SELECTRON PAIR PRODUCTION:

Our best chance for high-precision mass measurement for $\tilde{e}_R$, $\tilde{e}_L$

$$e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-$$

$$e_L^- e_L^- \to \tilde{e}_L^- \tilde{e}_L^-$$

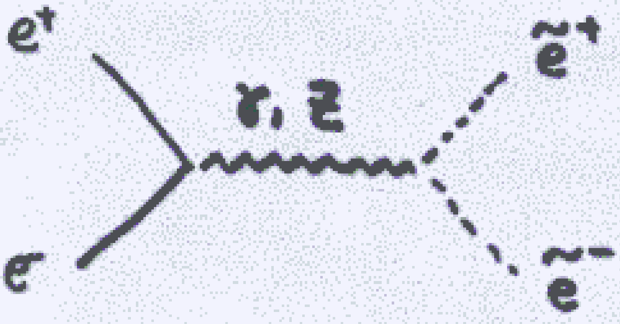
The availability of highly polarized beams in both incoming channels is vital for this measurement

PANDORA simulations done with the help of

Michael Peskin (SLAC)

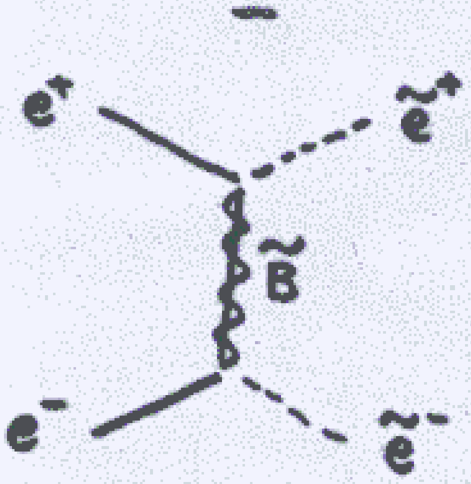
Tim Wolters (Aachen)

DO AS WE DID IN THE PAST: e^+e^- ...



BUT

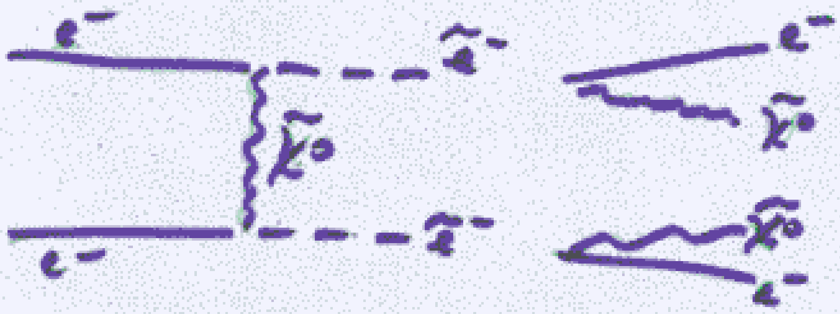
−



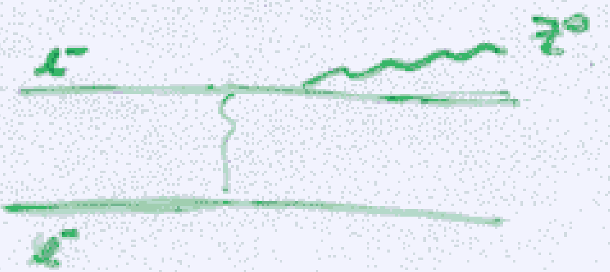
destructive interference

PLENTIFUL BACKGROUNDS

GO TO e^-e^- COLLISIONS:



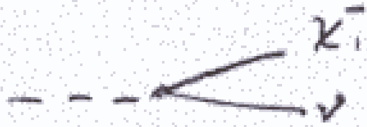
main background:



etc.

HAS CONSIDERABLE ADVANTAGES

once understood, the $\tilde{e}^-$ decay



may also become accessible

FIRST OBVIOUS TASK:

$\left.\begin{matrix}\tilde{e} \\ \tilde{\chi}_1^0\end{matrix}\right\}$ **MASS MEASUREMENTS**

Recall $\tilde{e}^-$ is a scalar,

BUT RECALLS HELICITY LABEL: $\tilde{e}_L^-$, $\tilde{e}_R^-$

we expect $m(\tilde{e}_L) > m(\tilde{e}_R)$ [most models]

certainly $\neq$

The neutralino masses are <u>not</u> predicted in their hierarchy, a vast parameter space to be explored

if gauginos are lightest, → "gaugino region"

