New Particle Searches at LEP200++

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- Searches Overview: what to look for?
- Update on LEP
- Search Results
  - Standard Model Higgs
  - “Standard” SUSY
  - Gauge Mediated SUSY Particles
  - Excited Leptons
  - Gravity in extra dimensions
- Conclusions

Why Search? Start from the Standard Model

Fermions

$$\begin{pmatrix} u \\ d \end{pmatrix}_L \begin{pmatrix} c \\ s \end{pmatrix}_L \begin{pmatrix} t \\ b \end{pmatrix}_L$$

$$\begin{matrix} u_R & c_R & t_R \\ d_R & s_R & b_R \end{matrix}$$

$$\begin{pmatrix} \nu_e \\ e \end{pmatrix}_L \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix}_L \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}_L$$

$$\begin{matrix} e_R & \mu_R & \tau_R \end{matrix}$$

Bosons

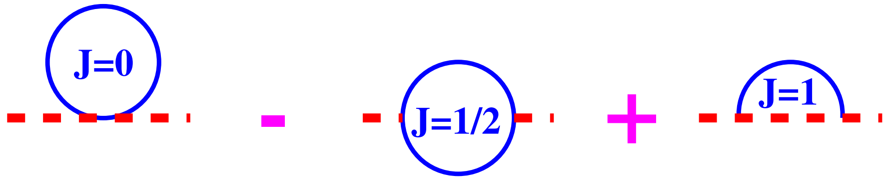
$$\left\{ W_1 \;\; W_2 \;\; W_3 \right\} \;\; B$$

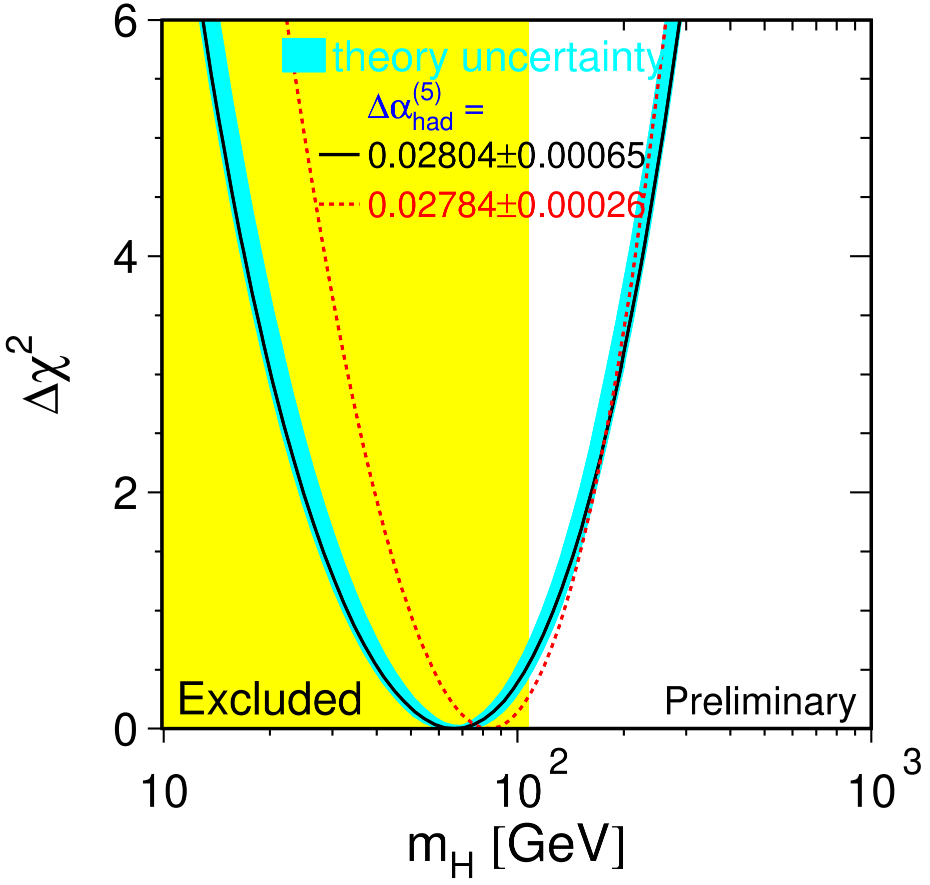
$$\Downarrow \; \cancel{EW}$$

$$\left\{ W^{+/-} \;\; Z^0 \;\; \gamma \right\}$$

$$H^0_{SM}$$

$$\delta m_{H^0_{SM}} =$$





⇒ Require many masses, generations, mixing angles, and fine tuning ...

Roadmap Beyond the Standard Model

$\{ W_1 \; W_2 \; W_3 \}$ B

$\begin{pmatrix} u \\ d \end{pmatrix} \begin{pmatrix} c \\ s \end{pmatrix} \begin{pmatrix} t \\ b \end{pmatrix}$

$\begin{pmatrix} \nu_e \\ e \end{pmatrix} \begin{pmatrix} \nu_\mu \\ \mu \end{pmatrix} \begin{pmatrix} \nu_\tau \\ \tau \end{pmatrix}$

MORE? $\Longrightarrow$ $\begin{pmatrix} t' \\ b' \end{pmatrix}$ $\begin{pmatrix} \nu_L \\ L \end{pmatrix}$

composite? $\Longrightarrow$ $\begin{pmatrix} q^*_{2/3} \\ q^*_{1/3} \end{pmatrix}$ $\begin{pmatrix} \nu^*_l \\ l^* \end{pmatrix}$

~~EW~~ $\Downarrow$

H^0_{SM} $\{ W^{+/-} \; Z^0 \; \gamma \}$

Hierarchy Problem $\Downarrow$

~~SUSY~~ $\xRightarrow{\text{Minimal}}$ MSSM $\xRightarrow{\text{FCNC}}$

SUGRA $\{$ STRINGY, $\tilde{\chi}^0$ CDM

GMSB $\{$ AVOID GRAVITY FCNC, ...

$\boxed{\text{SUSY}}$ $\Longrightarrow$ $\tilde{W}^{+/-} \; \tilde{Z}^0 \; \tilde{\gamma}$ $\begin{pmatrix} \tilde{u} \\ \tilde{d} \end{pmatrix} \begin{pmatrix} \tilde{c} \\ \tilde{s} \end{pmatrix} \begin{pmatrix} \tilde{t} \\ \tilde{b} \end{pmatrix}$

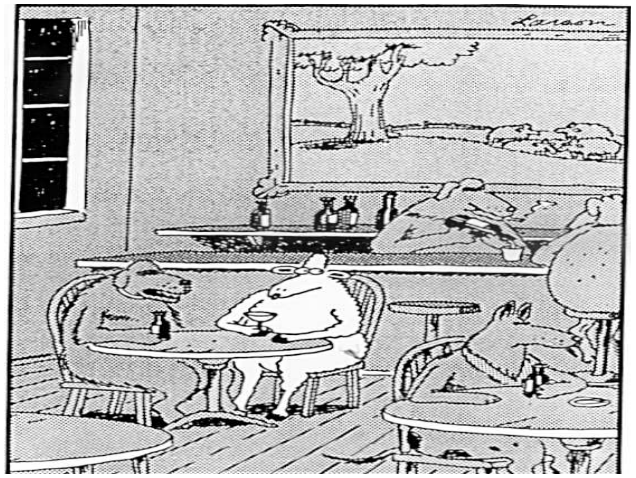
$\tilde{h}^0 \; \tilde{H}^0 \; \tilde{H}^{+/-}$ $\begin{pmatrix} \tilde{\nu}_e \\ \tilde{e} \end{pmatrix} \begin{pmatrix} \tilde{\nu}_\mu \\ \tilde{\mu} \end{pmatrix} \begin{pmatrix} \tilde{\nu}_\tau \\ \tilde{\tau} \end{pmatrix}$

$\Downarrow$ 2HDM

$h^0 H^0 A^0 H^{+/-}$

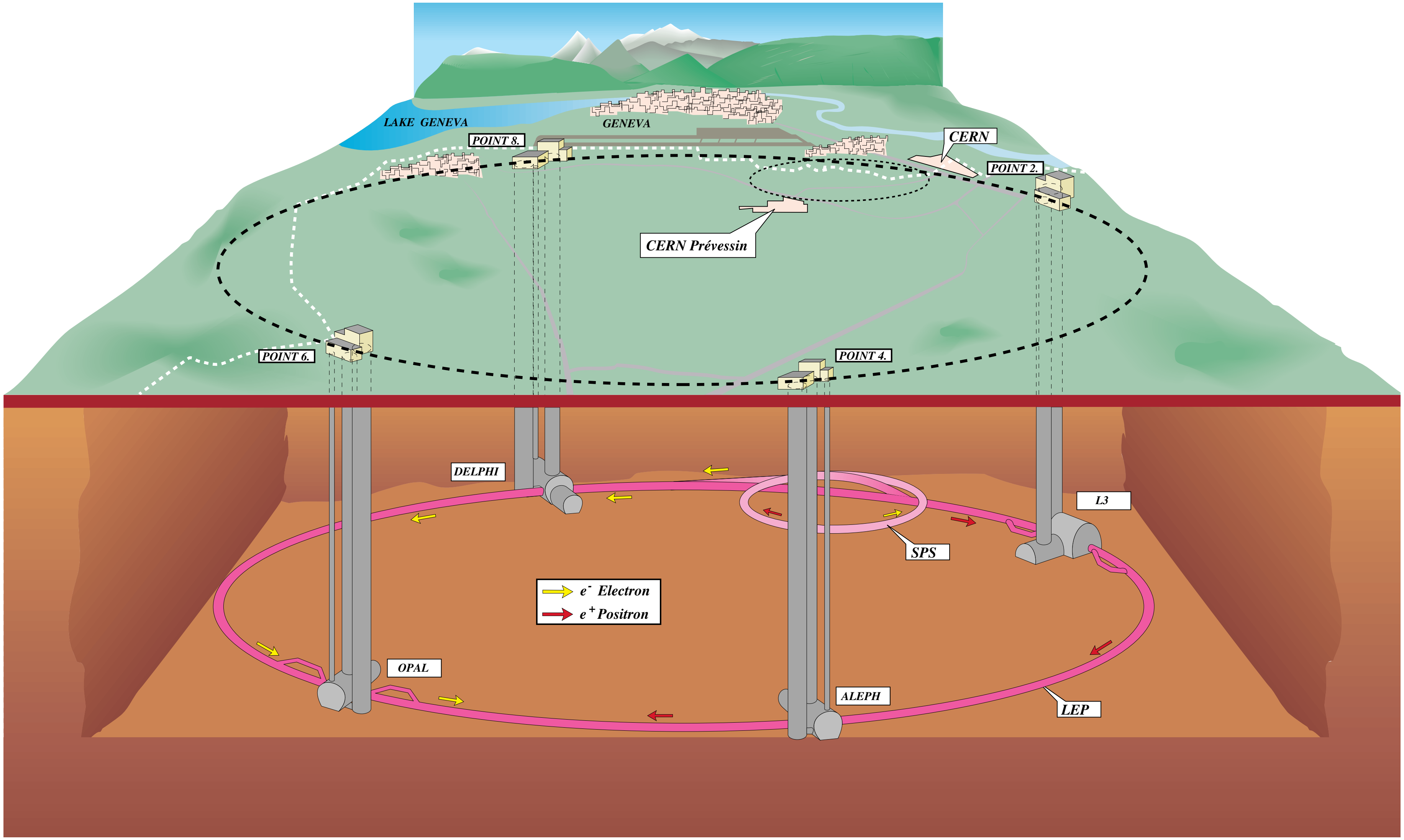
TECHNICOLOUR

GRAVITY IN EXTRA DIMENSIONS



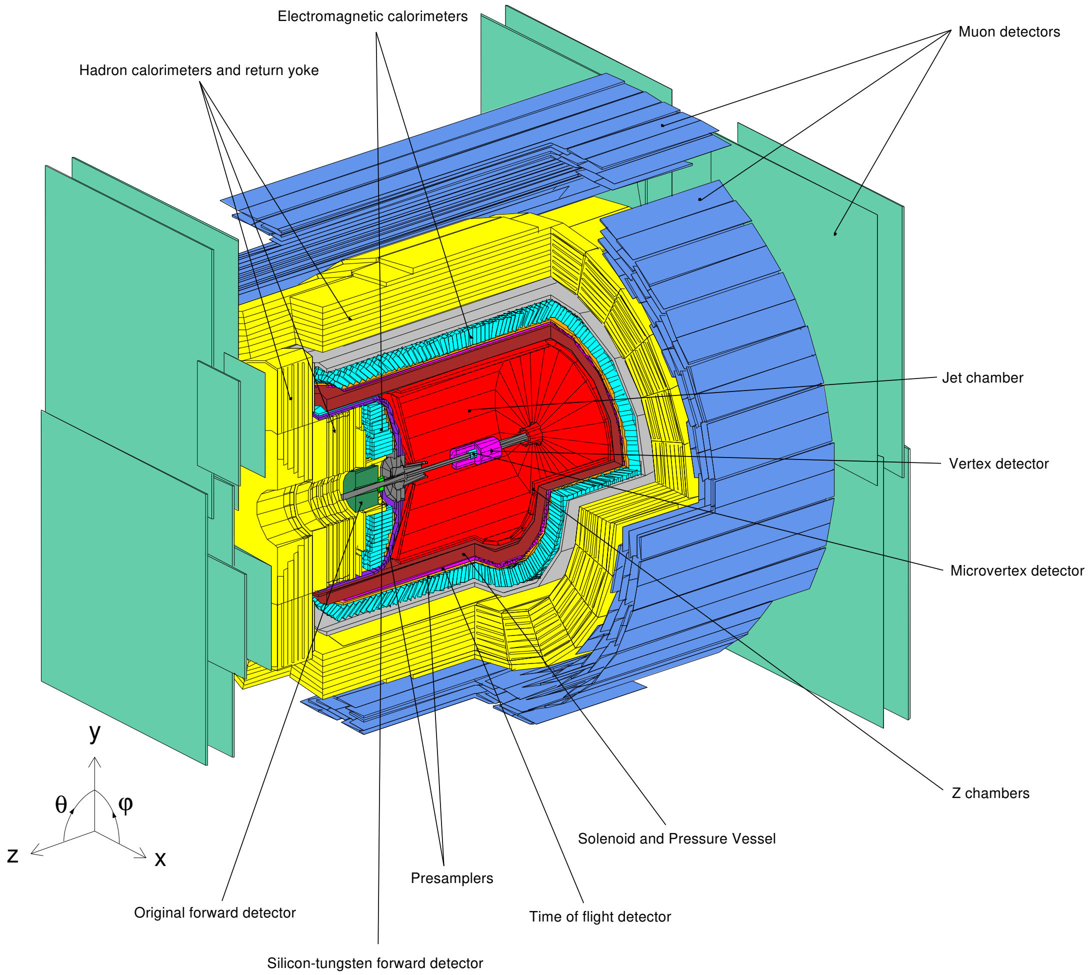
Confession time, Mona: I've lead you astray.

