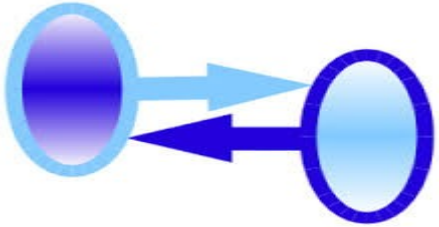


HepSim – Monte Carlo (MC) repository for physics and detector studies for particle experiments

S.Chekanov (HEP/ANL)

Argonne Mini-Workshop on Monte Carlo Methods

May 18, 2023

What is HepSim?

https://atlaswww.hep.anl.gov/hepsim/

Repository with MC files & software for

- Physics (discovery potential, future precision measurements, etc.)
- Exploration of general aspects of detectors & interactions with material using fast and full Geant4 simulations

Experiment neutral: Can be used for any current & future experiment & phenomenological paper

Organize MC samples for download using collision energy, collision type & physics topics

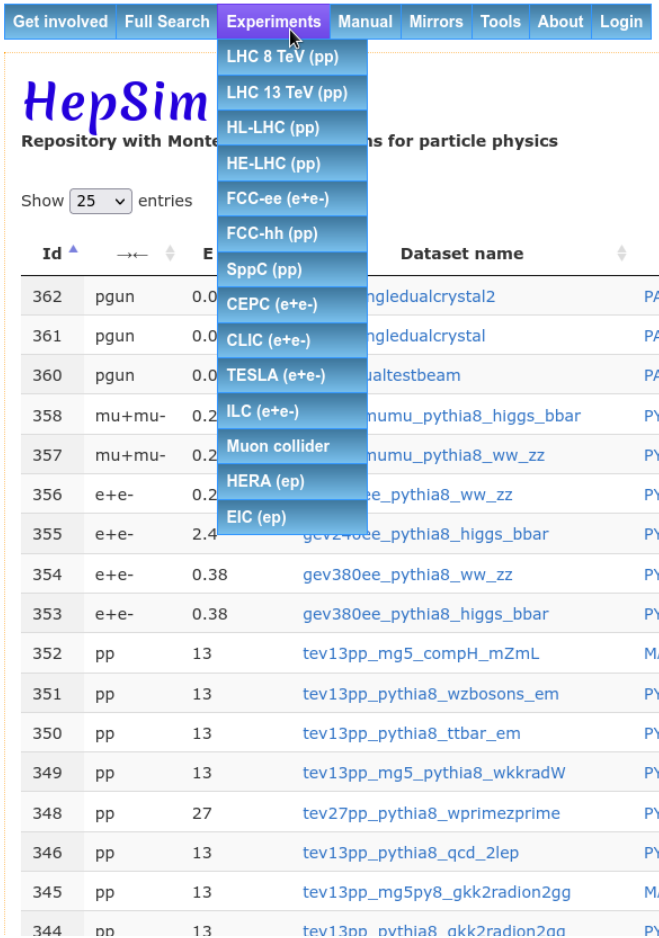
Event samples assigned to Digital Object Identifiers (DOI) in the form xx.yyyy/zzzzz (see osti.gov link)

Show all

$p \rightarrow\leftarrow p$
- 8 TeV
- 13 TeV
- 14 TeV
- 27 TeV
- 33 TeV
- 100 TeV

$e^+ \rightarrow\leftarrow e^-$
- 240 GeV
- 250 GeV
- 380 GeV
- 500 GeV
- 1 TeV
- 3 TeV

$\mu^+ \rightarrow\leftarrow \mu^-$
- 250 GeV
- 1 TeV
- 5 TeV
- 10 TeV
- 20 TeV
- 40 TeV



What is HepSim?

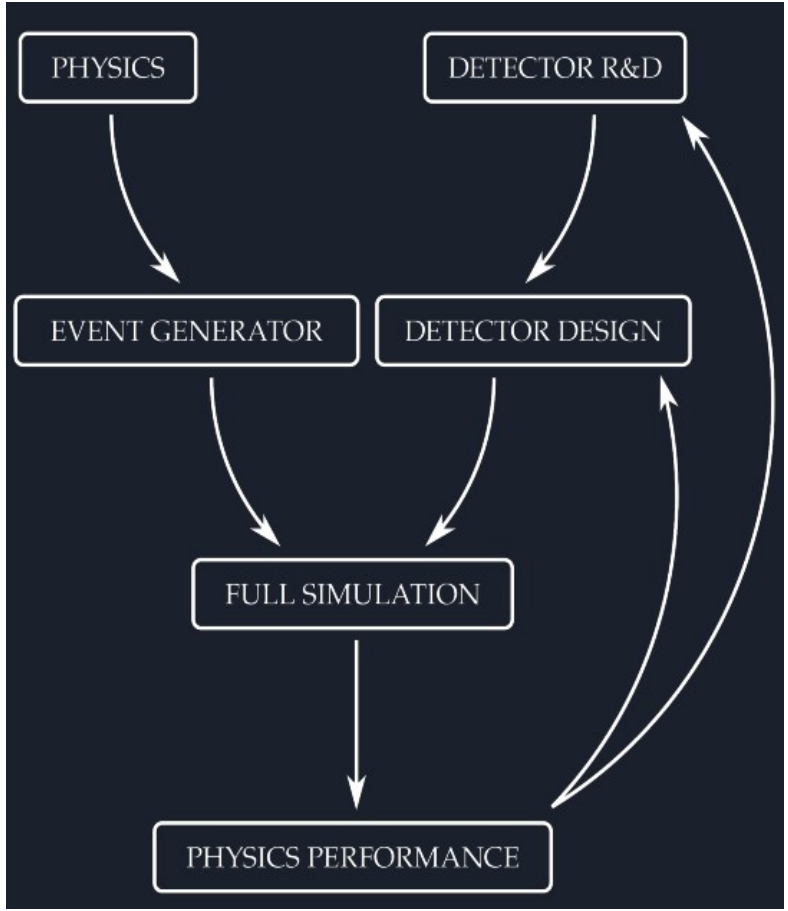
https://atlaswww.hep.anl.gov/hepsim/

- Consists of a web interface, distributed web storage, command-line tools, event browser, containerized software (docker/singularity image)
- Began at Snowmass DPF 2013 (Top/Higgs, see URL) and evolved to →
- Since 2015 used for physics and detector studies for future experiments (HL-LHC, HE-LHC, FCC, CLIC, CEPC, EIC, etc.) and several ATLAS/LHC papers
- 11 conceptual experiments, contributed to ~30 articles ~40 talks (see public results)

Why HepSim?

https://atlaswww.hep.anl.gov/hepsim/

- **Open access**
  - No authentication for use of event files
- **Preservation of MC data, settings and detectors**
- **Mitigate reproducibility problem in publications**
  - Cite Monte Carlo data using DOI identifies
- **Cache for iterative experiment design process**
- **Analysis using platform-independent software on Linux/Mac/Windows (+ URL data streaming)**



Credits to W.Armstrong (Physics/ANL)

How it works

Leveraging large-scale computing

Event Generators

- PYTHIA6
- PYTHIA8
- HERWIG++
- Madgraph5
- MCFM
- JetPhox
- FPMC
- NLOjet++
- LEPTO/Ariadne
- . . . . . .

