



# Generators in CMS

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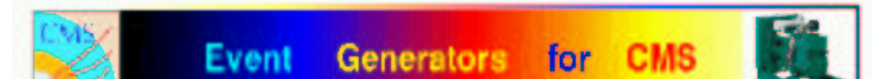
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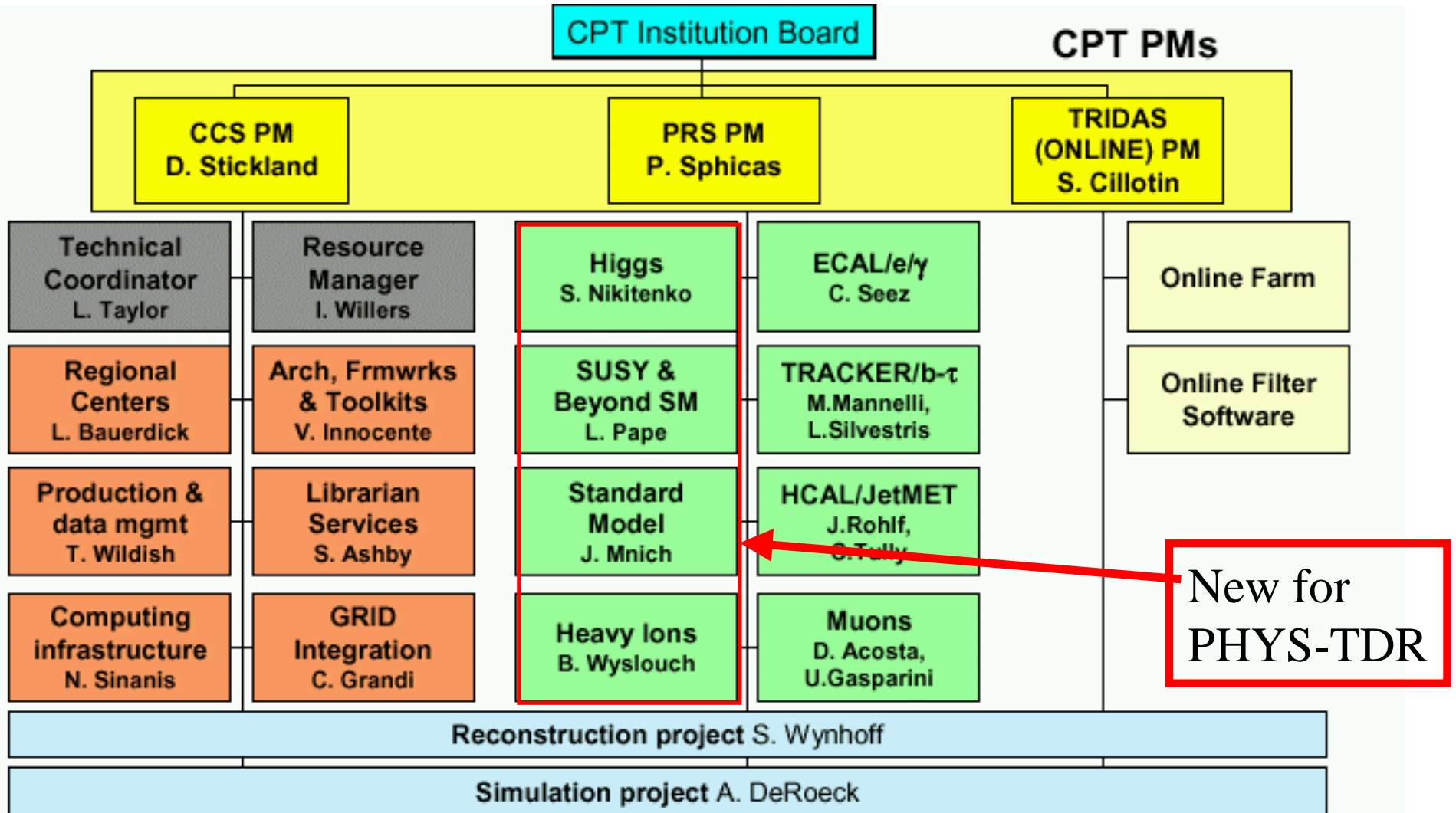
Monte Carlo Event Data Base

