Results from the OPAL Experiment

Christoph Rembser
CERN EP

On behalf of the OPAL Collaboration

LEPC Seminar September 5 2000

A Detector Status and Data Sets

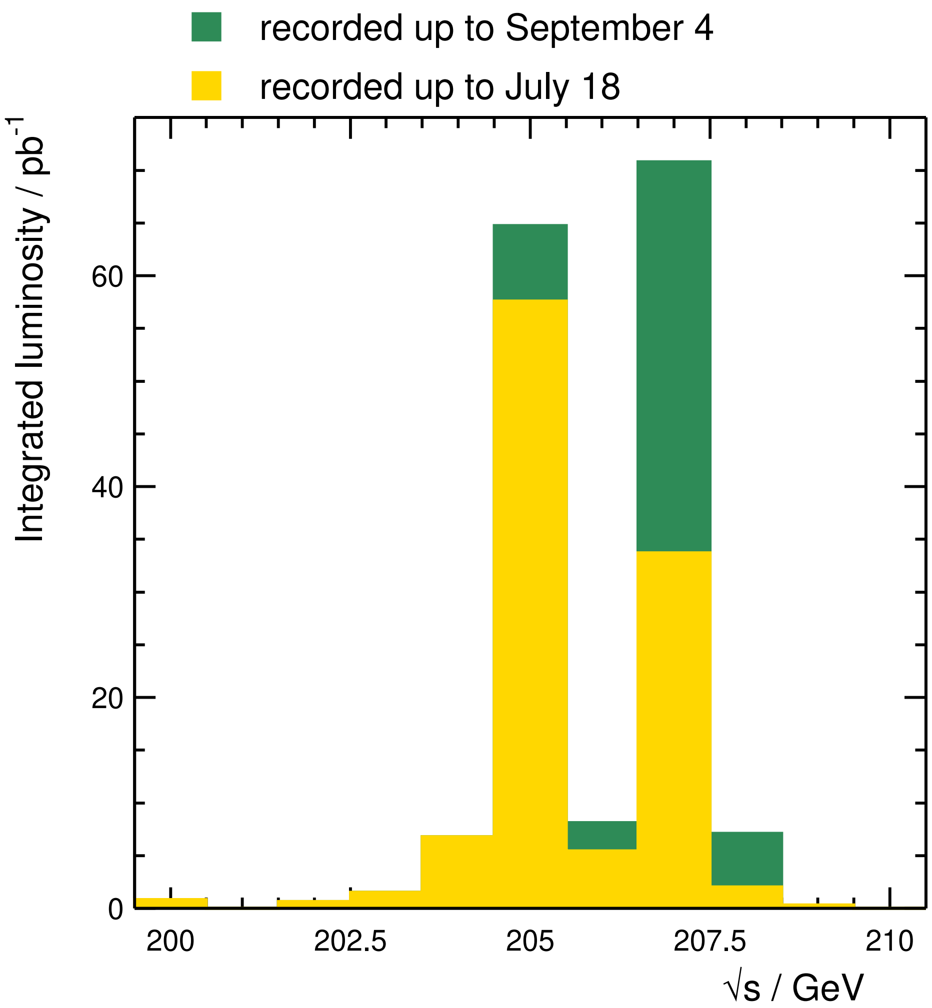
B LEP2 Results

- Standard Model Cross Sections
- New Particle Searches
- Higgs Searches, $e^+e^- \longrightarrow hZ^0$

C Run Request

Detector Performance

Data sample 2000



- **The detector works very well**
- **Background conditions are good**

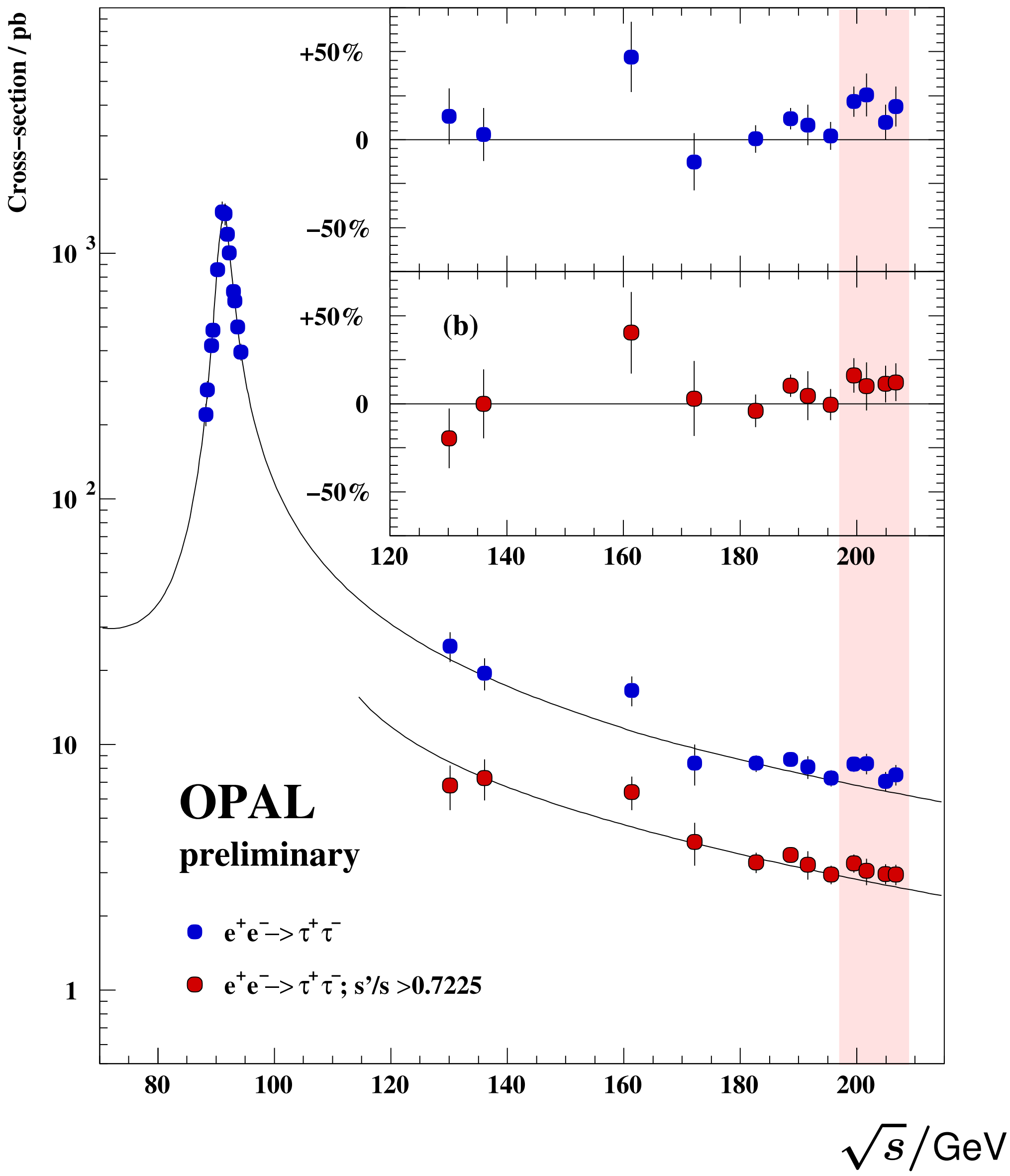
  Delivered by LEP: 175.9 pb^{-1}, THANKS!
- **Recorded by OPAL: 161.3 pb^{-1}**

