GEM TN-92-236

First Studies of GEM Baseline II Calorimetry From Arizona Mixture Level Simulation (UAZMIX)

November 23, 1992

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University of Arizona

Abstract:

The first results from the mixture level GEANT simulations of the GEM Baseline II design are presented.. The following items are included: 1) Longitudinal slice view of simulated baseline; 2) Representative event pictures; 3) Analysis of pion energy scan at eta=0; 4) Diplots of eta scans for 200 GeV/c pion; 5) Diplots of eta scans for 50 GeV/c electron; and 6) Views of forward calorimeter options being run now for analysis.

FIRST STUDIES OF GEM BASELINE II CALORIMETRY

FROM ARIZONA MIXTURE LEVEL SIMULATION (UAZMIX)

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ENCLOSED:

1) Longitudinal slice view of simulated baseline

2) Representative event pictures

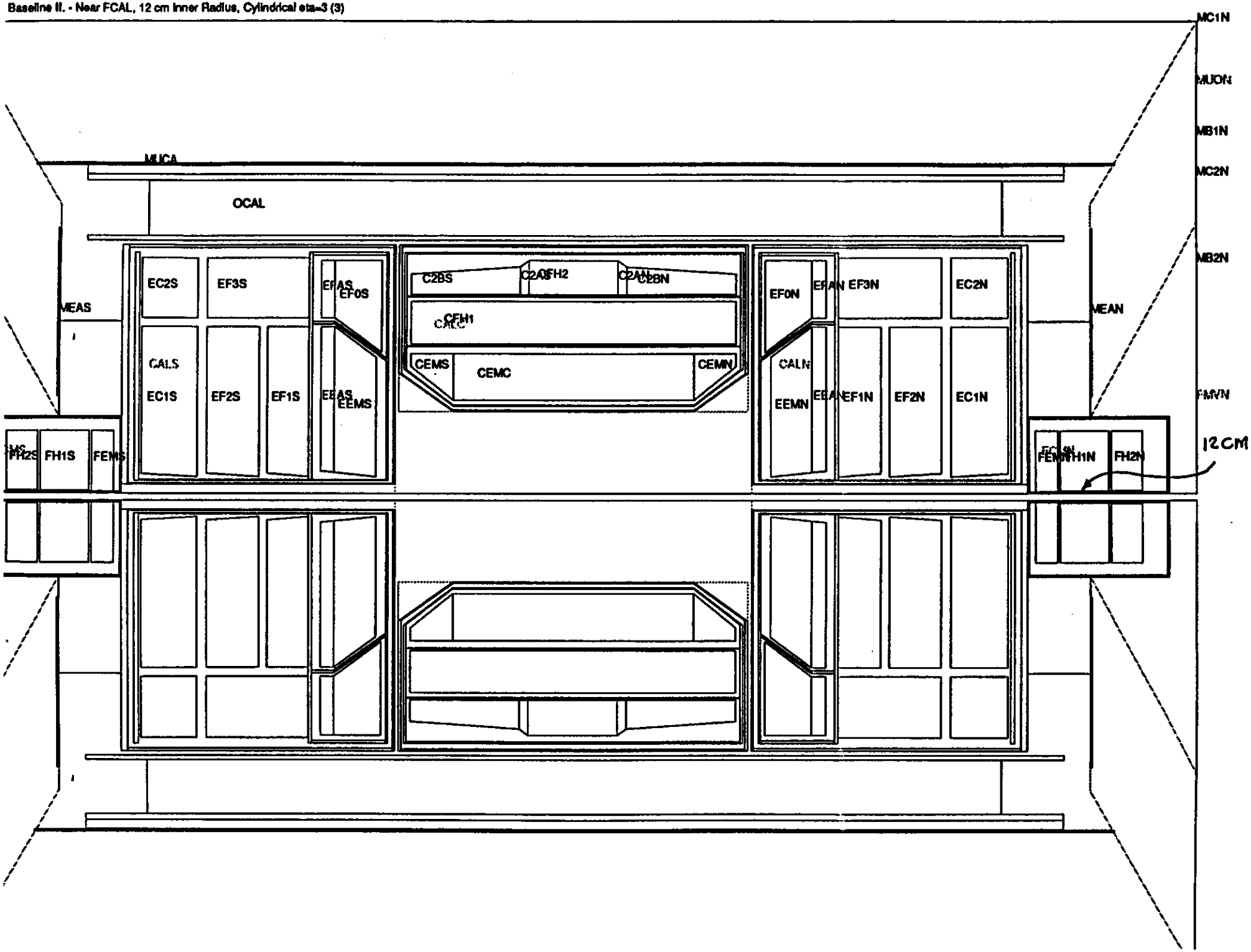
3) Analysis of pion energy scan at eta = 0

4) Diplots of eta scans for 200 GeV/c pion

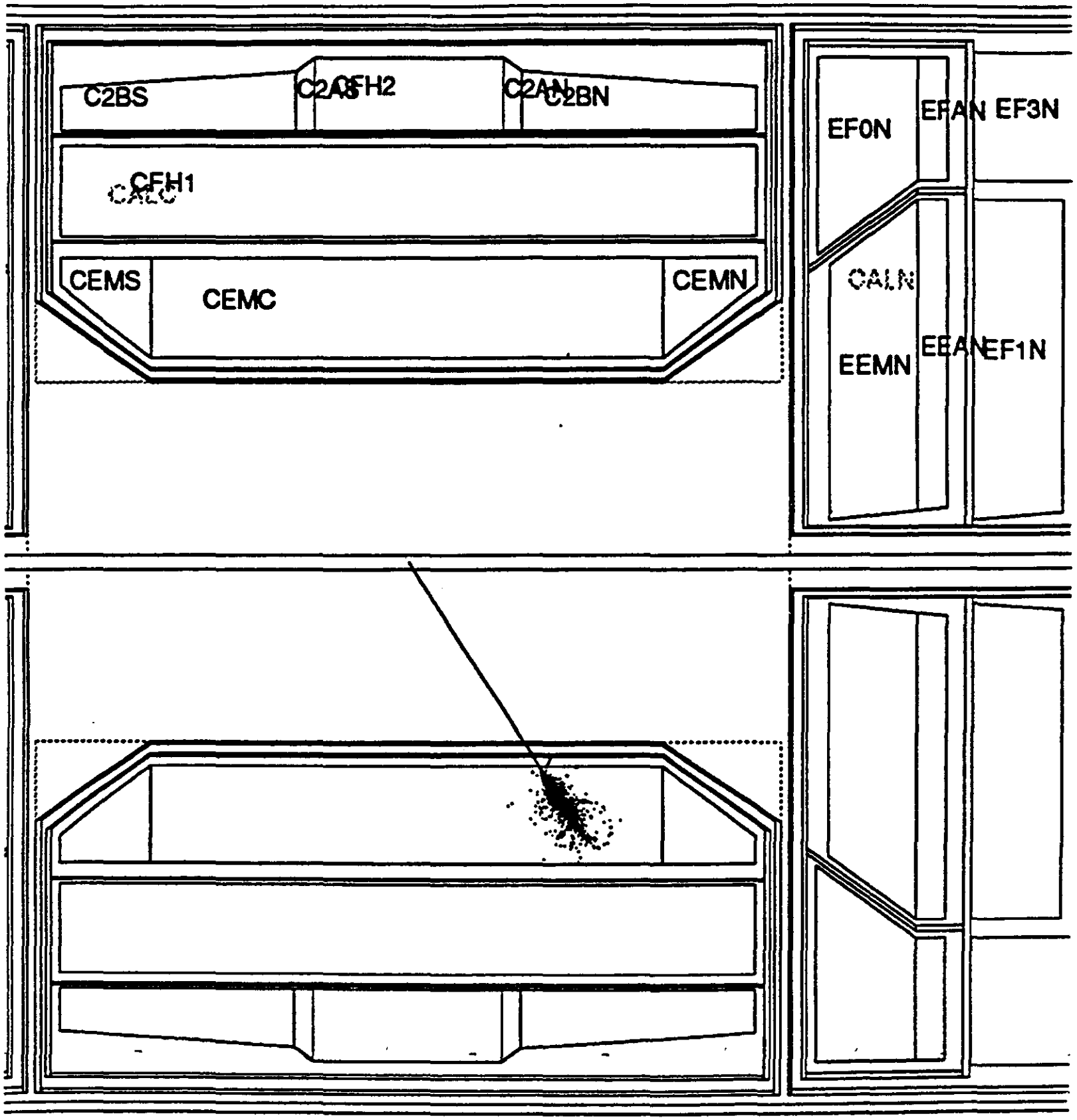
5) Diplots of eta scans for 50 GeV/c electron

6) Views of forward calorimeter options being run now for analysis.

Baseline II. - Near FCAL, 12 cm Inner Radius, Cylindrical eta=3 (3)



50 GeV/c e^-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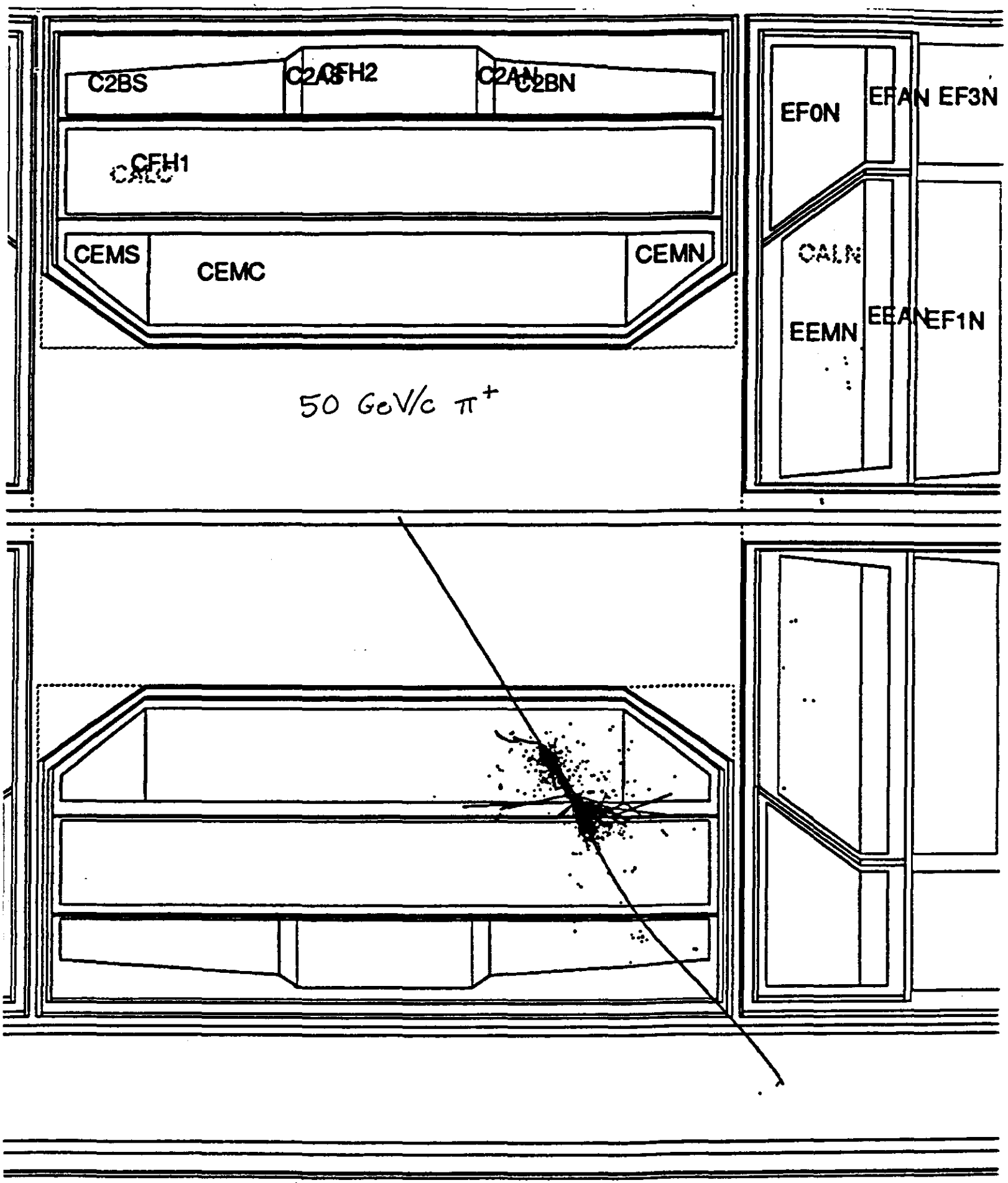
EEAN
EF1N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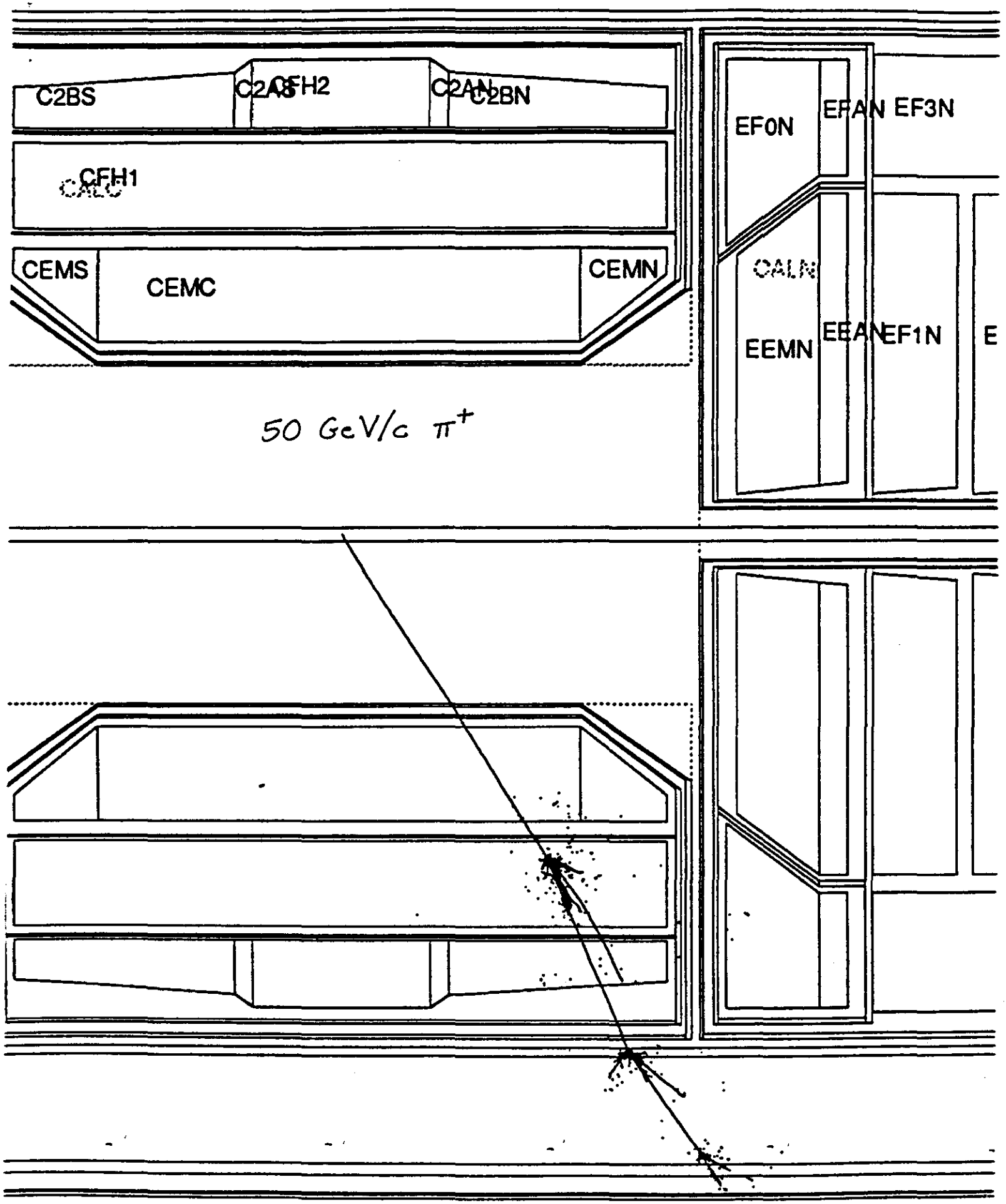
50 GeV/c π+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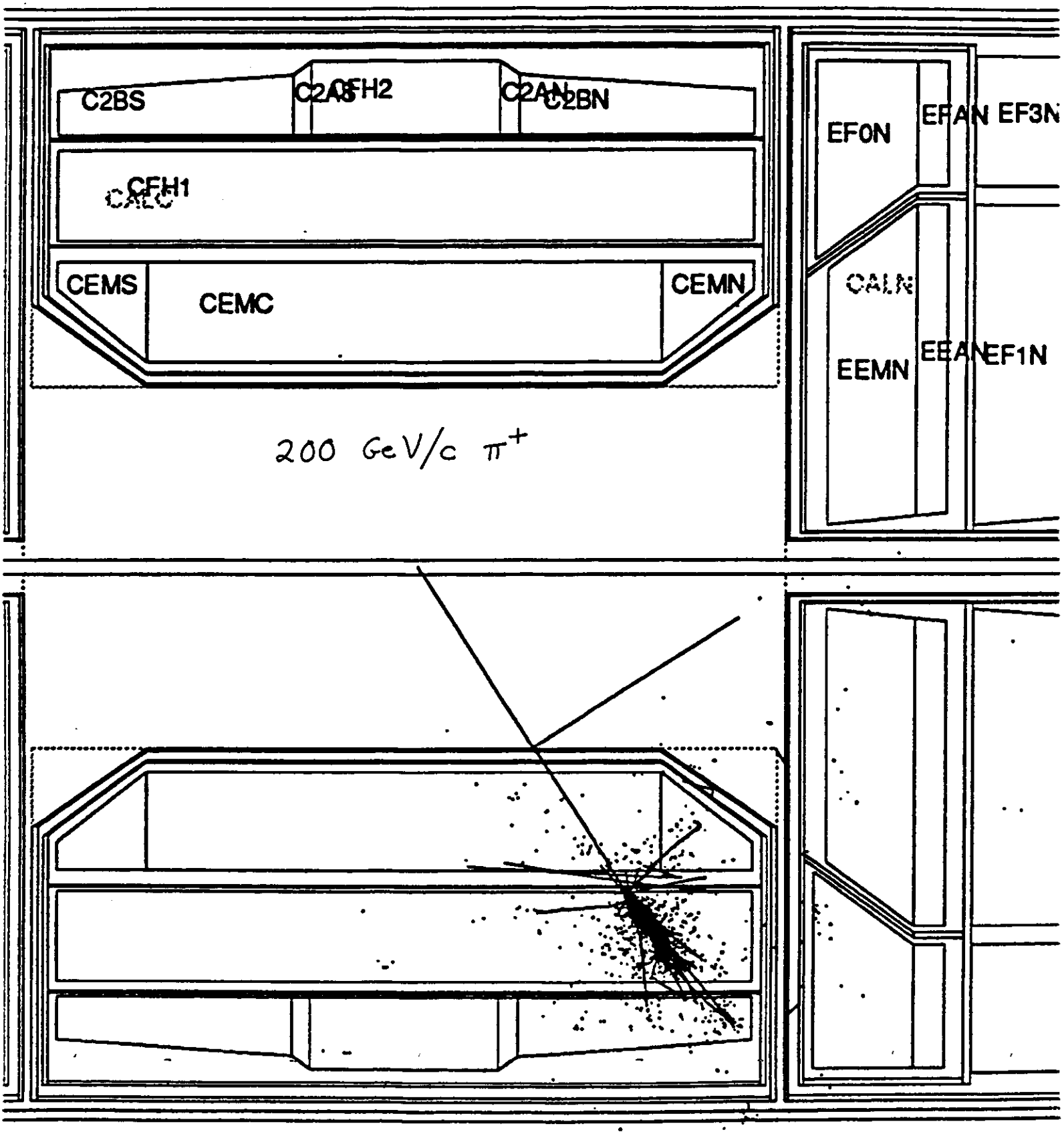
E
50 GeV/c π+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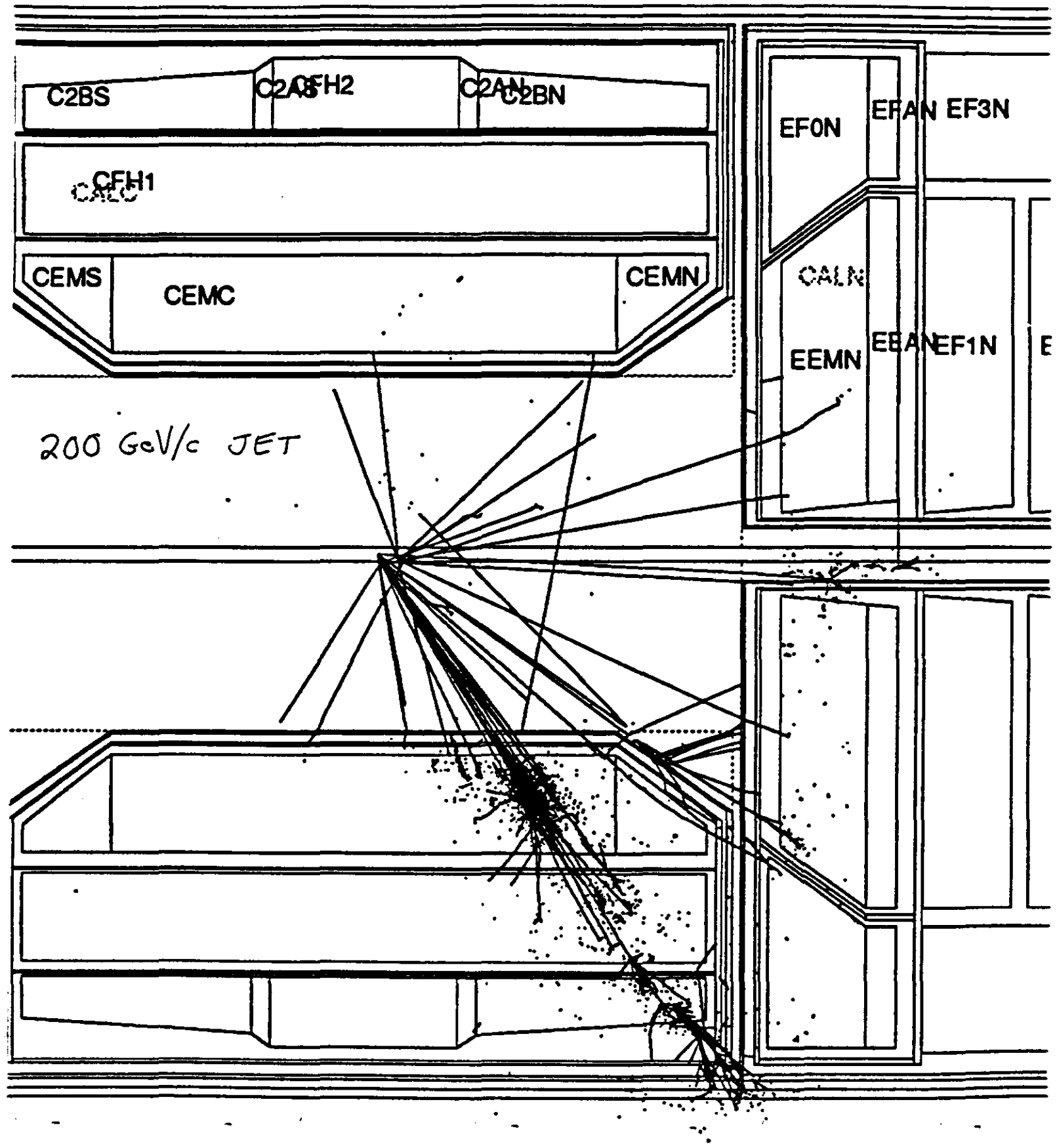
EF1N
200 GeV/c π+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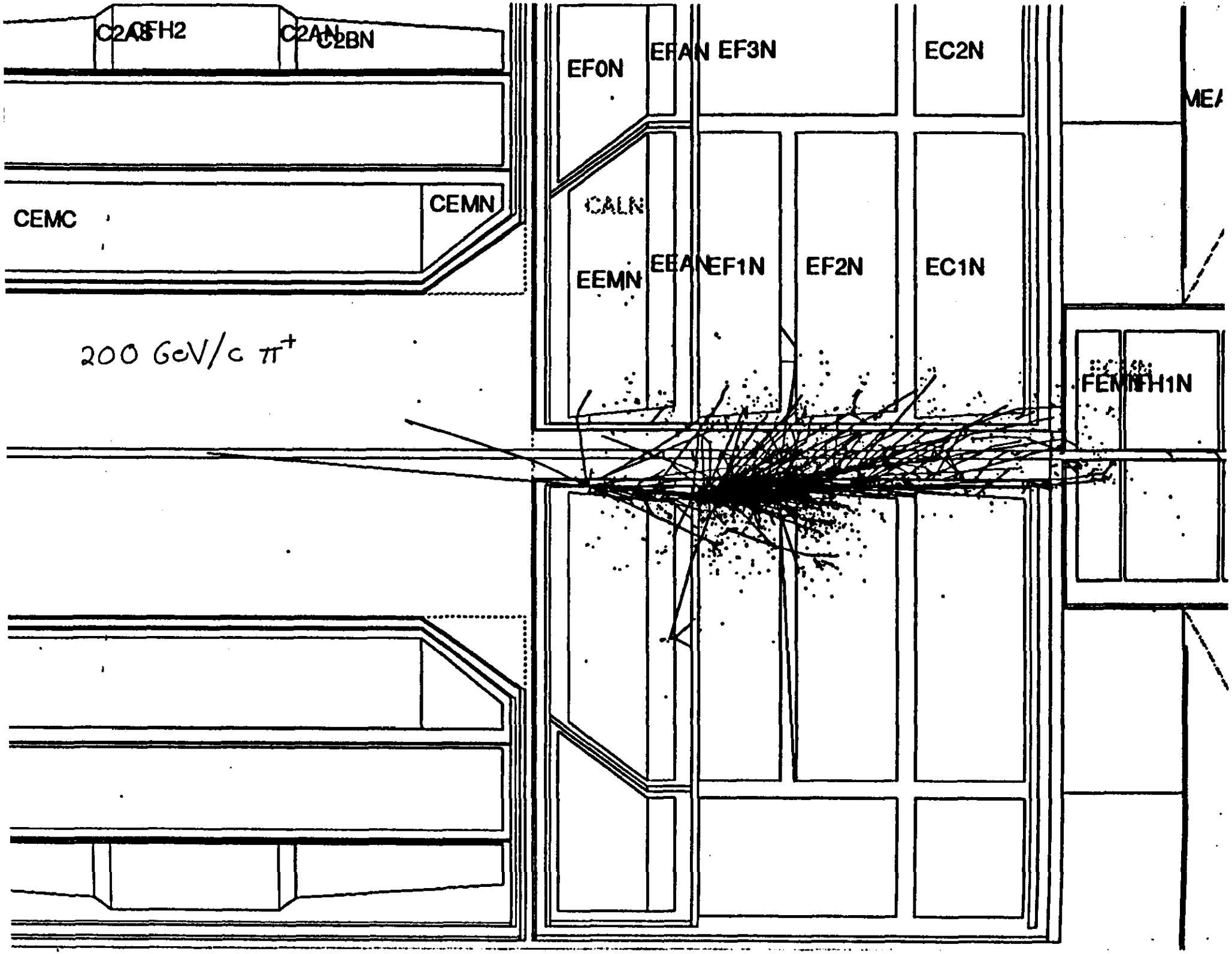
200 GeV/c JET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EEAN
EF1N
EF2N
EC1N
200 GeV/c π+
FEMN
FH1N