The LEP e^+e^- Collider



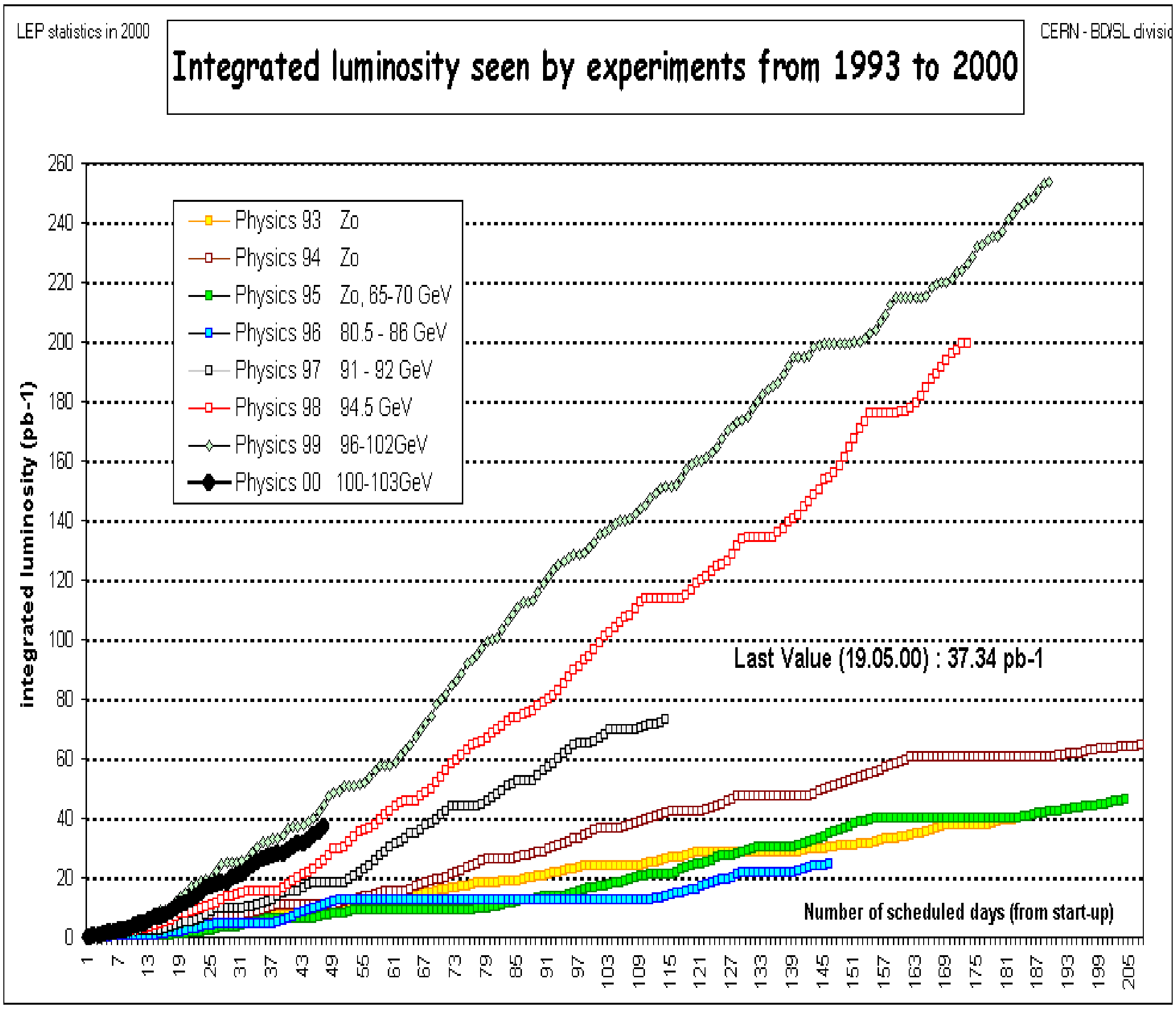
Typical LEP Detector

- Central drift chambers (x, y, z)
  - Magnet $\Rightarrow$ $\boldsymbol{p}$
- Si detector $\Rightarrow$ b-tag
- Hermetic Calorimetry
  - EM and Hadronic
  - $|\cos\theta| >\sim$ 20 mrad
- Muon chambers



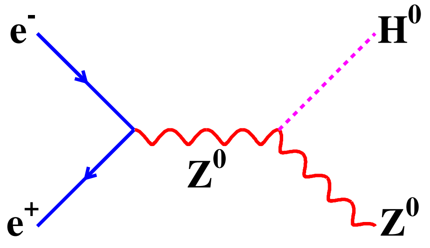
LEP2 Data Sets

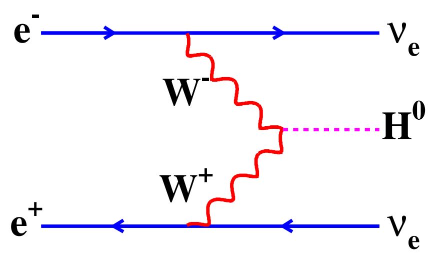
Stage	$\sqrt{s}$	Year	Luminosity
LEP 1	$\approx$ 91 GeV	1989-1995	175 pb^{-1}
LEP 1.5	130-140 GeV	1995	5 pb^{-1}
	161 GeV	1996	10 pb^{-1}
	172 GeV	1996	10 pb^{-1}
LEP 2	183 GeV	1997	55 pb^{-1}
	189 GeV	1998	$\sim$180 pb^{-1}
	192–202 GeV	1999	$\sim$230 pb^{-1}
	200–210! GeV	2000	???



Standard Model Higgs

- Production by "Higg-strahlung:" $e^+e^- \rightarrow ZH^0$



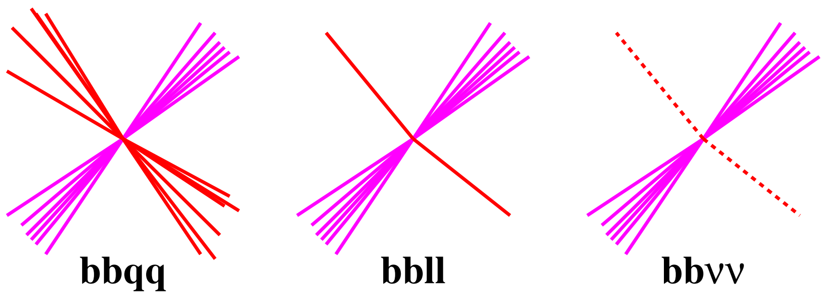


- Different Search Topologies:

$e^+e^- \longrightarrow$ H Z

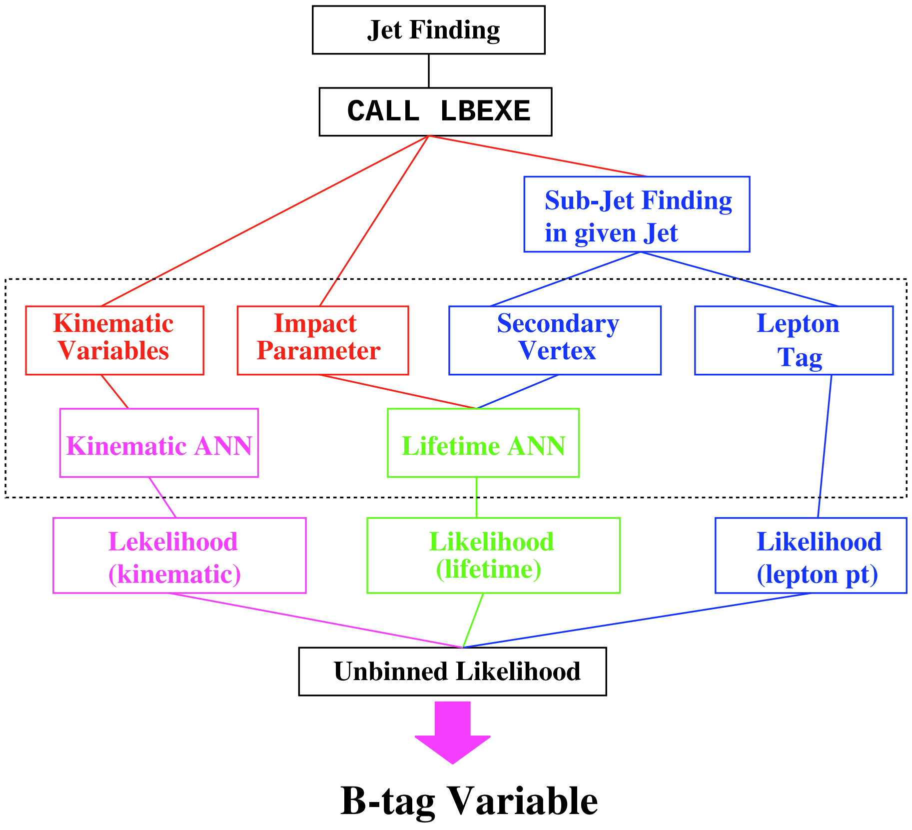
- H
  - $\rightarrow b\bar{b}$
  - $\rightarrow \tau^+\tau^-$
- Z
  - $\rightarrow q\bar{q}$
  - $\rightarrow \nu\bar{\nu}$
  - $\rightarrow e^+e^-, \mu^+\mu^-, \tau^+\tau^-$
  - $\rightarrow q\bar{q}$

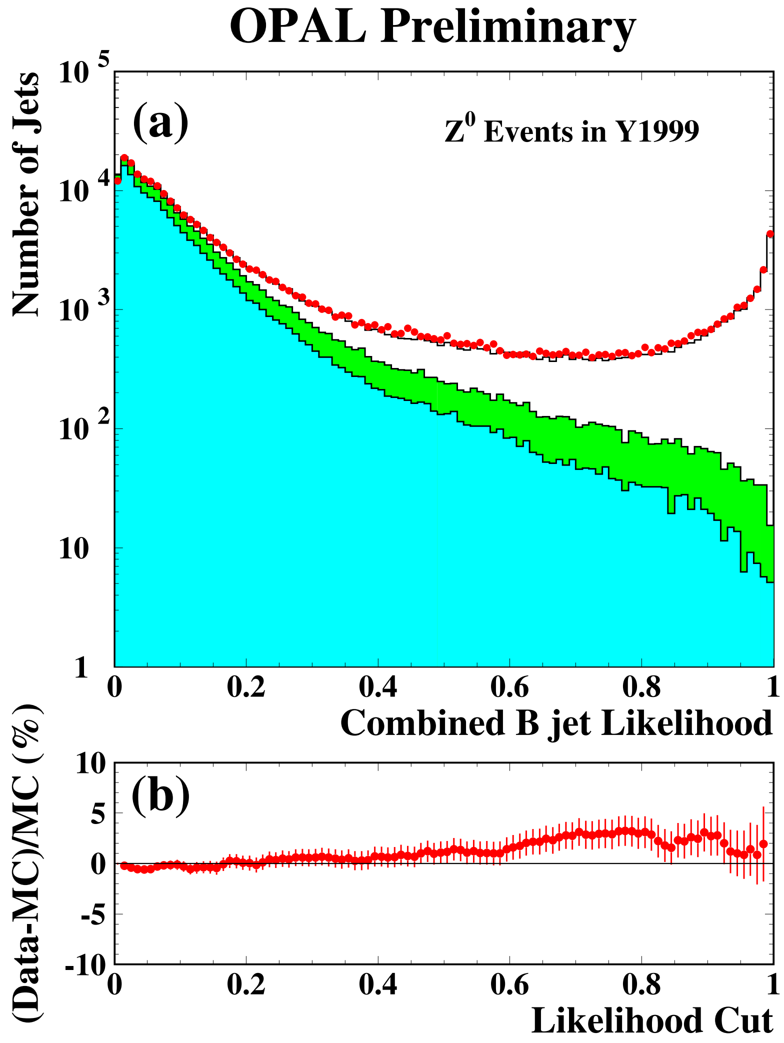
- Dominant Channels:



