DAVID J. MILLER
ICFA SEMINAR 6/10/9

WORLD-WIDE STUDY OF PHYSICS & DETECTORS FOR A LINEAR COLLIDER

- WHO & WHERE ?
- PHYSICS PUSH
- DETECTOR ISSUES (& MACHINE)

WHO?

1. ORGANISING COMMITTEE

LED BY UNIVERSITY EXPERIMENTERS.

CO-CHAIRS
C. BALTAY (YALE)
S. KOMAMIYA (TOKYO)
D.J.M. (U.C. LONDON)

+ 5 SENIOR PHYSICISTS FROM EACH REGION (SOME OF THEM HERE!)

MET FIRST IN VANCOUVER AT ICHEP '98

"BLESSED" BY ICFA.

2. WORKING GROUP CONVENERS

(3 EACH, FROM EACH REGION)

PHYSICS GROUPS: HIGGS, SUSY, QCD/TOP, ELECTROWEAK, ALTERNATIVE

SIMULATION: (GENERATORS, DETECTOR MODELS)

MACHINE/DETECTOR: INTERACTION REGION

$\gamma\gamma$ AND $e\gamma$

DETECTORS: TRACKING, VERTEXING, CALORIMETRY, PARTICLE ID, FORWARD REGION, $\mathcal{L}$ ETC.

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WHERE?

1. ON THE WEB

http://lcwws.physics.yale.edu/lc/ WORLD
http://acfahep.kek.jp/ ASIA
http://www.desy.de/conferences/acfa-desy-lc98.html EUROPE
http://lcwws.physics.yale.edu/lc/america.html N. America

LC NOTES JUST STARTING (WWW INDEX?)

2. REGIONAL WORKSHOPS

ALREADY RUNNING — NOW EVEN MORE EXCHANGE OF IDEAS & PEOPLE

NEXT
- ECFA/DESY – OBERNAI (STRASBOURG) 13–19/10/99
- ACFA – SEOUL NOVEMBER/DECEMBER
- N. AMERICA SPRING 2000

(COMPATIBLE WITH LHC. TDRs FOR 2001–2003)

3. LCWS

STARTED WITH SAARISELKÄ (FINLAND) 1991
THEN WAIKOLOA (HAWAII) 1993
MORIOKA-APPI (JAPAN) 1995

TAKEN INTO W-W STUDY FOR SITGES (SPAIN) MAY 1999

NEXT WILL BE AT FERMILAB OCTOBER 2000.

PHYSICS PUSH — A FEW FROM MANY POSSIBLE EXAMPLES:

A. LIGHT HIGGS ?

IF THERE, WILL BE SEEN AT (LEP ? TEVATRON? LHC?

BUT WHAT KIND OF HIGGS?

• LINEAR COLLIDER WILL PIN IT DOWN •

ELAVOUR: BRANCHING RATIOS.

$B_{b\bar{b}} = \Gamma_{b\bar{b}} / \Gamma_{TOT}$

$\Gamma_{\gamma\gamma}$ = 

NEEDS $\gamma\gamma$ OPTION

C.M. IF TRACKING GOOD ENOUGH →

YUKAWA COUPLING

NEEDS ON $t\bar{t}$ THRESHOLD

• HIGH $\int \mathcal{L} dt$

• V. GOOD BACKGROUND MODELS

c.f. $B_{c\bar{c}}$: HARDER! NEEDS VERY GOOD VERTEXING.

TOTAL WIDTH $\Gamma_{TOT} = \dfrac{\Gamma_{\gamma\gamma}}{B_{b\bar{b}}\,(\Gamma_{\gamma\gamma}/\Gamma_{b\bar{b}})}$

SITGES - WORK FROM ALL 3 REGIONS.

