How to create an interface between UrQMD and Geant4 Toolkit

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Abstract

An interface between the UrQMD-1.3cr model (version 1.3 for cosmic air showers) and the Geant4 transport toolkit has been developed. Compared to the current Geant4 (hybrid) hadronic models, this provides the ability to simulate at the microscopic level hadron, nucleus, and anti-nucleus interactions with matter from 0 to $10^{12}$ eV/A with a single transport code. This document provides installation requirements and instructions, as well as class and member function descriptions of the software.
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1 Introduction

Geant4 [1] use many transport codes to generate non-elastic reactions in macroscopic targets. The motivation was to provide a satisfactory level of description of final state hadron production for accurate and comprehensive simulations of particle detectors used in modern particle and nuclear physics experiments.

In Geant4 [1] there are mainly 4 codes which are frequently applied for simulating N-body collisions within the hadronic cascade models, namely, Binary [2], Bertini [3], FTF[4] and QGS[5]. The Geant4 Binary and Bertini cascade models implement large resonance collision term but multiparticle production through string formation and fragmentation is not considered, which sets the upper limit of model applicability in nucleon induced reactions to about 5 GeV/c incident momentum. In contrast to Binary and Bertini cascade models, FTF and QGS, takes multiparticle production into account, to handle interaction for particles above about 15-20 GeV/c.

For a reliable description of secondaries produced in high and low energy domains, Geant4 invoke Binary (Bertini) in the FTF(QGS) models. The corresponding hybrid model is called FTFB(QGSB).

To improve the simulation, it is worthwhile to supplement Geant4 toolkit with a single transport code which takes into account both resonance and multiparticle production. The UrQMD (Ultra relativistic Quantum Molecular Dynamics) model [6], which is first released in 1998, is designed to simulate (ultra) relativistic heavy ion collisions in a wide energy range from Bevalac and SIS up to AGS, SPS and RHIC. Thanks to the UrQMD collaborators, the UrQMD is provided as open source Fortran code on its website.

**Geant4-UrQMD** interface offers interactions of Protons, neutrons, pions and kaons (and their antiparticles) as well as light and heavy ions interactions with matter. It gives type, mass, energy, and momentum of all secondary
particles that are created in matter. Similar to CORSIKA-UrQMD [7] interface, the upper energy limit is recommended to be about several 100 GeV. For the simulation, the appropriate UrQMD cross sections (for determining the mean free path between interacting particles) are used. However, the probability for an interaction with matter at a given point is computed by the Geant4 cross sections classes.

This document provides installation requirements and instructions of the Geant4-UrQMD interface. More details about validation with Geant4 cascade models can be found in Ref.[8]. This interface is sponsored by King Abdulaziz City for Science and Technology /National Center for Mathematics and Physics- Saudi Arabia under the contract number 31-465.
2 Brief description of UrQMD model

The UrQMD model version 1.3cr (for cosmic air shower) is a Monte Carlo event generator for simulating hadron-hadron, hadron-nucleus, nucleus-nucleus interactions from $0$ to $10^6$ MeV. The main goal is to gain understanding about physical phenomena within a single transport mode. As such, it is relevant both to high-energy hadron/ion accelerators and cosmic radiation environments.

The UrQMD model is based analogous principles as the quantum molecular dynamic (QMD) model and the relativistic QMD (RQMD): the mean field potential applied to hadrons is treated similar to QMD, while the treatment of the collision term is similar to RQMD.

Compared with Geant4 simulation codes (e.g., Binary, Bertini, FTF, QGSM…), UrQMD has the following improvements to its physics (see Ref.[6] for full description):

- The collision term of the UrQMD treats 55 different baryon species (including nucleon, $\Delta, \Lambda, \Sigma, \Xi$ and $\Omega$ and their resonances with masses up to 2.25 GeV/$c^2$) and 32 different meson species (including strange meson resonances with masses up to 1.9 GeV/$c^2$) as well as their antiparticles and explicit isospin projected states. For excitations with higher masses than 2 GeV/$c^2$ the string model is used (The exited hadronic states can either be produced in inelastic $hh$ collision, resonance decays or string decays).
- All of these hadronic states can propagate and re-interact in phase-space.
- A mean field potential can be applied for the scattered nucleons.
• An analytic expression for the differential cross section of in-medium NN elastic scattering derived from the collision term of the relativistic Boltzmann-Uehling-Uhlenbeck (RBUU) equation is used to determine the scattering angles between the outgoing particles in hh collisions.

• An introduction of the formation time and leading pre-hadron effects. For the leading pre-hadrons, a reduced cross section is adopted according to the constituent quark model.

UrQMD-1.3cr is freely available from the website http://urqmd.org/.
3 Installation requirements

The Geant4 interface to UrQMD-1.3cr (for cosmic air showers) uses the following software tools and packages:

1. UrQMD-1.3cr (available at http://urqmd.org/ website)
2. The following Geant4 versions:
   - ver.9.3.p01 or ver.9.5

The interface and original UrQMD-1.3cr source code have been compiled and tested using:

- gcc 4.1.2 with g77 (FORTRAN77), gfortran (FORTRAN95) and GNUmake

Operating systems used for this test is: Red Hat Linux 4.1.2-64
4 Interface design

The use of UrQMD-1.3cr physics in Geant4 has resulted in the introduction of a new event model (\texttt{G4UrQMD1_3Model}).

4.1 Logical description of \texttt{G4UrQMD1_3Model}

The general steps in the logical sequence of the design are:

1. **Instantiation of \texttt{G4UrQMD1_3Model}**

   Upon instantiation of the UrQMD-1.3cr interface, the class constructor initialises variables associated with the class and the UrQMD-1.3cr FORTRAN model. The latter involves initialisation of a series of common-block variables from the C++ code, mimicking the initialisation process performed by the FORTRAN code when used in standalone mode.

2. **Generation of the interaction events**

   In order to generate interaction events, the \texttt{ApplyYourself} member function of Geant4 is executed. The details of the projectile and target are determined (e.g., mass number, charge, projectile energy…).

   If no data exist for the specific projectile-target combination, a “waning” is declared, and the program is stopped.
4.2 Class structure for model

The interface comprises **G4UrQMD1_3Model** class, which is derived from **G4HadronicInteraction**, and is defined within the Geant4 user physics list if access to **UrQMD1_3** physics is required. It controls initialisation of **UrQMD-1.3c** through common block variables.

A small FORTRAN subroutine is included with the G4UrQMD distribution. This is required to ensure that block data initialisation in G4UrQMD-1.3c is performed (through FORTRAN EXTERNAL statements). Specifically the new FORTRAN subroutine is:

- **g4urqmdblockdata.f**
5 Instructions for software installation in geant4-9.3

5.1 Installing UrQMD-1.3cr and building the libG4hadronic.urqmd13 library

Copy the file `g4urqmd-1.3cr.2012.tar` (available at [https://twiki.cern.ch/twiki/bin/view/Sandbox/Geant4UrQMDinterface](https://twiki.cern.ch/twiki/bin/view/Sandbox/Geant4UrQMDinterface)) to the directory:

```
cd $G4INSTALL/source/processes/hadronic/models
```

Unzip or untar the files, e.g.:

```
tar –xvzf g4urqmd-1.3cr.2012.tar
```

This creates the directory `UrQMD13`, which looks like:

![Diagram of UrQMD13 directory structure]

Note that the header and C++ files (`G4UrQMD1_3Interface.hh` & `G4UrQMD1_3Model.hh`) and `G4UrQMD1_3Model.cc` are in `UrQMD13/include` and `UrQMD13/src` respectively.