" higgsinos " " → "higgsino region"

of neutralino space

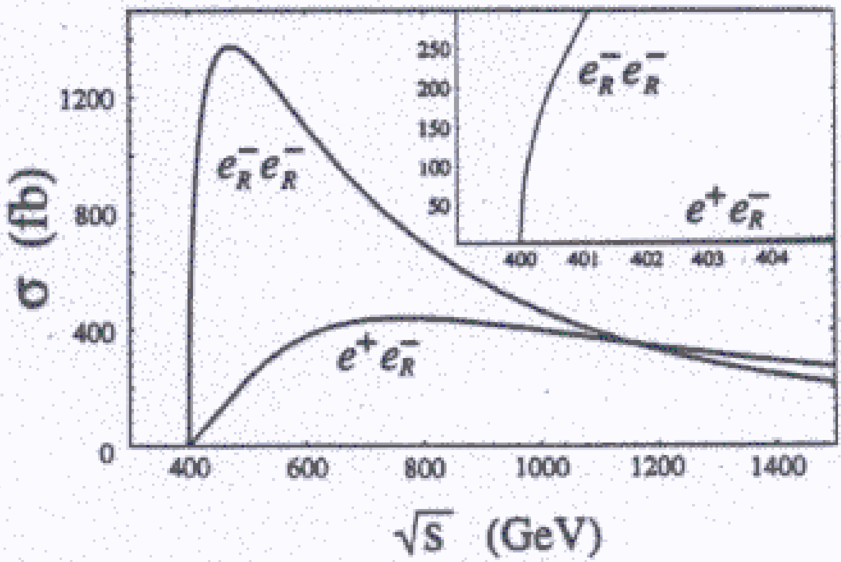
THE PRODUCTION OF PAIRS OF SCALARS AT THRESHOLD HAPPENS IN AN S STATE

($e^+e^- \to$ P STATE, β^3 FACTOR !)

(ANG' MOM' BARRIER)

PRECISION DETERMINATION

OF SELECTRON } MASS
SMUON



Cross sections $\sigma(e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-)$ and $\sigma(e^+ e_R^- \to \tilde{e}_R^+ \tilde{e}_R^-)$ for $m_{\tilde{e}_R} = 200$ GeV and $m_{\tilde{B}} = 100$ GeV. The inset is a magnified view for $\sqrt{s}$ near threshold. Effects of initial state radiation, beamstrahlung, and the selectron width are not included.

MODULO ΔE_{BEAM}

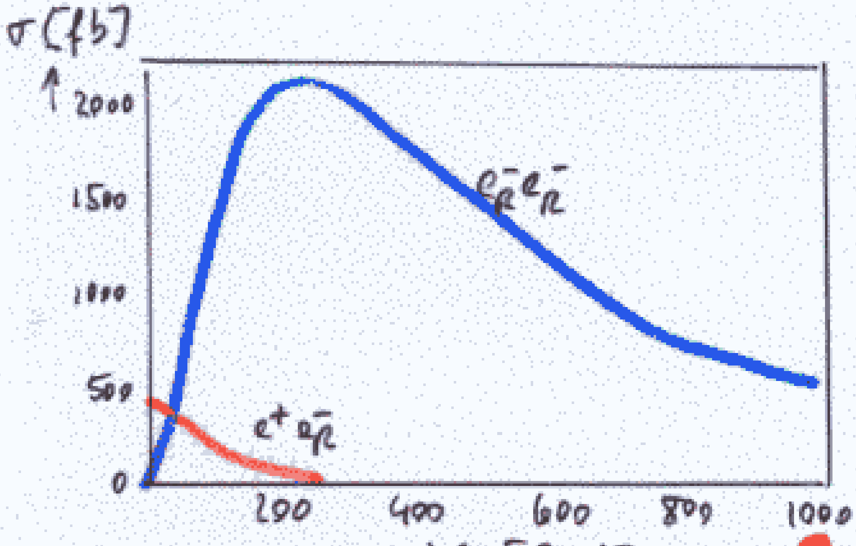
rad' corrections

$\Gamma_{\tilde{e}}, \tilde{\mu}$

M_1 mass measurement:

recall: $\sigma(e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-) \sim \left|\frac{M_{RR}}{t - M_1^2}\right|^2$

$\sim \frac{1}{M_1^2}$ **large M_1**



for $\sqrt{s} = 0.5$ TeV

$m_{\tilde{e}_R} = 200$ GeV

Bino mass

→ take $M_1 = 700$ GeV, find $\underline{1\sigma}$ stat' error from a 100 fb^{-1} high-luminosity measurement $\Delta M_1 \gtrsim 2$ GeV !

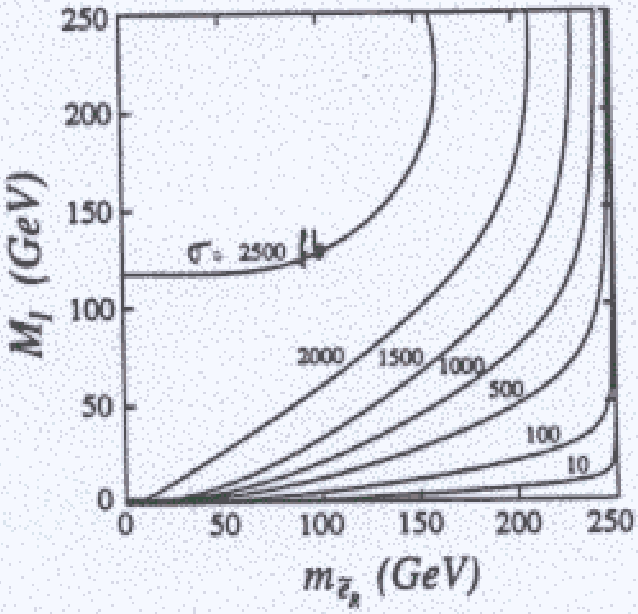
once M_1 is measured, **M_2** can be measured via