  (Efficiency 91.8 %)
- **Presented results based on ≈ 145 pb^{-1}**

  All results are preliminary

Two Fermion Cross Section

$e^+e^- \longrightarrow \tau^+\tau^-(\gamma)$



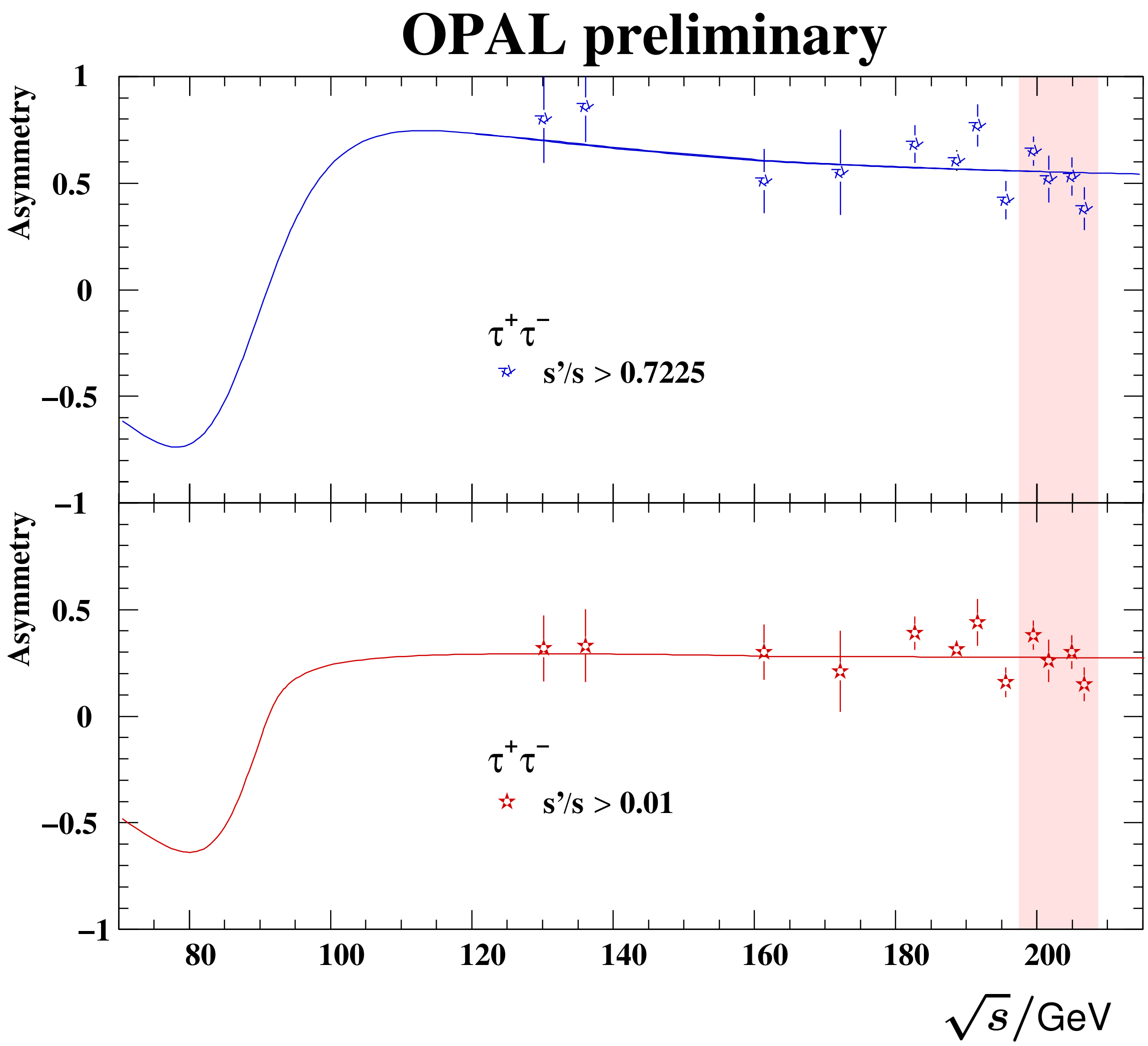
▷ **Recall excess reported July 20**

▷ **Excess persists ($\approx 2.6\,\sigma$ in high energy bins)**

▷ **Still under study**

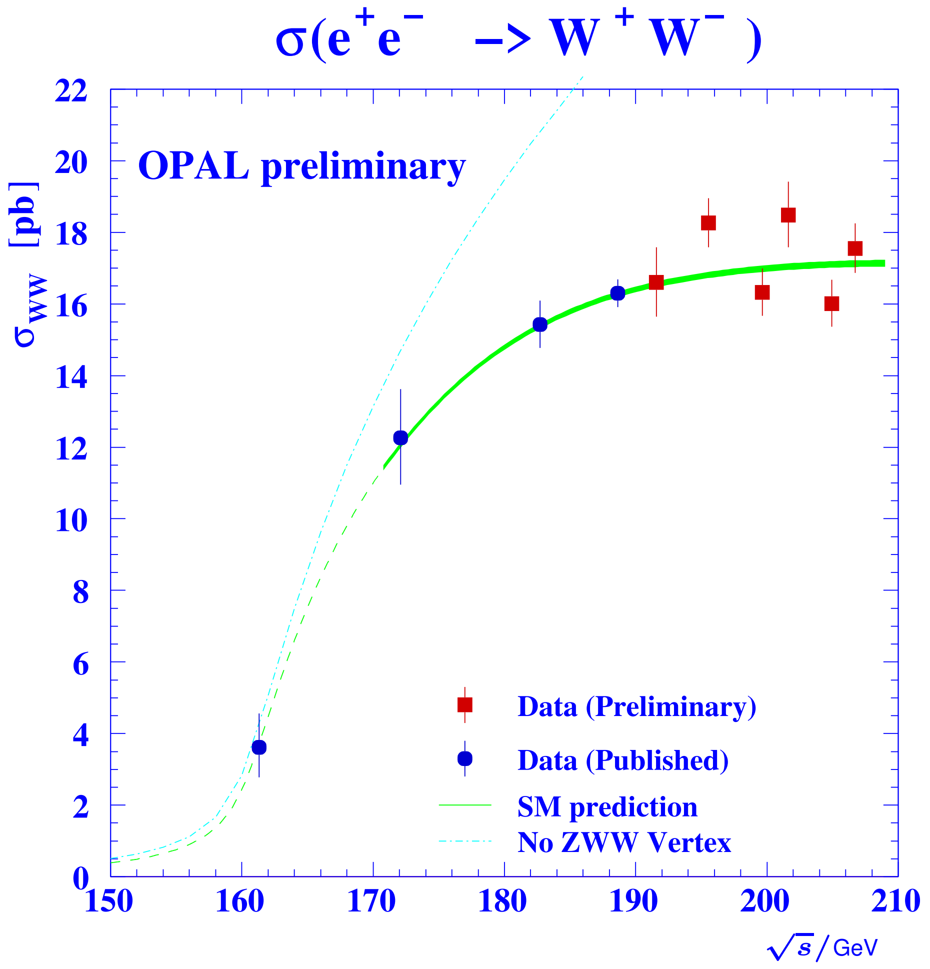
Forward-Backward Asymmetry

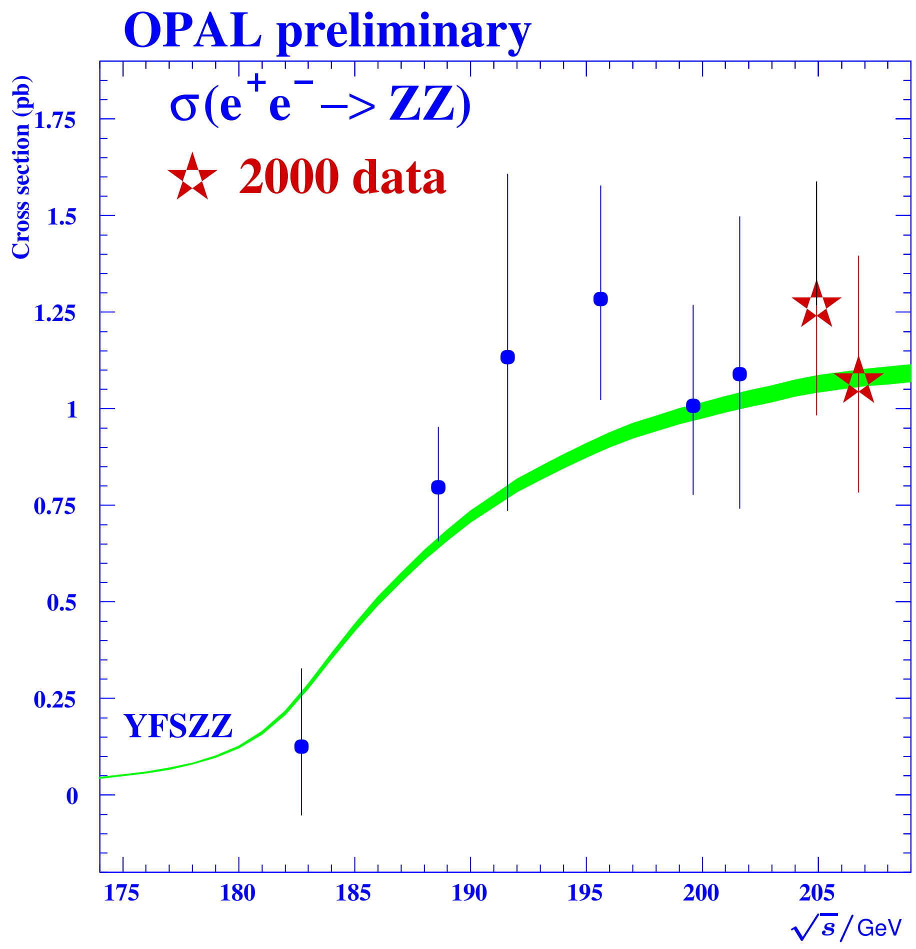
$e^+e^- \longrightarrow \tau^+\tau^-(\gamma)$



- **Asymmetries agree well with SM**
- **no systematic effect from eg. Bhabha contamination**