ENERGY SCANS AT ETA=0.

The following figures are sets of energies scans of pions at eta=0. Events are generated with total momenta of 5.0, 10.0, 50.0, 200.0, and 500.0 GeV/c, with the number of events at each energy proportional to 1./rt(E). The deposited energy is then analyzed as follows:

PTOT ALL: The energy from ALL volumes, including dead materials such as cryostat walls and structural tubes is summed. The GEANT mother volume is filled with air, but it is not infinite, so hadronic shower punchthrough and pion decays to muons are seen at low level in these distributions as energy leaving the detector. The means and widths of these distributions are all due to the nuclear binding energy losses. Recall that this simulation is GEANT mixtures. Each mixture volume is fully sampling, so there are no fluctuations due to sampling fraction or frequency, and e/MIP is 1.0. The "ALL" plots are representing a detector with very poor compensation since the EM energy is measured perfectly, and the hadronic energy is degraded and fluctuated by the binding energy losses (more below). NOTE: No segmentation has been done yet, so all results reported here correspond to perfect calorimeter segmentation.

PTOT SENS: The energy from all SENSITIVE volumes. The energy is accumulated in the same fashion as for PTOT ALL, but structural and other dead materials are dropped from the sum. Comparison with the ALL plots lets one see the effects of dead materials.

PTOT COMP: These plots show the response of a perfectly compensating detector. This is achieved in the following way: Separate energy scan runs were done of pion showers in large solid blocks of each of the mixture materials to determine the fraction of hadronic energy lost to nuclear effects in each material. This fraction was material dependent, but energy independent. The "boost" factor for each sensitive mixture was determined (the factor by which one multiplies the hadronic energy to return it to fully visible ON AVERAGE). The following boost factors were found:

EM accordion	- Pb/liquid krypton	2.22
EM accordion	- Cu/liquid argon	2.00
Fine hadronic	- Pb/liquid krypton	2.01
Fine hadronic	- Cu/liquid argon	2.00
Coar hadronic (unknown, used 2.00)		
Outer hadronic	- Cu/scintillator	2.00
Forw. hadronic	- W/liquid argon	1.94

For the energy scan of the full detector at eta=0., the EM energy in each sensitive volume was left "as is", and the hadronic energy was multiplied by the above factors, before accumulating the sums for the whole detector. So in summary, the COMP plots represent a detector with dead materials and hadronic energy fluctuations, but fully sampling and perfectly compensating.

PTOT HYBR: These plots take the adjustment of the COMP plots, and then multiply the hadronic energy by h/e for each detector material. At the moment, these factors are GUESSES since we do not have the test beam runs or detailed GEANT simulations done which are needed to find them. So all sets of plots beyond the COMP plots are subject to adjustment and must be taken with a grain of salt. They are being done currently to get a feeling for the magnitude of the various effects. The e/h factors result from the combined action of nuclear binding energy losses degrading the hadronic component and e/MIP degrading the EM component. However, we simply multiply the hadronic piece by h/e on the assumption that the modules are "calibrated" to the EM component. The e/h factors used currently are:

EM accordion	- Pb/liquid krypton	1.8
EM accordion	- Cu/liquid argon	1.8
Fine hadronic	- Pb/liquid krypton	1.6
Fine hadronic	- Cu/liquid argon	1.8
Coar hadronic	(unknown, used 2.00)	
Outer hadronic	- Cu/scintillator	1.2
Forw. hadronic	- W/liquid argon	1.4

It will be noted that these factors push the energy distributions back in the direction of the PTOT SENS plots, since they "undo" much of the compensation correction used in PTOT COMP. In summary, the HYBR plots represent the current guess on the response of the GEM Baseline II design.

PTOT COHA: These plots address the question of what the response would look like, given the EM accordion, if the hadronic calorimeter were perfectly compensating everywhere. No weighting schemes are applied since it has not been demonstrated yet that they can be made to work. As expected, the resolutions lie between the cases of HYBR and COMP.

PSME distributions: As an additionally speculative step, involving more guessed constants, the above COMP, HYBR and COHA distributions are subjected to EM and hadronic smearing for each sensitive volume and repeated as "PSME" plots. Currently only stochastic and constant term smearing are applied, since noise cannot be introduced correctly until segmentation is put in. The smearing factors in used currently are:

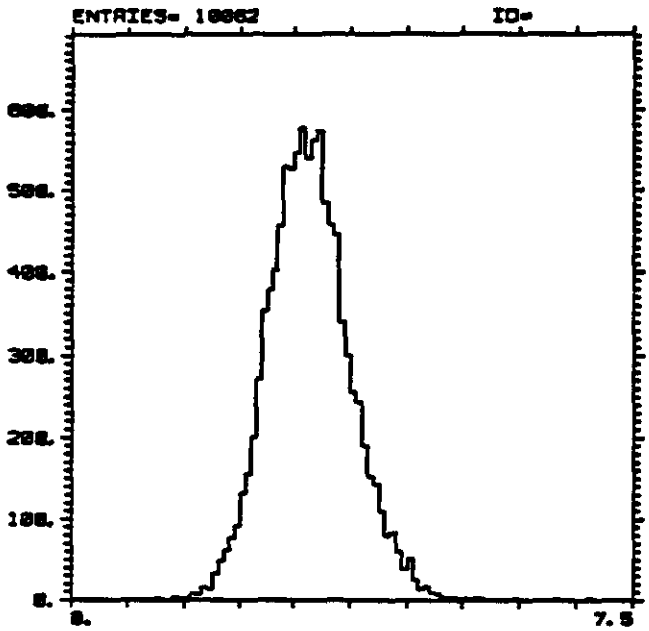
		EM-samp	Had-samp	Const
EM accordion	- Pb/liquid krypton	.06	.60	.004
EM accordion	- Cu/liquid argon	.075	.60	.004
Fine hadronic	- Pb/liquid krypton	.16	.60	.02
Fine hadronic	- Cu/liquid argon	.16	.60	.02
Coar hadronic	(unknown, used 2.00)	.16	.60	.02
Outer hadronic	- Cu/scintillator	.16	.60	.02
Forw. hadronic	- W/liquid argon	.40	.80	.04

As with the e/h factors, these need to be tuned from test beam and detailed GEANT simulation. The hadronic sampling smearings are intentionally lower that the full observed smearing. Recall that the EM energy is unsmeared by mixtures, so all smearing comes from the EM-samp factor, whereas the hadronic energy is already subject to binding energy fluctuations, so the Had-samp factor must combine in quadrature to give the total net resolution on the hadronic component.

Observations:

*** NONE of the distributions is a good Gaussian, so sigma calculations done on whole distributions give nonsense. The results are too new to have had time to do curve fitting or reconstruction of sigma from FWHM on all distributions. However, as a crosscheck, a FWHM construction on the unsmeared COMP distributions gives a stochastic term of .38/rt(E) and a constant term of less than .01. Again, these terms are arising from hadronic energy loss fluctuations and dead materials and leakage in a detector which is otherwise perfectly compensating. We will be systematizing the calculations of all resolution terms based on these plots so that a comparison can be made for the various cases.

*** Even given stable fitting procedures, the tails may be serious for some physics processes. We should gear up to do fast simulations using not only Gaussian smeared momenta, but, when possible, smearing using tables made from the above distributions which would include the skew and the tails.



PTOT ALL
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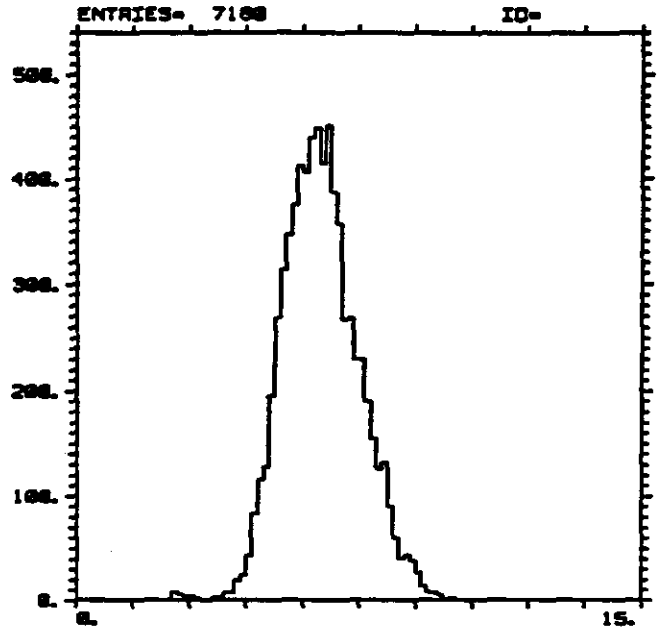
UFLO= 00 OFLO= 10



PTOT ALL
MEAN= 6.48967 +/- 0.986430
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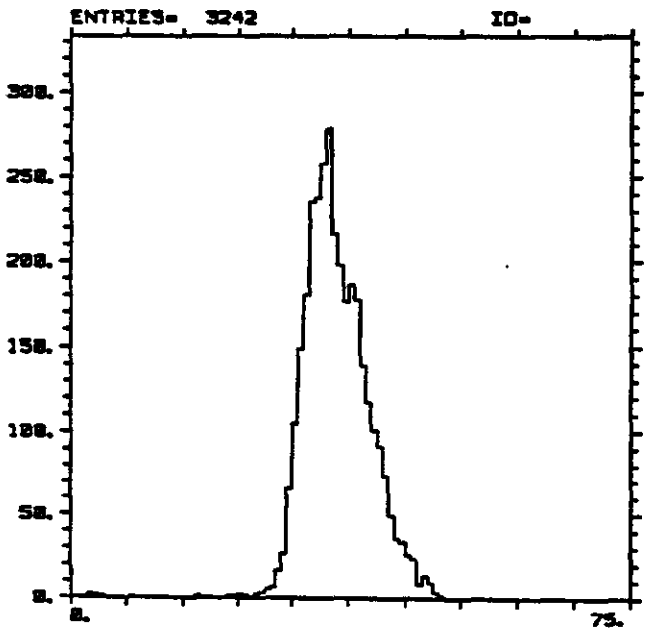

PTOT ALL
MEAN= 35.9524 +/- 4.21736
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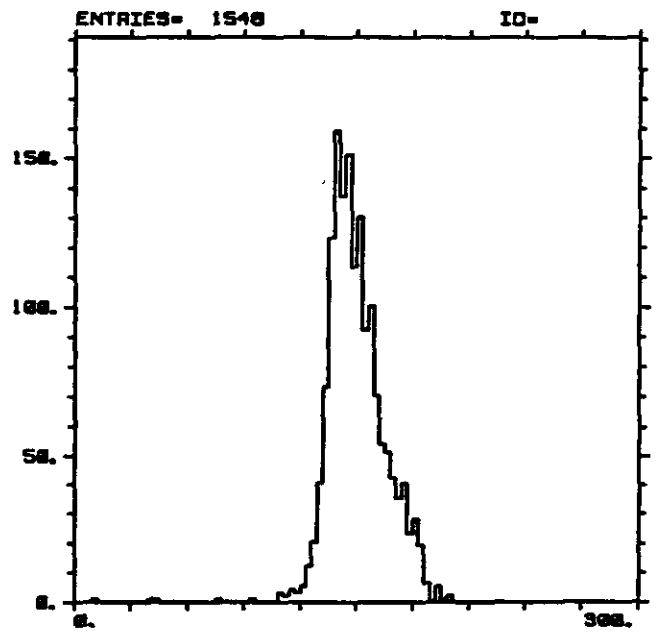