$\sigma(e_L^- e_L^- \to \tilde{e}_L^- \tilde{e}_L^-)$

__NOTE__: SUCH LARGE GAUGINO MASSES (possible in Higgsino region) in gravity mediated models) ARE __VERY__ HARD TO MEASURE ELSEWHERE.

mass determination: $\tilde{e}_R$, M_1

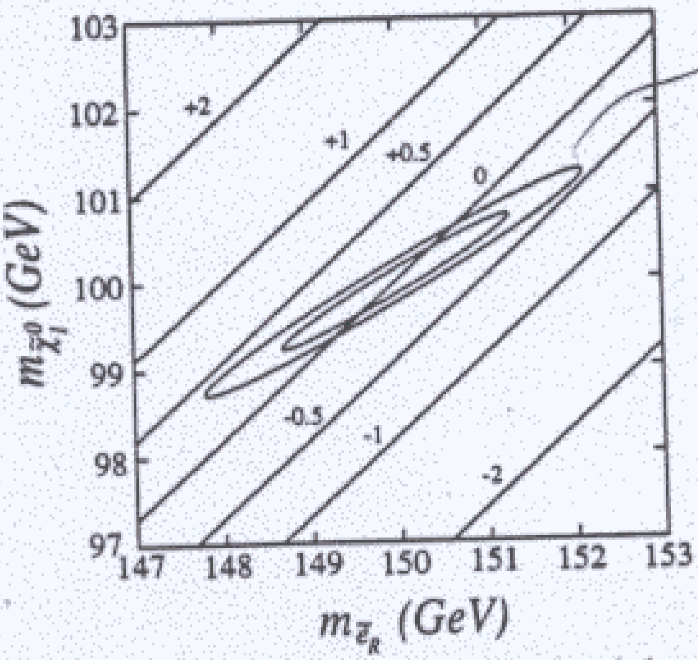
$\sqrt{s}$ = 500 GeV



Contours of constant $\sigma_R = \sigma(e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-)$ in fb in the $(m_{\tilde{e}_R}, M_1)$ plane for $\sqrt{s} = 500$

mass determination: $\tilde{e}_R$, $\tilde{\chi}_1^0$

uncertainty ellipsis $\Delta E = 0.3, 0.5$ GeV assuming $m_{\tilde{e}_R}$ = 150 GeV, $m_{\tilde{\chi}_1^0}$ = 100 GeV, end point measurement of final-state e



The allowed regions, "uncertainty ellipses," of the $(m_{\tilde{e}_R}, m_{\tilde{\chi}_1^0})$ plane, determined by measurements of the end points of final state electron energy distributions with uncertainties ΔE = 0.3 GeV and 0.5 GeV. The underlying central values are $(m_{\tilde{e}_R}, m_{\tilde{\chi}_1^0})$ = (150 GeV, 100 GeV), and $\sqrt{s}$ = 500 GeV. We also superimpose contours (in percent) of the fractional variation of σ_R with respect to its value at the underlying parameters.

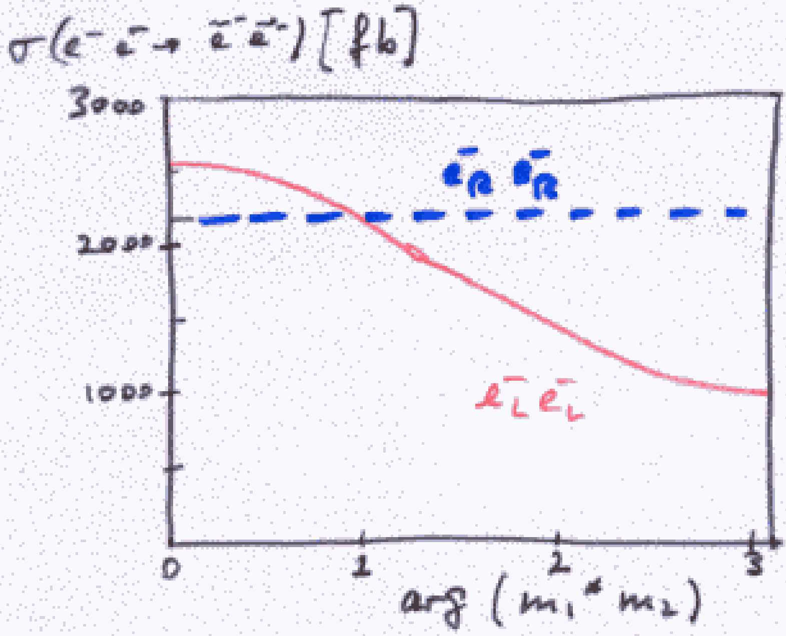
S. Thomas

CP violating phases:

phase-dependent interference takes place between different neutralino mass eigenstates in the same channel,

not suppressed well above threshold

TOTAL CROSS SECTION in pure $\left\{ \begin{matrix} \text{higgsino} \\ \text{gaugino} \end{matrix} \right\}$ limit:



$\sqrt{s} = 0.5$ TeV

$|m_1| = 100$ GeV

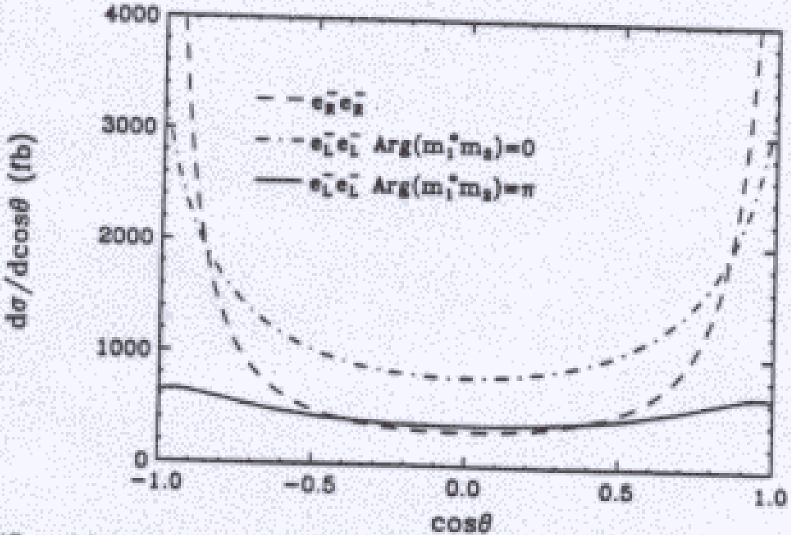
$|m_2| = 200$ GeV

$m_{\tilde{e}_R} = 130$ GeV

$m_{\tilde{e}_L} = 180$ GeV

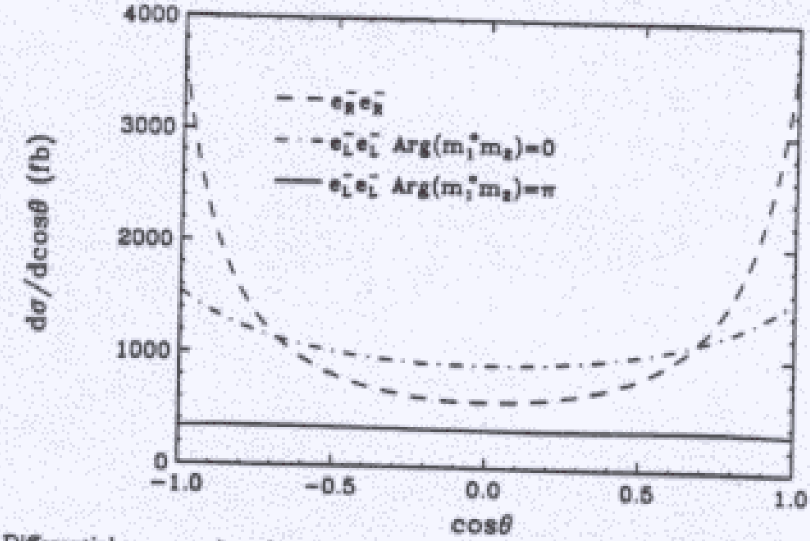
For comparison, note that

$R(\sqrt{s} = 0.5 \text{ TeV}) = 400$ fb



Differential cross sections for $e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-$ and $e_L^- e_L^- \to \tilde{e}_L^- \tilde{e}_L^-$ in the pure gaugino or Higgsino limit for $\mathrm{Arg}(m_1^* m_2) = 0, \pi$. The parameters are the same those in fig. 1.

sensitivity to chosen m's



Differential cross sections for $e_R^- e_R^- \to \tilde{e}_R^- \tilde{e}_R^-$ and $e_L^- e_L^- \to \tilde{e}_L^- \tilde{e}_L^-$ in the pure gaugino or Higgsino limit for $\mathrm{Arg}(m_1^* m_2) = 0, \pi$. The parameters are $\sqrt{s} = 500$ GeV, $|m_1| = 150$ GeV, $|m_2| = 300$ GeV, $m_{\tilde{e}_R} = 170$ GeV, and $m_{\tilde{e}_L} = 210$ GeV.

SUSY Breaking:

At low energies, three possibilities

- Gravity-mediated: SUSY is broken in a hidden sector, transmitted gravitationally to observable sector fields
  But: flavor problem
- •• Gauge-mediated: SUSY breaking is transmitted via gauge forces
  distinctive exp'tal signatures
- ••• Anomaly-mediated: Rescaling anomalies in the SUSY Lagrangian cause soft mass parameters for observable sector fields
  → must always be present when SUSY is broken

