Software organization of the projects related to TAUOLA

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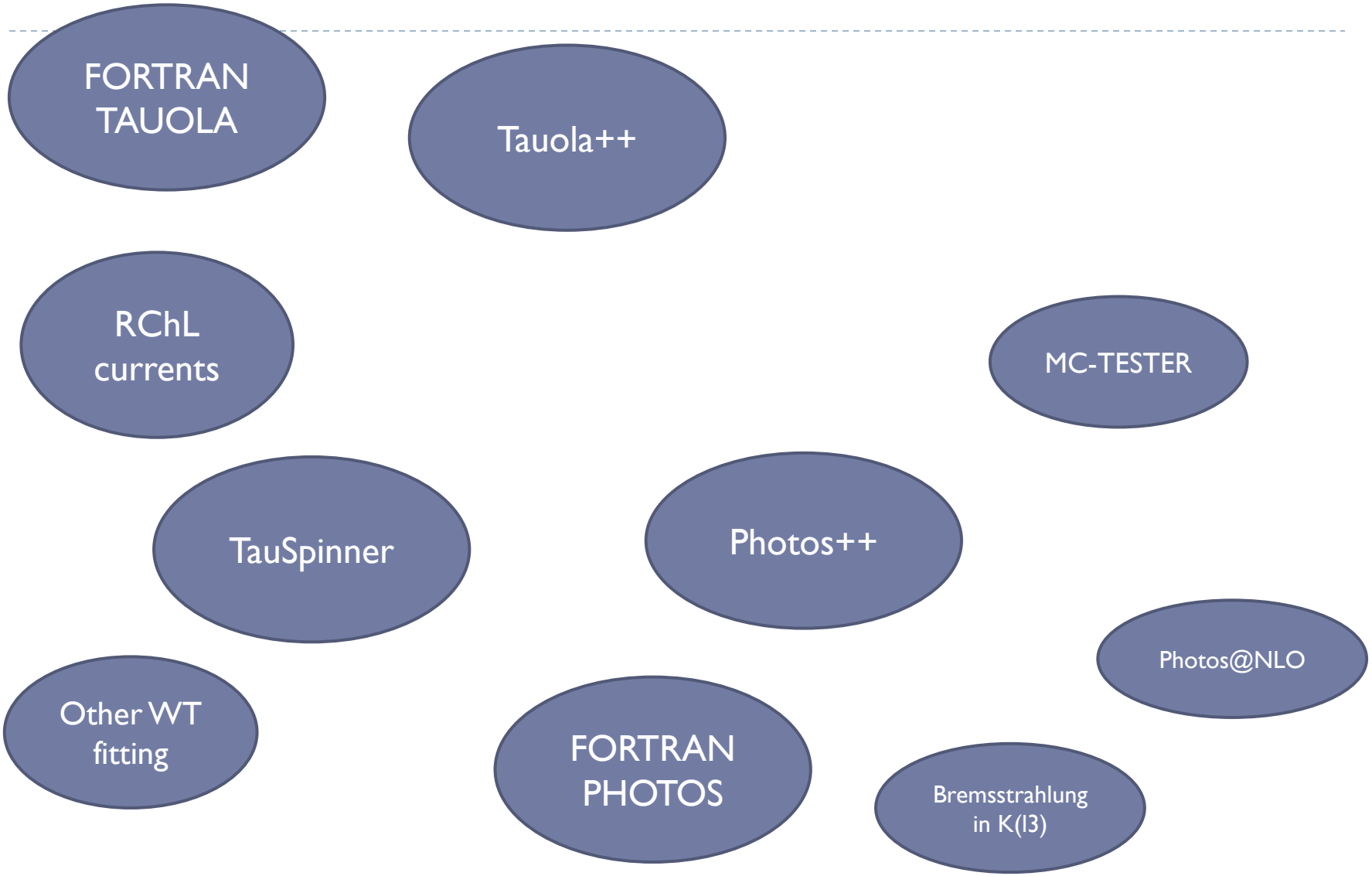
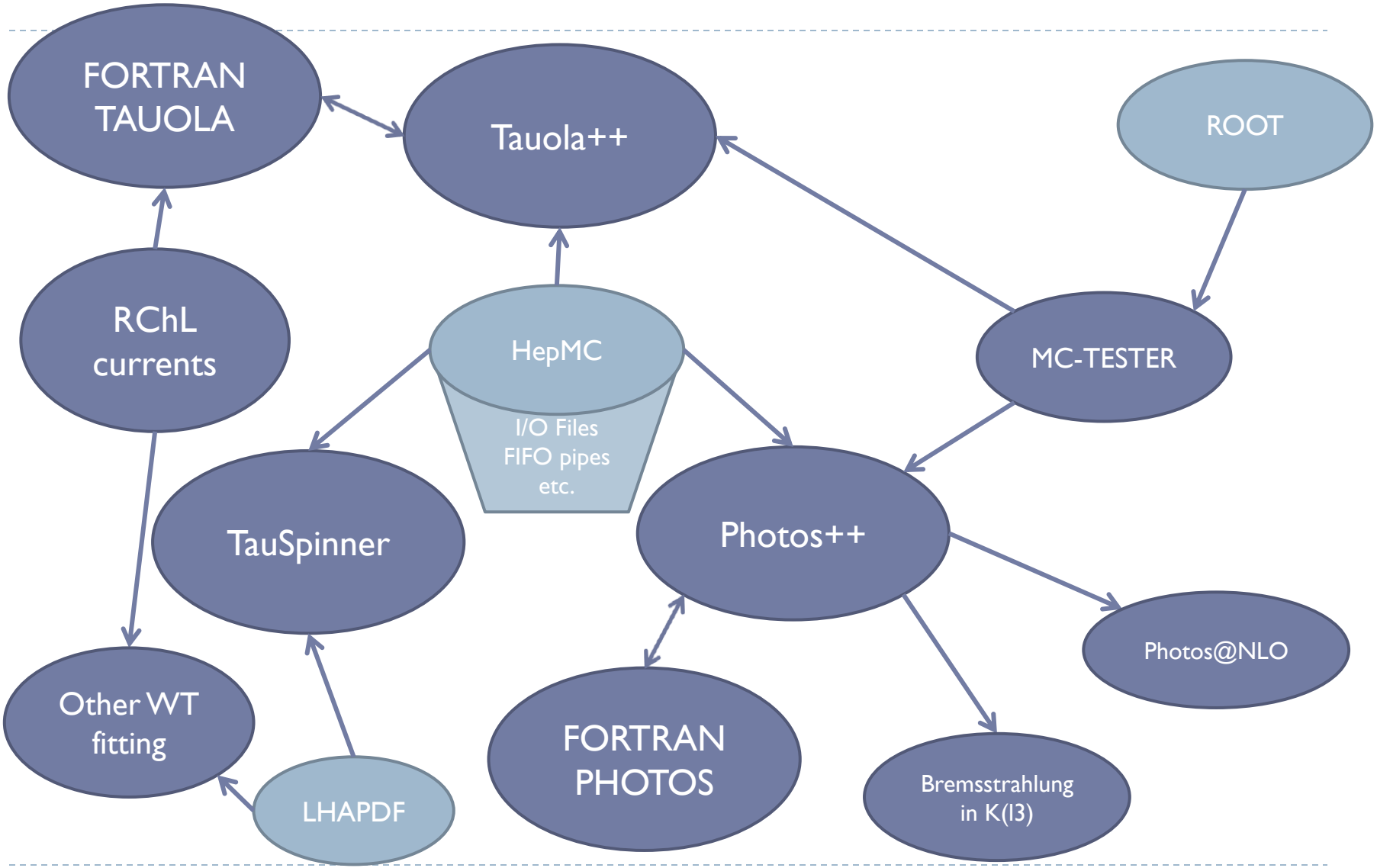
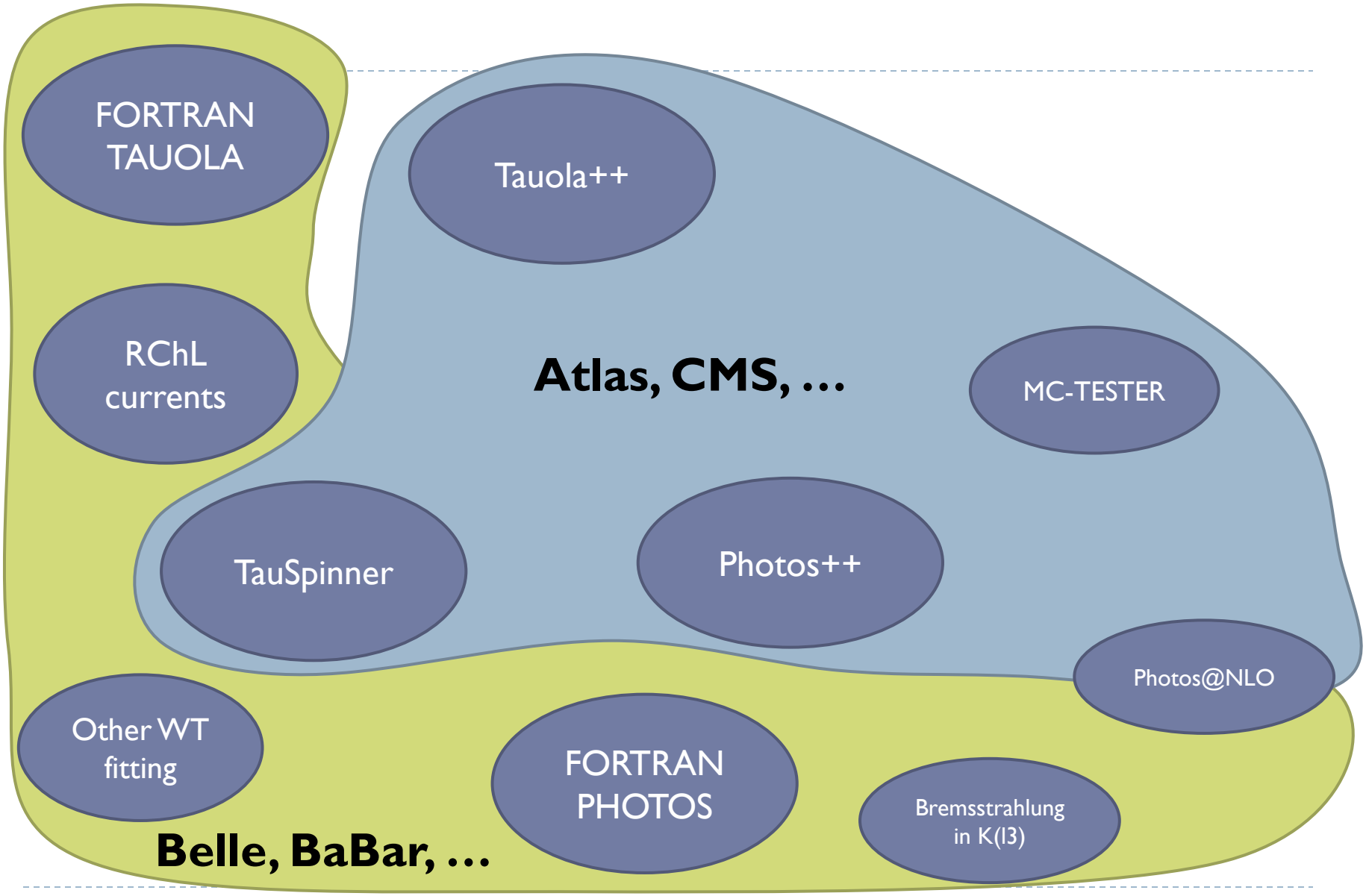
Plan:

