Experimental summary talk

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abstract

A summary of the experimental results presented at Moriond QCD 2001 are given.

Talk given at the XXXVIth RENCONTRES DE MORIOND
QCD and High Energy Hadronic Interactions
Les Arcs, Savoie, France, March 17-24, 2001

Experimental summary talk

B. PIETRZYK
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FRANCE

A summary of the experimental results presented at Moriond QCD 2001 are given.

Many interesting experimental results have been presented at this meeting. More details and all of the references can be found in the original contributions in these proceedings.

1 Higgs search

(*T. Kawamoto, Wu Ning, P. Garcia, G. Davies, E. Piotto, A. Okpara, L. Moneta, A. Lucotte, K. Assamagan, V. Drollinger, A. Tricomi*)

The Standard Model fits give us an idea of what is the most probable value of the Higgs mass. The minimum of the χ^2 distribution (Fig. 1) is at

$$\mathrm{m}_H = 98^{+58}_{-38}\ \mathrm{GeV}$$

and the one-sided 95% CL (90% two-sided) upper limit on m_H is 212 GeV. The value of 60^{+52}_{-29} GeV was given at the Osaka Conference as the official result. The most important change came from the use of BES data in the determination of $\Delta\alpha^{(5)}_{\mathrm{had}}$. What do BES data have to do with the Higgs mass? The α_{QED} is running. The contribution of the quark loops to the running is obtained by the integration of experimentally measured R in $\mathrm{e}^+\mathrm{e}^-$ anihillation. The BES Collaboration measured the R distribution (Fig. 1) between the c.m.s. energy of 2 and 5 GeV with high precision, reducing the uncertainty on $\Delta\alpha^{(5)}_{\mathrm{had}}$ by a factor of 2. Since the central value of $\Delta\alpha^{(5)}_{\mathrm{had}}$ has also changed the value of the predicted Higgs mass has increased by about 30 GeV.

Higgs at LEP is mostly produced together with Z (higgsstruhlung process - Fig. 2) and is identified by its characteristic decay into b quarks. Different topologies are related to different Z decay channels. Thus 70% of Higgs events should be observed in the 4-jet channel (Fig. 2), 20%

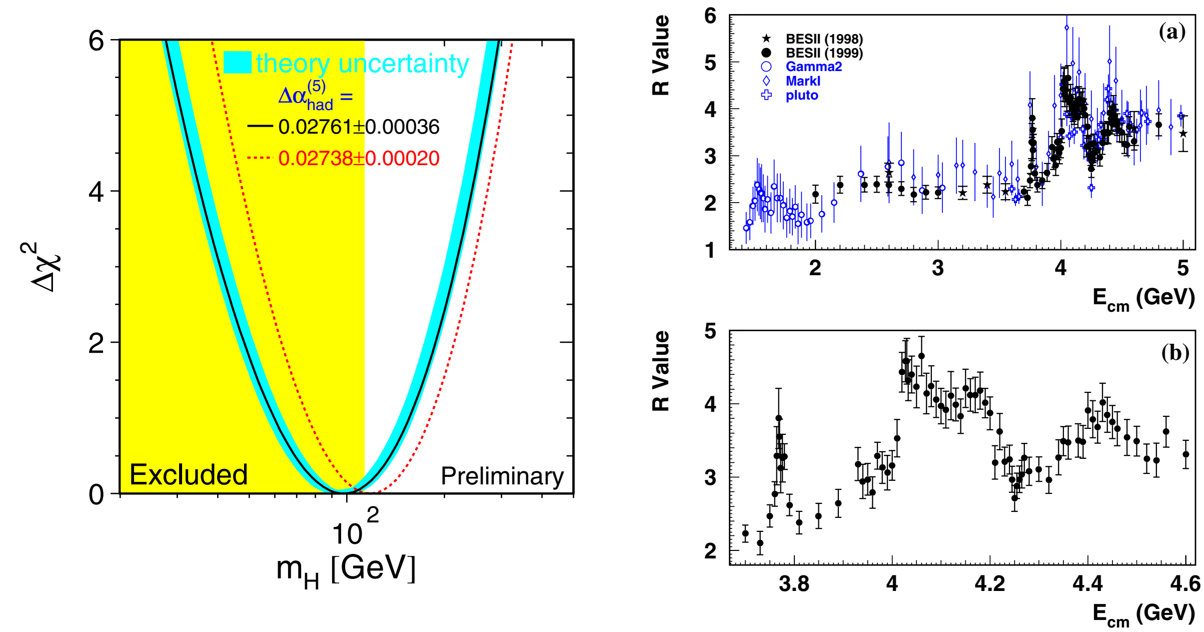

Figure 1: BES results (right) and Standard Model fits (left).

with missing energy, and about 10% with lepton pairs. For the Higgs mass of 115 GeV, 10 events are expected to be produced in total at LEP, including about 6.5 in the 4-jet channel. These are small numbers, so a large fluctuation is expected between the number of events produced in different experiments as well as between different observed topologies. This is precisely what has happened.

