OPAL Status 1997

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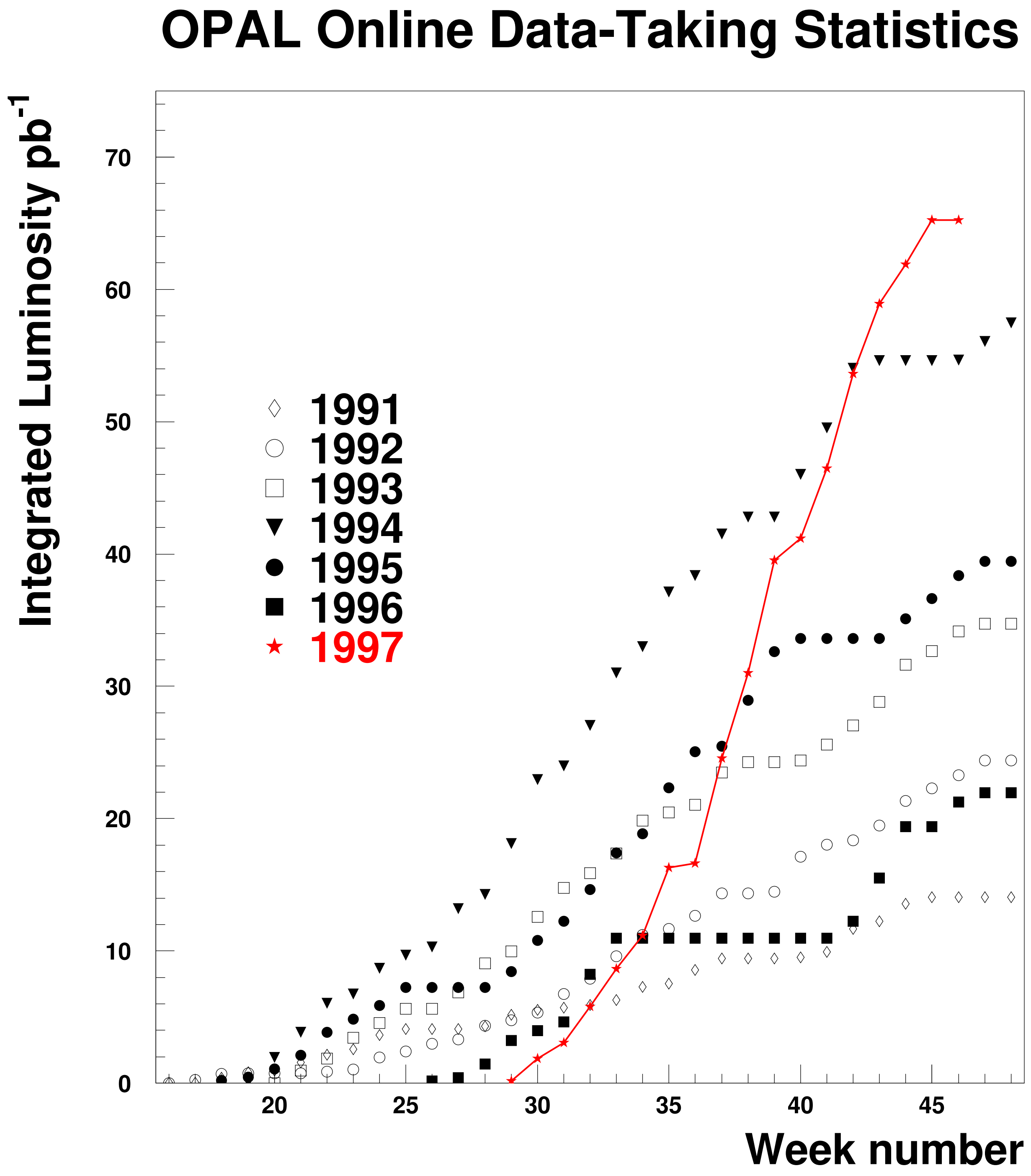
1. 1997 Running Experience & Shutdown Plans
2. Preliminary Physics Results
   - 4-jet results at 130-136 GeV
   - Standard Model physics at 183 GeV
   - Searches for new physics
3. Conclusions

OPAL's 1997 Running Experience

CONGRATULATIONS TO SL : BEST ONE YEAR $\int \mathcal{L}$

Over 65 pb^{-1} recorded by OPAL !
(Over 72 pb^{-1} delivered)



OPAL's 1997 Running Experience

Report on "New" detector systems:

1) Trigger improvements : revamped software and some new hardware, successfully implemented before data taking.

2) Tile Endcap (TE) scintillator extension:

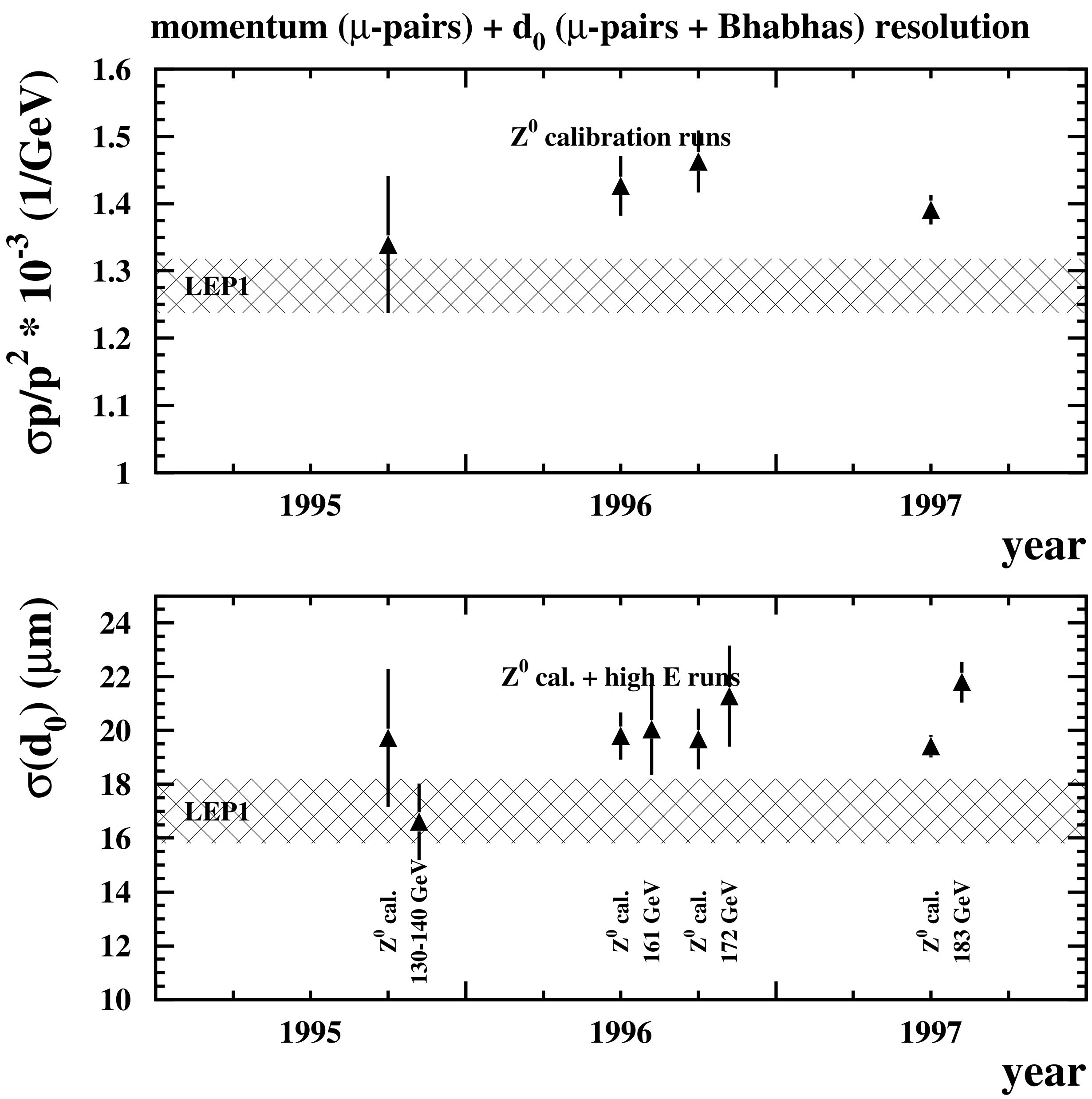
Extension to small angle coverage completed and working.

TE extension timing for bunch trains.

OPAL's 1997 Running Experience

Calibration Status

- Reconfirm that calibration of OPAL can be done with 0.5 pb^{-1}
- Momentum resolution and d0 resolution as for last year



OPAL's 1997 Running Experience

A few problems encountered...

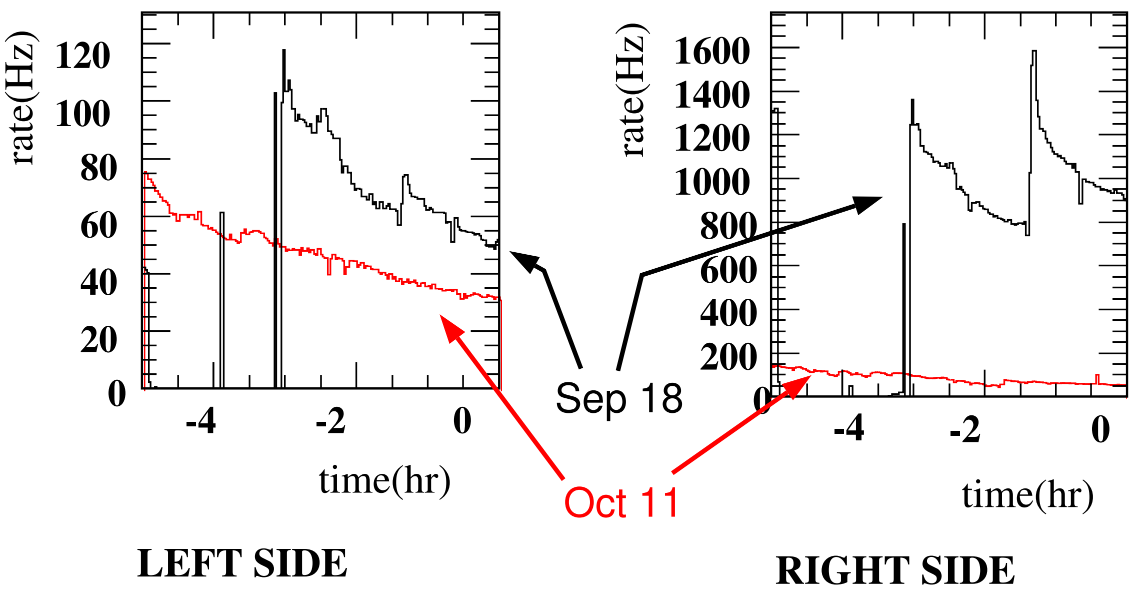
1) Beam background problems

Synchrotron background no problem (w/collimators)

Severe off-momentum problems for most of run

- Outgassing/dynamic vacuum $\rightarrow$ QS0 quenches
- Sep.1: RF671 vacuum window rupture $\rightarrow$ slow recovery
- $\rightarrow$ high trigger rates, high occupancy
- OK since October (THANKS for improvement), but still R/L asymm.

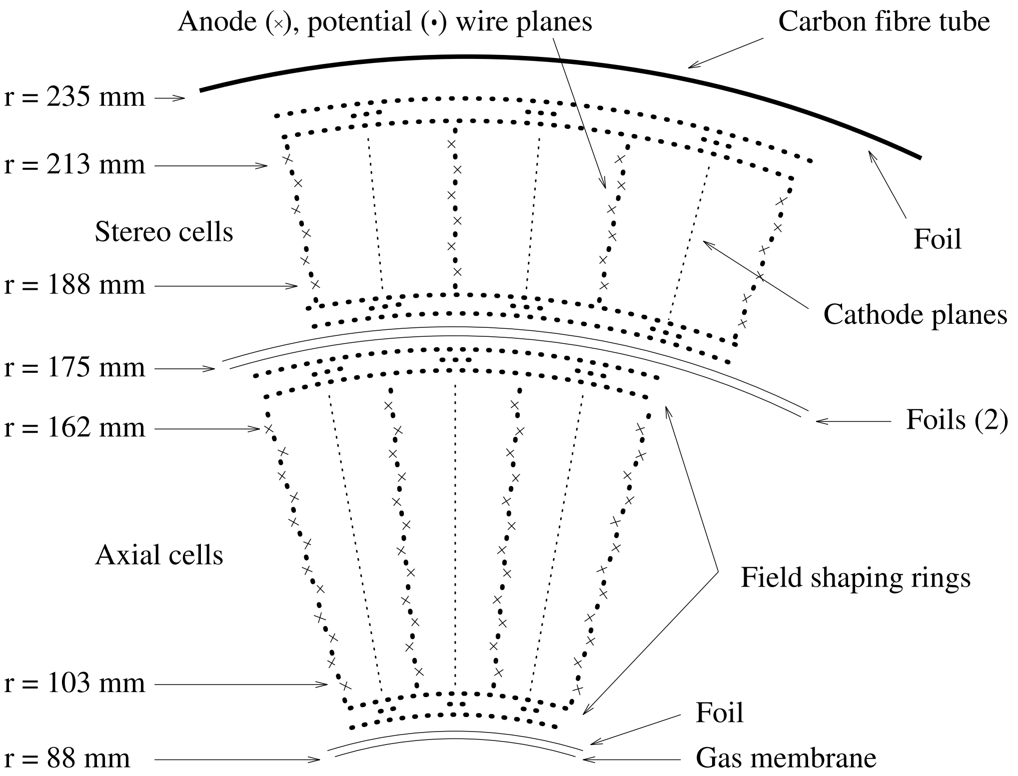
off momentum background rates



OPAL's 1997 Running Experience

2) Vertex chamber (CV) wire breakage

- Oct. 15, HV control hardware failure, "strange" voltages to chamber
- 3 sense wires broken in one stereo cell (6 wires/cell, 36 cells)
- NOT due to beam backgrounds, NOT due to wire aging
- Axial cells 100% OK, brought back 2/3 of stereo, a few runs without CV
- Effect on physics: Few % loss in z coord. matching to silicon microvertex
- → no repair attempt (probably can't be done in shutdown anyway)