- Overview of our projects
  - Tauola++ and Photos++
  - Tauola RChL currents
  - MC-TESTER
  - tauola-BBB
  - Bremsstrahlung in K(l3)
- LHC applications
  - Using new Tauola currents in LHC
  - TauSpinner
  - Photos @ NLO
- Adapting projects for LHC Computing Grid
- Multi-platform code development


FORTRAN TAUOLA
Tauola++
RChL currents
MC-TESTER
TauSpinner
Photos++
Photos@NLO
Other WT fitting
FORTRAN PHOTOS
Bremsstrahlung in K(l3)


FORTRAN TAUOLA
Tauola++
ROOT
RChL currents
HepMC
I/O Files
FIFO pipes
etc.
MC-TESTER
TauSpinner
Photos++
Photos@NLO
Other WT fitting
LHAPDF
FORTRAN PHOTOS
Bremsstrahlung in K(l3)


FORTRAN TAUOLA
Tauola++
RChL currents
Atlas, CMS, …
MC-TESTER
TauSpinner
Photos++
Photos@NLO
Other WT fitting
FORTRAN PHOTOS
Bremsstrahlung in K(l3)
Belle, BaBar, …

FORTRAN TAUOLA

S. Tsuno

Tauola++

E. Richter-Wąs
G. Nanava
N. Davidson

I'm sorry, I have surely forgotten important names

RChL currents

O. Shekhovtsova
P. Roig
V. Cherepanov

MC-TESTER

S. Lehti
I. M. Nugent

A. Buckley
I. M. Nugent

TauSpinner

Photos++

Q. Xu

Photos@NLO

Other WT fitting

Z. Czyczuła
S. Tsuno

FORTRAN PHOTOS

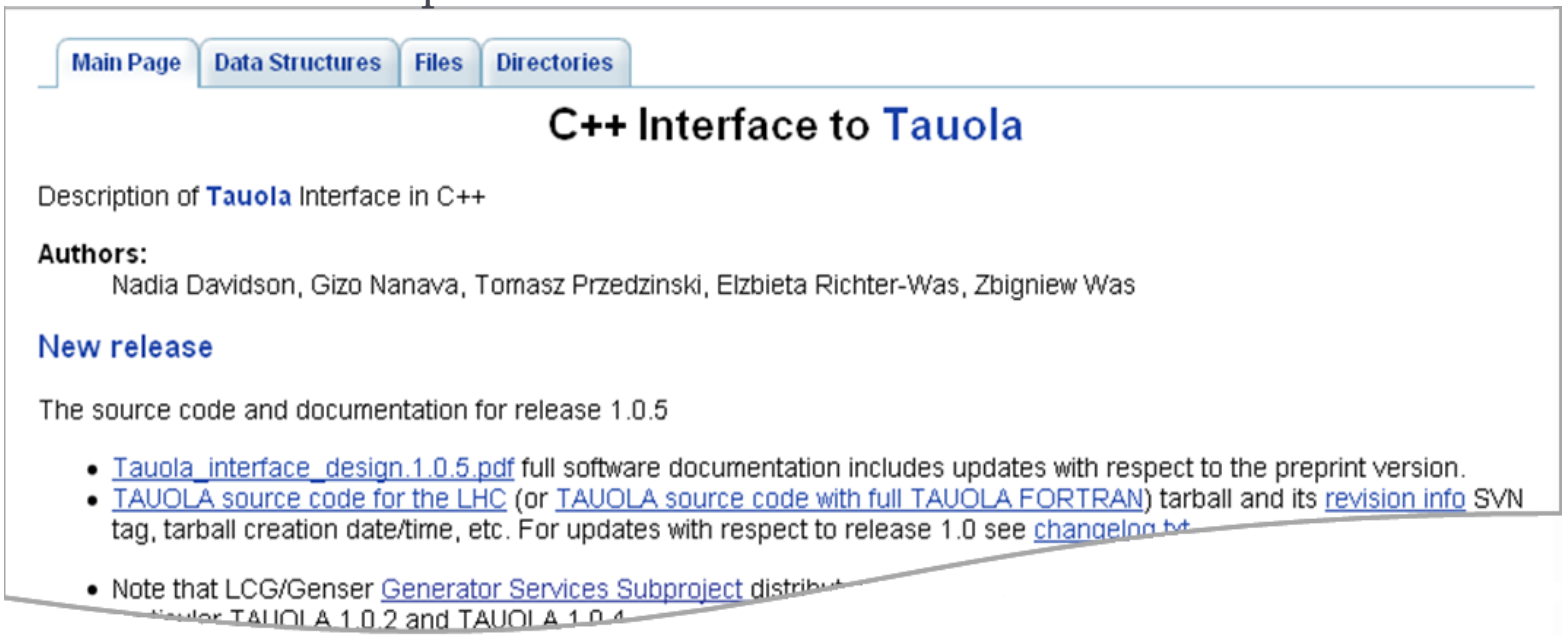
R. Sadykov

Bremsstrahlung in K(l3)

Tauola++ and Photos++

Tauola++

- Tauola++ available for LHC:
  GENSER project (http://sftweb.cern.ch/generators/)
  - /afs/cern.ch/sw/lcg/external/MCGenerators/tauola++/
- Development version and stable releases available from:
  - http://www.ph.unimelb.edu.au/~ndavidson/tauola/doxygen/index.html
  - Doxygen documentation serves as quick reference for looking up functions and parameters