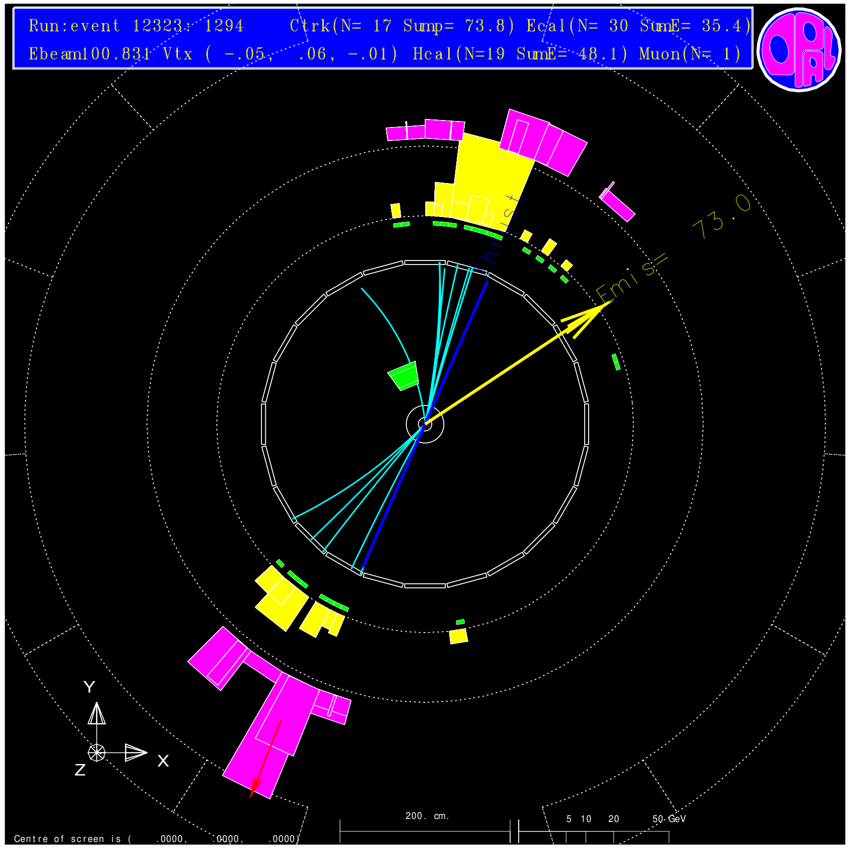
● Key to analysis: b-tagging ●

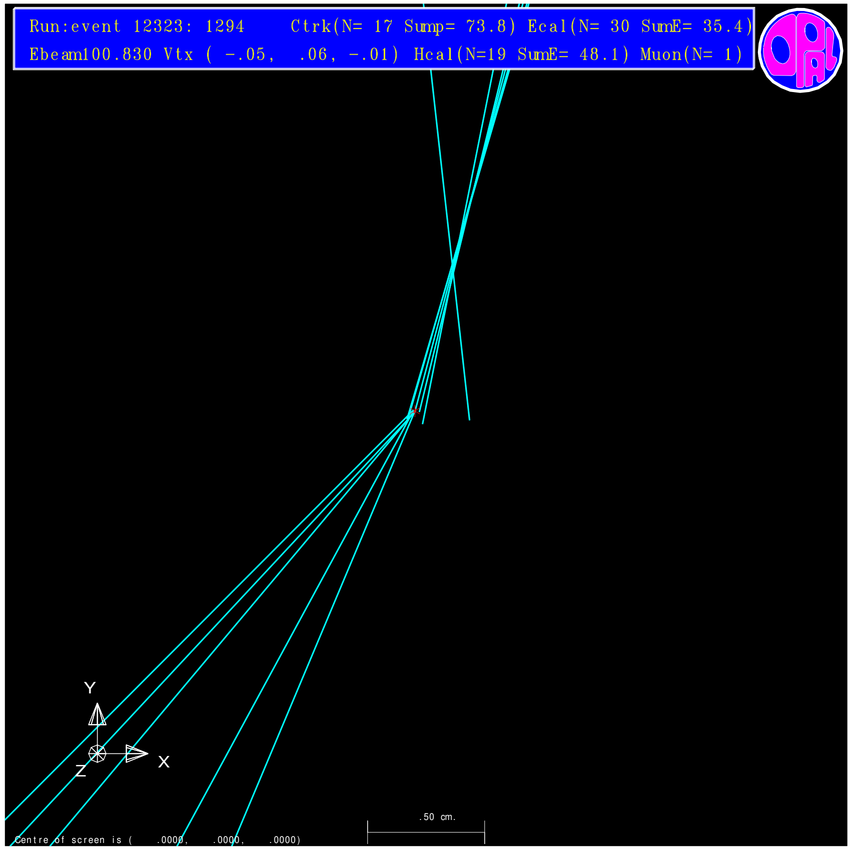
Example: higgs b-Tagging in OPAL





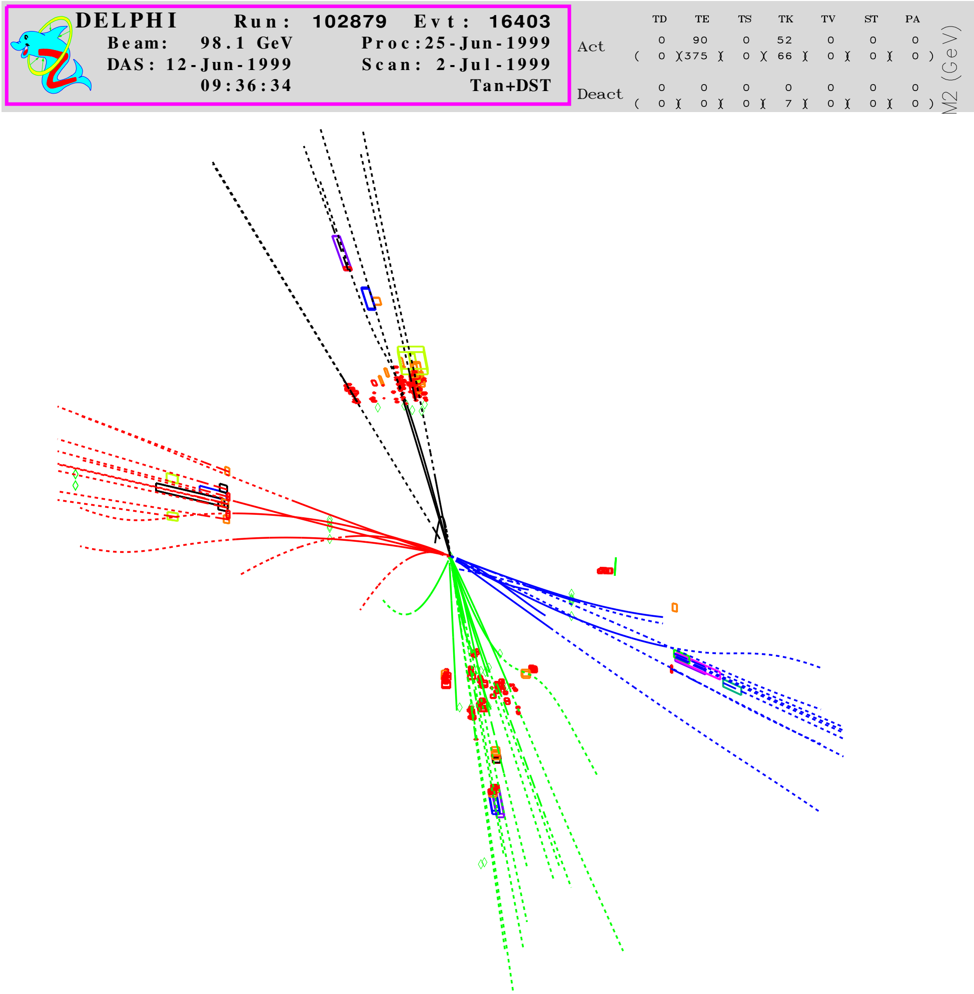
OPAL: Higgs Candidate at $\sqrt{s} = 202$ GeV

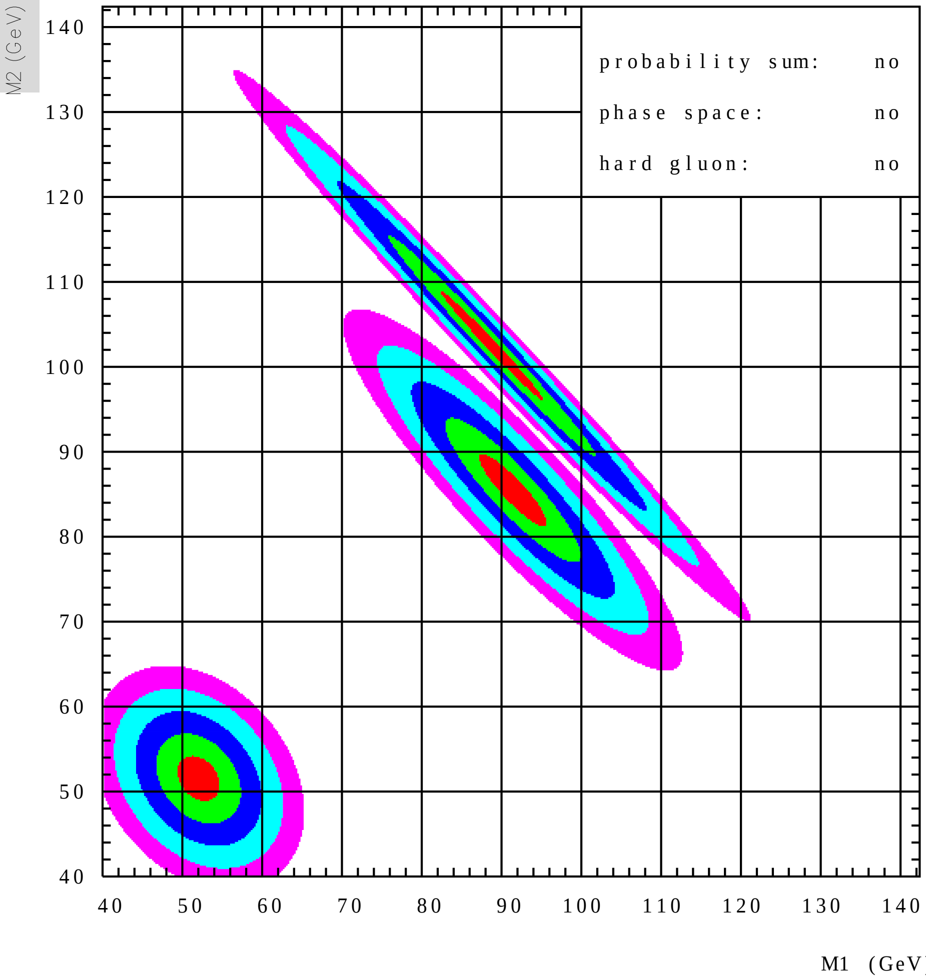




Candidate $\mathrm{e^+e^-} \rightarrow \mathrm{H^0Z^0} \rightarrow \mathrm{b\bar{b}}\nu\nu$ $M_{\mathrm{H^0}} = 106$ GeV

DELPHI: Higgs Candidate

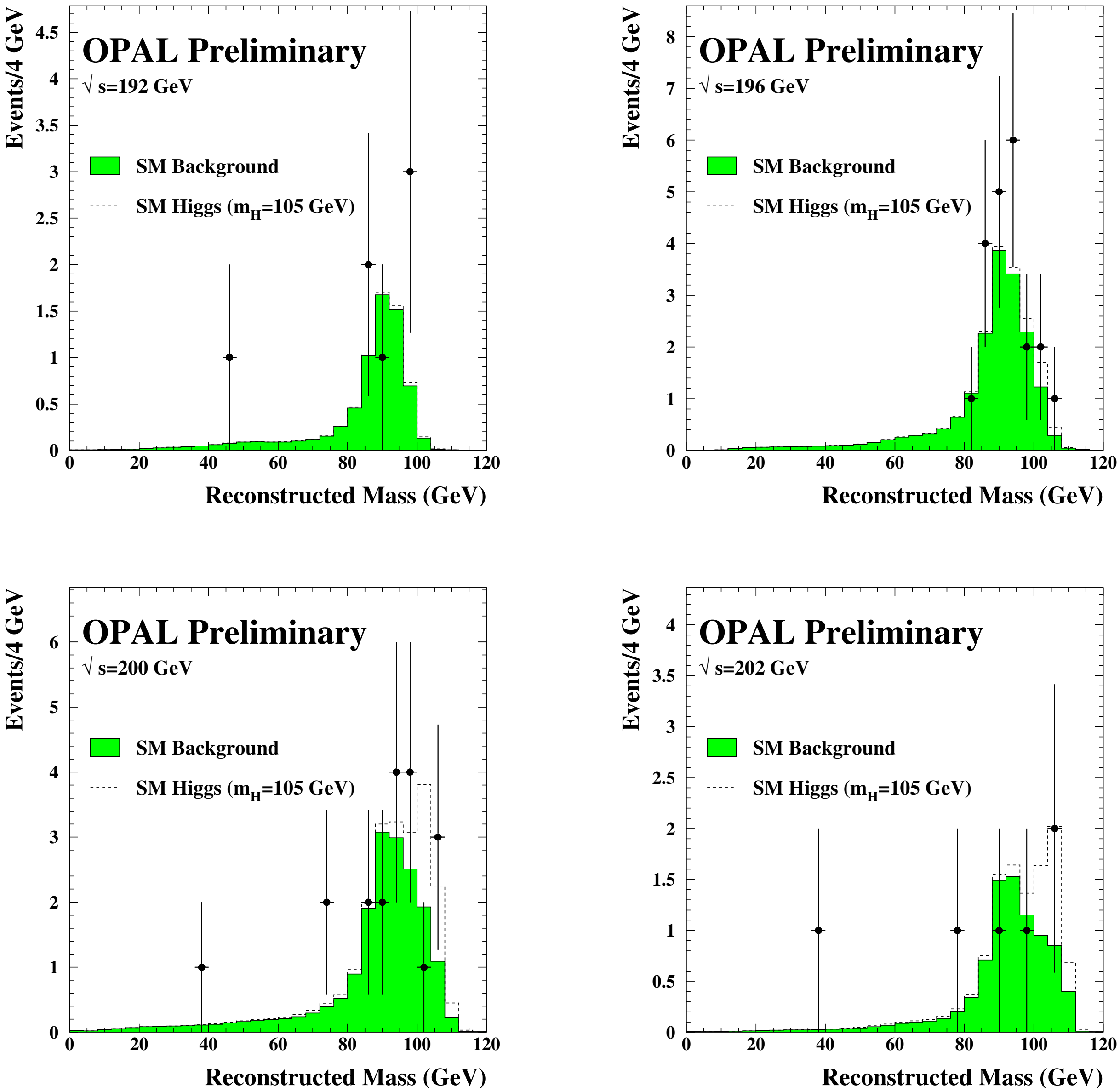




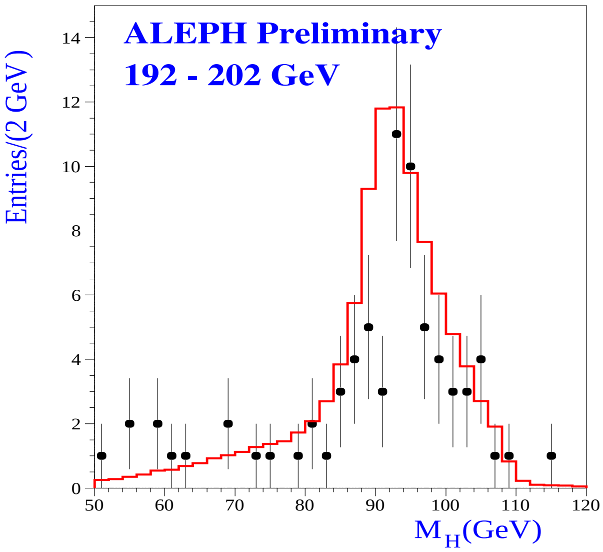
Higgs mass spectra

⇒ Look for high mass signal "turning on" with increasing $\sqrt{s}$

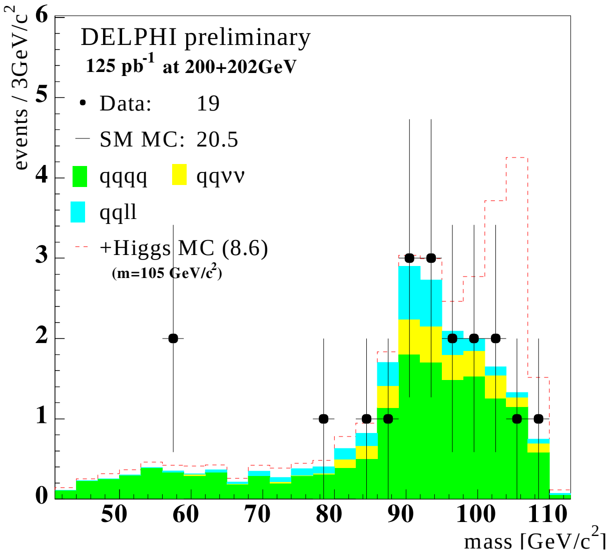
OPAL 1999 data: $\sqrt{s} \sim$ 192, 196, 200 and 202 GeV