Future Developments





# Organization



Generators presently part of simulation project  
Future: part of a phenomenology group



# CMS Monte-Carlo Handling

- Running MC generators
- Storing MC info for simulation
- Accessing MC info at Simulation, Reconstruction and Analysis
- Note: last 6 months main concern was preparation for DC04/changes to interfaces postponed until DC04 under way (= this summer)



# Event Generation

- So far MC generators written mainly in FORTRAN
  - Pythia, Herwig, ISAJet,.....
- HEPEVT common block is current standard
- Event structure with subtle differences
- Very different parameters
  
- CMKIN - wraps around the generators
  - Unified setting of key parameters (e.g. Z-mass)
  - Possibility to access all parameters



# MC Event Storage

- Generated events might be used
  - For different simulations
  - By several users
- Store in simple Ntuple format - CMKIN
  - Pre-selection code possible (in FORTRAN!)
- Store HEPEVT common block (current standard)
- Add special information (pt-hat)
- CMS production stores used version and all parameters in MySQL database
  - Fully reproducible at any time



# Event access in C++

- Implement exact copy of HEPEVT
- Class RawHepEvent()
  - Contains RawHepEventParticle()
    - momentum, vertex, status, mother-daughter relations
  - Particle properties (mass, charge, etc.) from HepPDT
  - Nice printout - like LULIST or tree structure
  - Can be filled from multiple source (event, event-vertex)
  - Validates event completeness from Mo-Da relations
  - Name already indicates:
    - to be replaced by something better (not Raw)
    - Original implementation 1999 - temporary solutions survive!



# Reading RawHepEvents

- Abstract class `BaseRawHepEventReader()`
  - Provides all particles for an event
  - Can combine signal and pileup events
  - Current implementations:
    - `HepEventTxtReader` (ASCII)
    - `HepEventCmkinNtupleReader`  
standard CMS ntuple, used in OSCAR (Geant4 simulation)
    - `HepEventPythia6Reader`  
directly from Pythia, used for FAMOS (fast simu & reco)
    - `HepEventParticleGunReader`
    - `HepEventG3EventProxyReader`  
from CMS database, used in ORCA (reconstruction) jobs



# Plans for Change

- Agreed on HepMC to replace RawHepEvent
  - More information about the particles
  - Store “run” specific info (parameters like PARU(57)...)
- Requires updated persistency
  - POOL based
  - Partially CMS specific (links to CMS event structure)
- Concern:
  - Full benefit from HepMC only if Generators give more info than for HEPEVT
  - Are theorists ready for C++?  
(not all experimentalists are)





# Event generator information

- S. Slabospitsky and ADR

**URL=** <http://cmsdoc/cern.ch/cms/generators/>

- Interface with CMS simulation software
- Mini-documentation on how to use program @LHC in CMS
- Install/check new releases (contact for each main generator)
- Example jobs



# Supported Programs

- Presently on the page

## *Supported packages*

general purposes	dedicated
PYTHIA	HDECAY, ...
HERWIG	TAUOLA
ISAJET	TopReX
CompHEP	Single Top
diffraction	HardDif
heavy ions Hijing,..	SIMUB
MC Events Data Base	ALPGEN
PDF	

Next: Phojet, MadGraph, (MadCup), GR@PPA, PHOTOS, MC@NLO, EVTGEN, ADD, Black Holes, Diffractive Higgs, low-x, Heavy Flavours...

- **PYTHIA**

- ◇ short page “How to run CMKIN with PYTHIA” is created
- ◇ two PDF files describe how to run standard CMS cmkin (pythia) which output can be used as an input both for cmsim and oscar.