EVGEN

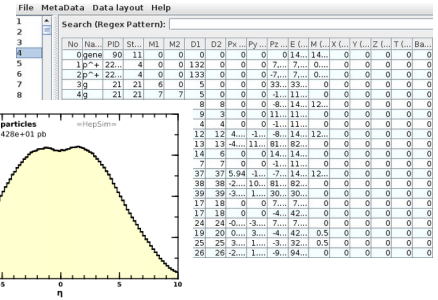
fast → Delphes fast simulation

full → Geant4 full simulation and reconstruction software

- **Integrated with Chicago-area computing:**
  - CPU: OSG Connect, UChicago, LCRC, ALCF
  - File storage: PETREL Data Management and Sharing Pilot
- **HepSim FrontEnd mirrored at JLab, NERSC, CERN**
- **Easy to link self-managed external file storage**

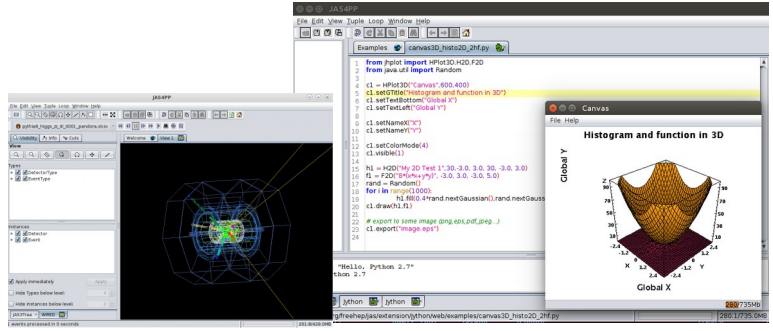
Software for end user

https://atlaswww.hep.anl.gov/hepsim/



Two OS-independent packages

- **(1) hs-toolkit (30 MB)**
  - Discovery and download Monte Carlo files in remote sites
  - Event browser for truth-level events
  - Processing truth-level files and full data-analysis with Lorentz vectors, jet algorithms, etc.
  - Histograms in 2D, 3D, X-Y plotting etc., → vector-graphics images
  - Includes full Python 2.7 API via Jython
- **(2) JAS4PP-** ***Java Analysis Studio for Particle Physics*** (https://atlaswww.hep.anl.gov/asc/jas4pp/) **(130 MB)**
  - hs-toolkit included
  - User friendly IDE
  - Analysis of detector-level files in LCIO file format
  - ROOT I/O + many physics libraries
  - Full experiment-independent event display

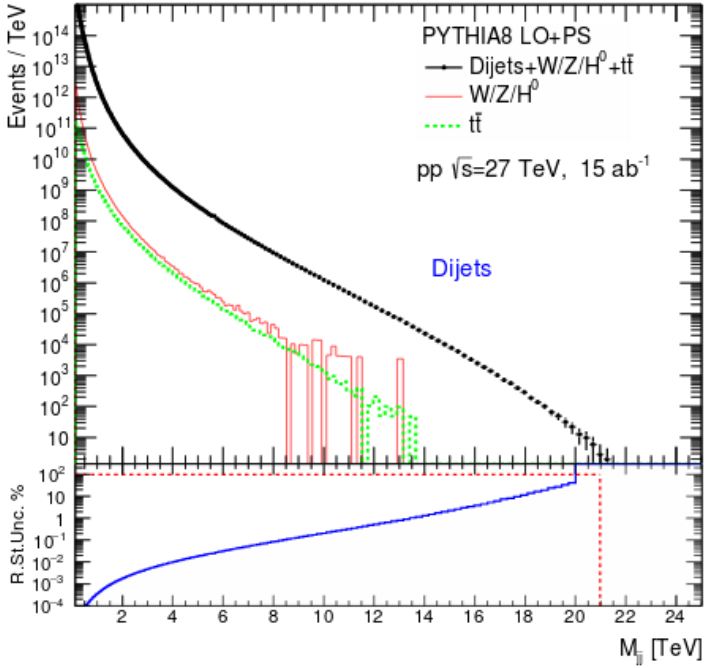


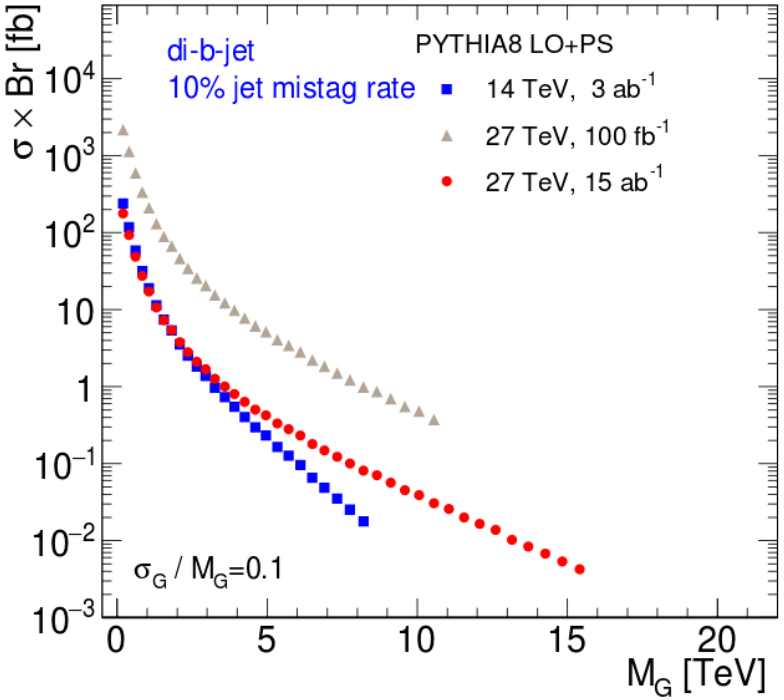
Some highlights

HL-LHC and HE-LHC studies

JINST 13 (2018) P05022
CERN-LPCC-2018-05

- Searches for high mass states in dijets (b-jets)
- 100 billion events created using HepSim singularity image at NERSC
- World's largest Monte Carlo event samples (15 ab-1)

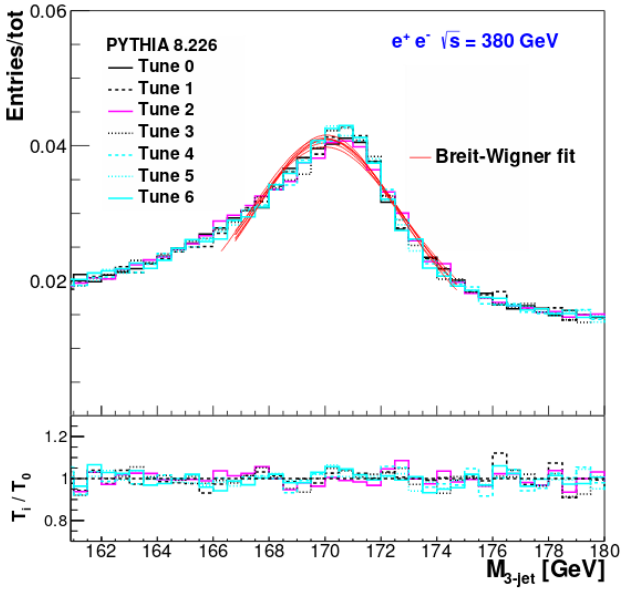


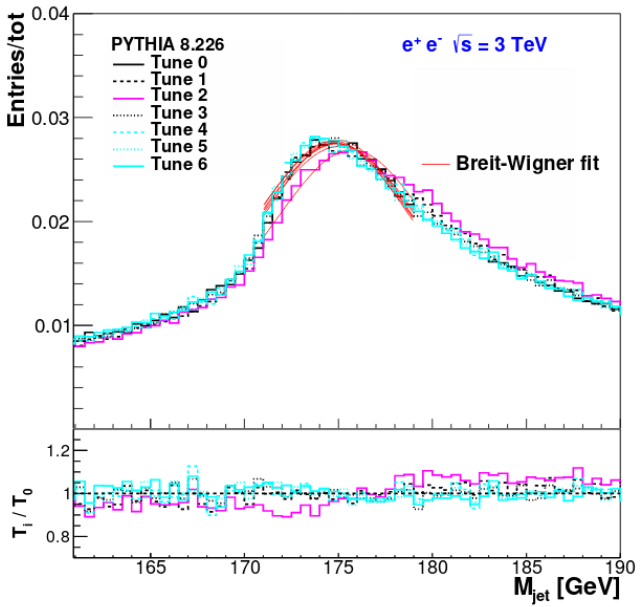


Studies of physics at CLIC

CLICdp-Note-2017-005 (2018) M. Demarteau, S.C., A. Fischer, J. Zhang

- At CLIC energies of 380 GeV, e+e- collision can produce $t\bar{t}$ pairs
- Can modeling non-perturbative phase in Pythia8 affect top mass reconstruction?