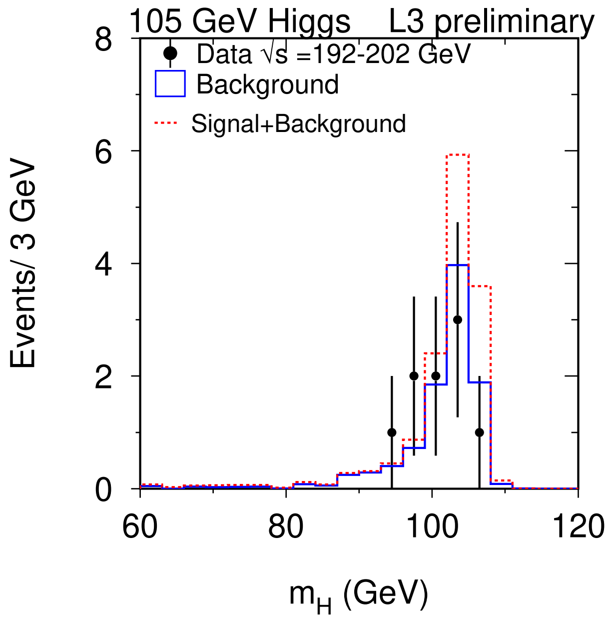
Higgs Mass Spectra, LEP 1999



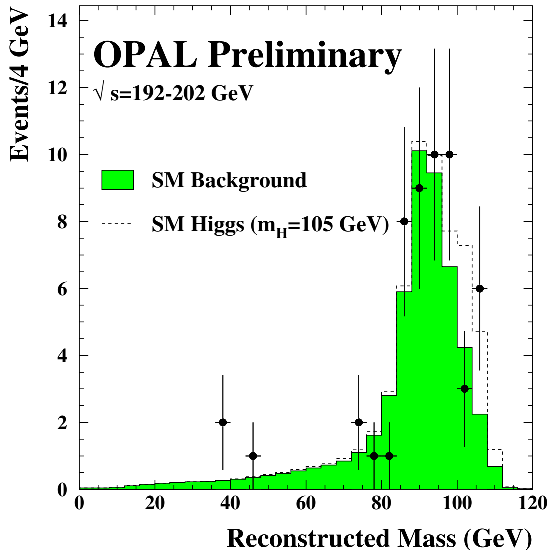
Data: 74
Bkg.: 97.8



Data: 19
Bkg.: 20.5



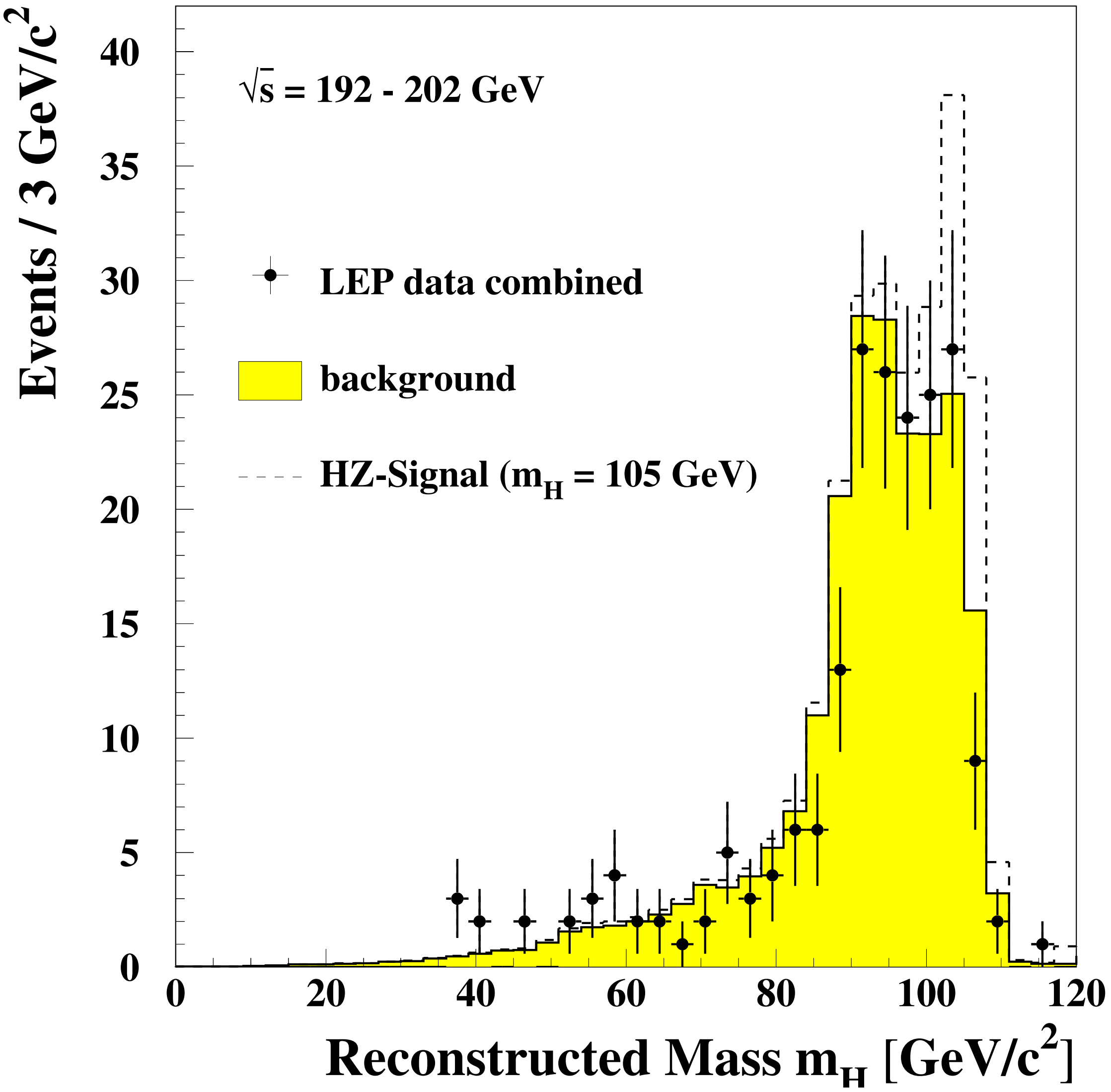
Data: 9
Bkg.: 9.9



Data: 53
Bkg.: 51.5

LEP Combined

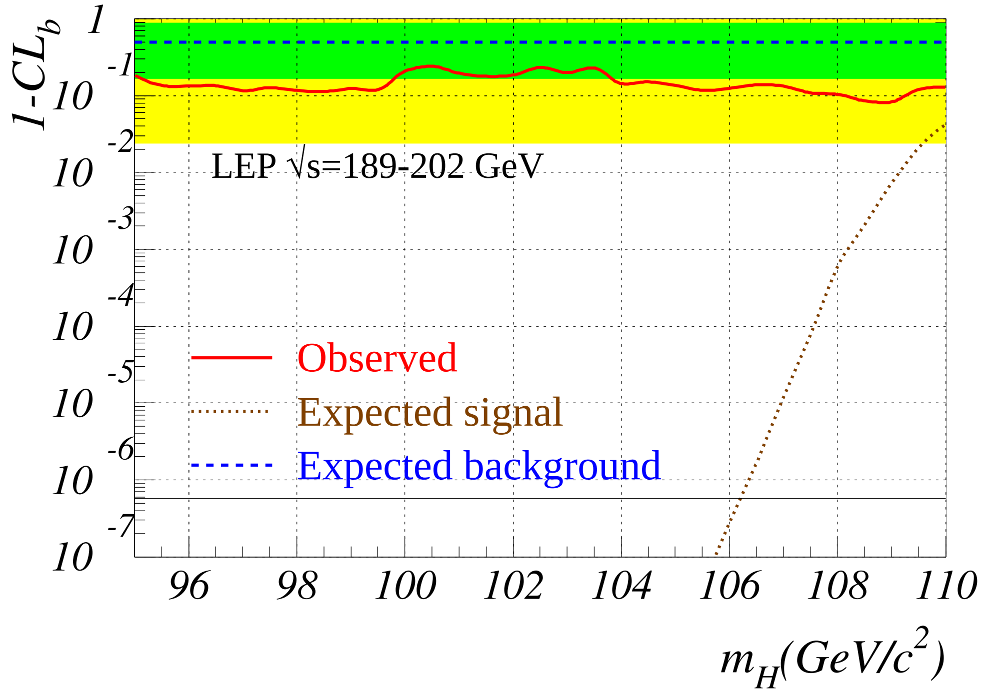
(Retune analyses to give same background per experiment)

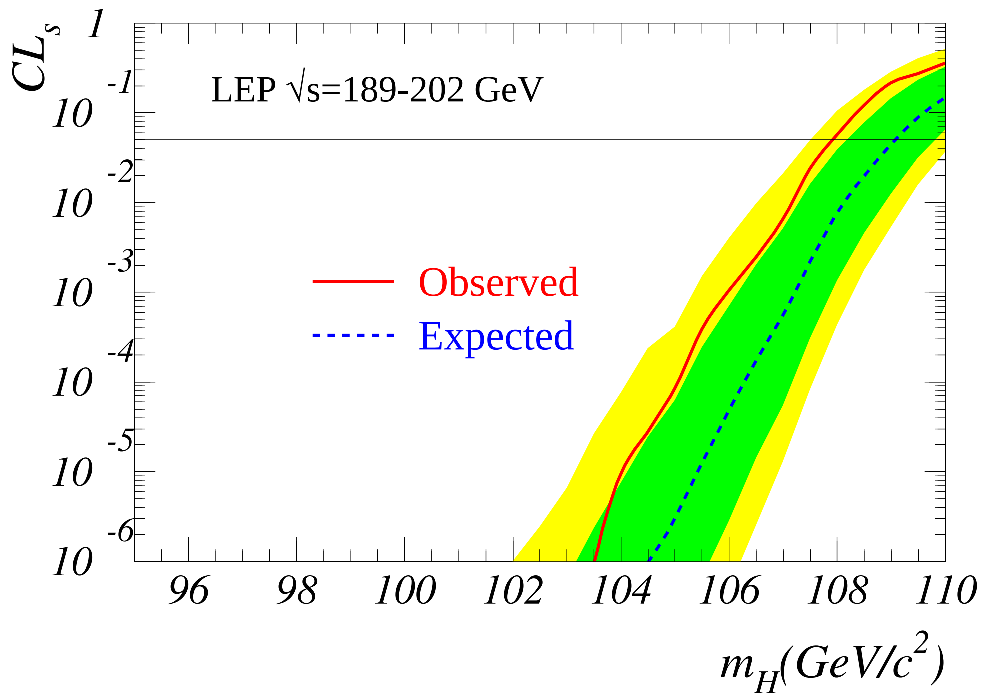


Data	Background (SM)	Expectation $M_{H^0} = 105$ GeV
201	220	40.7

SM Higgs: Mass Limits

LEP Combined 189-202 GeV





$M_{H^0} >$ 107.9 GeV at 95% C.L.

Median expected limit = 109.1 GeV

SUSY MODELS: guide the eye ...

Spin	0	1/2	1
	$\tilde{\ell}^{\pm}_{\mathrm{L,R}}\,\}\,\tilde{\ell}^{\pm}_{1,2}$	$\ell^{\pm}_{\mathrm{L,R}}$	
	$\tilde{\nu}_{\mathrm{L}}$	ν_{L}	
	$\tilde{\mathrm{q}}_{\mathrm{L,R}}\,\}\,\tilde{q}_{1,2}$	$\mathrm{q}_{\mathrm{L,R}}$	
		$\tilde{g}$	g
		$\tilde{\gamma}$	γ
	$\mathrm{h}^0, \mathrm{H}^0, \mathrm{A}^0$	$\tilde{\mathrm{h}}, \tilde{\mathrm{H}}$ $\Big\}\ \tilde{\chi}^0_{\mathrm{j}}$	
		$\tilde{\mathrm{Z}}^0$	Z^0
	$\mathrm{H}^{\pm}$	$\tilde{\mathrm{H}}^{\pm}$ $\Big\}\ \tilde{\chi}^{\pm}_{\mathrm{i}}$	
		$\tilde{\mathrm{W}}^{\pm}$	$\mathrm{W}^{\pm}$

"Minimal" Field content: MSSM

M_1, M_2, M_3	$U(1)$, $SU(2)$, $SU(3)$ Gaugino Masses
$m_{\tilde{f}}$	sfermion masses
v, $\tan\beta$, m_{A^0}, μ	Higgs(ino) mass/mixing parameters
A_U, A_D, A_L,	Trilinear sfermion/higgs coupling matrices

105 new parameters, unsupressed FCNC, ...

(SUGRA) Constrain it $\Rightarrow$ CMSSM

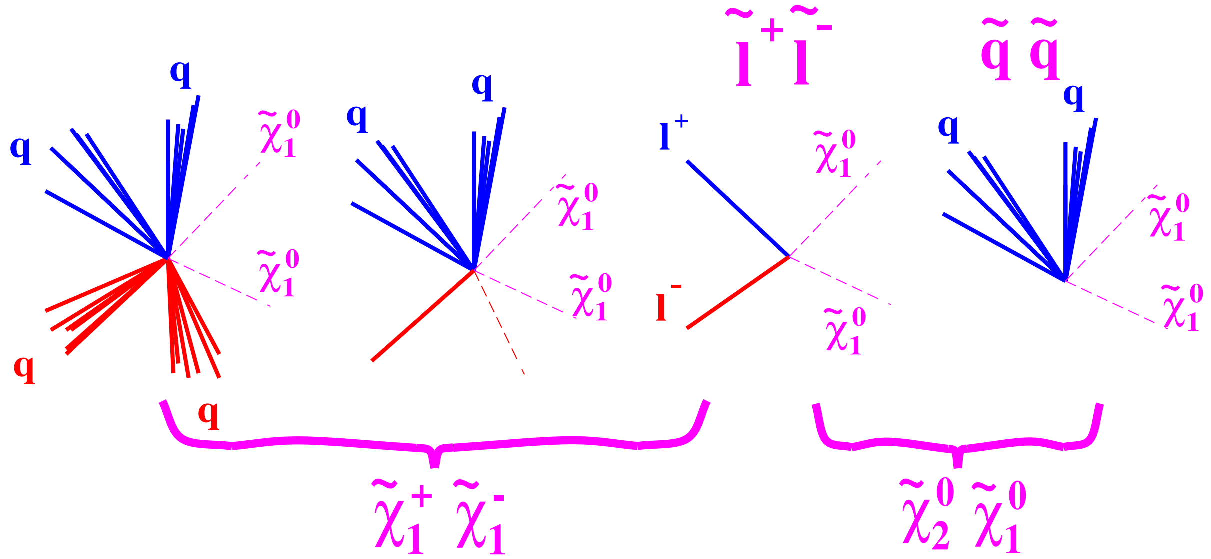
M_2	EW-scale $SU(2)$ Gaugino Mass
	(GUT Unification gives M_1, M_3)
m_0	Common GUT-scale (Plank!) scalar mass
	(EW-scale masses from RGE's)
$\tan\beta$	v_2/v_1, Ratio of vev's of two higgs doublets
A_0	Common trilinear coupling
μ	Higgs mixing parameter
m_{A^0}	Pseudo Scalar Higgs Mass

