OPAL

Status Report

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On Behalf of
The OPAL Collaboration

- Run Conditions
- What's seen in our data?
- Run Requests

OPAL Run Condition

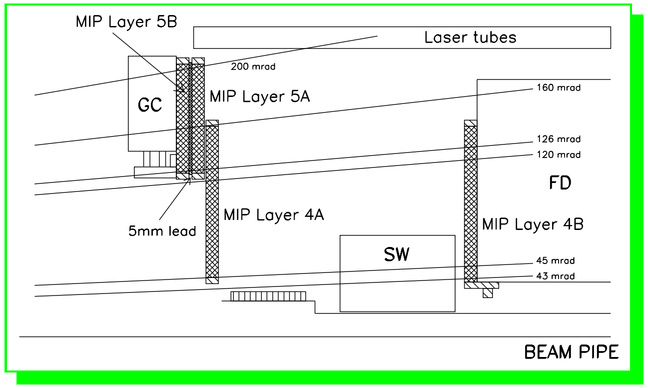
- **Background** usually **GOOD**

  Thanks to LEP RF/Vacuum experts for good conditioning of new Cu cavities before startup !!

Delivered	119.5 pb^{-1}
Recorded	108.9 pb^{-1}
Efficiency	91.2 %

Readout deadtime	-3.3 %
Background trips	-2.7 %
Jet chamber rampup	-0.6 %
Others(powercut etc)	-2.2%

Beam background caused high rate fake hits
in Forward scintillating tile detector (MIP-plug)



Sometimes the hits were observed in every collision.

$\longrightarrow$ **Solved** by collimator $\mathbf{17\sigma \rightarrow 13.5\sigma}$!

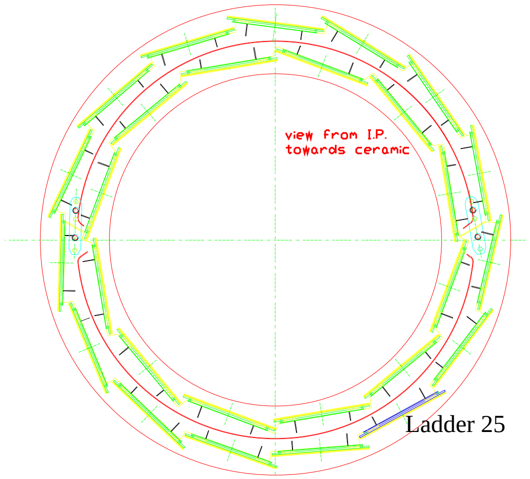
- Almost **No detector problem**

  Power cut incident on 29th June

  $\longrightarrow$ A lot of problems

  $\longrightarrow$ **All are solved quickly** except for one..

Si-μVTX problem with a ladder



Only $\sim$4 % of acceptance.
Inner layer is healthy.

$\rightarrow$ **NOT serious for physics**

- Mini-Ramp Fine.
- 2$\times$2 Welcome!

OPAL Y2K Physics

All results are PRELIMINARY

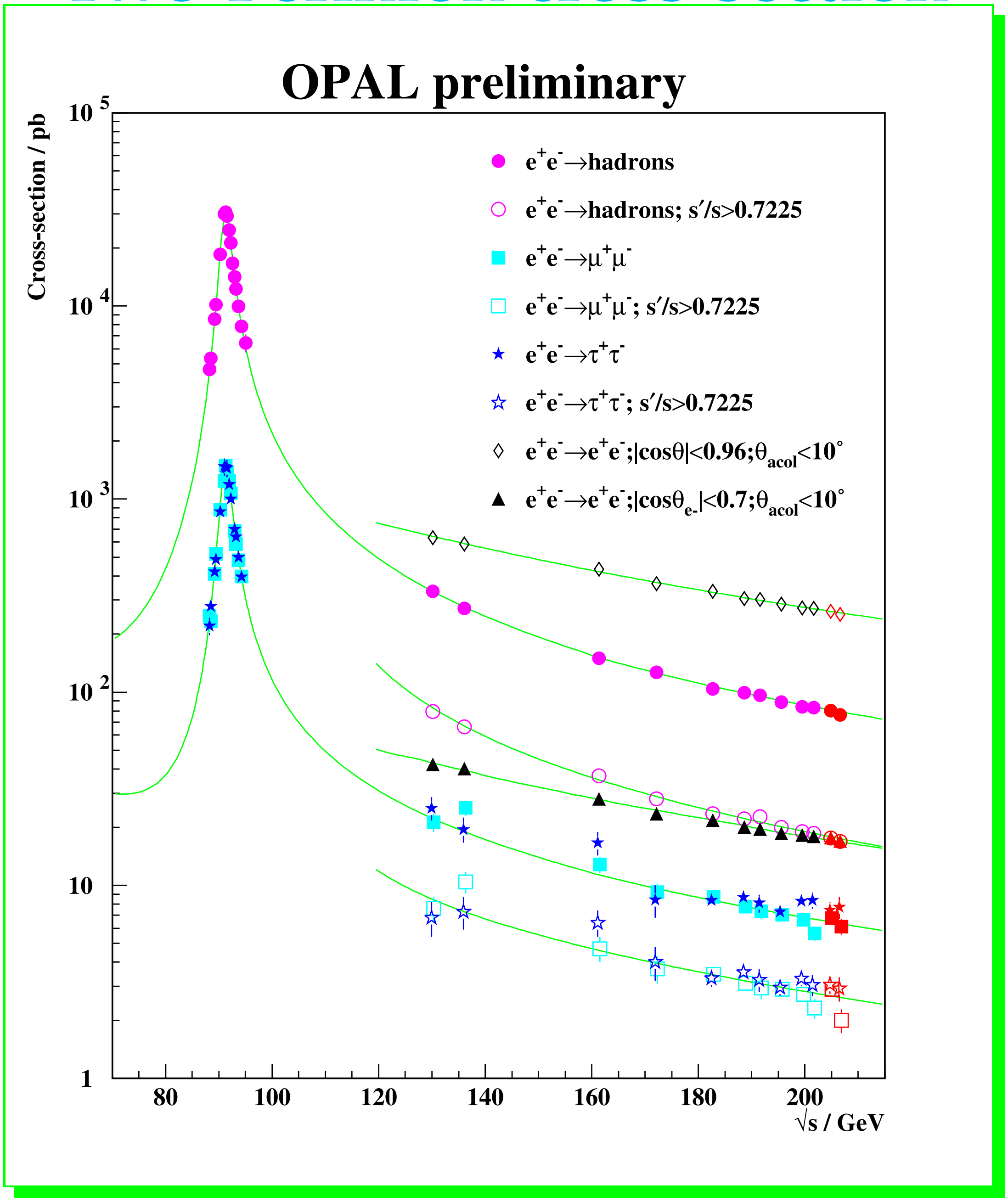
- **SM Measurements: Any deviation?**
- **New Particles Searches: Any Excess?**
- **Higgs Searches: Any Indication?**

Many thanks to LEP WG's for various cross-checks.

It worked well !

