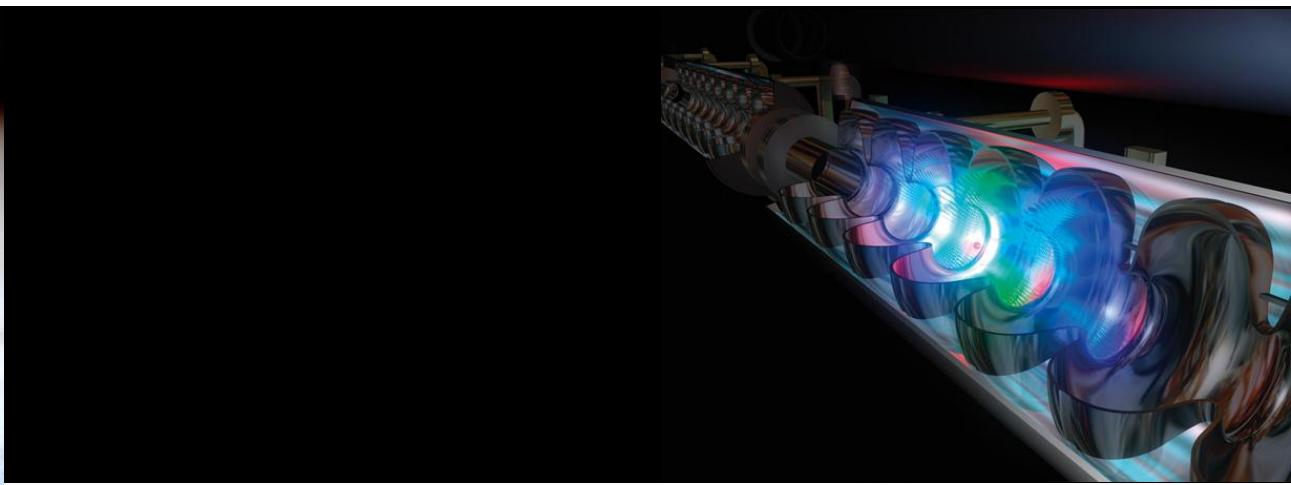


Reading stdhep files in Mokka/GEANT4

A new algorithm in HepLCIOInterface.



Benedikt Vormwald

ILD Software Working Group Meeting

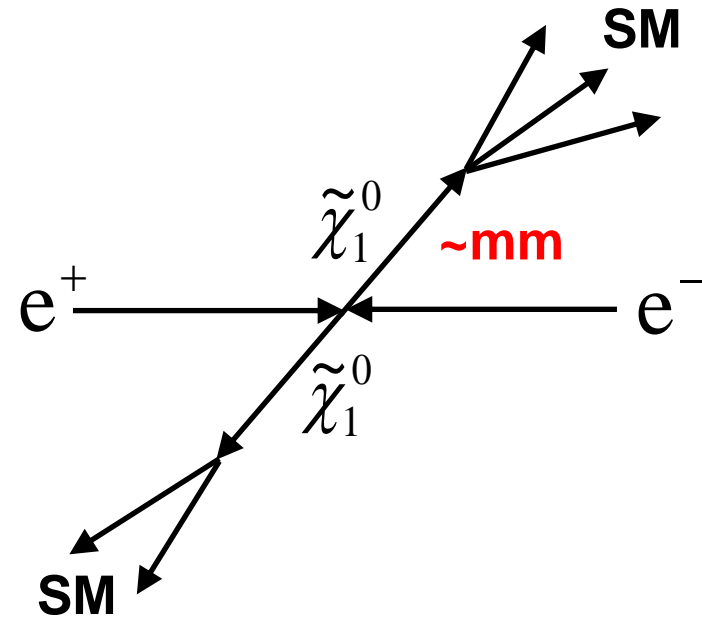
09.11.2011

Introduction

Model

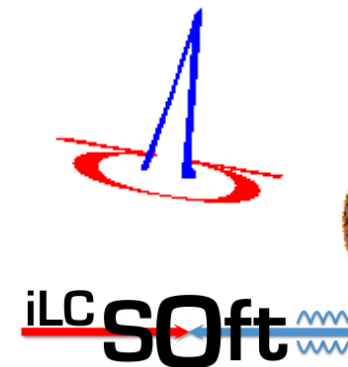
- SUSY with broken R parity (RPV)
- LSP (neutralino $\tilde{\chi}_1^0$) not stable anymore
- decays to SM particles
- for small RPV parameters, long lifetime of neutralino
- displaced vertices of some mm expected
- typical decay mode: $\tilde{\chi}_1^0 \rightarrow W\tau$