- 80 MeV shift was observed for top mass from 3-jet events
- 700 MeV for boosted mass (dominated by Montull tune)

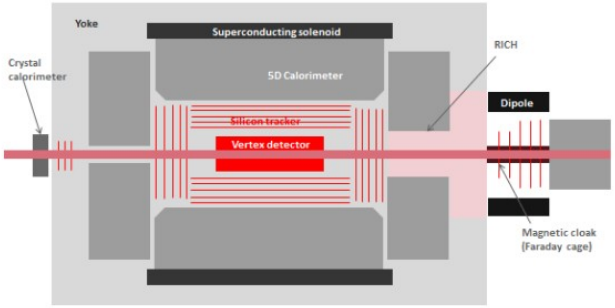
All samples for different tunes available from HepSim

Electron-Ion Collider (EIC) studies

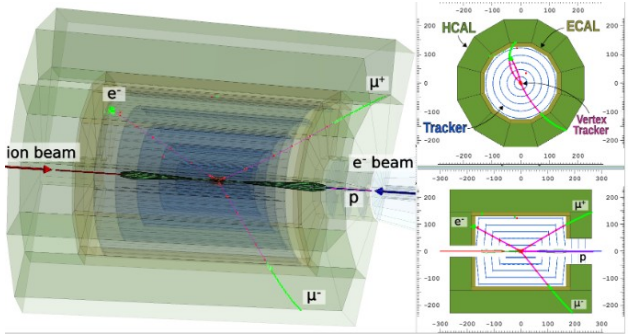
- **HEPSIM used within the EIC software consortium**
  - ANL, JLAB, BNL
- **Initial Argonne concept of 5D detector:**
  - Version 1: **SiEIC** (HEP& Physics divisions):
  - Version 2: **TOPSiDE**: Time-of-flight Optimized PID Silicon Detector for the EIC
- **HEPSIM keeps truth-level files (20 samples), detector geometry, reconstructed events**

See J.Repond talk
W.Armstrong talk

SiEIC



TOPSiDE

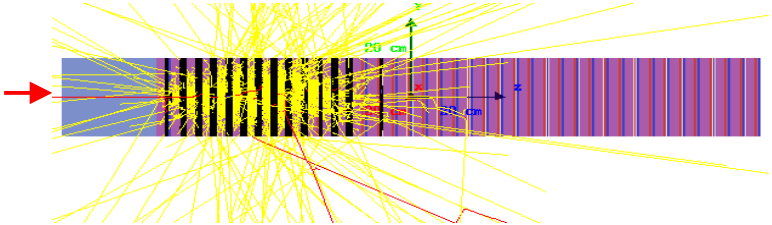


Geant4 single-photon precision simulations

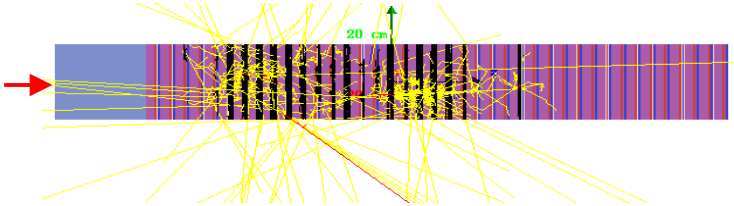
https://atlaswww.hep.anl.gov/hepsim/

- Data samples with simulated optical photons (Cherenkov and Scintillation) in different materials. Used to design hadronic calorimeters for future experiments

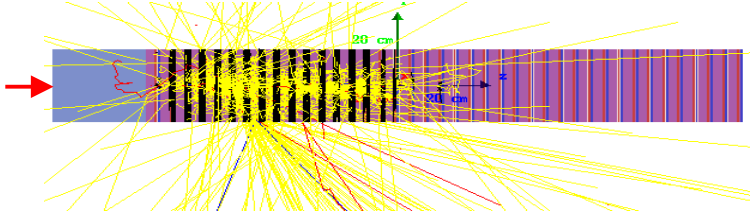
Electrons, 10 GeV



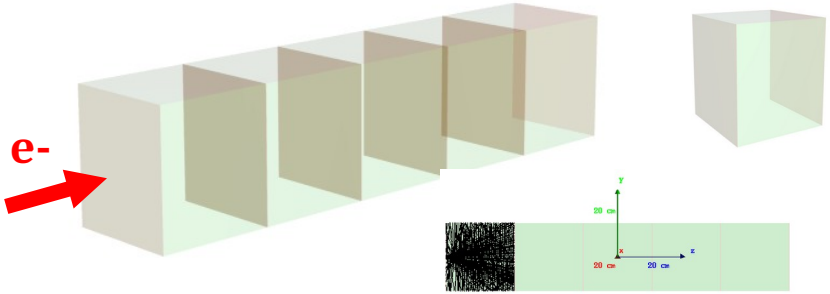
Neutrons, 10 GeV



Pions, 10 GeV



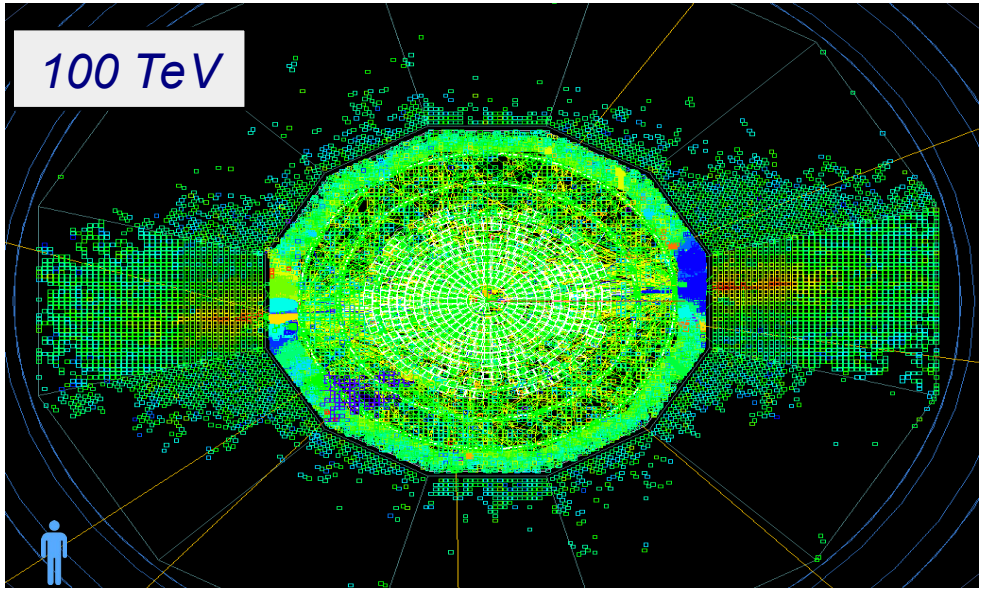
PbWO4 crystals

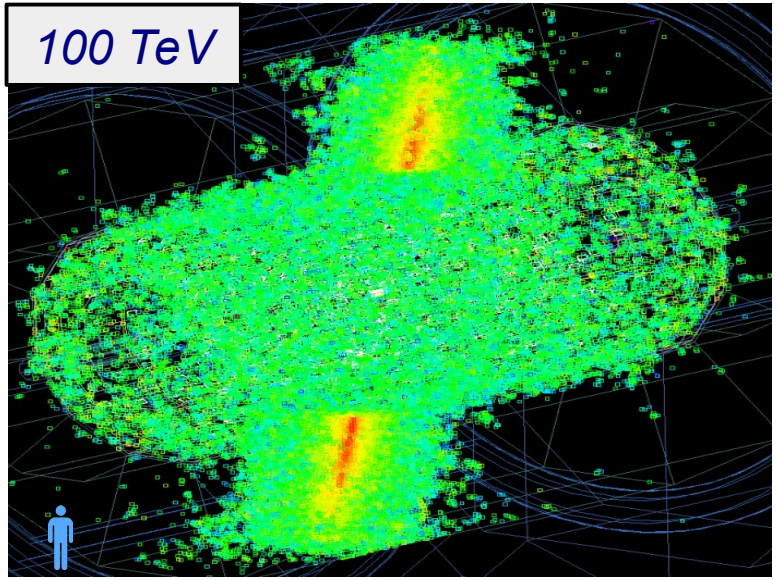


100 TeV pp collider: Event display of Z' (40 TeV) → $q\bar{q}$

World's first Geant4 simulation of ~20 TeV hadronic jets (FCC week, 2016)

High-granularity HCAL, 10k hits in ECAL, 46k hits in HCAL, 12k/1k hits in the outer/inner tracker





Studies of calorimeter granularity went to FCC-hh CDR (CERN, CERN-ACC-2018-0058)

NLO QCD calculations as “ntuples”

Theorists can use it too!