Change directory:

```
cd UrQMD13/UrQMD13src
```
If the file urqmd-1.3cr.tar doesn’t already exist in the directory, copy it from the web-site: http://urqmd.org/.

Execute the script patch_make_and_install.csh from a csh/tcsh environment. This initiates 2 steps:

1- All the relevant FORTRAN files are compiled in UrQMD13src, using
   
   FC= g77
   LD=g77
   FFLAGS=-g -Wall -Wsorprising -fbound -check
   LDFAGS= -g

2- The object files are copied to the directory:
   
   $G4TMP/$G4SYSTEM/G4hadronic_UrQMD13

Change directory and execute make on the C++ source:

   cd ..
   make

This will build the library:

   $G4LIB/$G4SYSTEM/libG4hadronic_UrQMD13.a

but note that the Gnumake file of your application must explicitly identify this library and the UrQMD1_3 headers. So in GNUmake file for you application, please add the following line:

CPPFLAGS += -I$(G4BASE)/processes/hadronic/models/UrQMD13/include

Note that if you perform:

   make clean

from UrQMD13 directory, this deletes the FORTRAN-compiled object files which were from UrQMD13/UrQMD13src to $G4TMP/$G4SYSTEM/libG4hadronic_uqmd13. Therefore, you should either re-copy the files, or re-run the script
patch_make_and_install.csh before performing a make in directory UrQMD13.

5.2 The main () program

Geant4 does not provide the main(). In the main(), one has to construct G4ProcessManager, in order to process a run for the interface.

Ensure that the GNUmake file for you application (in “main” directory) includes the following lines:

CPPFLAGS += -I$(G4BASE)/processes/hadronic/models/UrQMD13/include

EXTRALIBS += -L$(G4INSTALL)/lib/$(G4SYSTEM) -lG4hadronic_UrQMD13

If you want to compile the Geant4-UrQMD interface from your “main” directory, please add these lines in GNUmake file:

EXTRA_LINK_DEPENDENCIES:= $(G4INSTALL)/lib/$(G4SYSTEM)/libG4hadronic_UrQMD13.so

$G4INSTALL)/lib/$(G4SYSTEM)/libG4hadronic_UrQMD13.so: cd $(G4BASE)/processes/hadronic/models/UrQMD13; $(MAKE)
6 Class descriptions (summary)

Class G4UrQMD1_3Model

Public member functions

| Function | Description |
|----------|-------------|
| G4UrQMD1_3Model(const G4String& name = "UrQMD1_3"); | Constructor |
| virtual ~G4UrQMD1_3Model (); | Destructor |
| virtual G4HadFinalState *ApplyYourself(const G4HadProjectile&, G4Nucleus&); | Apply function |

Private member functions

| Function | Description |
|----------|-------------|
| G4int operator==(G4UrQMD1_3Model& right){return (this == &right);}; | Equality operator |
| G4int operator!=(G4UrQMD1_3Model& right){return (this != &right);}; | Inequality operator |
| void WelcomeMessage () const; | Welcome message |
| void InitialiseDataTables (); | Initialise data tables |
| G4bool offshell |
7 Class descriptions (full descriptions)

The following sub-sections describe in detail each of the new or modified classes introduced into Geant4 to treat the interface with UrQMD-1.3cr. The descriptions include the overall purpose of the class, the constructor, destructor, and private/public member functions of the classes, including identification of the arguments and quantities returned. It should be noted that, the units of all inputted and returned quantities are default units used in Geant4, e.g. lengths (such as nuclear radii) are stated in millimetres, areas (e.g. interaction cross-sections) in square-millimetres, and energies are stated in MeV.

7.1 Class G4UrQMD1_3Model

The G4UrQMD1_3Model class is the main class driving the UrQMD-1.3cr FORTRAN code and primarily acts as an event generator to Geant4 to determine the final state of an interaction. It is derived from G4HadronicInteraction class.

Public constructors, operators and member functions

G4UrQMD1_3Model(const G4String& name="UrQMD1_3");

public constructor which calls InitialiseDataTables (). This initialises all of the variables as required by UrQMD-1.3cr and held in FORTRAN common blocks based on the DEFAULT values, i.e. largely based on the UrQMD-1.3cr defaults, see CTParam(X) and CTOption(X) from Tables 5 and 6 of the UrQMD user guide (http://urqmd.org/).
~G4UrQMD1_3Model ();

Class destructor.

    virtual G4HadFinalState *ApplyYourself (const G4HadProjectile &theTrack, G4Nucleus &theTarget);

Member function to determine the Final State of the interaction process. The Final state is for the results of (and secondaries from) the projectile, described by theTrack, and the target nucleus, described by theTarget. This member function drives the UrQMD-1.3cr FORTRAN to enter information about an interaction event, and interprets the results into a product vector as a G4HadFinalState object.

Private constructors, operators and member functions

    const G4UrQMD1_3Model& operator=(G4UrQMD1_3Model &right);

Operator which is required by Geant4 physics lists.

    void WelcomeMessage ();

Prints to standard output (stdout) the information about the G4UrQMD1_3Model when the class is instantiated.

    void InitialiseDataTables ();

Initialises the UrQMD-1.3cr variables during the execution of either of the constructors. This is an initialisation process, primarily setting common block variables directly or through block data calls.
**Gbool offshell;**

Option to be fixed by the user:

**true** if nucleons are put “**off-mass-shell**” (default UrQMD option) and **false** if nucleons are “**on-mass-shell**” (recommended by the authors).

Note that this option strongly affects low energy cascade particles.

### 7.2 G4UrQMD1_3Interface: C++ --FORTRAN interface for common blocks and subroutines

Although not representing a class in itself, **G4UrQMD1_3Interface.hh** contains a series of structure definitions in order to permit access to FORTRAN common block variables. For each common block used by the Geant4 interface, there is an associated C/C++ struct. For example, common block **urqmdparams** becomes the variable **urqmdparams_** of struct type **ccurqmd13urqmdparams**, and variables **real*8 u_elab** and **integer u_at** in that common block are designated as **urqmdparams_.u_elab** and **urqmdparams_.u_at** respectively in the C/C++ interface.

The other function of **G4UrQMD1_3Interface.hh** is to define cross-references between the **UrQMD1.3cr FORTRAN subroutines** and C/C++ subroutines.
8 Changes to usage of geant4-9.5

In version 9.3.p01 (and older ones) the anti-nucleus characteristics and cross sections are not supplied with the geant4 source. Therefore, one has to install the most recent version of geant4 (9.5) in order to allow anti-nucleus interactions using UrQMD code. For installation, one has to use the so called CMAKE build system to compile and install the toolkit. CMAKE has been chosen to replace the old Configure/Make system. For more information on CMAKE itself, please visit http://www.cmake.org/.

