ALEPH 89-168
PHYSIC 89-65
J. Wear
10.11.1989

Minutes of QQbar physics group meeting of 9 November 1989

1) Andy Halley presented work (done with I.TenHave) on measuring charge asymmetries of jets in hadronic Z decays. They looked at the measurement's fragmentation dependence using three different models. All three models were tuned and all were optimized at the tuning weight of 0.4. There was seen a maximum systematic difference of 3% between the string and cluster models.

In a sample of opposite sign two-jet events, the probability of one of the jet charges being correct was 82%. They see the TPC track selection method to be quite stable against a large range of variations in the cuts and find 60% of events in this year's data to have oppositely charged jets.

There was some question over whether and how b-bbar mixing may affect the actual asymmetry calculation. Two methods for estimating the dilution of the sample were discussed. One estimation technique using the data was found to have an error 10 times smaller than one using Monte Carlo data.

At present it seems necessary to require 300,000 hadronic Z decays in order to make statements about Forward-backward charge asymmetries and sin**2(theta). By end of this year's run, one may anticipate 50% errors on the charge asymmetry.

2) Status of Hadronic Z selection and Luminosity determination.

The selection algorithm is still fine. Runs without the HCAL readout will be included with a slightly lower id efficiency folded in. The luminosity systematic error is being re-estimated due to changes in the LCAL trigger thresholds and accomodating changes in the offline energy cuts. It was decided not to reanalyze the September run's data in a new cross section calculation directly, but merely to use the results from that run with the new results.

Ed Blucher presented some statistics on the trigger efficiency. It remains good after removal of 1-2 bad runs. Some algorithm for isolating split events in the TPC is being introduced although this problem is also minimal.

3) Preliminary width measurement using the October run data.

Reisaburo Tanaka presented his results using a TPC track selection and visible energy cut to select his sample. Some problems with the recent data were mentioned but seemed to be isolated to certain runs of questionable quality. Results from his fits may be seen in the attached transparencies.

4) Definitive word on LEP fill energies.

John Harton circulated an extensively cross-checked table of LEP fill energies vs. ALEPH Run number. These numbers were based on LEP fill logbook numbers and should be available in the database soon to be released.

5) Z prime effects.

Hongbo Hu presented some transparencies on how a heavier Z particle may be seen/excluded from charge asymmetries and the Z0 width measurement.

6) Alain Blondel presented some calculations on what can be said about other Standard Model parameters with the present error on the Z mass. Refer to the transparencies for detailed numbers.

J.Wear

MEASURING THE QUARK ASYMMETRY

INGRID TEN HAVE
ANDY HALLEY

(a) CURRENT ETIMATION OF THE FRAGMENTATION DEPENDENCE.

(b) EFFECTS OF THE SELECTION OF TRACKS ON THE CHARGE DETERMINATION.

(c) ASYMMETRY CALCULATION AND SOURCES OF ERROR.

(d) MEASUREMENT PROSPECTS.

CHARGE FINDING ALGORITHM

ALGORITM HAS TO BE ROBUST AND SENSITIVE TO AVOID GIVING BAD AND LOW MOMENTUM TRACKS LARGE WEIGHTS.

$$q_{JET} = \frac{\sum_{i=1}^{N_{PART}} q_i \, \eta^{K} \, p_L^{\tau}}{\sum_{i=1}^{N_{PART}} \eta^{K} \, p_L^{\tau}}$$

η – PARTICLES PSEUDO-RAPIDITY RELATIVE TO THE JET.

p_L – PARTICLES LONGITUDINAL MOMENTUM COMPONENT ALONG THE JET.

THE p_L WEIGHT IS INTRODUCED TO DISCRIMINATE AGAINST LOW MOMENTUM TRACKS WHICH MAY BE GIVEN LARGE η WEIGHTS AND YET HAVE A LOW PROBABILITY OF CONTAINING THE PARENT QUARK CHARGE.

NOW WE HAVE TO FIX VALUES FOR K AND τ.

(a) FRAGMENTATION DEPENDENCE.

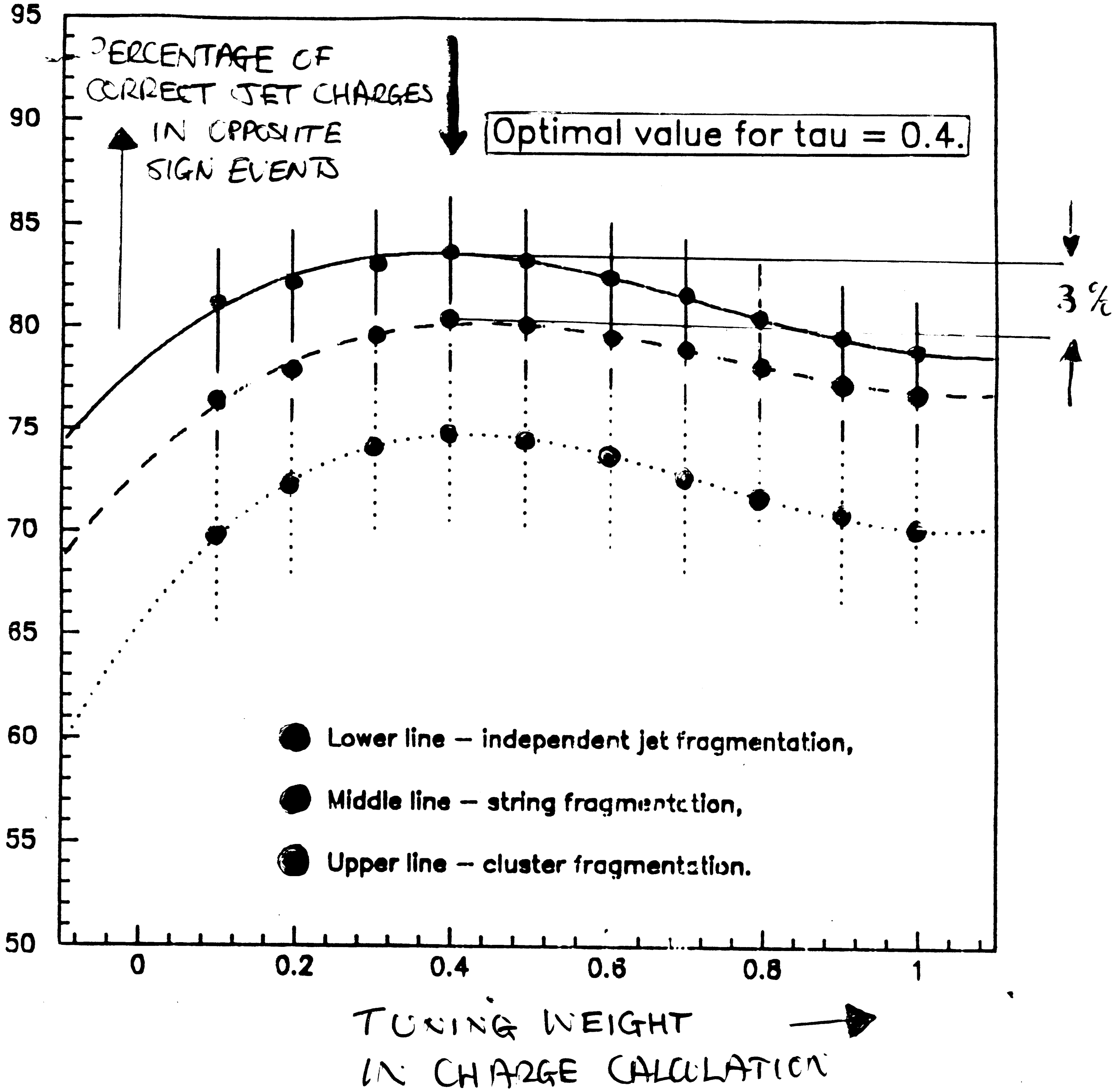
ONE OF THE MAJOR ERRORS ON THE ASYMMETRY IS DUE TO THE UNCERTAINTY INVOLVED IN THE QUARK PAIR FRAGMENTATION. THIS HAS BEEN ESTIMATED BY COMPARING EVENTS GENERATED USING STRING FRAGMENTATION, INDEPENDENT JET AND THE CLUSTER FRAGMENTATION MODELS.

COMPARISONS WERE MADE USING THE TUNING PROCEDURE FOR MAXIMISING THE NUMBER OF OPPOSITELY SIGNED JETS, FOR EACH TYPE OF FRAGMENTATION.

THE THREE MODELS AGREE CLOSELY ON THE FORM OF THE VARIATION, BUT GIVE A DIFFERENT VALUE FOR THE ABSOLUTE EFFICIENCY.

FROM THESE CURVES WE ESTIMATE A 'WORST CASE' VALUE OF 0.82 (±0.04) FOR THE CHARGE FINDING EFFICIENCY.

THIS COMBINES THE STATISTICAL ERROR ON THE CURVES WITH THE SYSTEMATIC DIFFERENCE.