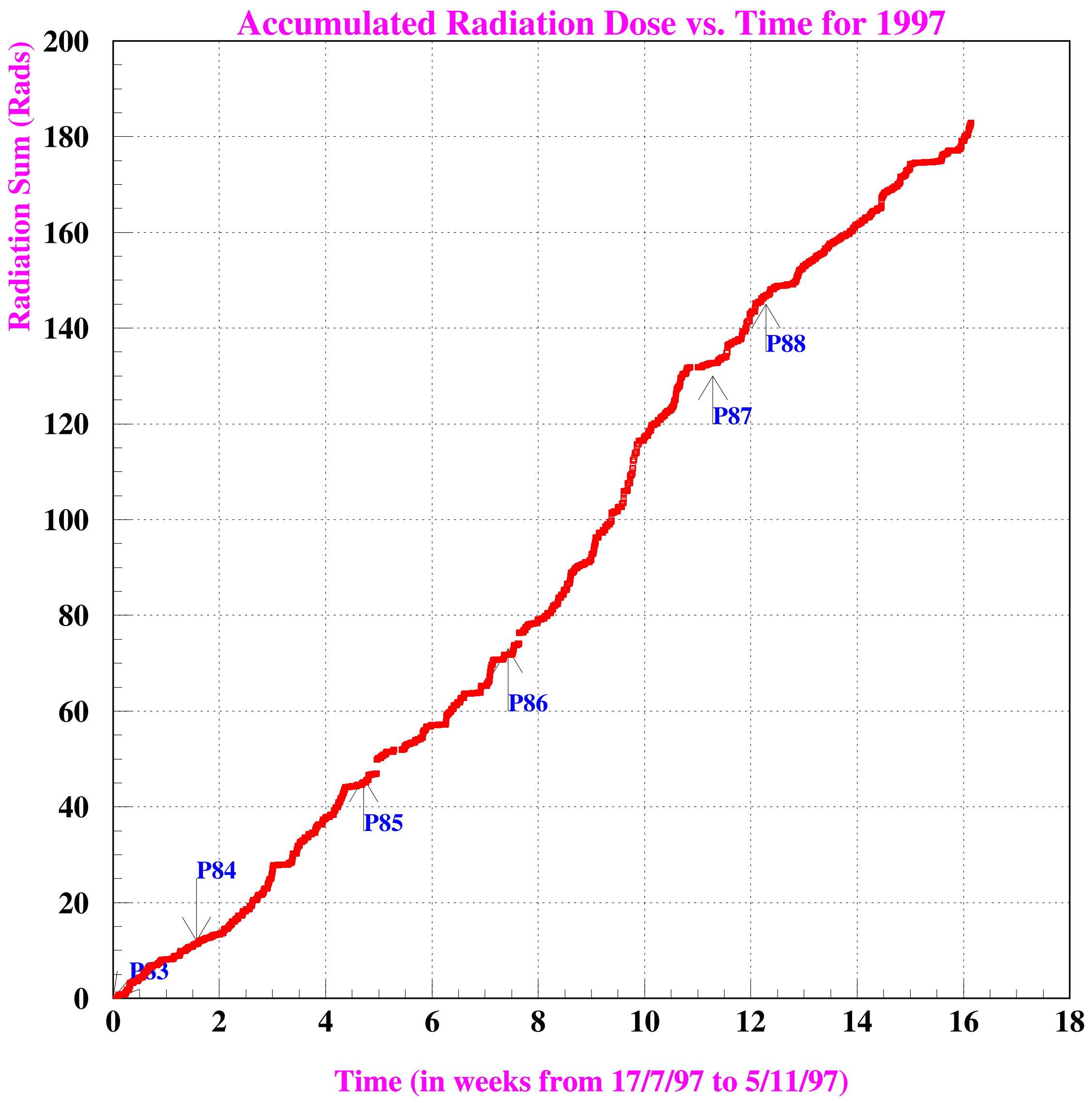


Note: loss of 1/3 stereo cells represents 1/9 of all vertex chamber wires.

OPAL's 1997 Running Experience

Radiation dose report (microvertex rad. monitors):

Total dose for this year: ≈200 Rads (96: 30 Rads, 95: 140 Rads)



OPAL's 1997 Running Experience

OPAL Integrated Luminosity and Efficiency

	M_Z	130-136	183	Total
Recorded $\int \mathcal{L}$ (pb^{-1})	2.1	5.9	57.2	65.2
Delivered $\int \mathcal{L}$ (pb^{-1})	2.3	7.0	63.3	72.6

Overall, our data taking efficiency was 90.8%, not too bad considering severe background problems in first few months. Breakdown of inefficiency:

- 3.0% -Readout deadtime
- 1.5% -Detectors ramping
- 1.1% -Chamber trips (about 50% from beam backgrounds)
- 3.5% -DAQ and subdetector readout problems + misc.

A few percent of this inefficiency due to off-momentum background, but still some room for improvement.

New Optics

Background situation similar to 90/60 (asymmetric off-mom). Perhaps slightly higher off-momentum for same beam currents.

In spite of problems, OPAL basically in very good shape, excellent overall performance of subdetectors and personnel.

OPAL Shutdown Planning

1) Far Forward upgrade:

- small lead/scintillator calorimeter back of superquads
- improve position resolution and larger acceptance (closer to beam pipe)
- physics: photon structure function, better 2-photon tags
- largely independent of rest of OPAL (dont need to open up)

2) Minor improvements for DAQ throughput/reliability

3) No interventions requiring open up OPAL, so should be ready to go before Easter 1998

4) Request to LEP: we would like an alignment survey done in our straight sections if possible – hope to improve off-momentum background situation.

OPAL Physics Results

All 1997 results are PRELIMINARY

Most results based on:

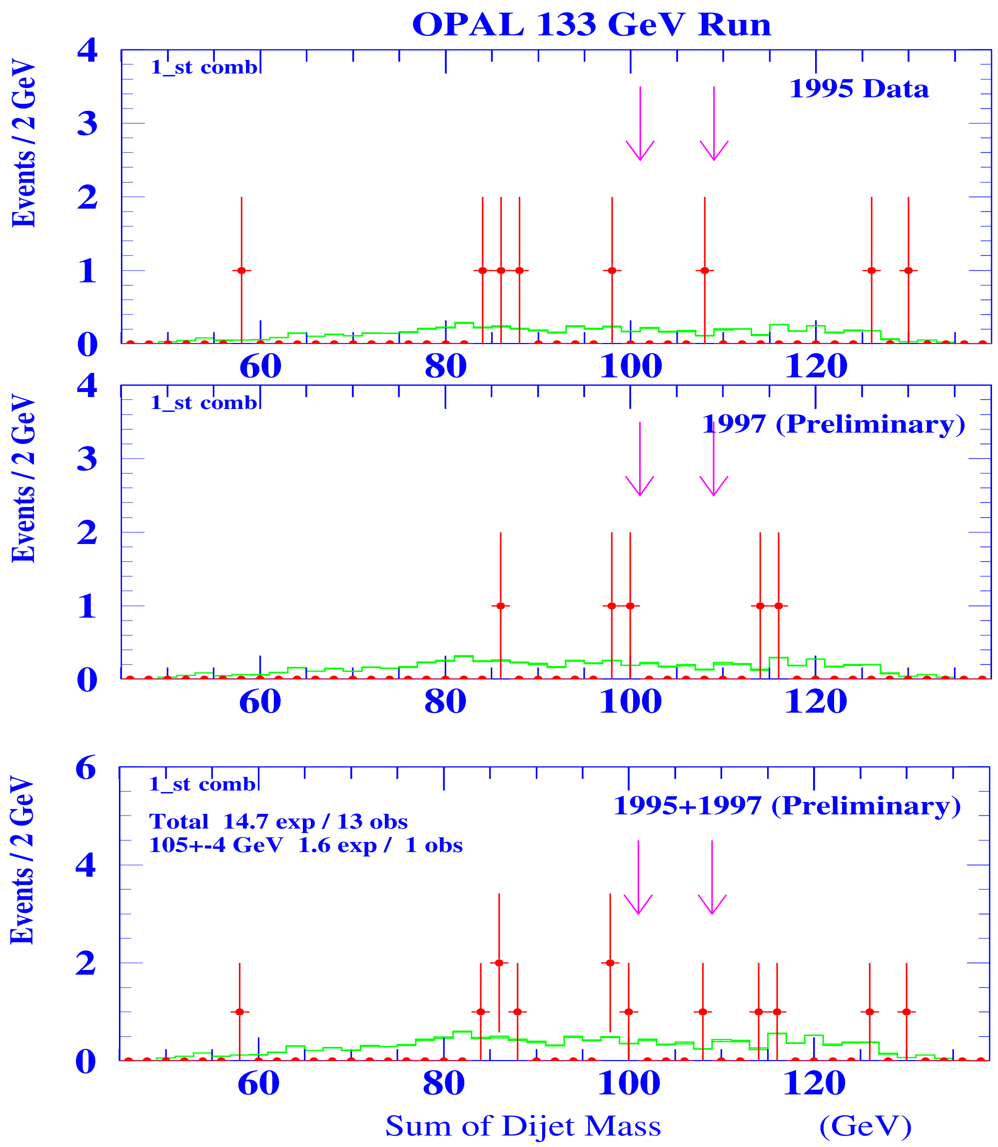
- $\int \mathcal{L} \approx 2.5$ pb^{-1} at $\sqrt{s}$ = 130 GeV
- $\int \mathcal{L} \approx 3.3$ pb^{-1} at $\sqrt{s}$ = 136 GeV
- $\int \mathcal{L} \approx 54$ pb^{-1} at $\sqrt{s} \approx 183$ GeV

All quoted limits are at 95% Confidence Level

OPAL 4-jet results

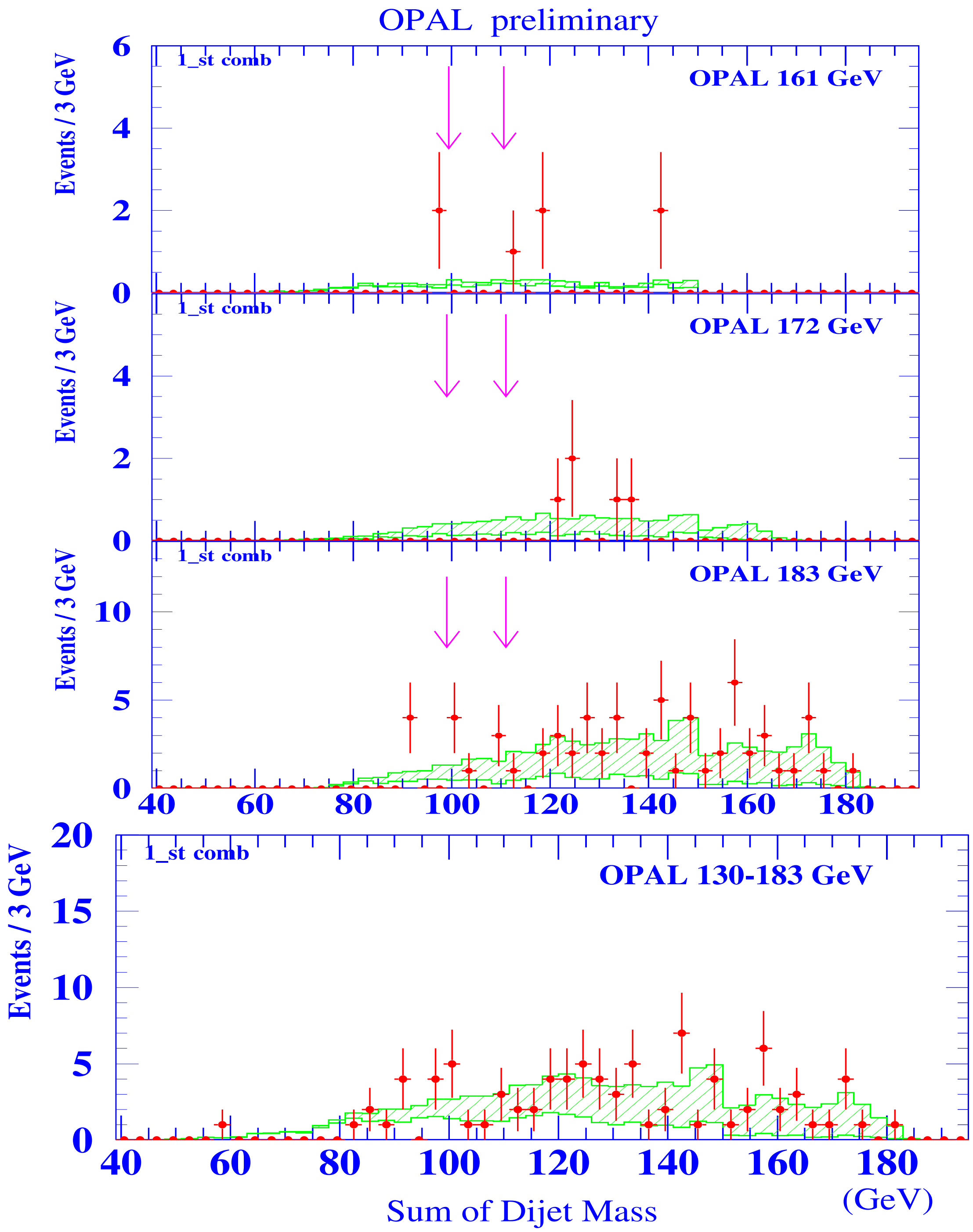
ALEPH 4-jet selection emulation (same as for 1995)

year	$\int \mathcal{L}$ (130+136)	N_{obs}	N_{exp}	$N_{obs}{}^{wind}$	$N_{exp}{}^{wind}$
1995	5.2 pb^{-1}	8	7.1	1	0.8
1997	5.8 pb^{-1}	5	7.6	0	0.9
95+97	11.0 pb^{-1}	13	14.7 ± 0.6	1	1.6 ± 0.2



OPAL 4-jet results

ALEPH 4-jet selection emulation, with WW veto for $\sqrt{s} \geq 161$ GeV



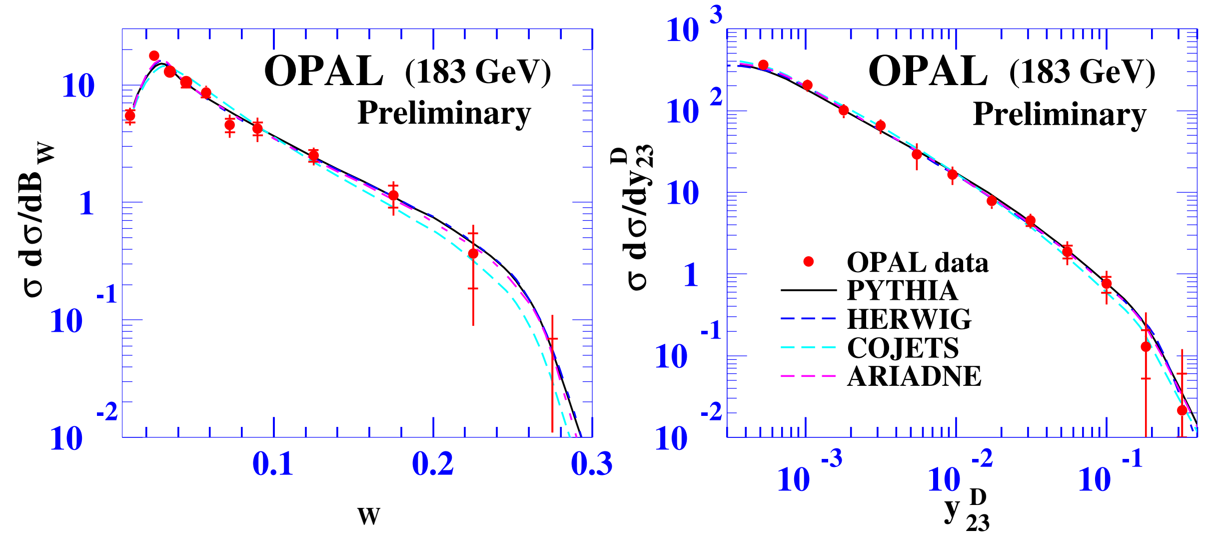
⇒ consistent between 95 and 97 at $\sqrt{s}$ = 130-136