$\Gamma_{\gamma\gamma}$ TO ~5% WITH $\gamma\gamma$ OPTION

$B_{b\bar{b}}$ TO ~3% WITH GOOD TRACKER

$(\Gamma_{\gamma\gamma}/\Gamma_{b\bar{b}})$ HARDER. NEEDS $\int \mathcal{L} dt$

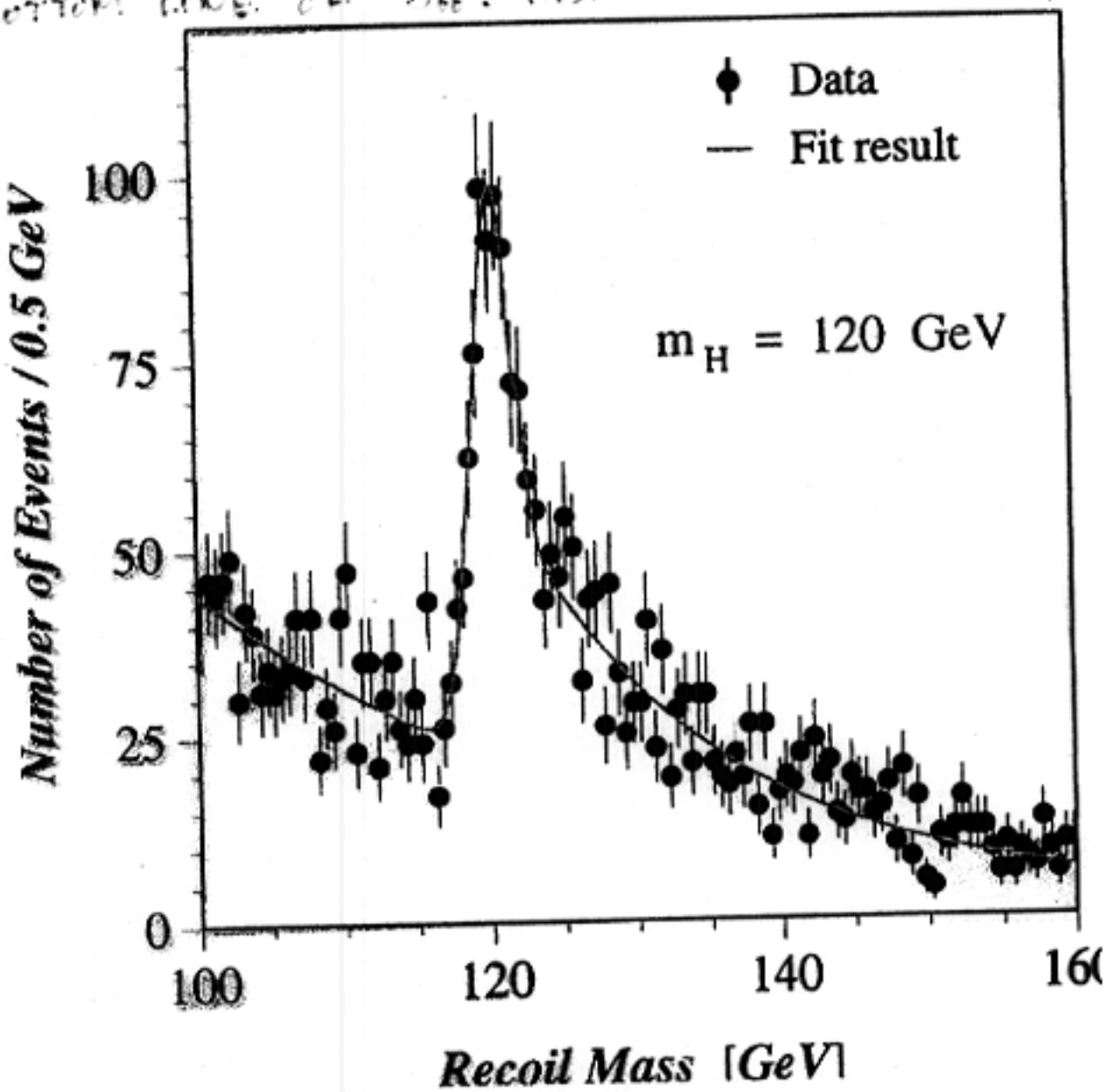
OR ASSUME SOME S.M. COUPLINGS; $h \to WW^*$ AND USE LHC DATA ??

E.A. Recoil Mass Fit, e^+e^-

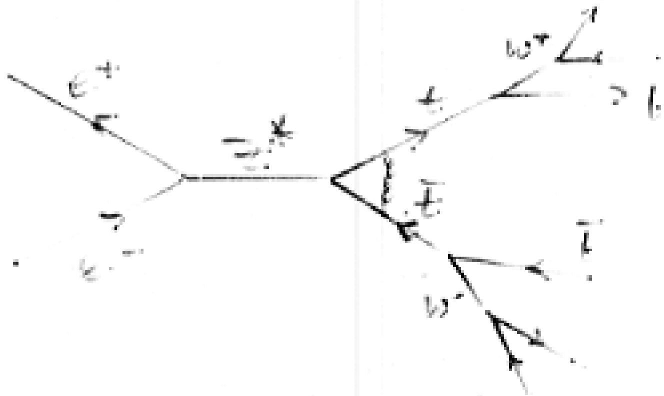
$$M_H = 120.48 \pm 0.14 \text{ GeV}$$

$$\sigma_H = 1.48 \pm 0.11 \text{ GeV}$$

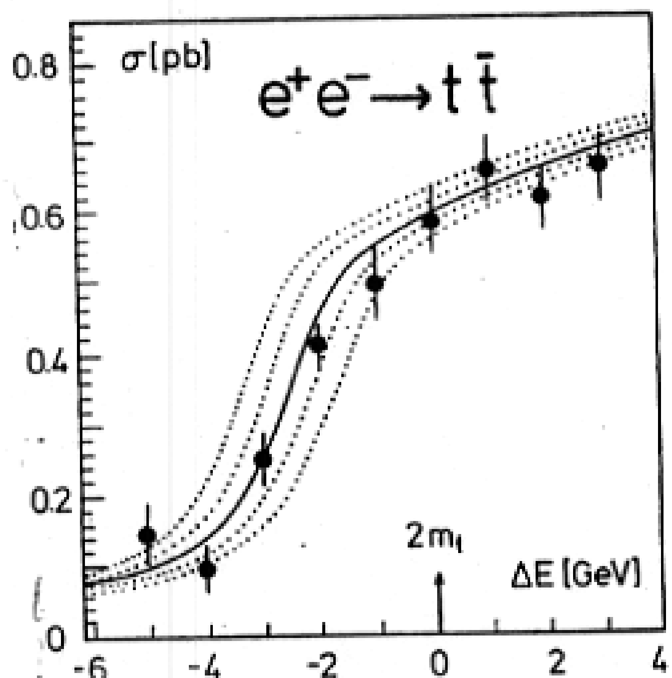
$$\sigma(ZH \to e^+e^-X) = 5.26 \pm 0.18 \pm 0.13 \text{ fb}$$



B. $t\bar{t}$ THRESHOLD SCAN.



FROM RECENT WORKSHOPS
NEW ... APPROACH
BY TEUBNER, ... et al
N.L.O. ... CORRECTION!



