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Fixed Target Beauty Physics Experimental Programs*

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FIXED TARGET BEAUTY PHYSICS EXPERIMENTAL PROGRAMS

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Abstract

The current and near term future fixed target physics efforts in observing particles with open beauty are reviewed. This includes a compilation of the non-observation upper limits and the observation of both upsilon and b-states. A short discussion of the theoretical predictions for the hadro-produced beauty pairs is included. The major part of this review is devoted to the techniques and tricks employed, a survey of the current and proposed experiments. A personal summary of the experimental prospects concludes this report. A similar review has been done by J.D. Bjorken (1).

Discovery and Obseration of the Upsilon

Any discussion at Fermilab of beauty physics would be incomplete without an acknowledgement (2) of the discovery of the upsilon by E-288 and the beautiful, hi-resolution results of E-605. The experimental layout of E-605 for closed geometry di-muon running and the observed three upsilon peaks and the high mass continuum are shown in Figures 1 and 2. Also included are the limits on new resonance-like objects decaying into di-muons at the level of a few percent (σ*B) of the Drell-Yan continuum. Finally, resulting limits and exclusion regions for axion production followed by decay to e+ e- taken in parallel with the open geometry phase of E-605 are included.

Non-Observation of Bottom in Fixed Target Experiments

During the late-1970's through the middle-1980's there have been several experiments at CERN and Fermilab searching for open bottom production in hadron (3,4) and muon (5) beams. The techniques employed both pion and proton beams, and open and closed geometries to search for 3 or 4 muons, or same sign di-muons which would signal production of b b-bar pairs followed by semi-leptonic decays into charm pairs, with subsequent charm decays into muons. The technique of WA-17 Goliath (4) was slightly different in that this open geometry experiment attempted to reconstruct exclusive decays of the b-particles into ψ-ϕ, ψ-π, or ψ-K-(n-π's). The cumulative results of these searches were 90% confidence limits on the production of beauty pairs at about the 2 nb/nucleon level. If the production of b b-bar was assumed to be diffractive-like, these limits would increase to about 10 nb/nucleon. These limits were quoted for 400 GeV proton beams and 190-350 GeV negative pion beams.

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Observation of Bottom Particles

Two experiments at CERN have observed bottom particles using pion beams. The WA-75 collaboration (6) used an 350 GeV π- beam, an emulsion target, and a closed geometry muon spectrometer. The total number of interactions observed was 3 x 10**8, 1.5 x 10**6 with a single muon trigger, and 10,000 with a single muon with Pt > 1 GeV cut. They observed one event in the emulsion with four decay verticies (Figure 3) in which two negative muons were analysed in the muon spectrometer. The most likely scenario is the production of a B+ B0-bar pair followed by decays to D0 and D- subsequently followed by the decays of the charmed particles. This observation is a very striking graphic of both the beauty of the physics and the difficulties and opportunities for event reconstruction awaiting electronic detectors.

The WA-78 collaboration (7) interacted a 320 GeV negative pion beam in a Uranium target calorimeter. The hardware trigger required two muons. Software cuts were applied to require both high Pt for the muons and missing energy signaling neutrino production. In this manner, 13 tri-muon events were obsered consistant with the production of B-pairs and semi-leptonic decays at at least three of the four bottom and charm decay verticies. The quoted cross section for 320 GeV π- U interactions is:

σ(π- U -> b b-bar) = 4.5 +- 1.4 +- 1.4 nb/nucleon (assume A**1)

or

σ(π- U -> b b-bar) = 17.6 +- 5.5 +- 5.5 nb/nucleon (assume A**0.75).

E. Berger (8) has reported that the WA-78 group has revised these cross sections downward after review of their acceptance calculations. The revised cross section reported at San Miniato, May, 1987 were:

σ(π- U -> b b-bar) = 2.4 +- 0.7 +- 0.8 nb/nucleon (assume A**1).

Theoretical Predictions for Hadroproduction of Beauty Pairs

A compilation of theoretical estimates of the beauty hadroproduction cross sections are shown in Figue 4 taken from the E-771 proposal (9,10). Also included are the production limits and observations of WA-75 (6) and WA-78 (7). The theoretical estimates of hadroproduction beauty cross sections are very sensitive to the assumed functional form of the QCD evolution scale, the assumed mass of the bottom quark, and any K-factor enhancement. Butler and Berger (11) have come up with benchmark cross sections that are useful for comparison of anticipated event yields for upcoming experiments. Berger suggests the following cross sections (K=1) which are near the center of most of the theoretical spread of predictions:

	σ (p p -> b b-bar X)	
400 GeV	0.3 nb	(0.2 to 0.6 range)
600 GeV	1.5 nb	(0.9 to 3.0 range)
800 GeV	4.5 nb	(2.0 to 9.0 range)

σ (π^- N -> b b-bar X)

400 GeV	3.0 nb	(1 to 6 range)
600 GeV	7.0 nb	(3 to 14 range)

These benchmark cross sections are also shown in Figure 4.

B-Physics Techniques and Tricks

All current attempts to study bottom production in Fixed Target experiments employ sophisticated vertex detectors to try to observe and isolate events with downstream secondary verticies signalling the decay of either the beauty particle or its charm particle daughter. It is also worth noting that each of these beauty experiments, notwithstanding the difficulties of observing beauty, is, in its own right, a powerful charm experiment. A brief preview of the varied techniques employed is given.

The vertex detectors chosen include silicon micro-strip detectors (SMD or SSD) by most experiments, emulsions (WA-75 and E-653), optical scintillating fiber targets (WA-84 and E-687), and a high resolution streamer chamber (T-755). In addition, the emulsion, scintillating fiber, and streamer chamber experiments also use silicon microstrips as part of their vertex detectors. Some experiments use very loose total hadronic or transverse energy triggers (E-687 and E-769). WA-82 uses a reconstructed vertex algorithm for triggering. Single lepton triggers are quite in style (WA-75, WA-82, E-653, E-706). The channel B => ψ X => μ+ μ- X is popular (E-771 and E-672-706). The son of E-605 proposes to search for exclusive two-body decays of bottom at high luminosity (P-789). E-690 will use a data driven track processor for full event reconstruction at the trigger level. Finally, the unique advantages of photon (E-687), muon (P-789), and hyperon (P-781, I/166, and P/233) beams will be used to enhance observation of bottom particles.

Note on Sensitivites and Projected Event Yields

For the following discussion and comparisons of individual experiments, I have tried to normalise all the expected sensitivities and event yields for a typical data run. The previously discussed benchmark cross sections were used. In addition, an A**1 dependence for the beauty cross sections was assumed unless otherwise noted. I have assumed the following models for a typical data run. At Fermilab, the 1987 fixed target run is 7 months long with an assumed 20% devoted to experiment startup. Typical maintainence and study periods and accelerator operational efficiency (65%) were assumed. This produces 3.4 x 10**6 data spill seconds per run. Similarly, the CERN 1987 run of 79 days with 3.0 second spill/10.8 second cycle and the projected LEP era schedule of 125 days with 3.0 second spill/15.6 second cycle both give 1.9 x 10**6 spill seconds per year run. Including a similar 20 % experiment startup and a 65 % accelerator efficiency typical of Fermilab operations, this gives a CERN rate of 1.0 x 10**6 data spill seconds per year. The experiments are assumed to be running at 30% dead time.

E-653. Fermilab E-653 (12) is a U.S., Japan, Korea Collaboration using a hybrid emulsion spectrometer to study the hadronic production and lifetimes of charm and bottom particles (Figure 5). The incident hadron beam is 10**4 particles/second impinging on a 5% interaction length target. The single muon trigger fires at approximately 0.03 times the total interaction rate. The heavy quark candidate events are identified in the conventional spectrometer. Secondary verticies are identified using the silicon microstrips. The event vertex is projected using the silicon microstrip detector back into the emulsion target. This is the starting point for the vertex scan. This experiment has recently completed its data taking and is presently is in an analysis-emulsion event finding phase. In the 1985 run with 800 GeV proton beam, 6 Million triggers were taken, giving a sensitivity of 1.2 events/nb, including trigger, reconstruction, and event finding efficiencies. In the 1987 run, a 600 GeV π- beam was used. This gave 9.6 million triggers and a sensitivity of 2 events/nb. These would correspond to approximately 5 b b-bar pairs produced for the proton data and 14 b b-bar pairs produced for the pion data.

WA-82-IMPACT (13) is a currently running experiment at CERN using the Omega spectrometer along with an impact parameter trigger. (Figure 6) The basic idea of the impact parameter trigger is shown in Figure 7. The pitch (strip resolution spacing) of the trigger SMD stations is chosen to be proportional to the distance downstream of the target. Given a well tracked beam particle, this provides a simple algorithm using the address of the hit strip to tag tracks that do not appear to originate in the primary vertex. For tracks that originate at the primary vertex, the strip addresses follow a particularly simple relation for each coordinate projection. n(a) = n(b) = n(c). For those tracks with finite impact parameters indicating a decay product, $n(a') \neq n(b') \neq n(c')$. The resolution of this impact parameter trigger is expected to be in the 100 - 1000 micron range.

This experiment will run with 360 GeV π- and 280 GeV enriched π+ beams. Its expected interaction rate is 0.9 x 10**4 interactions per second on a 0.84 % L-int W + 0.27 % L-int Si target. For a typical CERN running period of 40 days (including 8 days set-up), this would correspond to an expected sensitivity of 150 events/nb. Assuming 3 nb production cross section scaling as A**1 and a 1 picosecond b-particle lifetime, the expected b b-bar sample would be 1500. With a Pt > 1.3 GeV electron cut, this would be reduced to 135 b b-bar pairs (with a D D-bar background of 3000 pairs). A further missing Pt cut would produce 50 b's with a background of 60 D's.

WA-82 has recently completed a data run during the summer of 1987 (14). This included a 15 day setup period and 30 days of data. During this period 10 Million triggered and 3 Million unbiased events were recorded. 5 % have been analysed and several thousand charm events are expected from this data sample. This experiment is anticipating a similar run next year.

WA-84-SCIFI (15) is another CERN experiment using the Omega spectrometer with a specialised target. (Figure 8). The production target-detector consists of optical SCIntillating FIbers giving the experiment nickname. The scintillating Ce2-O3 fibers are 20 microns in diameter and are orientated longitudially along the beamline (Figure 9).

The readout is by a phosphor screen memory for trigger delays followd by a gated image intensifier and CCD readout. The beam's eye view of a monte carlo interaction is shown in Figure 10 with four decay verticies.

For comparison, E-687 (16) is also working to develop a scintillating fiber active target vertex detector SFT as shown in Figure 11. In this case, the fibers were chosen to run perpendicular to the beamline. A three stage gated intensifier is used. It is indended to test this device in the wide band photon beam during the current running period. Future enhancement may include small angle stereo to allow three dimensional tracking.

WA-84 will use a 360 GeV π- beam at incident intensity of 5 x 10**6 pions per second. A simple interaction trigger will gate the image intesifier within 50 nanoseconds. A 4-particle high Pt trigger developed (Figure 12) by WA-77 will arrive within 1 microsecond to veto to the clear for the CCD. Readout deadtime for the CCD is expected to be about 20 milisecond. The trigger rejection using this 4-particle trigger with Pt > 0.6 GeV is anticipated to be 1/600 with an efficiency of about 10 %. The request is for a 50 day data run producing 670 b b-bar pairs assuming a 3 nb production cross section, approximately 1/3 of these events with all four decay verticies observed within the SCIFI target. The experiment is awaiting a 15 day test run.

E-771 (17) is a study of beauty production associated with di-muon production in proton-nuleon interactions. Figures 13 and 14 show the augmented E-537/E-705 spectrometer and one possible configuration of a high rate target and silicon strip vertex detector. This experiment is preparing to run during the next Fermilab fixed target running period. The physics goals are to study the cross sections, lifetimes, mixing, and some exclusive decay modes of bottom particles. This experiment uses an open geometry spectrometer with a muon trigger, and silicon vertex detector. Future growth may include a (not yet approved) ring imaging cerenkov counter (RICH). The current E-705 spectrometer is capable of operating at 2 x 10**6 interactions per second with a data acquisition system capacity of 200 events/second. The trigger acceptance of the B => ψ => μ+ μ- is 25 %. The reconstruction and other efficiencies are estimated to be 60 %. A typical Fermilab data run would produce a production sensitivity of 160 events per picobarn/nucleon.

The main trigger of E-771 will use the large branching fraction of B => ψ (1 %) followed by ψ => μ+ μ- (7 %). This gives a total BR of 7 x 10**-4 (times two for each of the b and b-bar). Using a benchmark cross section for b-production of 4.5 nb/nucleon an a A**1 enhancement for a tungsten target, this would yield approximately 540 b b-bar events with a ψ => μ+ μ- tag in a typical data run.

The second physics goal is to study B0 - B0-bar mixing. This is manifested by same sign di-leptons from the semi-leptonic decays of the B's. Using the integrated luminosity and sensitivity above, 5400 non-mixed +- muon pairs would be observed. Using the ARGUS results and assuming 20 % mixing for the B0-s, there would be 650 ++ and -- mixed muon pairs. However there would be 2900 ++ and -- muon pairs from the b => c => μ decay chain where the semi-leptonic decay of a charm produced from a non-mixed beauty would mimic the mixing process. Therefore a 4/1 background to signal ratio is anticipated at this level. The signal will be cleaned up by reconstructing the decay verticies to insure that the observed trigger muons come from the parent b and not the daughter c decays. Cuts could also be placed on the effective mass of the ++ or -- muon pairs to possibly enhance the mixed content of the data sample.

A third physics goal of E-771 is to observe some exclusive decay modes including ψ similar to that of WA-17. Each of these decay channels: ψ K-, ψ K- π+, ψ ψ, ψ K+ K-, ψ π, are anticipated to have branching ratios on the order of 0.1 %. The study of these channels may also require the RICH counter which has not yet been approved by the Physics Advisory Committee.

E-706/E-672. The combined apparatus of E-706 and E-672 (18) has a capability of studying many of the topics covered by E-771. See Figures 15, 16, and 17. E-706 is a study of hadronic production of high Pt single photons and features a silicon microstrip target-detector, an open geometry magnetic spectrometer, and large aperture electromagnetic and hadronic liquid argon calorimeters (LAC). This LAC can provide a high Pt electron trigger for beauty physics. E-672 has a di-muon toroid spectrometer and trigger that was used in conjunction with the Fermilab Multi-Particle Spectrometer to study hadronic states associated with di-muon production. These two experiments share the apparatus, triggering, and data sets. After a lengthy startup period for the liquid argon calorimeter, these experiments have begun common data taking. The operation of the E-672 di-muon trigger processor is shown in Figure 18 showing the on-line trigger ψ resolution using only the toroid spectrometer. Similarly, the E-706 liquid argon calorimeter octant photon trigger and reconstructed π° mass resolution is shown in Figure 19. The lack of background feeding down from the "spectator" octant under the "trigger" octant Pt sum is encouraging both for photon and electron triggering.