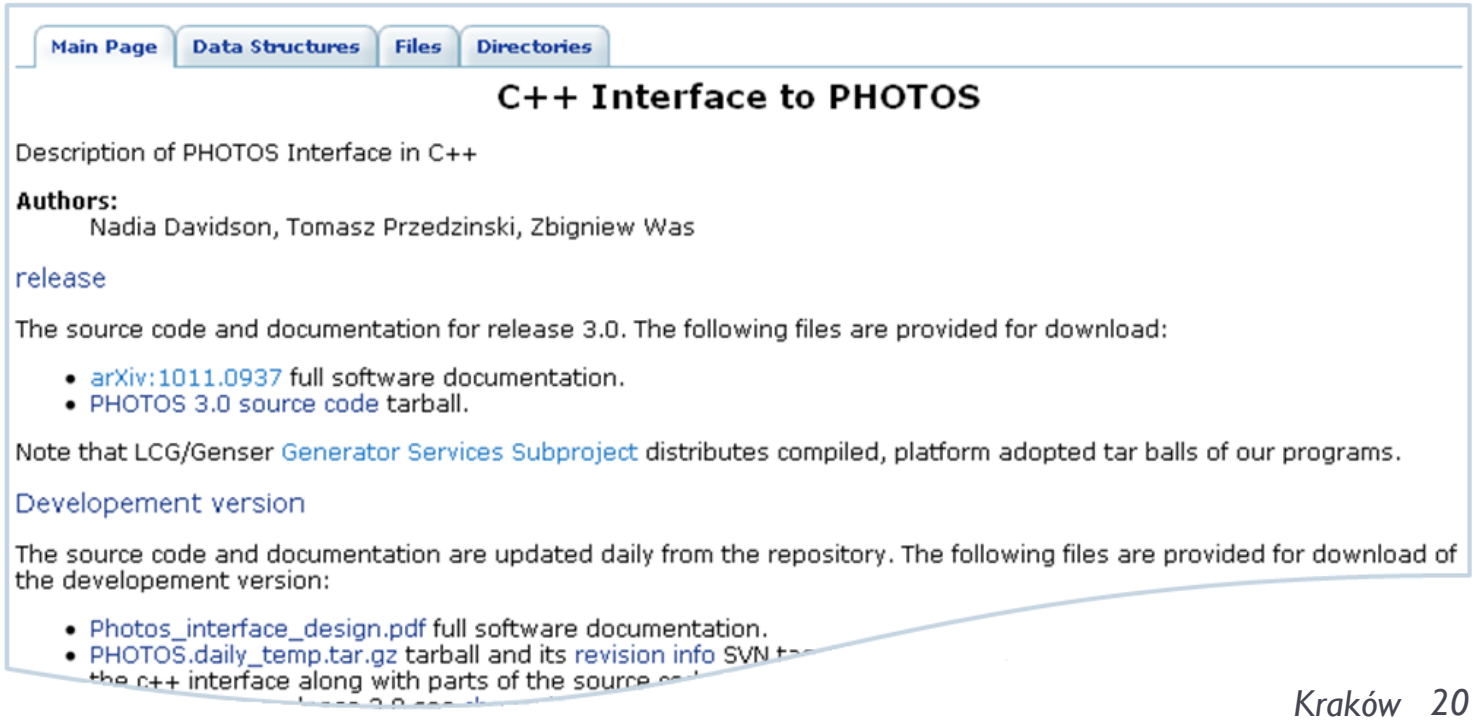
Tauola++

- All functionality of Fortran predecessor
- New physics
  - Transverse spin correlations
  - SANC electroweak corrections
- New options
  - Spin correlations on/off
  - Decay single tau (with / without polarization)
  - Redefine: modify event record before processing
  - Undecay: remove previous tau decays from event record

```
int main() {

  ...

  Tauola::initialize();

  Tauola::setSameParticleDecayMode(4);
  Tauola::setOppositeParticleDecayMode(4);

  // Begin event loop
  for(...)
  {
    if(!pythia.next()) continue;

    // Save pythia8 event in HepMC format
    GenEvent * HepMCEvt = new GenEvent();
    ToHepMC.fill_next_event(event, HepMCEvt);

    ...

    // Run Tauola on the event
    TauolaHepMCEvent evt(HepMCEvent);
    evt.decayTaus();

    ...

  }

  Tauola::summary();

  ...

}
```

Photos++

- Photos and Photos++ (Photos v3.0) available for LHC: GENSER project (http://sftweb.cern.ch/generators/)
  - /afs/cern.ch/sw/lcg/external/MCGenerators/photos/
  - /afs/cern.ch/sw/lcg/external/MCGenerators/photos++/
- Development version (v3.2 and following) available from:
  - http://www.ph.unimelb.edu.au/~ndavidson/photos/doxygen/index.html



Photos++

- Options for controlling ME:
  - ME correction for W
  - ME correction for Z
  - ME correction for scalars
  - Downgraded kernel, same for Z and W
- Options for event record
  - Process whole event
  - Suppress bremsstrahlung in specified decays (branchings)
  - Bremsstrahlung only in specified decays if present in event record
  - Bremsstrahlung in specific branching only
  - New options in v3.5 for correcting event record and adding history entries to the event record

```
int main() {

  ...

  Photos::initialize();

  Photos::setMeCorrectionWtForW(true);
  Photos::setMeCorrectionWtForZ(true);

  Photos::setInterference      (true);

  // Begin event loop
  for(...)
  {
    if(!pythia.next()) continue;

    // Save pythia8 event in HepMC format
    GenEvent * HepMCEvt = new GenEvent();
    ToHepMC.fill_next_event(event, HepMCEvt);

    ...

    // Run PHOTOS on the event
    PhotosHepMCEvent evt(HepMCEvt);
    evt.process();

    ...

  }

  ...

}
```

Photos++ and Tauola++

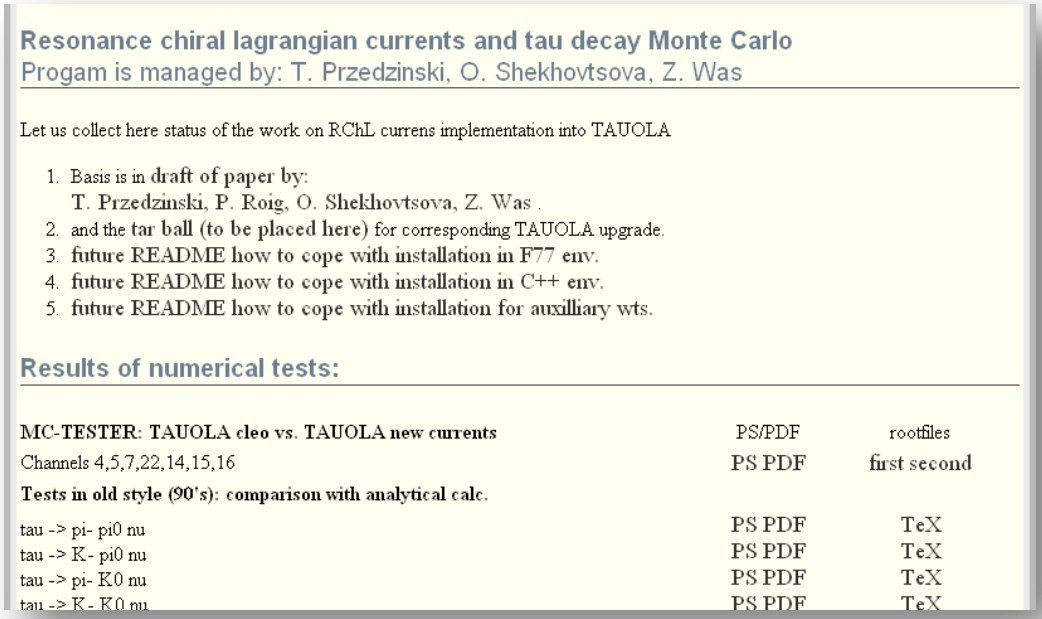
- Modularity
  - Core left in Fortran
  - Interface to Fortran separated from other algorithms
  - Abstract interface to event records
  - plotting / logging / debugging classes separated
  - Photos++: random number generator separated. Can be replaced.
  - Tauola++: separate module for SANC electroweak corrections
- Event record implementations
  - Multiple event records can be used in one project
  - Interface for HepMC prepared and tested
  - Sample interface for HEPEVT included as well
  - Software design allows to easily extend to any other event record, as needed

```
{
  ...

  TauolaHepMCEvent   *evt;
  TauolaHEPEVTEvent *evt2;

  PhotosHepMCEvent   *evt3;
  PhotosHEPEVTEvent *evt4;

  ...
}
```

