

# SoLID simulation with GEMC

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# Outline

- GEMC Update
- SoLID simulation with GEMC 2.x
  - “solid\_gemc” in general
  - EC simulation as an example
- Summary

# GEMC Update: Outline

- GEMC 1.x to 2.x, a major code rewrite
- use factory method as much as possible, easy to add plug-in and expand functionality
- Field map
  - Field info embedded in field map file, no separated definition needed
  - Map Reading 3-4x faster Swimming 30% faster
- Modular physics list (hadron+EM+optical)
- Updated GUI
- geometry and parameters, material, optical properties, hit process and output are all external
- Built-in hit type “flux” and step-by-step hit info
- New features like customized event generator input, voltage signal and FADC support
- Took a lot suggestion from SoLID and MEIC simulation and we contribute to its code and structure also

# GEMC Update: installation

- software installation streamlined by a set of scripts
- part of the general jlab software framework (including jana, ccdb and more)
- Everything in release package, no SVN or github download
- a single version control by env “Jlab\_version”
- Just an “App” to download on Mac, no install needed

Jlab_version	1.0	1.1	1.2	devel
GEMC	1.8	2.1	2.2	2.3?
geant4	9.5	9.5/9.6	10.0	10.1?

# GEMC update: GUI

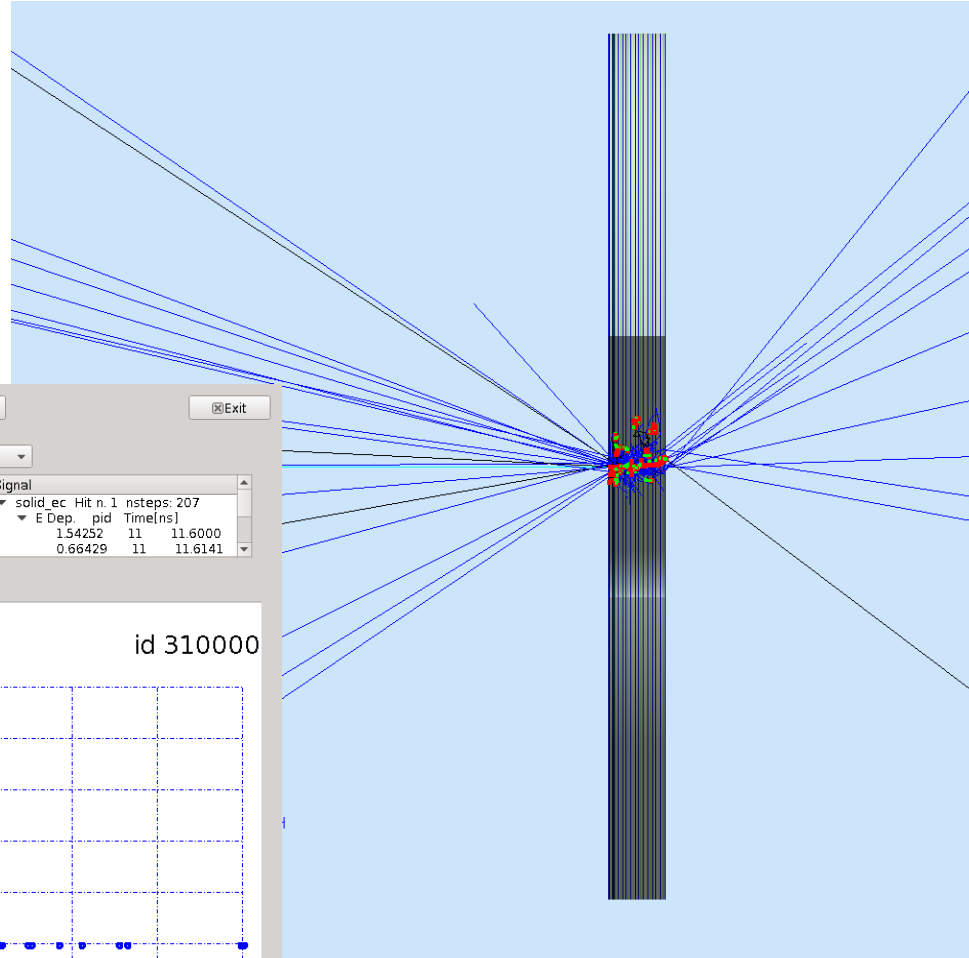
- qt5 and openGL

The screenshot displays the GEMC GUI interface. On the left, a vertical toolbar contains icons for Generator, Camera, Detector, Infos, G4Dialog, Signals, and Physics. The main control area is divided into several sections:

- Generator:** Includes a "N. Events: 1" field and "Run", "Cycle", "Stop", and "Exit" buttons. It features tabs for "Beam 1" and "Beam 2". Under "Momentum:", "Particle Type" is set to "e-". Parameters include p: 8 GeV,  $\theta$ : 25 deg, and  $\phi$ : 0 deg.
- Vertex:** Parameters include vx: 0,  $\Delta x$ : 0, vy: 0,  $\Delta y$ : 0, and vz: 10 cm.
- Hits List:** Shows "solid\_ec 195 hits". A table lists hits:

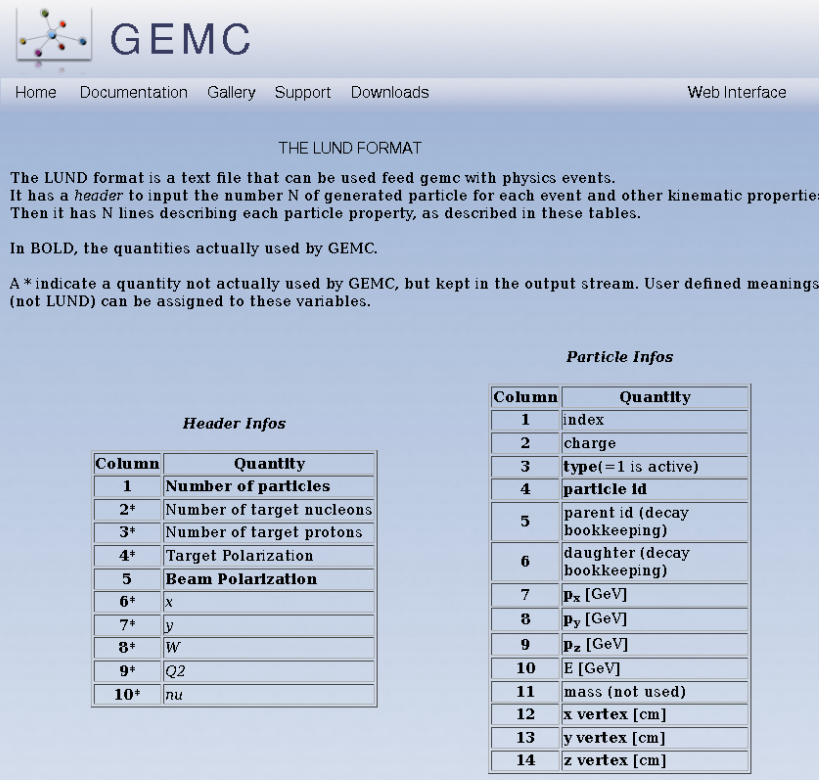
Hit n.	nsteps
Hit n. 1	207
Hit n. 2	134
Hit n. 3	118
- Signal:** A table shows signal data:

solid_ec	Hit n.	nsteps
154252	11	11.6000
0.66429	11	11.6141
- Signal Plot:** A scatter plot titled "id 310000" showing "E Dep." vs "time [ns]". The y-axis ranges from 0.0000 to 1.68, and the x-axis ranges from 11.570 to 13.181. Data points are colored red and cyan.



# GEMC update: Input

- All generators are still fully independent, interface by txt file in customized LUND format
- Fully pass customized header info into output



The screenshot shows the GEMC web interface. At the top, there is a navigation bar with links for Home, Documentation, Gallery, Support, Downloads, and Web Interface. The main content area is titled "THE LUND FORMAT" and contains text explaining the format. Below the text are two tables: "Header Infos" and "Particle Infos".

**Header Infos**

Column	Quantity
<b>1</b>	<b>Number of particles</b>
<b>2*</b>	Number of target nucleons
<b>3*</b>	Number of target protons
<b>4*</b>	Target Polarization
<b>5</b>	<b>Beam Polarization</b>
<b>6*</b>	x
<b>7*</b>	y
<b>8*</b>	W
<b>9*</b>	Q2
<b>10*</b>	nu