$\sqrt{s}$ (GeV) mean	range	$\int \mathcal{L}dt$ (pb^{-1})	$\Delta\mathcal{L}$ (%)
204.8±0.1	202.5 – 205.5	58	0.29
206.6±0.1	>205.5	28	0.33
205.4±0.1	>202.5	87	0.28

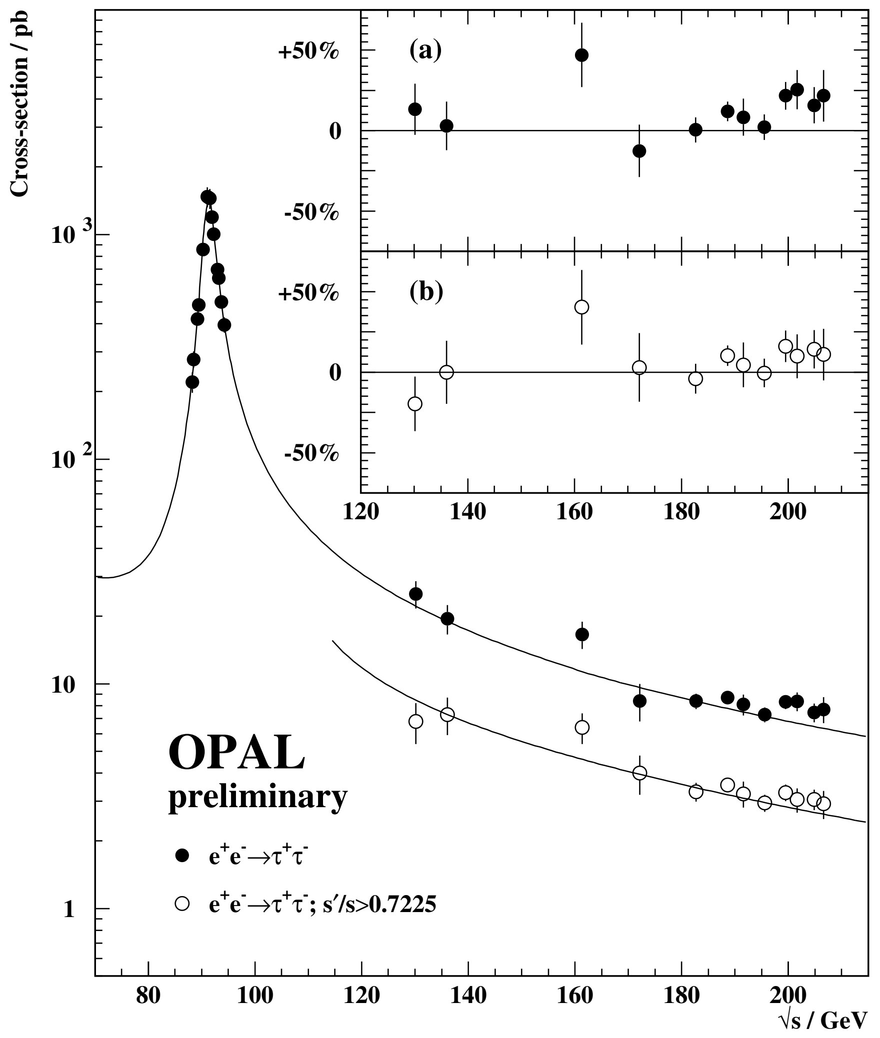
Two-Fermion cross-section



Still good agreement with the SM,

except for one..

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

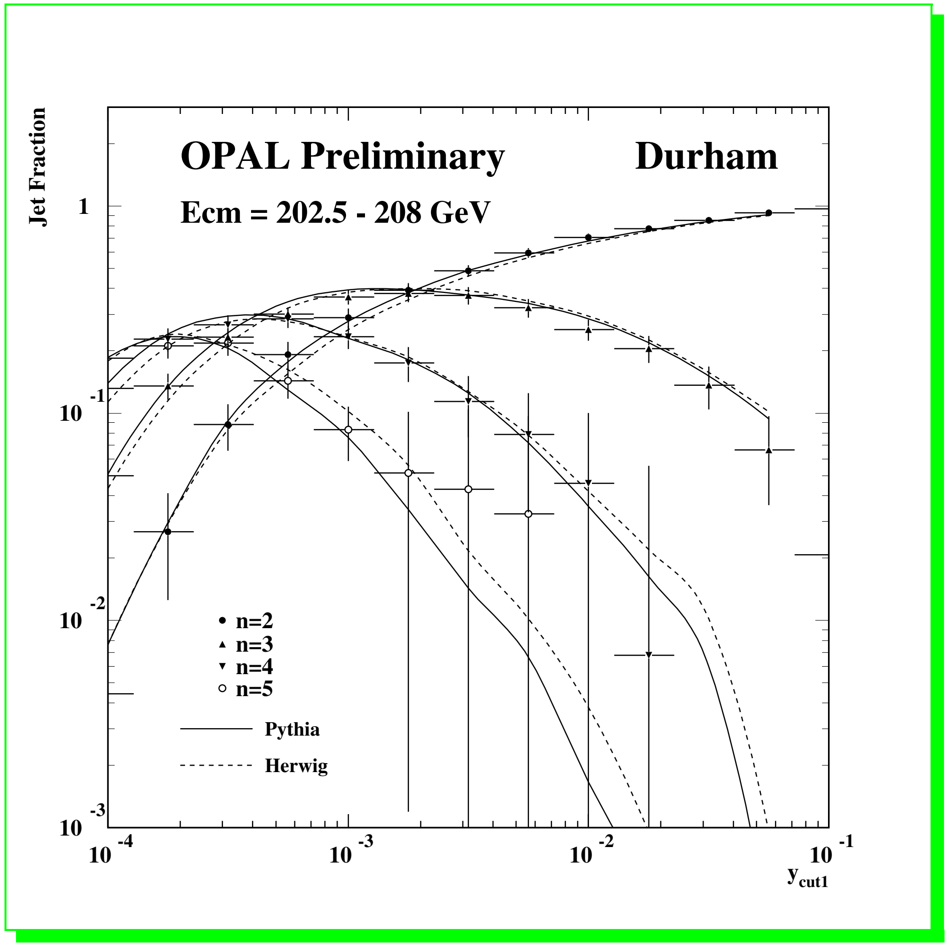


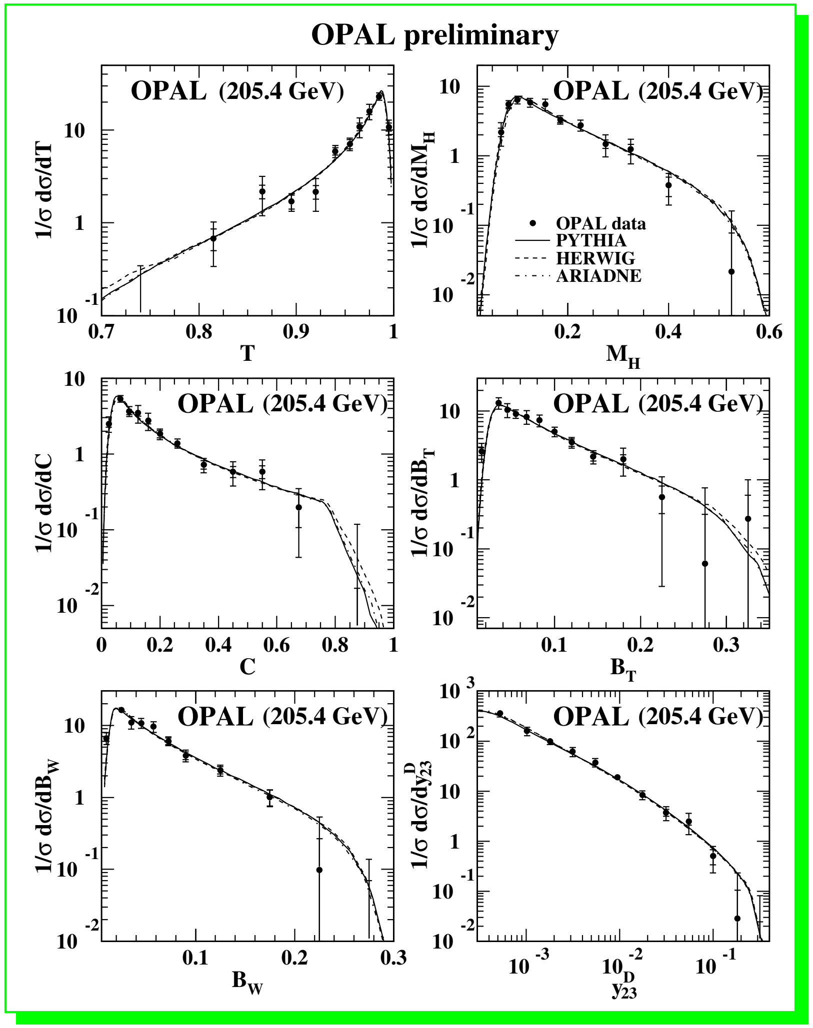
If we take last 4 points in inclusive
$e^+e^- \longrightarrow \tau^+\tau^-$

- Mean deviation per measurement is 1.8σ
- When combined, 2.64σ with correlation taken into account for systematic error

No obvious problem found.
$\longrightarrow$ Further checks are going on.

