

# Highlights from 9-10 november ECFA WG1+WG2 workshop on generators

F. Piccinini

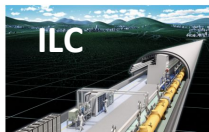
INFN Pavia, Italy



# ECFA statement July 2020

- *ECFA recognizes the need for the experimental and theoretical communities involved in physics studies, experiment designs and detector technologies at future Higgs factories to gather. **ECFA supports a series of workshops** with the aim to **share challenges and expertise, to explore synergies in their efforts** and to respond coherently to this priority in the European Strategy for Particle Physics (ESPP).*

*Goal: bring the entire  $e^+e^-$  Higgs factory effort together, foster cooperation across various projects; collaborative research programmes are to emerge*



P. Azzi, report at 109th plenary ECFA meeting, nov. 2021

# Recommendations from the IAC

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- Extension to include **electroweak** and **top** factory
  - **Extend the physics studies** (w.r.t studies of European Strategy update (EPPSU)), where relevant (not all completed at time of EPPSU), however, focus on  $e^+e^-$  potential  
→ no discussion of pros and cons of various machines or alternatives to  $e^+e^-$  Higgs factories
  - Understand better the **interplay between (HL)-LHC and an  $e^+e^-$  Higgs/EW/Top factory**
  - Development of **common tools** important (software, simulation, fast simulation, ...)
  - Development of **common analysis methods** of high interest
  - **Exploit synergies, discuss challenges**, do not restrict to common items
  - Need for **theoretical accuracy** and **MC generator improvements** ...
  - ...
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WG1 Physics Potential

WG2 Physics Analysis Methods

P. Azzi, report at 109th plenary ECFA meeting, nov. 2021

Conveners:

- J. Alcaraz
- J. List
- F. Maltoni
- J. Wells\*

Conveners:

- P. Azzi
- F. P.
- D. Zerwas

# WG1 activities

- **WG1-PREC: Precision calculations and theoretical, parametric and experimental systematic uncertainties**
- **WG1-EFT: Global interpretation in (SM)EFT and UV complete models**
- **WG1-HTE: Higgs, top and electroweak physics**
- **WG1-HF: Flavour Physics**
- **WG1-SRCH: Direct discovery potential**
- **Important note: strong LHC connections in all activities, plus HF factories for WG1-HF and non-collider experiments for WG1-SRCH**
  - **Already taken into account when choosing lead people**

J. Alcaraz, report at 109th plenary ECFA meeting, nov. 2021

# What is WG2?

GENERATORS

SIMULATION

RECONSTRUCTION

ALGORITHMS & TOOLS

SOFTWARE ECOSYSTEM

- Monte Carlo generators for e+e- precision EW, Flavour, Higgs, and top physics,
- Luminosity measurements
- Fast simulation and the limitations of such techniques
- Full Simulation
- Track and vertex reconstruction algorithms
- Jet algorithms / jet reconstruction
- Particle-flow reconstruction and global event description
- Requirements on particle identification
- Flavour tagging algorithms
- Importance of timing information
- Constrained fit

P. Azzi, report at 109th plenary ECFA meeting, nov. 2021

**Generators are a link between WG1 and WG2**

**9-10 November 2021 @ CERN**

## **First topical meeting on generators**

<https://indico.cern.ch/event/1078675/>

ECFA WG's activities are planned for the next two years

## having in mind

- $e^+e^- \rightarrow f\bar{f} (Z^0)$
- $e^+e^- \rightarrow 4f (WW, ZH)$
- $e^+e^- \rightarrow 6f (t\bar{t})$  and multi-boson final states
- ...

### Shower MC

- HERWIG
- PYTHIA

### pre/after burners

- CIRCE
- GUINEA PIG
- PHOTOS
- TAUOLA/TAUSPINNER

### multileg/automatic

- MG5\_aMC@NLO
- POWHEG
- SHERPA
- WHIZARD

### process taylored

- BABAYAGA
- KKMC/BHLUMI
- GENEVA

- Impressive potential for future developments of automatic generators (mainly developed for hadron collider)
  - Complexity of LHC processes and precision requirements triggered the developments of automatic methods to calculate scattering amplitudes leading to the so called “NLO revolution”
  - NLO (QCD and electroweak)+PS automatic calculation are reality
  - present challenge is NNLO automation and matching with SMC
  - future path is to convert the IS hadron machinery to  $e^+e^-$
  - recent work within HSF Physics Event Generator WG to increase efficiency in CPU time
    - porting ME calculation and event generation to GPU's and vector CPU's
    - recent experience and ongoing work with MadGraph