**Particle Infos**

Column	Quantity
<b>1</b>	index
<b>2</b>	charge
<b>3</b>	<b>type</b> (= 1 is active)
<b>4</b>	<b>particle id</b>
<b>5</b>	parent id (decay bookkeeping)
<b>6</b>	daughter (decay bookkeeping)
<b>7</b>	<b>p<sub>x</sub></b> [GeV]
<b>8</b>	<b>p<sub>y</sub></b> [GeV]
<b>9</b>	<b>p<sub>z</sub></b> [GeV]
<b>10</b>	<b>E</b> [GeV]
<b>11</b>	mass (not used)
<b>12</b>	<b>x vertex</b> [cm]
<b>13</b>	<b>y vertex</b> [cm]
<b>14</b>	<b>z vertex</b> [cm]

## Example of 2 DVCS events (ePy)

```
3 1. 1. 0 -1 0.209 0.336 6.373 1.448 -1.000
1 -1. 1 11 0 0 0.9636 -0.1675 7.2357 7.3015 0.0005 0.0000 0.0000 0.0000
2 1. 1. 2212 0 0 -0.6536 0.0604 0.3367 1.1935 0.9383 0.0000 0.0000 0.0000
```

# GEMC Update: Optical

- All properties defined external in “table” format similar to geometry

## Optical Properties

- surface
- type
- **optical properties:**
  - ▶ photonEnergy
  - ▶ indexOfRefraction
  - ▶ reflectivity
  - ▶ efficiency
  - ▶ specularlobe
  - ▶ specularspike
  - ▶ backscatter

```
Table of optical photon energies (wavelengths) from 190–650 nm:
my $energy =
" 1.9074494eV 1.9372533eV 1.9680033eV 1.9997453eV 2.0325280eV " .
" 2.0664035eV 2.1014273eV 2.1376588eV 2.1751616eV 2.2140038eV " .
" 2.2542584eV 2.2960039eV 2.3393247eV 2.3843117eV 2.4310630eV " .
" 2.4796842eV 2.5302900eV 2.5830044eV 2.6379619eV 2.6953089eV " .
" 2.7552047eV 2.8178230eV 2.8833537eV 2.9520050eV 3.0240051eV " .
" 3.0996053eV 3.1790823eV 3.2627424eV 3.3509246eV 3.4440059eV " .
" 3.5424060eV 3.6465944eV 3.7570973eV 3.8745066eV 3.9994907eV " .
" 4.1328070eV 4.2753176eV 4.4280075eV 4.5920078eV 4.7686235eV " .
" 4.9593684eV 5.1660088eV 5.3906179eV 5.6356459eV 5.9040100eV " .
" 6.1992105eV ";

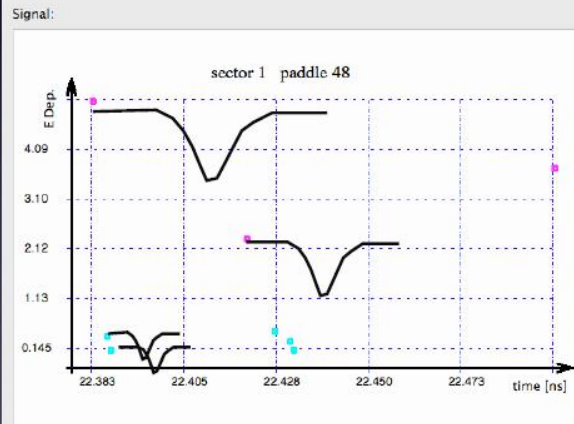
Reflectivity of AlMgF2 coated on thermally shaped acrylic sheets, measured by AJRP,
10/01/2012:
my $reflectivity =
" 0.8331038 0.8309071 0.8279127 0.8280742 0.8322623 " .
" 0.837572 0.8396875 0.8481834 0.8660284 0.8611336 " .
" 0.8566167 0.8667431 0.86955 0.8722481 0.8728122 " .
" 0.8771635 0.879907 0.879761 0.8831943 0.8894673 " .
" 0.8984234 0.9009531 0.8910166 0.8887382 0.8869093 " .
" 0.8941976 0.8948479 0.8877356 0.8876919 0.8999685 " .
" 0.9101617 0.8983005 0.8991694 0.8990987 0.9000493 " .
" 0.9065833 0.9028855 0.8985184 0.9009736 0.9088968 " .
" 0.9015145 0.8914838 0.8816829 0.8666895 0.8496298 " .
" 0.9042583 ";
```