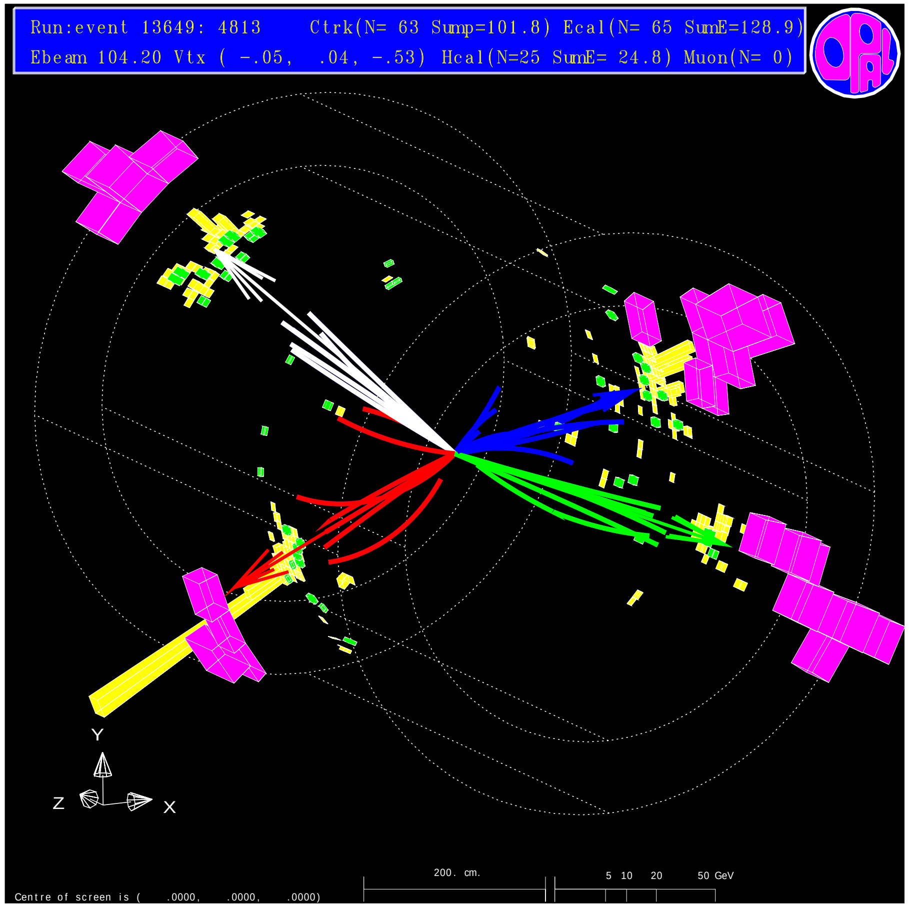
QCD Studies and α_s



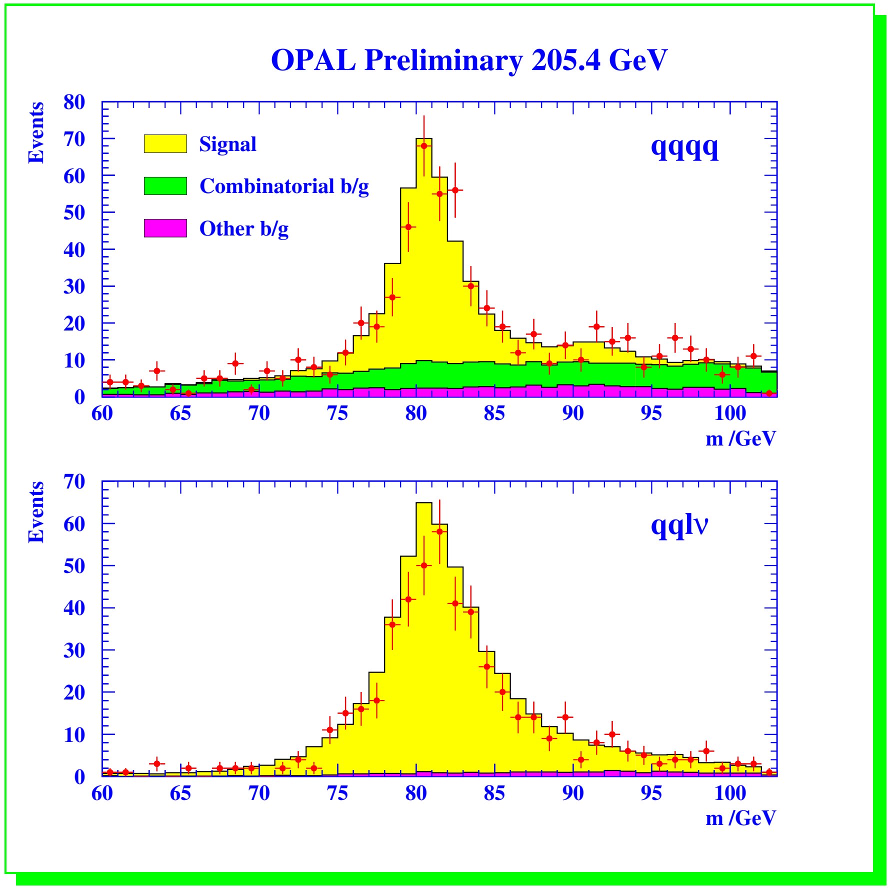


$$\alpha_s(205.4\,\text{GeV}) = 0.106 \pm 0.003(stat.) \pm 0.005(syst.)$$

Four-Fermion Processes



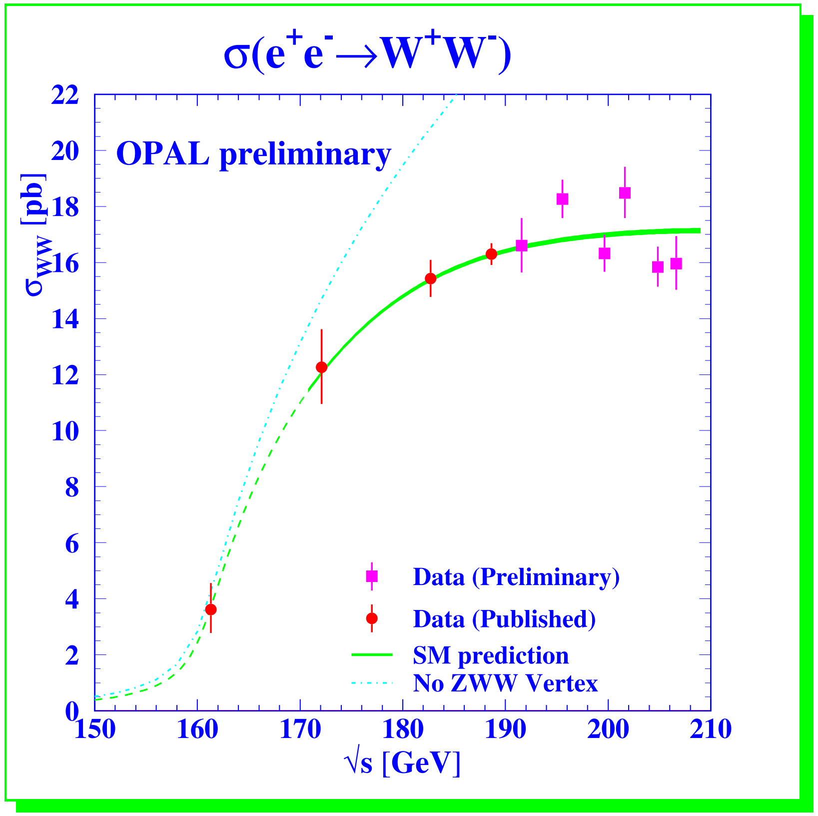
Event at $\sqrt{s}$ =208.4 GeV

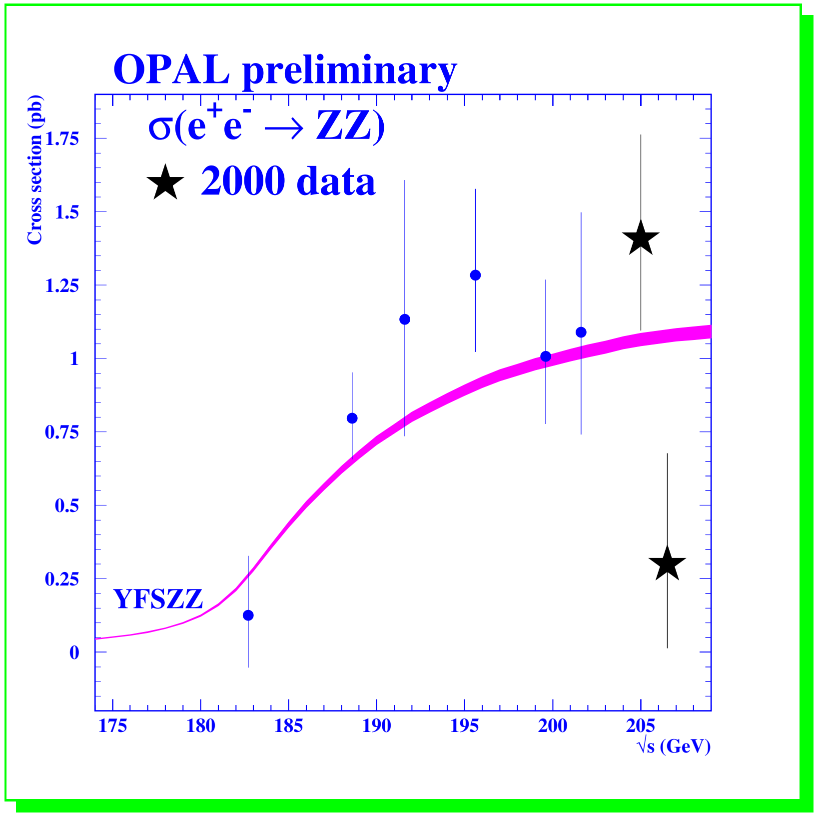


Mass Reconstruction is fine.

(MC M_W = **80.42** GeV)

WW/ZZ Cross-section





Healthy

also fine. No sign of Higgs at $\sim$ **90** GeV..

WW/ZZ Region No Anomaly Seen.

Let's see other regions $\longrightarrow$ Searches!

Search Channel List

$e^+e^- \to hZ$	$h \to b\bar{b}$	$b\bar{b}q\bar{q}$, $b\bar{b}\nu\bar{\nu}$, $b\bar{b}\ell^+\ell^-$
	$h \to \tau^+\tau-$	$\tau^+\tau^-q\bar{q}$
	$h \to q\bar{q}$	$q\bar{q}q\bar{q}$, $q\bar{q}\nu\bar{\nu}$, $q\bar{q}\ell^+\ell^-$
	$h \to \gamma\gamma$	$(q\bar{q}, \ell^+\ell^-, \nu\bar{\nu})+\gamma\gamma$
	$h \to WW^*$	$(\ell\nu q\bar{q}, q\bar{q}q\bar{q})+(q\bar{q}, \nu\bar{\nu})$
	$h \to \tilde{\chi}^0\tilde{\chi}^0$	$q\bar{q}$, $\ell^+\ell^- + \not{E}$
$e^+e^- \to hA$	$h, A \to b\bar{b}, \tau\tau$	$b\bar{b}b\bar{b}$, $b\bar{b}\tau^+\tau^-$
	$h \to AA$	$b\bar{b}b\bar{b}b\bar{b}$
$e^+e^- \to H^+H^-$	$H^+ \to q\bar{q}, \tau\nu$	$q\bar{q}q\bar{q}$, $q\bar{q}\tau\nu$, $\tau\nu\tau\nu$