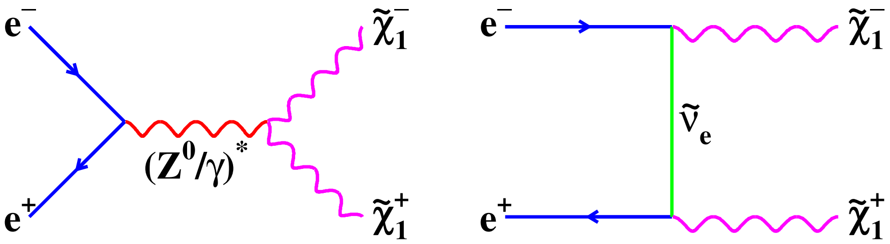
WW / ZZ Cross Section





$\Rightarrow$ **Good agreement with Standard Model**

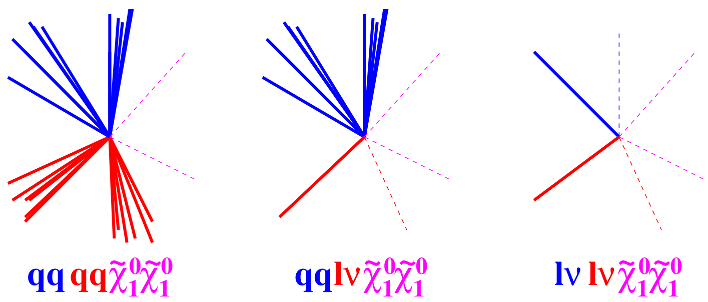
Charginos and Neutralinos



- Chargino decay via W (in a large fraction of MSSM space)

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

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



- OPAL has optimised analyses for different final states
- **Excess in analyses looking for**
  - **Low Multiplicity**
  - **Small mass differences ΔM for $\tilde{\chi}_1^\pm$ and $\tilde{\chi}_1^0$ ($\Delta M_{\leq} m_{\tilde{\chi}_1^\pm}/2$)**