6'ish new parameters, FCNC *etc.* controllable

Parameters $\longleftrightarrow$ Search Channels

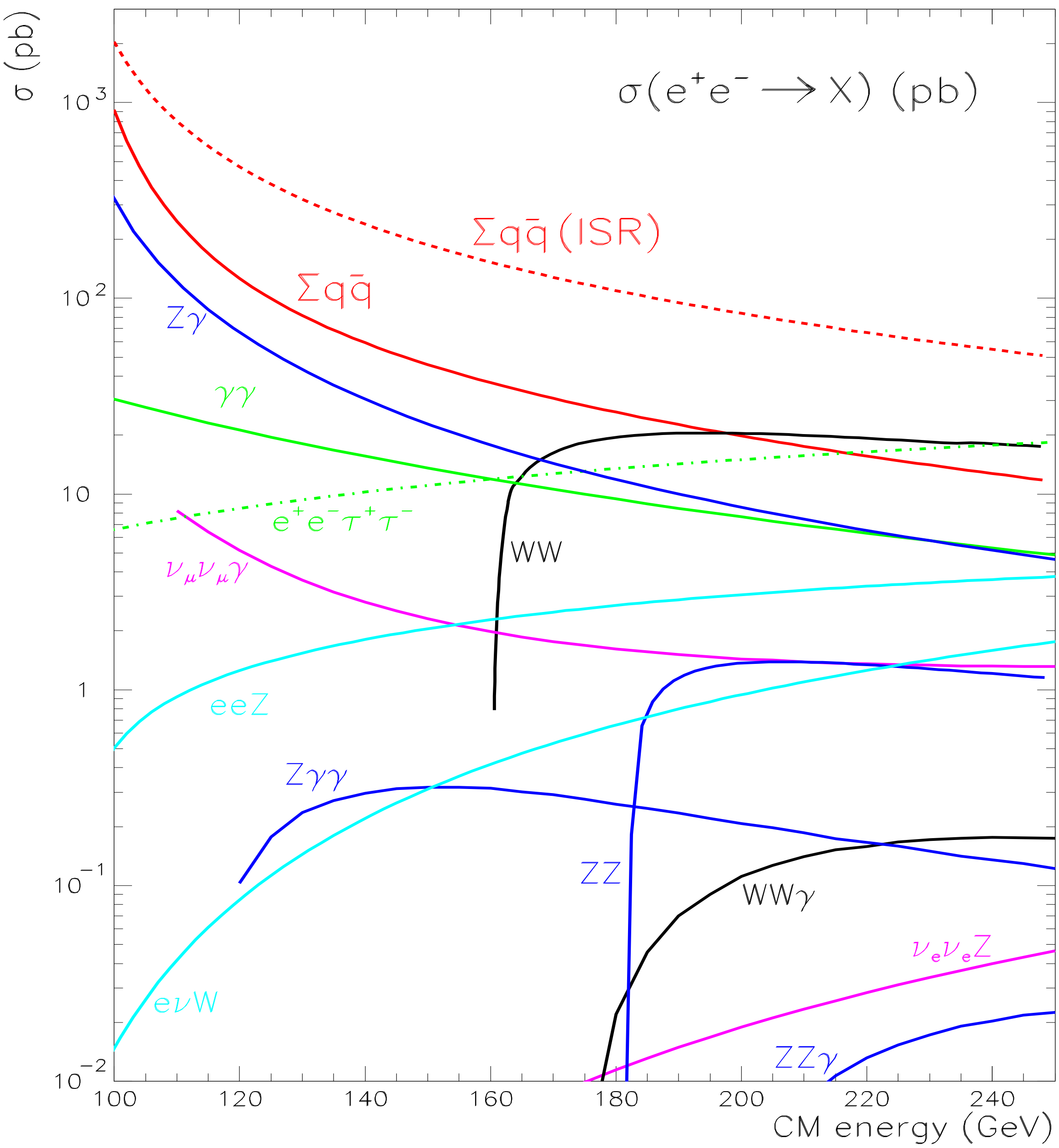
<table>
<tr><td rowspan="3">$\mu << M_2$
Higgsino Region
no $\tilde{\nu}$ coupling</td><td colspan="3">$\mu >> M_2$
Gaugino Region</td></tr>
<tr><td rowspan="2">Large $m_0, m_{\tilde{\mathrm{f}}}$</td><td colspan="2">Small $m_0, m_{\tilde{\mathrm{f}}}$</td></tr>
<tr><td></td><td>Large $\tilde{\mathrm{q}}$ Mix</td></tr>
<tr><td colspan="2">$\tilde{\chi}_1^+\tilde{\chi}_1^-, \tilde{\chi}_2^0\tilde{\chi}_1^0$</td><td>$\tilde{\ell}^+\tilde{\ell}^-$</td><td>$\tilde{\mathrm{t}}\tilde{\mathrm{t}}, \tilde{\mathrm{b}}\tilde{\mathrm{b}}$</td></tr>
</table>

Primary Search Topologies



- Select events with significant missing energy
- Categorize using
  - hadronic jets
  - charged leptons
  - Event Visible Energy, jet/lepton energies
- Depend Strongly on $\Delta M = M_{\mathrm{SUSY}} - M_{\mathrm{LSP}}$

Background from the SM



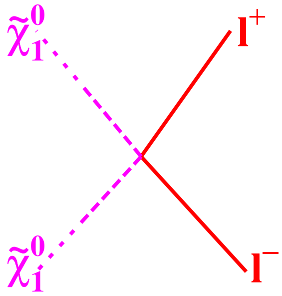
- 4-Fermion, especially $\mathrm{W^+W^-}$
  - $\sigma \sim$ 20 pb
  - Large visible energy (large ΔM region)
- $\mathrm{e^+e^-} \to \mathrm{e^+e^-}\gamma^{(*)}\gamma^{(*)} \to \mathrm{e^+e^-f\bar{f}}$
  - σ *enormous* (say $\sim$ 100-10000 pb)
  - Small visible energy (small ΔM region)

Scalar Lepton Searches

$e^+e^- \rightarrow \tilde{l}^+\tilde{l}^-$ pair

$\tilde{l}^- \rightarrow l^-\tilde{\chi}^0_1$

$\tilde{l}^+ \rightarrow l^+\tilde{\chi}^0_1$

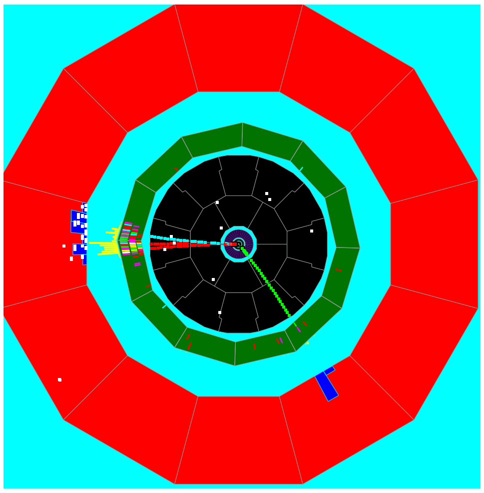


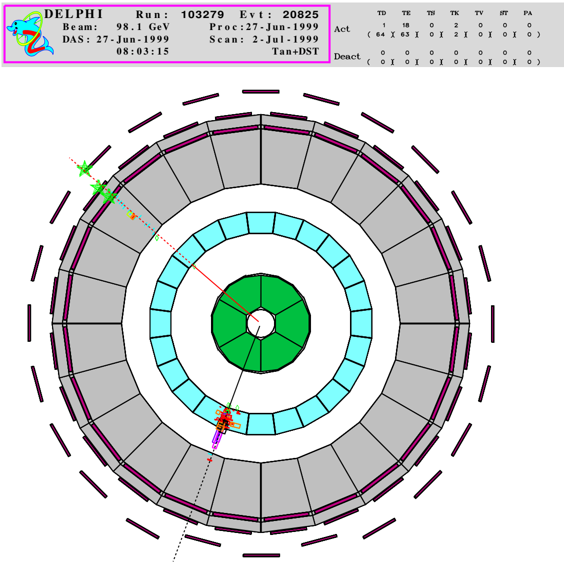
- Acoplanar lepton
- Missing E_T

Also signature for W^+W^-, H^+H^-, $\ell^{*\pm}\ell^{\mp}$

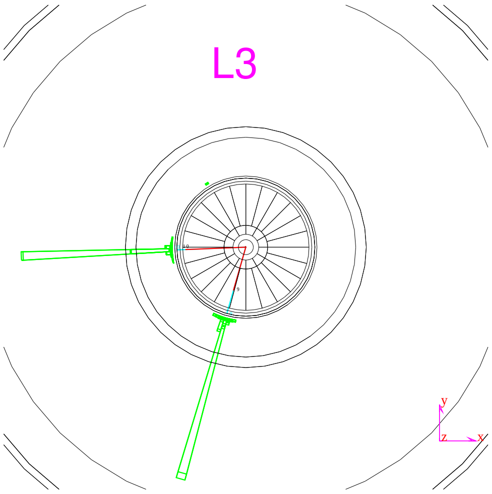
Many Candidates:

ALEPH

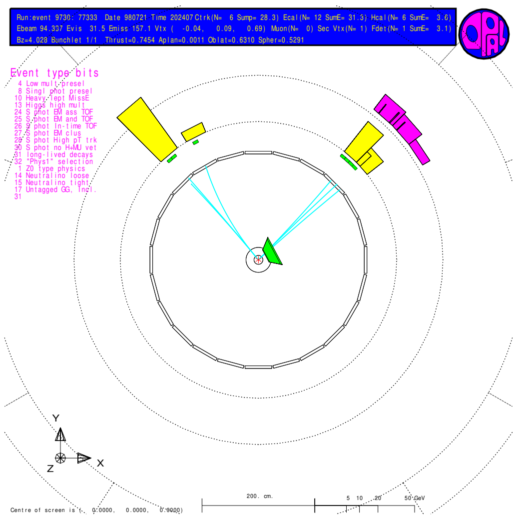




Run # 712704 Event # 3242 Total Energy : 103.94 GeV



Transverse Imbalance :	.6763	Longitudinal Imbalance :	-.2773		
Thrust :	.7310	Major :	.6748	Minor :	.0025
Event DAQ Time :	980805 40400				

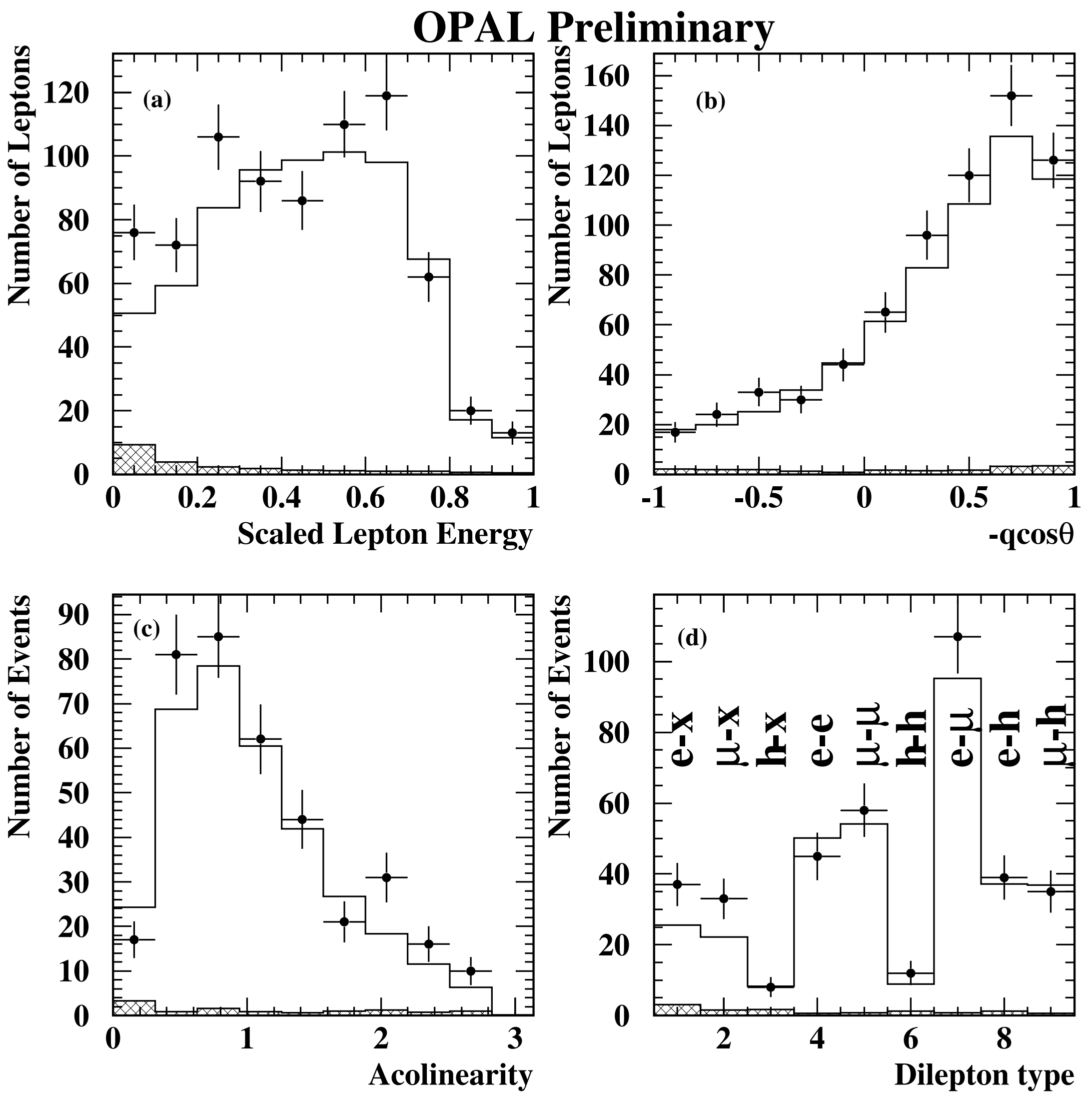


Slepton Searches, 192-202 GeV

	Experiment	Data	SM Background	
	ALEPH	42	48.1	-0.9σ
$\tilde{e}$	DELPHI	68	59.3	$+0.4\sigma$
	L3	24	24.5	-0.1σ
	OPAL	–	–	–
	ALEPH	39	43.4	-0.7σ
$\tilde{\mu}$	DELPHI	13	20.4	-1.6σ
	L3	48	40.1	$+1.2\sigma$
	OPAL	–	–	–
	ALEPH	46	34.2	$+2.0\sigma$
$\tilde{\tau}$	DELPHI	25	19.2	$+1.3\sigma$
	L3	41	33.7	$+1.3\sigma$
	OPAL	71	56.8	$+2.0\sigma$
	ALEPH	127	125.7	$+0.1\sigma$
Sum	DELPHI	106	98.9	$+0.7\sigma$
	L3	113	98.3	$+1.5\sigma$
	OPAL	381	343.3	$+2.0\sigma$

$\ell^+\ell'^- + \not{E}_T$: Data *vs.* SM

Eg: OPAL Data at $\sqrt{s} = 192$–202 GeV

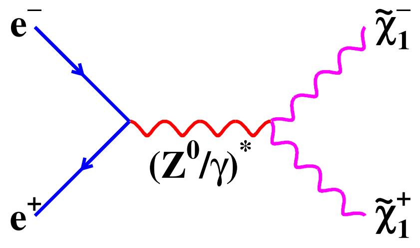


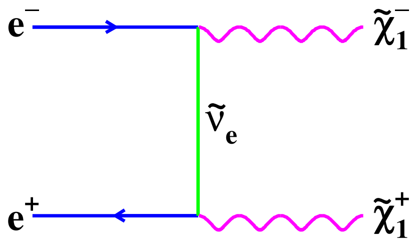
- Kolmogorov shape tests don't find anomalies

  All shapes consistent with the predominantly W^+W^- background

- Awaits detailed 4-experiment combination and checking (*SUSY2K,ICHEP2000,...*)