L.O.

TOTAL OF $50\,fb^{-1}$ IN SCAN

Figure 1.7: *Excitation curve of the top quarks including initial-state radiation and beamstrahlung. The errors of the data points correspond to an integrated luminosity of* $\int \mathcal{L} = 50\ fb^{-1}$ *in toto. The dotted curves indicate shifts of the top mass by 200 and 400 MeV. Ref.[26, 37].*

IF $\frac{\partial \mathcal{L}}{\partial \sqrt{s}}$ O.K. → GET ...

✓ FRARY + DJM: BHABHA ACOLLINEARITY IN 100-300 mr REGION
1991

WORLD WIDE INPUTS!
CHECKED BY KURIHARA (KEK)
CINABRO (AT SITES)
BEING TESTED NOW

(7) C. SUSY

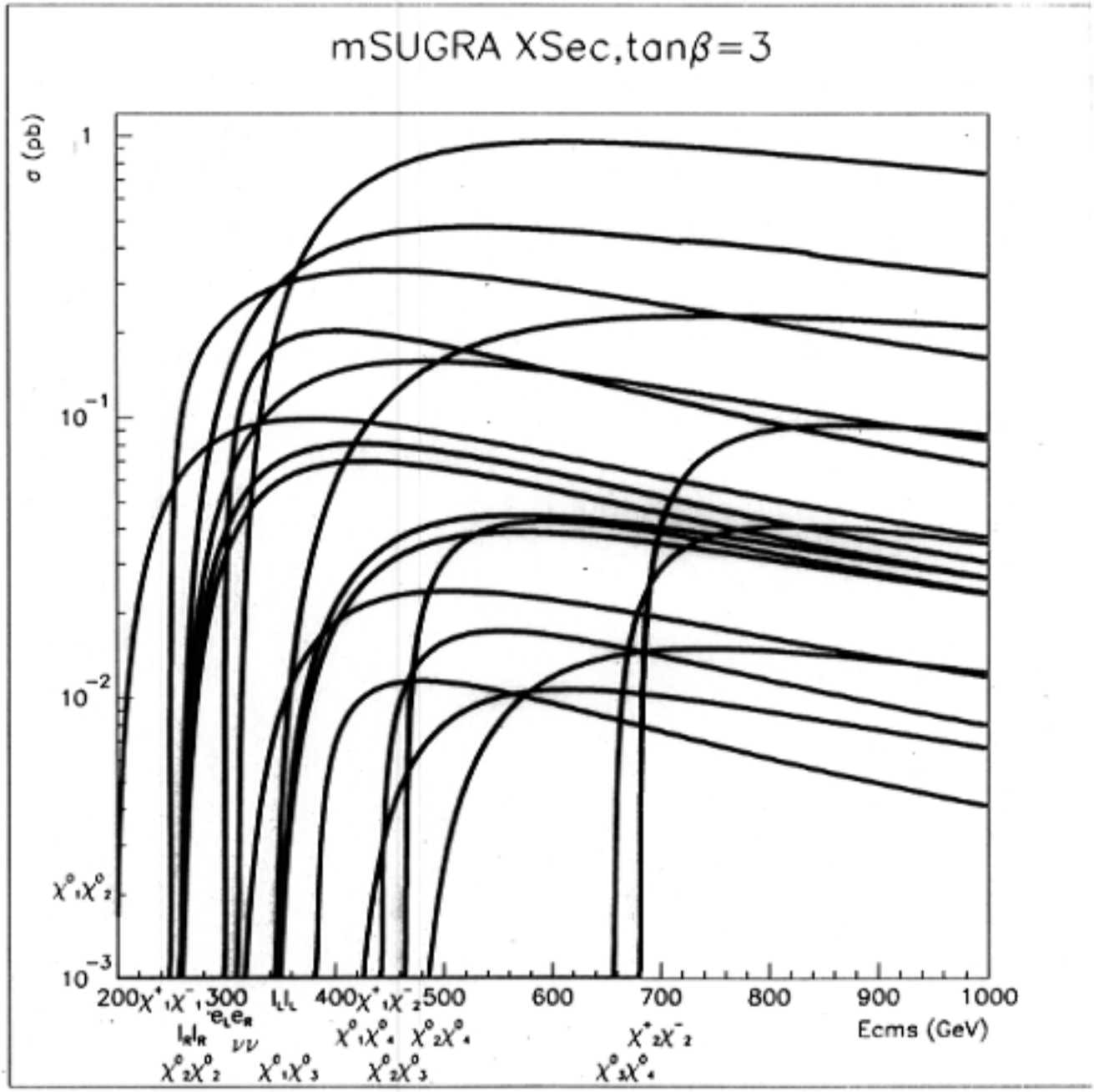
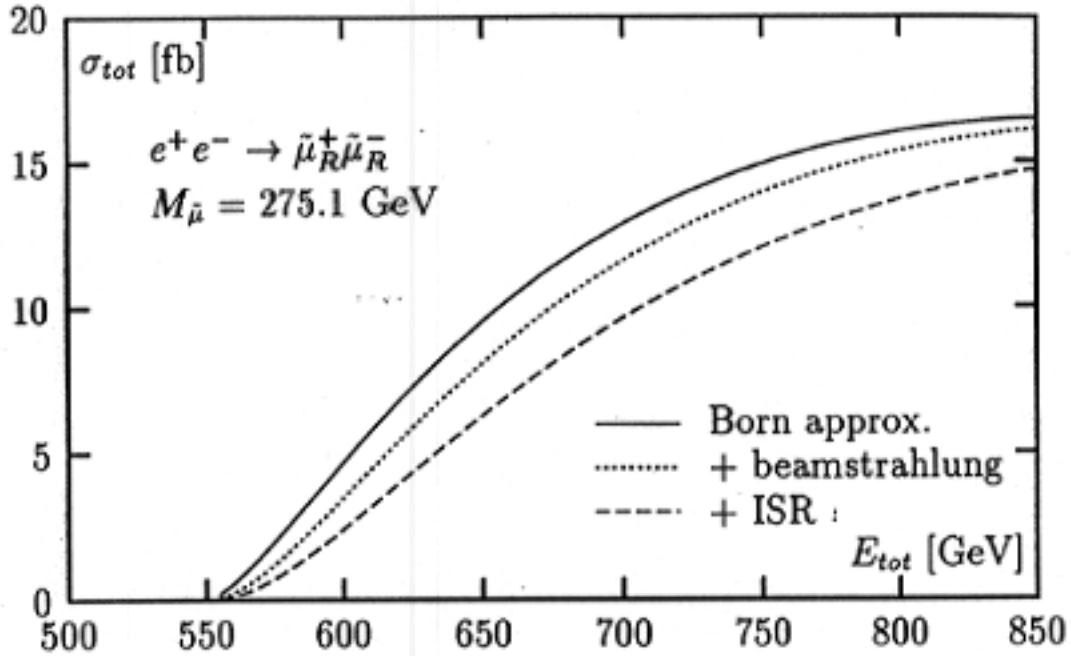