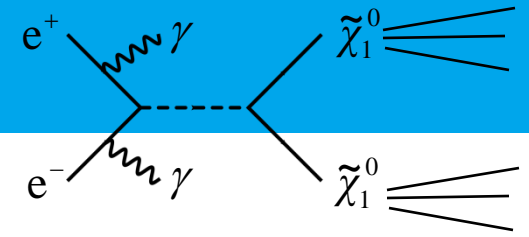
→ crucial point of the analysis: displaced vertices



Software versions

- SUSY production: ILC modified version of **Whizard 1.95**
- fragmentation and SUSY decays: **Pythia 6.422**
- detector simulation: **mokka-07-07**



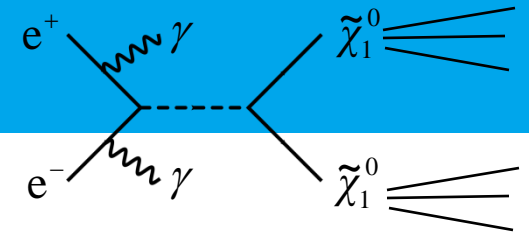


Dump of MCParticleCollection before Mokka run

index	PDG	px,	energy	gen	[simstat]	vertex x	endpoint	[parents] - daughters	
0	22	5.89e-05	4.46e-04	2	[0]	0.00e+00	0.00e+00	[] - [4]	WHIZARD
1	22	6.93e-03	1.03e+02	2	[0]	0.00e+00	0.00e+00	[] - [5]	
2	1000022	1.98e+01	2.41e+02	2	[0]	0.00e+00	0.00e+00	[] - [6]	
3	1000022	-1.98e+01	1.57e+02	2	[0]	0.00e+00	0.00e+00	[] - [7]	
4	22	5.89e-05	4.46e-04	1	[0]	0.00e+00	0.00e+00	[0] - []	PYTHIA
5	22	6.93e-03	1.03e+02	1	[0]	0.00e+00	0.00e+00	[1] - []	
6	1000022	1.98e+01	2.41e+02	2	[0]	0.00e+00	4.40e-01	[2] - [8,9]	
7	1000022	-1.98e+01	1.57e+02	2	[0]	0.00e+00	-9.79e-01	[3] - [17,18]	
8	24	1.65e+01	1.59e+02	2	[0]	4.40e-01	4.40e-01	[6] - [10,11]	
9	13	3.38e+00	8.18e+01	1	[0]	4.40e-01	0.00e+00	[6] - []	
10	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[8] - [12]	
11	12	4.64e+01	9.12e+01	2	[0]	4.40e-01	4.40e-01	[8] - [12]	
12	94	1.65e+01	1.59e+02	2	[0]	4.40e-01	4.40e-01	[10,11] - [13,14]	
13	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[12] - [15,16]	
14	12	4.64e+01	9.12e+01	1	[0]	4.40e-01	0.00e+00	[12] - []	
15	-11	-2.99e+01	6.75e+01	1	[0]	4.40e-01	0.00e+00	[13] - []	
16	22	-8.33e-05	1.90e-04	1	[0]	4.40e-01	0.00e+00	[13] - []	
17	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[7] - [19]	
18	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	-9.79e-01	[7] - [19]	
19	94	-1.98e+01	1.57e+02	2	[0]	-9.79e-01	-9.79e-01	[18,17] - [20,21]	
20	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[19] - [24,25]	
21	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	-9.79e-01	[19] - [22,23]	
22	-13	-2.06e+01	3.69e+01	1	[0]	-9.79e-01	0.00e+00	[21] - []	
23	22	-7.75e-02	1.36e-01	1	[0]	-9.79e-01	0.00e+00	[21] - []	



First run



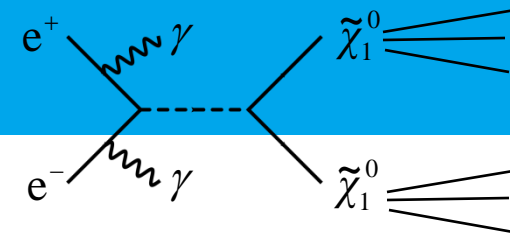
Dump of MCParticleCollection before Mokka run

