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The Reaction $\pi^+ p \rightarrow \pi^+ p \pi^0$ (fast) at 16 GeV/c

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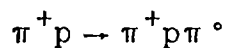
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This is the third (and last!) talk about an experiment done at the SLAC bubble chamber hybrid facility. (See View 1.) The last two talks described our apparatus and included some discussion about analyzing the data in the LEAD GLASS shower detector; namely, the isolation and identification of electromagnetic showers. In this talk, I will report on the progress of our analysis using some of the ideas from the previous talk. In addition, I will give a few early results based on a sample of our data.

The first system we are looking at is simply fast π^0 production from the reaction: (See View 2.)



with incident π^+ at 16 GeV, and π^0 energy $\gtrsim 8$ GeV. The study of this relatively well-known reaction differs from previous experiments in several important ways:

- 1) We restrict ourselves to FAST forward π^0 's ($E_{\pi^0} \gtrsim 8$ GeV).
- 2) The Pb-Glass detector yields an unprecedented knowledge of these π^0 's allowing for a careful and detailed study of the π^0 system.
- 3) We're at higher energy.

In particular, we are looking for the production of possibly new heavy mesons which decay into $\pi^+ \pi^0$.

This system has been studied before, and resonances in the $\pi^+ \pi^0$

invariant mass plot have been claimed for ρ , ρ' , g , S , and T . The identification of these resonances, based on previous experiments certainly seems reasonable, if you believe the π^0 's used in the mass plots are real.

It is just the presence of enormous background, and the fact that we are able to identify the π^0 's that makes our experiment unique.

Bubble chambers have traditionally used the following recipe for identifying π^0 events: (See View 3.)

I would briefly like to mention a few sources of background to this reaction which can cause so much confusion in the identification of a π^0 . (See View 4.)

Notice that we help to eliminate diffractive events simply by requiring $\gtrsim 8$ GeV of neutral energy in our trigger.

One may then check this selection by plotting the (missing mass)² for thusly selected events. (See View 5.)

Notice the rather glaring nonsymmetry of the (mm)² plot around the π^0 . In fact, the distribution is not even centered on the π^0 mass! A basic problem with this selection procedure is that it allows for fits of single π^0 's to all manner of neutral products, primarily due to the large uncertainties associated with the 1-C fit.

One then tries to do physics with a relatively dirty sample of π^0 's.

I will now describe how it has been possible for us to collect a relatively clean sample of π^0 events by introducing the information from our downstream

detector into the analysis. (See View 6.)

Let me now show you a couple of sample events which passed a single π^0 1-C fit.

This is a GOOD event. (See View 7.) Notice the charge tracks are swept clear of the Pb-Glass wall, and there is a single well-defined shower. red squares are hot spots, lavender are other blocks with less energy. (Please be aware this drawing is not to scale.) Also note the agreement between the energy deposited in the lead glass, and the calculated missing energy from BC information.

This next slide (See View 8) also shows an analyzable event. This time, however, the outgoing pion enters the Pb-Glass wall, but is detected both by its particular energy deposition between the active converter and back blocks, and by the proportional wire chambers.

Finally, a BAD event. (See View 9.) Lots of showers, and a gamma which converted in the Tantalum plate make this event hopelessly confused and nonanalyzable. Besides, it is probably not a single π^0 event.

By so selecting single π^0 events and plotting the bubble chamber's (missing mass)² again, we get this result. (See View 10.)

To within statistical errors, this distribution of events is properly symmetric and centered about the π^0 mass.

THIS CERTAINLY YIELDS A MORE CONFIDENT SAMPLE OF π^0 's.

It is also interesting to examine the bubble chamber's measured missing

momentum for all 1-C fits, and for our cleaned-up sample. (See View 11.)

Here we see a strong leading peak in missing momentum near beam energy with a rather largish tail extending back.

Our "good" π^0 's are now shaded into this plot. (See View 12.)

Notice that the 1-C fits which were not chosen to be "GOOD" seem almost to form a smooth background under the real π^0 's.

Secondly, the true π^0 's seem to fall into 2 distinct regions:

1) High Energy leading particle peak.

These are certainly associated with Δ^{++} production, which produces a fast π^0 .

2) The remaining events in the tail MAY be events of interest, that is, events producing a heavy meson.

The last histogram I want to show you is the invariant mass plot for the $\pi^+\pi^0$ system. We do not have sufficient statistics to make any statements about heavy meson production, but this is where we expect them to show up. (See View 13.)

As you can see, our statistics are practically nonexistent.

If we now remove π^0 events with Δ^{++} production, we are left with the following mass plot. (See View 14.)

Finally, we have been able to work out a very approximate and

preliminary cross section for this reaction. This task is complicated by our relatively complex hardware/software and scan cuts — and the issue has not been totally resolved; nevertheless, our preliminary value for cross section is:

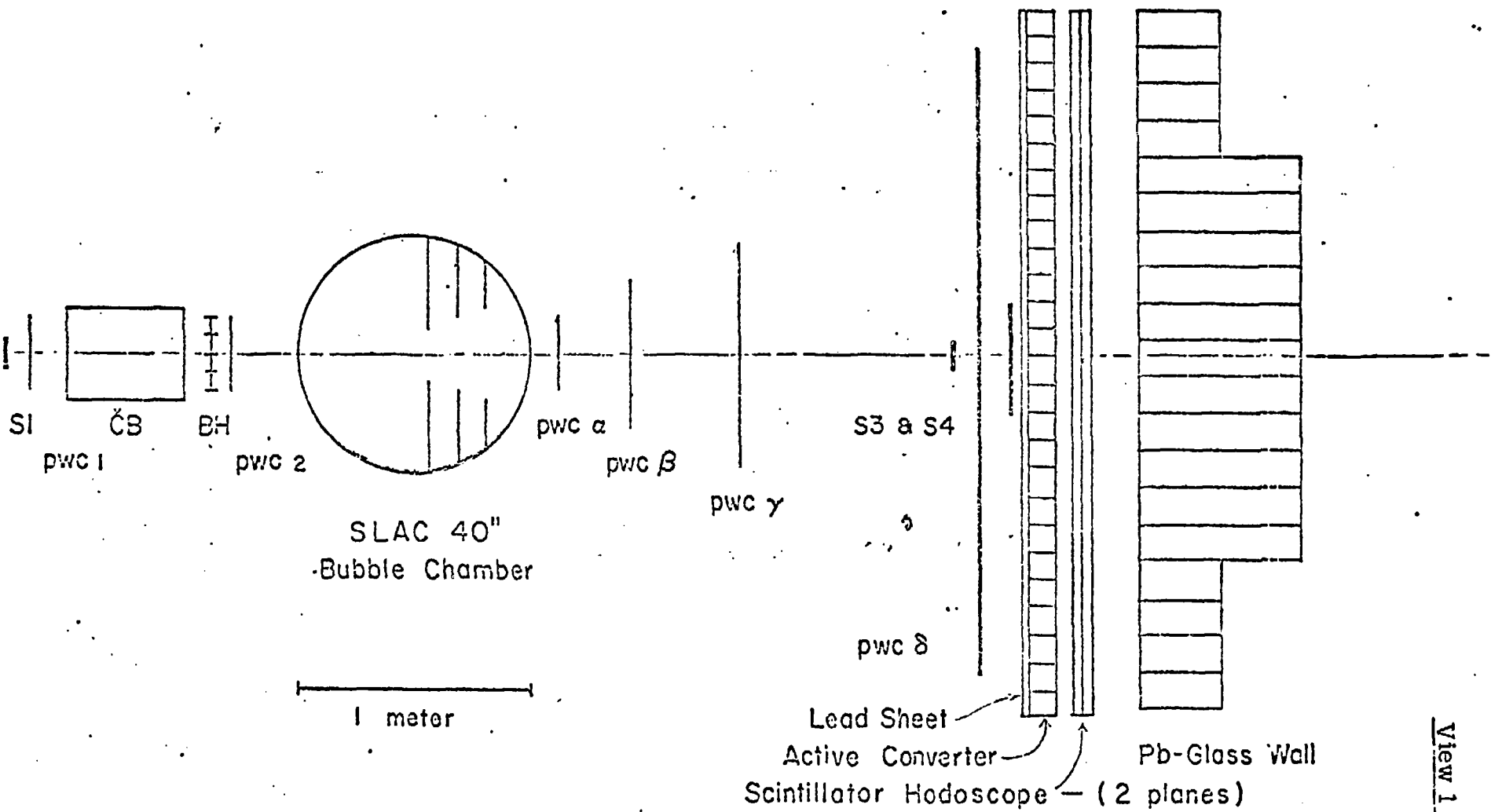
$$\sigma(\pi^+p \rightarrow \pi^+p\pi^0_{\text{fast}}) = 51.1 \mu\text{b}$$

which is probably good to 20%.

SUMMARY (See View 15.)

FUTURE WORK (View 16.)

BC-67 LAYOUT



View 1

2-prong events:



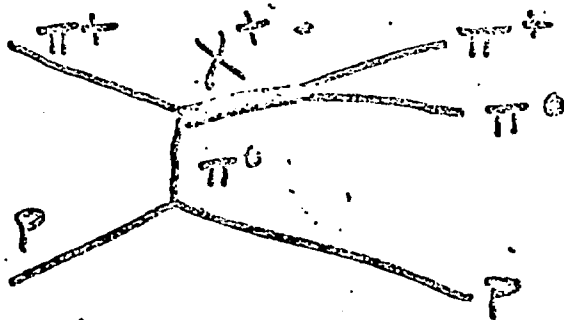
incident π^+ at 16 GeV/c

$\pi^0 \approx 8$ GeV/c

This experiment is different:

- ① FAST π^0 's
- ② Pb-Glass Wall allows for precise π^0 identification.
- ③ Higher Energy

New heavy mesons ?



(up to ≈ 5 GeV/c)

Previous X^+ 's:

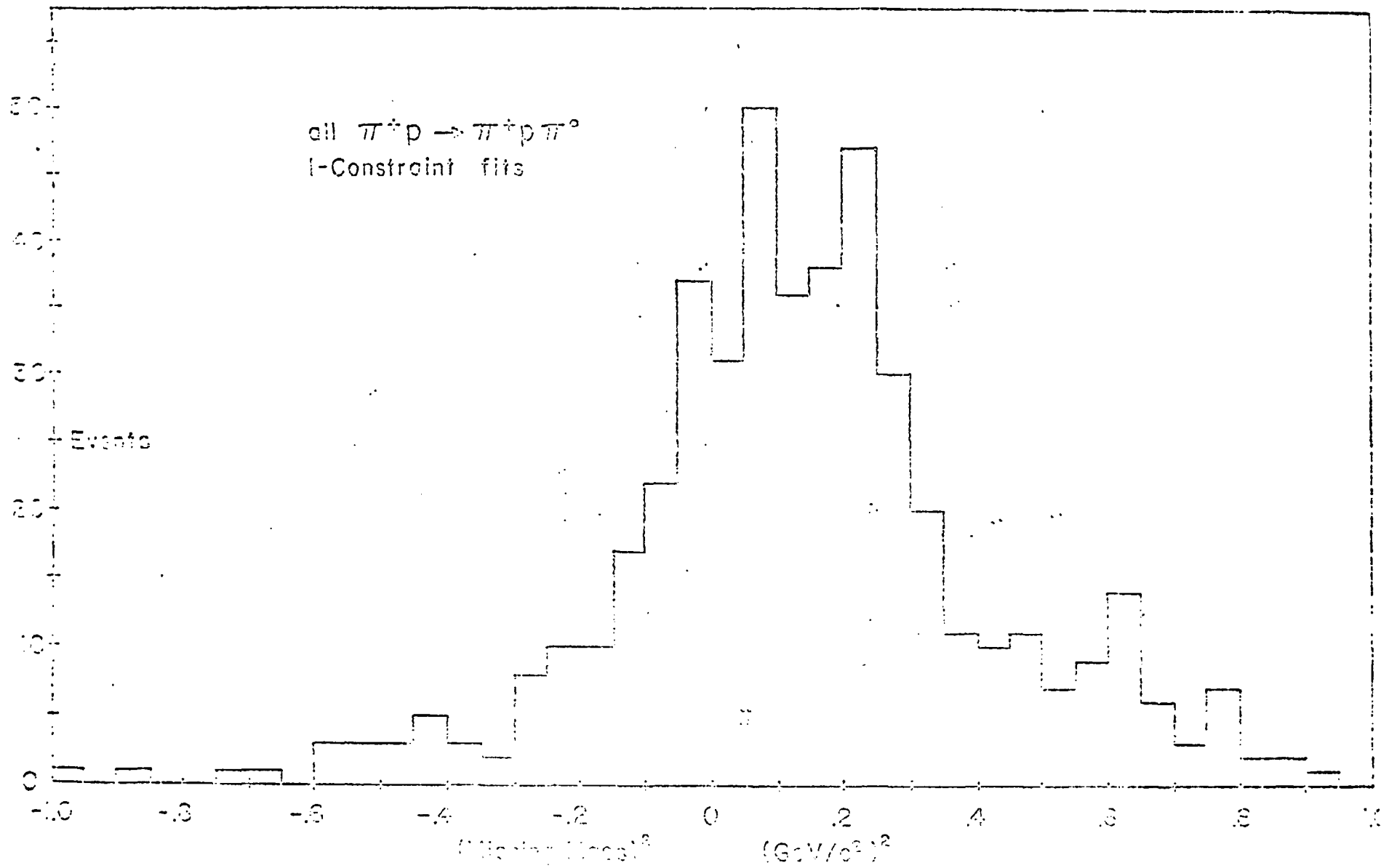
	J^P	C_n
ρ (770)	1^+ (1^-)	-
ρ' (1600)	1^+ (1^-)	-
ρ (1680)	1^+ (3^-)	-
S (1935)	(2^+)	
T (2190)	1^+ (3^-)	-

