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Status of PYTHIA 8

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On To C++

Currently HERWIG and PYTHIA are successfully being used,
also in new LHC environments, using C++ wrappers

Q: Why rewrite?
A1: Need to clean up!
A2: Fortran 77 is limiting Fortran 90
A3: Young experimentalists will expect C++

PYTHIA7 project $\Longrightarrow$ **ThePEG**

Toolkit for High Energy Physics Event Generation

(L. Lönnblad; S. Gieseke, A. Ribon, P. Richardson)

HERWIG++: complete reimplementation

(B.R. Webber; S. Gieseke, A. Ribon, P. Richardson, M. Seymour, P. Stephens, 3 new)

ARIADNE/LDC: to do ISR/FSR showers, multiple interactions

(L. Lönnblad; N. Lavesson)

SHERPA: in C++ from start, partly wrappers to PYTHIA Fortran

(F. Krauss; T. Gleisberg, S. Hoeche, A. Schaelicke, S. Schumann, J. Winter)

PYTHIA8: A fresh start

Problem: PYTHIA7 stalled, no other manpower

Solution?: take a sabbatical and work “full-time”!

($\Rightarrow$ baseline model, S. Mrenna & P. Skands join later ?)

Tentative schedule:

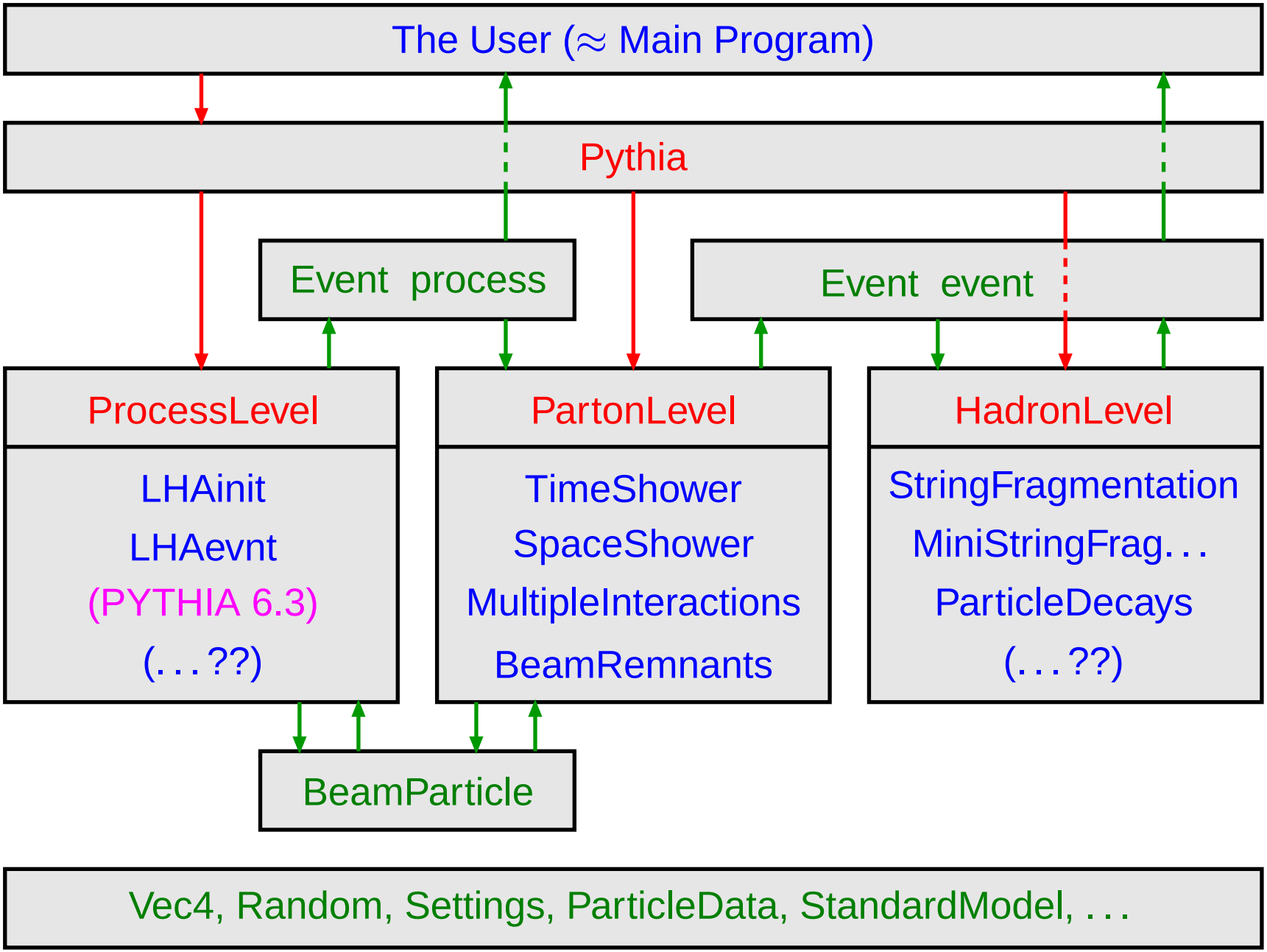
time	date	processes	final states
0 =	1 Sept. 2004	—	—
1 =	1 Sept. 2005	LHA-style input	incomplete draft
2 =	1 Sept. 2006	a few processes	complete, buggy(?)
3 =	1 Sept. 2007	more processes	stable, debugged