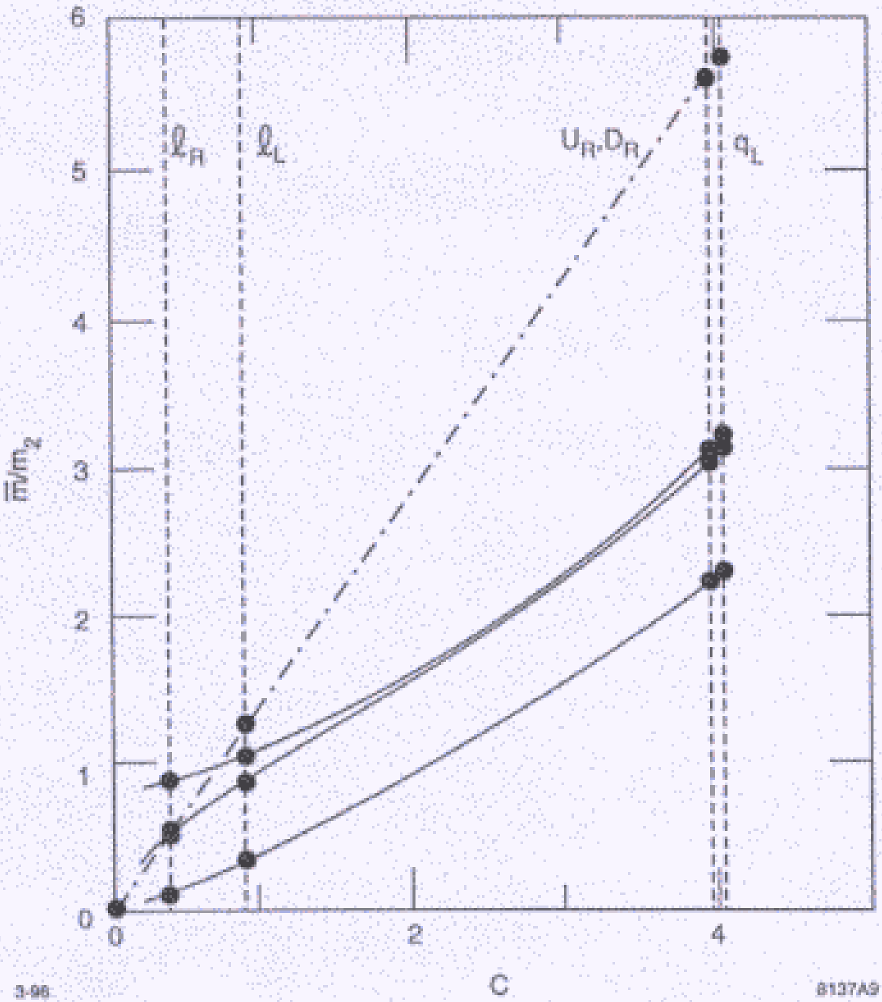
  Gherghetta, Giudice, Wells

(•••) LEADS TO THE NEED FOR HIGH-RESOLUTION MASS MEASUREMENT OF SLEPTON & NEUTRALINO SECTOR

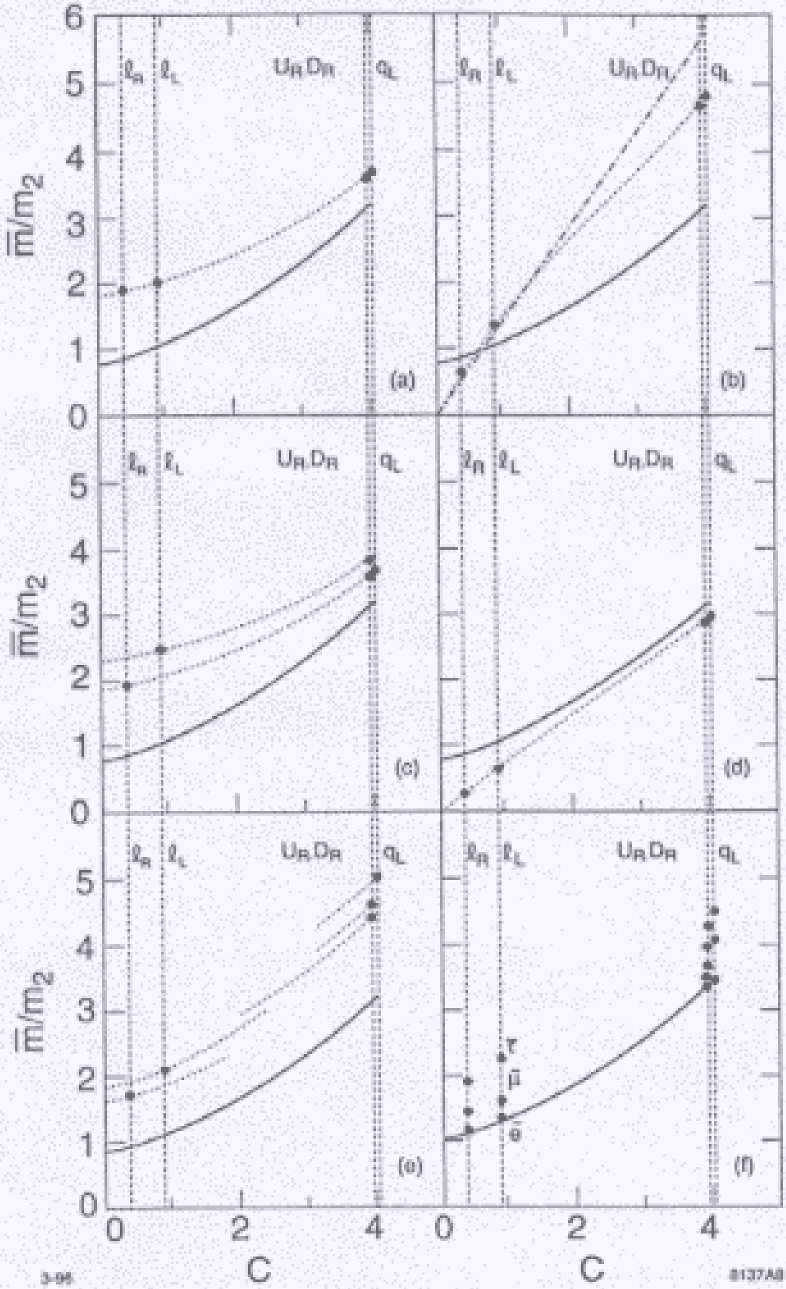
Right-handed }
Left-handed } selectrons may well differ in mass by a factor of 2

or by very small amounts

→ a harbinger of SUSY breaking mechanism



Some reference models displayed on the Dine-Nelson plot. The solid lines show the integration of the renormalization group equation for two values of the messenger scale. The dotted line shows the linear relation predicted in the model of Dine, Nelson, Nir, and Shirman.