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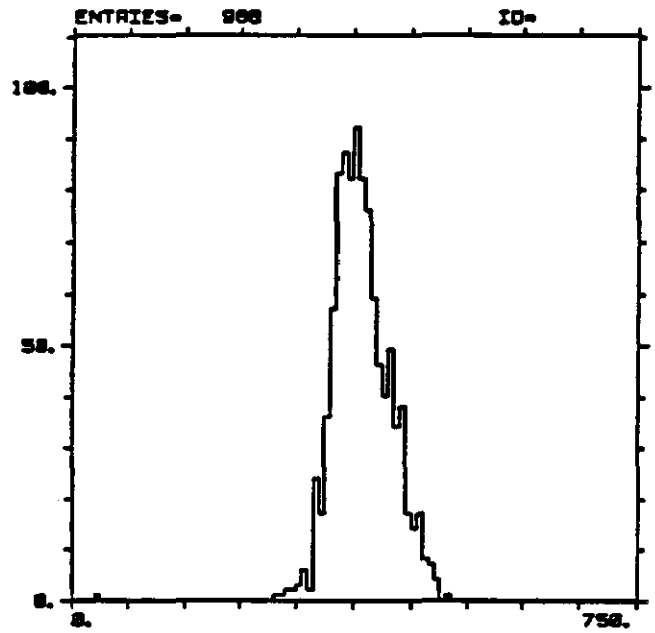

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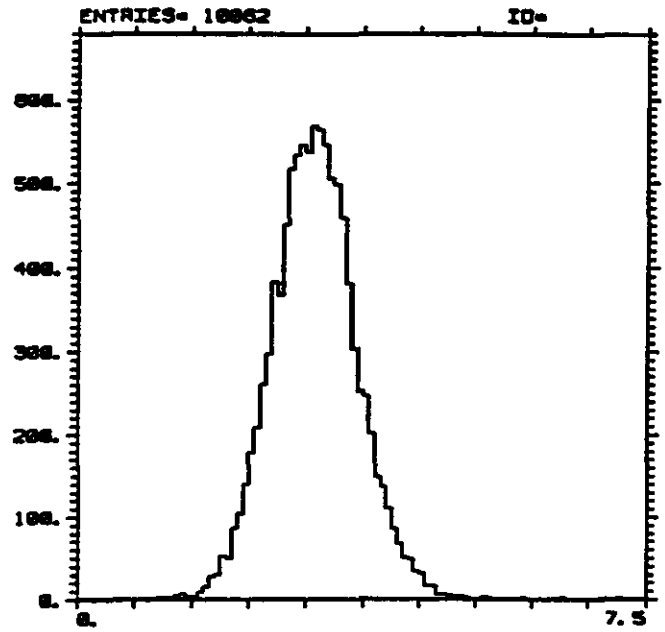

PTOT SENS
MEAN= 3.11584 +/- 0.547217
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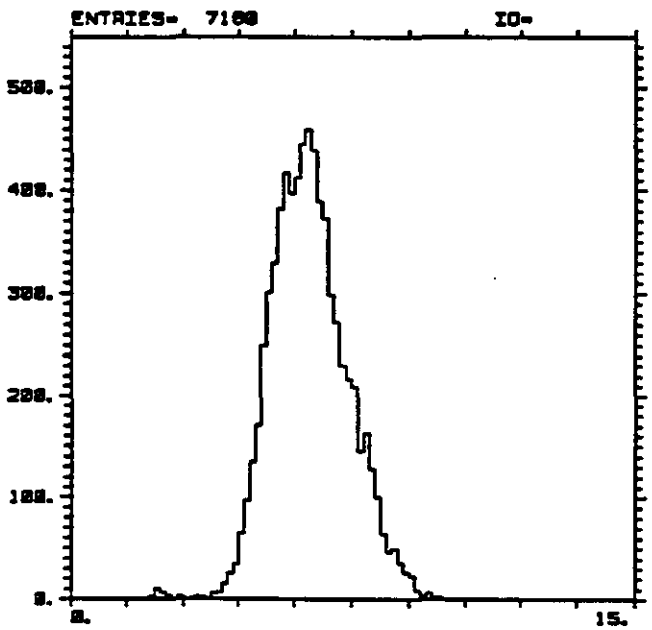

PTOT SENS
MEAN= 8.38004 +/- 0.988889
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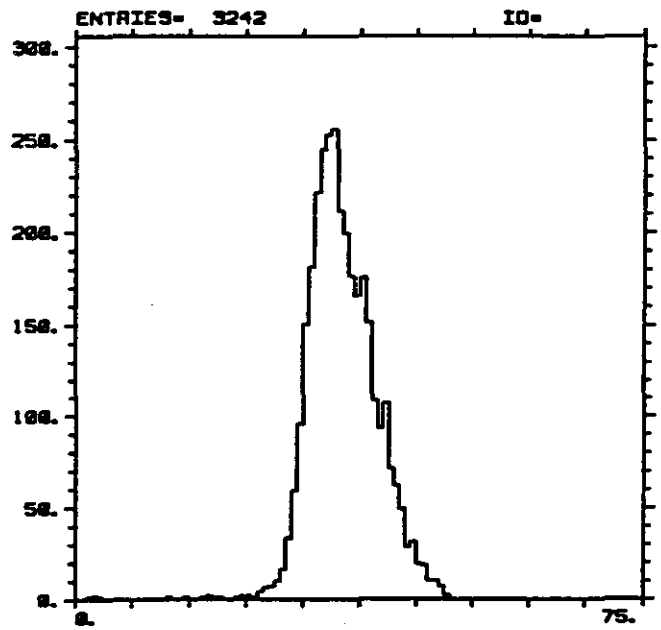

PTOT SENS
MEAN= 35.2648 +/- 4.43409
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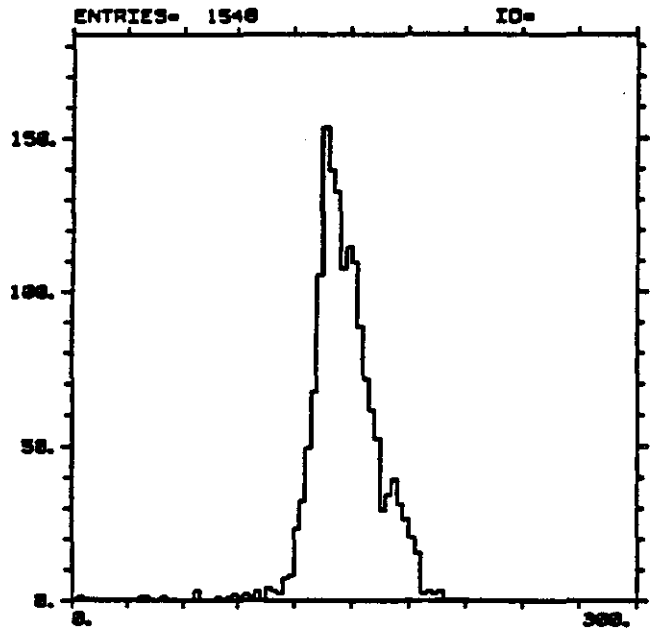

PTOT SENS
MEAN= 146.49 +/- 17.1676
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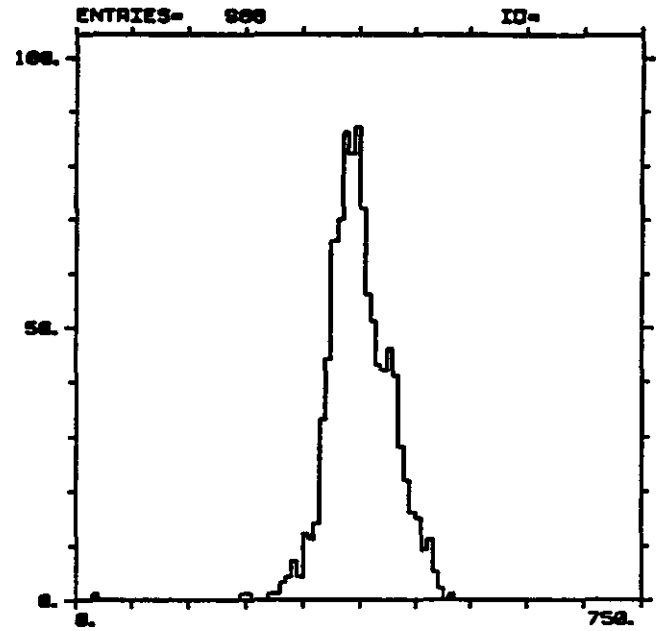

PTOT SENS
MEAN= 376.106 +/- 41.3132
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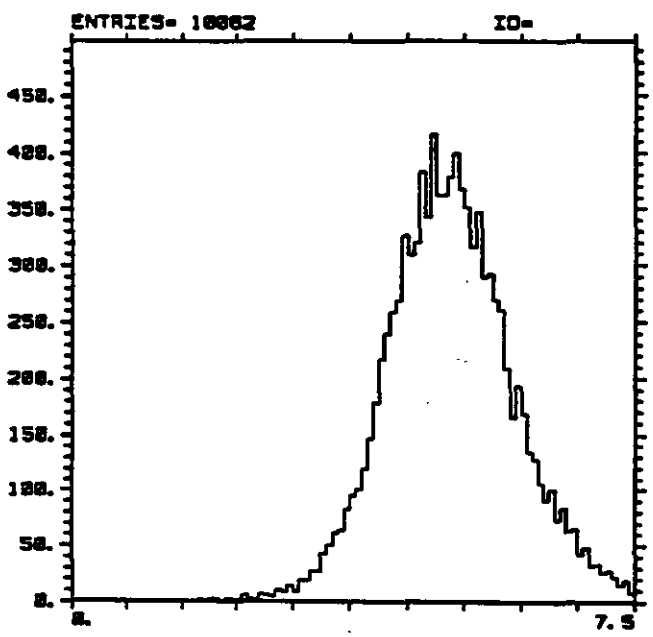

PTOT COMP
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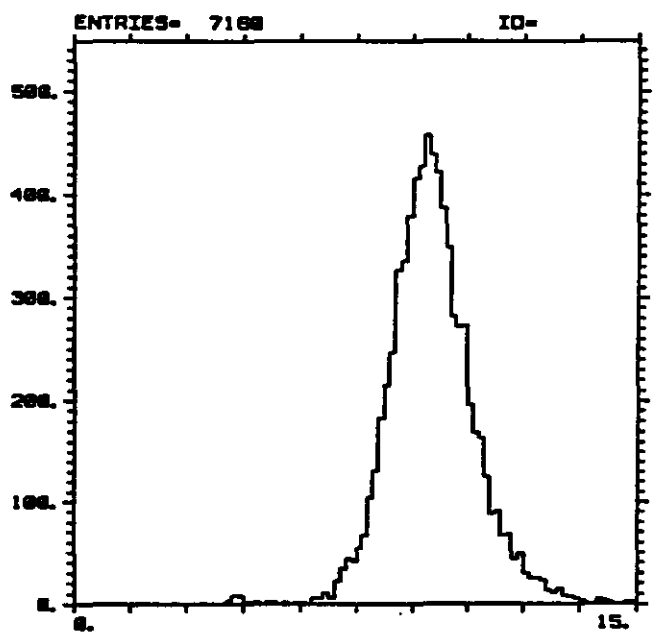

PTOT COMP
MEAN= 9.53308 +/- 1.12654
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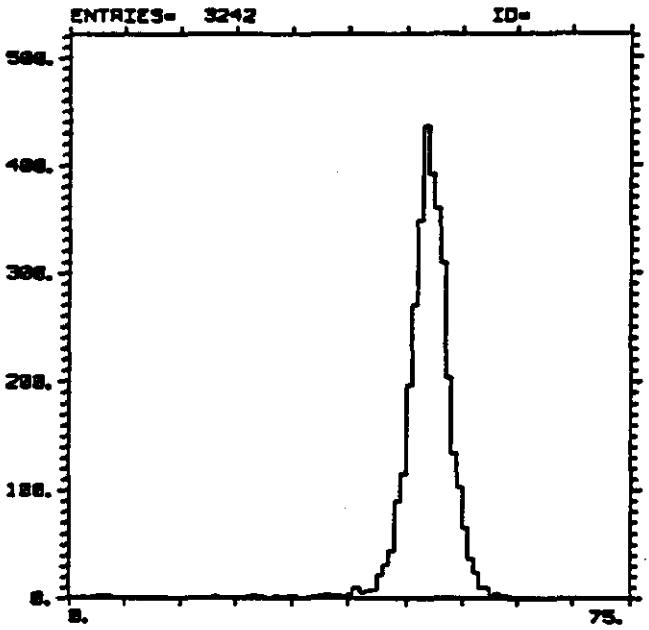

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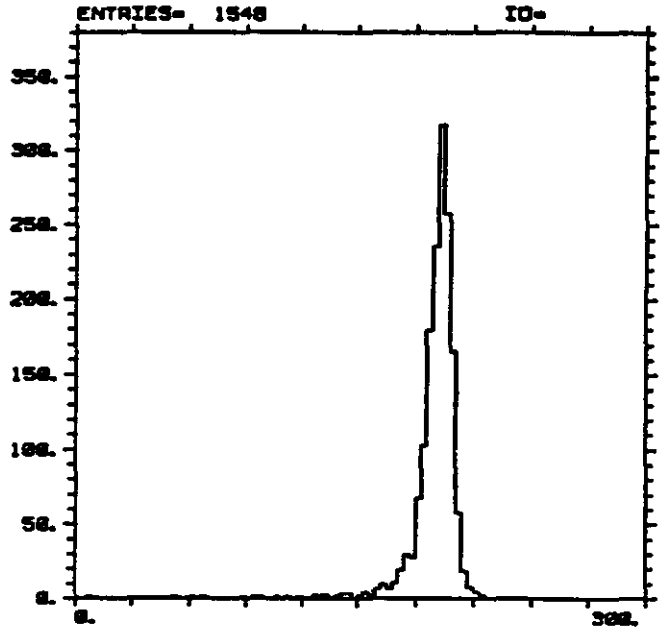

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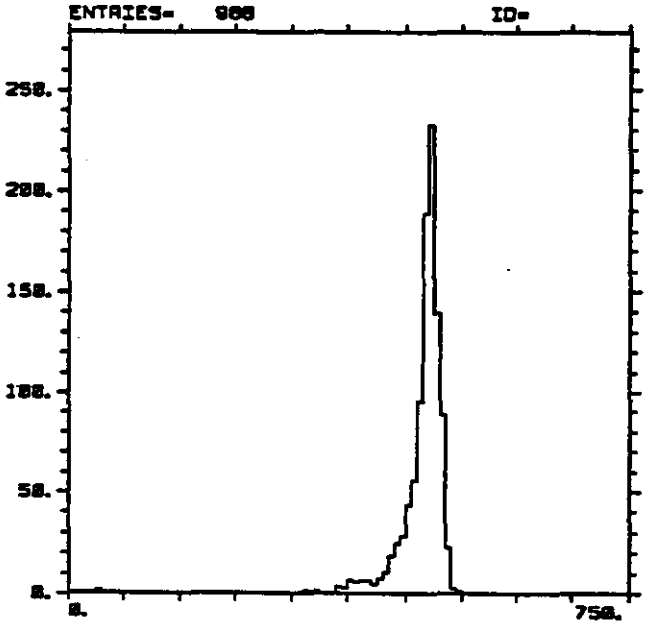

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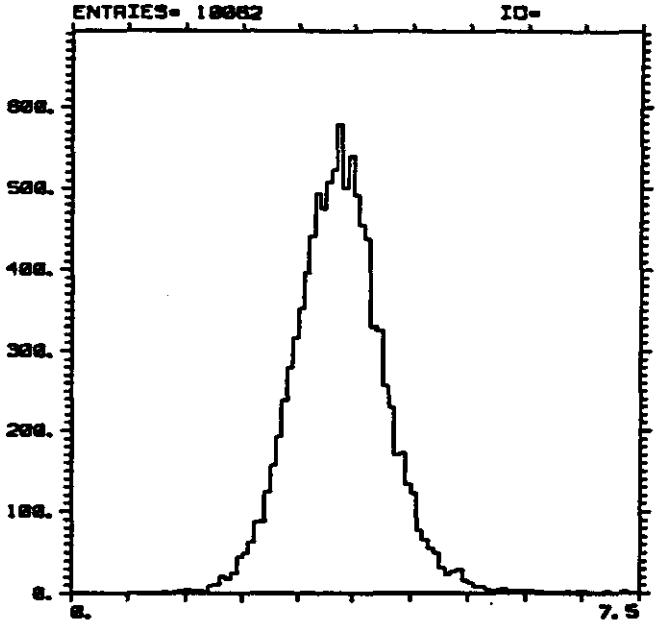

PTOT HYBR
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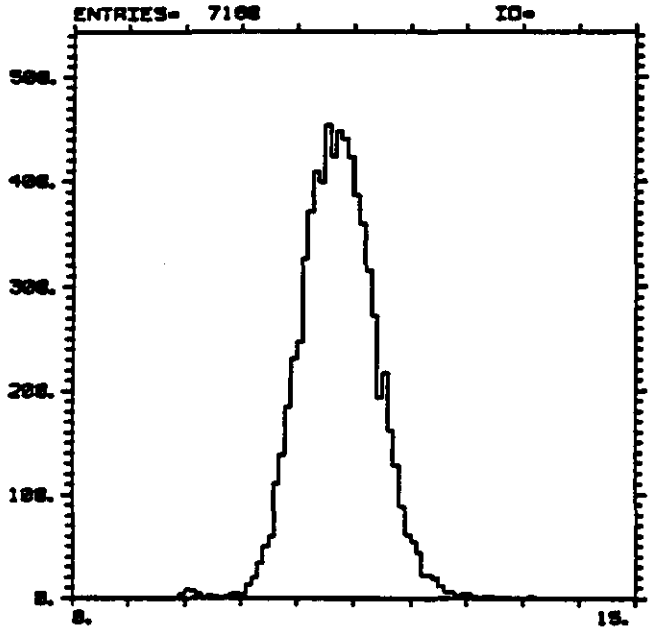

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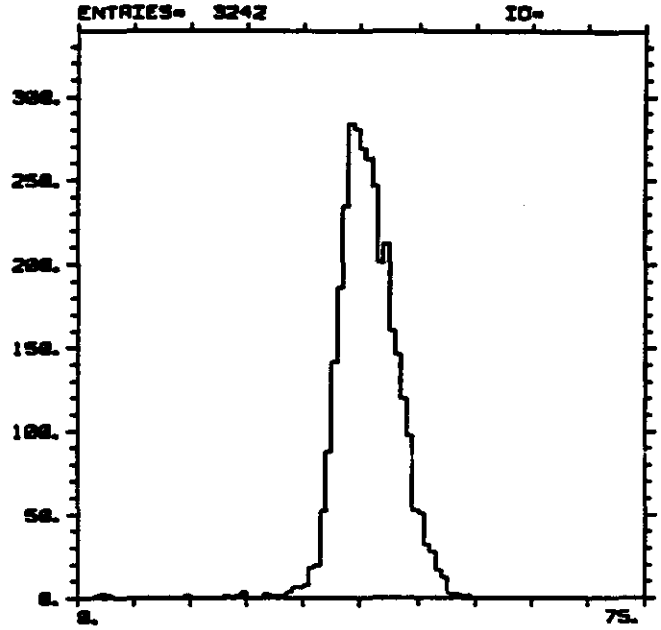