	$H^+ \to A^0W^{+(*)}$	$b\bar{b}b\bar{b} + (\ell\nu q\bar{q}, q\bar{q}q\bar{q})$
$e^+e^- \to \tilde{\chi}^+\tilde{\chi}^-$	$\tilde{\chi}^- \to W^*\tilde{\chi}^0$	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
$e^+e^- \to LQ\bar{LQ}$	LQ$\to \ell q$ (νq)	jets, $\ell^\pm$, ν

Acoplanar di-lepton $\ell^+\ell^- + \not{E}$ in Y2K

$e^+e^- \to W^+W^- \to \ell^+\nu\ell^-\bar{\nu}$ e.g. $e^+e^- \to \tilde{\ell}^+\tilde{\ell}^- \to \ell^+\tilde{\chi}_1^0 + \ell^-\tilde{\chi}_1^0$

Acoplanar di-lepton events								
1998–2000		Event Type	Year 1998		Year 1999		Year 2000	
Data	SM		Data	SM	Data	SM	Data	SM
132	121.6	e^+e^-	48	44.6	59	55.8	25	21.2
136	127.3	$\mu^+\mu^-$	47	47.3	66	57.9	23	22.1
52	48.4	$h + h$	21	18.7	24	21.7	7	8.0
240	224.8	$e + \mu$	78	82.8	125	102.9	37	39.1
123	137.2	$e + h$	36	50.1	70	62.5	17	24.6
135	128.2	$\mu + h$	52	47.8	61	58.2	22	22.2
9	8.0	$e + X$	3	3.1	1	3.6	5	1.4
11	5.7	$\mu + X$	3	2.1	6	2.5	2	1.1
2	1.7	$h + X$	1	0.6	1	0.8	0	0.3
840	**802.8**	Total	**289**	**297.1**	**413**	**365.9**	**138**	**139.8**

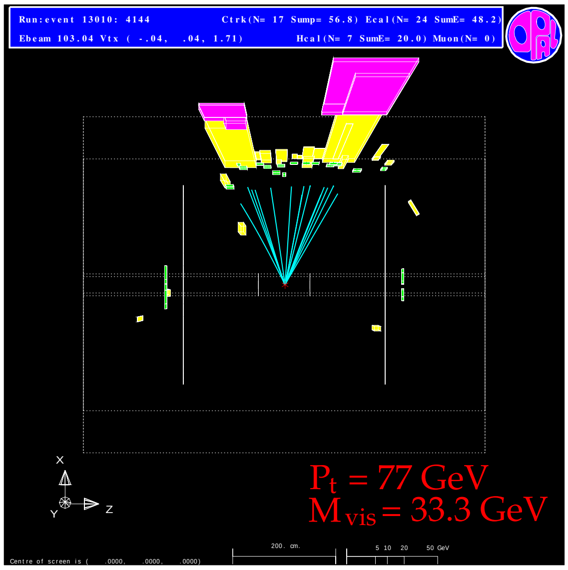
The excess observed in 1999 data has **NOT** shown up in Y2K data **so far.**