Traditional bubble chamber π^0 identificationschema:

1) Scan & Measure charged tracks in BC

2) Plot missing momentum for the events; and try a kinematic fit for each reaction to single π^0 production.

These "1-Constraint" fits then became the π^0 events.



New π^0 selection criteria:

- 1) Scan / measure
- 2) Events which survive 1-C π^0 kinematic fit

AND

- 3) Events are hand-selected by physicists at scan table, based on Pb-Glass wall information.

We selected events based on the presence of a single "unexplained" shower in the lead glass wall.

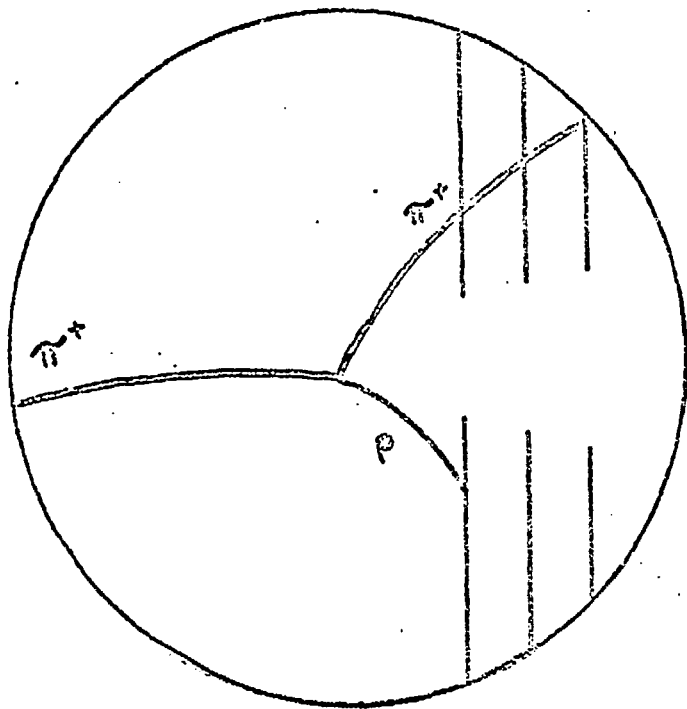
→ "unexplained" ⇒ not caused by charged tracks.

→ A single fast π^0 will essentially never resolve into² showers in the Pb-Glass wall.

YIELD $\sim 19\%$ of our original 1-C fits.

ROLL 458

FRAME 291

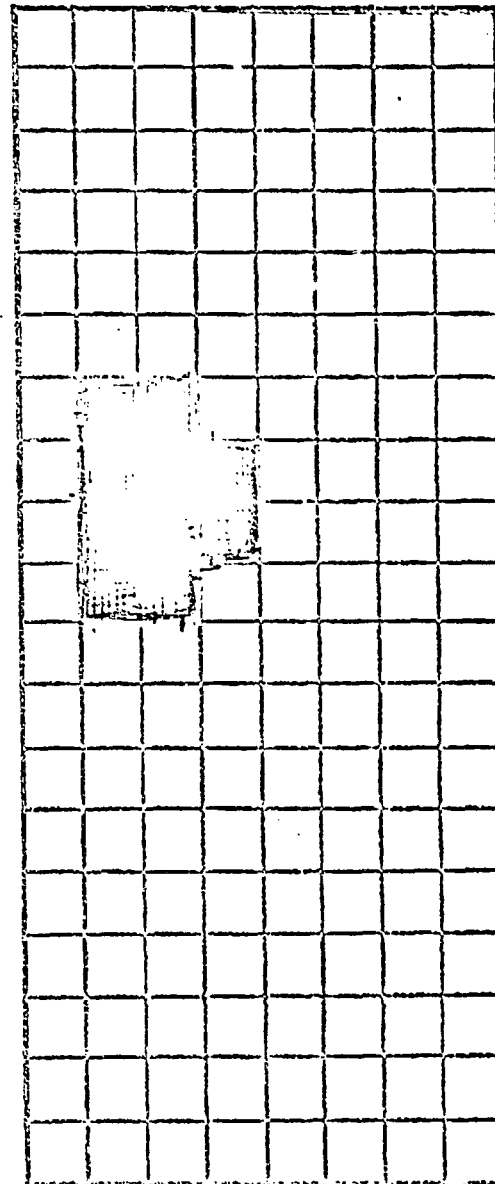
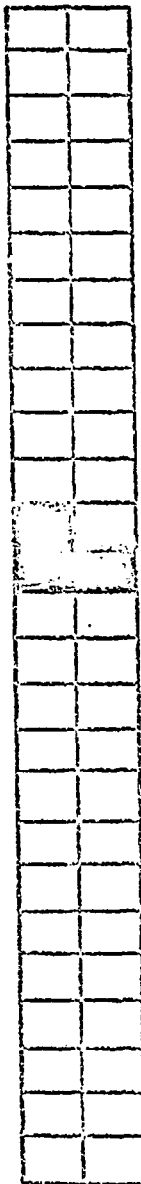