Figure 1: Cross sections of processes for tan β=3. The cross sections were obtained using Pythia and SUSYGEN interfaced to separate private codes of S.Ambrosanio and W.Porod

TOP STUDIES SHOW ~ 50 fb^{-1} ENOUGH FOR GOOD THRESHOLD SCAN → $\delta m \lesssim 200$ MeV

~ 1 PER YEAR AT 5×10^{33}

BUT CAN ALSO GET MASSES FROM KINEMATICS



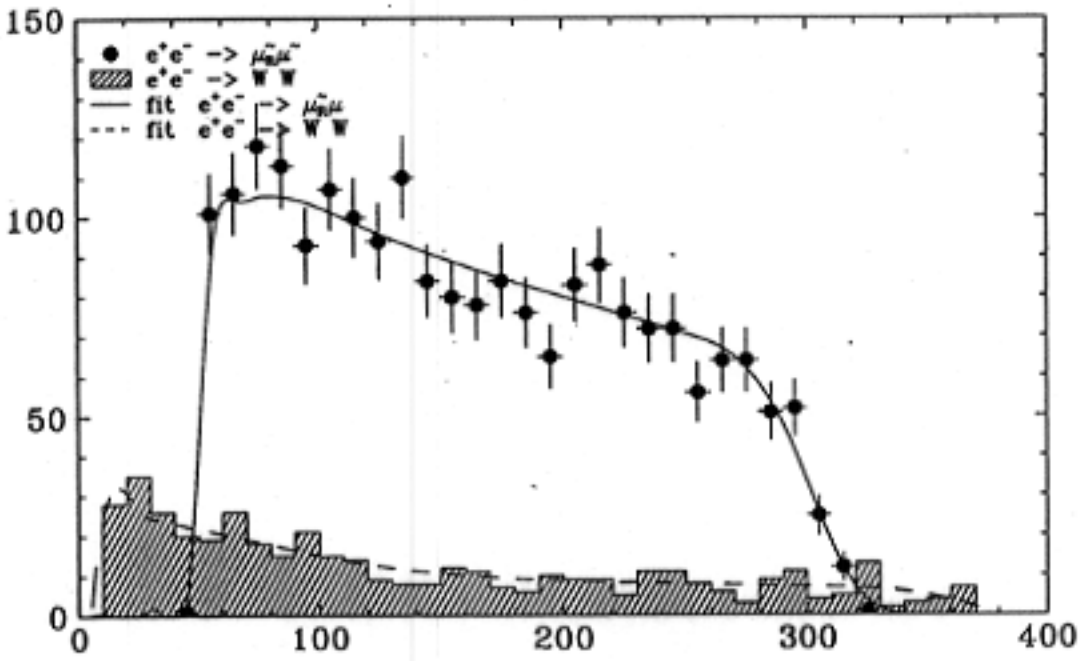


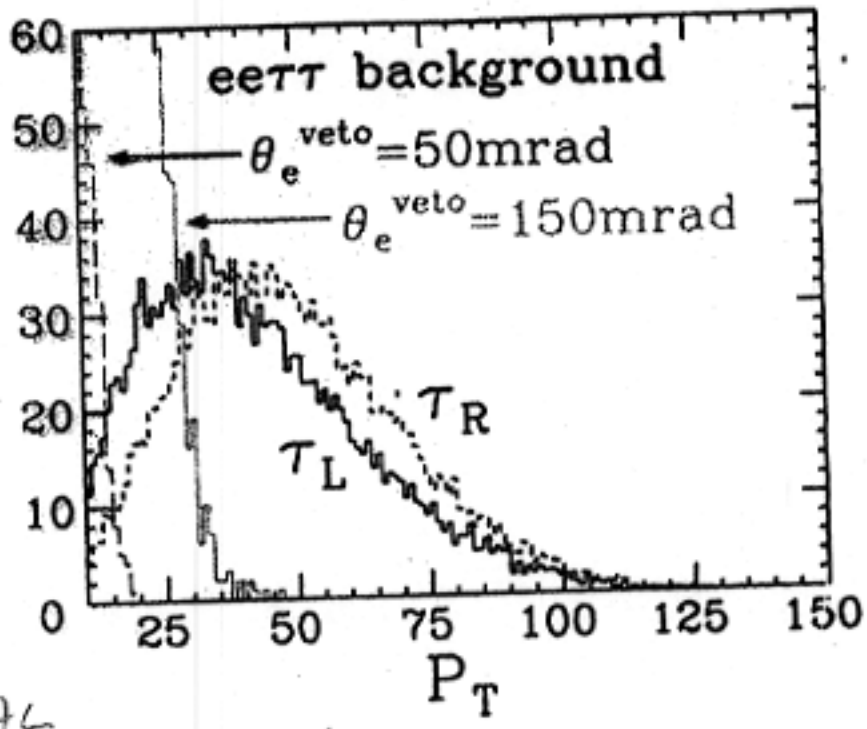
Figure 1.39: *Upper part: The cross section of the production of $\tilde{\mu}\tilde{\mu}$ pairs in e^+e^- collisions for different electron-beam polarizations. Lower part: Decay lepton energy spectrum in $\tilde{\mu}_R \to \mu\tilde{\chi}^0_1$ for $m_{\tilde{\mu}_R} = 275.1$ GeV and $m_{\tilde{\chi}^0_1} = 88.1$ GeV at the energy $\sqrt{s}$ = 800 GeV; also shown is the background from WW pair production. Ref.[148].*

ONE E.G.
OF MANY

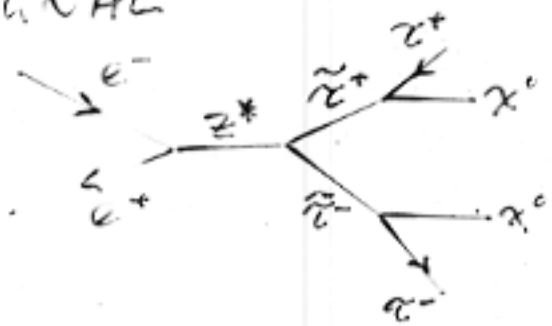
