Integration of INCL++ and Geant4 for GENIE FSI Processes

Robert Hatcher

GENIE INCL++ & Geant4 Review

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Modified and **Added** Files

config/HG4BertCascIntranuke.xml
config/HINCLCascadeIntranuke.xml
config/Messenger.xml
config/Messenger_inuke_verbose.xml
config/Messenger_laconic.xml
config/Messenger_rambling.xml
config/Messenger_whisper.xml
config/master_config.xml
configure
src/Apps/gEvGenHadronNucleus.cxx
src/Apps/gNtpConv.cxx (protection against possible missing mother/daughter link)
src/Physics/HadronTransport/HAIntranuke2018.cxx (minor formatting change)
src/Physics/HadronTransport/HG4BertCascIntranuke.cxx
src/Physics/HadronTransport/HG4BertCascIntranuke.h
src/Physics/HadronTransport/HINCLCascadeIntranuke.cxx
src/Physics/HadronTransport/HINCLCascadeIntranuke.h
src/Physics/HadronTransport/INCLConfigParser.cxx
src/Physics/HadronTransport/INCLConfigParser.h
src/Physics/HadronTransport/INCLConvertParticle.hh
src/Physics/HadronTransport/LinkDef.h
src/Physics/HadronTransport/Makefile
src/make/Make.include
src/make/Make.std-package-targets
src/scripts/setup/genie-write-gbuild

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Changes to `configure` and `src/make/Make.config`

The changes to `configure` follow the usual pattern for optional code. Use of `INCL++` currently also requires boost

```
incl        Interface with INCL++ for nuclear transport        default: disabled
geant4      Interface with Geant4 for nuclear transport        default: disabled

incl-inc    INCL++ includes path    needed if you --enable-incl    (if unset: tries to auto-detect it)
incl-lib    INCL++ library path     needed if you --enable-incl    (if unset: tries to auto-detect it)
boost-inc   boost includes path     needed if you --enable-incl    (if unset: tries to auto-detect it)
boost-lib   boost library path      needed if you --enable-incl    (if unset: tries to auto-detect it)
geant4-inc  Geant4 includes path    needed if you --enable-geant4  (if unset: checks for a \$GEANT4_INC e
geant4-lib  Geant4 library path     needed if you --enable-geant4  (if unset: checks for a \$GEANT4_LIB e
```

```
print MKCONF "GOPT_ENABLE_INCL=$gopt_enable_incl\n";
print MKCONF "GOPT_ENABLE_GEANT4_INTERFACE=$gopt_enable_geant4_interface\n";

print MKCONF "GOPT_WITH_INCL_INC=$gopt_with_incl_inc\n";
print MKCONF "GOPT_WITH_INCL_LIB=$gopt_with_incl_lib\n";
print MKCONF "GOPT_WITH_BOOST_INC=$gopt_with_boost_inc\n";
print MKCONF "GOPT_WITH_BOOST_LIB=$gopt_with_boost_lib\n";
print MKCONF "GOPT_WITH_GEANT4_INC=$gopt_with_geant4_inc\n";
print MKCONF "GOPT_WITH_GEANT4_LIB=$gopt_with_geant4_lib\n";
```

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Make.include changes for INCL++

```
INCL_LIBRARIES =
INCL_INCLUDES  =

ifeq ($(strip $(GOPT_ENABLE_INCL)),YES)

INCL_INCLUDES  = -I$(GOPT_WITH_INCL_INC) -I$(GOPT_WITH_BOOST_INC)
INCL_FLAGS     = $(shell $(GOPT_WITH_INCL_LIB)/../bin/inclxx-config --dflags )
INCL_LIBRARIES = -L$(GOPT_WITH_INCL_LIB)  $(shell $(GOPT_WITH_INCL_LIB)/../bin/inclxx-config --libs )

BOOST_LIBRARIES = -L$(GOPT_WITH_BOOST_LIB) -lboost_program_options -lboost_timer
                  -lboost_system -lboost_date_time
INCL_LIBRARIES := $(BOOST_LIBRARIES) $(FORT_LIBRARIES) $(INCL_LIBRARIES)
```

This relies on the `inclxx-config` script we are proposing to the INCL++ collaboration. The `-dflags` ensure consistency between which de-excitation models INCL++ was built with and those that GENIE will allow.