MISSING NEUTRAL
ENERGY = 15.30
GeV

DETECTED PHOTON
ENERGY = 14.98
GeV

ACTIVE
CONVERTER
ENERGY =
6.20 GeV

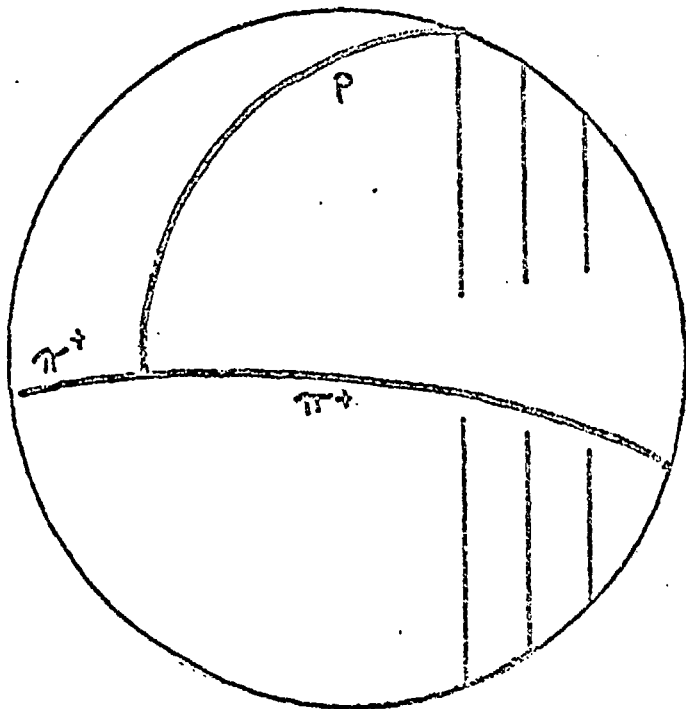
"Good". 1-C π^0 event



BACK BLOCK ENERGY
= 8.75 GeV

ROLL 490

FRAME 111

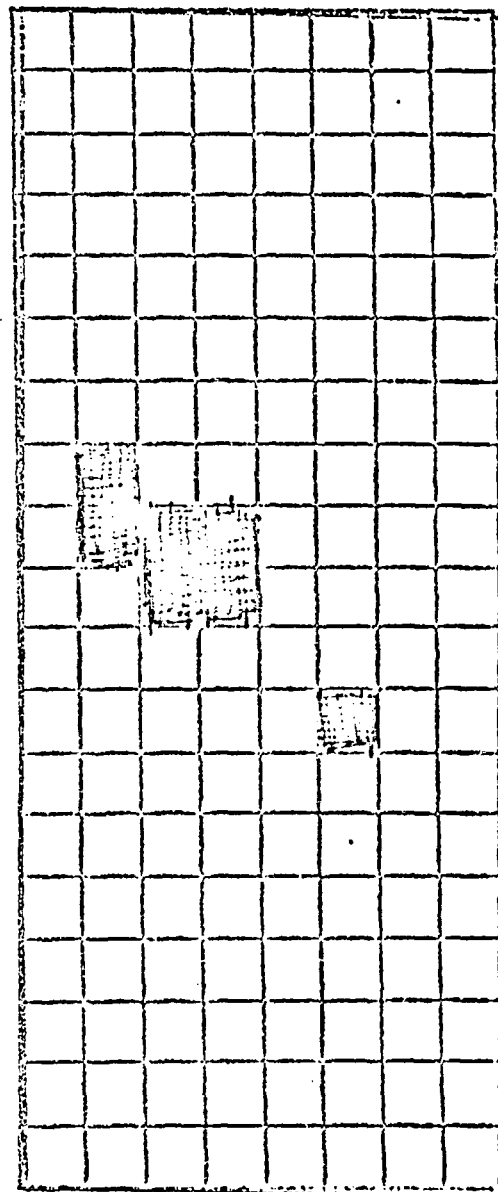
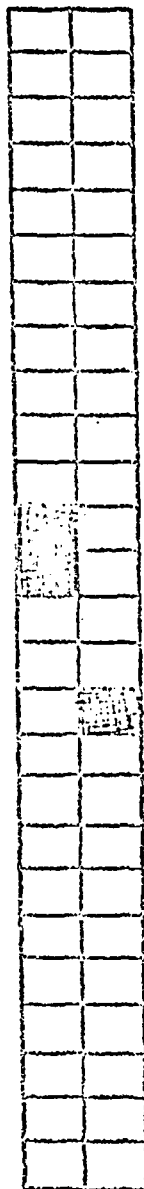


MISSING NEUTRAL
ENERGY = 7.13
GeV

DETECTED PHOTON
ENERGY = 7.20
GeV

ACTIVE
CONVERTER
ENERGY =
2.57 GeV

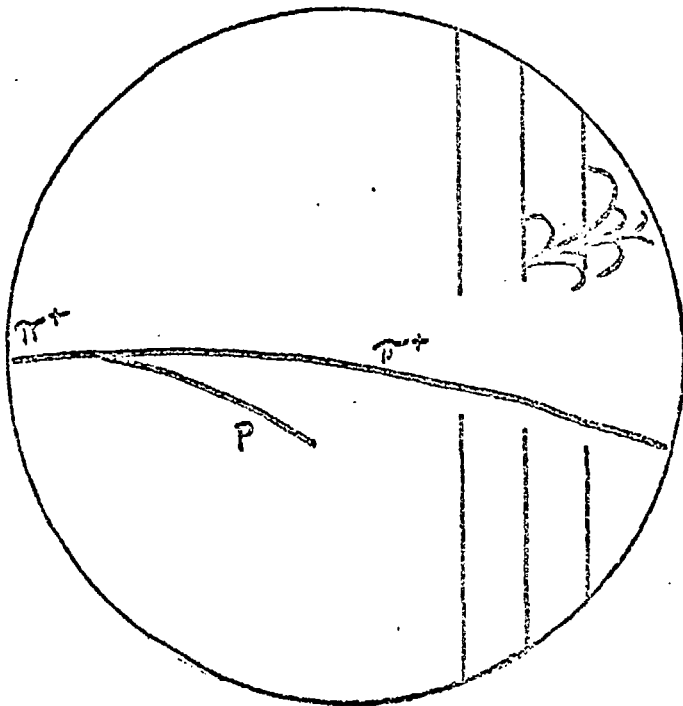
"Good" $i-C \pi^0$ event
(with hadron in Pb-Glass Wall)