History: No evidence for a Higgs with a mass below 113.3 GeV has been presented at the Osaka Conference. At the September LEPC meeting ALEPH presented three candidates with a high significance compatible with mass $\sim$ 114 GeV in the 4-jet channel. At the November LEPC meeting L3 showed a nice Higgs candidate with two jets and missing energy. LEP asked for one more year of running and got nothing. LEP experiment thought that they had a strong case. The evidence (Fig. 3) has increased from one experiment, one channel, and 2.6 σ significance in September, to more experiments, more channels, and 2.9 σ significance in November.

So the evidence for Higgs at LEP is as good as it could be... An ALEPH publication writes: More data, or results from other experiments, will be needed to determine whether the observations ...... are results of a statistical fluctuation or the first sign of direct production of the Higgs boson.

Four LEP experiments have published their results but ... L3 data are NOT available for Moriond 2001 combination (the November combination results are given here).

IF the observations are the first sign of direct production of the Higgs boson then we know its mass quite precisely

$$m_H = 115^{+1.3}_{-0.9}$$

More data will come from Tevatron. Luminosity was limited in Run I and the limit of 30 $\times$ SM cross-section was obtained. Run II started just before Moriond. The machine schedule is to deliver $\sim$ 2 fb^{-1} by 2002 and $\sim$ 15 fb^{-1} by 2007. A total 5–15 fb^{-1}/exp. are needed to obtain 3σ evidence for $<$ 130 GeV Higgs mass and 130-190 Higgs mass requires 8–20 fb^{-1}/exp.

IF 115 GeV Higgs is not there than the Tevatron can exclude it at 95% CL with 2 fb^{-1} in 2003. On the other hand, **IF** 115 GeV mass Higgs is there then 3 σ evidence could be obtained with 5 fb^{-1} in 2004-5.

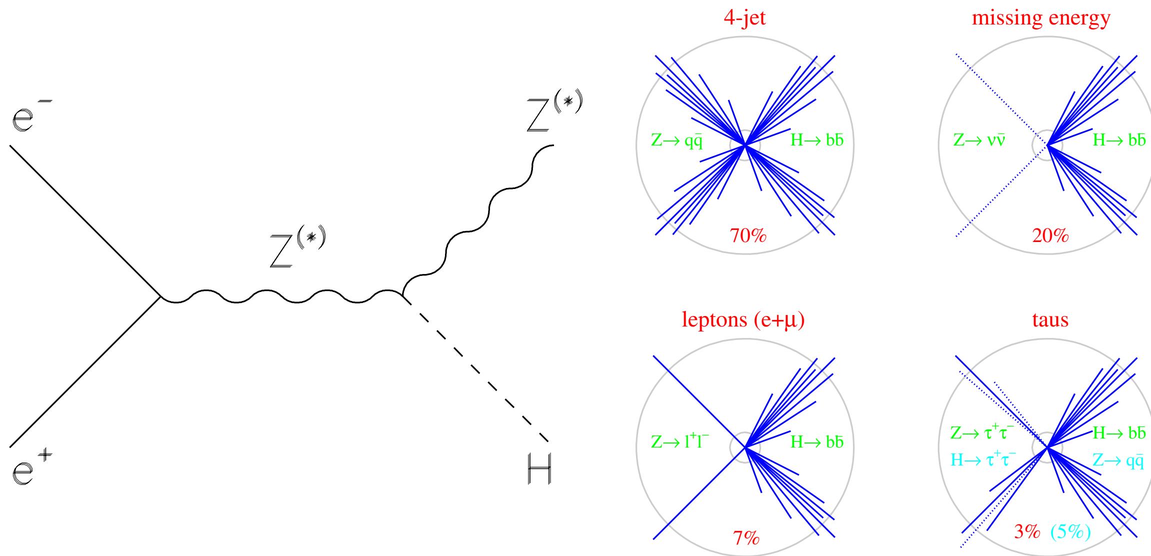

Figure 2: Higgsstruhlung process of Higgs production and different topologies of Higgs production at LEP.