PERCENTAGE OF CORRECT JET CHARGES IN OPPOSITE SIGN EVENTS
Optimal value for tau = 0.4.
3 %
95
90
85
80
75
70
65
60
55
50
0
0.2
0.4
0.6
0.8
1
Lower line — independent jet fragmentation,
Middle line — string fragmentation,
Upper line — cluster fragmentation.
TUNING WEIGHT IN CHARGE CALCULATION

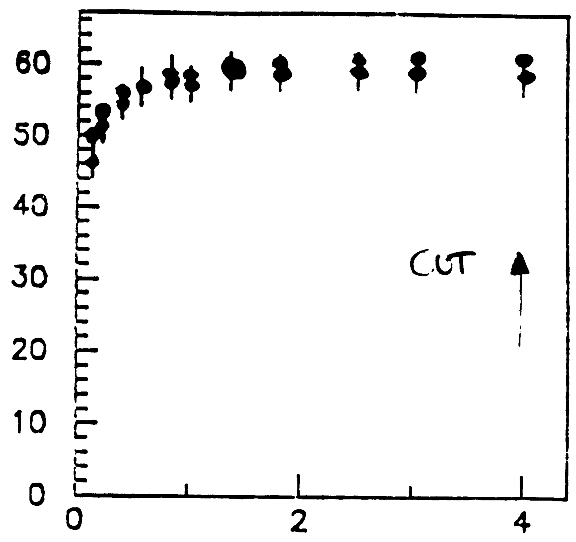
(b) EFFICIENCY VARIATION DUE TO TRACK SELECTION.

THE JET CHARGE CALCULATION IS ROBUST. IT RELIES ON HIGH MOMENTUM TRACKS IN JETS CUT AWAY FROM LOW ANGLES.

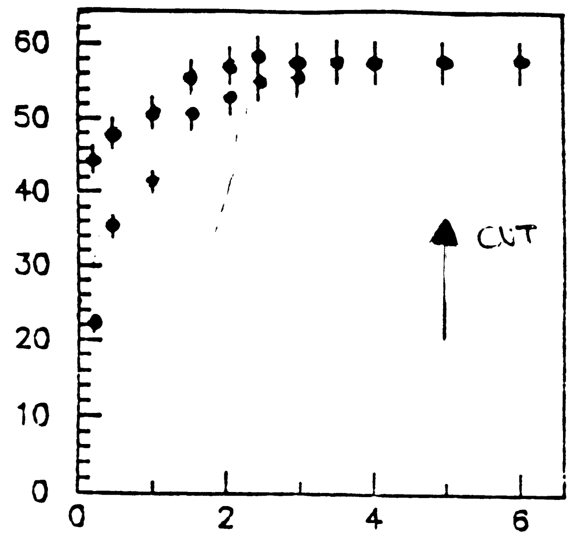
HENCE THE CHARGE EFFICIENCY SHOULD BE INSENSITIVE TO HOW WE SELECT 'GOOD' TRACKS.

IS THIS TRUE ?

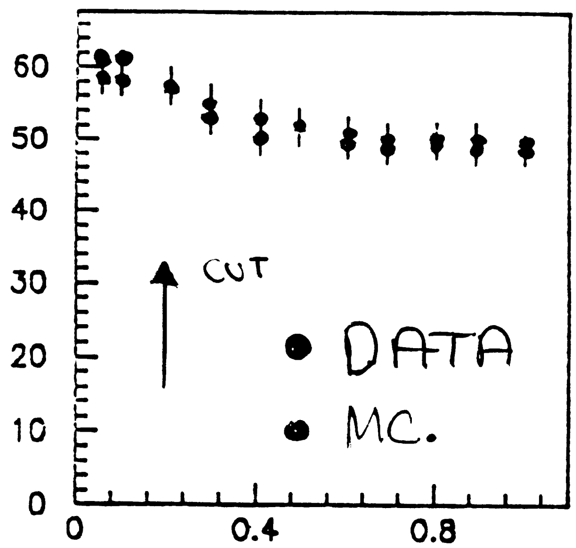
TRACK SELECTION CUTS:		
CUT	RANGE VARIED	CHOSEN VALUE
TRACK ANGLE WITH THE BEAM	5° → 20°	18°
NUMBER OF TPC COORDINATES	0 → 10	5
TRACK χ^2/D.O.F.	0 → 10	5
MINIMUM TRACK MOMENTUM	0 → 1 GeV	200 MeV
MAXIMUM TRACK MOMENTUM	20 → 100 GeV	70 GeV
TRACK D0	0 → 4.0 cm	2cm
TRACK Z0	0 → 6.0cm	5cm



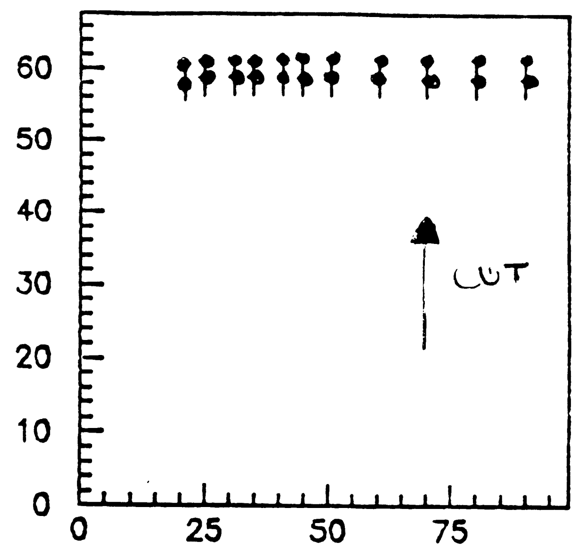
Opposite Signed Jets Against Track D0 Cut



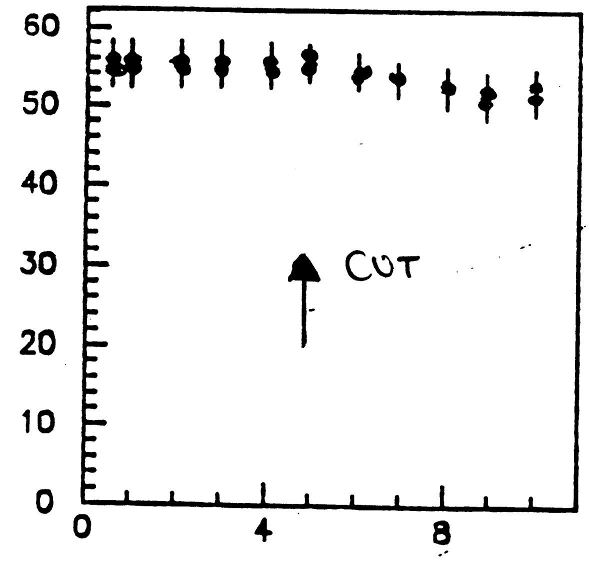
Opposite Signed Jets Against Track Z0 Cut



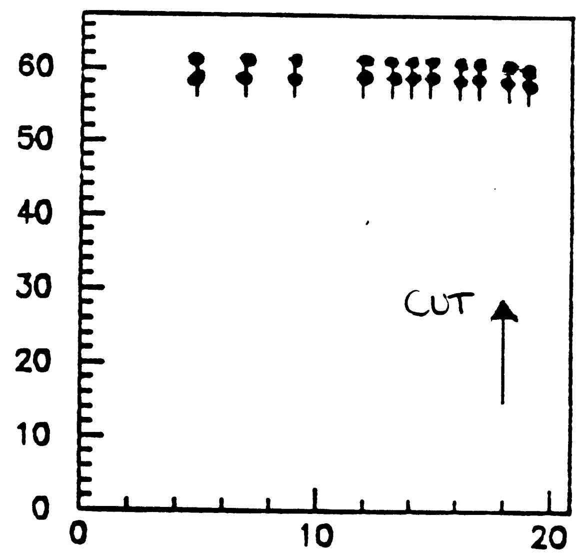
Opposite Signed Jets Against Min. P Cut



Opposite Signed Jets Against Max. P Cut



Opposite Signed Jets Against Number of Hits



Opposite Signed Jets Against Dip Angle Cut

(C) THE ASYMMETRY CALCULATION.

THE ASYMMETRY IS BASICALLY:

$$(A_{FB})_{measured} = f_d A_d - f_u A_u + f_s A_s - f_c A_c + (1-2\chi) f_b A_b$$

WHERE f DENOTES THE QUARK BRANCHING FRACTION, A IS THE ASYMMETRY AND χ IS THE $B_0 \bar{B}_0$ MIXING PARAMETER. (χ IS THE FRACTION OF 'MIXED' JETS).

IF WE ASSUME $\sin^2\theta_W = 0.230\ (\pm 0.008)$ AND $\chi = 0.125\ (\pm 0.08)$ THEN THIS GIVES:

$$(A_{FB})_{theory} = 2\{0.22\ (\pm 0.01) \times 11.2\ (\pm 0.1)\}_{u,c}$$

$$- 2\{0.17\ (\pm 0.01) \times 8.0\ (\pm 0.3)\}_{d,s}$$

$$+ \{[1 - 0.250\ (\pm 0.1)]\ (0.22\ (\pm 0.01) \times 11.2\ (\pm 0.1))\}$$

$$= \boxed{4.1\ (\pm 0.4)\ \%}$$

THIS SHOWS THAT THE b QUARK ASYMMETRY ALONE IS RESPONSIBLE FOR ~ 45% OF THE COMBINED VALUE.

SYSTEMATIC ERROR

TO MEASURE THE ASYMMETRY FROM DATA, WE CAN USE TWO METHODS:

(I) USE THE MONTE CARLO TO CALCULATE THE DILUTION FACTOR (THE PERCENTAGE OF MISIDENTIFIED CHARGES).

(II) USE THE MEASURED PERCENTAGE OF OPPOSITELY CHARGED EVENTS TO DEDUCE THE DILUTION FACTOR (DUE TO F. PERRIER).

IN METHOD (I) WE HAVE CALCULATED THE ATTENUATION FACTOR TO BE: **0·69 (±0·03)**

THE ERROR IS DOMINANT IN THE FINAL ASYMMETRY BUT <u>MAY</u> BE REDUCED BY GREATER MONTE CARLO STATISTICS. IE. THIS SERVES AS AN ESTIMATION OF THE DILUTION AT THIS LEVEL.