BACK BLOCK ENERGY
= 4.63 GeV

ROLL 281

FRAME 531

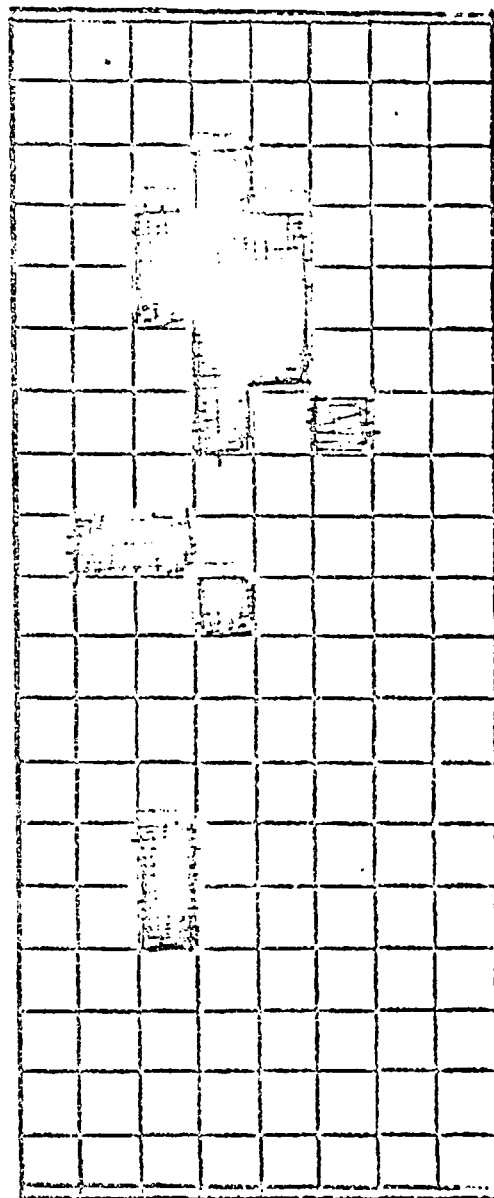
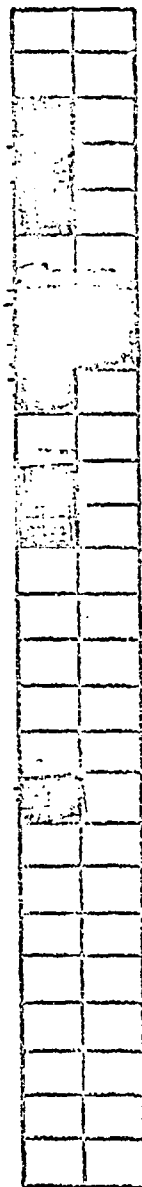