8.1 Building and installing CMAKE

Unpack the cmake-2.8.7.tar.gz to a location of your choice. For illustration only, assume it is unpacked in a directory /home/path, so that the CMAKE source sits in the directory

$ /home/path/make

$ tar –xvzf cmake-2.8.7.tar.gz

To configure the build:

$./bootstrap

(The following step is not written in the CMAKE manual)

$. ./configure --prefix=/home/path/cmake

$make

$make install

Here the Configure variable prefix is used to set the install directory, the directory under which CMAKE libraries, binaries and headers are installed.
Finally you will get the directory “cmake” which contains:
+-cmake
+-Bin/
  |+-ccmake
  |+-cmake
  |+-cpack
  |+-ctest
+-cmake-2.8.7/
+-doc/
  |+-cmake-2.8/
+-man/
  |+-man1/
+-share/
  |+-alocal/
  |+-cmake-2.8/

To make sure that everything is O.K., please write

$ cmake -version

You will get

$cmake version 2.8.7

To run cmake in any path terminal, you have to add few lines in your .bash_profile as follows.

First open your .bash_profile:
$nano .bash_profile

Write

PATH=/home/path/cmake/bin:$PATH

LD_LIBRARY_PATH=/home/path/cmake/lib:$LD_LIBRARY_PATH

Save your .bash_profile.

Finally, execute:

$source .bash_profile

8.2 Building and installing geant4.9.5

First make sure that there is no previous version of geant4 in your system.

To do this, please type:

$ printenv | grep G4

Maybe you find something in your .bash_profile. If you do, go to main terminal and write

$ nano .bash_profile

Erase or mark anything starts with G4.

To ensure that everything is O.K., write:

$source .bash_profile

$printenv | grep G4

If you find no “G4” proceed as follows:

Unpack the geant4.9.5.tar.gz to the location /home/path/geant4, so that the geant4 “unpacked files” sits in the subdirectory /home/path/geant4/geant4.9.5
The next step is to create a directory to configure and run the build and store the build products. This directory should be alongside your source directory (geant4-9.5):

$mkdir geant4.9.5-build

$ls
+-geant4/   +-geant4.9.5/   +-geant4.9.5-build/

To configure and build, change into the build directory:

$cd geant4.9.5-build

Since geant4 source is in /home/path/geant4/geant4.9.5, it is recommended to install it in /home/path/geant4/geant4.9.5-install

by typing:

$cmake -DCMAKE_INSTALL_PREFIX=/home/path/geant4/geant4.9.5-install ../geant4.9.5

When complete, do

$make

$make install

Finally, you will get “geant4.9.5-install” directory which contains

+-geant4.9.5-install

+-bin/

|+-geant4.csh
|+-geant4.sh
|+-geant4-config

+-include/

|+-Geant4/

|+-globals.hh
|+-G4ParticleDefinition.hh
Finally, make sure that geant4 binaries and libraries are available on your path. This is done by writing (in your `.bash_profile`):

```
PATH=$PATH:$HOME/geant4_workdir/bin/Linux-g++/
Source /home/path/geant4/geant4.9.5-install/share/Geant4-9.5.0/geant4make/geant4make.sh
```
8.3 Building and installing Geant4-UrQMD interface for version 9.5

With version 9.5, you may have problems linking C++ geant4 code against FORTRAN-UrQMD code. In order to resolve these problems it is recommended to use gfortran instead of g77.

Thus go to the GNUmake file in the directory:

```
$cd /home/path/geant4/geant4.9.5/source/processes/hadronic/models/UrQMD13
```

and make sure that these lines

```
FC= g77
LD=g77
FFLAGS=-g –Wall –Wsurprising –fbound –check
LDFLAGS= -g
```

are replaced with:

```
FC=gfortran
LD=gfortran
FFLAGS=-Fpic
LDFLAGS=’”-L/usr/lib64 –lgfortran”’
```

Also, it would be better to abandon the patch_make_and_install.csh environment and write few lines in GNUmake file:

```
.PHONY: all
all: urqmd lib
ifdef G4INCLUDE
CPPFLAGS += -I $(G4INCLUDE)
endif
UrQMDDIRNAME= UrQMDsrc
urqmd:
(cd ${URQMDDIRNAME} & & \
 tar -xzf urqmd-1.3cr.tar.gz & & \
 cp GNUmakefile urqmd-1.3cr & & cp *.f urqmd-1.3cr & & \
 cd urqmd-1.3cr & & ${MAKE} FFLAGS=-Fpic FC=gfortran LD=gfortran LDFLAGS=’”-L/usr/lib64 –lgfortran”’);
```
(mv ${URQMDDIRNAME}/urqmd-1.3cr/obj_Linux/*.o ${G4TMPDIR});

This will:

1- Move the object files to the directory

$HOME/path/geant4_workdir/tmp/Linux-g++/G4hadronic_UrQMD13

2- Create UrQMD library in the directory:

$HOME/path/geant4/geant4-9.5.0/Linux-g++ libGhadronic_UrQMD13.so

If the linking is O.K. goto UrQMD13 directory and type:

$ make includes

This will move the include files (G4UrQMD1_3Interface.hh & G4UrQMD1_3Model.hh) to Geant4 directory:

/home/path/geant4/geant.9.5-install/include/Geant4

Finally in the GNUmake file of your “main()” application, make sure that this line:

EXTRALIBS += -L/{G4lib}/${G4SYSTEM} -lG4hadronic_UrQMD13

is inserted.
9 The output file

--- Cascade Test (test30) Start ---

Start new run n 0 for 1 events 

NIST Database for Materials is used
Material is selected: G4_Zr
Test30Physics entry
Process is created; gen=UrQMD1_3

Interface to G4UrQMD_1.3 activated
Version number: 00.00.0B Date: 25/01/12
(Interface written by Kh. Abdel-Waged et al. for the KACST/NCMP)

seed: 1097569630
New generator for material G4_Zr Nelm= 1 Nmat= 1 Target element: Zr
Secondary generator <UrQMD1_3> is initialized
Nucleus with N= 94 Z= 40 A(amu)= 9.131840e+01Mass from G4NucleiProperties(GeV)= 8.745283e+01
The particle: anti_deuteron
The material: G4_Zr Z= 40 A= 94 Amax= 95
The position: (0.000000e+00,0.000000e+00,0.000000e+00) mm
The direction: (0.000000e+00,0.000000e+00,1.000000e+00)
The time: 0.000000e+00 ns
energy = 2.000000e+05 MeV RMS(MeV)= 0.000000e+00
emax = 2.500000e+01 MeV
pmax = 2.018669e+05 MeV

Log10 scale from -2.000000e+00 to 2.000000e+00 in 80 bins
Log book 57 histograms in <UrQMD1_3.root>
Histograms are booked output file <UrQMD1_3.root>

Test rotation= (0.000000e+00,0.000000e+00,1.000000e+00)

0-th event start
creation of table, wait-------

Please cite when using this model:
S.A.Bass et al. Prog.Part.Nucl.Phys. 41 (1998) 225
M.Bleicher et al. J.Phys. G25 (1999) 1859

