PROCEEDINGS OF SCIENCE

Standard SANC Modules

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In this talk we summarize the status of the standard SANC modules (in the EW and QCD sectors of the Neutral Current branch — version 1.10 and the Charged Current branch — version 1.11). All versions of the codes are accessible from the SANC project servers at Dubna *http://sanc.jinr.ru* and CERN *http://pcphsanc.cern.ch*.

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1. Introduction

The computer system SANC is aimed to carry out semi–automatic calculations at the one-loop precision level of realistic and pseudo–observables for various processes of elementary particle interactions to be investigated at the present and future colliders – Tevatron, LHC, ILC and others.

SANC is subdivided into three logical levels, each with a specific purpose.

The first level refers to analytical computations. It includes enhanced tools of FORM procedures. They compound a framework for analytical calculations of various parts of cross-sections and decay widths.

The analytical results are transferred to the numerical level where they are analyzed by a software package s2n.f (symbols-to-numbers), written in PERL. The s2n.f package automatically generates FORTRAN codes for subsequent numerical computations of decay rates and process cross-sections.

Then these codes are used at the third level of the system. Here Monte-Carlo (MC) generators at hadron level are created. They produces distributions of unweighted events.

For users attention we offer two types of SANC outputs [1]:

- stand-alone packages for calculation of the EW and QCD NLO RC at the parton level together with the environment in which it is run, i.e. the Standard SANC FORM (and/or FORTRAN) Modules (SSFM) ;
- MC event generators, for production of event distributions at the hadronic level, based on the FOAM algorithm [3].

We discuss these outputs below.

To work with SANC, one must install the SANC client. The SANC client can be downloaded from the project homepage [4].

2. FORM and FORTRAN modules

Complete analytical calculations of building-blocks for cross-sections and decay widths in SANC are presented in form of Standard FORM SANC Modules. Each module is a program in FORM language written with use of SANC FORM framework. In the Fig. [1] one can see screenshots of the client with the tree of modules for Charged Current of Drell-Yan process. We present here both modules for QCD and EW NLO corrections.

The complete calculation for process includes four types of modules. In SANC covariant amplitude and helicity amplitudes expressed in terms of scalar formfactors. FF module computes scalar formfactors for particular process. HA module computes helicity amplitudes. The BR module computes the soft and inclusive hard real photon or gluon emission. As far as hard photons or gluons are concerned, we realized two possibilities of the integration over their phase space: the semi-analytical one (module BR) and the one by means of a Monte Carlo integrator or generator (module MC). The MC module provides fully differential hard bremsstrahlung contribution to the

[1] We do not describe SANC system, referring the reader to published papers [1], [2].

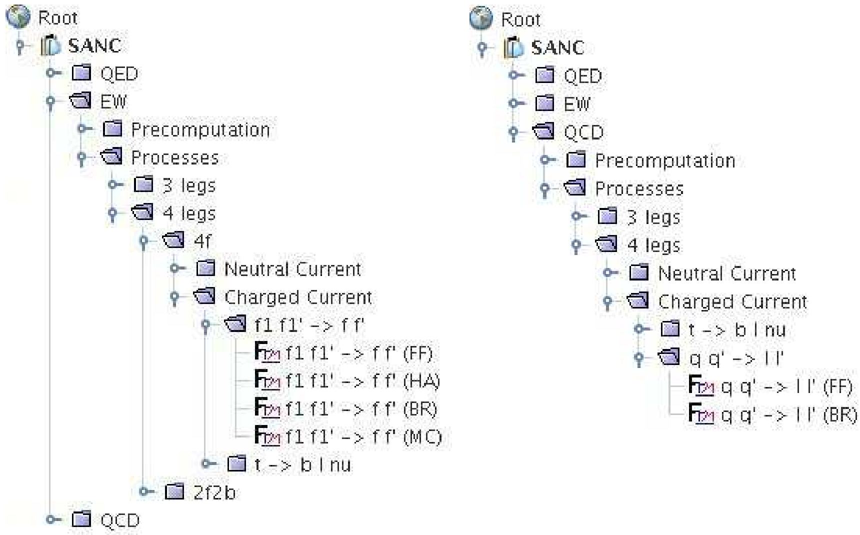


Figure 1: SANC tree for Drell-Yan Charged Current:EW and QCD modules

partonic cross-section. The contribution is given in a form suitable for further numerical integration or simulation of events in a Monte Carlo generator.

