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Installation of GEANT4 toolkit at CARDS computer cluster:

Technical Guide on building GEANT4.9.4 on Ubuntu 8.04 LTS

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Defence R&D Canada – Ottawa

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Abstract

To assist the ongoing risk assessment of radiological threats carried out at DRDC Ottawa, the GEANT4 radiation transport toolkit has been successfully installed on the CARDS computing cluster, and is ready for wide use. The ROOT package has also been installed and integrated into the GEANT4 framework for analysis purposes. The installed packages have been tested and work well with the local system.

Résumé

Afin d'aider à l'évaluation continue des risques associés aux menaces radiologiques menée à RDDC Ottawa, on a installé avec succès la trousse de simulation du transport du rayonnement GEANT4, dans la grappe d'ordinateurs CARDS, et elle est prête à être utilisée à grande échelle. On a également installé le progiciel ROOT, qui a été intégré au cadre d'applications de GEANT4 comme outil d'analyse. Les progiciels installés ont été mis à l'essai et sont compatibles avec le système local.

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Executive summary

Installation of GEANT4 toolkit at CARDS computer cluster

Chuanlei Liu; DRDC Ottawa CR 2012-178; Defence R&D Canada – Ottawa; October 2012.

Background: Radiological and Nuclear (RN) terrorism presents a threat to both Canadian civilians and and the Canadian Forces. The risk assessment and radiation detection are the two key parts in defending against RN threats. Both benefit from Monte Carlo simulations for calculating the effects of radiation. DRDC Ottawa requires a high quality RN simulation tools for radiation transport: the GEANT4 toolkit is one of these.

Principal results: The GEANT4 radiation transport simulation toolkit has been installed on the CARDS computing cluster at DRDC Ottawa. This document describes the procedure for installing the GEANT4 package and the related supporting libraries such as CLHEP and the ROOT analysis tool. In addition, the procedure described in this report can also serve as a guide for package upgrades or re-installation.

Significance of results: This report documents the setup of the GEANT4 radiation transport toolkit so that it can be used for RN risk assessment at DRDC Ottawa. The toolkit installed on the DRDC Ottawa CARDS cluster has been tested and shown to work well with the local system, and is ready for wide use.

Future work: It is without doubt that all software packages have a life cycle, and upgrades are generally required in the presence of patched and new versions. Therefore, it is recommended to keep track of the development of these software tools so that they can updated when necessary.

Sommaire

Installation of GEANT4 toolkit at CARDS computer cluster

Chuanlei Liu ; DRDC Ottawa CR 2012-178 ; R & D pour la défense Canada – Ottawa ; octobre 2012.

Contexte : Le terrorisme radiologique et nucléaire (RN) constitue une menace tant pour les civils canadiens que pour les Forces canadiennes. L´évaluation des risques et la détection du rayonnement sont les deux éléments clés de la défense contre les menaces RN. Ces deux volets profitent des simulations de Monte Carlo permettant de calculer les effets du rayonnement. RDDC Ottawa a besoin d´outils de simulation RN de haute qualité concernant le transport du rayonnement; la trousse GEANT4 en est un.

Résultats : La trousse de simulation du transport du rayonnement GEANT4 a été installée dans la grappe d´ordinateurs CARDS à RDDC Ottawa. Le présent document comporte une description de la procédure d´installation du progiciel GEANT4 et des bibliothèques nécessaires associées, comme CLHEP et l ´outil d´analyse ROOT. De plus, la procédure d ´écrite dans le présent rapport peut également servir de guide pour la mise à jour ou la réinstallation du progiciel.

Importance : Le présent rapport documente la configuration de la trousse de simulation du transport du rayonnement GEANT4 afin de permettre son utilisation pour l´évaluation des risques à RDDC Ottawa. La trousse installée dans la grappe CARDS de RDDC Ottawa a fait l´objet d´essais qui ont révélé sa compatibilité avec le système local et est prête à être utilisée à grande échelle.

Perspectives : Il ne fait aucun doute que tout progiciel est soumis à un cycle de vie, et des mises à jour sont généralement requises sous la forme de versions corrigées ou de nouvelles versions. Ainsi, il est recommandé de se tenir au courant des développements entourant ces outils logiciels de façon à pouvoir les mettre à jour lorsque nécessaire.