index	PDG	px,	energy	gen	[simstat]	vertex x	endpoint	[parents] - daughters
0	22	5.89e-05	4.46e-04	2	[0]	0.00e+00	0.00e+00	[] - [4]
1	22	6.93e-03	1.03e+02	2	[0]	0.00e+00	0.00e+00	[] - [5]
2	1000022	1.98e+01	2.41e+02	2	[0]	0.00e+00	0.00e+00	[] - [6]
3	1000022	-1.98e+01	1.57e+02	2	[0]	0.00e+00	0.00e+00	[] - [7]
4	22	5.89e-05	4.46e-04	1	[0]	0.00e+00	0.00e+00	[0] - []
5	22	6.93e-03	1.03e+02	1	[0]	0.00e+00	0.00e+00	[1] - []
6	1000022	1.98e+01	2.41e+02	2	[0]	0.00e+00	4.40e-01	[2] - [8,9]
7	1000022	-1.98e+01	1.57e+02	2	[0]	0.00e+00	-9.79e-01	[3] - [17,18]
8	24	1.65e+01	1.59e+02	2	[0]	4.40e-01	4.40e-01	[6] - [10,11]
9	13	3.38e+00	8.18e+01	1	[0]	4.40e-01	0.00e+00	[5] - []
10	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[8] - [12]
11	12	4.64e+01	9.12e+01	2	[0]	4.40e-01	4.40e-01	[8] - [12]
12	94	1.65e+01	1.59e+02	2	[0]	4.40e-01	-4.40e-01	[10,11] - [13,14]
13	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[12] - [15,16]
14	12	4.64e+01	9.12e+01	1	[0]	4.40e-01	0.00e+00	[12] - []
15	-11	-2.99e+01	6.75e+01	1	[0]	4.40e-01	0.00e+00	[13] - []
16	22	-8.33e-05	1.90e-04	1	[0]	4.40e-01	0.00e+00	[13] - []
17	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[7] - [19]
18	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	-9.79e-01	[7] - [19]
19	94	-1.98e+01	1.57e+02	2	[0]	-9.79e-01	-9.79e-01	[18,17] - [20,21]
20	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[19] - [24,25]
21	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	-9.79e-01	[19] - [22,23]
22	-13	-2.06e+01	3.69e+01	1	[0]	-9.79e-01	0.00e+00	[21] - []
23	22	-7.75e-02	1.36e-01	1	[0]	-9.79e-01	0.00e+00	[21] - []

WHIZARD

PYTHIA

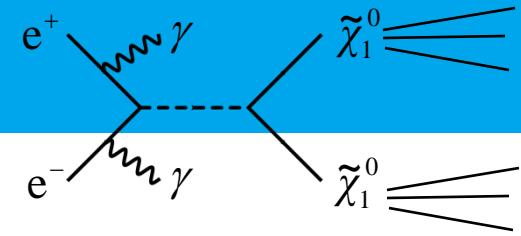




Dump of MCParticleCollection after Mokka run

index	PDG	px,	energy	gen	[simstat]	vertex x	endpoint	[parents] - [daughter]
0	22	5.89e-05	4.46e-04	2	[c s]	0.00e+00	3.28e+02	[] - [4]
1	22	6.93e-03	1.03e+02	2	[c s]	0.00e+00	2.74e-01	[] - [5]
2	1000022	1.98e+01	2.41e+02	102	[0]	0.00e+00	0.00e+00	[] - [6]
3	1000022	-1.98e+01	1.57e+02	102	[0]	0.00e+00	0.00e+00	[] - [7]
4	22	5.89e-05	4.46e-04	1	[0]	0.00e+00	0.00e+00	[0] - []
5	22	6.93e-03	1.03e+02	1	[0]	0.00e+00	0.00e+00	[1] - []
6	1000022	1.98e+01	2.41e+02	102	[0]	0.00e+00	4.40e-01	[2] - [8,9]
7	1000022	-1.98e+01	1.57e+02	102	[0]	0.00e+00	-9.79e-01	[3] - [17,18]
8	24	1.65e+01	1.59e+02	102	[0]	4.40e-01	4.40e-01	[6] - [10,11]
9	13	3.38e+00	8.18e+01	1	[1]	0.00e+00	4.46e+02	[5] - [646]
10	-11	-2.99e+01	6.75e+01	102	[0]	4.40e-01	4.40e-01	[8] - [12]
11	12	4.64e+01	9.12e+01	102	[0]	4.40e-01	4.40e-01	[8] - [12]
12	94	1.65e+01	1.59e+02	102	[0]	4.40e-01	4.40e-01	[10,11] - [13,14]
13	-11	-2.99e+01	6.75e+01	102	[0]	4.40e-01	0.00e+00	[12] - [15,16]
14	12	4.64e+01	9.12e+01	1	[1]	0.00e+00	7.50e+03	[12] - []
15	-11	-2.99e+01	6.75e+01	1	[c s]	0.00e+00	-1.34e+03	[13] - [...]
16	22	-8.33e-05	1.90e-04	1	[c s]	0.00e+00	-1.32e+03	[13] - []
17	-24	8.42e-01	1.20e+02	102	[0]	-9.79e-01	-9.79e-01	[7] - [19]
18	-13	-2.07e+01	3.70e+01	102	[0]	-9.79e-01	-9.79e-01	[7] - [19]
19	94	-1.98e+01	1.57e+02	102	[0]	-9.79e-01	0.00e+00	[18,17] - [20,21]
20	-24	8.38e-01	1.20e+02	2	[t]	0.00e+00	0.00e+00	[19] - [24,25,3]
21	-13	-2.07e+01	3.70e+01	102	[0]	-9.79e-01	0.00e+00	[19] - [22,23]
22	-13	-2.06e+01	3.69e+01	1	[1]	0.00e+00	-7.50e+03	[21] - []
23	22	-7.75e-02	1.36e-01	1	[c s]	0.00e+00	-1.63e+03	[21] - []

