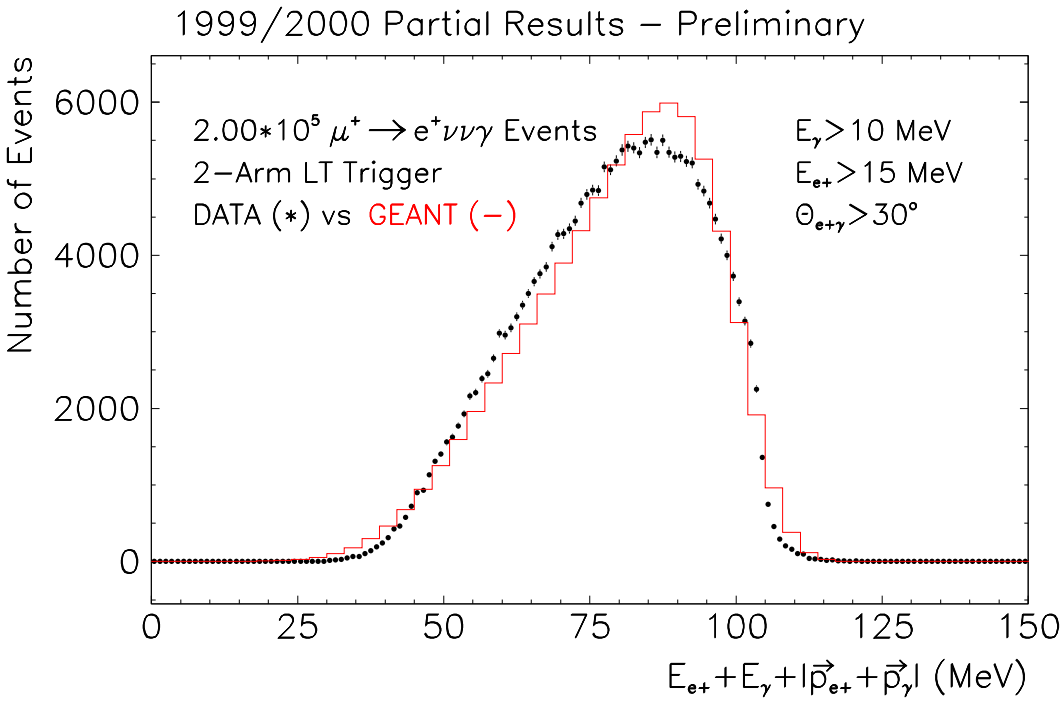
1999/2000 RESULTS: $\pi^+ \to e^+\nu\gamma$