- **HERWIG**

- ◇ short page “How to run CMKIN with HERWIG” is created
- ◇ several examples (routines, scripts) are available for the users

- **TAUOLA**

- ◇ TAUOLA is a stand-alone package providing a simulation of polarized  $\tau$ -lepton decays.
- ◇ the FORTRAN code, providing a simulation with PYTHIA, is created.
- ◇ now TAUOLA library could be used both for the user’s stand-alone program and for running with CMKIN

- **PDF**

- ◇ several links to Particle Distribution Functions (PDF) WEB pages
- ◇ LHAPDF interface for generating events with PYTHIA
- ◇ CTEQ6 PDF’s

- **CompHEP** package

- ◇ is created for calculation of multi-particle final states in collision and decay processes. The main idea in CompHEP is to enable one to go directly from the Lagrangian to the cross sections and distributions effectively, with the high level of automation.
- ◇ short page “How to run CompHEP” is created
  - how to install of CompHEP at CERN
  - how to run the package
  - CompHEP/PYTHIA interface

- **Heavy Ions**

- ◇ short page “How to run HIJING” is created
- ◇ several examples (routines, scripts) are available for the users

- **TopReX**

- ◇ is dedicated for simulation of “external” processes with PYTHIA:  
 $t\bar{t}$ , single top,  $WQ\bar{Q}$ ,  $H^\pm$  production
- ◇ the TopReX could be used :

- as a stand-alone generator,
- with CMSJET for fast MC simulation of CMS,
- with CMKIN-package: routines, data-card, scripts

- **SingleTop**

- ◇ is based on the CompHEP package and is dedicated for simulation of single-top production processes



# Example

## PYTHIA

The **PYTHIA** program can be used to generate high-energy-physics 'events', i.e. sets of outgoing particles produced in the interactions between two incoming particles. The objective is to provide as accurate as possible a representation of event properties in a wide range of reactions, with emphasis on those where strong interactions play a role, directly or indirectly, and therefore multihadronic final states are produced.

Pythia 6.2 manual [postscript](#)

[Pythia home page](#)

[Pythia7](#)

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## *How to run CMKIN with PYTHIA*

The short instructions is presented in [README](#) file. See [Event generation - KINE file](#) for details.

All files, needed for the work could be found [here](#)

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Tutorials: [click here](#)

How to run standard CMS cmkin (pythia) which output can be used as an input both for cmsim and oscar click for two PDF files:

[Jetmet exercise.1](#)

[Jetmet exercise.2](#)

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Contact persons in CMS:

[Alexandre Nikitenko](#)

[Sergey Slabospitsky](#)



# Generator Validation

- Comparison of Generators:

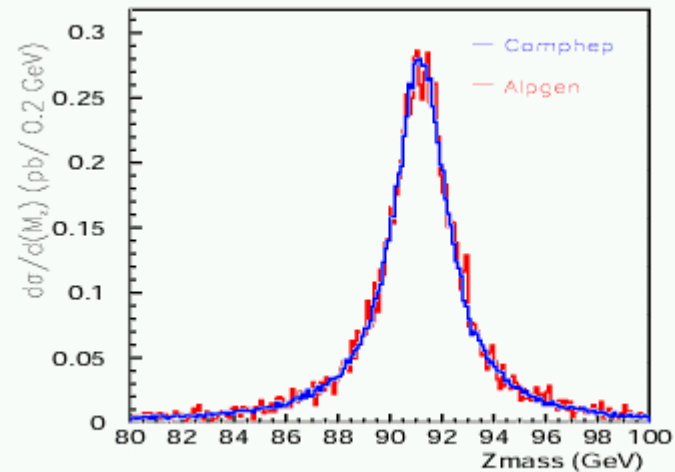
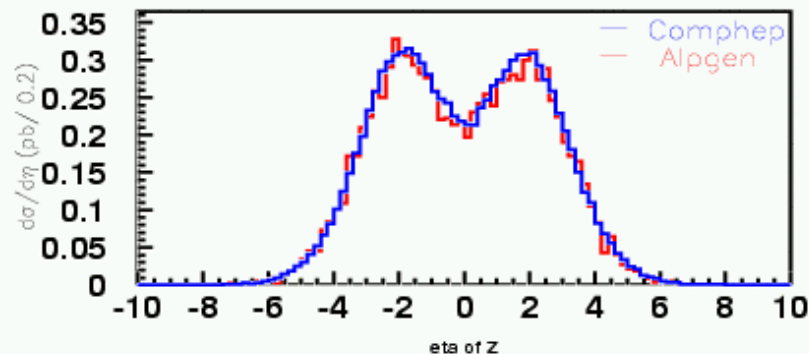
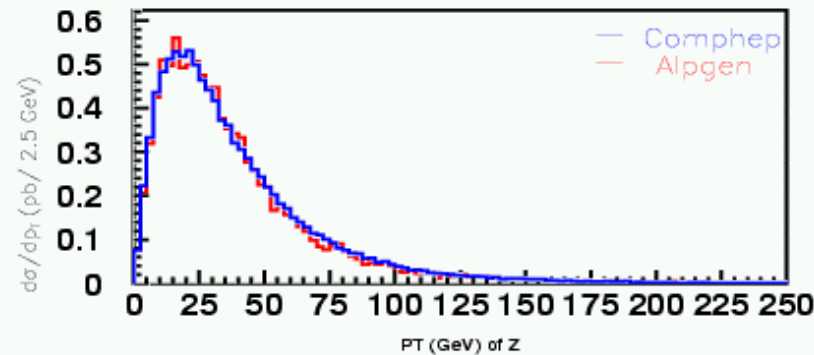
ALPGEN vs. COMPHEP (K. Mazumdar)