# GEMC Update: Voltage Signal

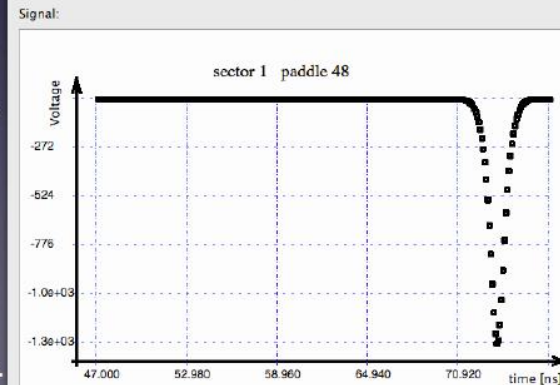
## Voltage Signal

Hits List		Signal			Variables	
▼ ftof_p1a	1 hit	▼ ftof_p1b	Hit n. 1	nsteps: 8	E Dep.	
	Hit n. 1	nsteps: 5	E Dep.	pid	Time[ns]	Mom
▼ ftof_p1b	1 hit		5.07042	211	22.3829	<x>
	Hit n. 1	nsteps: 8	2.34078	211	22.4204	<y>
	ftof_p2		3.73931	211	22.4953	<z>
			0.51959	11	22.4272	Voltage
			0.32308	11	22.4309	
			0.14808	11	22.4317	
			0.42340	11	22.3864	
			0.14539	11	22.3872	

Rise time: 1ns  
 Fall time: 2ns  
 Delay: 50ns  
 1 MeV = 100 mV



Hits List		Signal			Variables	
▼ ftof_p1a	1 hit	-138.44880	1000	72.2000	E Dep.	
	Hit n. 1	nsteps: 5	-175.39975	1000	72.3000	Mom
▼ ftof_p1b	1 hit		-220.80778	1000	72.4000	<x>
	Hit n. 1	nsteps: 8	-276.63591	1000	72.5000	<y>
	ftof_p2		-345.82767	1000	72.6000	<z>
			-432.24899	1000	72.7000	Voltage
			-539.73594	1000	72.8000	
			-669.90878	1000	72.9000	
			-819.10147	1000	73.0000	
			-975.76675	1000	73.1000	
			-1120.34641	1000	73.2000	
			-1229.00382	1000	73.3000	
			-1380.65055	1000	73.4000	



Total Signal is integral of all the step-signals.  
 Amazingly enough signal processing time is small.



# GEMC Update: Outlook

- FADC banks will emulate FADC output, including translation tables
- Hit process routines will be a plugin - completely independent from GEMC, to be loaded at run time. The routines can be stored together with the geometry / materials scripts.
- multithreading, following G4
- C++ 11

# SoLID simulation with GEMC 2.x

## solid\_gemc

- GEMC compiled as a lib during installation by default
- Then add customized hit process routing and other things and link to libgemc.so to keep all GEMC features, similar idea to “solgemc”
- This becomes “solid\_gemc” with matching version of GEMC

Solid\_gemc2/source

2.1

2.2

- Solid\_gemc.cc
- Hitprocess
  - Solid\_hitprocess.h
  - Solid\_ec\_hitprocess.cc
  - Solid\_ec\_hitprocess.h
  - .....

# EC simulation with solid\_gemc

- solid - Revision 746: /subsystem/ec/ec\_solid\_gemc
- ..
- config\_solid\_PVDIS\_ec\_forwardangle.dat
- readme
- solid\_PVDIS\_ec\_forwardangle.gcard
- solid\_PVDIS\_ec\_forwardangle.pl
- solid\_PVDIS\_ec\_forwardangle\_\_bank.txt
- solid\_PVDIS\_ec\_forwardangle\_\_geometry\_Original.txt
- solid\_PVDIS\_ec\_forwardangle\_\_hit\_Original.txt
- solid\_PVDIS\_ec\_forwardangle\_\_materials\_Original.txt
- solid\_PVDIS\_ec\_forwardangle\_\_parameters\_Original.txt
- solid\_PVDIS\_ec\_forwardangle\_real.pl
- solid\_ec\_bank.pl
- solid\_ec\_hit.pl
- solid\_ec\_materials.pl
- solid\_slice.vis

configuration file for generating

input file to run simulation

file to generate geomtry,bank,hit

generated bank

generated geometry

generated hit

generated material

parameters defines geometry

file to generate geometry

file to generate bank

file to generate hit

file to generate material

- Purple and orange files needed to generate files for simulation
- Red files needed to run simulation
- Red and orange files are in “table” format, they can be in
  - txt file
  - Database (mysql now, CCDB soon)
  - expanded to more sources