S.C. Adv. High Energy Physics, vol. 2015, 13609

- Stored several NLO QCD calculations (MCFM, JETPHOX, NLOjet++)
- Data structure is different compared to full parton-shower MC
  - “Particle record”: Usually 4-momenta of 3-4 particles per events
  - “Event record”: includes “weights” and deviations from central weights for different PDF eigenvector sets for calculations of PDF uncertainties

$$w_n = \left[1000 \times (1 - \frac{PDF(n)}{PDF(0)})\right]$$

N=1...51, for CT10 PDF

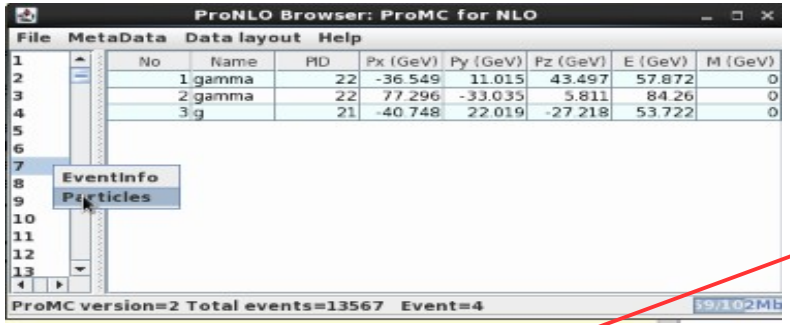
Weighted NLO events can be compactly stored using Google ProtocolBuffers:
→ *double precision “weights” → int64 varint (deviations) → 2 bytes per weight*
→ *Large deviations are stored using 4 or 8 bytes (rarely)*

NLO QCD calculations as “ntuples” for HEP experiments

MCFM prediction for H(→ γγ)+jet (pp 100 TeV)
“higgsjet_gamgam_mcfm” sample

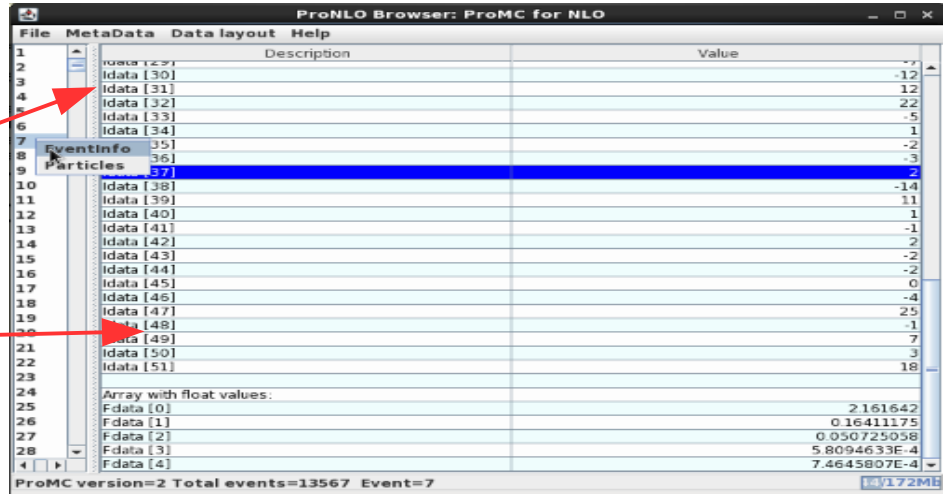
Some NLO samples using MCFM
have been created on Mira supercomputer
(BlueGene/Q)

4-momenta of particles

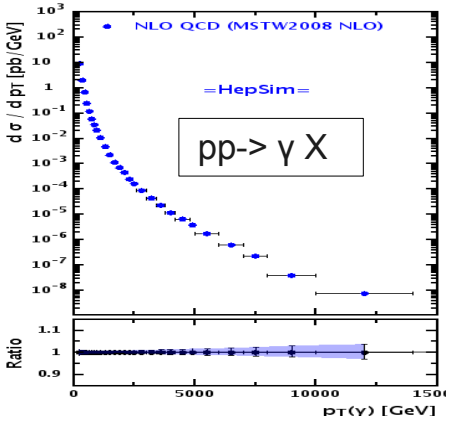


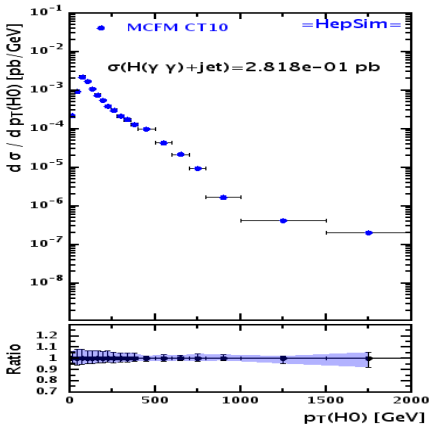
Event weights

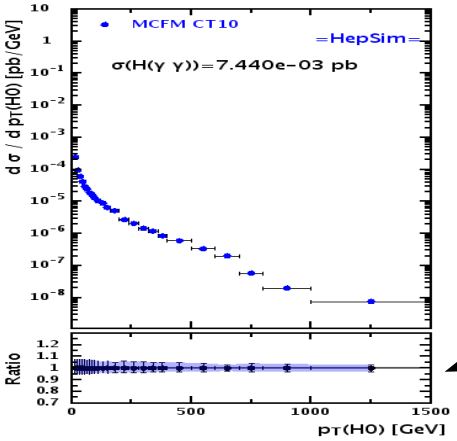
PDF variations for CT10 (51)



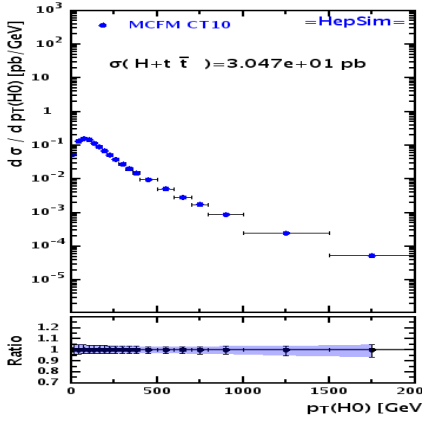
Differential cross sections for 100 TeV pp collider

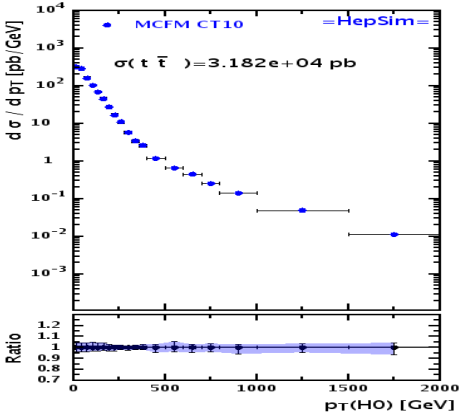


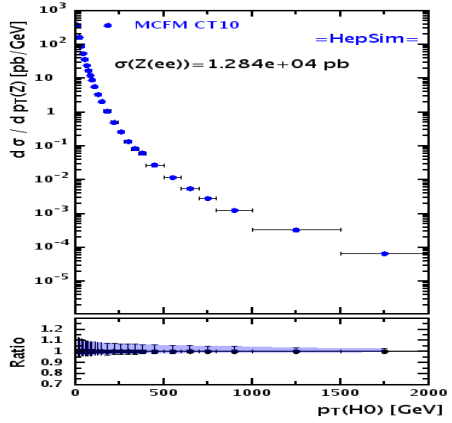




$$\frac{\sqrt{\sum_{i=1}^{N}(\sigma_i - \sigma_0)^2}}{\sigma_0}$$



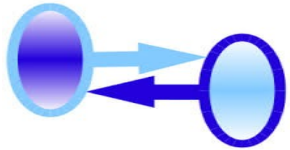




Data creation (~10GB) takes ~10000 CPU*h on a computer cluster

Analysis takes <30 min on a desktop

Thanks!