MISSING NEUTRAL
ENERGY = 9.80

DETECTED PHOTON
ENERGY = 8.58

ACTIVE
CONVERTER
ENERGY =
2.20 GeV

"Bad" 1-c. π^0 event



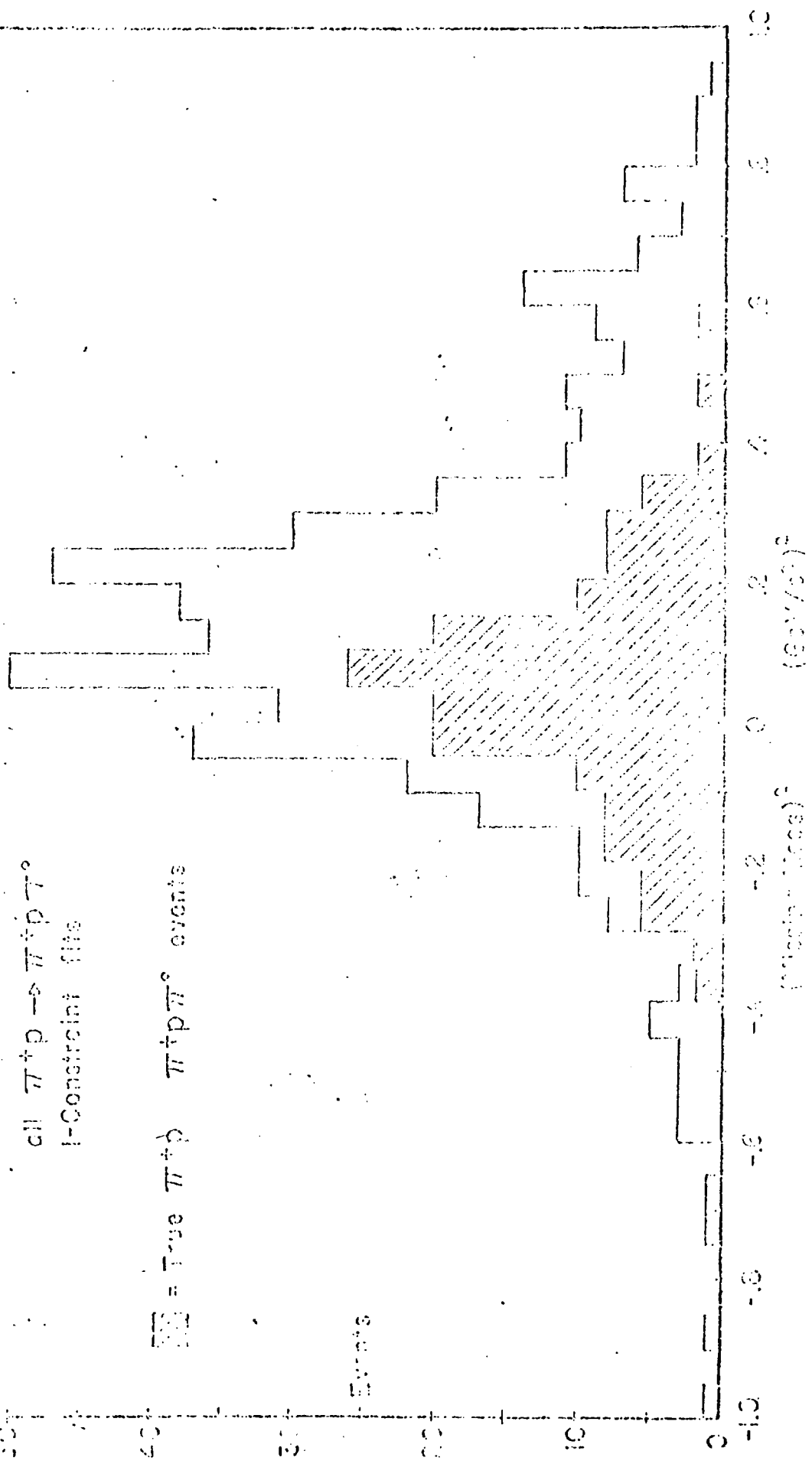
BACK BLOCK ENERGY
= 6.84 GeV

20 Apr 1968

all $\pi^+\rho \rightarrow \pi^+\rho\pi^0$
I-Constraint fits

\square = True $\pi^+\rho \pi^+\pi^0$ events

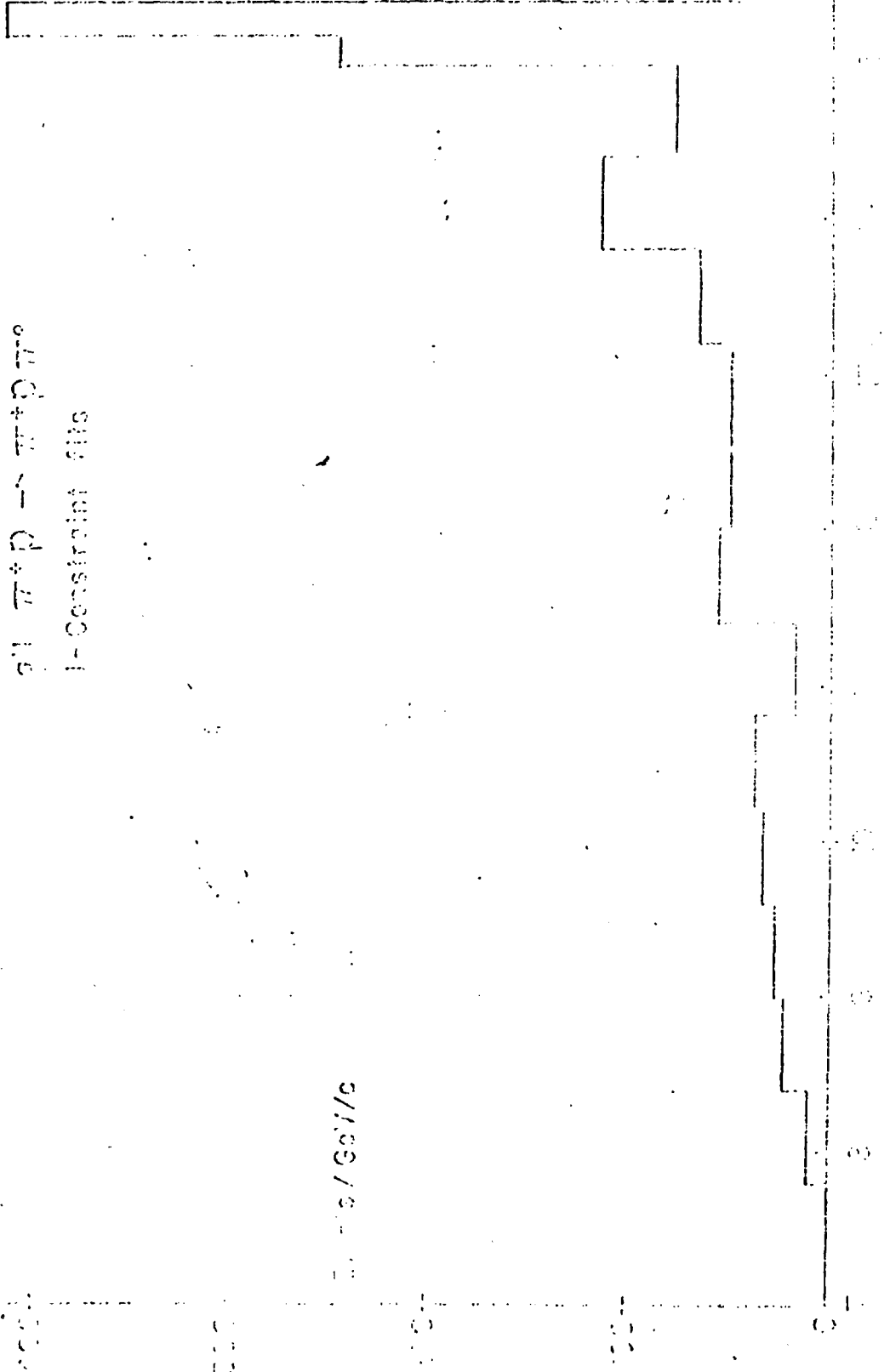