SUSY CHANNELS WITH MISSING ENERGY NEED AN HERMETIC DETECTOR (ARGUED V. STRONGLY BY U. NAUENBERG)

Minimum Veto Angle

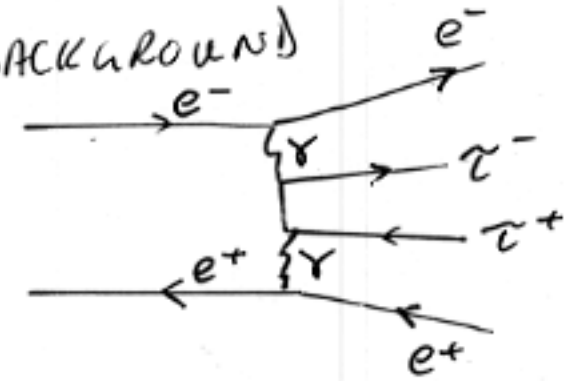
$\tilde{\tau}^{\pm}$ **Study : most demanding!**



SIGNAL



BACKGROUND



MUST VETO SCATTERED e^+, e^- DOWN TO $\lesssim 50$ mr.

D. STRONGLY INTERACTING ELECTROWEAK SECTOR. | "SENSE"

IF NO LIGHT HIGGS (AND ∴ NO SUSY)

UNITARITY REQUIRES NEW PHYSICS AT ABOUT THE TeV SCALE.

HOW? RESONANCE

WHERE? IN $W_L^- W_L^+ \to Z_L^0 Z_L^0$ (AND $+ \bar{t}t$)

COULD (MUST?) SHOW IN ANOMALOUS COUPLINGS. | LEARNING TO STUDY NOW AT LEP2 & TEVATRON

NEEDS: • HIGH ENERGY ($\sqrt{s} \sim 1$ TeV MAY BE ENOUGH)

• PRECISION → HERMETICITY FOR μ's & HADRONS → HIGH $\int \mathcal{L} dt$

• POLARISATION / e^- ONLY OR e^+ TOO?

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DETECTOR ISSUES

A. "LARGE" OR "SMALL"

- B ~ 3T
  TPC OR JET TRACKER
  (JAPAN, EUROPE, U.S.)
- B ~ 5T
  ALL Si TRACKER
  (U.S.)