PTOT HYBR
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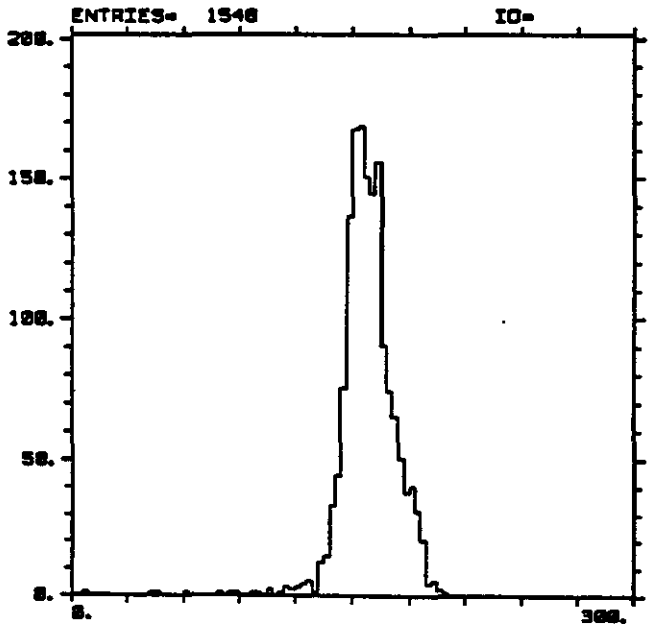

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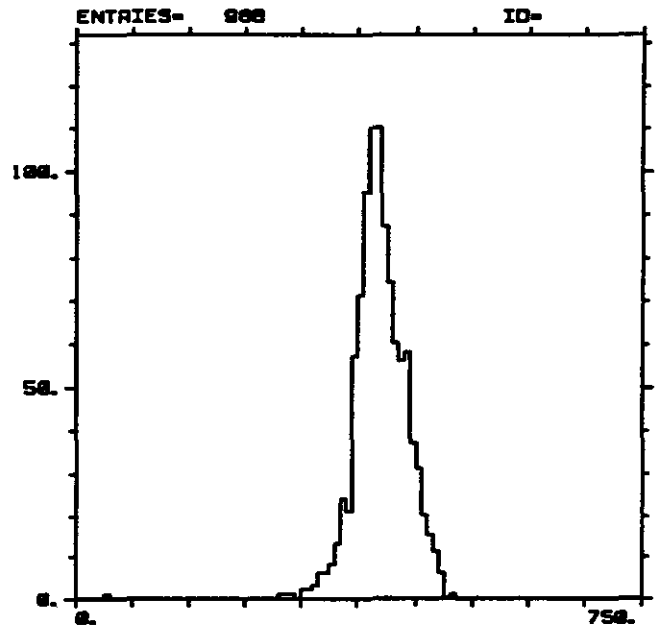

PTOT HYBR
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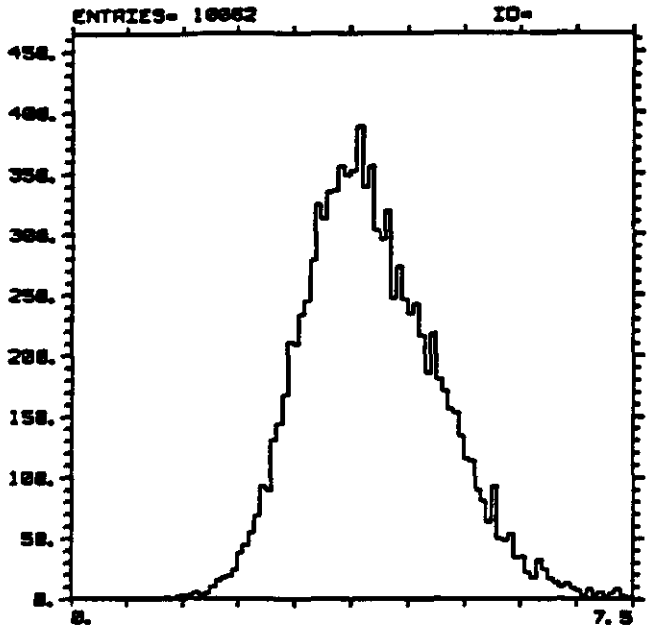

PTOT COHA
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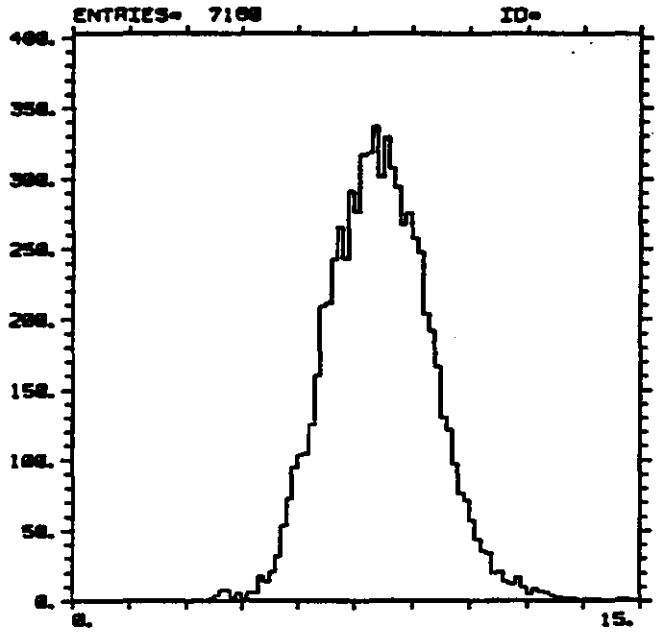

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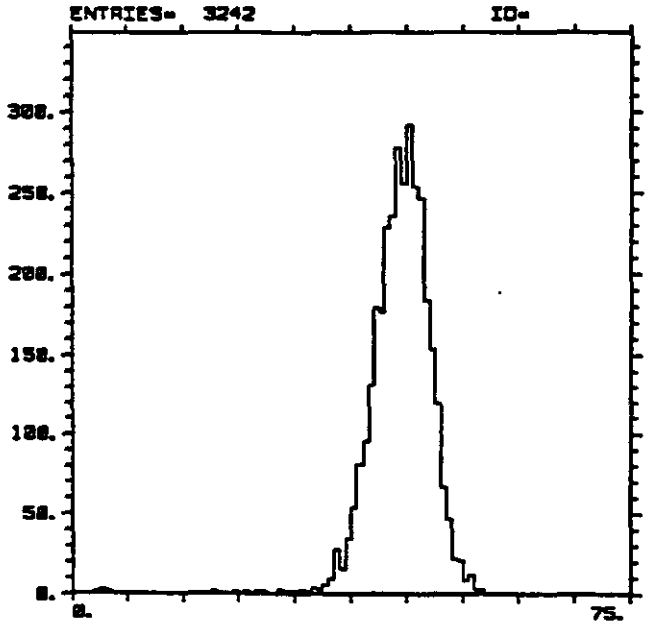

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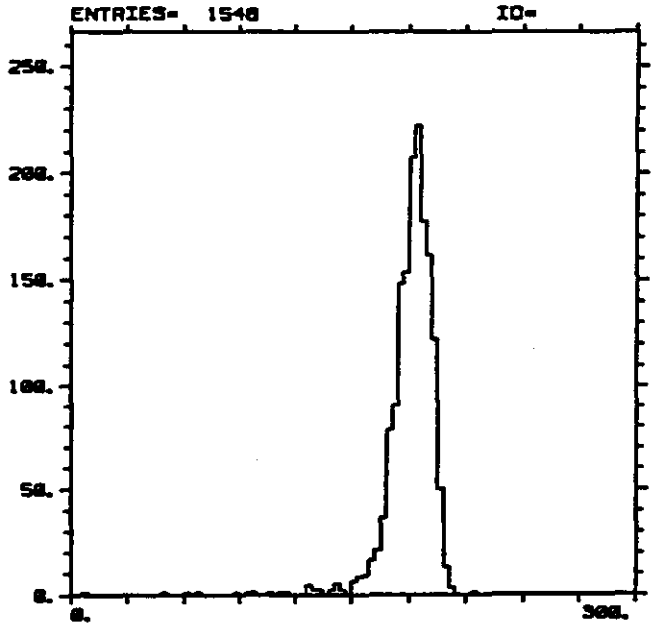

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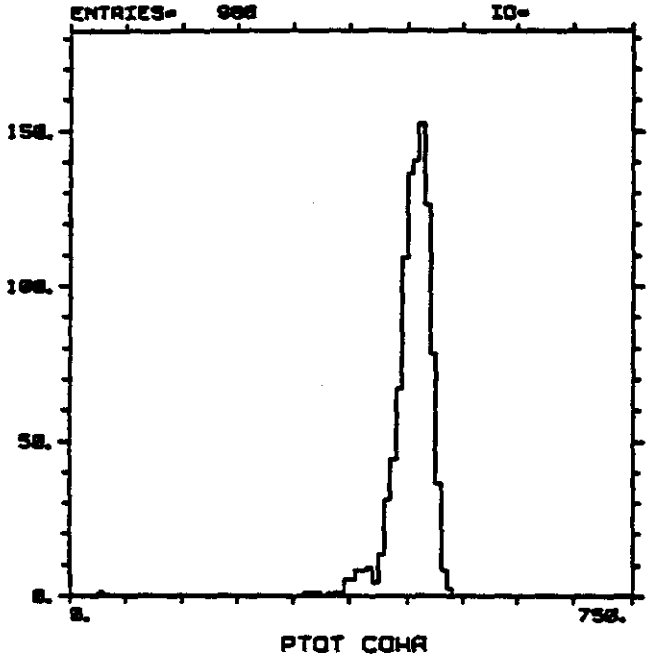

PTOT COHR
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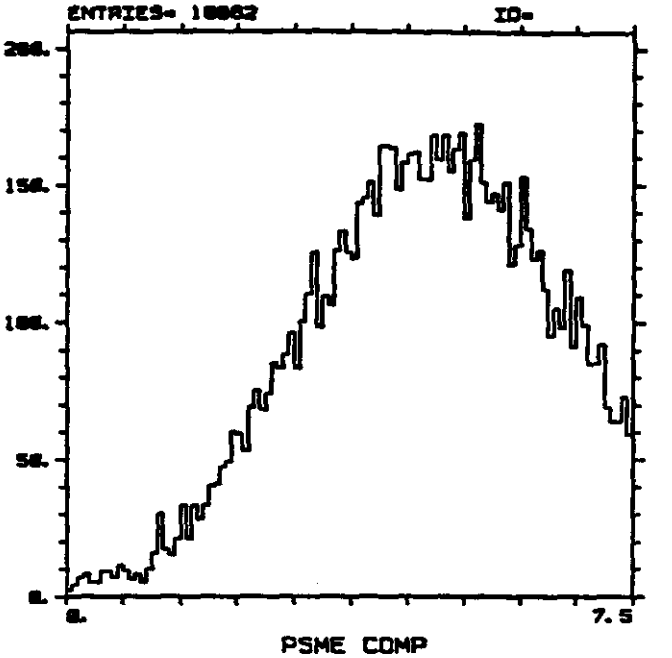

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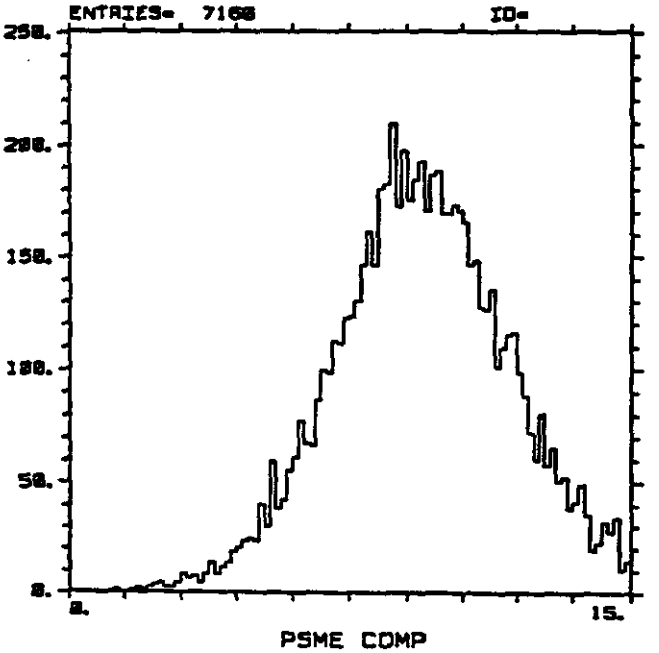

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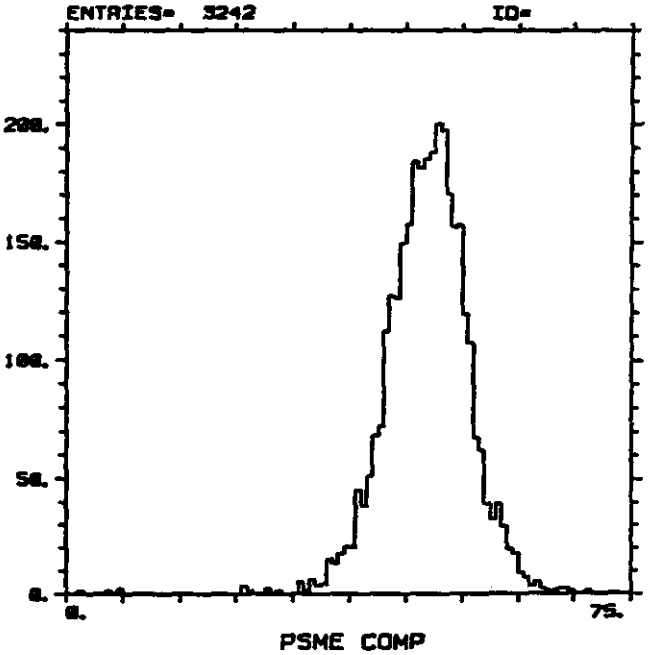

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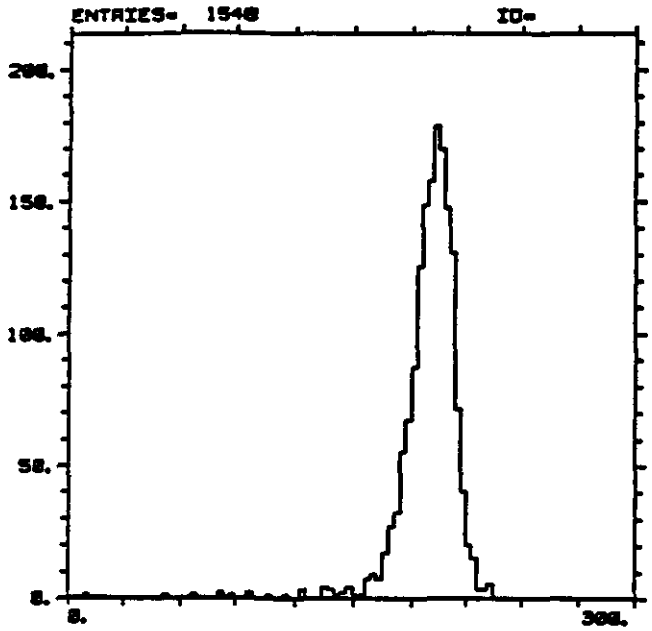

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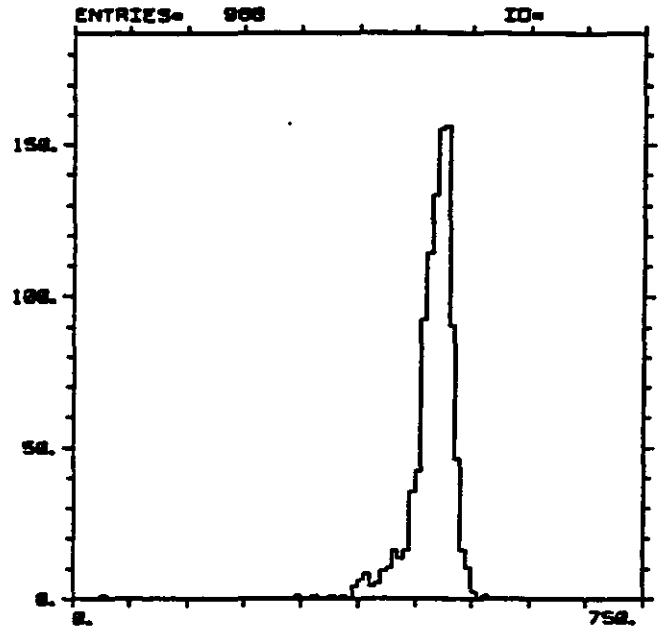
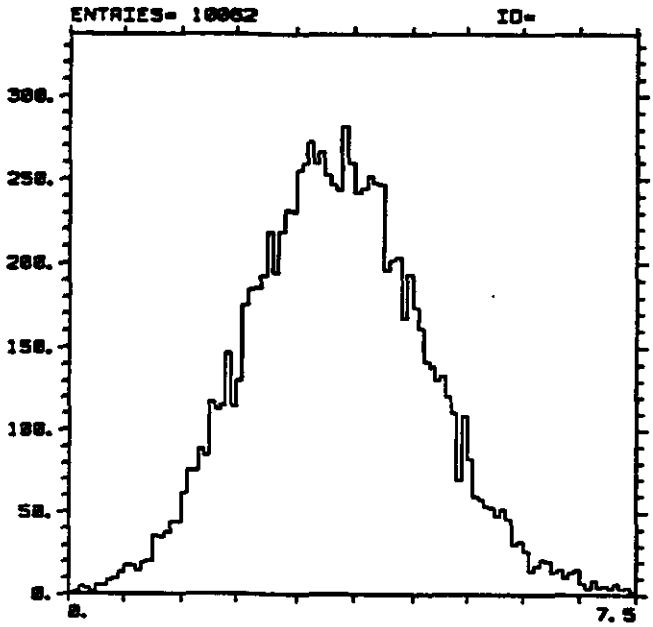
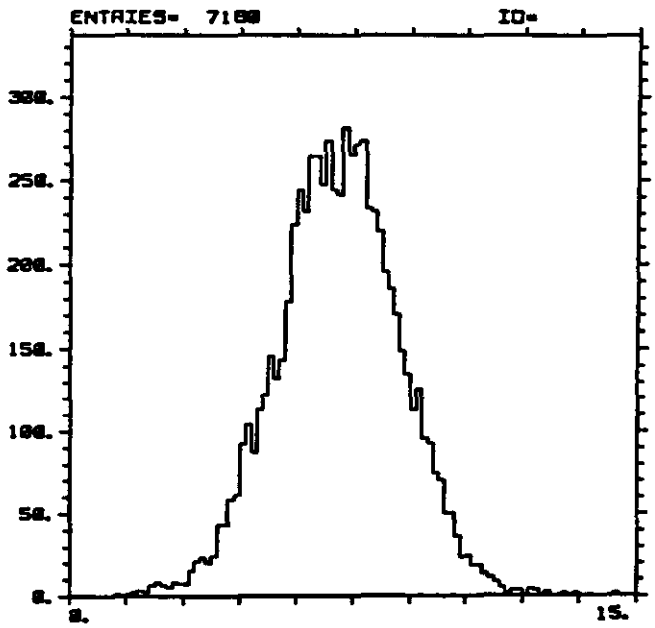


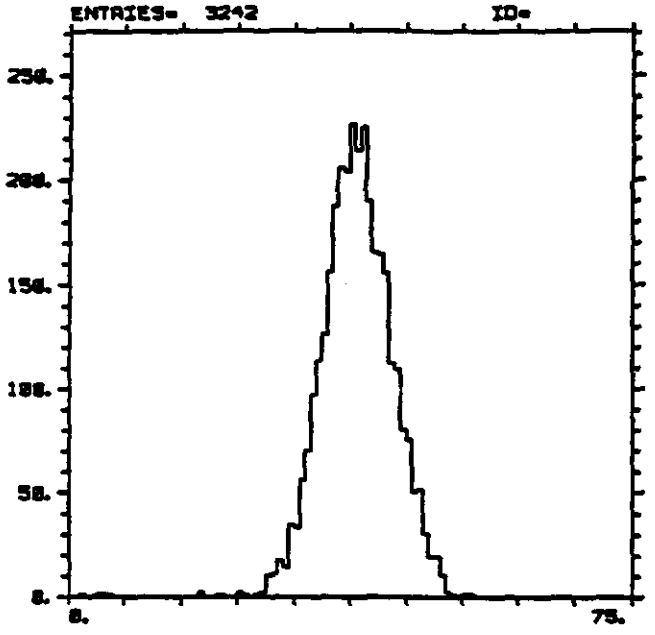
PSME COMP
MEAN= 473.512 +/- 30.599
UFLO= 00 OFLO= 00