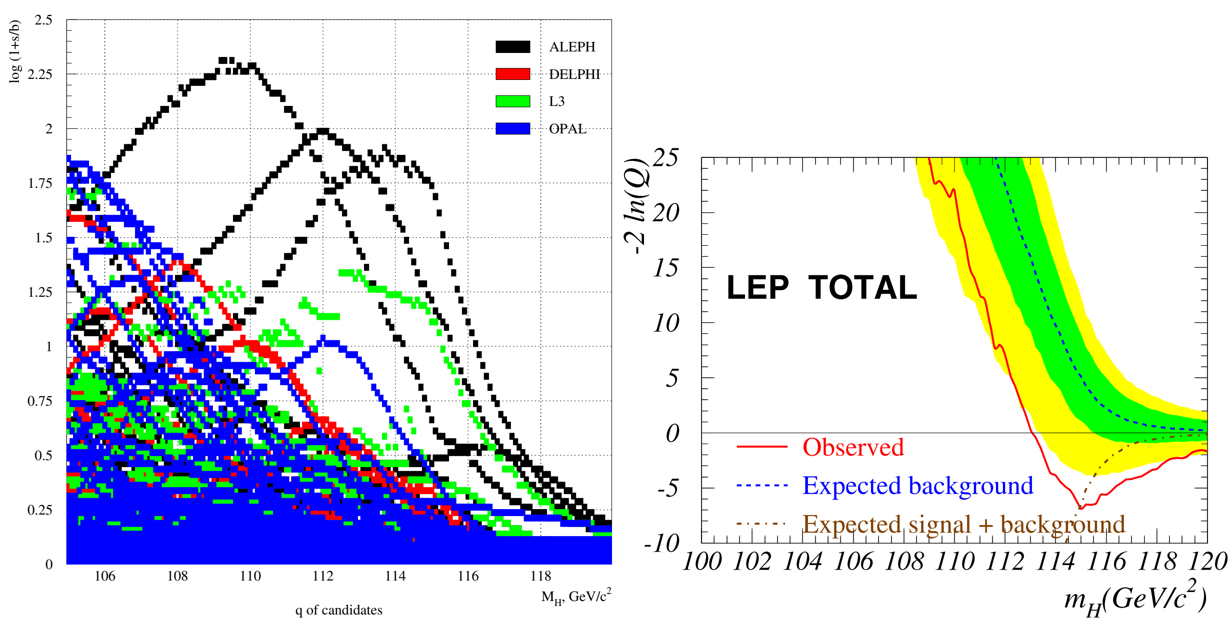

Figure 3: "Spagetti" plot giving a contribution of individual events (left) and the negative log-likehood ratio as a function of m_H (right).

The task is difficult. A combination of different channels is needed, a combination of D0, CDF, and perhaps a combination with LEP for the $\sim$ 115 GeV Higgs.

The LHC will start in 2006 and the SM Higgs could be discovered with 5σ after just one year for $m_H < 150$ GeV. A Higgs with a higher mass could be discovered even faster.

2 Other searches

(*M. Rosca, T. Alderweireld, S. Rieman, S. Braibant, M. Spiropulu, F. Moortgart, B. Knuteson, B. Olivier*)

This is a very important subject. Accelerators are mostly built to discover new particles.

Searches at LEP were presented for non-SM Higgses, Minimal Supersymmetric extension of the SM, RPV-SUSY, GMSB, Technicolor, Excited leptons, Leptoquarks, Contact interactions, R-parity violating scalar particles, extra gauge bosons, and single top production. Selected topics for searches at the Tevatron were also presented. D0 has searched for contributions from Virtual Graviton Exchange looking for deviations in distributions for $\cos\theta^*$ and M in massive e-pair and diphoton production. The scale for large extra spatial dimensions must be higher than $\sim$ 1 TeV. Sleuth – a quasi-model-independent search strategy for new physics – has been developed at the Tevatron for RUN II in order NOT to miss any major discoveries. Finally, the LHC group investigated how to observe MSSM heavy Higgs bosons decaying to sparticles.

3 Heavy ions

3.1 RHIC

(*A. Bazilevsky, C. Roland, J.J. Gaardhoje, S. Margetis, B. Jacak, S. White*)

RHIC has started taking data. It will have a big impact on heavy-ion collision physics in the future. There are two big detectors, collaborations of the LEP size (PHENIX and STAR) and two smaller detectors (PHOBOS and BRAHMS). These detectors will measure with a very high quality many different parameters of the same event.

The first run took place between June and September 2000. Au–Au interactions were observed at $\sqrt{s} = 56$ and 130 GeV. Global quantities were measured (E_t, $N_{\rm ch}$, flow, ...) as well as identified particle spectra and particle ratios. With an energy density $\sim 1.5 \times$ CERN about 4000 charged particle were observed. Already in the first run interesting physics results were obtained and this is only the beginning as statistics 100 times greater is expected for Moriond 2002.

Multiplicity at central rapidity increases with respect to both pp collisions and the SPS. Antiparticle/particle ratios are higher than at the SPS, but they have not yet reached 1 [as expected for quark–gluon plasma (QGP)]. Transverse energy per charged particle is independent both of $N_{\rm part}$ and $\sqrt{s}$ (Fig. 4), and transvers momentum distribution cannot be described by perturbative QCD. Is this evidence for jet quenching expected for QGP?

3.2 CERN

(*R. Arnaldi, B. Lenkeit, P. Wurm, D. Varga, D. Elia, G. Martinez-Garcja*)

RHIC is starting to take data but interesting results are still coming from CERN.

