# Notes on 2-fermion group activities

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EARLY QUESTIONS:

- What do we expect from each other?
- What is the size of ISR corrections?
- What is the th precision tag for?
- can we calculate ... once and for ever.?
- How the work should be started and how continued, in our case of schrinking man-power availability?

For workshop activities check every monday:
http://www.to.infn.it/~giampier/lep2.html

## How to start?

Let us start our work with study of:

- **A: separate theoretical phenomena**
- **B: list of experimental observables**

What is the best starting point?

- **Why A ?**
- **Why not A ?**
- **Why B ?**
- **Why not B ?**

Let us collect arguments ...

## separate theoretical phenomena first

YES:

- They give insight into physics goals
- allow to define optimal observables as one needs to know exactly what is supposed to be measured

NO:

- The size and nature of theoretical effects depends on details of observables in rather dramatic way.
- The higher precision required more complicated language must be used.
- In a limit of zero tolerance it is anymore possible to define predictions into separate ingredients such as ISR, FSR, vacuum polariz., pairs, interferences etc.
- The nature of individual ingredients is scheme dependent.

## experimental observables first

YES:

- **Now detectors are stable and understood. Experimental precision for given quantity (to be) measured can be calculated.**
- **This precision requirement is defining choice of strategies for theoretical calculations.**
- **Only experiments can take responsability in checking that the list of observables is complete.**
- **Our check-out attitude is motivated by approaching LEP2 finale and decreasing man-power available.**

NO:

- **Too much details. Redefinitions of observables is going on all the time. Theoretical predictions are important, OK, but not main difficulty. Experiments need help, no constraints.**
- **List of potentially interesting observables will be too long even to read.**

## Example of photonic corrections:

How the picture look at different precision level:

- **100 %** **Ignore, even** $\frac{\alpha}{\pi} \ln \frac{s}{m_e^2} \ln \frac{M_Z}{\Gamma_Z}$ **is small.**
- **20 %** **Any ISR radiation OK, no need to worry about cuts. Back of envelope calculation sufficient.**
- **3-5 %** **ISR radiation - at least LL** $\mathcal{O}(\alpha^2)$**; FSR radiation LL** $\mathcal{O}(\alpha)$**. Simple semi-analytical program or MC should be enough. Cuts must be included in the analysis.**
- **0.5-1 %** **Interferences show on, no more comfort of ISR FSR sparation. All cut-ff dependent.**
- **0.2-0.4 %** **Like above, but complete** $\mathcal{O}(\alpha)$ **becomes necessary, LL to** $\mathcal{O}(\alpha^3)$**, cross checks on the integration cut offs,etc necessary. NLL of** $\mathcal{O}(\alpha^2)$ **must be cross checked. Pairs.**
- **less than 0.1 %** **Like above, but technical checks of all most time consuming part of the game. Interplay between corrections becomes more and more important.**

## Where are we now?

How do we estimate required precision tag?

- **Decrease present single collaboration statistical error by factor of $\sqrt{12} \simeq 3.5$. We expect statistics to grow by factor of 3 and we will combine all 4 experiments.**
- **Experimental systematic error can go down by 2 to 3. Improvements and non-correlations among experiments.**
- **The two above should be added in quadrature.**
- **As required precision we take $1/3$ of that, so theoretical effects will not deteriorate experimental results by more than 10% .**

WARNING: Even 10 % is a lot. The same loss of precision for observable of roughly equal experimental statistical and systematic error would occur if $1/3$ of data was lost. That is like 1 year of LEP running !!!

## What should we expect from precision tags?

Some generic values:

- **cross sections for $q\bar{q}$ f. states: incl. 0.11 %, excl. 0.23 %**
- **cross sections for $e^-e^+$ final states: excl$_1$ 0.13 %, excl$_2$ 0.21 %**
- **cross sections and asymmetries for $\mu^-\mu^+$ final states: incl. 0.41 %, excl. 0.53 %**
- **cross sections and asymmetries for $\tau^-\tau^+$ final states: incl. 0.44 %, excl. 0.61 %**

WARNING: These numbers are for complete theoretical calculations. For ingredients: interferences pair corrections etc, precision tag must be more strict. Finally the tag for technical tests must be set another factor of few smaller.

## Cut off differences, does it matter?

- $M_{prop-}(\mu^+\mu^-)$: invariant mass of the $s$-channel propogator, with ISR/FSR interference subtracted.
- $M_{prop+}(\mu^+\mu^-)$: invariant mass of the $s$-channel propogator, with ISR/FSR interference not subtracted. In this case, the propogator 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 $\mu^+$ and $\mu^-$ - 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 $\mu^+$ and $\mu^-$ 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 bsaed on the reconstructed 4-momenta of the** $\mu^+$ **and** $\mu^-$.
- **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**

## Our plan:

- Collect list of observables and their precision tags using help from LEP2 $f\bar{f}$ working group and searches group.
- Order this list and discuss necessary ingredients of theoretical predictions. explain how they match experimental strategies etc. Question of idealized vs. realistic observables
- Construct list of observables with their theoretical uncertainties and parallel list of theoretical tools with descriptions.
- Tests and comparisons between theoretical caculations. Matching conventions etc.
- Summary: where do we stand at the given moment, where are the largest problems.

## Where do we stand now?

- **We have preliminary list of observables**
- **We have preliminary list of precision tags**
- **We have made first preliminary steps toward discussion of ambiguities of cuts and theoretical schemes**

For details see ...

- **Tomorrow session**
- **Our draft** `http://www.to.infn.it/~giampier/lep2.html`**, check mondays for new versions.**
- **Definitely we are at the beginning of our activity.**

Thank you for listening.