⇒ consistent with SM for all $\sqrt{s}$

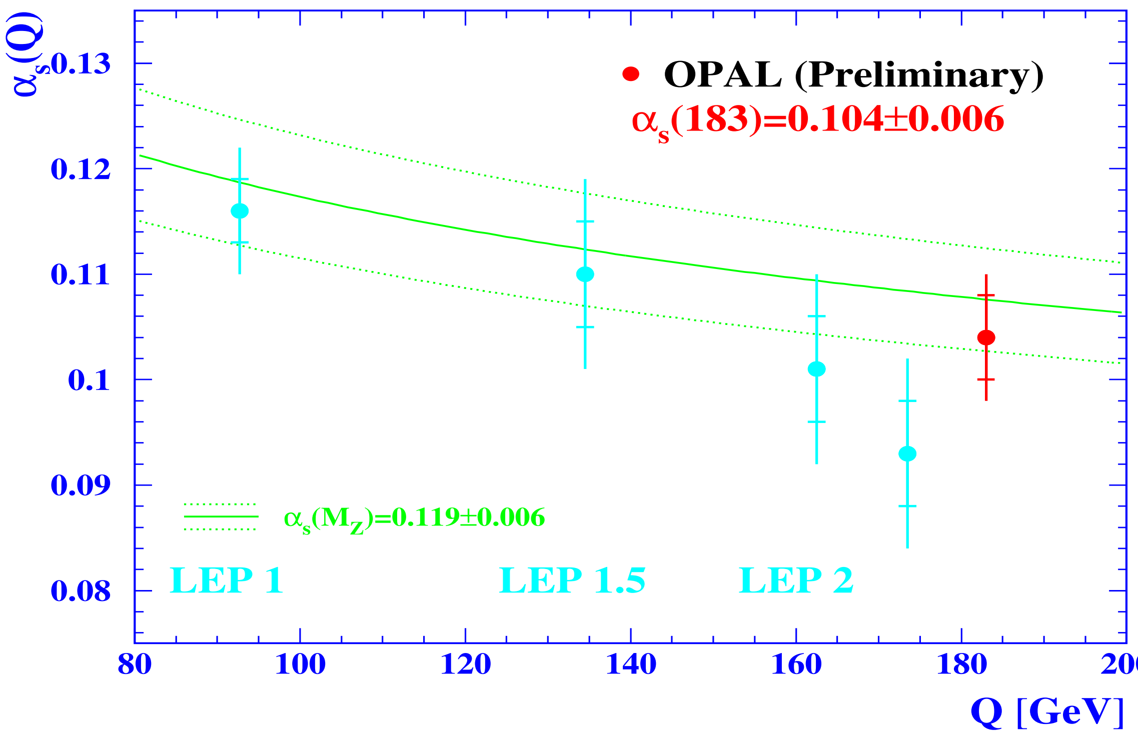
OPAL Standard Model physics 183 GeV

QCD studies

Large number of event shape observables compared with QCD predictions:

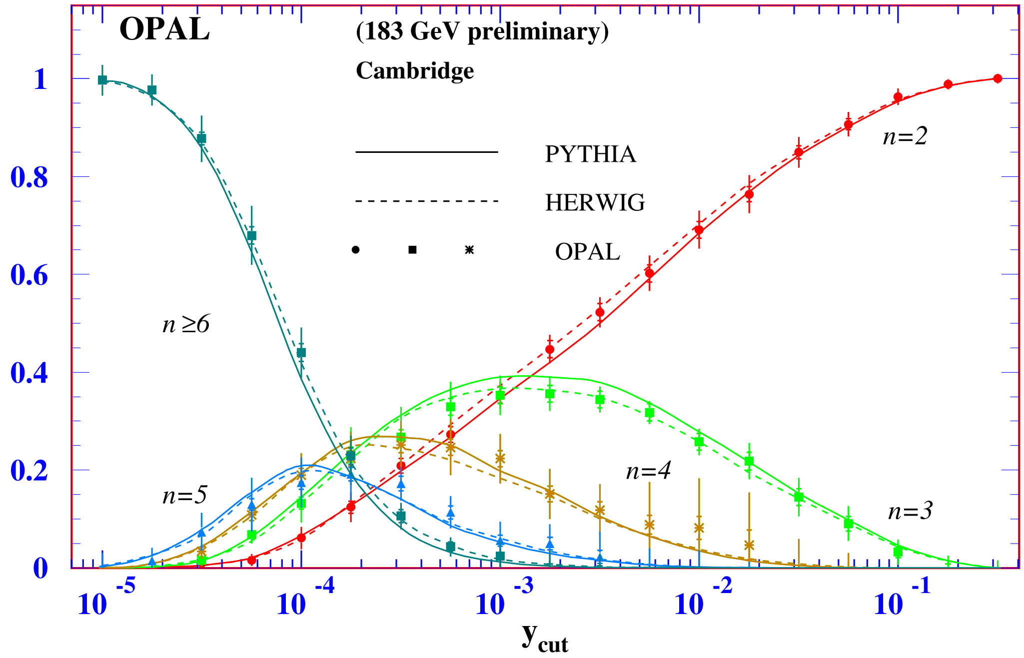


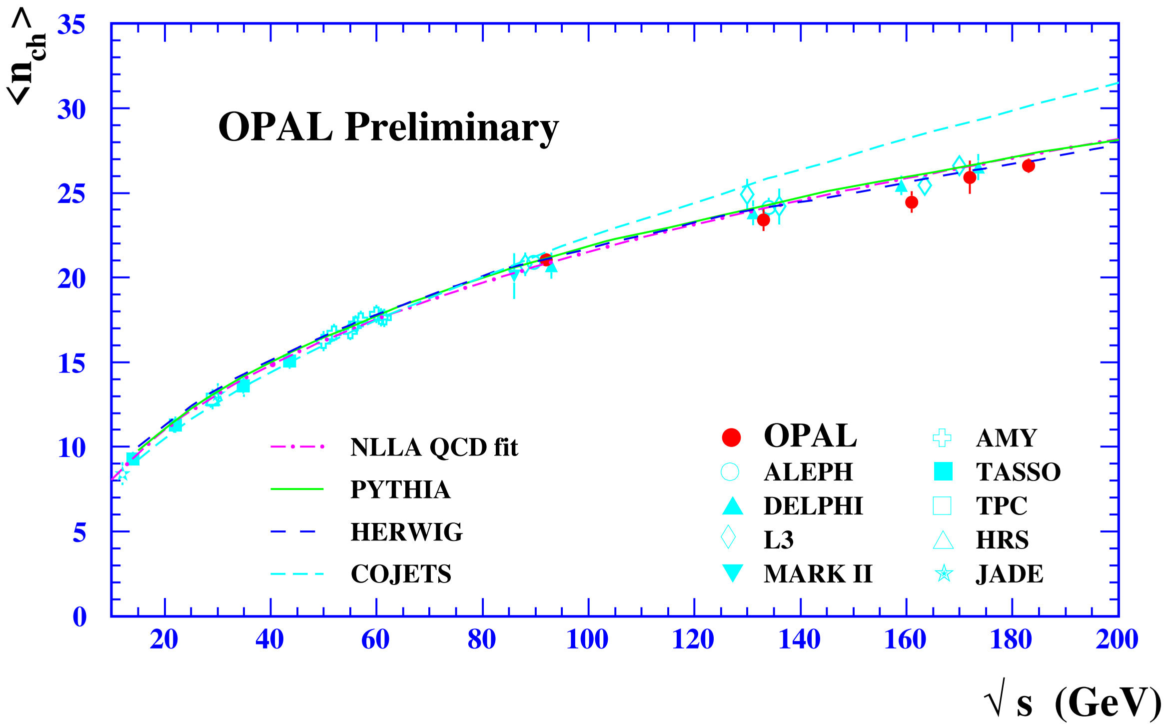
Good agreement, so fit 5 observables to obtain α_s(183 GeV):



OPAL SM physics: QCD

Good agreement with QCD predictions for jet production rates, charged momentum spectra, charged particle multiplicity:

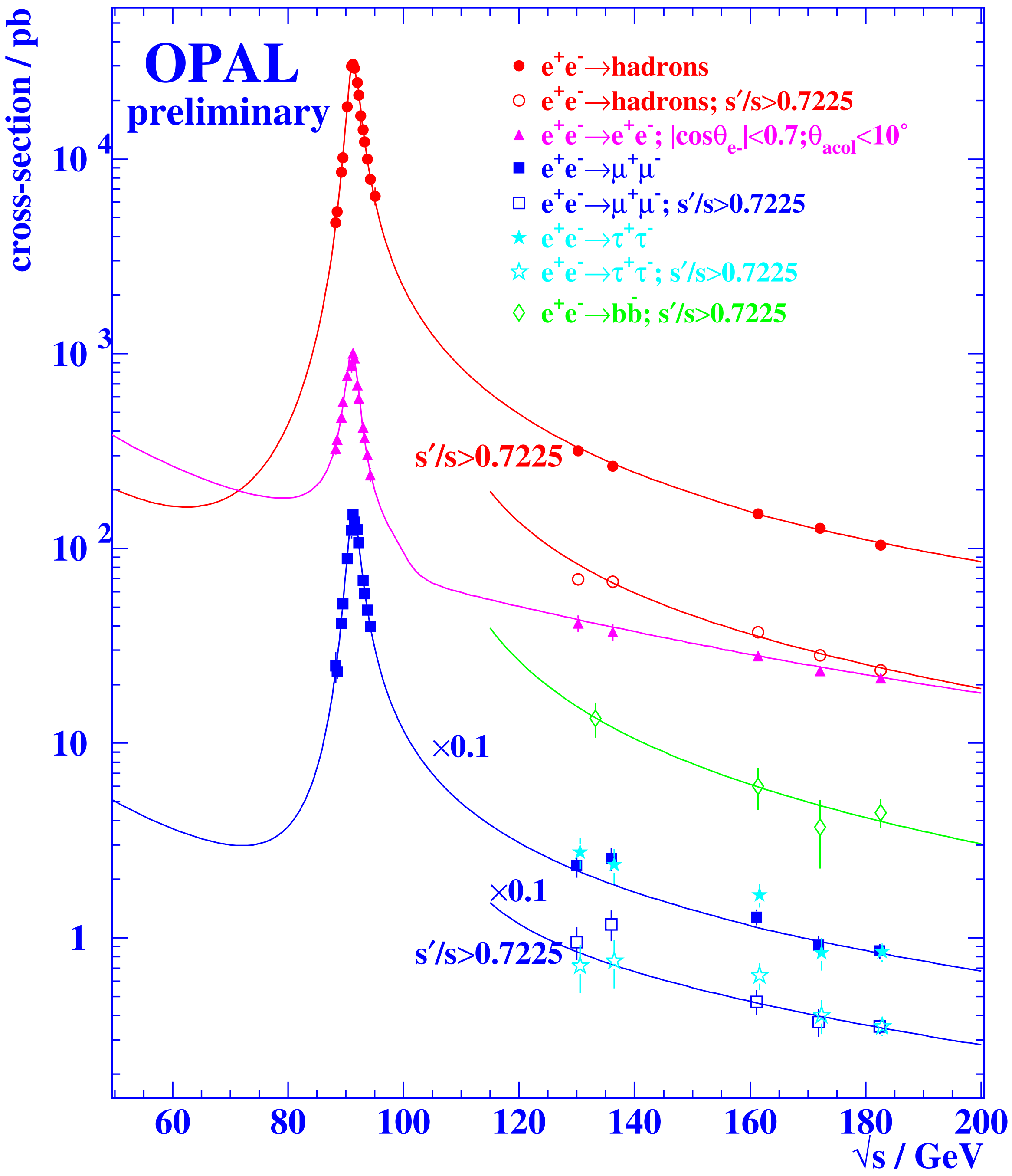




$< n_{\rm ch} >$ = 26.61 $\pm$ 0.27(stat) $\pm$ 0.32 (syst)

OPAL SM physics: $e^+e^- \rightarrow f\bar{f}$

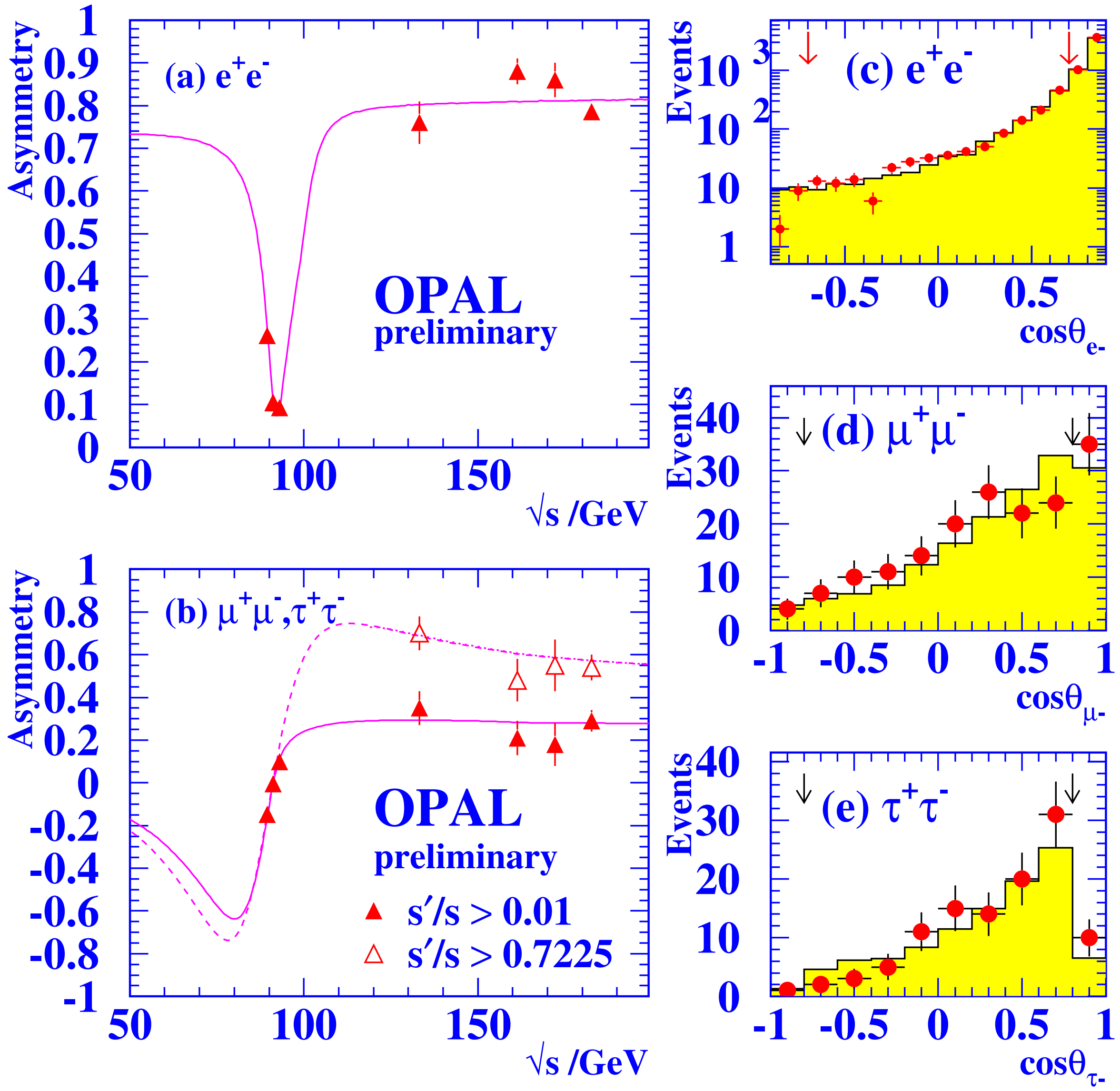
Total and "non-radiative" cross-sections have been measured for all 2 fermion final states:



Curves are from ZFITTER and ALIBABA (e^+e^- only)

OPAL SM physics: $e^+e^- \to f\bar{f}$

Forward-backward asymmetry from angular distributions:



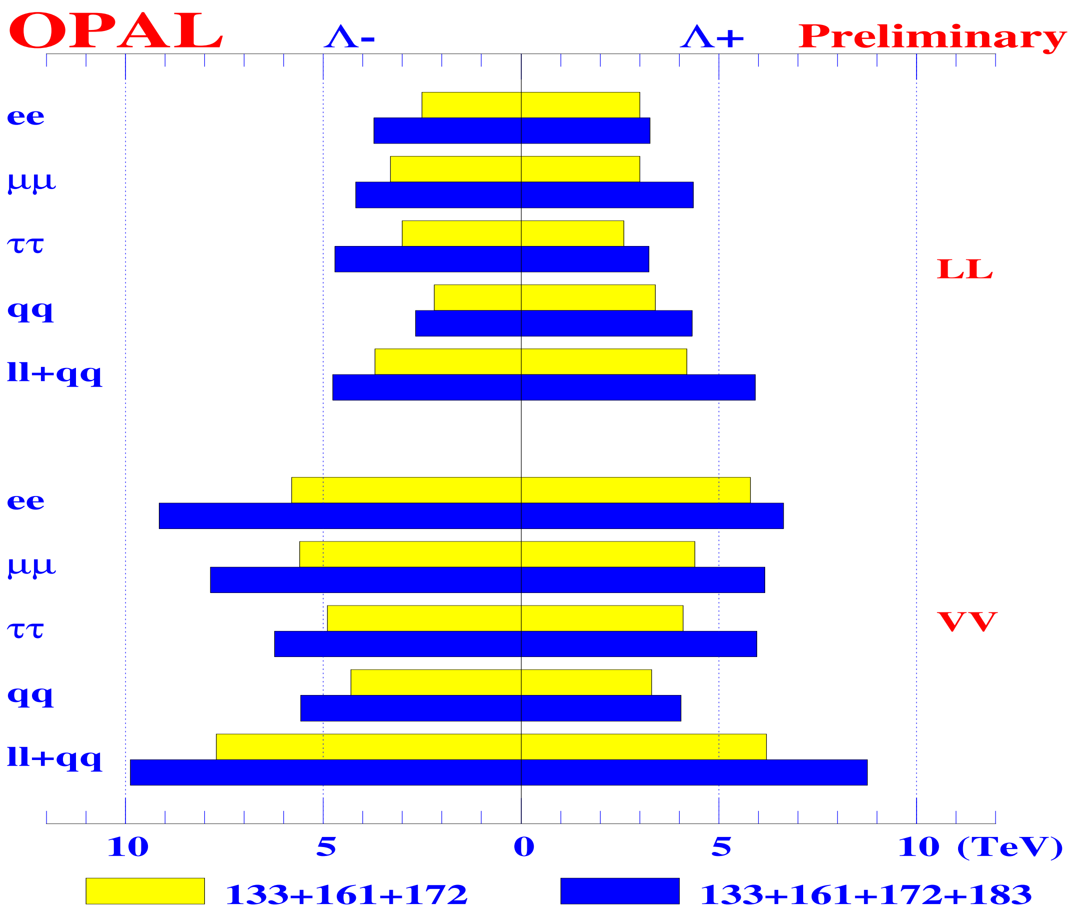
Curves are from ZFITTER and ALIBABA (e^+e^- only)

OPAL SM physics: $e^+e^- \rightarrow f\bar{f}$

Other measurements coming from 2 fermion final state cross-sections and $d\sigma/d(\cos\theta)$:

$1/\alpha_{em}$(182.6 GeV) = $127.3^{+6.1}_{-5.0}$, (SM: 127.9$\pm$0.1)

also limits on contact interactions:



$\Rightarrow$ Getting world's best limits

OPAL SM physics: WW

Results on $e^+e^- \to$ WW, all W decay modes

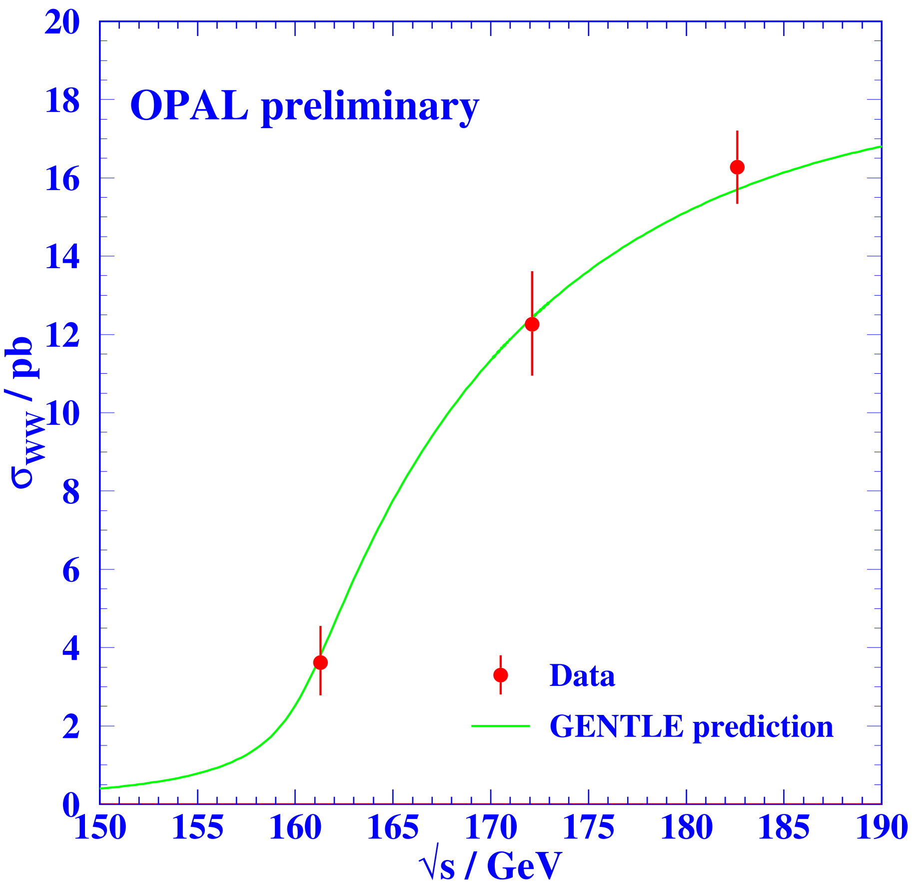
WW selection efficiencies and purities

decay mode:	$l\nu l\nu$	qq$l\nu$	qqqq
Efficiency	77%	83%	80%
Purity	94%	93%	80%

WW event selection results:

	N_{sig}	N_{bkg}	N_{exp}	N_{obs}
All channels	639 ± 20	94 ± 22	733 ± 30	754

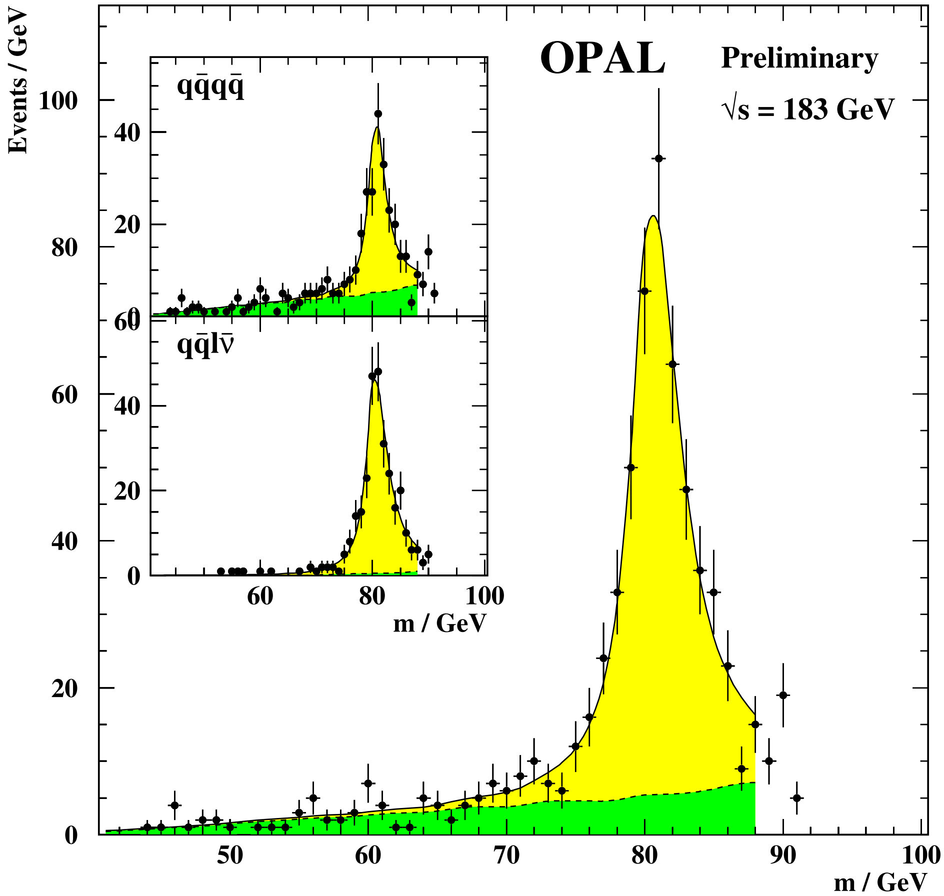
σ_{WW}(182.6 GeV) = $16.3 \pm 0.65 \pm 0.68$ pb



OPAL SM physics: WW

W mass and width

5C kin. fits to $\mathrm{W}^+\mathrm{W}^- \to \mathrm{q\bar{q}q\bar{q}}$ and $\mathrm{q\bar{q}}\, l\nu$



Final $\mathrm{M_W}$ and Γ_W waiting for $\mathrm{E_{beam}}$ and more systematic studies, expect errors:

- $\Delta\mathrm{M_W}(\mathrm{stat}) \approx$ 140 Mev
- $\Delta\Gamma_\mathrm{W}(\mathrm{stat}) \approx$ 350 Mev

$\Rightarrow \Delta\mathrm{M_W}$ same precision as D0, CDF

OPAL SM physics: WW

W Branching Ratios ($\sqrt{s}$ = 161,172,183 GeV)

Assuming W decays only to SM fermions:

- BR(W$\rightarrow$ $\mathrm{e}\nu$) = 0.117 $\pm$ 0.009 $\pm$ 0.005
- BR(W$\rightarrow$ $\mu\nu$) = 0.102 $\pm$ 0.008 $\pm$ 0.004
- BR(W$\rightarrow$ $\tau\nu$) = 0.111 $\pm$ 0.011 $\pm$ 0.007
- BR(W$\rightarrow$ $l\nu$) = 0.108 (Standard Model)

Assuming Lepton Universality:

- BR(W$\rightarrow$ $\mathrm{q\overline{q}}$) = 0.671 $\pm$ 0.013 $\pm$ 0.012
- BR(W$\rightarrow$ $\mathrm{q\overline{q}}$) = 0.675 (Standard Model)

Using the relation between Br(W$\rightarrow$ $\mathrm{q\overline{q}}$) and the CKM matrix element sum $\Sigma|\mathrm{V_{ij}}|$, along with the experimental (PDG) value:

$$|\mathrm{V_{ud}}|^2 + |\mathrm{V_{us}}|^2 + |\mathrm{V_{ub}}|^2 + |\mathrm{V_{cd}}|^2 + |\mathrm{V_{cb}}|^2 = 1.05 \pm 0.01$$

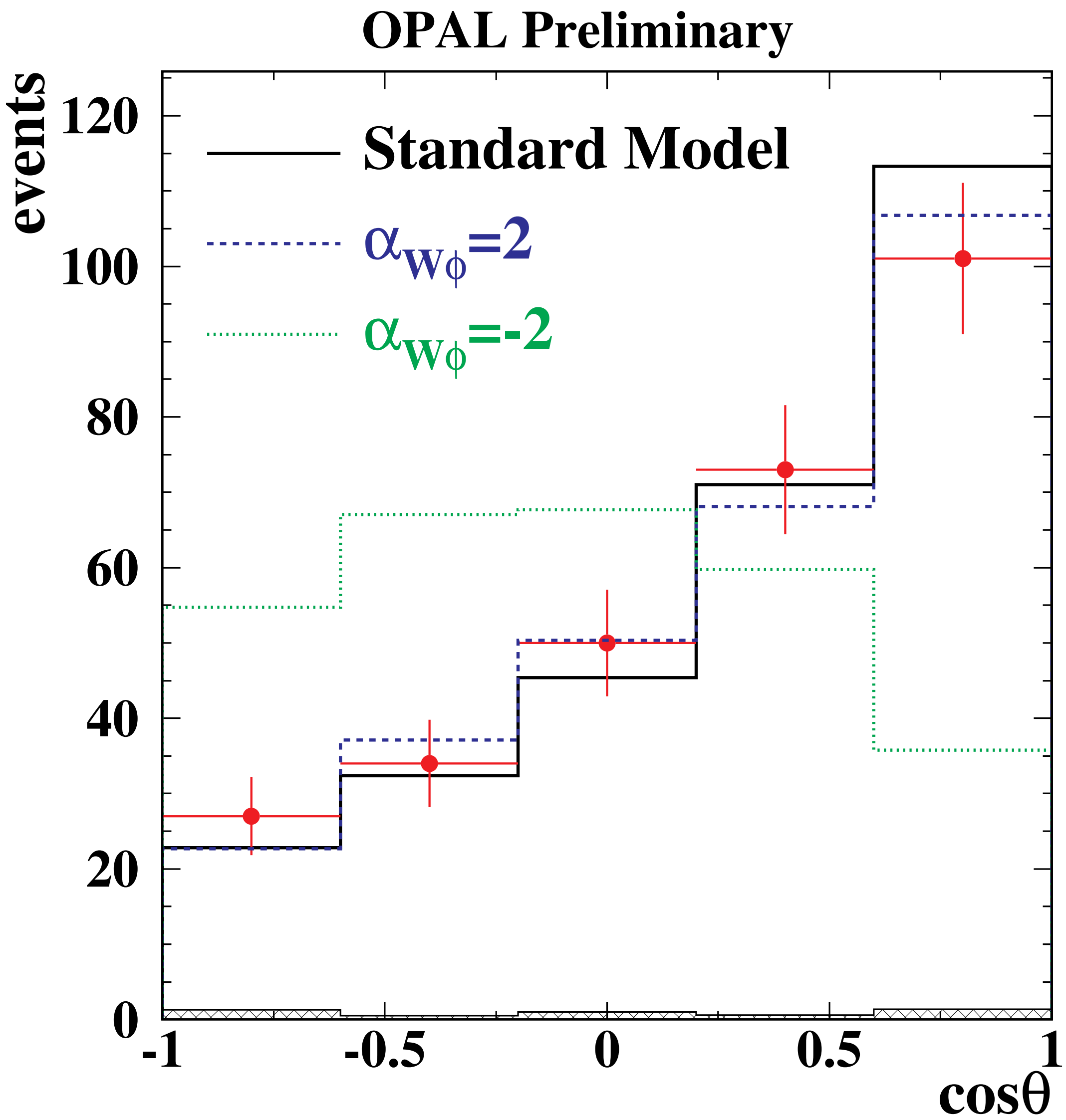
Above BR result can be interpreted as a measure of $|\mathrm{V_{cs}}|$:

$$|\mathrm{V_{cs}}|^2 = 0.95 \pm 0.06 \pm 0.05$$

OPAL SM physics: WW

W production angular distribution

The large data sample allows for putting stringent limits on anomalous Triple Gauge Couplings (TGC):