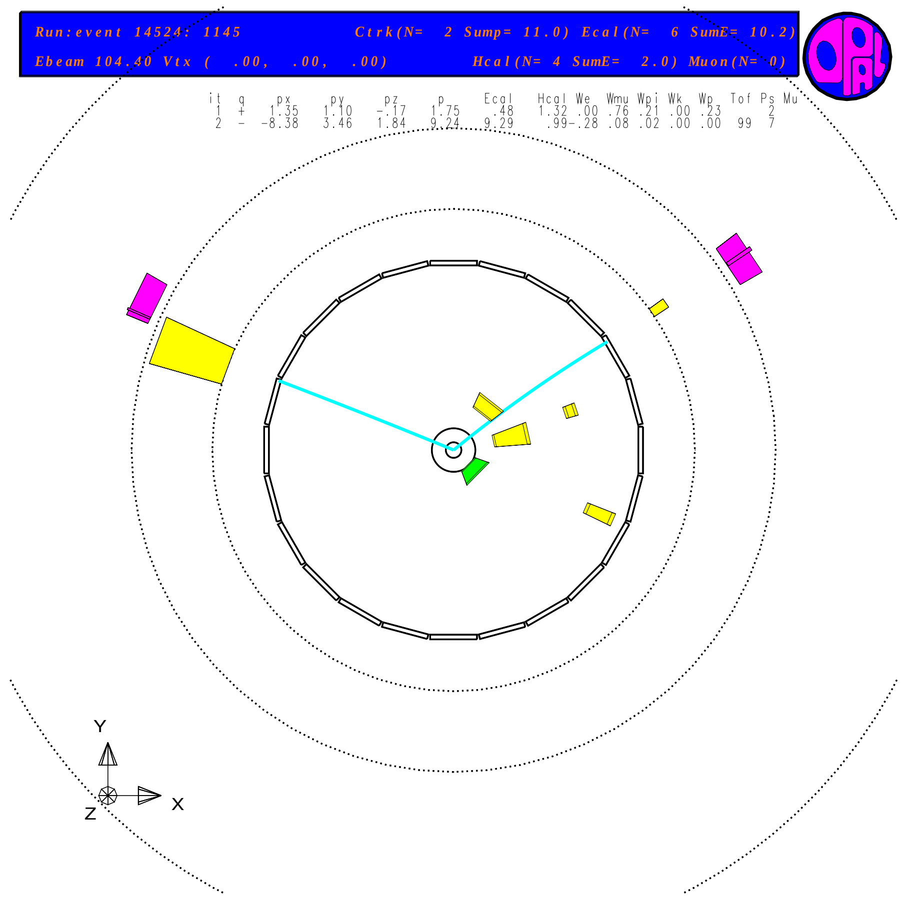
Charginos: Excess

In $\tilde{\chi}_1^+ \tilde{\chi}_1^-$ low multiplicity search with $\Delta M \sim$ 10 GeV

$\sqrt{s}$ (GeV)	Luminosity (pb^{-1})	Data	Background
$\sqrt{s} <$ 206.5 GeV	80.3	10	9.2 $\pm$1.0
206.5 GeV $< \sqrt{s} <$ 207.5 GeV	55.3	3	6.4$\pm$0.7
$\sqrt{s} >$ 207.5 GeV	6.4	5	0.74$\pm$0.08

$\Rightarrow$ Excess confirmed by likelihood analysis

***eg.* An event at $\sqrt{s} =$ 208.8 GeV:**



$\Rightarrow$ Events do not favour 100% W^* decays

A Study of Semileptonic b Decays

Context $\Rightarrow$ looking for a final state consistent with $M_{\tilde{\mathrm{b}}} \approx 3.6$ GeV, massless $\tilde{\nu}$, $\tau_{\tilde{\mathrm{b}}} \approx 1$ ps,

$$\mathrm{e}^+\mathrm{e}^- \to \tilde{\mathrm{b}}\bar{\tilde{\mathrm{b}}};\ \tilde{\mathrm{b}} \to c\ell\tilde{\nu} \text{ with } \ell = e, \mu$$

Analysis 1: emulation of ALEPH analysis (excess reported at LEPC July 2000)

Analysis 2: relaxed cut on thrust (less sensitive to details of signal simulation)

	Data	Bkg	ε^*	Data set
Analysis 1	15	20.5	15.0$\pm$1.6%	161-209 GeV
Analysis 2	19	23.3	13.7$\pm$1.6%	189-209 GeV

(ε^*=Efficiency for ALEPH $\mathrm{e}^+\mathrm{e}^- \to \tilde{\mathrm{b}}\bar{\tilde{\mathrm{b}}}$ signal MC)