THIS YIELDS A MEASURABLE ASYMMETRY OF:

$$(A_{FB})_{measured} = \{1 - (2 \times 0{\cdot}82(\pm 0{\cdot}04))\} \times \left[(A_{FB})_{theory} + \text{background}\right]$$

(bus; WHICH BECOMES NEGLIGIBLE)

$$= \underline{2{\cdot}6\ (\pm 0{\cdot}3)\ \%}$$

METHOD (II) RELIES ON THE MEASURED NUMBER OF EVENTS WHICH ARE FOUND TO HAVE OPPOSITELY SIGNED JETS.

WE THEN CAN CALCULATE THE PROBABILITY OF ANY GIVEN JET HAVING THE CORRECT CHARGE:

$$\text{ATTENUATION FACTOR} = \frac{1 + \sqrt{1 - 2\left(1 - \text{FRACTION OF OPPOSITE SIGNED EVENTS}\right)}}{2}$$

THIS AVOIDS ANY SYSTEMATIC ERROR DUE TO THE FRAGMENTATION AT THIS LEVEL. THUS FOR EXAMPLE:

FRACTION OF OPPOSITE SIGNED EVENTS = 59.3% (±0.01)

ATTENUATION FACTOR IS THEN:

0.695 (±0.004) ← from statistics.

WHICH COMPARES WELL WITH METHOD (I).

IN THIS METHOD, THE FRAGMENTATION DEPENDENCE ENTERS ONLY AS CORRECTIONS TO THE DILUTION FACTOR DUE TO THE EFFICIENCIES OF DIFFERENT FLAVOURS.

THESE CORRECTIONS ARE AT THE LEVEL OF 1%, HENCE THE FRAGMENTATION DEPENDENCE IS MUCH REDUCED.

STATISTICAL ERROR

THE STATISTICAL ERROR ON THE ASYMMETRY IS SIMPLY:

$$(\Delta A_{FB})_{statistical} \approx \frac{2}{\sqrt{\text{NUMBER OF SELECTED EVENTS}}}$$

ONE OF THE MAIN LOSSES OF EVENTS DURING THE SELECTION PROCESS, WAS CHOOSING 'HIGH QUALITY' TWO-JET EVENTS. IE. LOW SPHERICITY EVENTS.

THIS ENSURED THAT EVENTS WERE LARGELY $q\bar{q}$ PAIRS AS OPPOSED TO $q\bar{q}g$, OR HIGHER ORDER CONFIGURATIONS.

HOWEVER, THIS CAN LEAD TO LOSSES OF ~ 60% OF HADRONIC EVENTS. THE INCLUSION OF LOW ENERGY GLUON JETS IS MOST EASILY DONE BY RELAXING THE JETFINDER CLUSTER CUT-OFF.

THIS IS SHOWN TO INCREASE THE NUMBER OF SELECTED EVENTS WITHOUT SIGNIFICANT LOSSES FROM THE CHARGE FINDING EFFICIENCY.

	u, d and s quarks 6400 events			*b quarks* 14,000 events		
Cut Off	*Charge Effic.(%)*	*Stat. Error (%)*	*Fraction of 2 Jet (%)*	*Charge Effic. (%)*	*Stat. Error (%)*	*Fraction of 2 Jet (%)*
0.01	81.0	7.8	20.4	70.8	4.6	24.8
0.02	79.8	5.7	38.4	70.0	3.5	42.2
0.03	76.7	5.0	50.6	70.1	3.1	53.4
0.04	79.1	4.6	58.7	69.9	2.9	61.2
0.05	78.5	4.4	64.9	69.7	2.8	67.2
0.06	78.1	4.3	70.3	69.7	2.7	72.4

(d) MEASUREMENT PROSPECTS.

THE STATISTICS REQUIRED TO IMPROVE THE MEASUREMENT OF $\sin^2\theta_W$ OR THE χ MIXING PARAMETER ARE OF THE ORDER ~ 300,000 EVENTS. IE. BIG.

METHOD (II) FOR EXTRACTING THE CHARGE FINDING EFFICIENCY FROM DATA REDUCES FRAGMENTATION EFFECTS TO A MUCH LOWER LEVEL. AND GIVES A SMALLER ERROR ON THE DILUTION FACTOR.

WITH 20,000 SELECTED EVENTS (IE. 30,000 HADRONIC EVENTS) WE EXPECT A MEASUREMENT OF

$$(A_{FB})_{measured} = 2.8\,(\pm 1.4)\,\%$$

IE: 0.6% FROM DILUTION
48% FROM STATISTICS.

HENCE IT IS A USEFUL CHECK BUT NEEDS FAIRLY HIGH STATISTICS.

E. Blucher

Trigger Efficiency for Hadronic Events

ANSWER : ~ 100 %

Compare ECAL energy triggers with single μ triggers.

$$N_B = N \epsilon_E \epsilon_\mu$$

$$N_E = N \epsilon_E (1 - \epsilon_\mu)$$

$$N_\mu = N \epsilon_\mu (1 - \epsilon_E)$$

From new data:

$$\left.\begin{aligned} N_B &= 6986 \\ N_E &= 746 \\ N_\mu &= 3 \end{aligned}\right\} \quad \begin{aligned} \epsilon_E &= 0.9996 \pm 0.0002 \\ \epsilon_\mu &= 0.904 \pm 0.003 \end{aligned}$$

$$\epsilon_T = 0.99996 \pm .00002$$

Trigger Efficiency is checked for each run; run 5117 excluded because there were no ECAL triggers.

Still questions about some other runs: 5003, etc.

Measurement of the Z^0 width.

le 9, Novemble, 1989

Reisaburo TANAKA.

← Post-Doc. from Japan.

Now at École Polytechnique

Purpose : Quick Analysis on Γ_Z from Scan III.

Event Selection Criteria

I) # of good TPC tracks ≥ 5

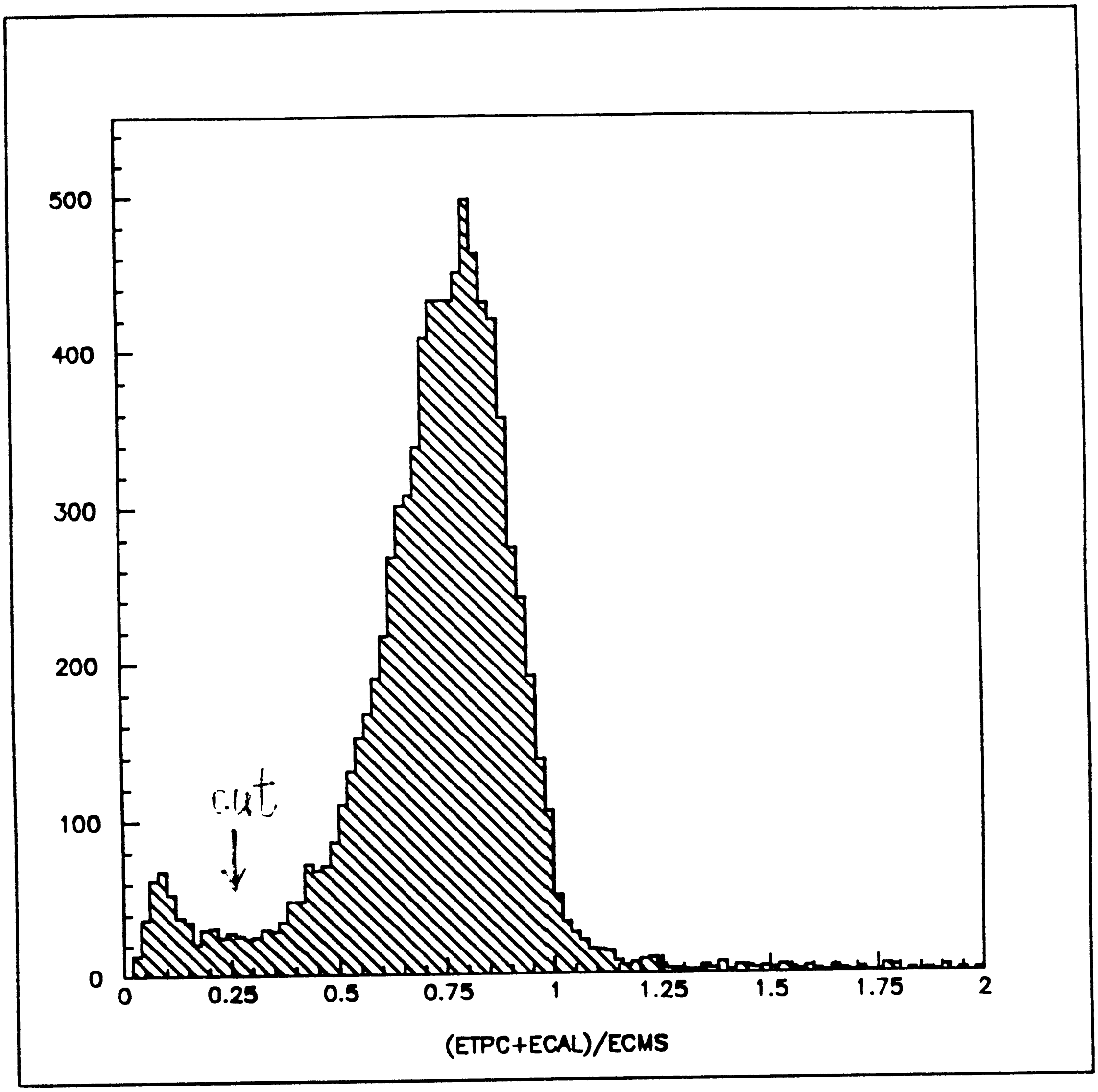
($N_{hit}^{TPC} \geq 4$, $|D_0| < 2.5$ cm, $|Z_0| < 10$ cm
$|\cos\theta_{tk}| < 0.95$, $P_t > 0.2$ GeV/c)