B. CCDs OR SMART PIXELS FOR VERTEXING

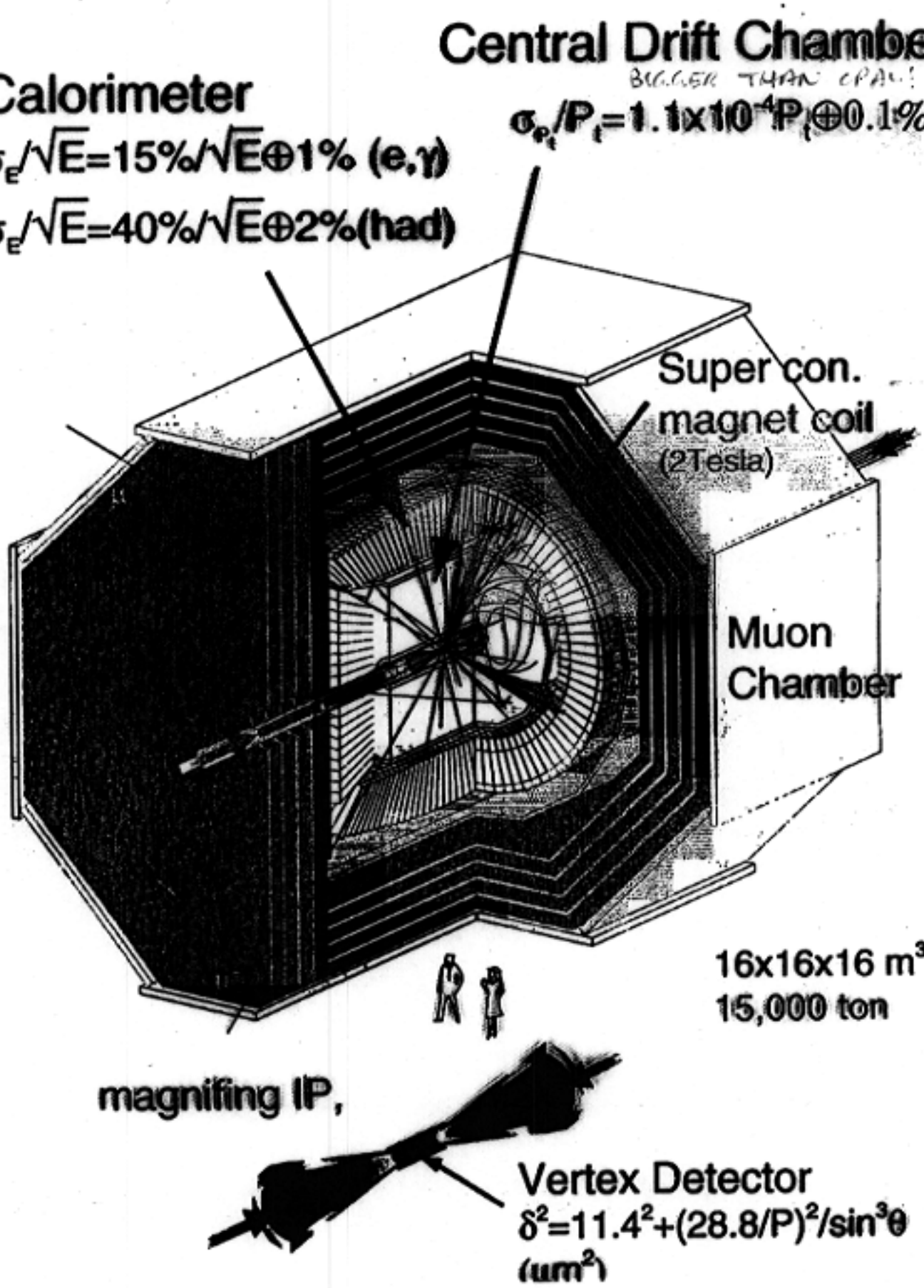
- WORLD WIDE FLAVOR I.D COLLABORATION
- SEPARATE PROJECTS IN REGIONS.