Events



$\pi^+ p \rightarrow \pi^+ p \pi^0$
1-Constraint fits

E_{π^+} / GeV

$\frac{d^2\sigma}{dE_{\pi^+} d\Omega}$




26 April 1960

View 12

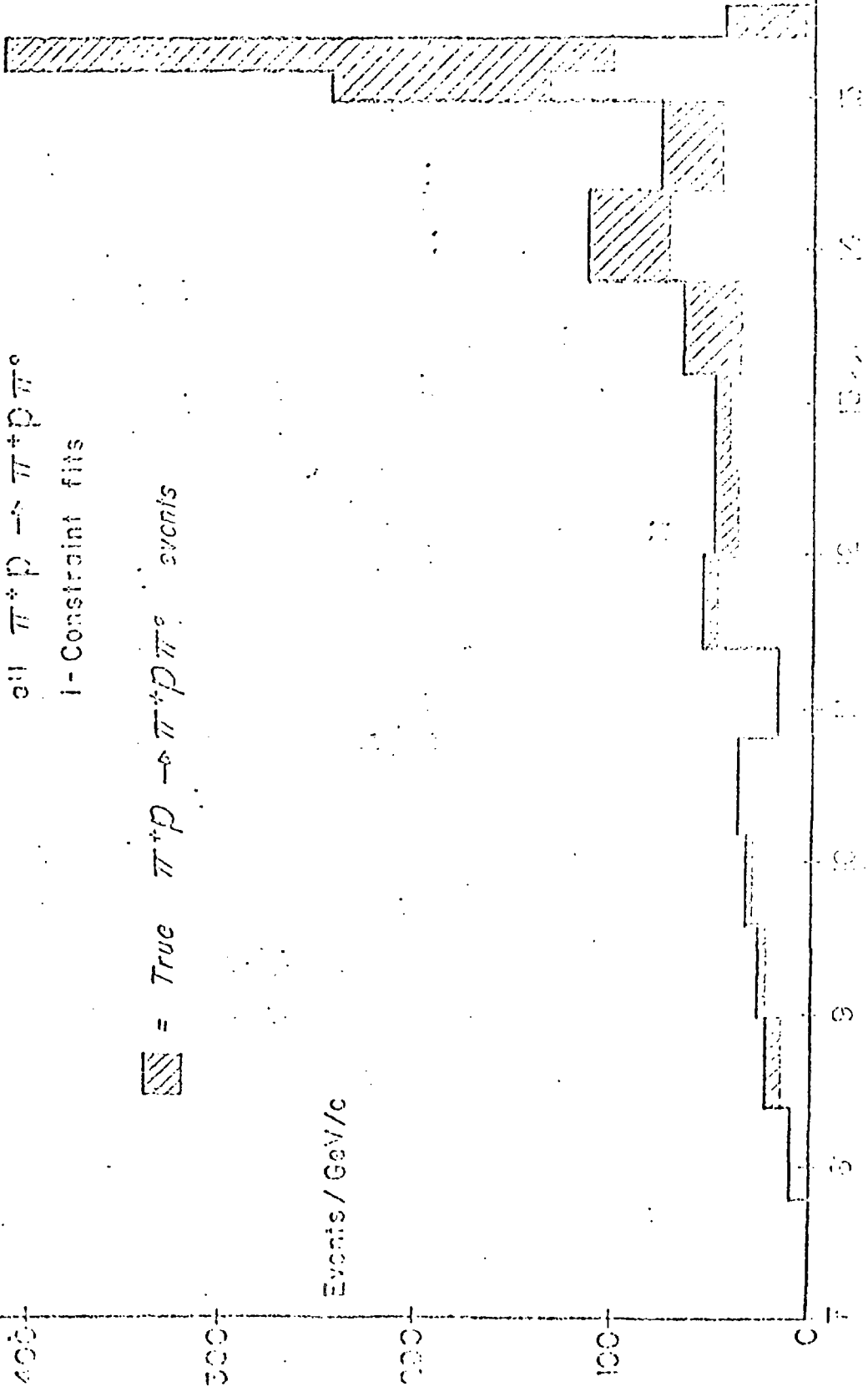
all $\pi^+\pi^- \rightarrow \pi^+\rho^-\pi^0$

1-Constraint fits

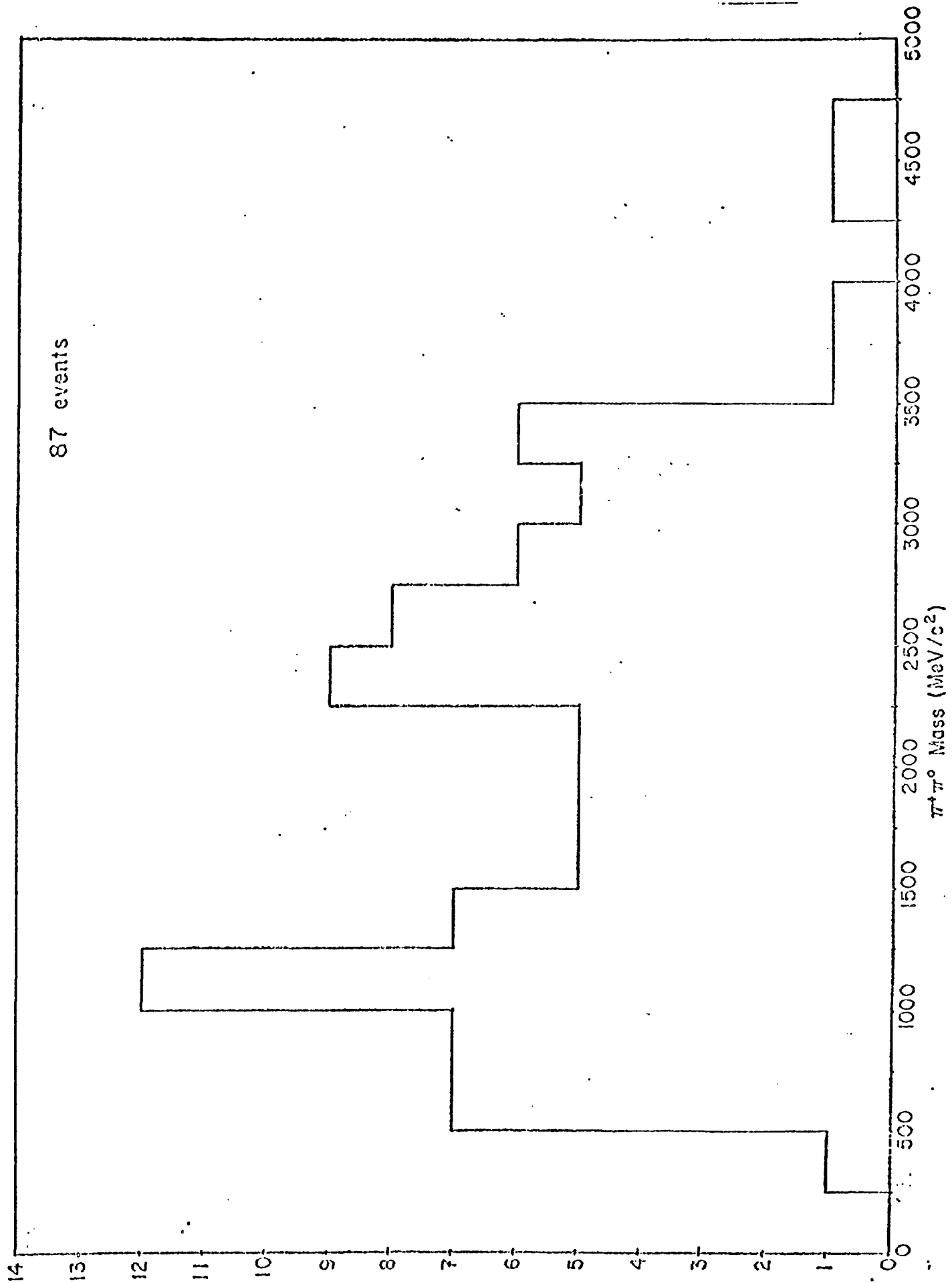
 = True $\pi^+\pi^- \rightarrow \pi^+\rho^-\pi^0$ events