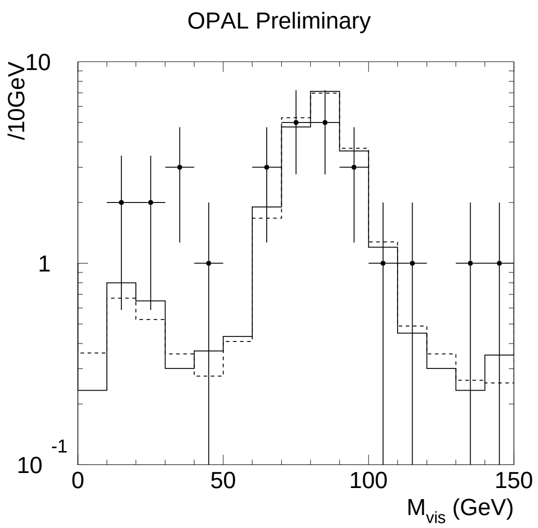
EXCESS !? Part 1

1. Mono-jet / Acoplanar di-jet Excess

Search Channel	Data	SM Bkg
$e^+e^- \to \tilde{\chi}^0_2\tilde{\chi}^0_1$ ($30 \leq \Delta M \leq 80$ GeV)	11	4.9
$e^+e^- \to LQ\bar{L}\bar{Q} \to \nu\bar{\nu}q\bar{q}$ (leptoquark)	6	3.3
Topological (jet+ $\not{E}$) ($M_{vis} < 60$ GeV)	8	2.5

large overlap of events among 3 selections





$\longrightarrow$ Informed LEP SUSY WG.

$\longrightarrow$ The excess was NOT confirmed.

EXCESS !? Part 2

2. Excess in $\ell^+\ell^-\gamma\gamma + \not{E}$

Main SM process: (typically one hard γ and one soft γ)

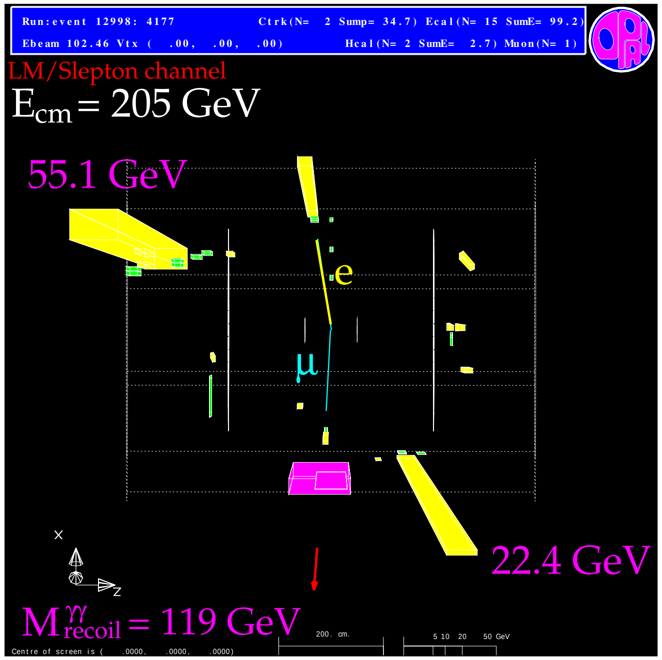
$e^+e^- \to Z^0\gamma\gamma \to \tau^+\tau^-\gamma\gamma \to \ell^+\ell'^-\nu\bar{\nu}\gamma\gamma$

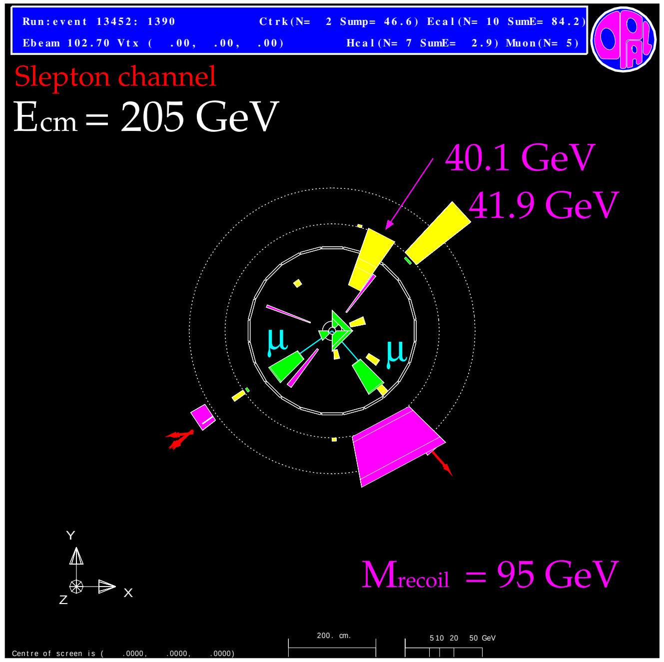
Example model (GMSB): (can have two hard γ's)

$e^+e^- \to \tilde{\ell}^+\tilde{\ell}^- \to (\ell^+\tilde{\chi}^0_1)(\ell^-\tilde{\chi}^0_1) \to (\ell^+\gamma\tilde{G})(\ell^-\gamma\tilde{G})$

$M_{\tilde{\ell}} - M_{\tilde{\chi}^0_1}$	Data	SM Bkg
3 – 10 GeV	1	0.5
10 GeV – $M_{\tilde{\ell}}/2$	2	0.7
$> M_{\tilde{\ell}}/2$	4	1.3

cuts on Eγ: $E_{\gamma_1} > 10$ GeV, $E_{\gamma_2} > 5$ GeV



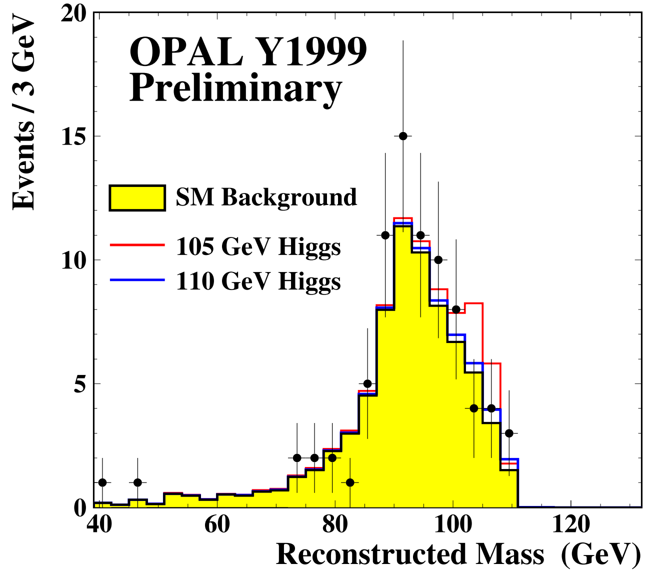


Two hard γ's are seen in two events.
We keep watching!

