Preliminary notes on two-fermion group activities

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Abstract

This note contains a preliminary discussion of the issues which are to be addressed by the 2-fermion group. New input or criticism would be most welcome. It contains a list of experimental and theoretical observables for difermion events, and provides estimates of their theoretical uncertainties, together with the one requested by experiments. Comparisons are made of predictions from different packages.

Technical Point: This file has the usepackage showkeys activated. For the normal printout form the appropriate line should be commented out. Then all information about the labels will disappear. At present it is printed for the sake of editing comfort.

To evolve into a chapter in future yellow book

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Contents

1 Introduction

It is probably fair to assume that the theoretical effort to describe difermion physics at LEP2 is now almost finished. The main goal of the difermion workshop should thus be to review our present knowledge of these theoretical predictions, collecting references from relevant papers and programs. It should estimate theoretical systematic errors for experimentally interesting quantities, etc. However, if important predictions are still missing, the present workshop should bring this to the attention of the theoretical community.

Our group will work closely with the LEP2 $f\bar{f}$ working group (coordinated by Pete Renton), which aims to develop the procedure for combining the results from the four LEP experiments. We should also interact with searches groups, for which Standard Model (SM) difermion processes are a source of background. It is natural that members of these working groups are best placed to formulate a list of practical observables for which theoretical predictions and their systematic errors are needed. They can also highlight cases where the theoretical issues need clarifying and estimate the relative urgency with which the different issues need to be addressed. Of course we should coordinate our efforts with other working groups of the workshop, in particular the 4-fermion as well as $\nu\bar{\nu}\gamma's$ working groups.

Two kinds of observables should be studied.

- Realistic observables which correspond more closely to the event selection cuts actually applied by experiments.
- Idealized theoretical quantities, such as the total cross sections or asymmetry with no cuts or very simple cuts. Such quantities are best suited for theoretically clear extraction of basic quantities such as particle masses or couplings. They also make it easier to average results from different experiments and allow a comparison with SM predictions from semi-analytical programs.

A list of such observables is given in **Section 2**. The list of realistic observables may be long and semi-repetitive . (e.g., Observables with cuts differing slightly by numerical value of some parameters – angles, energies etc.) However, this is necessary, as the discussion of theoretical systematic errors often depends on particular kinematical cuts applied. It may also contain observables which are known to have good theoretical predictions and reliably estimated theoretical errors. Later, we can decide on how to group and simplify the list according to e.g., convenience for discussion of theoretical errors. However, it is important that from the very beginning the list should be complete and describe exhaustively the event selections of the various experiments. Section 2 will also describe why some observables are better than others from an experimental point of view. It will also identify for which variables it is most urgent to have theoretical input, e.g., because experimental errors are small compared with theoretical ones, or where experimental cuts have to be modified to exclude phase space regions poorly known from theory. The list of idealized variables must use simple cuts, which make sense experimentally and can also be implemented in semi-analytical programs.

One of the most important tools to achieve the aim of this workshop is comparisons between different available theoretical calculations. Before making such comparisons, one need a clear understanding of definitions of quantities and tuning of input parameters. **Section 3** will therefore address the question of conventions and definitions in order to avoid such inconsistencies when using different programs. This chapter on definitions should also address the question of compatibility of LEP1 and LEP2 conventions and motivation of why they are chosen like that (gauge invariance, conventions of LEP1 published results, etc.). Eventually such section(s) could be part of general section of the whole report and could be taken over by the main editor.

In **Section 4**, we plan to describe the various theoretical programs and give the basic ideas behind them, together with the list of main publications and indication of where the present versions of these programs can be taken from.

Section 5 will contain numerical results and present theoretical studies of systematic errors for the individual (or for groups of) observables presented in Section 2. It should also assess theoretical errors on the difference between idealized and experimental observables, to determine how reliably experiments can correct their results to the idealized case. The aim will be, of course, not to list all the predictions for each case but to provide numerical benchmark and concentrate on the discussion of possible systematic errors. In this discussion the breakdown of errors and understanding of applicability of different components is important.

The contributions to this section will be the responsibility of the individual authors of the various packages used in making predictions of difermion production. We should ensure that all such packages are considered, not only those already used by experimentalists, but also all other which are officially released.

The ideal item in this section would be just extended citation to published papers (preprints or completed entries in this book) of the form which may look like the following one: "Observables (*list of labels from Section 2*) have theoretical systematic uncertainties of xx% as shown in [**?**]. These uncertainties are estimated with the help of the program [**?**], by varying the following assumptions/parameters .... Simmilarily on the basis of that calculations we expect that in the following cases: (*another list of labels from Section 2*) systematic errors for predictions should not exceed the tag of xx %. Finally in the following cases: (*again another list of labels from Section 2*) the predictions and their systematic errors can be calculated accordingly to scenario explained above, but we can not guess the numerical size of the outcome with enough certaintity.

We can not expect the ideal situation in case of all observables. We will need to adopt our approach, stimulate effort etc., accordingly to experimental importance of the particular observable, available theoretical results and manpower. In the cases where the theory error is unknown or possibly big, we will try to find other alternative observables with reliable/small errors.

Section 6 will provide numerical comparisons of predictions from different theory packages, comparisons for the observables listed in Section 2 .These comparisons will check the robustness of the error estimates provided in Section 5. Eventual traps or potential misunderstandings due to different conventions will be presented here.

Finally, **Section 7** will summarize the effort. In some cases we may find predictions to be insufficiently precise. In such cases stimulation for the future efforts can be generated.

2 Observables

From the preliminary discussion we find that at least the two classes of observables are to be discussed: those corresponding to realistic experimental cuts and those of an idealized nature. Furthermore, each of these may apply to either

1. 2 fermion final states
2. 2 fermion + visible photons (esp radiative return).

The perpendicular classification was of course on the basis of the level of the idealization of observable. It is thus rather reasonable to start with the creation first of individual entries in the list, and only later continue with ordering it.

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As it was pointed out, the first item should be discussed in close contact with the LEP2 ffbar subgroup of the LEP electroweak working group. It should help to facilitate the averaging procedure of the results of the four LEP experiments, and assess the theoretical and MC modelling errors for each experiment as well as their correlation in the average. It might even help to clearly define a benchmark 2-fermion "signal" for the averaging procedure in terms of s' definition, $\cos\theta$ definition, QED I/F interference, and pair radiation correction.