Tablenameurqmd.tab
Generating table...
(1/7) ready.
(2/7) ready.
(3/7) ready.
(4/7) ready.
(5/7) ready.
(6/7) ready.
(7/7) ready.
Writing new table...
O.K.
end to create table
UrQMDModel running--------
dsigma: calculating constants for ang. dist.
dsigma: calculation finished
User=3.225000e+01s Real=3.319000e+01s Sys=3.000000e-02s
Save histograms
End of run # 0 
Next line #exit

Fig.2 Sample header of the output of Geant4-UrQMD interface
10 G4UrQMD1_3.cc file

// ********************************************************************
// * License and Disclaimer                                          *
// *                                                                  *
// * The Geant4 software is copyright of the Copyright Holders of * *
// * the Geant4 Collaboration. It is provided under the terms and * *
// * conditions of the Geant4 Software License, included in the file * *
// * LICENSE and available at http://cern.ch/geant4/license. These * *
// * include a list of copyright holders.                            *
// *                                                                  *
// * Neither the authors of this software system, nor their employing *
// * institutes, nor the agencies providing financial support for this *
// * work make any representation or warranty, express or implied, * *
// * regarding this software system or assume any liability for its * *
// * use. Please see the license in the file LICENSE and URL above * *
// * for the full disclaimer and the limitation of liability.        *
// *                                                                  *
// * This code implementation is the result of the scientific and * *
// * technical work of the GEANT4 collaboration.                     *
// *                                                                  *
// * Parts of this code which have been developed by Abdel-Waged    *
// * et al under contract (31-465) to the King Abdul-Aziz City for  *
// * Science and Technology (KACST), the National Centre of         *
// * Mathematics and Physics (NCMP), Saudi Arabia.                   *
// *                                                                  *
// * By using, copying, modifying or distributing the software (or * *
// * any work based on the software) you agree to acknowledge its * *
// * use in resulting scientific publications, and indicate your * *
// * acceptance of all terms of the Geant4 Software license.         *
// ********************************************************************

#ifndef G4UrQMD1_3Model_hh
#define G4UrQMD1_3Model_hh

#include <G4UrQMD1_3Model.hh>
#include <G4UrQMD1_3Interface.hh>
#include <globals.hh>
#include <G4DynamicParticle.hh>
#include <G4IonTable.hh>
#include <G4CollisionOutput.hh>

#endif /* G4UrQMD1_3Model_hh */
#include "G4V3DNucleus.hh"
#include "G4Track.hh"
#include "G4Nucleus.hh"
#include "G4LorentzRotation.hh"
#include "G4ParticleDefinition.hh"
#include "G4ParticleTable.hh"

//AND->
#include "G4Version.hh"
//AND<-

#include "G4AntiHe3.hh"
#include "G4AntiDeuteron.hh"
#include "G4AntiTriton.hh"
#include "G4AntiAlpha.hh"

#include <fstream>
#include <string>

///////////////////////////////////////////////////////////////////////////
//////

G4UrQMD1_3Model::G4UrQMD1_3Model(const G4String& nam)
  :G4VIntraNuclearTransportModel(nam), verbose(0)
{

  if (verbose > 3) {
    G4cout << " >>> G4UrQMD1_3Model default constructor" << G4endl;
  }

  // Set the minimum and maximum range for the UrQMD model
  
  // SetMinEnergy(100.0*MeV);
  // SetMaxEnergy(200.0*GeV);
  //----------------------------
  
  // It would be better to turn "MASS-SHELL" OFF !!
  // because NUCLEONS should be "ON -MASS-SHELL".
  // However, we turn it on to get default UrQMD options!

  offshell=true;
  //----------------------------

  //
  // WelcomeMessage();
  //
  // CurrentEvent=0;
  //
  InitialiseDataTables();

}
// Destructor
// G4UrQMD1_3Model::~G4UrQMD1_3Model (){}

G4ReactionProductVector* G4UrQMD1_3Model::Propagate(G4KineticTrackVector* ,
          G4V3DNucleus* ) {
    return 0;
}

G4HadFinalState *G4UrQMD1_3Model::ApplyYourself (const G4HadProjectile &theTrack, G4Nucleus &theTarget) {
    //anti_new
    //  ------------------define anti_light_nucleus
    const G4ParticleDefinition* anti_deu =
            G4AntiDeuteron::AntiDeuteron();
    const G4ParticleDefinition* anti_he3=
            G4AntiHe3::AntiHe3();
    const G4ParticleDefinition* anti_tri=
            G4AntiTriton::AntiTriton();
    const G4ParticleDefinition* anti_alp=
            G4AntiAlpha::AntiAlpha();
    //-----------------------------------------------
    // The secondaries will be returned in G4HadFinalState &theResult -
    // initialise this. The original track will always be discontinued and
    // secondaries followed.
    //
    theResult.Clear();
    theResult.SetStatusChange(stopAndKill);

    G4DynamicParticle* cascadeParticle=0;

    //
    // Get relevant information about the projectile and target (A, Z, energy/nuc,
    // momentum, etc).
    //
    const G4ParticleDefinition *definitionP = theTrack.GetDefinition();
const G4double AP = definitionP->GetBaryonNumber();
const G4double ZP = definitionP->GetPDGCharge();
G4double AT = theTarget.GetN();
G4double ZT = theTarget.GetZ();

// -----------------------------------------------
G4int id = definitionP->GetPDGEncoding(); // get particle encoding
// -----------------------------------------------
G4int AP1 = G4lrint(AP);
G4int ZP1 = G4lrint(ZP);
G4int AT1 = G4lrint(AT);
G4int ZT1 = G4lrint(ZT);

// The following is the parameters necessary to initiate Uinit() and UrQMD()
// ------------------------------------------------------------------------
urqmdparams_.u_sptar = 0; // 0= normal proj/target, 1=special proj/tar
urqmdparams_.u_spproj = 1; // projectile is a special particle

// new anti
if (AP1 > 1 || definitionP == anti_deu || definitionP == anti_he3 ||
    definitionP == anti_tri || definitionP == anti_alp) {
    urqmdparams_.u_ap = AP1;
    urqmdparams_.u_zp = ZP1;
    urqmdparams_.u_spproj = 0;
} else if (id == 2212) { // proton
    urqmdparams_.u_ap = 1;
    urqmdparams_.u_zp = 1;
} else if (id == -2212) { // anti-proton
    urqmdparams_.u_ap = -1;
    urqmdparams_.u_zp = -1;
} else if (id == 2112) { // neutron
    urqmdparams_.u_ap = 1;
    urqmdparams_.u_zp = -1;
} else if (id == -2112) { // anti-neutron
    urqmdparams_.u_ap = -1;
    urqmdparams_.u_zp = 1;
} else if (id == 211) { // pi+
    urqmdparams_.u_ap = 101;
    urqmdparams_.u_zp = 2;
} else if (id == -211) { // pi-
    urqmdparams_.u_ap = 101;
    urqmdparams_.u_zp = -2;
} else if (id == 321) { // K+
    urqmdparams_.u_ap = 106;
    urqmdparams_.u_zp = 1;
} else if (id == -321) { // K-
    urqmdparams_.u_ap = -106;
urqmdparams_.u_zp=-1;
} else if(id==130 || id==310) {  // ! K0
    urqmdparams_.u_ap=106;
    urqmdparams_.u_zp=-1;
} else if(id==-130 || id==-310){  // ! K0bar
    urqmdparams_.u_ap=-106;
    urqmdparams_.u_zp=1;
} else {