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Pre-linking HadronTransport against INCL++

```
src/Physics/HadronTransport/Makefile

# Only need these here ... not in every package

ifeq ($(strip $(GOPT_ENABLE_INCL)),YES)
  # extra flags, include paths, and libraries to link to
  CXXFLAGS              += $(INCL_FLAGS)
  CPP_INCLUDES          += $(INCL_INCLUDES)
  ROOT_DICT_GEN_INCLUDES += $(INCL_INCLUDES) ${INCL_FLAGS}
  EXTRA_EXT_LIBS        += $(INCL_LIBRARIES)
else
  $(info $(PACKAGE) not built against INCL++)
endif
```

This makes the INCL++ specific flags/includes available to the `HadronTransport` subpackage only (as other GENIE subpackages don't need to know about these).

It also pre-links the INCL++ libraries into `libPhHadTransp` rather than requiring the linking knowledge to have to happen at the app level.

This should make integration into LArSoft easier.

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Other INCL++ issues

Currently INCL++'s `G4INCLConfig` class doesn't provide a sufficient interface for configuring the location of de-excitation data files (which needs to be overridden when the build area is not the deployment path, e.g. CVMFS), so this version includes the `INCLConfigParser` class (which has a `friend` relationship and can change that data), but this introduces the `boost` library dependence.

The plan is to have discussions with the INCL++ collaboration about this issue, and in the future it might be possible to remove this class and this extra dependency.

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Changes for Geant4

The changes to `src/make/Make.include` and `HadronTransport/Makefile` similarly follow those for INCL++.
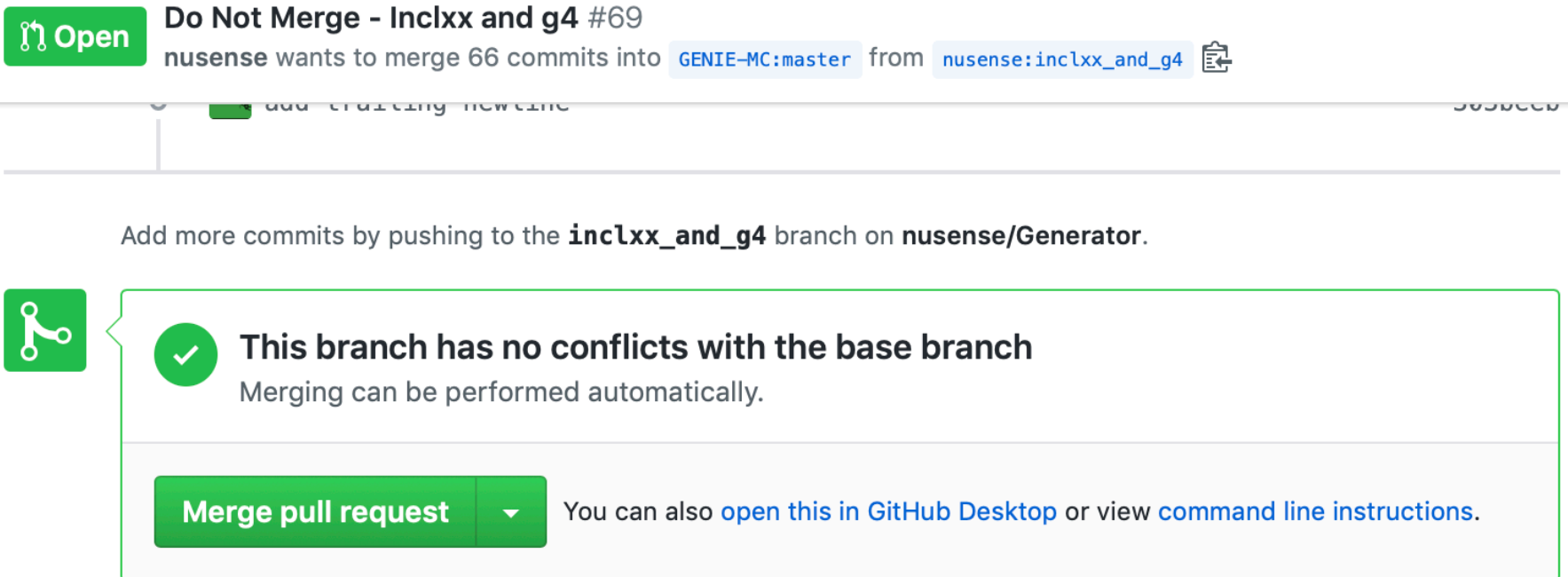
Again the Geant4 specific flags are only passed to the `HadronTransport` package builds. And the Geant4 libraries are pre-linked into `libPhHadTransp`

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Code Status

Code currently available via push request #69 (branch `inclxx_and_g4` from `nusense/Generator` fork):

https://github.com/GENIE-MC/Generator/pull/69

The code should merge cleanly

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