For each FORM module the system creates corresponding FORTRAN code – Standard SANC FORTRAN Module. As a rule of the SANC approach, we subdivide the RC into the virtual (loop) ones, the ones due to soft photon or gluon emission, and the ones due to hard photon emission with the aid of the soft–hard separator $\bar{\omega}$. For all SANC processes we demonstrate the numerical independence of this auxiliary parameter. The adopted form of presentation of the differential cross-section at the one-loop level in obvious notation is:

$$d\hat{\sigma}^{1-\mathrm{loop}} = d\hat{\sigma}^{\mathrm{Born}} + d\hat{\sigma}^{\mathrm{Subt}} + d\hat{\sigma}^{\mathrm{Virt+Soft}}(\bar{\omega}) + d\hat{\sigma}^{\mathrm{Hard}}(\bar{\omega}). \tag{2.1}$$

The second term stands for subtraction of collinear quark mass singularities. FORTRAN modules contains subroutines corresponding to terms in Eq. (2.1).

All these modules are stored in the data base of our project, that is accessible through the SANC client. User can run all codes in interactive session, yet it consumes a lot of CPU time.

3. FORTRAN packages

FORTRAN modules presented in form of FORTRAN packages. These packages provides sufficient environment for the modules to work independently from the system. Each package is a program for calculation of partonic cross-sections of processes. Their main purpose is to show the example of use of SSFM. However they can be used to study ratios of different RC on partonic level.

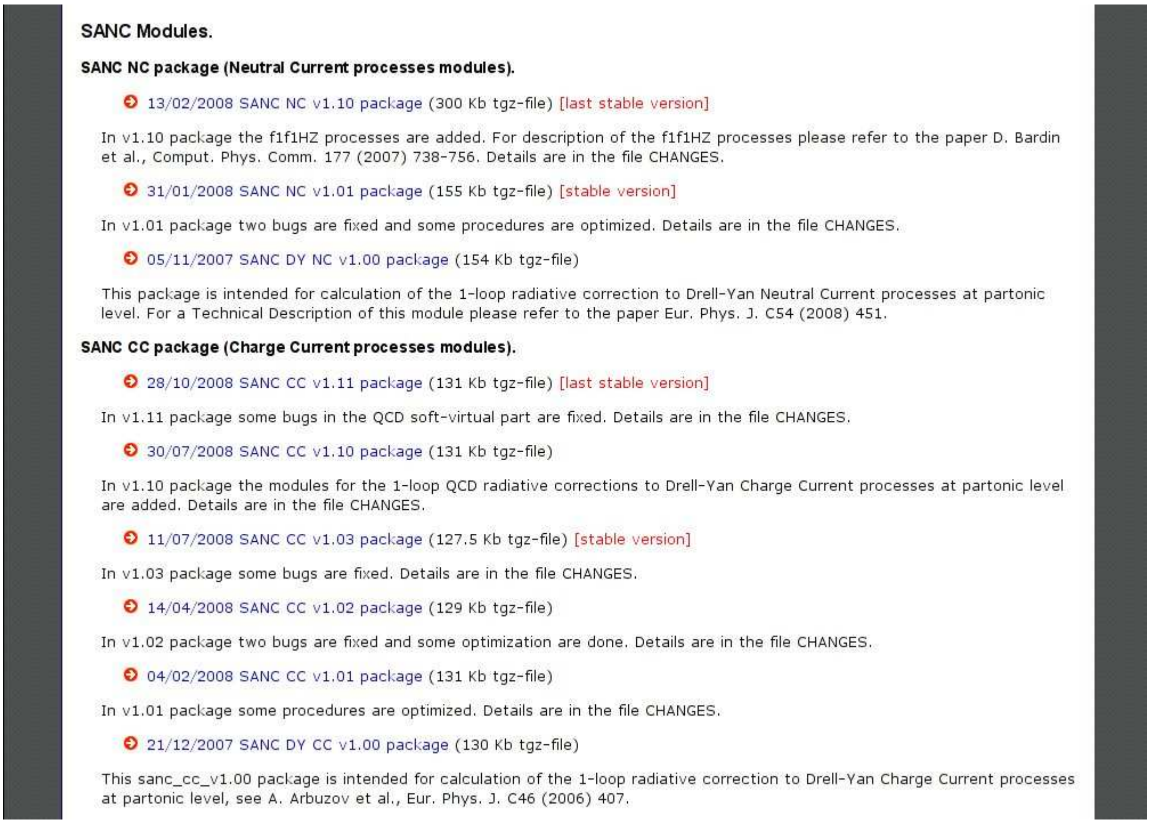
Package structure is :

- main file,
- SSFM,
- libraries,
- declaration, initialization and various setup files,
- documentation.