II) $E_{vis} > \frac{1}{4}\sqrt{s}$

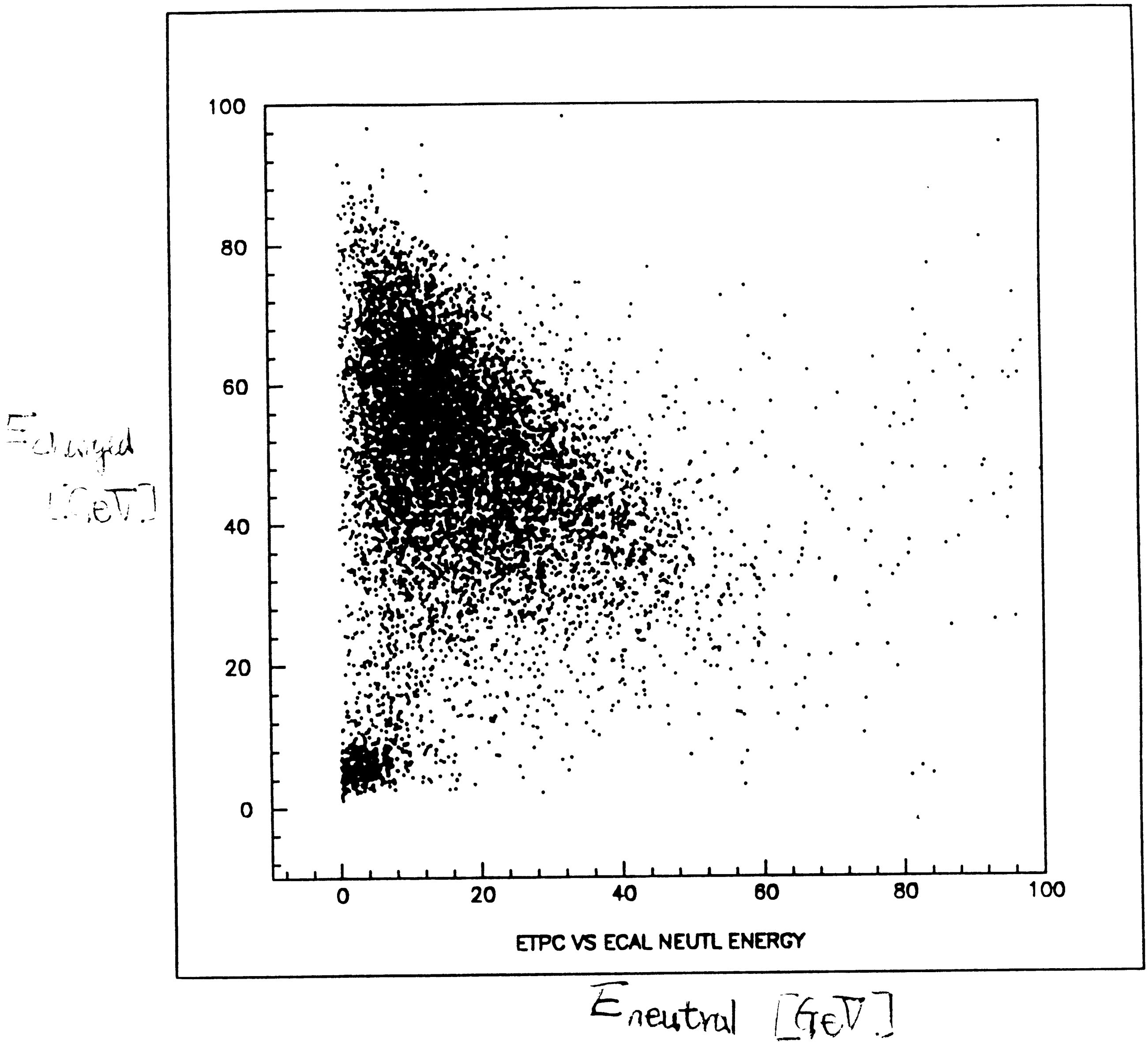
$$E_{vis} = \sum_{charged}^{TPC} \sqrt{P^2 + m_\pi^2} + \sum_{neutral}^{ECAL} E_{cl}$$

($E_{cl} > 0.5$ GeV, $|\cos\theta_{cl}| < 0.95$)

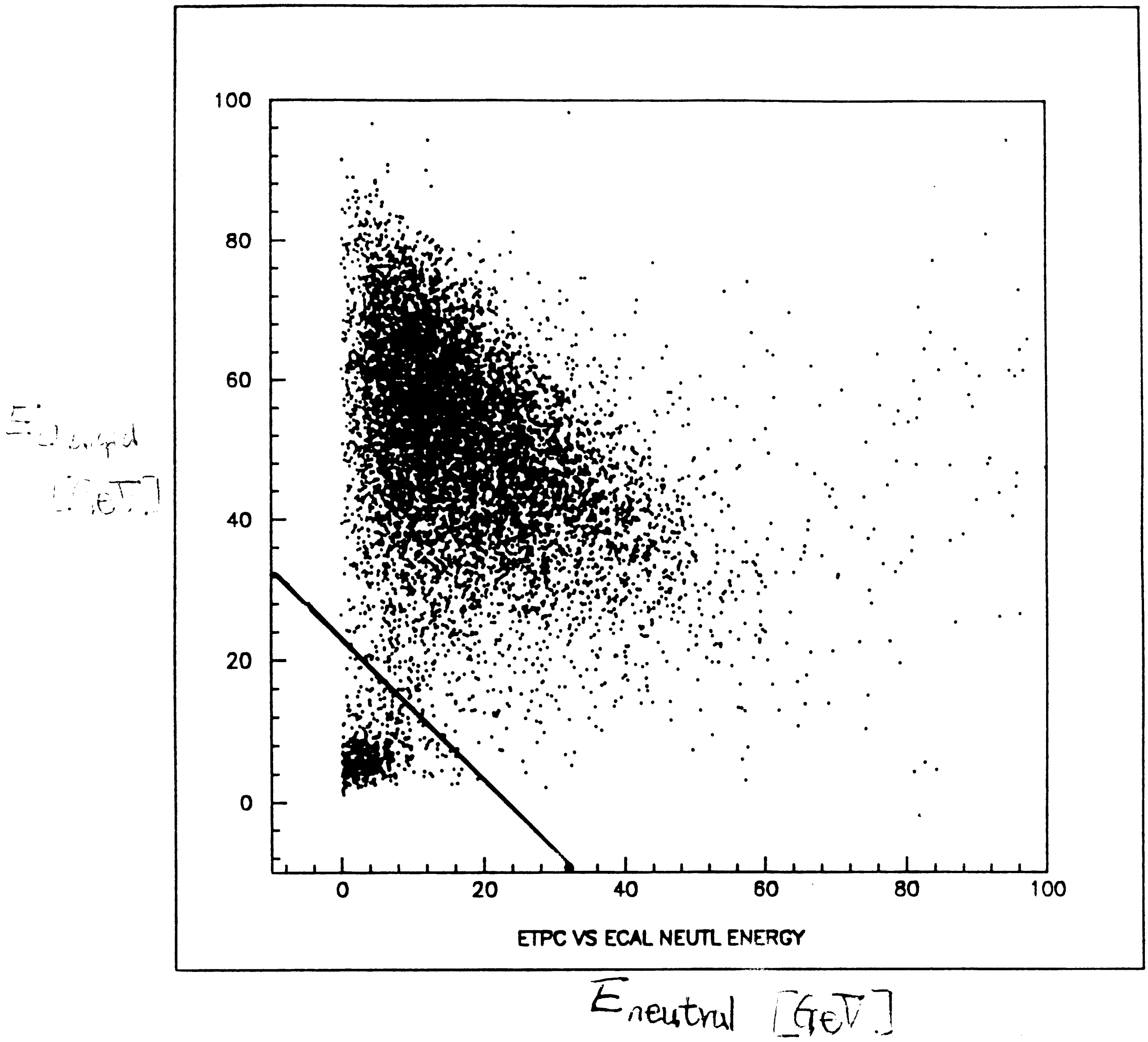
$\varepsilon \sim 0.966$


500
400
300
200
100
0
0
0.25
0.5
0.75
1
1.25
1.5
1.75
2
cut
(ETPC+ECAL)/ECMS

E_{vis}/E_{cms}



100
80
60
40
20
0
0
20
40
60
80
100
ETPC VS ECAL NEUTL ENERGY
E_charged [GeV]
E_neutral [GeV]



$$E_{vis} > \frac{1}{4}\sqrt{s} \sim 23\ \text{GeV}$$

Some Problems.

1. Missing Bank.

ⓐ ECAL.

Run#	Evt#	Missing.
5074	755	'EWDI/PEWI', 'PECO'
5155	8570	'EWDI/PEWI', 'EWHE'
〃	8572	'EWDI/PEWI', 'EWHE'

3 events all $Q\bar{Q}$ ($\because E_{TPC} > \frac{1}{4}\sqrt{s}$) Accept..

ⓑ Trigger.

'XTCN' Missing. 8 events. → Rejected.

2. Trigger Mismatch.

29 events / 8414 hadrons (0.34 %)

are not triggered by ECAL?