SM HIGGS

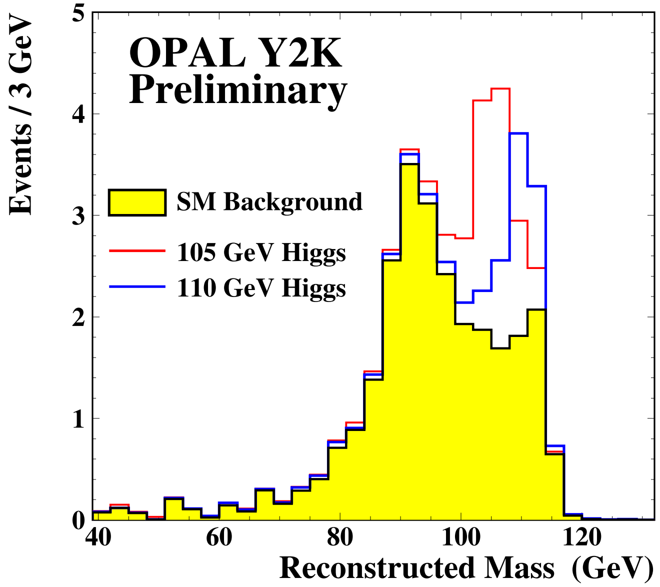
Last Year

No way to see ∼110 GeV Higgs indication...



THIS YEAR

Chance to see 110 GeV Higgs !!

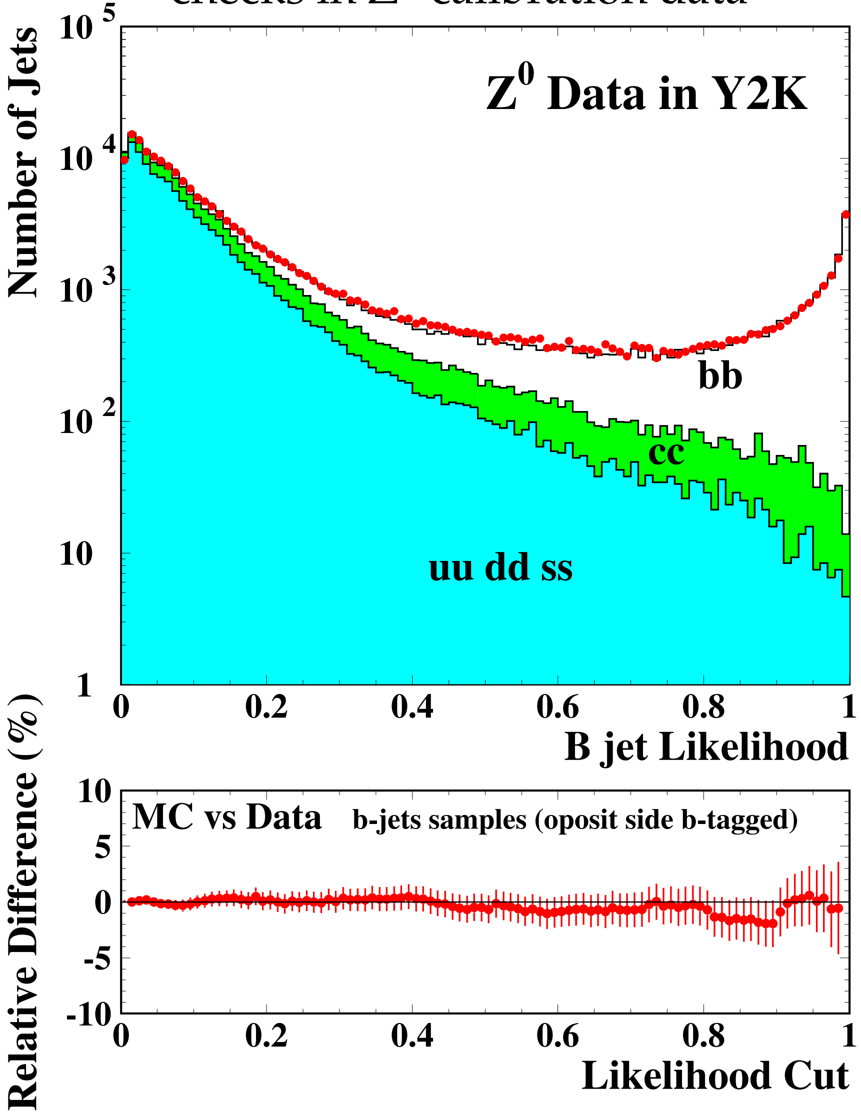


High Energy is quite Helpful for Higgs Hunting!