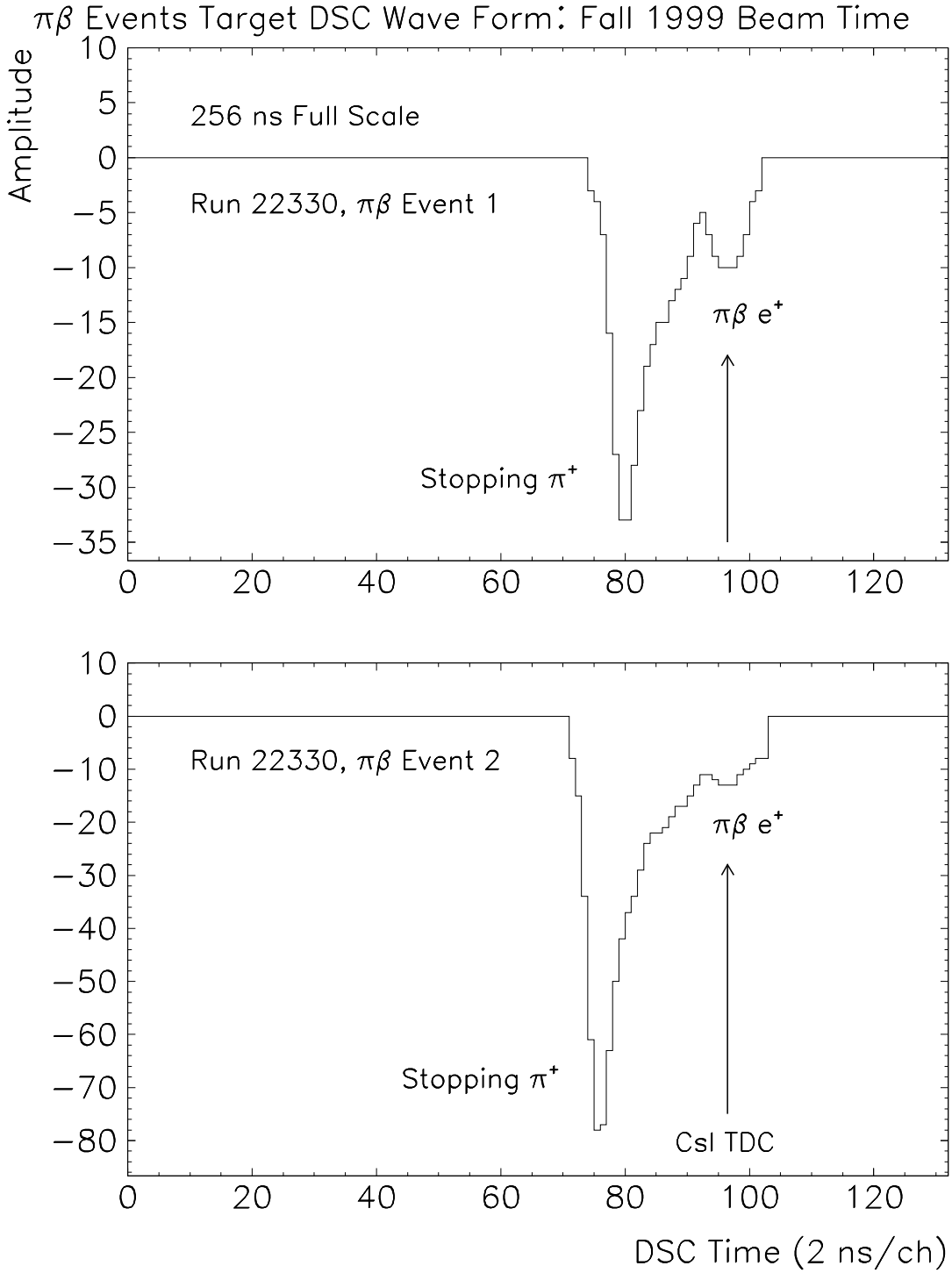


1999/2000 RESULTS: $\mu^+ \to e^+\nu\bar{\nu}\gamma$





1999/2000 RESULTS: $\pi^+ \to \pi^0 e^+ \nu$
Domino Sampling Chip (DSC) Analysis

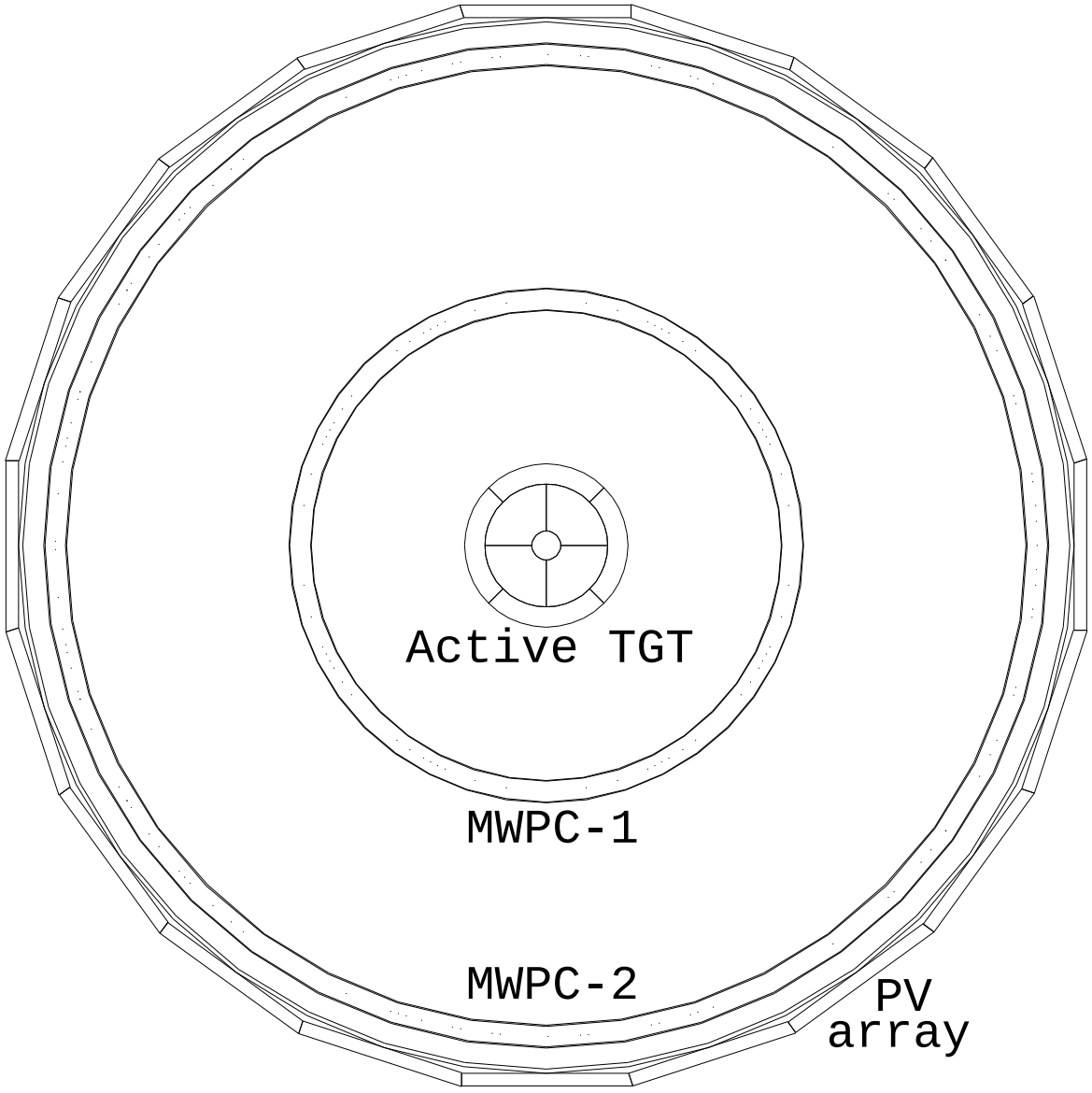