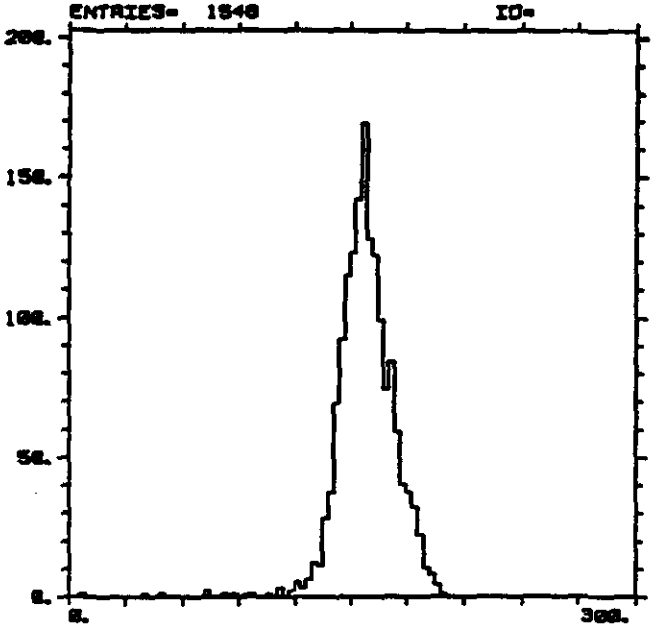
PSME HYBR
MEAN= 3.5376 +/- 1.15214
UFLO= 00 OFLO= 120



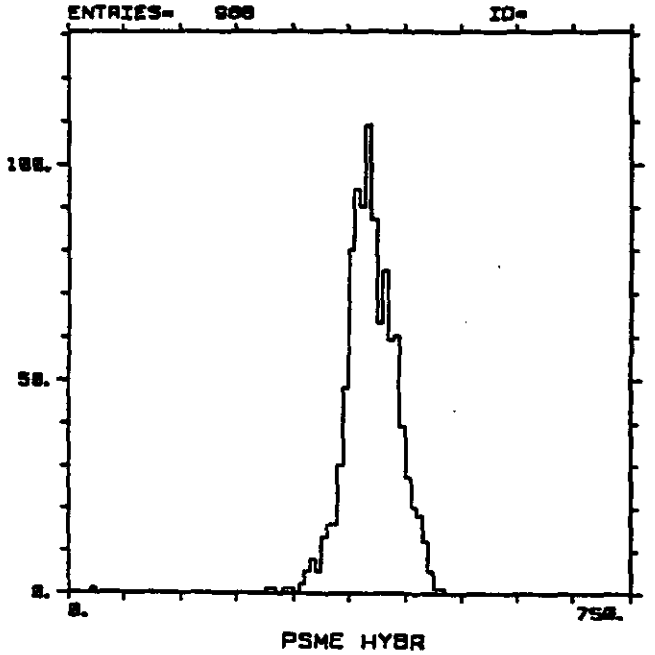
PSME HYBR
MEAN= 7.10539 +/- 1.60029
UFLO= 00 OFLO= 10



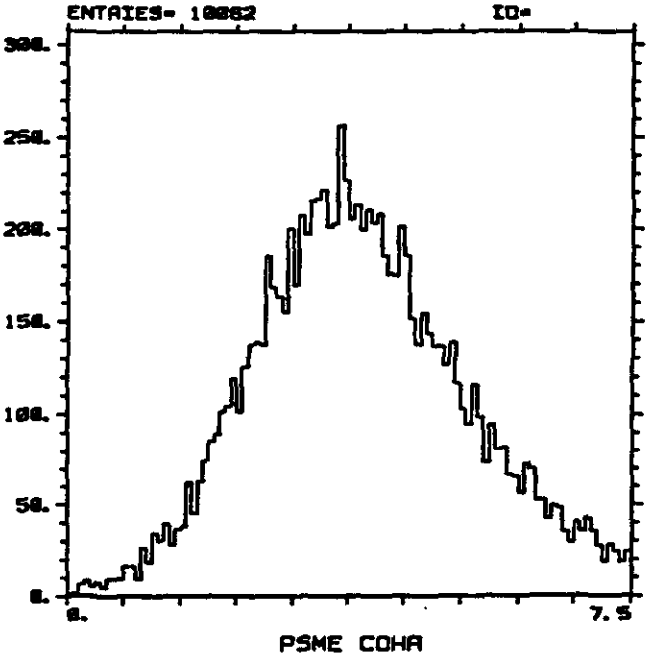
PSME HYBR
MEAN= 30.4525 +/- 4.66663
UFLO= 00 OFLO= 00



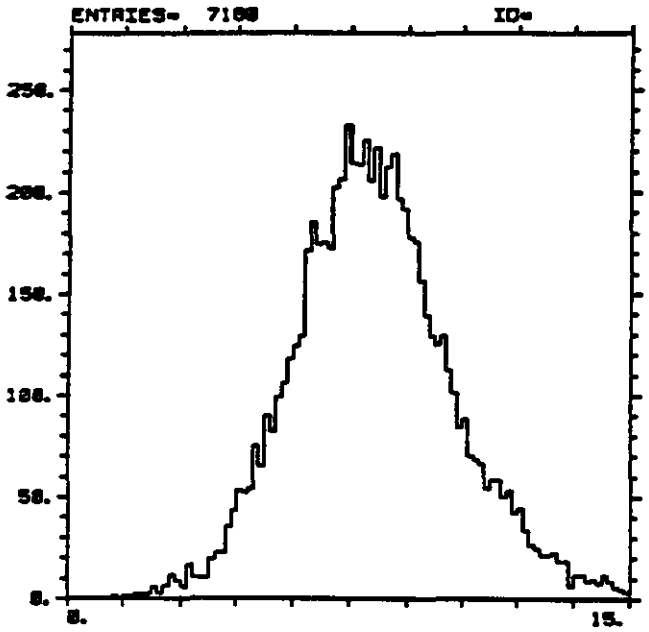
PSME HYBR
MEAN= 150.477 +/- 15.3454
UFLO= 00 OFLO= 00



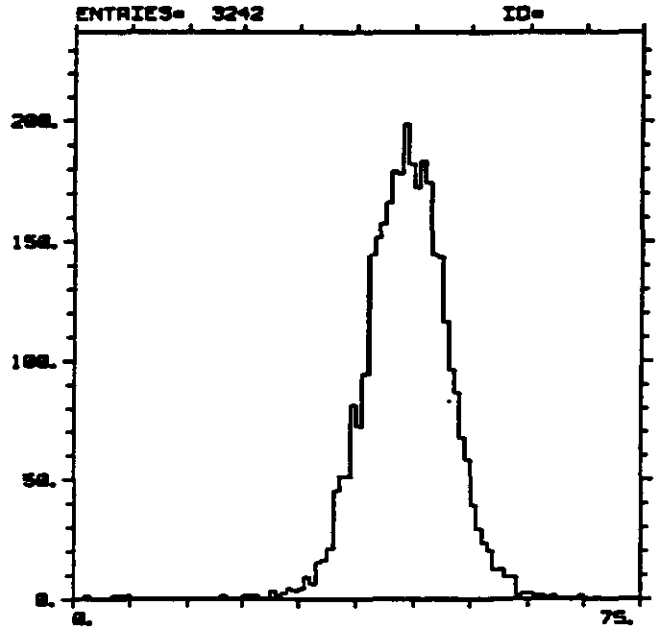
PSME HYBR
MEAN= 404.482 +/- 34.6148
UFLO= 00 OFLO= 00



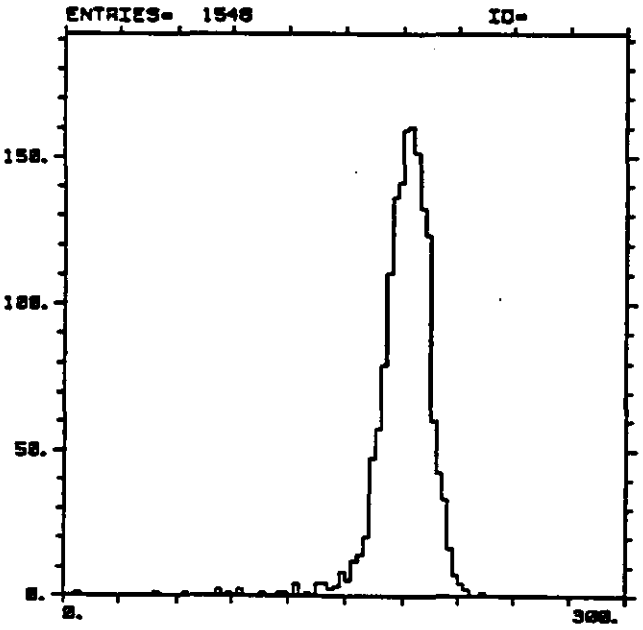
PSME COHA
MEAN= 3.90383 +/- 1.38038
UFLO= 00 OFLO= 2930



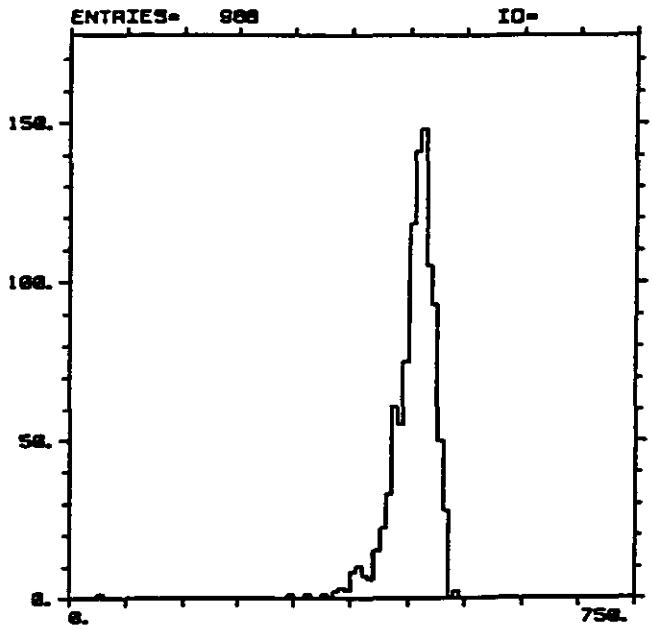
PSME COHR
MEAN= 8.13773 +/- 2.08892
UFLO= 00 OFLO= 270



PSME COHR
MEAN= 44.0918 +/- 5.355
UFLO= 00 OFLO= 00



PSME COHR
MEAN= 180.828 +/- 14.9412
UFLO= 00 OFLO= 00



PSME COHR
MEAN= 456.701 +/- 29.4788
UFLO= 00 OFLO= 00

ETA SCANS FOR 200 GEV/C PIONS

1) Ptotal vs. Eta

and

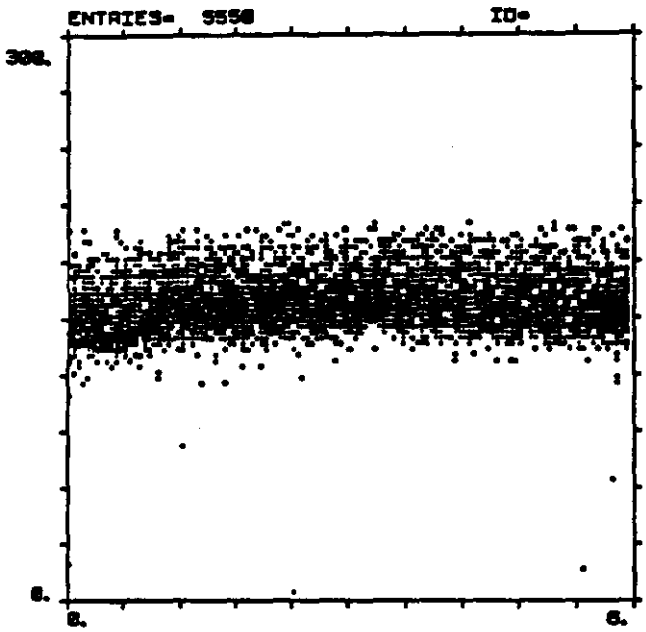
2) Pt/(sin(theta)) vs. Eta

FOR THE SAME SET OF ENERGY CORRECTIONS

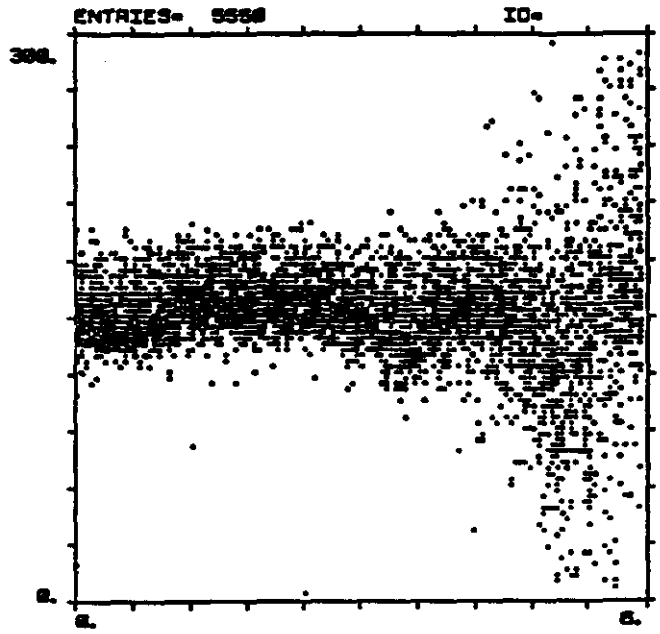
AS USED IN THE ENERGY SCANS:

ALL, SENS, COMP, HYBR, COHA

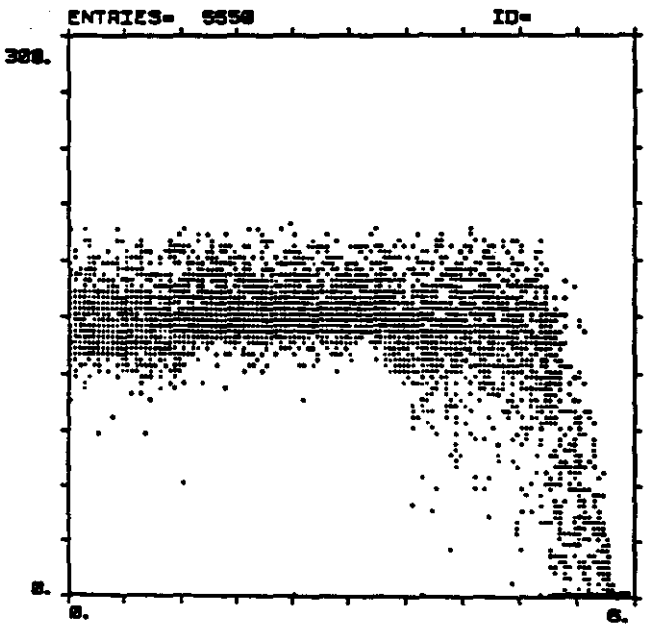
+(ALL THESE SMEARED)