Various checks for b-tagging

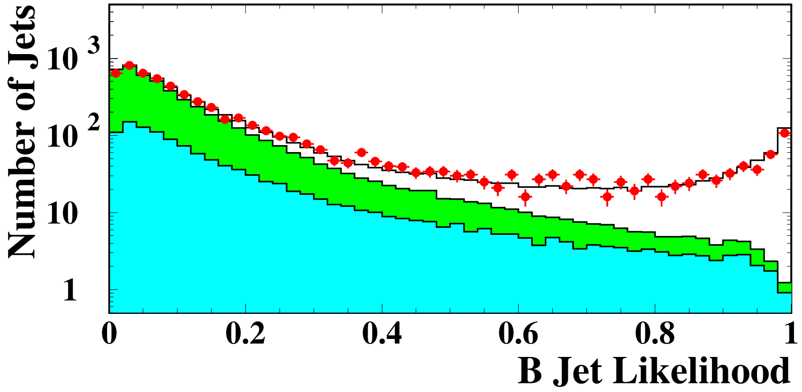
OPAL Preliminary

checks in Z^0 calibration data

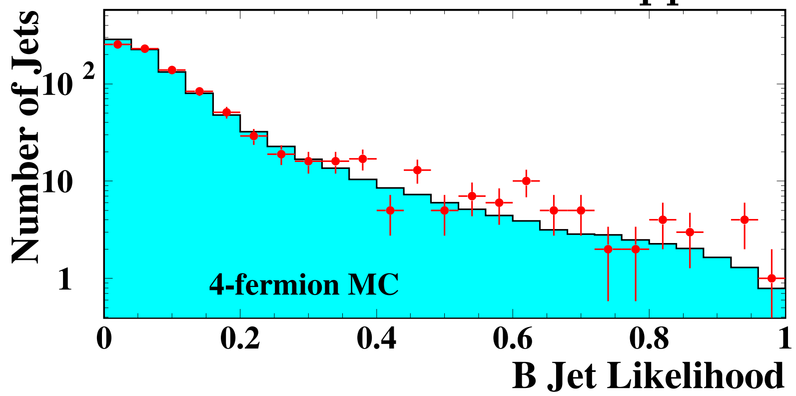


At $\sqrt{s} = 200 - 209$ GeV

checks with $q\bar{q}\gamma$ events



checks with $W^+W^- \longrightarrow q\bar{q}\ell\nu$

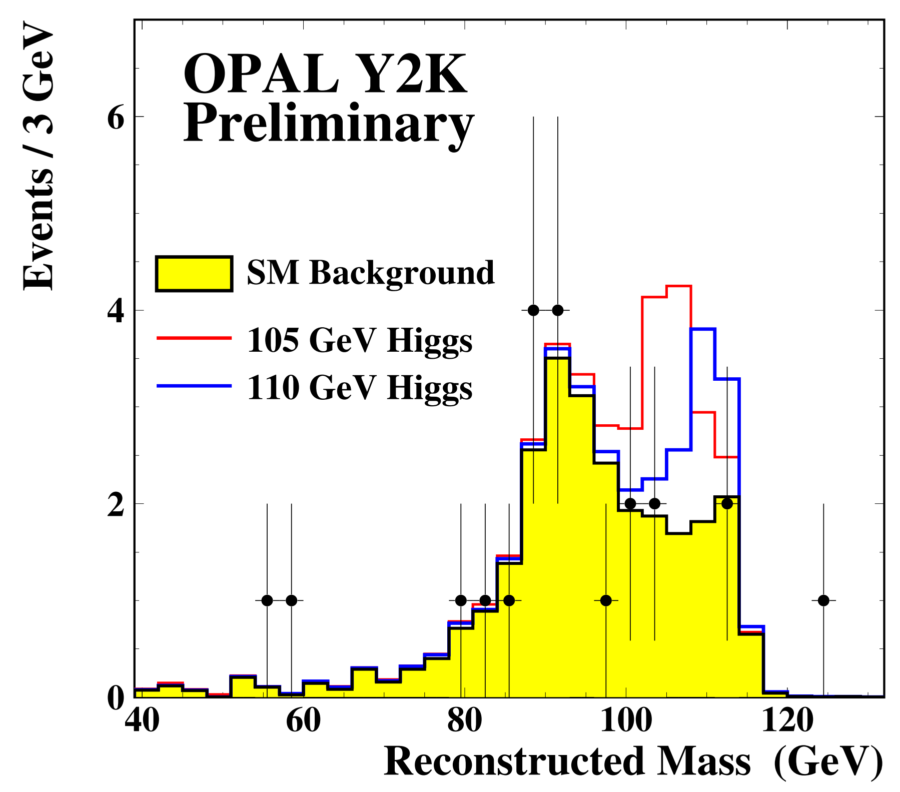


b-tagging works well
as usual

SM Higgs

$\mathcal{L} \sim 80\ \mathrm{pb}^{-1}$ analysed

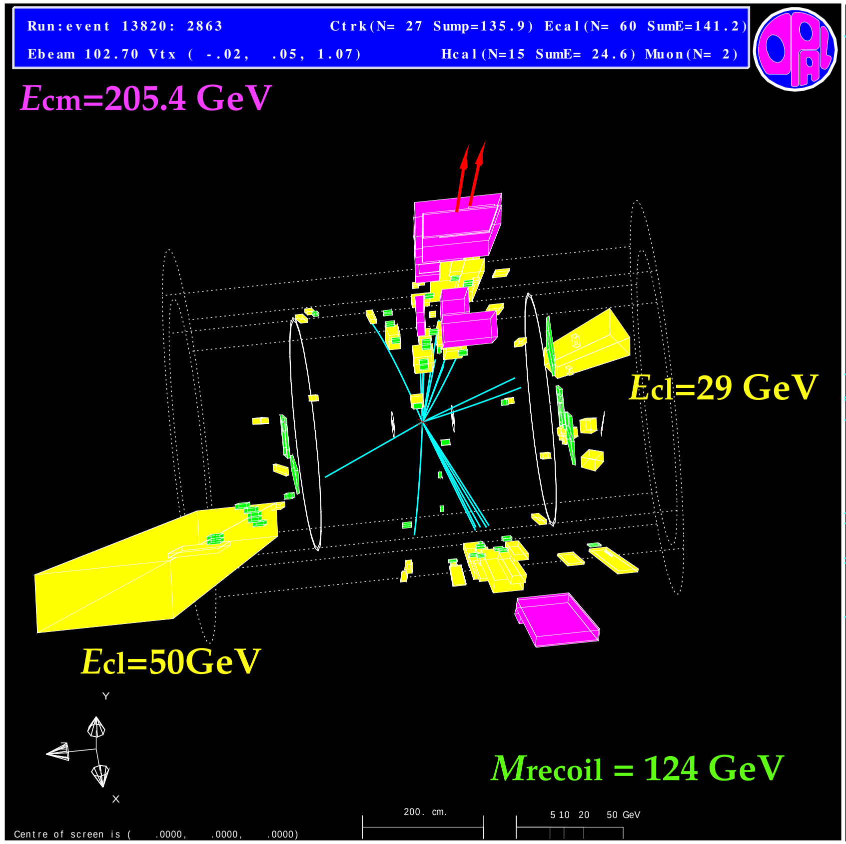
Selection Channel	OPAL Data	Total SM bkgrounds	SM Higgs 105 GeV	SM Higgs 110 GeV
$Z^0H^0 \to q\bar{q}b\bar{b}$	7	$8.9\pm\mathbf{1.1}$	4.8	2.9
$H^0\nu\bar{\nu}$	6	$13.6\pm\mathbf{1.3}$	2.4	1.5
$q\bar{q}\tau^+\tau^-$ & $H^0\tau^+\tau^-$	0	1.3 ± 0.2	0.5	0.3
$H^0e^+e^-$	2	$1.6\pm\mathbf{0.3}$	0.4	0.2
$H^0\mu^+\mu^-$	6	$1.4\pm\mathbf{0.3}$	0.4	0.2
Total Y2K	21	$26.8\pm\mathbf{2.8}$	8.4	5.1