EXPERIMENT SYSTEMATICS

Main sources of uncertainty:

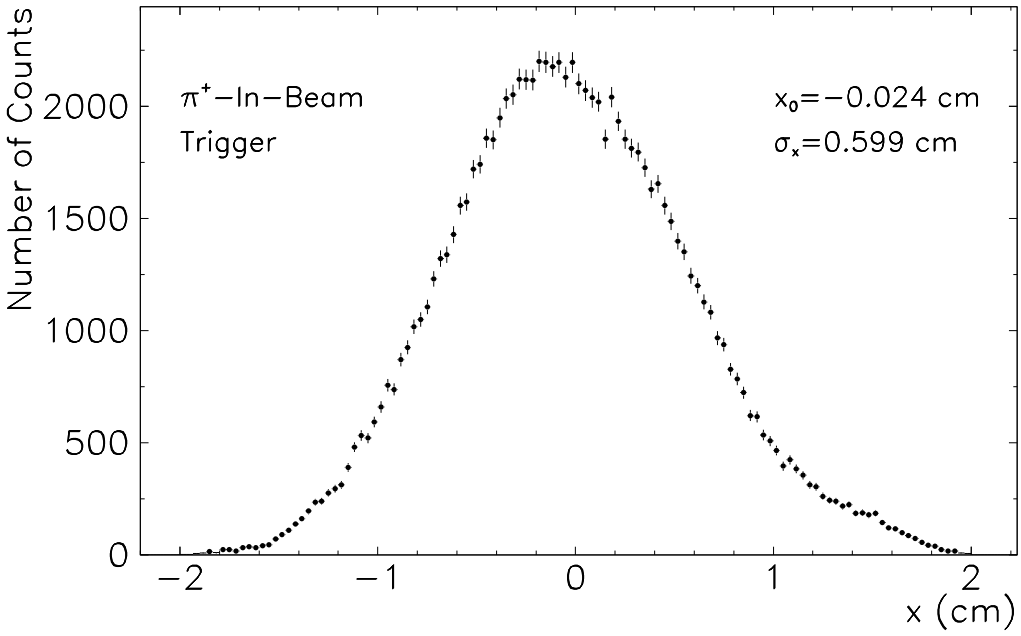
- Acceptance: beam geometry
- Timing: pion decay fraction
- External: BR($\pi \to e\nu$)