For more information, see the HepSim web manual and **hs-help** on the command line.

HepSim manual: https://atlaswww.hep.anl.gov/hepsim/doc/

HepSim contributors:
https://atlaswww.hep.anl.gov/hepsim/doc/doku.php?id=hepsim:contributions

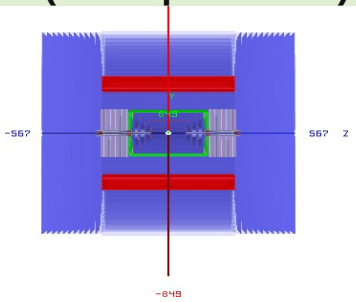
HepSim public results:
https://atlaswww.hep.anl.gov/hepsim/doc/doku.php?id=hepsim:public

~30 articles. Contributions to CEPC, CLIC, FCC-hh etc. conceptual design reports

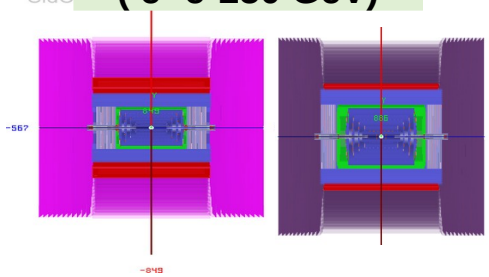
Backup

‘All-silicon’ design concepts supported in HepSim

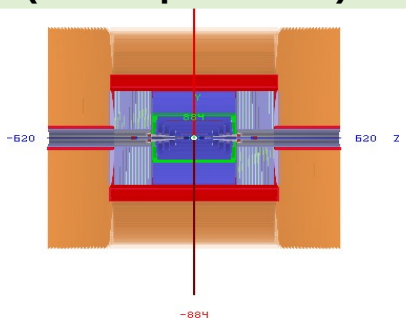
SiD (SiD LO3)
(e^+ e^- up to 1 TeV)



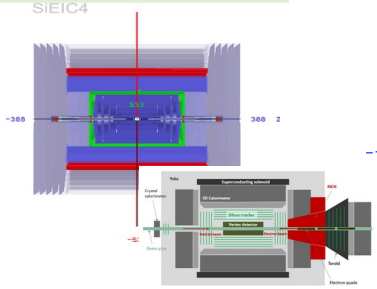
SiCPEC, SiDB
(e^+ e^- 250 GeV)



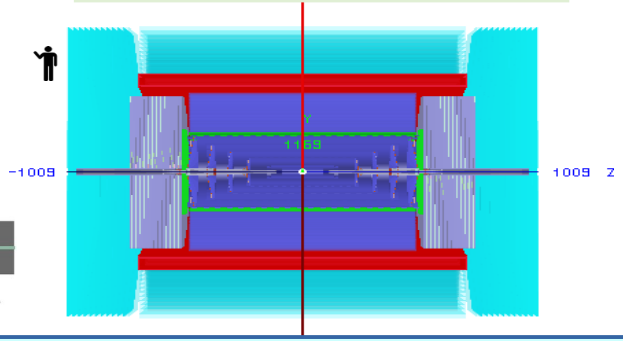
CLIC-SiD (CDR)
(e^+ e^- up to 3 TeV)



SiEIC, TopSide
(ep, 35-141 GeV)



SiFCC + 7 variations
(FCC-hh, pp 100 TeV)



Performance detectors:

- Physics reach studies using Geant4 simulations & full reconstruction
- Playground for various technologies and detector optimizations
- Fast turnover to modify detector & create events samples

Share similar design, but differ in sizes, calorimeter readouts etc

Interfaced with common Monte Carlo samples

Get involved | Full Search | Experiments | Manual | Mirrors | Tools | About | Login

HEP.ANL.GOV

Show all

$p \rightarrow\leftarrow p$
- 8 TeV
- 13 TeV
- 14 TeV
- 27 TeV
- 33 TeV
- 100 TeV

$e^+ \rightarrow\leftarrow e^-$
- 250 GeV
- 380 GeV
- 500 GeV
- 1 TeV
- 3 TeV

$\mu^+ \rightarrow\leftarrow \mu^-$
- 1 TeV
- 5 TeV
- 10 TeV
- 20 TeV
- 40 TeV

HepSim

Repository with Monte Carlo simulations for particle physics

- Apr 15, 2019: Moving to globus (petrel)
- Sep.10 2018: Zprime/DM event samples
- Mar.15 2018: Charged Higgs event samples
- Sep.22 2017: ZHiggs, nunuHXX event samples

Show 25 entries

Previous 1 2 3 4 5 … 13 Next Search:

Id	→←	E [TeV]	Dataset name	Generator	Process	Topic	Files	Created
338	pgun	1	pgun_eta0_b0	PARTICLE GUN	Single particles at Eta=Phi=0 with B-field=0	Single particles	Info	2019/09/03
337	pp	14	tev14pp_pythia8_gammajet_weighted	PYTHIA8	Direct photon production	SM	Info	2018/12/16
336	pp	13	tev13pp_pythia8_minbias_a14	PYTHIA8	MinBias (ND+SD+DD) A14	SM	Info	2018/11/23
335	pp	14	tev14pp_pythia8_minbias_a14	PYTHIA8	MinBias (ND+SD+DD) A14	SM	Info	2018/11/22
334	pp	13	tev13pp_mg5_chaH4FNS	MADGRAPH/PY8	Charged Higgs (H+t) production in 4FNS	Exotics	Info	2018/11/10
333	pp	13	tev13pp_pythia8_qcd_jz	PYTHIA8	QCD multijets with filtered in pT slices	SM	Info	2018/10/31
332	pp	13	tev13pp_pythia8_qcd_em	PYTHIA8	QCD multijets with filtered leptons	SM	Info	2018/10/26
331	pp	13	tev13pp_pythia8_ttbarwz_wgt	PYTHIA8	SM EW and top processes	SM	Info	2018/10/25
330	pp	13	tev13pp_mg5_dm_a_boson	MADGRAPH/PY8	Zprime for dijet+W/Z events and interference	Exotics	Info	2018/10/09
329	pp	13	tev13pp_mg5_dm_boson	MADGRAPH/PY8	Zprime for dijet+W/Z events	Exotics	Info	2018/09/26
328	pp	13	tev13pp_pythia8_rmm	PYTHIA8	Various SM/BSM process for ML	SM	Info	2018/09/16
327	pp	13	tev13pp_qcd_pythia8_proio	PYTHIA8	QCD dijets for ProIO tests	SM	Info	2018/08/27
326	pp	13	tev13pp_qcd_pythia8_proio_tests	PYTHIA8	QCD dijets for tests of ProIO	SM	Info	2018/08/20

Get involved | Full Search | Experiments | Manual | Mirrors | Tools | About | Login