J/ψ suppression by colour screening is predicted to be an unambiguous signature of QGP formation. NA50 has shown evidence for double-step pattern of this suppression vs $N_{\rm part}$. This confirmed distribution vs $E_{\rm T}$ observed before. The double-step pattern is expected since the suppression of directly produced J/ψ's and the suppression of J/ψ's from χ_c decays should not appear at the same time.

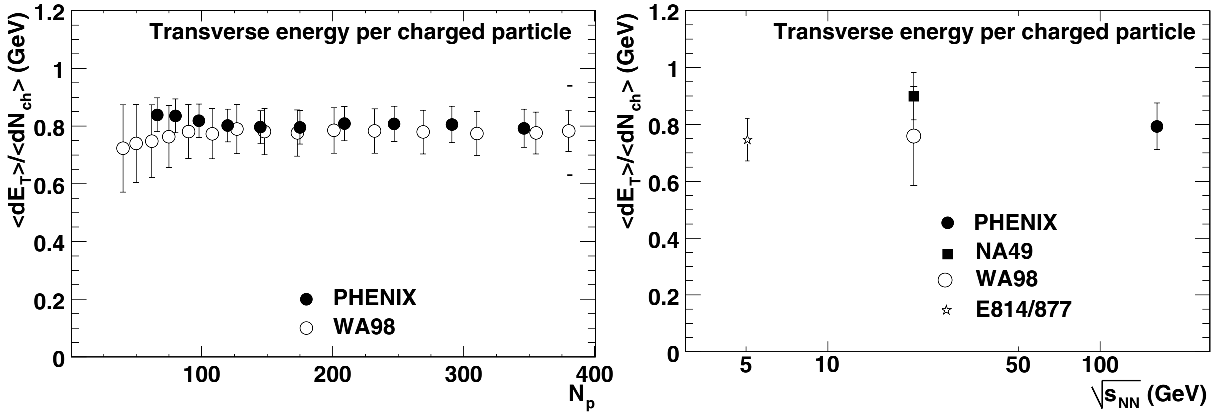

Figure 4: Transverse energy per charged particle at mid-rapidity vs $N_{\rm part}$ (left), and energy of participating nucleons (right) for the highest centrality bin.

NA60 (upgrade of NA50) will study the production of prompt dimuons and muons coming from the decay of charmed mesons. Interesting results on low-mass e^+e^- production have been presented by the CERES collaboration.

NA49 has observed enhancement in the ratio K^+/π^+ already in the pA reaction, an argument not really in favour of QGP.

On the other hand, NA57 has observed increased production of strange and multistrange antibaryons as a function of $N_{\rm part}$ with a threshold effect which could be interpreted as the onset of QGP formation.

Finally, SPS and RHIC are doing very well, but ALICE at the LHC will do much better: at the LHC plasma will be hotter, bigger, and longer.

3.3 Sonja's effect

(*Sonja Kabana*)

... or removing “salt” from “water”

We all know that when we heat water the temperature increases with time and then stays constant when the water boils. When we add different amounts of salt to water we get different distributions. Measuring these distributions and not knowing how much salt is contained in the water we cannot easily discover fundamental phase-transition.

Is it the same with heavy-ion results? The salt are baryons at central rapidity or chemical potential. If one extrapolates to the baryon number = 0 then the results from e^+e^-, $p\bar{p}$, pA, and AA fall on the same distribution with universal phase transition (Fig. 5) at

$$\epsilon_{\rm crit} \sim 1 \pm 0.5~{\rm GeV/fm^3}$$
$$T_{\rm lim} \sim 155 \pm 6 \pm 20~{\rm MeV}$$

4 Core QCD

(*J. Krane, H. Kang, S. Kluth, R. Poeschl, J. Hart, J. Ely*)

It was a pleasure to see that the jet analysis at the Tevatron and the SLD is more and more sophisticated.

At the Tevatron progress towards NNLO predictions has been made, and there also has been more rigorous treatment of experimental errors, inclusion of error estimates in the PDFs, and more consistent E_T calculations between experiments. No significant deviation of predictions from the data has been observed.

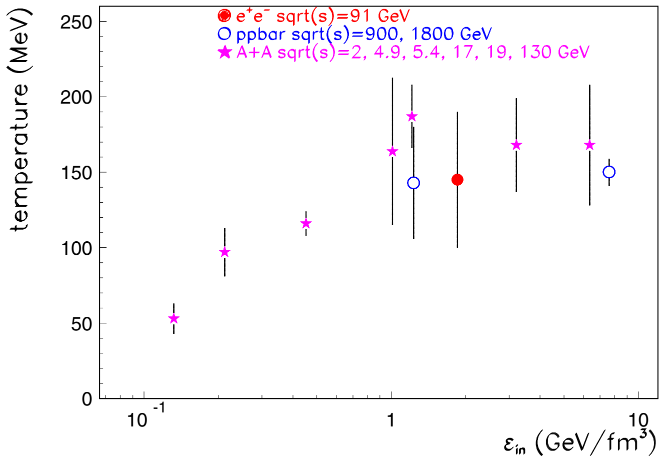

Figure 5: The temperature extrapolated to zero μ_B along an isentropic path, as a function of the initial energy density for several A+A, hadron+hadron and e^+e^- collisions.

