Milestones and Plans for Physics at Colliders in Torino

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Abstract

Something from the past, a lot from the present, a hint at the future in the first Network Meeting. Universidad de Granada (March 1-4, 2000).

Guided Tour of the Phenomenology Group in Torino

Members

- ▷ A. Arbuzov (till 02/01)
- ▷ A. Ballestrero
- ▷ E. Maina
- ▷ G. Passarino
- ▷ R. Pittau

also in hep-ph, although in QCD Network

- ▷ V. DelDuca
- ▷ L. Magnea

Welcome to Torino
Home of TOPAZO

- **Old codes** never die, ...,
- From **CERN-EP-2000-153**, *Z Lineshape and Leptonic Forward-Backward Asymmetries*,
  - *In order to estimate . . . the two most advanced calculational tools,* ZFITTER *and* TOPAZO *were compared*
  - *We would also like to thank . . . and the* TOPAZO *and* ZFITTER *teams . . .*
- Still updated and upgraded, now **Atomic Parity Violation**, **hep-ph/0102233**.

A Milestone in A.D. 2000
LEP2/MC Workshop

⟹ **CERN 2000-009**, Reports of . . .

Torino contributions:

- △ G. Passarino & R. Pittau (with S. Jadach) editors,
- △ G. Passarino, convenor of the 4 f sub-group (with M. Grünewald), **hep-ph/0005309**
- △ Codes, **Torino owned or based**, that contributed
  - ⊘ `(Next)calibur`, F. A. Berends (**Leiden U.**), C. G. Papadopoulos (**Democritos Nuclear Research Center**), R. Pittau (**Turin U. & INFN, Turin**)
  - ⊘ `WPHACT`, E. Accomando (**PSI**), A. Ballestrero & E. Maina (**Turin U. & INFN, Turin**)
  - ⊘ `WTO`, G. Passarino (**Turin U. & INFN, Turin**)
  - ⊘ `TOPAZ0`, for pair-production corrections in $e^+e^- \to 2\,\mathbf{f}$
- △ **Heritage** of the Workshop: the results documented in the Report will serve as the basis for **future developments**, in the light of the activities of the **Network**, in particular for studying **Linear Collider Physics**.

$\boxed{\textbf{in particular, fulfillments in 2K}}$

△ A. Arbuzov has produced a **new treatment** of the **third order** pair corrections in $e^+e^- \to 2\,\mathbf{f}$.

△ R. Pittau with F. A. Berends and C. G. Papadopoulos are working on the implementation in their code of a **gauge preserving scheme** (the so called **BBC** formalism), that allows for the inclusion of **gauge boson widths** and running of $\alpha_{\rm QED}$ without breaking $SU(2) \times U(1)$ gauge invariance.

During this part of the work, W. Beenakker, A. Chapovscky and A. Kanaki have joined the collaboration.

fulfillments in 2K, contd

△ R. Pittau, F. A. Berends and C. G. Papadopoulos (`Nextcalibur`), E. Accomando, A. Ballestrero & E. Maina (`WPHACT`), have developed their generators to deal with

all **four-fermion** $(+\ \gamma)$ processes in $e^+\ e^-$ collisions,

including **all masses** and **leading higher order**.

△ G. Passarino and independently E. Accomando, A. Ballestrero & E. Maina have **extended** the

Fermion-Loop scheme

to cover **single-W** production.

New Projects:

△ A. Ballestrero, after the experience with **six fermions** in the final state, is working for a **new generation MC** for **Linear Collider**.

△ A. Ballestrero & G. Passarino have started **an investigation** of **QED**-radiation for $n \to m$ processes.

They have shown that for **processes** that are **not dominated** by **annihilation** channels the following strategy works:

□ the **SF**-language is still **applicable** but **ONE** scale is not **enough** (quite obviously).

New projects, contd

- ▷ each external **LEG** in the **process** brings with it a **Structure Function**,
- ▷ since **ALL** charged legs talk to each other, **each SF** is **NOT** function of **ONE ad hoc** scale but
- ▷ **ALL** $< ij >$ scales enter into $\mathbf{SF}_i$ and the **exact** spectral-function is a convolution of **SFs**.

△ Work is in progress for the **MC implementation**

. . . but **Collider** is not only **L(inear)**,

A new Project:

△ R. Pittau is collaborating with M. Mangano (CERN) on the development of a code for the computation of the process

$$\text{hadron hadron} \to W b\bar{b} + \text{n jets}, \qquad \text{n} \leq 4,$$

relevant at **Hadron Colliders**.
All possible contributing **sub-processes** are taken into account, including

⊘ the possibility of generating **unweighted jet events** hadronized with `HERWIG`.

A new Project:

$\boxed{\text{Numerical Multi-Loops}}$

FULL two-loop EW needed for **GigaZ** ($10^9 Z$ events),
Numerical evaluation of **FD**?

$\boxed{\text{An evolutionary development:}}$

A **systematic** approach to **multi-loop calculation**

- Although a lot can be done by **approximations**:
  - ▷ **massless** internal lines,
  - ▷ small momenta **expansion**,
  - ▷ large momenta **expansion**
  - ▷ etc
- do we have a **new, implementable** algorithm for a full scale attack to the problem?

There is a **new** idea around

$\boxed{\textbf{Tkachov Theorem}}$

or

$\boxed{\textbf{generalized Bernstein theorem}}$

$$\mathcal{P}\left(x,\partial\right)\prod_i V_i^{\mu_i+1}(x) \;=\; B\prod_i V_i^{\mu_i}(x).$$

- $\mathcal{P}$ is a polynomial of $x = (x_1 \cdots x_n)$ (a vector of Feynman parameters) and
- $\partial_i = \partial/\partial_i$;
- B all coefficients of $\mathcal{P}$ are polynomials of μ_i and of the coefficients of $V_i(x)$.

Status of **preliminar** investigations (G. Passarino)

$\boxed{\textbf{One-loop}}$, **done** and tested versus analytical

$\boxed{\textbf{Two-loops}}$, a **modified BT-approach** developed $\Longrightarrow$

- **Sunset-diagram**,
  - △ `FORM` code developed,
  - △ `FORTRAN` code developed, **debugged and tested** and

    it works!!!
  - △ It works for **space-like, time-like** momenta, **fully massive**, even around **threshold** and **pseudo-threshold**,

    all in one code!!!
- Other **self-energies**, `FORM` codes developed,

Ready to leave **R&D**, forseeable massive production and applications.