$\Longrightarrow$ No excess in OPAL data

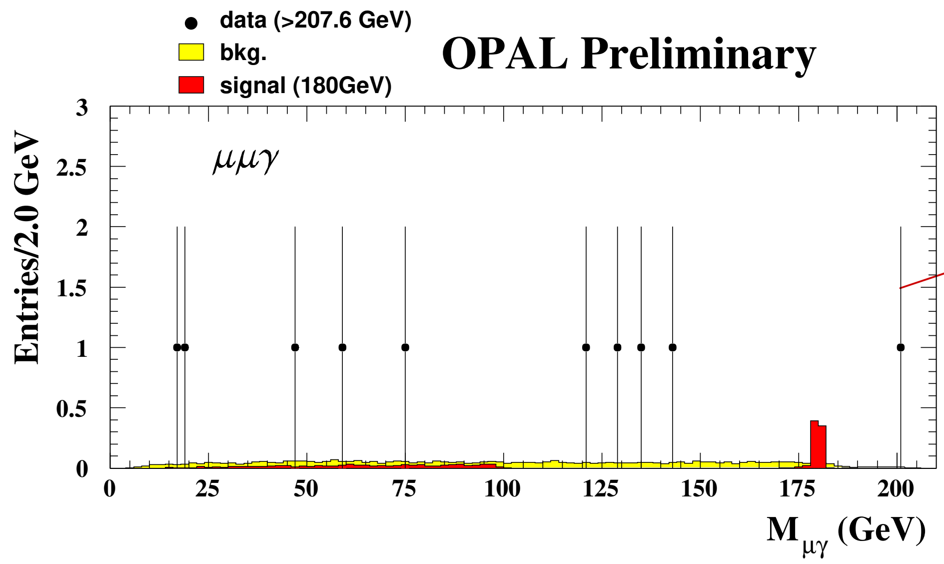
Excited Leptons

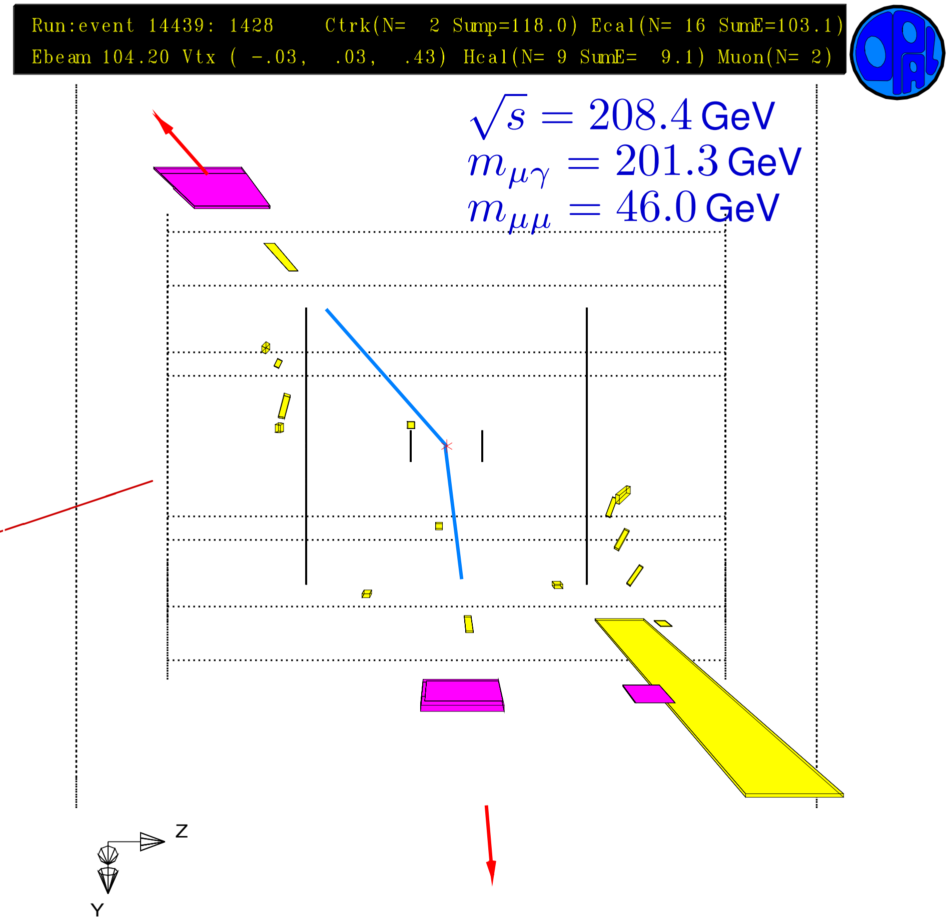
Searching for

$$e^+e^- \rightarrow \mu^* \, \mu$$
$$\mu^* \rightarrow \mu \, \gamma$$

Topology	$\sqrt{s}$	Data	SM
$\mu\mu\gamma$	200-209 GeV	47	48.3$\pm$0.9
	$>$207.6 GeV	5	2.1$\pm$0.1

Mass distribution of candidate events





Searches / Summary

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 $+ \not{E}$
	$\tilde{\chi}^0_2 \to \gamma\tilde{\chi}^0_1$	$\gamma + \not{E}$
$e^+e^- \to \tilde{\chi}^0_1\tilde{\chi}^0_1$	$\tilde{\chi}^0_1 \to \gamma G$	$\gamma\gamma + \not{E}$
	$\tilde{\chi}^0_1$ 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

Rob McPherson, University of Victoria & IPP *CIPANP, 28 May, 2000*

- All searches done in different $\sqrt{s}$ bins
- Would like more luminosity in highest energy bin (so far $\approx 7\ \mathrm{pb}^{-1}$)
- In addition to presented results: other excess in topologies with multiple hadronic jets + τ leptons (RPV, GMSB)
- Otherwise good agreement with SM...

Y2K h^0Z^0 Candidates

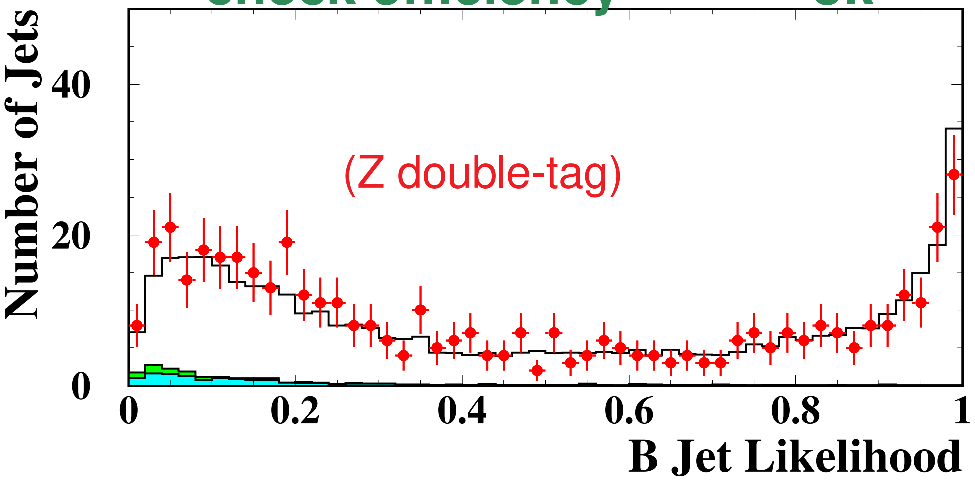
Luminosity: $140\ \mathrm{pb}^{-1}$ (August 23)