The SLD studied production of identified particles in quark and gluon jets, inclusive hadronic fractions for light flavour events, and quark and gluon jet comparisons.

5 Structure functions

(*J. McDonald, D. Kcira, A. Jgoun, F.H. Heisius, M. Klein, J. Hart, J. Ely*)

Interesting results on structure functions have been presented.

NuTeV presented preliminary results of $\frac{d^2\sigma}{dxdy}$, ΔxF_3, and F_2. ΔxF_3 favours values larger than the heavy flavour model prediction.

HERMES presented evidence that the internal transverse momentum distribution in the nucleon is flavour dependent by measuring different mean values of the transverse momentum for h^+, h^- and K^0_s.

Proton, Photon and Virtual Photon structure have been presented by H1 and ZEUS. For real photons NLO calculations describe data for $x_\gamma^{obs} > 0.8$, discrepancies are, however, observed for $x_\gamma^{obs} < 0.8$.

It is interesting to note that at low x and Q^2 a rise of $F_2(x,Q^2)$ and gluon $xg(x,Q_0^2)$ are still observed showing no sign of saturation (yet?).

Finally, $\alpha_s = 0.115 \pm 0.0017$(exp) $\pm$ 0.0009(5) (model) was measured ($\Delta\alpha_s = 0.005$).

Deeply Virtual Compton Scattering (DVCS) is interesting as it is sensitive to two parton correlations. It was observed first by ZEUS in 1996/97 and the H1 results were presented at this Conference. The existence of the process is clearly established but it is not yet used to measure two parton correlations.

HERMES is an experiment designed to measure the spin composition of the nucleon. It uses the polarized positron beam which is scattered on the polarized jet target. At this Conference, HERMES presented the first measurement of a DVCS single spin asymmetry. The measured value of $-0.18 \pm 0.05 \pm 0.05$ is close to the calculated one of -0.35.

6 Diffraction

(*A. Solodsky, V. Monaco, J. Figiel*)

New results from CDF have been presented on diffractive J/ψ production and on double diffraction. Diffractive J/ψ production provides measurement of the gluonic content of the

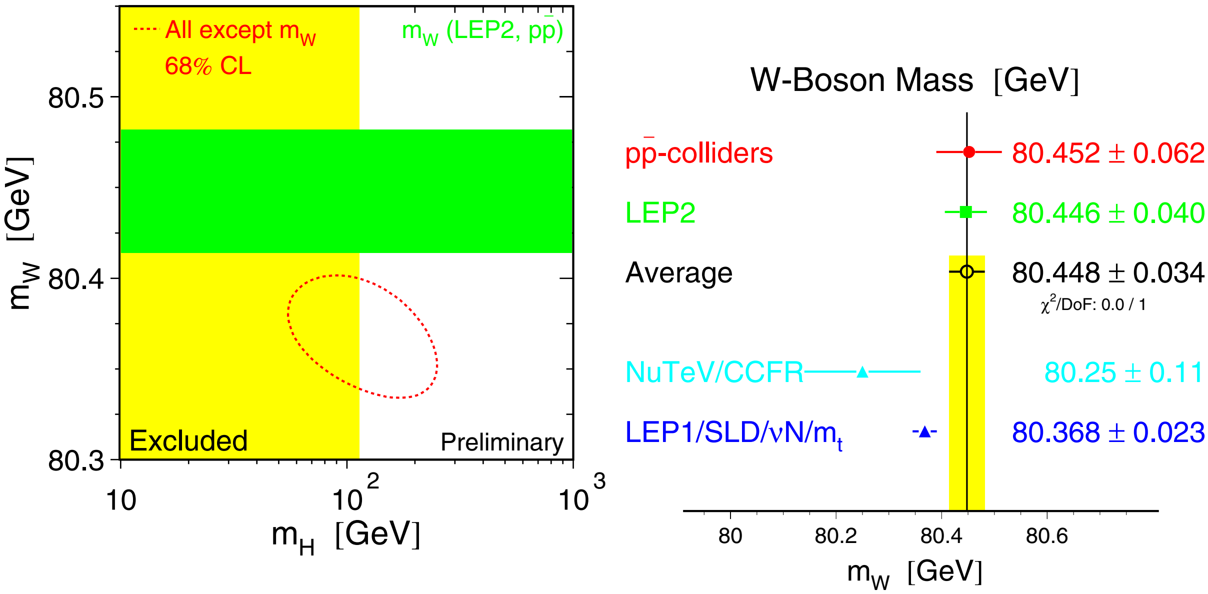

Figure 6: The 68% confidence level contour in m_t and m_W for the Standard Model fit to all data except the direct measurement of m_W, indicated by the shaded horizontal band of $\pm 1\sigma$ width (left) and comparisons (right).