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1 Introduction

Radiological and Nuclear (RN) terrorism presents a real threat to both Canadian civilians and Force. The risk assessment and the effectiveness on the radiation detection are the critical part in defensing RN threats, and nowadays tend to be more and more relying on the Monte Carlo simulation method. DRDC Ottawa secures a new RN simulator, GEANT4 (GEometry ANd Tracking) [1] radiation transport toolkit, to assist the current ongoing risk assessment work.

This report is the log file generated by installing GEANT4 release 4.9.4 on the CARDS Ubuntu 8.04.4 LTS Linux cluster. Additionally, this document can also be used as a guide for possible GEANT4 re-installation in the future. More comprehensive instructions can be found for these interested on the Internet, of which the recommended resource guides to read are from the GEANT4 homepage [2] and the SLAC GEANT4 Team [3]. Following similar procedures given in both recommended resources but adapting to the local system environment, GEANT4.9.4 has been successfully built up locally on the RACK cluster and is ready for wide use.

2 Requirements of GEANT4 installation

The GEANT4 package was initiated, developed and maintained by the High Energy Physics (HEP) community. Some specific tasks relevant to HEP such as random number generation, four vector computation and so on, are provided by a dedicated external class library CLHEP [4] (Class Library for High Energy Physics); Therefore, a successful CLHEP installation is a prerequisite for GEANT4 installation.

The gcc compiler is the other prerequisite in order to compile both CLHEP and GEANT4. As discussed in some GEANT4 fora, the version of the gcc compiler could be an issue for certain CLHEP releases and Linux platforms. In our case, a few versions of gcc compilers were tested and proved to be compatible with the local Linux system and the GEANT4 release under consideration.

The Listing 1 consists of a few checks before starting installation, with an attempt to understand the operating system and locally installed packages.

Listing 1: The OS and installed libraries at head-node

```
$ printenv | grep G4
// should return nothing to ensure GEANT4 was not previously installed

$echo $OSTYPE
linux-gnu

```

```
$ lsb_release -a.
Distributor ID: Ubuntu
Description:    Ubuntu 8.04.4 LTS
Release:        8.04
Codename:       hard

$ gcc -v
Using built-in specs.
Target: x86_64-linux-gnu
Configured with: ../src/configure -v
--enable-languages=c,c++,fortran, objc,obj-c++,treelang
--prefix=/usr --enable-shared --with-system-zlib --libexecdir=/usr/lib
--without-included-gettext --enable-threads=posix --enable-nls
--with-gxx-include-dir=/usr/include/c++/4.2 --program-suffix=-4.2
--enable-clocale=gnu --enable-libstdcxx-debug --enable-objc-gc
--enable-mpfr --enable-checking=release --build=x86_64-linux-gnu
--host=x86_64-linux-gnu --target=x86_64-linux-gnu
Thread model: posix
gcc version 4.2.4 (Ubuntu 4.2.4-1ubuntu4)
```

3 GEANT4 Installation

In this section, a step-by-step instruction is given on the pre-installation of the CLHEP library and the following GEANT4 package build-up. Before going any further, two directories are defined. One is the *documentation(source) directory* which is used to store and unpack downloaded packages. The other is the *build directory* where all build products are installed. During all installation steps below, these two directories refer to

Listing 2: Pre-defined directories

```
$ export SRCPATH=$HOME/Documents
$ export G4PATH=/mirror/geant4
```

3.1 CLHEP release

The CLHEP 2.1.0.1 is suggested to be the version compatible with GEANT4.9.4. In addition, the CLHEP 2.1.1.0 released in August 2011 is also tested to support GEANT4.9.4. Therefore, we downloaded the CLHEP 2.1.1.0 source package and successfully compiled it as the external library to GEANT4.9.4. Note that the GEANT4.9.5 released in December of 2011, last month, comes with an embedded CLHEP library. In this special case, the user has the option to use either the built-in or user-compiled CLHEP library.

3.2 gcc compiler

The gcc versions available at the head-node are 4.1.2, 4.2.4 and 4.6.2. The former two versions are installed under /usr/lib/gcc/x86_64-linux-gnu/ directory and the latter one is in /opt/local directory.

As mentioned above, warnings are given about the compatibility of the specific version of gcc compiler with certain CLHEP releases. Therefore, we checked these gcc compilers available at the head node and made tests in building CLHEP. The gcc version 4.2.4 and 4.6.2 (built by Pierre-Luc Drouin of RMC/Calian) are tested to work with CLHEP 2.1.1.0. Since the gcc compiler 4.6.2 has not yet distributed to any of slave nodes of CARDS cluster, we take gcc version 4.2.4 to proceed the following installations.