The beauty physics goals of E-706/E-672 are similar to those of E-771. It uses a 530 GeV π- or 800 GeV proton beam with a maximum interaction rate of 10**6 interactions per second. Since E-706 is primarily interested in direct photon studies, it will continue to use a 5% Carbon target to allow separation of the QCD Compton and Annihilation processes for π+ and π- beams. In a typical Fermilab data run, this would result in a production sensitivity of about 116 events/picobarn/nucleon. Including the A**1 enhancement would give a production sensitivity of 220 events/picobarn. The di-muon acceptance for B => ψ => μ+ μ- is 12 % giving an event yield of 200 b b-bar pairs. Similarly, for continuum muon production above the ψ the acceptance is 3.5 % for the study of mixing. This would lead to 120 same sign di-muon pairs from B0 - B0-bar mixing. The experiment is currently operational and taking data. It is expected that there will be approximately 500 hours of π- C data giving 25 B => ψ => μ+ μ- and 15 mixed ++ or -- muon pairs this run at 10**6 interactions per second.

Additional future (not yet approved) enhancements for the study of beauty physics would be the use of a heavy W target, the upgrade of the hadronic part of the Liquid Argon Calorimetry to provide hadronic triggers, the upgrade of the proportional chambers with higher resolution mini-drift electronics, and a possible ring imaging cerenkov counter (RICH).

E-690 and BNL E-766 (19) uses a high rate spectrometer and a data driven, real time, track reconstruction processor to study the production of charm and beauty. The track processor has operated at rates of 10**5 fully reconstructed events per second at the trigger level. This experiment has used the apparatus of Figure 20a. as Brookhaven E-766. This experiment had two weeks data using n-p interactions at 15-28 Gev, accumulating 300 Million events with a 9 or more track trigger. Similarly, another 300 Million events were taken in less that 2 weeks using 28 GeV p-p interactions requiring 10 or more (and some prescaled 8) track events. These data were typically taken at 10**6 interactions/second with 30 % dead time. The spectrometer is probably capable of operating at up to 2 x 10**6 interactions/second. Beyond that, it would be limited by overlapping event confusion. For the BNL data, the event processor was not available for triggering. The data was taken on tape and analysed later, at input physics data speeds, using the processor in a playback mode. At Fermilab, the processor is expected to provide on-line event reconstruction and trigger selection.

It was anticipated that E-690 would be installed at Fermilab for the next fixed target physics run in the experimental hall currently occupied by E-605/E-772. The proposal P-789 to use the E-605 spectrometer for studying exclusive two-body beauty states may have an impact on which beam may be made available for E-690.

E-690 has been split into two phases. The first approved phase (Figure 20b.) is to move the BNL E-776 spectrometer to Fermilab and add a forward spectrometer to study p + p => p(forward) + target fragmentation. The existing BNL E-766 spectrometer would study the target fragments. At 2 x 10**6 interactions/second, this would correspond to the production of 700,000 b b-bar pairs per run. A goal of Phase 1 is to search for beauty production among the target fragements. The recoil b b-bar state would have a laboratory momentum of 50-75 GeV/c, approximately three times that of the states studied at BNL. This Phase 1 detector uses a liquid hydrogen target, and does not have neutral particle or lepton detection. The vertex proportional chamhavers are claimed to have sufficiently high resolution for the study of b b-bar decays.

P-690 Phase 2 (Figure 20c.) would add a second analysis magnet, an additional cerenkov counter, EM and hadronic calorimetry, and a muon detector to increase the phase space region studied. This enhancement has not yet been approved by the Physics Advisory Committee.

P-789 (20) is a proposal by the E-605-E-772 collaboration to use the existing spectrometer in the open geometry configuration to study the two-body exclusive decays of b-particles at high luminosity. The main features of the apparatus are shown in Figure 21 and include the refurbished ring imaging cerenkov counter, a new collimator shield and high resolution proportional chamber station both at the downstream end of the mass selection magnet, and a pair of silicon microstrip vertex detector arrays to be placed just downstream of the primary target. Assuming a branching ration of about 0.01 % for exclusive two-body states such as $\pi+\ \pi-$, K+ K-, $\pi+$ K-, and K+ p-, this would correspond to a σ*B of approximately 1 picobarn per channel. This is comparable to the σ*B of $\Upsilon \Rightarrow \mu+\ \mu-$ of which E772 will obtain about 30 thousand upsilons during the 1987 closed geometry, high intensity data run. The general idea is to tune the spectrometer to 5 GeV masses corresponding to an acceptance of about 6 %, reduce the incident proton rate to 5 x 10**8 interactions per second corresponding to 10 interactions per RF bucket, improve the spectrometer mass resolution to approximately σ(m) = 1 MeV, and add the silicon vertex tracking system. Finally, add a lifetime vertex trigger processor to provide an on-line cut of 0.5 B lifetime with a σ(t) = 0.2 picosecond. There are many technical questions about the survivability of the silicon vertex trackers and their reconstruction confusion at high rates, the actual mass resolutions attainable, and the development of the vertex trigger hardware. If it all works, then in a single data run, P-789 may obtain:

B0-d => $\pi+\ \pi-$	800 events	S/N = 1/11
B0-d => K+ K-	800 events	S/N = 1/2.5
B0-s => K- $\pi+$	400 events	S/N = 1/7.5
Λ-b => K+ p-	400 events	S/N = 1/1.5

The rates and backgrounds are calculated based on the E-605 open geometry running experience.

P-791. This letter of intent (21) considers the extension of the currently running E-769 to study beauty physics. This would use the Tagged Photon Lab Spectrometer, Figure 22, which performed the very successful charm experiment E-691, with a secondary hadron beam upgraded to approximately 500 GeV. The current spectrometer drift chambers can operate at up to 4 x 10**4 interaction/second. The current SCC + RBUFF + ACP data acquisition can take up to 400 triggers per spill second at 35 % dead time. The current E-transverse trigger threshold of 2.2 GeV (0.33 σ-inelastic) can be increased to an equivalent of 0.05 σ-inelastic. In addition, high Pt lepton and multiplicity jump triggers will be considered. Such an interaction rate will allow a sensitivity of 4.6 events/pb or 23,000 produced b b-bar pairs in a typical fixed target running period, even without an additional A**1 target enhancement.

NA-32 - HELIOS. This currently running experiment (22) is intended to study the hadroproduction of electrons, muons, and neutrinos. Although it is not specifically designed to study beauty physics, its high resolution calorimetry, closed geometry, and silicon microstrip vertex detector, Figure 23, may be quite adaptable to study this physics. The apparatus is designed to use a 450 GeV proton beam incident upon a very thin beryllium target at an rate of 5 x 10**4 interactions per second, giving a sensitivity of 2 events per picobarn or about 800 b b-bar pairs produced for a typical data run including the A**1 enhancement.

E-687 (23) is a new spectrometer, Figure 24, featuring two analysis magnets, 20 planes of MWPC with mini-drift, 3 cerenkov counters, 2 muon detectors, 3 electromagnetic calorimeters, 2 hadronic calorimeters, and most importantly, a 8400 channel silicon microstrip vertex detector. It uses the high flux wide band electron beam at 350 GeV to study photoproduction of charm and beauty. This corresponds to approximately 2.5 times the photon flux used by E-691 in their successful charm photoproduction experiment.

Photon-Gluon Fusion Models predict a photoproduction cross section for beauty pairs that rises linearly from a threshold of about 100 GeV up to the range of 3-7 nb/nucleon at 500 GeV photon energies. The added feature of photoproduction is, that at a typical photon energy of 250 GeV, the ratio of b b-bar/hadrons is 1.8 nanobarn/120 microbarn = 1.5 x 10**-5, compared to a similar ratio of 1.7 x 10**-7 for 800 GeV p-p interactions, an enhancement of almost 100!

The 350 GeV electron energy was chosen to optimise the rate of detected b b-bar events per primary proton. The data acquisition system can handle up to 200 hadronic events per second. The expected event rate is 190 hadronic events produced per second over the range of tagged photons 150 - 400 GeV. This correspond to production of 0.1 b b-bar pair per pulse, 6 b b-bar pairs per hour, or 15,000 b b-bar pairs per run. The experiment trigger is designed for tight rejection of e+e- pairs with a loose hadronic trigger requirement of a minimal hadronic calorimeter energy or a di-muon pair. This experiment had attained a data taking mode before sustaining a damaging fire in early October, 1987. It is currently in a startup mode after rebuilding and expects to be ready to take another month of data this run.

<u>P-786</u> (24) is a follow-on experiment to E-665 which is in its first data run with the new muon beam and spectrometer. This future proposal would replace much of the wide angle spectrometer (Figure 25) with an 8 meter long Uranium-scintillator target calorimeter with an incident muon beam up to 750 GeV. The experiment would search for tri-muons which would include the beam-like muon and two high-Pt muons from b b-bar decays. The expected muo-produced hadronic events is expected to have 10**-4 b b-bar content. 10**9 hadronic events could be observed in a typical running period giving 10**5 b b-bar pairs produced leading to 10**3 μ+ μ- pairs and 100 mixed ++ or -- pairs.

<u>Production of Beauty with Hyperon Beams</u> Three experiments are proposed to use hyperon beams to study both charm and bottom production. These proposals have been encouraged by the apparently large cross sections for charmed baryons and exotics such as the Λ p-bar π's state at 3105 MeV which have recently been reported by E-400, WA-62, and BIS-2 using neutron and hyperon beams. These proposals or letters of intent include I/166 (25) which proposes to either bring a hyperon beam to NA-14 or NA-14 to a hyperon beam, P/233 (26) proposing to bring a hyperon beam to the Omega Spectrometer, and P-781 (27) proposing to build a new large-x baryon spectrometer for the Fermilab P-Center hyperon beam.

<u>T-755</u> (28) is a test of the diffusion suppressed high resolution streamer chamber developed by Yale University. The proponents consider a streamer chamber as an ideal device for the study of beauty physics due to its unique ability for pattern recognition and reduced combinatoric

backgrounds compared to silicon microstrip projection detectors. It will be able to reconstruct complex four vertex topologies including the important charged or neutral determination. Finally, this detector could operate along with some spectrometer such as P-791 at rates up to 8 x 10**3 interactions per second.

The streamer chamber has streamer diameter less than 50 microns, adjustable density of 7-15 streamers per millimeter, a diffusion σ of less than 12 microns, an adjustable memory time of 1-10 microseconds for triggering, and a dead time of 50-100 milliseconds limited by the Marx generator. The chamber size is 13 x 3.5 x 1.5 cm**3, giving typically 8 cm fiducial volume, 1 cm for beam tracking, and 6 cm for clear track measurement. An event observed in the Meson-Test beam is depicted in Figure 26 showing four tracks produced just upstream of the chamber. The vertex reconstruction width is less than 12 microns σ.

Typical chamber operating conditions are 28 atmospheres 50% He - 50% Ne with a 217 KV pulse of 2.8 nsec duration. The chamber works on the principle of capturing the produced ionisation by O2 (0.4 atmosphere O2) forming an O2- ion within 20 nanoseconds. This rapidly (10 nsec) converts to an O4- ion. While parked on this heavy ion, the thermal diffusion of the ionization is suppressed while the trigger is formed. Upon a decision to trigger, a photo-ionisation laser fires liberating the electron and the streamer chamber is pulsed. The lifetime of the O4- ion is controlled by the concentration of CO2 giving a lifetime of 6 microseconds for 10 mm Hg of CO2. Readout would be by CCD, Vidicon, or laser holography.

<u>Summary</u>

The current and near future fixed target beauty physics programs give the promise of:

a handful of beauty events with emulsions (E-653, WA-75),
a few hundred beauty events with specfic decays (E-771, P-780, E-672/E-706, NA-32),
a few thousand relatively unbiased beauty events (WA-82, WA-84, E-687, P-791),
and a few thousand beauty particles detected with special decay channels, topologies, or restricted triggers (E-690, P-789).

These will be sufficient numbers of events to investigate the b-cross sections with beauty identification by decay topologies. There will be the first attempts at full reconstruction and decay mode studies. The lifetimes of both the charged and neutral B's will be measured. There may be sufficient statistics to begin the observation of B0 - B0-bar mixing. However there will not be enough events for the interesting studies of CP violation.

Further progress will require both technological and conceptual breakthroughs.

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C. Aviles, et al., Proc. Symp. on Recent Developments in Computing, Processor, and Software Research for High Energy Physics, Guanajuato, Mexico, May 8-11, 1984, p. 45.
M. Church, et al., Computing in HEP, L.O. Hertsberger and W. Hoogland, editors, Esavir Science Pub., 1986, p. 247.

20. Fermilab P-789 Proposal, 1987, D. Kaplan, spokesperson.

21. Fermilab P-791 Letter of Intent, 1987, J. Appel, spokesperson.

22. CERN NA-32 Proposal, SPSC/P189, N.A. McCubbin, spokesperson.

23. Fermilab E-687 Proposal, 1981, J. Butler, J. Cumalat, and I. Gaines, spokespersons.

24. Fermilab P-786 Proposal, 1987, R. Wilson, spokesperson.

25. CERN Letter of Intent, SPSC/I166, 1987, no spokesperson.

26. CERN Proposal SPSC/P233, 1987, H.-W. Siebert, spokesperson.

27. Fermilab P-781 Propsoal, 1987, J. Russ, spokesperson.

28. Fermilab P-755 Proposal, 1984, J. Sandweiss, spokesperson.
See also Status Report of T-755, 1987.

Figures

Figure 26. T-755 Test beam event in diffusion suppressed streamer chamber.

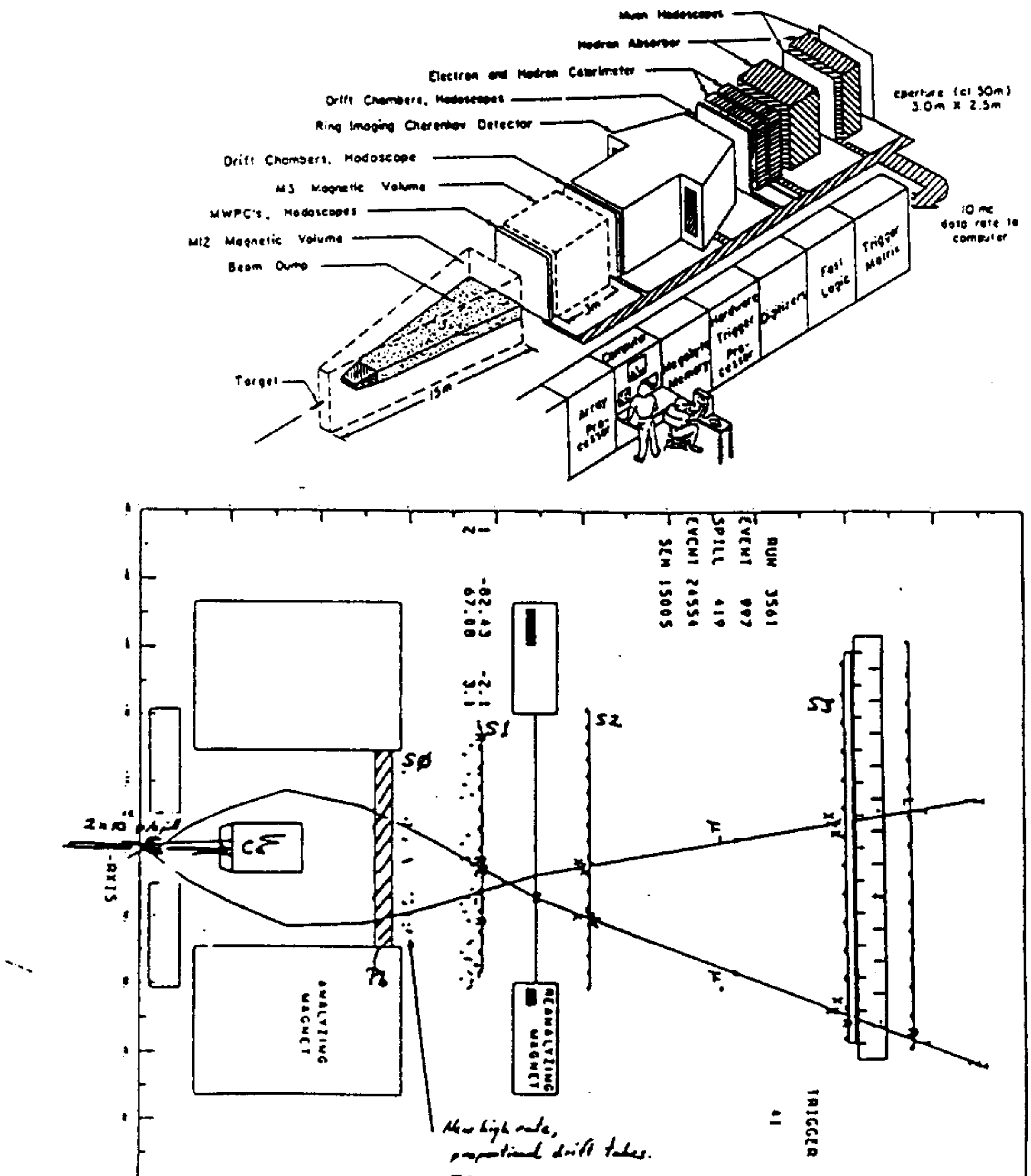


Figure 1. E-605.