Preliminary

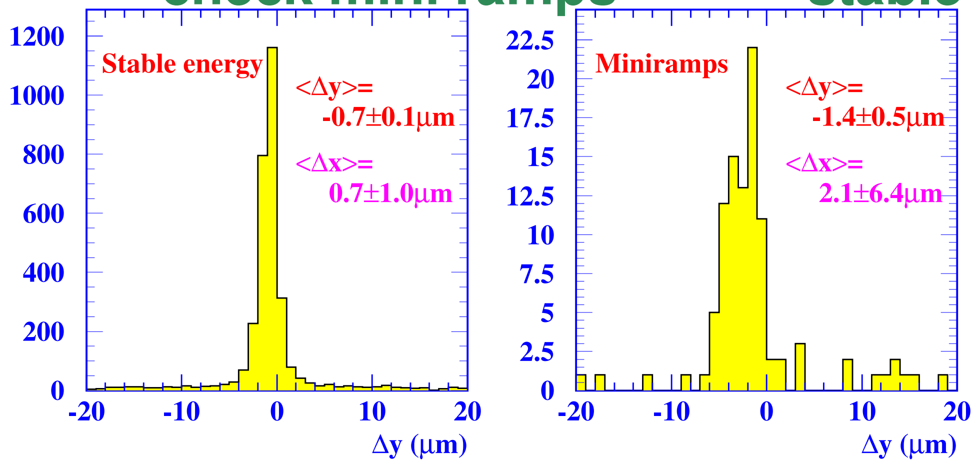
h^0Z^0 Channel	Data	Total bkg.	Efficiency (exp. signal events) $m_H = 110$ GeV	Efficiency (exp. signal events) $m_H = 115$ GeV
Four-jet	19	16.3 ± 2.0	44.9 % (5.06)	44.3 % (1.18)
Missing-Energy	19	23.9 ± 2.5	53.2 % (2.68)	45.8 % (0.85)
tighter cuts	6	7.7 ± 1.0	39.0 % (1.97)	33.6 % (0.63)
Tau	3	2.3 ± 0.3	29.2 % (0.55)	21.8 % (0.13)
Electron	2	2.6 ± 0.4	54.4 % (0.37)	52.0 % (0.09)
Muon	7	2.3 ± 0.5	59.5 % (0.45)	60.8 % (0.12)

B–tagging Performance

check efficiency → ok

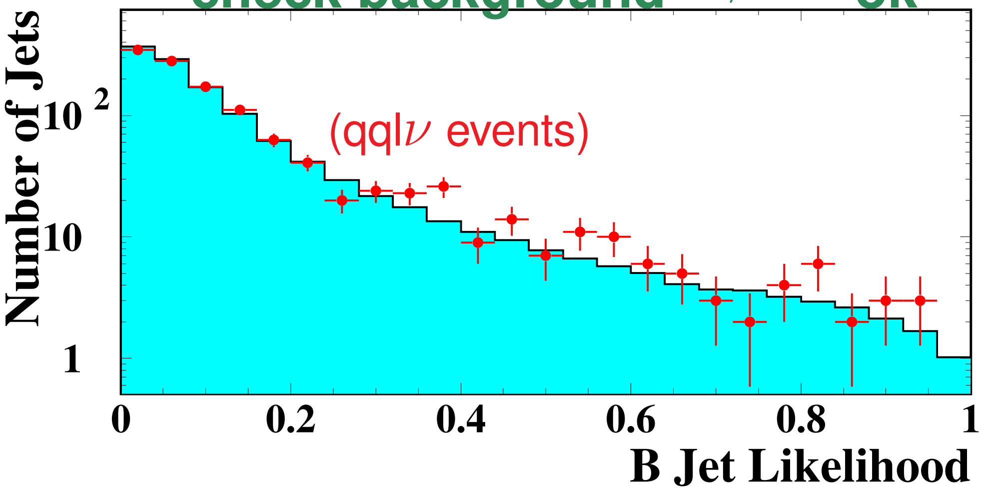


check mini ramps → stable



(Shift of beam spot during mini ramps, LEP fills 7837-8039)

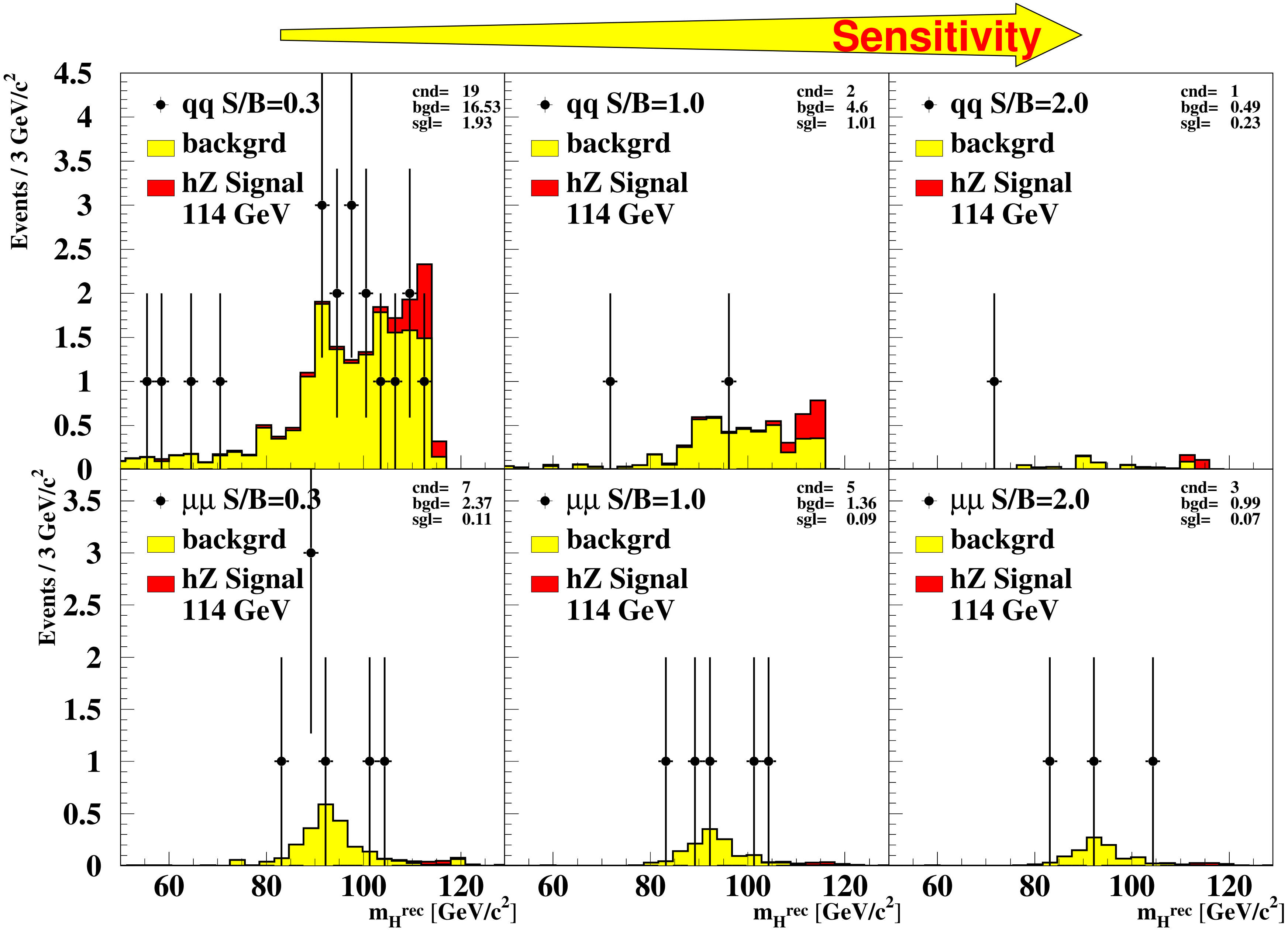
check background → ok



...and more checks.