Bit.			
∅	No Trig. Bits.		4 events.
1	Random Trig.		1 event.
4	LCAL	A-Low	2 events.
7		B-High	3 events.
14/15		Low⇔High.	2 events.
8	Single μ		12 events.
9	Single e		7 events.

ECAL Trig. Inefficiency or Data Error??

Detector Conditions

Require ① ECAL & LCAL Triggers Enabled.
② TPC, ECAL & LCAL H.V. On.

Event Selection Summary

ID	$\sqrt{s}$ [GeV]	$N_{e^+e^-}$	N_{had}	σ_{had} [nb]
−3	88.310	1407	196	4.68 ± 0.36
−2	89.320	788	221	9.20 ± 0.70
−1	90.330	1034	628	19.49 ± 0.99
0	91.080	1402	1322	29.76 ± 1.14
	91.320	2567	2519	30.80 ± 0.86
	91.575	2079	1928	28.95 ± 0.92
+1	92.320	1614	1073	20.42 ± 0.80
+2	93.340	637	295	13.91 ± 0.98
+3	94.310	810	232	8.43 ± 0.63

Total. 12,338 8,414

↓

$\int \mathcal{L} dt \sim 400 \, nb^{-1}$

Neutrino Counting from Γ_Z

$\Gamma_Z = 2573 \pm 83$ MeV

① $$\delta N_\nu = \frac{\Gamma_{tot}^{meas.} - \Gamma_{tot}^{S.M.}}{\Gamma_\nu^{S.M.}}$$

$$\Gamma_{tot}^{S.M.} = 3\Gamma_{\nu\bar{\nu}} + \Gamma_{\ell\bar{\ell}} + \Gamma_{had.}$$

Standard Model.

	α_s	m_Z	m_t	m_H	$\Gamma_{\nu\bar{\nu}}$	Γ_{tot}	
a.	0.12	91.2	60	100	166.1	2481	GeV
b.	0.12	91.2	230	1,000	168.4	2517	GeV

$$\delta N_\nu = 0.55 \pm 0.50 \quad (\text{for a})$$
$$0.33 \pm 0.49 \quad (\text{for b})$$

② $$\Gamma_{invisible} = \Gamma_{tot} - \Gamma_{had} - \Gamma_{\ell\bar{\ell}}, \quad N_\nu = \frac{\Gamma_{inv.}}{\Gamma_{\nu\bar{\nu}}}$$

$$R' = \frac{\Gamma_{had}}{\Gamma_{\mu\mu}} = 21.46 \pm 1.57$$ (ALEPH Paper $e^+e^- \to$

S.M. $R' = 20.81$ (for a)

20.79 (for b)

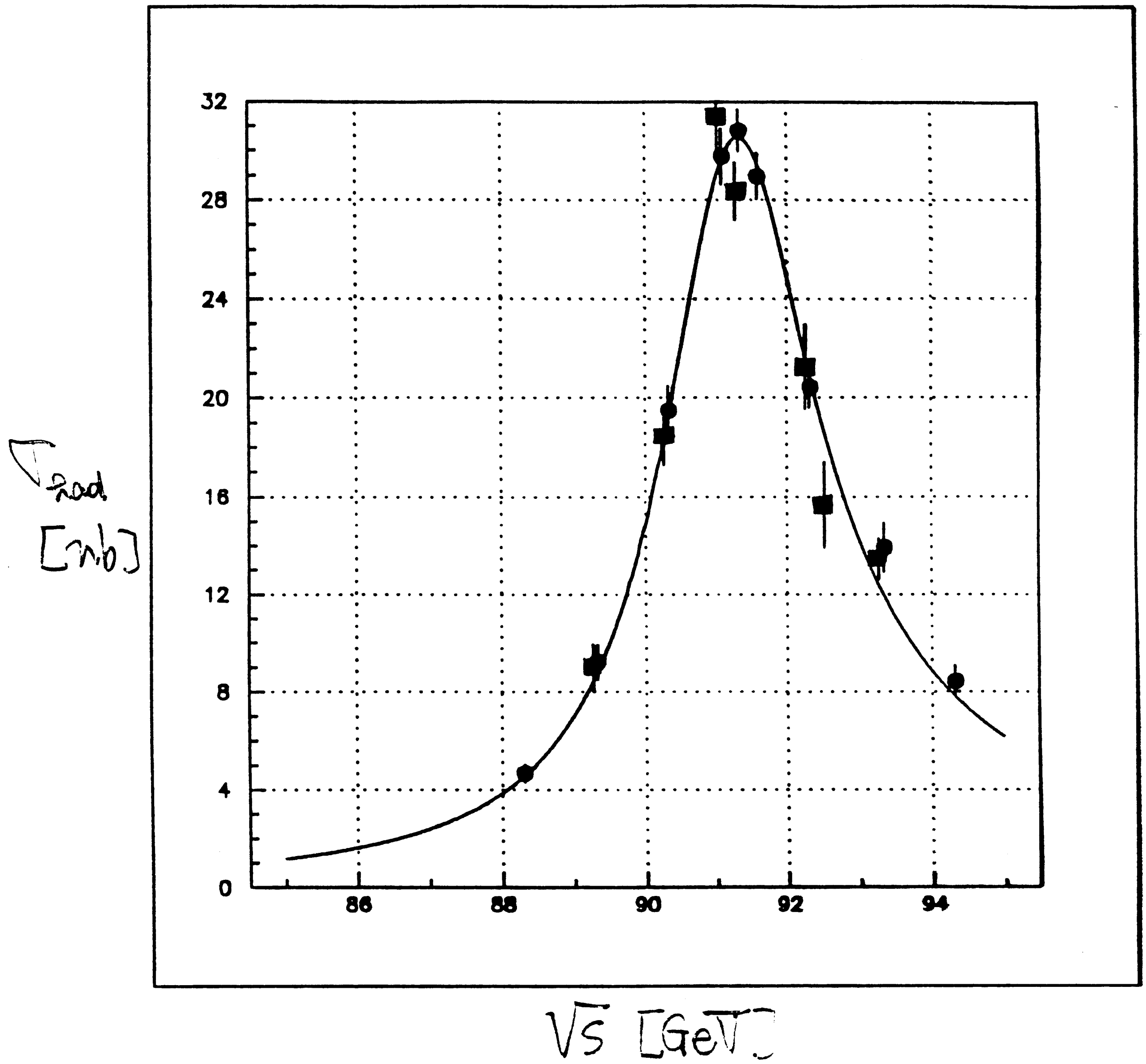
$$\Gamma_{invisible} = \Gamma_{tot}^{measure} - \Gamma_{\mu\mu}^{S.M}(3 + R')$$

$$= 536 \pm 155 \text{ MeV}$$

156

$$N_\nu = 3.22 \pm 0.93 \quad (\text{for a})$$
$$3.18 \pm 0.93 \quad (\text{for b})$$

ZØ Scan I.II & III



Solid Line : Standard Model

$$\begin{cases} m_Z = 91.2 \text{ GeV} \\ \Gamma_Z = 2.481 \text{ GeV} \end{cases}$$

(m_t=60 GeV, m_H=100 GeV)

■ Sept. Run

● Oct. Run

Z∅ Scan Ⅲ

二段Ⅱ

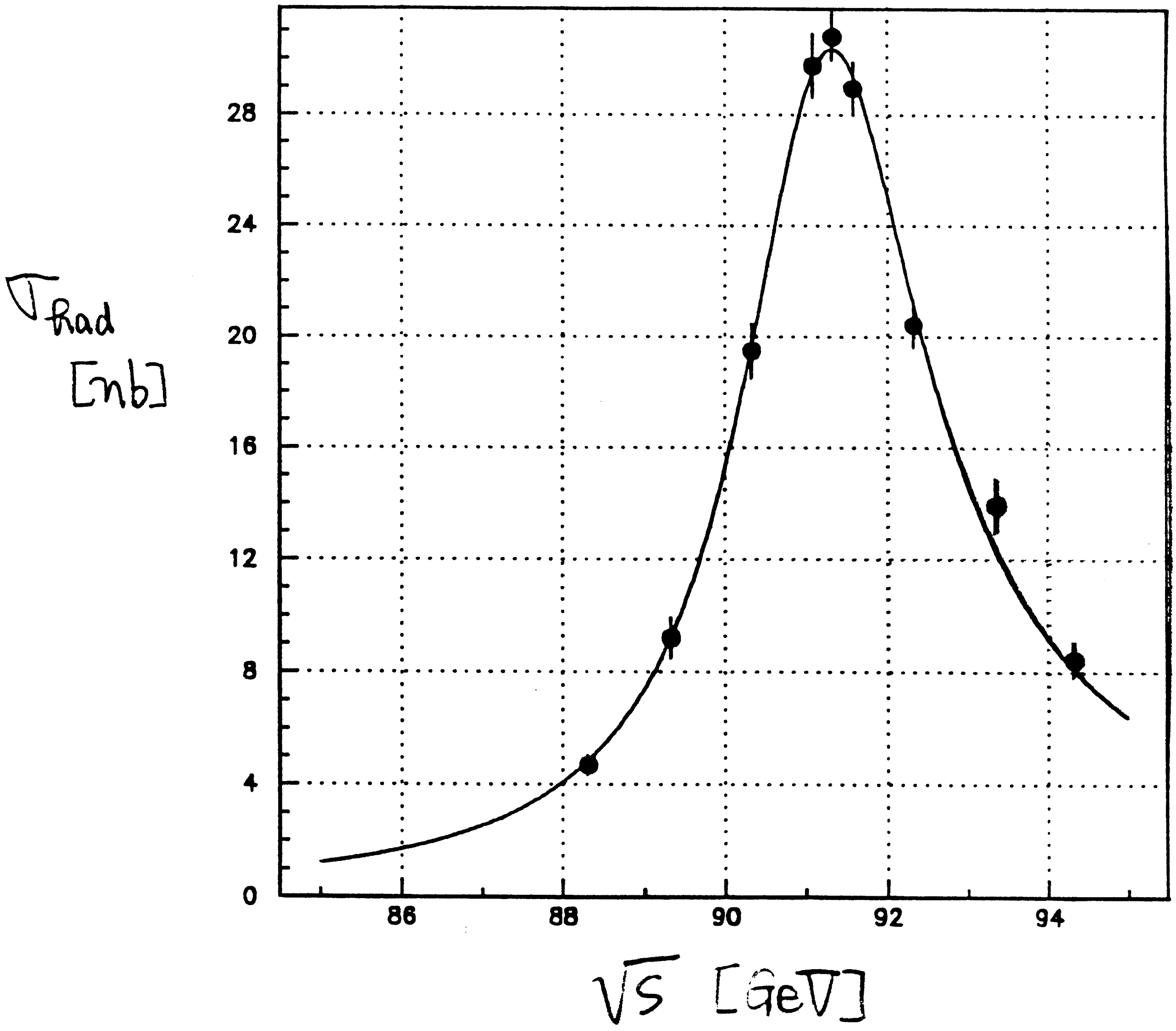
Best fit

$m_Z = 91.223 \pm 0.038 \pm 0.045$ GeV (91.178 ± 0.054)