Pomeron. The ratio of diffractive to non-diffractive J/ψ production is 1.45 ± 0.24 %.

The production of Vector Mesons at HERA is the QCD playground for the transition region between the non-perturbative and perturbative regime. For light Vector Mesons the virtuality of γ^* controls the transition between the soft and hard limits of strong interactions.

7 WW physics

(*O. Buchmueller, T. Ziegler, N. Van Remortel*)

W mass measurements have been updated by ALEPH
$m_W = 80.471 \pm 0.038$ (stat) $\pm$ 0.023 (sys) $\pm$ 0.015 (FSI) $\pm$ 0.017 (LEP)
and L3 $m_W = 80.398 \pm 0.048$ (stat) $\pm$ 0.050 (sys).
The value of the combined LEP W mass is in agreement with the Tevatron measurement (Fig. 6). It is also in agreement with the indirect measurements (Fig. 6), however, the difference has increased compared to the one presented at the Osaka conference. LEP experiments have improved the estimate of hadronization systematics. The last big challenge is the estimation (and reduction) of the systematics from Final State Interactions (FSI): colour reconnection and Bose-Einstein correlations. The goal is to obtain final results of W mass measurement for Moriond 2002.

FSI could play an important role in the W mass measurement. Quarks from the W-pair decay fragment at the same time and in the same place. Do the products of fragmentation interact through their colour fields or through Bose-Einstein correlations?

Colour reconnection is a "bloody important subject" - Y. Dokshitzer. These effects are studied by comparing soft particle production between the jets produced from the same W and between jets produced by different Ws (Fig. 7). Important progress has been made by LEP experiments. However, it was observed that fragmentation systematics is important. Models predicting large effects have already been excluded by the experimental data, whilst models predicting small effects on multiparticle distributions are being studied.

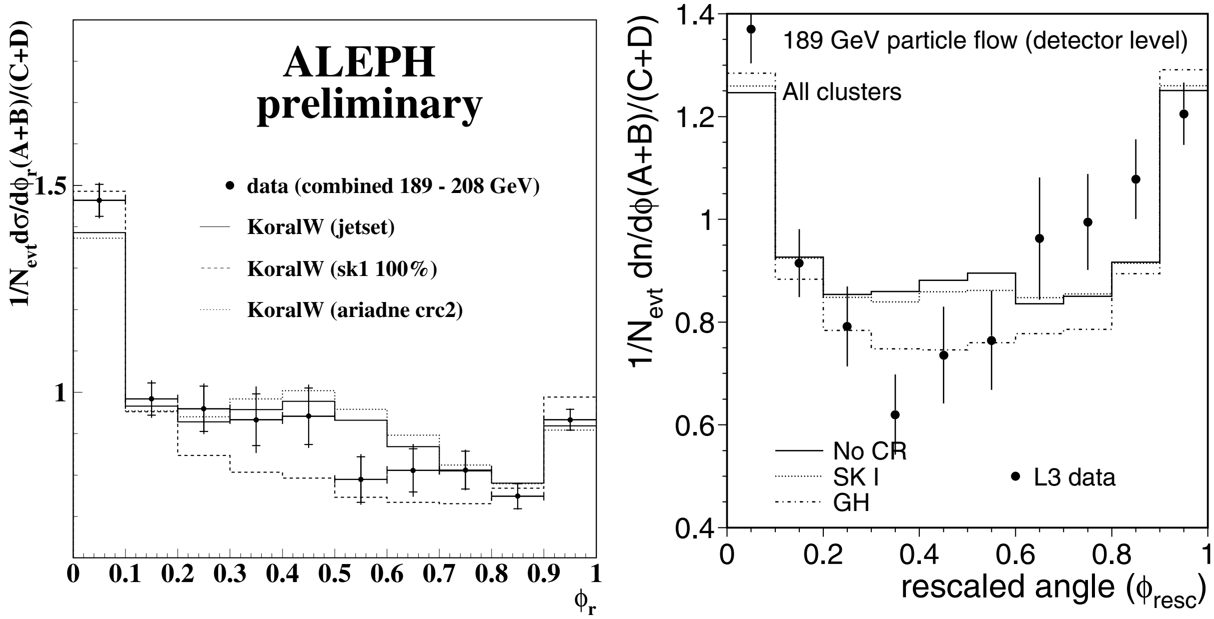

Figure 7: ALEPH and L3 results on colour reconnection.