The 2f+photon final state (i.e. high pt photons) , mainly consisting of radiative return events, is essential to be understood for searches for excited leptons , decaying to gamma-ℓ and anomalous ZZ-γ and γZ-γ couplings. Here the theory predictions , semi-analytical programs and MC generators agree worst with the data, especially for electrons. An improvement of these predictions and an assessment of remaining errors is crucial for obtaining valid limits (or discoveries) of new physics.

Precise realistic observables together with the required precision for each of the above categories are currently set up by the experimentalists.

In the definition of cuts we need to address the question of possible contamination of one process by another one. Often experimental cuts are specifically designed to eliminate such contaminations, but in practice some remnant contaminations may still stay. As simple example we can imagine the τ-predictions (case of the $\tau \to \mu$ decay) which can provide non-negligible contribution for the observable designed eg. for the measurement of μ-pair with ISR photons. As prediction for such τ-channel can be easily calculated we may expect the question on its size and related uncertainty.

More complicated is the case of 2-f versus 4-f definition, i.e. how to set the limit defining which pair radiation is a radiative correction to the 2f signal, and should be included in the measurement and the efficiency determination, and which is background, to be subtracted. To understand this interplay between 2-f and 4-f processes three groups have to work closely together: Our group, the LEP2 ffbar subgroup of the LEP electroweak working group and the 4-fermion subgroup of this MC workshop. Theoretically little effort has yet gone in this problem at LEP2, and there is urgent need for theorists to talk to experimentalists and vice versa, in order to define the work that has to be done (e.g. common exponentiation of pairs and photons, options to apply a cut on the pair mass) The outcome might even have some impact on LEP1 results, although there the effect is very much suppressed.

We may expect other similar situations, due e.g. of particle misidentiffications which we may need to include in our scheme of predictions and their systematic errors. There is no doubt that the higher precision required the more cut off details need to be included into observable definition. Also discussion of theoretical uncertainties will depend rather strongly on required precision.

2.1 Precision requirements

As we can see the observables can be divided into different classes of abstraction depending where they are placed on the spectrum from full experimental condition toward final idealized observables with QED corrections subtracted, 4π-detector etc. One of the most important ingredient of the observable definition is its precision tag. Obviously the higher precision the more complicated study of its theoretical uncertainties will be. Also more of the details of experimental cuts will be needed to get the answer on theoretical systematic errors. In cases when description will become extremely long a reference to experimental paper can be the only solution. For the convenience of editing we suggest that the references are directly taken from SLAC database including the bib-tex-reference-name!. This should be helpful in matching all into one long (or more of shorter) list(s). Every observable will enter as individual item in the tex-enumerate list.

The following rule of thumb with respect to the errors obtained for the data taken at $\sqrt{s} = 189$ GeV was suggested for estimating required precision in cases when there is no better scenario.

1. Experimental statistical error is decreased by factor of $\sqrt{12} \simeq 3.5$ with respect to present one for the single collaboration. We still expect statistics to grow by factor of 3 and combination of all 4 experiments brings total statistics factor of 12 bigger.
2. Experimental systematic error can be expected to go down by a factor of 2 (may be 3) due to improvements and partial non-correlations among experiments
3. The above estimates of experimental statistical and systematic error should be added in quadrature.
4. The required precision should be 1/3 of that to assure that theoretical effects will not deteriorate experimental results (will not increase an error) by more than 10% .

The demand of maximum 10 % increase of final experimental overall error due to theoretical uncertainties is not an over-demand. It is equivalent to decrease in running time of experiments by 20 % in cases when statistical error dominates. Similar 10% deterioration of an overall detection performance would occur only after 30 % decrease in data taking for measurements where statistical and systematic errors are similar in size. Having this in mind and also an enormous effort of so many peoples over so many years, not mentioning the costs may even lead to conclusion that our rule for precision requirements from theory is not enough strict.

In general as inclusive we understand cross section for $\sqrt{s'/s} > 0.1$ and exclusive for $\sqrt{s'/s} > 0.85$. For Bhabha Excl_1 denotes $|\cos\theta| < 0.9$ and Excl_2 denotes $|\cos\theta| < 0.7$ For asymmetries the (absolute) error tag can be obtained from the one of cross section multiplying it by $0.01{\cdot}\sqrt{2}$ and dropping the % symbol.

The following precision tags can be assumed if explicit numbers do not overrule them in the text:

1. cross sections for $q\bar{q}$ final states: incl. 0.11 %, excl. 0.23 %
2. cross sections for e^-e^+ final states: excl_1 0.13 %, excl_2 0.21 %
3. cross sections and asymmetries for $\mu^-\mu^+$ final states: incl. 0.41 %, excl. 0.53 %
4. cross sections and asymmetries for $\tau^-\tau^+$ final states: incl. 0.44 %, excl. 0.61 %
5. searches background cross sections from quarks and tagged hard photons 0.3 %
6. searches background cross sections from leptons and tagged hard photons:
   single photons 1.0 %, multiple photons 5%
7. searches background cross sections from neutrinos and tagged hard photons
   single photons 0.2 %, multiple photons 1%

   These numbers can serve as a starting point for definition of precision tags required from complete theoretical calculations. For separate ingredients such as interferences pair corrections etc, physical precision tag must be even more strict, to assure that their combination will not overcome the required tag. Finally the tag for technical tests must be set another factor of few smaller. This point will be extended later, at the moment let us assume that in general case of physical effect which is not-dominating overall theoretical uncertainty it must be smaller at least by factor of 3 than required precision tag. Of course technical precision of its calculation must be even more strict. To enable any meaningful comparisons between different theoretical calculations it must be at least another factor of 5 or so smaller, that is to be at the level of 0.05 of listed above precisions tags required by experiments.

2.2 Notation

In definition of observables we will use some short-hand notations to make it easier. Let me illustrate just a few of them.

- E_{cm}: centre of mass energy.

