# · Beam

· Ran a beam test at 150GeV
after the KTeV run in 2000

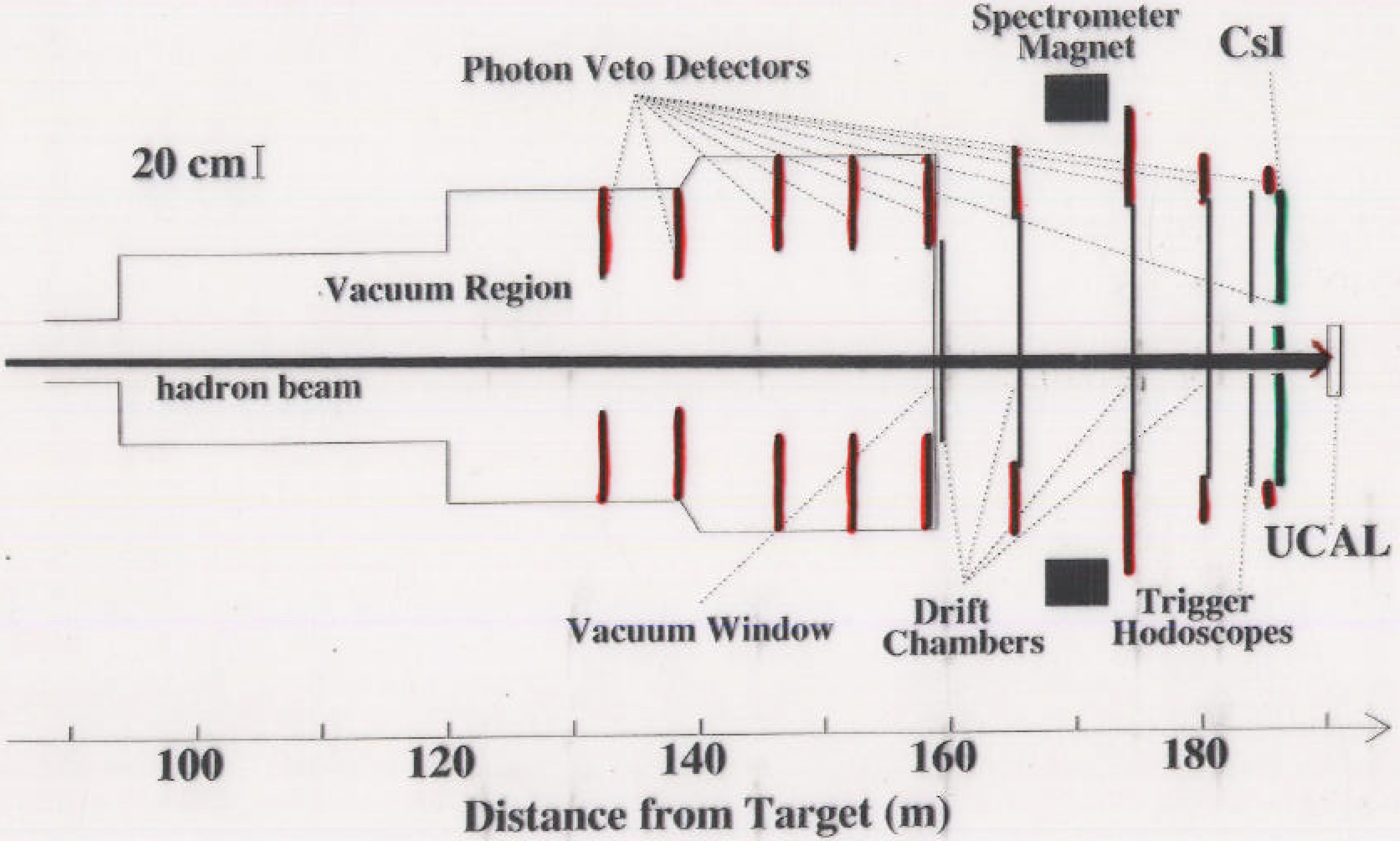
· Measured

Kaon energy spectrum, flux,
neutron " " , "

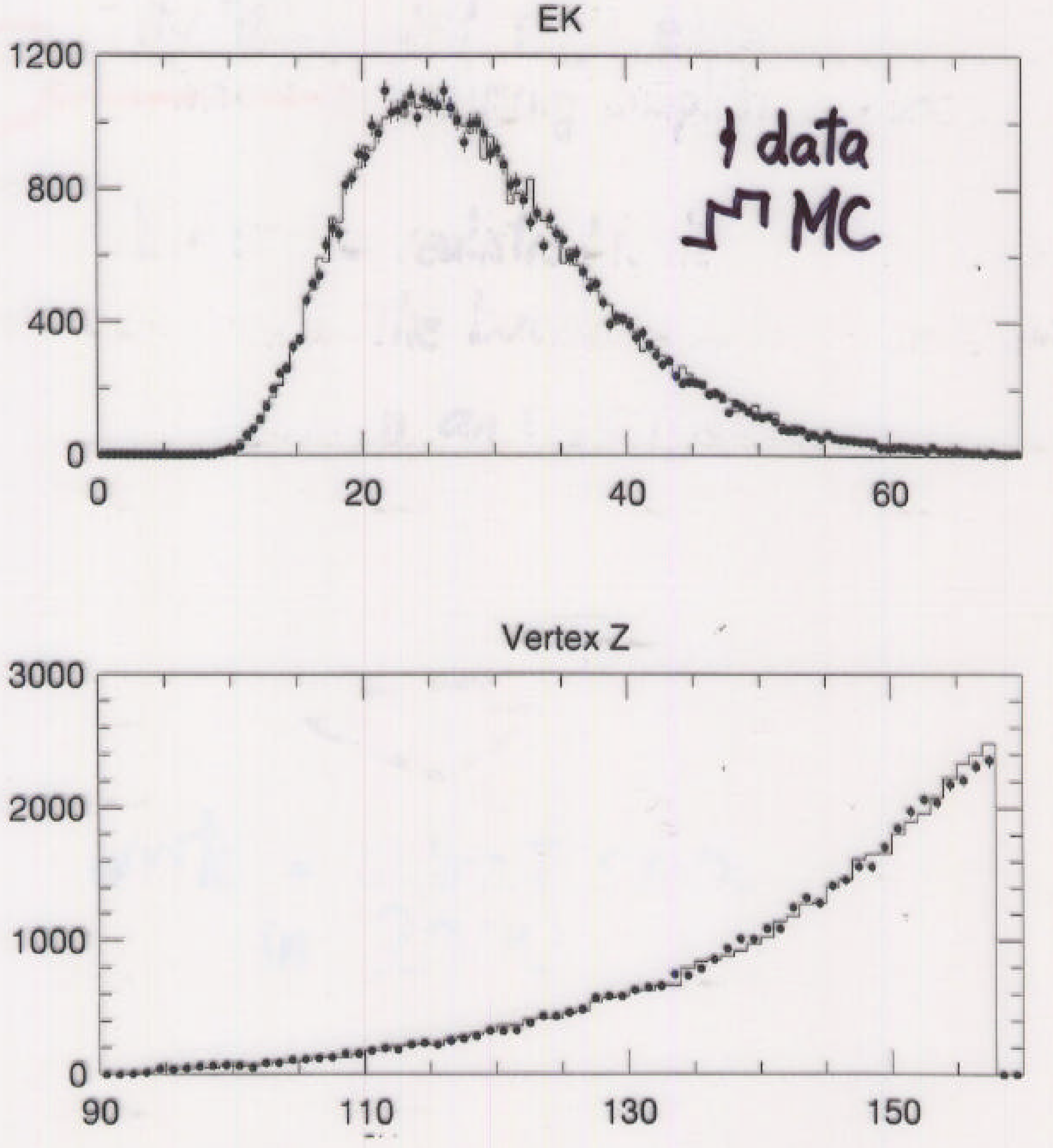
at various targetting angles and
various absorber thicknesses (after ta