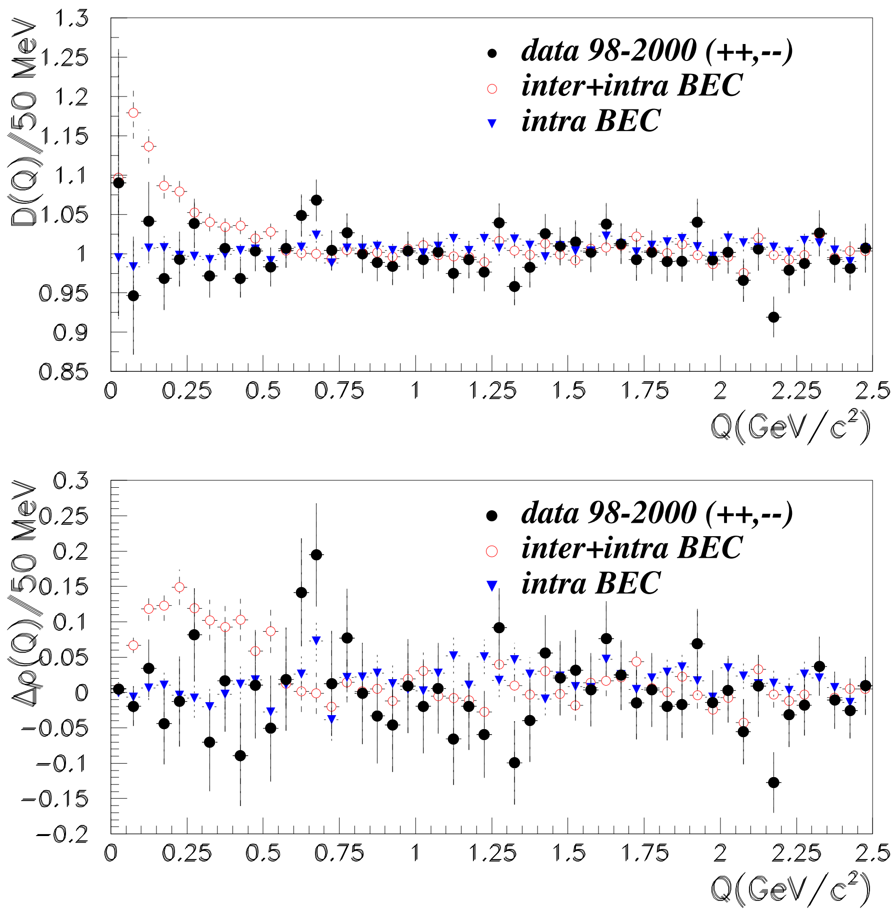

Figure 8: DELPHI results on Bose-Einstein correlations.

This was historical Moriond for investigation of Bose-Einstein correlations (BEC) between the products of fragmentation of W-pair decays produced at LEP. DELPHI has presented results (Fig.8) of measurements which are in agreement with the assumption that only pions originating from each individual W contribute to Bose-Einstein correlations, whilst the model allowing correlations between pions originating from different Ws is disfavoured by 3.2σ. The same conclusion was presented by ALEPH at Moriond two years ago and by L3 one year ago. So there is now consensus between LEP experiments on this conclusion.

This observation can have important consequences. Until now it was assumed that BEC in e^+e^- annihilation are produced from an incoherent source. A possible explanation of LEP observation was given by Bo Anderson in Moriond one year ago. He described BEC as emission from a coherent source. Of course non-observation of correlations reduces to a negligible value the uncertainty of the W mass measurement coming from BEC.

8 Heavy flavours

(*S. Worm, G. Nesom, T. Sloan, M. Dubrovin, D. Cronin-Hennesy, F. Wappler, K. Holtz, C. Brown*)

It was interesting to realize that the top physics at Tevatron is rich, and in the near future different numbers related to production and decay will be measured.

The SLD has obtained the world's best measurement of Gluon Splitting into $b\bar{b}$ Pairs $g_{b\bar{b}} = (2.44 \pm 0.59\ (\text{stat}) \pm 0.34\ (\text{sys})) \times 10^{-3}$, updated b-quark fragmentation, and measured $B\bar{B}$ energy correlations.

Heavy flavours are produced at HERA through the photon–gluon fusion process. For charm production NLO QCD is needed. It has already been known for a long time, and still not understood, that for beauty production NLO QCD predictions are a factor of 1.5–3 below data for photoproduction, DIS, and pp collisions.

CLEO presented the first measurement of the D^{*+} width: 96 ± 4 (stat) $\pm$ 22 (syst) and also the $b \to s\gamma$ branching ratio in agreement with the Standard Model and BELLE.

Polarization has been observed in the hadroproduction of botonium in the Fermilab 866/NuSea experiment.

New results on Rare Kaon Decays in NA48 have been presented.

9 Welcome to BABAR and BELLE

(*J. Beringer, H. Tajima, G. Cavoto, B. Casey, C.H. Wang, V. Brigljevic*)

This is first time that BABAR and BELLE present results at Moriond and they are already impressive. Their most important goal is to investigate CP violation in the B sector (Fig. 9) The following measurements of $\sin 2\beta$ were presented:
$\sin 2\beta = 0.34 \pm 0.20$ (stat) $\pm$ 0.05 (sys) (BABAR)
$\sin 2\beta = 0.58\ ^{+0.32}_{-0.34}$ (stat) $^{+0.09}_{-0.10}$ (sys) (BELLE)
The combined result is already 3σ above 0 (no CP violation). The Standard Model prediction is about 0.72 with large uncertainty.