Tauola RChL Currents

Tauola RChL currents

- Tauola CLEO core (as of year 2005) with small modifications
- RChL-currents
  - separate files with currents for different modes (2 PI, K PI, K K0, 3 PI, K K PI0, K K0 PI)
  - fit parameters stored in separate file for easier modification
  - TECHNICAL: wid_a1_fit.f – linear interpolation of pretabulated function for a1 width
  - Program for automatic generation of routine wid_a1_fit.f
- cross-check
  - compilation of several numerical and analytical tests
- reweighting algorithm
  - some details on next transparencies



Resonance chiral lagrangian currents and tau decay Monte Carlo

Progam is managed by: T. Przedzinski, O. Shekhovtsova, Z. Was

Let us collect here status of the work on RChL currens implementation into TAUOLA

1. Basis is in draft of paper by:
   T. Przedzinski, P. Roig, O. Shekhovtsova, Z. Was .
2. and the tar ball (to be placed here) for corresponding TAUOLA upgrade.
3. future README how to cope with installation in F77 env.
4. future README how to cope with installation in C++ env.
5. future README how to cope with installation for auxilliary wts.

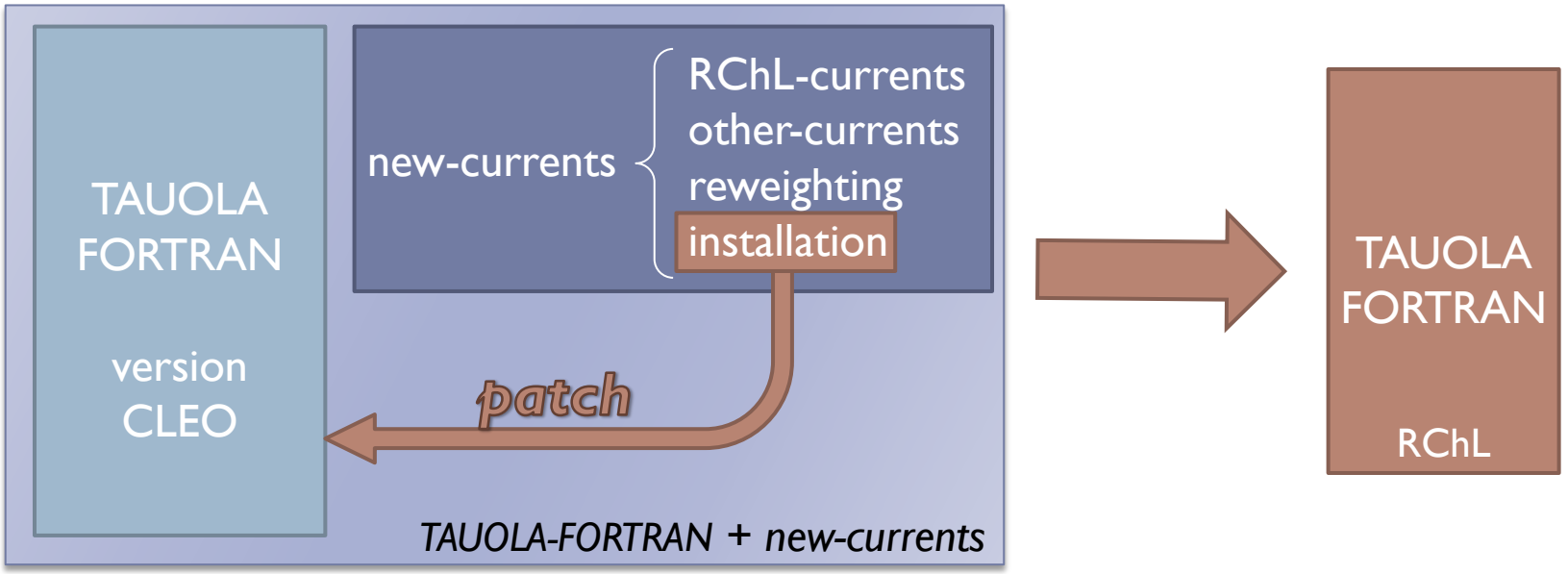
Results of numerical tests:

MC-TESTER: TAUOLA cleo vs. TAUOLA new currents	PS/PDF	rootfiles
Channels 4,5,7,22,14,15,16	PS PDF	first second
Tests in old style (90's): comparison with analytical calc.		
tau -> pi- pi0 nu	PS PDF	TeX
tau -> K- pi0 nu	PS PDF	TeX
tau -> pi- K0 nu	PS PDF	TeX
tau -> K- K0 nu	PS PDF	TeX

http://annapurna.ifj.edu.pl/~wasm/RChL/RChL.htm

Low energy application

- new-currents module compiled together with Tauola core
- Minimal number of changes to use new currents (modification of two files of *TAUOLA-FORTRAN*)
- Small changes if core other than CLEO



- Able to switch between old currents and new ones (RChL) useful for validation and reweighting

Sophisticated fits of new currents to Belle / BaBar data

- Method of recalculating weights for previously generated tau samples
- Example on how to do it with RChL currents
- **In this way, weights are attributed and any multi-dimensional distribution can be compared (including all detector effects)**

```
int main()
{
  ...

  // Initialize RChL currents
  inipcht_(1);

  // Initialize Tauola
  Tauola::Initialize();

  ...

  readParticlesFromFile(&tau, &tau_daughters);

  prepareKinematic(tau, tau_daughters);

  // Switch to TAUOLA CLEO currents
  inipcht_(0);

  // Determine decay channel and calculate weight
  double WT1 = calculateWeight(tau_pdgid, tau_daughters);

  // Switch to RChL currents
  inipcht_(1);

  // Determine decay channel and calculate weight
  double WT2 = calculateWeight(tau_pdgid, tau_daughters);

  // RChL / CLEO
  double WEIGHT = WT2/WT1;

  ...
}
```