· $K_L$: used $K_L \to 3\pi^0$
$K_L \to \pi^+ \pi^- \pi^0$

# Beam Test Detector Geometry



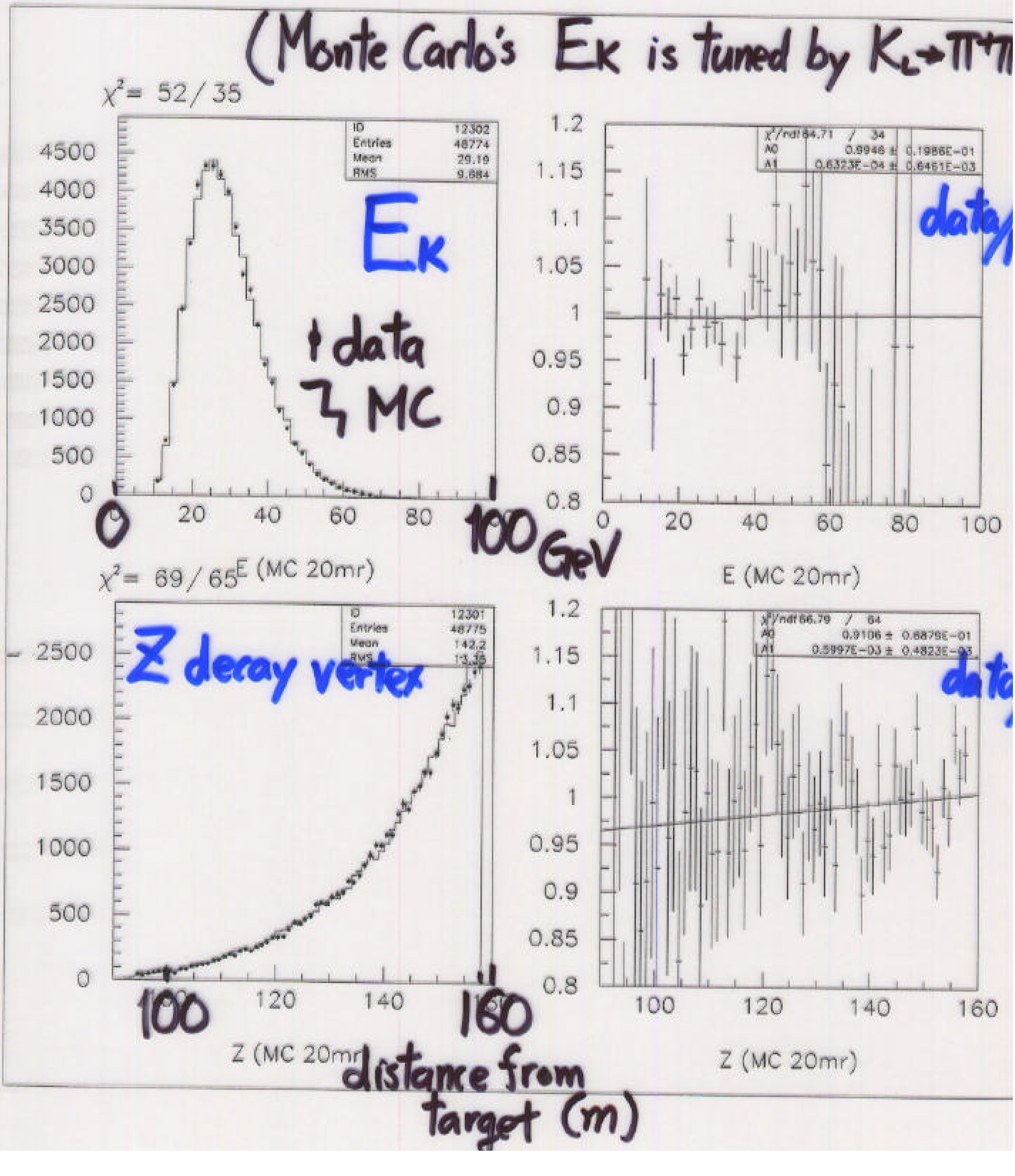
# $K_L \to \pi^+\pi^-\pi^0$ @ 150GeV



# $K_L \to 3\pi^0$ @ 150GeV

20mrad targetting angle

(Monte Carlo's $E_K$ is tuned by $K_L \to \pi^+\pi^-$



Eκ @ 90m from target

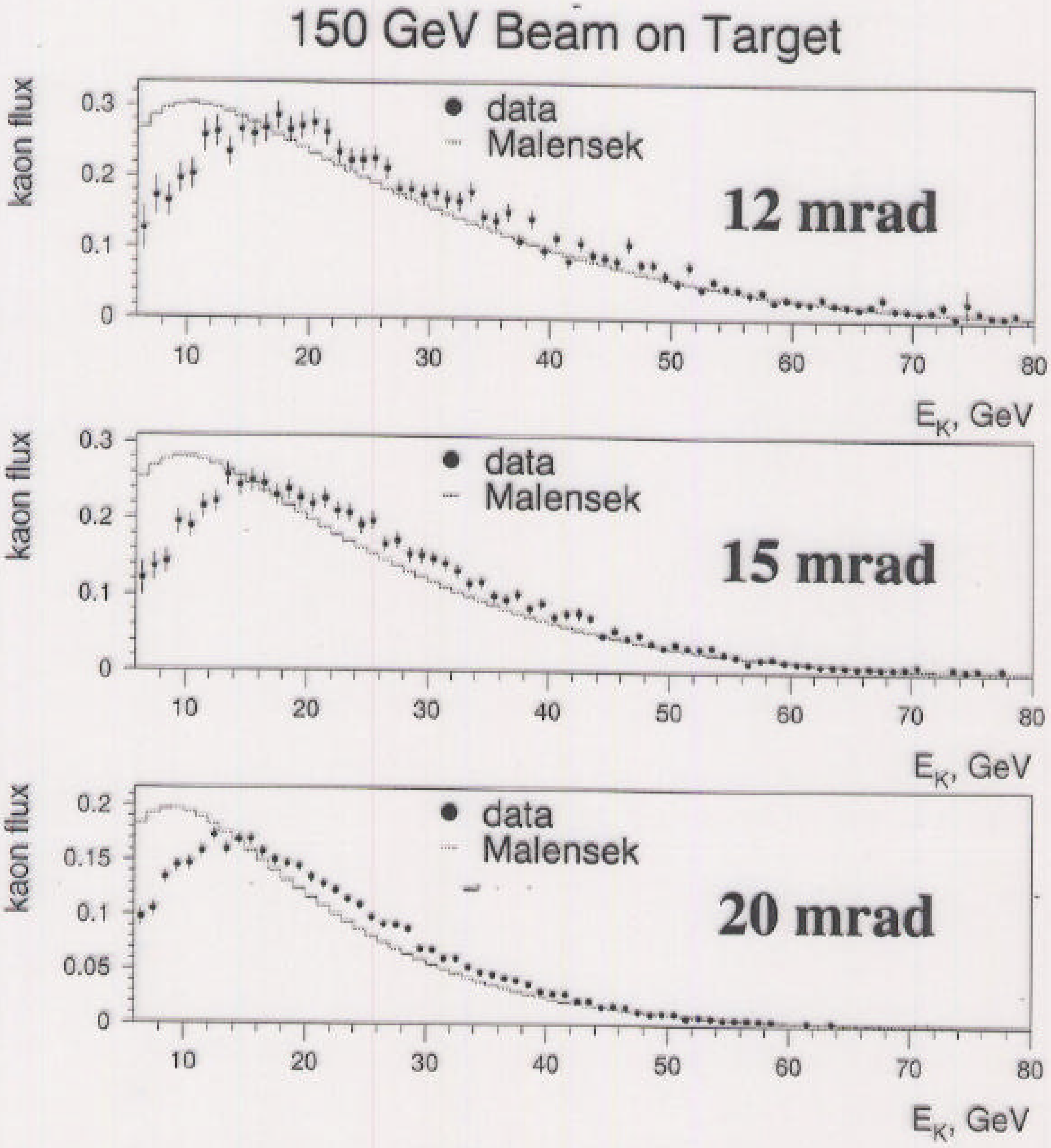
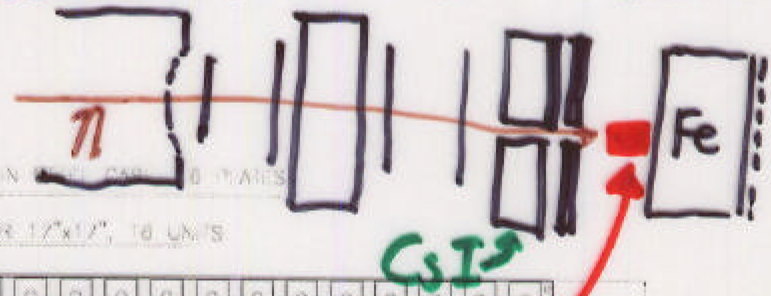



Figure 70: Kaon energy spectra for data (dots) compared with predictions based on the Malensek parametrization. The comparison is for $E_K > 6$ GeV and $Z_K = 90$ meters from the target. The Malensek spectrum is scaled to have the same area as the data.