⇒ reliable B-tag

Higgs Mass Plots by Channel (qq, $\mu\mu$)

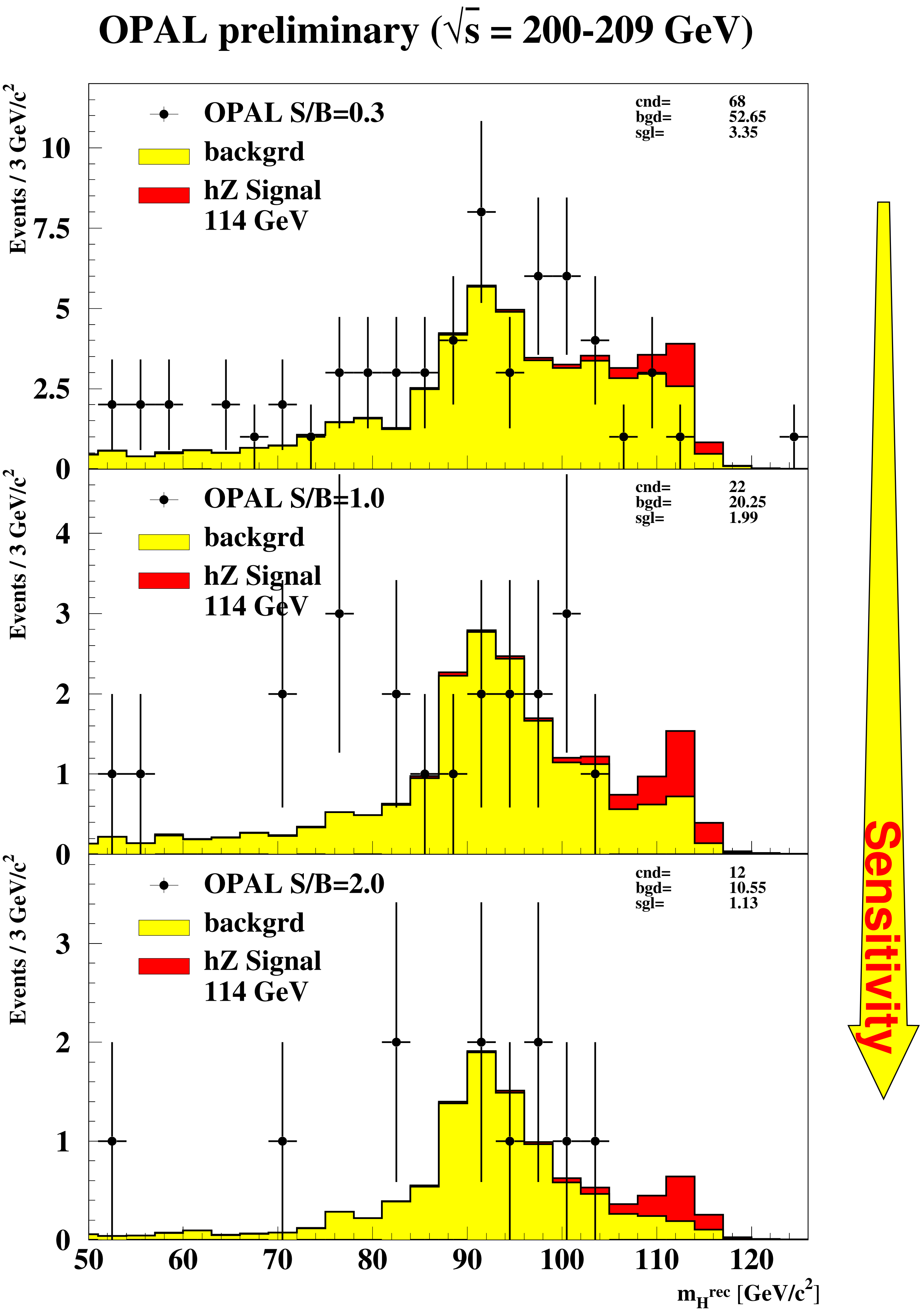


S/B for $m_H^{rec} > 109$ GeV/c^2

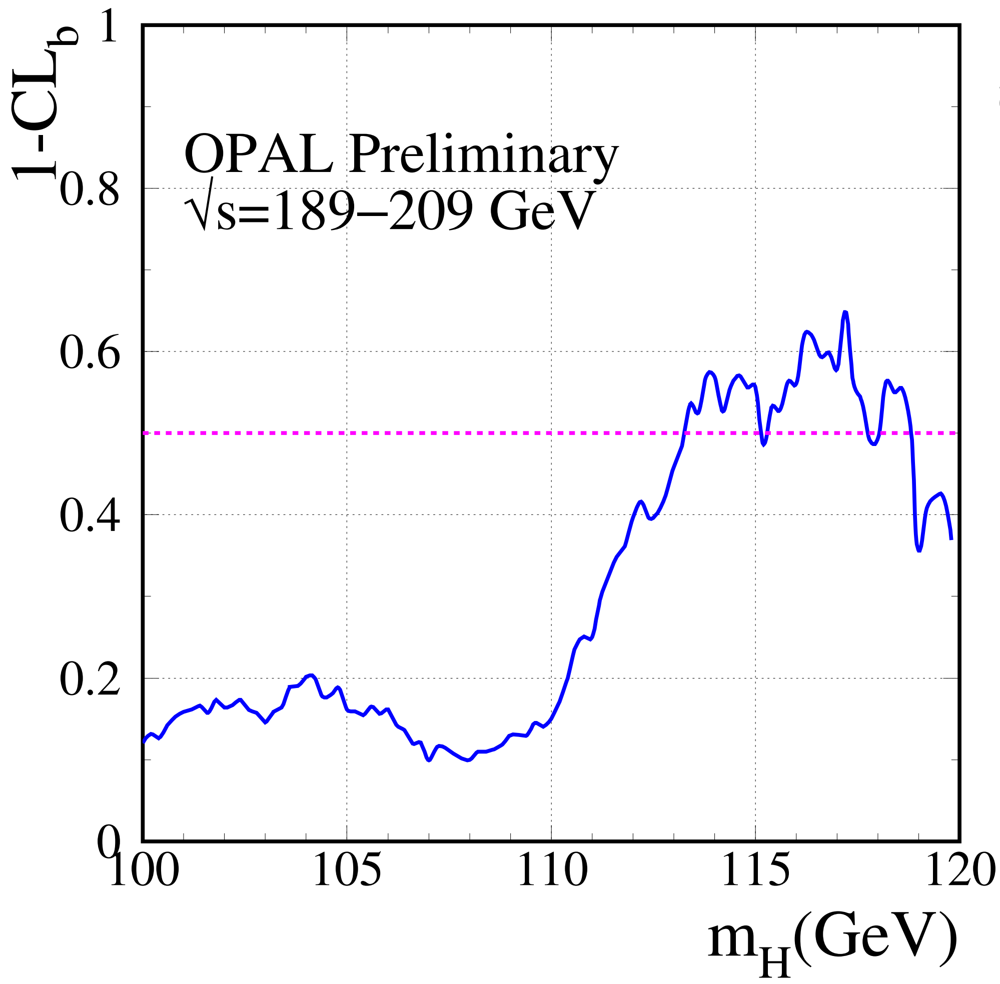
4-jet

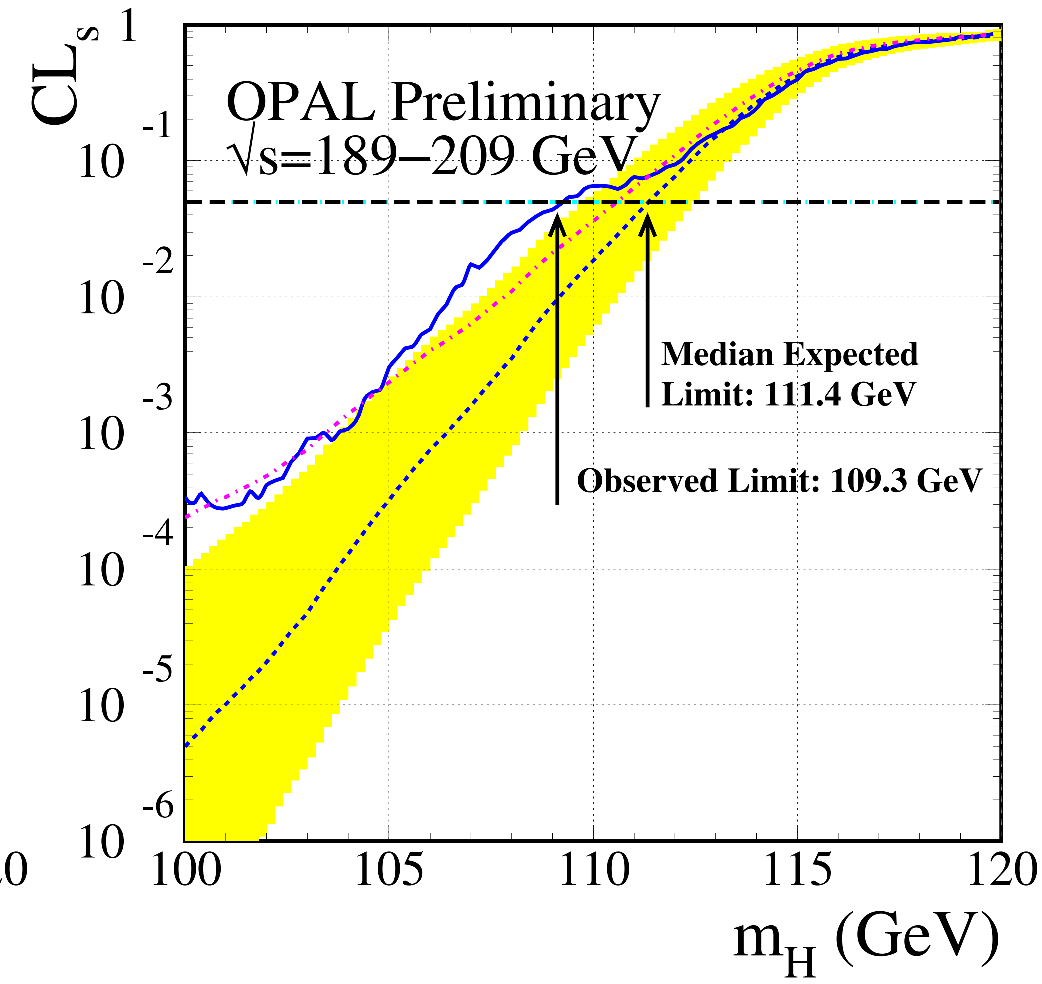
$\mu\mu$

Combined Higgs Mass Plots



Confidence Levels





- slight excess around 110 GeV

- $m_H > 111.4$ GeV/c^2 exp. 95% CL
- $m_H > 109.3$ GeV/c^2 obs.

Other Higgs Updates

Selection Channel	Data	bkground	Excl. Limit obs.	exp.
SM Higgs	37	31.2 ± 2.4	109.3 GeV	111.4 GeV
$e^+e^- \longrightarrow A^0h^0$			MSSM (m_h-max)	($\tan\beta > 1.0$)
$A^0h^0 \longrightarrow b\bar{b}b\bar{b}$	7	6.4 ± 0.7	80.0 GeV $< m_h$	(85.3 GeV)
$A^0h^0 \longrightarrow b\bar{b}\tau^+\tau^-$	3	2.9 ± 0.3	80.8 GeV $< m_A$	(87.0 GeV)
$H^0 \longrightarrow$ invisible		Invisible Higgs		
	27	44.4 ± 3.2	107.9 GeV	(105.6 GeV)
$H^0 \longrightarrow \gamma\gamma$		Fermiophobic Higgs		
	5	5.3 ± 0.5	104.4 GeV	(103.5 GeV)

Extension of LEP Running??

- OPAL detector is in good shape - we are enthusiastic to run if LEP run extended.

- Since there is a possibility that LEP experiments are observing Higgs production near the kinematic limit, OPAL requests:

  - **extension of the LEP run until Christmas. Review when $\int \mathcal{L}dt$ at $\sqrt{s} > 206$ GeV has doubled.**