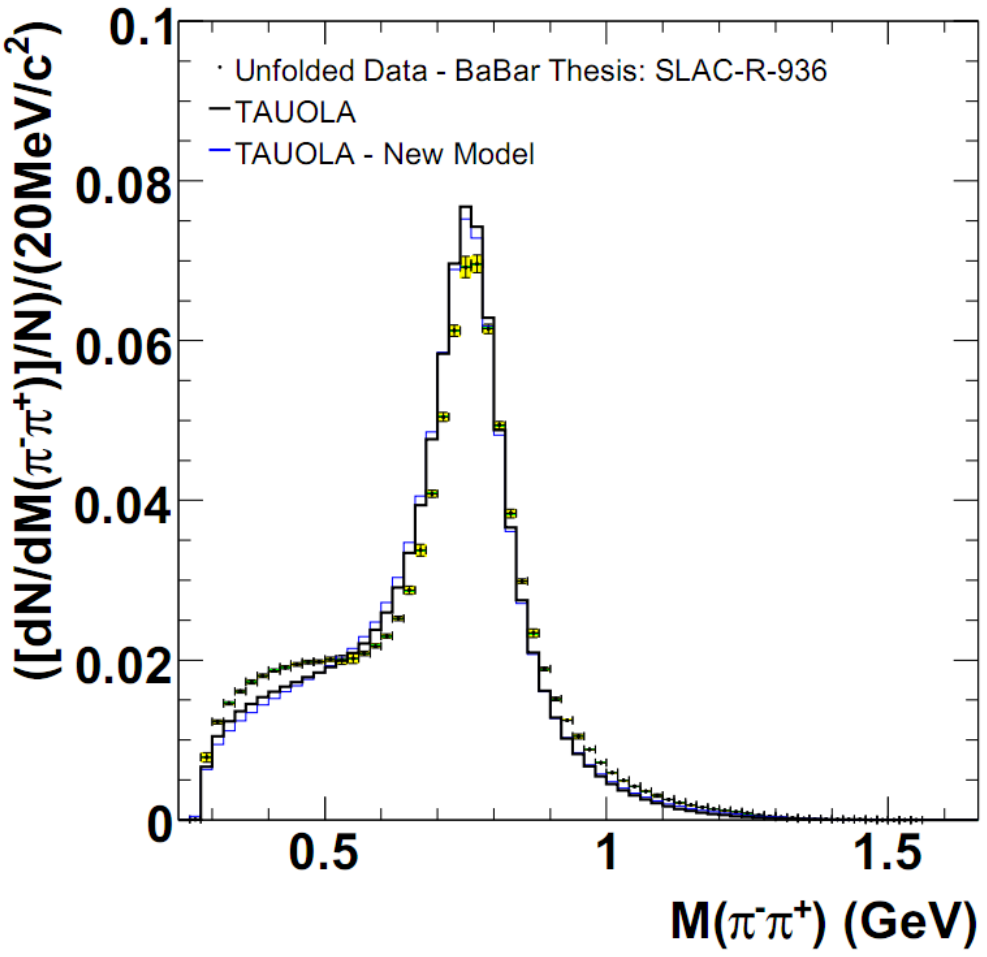
Sophisticated fits of new currents to Belle / BaBar data

- Input
  - 4-momenta and flavour of tau and its daughters
- Input from any source
  - MC generated with KKMC
  - ASCII files
  - Data files in HepMC::IO_GenEvent format
  - HepMC events stored in ROOT ntuples
  - Easy to adapt to any other format

```
int main()
{
  ...

  // Initialize RChL currents
  inipcht_(1);

  // Initialize Tauola
  Tauola::Initialize();

  ...

  readParticlesFromFile(&tau, &tau_daughters);

  prepareKinematic(tau, tau_daughters);

  // Switch to TAUOLA CLEO currents
  inipcht_(0);

  // Determine decay channel and calculate weight
  double WT1 = calculateWeight(tau_pdgid, tau_daughters);

  // Switch to RChL currents
  inipcht_(1);

  // Determine decay channel and calculate weight
  double WT2 = calculateWeight(tau_pdgid, tau_daughters);

  // RChL / CLEO
  double WEIGHT = WT2/WT1;

  ...
}
```

Sophisticated fits of new currents to Belle / BaBar data

- Can be used to test several different models simultaneously in comparison with Belle and BaBar data
- **How to perform such comparisons systematically and on multi-dimensional distributions as well**



MC-TESTER
(supporting project)