# Uranium calorimeter for neutro

$6\lambda_I$



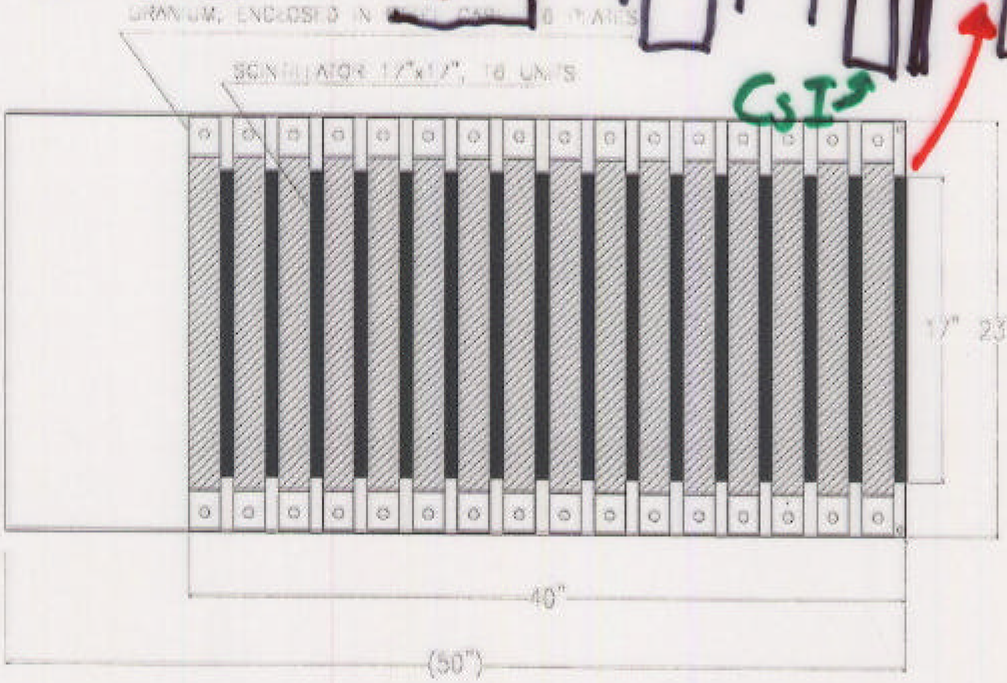




Figure 25: Top view of Uranium Calorimeter used to measure the n+k flux in the KTEV neutral hadron beam. Beam enters from the left. The U-slabs are hatched; the scintillation layers are solid. The 16'th scintillation plate did not fit in the actual experiment.

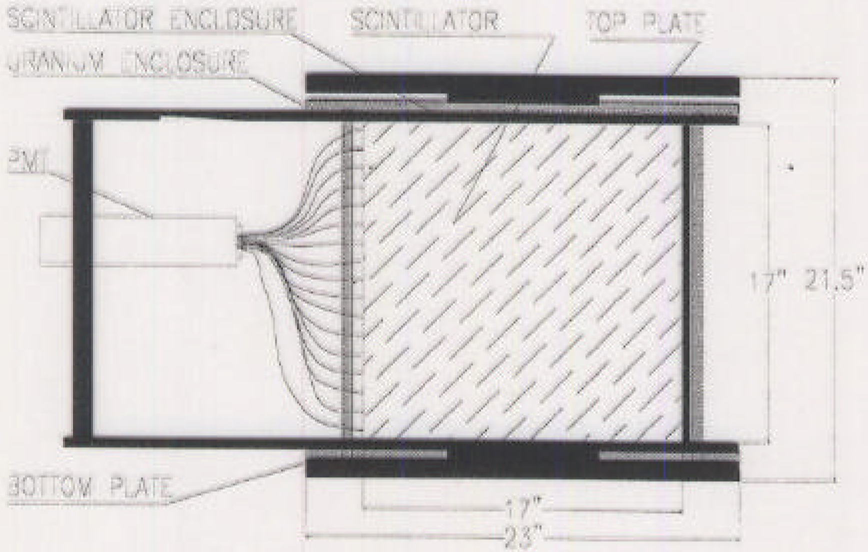
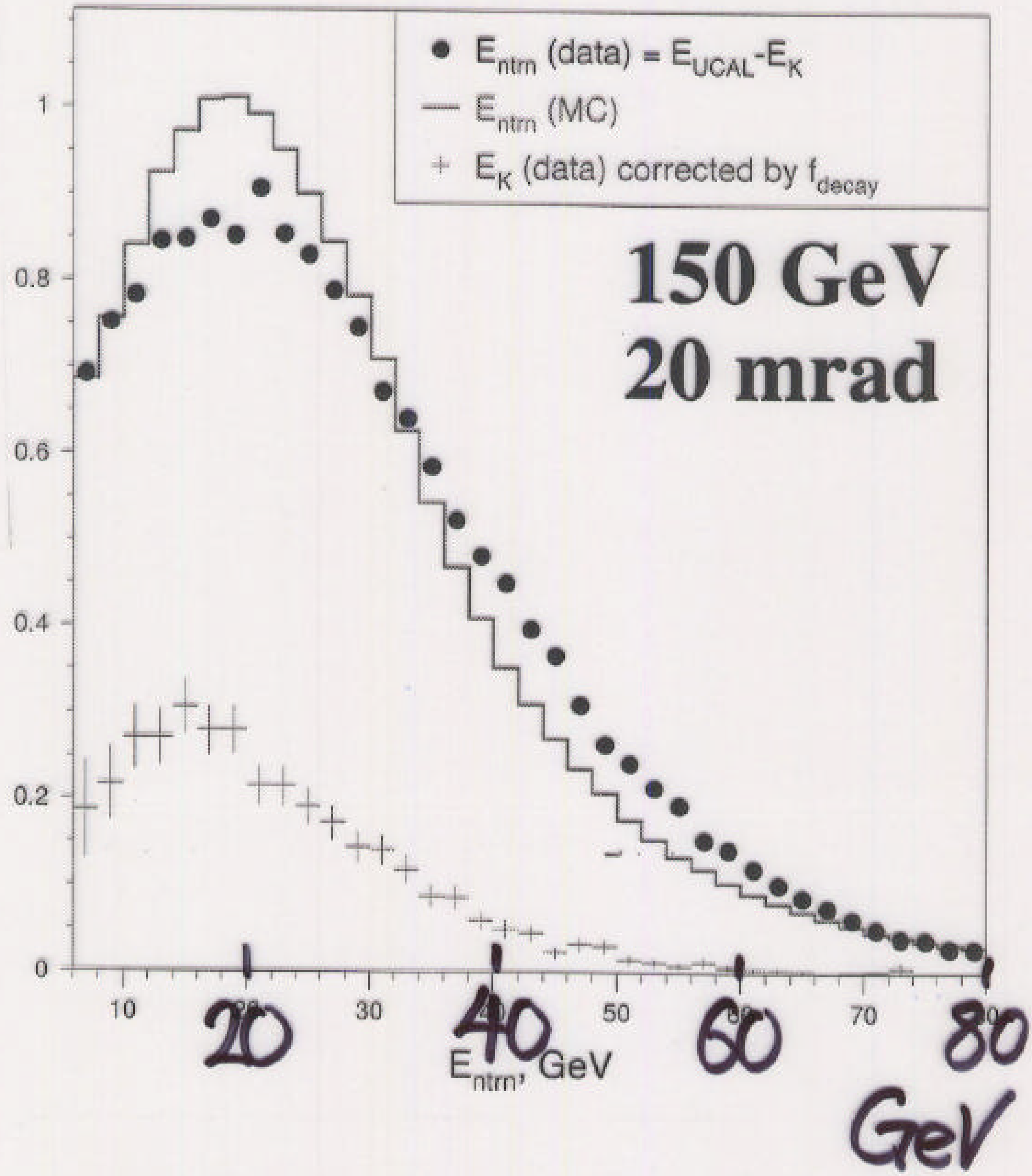
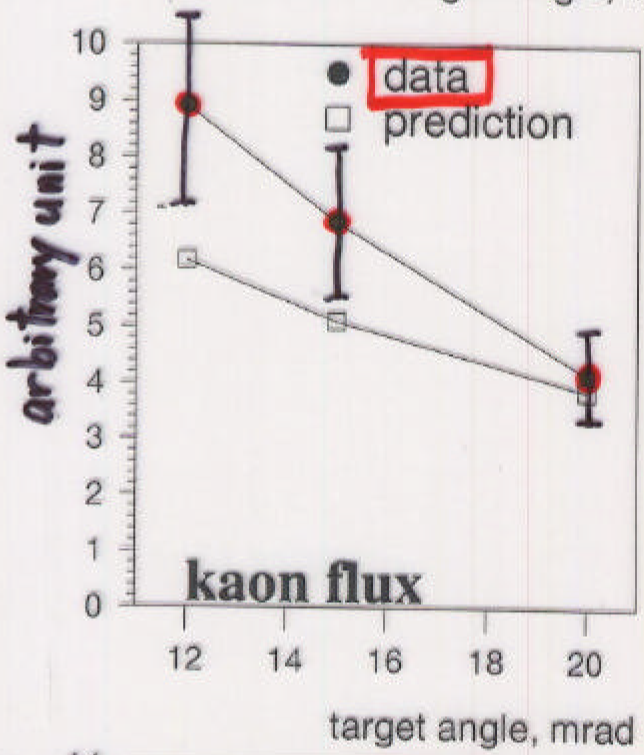