    G4cout << " Sorry, No definition for particle for UrQMD::"<<id<<" found" << G4endl;
    //AND->
    #if G4VERSION_NUMBER>=950
    //New signature (9.5) for G4Exception
    //Using G4HadronicException
    throw G4HadronicException(__FILE__,__LINE__,"Sorry, no definition for particle for UrQMD");
    #else
    G4Exception(" ");
    #endif
    //AND<-
    } //end if id

    urqmdparams_.u_at=AT1;  // Target identified
    urqmdparams_.u_zt=ZT1;

    // identify Energy
    //
    G4ThreeVector Pbefore = theTrack.Get4Momentum().vect();
    G4double T  = theTrack.GetKineticEnergy();
    G4double E  = theTrack.GetTotalEnergy();
    G4double TotalEbefore = E*AP1 + 
    theTarget.AtomicMass(AT1, ZT1) + theTarget.GetEnergyDeposit();
    //    -----------------------------------------------------------------
    if (AP1>1) {
        urqmdparams_.u_elab=T/(AP1*GeV);  // Units are GeV/nuc for UrQMD
        E  = E/AP1;                     // Units are GeV/nuc
    } else {
        urqmdparams_.u_elab=T/GeV;       //units are GeV

        TotalEbefore = E + 
        theTarget.AtomicMass(AT1, ZT1) + theTarget.GetEnergyDeposit();
    }
    //-----------------------------------------------------------------------

    // identify impact parameter
    urqmdparams_.u_imp=(1.1 * std::pow(G4double(AT1),(1./3.))); //units are in fm for UrQMD;
    //----------------------------------------------------------------------------
    //initialise///////////
    if (CurrentEvent==0)
    {
        G4cout << "\n creation of table, wait-------"<<G4endl;
    }
G4cout << "\n"<<G4endl;
G4int io=0;
uint_ (&io);

G4cout << "\n end to create table "<<G4endl;
CurrentEvent=1;
}

#ifdef debug_G4UrQMD1_3Model
G4cout <<"UrQMDModel running-------------" <<G4endl;
urqmd_ ();
#endif

//G4cout <<"Number of produced particles: " <<sys_.npart<<G4endl;
G4int n = sys_.npart; //no of produced particles
if (n<2)
{
G4cout <<"------------------Warning------------------"<<G4endl;
G4cout <<"-----------------------------"<<G4endl;

G4cout <<"Number of produced particles is very low: "
<<sys_.npart<<G4endl;
G4cout <<"-------------------------------"<<G4endl;

#if G4VERSION_NUMBER>=950
//New signature (9.5) for G4Exception
//Using G4HadronicException instead of base class
throw G4HadronicException(__FILE__,__LINE__,"Number of produced particle is very low");
#else
G4Exception(" "); //stop
#endif

else {
   for (G4int i=0; i<n; i++)
   {

G4int pid=pdgid_ (&isys_.ityp[i], &isys_.iso3[i]);

//Particle is a final state secondary and not a nucleus.
//Determine what this secondary particle is, and if valid, load dynamic
//parameters.

G4ParticleDefinition* pd=
   G4ParticleTable::GetParticleTable()->FindParticle(pid);

//-------------------new_offshell
if (offshell)
{
    //------//-------------------------------   true off-shell!! --//
    if (pd)
    {
        
        G4double px = (coor_.px[i]+ffermi_.ffermpx[i])* GeV;
        //units are in MeV/c for G4
        G4double py = (coor_.py[i]+ffermi_.ffermpy[i])* GeV;
        G4double pz = (coor_.pz[i]+ffermi_.ffermpz[i])* GeV;
        G4double et = (coor_.p0[i]) *GeV;

        // ----------------------------------Use "Lorentz vector"-----
        G4LorentzVector lorenzvec = G4LorentzVector(px,py,pz,et);
        cascadeParticle = new G4DynamicParticle(pd, lorenzvec); //
        theResult.AddSecondary(cascadeParticle);
    }
    else
    {
        //------//--better get rid of "off-mass-shell" nucleons--------//
        if (pd)
        {
            
            if (isys_.iso3[i]==1 || isys_.iso3[i]==-1) //nucleons from UrQMD
            {
                if (coor_.fmass[i] >=0.938) //units in GeV (UrQMD)
                {
                    G4double px = (coor_.px[i]+ffermi_.ffermpx[i])* GeV;
                    //units are in MeV/c for G4
                    G4double py = (coor_.py[i]+ffermi_.ffermpy[i])* GeV;
                    G4double pz = (coor_.pz[i]+ffermi_.ffermpz[i])* GeV;
                    G4double et = (coor_.p0[i]) *GeV;

                    // G4double mass = (coor_.fmass[i])*GeV;

                    // ----------------------------------Use "Lorentz vector"------
                    G4LorentzVector lorenzvec = G4LorentzVector(px,py,pz,et);
                    cascadeParticle = new G4DynamicParticle(pd, lorenzvec); //
                    theResult.AddSecondary(cascadeParticle);
                }
            }
            else //particles other than nucleons
            {
                G4double px = (coor_.px[i]+ffermi_.ffermpx[i])* GeV;
                //units are in MeV/c for G4
                G4double py = (coor_.py[i]+ffermi_.ffermpy[i])* GeV;
            }
        }
    }
}
G4double pz = (coor_.pz[i]+ffermi_.ffermpz[i])*GeV;
G4double et = (coor_.p0[i])*GeV;
// G4double mass = (coor_.fmass[i])*GeV;
// -----------------------------------------------Use "Lorentz vector"-----------------
G4LorentzVector lorenzvec = G4LorentzVector(px,py,pz,et);
cascadeParticle = new G4DynamicParticle(pd, lorenzvec);  //
theResult.AddSecondary(cascadeParticle);

} //else
//----------------------------------------------------------------------------------
} //if pd

} //else for off-shell

} //for
} //if warning

//-------------------------------------------------------------------------------
if (verbose >= 3) {

//
G4double TotalEafter = 0.0;
G4ThreeVector TotalPafter;
G4double charge = 0.0;
G4int baryon = 0;
G4int nSecondaries = theResult.GetNumberOfSecondaries();

for (G4int j=0; j<nSecondaries; j++) {
    TotalEafter += theResult.GetSecondary(j)->GetParticle()->GetTotalEnergy();
    TotalPafter += theResult.GetSecondary(j)->GetParticle()->GetMomentum();
    G4ParticleDefinition *pd = theResult.GetSecondary(j)->GetParticle()->GetDefinition();
    charge += pd->GetPDGCharge();
    baryon += pd->GetBaryonNumber();
}
//for secondaries