- θ_γ: The polar angle of particle γ with respect to the electron beam.
- $|\cos\theta_{f/\bar{f}}| < 0.9$: The polar angle of both particles f and $\bar{f}$ must satisfy the cut.
- E_γ: The energy of particle γ.
- $x_\gamma = 2E_\gamma/E_{cm}$: The energy fraction of particle γ.
- N_{trk}: Number of charged tracks in the event.
- a$col(e^+e^-)$: The acollinearity angle between particles e^+ and e^-.
- A_{FB}: forward-backward asymmetry constructed on the basis of final state charged particles.
- $M_{prop-}(\mu^+\mu^-)$: invariant mass of the s-channel propagator, with ISR/FSR interference subtracted.
- $M_{prop+}(\mu^+\mu^-)$: invariant mass of the s-channel propagator, with ISR/FSR interference not subtracted. In this case, the propagator mass is ambiguous for the interference contribution, so this part is actually evaluated using the $\mu^+\mu^-$ invariant mass excluding radiative photons.
- $M_{inv}(\mu^+\mu^-)$: invariant mass of μ^+ and μ^- - all other particles such as collinear photons are excluded. For realistic observables, this is determined from the reconstructed 4-momenta of the two particles.
- $M_{ang}(\mu^+\mu^-)$: invariant mass determined from the measured polar angles of particles μ^+ and μ^- with respect to the electron beam. This calculation is based on four-momentum conservation assuming that only one radiative photon is present. If no photon is seen in the detector, this radiative photon is assumed to go along the beam axis. If an energetic, isolated photon is seen in the detector, then its reconstructed polar angle is used.
- $M_{kine}(\mu^+\mu^-)$: invariant mass determined from a kinematic fit. This uses 4-momentum conservation to improve the mass estimate based on the reconstructed 4-momenta of the μ^+ and μ^-.
- s'$_{L3}$ for $\mu^+\mu^-$ or $\tau^+\tau^-$ from observed ISR photon (E more than 10 GeV, $|\cos\theta_\gamma| < 0.985$, separation to nearest fermion more than 10 degrees), *or* from fermion angles assuming photon escapes along the beam pipe
- s'$_{L3}$ for $q\bar{q}$ from observed ISR photon (E more than 10 GeV, $|\cos\theta_\gamma| < 0.985$, separation to nearest energy cluster more than 10 degrees), *or* from jet angles after kinematic fit

- s'$_{\mathrm{OPAL}}$ for $\mathrm{q\overline{q}}$: from a series of kinematic fits using observed ISR photons ($|\cos\theta_\gamma| <$ 0.985, isolated with less than 1 GeV energy flow in a cone of half angle 0.2 rad around them) plus hadronic jets. The fits allow zero, one or two additional photons emitted close to the beam direction. s' is taken from the fit with the lowest number of extra photons giving an acceptable χ^2.

- **No additional pair cut**$_{ALEPH}$: This will be added soon.

- **No additional pair cut**$_{DELPHI}$: This will be added soon.

- **No additional pair cut**$_{L3}$: This will be added soon.

- **No additional pair cut**$_{OPAL}$: This will be added soon.

In the following chapters the observables will be defined. For more details see respectively: ALEPH [?], DELPHI [?], L3 [?] OPAL [?, ?, ?] ($\mathrm{f\overline{f}}(\gamma)$), [?] ($\ell\overline{\ell}+\gamma$) [?, ?] ($\nu\overline{\nu}+\gamma$)

2.3 Realistic $e^+e^- \to q\bar{q}(\gamma)$ Observables

2.3.1 ALEPH

1. **Inclusive Selection:** Event clustered into jets with JADE algorithm until $(M_{jet-jet}/E_{cm})^2 > 0.008$. Low mass jets with high electro-magnetic energy fraction assumed to be radiative photons. Non-photon jets then cluster together until only two left, corresponding to the $q\bar{q}$ system. Then

   (a) $M_{inv}(q\bar{q}) > 50$ GeV (excluding photon jets),
   (b) $M_{ang}(q\bar{q}) > 0.1E_{cm}$,
   (c) $|\cos\theta_{q/\bar{q}}| < 0.95$.

2. **Exclusive Selection:** Same as inclusive selection, then following extra cuts,

   (a) $M_{inv}(q\bar{q}) > 0.7E_{cm}$ (excluding photon jets),
   (b) $M_{ang}(q\bar{q}) > 0.9E_{cm}$,
   (c) Event thrust > 0.85.

2.3.2 DELPHI

Events were retained if they contained at least 7 charged tracks and if the charged energy was greater than 15 % of the collision energy. In addition, the quantity $E_{rad} = \sqrt{E_F^2 + E_B^2}$, where E_F and E_B stand for the total energy seen in the Forward and Backward electromagnetic calorimeters, was required to be less than 90 % of the beam energy. Each event was first reconstructed assuming it was made of two jets and the $M_{prop+}(q\bar{q})$ was computed from jet directions. When an isolated energetic photon was reconstructed in the electromagnetic calorimeters the value of $M_{prop+}(q\bar{q})$ was computed from the measured photon energy.

3. **Inclusive Selection:** $M_{prop+}(q\bar{q}) > 75\ GeV$
4. **Exclusive Selection:** $M_{prop+}(q\bar{q})/E_{cm} > 0.85$

2.3.3 L3

Events are selected by restricting the visible energy, E_{vis}, to $0.4 < E_{\text{vis}}/\sqrt{s} < 2.0$. The longitudinal energy imbalance must satisfy $|E_{\text{long}}|/E_{\text{vis}} < 0.7$. These cuts account for a large reduction of the two-photon background. In order to reject background originating from lepton pair events, more than 18 calorimetric clusters with an energy larger than 300 MeV are requested. To reconstruct the effective centre-of-mass energy two different methods are used. For the first one, all events are reclustered into two jets using the JADE algorithm. A single ISR photon is assumed to be emitted along the beam axis and to result in a missing momentum vector. From the polar angles of the jets, θ_1 and θ_2, the photon energy can be estimated. The second method uses the clustered jets ($y_{\text{cut}} = 0.01$) obtained using the JADE algorithm. A kinematic fit is performed on the jets and the missing four-momentum vector using different hypotheses for the emitted ISR photons. The missing energy is attributed to zero, one or two ISR photons. From the differences given by the two methods, systematic errors on the effective centre-of-mass energy reconstruction are calculated. When an isolated energetic photon (energy larger than 10 GeV) is detected, the energy and momentum of this photon are added to the undetected ISR photons.