Show all

p →← p
8 TeV
13 TeV
14 TeV
27 TeV
33 TeV
100 TeV

e⁺ →← e⁻
250 GeV
380 GeV
500 GeV
1 TeV
3 TeV

SM
Higgs
Top
Exotic

HepSim

Repository with Mon arlo simulations for particle physics

- March 15 2018: Charged Higgs event samples
- Sep,22 2017: Z+Higgs → nunu+XX event samples
- Sep,15 2017: Higgs → mu+mu- event samples

Select by beam species, CM energy, and topic (SM, Exotic, etc)

ow 25

Previous 1 2 3 4 5 ... 13 Next Search:

Id				Generator	Process	Topic	Files
25	e-p			PYTHIA8	DIS events at Q2>1 GeV2	SM	Info
323	pp		tev13pp_mg5_chaHT_tbeta_hw	MADGRAPH/PY8	H- top with H- to HW and tan(beta)=1-7	Exotics	Info
322	pp	13	tev13pp_mg5_chaHT_tbeta_tb	MADGRAPH/PY8	H- top with H- to tb and tan(beta)=1-7	Exotics	Info
321	pp	13	tev13pp_mg5_chaHW_tbeta_tb	MADGRAPH/PY8	H+ W- with H+ decay to t-bbar tan(beta)=1-7	Exotics	Info
320	pp	13	tev13pp_mg5_chaHW_tbeta_hw	MADGRAPH/PY8	H+ W- with H+ decay to HW for tan(beta)=1-7	Exotics	Info
318	pp	13	tev13pp_pythia8_gamgam	PYTHIA8	Higgs to gamma gamma	SM	Info
315	pp	100	tev100pp_qcd_pythia8_weighted	PYTHIA8	QCD dijets (weighted)	SM	Info
314	pp	27	tev27pp_qcd_pythia8_weighted	PYTHIA8	QCD dijets (weighted)	SM	Info
313	pp	13	tev13pp_mg5_rho_techni	PYTHIA6	Technicolor rho_T to pi_T W	Exotics	Info

Show all

p →← p
8 TeV
13 TeV
14 TeV
27 TeV
33 TeV
100 TeV

e⁺→←e⁻
240 GeV
250 GeV
380 GeV
500 GeV
1 TeV
3 TeV

μ⁺→←μ⁻
250 GeV

HepSim

Repository with Monte Carlo simulations for particle physics

- Nov 1, 2022, Higgs, WW, ZZ production at 240, 250 GeV
- n at 380 GeV

Choose dataset based on generator and process descriptions

Selected: e⁺ e⁻ collisions, all energies, all type **Show selection**

Show 25 entries

Previous 3 Next Search:

Id	→←	E [TeV]	Dataset name	Generator	Process	Topic	Files	Created
356	e+e-	0.24	gev240ee_pythia8_ww_zz	PYTHIA8	Double boson production	Higgs	Info	2022/11/09
355	e+e-	2.4	gev240ee_pythia8_higgs_bbar	PYTHIA8	Higgs to bbar	Higgs	Info	2022/11/09
354	e+e-	0.38	gev380ee_pythia8_ww_zz	PYTHIA8	Double boson production	Higgs	Info	2022/10/27
353	e+e-	0.38	gev380ee_pythia8_higgs_bbar	PYTHIA8		gs	Info	2022/10/27
303	e+e-	0.38	gev380ee_pythia6_zhiggs_nu			gs	Info	2017/09/23
302	e+e-	0.38	gev380ee_pythia6_zhiggs_nunugg	PYTHIA6		gs	Info	2017/09/23
301	e+e-	0.25	gev250ee_pythia6_zhiggs_nunumumu	PYTHIA6	Z+Higgs to nunu+mumu	Higgs	Info	2017/09/23
300	e+e-	0.25	gev250ee_pythia6_zhiggs_nunugg	PYTHIA6	Z+Higgs to nunu+gg	Higgs	Info	2017/09/23
299	e+e-	0.38	gev380ee_pythia8_zhiggs_nunubbar	PYTHIA8	Z+Higgs to nunu+bbar	Higgs	Info	2017/09/21
298	e+e-	0.38	gev380ee_pythia8_zhiggs_nunugg	PYTHIA8	Z+Higgs to nunu+gg	Higgs	Info	2017/09/21

Then click on data set name to look at more closely

HepSim

Repository with Monte Carlo simulations for particle physics

- Apr 15, 2019: Moving to globus (petrel)
- Sep.10 2018: Zprime/DM event samples
- Mar.15 2018: Char... ...mples

This brings up information page for dataset. Starting with basic parameters, integrated luminosity, and a link to the download page

Dataset: *"tev100pp_qcd_pythia8_ptall"*

Summary	
Name:	*tev100pp_qcd_pythia8_ptall*
Collisions:	pp
CM Energy:	100 TeV
Entry ID:	219
Topic:	SM
Generator:	PYTHIA8
Calculation level:	LO+PS+hadronisation
Process:	QCD dijets in bins of pT
Total events:	490000
Number of files:	490
Cross section (σ):	4.582E+07 ± 7.751E+05pb
Luminosity (L):	0.0107 pb^{-1} *(or)* 1.069E-05 fb^{-1} *(or)* 1.069E-08 ab^{-1}
Format:	ProMC
Download URL:	http://mc.hep.anl.gov/asc/hepsim/events/pp/100tev/qcd_pythia8_ptall
Mirrors:	http://portal.nersc.gov/project/m1758/data/events/pp/100tev/qcd_pythia8_ptall
EVGEN size:	36.169 GB

Estimated from file Nr 1

Status: Available

Tags:

Fast simulation: rfast005 | Info — 100 / 1.56 GiB — 10/16/2016

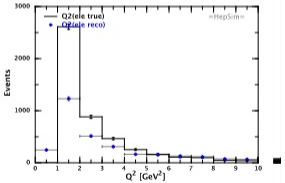
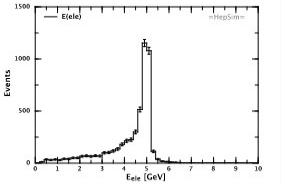
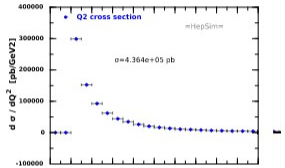
Full simulation: rfull015 | Info — 341 / 15.85 GB — 06/06/2017; rfull009 | Info — 434 / 57.82 GB — 06/23/2017

```
parameter EVGEN:ProcessID [int]
parameter EVGEN:DIS:Q2 [float]      // Truth-level Q^2
parameter EVGEN:DIS:W [float]       // Truth-level W
parameter EVGEN:DIS:XBJ [float]     // Truth_level x_bjorken
parameter EVGEN:DIS:YBJ [float]     // Truth_level y_bjorken
```