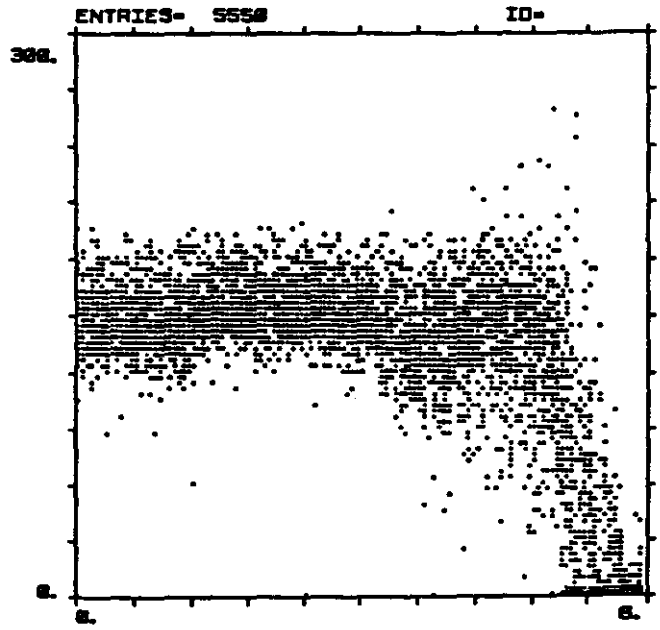
PTOT ALL V. ETA



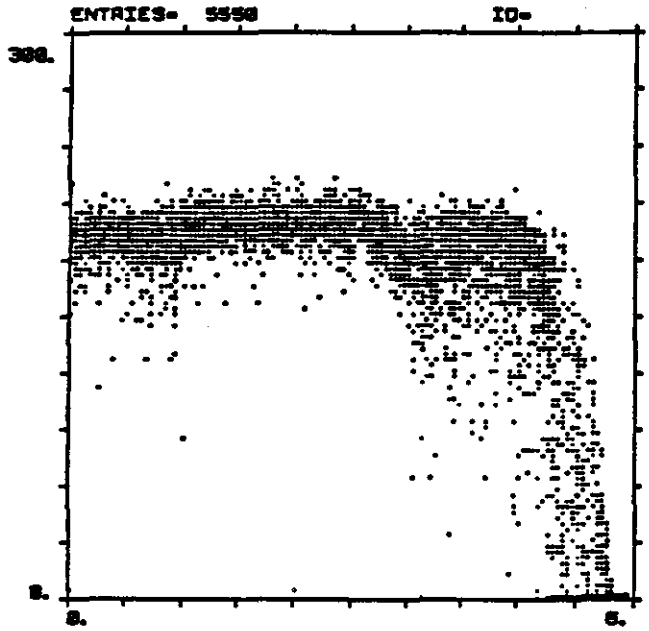
PT/S ALL V. ETA



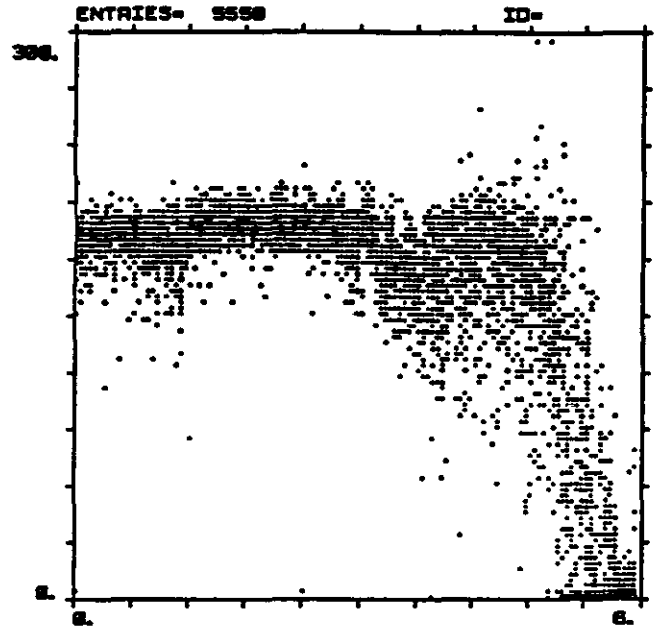
PTOT SENS V. ETA



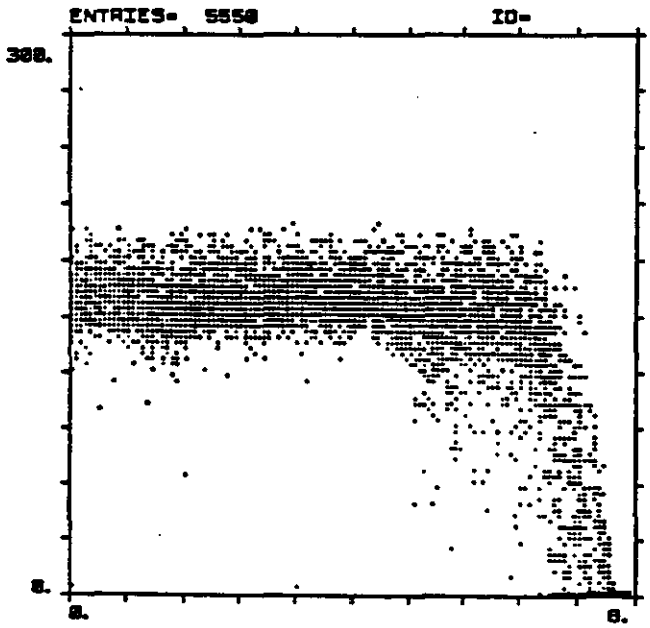
PT/S SENS V. ETA



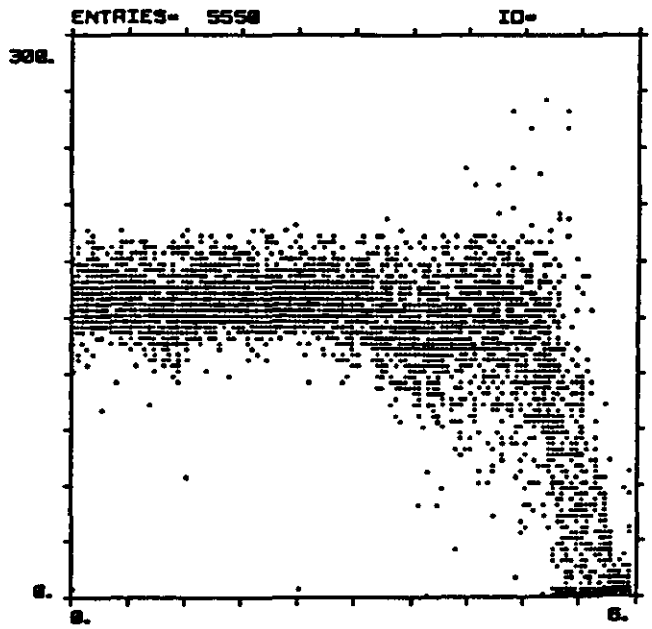
PTOT COMP V. ETA



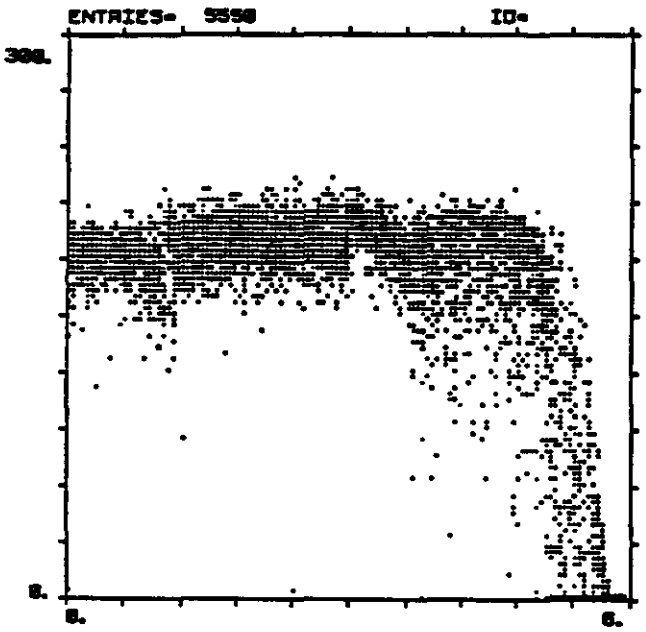
PT/S COMP V. ETA



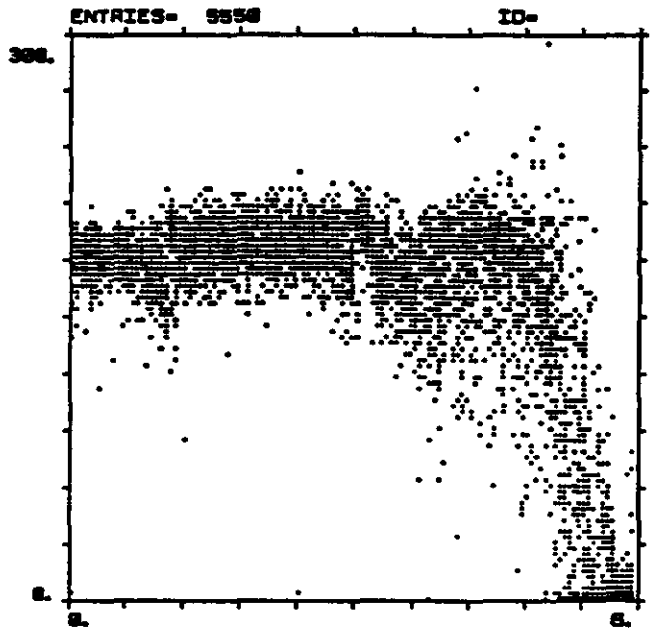
PTOT HYBR V. ETA



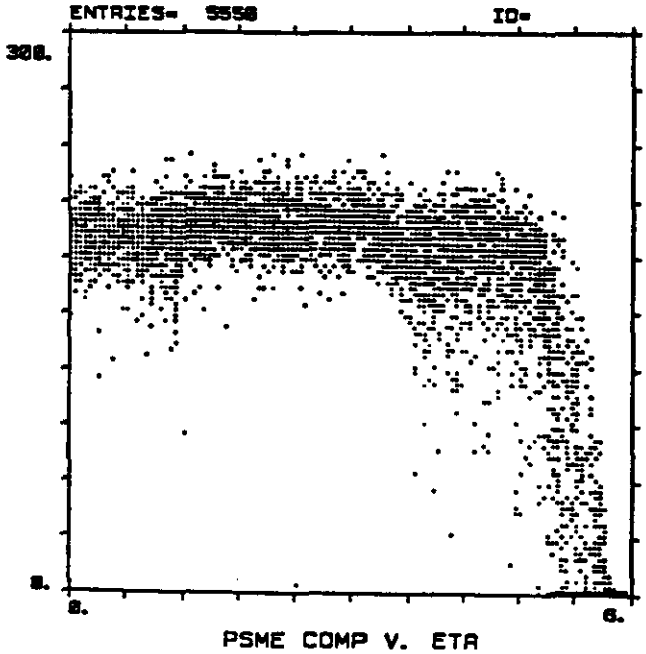
PT/S HYBR V. ETA



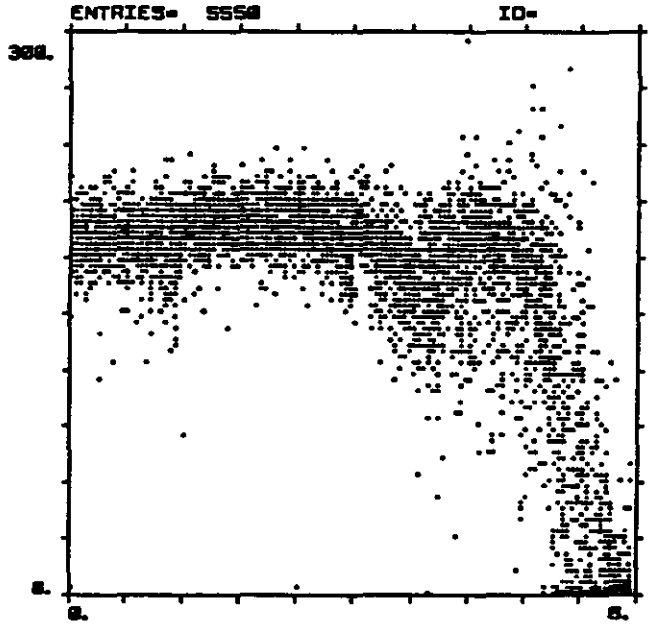
PTOT COHR V. ETR



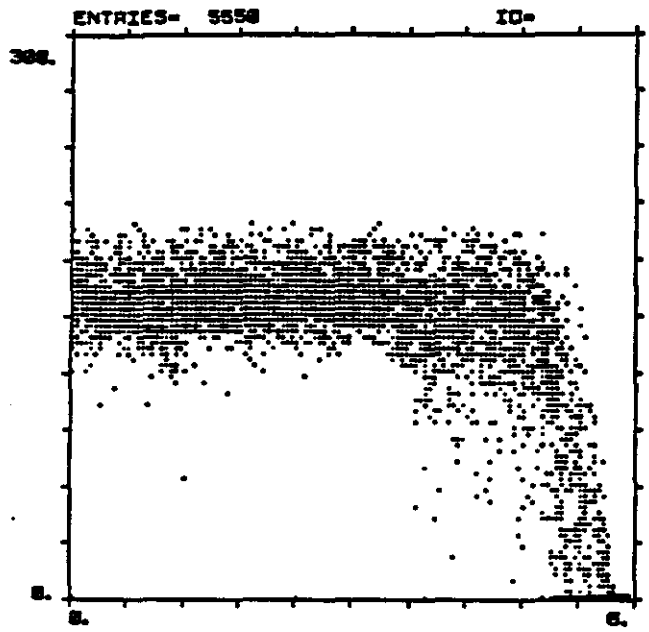
PT/S COHR V. ETR



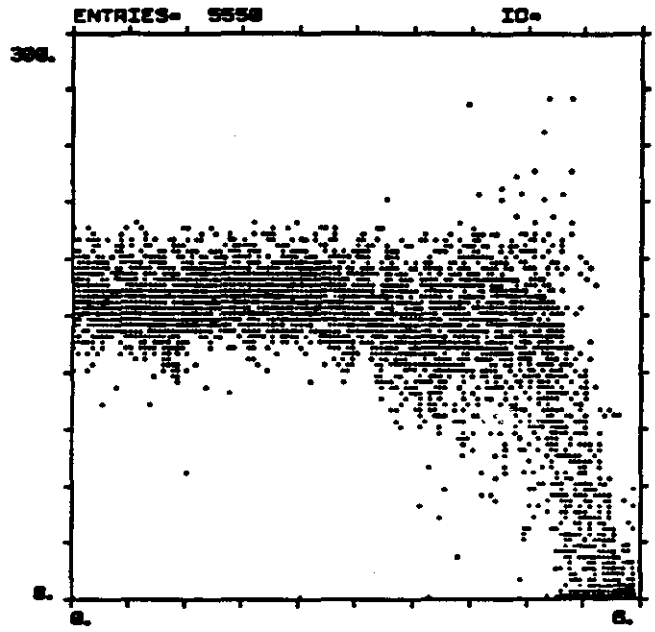
PSME COMP V. ETR



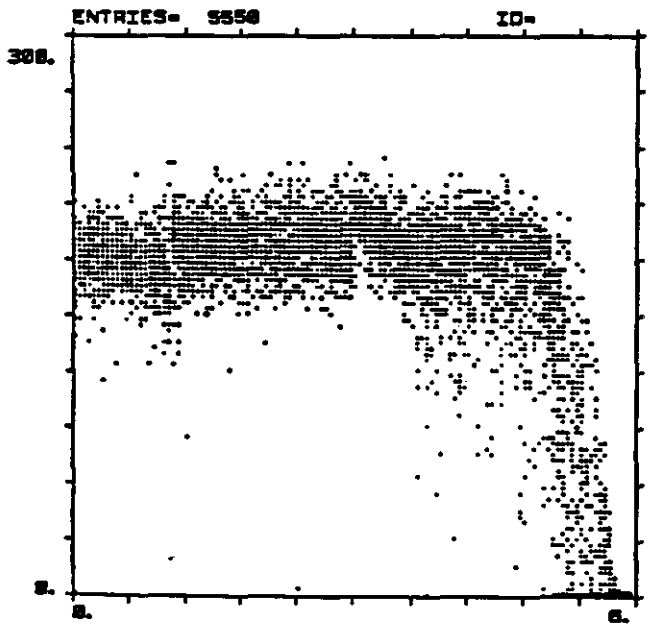
PTSM COMP V. ETR



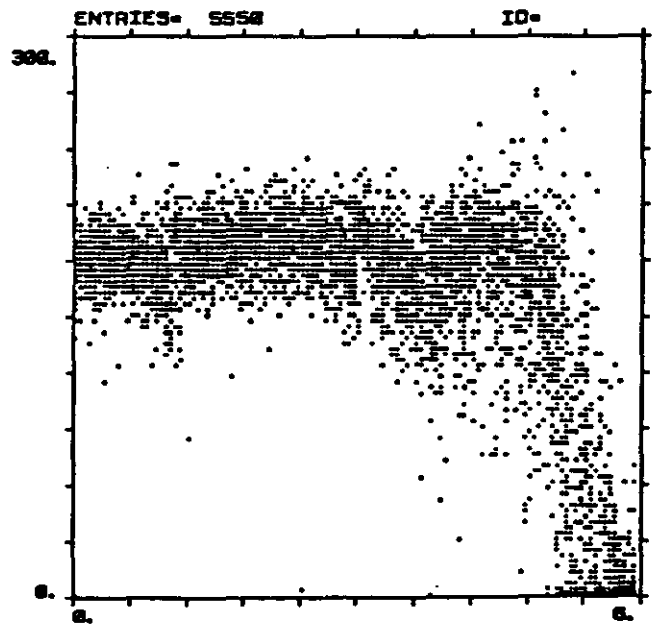
PSME HYBR V. ETA



PTSM HYBR V. ETA



PSME COHR V. ETA



PTSM COHR V. ETA

ETA SCANS FOR 50 GEV/C ELECTRONS

1) Ptotal vs. Eta

and

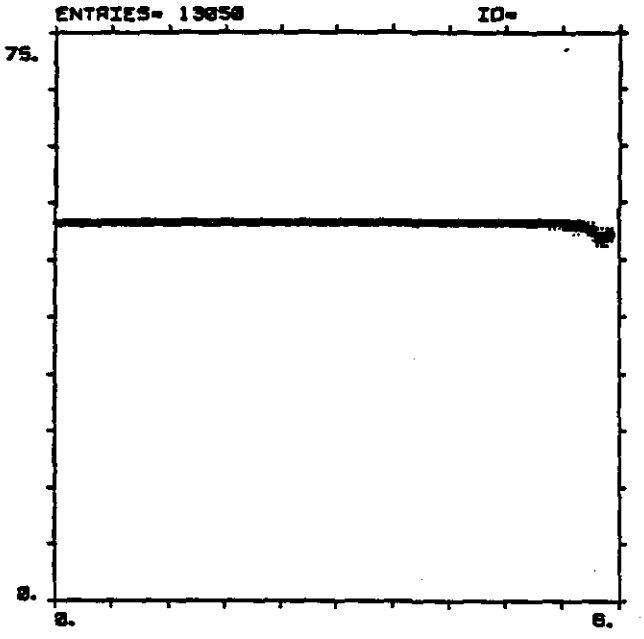
2) Pt/(sin(theta)) vs. Eta

FOR THE SAME SET OF ENERGY CORRECTIONS

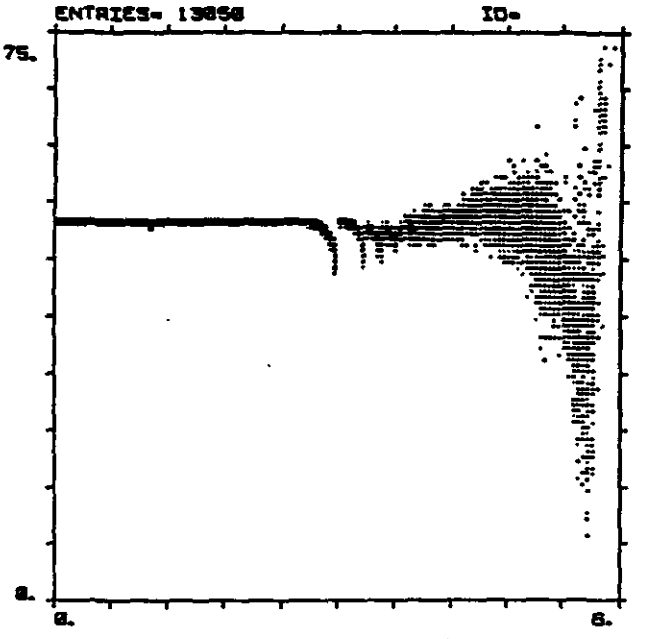
AS USED IN THE ENERGY SCANS:

ALL, SENS, COMP, HYBR, COHA

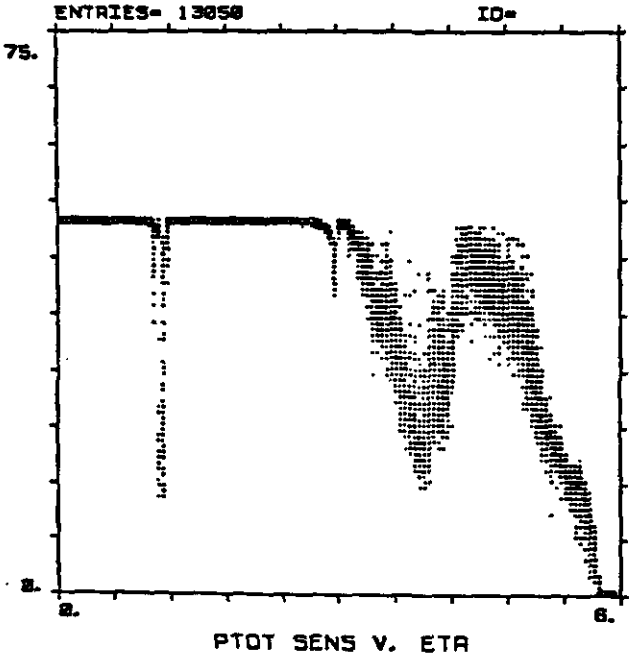
+(ALL THESE SMEARED)