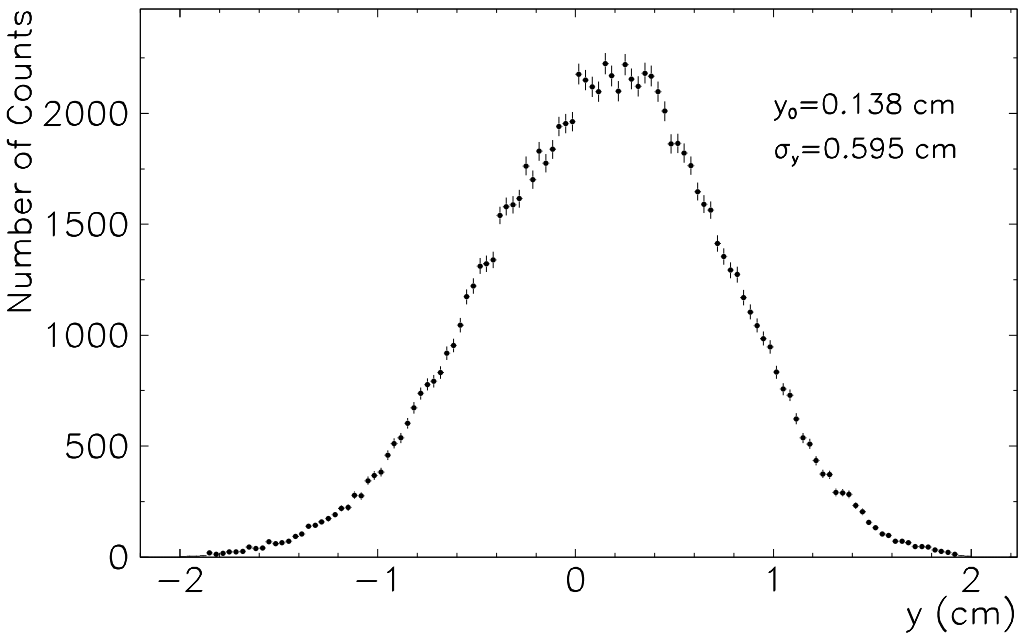
CENTRAL DETECTOR REGION



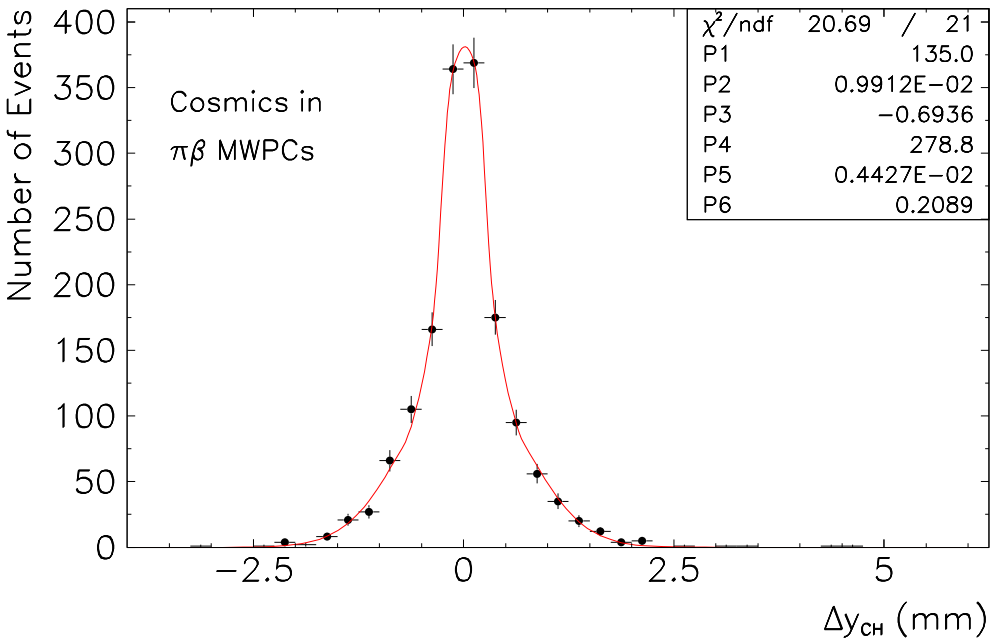
(beam is perpendicular at center)