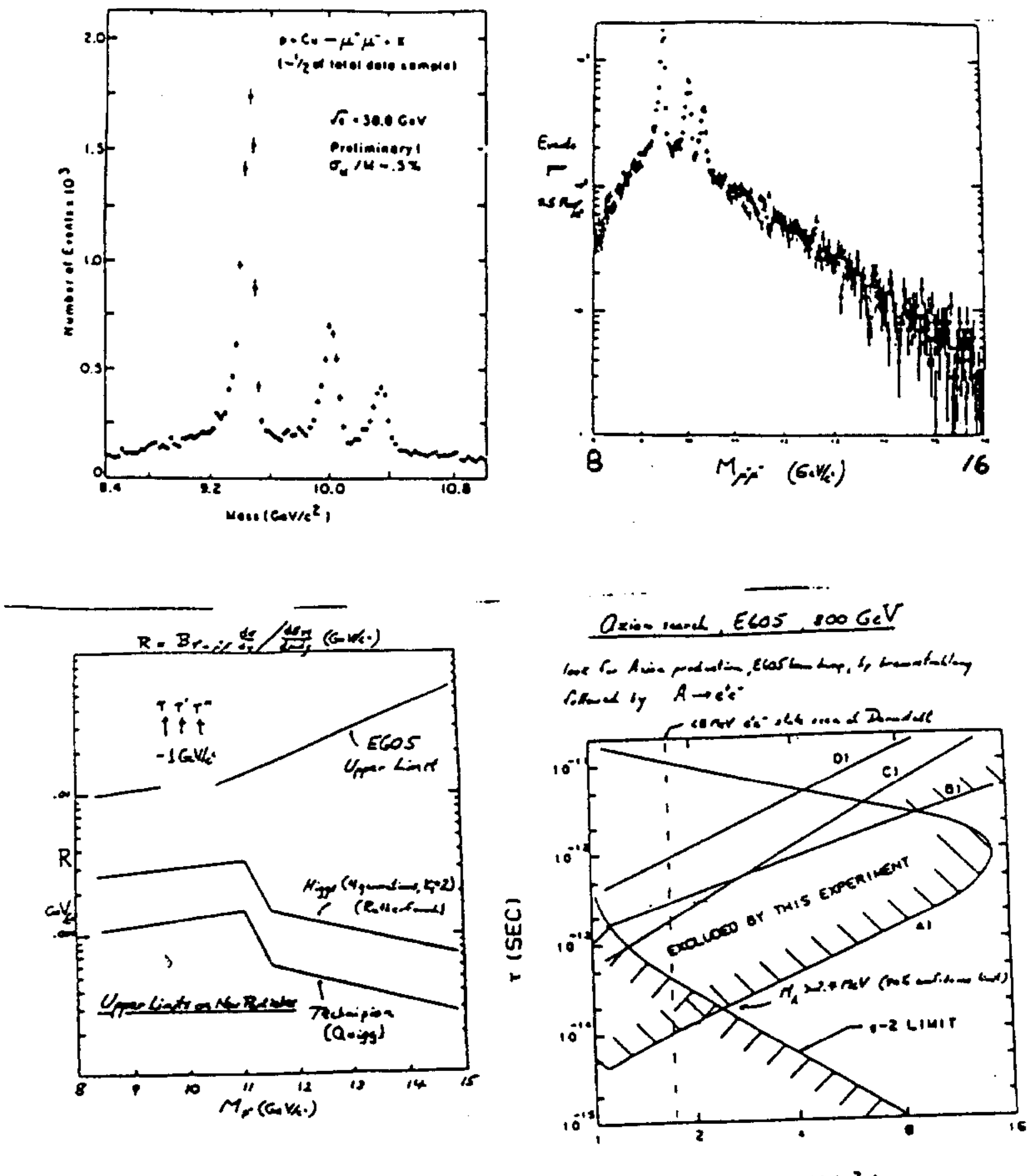


Figure 2. E-605 PRELIMINARY Data.

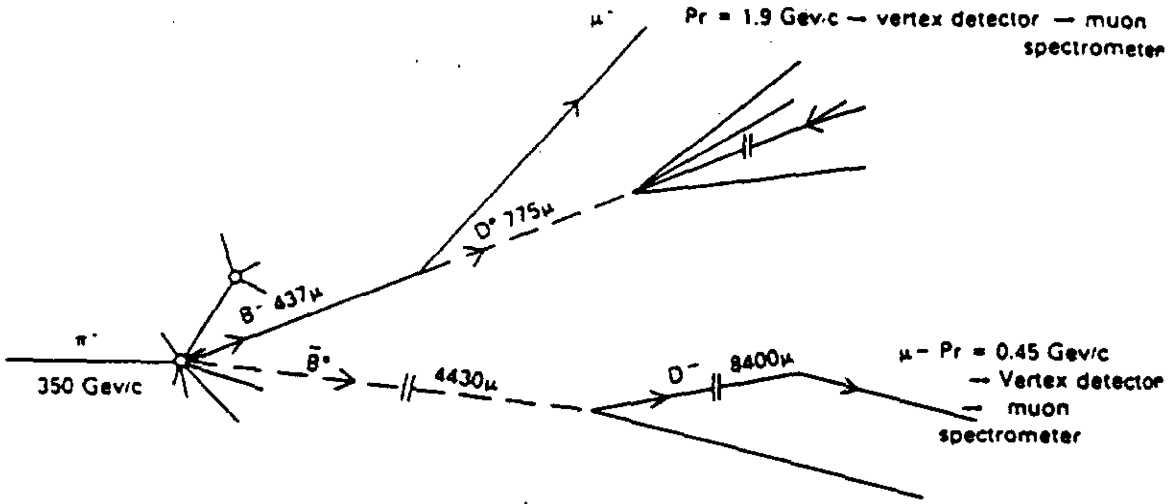


Figure 3. WA-75 observation of a four-decay vertex event in a π^- Emulsion collision.

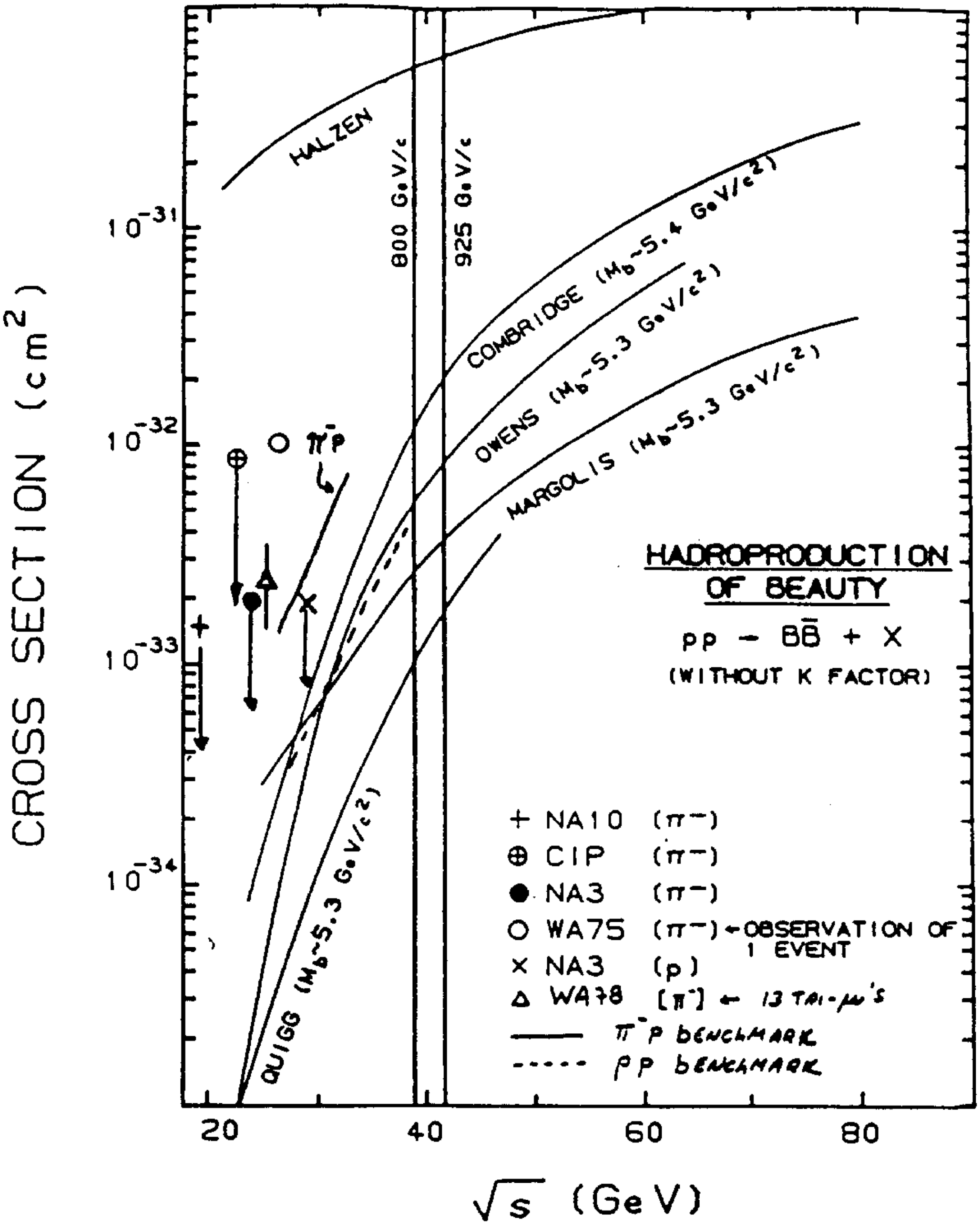


Figure 4. Compilation of theoretical cross sections, upper limits, and observations of beauty production.

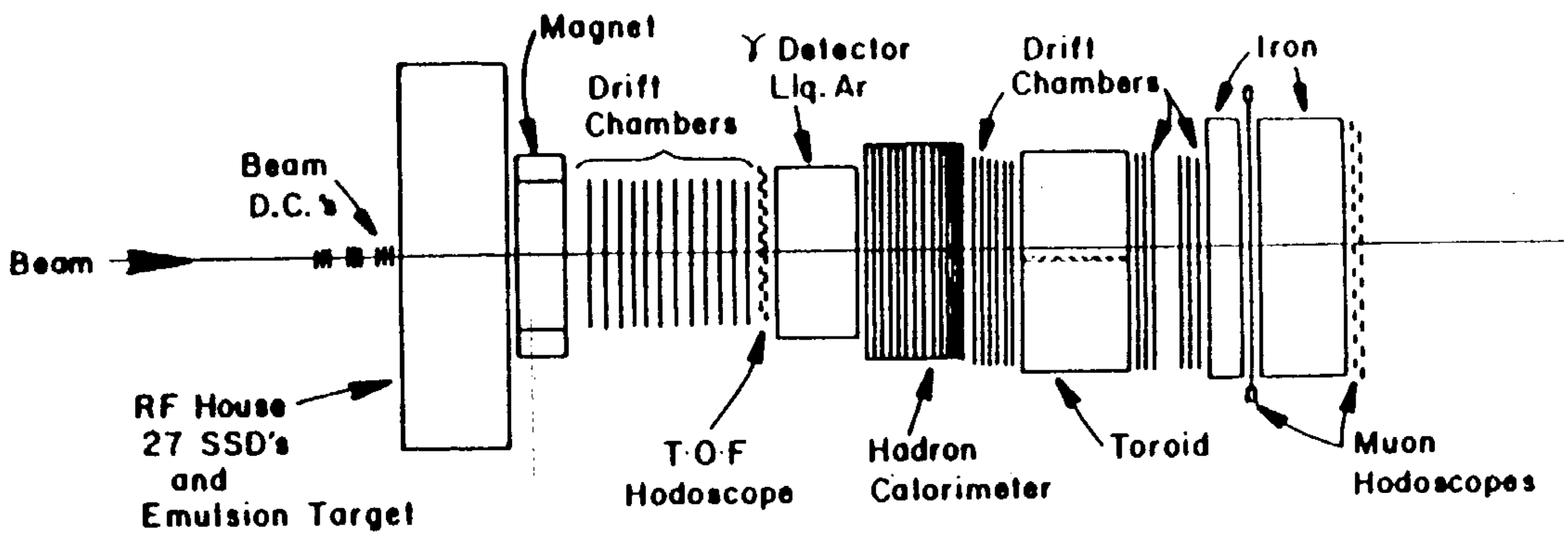


Figure 5. E-653.