Following list of packages can be downloaded from the project homepage, see Fig. [2]:

- SANC NC v1.10: SSFMs for the DY NC processes: $(uu,dd) \to (\mu\mu,ee)$ [5], SSFMs for the processes: $ee(uu,dd) \to HZ$ [2] and NC gluon-induced processes [6];
- SANC CC v1.11: SSFM for the DY CC processes: $(uu,dd) \to (\mu\nu_\mu,e\nu_e)$ [7] and CC gluon-induced processes [6].

One has to emphasize that the CC v1.11 contains first `SANC` modules for the calculation of NLO QCD corrections [8]. Some results about interplay of QCD/EW correction were reported in talks to ATLAS MC group [9],[10],[11].



SANC Modules.

SANC NC package (Neutral Current processes modules).

13/02/2008 SANC NC v1.10 package (300 Kb tgz-file) [last stable version]

In v1.10 package the f1f1HZ processes are added. For description of the f1f1HZ processes please refer to the paper D. Bardin et al., Comput. Phys. Comm. 177 (2007) 738-756. Details are in the file CHANGES.

31/01/2008 SANC NC v1.01 package (155 Kb tgz-file) [stable version]

In v1.01 package two bugs are fixed and some procedures are optimized. Details are in the file CHANGES.

05/11/2007 SANC DY NC v1.00 package (154 Kb tgz-file)

This package is intended for calculation of the 1-loop radiative correction to Drell-Yan Neutral Current processes at partonic level. For a Technical Description of this module please refer to the paper Eur. Phys. J. C54 (2008) 451.

SANC CC package (Charge Current processes modules).

28/10/2008 SANC CC v1.11 package (131 Kb tgz-file) [last stable version]

In v1.11 package some bugs in the QCD soft-virtual part are fixed. Details are in the file CHANGES.

30/07/2008 SANC CC v1.10 package (131 Kb tgz-file)

In v1.10 package the modules for the 1-loop QCD radiative corrections to Drell-Yan Charge Current processes at partonic level are added. Details are in the file CHANGES.

11/07/2008 SANC CC v1.03 package (127.5 Kb tgz-file) [stable version]

In v1.03 package some bugs are fixed. Details are in the file CHANGES.

14/04/2008 SANC CC v1.02 package (129 Kb tgz-file)

In v1.02 package two bugs are fixed and some optimization are done. Details are in the file CHANGES.

04/02/2008 SANC CC v1.01 package (131 Kb tgz-file)

In v1.01 package some procedures are optimized. Details are in the file CHANGES.

21/12/2007 SANC DY CC v1.00 package (130 Kb tgz-file)

This sanc_cc_v1.00 package is intended for calculation of the 1-loop radiative correction to Drell-Yan Charge Current processes at partonic level, see A. Arbuzov et al., Eur. Phys. J. C46 (2006) 407.

Figure 2: Available versions of the SSFM

4. MC generators

The sanc_nc_foam_v1.10 and sanc_cc_foam_v1.10 packages are intended for generation of unweighted events of the DY processes in NC and CC sector at the hadronic level taking into account the one-loop EW radiative correction based on `FOAM` algorithm [3]. These generators use the standard `SANC` Fortran modules for calculation of NLO EW corrections as well as `LoopTools-2.1` [12], `SancLib-v1-00` libraries for evaluation of scalar and tensor one-loop integrals. Also you need `ROOT` package to be installed.

In the present version of packages we include the possibility to write the output in data files containing the event information in the standard Les Houches Accord format [13] in order to organize the transfer of information between `SANC` generators and general purpose programs such as `PYTHIA` [14] and `HERWIG` [15].

5. Conclusion

We introduce the Standard `SANC` Form and Fortran Modules.

They were used in the Fortran packages at the parton level for quick studies of different features of the given sub-processes: estimates of effects due to variations of input parameters, interplay of different RC contributions (QED-EW-QCD, initial and final state radiation) *etc.*

Also they were used in the `SANC` Monte Carlo event generators that provide distributions of the final state particles with full kinematics, which was interfaced with parton showering codes (`PYTHIA` and `HERWIG`) and the events can be further processed through the whole experiment simulation environment.

References

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