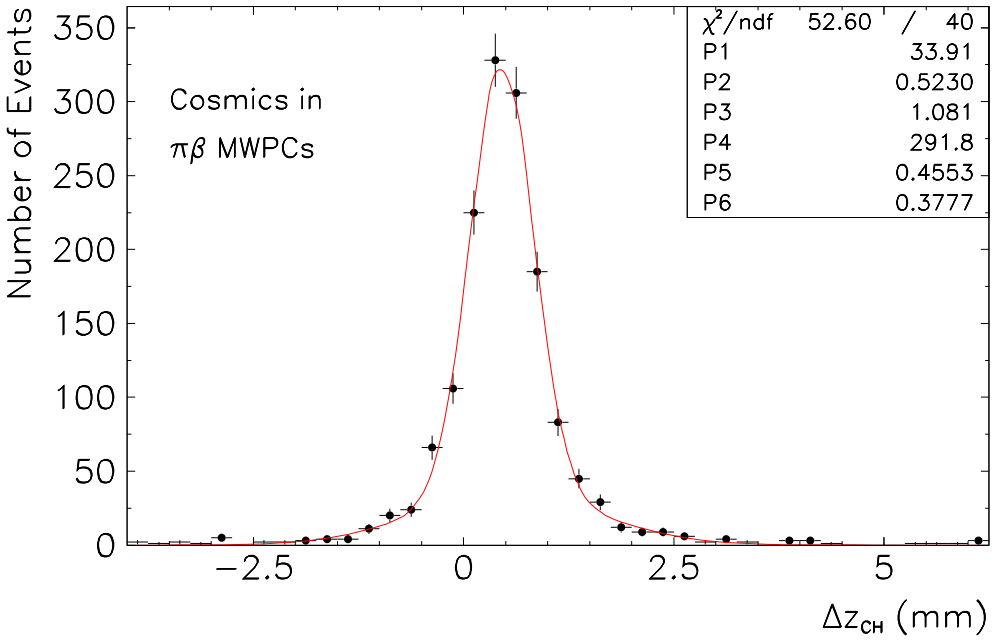
Beam geometry: TGT rate deconvolution



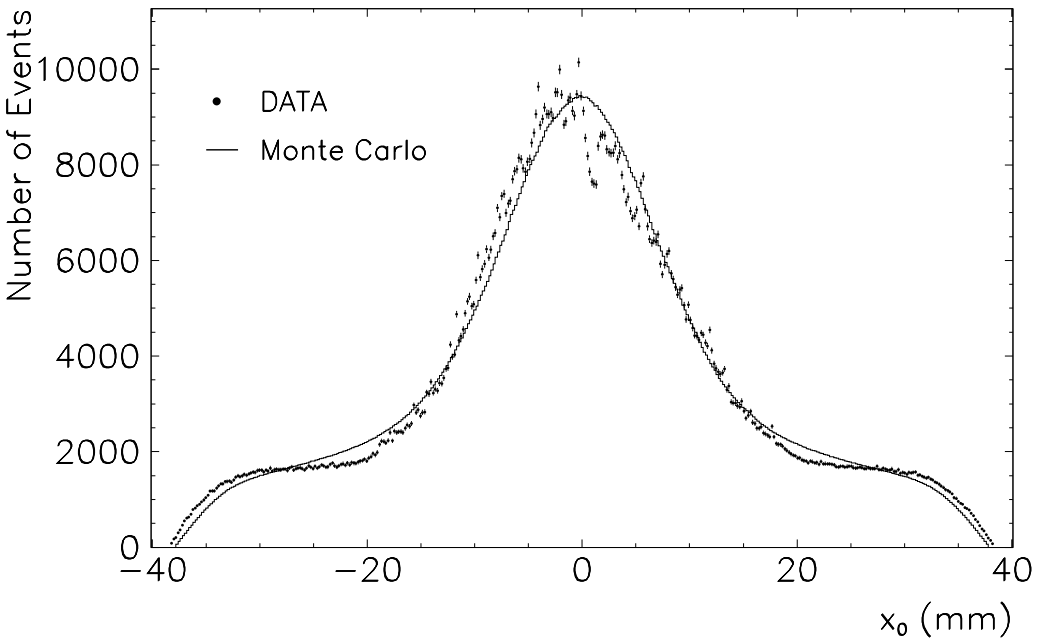


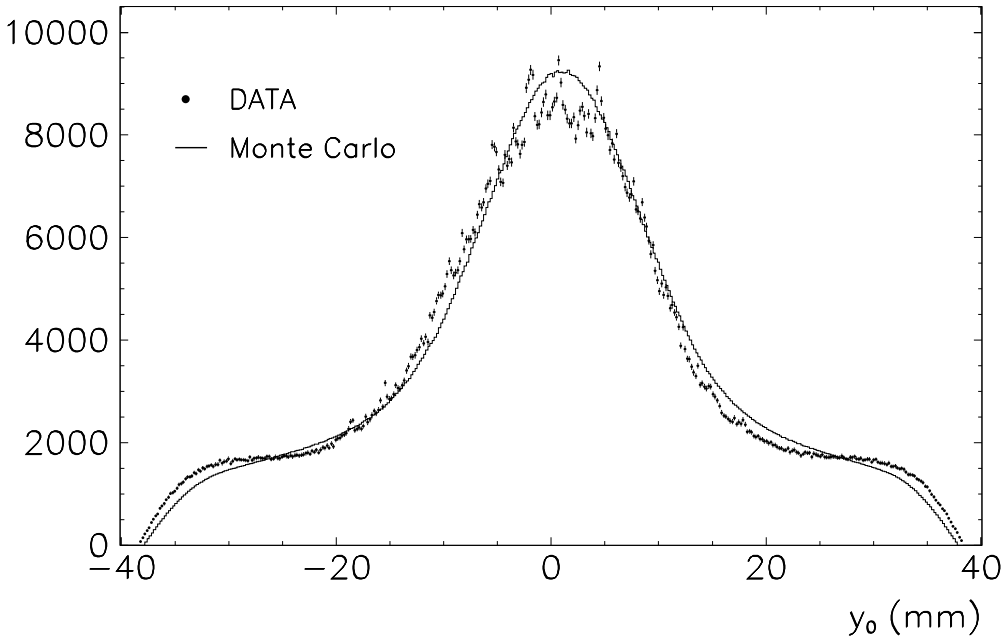