First run



Dump of MCParticleCollection after Mokka run

index	PDG	px,	energy	gen	[simstat]	vertex x	endpoi	[f]
0	22	5.89e-05	4.46e-04	2	[c s]	0	28e	
1	22	6.93e-03	1.03e+02	2	[c s]	0	74e	
2	1000022	1.98e+01	2.41e+02	102	[0]	0.00e+00	0.00e	
3	1000022	-1.98e+01	1.57e+02	102	[0]	0.00e+00	0.00e+00	[] - [7]
4	22	5.89e-05	4.46e-04	1	[0]	0.00e+00	0.00e+00	[0] - []
5	22	6.93e-03	1.03e+02	1	[0]	0.00e+00	0.00e+00	[1] - []
6	1000022	1.98e+01	2.41e+02	102	[0]	0.00e+00	4.40e-01	[2] - [8,9]
7	1000022	-1.98e+01	1.57e+02	102	[0]	0.00e+00	-9.79e-01	[3] - [17,18]
8	24	1.65e+01	1.59e+02	102	[0]	4.40e-01	4.40e-01	[6] - [10,11]
9	13	3.38e+00	8.18e+01	1	[1]	0.00e+00	4.46e+02	[5] - [646]
10	-11	-2.99e+01	6.75e+01	102	[0]	4.40e-01	4.40e-01	[8] - [12]
11	12	4.64e+01	9.12e+01	102	[0]	4.40e-01	4.40e-01	[8] - [12]
12	94	1.65e+01	1.59e+02	102	[0]	4.40e-01	-4.40e-01	[10,11] - [13,14]
13	-11	-2.99e+01	6.75e+01	102	[0]	4.40e-01	0.00e+00	[12]
14	12	4.64e+01	9.12e+01	1	[1]	0.00e+00	7	[2]
15	-11	-2.99e+01	6.75e+01	1	[c s]	0.00e+00	-1.3e+03	[13]
16	22	-8.33e-05	1.90e-04	1	[c s]	0.00e+00	-1.3e+03	[13]
17	-24	8.42e-01	1.20e+02	102	[0]	-9.79e-01	-9.79e-01	[7] - [19]
18	-13	-2.07e+01	3.70e+01	102	[0]	-9.79e-01	-9.79e-01	[7] - [19]
19	94	-1.98e+01	1.57e+02	102	[0]	-9.79e-01	0.00e+00	[18,17] - [20,21]
20	-24	8.38e-01	1.20e+02	2	[t]	0.00e+00	0.00e+00	[19] - [24,25,3]
21	-13	-2.07e+01	3.70e+01	102	[0]	-9.79e-01	0.00e+00	[19] - [22,23]
22	-13	-2.06e+01	3.69e+01	1	[1]	0.00e+00	-7.50e+03	[21] - []
23	22	-7.75e-02	1.36e-01	1	[c s]	0.00e+00	-1.63e+03	[21] - []

particles with generator status 2 taken for simulation

simulated particles (simstat ≠ 0) have vertex at 0

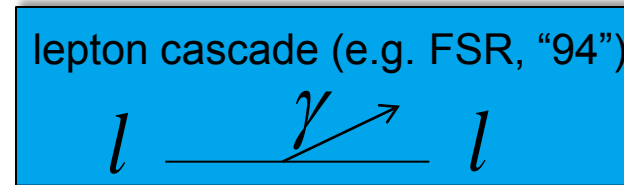
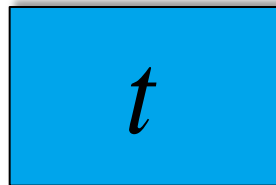
→ problem in the interface, where MCParticles are given to Mokka/GEANT4