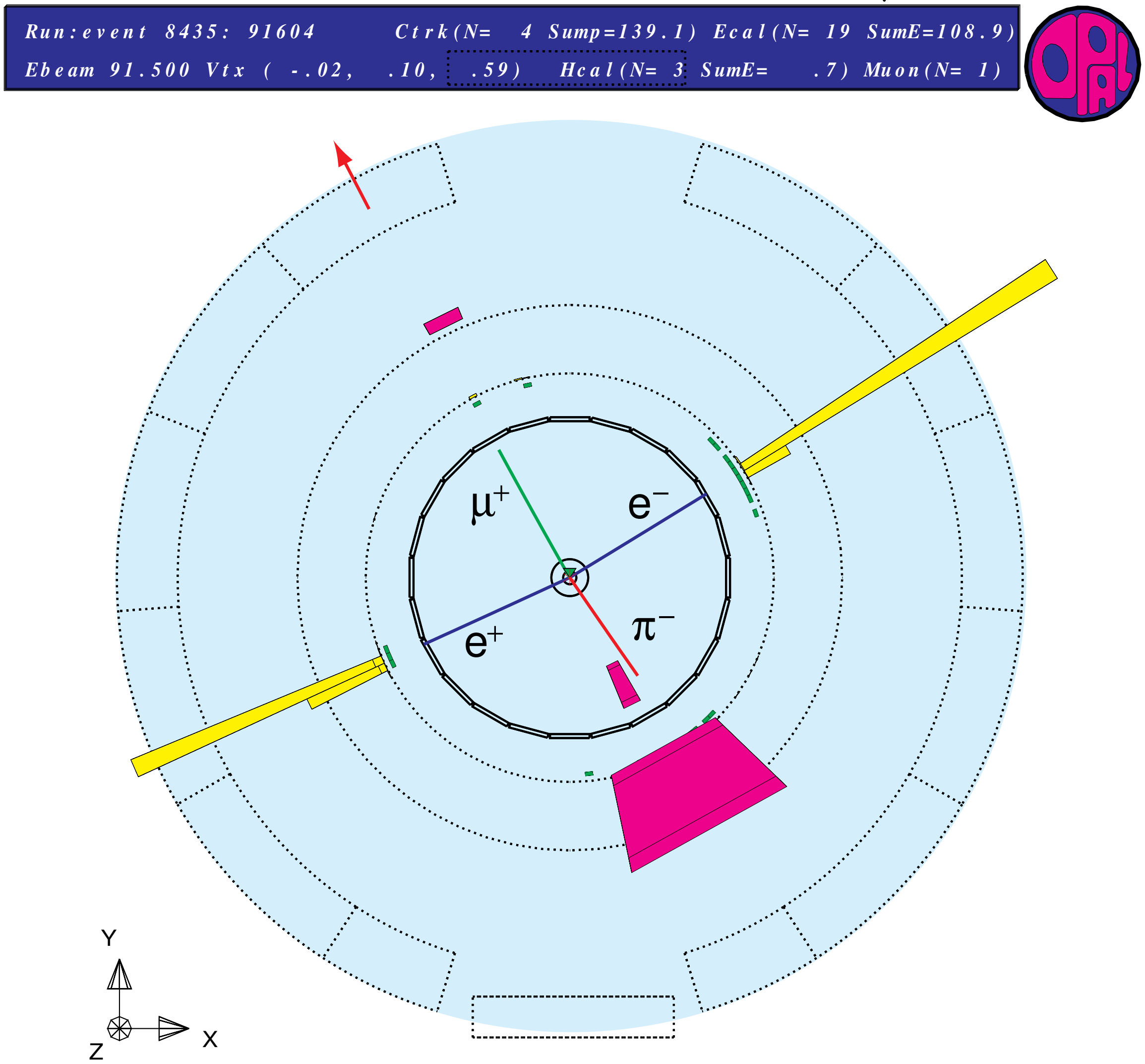
OPAL SM physics: ZZ, 4f

$< E_{beam} >$ = 91.3 GeV $\Rightarrow$ just above ZZ threshold.

$$e^+e^- \rightarrow Z^0Z^0 \rightarrow e^+e^- \tau^+\tau^-$$

$\quad\hookrightarrow \pi^- X$

$\quad\hookrightarrow \mu^+ \nu_\mu \bar{\nu}_\tau$



Mass (e^+e^-) = 89.5 +/- 3.4 GeV
Mass (recoil) = 90.7 +/- 3.1 GeV

Expectation from ZZ:

channel	N_{exp}	N_{obs}
eeqq, $\mu\mu$qq	0.7	0
$llll$	0.1	1

OPAL New Physics Searches

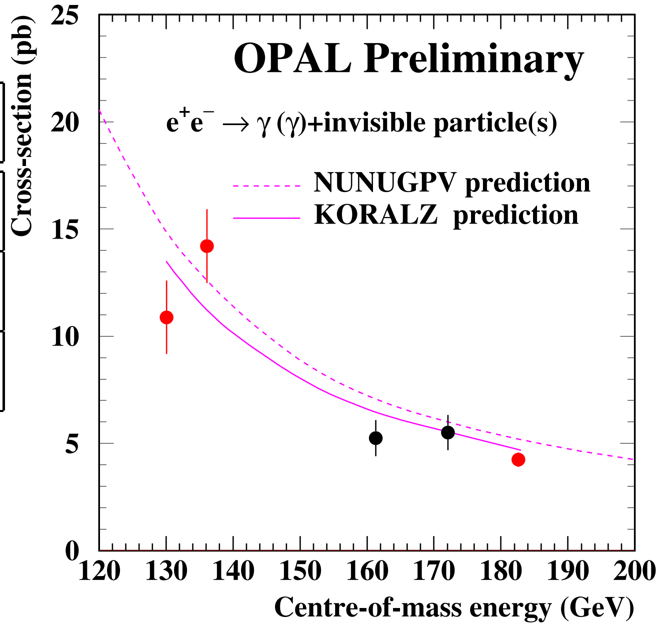
Anomalous photonic events with missing $\mathrm{E_T}$

- Standard Model measurement $\mathrm{e^+e^-} \to \nu\bar{\nu}\gamma(\gamma)$
- New physics: $\tilde{\chi}^0_2\tilde{\chi}^0_2$ ($\tilde{\chi}^0_1$ LSP), $\tilde{\chi}^0_1\tilde{\chi}^0_1$ (light $\tilde{\mathrm{G}}$ LSP), $\nu^*\overline{\nu}^*$

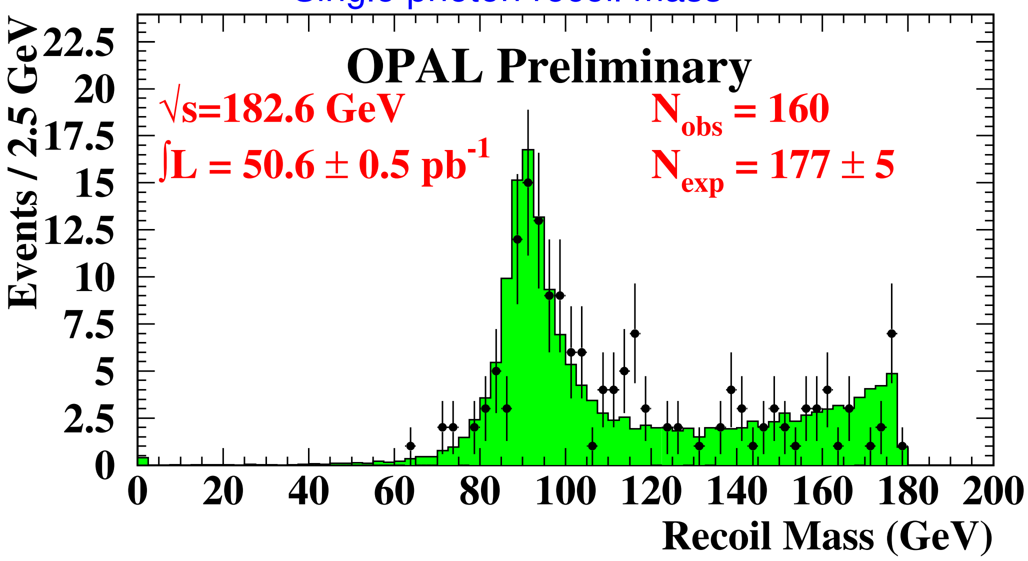
Analysed 1997 130-136 GeV data due to somewhat poor agreement with SM for the single and acoplanar photon pair rates in 1995 130-136 GeV data.

Single photon results:

$\sqrt{s}$ (GeV)	$\mathrm{N_{exp}}^{\mathrm{KORALZ}}$	$\mathrm{N_{obs}}$
130	25.4 ± 0.4	22
136	30.5 ± 0.4	34
183	177 ± 5	160

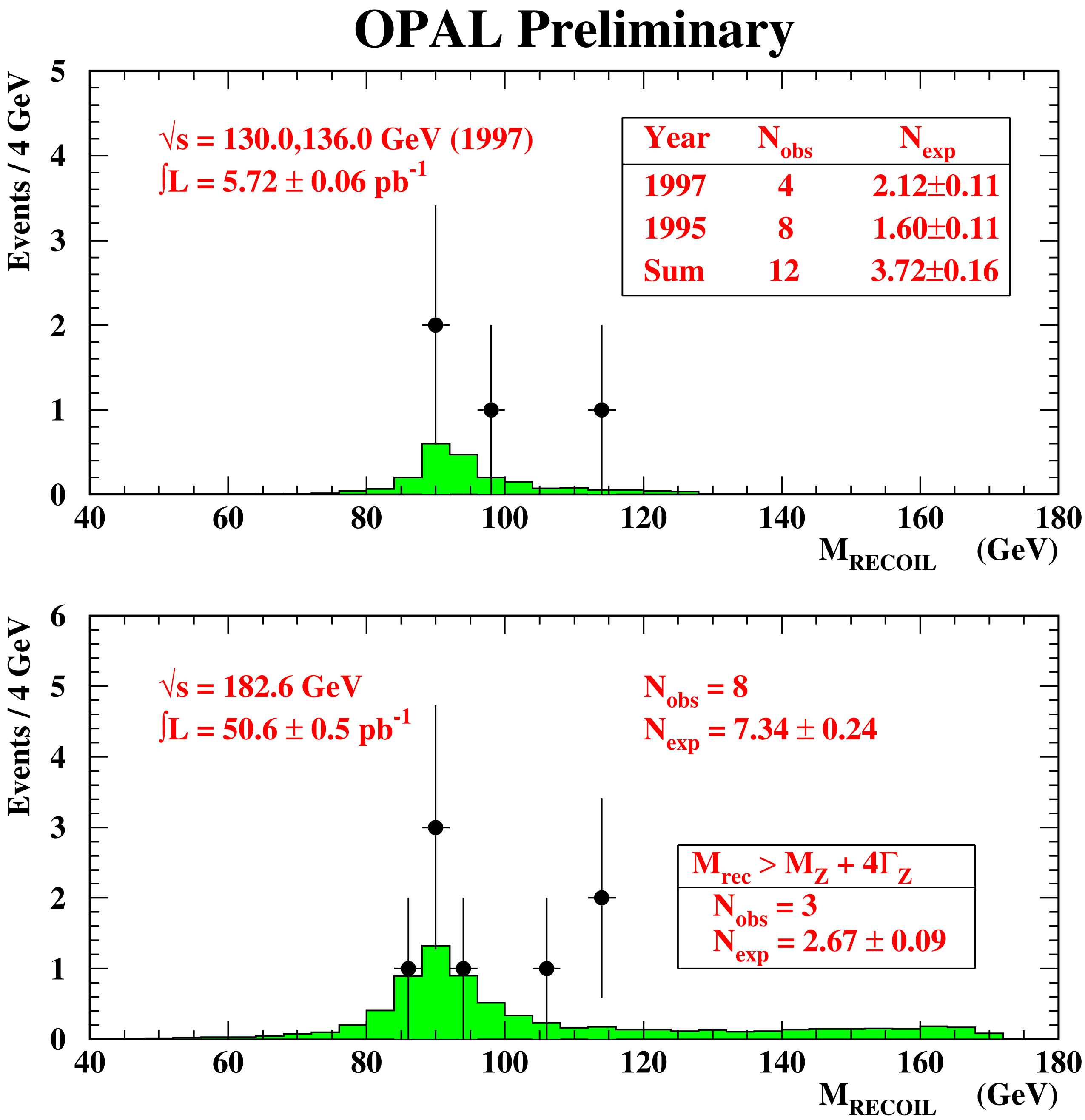


Single photon recoil mass



OPAL New Physics Search: Photons

Results for Acoplanar Photon Pairs:



Do other LEP experiments see too many acoplanar photons at 130-136 GeV?