$\Gamma_Z = 2.573 \pm 0.083$ GeV (2.66 ± 0.15)

$\sigma_0 = 41.01 \pm 0.85$ nb (39.1 ± 1.6)

$\chi^2 = 4.7/6$ D.F.



Standard Model.

m_Z	m_t	m_H	Γ_Z
91.2	60	100	2481 GeV
91.2	230	1000	2517 GeV

HARTON
9/11/89

OCTOBER BEAM ENERGIES

RUNS	FILLS		ENERGY TAKEN FROM
4981 -5054	84 -91	}	INDIVIDUAL FILL SHEETS AT LCR
5060 -5176	92 -107	}	SUMMARY SHEET FROM V. HATTON (Similar from H. WACHSMUTH)

CHECKED: ① E(JLH) = E(HB)

② FILL DATE/TIME |ALEPH CCC = FILL DATE TIME |LCR

③ LEP SCAN PLAN = LEP FILL SHEETS

84	4981	4982	45.642
86	4987	4991	45.643
87	4998	5003	46.143
90	5045	5045	45.767
91	5048	5054	45.767
92	5060	5061	45.143
93	5062	5063	45.143
94	5067	5073	45.518
95	5074	5084	46.643
96	5095	5100	45.642
97	5109	5110	44.642
98	5111	5117	44.643
99	5122	5126	45.768
101	5129	5133	45.771
102	5145	5147	47.142
104	5153	5156	44.143
105	5157	5161	45.519
106	5164	5169	45.643
107	5170	5176	46.145

LEP S .TISTISC FOR WEEK NO : 44 (30.10.89 ---> 05.11.8

date	fill no	nominal energy	dipole I energy	best estimate of energy	start coast	end coast	duration (hours)	time between fills	um.initial 1E+29 c±5% beta=7	um.initial 1E+29 c±10% beta=7	total intensity (mA)	lifetime first 30mns (hours)	I*torr	e- Int. (mA)	e+ Int (mA)	lost/ killed	comments
30/10/89	92	45.125	45.143	45.143	5:50	9:50	4:00		10.7	7.6	1.30	6.00	7.82	0.635	0.668	K	
30/10/89	93	45.125	45.143	45.143	13:30	17:00	3:30	3:40	7.0	4.9	1.12	7.00	7.85	0.366	0.756	K	
30/10/89	94	45.5	45.518	45.518	21:50	4:00	6:10	4:50	13.7	9.7	1.54	11.00	16.92	0.985	0.553	K	
31/10/89	95	46.625	46.643	46.643	5:30	16:55	11:25	1:30	14.7	10.4	1.53	12.00	18.36	0.76	0.77	K	problems with accn. of e-. optimisatio
1/11/89	96	45.625	45.642	45.642	1:50	8:08	6:18	8:55	21.3	15.1	1.84	11	20.24	0.9	0.94	K	problems with accn. of e-. optimisatio
1/11/89	97	44.625	44.642	44.642	20:40	0:50	4:10	12:32	8.3	5.9	1.40		0.00	1.1	0.3	K	
2/11/89	98	44.625	44.643	44.643	3:20	8:00	4:40	2:30	16.8	11.9	1.63	12	19.61	0.788	0.846	L	vacuum sector valves closed in 4
2/11/89	99	45.75	45.768	45.768	16:50	0:15	7:25	8:50	36.6	25.9	2.43	11	26.73	1.07	1.36	K	e- lost after 5 hours in coast
3/11/89	101	45.75	45.771	45.771	4:17	10:25	6:08	4:02	27.2	19.2	2.09	11	22.94	0.957	1.128	K	thunderstorms/delphi magnet
4/11/89	102	47.125	47.142	47.142	4:20	12:00	7:40	17:55	15.9	11.2	1.59	12	19.08	0.83	0.76	K	compressed air failed in point 6
4/11/89	104	44.125	44.143	44.143	21:00	4:00	7:00	9:00	26.4	18.7	2.06	8	16.48	0.92	1.14	K	
5/11/89	105	45.50	45.519	45.519	5:20	12.00	6:40	1:20	19.9	14.1	1.78	11	19.58	0.84	0.94	K	
5/11/89	106	45.625	45.643	45.643	21:15	3:00	5:45	9:15	18.6	13.2	1.74	11	19.14	1	0.74	K	
6/11/89	107	46.125	46.145	46.145	4:28	12:00	7:32	1:28	25.9	18.3	2.14		0.00	1.418	0.726		
				AVERAGES			6:20	6:40	18.78	13.28	1.73	10.25	15.34	0.90	0.83		

TOTAL HOURS IN COAST	88:23
AVERAGE LENGTH OF COAST	6:20
AVERAGE TIME BETWEEN FILLS	6:40

Hu Hongbo

A simple estimation on possible deviation of Γ_Z apart from SM

For model $SU(2)_L \times U(1) \times U(1)'$, the Lagriangian which includes neutral currents is

$$L = g_L J_{3L} W_{3L} + g_Y J_Y B + g_{Y'} J_{Y'} B'$$

so the mass can be got from

$$\sum_i \langle | D_\mu \Phi_i |^2 \rangle = \langle \left| \left[g_L I_{3L} W_{3L} + g_Y \frac{Y}{2} B + g_{Y'} \frac{Y'}{2} B' \right] \right|^2 \rangle$$

keep the symetry of $Q = I_{3L} + \frac{Y}{2}$ unbroken, then we got a 2-D mass matrix. Denotes it as

$$M^2 = \begin{pmatrix} M_Z^2 & \mu^2 \\ \mu^2 & M_{Z'}^2 \end{pmatrix}$$

in which

$$M_Z^2 = 2(g_L^2 + g_Y^2) \langle I_{3L}^2 \rangle$$
$$\mu^2 = 2(g_L^2 + g_Y^2)^{1/2} g_{Y'} \langle I_{3L} \frac{Y'}{2} \rangle$$
$$M_{Z'}^2 = 2 g_{Y'}^2 \langle \frac{Y'^2}{4} \rangle$$

assume

$$\mu = \epsilon M_Z$$
$$M_{Z'} = \tau M_Z$$

after diagonizing the matrix, we get the correction of the light Z boson as

$$\Delta M_Z = \frac{\epsilon}{\tau - 1} M_Z$$

Untill now, we have not divided the real and imagine part of the mass, as a good approximation, we think