Charginos

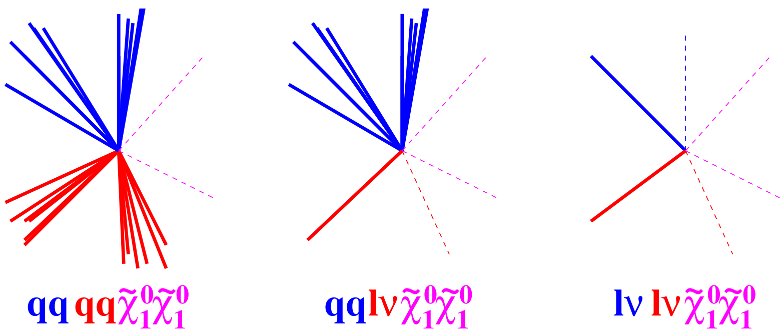




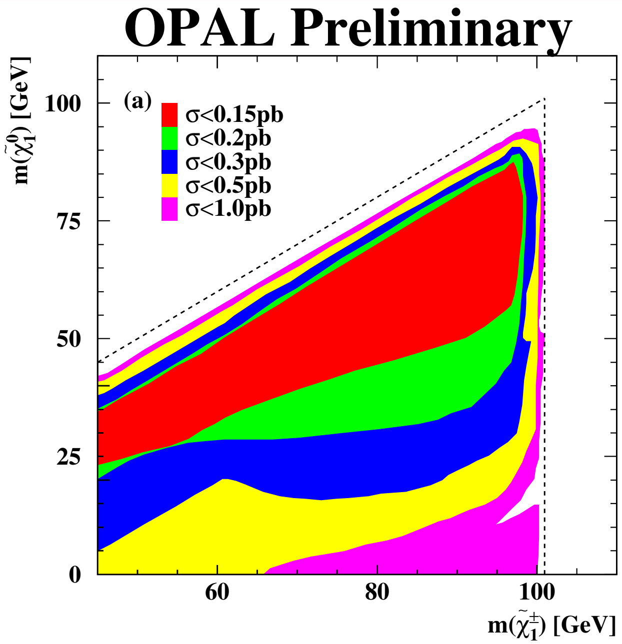
- $\sigma > 4$ pb unless $\tilde{\nu}_e$ is light.
- Chargino decay via W (most of MSSM)

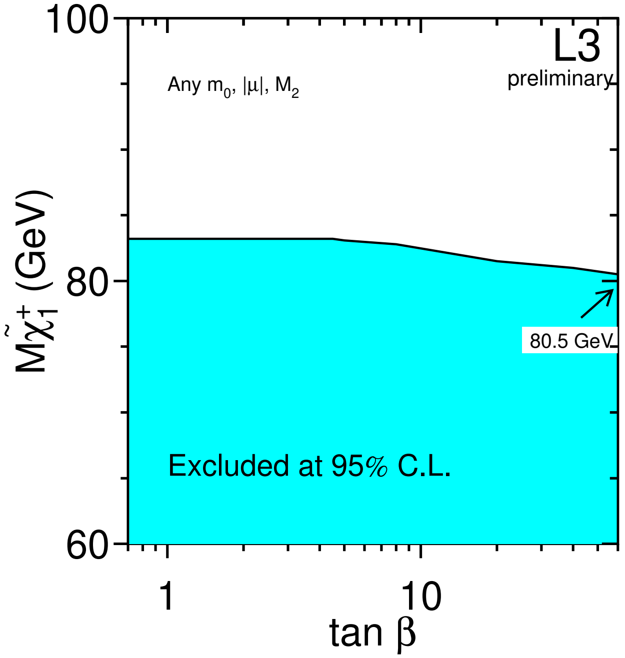
$$\tilde{\chi}_1^+ \tilde{\chi}_1^- \longrightarrow (W^+ \tilde{\chi}_1^0)(W^- \tilde{\chi}_1^0)$$

- Signature : W^+W^- plus missing energy



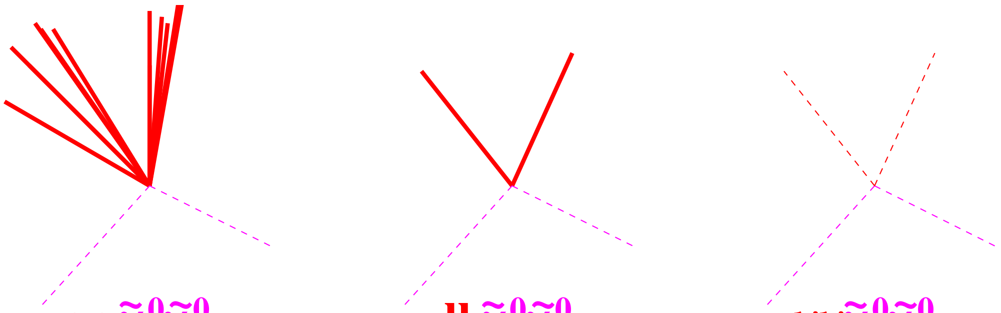
- Many selections $\Rightarrow$ Consistent with SM





Neutralino Search

- Enough luminosity to search for neutralino production
- Observed as : $\tilde{\chi}^0_2\tilde{\chi}^0_1 \rightarrow \tilde{\chi}^0_1\tilde{\chi}^0_1 Z^* \rightarrow \tilde{\chi}^0_1\tilde{\chi}^0_1 f\bar{f}$

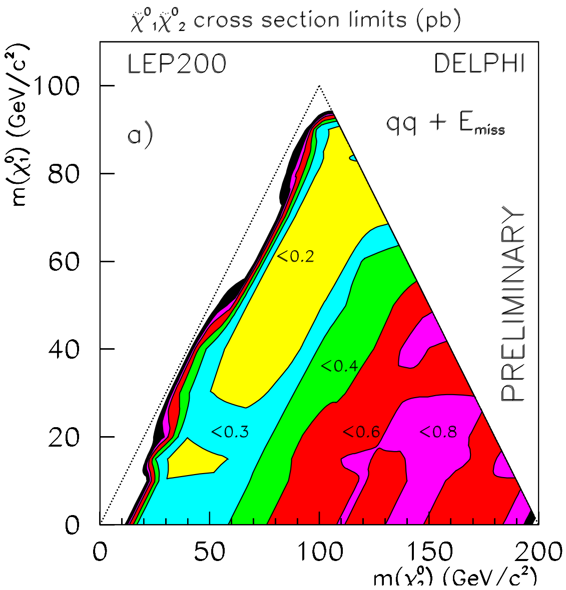


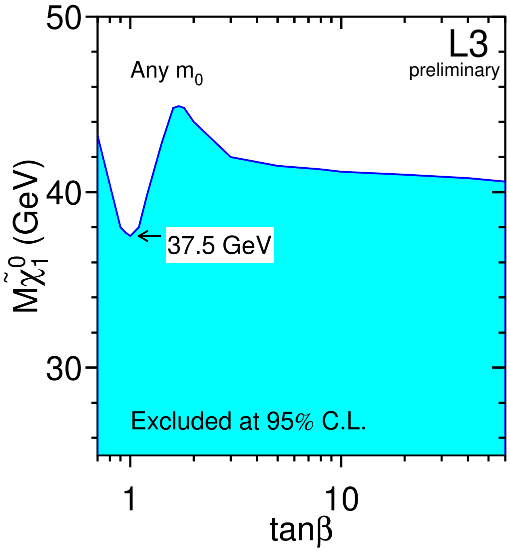
$qq\tilde{\chi}^0_1\tilde{\chi}^0_1$ $ll\ \tilde{\chi}^0_1\tilde{\chi}^0_1$ $\nu\nu\tilde{\chi}^0_1\tilde{\chi}^0_1$

- Everything consistent with SM here too ...

LIMITS

Cross-section Mass





What do mass limits really mean? $\Rightarrow$

MSSM Parameter Limits

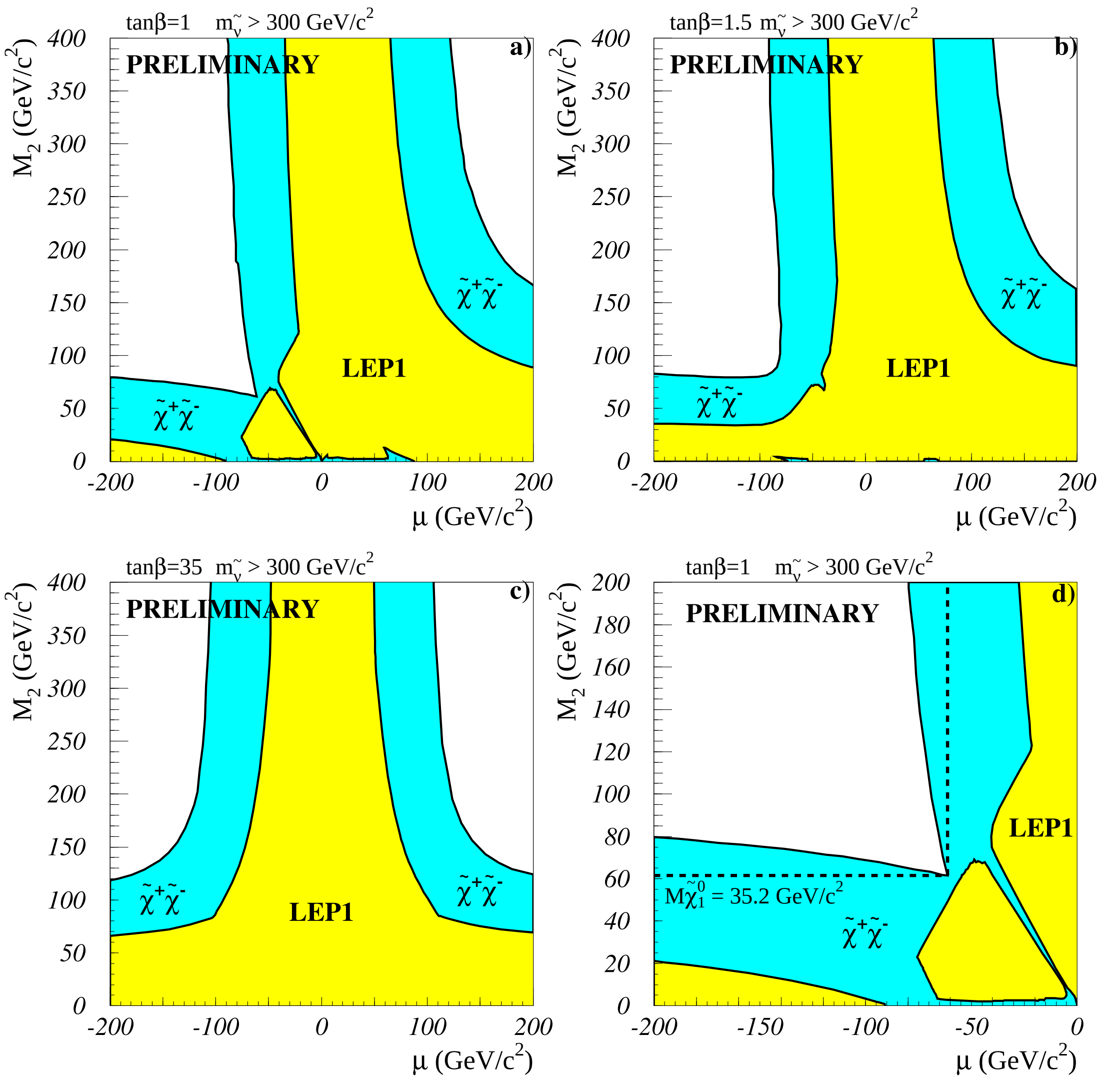
- Important parameters: $\tan\beta$, M_2, μ, m_0
- A_0 matters if including MSSM higgs

$\Rightarrow$ Plot M_2 *vs.* μ for different $\tan\beta$

— Show Large and "any" m_0 separately (heavy/light $\tilde{\nu}$)

"any" $\Rightarrow$ parameter scan over allowed ranges

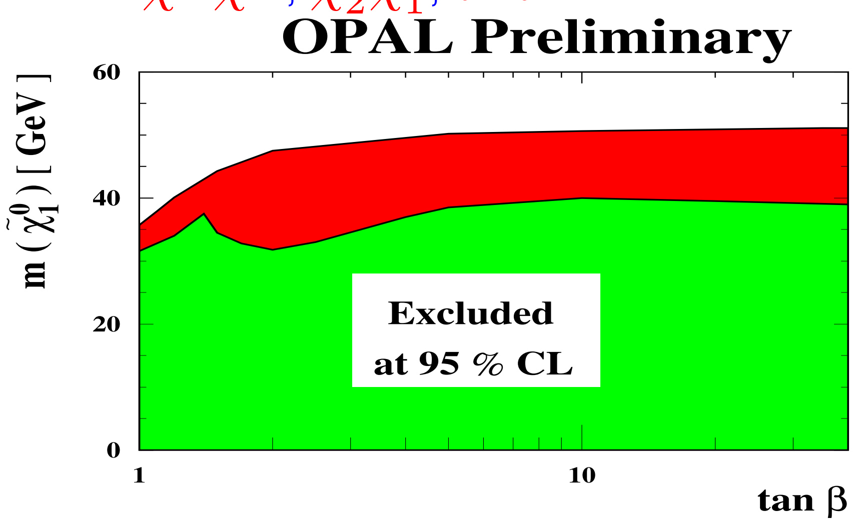
DELPHI MSSM limits at 202 GeV



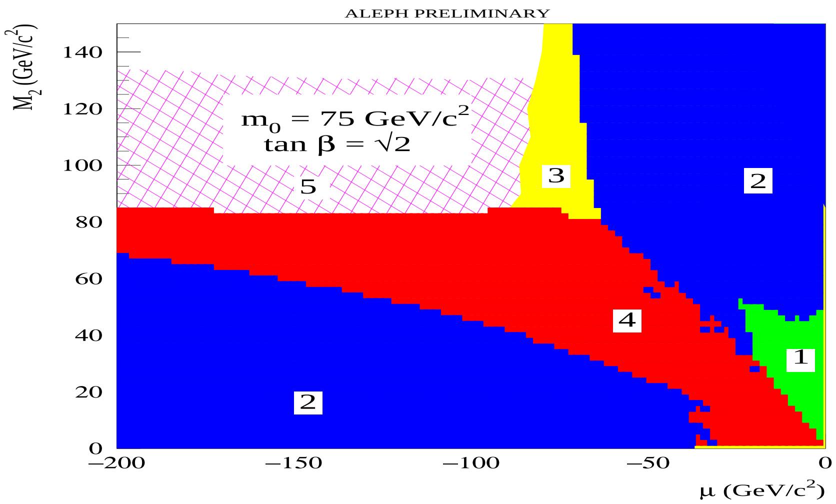
M_χ Excluded: All $\{\tan\beta, M_2, \mu, m_0, A_0\} \Rightarrow M_\chi$ excluded

$\tilde{\chi}_1^0$ LSP Mass Limit

$\tilde{\chi}^+\tilde{\chi}^-$, $\tilde{\chi}_2^0\tilde{\chi}_1^0$, $\tilde{\ell}^+\tilde{\ell}^-$



MSSM higgs hA too?