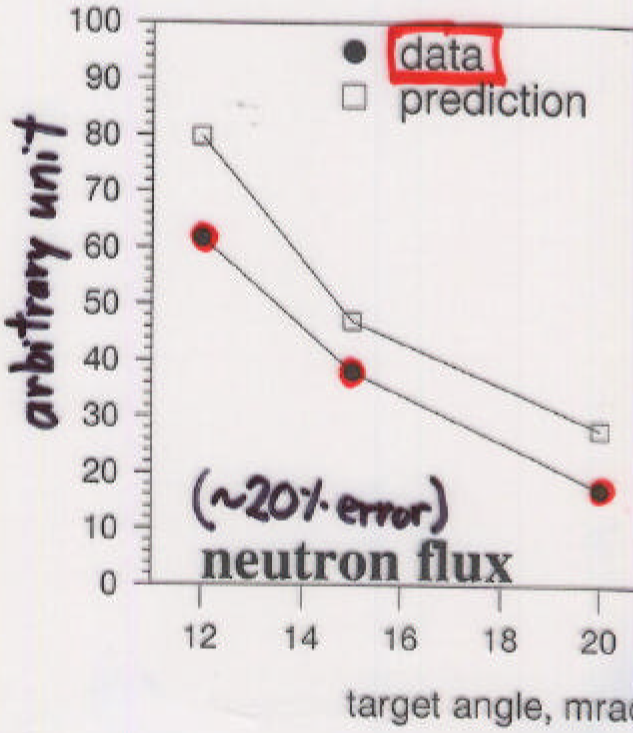

Figure 26: One of 15 PMT/scintillator channels. Beam comes out of page.

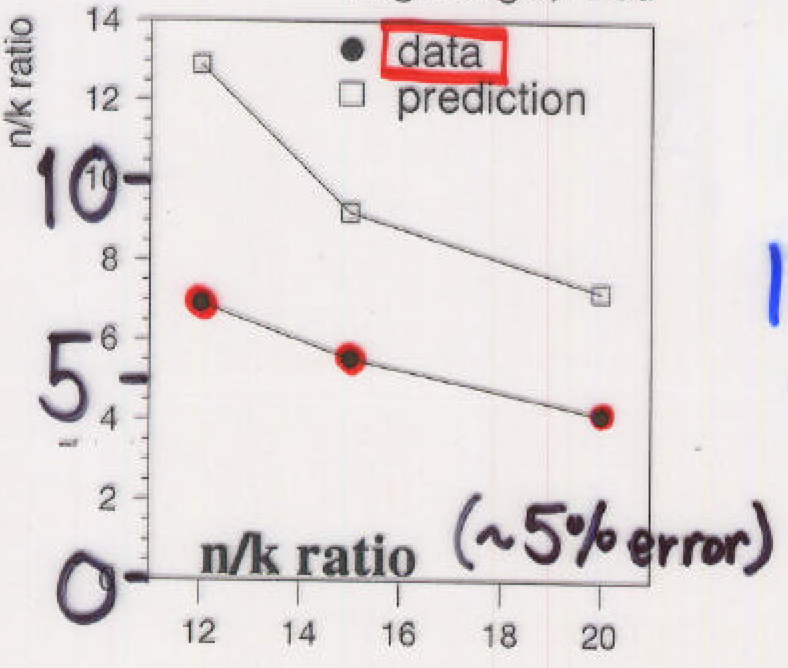
# Neutron energy spectrum



n,k Flux vs. Target Angle, 150 GeV beam with NO Be absorber




lower n/K than predicted.

Figure 6(c)

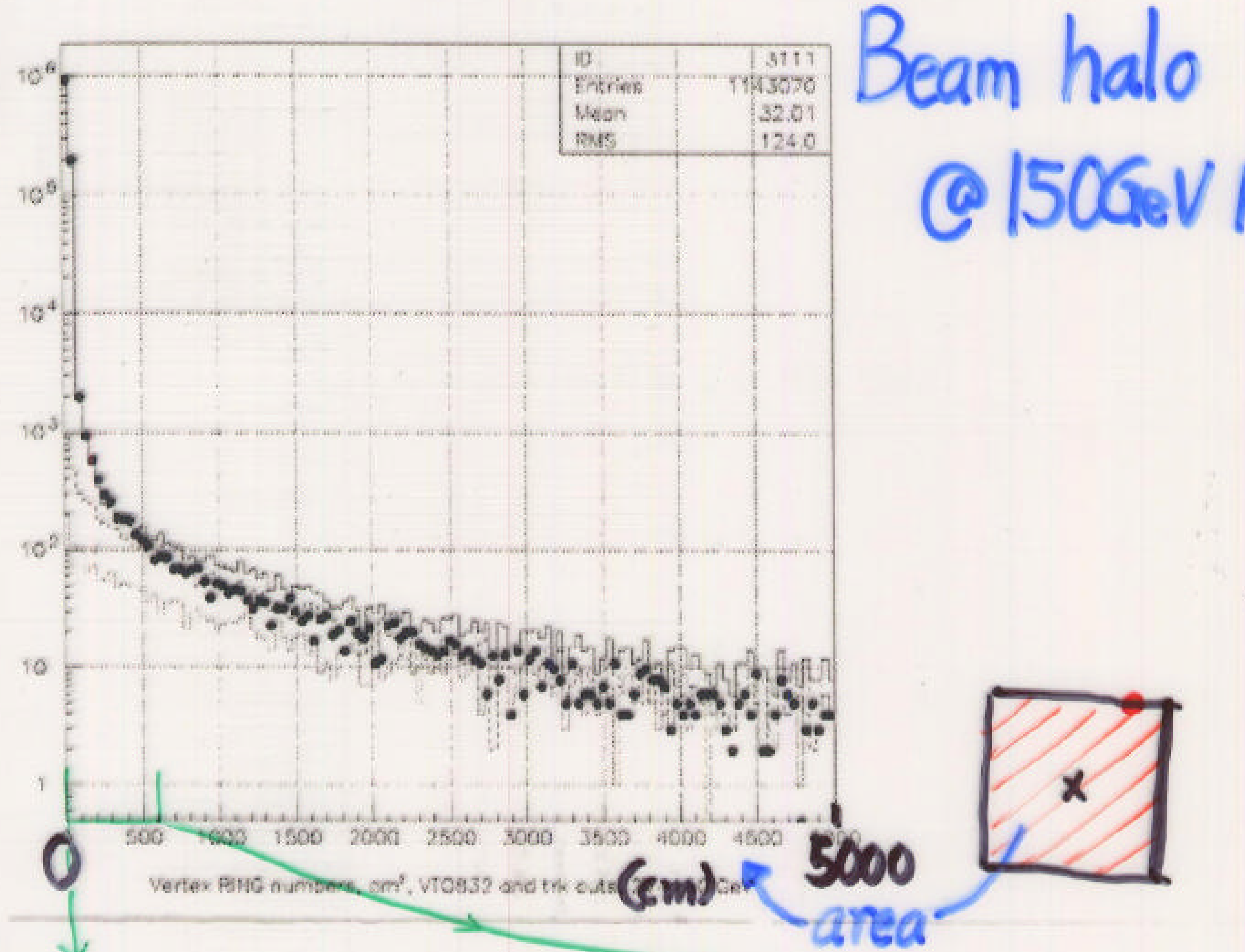
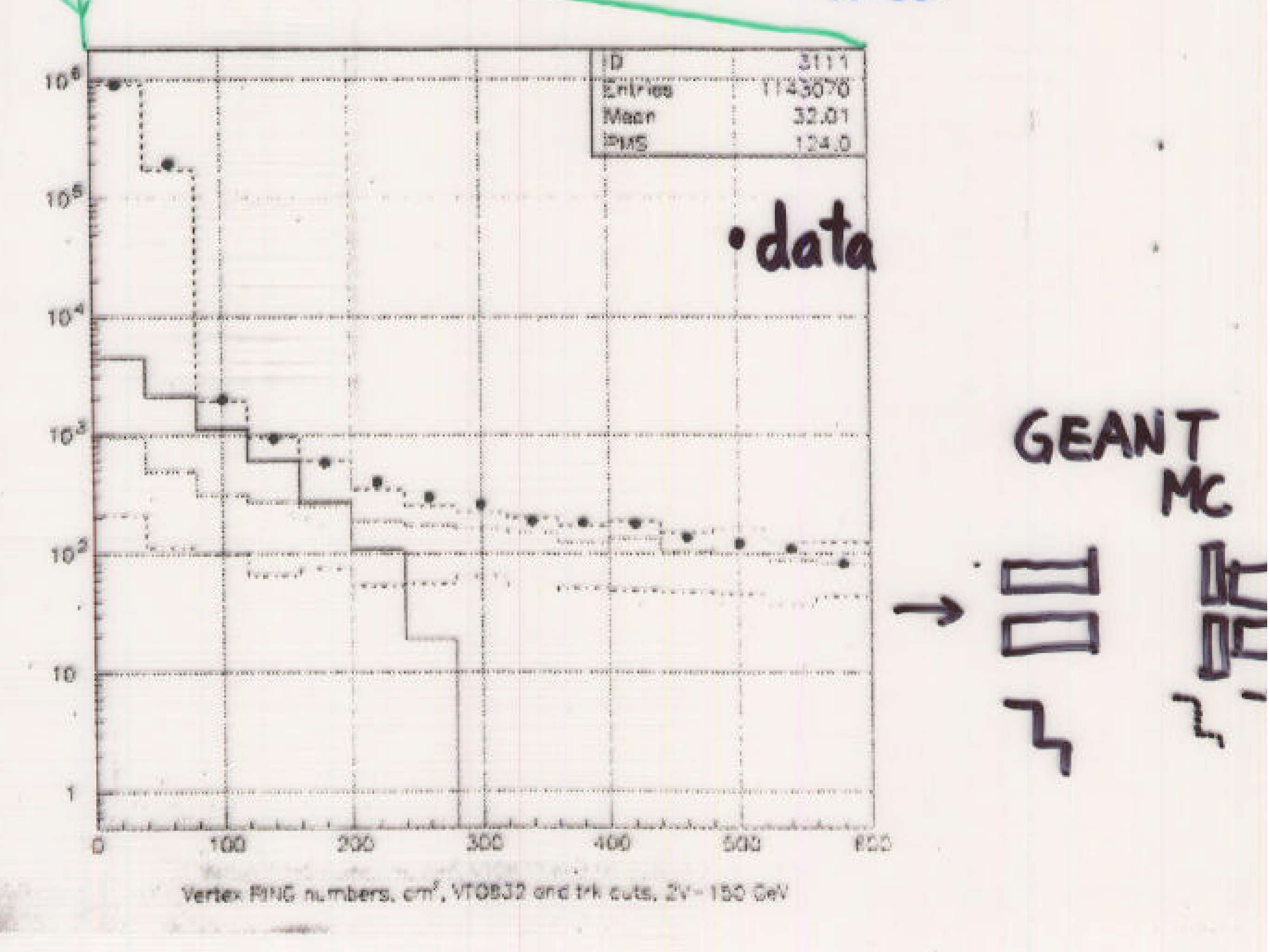