$$\Delta \Gamma_Z = \frac{\epsilon}{(\tau - 1)} \Gamma_Z$$

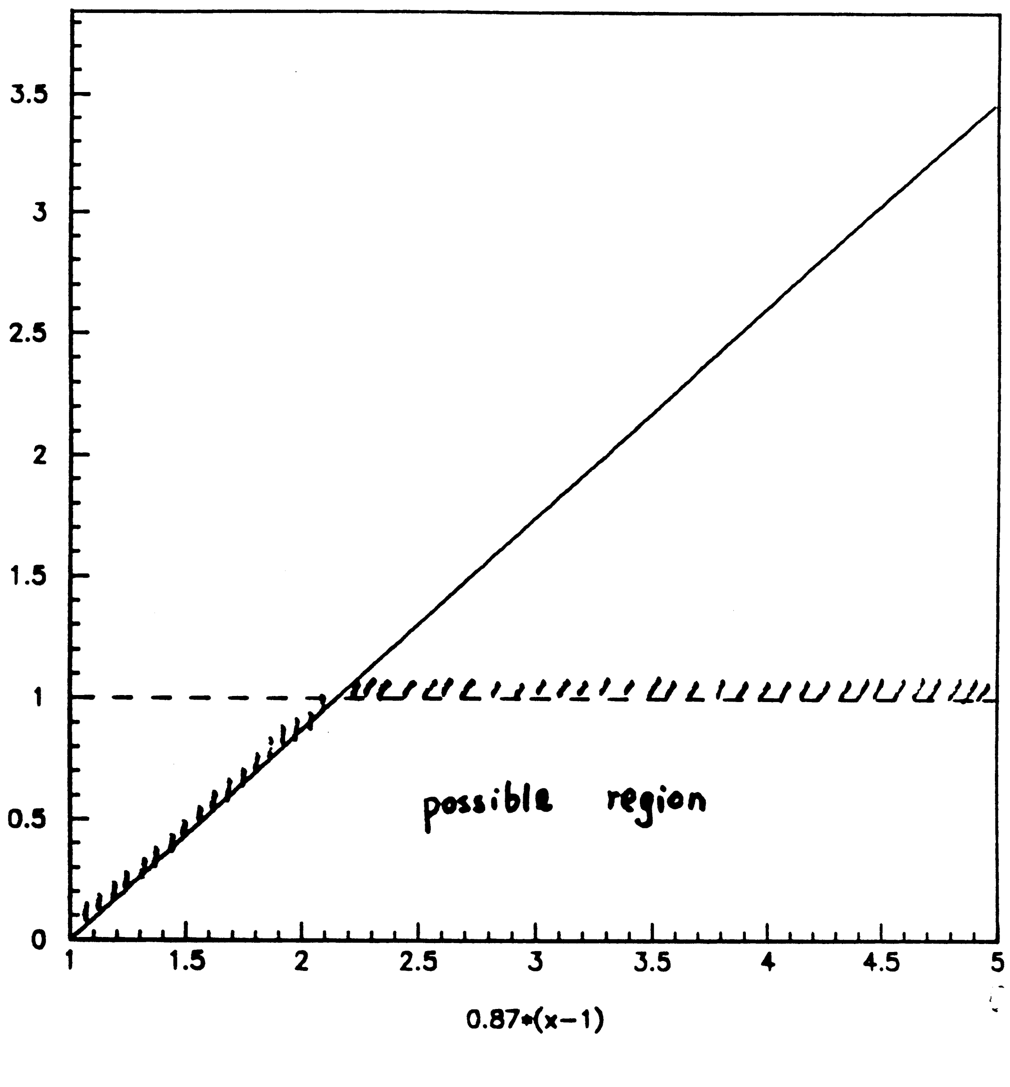
and turn to the number of nutrino, we have

$$\Delta N_\nu = \frac{\epsilon}{\tau - 1} N_\nu$$

considering the ALEPH result $N_\nu = 3.27 \pm 0.3$, we are able to say that $N_\nu < 3.87$, so we can give a limite on parameters ϵ、τ (see fig.)

People has suggested to mesure the F-B asymmetry of hadron to see if we can find some evidence of an additional Z Boson is really exist.

Here we would like to propose an experiment of measuring the charge F-B asymmetry. We shall have enough hadron events (order of 10^6) before the polarized beam can be served at maybe the end of 1990.



3.5
3
2.5
2
1.5
1
0.5
0
1
1.5
2
2.5
3
3.5
4
4.5
5
possible region
0.87*(x-1)

A. Blondel

Implications of $\Delta m_Z \leq 50$ MeV on electroweak Physics.

1. Δr

2. m_t in MSM (no further stuff.)

3. $\sin^2 \hat{\theta}_W \equiv \dfrac{e^2(-m_Z^2)}{g^2(-m_Z^2)} \Rightarrow$ SU(5), SUSY SU(5)

1. Δr

Δr is the relation between

m_W, m_Z, α, G_μ:

$$m_Z^2 = \frac{\pi\alpha}{\sqrt{2}G_\mu} \frac{1}{\frac{m_W^2}{m_Z^2}\left(1-\frac{m_W^2}{m_Z^2}\right)} \frac{1}{1-\Delta r}$$

(by definition of Δr)

$\frac{m_W}{m_Z}$ is measured
- → directly in UA1, UA2, CDF
- → indirectly in $\frac{\nu N \to \nu X}{\nu N \to \mu X'}$ (ratio of W and Z propagators, see A.B. in CERN-EP 89-84 -

UA1	0.889 ± 0.017	0.883 ± 0.005	0.8793 ± 0.00
UA2	0.887 ± 0.009		
CDF	0.880 ± 0.007		
νN	0.8777 ± 0.0034		

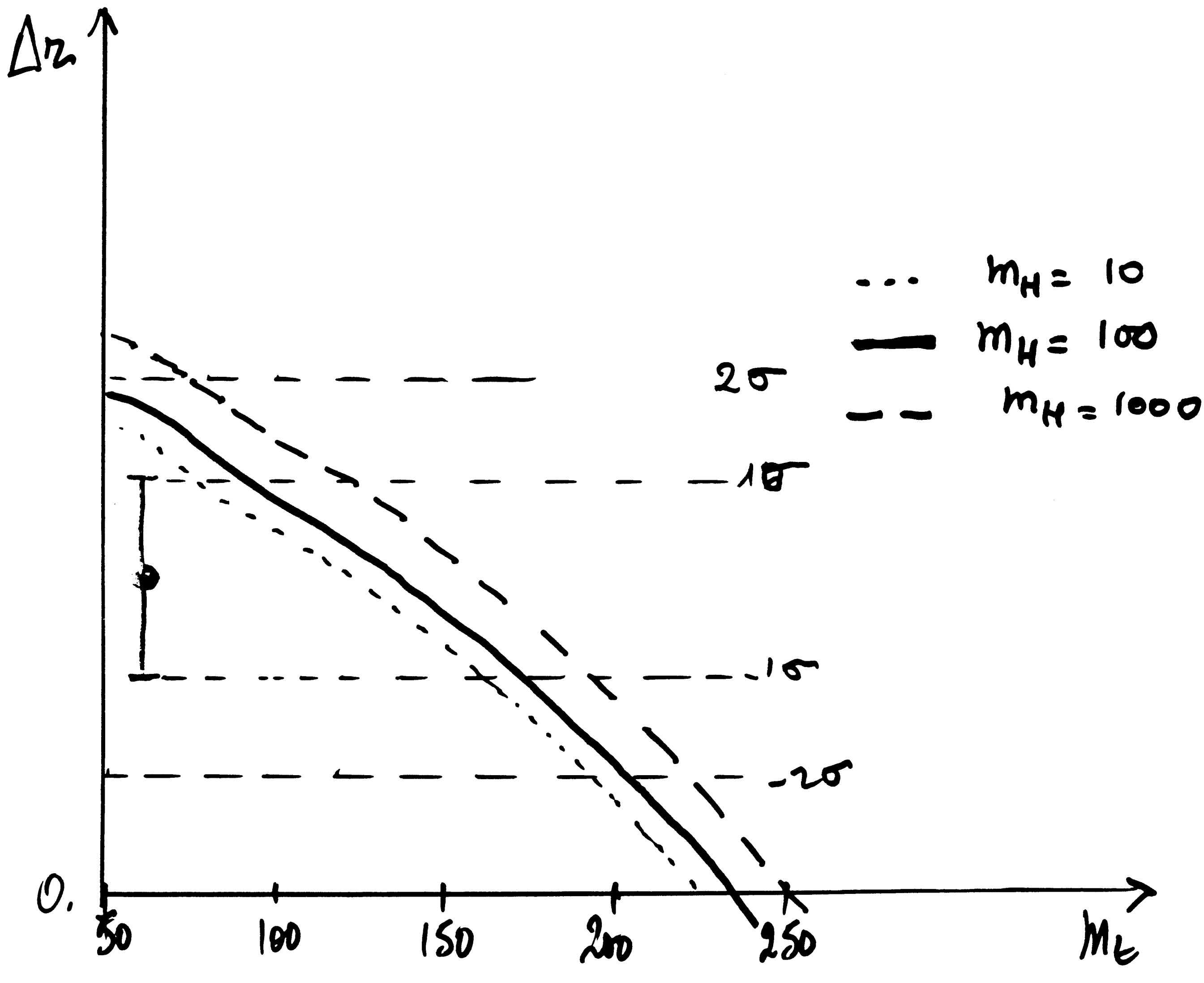
i.e. $1-\frac{m_W^2}{m_Z^2} = 0.2268 \pm 0.0049$

$$\Rightarrow \quad \Delta r = 1 - \frac{\pi\alpha}{\sqrt{2}G_F}\,\frac{1}{m_Z^2}\,\frac{1}{1-\frac{m_W^2}{m_Z^2}}\,\frac{1}{\frac{m_W^2}{m_Z^2}}$$

$$= 0.046 \pm 0.0146 \qquad \text{for } m_Z = 91.20 \pm 0.05$$

$$\Delta(\Delta r) = 0.001 \quad (m_Z)$$

$$0.0145 \quad (m_W/m_Z)$$



2. m_t.

Assume Minimal Standard Model.