## An example line of a txt file

```
solid_PVDIS_ec_forwardangle_real_shower | root
|solid_PVDIS_ec_forwardangle_real_shower | 0*cm 0*cm
350*cm | 0*deg 0*deg 0*deg | ff0000 | Tube | 110*cm
365*cm 21.728*cm 0*deg 360*deg | G4_AIR | no | 1 | 1 | 1
| 1 | 1 | no | no | no
```

# Customized hit process routine

## “solid\_ec”

```
insert_bank_variable(\%configuration, $bankname, "bankid", $bankid, "Di", "$bankname bank ID");
insert_bank_variable(\%configuration, $bankname, "pid", 1, "Di", "ID of the first particle entering the sensitive volume");
insert_bank_variable(\%configuration, $bankname, "mpid", 2, "Di", "ID of the mother of the first particle entering the sensitive volume");
insert_bank_variable(\%configuration, $bankname, "tid", 3, "Di", "Track ID of the first particle entering the sensitive volume");
.....
insert_bank_variable(\%configuration, $bankname, "id", 24, "Di", "id number");
insert_bank_variable(\%configuration, $bankname, "hitn", 99, "Di", "Hit Number");
```

solid\_ec\_bank.pl

```
dgtz["pid"] = (double) aHit->GetPID();
dgtz["mpid"] = (double) aHit->GetmPID();
dgtz["tid"] = (double) aHit->GetTId();
.....
dgtz["id"] = id;
dgtz["hitn"] = hitn;
```

solid\_ec\_hitprocess.cc

- Totally flexible to any raw and digitized hit processing and output, fit any level of simulation and digitization need
- As far as the two match each other to give consistent result, “solid\_gemc” need recompile if any change

# Hit process control

## solid\_ec\_hit.pl

```
$hit{"name"} = "solid_ec";  
$hit{"description"} = "solid ec hit definition";  
$hit{"identifiers"} = "id";  
$hit{"signalThreshold"} = "0*MeV";  
$hit{"timeWindow"} = "400*ns";  
$hit{"prodThreshold"} = "1*mm";  
$hit{"maxStep"} = "1*cm";  
$hit{"delay"} = "10*ns";  
$hit{"riseTime"} = "1*ns";  
$hit{"fallTime"} = "1*ns";  
$hit{"mvToMeV"} = 100;  
$hit{"pedestal"} = -20;
```

- Fine tuning hit processing without source code change
- No need to recompile solid\_gemc

# External parameters

solid\_PVDIS\_ec\_forwardangle\_\_parameters\_  
Original.txt

```
Nlayer | 194 | | Nlayer | - | - | - | - | - | - | -  
Thickness_lead | 0.05 | cm | Thickness_lead | - | - | - | - | - | - | -  
Thickness_scint | 0.15 | cm | Thickness_scint | - | - | - | - | - | - | -  
Thickness_gap | 0.024 | cm | Thickness_gap | - | - | - | - | - | - | -  
Thickness_shield | 1.0274 | cm | Thickness_shield | - | - | - | - | - | - | -  
Thickness_prescint | 2 | cm | Thickness_prescint | - | - | - | - | - | - | -  
Thickness_support | 2 | cm | Thickness_support | - | - | - | - | - | - | -  
z_shower | 350 | cm | z_shower | - | - | - | - | - | - | -  
Rmin | 110 | cm | Rmin | - | - | - | - | - | - | -  
Rmax | 365 | cm | Rmax | - | - | - | - | - | - | -  
Sphi | 0 | deg | Sphi | - | - | - | - | - | - | -  
Dphi | 360 | deg | Dphi | - | - | - | - | - | - | -
```

- It can take source from survey data
- And can be part of calibration database

# solid\_gemc summary

- status
  - EC, GEM, MRPC, SPD have initial implementation at various stages
  - Cherenkov implementation is under work
- advantage
  - fast MC and full MC within one framework
  - The exact same files for standalone simulation and combined simulation

# Other things

- Record simulation condition
  - GEMC record all input options into EVIO file
  - We can think of ways to record detector related input (as SVN or github version or database entry with index like run number? It will depends on where we store them)
- Output file format
  - “evio2root”, convert evio to root tree, included with framework
  - “clas-root”, read evio like a root tree, will include <https://userweb.jlab.org/~gavalian/clas12docs/sphinx/html/rootio/introduction.html>
- Documentation
  - Nice GEMC tutorials available
  - Doxygen for source code
  - Wiki [https://hallaweb.jlab.org/wiki/index.php/Solid Software](https://hallaweb.jlab.org/wiki/index.php/Solid_Software)