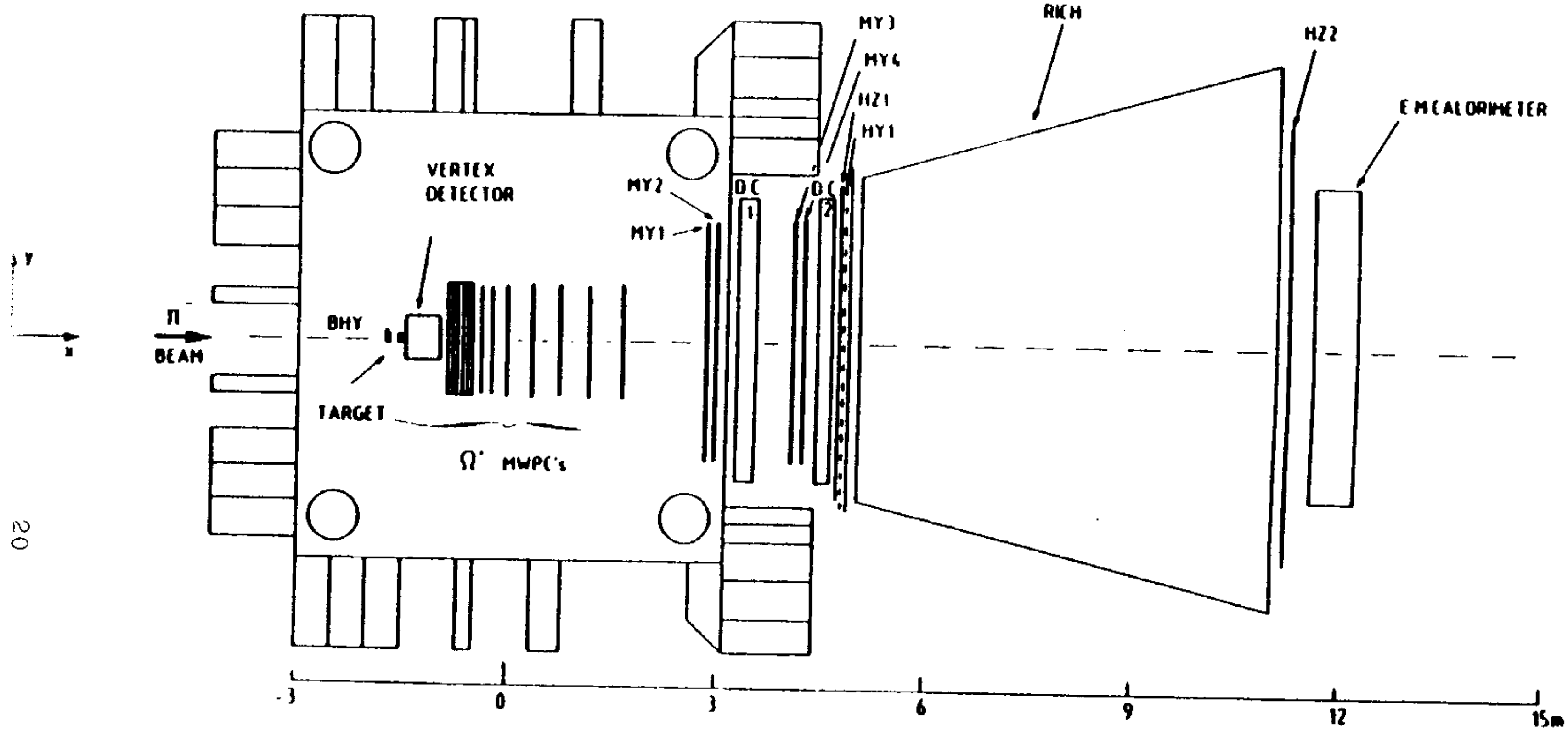
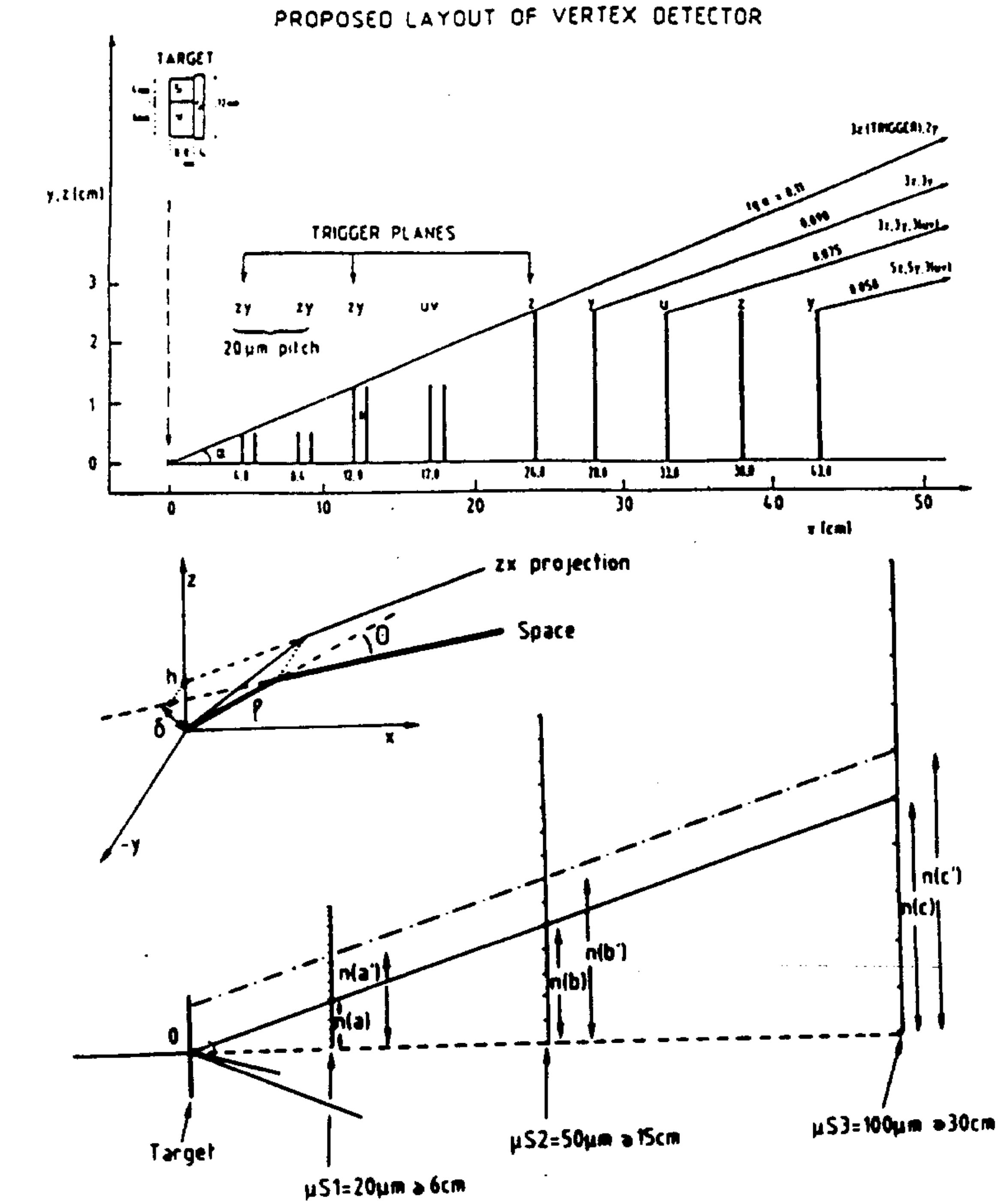


Figure 6. WA-82 OMEGA-IMPACT.



Principle of the Trigger

Figure 7. WA-82 IMPACT Vertex Detector and Trigger Scheme.

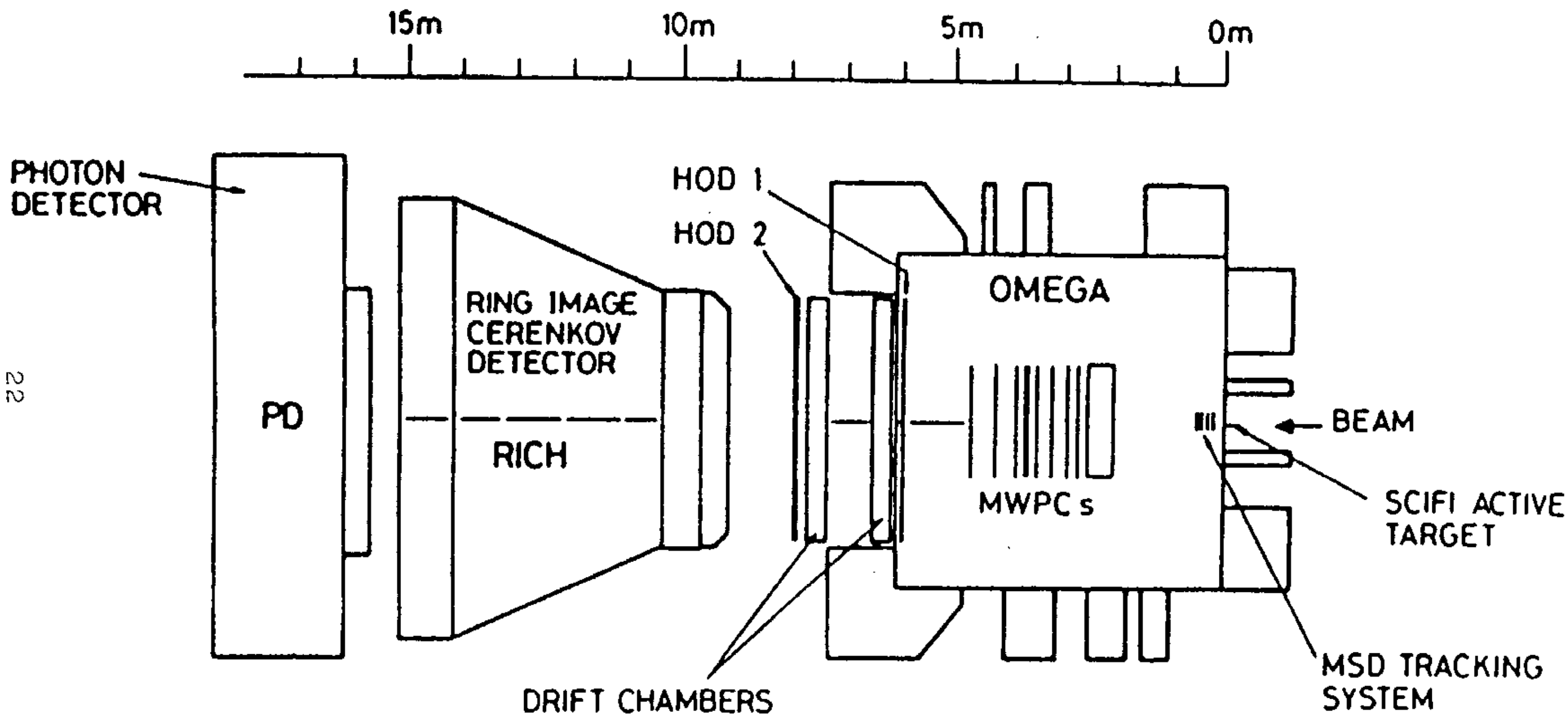


Figure 8. WA-84 OMEGA-SCIFI.

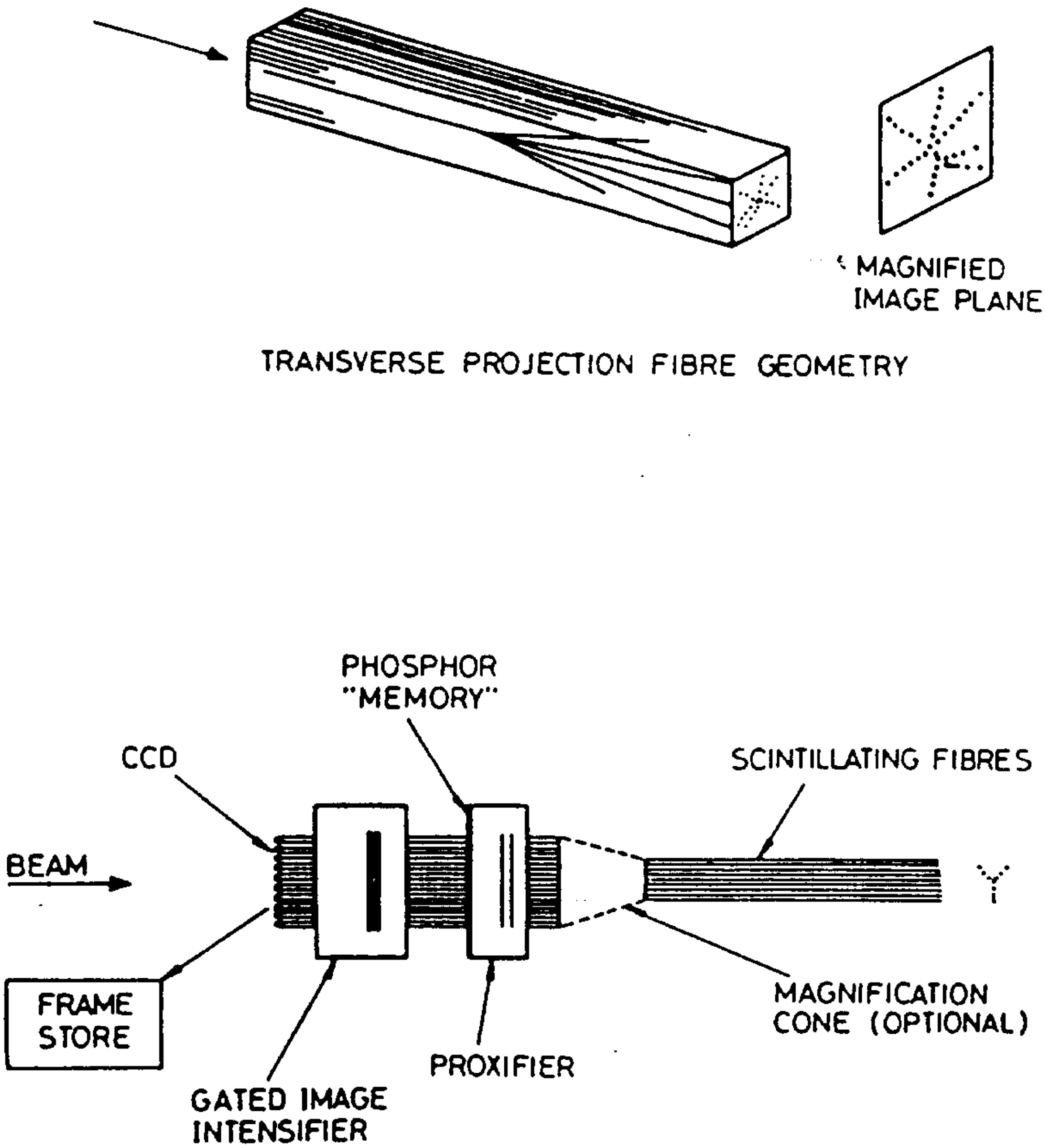


Figure 9. WA-84 SCIFI Scintillating Fiber Active Target.