Please refer the HepSim manual

File metadata: Show

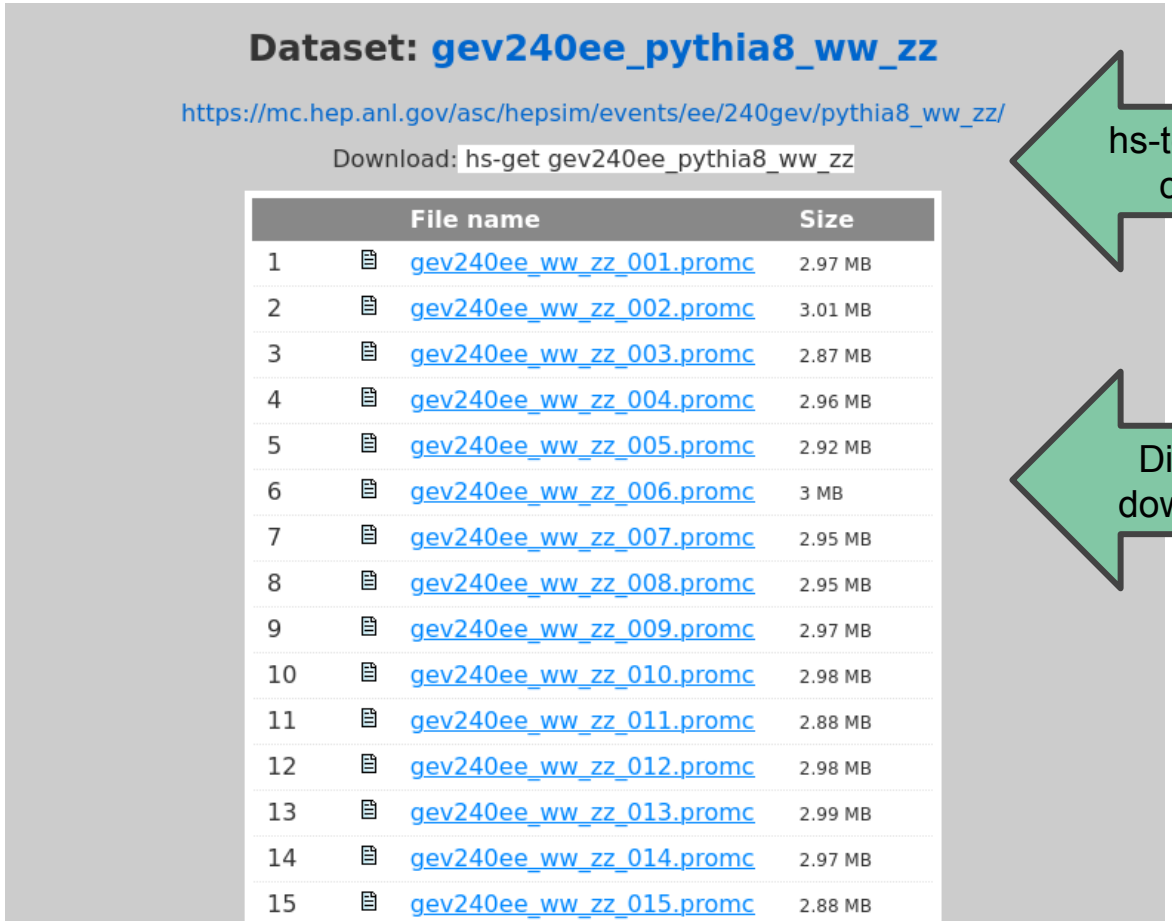
Validation:

Nr	Analysis code	Output image	Output data
1	truth_q2_dislowq2_lcio.py Run		JDAT file
2	truth_ele_dislowq2_lcio.py Run		JDAT file
3	lepto6ard_dislowq2.py Run		JDAT file

Uses Python (Jython) scripts

Can be executed on Web browsers, Windows etc

Web Interface - Truth Level Navigation



Web Interface - Truth Level Navigation

Get involved | Full Search | Experiments | Manual | Mirrors | Tools | About | Login

HEP.ANL.GOV

Show all

- $p \rightarrow\leftarrow p$
  - 8 TeV
  - 13 TeV
  - 14 TeV
  - 27 TeV
  - 33 TeV
  - 100 TeV
- $e^+ \rightarrow\leftarrow e^-$
  - 250 GeV
  - 380 GeV
  - 500 GeV
  - 1 TeV
  - 3 TeV
- $\mu^+ \rightarrow\leftarrow \mu^-$

HepSim

Repository with Monte Carlo simulations for

Navigate by detector and/or experiment

29, 2017: rfull058 tag with improved tracking strategy from
yth
20, 2017: rfull057 tag with alternative tracking strategy from
yth

Here is a list of tags with simulation of detectors.

Tags with full simulations

Nr	Find data	Detector	Experiment	Description
1	rfull001	sidloi3	ILC	Info
2	rfull002	sidcc1	CEPC	Info
3	rfull003	sidloi4	ILC	Info
4	rfull006	sifcch4	FCC-hh, SppC	Info
5	rfull009	sifcch7	FCC-hh, SppC	Info
6	rfull010	sifcch8	FCC-hh, SppC	Info
7	rfull011	sifcch9	FCC-hh, SppC	Info
8	rfull012	sifcch10	FCC-hh, SppC	Info
9	rfull013	sifcch11	FCC-hh, SppC	Info

- 5 TeV
- 10 TeV
- 20 TeV
- 40 TeV

- $e^- \rightarrow \leftarrow p$
- 318 GeV
- 141 GeV
- 35 GeV

- *Misc.*
- 1 particle
- 2 particles
- 1 jet

11	rfull015	sifcch7	FCC-hh, SppC	Info
12	rfull016	sifcch7	FCC-hh, SppC	Info
13	rfull017	sifcch7	FCC-hh, SppC	Info
14	rfull051	sieic1	EIC	Info
15	rfull052	sieic2	EIC	Info
16	rfull053	sieic3	EIC	Info
17	rfull054	sieic4	EIC	Info
18	rfull056	sieic5	EIC	Info
19	rfull057	sieic5		Info
20	rfull058	sieic5		Info
21	rfull059	sieic5		Info
22	rfull101	sidcc2	CEPC	Info
23	rfull201	sidclic1	CLIC	Info

Use Info link to learn more about a tag

Tags with fast simulations

Nr	Available datasets	Detector	Experiment	Info
1	rfast001	delphes_fcchh1	FCC-hh, SppC	Info
2	rfast002	delphes_fcchh2	FCC-hh, SppC	Info

Web Interface - Simulation Tag Navigation

13 TeV
14 TeV
27 TeV
33 TeV
100 TeV

$e^+ \rightarrow \leftarrow e^-$
250 GeV
380 GeV
500 GeV
1 TeV
3 TeV

$\mu^+ \rightarrow \leftarrow \mu^-$
1 TeV
5 TeV
10 TeV
20 TeV
40 TeV

$e^- \rightarrow \leftarrow p$
318 GeV
141 GeV
45 GeV
35 GeV

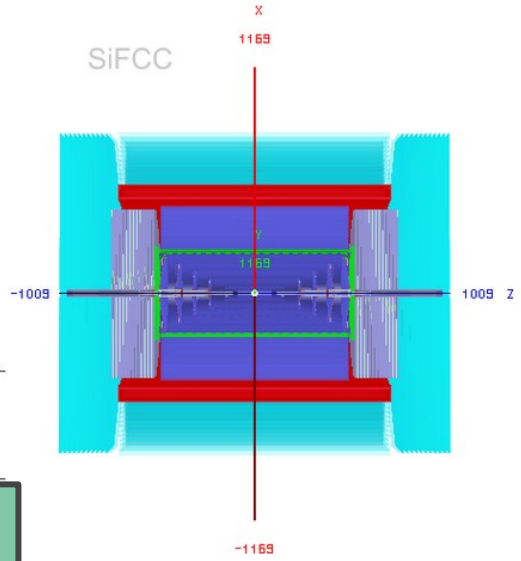
Misc.

Information about the "*sifcch7*" detector

Summary

Name:	*sifcch7*
Title:	*A silicon Detector for FCC-hh studies. Described in JINST 12 (2017) P06009 (arXiv:1612.07291)*
Author:	*S.Chekanov, A.Kotwal, J.Zuzelski, etc.*
Status:	*development*
Version:	*$Id: compact.xml,v3.0 2016/09/09 23:46:56 Sergei Chekanov Exp $*
Level:	Geant4 simulation and full event reconstruction
Summary:	view
3D View:	
GeoManager:	
Calibrations:	view
Tracking:	view
Last modified:	September 07, 201

Interactive 3D Visualization



Reconstruction tags

Tag lists: rfull009 | rfull015 | rfull016 | rfull017

Detector geometry files

HEPREP:	sifcch7.heprep
GDML:	sifcch7.gdml.gz
JSON:	sifcch7.json.gz
LCDD:	sifcch7.lcdd
Pandora:	sifcch7.pandora