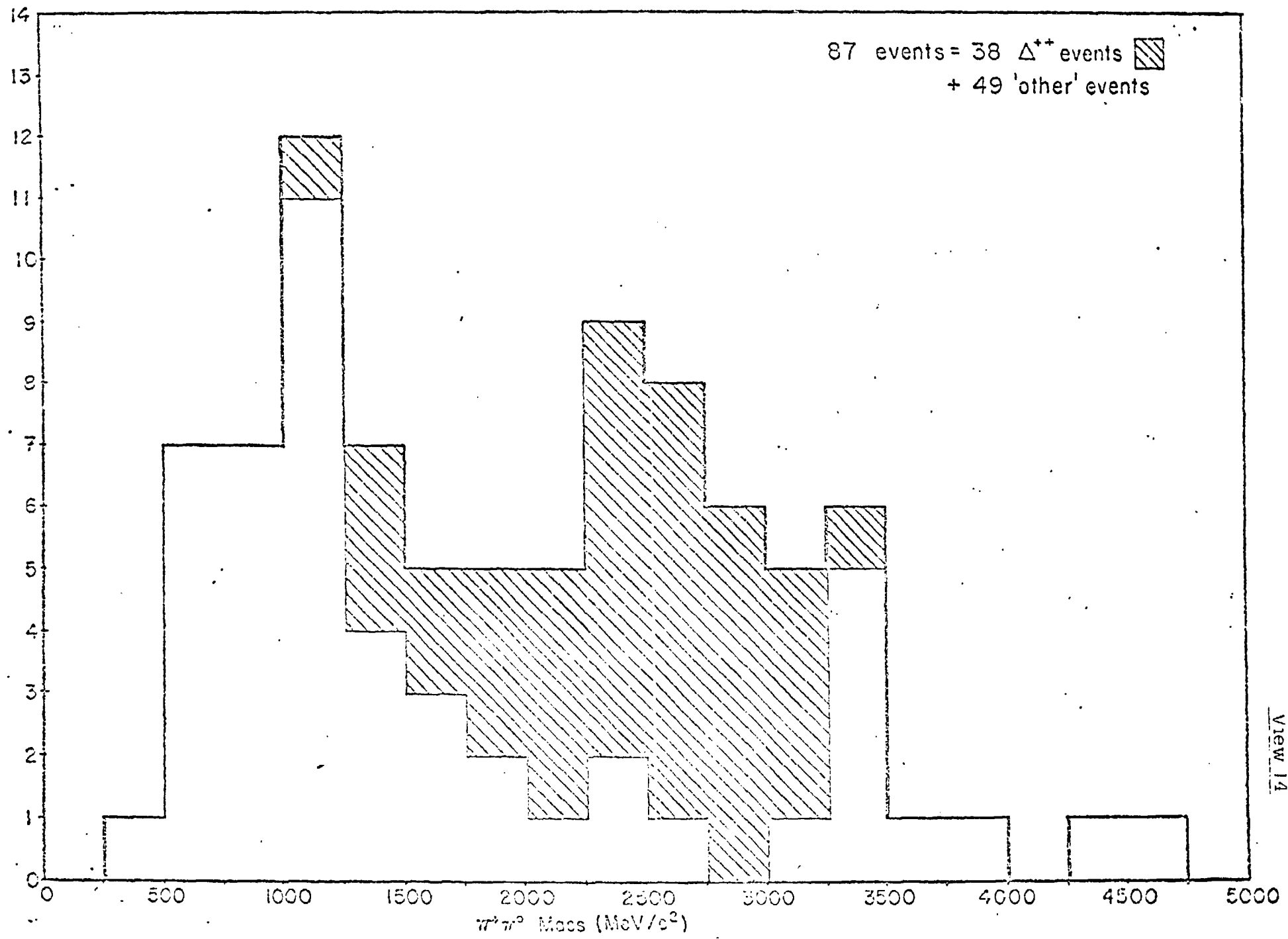
Events / GeV/c

\sqrt{s} (GeV/c)



87 events





SUMMARY

- ① BC + Pb-Glass wall can yield clean π^0 events.
- ② Not yet sufficient statistics.
(should improve by $\sim \times 10$)
- ③ $\sigma(\pi^+p \rightarrow \pi^+p\pi^0_{fast}) = 51.1 \mu\text{b}$
 $\pm 20\%$
(will improve with further analysis)

FUTURE

- ① Fine tuning in analysis programs.
- ② Add nearly $\times 10$ in statistics
- ③ Will soon have 4-C π^0 kinematic fits — to replace (hopefully!) physicist hand-selection of π^0 events.
[All ready successful on small sample of events.]
- ④ Will also begin to consider multiple π^0 and η^0 production events.