G4cout <<"----------------------------------------" <<G4endl;
G4cout <<"Total energy before collision = " <<TotalEbefore  //MeV
<<" MeV" <<G4endl;
G4cout << "Total energy after collision    = " << TotalEafter / MeV << "MeV" << G4endl;
G4cout << "----------------------------------------" << G4endl;
G4cout << "Total momentum before collision = " << Pbefore / MeV / c << "MeV/c" << G4endl;
G4cout << "Total momentum after collision  = " << TotalPafter / MeV / c << "MeV/c" << G4endl;
G4cout << "----------------------------------------" << G4endl;
if (verbose >= 4) {
  G4cout << "Total charge before collision  = " << (ZP+ZT)*eplus << G4endl;
  G4cout << "Total charge after collision    = " << charge << G4endl;
  G4cout << "----------------------------------------" << G4endl;
  G4cout << "Total baryon number before collision = " << AP+AT << G4endl;
  G4cout << "Total baryon number after collision  = " << baryon << G4endl;
  G4cout << "----------------------------------------" << G4endl;
} // if verbose4
G4cout << "----------------------------------------" << G4endl;
return &theResult;
} //G4hadfinal

void G4UrQMD1_3Model::WelcomeMessage () const {
  G4cout << G4endl;
  G4cout << "*****************************************************************
  Interface to        G4UrQMD_1.3 activated
  Version number : 00.00.0B          File date : 25/01/12
  (Interface written by Kh. Abdel-Waged et al. for the
   KACST/NCMP)
  *****************************************************************
" << G4endl;
} // WelcomeMessage

// WelcomeMessage
void G4UrQMD1_3Model::InitialiseDataTables ()
{
//
// The next line is to make sure the block data statements are
// executed.
//
g4urqmdblockdata_ ();

nombre; nom=1097569630;
G4cout <<"\n seed: " <<nom <<G4endl;
ssed_ (&nom);
loginit_();
}
#ifndef G4UrQMD1_3Model_hh
#define G4UrQMD1_3Model_hh
%
MODULE: G4UrQMD1_3Model.hh
%
VERSION: 0.B
DATE: 20/10/12
AUTHOR: Kh. Abdel-Waged and Nuha Felemban
REVISED BY: V.V. Uzhinskii
SPONSERED BY:
CUSTOMER: KACST/NCMP

%
#include "G4Nucleon.hh"
#include "G4Nucleus.hh"
#include "G4VIntraNuclearTransportModel.hh"
#include "G4 KineticTrackVector.hh"
#include "G4FragmentVector.hh"
#include "G4ParticleChange.hh"
#include "G4ReactionProductVector.hh"
#include "G4ReactionProduct.hh"
#include "G4IntraNucleiCascader.hh"
#include "G4Track.hh"
#include <fstream>
#include <string>

class G4UrQMD1_3Model : public G4VIntraNuclearTransportModel {

public:

    G4UrQMD1_3Model(const G4String& name = "UrQMD1_3");

    virtual ~G4UrQMD1_3Model();

    G4ReactionProductVector* Propagate(G4KineticTrackVector* theSecondaries, G4V3DNucleus* theTarget);

    virtual G4HadFinalState *ApplyYourself
    (const G4HadProjectile &, G4Nucleus &);

private:

    G4int operator==(G4UrQMD1_3Model& right) {
        return (this == &right);
    }

    G4int operator!=(G4UrQMD1_3Model& right) { 

return (this != &right);
}

G4int verbose;  // print options
G4bool  offshell; // nucleons on- or off-shell

void InitialiseDataTables();

G4int CurrentEvent;

private:

  void WelcomeMessage () const;

G4HadFinalState theResult;

};

// inline G4double G4UrQMD1_3Model::GetMinEnergy( const G4Material *,
//  const G4Element * ) const
//  {return theMinEnergy;}
//  //////////////////////////////////////////////////////////////////////////
//  // 
// inline G4double G4UrQMD1_3Model::GetMaxEnergy( const G4Material *,
//  const G4Element * ) const
//  {return theMaxEnergy;}

///////////////////////////////////////////////////////////////////////////
///////////////////////////////////////////////////////////////////////////

#ifdef

#endif
12 G4UrQMD1_3Interface.hh file

// ********************************************************************
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// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
// * This code implementation is the result of the scientific and *
// * technical work of the GEANT4 collaboration.                    *
// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
// * Parts of this code which have been developed by Abdel-Waged     *
// * et al under contract (31-465) to the King Abdul-Aziz City for *
// * Science and Technology (KACST), the National Centre of          *
// * Mathematics and Physics (NCMP), Saudi Arabia.                   *
// * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * * *
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// ********************************************************************

#ifndef G4UrQMD1_3Interface_hh
#define G4UrQMD1_3Interface_hh

 mụn
g

// MODULE: G4UrQMD1_3Model.hh
// Version: 0.B
// Date: 20/12/12
// Author: Kh. Abdel-Waged and Nuha Felemban
// Revised by: V.V. Uzhinskii
// SPONSERED BY
// Customer: KACST/NCMP
// Contract: 31-465

//

// Class Description
//
// Class Description - End
//
/*
  //  coms.hh
  //  comres
  const G4int  nmax  = 500;
  const G4int  nspl  = 500;
  const G4int  smax  = 500;
  //  comres
  const G4int  minnuc=1;
  const G4int  minmes=100;
  const G4int  maxmes=132;
  const G4int  numnuc=16;
  const G4int  numdel=10;
  const G4int  maxnuc=minnuc+numnuc-1;
  const G4int  mindel=minnuc+maxnuc;
  const G4int  maxdel=mindel+numdel-1;
  const G4int  minres=minnuc+1;
  const G4int  maxres=maxdel;
  const G4int  numlam=13;
  const G4int  numsig=9;
  const G4int  numcas=6;
  const G4int  numome=1;
  const G4int  minlam=mindel+numdel;
  const G4int  maxlam=minlam+numlam-1;
  const G4int  minsig=minlam+numlam;
  const G4int  maxsig=minsig+numsig-1;
  const G4int  mincas=minsig+numsig;
  const G4int  maxcas=mincas+numcas-1;
  const G4int  minome=mincas+numcas;
  const G4int  maxome=minome+numome-1;
  const G4int  minbar=minnuc;
  const G4int  maxbar=maxome;
  const G4int  offmeson=minmes;
  const G4int  maxmeson=maxmes;
  const G4int  maxbra=11;
  const G4int  maxbrm=25;
  const G4int  maxbrs1=10;
  const G4int  maxbrs2=3;
  const G4int  nsg= 10;
  const G4int  itblsz= 100;
  const G4int  maxreac = 13;
  const G4int  maxpsig = 12;
  //
  //comwid
  //
  const G4int  widnsp=120;
  const G4double mintab=0.10;
  const G4double maxtab1=5.0;
  const G4double maxtab2=50.0;
  const G4int  tabver=9;
  //
  // options
  //
  const G4int numcto=400;
  const G4int numctp=400;
  const G4int maxstables=20;
  //*/
// colltab (collision tables)
//
const G4int ncollmax = 100;
//
// inputs
//
const G4int aamax=300;
//
// newpart (new created particles)
//
const G4int mprt=200;
const G4int oprt=2;
//
// boxinc
//
const G4int bptmax=20;
//

// This next line is required as the default version of FORTRAN LOGICAL is
// four bytes long, whereas storage for G4bool is one byte.
//
// comnorm
const G4int n = 400;
//
// comstr
const G4int njspin=8;
//
//iso
const G4int jmax=7;