OPAL New Physics Search: SUSY

R-parity conserving SUSY (MSSM) searches:

charginos:

- $\mathrm{e^+e^-} \to \tilde{\chi}^+\tilde{\chi}^-, \tilde{\chi}^+ \to \mathrm{W}^{*+}\tilde{\chi}^0$
- $\Rightarrow$ 4jets, 2jets+l, 2l all with missing $\mathrm{E_T}$

neutralinos:

- $\mathrm{e^+e^-} \to \tilde{\chi}^0_2\tilde{\chi}^0_1, \tilde{\chi}^0_2 \to \mathrm{Z}^*\tilde{\chi}^0_1$
- $\Rightarrow$ 2jets or 2l with missing $\mathrm{E_T}$

sleptons:

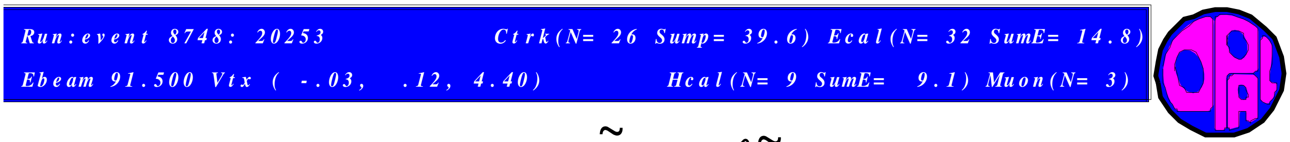
- $\mathrm{e^+e^-} \to \tilde{l}^+\tilde{l}^-, \tilde{l}^+ \to l^+\tilde{\chi}^0$
- $\Rightarrow$ 2l with missing $\mathrm{E_T}$

squarks: stop/sbottom

- $\mathrm{e^+e^-} \to \tilde{\mathrm{t}}\overline{\tilde{\mathrm{t}}}$, $\tilde{t} \to$ c$\tilde{\chi}^0$ or $\tilde{t} \to$ b$l\tilde{\nu}$
- $\mathrm{e^+e^-} \to \tilde{\mathrm{b}}\overline{\tilde{\mathrm{b}}}$, $\tilde{b} \to$ b$\tilde{\chi}^0$
- $\Rightarrow$ 2jets or 2jets + 2l with missing $\mathrm{E_T}$

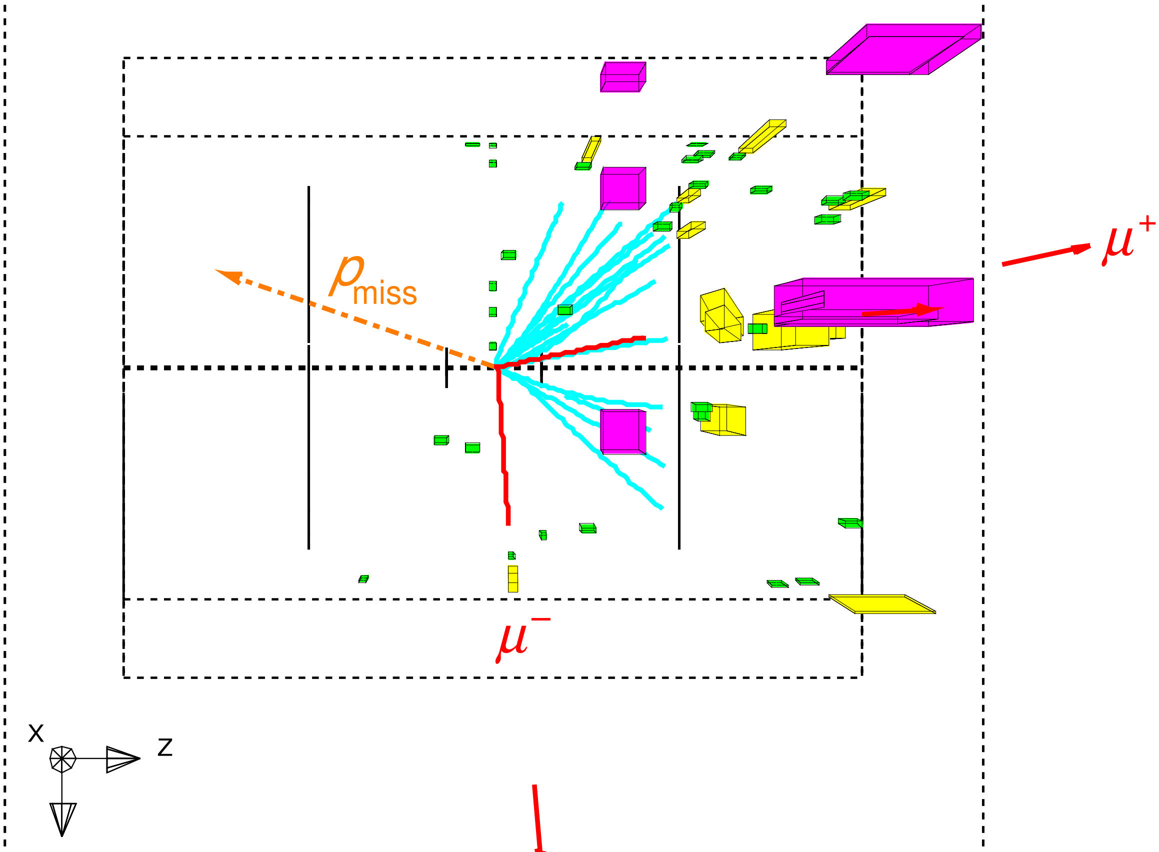
Some candidates but no evidence for excesses

OPAL New Physics Search: SUSY



Stop candidate: $\tilde{t} \to b \ell \tilde{\nu}$

2 jets, 2 leptons, miss E



Chargino candidate: $\tilde{\chi}^- \to \tilde{\chi}^0_1 \ell \nu \quad \tilde{\chi}^+ \to \tilde{\chi}^0_1 q \bar{q}$

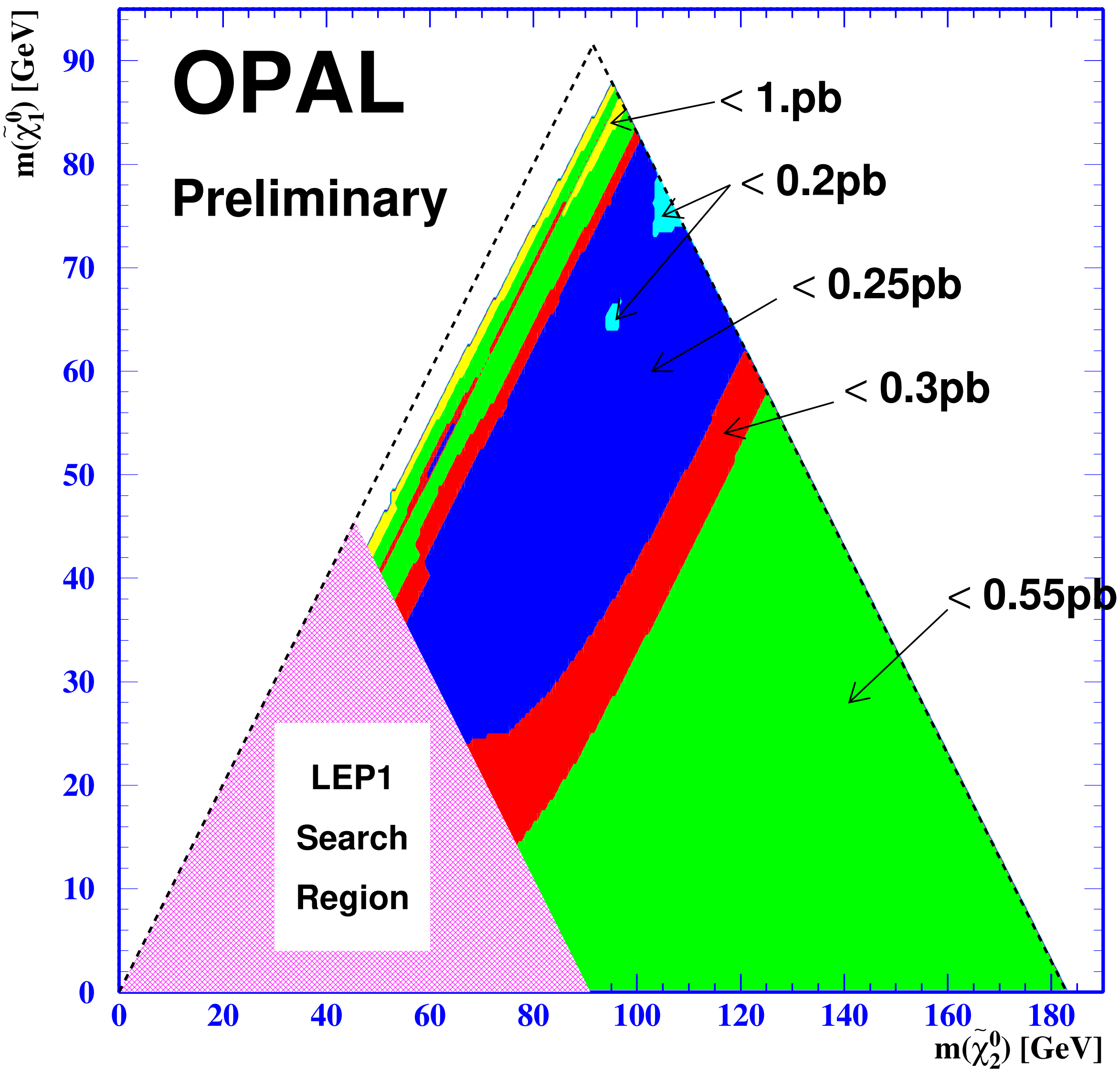
isolated lepton, miss E

But consistent with background, eg could be WW

OPAL New Physics Search: SUSY

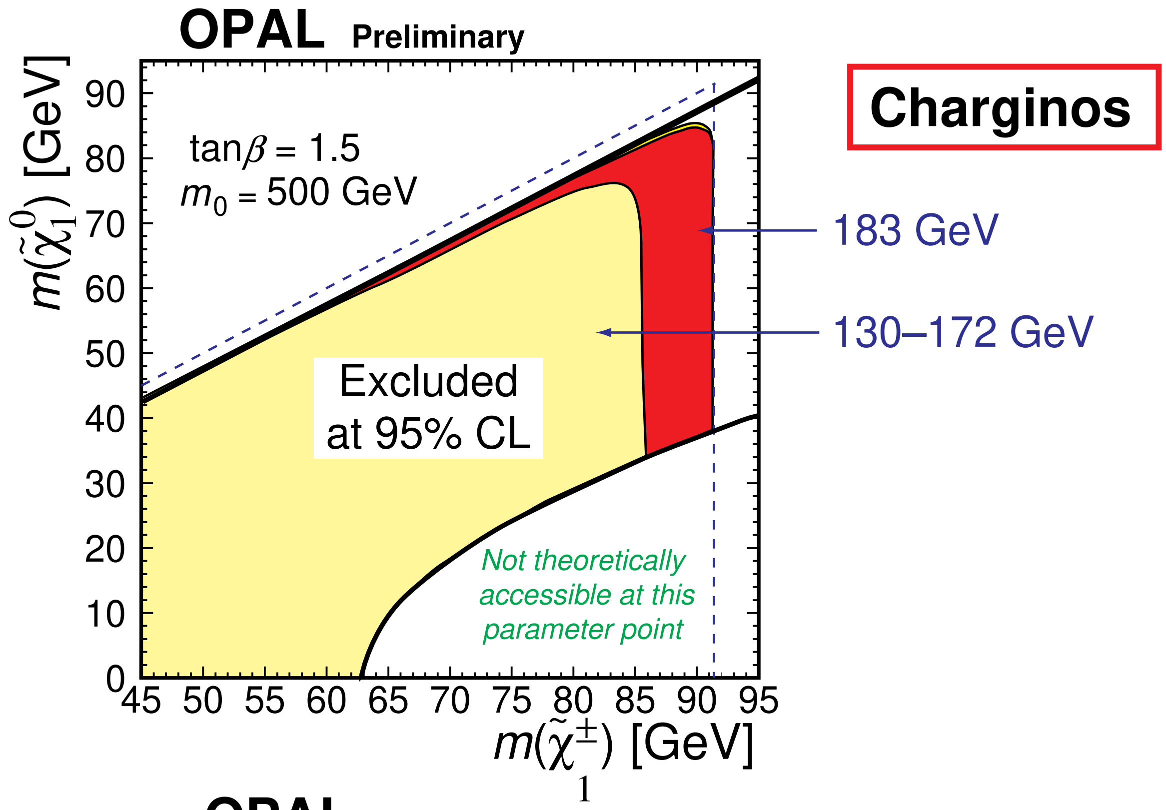
Using the efficiencies determined from Monte Carlo, we then obtain model independent cross-section limits, for example for neutralinos:

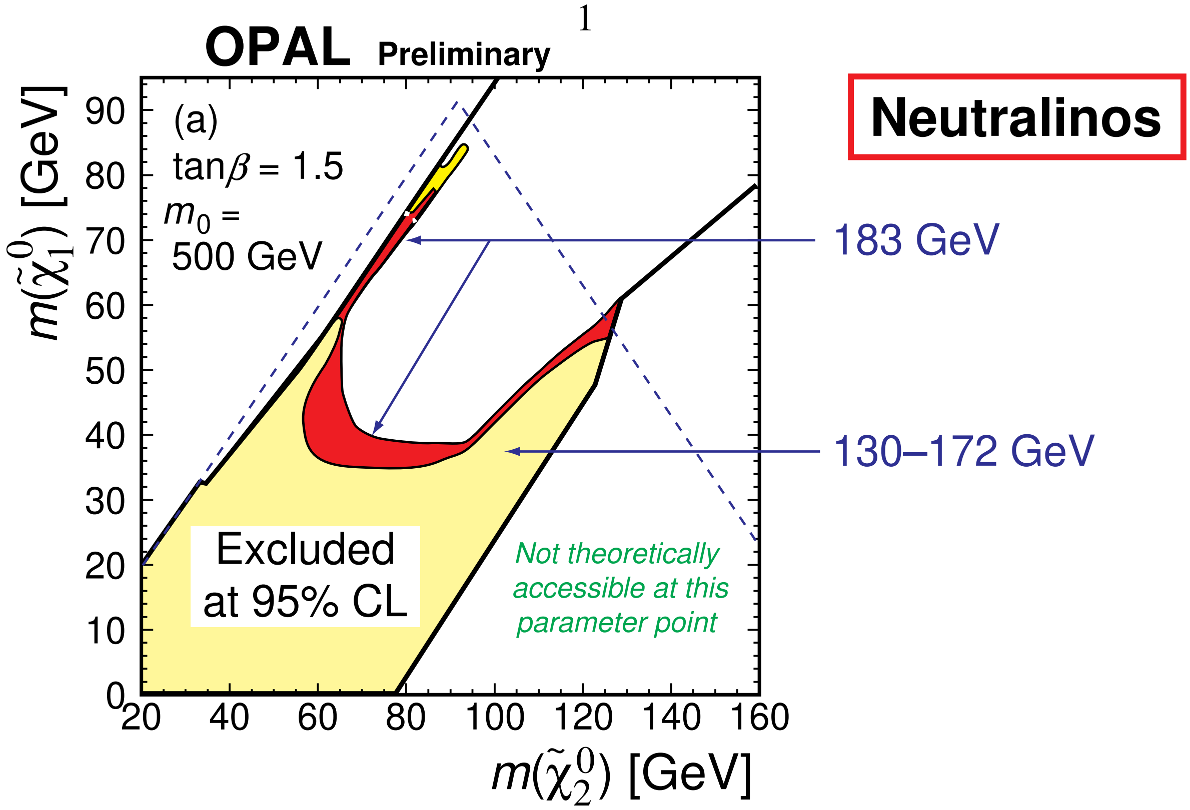
Assuming 100% BR($\tilde{\chi}^0_2 \rightarrow Z^* \tilde{\chi}^0_1$)