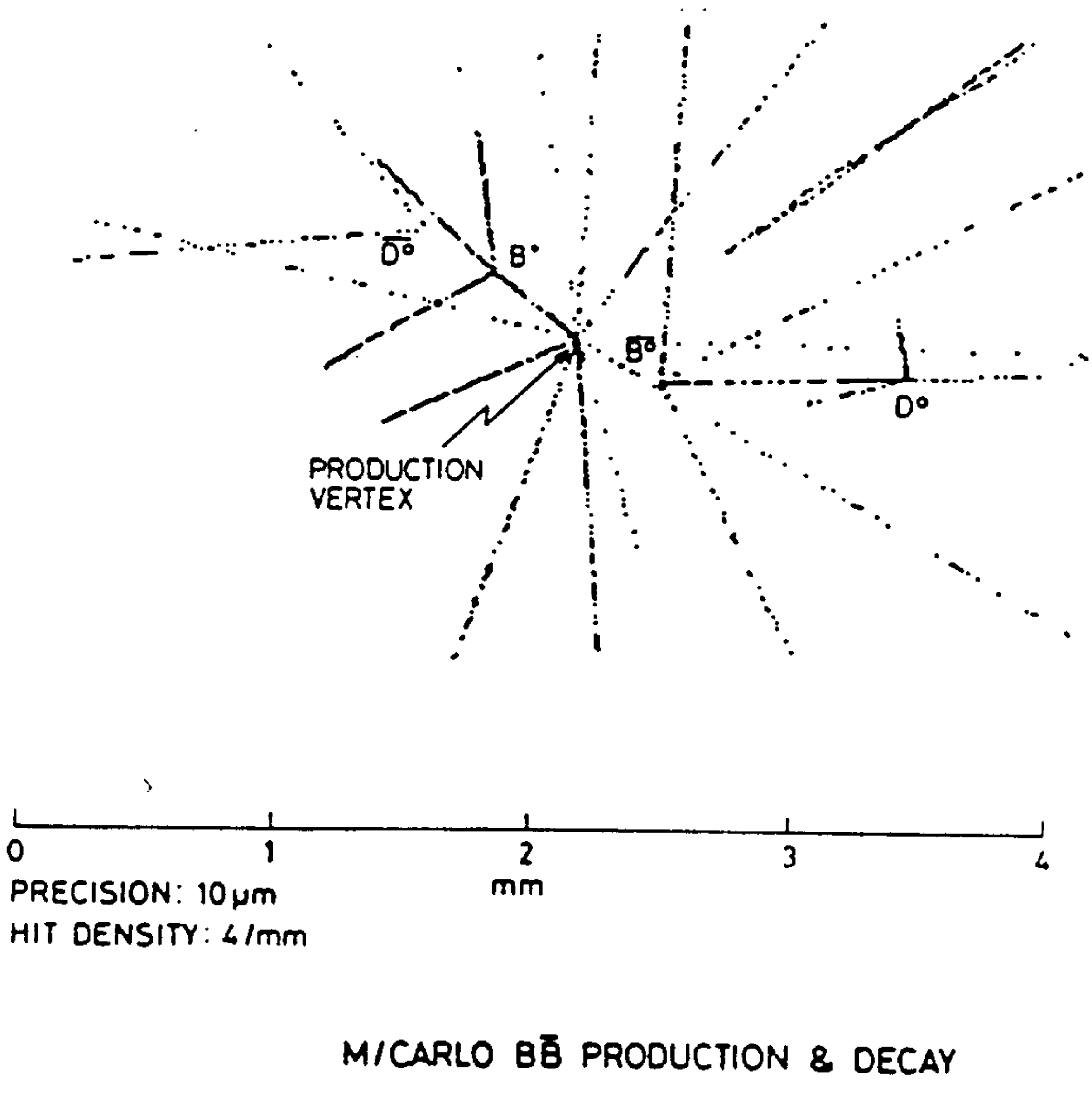


Figure 10. WA-84 SCIFI Beam's Eye View.

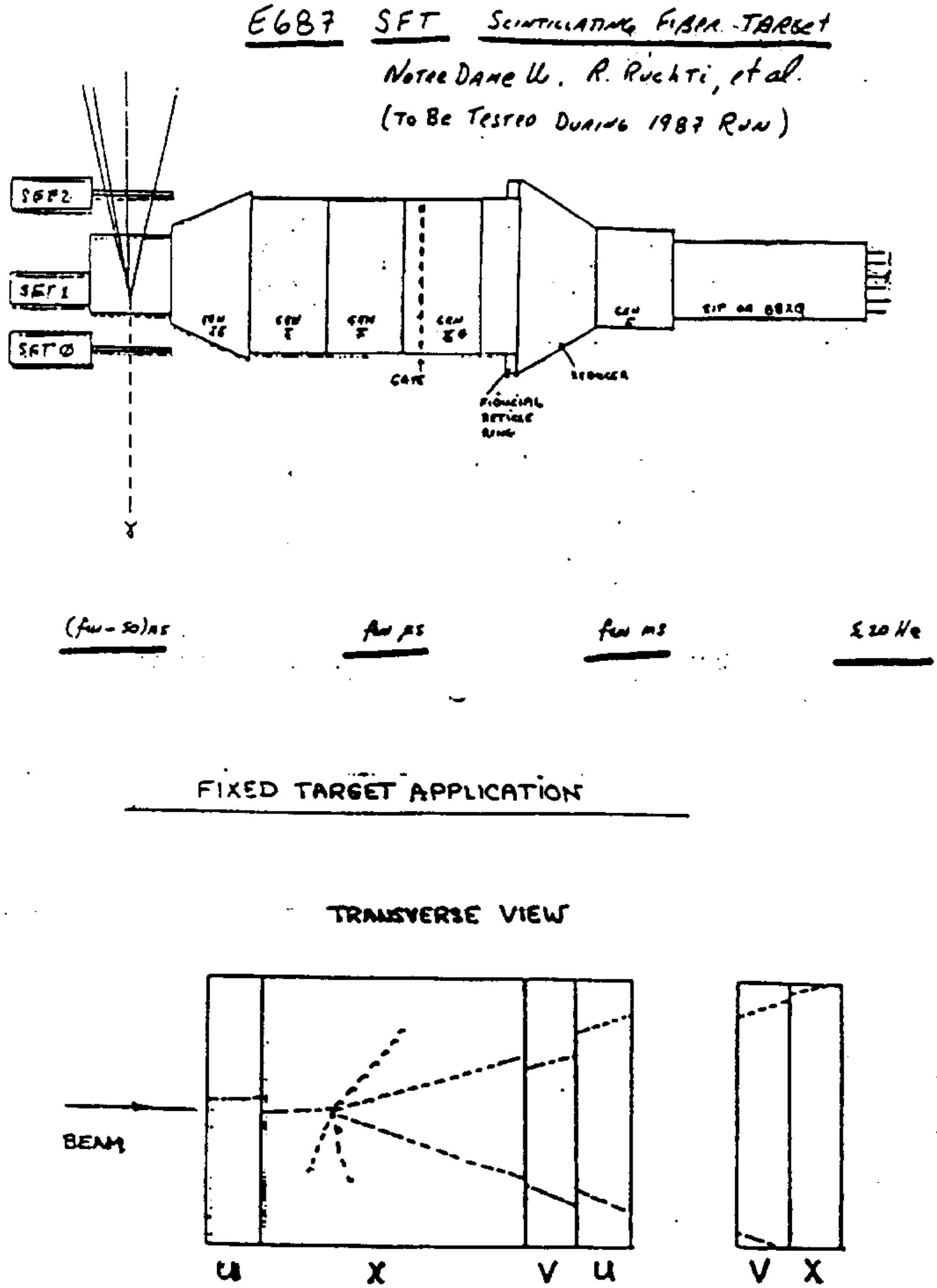


Figure 11. E-687 Scintillating Fiber Active Target.

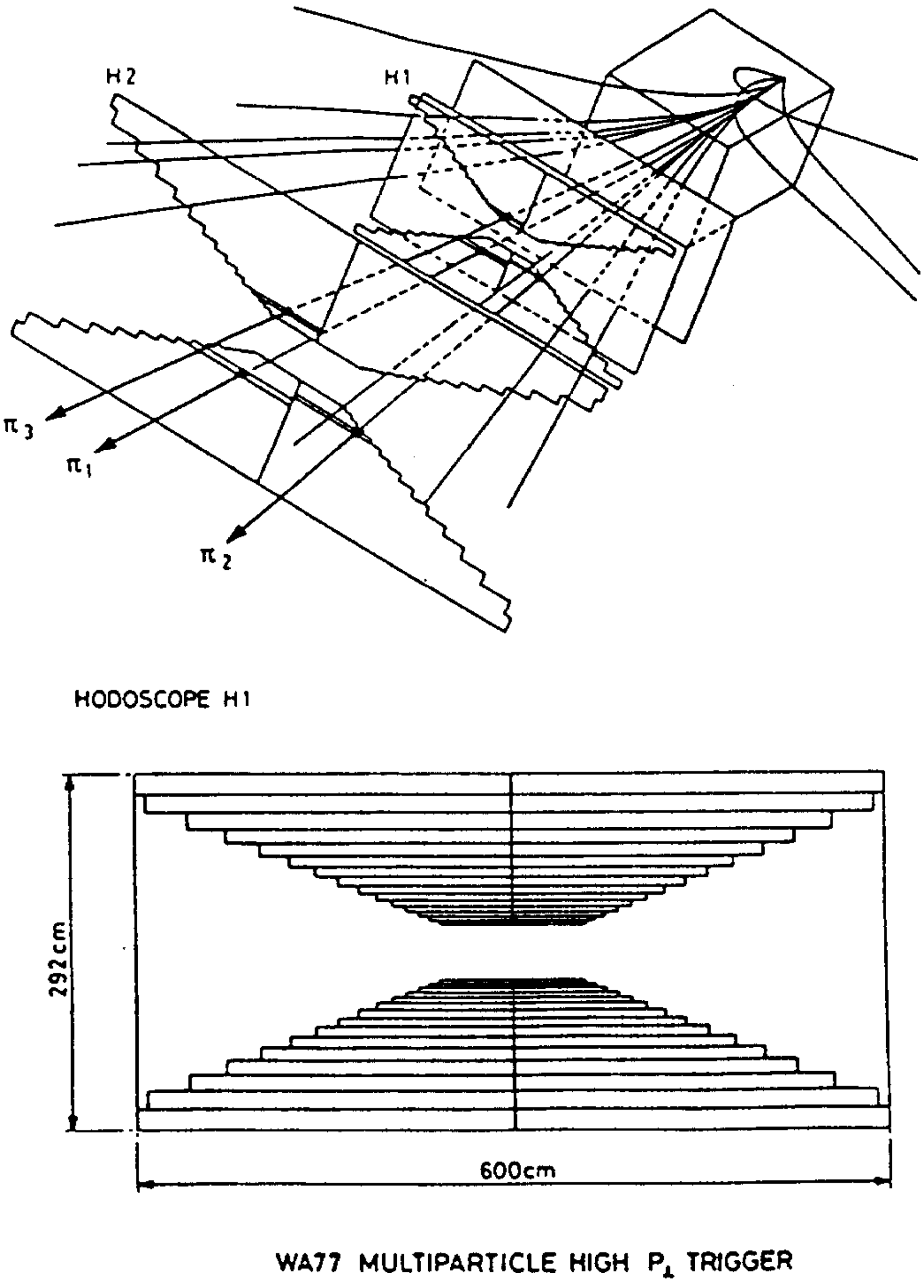


Figure 12. WA-84 SCIFI Trigger Geometry.

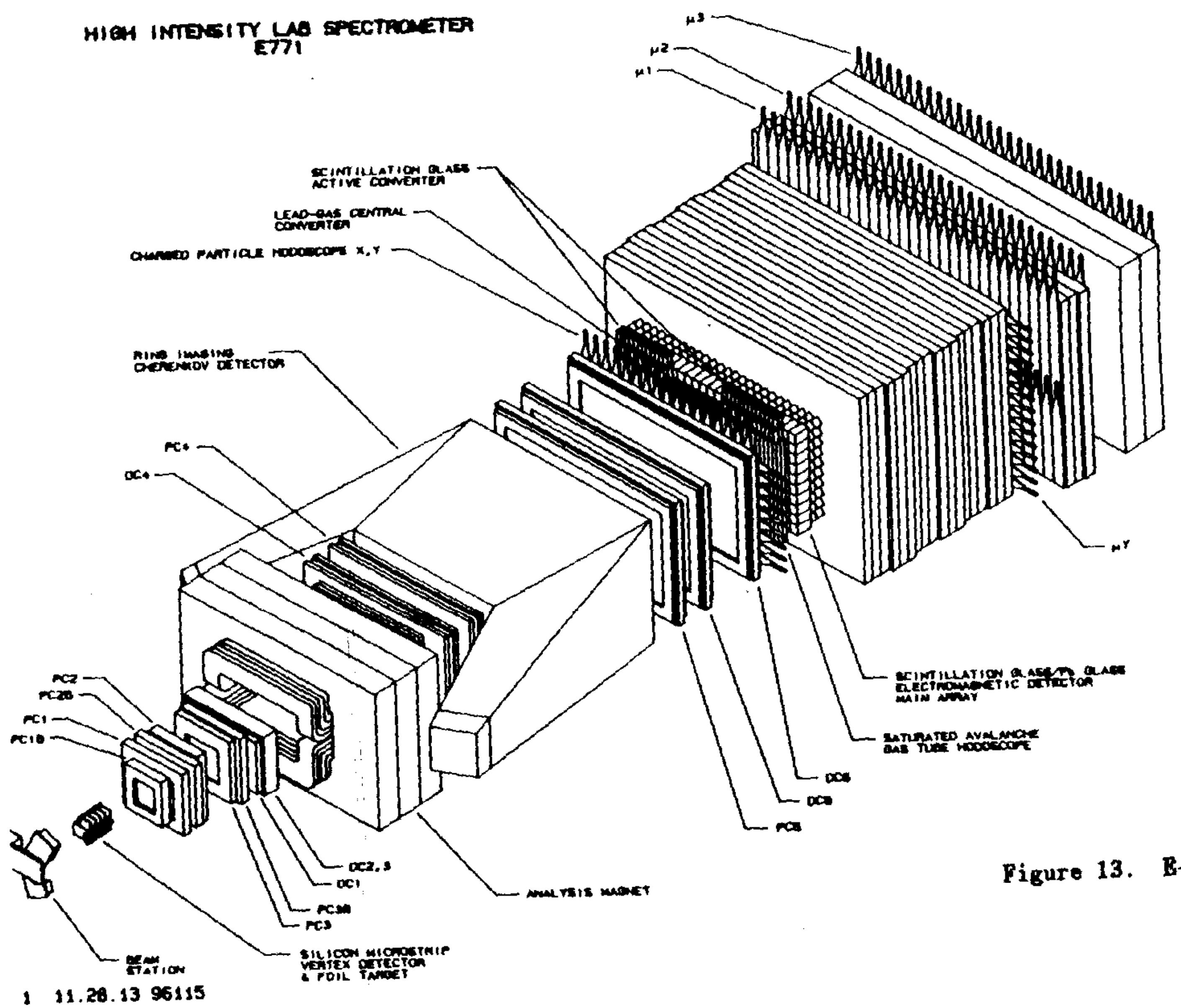


Figure 13. E-771.