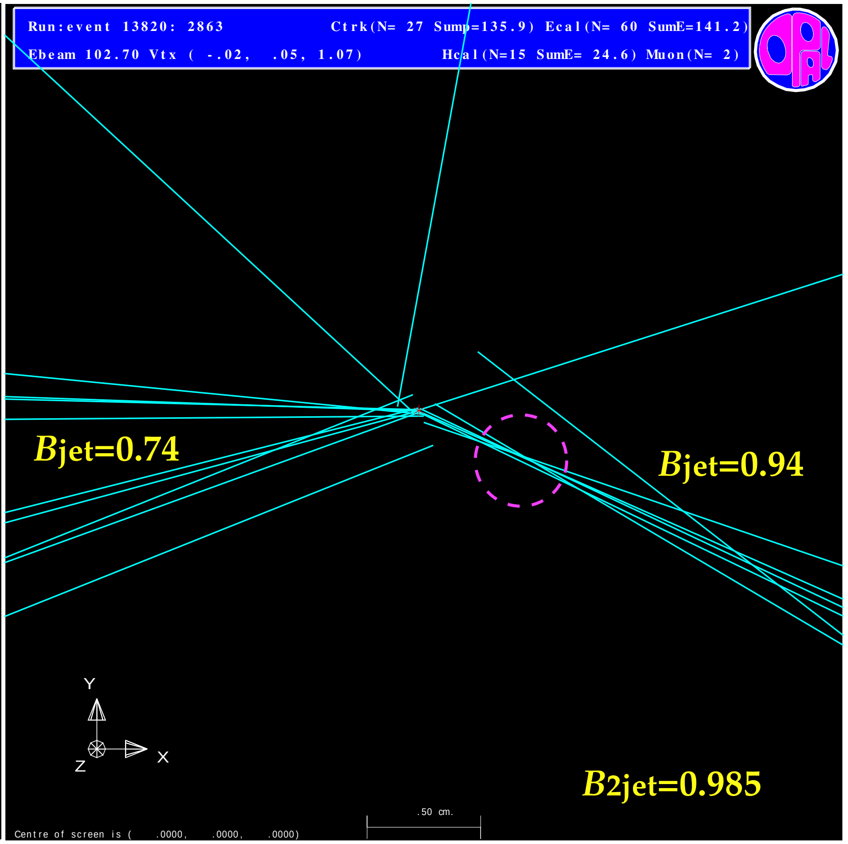
SM Higgs

Highest Mass Candidate $M_{\mathrm{Higgs}} = 124$ GeV

$$e^+e^- \to H^0e^+e^- \to b\bar{b}e^+e^-$$

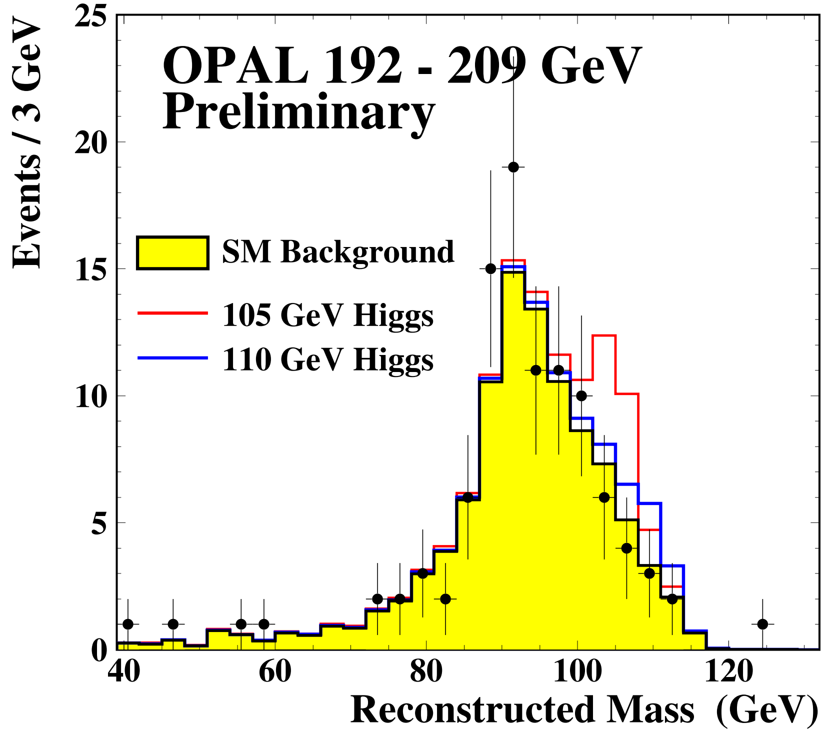


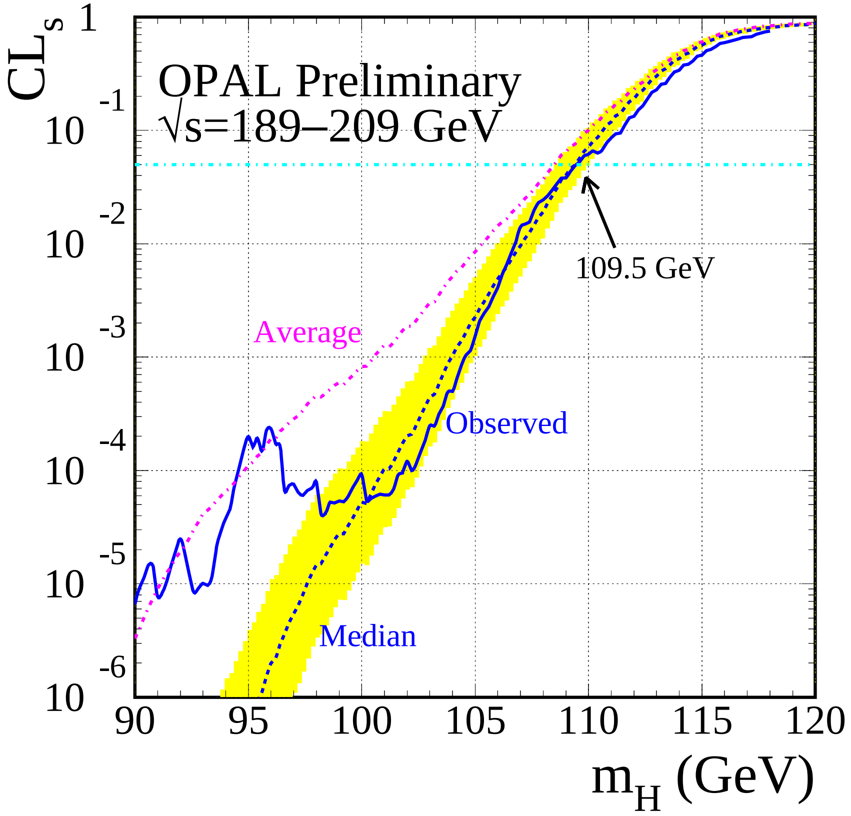
one electron is poorly measured.



good b-tag

SM Higgs





SM Higgs Limit = 109.5 GeV (95% CL)

(expected median 109.5 GeV)

HIGGS SUMMARY

In all channels, the sensitivities go up

Thanks to LEP for the High Energy and High $\mathcal{L}$!

Don't forget that **all the analyses** have **continued to be improved!!**

Selection Channel	Data	bkgrounds	Limits **(y1999→Y2K)**	(expected)
SM Higgs	21	26.8±**2.8**	**103.0** → **109.5 GeV**	(109.5 GeV)
$e^+e^- \to$ **A^0h^0**			MSSM (m_h-max)	($\tan\beta$ >1.0)
$A^0h^0 \to b\bar{b}b\bar{b}$	4	3.7±**0.4**	**79.2**→**80.7 GeV** $< m_h$	(84.4 GeV)
$A^0h^0 \to b\bar{b}\tau^+\tau^-$	0	1.7±**0.2**	**80.2**→**83.2** GeV $< m_A$	(86.6 GeV)
H^0 →invisible			Invisible Higgs	
	21	30.4±**2.2**	**101.0** → **105.8 GeV**	(103.8 GeV)
H^0 $\to \gamma\gamma$			Fermiophobic Higgs	
	13	9.6±0.9	**102.3** → **103.1 GeV**	(103.5 GeV)
e^+e^- →**H^+H^-**			Any Br($H^+ \to \tau^+\nu$)	
(mass dependent)			70.5→70.5 GeV	(75.6 GeV)

NO HIGGS SIGNAL INDICATION, **YET**

Don't blame us !

RUN REQUESTS

- **VITAL** to understand the **energy calibration** of LEP.
  Must be understood before LEP stops.
  MD's strongly encouraged.
- Want to **MAXIMIZE HIGGS REACH.**
  Present running almost optimal
  — **gaining already** by going more rapidly to
  1 KLYSTRON RESERVE.
- Need $>$ **10** $\mathbf{pb^{-1}}$ at the **Highest Possible Energy** for SUSY searches **a.s.a.p**:
  - Try 2×2 bunch operation.
  - Run with 0 klystron reserve.
- **Running in 2 Reserve Weeks could be very beneficial. OPAL would like to use them!**
- An extension until December would allow to either
  - confirm signal for new physics, **if we have a signal before September,** or
  - record about **200** $\mathbf{pb^{-1}}$ **at 161 GeV** and make an independent measurement of the W mass to roughly the same precision as the direct reconstruction method.
    $\rightarrow$ **Studies of LEP performance at 161 GeV needed soon.**

SUMMARY OF OPAL DETECTOR / PHYSICS

- **NO SERIOUS PROBLEM in detector**
  Background situation is usually **GOOD**.
- In $e^+e^- \rightarrow \tau^+\tau^-$ cross-section measurements, we see some deviation from the SM calculation.
  No obvious problem was found. Keep investigating.
- Other results of the SM measurements agree well with the expectation although the accuracies are still limited mostly by statistics.
- Various event topologies have been examined, and **excesses** are observed for instance in;
  1. acoplanar di-jet and mono-jet topologies, and
  2. $\tau^+\tau^-\gamma\gamma + \not{E}$ topology.

  These are still interesting.
- NO indication of HIGGS **YET** in OPAL
  Sensitivity already went up by $\sim$5 GeV
  SM Higgs Limit = **109.5 GeV**

Many Many Thanks to
All Accelerator Staff Members
and
Good Cooperation in LEP WG's !!

PLEASE

PLEASE

PLEASE

GIVE US BEAM
AS MUCH AS POSSIBLE !

WE ARE READY TO
WORK WITHOUT SLEEP
!!!!!