OPAL New Physics Search: SUSY

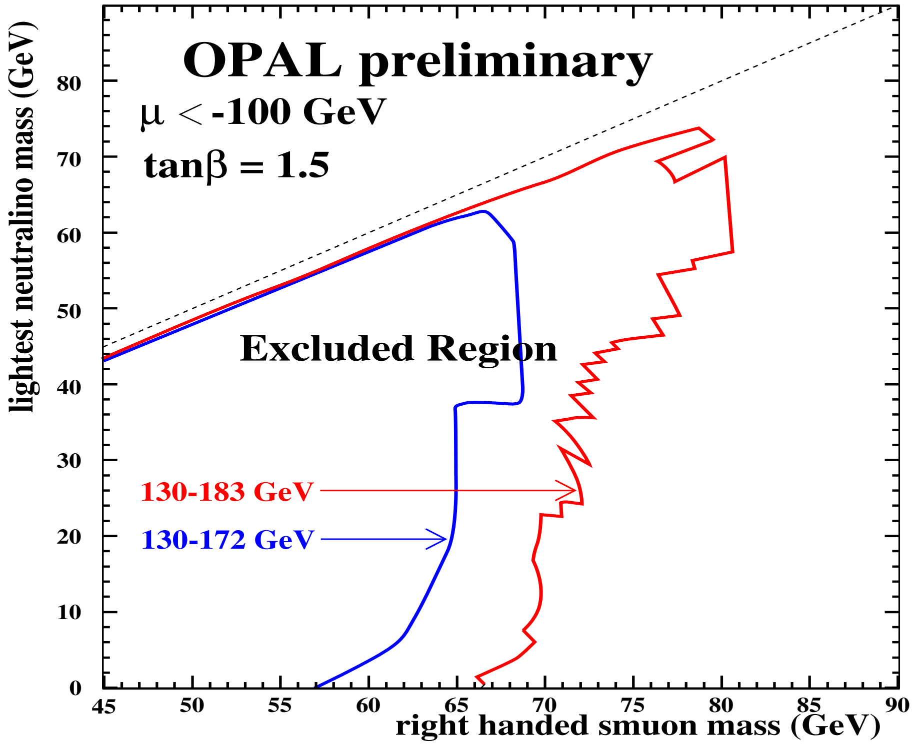
We also obtain model dependent exclusion limits based on MSSM parameter choices:



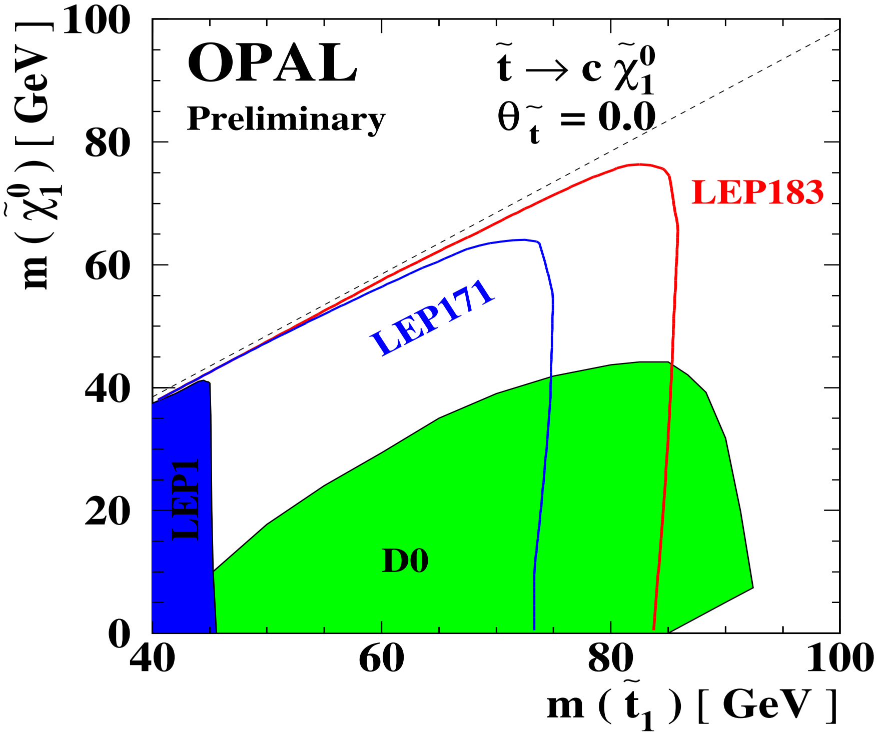


OPAL New Physics Search: SUSY

Model dependent exclusion limit for $\tilde{\mu}$:



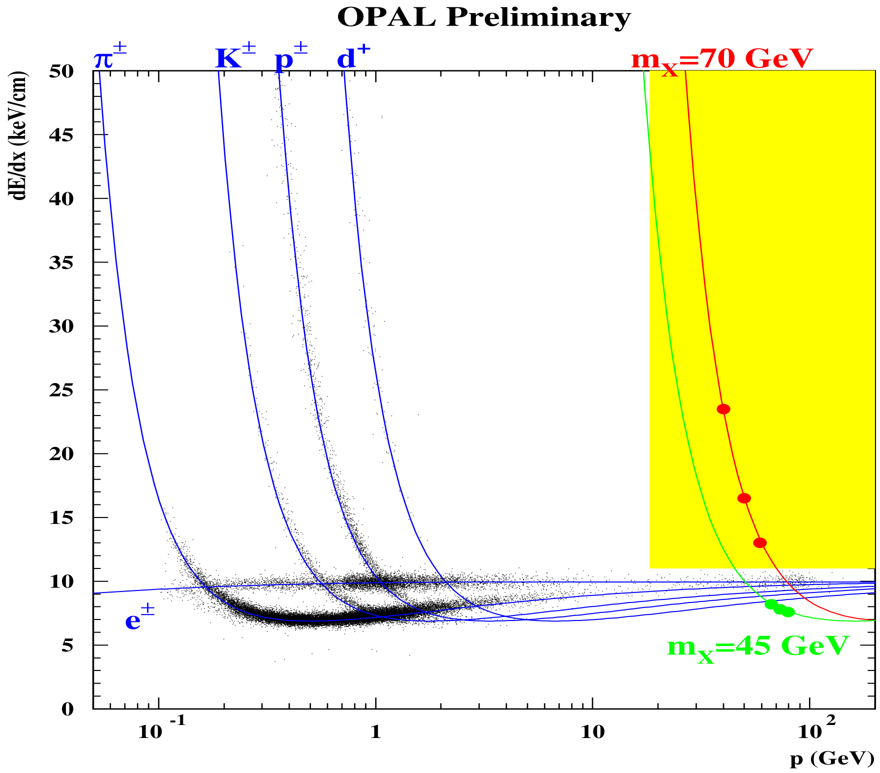
Model dependent exclusion limit for $\tilde{t}$:



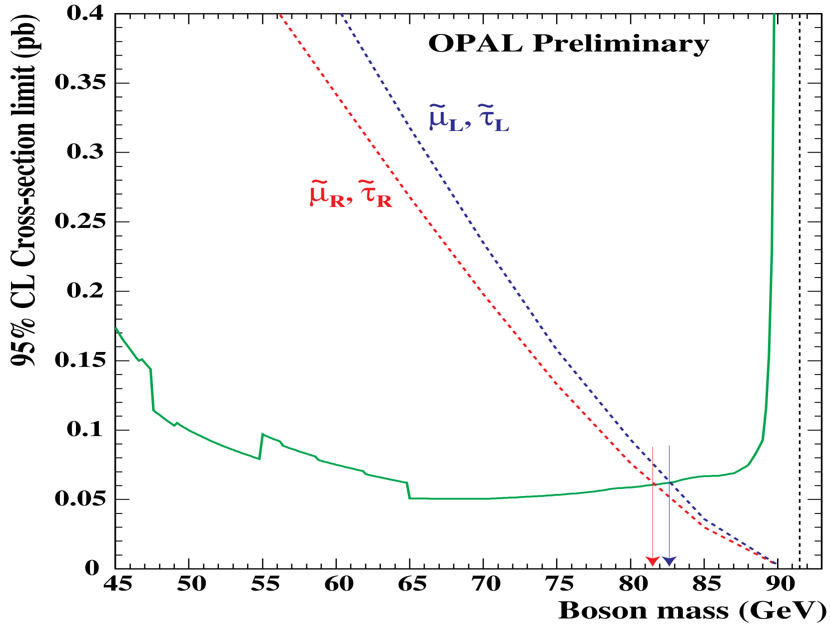
OPAL New Physics Search

Search for long-lived pair produced charged particles (in some SUSY scenarios or extensions of SM):

Use jet chamber dE/dx and event kinematics



Can exclude heavy stable $\tilde{\mu}$ and $\tilde{\tau}$:



$\mathrm{M}(\tilde{\mu_{\mathrm{R}}}, \tilde{\tau_{\mathrm{R}}}) >$ 81.5 GeV, $\mathrm{M}(\tilde{\mu_{\mathrm{L}}}, \tilde{\tau_{\mathrm{L}}}) >$ 82.5 GeV

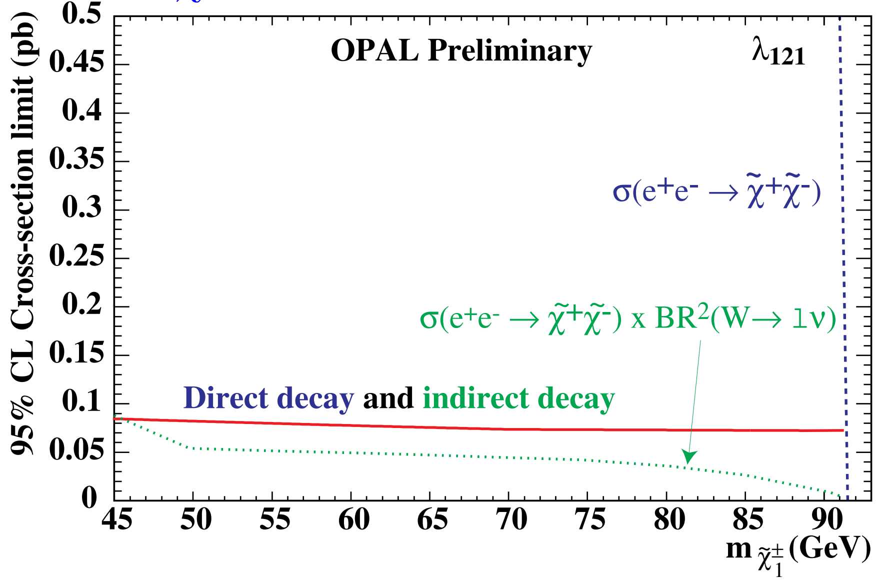
OPAL New Physics Search: RPV SUSY

With R-parity violation (RPV), can have sparticle $\rightarrow$ particles. This results in some unusual final states with low SM background.

Charginos: $\tilde{\chi}^+ \rightarrow l^+\tilde{\nu}^* \rightarrow l^+l^+l^-$ or $\rightarrow \mathrm{W}^{*+}\tilde{\chi}^0 \rightarrow l^+\nu l^+l^-\nu$

$\Rightarrow$ 6l or 6l + missing $\mathrm{E_T}$

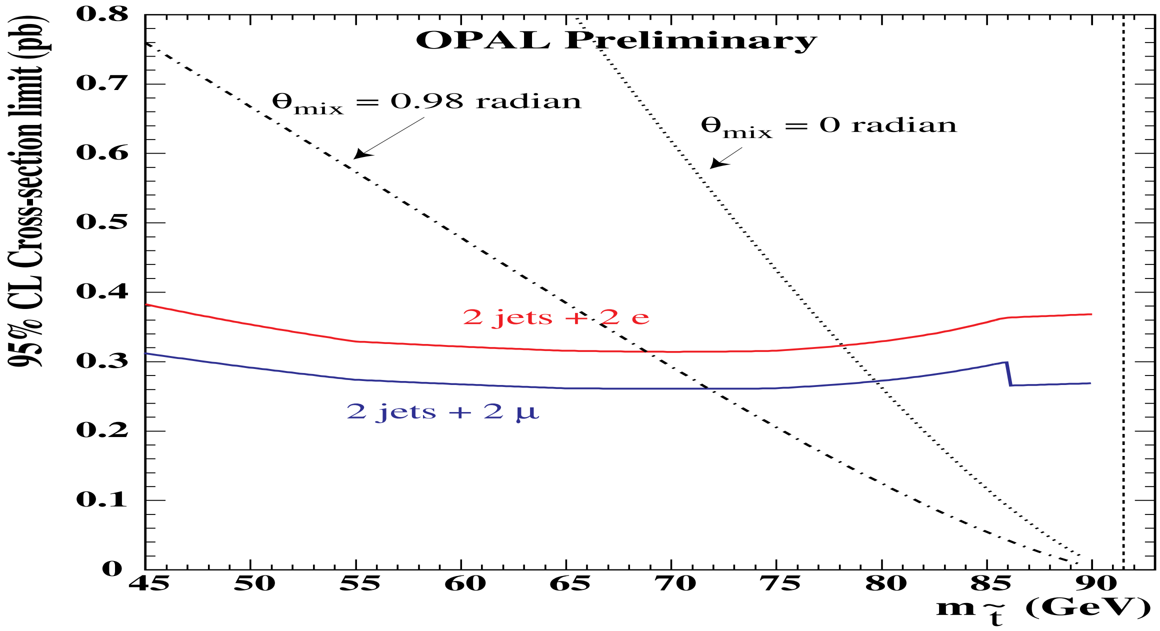
$\tilde{\chi}^+$ mass limits from 6l selection



$\tilde{t}$: if mixing results in light $\tilde{t}$, then $\tilde{t} \rightarrow ld$

$\Rightarrow$ 2l+2jets (only 4f SM background)

$\tilde{t}$ mass limits from 2l+2jets selection



OPAL New Physics Search: l^*,ν^*

Search for excited leptons (l^*,ν^*):