3.3 The CLHEP build-up procedure

Below are the steps to install CLHEP 2.1.1.0 at the head-node.

Step 1. Download the source file

Go to *http://proj-clhep.web.cern.ch/proj-clhep/DISTRIBUTION/* and download the source package for CLHEP2.1.1.0 to the *source* directory. The size of the tar file is about 4.1 M-bytes.

Step 2. Unpack the tar file

Go to the directory where the downloaded package was saved and unwind the tar file with command *tar -zxvf clhep-2.1.1.0.tgz*.

Step 3. Configure with a customized path, as shown in Listing 3

The path here is the location to place installed files (bin, lib and include) and should be explicitly given with a full (absolute) path. If option *prefix* is not specified, the default directory /user/local is used to install these files. In the latter case, only the privileged user of the system has the permission to run the configuration.

Listing 3: CLHEP configuration

```
1 // create the installation directory
2 $ mkdir -p $G4PATH/CLHEP/2.1.1.0
3
4 // go to the source directory
5 $ cd $HOME/Documents/2.1.1.0/CLHEP
6 $ ./configure --prefix $G4PATH/CLHEP/2.1.1.0 |  tee configure.log
```

The configure.log is the log file for this configuration step. The presence of any errors in this step may indicate a failure of finding CLHEP dependencies.

Step 4. Run the CLHEP build process, as shown in Listing 4

Listing 4: CLHEP build up and install

```
$ make -j 8 | tee make.log
$ make install -j8 | tee make_install.log
$ ls $G4PATH/CLHEP/2.1.1.0/
  bin  include  lib
```

The *make -j 8* step aims to build a temporary copy of libraries and executables, while the following step with *make install -j 8* is to copy these binary and header files together with libraries into the *build* area specified in the *configure* step. This second step is essential and especially helpful to simplify the procedure to integrate CLHEP to other packages. As the installation completes, listing the installation area will show directories such as *bin*, *include* and *lib*.

For now, you are done with setting up CLHEP library. For more detailed instruction on CLHEP installation, please visit CLHEP web site [4].

3.4 The GEANT4.9.4 installation procedure

After CLHEP installation, we can move to the next stage to build and install GEANT4.9.4.

Step 1. Download GEANT4.9.4 source package and the related data files

Go to *http://geant4.cern.ch/support/source_archive.shtml* to get the GEANT4 source package of interest. (or *http://geant4.cern.ch/support/download.shtml* to get the latest release.) The downloaded package, for example the geant4.9.4.p03.tar.gz file, is saved under *documentation* directory.

The standard data files for HEP processes (for example, the electromagnetic, hadronic, decay processes and so on) are included in the GEANT4 package. However, for using certain specific processes such as nuclear fission, photon evaporation or radioactive processes, the user is responsible for getting appropriate data files and implementing them into the GEANT4 framework. Wide application of GEANT4 in many scientific fields such as nuclear physics, medical physics and astrophysics leads to the presence of data files dedicated for specific process/purpose. Therefore, it is rather easy to find these up-to-date data files and incorporate into GEANT4.

For RED (Radiation Explosure Device) study, all data files except the *neutron data files with thermal cross sections* at *http://geant4.cern.ch/support/download.shtml* have been down-

loaded locally. These data files were saved in the same directory as the GEANT4 installation area. Uncompress these files with

Listing 5: Uncompress data files

```
$ cd $G4PATH
$ pwd
  /mirror/geant4

$ mkdir -p geant4-build/9.4.p03 geant4-build/data
$ ls $G4PATH/geant4-build
  9.4.p03  data
// the data files are stored alongside GEANT4 installation directories
$ ln -s geant4-build geant4

// uncompress data files after saving them in "data" subdir
$ cd $G4PATH/geant4-build/data
$ ls -1 *.gz | awk '{print "tar -zxvf "$1}' | sh
```

Step 2. GEANT4 initial build

The initial configuration/build starts with invoking *./Configure -build* command as shown in Listing 6, following which the dependency of GEANT4 to system and other packages like CLHEP and data files are tested and configured. In this step, you will be prompted with many questions about the configuration. In most cases, the default answer will be taken except these specific questions given below.