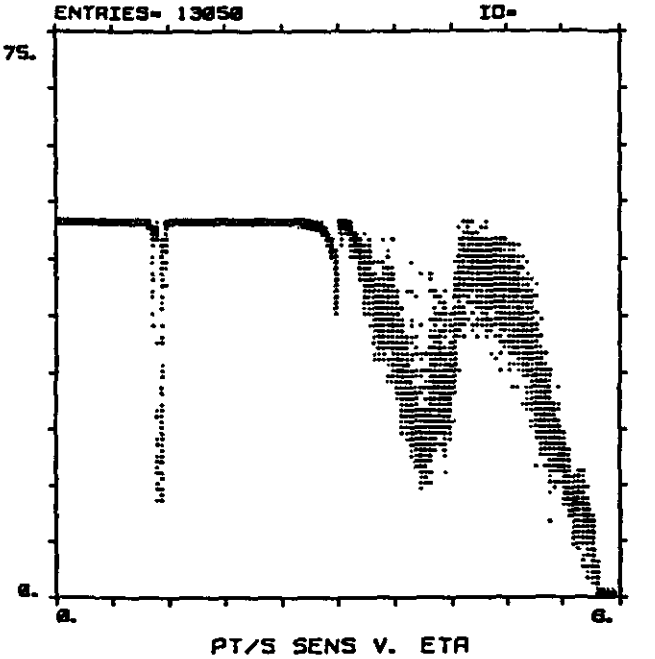
PTOT ALL V. ETA



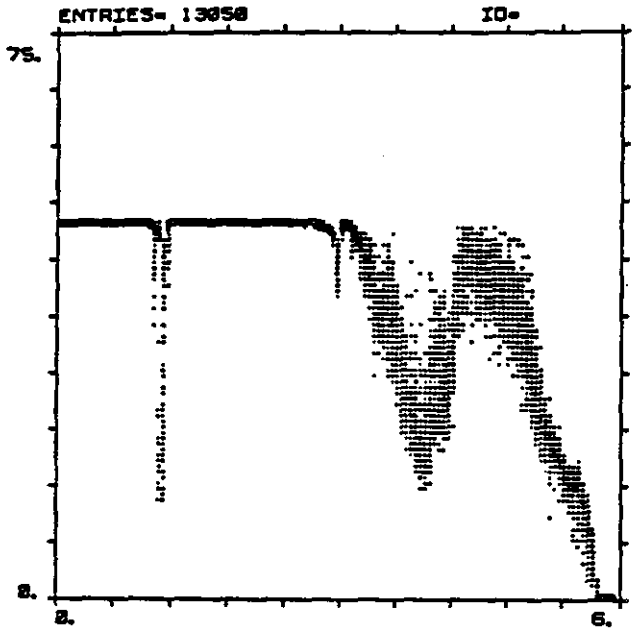
PT/S ALL V. ETA



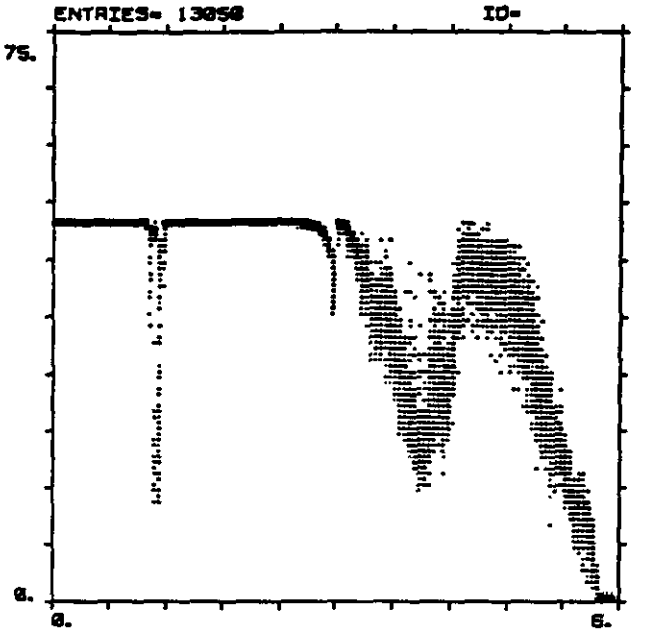
PTOT SENS V. ETA



PT/S SENS V. ETA



PTOT COMP V. ETA



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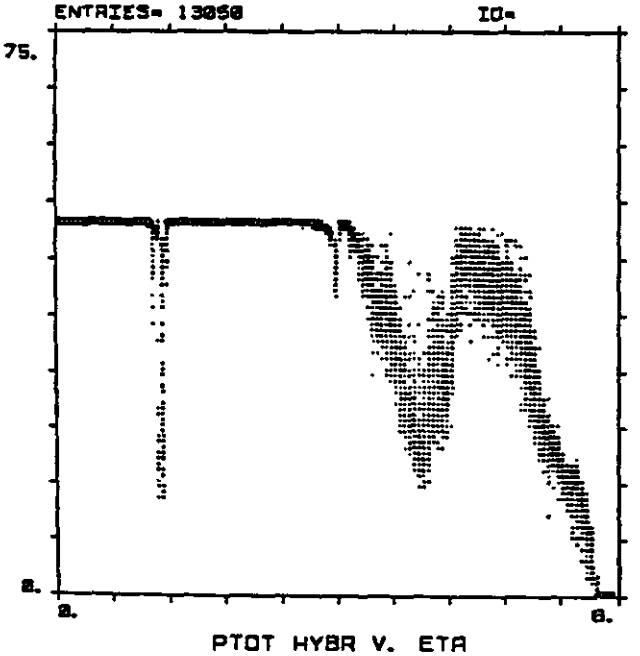
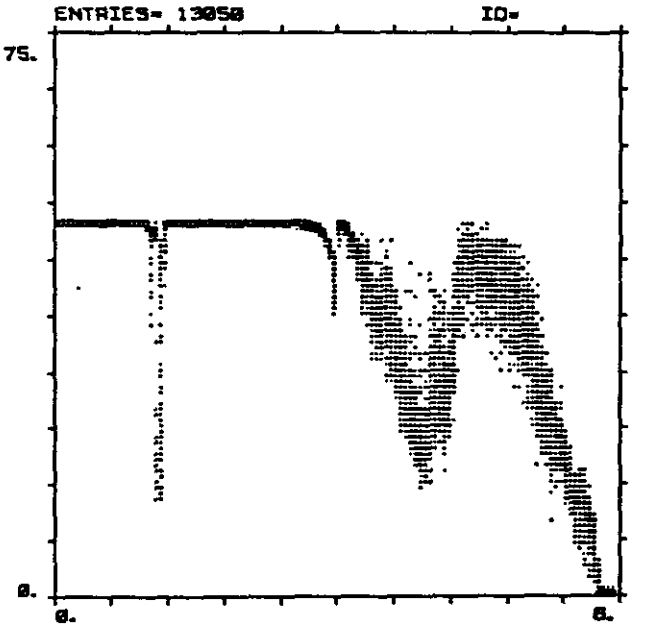
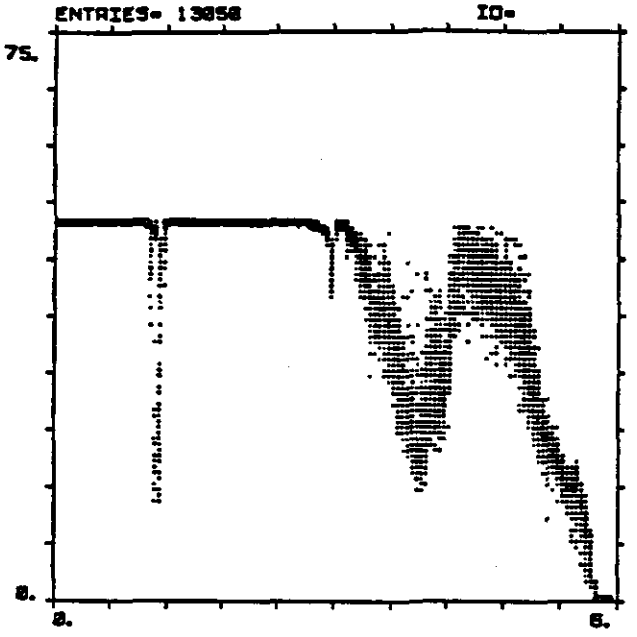