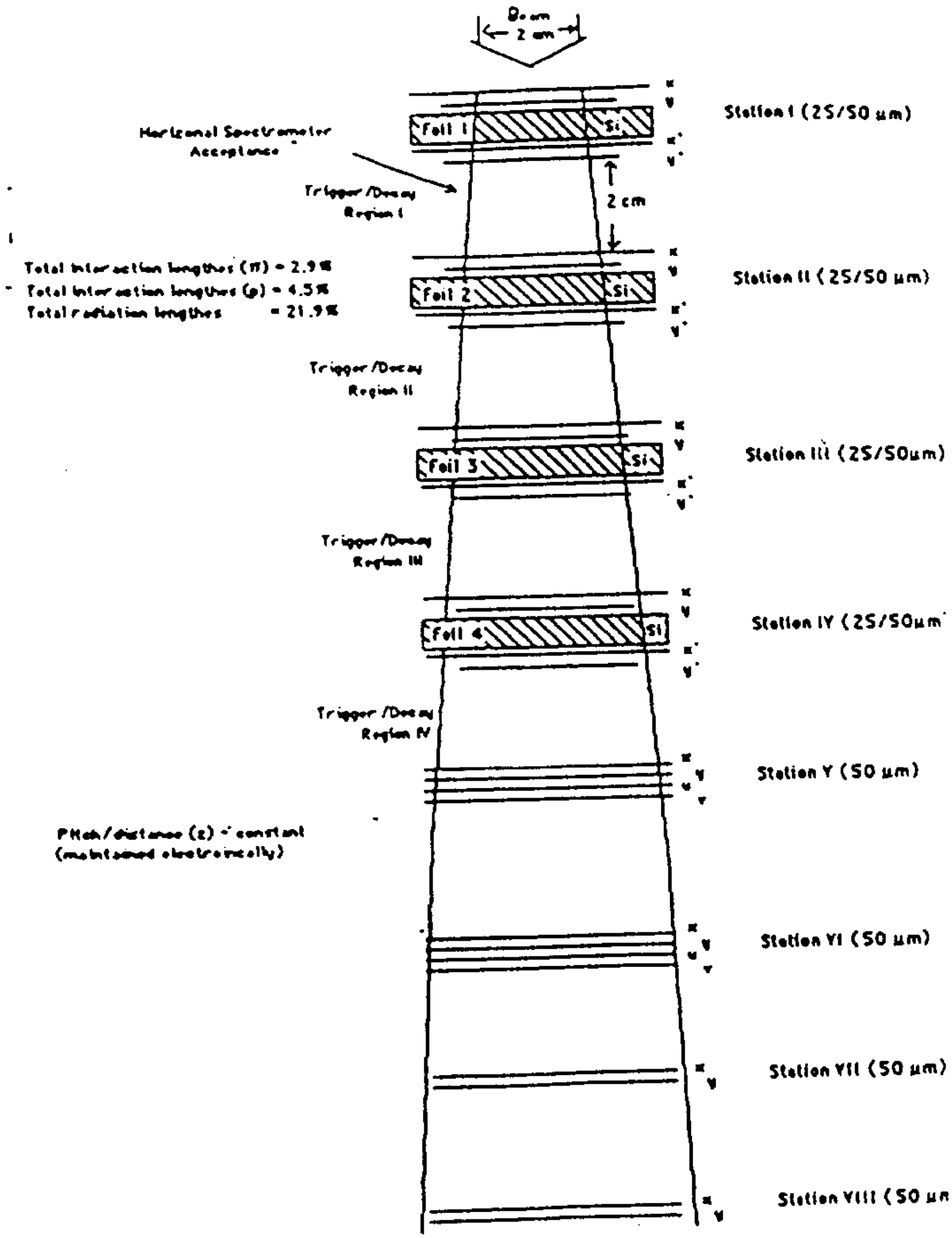


Figure 14. E-771 Vertex Spectrometer.

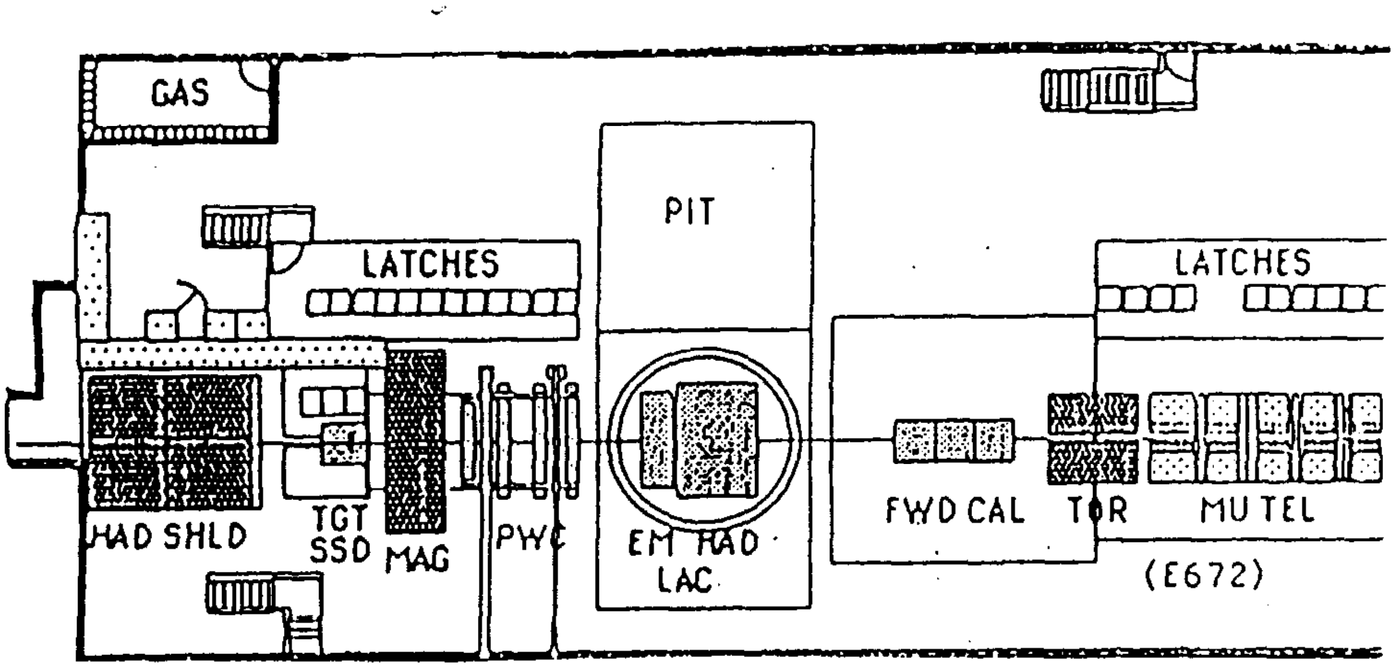


Figure 15. E-706 and E-672.

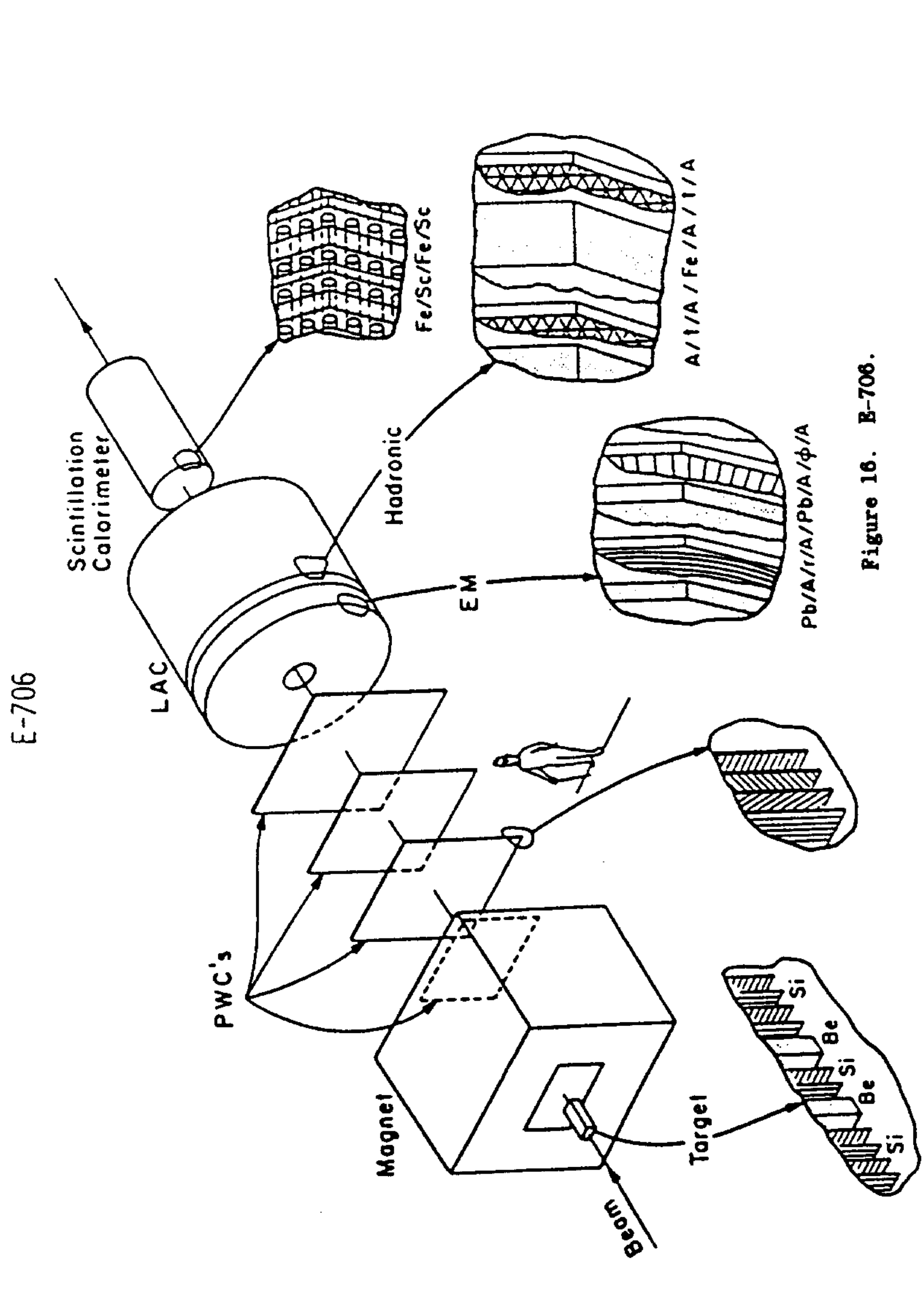


Figure 16. E-706.

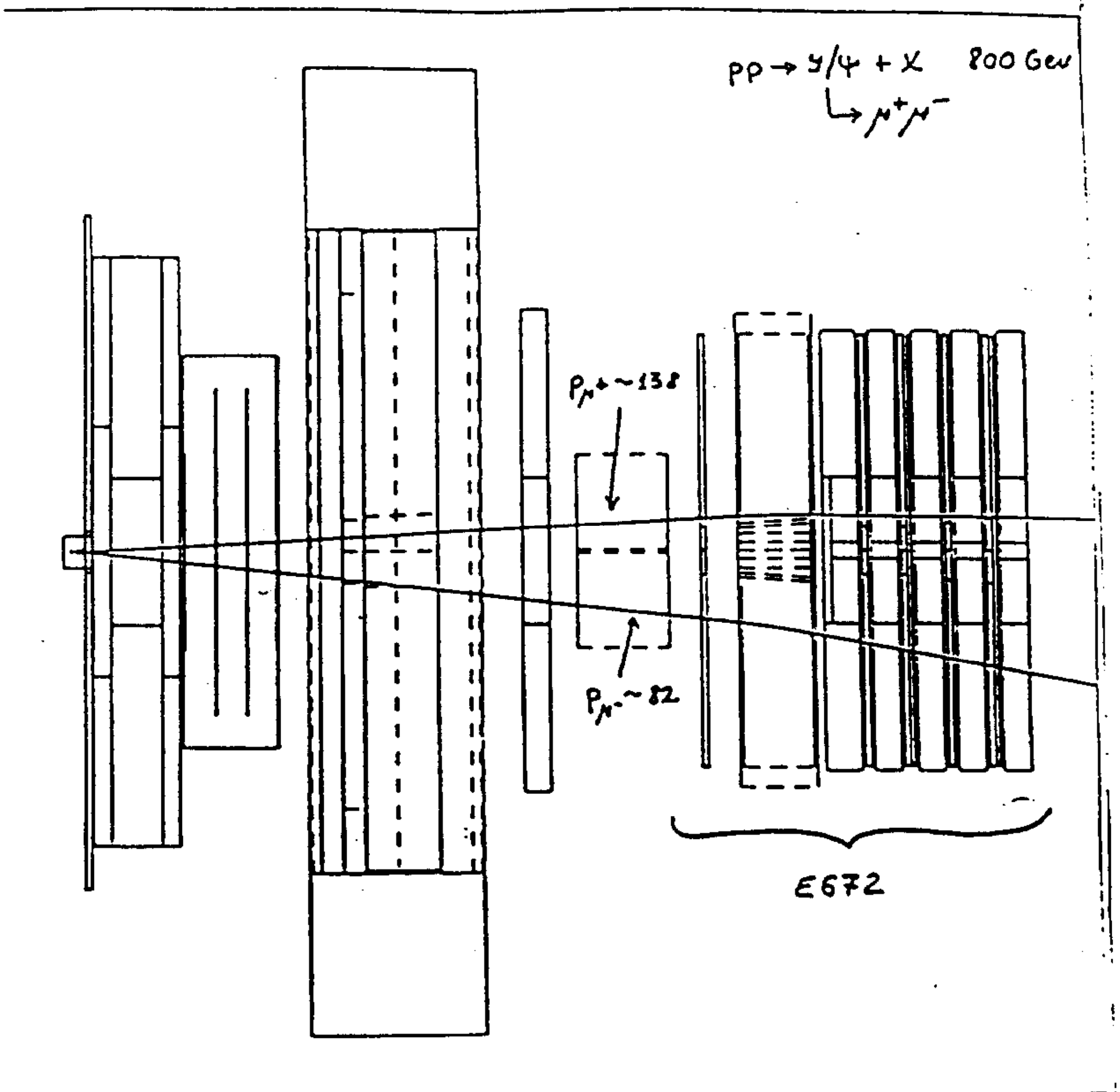
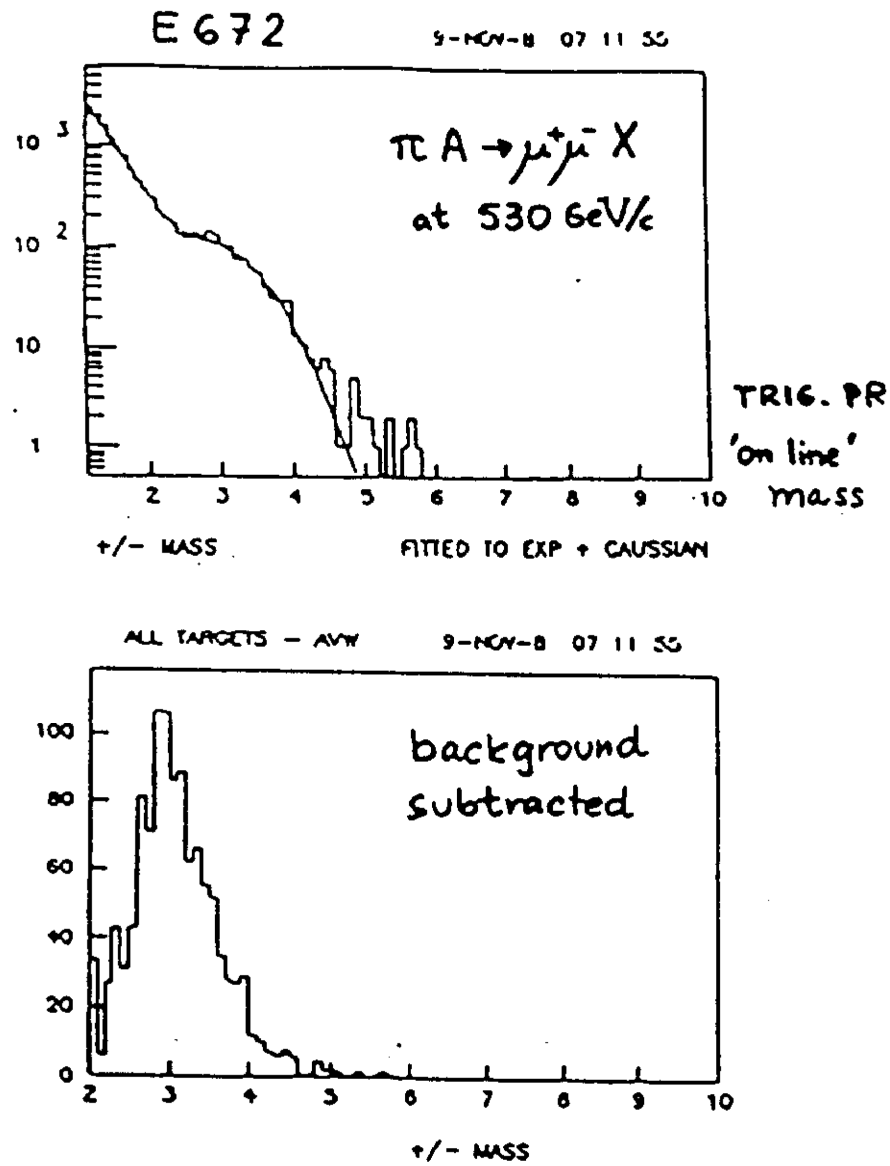


Figure 17. E-672.



observed rate : $1\Psi / 4 \cdot 10^{6}$ IB

Figure 18. E-672 "on-line" trigger processor di-muon mass.