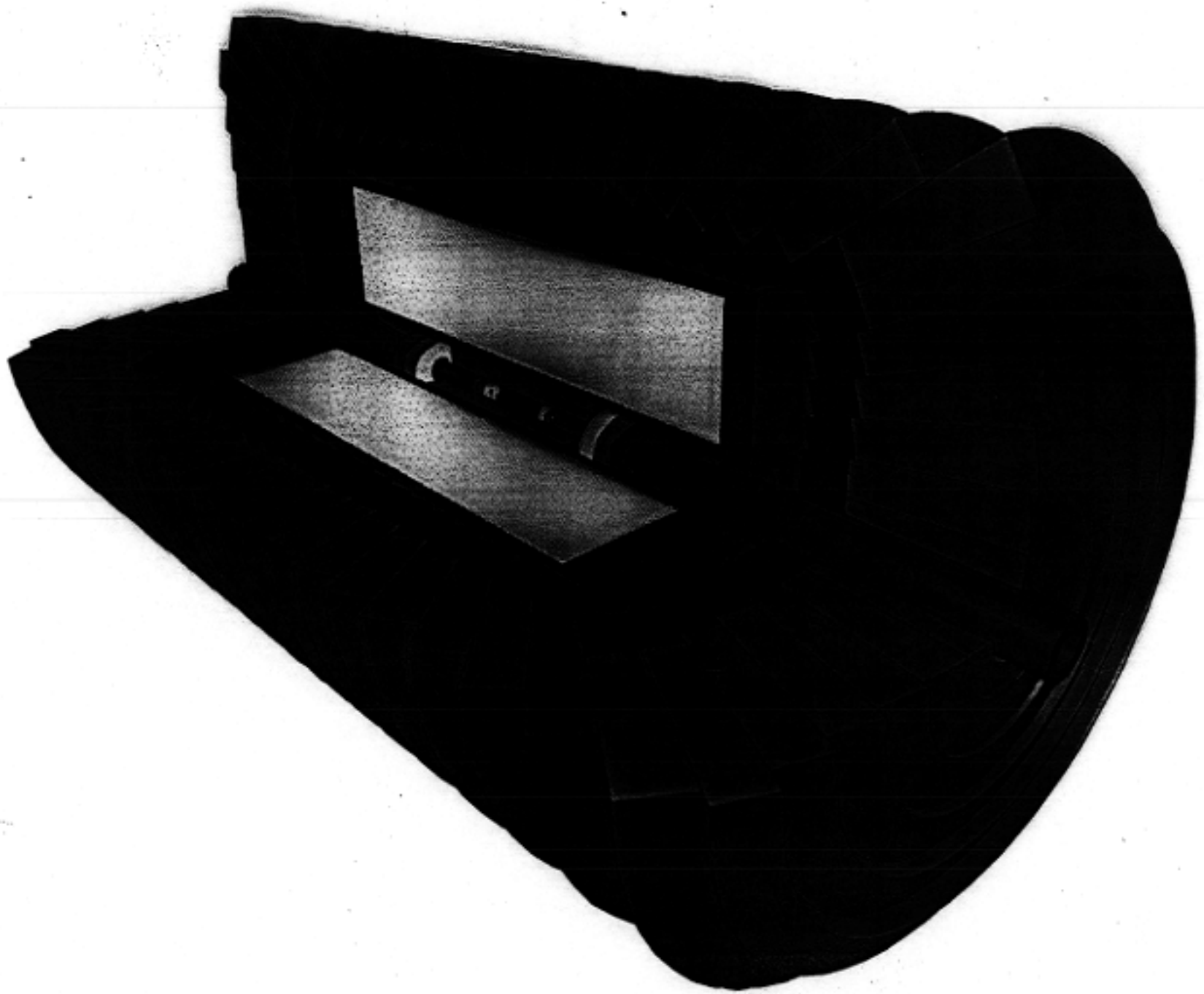
C. CALORIMETRY ⟹ SMALL (CHEAP)

- ALL Si W ?
  (GOOD POINTING & E. FLOW
  COST ?
  O.K. FOR 'S")
- CRYSTALS ?
  (GOOD δE/E
  POOR POINTING)
- TILES + Si W ?
  (COMPROMISE FOR "L" DETECT

Small Detector in Pit Sized for Door Opening with Attempt at Quad Support

JLC detector





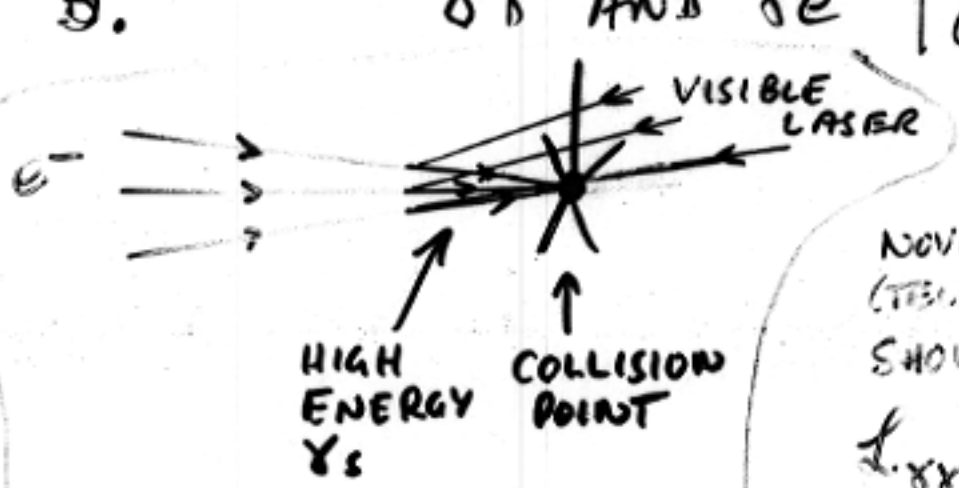
EUROPEAN "L" DETECTOR — INSIDE COIL CAVITY. (A 4m DIAMETER COIL)

MACHINE / DETECTOR ISSUES

A. FORWARD REGION

- W MASK TO PROTECT TRACKERS ⇒ LOSE HERMITICITY !!
- INSTRUMENTS INSIDE MASK
- μ TRACKING HADRONS ? ELECTRON TAGGING ?