$\sqrt{s} =$ 192-202 GeV	LSP $\tilde{\chi}_1^0$ limit (GeV) Large m_0	Any m_0
ALEPH	36.8	32.3
DELPHI	35.2	23.4
L3	–	37.5
OPAL	35.7	31.6

Gauge-Mediated SUSY Breaking

- SUSY breaking mechanism unknown:
- Assume mediation method:

Gravity | Gauge

Hidden
$\cancel{\textbf{SUSY}}$

$\sqrt{F} \sim \sqrt{\frac{M}{G_F^{1/2}}}$

$M \sim M_P \sim 10^{18}$ GeV
$\sqrt{F} \sim 10^{11}$ GeV

$10^3 < M < 10^{15}$ GeV
$10^3 < \sqrt{F} < 10^{10}$ GeV

M

But: FCNC

No FCNC

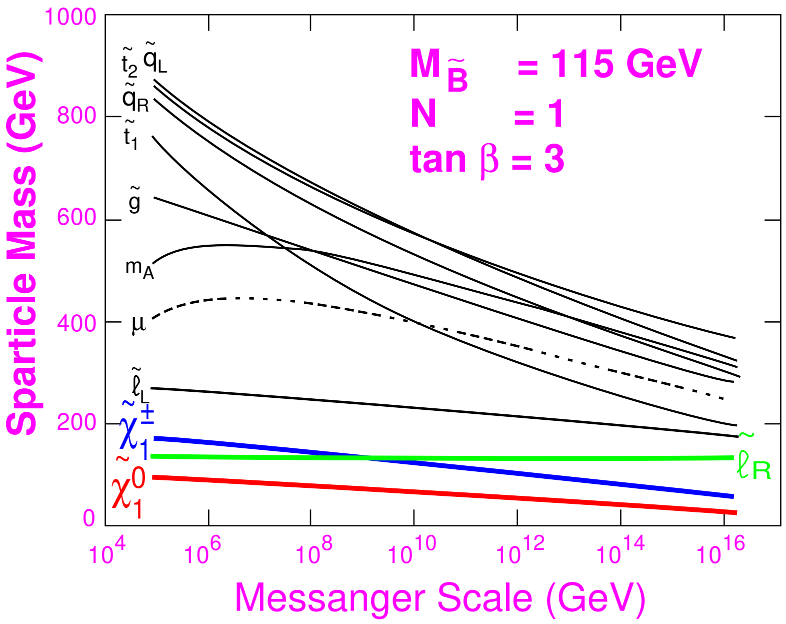
Visible
$e, \mu, \tau, \ldots, W^{\pm}, Z^0$
$\tilde{e}, \tilde{\mu}, \tilde{\tau}, \ldots, \tilde{\chi}^{\pm}, \tilde{\chi}^0$

Spectrum: $\Lambda = k\frac{F}{M}$

$M_{\tilde{G}} \sim 2.5$ TeV

$M_{\tilde{G}} < 1$ GeV $\Rightarrow$ LSP

Example GMSB mass spectra
(Dimopoulos *et al.*, hep-ph/9609434):



NLSP

$\tilde{\chi}_1^0 \rightarrow \gamma \tilde{G}$

$\tilde{\ell}_R^{\pm} \rightarrow \ell^{\pm} \tilde{G}$

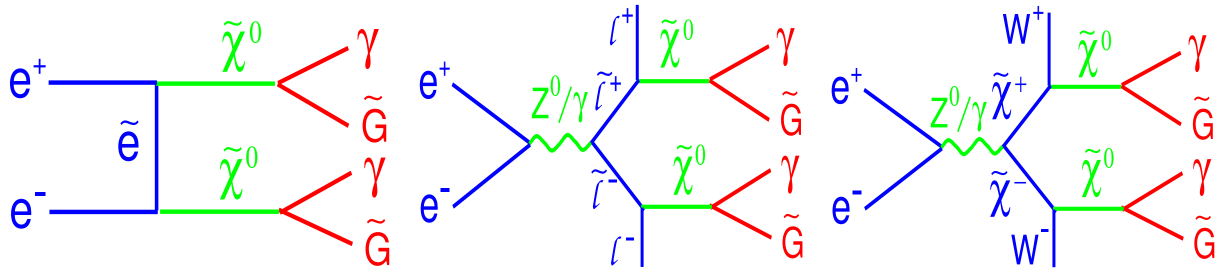
NLSP $c\tau =$

1 μm–10^{11} km

Minimal Model: $F,\ \Lambda,\ M,\ N,\ \tan\beta$ and $\mathrm{sign}(\mu)$

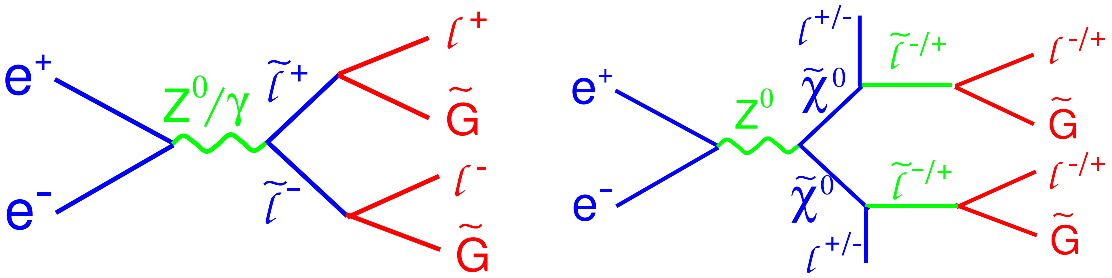
$\tilde{\chi}_i^+\tilde{\chi}_i^-, \tilde{\chi}_i^0\tilde{\chi}_j^0, \tilde{\ell}^+\tilde{\ell}^- \ \ldots$

$\tilde{\chi}_1^0$ NLSP



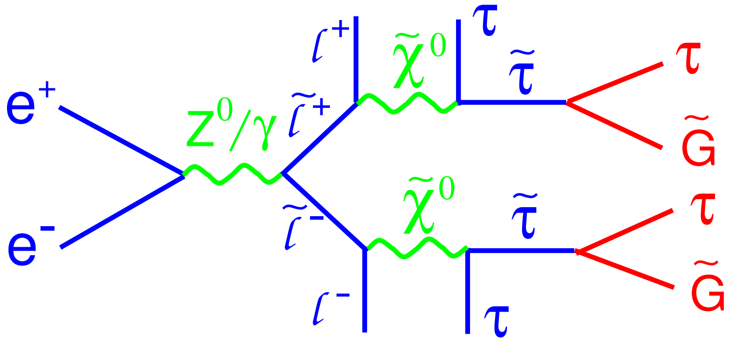
$c\tau \sim 0:$	$\gamma\gamma + \not\!\!E_T$	$\ell^+\ell^-\gamma\gamma + \not\!\!E_T$	$\gamma\gamma + \text{jets}/\ell^\pm + \not\!\!E_T$
$0 < c\tau < \infty:$	$\gamma + \not\!\!E_T$	$\ell^+\ell^-\gamma + \not\!\!E_T$	$\gamma + \text{jets}/\ell^\pm + \not\!\!E_T$
$c\tau \sim \infty:$	$\not\!\!E_T$	$\ell^+\ell^- + \not\!\!E_T$	$\text{jets}/\ell^\pm + \not\!\!E_T$

$\tilde{\ell}^\pm$ NLSP



$c\tau \sim 0:$	$\ell^+\ell^- + \not\!\!E_T$	$4 \times \ell^\pm + \not\!\!E_T$
$0 < c\tau < \infty:$	$2 \times$ Kinked Tracks	$2 \times \ell^\pm + 2 \times$ Kinked Tracks
$c\tau \sim \infty:$	$2 \times$ Stable Charged	$2 \times \ell^\pm + 2 \times$ Stable Charged

$\tilde{\tau}^\pm$ NLSP ($\tan\beta > 10$)

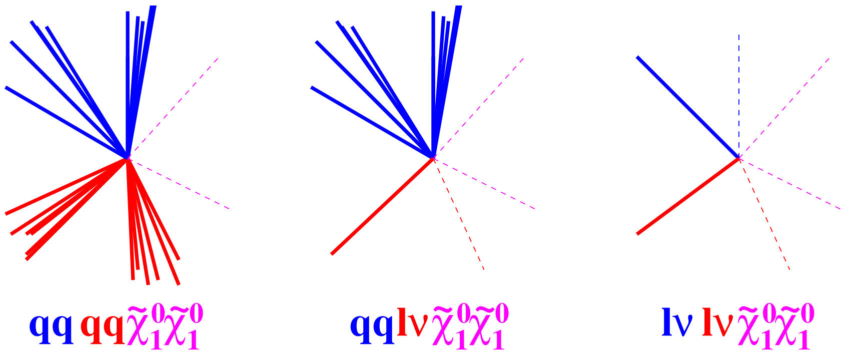


$c\tau \sim 0:$	$\tau^\pm\tau^\pm + (\ell^\pm\tau^\mp\ell^\pm\tau^\mp)$
$0 < c\tau < \infty:$	Kinked Tracks $+ (\ell^\pm\tau^\mp\ell^\pm\tau^\mp)$
$c\tau \sim \infty:$	Stable Charged $+ (\ell^\pm\tau^\mp\ell^\pm\tau^\mp)$

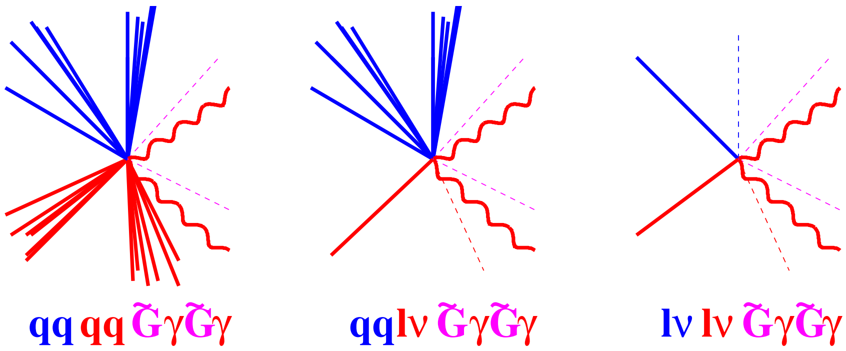
$\tilde{\chi}_1^+\tilde{\chi}_1^-$ with $\tilde{\chi}_1^0$ NLSP

Final state topology depends on the $\tilde{\chi}_1^0$ decay length ($c\tau$)

Long τ :



Short τ :



- Search topology: ≥ 1 photon + missing energy
- photon may be displaced from origin

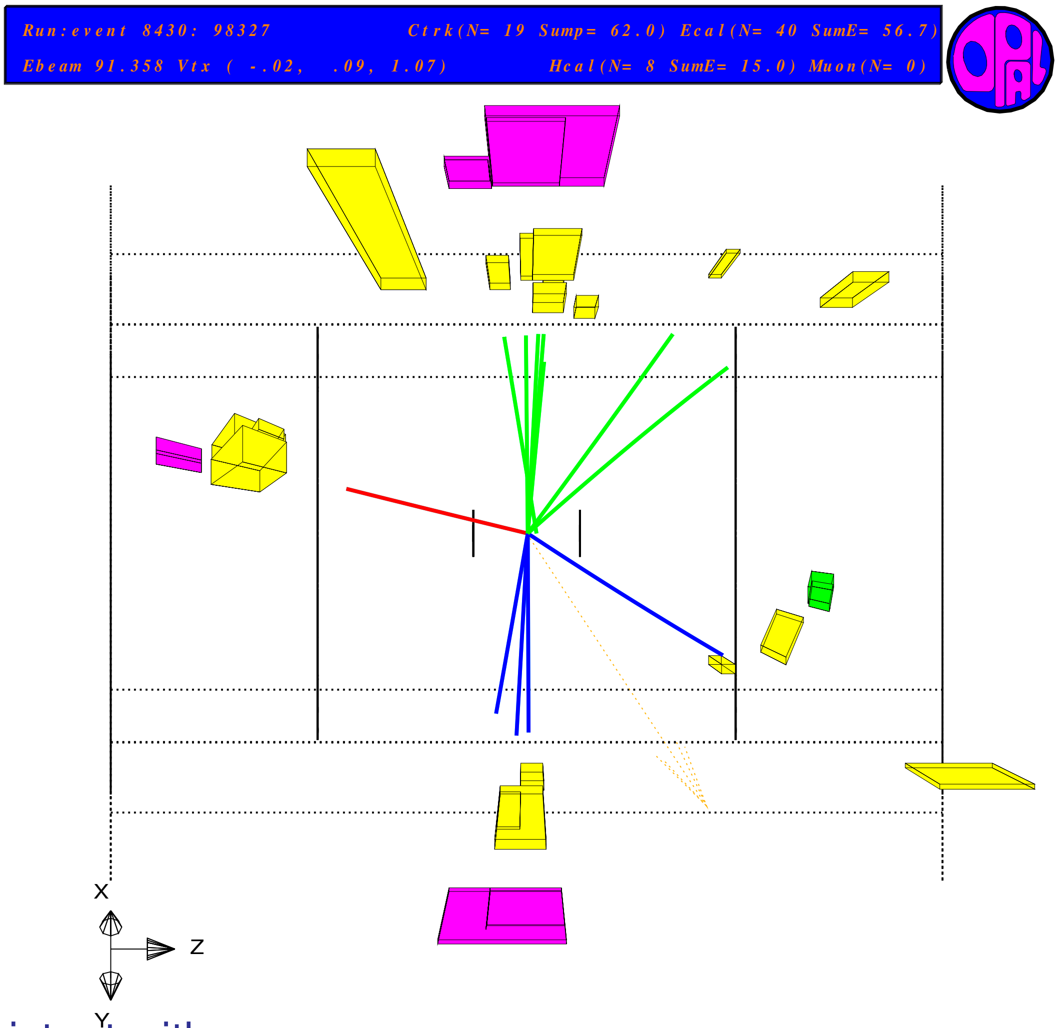
Model Interesting $\Rightarrow$

New Experimental Signatures

Results: $\tilde{\chi}_1^+\tilde{\chi}_1^-$ with $\tilde{\chi}_1^0$ NLSP

Channel	$1\,\gamma$		$2\,\gamma$	
OPAL'99	Bkg	Data	Bkg	Data
Low Mult	9.5 ± 0.4	10	0.9 ± 0.1	0
High Mult	20.2 ± 4.8	18	9.0 ± 2.2	6