TGT tomography: MWPC resolution



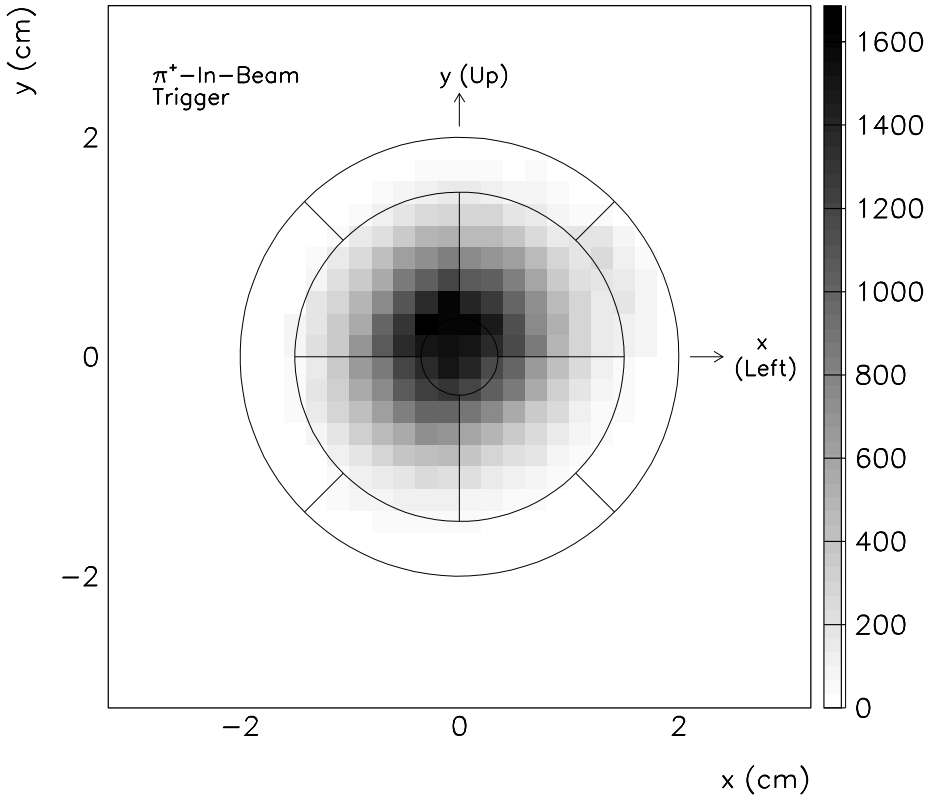


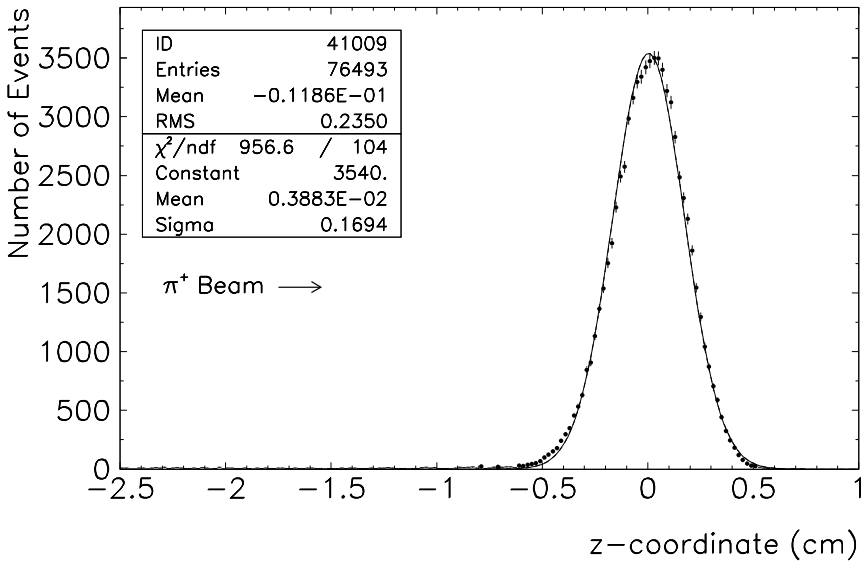