Old algorithm (HepLCIOInterface)

Process

1. Identify particles that should not be tracked by GEANT4, to avoid e.g. double counting of lifetimes:



2. Modify generator status (+100) of identified particles and all parents of particle
→ ignore them for further simulation
3. Translate particles with generator status < 100 into G4PrimaryParticles, establish relations between them and put very first to G4PrimaryVertex (= (0,0,0))

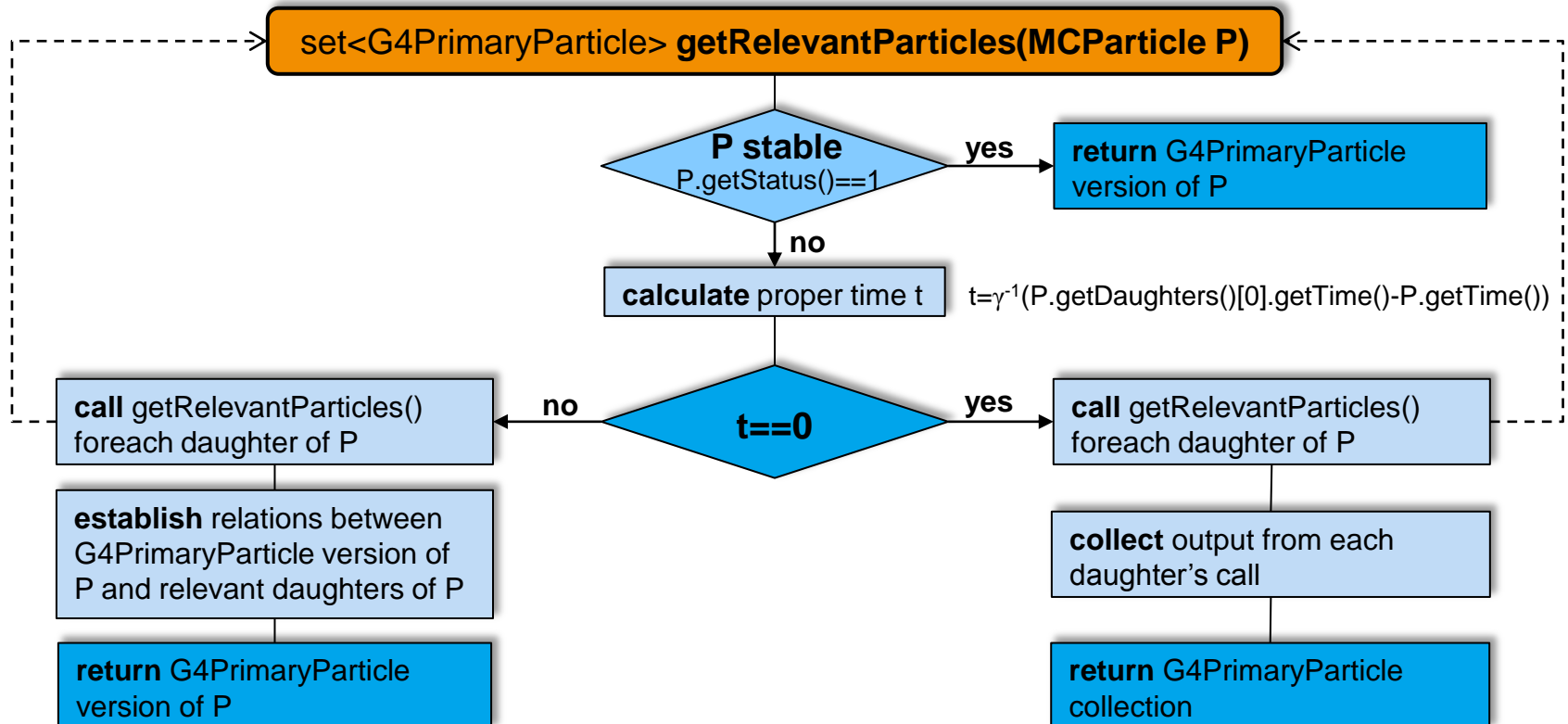
Problems

- loss of all information in a decay chain where tops, neutrinos or lepton cascades appear
- any displaced vertices in the decay chain flagged with 102 are not considered
- inconvenient and error-prone to define "special cases"