5. **Inclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.10$
6. **Exclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.85$

2.3.4 OPAL

Events are required to have at least 7 electromagnetic clusters and at least 5 tracks. The total energy deposited in the electromagnetic calorimeter has to be at least 14% of the centre-of-mass energy. The energy balance R_{bal} along the beam direction has to satisfy $R_{bal} \equiv\mid \Sigma(E_{clus} \cdot \cos\theta) \mid /\Sigma E_{clus} < 0.75$, where the sum runs over all clusters in the electromagnetic calorimeter, θ is the polar angle, and E_{clus} is the energy of each cluster. Events selected as W-pair candidates according to the criteria of [?] are rejected.

7. **Inclusive Selection:** $\sqrt{s'_{OPAL}/s} > 0.10$
8. **Exclusive Selection:** $\sqrt{s'_{OPAL}/s} > 0.85$

2.4 Idealized $e^+e^- \to q\bar{q}(\gamma)$ Observables

2.4.1 ALEPH

9. **Inclusive Selection:** $M_{prop+}(q\bar{q})/E_{cm} > 0.1$ and $|\cos\theta_q| < 0.95$. No additional pair cut$_{ALEPH}$.

10. **Exclusive Selection:** $M_{prop+}(q\bar{q})/E_{cm} > 0.9$ and $|\cos\theta_q| < 0.95$. No additional pair cut$_{ALEPH}$.

2.4.2 DELPHI

11. **Inclusive Selection:** $M_{prop+}(q\bar{q})/E_{cm} > 0.1$ and $|\cos\theta_q| < 1.0$.

12. **Exclusive Selection:** $M_{prop+}(q\bar{q})/E_{cm} > 0.85$ and $|\cos\theta_q| < 1.0$.

2.4.3 L3

13. **Inclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.10$ and $|\cos\theta_q| < 1.0$.

14. **Exclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.85$ and $|\cos\theta_q| < 1.0$.

2.4.4 OPAL

15. **Inclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.10$ and $|\cos\theta_q| < 1.0$.

16. **Exclusive Selection:** $M_{prop-}(q\bar{q})/E_{cm} > 0.85$ and $|\cos\theta_q| < 1.0$.

2.5 Realistic $e^+e^- \to e^+e^-(\gamma)$ Observables

2.5.1 ALEPH

17. **Exclusive Selection 1:** $2 \leq N_{trk} \leq 8$. Two of tracks must be identified as electrons, have $|\cos\theta| < 0.9$ and opposite charge. The scalar sum of their momenta should exceed $0.3E_{cm}$. The sum of their energies including photons within $20°$ of each tracks should exceed $0.4E_{cm}$. Then $M_{inv}(e^+e^-) > 80$ GeV (reconstructed from track momenta), $M_{ang}(e^+e^-) > 0.9E_{cm}$ (where radiative photons reconstructed as for $q\bar{q}$ selection), and $-0.9 < \cos\theta_{e^-} < 0.9$.

18. **Exclusive Selection 2:** Same as exclusive selection 1, but $-0.9 < \cos\theta_{e^-} < 0.7$.

2.5.2 DELPHI

19. **Exclusive Selection:** The electron and positron were required to be in the polar angle range $44° < \theta < 136°$ and the non-radiative events were selected by asking the acollinearity to be smaller than $20°$.

2.5.3 L3

The electron and positron are required to be in the polar angle range $44° < \theta < 136°$ or $20° < \theta < 160°$ and non-radiative events are selected by asking the acollinearity to be smaller than 20° OR $M_{inv}(e^+e^-)/E_{cm} > 0.85$.

20. **Exclusive Selection 1:** $M_{inv}(e^+e^-)/E_{cm} > 0.85$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

21. **Exclusive Selection 2:** $acol(e^+e^-) < 20deg.$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

22. **Inclusive Selection 1:** $M_{inv}(e^+e^-)/E_{cm} > 0.10$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

23. **Inclusive Selection 2:** $M_{inv}(e^+e^-)/E_{cm} > 0.10$ and $|\cos\theta_{e^+/e^-}| < 0.94$.

2.5.4 OPAL

Events selected as electron pairs are required to have at least two and not more than eight clusters in the electromagnetic calorimeter, and not more than eight tracks in the central tracking chambers. At least two clusters must have an energy exceeding 20% of the beam energy, and the total energy deposited in the electromagnetic calorimeter must be at least 50% of the centre-of-mass energy. For the inclusive selection and the exclusive selection 1, at least two of the three highest energy clusters must each have an associated central detector track. If all three clusters have an associated track, the two highest energy clusters are chosen to be the electron and positron. For the large acceptance exclusiv selection 2, no requirement is placed on the associationof tracks to clusters, but the requirement on the total electromagnetic energy is increased to 70% of the centre-of-mass energy.

24. **Inclusive Selection :** $\mathrm{acol}(e^+e^-) < 170°$ and $|\cos\theta_{e^+/e^-}| < 0.9$.

25. **Exclusive Selection 1:** $\mathrm{acol}(e^+e^-) < 10°$ and $|\cos\theta_{e^-}| < 0.7$.

26. **Exclusive Selection 2:** $\mathrm{acol}(e^+e^-) < 10°$ and $|\cos\theta_{e^+/e^-}| < 0.96$.

2.6 Idealized $e^+e^- \to e^+e^-(\gamma)$ Observables

2.6.1 ALEPH

27. **Exclusive Selection 1:** $M_{inv}(e^+e^-)/E_{cm} > 0.1$ and $-0.9 < \cos\theta_{e^-} < 0.9$. No additional pair cut_{ALEPH}.

28. **Exclusive Selection 2:** $M_{inv}(e^+e^-)/E_{cm} > 0.9$ and $-0.9 < \cos\theta_{e^-} < 0.7$. No additional pair cut_{ALEPH}.

2.6.2 DELPHI

29. **Exclusive Selection:** $M_{inv}(e^+e^-)/E_{cm} > 0.85$ and $|\cos\theta_{e^+/e^-}| < 0.7$.

2.6.3 L3

30. **Exclusive Selection 1:** $M_{inv}(e^+e^-)/E_{cm} > 0.85$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

31. **Exclusive Selection 2:** $acol(e^+e^-) < 20deg.$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

32. **Inclusive Selection 1:** $M_{inv}(e^+e^-)/E_{cm} > 0.10$ and $|\cos\theta_{e^+/e^-}| < 0.71934$.