Listing 6: Start the GEANT4 initial build

```
$ cd  $SRCPATH
$ pwd
  /mirror/chuanlei/Documents

$ ls
  geant4.9.4.p03.tar.gz geant4.9.4.p03

$ cd geant4.9.4.p03
$ ./Configure -build
 // Or if you already have a configuration file called config.sh and
 // you want to take all options in this fill, then do
 // $ ./Configure -e -build -f config.sh
```

The following are the first part of these questions that need a response

Listing 7: Part 1 of initial build: questions about config file and installation directory

```
There exists a config.sh file. Shall I use it to set the defaults? [y]
Fetching default answers from your old config.sh file...

```

```
Do you expect to run these scripts and binaries on multiple machines?[n]
n

*OPTIONS FOR GEANT4 INSTALLATION PATHS*
What is the path to the Geant4 source tree?
[/mirror/chuanlei/Documents/geant4.9.4.p03]

Where should Geant4 be installed?  [/mirror/geant4/geant4/9.4.p03]

Do you want to install all geant4 headers in one directory? [n] y
```

The last step in Listing 7 will take an additional time to place all header files (>3k files) in the *include* directory. However, having all header files in one directory sometimes will ease the installation process of some other packages for which the path of GEANT4 header files must be specified. One such example is the AIDA [5] package installation.

Listing 8: Part 2 of initial build: questions on building libraries

```
*geant4 LIBRARY BUILD OPTIONS*
Do you want to build shared libraries? [y] y
Do you want to build static libraries too? [n] n
Do you want to build global libraries? [y]
Do you want to build granular libraries as well? [n]
Do you want to build libraries with debugging information? [n]
```

If you answer *yes* in both static and shared libraries for questions shown in Listing 8, the installation process is OK; however, problems might occur when running the GEANT4 application. The reason is not investigated or understood so far. So be advised to take the default answers in this step if there are no specific reasons for a change.

The following part in Listing 9 is for a check and inclusion of data files. In this step, make sure all data files needed are available for inclusion into the GEANT4 framework. A good example here is the *PhotonEvaporation2.1* data file that is not yet available, so the failure message advises to get these missing files included. On the other hand, if the default answer *f* is entered in this case, all installation process and the application run perfectly OK. However, the results related to γ radiation could be incorrect.

Listing 9: Part 3 of initial build: questions about the including data files

```
*CHECKS AND OPTIONS FOR geant4 PHYSICS DATA FILES*
Specify the path where the geant4 data libraries are installed:
[/mirror/geant4/geant4/data]

checking for PhotonEvaporation2.1... no
checking for RadioactiveDecay3.3... yes
checking for G4EMLOW6.19... yes
checking for G4NDL3.14... no
checking for G4ABLA3.0... yes
```

```
checking for RealSurface1.0... yes
checking for G4NEUTRONXS1.0... yes
checking for G4PII1.2... yes

Failed to locate one or more of the Geant4 data libraries in

/mirror/geant4/geant4/data

Please enter
1) Another path to search in
2) 'f' to force the use of the path you entered previously (the data
   libraries are NOT needed to build geant4, but are needed to run
   applications later).
3) 'c' to customize the data paths, e.g. if you have the data
   libraries installed in different locations.
[f]
```

In case there are multiple processors available on the system, one can run the GEANT4 installation in parallel, fully utilizing CPU resources. This is done by specifying the number of parallel jobs and is illustrated below in Listing 10.

Listing 10: Part 4 of initial build: questions about running parallel jobs

```
How many parallel jobs should make launch? [1] 8
```

The following is the place to include CLHEP into GEANT4 framework. This is done by specifying the path of the CLHEP installation area.

Listing 11: Part 5 of initial build: questions about the CLHEP package

```
Is this the CLHEP installation you want to use?
[/usr/local] /mirror/geant4/CLHEP/2.1.1.0

You can customize paths and library name of you CLHEP installation:

1) CLHEP_INCLUDE_DIR:           /mirror/geant4/CLHEP/2.1.1.0/include
2) CLHEP_LIB_DIR:               /mirror/geant4/CLHEP/2.1.1.0/lib
3) CLHEP_LIB:                   CLHEP
```

GEANT4 comes with several visualization interfaces. One can answer the questions below to select one visualization tool of interest. In the RED study, OpenGL is chosen for visualization purposes.

Listing 12: Part 6 of initial build: questions about the visualization tool installation

```
*OPTIONS FOR geant4 VISUALIZATION DRIVERS*
Enable building of visualization drivers? [y]
Enable building of the X11 OpenGL visualization driver? [n] y
......
Enable building of the X11 RayTracer visualization driver? [n] y
```

The questions coming up by the end of initial build looks like those in Listing 13. The last chance is given to re-configure your installation.