Geometry in various formats

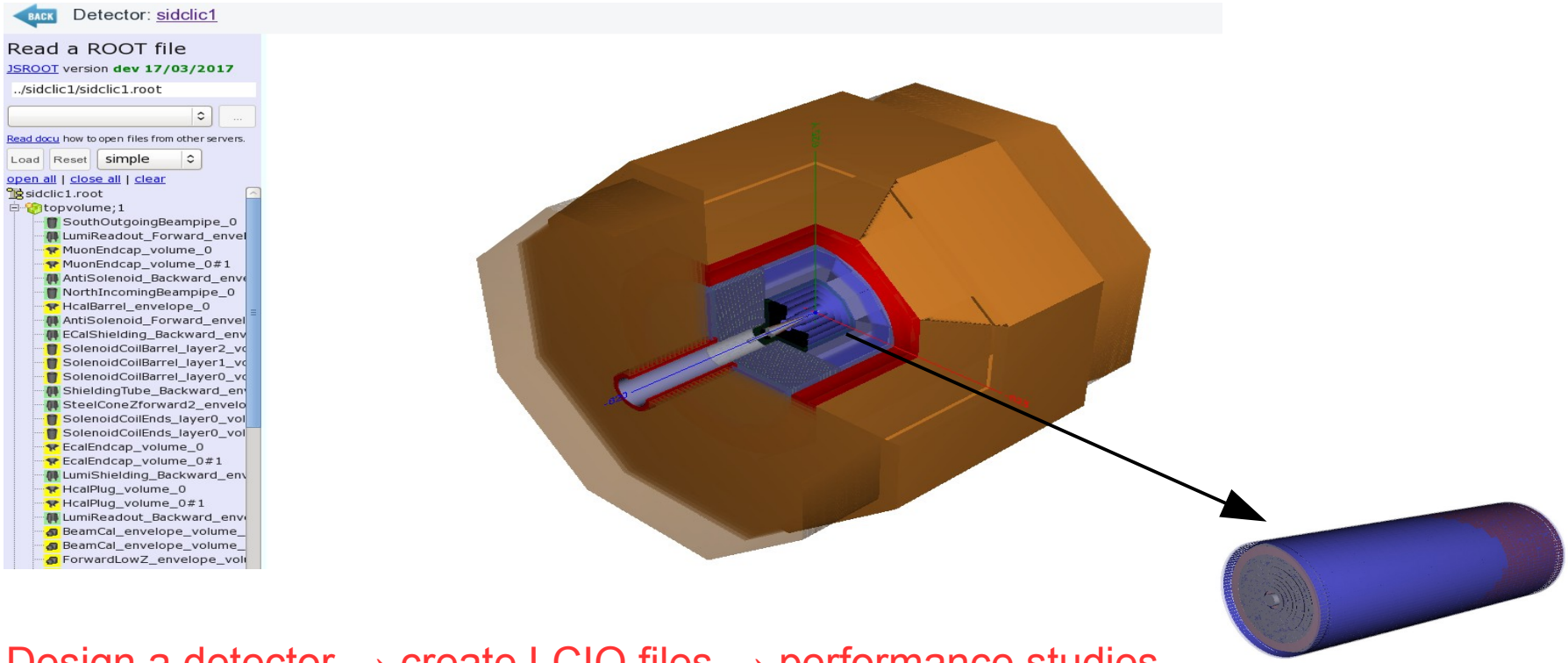
Download of complete detector

Download: sifcch7.zip

Comment

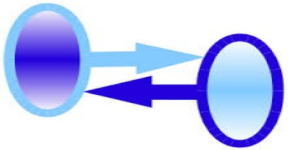
Web-based 3D browser for detector geometries

- Detector volumes can **interactively** be studied in 3D using GeoManager



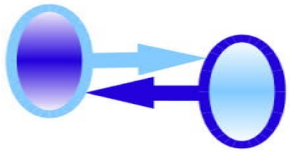
Design a detector → create LCIO files → performance studies

How your work can benefit from HepSim



- **Physics studies:**
  - Use truth-level Monte Carlo samples
  - Use fast detector simulations using Delphes
- **Detector design: full simulation and reconstruction software chain**
  - Using HepSim's truth-level samples as input
  - Produce simulated/reconstructed samples at key points
  - HepSim simulation tags serve as a means to distribute and organize samples
- **Comparisons with previous experiments (+ experiments that have never been built!), technical single particle samples or Geant4 samples for detector designs**

HepSim Tutorial



- How to search and download a file with 10,000 e+e-: H→ bbar process
- What is inside the download file?
- How to fill a few histogram from the truth-level file

Require Java

- How to create Pythia8 events in the HepSim format
- Conversions to ROOT, STDHEP, LCIO, HEPMC formats
- How to create fast Delphes simulations

Require Linux / ROOT / GCC compilers /
/cvmfs/sw.hsf.org/key4hep/

URL link with this tutorial:
https://atlaswww.hep.anl.gov/hepsim/doc/doku.php?id=fcs:fccee:tutorial

FCC-ee HepSim tutorial - 1

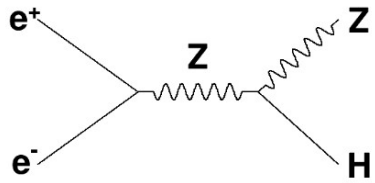
This part of the tutorial does not use any C++ specific libraries and can be done on any computers with Java installed. Check java:

```
java -version
```

Typically, it tells “openjdk version “1.8.0_352” or higher Java version.

```
wget https://atlaswww.hep.anl.gov/hepsim/soft/hs-toolkit.tgz -O - | tar -xz;
source hs-toolkit/setup.sh
```

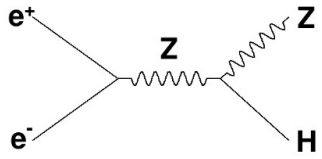
Let's look at a few events: Z→ Z H,
where Z→ nunu, and H decays to bbar.



The CM energy is 250 GeV.

The sample is described in https://atlaswww.hep.anl.gov/hepsim/info.php?item=353

FCC-ee HepSim tutorial – 2 part



First, print all files with Higgs processes: `# hs-find higgs`
Then grab the file with H to bbar at e+e-: `# hs-ls gev250ee_pythia8_zhiggs_nunubbar`
Download 10 files (in 2 threads): `# hs-get gev250ee_pythia8_zhiggs_nunubbar data 2 10`

We should have 10 files in the directory “data”. Take a look at a single file. We what to check how many events in the file, how many events: `# hs-info data/gev250ee_zh_nunubb_001.promc`

Do you want to print 1st event? Do this: `# hs-info data/gev250ee_zh_nunubb_001.promc 1`

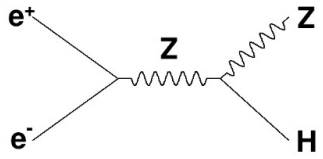
Want to examine the log file? Do this: `# hs-log data/gev250ee_zh_nunubb_001.promc`

Let's study each event in the GUI mode (needs X-session!). Start this GUI and click each event number using the left panel:

`# hs-view data/gev250ee_zh_nunubb_001.promc`

Run over this file using Python syntax and make a few simple distributions:
https://atlaswww.hep.anl.gov/hepsim/doc/doku.php?id=fcs:fccee:tutorial#validation

FCC-ee HepSim tutorial – 3 part



Fast simulations: Use the key4hep setup with gcc11 + ROOT:

```
# source /cvmfs/sw.hsf.org/key4hep/setup.sh

# wget http://atlaswww.hep.anl.gov/asc/promc/download/current.php -O ProMC.tgz
# tar -zvxf ProMC.tgz
# cd ProMC
# ./build.sh                        # build all source files
# ./install.sh lib                  # install into the "lib" directory
# source lib/promc/setup.sh         # make it available
```

Install Delphes:

```
# wget http://cp3.irmp.ucl.ac.be/downloads/Delphes-3.5.0.tar.gz
# tar -zxf Delphes-3.5.0.tar.gz
# cd Delphes-3.5.0;  make
```

Run:

```
# ./DelphesProMC  ./cards/delphes_card_CircularEE.tcl \
  ../data/gev250ee_zh_nunubb_001.root  ../data/gev250ee_zh_nunubb_001.promc
```