33. **Inclusive Selection 2:** $M_{inv}(e^+e^-)/E_{cm} > 0.10$ and $|\cos\theta_{e^+/e^-}| < 0.94$.

2.6.4 OPAL

34. **Inclusive Selection :** $\mathrm{acol}(e^+e^-) < 170°$ and $|\cos\theta_{e^+/e^-}| < 0.9$.

35. **Exclusive Selection 1:** $\mathrm{acol}(e^+e^-) < 10°$ and $|\cos\theta_{e^-}| < 0.7$.

36. **Exclusive Selection 2:** $\mathrm{acol}(e^+e^-) < 10°$ and $|\cos\theta_{e^+/e^-}| < 0.96$.

2.7 Realistic $e^+e^- \to \mu^+\mu^-(\gamma)$ Observables

2.7.1 ALEPH

37. **Inclusive Selection:** $2 \leq N_{trk} \leq 8$. Two of tracks must be identified as muons, have $p > 6$ GeV, $|\cos\theta| < 0.95$ and opposite charge. The scalar sum of their momenta should exceed 60 GeV. Event clustered into jets with JADE algorithm until $(M_{jet-jet}/E_{cm})^2 > 0.008$. Then $M_{ang}(q\bar{q}) > 0.1E_{cm}$ (where radiative photons reconstructed as for $q\bar{q}$ selection).

38. **Exclusive Selection:** Same as inclusive selection, then following extra cuts, $M_{ang}(q\bar{q}) > 0.9E_{cm}$ (where radiative photons reconstructed as for $q\bar{q}$ selection) and $M_{inv}(q\bar{q}) > 110$ GeV (excluding these photons).

2.7.2 DELPHI

An event was required to have two identified muons in the polar angle range $20° \leq \theta_\mu \leq 160°$ and the highest muon momentum of at least 30 GeV/c. $M_{inv}(\mu^+\mu^)$ was calculated from a kinematical fit, where four different topologies were investigated for each event: i) no photon radiated, ii) one photon radiated along the beam line, iii) one seen and one unseen photon in any direction, iv) a single unseen photon in any direction. The seen photon fit was performed if a neutral energy deposit greater than 5 GeV was measured in the electro-magnetic calorimeters.

39. **Inclusive Selection:** $M_{inv}(\mu^+\mu) > 75\ GeV$

40. **Exclusive Selection:** $M_{inv}(\mu^+\mu)/E_{cm} > 0.85$

2.7.3 L3

An event must have two identified muons in the polar angle range $20^\circ \leq \theta_\mu \leq 160^\circ$ and the highest muon momentum should exceed 35 GeV. The effective centre-of-mass energy for each event is determined assuming the emission of a single ISR photon. In case the photon is found in the detector it is required to have an energy, E_γ, larger than 15 GeV in the electro-magnetic calorimeter and an angular separation to the nearest muon of more than 10 degrees. Otherwise the photon is assumed to be emitted along the beam axis and its energy is calculated from the polar angles of the outgoing muons.

41. **Inclusive Selection:** $M_{ang}(\mu^+\mu)/E_{cm} > 0.10$

42. **Exclusive Selection:** $M_{ang}(\mu^+\mu)/E_{cm} > 0.85$

2.7.4 OPAL

$N_{trk} \geq 2$. A pair of tracks is taken as muon pair candidate, if both tracks are identified as muons, have $p > 6$ GeV, $|\cos\theta| < 0.95$ and are separated by 320 mrad in azimuthal angle ϕ. If more than one pair of tracks satisfies the above conditions, the pair with the largest scalar momentum sum is chosen. The event is rejected if more than one other track has a transverse momentum greater than 0.7 GeV. Finally, E_{vis}, defined as the scalar sum of the two muon momenta plus the energy of the highest energy cluster in the electromagnetic calorimeter, has to be larger than $0.35\sqrt{s} + 0.5M_z^2/\sqrt{s}$.

43. **Inclusive Selection:** $M_{ang}(\mu^+\mu)/E_{cm} > 0.10$
and $M_{inv}(\mu^+\mu^-) > 70$ GeV, if $0.35\sqrt{s} < E_{vis} - 0.5M_z^2/\sqrt{s} < 0.75\sqrt{s}$.

44. **Exclusive Selection:** $M_{ang}(\mu^+\mu)/E_{cm} > 0.85$
and $M_{inv}(\mu^+\mu^-) > \sqrt{M_Z^2 + 0.1s}$.

2.8 Idealized $e^+e^- \to \mu^+\mu^-(\gamma)$Observables

2.8.1 ALEPH

45. **Inclusive Selection:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.1$ and $|\cos\theta_{\mu^-}| < 0.95$. No additional pair cut$_{ALEPH}$.

46. **Exclusive Selection:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.9$ and $|\cos\theta_{\mu^-}| < 0.95$. No additional pair cut$_{ALEPH}$.

2.8.2 DELPHI

47. **Inclusive Selection:** $M_{inv}(\mu^+\mu^-) > 75\ GeV$ and $|\cos\theta_{\mu^-}| < 0.95$.

48. **Exclusive Selection:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.85$ and $|\cos\theta_{\mu^-}| < 0.95$.

2.8.3 L3

49. **Inclusive Selection:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.10$ and $|\cos\theta_{\mu^-}| < 0.90$.

50. **Exclusive Selection 1:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.85$ and $|\cos\theta_{\mu^-}| < 0.90$.

51. **Exclusive Selection 2:** $M_{inv}(\mu^+\mu^-)/E_{cm} > 0.85$ and $|\cos\theta_{\mu^-}| < 1.0$.

2.8.4 OPAL

52. **Inclusive Selection:** $M_{prop-}(\mu^+\mu^-)/\sqrt{s} > 0.10$ and $|\cos\theta_{\mu^-}| < 0.95$.

53. **Inclusive Selection:** $M_{prop-}(\mu^+\mu^-)/\sqrt{s} > 0.10$ and $|\cos\theta_{\mu^-}| < 1.00$.