New algorithm (HepLCIOInterface)

Process

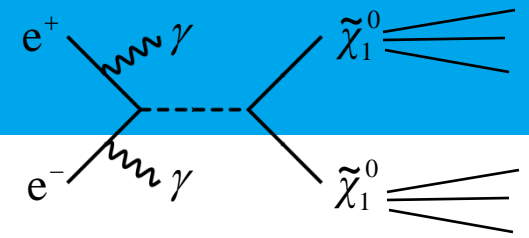
1. Find all MC particles without parents → initial particles
2. Run foreach initial particle P `getRelevantParticles(P)`



3. Add `G4PrimaryParticles` returned by initial call of `getRelevantParticles()` to `G4PrimaryVertex`
→ take MC generator life time information instead of defining “special cases”

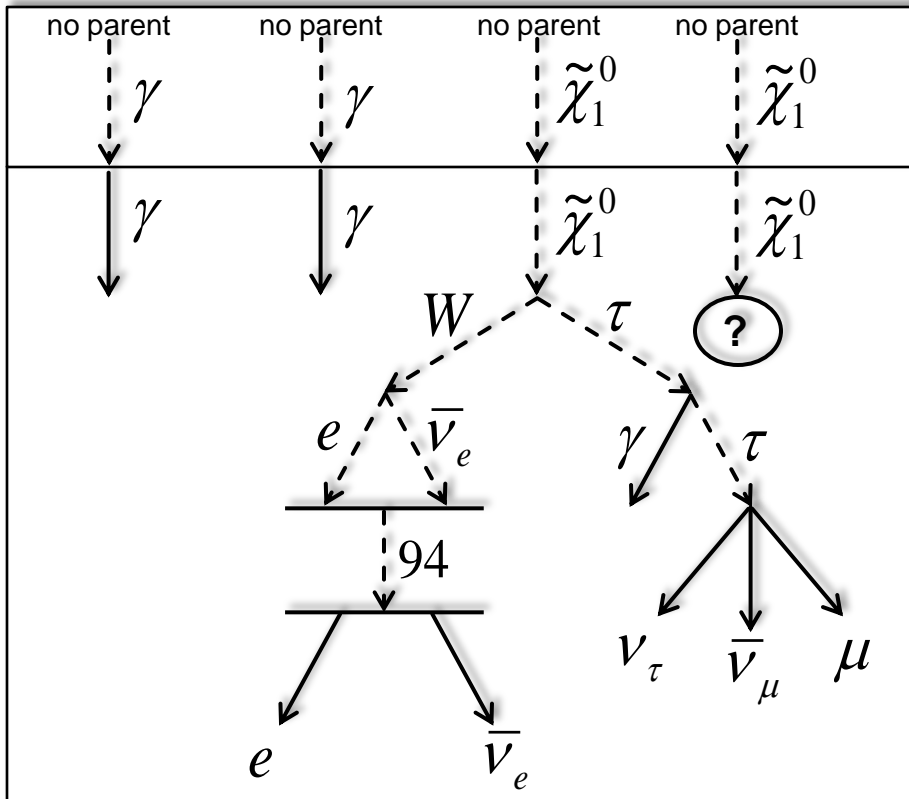


New algorithm (HepLCIOInterface)



Example

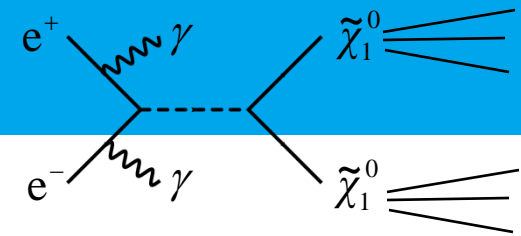
LCIO MCParticle Collection:



solid line: generator status 1 \rightarrow stable
dashed line: generator status 2 \rightarrow unstable