Six classes of models of supersymmetry breaking, displayed as patterns on the Dine-Nelson plot. The solid reference line is the result of integrating the renormalization group equation from the string scale. The models (a)-(f) are described in the text.

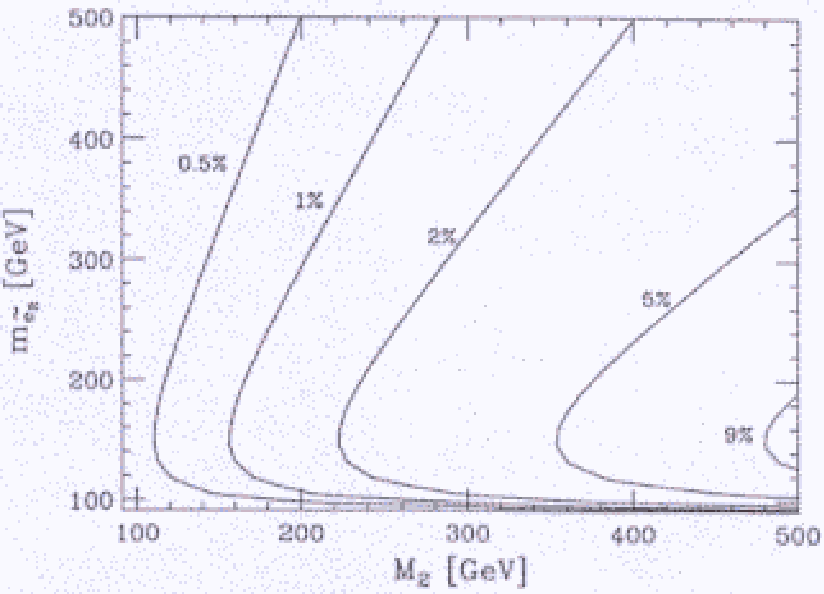
Anomaly-mediated SUSY Breaking:

$$\Delta_{\tilde{\ell}} = m^2_{\tilde{e}_L} - m^2_{\tilde{e}_R} = (11\tan^4\theta_W - 1)\frac{3}{2}M_2^2 + (-\frac{1}{2} + 2\sin^2\theta_W)m_Z^2 \cos 2\beta + \frac{1}{8\pi^2}\left(\frac{9}{5}g_1^2 M_1^2 - 3g_2^2 M_2^2\right)\ln\frac{m_{\tilde{e}_R}}{m_Z}$$

Several numerical accidents, such as

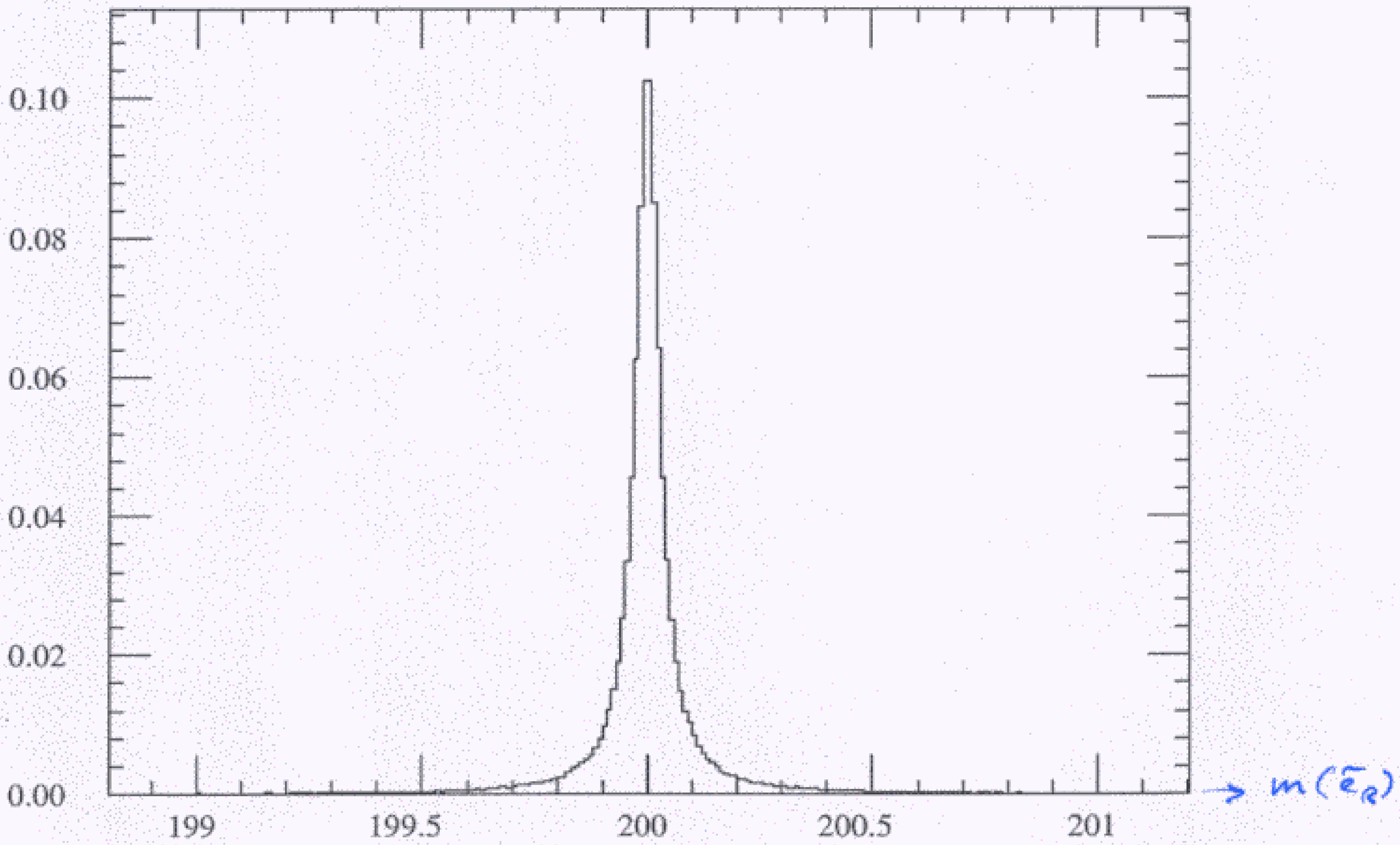
$$\sin^2\theta_W = \frac{1}{1+\sqrt{11}} = 0.2317 \quad (!)$$