Lifetime and mixing measurements by BELLE (left) and BABAR (right) were also presented. Uncertainties in the results are comparable or close to the existing best measurements:
$\tau(B^0) = 1.548 \pm 0.035,\ 1.546 \pm 0.032 \pm 0.022$ ps
$\tau(B^{-+}) = 1.656 \pm 0.038,\ 1.673 \pm 0.032 \pm 0.022$ ps
$\Delta m_d = 0.522 \pm 0.026,\ 0.499 \pm 0.010 \pm 0.012\ \text{ps}^{-1}$ (semileptonic)
$\Delta m_d = 0.527 \pm 0.032,\ 0.519 \pm 0.020 \pm 0.016\ \text{ps}^{-1}$ (hadronic)

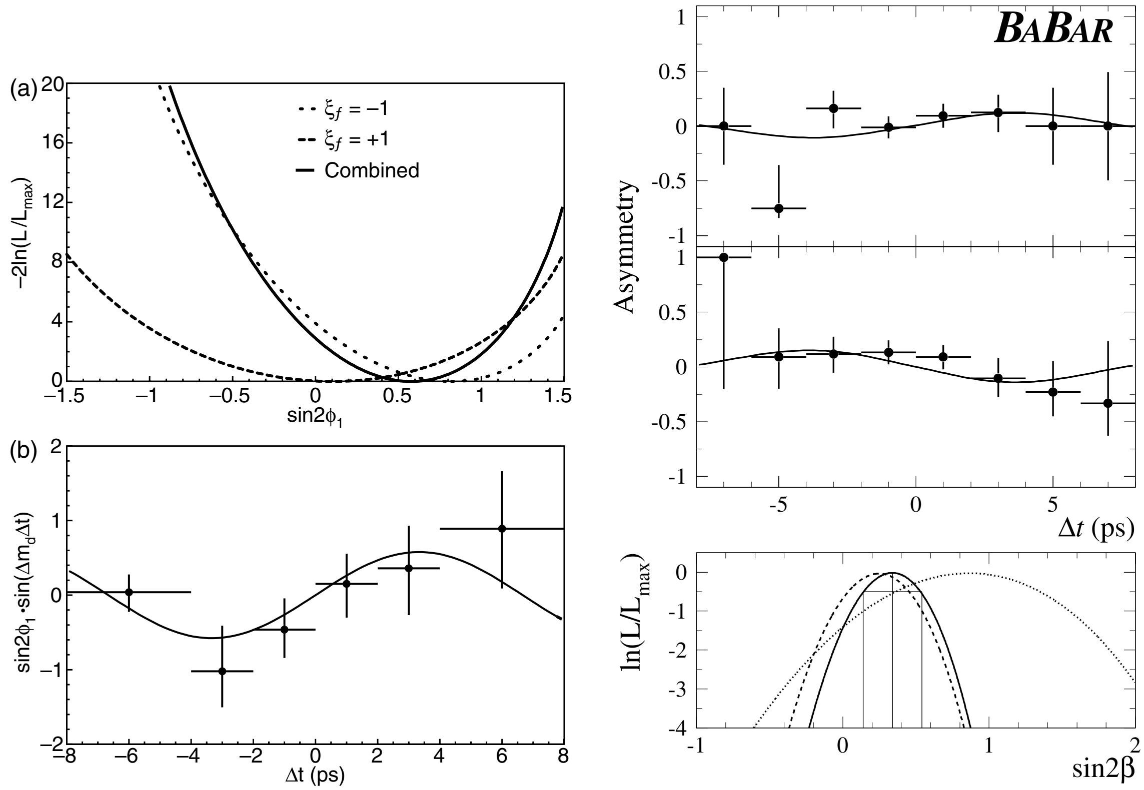

Figure 9: The asymmetry measured in BELLE (left) and BABAR (right).

Charmless Hadronic B decays have also been measured at BABAR and BELLE. Many studies have been made on charmonium modes, branching ratios, polarization, etc. Results on V_{cb} measurements were given.

10 Conclusions

Many extremely interesting results have been presented. We have had many discussion. It is impressive that after 36 years Moriond (Tran's) spirit is still conserved.

At Moriond 2002 we should have:
the final or nearly-final LEP results, RUN II results from Tevatron, 100 times higher statistics results from RHIC, results with much higher statistics from BABAR and BELLE, new processes, more sophisticated analysis, results from HERA, etc.

I will therefore finish with a sentence from a talk:
"The best is yet to come" – next year.

The physics was beautiful but the weather was less beautiful. The Programme Committee should start an intensive and ambitious programme of weather control in order to improve it next year!