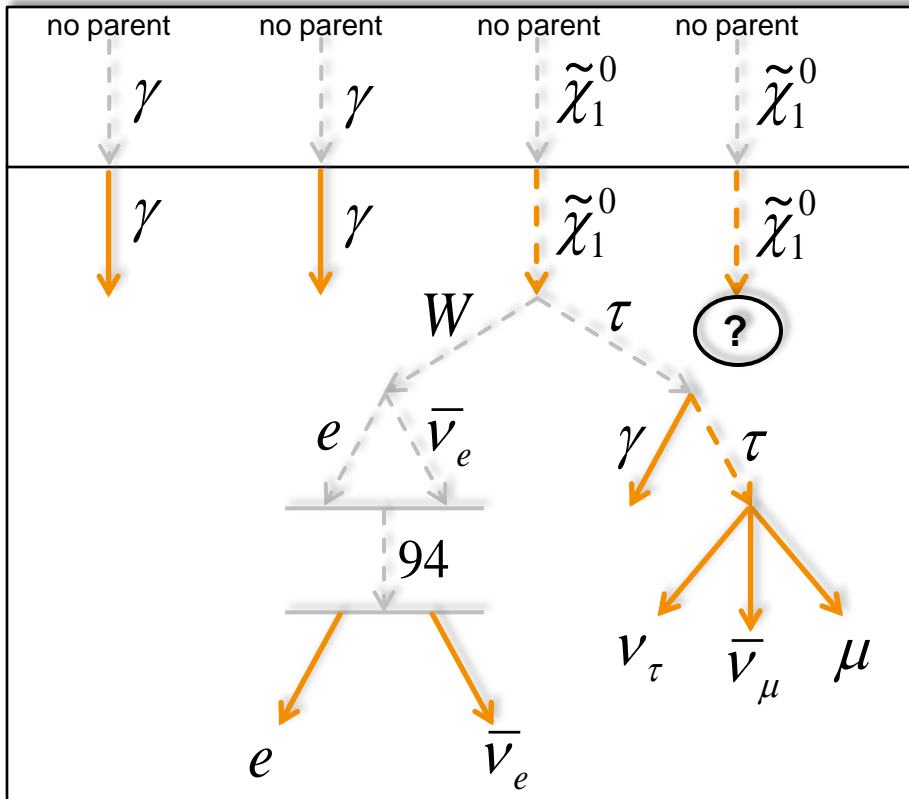


New algorithm (HepLCIOInterface)

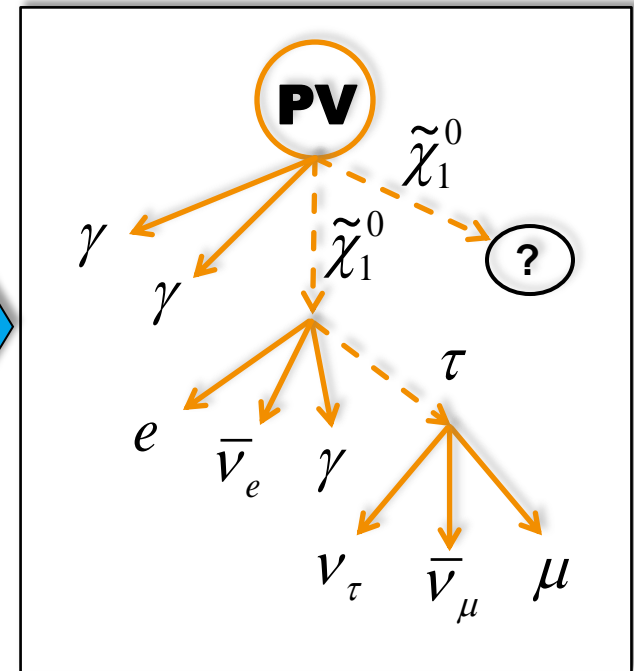


Example

LCIO MCParticle Collection:



G4PrimaryParticles:



take only relevant particles

solid line: generator status 1 → stable
 dashed line: generator status 2 → unstable
 colored line: relevant particles (stable or lifetime!=0)



New algorithm (HepLCIOInterface)

Dump of MCParticleCollection after Mokka run (new algorithm)