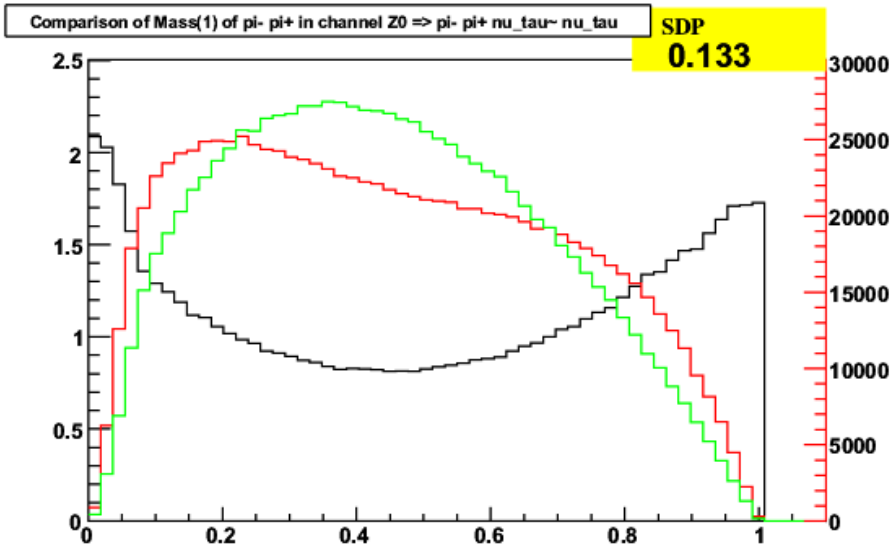
MC-TESTER

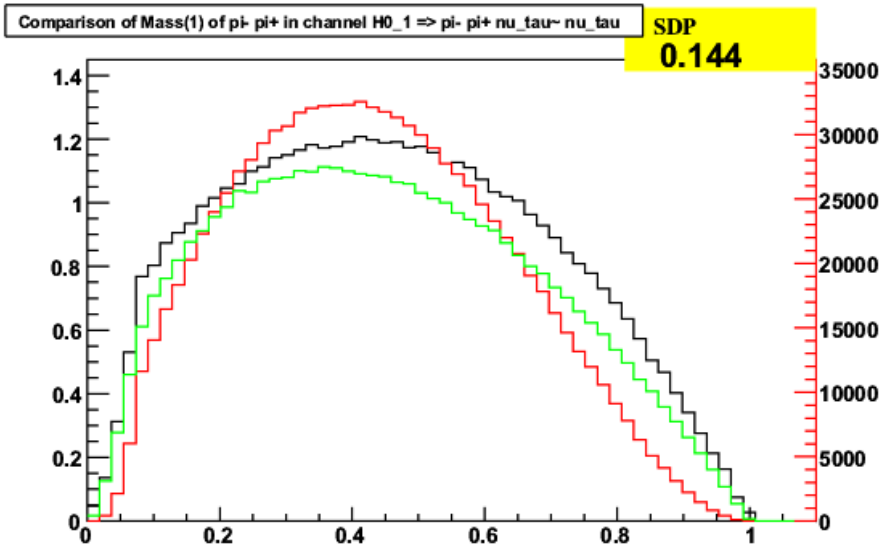
- Universal tool for comparison of different MC generators
- Generates .pdf booklet with reference table for all decay channels and detailed comparison for each channel

Decay channel	Branching Ratio ± Rough Errors		Max. shape dif. param.
	Generator #1	Generator #2	
$\tau^+ \to \pi^+\pi^0\tilde{\nu}_\tau$	25.3029 ± 0.0159%	25.0750 ± 0.1584%	0.00000
$\tau^+ \to \tilde{\nu}_\tau\nu_e e^+$	18.1201 ± 0.0135%	18.1030 ± 0.1345%	0.00000
$\tau^+ \to \tilde{\nu}_\tau\nu_\mu \mu^+$	17.6046 ± 0.0133%	17.7180 ± 0.1331%	0.00000
$\tau^+ \to \pi^+\tilde{\nu}_\tau$	11.1618 ± 0.0106%	11.2340 ± 0.1060%	0.00000
$\tau^+ \to \pi^+\pi^0\pi^0\tilde{\nu}_\tau$	9.2787 ± 0.0096%	9.3770 ± 0.0968%	0.00029
$\tau^+ \to \pi^-\pi^+\pi^+\tilde{\nu}_\tau$	8.7599 ± 0.0094%	8.6890 ± 0.0932%	0.00000
$\tau^+ \to \pi^-\pi^+\pi^+\pi^0\tilde{\nu}_\tau$	4.5342 ± 0.0067%	4.5480 ± 0.0674%	0.00014

- All combinations of invariant masses ploted and compared separately for each channel
- Like Tauola++ and Photos++ works with HepMC and HEPEVT event record and can be easily adapted to others

MC-TESTER





- Example plots automatically generated by MC-TESTER
  Test of longitudinal polarization – plots of $\pi^+ \pi^-$ spectrum for Z (left) and H (right) decaying to tau pair.

  Red – spin correlations turned on
  green – without spin correlations
  black – ratio red/green

MC-TESTER

- Setup files storing analysis options
- Multitude of options
  - Plotting
    - histogram binning
    - logarithmic scale
    - mass squared
    - scale X axis
  - Generator description
  - Attaching additional user histograms
  - Different methods of SDP calculation; user can write new mehtods
  - User analysis – attaching ROOT scripts to plot specific observables, compiled on-the-flight during analysis.

Monte Carlo tests for Bremsstrahlung: Example: K(l3) decays

PHOTOS Monte Carlo tests for Bremsstrahlung in K(l3) decays.
Authors: Qingjun Xu, Z. Was

Paper

Special version of PHOTOS MC was prepared. New options useful for tests were prepared. The following versions are used for the comparisons listed below

1. "Standard PHOTOS" denotes **F77** version 2.15, or **C++** version 3.0
2. For "standard phase-space" no modification in phase space generation are introduced.
3. For "exact phase space" single generation channel is used. Comparison with "standard phase-space" helps to establish numerical precision for standard phase space generation, and is of more technical nature. This comparison is important for evaluating of systematic errors eg. for multibremmstarhlung algorithm.
4. "M.E. of V. Cirigiano" means that instead of M.E. obtained from scalar QED M.E. from paper *V. Cirigliano et al. JHEP 0811 (2008) 006* is used.
5. For PDF we're using logarithmic scale, while for PS linear scale is used.

http://hibiscus.if.uj.edu.pl/~przedzinski/Kl3/

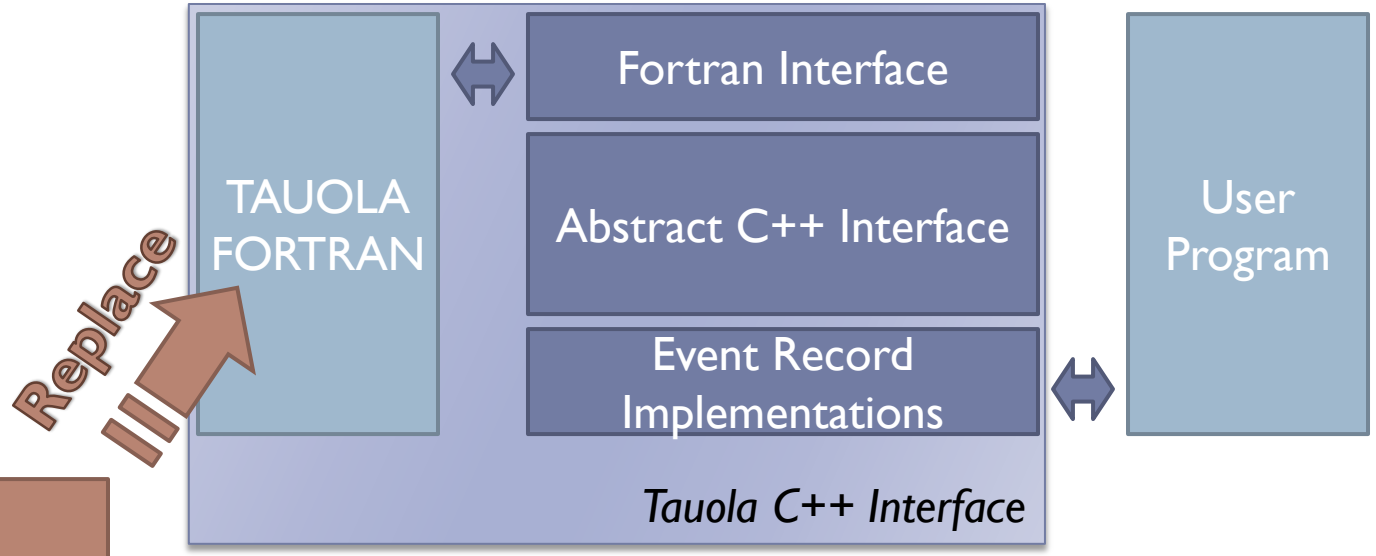
Tauola-BBB (2004)