. . . but don’t forget Murphy’s law

Objectives:

- clean up, keep the most recent models
- Les Houches Accord style input central
- independent of ThePEG (or anything else), but
- interface to ThePEG later written by Leif (?)

Current PYTHIA8 structure



Event generation structure

1) Initialization step
- select process(es) to study
- modify physics parameters
- set kinematics constraints
- modify generator settings
- initialize generator
- book histograms

```
#include "Pythia.h"
using namespace Pythia8;
Pythia pythia;
pythia.readString("command");
pythia.readFile("command.file");
pythia.init(idBeamA,idBeamB,eCM);
```

2) Generation loop
- generate one event at a time
- analyze it (or store for later)
- add results to histograms
- print a few events

```
pythia.next();
pythia.process.list();
pythia.event.list();
int id = pythia.event[i].id();
```

3) Finishing step
- print deduced cross-sections
- print/save histograms etc.

```
pythia.statistics();
pythia.settings.listChanged();
```

Sample input cards

```
! This file contains commands to be read in for a Pythia8 run.
! Lines not beginning with a letter or digit are comments.

! 1) Settings that could be used in a main program, if desired.
Main:idBeamA = 2212                ! first beam, p = 2212, pbar = -2212
Main:idBeamB = 2212                ! second beam, p = 2212, pbar = -2212
Main:eCM = 14000.                  ! CM energy of collision
Main:numberOfEvents = 1000         ! number of events to generate
Main:numberToPrint = 2             ! number of events to print
Main:numberToShow = 50             ! show how far along run is
Main:showChangedSettings = on      ! print changed flags/modes/parameters
Main:showAllSettings = off         ! print all flags/modes/parameters

! 2) Settings for the hard-process generation.
! Based on an interface to the Fortran Pythia6 program.
#Pythia6:msel = 1                   ! QCD production
#Pythia6:ckin(3) = 100.             ! pTmin cut
Pythia6:msel = 6                   ! t tbar production

! 3) Settings for the event generation process in the Pythia8 library.
#PartonLevel:MI = off               ! no multiple interactions
#PartonLevel:ISR = off              ! no initial-state radiation
PartonLevel:FSR = off              ! no final-state radiation
#HadronLevel:Hadronize = off        ! no hadronization
SpaceShower:pT0 = 2.0              ! dampening of pT -> 0 divergence
MultipleInteractions:pTmin = 3.0   ! lower pT cutoff for interactions
```