permit (near-) degeneracy of $m_{\tilde{e}_R}$, $m_{\tilde{e}_L}$



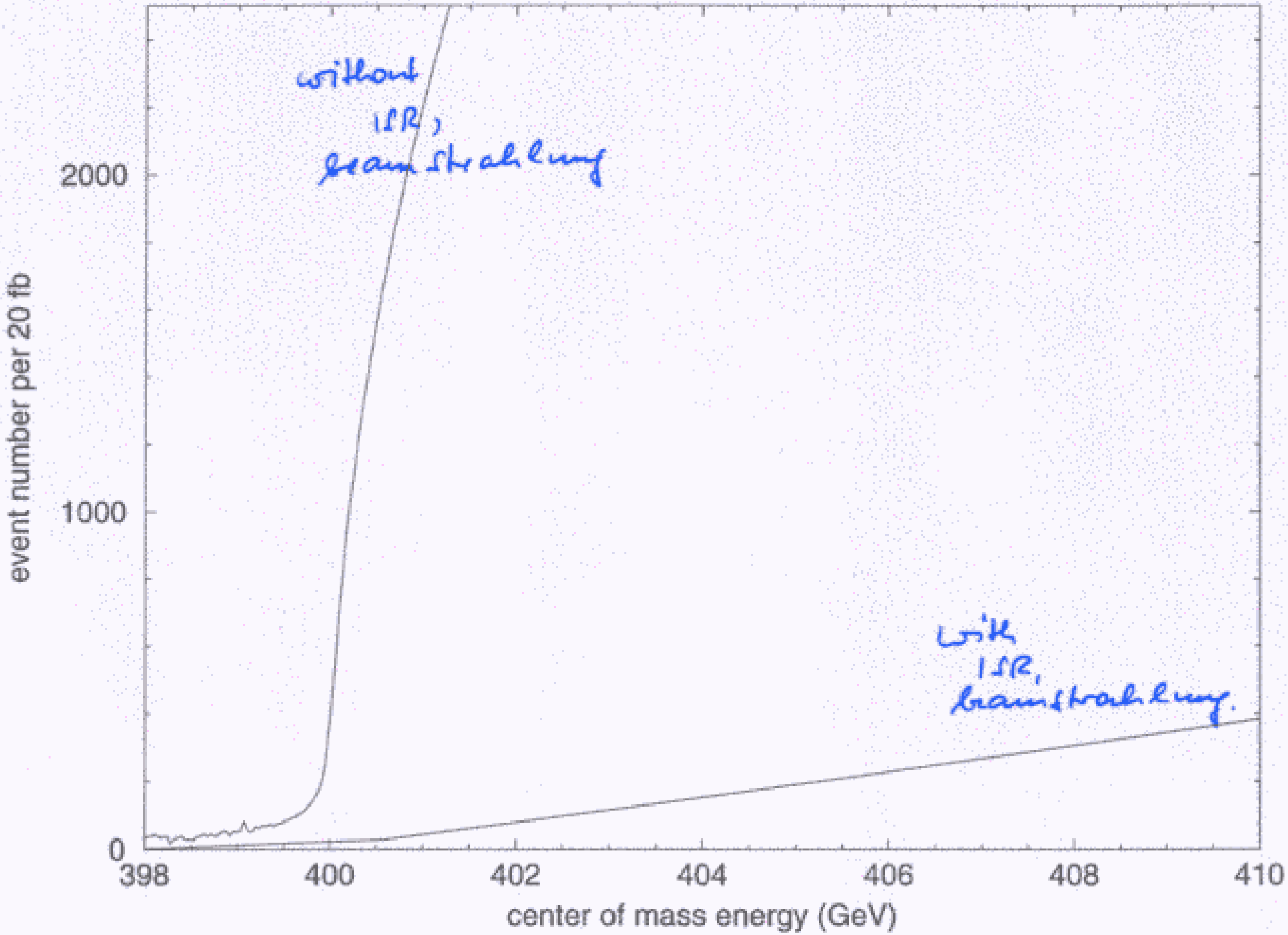
Contours of $100\% \times (m_{\tilde{e}_L} - m_{\tilde{e}_R})/m_{\tilde{e}_R}$ in the M_2-$m_{\tilde{e}_R}$ mass plane with large $\tan\beta$, which maximizes the mass splitting.