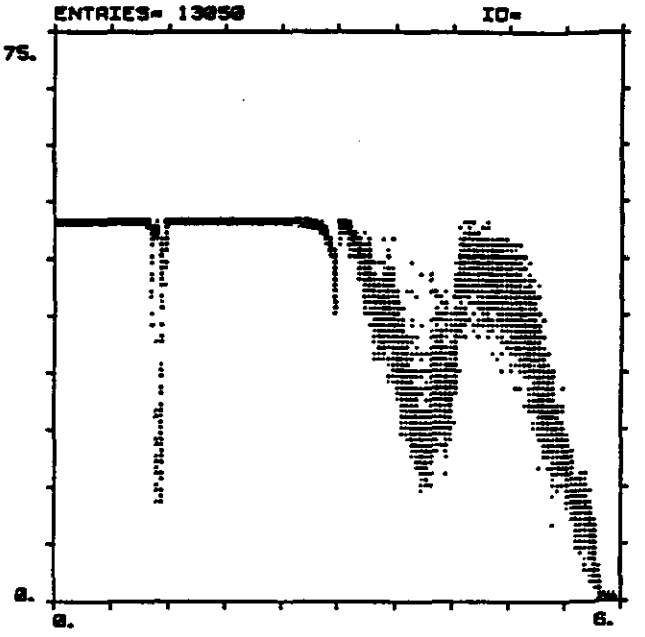
PTOT HYBR V. ETA



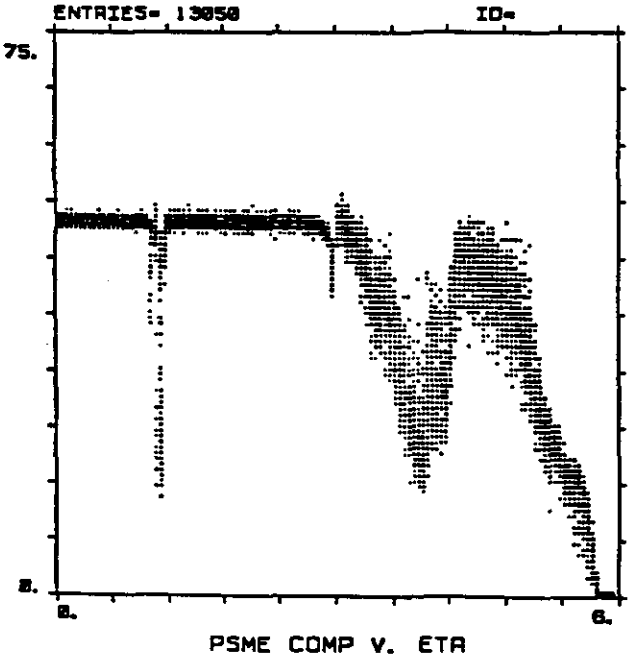
PT/S HYBR V. ETA



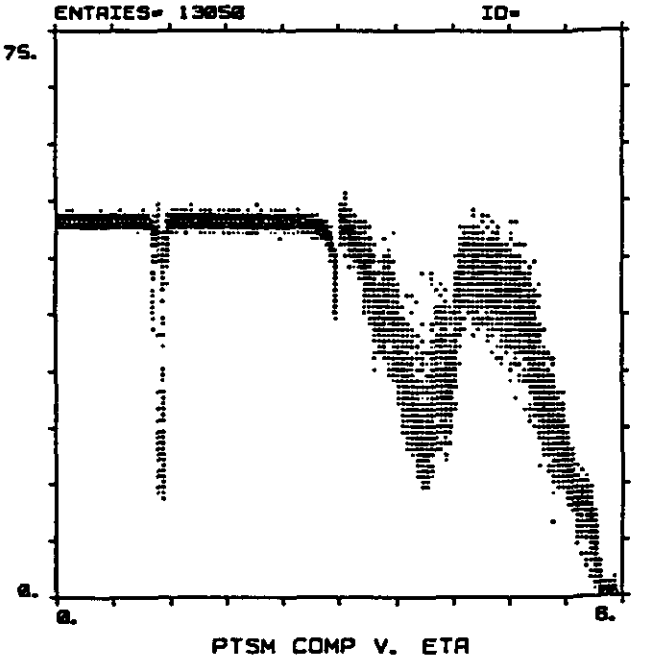
PTOT COHR V. ETR



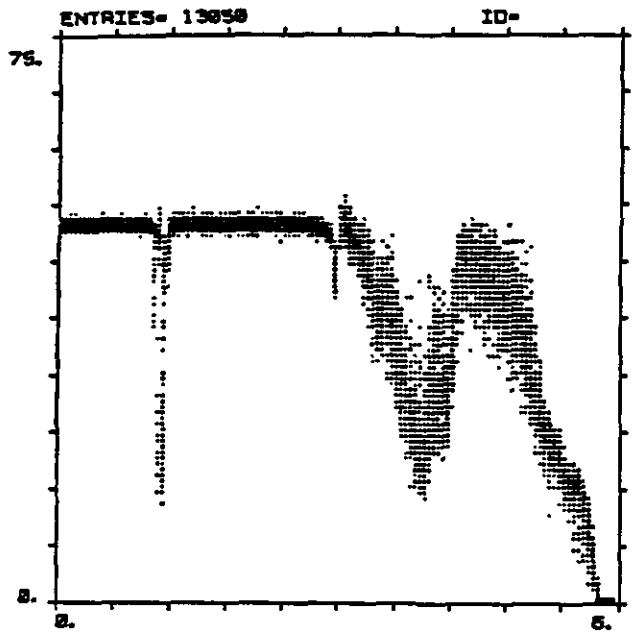
PT/S COHR V. ETR



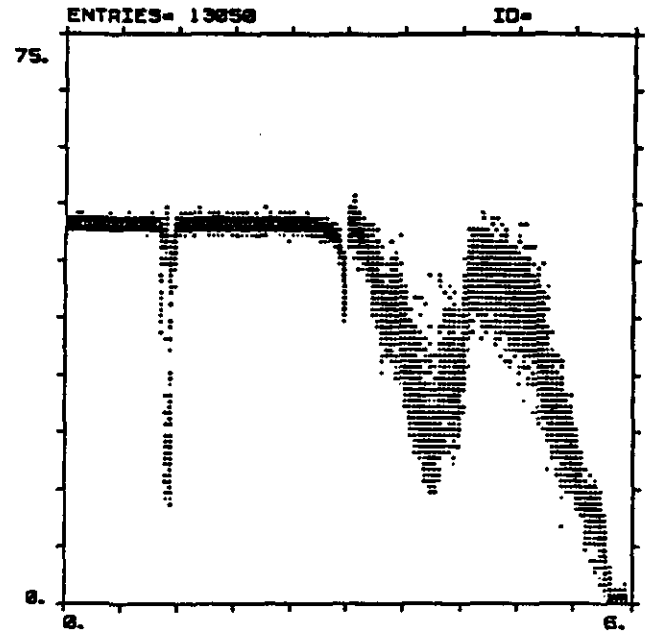
PSME COMP V. ETR



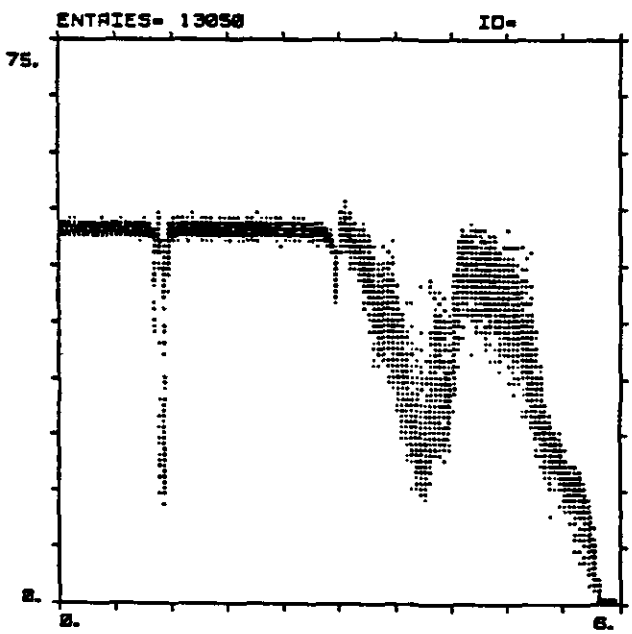
PTSM COMP V. ETR



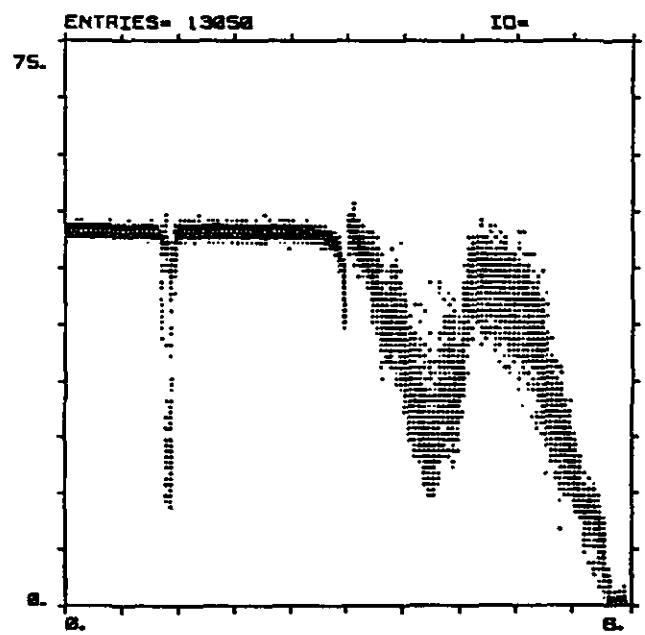
PSME HYBR V. ETA



PTSM HYBR V. ETA



PSME COHR V. ETA

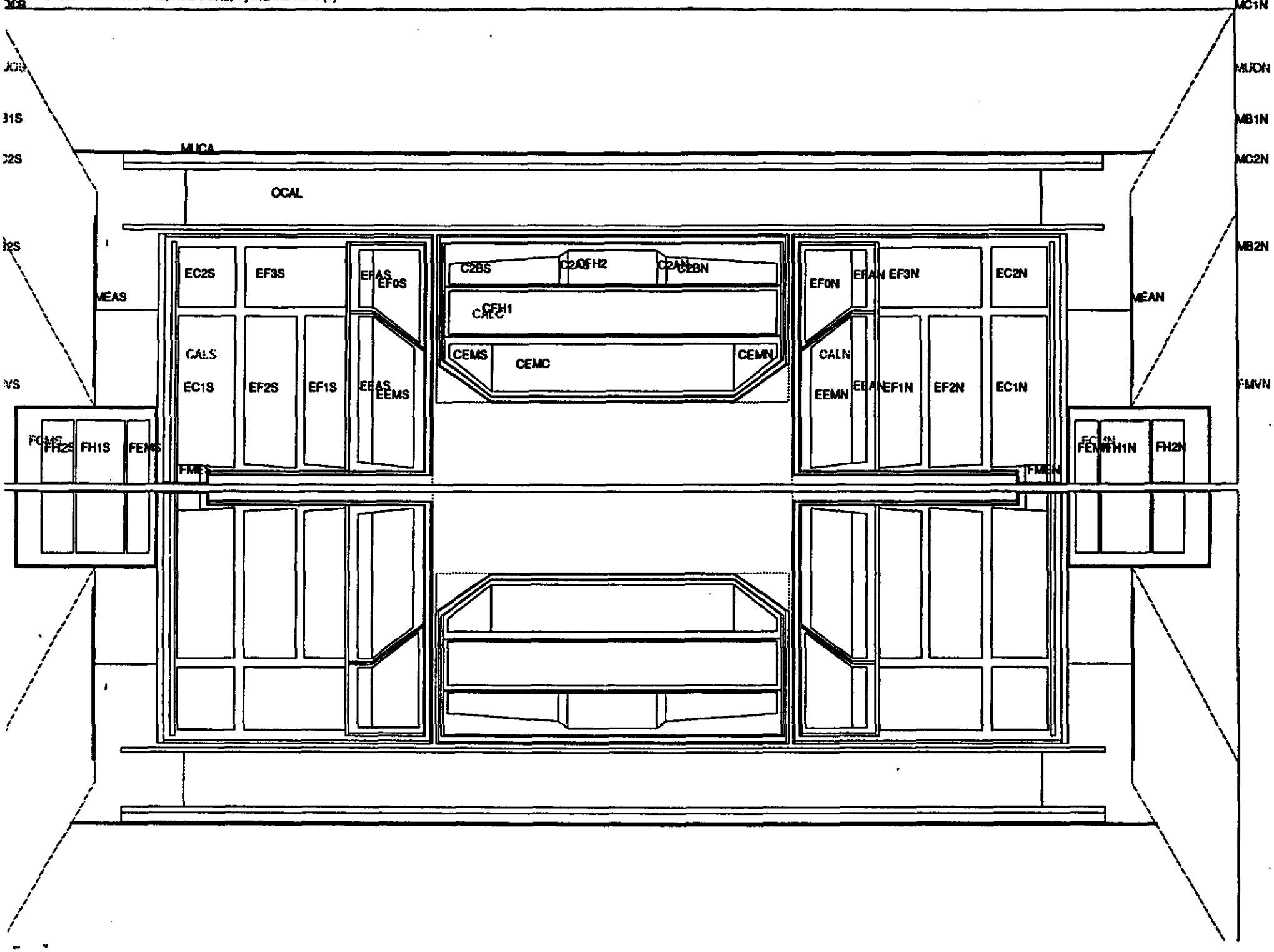


PTSM COHR V. ETA

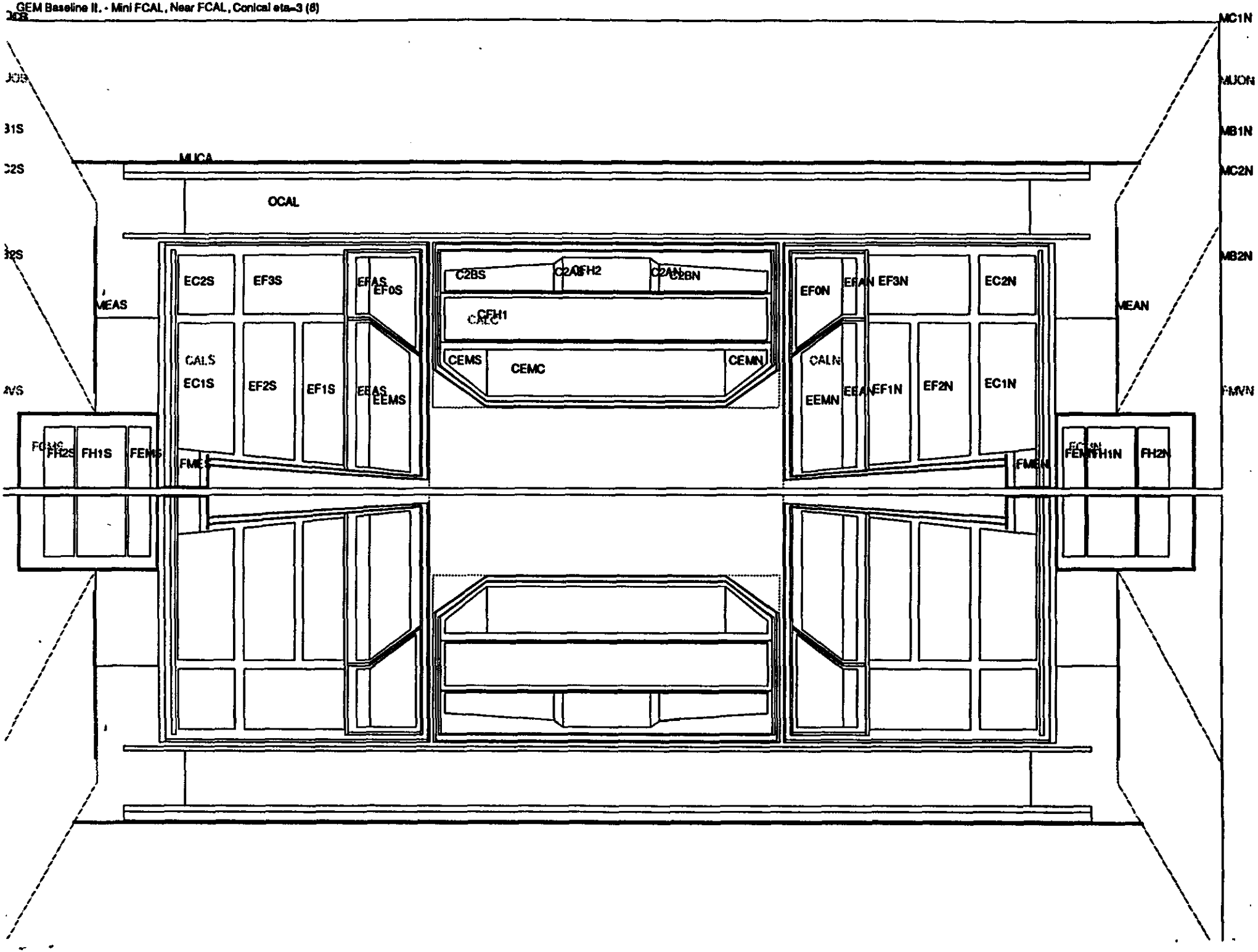
FORWARD CALORIMETER OPTIONS BEING

RUN FOR SIMULATION

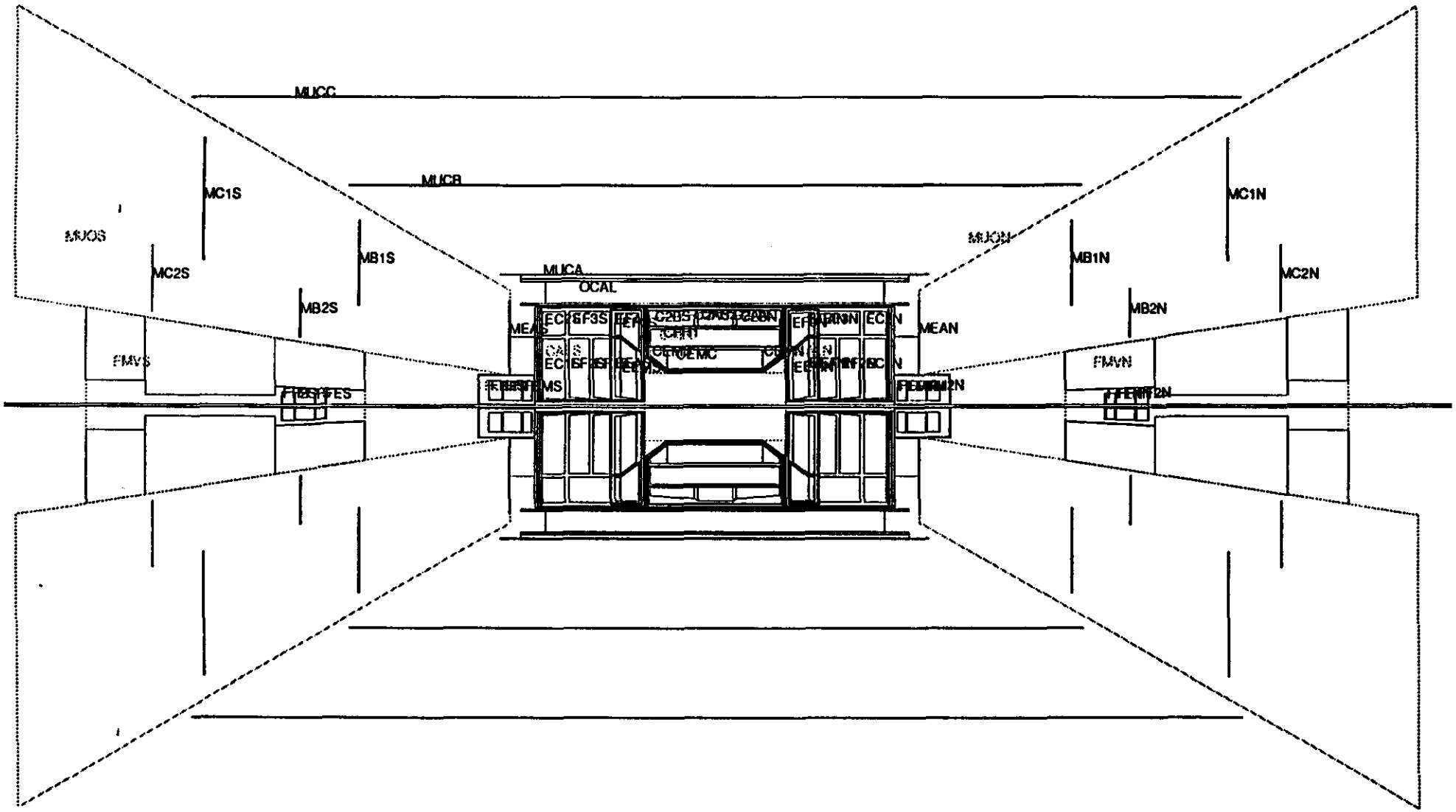
GEM Baseline II. - Mini FCAL, Near FCAL, Cylindrical eta=3 (7)



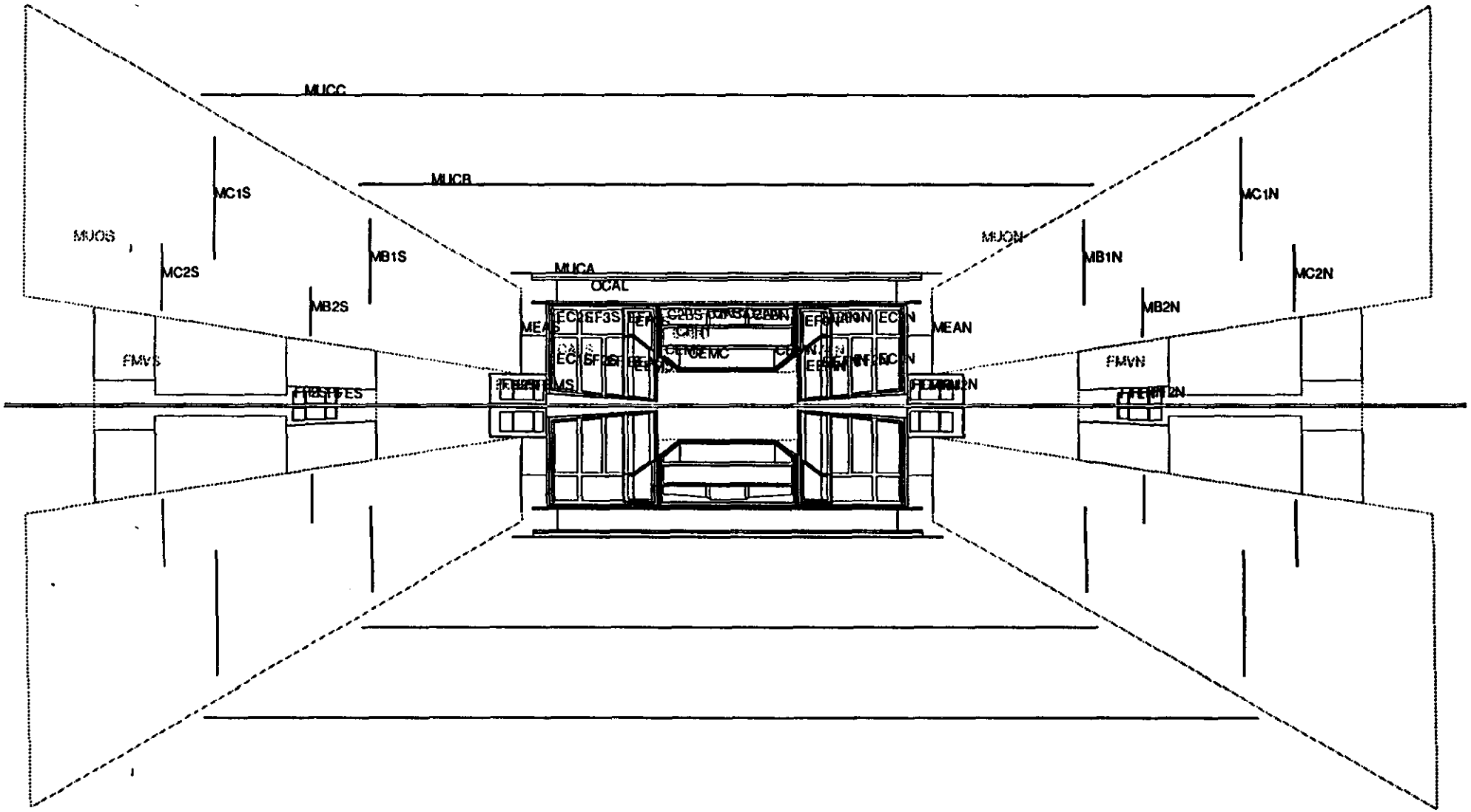
GEM Baseline II. - Mini FCAL, Near FCAL, Conical eta=3 (8)



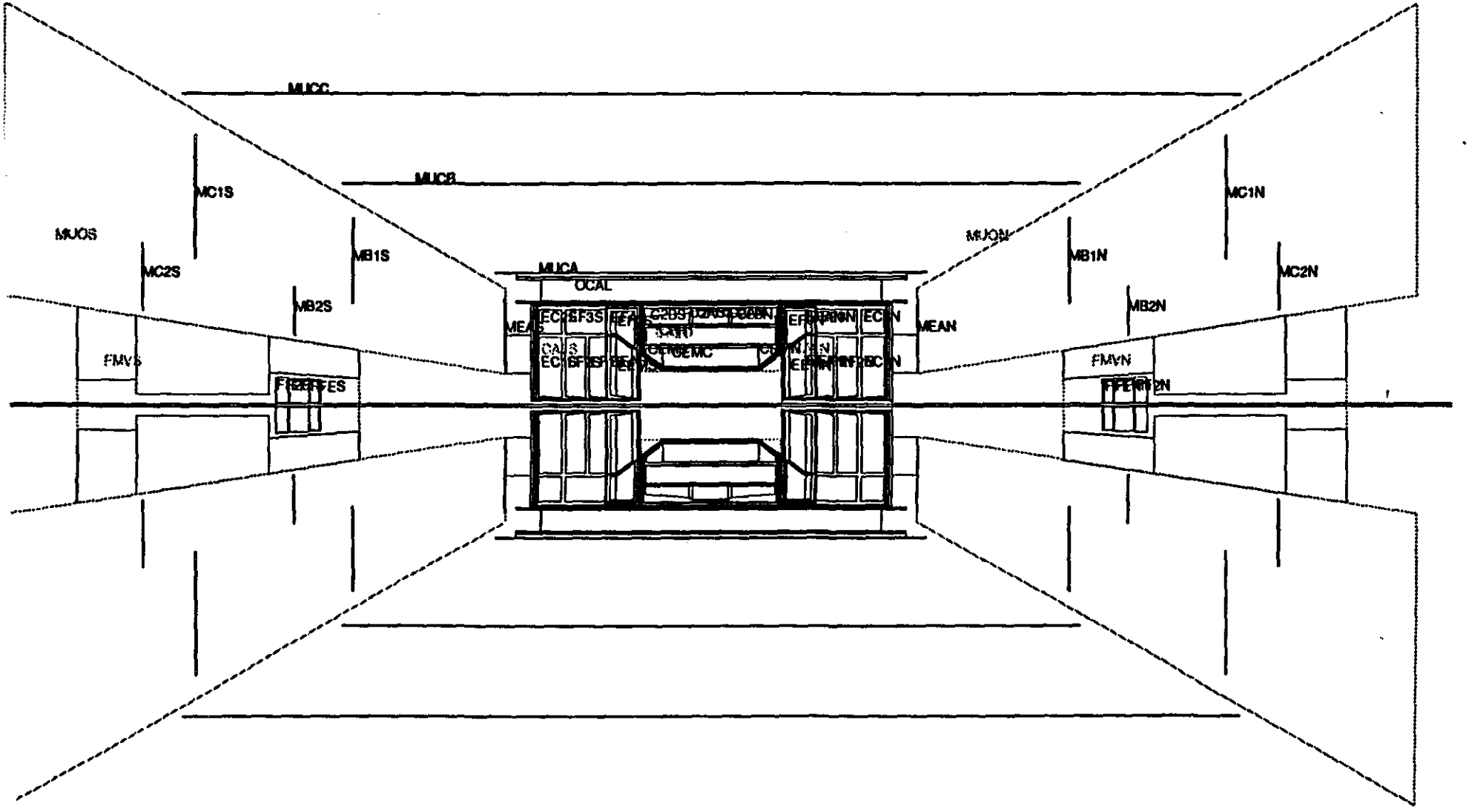
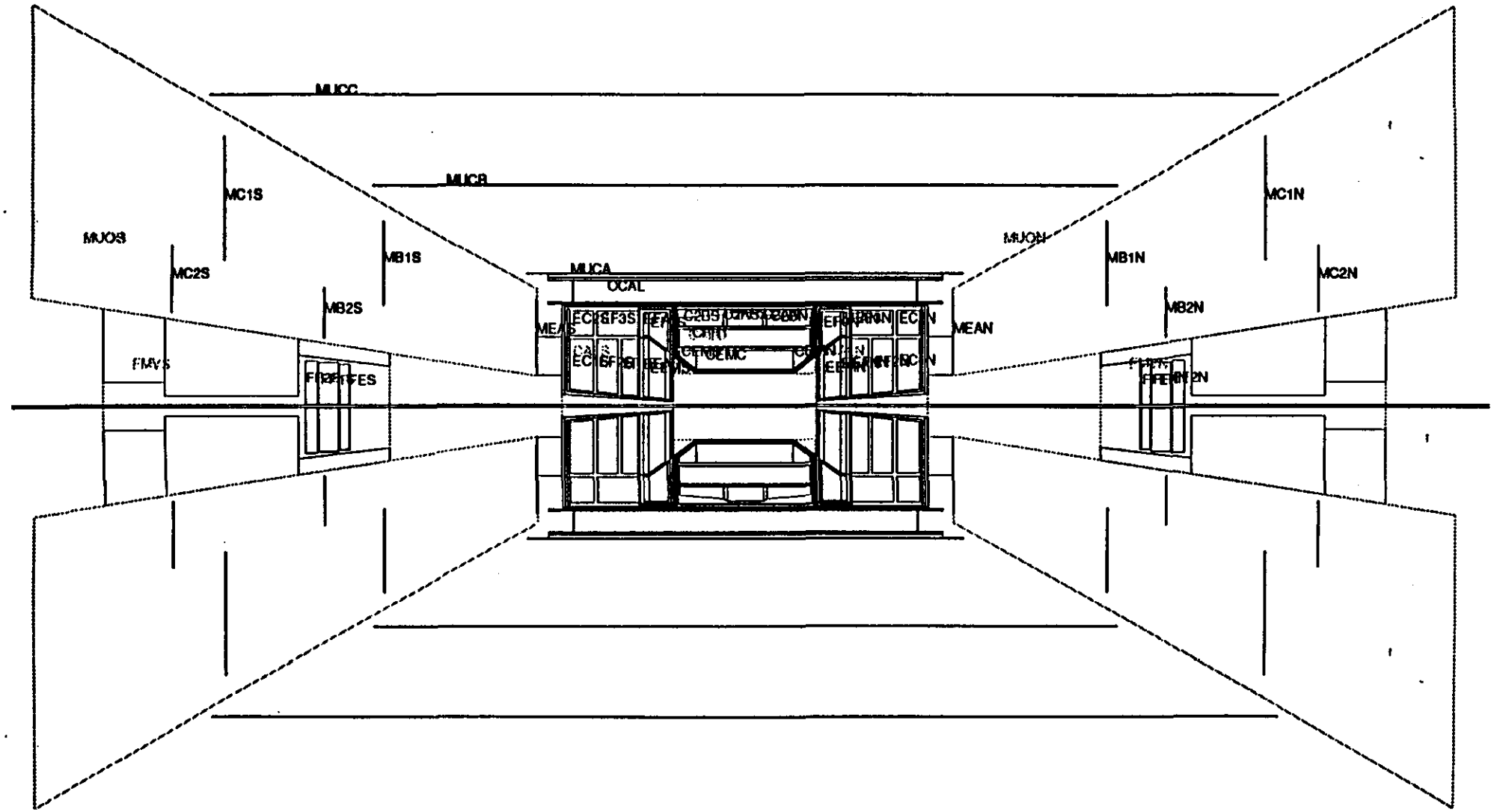
GEM Baseline II. - NEAR FCAL to eta=4.4, FAR FCAL, Cylinder eta=3 (11)



GEM Baseline II. - NEAR FCAL to eta=4.4, FAR FCAL, Conical eta=3 (12)



GEM Baseline II. - Far FCAL Covering to eta=3.6, Cylindrical Endcap (10)



GEM Baseline II. - Far FCAL Covering to eta=3, Conical eta=3