Listing 13: Part 7 of initial build: finalize the configuration step

```
Creating configuration setup file...

WARNING: the generated configuration file can be edited if necessary!
You can introduce any change to the configuration file

$SRCPATH/geant4.9.4.p03/.config/bin/Linux-g++/config.sh
before the final installation.

To do so, use a shell escape now
(e.g. !vi $SRCPATH/geant4.9.4.p03/.config/bin/Linux-g++/config.sh).
```

After entering a confirmation without changing any configuration options, the GEANT4 library building process starts. It takes less than 10 minutes to complete the initial build process if all 8 cores at the head-node are used. The last part of the message in this step reads like

Listing 14: The last part of message of the initial build

```
Creating global shared library ..../lib/Linux-g++/libG4interfaces.so ...
Creating shared library ..../lib/Linux-g++/libG4modeling.so ...
Creating shared library ..../lib/Linux-g++/libG4vis\_management.so ...
Creating shared library ..../lib/Linux-g++/libG4FR.so ...
Creating shared library ..../lib/Linux-g++/libG4visHepRep.so ...
Creating shared library ..../lib/Linux-g++/libG4RayTracer.so ...
Creating shared library ..../lib/Linux-g++/libG4VRML.so ...
Creating shared library ..../lib/Linux-g++/libG4Tree.so ...
Creating shared library ..../lib/Linux-g++/libG4visXXX.so ...
Creating shared library ..../lib/Linux-g++/libG4GMocren.so ...
Creating shared library ..../lib/Linux-g++/libG4gl2ps.so ...
Creating shared library ..../lib/Linux-g++/libG4OpenGL.so ...
Building library management utility liblist ...
Libraries installation completed !

#####################################################
# Your Geant4 installation seems to be successful!
# To be sure please have a look into the log file:
# $SRCPATH/geant4.9.4.p03/.config/bin/Linux-g++/g4make.log
#####################################################
```

The log file of the initial build step is saved in ./config/bin/Linux-g++/g4make.log file, from which one can obtain more information about this process. You can be relieved once seeing the message about successful installation. Take a coffee before going to the next step.

Step 3. Copy lib, inc and src files into the installation area

After the initial library building process, the built products are stored in the same directory where the GEANT4 source code is located. If only the single user mode is needed, one can run GEANT4 without issues right at this stage of installation. If one likes to distribute GEANT4 to other users (the multi-user mode which GEANT4 supports), one additional command (as shown in Listing 15) is needed in order to copy all built products and **src** files to the predefined installation area given in Listing 7.

Listing 15: Final installation for multi-user mode

```
$pwd
  /mirror/chuanlei/Documents/geant4.9.4.p03

$ ./Configure -install

On this machine the

G4SYSTEM=Linux-g++
G4INSTALL=/mirror/chuanlei/Documents/geant4.9.4.p03
G4INCLUDE=/mirror/geant4/geant4/9.4.p03/include/geant4
G4TMP=/mirror/chuanlei/Documents/geant4.9.4.p03/tmp
G4LIB=/mirror/chuanlei/Documents/geant4.9.4.p03/lib
G4LEVELGAMMADATA=/mirror/geant4/geant4/data/PhotonEvaporation2.1
G4RADIOACTIVEDATA=/mirror/geant4/geant4/data/RadioactiveDecay3.3
G4LEDATA=/mirror/geant4/geant4/data/G4EMLOW6.19
G4NEUTRONHPDATA=/mirror/geant4/geant4/data/G4NDL3.14
G4ABLADATA=/mirror/geant4/geant4/data/G4ABLA3.0
CLHEP_BASE_DIR=/mirror/geant4/CLHEP/2.1.1.0
CLHEP_INCLUDE_DIR=/mirror/geant4/CLHEP/2.1.1.0/include
CLHEP_LIB_DIR=/mirror/geant4/CLHEP/2.1.1.0/lib
CLHEP_LIB=CLHEP
G4VIS_BUILD_OPENGLX_DRIVER=1
G4VIS_USE_OPENGLX=1
G4LIB_BUILD_SHARED=1

Starting installation...

Installing sources...
Installing headers...
Installing header files in /mirror/geant4/geant4/9.4.p03/include/geant4
Installing libraries...

$ ls $G4PATH/geant4/9.4.p03
  include  lib  src
```

The GEANT4 installation is in principle complete now. The following additional steps are used to create scripts to set up GEANT4 environment variables to ensure proper use.