-------- Pythia Event Listing (complete event) ----------

no	id	name	status	mothers		daughters		colours		p_x	p_y	p_z	e	m
0	90	(system)	-11	0	0	0	0	0	0	0.000	0.000	0.000	14000.000	14000.000
1	2212	(p+)	-12	0	0	187	0	0	0	0.000	0.000	7000.000	7000.000	0.938
2	2212	(p+)	-12	0	0	188	0	0	0	0.000	0.000	-7000.000	7000.000	0.938
3	21	(g)	-21	7	0	5	6	101	102	0.000	0.000	53.792	53.792	0.000
4	21	(g)	-21	8	8	5	6	103	101	0.000	0.000	-829.022	829.022	0.000
5	-6	(tbar)	-22	3	4	9	9	0	102	-107.572	-45.614	-345.827	404.638	174.595
6	6	(t)	-22	3	4	10	10	103	0	107.572	45.614	-429.402	478.176	174.969
7	21	(g)	-41	12	12	11	3	105	102	-0.000	-0.000	76.351	76.351	0.000
8	21	(g)	-42	13	0	4	4	103	101	-0.000	0.000	-829.022	829.022	0.000
9	-6	(tbar)	-44	5	5	14	14	0	102	-127.853	-17.612	-332.165	396.829	174.595
10	6	(t)	-44	6	6	15	15	103	0	90.752	68.837	-379.579	433.208	174.969
11	21	(g)	-43	7	0	16	16	105	101	37.101	-51.226	-40.927	75.336	0.000
(skipped)														
63	21	(g)	-31	111	0	65	66	112	111	0.000	0.000	0.070	0.070	0.000
64	-4	(cbar)	-31	112	112	65	66	0	110	0.000	0.000	-926.957	926.957	0.000
65	21	(g)	-33	63	64	113	113	112	110	5.011	-0.788	-104.687	104.810	0.000
66	-4	(cbar)	-33	63	64	114	114	0	111	-5.011	0.788	-822.200	822.217	1.500
(skipped)														
237	2101	(ud_0)	-63	1	0	0	0	0	137	0.240	-0.007	3177.306	3177.306	0.579
238	-1	(dbar)	-63	1	0	0	0	0	124	1.153	-0.432	839.002	839.003	0.330
239	2101	(ud_0)	-63	2	0	0	0	0	142	-1.091	0.128	-2613.733	2613.733	0.579
240	4	(c)	-63	2	0	0	0	142	0	-0.557	1.321	-174.031	174.043	1.500
(skipped)														
241	-24	(W-)	-22	195	0	245	245	0	0	-102.292	-46.372	-349.729	376.307	81.747
242	-5	(bbar)	-23	195	0	243	244	0	102	-39.504	23.812	-8.300	47.111	4.800
243	-5	(bbar)	-51	242	0	248	248	0	144	-26.921	15.510	-8.835	32.656	4.800
244	21	(g)	-51	242	0	246	247	144	102	-12.740	8.184	-0.143	15.143	0.000
245	-24	(W-)	-52	241	241	263	264	0	0	-102.135	-46.255	-349.051	375.619	81.747
(skipped)														
263	11	(e-)	-23	245	0	265	266	0	0	-49.476	20.517	-126.258	137.149	0.001
264	-12	(nu_ebar)	-23	245	0	267	267	0	0	-52.659	-66.772	-222.793	238.470	0.000
265	11	e-	51	263	0	0	0	0	0	-48.966	20.308	-124.957	135.736	0.001
266	22	gamma	51	263	0	0	0	0	0	-0.510	0.210	-1.301	1.413	0.000
267	-12	nu_ebar	52	264	264	0	0	0	0	-52.659	-66.772	-222.793	238.470	0.000
(skipped)														
285	323	K*+	73	247	0	0	0	0	0	-8.774	4.484	-1.202	9.966	0.892
286	533	B*_s0	73	248	0	0	0	0	0	-24.787	14.045	-6.657	29.754	5.416
287	423	D*0	73	240	0	0	0	0	0	-0.604	1.434	-307.590	307.600	2.007
288	223	omega	73	240	0	0	0	0	0	-0.097	-0.243	-316.742	316.743	0.782
289	113	rho0	73	239	0	0	0	0	0	-0.424	-0.021	-525.177	525.178	0.768
290	2212	p+	73	239	0	0	0	0	0	-0.522	0.279	-1638.254	1638.254	0.938
(skipped)														
490	223	omega	73	237	0	0	0	0	0	0.481	-0.049	154.560	154.563	0.782
491	2212	p+	73	237	0	0	0	0	0	-0.269	-0.100	2588.971	2588.972	0.938
									Sum:	-0.000	-0.000	-0.000	14000.000	14000.000

-------- End Pythia Event Listing ----------

Current PYTHIA8 status

	Existing classes		Missing classes/topics
Process Level	LHAinit	⋆⋆	ThePEG input, alternatively
	LHAevnt	⋆⋆	Cross section administration
	(PYTHIA 6.3)	⋆⋆⋆	Phase space selection
			Process matrix elements
Parton Level	TimeShower	⋆⋆	Parton density libraries
	SpaceShower	⋆⋆	Resonance decays
	MultipleInteractions	⋆	
	BeamRemnants	⋆	MI/ISR/FSR interleaving
			colour flow models
Hadron Level	StringFragmentation	⋆	ME/PS matching
	MiniStringFrag. . .	⋆	
	ParticleDecays	⋆⋆	Junction fragmentation
			Popcorn baryons
—	Event	⋆⋆	updated decay tables
	BeamParticle	⋆⋆	Bose-Einstein
	Vec4, Random	⋆⋆⋆	
	Settings	⋆⋆	event analysis routines
	ParticleData	⋆⋆	
			. . . and much, much more

Outlook

• Fortran PYTHIA 6.3 still main workhorse •

⋆ will be used into early LHC era ⋆

⋆ development ongoing but winding down ⋆

⋆ (NRQCD for J/ψ last major news?) ⋆

⋆ bug fixes will continue for a while ⋆

⋆ *need help to assess gcc 4.0* ⋆

⋆ "final" manual to come ⋆

• C++ PYTHIA 8 is coming along •

⋆ Roughly according to three-year plan so far! ⋆

⋆ Code has been shown/given to a few people ⋆

⋆ *Private feedback from a few more would be welcome* ⋆

⋆ First public "proof-of-concept" version by GENSER July meeting (?) ⋆

⋆ First useful — but incomplete — version in a year's time (??) ⋆

⋆ Debugged and tuned by LHC startup (???) ⋆

⋆ Overtaking Fortran version usage by 2008–2009 (????) ⋆