Figure 6(a)



Precision collimator between primary and defining collimators help

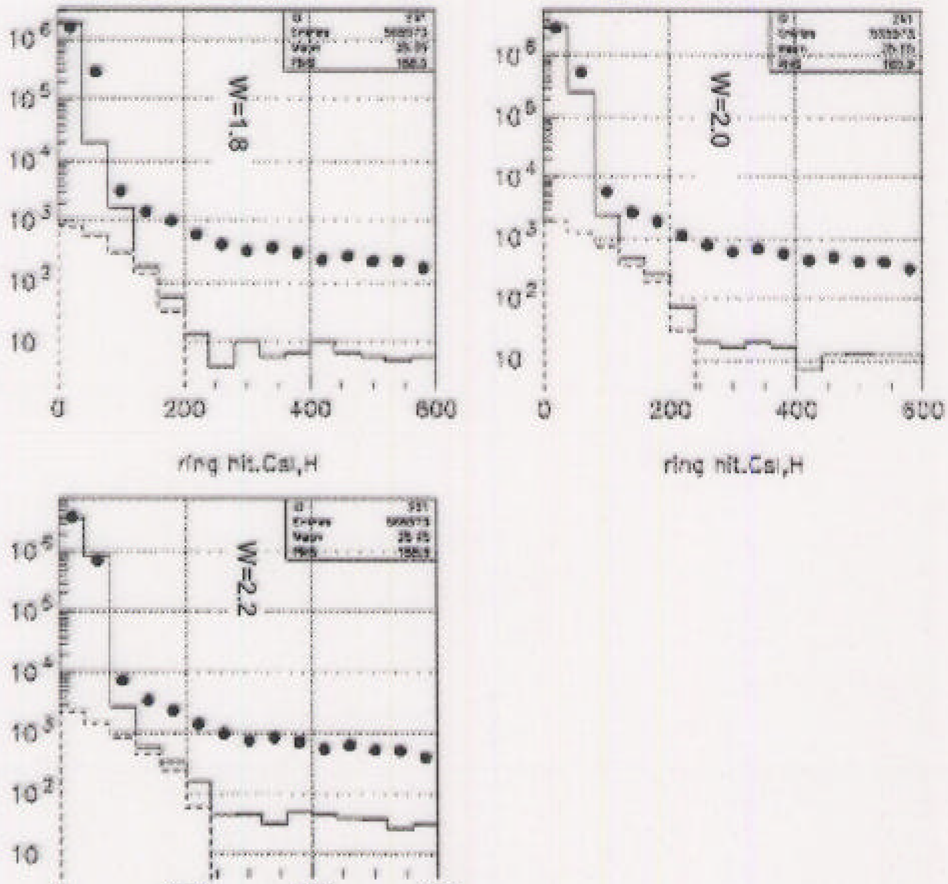



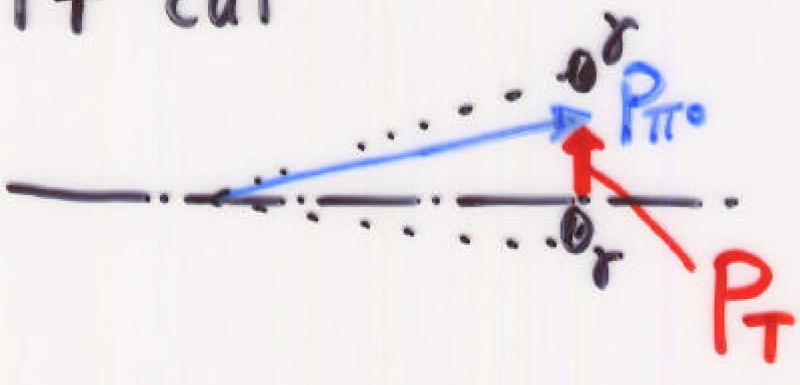

Figure 8

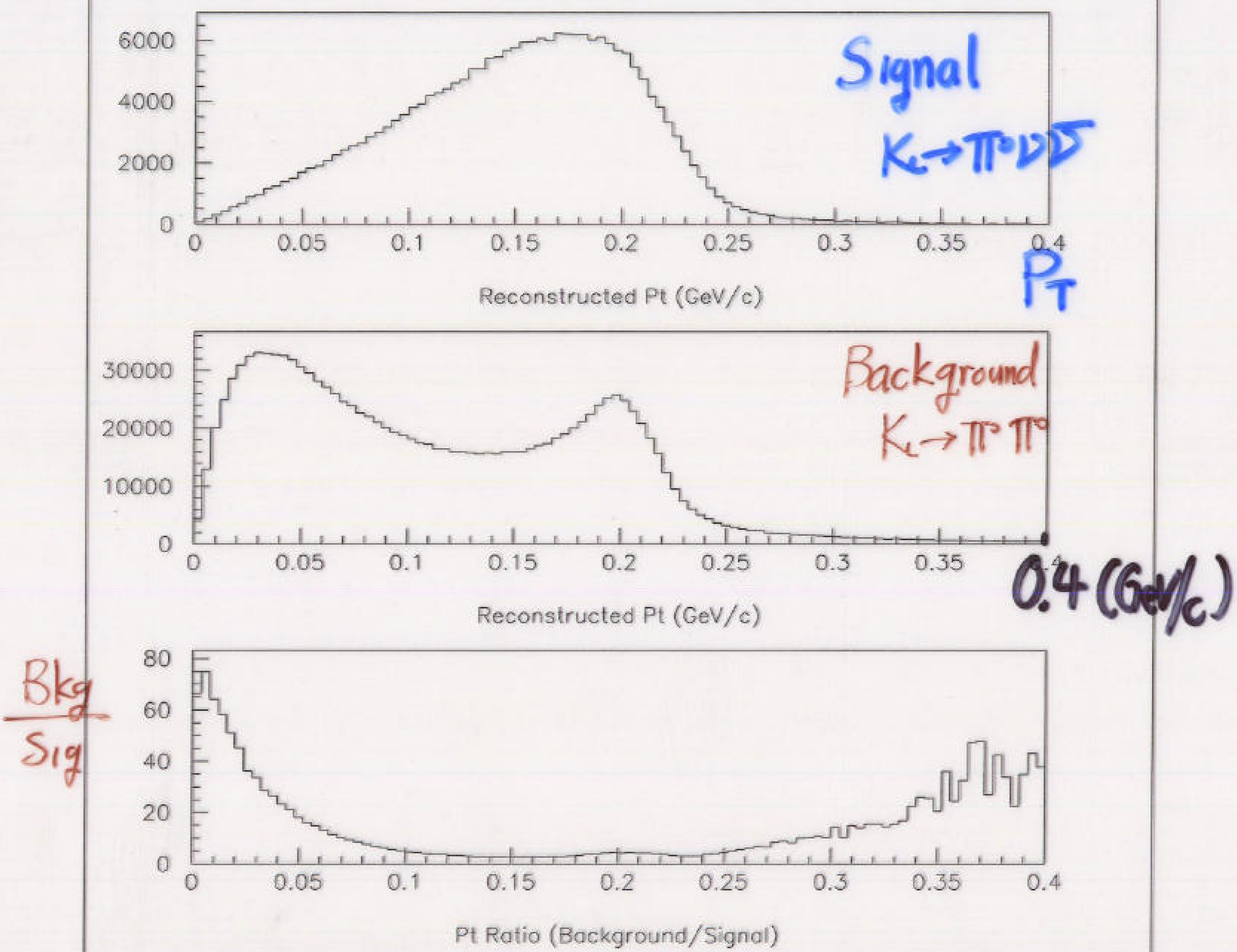
# Reconstruction & cuts

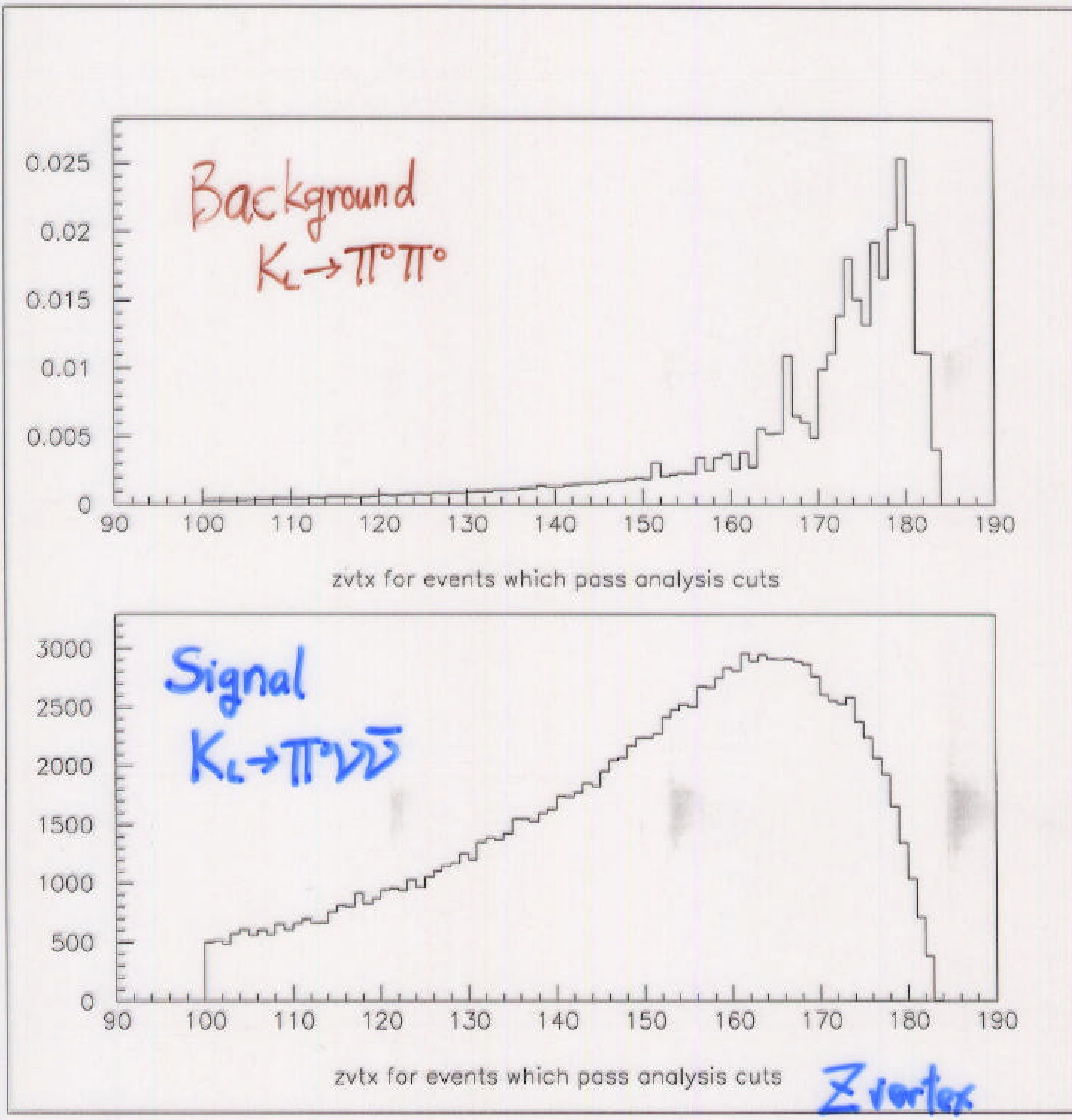
- No $\gamma$ in $\gamma$-veto (w/ inefficiency)
- 2 $\gamma$ in CsI, $E_\gamma > 1\,\mathrm{GeV}$
  $E_1 + E_2 > 5\,\mathrm{GeV}$
- 


cut on $Z' = \sqrt{E_1 \cdot E_2} / m_{\pi^0}$
Z vertex assuming $\pi^0$

- $P_T$ cut




6000
4000
2000
0
0.05
0.1
0.15
0.2
0.25
0.3
0.35
0.4
Reconstructed Pt (GeV/c)
Signal
$K_L \to \pi^0 \nu \bar{\nu}$
$P_T$
30000
20000
10000
Reconstructed Pt (GeV/c)
Background
$K_L \to \pi^0 \pi^0$
0.4 (GeV/c)
80
60
40
20
Pt Ratio (Background/Signal)
Bkg/Sig


Background
$K_L \to \pi^0 \pi^0$
0.025
0.02
0.015
0.01
0.005
0
90 100 110 120 130 140 150 160 170 180 190
zvtx for events which pass analysis cuts
Signal
$K_L \to \pi^0 \nu \bar{\nu}$
3000
2500
2000
1500
1000
500
0
90 100 110 120 130 140 150 160 170 180 190
zvtx for events which pass analysis cuts
Z vertex

# Acceptance, yield

- $3 \times 10^{13}$ p/spill, 120GeV, 15mrad.
- 1spill / 3sec $\times 2 \times 10^{7}$ sec/year
- decay : $\Delta Z = 44m$
- Accept $P_T > 140$ MeV/c
- K beam : 0.3μstr, no absorber
- 3m×3m calorimeter
- γ-veto w/ measured inefficiency