// This next line is required as the default version of FORTRAN LOGICAL is
// four bytes long, whereas storage for G4bool is one byte.
//
typedef G4int ftnlogical;
//
// Standard common block for UrQMD
// Common options for coms.f
// 20 commons
//
// struct ccurqmd13urqmdparams
//{
//  G4int u_at,u_zt,u_ap,u_zp;
//  G4double u_elab,u_imp;
//  G4int u_sptar,u_sproj;
//};

// struct ccurqmd13sys
//{
//  G4int npart, nbar, nmes, ctag,nsteps,uid_cnt,
//       ranseed,event,ap,at,zp,zt,eos,dectag,
//      nhardres, nsoftres, ndecres, nelcoll, nblcoll;
//};

// struct ccurqmd13rsys
//{
//  G4double time,acttime,bdist,bimp,bmin,ebeam,ecm;

```c
struct ccurqmd13comseed {
  ftnlogical
    firstseed;
};

struct ccurqmd13logic {
  ftnlogical
    lsct[nmax], logSky, logYuk, logCb, logPau;
};

struct ccurqmd13mdprop {
  G4double
    r0_t[nmax], rx_t[nmax], ry_t[nmax], rz_t[nmax];
};

struct ccurqmd13cuts {
  G4double
    cutmax, cutPau, cutCb, cutYuk, cutSky, cutdww;
};

struct ccurqmd13spdata {
  G4double
    spx[nspl], spPauy[nspl], outPau[nspl],
    spCby[nspl], outCb[nspl],
    spYuky[nspl], outYuk[nspl],
    spSkyy[nspl], outSky[nspl],
    spdwwy[nspl], outdww[nspl];
};

struct ccurqmd13isys {
  G4int
    spin[nmax], ncoll[nmax], charge[nmax], ityp[nmax],
    lstcoll[nmax],
    iso3[nmax], origin[nmax], strid[nmax], uid[nmax];
};

struct ccurqmd13coor {
  G4double
    r0[nmax], rx[nmax], ry[nmax], rz[nmax],
    p0[nmax], px[nmax], py[nmax], pz[nmax],
    fmass[nmax], rww[nmax], dectime[nmax];
};

struct ccurqmd13frag {
```
G4double
tform[nmax], xtotfac[nmax];
}

struct ccurqmd13aios
{
G4double
    airx[nmax], airy[nmax], airz[nmax],
    aipx[nmax], aipy[nmax], aipz[nmax],
    aorx[4][nmax], aory[4][nmax], aorz[4][nmax],
    aopx[4][nmax], aopy[4][nmax], aopz[4][nmax];
};

struct ccurqmd13pots
{
G4double
    Cb0, Yuk0, Pau0, Sky20, Sky30, gamSky,
    gamYuk, drPau, dpPau, gw, sgw, delr, fdel,
    dt, da, db, dtimestep;
};

struct ccurqmd13scoor
{
G4double
    r0s[smax], rxs[smax], rys[smax], rzs[smax],
    p0s[smax], pxs[smax], pys[smax], pzs[smax],
    sfmass[smax];
};

struct ccurqmd13sisys
{
    G4int
        sspin[smax], scharge[smax], sityp[smax], siso3[smax],
        suid[smax];
};

struct ccurqmd13ssys
{
    G4int nspec;
};

struct ccurqmd13rtdelay
{
G4double
    p0td[nmax][2], pxtd[nmax][2], pytd[nmax][2], pzdtd[nmax][2],
    fmasstd[nmax][2];
};

struct ccurqmd13itdelay
{
G4int
    ityptd[nmax][2], iso3td[nmax][2];
};

struct ccurqmd13svinfo
G4int
  itypt[2], uidt[2], origint[2], iso3t[2];
};

struct ccurqmd13ffermi
{
  G4double
    ffermpx[nmax], ffermpy[nmax], ffermpz[nmax];
};

struct ccurqmd13peq
{
  G4double peq1, peq2;
};

// // Definition for Collision Term
// Commons comres
// 4 commons

struct ccurqmd13versioning
{
  char versiontag[45];
};

struct ccurqmd13resonances
{
  G4double massres[maxbar-minbar+1], widres[maxbar-minbar+1];
  G4double massmes[maxmes-minmes+1];
  G4double widmes[maxmes-minmes+1];
  G4double mmesmn[maxmes-minmes+1];
  G4double branres[maxdel-minnuc][maxbra+1];
  G4double branmes[maxmes-minmes][maxbrm+1];

  G4double branbsl[maxsig-minlam][maxbrs1+1];
  G4double branbs2[maxcas-mincas][maxbrs2+1];

  G4int bs1type[maxbrs1+1][4], bs2type[maxbrs2+1][4];
  G4int lbs1[maxsig-minlam][maxbrs1+1];
  G4int lbs2[maxcas-mincas][maxbrs2+1];
  G4int lbm[maxmes-minmes][maxbrm+1];

  G4int jres[maxbar-minbar+1];
  G4int jmes[maxmes-minmes+1];
  G4int lbr[maxdel-minnuc][maxbra+1];
  G4int brtype[maxbra+1][4];
  G4int pares[maxbar-minbar+1], pames[maxmes-minmes+1];
  G4int bntype[maxbrm+1][4];
  G4int isores[maxbar-minbar+1], isomes[maxmes-minmes+1];
  G4int strres[maxbar-minbar+1], strmes[maxmes-minmes+1];
  G4int mlt2it[maxmes-minmes];
};

struct ccurqmd13sigtabi
{
  G4int sigmaln[maxreac][2][maxpsig];
  G4int sigmainf[20][nsigs];
struct curqmd13sigtabr
{
    G4double sigmas[itblsz][nsigs], sigmascal[5][nsigs];
};

// comwid
struct curqmd13decaywidth
{
    G4double tabx [widnsp];
    G4double fbtaby[2][maxbar-minbar+1][widnsp];
    G4double pbtaby[maxbra+1][maxbar-minbar+1][2][widnsp];
    G4double fmtaby [2][maxmes-minmes+1][widnsp];
    G4double pmtaby [maxbrm+1][maxmes-minmes+1][2][widnsp];
    G4int wtabflg;
};

struct curqmd13brwignorm
{
    G4double bwbarnorm[maxbar-minbar+1];
    G4double bwmesnorm[maxmes-minmes+1];
};

struct curqmd13xsections
{
    G4double tabxnd [widnsp];
    G4double frrtaby[maxdel-1][2][2][widnsp];
};

struct curqmd13tabnames
{
    char tabname[77];
};

struct curqmd13options
{
    G4int    CTOption[numcto];
    G4double CTParam[numctp];
};

struct curqmd13optstrings
{
    char ctodc[numcto][2];
    char ctpdc[numctp][2];
};

struct curqmd13loptions
{
    ftnlogial
fixedseed, bf13, bf14, bf15, bf16, bf17, bf18, bf19, bf20;

struct ccurqmd13stables
{
    G4int nstable;
    G4int stabvec[maxstables];
};