- codes specifically designed for  $e^+e^-$  already reach the  $\mathcal{O}(\text{few } 10^{-4})$  precision level

e.g. KKMCEE

- Very recent developments on QED ISR

$$d\Sigma_{e^+e^-}(P_{e^+}, P_{e^-}) = \sum_{kl=e^+e^-\gamma} \int dy_+ dy_- \mathcal{B}_{kl}(y_+, y_-) d\sigma_{kl}(y_+ P_{e^+}, y_- P_{e^-})$$

$$d\sigma_{kl}(p_k, p_l) = \sum_{ij=e^+, e^-, \gamma} \int dz_+ dz_- \Gamma_{i/k}(z_+, \mu^2, m^2) \Gamma_{j/l}(z_-, \mu^2, m^2) \\ \times d\hat{\sigma}_{ij}(z_+ p_k, z_- p_l, \mu^2) + \mathcal{O}\left(\left(\frac{m^2}{s}\right)^p\right)$$

- $\Gamma_{i/j}$  PDFs with NLL accuracy  $(\alpha \log(E/m))^k + \alpha(\alpha \log(E/m))^{k-1}$

talk by S. Frixione

- Discussions on beamstrahlung

- present in all machines (not only linear)

e.g. at LEP origin of luminosity bias Voutsinas, Perez, Dam, Janot, arXiv:1908.01704

- avoid double counting of beam- and brems-strahlung
- interface standardization with hard scattering generators

# Generator WS - Day2 - Interface

## Interface generators-Software

### Ecosystem:

- key4Hep
- EDM4HEP
- HepMC

### Production Experience:

- feedback from ILC and CLIC
- feedback from FCC-ee
- feedback from LHC

## Main points:

- Data models discussion (HepMC,EDM4HEP,..)
- Lessons learned from LHC experience:
  - Big productions need care
  - Communication with authors essential
  - Performance (for LHC) still an issue
- Benchmarks: important topic that will need follow-up meeting(s) also including WG1

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- **Topical Meetings (1-2 days)**

- Simulation Topical Workshop, 1-2 February 2022 @Padova (Hybrid)
- Reconstruction Topical Workshop, Spring 2022 @? (Hybrid)
- Followup Generator Workshop, before Summer 2022 (proposal by Siegen to be discussed) (Hybrid)

- **Follow-up Seminar-Style Meetings (half-day)**

- Beam Issues, 12 January 2022 (Zoom)  
<https://indico.cern.ch/event/1100734/>
- Interface Generator-KEY4HEP, TBA (Zoom)
- Generator Benchmarks, TBA - *content to be defined with WG1*

## The unit and its support

As of 1st of October, the unit exists as RCS/PRJ/FC, under the Directorate of Research and Computing

Users' registration:

- the unit allows those not affiliated with a CERN expt, or TH, to register as CERN user

Resources:

- 24 months of scientific associates (SASS) per year, during the 2022-2024 period
- budget to support short visits (per diem), organize activities (workshops), ...
- fellows, project associates or further SASS , as made available by the individual projects under their MTP allocations (FCC, CLIC, mucoll).

M.L. Mangano

## Collaboration with ECFA WG1 and WG2

- Host their mtgs and provide general logistic support: **eg this mtg**
- Stimulate/coordinate CERN's contribution to the ECFA WG studies:
  - **waiting to understand how the ECFA WGs will set up the activities, inputs, etc**
- Develop commons plan for the long-term projects that may arise within WG 1 & 2, and identify areas where resources/support could come from the FC unit.

### For example:

- **development/validation of MC tools** & calculations for future ee colliders:
  - develop LesHouches-like accords to streamline sharing of matrix-element (ME) and MC events, ME calculations, facilitate interoperability and comparison of tools?
- **development of the common software platform** for event simulation, liaise with ME/MC developments
  - host at CERN common MC event datasets, documentation, twiki's, ... ?
  - organize software tutorials?
- **Host and support extended Workshops/Institutes** with expert participation to carry out the above work?
- Coordinate initiatives bringing together (HL-)LHC and ECFA ee WGs