TGT tomography: track reconstruction



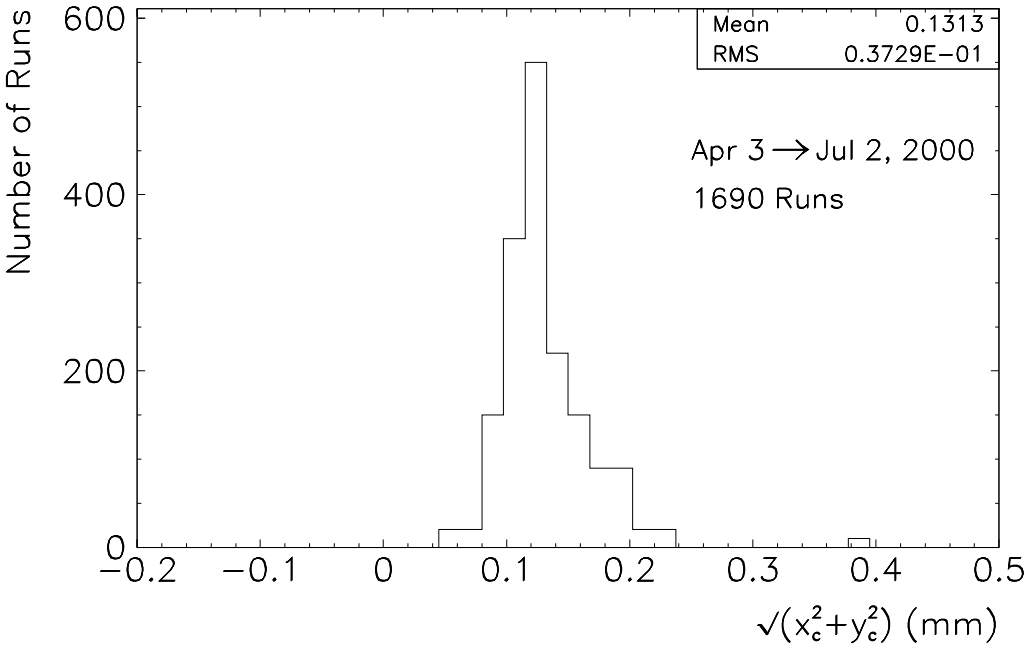


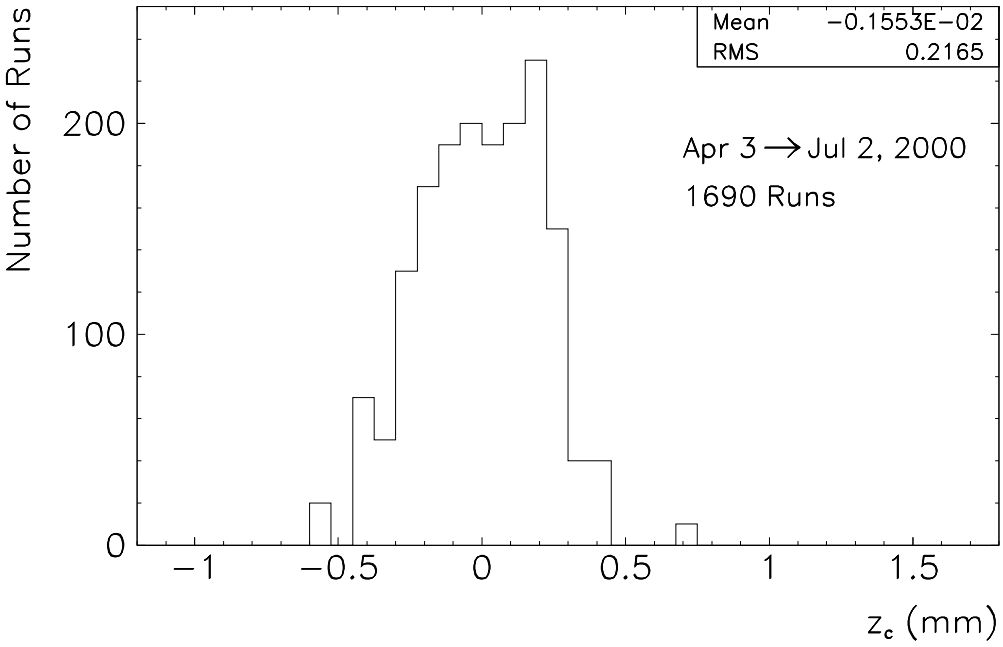
Beam geometry: π^+ stopping distribution