Step 4. Create environment setup script and the working directory

Starting from here, all necessary libraries, header files and source files are installed under the *build* directory. Note that the src directory under $\$G4PATH/geant4/9.4.p03$ contains all of the useful example applications, and the default environment setup script can be created from there.

As shown in Listing 16, once the *Configure* command is issued without any options, the GEANT4 environment setup scripts (env.sh or env.csh) are created and copied to the local directory to be ready for use. Every time when using GEANT4, this script should be executed before hand. If taking a closer look at this script, you will find that all relevant environment setup for use of GEANT4 are there, for example, the CLHEP, data file and the visualization tool etc..

Listing 16: GEANT4 environment setup script

```
$ cd $G4PATH/geant4/9.4.p03/src/geant4
$ ls
  config  Configure  environments  examples  source

$ ./Configure
$ ls
  config  Configure  env.csh  environments  env.sh  examples  source

$ export G4WORKDIR=~/g4work
$ source env.sh
```

The evn.sh[csh] script will be copied to your current directory after issuing the *Configure* command, and from where you can set your GEANT4 env by *source env.sh[csh]* every time you are about to use GEANT4. The "export" step in Listing 16 is to create a working directory for your concrete GEANT4 application. Note that the working directory is suggested to be separated from both GEANT4 *source* and *build* area.

To save efforts on the GEANT4 environment setup, you may wish to put a piece of code like that in Listing 17 in a shell initialization file like /.bashrc, /.bash_login, or /.bash_profile etc.. By doing this, every time when bash shell is invoked, the GEANT4 environment will be automatically set up right away for use.

Listing 17: Set up GEANT4 environment in shell initialization files

```
## for geant env setup
export G4WORKDIR=$HOME/g4work

export G4INDIR=/mirror/geant4
export LD_LIBRARY_PATH=$G4INDIR/CLHEP/2.1.1.0/lib/:$LD_LIBRARY_PATH
source $G4INDIR/geant4/9.4.p03/src/geant4/env.sh
```

4 ROOT installation

As shown in some application examples in the GEANT4.94 package, the AIDA (Abstract Interfaces for Data Analysis [5]) interface is used to support histogramming and ntuple purpose. As the name implies, AIDA provides an *abstract* interface understandable to the actual application tool in which the common physics analyses requiring histograms, ntuples trees and plots are performed.

Alternatively, ROOT [6] (an object-oriented program and library developed by CERN) can be easily integrated into the GEANT4 framework to meet histogram and ntuple needs. Different from AIDA, ROOT must use concrete objects in order to apply methods. ROOT is able to do similar work as what AIDA does (except the multiple file format support), however it possesses more powerful analysis functionality. In this project, ROOT was selected as the analysis tool and the installation procedure is given below in detail.

Step 1. Download ROOT source

Download the pro version of ROOT from website *http://root.cern.ch/drupal/content/production-version-532*, unpack the file and follow steps in the README/INSTALL file to install.

Step 2. Do the location independent installation

As the installation instruction at webpage *http://root.cern.ch/drupal/content/installing-root-source* says, one can choose the build and installation methods to meet the specific installation requirements and user needs. Two different installation methods are provided, location dependent (fixed location) or independent. The fixed location installation is preferred in case that multiple users will run ROOT and the permission of installing at a system location (/user/local is by default) is granted. With this method, all users don't have to specify the ROOT PATH in order to run ROOT.

However, in case of no system super-user privilege to install, one can take the second method to install ROOT at the directory where it was built in, and later simply set the ROOT system variables to PATH and LD_LIBRARY_PATH. In our case, the ROOT was built and installed using the second method describing here, as shown in Listing 18. In this method, the configuration step is provided without any options.

Listing 18: ROOT configuration without options

```
1 $ cd $G4PATH/root/5.32
2 $ ./configure
```

Step 3. Build and install ROOT library

After running *make* command once as shown in Listing 19, The ROOT libraries were built and installed locally where the source files are.

Listing 19: Start to build and install ROOT library

```
$ time make -j9
$ source ./bin/thisroot.sh
```

The second step here is to add the *bin* and *lib* paths to the system environment PATH and LD_LIBRARY_PATH variables.

Step 4. Run *root* command to test

Just run the *root* command to check the installation. For a successful installation, you will be greeted with a welcome interface like below in Listing 20 to verify your root installation.