E706

ELECTROMAGNETIC TRIGGER

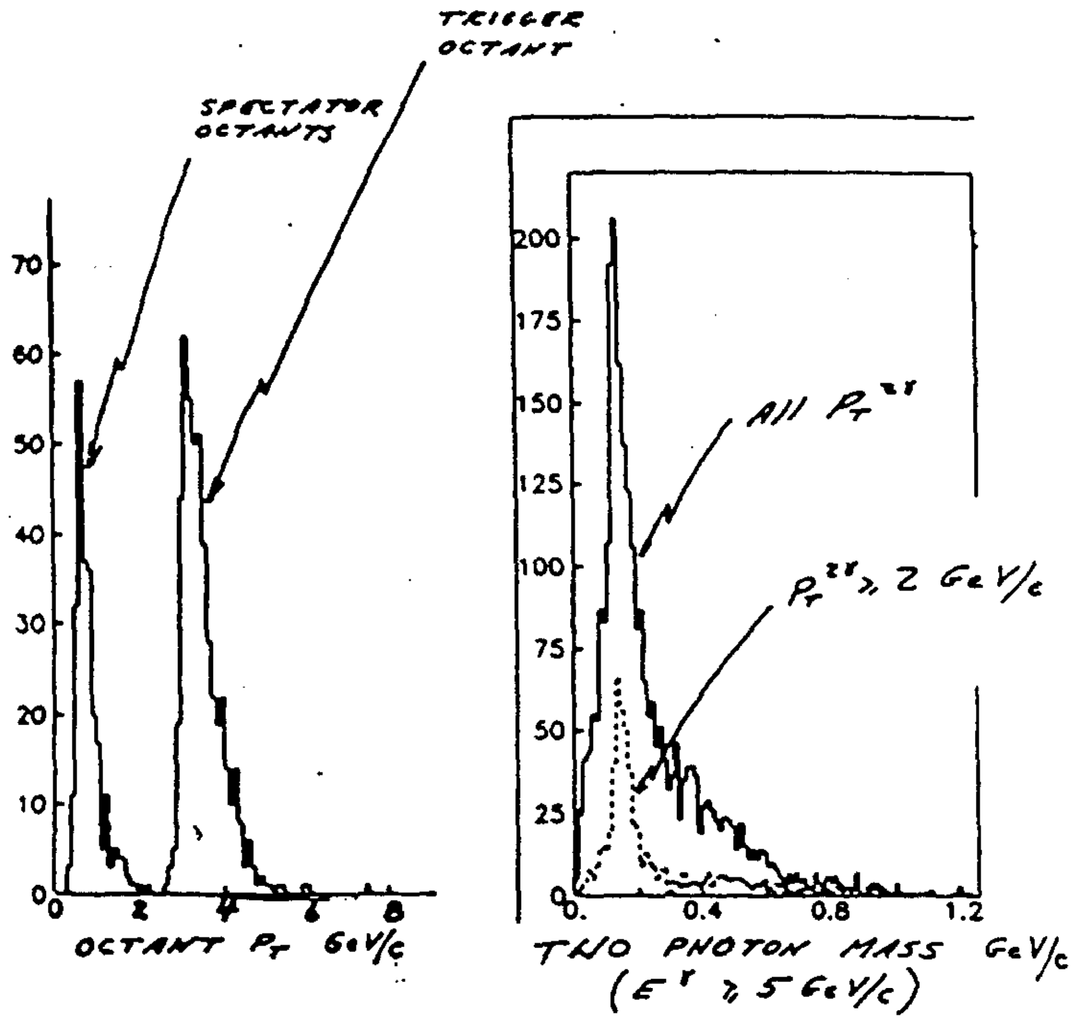


Figure 19. E-706 Photon trigger spectra and π^0 mass.

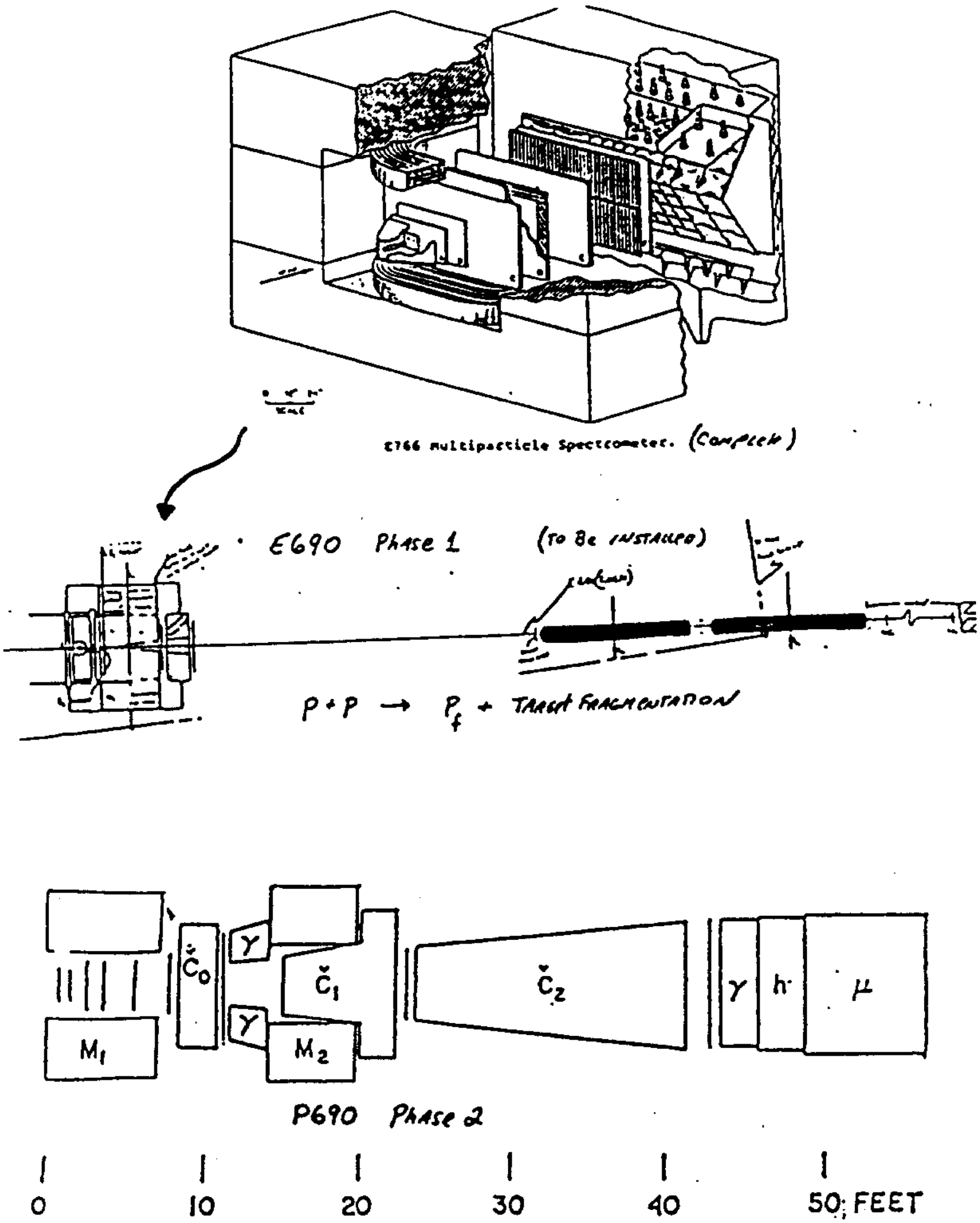


Figure 20. BNL E-766, E-690 Phase 1, and E-690 Phase 2.

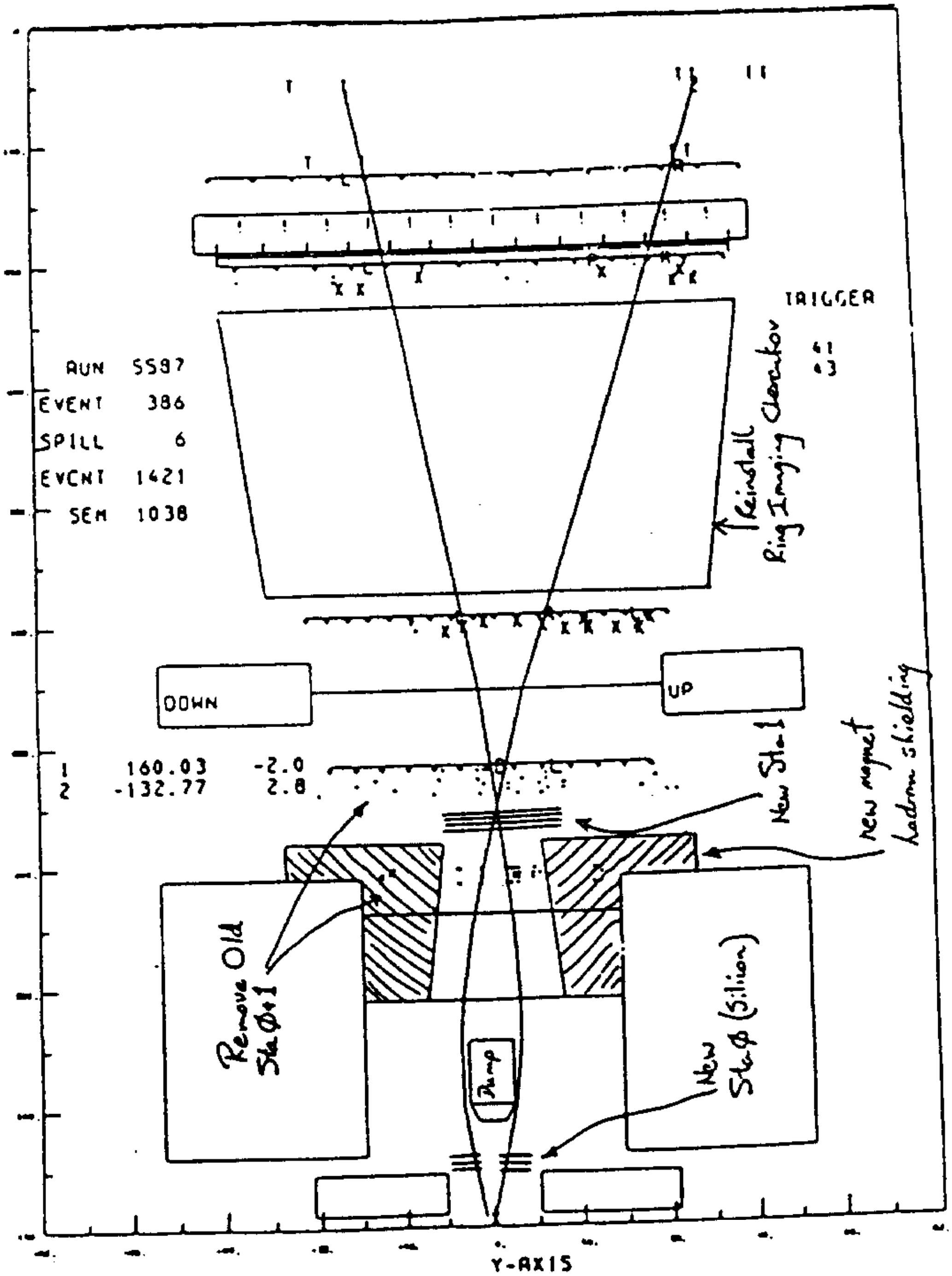


Figure 21. P-789.

E-769

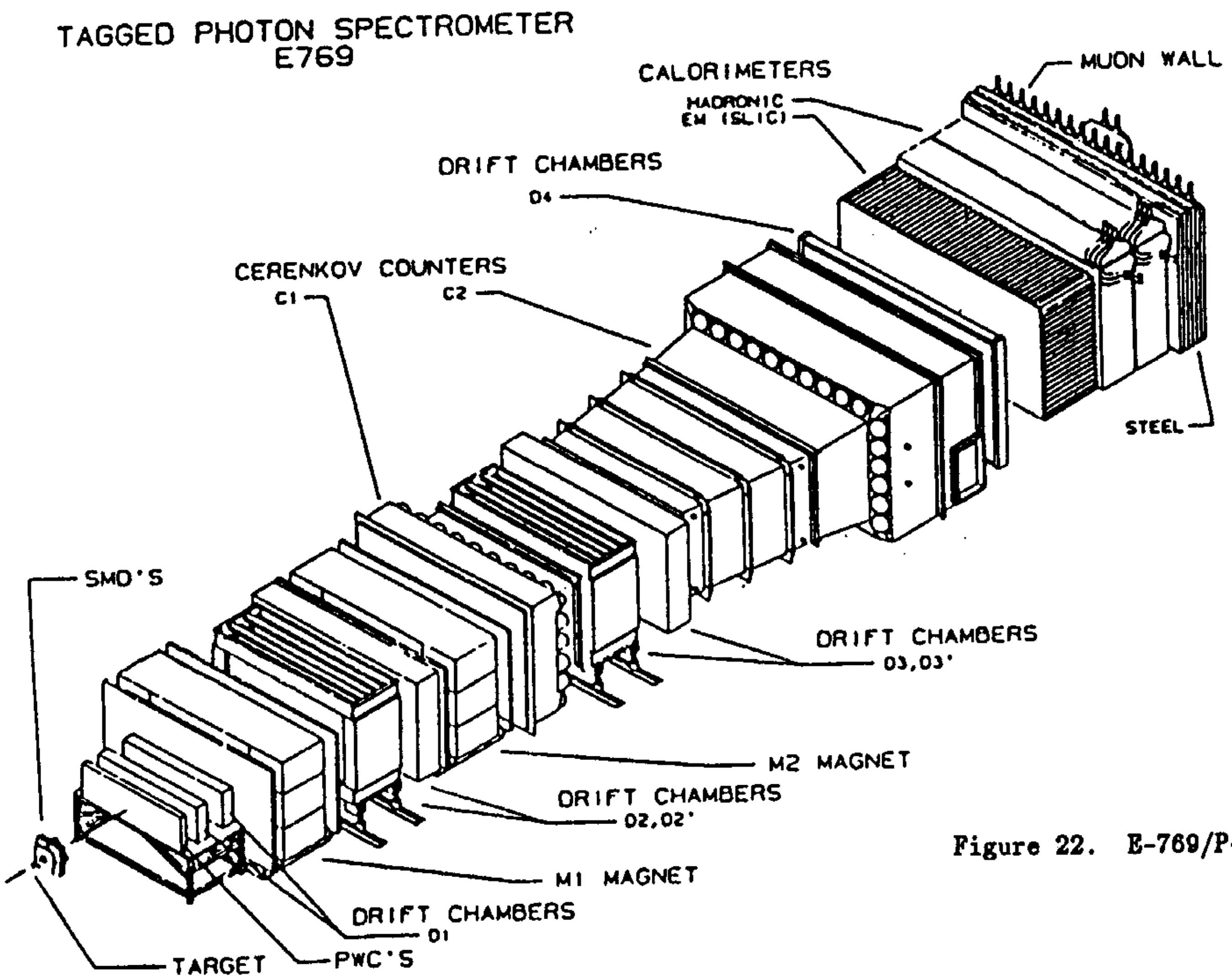


Figure 22. E-769/P-791.