- New decay channels for Tauola
- Need to be integrated to present version of the code
- When finished, result will be automatically available for Belle, Babar and LHC.

LHC applications

LHC application: Future use of Tauola currents in Tauola C++

- This feature is prepared and works semi-automatically, accordingly to short instruction



TAUOLA FORTRAN with RChL currents

- Tests and validations (maybe also fits to Belle and BaBar data) must be completed first

LHC application with weighted events
(Talk of Z. Czyczuła)

TauSpinner: tau spin reweight algorithm
Authors: Z. Czyczula, T. Przedzinski, Z. Was

PHYSICS PURPOSE:
For previously generated sample involving tau, its spin effects can be:

1. validated. Eg. if spin effects were taken into account when events were generated
2. calculate spin weght for previously generated events and stored on the tape.
   - In original sample spin effects could have been missing.

     Then spin weight will be in range $(0 , 2^n)$;
     n denotes number of taus in final state.
   - In original sample spin effects are eg for W+ and we would like to see how it would look if H+ was present instead.
3. reweight on flight such events with spin weight. Such unweighted events can be then monitored with MC-Tester for quick evaluation of spin effects

At present only nine main decay channels of tau have their spin effects used in algorithm.
These channels cover already now above 95% of total tau width.

For more information on agorithm use see **README**
(This README is included in distribution tarball as well)

http://hibiscus.if.uj.edu.pl/~przedzinski/tau-reweight/

LHC application with weighted events:
example of TauSpinner in use

```
int main() {

  // Initialize Tauola
  Tauola::initialize();

  // Initialize TauSpinner
  initialize_spinner(Ipp, Ipol, CMSENE);

  // Begin event loop
  for(...) {

    // SimpleParticle consist of 4 momentum and PDGid
    SimpleParticle X, tau, tau2;
    vector<SimpleParticle> tau_daughters, tau_daughters2;

    // Read event from input_file
    readParticlesFromHepMC( ... );

    // Calculate weight
    if( abs(X.pdgid())==24 || abs(X.pdgid())==37 )
    {
      WT = calculateWeightFromParticlesWorHpn( ... );
    }
    else if( X.pdgid()==25 || X.pdgid()==36 ||
             X.pdgid()==22 || X.pdgid()==23 )
    {
      WT = calculateWeightFromParticlesH( ... );
    }
}
```

Highlighted function fills tau decay information from HepMC::IO_GenEvent data file.

Similar function can be written for any other source

Details on the webpage and in example distirbuted with the code.

Photos@NLO
(Talk of T.K.O.Doan)

- **Test with KKMC** NLO; Z to e+e-
- **Test with KKMC** LO; Z to e+e-
- **Test with KKMC** NLO; Z to mu+mu-
- **Test with KKMC** LO; Z to mu+mu-

- **Comparisons PHOTOS LO with PHOTOS NLO**
  are published, see papers by P. Golonka and Z. Was for Z decays and by G. Nanava and Z. Was on W and H decays

- **Comparisons PHOTOS with ME**
  calculated from program of SANC group. The purpose is to prepare benchmarks where fixed first order QED is used by PHOTOS and SANC as well. It is necessary not only for tests of FSR QED but is essential first step for establishing prper matching with complete calculations. In particular complete weak corrections, hadronic/QCD contributions to vacuum

Webpage with comparisons:

- LO vs NLO
- Comparison with KKMC
- Comparison with SANC. Agreement at 0.01% level.
- Detector-oriented results

http://annapurna.ifj.edu.pl/~wasm/photosNLOtest.html

LHC Computing Grid and multi-platform code development

Applications for LHC Computing Grid

- Code must work:
  - on multiple 32-bit and 64-bit platforms
  - with different sets of compilers
  - with several different configurations (ROOT, HepMC)
  - in several different experiments environments
- Autotools
- Separate configuration for specific cases
- Different configuration for individual users

Problems with multi-platform, multi-language code

- Compiler-specific problems
  - older compilers lack proper debugging tools
  - however, to some extent, older Fortran compilers are more reliable than newer ones
- 32-bit / 64-bit problems in Fortran code
  - rounding instability
  - REAL*4, REAL*8 precision downgrade
- C++ / Fortran communication problems
  - common block definitions
  - function parameters and return values
- Fortran specific problems
  - memory overwriting
- C++ specific problems
  - memory leaks

Problems with multi-platform, multi-language code

- Platform dependent bugs or C++ / Fortran communication problems **may cause numerical instability!** or worse: may appear as statistical fluctuation.

- Numerical instability can occur when running:
  - with different parameters
  - with different seed
  - on different platforms
  - with different compilers
  - in different environments
  - when single, all or only several modules are used

Summary

- I have made a review of tasks in our projects as seen from computing side
- This is of course only one of the aspects of these projects
- We have several papers and applications and programs which are already in use
- Projects are being developed with:

  D. Bardini, V. Cherepanov, Z. Czyczuła, G. Nanava, E. Richter-Wąs, P. Roig, R. Sadykov, O. Shekhovtsova, S. Tsuno, Z. Wąs, Q. Xu

- In cooperation with:

  Atlas, BaBar, Belle, CMS, CDF, …

Thank you for listening!