Listing 20: Running root command

```
chuanlei@headnode:~$ root

   ****************************************
   *                                      *
   *        W E L C O M E  to  R O O T     *
   *                                      *
   *   Version   5.32/00   2 December 2011  *
   *                                      *
   *  You are welcome to visit our Web site  *
   *          http://root.cern.ch          *
   *                                      *
   ****************************************

ROOT 5.32/00 (branches/v5-32-00-patches@42372,
De 15 2011, 15:35:00 on linuxx8664gcc)

CINT/ROOT C/C++ Interpreter version 5.18.00, July 2, 2010
Type ? for help. Commands must be C++ statements.
Enclose multiple statements between { }.
root [0]
```

Step 5. Set ROOT bin and lib path for future use

In order to simplify your use of the *root* package in the future, you might wish to set up the *root* environment in the shell initialization file, as explained in GEANT4 environment setup step. Simply adding the following piece of code given in Listing 21 next to the GEANT4 environment setup in the same file.

Listing 21: ROOT environment setup

```
## for root
source /mirror/geant4/root/5.32/bin/thisroot.sh
#export ROOTSYS=/mirror/geant4/root/5.32
#export PATH=$ROOTSYS/bin:$PATH
#export LD_LIBRARY_PATH=$ROOTSYS/lib:$LD_LIBRARY_PATH
```

It could be mid-night after the installation described above, if yes, please don't take any more coffee rather than go to sleep directly.

5 Testing GEANT4 installation with an application

For the purpose of testing the current GEANT4 installation, an application (the A01 example under examples/extended/analysis directory) has been built at the working directory. The results from the follow-up test proves the successful installation. The following are all the steps to perform this test.

Step 1. Copy A01 application to the GEANT4 working directory

Start the test with copying the A01 application into the current GEANT4 working directory.

Listing 22: Get A01 application

```
$ echo $G4WORKDIR
  /mirror/chuanlei/g4work
$ cd  $G4WORKDIR

$ cp -r $G4INSTALL/examples/extended/analysis/A01 .

$ cd A01/
$ ls
A01app.cc              heprep2-000-gz.mac   README
aida.mac               heprep2-000-zip.mac  README.JAIDA
bheprep2-000-gz.mac    heprep2gz.mac        setup-analysis.csh
bheprep2-000-zip.mac   heprep2.mac          setup-analysis.sh
bheprep2gz.mac         heprep2zip.mac       setup-analysis.win32
bheprep2.mac           History              src
bheprep2zip.mac        include              test.in
GNUmakefile            novis.mac            test.out
hadlist.gmk            opengl.mac           vis.mac
```

Step 2. Compile A01

Just run *make* to compile the application. The very end of the compilation message is given in Listing 23, indicating a successful compilation.

Listing 23: Compile A01 application

```
$ make
......

Compiling A01PrimaryGeneratorMessenger.cc ...
Creating shared library
/mirror/chuanlei/g4work/tmp/Linux-g++/A01app/libA01app.so ...
Compiling A01app.cc ...
Using global libraries ...
Linking A01app
... Done!
```

Step 3. Run A01app

Try to run A01 application with a graphic interface by following steps shown in Listings 24 and 25.

Listing 24: Start to run A01app

```
$ A01app

*************************************************************
 Geant4 version Name: geant4-09-04-patch-03    (9-December-2011)
                      Copyright : Geant4 Collaboration
                      Reference : NIM A 506 (2003), 250-303
                            WWW : http://cern.ch/geant4
*************************************************************

Visualization Manager instantiating with verbosity "warnings (3)"...
Visualization Manager initializing...
Registering graphics systems...

You have successfully registered the following graphics systems.
Current available graphics systems are:
  ASCIITree (ATree)
  DAWNFILE (DAWNFILE)
  G4HepRep (HepRepXML)
  G4HepRepFile (HepRepFile)
  RayTracer (RayTracer)
  VRML1FILE (VRML1FILE)
  VRML2FILE (VRML2FILE)
  gMocrenFile (gMocrenFile)
  OpenGLStoredX (OGL)
  OpenGLImmediateX (OGLI)
```

```
  OpenGLStoredX (OGLS)
  OpenGLImmediateX (OGLIX)
  OpenGLStoredX (OGLSX)
  RayTracerX (RayTracerX)

......

Idle>
```

Make sure the OpenGL graphic system was registered when checking the output messages.