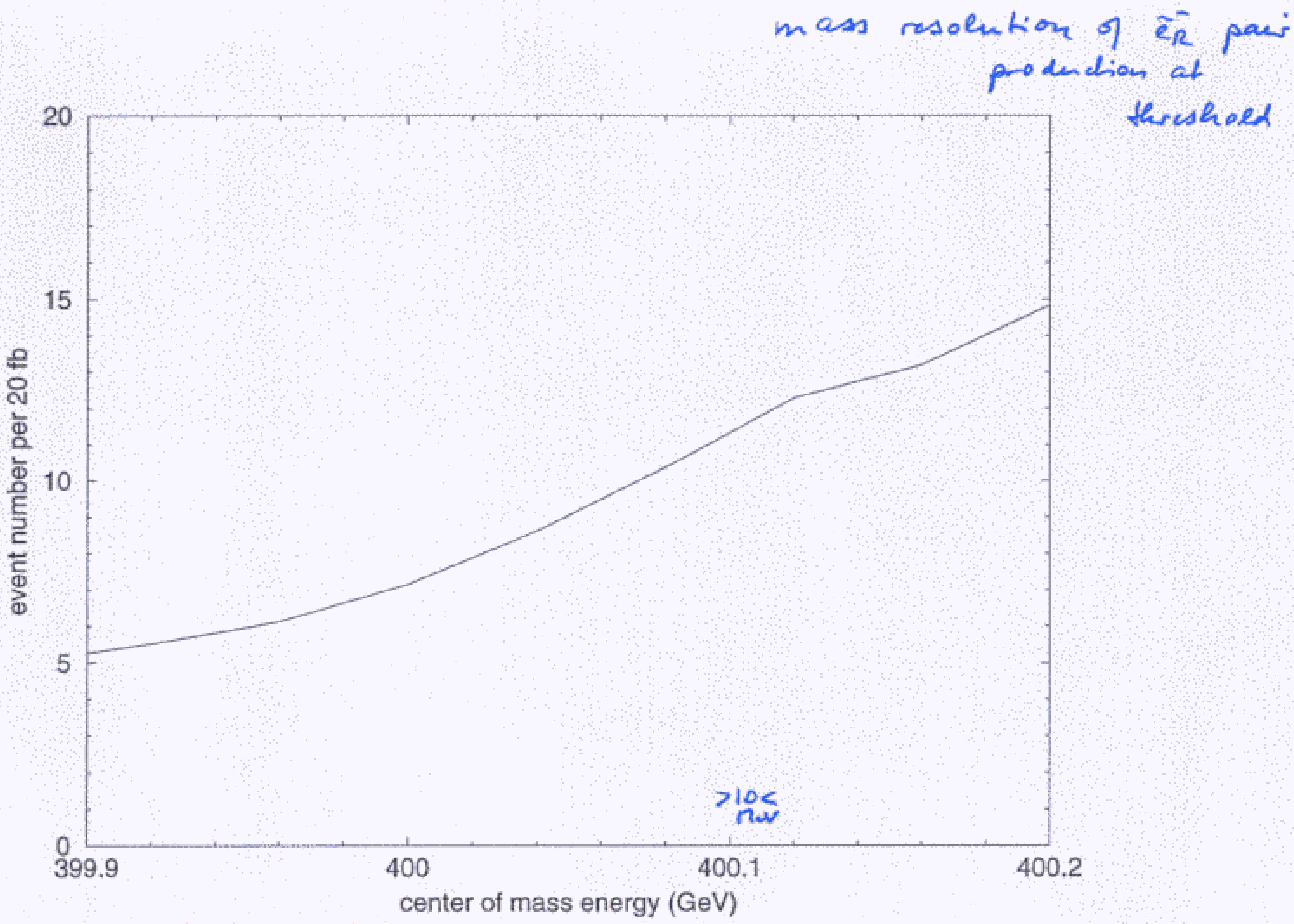
THIS MAKES A VERY PRECISE $m(\tilde{e}_R)$, $m(\tilde{e}_L)$ MEASUREMENT HIGHLY DESIRABLE !



PANDORA input: mass and width of $\tilde{e}_R$

$e_R^- e_R^- \to \tilde{\tau}_R^- \tilde{\tau}_R^-$
at threshold.




mass resolution of $\tilde{e}_R$ pair production at threshold
20
15
10
5
0
event number per 20 fb
399.9
400
400.1
400.2
center of mass energy (GeV)