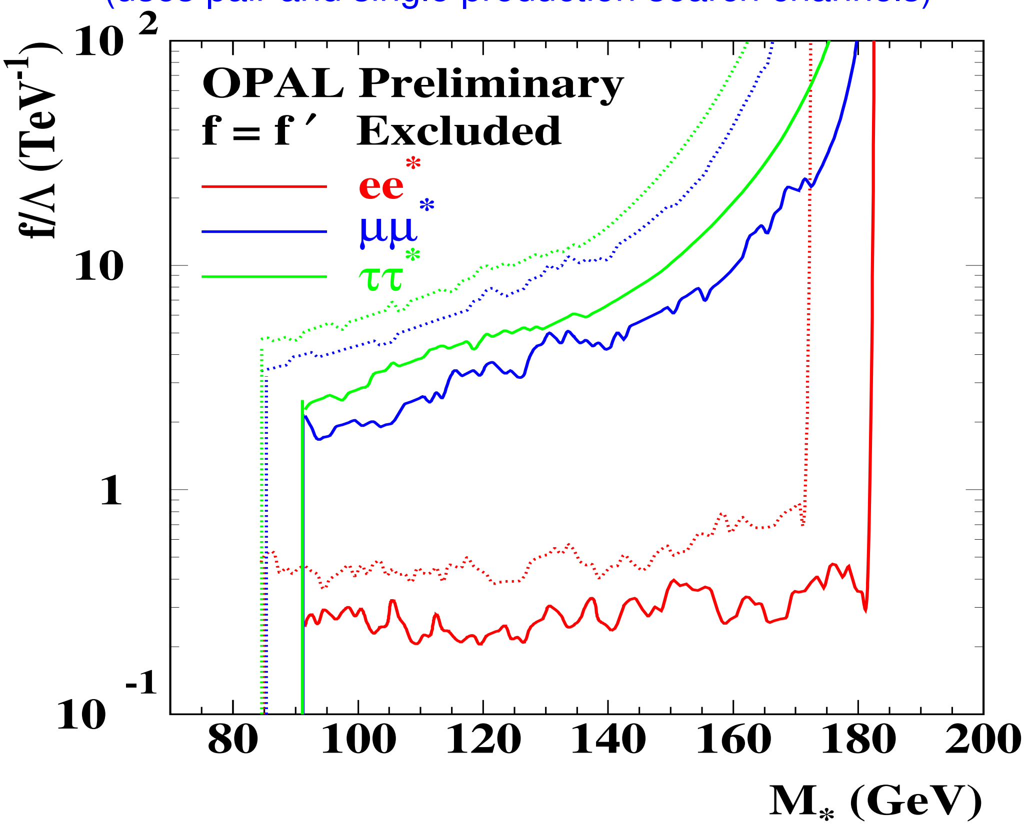
- decays considered: $l^* \to l\gamma$ and $\nu^* \to \nu\gamma$

Pair production search: $ll\gamma\gamma$ and $\nu\nu\gamma\gamma$ final states

Flavour	Decays	Coupling	Mass Limit(GeV) $\sqrt{s} = 161$–172	Mass Limit(GeV) $\sqrt{s} \sim 183$
e^*	Photonic	$f = f'$	85.0	91.2
μ^*	Photonic	$f = f'$	85.3	91.2
τ^*	Photonic	$f = f'$	84.6	91.1
ν_ℓ^*	Photonic	$f = -f'$	84.9	91.0

Upper limits on coupling/compositeness scale ratio f/Λ

(uses pair and single production search channels)

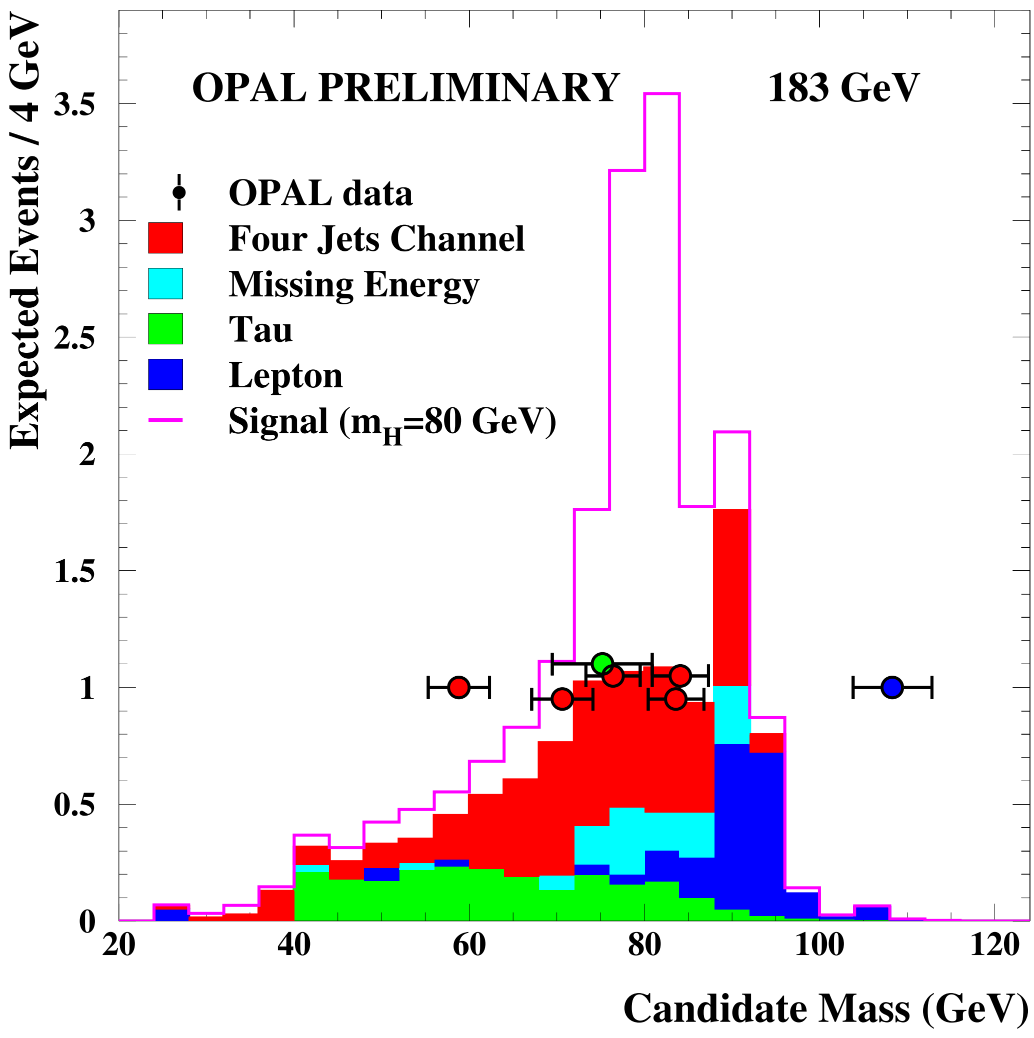


OPAL New Physics Search: SM Higgs

- $e^+e^- \rightarrow ZH$, uses $\int \mathcal{L} \approx 39\mathrm{pb}^{-1}$
- Search in 4 channels: qqbb, $\nu\nu$qq, $\tau\tau$qq, and eeqq+$\mu\mu$qq
- Likelihood for 4-jet, $\nu\nu$qq

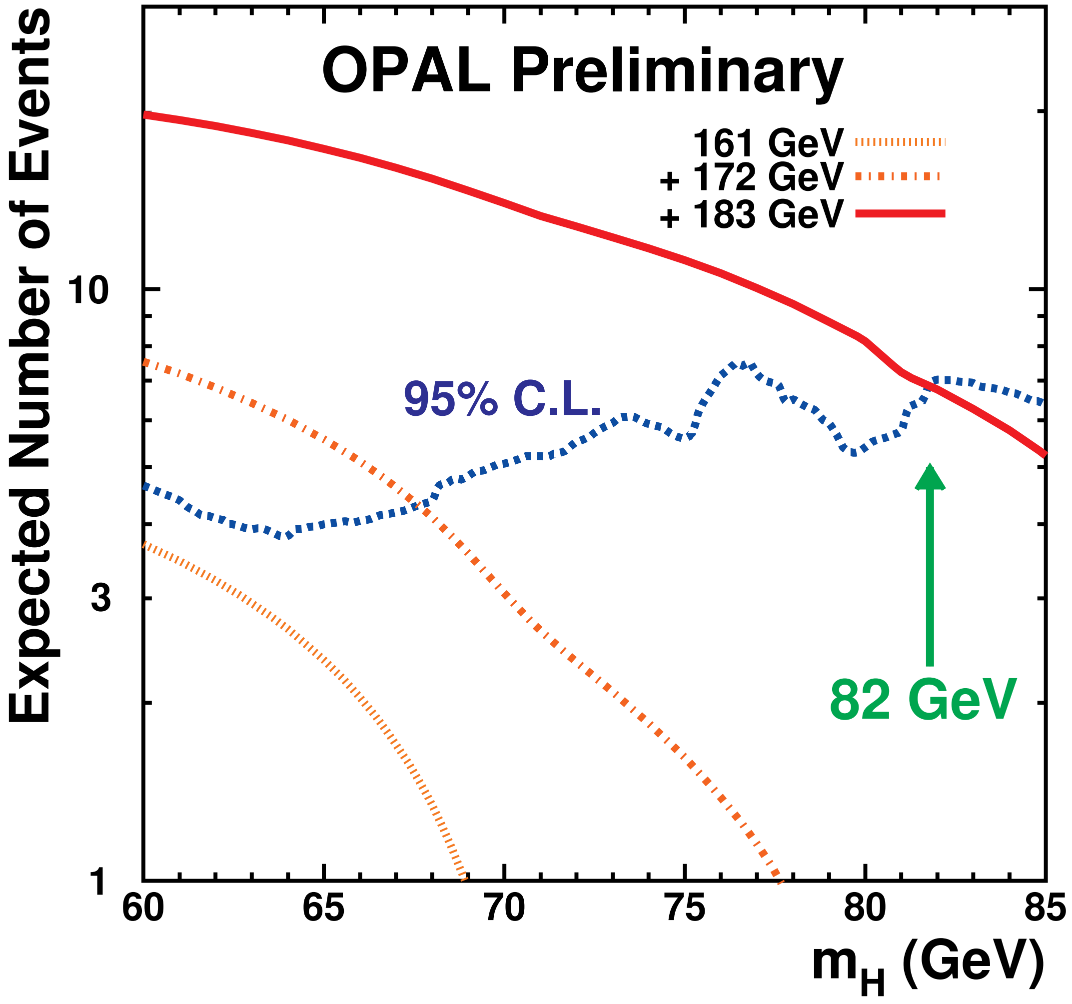
$\sqrt{s}$ (GeV)	161	172	183	Total
N_{exp}	1.9 $\pm$0.1 $\pm$0.3	2.2 $\pm$0.1 $\pm$0.3	10.8 $\pm$0.5 $\pm$2.0	14.9 $\pm$0.5 $\pm$2.5
N_{obs}	1	1	7	9

Higgs candidate mass for selected events:



OPAL New Physics Search: SM Higgs

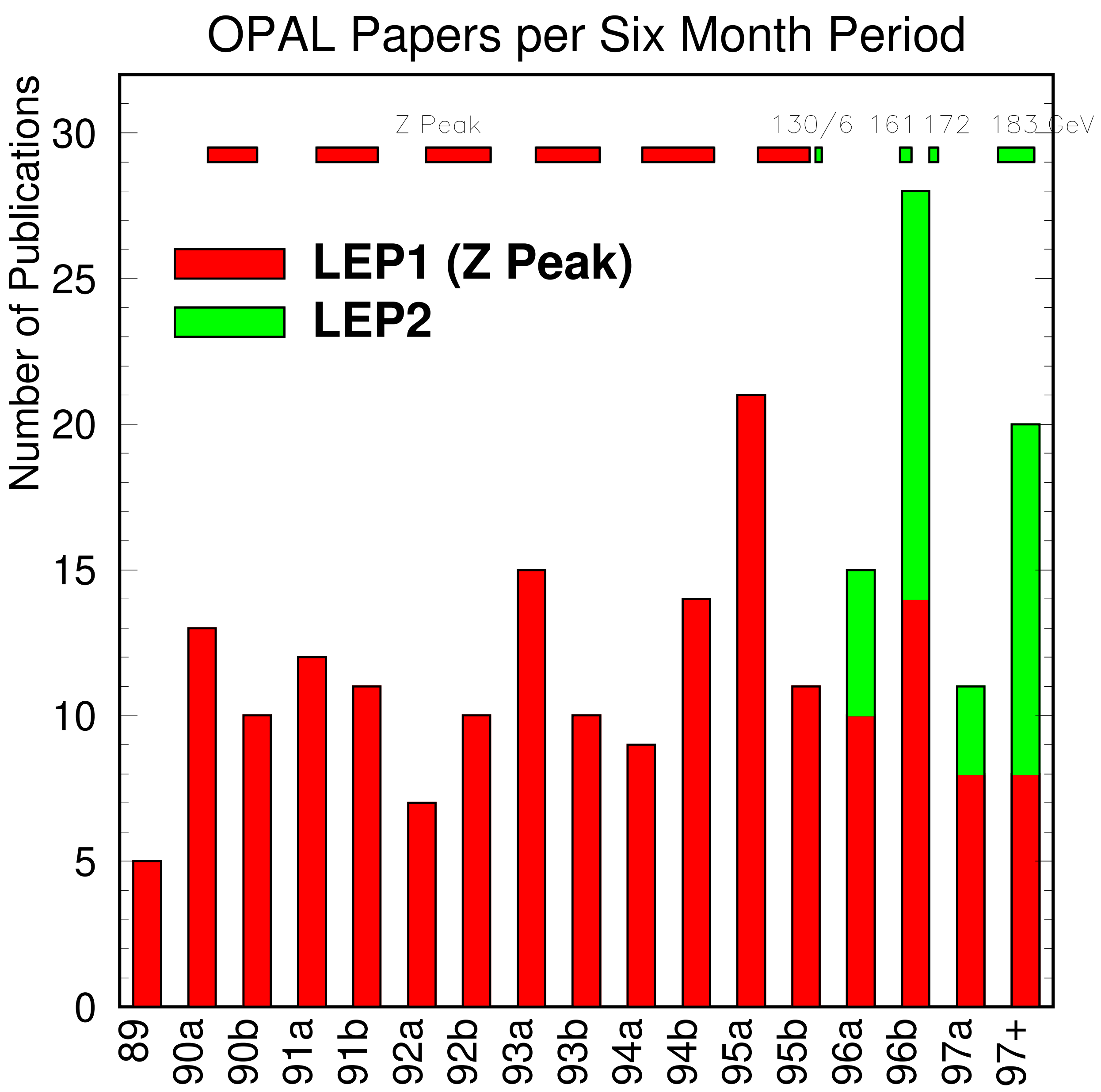
SM Higgs Mass Limit = 82 GeV



OPAL Physics Analyses

Note: Many unmentioned LEP 2 analyses on-going

Still much activity on LEP 1 as well



Conclusions

Efficient running for OPAL for 1997 in spite of background difficulties and some hardware problems (with minor effect on physics).

Small improvements but no major interventions during winter shutdown.

Good standard model measurements at $\sqrt{s}$= 183 GeV with $\int \mathcal{L} \approx 54\mathrm{pb}^{-1}$.

Searched in many channels for New Physics:
$\longrightarrow$ unfortunately no strong evidence yet seen
$\longrightarrow$ the Standard Model still rules!

LEP run in the year 2000:

- LEP running in 2000 very important
- Unanimous support from all of the OPAL institutes
- OPAL is prepared to run in 2000