$$p p (gg, u\bar{u}, d\bar{d}) \rightarrow Z b\bar{b}, Z \rightarrow e^+ e^-$$

$$\sigma(\text{ALPGEN}) = 11.15 \pm 0.016 \text{ pb}$$

$$\sigma(\text{COMPHEP}) = 10.36 \text{ pb}$$

- No systematic validation or general tools developed
- Count on LCG generator project & CERN generator workshop
- Some studies ongoing e.g on comparison between generators





# MC event data base

- L. Dudko, A Sherstnev (← details)

- Motivation:

Experts/authors prepare MC files. Experimental collaborators want to use (correct) files

CMS: PEVLIB example of a MC data base (based on model used at FNAL: FNAL MCDB)  
/afs/cern/ch/cms/physics/PEVLIB with directory structure.

Used by some physics groups already.  
Expect increase as PHYS-TDR progresses



# Monte-Carlo Events Data Base



## [tt+2 jets process](#)

The events samples (20 samples with ~105K events per the sample) are generated by CompHEP 41.10. The jets are  $u, d, s, c$ -quarks and gluons but in some approximation (see the article)  
published: 01/04/2003 | author: Viacheslav A. Ilyin | category: TOP ::

## [tt+jet process](#)

The events samples (~281K events) are generated by CompHEP 41.10. The jets are  $u, d, s, c$ -quarks and gluons but in some approximation (see the article)  
published: 05/03/2003 | author: Viacheslav A. Ilyin | category: TOP ::

## [tt+bB process](#)

### **Process: $p, p \rightarrow t\bar{t} + b\bar{b}$**

Samples of the process (~617k events) are generated by CompHEP 41.10  
published: 05/03/2003 | author: Viacheslav A. Ilyin | category: TOP ::

## [tt+Z process](#)

### **Process: $p, p \rightarrow t\bar{t} + Z$**

The events samples (~700K events) are generated by CompHEP 41.10  
published: 04/03/2003 | author: Viacheslav A. Ilyin | category: TOP ::

## [tt+W process](#)

### **Process: $p, p \rightarrow t\bar{t} + W$**

The samples (~21K and ~11 events) are generated by CompHEP 41.10  
published: 03/03/2003 | author: E.Boos | category: TOP ::

## [ttbar events generated by CompHEP](#)

Generated events for the  $pp \rightarrow t, \bar{t}$  and  $pp \rightarrow t, \bar{t} \rightarrow W, W, b, \bar{b}$  processes. For the last process the full matrix elements has been calculated.

HIGGS

TOP

W and n jets

Z and n jets

Gamma and n jets

WW and n jets

ZZ and n jets

WZ and n jets

Gamma Gamma n jets

W Gamma n jets

Z Gamma n jets

QCD multijets

REQUESTS

PROGRAMS

FAQ

Publish New Document:

non authorized author

authorized author

[HELP](#)



# Outlook

- **Event structure: will switch to HepMC after summer workshop (unless...)**
- **Validation tools: count on LCG generation project to start off/ can contribute**
- **Central installation of libraries: highly desired/identified contacts for CMS**
- **MCDB: a prototype started being used in CMS. Same team engaged in the development of the LCG related projected**