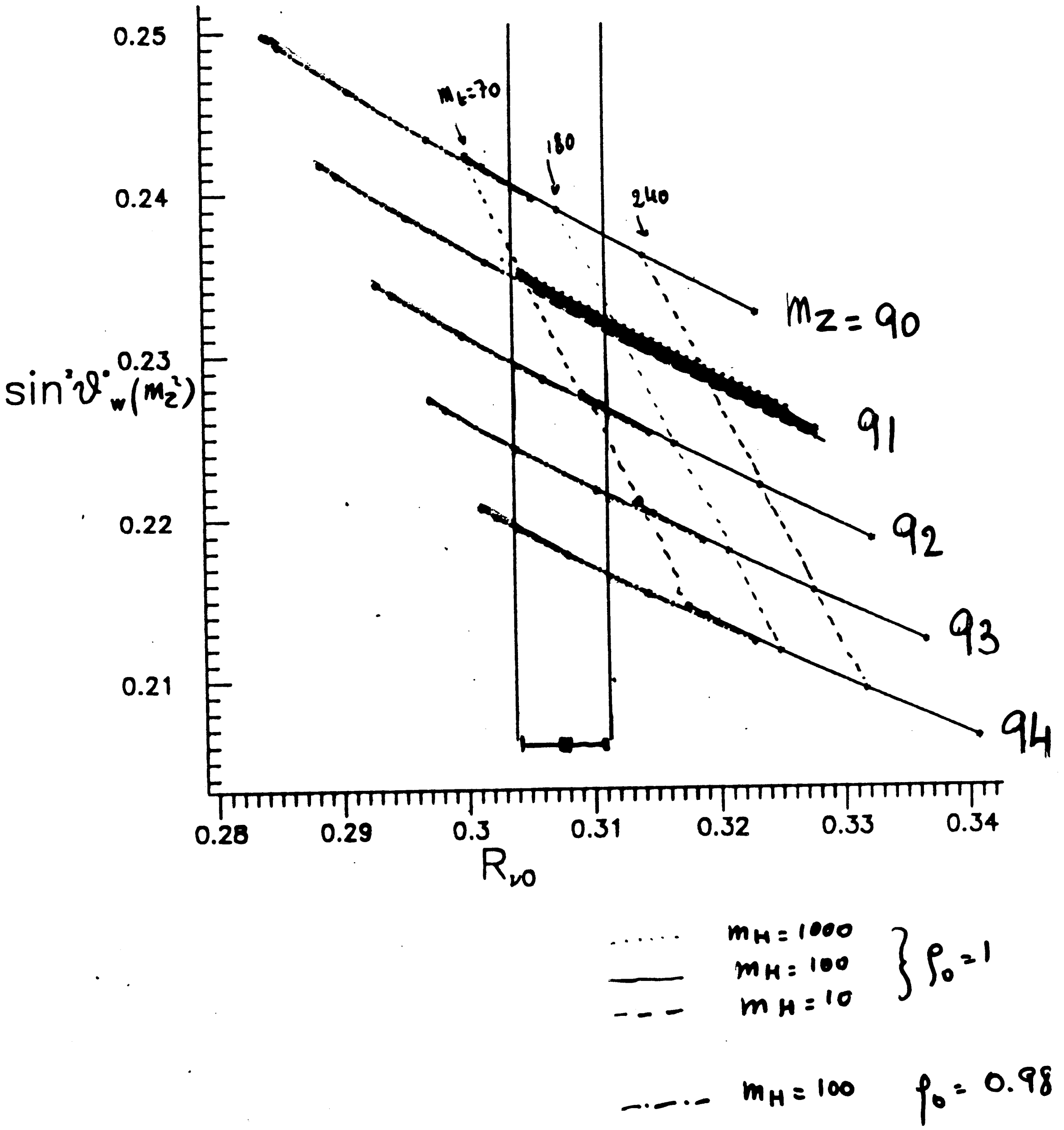
- only m_t, m_H
- no Higgs triplets ⇐ CRUCIAL
- no other new particles ⇐ less crucial

⇒ ALLOWED DOMAIN FOR m_t

	68% CL	95% CL
$m_H = 10$	[76 – 160]	< 195
100	[92 – 173]	– < 205
1000	[120 – 193]	[76 – 220]

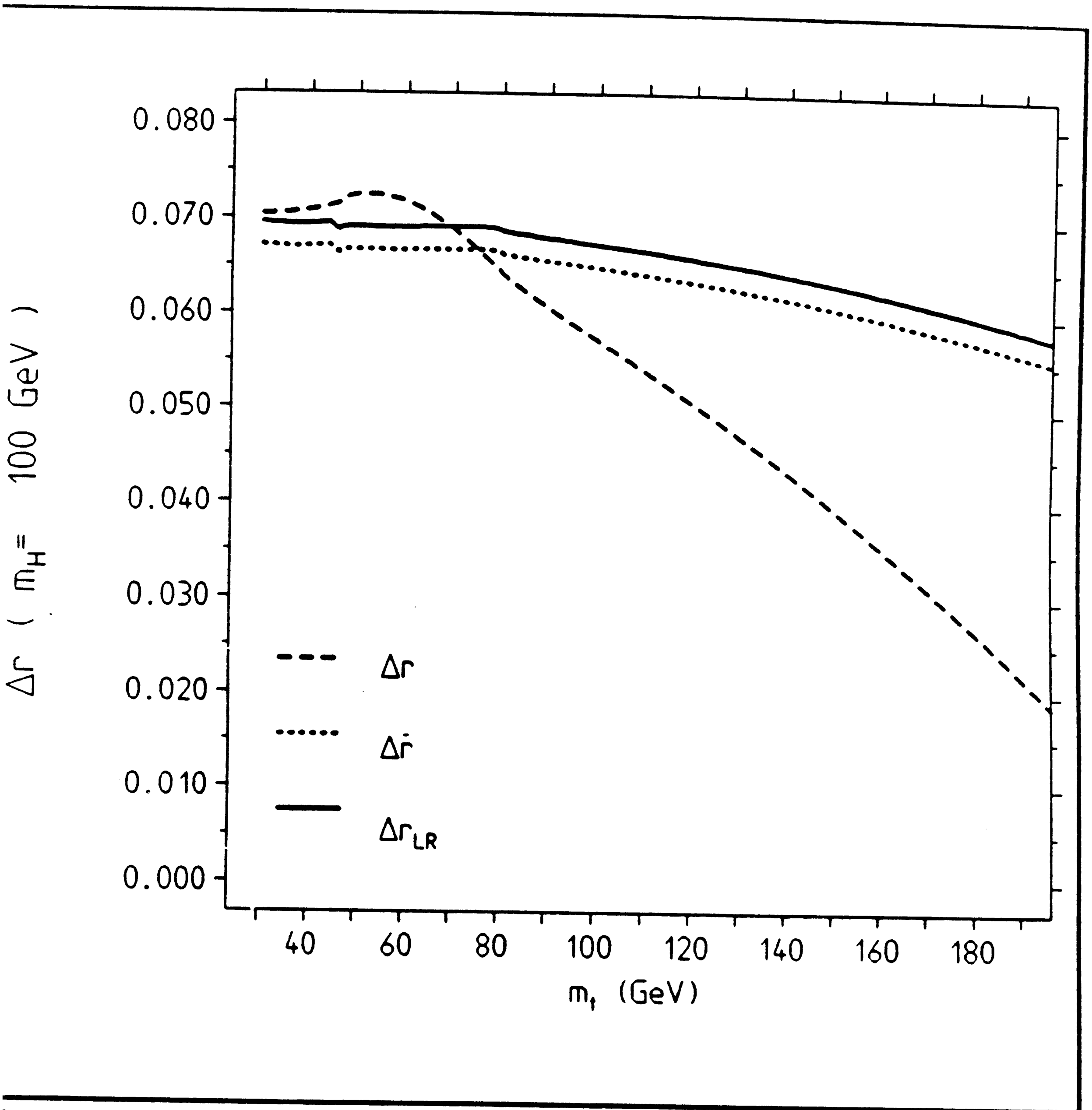
$$\Rightarrow \quad m_t = 136^{+37}_{-44}\ {}^{+22}_{-14}\ \text{GeV}$$

↑ $\frac{m_W}{m_Z}$, m_Z ↑ m_H $^{1000}_{10}$


0.25
0.24
0.23
0.22
0.21
0.28
0.29
0.3
0.31
0.32
0.33
0.34
$\sin^2\vartheta^\circ_w(m_Z^2)$
$R_{\nu 0}$
$m_t = 70$
180
240
$m_Z = 90$
91
92
93
94
$m_H = 1000$
$m_H = 100$
$m_H = 10$
$\rho_0 = 1$
$m_H = 100$
$\rho_0 = 0.98$

$$\Delta\bar{r}^{Higgs} \simeq \frac{\sqrt{2}G_\mu M_W^2}{16\pi^2}\left\{\frac{1+9s_W^2}{3c_W^2}(\ln\frac{m_H^2}{M_W^2}-\frac{5}{6})\right\}, \tag{45}$$

ɔectively. Except from extra top contributions in the case $f = b$, all heavy particle cts are universal i.e. $\Delta r^{top}_{f\neq b} = \Delta\bar{r}^{top}$ and $\Delta r^{Higgs}_f = \Delta\bar{r}^{Higgs}$.
: LEP1 version $\Delta\bar{r}$ of Δr is a factor of 3.3 less sensitive to a heavy top and a or of 2.3 less sensitive to a heavy Higgs as compared to the LEP2 observable Δr Fig. 2). This does not mean that LEP1 experiments are less suitable to get



igure 2: Comparison of the top-mass dependence for different definitions of Δr

ɪrtant information on heavy physics, however. Thanks to the higher statistics of l experiments, LEP1 observables are measured with higher precision . Furthermore, elative sensitivity to the Higgs is higher at LEP1, a welcome fact, since the Higgs ins *the big unknown* in the Standard Model. From the measured effective $\sin^2\Theta_i$'s ay evaluate

3. $\sin^2\hat{\theta}_W$

(either $\sin^2\theta_{W\,\overline{MS}}(-m_Z^2)$, $\sin^2\theta_W^*(m_Z^2)$, $\sin^2\overline{\theta}_W$)

SIRLIN LYNN HOLLIK

⇒ 1. $\Delta\hat{r}$ is much less sensitive to m_t than Δr

2. $\sin^2\hat{\theta}_W$ is predicted by GUTS.

with R_ν only. ⇒

$$\sin^2\theta_W^*(m_Z^2) = 0.2325 \pm 0.002 \pm 0.001 (m_H,$$

↑ $\frac{m_W}{m_Z}$

- Does not assume Higgs triplets or new physics.

compare	$\sin^2\hat{\theta}_W$	SU(5)	0.215 ± 0.004 — OK
		SUSY SU(5)	0.237 ± 0.004 <u>OK</u>