122 $K_L \to \pi^0 \nu\bar{\nu}$ events/year

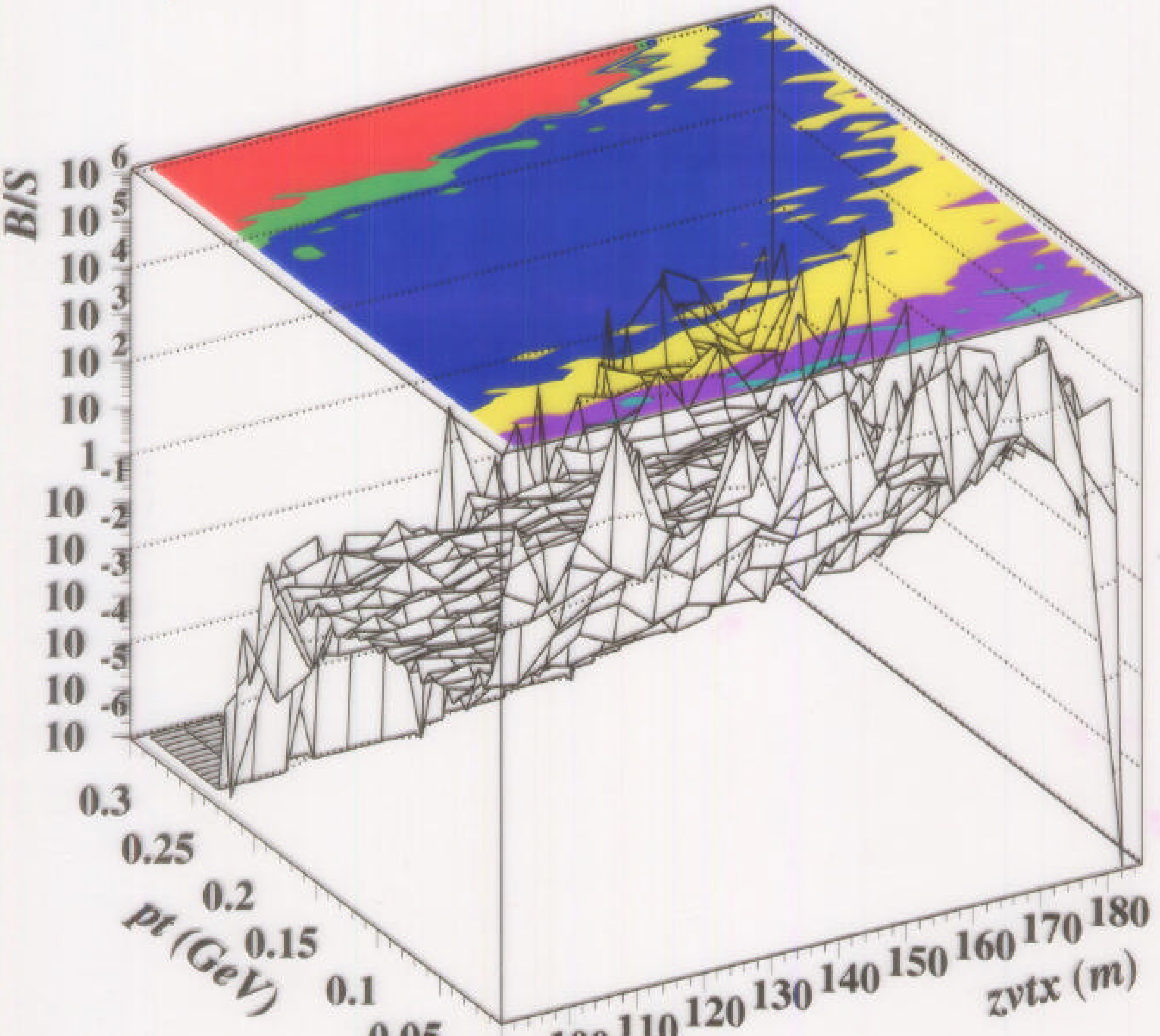
assuming $BR = 3 \times 10^{-11}$

31 $K_L \to \pi^0 \pi^0$ background evts/y

$S/N \sim 4$

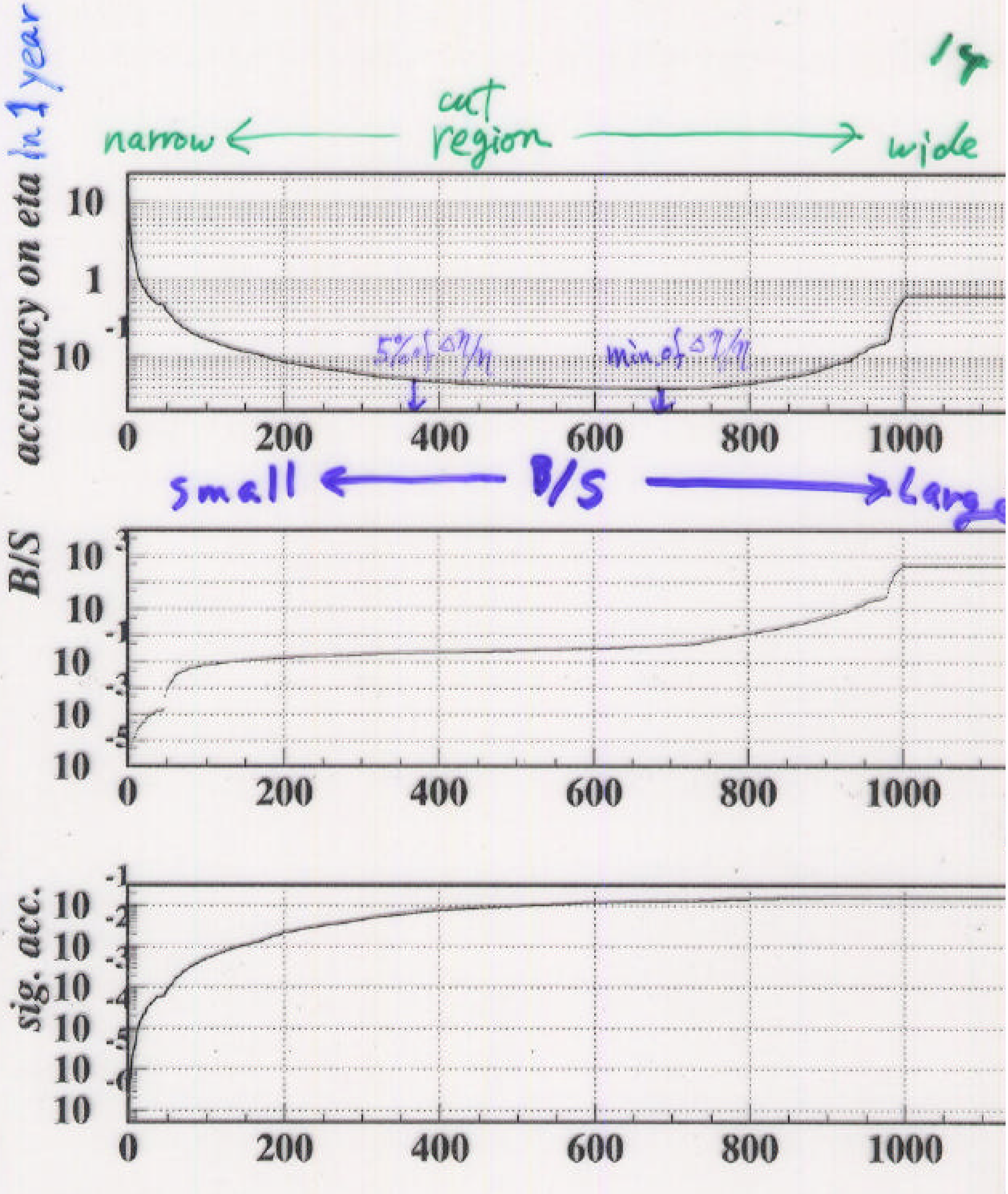
$\Delta\eta/\eta \sim 5\%$

# Optimization of cut region

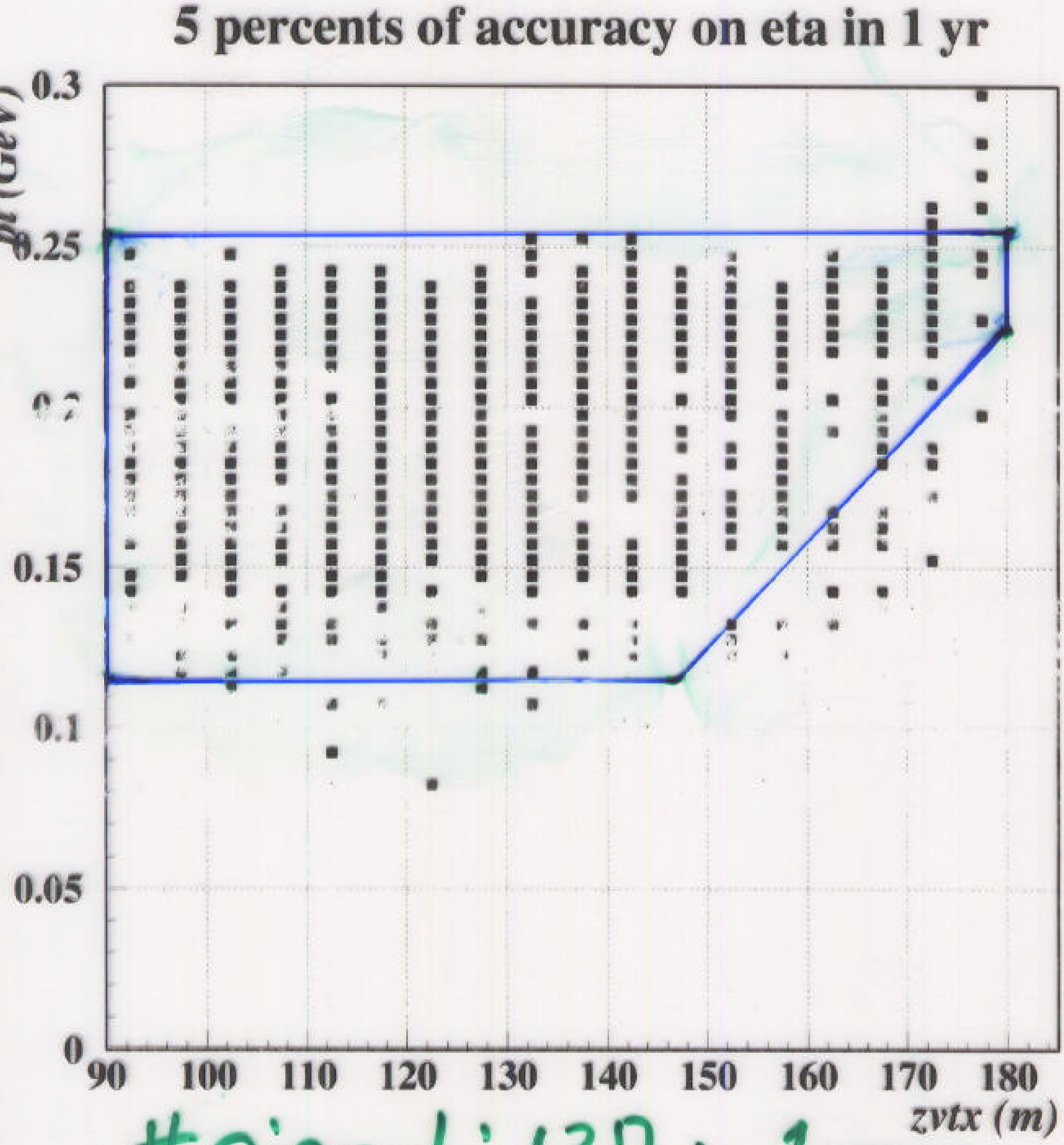



$$Z_{CsI} - Z_{vtx} = \frac{r_{12}}{m_{\pi^0}} \sqrt{E_1 \cdot E_2}$$

$Z_{CsI}$ : the position of CsI, $Z_{vtx}$: Z-vertex.
$r_{12}$ : the distance between clusters; $m_{\pi^0} = 135$ MeV
$E_1 (E_2)$ : the energy of cluster 1 (cluster 2)

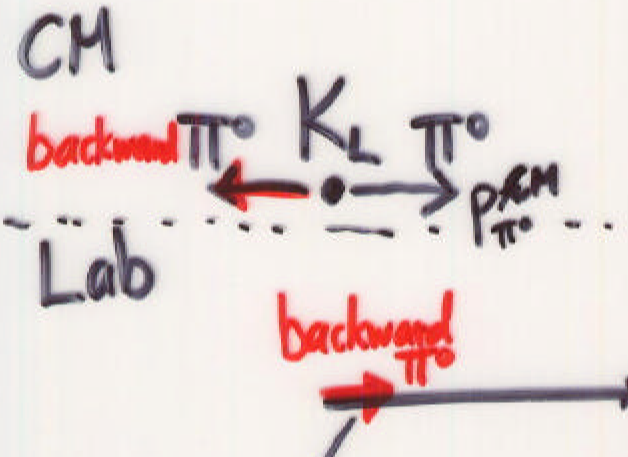



$$\Delta\eta/\eta = \frac{\sqrt{N_{sig}+N_{bkg}}}{N_{sig}}$$



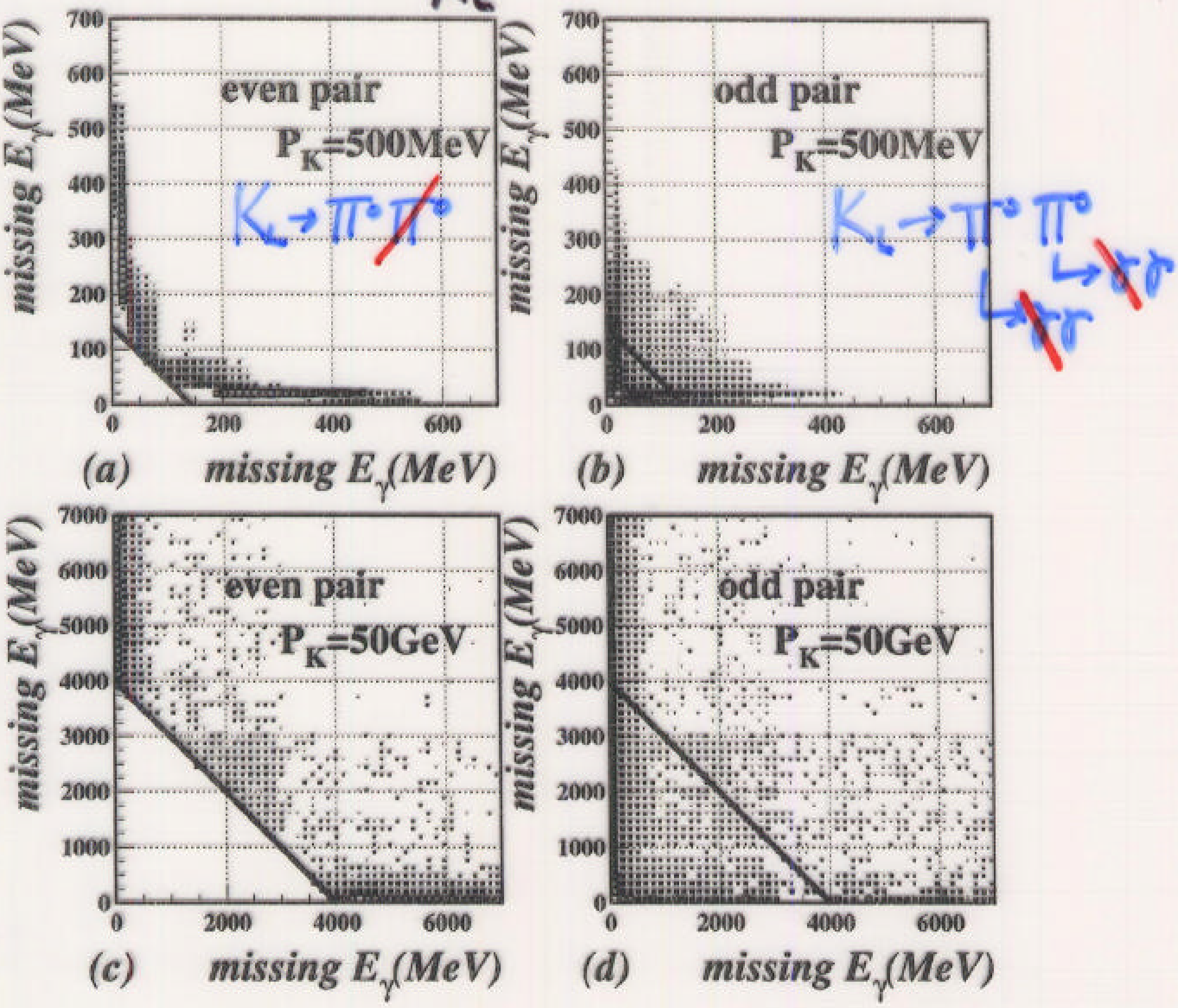

#Signal : 137 in 1 year

B/S : 0.31




$$E'_{\pi^0} = \gamma^*\left(\frac{m_K}{2} - \beta^* p^{CM}_{\pi^0}\right) \approx 80\, E_K(\mathrm{GeV}) \text{ for } \beta \sim 1$$

497.7 MeV/c² — 209 MeV/c — $K_L$



- **High acceptance**