54. **Exclusive Selection:** $M_{prop-}(\mu^+\mu^-)/\sqrt{s} > 0.85$ and $|\cos\theta_{\mu^-}| < 0.95$.

55. **Exclusive Selection:** $M_{prop-}(\mu^+\mu^-)/\sqrt{s} > 0.85$ and $|\cos\theta_{\mu^-}| < 1.00$.

2.9 Realistic $e^+e^- \to \tau^+\tau^-(\gamma)$Observables

2.9.1 ALEPH

56. **Inclusive Selection:** Two identified τ candidates with $M_{inv}(\tau^+\tau^-) >$ 25 GeV and a$col(\tau^+\tau^-) < 250$ mrad in plane perpendicular to beam axis. Then $M_{ang}(\tau^+\tau^-) > 0.1E_{cm}$ (where radiative photons reconstructed as for $q\bar{q}$ selection).

57. **Exclusive Selection:** Same as inclusive selection, then following extra cut $M_{ang}(\tau^+\tau^-) > 0.9E_{cm}$ (where radiative photons reconstructed as for $q\bar{q}$ selection).

2.9.2 DELPHI

The leading track in each hemisphere was required to lie in the polar angle range $|\cos\theta| <$ 0.94, and the observed charged particle multiplicity was requested to be unity in one hemisphere and no more than five in the other. At least one of the leading tracks was required to have momentum greater than $0.025 \times \sqrt{s}$. Full description of the cuts can be found in [?]. The $M_{ang}(\tau^+\tau-)$ was calculated from fermion directions estimated by leading tracks.

58. **Inclusive Selection:** $M_{ang}(\tau^+\tau-) > 75\ GeV$

59. **Exclusive Selection:** $M_{ang}(\tau^+\tau-)/E_{cm} > 0.85$

2.9.3 L3

Taus are identified as narrow, low multiplicity jets, containing from one to five charged particles. Tau jets are formed by matching the energy depositions in the electro-magnetic and hadron calorimeters with tracks in the central tracker and the muon spectrometer. Two tau jets of at least 3.5 GeV are required to lie within the polar angular range $|\cos\theta| < 0.92$. To reject background from two photon processes the most energetic jet must have an energy larger than 20 GeV. The reconstruction of the effective centre-of-mass energy follows the procedure described in the muon subsection, using the polar angles of the two tau jets. Full description of the cuts can be found in [?].

60. **Inclusive Selection:** $M_{ang}(\tau^+\tau-)/E_{cm} > 0.10$

61. **Exclusive Selection:** $M_{ang}(\tau^+\tau-)/E_{cm} > 0.85$

2.9.4 OPAL

Tau-pair candidates are events with exactly two charged, low multiplicity cones with 35° half-angle.

- The Event is rejected if it was selected as a μ pair.
- $\mathrm{N_{trk}} < 7$, where $\mathrm{N_{trk}}$ is the number of tracks in the central detector.
- $\mathrm{N_{trk}} + \mathrm{N_{clus}} < 16$, where $\mathrm{N_{clus}}$ is the number of ECAL clusters.
- $|\cos\theta_{\tau^+\tau^-}| < 0.90$, where $|\cos\theta_\tau|$ is the cosine of the respective cone axis.
- $0.02 < \mathrm{R_{shw}} < 0.7$, where $\mathrm{R_{shw}}$ is the summed ECAL energy scaled by the centre of mass energy.
- $\mathrm{R_{trk}} < 0.8$, where $\mathrm{R_{trk}}$ is the scalar sum of track momenta scaled by the centre of mass energy.
- $\mathrm{R_{shw}} > 0.2$ or $\mathrm{R_{trk}} > 0.2$.
- $\mathrm{R_{shw}} + \mathrm{R_{trk}} < 1.05(1.10)$, for $|\cos\theta| > 0.7$ (< 0.7),where $|\cos\theta|$ is the average of the two tau cones.
- $|\cos\theta_{\mathrm{p^{ECAL}_{missing}}}| < 0.99$, where $\cos\theta_{\mathrm{p^{ECAL}_{missing}}}$ is the cosine of the direction of missing momentum calculated using the ECAL.
- $\mathrm{p_t^{ECAL}} > 0.015\sqrt{\mathrm{s}}$ where p_t^{ECAL} is the sum of the transverse ECAL energy.
- Events are rejected if $0.9 < \mathrm{E/p} < 1.1$ in both cones.

- Using the values of θ_τ, the expected energy of each lepton is calculated assuming that the final state consists only of two leptons plus a single unobserved photon along the beam direction. We then require that $0.02 < \sqrt{(X_{E1}^2 + X_{E2}^2)} < 0.8$, and $\sqrt{(X_{P1}^2 + X_{P2}^2)} < 0.8$, where $X_{E1,E2}$ are the total electromagnetic calorimeter energies in each tau cone normalized to the expected value calculated above, and $X_{P1,P2}$ are the scalar sums of track momenta in the two tau cones, also normalized to the expected values.

- $\theta_{\mathrm{acolinearity}} < 180° - 2\tan^{-1}\left(\frac{2\mathrm{M_Z}\sqrt{\mathrm{s}}}{\mathrm{s}-\mathrm{M_Z^2}}\right) + 10°$. This cut is placed 10° degrees above the expected radiative return peak.

- $\theta_{\mathrm{acoplanarity}} < 30°$.

62. **Inclusive Selection:** $M_{ang}(\tau^+\tau^-)/\sqrt{s} > 0.10$.

63. **Exclusive Selection:** $M_{ang}(\tau^+\tau^-)/\sqrt{s} > 0.85$.

2.10 Idealized $e^+e^- \to \tau^+\tau^-(\gamma)$Observables

2.10.1 ALEPH

64. **Inclusive Selection:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.1$ and $|\cos\theta_{\tau^-}| < 0.95$. No additional pair cut$_{ALEPH}$.

65. **Exclusive Selection:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.9$ and $|\cos\theta_{\tau^-}| < 0.95$. No additional pair cut$_{ALEPH}$.

2.10.2 DELPHI

66. **Inclusive Selection:** $M_{inv}(\tau^+\tau^-) > 75\ GeV$ and $|\cos\theta_{\tau^-}| < 0.95$.

67. **Exclusive Selection:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.85$ and $|\cos\theta_{\tau^-}| < 0.95$.