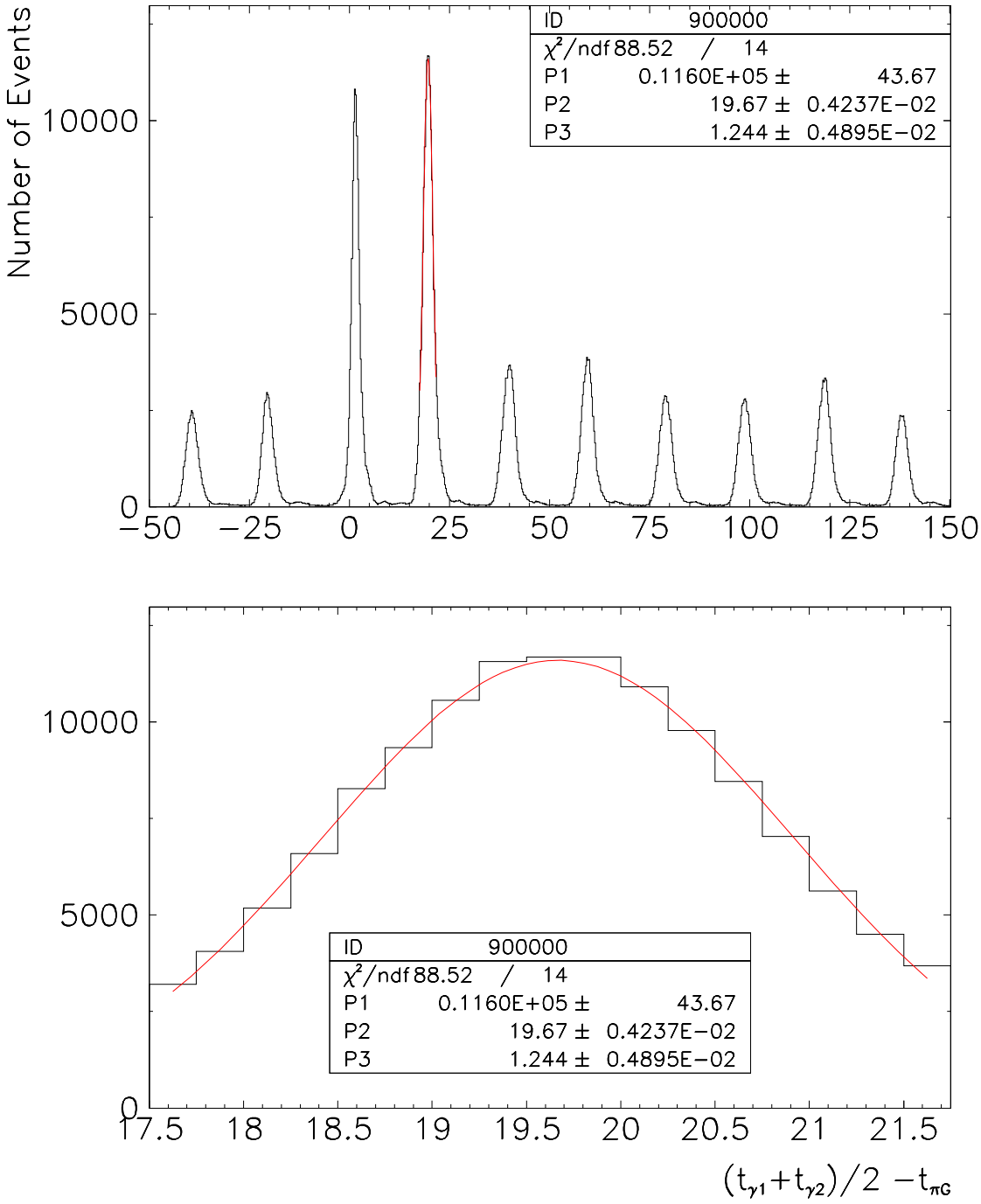


Beam stability





Pion stop timing



SUMMARY OF UNCERTAINTIES

		current (%)	final (%)
external			
	pion lifetime	0.019	0.019
	$BR(\pi \to e\nu)$	0.33	~ 0.1?
	$BR(\pi^0 \to \gamma\gamma)$	0.032	0.032
internal			
	$A(\pi\beta)/A(e\nu)$	0.35	< 0.2
	$\Delta t(\gamma - e)$	0.03	0.03
	E thresh.	< 0.1	< 0.1
statistical:		0.5	0.33
total:		0.70	~ 0.41

2001 BEAM REQUEST AND PLANS

- Run $\sim$8 months, collect another $\sim$ 40$-$50 k $\pi\beta$ events.

- Bring analysis up to the proposed level of uncertainty.

- Prepare new proposal for a precise $\pi \rightarrow e\nu$ measurement.

http://pibeta.phys.virginia.edu/$\sim$pibeta
http://pibeta.psi.ch/$\sim$pibeta