  ⇒ Less #K, #n ⇒ Less hadronic background

- The study only assumes $P_T$ cut only. Has a room to further improve by measuring/cutting other parameters.

- **Broad physics program**
  - $K_L \to \pi^0 ee$, $\pi^0 \mu\mu$,
  - $K_L \to \pi\pi ee$, $\pi\pi\mu\mu$
  - $K_L \to \pi^0 \mu e$
  - $K_L \to eeee$, $ee\mu\mu$,

  ⋮

sensitivity : $O(10^{-13}) \sim O(10^{-14})$

# Schedule

- ~~Jan.~~ Apr. 2001 Proposal
- June 2001 Approval
- Early 2002 Detector and beamline upgrade begins
- Early 2005 Data taking

# R&D program

- Beam veto
- $\gamma$ veto
- fiber tracking
- electronics
- beam test
- vacuum engineering
- how to prove the background level

⋮

# Summary

- KAMI utilizes high energy beam to get
  - better $\gamma$ veto power

    ⇓
  - lower $K_L \to \pi^0 \pi^0$ background
  - lower $n/K$ ratio
  - higher acceptance
- $\sim 120$ $K_L \to \pi^0 \nu \bar{\nu}$ events

  ⇓

  $\Delta\eta/\eta \sim 5\%$
- Broad Kaon program