2.10.3 L3

68. **Inclusive Selection:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.10$ and $|\cos\theta_{\tau^-}| < 0.92$.

69. **Exclusive Selection 1:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.85$ and $|\cos\theta_{\tau^-}| < 0.92$.

70. **Exclusive Selection 2:** $M_{inv}(\tau^+\tau^-)/E_{cm} > 0.85$ and $|\cos\theta_{\tau^-}| < 1.0$.

2.10.4 OPAL

71. **Inclusive Selection 1:** $M_{prop-}(\tau^+\tau^-)/\sqrt{s} > 0.10$ and $|\cos\theta_{\tau^-}| < 0.90$.
72. **Inclusive Selection 2:** $M_{prop-}(\tau^+\tau^-)/\sqrt{s} > 0.10$ and $|\cos\theta_{\tau^-}| < 1.00$.
73. **Exclusive Selection:** $M_{prop-}(\tau^+\tau^-)/\sqrt{s} > 0.85$ and $|\cos\theta_{\tau^-}| < 0.90$.
74. **Exclusive Selection:** $M_{prop-}(\tau^+\tau^-)/\sqrt{s} > 0.85$ and $|\cos\theta_{\tau^-}| < 1.00$.

2.11 $q\overline{q}\gamma$'s observables

This section contains precision requirements for regions of phase space selected in searches for anomalous neutral gauge couplings (ZZγ,Z$\gamma\gamma$), especially for the visible $\gamma + Z \rightarrow \gamma + q\overline{q}$ final state. The prominent Standard Model process populating this region is the radiative return to the Z.

2.11.1 ALEPH

2.11.2 DELPHI

2.11.3 L3

2.11.4 OPAL

75. **Total Cross-Section**

    Events are selected with two jets and one visible photon, fulfilling a 3C kinematic fit, allowing an additional photon of at most 5% of the beam energy to be radiated along the beam pipe. The relevant phase space is defined by

    (a) $E_\gamma > 50$ GeV
    (b) $15° < \theta_\gamma < 165°$
    (c) angle between photon and closest jet, $\alpha_{\gamma-jet} > 30°$.

    The required precision tag for the radiative return cross-section in this phase space for a LEP-combined analysis is 0.3%. It assumes uncorrelated experimental systematics and is dominated by the experimental statistics. For fully correlated experimental systematics the precision tag is 0.4%. Currently, the predictions of the KK2f and PYTHIA generators in this phase space differ by 15%.

76. **Differential Cross-Section** Selected Events in the above phase space are subjected to a maximum likelihood fit in the differential distributions of $E_\gamma, \cos\theta_\gamma$, and $\cos\theta_q^\star$, which is the angle of the final state quark-jets in the Z restframe.

    Precision tag: The ratio between the rate of events within $|\cos\theta_\gamma| < 0.7$ and the boundary of the acceptance has to be known within about 1%. The discrepancy between KK2f and Pythia in the region $|\cos\theta_\gamma| < 0.7$ is currently at level of 30% (stat. significance 2σ).

2.12 $\ell\bar{\ell}\gamma$'s observables

This final state is primarily used to search for single (one photon) or pair (two photons) production of excited leptons. In principle, the radiative return peak in $M_{\ell\ell}$ can be rejected in these searches, which is not possible in the anomalous neutral coupling analyses (see above). In practice, however, experimental resolution and further (final state) radiation reduce the power of such an anticut. Thererfore both topologies (inlcuding and omitting the anticut) need to be studied.

2.12.1 ALEPH

2.12.2 DELPHI

2.12.3 L3

2.12.4 OPAL

Photon candidates are required to have an energy exceeding 5% of the beam energy, and have to lie within $|\cos\theta_\gamma| < 0.95|$. Leptons are also identified within $|\cos\theta_\ell| < 0.95|$ and are required to have $p_t > 1$ GeV. Photons, electrons, and muons are required to be isolated by at least 20 degree from the nearest charged track of momentum larger than 1 GeV.

- **$\ell\bar{\ell}$plus one photon**
  There must be at least two identified leptons of the same type and at least one photon. The two most energetic leptons and the most energetic photon are used in the analysis. Their energy sum is called E_{vis} in the following. The precision tag assumes uncorrelated experimental systematics and is dominated by the expected statistical precision of the LEP combined result. For correlated experimental systematics the required theoretical precision is loosened by about 0.3%.

77. **eeγ w/o rad return rejection**
    - $E_{vis} > 1.6 E_{\mathrm{beam}}$
    - $|\cos\theta_\gamma| < 0.70$
    - $|\cos\theta_e| < 0.70$ for at least one electron.

    Precision tag: 1.0%
78. **eeγ with rad return rejection**
    - $E_{vis} > 1.6 E_{\mathrm{beam}}$
    - $|\cos\theta_\gamma| < 0.70$
    - $|\cos\theta_e| < 0.70$ for at least one electron.
    - reject events with 85 GeV $< M_{ee} <$ 95 GeV

    Precision tag: 1.0%
79. **$\mu\mu\gamma$ w/o rad return rejection**

- $E_{vis} > 1.6E_{\rm beam}$

Precision tag: 1.2%

80. **$\mu\mu\gamma$ with rad return rejection**
    - $E_{vis} > 1.6E_{\rm beam}$
    - reject events with 85 GeV $< M_{\mu\mu} <$ 95 GeV

    Precision tag: 1.5%

81. **$\tau\tau\gamma$ w/o rad return rejection**
    - $0.8E_{\rm beam} < E_{vis} > 1.9E_{\rm beam}$

    Precision tag: 1.1%

82. **$\tau\tau\gamma$ with rad return rejection**
    - $0.8E_{\rm beam} < E_{vis} < 1.9E_{\rm beam}$
    - reject events with 85 GeV $< M_{\tau\tau} <$ 95 GeV

    Precision tag: 1.2%

- **$\ell\bar{\ell}$plus two photons**
  There must be at least two identified leptons of the same type and at least two photons. The two most energetic leptons and the two most energetic photons are used in the analysis. Their energy sum is called E_{vis} in the following. The precision tag is dominated by the statistical error of the selection.

83. **ee$\gamma\gamma$ w/o rad return rejection**
    - $E_{vis} > 1.6E_{\rm beam}$
    - minimum opening angle among all electron-photon combinations $|\cos\alpha^{e\gamma}_{\rm min}| <$ 0.90.