- High Multiplicity Candidate : $E_\gamma = 25\ \mathrm{GeV}$



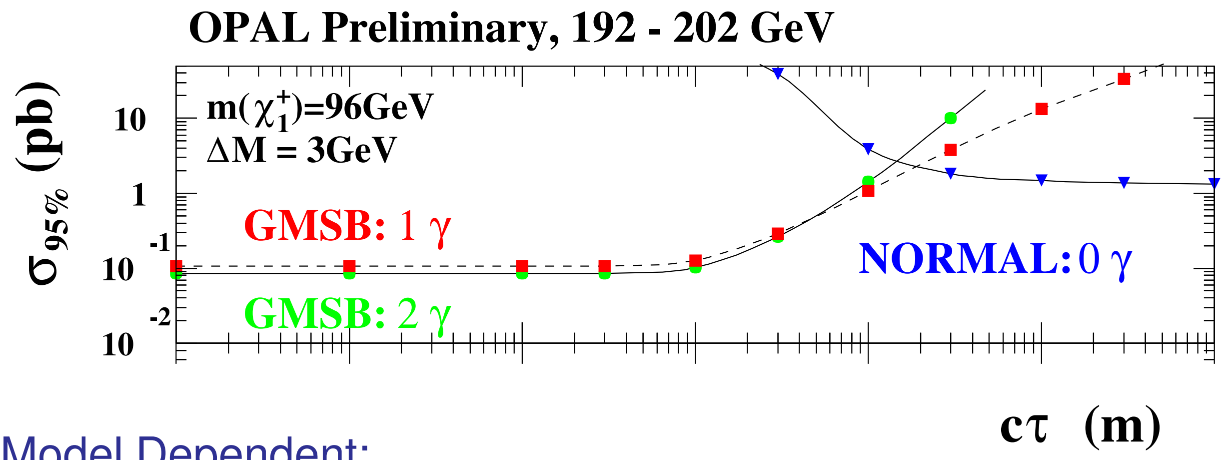
Consistent with :

- Signal : $\tilde{\chi}_1^+\tilde{\chi}_1^- \rightarrow q\bar{q}\tilde{\chi}_1^0\tau\nu\tilde{\chi}_1^0$ (1 $\tilde{\chi}_1^0 \rightarrow \tilde{G}\gamma$)
- SM Background : $W^+W^- \rightarrow q\bar{q}\tau\bar{\nu}_\tau$ isolated (γ/π^0)

GMSB Limits

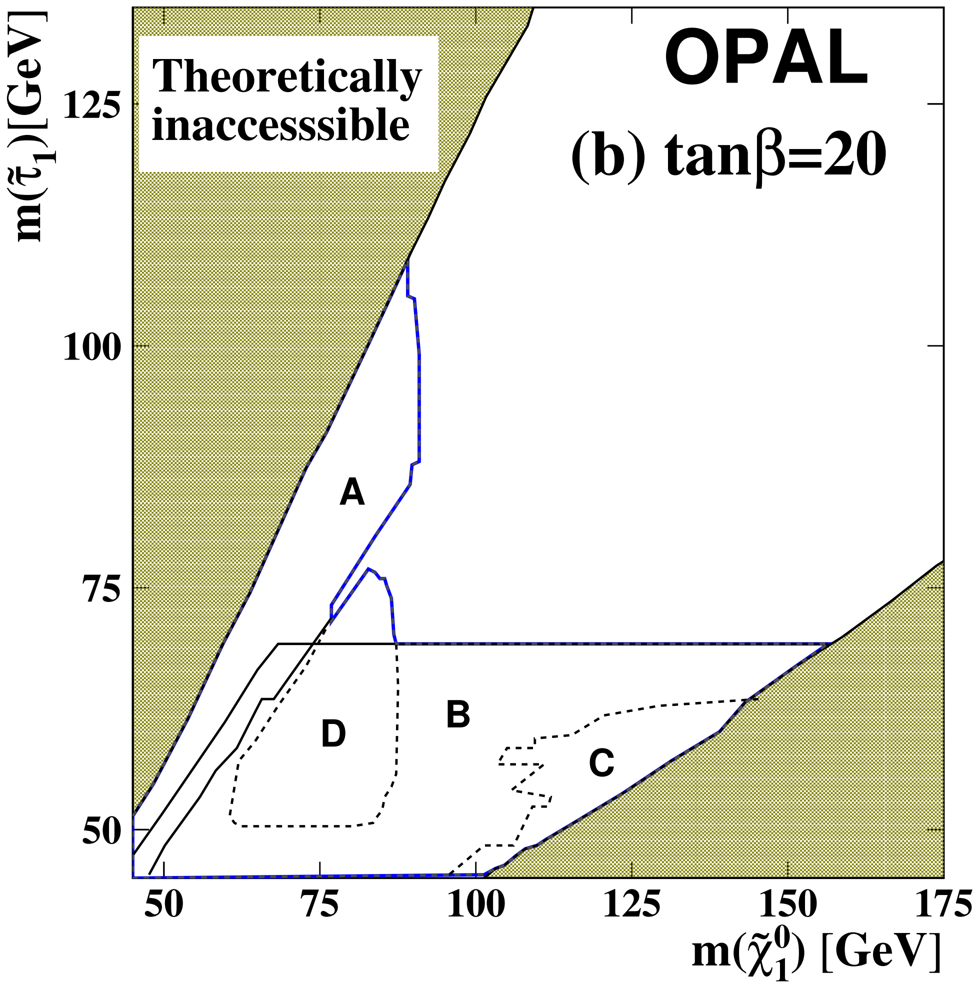
Model Independent:

- Production cross-section vs. NLSP lifetime



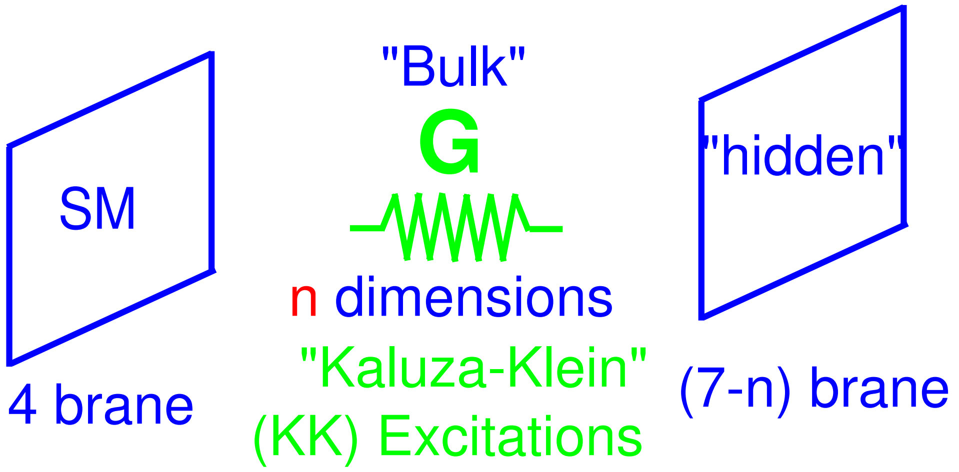
Model Dependent:

- Scan GMSB parameter space, exclude mass regions

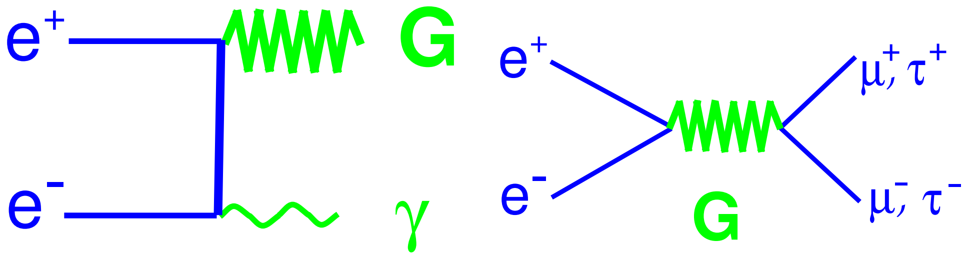


Gravity in Extra Dimensions

Overall Picture



Can affect Measurable Phenomena



WHY??

- Gravity “diluted”
  $\Rightarrow$ “$M_{\rm plank}$”$= M_D = M_{\rm EW}$
- No hierarchy problem

$$M_{Pl}^2 = R^n \times {M_D}^{n+2}$$

R : Extra dim. Compactification Radius

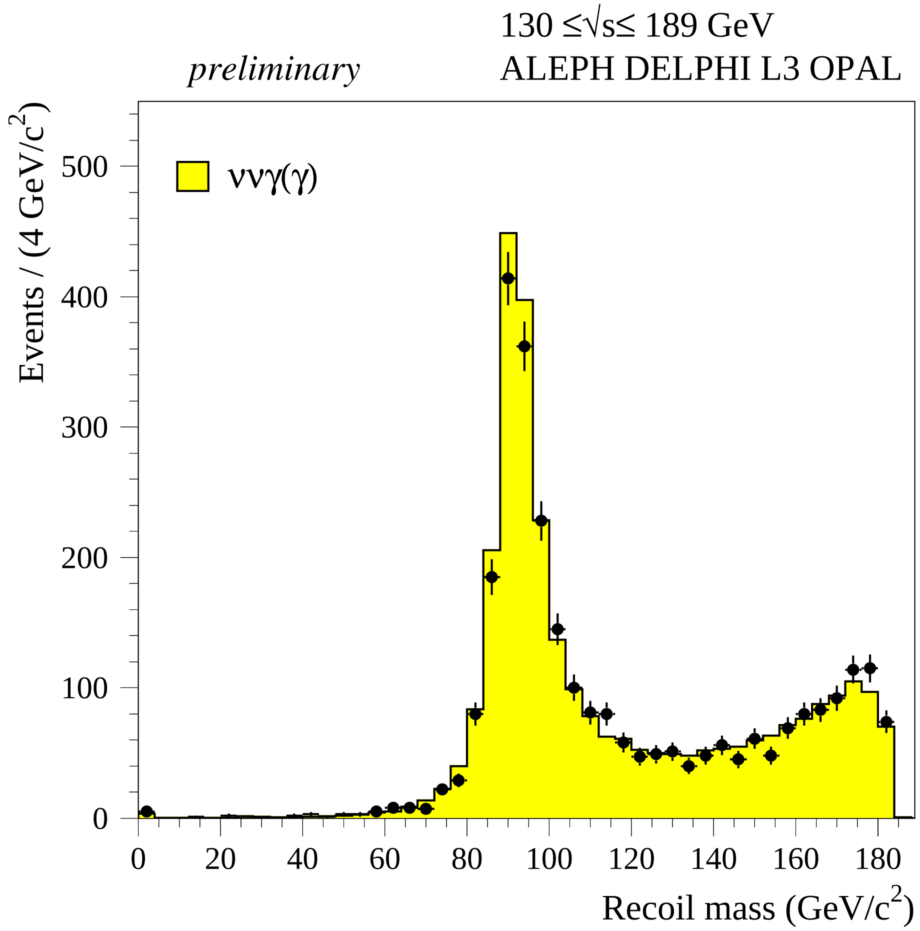
n : Number of large dim., $1 < R < 7$

n	R	Possible?
1	10^{13} cm	Excluded
2	1 mm	Not excluded!!
7	1 fm	Not excluded

Gravity in Extra Dim: Results

Example: $e^+e^- \to \gamma G$

$$\frac{d^2\sigma}{dE_\gamma d\cos\theta} \propto \frac{1}{{M_D}^2}\left(\frac{\sqrt{s}}{M_D}\right)^n$$



eg. OPAL 189 GeV

n	M_D Lower Limit (GeV) 95%C.L.
2	1086
3	862
4	710
5	605
6	528
7	470

Search Channel List

$e^+e^- \to hZ$	$h \to b\bar{b}$	$b\bar{b}q\bar{q}$, $b\bar{b}\nu\bar{\nu}$, $b\bar{b}\ell^+\ell^-$
	$h \to \gamma\gamma$	$(q\bar{q}, \ell^+\ell^-, \nu\bar{\nu})+\gamma\gamma$
	$h \to \tilde{\chi}^0\tilde{\chi}^0$	$q\bar{q}$, $\ell^+\ell^- + \not{E}$
$e^+e^- \to hA$	$h, A \to b\bar{b}, \tau\tau$	$b\bar{b}b\bar{b}$, $b\bar{b}\tau^+\tau^-$
	$h \to AA$	$b\bar{b}b\bar{b}b\bar{b}$
$e^+e^- \to H^+H^-$	$H^+ \to q\bar{q}, \tau\nu$	$q\bar{q}q\bar{q}$, $q\bar{q}\tau\nu$, $\tau\nu\tau\nu$
$e^+e^- \to \tilde{\chi}^+\tilde{\chi}^-$	$\tilde{\chi}^- \to W^*\tilde{\chi}^0$	jets $(+\ell^\pm)$, $\ell^+\ell^- + \not{E}$
	(In)Direct RPV	jets, $\ell^\pm$, ν
	$(\tilde{\chi}^0 \to \gamma\tilde{G})$	jets, $\ell^+\ell^-$, $\gamma\gamma + \not{E}$
$e^+e^- \to \tilde{\chi}^0_2\tilde{\chi}^0_1$	$\tilde{\chi}^0_2 \to Z^0\tilde{\chi}^0_1$	2 jets $+ \not{E}$
	$\tilde{\chi}^0_2 \to \gamma\tilde{\chi}^0_1$	$\gamma + \not{E}$
$e^+e^- \to \tilde{\chi}^0_1\tilde{\chi}^0_1$	$\tilde{\chi}^0_1 \to \gamma\tilde{G}$	$\gamma\gamma + \not{E}$
	$\tilde{\chi}^0_1$ Lifetime	non-pointing γ
	RPV Decays	jets, $\ell^\pm$, ν
$e^+e^- \to \tilde{\ell}^+\tilde{\ell}^-$	$\tilde{\ell}^- \to \ell^-\tilde{\chi}^0_1$	$\ell^+\ell^- + \not{E}$
	$(\tilde{\chi}^0 \to \gamma\tilde{G})$	$\ell^+\ell^-\gamma\gamma + \not{E}$
	(In)Direct RPV	2,4,6$\times\ell^\pm + \not{E}$
	$\tilde{\ell}^\pm$ Lifetime	Kinked Tracks
		Stable, Charged
$e^+e^- \to \tilde{\nu}\tilde{\nu}$	(In)Direct RPV	$\ell^+\ell^-\ell^+\ell^-$
		jets $+ \not{E}$
$e^+e^- \to \tilde{t}_1\tilde{t}_1$	$\tilde{t}_1 \to c\tilde{\chi}^0_1$	2 jets $+ \not{E}$
	$\tilde{t}_1 \to b\ell^+\tilde{\nu}$	2 jets $+ \ell^+\ell^- + \not{E}$
	(In)Direct RPV	$\ell^+q\ell^-q$
$e^+e^- \to N\bar{N}$	$N \to \ell W$	jets $+\ell^\pm$
$e^+e^- \to L^+L^-$	$L^+ \to \nu W$	jets, $\ell^\pm + \not{E}$
$e^+e^- \to \ell^{*+}\ell^{(*)-}$	$\ell^{*+} \to \ell^+\gamma$	$\ell^+\ell^-\gamma(\gamma)$
$e^+e^- \to \nu^*\bar{\nu}^*$	$\nu^* \to \nu\gamma$	$\gamma(\gamma) + \not{E}$
$e^+e^- \to \ell^*\ell, \nu^*\nu$	$\ell^* \to \ell Z$	jets, $\ell^\pm$, ν

Conclusions

- LEP ran very well at $\sqrt{s} \sim$ 192–202 GeV in 1999
- No significant excesses in new particle search topologies, *but...*
  - Some intriguing features in current data
  - Still finding new things to look for
- 2000:
  - LEP has turned on very well at $\sqrt{s} >$ 200 GeV
  - Looking forward to $\sqrt{s} \sim$ 210 GeV !!
  - ... And remaining ready for the unexpected