index	PDG	px,	energy	gen	[simstat]	vertex x	endpoint	[parents]	-[daughters]
0	22	5.89e-05	4.46e-04	2	[0]	0.00e+00	0.00e+00	[]	- [4]
1	22	6.93e-03	1.46e+02	2	[0]	0.00e+00	0.00e+00	[]	- [5]
2	100022	1.98e+01	1.59e+02	2	[0]	0.00e+00	0.00e+00	[]	- [6]
3	100022	-1.98e+01	1.59e+02	2	[0]	0.00e+00	0.00e+00	[]	- [7]
4	22	5.89e-05	4.46e-04	1	[c s]	0.00e+00	1.60e+02	[0]	- []
5	22	6.93e-03	1.46e+02	1	[c s]	0.00e+00	2.76e-01	[1]	- []
6	100022	1.99e+01	1.59e+02	2	[t]	0.00e+00	4.40e-01	[2]	- [8,9]
7	100022	-1.99e+01	1.59e+02	2	[t]	0.00e+00	-9.81e-01	[3]	- [17,18]
8	24	1.65e+01	1.59e+02	2	[0]	4.40e-01	4.40e-01	[6]	- [10,11]
9	13	3.38e+00	8.18e+01	1	[v l]	4.40e-01	5.04e+02	[6]	- []
10	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[8]	- [12]
11	12	4.64e+01	9.12e+01	2	[0]	4.40e-01	4.40e-01	[8]	- [12]
12	94	1.65e+01	1.59e+02	2	[0]	4.40e-01	4.40e-01	[10,11]	- [13,14]
13	-11	-2.99e+01	6.75e+01	2	[0]	4.40e-01	4.40e-01	[12]	- [15,16]
14	12	4.64e+01	9.12e+01	1	[v l]	4.40e-01	7.50e+03	[2]	- []
15	-11	-2.99e+01	6.75e+01	1	[v c s]	4.40e-01	-1.62e+03	[3]	- [...]
16	22	-8.33e-05	1.90e-04	1	[0]	4.40e-01	0.00e+00	[13]	- []
17	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[7]	- [19]
18	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	-9.79e-01	[7]	- [19]
19	94	-1.98e+01	1.57e+02	2	[0]	-9.79e-01	-9.79e-01	[18,17]	- [20,21]
20	-24	8.42e-01	1.20e+02	2	[0]	-9.79e-01	-9.79e-01	[19]	- [24,25]
21	-13	-2.07e+01	3.70e+01	2	[0]	-9.79e-01	0.00e+00	[19]	- [22,23]
22	-13	-2.06e+01	3.69e+01	1	[v l]	-9.81e-01	-7.50e+03	[21]	- []
23	22	-7.75e-02	1.36e-01	1	[v c s]	-9.81e-01	-1.62e+03	[21]	- []



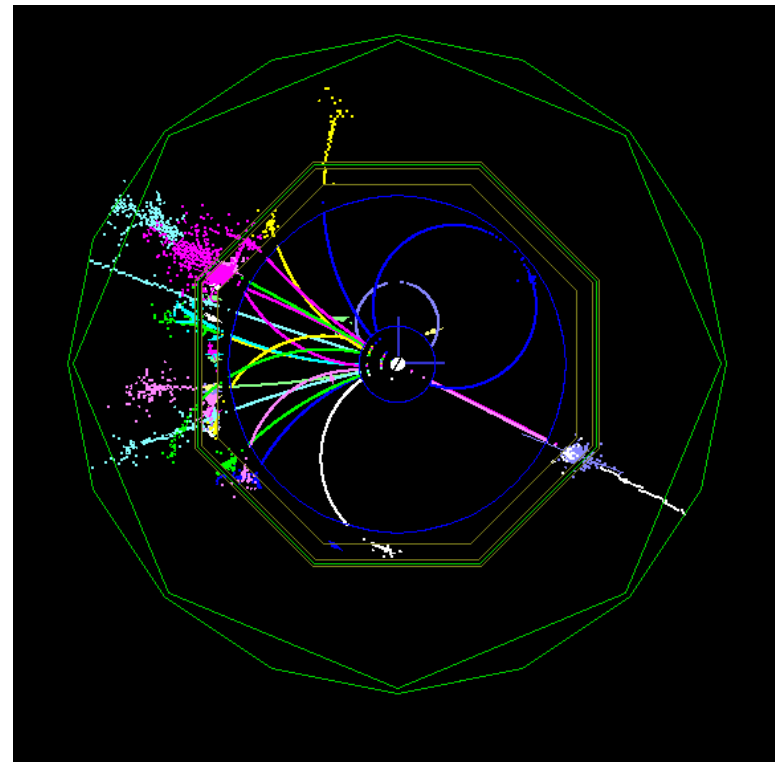
Conclusion

Summary

- > not necessary to define special cases anymore
- > MC generator information used for decision if a particle is relevant for simulation or not
- > new algorithm also tested for SM sample (sbsb)
- > new algorithm seems to be very robust (and fast)

Open issues

- > Momentum seems to change ($\sim 1\%$), if neutralino is tracked (under investigation)
- > **Further tests with more samples necessary**



$$\tilde{\chi}_1^0 \tilde{\chi}_1^0 \rightarrow (W\mu)(W\mu) \rightarrow (e\nu\mu)(u\bar{d}\mu)$$

hopefully in future with displaced vertices