    Precision tag: 3%

84. **ee$\gamma\gamma$ with rad return rejection**
    - $E_{vis} > 1.6E_{\rm beam}$
    - minimum opening angle among all electron-photon combinations $|\cos\alpha^{e\gamma}_{\rm min}| <$ 0.90.
    - reject events with 85 GeV $< M_{ee} <$ 95 GeV

    Precision tag: 3%

85. **$\mu\mu\gamma\gamma$ w/o rad return rejection**
    - $E_{vis} > 1.6E_{\rm beam}$

    Precision tag: 5%

86. **$\mu\mu\gamma\gamma$ with rad return rejection**
    - $E_{vis} > 1.6E_{\rm beam}$

– reject events with 85 GeV $< M_{\mu\mu} <$ 95 GeV

Precision tag: 6%

87. $\tau\tau\gamma\gamma$ **w/o rad return rejection**

    – $0.8E_{\mathrm{beam}} < E_{vis} > 1.9E_{\mathrm{beam}}$

    Precision tag: 5%

88. $\tau\tau\gamma\gamma$ **with rad return rejection**

    – $0.8E_{\mathrm{beam}} < E_{vis} < 1.9E_{\mathrm{beam}}$

    – reject events with 85 GeV $< M_{\tau\tau} <$ 95 GeV

    Precision tag: 6%

2.13 $\nu\bar{\nu}\gamma$'s observables

The observables listed above do not include the cut to eliminate regions of phase space dominated by the radiative return to Z. Such events are usually selected by the cut-off on the mass of the invisible system, or, cut on photon energy in simpler, single photon case. For such extended observables the required precision tag should be simply scaled with the somewhat decreased statistics. In general we need however complete predictions on full multi-dimensional distributions of photon(s) energies and directions, with the precision up to the level of the one for indicated for the total cross section.

2.13.1 ALEPH

89. Single photon and missing energy:

    Exactly one photon with $|\cos\theta_\gamma| < 0.95$ and $P_t > 0.0375 * E_{cm}$. No other photon with $|\cos\theta_\gamma| < 0.9997$ and $E_\gamma > 1$ GeV. No additional pair cut$_{ALEPH}$. The required precision tag is 0.2%.

90. Two or more photons and missing energy:

    Two or more photons with $E_\gamma > 1$ GeV and $|\cos\theta_\gamma| < 0.95$. The transverse momentum of the multi-photon system must be such that $\Sigma P_t > 0.0375*(E_{cm} - \Sigma E)$. No additional pair cut$_{ALEPH}$. No other photon with $|\cos\theta_\gamma|$ between 0.95 and 0.9997, and $E_\gamma > 1$ GeV. The required precision tag is 1%.

2.13.2 DELPHI

91. Single photon and missing energy:

    Require exactly one observed photon with energy requirement varying with polar angle

(a) Very forward: $3.8^o < \theta < 6.5^o$, $x_\gamma > 0.3$ or $x_\gamma > (9.2 - \theta)/9$

(b) Forward: $12^o < \theta < 32^o$, $x_\gamma > 0.2$

(c) Barrel: $45^o < \theta < 90^o$, $x_\gamma > 0.06$

No additional photons with $E_\gamma > 0.8$ GeV and $\theta < 38$ mrad unless they are within 3^o, 15^o and 20^o from the primary photon for the very forward, forward and barrel regions, respectively. The required precision tag is 0.2%.

92. Two or more photons and missing energy :

Two or more photons with $E_\gamma > 0.05 * E_{beam}$ and $|\cos\theta_\gamma| < 0.985$, at least one of which has $|\cos\theta_\gamma| < 0.906$. No additional photon with $E_\gamma > 0.02 * E_{cm}$ and $|\cos\theta_\gamma|$ between 0.985 and 0.9994. The required precision tag is 1%.

2.13.3 L3

93. Single photon and missing energy:

Exactly one photon with $|\cos\theta_\gamma| < 0.97$ and:

(a) energy and $P_t > 5GeV$ if $14^o < \theta$ /endcaps/

(b) energy and $P_t > 1GeV$ if $43^o < \theta$ /barrel/

No other photon with $|\cos\theta_\gamma| < 0.9997$ and $E_\gamma > 10$ GeV.

The required precision tag is 0.2%.

94. Two or more photons and missing energy:

Two or more photons selected as above:

(a) energy and $P_t > 5GeV$ if $14^o < \theta$ /endcaps/

(b) energy and $P_t > 1GeV$ if $43^o < \theta$ /barrel/

The transverse momentum of the multi-photon system must be greater than 5 GeV and the acollinearity greater than 2.5 deg.

No other photon with $|\cos\theta_\gamma| < 0.9997$ and $E_\gamma > 10$ GeV.

The required precision tag is 1%.

2.13.4 OPAL

95. Single photon and missing energy :

    The maximum energy photon must have $|\cos\theta_\gamma| < 0.9660$ and $P_t > 0.05 * E_{beam}$. There may be at most ONE additional photon with $E_\gamma > 0.3$ GeV and $|\cos\theta_\gamma| < 0.9848$. The required precision tag is 0.2%.

96. Two or more photons and missing energy:

    Two or more photons with

    (a) $E_\gamma > 0.05 * E_{beam}$ and $|\cos\theta_\gamma| < 0.9660$,

    (b) $E_\gamma > 1.75$ GeV, $|\cos\theta_\gamma| < 0.8$ and the sum of their $P_t > 0.05 * E_{beam}$

    (c) $E_\gamma > 1.75$ GeV, $|\cos\theta_\gamma| < 0.966$ and the sum of their $P_t > 0.05 * E_{beam}$

    The required precision tag is 1%.

3 Conventions and translation guidelines

4 Semi-analytical and Monte Carlo tools used

5 Theoretical uncertainties of observables

Here is now the place for main activity. All observables are latex-labelled and should be referred in such a way in the presentations of individual programs and their capabilities In this way any change of observable content will not be a problem at all as indexing will get readjusted

And let us give here an example on how to refer to observables (**Obs.** 96b) (**Obs.** 91b)

6 Tests and comparisons

7 Summary – what will remain to be done by th community later ...