Listing 25: Run one event with visualization

```
Idle> /vis/open OGL
// will open the OpenGL graphic interface window.

Idle> /vis/drawVolume
// draw detector layout

Idle> /vis/scene/add/trajectories
Idle> /vis/scene/add/hits
// to visualize the trajectories and hits

Idle> /run/beamOn 1
// start to run 1 event

Idle> /vis/ogl/set/printMode pixmap
// this step must be performed before the next step in case of
// crash problems found graphic interface remotely as doing here.

Idle> /vis/ogl/printEPS
File G4OpenGL_0.eps has been saved
```

In the end, the detector setup and one event has been simulated and the graphic illustration has been saved as a EPS file, which is shown in Figure 1.

6 Summary and plans

The GEANT4 toolkit and the ROOT analysis tool have been successfully installed locally at the head node of the CARDS cluster and are ready for use by all users. Although we are trying to get the latest version installed, it is without doubt that new versions with improvement or patching versions with fixed debug are available from time to time. It is necessary to keep the software up to date, probably not so frequently, but at least in case of a big improvement relevant to its functionality or performance. Therefore, keeping updated on the latest news about this software and a periodic update/upgrade on the package is definitely good in term of maintenance and improvement.

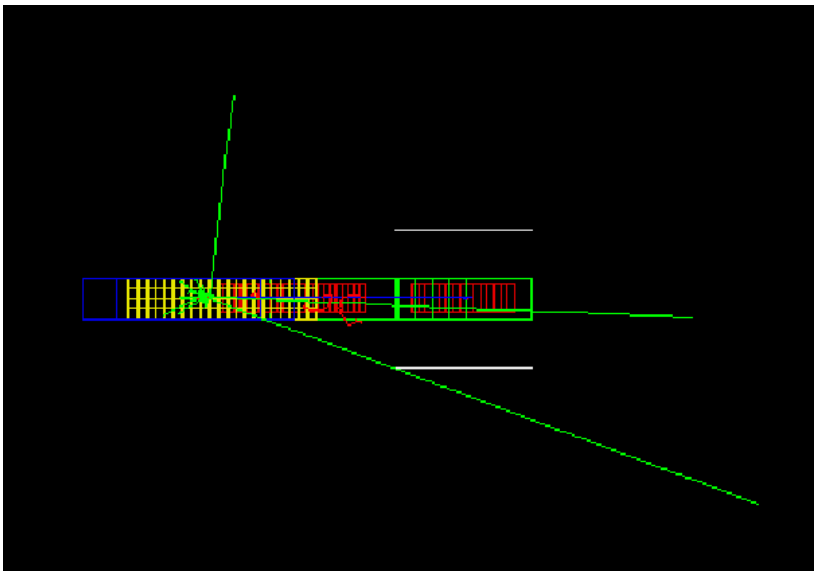

Figure 1: A visualized event simulation in A01 example

References

[1] S. Agostinelli et al., Nuclear Instruments and Methods in Physics Research, **A 506**, 250-303, (2002)

[2] GEANT4 homepage: https://geant4.web.cern.ch/geant4/support/gettingstarted.shtml

[3] SLAC GEANT4 Team webpage: http://geant4.slac.stanford.edu/installation/

[4] CLHEP project webpage: http://proj-clhep.web.cern.ch/proj-clhep/

[5] AIDA webpage: http://aida.freehep.org/index.thtml

[6] ROOT webpage: http://root.cern.ch/drupal/

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To assist the ongoing risk assessment of radiological threats carried out at DRDC Ottawa, the GEANT4 radiation transport toolkit has been successfully installed on the CARDS computing cluster, and is ready for wide use. The ROOT package has also been installed and integrated into the GEANT4 framework for analysis purposes. The installed packages have been tested and work well with the local system.

Afin d'aider à l'évaluation continue des risques associés aux menaces radiologiques menée à RDDC Ottawa, on a installé avec succès la trousse de simulation du transport du rayonnement GEANT4, dans la grappe d'ordinateurs CARDS, et elle est prête à être utilisée à grande échelle. On a également installé le progiciel ROOT, qui a été intégré au cadre d'applications de GEANT4 comme outil d'analyse. Les progiciels installés ont été mis à l'essai et sont compatibles avec le système local.

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GEANT4 installation
CLHEP (Class Library for High Energy Physics) installation
ROOT analysis tool
Monte Carlo Simulation
Ubuntu 8.04.4 LTS
Linux system
gcc compiler
Radiation Transport and Detection