// //colltab //
struct ccurqmd13colltab
{
    G4double
ttime[ncollmax+1], ctsqrts[ncollmax],
    ctsigtot[ncollmax], tmin;
    G4int
    cti1[ncollmax], cti2[ncollmax];
    G4int
    nct, actcol;
    ftnlogical
tvalid[ncollmax];
    G4int
    ctsav[ncollmax];
    G4int
    nsav, apt;
    G4double
tcolfluc[ncollmax];
};

// // inputs //
struct ccurqmd13inputs
{
    G4int nevents, spityp[2], prspflg;
    G4int trspflg, spiso3[2], outsteps, bflag, srtflag, efuncflag;
    G4int nsrt, firstev, npb;
};

struct ccurqmd13input2
{
    G4double srtmin, srtmax, pbeam, betann, betatar, betapro;
    G4double pbmin, pbmax;
};

struct ccurqmd13protarints
{
    G4int pt_iso3[2][aamax], pt_ityp[2][aamax], pt_spin[2][aamax];
    G4int pt_charge[2][aamax], pt_aa[2], pt_uid[2][aamax];
};

struct ccurqmd13protarreals
{
    G4double pt_r0[2][aamax], pt_rx[2][aamax], pt_ry[2][aamax],
    pt_rz[2][aamax], pt_fmass[2][aamax], pt_dectime[2][aamax];
    G4double pt_p0[2][aamax], pt_px[2][aamax], pt_py[2][aamax],
struct ccqmd13inewpart
{
  G4int itypnew[mprt],i3new[mprt],itot[mprt],inew[mprt],nexit;
  G4int iline,strcount,pslot[oprt],nstring1, nstring2,
      sidnew[mprt],itypold[oprt],iso3old[oprt];
};

struct ccqmd13rnewpart
{
  G4double  pnew[mprt][5],xnew[mprt][4],betax,betay,betaz,
            pold[oprt][5],p0nn,pxnn,pynn,pznn,pnn, mstring[2],
            pnnout,xtotfacold[oprt];
};

struct ccqmd13fnewpart
{
  G4double leadfac[mprt];
};

struct ccqmd13boxic
{
  G4int cbox;
  G4int boxflag;
  G4int mbox;
  G4int bptityp[bptmax],bptiso3[bptmax],bptpart[bptmax];
  G4int edensflag,para,solid, mbflag,mtest;
};

struct ccqmd13boxrc
{
  G4double bptpmax[bptmax];
  G4double edens;
  G4double lbox;
  G4double lboxhalbe;
  G4double lboxd;
  G4double mbp0, mbpx, mbpy, mbpz;
};

struct ccqmd13normsplin
{
  G4double x_norm[n][4],y_norm[n][4];
  G4double y2a[n][4],y2b[n][4], dx;
};

struct ccqmd13FRGSPA
{
  G4double pjspns, pmix1s[njspin][3], pmix2s[njspin][3]
        , pbars, parqls, parrs;
};

struct ccqmd13FRGCPA
{
  G4double
struct ccurqmd13coparm
{
    G4double parm[njspin];
};

struct ccurqmd13const
{
    G4double pi;
};

// freezeout

struct ccurqmd13frcoor
{
    G4double frr0[nmax], frrx[nmax], frry[nmax], frrz[nmax], frp0[nmax], frpx[nmax], frpy[nmax], frpz[nmax];
};

// input

struct ccurqmd13values
{
    G4double valint[1];
};

// cascinit

struct ccurqmd13ini
{
    ftnlogical bcorr;
};

// iso

struct ccurqmd13factorials
{
    G4double logfak[101];
};

struct ccurqmd13cgks
{
    G4double cgktab[jmax+1][2*jmax+1][2*jmax+1][jmax+1][jmax+1];
};

// UrQMD

struct ccurqmd13energies
{
    G4double ekinbar, ekinmes, esky2, esky3, eyuk, ecb, epau;
};

// urqmd

extern "C"
{
    extern int time_();
    extern void loginit_();
    extern void sseed_(int*);
    extern void uinit_(int*);
}
extern void urqmd_();
extern int pdgid_ (int*, int*); //ityp

extern void g4urqmdblockdata_();

// urqmdparams
extern struct ccurqmd13urqmdparams urqmdparams_;
//coms
extern struct ccurqmd13sys sys_;  
extern struct ccurqmd13rsys rsys_;  
extern struct ccurqmd13comseed comseed_;  
extern struct ccurqmd13logic logic_;  
extern struct ccurqmd13mdprop mdprop_;  
extern struct ccurqmd13cuts cuts_;  
extern struct ccurqmd13spdata spdata_;  
extern struct ccurqmd13isys isys_;  
extern struct ccurqmd13coor coor_;  
extern struct ccurqmd13frag frag_;  
extern struct ccurqmd13aios aios_;  
extern struct ccurqmd13pots pots_;  
extern struct ccurqmd13scoor scoor_;  
extern struct ccurqmd13sisys sisys_;  
extern struct ccurqmd13ssys ssys_;  
extern struct ccurqmd13rtdelay rtdelay_;  
extern struct ccurqmd13itdelay itdelay_;  
extern struct ccurqmd13svinfo svinfo_;  
extern struct ccurqmd13ffermi ffermi_;  
extern struct ccurqmd13peq peq_;  
//comres
extern struct ccurqmd13versioning versioning_;  
extern struct ccurqmd13resonances resonances_;  
extern struct ccurqmd13sigtabi sigtabi_;  
extern struct ccurqmd13sigtabr sigtabr_;  

//comwid
extern struct ccurqmd13decaywidth decaywidth_;  
extern struct ccurqmd13brwignorm brwignorm_;  
extern struct ccurqmd13xsections xsections_;  
extern struct ccurqmd13tabnames tabnames_;  
//options
extern struct ccurqmd13options options_;  
extern struct ccurqmd13optstrings optstrings_;  
extern struct ccurqmd13loptions loptions_;  
extern struct ccurqmd13stables stables_;  
//colltab
extern struct ccurqmd13colltab colltab_;  
//inputs
extern struct ccurqmd13inputs inputs_;  
extern struct ccurqmd13input2 input2_;  
extern struct ccurqmd13protarints protarints_;  
extern struct ccurqmd13protarreals protarreals_;  
//newpart
extern struct ccurqmd13inewpart inewpart_;  
extern struct ccurqmd13rnewpart rnewpart_;  
extern struct ccurqmd13fnewpart fnewpart_;  
//bocinc
extern struct ccurqmd13boxic boxic_;  
extern struct ccurqmd13boxrc boxrc_;  
//commnorm
struct ccurqmd13normsplin normsplin_;  
//comstr
struct ccurqmd13FRGSPA  FRGSPA_;  
struct ccurqmd13FRGCPA  FRGCPA_;  
struct ccurqmd13coparm  coparm_;  
struct ccurqmd13const   const_;  
// freezeout  
struct ccurqmd13frcoor  frcoor_;  
// urqmd  
extern struct ccurqmd13energies energies_;  
// input  
extern struct ccurqmd13values values_;  
// cascinit  
extern struct ccurqmd13ini ini_;  
// iso  
extern struct ccurqmd13factorials factorials_;  
extern struct ccurqmd13cgks cgks_;  
}  

#endif
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