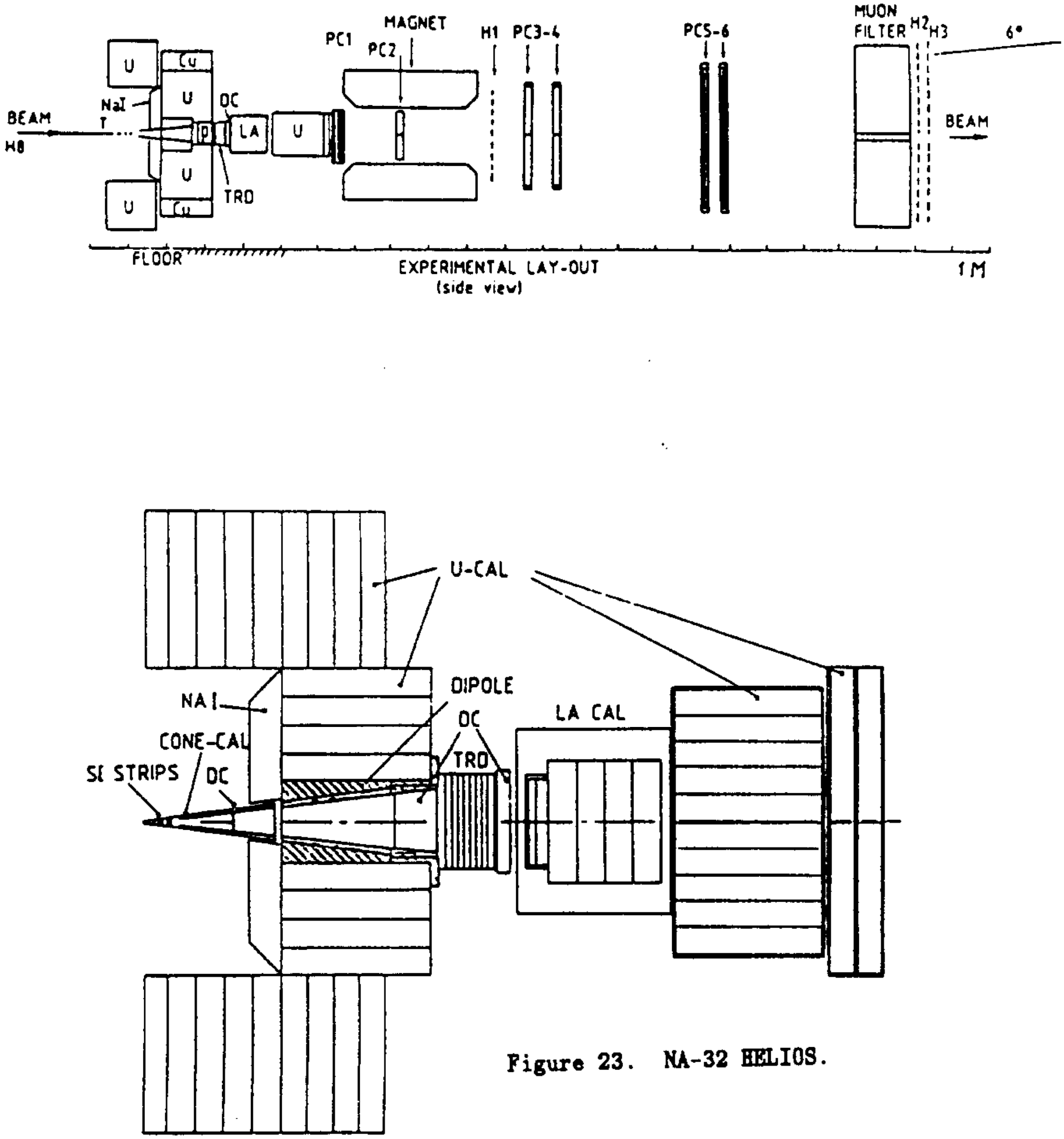


Figure 23. NA-32 HELIOS.

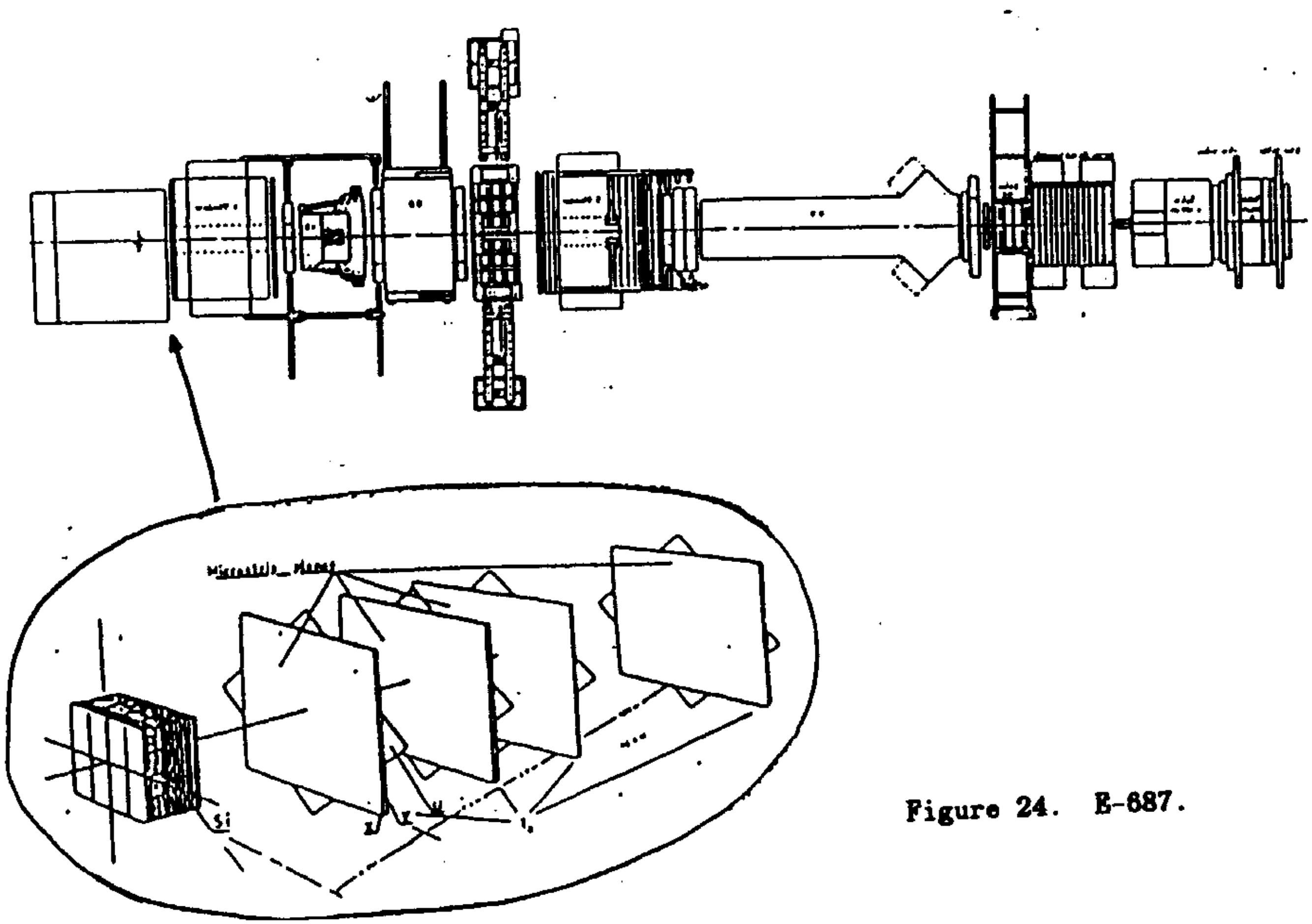
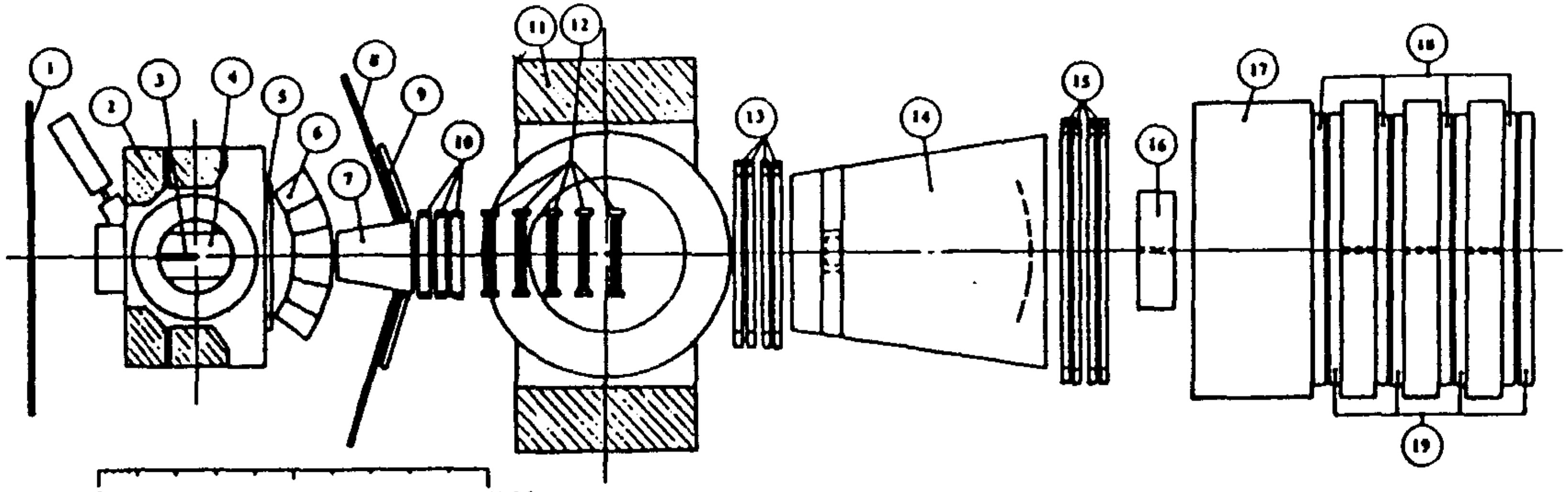


Figure 24. E-687.

E-665



1. 7M x 3M Veto Counter Wall
2. CERN Vertex Magnet
3. 1M LH_2/LD_2 Target
4. 1M x 2M x 0.7M Streamer Chamber
5. 3M x 1M MWPC, 6 Planes
6. 144 Cell Threshold Cerenkov Counter
7. 58 Cell Threshold Cerenkov Counter
8. 4M x 1.6M Scintillation TOF Arrays
9. 2M x 2M Prop. Tube Arrays, 4 Planes
10. 2M x 2M MWPC, 12 Planes
11. SC Chicago Cyclotron Magnet
12. 2M x 1M MWPC, 15 Planes
13. 4M x 2M Drift Chambers, 8 Planes
14. Ring Imaging Cerenkov Counter
15. 6M x 2M Drift Chambers, 8 Planes
16. 3M x 3M EM Shower Calorimeter
17. 7M x 3M x 3M Iron Absorber
18. 7M x 3M Prop. Tube Arrays, 8 Planes
19. 7M x 3M Scintillation Counter Arrays

Figure 25. E-665/P-786.

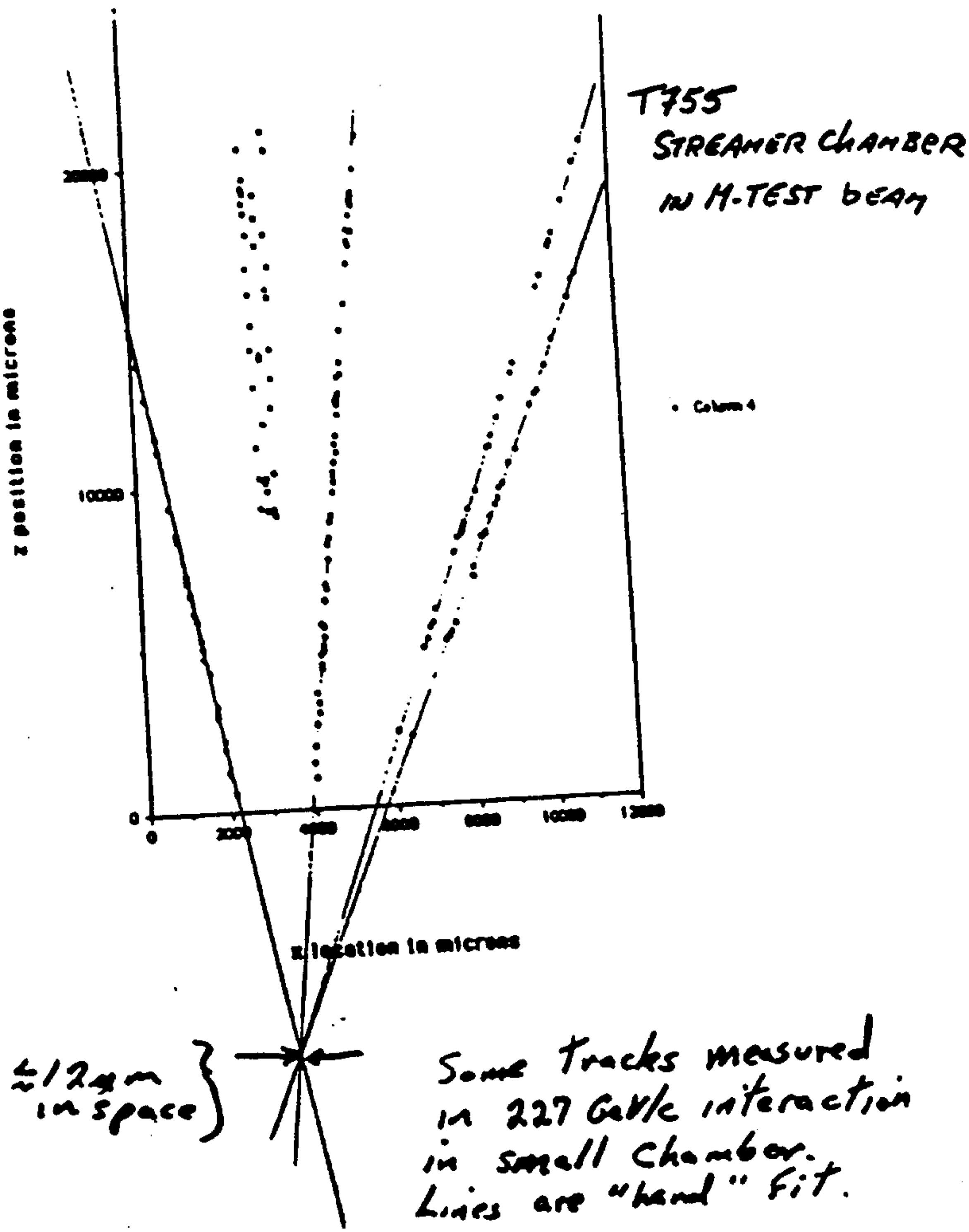


Figure 26. T-755 Test beam event in diffusion suppressed streamer chamber.