B. γγ AND γe | COMPTON COLLIDER | 2ND I.R. ?



SAME, OR JUST e^-, IN OPPOSITE DIRECTION

NOVOSIBIRSK GROUP (TELNOV, GINZBURG, ET AL.) SHOWED CAN HAVE

$\mathcal{L}_{\gamma\gamma} \gtrsim \mathcal{L}_{ee}/10$

$\sqrt{s}_{\gamma\gamma} \approx 0.8\sqrt{s}_{ee}$

NO KILLER TECHNICAL PROBLEMS
BUT MUCH R&D NEEDED
MUST BE PHYSICS-DRIVEN;

$\Gamma^{Higgs}_{\gamma\gamma}$, SUSY, F_2^γ, ANOMALOUS COUPLINGS

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MACHINE ISSUES

A. e^+ POLARISATION

DOES THE PHYSICS DEMAND IT?

B. HIGH $\mathcal{L}$ AT LOW $\sqrt{s}$

→ RETURN TO Z WITH LARGE $\mathcal{L}$ AND POLARISATION?

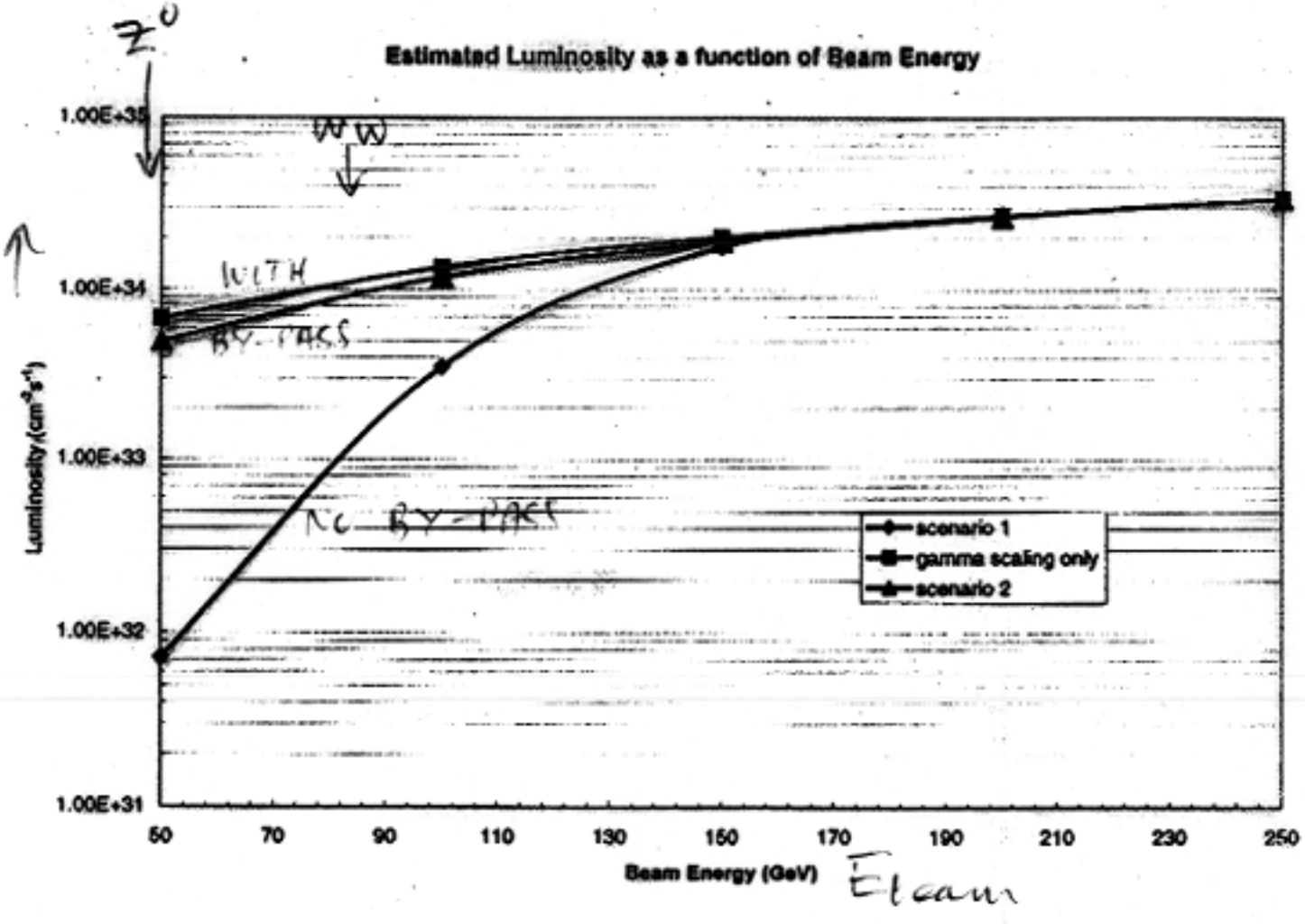
↓ RETURN TO THRESHOLD FOR $\bar{t}tH$

(+ δm_t, TEST S.M. IF HIGGS OR NOT)

↑ δm_t FROM $t\bar{t}$?

C. HIGH $\mathcal{L}$ AT HIGH $\sqrt{s}$

High - $\mathcal{L}$ at $E_{beam} \lesssim 150$ GeV with 2nd e^+e^- source / bypass line.



$\mathcal{L}$ ↑

E_{beam}

PROTECTED TESLA PERFORMANCE AT LOW ENERGY